SPATIALLY DISTRIBUTED HIGH-RESOLUTION SNOW EVOLUTION MODELING

3D-MODELING OF SNOW IN THE SAARISELKÄ REGION DURING THE WINTER 2015-2016

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* From January 1, 2018 at Alfred Wegener Institute for Polar and Marine Research, Bremerhaven, Germany

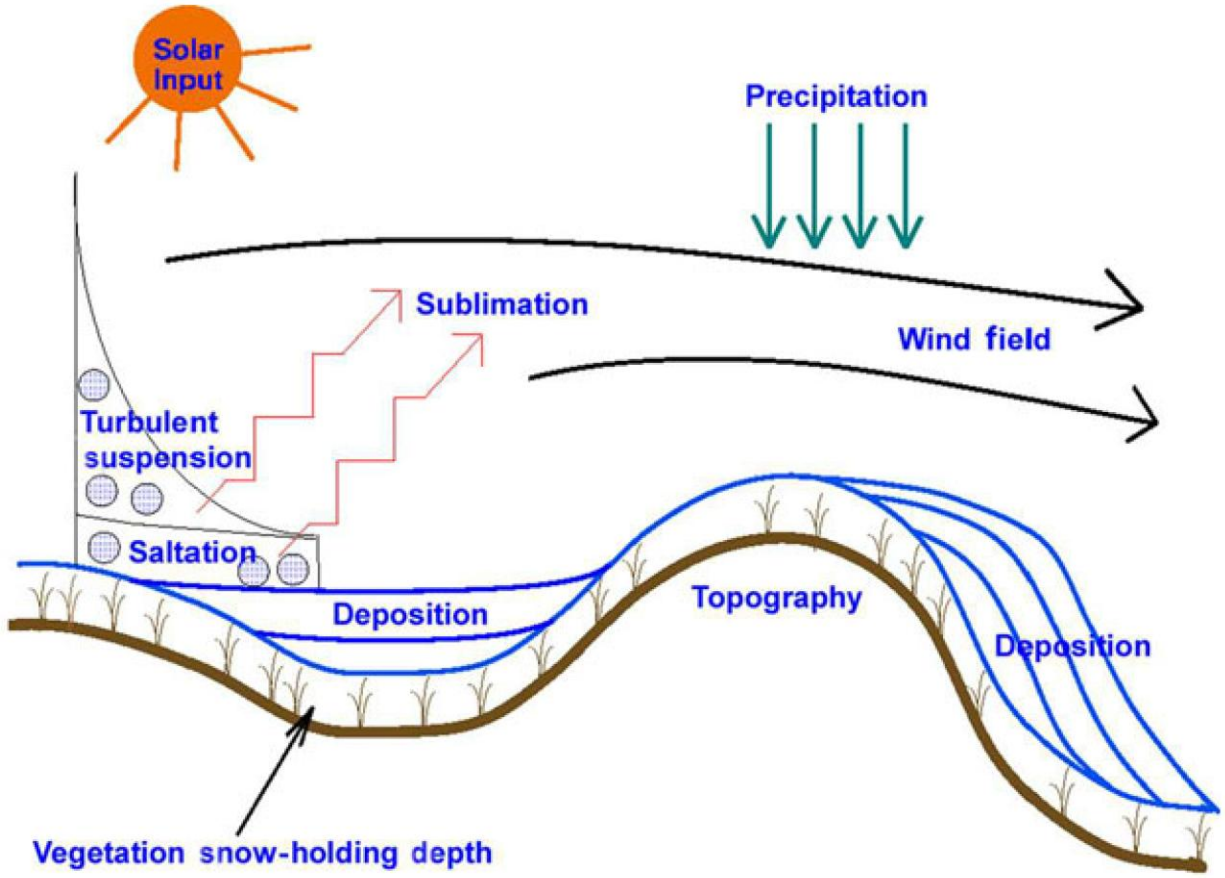
OUTLINE OF THE PRESENTATION

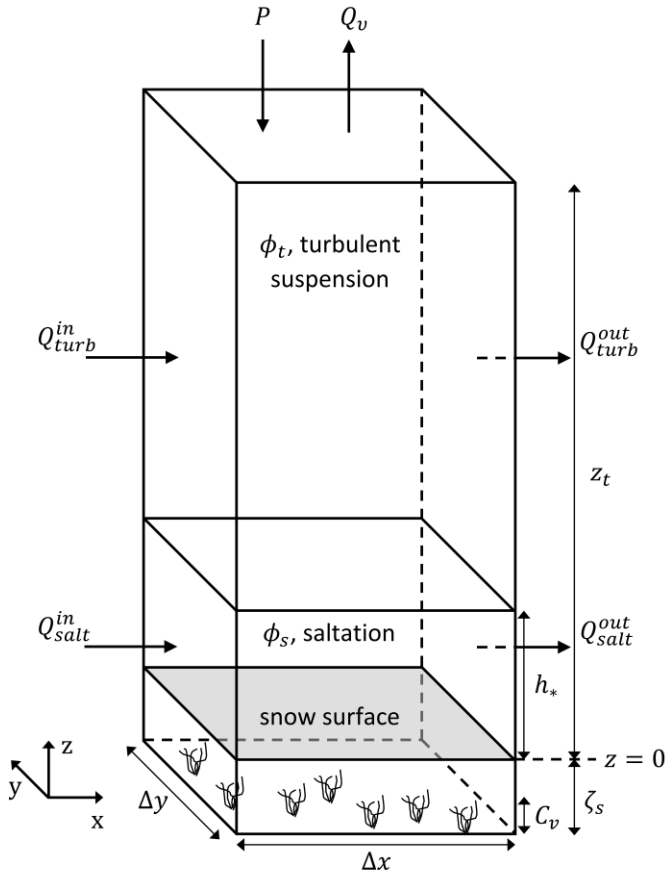
1. Motivation, model description, and the area of interest
2. Simulation results
3. Conclusions

APPLYING SNOWMODEL IN FINNISH LAPLAND

- Uniqueness and complexity of snow
- Snow distribution and blowing snow studying
- SnowModel: state-of-the-art high-resolution spatially distributed snow modeling system (Liston & Elder, 2006)
- Never used for modeling a Finnish domain before
- Lapland guarantees snow-sure conditions with varying topography and vegetation to make modeling challenging and interesting

