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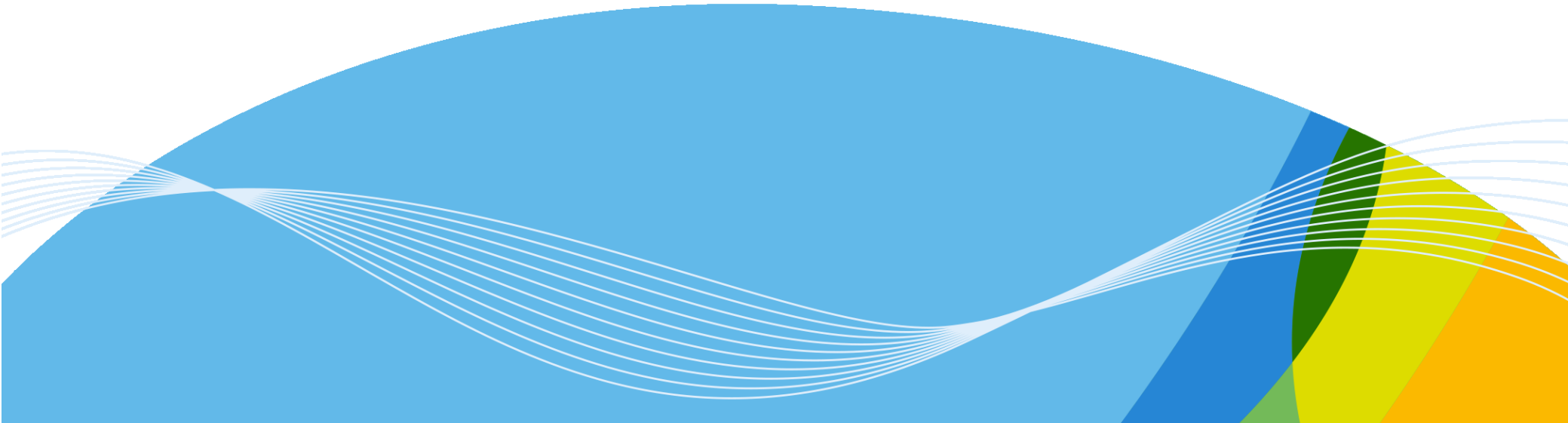
Setting the scene: experience from GlobSnow

J.Pulliainen, M. Salminen, Finnish Meteorological Institute (FMI)



ESA DUE GlobSnow project

- Production of **novel hemispherical Snow Extent** (SE) and **Snow Water Equivalent** (SWE) climate data records
- **Generation of long time series employing FMI supercomputing facilities** (daily, weekly and monthly maps of SE and SWE for northern hemisphere) **+ NRT processing**
- Consortium members:
  - Finnish Meteorological Institute (FMI) with ENVEO IT GmbH (Austria)
  - GAMMA Remote Sensing (Switzerland)
  - Norwegian Computing Center
  - Finnish Environment Institute (SYKE)
  - Environment Canada (EC)
  - Uni. Bern
  - MeteoSwiss
  - ZAMG
  - Norut

Details and products available at www.globsnow.info

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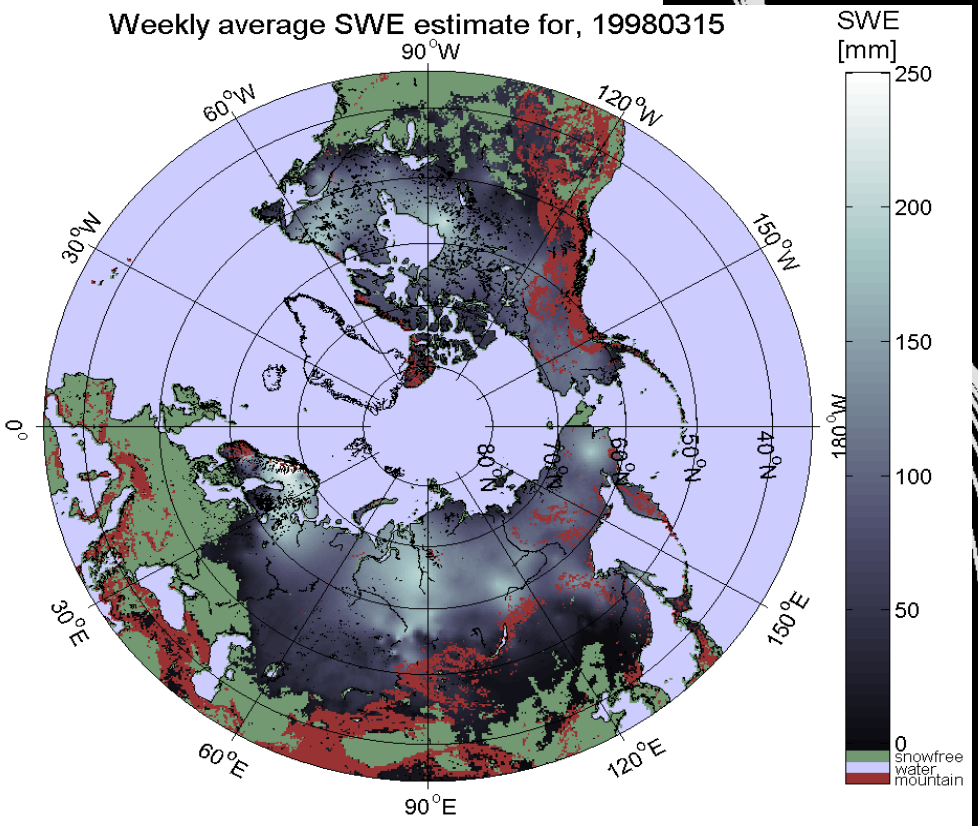
30 year-long CDR time series on snow conditions of Northern Hemisphere

- First time reliable daily spatial information on SWE (snow cover):
  - Snow Water Equivalent (SWE)
  - Snow Extent and melt (+grain size) 25 km resolution (EASE-grid)
  - Time series for 1979-2012
- Passive microwave radiometer data combined with ground-based synoptic snow observations
  - Variational data-assimilation
- Available at open data archive: www.globsnow.info
- Demonstration of NRT processing since October 2010 (Greenland, glaciers & mountains masked out)



Takala, M., Luojus, K., Pulliainen, J., Derksen, C., Lemmetyinen, J., Kärnä, J.-P, Koskinen, J., Bojkov, B., "Estimating northern hemisphere snow water equivalent for climate research through assimilation of spaceborne radiometer data and ground-based measurements", Remote Sensing of Environment, Vol. 115, Issue 12, 15 December 2011, doi: 10.1016/j.rse.2011.08.014

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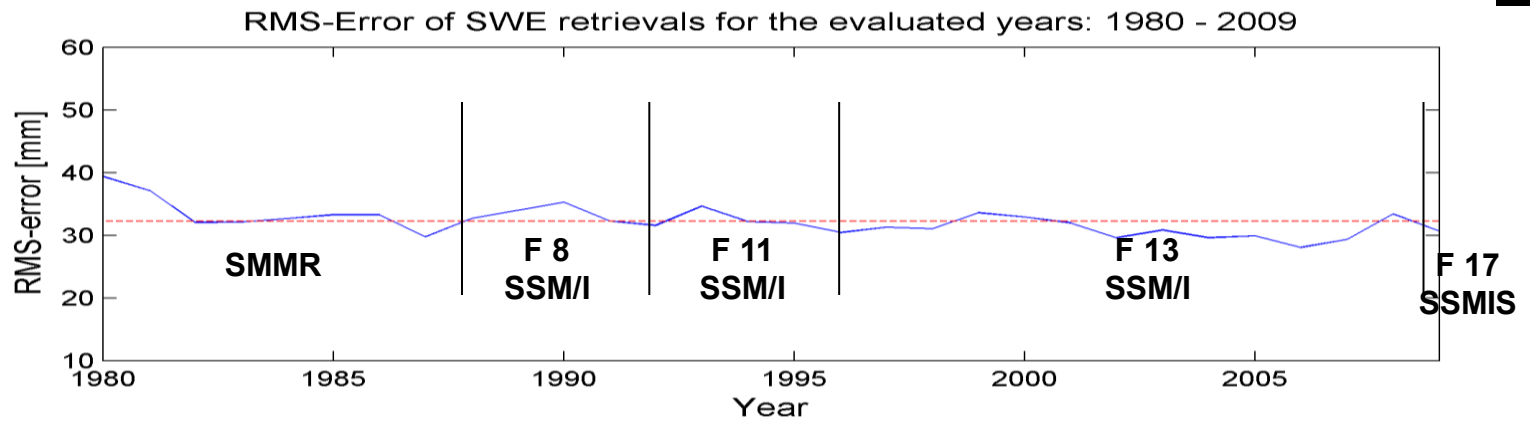
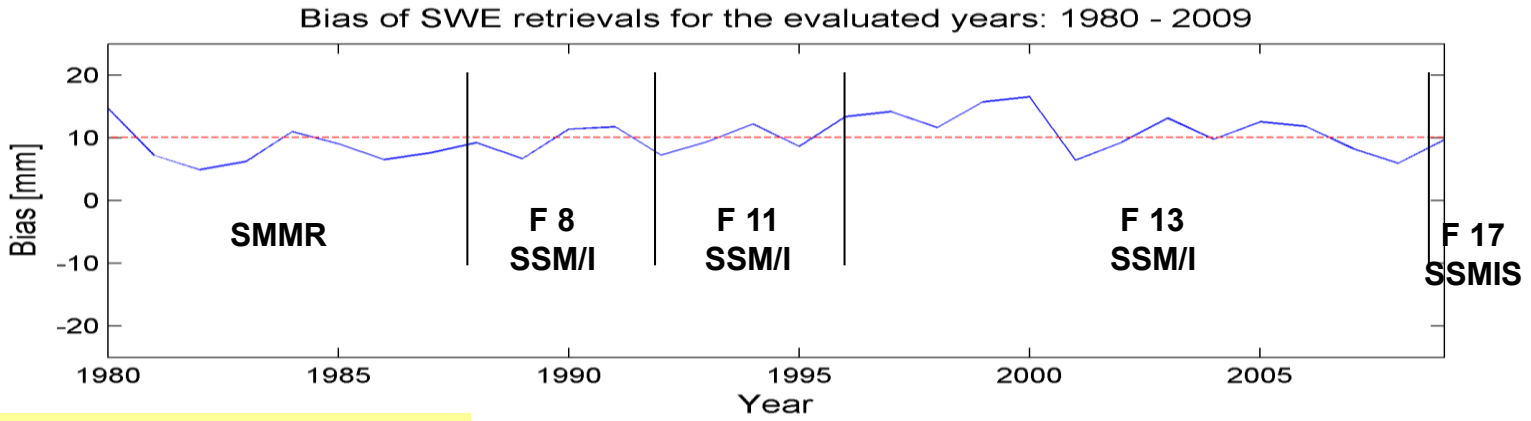
Long term consistency of SWE v2.0 FPS

- RMS error and retrieval bias calculated independently for each year 1980-200
- Reference data: snow courses from Russia (INTAS-SCCONE)





SWE<150 mm; 146.000 samples

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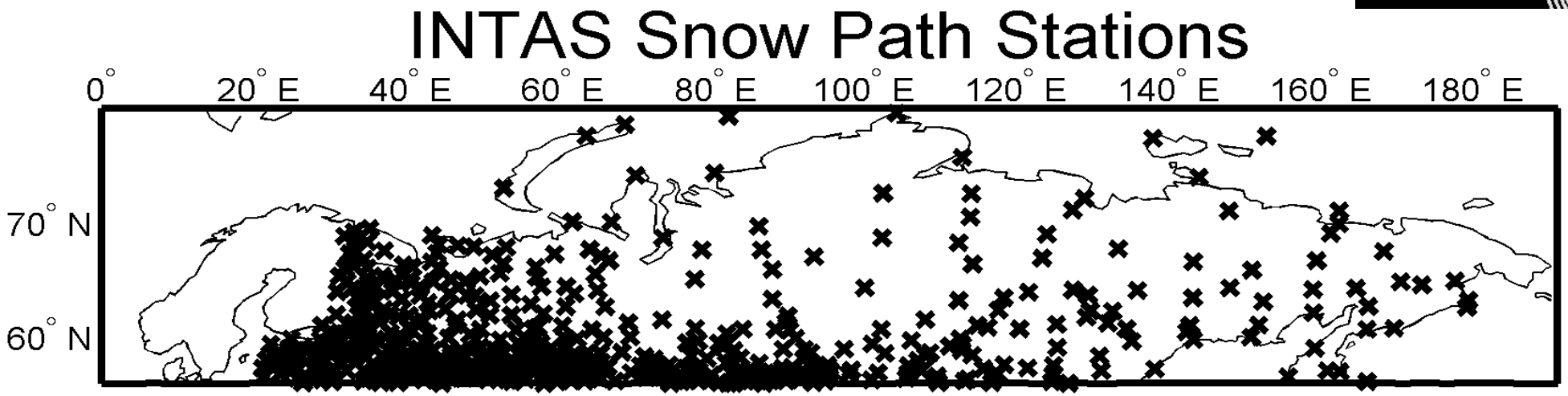
Validation – Northern Eurasia

