

2nd Workshop on International Cooperation
in Spaceborne Imaging Spectroscopy

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PRISMA data for cryospheric applications in Alpine and polar environments

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Julitta T. (5), Kokhanovsky A. (6), Guanter L. (7), Giardino C. (8), Panigada C. (2), Rossini M. (2) and Colombo R. (2)

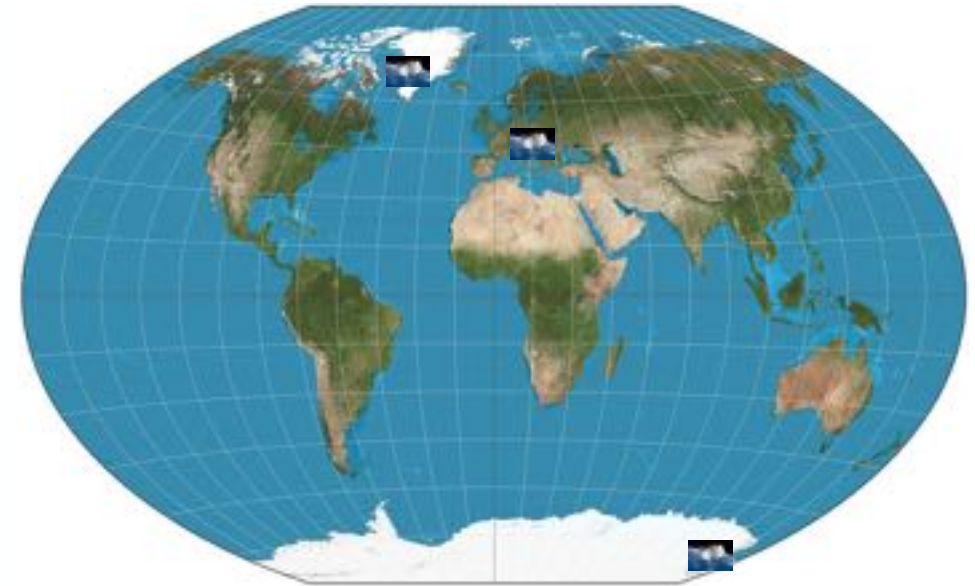
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- (8) Institute for Electromagnetic Sensing of the Environment, National Research Council (CNR-IREA), Milan (Italy)



Objectives of the presentation

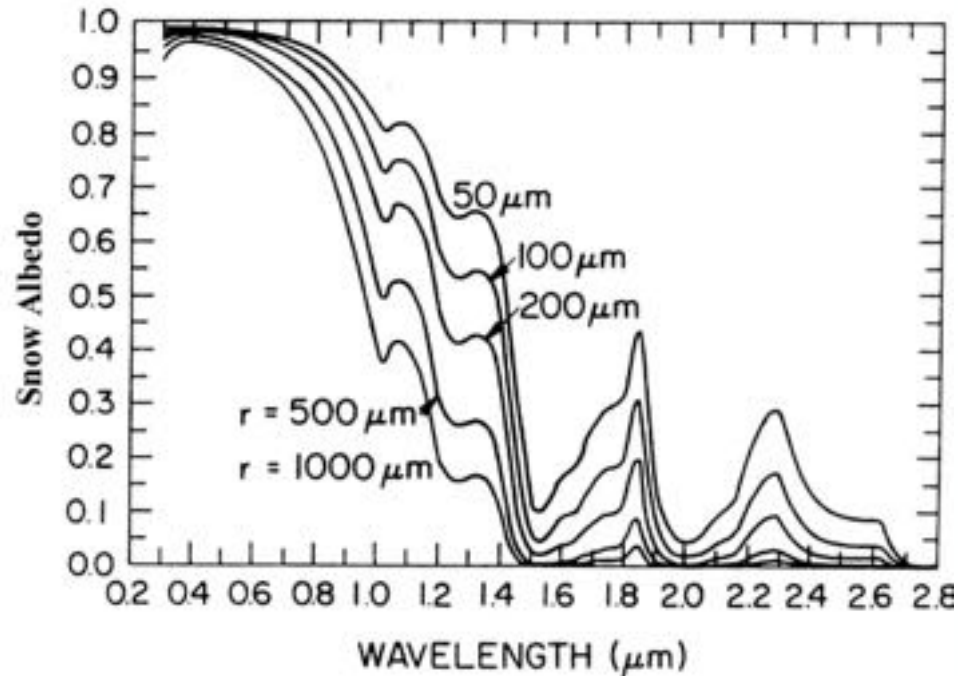


- To briefly review hyperspectral remote sensing of snow and ice
- To present PRISMA Cal/Val activities in the Alps
- To show first applications of PRISMA in the Alps, Greenland and Antarctica

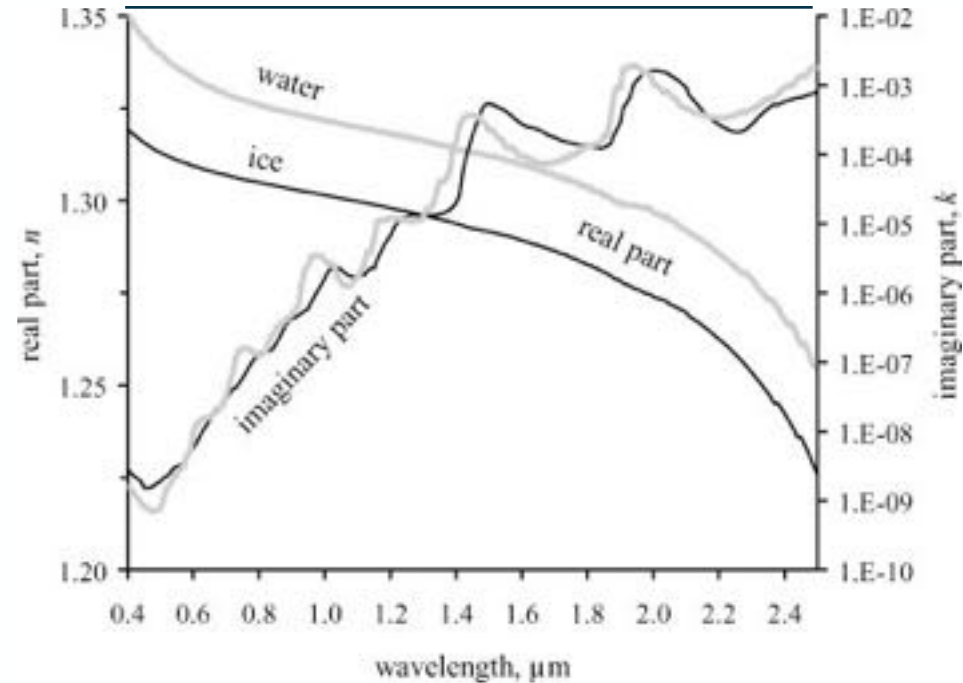




Hyperspectral remote sensing of snow and ice



Wiscombe & Warren 1980

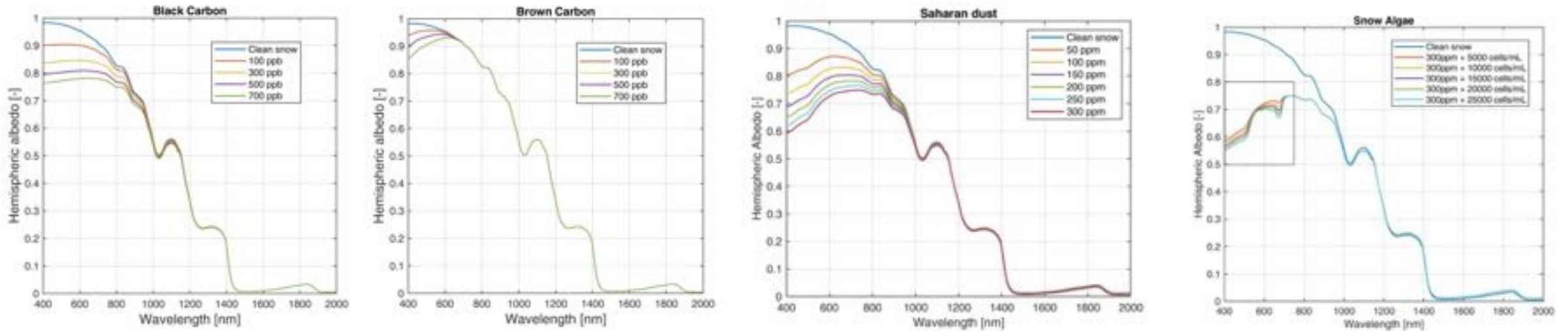


Painter & Dozier 2004

- **Snow reflectance** in the Visible and Near-Infrared wavelengths decreases as snow ages (increase in grain size)
- **Absorption features** (800 nm, 1030 nm, 1250 nm, 1500 nm, 2000 nm) are related to the imaginary part of the refractive index



Hyperspectral remote sensing of snow and ice

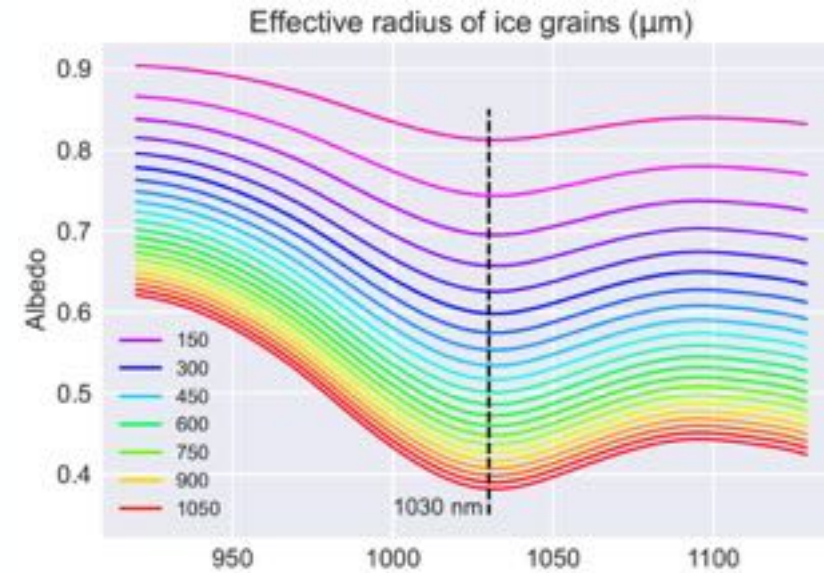
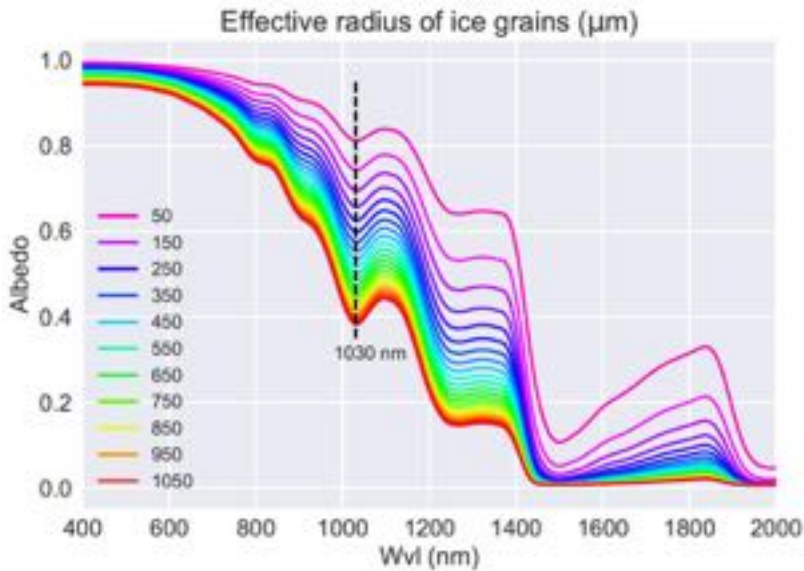


