3rd WORKSHOP ON INTERNATIONAL COOPERATION IN SPACEBORNE IMAGING SPECTROSCOPY

13-15 November 2024 | ESA-ESTEC | Noordwijk | The Netherland

Snow and ice surface properties derived from imaging spectroscopy data: algorithm and sensor comparison

Di Mauro B. [1]*, Traversa G. [1], Cogliati S. [2], Ravasio C. [2], Gatti O. [2], Bohn N. [3], Kokhanovsky A. [4], Brell M. [4], Garzonio R. [2], Marin C. [5], Giardino C. [6], Matta E. [6], Rossini M. [2] and Colombo R. [2]

(1) Institute of Polar Sciences, National Research Council, Milan (Italy)
(2) Earth and Environmental Sciences Department, University of Milano-Bicocca, Milan (Italy)
(3) Jet Propulsion Laboratory, California Institute of Technology, Pasadena, CA (USA)
(4) GFZ German Research Centre for Geosciences, Potsdam (Germany)
(5) EURAC Research -Institute for Applied Remote Sensing, Bolzano (Italy)
(6) Institute for Electromagnetic Sensing of the Environment, National Research Council (CNR-IREA), Milan (Italy)

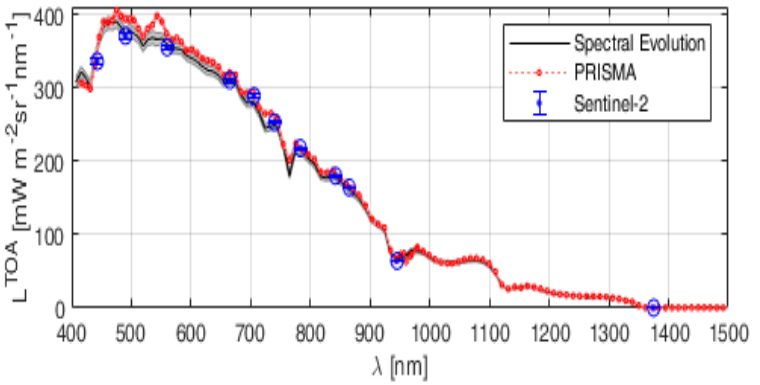
Aim/summary of the presentation

- Evaluation of L1 and L2 products for PRISMA and EnMAP for snow and ice (Alps, Greenland and Antarctica) → comparison with field spectroscopy data
- Liquid water content (LWC) detection in snow (Alps) → sensor comparison
- Mineral dust concentrations in snow retrieval (Alps) → algorithm comparison

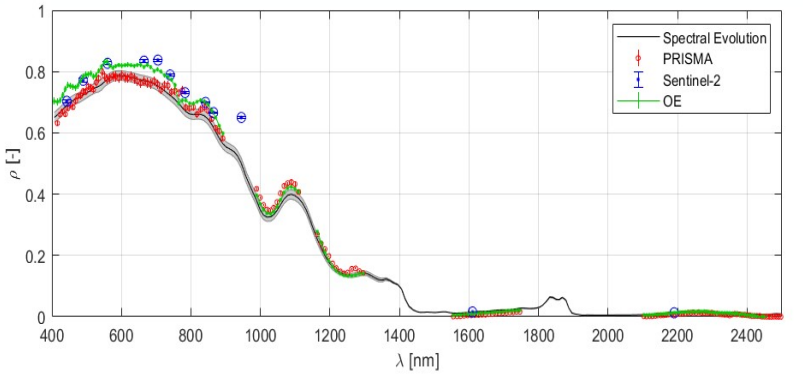
Data quality assessment [PRISMA L1 and L2D]

- Contemporary field spectroscopy acquisition during PRISMA overpass
- Two Alpine sites and one Antarctic site
- Mean Absolute Difference (MAD) lower than 5% for flat terrain
- Higher uncertainties over complex terrain

PRISMA L1 (TOA radiance)

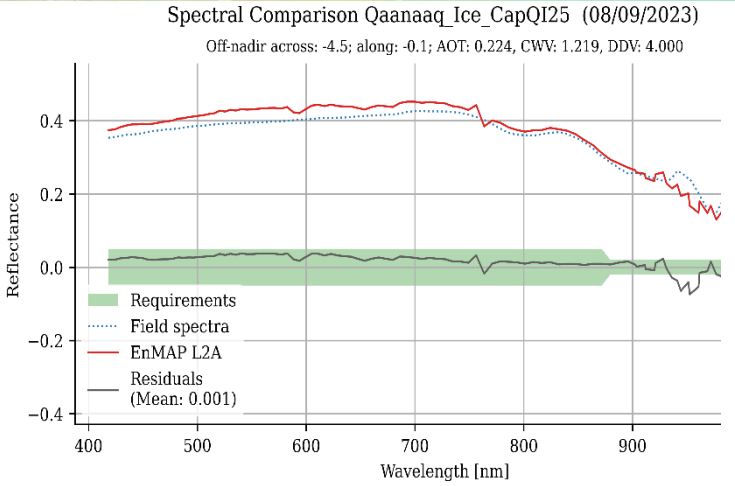


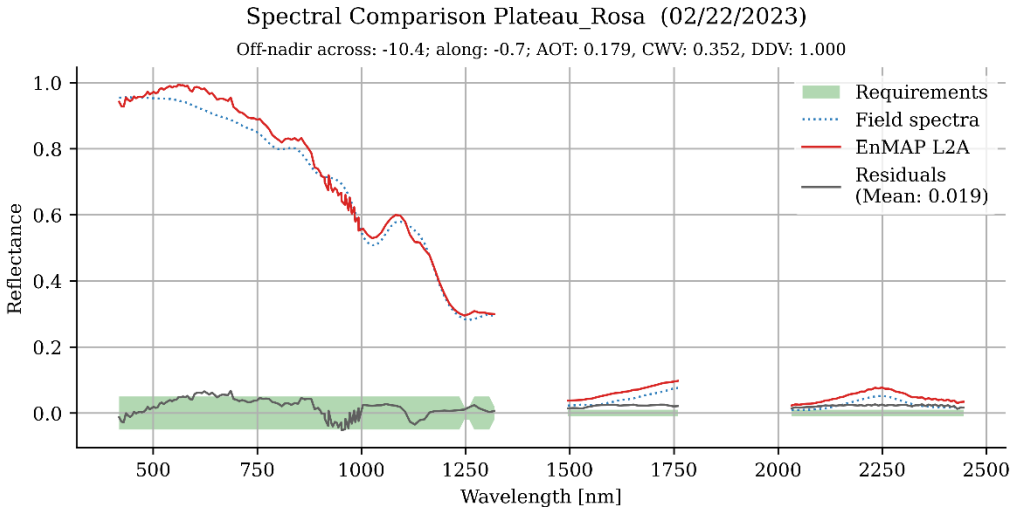
PRISMA L2D (BOA reflectance)

