

# Pan European High Resolution Snow & Ice Monitoring of the Copernicus Land Monitoring Service (CoSIMS)



Land Monitoring

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European Environment Agency





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# Copernicus Land Monitoring Service (CLMS)

The screenshot shows the website's navigation bar with a home icon, 'Global', 'Pan-European', 'Local', and 'Imagery and reference data' links. On the right, there is a 'Product portfolio' dropdown and social media icons for Facebook, Instagram, Twitter, and LinkedIn, followed by a 'News' dropdown. Below the navigation is a large aerial photograph of agricultural fields. A white text box is overlaid on the image, containing the following text:

Copernicus is a European system for monitoring the Earth. Data is collected by different sources, including Earth observation satellites and in-situ sensors. The data is processed and provides reliable and up-to-date information in six thematic areas: land, marine, atmosphere, climate change, emergency management and security. The land theme is divided into four main components:

- Global**: provides a series of biogeophysical products on the status and evolution of the land surface at global scale at mid and low spatial resolution
- Pan-European**: provides information about the land cover and land use (LC/LU), land cover and land use changes and land cover characteristics
- Local**: focuses on different hotspots, i.e. areas that are prone to specific environmental challenges and problems
- Imagery and reference data**: satellite imagery forms the input for the creation of Copernicus land products. In order to ensure an efficient and effective use of satellite data the Copernicus land monitoring service needs access to in-situ data

The 'Pan-European' component is highlighted with a green rounded rectangle, and a small box labeled 'EEA' is positioned below it.



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## Project Objectives

- The snow and ice service aims at producing **high resolution snow and ice products over Europe from Sentinel-2 data.**
- The products will contain information on **fractional snow cover, permanent snow line and river and lake ice extent.**

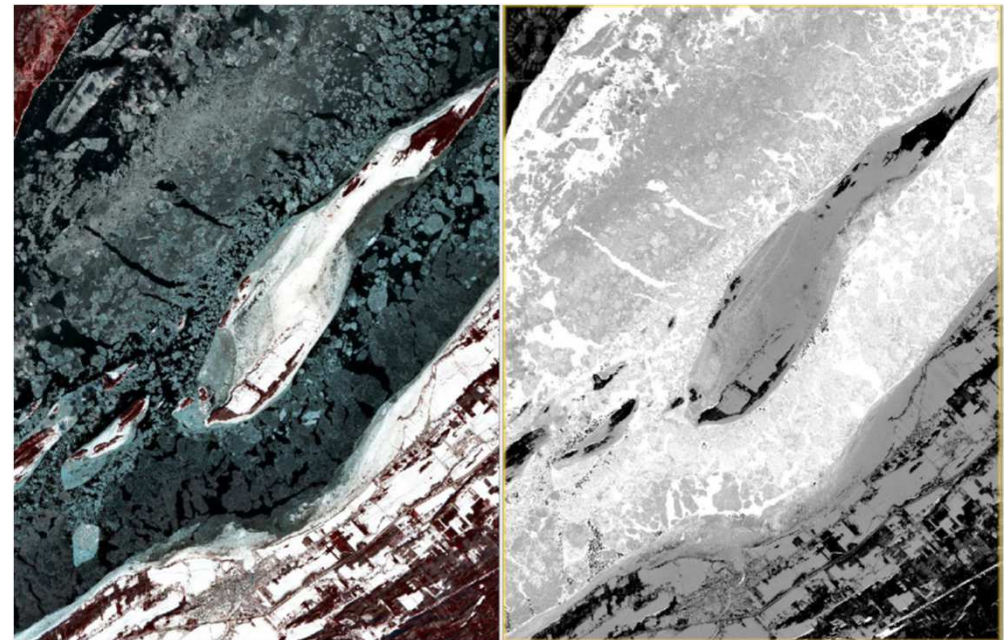
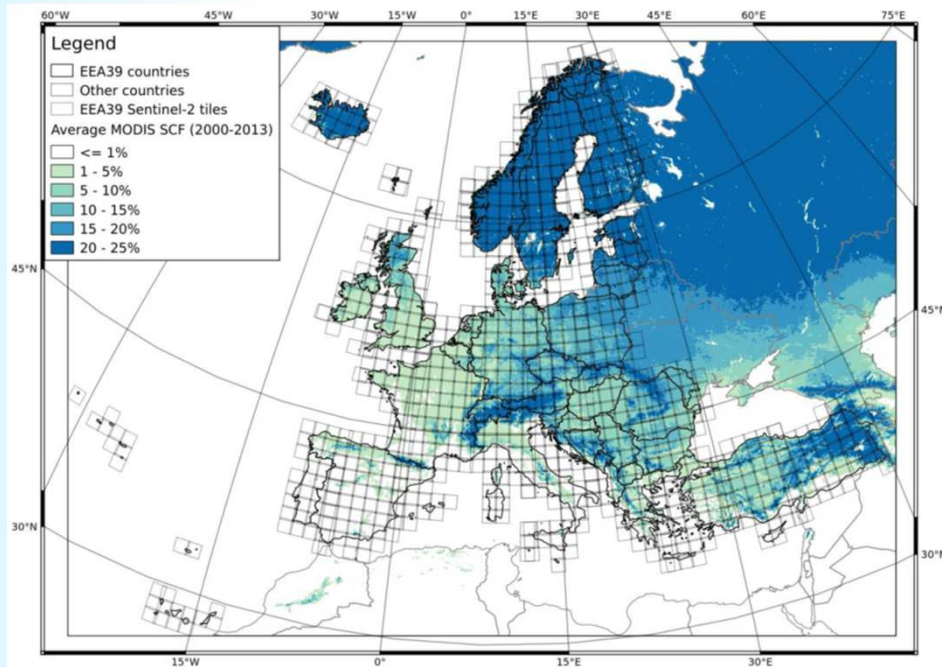




## Project Objectives

Average fractional snow cover from MODIS snow product (5 km resolution) over EEA-39 countries.

- Sentinel-2 false color image and its Ice Index (NDWI2) image created using ESA SNAP.





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## Project Objectives

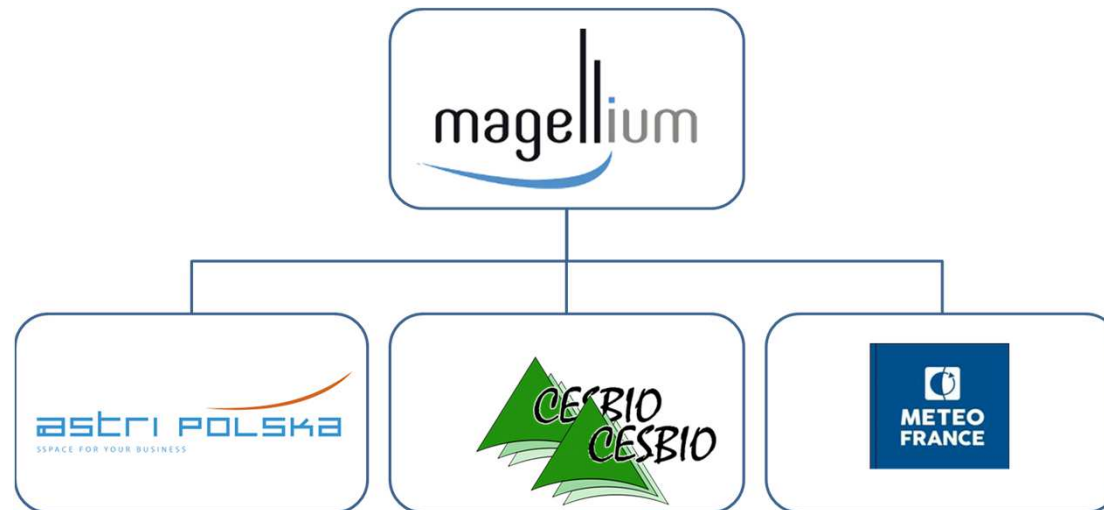
- Main steps:
  - From May 2019 to March 2020 : set-up of the service
  - From April 2020 to December 2022: Operational production of High Resolution Snow and Ice products over Europe from Sentinel-2 data
  - Reprocessing of Sentinel-2 data from September 2016 onwards
- Main requirements:
  - operational service: NRT, timeliness, availability, sustainability
  - state-of-the-art service at European Scale
  - fully validated
  - connected to users (needs, validation): friendliness, responsiveness, uptake



