Using ground based high resolution photography for seasonal snow and ice dynamics (Austre Lovénbreen, Svalbard, 79°N)

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Most of arctic alpine type glaciers are located in Western Spitsbergen.
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Austre Lovénbreen, the studied glacier is one of the many alpine type glacier (Brøgger peninsula, 79°N)
Surveying the glacial basin is important to understand past, present and future changes.
Six automatic photo stations
Automatic photo station network
Monitoring of the glacier basin

In situ acquisition 3 photos / day  (time resolution)
Camera sensor at 10 Mpixels  (spatial resolution)

6570 photos/year
the 6500 photos per year have to be sorted out
(mathematical process and human post analysis)

Oblique views provide a qualitative information on daily glacier evolution.

In order to extract quantitative information, these images must be projected.

but no reference point on the glacier
Data processing: geometrical correction

GPS markers

orange flags are positioned on the whole glacier surface

GPS position recorded for each flag
Data processing: geometrical correction

GPS position recovery and projection

GIS
Data processing: geometrical correction

Recovery of the visible flags
Operation depends both on software and a good knowledge of the field
Data processing: geometrical correction

Additional control points on the slopes

Ground-based camera picture
Space-borne satellite image

22 Jul. 2009
Data processing: geometrical correction

Projected control points
Data processing: geometrical correction

Delaunay interpolation triangle (TIN)
Data processing: geometrical correction

Latitude and longitude simulation
Data processing: geometrical correction

Example of 5th of July 2009

- Camera position
- Formosat image
- Projected photo
- Hidden zone
Data processing: geometrical correction

Combination of images from 5 cameras
Data processing: geometrical correction

Combination of images from 5 cameras
Data processing: snowcover interpretation

Accurate mosaics for accurate snow mapping
Data processing: snowcover interpretation

An example for the 2009 melting season

Starting in early July

Finishing at the end of August
Data processing: snowcover interpretation

We can expect about 60 mosaics for the melting season

Quantitative analysis of mosaic images: identify snow covered area

Objective: feed the melt coefficient value of a day-degree model (insufficient time resolution of satellite images)
Data processing: snowcover interpretation

« contact sheets » to select pictures
Data processing: snowcover interpretation

After selecting images, mosaics are assembled

Jul. 28th

77.23 %

3.52 km²
Aug. 1st

73.16%  
3.32 km²
Data processing: snowcover interpretation

Aug. 11th

47.76 %
2.16 km²
Data processing: snowcover interpretation

Aug. 19th

44.08%
1.99 km²
Data processing: snowcover interpretation

Aug. 23th

37.53 %

1.71 km²
Data processing: snowcover interpretation

Only a subset of daily images is needed for quantitative analysis
Data processing: snowcover interpretation

4 to 22 Jul

28 Jul to 01 Aug

03 Aug to 07 Aug

11 Aug to 23 Aug

100 %

37 %
Data processing: snowcover interpretation

Only a few significant events although we have daily information
Data processing: snowcover interpretation

Snowcovered area (%)
Conclusion: next step
Hydrological process

Daily / hourly thermic state
weq melt = $\Delta T \times k, \Delta T > 0$

Conclusion: next step
 Hydrological process

$k_{\text{snow}} \neq k_{\text{ice}}$

Snow / ice discretization from mosaïc of projected in situ images

Mean daily air temperature
IDW interpolate map
Conclusion

This original approach allows to have an accurate monitoring of snowcover dynamics and its participation in the hydrological process:
- identification of geolocated control points
- geometrical correction of images
- assembling mosaics
- manual identification of the snow/ice boundary
- calculation of the snow covered area fraction

Perspective

It is now possible to estimate snow melt, and hence the water equivalent thickness for each pixel, in order to define the fraction of ice and snow melt in the hydrological budgets during the melting season.

The next step is now to have a comparative approach with the hydrological measurements downstream to better understand the dynamics of the hydrosystem.
THANKS FOR YOUR ATTENTION
Data processing: snowcover interpretation

4 to 22 jul

100 %
Data processing: snowcover interpretation

4 to 22 Jul

28 Jul to 01 Aug