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

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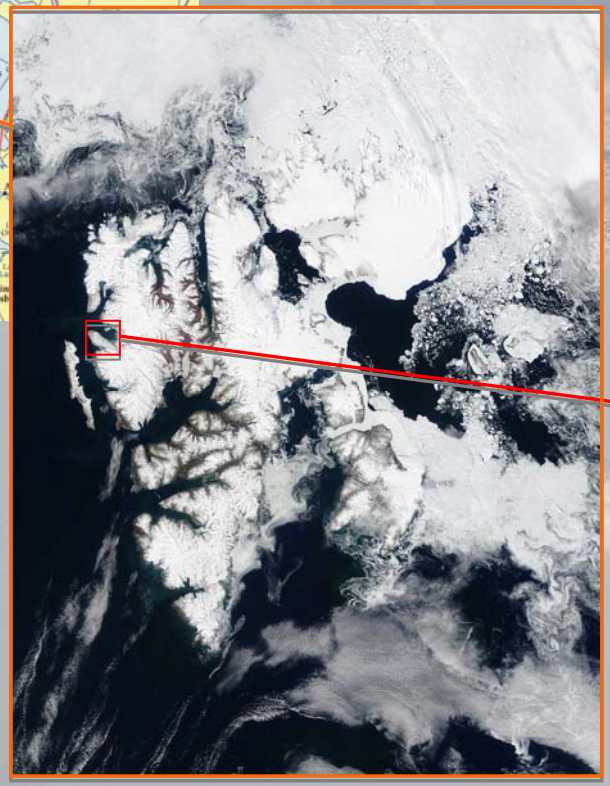
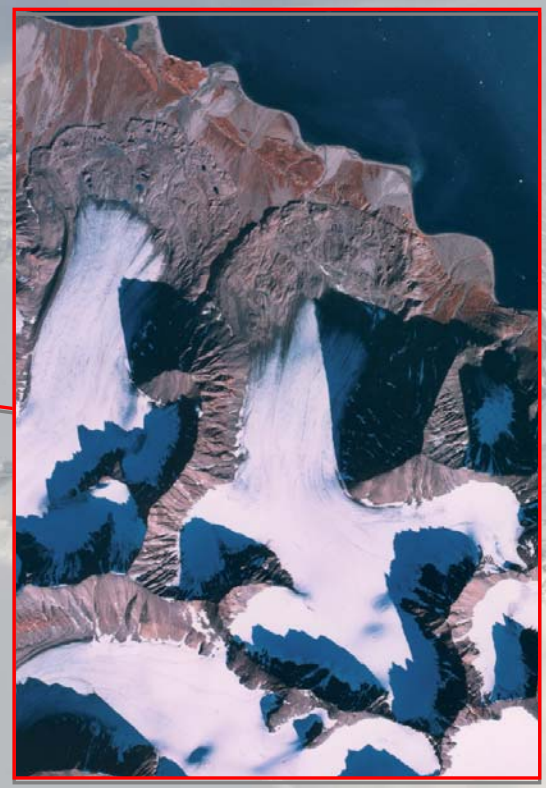
Most of arctic alpine type glaciers are located in Western Spitsbergen.

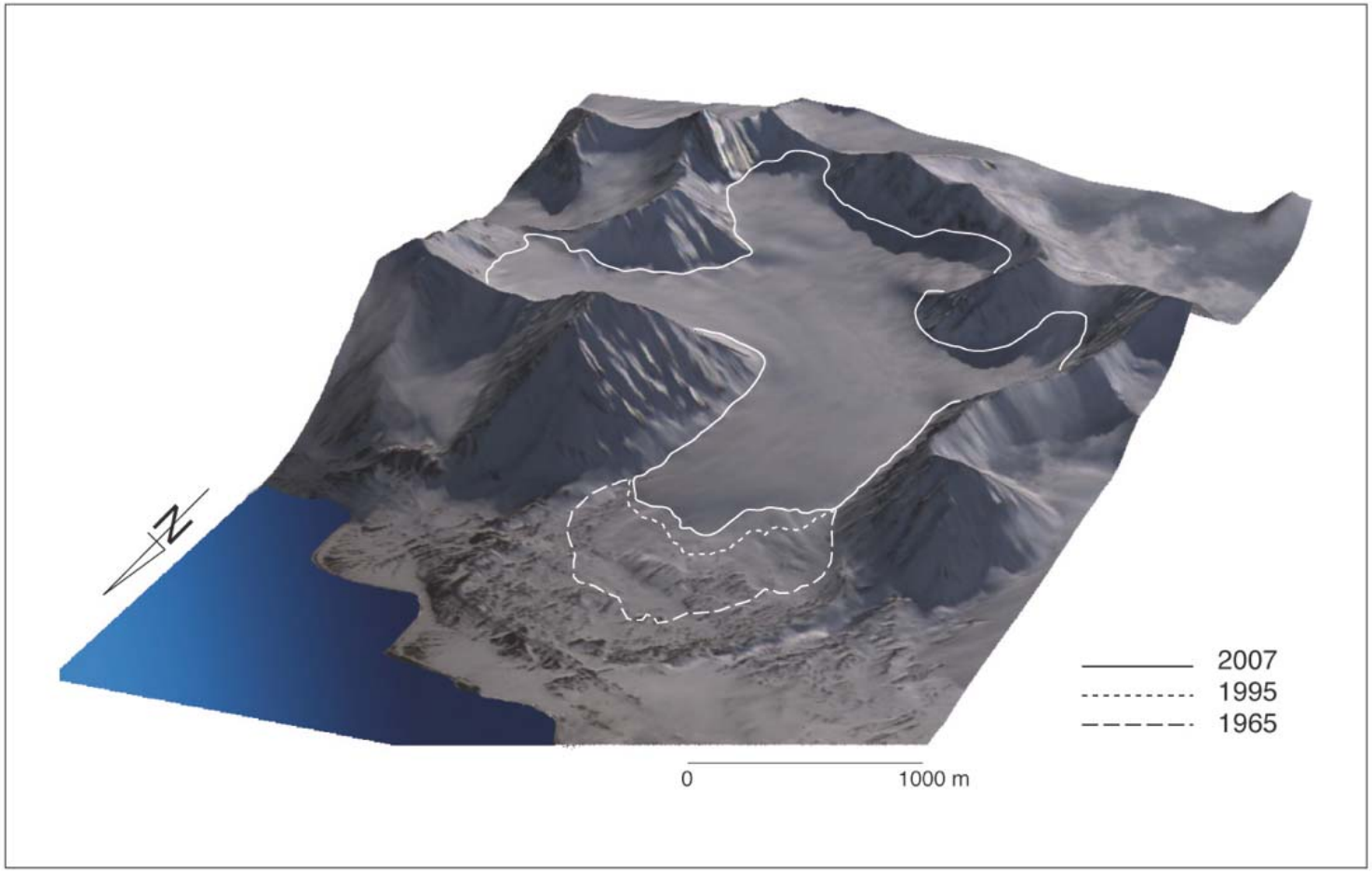
Austre Lovénbreen, the studied glacier is one of the many alpine type glacier
(Brøgger peninsula, 79°N)

Most of arctic alpine type glaciers are located in Western Spitsbergen.