(SIMPLE) FIRST-ORDER PHYSICS WITH AN EMPIRICAL TOUCH





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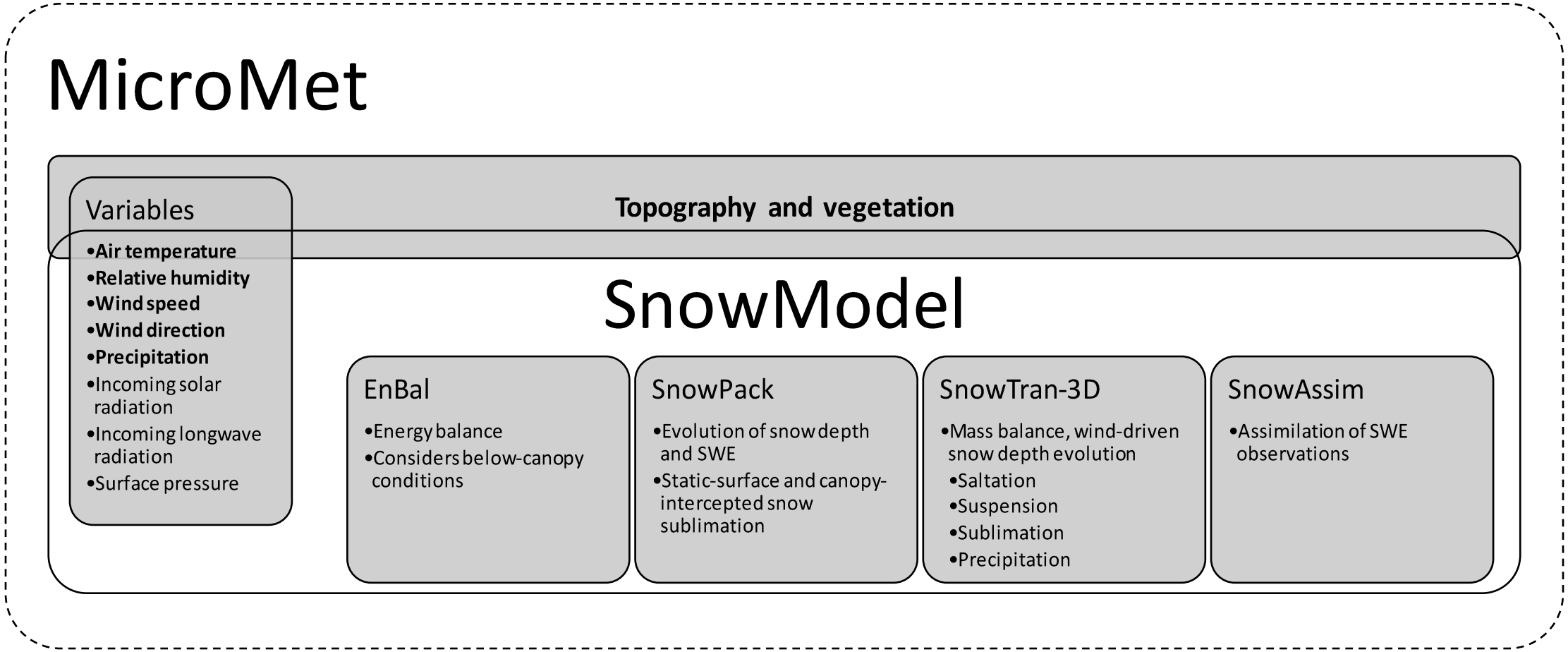
MICROMET FEEDS SNOWMODEL

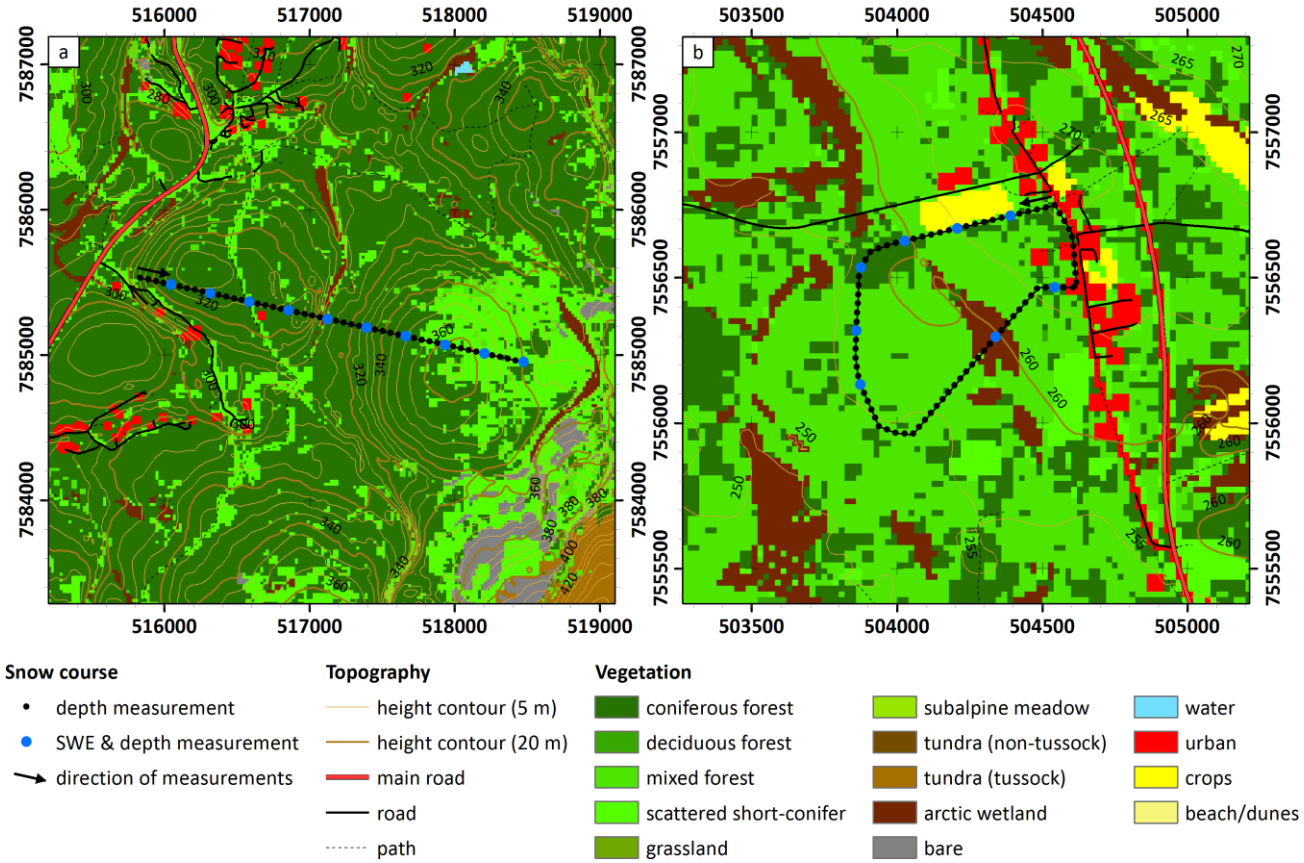


SIMPLE INPUT DATA

1. Digital elevation model
   - 10 m → 60 m
2. Vegetation (24-30 classes)
   - Reclassified CORINE, 20 m → 60 m
3. Atmospheric data
   - 6 stations, hourly forcing
     - Air temperature
     - Relative humidity
     - Wind speed
     - Wind direction
     - Precipitation
     - (Snow depth)

