

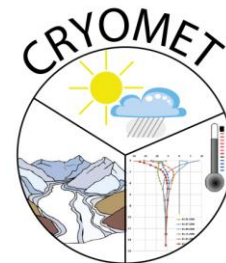
High-Resolution Snow Distribution Modeling in the Mountains of Southern Norway

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University of Oslo



Statkraft



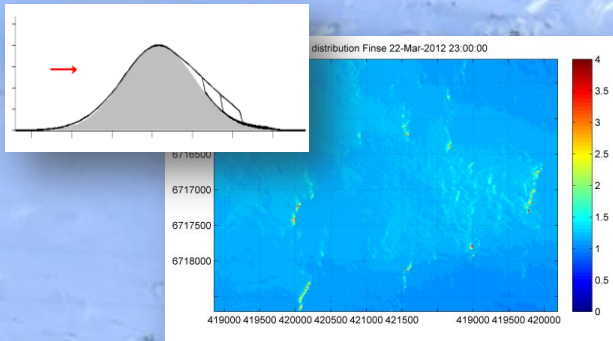
Motivation:

Establish a calibration scheme for modeling snow distributions in Norway.



Datasets:

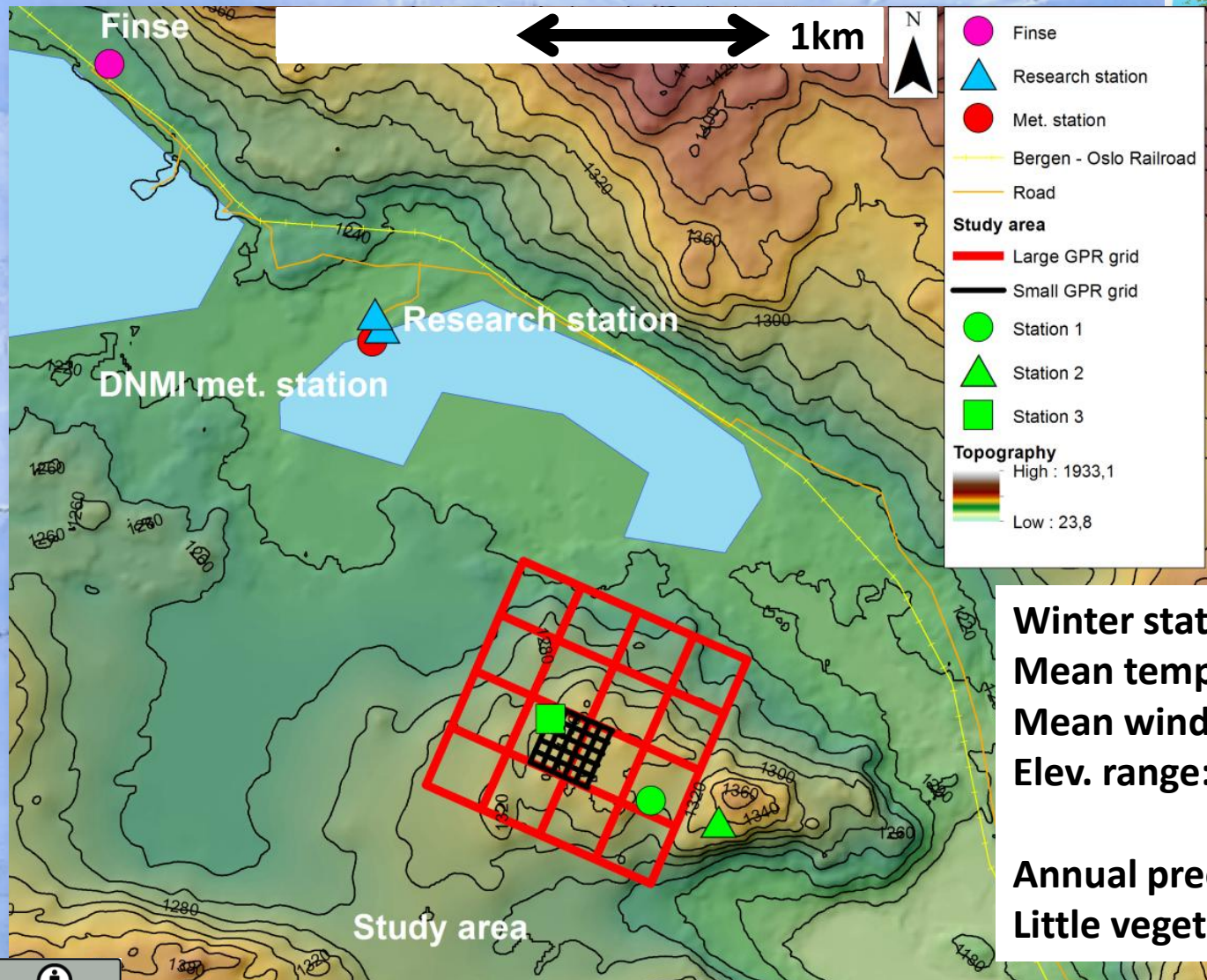
Collect wind speed, wind direction and distributed snow depth data from a high-wind, mountainous region.



Modeling:

Test the validity of Snowmodel in these conditions. Preliminary results.

