

## UNESCO Space Partnerships for Natural and Cultural Heritage

Mario Hernandez  
*m.hernandez@unesco.org*  
UNESCO  
France  
<http://www.unesco.org>

**Keywords:** natural heritage, cultural heritage

**Abstract:** tbd

## **CNES and Earth Observation: Past, Current and Future Perspectives**

Pascale Ultré-Guérard  
*Pascale.Ultre-Guerard@cnes.fr*  
CNES  
France

Aurélie Sand  
*aurelie.sand@cnes.fr*  
France

**Abstract:** tbd

## Very High Resolution Satellite Data in Archaeology and Paleoenvironmental Studies

Rosa Lasaponara  
*lasaponara@imaa.cnr.it*  
CNR-IMAA, Tito Scalo (PZ)  
Italy

R. Coluzzi  
*coluzzi@imaa.cnr.it*  
CNR-IMAA, Tito Scalo (PZ)  
Italy

N. Masini  
*n.masini@ibam.cnr.it*  
IBAM-CNR, Tito Scalo (PZ)  
Italy

**Abstract:** The importance of applying space technology to archaeological research has been paid great attention worldwide, mainly because nowadays the spatial capability of Very High Resolution (VHR) satellite data is comparable with aerial photogrammetric images. For the last century, aerial photos have been the most common remote sensing data source used in the field of archaeological investigations. The low spatial resolution of early satellite sensors, such as Landsat Thematic Mapper (30 m) or Spot (10 m), did not provide sufficient precision for the identification and inspection of archaeological sites. This restricted the application of satellite data to human ecology, landscape archaeology (Sheets and Sever, 1988; Clark et al. 1998, Sever, 1998) and paleo-geographic studies (Parry, 1992, Drake, 1997, White and Asmar 1999).

In the last decade, the increasing development of ground, aerial and space remote sensing techniques and the tremendous advancement of Information and Communication Technologies (ICT) have focused a great interest on the use of satellite imagery in archaeology and paleoenvironmental studies. In particular, the improved spatial and spectral capability of active and passive sensors has opened a new challenging perspective for the use of remote sensing technologies not only for the investigation, but also for the management and valorisation as well as for the monitoring and preservation of cultural resources.

The availability of Very High resolution (VHR) of multispectral satellite images, such as (i) IKONOS (1999) with panchromatic at 1 m, and multispectral at 4m, (ii) QuickBird (2001) with panchromatic at 0.6m and multispectral at 2.4, and (iii) Worldview (launched in the late 2007) panchromatic at 0.5m, offers improved capability in locating potential buried archaeological sites.

Moreover, the launch of WorldView-2 (anticipated October 2009) will provide imagery with a spatial resolution of 46 cm (panchromatic) and 1.84 m (multispectral -Blue, Green, Red Near-Infrared). Beside the four standard bands the WorldView-2 imagery will also contain 4 additional colours (red edge, coastal, yellow and near-IR2).

The application satellite remote sensing techniques has significant potentiality for archaeological research and paleo-environmental studies in different applications (i) detection, identification and mapping of new archaeological features (such as sites, road segments, and field patterns), (ii) reconstruction of ancient landscape, (iii) documentation, management and valorization of cultural heritage, (iv) monitoring of natural risks (such as landslide, fire, earthquake, flood) for cultural heritage. Examples of investigation focused on points (i) to (iv) will be presented in detail for several archaeological areas in South America (Tiwanaku -Bolivia, Nasca Perú;), Italy and Turkey.

## Advancement in Automatic Monitoring and Detection of Archaeological Sites using a Hybrid Process of Remote Sensing, GIS Techniques and a Shape Detection Algorithm

Archelological site monitoring using new available high resolution radar data

Alessio Adi Di Iorio  
*adi@rovsing.dk*  
ROVSING A/S  
Denmark  
<http://www.rovsing.dk>

Nazzareno Nst Straccia  
*nazzareno.straccia@tiscali.it*  
ALMA Sistemi SAS  
Italy

Renzo Rci Carlucci  
*rcarlucci@aec2000.eu*  
AC2000 S.r.l.  
Italy

**Keywords:** Archeological site monitoring and detection, gis, remote sensing, SAR, Cosmo Sky-Med.

**Abstract:** The method developed in the frame of the project HORUS (Heritage Observation and Retrieval Under Sand funded by European Space Agency) for the automatic monitoring and identification of lost or undiscovered archaeological sites in Egypt has been improved and applied to the new available high resolution radar images by Cosmo Sky-Med satellites. The use of active high resolution active sensors enables continue monitoring of the target area with all whether condition (day, night with any cloudy coverage) and Cosmo Sky-Med satellites are mainly devoted to observe the “Mediterranean area (“Med in fact is for “Mediterranean”) where is the highest density of the Archaeological sites in the world. The method uses shape detection techniques on satellite imagery superposed in a GIS environment. For an area of interest, the EO data available from various satellites is pre-processed and from historical plans a shape file of the archaeological structure of interest is produced. A shape detection algorithm employing a shape matched operator is applied to the EO image to produce a detection image identifying the most probable location of the archaeological structure of interest. The shape-matched operator employed is the derivative of double exponential (DODE) operator. The final product is a GIS data set assembled as a list of required features and layers, all converted and processed in the same Geographical Reference System. The article shows the most recent advancement using the operator applied to high resolution X-band SAR images by Cosmo Sky-Med.

## Very High Resolution Satellite Remote Sensing as Part of an Integrated Approach for Archaeological Prospection at Tepe Düzen (Southwest Turkey)

Véronique De Laet  
*Veronique.DeLaet@ees.kuleuven.be*  
K.U.Leuven  
Belgium

B. Music  
University of Ljubljana  
Slovenia

S. Aydal  
Turkey

K. Vyncke  
K.U.Leuven  
Belgium

H. Vanhaverbeke  
Mehmet Akif Ersoy University  
Turkey

E. Paulissen  
K.U.Leuven  
Belgium

G. Verstraeten  
K.U.Leuven  
Belgium

M. Waelkens  
K.U.Leuven  
Belgium

**Keywords:** Remote sensing, Quickbird, geophysics, archaeological survey, excavations, Turkey

**Abstract:** Very high spatial resolution satellite (VHSRS) systems have considerably enhanced the possibilities of detailed archaeological prospection. An excellent illustration of the potential of VHSRS imagery is the discovery and the continuing evaluation of the archaeological site of Tepe Düzen (Turkish for “flat hill”) in southwest Turkey in 2004.

During extensive archaeological prospections on Tepe Düzen in 1994 and 1997 the extent and importance of the site were not acknowledged, because only some structures made of fieldstones and rocks were identified, and undiagnostic pottery was collected. Specific enhancement techniques on Quickbird imagery showed many rectilinear features forming building-like configurations. The analysis revealed that Tepe Düzen was most likely covered with a large site, extending over an area of at least 1.2 km<sup>2</sup>. Its presence and extent was later confirmed by a targeted archaeological survey. Despite its positive contributions, the possibilities of satellite imagery for mapping and interpretation of structures on archaeological sites depend on the type and characteristics of the VHSRS data and on on-site parameters, such as the dimensions of the remnants and the spectral contrast of the marks (shadow, soil and crop marks). Additional information about the internal site structures,

which is absolutely necessary for further interpretation of the VHSRS data, is mainly retrieved from geophysics (electrical resistivity, magnetic survey, GPR) combined with ground control (intensive archaeological survey and excavations). Satellite remote sensing is not an exclusive prospection technique, but should be used in combination. This paper presents a stepwise interdisciplinary integration and back-coupling of very high resolution satellite remote sensing, archaeological survey, topographic mapping, geophysics and excavations for archaeological prospection.

## Kemmelberg (Belgium) Case Study: Comparison of DTM Analysis Methods for the Detection of Relicts from the First World War

Cornelis Stal

*Cornelis.Stal@UGent.be*

PhD-student, dept. of Geography, Ghent University  
Belgium

Jean Bourgeois

*Jean.Bourgeois@UGent.be*

Professor, dept. of Archeology, Ghent University  
Belgium

Philippe De Maeyer

*Philippe.DeMaeyer@UGent.be*

Professor, dept. of Geography, Ghent University  
Belgium

Guy De Mulder

*Guy.DeMulder@UGent.be*

Assistant, dept. of Archeology, Ghent University  
Belgium

Alain De Wulf

*Alain.DeWulf@UGent.be*

Professor, dept. of Geography, Ghent University  
Belgium

Rudi Goossens

*Rudi.Goossens@UGent.be*

Professor, dept. of Geography, Ghent University  
Belgium

Timothy Nuttens

*Timothy.Nuttens@UGent.be*

PhD-student, dept. of Geography, Ghent University  
Belgium

Birger Stichelbaut

*Birger.Stichelbaut@UGent.be*

PhD, dept. of Archeology, Ghent University  
Belgium

**Keywords:** airborne laserscanning, archeology, convolution

**Abstract:** Laserscanning is a well known technology in a various range of scientific disciplines. This paper focuses on the manipulation of high resolution DTM's (Digital Terrain Models), to easily detect relicts in the landscape, dating from the First World War. Possible objects to detect are shell holes, trenches and other features related to the material remains of the First World War. A common method to detect these objects is the use of historical aerial photographs taken during this war (1914-1918). A database, containing relicts can be made, based on the interpretation of these images (remote sensing), possibly complimented by validation on site (fieldwalking). The interpretation of historical photographs requires thorough and specialized knowledge of the elements on

these pictures. Stichelbaut (2009) has made an extensive research on the archaeological application of First World War aerial photographs in Flanders, Belgium. After the First World War, the existing landscape has totally been destroyed around the Mount Kemmel (municipality of Heuvelland, Belgium), and many war-related elements were removed during the reconstruction. However, in existing cases, elements are conserved, and still visible in the landscape. Some of these features still exist but the height difference with the surrounding surface is very small and therefore these features cannot be seen on site.

A thorough analysis of new aerial pictures will not always give satisfactory results in many cases. This paper focuses on the different technical filter techniques to detect these objects. For example, this can be done by emphasizing the altitudes in a DTM, by the use of edge detectors. Different mathematical methods, using a convolution matrix, will be analyzed. The resulting data is a very important research tool for the cultural management of this fragile heritage.

## Public Spatial Data in Service of Polish Archaeologists

Advantages and disadvantages of Web Map Servers usage.

Lukasz Banaszek  
*lukas.banaszek@wp.pl*  
Poland

**Keywords:** WMS Servers, GIS, photogrammetry, heritage management and protection, archaeological teaching, Local Development Plans

**Abstract:** The EU 'INSPIRE' directive forces governmental authorities to share public spatial data with taxpayers. It is the main reason of launching WMS Servers in Poland. According to the law, local authorities are saddled with the responsibility to create web-based spatial data-bases. Consequently, the range of geoportals is local as well. Although these are still sparse, the numbers are growing and archaeologist cannot underestimate that fact.

The aim of this paper is to present aspects of Web Map Servers usage in archaeological interrogation. Currently, archaeological spatial information is inefficiently collected and archived in paper. According to this account, it will be demonstrated, that the use of WMS Servers by archaeologists makes management and display of existing data easier and more effective. Both profits and drawbacks of geoportals usage will be discussed.

One can often spot archaeological sites on aerial photographs displayed in WMS Servers. Heritage management offices, which are concerned about every archaeological data that goes into public, have to face it. As the process of public spatial data release is unstoppable, it forces changes in management policy. Free of charge access to Web Map Servers together with the popularity and usability of open-source GIS software give comfortable possibilities to work on diverse fields of archaeological interest.

Rapid growth of GIS tools in dealing with geographical information is an undisputable fact. However archaeological services in Poland seem to have neither knowledge nor need to appreciate it. Furthermore field-walking remains the main method of archaeological data collecting. The results of it are far from ideal because of many reasons. Defects in precise description of site locations and difficulties in managing and sharing of data are the main vices of current approach.

User-friendly WMS Servers can become a simple GIS platform. Displaying current archaeological data on the same layers as offered by geoportals gives extraordinary effects. High quality and actual orthophotomaps as well as open access to the Local Development Plans are a real assist in heritage protection and management. Linking archaeological data-bases with Local Development Plans leads to a better understanding of threats for archaeological sites due to premeditated urbanisation processes. Actual orthophotomaps uploaded into servers in short time intervals (usually every 2-3 years) offer a deep view into illegal, unplanned and dispersed space creation and usage which endanger heritage. Use of Web Map Servers is also a great weapon in school teaching and creating local identities. Unfortunately, since geoportals are not created particularly for archaeological purposes, archaeological information is often missing. Furthermore, as WMS Servers are launched on local level, they often provide in diverse ways information that vary in kind and in quality.

## New Developments in Population Estimate from Remote Sensing

Herbert Hansen  
*hhansen@keyobs.com*  
Keyobs  
Belgium

Sophie Taupin  
*staupin@keyobs.com*  
Keyobs  
Belgium

Amélie Desgropes  
*amelie.desgropes@gmail.com*  
IFRA  
Kenya

**Keywords:** remote sensing, population estimate, landcover

**Abstract:** Satellite imagery constitutes an interesting support or alternative to ground surveys in many fields. Concerning population estimates, it can be of great help to provide a rapid updated assessment of a population. Low cost, comprehensive vision of a region which may be otherwise inaccessible, time sparing and updated situation are incentives to resort to this kind of technique. In the case of Kibera (Nairobi, Kenya), one of the biggest informal settlements in the world where people live in an extremely dense urban context, the challenge was to provide an updated estimate of the population where many varying figures have been suggested. On basis of a satellite image acquired in February 2009, buildings were extracted and helped supporting field surveys and estimates. Field surveys were organised randomly throughout the slum and collected figures were then extrapolated for the whole Kibera on basis of the information extracted from the image.

Comprehensive field surveys should be made in order to further validate our result and to answer some questions: - To what extent is the satellite imagery useful with regards to field survey? What is the best combination to reach the most accurate estimate? - Is the degree of error in estimating the population proportional to the level of detail extracted from the satellite imagery? - Can we draw rules for any kind of urban settlement?

Keyobs experts are now developing operational techniques in order to propose new services for population estimates and follow-up in rural and urban areas.

## Extraction of Buildings from QuickBird Imagery for Municipal Use – the Relevance of Urban Context and Heterogeneity

Sergio C Freire

*sfreire@fcsh.unl.pt*

e-GEO, Centro de Estudos de Geografia e Planeamento Regional, Faculdade de Ciências Sociais e Humanas – Universidade Nova de Lisboa, Avenida de Berna, 26–C, 1069–061 Lisboa  
Portugal

<http://e-geo.fcsh.unl.pt/uk/index.asp>

Teresa Santos

*teresasantos@fcsh.unl.pt*

e-GEO, Centro de Estudos de Geografia e Planeamento Regional, Faculdade de Ciências Sociais e Humanas – Universidade Nova de Lisboa, Avenida de Berna, 26–C, 1069–061 Lisboa  
Portugal

Ana Fonseca

*anafonseca@lnec.pt*

National Laboratory for Civil Engineering (LNEC), Lisbon, Portugal  
Portugal

Jose A Tenedório

*ja.tenedorio@fcsh.unl.pt*

e-GEO, Centro de Estudos de Geografia e Planeamento Regional, Faculdade de Ciências Sociais e Humanas – Universidade Nova de Lisboa, Avenida de Berna, 26–C, 1069–061 Lisboa  
Portugal

**Keywords:** QuickBird, feature extraction, urban planning, Lisbon

**Abstract:** A spatial component is associated with the majority of municipal activities, namely in urban planning and management. The high frequency and scope of spatial changes in cities demands ways of expediting the production and updating of large-scale geographic information, as required by Portuguese legislation. For that purpose, current and future very high spatial resolution satellite imagery (VHR) may be an advantageous alternative to classical data sources and methods, i.e., aerial photography and photogrammetry. Therefore the nature of this recent data source, volume of data, and expanding range of applications has been driving the development of advanced semi-automated object-based image analysis methods for efficient feature extraction. At the same time, the urban environment is becoming more complex and heterogeneous, possibly turning the feature extraction process more challenging. While much research has focused on developing, adapting and applying these approaches, less attention has been devoted to the interplay of data source (imagery), feature extraction methods, and geographic characteristics of the area under analysis.

The work presented in this paper takes place in the context of the exploration of VHR satellite imagery and new methods as an alternative source of geospatial information for large scale mapping to assist urban planning in Lisbon, Portugal. Lisbon is both a historical and modern city having a dynamic and complex landscape. This effort tests the semi-automated extraction of buildings from areas with different characteristics, and analyzes the impact of the heterogeneity of these features in the extraction process. For this purpose, three study areas having the same size but diverse character were selected: one in the more homogenous and slow-changing old historical district, another in a heterogeneous residential and old industrial area, and a third in a new residential area under development. Buildings were characterized with respect to intrinsic and contextual features, namely roof type (color and material), size, shape, and density. Multispectral and panchromatic QuickBird images were orthorectified and subjected to pansharpening, and feature extraction software was

employed to digitize buildings. Extraction performance regarding both quality of extraction and relative workload (time by building) was analyzed in a geographic information system considering the building's characteristics.

Quality assessment was exhaustive and used reference datasets independently collected from the imagery by visual interpretation. GPS-assisted field work was also conducted to characterize the areas and document the buildings. Results indicate that the geographical context is relevant for the success of semi-automated feature extraction and that the process becomes more challenging with the increasing heterogeneity and complexity of the built environment.

## Mapping Urban Change for Planning the Future

Maputo City change model and the Municipal Structure Plan

Cristina D Henriques

*cdh@fa.utl.pt*

e-GEO, Faculdade de Arquitectura, Universidade Técnica de Lisboa

Portugal

<http://cdh.fa.utl.pt>

José António Tenedório

*ja.tenedorio@fcsb.unl.pt*

e-GEO, Faculdade de Ciências Sociais e Humanas, FCSH, Universidade Nova de Lisboa

Portugal

**Keywords:** Mapping, Urban land use, Change model, Maputo, Urban planning

**Abstract:** The process of transformation of Maputo City (in Mozambique) was observed and mapped over 5 decades (between 1964 and 2008) based on several different data sources (historical aerial photos, digital base maps, Quickbird and Ikonos satellite images). As a first result the time series of maps and mapping process in GIS will be presented. Special attention will be given to the fact that the nomenclature includes a morpho-functional semantics incompatible with an automated process using digital image processing. The “Land Change Modeler for ArcGIS” was used for the quantification and localization of land use change. A second result will point out a dichotomy between the urbanized colonial city and the sprawling suburbs, which corresponds to the general model of land use organization and its change. Two types, which are also categories of change, can be identified: the central land use changes which have little significance, but are important from a functional point of view; and the suburban land use changes, which involve vast areas of dominant residential land use. The third result corresponds to the analysis of these changes in the context of the Municipal Urban Master Plan, recently approved. The guidelines of this plan and the relevance of the thematic cartographic information in which it was based are discussed in this paper. The significance of the land use change model calculated for the plan proposal and the simulation of future scenarios for urban expansion will also be discussed. Focus on the importance of the land use maps produced, in the absence of other maps, to provide the Municipal Urban Master Plan, and its permanent update based on satellite images providing territory monitoring.

## Urban Atlas Updating by Semi-automatic Change Mapping

Overview of the different methodologies tested in geoland2 applied to Urban Atlas change detection in the urban environment

Joeri Van Wolvelaer  
*joeri.van.wolvelaer@eurosense.com*  
Belgium

César Santos González  
*csantos@indra.es*  
Spain

Antonio Garzón López  
*agarzon@indra.es*  
Spain

Anna Maria Deflorio  
*deflorio@planetek.it*  
Italy

**Keywords:** Urban Atlas, geoland2, change mapping

**Abstract:** By the end of 2010, the first edition of the Urban Atlas should be available for over 300 large and medium-sized cities in the EU. This includes European capitals and a number of cities participating in the European Urban Audit – a programme to collect and compare statistical data from some 300 participating cities in Europe. This map will provide, for the first time, homogeneous and up-to-date information on urban environments, allowing for a comparison of different cities all across Europe. Future editions of Urban Atlas are planned in three-to-five-year intervals in parallel with the Urban Audit exercise. The efforts needed for these future editions should be minimized by using an efficient Urban Atlas updating procedure, benefitting from previous efforts.

Within geoland2, one of the tasks addresses the Local Land Monitoring Core Service (i.e. the Urban Atlas) to explore the capabilities for updating these Urban Atlas maps. The produced Urban Atlas data are evaluated to assess its potential for a semi-automatic change mapping approach. Goal is thereby to develop a standard updating protocol guarantying the creation of homogeneous future editions of the Urban Atlas (with a first reference year 2011) and the corresponding change database. The overall aim is to produce an updated Urban Atlas (UA(t1)) database and a database of land cover changes between the first inventory (t0) and the current situation (t1) (UAchanges).

An object-based procedure for detecting infrastructure changes by VHR imagery is proposed. The change analysis procedure consists of different steps: pre-processing, including pan-sharpening, geometric correction and radiometric balancing, object and feature extraction, and statistical change/no-change detection. In a next step the results from these processing steps will be used in a manual on-screen digitizing in order to evaluate and interpret the detected changes. Specific change mapping guidelines have been drawn up to harmonise this visual interpretation. In general, the creation of the updated Urban Atlas can be divided into three steps: (1) an automatic comparison of image data to detect changes – pre-screening; (2) change interpretation and mapping; (3) creation of the 2nd edition map by combining the first inventory of the Urban Atlas with the created change database.

This paper will give an overview of the different methodologies tested in geoland2 applied to land use / land cover change detection in the urban environment. Tested algorithms include image differencing, segmentation comparison and post-classification comparison, all taking into account phenomena / processes as mis-registration, histogram matching, change filtering, image transformations, etc.

## Analysis of the Relationship between Urban Land Use and Urban Heat Island using RS Methods

László Mucsi

*mucsi@geo.u-szeged.hu*

associate professor

Hungary

<http://www.geo.u-szeged.hu/web/dr-mucsi-laszlo>

László Henits

*henits@geo.u-szeged.hu*

PhD student

Hungary

János Unger

*unger@geo.u-szeged.hu*

associate professor

Hungary

**Keywords:** urban land use, urban heat island, spectral mixture analysis, standard deviation of NDVI

**Abstract:** Remote sensing has considerable potential for providing accurate, up-to-date information in urban areas. Urban remote sensing is complicated, however, by very high spectral and spatial complexity. In this paper, beside traditional per-pixel method (annual NDVI change detection using Landsat TM images), Normalized Endmember Spectral Mixture Analysis (NSMA) was applied to map urban land cover. The TM images were acquired over the city of Szeged, Hungary in 1986 and 2009. The urban land use categories were classified according to the standard deviation (SD) of NDVI values of 8 TM images in 1986. Significant linear connection was calculated between the SD values and the sub-pixel rate of impervious surfaces. Impervious surface, one of the most important elements of the VIS model, has been recognized as a key indicator in assessing of the change of the urban environment in the last 25 years in the city. Fractional images of impervious surfaces developed from LTM images acquired in 1986 and 2009 were compared with each other and with the SD image of NDVI values. The spatial statistical analysis of internal land use change was developed on the the traditional urban zones.

Later, the urban land cover map was the main database for the estimation of spatial distribution of urban heat island. The result of the geostatistical analysis demonstrated a very strong connection between urban land cover classes and spatial characteristics of urban heat island.

## Improving the Characterization of Urban Form and Function with Spatial Metrics using Remote Sensing Data

Sven Vanderhaegen  
*svdhaege@vub.ac.be*

Cartography and GIS Research Group, Department of Geography, Vrije Universiteit Brussel

Frank Canters  
*fcanters@vub.ac.be*

Cartography and GIS Research Group, Department of Geography, Vrije Universiteit Brussel  
Belgium

**Keywords:** remote sensing data, spatial metrics, urban land use, urban morphology

**Abstract:** To understand changes in urban form and function, and how these changes relate to urban development processes that drive these changes or that are affected by it, increasing use is made of computer-based urban growth models. The performance of these models strongly depends on the availability of time series of data on urban land use, needed for calibration of these models. Producing such data from available data sources is time-consuming. Land-use interpretation is also a rather subjective process, which may lead to inconsistencies in land-use maps derived for different time steps or for different areas. This hampers the use of such data in developing urban growth models, and in comparative studies on urban dynamics. These obstacles call for a formalisation of the land-use interpretation process and for the development of (semi-) automatic approaches for inferring urban form and function from available data sets.

Several studies have shown the potential of spatial metrics for identifying distinct types of urban form and function. Such metrics can be calculated for relative homogeneous areas that constitute the urban fabric, e.g. urban blocks. Urban blocks are typically composed of built-up and non built-up areas, with a specific composition and spatial configuration. The wide spread use of GIS-based tools makes that for most cities large-scale vector data sets are produced, containing detailed information on the structure of the built-up area. However, while these data sets usually include detailed representations of the outline of individual buildings, in most cases no information is included on the physical characteristics of the areas that surround the buildings, and together with these buildings characterize the block as a whole. This makes it difficult to distinguish different types of urban form and function based on this type of data.

High-resolution remote sensing data may complement large-scale building data sets by providing information on the structure of the non-built area, e.g. parking lots, vegetation patches, and thus enable a better characterisation of urban form at block level. This research focuses on the added value of high resolution remote sensing data, in addition to urban building data, for describing and mapping urban form and function, using spatial metrics. The approach proposed is applied on the Brussels Capital Region, using the UrbIS large-scale reference data base of the region as well as high-resolution Ikonos data covering the area. A typology of urban form and function, based on traditional and newly developed spatial metrics is presented.

## High Precision Monitoring of Urban Sealing

Object-based Analysis of Aerial- and Satellite Images

Andreas Müterthies  
*andreas.mueterthies@eftas.com*  
Geographer  
<http://www.eftas.com>

Klaus Ulrich Komp  
EFTAS  
Germany

**Keywords:** REFINA, Automatic Image Analysis, Pattern Matching, Urban sealing, Sustainable Land Management

**Abstract:** From 1997 until 2000 the daily increase of built-up areas in Germany was 129 ha while the German population remained constant. According to national policy, this land consumption rate shall be reduced to 30 ha per day until 2020. In this context the Federal Ministry of Education and Research (BMBF) of Germany initiated the support program “REFINA” (Research for the reduction of land consumption and sustainable surface management). One of the funded research projects is the “development and trial of semi-automatic and automated methods for surveying and assessing settlement and traffic areas using remote sensing”.

This project is coordinated by EFTAS Fernerkundung Technologietransfer in cooperation with the University of applied science of Osnabrück, the municipality of Osnabrück and the “Landesamt für Bergbau, Energie und Geologie” of the German state of Lower Saxony.

The Research objectives in this project focussed on the Development of semi-automatic methods for a faster and cheaper integration of image information into the urban planning process. Test sites in the city of Osnabrück (Northern Germany) have been selected in close cooperation with all relevant stakeholders (Department of city planning of Osnabrück, Department of urban green of Osnabrück, environmental protection agencies of the urban and state government).

Embedded tasks of the project are: · Area-wide survey and preparation of actual and historical image information · Analysis of the usability of new satellite sensor- and camera systems for high precision monitoring · Analysis of Historical area development by multi-temporal analysis from 1935 until 2005 · Image pre-processing · object class definition in cooperation with stakeholders · Development of object-oriented classification methods and methods for pattern matching · Evaluation of the classification- and pattern matching results

The results of the project underline the suitability of remote sensing techniques to support city planning processes.

## Time-series Analysis of Late Summer Snow Patches in Northern Swedish Lapland

A climate change analysis

Eberhard Parlow  
*eberhard.parlow@unibas.ch*  
University Basel  
Switzerland  
<http://www.mcr.unibas.ch>

**Keywords:** time series, climate change

**Abstract:** Snow patches are found all over in high-mountain and arctic areas. In these regions climate change is supposed to be faster than at other latitudes and the change is predicted to be very likely to continue. In recent decades, remote sensing data are extensively used for change detection analysis due to climate change processes. In many research strategies the change in vegetation cover is used to indicate a change in landscape. But the slow and very gradual changes in vegetation cover are hard to be detected in multi-spectral satellite imagery. This study uses four-teen satellite images covering the time period from to 2006 to explore spatial and temporal variations in the extent of late summer snow patches in the Abisko Mountain in subpolar Northern Sweden to detect the impact of climate change. Late summer snow patches are used because they interact with weather conditions on an annual scale and they contrast extremely with no-snow areas in satellite imagery which makes their analysis feasible and significant in the statistical sense. Landsat, Aster, IRS and SPOT satellite data are used for this study covering a period of 34 years. Since there exist extreme climate gradients in the area from maritime to continental climate within a distance of 100 km special attention had to be paid on this regional variability. Therefore special statistical filter techniques were developed to tackle the problems of climate gradients of snow precipitation, altitudinal effects etc.

## Use of Cloud Observations by Geostationary Satellite to Correct Photolysis Reaction Rates

Arastoo Pour Biazar  
*biazar@nsstc.uah.edu*  
UAH/NSSTC/ESSC  
United States

Richard McNider  
*McNider@nsstc.uah.edu*  
UAH/NSSTC/ESSC/USRA  
United States

**Keywords:** GOES, Geostationary satellite, Air Quality, Photolytic reactions, photolysis rate, cloud radiative impact

**Abstract:** A key component in air quality modeling is the correct estimation of photolysis rates. Photolysis rates depend on the intensity of solar radiation in the atmosphere and the molecular properties of the molecule undergoing photodissociation. Therefore, attenuation or enhancement of radiant energy due to atmospheric absorption and scattering is important in determining the photolysis rates. Since clouds can significantly alter the solar radiation in the wavelengths affecting the photolysis rates, they can have considerable impact on the photochemistry.

In this study we use satellite retrieved cloud transmissivity, cloud top height, and observed cloud fraction to correct photolysis rates in the USEPA's Community Multiscale Air Quality (CMAQ) modeling system. To test and evaluate the technique, CMAQ simulations for August of 2000 and 2006 for a variety of domains and grid resolutions were performed. The results from simulations using this method were compared with simulations using model clouds as input and were evaluated against USEPA's surface monitors and special observations during Texas Air Quality Studies.

The results clearly indicate that not using the cloud observations in the model can drastically alter the predicted atmospheric chemical composition within the boundary layer and exaggerate or under-predict ozone concentration. Cloud impact is acute and more pronounced over the emission source regions and can lead to drastic errors in the model predictions of ozone and its precursors. Clouds also increased the lifetime of ozone precursors leading to their transport out of the source regions and causing further ozone production down wind. Longer lifetime for NO<sub>x</sub> and its transport over regions high in biogenic hydrocarbon emissions (in the eastern part of the domain) led to increased ozone production that was missing in the control simulation.

## Use of Ozone Monitoring Instrument (OMI) Ozone Profiles in Air Quality Assessment Studies

Arastoo Pour Biazar  
*biazar@nsstc.uah.edu*  
UAH/NSSTC/ESSC  
United States

Richard T McNider  
*McNider@nsstc.uah.edu*  
UAH/NSSTC/ESSC/USRA  
United States

Maudood Khan  
USRA  
United States

Yun-Hee Park  
University of Alabama - Huntsville  
United States

Mike Newchurch  
UAH/NSSTC/ESSC  
United States

Lihua Wang  
University of Alabama - Huntsville  
United States

**Keywords:** Aura, OMI, CMAQ, Air Quality

**Abstract:** Newly available satellite observations of tropospheric trace gases provide a wealth of information that can potentially reduce some of the persistent uncertainties in the air quality assessment studies. Satellite measurements can also help in evaluating the performance of the models used in these studies. Numerical air quality models are the preferred tools used for air quality forecast and in regulatory air quality assessment practices. Improving the performance of these models through the utilization of satellite observations is particularly beneficial.

In this study, we have utilized the observations of tropospheric ozone profiles by Ozone Monitoring Instrument (OMI) on board NASA Aura satellite to provide the initial state of the atmosphere, as well as the lateral boundary conditions for the U.S. EPA's Community Multiscale Air Quality (CMAQ) Modeling System. Model simulations span over August 2006 and cover the continental United States. This period coincides with INTEX Ozonesonde Network Study 2006 (IONS-06) campaign and offers a unique comprehensive set of ozonesonde measurements for evaluating OMI ozone vertical profiles, as well as model predictions in the free troposphere. Model predictions were also evaluated against measurements from EPA's surface monitors, as well as detailed surface and aircraft measurements from second Texas Air Quality Study (TexAQSI).

OMI ozone profiles showed a good agreement with the ozonesonde measurements. The model results indicated a significant improvement in the predictions of tropospheric ozone when satellite data is utilized. The use of satellite observation for specifying lateral boundary conditions could considerably improve the ozone predictions in the upper troposphere where a significant vertical gradient in ozone concentration exists. This indicates that in this region horizontal transport is the dominant factor in determining ozone concentrations and the correct specification of the lateral boundary condition can also correct some of the error caused by improper top boundary condition.

## Footprint Modelling Applied to ASTER Derived Heat Fluxes

Corinne M Frey  
*corinne.frey@unibas.ch*  
Switzerland

<http://www.mcr.unibas.ch/typo3/>

Eberhard Parlow  
*eberhard.parlow@unibas.ch*  
Switzerland

<http://www.mcr.unibas.ch/typo3/>

**Keywords:** footprint, ASTER, urban, heat fluxes, energy balance

**Abstract:** Land surface heat fluxes were estimated using the LUMPS scheme with ASTER data from Cairo, Egypt. The LUMPS scheme is built on the premise that heat fluxes can be modelled using net radiation, the ground heat flux, air temperature and two empirical parameters that describe the surface cover (availability of water) and morphometry (roughness elements, and density respectively). These two empirical parameters were deduced from eddy covariance measurements at three typical sites from a measurement campaign in Cairo in 2007/2008 and applied to the ASTER image according to the land use. The energy balance of the in situ measurements was not closed; hence a Bowen-ratio based closure forcing was applied. Spatial net radiation was calculated from the short- and longwave radiance data of the ASTER images and associated radiative transfer modelling runs using MODTRAN. The ground heat flux was assessed using different methods based on net radiation and vegetation indices. Three different flux footprint models were used to assess land surface heat fluxes. The used footprint models are the model from Kormann Meixner, the model from Hsieh and the model of Horst Weil. The output of these models was fit to the spatial resolution of the ASTER data and overlaid over latter according to the wind direction. Finally, the results were compared to the in situ data. A first constraint in the methodology is given by the limitation of control points: The tested stations are the same as the input stations for the empirical constants of the LUMPS scheme. A second constraint is given by the presence of clouds in the footprint area of some of the ASTER data, limiting the number of useful pixels in the footprint analysis. Even though the models produced different flux prints, the resulting turbulent heat fluxes at the three stations did not differ significantly. The agreement between the in situ measured and the ASTER retrieved sensible heat fluxes was improved in some cases.

## The US/F A-TRAIN Concept

Observing the Earth from Space as an Integrated System

Gerard Begni  
*gerard.begni@cnes.fr*  
 CNES  
<http://www.cnes.fr>

Didier Renaut  
*dider.renaut@cnes.fr*  
 CNES  
 France  
<http://www.cnes.fr>

Didier Tanre  
*didier.tanre@univ-lille1.fr*  
 Laboratoire d'Optique Atmosphérique  
 France

Jacques Pelon  
*Jacques.Pelon@aero.jussieu.fr*  
 Laboratoire d'Aéronomie  
 France

**Keywords:** Earth system, Earth surface, climate, aerosols, clouds, CO<sub>2</sub>

**Abstract:** Observing and analyzing the Earth as an integrated system at various scales paved the way to dramatic advances in Global Change understanding, mitigation and adaptation, which in turn evidenced needs for innovative observation systems. Such an integrative concept is the guideline of the Earth System Science Partnership (ESSP). Space programmes developers understood for long that fulfilling such needs required a wide range of quite different simultaneous observations systems from space and ground. They implemented relevant cooperation. This widens the scope of 'Remote Sensing' to a contribution to a system approach of the Earth System at various scales, and not only to Earth surface observation, as often understood. In terms of space systems, two quite different concepts can be developed. First, implementing different instruments on the same large satellite: this is the ESA/ENVISAT concept – by far the largest environment satellite ever built and operated. This is well known by the EARSeL community. The other solution is much poorly known. The basic concept is to implement several mini or micro-satellites close to one another on the same orbit, thus crossing the equator within a few minutes interval.

This has led to so-called "A-Train" French/US satellites formation, which includes 7 mini or micro-satellites: AQUA, AURA, CLOUDSAT, CALIPSO, PARASOL,OCO (which failed to be launched) and GLORY. It is quite interesting first to analyze each of these satellites as a single dedicated observatory, then to understand how their synergy within the A-Train concept allows better answering some basic Earth system questions, such as:

- better understanding and quantifying some Earth surface properties, - better characterizing the aerosols types and how do observation match global emission and transport models, - better understanding and quantifying the vertical distribution of cloud water/ice in cloud systems, - better understanding the role of polar stratospheric clouds in ozone loss and their linkages with the Arctic vortex. - In a more global way, better understanding the Earth system major cycles (especially the role of aerosols and cloud layering in radiation budget and forcing).

Answering such basic questions are critical paths to better characterize, understand and predict global Earth system changes and the related impacts at global and regional scales such as for

instance Europe or the Mediterranean basin, as well as their coupling and teleconnections. This shows the European capacity to develop international cooperation and bring relevant innovative observation systems to contribute to the objectives of the ESSP scientific community.

European Earth remote sensing research, science and technology has always been on the forefront, such giving Europe a great and respected scientific capacity, making it a reliable partner for scientific and high-tech cooperation, and giving European Union sound capacities to build up in-house and international policies about global change issues.

The A-Train capacities contribute to these worldwide efforts. They have to be developed, widely advertised and exploited at their full capacity.

## Towards the Pleiades Thematic Commissioning Phase

Benoit Boissin  
*benoit.boissin@cnes.fr*  
CNES DSP/OT  
France

Hélène De Boissezon  
*helene.deboissezon@cnes.fr*  
CNES DCT/SI/AP  
France

Manuel Grizonnet  
*manuel.grizonnet@cnes.fr*  
CNES DCT/SI/AP  
France

Aurélie Sand  
CNES  
France

**Keywords:** Pléiades, accompagnement program

**Abstract:** The Pléiades program is a dual program developed in cooperation between the space agencies of France, Sweden, Belgium, Spain and Austria. It has been designed to provide high resolution optical data for the benefits of civilian and defence users in term of operational capacity, rapid access and protection of defence interests. The space component is composed of two "small satellites" (mass of one ton) offering a spatial resolution at nadir of 0.7 m and a field of view of 20 km.

Their great agility enables 1) a daily access all over the world, which is a critical need for defence and civil security applications, and 2) an high coverage capacity necessary for cartography applications. Moreover, to meet the needs for detailed mapping, specially in urban areas and to complement aerial photography, Pléiades will offer instantaneous stereoscopic acquisition and the capability to cover large areas by acquiring collateral stripes in the same path.

Beside the Pléiades system developments, an extended accompagnement program has been operating since 2004, to prepare, accompany and promote the future exploitation of the Pléiades images. The objectives of this program are 1) to assess the thematic capability of the Pléiades system to produce the various services required by end-users for distinct thematics (defence, risks, cartography, hydrology, forestry, agriculture ...) and 2) to develop efficient tools to facilitate image information extraction by end-users.

The Thematic part of the accompagnement program covers a large range of applications (civil and defence ones), and aims at specifying and validating value added products and services required by end users. An in-depth work of user needs assessments in eight thematic domains (sea and coast-line, risks and humanitarian aid, cartography and town planning, geophysical hazards, hydrology, forestry, agriculture and defence) has given rise to a large number of feasibility studies. This part includes consideration about products integration in the operational systems or processing lines and a careful thought on intermediary structures to be developed to help "on the field end users". Lastly, this part aims at raising future users awareness, through practical demonstrations and validations. The Methodological Part of the accompagnement programme aims to prepare and accompany the use and the exploitation of the sub-metric images, both optical and radar. The French Space Agency (CNES) decided to develop the Orfeo Toolbox (OTB), a set of algorithmic components capitalising the methodological know how and its generic applicative tool Monteverdi. OTB/Monteverdi is distributed as an open source library of image processing algorithms. It is distributed under a

free software licence CeCILL (similar to GPL) to encourage contribution from users and to promote reproducible research. The library is intensively tested on several platforms as Linux, Unix and Windows. Functionalities are also adapted to process huge images using streaming and multi-threading as often as possible. Among other, OTB provides a number of heavily documented functionalities as image access, filtering, feature extraction, image segmentation; classification; change detection; GIS links; psy"BC.

After a brief description of the Pléiades system, this paper will present the first results obtained in the accompaniment program and the organisation of the Pléiades Thematic Commissioning phase, to be performed during the first year of Pléiades life.

## The PROBA-V Mission: Data Continuity for Daily Global Vegetation Monitoring

Jean-Christophe Schyns  
*schy@belspo.be*  
BELSPO  
Belgium

**Keywords:** satellite mission; vegetation, global monitoring

**Abstract:** The VEGETATION instruments on board of the SPOT-4 and SPOT-5 satellites have provided researchers and operational users daily low resolution (1 km ground sampling distance, GSD) remote sensing images on a global scale for vegetation monitoring for more than 10 years. To ensure the continuity of this service, the ESA PROBA-V (V for Vegetation) mission is under development, due to be launched in 2012.

The system will satisfy the original VGT requirements, i.e.: [U+F0A7] Daily coverage of the terrestrial surface, at least over Europe Requirement [U+F0A7] Equator crossing time 10:30 +/- 20 mn [U+F0A7] GSD better than 1 km at Nadir [U+F0A7] Geo-localisation < 0.3 pixel [U+F0A7] Bands co-registration < 0.3 pixel [U+F0A7] Spectral bands: blue, red, NIR and SWIR

The instruments, however, will be different: the PROBA-V minisatellite will fly a very compact and lightweight camera system consisting of three Three-Mirror-Anastigmatic (TMA) telescopes (to cover the 2250 km swath width), each equipped with blue, red, near-infrared line sensors and an array of staggered short-wave infrared (SWIR) sensors.

In order to ensure the continuation of VEGETATION products, the historical data set with 1km ground resolution will be continued but complemented with products featuring 300m ground resolution. Hereto, a user segment will be developed similar to the one for SPOT-VEGETATION. This user segment will consist of three modules: the image quality control center, the processing facility and the product distribution facility. The processing facility contains three submodules: the archive, the processing itself and the product quality control.

The user segment will generate the following products at two resolutions, 300 m and 1 km: P (primary) products, S1 (daily) synthesis and S10 (decadal) synthesis. P products are adapted for scientific applications requiring highly accurate physical measurements. S1 and S10 products are compiled by merging "segments" acquired over a period of one day, respectively ten days. All the segments of this period are compared pixel by pixel to pick out the "best" ground reflectance observations.

## Generating Consistent Land Surface Temperature and Emissivity (LSTE) Products Between ASTER and MODIS Data for Earth Science Research

Glynn Hulley

*glynn.hulley@jpl.nasa.gov*

Jet Propulsion Laboratory

United States

<http://science.jpl.nasa.gov/people/Hulley/>

Simon Hook

*simon.j.hook@jpl.nasa.gov*

Jet Propulsion Laboratory

United States

**Keywords:** Thermal Infrared, Emissivity, MODIS, ASTER

**Abstract:** Land surface temperature and emissivity (LSTE) products are generated by the Moderate Resolution Imaging Spectroradiometer (MODIS) and Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) on NASA's Terra satellite. These products are generated at different spatial, spectral and temporal resolutions resulting in discrepancies between them that are difficult to quantify, compounded by the fact that different retrieval algorithms are used to produce them. For example, the MODIS LST product has good accuracy over graybody surfaces such as dense vegetation and water, but is less accurate over deserts or semi-arid regions, while the ASTER product provides accurate LST's over arid regions but less-accurate LST's over graybody surfaces. This lack of consistency between products makes intercomparison and validation difficult, and limits their usefulness in models and as climate data records which require accurate LSTE's over the entire land surface at a range of spatial, spectral and temporal scales. This study aims to address this problem by using the ASTER Temperature Emissivity Separation (TES) algorithm combined with an improved atmospheric correction method to retrieve LSTE products from ASTER and MODIS in a consistent manner. The synergy of multi-platform, multi-sensor products is essential for laying down a baseline quality metric to which future climate datasets and trends can be measured, and this method will open up the opportunity for generating a unified LSE product that can be used by the scientific community to provide accurate LST and other products in a consistent manner at multiple temporal, spatial and spectral scales.

