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GLOBSNOW RER-Meeting
Potential SWE Product

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J. Pulliainen

Finnish Meteorological Institute
(FMI)

General outline of the potential product

- Assimilation of available *in situ* information with radiometer data
  - Point-wise snow depth observations at synoptic weather station applied to estimate the regional behavior of the effective snow grain size of the snowpack
  - In case of “dense” in situ network SWE interpolated from ground stations provides an additional information source (weight depends upon the density of ground observations)
- Non-linear (Bayesian) statistical inversion approach applied
  - Non-linear modeling of space-borne observed brightness temperature with the HUT snow emission model
  - Use of physical model enables the direct implementation to different instruments
- Up-to-date algorithm validation experiments carried out for northern Eurasia and Finland

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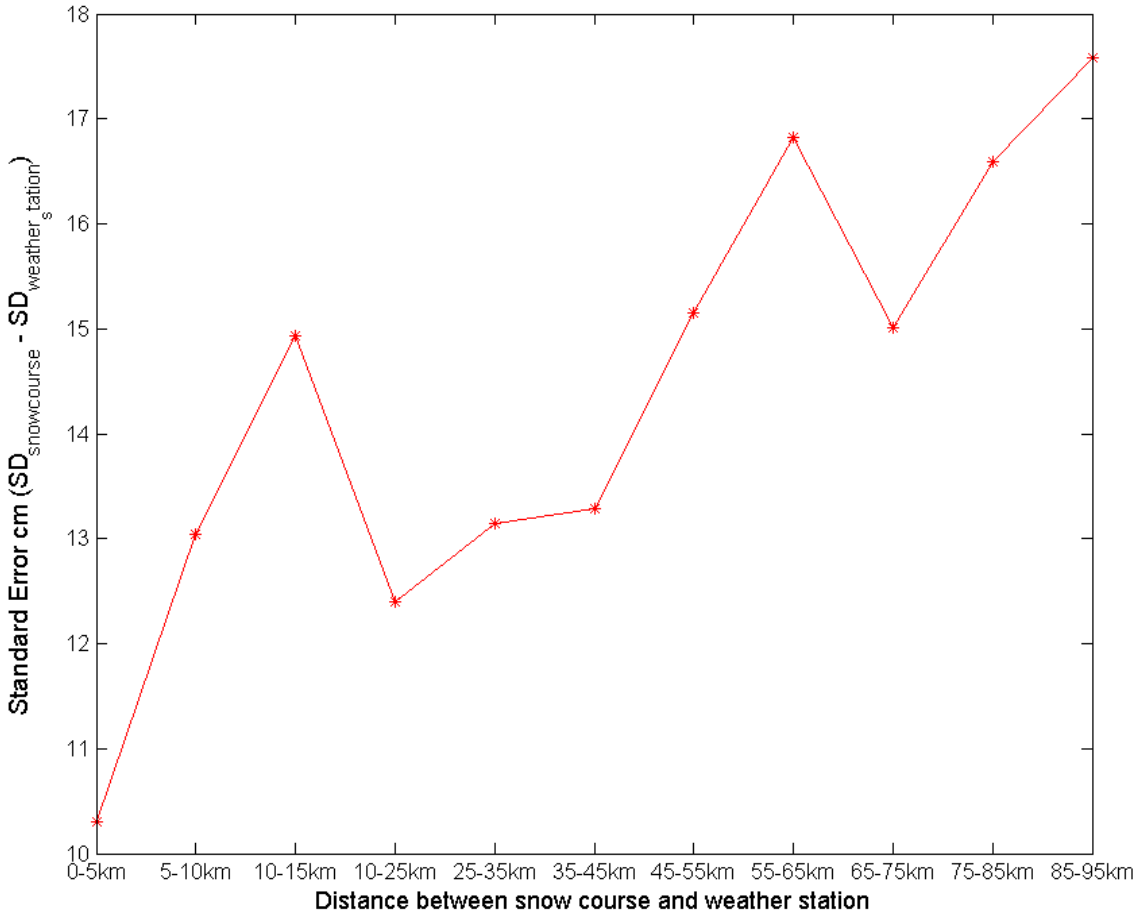
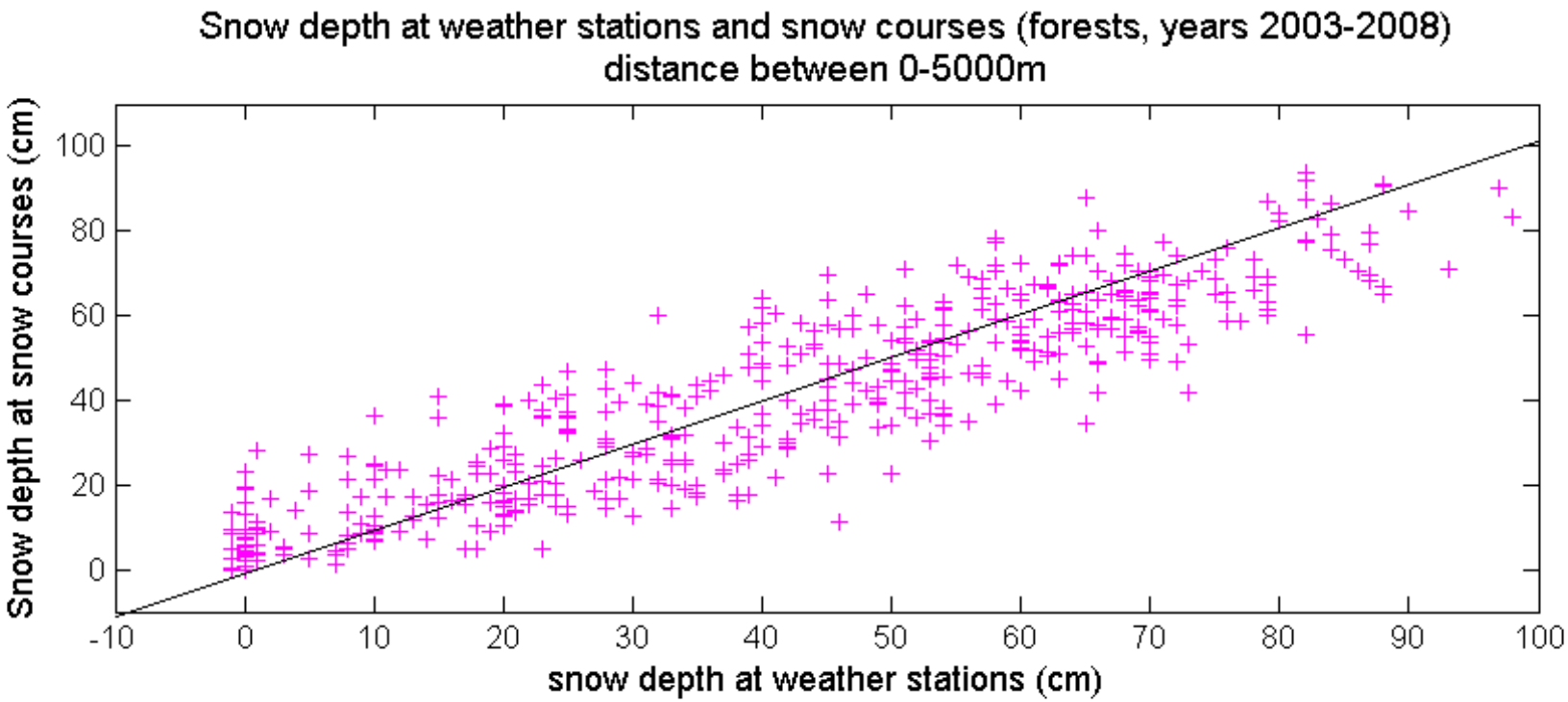
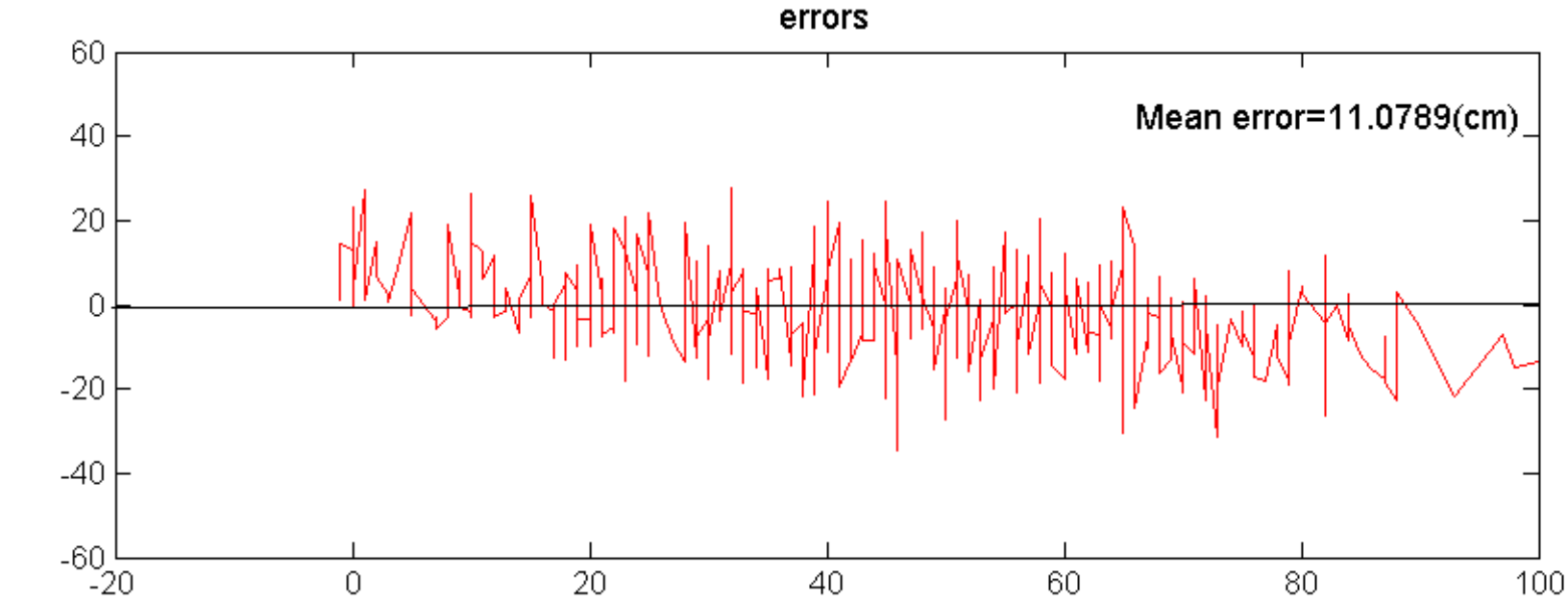
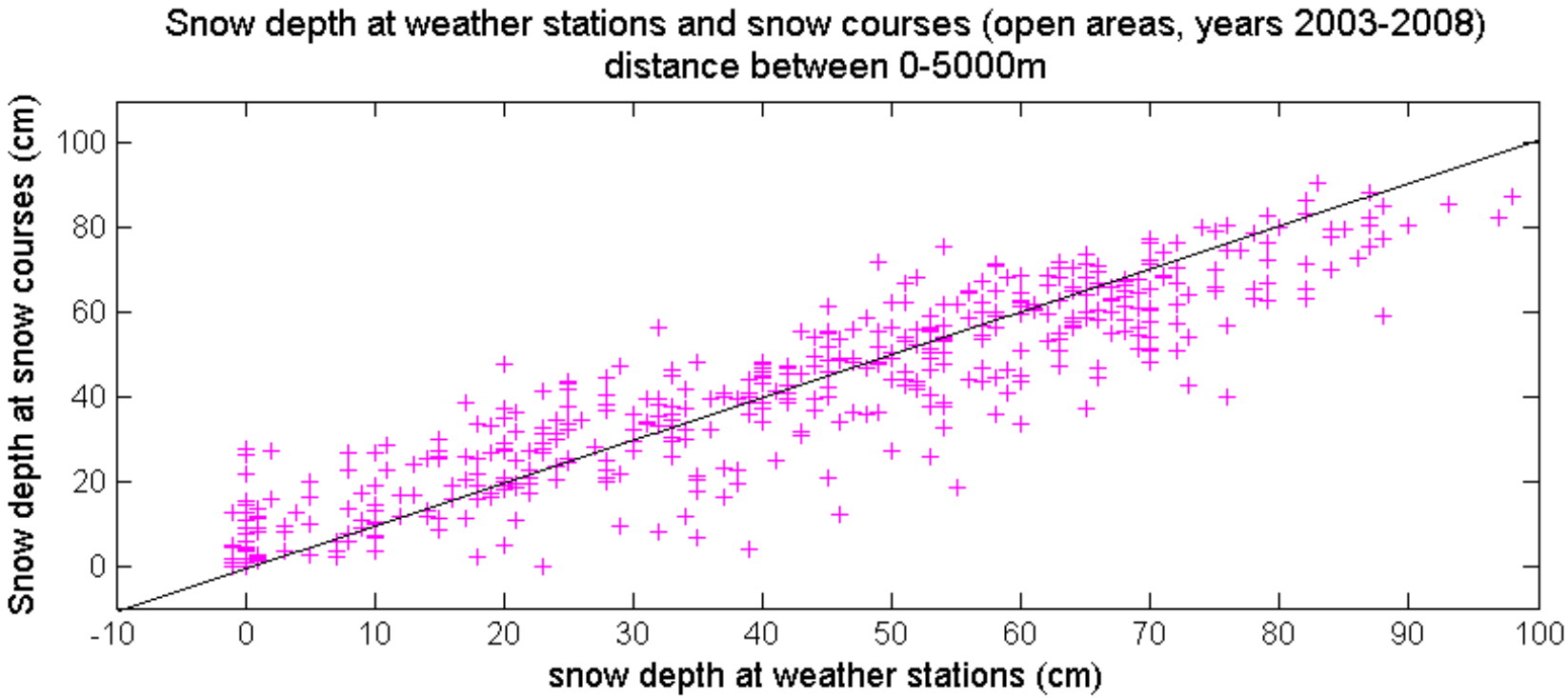
How well does a point-wise snow depth observation reperesent a regional value at the same location or further away?