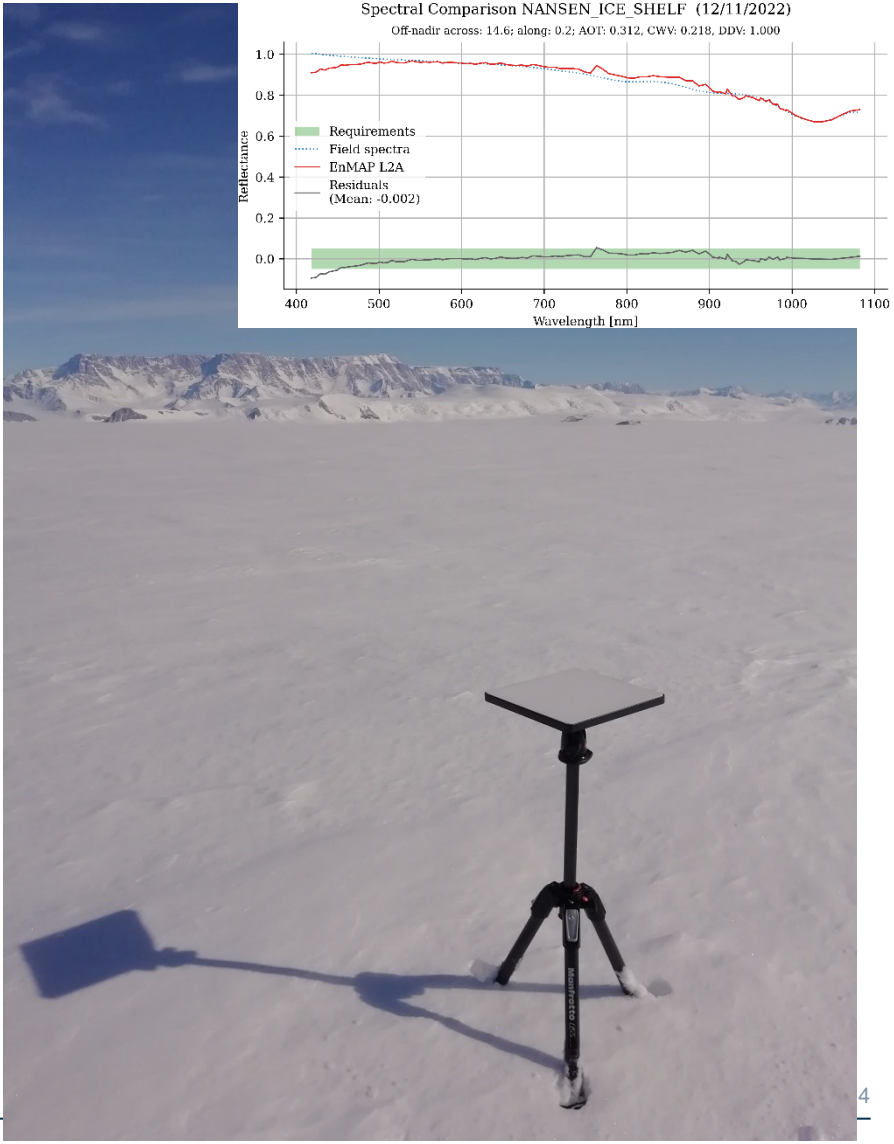


Di Mauro, B. et al. (2024). *Earth and Space Science*

Data quality assessment [EnMAP L2A]