# Effects of Aliasing and Mis-Registration on Pan-Sharpening Methods Based on Either Component Substitution or Multi-Resolution Analysis

Advanced Pan-Sharpening Methods

Andrea Garzelli  
*garzelli@dii.unisi.it*

Department of Information Engineering - University of Siena, IFAC-CNR  
Italy  
<http://www.dii.unisi.it/garzelli>

Bruno Aiazzi  
*b.aiazzi@ifac.cnr.it*  
IFAC-CNR  
Italy

Luciano Alparone  
*alparone@lci.det.unifi.it*  
DET-University of Florence  
Italy

Stefano Baronti  
*s.baronti@ifac.cnr.it*  
IFAC-CNR  
Italy

Massimo Selva  
*m.selva@ifac.cnr.it*  
IFAC-CNR  
Italy

**Keywords:** Aliasing, Mis-Registration, Data Fusion, Pan-Sharpening

**Abstract:** Pan-sharpening is a branch of data fusion, more specifically of image fusion, that is receiving an ever increasing attention from the remote sensing community. New-generation space-borne imaging sensors operating in a variety of ground scales and spectral bands provide huge volumes of data having complementary spatial and spectral resolutions. Constraints on the signal to noise ratio (SNR) impose that the spatial resolution must be lower, if the desired spectral resolution is larger. Conversely, the highest spatial resolution is obtained whenever no spectral diversity is required. The trade-off of spectral and spatial resolution makes it desirable to perform a spatial enhancement of the lower resolution multi-spectral (MS) data or, equivalently, to increase the spectral resolution of the data-set having a higher ground resolution, but a lower spectral resolution; as a limit case, constituted by a unique panchromatic image (Pan) bearing no spectral information. To pursue this goal, an extensive number of methods have been proposed in the literature over the last two decades. Most of them follow a general protocol, that can be summarized in the following two key points: 1) extract high-resolution geometrical information of the scene, not present in the MS image, from the Pan image; 2) incorporate such spatial details into the low-resolution MS bands, interpolated to the spatial scale of the Pan image, by properly modelling the relationships between the MS bands and the Pan image.

In general, the image fusion methods described by this protocol can be divided into two main classes depending on how the spatial details are extracted from the Pan image: component substitution

(CS) techniques that are based on a spectral transformation of the MS data followed by replacement of the first transformed component with the Pan image and reverse transformation to yield back the sharpened MS bands; techniques that employ multi-resolution analysis (MRA) to extract the geometrical information that will be added to the MS bands, from the Pan image.

CS-based pan-sharpening is a typology of simple and fast techniques based on a spectral transformation of the original bands in a new vector space. Most widely used transformations are intensity-hue-saturation (IHS), principal components analysis (PCA) and Gram-Schmidt orthogonalisation procedure. IHS fusion technique, originally defined for three bands only, has been extended to an arbitrary number of spectral bands. The rationale of CS fusion is that one of the transformed components (usually the first component or intensity  $I(L)$ ) is substituted by the high-resolution Pan image,  $P$ , before the inverse transformation is applied. To ensure global preservation of radiometry,  $P$  is histogram-matched to  $I(L)$ , in such a way that the histogram-matched sharpening Pan, once degraded to the spatial resolution of  $I(L)$ , exhibits same global mean and variance as  $I(L)$ . However, since the histogram-matched Pan image and  $I(L)$  may not have the same local radiometry, spectral distortion, appearing as local colour changes in a composition of three bands at a time, may occur in pan-sharpened products. To mitigate local spectral distortion,  $I(L)$  may be taken as a linear combination of the MS bands with weighting coefficients adjusted to the extents of overlap between the spectral response of each MS channel and that of the Pan image. In principle, if the low-pass approximation of the Pan image synthesized by combining the spectral channels exactly matches the low-resolution version of  $P$ , spectral distortion does not occur.

MRA-based techniques substantially split the spatial information of the MS bands and of the Pan image into a series of band-pass spatial frequency channels. The high frequency channels are inserted into the corresponding channels of the interpolated MS bands. The sharpened MS bands are synthesized from their new sets of spatial frequency channels. The “à trous” wavelet transform and the Laplacian pyramid are most widely used to perform the MRA. In such cases, the zero-mean high-frequency spatial details are simply given as the difference between,  $P$ , and its low-pass filter version  $PL$ . Recent studies have demonstrated that if the low-pass filter is designed in such a way that it matches the modulation transfer function (MTF) of the spectral channel in which details will be injected, the spatial enhancement provided by MRA techniques becomes comparable to that of CS techniques.

Regardless of how spatial details have been obtained, their injection into the interpolated MS bands may be weighed by suitable gains, different for each band, possibly space-varying, i.e. a different gain at each pixel. Algorithms based on context-adaptive, i.e. local, models generally perform better than models fitting each band globally.

CS-based and MRA-based fusion techniques exhibit complementary spectral-spatial quality trade-off. The former provide fused images with high geometrical quality of spatial details, but with possible spectral impairments. The latter are spectrally accurate in general, but may be unsatisfactory in terms of spatial enhancement. However, once CS is optimized for spectral quality of pan-sharpened products and MRA is optimized for spatial quality, the two categories of methods yield very similar results in terms of overall quality.

In this paper, the characteristics of CS-based and MRA-based fusion method will be investigated, both theoretically and experimentally on QuickBird data sets. The conclusion is that MRA-based fusion is far more sensitive than CS-based fusion to: a) registration errors, i.e. spatial misalignments between MS and Pan images, possibly originated by cartographic re-sampling of individual data sets; b) aliasing occurring in MS bands and stemming from an MTF excessively broad relatively to the sampling interval.

Conversely, fusion methods relying on MRA are particularly sensitive to temporal misalignments, i.e. MS and Pan acquired not at the same time, that may introduce severe spectral distortions.

## Digital Elevation Models as Data Source for Land Suitability Analysis in Colombia

Luis Joel Martinez Martinez  
*ljmartinezm@unal.edu.co*  
Universidad Nacional de Colombia  
Colombia  
<http://www.unal.edu.co/>

**Keywords:** DEM, land suitability, Colombia

**Abstract:** Land unit definition and its characterization are basic tasks in the land suitability analysis. Until recently manual methods were used for delineating land units and suitability analysis was done mainly in a qualitative way. The availability of DEMs and the GIS capabilities make feasible to apply a more quantitative approach. The purpose of this study was to evaluate the capabilities of Digital Elevation Model GIS to determine several terrain parameters that can be useful in the land suitability analysis and integrate them in a suitability model. A DEM from Terra-ASTER data and a one from SRTM were used to calculate curvature, slope, aspect, wetness index, relief index solar radiation. Results for key parameters were compared with those of traditional methods and indicate that a good improvement of traditional methods can be obtained at a low cost and with appropriated confidence.

## Cultural Heritage Spatial Data Infrastructures (SDI)

Unlocking the potential of our cultural landscape data

Anthony J Corns

*anthony@discoveryprogramme.ie*

The Discovery programme

Ireland

[http://www.discoveryprogramme.ie/about\\_staff\\_anthony\\_corns.html](http://www.discoveryprogramme.ie/about_staff_anthony_corns.html)

Robert Shaw

*robert@discoveryprogramme.ie*

The Discovery Programme

Ireland

[http://www.discoveryprogramme.ie/about\\_staff\\_robert\\_shaw.html](http://www.discoveryprogramme.ie/about_staff_robert_shaw.html)

**Keywords:** SDI, GIS, remote sensing, LiDAR, geophysics, e-infrastructures, photogrammetry

**Abstract:** The creation and use of digital spatial data within cultural heritage studies has increased over the past decade. The commissioning of high quality LiDAR, photogrammetric and geophysical datasets has brought about a better understanding of how human activity has shaped our landscape. However, the ability to realize the full potential of this cultural heritage data through re-use and sharing with external organizations and the wider research community is limited by technological, semantic and organizational barriers. Capturing and processing primary spatial data is expensive and any failure to fully exploit the investment in such cultural heritage data could result in reluctance to commission future projects.

The development of open standards and technologies has enabled the creation of spatial data infrastructures (SDI) that allow users to discover, evaluate and use spatial data sets, and incorporate them into their own research. Much of the effort to date has been to harmonize environmental and security related spatial data. Cultural heritage information experts should adopt and adapt many of the standards established within the wider research community. This paper explores the requirements and research necessary for the development of a spatial data infrastructure (SDI) for the sharing and re-use of cultural heritage data, allowing for the efficient understanding and management of our shared cultural heritage.

## Remote Sensing for the Monitoring of UNESCO World Heritage Natural Sites

Development of an operational remote sensing system for tropical environments

Valerie Obsomer

*valerie.obsomer@uclouvain.be*

UCL-Earth and Life Institute

Belgium

<http://www.uclouvain.be/valerie.obsomer>

Mario Hernandez

*M.Hernandez@unesco.org*

UNESCO - Remote sensing

France

[http://remotesensing01.lomitko.net/?id\\_page=9lang=fr](http://remotesensing01.lomitko.net/?id_page=9lang=fr)

Pierre Defourny

*pierre.defourny@uclouvain.be*

UCL- Earth and Life Institute

Belgium

<http://www.uclouvain.be/pierre.defourny>

**Keywords:** remote sensing, GIS, tropical forest, monitoring, natural world heritage sites

**Abstract:** Natural World Heritage sites face a variety of potential threats including uncontrolled agricultural and urban development, conflicts, natural catastrophes, climate change, excess of tourism, and so on. Currently, only 15

This research proposes to provide an overall assessment about conservation in World Heritage sites using land cover change detection from satellite observation. The methodology and processing chain target an automatic detection of forest and land cover change on regular basis as support to the Periodic reporting exercise. Based on various recent developments in object-based change detection and automated land cover classification, the currently available algorithms and methods are adjusted to process large areas using high resolution imagery. The method is tested on 12 sites for prototyping and demonstration purposes. The fitness to use will be assessed with the UNESCO team and the local stakeholders before design of a monitoring system to insure the monitoring over the next 10 years.

## GlobWetland II

A regional pilot project of the Ramsar Convention on Wetlands

Herbert Hansen  
*hhansen@keyobs.com*  
Keyobs  
Belgium

Weise Kathrin  
Jenoptik  
Germany

Marc Paganini  
ESA-ESRIN  
Italy

Eleni Fitoka  
EKBY  
Greece

Manfred Keil  
DLR  
Germany

Eric Van Valkengoed  
Terrasphere  
Netherlands

Inge Melotte  
I-mage  
Belgium

**Keywords:** wetlands landcover mapping remote sensing

**Abstract:** The overall objective of Globwetland-II (GW-II) is to facilitate the integration of remote sensing techniques into the conservation and management of wetlands. GW-II will develop a G-WOS (Global Wetland Observing System) pilot system for the production of a number of wetland related geo-information maps and indicators but also demonstrate the capability of the system for 200 wetland sites and surrounding areas of the Southern and Eastern part of the Mediterranean basin.

The project is intended to serve the needs of many wetland conservation practitioners from the wetlands managers up to the stakeholders of the Ramsar Convention. The targeted user communities of the project are the Ramsar Administrative Authorities and National Focal Points of the subject countries and their supporting conservation agencies.

The project team will apply three major instruments to achieve the ambitious objectives of GlobWetland II, the active involvement of users, capacity building and the provision of prototype products together with instruments to integrate and extrapolate the use of Earth Observation within the users range of activities.

To demonstrate and ensure the use of the GW-II system the user will be provided with the system software and prototypes. The user will also be trained to the use of the prototype products and software.

Wetlands conservation and management is one of the many thematic domains in which satellites

observations together with novel and cutting edge geo-spatial technologies have contributed to improve the assessment and monitoring of essential wetland ecosystem variables by wetland managers and local territorial authorities.

Geo-spatial analysis and modelling tools as used in the predecessor project GlobeWetland I has demonstrated how satellite Earth Observation technology can be a cost-effective and productive tool for the Ramsar Convention and for the conservation and management of wetlands in overall. In GlobeWetland II the establishment of EO-based services to support the inventory, mapping, monitoring and assessment of wetlands ecosystems will be evaluated especially to build the foundation in the Ramsar community for a wide scale deployment of a Global Wetland Observing System.

The GW-II system which is based on satellite Earth Observation technologies and state-of-the-art geo-spatial technologies can support the inventories especially in the countries in the coastal catchment basins of the Southern and Eastern of the Mediterranean Sea that have not achieved their national inventory. Inventory and delineation of wetlands is one of the major basic steps to establish their conservation and management. The coastal catchment basins of the Southern and Eastern part of the Mediterranean Sea, from Morocco to Turkey, are of particular interest for biodiversity due to the fact that several endemic species listed as critically endangered or extirpated by the IUCN.

The GlobWetland II project is funded by the Data User Element (DUE). The Data User Element (DUE) is a programmatic component of the 3rd Earth Observation Envelope Programme (EOEP-3), an optional programme of the European Space Agency.

## Cultural Heritage between the Mountains and the Sea in the Eastern Adriatic

Vlasta Begovic  
*vlasta.begovic@iarh.hr*  
Croatia

Ivancica Schrunk  
*idschrunk@stthomas.edu*  
United States

**Keywords:** cultural heritage, archaeology, Eastern Adriatic

**Abstract:** Tectonic movements and climate change endanger historical and archaeological sites which are located in the coastal areas of the eastern Adriatic. Steep mountain slopes and narrow coastal lines with many bays and promontories dominate the topography of the region. These were advantageous for human habitation and construction in the past, but today represent a dangerous location between the mountains and the sea. Only within the last few months there have been several very dangerous flash floods and inundations in this region. In November 2009, flash floods and high winds damaged the historic urban cores of Dubrovnik and Pula. A minor tectonic off-shore movement in December 2009 caused a tsunami which affected the central Dalmatian coast and the islands. Later in December, hard rain (110 liters per m<sup>2</sup>) caused flash floods and tidal waves up to one meter high, which flooded Rijeka (ancient Tarsatica). A waterspout brought destruction to central Dalmatia. In January 2010, the river Neretva and its tributary Norin flooded and endangered the ancient site of Narona (Vid near Metković) in the delta. The cause was the melting of snow in the Dinaric mountain range, an unusual event in January. The same cause triggered floods of the rivers Krka, Vrlika and Lika in the northern Dalmatia, where the water level rose 0.5-1 m per day. The ancient settlement of Scardona on the Krka was threatened.

The sea level in the eastern Adriatic has risen about 2 m since antiquity due to the movement of the tectonic plates – the Eurasian plate and the European micro-plate, which meet in the middle of the Adriatic. The rising of the sea level could be measured on the sites of Roman maritime villas, whose structures (porticoes with exedras, harbors, fish ponds) built on the ancient shore are today submerged. At the site of the maritime villa by Medulin near Pula a tall and long wall has been built along the sea to protect fine mosaics. These natural events are threatening cultural heritage. Remote sensing techniques, such as aerial and satellite imagery are necessary to keep systematic control and detection of changes and damage in order to protect cultural sites and landscapes.

## Monitoring from Space of UNESCO Sites in Danger

The Islamic capital of Samarra (Iraq) and Chan Chan, the capital of Chimu kingdom (Peru)

Nicole Dore  
*nicole.dore00@gmail.com*  
ESA-ESRIN  
Italy

Jolanda Patruno  
*jolanda.patruno@gmail.com*  
ESA-ESRIN  
Italy

Ana Belen Ruescas Orient  
*ana.belen.ruescas.orient@esa.int*  
ESA-ESRIN  
Italy

Francesco Sarti  
*francesco.sarti@esa.int*  
ESA-ESRIN  
Italy

Mario Hernandez  
*mario.hernandez@unesco.org*  
UNESCO  
France

**Keywords:** Remote Sensing, Archaeology

**Abstract:** Archaeological research from space is becoming more and more usual thanks to the increasingly larger archives of satellite imagery and the progressively higher spatial resolution of the sensors (optical and radar). It is possible to monitor sites in danger and detect ancient features underground using indirect indicators, such as moisture content and vegetation growth detected measured from space. Remote sensing from satellite is a non invasive technique of interest for monitoring archaeological remains in remote areas and/or of difficult access. It constitutes a great support for preservation and conservation plans, even where political events make very difficult the surveys in situ, as in one of the cases presented here.

This study focuses on two ancient cities inscribed in the UNESCO (United Nations Educational Science and Cultural Office) List of Sites in Danger: Samarra (Iraq 43°45'50"- 43°51'70" N 34°25'34"- 34°05'12"E) and Chan Chan (Peru, central coordinates 08°06'22"S 79° 04'26.77"W). Samarra was the second capital of the Abbasid Caliphate and the Advisory Body of UNESCO withdrew its supervision in 2003 due to the war in Iraq. This city was very well preserved before that date because it suffered from a sudden abandon and in 2007 UNESCO decided to add the Islamic capital in the List of Sites in Danger. In addition, adverse climate condition such as winds and isolated storms are affecting the preservation of the site. Furthermore, since construction laws have not been upheld, also the sprawl of the human settlements occupying archaeological areas is causing the loss of some ancient buildings. Samarra has been studied mostly with optical data. A multitemporal analysis has been done thanks to SPOT-2 and SPOT-4 satellite from 2000 to 2009. For ALOS AVNIR-2 images, spanning from 2007 to 2009, allowed appreciating changes in vegetation growth and / or in settlement expansion, despite the short temporal period. In addition, also two full polarimetric ALOS PALSAR images and seven ENVISAT ASAR data were analyzed for multitemporal analysis.

All the data were then overlapped to 20 georeferenced site maps of the city (45 km length) in order to detect anomalies corresponding to archaeological structures.

The archaeological site of Chan Chan is situated in the Trujillo province, in Peru. The archaeological area (about 20 square kilometers) includes citadels and palaces of the Chimu kingdom. The capital, Chan Chan, reached its apogee in the 15th century. The strictly hierarchical urban space in which Chan Chan is organized made it the largest city in pre - Columbian America and reflects a strict political and social strategy. The adobe, or earthen, structures of the site are constantly damaged by natural erosion, exposed to air and torrential rains. For this reason, they require continuous conservation efforts and substantial ancillary measurements. UNESCO decided to add it to the List of Sites in Danger in the 1986. Chan Chan was analyzed predominantly with radar data (Synthetic Aperture Radar, SAR). Three full polarimetric ALOS PALSAR images were processed to distinguish surface and subsurface features as well as land changes in the time frame of two years (2007 - 2009). Moreover, a multitemporal analysis has been carried out thanks to nine ENVISAT ASAR images (2002-2006). All the SAR data were then georeferenced and projected onto the only available map of the site, dating back to 1986. One optical high resolution image from KOMPSAT-2 (2007) was compared to a SPOT-4 image (2000), in order to analyze urban and agricultural changes occurred over seven years.

## A Spatial Data Infrastructure for the Monitoring and Management of World Heritage Sites

Towards a web portal for World Heritage Site management

Aurélie M Sand  
*aurelie.sand@cnes.fr*  
CNES  
France

F. Huynh  
IRD  
France

Vincent Heurteaux  
Geomatys  
France

M. Hernandez  
UNESCO, Paris  
France

**Abstract:** The management and monitoring of World Heritage Sites represents a considerable challenge for the future of the planet, both for the member states, in particular for poorer countries, as well as for UNESCO.

In March 2007, the French Space Agency (CNES) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) signed an agreement through which CNES joined the ‘Open Initiative From Space to Place,’ headed by the European Space Agency and UNESCO. The initiative invites space agencies, space research institutions, and universities to work jointly to bring to developing countries the benefits of space technologies as applied to the conservation, monitoring, and documentation of the prestigious World Heritage Sites. This paper illustrates the contributions of CNES and its partners to this initiative.

Management and monitoring both depend on reliable access to current information so that the tools and methods of intervention remain pertinent to existing conditions. However, the multitude of actors intervening on these protected areas, from local managers to international organizations passing through researchers and non-governmental organizations, produce and use a wide body of disparate information. Lack of knowledge of the information resources available can even lead to the redundant collection of similar data causing a costly loss of efficiency.

To improve the widespread knowledge of existing resources and to provide ready access to those data, CNES joined the French Institute for Research on Development (IRD) and the private company Geomatys to develop and propose to UNESCO a web based, spatial data infrastructure designed for the needs of the World Heritage Sites. This information system focuses on collaborative aspects of information aggregation and distribution, enabling each contributor to leverage and share with all other actors concerned, data and results related to these zones of global importance.

The technological components of this information system were selected to foster interoperability. The system therefore rests on the international standards for spatial data definition and exchange developed by the International Organization for Standardization (ISO) and the Open Geospatial Consortium (OGC). Beyond simply building the information system, this work has also led to the production of software implementations of newer standards, such as the recently published standard for metadata related to imagery, ISO 19115-2, and to work on developing new standards, such as the upcoming Web Map Tiling Service (WMTS) standard of the OGC focused on the efficient delivery of cartographic and imagery data over the World Wide Web.

## Use of Landsat TM for mapping of World Heritage Sites, Forest Biodiversity, and National Natura 2000 Assessment

Erik Prins

*prinsengineering@gmail.com*

Prins Engineering

Denmark

<http://www.prinsengineering.com>

**Keywords:** World Heritage Sites, old forest, Natura 2000, landscape indices, Belarus, Denmark, Poland, Lithuania, Landsat TM

**Abstract:** The poster show two cases of Landsat TM based mapping of World Heritage Sites. Bialowieza / Belovezhskaya primeval forest is the only larger fragment of natural deciduous and mixed forest in the European lowland. The forest has an outstanding biological value and is a UNESCO's World Heritage Site. The forest is considered to be the biological riches lowland forest in Europe. 2/3 of the forest is situated in Belarus and 1/3 in Poland. The initial Landsat based forest classification contain 45 classes where more than 12 classes that can be directly linked to old growth and appearance of dead-wood and e.g. woodpeckers. Biodiversity analysis is based upon richness filters of old growth. Biodiversity analysis and various types of data for daily management have been integrated into the GIS / forest compartments. The satellite derived methodology was developed in the Polish part from 1997-99 and extended to encompass the Belarusian part in 2003. The overall result will enhance cross-border management of the forest by the use of a common forest map. Furthermore, the forest base map is used for further research in modeling of habitats and has recently documented the habitat selection of Raven. In 2009, the Landsat based methodology to map old forest stands has been implemented on a national scale in Denmark - as a part of the GMES forest service element In Lithuania, we used Landsat TM data and GIS techniques to estimate the extent of more than twenty Natura2000 habitat classes. National habitat specialists were involved in the classification procedures by visual interpretation of classes, digitalization of specific habitat areas, integration of existing field data and discussion on criteria's for habitat mapping that should be modeled in GIS. The analysis and simulation of habitat areas included the use of national vector layers on forest, water courses, bogs, land use, and Digital Elevation Models. The assessment of e.g. Taiga was within few percent from what could be interpreted from national forest statistics, overall the result was used to identify potential new habitat areas and as such supported the assessment of actual extent. A part of the Landsat based Natura2000 classification was the UNESCO World Heritage Site- Curonian Spit which was mapped into Natura 2000 sub classes.

## Remote Sensing of Reedbeds

Remote sensing of reedbeds

Alex O. Onojeghuo  
*a.onojeghuo@lancs.ac.uk*  
LANCASTER ENVIRONMENT CENTRE  
United Kingdom  
<http://www.lancs.ac.uk>

George A Blackburn  
*alan.blackburn@lancaster.ac.uk*  
LANCASTER ENVIRONMENT CENTRE  
United Kingdom  
<http://www.lancs.ac.uk>

**Keywords:** Reedbed, classification, hyperspectral, Quickbird, LiDAR

**Abstract:** In the UK reedbeds dominated by *Phragmites australis* have been identified as a priority habitat for most regional Biodiversity Partnerships. Information on the current distribution and quality of reedbed sites across the UK is lacking, yet such information is vital in developing suitable management plans for the conservation and expansion of this threatened habitat. The aim of this study was to develop a suitable methodology for accurately mapping the distribution and assessing the status of reedbed habitats using remotely-sensed imagery. Three study sites situated in the North West region of the UK were used: Leighton Moss nature reserve in Lancashire, and River Leven and Esthwaite Water situated in Cumbria. At each of the sites satellite and airborne imagery were acquired along with ground-based spectral and canopy biophysical data. The study demonstrated that a methodology based on analysis of image texture was able to accurately map reedbeds using high resolution QuickBird multispectral data acquired in winter (November 2008). By analysing multi-seasonal (winter and summer) QuickBird data it was possible to improve the accuracy of reedbed delineation. Using in situ data from a field spectroradiometer, variations in the spectral reflectance of reedbeds were measured throughout the seasonal phenological cycle and optimal spectral indices for quantifying canopy biophysical properties were identified. The potential for quantifying canopy biophysical properties from LiDAR data obtained during the leaf-off period was also investigated. While accurate estimates of canopy height could be derived from first return data, and this is a valuable indicator of habitat quality, the lack of any subsequent returns from reedbeds prevented the extraction of any further biophysical variables. Current work is investigating the combination of hyperspectral and LiDAR data for improving the accuracy of reedbed mapping and quantifying canopy biophysical properties.

## Laser Scanning Techniques for Remote 2D Hyperspectral Imaging of Decorated Monumental Surfaces

Francesco Colao  
*colao@frascati.enea.it*  
ENEA  
Italy

L. Caneve  
*caneve@frascati.enea.it*  
Italy

Roberta Fantoni  
*fantoni@frascati.enea.it*  
ENEA  
Italy

Luca Fiorani  
*fiorani@frascati.enea.it*  
ENEA  
Italy

**Keywords:** laser remote sensing, laser scanning

**Abstract:** Laser scanning prototypes, formerly developed in active remote sensing systems (such as fluorosensor lidar), have been specialized for high resolution multispectral applications suitable to be used in the characterization of large surfaces relevant to monumental cultural heritage.

A LIF (laser induced fluorescence) scanning system, capable of collecting 2D monochromatic images acquisition on up to 90 different spectral channels in the visible/UV range has been developed to investigate the presence and the aging of consolidants as well as the occurrence of bio degradation. Data processing software, based on SAM (spectral angle mapper) and PCA (principal component analysis) has been implemented to extract the information relevant to conservation strategy and to best visualize damaged areas in suitable false color combinations of the collected images. Data bases relevant to pigments, consolidants and bio-degrading agents have been built for Cultural Heritage materials on different substrates (e.g. plaster, ceramics, wood).

The original point scanner has been recently replaced by a line scanner which, once properly matched with the CCD detector, allowed for increasing of more than two order of magnitude the data acquisition speed.

Examples of data collected during recent field campaigns on fresco's (up to 12 m distance) and painted wooden artifacts will be presented. Results relevant to preliminary laboratory investigations on stones and mosaics aimed to ascertain both the provenance and the degree of conservation of the materials will be also presented.

## Evolution Estimated by Remote Sensing of Forest Boundaries in Two Parks in the Rainforest of Madagascar Labeled UNESCO

Dominique Hervé  
*dominique.herve@ird.fr*  
IRD, Antananarivo  
Madagascar

A. Andrianarivo  
*anarivoandriana@gmail.com*  
Université de Fianarantsoa, MEM, ENI, Madagascar  
Madagascar

S. Razanaka  
*rzanakasamy@yahoo.fr*  
CNRE, Antananarivo  
Madagascar

A. Batti  
*ahmed.batti@geohyd.fr*  
Géo-Hyd, Olivet  
France

L. Dadu  
*dadu@animail.com*  
IRD, Montpellier  
France

E. Delaitre  
*eic.delaitre@ird.fr*  
IRD, Montpellier  
France

F. Huynh  
*huynh@ird.fr*  
IRD, Montpellier  
France

**Keywords:** park, eastern humid forest, clearing, tree line, land use, change detection

**Abstract:** In Madagascar, increasing poverty is driving the population along the protected areas into continue clearing. The annual deforestation rate is estimated at 1

The data allowed the listing of World Heritage in the Eastern forests have clearly mentioned the lack of monitoring of violations in the parks. To consolidate a state 0 at the label, details have to be gathered on the magnitude of the pressure before and after. The detection of land use change in this interval will help scheduling a future periodic evaluation every 5 years.

Since the under protected area status of the two parks Ranomafana (1991) and Andringitra (1927 as a nature reserve and 2001 as a national park), the pressure was reduced and controlled. However, in remote areas controls are virtually nonexistent and deforestation continues. Remote sensing evaluation may take advantage of SPOT improved spatial resolution images from 20 to 2.5 m and performance of processing tools (OTB from CNES). Land use changes were evaluated in 20 years between two dates, 1988-2009 in Ranomafana and 1986-2008 in Andringitra. The SPOT images

(CNES-ISIS) were treated by ENVI 4.5 and ArcGIS 9.2; supervised classifications use the maximum likelihood algorithm; the detection of changes between two dates, is made with ENVI and OTB. For each park, two scenes, north and south, have been assembled. In Ranomafana the difference of shooting dates in 1988 is solved by radiometric corrections. The delineation of a buffer zone of ten kilometers around the park boundaries includes their peripheral areas. Clouds, cloud shadows and shadows of the slopes are the difficulties encountered. Several fields transects were carried out for verification and validation at the same time than laboratory work.

For the two parks, 11 classes were identified among which 4 are common: water, bare soil, savanna, crop-fallow mosaic. Differences remain for the distinctions forest-afforestation, wetland-rice field, and levels of forest degradation. The detection of changes between two dates encounters two problems: the difference in resolution between the two dates and the confusion between degraded forest and fallows. The clearing rate in Andringitra is estimated at 10

The methodology followed could be used in humid eastern forests integrating corridors that connect parks between them and correcting distortions due to relief. These lessons would be recovered in the labeling procedure of dry forests of Madagascar.

## Calakmul 4D GIS: an Information Management System for the Conservation of Natural and Cultural Heritage

The future for our past

Vincent Tigny  
*vincent@gim.be*  
GIM/ EO  
Belgium  
<http://www.gim.be>

Philippe De Maeyer  
*philippe.demaeyer@ugent.be*  
Universiteit Gent  
Belgium

Roland Billen  
*rbillen@ulg.ac.be*  
Université de Liège  
Belgium

Luc Van Gool  
*Luc.VanGool@esat.kuleuven.be*  
Katholieke Universiteit Leuven

**Keywords:** ICT, GIS, Remote Sensing, World Heritage

**Abstract:** Funded by the Belgian Science Policy Office (BELSPO) in the framework of a collaboration agreement with UNESCO, the Calakmul 4D GIS project aims at developing and implementing an “Information Management System” for the conservation authorities of the Biosphere Reserve and Archaeological Urban Centre of Calakmul (Mexico). This online system will allow Mexican managers of Natural and Cultural Heritage to store, share, visualise and create interaction between their data, in order to coordinate various actions of conservation, management, planning, monitoring and research undertaken in the area.

The name “Calakmul” refers to an ecological reserve including an ancient Maya city. The study zone lies in the South East of the Campeche State, in the middle of the Yucatan peninsula. The Calakmul Biosphere Reserve was created in 1989. It covers an area of almost 7.300 square kilometers and constitutes one of the largest protected forests of the tropical zones. This biodiversity hotspot shelters rare species of flora and fauna. It also includes many archaeological sites, Calakmul being the most important one. This pre-Colombian city has been registered on the World Heritage List (cultural part) in 2002.

Within recent years, settlement pressure, farming, extraction of commercial timber, tourism, etc. caused threats to this natural and cultural heritage. In order to help the Mexican authorities INAH (Instituto Nacional de Antropología e Historia) and CONANP (Comisión Nacional de Áreas Naturales Protegidas) to preserve it, Belgian researchers conducted a RD project based on the use of new technologies and scientific developments in the GeoICT, Archaeomatic and Spatio-temporal Analysis, Computer Vision and Earth Observation fields.

The developed information management system is centred on an online tool integrating 2D GIS layers and 3D objects, large and small scales cartography layers and the time dimension. It also includes a set of open source tools to create, store, catalogue, share and disseminate data and is based on emerging open standards, but also innovative methods and data models to integrate archaeological and ecological data containing time attributes.

Earth Observation data from Formosat 2 and SPOT sensors has been used to analyse the evolution of the land use/land cover in the area and to investigate the potential of remote sensing to document Maya ruins and detect evidences of the presence of archaeological remains in a tropical forest environment. This data set has been processed using innovative object-based image analysis techniques. The results will be integrated in the system and used to elaborate posters for educational purposes.

## SARVisor: An Integrated Tool to Facilitate SAR Data Selection

Aurélie Sand  
*aurelie.sand@cnes.fr*  
France

Nadine Pourthié  
*nadine.pourthie@cnes.fr*  
CNES  
France

Fifamè Koudogbo  
*fifame.koudogbo@altamira-information.com*  
France

Javier Duro  
*javier.duro@altamira-information.com*  
Spain

Anne Urdiroz  
*anne.urdiroz@altamira-information.com*  
France

Mario Hernandez  
*Ma.Hernandez@unesco.org*  
France

**Keywords:** "SAR data selection", SAR acquisition parameters" "open source" "World Heritage"

**Abstract:** In March 2007, the French Space Agency (CNES) and the United Nations Educational, Scientific and Cultural Organization (UNESCO) signed an agreement through which CNES joins the European's Space Agency – UNESCO's 'Open Initiative From Space to Place'. This initiative invites space agencies, space research institutions and universities to work jointly to bring the benefits of space technologies to developing countries as applied to the conservation, monitoring and documentation of the prestigious World Heritage sites.

The ultimate goal of UNESCO is to make earth observation an integrated and operational tool for the monitoring of World Heritage sites. This paper illustrates the contributions of CNES to the challenging requirements of UNESCO.

Satellite radar data have already demonstrated their capability especially in cloudy areas, or for small movement detection using the interferometry technique. However the selection of adequate acquisition parameters can be difficult in relief area where the geometrical effects of layover, foreshortening or shadow must be taken into consideration.

To facilitate the use of radar data and support UNESCO initiative, CNES decides to provide a tool for SAR visibility prediction. The tool is designed to help users in the selection of the most appropriate SAR data acquisition parameters for the imaging of a particular Area Of Interest (AOI). CNES appointed Altamira Information to develop the tool. It integrates the main civilian SAR missions (ERS, Envisat/ASAR, Radarsat-1 -2, ALOS/PalSAR and TerraSAR-X) and selects for each of them the parameters, in terms of acquisition modes and incidence angles, which are the more suitable to cover the considered area. Once the appropriate parameters and a Digital Elevation Model have been chosen, a SAR image is generated, allowing the user to check the visibility of its AOI and thus confirming the selection of the most effective mission and acquisition parameters.

Following some preliminary work conducted at CNES with Envisat data, the sanctuary Machu Picchu (Peru), World Heritage Site of the UNESCO since 1983, constitutes the zone of the tool

validation. Due to its location in the highly mountainous area, the site combines all kinds of geometric distortions inherent to the SAR imaging. Layover, foreshortening and shadow will be taken in consideration in order to select the optimum parameters for the SAR observation over this zone.

This tool, as a CNES contribution to the Open Initiative and the SAR users community, is available free of charge.

## Geometric Potentiality of GoeEye-1 In-Track Stereo Pairs and Accuracy Assessment of Generated Digital Surface Models

Mattia Crespi

*mattia.crespi@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"

Italy

<http://w3.uniroma1.it/mattia.crespi/>

Paola Capaldo

*paola.capaldo@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"

Italy

Laura De Vendictis

*guest517.devendictis@e-geos.it*

e-Geos S.p.A.

Italy

Francesca Fratarcangeli

*francesca.fratarcangeli@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"

Italy

Andrea Nascetti

*andrea.nascetti@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"

Italy

Francesca Pieralice

*francesca.pieralice@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"

Italy

Gabriele Murchio

*gabriele.murchio@e-geos.it*

e-Geos S.p.A.

Italy

**Keywords:** GeoEye-1, DSM, image matching, orientation models

**Abstract:** The Geoeye-1 satellite, launched in September 2008, is able to acquire imagery in panchromatic mode and in multispectral mode with a spatial resolution of 0.41 m and 2.0 m at nadir, being the highest resolution sensor from space presently commercially available.

The aim of the work is to evaluate the quality of the GeoEye-1 stereo pair panchromatic product through the accuracy assessment of the orientation and of the generated Digital Surface Model (DSM).

The area covered by the stereo pair is the city of Rome, a long time established test field where different products acquired by several sensors were checked during the past years. The analysed stereo pair has 0.5 m pixel size and it belongs to the GeoStereo product class; it was acquired on December 5, 2009, but it was made available only at the end of January 2010, so that, at present, only very preliminary analyses were carried out.

The GeoStereo products are radiometrically corrected map oriented image, suitable for a wide range of uses. GeoStereo images are projected onto an “inflated” ellipsoid, derived from the WGS84, choosing a certain ellipsoidal height.

Thanks to the very high resolution and the good radiometric quality of the images, it seems possible to extract a DSM at a 2-3 meter accuracy level, comparable to those coming from middle scale aerial products, supporting a wide range of geomatics applications such as mapping, spatial and temporal change detection, feature extraction and data visualization.

The stereo pair orientation has been carried out with the rigorous models embedded into the scientific software used is SISAR, developed at the Geodesy and Geomatic Area of the University of Rome “La Sapienza”; it is based on well know collinearity equations, with the reconstruction of the orbital segment during the image acquisition and possibly self-calibration parameters estimation. The results have been checked with the commercial software PCI Geomatica 10.2, which includes the well known Toutin’s rigorous model.

Further, the image matching has been performed with the new matching facility of the software SISAR and were checked both with PCI Geomatics v. 10.2, and with the scientific software DPCOR, kindly supplied by Prof. Jacobsen (Leibniz University of Hannover).

The new SISAR image matching facility is presently based on two different algorithms. In the first algorithm the advantages of ABM to those of FBM has been combined to decrease the efforts for the initial manual points collimation needed to start the matching process. The second one uses a two-stage dynamic programming technique to obtain a disparity map from a correlation volume; in this way it was possible to improve the reliability and accuracy of matching in urban area; this approach has been already tested on stereo pairs with quasi-epipolar geometry (like GeoEye-1), as Ikonos stereo products.

In order to evaluate the accuracy of the DSM extracted a comparison with 3D vector cartography at 1:2000 scale was carried out and the derived results are presented and discussed.

## Producing a Building Change Map for Urban Management Purposes

Teresa Santos  
*teresasantos@fcsh.unl.pt*  
Portugal

Sérgio Freire  
*sfreire@fcsh.unl.pt*  
Portugal

Ana Fonseca  
*anafonseca@lnec.pt*  
Portugal

José António Tenedório  
*ja.tenedorio@fcsh.unl.pt*  
Portugal

**Keywords:** QuickBird, LiDAR, feature extraction, urban planning, change detection, Lisbon

**Abstract:** Land information is required for the major activities of the municipal authorities. At this level, decision-making is supported by large-scale maps that include both topographic and thematic information. For these purposes, the efficient use of very high spatial resolution (VHR) imagery suggests the development of approaches that enable a timely discrimination, classification and delineation of urban elements according to quality standards. The current framework of the Portuguese large scale map production is very time-consuming and expensive, since it is based on manual editing of ortho-photographs to comply with very demanding technical specifications. Consequently, the time lag between availability of updated maps is generally 10 years. The main advantage of having a change map based on remote sensing data and a semi-automatic extraction methodology is to allow a more efficient mapping process, concentrating the updating efforts only in those areas or elements that changed. With such application cartographic products could be updated on an annual basis.

The work presented in this paper is the exploration of VHR imagery as an alternative source of geospatial information for large scale mapping to assist municipal urban planning in Portugal. The data base concerns spectral and altimetric data. For the spectral data base, multispectral and panchromatic QuickBird images from 2005, of the city of Lisbon, are available. Furthermore, an altimetric data set composed by a LiDAR (Light Detection And Ranging) image of the second pulse from 2006 and a Digital Terrain Model (DTM) are also available. The methodology was tested over a study area of 64 ha, located in Lisbon. This area is characterized by several building typologies that include industrial properties, schools, apartments and single-family housing.

The QuickBird images were orthorectified and subjected to a pansharpening fusion. The LiDAR data and the DTM were used to produce the normalized Digital Surface Model (nDSM). The extraction methodology was applied to this data set using a feature extraction software, in order to produce a map of the buildings present in the image. After building extraction, a post-processing was conducted to enhance the geometric quality of the elements. Afterwards, a quality assessment was performed. The assessment was exhaustive and involved comparisons of extracted features against a reference dataset collected by visual interpretation of the imagery.

Having the 2005 building map, the next step was to produce a changed map using the municipal map, at 1:1000 scale, from 1998. The change detection process was able to identify missing structures and to detect new ones. However, its geometric and thematic quality is not yet sufficient to allow a direct updating of the municipal databases. The goal is rather to produce an alarm system that indicates

the location of potential changes in the building areas. This layer can be used by the municipal technicians as the basis for manual editing, following the technical specifications indicated for the 1:1 000 scale.

## DEM Extraction from High Resolution Satellite Stereopairs to Investigate the Hydraulic Hazard of Areas Subjected to River Floods

Alessio Furini

*alessio.furini@unife.it*

Dipartimento di Ingegneria Civile - Università di Ferrara, via Saragat, 1 - 44122 Ferrara, Italy  
Italy

Francesca Fratarcangeli

*francesca.fratarcangeli@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Sapienza Università di Roma, via Eudossiana, 18 - 00184  
Rome  
Italy

Francesca Pieralice

*francesca.pieralice@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Sapienza Università di Roma, via Eudossiana, 18 - 00184  
Rome  
Italy

Alberto Pellegrinelli

*alberto.pellegrinelli@unife.it*

Dipartimento di Ingegneria Civile - Università di Ferrara, via Saragat, 1 - 44122 Ferrara, Italy  
Italy

**Keywords:** stereo orientation, DEM extraction, accuracy assessment, Ikonos

**Abstract:** As far as the monitoring of the hydraulic hazard of flat areas is concerned, a very important role is played by studies concerning the outflow of water after river floods or downpours. Such studies are based on complex forecasting hydraulic models, which need an accurate and detailed DEM as input together with planimetric and altimetric data regarding all the natural and anthropic objects, as riverbanks or roads in relief, which may interfere with the outflow of water.

The aim of this work is the evaluation of DEMs extracted from high resolution stereo pairs (both panchromatic and multi spectral) for their application in hydraulic hazard analysis. The advantages arising from the use of satellite images are mainly relative low costs and fast elaboration.

The investigation has been carried out on an in-track Ikonos stereopair acquired over the area of the town of Ferrara (Northeastern Italy, near the Po delta) on July 2004.

The best workflow to generate the DEM has been evaluated: the orientation has been performed both with the commercial software PCI Geomatics OrthoEngine v10.2 and with the scientific software SISAR, developed by La Sapienza University of Rome, and SAT-PP, developed by ETH Zurich and now delivered by 4DiXplorer.

Image matching and DEM extraction have been performed not only with PCI Geomatics and SAT-PP but also with the scientific software BLUH, developed by Leibniz University of Hannover.

The DEM accuracy has been evaluated by sample comparisons, based on a consistent number of Check Points (CPs), surveyed by kinematic GNSS with a mean 3D accuracy of about 0.3 m. Areas with different land cover have been selected, in order to identify critical zones with low mean accuracy which may introduce significant errors in hydraulic modeling.

## Accuracy Control of ALOS DSM

Konstantinos G. Nikolakopoulos

*knikolakopoulos@igme.gr*

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION

Greece

Evagelia Gioti

*gs20505@hua.gr*

Harokopio University of Athens

Greece

**Keywords:** DSM, ALOS Prism, Airphoto, Stereopairs

**Abstract:** The possibility to create DSM from stereo pairs is based on the Pythagoras theorem and on the principles of photogrammetry that are applied to aerial photographs stereo pairs for the last seventy years. The application of these principles to digital satellite stereo data was inherent in the first satellite missions. During the last decades the satellite stereo-pairs were acquired across the track in different days (SPOT, ERS etc.). More recently the same-date along the track stereo-data acquisition seems to prevail (Terra ASTER, SPOT5 HRS) as it reduces the radiometric image variations (refractive effects, sun illumination, temporal changes) and thus increases the correlation success rate in any image matching.

One of the newest satellite sensors with stereo collection capability is ALOS PRISM. It can acquire stereopairs along the track with a 2,5m spatial resolution covering areas of 35X35km.

In this study we control the accuracy of a DSM created from ALOS data. The study area is Antiparos Island, Greece. The DSM was compared to a DSM created from airphotos stereopairs and to ground control points collected with a Differential GPS.

After a first control for random or systematic errors a statistical analysis was done. Points of certified elevation have been used to estimate the accuracy of the DSM. The elevation difference between the two DSMs was calculated. 2D RMSE, correlation and the percentile value were also computed and the results are presented.

## Accuracy Control of ASTER GDEM and Comparison to DSM Created with Classical Photogrammetric Techniques

Konstantinos G. Nikolakopoulos

*knikolakopoulos@igme.gr*

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION  
Greece

Panagiotis I. Tsombos

*ptsombos@igme.gr*

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION  
Greece

**Keywords:** ASTER GDEM, accuracy control, DSM

**Abstract:** ASTER Global Digital Elevation Model (GDEM) was released on June 29, 2009. The GDEM was created by stereo-correlating the 1.3 million scene ASTER VNIR archive, covering the Earth's land surface between 83N and 83S latitudes. The GDEM is produced with 30 meter postings, and is formatted in 1 x 1 degree tiles as GeoTIFF files. Each GDEM file is accompanied by a Quality Assessment file, either giving the number of ASTER scenes used to calculate a pixel's value, or indicating the source of external DEM data used to fill the ASTER voids.

