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Automated Monitoring of Fractional Snow Cover from MONIMET Camera Network in Finland

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Outline

- Short Introduction to COST Action ES1404
- MONIMET Camera Network
- Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)
- Snow Cover Fraction Algorithm
- Snow Cover Fraction Analyses

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ESSEM COST Action ES1404

A European network for a harmonised monitoring of snow for the benefit of climate change scenarios, hydrology and numerical weather prediction

INTRODUCTION TO ESSEM COST Action ES1404

This COST Action on SNOW aims at building a better connection between snow measurements and models, between snow observers, researchers and forecasters, for the benefit of various stakeholders and the entire society

Aim of the Action

To enhance the capability of the research community and operational services to provide and exploit quality-assured and comparable regional and global observation-based data on the variability of the state and extent of snow.

Overall Objectives & Benefits:

1.Establish a European-wide science network on snow measurements for their optimum use and applications benefitting on interactions across disciplines and expertise.
2.Assess and harmonise practices, standards and retrieval algorithms applied to ground, air- and space-borne snow measurements => Foster their acceptance by key snow network operators at the international level.
3.Develop a rationale and long term strategy for snow measurements, their dissemination and archiving.
4.Advance snow data assimilation in European NWP and hydrological models and show its benefit for relevant applications.
5.Establish a validation strategy for climate, NWP and hydrological models against snow observations and foster its implementation within the European modelling communities.
6.Training of a new generation of scientists on snow science and measuring techniques with a broader and more holistic perspective linked with the various applications.

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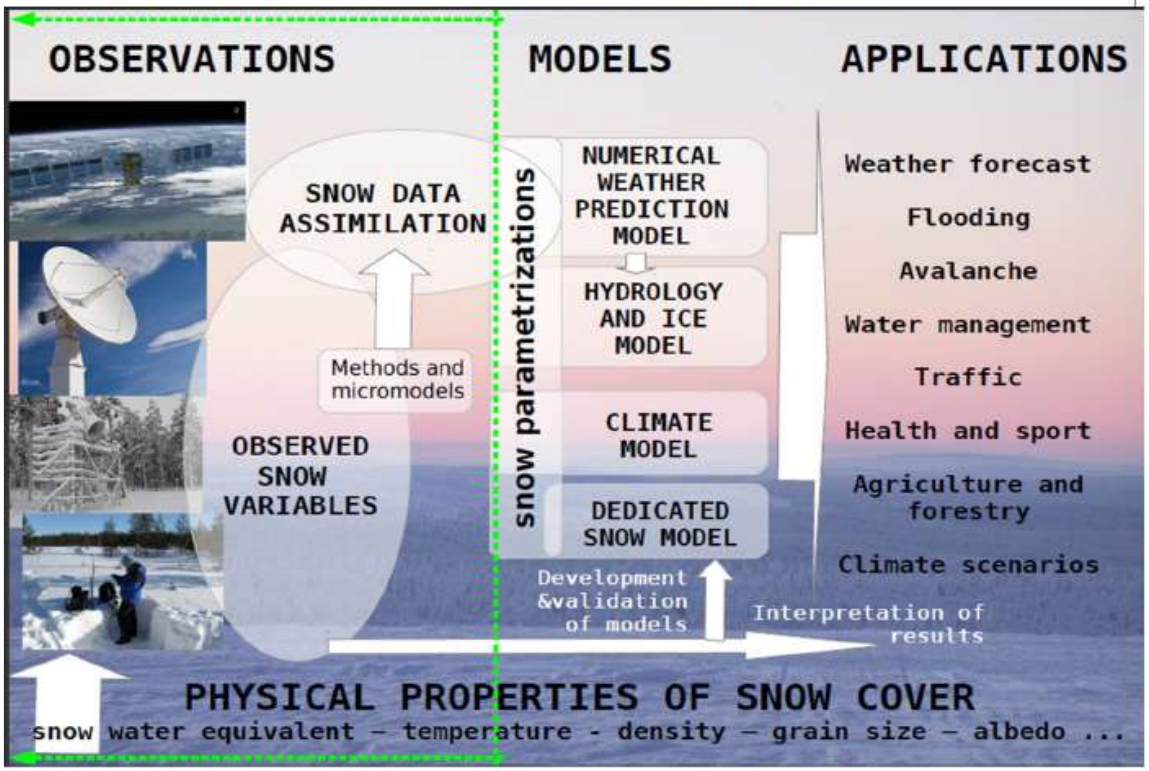
WORKING GROUPS (WG):

WG1: Physical characterization of snow properties

WG2: Instrument and method evaluation

WG3: Snow data assimilation and validation methods for NWP and hydrological models

The Action focuses on observations and data assimilation:



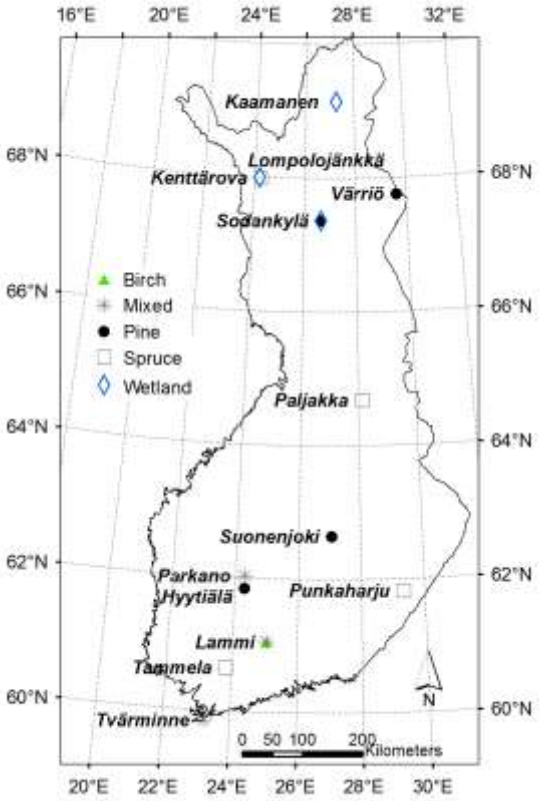
Camera Networks

- **Environmental Monitoring**
  - Research Institutes
  - Environment Institutes
  - Universities
- **Traffic**
  - Traffic Agencies
- **Safety**
  - Ski resorts
  - Traffic Agencies
  - Police
- **Touristic**
  - Ski Resorts
  - Municipalities

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MONIMET Camera Network

- **14 Locations**
- **28 Cameras**
- **Wired (ethernet) or wireless (3G/GPRS) connection to the cameras**
- **Data access by FTP**



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MONIMET Camera Network



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Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)

A toolbox which,

Implemented
Not implemented yet

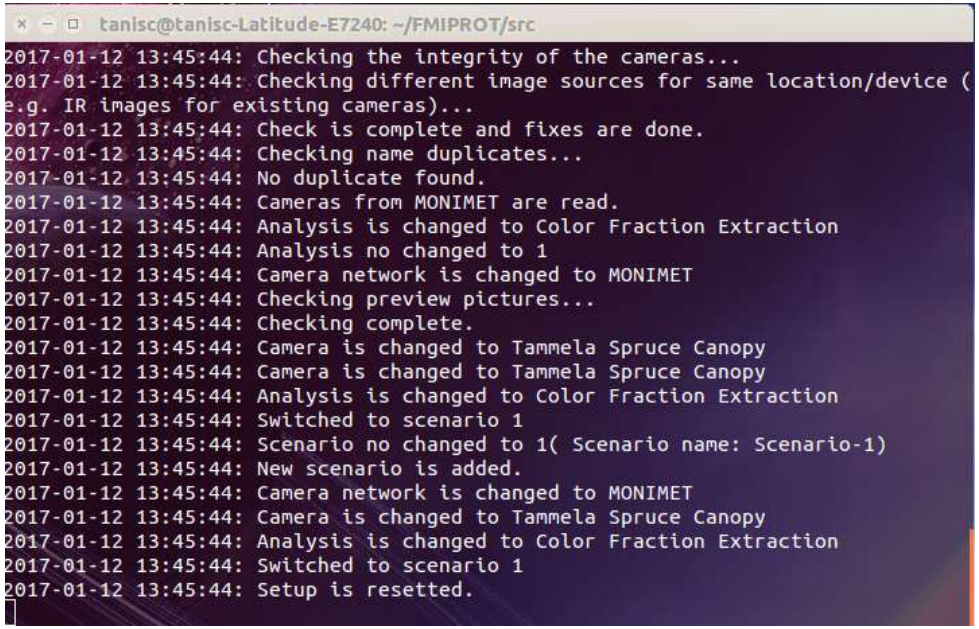
- Different camera networks can be used with
- Downloads camera images from multiple networks
- Handles downloaded images independent from the camera network
- Has interface to select analyses parameters
- Saves analyses parameters in files for later use and sharing
- Run analyses independent from the camera network
- Designed in a way to implement different algorithms by the developer(s) and by the users
- Filters input data and post-processes output data
- Generate previews (configurable plots and maps) of output data
- Generate scripts for production of operational products

Tanis, C. M., et al., “Automatic Digital Image Processing System for Multiple Camera Networks.” *Agricultural and Forest Meteorology,* under review.

