The support of terrestrial photography on cryospheric studies in Svalbard islands

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What is terrestrial photography?

"An economic and either alternative or complementary approach to satellite imagery is the use of oblique terrestrial photography, which allows high temporal and spatial resolution."

[Corripio, 2004 – doi: 10.1080/01431160410001709002]

Synonyms

Time-lapse photography

Terrestrial photogrammetry

What is the contribution?

Estimation of:

- Fractional snow cover
- Snow reflectance
- Surface roughness

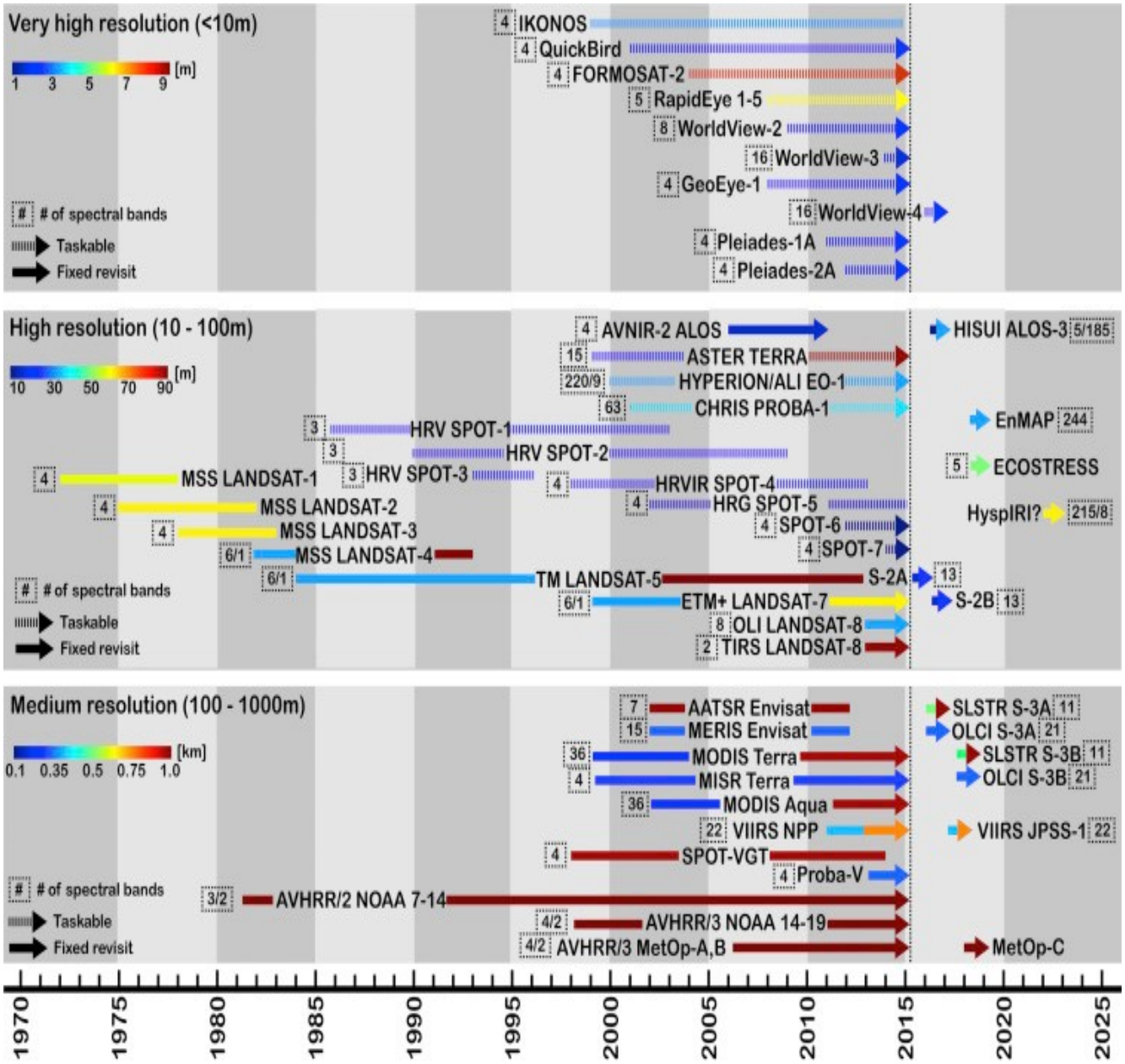
Potential applications in:

- Hydrology
- Glaciology
- Optical remote sensing
- Microwave remote sensing
- Atmospheric sciences
- Ecology

Remote sensing of snow

Problem:
Satellite missions offers a large variety of sensors that are characterized by different revisiting time, spatial resolution and life time.

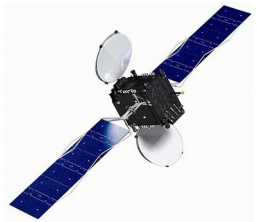
Solution:
Terrestrial photography can offer complete time series of FSC that can be adapted to different resolution grids.



From Houborg et al 2015

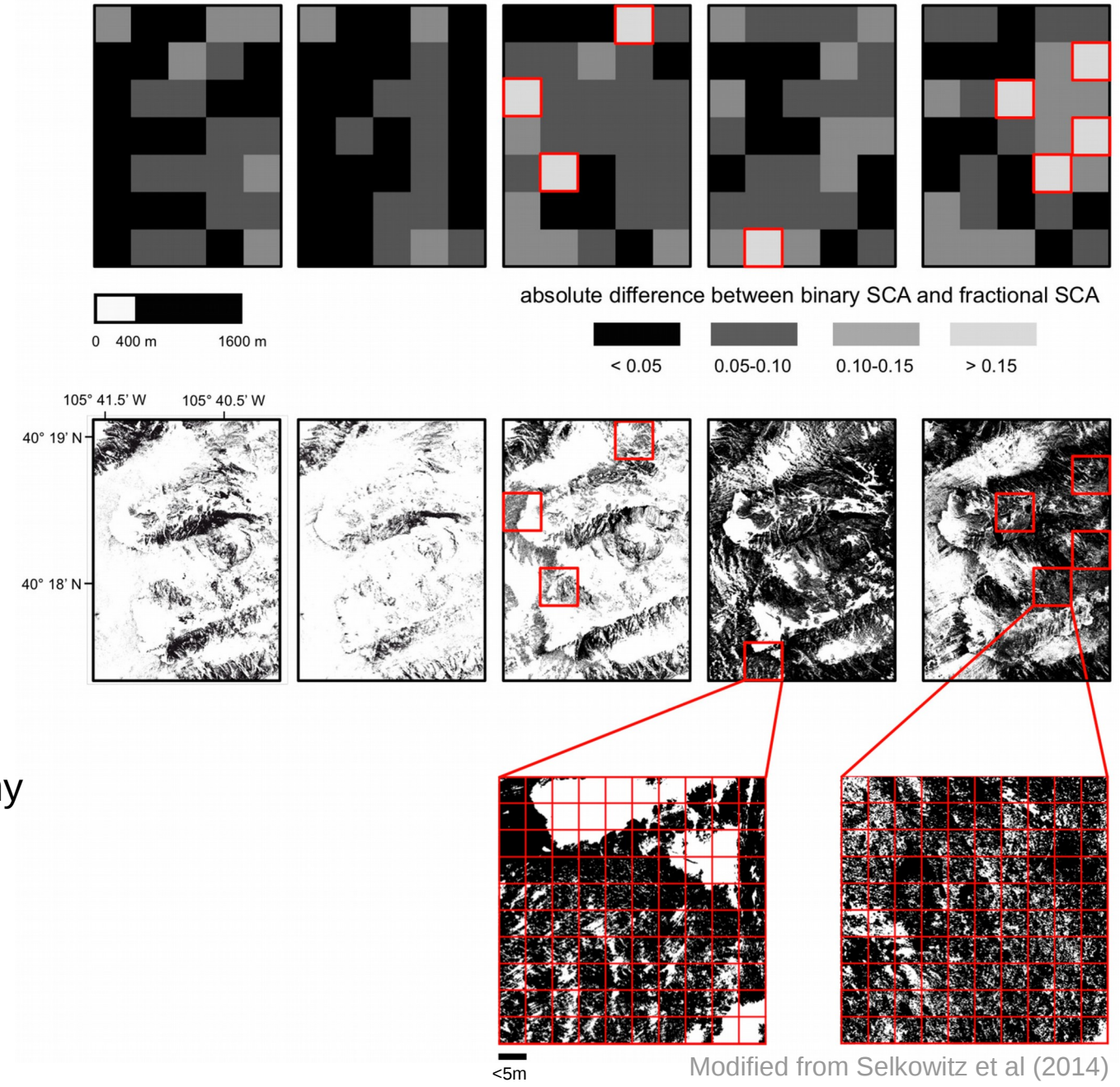
Fractional Snow Cover

Medium resolution



High resolution

Terrestrial photography



Modified from Selkowitz et al (2014)