In this study the accuracy of ASTER GDEM was examined using other DSMs created from ASTER stereopairs using classical photogrammetric techniques. Points of certified elevation collected with DGPS have been used to estimate the accuracy of the DSM. The elevation difference between the two DSMs was calculated. 2D RMSE, correlation and the percentile value were also computed and the results are presented

## Validating the EUMETSAT HydroSAF Snow Recognition Product over Mountainous Areas of Turkey

Serdar Sürer

*serdarsurer@gmail.com*

METU Geodetic and Geographic Information Technologies

Turkey

<http://www.serdarsurer.com>

Zuhal Akyürek

*zakyurek@metu.edu.tr*

METU Civil Engineering Department

Turkey

Unal Sorman

*sorman@metu.edu.tr*

METU Civil Engineering Department

Turkey

**Keywords:** snow recognition, mountain, HydroSAF

**Abstract:** An algorithm has been running in order to produce real-time snow cover maps from MSG-SEVIRI sensor imagery, covering whole Europe, for more than two years under the framework of EUMETSAT Hydrology-SAF (HydroSAF) Project. Hydrological processes and climate in the mountainous areas are highly affected by the seasonal snow cover. Due to lack of enough field observations because of the inaccessibility of high mountains, it is convenient to monitor the amount of snow with remote sensing satellite data besides setting up and managing ground weather stations. Developed algorithm is based on a multi-spectral thresholding method which uses visible, shortwave-infrared and near-infrared channels of MSG-SEVIRI. For a single day, 32 successive satellite images which have 15 minutes time interval between each of them are interpreted in order to produce a daily snow cover map. The algorithm uses Nowcasting-SAF (SAFNWC) cloud products in classifying the clouds.

In this study 2007-2008 and 2008-2009 snow melting seasons are considered for the validation and evaluation purposes of the HydroSAF snow recognition product. The validation is performed for the mountainous region in the eastern part of Turkey on a daily basis by using the ground observations from 30 climate stations operated by Turkish State Meteorological Service (TSMS). The snow depth was recorded to the nearest 1 cm and reported in integer form. Besides the validation of snow product with ground data, the utility of the snow product in deriving the snow depletion curves (SDC) is evaluated. Other satellite snow products namely, MODIS 8-day snow cover data (MOD10C2) are also used in deriving the snow depletion curves.

Results show high agreement between ground snow measurements and HydroSAF snow recognition product. The overall accuracies for 2008 and 2009 are calculated as 90.96

## Combining High Spatial Resolution and Revisit Capabilities in the Thermal Infrared: the MISTIGRI Mission Project

Jean-Pierre Lagouarde

*lagouarde@bordeaux.inra.fr*

INRA-EPHYSE, 71 avenue E. Bourlaux, BP 81, 33883 Villenave d'Ornon  
France

M. Bach

CNES, Toulouse

France

G. Boulet

CESBIO Toulouse

France

X. Briottet

ONERA-DOTA, Toulouse

France

S. Cherchali

CNES, Toulouse

France

B. Coudert

CESBIO Toulouse

France

G. Dedieu

CESBIO Toulouse

France

O. Hagolle

CESBIO Toulouse

France

F. Jacob

IRD-LISAH, Montpellier

France

F. Nerry

LSIIT/TRIO, Illirch

France

A. Oliosio

INRA-EMMAH, Avignon

France

C. Ottlé

LSCE, Gif-sur-Yvette

France

V. Pascal

CNES Toulouse  
France

J.-L. Roujean  
CNRM-GAME Toulouse  
France

J.A. Sobrino  
UCG/IPL Valencia  
Spain

F. Tintó Garcia-Moreno  
CESBIO Toulouse  
France

**Keywords:** Thermal Infrared, micro-bolometer, microsatellite, water budget, agriculture, hydrology, continental biosphere

**Abstract:** Remote sensing in the thermal infrared (TIR) domain is well suited to the monitoring of the land surface processes governed by the energy exchanges between the canopies and the atmosphere. The context of climate change and growing anthropogenic pressure throughout the world makes applications dealing with agriculture, water use, monitoring of biogeochemical cycles and vegetation crucial. Although it is required to access to the agricultural field scale and simultaneously to cope with possible rapid variations of surface temperature related to water status and meteorological conditions, no system currently provides the needed combination of high spatial resolution with high revisit capabilities in the TIR. Users have still to face the dilemma between high revisit / low resolution (with Meteosat, Goes, AVHRR, MODIS) and high resolution / low revisit (ASTER, Landsat ETM+).

We present the MISTIGRI project (MicroSatellite for Thermal InfraRed Ground Surface Imaging) initiated by the French Space Agency CNES in cooperation with Spain and designed to fill this gap by proposing a spatial resolution of around 50m and a revisit of 1 or 2 days.

The scientific priorities of the mission primarily devoted to the monitoring of the continental biosphere are first described, and other possible fields of application (urban areas, coastal zones among others) are listed. We also discuss the concept of the MISTIGRI mission, similar to that of VEN $\mu$ S, and based on a microsatellite combined with a network of ground experimental sites and associated scientific teams.

The mission specifications are then presented. The results of a feasibility study of the MISTIGRI mission performed during a 0 phase and a A phase currently carried on are briefly described together with a preliminary instrumental concept based on the use of a micro-bolometer designed by Thales Alenia Space for CNES.

## Assessment of Biomass and Carbon Sequestration in Kazakhstan: Comparison of Moderate to Coarse Resolution Sensors

Martin W. Kappas  
*mkappas@gwdg.de*  
University Professor  
Germany  
<http://www.martinkappas.de>

Pavel Propastin  
*ppropas@uni-goettingen.de*  
senior scientist  
Germany

Stefanie M. Herrmann  
*stefanie.herrmann@nasa.gov*  
Senior scientist  
United States

Compton J. Tucker  
*compton.j.tucker@nasa.gov*  
Professor  
United States

**Keywords:** Carbon sequestration, Seawifs, MODIS, Kazakhstan

**Abstract:** In the context of advancing global change science, explicit spatial data on terrestrial carbon sequestration become more and more important (IPCC, 2007). The terrestrial carbon cycle is a highly dynamic system that includes several storage pools and such components of the flux as gross primary production (GPP) and net primary production (NPP). This study attempts to fill knowledge gaps in the long-term monitoring of carbon sequestration in grasslands of Kazakhstan. Our objective is the use of a modified Light Use Efficiency (LUE) model in order to expand the satellite-based assessment of NPP dynamics in the grasslands of Kazakhstan by means of coarse-resolution satellite data (NOAA AVHRR and SeaWifs) over a period of three decades. The influence of different satellite data sets on the results of NPP simulation are addressed with respect to spatial coherency of NPP distribution and inter-annual trends of the total carbon sequestration in the study area. The modelling results are verified against other available NPP data sets derived from field studies and MODIS data. The overall distribution of NPP turned out to be more spatially and temporally consistent after inter-calibration of the satellite data. Furthermore it has been observed that the MODIS global NPP product tends to slightly underestimate high NPP-values and overestimate low NPP values for the study area.

## Analysis of Land Surface Temperature Variations due to Fire at Oil Terminal, Jaipur, India

Sumit Khandelwal

*khandusa@gmail.com*

Malaviya National Institute of Technology, Jaipur  
India

Rohit Goyal

Malaviya National Institute of Technology, Jaipur  
India

**Keywords:** Fire, Thermal pollution, Land Surface Temperature, MODIS

**Abstract:** Thermal pollution, also called heat pollution, occurs when heat released into water or air produces undesirable effects and it can occur as a sudden, acute event that may result from natural events or from human-induced events (Botkin and Keller, 1995). Present study has been carried out in wake of a recent fire catastrophe that occurred at petroleum products storage terminal at Sitapura, Jaipur, India on October 29, 2009. Daily land surface temperature (LST) product of MODIS/Aqua remote sensing satellite has been analyzed to identify zones affected due to the fire event. During the fire event predominant wind direction was NNW/NW and maximum impacted area for thermal pollution was towards SE/SSE direction of the terminal. Area falling within South and East directions of the terminal was divided into 9 directions at an interval of 10° which were further divided into zones based on their distance from the terminal. In order to compare LST values of different dates, LST was normalized using an identified unaffected base area. Normalized mean LST (NLST) values were calculated for all the zones for dates one week prior to the incidence and up to 5 days after the incidence. It was observed that for the week prior to the incidence NLST values for different zones varied up to 50

## Effect of Vegetation and Urbanization over Land Surface Temperature: Case Study of Jaipur City

Sumit Khandelwal

*khandusa@gmail.com*

Malaviya National Institute of Technology, Jaipur  
India

Rohit Goyal

Malaviya National Institute of Technology, Jaipur  
India

**Keywords:** Urban Heat Island, Land Surface Temperature, EVI, MODIS, Road Density

**Abstract:** The introduction of new surface materials coupled with emission of heat, moisture and pollutants change radiative, thermal and emission properties of the surface and the atmosphere above (Roth, 2002). Such modifications, normally due to urbanization, lead to a modified thermal climate which is warmer than the surrounding non-urbanized areas, particularly at night (Voogt and Oke, 2003). The objectives of present research are to analyze the spatial pattern of the night land surface temperature (LST) observed by remote sensing satellites and to investigate the effect of vegetation and urbanization over LST of Jaipur city, India. Enhanced vegetation index (EVI) has been used as an indicator for vegetation level and road density for level of urbanization. The study has been undertaken for summer, monsoon and winter seasons. Since the average night temperatures for different seasons are different, Normalized LST (NLST) for each season was calculated using maximum and minimum temperatures of that image. Road network map was used to calculate road density (RD) per pixel. It was found that about 3

## Automatic Mapping of Earthquake Damage using Post-event Radar Satellite Data: The story goes on.

Post-event spaceborne VHR SAR and earthquake damage mapping

Fabio Dell'Acqua

*fabio.dellacqua@unipv.it*

University of Pavia and EUCENTRE

Italy

<http://tlclab.unipv.it/sito<sub>tlc</sub>/people.do?id = fdellacqua>

Diego Aldo Polli

*diegoaldo.polli@unipv.it*

University of Pavia

Italy

Gianni Lisini

*gianni.lisini@unipv.it*

University of Pavia

Italy

**Keywords:** very high resolution radar, spaceborne, earthquakes, damage assessment

**Abstract:** Destructive earthquakes challenge Earth Observation (EO) systems to demonstrate their usefulness in supporting intervention and relief actions. The use of EO data in earthquake contexts, especially for damage assessment purposes, has been widely proposed and a number of results have been presented after every event, mostly based on optical data and manual interpretation. In this paper, the latest in a series, we instead try and focus on radar data and on automatization of the damage assessment procedure. Using COSMO/SkyMed data, made available thanks to the cooperation of the EUCENTRE with the Italian Civil Protection Department, we are investigating the possibility to use only post-event, Very High Resolution (VHR) radar data to estimate the damage level aggregated at the size of the city block. The usefulness of considering post-event only data lies in the independence from availability of pre-event VHR data, still quite scarce given the young age of meter-resolution spaceborne SAR systems.

The latest disastrous earthquake event in Haiti is currently being investigated in close cooperation with the Italian Space Agency and this paper will illustrate the latest findings.

## Georeference of High Resolution TerraSAR Images with RPFs

Dimitra Vassilaki  
*dimitra.vassilaki@gmail.com*  
NTUA  
Greece

Charalambos Ioannides  
*cioannid@survey.ntua.gr*  
NTUA  
Greece

**Keywords:** TerraSAR, georeference, RPFs

**Abstract:** The first civilian satellite SAR sensor was launched in 70s. Optical sensors, launched in the same decade, attracted more interest than SAR sensors, as they have the advantage of true optical color, while the complex geometry of SAR sensors usually makes radar images look odd, especially in ragged terrain and urban areas. During the last 40 years, optical systems were actively developed to offer products of 1 or even 0.4 m resolution. During the same period SAR products were of very low resolution of 10 or even 25 m.

But this has recently changed. During the last two years, there are commercially available high resolution SAR images by the German satellite TerraSAR-X and by the Italian satellite constellation CosmoSkyMed. The resolution of 1 m that is available for these systems, can be compared to optical systems. Although modern SAR products are still very expensive and they suffer from speckle noise and distortions inherited from their geometry, SAR is an all-weather, day and night sensor, offering information about the properties of the targets, their 3D geometry and their evolution through time. As a result, there is a growing demand for processing methods on par with optical processing methods.

In this paper, Rational Polynomial Functions (RPFs) are investigated for the georeference of high resolution TerraSAR images. A whole scene is georeferenced using real, measured Ground Control Points (GCPs). The scene covers a typical area in Greece: ragged terrain covered with sparse vegetation and scattered buildings. The results are tested with the use of independent Check Points (CPs).

## Multitemporal RADARSAT-2 Polarimetric SAR Data for Urban Land Cover Classification using Support Vector Machine

Xin Niu

*xin.niu@abe.kth.se*

Division of Geoinformatics, Department of Urban Planning and Environment, Royal Institute of Technology – KTH  
Sweden

<http://www.infra.kth.se/GIS/staff/niu/>

Yifang Ban

*yifang@kth.se*

Division of Geoinformatics, Department of Urban Planning and Environment, Royal Institute of Technology – KTH  
Sweden

<http://www.infra.kth.se/GIS/staff/ban/>

**Keywords:** RADARSAT-2, Polarimetric SAR, Urban Land Cover, Object-based Classification, SVM, Rule-based Approach

**Abstract:** This study investigates the capability of the RADARSAT-2 Polarimetric SAR data for urban land-cover mapping using a novel classification approach. Six-dates of RADARSAT-2 polarimetric SAR data were acquired during June to September of 2008 in the rural-urban fringe of the Greater Toronto Area. The major landuse/land-cover classes were high-density built-up areas, low-density built-up areas, roads, forests, parks, golf courses, water and several types of agricultural crops. In the proposed approach, support vector machine (SVM) is combined with the rule-based method for the object-based classification of the multitemporal polarimetric SAR data. First, various SAR polarimetric parameters are derived from coherency matrix as well as Pauli, Freeman and H/A/a decompositions of the SAR data. Second, the multi-resolution segmentations of the selected SAR features are performed to generate meaningful image objects. Then the image objects containing the SAR polarimetric features are classified using the SVM classifier.

The SVM classification results are further refined using a rule-based approach. Rules are built to recognize specific classes defined by the shape features and the spatial relationships within the context. Effectiveness of different SAR polarimetric parameters for urban land cover classification are compared. The primary result shows that the object-based classification using SVM and rule-based approach is promising for urban land cover mapping. In addition, finer urban structures such as roads could be extracted and certain changing areas such as construction sites could be detected.

## Radargrammetric Application with Cosmo-SkyMed Imagery: Definition and Implementation of an Orientation Model for Spotlight Stereo Pairs

Mattia Crespi

*mattia.crespi@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"  
Italy

<http://w3.uniroma1.it/mattia.crespi/>

Paola Capaldo

*paola.capaldo@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"  
Italy

Francesca Fratarcangeli

*francesca.fratarcangeli@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"  
Italy

Francesca Pieralice

*francesca.pieralice@uniroma1.it*

DITS - Area di Geodesia e Geomatica - Università di Roma "La Sapienza"  
Italy

**Keywords:** SAR, radargrammetry, Cosmo-SkyMed, DSM

**Abstract:** The availability of new high resolution radar spaceborne sensors offers new interesting potentialities for the acquisition of the data useful for the generation of Digital Surface Models (DSMs). Two different methods may be used to generate DSMs from Synthetic Aperture Radar (SAR) data: the interferometric and the radargrammetric approaches.

Actually, due to the low resolution amplitude supplied by the spaceborne radar sensors available until now (at the level of tens of meters), usually the first approach has been used, being aware that the radar interferometry may suffer for lack of coherence (for example in vegetated areas).

At present, the importance of the radargrammetric approach is rapidly growing due to the new high resolution imagery (up to 1 m GSD) which can be acquired by COSMO-SkyMed, TerraSAR-X and RADARSAT-2 in SpotLight mode. In this sense, it seems useful to underline that the two approaches should be considered complementary, in order to obtain the best (accurate and complete) product. It is well known that the two main steps for DSMs generation from SAR imagery according to the radargrammetric approach are the stereo pair orientation and the image matching.

In this paper they are investigated the topics related to image orientation of SAR stereo pairs in zero doppler geometry acquired by COSMO-SkyMed sensor in SpotLight mode. As regards the general geometric setup, unlike the interferometric approach, the radargrammetric one is based on the signal amplitude, exploits the stereoscopy similarity to optical methods and the baseline between the orbital tracks from which stereo pairs is acquired have to be long. To obtain good stereo geometry, the optimum configuration for the radargrammetric application is when the target is observed in opposite-side view; however it causes large geometric and radiometric disparities hindering image matching. A good compromise is to use a same-side stereo pair in order to increase the efficiency in the correlation image process. This geometry acquisition may be easily satisfied thanks to the constellation of satellites (presently three of four are active) supplied by COSMO-SkyMed.

As regards the radargrammetric orientation model, it has to be underlined that, starting from

the model proposed in the classical book of Leberl (Radargrammetric Image Processing, 1990), a refinement of the orbital model is needed to comply with and to exploit the potentialities of the novel high resolution (both in azimuth and in range). Then, the defined and implemented model performs a 3D orientation based on two range and two zero-Doppler equations, allowing for some calibration parameters least squares estimation, related to satellite position and velocity.

The new model has been tested over a stereo pair acquired by COSMO-Skymed in SpotLight mode on the well known Mausanne (South France) test site and the results are reported and discussed.

## Evaluation of DEMs Derived by TerraSAR-X InSAR Data

Umut Günes Sefercik  
*ugsefercik@hotmail.com*

Zonguldak Karaelmas University, Department of Geodesy and Photogrammetry Engineering  
Turkey

<http://jeodezi.karaelmas.edu.tr/linkler/akademik/sefercik/sefercik.htm>

Uwe Soergel  
*soergel@ipi.uni-hannover.de*

Leibniz University of Hannover, Institute of Photogrammetry and GeoInformation  
Germany

<http://www.ipi.uni-hannover.de/us.html>

**Keywords:** TerraSAR-X (TSX), Interferometric Synthetic Aperture Radar (InSAR), Digital Elevation Model (DEM), Accuracy, Visualization

**Abstract:** As it is well known, a Digital Elevation Model (DEM) is the simplest form of digital representation of topography and the most common. DEMs are necessary for several applications like generation of orthoimages, terrain determination (such as point elevation, slope, distance, aspect), environmental analysis, generation of contour lines, modeling of hydrologic functions, cartography, civil applications, geographical information system (GIS), urban planning, disaster management (forest fires, erosion control, flood management, earthquake analysis), agriculture, visibility check and also for 3D-views. Because of this large application field, in order to satisfy the need, various DEM generation techniques have been developed up to this time. These techniques can be grouped under two headings according to data collection methods as ground survey and remote sensing. Remote sensing contains four sub-techniques for DEM generation as traditional photogrammetry based on aerial photos, stereo-optical satellite imagery, air-borne laser scanning (LIDAR) and interferometric synthetic aperture radar (InSAR). DEM generation using InSAR technique has several advantages. In this method, data collection is independent from weather conditions except heavy rainfall, moreover clouds can be penetrated and so large coverage up to global can be obtained rapidly at specific short times. Besides, it permits imaging at very shallow look angles thus results in remarkable different perspectives than common vertical photographs. Additionally, it enables resolution to be independent of distance to the target objects, polarization effects can be used and so on. But also there are some disadvantages in comparison with other techniques that, object recognition is poor in SAR images that's why the selection of Ground Control Points (GCPs) are more difficult and because of imaging geometry and related distortions as foreshortening, layover and shadow accuracies of DEMs are lower partially in steep, mountainous and forestry topographies. By this time, several space-borne SAR sensors have been used for Interferometry. Mains of these sensors are SRTM, ENVISAT ASAR, ERS 1/2, RADARSAT 1/2, JERS and ALOS PALSAR. And the most actual space-borne SAR sensor is TerraSAR-X (TSX) which is the main topic of this paper. TSX is the most modern and technological InSAR satellite which has been launched on 15 June 2007 from oldest Russia's space launch facility, Baikonur Cosmodrome in Kazakhstan. It is a German made satellite and its lifetime will be at least 5 years on the space. It is the most advanced SAR satellite using interferometry up to this day and offers the highest quality spatial data that were not available from space before using high frequency X-band SAR sensor which can be operated in different imaging and polarization modes. TSX uses 3 different operation modes as high resolution Spotlight ( 1m), Stripmap ( 3m) and ScanSAR ( 16m).

The aim of this study is the evaluation of the DEMs derived by TSX InSAR image-pairs that's why the elevation models have been generated using interferometric processing and afterwards different kinds of analysis have been performed on them. High resolution Spotlight (HRS) mode TSX and pancromatic (PAN) IKONOS image-pairs were used in this study at Istanbul test field and

the generated DEMs which have 3m grid spacing were compared using a more accurate reference photogrammetric DEM which has 1m grid spacing and 10cm up to 2m accuracy. At the evaluation of produced HRS mode TSX and PAN IKONOS DEMs, the absolute and relative accuracies were determined, frequency distributions of Z-differences and dependency up on the aspects were identified, influence of interpolation analysis and morphologic detail analysis were performed, differential DEMs (DIFFDEMs) and shadings were generated. After the evaluation analysis of the DEMs, it has been seen that HRS mode TSX model has nearly same visual quality and absolute accuracy with IKONOS DEM and has better relative accuracy.

## 3-pass and 2-pass Differential Interferometry and Result Comparison

On areas with abandoned open brown coal mines or undermined areas

Milan Borik  
*borikm@mat.fsv.cvut.cz*  
Czech Republic

**Keywords:** differential interferometry, 2-pass method, 3-pass method, terrain deformations

**Abstract:** We concentrate on areas with abandoned open brown coal mines, or undermined areas. We made analyzes of terrain deformation in the area of the Slatinice above-level dump that is monitored because of potential terrain deformations. Further we concentrated on the Jirkov-Most route and railway that slides and is also monitoring and levelled very precisely. Especially its part called the Ervenice corridor.

The 3-pass method for differential interferometry was performed in the GAMMA software. Perpendicular baseline of the topo pair is 160m. This baseline for the deformation pair is 4m. Then their relation is 0,025. It is the best configuration for all scenes we kept at disposition.

The phase of differential interferograms is in  $[-\pi, \pi)$ , and thus the phase ambiguity occurs. Therefore, we are not able to recognize jump deformations larger than 2.8 cm. For subsidence confirmation, we demand as continuous phase as possible with a sufficient number of neighboring pixels and lines. The suspect areas of subsidence must be sufficiently coherent. For incoherent areas there occurs decorrelation and thus loss of data. Areas were not much coherent. Data were often decorrelated. In this article we used the 2-pass method to compare results of both methods. The differential interferogram for the 2-pass method was filtered and then unwrapped. Due to filtering we achieved much better coherence. Unwrapped phase of that differential interferogram can also be used for a terrain-deformation detection more profitably.

## Use of PS Method for Subsidence Monitoring in Mining Areas

Barbora Knechtlova  
*barbora.knechtlova@fsv.cvut.cz*  
Czech Republic

Lena Halounova  
*lena.halounova@fsv.cvut.cz*  
Czech Republic

Ivana Hlavacova  
*hlavacova@insar.cz*  
Czech Republic

**Keywords:** Subsidence, InSAR, Permanent Scatterers

**Abstract:** North-Bohemian coal basin is a largely unstable area with very old mining sites, which are potentially dangerous for people living there. Mining has been performed for several centuries; deep mines were active in the past (the surface above is not expected to subside any more), and currently open-pit mines are used for exploitation. Most of them are later reclaimed to forests, lakes, agriculture fields etc. Landslides and subsidence occur in these areas and they need to be monitored. In addition to classical levelling methods new methods are being used for detection of possibly dangerous areas. One of them is radar interferometry. It allows for Earth-crust deformation mapping with the use of satellite images, without the necessity of expensive on-site measurements. Its accuracy may even reach several mm/yr in the theoretical case. This method is usable in areas with low amount of vegetation and for objects, which are not expected to change their spectral characteristics during monitoring. This applies to artificial objects (buildings, roads, railways), which are of most interest to public (centres of villages, cultural monuments, communications and industrial areas). A significant limitation of standard InSAR processing is the impact of atmosphere, which shows strong spatial correlation and is uncorrelated in time, whereas target motion is usually correlated in time. Therefore the method of Permanent Scatterers is used in order to deal with this atmospheric effect. To improve the method, corner reflectors are installed in the neighbourhood of the area of interest. That usually is in village centres, next to cultural monuments and water reservoirs and some in industrial areas.

## DeCOVER 2 Services to Support Land Cover Data Update, NATURA 2000 Monitoring and Cross Compliance using RapidEYE and TerraSAR-X

Oliver Buck  
*oliver.buck@eftas.com*  
Germany  
<http://www.eftas.com>

**Keywords:** NATURA 2000, Rapideye, TerraSAR-X, Change detection, GMES, Cross Compliance

**Abstract:** DeCOVER serves as a national extension of the European Global Monitoring for Environment and Security (GMES) initiative. It was initiated to provide land cover information adapted to German user needs and to support existing land cover / land use data systems at regional, national and international level using innovative remote sensing and data modelling techniques. The uses requirement studies of DeCOVER Phase 1 (2006-2008) showed, that currently available land cover / land use systems such as the European CORINE land cover (CLC), the planned GMES Land Monitoring Core Service, the German topographic reference data set (ATKIS/DLMpsy"D2) or the State-wide environmental habitat mapping schemes (BNTK in its national specification) are not sufficient on their own to fulfil all user requirements.

To support these systems not only accurate update information but also additional information (e.g. new LC classes, attributes) are required. Under DeCOVER 2 update processes based on the now operational satellite systems RapidEye (RE) and TerraSAR-X (TSX) will be developed to support the above mentioned target data systems. This so called DeCOVER Core Service will essentially be based on Vector-Raster change detection methods to provide reliable change information for existing t0 vector data using t1 TSX and RE.

In addition to the DeCOVER Core Service thematic services will be developed to provide monitoring information as required under existing European agricultural and environmental policies. Information on agricultural conditions and landscape elements are required under the so called Cross Compliance mechanism (Council Regulation 1782/2003 and Commission Regulation 796/2004). To obtain information on the required "Good Agricultural and Environmental Conditions" multitemporal classification models will be developed using RE and TSX time series for selected test sites. These time series will also be used to model phenological aspects of selected habitat types within protected NATURA 2000 sites. NATURA 2000 is a network of protected sites under the Flora-Fauna-Habitat directive (Council Directive 92/43/EEC) for which regular monitoring information on habitat changes and threats are required.

This paper will present first results on the service specification and implementations.

The DeCOVER 2 project is funded by the Federal Ministry of Economics and Technology (BMWi) via the German Aerospace Center (DLR): FKZ 50EE0908, 50EE0909, 50EE0910, 50EE0911, 50EE0912, 50EE0913, 50EE0914, 50EE0915.

## Update of the European High-resolution Layer on Built-up Areas and Soil Sealing 2006 with Image2009 Data

Ute Gangkofner  
*gangkofner@geoville.com*  
GeoVille  
Austria

Juergen Weichselbaum  
*weichselbaum@geoville.com*  
GeoVille  
Austria

Steffen Kuntz  
*Steffen.Kuntz@infoterra-global.com*  
Infoterra  
Germany

Lukas Brodksy  
*lukas.brodsky@gisat.cz*  
GISAT  
Czech Republic

Karin Larsson  
*Karin.Larsson@lm.se*  
Metria  
Sweden

Vito De Pasquale  
*depasquale@planetek.it*  
Planetek  
Italy

**Keywords:** geoland2, euroland, change detection, satellite data, built-up areas, soil sealing

**Abstract:** The European Environment Agency (EEA) requested from the FP7 geoland2 project a year 2009 update of the European high resolution layer on built-up areas and soil sealing, which was derived from the IMAGE2006 satellite coverage. Methodological development of the automated change detection approach is covered by the Core Mapping Service (CMS) EUROLAND, which further develops the GMES Land Monitoring Core Service, including advanced approaches for continental land cover and land cover change mapping. The objective is to derive a comparable product of highest possible quality, showing changes of the built-up area between 2006 and 2009 as well as changes in the sealing degree within the 2006 sealed surfaces in 1ha resolution. As for the 2006 soil sealing layer, bi-temporal Spot and IRS-P6 satellite data with a nominal pixel size of 20m (IMAGE2009) are being used. The 2006 built-up layer resulted from a combined approach based on automatic image classification and subsequent visual post-classification editing. Corresponding sealing degrees (1

Starting point is the automated derivation of 2006-2009 changes of the built-up area. This task is solved with a change detection approach, which follows a similar methodology as for the 2006 mapping in order to guarantee the highest possible degree of consistency and comparability of these products. The built-up area change detection would work in a comparable way for all European landscapes using standard change detection and mapping techniques. However, the update of

the sealing degrees is a more challenging and complex task as it includes both the determination of sealing degrees of newly built-up areas, consistent with the original product, as well as the derivation of sealing changes within areas previously assigned as built-up ones. Thus the sealing update methodology depends on an adaptation of the 2009 NDVIs to the 2006 sealing degrees. For this purpose a procedure was developed that automatically derives adapted sealing degrees from the 2009 NDVIs via a series of histogram matching steps, taking into account the partly non-linear relation between NDVI and sealing degrees. First methodology tests show that newly derived 2009 sealing values are matching the 2006 sealing values to a high degree and that this procedure can be used for a sealing update, if sufficient care is applied to the definition of spatial and spectral thresholds for the sealing changes. Further on, these “sealing images” adapted to the 2006 NDVI calibration are derived for the total area of interest for both years and used as a basis for the change detection of both built-up surfaces as well as for deriving the sealing degrees within newly built-up areas.

The results of this geoland2 CMS EUROLAND activity shall serve as an essential input to support Europe-wide urban sprawl assessment for EEA and user DGs (i.e. DG REGIO, DG ENV and DG Agri) and to support Member States in upgrading their national data bases.

## Landscape Change and Implications on Protected Areas

Case of Dilek Peninsula-Big Meander Delta National Park, Turkey

Hayriye Esbah  
*hayriyeesbah@yahoo.com*  
Istanbul Technical University  
Turkey

Bulent Deniz  
*bulentdeniz@yahoo.com*  
Adnan Menderes University  
Turkey

Baris Kara  
*bkara@adu.edu.tr*  
Adnan Menderes University  
Turkey

Birsen Kesgin  
*birsenkesgin@yahoo.com*  
Aegean University  
Turkey

Erdinc Kutsal  
National Park Service, Kusadasi  
Turkey

**Keywords:** Landscape change, object based classification, landscape structure indices, protected areas

**Abstract:** The purpose of this study is to detect the characteristics of the landscape change in the protected area environments by using Remote Sensing, GIS and landscape structure indices. Dilek Peninsula Big Meander Delta National Park of Aydin Province, Turkey is the focus of this case study. SPOT 2X and ASTER images are utilized in object oriented classification to detect changes respectively between 1994 and 2005. 3 landscape structure indices are applied to the classified maps: connectivity index, matrix utility index and core set of metrics. The results have displayed a decrease of the coniferous forests, high maqui, low maqui, grasslands and salt flats, and an increase of the moderately high maqui, garrigue, salt marshes, arable lands and permanent crop fields, and artificial surfaces. Major drivers of the landscape change includes urbanization, agriculture, grazing, fire, and clearing of original vegetation for heating and timber. Subsequently, high maqui and grasslands have been most negatively affected from fragmentation. While the natural patches have become isolated, the corridors between them were diminishing, hence decrease in the connectivity index. Matrix utility index has yielded that Dilek Peninsula Big Meander Delta National Park was subjected to increasing edge effects. Recommendations with regards to the sustainable landscape protection are presented.

## Change Detection in Urban Areas With Landsat And Alos Imageries in Antakya, Turkey

Aysel Güzelmansur  
*aguzelmansur@cu.edu.tr*  
Turkey

Seref Kilic  
*skilic@mku.edu.tr*  
Turkey

**Keywords:** Antakya city, urban, change detection, imagery

**Abstract:** Rapid urbanization has significant impact on conditions of urban ecosystems. With increased availability and improved quality of multi-spatial and multi-temporal remote sensing data, it is now possible to detect urban changes in a timely and cost-effective way.

This study aims to quantify changes in urban area of Antakya located in Mediterranean region of Turkey, using LANDSAT and ALOS imagery. Urban changes were detected by satellite images of Landsat MSS in 1972, Landsat TM 1987, Landsat ETM 2001, Alos 2008, using geographic information system (GIS).

The population has been grown 5.52 times during the past 36 years as a result of industrial developments and permanent migration was main driving force of the urbanization. According to the results, the extent of urban areas has increased by 132

## Actual State of Danube Delta Biosphere Reserve, using Aerospace and GPS Data

Iva Boneva Ivanova

*ivboneva@abv.bg*

SRI

Bulgaria

<http://www.sapace.bas.bg>

Roumen Nedkov

*rnedkov@space.bas.b*

SRI

Bulgaria

<http://www.sapace.bas.bg>

**Keywords:** Danube Delta Biosphere Reserve, aerospace and GPS data, floating reed islets, satellite images

**Abstract:** In this paper we describe the actual state of Danube Delta Biosphere Reserve, using aerospace and GPS data. The Danube Delta Biosphere Reserve is situated in the south-eastern part of Romania and the north of Dobrudja, being limited on its north side by the Danube River and Chilia Branch, at east by the Black Sea and at south and east by the hills of the Dobrudjan plateau. Danube Delta is the third largest delta in Europe, with over 5,400 species of plants and animals identified, is the third area in the world in terms of biological diversity, Danube Delta has a surface of 4,178 km<sup>2</sup>, stretched over two neighbour countries, Romania (82

The methodology involves detection, identification and recognition of the components of Danube delta. That's includes water bodies, reed beds, green areas, villages, relief. As a primary attention is given to floating reed islets which are typical for the region. These floating islands represent specific habitats of flying reed in places with greater water depths currently is found only in the Danube Delta in Romania and Sreburna Lake in Bulgaria. They occupy large areas in the Danube Delta and depending on the water level and their width, they can be: mobile : moving along the lakes under the action of wind and stream; stuck: in shallow areas where the level water is low; fixed on other stuck reed islets, but having water underneath, which represents an excellent habitat for species of fish. This moving of reed islets can be very dangerous, as some channels can be closed in this way and the sailing would be very difficult.

We have used topographic maps and satellite images from IKONOS. For that purpose are used specific spectral channels of satellite images, which makes it possible to be achieved maximum likelihood of recognition. It is necessary all input data to be converted into a digital form and georeference.

The purpose of this paper is to analyse this state, which will be helpful for making an adequate decision for a better management of the reserve and preservation of these floating islands with minimum impact on the native flora and fauna.

## Landscape Planning of Land-Use Using High Resolution Satellite Images and Ground-Based Data

Eugenia Roumenina  
*eroumenina@gmail.bg*  
Bulgaria

Lachezar Filchev  
Bulgaria

Vanya Naydenova  
*vnaydenova@gmail.com*  
Bulgaria

Petar Dimitrov  
*petarkirilov@mail.bg*  
Bulgaria

Georgi Jeleu  
*gjelev@space.bas.bg*  
Bulgaria

**Keywords:** remote sensing data, GIS, landscape planning, land use

**Abstract:** A great advantage of satellite images is that all the environmental elements can be visualized on them. Therefore they serve as a main source of information for the extraction of natural features in landscape-ecological research. The application of remote sensing and geographic information systems (GIS) in landscape planning allows us fast and objectively to analyze the relations and interdependences of landscape features and factors, to investigate the changes in land-use as well as to design different simulation models of the landscape. The main objective of the research is the application of archive and modern satellite images and aerial photos in the large-scale landscape planning of the land-use. For the elaboration of a landscape plan in scale 1:10,000 the land of Novi Iskur town, Sofia municipality was chosen, which is part of one of the aerospace test sites on the territory of Republic of Bulgaria. The choice of the study area is determined by its high rate of antropogenization as a result of the uranium-ore extraction and open coal mining, carried out in the second half of 20th century. For the study high resolution panchromatic and multispectral georeferenced and orthorectified satellite images from QuickBird and IKONOS satellites, along with declassified high-resolution panchromatic satellite images from KH-7 acquired respectively in 2008, 2002 and 1966 were used. The employed methods are object-oriented classification and computer-aided visual interpretation with minimal mapping unit of 0.1 ha of the satellite images. A combined land cover/land use classification diagram has been used, based on the two international classifications – USGS and CORINE Land Cover.

The developed methods for monitoring of the land-use aiming at landscape planning of the territory were applied in four main stages: 1). Creation of integrated geodatabase which stores information for climate, relief, geology, soil and vegetation cover, as well as georeferenced and orthorectified satellite dataset; 2). The second stage is conductance of change detection of the land use / land cover using archive and modern satellite images. Field check and accuracy assessment of the classification results is done. The accuracy assessment of the object-oriented classification is 90

## An Approach for Accuracy Assessment Comparison between Per-pixel Supervised and Object-oriented Classifications on a QuickBird Image

Vassil Vassilev

*vassilev<sub>v</sub>,as@yahoo.com*

Space Research Institute - Bulgarian Academy of Sciences

<http://www.space.bas.bg>

**Keywords:** QuickBird, Land use/land cover, Image analysis, per-pixel supervised classification, object-oriented classification, Feature Analyst

**Abstract:** An approach for accuracy assessment comparison between two types of Land use/Land cover image classifications based on extraction of thematic information from very high resolution multi-spectral QuickBird image acquired on 31.05.2008 is presented in the present paper. Two types of classifications are compared in the present paper: 1) per-pixel supervised classification, and 2) object-oriented classification. The object-oriented classification was applied in ArcGIS software using the Feature Analyst 4.2. extension tool, while for the per-pixel supervised classification ERDAS Imagine software was used. The proposed approach includes several work stages and it has been applied on a highly fragmented urban and agricultural land, district of Novi Iskur, Sofia municipality, Bulgaria. A land use/land cover classification scheme for the area studied was created. A large scale land use map for the Novi Iskur district is composed on the base of the final results, and the differences of the land use classes are assessed using image analysis. Essential part of this approach for image processing is using a combination of spectral reflectance and texture differences for extracting different land use/land cover classes. Unsupervised classification, fuzzy convolution filter, relief data, and Normalized difference vegetation index (NDVI), were supplemented and used as an ancillary data in the classification process for additional analysis. The accuracy assessment was calculated for both classifications using accuracy assessment tool in ERDAS Imagine software. It was found that the object-oriented classification has better overall classification accuracy (94.15

## Integrating MODIS-EVI and Gridded Rainfall/Temperature Fields for Assessing Land Degradation Dynamics in Horqin Sandy Lands, Inner Mongolia (China)

Joachim Hill  
*hillj@uni-trier.de*  
Trier University  
Germany

Claudia Dach  
Trier University  
Germany

Gabriel del Barrio  
Estacion Experimental de Zonas Aridas, Almería  
Spain

Marion Stellmes  
Trier University  
Germany

Ulf Helldén  
Lund University, GeoBiosphere Science Centre, Lund  
Sweden

**Abstract:** Horqin Sandy Lands in NE-China represent a widely discussed case of ongoing land degradation which receives much attention in China and the outside world. Located in an area of strongly continental climate and extended sandy substrates, the region is undergoing substantial land use change dynamics, largely determined by political decisions and regulations issued by the central and regional government. A simple analysis of trends derived from existing satellite time series is felt not fully adequate for characterizing the changes in biological productivity during the past decades. As climate data suggest for some stations an increase in annual precipitation during the past 10 years it appears mandatory to relate satellite measurements of biological productivity to corresponding changes in plant-available water over time.

In the course of EU-funded research projects (LADAMER; DeSurvey) an approach based on ecological responses of vegetation to physical drivers (e.g. 2dRUE ) has been developed to more adequately characterize areas affected by desertification and transitional land use change processes. The concept relates to earlier work (Le Houérou 1984; Prince et al., 1998) and departs from the assumption that Rain Use Efficiency, i.e. the ratio of net primary productivity to precipitation, decreases with land degradation. The approach is based on combining satellite-derived indicators of biological productivity (e.g. EVI, FAPAR) and spatially interpolated climate data, and it is climatically de-trended for aridity.

The concept is currently applied to different case studies of the DeSurvey Project, one of which covers the Horqin Sandy Lands in Inner Mongolia (China). Results for this site are produced by integrating gridded climate station data and EVI time series acquired by MODIS for the time span 2001-2002, and will be compared to a calibrated 20-year-time-series of Landsat-TM/ETM+ data (1987-2007).

## Semi-Automated LULC Classification of VHR Optical Satellite Data in the Context of Urban Planning

Holger Thunig

*thunig@ph-heidelberg.de*

University of Education, Heidelberg  
Germany

Simone Naumann

*naumann@ph-heidelberg.de*

University of Education, Heidelberg  
Germany

Alexander Siegmund

*siegmund@ph-heidelberg.de*

University of Education, Heidelberg  
Germany

**Keywords:** urban areas, urban sprawl, very high resolution satellite data, object-based land use classification, multi-criteria decision support system

**Abstract:** One of the major accompaniments of the globalisation is the rapid growing of urban areas. Whereas at the end of the 1970th only 38

The study is part of the GAUS-project (Gaining additional urban space (GAUS) – Detection and valuation of potential areas for inner urban development with remote sensing and GIS. The project is dedicated to the development of a Multi-criteria Decision Support System (MDSS) as a tool for supporting the municipal management authorities with regard to urban consolidation and smart growth. The presented classification framework aims at feeding the MDSS with up-to-date LULC information.

This work deals with the strategy and workflow (data, preprocessing, classification processes, accuracy assessment) towards a semi-automated LULC classification of urban areas, following an object-oriented approach. Furthermore, an overall goal of this work is to figure out generic methods and strategies towards LULC classification with VHR optical data to ensure robustness and transferability, which are crucial preconditions in order to automate processes. Different QuickBird scenes of the Ruhr Area (Nordrhein-Westfalen, Germany), Berlin (Germany) and Istanbul (Turkey), allow to consider potential variabilities of the input data (spatial resolution, seasonal effects, plurality of LULC occurrences) when developing the framework for the classification.

Since the availability of VHR remote sensing data with spatial resolution from 1 m and higher new application ranges were explored. Within the context of urban planning, there is a need for semi-automated processes. Because applied urban planners are often inhibited to use satellite data because of absence of remote sensing software and know how. Therefore a semi-automated LULC classification was developed.

## Land Cover/Use Mapping Using Object Based Classification of SPOT Imagery

K. Dimitrakopoulos

*dimitrakopoulos\_k@hotmail.com*

Aristotle University of Thessaloniki, School of Forestry Natural Environment  
Greece

Ioannis Z. Gitas

*igitas@for.auth.gr*

Aristotle University of Thessaloniki, School of Forestry Natural Environment  
Greece

A. Polychronaki

*anpolych@for.auth.gr*

Aristotle University of Thessaloniki, School of Forestry Natural Environment  
Greece

T. Katagis

*thkatag@for.auth.gr*

Aristotle University of Thessaloniki, School of Forestry Natural Environment  
Greece

Chara Minakou

Greece

**Keywords:** land cover/use mapping, SPOT HRVIR, object based classification, remote sensing, geographical information systems, cartography

**Abstract:** National authorities and international organisations worldwide are interested in the division of the landscape according to the various classes of land cover/use, for example, into urban areas, arable land, grasslands, forests or wetlands. The creation of a land cover/use map emerges not only from the need to generate information that would be useful for general policy purposes, but also from the need to control development at a local level; for example, the need to conserve natural resources, to deal with problems incurring as a result of tourism development and local authority planning, among others.

Today, a wide range of satellite sensors such as Landsat TM, IRS and SPOT HRVIR, are extensively used for land cover/use mapping on different scales, by employing a large number of image interpretation techniques. A classification technique that has recently been developed is object-based image analysis (OBIA). The concept of OBIA is that information necessary to interpret an image is not represented in single pixels, but in meaningful image objects. The technique is an approach that uses not only spectral information, but also spatial information of image objects.

The aim of this work was to examine the potential of OBIA in the mapping of basic land cover/use classes when employing SPOT HRVIR imagery. The specific objectives were: psy"B7 to develop an object based classification model for mapping the land cover/use classes using a SPOT image, psy"B7 to examine the transferability of the model by applying the same model on a second SPOT image of a different area, and psy"B7 to estimate the accuracy of the model by comparing the results with data collected in the field, as well with data derived from photo-interpretation of very high resolution imagery.

The combination of SPOT data and OBIA revealed promising results (79.11

## Land Cover Mapping by an Optimized Object-oriented Approach: Case of Study: Mediterranean Landscapes

Javier Sanchez  
*jarsahe@hotmail.com*  
Politech. University of Madrid  
Spain

Estibaliz Martinez  
*emartinez@fi.upm.es*  
Politech. University of Madrid  
Spain

Agueda Arquero  
*aarquero@fi.upm.es*  
Politech. University of Madrid  
Spain

Diego Renza  
*diegoerre@gmail.com*  
Politech. University of Madrid  
Spain

**Keywords:** Mapping, object-oriented approach, segmentation

**Abstract:** The land cover mapping emerges for various purposes, among others, to control development at a local level, to conserve natural resources and recently, to deal with problems that arise as a result of human impact on natural landscapes through urbanization and agricultural expansion. The uncontrolled urban development causes unexpected and unwanted environmental changes. Particularly, the Mediterranean landscape is a good example because it has been under serious and continuous anthropogenic pressure since historical times. Their land cover features include both natural and anthropogenic attributes and are characterized by being in a state of constant change due to the pervasive influence of human activity.

The coexistence of built-up structures, vegetation, bare soil or water areas, and the high dissimilarity of functions like industrial or residential areas, as well as parks or agricultural regions can cause problems to discriminate the land covers (Taubenböck 2006). Moreover, the existence of undulating relief, a common feature of Mediterranean landscape, increases spatial reflectance variability, thus introducing extra limitations to a conventional classification. Conventional pixel-based methods only utilizing spectral information for land cover classification are inadequate for classifying high spatial resolution images; on the other hand, the object-based methods have become one of the most commonly used strategies for the processing of high resolution imagery with many successful case studies reported (Zhou 2008).