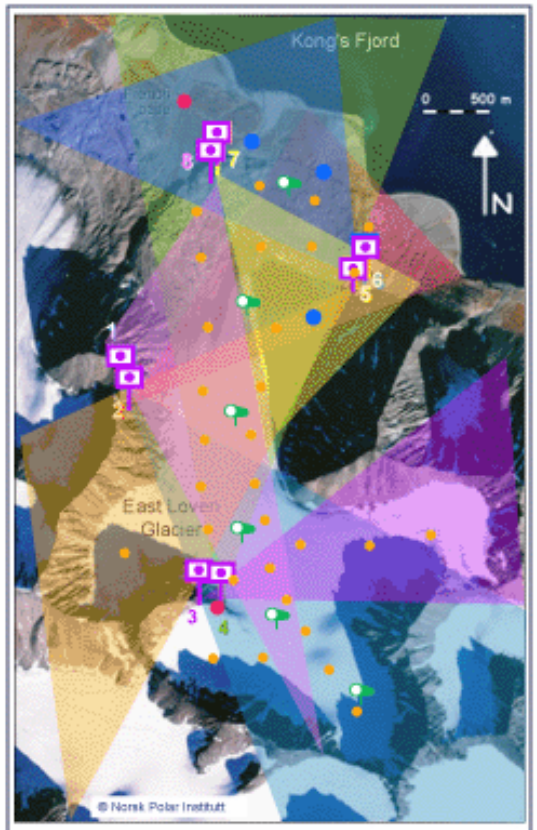
3D glacier basin



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

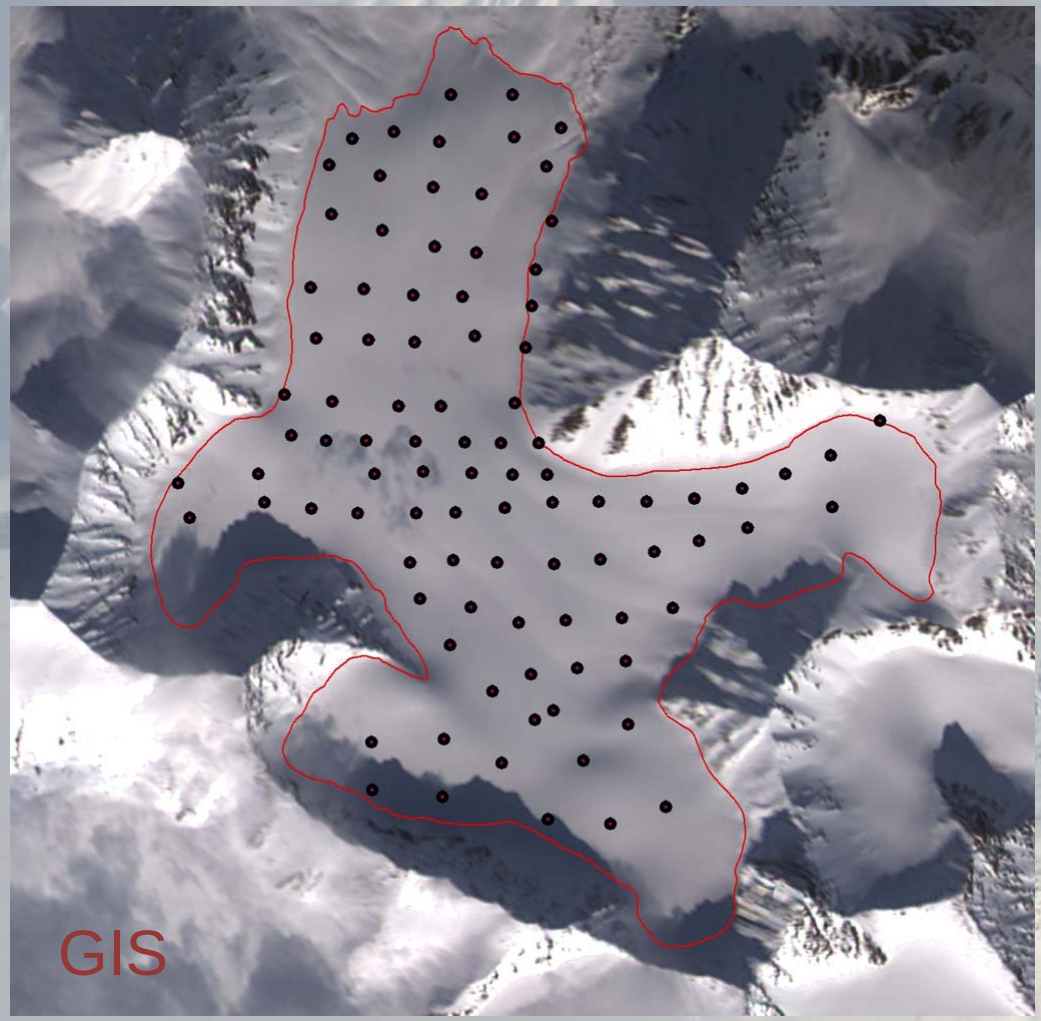
GPS markers

orange flags are positioned on the whole glacier surface

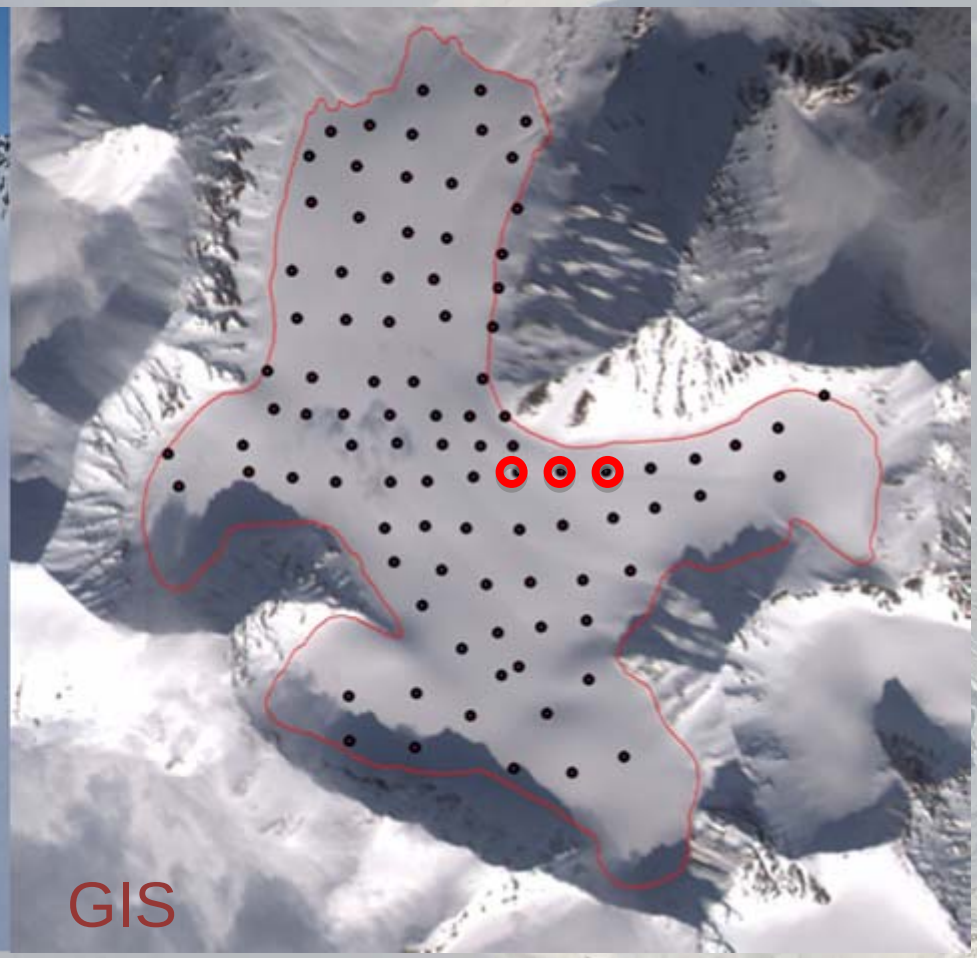
GPS position recorded for each flag

Data processing: geometrical correction

GPS position recovery and projection



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

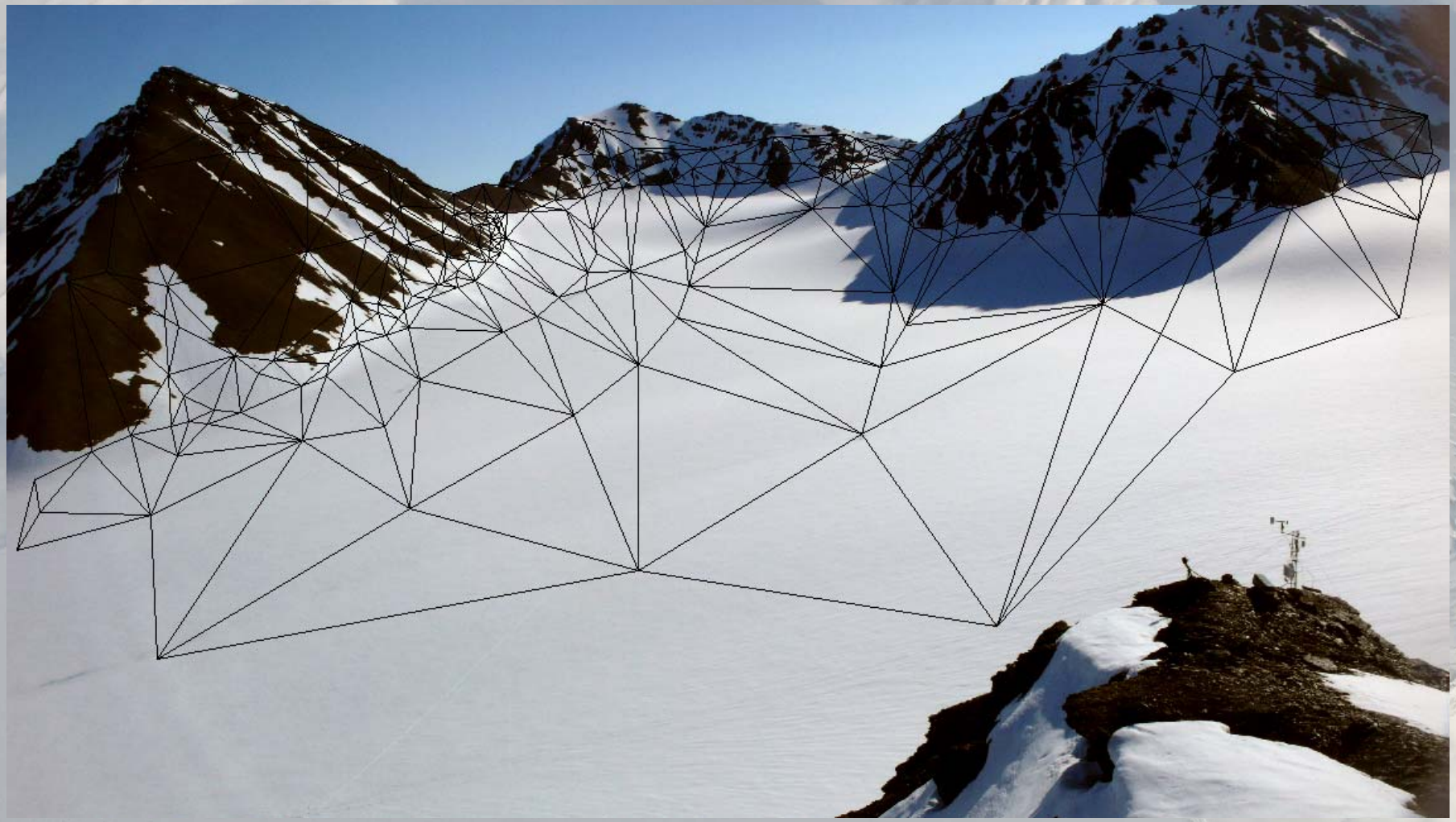
22 Jul. 2009

Data processing: geometrical correction

Projected control points

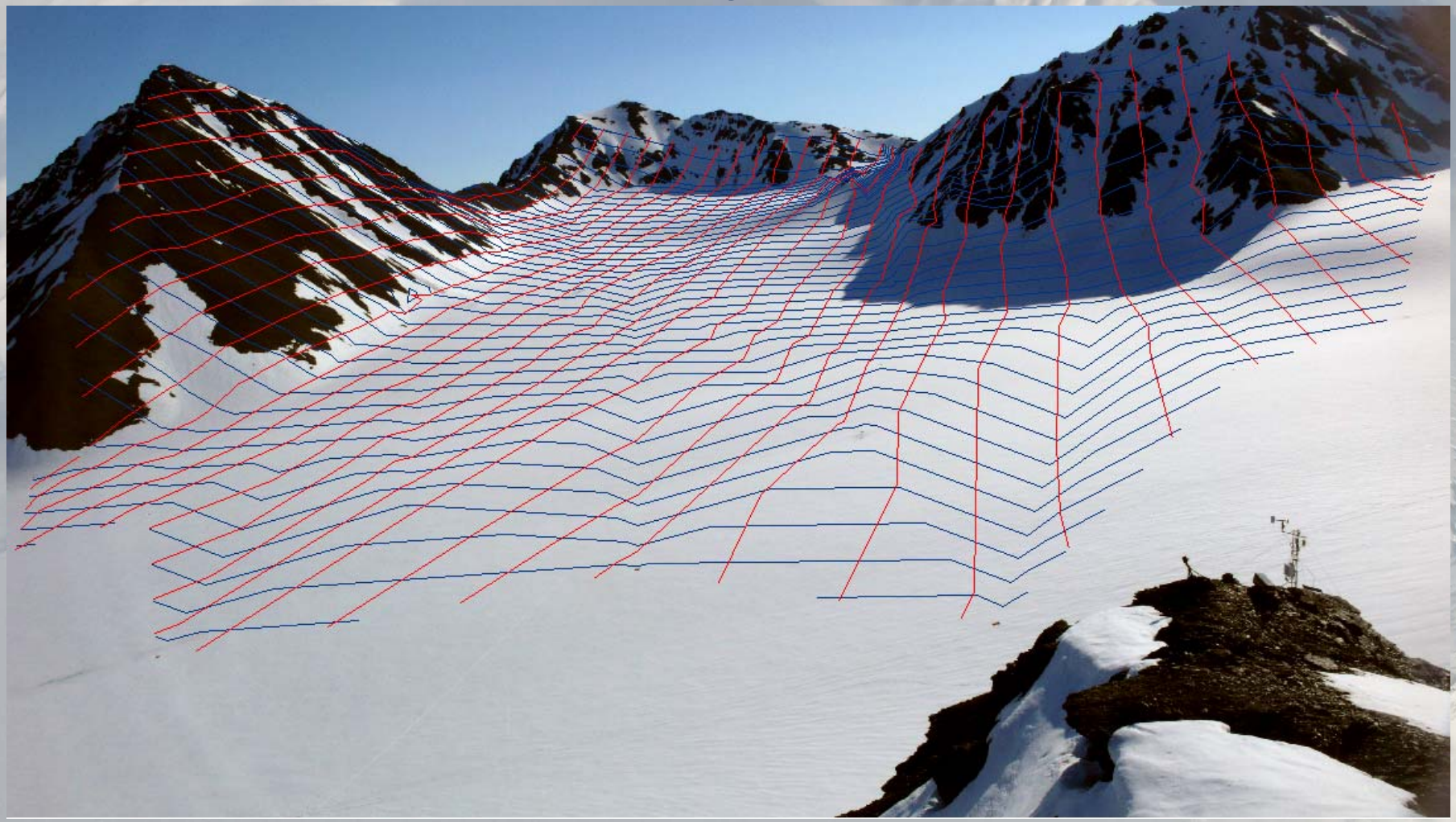
Data processing: geometrical correction

Delaunay interpolation triangle (TIN)