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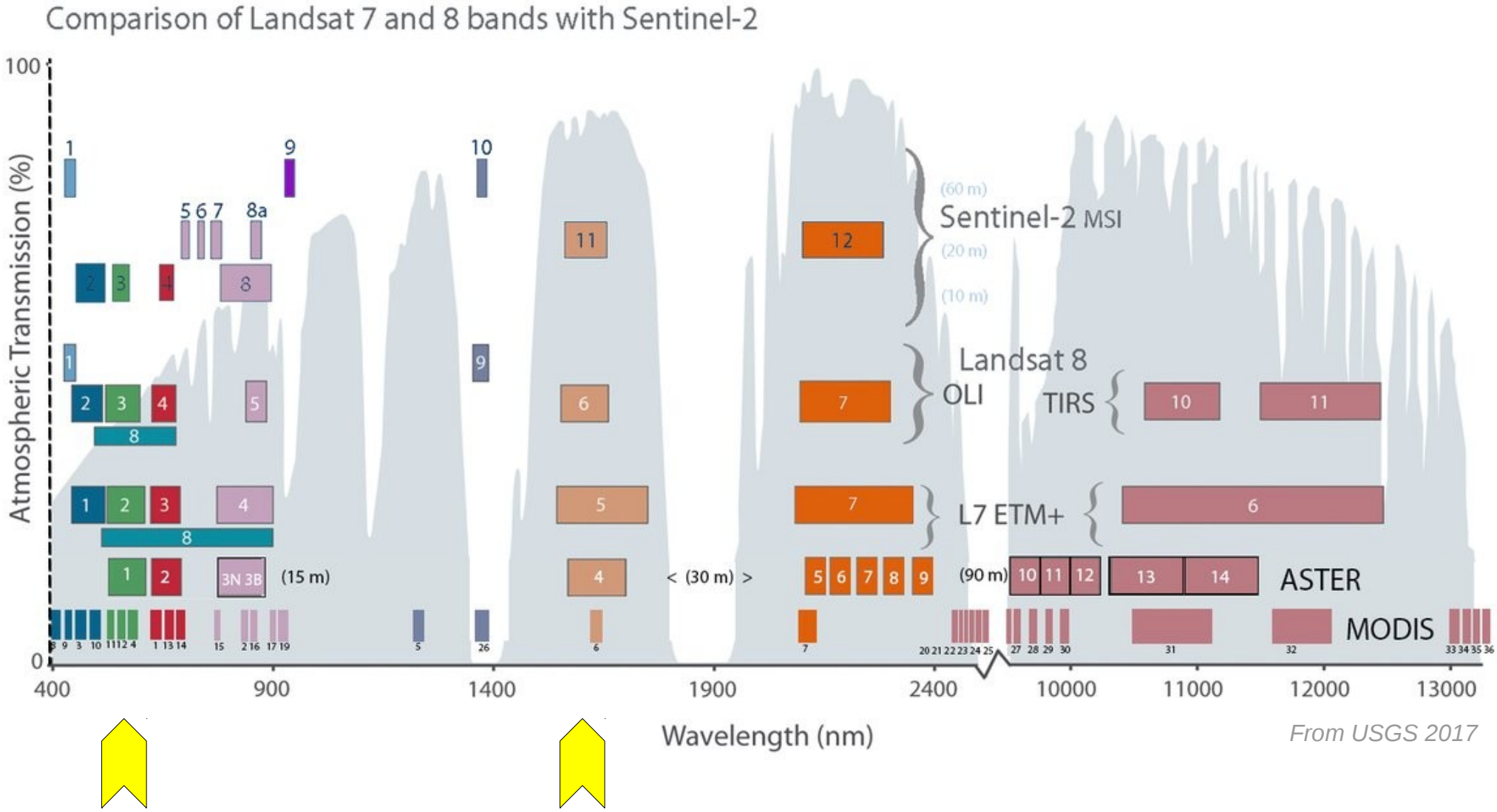
Normalized Difference Snow Index

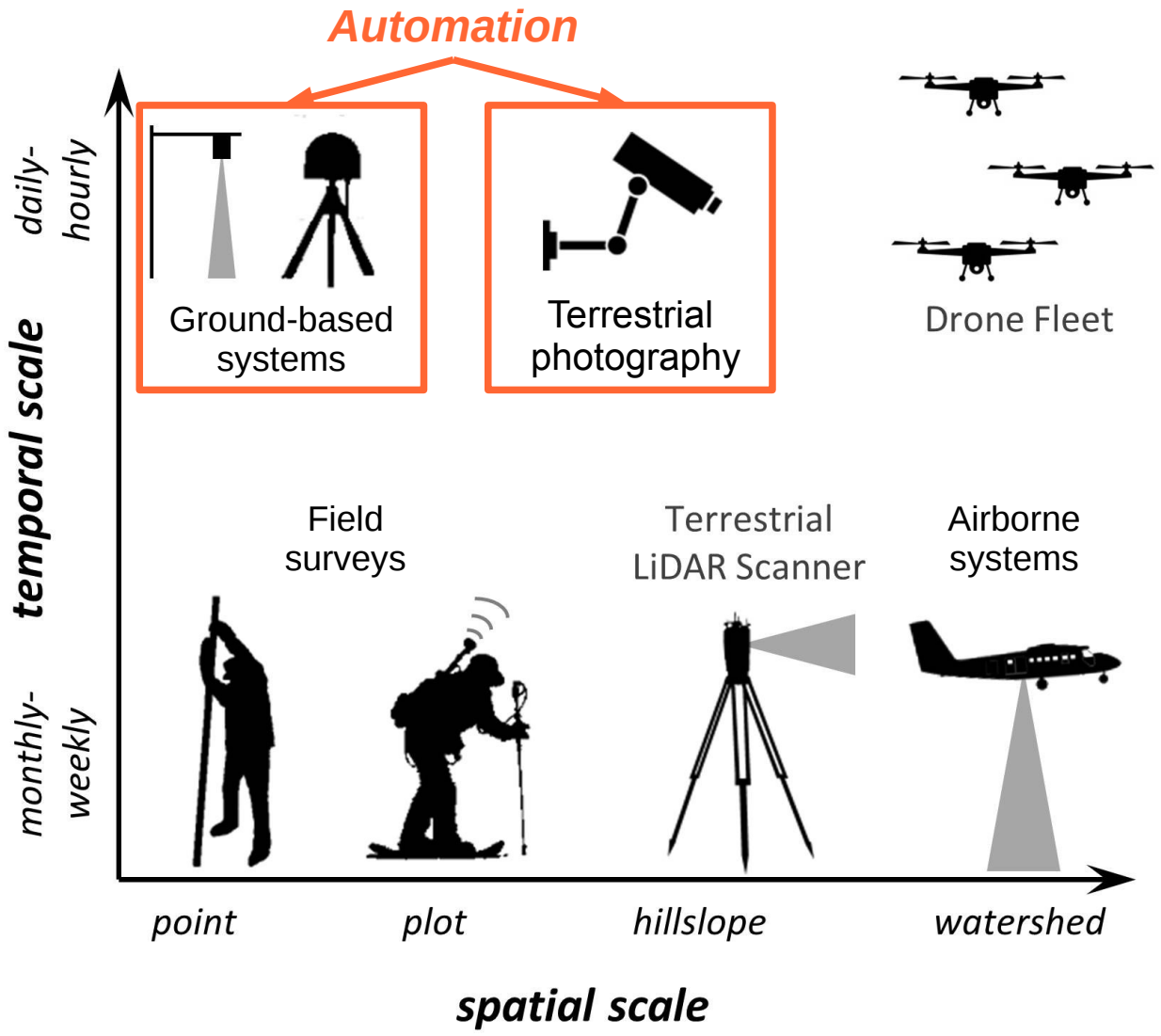
Problem: *Spectral reflectance of snow can vary significantly*