A prerequisite to object-based image analysis is image segmentation, which is normally defined as the subdivision of an image into separated regions (Li 2007). This is usually performed as a preprocessing step for many image interpretation applications, for example in some land-cover and land-use classification systems. The success of object-based image analysis is very dependent on the quality of the results of preprocessing steps such as segmentation.

In this research, we present a methodology to characterize Mediterranean land covers in high spatial resolution images by means an object-oriented approach. It uses a self-calibrating multi-band region growing approach (Paglieroni 2003), optimized by preprocessing the image with a bidirectional filter. The results of object-based approach obtained from the segmentation with and without filter are compared with the results obtained from a classical pixel-based classification.

REFERENCES [Taubenböck 2006] Taubenböck, H. and Esch T. 2006. An urban classification approach based on an object- oriented analysis of high resolution satellite imagery for a spatial structuring within urban areas. 1st EARSeL Workshop of the SIG Urban Remote Sensing Humboldt-Universität zu Berlin.

[Zhou 2008] Zhou, W. and Troy, A. 2008. An object-oriented approach for analysing and characterizing urban landscape at the parcel level. *International Journal of Remote Sensing*, 29(11), 3119-3135.

[Li 2007] Li, P. and Xiao, X. 2007. Multispectral image segmentation by a multichannel watershed-based approach. *International Journal of Remote Sensing*, 28(19), 4429-4452.

[Paglieroni 2003] Paglieroni, D. 2003. A self-calibrating multi-band region growing approach to segmentation of single and multi-band images, SPIE Photonics West, Optical Engineering at LLNL.

## Remote Sensing and Cartographic Diversity of Spatial Structure in Pomerania Landscape

Mieczyslaw Kunz

*met@umk.pl*

Nicolaus Copernicus University

<http://www.geo.uni.torun.pl/eng/index.html>

**Keywords:** land cover, landscape indices, Pomerania, Landsat, NDVI, CLC 2006

**Abstract:** The spatial structure of a landscape is the subject of many scientific studies. It may be analyzed with various research methods and tools, criteria and indices, sources of data and various components. From the ecological point of view, the element that differentiates the spatial structure of the landscape may be a land cover. The knowledge about the land cover and its quantization for a defined spatial unit applying indices used in the landscape ecology, makes it possible to understand and find out relations between man and environment. It is also very important for planning activities in this area.

Research concerning the analysis of spatial landscape structure was done in the area of Pomerania. The analyzed area of almost 50 000 square km is surrounded by natural borders. There are the Odra River on the west, the Baltic Sea on the north, the Vistula River on the East, and the Notec River and the Warta River on the south. The basic unit where the chosen analysis took place was a borough (commune). The total number of boroughs was 258.

For this defined basic unit landscape structure was analyzed with the application of the following landscape measures: the number of land cover categories (NumC), the number of patches (NumP), total length of edges (TE), a shape index (MSI), Shannon diversity index (SDI) and NDVI and a fragmentation index. The first five indices were calculated on the basis of CORINE Land Cover database from 2006, and the last two indices (NDVI and fragmentation index) on the basis of Landsat satellite imagery from 2003.

All spatial landscape measures, and the correlation among indices were defined for each borough. Moreover, the bonitation of boroughs took place taking into consideration resultant, total of the landscape diversity. The goal of the study is the remote sensing and cartographic valorization of boroughs in Pomerania taking into consideration the spatial diversity of the landscape.

The study was done with the technology of geographical information system. The paper is supported by the Grant of Polish Ministry of Science and Higher Education No N N304 220835.

## Updating the 1/50.000 Geological Maps of IGME with Remote Sensing Data, GPS Measurements and GIS Techniques. The Case of Antiparos Island

Konstantinos G. Nikolakopoulos

*knikolakopoulos@igme.gr*

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION  
Greece

Panagiotis I. Tsombos

*ptsombos@igme.gr*

INSTITUTE OF GEOLOGY AND MINERAL EXPLORATION  
Greece

**Keywords:** Geological Maps, Antiparos Island, GIS, Remote Sensing Data

**Abstract:** The basic cartographic scale for geological mapping at the Institute of Geological and Mineral Exploration of Greece (IGME) is 1:50,000; at this scale, the whole country has been covered, by 325 map sheets. Field work for these maps was undertaken during the last six decades, by both Greek and other geologists. As a result of this procedure, there are still significant problems regarding the standardisation of geological terms (lithostratigraphic and structural names) and about where the stratigraphic and tectonic boundaries lie within Greece.

In many regions, it has been noted that adjacent geological maps show marked inconsistencies at their boundaries. These have arisen because the different geologists, working at different times, have interpreted their mapping with different geological and geotectonic models. A particular problem is that the currently used model for the geotectonic zones of Greece was developed after 1970.

The Institute of Geological and Mineral Exploration of Greece (I.G.M.E), acting within the framework of CSF 2000–2006 (Community Support Framework 2000–2006, Operational Program Competitiveness, Priority axis 7: Energy and Sustainable Development, Measure 7.3: Exploitation of natural resources and support in meeting environmental commitments, Action 7.3.1) has been implementing a project called “Collection, codification and documentation of geothematic information for urban and suburban areas in Greece - pilot applications”. The sixth sub-project has been concerned with updating fifty 1:50,000 geological map sheets, using GIS and remote sensing techniques. The geological map sheet, Antiparos Island, has been included in the updating project and a new geological map is being produced by IGME.

Middle and high resolution satellite data were used for the detection and mapping of the tectonic features. Extended field work, including new geological mapping, GPS measurements and field data collection was undertaken during the previous years. All the collected data will be compiled and stored in the IGME integrated geographic database.

## HUMBOLDT Scenario: Protected Areas - Harmonisation capabilities for a future ESDI

Paolo Villa  
*villa.p@irea.cnr.it*  
IREA-CNR  
<http://milano.irea.cnr.it/>

Mario A. Gomarasca  
CNR-IREA  
Italy

Roderic Molina  
GISIG  
Italy

Emanuele Roccatagliata  
GISIG  
Italy

**Keywords:** Data Harmonisation, ESDI, INSPIRE, geoinformation management

**Abstract:** The HUMBOLDT project, started in October 2006 and supported by the European Community with the aim of bringing together a variety of scientific, technical, economic and policy driven points of view to reach the goal of a Framework implementation for harmonisation of data and services in geoinformation domain, under the INSPIRE Directive and in the context of GMES Initiative.

The two-pronged approach of HUMBOLDT comprises a technical side of framework development and an application side of scenario testing and validation, through an iterative refinement of the harmonisation solutions provided within the project. As the outcomes of implemented harmonisational framework grows mature, the application side of the project grows more and more prominent.

Among the HUMBOLDT application Scenarios designed to demonstrate the capabilities of the Framework there is the one covering Protected Areas themes and use cases. Coordinated by GISIG, the Protected Areas Scenario aims to transform geoinformation, managed by park author ities, into a seamless flow that combines multiple information sources from different governance levels (European, national , regional) , and exploits this newly combined information for the purposes of planning, management and tourism promotion.

The scenario defines a number of use cases for which detailed user stories have been developed to address and examine planning and management issues, as well as tourism added value. The scenario develops the harmonisation process via active engagement with various stakeholders at the national and trans-national levels including national authorities and European agencies.

The Protected Areas Scenario Demonstrator Portal has been developed and the first version of one of the foreseen Application Cases is described in the work. To test and create examples of the use of the HUMBOLDT tools a Desktop and Web GIS environment together with a server environment was set up and the resulting tests with two HUMBOLDT Web Processing Services have been documented. All the operations have been done using Opensource tools, from the pre-processing of the data sets to the visualisation of final results.

This harmonisation application capabilities set an important stone in the technical approach at the implementation of the European Spatial Data Infrasctructure following INSPIRE rules and compliances with reduced data management efforts.

## Road Classification from VHR Imagery

Marketa Potuckova  
*mpot@natur.cuni.cz*

Charles Univerzity in Prague, Faculty of science, Department of Applied Geoinformatics and  
Cartography  
Czech Republic  
<http://www.natur.cuni.cz/gis>

Lucie Kupkova  
*lucie.kupkova@gmail.com*

Charles Univerzity in Prague, Faculty of science, Department of Applied Geoinformatics and  
Cartography  
Czech Republic  
<http://www.natur.cuni.cz/gis>

Sona Kolankiewiczova  
*sona.kolank@centrum.cz*

Charles Univerzity in Prague, Faculty of science, Department of Applied Geoinformatics and  
Cartography  
Czech Republic  
<http://www.natur.cuni.cz/gis>

**Keywords:** OBIA, road extraction, QuickBird, aerial orthophoto

**Abstract:** Updating of topographic maps or rapid mapping for supporting crisis management are examples of applications where automated or semi-automated procedures of road extraction are demanded. The paper focuses on development of classification rules for road extraction from very high resolution satellite images and aerial orthoimages. From the methodological point of view, a main emphasis is on object based image analysis. Results of practical tests on QuickBird images from the surroundings of Prague (combination of agriculture, urban and forest areas) are presented. Necessary changes of the classification base for road extraction from aerial images are discussed. A comparison with supervised, per-pixel approach is carried out. Applicability of the developed classification rules for other areas with different land cover are evaluated based on comparison with a national topographic database that was used for accuracy assessment of classification.

## High Value Nature and Culture Landscapes in Europe

Application of Remote Sensing for Agri-Environmental Indicators

Dirk M Wascher  
*Dirk.Wascher@wur.nl*  
Alterra  
Netherlands  
<http://www.alterra.nl>

Gerard Hazeu  
*Gerard.Hazeu@wur.nl*  
Alterra  
<http://www.alterra.nl>

Michiel van Eupen  
*Michiel.vaneupen@wur.nl*  
Alterra  
Netherlands  
<http://www.alterra.nl>

Anne van Doorn  
*anne.vandoorn@wur.nl*  
Alterra  
Netherlands  
<http://www.alterra.nl>

Berien Elbersen  
*Berien.Elbersen@wur.nl*  
Alterra  
Netherlands  
<http://www.alterra.nl>

**Keywords:** remote sensing, high resolution, biodiversity, farming, rural development, agricultural policy, monitoring

**Abstract:** The AgriEnv Core Information Service of the EU project Geoland2 aims at evaluating the utility of the Core Monitoring Service products for the supply of EO-based indicators assessing the impact of agriculture on the environment and the effectiveness of Agri-Environmental Measures (AEM). These services are related to: 1. The agriculture state and trends 2. The farming pressure on water and soil resources 3. The contribution of agricultural land use changes in terms of impacts on biodiversity and landscapes.

The source of information relies on HR EO data and derived indicators from Euroland, BioPar and SATChMo. These EO data set and products are available for 4 demonstration and local sites in European countries. In order to improve the interpretation, an effort of standardization in the production of environmental indicators is done.

The focus of this presentation will be on the methodological approaches for the indicators in the third category, biodiversity and landscapes. In the service category on ‘Agricultural land use changes as driving forces for sustainability – Biodiversity’, the assessments of two High Nature Farmland indicators (percentage land use change) it is proposed to use the Normalised Difference Vegetation Index (NDVI) to measure and monitor plant growth and vegetation. Also already existing reference maps such as national and European HNV assessments as well as the landscape typology LANMAP2 will be taken into account to ensure adequate integration into European assessments. The indicator

'Landscape Coherence' is being developed to assess migration corridors between intensively used lands for specific target species, making use of data on the Natura 2000 network as well as of national data.

The last service on Landscapes comprises the indicators 'Openness./Closedness', 'Landscape Diversity' and 'Cultural Heritage'. For all three landscape indicators, LANAMP2 will serve as a basic spatial reference in combination with land use change data deriving from SatchMo-03 in combination with expert advice. During the last years, the exploration of landscape indicators as a key to measuring socio-economic transitions that affect the direct perception and sense of regional identity of people have received increasing attention. With the signing of the European Landscape Convention by most EU Member States, a new commitment towards landscape related objectives have become more concrete.

## Updating Objects for Topographic Map Information using High Resolution Satellite Images of Zonguldak Testfield

Mehmet Alkan  
*mehmetalkan44@yahoo.com*  
Zonguldak Karaelmas University  
Turkey  
<http://www.karaelmas.edu.tr>

Umut Günes Sefercik  
Zonguldak Karaelmas University  
Turkey

Aycan Murat Marangoz  
Zonguldak Karaelmas University  
Turkey

Serkan Karakis  
Zonguldak Karaelmas University  
Turkey

**Keywords:** Remote Sensing, GIS, High resolution imagery

**Abstract:** High resolution satellite imagery data is very important for many applications areas today's and future . And also, high resolution satellite imagery data will be used in many applications for different purposes. Information systems needs to high resolution imagery data for updating. One of this area will be updated and kept alive topographic map information. High resolution satellite imagery is used with different data base which serve map information via internet and different aim of information systems applications in future topographic and cartographic information systems will very important in our country in this sense use of the satellite images will be unavoidable. In this study explain to how is acquired to satellite images and how is use this images in information systems. Firstly, pan-sharpened QuickBird IKONOS's images have been produced by fusion of high resolution PAN and MS images using PCI Geomatica v9.1 software package. Automatic object extraction has been made using eCognition v4.0.6. On the other hand, these objects have been manually digitized from high resolution images using ArcGIS v9.3. software package. Application section of in this study, satellite images data will be compared each other and topographic map data. It is also determined which data is useful in Geographic Information Systems. Finally, this article explains that integration of remote sensing technology and GIS applications.

## The Possibilities of New Satellite Image Types in the Control of Area-based Subsidies and in Ragweed Monitoring System

Gábor Csornai  
FÖMI  
Hungary

Gábor Mikus  
FÖMI  
Hungary

Gizella Nádor  
FÖMI  
Hungary

Irén Hubik  
FÖMI  
Hungary

István László  
*laszlo.istvan@fomi.hu*  
FÖMI  
Hungary

Katalin Lipták  
FÖMI  
Hungary

**Keywords:** control of area-based subsidies, ragweed monitoring, on-the-spot control, very high resolution images

**Abstract:** In the assessment of the effectiveness of a remote sensing based land cover or land use mapping application, it is desirable to survey as large area as possible at a given spatial resolution, and with high thematic accuracy. To achieve these goals, remote sensing is usually supported by classical on-the-spot check, either in advance, with ground truth data collection, or after, with the validation of remote sensing mapping results.

In the various applications there is a huge difference in the ratio between classical field survey and remote sensing. In our article the connection between field and GIS work will be presented in the frame of two operational projects, together with the changes in the ratio of these approaches and the future possibilities.

The first project is Control with Remote Sensing of Area-based Agricultural Subsidies. This kind of subsidies exist in EU for about two decades. Traditionally, the crop cultivated and its area are principal questions. There is a change in the task of control: since a reform in the subsidy system after 2000, the preservation of environment gained much more importance. This resulted in the involvement of a new set of standards in the control, which is called Good Agricultural and Environmental Conditions (GAEC). For example, preventing soil erosion and fighting against unwanted vegetation belong to these standards. The change in regulations and the development of technology results in a continuous evolution of control methods. Besides, methods differ from country to country. The two major approaches are classical field inspection and remote sensing control. Within remote sensing, there are several possibilities depending on the number, properties and dates of images. There is also a possibility to carry out so-called Rapid Field Visits, which complement remote sensing: in some cases - mainly in the determination of crop type - it gives more reliable answer, or it confirms remote sensing results. In past years, it is compulsory to use very

high resolution (VHR) satellite images (or ortho-photos) for area measurement. This is because of the strict rules on positional accuracy and area measurement precision. The sensitivity of this project enforces the usage of the most precise remote sensing data. It is also important to involve VHR images in the control of GAEC. For example the detection of appearance and encroachment of unwanted vegetation and its exact delimitation can be carried out much more efficiently with VHR images.

The other project is ragweed monitoring. Due to the increasing pollen contamination in Hungary, Ragweed Control Program has grown to a priority project of past years. Ragweed detection with remote sensing has been introduced formerly as one of the high-tech components of this program. Due to the spatial and temporal behavior of ragweed and the difficulties in its recognition it is very important to use a good quality remote sensing data set. A necessarily dense time series plays a crucial role, as ragweed must be recognized and exempted before pollen scattering in order to successfully block pollen spread. However, it has been proven during the control program carried out in past years that the accuracy of spots delineated with remote sensing has also a principal role in order to effectively collaborate with on-the-spot inspection. In the past years the Institute of Geodesy, Cartography and Remote Sensing used medium and high resolution satellite images in this task, which provided sufficient accuracy. Nevertheless, it is seen now that introducing very high resolution images would further increase spatial accuracy and thus the effectiveness of monitoring, and would give stronger support to on-the-spot checks. The procedure that has been used with proven efficiency for several years in the subsidy control, and especially, in the control of GAEC standards, seems to be a promising opportunity in ragweed reconnaissance, as well. In case financial conditions allow, we are technologically ready to its introduction.

It is demonstrated by these two projects that increasing demands and the change of regulatory background requires the continuous development of technology. An important element of this is getting acquainted with integrating into survey tasks of newly introduced remote sensing data sets and the utilization of their mutually advantageous properties.

## Towards a Harmonized Biomass Potential Assessment in Europe: User Requirements and Initial Developments Using EO and Terrestrial Data

Chariton Kalaitzidis  
*chariton@maich.gr*

Mediterranean Agronomic Institute of Chania  
Greece

Manuela Hirschmugl  
*manuela.hirschmugl@joanneum.at*  
Joanneum Research  
Austria

Roland Perko  
*roland.perko@joanneum.at*  
Joanneum Research  
Austria

**Keywords:** biomass, harmonization, combined use of terrestrial and EO data

**Abstract:** This paper summarizes the current status and findings of the project CEUBIOM (Classification of European Biomass Potential for Bioenergy Using Terrestrial and Earth Observations). The overall aim of this coordination and support action is to develop a harmonized method for the assessment of biomass for bioenergy applicable in whole Europe.

In previous work packages, the terrestrial methods as well as remote sensing algorithms were reviewed and analysed for their usability for a harmonized approach. In addition, international and European initiatives, projects and their results were examined.

Within the harmonization work package the first step towards the design of a harmonized approach was the user requirements assessment. Based on 43 questionnaires received from national users of 15 countries, the preliminary user requirements were extracted, which will be refined when the European user requirements are integrated. However, based on this first set of requirements, the development of a harmonized assessment has started. A review of state-of-the-art combination methods for terrestrial and remote sensing data for both forest and agricultural biomass was the next step. In parallel to the method review, an inventory of terrestrial data available in each of the fifteen countries involved in the project was undertaken.

Based on the method review, for forest biomass, a top-down approach based on optical data is recommended, to classify main forest parameters such as species, density and age. In addition, tree height should be included if possible. Based on these parameters, yield tables from terrestrial measurements can be used to calculate the theoretical biomass potential.

For agricultural biomass, the review led to the result that SAR data would be the best option to measure biomass. However regarding the high complexity of SAR processing technology opposed to a maximum 'intermediate' complexity required by the users, the alternative would be an approach using land cover classes from remote sensing and combining them with production or yield statistics from national sources or EUROSTAT.

In the next step, the recommended methods and available data sets will be compared and combined to calculate the theoretical biomass potential. Then a set of boundary conditions (use for food and fibre, sustainability, economic criteria etc) will be defined to generate a feasible method to assess biomass potential for bioenergy in a harmonized manner.

## About the Accuracy of the Vegetation Indices from Multispectral Images: NDVI vs PVI

Enrico Borgogno Mondino  
*enrico.borgogno@unito.it*  
DEIAFA - University of Turin  
Italy

**Keywords:** NDVI, PVI, accuracy, error propagation, change detection

**Abstract:** Many remote sensing applications make a wide use of vegetation indices and a huge number of users is very familiar with them. Nevertheless important issues, concerning their correct use, are often neglected: which is their precision? Is it possible to estimate it? How does the uncertainty related to the reflectances defining them act inside the index formulas? From a practical point of view the answer to these questions permits to define which index differences can be considered meaningful and which not over the same scene or along time series. The proposed approach is based on the statistical concept of the Variance Propagation Law describing how the error of direct measurements (reflectances) conditions the precision of those indirect measurements (indices) that depend on them. Rigorously speaking all of the factors conditioning the reflectance value recovering (sensor features, atmospheric model, topography, etc.) should be taken into consideration and all of the error components should be followed along the adopted formulas. In this work such level of detail is not reached. Nevertheless interesting conclusions can be given just basing the reasoning on an hypothetical error value affecting the reflectances. In this paper two vegetation indices, NDVI (Normalized Difference Vegetation Index) and PVI (Perpendicular Vegetation Index), respectively representing the slope- and distance-based families of indices, are considered. According to their definition error propagation is evaluated both along the index definition and along the difference between indices of different times.

## Spectral Remote Sensing of Infected with Tomato Mosaic Virus (ToMV) Tomato Plants (*Lycopersicon esculentum* L.)

Dora D. Krezhova

*dkrezhova@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Toni K. Yanev

*tyanev@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Ilko Ts. Iliev

*iiliev@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Dimitrina P. Hristova

*di.p.hristova@abv.bg*

Plant Protection Institute  
Bulgaria

**Keywords:** tomato plants, tomato mosaic virus, spectral reflectance, virus detection

**Abstract:** Spectral remote sensing technique was applied to establish injury on leaves of young tomato plants infected with Tomato mosaic virus (ToMV). The analysis was carried out on tomato plants (*Lycopersicon esculentum* L.), cultivar Ideal sensitive to this virus. The plants were grown in a green house under controlled conditions. They were divided into six groups. The first group consisted of untreated (control) plants. At growth stage 4-6 expanded leaf, the second group was inoculated with ToMV. The other four groups were treated with following growth regulators: polyamine (preparation Spermine), derivatives of dicarboxylic acids (preparation MEIA: beta-monomethyl ester of itaconic acid,), phenylcarbamide cytokinins (preparation : benzo(1,2,3)thiadiazole-7-carbothioic acid-S-methyl ester,) and Phytoxin VS. On the next day, the tomato plants of these four groups were inoculated with V race 0. In this study, we have investigated the potential of leaf spectral reflectance changes in viral infected tomato plants against control in developing non-invasive techniques for green house-based 'real-time' diagnosis of viral infections. We used detached leaves from uninfected and infected plants. Spectral measurements were performed at 7th and 14th day after the inoculation of plants.

The viral concentrations in the plants were determined by the serological method Double antibody sandwich enzyme-linked immunosorbent assay (DAS-ELISA). The extinction values of DAS-ELISA of BTH treated plants were approximately equal to inoculated only with ToMV plants, and about three times higher than those of healthy (control) tomato plants. Inhibition of ToMV by the growth regulators was observed in plants treated by Spermine and the standard Phytoxin VS followed by those sprinkled with IA.

Specific differences of the reflectance spectra in certain wavelength intervals were observed between virus-infected and uninfected leaves in the green (near 520-580 nm), red (640-680 nm), red edge (690-710 nm) and near infrared (720-760 nm). The statistical significance of the differences in these intervals was established using the Student t-criterion and linear discriminant analysis. Changes in the reflectance spectra of the leaves and their correlation with DAS-ELISA results for presence of ToMV suggest spectral reflectance technique as a promising tool for cost-effective, nondestructive method for diagnosis of viral infections.

## Chlorophyll Fluorescence Analysis of Infected with Tomato Mosaic Virus (ToMV) Tomato Plants (*Lycopersicon esculentum* L.)

Dora D. Krezhova

*dkrezhova@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Ilko Ts. Iliev

*iiliev@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Tony K. Yanev

*tyanev@stil.bas.bg*

Solar Terrestrial Influences Institute  
Bulgaria

Dimitrina P. Hristova

*dip.hristova@abv.bg*

Plant Protection Institute  
Bulgaria

**Keywords:** chlorophyll fluorescence, tomato mosaic virus (ToMV), plant growth regulators,

**Abstract:** The chlorophyll fluorescence is a sensitive indicator of the conversion of photosynthetic energy that occurs during the plant reaction to light; it has been proved as very useful in studies on the effects of photosynthesis. The chlorophyll fluorescence can be modified by any factor that affects the light reaction pathway of photosynthesis, including many diseases and environmental stresses.

We report on the application of the chlorophyll fluorescence technique to evaluate the influence of tomato mosaic virus (ToMV) on leaves of young tomato plants (*Lycopersicon esculentum* L.), cultivar Ideal, which is sensitive to this virus. The chlorophyll fluorescence was registered by an Ocean Optics USB2000 spectrometer in the spectral range 600-850 nm. As a source of actinic light, a light emitting diode with the maximum of the light output at 470 nm was used. The fluorescence spectra were collected in time acquisition mode from randomly selected leaves from 20 untreated (control) and by 20 leaves from each group of treated plants.

All plants were grown in a green house under controlled conditions: temperature 25°C, illumination 3500-4000 luxes and photoperiod 16/8 hours day and night. The treated plants were divided into five groups. At growth stage 4-6 expanded leaf, the plants from the first group were infected with ToMV. The plants from the other groups were treated with four growth regulators: preparations Spermine, MEIA (beta-monomethyl ester of itaconic acid), (benzo(1,2,3)thiadiazole-7-carbothioic acid-S-methyl ester,) and Phytoxin VS. On the next day, the tomato plants of these four groups were inoculated with V race 0.

Fluorescence measurements were performed on the 7th and 14th day after the treatment. Changes in the course of fluorescence spectra and the statistical significance of the differences between normalized (against second maximum) average spectra of control and treated plants were established. In the spectral range 600-850 nm the Student's t-criterion and linear discriminant analysis were applied at five characteristic wavelengths: in the middle of the leading edge, first maximum, between first and second maximum, second maximum and the middle of the trailing edge. Statistically significant differences between the mean values of the data of the control and treated with preparation MEIA, BHT, Phytoxin VS, and treated only with ToMV plants at the first three wavelengths were

established at  $p < 0.05$  by the two methods applied. The average curves of the fluorescence spectra of the plants treated only with ToMV and those treated with BHT practically coincided in the spectral range 650-800 nm. The spectral data of leaves treated with a preparation Spermine differed non-significantly from the control plants data. Spermine provoked a stronger inhibition of ToMV. The correlation between the chlorophyll fluorescence results and the outcome from the spectral reflectance analyses and the serological analyses (DAS-ELISA) for presence of ToMV performed on the same plants suggest the chlorophyll fluorescence technique as a promising tool for express and reliable diagnosis of viral infections.

## Mophotectonic Features and Kinematic Analysis of the North Anatolian Fault Zone (NAFZ) around the Tasova (Amasya) Region using ERS-2 SAR and LANDSAT ETM+ Images

Kaan Sevki Kavak

*kaank@cumhuriyet.edu.tr*

Cumhuriyet University, Dept of Geological Engineering, Sivas  
Turkey

Suha Ozden

*ozden@comu.edu.tr*

Canakkale OnSekiz Mart University, Dept of Geological Engineering  
Turkey

Semir Over

*over@mku.edu.tr*

Mustafa Kemal University, Dept of Geophysics Engineering, Hatay  
Turkey

Recai Kilic

*recaikilic@gmail.com*

Cumhuriyet University, Dept of Geological Engineering, Sivas  
Turkey

**Keywords:** ERS-2SAR, image processing, kinematic analysis, Landsat, North Anatolian Fault Zone, Tasova

**Abstract:** The North Anatolian Fault Zone (NAFZ) is one of the most known and remarkable examples of dextral active strike-slip systems, located in Turkey. As is well known, radar images acquired from ERS-2 SAR and other similar active sensors rather than optical sensors such as Landsat, SPOT and ASTER systems aid the understanding of developed structural patterns of deformation in strike-slip regions in any parts of continental crust. This study is aimed to determine morphostructural elements of the NAFZ, which is elongated approximately in a direction of N 70° W around the Tasova (Amasya) region. Within this context, speckle reduction, edge detection, texture analysis and data merging methods were applied to ERS-2 SAR and Landsat ETM+ images of the study area respectively. In light of these processes, distribution of structural features of the NAFZ around the study area such as elongated hills, pressure ridges and segmentation along the Tasova basin of the NAFZ were exposed as examples of typical strikeslip fault morphology. These morphological evidences were also observed during field studies in the region. At the end of this study, the presence of three different tectonic phases were exposed compatible with each other to understand behavior style of the region using kinematic analysis during field studies. The oldest tectonic phase is represented with reverse faults. Secondly, following strike-slip regime active in a NW-SE direction, the region is of transpressional/transensional character and can be also assumed synchronous with former reverse faulting. Thirdly, extensional regime developed in NE-SW direction is compatible with this strike-slip regime. According to measurements obtained from Mesozoic to Quaternary aged rock units, compressional direction (ps<sub>731</sub>) is in NW-SE and extensional direction (ps<sub>733</sub>) is NE-SW in the study area. Image procedures and our observations during field studies show that the Tasova basin is a pull-apart basin and represented the Niksar-Destek and Esencay segments of the NAFZ.

## National Wetlands Mapping in Uganda

Herbert Hansen  
*hhansen@keyobs.com*  
Keyobs  
Belgium

Enrico Bonino  
*ebonino@keyobs.com*  
Keyobs  
Belgium

Moses Musinguzi  
*musinguzim@tech.mak.ac.ug*  
Makerere University  
Uganda

Norah Namakambo  
*namakambo@yahoo.com*  
Wetlands management Department, Ministry of Water and Environment  
Uganda

**Keywords:** wetlands landcover mapping remote sensing

**Abstract:** Wetland Management Department (WMD) of the Ministry of Water and Environment in Uganda is the leading Agency for Wetland Management in Uganda. To facilitate the understanding of the evolution of Uganda's wetlands, WMD analysed ASTER and SPOT images for the period 2005-2009. The exercise was done in collaboration with KEYOBS sa, Belgium and Sunshine Projects ltd, Uganda. The methodology included manual- and semi-automatic image classification, field validation and database compilation. Manual methods included visual inspection and screen digitizing while semi-automatic techniques involved use of a 1  
The final results are a complete GIS database presenting all wetlands maps and satellite images. Districts wetland map sheets have also been produced. The updated dataset will be a big step forward in the management of wetlands in Uganda.

## An Intercomparison of Time-series Satellite Data for Monitoring Vegetation Phenology in Western Africa

Bernard Lacaze

*lacaze.bernard@gmail.com*

CNRS-PRODIG

France

<http://prodig.univ-paris1.fr/umr/>

Benoit Toulouse

CNRS-PRODIG

France

Jose-Luis San Emeterio

CNRS-PRODIG

France

**Keywords:** vegetation, phenology, NDVI, time-series, Western Africa, temporal compositing

**Abstract:** Several data sources are available to derive time-series of vegetation indices like NDVI on a global or continental basis. As the oldest archive is obtained from NOAA-AVHRR sensor (data available since 1981), it is required to test the compatibility of these data with more recent time-series, as those issued at global level from SPOT-VEGETATION (since 1998) or MODIS-TERRA (since 2000). In addition, are considered MSG-SEVIRI NDVI data over Western Africa region, archived since September 2005 in the AMMASAT data base on a daily basis at  $0.05^\circ$  spatial resolution.

Considering the Western Africa area ( $25^\circ$  W to  $25^\circ$  E,  $20^\circ$  N to  $5^\circ$  S), a data base comprising the above-mentioned 4 data sources has been constructed for the years 2006 to 2009, with data re-sampled at the same spatial resolution ( $0.05^\circ$ ). Temporal resolutions are different, as temporal compositing periods are respectively 16 days (MODIS), 15 days (NOAA), 10 days (SPOT) and 1 day (MSG).

A comparison is made between daily NDVI data from MSG, averaged over 10, 15 or 16 days, and NDVI obtained from the other 3 data sources. Training areas are pixel groups sampled from phenological regions as defined by White et al. (2005), and/or from land-cover/land-use units mapped at global level (GLC 2000 or GLOBCOVER). Results indicate a very good agreement between NOAA-AVHRR and SPOT-VEGETATION data, and fair to good agreement between TERRA-MODIS or MSG-SEVIRI and the 2 other sources.

The interest of daily data from MSG-SEVIRI is discussed: it appears that NDVI data show a very high day to day variability in some areas at some dates, due to shortcomings in the implementation of the inverse BRDF model used to derive spectral albedos and NDVI. It is thus recommended to apply filtering techniques to these daily data. However, these techniques are not adequate in case of need of real-time monitoring and short-term forecasting of phenological events. It is thus requested that alternative compositing techniques should be applied to MSG-SEVIRI data in order to provide near real-time NDVI data on a regular basis. The approach based upon the search of the time of daily maximum brightness temperature, and derivation of NDVI from visible and near infrared radiances recorded at the same time of day, as proposed by Lacaze and Bergès (2006) appears suitable to obtain cloud-free NDVI data with a 4 to 5 days compositing period.

## Vegetation and Forage Resource Mapping by Combination of LANDSAT ETM+ Mosaic and NOAA NDVI Time Series

Andrieu Julien  
*julien.andrieu@univ-paris-diderot.fr*  
France

**Keywords:** Vegetation mapping, Africa

**Abstract:** Within a program studying forage resource in West-Africa, we are searching for satisfying methods of vegetation mapping containing useful information for forage resource analyses. Though, vegetation remote sensed mapping faces difficulty for detection of both local scale variability (land-cover) and large scale variability (phyto-climatic zonation). We are searching for improvement thanks to combination of low resolution NDVI time series and high resolution multispectral images. We here present maps (and mapping methods) created with NOAA NDVI synthesis of year 2003 and LANDSAT scene mosaic of 2003 over northern Benin and southern Niger.

The mapping of phenologic rhythms is provided by Principal Component Analysis time series. The objective is the mapping of regions with a quite homogenous temporal profile of vegetal activity. The first step is a computation of principal components and their spatio-temporal analysis. Classification with K-means then leads to the spatial discrimination of phyto-climatic zones.

The mapping of vegetation land cover with LANDSAT TM images is provided by a multistage unsupervised classification. The objective is the mapping of land cover, with a predefined typology, by means of a reproducible method that could be easily generalized to all the scenes of a mosaic. The first step is an interpretation of the unsupervised classification, which clusters are regrouped according to the typology. The classification is then improved by stretching radiometric contrasts with Principal Component Analysis applied to LANDSAT bands followed by a second unsupervised classification to re-classify properly the previously ill-classified cells.

## Use of Multi-temporal Satellite Data for Land-use/Land-cover Change Analyses and its Impacts on Soil Properties in the Northern Part of Gadarif Region, Sudan

Khalid Biro

*khalidturk76@yahoo.co.uk*

<http://kartographie.geo.tu-dresden.de>

Biswajeet Pradhan

Germany

<http://kartographie.geo.tu-dresden.de>

Manfred Buchroithner

Germany

<http://kartographie.geo.tu-dresden.de>

Franz Makeschin

Germany

<http://boku.forst.tu-dresden.de>

**Keywords:** Land use/land cover; change detection; Landsat image; ASTER image; Gadarif region; Sudan

**Abstract:** Several decades of intensive dryland farming have taken place in the Gadarif region, located in the East part of Sudan. Rapid land-use/land-cover (LULC) changes have occurred within this region, mainly due to agricultural expansion, government policies and environmental calamities such as drought. In this paper, an attempt has been made to analyse and monitor the LULC changes using multi-temporal Landsat data of the years 1979, 1989 and 1999 and ASTER data of the year 2009. In addition, efforts have been made to discuss the impacts of LULC changes on the selected soil properties. For this, a post-classification comparison technique was used to detect LULC changes from the satellite images. Three main LULC types were selected to investigate the properties of soil namely; cultivated land, fallow land and woodland. Moreover, soil samples were collected from ten sample plots for each LULC type at two depths of surface soil. In the soil samples, various soil properties such as texture, bulk density, organic matter, pH, electrical conductivity (EC), sodium adsorption ratio (SAR), phosphorous and potassium were analysed. Results showed that, there is a significant and extensive change of LULC patterns occurred in the last three decades in the studied area. Further, laboratory tests revealed that, soil properties were significantly affected by the LULC changes. It has been observed that, bulk density increased where as organic matter decreased in the cultivated land as compared to the woodland and fallow land. The physical and chemical properties of soil were found to be lower in the cultivated land as compared to the woodland and the fallow land. The change of the physical and chemical properties of the soil may be attributed due to the changes in LULC contributing to land degradation, which in turn leads to decline in the soil productivity. As a conclusion, dryland-farming systems within the study area needs to be improved by developing sustainable land use practices in order to reduce the rate of soil degradation in future.

## Crop Mapping in Areas with Small-scale Farming

Sub-pixel classification of wide-swath multispectral imagery

Josefien Delrue  
*josefien.delrue@vito.be*  
Vito  
Belgium  
<http://www.vito.be>

Sven Gilliams  
*sven.gilliams@vito.be*  
Vito  
Belgium  
<http://www.vito.be>

Isabelle Piccard  
*isabell.piccard@vito.be*  
Vito  
Belgium  
<http://www.vito.be>

**Keywords:** crop mapping, Sub-Saharan Africa, sub-pixel classification, wide-swath multispectral images

**Abstract:** The launch of wide swath high resolution multispectral sensors, such as AWiFS, CBERS or DMCii have opened up new perspectives for mapping crop land in an operational context. Vast areas can be covered a number of times during the growing season and with a pixel size that allows to discriminate common sized parcels. However, the spatial detail is mostly not sufficient to easily map agriculture in regions where subsistence farming is dominating. The fractioned landscape and the small field size result in a considerable amount of mixed pixels. To be able to take advantage of the wide swath images in such regions, a classification approach that looks at the sub-pixel level is required.

We made a case study on crop type mapping in the Ethiopian central highlands with DMCii supplemented with Landsat ETM+. By means of an artificial neural network, the per pixel fractions of cereals, pulses/oilseeds and other land use types were estimated. The network was trained with well distributed samples of accurate crop classifications derived from very high resolution KOMPSAT2 images. The resulting area fraction maps give an indication of the occurrence of the respective classes over the region.

## Geoprocessing and GIS for Ecotourism Evaluation and Planning in the Ngounié-Nyanga Region Southwest Gabon

Dieudonne Mouketou-Tarazewicz

*d.mouketou@uw.edu.pl*

KGiT

[http://www.telegeo.wgsr.uw.edu.pl/index\\_pl.html](http://www.telegeo.wgsr.uw.edu.pl/index_pl.html)

**Keywords:** Ecotourism potential mapping, Satellite images, GIS, geographic analysis, Ngounié-Nyanga region, Gabon.

**Abstract:** The success of an ecotourism program is determined by tourism planning, development research and marketing, the first thing we review in this article is GIS application for ecotourism potential inventory and planning. Both ecotourism and IT increasingly provide strategic opportunities and powerful tools for economic growth, redistribution of wealth and development of equity around the world. Geo-processing and GIS technology offers great opportunities for the development of sustainable tourism applications using maps. These modern technologies integrate common database operations such as query with the unique visualization and geographic analysis benefits offered by maps. Geo-processing and GIS are used for bringing the geo-referenced information (spatial and non spatial) of the Ngounié-Nyanga region (South west Gabon) into digital maps. Each object is assigned to a thematic layer. Each layer combines related objects like roads, building, protected areas or watercourses. In this research the authors used satellites images and GIS in three types of applications such as inventory, analysis and evaluation of plan based on tourism development.

## Developing a Monitoring System for Sand Dunes Migration in Dakhla Oasis, Western Desert, Egypt

Mohammed Ghadiry  
*ghadiry@felis.uni-freiburg.de*

University of Freiburg  
Germany

<http://portal.uni-freiburg.de/felis/index.html> – *en/view?set\_language = en*

Barbara Koch  
*barbara.koch@felis.uni-freiburg.de*

University of Freiburg  
Germany

<http://portal.uni-freiburg.de/felis/Abteilung/Leitung>

**Keywords:** Sand Dunes, Dakhla Oasis, Spot Images, Python Programming Language

**Abstract:** Movements of sand dunes are considered one of the most serious economical and environmental problems in Egypt. As the sand dunes cover large areas of the Western Desert, and particularly pose a threat to inhabited oases in the middle of the Sahara. The current research envisages monitoring and assessing the recent movements of the sand dunes belts in Dakhla Oasis area using multi-temporal satellite images and GIS-developed model using Python script in ArcGIS. The satellite images (SPOT images, 1995 10 m 2007 2.5 m) were geo-rectified and processed into 2.5 meter spatial resolution using Erdas Imagine and ArcGIS to delineate the geographical distribution of sand dunes at these different dates. The frontiers of individual dunes were measured at these different dates and these movement rates were analysed in GIS. The encroachment rates of these dunes are highly variable and range from 5 to 15 meter per year. The landuse and landcover were also mapped from the available satellite images in order to identify the most vulnerable areas to the path of sand dunes. The current adopted technique by the locals is to cultivate grain and fodder crops in the inter-dune areas that are, in parts, slowly covered by the advancing sand dune. On the long-term, the agriculture areas and associated infrastructures are wandering the exposed inter-dune areas. The current research recommends the sustainable developments in areas that not sensitive to the migration of sand dunes.

## “EURAC Junior – Glacier Schoollab” at the European Academy of Bolzano/Italy

A mid/long term approach to bring together research and schools

Uta Fritsch  
*uta.fritsch@eurac.edu*  
Germany

Philipp Rastner  
*philipp.rastner@eurac.edu*  
Researcher  
Italy

Francesca Taponecco  
*francesca.taponecco@eurac.edu*  
Italy

Matthias Mühlberger  
*matthias.muehlberger@eurac.edu*  
Italy

Christian Steurer  
*christian.steurer@eurac.edu*  
EURAC Institute for Applied Remote Sensing  
Italy  
<http://www.eurac.edu>

**Keywords:** schoollab, science education, young researcher

**Abstract:** With the project EURAC junior the European Academy Bolzano/Italy establishes an interface between schools and science. In this framework EURAC junior offers together with the research Institute for Applied Remote Sensing a three hours glacier-schoollab that introduces high school kids to the topic of earth observation focused on glaciers. Students take part in a well balanced program that combines theory and practical experience. In several short picturesque presentations students receive background information on satellite systems and the basics of remote sensing and deals with the properties of glaciers and how to interpret satellite images regarding the topics snow and ice. The practical part includes the application of remote sensing techniques and also the use of GIS software in different exercises who shows the change of glacier due to climate change. Students experience a scientific working atmosphere and get the opportunity to approach scientists directly. The set up of the schoollab highlights links to school subjects like Math, English, Geography, Physics and Ecology. The activity of EURAC junior has as vision the building of a vivid platform in South Tyrol for initiatives that propose current research topics for teachers and students in every level of education. This opens new opportunities for the teachers to enhance their teaching tool kit and their own education. Students benefit not only from the diversification of teaching methods, but also the contact to science might motivate them for their own career. EURAC Junior has successfully passed his first year of build-up with more than 30 schoollabs and goes now in his second phase focused on the standardization of current formats and on the development of new formats related to the research areas of the different institutes at the European Academy of Bolzano.

## Combining a Learning Management System with Interactive Learning Content for Remote Sensing Education in Schools

Henryk Hodam

*h.hodam@geographie.uni-bonn.de*

University of Bonn

Germany

Kerstin Voss

*k.voss@geographie.uni-bonn.de*

University of Bonn

Germany

<http://www.giub.uni-bonn.de/fis/>

Roland Goetzke

*r.goetzke@geographie.uni-bonn.de*

University of Bonn

Germany

**Keywords:** remote sensing, schools, education, interactive learning applications, learning management system

**Abstract:** The project “Remote Sensing In Schools” aims at finding ways to integrate Remote Sensing in secondary school and college classes and to develop learning material by which this can be realized. The development as well as the evaluation of the created material has been limited to a number of cooperating schools. In the second phase of the project the material will be made widely accessible through a Learning Management System (LMS) in order to further facilitate the usage of the applications and allowing up to date ways of structured learning and teaching.

After considering to fit the applications into one of the many existing environments we decided to modify an existing Open Source system in a way allowing us to integrate the material without restrictions or taking the risk of choosing the wrong system in an ongoing and undecided competition of learning environments.

The work to be carried out is thereby divided into two interdependent fields which are the modification of the LMS itself and the integration of existing and future learning applications into the environment. This interdependent workflow gives the opportunity of matching the LMS to the needs of the learning applications and on the other hand modifying them to fully benefit from the possibilities of the LMS.

We demonstrate this process based on an interactive learning application for biology and geography classes.

## Using Remote Sensing Data in the Context of the Education for Sustainable Development

Markus Jahn

*jahn@ph-heidelberg.de*

Department of Geography, University of Education Heidelberg  
Germany

Michelle Haspel

Department of Geography, University of Education Heidelberg  
Germany

Alexander Siegmund

Department of Geography, University of Education Heidelberg  
Germany

**Keywords:** web-based learning management system, learning modules, satellite image analysis, education for sustainable development, fieldwork, micro-drone

**Abstract:** Remote sensing data offer a new perspective on globalisation processes. Whether deforestation tracks in tropical rain forests or transformations of natural habitats into urban areas by spreading mega-cities are of interest, satellite sensors detect alterations in human-environment-interactions from a local to global scale in a high temporal resolution. At present, a lot of these relationships between the three dimensions economy, ecology and society are not sustainable. Due to those problems, the United Nations (UN) launched a political program for action in 1992, the Agenda 21. Moreover, the UN initiated the corresponding UN Decade of Education for Sustainable Development (2005-2014). In the Agenda 21, implementation of sustainability has the first priority: Mankind should orientate itself towards a more ecologically compatible, economically effective and socially righteous way of living in the 21st century. Education on sustainability, as indicated by the UN Decade, should start from an early age. In this context, digital remote sensing data are an important learning medium for adolescents to understand the current problems in human-environment-relationships. From a didactical viewpoint, understanding these problems is the first step towards a well-founded evaluation of their effects on sustainability.