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## Consortium

- Strong Scientific background for a State-of-the-Art Service
  - well-experienced scientific teams able to provide the required scientific advices for setting up, assess, evolve and operate the service
  - strong links to R&D initiatives at national and European levels





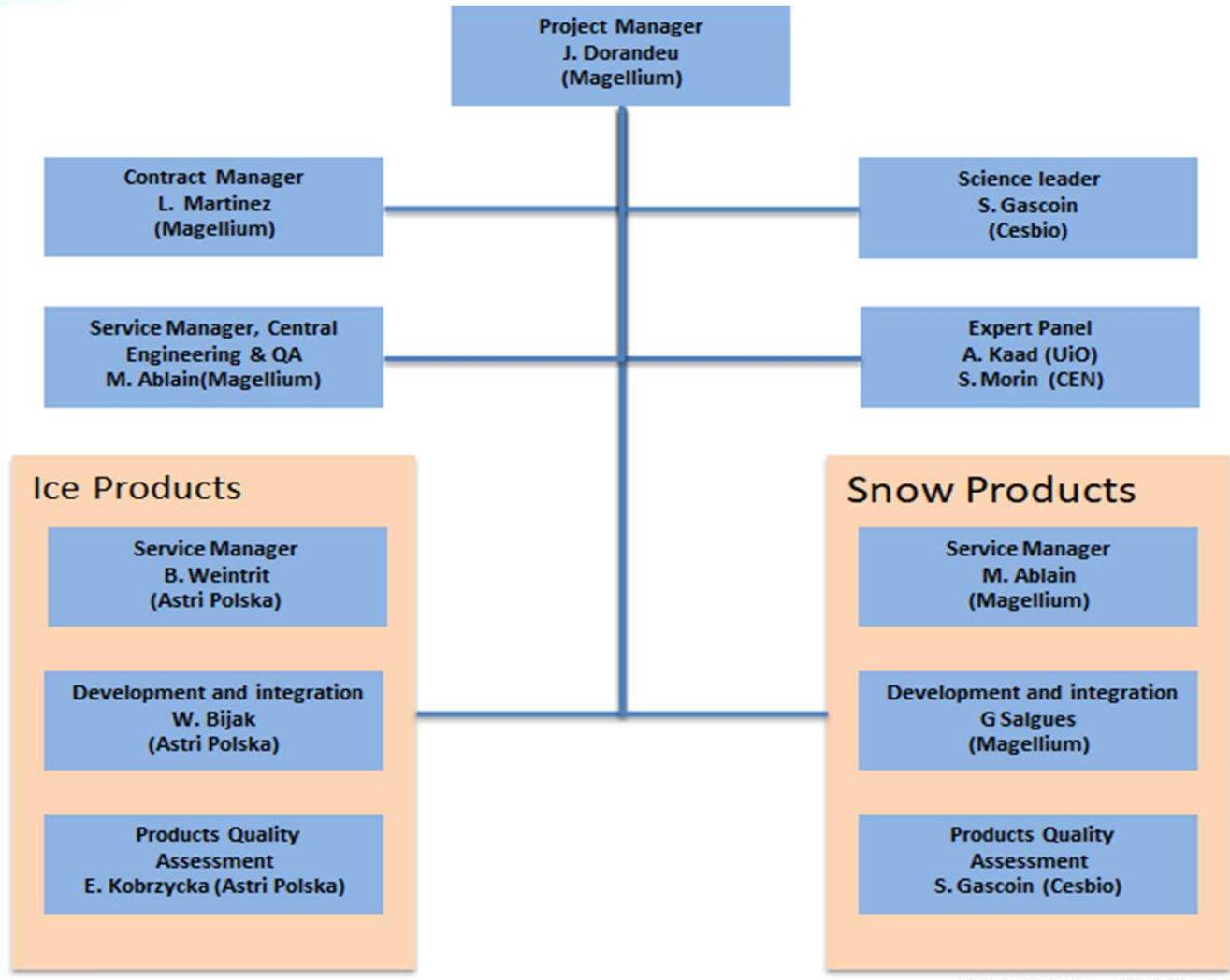
## Consortium

- Forte implication du CNES dans les phases initiales de montage du consortium:
  - Valorisation des investissements CNES dans le système THEIA
  - Un schéma qui a fait ses preuves: océano (DUACS->CMEMS, HydroWeb->Global Land, THEIA MAJA+LIS -> Land/Pan-European)
    - Agence Spatiale (CNES) qui investit et prépare la R&D + système pré-opérationnel
    - Laboratoire d'excellence scientifique
    - Société privée qui s'engage sur la thématique et la durée: industrialisation, lien scientifique, opérations
- Accompagnement CNES:
  - Support au laboratoire CESBIO
  - Support à Magellium



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# Consortium







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## Project Objectives

- Transition of precursor services into Copernicus
  - the Copernicus Service benefits from past or current investments
  - National services respectively the Theia Snow Collection in France and the river ice monitoring service in Poland
- Integration within Copernicus Services and National services
  - Global Land Service (CGLOPS-2 - Cryosphere and water)
  - National Services (R&D and prototypes)
  - involvement or interactions with R&D projects (CCi, H2020...).



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## Project Objectives

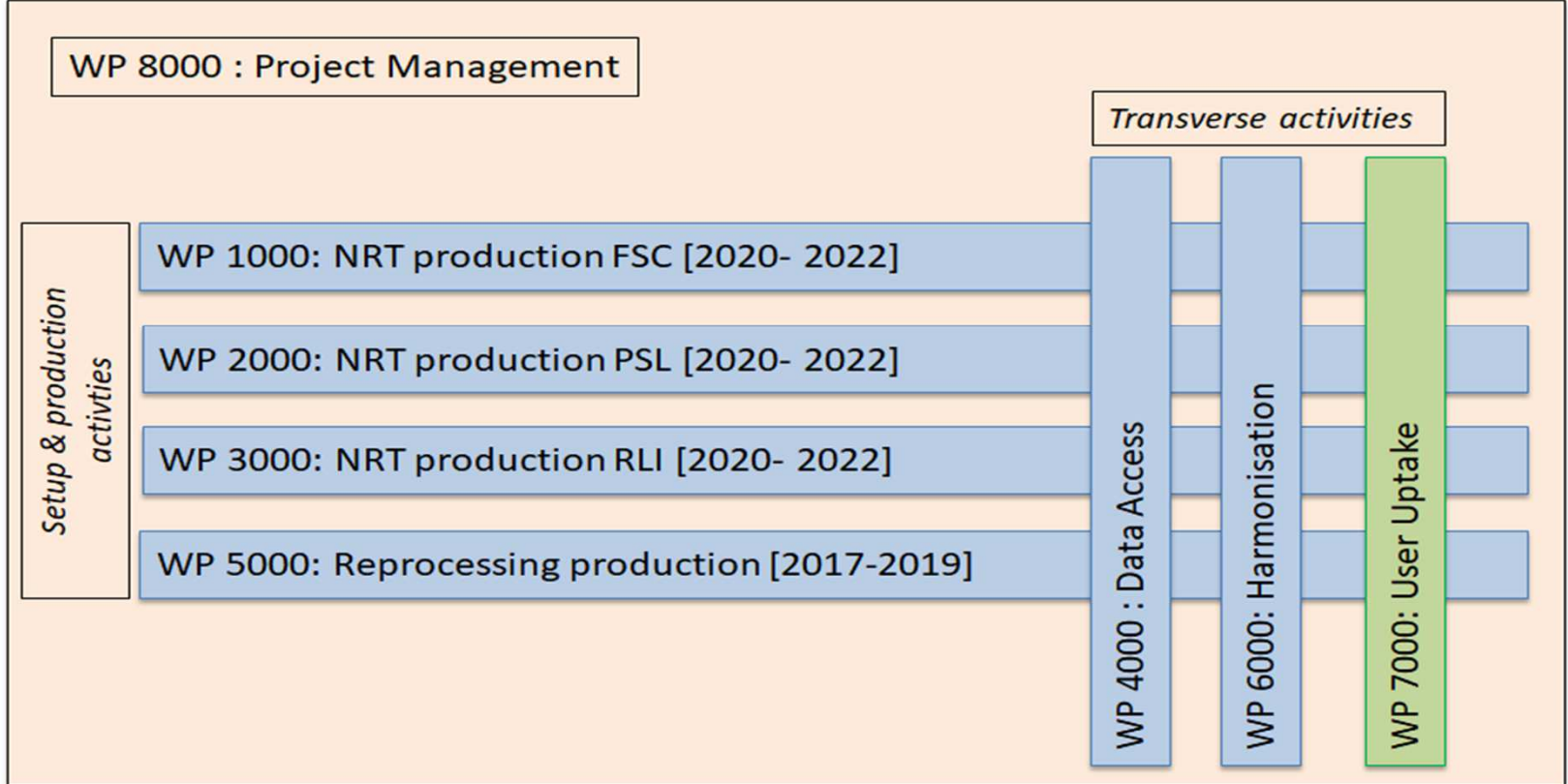
- Operational service:
  - **Based on already demonstrated operational services at national level.** Service to be geographically extended and consolidated (operational requirements)
  - Rigorous project management and technical methodology, building on current and past experiences: project life cycle, phases and corresponding deliverables are proposed following standards successfully demonstrated in other Copernicus Services.
  - **Operational Production Environment: DIAS**
    - taking benefit of EU investments (DIAS)
    - national infrastructures as backup