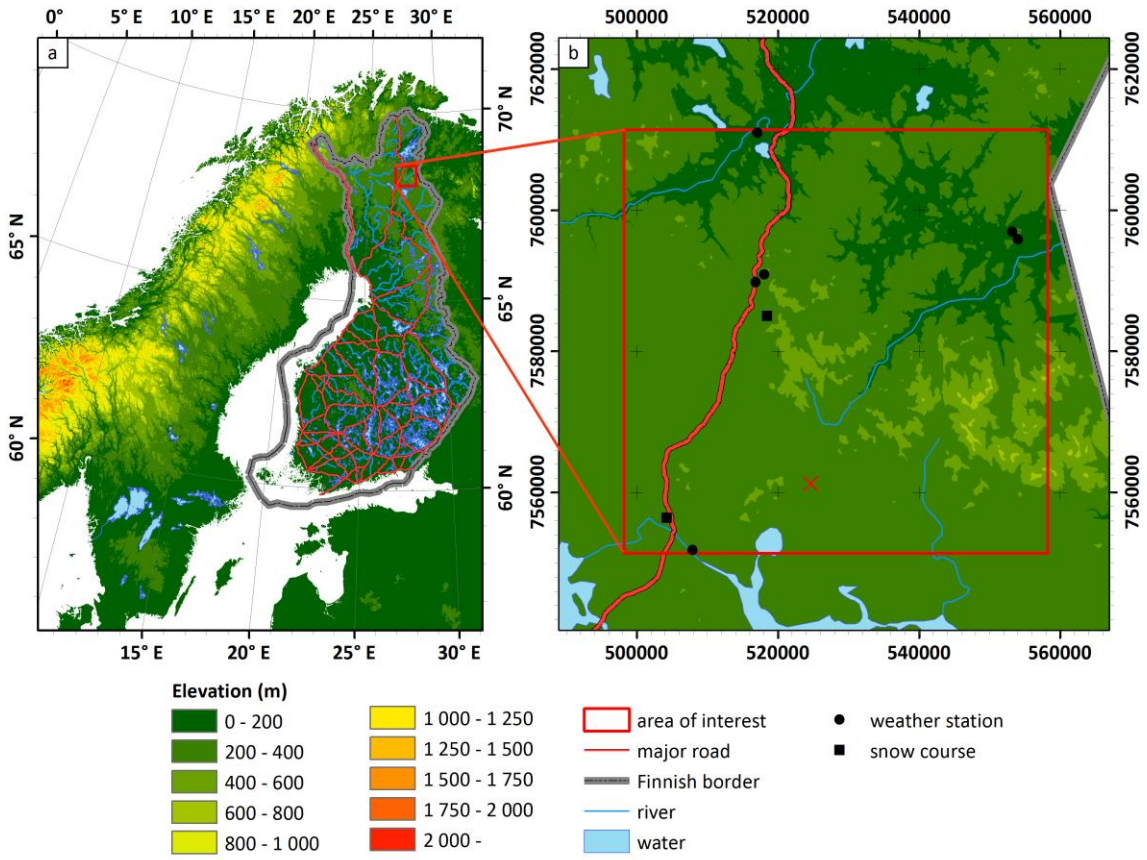
GROUND TRUTH FOR ASSIMILATION

4. Snow courses
   - 2 courses, 6 measurement days
   - 2-4 km track
   - 50-80 snow depth measurements
   - 8-10 snow water equivalent measurements
   - Covering land covers typical for the area

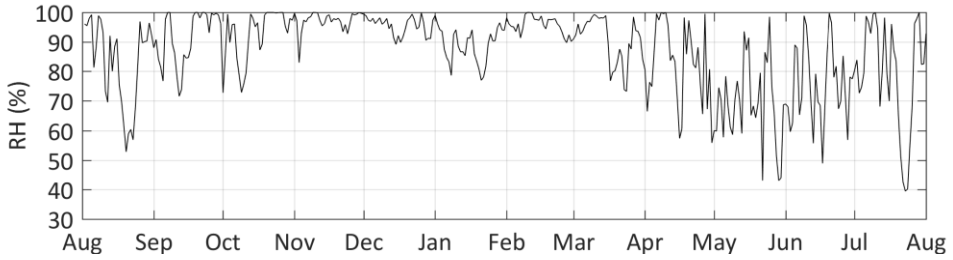


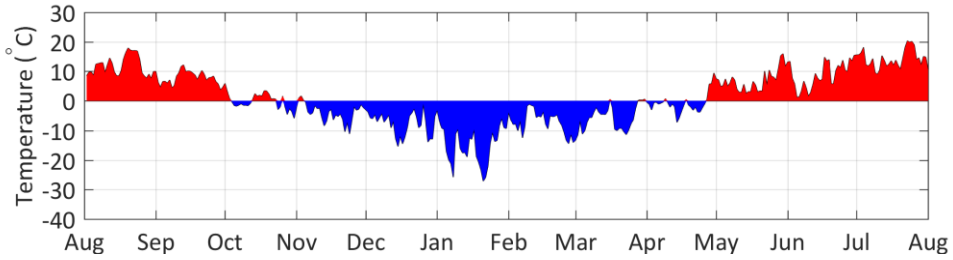
Unaveraged snow course data provided by hydrologist Heidi Sjöblom from the Finnish Environment Institute. The cooperation is very much appreciated!