From USGS 2017

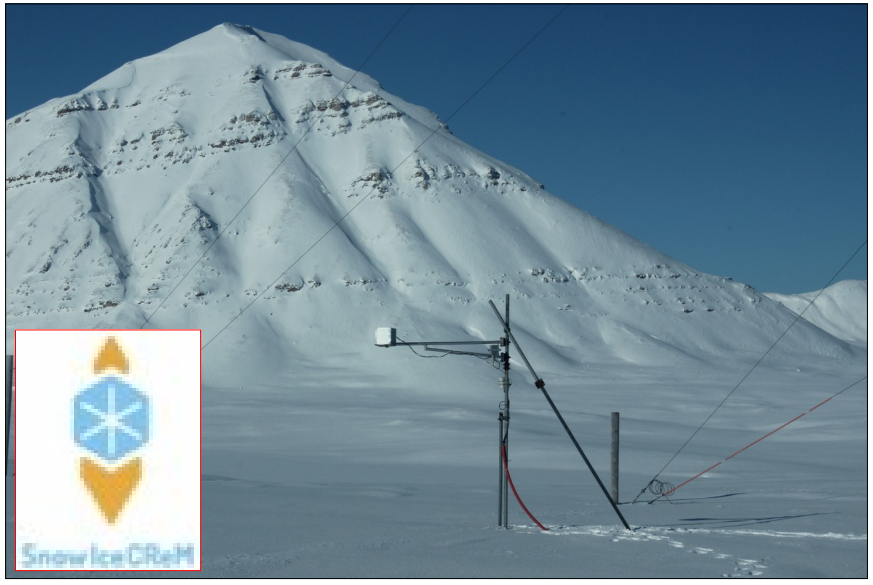
Solution: *Continuous and discontinuous field measurements*

Ground-truth techniques



Modified from Small & Raleigh (2018)

Field surveys



Data availability

Ny Alesund

Point scale
Facility: CReM
Owner: CNR-IIA
Variable: Albedo, FSC
Availability: Private

Plot scale
Facility: CCT tower
Owner: CNR
Variable: FSC
Availability: Private

Plot scale
Facility: Scheteligfjellet
Owner: UiO
Variable: FSC
Availability: Public

Watershed scale
Facility: Zeppelin
Owner: NILU
Variable: FSC
Availability: Public

Longyearbyen

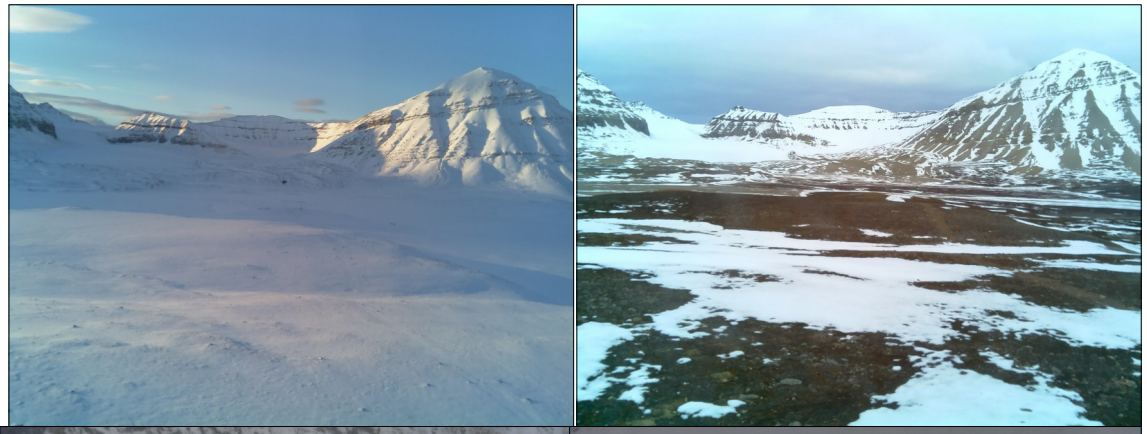
Watershed scale
Facility: several
Owner: UiO - UNIS
Variable: FSC
Availability: Private

Hornsund

Watershed scale
Facility: Fugleberget
Owner: PAS
Variable: FSC
Availability: Public