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# Project Tasks

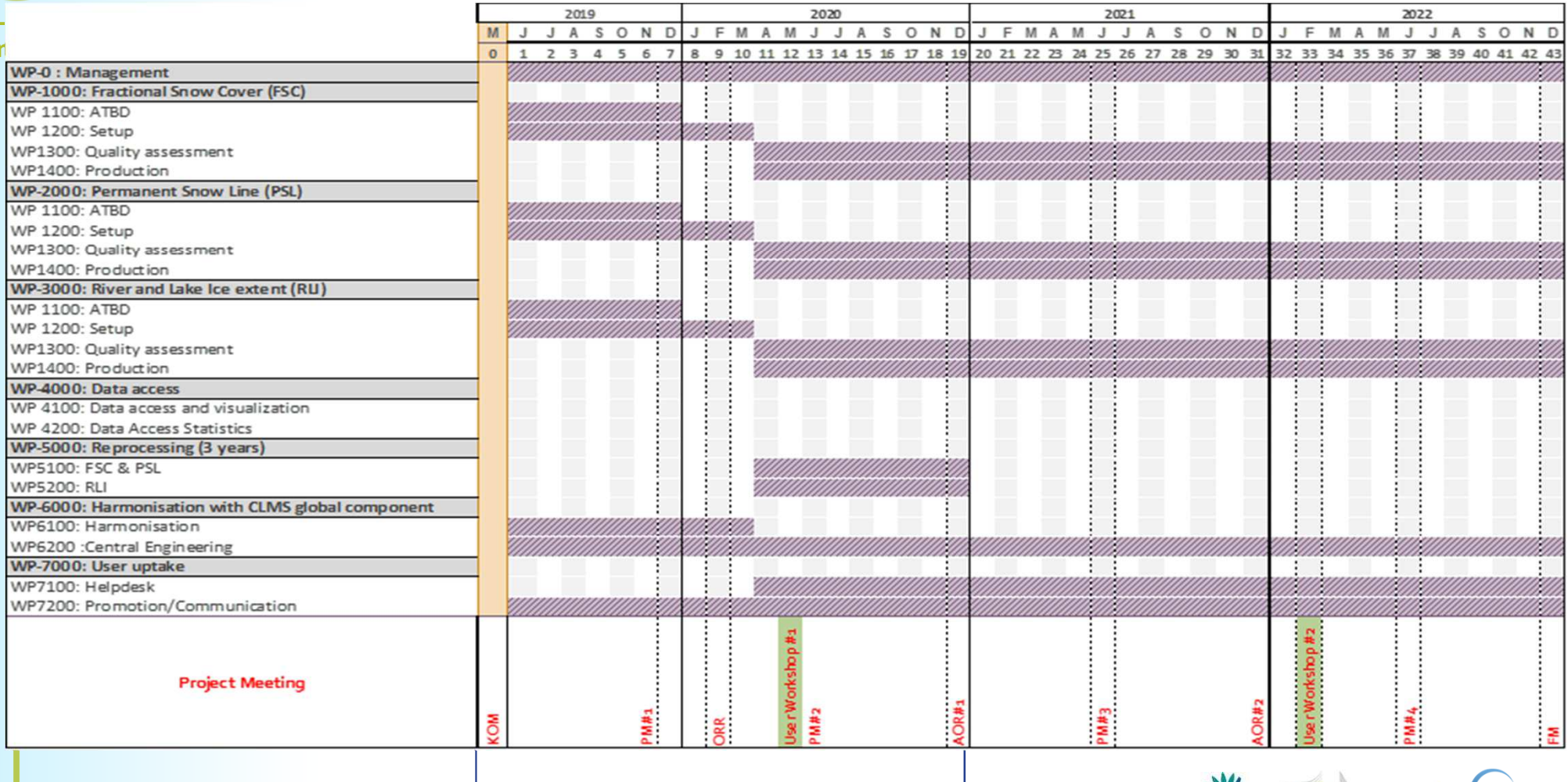
## WORK LOGIC





# Project Schedule

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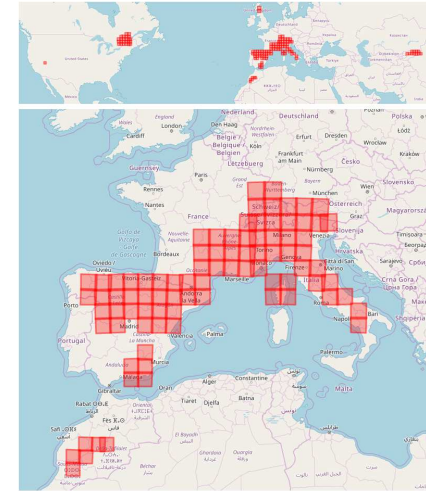
Specific Contract # 1



# Snow cover algorithms

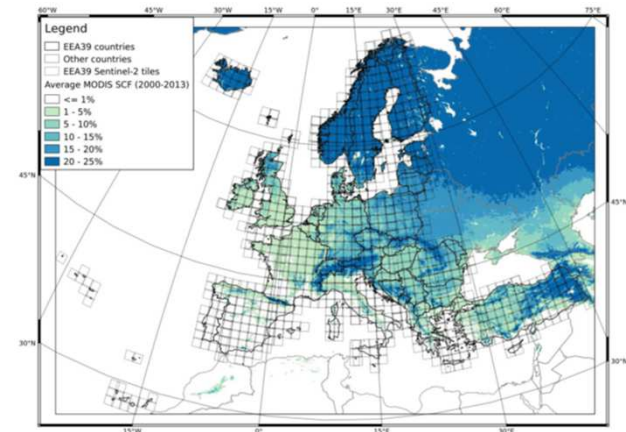
## What we currently do

- Snow cover **area** from Sentinel-2 and Landsat-8
- Operational, product released about 2 to 5 days after acquisition
- Selected mountain regions



## What we will do for CoSIMS

- Snow cover **fraction** from Sentinel-2 (10% RMSE)
- Product released in less than 3 hours after L1C dissemination
- Pan-European



