Main Results and Considerations from Presentations and Discussion

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Passive and active microwave sensors

Partitioning the incoming solar radiation into latent and sensible heat components from knowledge of the soil moisture content is an important approach in hydrology and agriculture. But, as pointed out by T. Schmugge of the HydroL, Lab., USDA-Beltsville, no remote sensing technique is able so far to detect the amounts of water stored in the soils with the exception of microwaves at long wavelengths (> 10 cm) for a surface 5 cm layers. This approach is based on the large dielectric contrast between water and dry soil. The capability of the NASA Push Broom Microwave Radiometer (PBMR) operating at a wavelength of 21 cm with four horizontally polarized beams has to be pointed out in this respect. It detects a wide range of moisture contents from very dry to saturated soil with a very good correlation between the microwave response and soil moisture. This performance can be successfully applied to runoff prediction, determination of direct evaporation and determination of boundary conditions for models describing the moisture profile in soil.

In spite of the present limitation on their practical use from space, passive microwave techniques confirm also to be very promising for the characterization of global phenomena such as hydrological cycles and evapotranspiration processes. According to P. Paloscia of IROE, CNR Florence, monitoring of vegetation cover changing and of desertification processes can be single out even if minimum footprints of 30 Km only has foreseen to be attained with the next space sensors’ generation. The most realistic use for monitoring soil and crop conditions comes from radiometers at L, X and Ka bands on aircraft platforms, which allows more resolving and timely operation. Moreover results can be explained only using some theoretical models based on the radiative transfer theory.

Paloscia et al. of the same Institute have also performed an experiment using two airborne passive microwave profile radiometers and a IR radiometer for the detection of soil moisture content in a typically eterogenous agricultural area (Montespetoli in Italy). A study has followed on the influence of surface roughness on microwave emission for base soils. Preliminary results have confirmed a pretty good sensitivity of microwave emission to soil moisture at least in flat soils and an expected reduction of sensitivity to soil moisture for cropped surfaces which are typical of this area. Never as microwaves remote sensing from space, calibration-validation confirms to be a necessary step towards the practical use of SAR data, which are expected to play an important role in land and agriculture applications. New calibration standards have been developed by the European Space and Technology Centre of the European Space Agency as a support to the development of the actual and future spaceborne SAR instruments. As communicated by Y.I. Desnos of ESTEC, ESA has introduced new calibration standards for the ERS-1 SAR thanks to the development of high precision transponders. As compared with those obtained using conventional corner reflectors, the data calibration results are satisfactory. ESA announces to have being working on airborne multifrequency polarimetric SAR data with like results.

Modern programmes in agriculture require increasingly detailed and real-time agrometeorological information. In this respect, G. Vezzani et al., of SMA- Florence recommend the use of weather radar systems of last generation (excellent stability of transceiver, high definition of antenna pattern, good electronics quality, etc.). Many are the advantages which come from the use of these systems; they can perform accurate analyses of the atmosphere’s status inside the covered sky volume and allow more reliable nowcasting of weather phenomena and rainfall intensity. They are very useful instruments for hydrological monitoring and rain stimulation processes and thanks to them one can more easily decide about site and moment of clouds’ insemination. They act promptly in matter of crop defence against hail storms and perform time continuous and space distributed measurements of rainfall, which allows highly accurate estimations of rainfall rate on the areas covered by agrometeorological models.

Applying successfully modern neural network techniques to calibration of meteorological radar is possible. An innovative approach using two neural network in parallel has been implemented by A. Basile et al. of Fondazione Scienza per l’Ambiente, Florence and applied to real application data to determine the relationship between radar measurement and rainfall data.

Among the different methods which are currently used for in-field soil moisture measurement, the dielectric constant method offers the advantages of being more accurate and of easier and prompter use. G. Luzi et al. of Fondazione Scienza per l’Ambiente, Florence have extensively tested a commer-
cially available proximity sensing probe, working on the L band (1.42 GHz). The instrument computes real and imaginary parts of the DC of soil from the measured amplitude and phase of the reflection coefficient of an open ended coaxial cable in contact with the investigated medium. The method confirmed to be more effective compared to the traditional method base on gravimetric sampling.

As pointed out by V. Matteini et al of ESA/ESTEC the SAR image may often result speckled and the intrinsic field texture is masked by noise effects. Therefore monitoring agricultural land features becomes rather difficult. The solution of this problem consists in smoothing speckle while preserving like edges and fine details. The segmentation of agricultural scenes becomes possible when an efficient edge detector is applied directly to the image or after speckle filtering process. Adaptive filters look to be most efficient in this case.