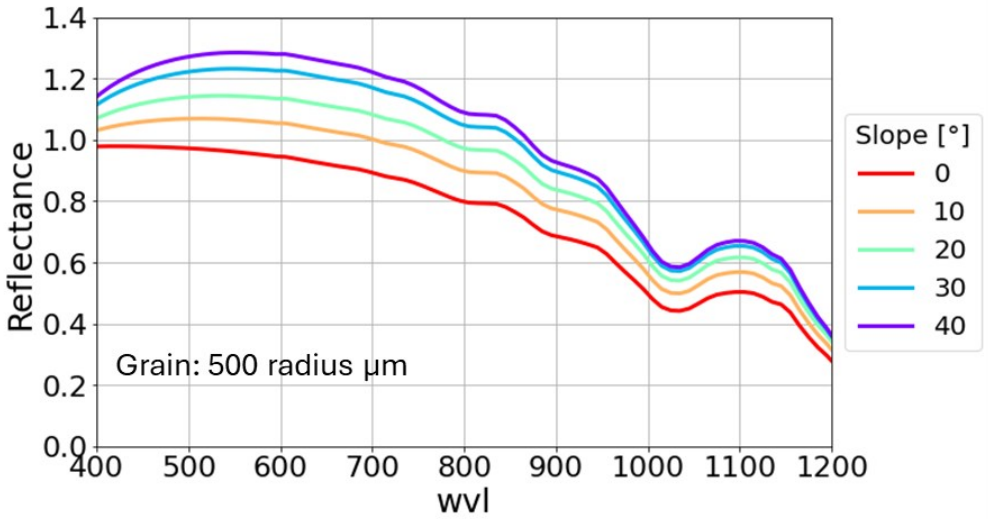


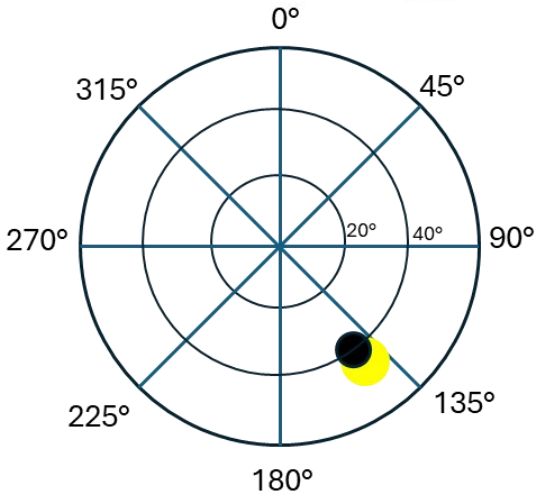




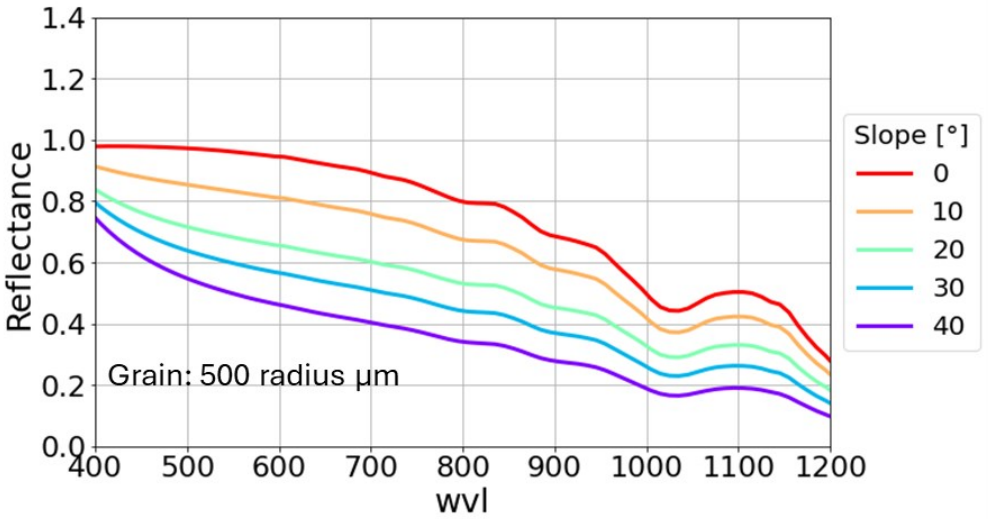
Brell. et al. (*under review*).

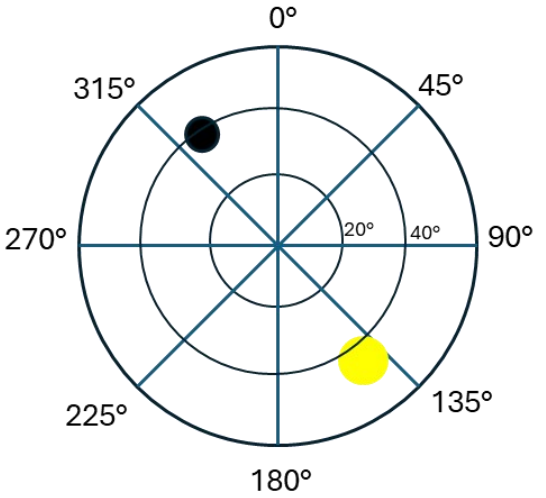
Impact of topography





Azimuth: 145°
Solar zenith angle: 40°
Aspect: 145°

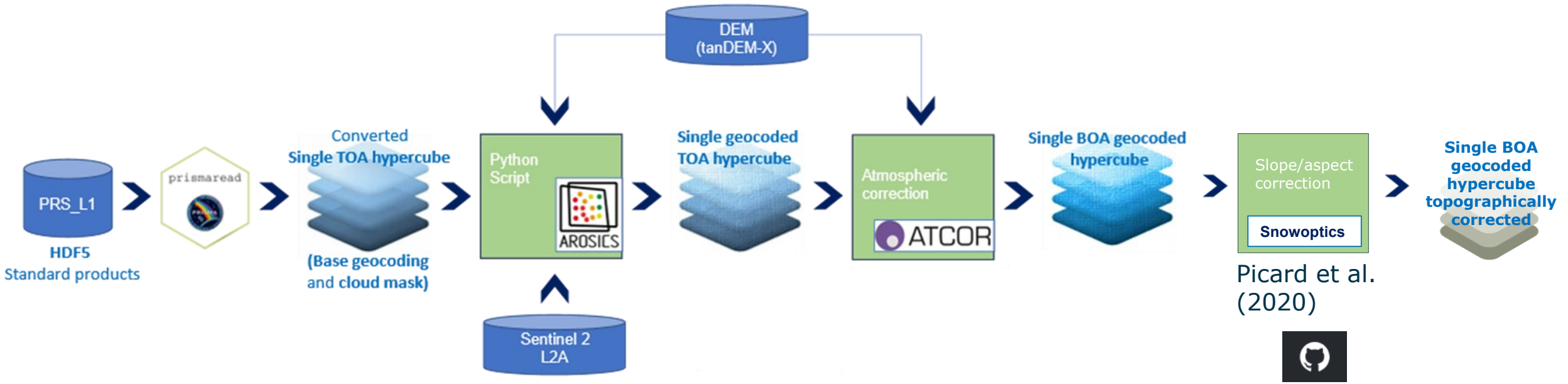




Azimuth: 145°
Solar zenith angle: 40°
Aspect: 325°

Simulations made using Picard et al. (2020) *Cryosph.*

New reflectance product "L2D_SCIA"

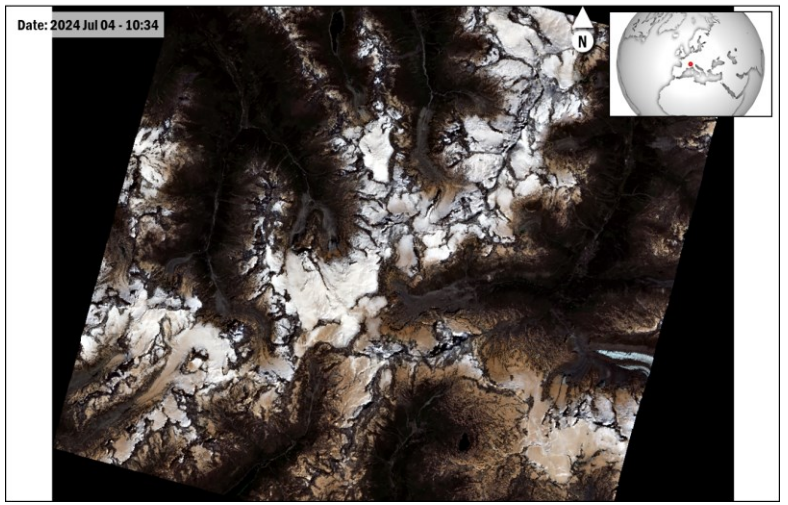


Picard et al. (2020)