Terrestrial photography

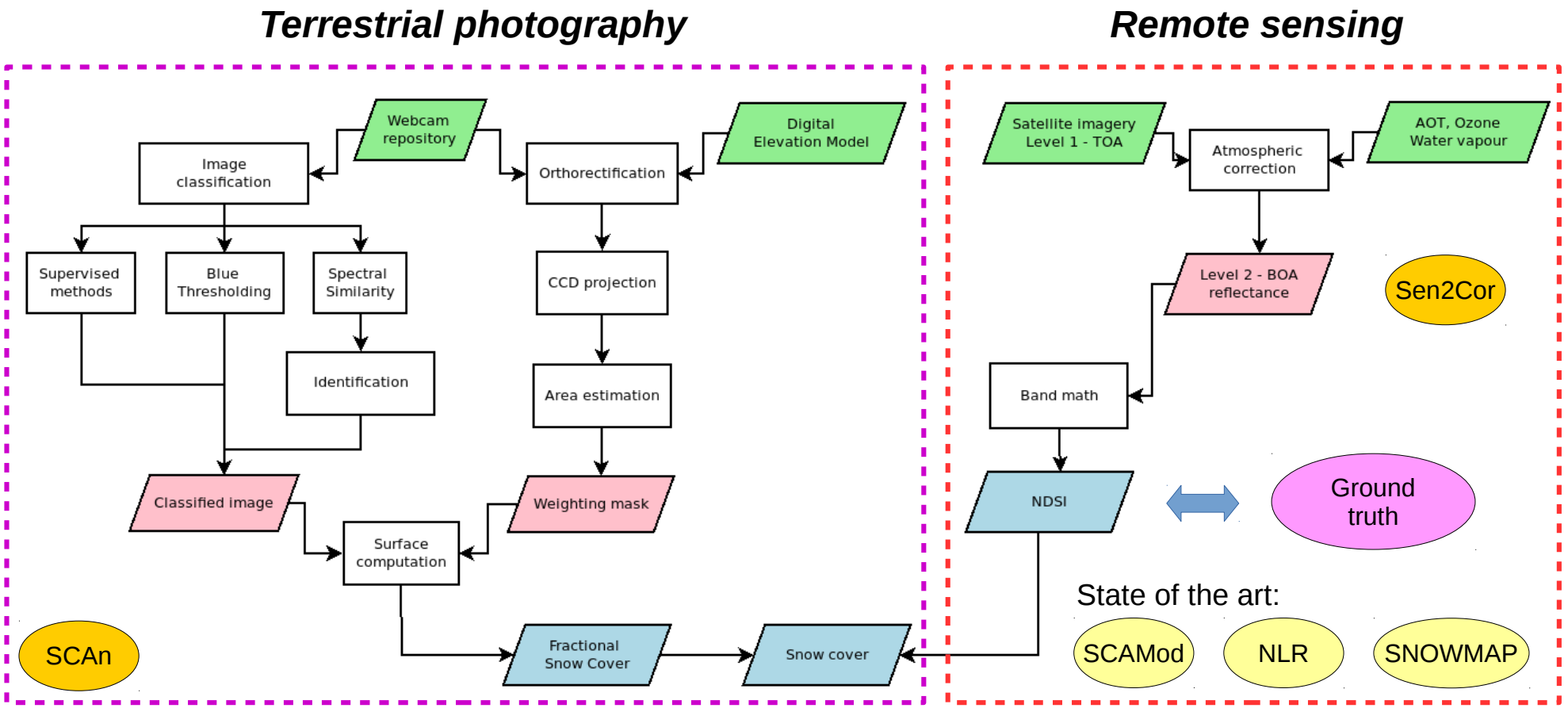
Broggerdalen
2018-2019
~ 1 km^2



CCT Tower
2015-2019
~ 5 m^2

Zeppelin
2000-2019
~ 10 km^2

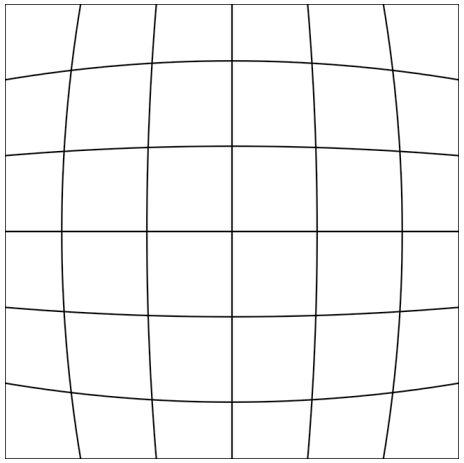
Data processing



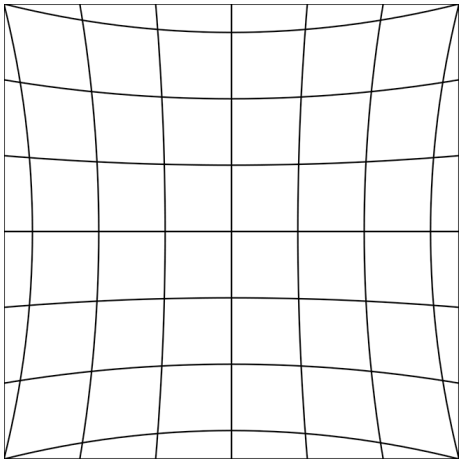
More details in Salzano et al. (2019) [doi:https://doi.org/10.3390/geosciences9020097]

Lens Intrinsic distortion

Barrel



Pincushion

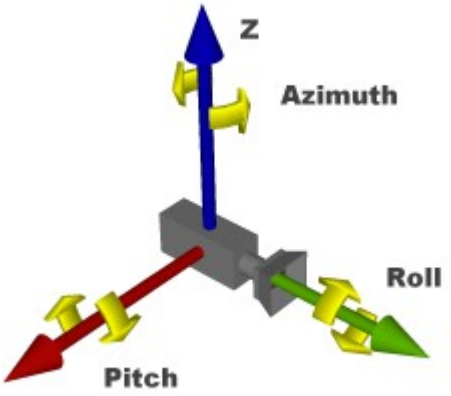


Radial distortion can assessed using the “chessboard” calibration

The camera setup must be described in terms of:

- Sensor type
- Sensor geometry (pixel resolution, pixel element shape, pixel numbers)
- Focal length
- Camera optical center (height, width)

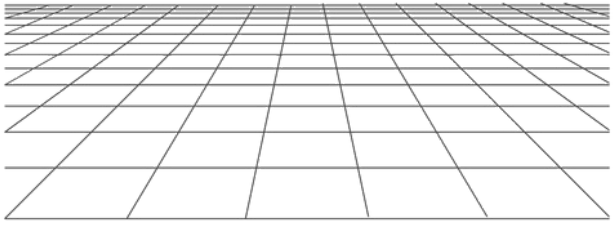
Perspective distortion



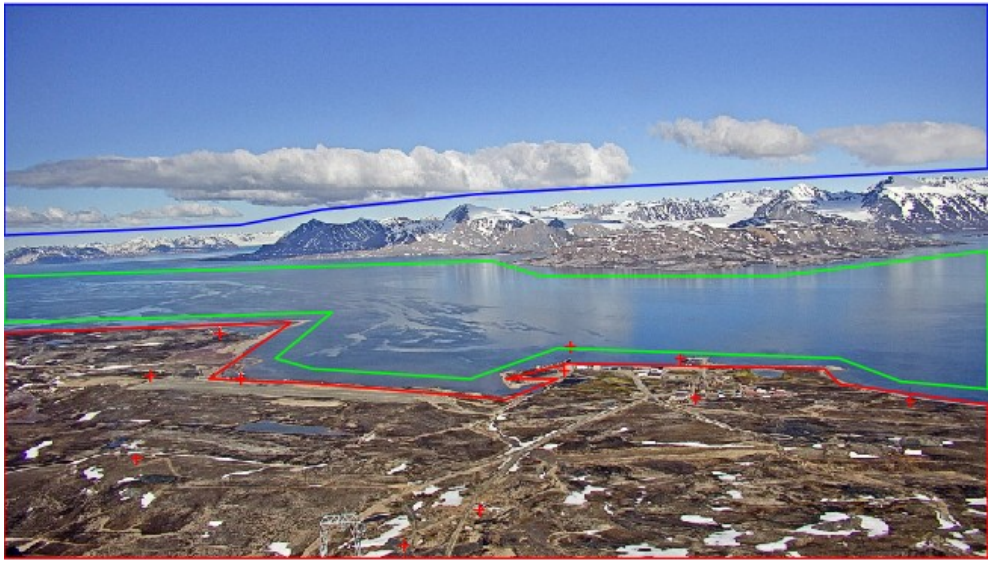
Perpsective distortion can be assessed using ground control points

The camera setup must be described in terms of:

- Camera coordinates (X, Y, Z)
- Camera view angles (Azimuth, Pitch/Elevation, Roll)



Preliminary activities

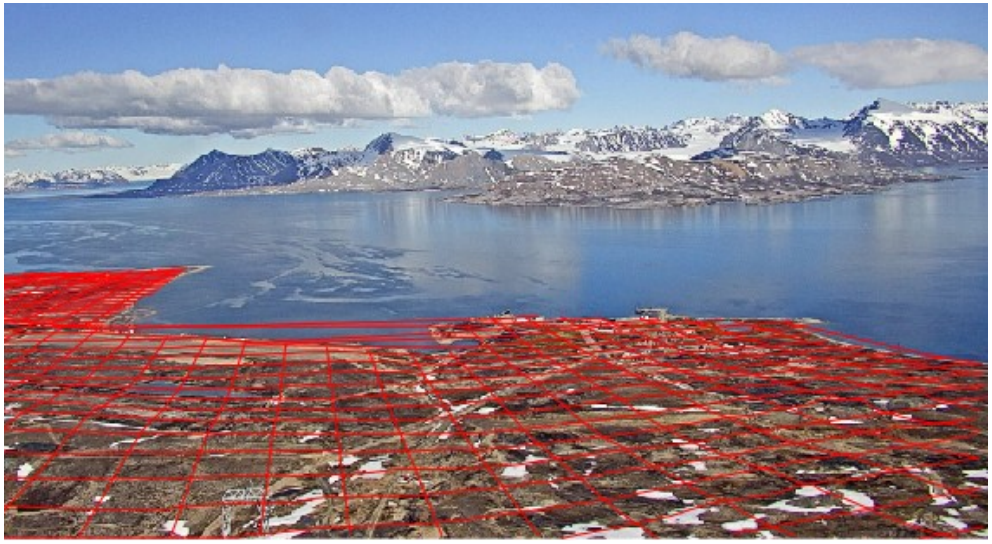


The first step consists on defining the regions of interest:

- Sky → cloud cover
- Sea → sea ice and naval traffic
- Land → snow cover and coastal lakes