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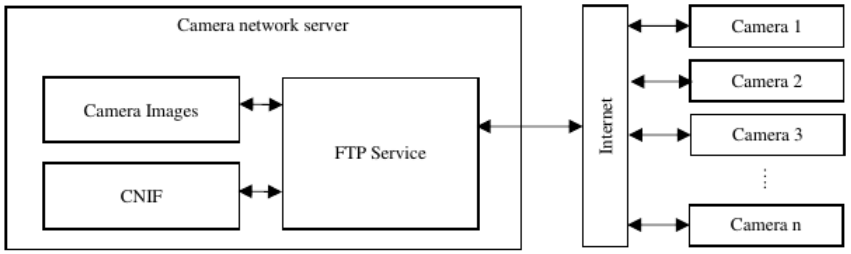
Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)





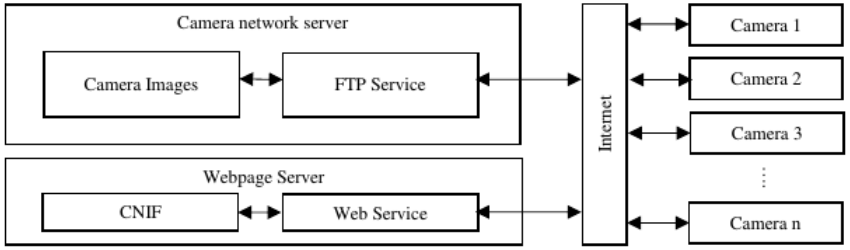
Multiple camera networks

Camera network configurations



A camera network configuration of using FTP for both camera network information file
and images from various cameras.

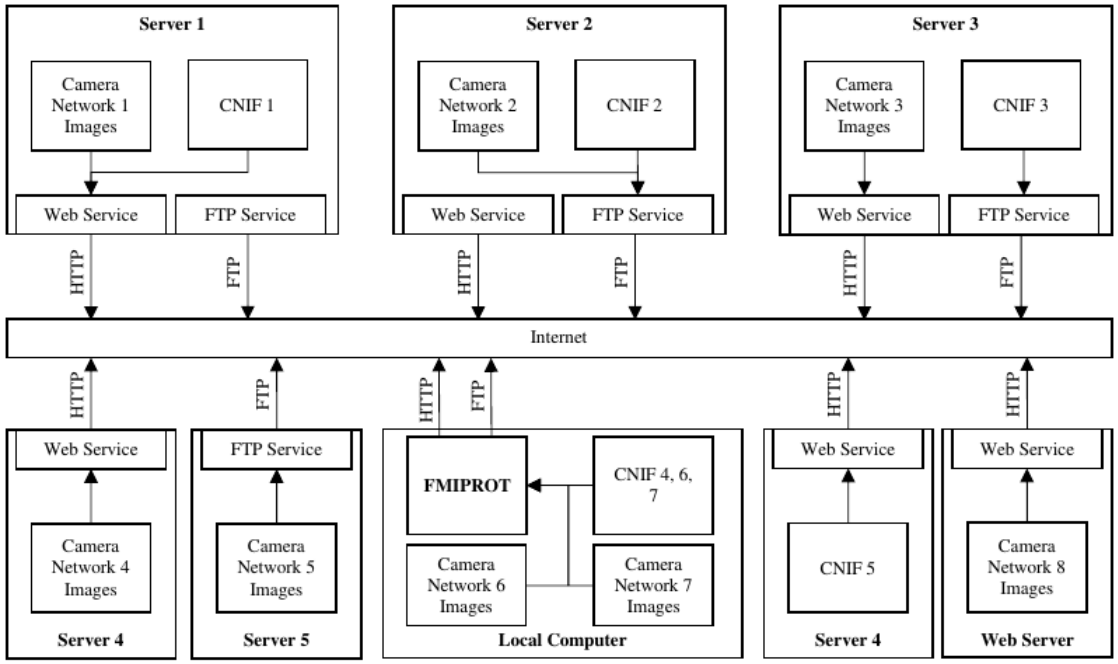
A camera network configuration of using FTP for images from various cameras and
HTTP over a web service for the camera network information file.



