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
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.
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
MONIMET Camera Network

- 14 Locations
- 28 Cameras
- Wired (ethernet) or wireless (3G/GPRS) connection to the cameras
- Data access by FTP
MONIMET Camera Network
Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)

A toolbox which,

• 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

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
Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)
Finnish Meteorological Institute Image Processing Toolbox (FMIPROT)

Setup

Scenario 1
- Analysis 1
- Analysis 2

Scenario 2
- Analysis 1
- Analysis 2
- Analysis 3

Scenario 3
- Analysis 1

Setup file
Features – Scenarios – Camera
Features – Scenarios – Temporal Filtering
Features – Scenarios – Thresholds
Features – Scenarios - Masking
Features – Scenarios – Analyses
Features – Previewing output data
Features – Plugins
If the code of an algorithm can be compiled to binary, it can be used as a plugin

FMIPROT Plugins Directory

myplugin

myplugin.exe  myplugin  myplugin.def  Auxiliary file(s)  Auxiliary directory(s)
Snow cover fraction algorithm
Snow covered pixel detection algorithm by Salvatori et al. (2011)

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.**

Snow cover fraction algorithm

Snow cover fraction algorithm

Change from world to camera coordinate system.

Simplified geometry of the perspective projection for one single point.

Snow cover fraction algorithm

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

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

# Snow cover fraction algorithm

<table>
<thead>
<tr>
<th>Time</th>
<th>Image 1</th>
<th>Image 2</th>
</tr>
</thead>
<tbody>
<tr>
<td>2015.05.17 12:01:39</td>
<td><img src="image1" alt="Image 1" /></td>
<td><img src="image2" alt="Image 2" /></td>
</tr>
<tr>
<td>FSC (%) (ROI 1 – ROI 2)</td>
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<td>2</td>
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<table>
<thead>
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<th>Time</th>
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<th>Time</th>
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<tbody>
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<td>2014.10.23 12:01:38</td>
<td><img src="image1" alt="Image 1" /></td>
<td><img src="image2" alt="Image 2" /></td>
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<tr>
<td>FSC (%) (ROI 1 – ROI 2)</td>
<td>23</td>
<td>28</td>
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<thead>
<tr>
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<tbody>
<tr>
<td>2015.05.09 13:01:39</td>
<td><img src="image1" alt="Image 1" /></td>
<td><img src="image2" alt="Image 2" /></td>
</tr>
<tr>
<td>FSC (%) (ROI 1 – ROI 2)</td>
<td>28</td>
<td>0</td>
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# Snow cover fraction algorithm

<table>
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<tr>
<th>Image</th>
<th>Time</th>
<th>FSC (%) (ROI 1 – ROI 2)</th>
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</thead>
<tbody>
<tr>
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<td>2015.10.04 12:01:38</td>
<td>63</td>
</tr>
<tr>
<td></td>
<td>2015.05.07 11:01:35</td>
<td>66</td>
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<tr>
<td></td>
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<table>
<thead>
<tr>
<th>Image</th>
<th>Time</th>
<th>FSC (%) (ROI 1 – ROI 2)</th>
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</thead>
<tbody>
<tr>
<td></td>
<td>2015.04.18 12:31:38</td>
<td>75</td>
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<tr>
<td></td>
<td>2015.05.02 12:01:38</td>
<td>90</td>
</tr>
<tr>
<td></td>
<td></td>
<td>80</td>
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<tr>
<td></td>
<td></td>
<td>74</td>
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</table>
Snow cover fraction algorithm

<table>
<thead>
<tr>
<th>Image</th>
<th>Time 1</th>
<th>Time 2</th>
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</thead>
<tbody>
<tr>
<td>FSC (%) (ROI 1 – ROI 2)</td>
<td>90</td>
<td>88</td>
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</table>
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
Snow cover fraction analyses
Sodankylä Peatland Camera

Sodankylä Peatland Ground Measurements

Sodankylä Peatland Image Processing

Ground data by FMI, litudb.fmi.fi
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:
3836

ROI
Snow cover fraction analyses
Sodankylä Ground Camera

Ground data by FMI, liltdb.fmi.fi
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
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
Snow cover fraction analyses
Kenttärova Cameras

Kenttärova Canopy Image Processing

Snow Cover Fraction


Kenttärova Ground Image Processing

Snow Cover Fraction


Kenttärova Station Ground Measurements

Snow Depth (cm)


Ground data by FMI, fmi.fi
SNOW ON REFERENCE PLATE
SNOW ON REFERENCE PLATE
FMIPROT is available at
http://monimet.fmi.fi/?page=FMIPROT