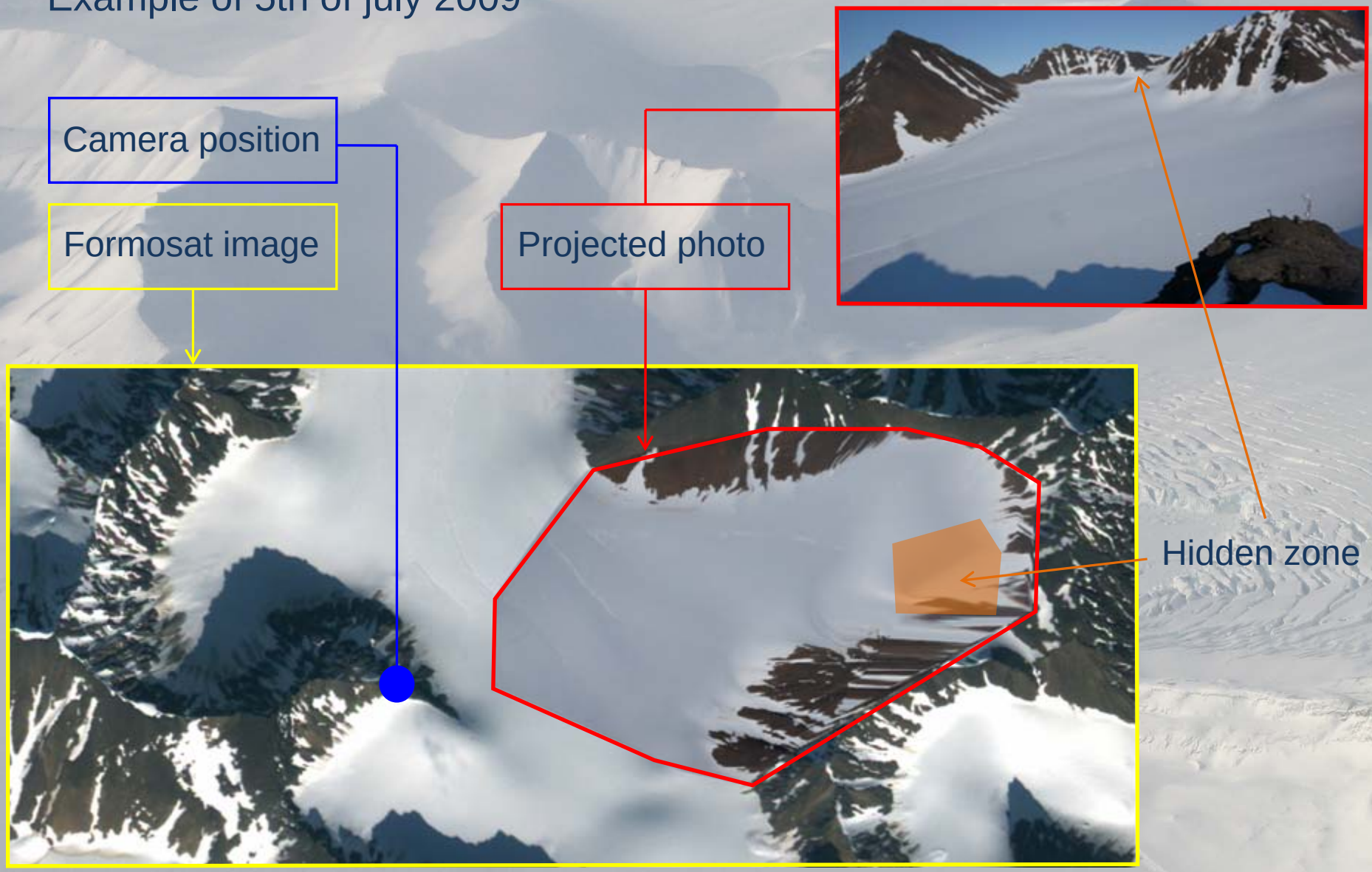
Data processing: geometrical correction

Latitude and longitude simulation



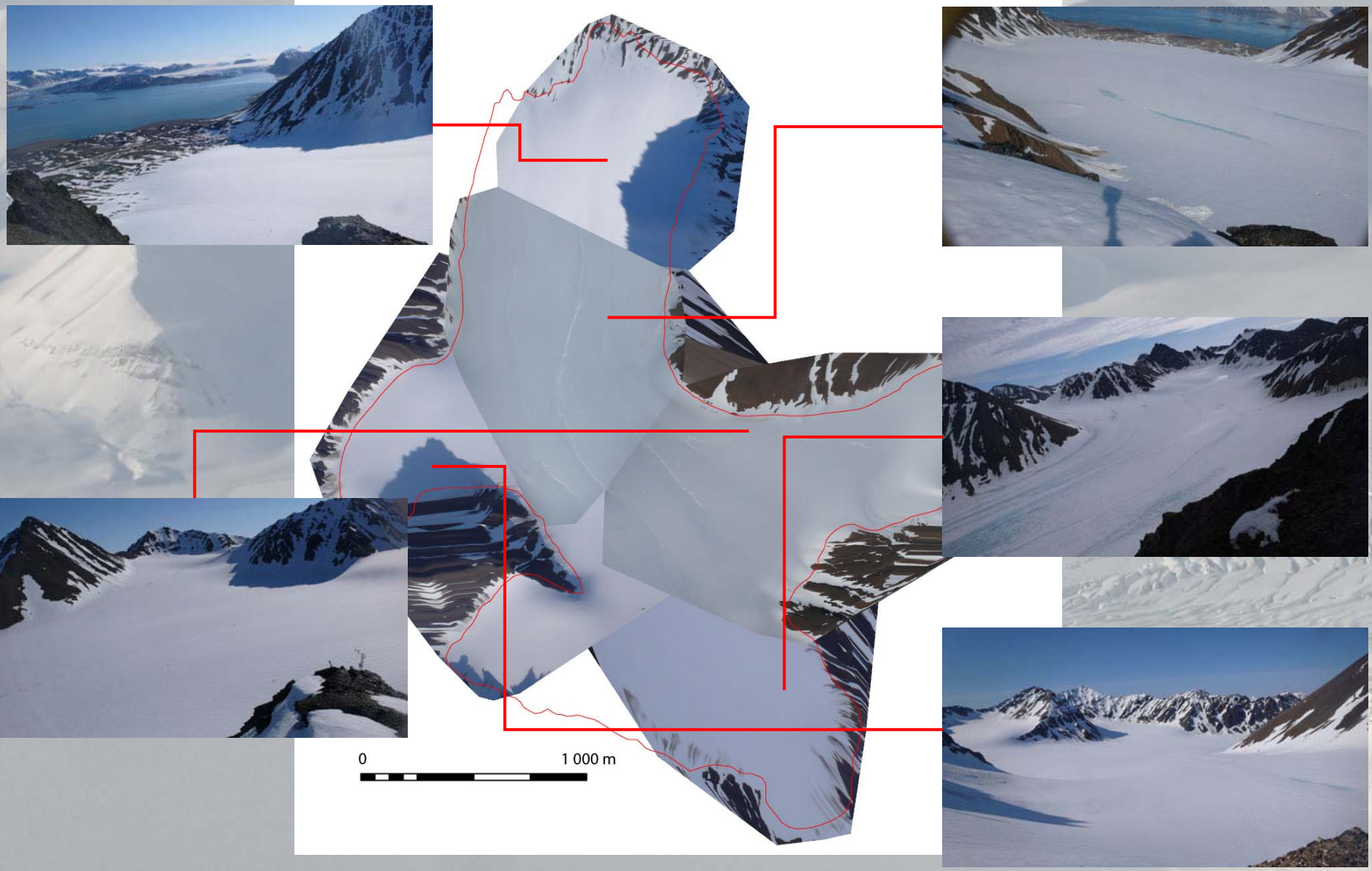
Data processing: geometrical correction

Example of 5th of july 2009



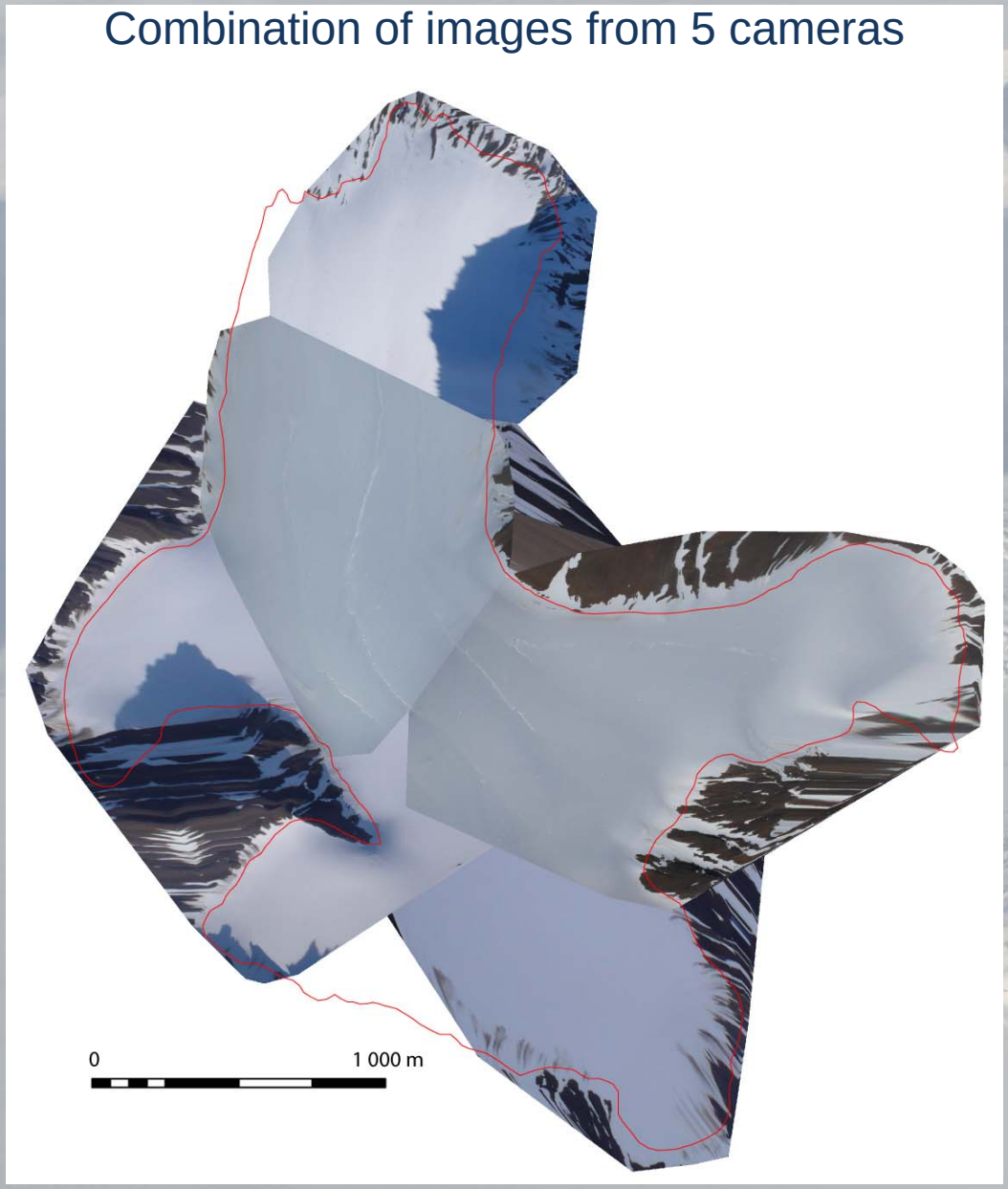
Data processing: geometrical correction

Combination of images from 5 cameras

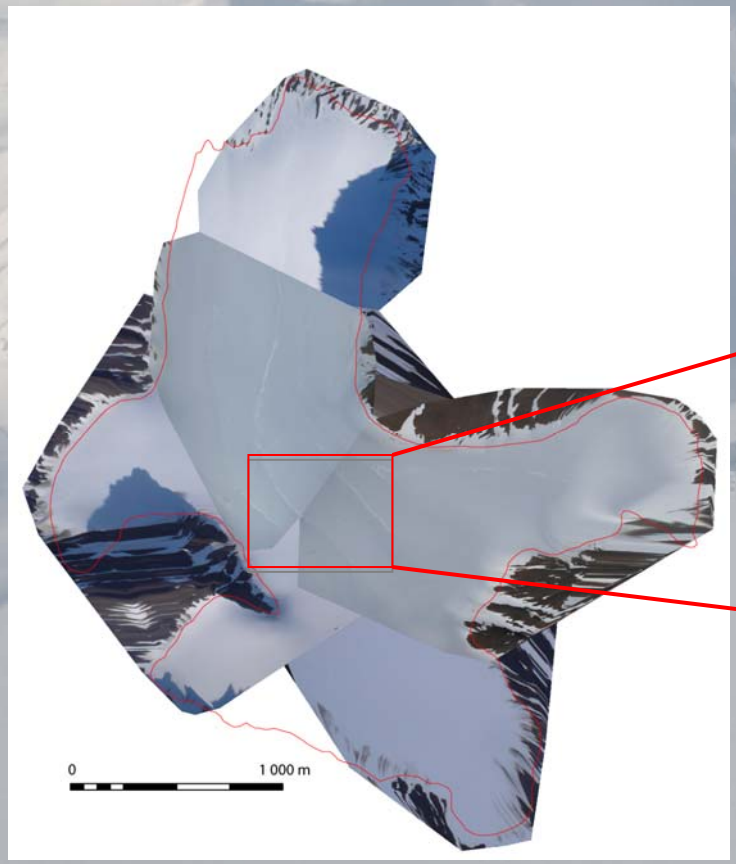


Data processing: geometrical correction

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

