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MODIS images and avalanche: operational use of satellite images in forecasting avalanche Hazard .

Routine and near-real-time monitoring of snow cover for avalanche hazard forecasting using satellite data.

Mauro Valt (1), Rosamaria Salvatori (2), Roberto Salzano (3)

(1) ARPAV-DRST Avalanche Center Arabba, Via Arabba-Pradat 5, 32020 Livinallongo del Col di Lana mauro.valt@arpa.veneto.it
(2) National Research Council of Italy - Institute of Polar Sciences, Via Salaria km 29,300, 00015 Monterotondo (Roma), Italy
(3) National Research Council of Italy - Institute for Atmospheric Pollution Research, via Madonna del Piano 10, 50019 Sesto Fiorentino (FI), Italy

Rationale

The avalanche hazard is a critical task for the regional services in the Alpine region. For this reason, the characteristics of surface snow are continuously monitored in terms of micro-physics and metamorphism. The spatial distribution of the different types of snow covers (fresh snow, drift snow, melted snow, surface hoar, rain crusts, wet snow, dry snow) **are used in the models aimed to forecast the avalanche hazard.**

In a multispectral image, different types of snow can be studied by analysing the spectral behaviour of the surfaces.

This paper present the workflow used for the detection of snow surfaces on MODIS images with low latency (near-real time).

Snow surface (dry and melt)

New Snow
(***PP- Precipitation Particles, DF Decomposing and Fragmented Precipitation Particles)***

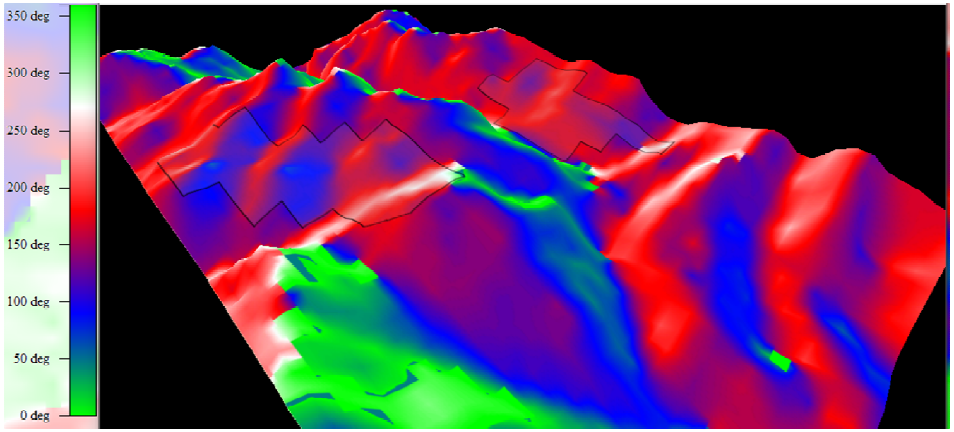
Drifted snow
(RG –Rounded Grains)

Surface hoar Crystals
(SH Surface Hoar)

Melt-freeze crust
(MF- Melt Form: MFcl Clustered rounded grains; MFpc Rounded Polycrystals,MFcr Melt-freeze crust)

Ice Formations (IF)

Ground snow observations



The study area is located in the Dolomites, between Marmolada and Pale di San Martino groups (Veneto Region, Italy). We identified two training sites where ground snow observation are routinely performed concerning snow microphysics.