Snow model test site

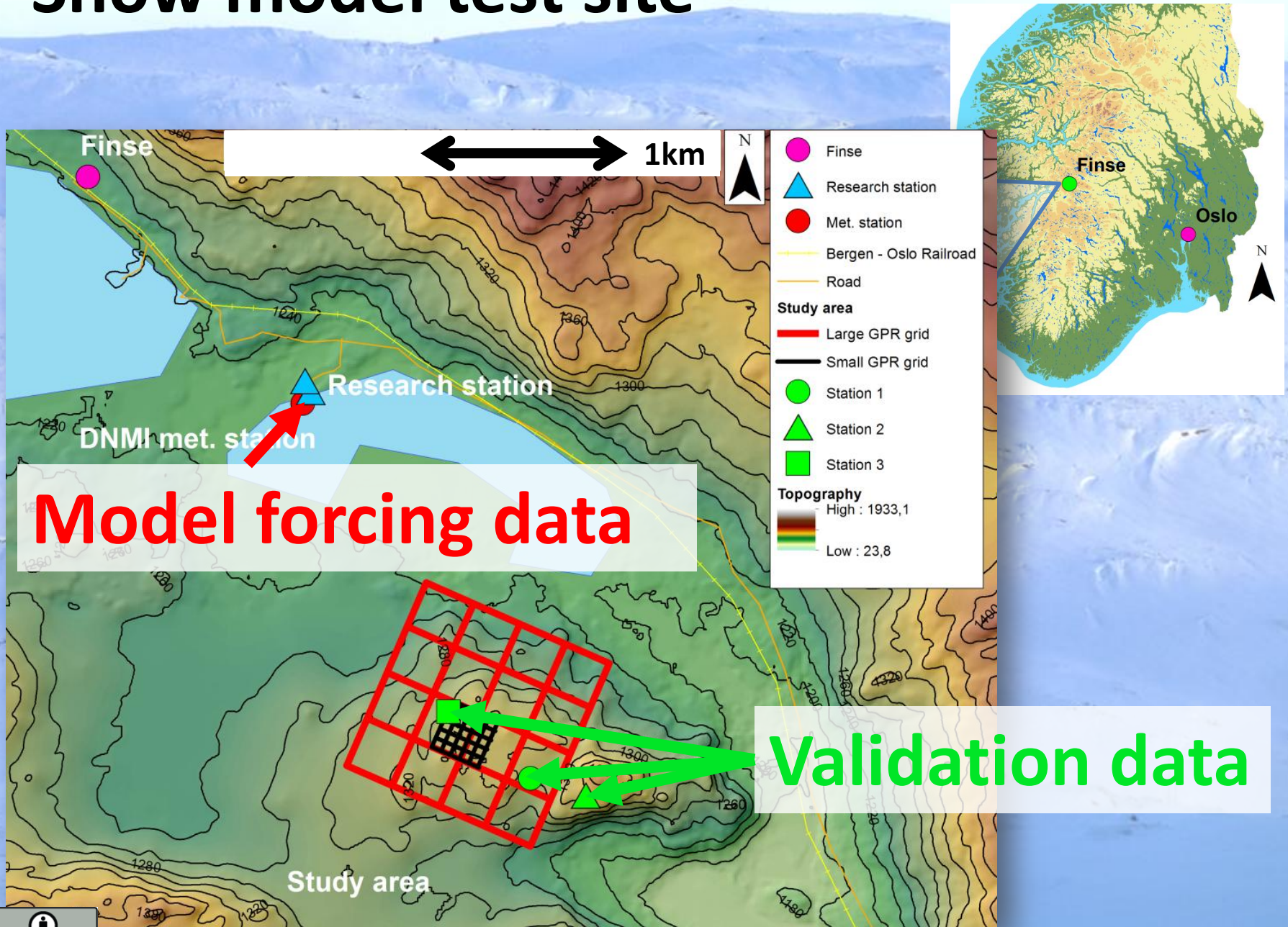


Winter statistics:

Mean temp:	-8.4°C
Mean wind :	6.4 m/s
Elev. range:	1100-1400m

Annual precip:	990 mm
Little vegetation	<20 cm

Snow model test site



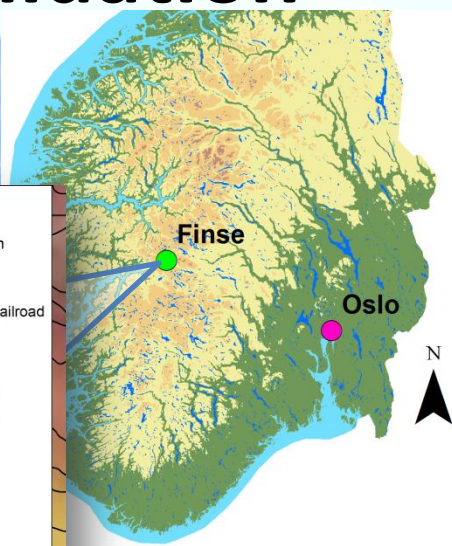
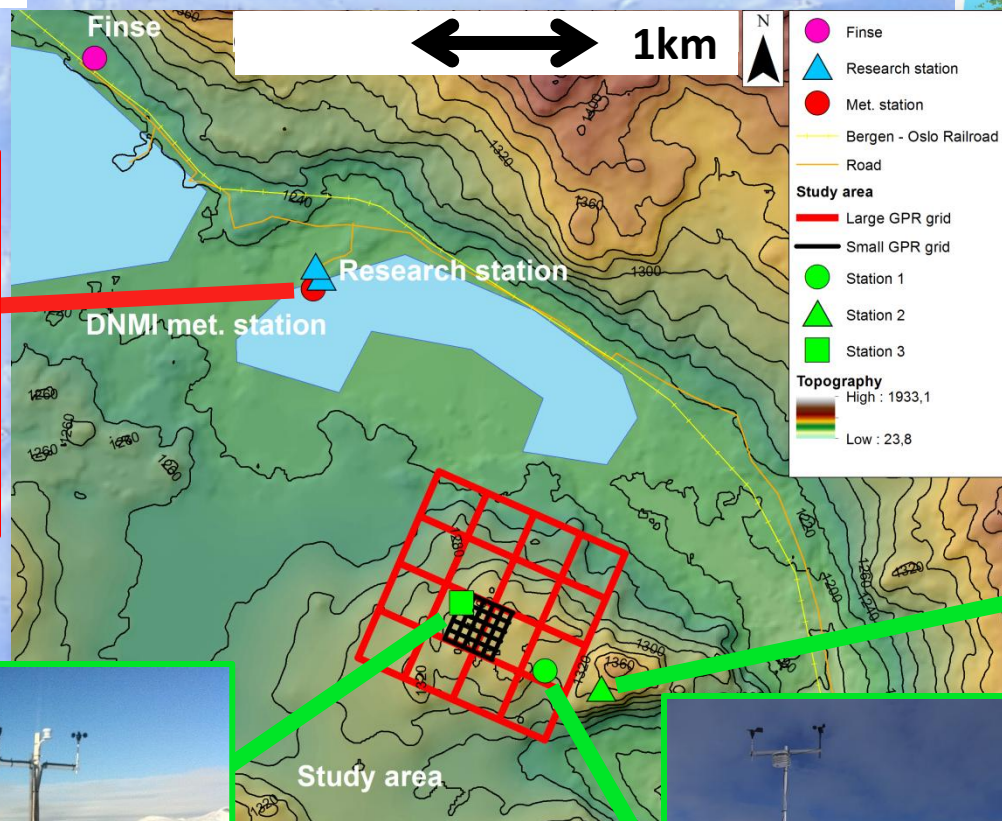
Installation of met. validation

Hourly:

Wind speed

Wind direction

Temperature

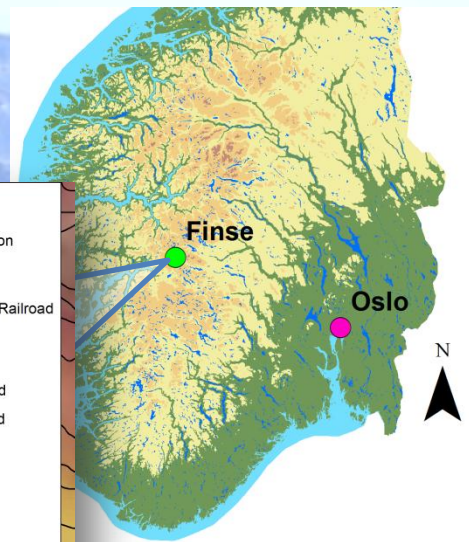
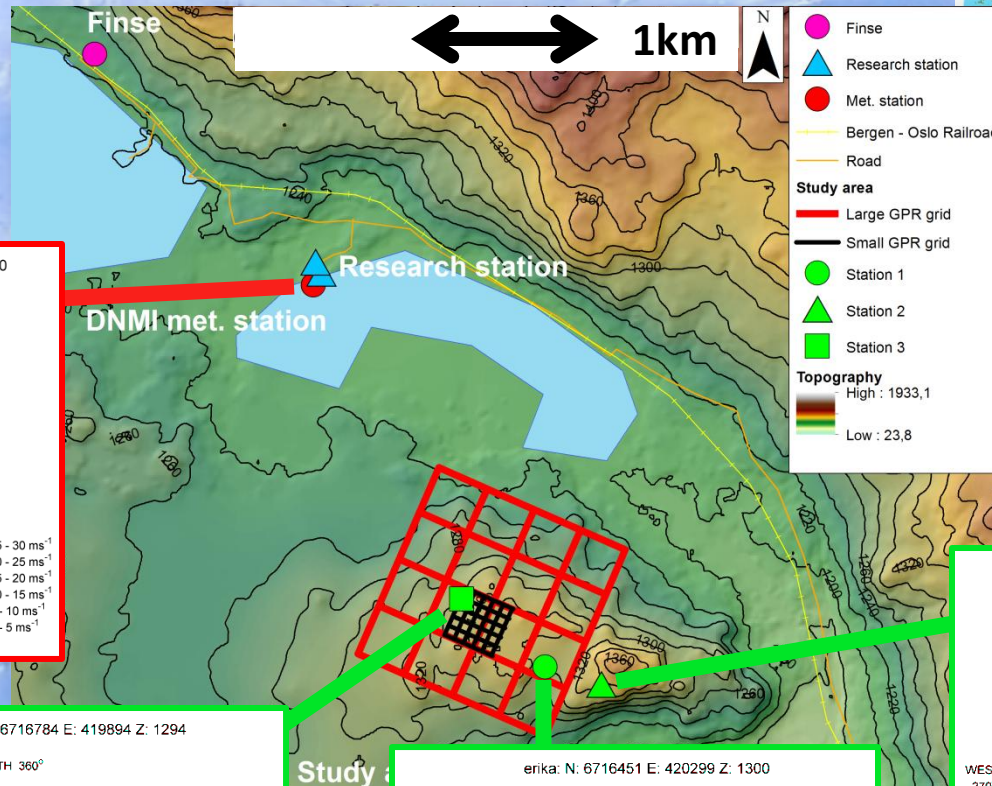
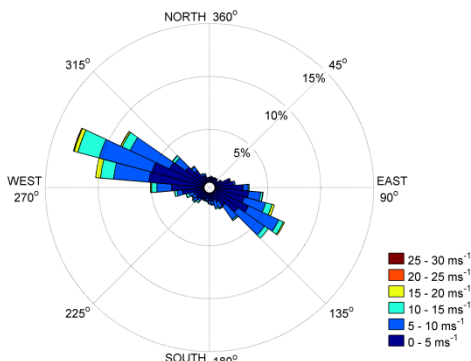


Wind direction data

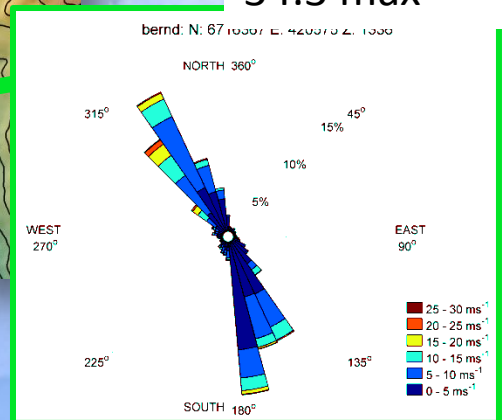
Topographic effects
on wind speed and
direction.

46% above 5
5.2 average
26.5 max

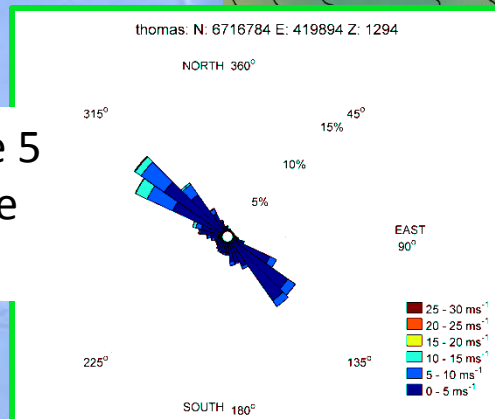
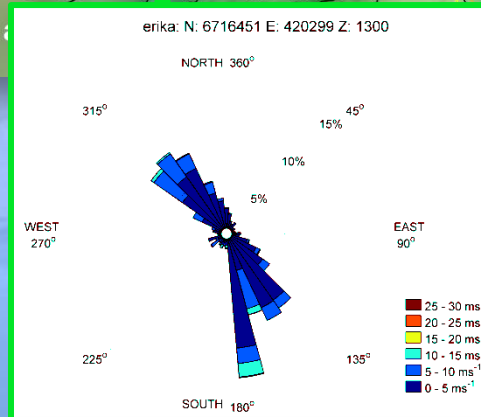
met.no Finse: N: 6718278 E: 419089 Z: 1210.000000