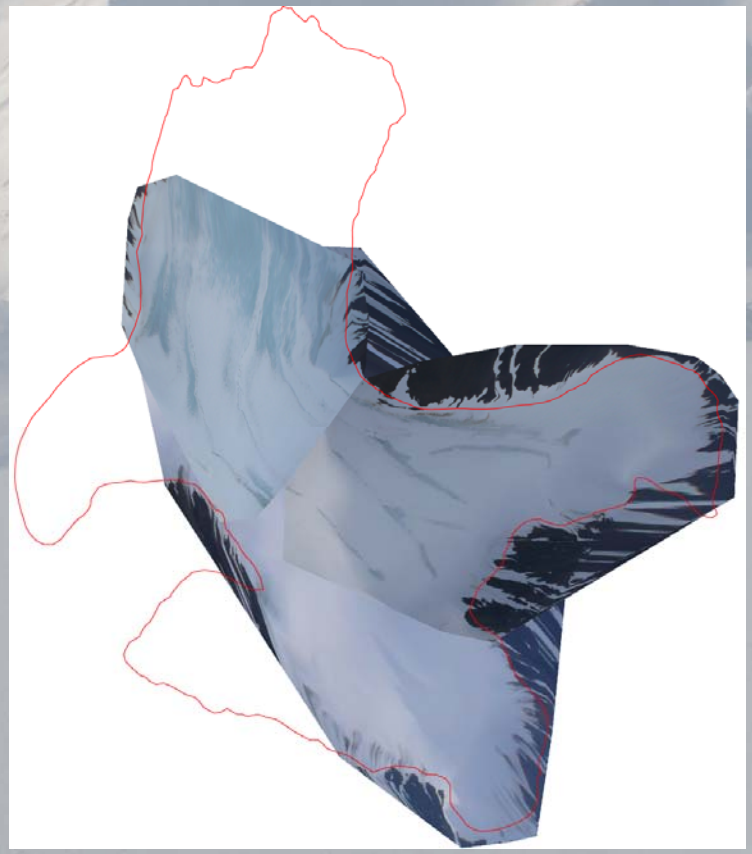
Data processing: snowcover interpretation

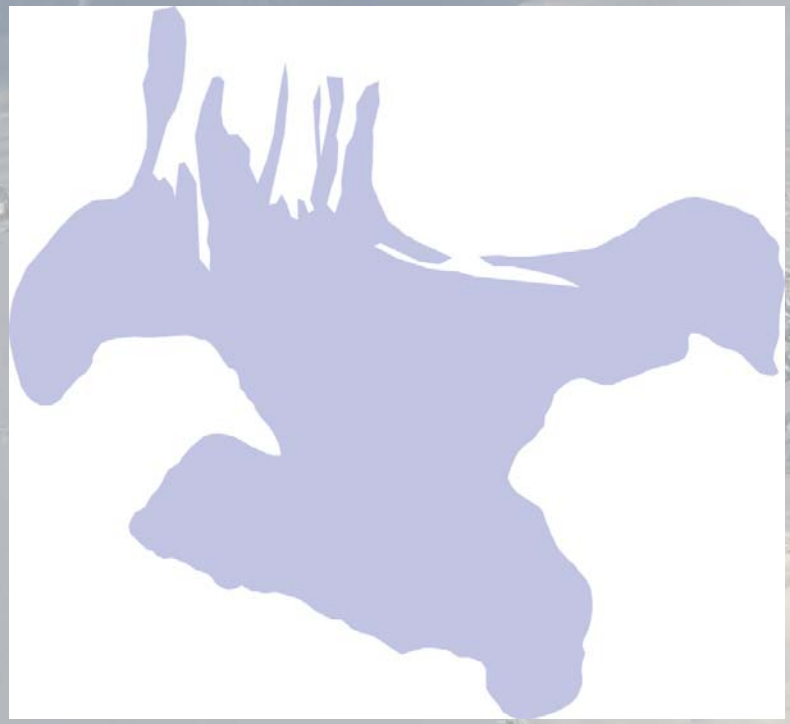
After selecting images, mosaics are assembled

Jul. 28th

77,23 %

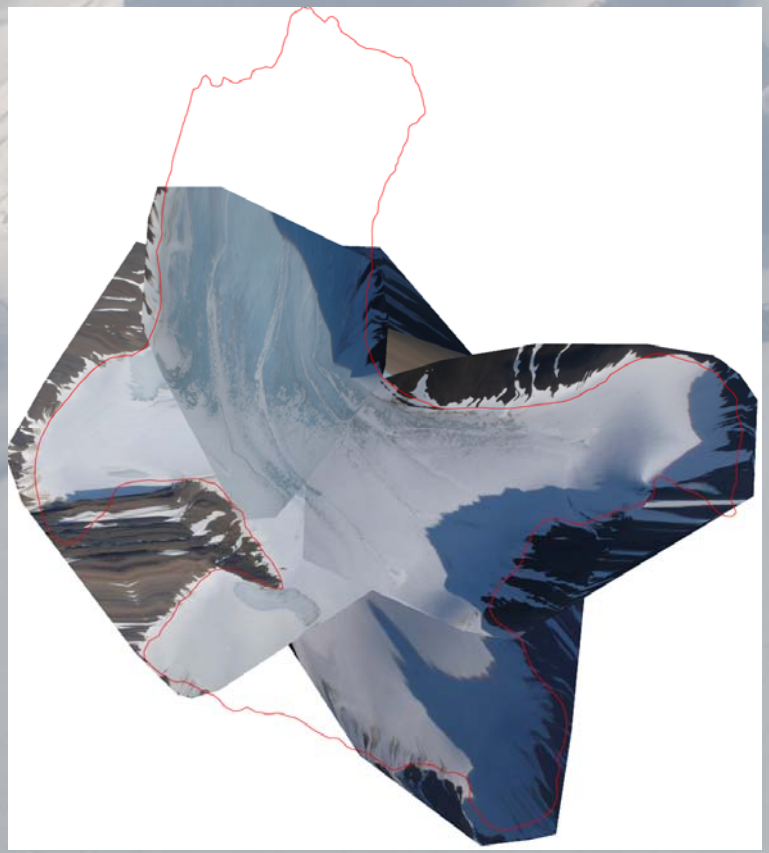
3,52 km^2





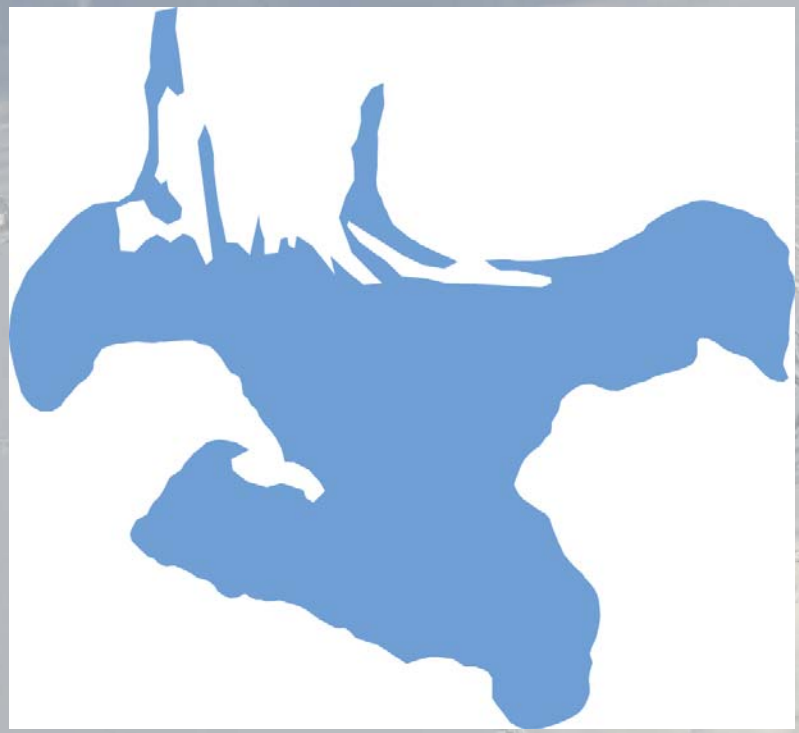
Data processing: snowcover interpretation

Aug. 1st



73,16 %

3,32 km^2

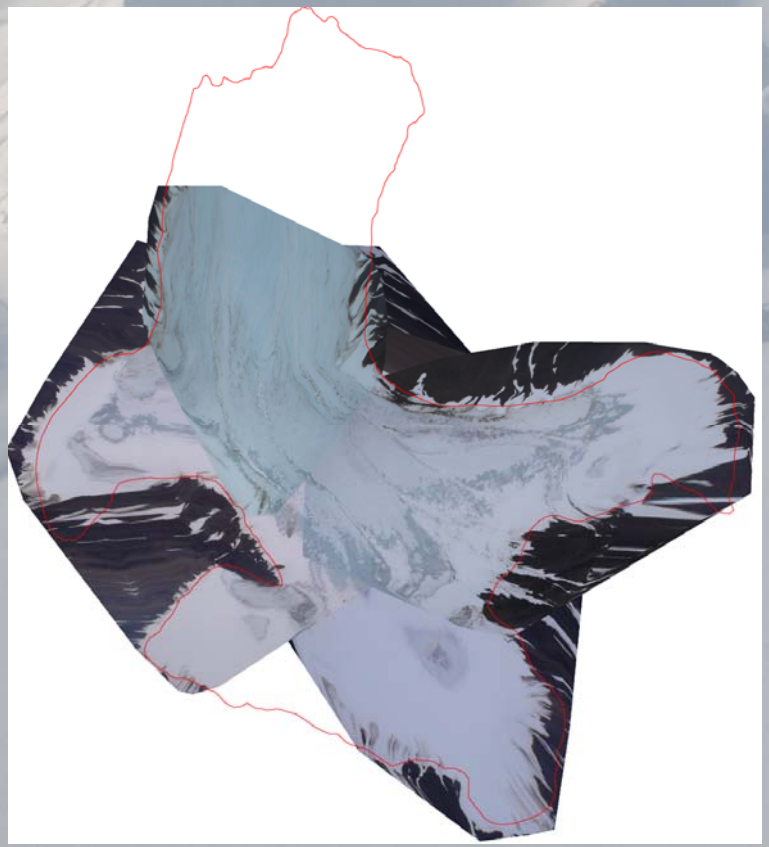


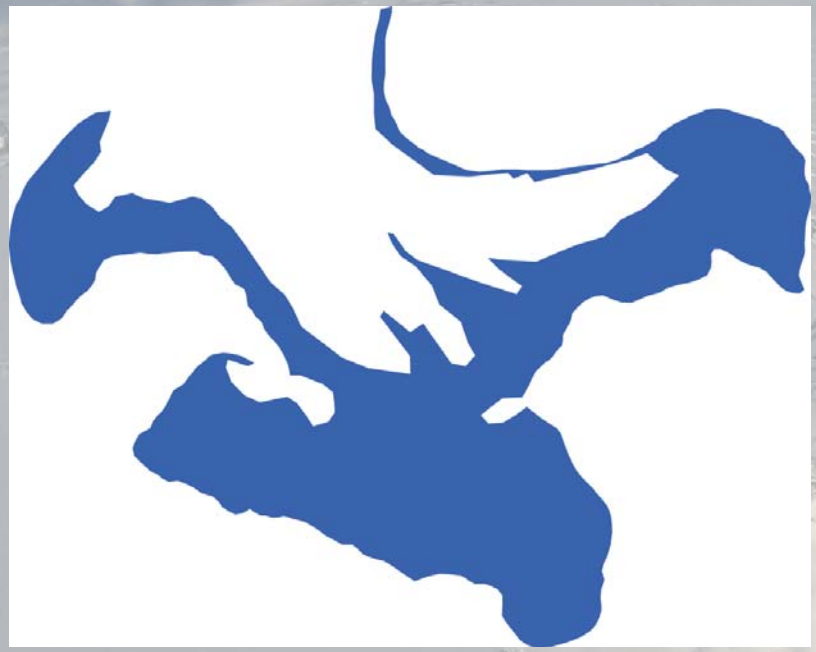
Data processing: snowcover interpretation