Visible and thermal sensors

Monitoring of rainfall by satellite is being performed since 1970 through relatively physically methods based on visible and/or infrared imagery. Modern interactive techniques involving also use of collateral data, have been set up and actively work on an operational basis. In spite of this, confirms E. Barrett of Dept. of Geography, University-Bristol, this pretty variable (spatially and temporally) parameter is still very inadequately monitored. Objective or automatic techniques have come to dominate, perhaps using a wide range of ancillary data within a detailed GIS context. Wide use is made of geostationary satellites, mainly on the tropics. In middle to high latitudes recourse in made to data from near polar orbiting satellites. Some of them (NOAA) provide greater spatial resolution and help differentiate between probably precipitating and probably not precipitating layered clouds. All of these techniques rely upon cloud top radiation, which may be misleading so far as the rain itself—which falls from the bases of clouds—is concerned.

In recent years the greatest focus has been on IR imagery (for it is also available during night time) and some of its physical implication is more consistent, expectly the relationship between cloud top temperature and cloud top height. In the more advanced techniques satellites are interpreted alongside all available climatological and meteorological data sets. One of them the B4’s one, is generating daily rainfall estimates from 2-hourly METEOSAT images on a 25 km grid square basis, using climate background fields and GTS weather stations as calibrators. Weekly and monthly total rainfall are also being computed. A progress is now being made in respect of operational satellite rainfall monitoring for agrometeorology. Also true uses, which have been so far rather limited, will increase and become more important by the return of century.

It is also of interest to uses of remote sensors the recent realization of a miniaturized semiconductor diode laser tunable in the visible-near infrared spectral range. It has been realized thanks to the stabilization obtained by means of an extended cavity configuration. Its frequency stability is better than one part per million while the amplitude noise is reduced to less than one part per million. As stressed by designers C. Fort et al of Dept. of Fisica, Univ. of Florence, this opens the possibility of investigation on sensors whose sensitivity allows measuring very low trace gas amounts. In addition to its local detection capability this sensors will be useful to remote sensing. Infact it can be used as injection seeding for last electronic control of pulsed sources applied to LIDAR detection.

In the fields of innovative sensors for agriculture, hydrology and environment an interesting contribution has been given by F. Boragine et al of Officine Galileo, Florence with the project of the VIRS-201 airborne visible-infrared scanner VIRS-201. A high spectral resolution in the 0.4-1.00 mm part of the spectrum has been obtained by means of a CCR matrix in which each line of 550 dots represents a 2.5 nm wide spectral window on a foot-print line. For data acquisition on the 8-12 μm spectral range a wisk broom scanning technique which involves a 10-faces polygonal mirror. 20 visible-near infrared spectral channels are then selected out the 240 available ones. Data resultant from both images are digitized together before recording. The role of support to agrometeorological applications to be covered by this instrument is foreseen for a variety of tasks: assessment of water content in soils, monitoring of crop growth and evapotranspiration, etc. We wish to this advanced high resolution multispectral scanner a wide application in the European remote sensing area.

Crop monitoring and in particular yield estimating and forecasting are considered of great importance for those organizations in charge of monitoring agrarian seasons. The potential use of NDVI from AVHRR for crop monitoring has been investigated in the Emilia Romagna area. The basilar importance of continuous observation from space during the whole growth season has been confirmed by R. Benedetti and P. Rossini of Dept. Osservazioni della Terra, Telespazio-Rome.

An interesting structure extraction technique from remotely sensed imagery is proposed by V. Cappellini et al of Dept. di Ingegneria Elettronica, University of Florence. In order to extract meaningful structures from space imagery, detection and tracking are needed of linear discontinuities in the scene. A novel very robust line follower is proposed which constitutes the basis for the realization of an automatic system, capable to extract contour line networks (i.e. agricultural fields and forest borders). The experiments performed on different satellite remote sensing images confirmed the high efficiency of these techniques for cartographic map updating.

Estimation of biophysical parameters

The application of NOAA/AVHRR data for crop monitoring has been extensively studied in the last years by several Institutes and Labs of Remote Sensing in Europe. NOAA/AVHRR data appear to be well suited for use on extended agricultural production areas with large fields and extensive crop cultivation. The interest of NDVI and Ts measurement with NOAA has been confirmed for a quantitative assessment of yearly crop status in relation with the main land use features. Moreover, as B. Seguin of INRA-Bioclimatologie in Avignon points out, some limiting factors hamper a
precise qualitative assessment of the yearly crop status in the European continent. This factors consist primarily in the diffuse smallness of the agricultural pixel size and in the intensive production level of most crops, which prevent a correct biomass assessment for quantitative estimates. Progress has been realized to overcome these difficulties, as the adoption of the “mixed pixel concept” associated to the NOAA-AVHRR resolution on ground of 1x1 km.