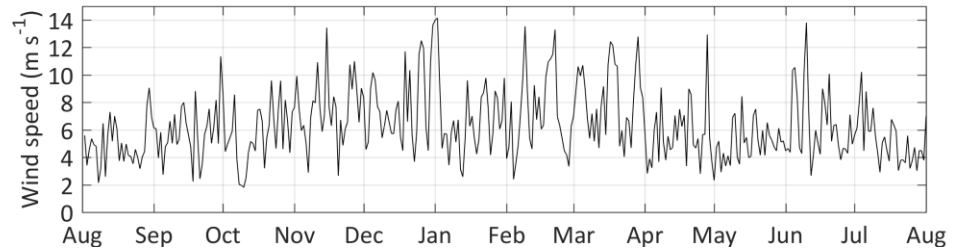
WINTER-SURE WONDERLAND

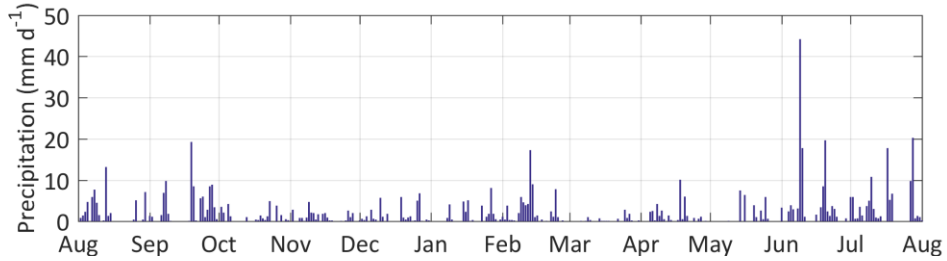


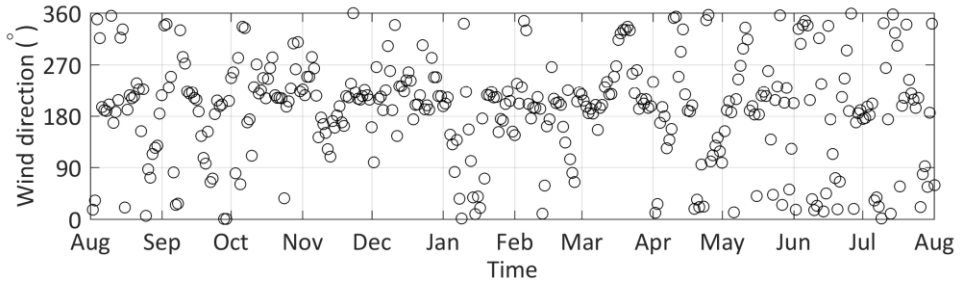
NORMAL(ISH) WINTER



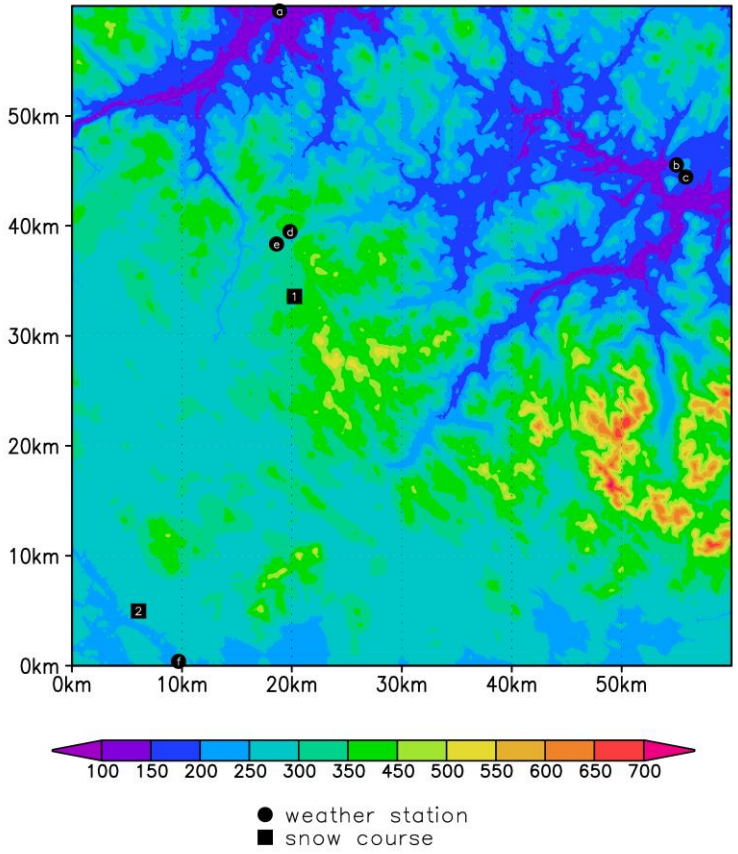


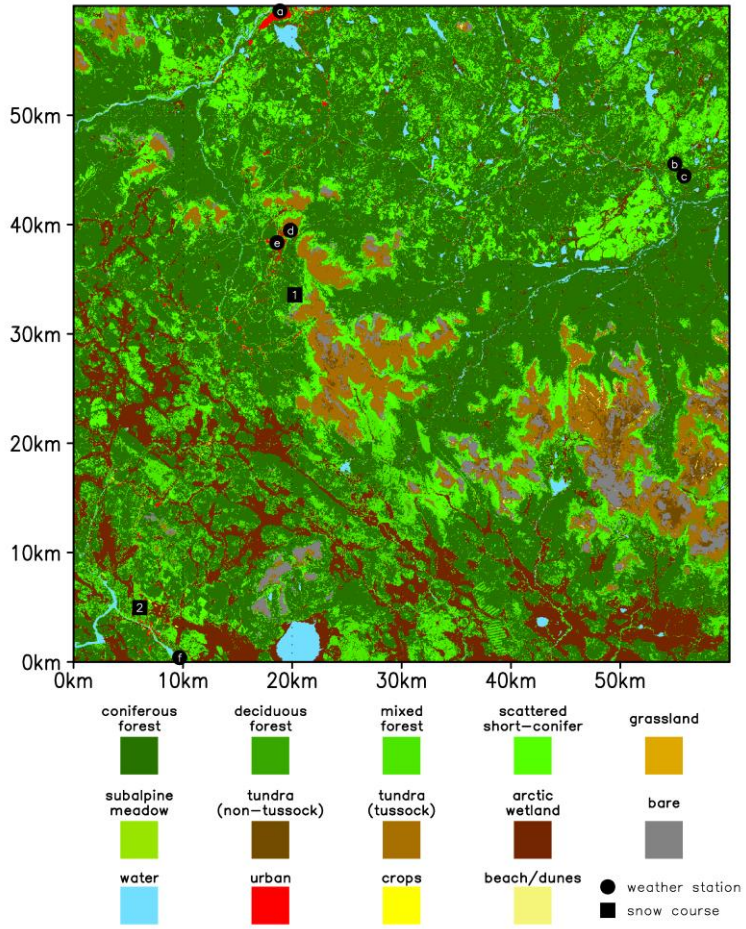






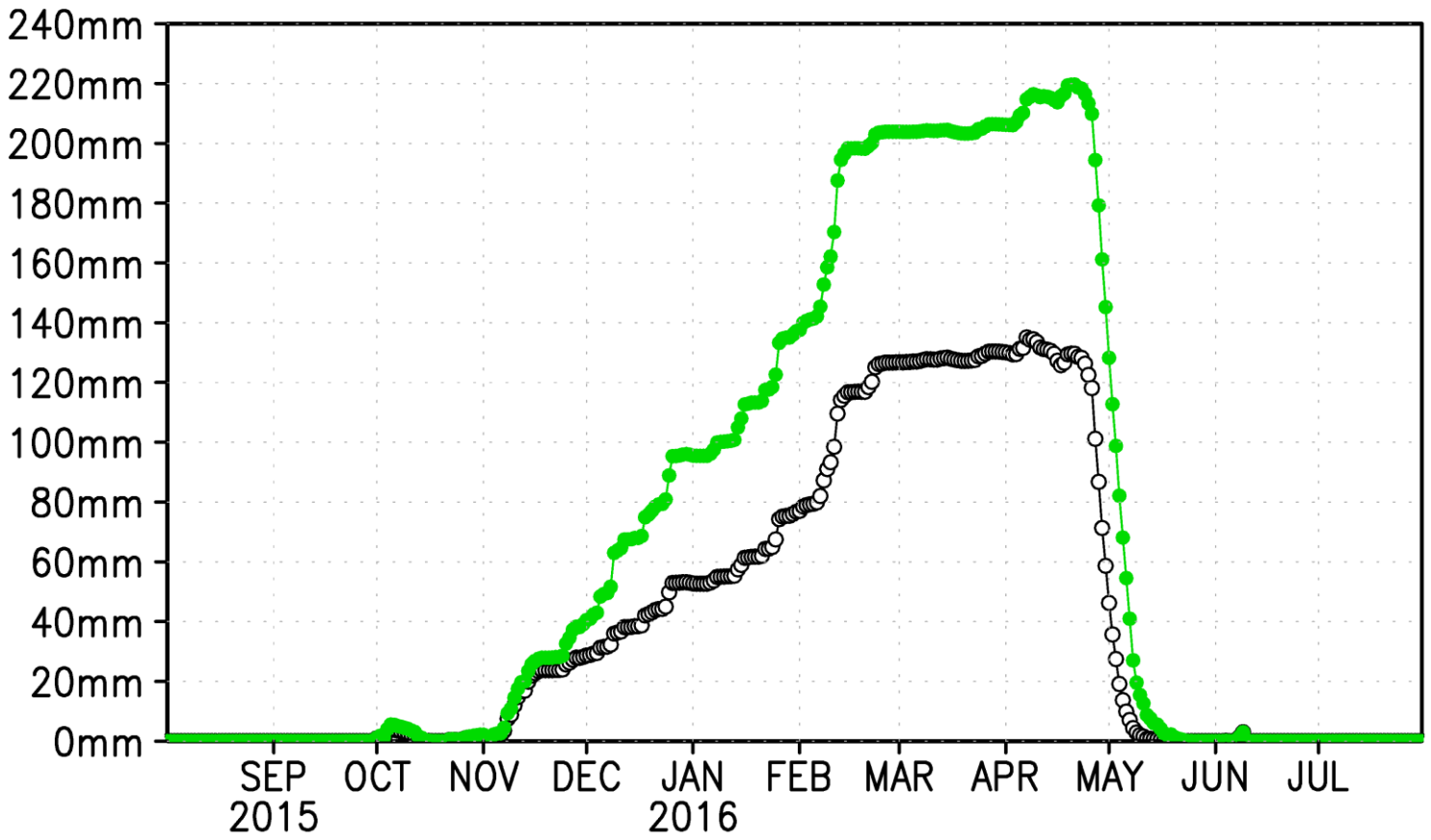
VARYING TOPOGRAPHY AND VEGETATION