Aug. 11th

47,76 %

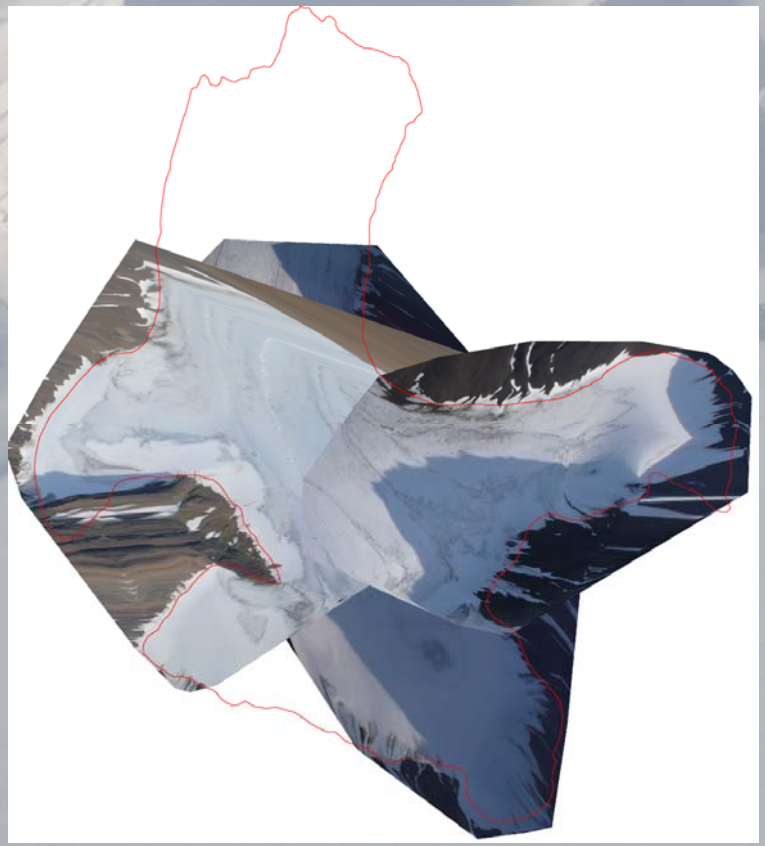
2,16 km^2





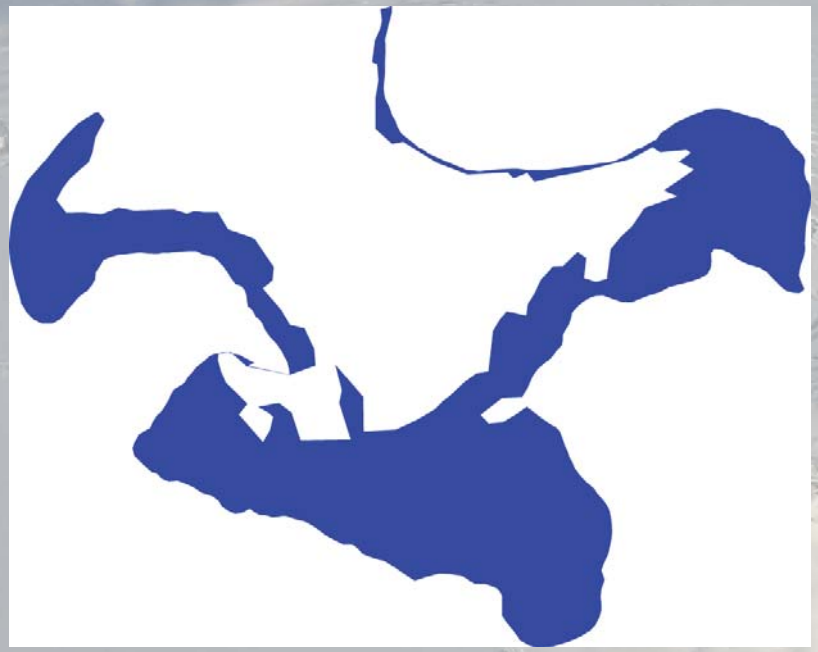
Data processing: snowcover interpretation

Aug. 19th



44,08%

1,99 km^2



Data processing: snowcover interpretation

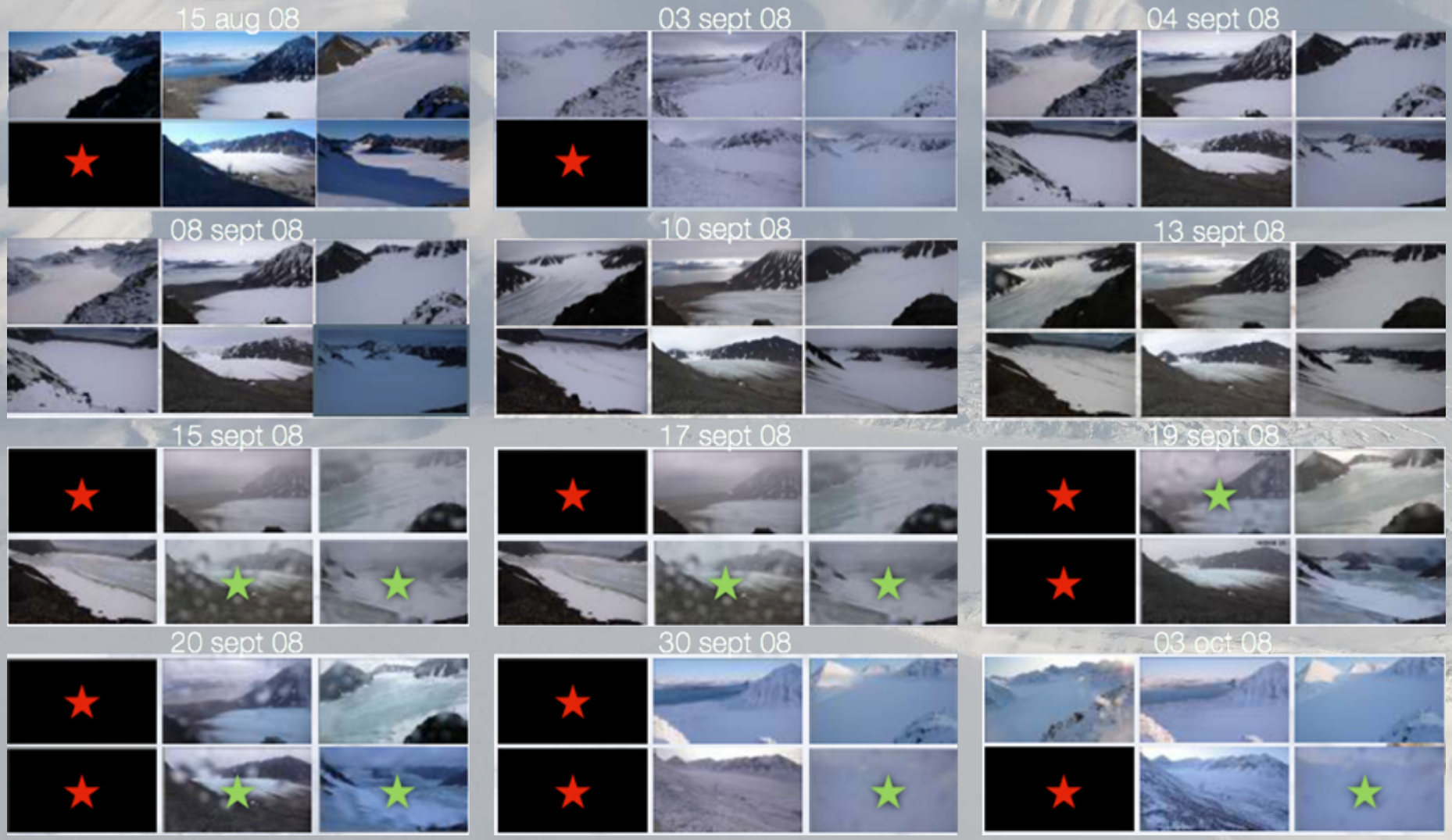
Aug. 23th

37,53 %

1,71 km^2

Data processing: snowcover interpretation

Only a subset of daily images is needed for quantitative analysis



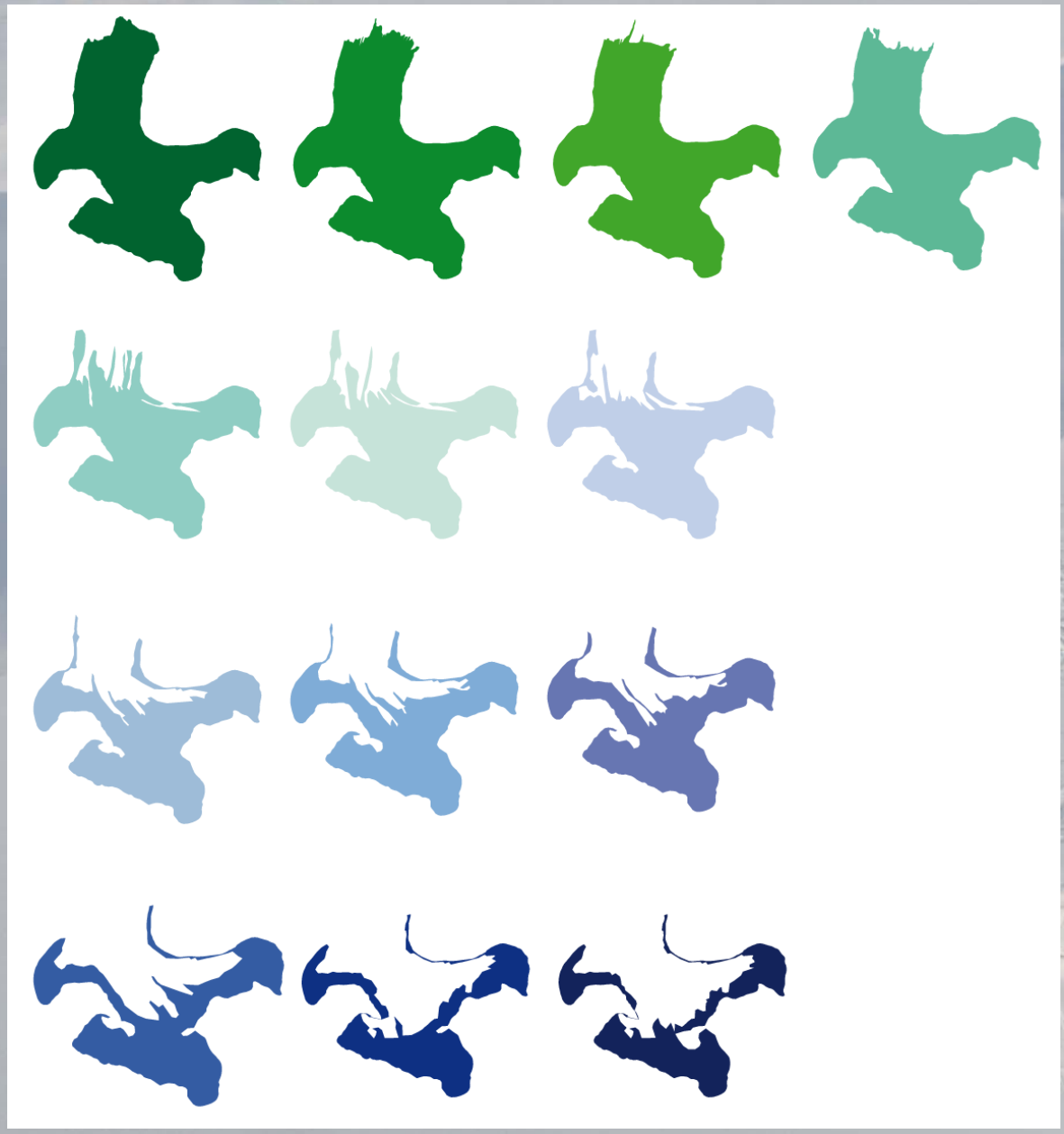
Data processing: snowcover interpretation