Di Mauro et al. 2021. Light-Absorbing Particles in Snow and Ice: A Brief Journey Across Latitudes. *Springer Series in Light Scattering*

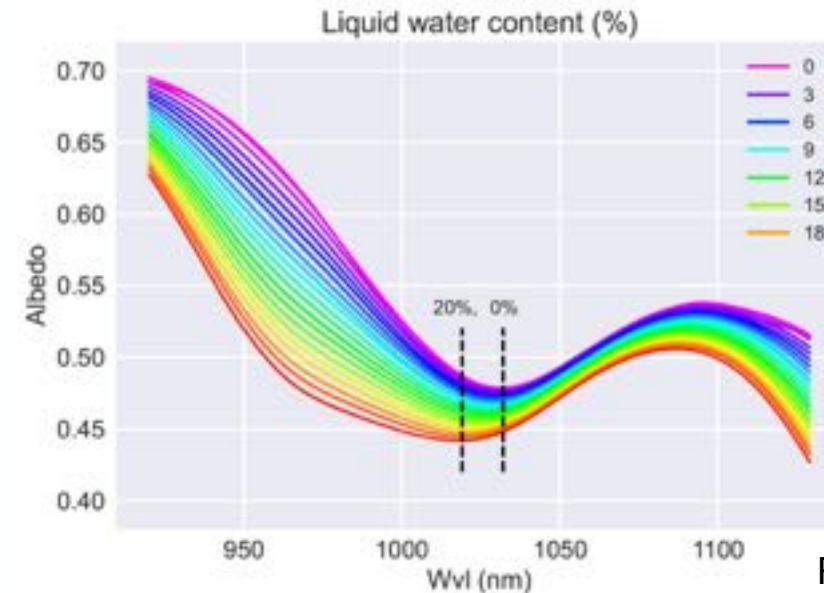
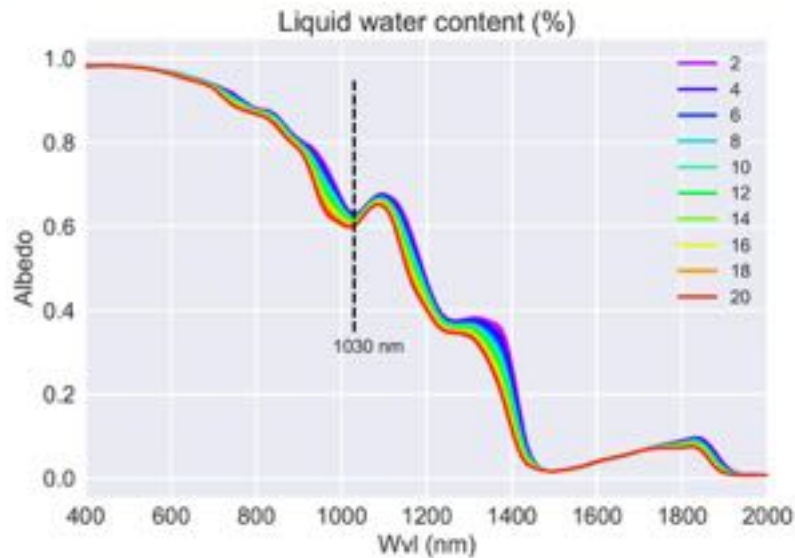
- **Snow reflectance** in the Visible wavelengths allows to derive the nature, concentration and radiative forcing of **light-absorbing impurities** (e.g. mineral dust, cryoconite, algae) in snow and ice
- These impurities are involved in the **snow/ice-albedo feedback** and play an important role in snow and ice melting at global scale



Hyperspectral remote sensing of snow and ice



BioSNICAR model



Ravasio et al. (in prep) 5

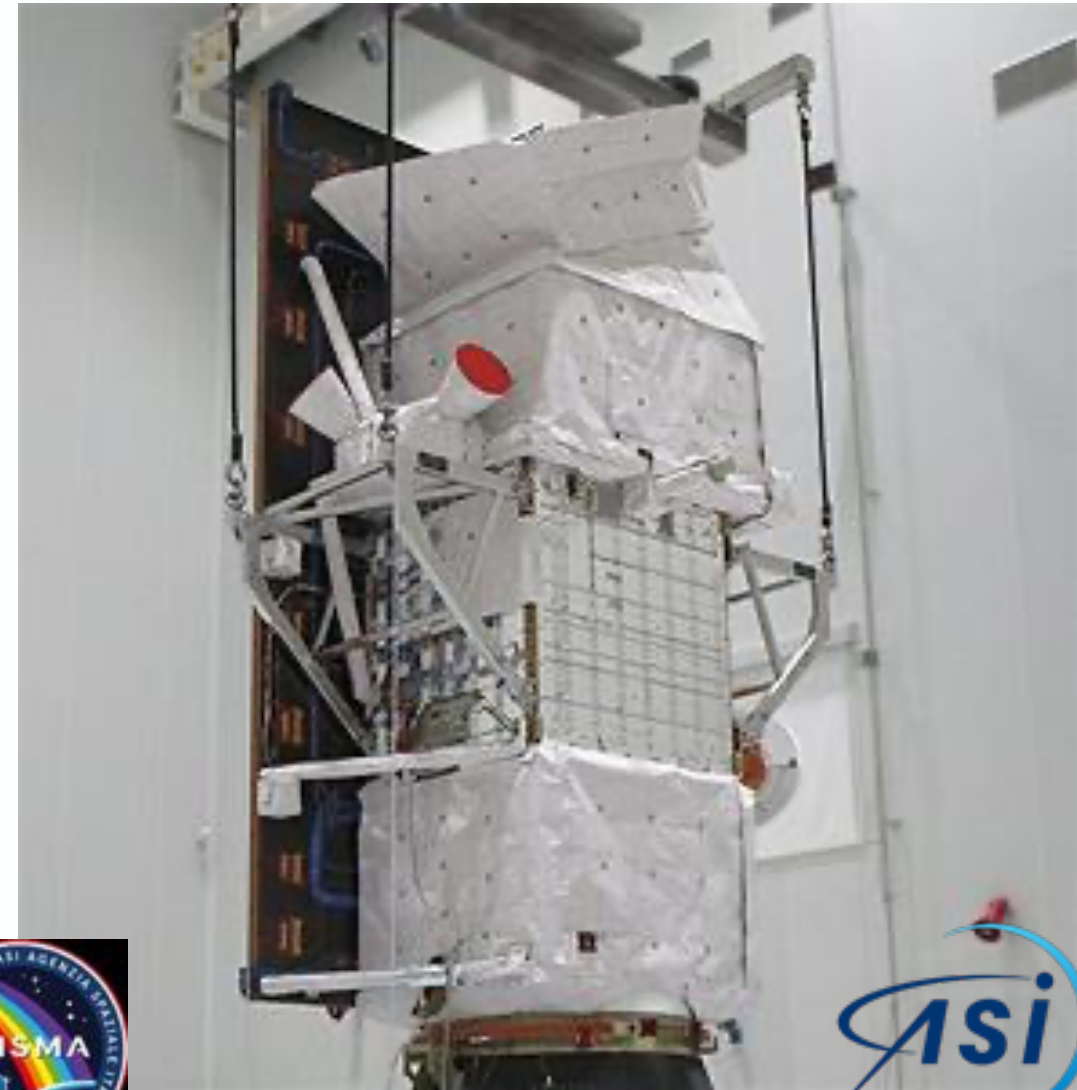




PRISMA imaging spectrometer



- **PRISMA** (PRecursores IperSpettrale della Missione Applicativa) is a satellite mission by the Italian Space Agency (**ASI**).
- Launched in April 2019
- On-demand hyperspectral data of Earth surface
- The imaging spectrometer features **239 bands** covering the **visible, near infrared** and **shortwave infrared** wavelengths (400-2500 nm) with a **spectral resolution** <12nm.
- Spatial resolution: 30m, Swath: 30 km.



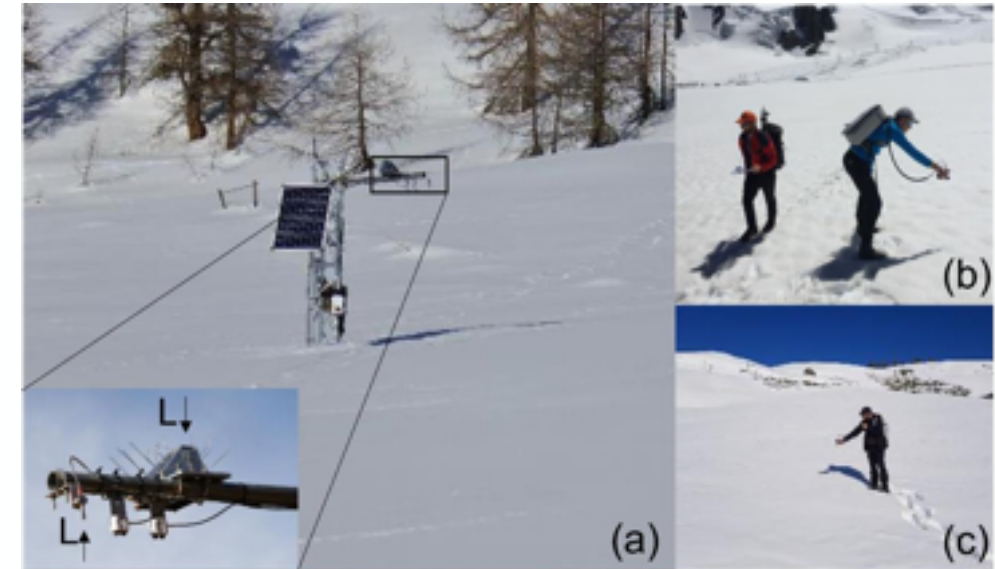
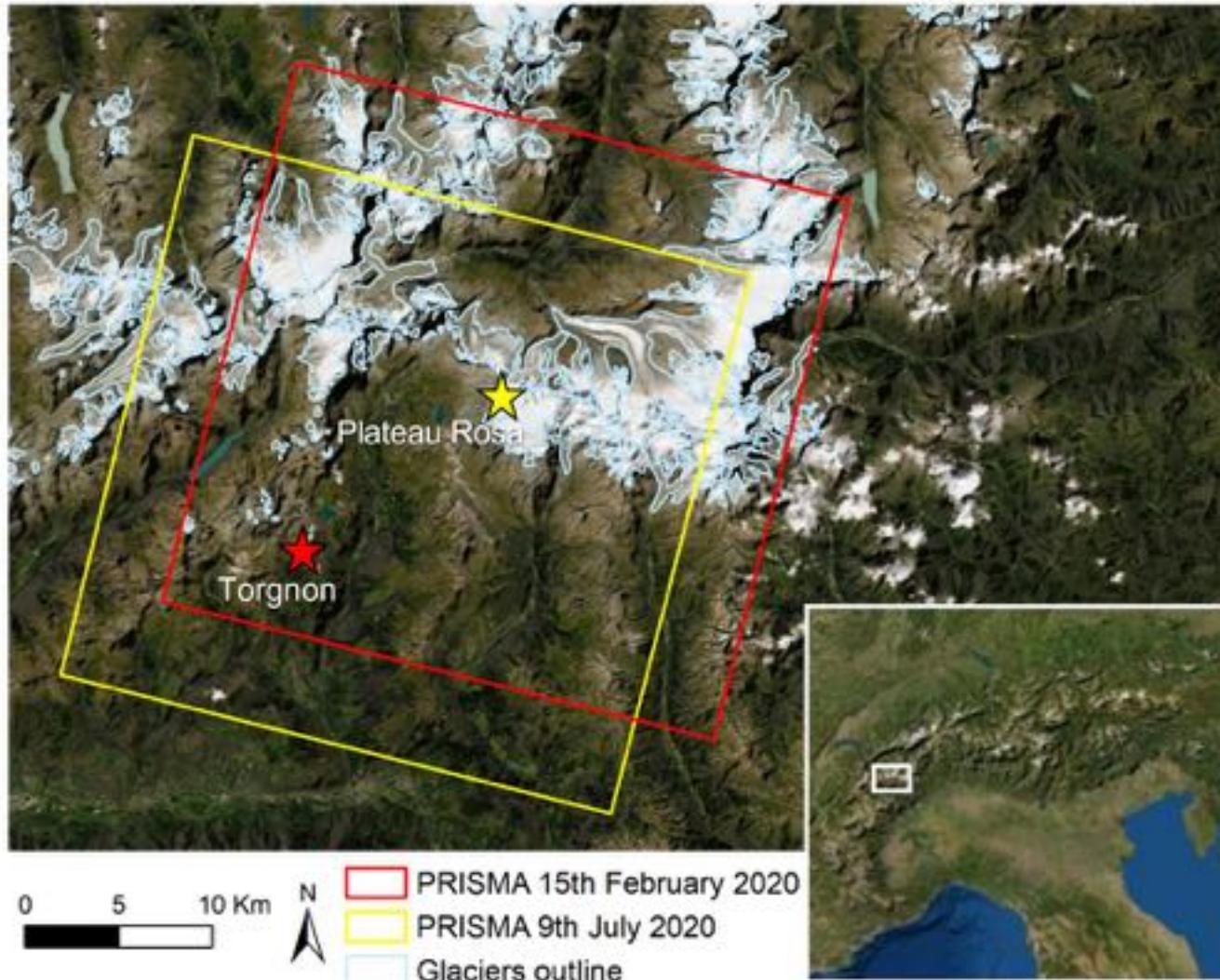
Agenzia Spaziale Italiana