47% above 5
5.3 average
34.3 max



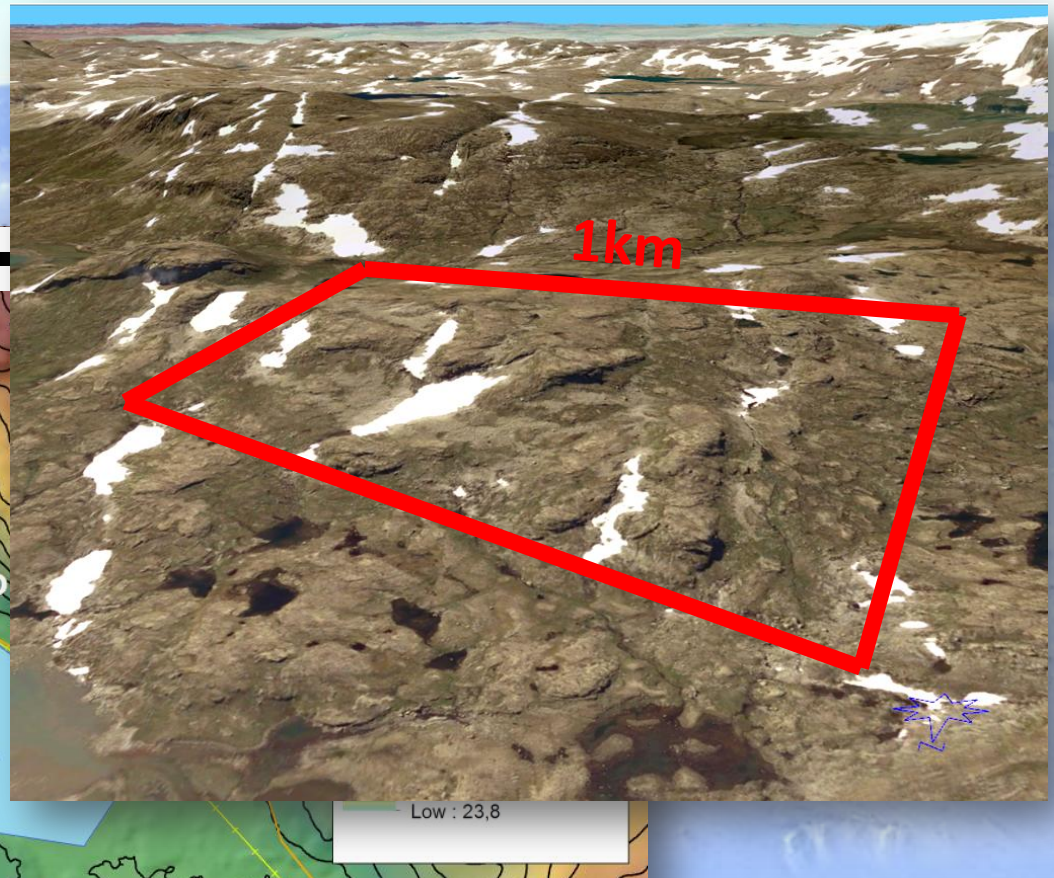
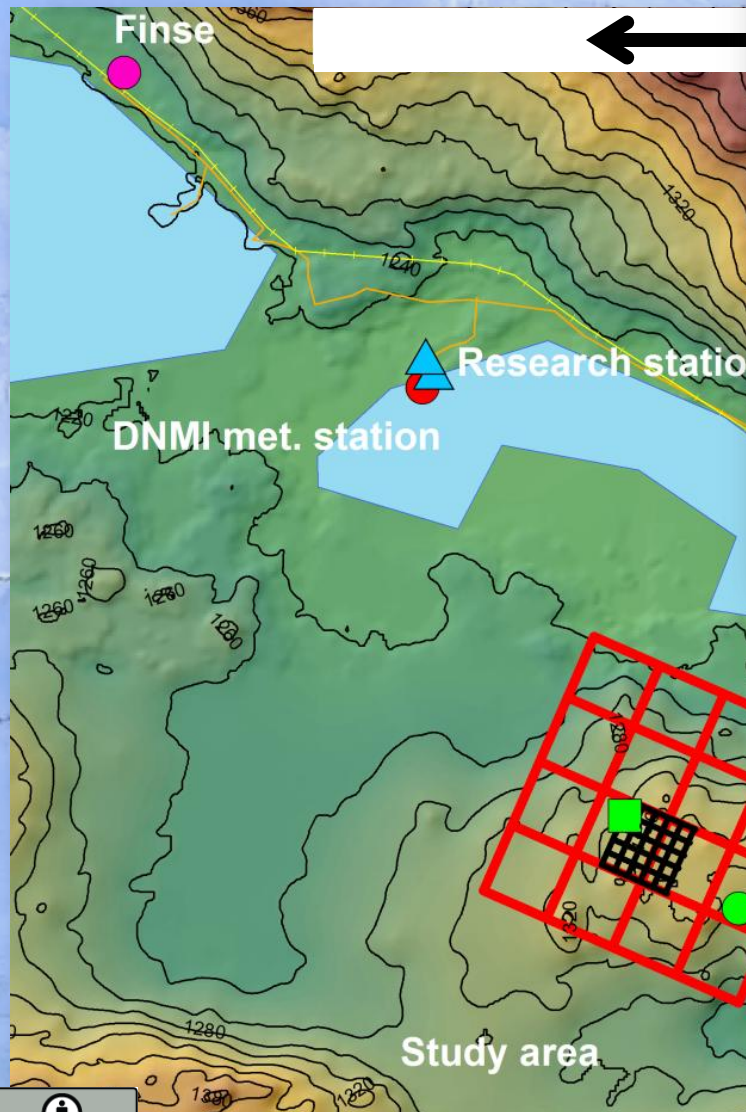
25% above 5
3.2 average
17.6 max



15% above 5
3.1 average
17.1 max

GPR data

Once a month, 2011-2013



Malå 800Hz, 0.25s recording interval.
1 km² area, 250m and 50m grid spacing.



GPR tracks give a good representation of general terrain characteristics

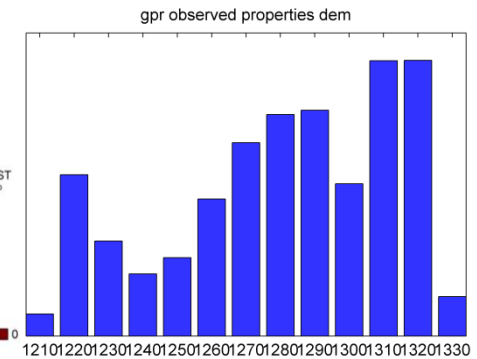
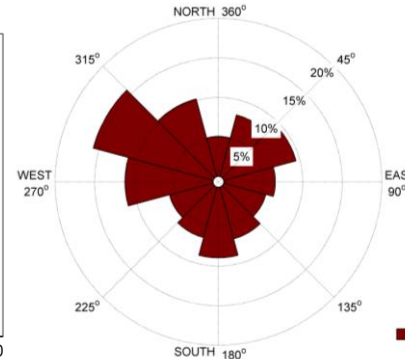
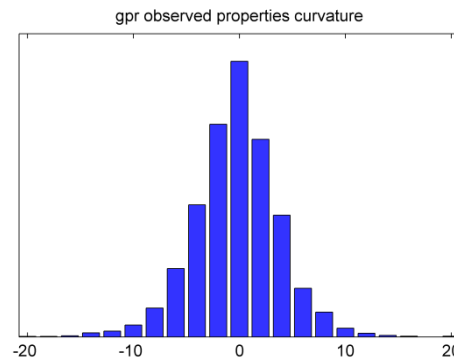
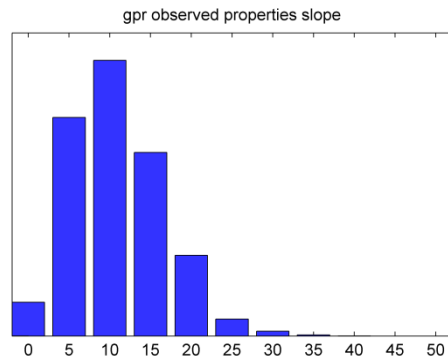
Slope

Curvature

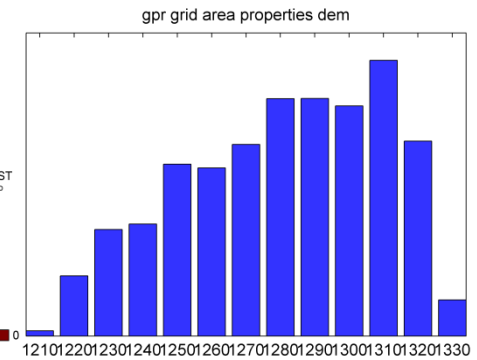
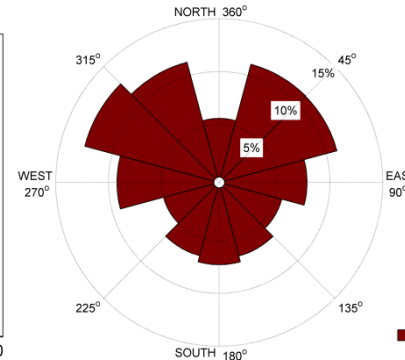
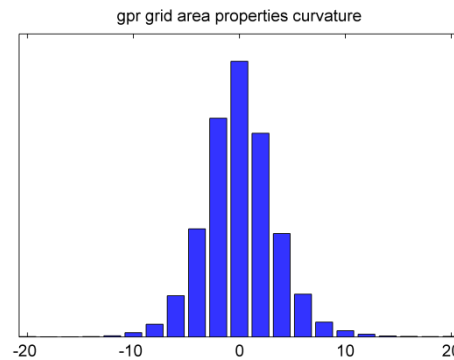
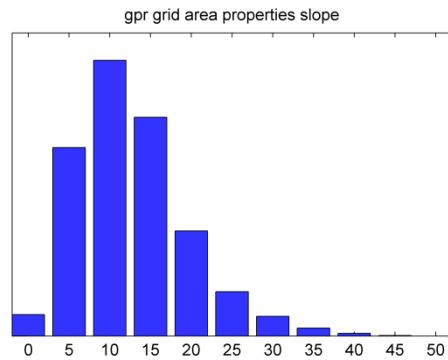
Aspect