4 to 22 jul

28 jul to
01 aug

03 aug to
07 aug

11 aug to
23 aug

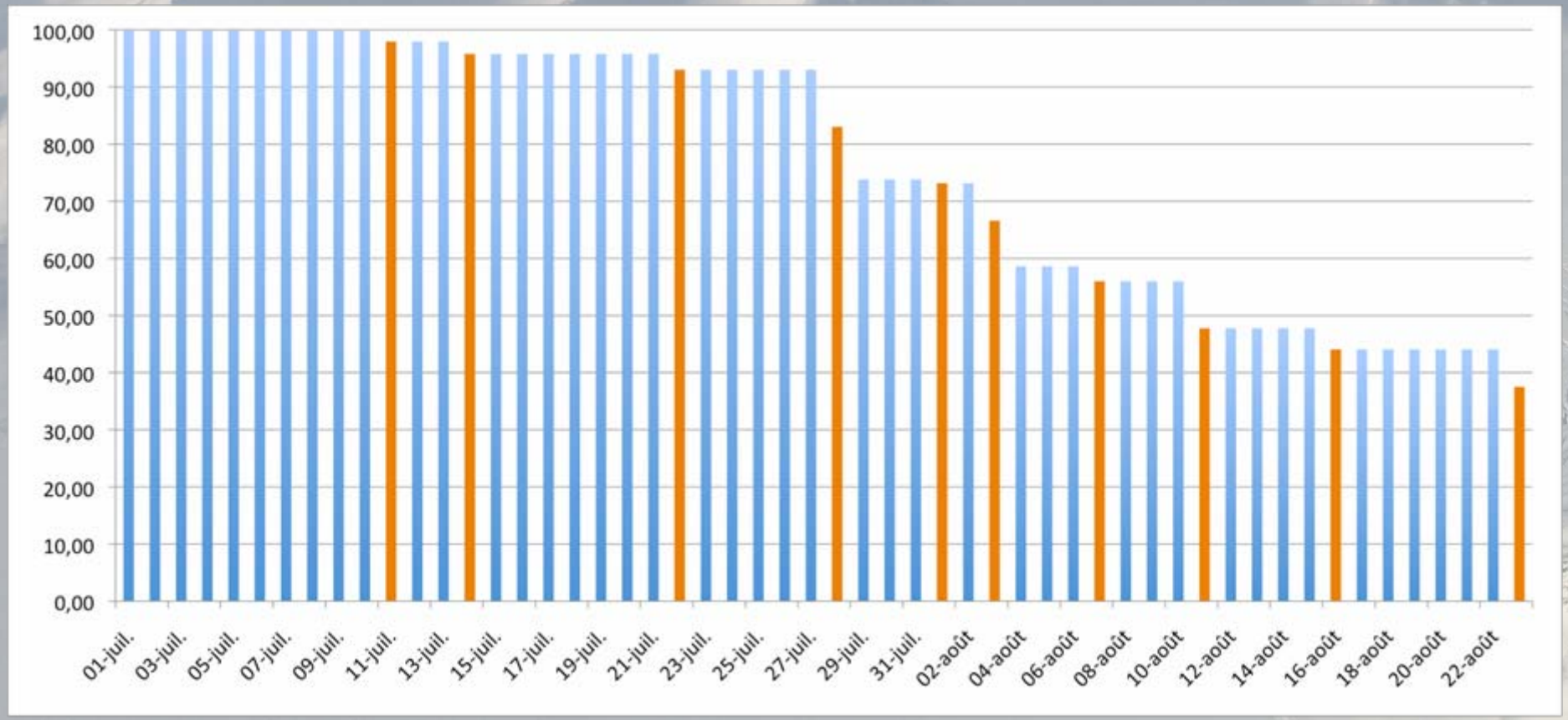


100 %

37 %

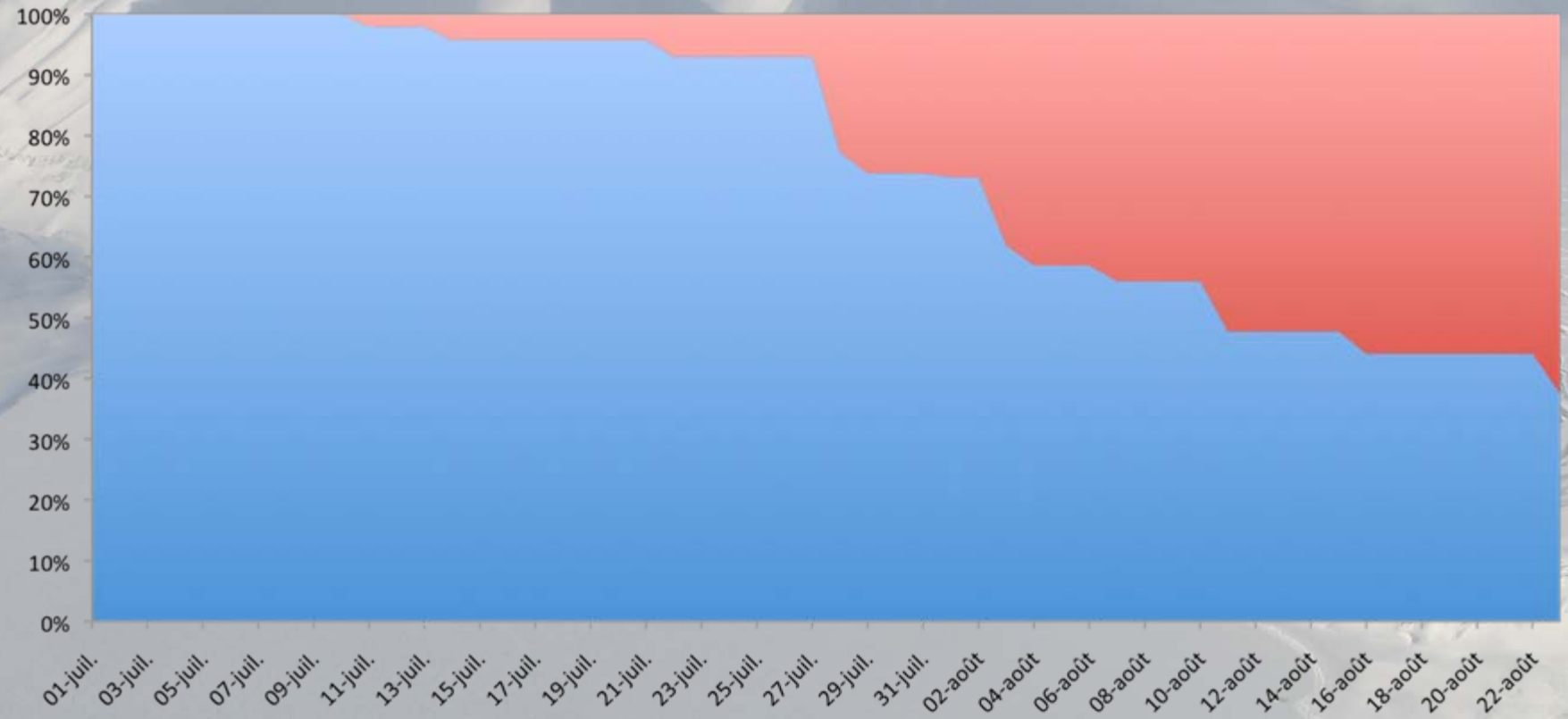
Data processing: snowcover interpretation

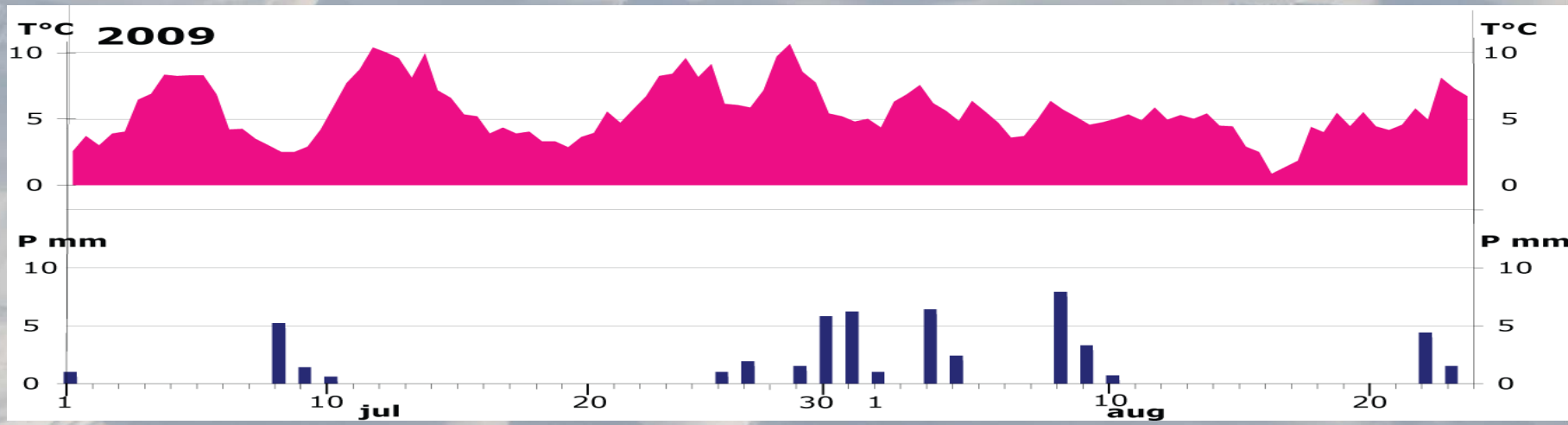
Only a few significant events although we have daily information

