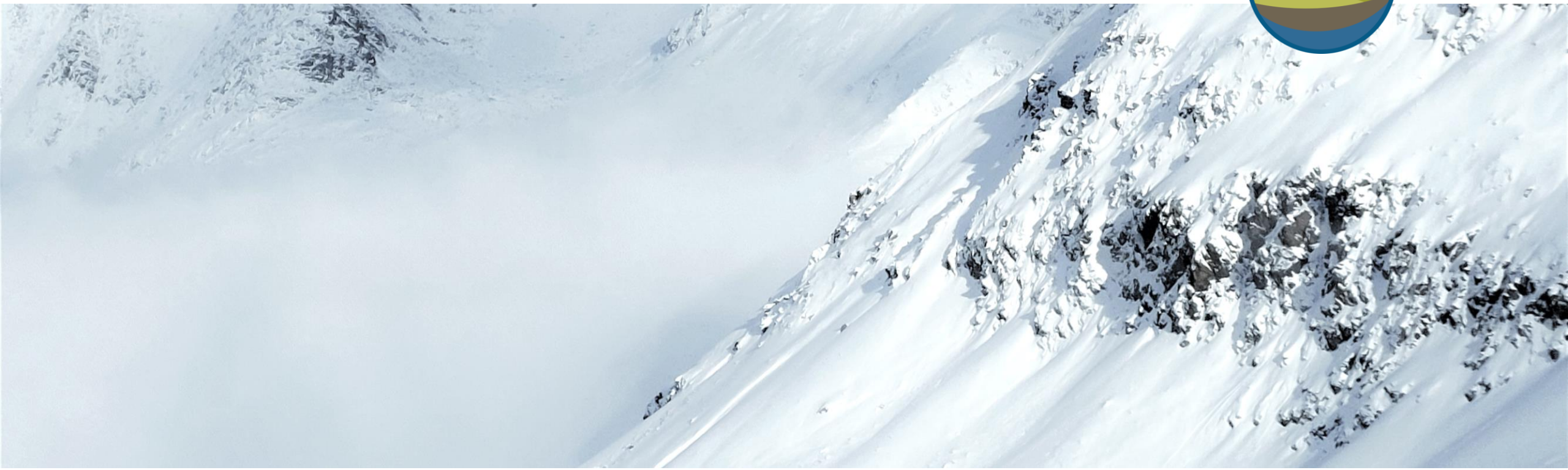


Snow from Space

Combined analysis of Snow Water Equivalent from Cosmic Ray Neutron Sensors and Fractional Snow Cover from Sentinel and MODIS

Nora Krebs[1], Paul Schattan[1], Sascha Oswald[2], Martin Schrön[3], Martin Rutzinger[1], Johann Stötter[1]

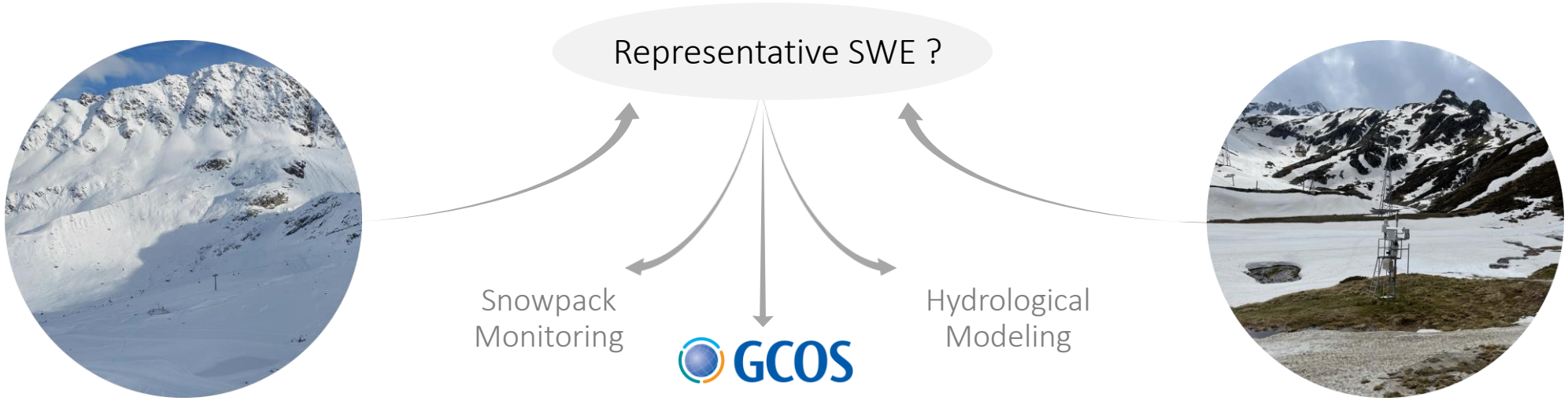
[1] Institute of Geography, University of Innsbruck, Austria

[2] Institute of Environmental Science and Geography, University of Potsdam, Germany

[3] Department of Monitoring and Exploration Technologies, Helmholtz Centre for Environmental Research – UFZ Leipzig, Germany

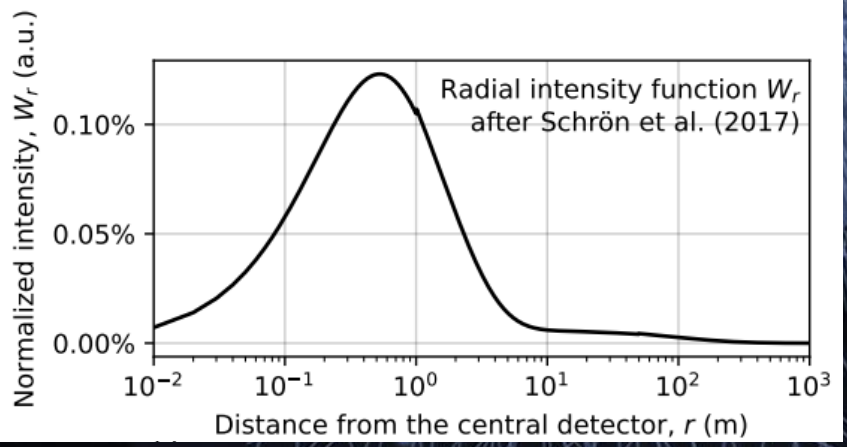
Overall Research Goal

A better understanding of the **Cosmic Ray Neutron Sensing** (CRNS) signal to make **Snow Water Equivalent** (SWE) measurements in heterogeneously distributed snowpacks more reliable.