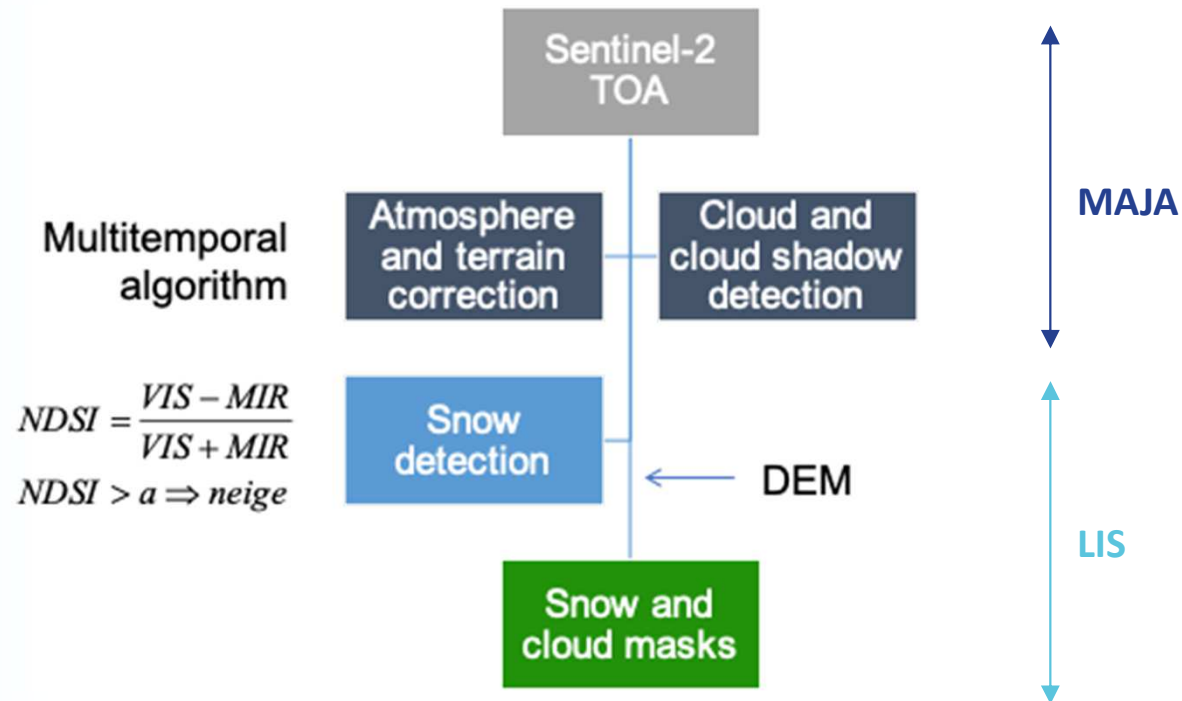


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# Snow cover algorithms

## What we currently do

- Snow cover **area** from Sentinel-2 and Landsat-8

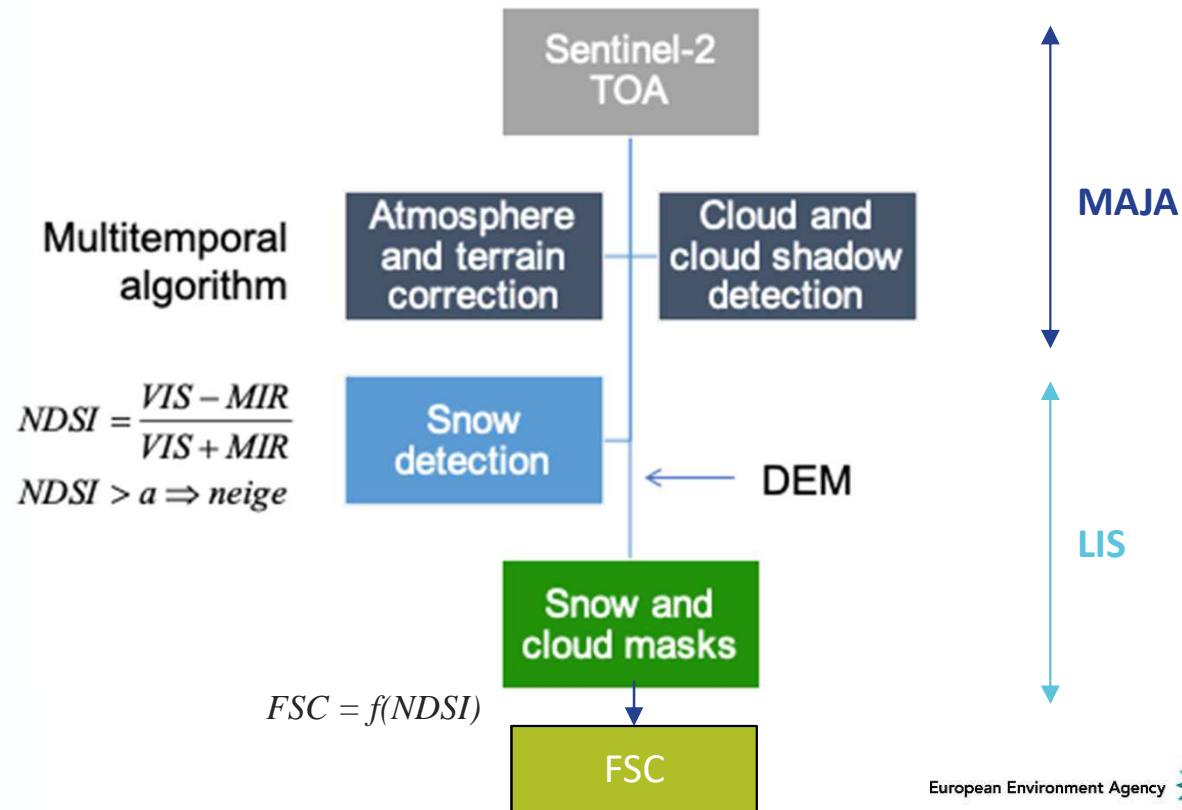




# Snow cover algorithms

## What we will do

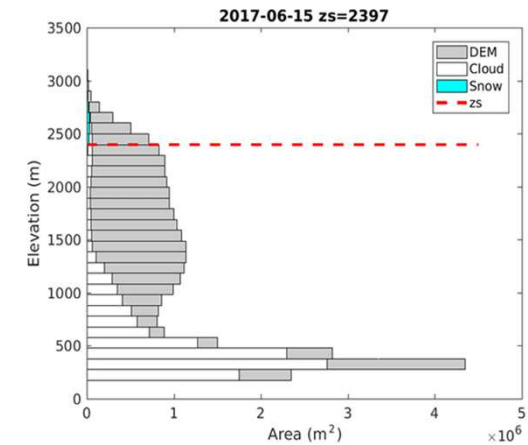
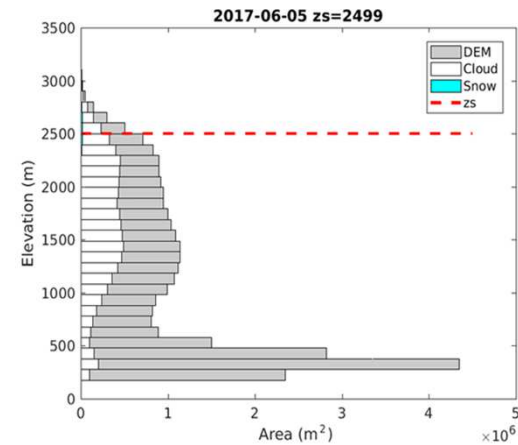
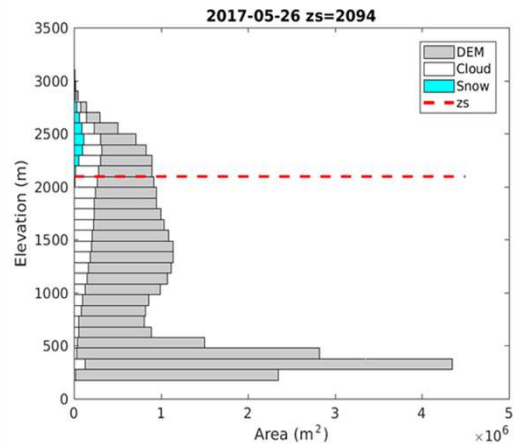