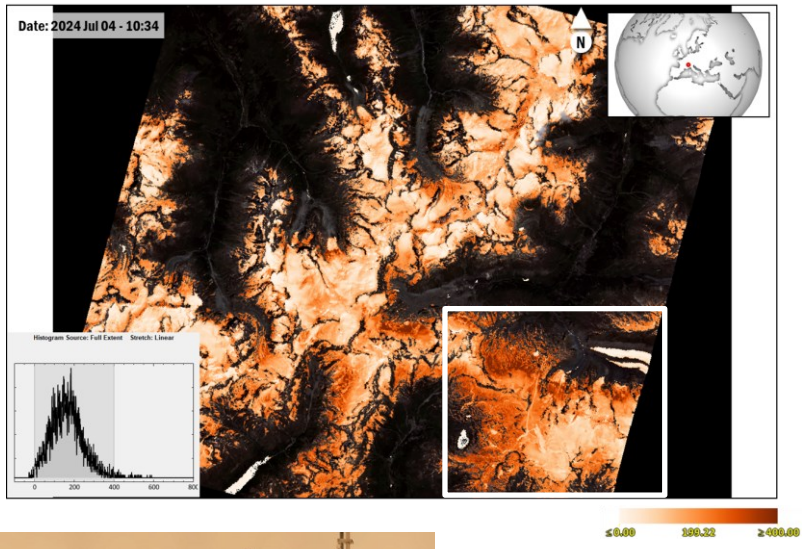
https://github.com/ghislainp/snowoptics

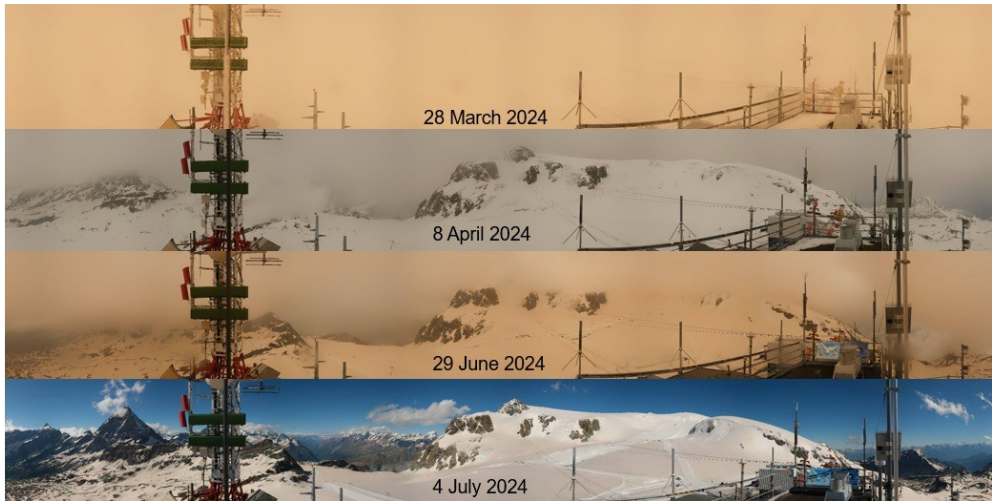
Dust concentration retrieval from PRISMA

PRISMA – RGB 04-07-2024



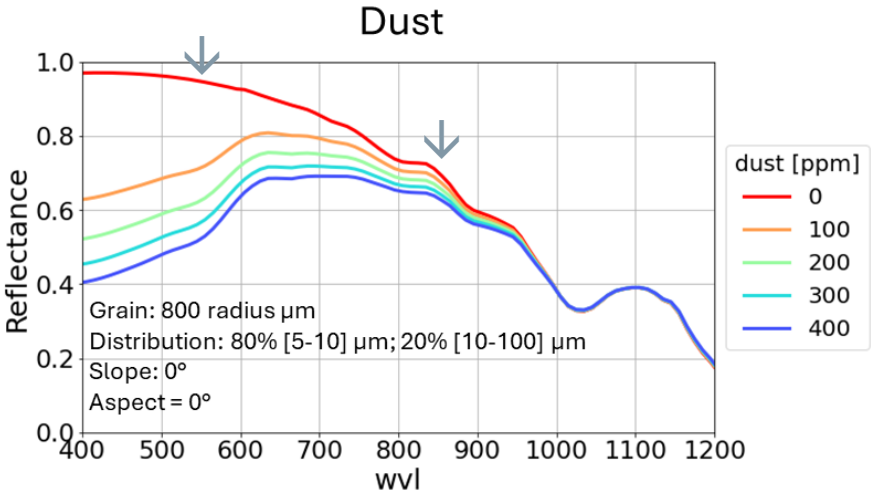
Dust concentration [ppm]





biosnicar

https://github.com/jmcook1186/biosnicar-py



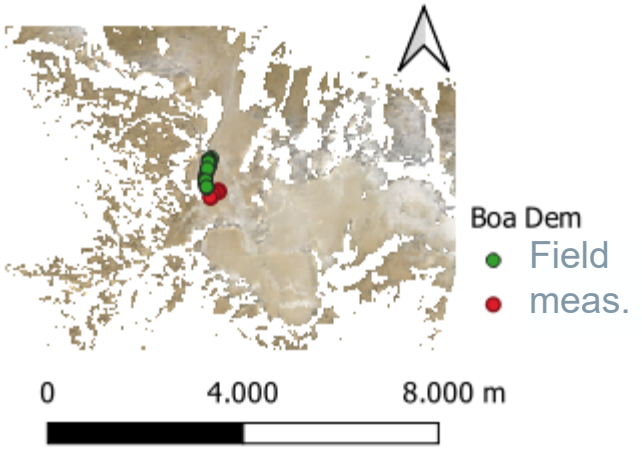
$$\mathbf{I_{imp}} = \frac{\ln(R(543;\ 578nm))}{\ln(R(855;\ 875nm))}$$

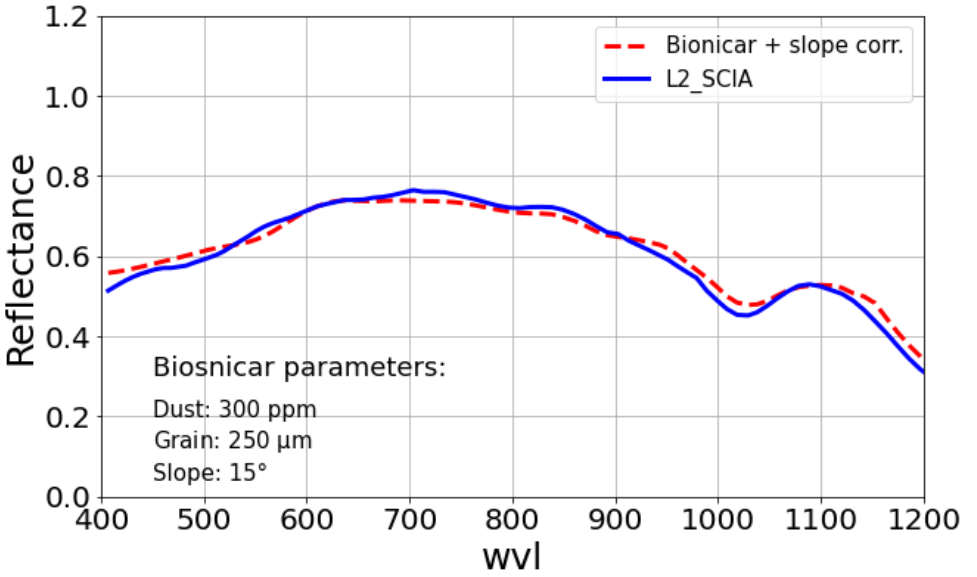
Dumont et al. 2014 Nat. Geosci.