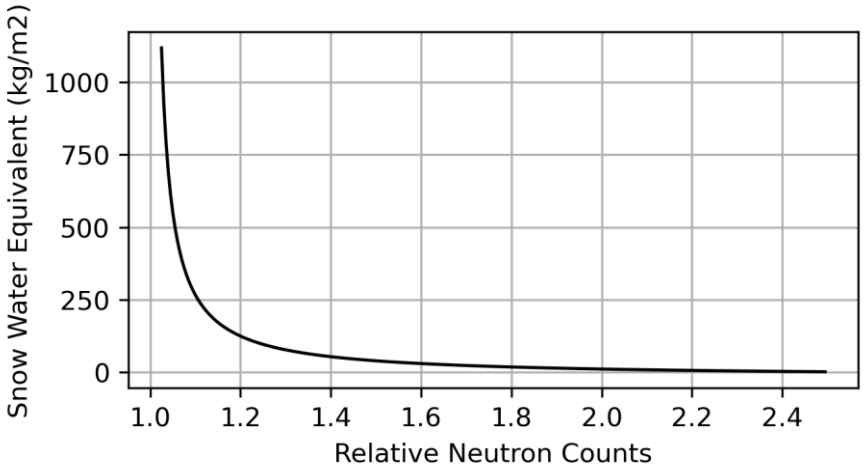
Cosmic Ray Neutron Sensing (CRNS)

Radial Intensity Function

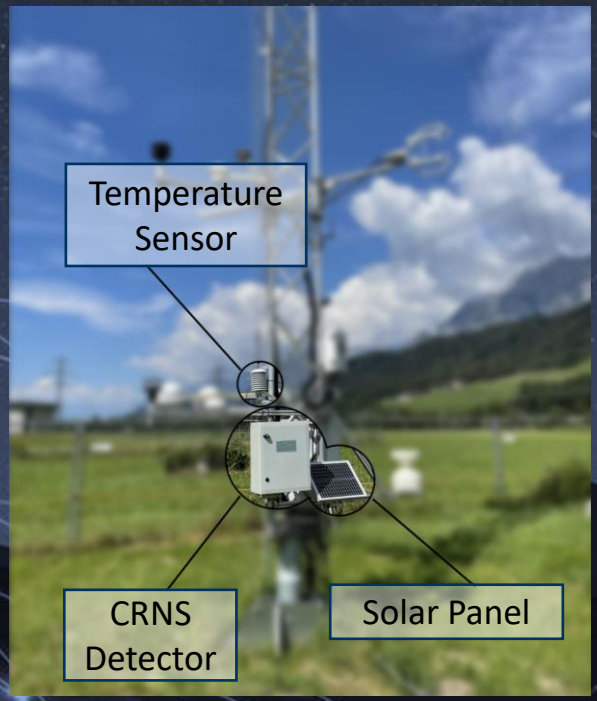


SCHRÖN et al., 2022

Conversion Function



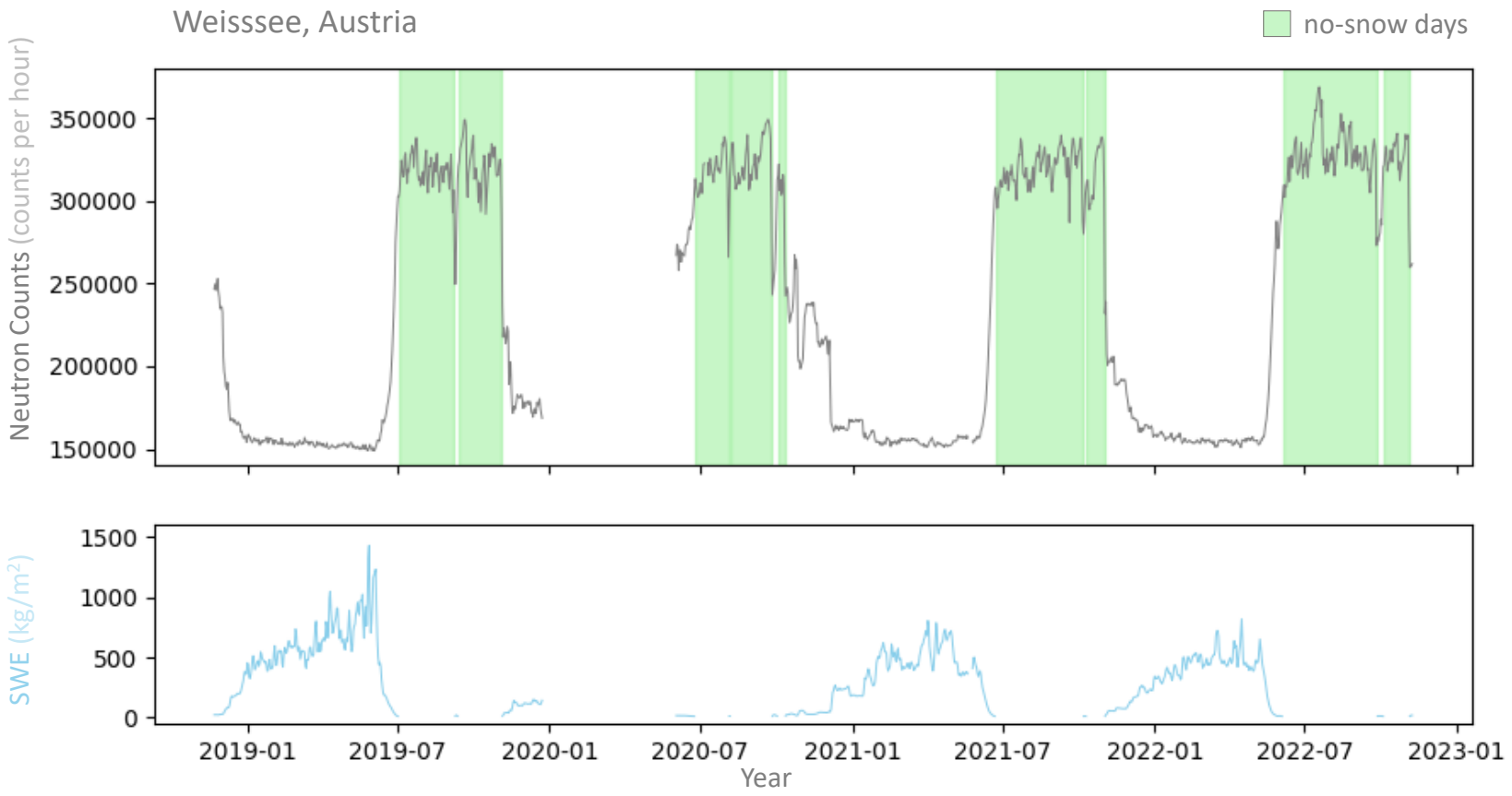
After Paul SCHATTAN



Sott.net

Estimating SWE from CRNS

Calibration of the Neutron-to-SWE conversion function



Terrestrial Laser Scanning

Snow gauging tube

Is every station suited for SWE measurements with CRNS?