Elevation

GPR track of 22.03.2012



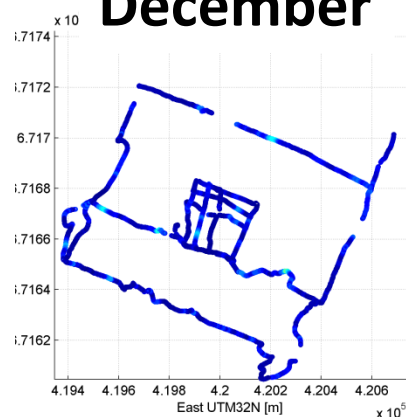
Entire study area



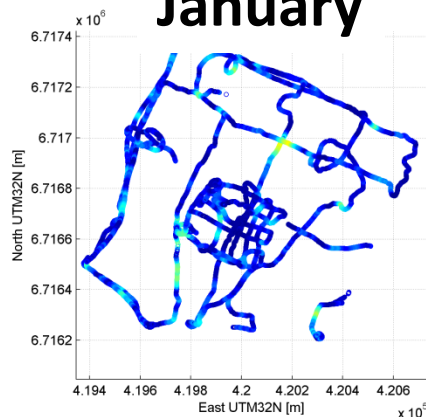
GPR: 114 km, 14 km average, $\approx 0.5\text{m}$ point density