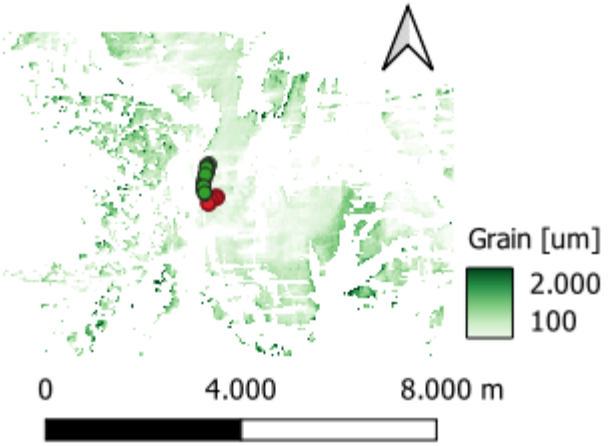
Dust concentration retrieval from PRISMA

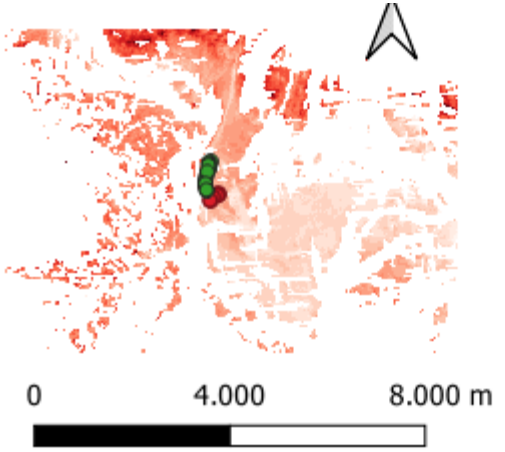
We then tested a supervised machine learning method (K Nearest Neighbours Regressor) to estimate dust conc. in PRISMA data.

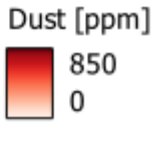
The method takes into account slope and aspect by using Picard et al. (2020) model for "small slope" (<20°)