A classification of Europe-wide CRNS stations after Sentinel-2 and MODIS Fractional Snow Cover (FSC) products

Research sites:

- COSMOS-EU network (Bogena et al., 2022)
- Moosbeere network

Approach:

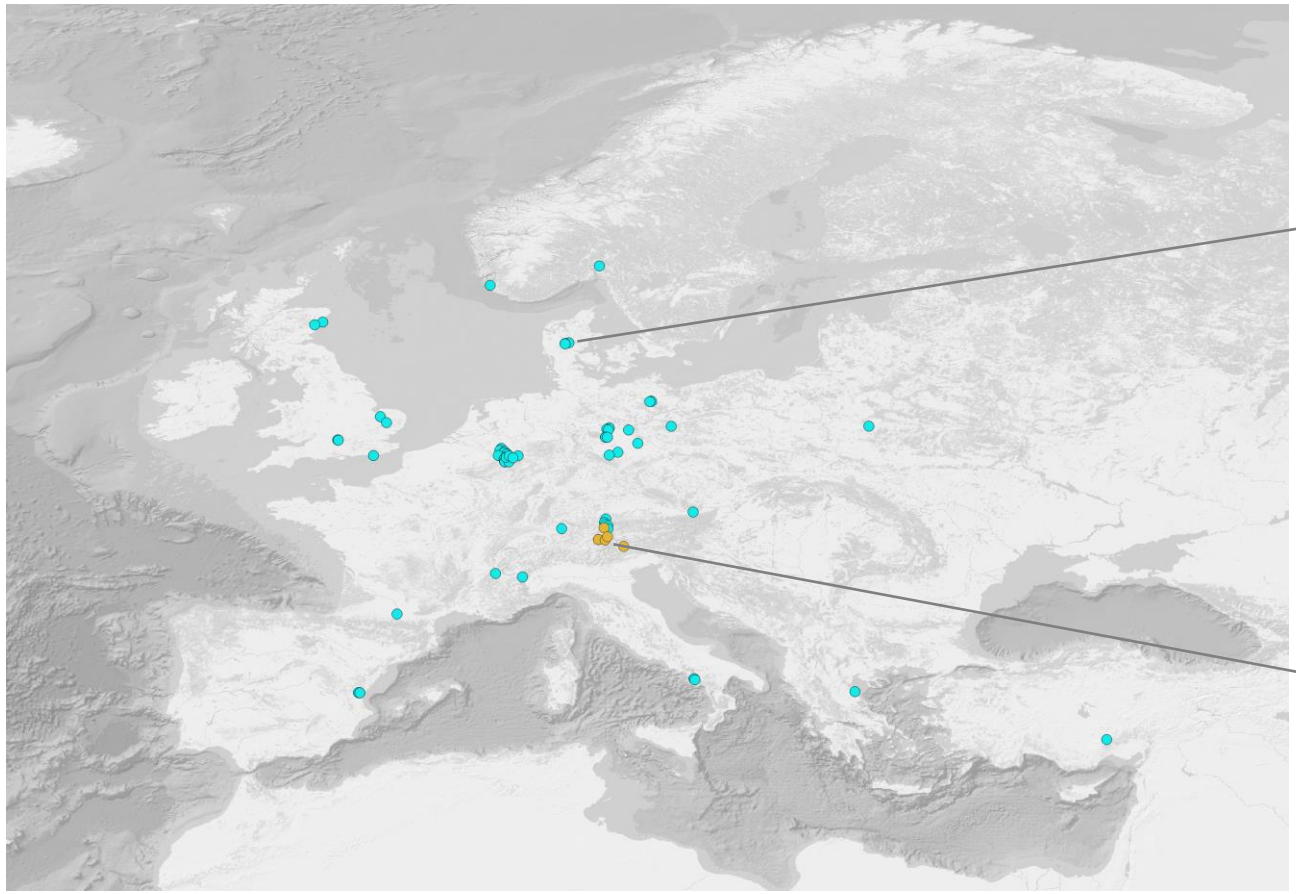
data collection

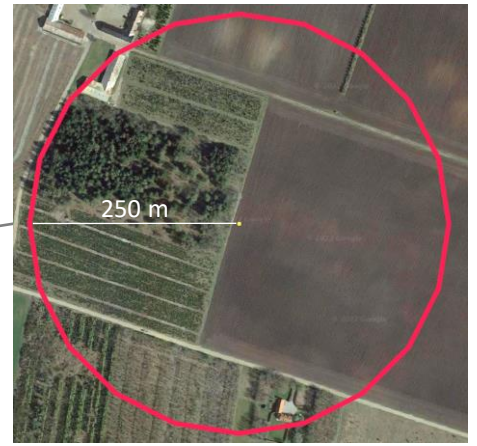
↓

footprint analysis

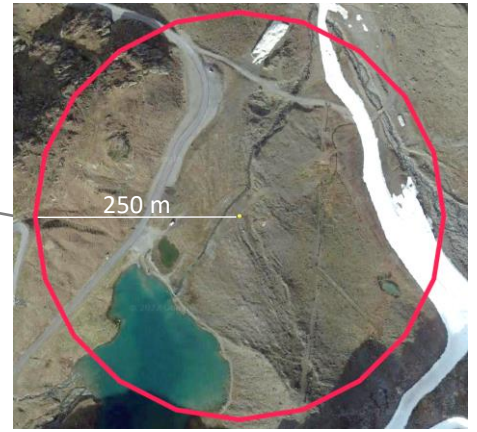
↓

joining data





Voulund

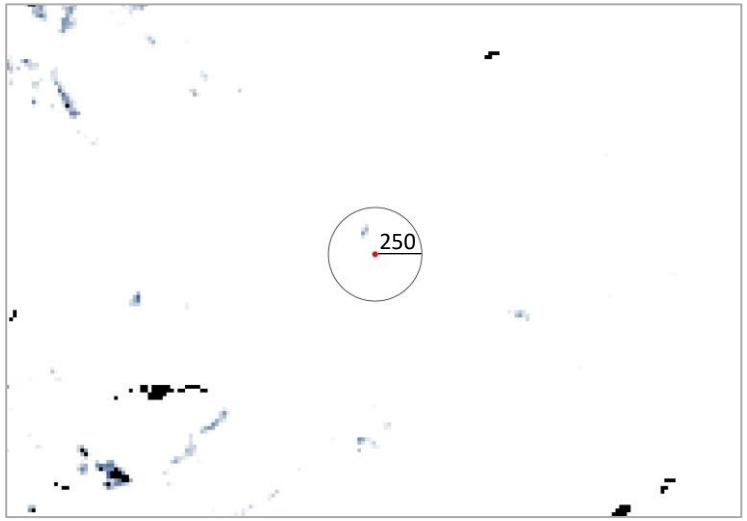