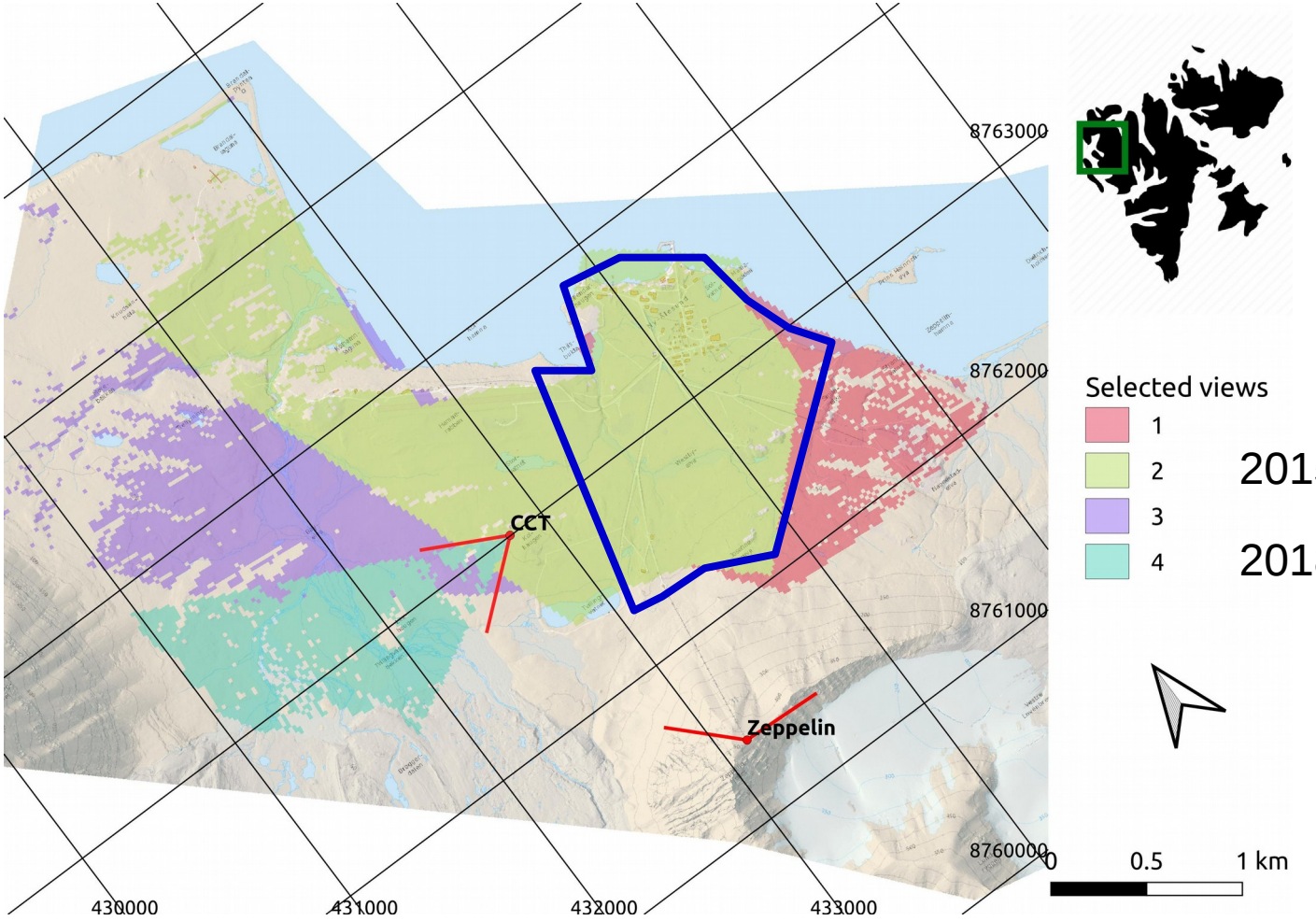
The second step is aimed to optimize the intrinsic and the external parameters of each camera view.

- 5 different cameras
- 10 different perspective views
- 100000 images



Camera views

2000-2018



Data processing

Image selection:
- File corruption
- Low illumination
- Intense cloud cover

Quality check:
- Camera orientation
- Lens interferences (rain drops or ice crusts)

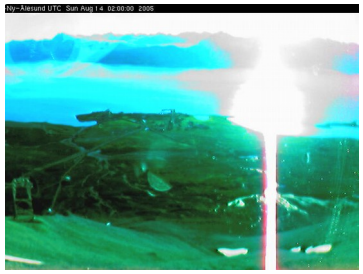
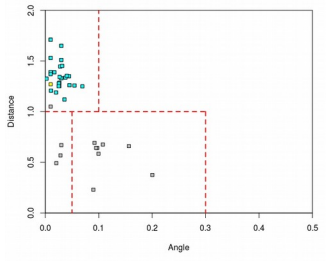
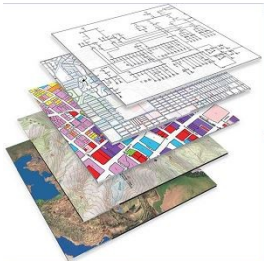


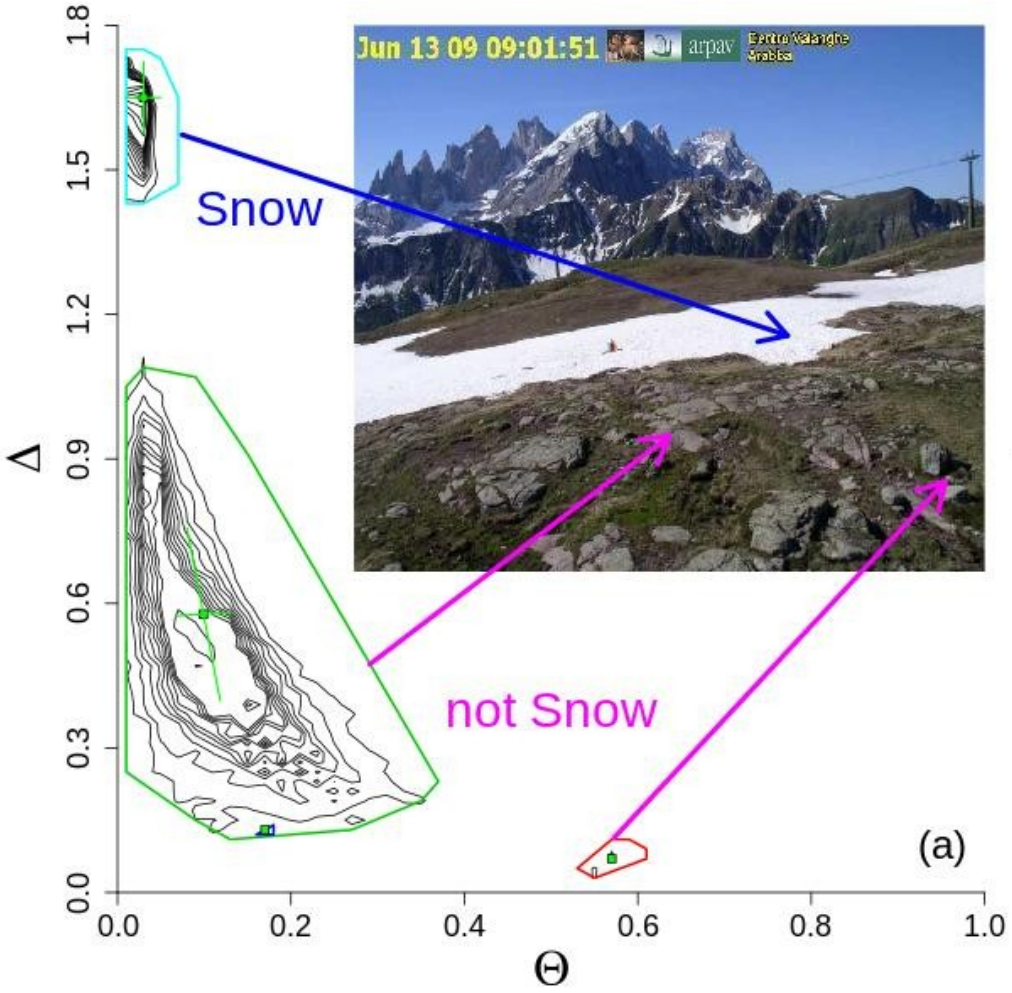
Image classification:
- Segmentation
- Snow detection