Tanis et al., under review

Multiple camera networks

Camera network configurations

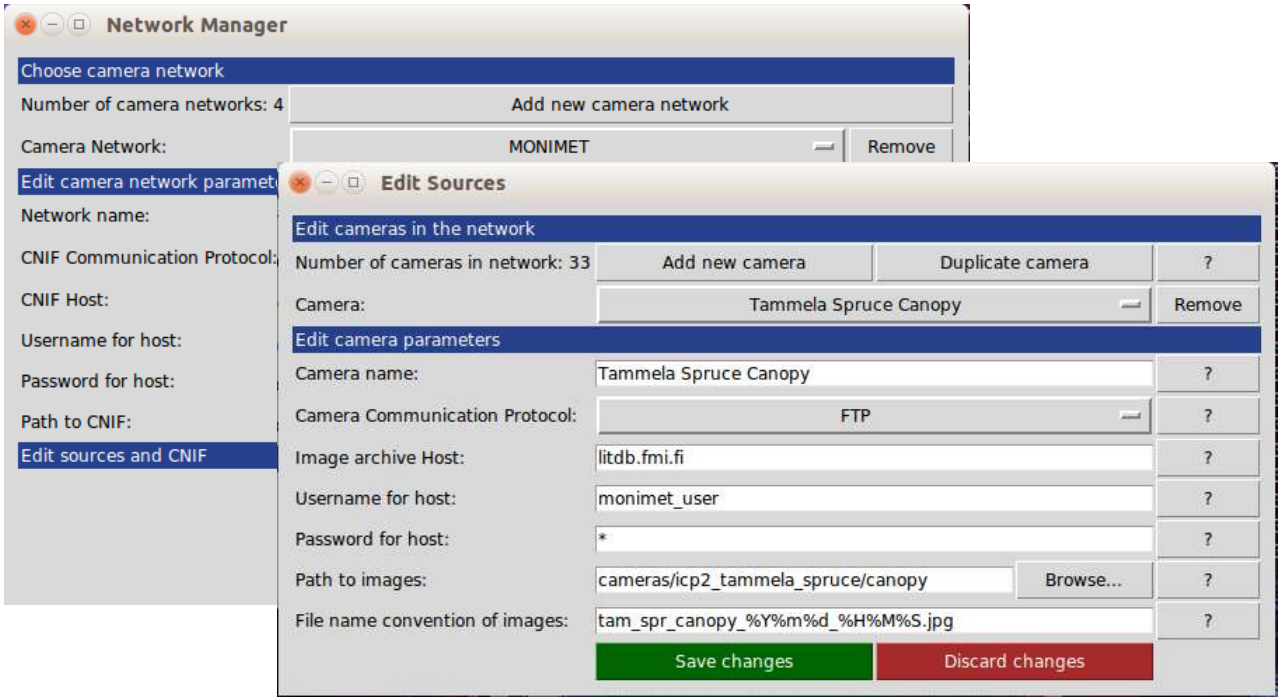


An example of using 8 different camera networks with different configurations

Tanis et al., under review

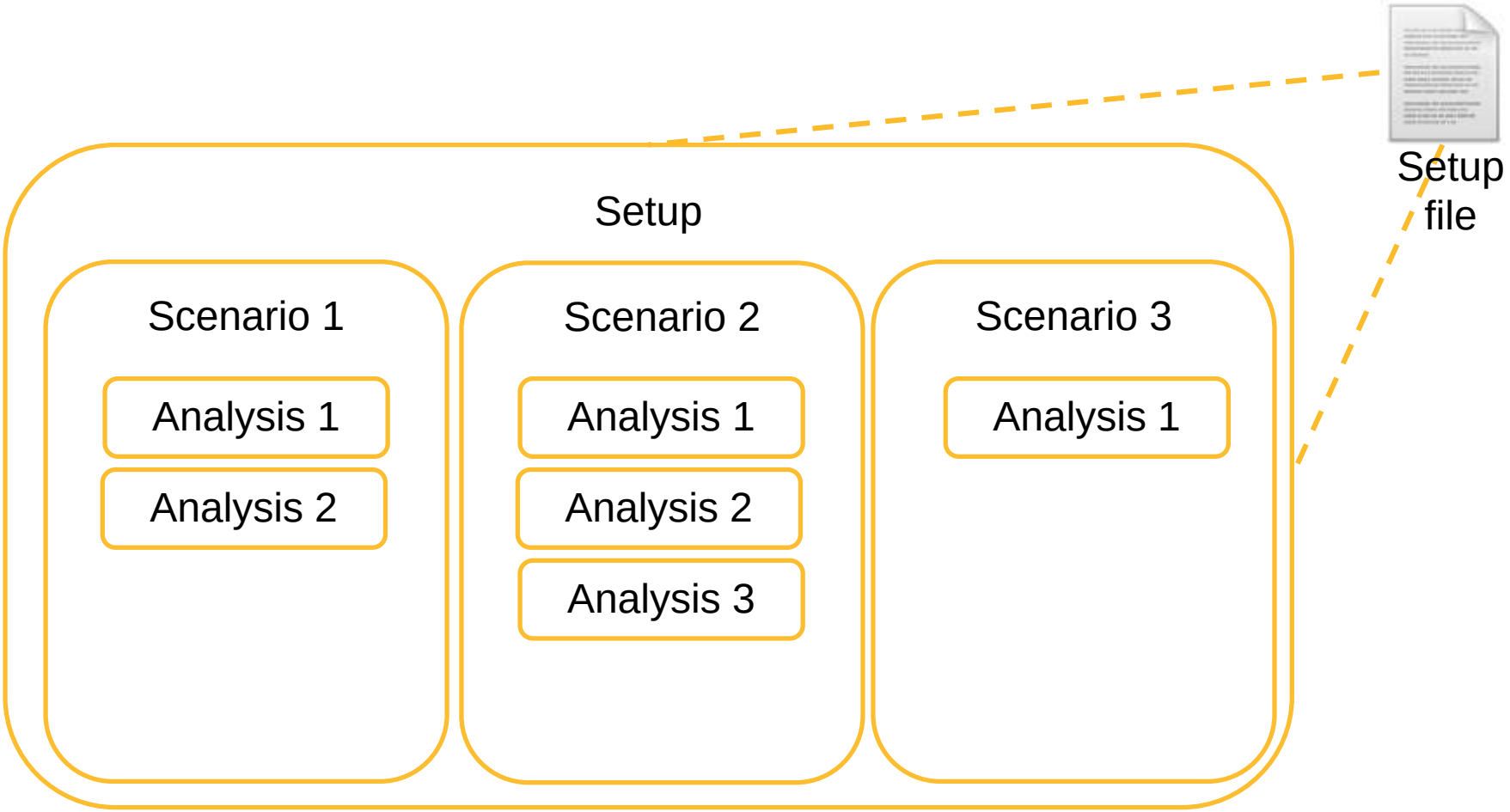
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Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)

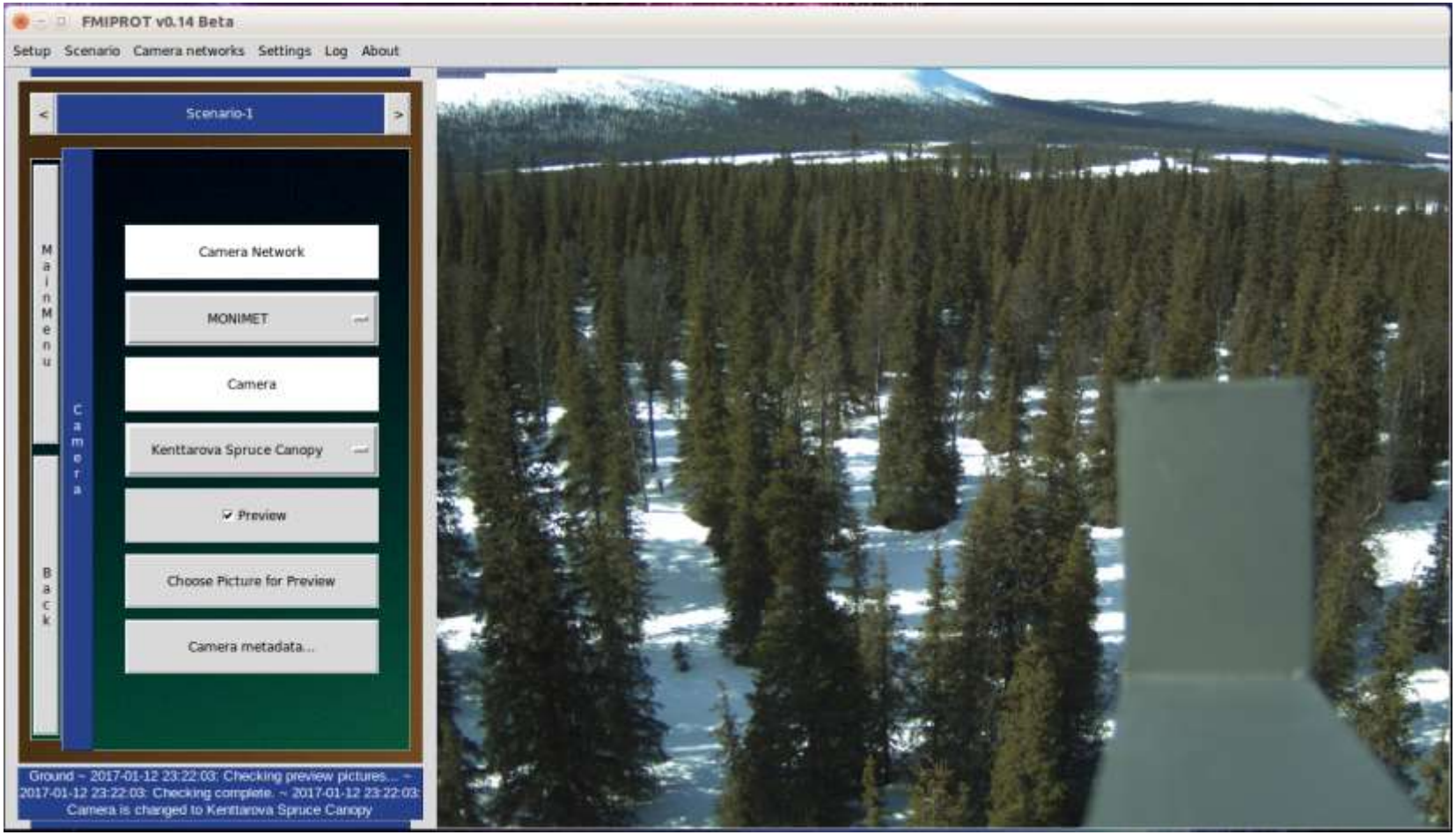


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Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)



Features – Scenarios – Camera



Features – Scenarios – Temporal Filtering





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Features – Scenarios – Thresholds