Weisssee

Sentinel-2 and MODIS Fractional Snow Cover (FSC) Products

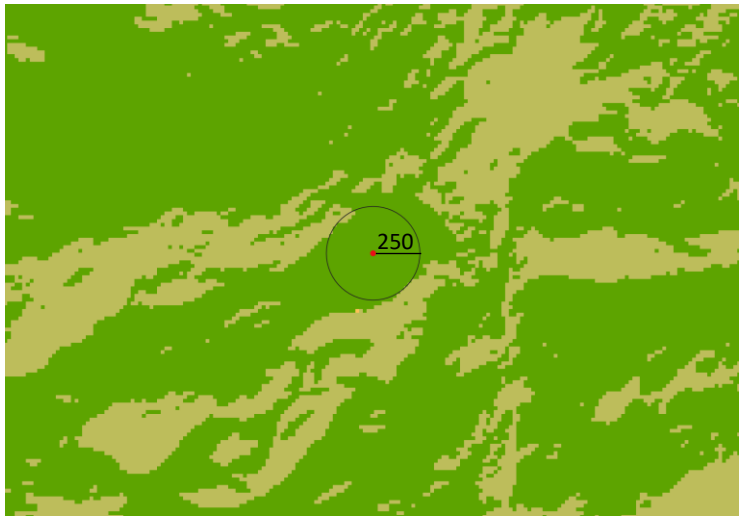
Weisssee – Sentinel-2 L2A: 21.02.2019

Sentinel-FSC: product



~ 0 % → ~ 100 % snow no data

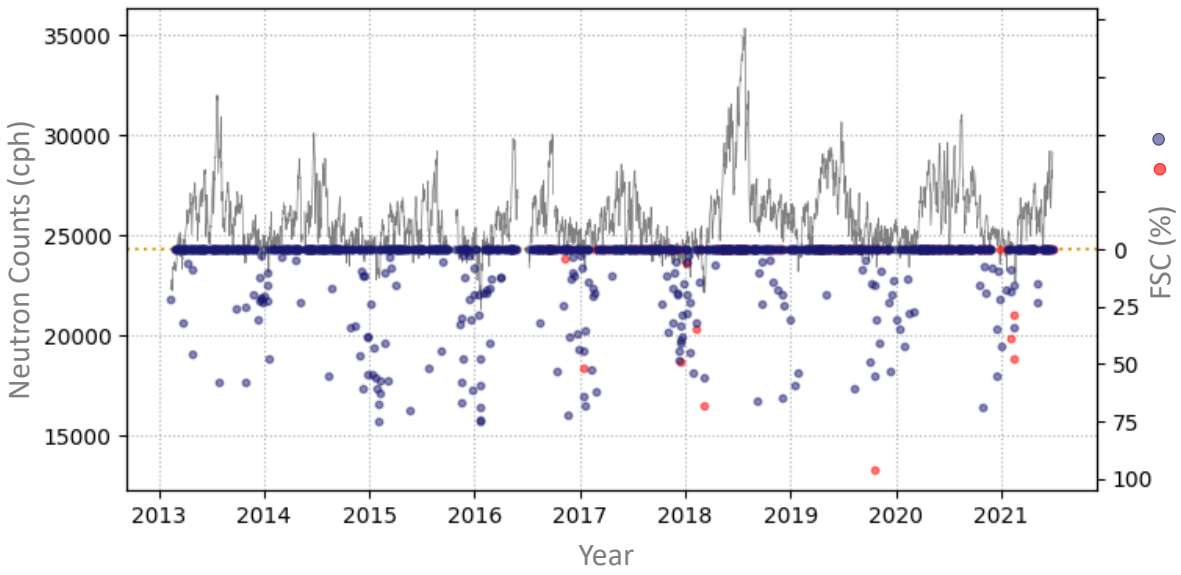
Sentinel-FSC: Quality Flag



0 1 2 3

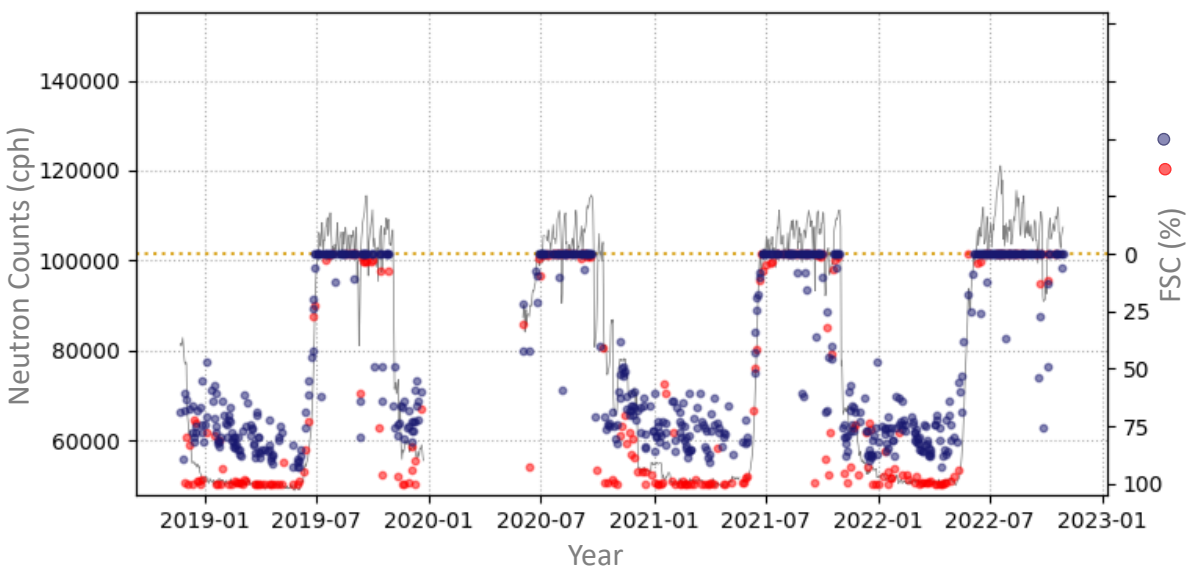
Comparison of Neutron Count Rates and Fractional Snow Cover

Voulund, Denmark



vs.