2011-2012
2012-2013

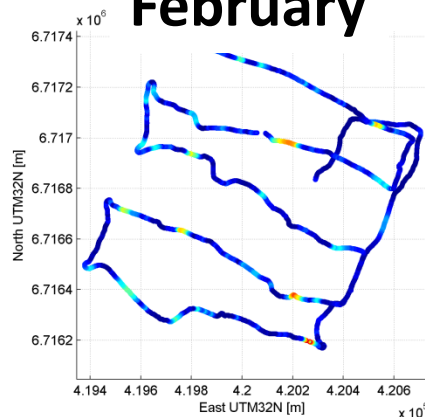
December



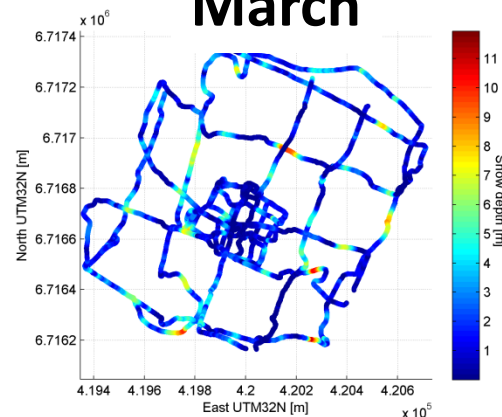
January



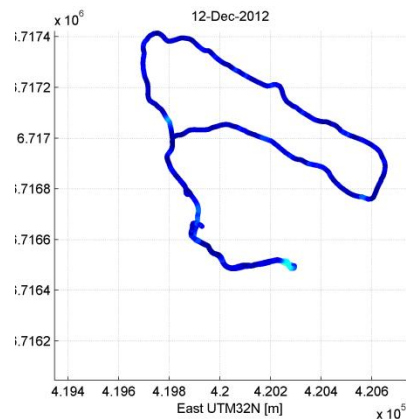
February



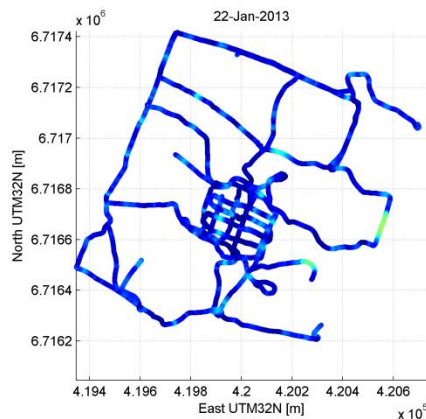
March



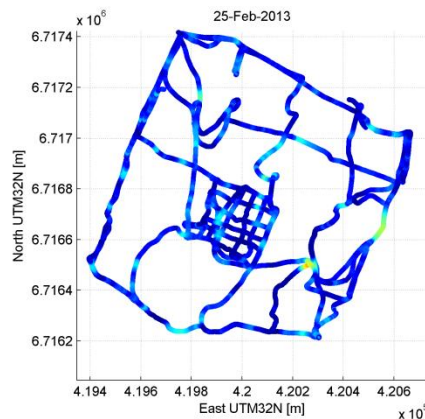
12-Dec-2012



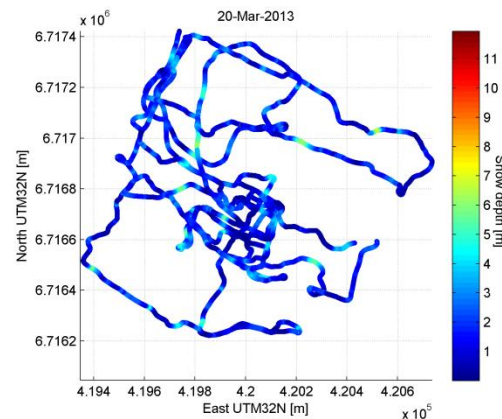
22-Jan-2013



25-Feb-2013



20-Mar-2013



1 km

Mean snow depth increases through season, distribution gets wider

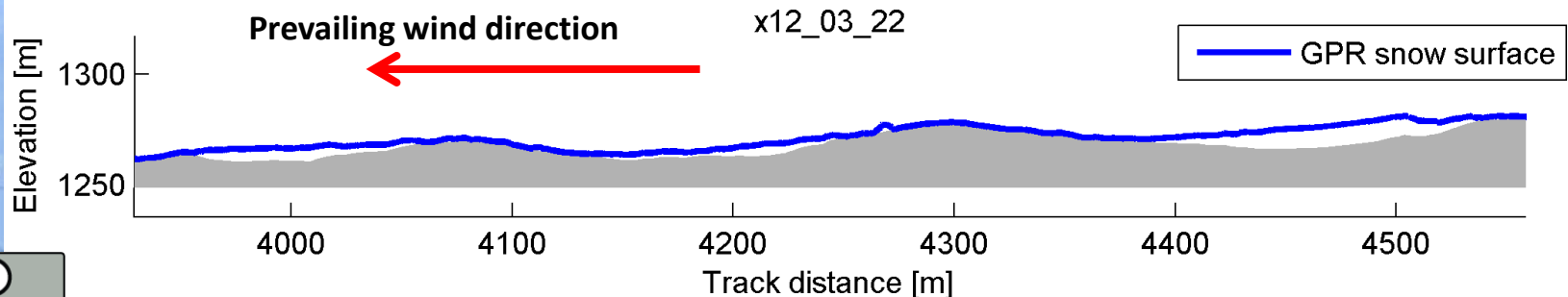
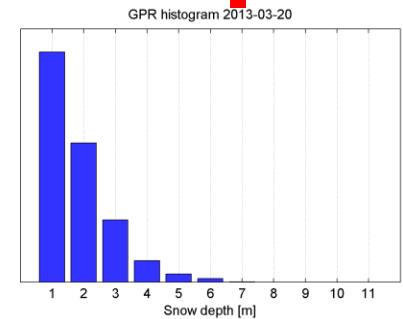
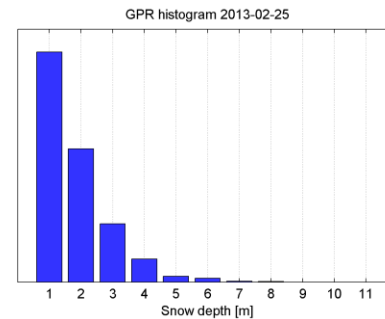
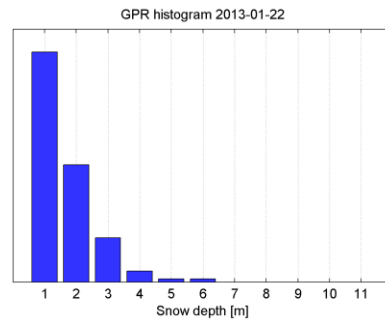
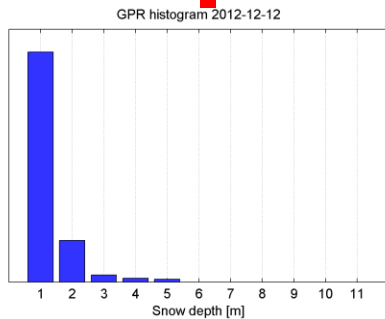
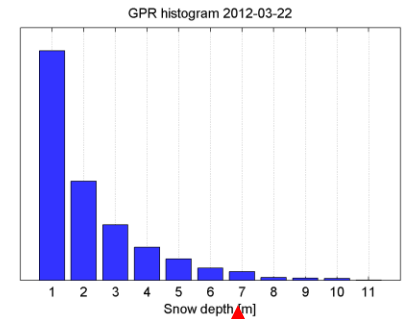
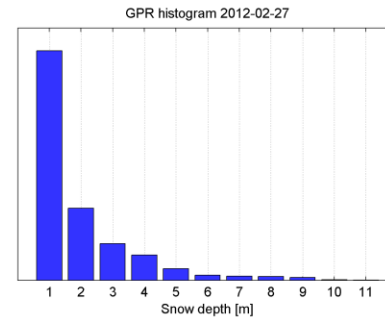
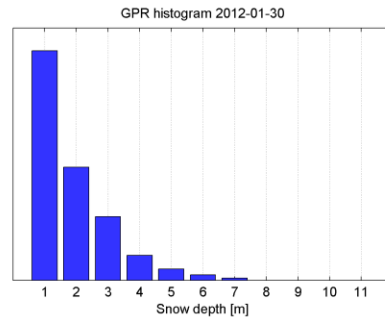
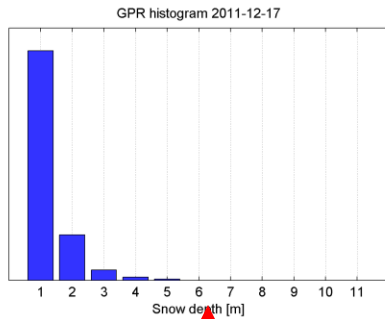
2011-2012
2012-2013