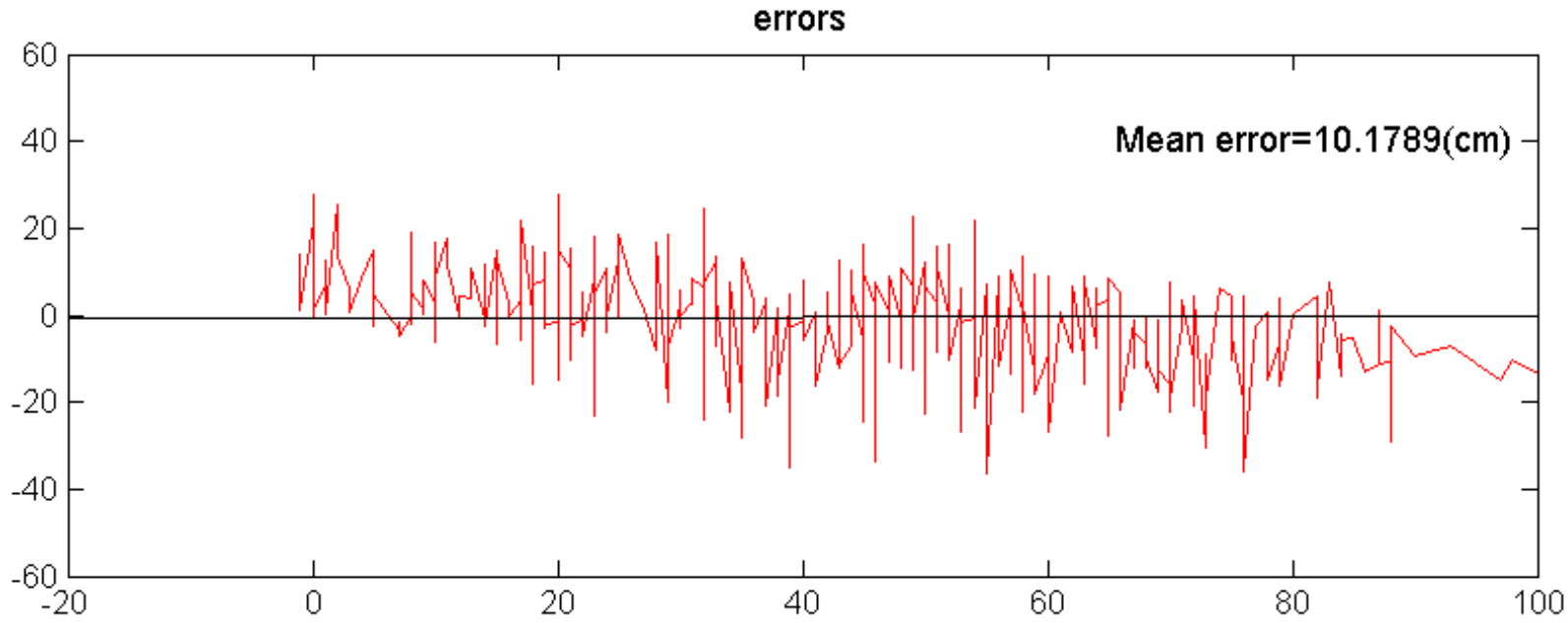
- Test case the whole region of Finland




Snow depth at weather stations and snow courses (forests, years 2003-2008)
distance between 0-5000m
Snow depth at snow courses (cm)
snow depth at weather stations (cm)
100
80
60
40
20
0
-10
0
10
20
30
40
50
60
70
80
90
100