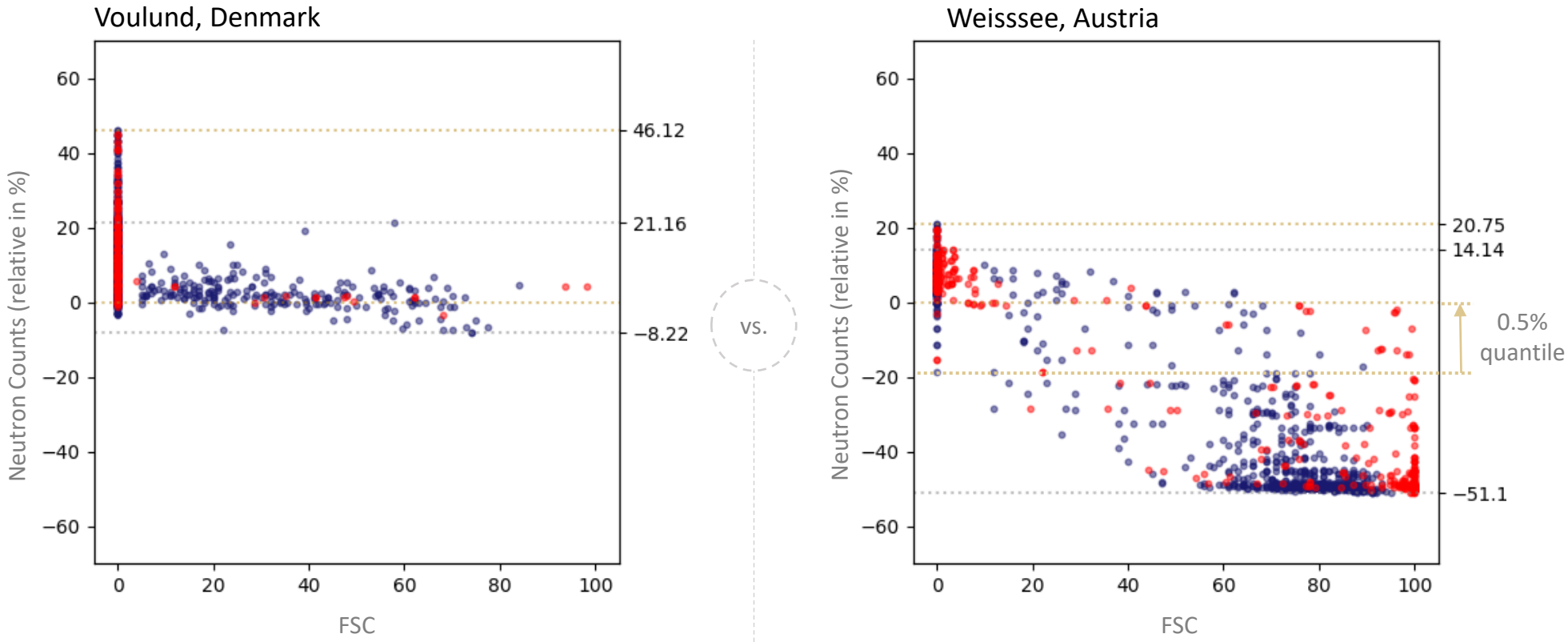
Weisssee, Austria



Sentinel-2 MODIS

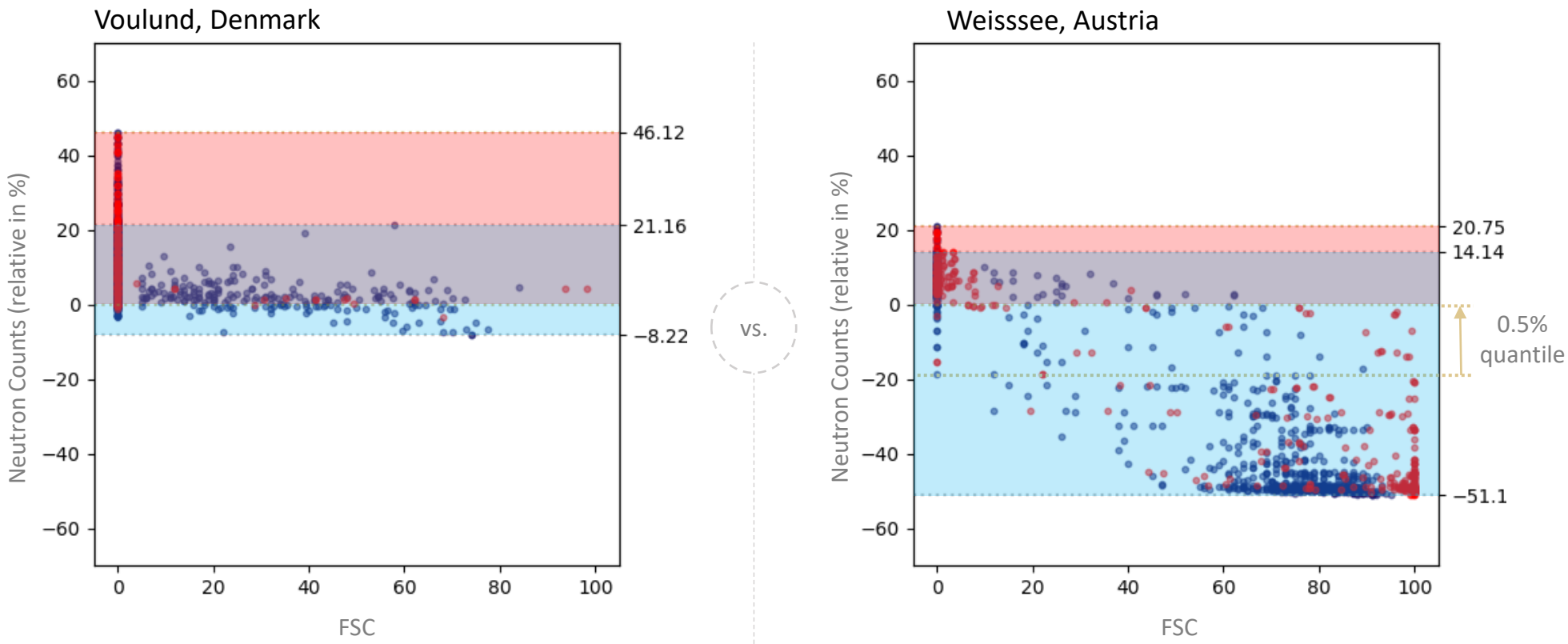
Classification after ‘summer’ and ‘winter’ count rates

- Sentinel-2
- MODIS



Classification after ‘summer’ and ‘winter’ count rates

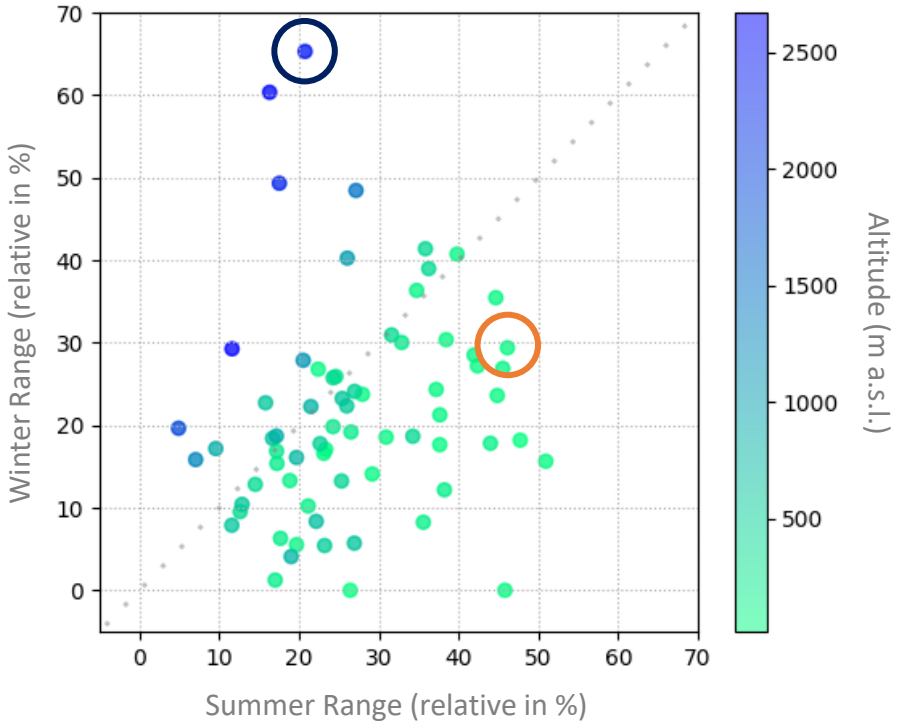
- Sentinel-2
- MODIS
- Summer Range
- Winter Range
- Overlap