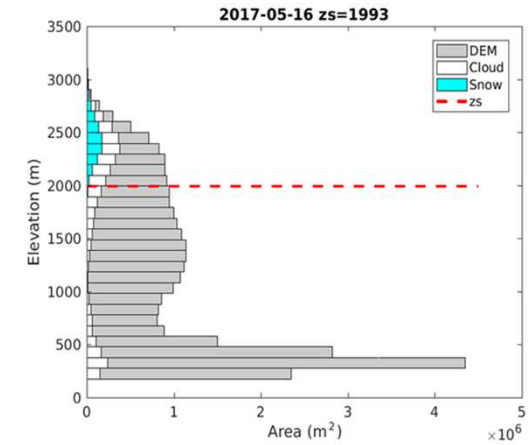
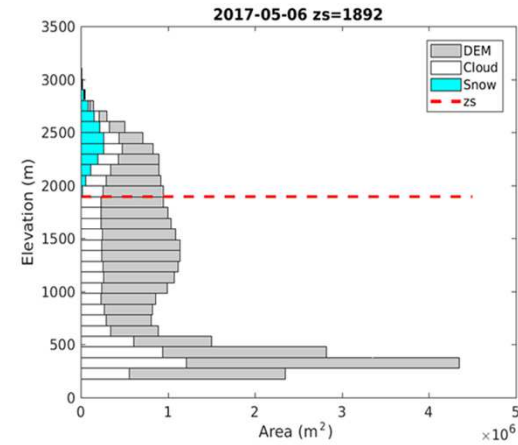
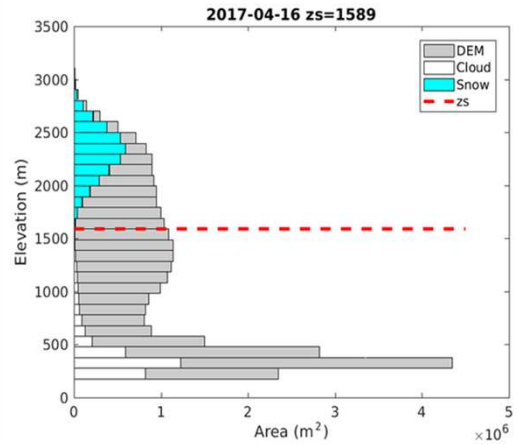
- Snow cover **fraction** from Sentinel-2





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# Snow cover algorithms

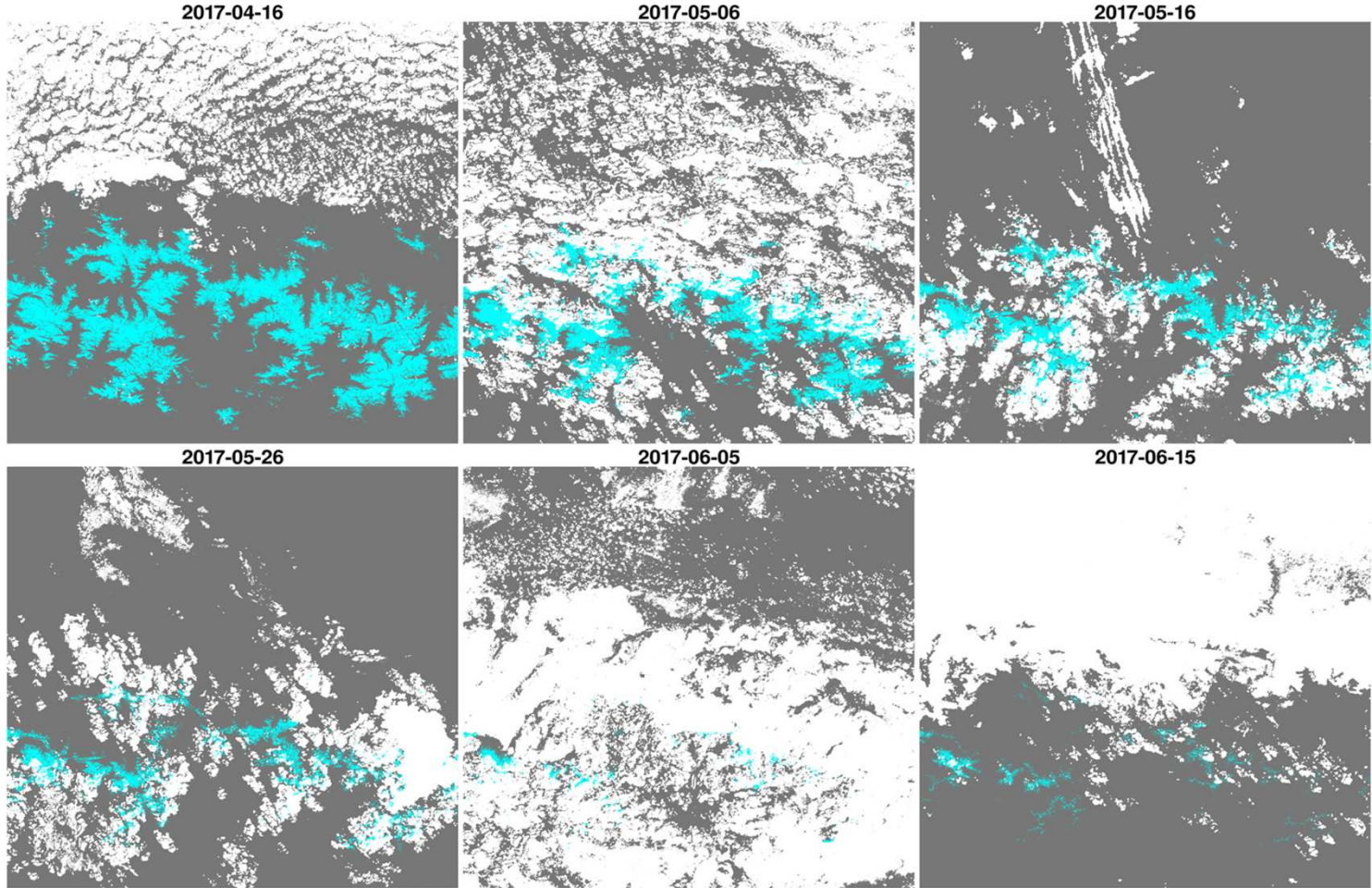






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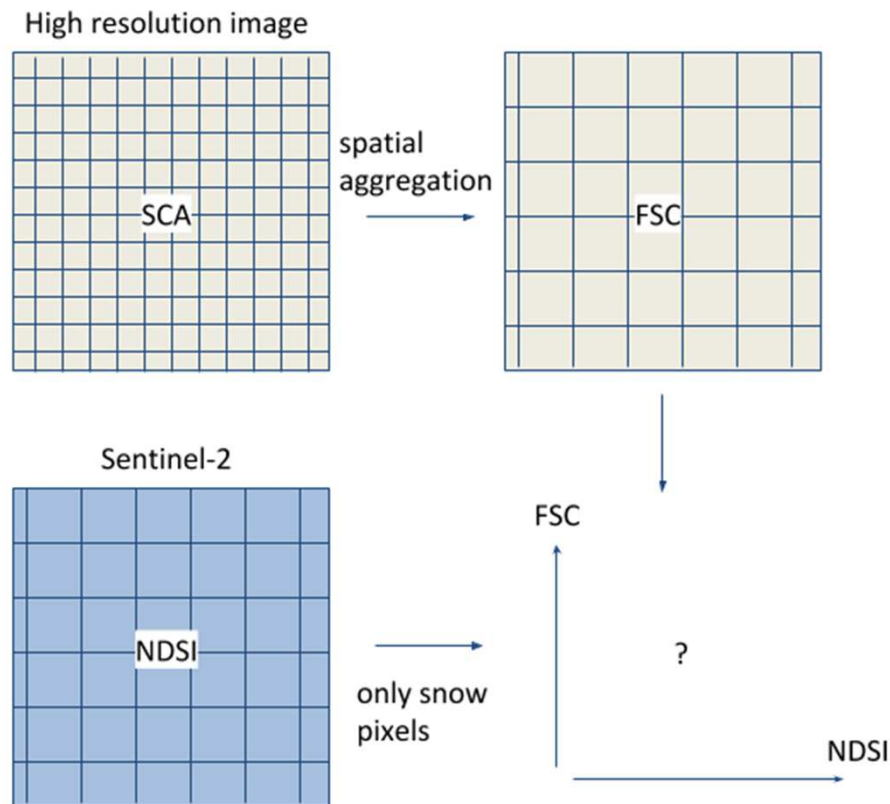
# Snow cover algorithms