Snow Survey data (from the former USSR and Russia)

- There are 500-1200 snow courses per year with data during 19
  - Manual ground-based measurements on Snow Depth/SWE
  - 1 - 2km snow courses, measurements every 100m - 200m
  - Time lag between observations from 5 to 30 days => 160 000 ob
  - http://meteo.ru/english/climate/snow1.php



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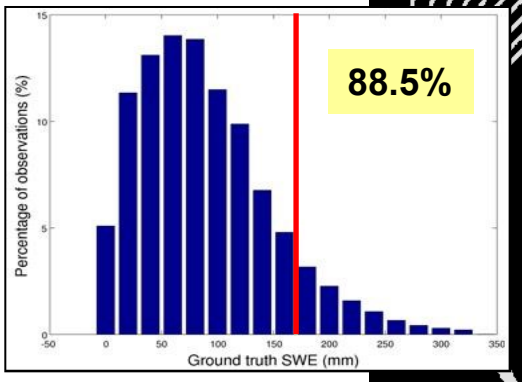
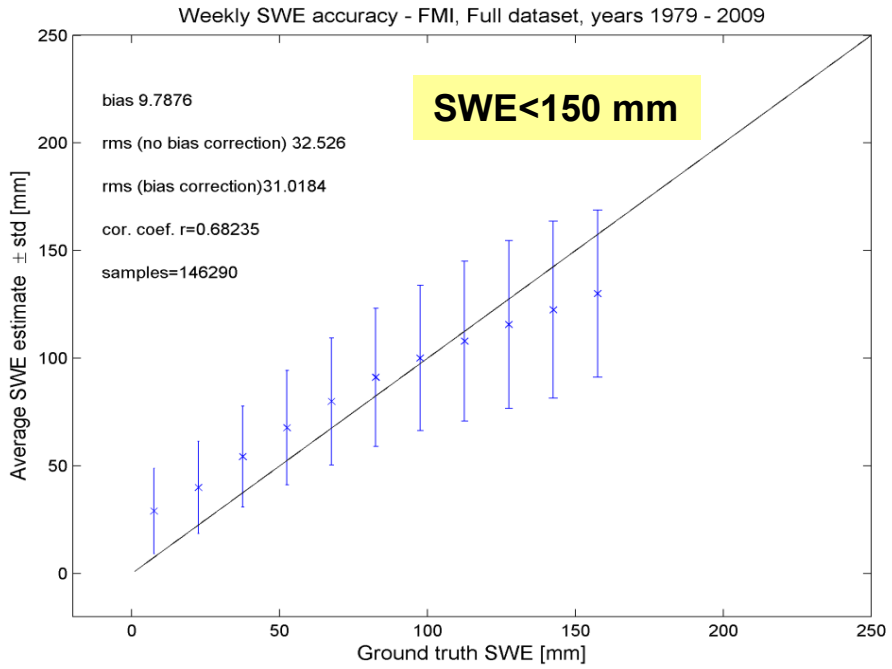
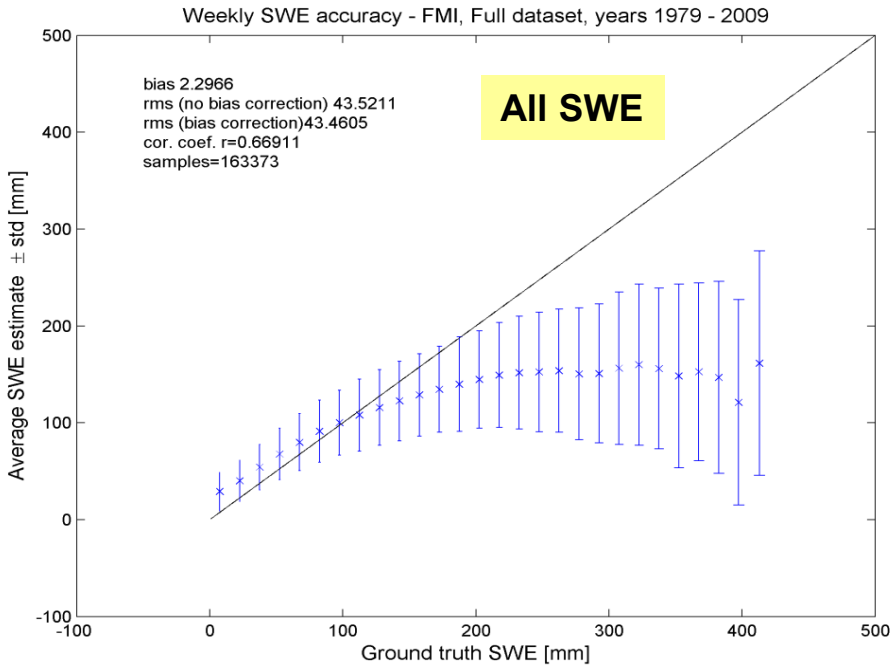
Algorithm Evaluation: Eurasia



Majority (88.5%) of seasonal SWE values fall below 150mm

- Based on INTAS SCCONE data from Russia, applicable for Eurasia





Bias +9.8 mm, RMS-error: 32.5 mm

Bias +2.3 mm, RMS-error: 43.5 mm

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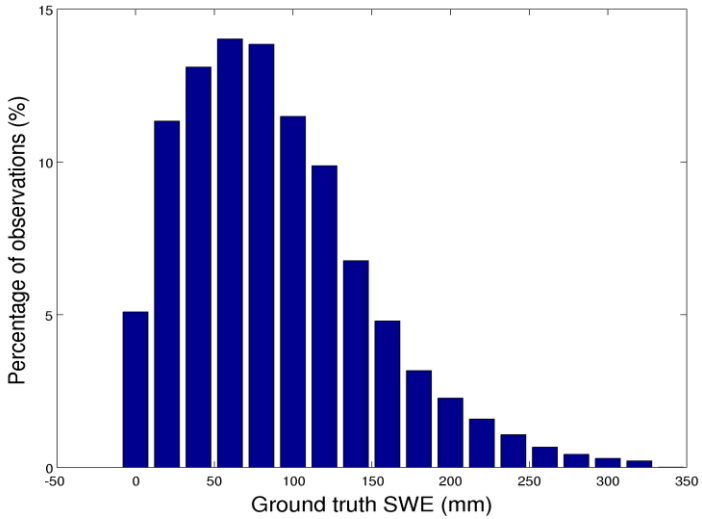
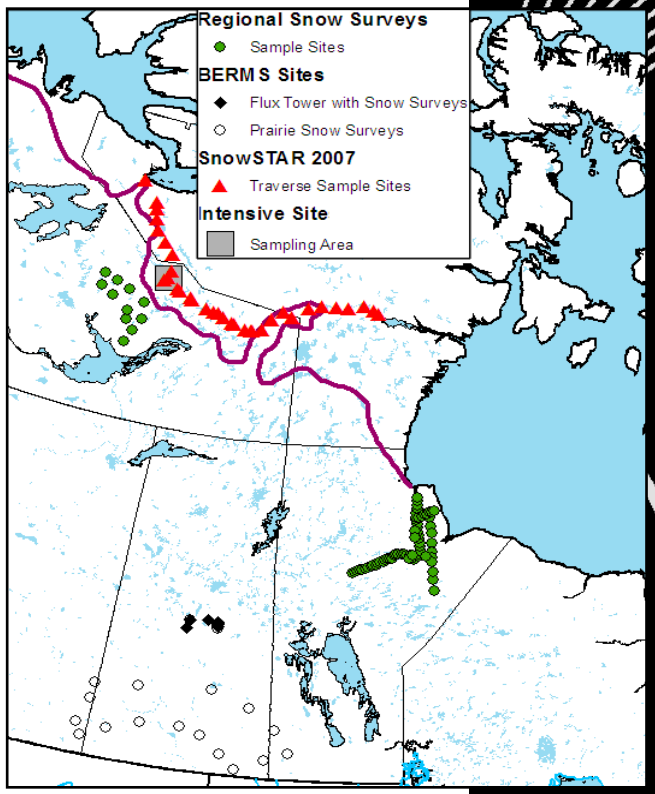
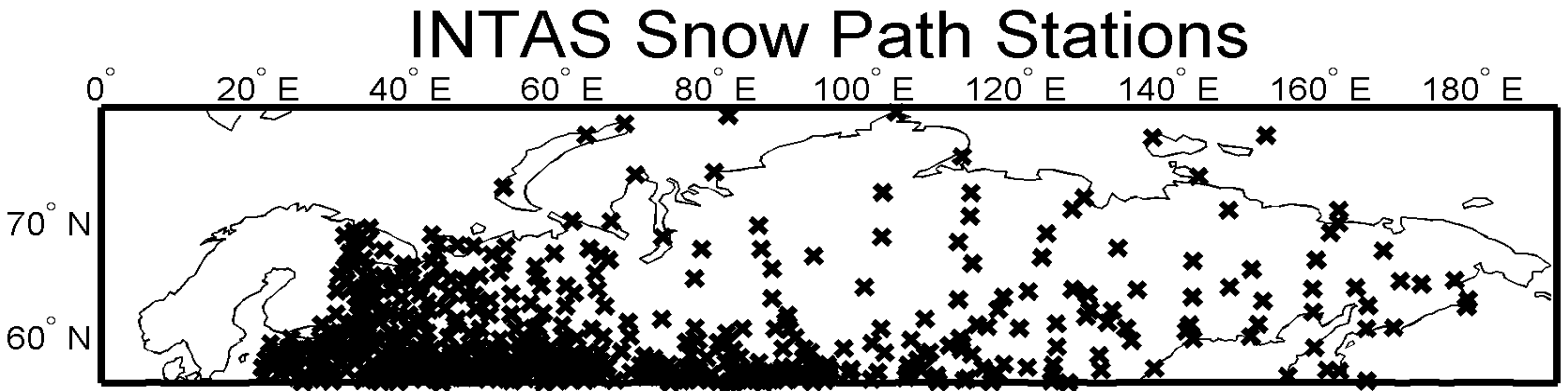
Investigation of the SWE retrieval accuracy for different regions and time periods using the available validation datasets