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PRISMA cal/val - Experimental sites in the Alps



Di Mauro et al. (*in prep*)₇





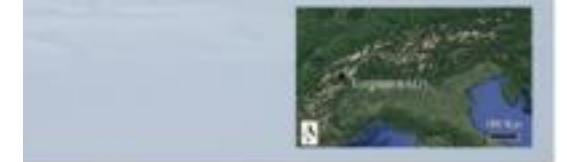
PRISMA cal/val – Torgnon site



General: High altitude (2160 m) experimental site (Torgnon, Aosta Valley) in the Western Alps.

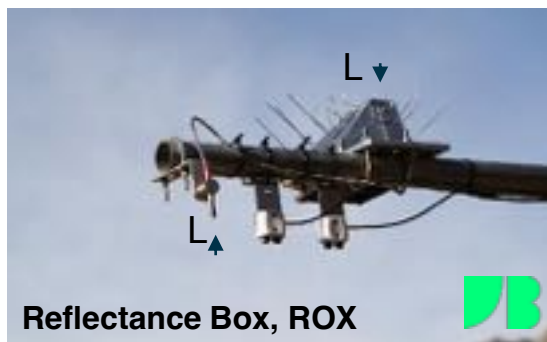
Snow cover duration: October-May

Instruments operating at the site: net radiometer, webcam, sensors for snow depth, snow water equivalent, snow surface temperature, snow spectral reflectance (400-900nm)

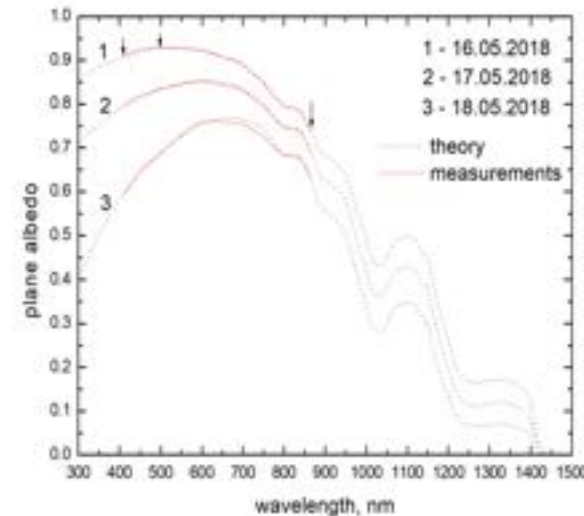


Di Mauro et al. (2019) *The Cryosphere*

PRISMA acquisition:
15th February 2020



Reflectance Box, ROX

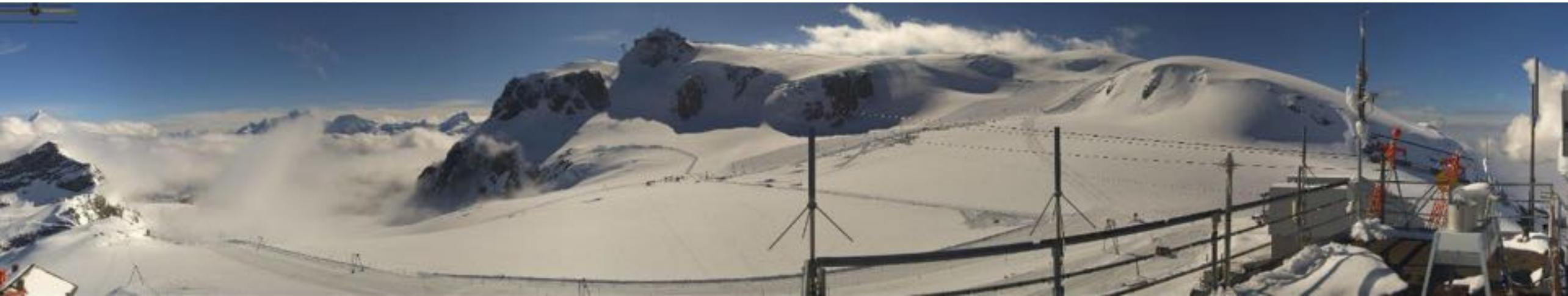


Kokhanovsky et al. (2021) *Front. Env. Sciences*



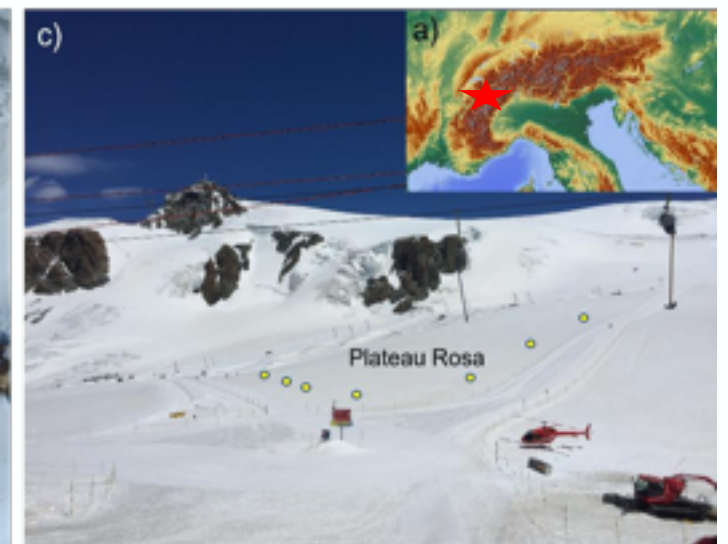
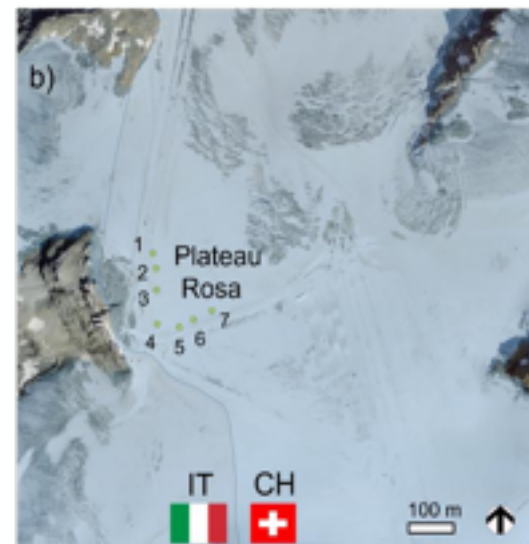


PRISMA cal/val – Plateau Rosa site



- Plateau Rosa is located in the Monte Rosa massif at 3500m asl
- Almost flat area easy to reach with the cableway
- Snow is present on the glacier also during the summer season

PRISMA acquisition:
9th July 2020

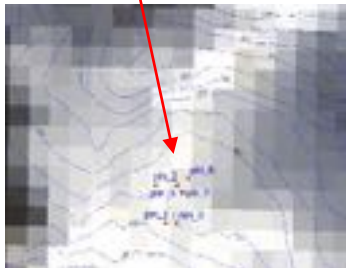
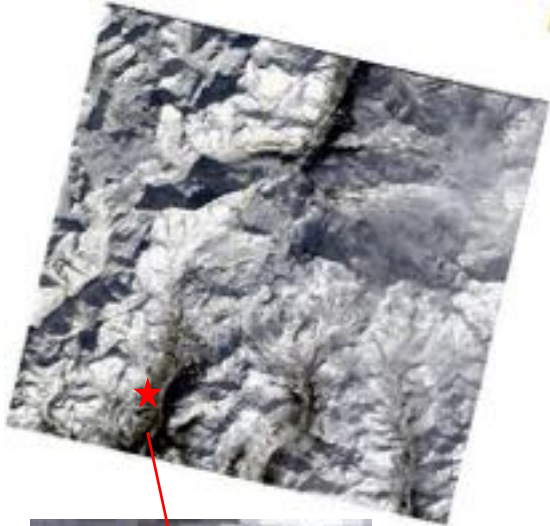




Cal/Val activities in the Alps



Torgnon



- Feb 15th, 2020
- SZA 61°
- VZA 8.7°-10.2°
- SAA 159°
- RAA 55°
- fresh snow
- Sentinel-2 (Feb 14th 2020)
- RoX spectra