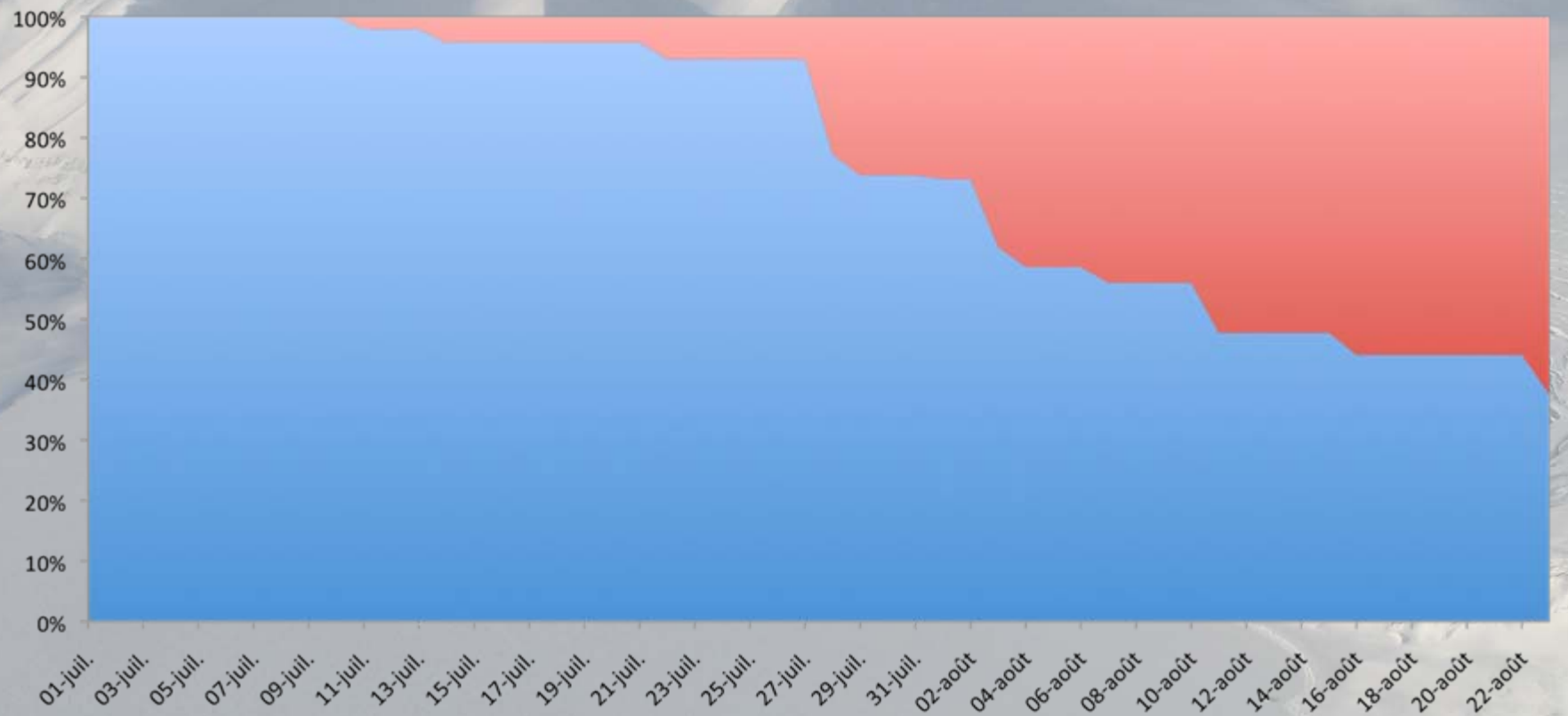


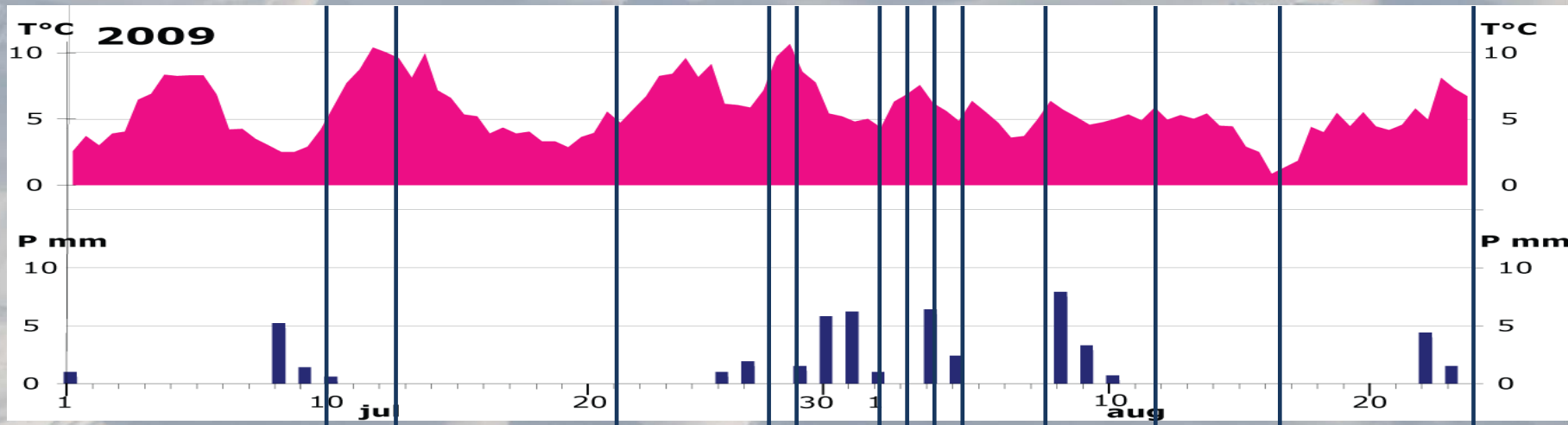
Data processing: snowcover interpretation

Snowcovered area (%)




T°C
2009
10
5
0
T°C
10
5
0
P mm
10
5
0
P mm
10
5
0
1
10
jul
20
30
1
10
aug
20


100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
01-juil.
03-juil.
05-juil.
07-juil.
09-juil.
11-juil.
13-juil.
15-juil.
17-juil.
19-juil.
21-juil.
23-juil.
25-juil.
27-juil.
29-juil.
31-juil.
02-août
04-août
06-août
08-août
10-août
12-août
14-août
16-août
18-août
20-août
22-août


T°C
2009
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T°C
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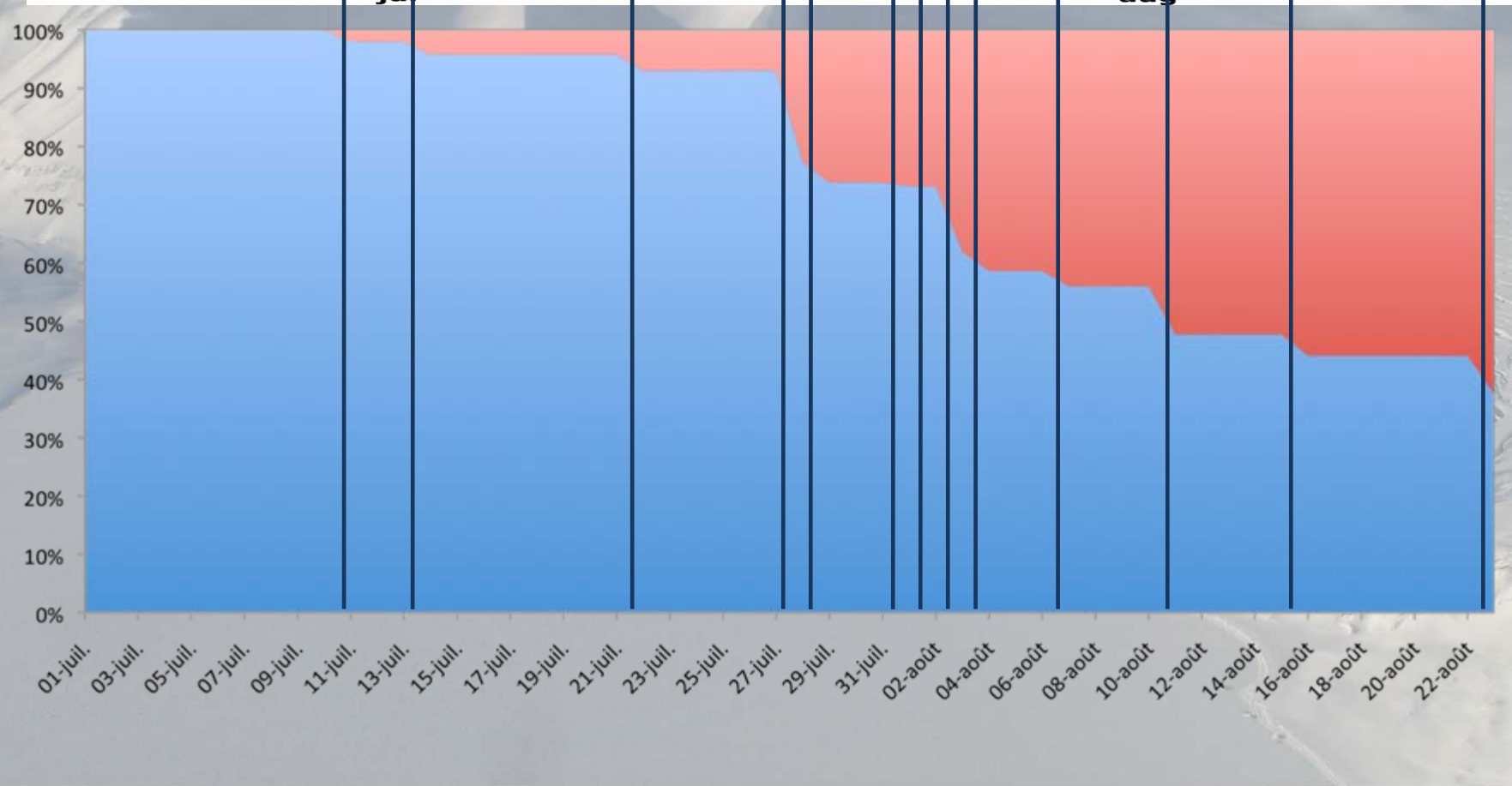
100%
90%
80%
70%
60%
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30%
20%
10%
0%
01-juil.
03-juil.
05-juil.
07-juil.
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29-juil.
31-juil.
02-août
04-août
06-août
08-août
10-août
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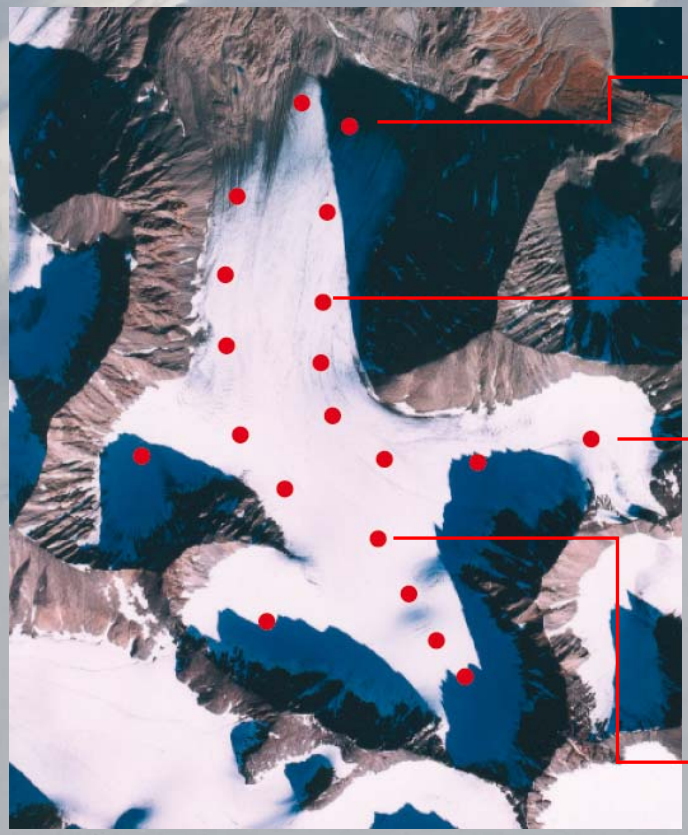
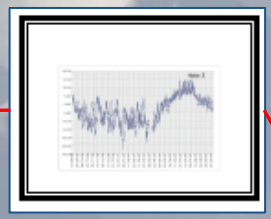
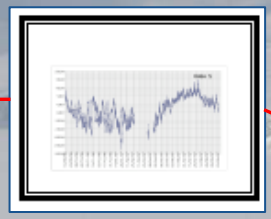
14-août
16-août
18-août
20-août
22-août