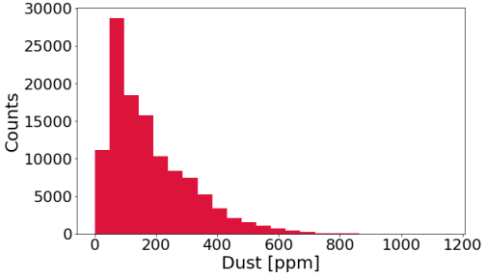






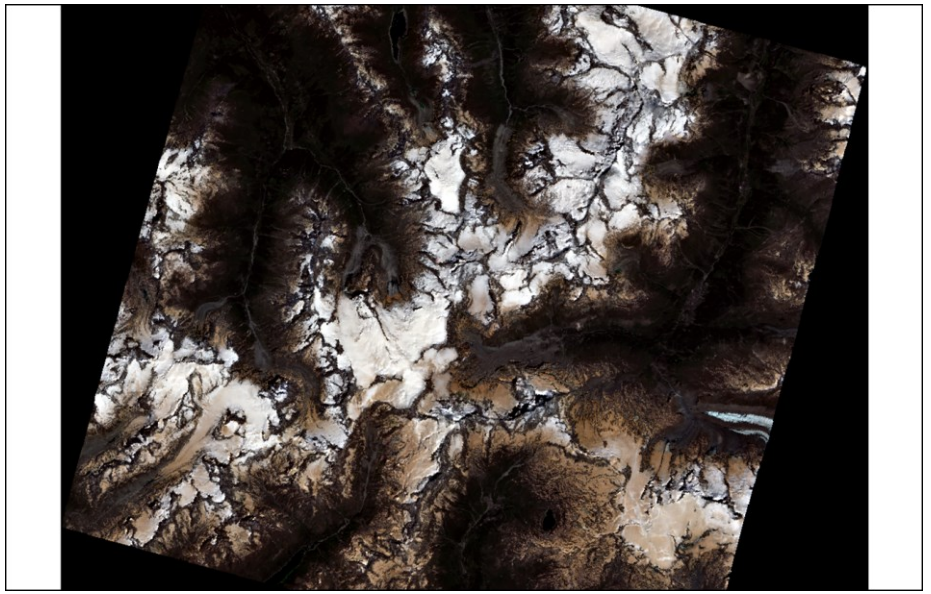


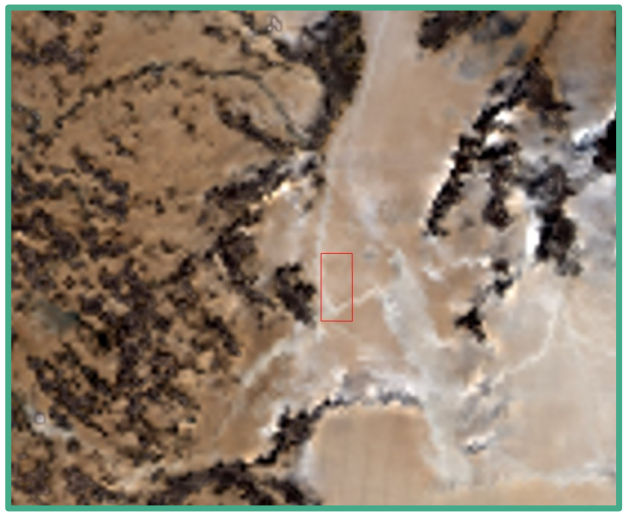


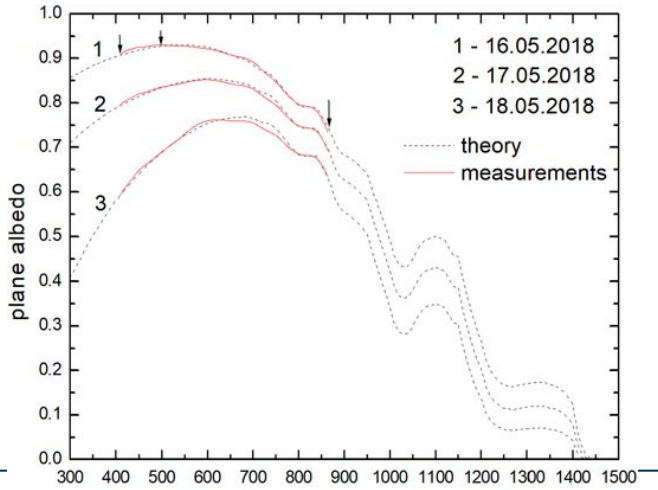


Dust concentration retrieval from PRISMA

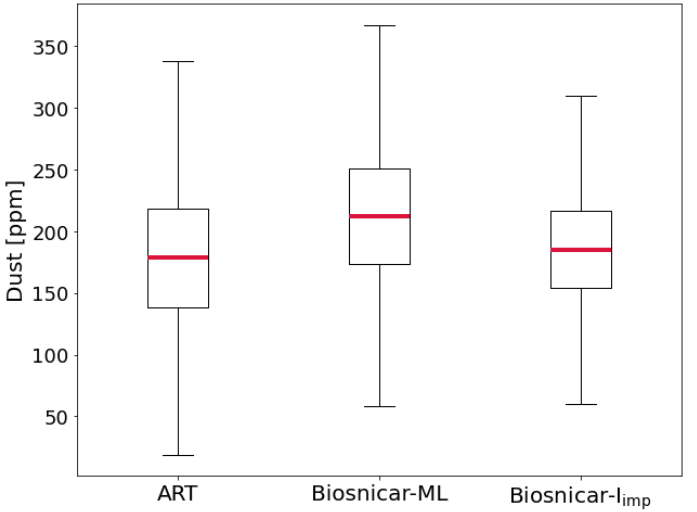
We finally applied ART theory (Kokhanovsky et al. 2021) to estimate dust concentration in our study area





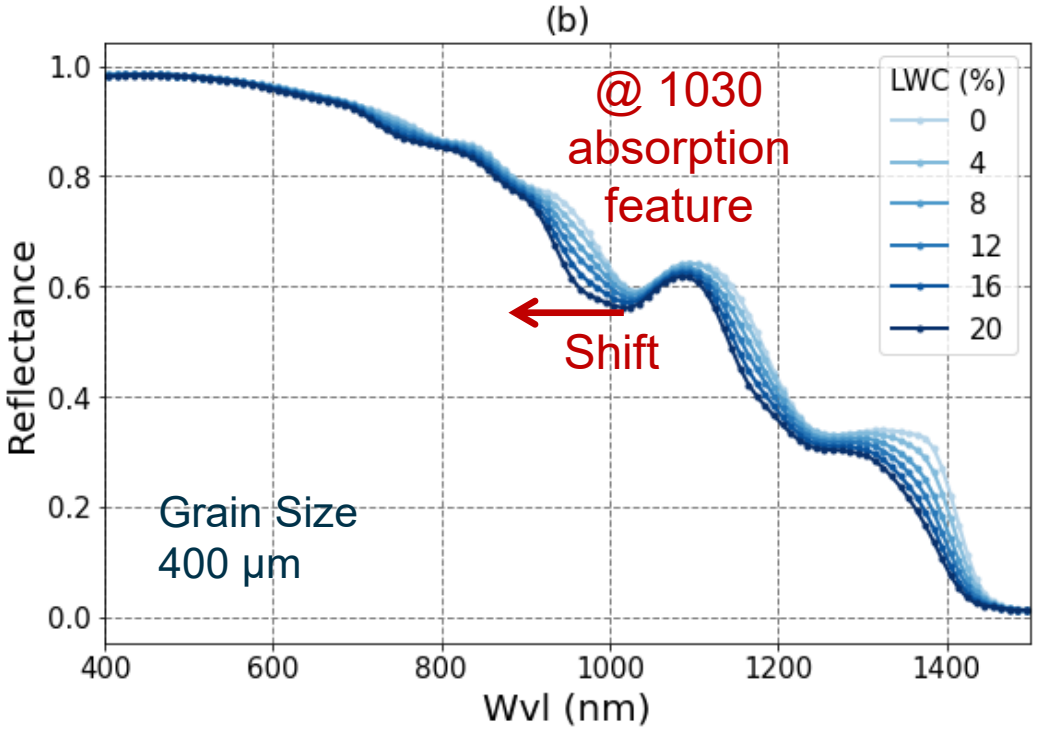


Method comparison



Kokhanovsky et al. (2021) *Front. Env. Sci.*

Liquid water content (LWC) in snow



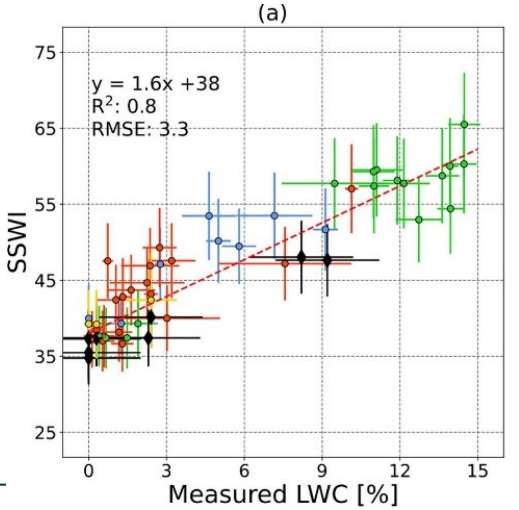
SSWI (Snow Surficial Water Index)

$$SSWI = \frac{1}{d_{dry}} A_{1025}$$

$$= \frac{1}{d_{dry}} \int_{\lambda=905}^{\lambda=1025} \frac{R_c - R}{R_c} d\lambda$$

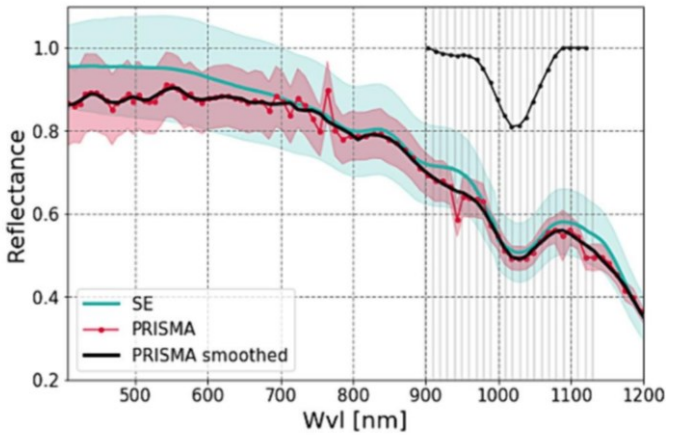
depth of the CR for dry snow

semi-area of CR between 905 and 1025 nm (Nolin and Dozier, 2000)