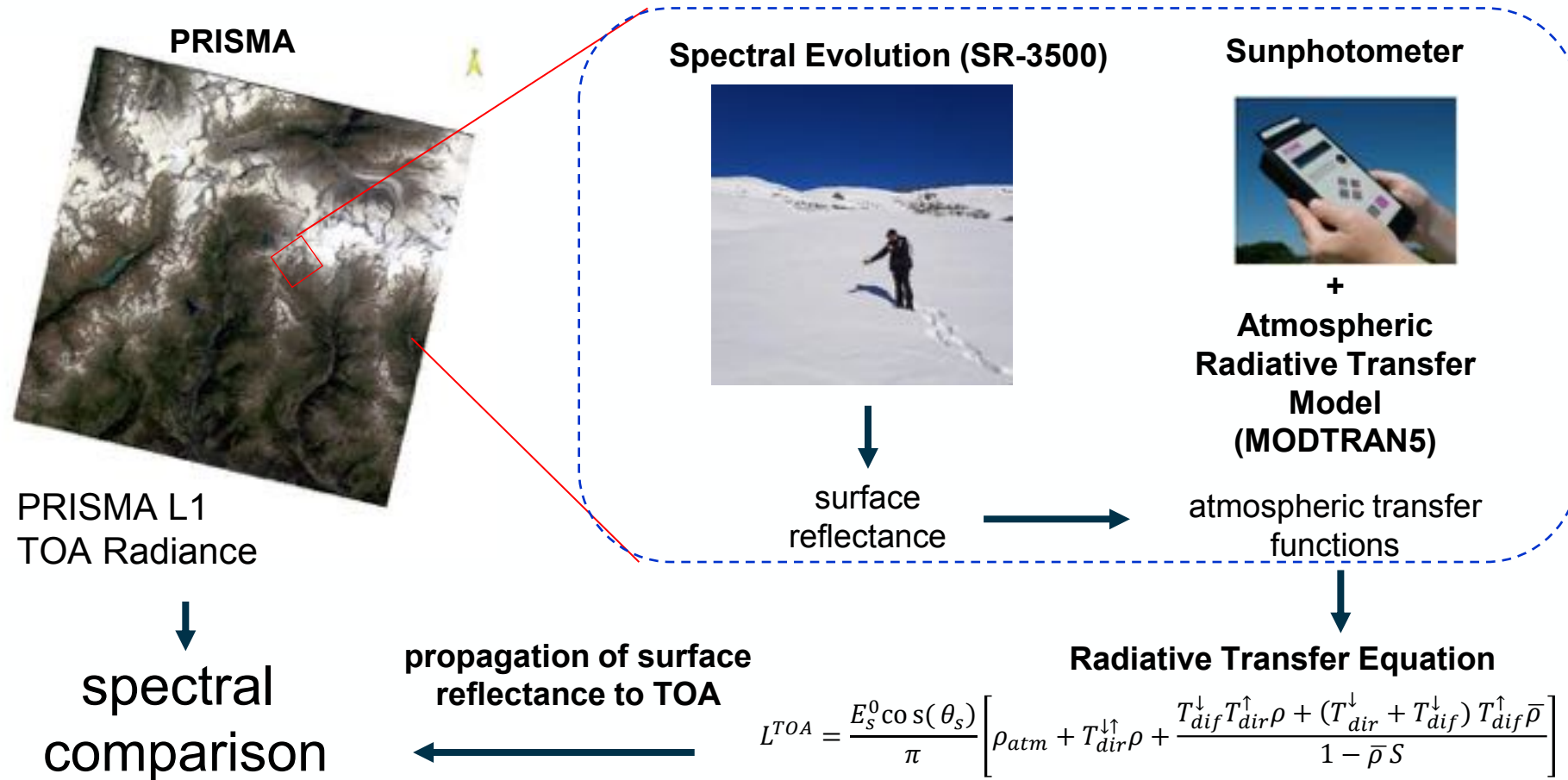
Plateau Rosa



- Jul 9th, 2020
- SZA 27°
- VZA 8.7°-10.2°
- SAA 145°
- RAA 42°
- aged snow
- Sentinel-2 (July 8th 2020)

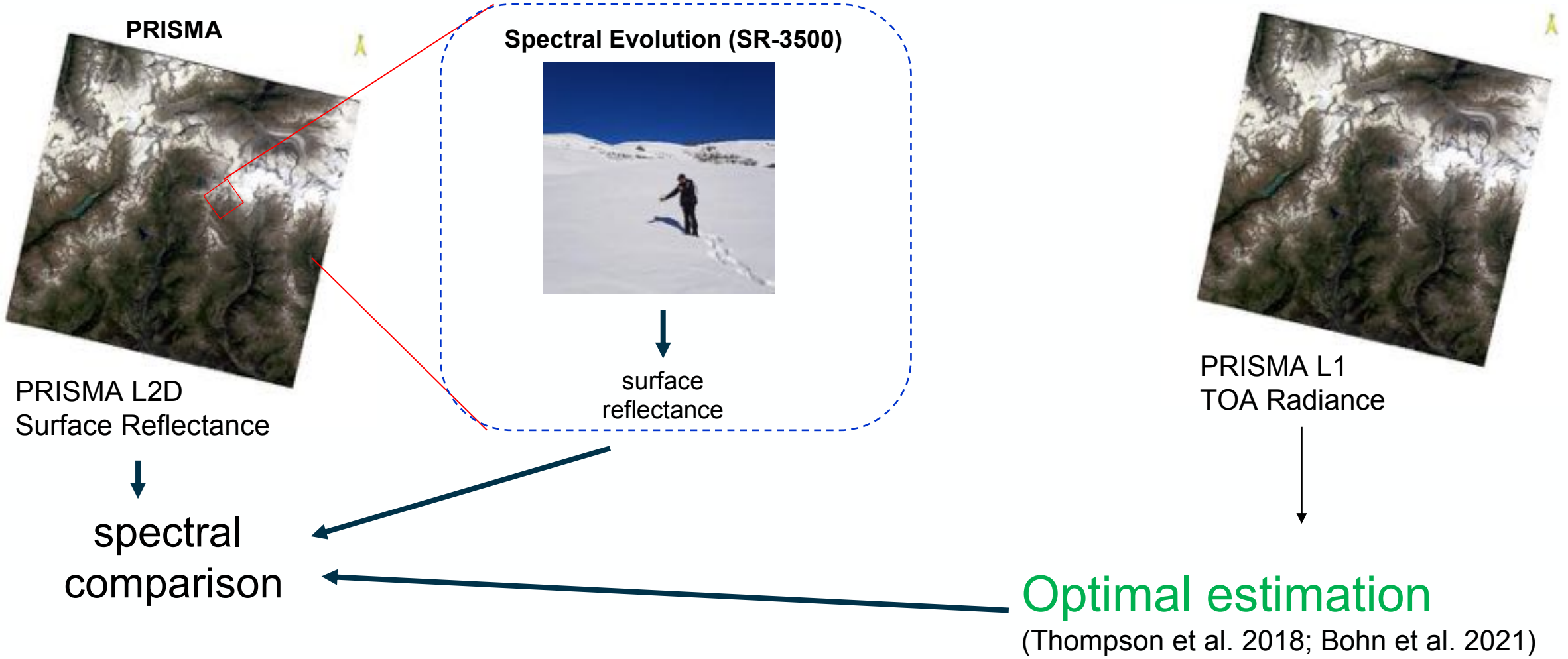


Cal/Val activities in the Alps – TOA Radiance





Cal/Val activities in the Alps – BOA Reflectance





Cal/Val activities in the Alps – TOA Radiance



Some cirrus clouds

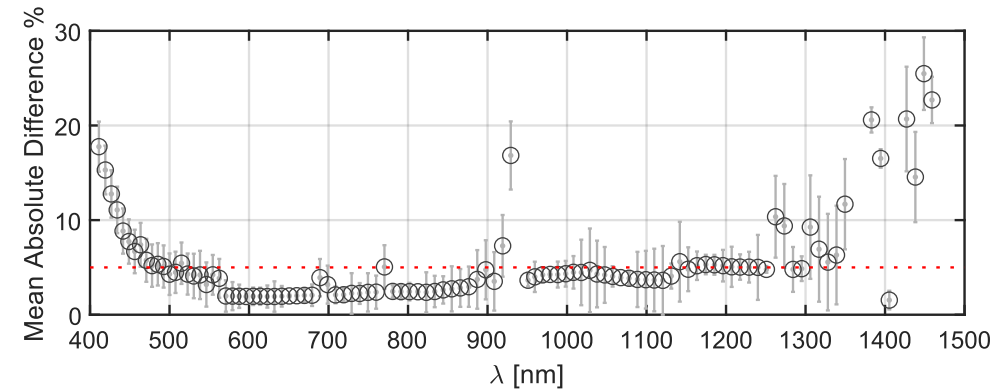
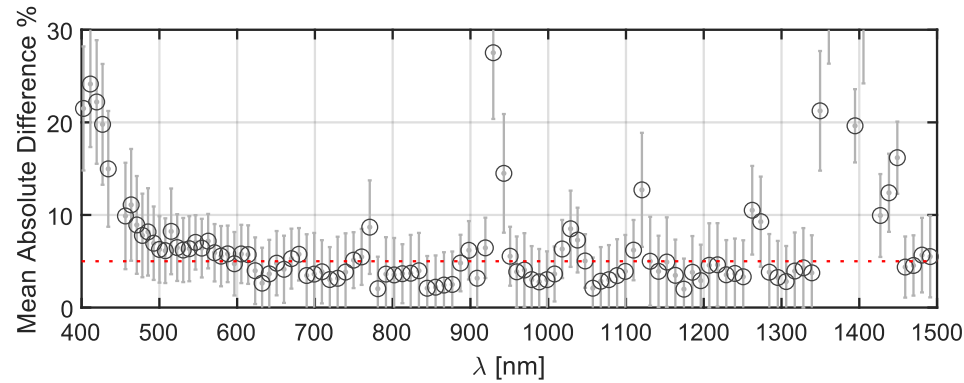
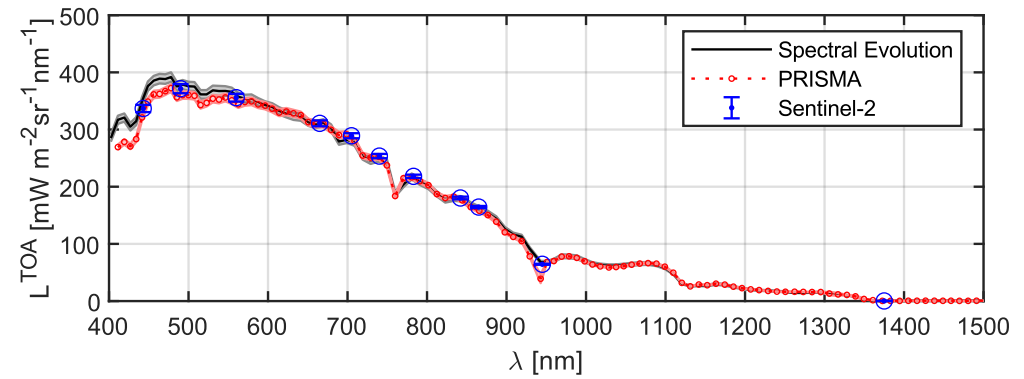
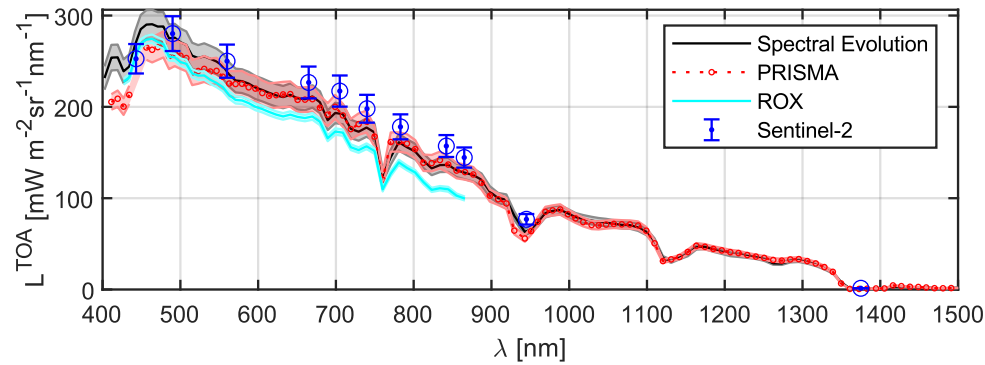


Torgnon

Clear sky



Plateau Rosa



Di Mauro et al. (*in prep*)