errors
Mean error=11.0789(cm)
60
40
20
0
-20
-40
-60
-20
0
20
40
60
80
100

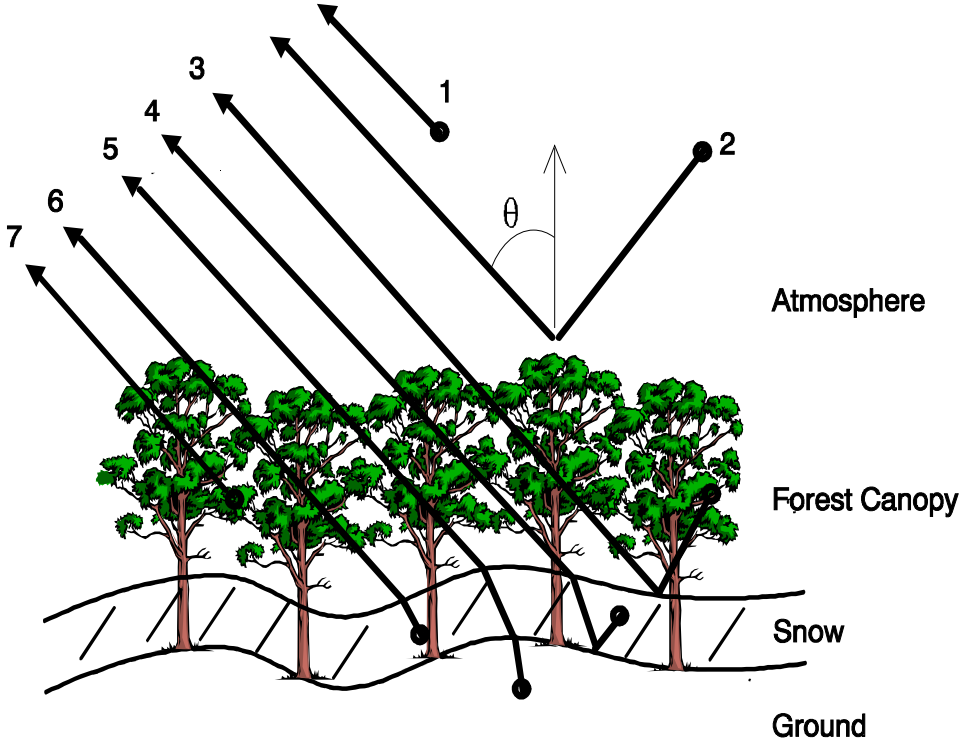

Snow depth at weather stations and snow courses (open areas, years 2003-2008)
distance between 0-5000m
Snow depth at snow courses (cm)
snow depth at weather stations (cm)
100
80
60
40
20
0
-10
0
10
20
30
40
50
60
70
80
90
100


errors
Mean error=10.1789(cm)
60
40
20
0
-20
-40
-60
-20
0
20
40
60
80
100

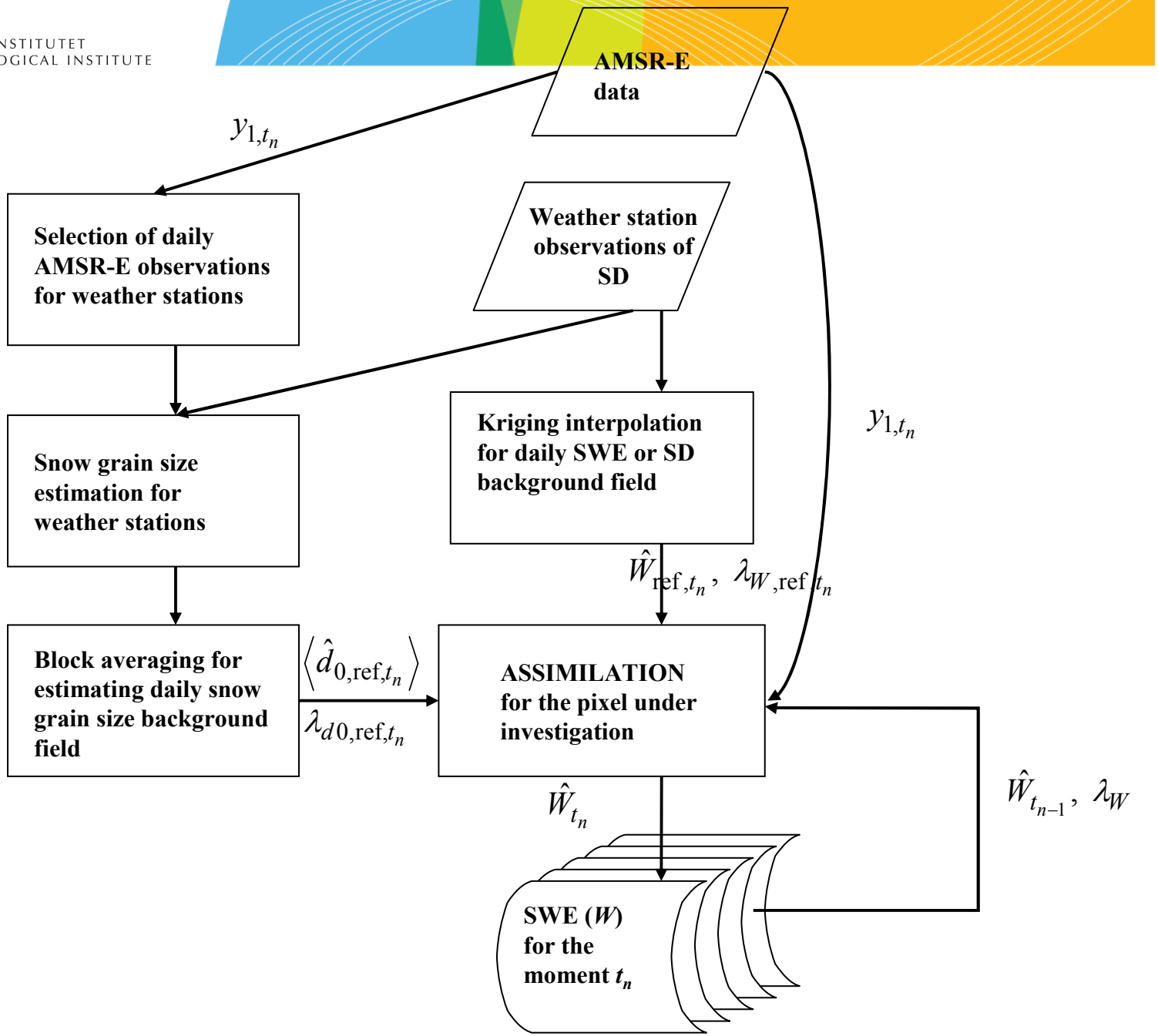
HUT snow emission model

- Background
  - Semi-empirical model simple enough to be used for parameter retrieval from space-borne or airborne data

- Basic characteristics
  - Scalar radiative transfer model for single snow layer
  - Semi-empirical formulas for snow permittivity and extinction coefficient
  - Empirical coefficient for radiation contribution scattered in snow layer
  - Incoherent approach used for medium boundary effects
  - Soil-snow reflectivity by empirical soil emission models
  - Empirical formulas for atmospheric and forest cover effect



Reference: Pulliainen, J., Grandell, J., and Hallikainen, M. (1999), HUT snow emission model and its applicability to snow water equivalent retrieval. *IEEE Transactions on Geoscience and Remote Sensing*, 37:1378-1390.