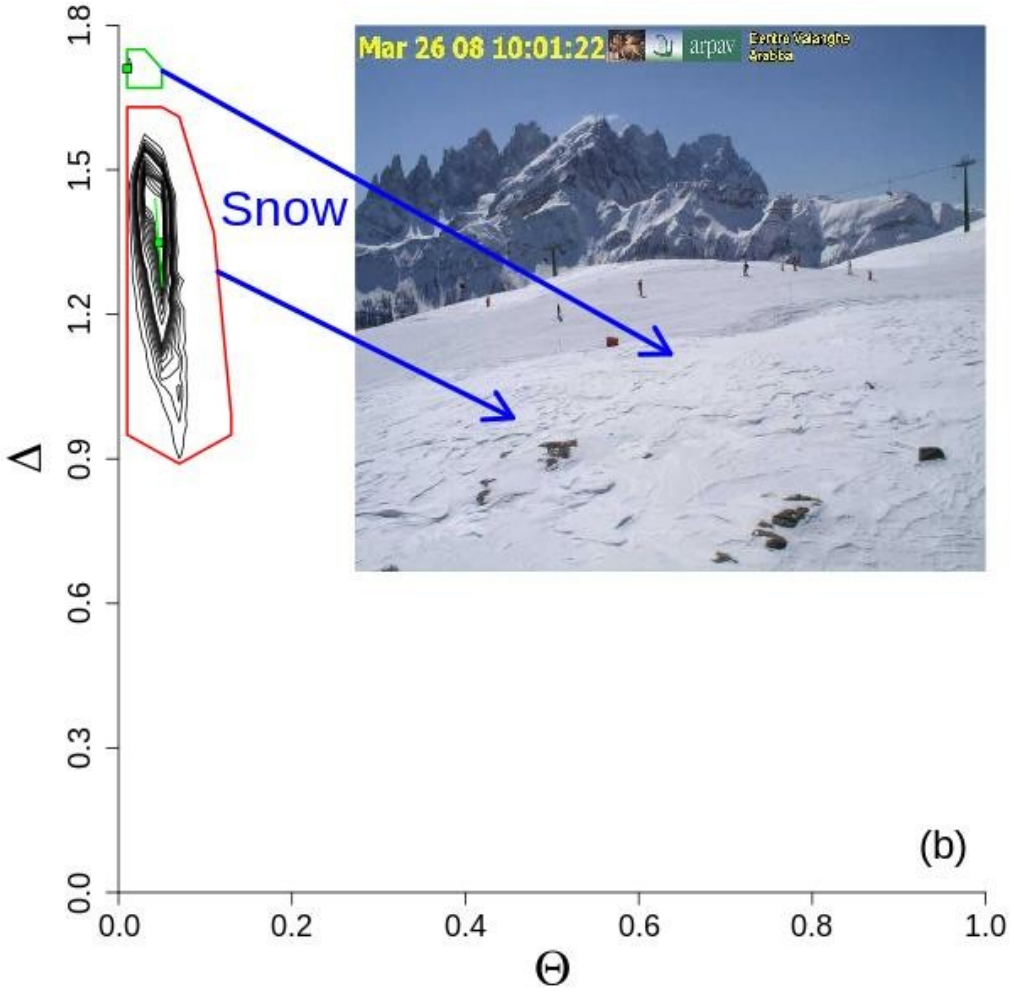


Dataset preparation:
- Grid extraction
- Data formatting



"Spectral similarity" (SS)





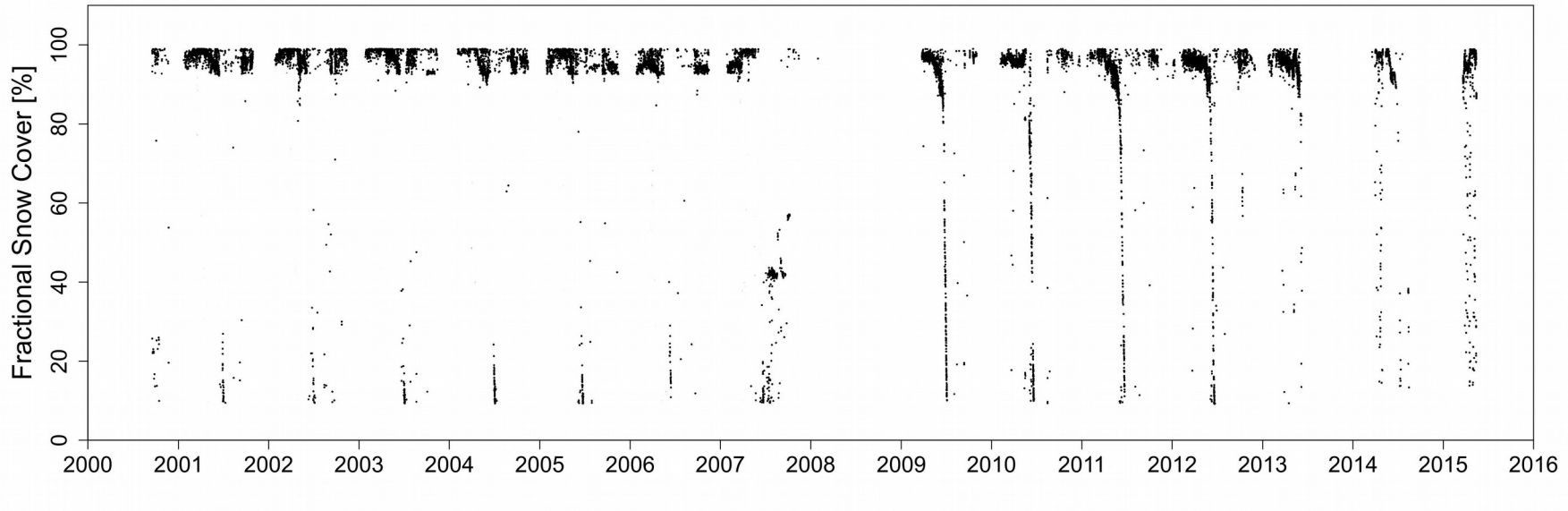
"Spectral" features:

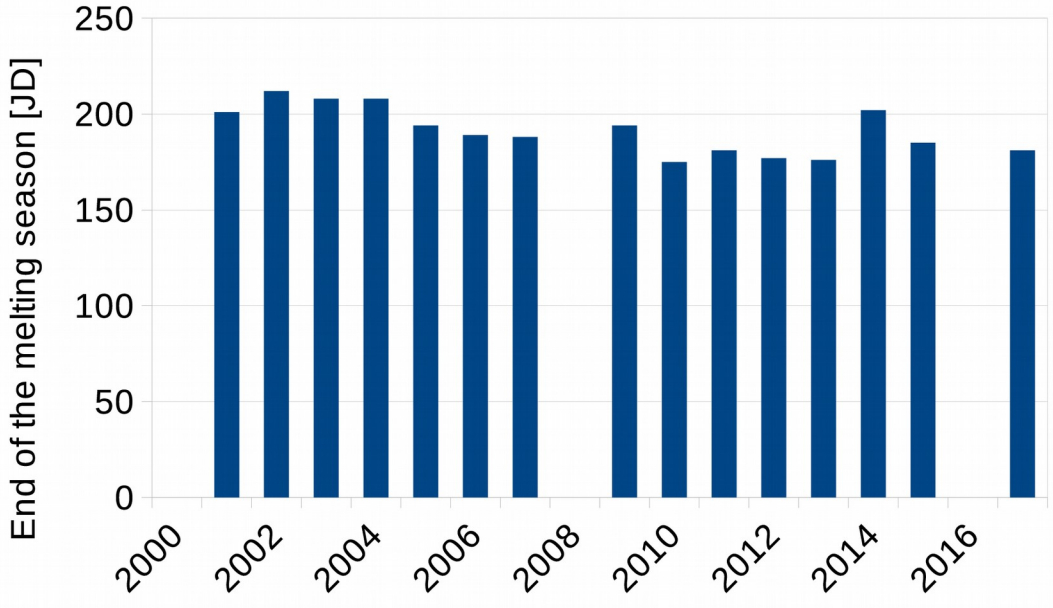
Δ Distance from the reference "black"