# Snow cover algorithms

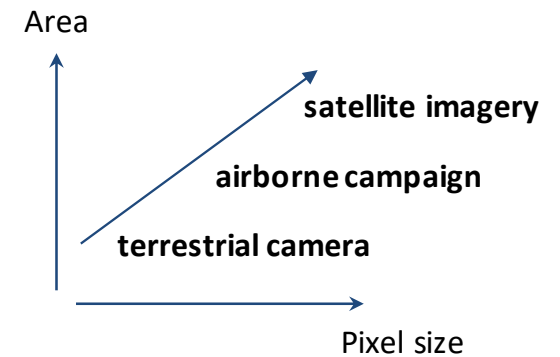
- How to establish  $FSC = f(NDSI)$  ?



## Reference datasets

- From Kalideos VHR images by supervised classification
- Publicly available products

### Trade-off resolution vs. coverage in reference datasets

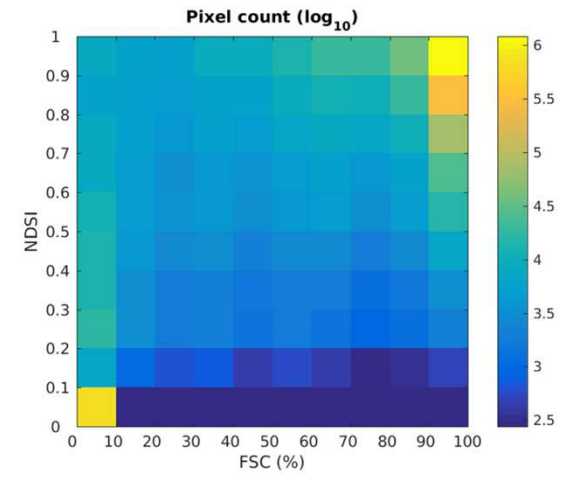
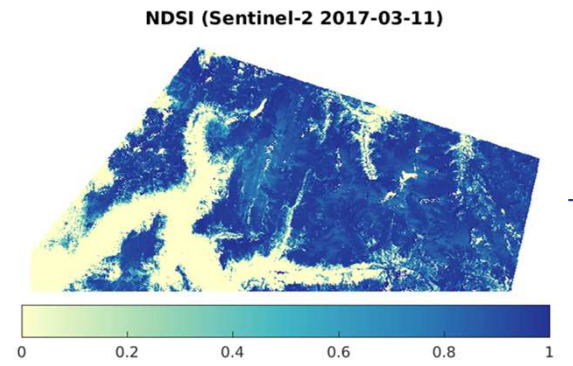
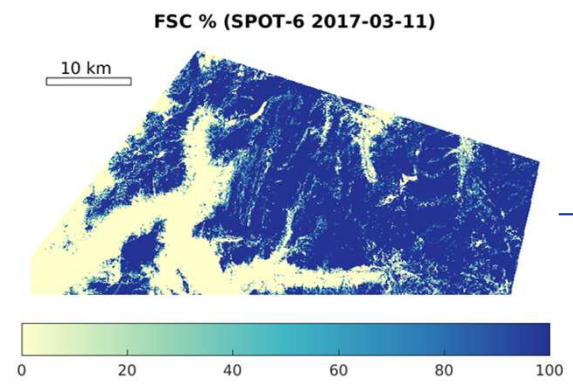




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# Snow cover algorithms

- How to establish  $FSC=f(NDSI)$  ?





## Snow cover algorithms

- How to establish  $FSC=f(NDSI)$  ?