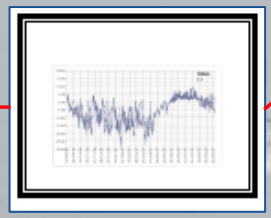
Conclusion: next step

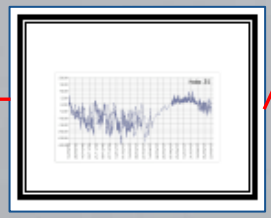
Hydrological process

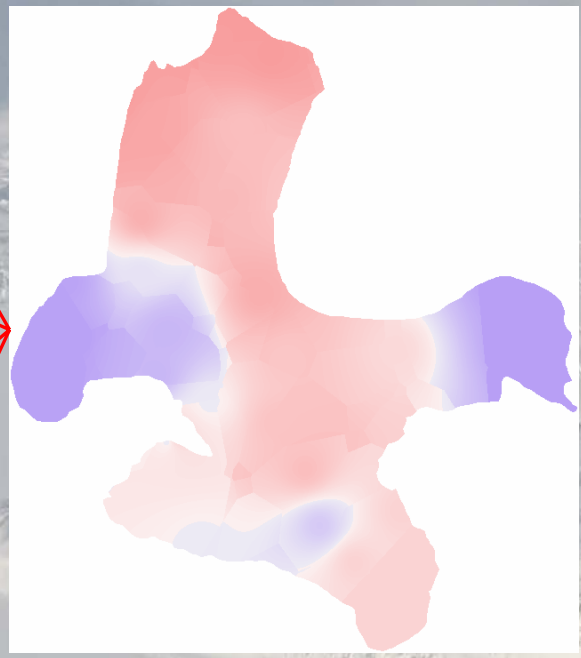










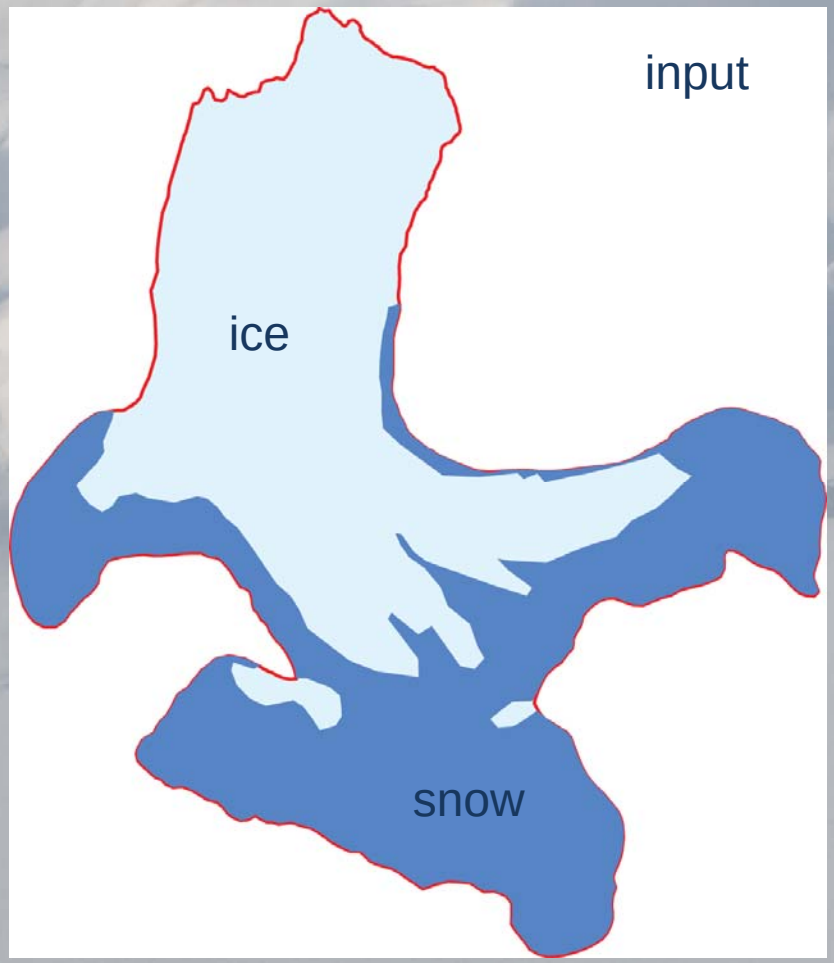


Daily / hourly thermic state

Conclusion: next step

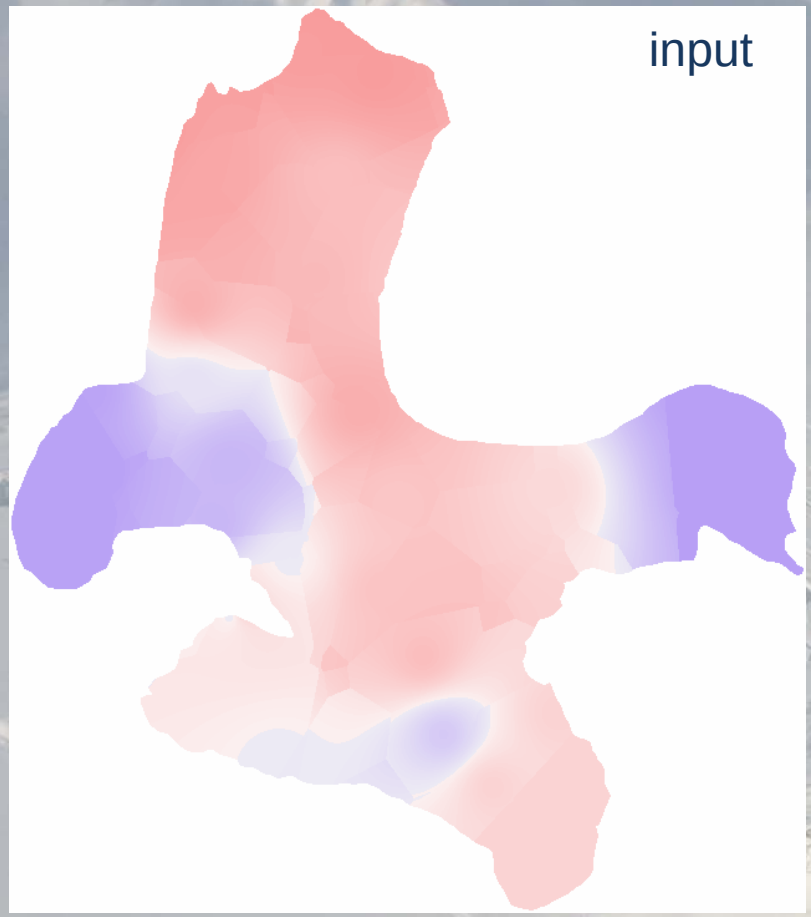
Hydrological process

k snow ≠ k ice



Snow / ice discretization from mosaïc of projected in situ images

weq melt = ΔT × k, ΔT > 0



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

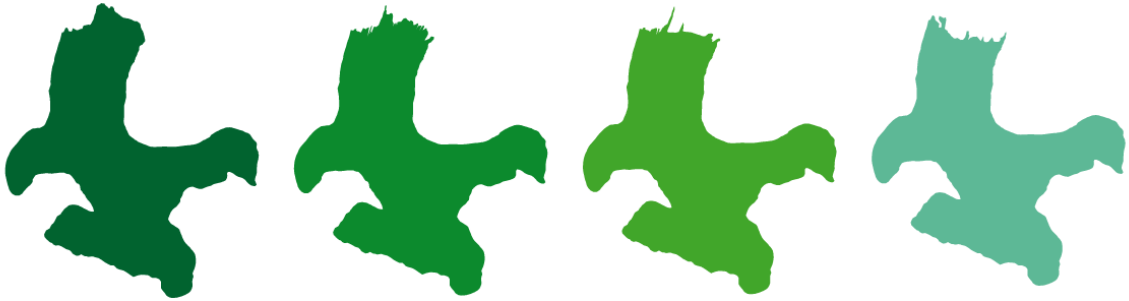
It is now possible to estimate snow melt, and hence the water equivalent thickness for each pixel, in order to define the fraction of ice and snow melt in the hydrological budgets during the melting season.

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

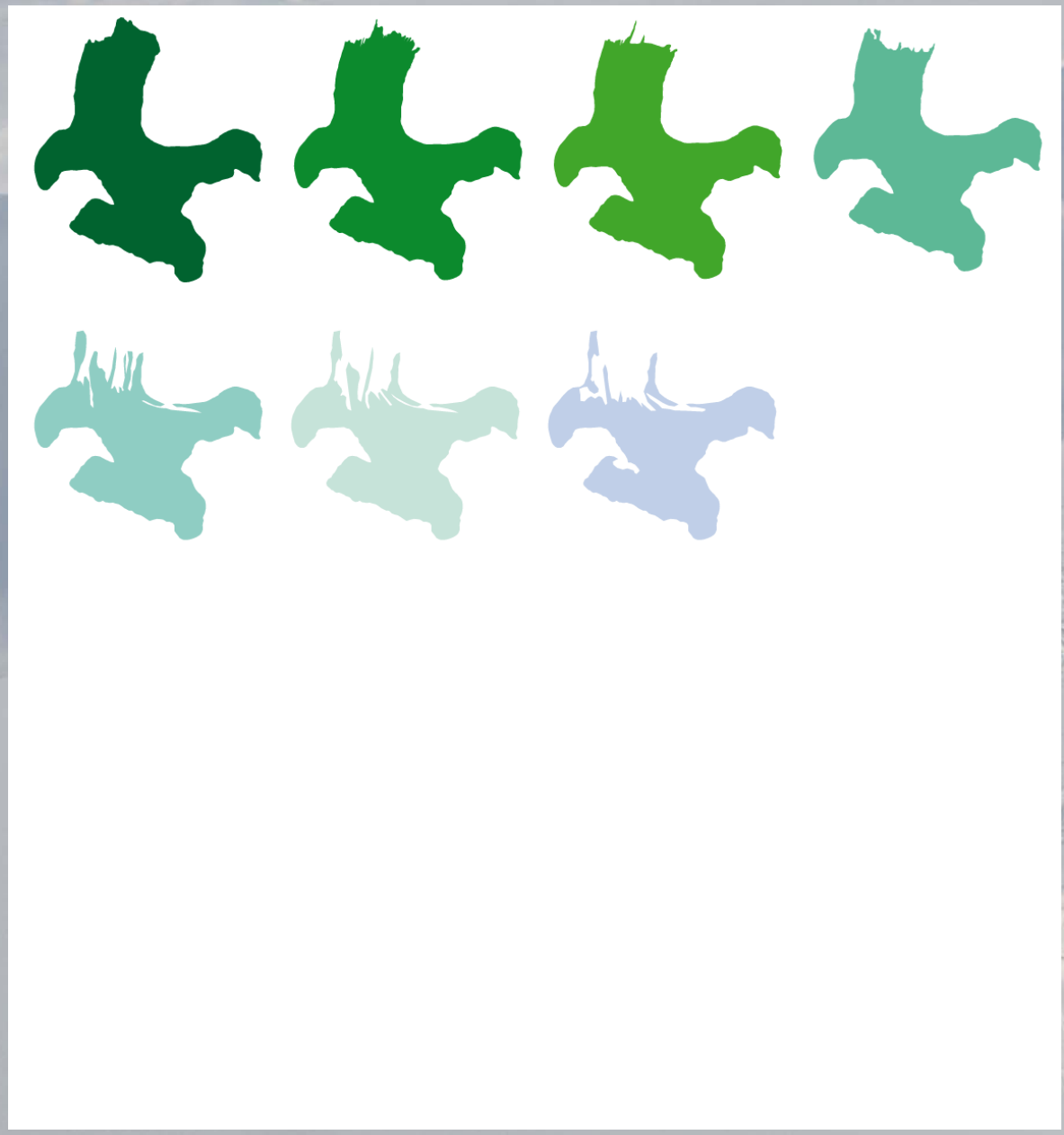


100 %

Data processing: snowcover interpretation

4 to 22 jul

28 jul to
01 aug



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07 aug