AMSR-E data
y_{1,t_n}
Selection of daily AMSR-E observations for weather stations
Weather station observations of SD
Snow grain size estimation for weather stations
Kriging interpolation for daily SWE or SD background field
y_{1,t_n}
$\hat{W}_{\mathrm{ref},t_n}$, $\lambda_{W,\mathrm{ref}\,t_n}$
Block averaging for estimating daily snow grain size background field
$\langle \hat{d}_{0,\mathrm{ref},t_n} \rangle$
$\lambda_{d\,0,\mathrm{ref},t_n}$
ASSIMILATION for the pixel under investigation
$\hat{W}_{t_n}$
$\hat{W}_{t_{n-1}}$, λ_W
SWE (W) for the moment t_n

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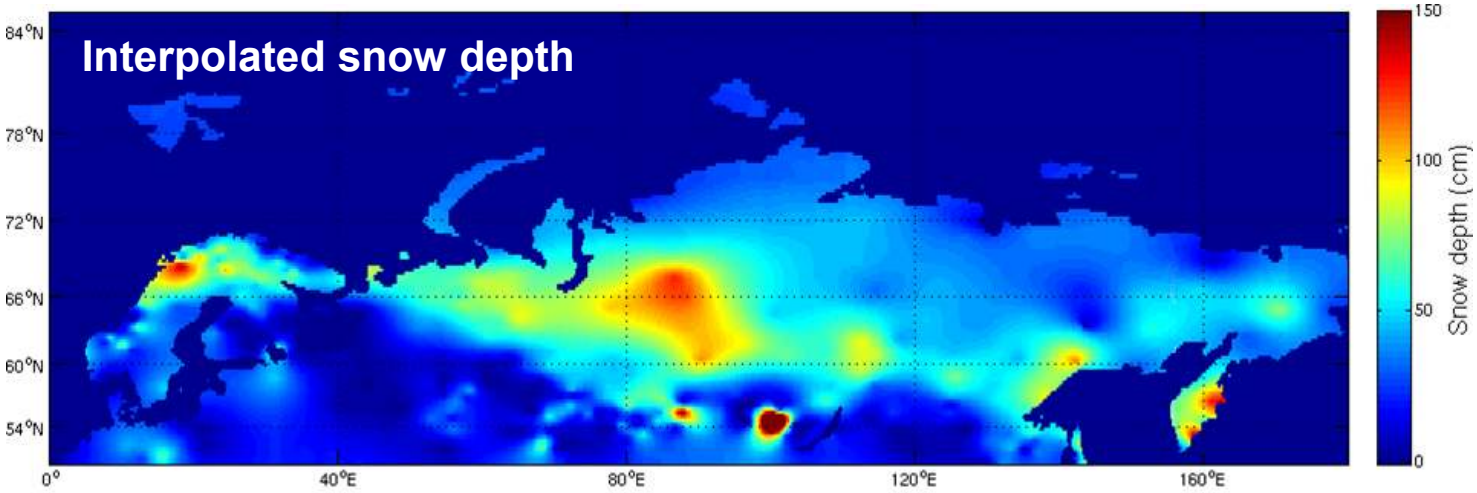
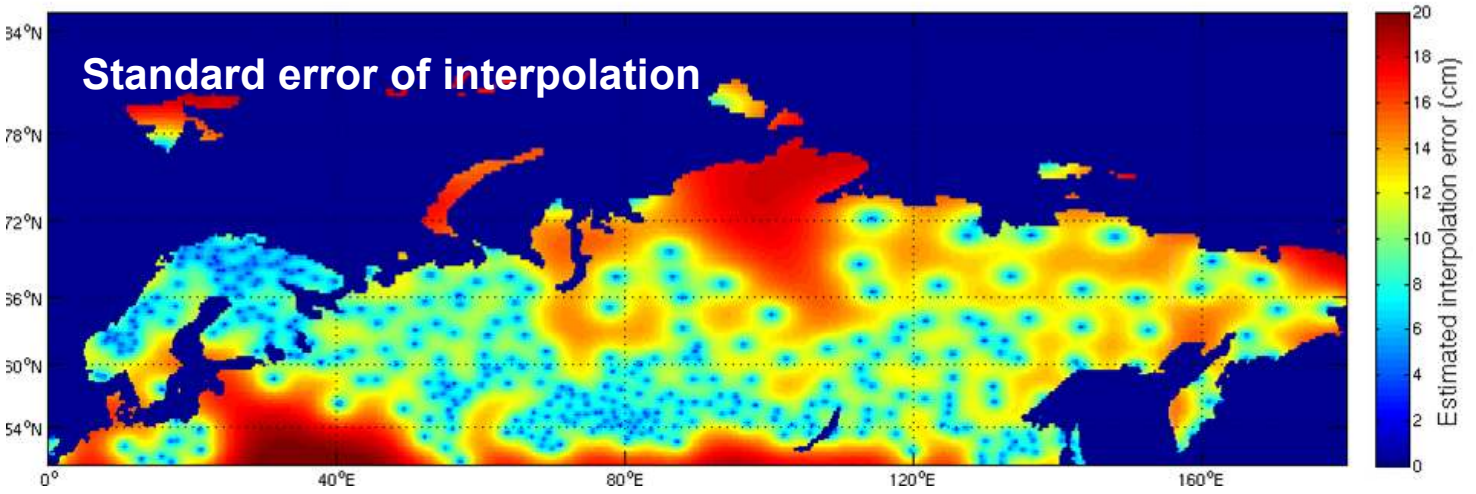
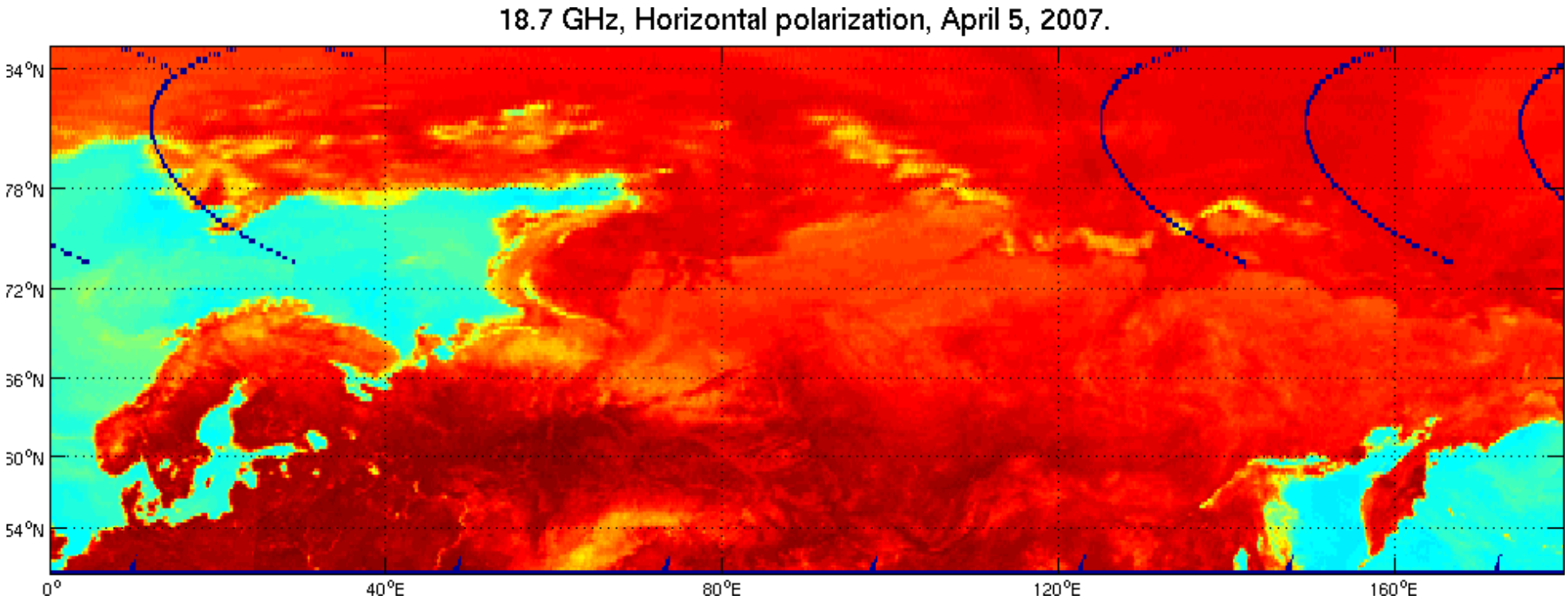
Example on ground data interpolation for April 5, 2007