- Elevation between 110-718 m
- Mostly uninhabited wilderness
- Vegetation mostly coniferous (56 %), scattered short-conifer (12 %), and wetland (11 %)

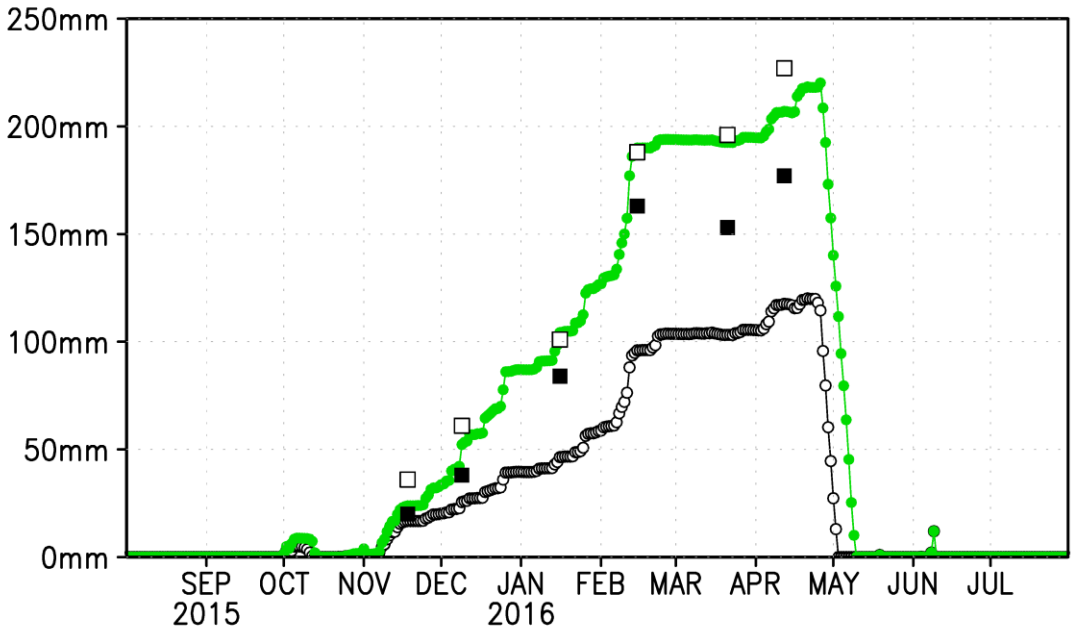
ASSIMILATION AFFECTS THE AMOUNT AND THE TIMING OF SNOW



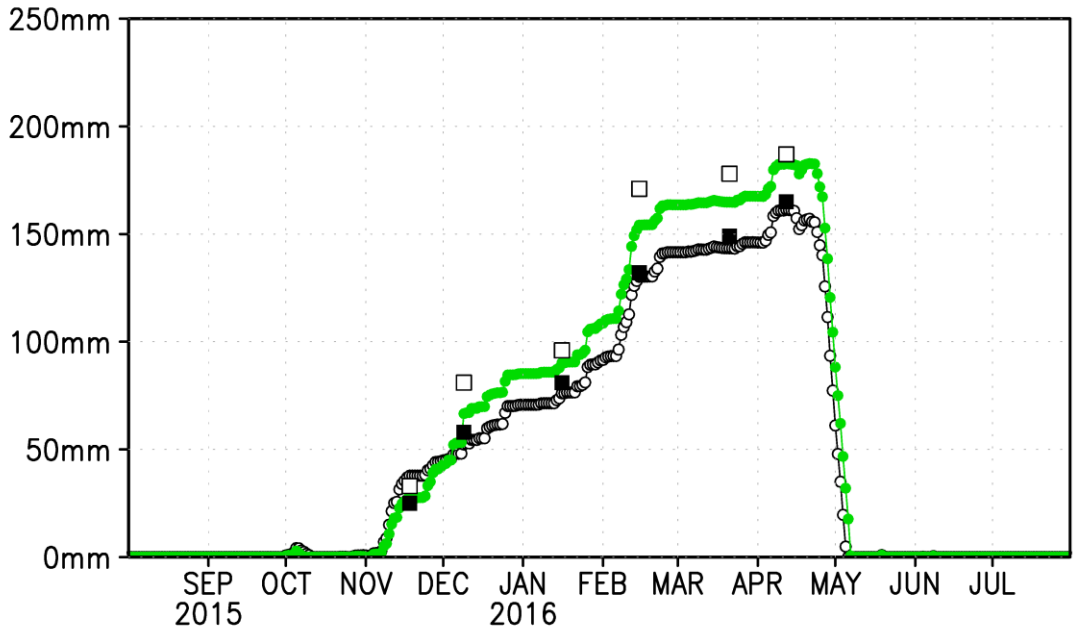
- Black: original run
- Green: assimilation