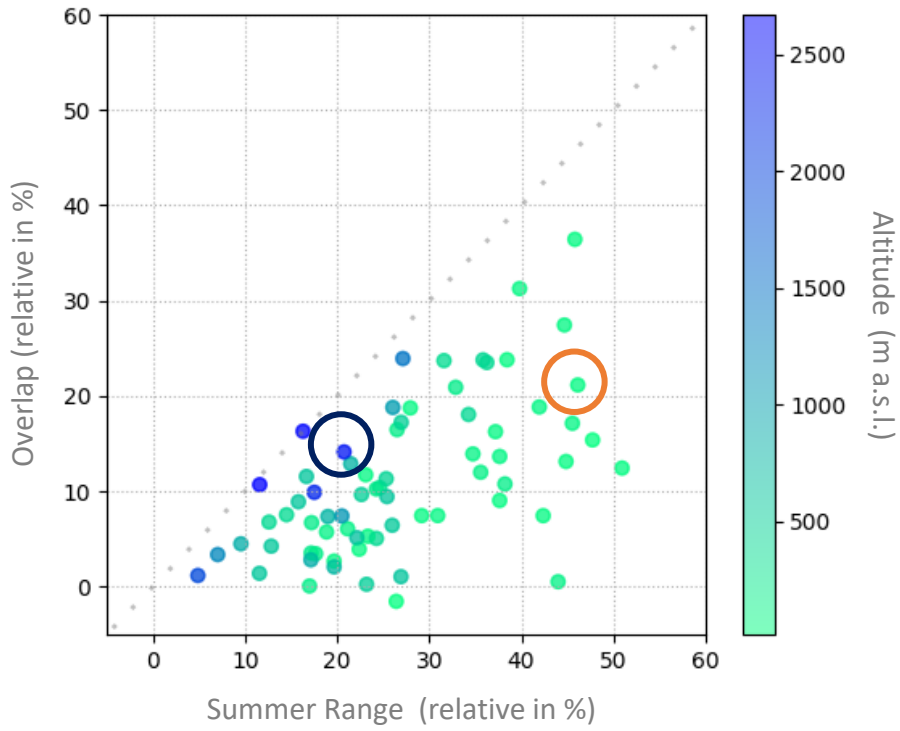


Comparison of all Europe-wide CRNS stations with Altitude

Voulund, Denmark

Weisssee, Austria

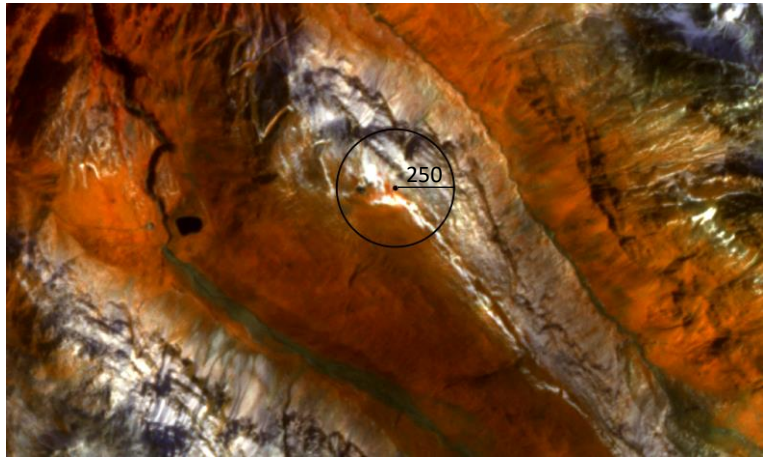




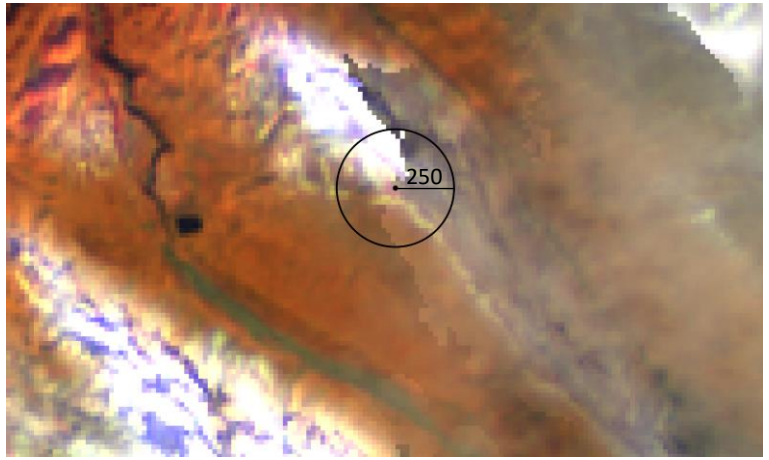
Spatial Uncertainty: Effects of Sentinel-2 and MODIS resolutions

Station: Hohe Mut, 20.09.2022

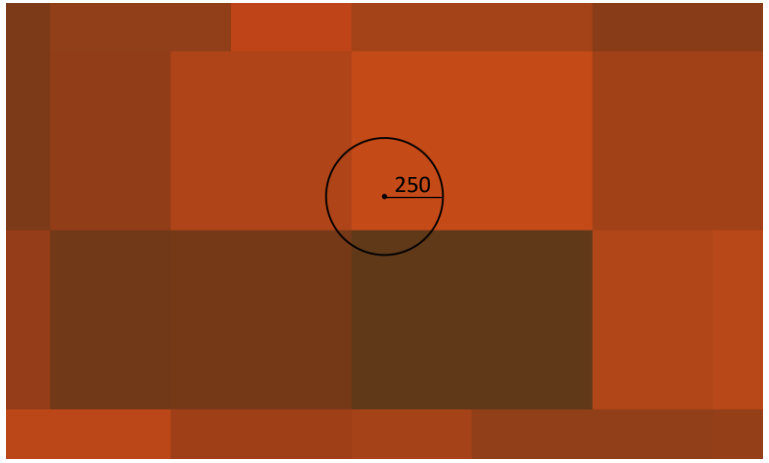
Planet (3 m)



Sentinel-2 (20 m)



MODIS (500 m)