December

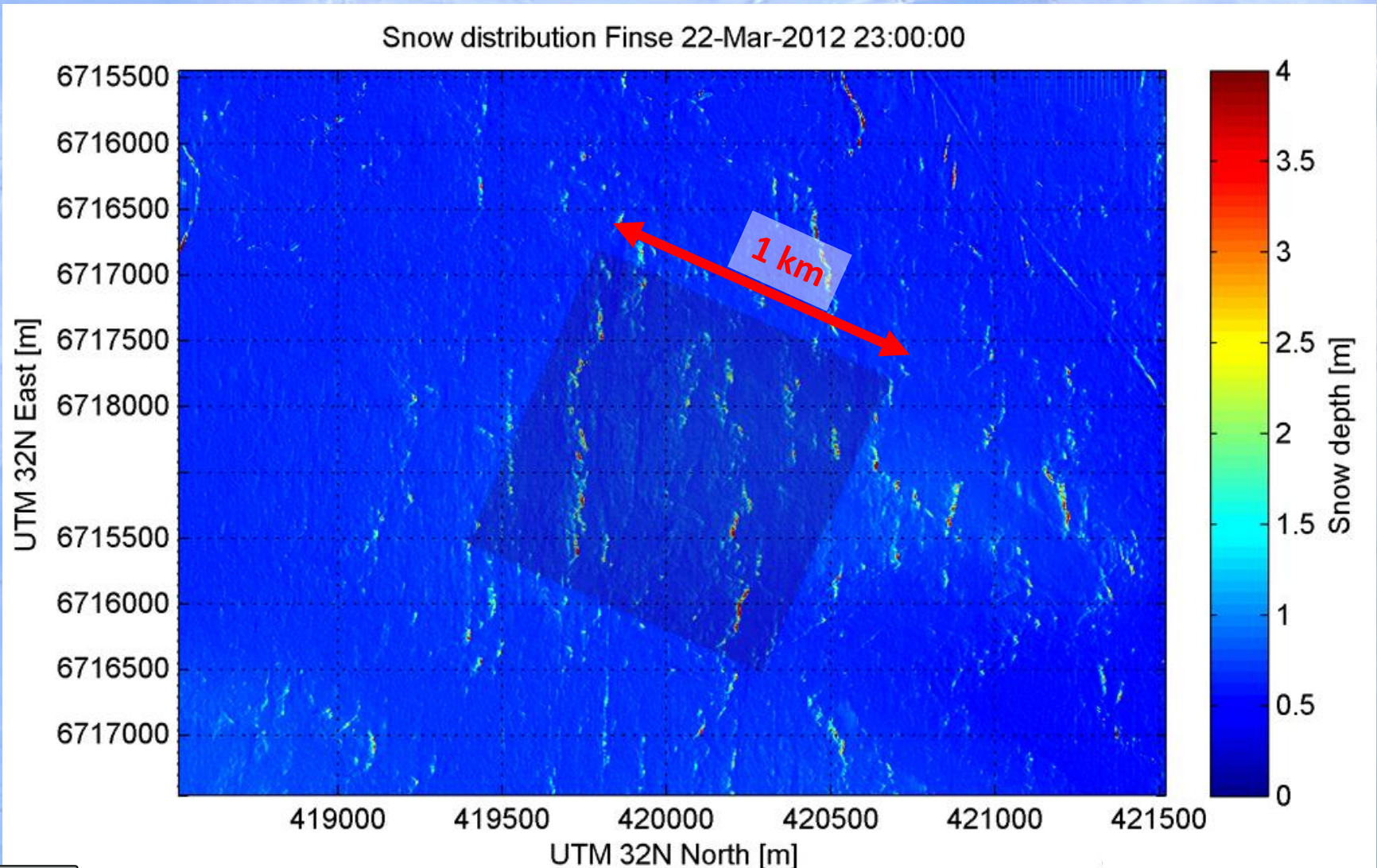
January

February

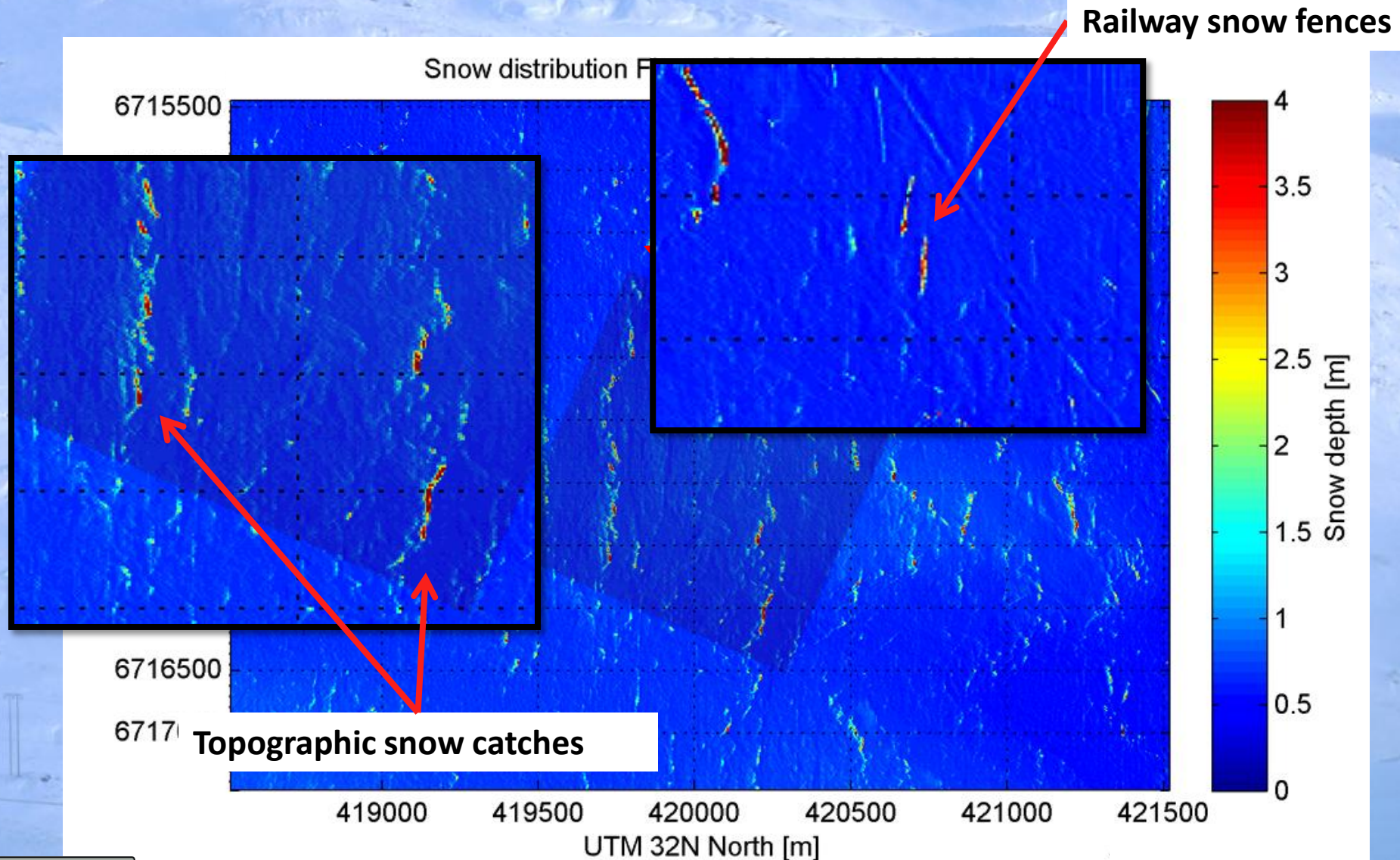
March



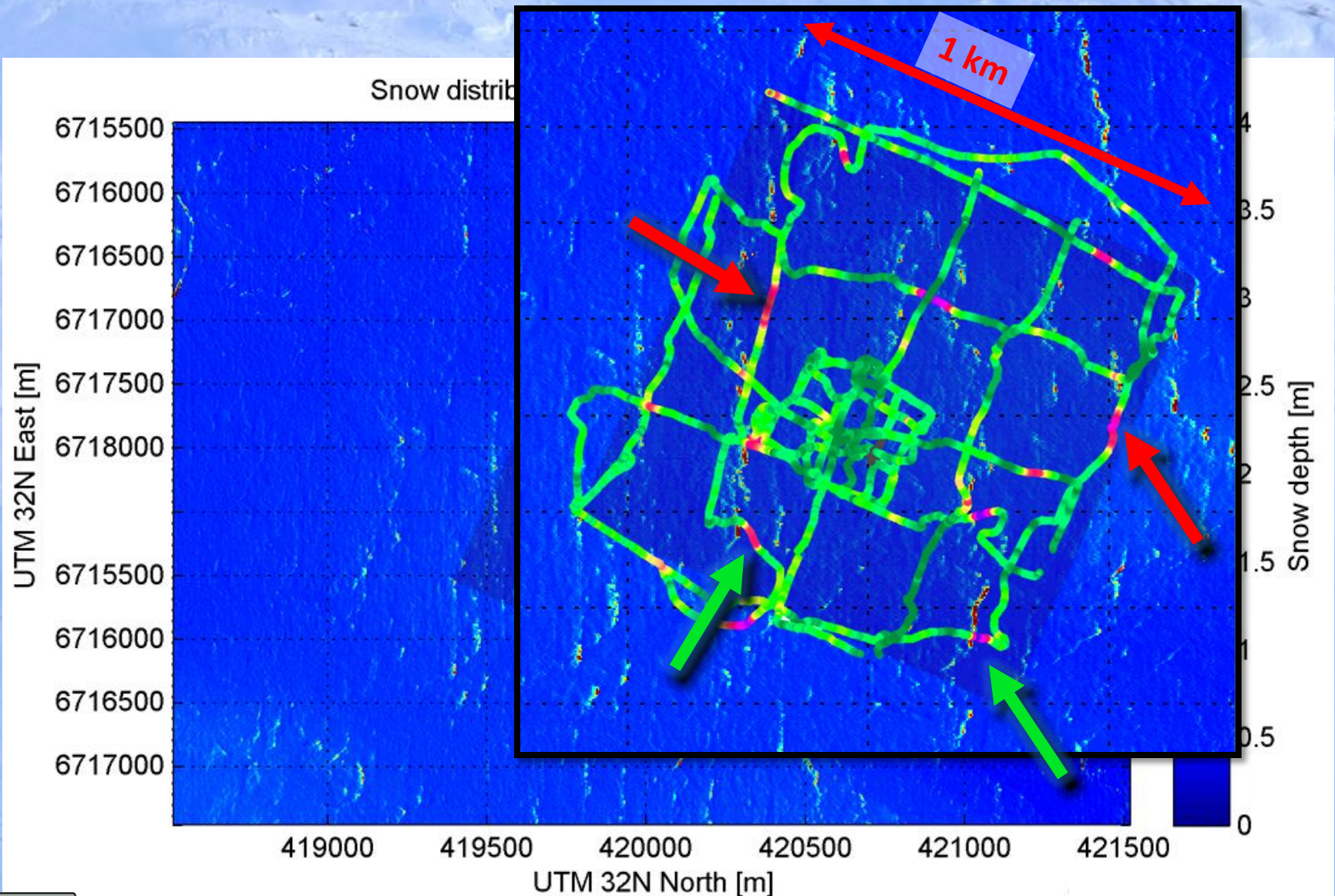
Snowmodel is a spatially distributed snow-evolution modeling system (Liston et al,2007)



Model simulates prominent topographic snow catches...