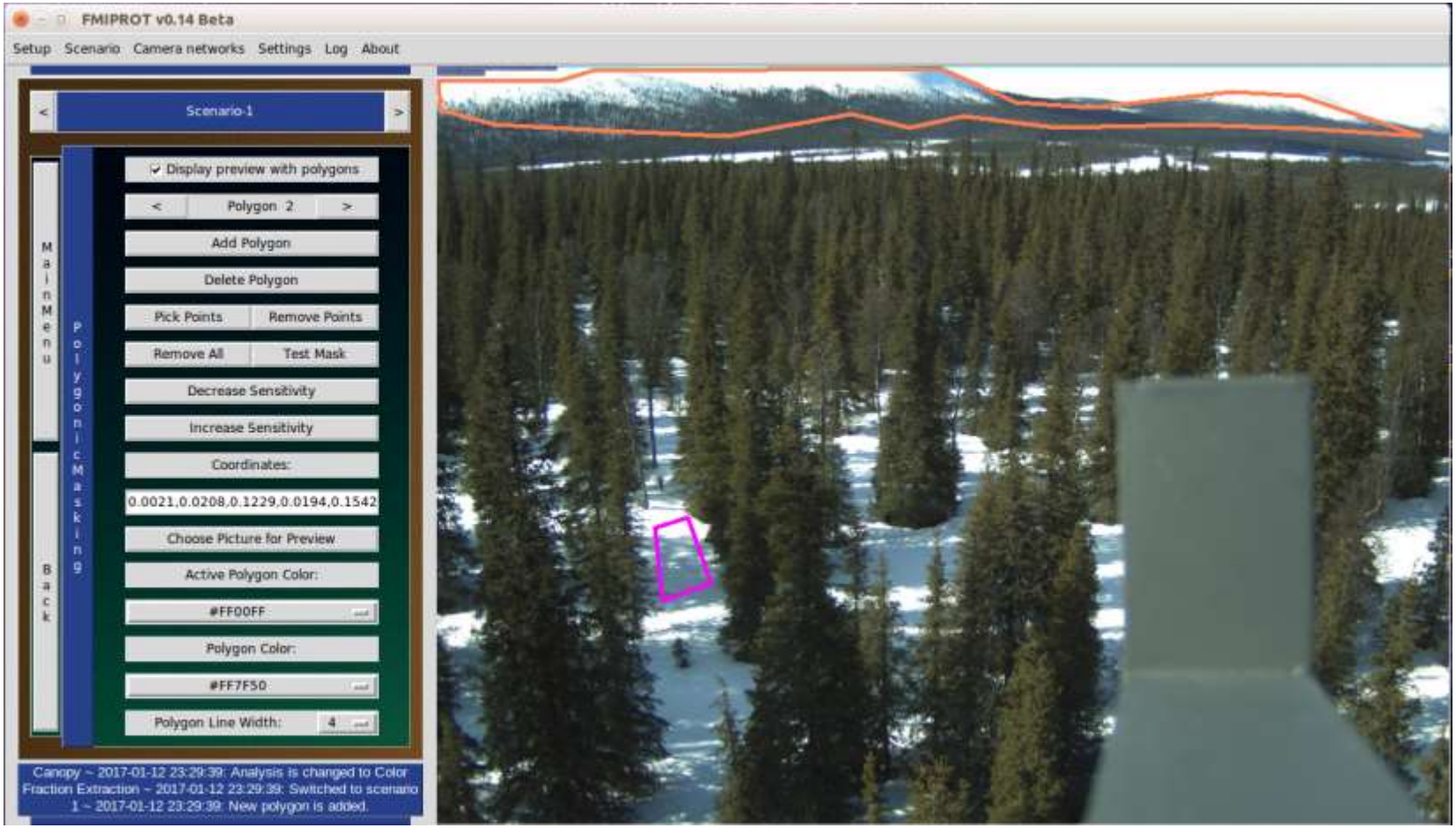






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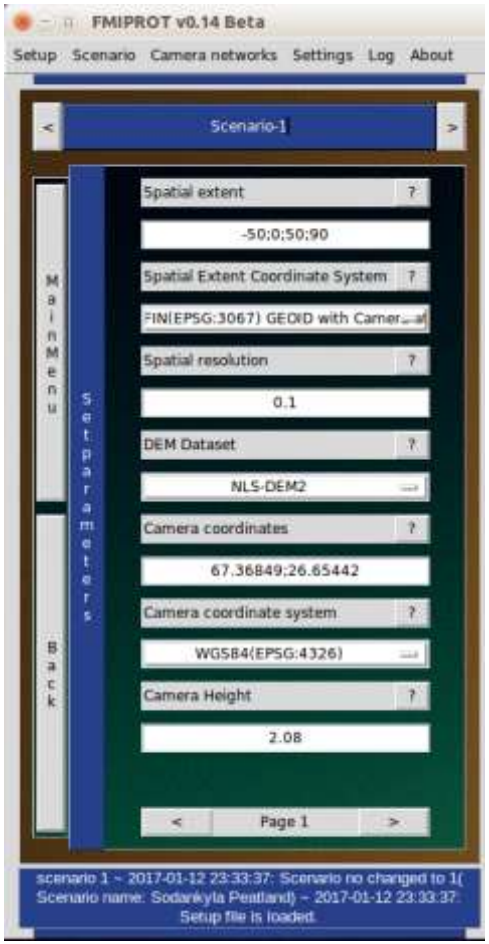
Features – Scenarios - Masking

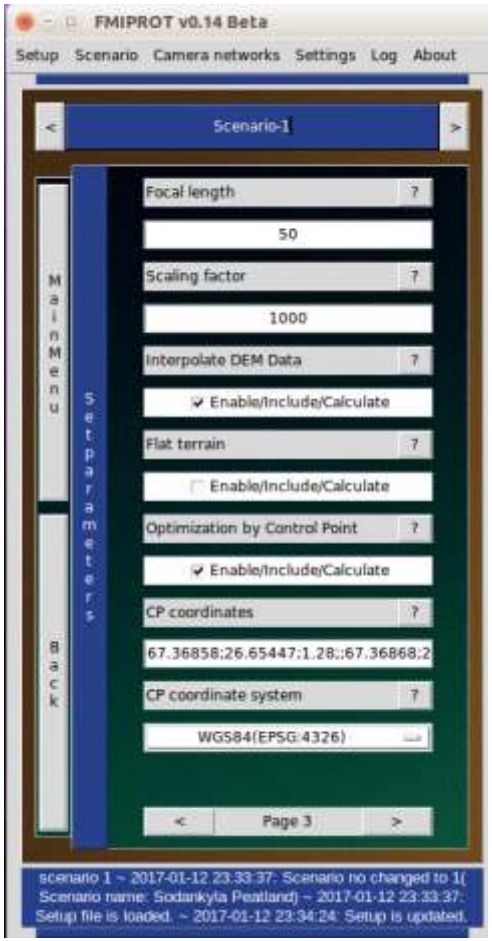


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Features – Scenarios – Analyses