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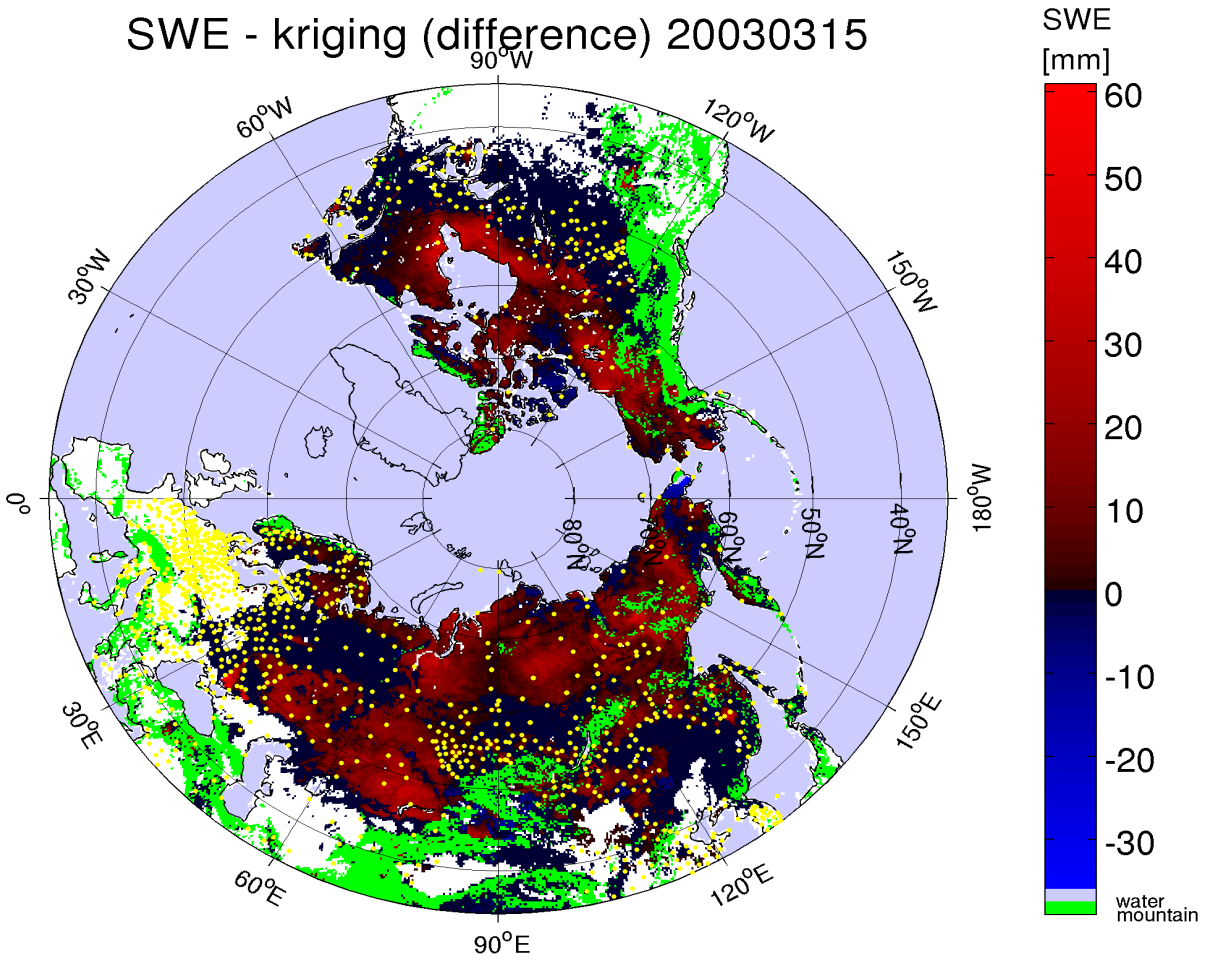
The effect of radiometer data in SWE algorithm compared to using only interpolated WMO weather station Snow Depth (SD)



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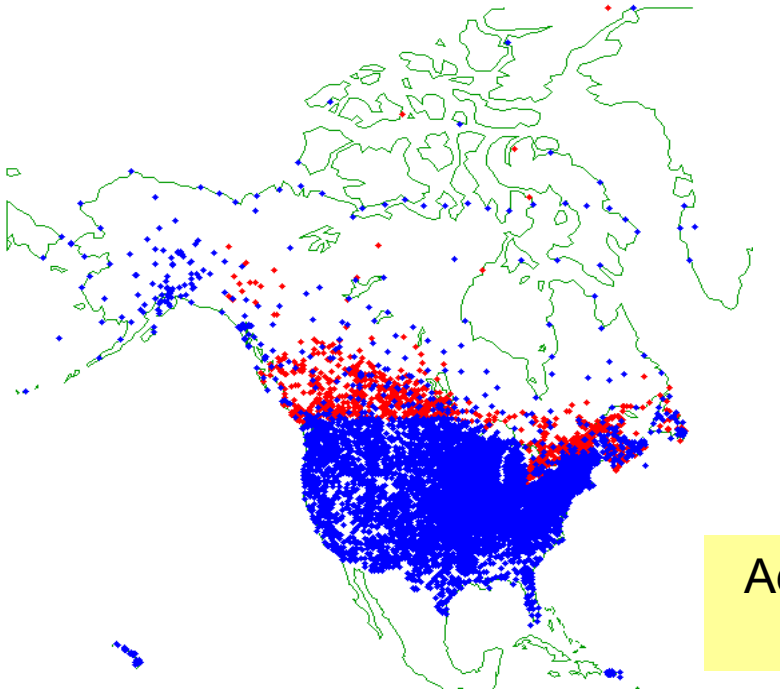
GlobSnow SWE v2.0

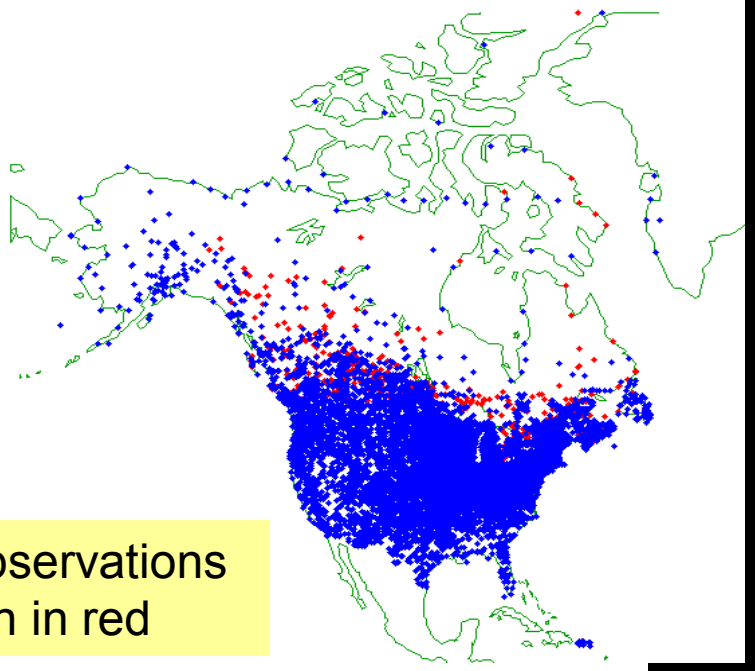
Earlier GlobSnow-1 SWE FPS had a gap for 1980-1981

- Additional SD data from Canada was acquired to improv
  coverage for winters 1980 and 1981 in North America



January - March 1980

Added observations shown in red



January - March 198

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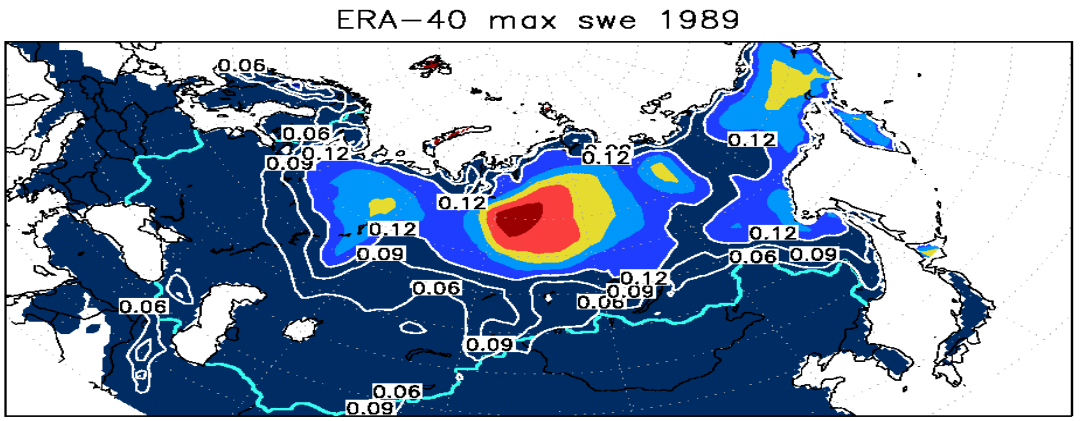
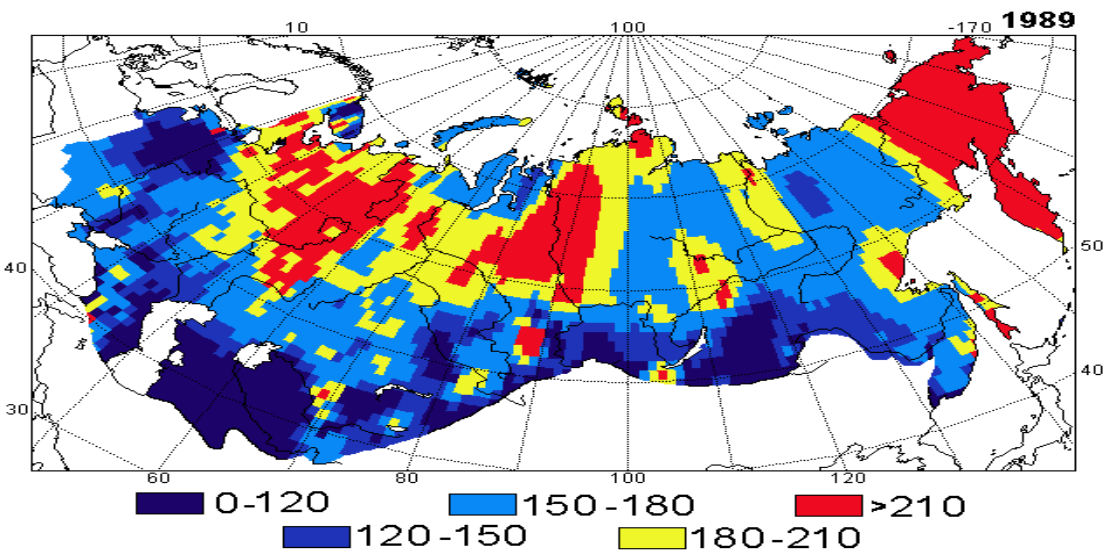
Deficits of re-analysis data and ground data interpolation => need for global satellite data products such as GlobSnow

- ERA-40 re-analysis data of ECMWF:
  - Maximum SWE in 1989

  (SWE = snow water equivalent indicating the total amount of snow)



- Corresponding INTAS-SCCONE Russian ground based observations (SWE from 210 snow courses around northern Eurasia)



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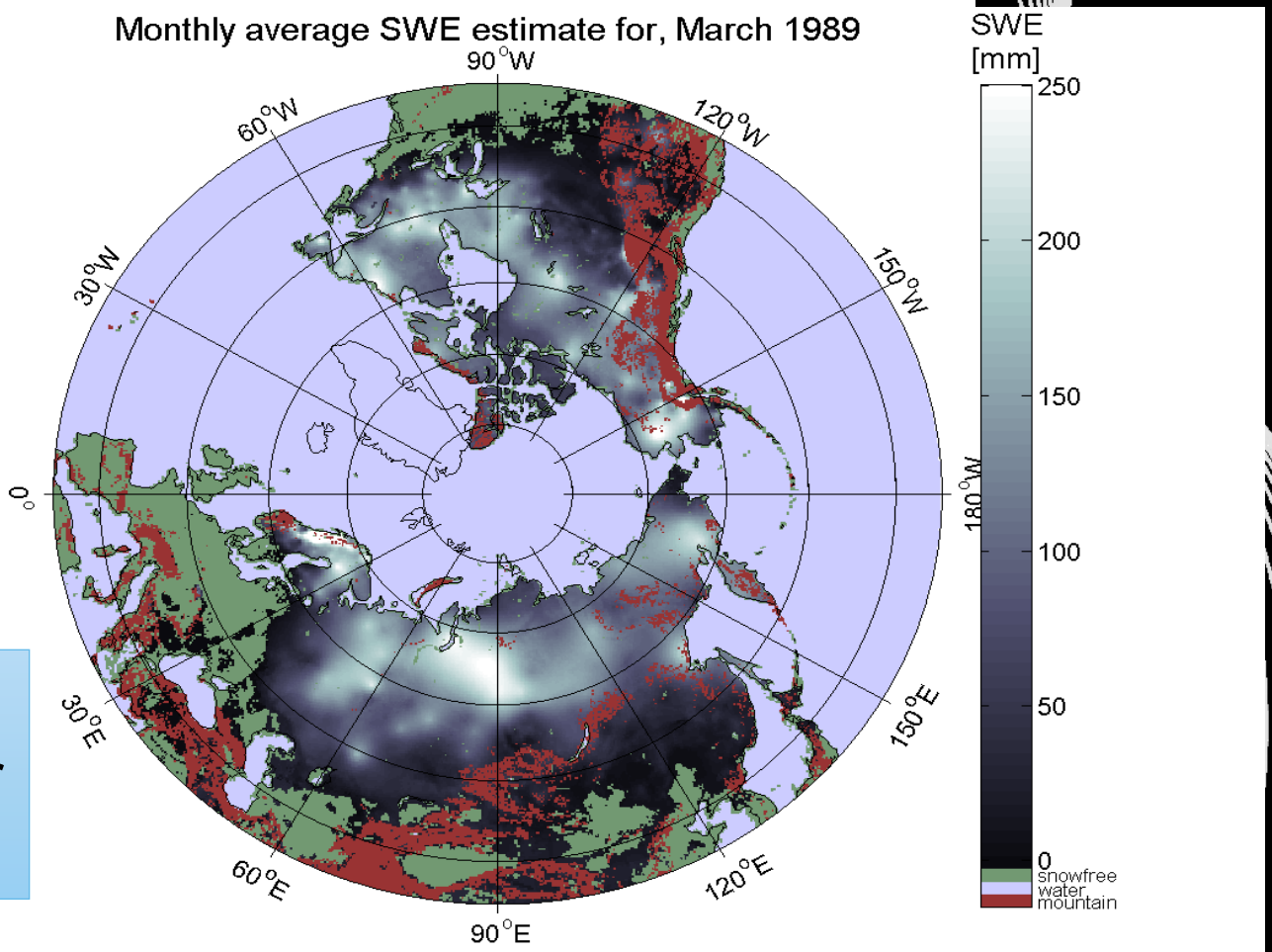
Corresponding GlobSnow SWE map