*Webcam*



*Sentinel-2*



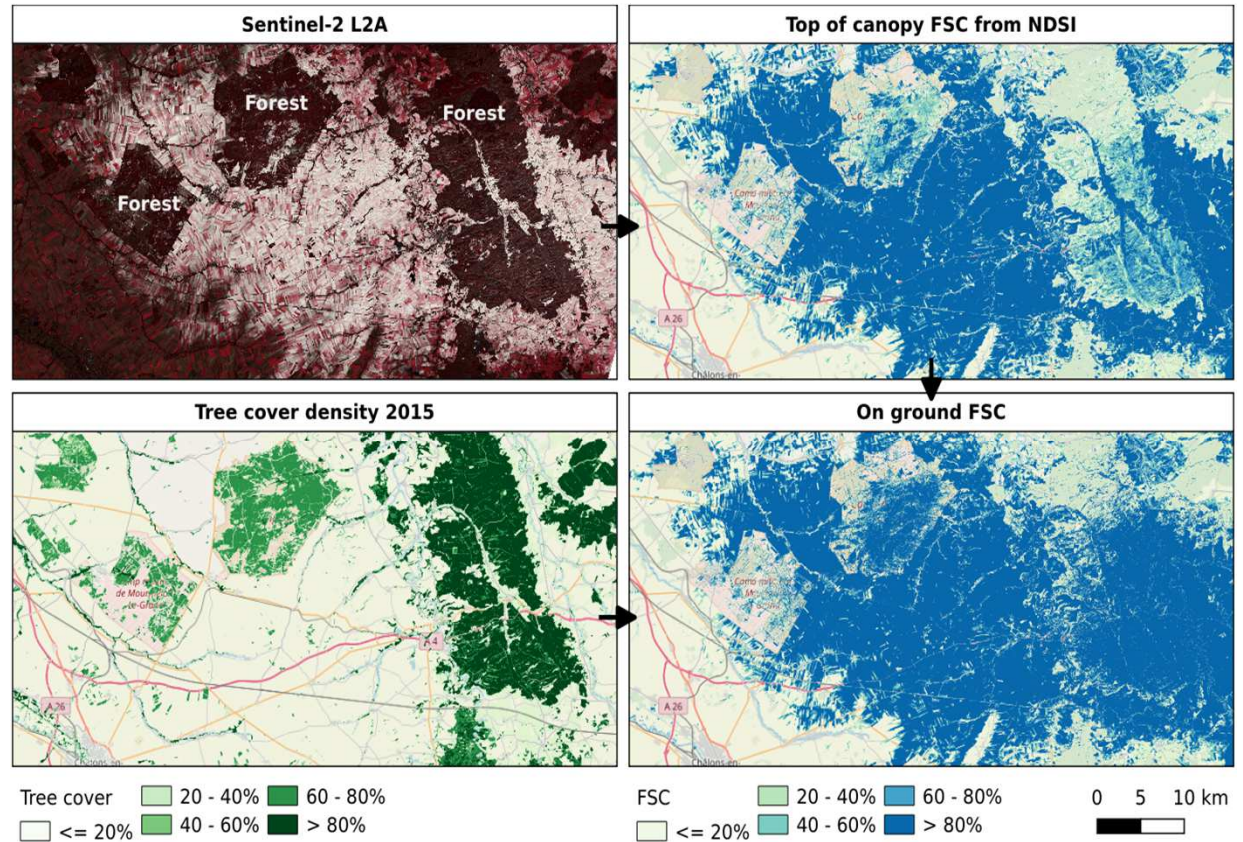


# Snow cover algorithms

- Dealing with forests

$$FSC_{On-Ground} = FSC_{Top-Of-canopy} / (1 - TCD)$$

with *TCD*: Copernicus High Resolution Layer Tree Cover Density



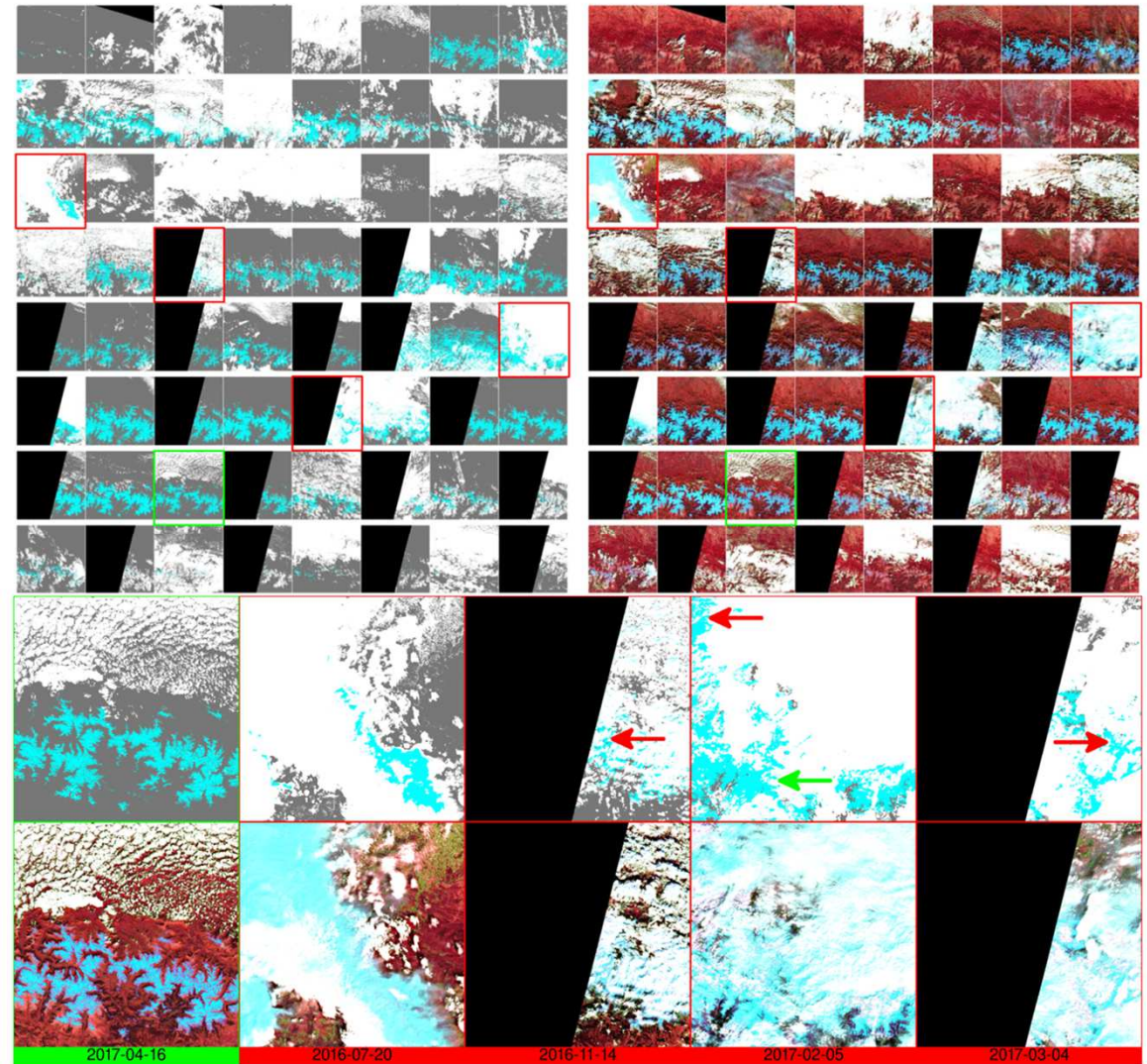


## Snow cover algorithms

- Known issues

[https://gitlab.orfeo-toolbox.org/remote\\_modules/let-it-snow/issues](https://gitlab.orfeo-toolbox.org/remote_modules/let-it-snow/issues)

High cold clouds  
classified as snow



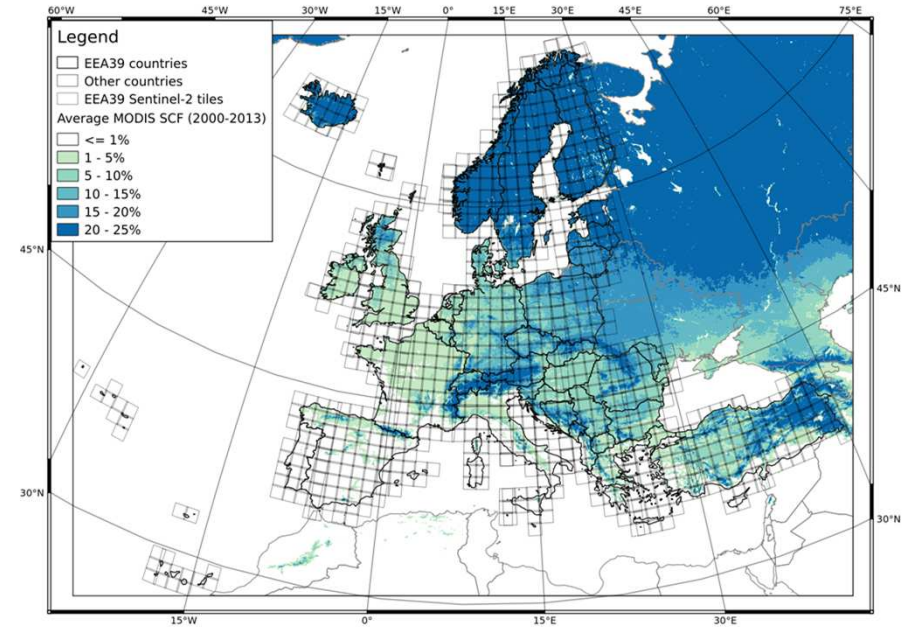


# Snow cover algorithms

- Unknown issues

High latitudes (Sweden, Norway, Finland)

- Low solar illumination
- Extensive evergreen forest





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## Permanent snowline

### What we currently do

Temporal synthesis of Theia snow products over any period of time

- What we will do for CoSIMS

Annual synthesis of FSC products

Extract pixels with snow cover duration > 360 days





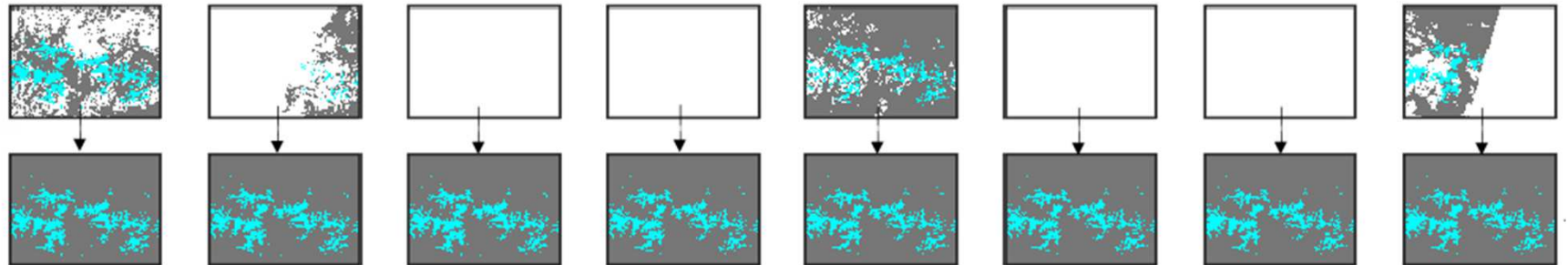
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# Permanent snowline