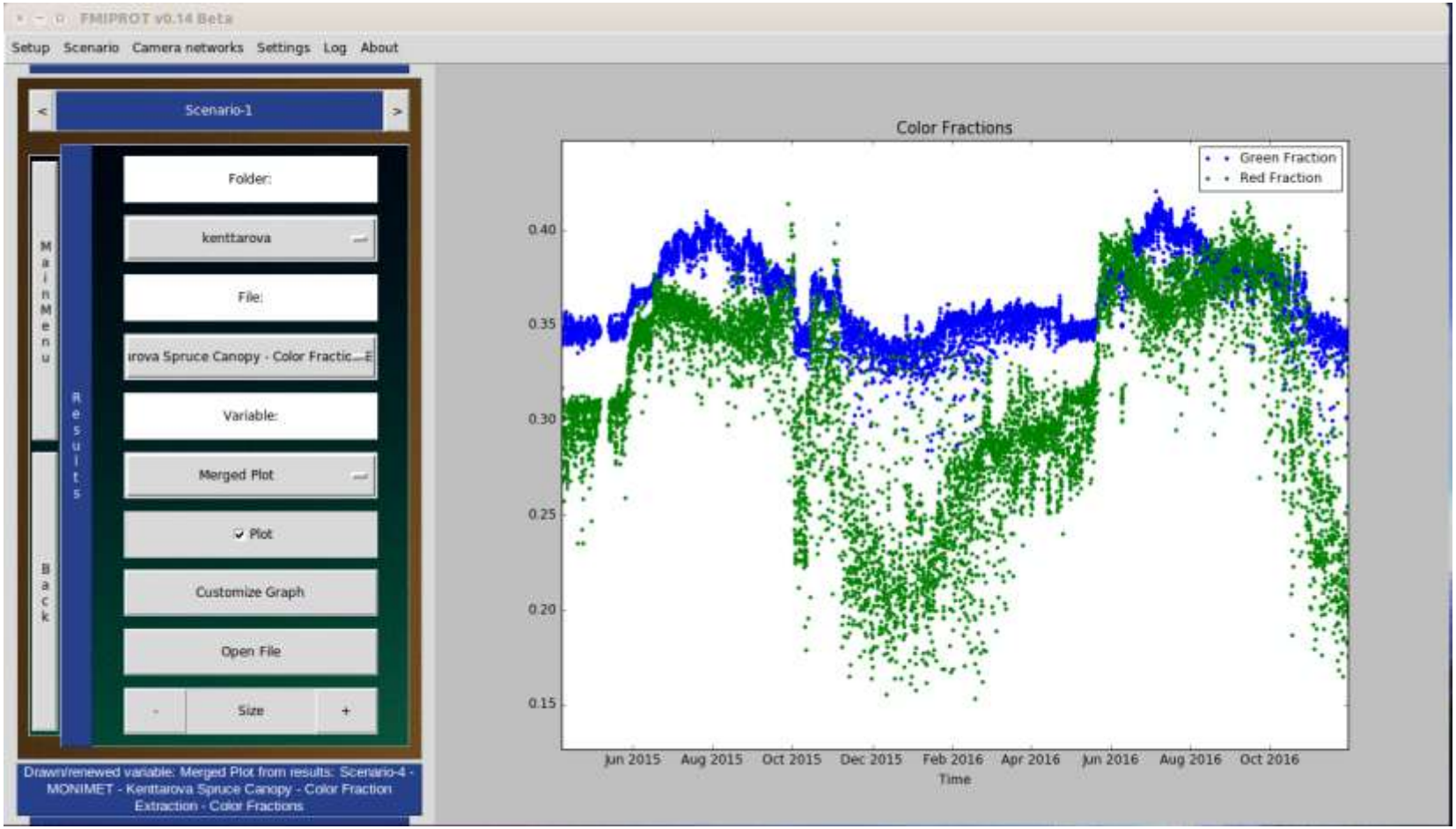






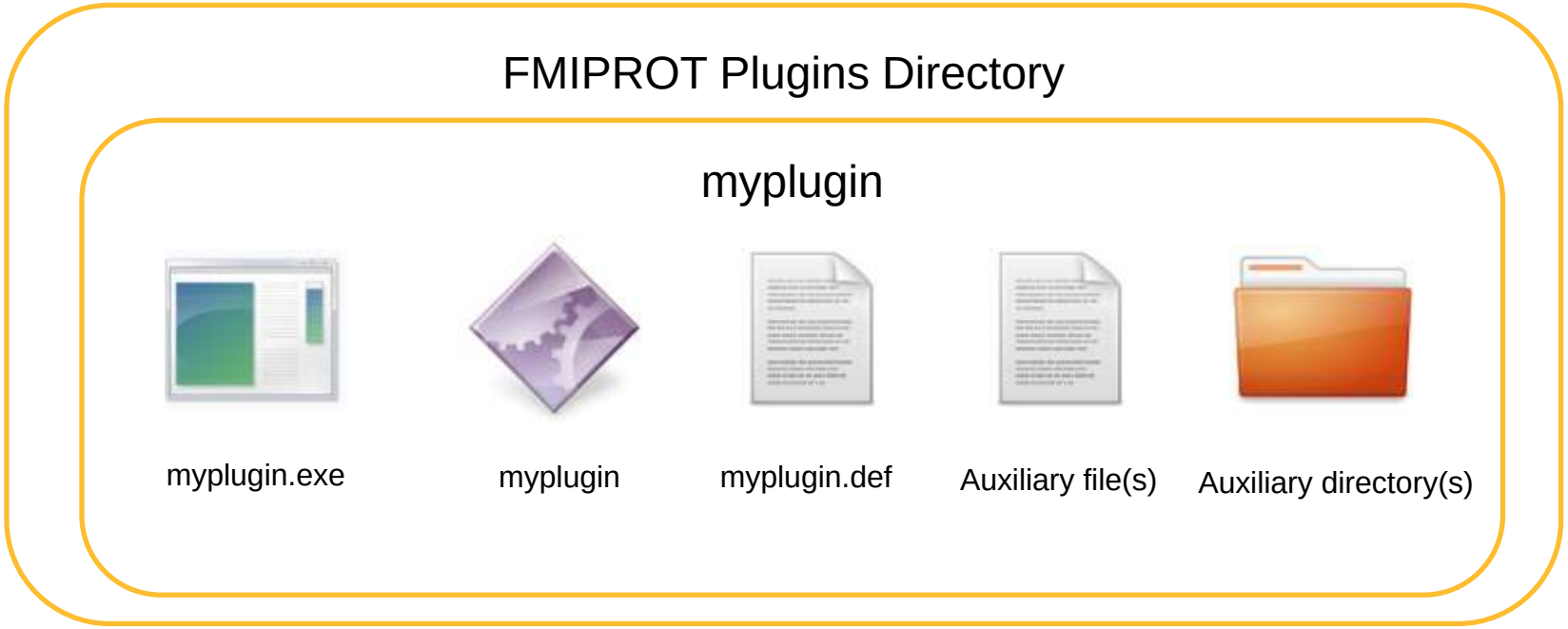
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Features – Previewing output data



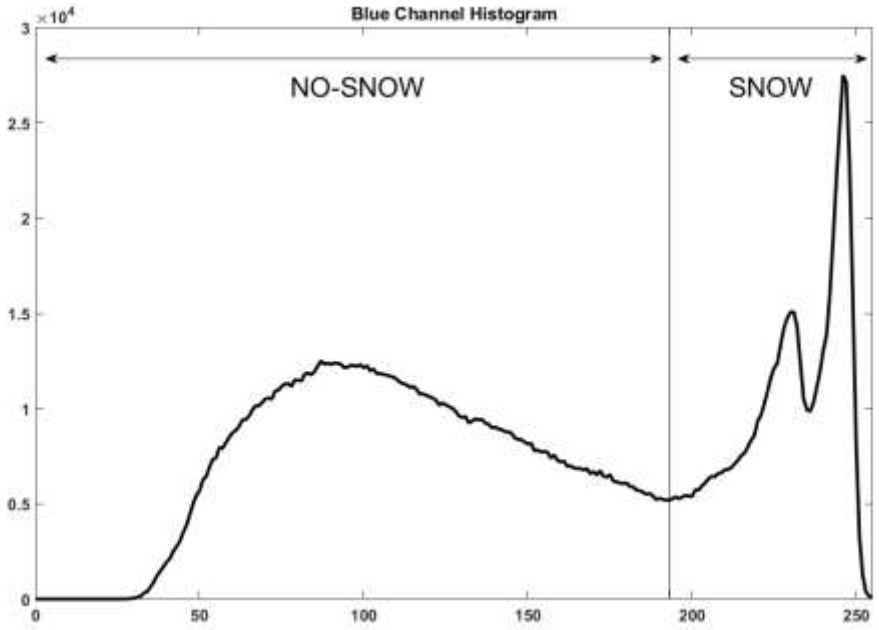
Features – Plugins

If the code of an algorithm can be compiled to binary, it can be used as a plugin



Snow cover fraction algorithm

Snow covered pixel detection algorithm by Salvatori et al. (2011)



Defining the threshold for snow covered pixels

In the algorithm, threshold value for the image is chosen by finding the first local minima after digital number (DN) 127 in the histogram of the blue channel. The algorithm is tested on the images from different cameras looking over the mountains in the Alpines and Southern Italy.

In this study, this algorithm is used to detect snow cover in the boreal region, where the monitored areas include wetlands, forests and hills.

Salvatori, Rosamaria, et al. "Snow cover monitoring with images from digital camera systems." *Ital. J. Remote Sens* 43 (2011): 137-145.