A detailed description of maximum snow cover for the winter of 1989

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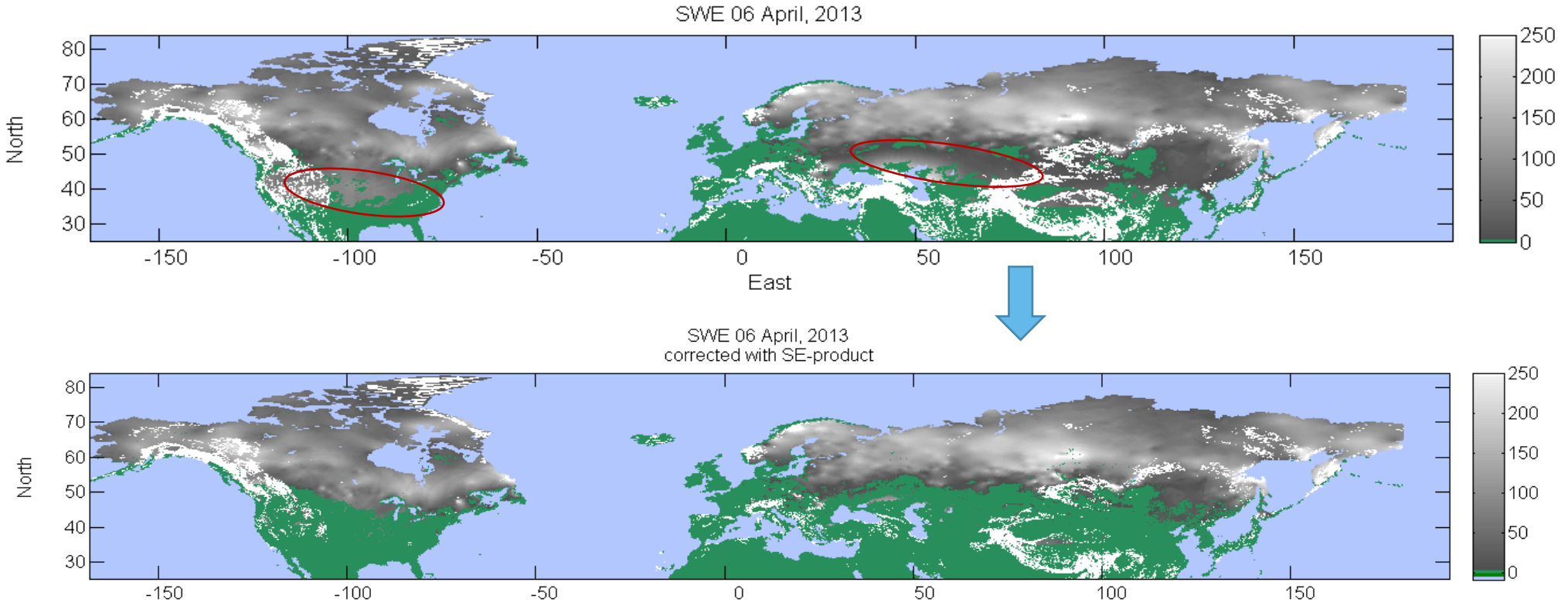
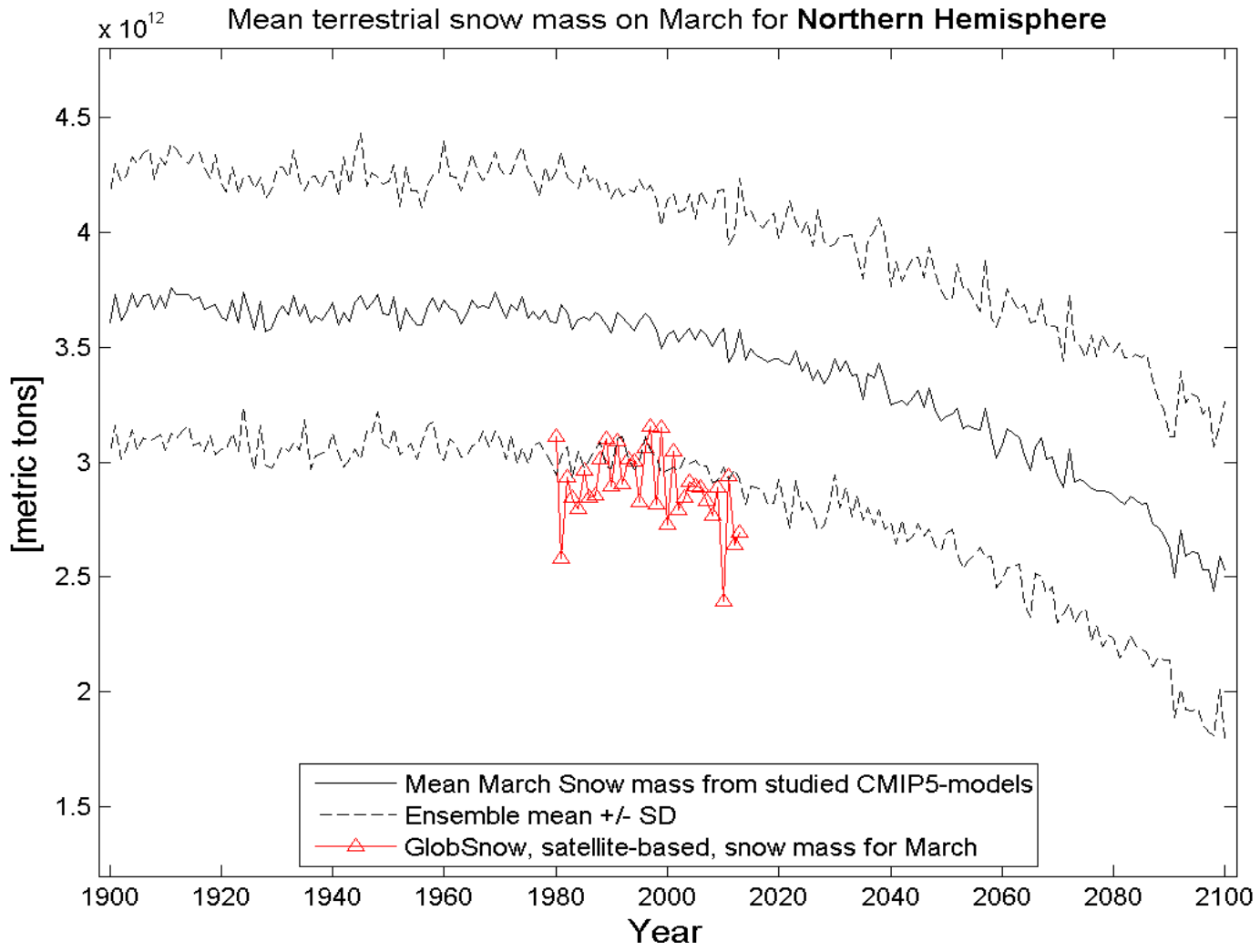
Fusion of GlobSnow SE and SWE product for concise snow cover information



GlobSnow SWE NRT-product has difficulties in detecting snow line in some cases
-> snow line identification from SE-product

Utilization of GlobSnow 2.0: SWE vs. Ensemble historical & RCP8.5 ”forecast” *March, Preliminary: 16 models*




Thank You for Your Attention!

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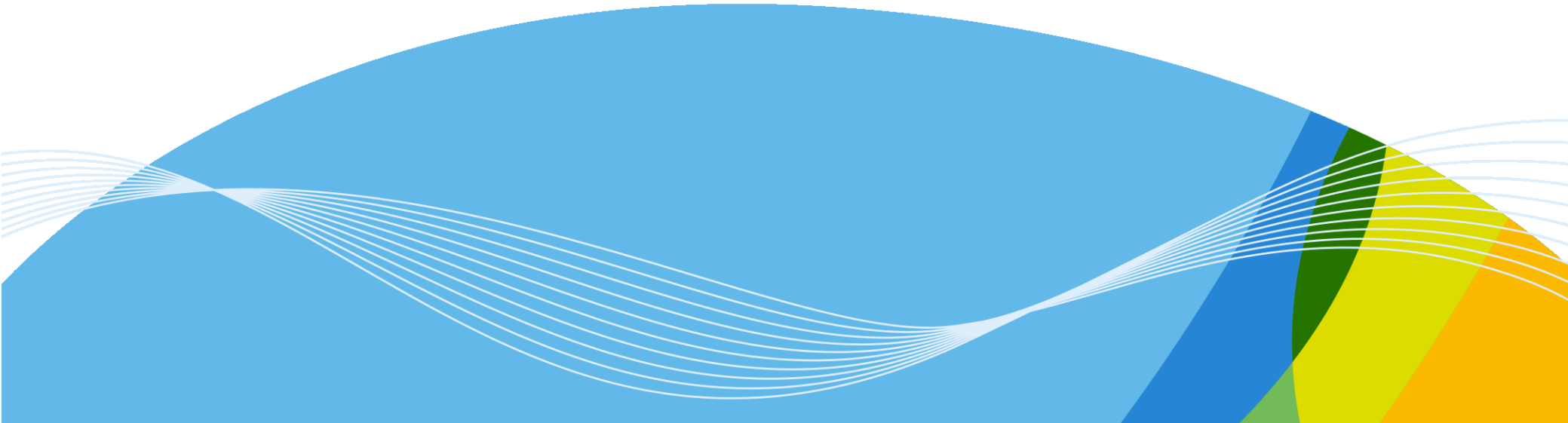
Data holdings at FMI

M. Salminen, J. Pulliainen, Finnish Meteorological Institute (FMI)



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Current available *in situ* data at FMI – Northern Eurasia

Distributed snow courses

Snow Water Equivalent (SWE)
- 1966-2009
- Near WMO stations

Snow Water Equivalent (SWE)
- 1979-2014
- Some courses start 1971
- Archives extending to 1920's only in paper reports

Point-wise stations

Snow Depth (SD)
- 1881-2001
- At WMO stations

Snow Depth (SD)
- Through 20th century
- Finnish WMO data is a subset of this synoptic dataset

Finnish Snow Course data, Finnish Environment Institute (SYKE)

INTAS-SCCONE data, Former Soviet Union (FSU) compiled by FMI and international partners

Finnish weather station data, Finnish Meteorological Institute (FMI)

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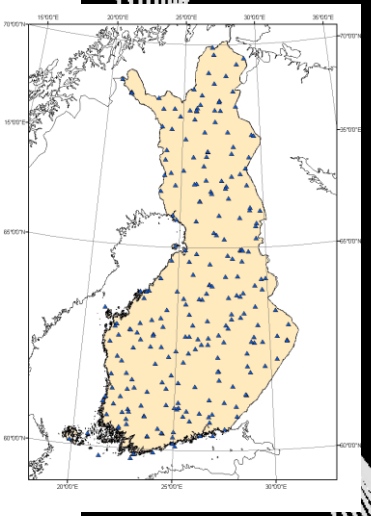
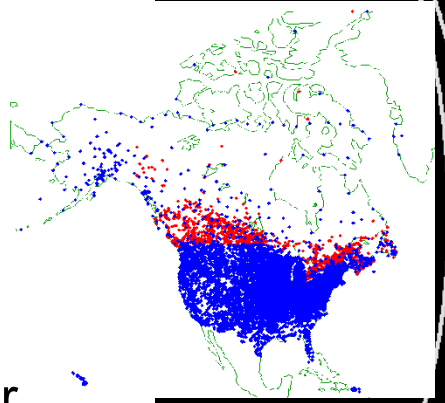
Current *in situ* data at FMI – Finland, Eurasia and North America