13

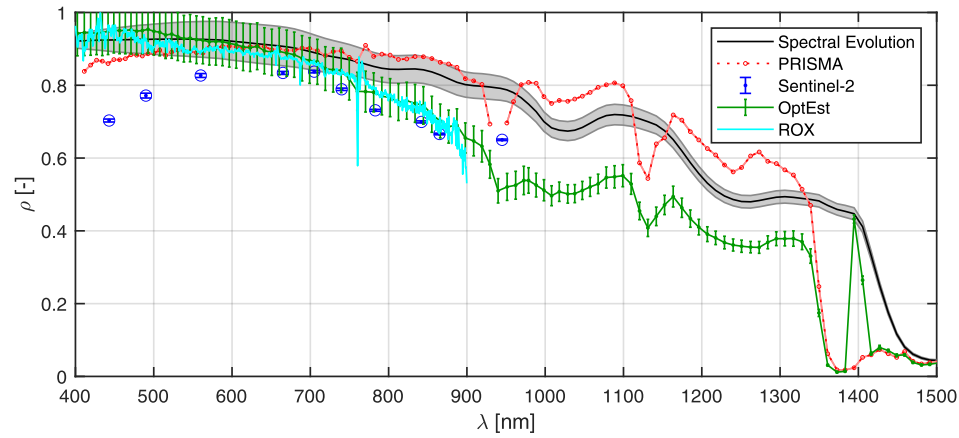




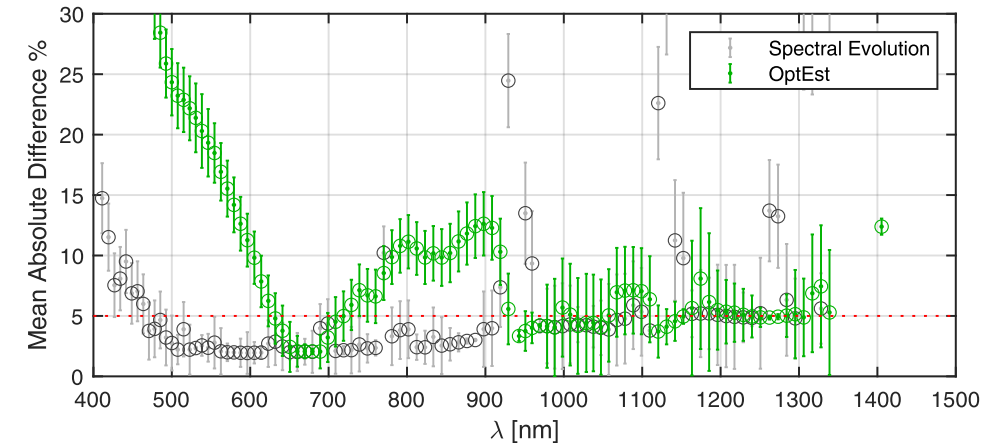
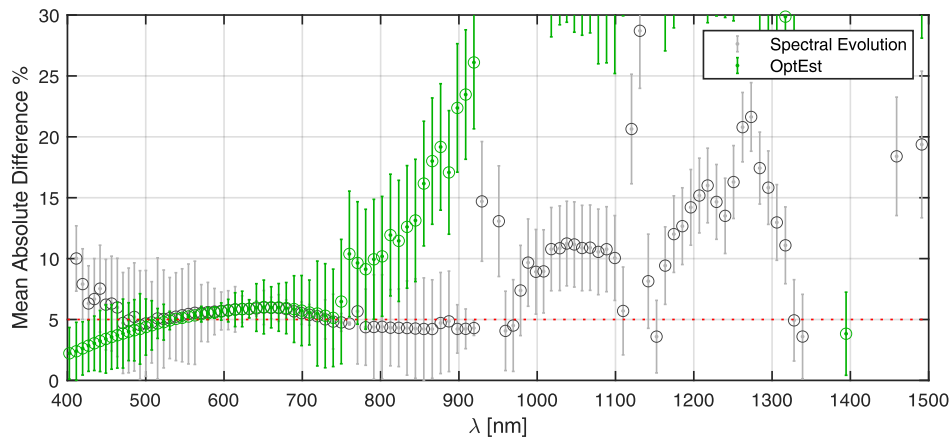
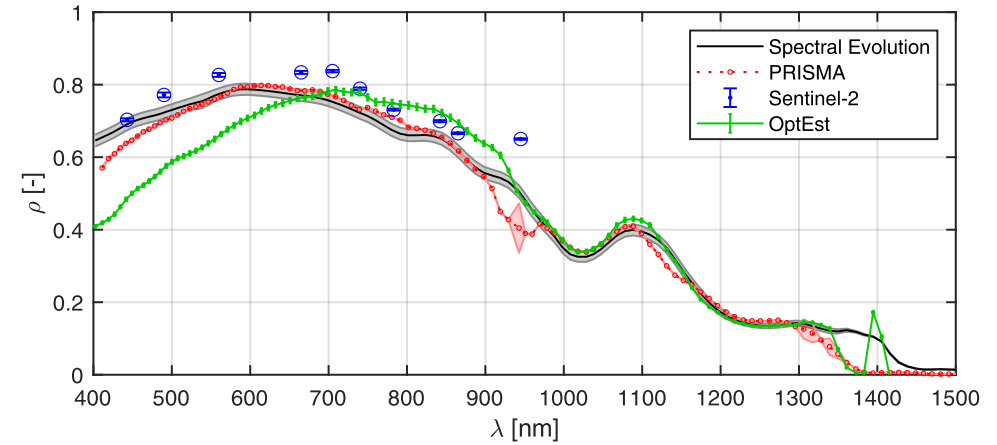
Cal/Val activities in the Alps – BOA Reflectance



Torgnon



Plateau Rosa



Di Mauro et al. (in prep) 14

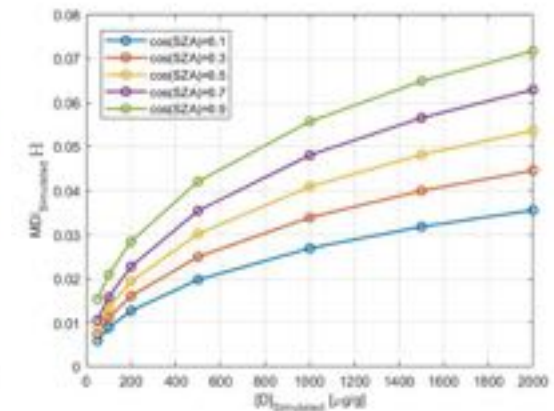
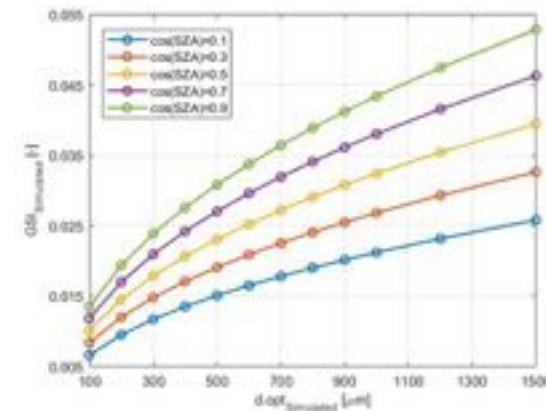
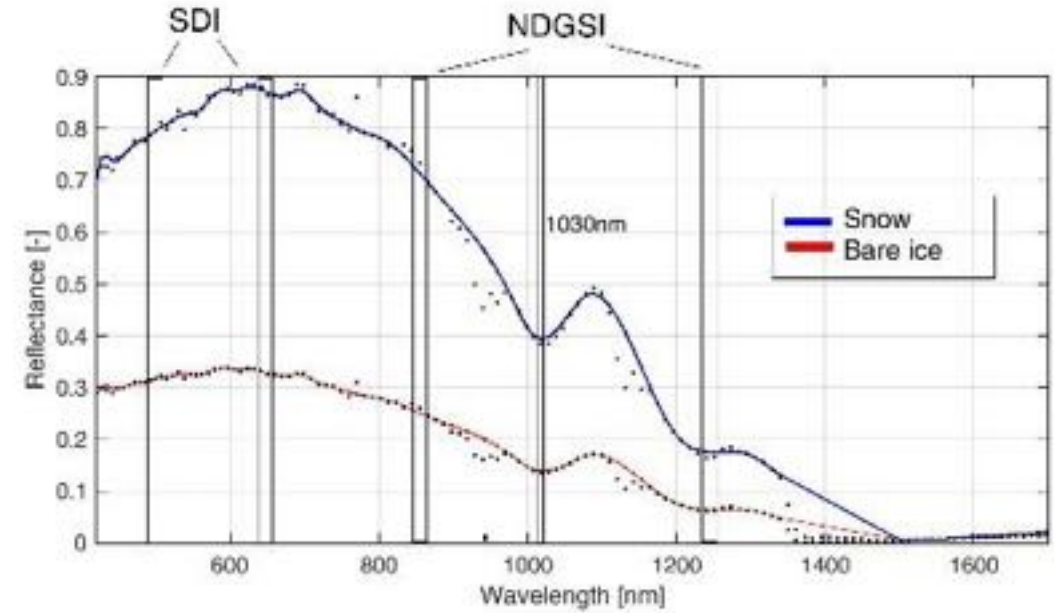
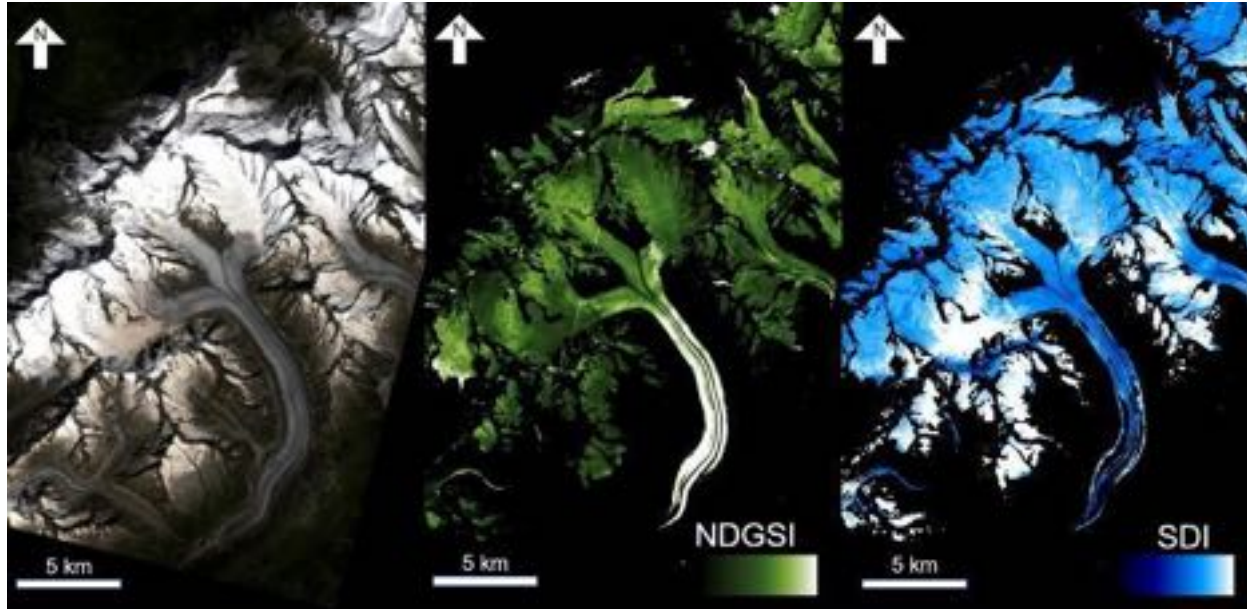




Mapping grain size and impurities at the Aletsch glacier (Swiss Alps)



PRISMA true color (7 August 2020)



Normalized Difference Grain Size Index (NDGSI) [Painter et al, 2012]

Snow Darkening Index (SDI) [Di Mauro et al. 2015]