“Glokal Change” is a web-based learning management system (LMS) under construction (soon available at [www.glokalchange.de](http://www.glokalchange.de)). The intended user group is made up of lower secondary school students and adolescents participating in extracurricular environmental education activities aged 10 to 16 years. The LMS embeds the analysis of remote sensing data into the teaching for the education for sustainable development. By using satellite images, the adolescents shall learn to analyse the economical, ecological and social dimensions that are given in different geographical areas on earth. Satellite images are familiar to many adolescents from programs such as Google Earth. They do not only visualise spatial objects and structures and their changes in time, but also provide valuable information about the three dimensions of sustainability in an entire geographical area.

The core of the LMS “Glokal Change” is composed of four interactive learning modules that cover certain fields of relationships between humans and the environment: “Biofuels in Agriculture”, “Ecosystem Forest and its Management”, “Mining Resources in Open-Cast Mines” and “Land Use Change”. Each module consists of several geographical examples from the global to the local (German) scale. With regard to contents, they broach the issue of the economical, ecological and social circumstances in these geographical areas, which are not sustainable. Beside several learning methods and sources of information, the analysis of digital remote sensing data is a key method for the user to obtain knowledge about the economy, ecology and society in the mapped area. “Glokal Change” offers satellite images, which have already been processed from LANDSAT data. The information provided by true colour images is supplemented by the expressiveness of false colour

composites. The combination of images from different time slots enables the user to regard the dimensions' historical and recent development throughout the area. Comparing images from various geographic examples may lead to the recognition of superior spatial and thematic patterns and/or relationships within the module's topic.

An innovative feature of the LMS "Glokal Change" is an interactive map showing satellite images from the entire territory of Germany. The interactive map is located on a map server. After the global-to-local-scale perspective in the learning modules, the user can explore his/her personal local surroundings on the interactive map. Every German adolescent can thus navigate to his/her individual local area, adding the important aspect of personality to the entire learning process. On the map server, remotely sensed data from 1985, 2000 and 2007 are available for free download and individual handling and analysis. Each time slot contains true colour and different false colour composites (e.g. showing the NDVI) already processed from LANDSAT data. On the map surface, the user can perform several operations to work with these data. In the didactical concept of "Glokal Change", exploring one's own land area on an interactive satellite image map is a pre-stage for the adolescents to go out into this area and examine it in reality.

Hence, "Glokal Change" does not only focus on learning with the computer. Combining computer work and fieldwork is a comprehensive method to improve the entire learning process. In the field, the knowledge about the human-environment-relationships can be applied to the location, where the adolescents are. For this issue, papers with theoretical background knowledge as well as manuals for module-specific, action-orientated fieldwork (worksheets) will be offered. The satellite images from the map server can be used as a helpful tool before and during the original encounter.

Using a micro-drone for high resolution aerial photos is an additional unique feature of "Glokal Change". This low-flying "satellite" has a didactical purpose: it allows adolescents to learn about the fundamental aspects, principles and difficulties of remote sensing during its usage in the field. In addition, real-time aerial photos of the surroundings are produced.

## Innovative Laboratory on the Base of UniScan Technology at a University

Real-time Earth remote sensing in universities.

Vitaly Ippolitov  
*mkuznecova@scanex.ru*  
Russian Federation  
<http://www.scanex.ru>

Vladimir Gershenzon  
*mkuznecova@scanex.ru*  
Russian Federation

Olga Gershenzon  
*mkuznecova@scanex.ru*  
Russian Federation

Marina Sergeeva  
*mkuznecova@scanex.ru*  
Russian Federation

**Keywords:** Earth remote sensing, space monitoring centers, UniScanpsy"D4 ground station, geo-portal

**Abstract:** Delivering targets of boosting the economic competitiveness of any country is not possible without reinforcing the role of the higher professional education. Today, the conventional education, as an access to learning, can not keep up with the current requirements of science and industry.

Russian company RD Center SCANEX believes that setting up Remote Sensing Laboratories, or Remote Sensing Centers allowing real-time imagery acquisition from Earth observing satellites within the structure of Universities is one of the solution of the above mentioned problems. This will provide the proper environment for innovative education, to deliver the efficient training for scientific and academic and teaching personnel, secure the role of the young professionals in science, education and hi-tech, and maintain the continuity of generations in science and education. SCANEX has delivered the land based UniScan centers to over 20 higher education institutions in Russia, Kazakhstan, and Spain. These stations serve as the basis for Earth monitoring from space centers providing the training and advanced training to produce the specialists having the state-of-the-art knowledge in Earth Remote Sensing and GIS, as well as the land-use monitoring and geo-data service for the economic operators in such diverse areas as the nature resource management, agriculture, land property management etc.

Since early 2009 satellite imagery service to Universities has extended worldwide outside the Russian territory, providing EROS A satellite imagery at 1.8 m resolution, IRS-1D imagery at 5.8 and 23 m, and SPOT 4 satellite imagery at 10 and 20 m resolution. Based on the Agreement between SCANEX and the satellites Operators, and on flexible financial terms, the international universities can purchase the universal compact UniScan stations including telemetry for the first year of operation.

Creation of state-of-the-art remote sensing laboratories/centers at universities will lead to a new quality level for education and scientific studies and will enable to make education system in such innovation institutions open to modern research work and economy.

1. Introduction Inclusion of higher education schools in Bologna process sets a mission of quality support and quality assurance as the top priority in improving higher education. Such an index as

the education quality comes along with education results, currently most often referred to as “competence”. Innovation of education should be more competence-oriented than passing of knowledge that always gets out of date. Following this pattern knowledge can be acquired on an individual bases. Such kind of education should be more connected to practice than the traditional one. Reducing competitiveness of traditional education institutions, as well as insufficient science and production integration indicate that new types of higher education institutions should be created. Nowadays, often traditional education as the system of gaining knowledge lags behind the actual current requirements of contemporary science and production.

2. Solution from SCANEX One of the solutions to resolve these problems can be the introduction of Remote Sensing Laboratories or Centers for Earth observation from Space for territories changes monitoring as research and development links in the chain of universities. This will allow the students to master practical skills having an ultra-modern laboratory base.

Traditionally, remote sensing centers at universities are equipped with ground stations enabling to receive free data, such as worldwide known AVHRR from NOAA satellites series with resolution of 1,100 m and MODIS from Terra and Aqua satellites with 250, 500 and 1,000 m resolution. Important positive peculiarity of these data in that there are many open and free software tools and many of them can be found in Internet. This opens a wide field for students and researchers to change of knowledge, ideas and new developments investigating AVHRR and MODIS data for global changes on vast territories. But at the same time low resolution of these data makes considerable restrictions for their practical applications for more precision changes of local areas of the Earth.

At the same time one who wishes to receive data with middle and high resolution faces with such problems as high price for ground station and expensive telemetry fee. Usually only national large remote sensing centers have a possibility to receive data with middle and high resolution. However, it was a dream for universities... Since 2009 SCANEX has been exercising the possibility of equipping foreign universities with technologies for receiving Earth remote sensing data of high resolution (up to 1.8 m) in real time. Participants of the world educational community can purchase the universal UniScan ground station for receiving space data already completed with licenses for the right to receive 100 scenes of EROS A, 600 minutes of IRS-1D and unlimited access to SPOT 4 images for the first year of operation. Initial inclusion of the license in the functionality of UniScan ground station (pursuant to agreements with the Operators of respective Earth remote sensing missions) leads to significant cost reduction of receiving station and space imagery for universities. As a result the world universities will be able to effectively utilize the state-of-the-art space technologies in their educational process and scientific research by working with up-to-date satellite data received at their own stations with the footprint of up to 2.5 thousand kilometers in radius.

3. Experience and technology To date, there are over 20 Remote Sensing Centers/Laboratories operating on UniScan ground stations deployed at the leading universities in Russia, Kazakhstan and Spain. In the most cases they receive MODIS data. But among them 7 UniScan ground stations in universities of Russia are equipped not only for MODIS data, but also for other satellites (SPOT 4, IRS-P5, IRS-P6, EROS A/B, RADARSAT-1) thanks to flexible licensing policy implemented in the Russian Federation.

Based on SCANEX technology Remote Sensing Centers/Laboratories have already been operating with an excellent track record in such Russian Universities as Altay State University, Belgorod State University, Ufa State Aviation Technical University, Tyumen State University, Moscow State Technical University n.a. N.E. Bauman.

Samara Space Geoinformation Center has been operating in Samara State Aerospace University since December 2006, and is currently the best equipped Earth Remote Sensing Center in Russia and CIS countries, not only among the educational facilities, but also the state and private space monitoring centers.

Earth Remote Sensing Centers/Laboratories have been launched in 2007-2008 as a part of “Education” National Project in Siberian and Southern Federal Universities. It has been currently the worldwide practice to set up Remote Sensing Laboratory/Center at the higher education facilities and other educational organizations. Thus, UniScan based laboratories and centers have been in operation at Kazakhstan-British Technical University of Republic of Kazakhstan (Almaty) under

the auspices of Kazakhstan System Modeling Research Institute, at Satpayev Kazakhstan Research Science and Technology Institute (Almaty), at two universities in Spain (Valladolid and Valencia). The Remote Sensing Centers/Laboratories deliver the real-time training for executive decision making support technology at the regional and municipal levels. The Centers can also provide the commercial service as well, e.g., training at professional development programs, contracted areal monitoring work management in a range of various applications (management of natural resources, agriculture and forestry management, emergency response, mapping updates, cadastral work, etc.) or research and development in various fields of knowledge.

UniScan ground station is intended for receiving and processing information transmitted from Earth low-orbit satellites via X-band radio channels with the data rates up to 170 Mbps in one channel. Such rates correspond to images with a spatial resolution better than 1 meter. At present the UniScan station provides for reception and processing of data from Terra, Aqua, IRS-P5, IRS-P6, CARTOSAT-2, SPOT 4, EROS A, EROS B and RADARSAT-1, ENVISAT-1 satellites. UniScan hardware is universal and programmable and, in most cases, ground station can be upgraded for new satellites on the software level.

UniScan is completed with software for data reception, preliminary processing, archiving, cataloguing and creation of thematic products further to be imported into various GIS formats and applications. The most popular among the specialists in Remote Sensing and GIS are ScanMagicspy"D2 and ScanEx Image Processorpsy"D2 software applications with more than 200 licenses throughout Russia and abroad.

4. Remotely sensed data application Data received from the satellites in real-time are converted into ready-for-further-analysis products within 0.5-1 hour after being received from space, which indicates a high operational degree of the process (no data, available via Internet, can be obtained in such a quick mode).

Contemporary Remote Sensing Laboratory/Center at a university allows to: - turn the university into one of the world leading education institutions equipped with cutting-edge technology and firmware for Earth observation from space (footprint of ground station is about 12 million square kilometers); - carry out training and advance training of specialists having skills in remote sensing and GIS, used for decision-making support; - monitor territories and submit data in support of decision-making of regions and sub-regions.

Remotely sensed data received by Remote Sensing Laboratory/Center of a university will allow resolving following practical tasks concerning change detection using different types of remotely sensed data both optical and radar: - topographic maps updating; - forest fires early detection and monitoring; - ice and snow cover condition operational assessment; - on/off shore oil spills detection within the oil production and transportation areas; - ecological situation of water areas and new seaports, pipelines and oil terminals construction sites; - illegal fishing control; - license agreements compliance monitoring within the fields of natural resources development; - forestry monitoring (logging dynamics, logging status); - agricultural monitoring for crop rotation rules observation and proper arable lands use; - illegal construction control; - monitoring of infrastructure development; - independent and operational natural disaster damage assessment; - hydraulic structures condition monitoring; - creation of up-to-date thematic maps of natural objects condition (vegetation, soil cover, areas hazard rate, etc.); - environmental impact assessment of a territory development. - solution of hydro-meteorological and weather forecast tasks; - environmental monitoring and others.

5. Conclusion Creation of state-of-the-art Remote Sensing Laboratory/Center at universities will lead to a new quality level for education and scientific studies and will enable users to make educational system in such innovation institutions open to modern research work and economy.

## Remote Sensing Education at Bulgarian Universities and High Schools

State of the art, perspectives and significance

Lachezar H Filchev

*lachezarhf@gmail.com*

Space Research Institute, Remote Sensing of the Earth Department

Bulgaria

<http://rse-sri.com/index.php?l=4>

Stefan K Stamenov

*stamenovstefan@gmail.com*

Space Research Institute, Remote Sensing of the Earth Department

Bulgaria

<http://rse-sri.com/index.php?l=4>

**Keywords:** remote sensing, geo-information, education, history, perspectives

**Abstract:** In the second half of the last century, remote sensing methods became increasingly influent in the civil sector of the economy. Their various applications such as monitoring and analysis of the atmosphere, terrestrial and aquatic features of the environment made them widely applicable in numerous scientific fields. During the last decade the integration of the remote sensing, geographic information systems, cartography and photogrammetry as well as the processes of diversification of the application fields of remote sensing for earth observation introduced the remote sensing and geo-information methods in new scientific fields and in high-school and university education. Such tendencies are observed in the application of remote sensing in agriculture, ecology, civil engineering, preserving of natural and cultural heritage etc.

The purpose of present work is to describe the past, current status, future perspectives and significance of remote sensing education at Bulgarian universities and high schools. The methods used are review of the literature and interviews with students and academic staff.

The beginning of the remote sensing education for civil purposes in Bulgaria started in the 1940's with the establishment of the Higher Technical School in Sofia. From the 1970's remote sensing methods were developed, studied and applied in the institutes of the Bulgarian Academy of Sciences (BAS). Some of the pioneers in the development of specialized applications and education in remote sensing of Ph.D. students in Bulgaria are Space Research Institute, National Institute of Meteorology and Hydrology, Institute of Geography and Central Laboratory of Geodesy and, recently, Institute of Oceanology at BAS. Nowadays, remote sensing disciplines are included in the curriculum of several universities such as The University of Architecture, Civil Engineering and Geodesy (UACEG); Sofia University St. Kliment Ohridski, University of Mining and Geology, Technical University of Sofia, University of Forestry, New Bulgarian University, South-West University. At present, the principles and methods of remote sensing have their application in geodesy, civil engineering, geology, geography, landscape science, ecology and geomorphology and in some extent in archaeology and preserving the cultural heritage. In the high-school education remote sensing introductory courses have been read since the middle of 1990's at the National High School of Mathematics and Science. In summary, the perspectives of remote sensing education in Bulgaria are connected with better understanding of the essence and effectiveness of remote sensing at solving of the global issues of 21st century as well as wider approach of the remote sensing in different research areas. These processes depend on the national and international policy in those areas, the approval and the support of the academic council at each university and the advisory board at high schools. The advancement of Internet technologies for distant education, i.e. e-learning systems, will also bring forward the advancement of remote sensing education.

## First Year Science Students' Understanding the Relationship between Scientific Epistemological Beliefs and Nature of Science

Epistemolojik belief and nature of sciences

Fulya Oztas  
*fullyoztas@yahoo.com*  
Dr.  
Turkey

**Keywords:** Epistemology, NOS, teacher candidates, science.

**Abstract:** Currently education standards argue that students should learn science conceptions more deeply as well as develop their skills of doing science. Since, science education research has repeatedly found an interacting between students' view about the nature of science and their learning approaches to science. The research on students' beliefs about the nature of science, or their scientific epistemologies appear to share much with scientific practice but their expressed epistemological beliefs seem hopelessly naive.

It could be interesting to know is there any relationship between the science teacher candidates' epistemological belief (EB) and their views about nature of science (NOS) that this somehow may affect their learning science as science teacher candidate. Overall, the results of this study have been shown that there is a meaningful relationship ( $P < 0.01$ ) between students' epistemological beliefs and nature of science.

## Development of a New Education Programme in Geodesy and Geoinformatics for Tajikistan – Highlights and Experiences

Zamirakhon Kodirova  
*kadirovaz@gmail.com*  
Tajikistan

**Keywords:** geodesy, education, Tajikistan

**Abstract:** In this thesis we will share our experience in developing a new education programme in “Geodesy and geoinformatics” for Tajikistan.

Since 1931 when Tajik agrarian institute was established, students of the Hydromelioration faculty are taught in geodesy. At the end of 1991, Tajikistan became an independent state when the former Soviet Union collapsed. After independence, a period of political instability followed and a civil war broke out, which further aggravated the already difficult situation. Equipment purchased during Soviet times became old and there was not funding to purchase new.

In 2006, the Royal Institute of Technology (KTH) in Stockholm together with University of West Hungary (UWH) and Tajik Agrarian University (TAU) proposed a joint European project to improve higher education in Tajikistan in the field of geodesy and geographic information technology. A new education programme "Geodesy and Geoinformatics" was developed at the Tajik Agrarian University (TAU) so that Tajikistan would be able to educate its own geodetic engineers and specialists in geographic information.

As a result of this project, the faculty of Hydromelioration has now new modern geodesy equipment, a GIS Center and a Digital Mapping Laboratory. Additionally, a new curriculum program on “Geodesy and Geoinformatics” including BSc and MSc courses was developed. In the autumn of 2009, the new courses started. However, a number of challenges remain: Since approaches and methods are new, the faculty has no qualified teachers. Furthermore, the teaching language is the state language, which is Tajik and all teaching material has to be newly elaborated or translated. This requires English language training for our geodesy teachers and capacity building in new subjects like GIS, digital mapping, and remote sensing. Exchange with other European Universities is a good opportunity to reach our goals.

## Using Remote Sensing for the Understanding of Territorial Changes in the Schools of Lake Garda

Mariano Bresciani  
*bresciani.m@irea.cnr.it*  
CNR-IREA  
Italy

Alba L'Astorina  
*lastorina.a@irea.cnr.it*  
CNR-IREA  
Italy

Rossella Palmieri  
School Trebeschi-Catullo  
Italy

Guido Parmeggiani  
Associazione Airone Rosso  
Italy

Paolo Villa  
CNR-IREA  
Italy

**Keywords:** Environmental education, Remote Sensing, Lake Garda, land change

**Abstract:** The awareness of changes that affected the environment over the years is something that is lacking in the younger generations, in particular students find themselves hardly in contact with nature and rather with human built ups. The loss of contact with nature weakened the opportunity to fully understand the importance of biodiversity in an human-shaped environment where some landscapes cannot be reproduced by man. The area south of Lake Garda, has suffered from a high overbuilding due to the touristic and economic development that led to significant environmental changes. Hotels, restaurants, shops and roads have subtracted space to plants, fields and reeds. Remote sensing has been used in the past five years in the schools to help students to see and understand how their territory has changed over the last fifty years; the analysis of orthophotos of the 60's and 70's and the comparison with those available for the year 2000 and with some satellite (e.g. IKONOS, SPOT, LANDSAT) and airborne hyperspectral images (MIVIS), allowed them to better figure how and where their territory has changed. In three towns of the Lake Garda in the Brescia province (Padenghe, Desenzano and Sirmione) students have estimated how much of the natural surfaces of their territory have become buildings through the years. Based on optical physics concepts students could understand how the information contained in electromagnetic radiation can be used to study the Earth surfaces. They were also able to assess the health status of reed vegetation, another sensitive environmental issue of the lake shores, over the years and they were able to analyse water quality of the lake by using maps derived from satellite images acquired by the MERIS sensor.

Students have also identified natural areas that have not changed over the years and, among these, one has been identified as being of particular environmental value; students were able to visit the area and they supported local environmental groups to awake the awareness of the public administration and of the regional governments and municipalities to declare it as a protected natural area. This wetland has become a Natural Monument in 2008 and currently is managed by the association "Airone rosso"; at the natural monument take place activities of Environmental Education which also include monitoring using orthophotos and by applying techniques of proximal sensing.

## International Charter ‘Space and Major Disasters’

experience of CNES and the French Civil Protection

André Husson  
*andre.husson@cnes.fr*

Catherine Proy  
*catherine.proy@cnes.fr*  
CNES  
France

Pierre Chastanet  
*pierre.chastanet@interieur.gouv.fr*  
French Civil Security  
France

**Keywords:** Earth-imaging satellites, disasters, emergency, Haiti earthquake

**Abstract:** International Charter ‘Space and Major Disasters’ is a unique initiative employing space technologies to help save lives and assess the damage due to natural disasters that leave a trail of destruction around the world, including in Europe. The aim of the charter is to help get relief to those who need it. Earth-imaging satellites provide archive images or specifically tasked imagery of disaster areas that emergency response teams can use to organize the on the spot assistance and aid.

CNES and ESA instituted the International Charter ‘Space and Major Disasters’ in 2000 to respond to such emergencies. The charter is an international agreement between the ten European and non European space agencies of France, Europe, the United Kingdom, the United States, Canada, Argentine, China, India and Japan, making their resources available to emergency operations during crisis situation. The members participate with no exchange of funds and on a best effort basis. Each member agency mobilizes its earth-observation satellites and commits operational resources to support the activities of the Charter.

Since its inception in November 2000, the Charter has been activated all over the world more than 250 times in more than 80 countries, in response to meteorological disasters such as hurricanes and floods (60

The Charter is a global mechanism, a coordinated system with two fold missions: - to task satellites in emergency situation (the Charter does not concern the prevention/rehabilitation phases), - to supply emergency organizations, essentially the national civil protection agencies, with a timely, free and co-ordinated access to satellites data in case of major natural or man made disaster (the Charter does not concern the long humanitarian crisis)

We will describe the latest activations from the French Civil Protection with a special focus on the Haiti earthquake, the disasters assessment products obtained and the feedbacks from the Users.

## Ten Years of Disaster Response with ASTER Data

Michael Abrams  
*michael.abrams@jpl.nasa.gov*  
NASA/Jet Propulsion Lab  
United States

**Keywords:** natural disaster; ASTER

**Abstract:** The Advanced Spaceborne Thermal Emission and Reflection Radiometer (ASTER) is a joint Japan/U.S. space activity, operating on NASA's Terra spacecraft since March 2000. ASTER acquires 450 images per day in 14 spectral bands in the visible, shortwave infrared, and thermal infrared wavelength regions, with a spatial resolution of 15 to 90 m per pixel. An additional off-nadir visible stereo band allows creation of digital elevation models. ASTER data have been extensively used to monitor natural hazards and disasters, and the ASTER project has responded to data acquisition requests through the International Charter. Early in the mission, the ASTER Science Team realized there would be a need for urgent data acquisitions, and rapid data turnaround. A system was put in place that allows scheduling of data takes up to 36 hours in advance, and provides 2-4 hour processing time after scenes are acquired. This process is made available to emergency responders, including the US Geological Survey's emergency response team, who coordinates requests from a number of US Federal agencies.

In this presentation, examples will be shown of the uses of ASTER data during episodes of natural disasters. The principal events we respond to are: 1) Flooding from hurricanes (Hurricane Katrina), snow and ice melt (Midwestern US), and tsunamis (Sumatra); 2) Fires: forest fires all over the world; 3) Earthquakes: 2008 Sichuan and 2010 Haiti earthquakes, and resultant landslides; 4) Volcanic eruptions: Kamchatka volcanoes and aircraft hazards; SO<sub>2</sub> plume detection.

## Detection of the Damages Affecting Buildings in an Outer Urban Environment after an Earthquake from Quickbird Images

(the case of the earthquake of BOUMERDES earthquake, in 2003)

Benachir Aniss

*benachiraniss@hotmail.com*

UMR CNRS PRODIG, laboratoire PPF Pôle Image  
France

Merring Catherine

UMR CNRS PRODIG, laboratoire PPF Pôle Image  
France

**Keywords:** Satellite remote detection and VHR images (QUICKBIRD), Natural disasters, Risk in urban and outer-urban milieus, Detection damage areas, approach by object

**Abstract:** So far as we can detect the elements of the built frame on infra metric resolution images, the use the images very high-resolution satellite images (VHRSI) can be considered, to produce a large-scale mapping(cartography) of the various types of damage caused by a natural disaster in an urban milieu. We can also envisage that the use of automatic procedures of treatment of images should lead to a reduction of times and of costs of works aimed at assessing the outcome/toll of the devastated areas.

We are presenting here a method of automatic detection of devastated areas after an earthquake in urban zones from QUICKBIRD images framing the earthquake, by taking the example of the city of BOUMERDES which was hit by a destructive earthquake of a 6.7 magnitude on the Richter scale in May 2003.

We were more particularly interested here in an analysis of the damage in the outer-urban zones whic were the most affected by the earthquake; they are areas that do not allow the automatic classification nor the distinction between the built-up areas and the surrounding agricultural and vegetal zones existing in the outskirts of the city.

We also find particular cases as: 1. The existence of new objects (between 2 images): problem bound to the frequency of the updates. 2. The difference in recording angle (between 2 images): which does not allow the same localization/spotting of objects (as for high buildings/ or buildings built on high spots?) on 2 images. 3. The shadow is not the same because the images are not taken at the same moment.

The first results will be presented as well as the solution adopted in our method; a solution based on the spotting of the built frame shadows which remain the first evident element to be automatically classified, because it is certain that the disappearance of a built frame shadow remains a relevant indicator(informer) of the destruction or the damage of the built frame on a large scale, allowing thus a first assessment of the state of the built frame ( buildings) after a disaster.

The reached objective of our study is to manage, thanks to the VHRSI, to assess the damage and to locate devastated areas so as to get to the performing, in the long run, of urban planning and implementation of a GIS for the management and the prevention of disasters.

## Vulnerability Analysis of Floods in Urban Areas using Remote Sensing and GIS

Orkan Ozcan

*orkan@cscrs.itu.edu.tr*

ITU, Center for Satellite Communications and Remote Sensing, Istanbul  
Turkey

Nebiye Musaoglu

*musaoglune@itu.edu.tr*

ITU, Geomatics Engineering Division, Maslak Istanbul  
Turkey

**Keywords:** Urbanization, Digital Terrain model (DTM), Remote Sensing, Flood, GIS, Istanbul

**Abstract:** Flash floods are dangerously fast moving floods caused by a large amount of heavy rain in a localized area. These kinds of floods occur for a variety of reasons including concentrated rainfall with an enormous impact on the environment and society. They destroy drainage systems in cities buildings can be significantly damaged and even destroyed. Many developing countries face with rapid and uncontrolled urbanization especially settlements that were built close to riverbed. Urbanization occurred in this way would cause impermeable surface where infiltration cannot occur and effect of flood also increases.

This study focused on, analyses of flood risk on urban areas near riverbed. Study area was chosen as Ayamama River and its watershed where heavy urbanization is present. SPOT 5 satellite image with 2.5 m spatial resolution was used to determine urban areas. For this aim, object-based nearest neighbor classification method was performed after image segmentation. A precise Digital Terrain Model was analyzed in order to derive the parameters such as height, slope, and aspect. In the next step, vulnerability of urban areas was established within zones using multi-criteria decision analyses. Vulnerability zones were determined according to distance of the settlements to the riverbed.

## Identification of Structural Changes caused by Natural Disasters in Agriculture by Synergistic Use of Optical and Radar Data

Identification of structural changes caused by natural disasters

Gizella Nádor

*nador.gizella@fomi.hu*

Institute of Geodesy, Cartography and Remote Sensing  
Hungary

Diána Fényes

*fenyes.diana@fomi.hu*

Institute of Geodesy, Cartography and Remote Sensing  
Hungary

György Surek

*surek@mlog.hu*

MLOG Ltd.

Hungary

**Keywords:** polarimetric radar data, structural change, natural disasters

**Abstract:** The Remote Sensing Centre (RSC) of the Institute of Geodesy, Cartography and Remote Sensing (FÖMI) has provided many services in the past 30 years to the Ministry of Agriculture and Rural Development (MARD) and the Ministry of Environment and Water (MEW). FÖMI also accumulated operational experiences in the applications of remote sensing. The unique methodology of the operational Crop Monitoring and Production Forecast Programme (CROPMON, 1997 - 2003) provided an excellent methodology basis for further applications development. One of the operationally proven programme was the Western Corn Rootworm (WCR) damage identification, which demonstrated the potential in the integrated assessment of optical and radar (ALOS PALSAR) satellite images to assess and identify the disorder and structural changes caused by WCR larvae. Using polarimetric radar technique increased the accuracy significantly. Based on the achieved objectives of that project there is potential in the integrated analysis of optical and radar images to assess and identify disorders and structural changes in agriculture.

Crop damages caused by different type of natural disasters (wild animal, hail, storm) can cause also structural changes on crop fields. We suppose that we can distinguish the damaged crop fields from the control ones by radar polarimetry. We characterize quantitatively the discriminating efficiency of different type of polarimetric radar data.

The challenge of this project is to identify the structural changes caused by different type of damages on crop fields regionally using optical (DMC, SPOT) satellite time series and radar data (RADARSAT2, ALOS PALSAR and ENVISAT ASAR AP). It includes the reference data collection, the quantitative evaluation of the optical and radar time series data, the comparative analysis of the crop damage or weed infection maps derived from different types of radar data and the quality control of the thematic results. The first results of this project will be presented in the symposium. To develop and extend the present method is worthwhile as crop damage identification system is expeditious, objective and economical. The development of the system creates the possibility to identify the spread of crop damage on larger areas.

## Drought Estimation Maps by means of Multidate LANDSAT Fused Images

Diego Renza  
*diegoerre@gmail.com*  
Spain

Estibaliz Martinez  
*emartinez@fi.upm.es*  
Spain

Agueda Arquero  
*aarquero@fi.upm.es*  
Spain

Javier Sanchez  
*jarsahe@hotmail.com*  
Spain

**Keywords:** Drought estimation maps, change detection, fused data

**Abstract:** In the last few years, several regions in Europe have been affected by drought. It is anticipated that these droughts will be more frequent due to global climate change involving future increases in temperature and changes in precipitation [1]. Drought is a normal, recurrent feature of climate, although often erroneously considered an unexpected and extraordinary event. Its main origin is reduced precipitation over an extended period, usually one season or more. Human activities such as over exploitation of aquifers, loss of soil covers or vegetation due to inadequate land use may aggravate their effects.

An analysis of the “observed” changes of the development of land covers may hence serve as a key indicator of the drought impact. In this sense, a number of studies show the use of remote sensing data for characterization and monitoring of drought conditions within a region, based on the fact that satellite remote sensing observations can provide a synoptic view of the land and provide a spatial context for measuring it.

Regarding this, a recent index, the Normalized Difference Drought Index (NDDI) can offer us an appropriate measure of the dryness of a particular area, because it combines information on both vegetation and water, i.e., NDDI combines information from the NDWI (Normalized Difference Water Index) and NDVI (Normalized Difference Vegetation Index) data. The first is an index calculated from the visible red and near infrared channels, measuring the changes in chlorophyll absorption and reflection in the spongy mesophyll of the vegetation canopy that are reflected in these bands. For its part, NDWI are derived from the near-infrared and short wave infrared channels, reflecting changes in both the water content and spongy mesophyll in the vegetation canopy [2].

For the calculation of these normalized differences can use data from different sensors like the advanced Very High Resolution Radiometer (AVHRR) or moderate resolution imaging spectroradiometer (MODIS). In recent studies, the trend is to use data from the MODIS sensor, which has resolutions of 250, 500 and 1000 m. These resolutions provide the analysis of large regions but lack the detail required for local analysis.

For a local analysis can be thought of data with greater spatial resolution, as provided by the sensor Landsat 7 ETM+. In this case we have the necessary bands in the red and infrared spectrum to facilitate the calculation of indices. Also the analysis can be further facilitated with fused data [3], which can be obtained from the original Landsat bands obtaining new bands with twice resolution. The purpose of this paper is to analyze the usefulness of traditional indexes, such as NDVI and NDWI along with a recently proposed index (NDDI) using merged data for multiples dates, with

the aim of obtaining data (statistical and visual) to facilitate the analysis for government premises. In this study we have used Landsat 7 ETM+ data for the month of June (2001-2009), which merged to get bands with twice the resolution. The three previous indices were calculated from these new bands, getting in turn maps of drought that can facilitate rapid analysis of a particular region. Also the analysis of data obtained showed an increasing trend in terms of dryness of the land studied (near the community of Madrid, Spain).

[1] Gu et al., (2007), A five-year analysis of MODIS NDVI and NDWI for grassland drought assessment over the central Great Plains of the United States, *Geophys. Res. Lett.*, 34, L06407. [2] Mänd et Al., (2009), Responses of the reflectance indices PRI and NDVI to experimental warming and drought in European shrublands along a north–south climatic gradient., *Remote Sensing of Environment* 114 (2010) 626–636. [3] Renza et Al., (2009), Optimizing classification accuracy of remotely sensed imagery with DT-CWT fused images. *Lecture Notes in Computer Science* 5856-2009, 1031-1038.

## Use of Remote Sensing Data and GIS to Produce Landslide Susceptibility Map of a Landslide Prone Area (Bertam Valley, Malaysia), using Weight of Evidence Model

Saro Lee

Korean Institute of Geoscience Mineral resources, Daejeon, Korea  
Korea, Republic of

Biswajeet Pradhan

*biswajeet24@gmail.com*

Institute of Cartography, Dresden University of Technology, Germany, Tel. +49-351-46333099;  
Fax. +49-351-46337028  
Malaysia

Hyun-Joo Oh

Korean Institute of Geoscience Mineral resources, Daejeon, Korea  
Korea, Republic of

Manfred F. Buchroithner

Institute of Cartography, Dresden University of Technology, Germany  
Germany

**Keywords:** Landslides, remote sensing, weight of evidence, gis

**Abstract:** Preparation of landslide susceptibility maps is important for engineering geologists and geomorphologists. However, due to complex nature of landslides, producing a reliable susceptibility map is not easy. In this paper, the weights-of-evidence model (a Bayesian probability model) was applied to the task of evaluating landslide susceptibility using GIS. Using landslide location and a spatial database containing information such as topography, soil, landcover, geology, and lineament, the weights-of-evidence model was applied to calculate each relevant factor's rating for the studied area. In the topographic database the factors were slope, aspect, distance to road, and curvature; in the soil database they were soil texture, soil material, and topographic type; lithology was derived from the geological database; land-cover information extracted from Landsat TM satellite imagery; and lineament data derived from SPOT 5 satellite imagery. Tests of conditional independence were performed for the selection of factors, allowing 33 combinations of factors to be analyzed. For the analysis of mapping landslide susceptibility, the contrast values,  $W+$  and  $W-$ , of each factor's rating were overlaid spatially. The results of the analysis were validated using the previous actual landslides locations in the study area. The combination of slope, curvature, topography, distance to road and distance to drainage, showed the best results. The results can be used for hazard prevention and land-use planning.

## Earth Observation for a Better Flood Anticipation, Risk Understanding and Crisis Management

Sonia Heitz

*heitz@lippmann.lu*

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

Patrick Matgen

*matgen@lippmann.lu*

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

Renaud Hostache

*hostache@lippmann.lu*

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

Christine Fosty

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

Laurent Pfister

*pfister@lippmann.lu*

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

Lucien Hoffmann

*hoffmann@lippmann.lu*

Centre de Recherche Public - Gabriel Lippmann

Luxembourg

**Keywords:** flood, risk management, SAR, ASCAT

**Abstract:** Over the last decade, there was a growing interest in the capabilities of Earth Observation (EO) data for improving the effectiveness of operational flood forecasting systems. Both hydrological processes understanding and flood risk management take benefit from the availability of spatially distributed remote sensing data, especially in ungauged basins. Actually, thanks to their high geographic coverage and the variety of existing sensors, satellites offer a large range of geo-information data that may be useful throughout all phases of flood risk management and may be helpful for the stakeholders in flood management for prevention, anticipation and crisis management.

The purpose of the work is to present different ways EO information can (i) help to anticipate inundation risk, (ii) contribute to the crisis management and (iii) assess and prevent flood damages. To demonstrate the possibility of enhanced prediction of flood risk through remote sensing observations, a systematic remote sensing-based monitoring of the state of saturation is performed. The information derived from the satellite has the potential to complement and/or replace field measurement networks for a better understanding of the runoff generation in the basins. Active microwave sensors can be used to assess the mean soil moisture; especially since their high imaging frequency is advantageous in operational applications. In this study, surface soil moisture estimates are derived from coarse-resolution (25 km) active microwave data of the ASCAT scatterometer instrument (onboard METOP), issued by EUMETSAT.

From the crisis management point of view, EO data gives detailed information about inundated areas. On SAR images of floods, water appears with very low backscatter compared to other objects. The extraction of the flooded areas from the radar data is performed by the means of a radiometric thresholding, which consists in extracting all image pixels having a backscatter lower than a given threshold. Finally, by fusing remote sensing-derived flood inundation maps with DEMs, water stage estimates can be inferred at the land-water interface.

Remote sensing data are systematically integrated into hydraulic and hydrologic flood forecasting models. In order to increase the accuracy and reliability of flood predictions, Particle Filter-based data assimilation is performed. The methodology consists of adjusting the soil reservoirs simulated by a hydrologic model and water levels simulated by hydrodynamic models, by comparing an ensemble of modeled soil wetness indices and water stages with those that are derived from remote sensing observations.

Finally, the technical post-crisis evaluation consists in performing a detailed update of the landuse changes with high-resolution optic data. All new construction can be detected with a recent image via change detection, thereby allowing a total damage assessment and highlighting areas characterized by deficits of protection against flooding.

This study uses the advantage of the variety of EO data and their ability to replace, complete or update the available state variables and basin characteristics such as hydro-meteorological parameters or landuse changes. Thus, a better knowledge of hydrological processes and basin characteristics allow and help the stakeholders for a better flood risk evaluation, protection and management.

## The Application of Multitemporal Imageries for Verification of Mud Flow Model in East Java, Indonesia

Gatot H Pramono

*gatot@bakosurtanal.go.id*

Indonesia

<http://www.bakosurtanal.go.id>

Dewayani Sutrisno

*dewayani@bakosurtanal.go.id*

Indonesia

<http://www.bakosurtanal.go.id>

**Keywords:** multitemporal image, disaster management, model verification

**Abstract:** The hot mud extrusion from the oil exploration in East Java, Indonesia since May 29, 2006 has impacted many aspects including social, culture, economy and transportation. About 1,200 hectare areas which were previously rice paddies, houses and industries have been inundated. A three dimensional model was developed to estimate the volume and affected areas for four years. The main model inputs are the mud debit rate, the rate of subsidence and the topographic conditions. The model accuracy needs to be obtained to ensure whether the simulation is capable of predicting the mud flow behavior. The purpose of this research is to assess the mud flow model accuracy by comparing the simulation results with the multitemporal satellite imageries. IKONOS images with an interval of about one month are used to compare the mud extent predicted by the model. The overlay analysis in Geographic Information Systems is employed to identify the differences. The results show that the model is, in general, able to predict the mud extent. However, a few discrepancies especially in previously paddy field areas in which the mud flow is hard to estimate.

## In-depth Spatial Assessment of Large Area Forest Cover Maps in Europe

For year 2000

Lucia M Seebach  
*lucia.seebach@jrc.ec.europa.eu*  
JRC - IES / University of Copenhagen  
Italy

Peter Strobl  
*peter.strobl@jrc.ec.europa.eu*  
JRC-IES

Jesus San-Miguel-Ayanz  
*jesus.san-miguel@jrc.ec.europa.eu*  
JRC-IES  
Italy

Pieter Kempeneers  
*pieter.kempeneers@jrc.ec.europa.eu*  
JRC-IES  
Italy

Fernando Sedano  
*fernando.sedano@jrc.ec.europa.eu*  
JRC-IES  
Italy

**Keywords:** forest cover maps, spatial agreement, proportion maps, Europe, comparative analysis

**Abstract:** Several studies have attempted to assess the spatial agreement and disagreement on forest and land cover map products, in particular of global land cover products. For Europe, spatial assessments are less common and focus rather on thematic similarities of the land cover classes. With the increasing number of available pan-European forest cover maps the choice of a given map for a particular application becomes difficult, in particular if quality assessments are not available. The purpose of the present study is to assess the available forest cover maps of Europe concerning their spatial agreement and to highlight potential advantages and limitations in their use at the European level. While previous spatial comparison studies were commonly performed on crisp land cover maps, we propose a novel approach for a spatial comparison of continuous maps (CLC2000: Corine Land Cover 2000, CEFM: Calibrated European Forest Map, FMAP2000: High resolution pan-European Forest Map) using two criteria: detail of thematic content within each map and local spatial agreement, in order to identify trends in differences in various biogeographic regions. Concerning their individual thematic content, CLC2000 showed a high underrepresentation of low forest proportions and an accumulation of non-forested areas, while the FMAP2000 preserved a high detail in forest spatial pattern. In the analysis of the spatial agreement, good agreement was found for CLC2000 and FMAP2000 within about 70

## Tree Species Classification based on the Analysis of Hyperspectral Remote Sensing Data

Petra M. Krahwinkler

*krahwinkler@mmi.rwth-aachen.de*

Institute of Man-Machine Interaction

Germany

<http://www.mmi.rwth-aachen.de/index.php?id=19L=1>

Jürgen Rossmann

*rossmann@mmi.rwth-aachen.de*

Institute of Man-Machine Interaction

Germany

<http://www.mmi.rwth-aachen.de>

**Keywords:** tree species classification, hyperspectral data, forest inventory, LIDAR, remote sensing

**Abstract:** Tree species classification is a prerequisite for forest inventory and therefore for sustainable forest management. Current algorithms aim for stand-wise classification and therefore high-resolution satellite data is sufficient. The wavelengths of the spectral bands of these sensors cannot be changed to meet the needs of tree species classification. Satellite data usually contain more spectral bands at a lower resolution compared to airborne images.

Local forest inventories at a small-scale level as well as biodiversity monitoring need single tree based classification to meet their demands on granularity, which implies the use of very high resolution airborne data. Furthermore, the spectral bands of airborne data might be influenced by adding another sensor to the setup.

To allow discrimination of several species based on spectral data a hyperspectral data set containing 235 bands in the near infrared and short wavelength infrared regions is analyzed. The hyperspectral data set is compared to RGB and CIR airborne images and LIDAR data to find the wavelengths with the highest information gain and to find criteria for the separation of different tree species. Special attention is given to difference and ratio bands of the available data as they can provide better discrimination criteria than the spectral bands themselves.

The extracted information is used to develop a new highly specialized algorithm for tree species classification based on image segments. Furthermore a measure of reliability is implemented to denote critical areas where lighting changes, shadows and other effects might compromise the quality of the classification. The results obtained at a test site of about 300km<sup>2</sup> are presented in the final paper.

The resulting tree species map is a key requisite to forest inventory based on remote sensing data and can also be used to support single tree delineation.

## Method for the Estimation of Continuous Forest Variables on Pan European Forest and National Level

Mathias Schardt

*mathias.schardt@joanneum.at*

Joanneum Research, Institute of Digital Image Processing  
Austria

Martin Steinegger

*martin.steinegger@joanneum.at*

Joanneum Research, Institute of Digital Image Processing  
Austria

Heinz Gallaun

*heinz.gallaun@joanneum.at*

Joanneum Research, Institute of Digital Image Processing  
Austria

**Abstract:** Comment: Submitted to the GEOLAND Session

European forests play a key role in aspects related to the protection of European ecosystems, the sustainable use of natural resources, carbon sequestration, climate change, and biodiversity. The implementation of European Union environmental policies therefore requires pan European information on status and distribution of forests. Access to harmonized maps and GIS – data on forest parameters however is often difficult, as this information is frequently scattered in remote databases, underlies different nomenclatures and is covering different scales. One major challenge therefore is the harmonization of information on European forests.

The forest task within the GMES project GEOLAND II is therefore aiming at the development of methods and processing lines that allow for effective harmonized assessment of key forest parameters most relevant for the implementations of European forest policies. Main forest parameters the forest team is dealing with are forest type and crown closure as these variables provide basic information for the estimation of biomass, timber volume, carbon stock as well as forest disturbances. An essential challenge concerning the method developments is resulting from the requirement that this information should be suitable both for pan European and national users. Furthermore, it should be noted that forest area definitions differ not only between different countries but also depend on the applications and the processes they are used for.

The methods developed therefore produce continuous information on crown closure and forest type that can be stratified into different categories defined by the different users according to their specific requirements. Regression models satisfy this requirement and are therefore applied for the estimation of the requested forest parameters. Following this approach the classification of forest and non forest area is performed by logistic regression. Logistic regression is a variation of ordinary regression which is used when the dependent (response) variable is a dichotomous variable and the independent (input) variables are continuous, categorical, or both. The logistic regression delivers for each pixel a probability of occurrence of forest from which the final binary forest map is derived. The continuous estimation of the proportion of forest types (share of coniferous and deciduous) and the percentages of crown closure is based on linear regression models describing the relationship between grey values in different bands found in the satellite image and the continuous forest variables. As a result, for each pixel the proportion of conifers and the crown cover is estimated that can later be summarized into boundaries defined by users by means of thresholding and aggregation procedures, whereas the number of classes to be derived should be oriented on the quality of the regression functions.