- Finnish Snow course data set (by SYKE)
  - Snow Water Equivalent (SWE) data (1979-2014, some 1971)
  - Other variables: Snow Depth, density and supplementary information
  - Max. yearly number of snow courses :170
  - Total number of observations: 30 298
- Eurasian WMO quality controlled synoptic stations (1979-)
  - 1200 stations with SD
  - 50 000 (daily) observations per month
- NA extended WMO quality controlled synoptic stations
  - GlobSnow data set (Rutgers Univ./Robinson et al., open access not certain)
  - Dataset starting from the year 1900
  - 1500 SD stations with over 100 000 (daily) observations per month on SD (since 1979)





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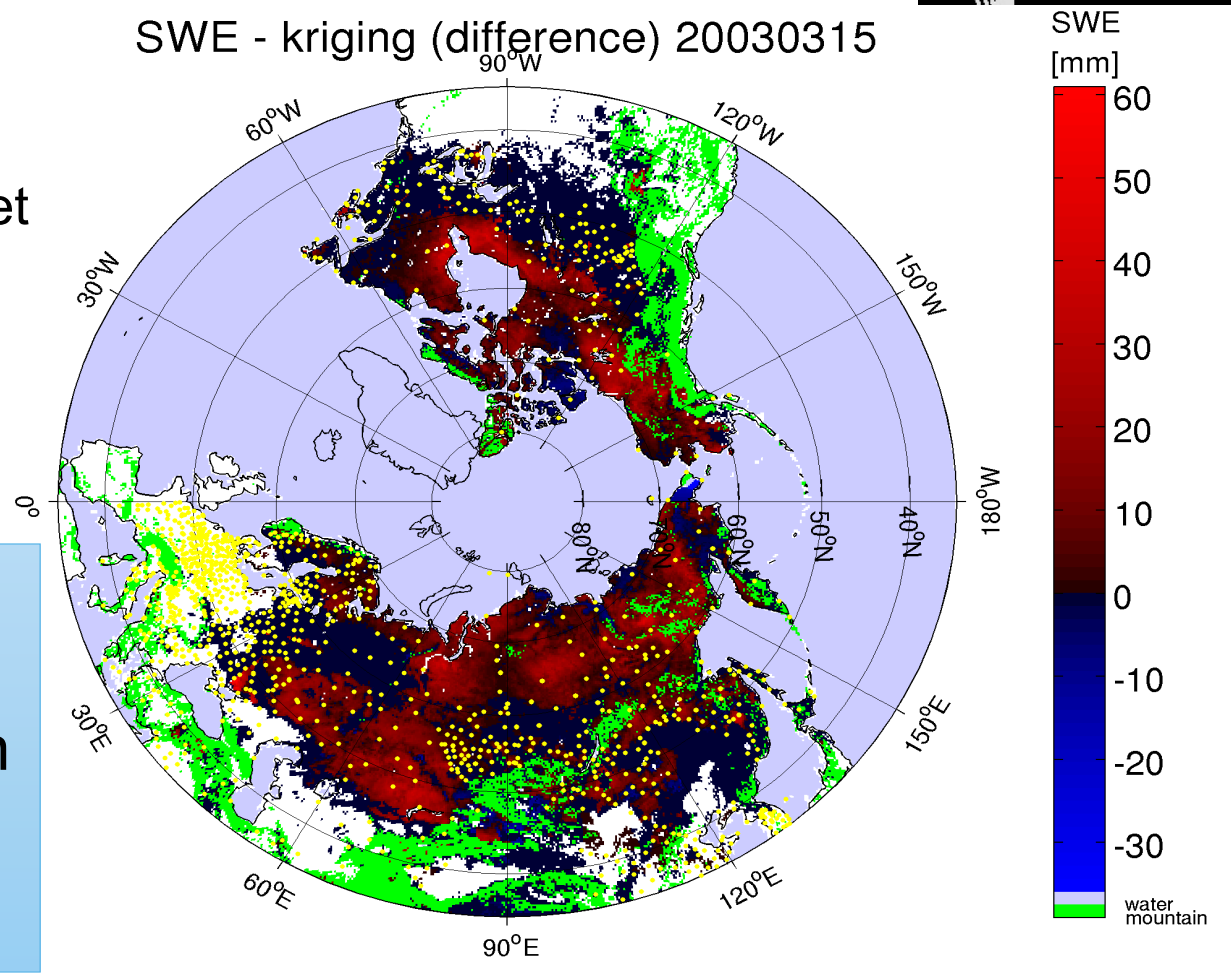
The effect of radiometer data in SWE algorithm compared to using only interpolated WMO weather station snow depth

- In addition to WMO station data (yellow dots) there are observations available in FMI database covering Former Soviet Union (FSU) and Finland



Yellow dots represent the spatial distribution of WMO weather stations available in ECMWF database
(including SD observations)

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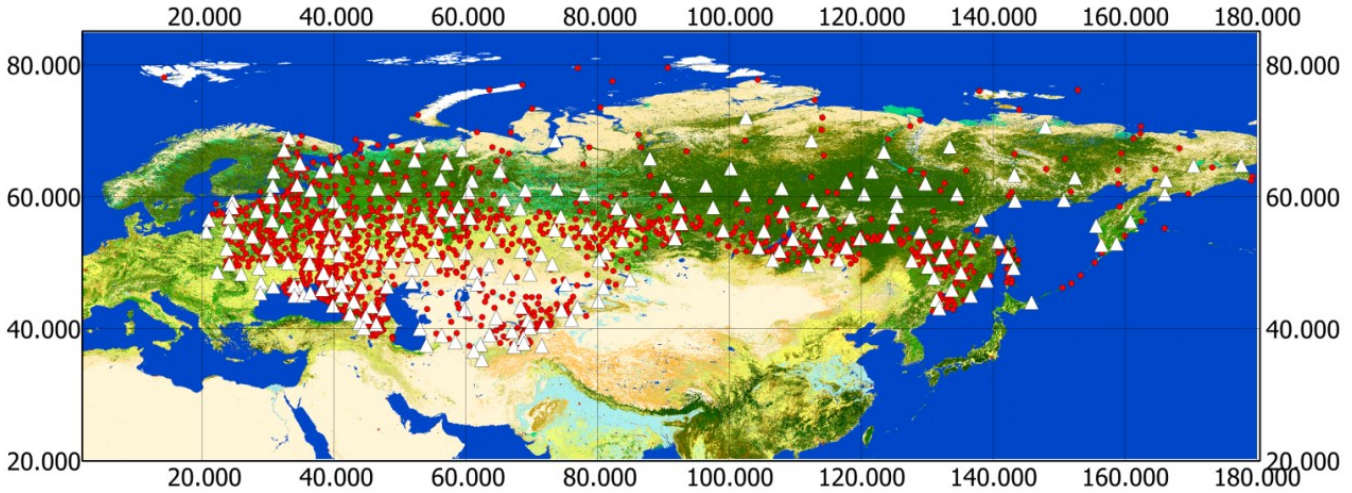
Current available *in situ* data at FMI – Former Soviet Union (FSU)

- Pointwise data at WMO stations
  - Total number of stations 223 (***white triangles***)
  - ***Daily*** Snow Depth (SD)
  - 1881-2001 (INTAS-SCCONE)
- Snow course data close to WMO stations
  - Total number of snow courses 1359 (***red dots***)
  - Snow Water Equivalent (SWE), Snow Depth (SD) & density
  - Time lag between observations from 5 to 30 days
  - 1966-2009 (extended INTAS-SCCONE)



INTAS-SCCONE snow survey data (1881-2000) from Former Soviet Union (compiled by FMI and international partners)

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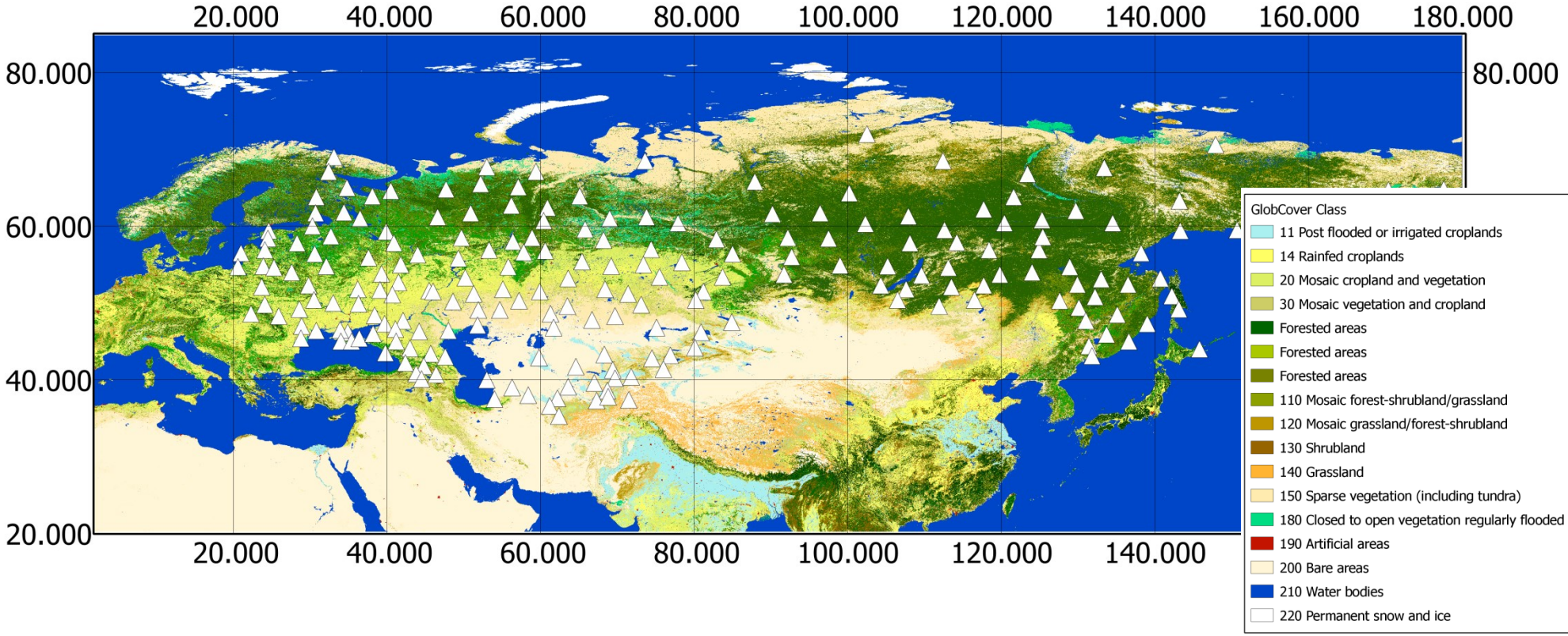
Point-wise Snow Depth at WMO stations

Daily Snow Depth (SD)
- 1881-2001
- At WMO stations

INTAS-SCCONE data, Former Soviet Union (FSU) compiled by FMI and international partners