Snow cover fraction algorithm

Geo-referencing algorithm by Corripio (2004)

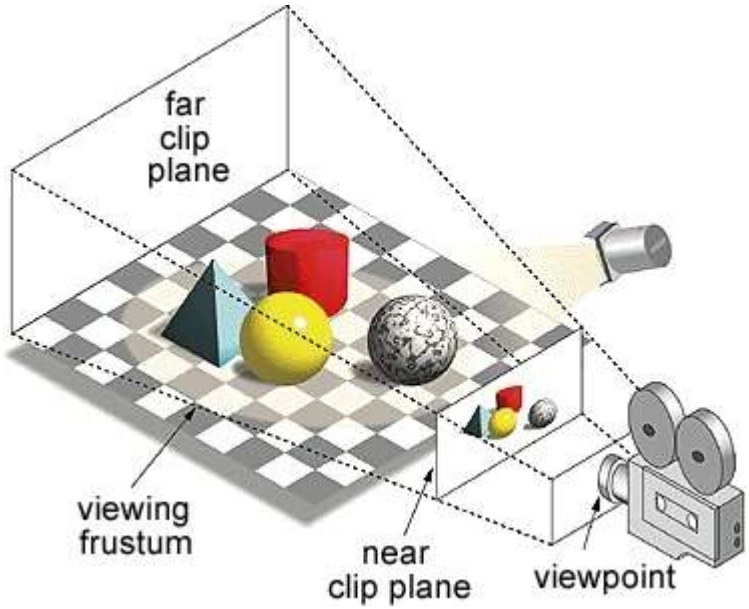
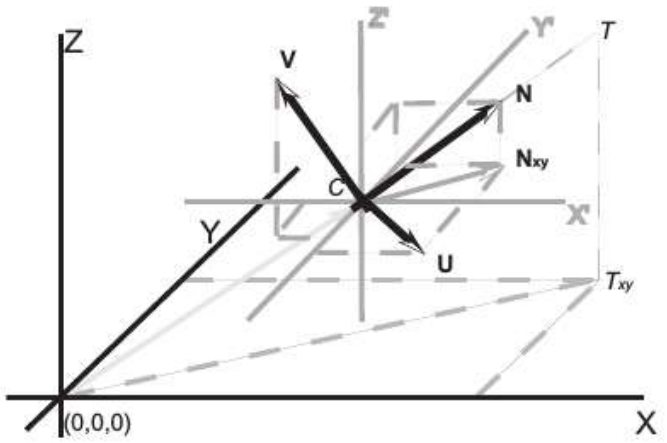


Image credit: Tim Hubson Tutorials

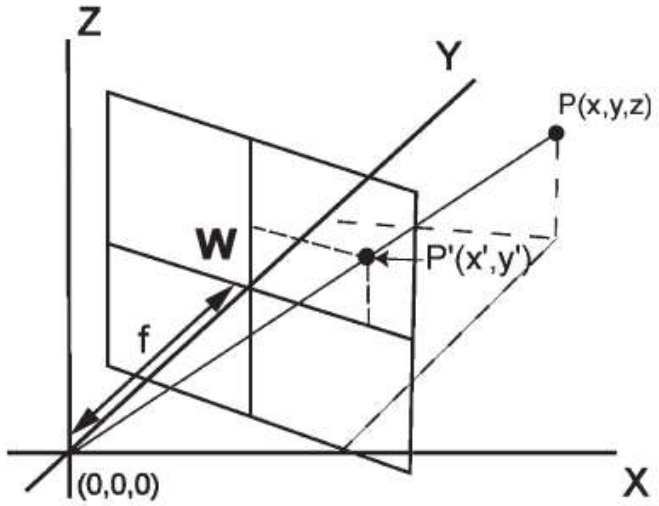
Corripio, Javier G. "Snow surface albedo estimation using terrestrial photography." *International journal of remote sensing* 25.24 (2004): 5705-5729.

Snow cover fraction algorithm

Geo-referencing algorithm by Corripio (2004)



Change from world to camera coordinate system.

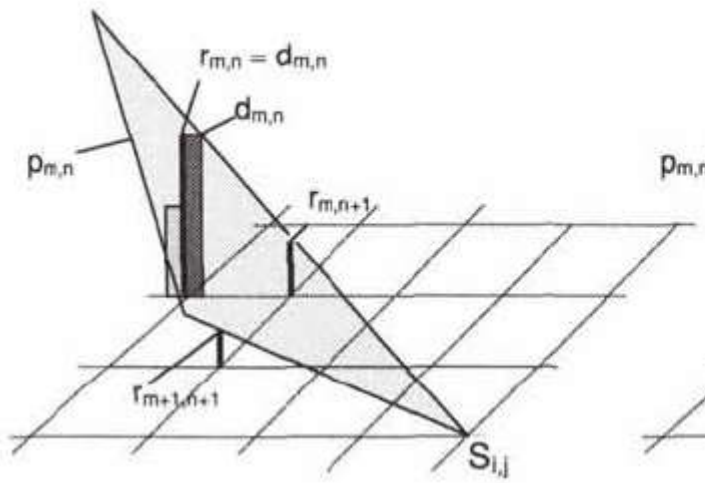


Simplified geometry of the perspective projection for one single point.

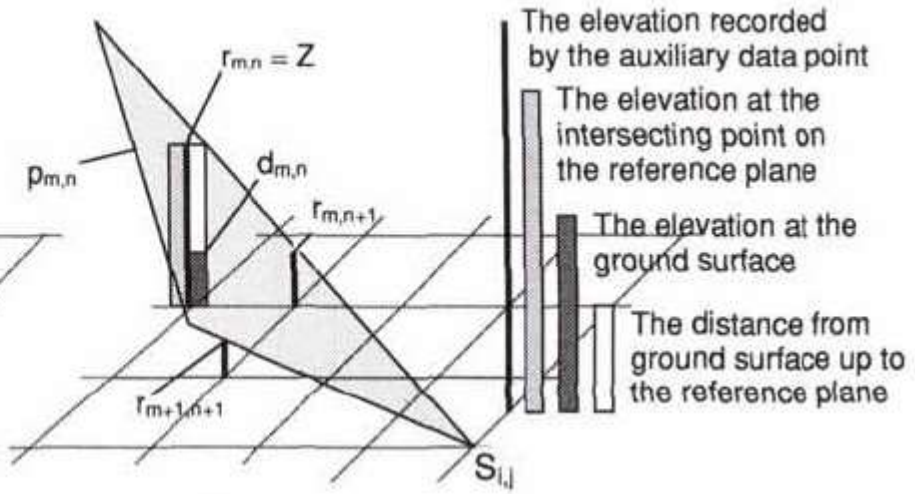
Corripio, Javier G. "Snow surface albedo estimation using terrestrial photography." *International journal of remote sensing* 25.24 (2004): 5705-5729.

Snow cover fraction algorithm

View shed algorithm by Wang (2000)



Point m,n is visible to the point i,j



Point m,n is not visible to the point i,j

Wang, Jianjun, Gary J. Robinson, and Kevin White. "Generating viewsheds without using sightlines." Photogrammetric engineering and remote sensing 66.1 (2000): 87-90.

Snow cover fraction algorithm

Basic lens distortion correction

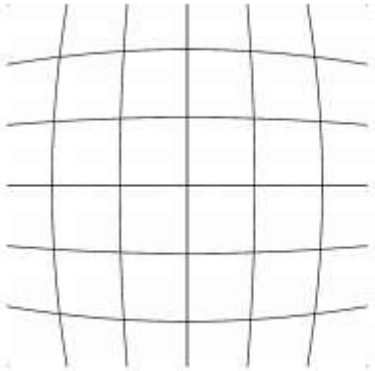
$$X - X_0 = c_1 (\hat{x} - x_0)$$
$$Y - Y_0 = c_2 (\hat{y} - y_0)$$

Real coordinates

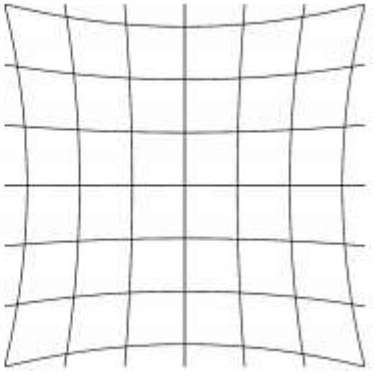
Scale factors

Image (distorted) coordinates

Offset coordinates



Barrel type distortion



Pincushion type distortion

Hugemann, Wolfgang. "Correcting lens distortions in digital photographs." Ingenieurbüro Morawski+ Hugemann: Leverkusen, Germany (2010).