The method described is applied on alpine test site consisting of different forest types and crown closure classes. Accuracy assessment is performed by using 95

## Classification of TerraSAR-X Imagery for the Characterization of Amazon Tropical Forests

João Roberto dos Santos

*jroberto@dsr.inpe.br*

National Institute for Space Research - INPE  
Brazil

José Claudio Mura

National Institute for Space Research - INPE  
Brazil

Hermann Johann Heinrich Kux

National Institute for Space Research - INPE  
Brazil

Cesar Edwin Garcia

National Institute for Space Research - INPE  
Brazil

Steffen Kuntz

Infoterra GmbH  
Germany

Irving Foster Brown

Woods Hole Research Center  
United States

Nara Vidal Pantoja

Institute for the Environment and Renewable Natural Resources - IBAMA/Acre,  
Brazil

**Keywords:** monitoring, tropical forest, image processing, SAR data, land cover

**Abstract:** The objective of this study is to analyze the potential of TERRA SAR-X dual images, on the StripMap mode, for classification of forest cover and of land use classes resulting from human activities. The area under study is located in the portions of SW Brazilian Amazon region, Acre State. The Single Look Complex images of TERRA SAR-X (ascending mode, slant range and azimuth resolution of 1m and 6m, respectively) in HH and VV polarizations, were processed in accordance with the following methodological steps: (a) generation of the covariance matrix (windows of 3x5 pixels); (b) application of the Enhanced Lee filter to reduce the speckle noise; (c) targets decomposition technique based on the Cloude and Pottier theorem; (d) thematic classification by algorithm MLC + ICM (Maximum Likelihood Classifier + Iterated Conditional Modes); (e) assessment of classification accuracy by Kappa statistics. This approach has shown the potential of TERRA SAR-X images for the discrimination of primary forest, degraded forest, pastures and agricultural areas/bare soil. The best classification performance was derived from the combination of the amplitude image (resulting from covariance matrix) and the entropy image generated from the decomposition of targets. The overall classification accuracy was 76

## Estimation of Forest Cover Evapotranspiration in Algeria with Remotely- sensed Data

Forest evapotranspiration

Zahira Souidi  
*souidi.z@gmail.com*  
Docteur  
Algeria

Abdelrahmane Hamimed  
Docteur

Khalladi Mederbal  
Professeur

**Keywords:** Evapotranspiration, remote sensing, SEBAL, Landsat-7 ETM+, forest cover, Algeria.

**Abstract:** The present study had a main purpose is to establish the possibility for mapping the actual evapotranspiration (aET) of a forest cover using remote sensing data, for monitoring water state vegetation in the perspective of forest fire risk prevention in Algeria. The methodology relied on approach SEBAL (Surface Energy Balance Algorithm for Land) to solve the energy balance equation. The study area corresponds at two near forests in west Algerian region. The parameters in input, involves the NDVI (Normalised Difference Vegetation Index), the surface temperature and the albedo. The data encompassed by seven spectral bands of satellite Landsat-7 ETM+ and some ground data. To assess the sensible heat flux which represents the delicate point in the resolution of the energy balance equation, we used the Monin–Obukhov similarity hypothesis which consider that the soil and vegetation as a only convective boundary layer. We offered then the possibility to estimate the sensible heat flux and consequently dissect the energy balance equation to assess the latent heat flux. Finally, evapotranspiration and different moisture indicators (evaporative fraction, Priestley and Taylor parameter and the Bulk surface resistance to evaporation) were calculated. These moisture indicators facilitate the quantitative diagnosis of moisture stress status in pixel basis. The authors tried to validate an aET estimation method using remote sensing in soil measures. The values obtained by SEBAL approach were compared with other methods of aET calculated and with field measurements. These comparisons had good agreement and shown that the approach SEBAL is sufficiently accurate to be used for monitoring of the water budget of forest cover characterized by heterogeneous land surface and difficult access. This new approach has demonstrated its importance in showing the relative spatial differences in evaporation under data scarce conditions and has served as a source of ancillary information in the process of actual evapotranspiration estimation using conventional methods. This method has important applications in future for moisture stress studies in Africa where meteorological data is extremely scarce and for fire prevention.

## Digital Photogrammetric Survey in the National Forest Inventory (NFI) in Czech Republic

Filip Hajek

*hajek.filip@uhul.cz*

Forest Management Institute (UHUL), Brandys nad labem  
Czech Republic

Radim Adolt

*adolt.radim@uhul.cz*

Forest Management Institute (UHUL), Brandys nad labem  
Czech Republic

**Keywords:** National Forest Inventory (NFI), sample plot survey, aerial stereo-image interpretation, UltraCam X, ENFIN

**Abstract:** The Czech National Forest Inventory is a sample survey executed by the Forest Management Institute Brandýs nad Labem (FMI) since 2001. As typical for most NFIs, a large number of tree, stand and site parameters is assessed using data acquired on terrestrial plots. In the following survey period (starting in 2011) a sophisticated utilization of digital photogrammetry presents the most significant improvement in terms of expected accuracy. When compared to terrestrial survey, the photogrammetric assessment will take part on a four times denser sample grid, with a limited set of acquired variables.

The NFI stereo-image interpretation will ensure following benefits: [U+FOA0] increased precision of point estimates thanks to the sophisticated usage of obtained auxiliary information (double sampling methods, poststratification) [U+FOA0] an effective provision of parameters for landuse/landcover classes (landscape structural characteristics, scattered woody vegetation, site diversity measures etc., ) without dedicated field survey) [U+FOA0] effective and reliable identification of sample locations where terrestrial assessment will take place [U+FOA0] excellent foundation for navigation of field crew to identified sample locations [U+FOA0] preliminary forest (other wooded land) borderline vectorisation, reducing the field work in terms of an effective post-hoc GIS driven edge effects compensation

The paper aims to describe the photogrammetric survey methodology as implemented within a custom extension of PhoTopoL software. This utility called PHONIL enables a fully digital stereo-interpretation workflow. Its fundamental task is to preclassify sample locations into several landuse/landcover categories. Additionally on plots classified as forest, characteristics such as stand development phase, tree species composition and crown closure are assessed. Furthermore, on a limited number of plots (2 x 2 km grid) an interpretation of landscape elements within a 500m long transect is performed. These elements include boundaries of landuse/landcover classes, alone standing trees and their small groups, woody vegetation stands smaller than 0.5ha (minimum size for forest, OWL and OLWTC according to FAO definitions), linear woody vegetation, field baulks, small waterbodies, etc. The obtained statistics on scattered woody vegetation and landscape diversity widen the traditional focus of national forest inventories toward a more complex environmental survey. This can be achieved by relatively small additional cost with an intensive reutilization of statistical-survey experience and technological facilities present and developed by local NFI responsible organizations.

## Deforestation Analysis by Multi-temporal LANDSAT Imagery in the Bulisa Region – Uganda

Eva S. Malinverni

*e.s.malinverni@univpm.it*

DARDUS - UNIVERSITA' POLITECNICA MARCHE

<http://www.univpm.it>

**Keywords:** Remote sensing, multi-temporal classification, Landsat, deforestation, open source software

**Abstract:** The paper describes methods and results of a multi-temporal Landsat imagery analysis for the 1986, 1990 and 2002 in the Bulisa region of Uganda, surrounding the Nilo river at the north of the Albert Lake. Taking the opportunity to have free and unrestricted access to the Landsat data and using Open Source software we processed the remote sensing data in ILWIS 3.4 and organized the results in the open GIS gvSIG putting in evidence the vegetation changes in the study area. Selecting different spectral bands related to the Landsat sensors MSS, TM and ETM+, resampling them to the same ground resolution (28.5 meters) and applying different vegetation and water indices (NDVI, GNDVI, NDWI) and some ratio images a significant land cover analysis came out. To perform the comparison between the multi-temporal results we applied an unsupervised clustering, grouping the data in few representative classes. Following a statistical analysis and the overlay mapping into the GIS produced a series of thematic maps to display the general and local trend of the deforestation in the two decades. The results of the research, in term of deforestation percentage, are in trend with the reports provided by some international organizations (i.e. FAO “Global Resources Assessment”, 2005) related to Uganda and Africa sub-continental. Not forgetting that the tropical forests are important for the biological diversity, the habitat and in the reduction of the greenhouse gases, the remote sensing analysis supported now by the open source environment, data and tools, could be the winner key to take under control these areas with a continuous monitoring.

## Integration of Remote Sensing, GIS and Terrestrial Forest Inventory in Estimation of Acacia Senegal Trees' Parameters

Application of remote sensing in forest inventory

Hassan Elonur Adam  
*hassanadam@hotmail.com*

Elmar Csaplovics

**Keywords:** Remote sensing, GIS, regression, forest inventory, Acacia senegal

**Abstract:** Remote sensing is the technique available for estimating forest biophysical information properties related to forest stand parameters over large areas. The purpose of this study is to explore the relationship between remotely sensed data and forest parameters of Acacia senegal trees in gum arabic belt. The study was conducted in Elhemmera plantation forest in Kordofan State in Sudan. Forest parameters (volume, basal area, tree density, tree height and tree diameter) were collected from (47) circular sample plots located in systematic grid using GPS. The remotely sensed data were integrated in a Geographical Information System (GIS), to extract the pixel values from the satellite images, using two different sources (2x2 and 3x3 pixel windows) from TERRA-ASTER image acquired in 2007. Five regression equations (linear, logarithmic, polynomial-quadratic, polynomial-cubic, power and exponential) and factor analysis were used to construct relationships between the measured forest parameters and the reflectance of green, red and infra-red bands. Several model types and attribute combinations were tested and compared to construct relationships between the measured forest parameters and the satellite data. The preliminary results on the regression analysis have showed significant relation between the satellite data and Acacia senegal parameters. The volume, basal area and tree density are positively related with the remotely sensed data, while tree height and tree diameters are negatively related to the bands. The relationship between pixel values of band 3 (NIR) and the volume of Acacia senegal is significant ( $R^2 = 0.57$ ) with the polynomial-quadratic regression. While the basal area has a significant relationship with band 1 (Blue) ( $R^2 = 0.50$ ) in polynomial-cubic regression.

## Analysis of the Dynamics of Vegetation Parameters LAI, EVI and FPAR for Forest Areas using MODIS Data

Vanya Naydenova  
*vnaydenova@gmail.com*  
Bulgaria

Petar Dimitrov  
*petarkirilov@mail.bg*  
Bulgaria

Georgi Jelev  
*gjelev@abv.bg*  
Bulgaria

Eugenia Roumenina  
*roumenina@space.bas.bg*  
Bulgaria

**Keywords:** vegetation indexes, MODIS data, forest fragmentation

**Abstract:** Vegetation is a dynamic characteristic of the ecosystems and responds to the changes in climatic, hydrologic and edaphic conditions in multiyear aspect. The natural vegetation on the territory of Bulgaria is represented mainly by forest canopy with prevalence of deciduous and coniferous species. The observations on how the forest reacts to the variations in the environmental conditions are limited because of their local characteristics and the lack of evident indexes. In this respect the remotely measured biophysical parameters such as fPAR and LAI, as well as the vegetation indexes like EVI can characterized the vegetation state on large territories in comparable way and in time. The purpose of the paper is to present the results from the conducted study of the dynamics of the vegetation parameters LAI, EVI and fPAR for deciduous and coniferous forest areas on the territory of Rhodopi Mountain, Bulgaria, using MODIS data for 10-year period (2000-2009). The study area is situated on the territory of Bulgaria and in south it continues in Greece. The predominant part of the forest vegetation for the east part of Phoropi Mountain is deciduous, while the West Rhodopi consists of coniferous and deciduous species. For the present study 8-day operationally produced from MODerate Resolution Imaging Spectroradiometer (MODIS) data for the vegetation indexes EVI, LAI and fPAR are used with spatial resolution 1 km. The analysis is conducted for coniferous and deciduous forest by choosing 2 test sites for each forest type. For the test sites' determination, an assessment of the forest fragmentation of the territory is made and 6 categories are defined – interior, patch, transitional, edge, perforated and undetermined. The assessment of the forest fragmentation is carried out using land cover data from the operational land cover product of the spectroradiometer MODIS For the purpose of the analysis the land cover classes are aggregated to 2 land cover type – forest and non-forest areas. For the analysis of the dynamics of the vegetation parameters, test sites from category “interior” forests were chosen, for which  $P_f = 1.0$  (i.e. all of the pixels surrounding the center pixel are forest). The change of the fPAR, LAI and EVI values is studied in the course of 10 years (2000-2009) for a certain moment of the vegetation period the mid of August. The values of the three indexes from the relevant MODIS products were extracted for each of the four test sites using only the pixels with good quality described in the metadata. The obtained results for the two test sites from each forest vegetation type were compared and the relation between these three indexes was explained. The results can help revealing whether and in such way the forest ecosystems in the study area respond to the changing environmental conditions, and as well as the way these changes are presented in the vegetation parameters.

## The Use of LIDAR Technology for Sustainable Forest Management in Glen Affric

Chue Poh Tan  
*chuepoh@yahoo.com*  
United Kingdom

Iain Woodhouse  
Dr.  
United Kingdom

Juan Suarez  
United Kingdom

Colin Edwards  
Dr.  
United Kingdom

Mike Perks  
Dr.  
United Kingdom

**Keywords:** LIDAR, REMOTE SENSING, FOREST

**Abstract:** As far as global climate change is concerned, it is crucial to measure and understand the forest ecosystems by characterizing the forest structures. Therefore, employing remote sensing technology in this study allows us to assess and monitor vast area of forests. In this paper, the estimation of canopy cover and height across the forests in Glen Affric, North West Highlands of Scotland is presented. The study area consists of both plantation and semi-natural forest which covers extensive and diverse woodlands of native woodland with varied topography. The utilization of airborne LIDAR (Light Detection and Ranging) technology to characterize the forest structure has made the estimation of the foliage cover and height possible. It has become a prominent tool to collect not only accurate high-resolution three-dimensional data, but also able to demonstrate detailed forest profiles. Upon examining and retrieving the signals from the LIDAR sensor, the analysis of the canopy surface and height of the forest cover is conducted to highlight the useful information carried by the LIDAR data. Besides, the estimation of the canopy closure based on the different height breaks has been carried out. The results offer a great potential for conservation and management of Glen Affric invaluable forest wealth.

## Aster Data Utilization to Gain Information about Density in Forest

Maryam Daghestani  
*maryamdaghestani@yahoo.com*  
student  
Iran, Islamic Republic of

**Keywords:** density, satellite data, forest

**Abstract:** Forest managers require accurate maps of forest type and structure, also forest density is an important factor for determining stand type and quality. In recent years satellite remote sensing, due to number of inherent characters that the satellite datas possess, such as repeatability, availability of data in inaccessible areas, digital nature and low cost of it, has emerged as one of the powerfull technology for generating of spatial informations. This study investigates the potential of remote sensing system to estimate forest density in Caspian forest. For this reason we gathered a data set consisting of 21 field plots. Inter plots, number of trees(number of tree per hectar) counted and recorded. Geometric correction were performed up to orthorectification level with offline transformation and resampeling of nearest neighbour. Digital numbers maching with plots from principal and synthetic bands( produced from ratio and principal component) were extracted and used in regression analysis test. The results indicated that number of trees per hectar( forest density) strongly related to reflectance with correlation coefficient of -74.4

## Monitoring the Dynamics of Vegetation Cover and Rain Water Use Efficiency (WUE) for Integrated Management of the Sahelian Savanna

Benoit Toulouse  
*benoit.toulouse@univ-paris-diderot.fr*  
University Paris 7  
France

bernard Lacaze  
*lacaze.bernard@gmail.com*

**Keywords:** Remote Sensing, NDVI, rainfall, savannah, Sahel, agroforestry

**Abstract:** Analysis of satellite images at different spatial and temporal resolutions allow to map the dynamics of the earth for thirty years, and particularly the savannah. These maps show a clear trend in the revegetalization of areas previously degraded since the late 1990s due to the relative increase in rainfall across the Sahel. But, in some areas more densely populated, the vegetation cover tends to decrease, probably under the combined pressure of agriculture, pastoralism, and abuse of wood energy. We propose here to use the Sahel Product NDVI time series derived from MODIS imagery (250m) and TRMM and CRU rainfall estimation, and some region of interest of medium resolution images ASTER and Landsat, to perform a simultaneous monitoring of chlorophyll activity and rain water use efficiency (WUE) by plants. This approach will allow in the future analyzing the temporal variability of the condition of vegetation across the Sahel. The results, validated from region of interest (Ferlo in Senegal Gourma in Mali, east of Niamey, Niger), show the use of images to medium and low resolution to monitoring in time and geographical space, areas subjected to high rainfall variability. This high variability has a major impact on livestock-environment interactions in an area where rural societies are still very dependent on natural resources.

## Considering Uncertainty in Archaeological Predictive Modelling: A Case Study in Southern Rhineland-Palatinate (Germany)

Silke Boos

*boos@geoinform.fh-mainz.de*

Institute for Spatial Information and Surveying Technology (i3mainz), Mainz University of Applied Sciences  
Germany

Sabine Hornung

*hornusa@uni-mainz.de*

Institute for Pre- and Protohistory, Mainz University  
Germany

Hartmut Mueller

*mueller@geoinform.fh-mainz.de*

Institute for Spatial Information and Surveying Technology (i3mainz), Mainz University of Applied Sciences  
Germany

**Keywords:** Cultural Heritage Management, Predictive site modeling

**Abstract:** Most archaeological predictive models- may these models have been developed by use of inductive or deductive methodologies- have a limited explanatory power because fuzziness of data and uncertainty in knowledge about human behaviour and natural processes are hardly ever considered. One approach to cope with such uncertainties is utilization of methods, which base on approaches of the probability theory like Bayes Theorem or Dempster-Shafer-Theory.

In our case study we analyze an area of 50 km<sup>2</sup> in southern Rhineland Palatinate (Germany) near the celtic oppidum “Hunnenring” by use of Dempster-Shafer’s theory of evidence for predicting a spatial distribution of archaeological site probabilities. This technique incorporates uncertainty by combining various weights of evidence for defined variables and enable in that way estimating the probability for supporting a specific hypothesis (in our case the hypothesis presence or absence of a site). In the field of Cultural Heritage Management (CHM) this approach seems appropriate, since various assumptions base upon untested hypothesis and the specification of all influencing factors for settlement processes are impossible to identify.

Selection of variables for our model relies both on assumptions about settlement patterns and on statistically tested relationships between known archaeological sites and environmental factors. The modelling process is conducted in a Geographic Information System (GIS) by generating raster-based likelihood surfaces with a cell resolution of 10 m for the six selected variables distance to water, distance to road network, distance to graves, slope, landforms and geology. The single likelihood surfaces are aggregated to a final weight of evidence surface, which ascertains every single cell a value of likelihood for being a site or a non-site. Finally the result is tested against a database of known archaeological sites for evaluating the gain of the model. Due to high potential for soil erosion processes in the low mountain range situation in our area of study a model was developed which allocates erosion and deposition zones. In combination with the predictive model this enables a more differentiated estimation, especially with regard to the assumed conservation of potential archaeological remains.

## Application of Close Range Photogrammetry In San Agustin (Huila), Colombia, World Historical Heritage.

Application of Close Range Photogrammetry In San Agustin (Huila), Colombia

William Barragan  
wbarraganz@udistrital.edu.co  
professor  
<http://www.udistrital.edu.co>

**Keywords:** Close Range Photogrammetry, Heritage Conservation, Virtual 3D model, Archeology, Digital image

**Abstract:** The development of the Digital and Analytic Photogrammetry has facilitated the utilization of not metric cameras as devices of images acquisition in Photogrammetry projects. This work shows an application of close range Photogrammetry in the geometric documentation of Statue "Triangular Face" in the archaeological park of San Agustin (Huila), Colombia, utilizing a digital camera of 5 Mega Pixels.

The project was developed in 3 phases: 1. Calibration of the digital camera (reconstruction of the internal geometry of the camera). 2. Development of a pilot test with a statue of similar geometry to the one in San Agustin; in order to determine the efficacy of the proposed methodology. 3. Field work and restitution of the generated models, to integrate the Digital Model of Land and the Virtual Model of the Statue.

The work was doing in the main archaeological park in Colombia (San Agustin). International scientific community recognizes its importance highlighting the Augustinian Statuary as the most important one of the South American Pre-hispanic world, and by his ancient culture, even greater than the Aztec or Inca's cultures. Although several theories of diverse anthropologists present discrepancies on the same town and on some aspects of chronology, Carbon-14 tests registers the oldest Augustinian antecedents further back to the year 3,000 B.C. what would represent antiquity of about five thousand years. Almost six hundred megaliths, some of them, five meters height and carefully carved with anthropomorphous motives have been found in a nearby region of approximately 500 square Kilometers.

## Probability Modelling of Archaeological Sites with the Use of Geoinformation

Athanasios K Moysiadis  
*moysiadis@uth.gr*  
University of Thessaly  
Greece  
<http://www.prd.uth.gr>

Konstantinos G Perakis  
*perakis@uth.gr*  
University of Thessaly  
Greece  
<http://www.prd.uth.gr>

**Keywords:** geoinformation, archaeology, probability map, ignorance

**Abstract:** The exploration of archaeological sites is a laborious and time consuming process. The use of Geoinformation offers great potential for archaeological research and predictive modelling facilitates the way of finding new archaeological sites. Geospatial data such as aerial photographs, satellite imagery, maps and ground truth data in raster and vector format have to be compatible in order to be incorporated in a digital Cartographic Geographic Database. Satellite data need to be corrected both radiometrically and geometrically and geo-referenced along with the other data in a common geographical coordinate system. Predictive modelling is a dynamic process that offers new information as soon as new data are available. Probability maps are made showing the probability of existence of archaeological sites based on the characteristics of each data. Many sources of heterogeneous information related indirectly to hypothesis are aggregated to predict the probability of the existence of archaeological sites. The probability of ignorance is taken into consideration during the use of the orthogonal sum operation to compose by couple all the existing probability maps. Consequently, the generation and update of a spatial model, based on probability maps, will form the database of existing archaeological sites and of those that have not been explored yet.

## Sediment Fingerprinting and Spatial Analysis of Landscape Dynamics using Remote Sensing Data in the Çanaklı Ovası, SW Turkey

Véronique De Laet  
*Veronique.DeLaet@ees.kuleuven.be*  
K.U.Leuven  
Belgium

G. Verstraeten  
K.U.Leuven  
Belgium

E. Paulissen  
K.U.Leuven  
Belgium

K D'Haen  
K.U.Leuven  
Belgium

B. Duser  
K.U.Leuven  
Belgium

M. Waelkens  
K.U.Leuven  
Belgium

**Keywords:** remote sensing, sediment fingerprinting, geochemistry, Turkey

**Abstract:** The palaeo-environment is not only time-dependent, but has also an important spatial dimension as land use on a given territory during a specific period is function of physical characteristics as well as time-dependent socio-economic values. Land use changes have a major impact on the erosion and deposition of sediments in the catchment. Spatial analyses of landscape dynamics therefore are crucial to understand the possible influence of changing settlement patterns on the physical landscape. To contribute to this spatial dimension, novel techniques of interpretation of very high (Ikonos and Quickbird) and medium (Aster) spatial resolution satellite images are combined with resistivity measurements and geochemical analysis of soil samples. Focus is on the Çanaklı Ovası, an intra-mountain basin in the surroundings of the ancient town of Sagalassos in the Western Taurus Mountains, 100 km north of Antalya, SW Turkey. The Çanaklı Ovası was selected since different colour zones could be identified in the imagery, which probably have a sedimentological or mineralogical origin. For this research about 21 cores and 31 surface samples have been taken along 5 profiles crossing different colour zones.

Preliminary interpretation of remote sensing data in combination with resistivity measurements and geochemical analysis shows that the colour variations in the imagery are most likely related to the development of fans of which the material is originating from different lithological units.

## Remote Sensing and GIS in Bulgarian Archaeology

Stefan Kirilov Stamenov  
*stamenovstefan@gmail.com*  
Bulgaria

**Keywords:** remote sensing, GIS, geophysical prospection, archaeology

**Abstract:** In Bulgarian archaeology remote sensing and GIS are applied for discovery, preliminary investigation, mapping and visualizing archaeological sites. The purpose of this paper is to represent their usage in researching archaeological sites in Bulgaria and the achieved results, from the beginning of their application till the current projects and ideas.

Remote sensing, such as aerial photos, were used for the survey and mapping of the ancient Bulgarian capitals Pliska and Preslav, and the medieval fortresses of Kaliakra, Cherven, Hisaria and Krakra during the 60s and 70s of the past century. In 1976 aerial photos were made to reveal the urban plan of the roman town of Ratiaria, located south-west of the town of Vidin, at the Danube river coast.

At the same period, the usage of geophysical prospecting of archaeological sites began. In the 60s, several investigations of tumuli in the region around the town of Kazanluk were made using geomagnetic and electroresistive methods. In the 70s, a team from the Institute of Mining and Geology (today University of Mining and Geology) researched tumuli of the Sveshtari necropolis. By geophysical prospection in 1982 was discovered the tumulus Ginina mogila (The Sveshtari Tumulus), near the village of Sveshtari. In 1981 as part of the Laboratory of Geotechnics at the Bulgarian Academy of Sciences (BAS) was created Group for instrumental methods in Geotechnics and Archaeology. Later, part of its team was transferred to the National Institute of Archaeology and Museum-BAS, where at the 90s a Department of Interdisciplinary Research was created.

At the archaeological reserve of Sboryanovo the geophysical prospection investigations have been conducted uninterruptedly since 1983. At the Emporium Pistiros, near the village of Vetren, Pazardjik district, such investigations have been conducted for about ten years, and at the Kazanluk region - since 1992.

In the last several years, geographic information system found its place in Bulgarian archaeology as an instrument for localization and visualization of the archaeological sites and structures located on the terrain. A project entitled Information technologies and the archaeological heritage of Bulgaria is accomplished by the National Institute of Archaeology and Museum-BAS. GIS technologies make possible a much better representation of archaeological sites, structures and artifacts and their chronological distinction on an electronic map or atlas.

The remote sensing and geophysical prospection are essential methods for a better and, more important, nondestructive research of the archaeological sites. Combined with GIS technologies they would reveal more completely the contextual specifics of the archaeological sites and their relations with the relief and landscape, and derive new information about the features of the ancient cultures.

## A Medieval Town (Szamotuły) as a Testing Area for Non-invasive Methods – GPR MALA ProEx

Andrzej Kijowski

*kij@amu.edu.pl*

Adam Mickiewicz University Poznan  
Poland

Marcin Słowik

*slowikgeo@poczta.onet.pl*

Adam Mickiewicz University Poznan

Wlodek M. Rączkowski

*wlodekra@amu.edu.pl*

Adam Mickiewicz University Poznan  
Poland

**Keywords:** GPR, medieval town, integration of methods, non-invasive methods

**Abstract:** In 2006 the remains of a medieval (13th /14th century) town (Szamotuły), visible as cropmarks, were uncovered during aerial reconnaissance. This unique discovery created a lot of interest amongst archaeologists and historians. In order to preserve it, the site was listed as a monument and is under full legal protection. The Regional Conservator of Monuments in Poznan has decided that archaeological excavations cannot be carried out on this site. For many archaeologists in Poland, who equate archaeology with excavations, this situation is unacceptable, as it will not be possible to acquire information about the town.

The site therefore sets a challenge for non-invasive methods, how to gain as precise information as possible without digging a spade into the ground. Apart from the interpretation of aerial photographs which has already been completed (such a reconnaissance is carried out annually and provides fresh information) magnetic and electrical resistivity prospecting have been performed. Both methods have provided more information about the spatial structure of the town.

In 2009 two pilot tests using GPR MALA ProEx were carried out. The first test covered two profiles cutting across different zones of the town (200 m and 80 m). The aim of the second test was to acquire a tomographic image. All together 40 measurement profiles (60 x 20 m) were performed. The distance between specific measurement lines was 1.5 m. 100 MHz and 250 MHz antennas were used in both tests. The images recorded in these tests were adapted using the ReflexW 5.0 programme. A spatial layout of the measured profiles was achieved through 3D module visualisation.

It is possible to adjust the depth scale of the echograms by locating a well-defined reflection, the cause of which is an object lying at a known depth. The axis of ordinates shows the time at which this reflection is recorded. On this basis it is possible to calculate the speed of electromagnetic waves at the site being measured.

The initial results of the GPR survey indicate certain interpretation problems, however, at the same time they can also inspire critical reflection on images acquired earlier. The integration of the results from various non-invasive methods can lead to further information about a deeper knowledge of what happened to the town, and also the potential and limitations of non-invasive methods.

## Documentation of the Abandoned Town La Ciudad Perdida In Peru Combining of VHR Satellite Data and Terrestrial Measurement

Abstract

Karel Pavelka

*pavelka@fsv.cvut.cz*

Laboratory of Remote Sensing, Laboratory of Photogrammetry

<http://lfgm.fsv.cvut.cz>

Michal Bukovinský

*michal.bukovinsky@fsv.cvut.cz*

Laboratory of Photogrammetry

Czech Republic

<http://gama.fsv.cvut.cz>

Jirina Svatuskova

*jirina.svatuskova@fsv.cvut.cz*

Laboratory of Photogrammetry

Czech Republic

<http://gama.fsv.cvut.cz>

**Keywords:** VHR data, cultural heritage, satellite image, archaeology, La Ciudad Perdida

**Abstract:** The abandoned town near Huayuri (La Ciudad Perdida de Huayuri in Spain) is situated in Peru near Nasca plateau in the Ica region of Santa Cruz district in Palpa province. The valley is oriented northeast aslant from the Santa Cruz River, at Huayuri village. It is possible to get there from Palpa to the West by the transatlantic highway or from Ica to the East (approximately an hour by a car). The Abandoned town is a pre-Columbian town in Peru in the late medieval period. Its period is dated sometimes between years 1000 and 1450 but it is very hard to say its exact beginning and the end. It is assumed that it starts at the Huari culture decline and finish with the Inca culture coming. But the elements of this period had been appearing at some regions only for a short time, though at other regions for a much longer time. There are some indicators that this district had been inhabited also during the Inca's reign.

The town remains spread in the valley at about 15 hectares area. There are remains of building walls in the bottom of the valley and the slopes around. Buildings are close to each other with a very small space between them that is typical for this architecture. The building structure is only for living in them; there were found no building and objects remains which should have other purposes - such as religious or economical for example.

At present there is a very few information about the Abandoned town its inhabitants and their customs. The most information come from natives and partly from the previous research made in the years 1975 and 1984. There had been also the project PAHUAY - proyecto archeologico de Huayuri since 2002 to 2005. The project was done in cooperation with University of Pittsburgh and Peruvian universities and colleges and graduate student Viviana Siveroni as a project leader. The main goal of the project was to understand a process and conditions for "nucleation" of population - they used to live mainly in small settlements before. There is almost no information on the results of the project.

Working with the photographs and the satellite images of the area creates the map of the abandoned town. The photos were taken during the sixth expedition Nasca/Peru 2008. The expedition was organized with cooperation between HTW Dresden and CTU in Prague. The GPS measurement in the area of the Nasca plateau for the following satellite images corrections was the main purpose of the expedition. During the expedition were also taken photographs in the area of the abandoned

town near Huayuri and other photographs and measurements of next historical objects and sites in Palpa and Nasca region. The photographs were made by a professional digital camera Canon EOS 20D. Satellite data were made on demand (new data especially for this project) by the GeoEye-1 satellite with spatial resolution 0,5 m in panchromatic and 1,64m resolution in multispectral imagery. The photos were used by means the intersection photogrammetry. The Photomodeler software made the model of a part of the abandoned town uncovered by a previous archaeological research. This model was placed into the area with the help of the GPS points measured during the expedition. An important part of the area was evaluated from adjusted and processed satellite data transformed by using of measured GPS points. The final model of the abandoned town near Huayuri is placed into Peruvian coordinate system PSAD56. A new prepared DEM from Terra/Aster stereo satellite images was used for satellite data processing with resolution of about 15m. Two scenes of Aster data were used from Pacific Ocean to Cordilleras (about 60x120km, resolution 15m). Necessary control points were localised on maps, photos or image sketches made from satellite images; these points were measured by Trimble GeoExplorer XP GPS instrument. The base station and rover configuration was used with post processing accuracy of about 50-100cm in position. The quality of this DEM is not very high, but sufficient for creating of hypsography a orthogonalising of VHR data (there are no better DEM for using). The results of the work: [the map the Abandoned town near Huayuri in Peru](#) [the 3d area view in vml format](#) [video demonstration of flying over the 3D model](#) [the kml file for GoogleEarth](#)

## Airborne Full-waveform Laser Scanning, Aerial Photos and Satellite Images to Detect and Map Archaeological Remains: Monteserico Case Study

Rosa Lasaponara  
*lasaponara@imaa.cnr.it*  
CNR-IMAA, Tito Scalo (PZ)  
Italy

R. Coluzzi  
*coluzzi@imaa.cnr.it*  
CNR-IMAA, Tito Scalo (PZ)  
Italy

A. Guariglia  
*a.guariglia@geocart.net*  
Geocart srl, Potenza  
Italy

B. N. Masini  
*b.masini@ibam.cnr.it*  
CNR-IBAM, Tito Scalo (PZ)  
Italy

**Abstract:** This paper focuses on the detection and spatial characterization of microtopographic reliefs linked to archaeological and geomorphological features using Airborne Laser Scanning (ALS). ALS is an optical measurement technique for obtaining high-precision information about the Earth's surface including basic terrain mapping, such as DTM (Digital Terrain Model) and DSM (Digital Surface Model). LiDAR data can provide detailed information useful for feature extraction, but the identification of microtopographic reliefs is still a challenge especially for vegetated and highly sloped areas.

The investigation was carried out for an archaeological area (Monte Irsi in the Basilicata Region) characterized by dense herbaceous cover and complex topographical and morphological features, which make air/space prospection very difficult. Results from our investigations pointed out that the ALS is a valuable data source to detect and map micro-topographic reliefs linked both to cultural and geomorphological features also covered by dense vegetation.

## The Use of Interferometric Synthetic Aperture Radar (InSAR) Cultural Heritage Preservation

Diane L. Evans  
*diane.l.evans@jpl.nasa.gov*  
JPL  
United States

Paul A Rosen  
JPL  
United States

Tom G. Farr

**Keywords:** InSAR, Cultural Preservation

### **Abstract:**

The use of remote sensing data for archeology and cultural resource management is an emerging field. In particular, the use of both polarimetric and interferometric Synthetic Aperture Radar (InSAR) data has increased substantially over the last decade. Many studies in the recent literature point to the potential of developing mitigation strategies for archeological and cultural heritage sites based on systematically acquired InSAR data. Topographic changes observed with InSAR can be used to identify areas vulnerable to landslides, ground subsidence, earthquakes and volcanic eruptions and inform mitigation strategies in response to these threats. Both spaceborne and airborne SAR data acquired over the Angkor area in Cambodia have been used to elucidate the paleohydrology and evolution of the site. Since the inscription of the site in the UNESCO World Heritage List in 1992, the expansion of the population and the tourism infrastructure has greatly accelerated the utilization of underground water sources. The resulting subsidence and other ground instabilities could become significant risk factors as infrastructure is developed. In this study data from the Japanese PALSAR between December, 2006 and February, 2009 were processed to assess whether subsidence could be detected. Significant changes in the shoreline of Tonle Sap are visible after one year. In addition, there is evidence of topographic change in the areas around Siem Reap and Angkor Thom.

## Remote Sensing of the Hydrologic History of Southern Egypt

Tom G Farr

*Tom.farr@jpl.nasa.gov*

Jet Propulsion Laboratory

[Http://science.jpl.nasa.gov/people/Farr](http://science.jpl.nasa.gov/people/Farr)

Ron G Blom

Jet Propulsion Laboratory

United States

Philippe Paillou

Observatoire Aquitain des Sciences de l'Univers

France

**Keywords:** Radar, subsurface, hydrology, archaeology

**Abstract:** The region of the Gilf Kebir in southeastern Egypt has never been thoroughly mapped in terms of the landforms and subsurface signs of past climates conducive to human occupation. As part of NASA's Space Archaeology program, we are generating new maps of the paleohydrology, topography, geomorphology, and surficial deposits of the area and developing GIS-based models which use the data to pinpoint past resources and travel pathways. The maps we are generating will constitute a unique resource for exploration for archeological sites in the Gilf Kebir and other regions of N Africa.

That the Sahara was favorable for human habitation at times has long been known. With the remarkable paleo-landscape revealed by the L-band (25 cm) Shuttle Imaging Radar-A in 1981, it became clear that ancient humans concentrated along integrated drainage systems dubbed "radar rivers" by McCauley et al. (1986). However SIR-A and subsequent long-wavelength radar coverage was limited and regional understanding of the drainage network has remained elusive. A complete map of the buried channels of the region could also prove useful for development of water resources in southern Egypt and northern Sudan (Robinson et al., 2006; El-Baz et al., 2007).

We are mapping the area with three sensors optimized for mapping and characterizing arid regions: The Japanese PALSAR L-band imaging radar, NASA's SRTM, and ASTER. Together these sensors allow characterization of surface and subsurface landforms formed and modified by former wetter climates. A mosaic of PALSAR images (Paillou et al., 2009) uses as a base the topographic map produced by the Shuttle Radar Topography Mission, flown in 2000. SRTM also produced C-band images, similar to those being produced by Europe's ERS and Envisat and Canada's Radarsat satellites which, despite their shorter wavelength (5.5 cm) and thus decreased penetration capability, have been used for mapping buried Sahara drainages (El-Baz et al., 2007). An advantage of the SRTM C-band images is that they are inherently registered to the topographic data and provide full, mosaicked coverage.

A third data set, visible-near infrared to thermal IR images from ASTER and Landsat TM, is being used for mapping surficial landforms and vegetation. These wavelengths are sensitive to surface composition including rock types, weathering phenomena, and soil types.

A global hydrologic net, Hydrosheds, has been generated from the SRTM DEM and released by the USGS (<http://hydrosheds.cr.usgs.gov/>). Many of the drainage lines in this data set are related to the ancient river valleys, indicating some surficial manifestation of their presence. This could be due to incomplete burial, sagging of the mantling sediment, or a small amount of penetration of the SRTM C-band radar signals.

Another way to map the signs of past wet periods is to map the distribution of calcareous deposits related to springs and lakes. These are associated with cultural artifacts of all ages (Wendorf et al., 1987). We are using ASTER to map the spectral signatures of calcium carbonate, travertine, playa clays, and other signs of springs and lakes found throughout the area.

Archaeologists have never had a synoptic view of the region around Gilf Kebir. In addition, the national governments of the region need a detailed map of landforms and resources for conservation efforts. The data and maps produced by this study will be unique and will be useful as a base for further studies of the archaeology of the region as well as other applications in hydrology, ecology, geomorphology, and tourism.

#### ACKNOWLEDGMENT

Part of this work was done under contract with NASA.

#### REFERENCES

- El-Baz, F., C.A. Robinson, T.S.M. Al-Saud, 2007, Radar images and geoarchaeology of the eastern Sahara, ch. 2 in Wiseman and El-Baz, *Remote Sensing in Archaeology*, Springer.
- McCauley, J.F., C.S. Breed, G.G. Schaber, W.P. McHugh, B. Issawi, C.V. Haynes, M.J. Grolier, A. El Kilani, 1986, Paleodrainages of the eastern Sahara- the radar rivers revisited (SIR-A/B implications for a mid-Tertiary trans-African drainage system), *IEEE Trans. Geosci. Rem. Sens.*, v. GE-24, 624-648.
- Paillou, P., M. Schuster, S. Tooth, T.G. Farr, A. Rosenqvist, S. Lopez, J-M Malezieux, 2009, Mapping of a major paleodrainage system in eastern Libya using orbital imaging radar: The Kufrah River, *Earth and Planet. Sci. Lett.*, v. 277, p. 327-333, doi:10.1016/j.epsl.2008.10.029.
- Robinson, C., F. El-Baz, T.S.M. Al-Saud, S.B. Jeon, 2006, Use of radar data to delineate paleodrainage leading to the Kufra Oasis in the eastern Sahara, *J. African Earth Sci.* v. 44, p. 229-240.
- Wendorf, F., A.E. Close, R. Schild, 1987, A survey of the Egyptian radar channels: An example of applied archaeology, *J. Field Arch.*, v. 14, p. 43-63.

## The Earth Observation Programme of ESA - Educational Tools for Schools

Francesco Sarti  
*Francesco.Sarti@esa.int*  
ESA/ESRIN  
Italy  
<http://www.esa.int>

**Keywords:** Remote Sensing Education, Eduspace

**Abstract:** Earth Observation (EO) from satellites is increasingly important for the understanding of the Earth's system and its processes. Today, this is more important than ever, in a planet threatened by global change and climate change, where the uncontrolled use of natural resources like biomass, carbon and clean water associated to the explosion of demography could make life conditions of future generations hard, unless a policy of sustainable development is adopted. Youngsters and future decision-makers should be made well aware, through adequate education programmes, of the importance of an intelligent development, making a sustainable use of natural resources and preserving the environment. The observation of the changing earth from space can provide a valid support to the creation of public awareness and the education of young generations about these issues. The first missions conceived by Earth Observation Programme of the European Space Agency (ESA) were in the area of meteorology, with the successful launch of Meteosat in 1977, followed by a series of meteorological satellites, including Meteosat Second Generation and METOP (all operated by EUMETSAT). Moreover, in 1991, ESA launched its first EO satellite with a synthetic aperture radar payload, ERS-1, followed by ERS-2 (1996) and Envisat (2002), the largest EO satellite ever launched and with a variety of different sensors for the observation of land, ocean, cryosphere and atmosphere, providing a precious information serving the scientific community, as well as an increasingly larger number of operational and commercial users. In parallel, ESA is preparing scientific Earth Observation missions called Earth Explorers, dedicated to the study of scientific challenges identified by the science community. The first two, GOCE (measuring the Earth's gravity field), and SMOS (determining soil moisture and ocean salinity) are already in orbit, whereas CryoSat (observing continental ice sheets and marine ice cover) is about to be launched, to be followed by other satellites for a variety of scientific objectives. Other important issues are the observation and fast response in case of natural disasters and all environmental hazards. In this context, GMES (Global Monitoring for Environment and Security), a joint initiative of ESA and the European Union, aims to monitor the state of the environment on land, at sea and in the atmosphere and to deliver policy-relevant EO information that can be used to improve the security of the citizens. Its Space Component comprises five types of new missions called Sentinels, plus so-called Contributing Missions from Member States and other organisations, with their associated Ground Segment infrastructure, developed by ESA. The Sentinel missions include radar and superspectral imaging for land, ocean and atmospheric monitoring. Associated to this challenging programme of Earth Observation, ESA is carrying out a programme of EO Education, in cooperation with other national space agencies and with international bodies, like UNESCO or the Committee on Earth Observation Satellites (CEOS) and its Working Group for Education. In this frame, dedicated tools for schools, such as Eduspace, have been developed with the objective to create awareness about the potential of Earth Observation from space among young generations and to bring 'space' closer to youngsters. A variety of different tools have been developed and a series of training courses at different levels (university, post-doc, scientific or professional oriented) are provided by ESA and other institutes cooperating with ESA.

## The Planet Action Initiative Supporting Projects on Climate Change Issues: Update and Achievements

Louis-François Guerre  
*Louis-Francois.Guerre@spotimage.fr*  
Spot Image  
France  
<http://www.spotimage.fr>

**Keywords:** Planet Action

**Abstract:** Spot Image has launched in 2007 a non-profit initiative, Planet Action, to bring its contribution to the Climate Change environmental issues. Through this initiative, Spot Image provides satellite images to support local projects addressing climate change aspects to assist decision makers. Spot Image has gathered other international partners such as ESRI (GIS technologies), or UNESCO to work on World Heritage sites impacted by climate change. Today, three years after having started, Planet Action, supports more than 300 local projects worldwide on avoided deforestation, biodiversity conservation, or impact mitigation. Planet Action has initiated as well several activities to raise awareness on the actions taken by these environmental projects. This presentation will make an update on the Planet Action's achievements since it has been presented at the 2008 EARSEL Symposium in Turkey.

## Coastal ENVISAT RA-2 Data Validation in the Gulf of Cadiz (Spain)

Jesus Gomez-Enri  
*jesus.gomez@uca.es*

Patricia Lopez-Leon

Stefano Vignudelli

Paolo Cipollini

Christine Gommenginger

Scott Gleason

Jerome Benveniste

Pilar Villares

**Keywords:** Altimetry, Tide Gauge, Gulf of Cadiz, Validation.

**Abstract:** Validation is the process that quantifies the accuracy of the altimeter-derived estimates of sea level against an independent corroborative record of ground-based measurements. In this paper we present a case-study of validation in the Gulf of Cadiz (SW Iberian Peninsula) using the outputs of the new coastal processor of ENVISAT RA-2 data, developed under the frame of the ESA funded COASTALT project. Geophysical parameters (significant wave height, wind speed and sea level) are obtained at higher frequencies (18Hz) than standard product (1Hz). We use the track segments of all the ENVISAT RA-2 passes crossing the Gulf of Cadiz. The new products will be compared against in-situ ground truth measurements in the zone. Thus, it will be possible to assess the improvement of the new products, in comparison with the standard ones. This work will be focused on the closest track segments to the coast (typically 30 km offshore).