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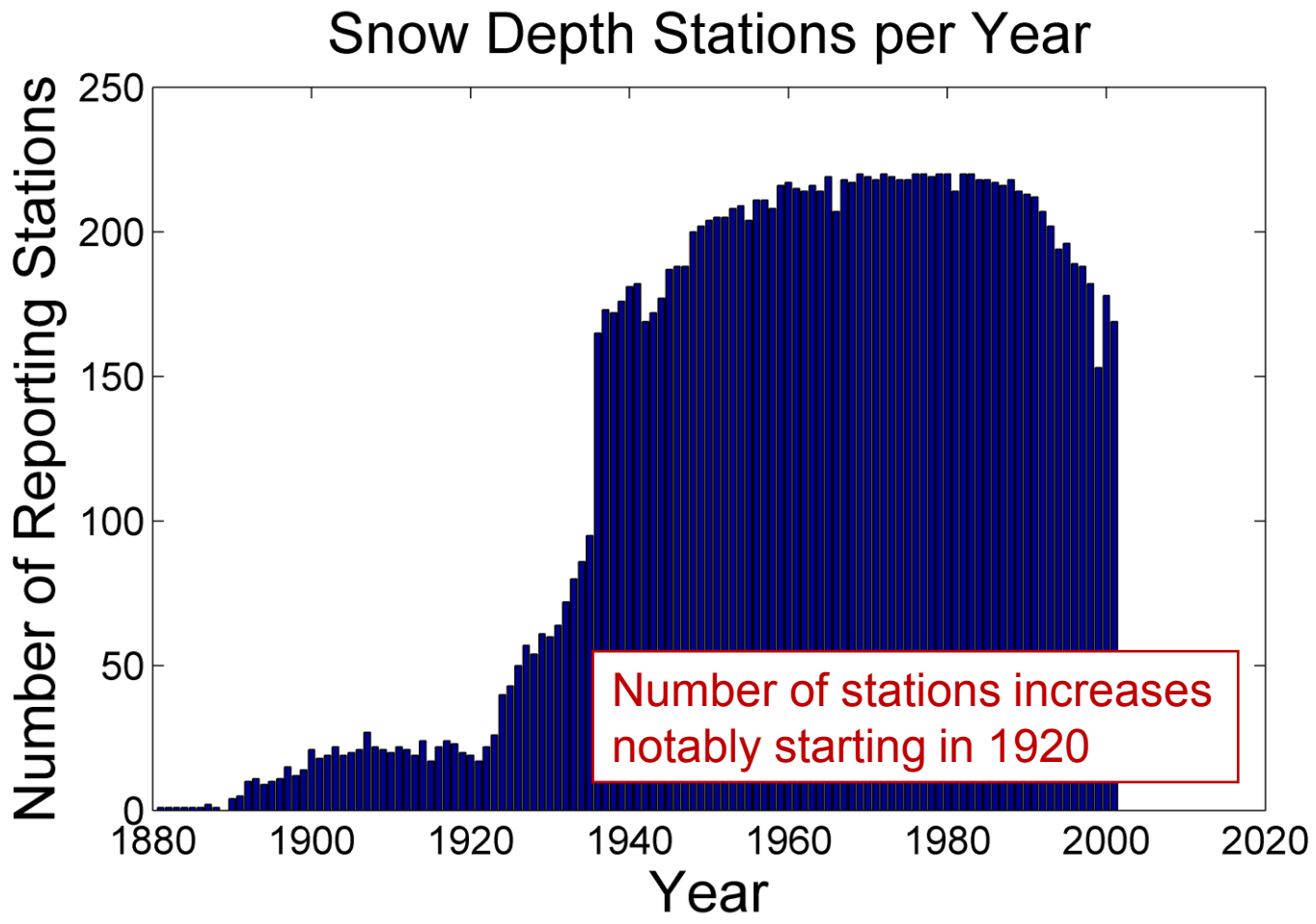
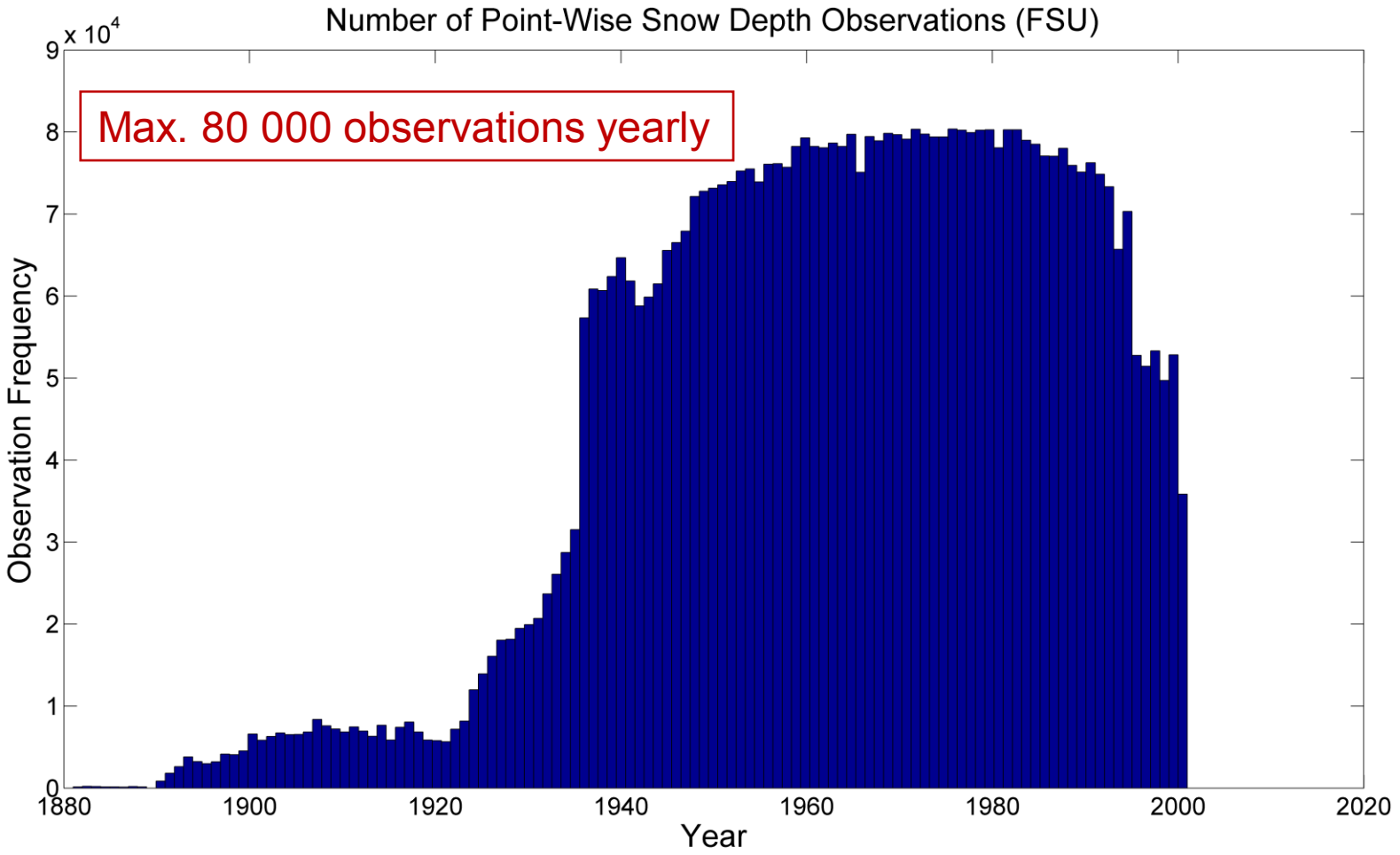
Point-wise Snow Depth 1881-2001

Total number of stations 223



Point-wise Snow Depth 1881-2001

Total number of observations over 5 million



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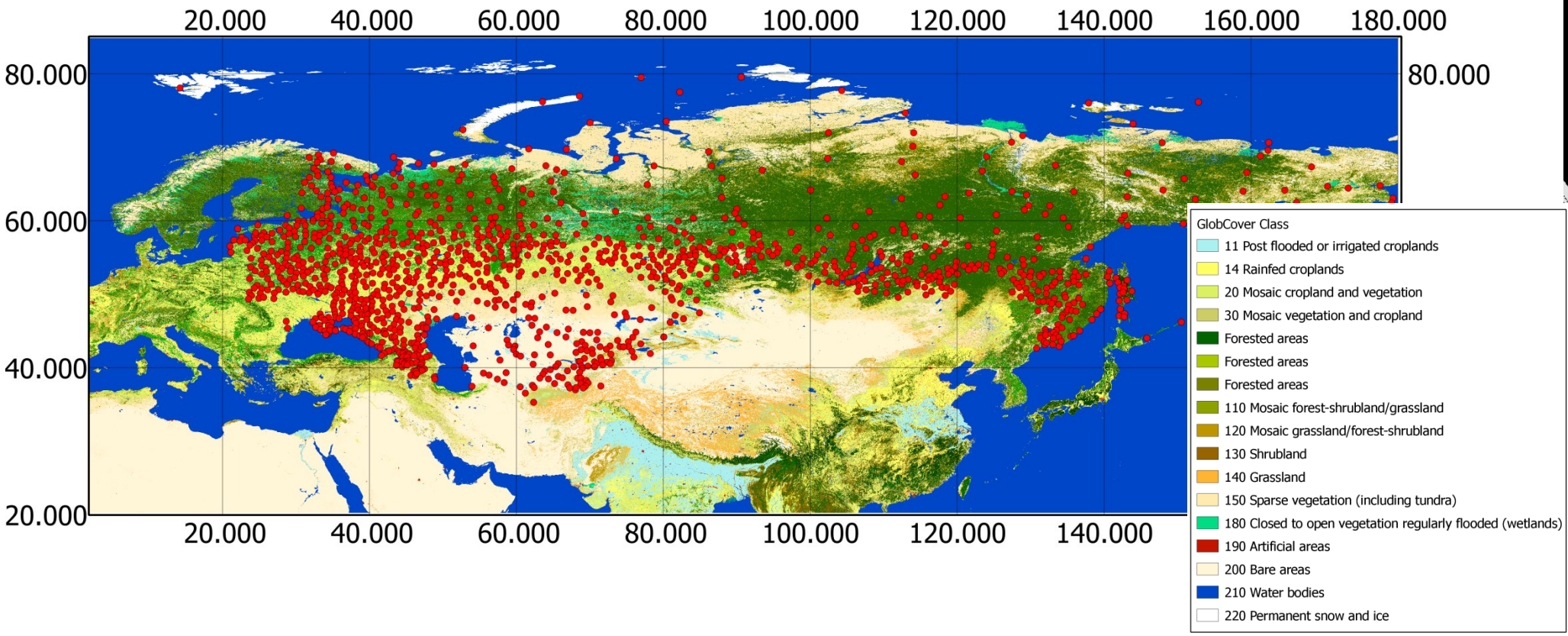
Snow courses near WMO stations

Snow Water Equivalent (SWE)
- 1966-2009
- Near WMO stations

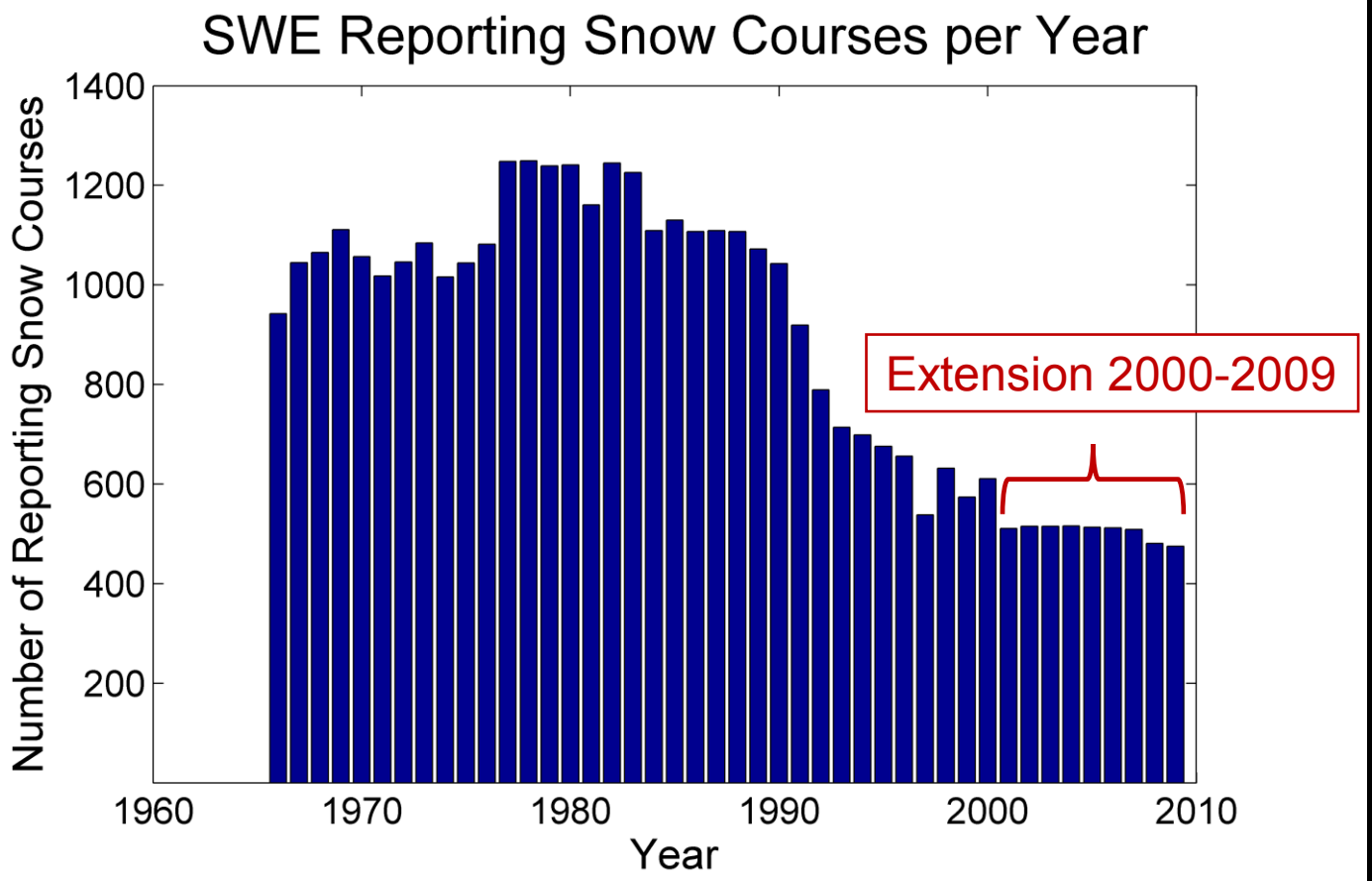
INTAS-SCCONE data, Former Soviet Union (FSU) compiled by FMI and international partners