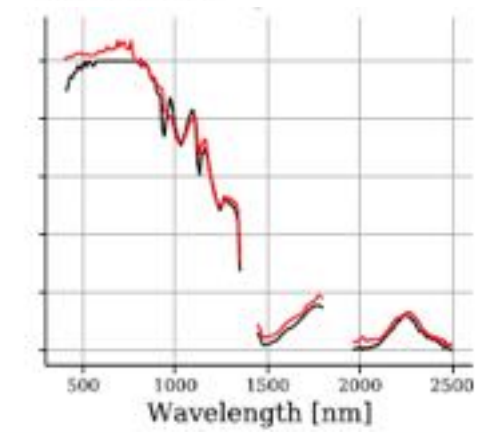
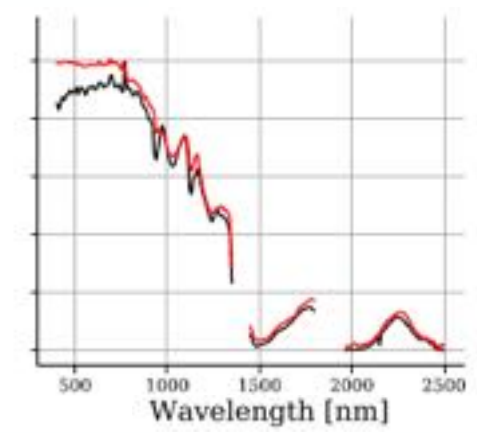
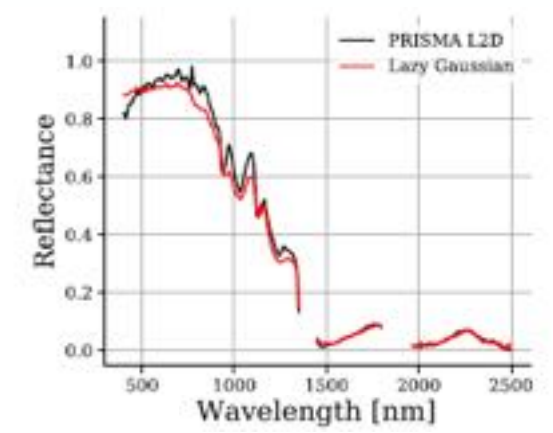
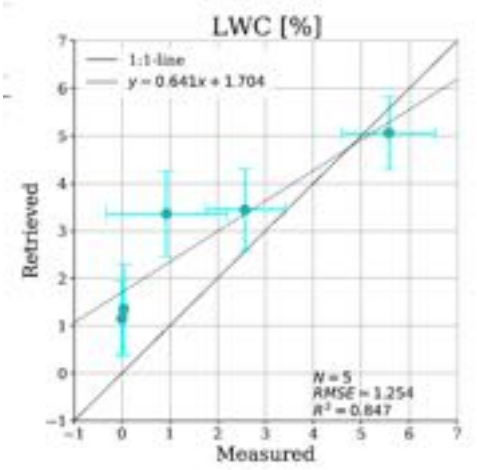
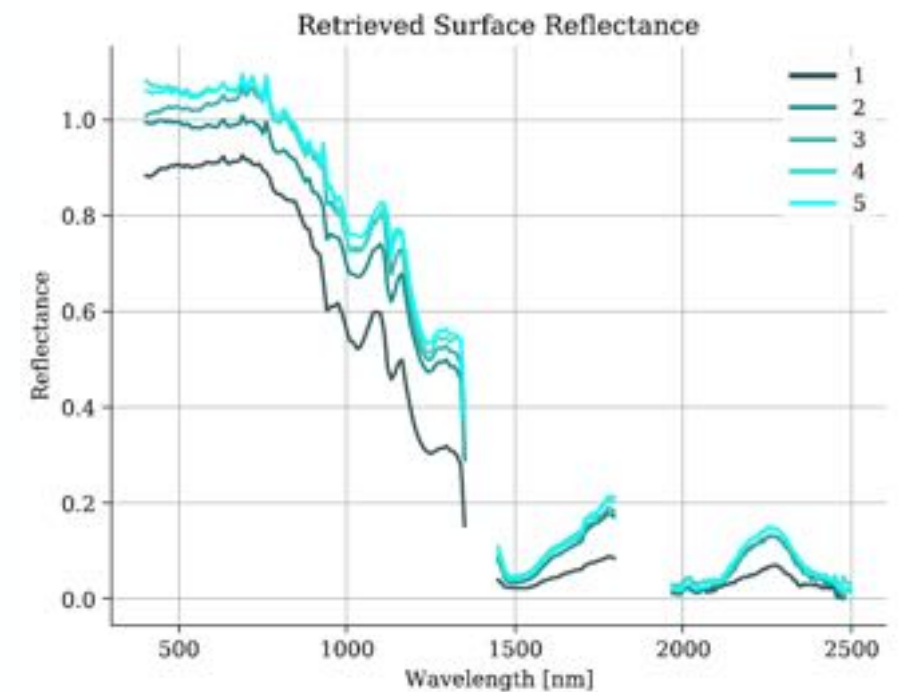
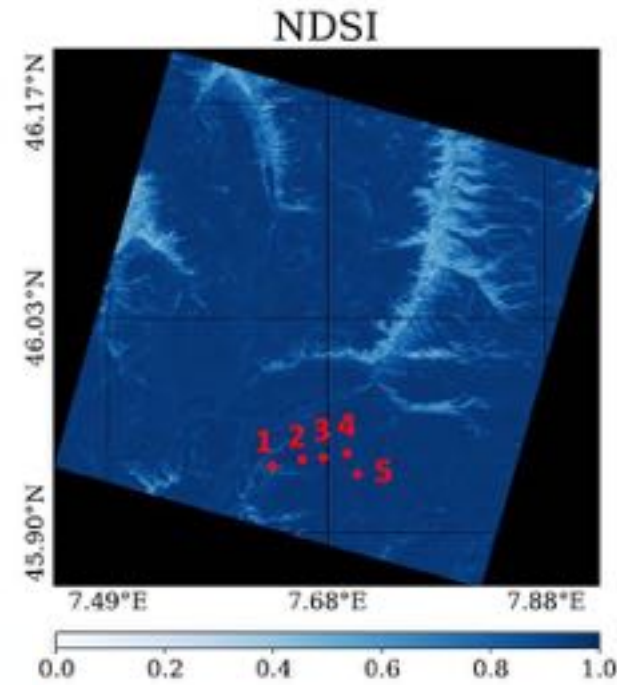
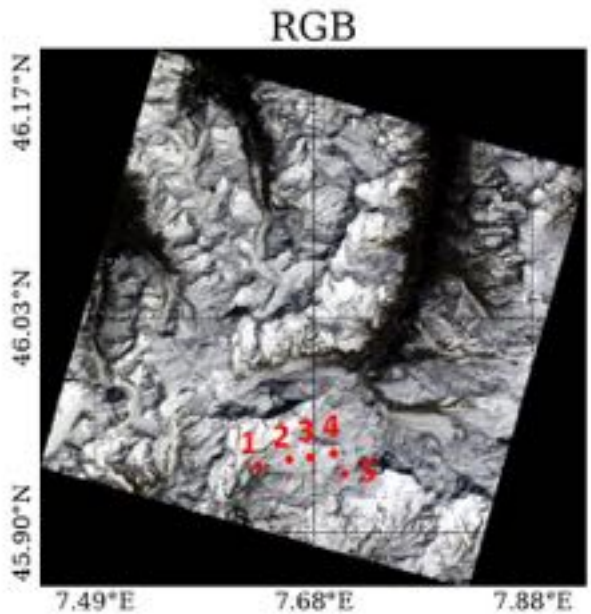
SNICAR-ADv3 model₅



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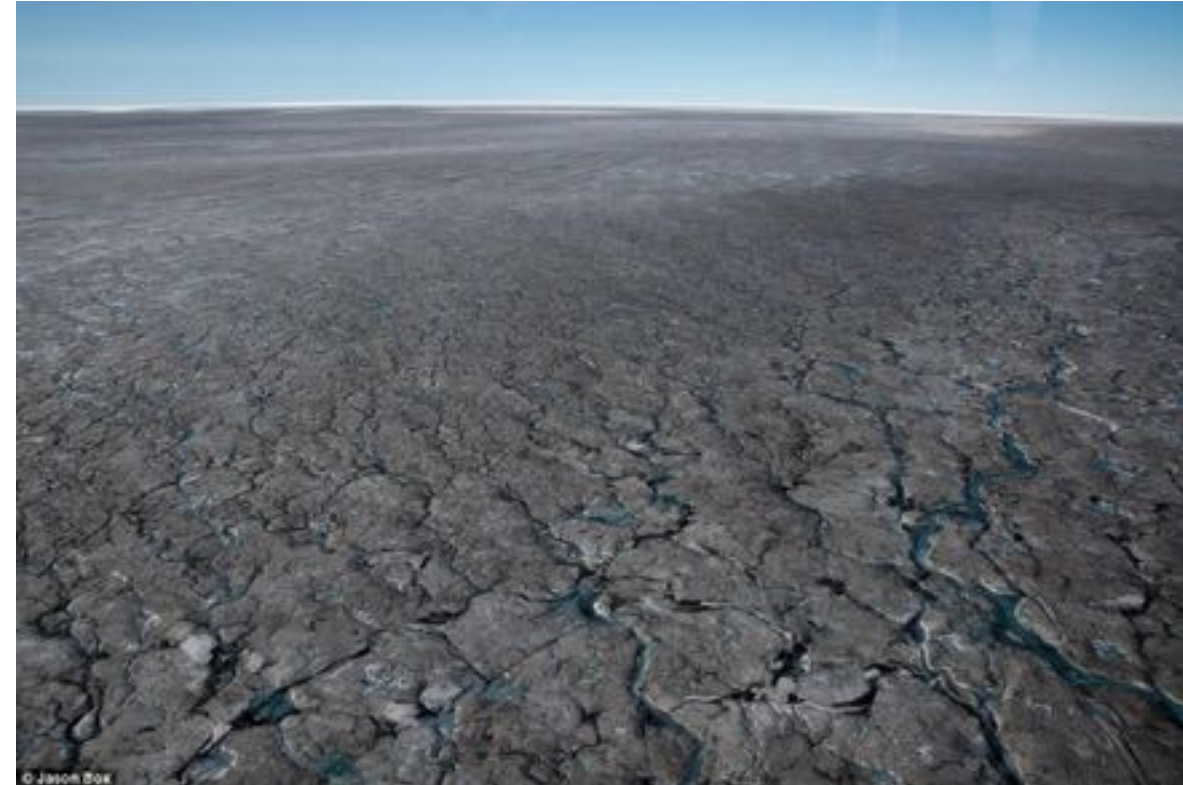
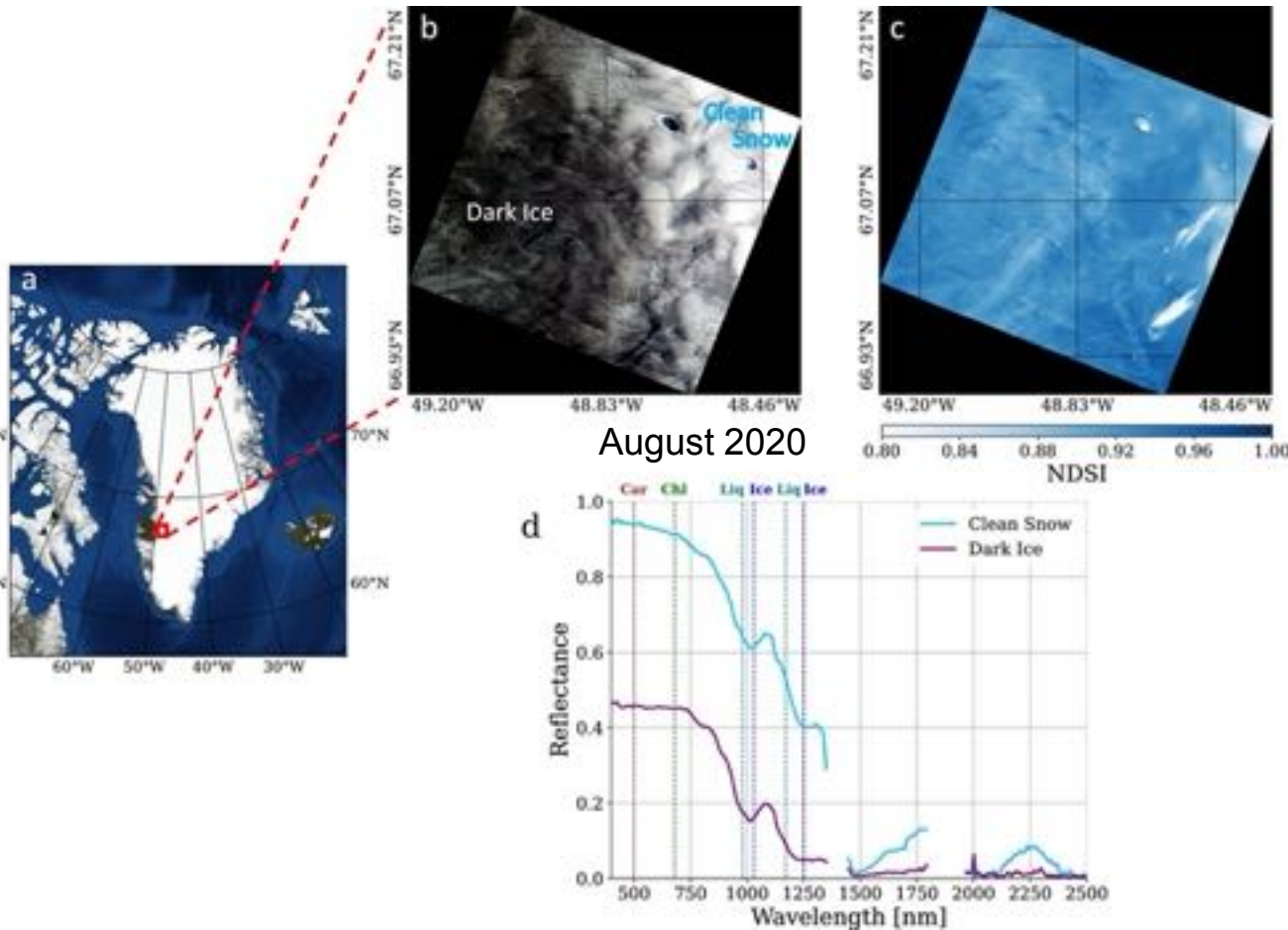