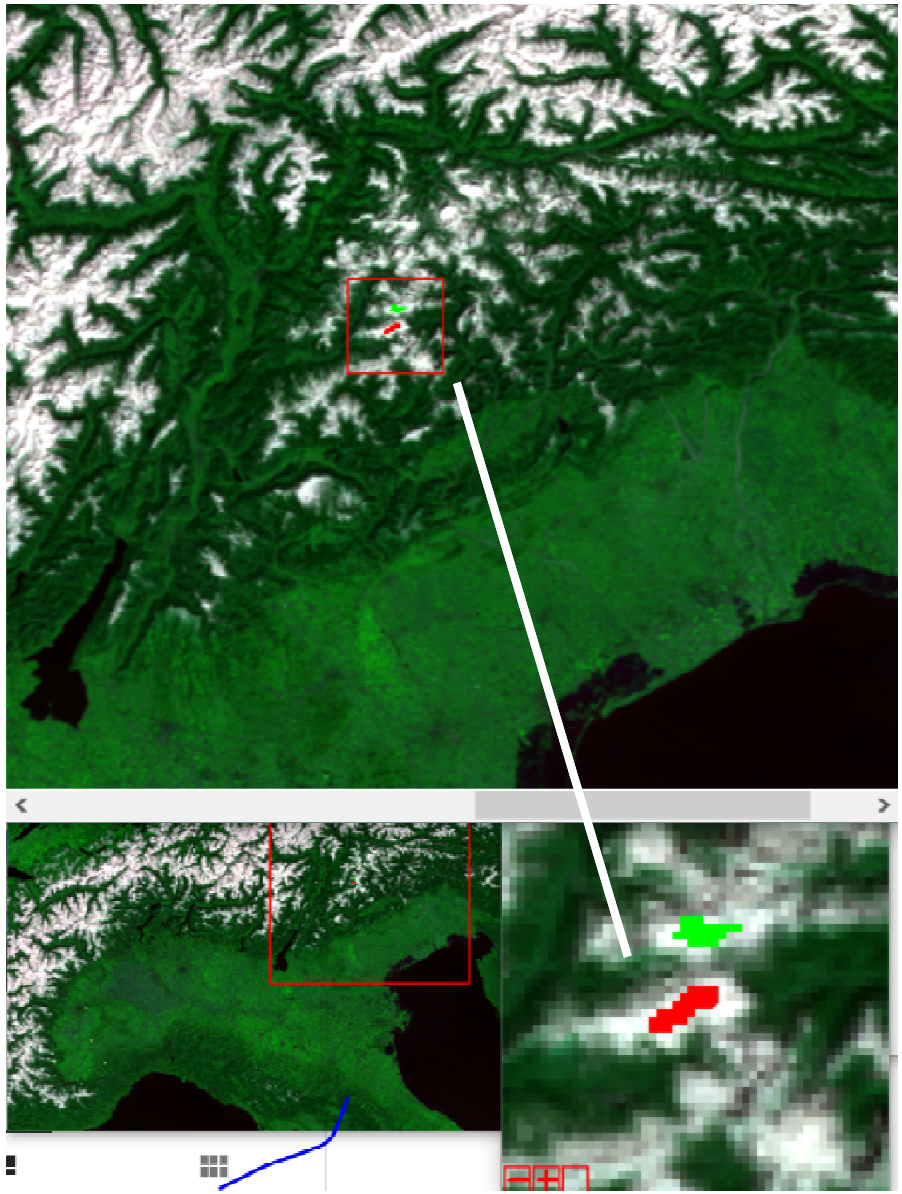
The two sites are 8 and 5 km^2 wide, respectively.