Snow courses near WMO stations

Snow Water Equivalent (SWE)
- 1966-2009
- Over 700 000 observations

INTAS-SCCONE data extended to year 2009



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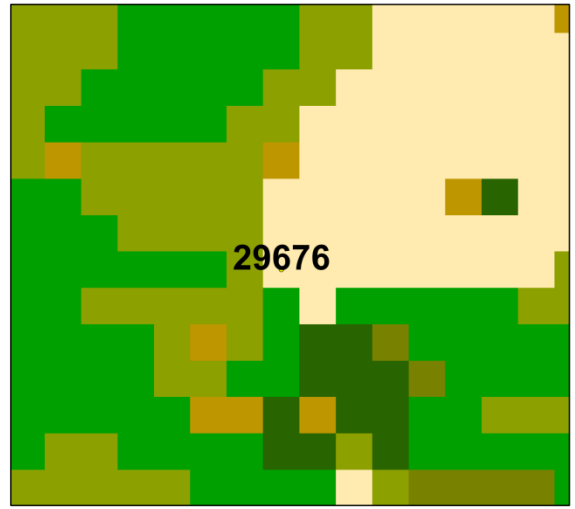
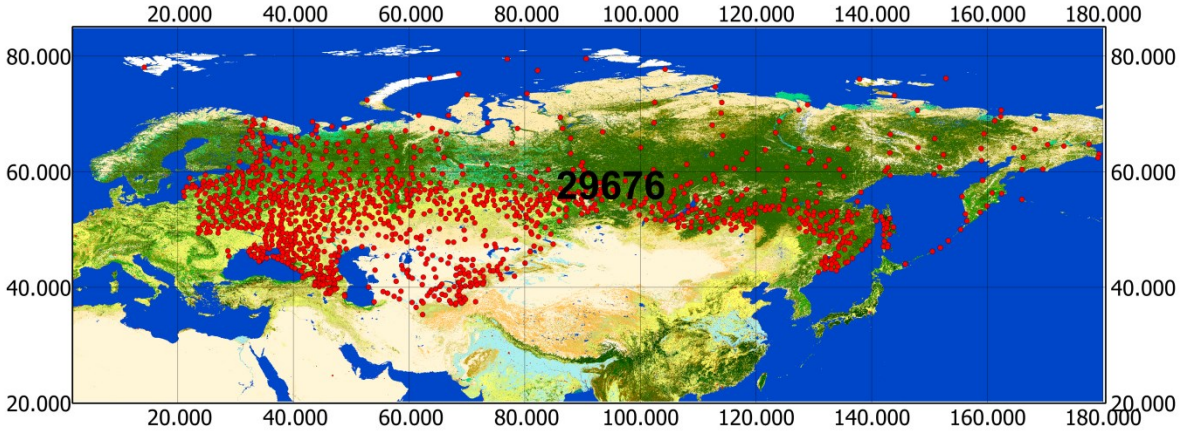
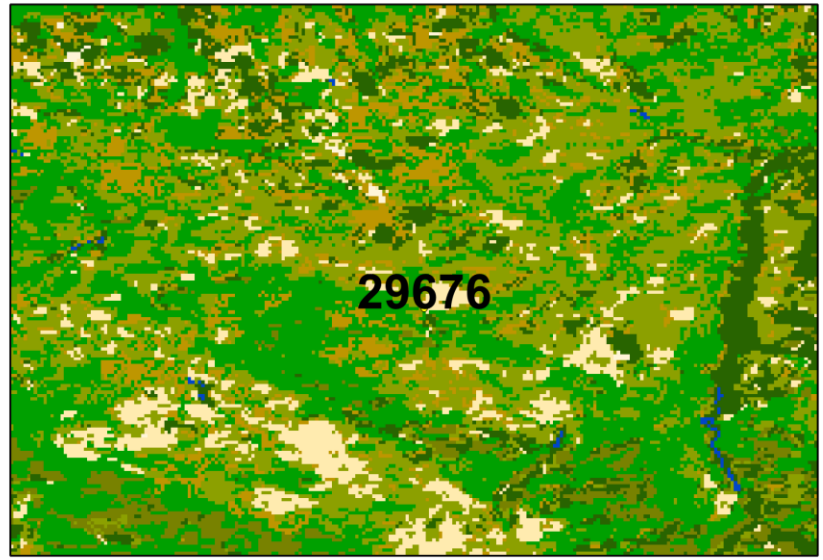
SWE time series: WMO station 29676

Field No	Contents
1	WMO station index
2	Year
3	Month
4	Day
5	Path type: 1 - field environment; 2 - forest environment; 3 –rawine (canions)
6	Day of path observations
7	Snow cover depth average (sm)
8	Snow density (g/sm^3)
9	Water equivalent of snow cover (mm)
10	General water amount (mm)
11	Flag for snow cover depth and snow density (Attention: this field reserved for the future expansions of coded situations)







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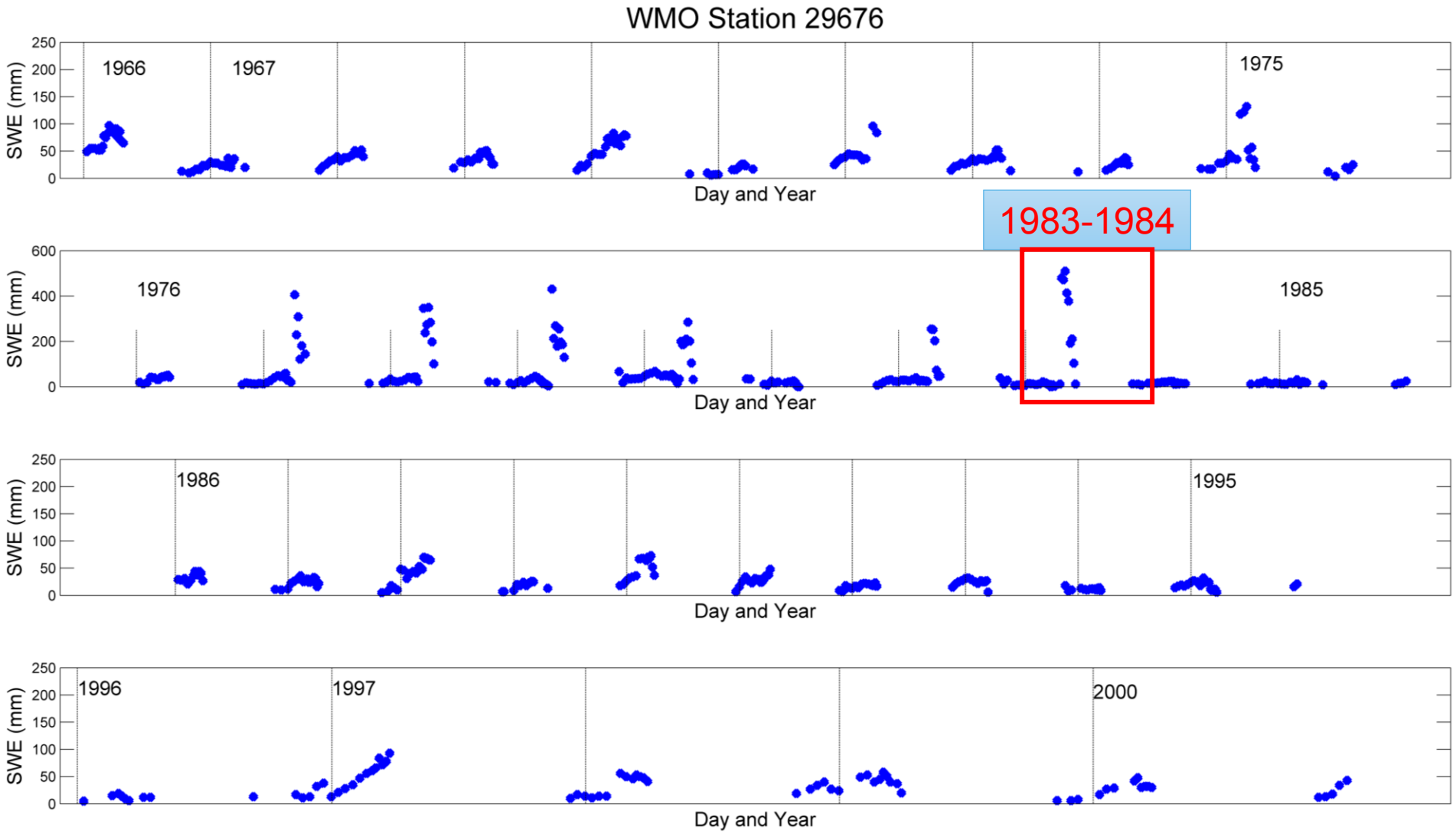
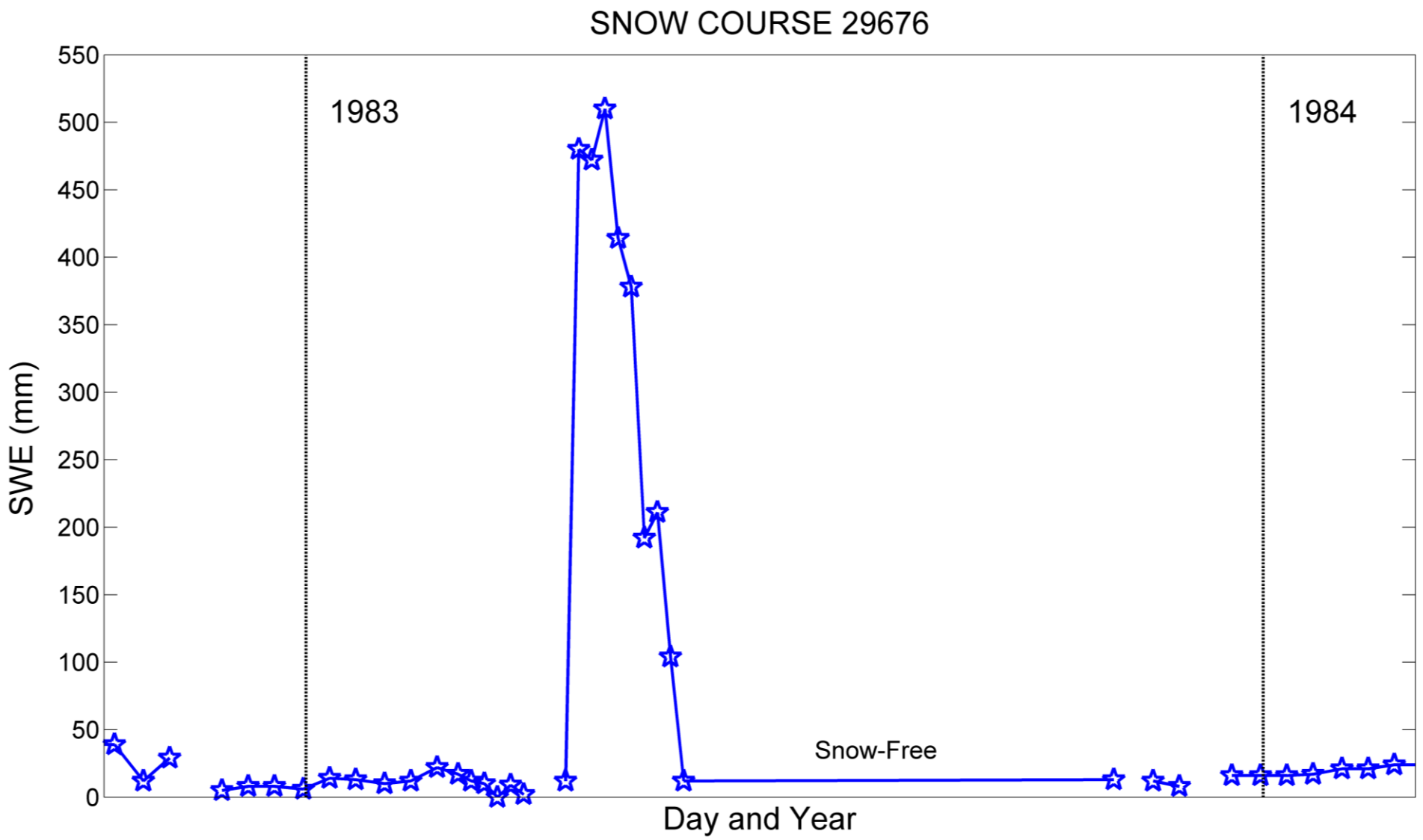
SWE time series since 1966