- Domain-averaged SWE
- Shift in the timing of the maximum SWE

ASSIMILATION GUARANTEES CORRECT SWE RESULTS

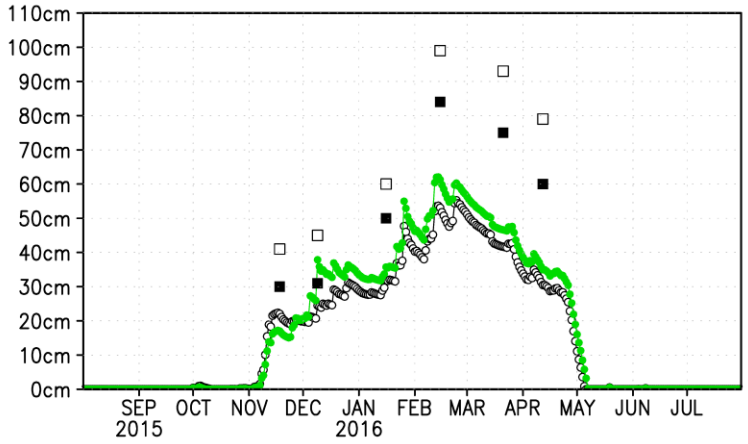


Snow course in Laanioja

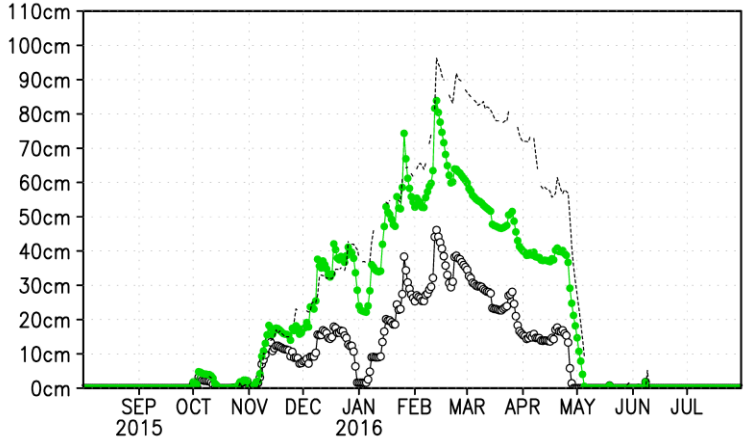


Snow course in Vuotso

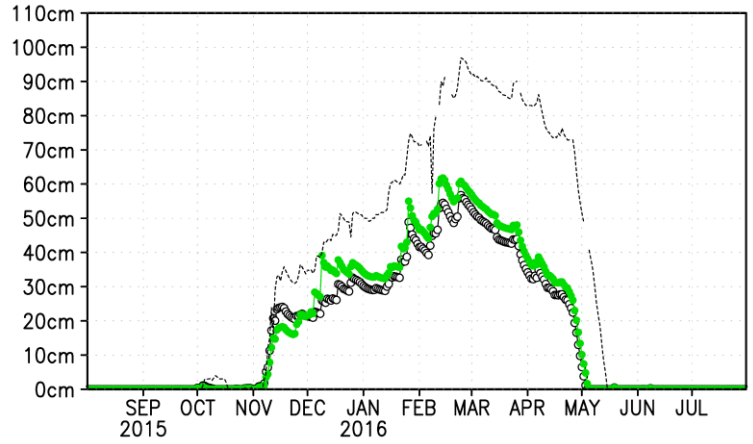
POOR ACCURACY OF SNOW DEPTH



← Snow depth at the snow course in Laanioja

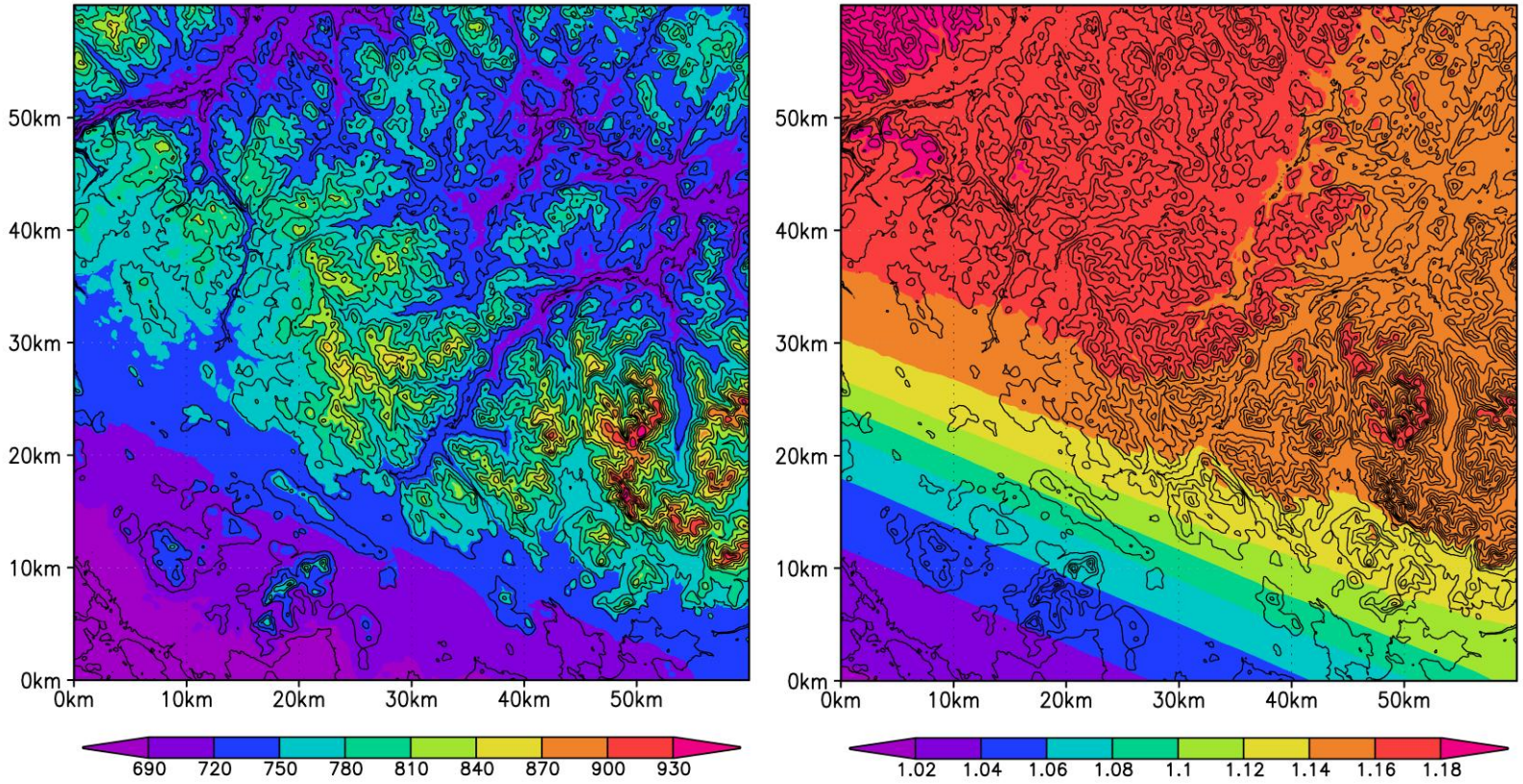


← Snow depth at the AWS in Saariselkä Kaunispää



Above: Snow depth at the AWS in Vuotso

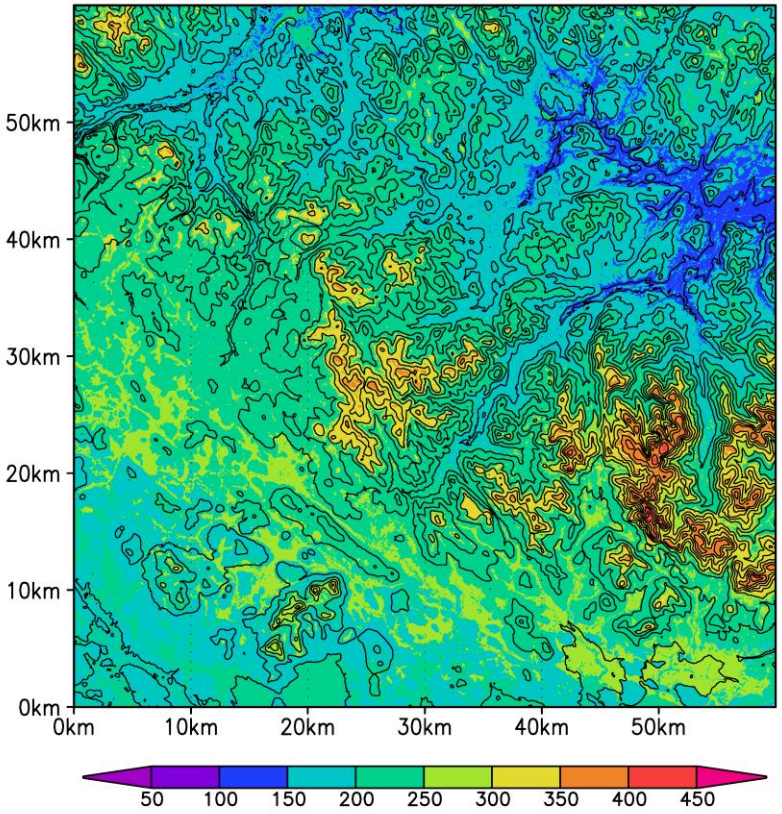
OBSERVED WINTER PRECIPITATION INADEQUATE



Left: Summed precipitation

Right: Ratio of simulated precipitation to interpolated observed precipitation