Snow cover fraction algorithm

Image				
Time	2015.05.17 12:01:39		2014.11.11 12:31:39	
FSC (%) (ROI 1 – ROI 2)	5	2	11	21
Image				
Time	2014.10.23 12:01:38		2015.05.09 13:01:39	
FSC (%) (ROI 1 – ROI 2)	23	28	28	0

Snow cover fraction algorithm

Image				
Time	2015.10.04 12:01:38		2015.05.07 11:01:35	
FSC (%) (ROI 1 – ROI 2)	63	3	66	7
Image				
Time	2015.04.18 12:31:38		2015.05.02 12:01:38	
FSC (%) (ROI 1 – ROI 2)	75	80	90	74

Snow cover fraction algorithm

Image				
Time	2015.04.14 12:31:39		2014.12.06 12:31:39	
FSC (%) (ROI 1 – ROI 2)	90	88	93	93

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Snow cover fraction analyses

Sodankylä Peatland Camera

Camera Location:

67.36849° N, 26.65442° E

Images between dates:

23.05.2014 – 29.01.2017

Images between time of day:

10:45 – 12:45

Number of images:

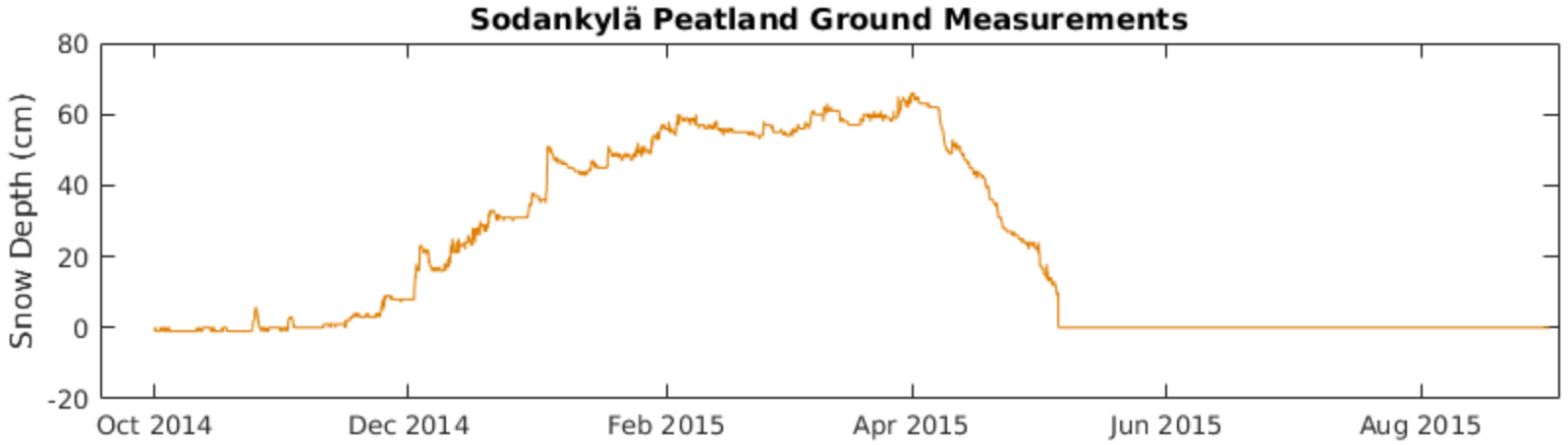
3827

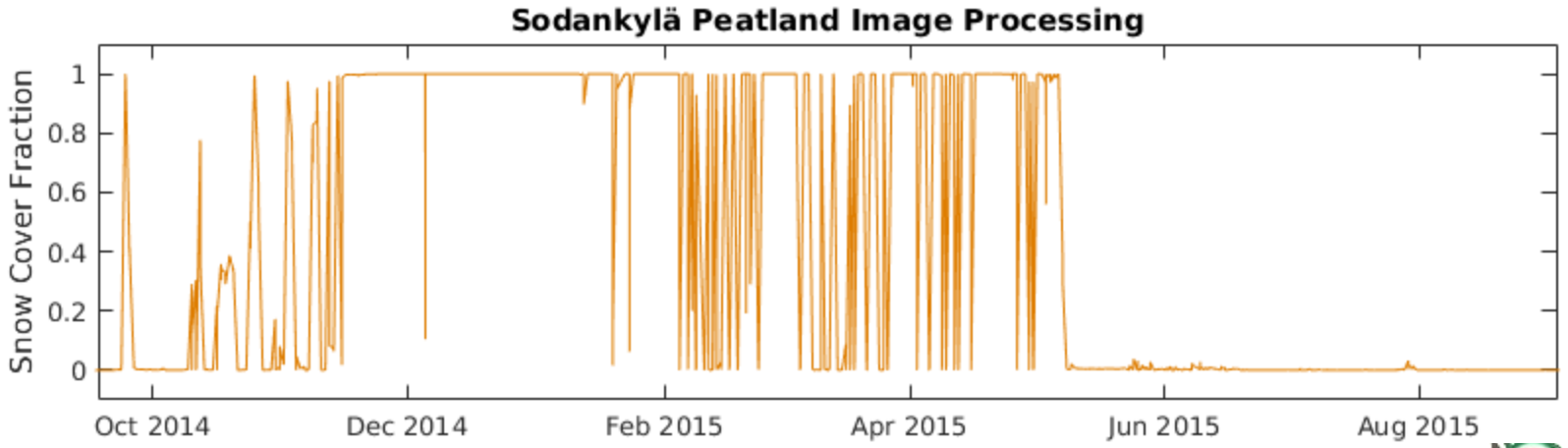


ROI

Snow cover fraction analyses

Sodankylä Peatland Camera





Ground data by FMI, litdb.fmi.fi

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Snow cover fraction analyses

Sodankylä Ground Camera

Camera Location:

67.36201° N, 26.63751° E

Images between dates:

23.05.2014 – 29.01.2017

Images between time of day:

10:45 – 12:45

Number of images:

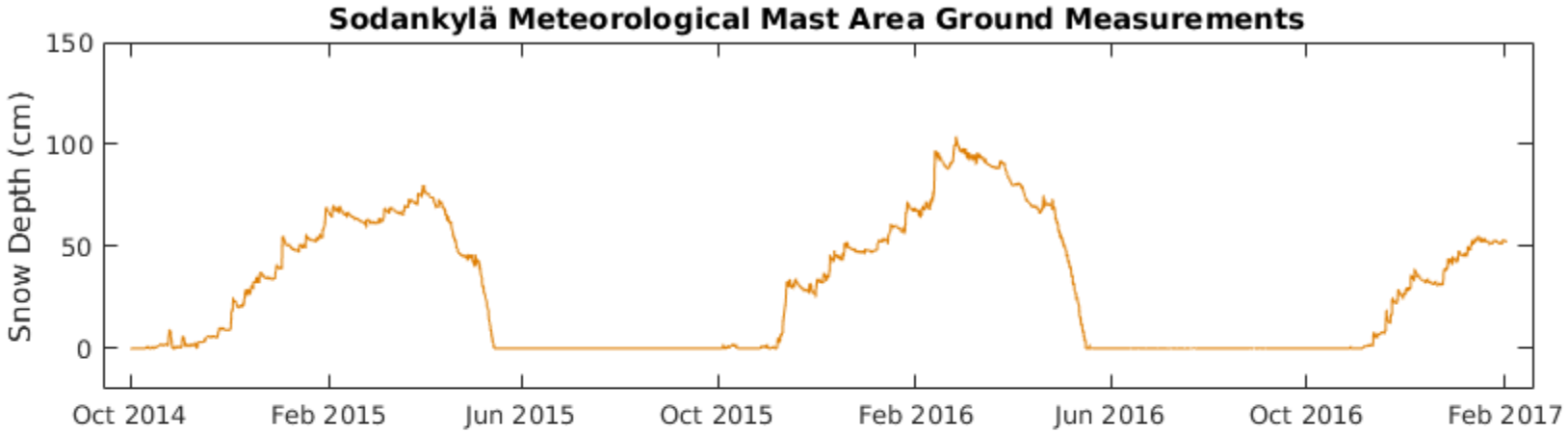
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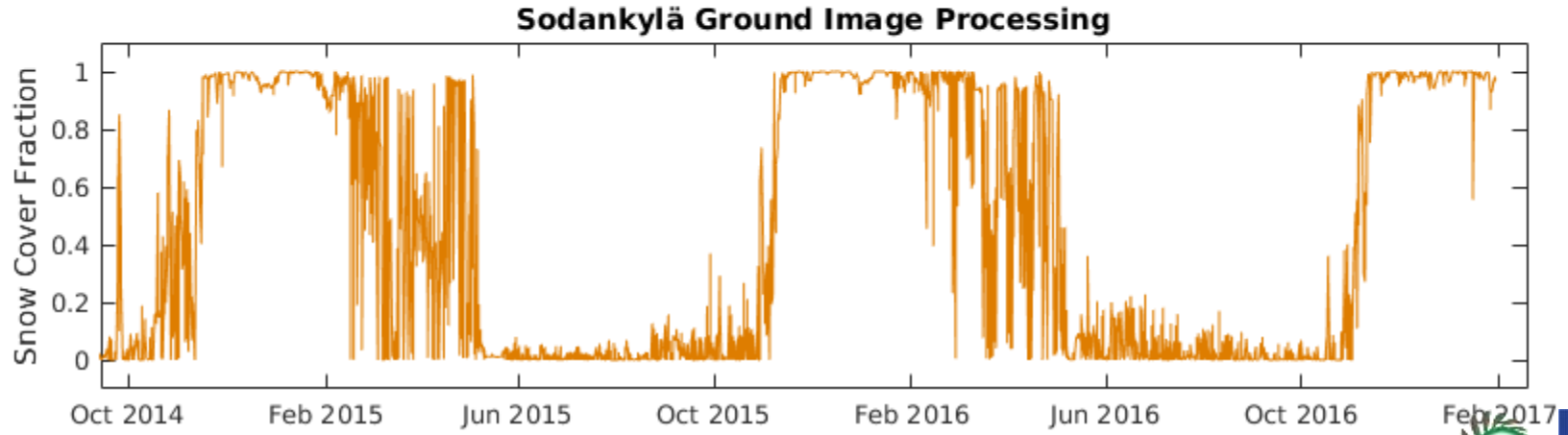