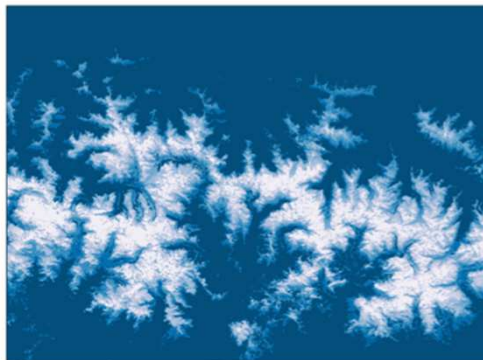
## What we currently do

Temporal synthesis of Theia snow products over any period of time

1) Linear interpolation in the time dimension



2) Summation in the time dimension

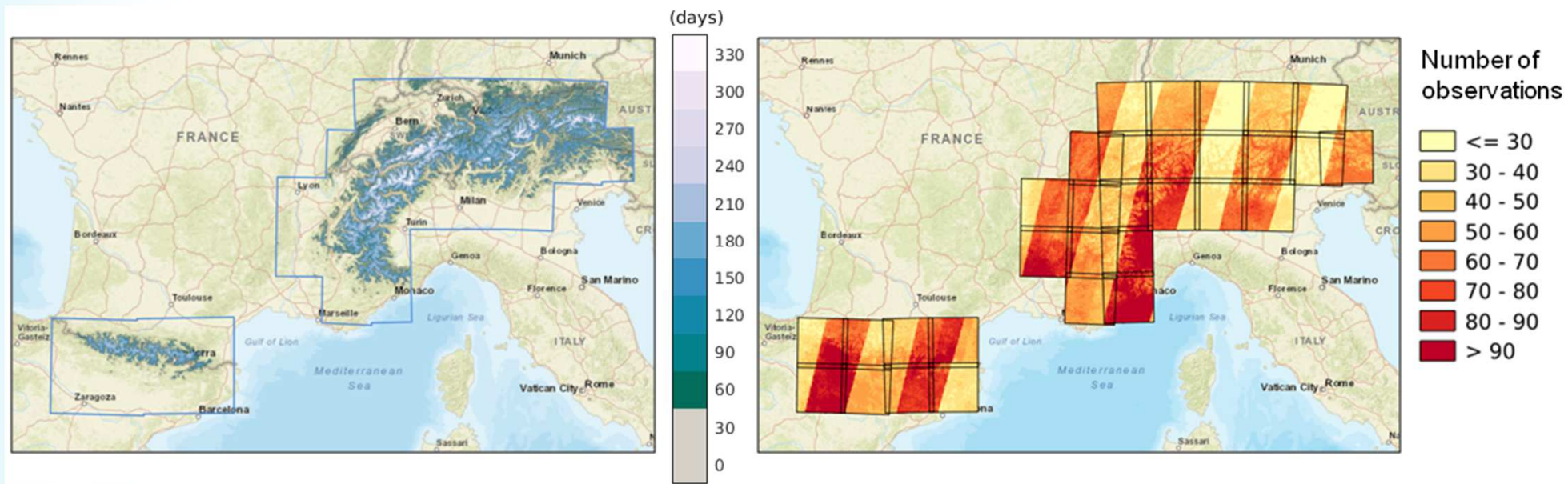




# Permanent snowline

## What we currently do

Temporal synthesis of Theia snow products over any period of time



<http://osr-cesbio.ups-tlse.fr/echangeswww/majadata/simon/snowMaps.html>

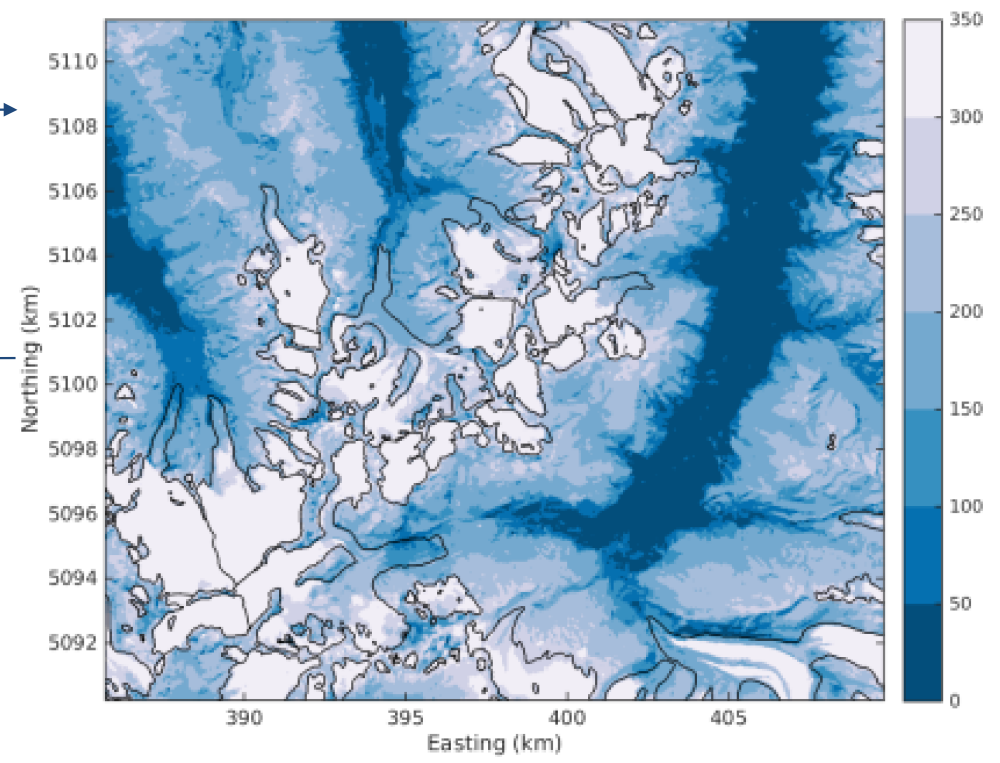
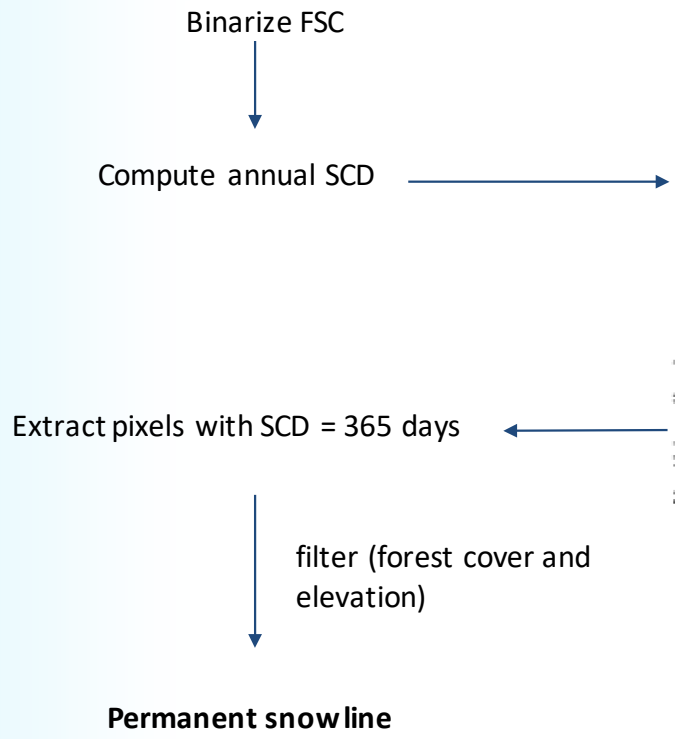


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# Permanent snow line

## What we will do

### Permanent snow line extraction





## Conclusion

- **FSC and PSL code are minor extensions of existing let-it-snow codes**
- Main development is  $FSC=f(NDSI)$
- ATBD and code will be kept open source [https://gitlab.orfeo-toolbox.org/remote\\_modules/let-it-snow](https://gitlab.orfeo-toolbox.org/remote_modules/let-it-snow)
- Challenges
  - Specified accuracy of FSC
  - Snow/cloud confusion
  - High latitudes regions