## The Coastal Squeeze on Island Biodiversity in South East Asia and Oceania

Florian T. Wetzel

*f.wetzel@klivv.oeaw.ac.at*

Konrad Lorenz Institute for Ethology, Austrian Academy of Sciences, Savoyenstraße 1a, A-1160  
Vienna, Austria  
Austria

Helmut Beissmann

*h.beissmann@klivv.oeaw.ac.at*

Konrad Lorenz Institute for Ethology, Austrian Academy of Sciences, Savoyenstraße 1a, A-1160  
Vienna, Austria  
Austria

Dustin J. Penn

*d.penn@klivv.oeaw.ac.at*

Konrad Lorenz Institute for Ethology, Austrian Academy of Sciences, Savoyenstraße 1a, A-1160  
Vienna, Austria  
Austria

Walter Jetz

*walter.jetz@yale.edu*

Department of Ecology and Evolutionary Biology, Yale University, 165 Prospect Street, New  
Haven, CT 06520-8106, USA  
United States

**Keywords:** sea-level rise, coastal areas, climate change, threatened species

**Abstract:** Global climate change will cause substantial ecological impacts in this century, and islands are particularly susceptible to the anticipated rise in sea levels. In this study, we examined the potential ecological consequences of relative sea-level rises (RSLR) for 14,247 islands (covering ca. 3 million km<sup>2</sup>) in the Pacific and South East Asia - which have unusually high levels of biodiversity and species endemism. We estimated the total area expected to be inundated using three different RSLR scenarios (i.e., 1, 3, and 6 m RSLR). We found that the Pacific Region is the most vulnerable region under all RSLR scenarios, and it is twice as vulnerable as the Australasian biogeographic realm, and three times more than the Indomalayan biogeographic realm. We also found different vulnerabilities of taxonomic groups living in these realms. Our analyses suggest that sea-level rise will result in a high island fragmentation and complete inundation of many small islands (<1km<sup>2</sup>). We expect that around 2500 islands (17 percent of all islands) will be completely inundated in a 1m-rise scenario. Our findings indicate that even the most conservative sea-level rise scenario will be ecologically devastating for these islands and their inhabitants.

## Microphytobenthos Assessment by Hyperspectral Remote Sensing: the New Challenges

Vona Méléder

*vona.meleder@univ-nantes.fr*

France

Farzaneh Kazemipour

*farzaneh.kazemipour@univ-nantes.fr*

France

Patrick Launeau

*patrick.launeau@univ-nantes.fr*

France

Jean-Philippe Combe

United States

Laurent Barillé

*laurent.barille@univ-nantes.fr*

France

**Keywords:** Hyperspectral remote sensing, microphytobenthos, biomass, biodiversity, photosynthetic capability, shellfish ecosystem

**Abstract:** Estuaries and coastal areas are highly important natural habitats, amongst the most productive marine ecosystems on earth. They provide vital ecosystem services to mankind and are particularly valuable as habitats and feeding grounds for a variety of organisms, such as birds, demersal fish and invertebrates. Over the last two decades, it has been established that the intertidal mudflats play a central role in the productivity of these coastal areas to the enrichment of the adjacent terrestrial and marine ecosystems via related trophic (aquatic transport of organisms and mobile consumers) and hydrodynamic (tidal and wave currents) pathways. The high productivity of the intertidal mudflats is due to their intensive microbial activity mainly generated by the microphytobenthos, supporting also an important local activity: shellfishery.

Microphytobenthos consists of unicellular phototrophic microorganisms group, dominated by diatoms (Bacillariophyceae class) at north mid-latitude (Europe and America), inhabiting the first millimetres of sediment. Epipellic diatoms, until now the most studied group of MPB, are able to migrate through the sediment and form a brown biofilm at the mudflat surface during diurnal low tide. These biofilms are easily observable and can cover several hectares. Despite the importance of such ecosystem functioning, only a few number of studies has dealt with microphytobenthic structure using field samples, on mesoscale and macroscale because of the difficulties to reach such muddy areas. Therefore, the remote sensing became an important tool in this case as shown in recent works (Méléder et al., 2003 and Combe et al., 2005).

Mapping microphytobenthos biomass from hyperspectral images using either relationships between biomass and indices (as NDVI) or spectral shape (Combe et al. 2005) or more recently, using a physical model linking microphytobenthic biomass to spectral data by the mean of optical properties, absorption coefficient,  $\alpha$ , and refractive index,  $n$  (Kazimipour et al. 2009), provide more and more accurate spatial information. However, these studies focused on chlorophyll *a* estimation, use as the proxy for biomass, whereas all the spectral shape is due to all the pigments incorporated in cells forming coloured biofilm. Moreover, carotenoid pigments are commonly used as taxonomic biomarkers to characterise planktonic and benthic communities and also as physiological one to estimate photosynthetic capability of primary producer. Then, microphytobenthos biodiversity and photosynthetic capability estimation at the scale of an entire shellfish ecosystem are very original

perspectives opened by hyperspectral data availability. Primary results are presented to illustrate these new challenges for microphytobenthos assessment.

Combe JP, Launeau P, Carrere V, Despan D, Meleder V, Barille L, Sotin C (2005) Mapping microphytobenthos biomass by non-linear inversion of visible-infrared hyperspectral images *Remote Sensing of Environment* 98, 371-387.

Kazemipour F, Launeau P, Meleder V (2009) in First IEEE GRSS Workshop on hyperspectral image and signal processing (Grenoble, France).

Méléder V., Launeau P., Barillé L. Rincé Y (2003) Cartographie des peuplements du microphytobenthos par télédétection spatiale visible-infrarouge dans un écosystème conchylicole. *CR Acad. Sci. Paris-Biologie*, 326:377-89.

# The Determination and Comparison of Hydrological Properties of Catchment Basins from Topographic Maps, DTM, ALOS/PRISM, and SRTM DEMs. A Case of Part of Roman Water Supply System

A Case of Part of Roman Water Supply System

Cihan Uysal  
*uysalc@yahoo.com*  
Istanbul Technical University  
Turkey

Gizem İnce  
*incegizem@yahoo.com*  
Istanbul Technical University  
Turkey

İrfan Akar  
*irfanakar@gmail.com*  
Marmara University  
Turkey

Derya Maktav  
*maktavd@itu.edu.tr*  
Istanbul Technical University  
Turkey

James Crow  
*jim.crow@ed.ac.uk*  
Univ. Of Edinburgh  
United Kingdom

**Keywords:** Hydrology, DTM, ALOS/PRISM DEM, SRTM

**Abstract:** GIS plays an important role in the studies of drainage network morphometry. Data source that is produced and supplied with GIS contributes a lot to comment on the drainage features of the worked-on area and to get digital data. Different types of data can be used for determination and comparison of the difference of catchment areas.

In this study, catchment basins of the two streams Binkılıç and Kurşunlugerme within the boundaries of the Çatalca District of Istanbul (in Thrace) has been investigated. These basins are also hydrologically related to the Roman and Byzantine water supply system passing through this region. The data source types consisted of 1:25000 scale digital topographic maps, SRTM (3 arcsecond), DTM and ALOS/PRISM DEM. For analyzing the data Arc Hydro tool of Arcinfo 9.2 software was used. In order to determine hydrographic data, such as drainage density, stream frequency, stream length, and its profile to the length, Strahler method was utilized. Consequently, among four different types of data, digital topographic map provided the best solution for determining hydrological properties of the catchment basins.

## Patterns of Seasonal Variability of Near Surface Chlorophyll A in the Northwestern Black Sea Shelf from Ocean Color Satellite Data

Violeta Slabakova

*v.slabakova@io-bas.bg*

Institute of Oceanology - Bulgarian Academy of Sciences  
Bulgaria

Snejana Moncheva

*snejanam@abv.bg*

Institute of Oceanology - Bulgarian Academy of Sciences  
Bulgaria

Natalia Slabakova

*n.slabakova@abv.bg*

Institute of Oceanology - Bulgarian Academy of Sciences  
Bulgaria

**Keywords:** Northwestern Black Sea shelf, Satellite remote sensing, Ocean color, Chlorophyll, Seasonal variations

**Abstract:** Ten years (January 1998 – December 2007) of Sea-viewing Wide Field-of-View Sensor (SeaWiFS) ocean color data have been used to study spatial and temporal variability of the near surface chlorophyll a in the northwestern Black Sea shelf (NWS). The seasonal dynamics of pigment concentrations in the four major sub-regions of the NWS have been investigated in relation to the variability of physical forcing influencing phytoplankton distribution: Photosynthetically Available Radiation (PAR), Sea Surface Temperature (SST) and wind stress. Significant decreasing trend of chlorophyll a during the last 10 years is evident, interrupted by the peak anomalies in 2001 and 2006. Furthermore, the analyzes of interannual variation has been discussed. This study aims to improve understanding of temporal and spatial patterns of chlorophyll a concentrations, as well as the role of the physical factors driving the phytoplankton distribution in the most productive area of the Black sea.

## Using High Resolution Ground Survey and LiDAR Data to Monitor Embryo Dune Development in a Conservation Area, North Lincolnshire (UK)

Anne-Lise ALM Montreuil  
*A.L.Montreuil@lboro.ac.uk*  
Loughborough University  
United Kingdom

<http://www.lboro.ac.uk/departments/gy/staff/pgrs.html>

Joanna Bullard  
*J.E.Bullard@lboro.ac.uk*  
Loughborough University  
United Kingdom

<http://www.lboro.ac.uk/departments/gy/staff/gyjeb/index.html>

**Keywords:** embryo dunes, terrestrial laser scanning, Digital Terrain Model, nature reserve

**Abstract:** Coastal dunes are natural features, reflecting interaction among geomorphological, biological and ecological processes and are important for landscape evolution, habitat provision and coastal defence. Coastal dune systems include embryo dunes, primary and secondary foredunes and other more established features. Despite the fact that they are often important precursors to the development of established foredunes, few studies have focused on embryo dunes. This study has monitored the development of a patch of vegetated embryo dunes (approx. 600m x 50m) of more than 1 m height using aerial photographs and LiDAR data since they first appeared in 2001. For the past year seasonal surveys of the dunes have also been conducted using high resolution terrestrial laser scanning (TLS). The embryo dunes are located within a national nature reserve on an accreting coastline in eastern England. Evidence from the same site suggests that embryo dunes can be important in the development of other coastal landforms such as saltmarsh, by causing seawater ponding on the landward side. The meso-scale results of embryo dune Digital Terrain Model (DTM) generated from aerial photographs, Lidar data indicate a positive volumetric change of 1060m<sup>3</sup> for the yearly interval 2001-2007, which corresponds to a sand gain of more than 175m<sup>3</sup> /year. The seasonal TLS morphological surveys have showed that the embryo dune patch is highly dynamic with a spatial tendency to advance seaward. Incoming marine sand material by storms and then transported by onshore winds seems to be the main vectors of the formation and the development of the embryo dunes.

## Analysis of Geomorphologic Changes of the Po River Ecosystem

Mariano Bresciani  
*bresciani.m@irea.cnr.it*  
CNR-IREA  
Italy

Mirco Boschetti  
*boschetti.m@irea.cnr.it*  
CNR-IREA  
Italy

Daniela Stroppiana  
*stroppiana.d@irea.cnr.it*  
CNR-IREA  
Italy

Rossano Bolpagni  
*rossano@server1.dsa.unipr.it*  
University of Parma  
Italy

Paolo Villa  
Italy

**Keywords:** remote sensing, river, geomorphology, multitemporal

**Abstract:** The riverine environment and its geomorphologic characteristics are particularly influenced by both natural and anthropogenic conditions; these factors directly influence the ecological status of a river. In the last decades, the Po river, the longest river in Italy (length: 652 km; basin area: 71000 km<sup>2</sup>), has been facing a progressive decrease of the hydrometric levels and significant changes of width and morphology of the riverbed due to changes of the hydrological regime and massive extraction of inert material. The aim of this work is to quantify the present conservation status and its temporal changes of the Po river, including wetlands and surrounding areas in the Province of Mantova, Italy. In order to achieve this objective we acquired and processed remote sensing images (LANDSAT (MSS, TM5, TM7) e ASTER) in the period 1977 to 2007. River conditions were assessed analyzing the temporal dynamics of different hydro-morphological characteristics, satellite data were processed to extract the following features: sinuosity index, braiding index, average channel width, the index of naturalist geomorphologic, the water surface, number of islands, index of island stability and humid areas density and extension. The values related to the water surface were normalized with respect to river discharge. We analysed an enlarged portion of the river bed computed with reference to full with a return time of 200 years, this portion of the river has been divided in eight transverse subregions and for each of them the above mentioned hydrological aspect were quantified. These analyses allowed us to evaluate changes of the morphological characteristics due to both river flow and variations of the regional groundwater. The multitemporal analysis highlighted a progressive closure of the lateral branches of the river that leads to an increase of the islands surface and of their movements; significant changes in the river morphology starting from the 80's. The study, thanks to the exploitation of satellite image, contributes to highlight in a spatially distribute way the processes that occur in the Po river confirming what previously assess by specific field study.

## Monitoring Recent Land-use/Land-cover Changes in Arganeraie Biosphere Reserve, Morocco

Bernard Lacaze

*lacaze.bernard@gmail.com*

CNRS-PRODIG

France

<http://prodig.univ-paris1.fr/umr/>

Mohamed Faouzi Smiej

CRTS, Rabat

Morocco

Ahmed El Aboudi

Université Mohammed V, Rabat

Morocco

**Keywords:** remote-sensing, Argan tree, Biosphere Reserve, land-use/land-cover, decadal trends, conservation

**Abstract:** Located in the southwest of Morocco, Arganeraie Biosphere Reserve covers a vast intramontane plain of more than 2,560,000 hectares, bordered by the High Atlas and Anti-Atlas Mountains and open to the Atlantic in the west. Of main conservation interest is the endemic Argan tree [*Argania spinosa* (L.) Skeels]. Argan wooded savannas, and scattered trees in rainfed cereal fields, not only act as a buffer against desertification, but are also a source of livelihood for more than 2 million people in rural Morocco who depend on the trees for oil, fodder, honey, charcoal, fuel and construction wood. These agroforests suffer from continued degradation induced by intense use such as fuelwood gathering and grazing in the hilly areas, and, in the plain, from tree removal to introduce irrigated crops. The Biosphere Reserve status is not effective, because local regulations allow traditional uses of Argan trees even in protected areas.

In the present work, a land-use/land cover map derived from Landsat images (GLOVE Project, CRTS, Rabat, 2000) is compared with GLC 2000 and GLOBCOVER maps, showing that global classes legend is not suited for regional land cover mapping. To study the evolution during the last ten years (2000-2009), MODIS time series at 250 m resolution (1 image each 16 days) have been analyzed, using principal component and wavelet analysis. Results are discussed with reference to available high spatial resolutions images (Landsat, ASTER, SPOT). Decadal trends show a marked regional pattern of human-induced changes, due to urbanization and intensification of agricultural practices in the coastal zone and in lower parts of the Biosphere Reserve. Even if traditional land management practices are maintained, the conservation of Argan trees is questionable, because actual practices are focused on the economic value of Argan oil production, without reference to sustainability of this endangered ecosystem (no regeneration of trees, and very limited reforestation areas).

## A Review of Change Detection Algorithms and their Suitability for Certain Applications in regard to Operational Implementation

Frank Thonfeld

*frank.thonfeld@uni-bonn.de*

<http://www.zfl.uni-bonn.de/>

Antje Hecheltjen

*a.hecheltjen@uni-bonn.de*

Germany

<http://www.zfl.uni-bonn.de/>

Matthias Braun

*matthias.braun@uni-bonn.de*

Germany

<http://www.zfl.uni-bonn.de/>

Gunter Menz

*g.menz@uni-bonn.de*

Germany

<http://www.giub.uni-bonn.de/rsrg/www/site/index.htm>

**Keywords:** review, change detection, cross-sensor, object-based, class-specific change detection, process chain, SAR, automated change detection

**Abstract:** Change detection has become an evolving issue in remote sensing due to rapidly growing data archives and the need for operational implementation and update of land cover information for a variety of purposes. The increasing amount of sensors and data types causes considerable heterogeneity that needs to be addressed by the various algorithms available.

In literature, quite a number of change detection algorithms have been suggested for specific sites or targets. However, the problem is to choose the most appropriate set of algorithms that enables regional and spatial transferability. Existing reviews on change detection have succeeded in establishing a categorization of change detection techniques, compiling characteristics, advantages and disadvantages of different algorithms, linking main ecosystem monitoring issues to change detection algorithms, and linking methods of data transformation with analysis techniques used to detect change. Several studies have also empirically compared the accuracy of different change detection algorithms. However, none of the existing reviews fully addresses the whole process chain needed to generate change products. Besides, they neither include object-based approaches nor do they consider the use of optical and SAR data equally. The essential aspect of automation is disregarded likewise. The launch of new satellites has effected the development of new algorithms in the last decade, some of which have not been reviewed yet.

In the first part of this review we look at change detection from an application-oriented point of view. This includes the appraisal of processing chains for change detection which are currently used at an operational level in projects such as Corine Land Cover. It also includes a systematic review of more than 1000 articles from the last four decades on digital change detection techniques for monitoring land cover changes. By a quantitative assessment in terms of number of articles, we conclude which change detection algorithms are most commonly used for which applications.

The second part of this review focuses on scientific innovations in the context of remote sensing based change detection. For this purpose we qualitatively analyze those papers, which describe a methodology for the first time in the field of remote sensing or which account for further developments of existing approaches. Each approach is inserted into a matrix and broken up into separate steps of the process chain, e.g. pre-processing, change detection, thresholding, change labeling, and

accuracy assessment. Our matrix also accounts for different data types including SAR, cross-sensor approaches, object-based techniques, and grade of automation. The issue of temporal and spatial scale is addressed as well. The analysis of the matrix gives a clear picture of the latest developments of algorithms and their evolution.

Although the latest innovations in the field of remote sensing change detection offer a high degree of automation for the detection of changes itself and threshold selection there is still no proper solution for the automation of change labeling. Nevertheless, a comparison of the two parts of this review shows discrepancies between the potential of scientific developments and the status quo of operational change detection. Operational approaches are using rather old algorithms and parts of the process chains have to be accomplished by computer assisted photo interpretation. Scientific developments show potential for automation for all steps of the process chain.

Based on our matrix, we propose modules for the different steps of the process chain in order to optimize automation for large scale operational change detection.

# Characterizing Land Use Change in a Complex Semi-arid Landscape by Combined Assessment of Land Transformations and Modifications

Achim Roeder

*roeder@uni-trier.de*

University of Trier, FB VI Geography/Geosciences, Remote Sensing Department

Stella Hubert

University of Trier, FB VI Geography/Geosciences, Remote Sensing Department

Marion Stellmes

University of Trier, FB VI Geography/Geosciences, Remote Sensing Department  
Germany

Peter Scarth

The Remote Sensing Centre, Department of Environment and Resource Management, Queensland  
Australia

Joachim Hill

University of Trier, FB VI Geography/Geosciences, Remote Sensing Department  
Germany

Susana Bautista

University of Alicante, Department of Ecology and Biodiversity  
Spain

Jordi Cortina

University of Alicante, Department of Ecology and Biodiversity  
Spain

**Keywords:** land use change, classification, multi-date spectral unmixing

**Abstract:** Following Spain's accession to the European Union, highly dynamic land use transformations were observed, involving intensification and urbanisation as well as land abandonment and extensification as extreme ends of the land use intensity gradient. Characterizing spatio-temporal dynamics under such complex conditions necessitates appropriate data processing and interpretation strategies to assess both, transformation of land use classes as well as modifications within classes. Using a combination of time series and multi-seasonal Landsat-TM and -ETM+ imagery we assessed qualitative and functional landscape properties of a test area comprising diverse land uses, ranging from forests, rangelands and shrublands to intensively irrigated agriculture and urban agglomerations.

Radiometric correction of the data was based on a rigorous radiative transfer modelling scheme which included a model-component of topography-induced illumination variations. The transfer model was parameterized using coincident MODIS reflectance data as a reference to invert the model for Angstrom parameters and water vapour transmission coefficients.

To map land use classes, a k-means based classification approach was combined with greenness trajectories and a majority-based class assignment. For semi-natural areas, woody and non-woody vegetation types and their coverage were derived using a multi-date spectral unmixing approach. To achieve an optimum characterization of the spectral feature space and its seasonal dynamics, we tested several approaches for endmember selection: using field- and laboratory spectral reflectance measurements, using individual endmember sets for the different scenes, and by calculating a global

endmember set for all scenes using a simplex-based characterization of the feature space.

Merging results for the natural and non-natural domains provides an excellent representation of the complex land mosaic and allows to assess its change with time. Results show a distinct gradient between the plain areas almost completely used for urban development and intensive agriculture, while the mountainous areas are characterized by an abandonment of uses. Depending on local conditions, stable communities of either sparse shrublands or matorrals prevail, while in other areas shrub encroachment with subsequent accumulation of fuels occurs, often causing devastating wildfires.

## Automated Methods for Change Detection

Manfred Ehlers  
*manfred.ehlers@uos.de*  
IGF, University of Osnabrück  
Germany

Sascha Klonus  
*sklonus@igf.uos.de*  
IGF, University of Osnabrück  
Germany

Daniel Tomowski  
*dtomowski@igf.uos.de*  
IGF, University of Osnabrück  
Germany

Ulrich Michel  
*michel@ph-heidelberg.de*  
Heidelberg University of Education  
Germany

Peter Reinartz  
*peter.reinartz@dlr.de*  
German Space Center  
Germany

**Keywords:** Change Detection, Fourier Domain, Edge Extraction, Texture, Morphological Operations

**Abstract:** A fast detection and visualization of change in areas of crisis or catastrophes is an important condition for planning and coordination of help. The availability of new satellites with high temporal resolution (e.g., Rapid Eye) and/or high spatial resolutions (e.g., GeoEye or Quickbird) new remote sensing data is available to get a better visualization of multitemporal change. This paper describes the results of new methods for the automated detection of changes. The methods are based on frequency analysis and texture parameters. For the frequency analysis, different band pass filters are applied and their effects are observed in the spatial domain to identify the relevant frequency information for change detection. After transforming the multitemporal images via a fast Fourier transform (FFT) and applying the most suitable band pass filter, four different methods are available to extract changed structures: differencing and correlation in the frequency domain and correlation and edge detection in the spatial domain. For the texture analysis, we calculate four different parameters (“energy”, “correlation”, “contrast” and “inverse distance moment” for the multitemporal images. The next step is the application of several change detection methods (difference, ratio, regression and principal component analysis) to visualize the changes in the texture images. The methods were tested with satellite images of high spatial resolution for the crisis areas of Darfour and Haiti. For the frequency based change detection, best results were obtained with an adaptive band pass filter and a Canny operator for edge detection. For the texture based methodology, a selective bitemporal principal component analysis for the texture feature “energy” lead to the best results for the visualization of change. The next steps will involve the combination of both methods to strengthen the change/no change decision and to test the algorithms for a broader application of change analysis (e.g. environmental, phenological change).

## Estimates of Yield Reduction Caused by Drought

Case study Poland

katarzyna Dabrowska - Zielinska  
*kasia@igik.edu.pl*  
Institute of Geodesy and Cartography

Wanda Kowalik  
*wanda.kowalik@igik.edu.pl*  
Poland

Alicja Malinska  
*alicja.malinska@igik.edu.pl*  
Poland

Maria Budzynska  
*maria.budzynska@igik.edu.pl*  
Poland

Jedrzej Bojanowski  
*jedrzej.bojanowski@igik.edu.pl*  
Poland

maciej Bartold  
*maciej.bartold@igik.edu.pl*

**Keywords:** Indices drought effect, statistics, evapotranspiration

**Abstract:** The great demand on quick actual information on crop growing conditions and yield forecast for cereals caused the development of the method, which is, based 1. On indices created only from remotely sensed data 2. Implementation of Evapotranspiration calculated from satellite data and meteorological parameters. During the vegetation growth, for the official crop yield forecast a great number of information about actual crop growth conditions come from agricultural correspondents working in different regions of the country. All this information is used by experts in the Central Statistical Office to prepare official estimates of yield of the main crops. Unfortunately, in situ data are very limited and some of the administrative regions are not covered by ground measurements. They are applied in rather small areas and results are extrapolated to incomparable greater surfaces. The data from SPOT VEGETATION and NOAA AVHRR have been used as the main source of information about the crop due to high temporal resolution, of images.

Observations from SPOT VEGETATION give the daily coverage of the Earth of spatial resolution of 1km. and are delivered as 10-day composite images corrected for atmospheric effects and with the cover of the cloud mask. NOAA operational polar-orbiting satellites provide synoptic information and a regular repetitive observation. The NOAA AVHRR station was situated in the Institute of Geodesy and Cartography.

From SPOT VEGETATION, the Normalized Vegetation Index (NDVI) for each decade of the year has been obtained. The AVHRR data collected in the first two channels have been used to calculate NDVI and the data obtained in the channels 4 and 5 have been used to calculate surface temperature (Ts). Three indices - Vegetation Condition Index (VCI), Accumulated Vegetation Condition Index (AVCI) were based on NDVI and Temperature Condition Index (TCI) was based on surface temperature. These indices have been computed for agriculture area for each ten-day period of the year. The sensitive period of crop development where soil moisture is important has been found The procedure of Kogan (1997) followed by other authors (Dabrowska-Zielinska

et al. 2002; have been presented. New methodology of introducing the moisture index based on evapotranspiration coupling different indices has been introduced.

## Development of a Spectral Library for Mediterranean Land Cover Types

Ioannis Manakos

*ioannis.manakos@earsel.org*

Mediterranean Agronomic Institute of Chania  
Greece

K. Manevski

Mediterranean Agronomic Institute of Chania  
Greece

G. P. Petropoulos

Mediterranean Agronomic Institute of Chania  
Greece

M. Elhag

Mediterranean Agronomic Institute of Chania  
Greece

C. Kalaitzidis

Mediterranean Agronomic Institute of Chania  
Greece

**Keywords:** field spectroradiometric measurements, spectral library

**Abstract:** Land Cover/ Use mapping and classification algorithms require detailed information about the spectral separability between land cover types. Up to an extent, the increased spatial and radiometric resolution of the satellite sensors supports these activities. Spectral libraries are utilized to fine tune the selection of specific wavelength ranges or wavelength algebraic combinations for land cover type discrimination. Mostly these libraries, being integrated in a wider database or stand alone, apply to specific climatic, geographic conditions, and growth stage and status of the plants. Research activities throughout Europe have been enriching data collection about numerous surface targets for a long time. The lack of such information was identified for the South East Mediterranean land cover types and is addressed by the present study. Focused on the vegetation cover and changes registration, the development of a measurement construction and strategy, similar and compliant to the rest European activities framework, but adjusted to the terrain conditions of South Eastern Mediterranean, was carried out within the GI@MED project in the framework of the Hellenic AID Programme. Field spectra are being acquired from Crete (Chania Prefecture) and Egypt (Nile Delta) under a common methodology framework, and incorporated into a common spectral library for data and knowledge base development about various land cover types. Measurement results are cited, and the measurement strategy is discussed.

## Assessing Human Factors in Remote Sensing Image Analysis: a Web-based Approach

Soetkin Gardin  
*Soetkin.Gardin@UGent.be*  
Ghent University  
Belgium

Sébastien M.J. Van Laere  
*Sébastien.Vanlaere@UGent.be*  
Ghent University  
Belgium

Frieke M.B. Van Coillie  
*Frieke.VanCoillie@UGent.be*  
Ghent University  
Belgium

Frederik Anseel  
*Frederik.Anseel@UGent.be*  
Ghent University  
Belgium

Wouter Duyck  
*Wouter.Duyck@UGent.be*  
Ghent University  
Belgium

Robert R. De Wulf  
*Robert.Dewulf@UGent.be*  
Ghent University  
Belgium

**Keywords:** remote sensing, operator performance, accuracy, human factors

**Abstract:** Human perception and interpretation is an indispensable component in many aspects of remote sensing image analysis and other types of geodata processing such as GIS and cartography. Over the last decades, image processing became more and more automated, but human screening and interpretation is still needed at certain stages. Although it is crucial for adequately assessing automated systems' performance, virtually no research has focussed on operator functioning. Instead, a manual image interpretation is often considered 'ground truth', implicitly assuming that operator performance approaches perfection, and that infrequent errors are randomly distributed across time, operators and image types. In order to test these assumptions and to determine the human factors that influence operator functioning, a web application has been developed including several experiments testing operator performance. The web application consists of two major parts, first a personal profile is drawn departing from of some demographics like age and gender, a personality questionnaire and an interactive tool that measures the capacity of the visual working memory. The second part consists of a long series of digitizing tasks. So far, a try-out took place in a controlled environment with mainly novices in the field of remote sensing. The results of this control group already showed significant variability amongst operators that could partly be explained by human factors. In order to get more valuable results, it is extremely important to reach a large group of experts, so interested researchers are invited to participate in the experiment at <http://wavars.ugent.be>.

## Interoperability based on Oracle Locator

Michael Mutale  
*mikemost@gmail.com*  
Copperbelt University  
Zambia  
<http://mikebianca.we.bs>

**Keywords:** Interoperability, GIS, Geotechnology, Geospatial, Organisations, Autodesk, Intergraph

**Abstract:** The field of Geographic Information System (GIS) has evolved over the years with a vast increase in membership, numbers, interest groups, backgrounds and depth of understanding in the Geotechnology Community. There has also been an increase in the amount of information that can be contained and manipulated in a map. Additionally, there has been an increase in the number of GIS applications with improved functionality to handle and manipulate geospatial data. On the other hand, new and improved computer systems are available on the market designed with improved capability in terms of data manipulation and storage.

This has brought up challenges which have to be addressed if there has to be efficient use of the vast amounts of data produced by the different organisations. This is much more the case in the third world countries, where many organisations have problems of geo-information sharing, access and management both within the same organisation and with other organisations.

To address this issue of accessibility to data, this research proposes a solution by introducing interoperability based on a common database. Organisations should now focus more on ensuring that their systems, procedures and cultures are managed in such a way as to maximise opportunities for exchange and re-use of information, whether internally or externally. Thus, encompassing interoperability in the way systems are designed and business processes of the organisation are run, is a vital step for any organisation.

Autodesk Map 2008 and Intergraph GeoMedia have been used to test and come up with the best way to connect them to the data in Oracle Locator. The data used in this research has been provided by the Landesanstalt für Umwelt, Messungen und Naturschutz Baden-Württemberg (LUBW – State Administration for Environment, Measurement, and Nature Conservation Baden Württemberg) which delivers Geodata (Geobasisdaten und Geofachdaten) to all counties in the state of Baden-Württemberg in Germany.

## Comparison of ASTER GDEMs with SRTM Height Models

Karsten Jacobsen  
*jacobsen@ipi.uni-hannover.de*  
Leibniz University Hannover  
<http://www.ipi.uni-hannover.de>

**Keywords:** ASTER GDEM, SRTM DSM, analysis

**Abstract:** With the free of charge available, close to worldwide covering SRTM C-band height models several problems of the remote sensing community have been solved or made simpler. Nevertheless the SRTM-height models are limited to the range from 56° southern up to 60.25° northern latitude and gaps exist especially in mountainous regions, dry sand deserts and water bodies. In addition outside the USA only height models with 3 arcsec spacing (92m at the equator) are available. With the ASTER GDEM now another free of charge available height model can be used, covering the earth from 83° southern up to 83° northern latitude without the partially larger gaps of the original SRTM digital surface models (DSMs) and having an improved spacing of 1 arcsec (31m at the equator). An intensive validation of the ASTER GDEM is available at the WEB-page of ASTER GDEM, but it covers not all important topics of the height model analysis. For example no analysis of the important accuracy dependency from the terrain inclination and no morphologic aspects are respected.

With eleven test areas located in the USA, France, Germany, Poland, Turkey and Jordan ASTER GDEMs and SRTM DSMs have been analyzed in relation to precise reference height models. It is obvious, that ASTER GDEMs have not an even accuracy, it depends upon the number of stacks/object point (stacks = number of used ASTER images), which can exceed 50, but in one test area in the average just 2.5 stacks/point have been used. In addition the scene location error cannot be neglected and we have a clear dependency upon the terrain inclination. As SRTM DSMs, ASTER GDEMs are describing the visible surface, which in urban areas and in forests is shifted against the bare ground.

In general ASTER GDEMs have slightly larger standard deviations as SRTM height models. In spite of the improved point spacing, ASTER GDEMs are not including more morphologic details as the SRTM DSMs with three times point spacing. The 1 arcsec SRTM height models in the USA or the not free of charge SRTM X-band DSM show more morphologic details. Nevertheless the ASTER GDEMs are very helpful especially in mountainous areas and the area below 56° southern and above 60.25° northern latitude.

## DSM Generation and Filtering from High Resolution Optical Stereo Satellite Data

Peter Reinartz  
*peter.reinartz@dlr.de*  
DLR  
Germany  
<http://www.caf.dlr.de>

Pablo d'Angelo  
*pablo.angelo@dlr.de*  
DLR  
Germany

Thomas Krauß  
*thomas.krauss@dlr.de*  
DLR  
Germany

Houda Chaabouni-Chouayakh  
*houda.chaabouni-chouayakh*  
DLR  
Germany

**Keywords:** Optical stereo data, DSM generation, Image Matching, DSM filtering

**Abstract:** The generation of digital surface models (DSM) of urban areas from high and very high resolution (VHR) stereo satellite imagery requires advanced methods. In the classical approach of DSM generation from stereo satellite imagery interest points get extracted and correlated between the stereo pairs using an area based matching followed by a least-squares sub-pixel refinement step. After a region growing the 3D point lists get triangulated to the resulting DSM. In urban areas this approach does not lead to satisfactory results due to the size of the correlation window which e.g. smoothes out the usual steep edges at buildings. Also missing correlations as in partly – in one or both of the images – occluded areas will simply be interpolated in the triangulation step. So an urban DSM generated with the classical approach results in a very smooth DSM, missing objects like steep walls, narrow streets and courtyards. To overcome these problems algorithms from computer vision are introduced and adopted to satellite imagery. These algorithms do not work using local optimisation like the area based matching but try to optimize a (semi-)global cost function. Analysis shows that dynamic programming approaches based on epipolar images like dynamic line warping or semiglobal matching (SGM) yield the best results. However, for cases where only a single stereo pair is available, the results sometimes still contain a small number of outliers, mostly in scenes that are dominated by agricultural areas or near cloud shadows and boundaries. Image matching fails in these areas and a small number of mismatches remain, mainly due to strongly changing reflectance behaviour and movement of object borders. Classical DSM filtering methods are not suitable for these kinds of outliers, as they affect many well recovered man made objects such as large houses. As SGM and other global, pixel based matching algorithms consider the relationship between all disparity values at the same time, they typically produce outlier regions, and not outlier points. This is already exploited by the original SGM algorithm, where a left right check (consistency of matching the first image with the second image and vice versa) is performed, and the resulting disparity map is segmented into regions with similar disparities, and small regions are removed. In this paper a method for improved outlier detection and removal is presented. It removes disparity segments, similar to the SGM algorithm and can be described as a refined version of the small

region removal of the SGM, where a second matching with a different cost function and parameters is performed to remove inconsistent regions. In addition the minimum region size, an overlap ratio for the consistency check, needs to be chosen.

The Working Group 4 of ISPRS Commission I on “Geometric and Radiometric Modelling of Optical Spaceborne Sensors” provides on its website several stereo data sets from high and very high resolution spaceborne sensors. Among these are data from the 2.5 meter class like ALOS-PRISM and Cartosat-1 as well as, in near future, data from the highest resolution sensors (0.5 m class) like GeoEye-1 and Worldview-1 and -2. The region selected is an area in Catalonia, Spain, including city areas, rural areas and forests in flat and medium undulated terrain as well as steeper mountains. In addition to these data sets, ground truth data: orthoimages from airborne campaigns and Digital Elevation Models (DEM) produced by laser scanning, all data generated by the Institut Cartogràfic de Catalunya (ICC), are provided as reference for comparison. The goal is to test algorithms on DEM generation, to see how they match with the reference data and to compare the results within the scientific community.

First evaluations of some of these datasets are presented especially for urban and suburban environment, which show promising results, with minimal influence of the filtering on the correctly matched regions and applicability also to larger datasets. A comparison to the reference data from ICC is performed and the quality improvement is shown.

## Analysis of 3D Forest Canopy Height Models Resulting from Stereo-radargrammetric Processing of TerraSAR-X Images

Roland Perko

*roland.perko@joanneum.at*

Institute of Digital Image Processing, Joanneum Research, Austria  
Austria

Hannes Raggam

*hannes.raggam@joanneum.at*

Institute of Digital Image Processing, Joanneum Research, Austria  
Austria

Karlheinz Gutjahr

*karlheinz.gutjahr@joanneum.at*

Institute of Digital Image Processing, Joanneum Research, Austria  
Austria

Mathias Schardt

*mathias.schardt@joanneum.at*

Institute of Digital Image Processing, Joanneum Research, Austria  
Austria

**Keywords:** TerraSAR-X, stereo-radargrammetry, 3D mapping, canopy height model

**Abstract:** Forest parameters are an important source of information for monitoring climate change issues, quantifying renewable resources, and in general to observe deforestation and forest degradation. These parameters can best be estimated when 3D information on forest is integrated into the classification process [1]. Forest is in general hard to map with optical sensors due to cloud coverage, which may be especially high over rain forests. So the question remains whether radar data, in particular high-resolution TerraSAR-X products [2], can be reasonably used for 3D forest mapping. For areas of forest, SAR interferometry using TerraSAR-X data cannot be applied practically due to the strong temporal phase decorrelation caused by the small wavelength of X-band [3]. Therefore, this study is based on the authors' previous work [4,5] where 3D surface reconstruction is performed by a stereo-radargrammetric approach incorporating multiple images acquired at different off-nadir look angles.

Stereo-matching of forested areas in TerraSAR-X images in general is a very challenging task. In such regions SAR speckle as well as SAR layover, foreshortening and shadow effects complicate the task of identifying homologous points via fully automatic stereo matching procedures. This difficulty gets even worse when incorporating steep off-nadir look angle images, as the ground sampling distance decreases with the look angle. As a result, this work proposes a solution and discusses the influence of off-nadir look angles as well as multi-image intersection angles for the specific task of canopy height model extraction. The major contribution of this study is given by an in-depth analysis of the resulting 3D surface models. These models are evaluated by comparison to laser scanner LiDAR digital surface models, yielding an accuracy estimation along with quantitative statistical results (a residual standard deviation of about 2m is achieved). In addition, the LiDAR data is used to extract digital terrain models, which are the basis for deriving 3D forest canopy height models. Future work will focus on forest parameter estimation, like crown closure, vertical stand structure or stand height, given the derived canopy height models. Time will show whether future TanDEM-X and TanDEM-L missions can provide an even better accuracy for forest canopy height models than the proposed method.

[1] Hyyppä J., Hyyppä, H., Inkinen, M., Engdahl, M., Linko, S., and Zhu, Y.-H.: Accuracy comparison of various remote sensing data sources in the retrieval of forest stand attributes. Forest

Ecology and Management, 2000, 128:109–120.

[2] DLR, 2008. TerraSAR Ground Segment – Basic Product Specification Document, Doc. TX-GS-DD-3302, issue 1.5, 103 pages.

[3] Bamler, R., Adam, N., Hinz, S., Eineder, M.: SAR-Interferometrie für geodätische Anwendungen. Allgemeine Vermessungs-Nachrichten, 2008, 243-252. [4] Raggam H., Perko, R., and Gutjahr, K.H.: Investigation of the Stereo-Radargrammetric Mapping Potential of TerraSAR-X. 29th Annual EARSeL Symposium, Chania, Greece, 15th – 18th June, 2009.

[5] Raggam, H., Gutjahr, K.H., Perko, R. and Schardt, M.: Assessment of the Stereo-Radargrammetric Mapping Potential of TerraSAR-X Multibeam Spotlight Data, IEEE Transactions on Geoscience and Remote Sensing, 2010, 48(2), 971-977.

## Accuracy Assessment of the SRTM and ASTER DSMs on a Large Area in Northern Italy

Vittorio Casella

*vittorio.casella@unipv.it*

University of Pavia - Department of Building and Territorial Engineering  
Italy

Marica Franzini

*marica.franzini@unipv.it*

University of Pavia - Department of Building and Territorial Engineering  
Italy

Barbara Padova

*barbara.padova@unipv.it*

University of Pavia - Department of Building and Territorial Engineering  
Italy

**Keywords:** DEM, SRTM, ASTER, accuracy, validation

**Abstract:** Digital terrain and surface models are continually gaining an increased importance in several sectors of geographic information, photogrammetric production, land management, territorial risk assessment and emergency recovery. The SRTM and ASTER DSMs are particularly interesting and useful because they are freely available and global. Their characteristics, in terms of overall accuracy, systematic and random errors are still a research topic, even if some studies are already available; this is especially true for the ASTER digital model, whose availability is more recent. The Lombardia Region, located in Northern Italy, whose main city is Milano, has a good geodetic and cartographic infrastructure: the whole region is covered by a GPS network constituted by more than 500 vertices whose coordinates are freely available; some parts have denser networks such as the Milano and Cremona cities and the Pavia Province. The vertices of the listed networks are very good check points as their coordinates (East, North and ellipsoidal and orthometric heights) are known at the centimetre level. Moreover, the regional topographic database has many features which can be downloaded from the so-called Region geo-portal: the raster 1:10000 map; many vector thematic layers such as soil classification; a DSM having a 20 m resolution and a nominal accuracy of 5 m. Finally, the authors are provided with several lidar datasets acquired above the Pavia city: their extent is only 20 sq km, but their overall accuracy is between 15 and 20 cm.

The paper concerns the rigorous assessment of the SRTM and ASTER DSMs above the Lombardia Region, in Italy. Lombardia is one of the 20 Italian regions and is 24000 sq km wide; its territory includes flat areas, hills and mountains; urban and country areas, the latter being subdivided into wooded, cropped and waste land. The assessment is performed in three ways. For the city area of Pavia, the investigated DSMs are compared with the lidar ones, whose accuracy is well known from previous studies and papers.

Secondly, the ASTER and SRTM models are compared to the GPS points. In order to separate the error sources, control points are preliminarily classified by visual inspection, depending on their closeness to buildings; the aim being to separate the pure altimetric error contained in the investigated DSMs from the interpolation one, which happens when a DSM tile contains open and built-up terrain. Finally the Region DTM is assessed by the GPS in order to determine its actual accuracy figures; then it is used as a reference for the investigated DSMs.

For each control point, GPS point or node of the regional DTM, a row is added to the report table; it contains the height difference, the terrain typology and also terrain slope, derived from the Region model. Results are summarized according to following categories: urban; flat and steep open terrain; flat and steep forest.

## Digital Height Models Generation by Means of Optical Stereoscopy and Interferometry – Case Study

Iulia F Dana  
*iulia.dana@rosa.ro*  
Romanian Space Agency  
Romania  
<http://www.rosa.ro/>

**Keywords:** digital height model, optical stereoscopy, interferometry, synthetic aperture radar, digital surface model, filtering, digital elevation model, accuracy

**Abstract:** Presently, Digital Height Models (DHMs) are used in a wide range of applications in many different domains: civil and industrial engineering (e.g. highways, railways, dams, irrigation systems, electric networks design), military (e.g. flight simulation), environmental studies (e.g. climatic impact studies, disaster management, vegetation monitoring), agriculture (e.g. surface modeling, land use management, precision farming), geology and geomorphology (e.g. erosion processes, landslides, landform genesis), hydrology (e.g. water sources management, hydrological modeling, flood risk assessment, glaciology), communications (e.g. visibility analysis), navigation (e.g. air traffic control) as well as geodesy (e.g. geodetic networks design) and cartography, photogrammetry and remote sensing (e.g. georeferencing, geometric and radiometric corrections of images, orthoimages creation, contour lines generation) [1].

This paper presents two different techniques for DHMs generation: optical stereoscopy using satellite images (SPOT 5 HRG data) and interferometry using Synthetic Aperture Radar (SAR) images (ERS 1/ERS 2 Tandem, ENVISAT ASAR, TerraSAR-X StripMap and High Resolution Spotlight data). In the framework of the case study, two test sites have been selected: Bucharest (urban area) and Siret (flat up to rolling area). In case of test area Bucharest, a number of Digital Surface Models (DSMs) have been generated by means of automatic image matching and interferometry using the above mentioned satellite data (optical and radar). These DSMs have been edited in order to remove the artifacts remained after their automatic generation. Finally, a comparative study regarding the accuracy of the generated DSMs has been performed, including other available DSMs for the test area (SPOT 3D, SRTM, dTED0 and ASTER GDEM). For test area Siret, the DSMs have been generated using only optical stereoscopy (based on SPOT 5 HRG data). These models have been filtered in order to remove the points not belonging to the bare ground and to obtain the Digital Elevation Model (DEM). Also, a comparative analysis has been made using data available for this test site (SPOT 3D, SRTM, dTED0, ASTER GDEM, a DEM provided by the National Agency for Cadastre and Land Reclamation and a DEM created by cartographic digitization of the contour lines extracted from the existing topographic maps).