The effectiveness of the combined use of Earth observation satellites and meteo satellites has been stressed by B. Seguin et al. for cereal yield assessment, mainly in semiarid environment. Two important variables of crop physiological development are physically related to remote measurement. The first one is photosynthesis, involving PAR absorption and being related to reflectance in the visible-near infrared spectral range, while the second one is water use, involving evapotranspiration which is related to surface temperature measured by thermal infrared radiances. NOAA-AVHRR is able to give information on these two variables. NDVI profiles can be used in very simplified model of potential biomass (and yield) production while surface temperature data, combined with meteorological data at maximum air temperature, can be expressed as water stress indices (Stress Degree Day). AVHRR pixel contents can be interpreted by using SPOT data for crop identification.

The estimation of agrometeorological parameters, such as surface temperature, evapotranspiration, albedo etc. from satellite data often find noticeable difficulties in heterogeneous landscape due to the need for environmental information which is often not available. To overcome these problems a spatial stratification of the area investigated is proposed by G. Maracchi et al. of I.A.T.A. CNR-Florence and applied to different case studies in Africa. From the first results, statistical methods of spatial stratification have been shown to be highly effective in removing uninteresting variance and isolating the information for the estimation of agrometeorological parameters. In particular, precipitation and soil or crop surface temperature can be more effectively estimated. Future methodological results are expected towards a more straightforward estimation of the water balance parameters by the joint use of Landsat, NOAA-AVHRR and ancillary data.

A system for timely forecasting the production of the most important crops in the European Community is being developed by the Institute of Remote Sensing Applications, JRC-Ispra in support to the statistical Office (EUROSTAT) and the Directorate-General for Agriculture in Brussels. As pointed by P. Vossen of IRSN, JRC-Ispra, the output of the system refer to crop acreages and quantitative assessment of yield and to qualitative state monitoring. A methodology for the use of SPOT and LANDSAT TM satellite imagery has been developed and successfully validated.

For the quantitative crop yield prediction, agrometeorological models are being developed. They are using meteorological data, soil information and research based knowledge on crop growing condition. NOAA-AVHRR satellite information and meteorological data will be use for crop state monitoring. It should be pointed out that all of the outputs can only provide information which is reliable on large regional, national or continental scale. No doubt, this is a great moment's programme.

Application of agrometodelling

Traditional agrometeorological techniques and remote sensing complement each other for operational purposes in crop monitoring and forecasting for developing countries. According to R. Gommes of Remote Sensing Centre for Agriculture, FAO, Rome, it is foreseeable that remote sensing input will become of common-use for agrometeorological models. In this respect a continuous effort is being produced by FAO for the integration of agrometeorology and remote sensing at data level, which includes also weather data (rainfall estimates) and crop information (crop condition and phenology from NDVI). Weather data remain the major influencing parameter behind the variability of yields. It seems likely that future developments will include both a deeper integration at the product level (e.g. areal averaging of yields using NDVI as an auxiliary variable) and additional inputs as new variables to become routinely available (e.g.: radiation based on cloud data from METEOSAT satellites and soil moisture from microwave satellites).

As a first step, FAO has established an homogeneous agromet and agrometric data bank, for internal and external users. Afterwards an agrometeorological crop monitoring and forecasting model was designed used meteo, climate and agronomic information. The model is presently in operation in some 30 countries of tropical and sub-tropical Africa and Asia. In the last few years more and more remote sensing products have been integrated.

Simulation models may estimate yield levels of various crops on a regional level and help in exploring the effect of increase in temperature and CO2 concentration and agriculture and natural ecosystems. According to F. Miglietta et al. of I.A.T.A., CNR-Florence, these are two of the most promising areas of application. Following the present tendencies to an operational use, crop models have to be simple, with limited input requirements and should be capable of fully integrating ground observation with remote sensing data, mostly for developing areas with insufficient ground observation. Moreover one must keep in mind that field experimentation does remain the most important source of information data for a correct application of crop simulation models.

According to M.C. Llasat et al. of Universidad-Barcelona, it can be useful making an integrated use of ground agrometeorological networks and remote sensing for a better management of agricultural resources. This can be particularly helpful in respect to agricultural land investigation scheduling, best management and making the algorithms used in satellite thermal image processing. Moreover satellite imagery interpretation allows to select ideal siting for meteorological stations. It exists the possibility of using information obtained by remote sensing to replace climatic data in zones where multitemporal temperature data are not available.