LWC retrievals in Western Alps





Glacier ice parameters retrieval from PRISMA



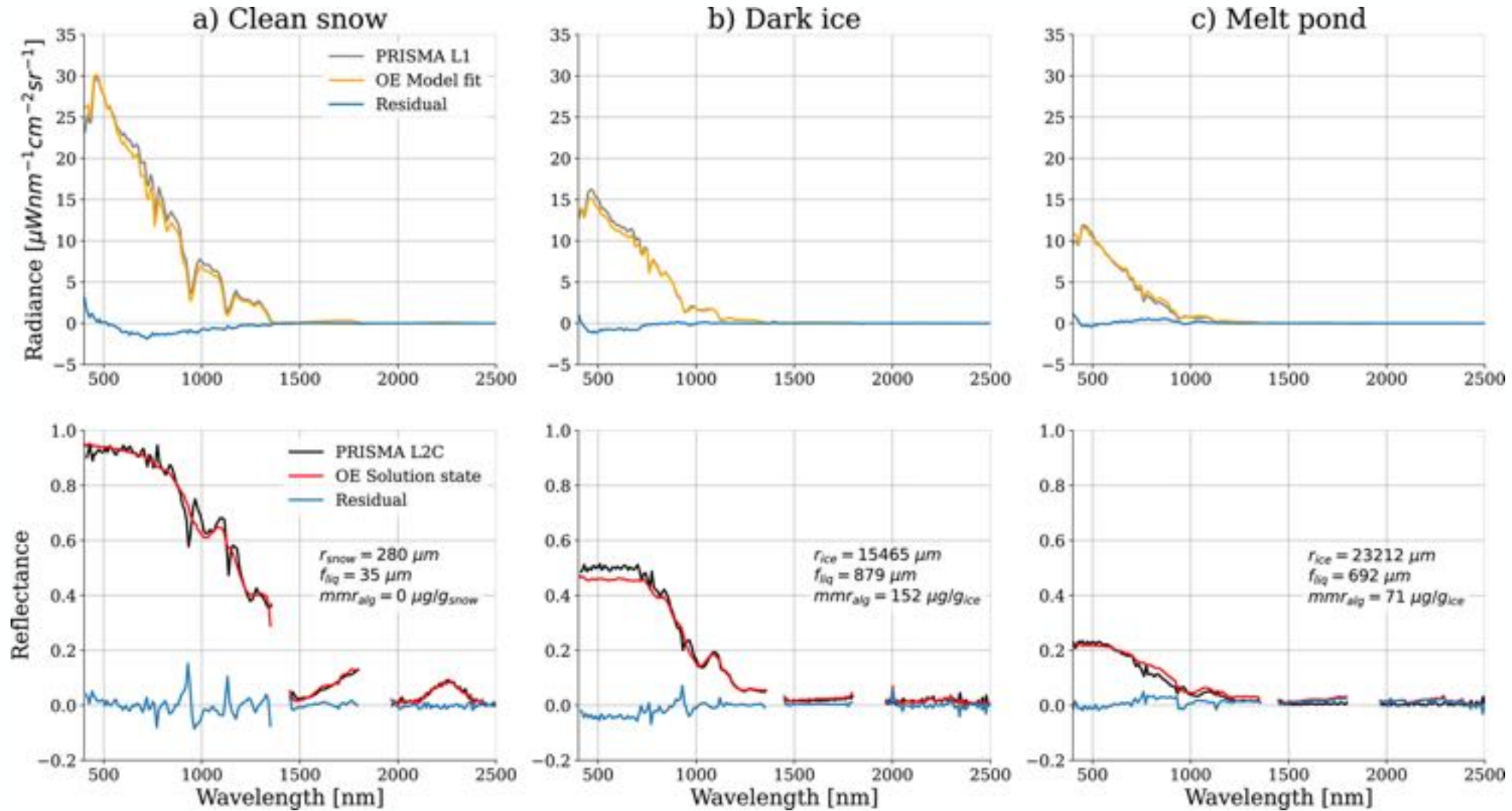
Credits: Jason Box

Bohn, N., Di Mauro, B., Colombo, R., Thompson, D. R., Susiluoto, J., Carmon, N., Turmon M. J., Guanter L. (2022). Glacier ice surface properties in South-West Greenland Ice Sheet: First estimates from PRISMA imaging spectroscopy data. *Journal of Geophysical Research: Biogeosciences*, 127, e2021JG006718. <https://doi.org/10.1029/2021JG006718>



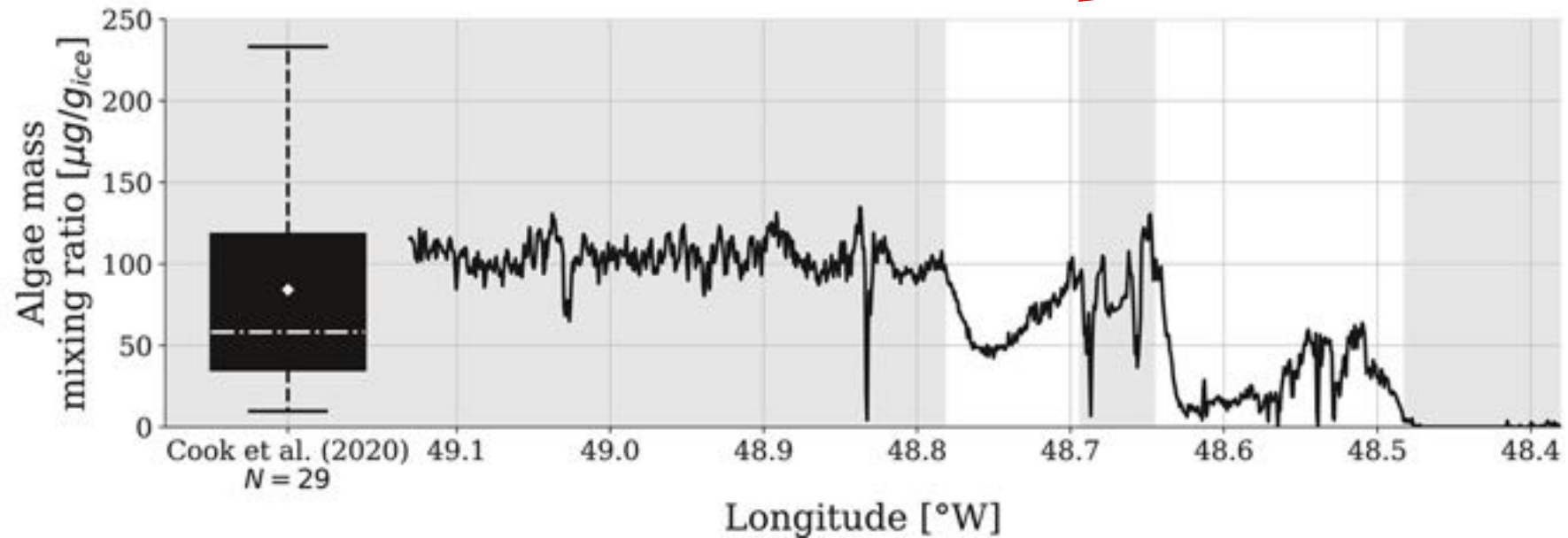
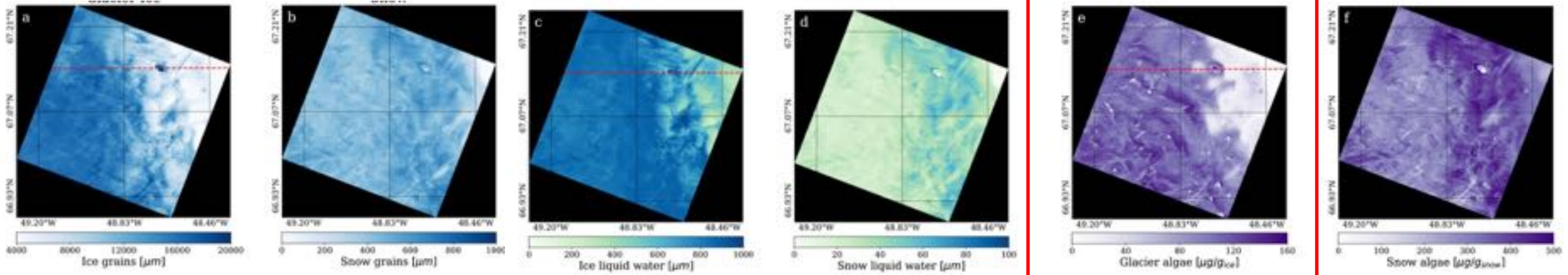