SIMULATED SWE FOLLOWS TOPOGRAPHIC AND VEGETATION RELATIONS



- End-of-winter SWE distribution on April 21, 2016

INDIVIDUAL SNOWFALL EVENTS ARE WELL SIMULATED

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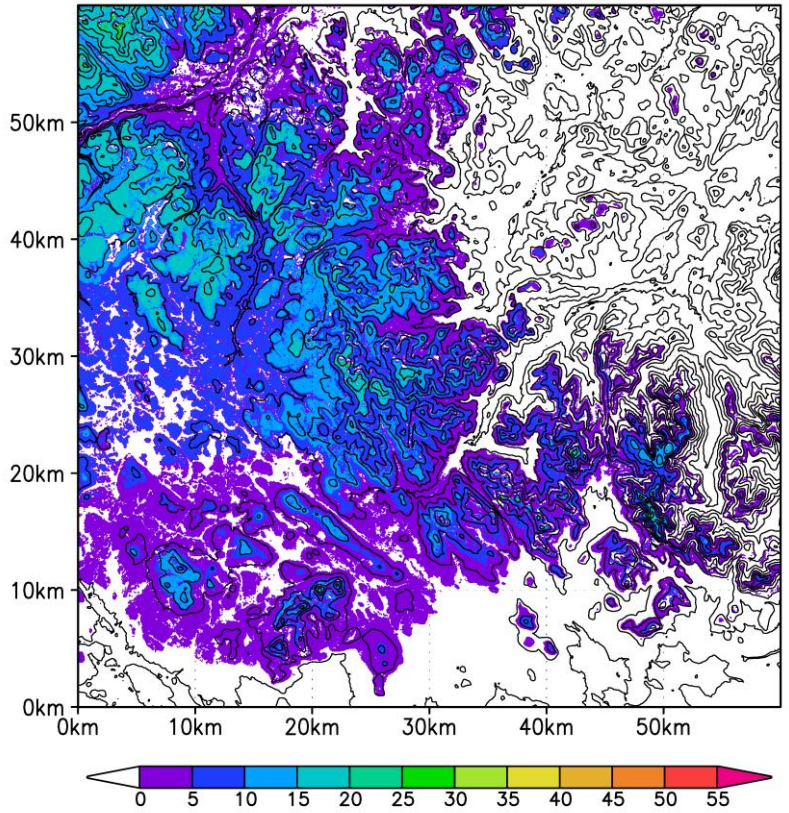
UUTISET > NEWS

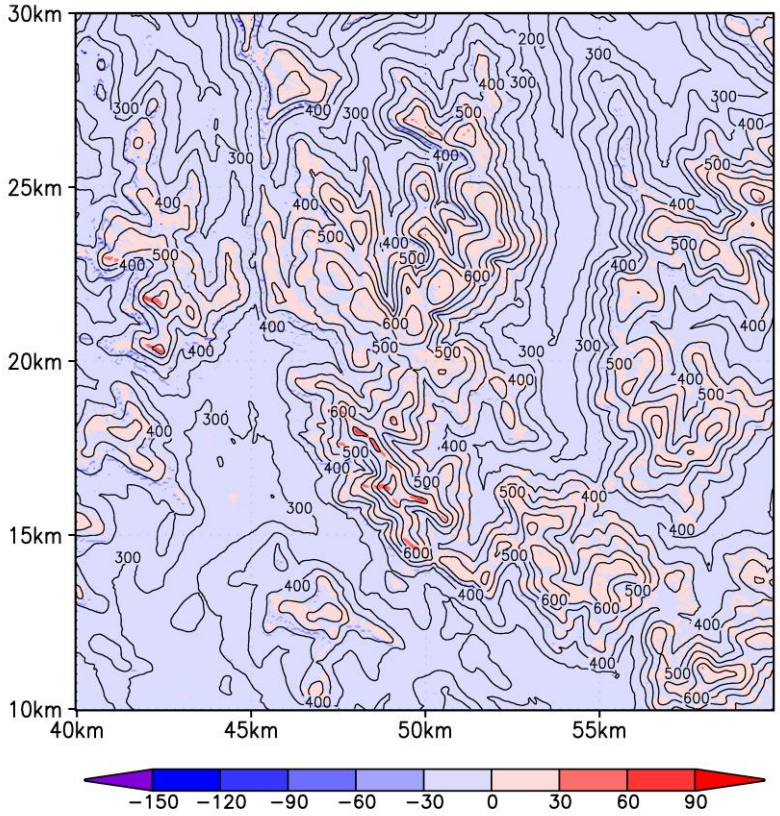
News 9.6.2016 9:42 | updated 16.11.2016 9:38

Storm cuts power to 1000s, brings snow to Lapland

A storm with high winds which swept across western and northern Finland Wednesday night and during the early hours of Thursday downed trees and cut power supplies to up to 14,000 households. Parts of Finnish Lapland have also seen a "summery" eight centimetres of snow.