[1] Sulebak, J. R. (2000). Applications of Digital Elevation Models, SINTEF Institute of Applied Mathematics, Department of Geographic Information Technology, DYNAMAP Project, White Paper

## Three-dimensional Visualization of Spatial Development of Torun City (Poland) using Digital Photogrammetric Workstation

Marek Wlodek  
Nicolaus Copernicus University  
Poland  
<http://www.geo.uni.torun.pl/eng/index.html>

Mieczyslaw Kunz  
*met@umk.pl*  
Nicolaus Copernicus University  
Poland  
<http://www.geo.uni.torun.pl/eng/index.html>

**Keywords:** city 3D, digital photogrammetric workstation, residential district, Torun

**Abstract:** In the landscape analysis possibility of creation and use of the third dimension influenced analysis, conclusions and visualization of the research point essentially. For urban areas 3-D models have become standards, and the three-dimensional visualization of buildings and also whole housing estates or even cities is today commonly used. However, in such applications the three-dimensional visualization is usually created. It sometimes has thematic layer added on the bases of the current state. Their goal is mainly a realistic visualization itself.

From the point of view of spatial development of the city, planning new investments, defining new areas for some activities, and analyzing the current state together with the estimation of past activities and decisions, third dimension is essential, useful and very much appreciated. However, analysis showing in such a way the development of estates in a longer period of time is rarely done. There are several ways for generating the third dimension for 3-D model of cities. Each of them needs characteristic details, time consumption, and specific technical features, and the gained effect may be qualified according to CityGML standard to five different levels of precision (LoD).

Studies were done in the Wrzosey residential district in Toruń. It is situated in the northern part of the city, and it is surrounded by forests. This housing estate of the area of 3.8 square km is inhabited by over 20 000 residents. It is one of the biggest typically organized residential district with single-family dwellings in Poland.

The goal of the study was the three-dimensional visualization of the Wrzosey residential district in Toruń with the analysis of its spatial development in 1975-2005 on the basis of aerial photographs. In this visualization and analysis stereoscopic, panchromatic, and color aerial photographs from 1975, 1998 and 2005 were used. For each of these stages three-dimensional models were created with the precision of LoD2. These models were done with the application of Dephos digital photogrammetric workstation. The precision GPS receiver was used to absolute orientation of stereograms. The City Walker software was used to final animation. This built 3-D model of Wrzosey residential district has also extended by its network of roads.

## Learning Tools for Laser Scanner Data: Wiimote and IRpen

Dante Abate  
*dante.abate@enea.it*  
ENEA Research Centre  
Italy

Graziano Furini  
*graziano.furini@enea.it*  
ENEA Research Centre  
Italy

Silvio Migliori  
*silvio.migliori@enea.it*  
ENEA Research Centre  
Italy

Samuele Pierattini  
*samuele.pierattini@enea.it*  
ENEA Research Centre  
Italy

**Keywords:** laser scanner data; cultural heritage; wiimote; IR (Infra Red) pen; motion tracking; learning; interaction.

**Abstract:** Laser Scanner 3D is a well known technique. Data are represented by point clouds, each of which is characterized by the three spatial coordinates x, y, z, the reflectance and, eventually, Red Green Blue (RGB) value. Nowadays the main innovations in this field of study are mostly represented by more and more compact dimensions of the apparatus and by the increasing speed of acquisition of new models.

The possibility to realize low cost tools for the direct interaction “user-software-data” allows to explore new ways for the usage of point clouds data especially for learning environments.

The main aim of this study is to create a different approach to the laser scanner data, more direct and involving, where operators and specialists can work in direct contact with it.

A new opportunity is offered by exploiting the characteristics of a video game console available on the market.

In 2006, Nintendo has released a new console called Wii. Instead of using traditional joypad, this console can be controlled through the so-called wiimote, a wireless joypad. The wiimote controller consists of an accelerometer and an IR camera with the addition of traditional buttons. Because of the low cost of this controller and its high speed tracking abilities it can be used successfully to test the potential degree of usability in a field of studies like cultural heritage, where often fund raising is tricky and interaction with digital data are often required.

The hardware used is composed by: 3 wiimotes, 1 IR pen, retro-projected stereo wall system.

The software used are: GlovePie open source software to emulate the mouse movements with the wiimote; Smoothboard software for the calibration of the IR pen used to interact directly with the point clouds; Cyclone 7.0; OpenSceneGraph viewer.

Three wiimotes, connected by Bluetooth to the pc, were used: one to navigate the point cloud and two to track the IR pen which was capturing the points on the virtual whiteboard.

The first wiimote emulate the mouse movements using GlovePie open source software. The operator, just pitching and rolling the controller and pushing the buttons, is able to navigate the point cloud. The other two wiimotes are used to track the IR pen, previously calibrated using Smoothboard software. The IR pen is a pen which have an IR led on its tip, so the wiimotes are able to identify properly its position.

We tested this new method firstly on a commercial software like Cyclone 7.0 and then on an open source solution like OSGviewer, using the point cloud of the Basilica of San Paolo Maggiore in Bologna acquired during summer 2009 by ENEA researchers.

Working with the IR pen, and the wiimote for pan, zoom and orbit, on Cyclone appears very fast and comfortable in exploiting the different tools of the software like measuring and drawing.

With the OSGviewer we tried to experience the direct interaction with the point cloud in a 3D virtual environment using a retro projected stereo wall system and 3d passive glasses.

## Multi-temporal MODIS Snow Cover Monitoring over the Alpine Regions for Civil Protection Applications

Nico Mölg  
*nico.moelg@eurac.edu*  
Researcher

Philipp Rastner  
*philipp.rastner@eurac.edu*  
Researcher  
Italy

Luca Irsara  
*luca.irsara@eurac.edu*  
Software Developer  
Italy

Claudia Notarnicola  
*claudia.notarnicola@eurac.edu*  
Senior Researcher  
Italy

Christian Steurer  
*remote.sensing@eurac.edu*  
EURAC Institute for Applied Remote Sensing  
<http://www.eurac.edu>

Marc Zebisch  
*marc.zebisch@eurac.edu*  
Scientific Director  
Germany

**Keywords:** MODIS, snow cover, Civil Protection,

**Abstract:** This study presents a comparison on a multi-temporal basis between snow cover data derived from (1) MODIS images and (2) LANDSAT images as well as the derivation of related information from these maps [1,3]. The test area is located in the Southern Alps and covers the Italian Autonomous Province of Bolzano/Bozen.

The knowledge of snow cover is a key information in hydrology, weather forecast and flood warning as well as in climatological models, ecology or phenology. Satellite sensors offer a unique advantage in monitoring snow cover due to their temporal and spatial synoptic view. The Moderate Resolution Imaging Spectrometer (MODIS) from NASA is especially useful for this purpose due to its high temporal frequency.

The snow cover maps derived from MODIS images are obtained using a newly developed algorithm taking into account the specific requirements of mountain regions with a focus on the Alps [2]. This algorithm requires the standard MODIS products MOD09 and MOD02 as input data and generates snow cover maps at a spatial resolution of 250 m. The final output map derives from a combination of MODIS AQUA and MODIS TERRA snow cover maps, thus reducing the presence of cloudy pixels and no-data-values due to topography. By using these maps, daily time series starting from the winter season (November – May) 2002 until 2008/2009 have been created.

Along with snow maps from MODIS images, also some snow cover maps derived from LANDSAT images have been used. Due to their high resolution (< 30 m) they have been considered as evaluation data.

From the snow cover maps other information are extracted such as snowline, depletion curves and snow cover duration. By using the new algorithm with respect to the NASA MOD10 and MYD10, the preliminary results indicate an improvement of the classification results from around 85

The main aim of the activities is to provide useful information such as daily snow cover maps, 8-day and 16-day composite snow cover maps and snow line for the avalanche prevention service of the Regional Civil Protection.

References [1] Rigon R., Bertoldi G. and Over T.M. 2006. GEOtop: A Distributed Hydrological Model with Coupled Water and Energy Budgets, *Journal of Hydrometeorology*, 7: 371-388. [2] Rastner P., Irsara L., Schellenberger T., Della Chiesa S., Bertoldi G., Endrizzi S., Notarnicola C., Steurer C., Zebisch M. 2009. Monitoraggio del manto nevoso in aree alpine con dati MODIS multi-temporali e modelli idrologici, 13th ASITA National Conference, 1-4.12.2009, Bari, Italy. [3] Zanotti F., Endrizzi S., Bertoldi G. and Rigon R. 2004. The GEOtop snow module. *Hydrological Processes*, 18: 3667–3679. DOI:10.1002/hyp.5794.

## Groundwater Flow Paths Delineation using Remote Sensing Techniques and GIS

Constantine A Papatheodorou  
*conpap@teiser.gr*  
Assist. Professor  
Greece

**Keywords:** remote sensing, band ratio, groundwater, geochemistry, ion ratio, recharge

**Abstract:** Groundwater exploitation in the western part of the plain of Thessaly (Greece) started during the 50's and led to a significant reduction of groundwater resources, thus creating the necessity of groundwater resources management and protection. Within that context, a case is presented where Landsat TM images, band rationing and color composites were used to map lineaments and identify fractures and faults in the area. By combining remote sensing results with groundwater chemical analyses data, groundwater inflow paths through theoretically impermeable formations, were identified. Based on the above, groundwater protection zones were delineated in order to protect recharge areas and to help preserve groundwater quality.

## Using Remote Sensing and GIS Technologies for Hydrological Modelling

Nataliya Ershova  
*natasha-er@yandex.ru*  
Kyrgyzstan

Nataliya Ivanova  
Kyrgyzstan

**Keywords:** Hydrological model, Glacier area, Land use, Remote Sensing, GIS technologies

**Abstract:** At present time hydrological modelling of river flow is important element for planning and management of water resources, development river flow forecast as well as research of river flow formation.

Investigation impact of climate and land use changes on the Sokuluk river (one of the typical river in Kyrgyzstan) was done using hydrological model PREVAH. Input data of model were spatial and meteorological data. The aim of the poster is to show using Remote Sensing and GIS technologies for hydrological modelling. Several Landsat images were used for creation land cover map and dynamic of glacier area map in the Sokuluk river basin. Created maps allowed improving quality of hydrological modeling.

## Determination of Surface Water Resources Changes by Multi Temporal Satellite Imagery and Investigations of Groundwater by using Geoistatistical Method

Buyuk Menderes Basin

Yasemin Ozdemir  
ozdemiry@marmara.edu.tr  
Turkey

**Keywords:** Geoistatistical, Remote Sensing, GIS, surface water, groundwater

**Abstract:** Water has vital importance for living. According to UNESCO's report, it is envisaged that one billion and hundred people will experience water scarcity in 2025. Due to the unbalanced distribution of population density in the world during the ten-year-duration, it is foreseen that water needs of 40

To determine the changes in the field of surfacewaters; MSS, 1987 TM, 2000 and 2006 ETM LANDSAT images, supervised clasification and manuel digitazing methods were used. Data of 450 wells which opened by General Directorate of State Hydraulic Works (DSI) was evaluated. Related to these 450 wells of Büyük Menderes River Basin, databases were developed about the depth of the water wells, static water level, dynamic water level, well yield and etc. Using Geostatistical Analyst module of ArcInfo and Krigging interpolation technique groundwater level,static and dynamic groundwater level,groundwater productivity maps were created. To produce this spatial distribution maps kriging interpolation technique was used. Interpolation procedures; IDW, trend surface analysis, and simple mathematical models, such as Thiessen polygons or kriging, spline geostatistical more complex methods such as can be done . In this study, kriging method was used. The performance of kriging techniques of data variability, spatial structure and used to estimate the variogram model of selection, research in distance and number of samples can be affected significantly. Finally,in parallel with population growth within the basin, agricultural areas are also on the rise. Therefore, over the years of groundwater level and productivity significantly negatively affected have been identified. Surface waters within the basin, this case clearly been identified. In 2000, the changes in water resources in particular is very clear. At studies which used remote sensing and geoistatistical methods have advantages related to water resources.

## Forest Fires Emissions Estimation Coupling Remotely Sensed Imagery and GIS Modeling

Gherardo Chirici  
*gherardo.chirici@unimol.it*  
Italy

Enrico Marchi  
Italy

Marco Ottaviano

Daniela Tonti

Marco Marchetti

**Keywords:** forest fires, emissions, k-nn, forest biomass

**Abstract:** Emissions from forest fires have a relevant impact on environment, human health and security. The estimation of air pollution generated by vegetation fire smoke (VFS) is a relevant issue at global level. In Europe (from 19 Countries in the period 2000 - 2005) the estimated annual burned biomass ranges between 4.2 and 11.0 Tg in the USA it ranges between 9 and 59 Tg. Remote sensing plays a relevant role in providing a large number of useful information supporting the estimation of pollution from VFS. This paper presents the first results from a test carried out in central Italy (Molise region) where multispectral high resolution SPOT5 imagery was used to estimate the pre-fire vegetation biomass and to map both the fuel and the burned area. The k-nearest neighbors (k-nn) non-parametric method was used to map vegetation biomass on the basis of a field survey.

The biomass map was then overlaid with a detailed fire map created outlining and classifying the burned area in terms of burning efficiency, vegetation and fuel types. The resulting GIS based model is able to derive a detailed raster based fire emission map with the same geometric resolution of the input SPOT5 imagery. Smoke plumes were also modelled on the basis of local meteorological conditions. The results are compared with the information provided by the European Forest Fire Information System (EFFIS) developed by the Joint Research Centre of the European Commission.

## Forest Fire Damage Estimation Using Remote Sensing and GIS

Ugur Alganci  
*ugur@cscrs.itu.edu.tr*  
Res. Assist.  
Turkey

Elif Sertel  
*sertele@itu.edu.tr*  
Asist. Prof. Dr.  
Turkey

Cankut Ormeci  
*cankut@itu.edu.tr*  
Prof. Dr.  
Turkey

**Keywords:** forest fire, SPOT4, classification, NDVI, change analysis

**Abstract:** Forest fires have been causing serious damages and threats in Turkey especially over Aegean and in Mediterranean Regions. Remote sensing technology can be used in different phases of fire management which are risk estimation, detection and assessment. Risk assessment is made before the fire while fire detection can be done during the fire using near real time satellite images. Fire assessment done after the fire is the main focus of this research where we analyzed a forest fire occurred on 10th August 2009 in Seferihisar district of Izmir, Turkey. SPOT 4 images obtained before (01.08.2008) and after (31.08.2009) the fire were used in this study. First, both images were orthorectified using Ground Control Points and 1/25000 scale topographic map derived Digital Elevation Model. Normalized Difference Vegetation Index (NDVI) images of the region were created using red and near infrared channels of satellite image data. Level slicing method was applied to NDVI images to determine the burned and fire affected areas. Pre- and post- fire images were classified to identify land cover types before and after the fire. NDVI images and classified were compared to find out the fire impact on Seferihisar forest area. Also, processed satellite images, digital elevation model and meteorological data were analyzed within a geographical Information System to reveal the relationships among the topography, meteorological variables and fire magnitude.

## Fire Impacts on Savanna Vegetation Trends in Madagascar using a Remote-sensing Based Statistical Analysis

Anne Jacquin  
*anne.jacquin@purpan.fr*  
Ecole d'ingénieurs de Purpan  
France

Véronique Chéret  
Ecole d'Ingénieurs de Purpan  
France

**Keywords:** savanna , fire , vegetation trend , remote sensing , Madagascar

**Abstract:** Fire is an important disturbance factor of savanna vegetation dynamics which interacts in a complex way with other factors such as land use and climatic conditions. Fire could be considered as a factor that maintains savanna or as a degradation agent. In a context of land degradation prevention, the objective of this study is to understand the role of fires in savanna vegetation cover trends. The study site is located in the Marovoay watershed, on the north-west coast of Madagascar. This is one of the five pilot sites of a national program of soil erosion control called PLAE.

The role of fires in the savanna vegetation cover trends is addressed through a landscape-scale analysis of the spatial relation between a fire regime indicator, which combines fire seasonality and frequency, and an indicator of vegetation cover change. These data are derived from MODIS remote sensing time series data covering the 2000-2008 period. For each type of savanna vegetation cover trends observed (negative, positive or stable), different multivariate regression models are proposed.

The results of this study clearly support the idea that fires have widely varying impacts on savanna vegetation cover. Fires could be considered as a savanna management tool. But, their usages through the seasonality and the frequency should be adapted according to land use (agricultural area, pastoralism, protected area).

To define fire management plan at the landscape-scale, there is a need to study locally the interactions between fire usages, land-use and vegetation cover trends. The methods based on remote sensing time series analysis provide relevant results. In the Malagasy savanna, according to land-use, it exists statistically significant relations between fire regime and vegetation cover trends. Finally, this study shows that, for a known land-use, by monitoring fire regime modifications, it is possible to understand variations of savanna vegetation cover trends.

## Fire-induced Changes in Land Surface Temperature, Surface Albedo and Thermal Inertia Assessed with MODIS

Sander Veraverbeke  
*Sander.veraverbeke@ugent.be*  
Ugent  
Belgium

Rudi Goossens

Ruben Van De Kerchove

Willem Verstraeten

Stefaan Lhermitte

**Keywords:** fire, climate, MODIS, land surface temperature, albedo, thermal inertia

**Abstract:** The effect of the large 2007 Peloponnese (Greece) wildfires on changes in broadband surface albedo ( $a$ ), day-and night-time land surface temperature (LST) and apparent thermal inertia (ATI) were studied. This was done based on a two-year post-fire Moderate Resolution Imaging Spectroradiometer (MODIS) satellite images sequence. Firstly, a pixel-based control plot selection procedure was initiated based on a pre-fire time series similarity of biophysical variables ( $a$ , LST, ATI and Normalized Difference Vegetation Index (NDVI)). Then differences in mean  $a$ , LST, ATI and NDVI of the control and burned pixels were compared. Immediately after the fire event mean  $a$  dropped with  $0.028 \pm 0.017$  ( $p < 0.0001$ ), mean day-time LST increased with  $5.21 \pm 3.01$  K ( $p < 0.0001$ ), mean night-time LST decreased with  $0.22 \pm 1.28$  K ( $p > 0.0001$ ) and mean ATI decreased with  $0.013 \pm 0.009$  K-1 ( $p < 0.0001$ ). During the wet Mediterranean winter periods changes in  $a$ , day-time LST and ATI were small and most of the time statistically insignificant ( $p > 0.0001$ ), while the night-time LST decrease was occasionally significant and up to  $-0.46$  K. During the subsequent dry Mediterranean summer periods, the magnitudes of changes attenuated with time as a consequence of vegetation regeneration processes, however differences in  $a$ , day-time LST and ATI between control and burned pixels remained significant two summers after the fire ( $p < 0.0001$ ). Conversely to the immediate post-fire drop, albedo increased (up to mean increases of 0.01) during the subsequent summer periods. The magnitude and persistency of changes in  $a$ , LST, and ATI showed a clear relation with fire/burn severity, elucidating the importance of vegetation as a regulator of land surface energy fluxes. This research provides insights in the understanding of short-term fire effects on regional climate.

## MODIS Data Mining to Map Burnt Areas

Carmen Quintano  
*menchu@tele.uva.es*  
University of Valladolid  
Spain

Alfred Stein  
*stein@itc.nl*  
Twente University, Faculty of Geo-Information Science and Earth Observation (ITC)  
Netherlands

Wietske Bijker  
*bijker@itc.nl*  
Twente University, Faculty of Geo-Information Science and Earth Observation (ITC)  
Netherlands

Alfonso Fernández-Manso  
*alfonso@unileon.es*  
University of León  
Spain

**Keywords:** Burnt areas, MODIS, data mining

**Abstract:** An estimation of the size of areas burnt by forest fires in Mediterranean countries is achieved by applying an image mining method to MODerate-resolution Imaging Spectroradiometer (MODIS) satellite data. The proposed method relies on a single post-fire image as input (unitemporal perspective) and involves three steps: kernel based smoothing, modelling as a sum of Gaussian functions and thresholding. The optimal smoothing parameter, the optimal stopping rule of the modelling iterative algorithm and the optimal threshold are identified by using the psy<sup>6</sup>B statistic. This statistic determines the accuracy of the estimated size of the burnt areas by relating it with perimeters of these area measured by Global Positioning System (GPS). Two indices, specifically designed for burnt area identification are used as an input: the Burnt Area Index (BAI) and the Normalized Burn Ratio (NBR). These indices are more adequate to identify burnt areas than the Normalized Difference Vegetation Index (NDVI). A z-test based on the psy<sup>6</sup>B statistic compares the accuracy of these estimations with the accuracy obtained from a direct classification of the input image. Results show that image mining based methods result in a higher accuracy of the burnt areas estimation. We conclude that MODIS data mining is well suited to accurately map burnt areas.

## Fractional Type Convolution Pre-filtering to Map Burned Areas

Eduardo Cuesta  
*eduardo@mat.uva.es*  
 University of Valladolid

Carmen Quintano  
*menchu@tele.uva.es*  
 University of Valladolid  
 Spain

**Keywords:** Burned areas, MODIS, fractional filtering, convolution filtering

**Abstract:** The present study considers a single-date approach to map burned areas in Mediterranean countries (Spain). MODerate-resolution Imaging Spectro-radiometer (MODIS) on board the TERRA satellite provided the post-fire data. The original MODIS bands were classified (conventional pixel-oriented classifier) to estimate the burned areas. The main novelty is a filter based on convolution equations of a fractional type used as a pre-classification step. Particularly, the fractional filtering was based on the following partial fractional differential equation:

$\frac{\partial u(t,x)}{\partial t} = \lambda u(t,x), (t,x) \in [0,T] \times \mathbb{R}^2, u(0, x) = u_0(x),$

where  $\frac{\partial u(t,x)}{\partial t}$  stands for the time derivative of order  $\alpha > 0$  (even for non-integer  $\alpha$ ) in the sense of Riemann–Liouville and,  $u_0$  stands for the original image. The fractional filter we propose as pre-classifier fits into a closed mathematical framework of well-posedness and numerical solvability. The results in the two considered study areas showed: 1) despite of Producer Accuracy (PA) remained almost constant, the User Accuracy (UA) increased when the fractional filter was employed (commission error decreases); and 2) the Kappa statistic increased by using the proposed fractional filter in 5

## Object-Based Image Analysis of Fraction Images to Map Fire Scars

Oscar Fernández-Manso  
*out-fermanos@jcyL.es*  
Junta de Castilla y León  
Spain

Carmen Quintano  
*menchu@tele.uva.es*  
University of Valladolid  
Spain

Alfonso Fernández-Manso  
*alfonso@unileon.es*  
University of León  
Spain

Yosio Shimabukuro  
*yosio@dsr.inpe.br*  
Instituto Nacional de Pesquisas Espaciais (INPE)  
Brazil

**Keywords:** Burned areas, MODIS, OBIA, SMA

**Abstract:** This work presents a methodology based on the combined use of Spectral Mixture Analysis (SMA) and Object-Based Image Analysis (OBIA) to map fire scars. Firstly, a linear SMA was applied to the original bands. Next, the obtained fraction images were used as inputs of OBIA. Image objects were extracted from the fraction images in the segmentation procedure prior to classification. Finally, the classification accuracy was evaluated using ground referenced data from field surveys. A post-fire image provided by the MODerate Resolution Imaging Spectroradiometer (MODIS) was used to show the proposed method. The study area was the large forest fire happened in Arenas de San Pedro (central Spain) from 28th July 2009 to 1st August 2009. Results showed that during the segmentation process the fraction images allowed extracting features that were not well distinguishable in the multispectral image. These features based on object information (from fraction image-abundance values) as well as object contextual information were used in the subsequent classification process. Two different levels of image objects representing different scales were created to identify the burned area perimeter. We conclude that combination of SMA and OBIA improve the results obtained by using just one of them.

## Effectiveness Over Time of a Short Training Initiative Related to Free and Open Source Software for Earth Image Processing

Jos M.F. Van Orshoven  
*jos.vanorshoven@ees.kuleuven.be*  
Belgium  
<http://www.sadl.kuleuven.be>

Rafal Wawer  
*rafal.wawer@sadl.kuleuven.be*  
Belgium  
<http://www.sadl.kuleuven.be>

**Keywords:** Education, Earth image processing, FOSS4G, Effectiveness

**Abstract:** In the summers of 2007, 2008 and 2009 we conducted an in-class, two-week training initiative dealing with free and open source software (FOSS) for geomatics (FOSS4G) in the context of land evaluation and land use planning. Although the particular set up, content and focus of the courses evolved over time, in each course trainees were amply exposed to the earth image processing capabilities of the -at the time- most recent version of the FOSS 'GRASS for Windows'. At the end of each the three courses, 5 months after the 2009- training, 17 months after the 2008-edition and 29 months after the 2007-edition, we enquired the 62 participants, coming predominantly from educational and research settings in developing countries, about their intended and effective further use of the FOSS and the other training materials. With this enquiry we aimed at documenting their perspective on the use of FOSS4G in education in general and of FOSS for earth image processing in particular.

The survey results show that at the end of the courses, a majority of the participants intended to take the step to GRASS in their professional practice including teaching, but that a relatively small fraction of the responding participants has effectively done so. This fraction is slightly increasing with time though, from 20

## EUFAR On-board Training Opportunities to Advance Airborne Research

Ils Reusen  
*ils.reusen@vito.be*  
VITO  
Belgium  
<http://www.vito.be>

Jean-Louis Brenguier  
*bureau@eufar.net*  
France

Phil Brown  
*phil.brown@metoffice.gov.uk*  
United Kingdom

Manfred Wendisch  
*m.wendisch@uni-leipzig.de*  
Germany

**Keywords:** airborne, atmosphere, hyperspectral, training

**Abstract:** EUFAR, European Facilities for Airborne Research, is an FP7 project (<http://www.eufar.net>) funded by the European Commission with 33 partners that aims at providing and improving the access to European airborne facilities (i.e. aircraft, airborne (imaging) instruments, data processing centres) for researchers in environmental and geo-sciences through Networking Activities, Transnational Access and Joint Research Activities.

This paper reports on the training opportunities within EUFAR for European researchers.

In EUFAR now four types of training opportunities are offered: [U+FOA7] Participate in training courses (ET-TC) [U+FOA7] Join an existing field campaign (ET-EC) [U+FOA7] Participate in the design of a new field campaign (ET-TA), in the frame of EUFAR Transnational Access and tutored by more experienced researchers [U+FOA7] Visit to aircraft/instrument operators for exchange of knowledge and know-how (ET-VO).

During the 4-year EUFAR project (2008-2012), 4 training courses covering the complete chain from acquisition to interpretation of airborne data and (hyperspectral) images will be organised during spring/summer for early-stage researchers as well as university lecturers (new in FP7 EUFAR) in airborne research. Proposals for the organisation of EUFAR training courses can be submitted on-line through EUFAR Transnational Access (TA). The training courses have an equal focus on theory and practical training/demonstration and each training course will be accompanied by a “student” airborne field campaign. Participants will be trained by top-class scientists, aircraft and/or instrument operators and each participant will get the opportunity to design his/her own experiment and to participate to that flight experiment.

Furthermore, researchers have the opportunity to join an existing field campaign and work with more experienced researchers, aircraft and/or instrument operators. The list of airborne field campaigns open to join and the eligibility criteria, can be consulted at the EUFAR website.

Researchers have the opportunity to participate in the design of a new field campaign in the frame of EUFAR Transnational Access (TA). TA provides access to either aircraft or instrumentation that are not otherwise available to applicants within their own national research funding regime. Researchers can join a host research group and participate in the design of an airborne field campaign, the flight and the analysis of the acquired data. TA is open to both experienced and inexperienced researchers. If the latter, applicants will be offered feedback from within the EUFAR community

of expert scientists in order to develop and improve their proposals prior to formal review. In addition, applicants to the TA process may be offered opportunities to cluster their field campaigns with others making use of the same facility, hence providing further opportunities for interaction with more experienced users of research aircraft and instrumentation.

And finally, a new training opportunity is offered for aircraft/instrument operators to exchange personnel (typically 1 week visit). The objective is to share their knowledge and know-how (about instrument calibration, data acquisition, etc.) during field campaigns or tests at a ground facility.

For on-line submission of EUFAR Education and Training proposals/applications, visit <http://www.eufar.net>.

## The GEO Network for Capacity Building (GEO-Net-CaB)

Sylvie Marzocchi  
*sylvie.marzocchi@cnes.fr*  
CNES Paris  
France

A. Sand  
CNES Toulouse  
France

M. Noort  
ITC, Enschede  
Netherlands

F. Huynh  
IRD, Montpellier  
France

JC Desconnet  
IRD, Montpellier  
France

**Keywords:** GEO, Capacity Building, education, earth observation, climate monitoring, brokerage network

**Abstract:** The purpose of the GEO Network for Capacity Building (GEO-Net-CaB) project is to create the conditions for the improvement and increase of the GEO capacity building activities and framework, with special emphasis on developing countries, new EU member states (and EU neighbouring states) and climate monitoring . It will serve the bigger goal of improved effectiveness and efficiency of GEO capacity building for application in the GEO societal benefit areas. Coinciding with this purpose, successful brokerage with (potential) clients for earth observation products and services will be facilitated.

The project will deliver the following outputs: 1. Capacity building needs in earth observation are identified (at a generic and global level, but with emphasis on the target regions). 2. Specifications for earth observation capacity buildings are described. 3. Resource providers are identified. 4. Sustainable brokerage between stakeholders (including resource providers) is established. 5. A mechanism to facilitate cooperation between stakeholders and providers is established. 6. A global base of technical expertise for education and training in earth observation is established (with emphasis on developing countries, new EU member states and climate monitoring). 7. Monitoring and evaluation mechanisms for determining the efficacy of GEO capacity building efforts are established. To achieve maximum impact demonstration projects will be carried out in Southern Africa, the French-speaking countries in Africa, Central and Eastern Europe, with spin-offs to EU neighbouring countries and Latin America and Asia. The project (with a duration of three years) will be carried out by a well balanced consortium of partners from the Netherlands, France, South Africa, Morocco, Czech Republic and Poland, supervised by an advisory board with worldwide representation and strong connections to GEO.

## Developing Educational Simulations for Remote Sensing in Universities

Henryk Hodam  
*h.hodam@geographie.uni-bonn.de*  
University of Bonn

**Keywords:** remote sensing, university, teaching, interactive, educational simulation, 3D, 2D

**Abstract:** This contribution shows how methods of image data interpretation in Remote Sensing can be integrated into educational simulations. The aim of these simulations is to support the teaching of Remote Sensing in universities.

The range of technical tools and possibilities to create such simulations make it hard to predict in how far they influence the success of learning. Learning through educational simulations is based on individually encoding a mental model of the processes shown in the simulation. Investigating to what extent techniques of 3D and 2D interaction and display affect this encoding process is a main goal of this PhD work.

The preliminary work to these investigations consists mainly of creating the educational simulations themselves. Therefore functionalities of remote sensing software are recreated in new environments that enable the learner to comprehend the processes by working with the simulation. The development of educational simulations for remote sensing is based on two main steps:

1. The elaboration of the remote sensing functionalities Because simulations do not produce pre-defined results but results depending on user input, the simulations are using the same, although reduced, methods for image analysis that remote sensing software uses.
2. Design of interaction and result output The visual output as well as the interaction with the processes serve the purpose of supporting the conveyance of those processes into a mental model. Integrating 2D and 3D interaction and displaying methods is part of this step.

Using the examples of the already created simulations for “Additive Color Mixing“ as well as “Feature Space and Classification“ those steps in developing educational simulations for remote sensing are to be explained in the course of this presentation.

## Monteverdi - Remote Sensing Software from Educational to Operational Context

Manuel Grizonnet  
*manuel.grizonnet@cnes.fr*  
CNES  
France

Jordi Inglada  
*jordi.inglada@cnes.fr*  
CNES  
France

**Keywords:** Remote sensing process, Education, Orfeo Toolbox, Monteverdi

**Abstract:** The Orfeo Toolbox (OTB) is an Open Source Remote Sensing Image Processing software toolkit developed by CNES which aims at gathering a large set of state of the art building blocks for building processing chains.

The Monteverdi integrated application is based on OTB and provides a user-friendly graphical interface to many of the algorithms available in the OTB library. The modular architecture of the software allows to easily extend the application with custom algorithms seamlessly integrated in the main application.

All these features make Monteverdi a candidate to provide quick and efficient solutions in educational contexts. It has already been used for several remote sensing trainings and capacity building activities. This paper will present OTB/Monteverdi in terms of available functionalities, but also in terms of philosophy of openness and future evolution.

## Facing the Archaeological Looting in Peru by using Very High Resolution Satellite Imagery and Local Spatial Autocorrelation Statistics

Rosa Lasaponara  
*lasaponara@imaa.cnr.it*  
CNR-IMAA, Tito Scale  
Italy

Nicola Masini  
*n.masini@ibam.cnr.it*  
CNR-IBAM, Tito Scalo  
Italy

**Keywords:** looting, NASCA, satellite, Spatial autocorrelation statistics

**Abstract:** The protection of archaeological heritage from looting is generally based on a direct or aerial surveillance, which is time consuming, expensive and not suitable for extensive areas. Very high resolution (VHR) satellites (GeoEye, WorldView1-2, QuickBird2, Ikonos) offer a suitable chance thanks to their global coverage and frequent re-visitation times.

This paper is focused on results we obtained from ongoing research focused on the use of VHR satellite images and spatial autocorrelation statistics, such as Moran's I, Geary's C, and Getis-Ord Local Gi index (see Anselin 1995; Getis and Ord 1992), for the identification and monitoring of looting.

A time series of satellite images (QuickBird-2 and World-View-1) has been exploited to analyze and monitor archaeological looting in Cahuachi (Peru), the largest adobe Ceremonial Centre in the World built the Nasca Civilization. The spatial autocorrelation statistics enabled us to extract spatial anomalies linked to illegal excavations and to recognize and quantitatively characterize looting patterns over the years.

## Advancement of Relief Interpretation with Sky-view Factor

Archaeological application of an advanced visualisation technique based on diffuse illumination

Žiga Kokalj

*ziga.kokalj@zrc-sazu.si*

ZRC SAZU

Slovenia

<http://iaps.zrc-sazu.si/index.php?q=en>

Klemen Zakšek

*klemen.zaksek@zmaw.de*

University of Hamburg

Germany

<http://www.geophysics.zmaw.de/index.php?id=11L=1>

Krištof Oštir

*kristof@zrc-sazu.si*

ZRC SAZU

Slovenia

<http://iaps.zrc-sazu.si/index.php?q=en>

**Keywords:** sky-view factor, relief visualization, historic landscape, airborne laser scanning, lidar imaging, digital elevation model

**Abstract:** The elements of recent and past cultural landscapes are usually recorded through field surveys that continue to be inevitable for obtaining detailed data. Remote sensing techniques enable much faster and more systematic acquisition of information. In addition they frequently enable the recognition of features that cannot be detected with traditional field reconnaissance techniques due to their configuration or environmental peculiarities. The focus of interest has shifted from aerial photography, which has been in use since the beginning of the previous century, towards multispectral and hyperspectral satellite imagery, and active techniques such as laser scanning. With airborne laser scanning we can observe details with high elevation accuracy and with a spatial resolution of less than one meter. However, an effective interpretation of the digital elevation models (DEMs) created from these data requires appropriate visualization. Hill-shading is the most frequently used relief visualization technique and is well suited for printed maps; however it has limited use in the shades. Several authors have tried to overcome its limitations by using multiple angle shading and filtering. The sky-view factor is a new method that computes the portion of visible sky limited by the relief for every point on the ground. By applying it to lidar data we have been able to accurately map unknown archaeological sites and update the existing maps. Sky-view factor additionally proved to be a superior visualization technique as it reveals small relief features while preserving the perception of general topography. Rather than just presenting or visualizing the same information in a new way it extracts new information that can be further processed. In addition to the studies of the past cultural and natural landscapes it can be effectively used in other scientific fields in which digital elevation model visualizations and automatic feature extraction techniques are indispensable, e.g. geography, geomorphology, cartography, hydrology, glaciology, forestry and disaster management.

## GPS RTK Mapping, Kite Aerial Photogrammetry, Geophysical Survey and GIS Based Analysis of Surface Artifact Distribution at the Pre-Hispanic Site of the Castillo de Huarmey, North Coast of Peru

Miron Bogacki

*miron.bogacki@gmail.com*

Institute of Archaeology, Warsaw

Poland

Milosz Giersz

University of Warsaw, Center for Pre-Columbian Studies, Warsaw

Poland

Patrycja Prządka-Giersz

University of Warsaw, Center for Pre-columbian Studies, Warsaw

Poland

Wiesław Malkowski

*wmalkowski@uw.edu.pl*

Institute of Archaeology, University of Warsaw

Poland

Krzysztof Misiewicz

Institute of Archaeology, University of Warsaw

Poland

**Abstract:** A comprehensive archaeological survey of the Castillo de Huarmey site, one of the most important pre-Hispanic Middle Horizon period (AD 600-900) ceremonial and religious centers on the Peruvian North Coast, was carried out by Polish scholars. The survey compared different nondestructive methods: GPS RTK mapping, kite aerial photogrammetry, cesium magnetometry and spatial analysis of surface artifact distribution. The survey data was combined with spatial information using a geographic information system database to record the monumental mud-brick architecture and the vast necropolis of the high-ranking members of pre-Hispanic elites, and to reflect the subsurface site. The undertaking of methodical and comprehensive nondestructive archaeological survey on the North Coast of Peru was one of the first such projects in this region, and is promising for achieving significant advances in the current understanding of local pre-Hispanic societies.

## Application of UAV Documentation of Archaeological Digs and the Derivation of Very High Resolution Digital Elevation Models

Hans-Peter Thamm

*hp.thamm@gmail.com*

Free University of Berlin, Geographical Department, Remote Sensing, GIS and Cartography  
Germany

Konstantin Scheele

Free University of Berlin, Geographical Department, Remote Sensing, GIS and Cartography  
Germany

Verena Henrich

Free University of Berlin, Geographical Department, Remote Sensing, GIS and Cartography  
Germany

**Abstract:** For archeological research remote sensing in a very high spatial resolution is a very useful tool. Due to the technical progress this images can be taken with small remote controlled ultra light air vehicles (UAV). Because of their small size, easy handling and quite reliable flight properties they offer interesting application options. In the paper the application of UAV (remote controlled Octocopter and parachute UAV) for archeological research is presented.

The UAV have some advantages in comparison with classical methods of gaining aerial photos or performing ground survey. Due to the fact that they can be applied by the researcher themselves the images can be taken when it is necessary in the desired spatial and temporal scale. So the documentation of digs can be done every day or even more often.

As well with the UAV unknown find spots can be detected by differences by in the phenology of the vegetation caused by artefacts in the underground changing the hydrological conditions. These differences are in general visible only a few days in the year and are specific for the every site. With UAV it is possible to get information for exact time slice where a detection is possible. With the stereos images gained from the UAV it is possible to derive digital surface models / digital terrain models from the area of investigation in a very high resolution up to several centimeter. This method is much faster that the classical terrestrial survey. With the DSM / DTM topographical context of the find spot can be analyzed. As well other information, like volumes of barrows or mining dumps can be estimated, which allows conclusions on the number of people had been living in the settlements or had worked in the mines.

At the example of a digging sites in Prietele (Romania) and Germany the whole work flow of the application of UAV will be presented and the possibilities and challenges of the different UAV systems will be discussed. As well the processing of the images with the, in comparison, limited image quality because of the small cameras and sometimes poor geometric precision caused by the unstable flight of the UAC are highlighted.

In an outlook enhanced possibilities by using other sensors (thermal, multi-spectral) will be discussed.

## Extreme Climate Events in Polar Regions (Arctic)

Jean Claude Gascard  
*jga@locean-ipsl.upmc.fr*  
Université Pierre et Marie Curie  
France

**Abstract:** During the past 20 years, we observed drastic changes in the Arctic regions culminating during the 4th IPY with a spectacular retreat of the sea-ice cover in September 2007. Compare to the situation 30 years ago, the summer minimum sea-ice extent in the Arctic has been reduced by half based on satellite remote sensing observations. The average sea-ice thickness has also decreased by a factor of 2 and combined with the minimum sea-ice extent reduction at the end of the summer, that would imply the sea-ice mass (or volume) has decreased by 75 percent. This can be considered as a tipping point. We can attribute part of these changes to the atmosphere and part to the ocean due to very strong positive feedbacks such as the albedo responsible for the polar amplification of the actual global warming. In this presentation, I will focus attention on remote sensing techniques, able to provide some very critical information such as sea-ice extent, sea-ice concentration, sea-ice thickness, sea-ice types and ages, sea-ice drift. I will demonstrate the real importance of remote sensing based information for improving our understanding and predictive capabilities related to extreme climate changes in polar regions.

## SEOS - Science Education through Earth Observation for High Schools

e-Learning tutorials for high school education and GMES services

Rainer Reuter  
*rainer.reuter@uni-oldenburg.de*  
University of Oldenburg  
Germany  
<http://las.physik.uni-oldenburg.de>

and the SEOS Project Team

**Keywords:** e-Learning, internet tutorials, science education, GMES services

**Abstract:** SEOS is an initiative for using remote sensing in science education curricula in high schools funded under the 6th Framework Programme of the European Commission (EC). Eleven partners from several European countries, in cooperation with the European Space Agency (ESA) and teachers from European high schools, created e-learning tutorials for science students in high schools across Europe.

Based on real examples, the tutorials use remote sensing images and data to involve students in different aspects of current environmental research and monitoring. The tutorials demonstrate how information from satellites can be directly relevant to everyday life conditions and emphasise the importance of awareness of the environment. They cover a broad range of topics, from daily weather data to long-term climatic conditions, landcover changes, marine pollution and environmental hazards, ocean currents, coral reefs and coastal water quality, natural and cultural heritage and conservation, time series analysis and modelling, to name but a few. Connections between different topics are made clear, and links make it possible for teachers and students to follow their own route through the lessons according to their own interests. The tutorials use the method of Enquiry-based Learning, which is also supported by worksheets highlighting an interesting scenario in the environment followed by questions or tasks which can be solved when studying the web-based tutorials. Advanced information on a more complex level is available through links to supplementary pages, which is particularly relevant with tutorials that are used in physics and mathematics classes.

The tutorials are the core element of the SEOS Learning Management System, allowing teachers to create their own courses, to distribute already available or new worksheets to the students for homework and to collect the results. Forums are available for teachers, students and other (e.g. GMES) users to exchange information and discuss topics relevant for their study.

The project covers many disciplines such as physics, biology, geography, mathematics and engineering, emphasising the interdisciplinary character of remote sensing. Students learn to connect personal observations with global perspectives, and thus gain an understanding of the techniques used to receive and interpret remote sensing data. In this way, they also gain insight into the nature of scientific enquiry, and develop their investigative skills - key aims of modern science education. Integrating earth observation into science education in high schools provides students with a basis for using environmental monitoring techniques in their subsequent working life. For this reason, the tutorials also meet the demands of training courses for the users of the Global Monitoring for Environment and Security (GMES) services. UNESCO will use the SEOS training materials for educational purposes in selected developing countries, thus extending the benefits of this project to an even larger audience.

The tutorials are available in English, German, French, Greek, Dutch and Arabic language, and shall be translated in Spanish and Italian in the near future.

## ESA's Earth Observation Programmes - Achievements, Current Status and Plans for the Future

Volker Liebig  
*volker.liebig@esa.int*  
ESA-ESRIN  
Italy  
<http://www.esa.int>

Michael Rast  
*michael.rast@esa.int*  
ESA-ESRIN  
Italy  
<http://www.esa.int>

**Keywords:** ESA, earth observation programmes

**Abstract:** The explanation of the complex processes of the Earth remains a paramount challenge at the beginning of the third millennium. Earth observation satellites are undoubtedly important to help improving the understanding of processes of our Changing Earth. This knowledge forms the basis for the development of current and future measurement systems for science and applications. ESA has more than thirty years experience in developing and managing Earth observation satellites. Today, its flagships ERS-2 and Envisat are used for a wealth of scientific studies and applications. Their observations underline the trend of global climate change, having detected an accelerated level of global warming and sea level rise - they have shown the shrinking of the Arctic ice cover and a decrease in snow extend on both hemispheres. Furthermore, they help to increase the knowledge of global change processes by monitoring clouds and aerosols, greenhouse gas concentrations, vegetation extent, ocean salinity and many other aspects. With ESA's aim at serving the user community by distilling needs expressed in international context the presentation will not only present achievements as attained by its currently operating Earth Observation satellites, but also explain the status and prospects of ESA's Earth Observation programmes such as GMES and the suite of science-driven Earth Explorer missions, and their projection into the future.

## CNES Application Tools for Remote Sensing from Space

Aurélie Sand  
*aurelie.sand@cnes.fr*  
CNES  
France

Manuel Grizonnet  
*manuel.grizonnet@cnes.fr*  
France

**Abstract:** The Orfeo Toolbox (OTB) is an Open Source Remote Sensing Image Processing software toolkit developed by CNES which aims at gathering a large set of state of the art building blocks for building processing chains. The Monteverdi integrated application is based on OTB and provides a user-friendly graphical interface to many of the algorithms available in the OTB library. The modular architecture of the software allows to easily extend the application with custom algorithms seamlessly integrated in the main application. All these features make Monteverdi a candidate to provide quick and efficient solutions in educational contexts. It has already been used for several remote sensing trainings and capacity building activities. This paper will present OTB/Monteverdi in terms of available functionalities, but also in terms of philosophy of openness and future evolution.