...but fails to simulate snow depth accumulations in moderate slopes.

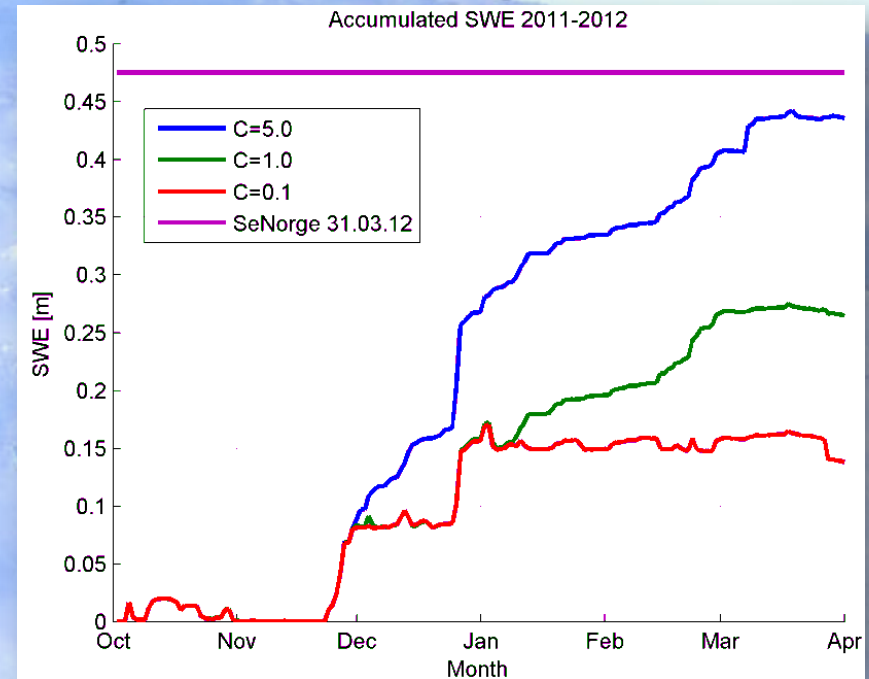


Surface snow density calculations not sensitive enough to wind speed

Hurdles:

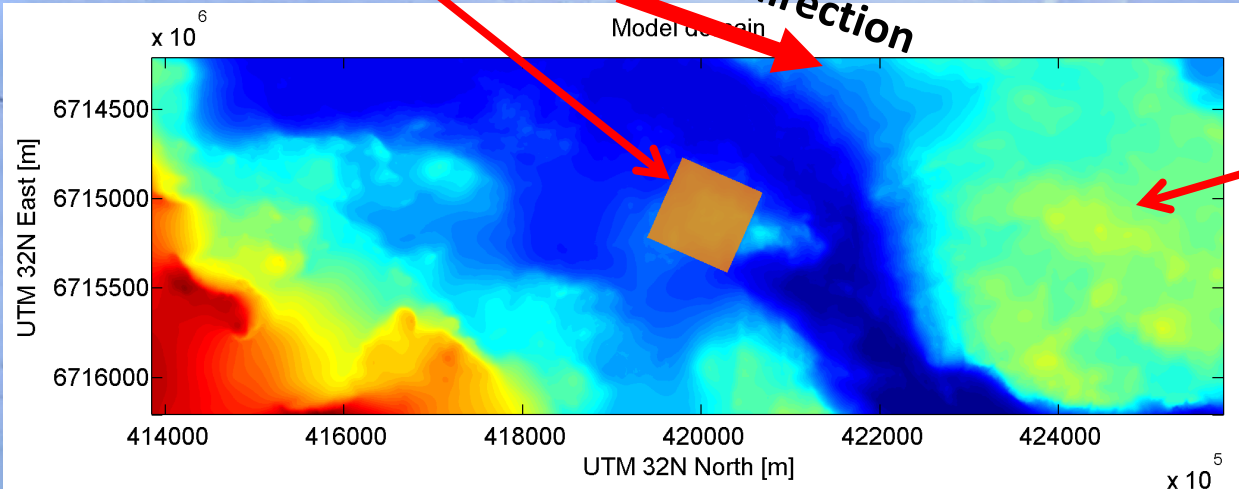
- (1) Snow density not sufficiently altered by wind speed.
- (2) Hard snow created by wind, model only handles temperature.
- (3) Wind speed and direction not sufficiently altered by topography.
- (4) Snow transported out of modeling domain.

Mean SWE depth in study area



Study area 1 km²

Main wind direction



Model area 40 km²

Terrain model

Motivation:

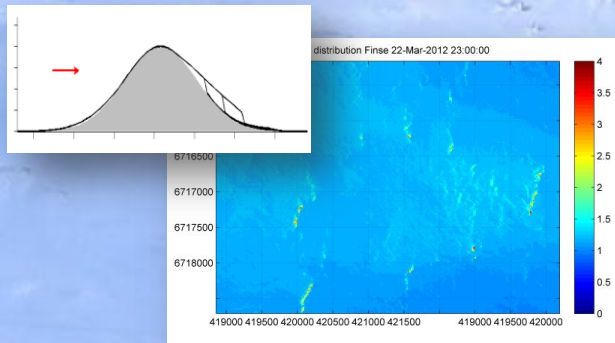
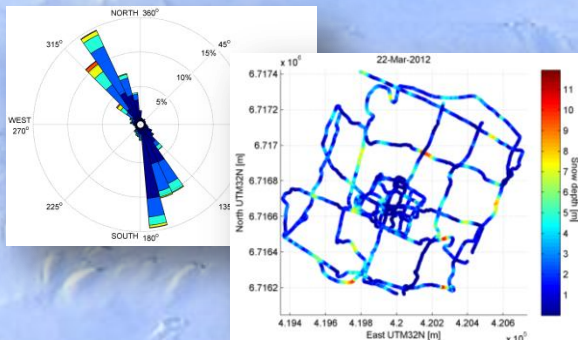
Establish a calibration scheme for modeling snow distributions in Norway.

Datasets:

2 years, 250 000 GPR depth observations

1 year + of meteorological data

Both GPR and met. data represent topographic variation well.



Modeling:

Initial results show evolution of snow catches through season, corresponding to observations. Further model calibration and development needed.

Any questions?