# Validation and enhancement of **Theia Snow Cover Extent products** from High Resolution Images



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Introduction

Snow cover is a key factor of many ecological, climatological processes in cold regions. The monitoring of the snow cover is of particular societal relevance in mountain regions since the seasonal snow melt modifies soil moisture, groundwater recharge and river flow, often providing critical water resources to downstream areas.

Since 2015, CNES and CESBIO have been developing an algorithm called Let-It-Snow (LIS) for an operational snow cover extent product from Sentinel-2 data, with a spatial resolution of 20 meters and a temporal resolution of 5 days (in the absence of clouds). Recently, it has been selected for production by CNES on the Theia platform for several mountains in Europe and also for the Atlas in Morocco. Following the introduction of the algorithmn, an extended large scale validation was needed.



## Algorithm Presentation

#### Validation Method

## **Reference Snow Maps Creation**





The validation was done by **direct** comparison from higher resolution images (HR) Spot 6/7 in the Alps. They make it possible to produce highresolved reference snow maps over areas large enough to cover varying snow conditions and physiography (slope, exposure, geology, etc.).

The difficulty with high-resolution images like Spot 6/7 is the lack of a spectral band in the mid-infrared  $(~1.5 \mu m)$  that is usually used to detect snow by calculating the spectral index NDSI. So, in order to extract these snow cover maps at six different dates, several methods were tested, in absence of clouds.



17/12/2016 SPOT 7 image





The method chosen is **Random** Forest, based on a pixel supervised classification on the image 4 bands and NDVI band for which we obtain very good performances, in the limit of the trained eye.



True Positive

False Positive

True negative

False negative

 $red_{2} = 120$ 



Associated snow mask (white: snow – grey: nosnow – black: no-data)

Accuracy : 0,99 – F1-score : 0,97 – Kappa 0,96

## Results

# Improvements

Six LIS snow map products were compared to their reference snow maps, close temporally. They obtain **good performances** in general. But it appeared that there was a lot of **under-detected snow** which mostly corresponds to the shaded slopes.



Accuracy : 0,92 – F1-score : 0,87 – Kappa 0,87 Sub-detections : 18 % – Over-detections : 6 %

We found that **decreasing the value of red**, from 120 to 40. enabled a reduction of the sub-detections from 18 % to 5 % and a general increase of the performances of the algorithm.



Accuracy : 0,92 (+0,03) – F1-score : 0,87 (+0,06) – Kappa 0,87 (+0,02) Sub-detections : 5 % (-13 %) – Over-detections : 8 % (+2 %)

#### Conclusions

 $\rightarrow$  red<sub>2</sub> = 40

- The study allowed us to validate the algorithm by giving us quantitative data of its perfomances
- > It has allowed the improvements of the snow detection by decreasing the subdetections by 13 %
- > This modification is now implemented in the Theia platform





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