- **Applied AMSR-E data for the same day: example on observations for a single channel**



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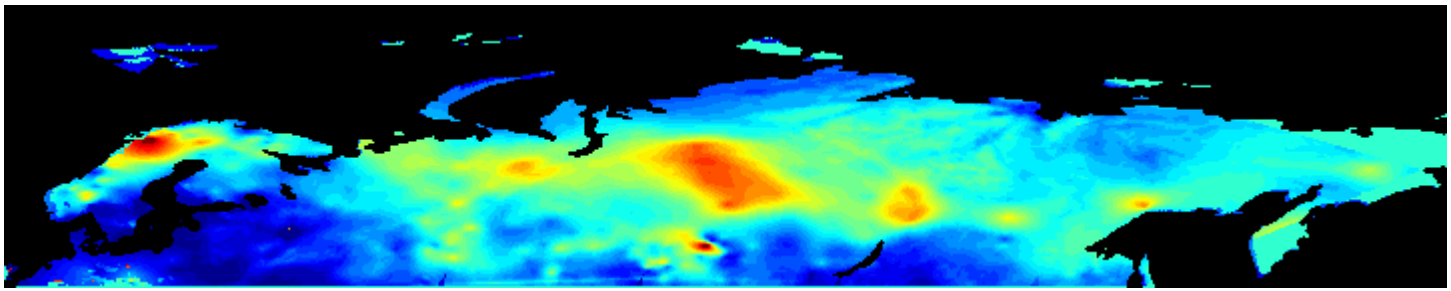
Polar View

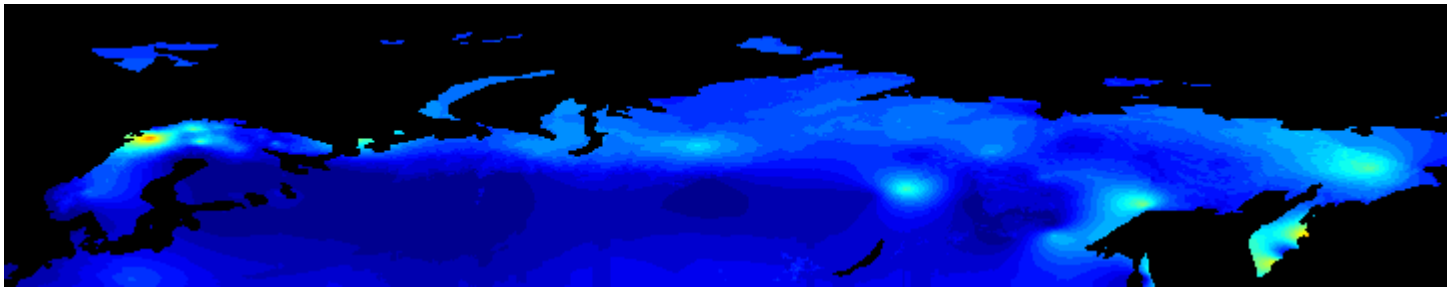
ASSIMILATION RESULT:

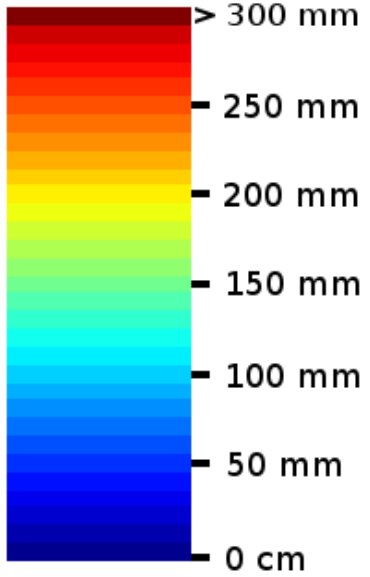
- Snow Water Equivalent and Snow Depth by assimilating AMSR-E microwave radiometer and synoptic weather station data
- Current ESA GMES PolarView Service of FMI:
  Northern Eurasian Snow Monitoring