Θ Angle from the reference "white"

Mathematical description described in Salzano et al 2019 [Geosciences, 9, 97]

Time series

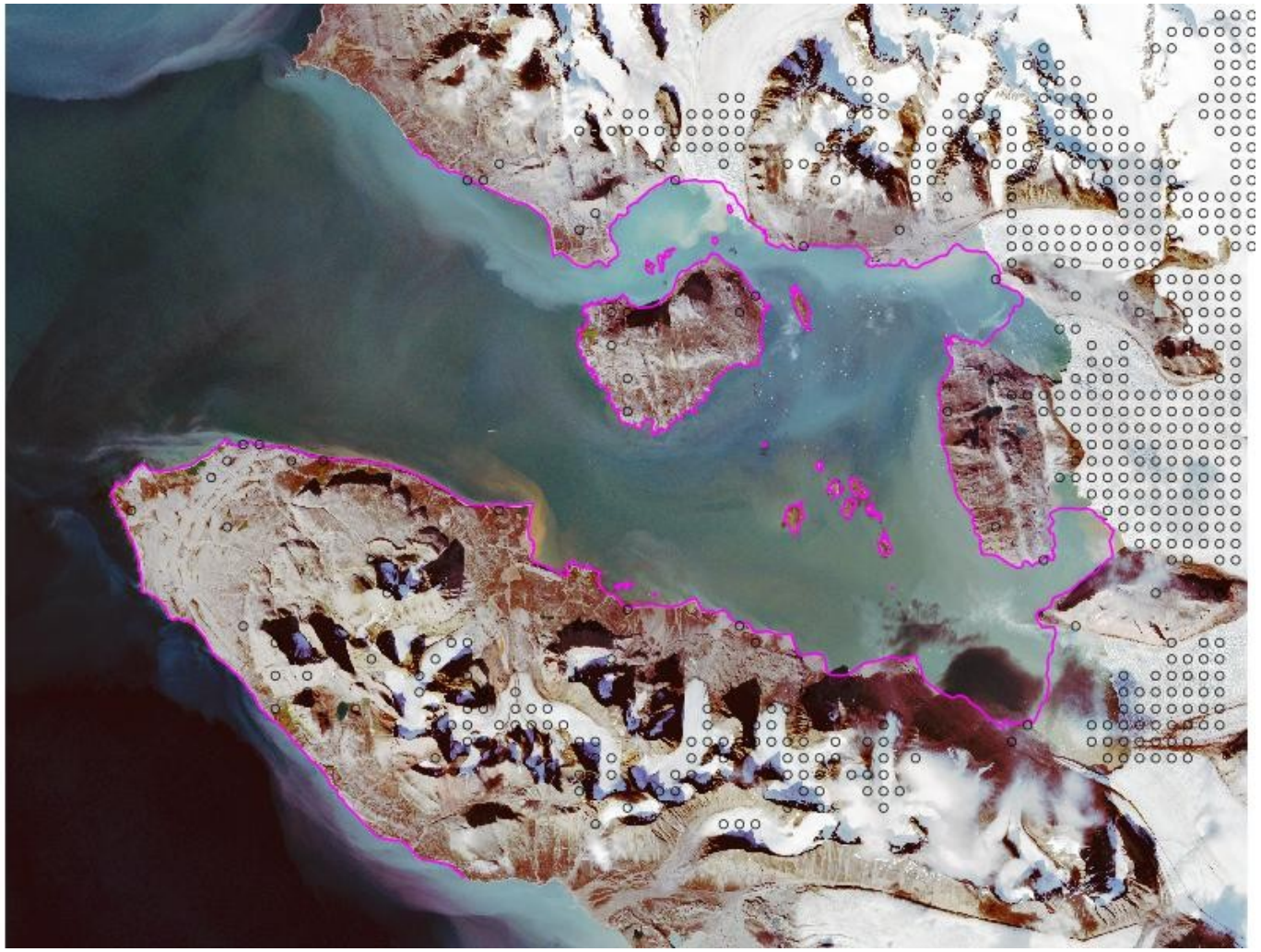


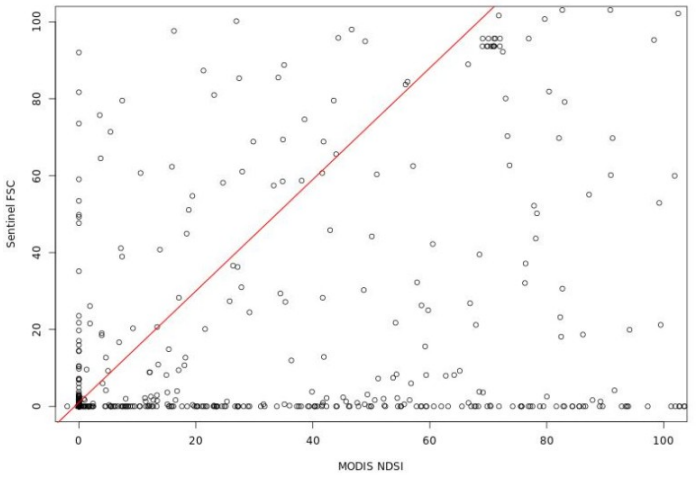


The estimation of FSC in a long time-series provides useful information for describing the snow cover evolution with high time and spatial resolutions

Data integration

Different dataset can be integrated with the FSC product with the aim to increase the efficiency of remotely-sensed imagery on identifying the snow cover in particularly-difficult situations such as Svalbard islands.





Some tests have been implemented in a cloud environment in order to integrate the activity with other services.