ROI

Snow cover fraction analyses

Sodankylä Ground Camera





Ground data by FMI, litdb.fmi.fi

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Snow cover fraction analyses

Kenttärova Canopy Camera

Camera Location:

67.98726° N, 24.24302° E

Images between dates:

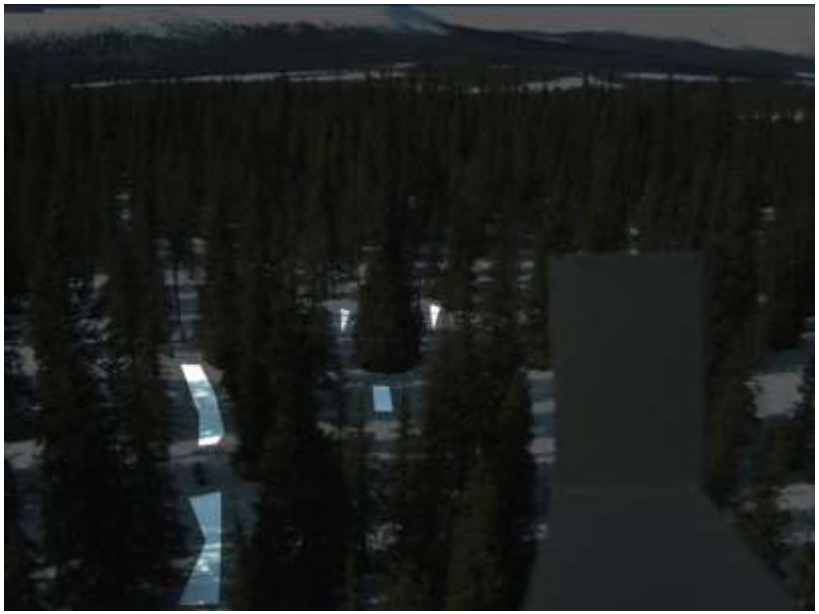
07.04.2015 – 29.01.2017

Images between time of day:

10:45 – 12:45

Number of images:

2592



ROI

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Snow cover fraction analyses

Kenttärova Ground Camera

Camera Location:

67.98726° N, 24.24302° E

Images between dates:

07.04.2015 – 29.01.2017

Images between time of day:

10:45 – 12:45

Number of images:

2579

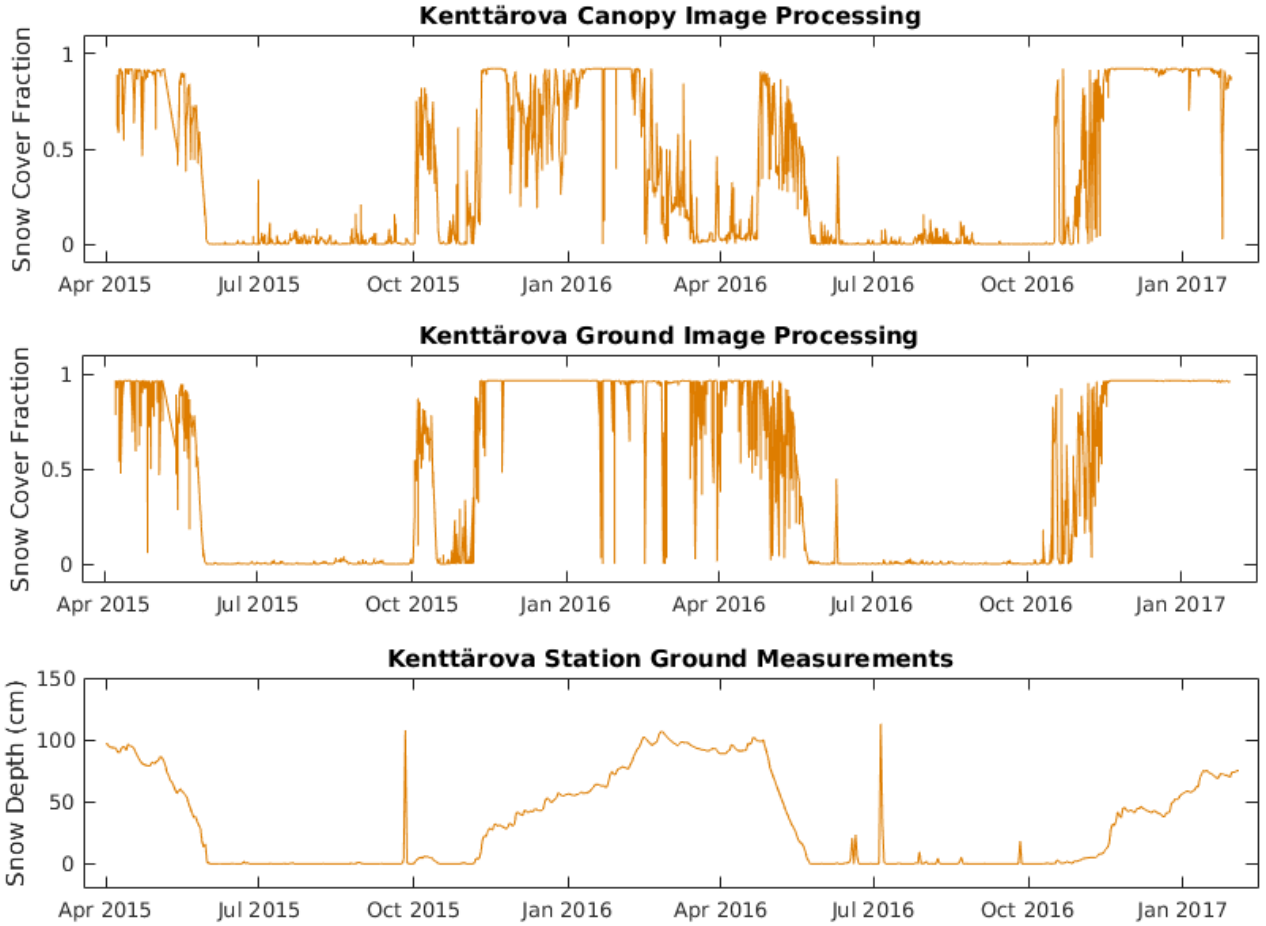


ROI

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Snow cover fraction analyses

Kenttärova Cameras



Ground data by FMI, fmi.fi


SNOW ON REFERENCE PLATE


SNOW ON REFERENCE PLATE


FMIPROT is available at
http://monimet.fmi.fi/?page=FMIPROT
LifeMonimet
LIFE12 ENV/FI/000409