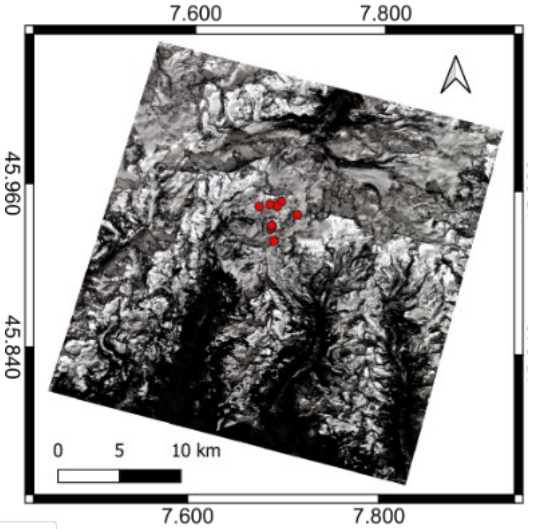


- SSWI is independent from grain size
- SSWI resulted linearly correlated with measured LWC in snow, thus we applied it to PRISMA scenes

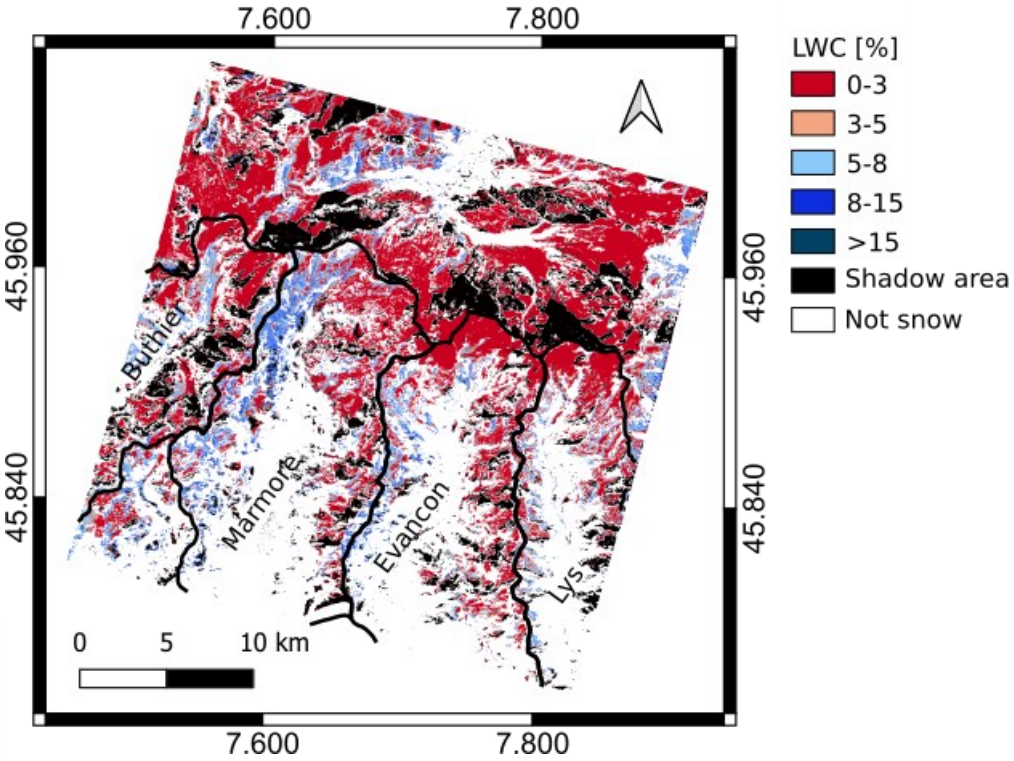
Liquid water content (LWC) from PRISMA

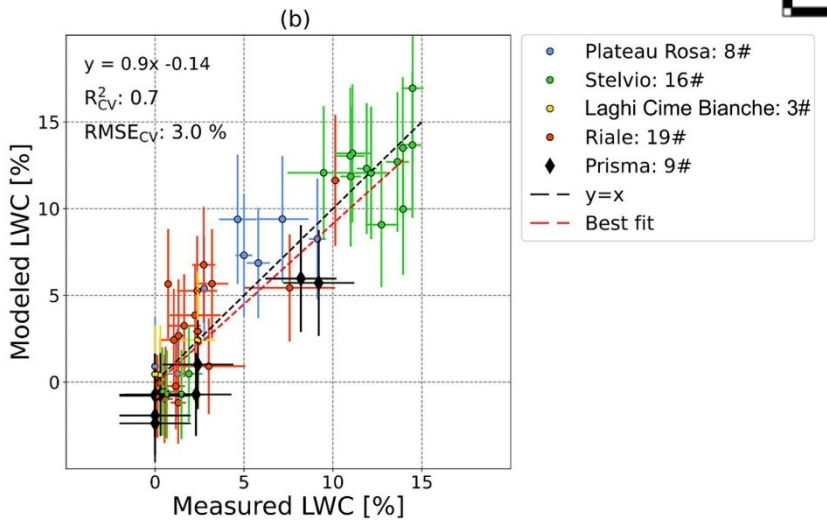


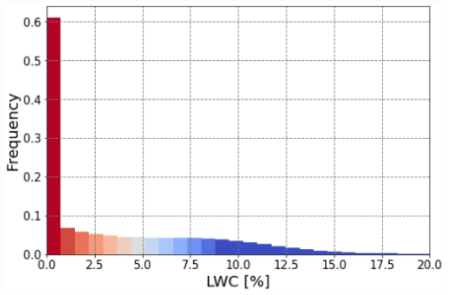
PRISMA – 21-02-2023



LWC map



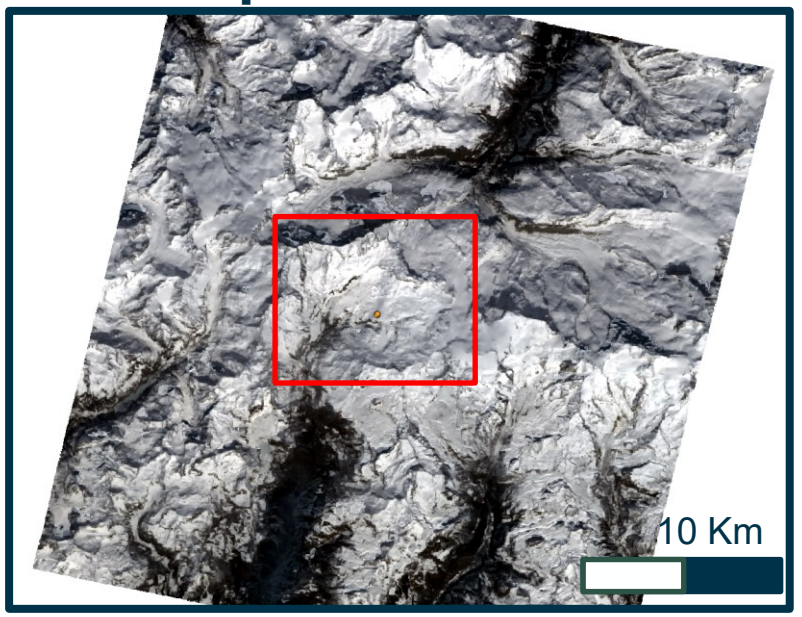




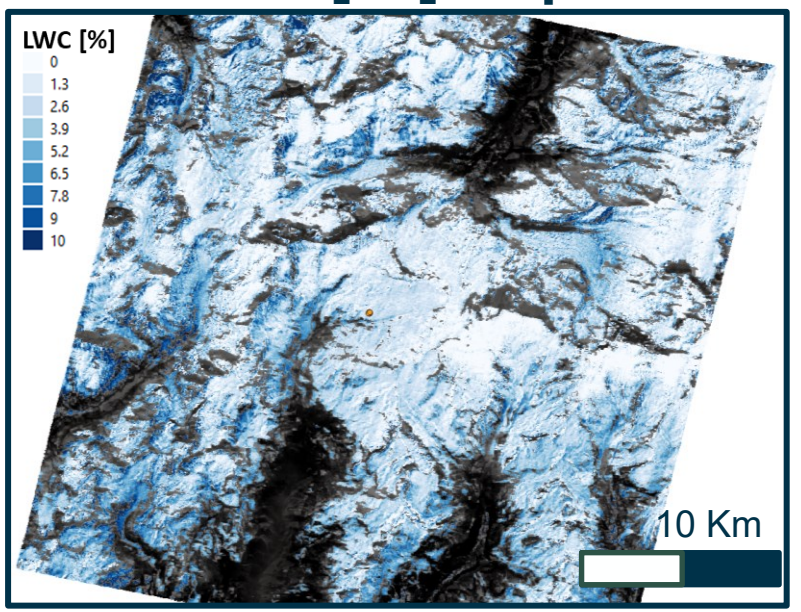
Ravasio, et al. (2024). *Remote Sens. Environ.*

Liquid water content (LWC) from EnMAP

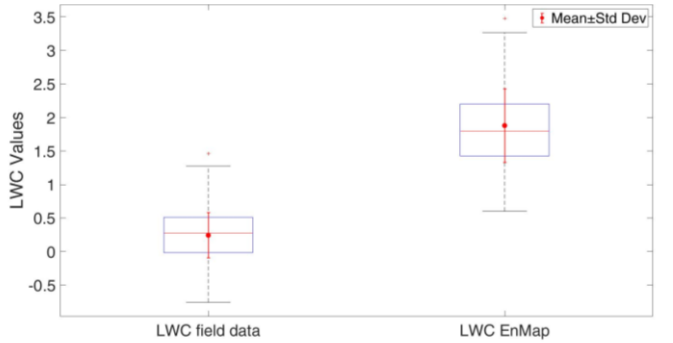
EnMap – RGB 25-03-2024

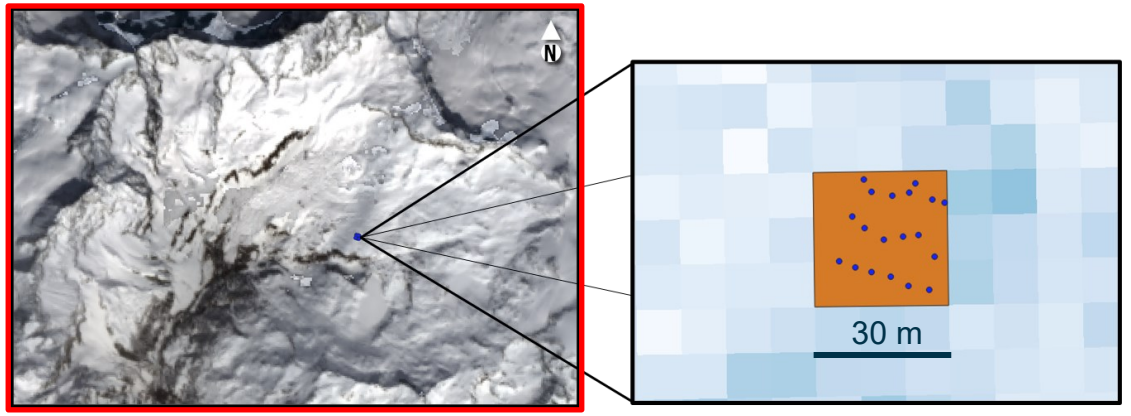


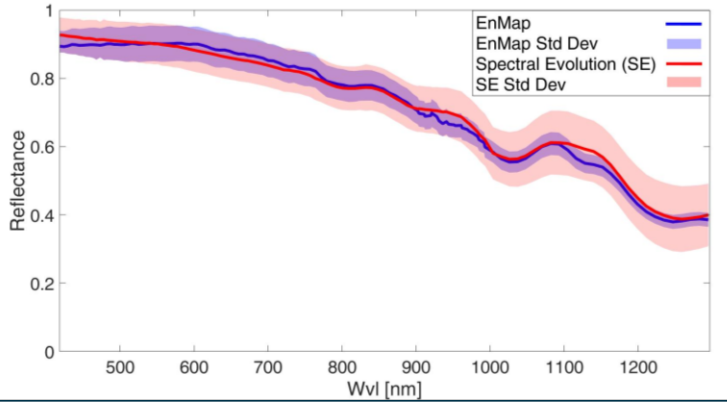
LWC [%] map



- Low LWC values (<2%) in the study area.
- Comparable with accumulation phase in Alpine basins







Conclusions and next steps

- PRISMA/EnMAP L1 and L2X spectra show a good agreement with field measurements, generally within the MRD requirements (lower than 5%). Higher errors were observed for areas with complex topography

- We developed a novel custom L2 (namely “L2_SCIA”) geocoded BOA reflectance product that also accounts for slope/aspect correction

- **Liquid Water Content (LWC)** in snow can be successfully retrieved from IS data (with ~10nm spectral resolution). The method has been developed using the BioSNICAR radiative transfer model and then tested on both field spectral data and satellite imagery (PRISMA, EnMAP)

- **Mineral dust concentration** in snow has been retrieved from IS data using three methods based on different radiative transfer simulations, with promising results. → need to be validated with dust concentration measurements (in progress)

Acknowledgements

- **PRISCAV** project: «Attività Scientifica di CAL/VAL della missione PRISMA»
- **SCIA** project: «Sviluppo di algoritmi per lo studio della Criosfera mediante Immagini PrismA»
- **BioGeoAlbedo** project: «Bio-Geo Albedo feedback on the margins of the Antarctic Ice Sheet»
- **TUPILAQ** project: «Triple UP-scaling of Ice-Light-Absorbing particles at Qaanaaq ice cap»
- **EnMAP validation team**

Contact: biagio.dimauro@cnr.it