Glacier ice parameters retrieval from PRISMA



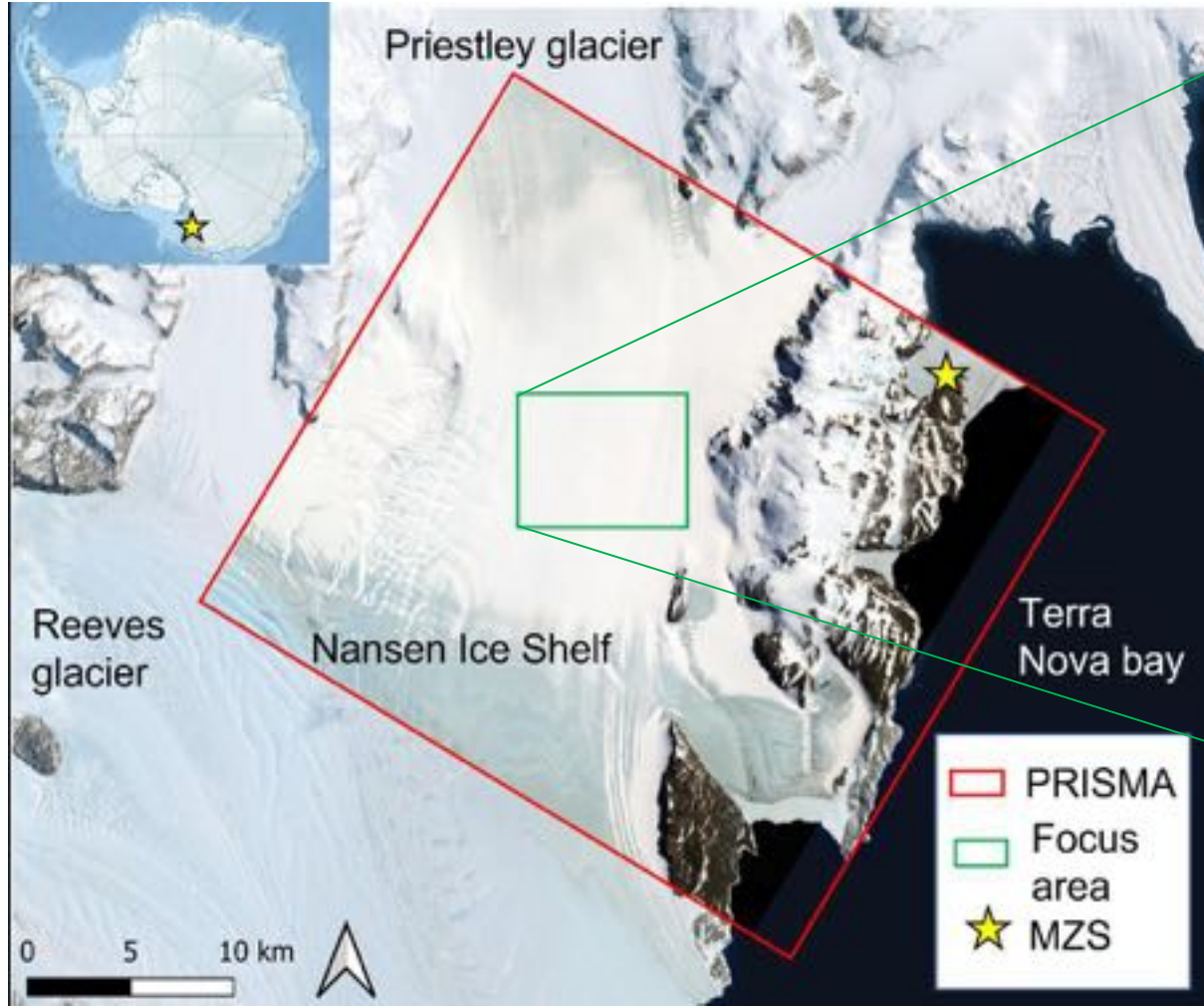


Glacier ice parameters retrieval from PRISMA

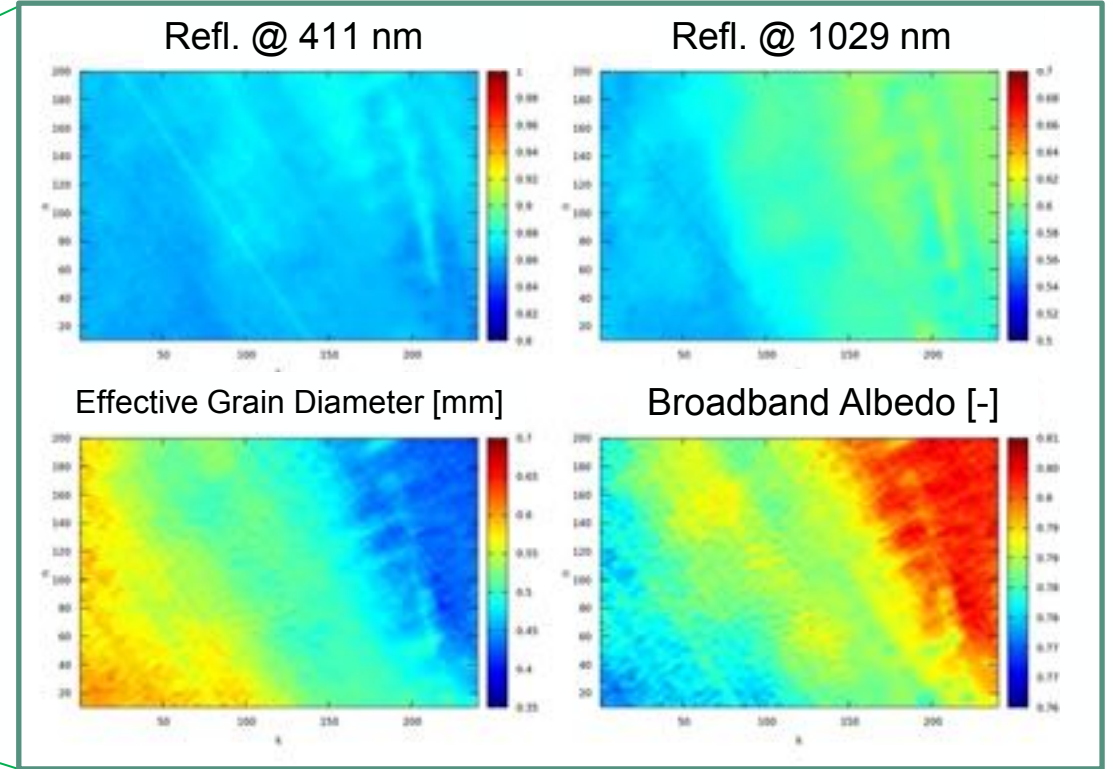




Snow surface properties over the Nansen Ice Shelf (East Antarctica)



December 2020



Snow surface properties derived from PRISMA satellite data over the Nansen Ice Shelf (East Antarctica).

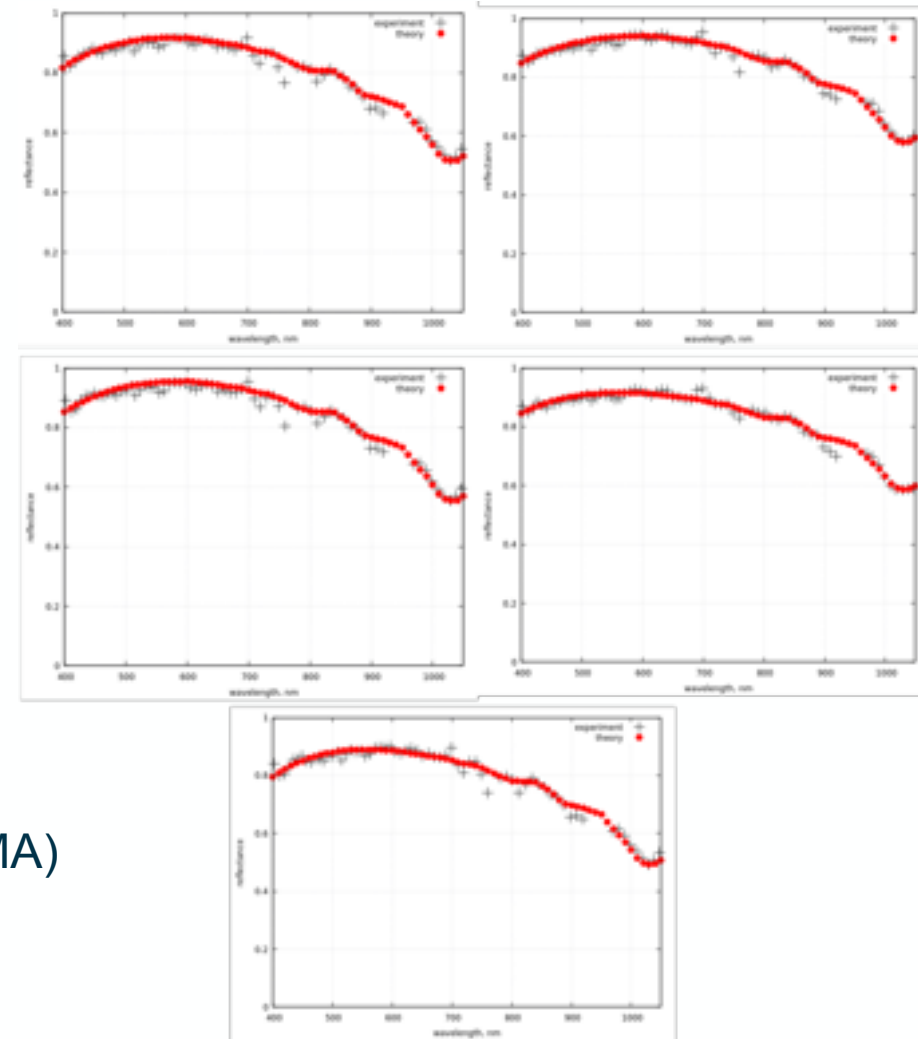
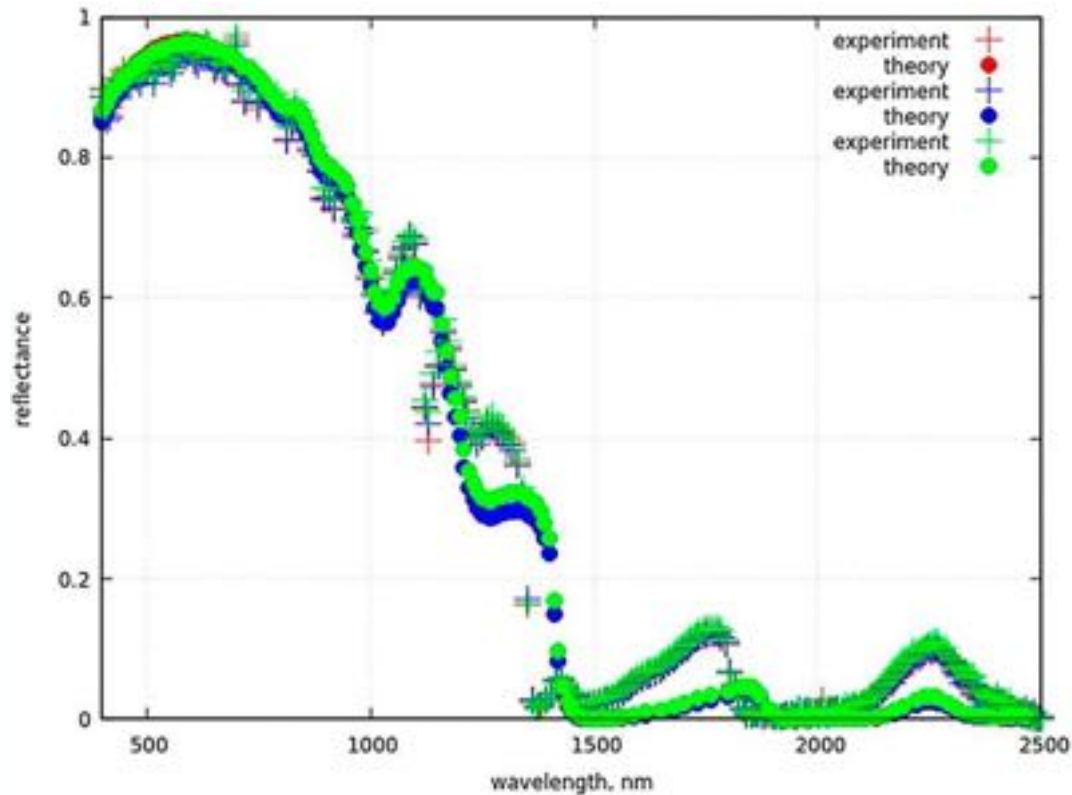
Kokhanovsky A., B. Di Mauro, R. Colombo (2022)

Front. Env. Sci.





Snow surface properties over the Nansen Ice Shelf (East Antarctica)



Comparison between theory and experimental data (PRISMA) revealed a decrease in $wl < 500nm$

→ Test with different atmospheric correction methods

Kokhanovsky et al. (2022)





Conclusions and perspectives

Two experimental sites were employed to investigate PRISMA performance on snow-covered areas and two field campaigns were carried out simultaneously to PRISMA overpasses in the Western Alps

PRISMA L1 and L2D spectra show a **good agreement** with field measurements and Sentinel-2 data, within the MRD requirements (lower than 5%) for most of the wl.

Tests over Greenland and Antarctica showed a great potential of PRISMA for mapping snow and ice surface properties from space in polar areas

PRISMA data look promising for applications in the study of the cryosphere. In particular, for the retrieval of parameters such as: **albedo**, **grain size**, **impurities** (concentration and radiative forcing) and **liquid water content**.

There is a need for a **comparison** among different **atmospheric/topographic correction** in order to improve PRISMA L2 Reflectance product and with other imaging spectroscopy data (e.g. EnMAP)



Acknowledgements



PRISCAV project: «Attività Scientifica di CAL/VAL della missione PRISMA»

SCIA project: «Sviluppo di algoritmi per lo studio della Criosfera mediante Immagini Prisma»

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Thanks for the attention