False Color Images - R/G/B: NIR/red edge/coastal blue

R/G/B: NIR/Red/Blue

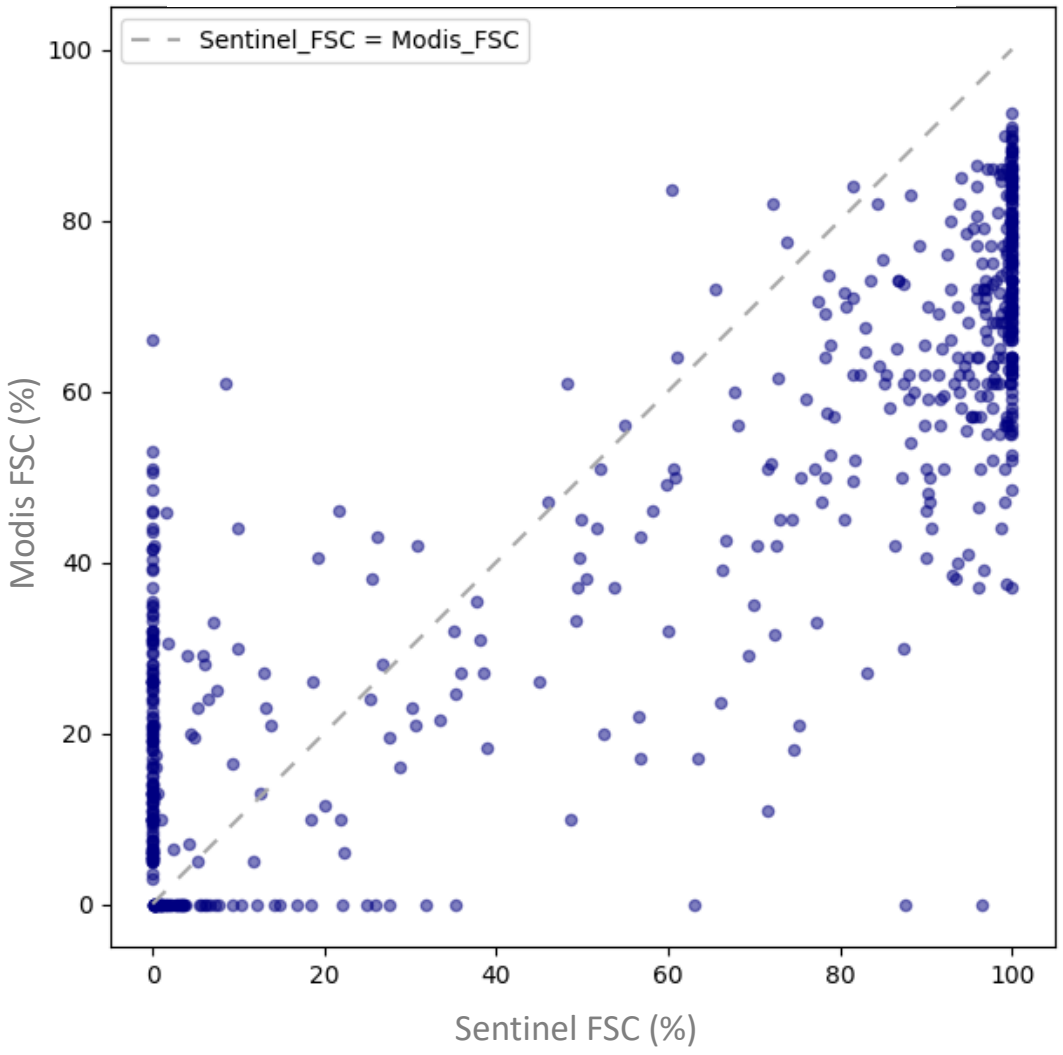
Spatial Uncertainty

Effects of Sentinel-2 and MODIS resolutions

FSC Differences

- **MODIS** FSC is generally **lower** than Sentinel-2 FSC
- MODIS produces **never FSC = 100 %**
- Modis produces **often FSC > 0 %** when Sentinel-2 FSC = 0 %

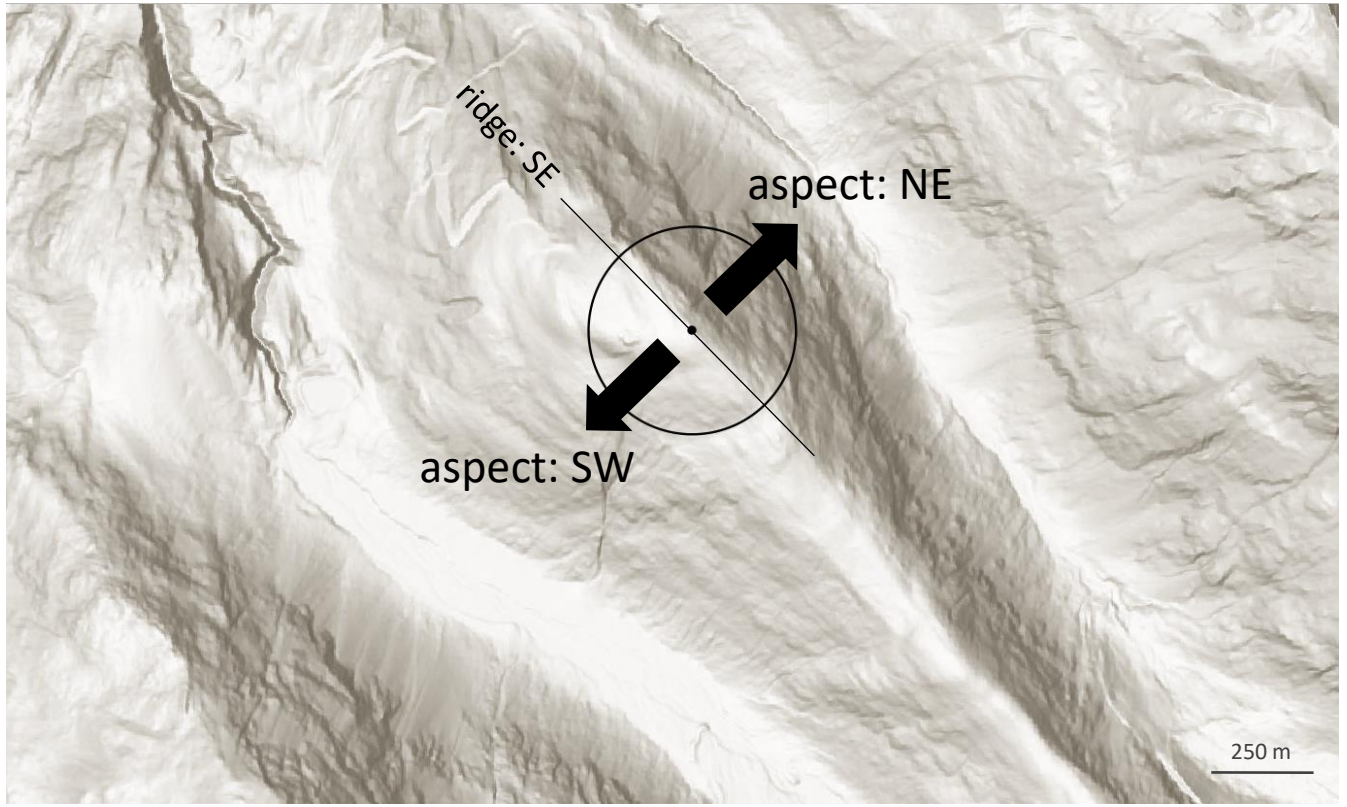
Differences in FSC may be related to the difference in **spatial resolution** and FSC computation **algorithm**