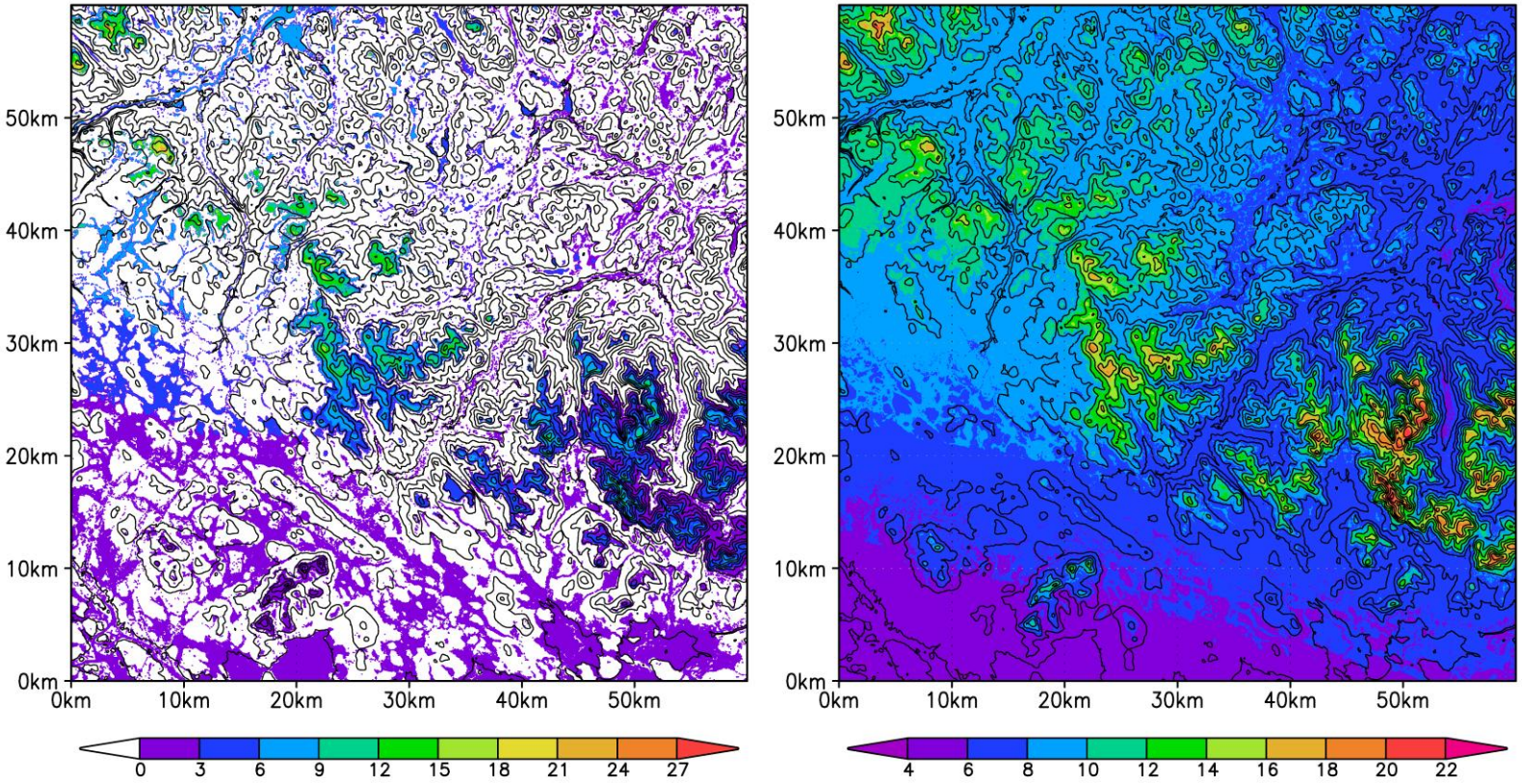


WIND-TRANSPORT ALONG THE DOMINATING WIND DIRECTION SW



- Summed blowing-snow transport

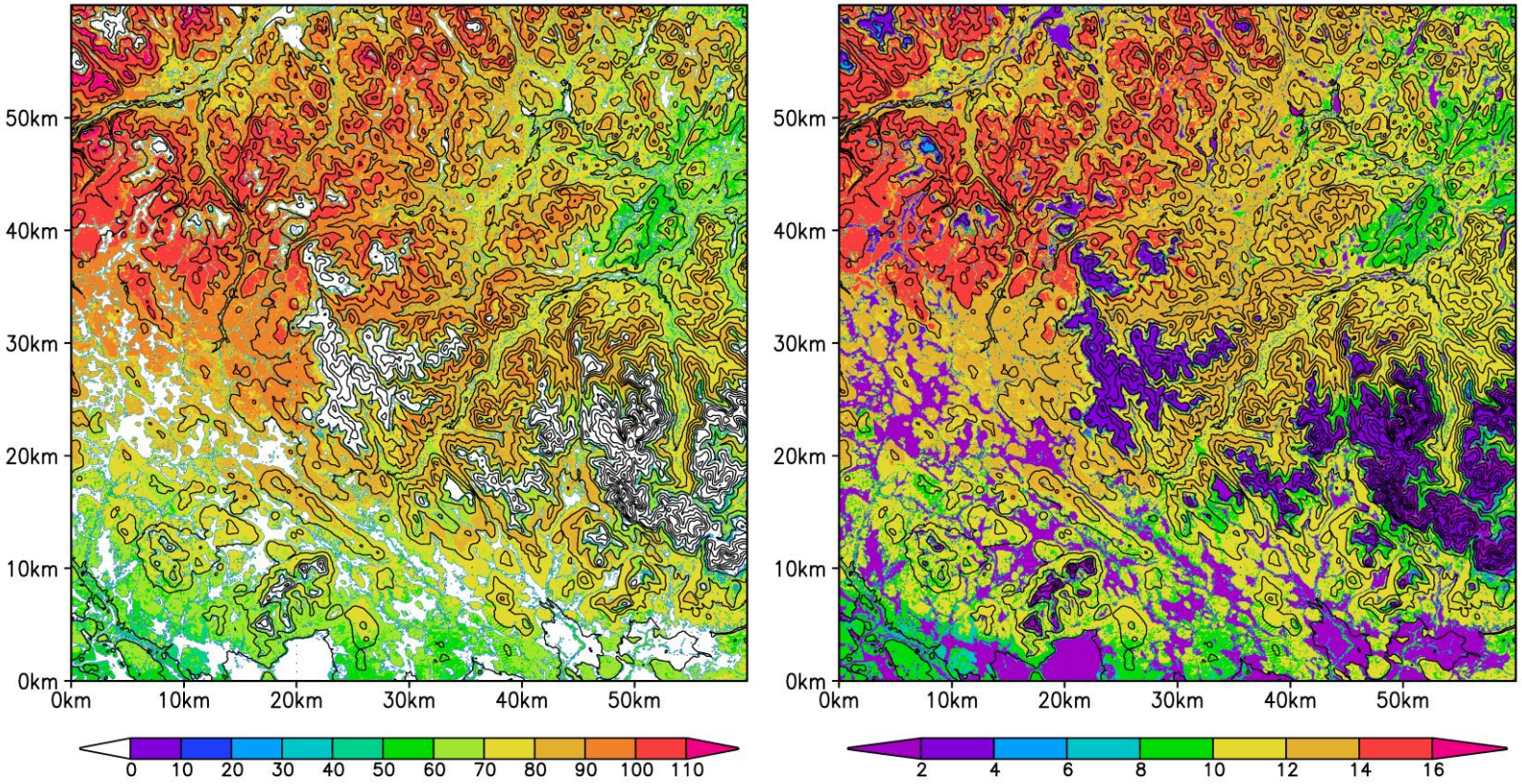
TWO-PHASED SUBLIMATION



Left: Summed blowing-snow sublimation

Right: Summed static-surface sublimation

UP TO 16 % OF THE PRECIPITATION RETURNED TO THE ATMOSPHERE



Left: Summed canopy-intercepted snow sublimation

Right: Summed sublimation-to-precipitation ratio

CONCLUSIONS AND FUTURE TASKS

- Simulation without assimilation underestimates the results
- Too dense snow: snow depth is not a reliable variable to assess model performance
- Model reproduces known topographical and vegetation dependencies on SWE distribution
- Timing of snow simulated rather well
- New estimate for snow sublimation: up to 16 % of annual precipitation
- Need of SWE assimilation could be decreased by more detailed input data and fine-tuning the hard-coded variables

- Sensitivity analysis
- Tailoring the hard-coded variables
- Fine-tuning densification

- …suggestions?