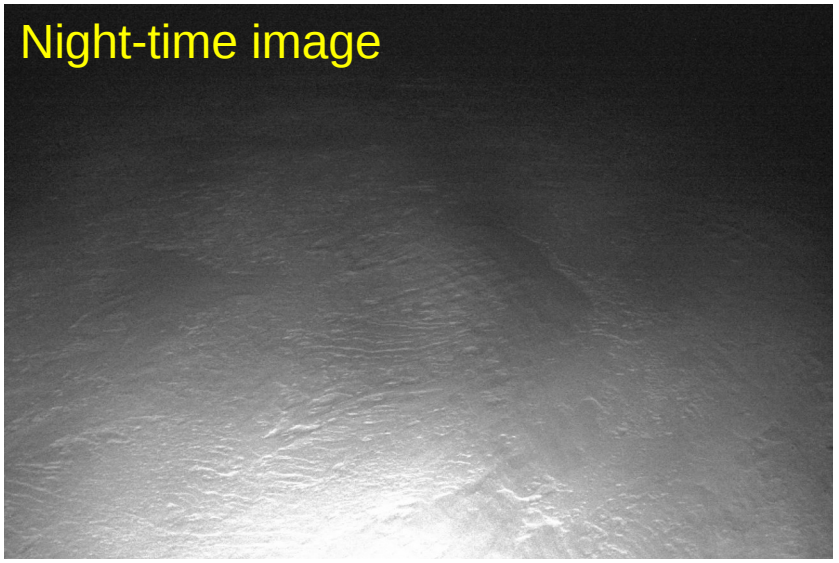
ESSI Lab

VLAB

Improvements

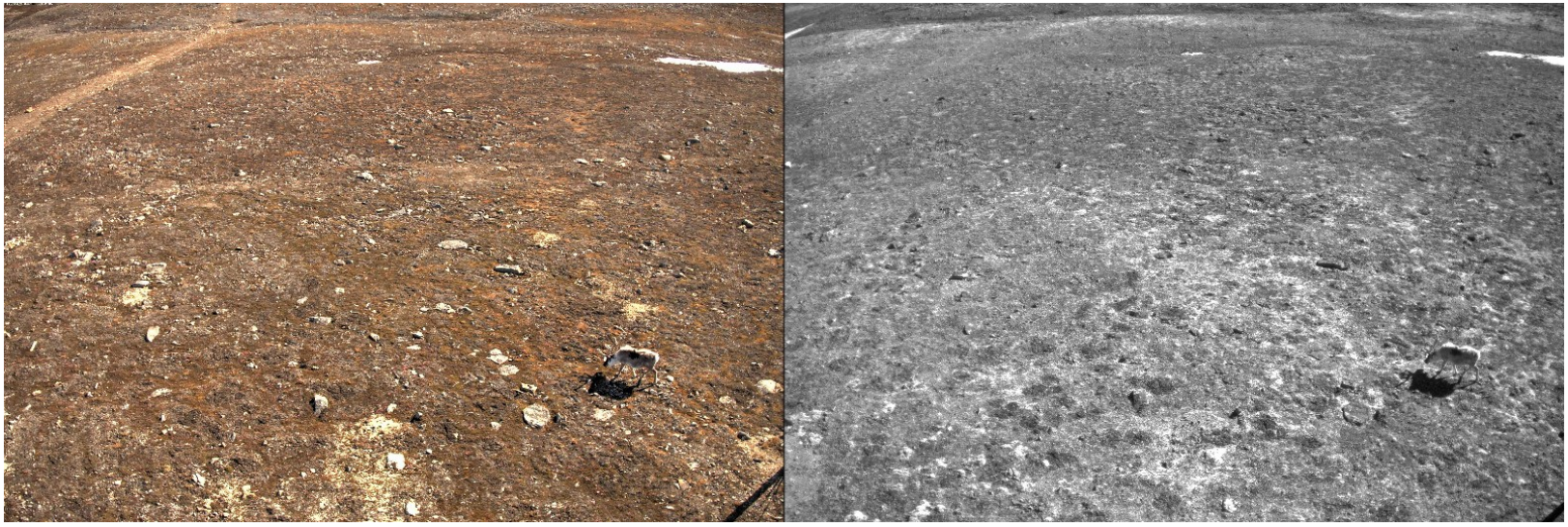
Estimation of:

- Fractional snow cover
- Snow reflectance
- Surface roughness



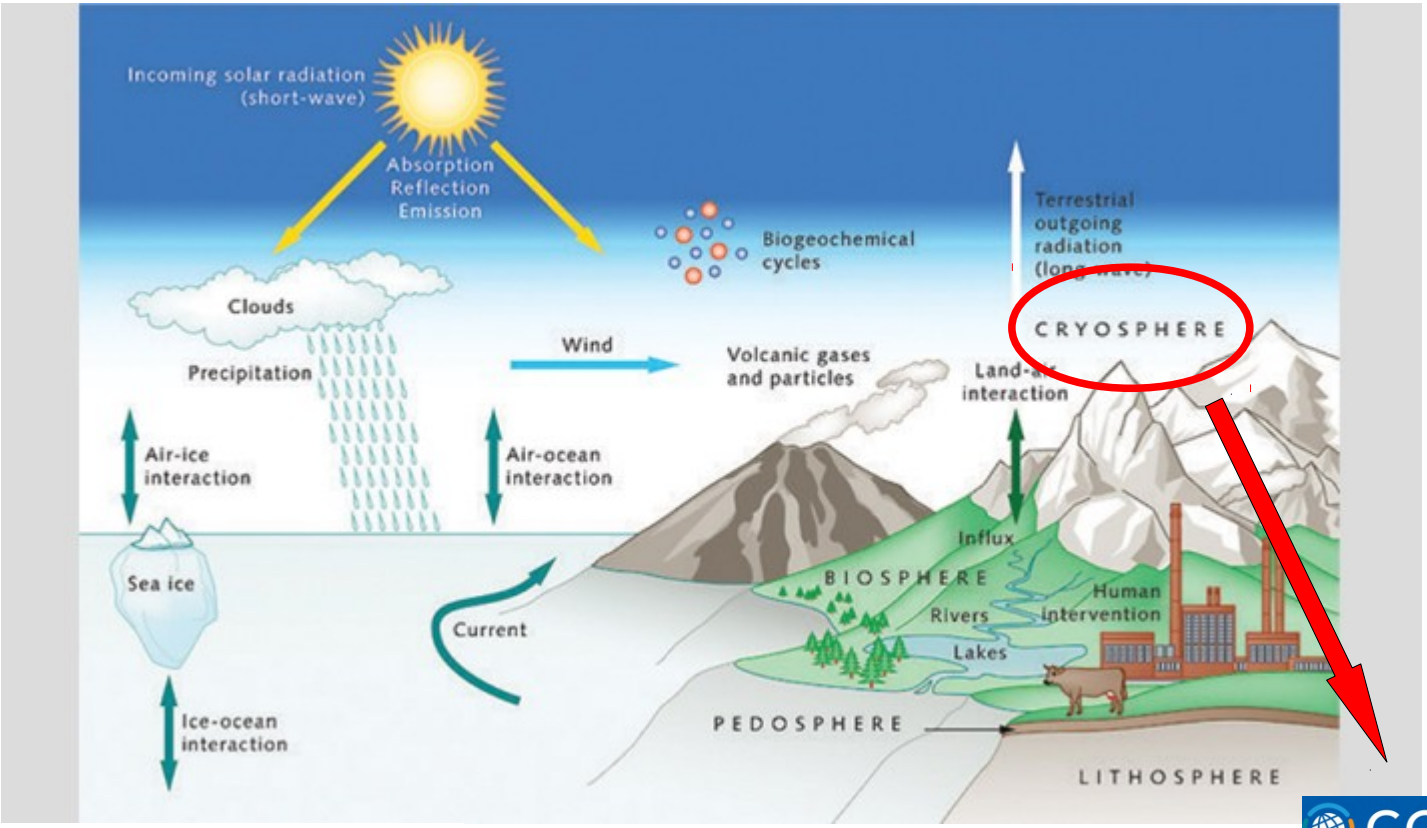
NIR

Vis



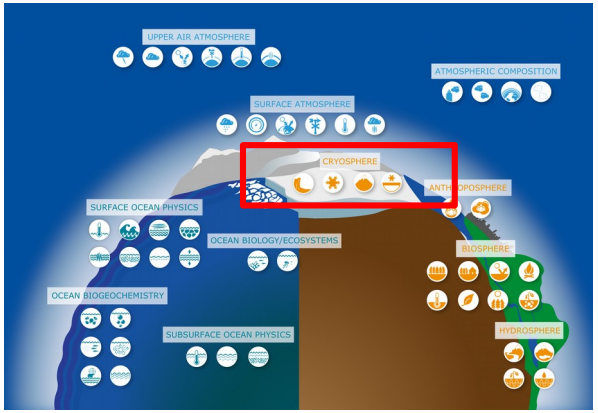
NIR

Variables & Indicators



GCOS

SUSTAINABLE DEVELOPMENT GOALS
17 GOALS TO TRANSFORM OUR WORLD



Dissemination activities

Educational activities have been started with an Italian school in Prato, in order to enhance citizen awareness about Climate Change.
Students (more than 100 hundred) are going to be trained for tagging and classifying panoramic images with the aim to observe snow cover variations in the last 10 years.

Aknownledgements

This activity is part of the iCUPE project, that received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 689443.

The data access to the Zeppelin image repository is provided by the Norwegian Polar Institute [Pedersen, C. (2013). Zeppelin Webcamera Time Series doi: 10.21334/npolar.2013.9fd6dae0]

This activity is integrated in the framework of the reasearch programs supported by the National Research Council of Italy in Ny Alesund at the Italian Arctic Station "Dirigibile Italia".

This activity is part of the research project RIS-ID 10241 "Continuous Vis-NIR Characterization of snow-ice surface in Ny-Ålesund"