8.3.2007



30.4.2007





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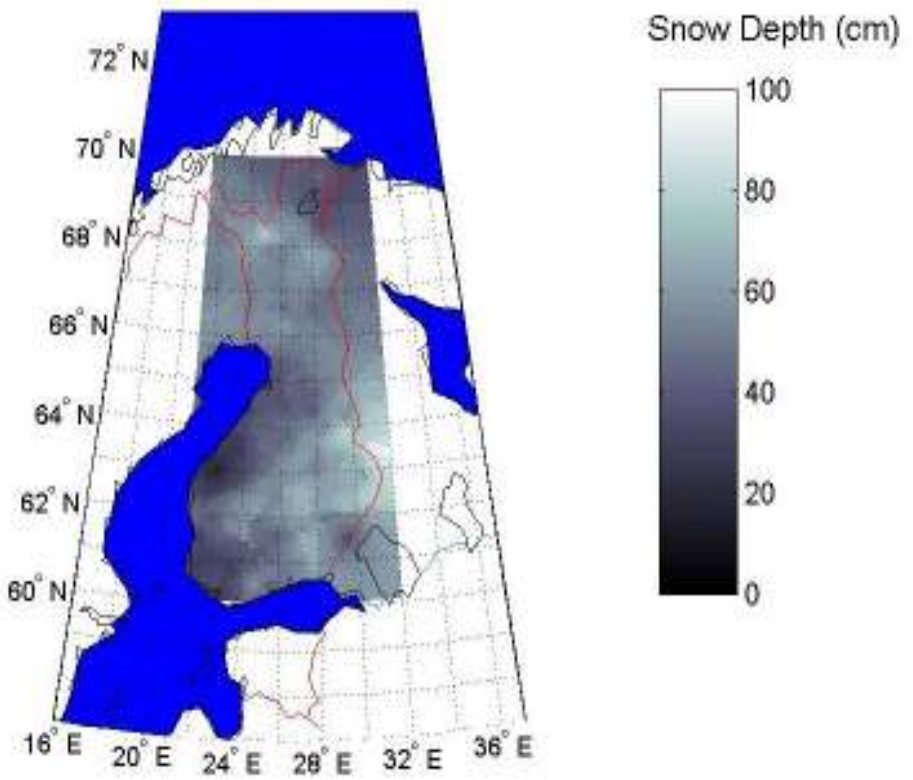
Snow water equivalent (SWE) and snow depth (SD) estimates from satellite microwave radiometer data

Technology: assimilation of satellite data with in situ observations (weather and hydrological stations)

Applications/end-users: hydrological models (e.g. floods), climate change studies, hydropower industry, weather forecasting, transportation

AMSR-derived snow depth for 2 Feb. 2004



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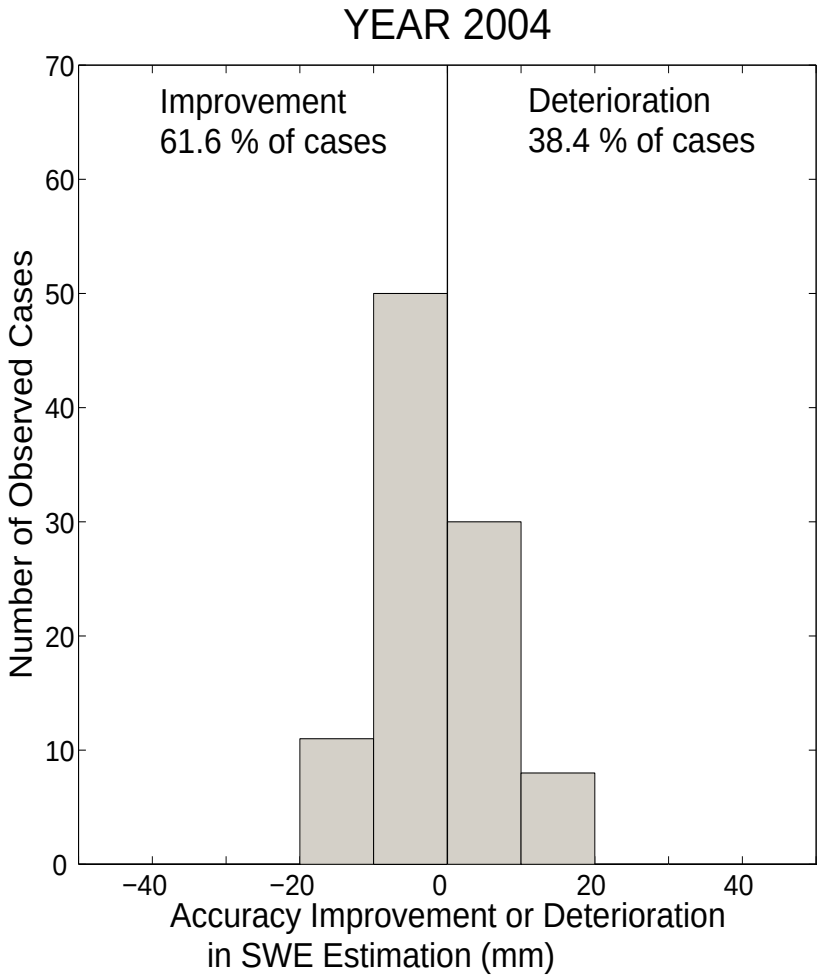
Performance of SWE estimation in Finland for Feb. 2004