Remote sensing of the snow cover

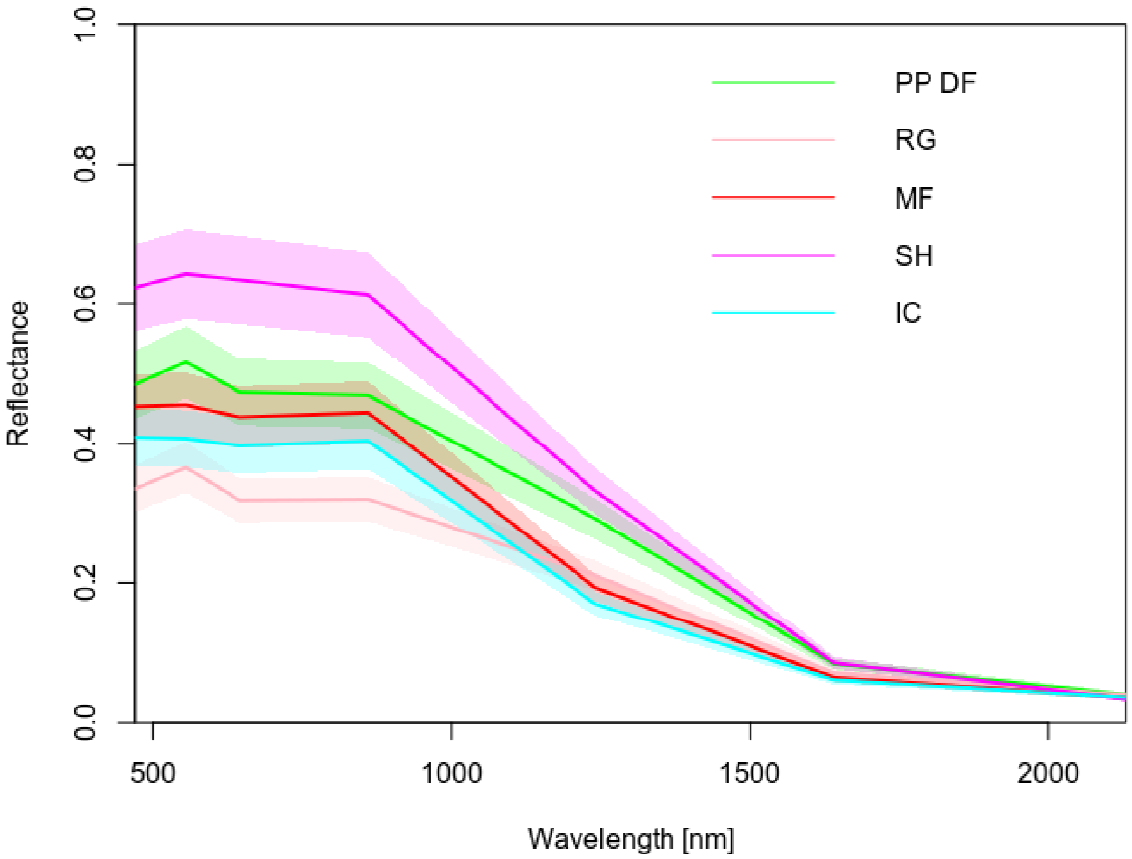
The requirements for an operational service are low latency (near-real time) and high revisiting time. The Moderate Resolution Imaging Spectroradiometer (MODIS), onboard on the Terra and Aqua platforms, are an useful source of information even if the spatial resolution is limited to hundreds of meters.

The considered dataset is based on imagery obtained by the TERRA platform. The selected near-real time product (MOD02HKM) offers a daily product on calibrated radiances that revisit northern Italy in the morning. The overpass occurs at local 10am and it is released around 2.5 hours later.

This dataset was filtered considering the time interval 2009-2020 and the cloud cover below 10%. The selected subset included about 150 images.



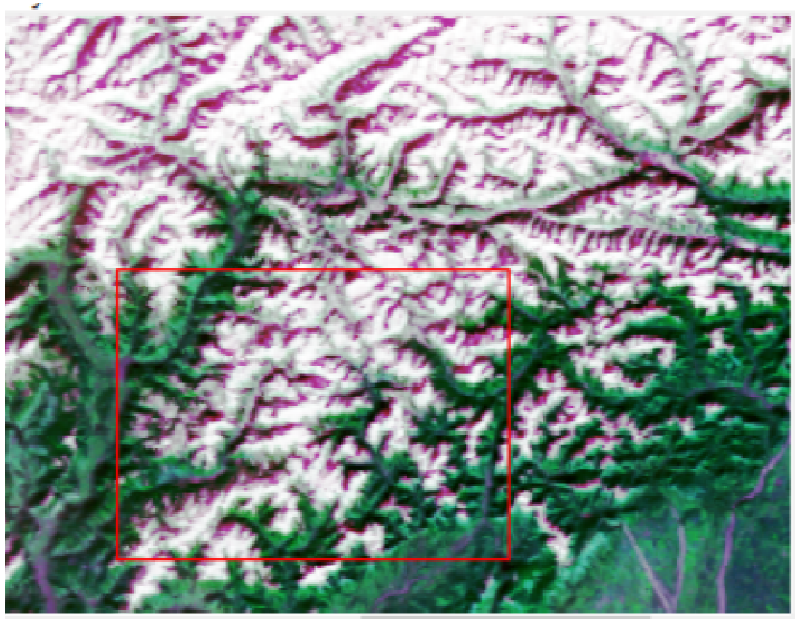
The spectral behaviour of snow



Spectral signatures of the different types of snow derived from MODIS image collected in the period between 2009-2020 in the test areas. Data from the images were verified with field surveys and weather data from the closest measurement stations (New Snow, Snow Depth, Air Temperature, Albedo, Wind, et.).