Quality Uncertainty: Masking of steep slopes

Station: Hohe Mut (Obergurgl, Austria)

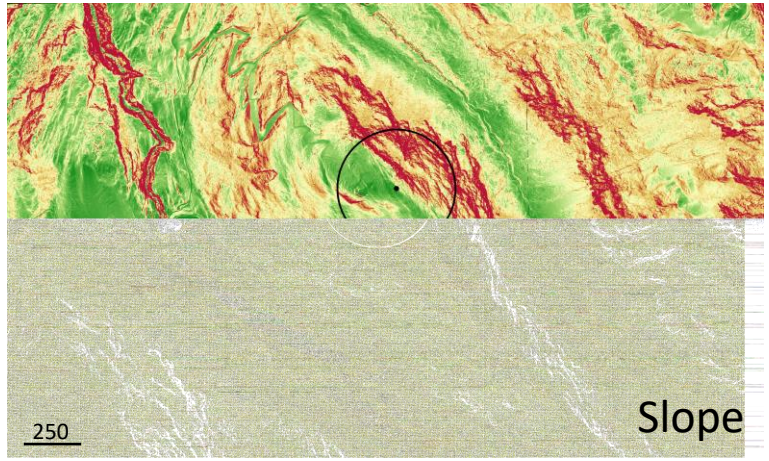
- Station is located on a ridge
- Footprint is devided into **two slopes** with opposing aspects
  - NE-aspect: **cold** shadow side
  - SW-aspect: **warm** sunny side



Quality Uncertainty: Masking of slopes

Melting Season Effect

- Snow remains on **N-exposed slopes**, but slopes are often masked
  - Calculating FSC on remaining pixels would introduce **bias**
  - Calculating FSC only in ‚full high quality pixel scenes' would **exclude valuable data**



Tyrol DEM: data.tirol.gv.at

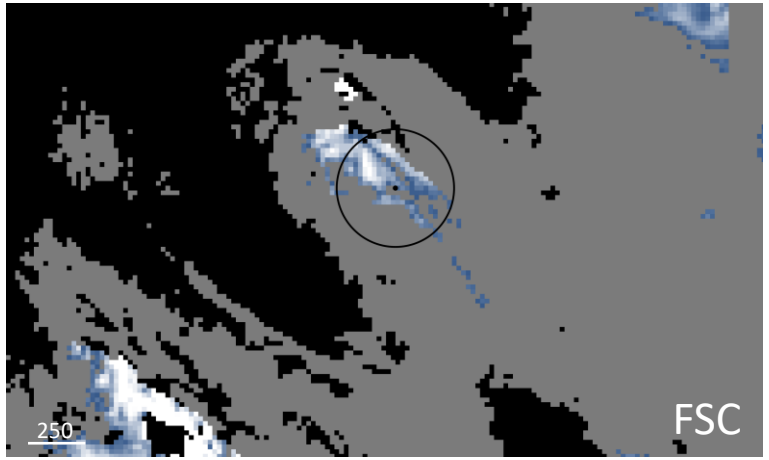
Slope (1 m) section on hillshade

< 20 % < 30% < 40% < 50% > 50%

Hohe Mut: 20.09.2022

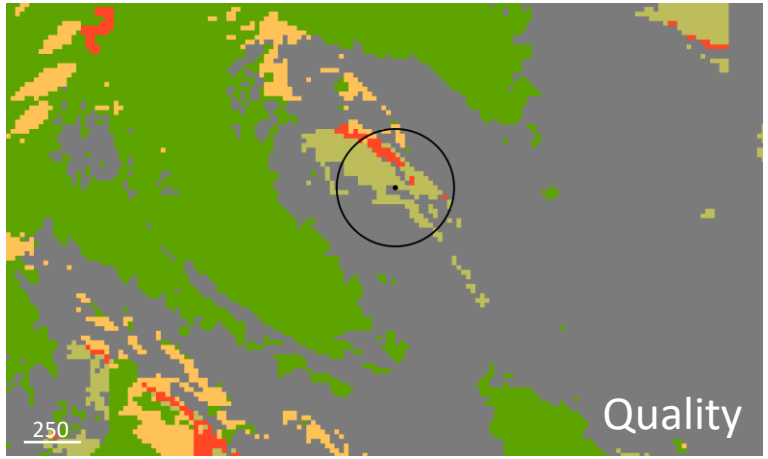
Sentinel-2 True Color Image (10 m)

Masked areas in FSC product



Sentinel-2 FSC-product (20 m)

~ 0 % → ~ 100 % snow no data



Sentinel-2 FSC-product quality control (20 m)

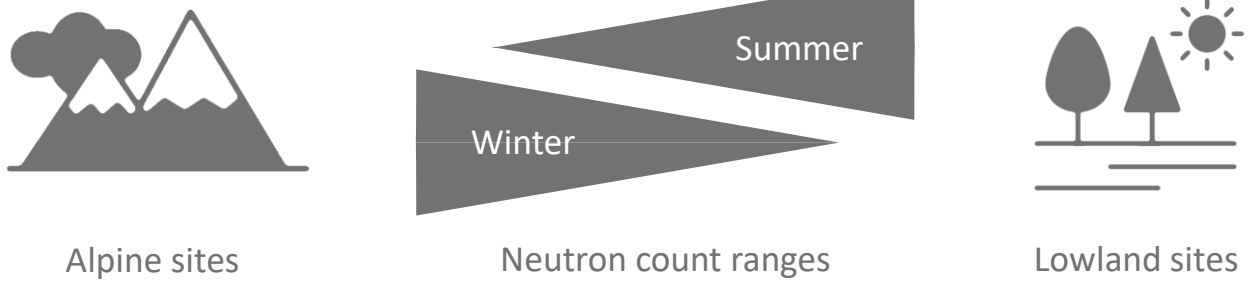
high medium low minimal

Outcomes

- Remote Sensing **FSC** products can be used to **interpret** drops in the **CRNS** signal
- With **increasing** station **altitude** the neutron count signal shows a **decreasing 'summer range'** and a **increasing 'winter range'**

Outlook

- Using **CRNS** to **complement** and **calibrate** **FSC RS** products
- Using RS products, to **characterize** stations after their **suitability** for SWE measurements with CRNS



Challenges

- Extracting the **precise FSC** from RS products is **challenging**, due to masking, product uncertainties and coarse spatial resolution

Thank you!