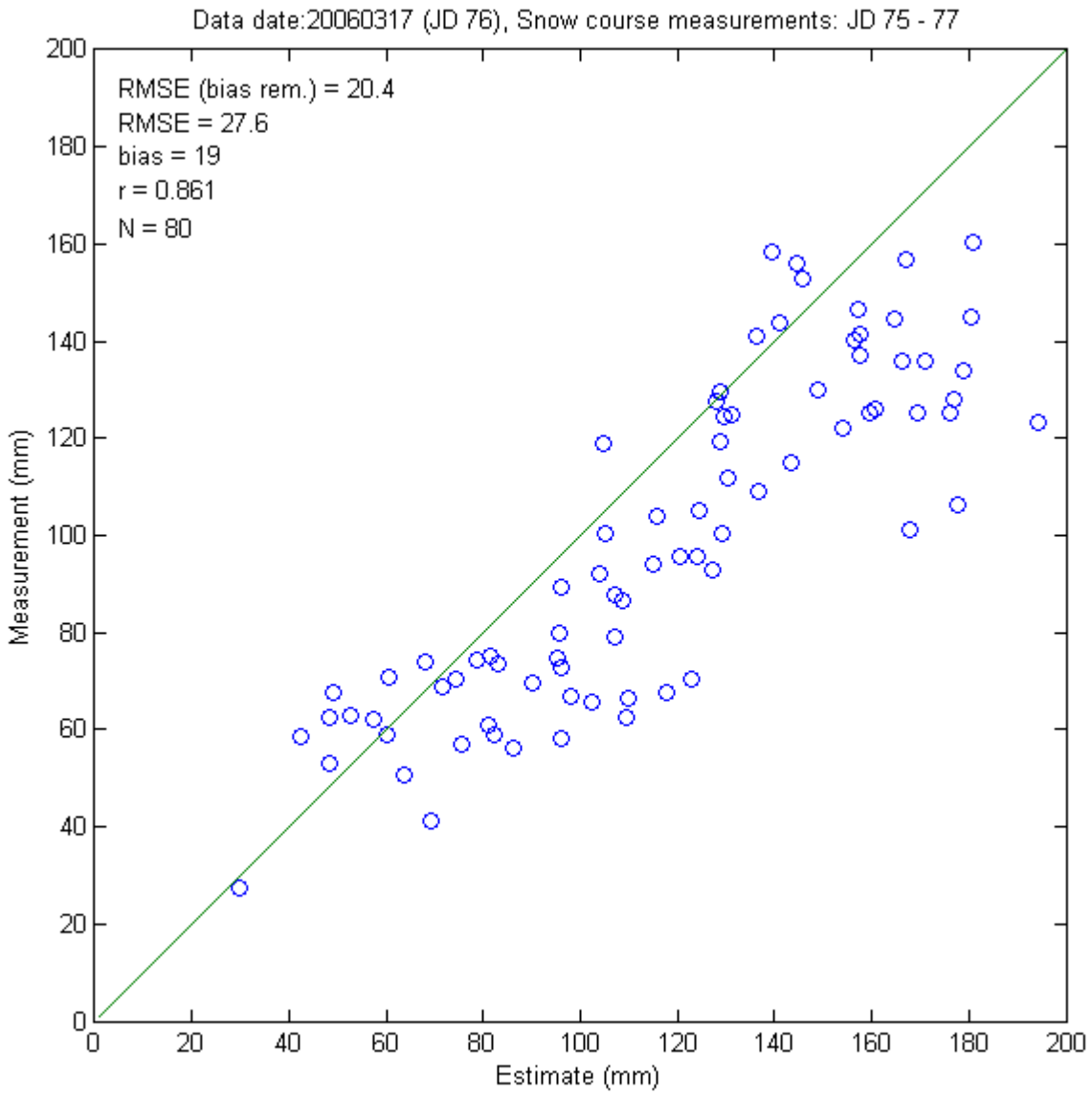
- **Histogram on the accuracy improvement for Feb. 2004:**
  - Test region: Finland
  - Areal SWE, SD and snow density values from the operative snow course network used as independent reference data (snow course length 2-4 km)



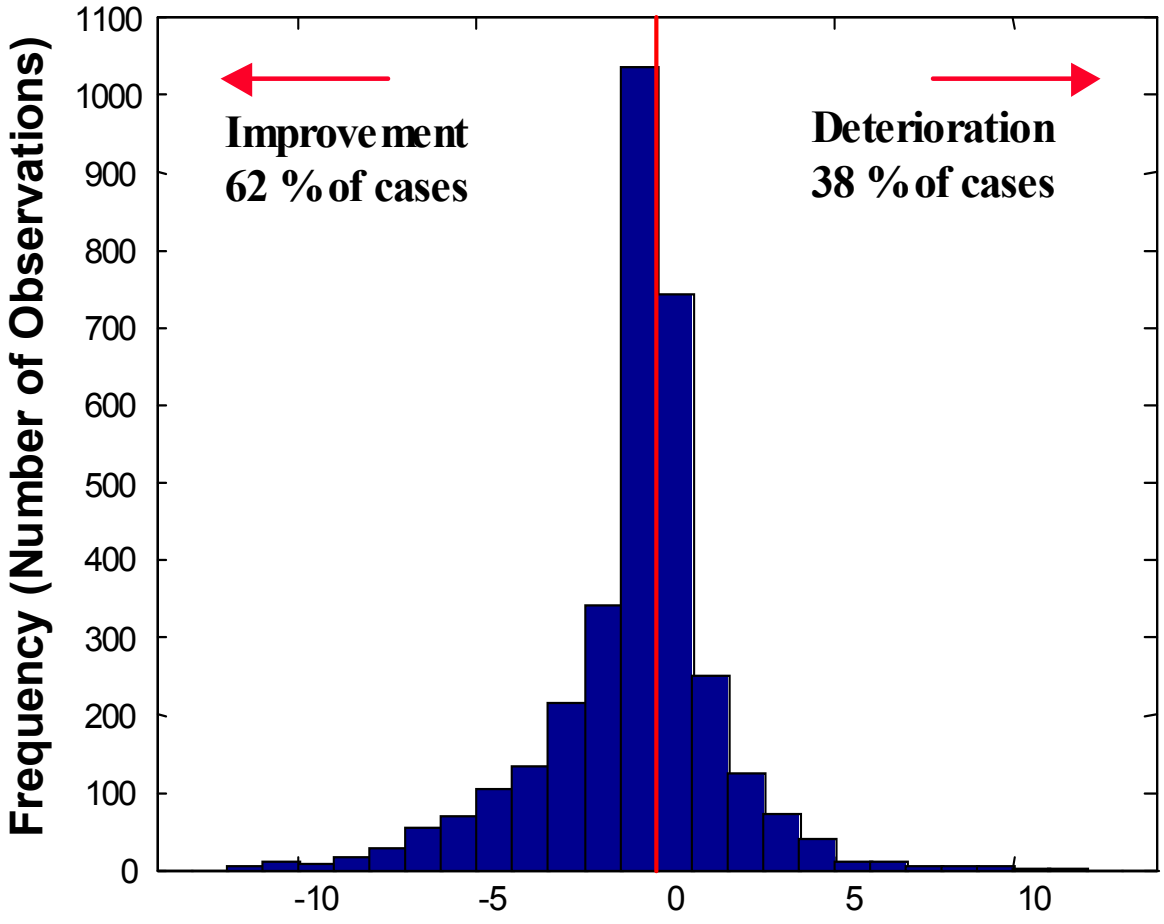
Reference: Pulliainen, J. (2006), Mapping of snow water equivalent and snow depth in boreal and sub-arctic zones by assimilating space-borne microwave radiometer data and ground-based observations. *Remote Sensing of Environment*, 101:257-269.

- Scatterplot of assimilation results for Finland

- Example for single day (March 17, 2007)
- Assuming a prefixed constant snow density (0.24 g/cm^3)



Histogram on the improvement obtained for test sites around Russia: Comparison of assimilation with interpolated ground data



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Scattergram of snow depth estimation results for North-West Russia

- Results for daily SSM/I observations without assimilation (inversion of HUT emission model with constant parameters without any *a priori* information)
- Nov. -93 to April -94
- Prefixed parameters:

density 0.25 g/cm^3

$\langle d_0 \rangle$ = 1.4 mm