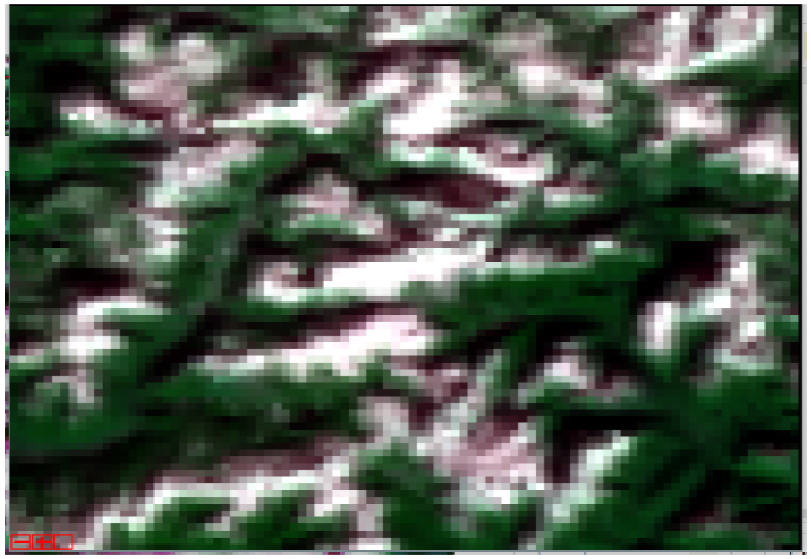
The snow spectral behavior extracted from the images, underline the possibility to process MODIS images in order to detect not only the snow cover extension but also the spatial distribution main snow types

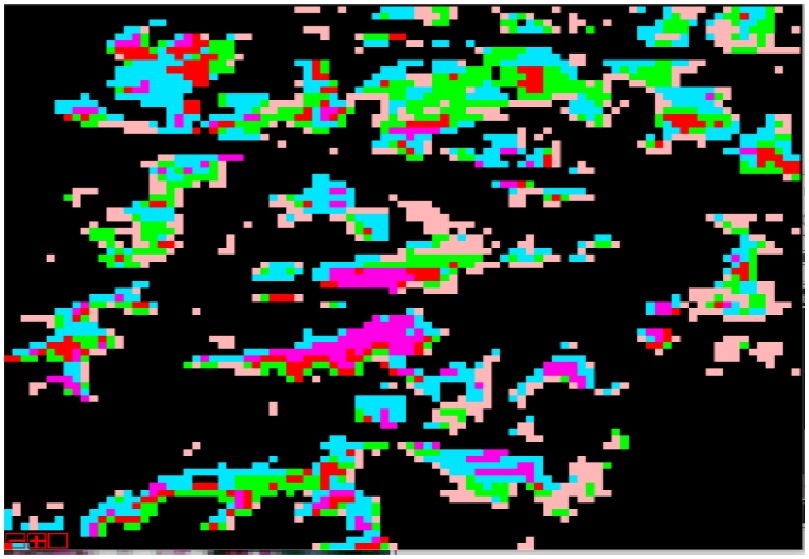
Modis Image (30/1/ 2020)



Preliminary results

- Surface Hoar [SH]
- Melt Form (Clustered Rounded Grains, Melt-freeze crust [MF])
- Drifted Snow (Rounded Grains [RG])
- Ice Formations [IF]
- New Snow (Precipitations Particles [PP]; Decomposing and Fragmented precipitation particles [DF]





Snow types map obtained classifying the MODIS image with SAM algorithm: the spectral endmenbers were recognized with field observation and statistical analysis

Conclusion

The workflow proposed in this paper represent an effective tool for avalanche services that need to analyze well-defined areas of the territory in a very short time.

All the steps can be easily managed in one day because:

- the images are acquired by the satellite between 9:30 and 10:30 UTC and are made available within 2:30-3:00 hours:
- the georeferencing procedure can be carried out with a maximum of 50 points
- the Image processing, with commercial software (ENVI), takes about 1 hour of an expert technician
- the results are already available for the Avalanche Service at 15:00 UTC

The preliminary results support the availability of a reliable tool based on remotely sensed data, evidenced by the good agreement with field observations, which can be an optimal input for avalanche forecasting.

Future steps:

➢ Implementation of the workflow in a data service

➢ Validation of the workflow on different alpine regions.