SWE time series: zoom to 1983-1984



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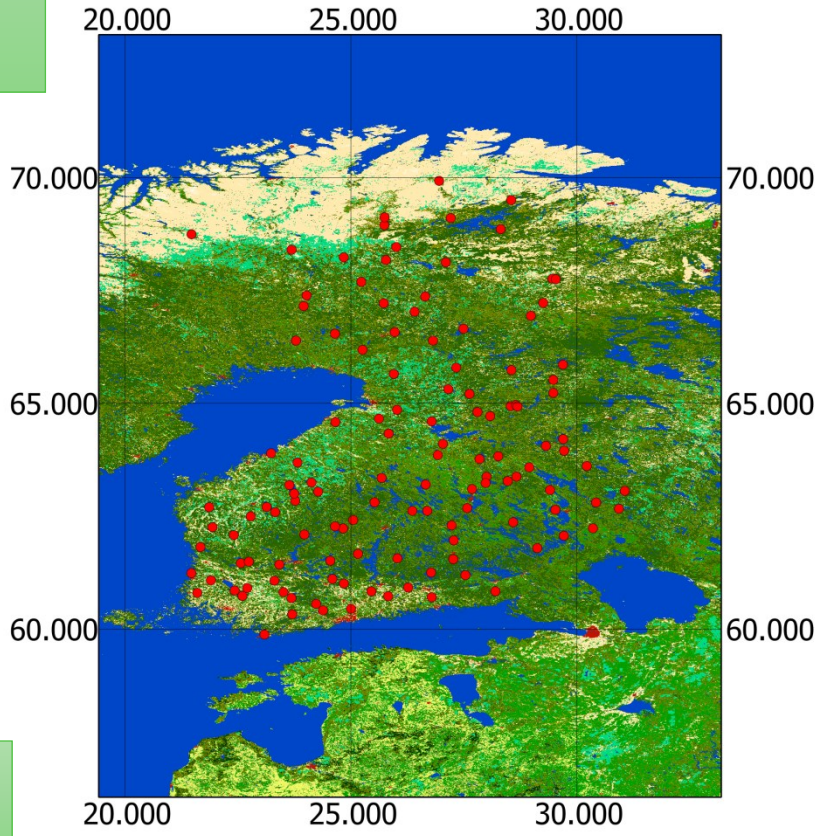
Finnish Snow courses

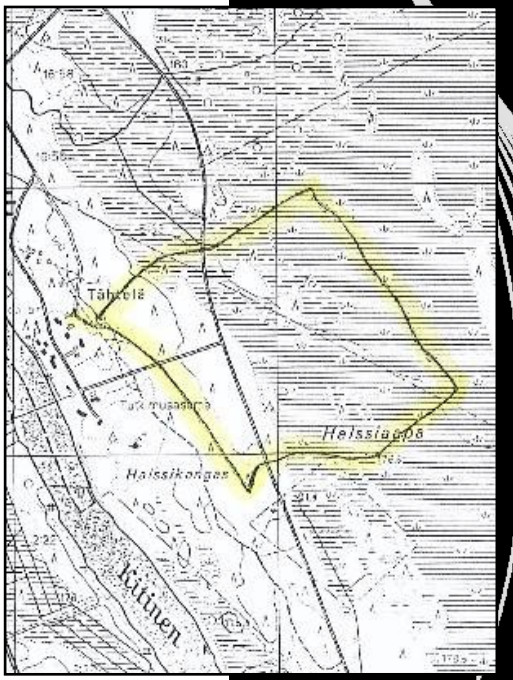
Snow Water Equivalent (SWE)

- 1979-2014
- Some courses starting 1971
- Historical data available from early 1900's (not digitized)

- Monthly/bi-monthly measurements by SYKE
- National network of +100 snow courses
  - 2 - 4 km
  - 40 - 80 snow depth measurements points
  - 8 snow density measurements points
  - Distinction into five land cover classes



Example: snow course in Tähtelä, Sodankylä



Finnish Snow Course data, Finnish Environment Institute (SYKE)

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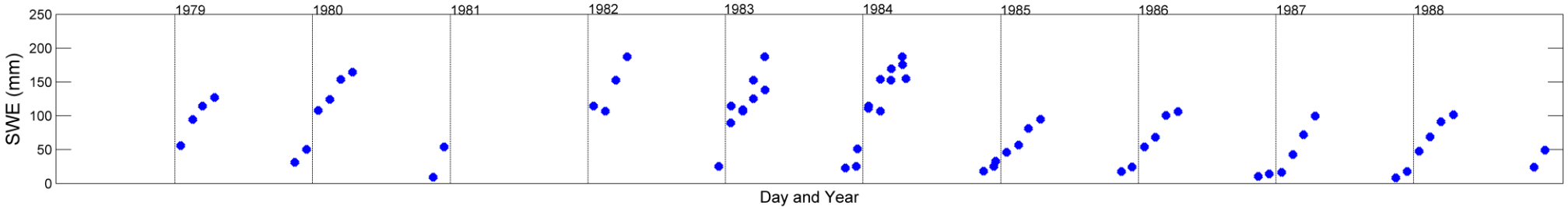
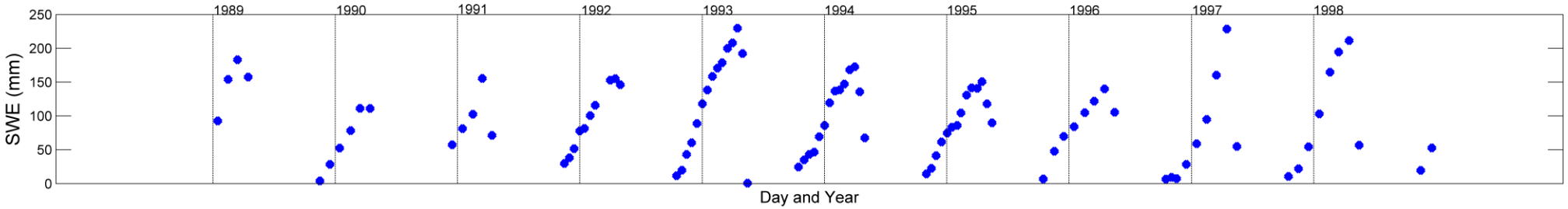
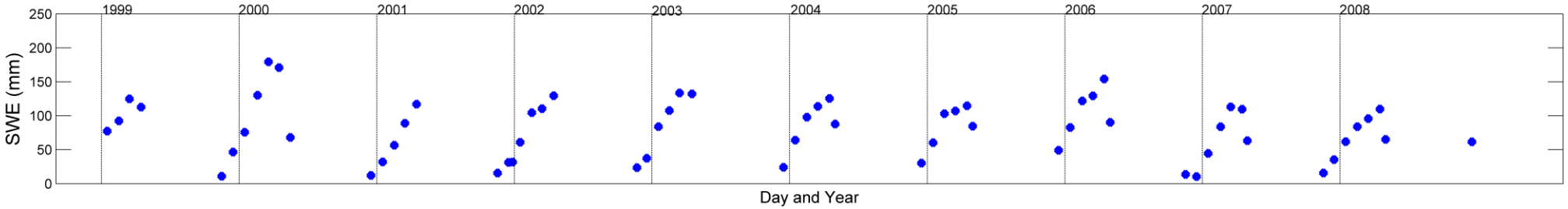
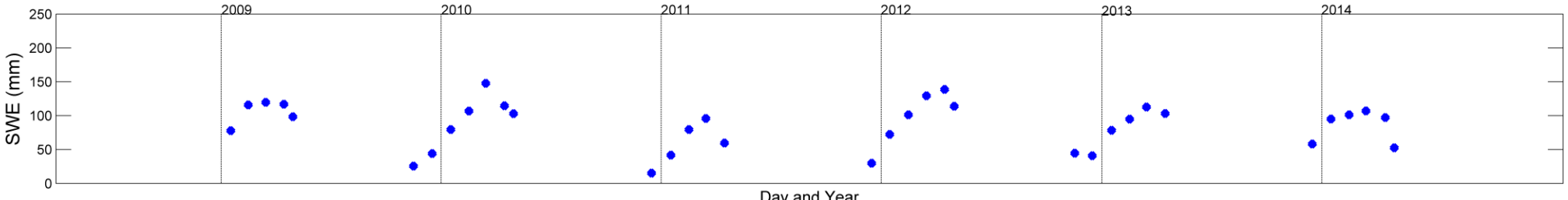
SWE time series 1979-2014









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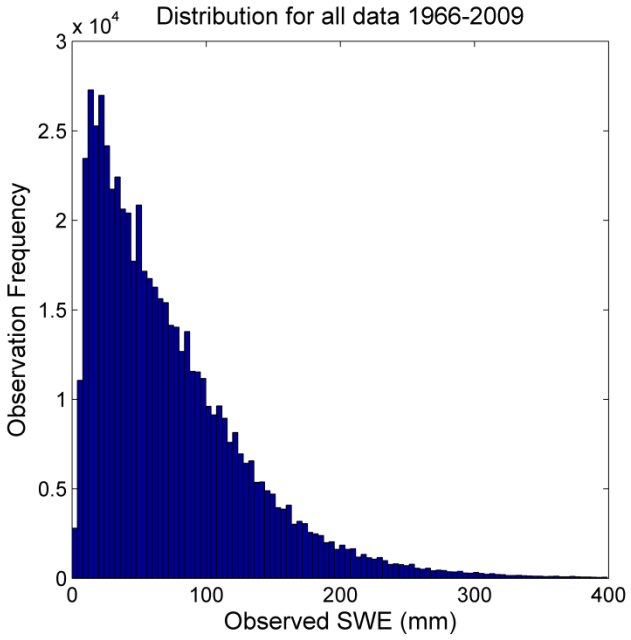
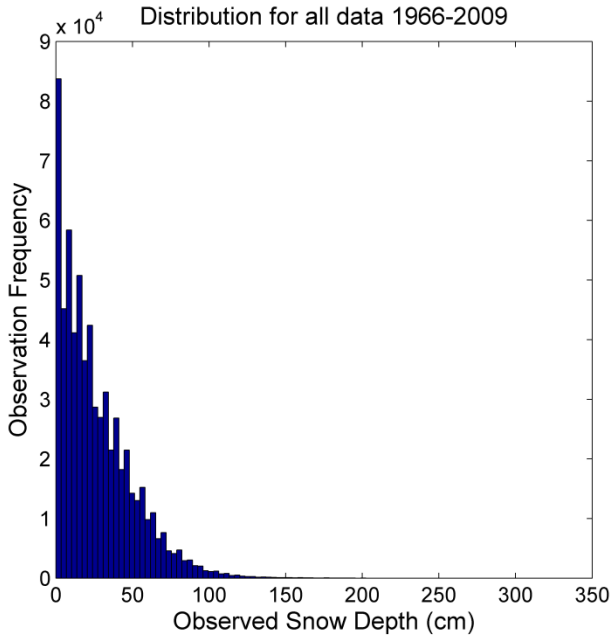
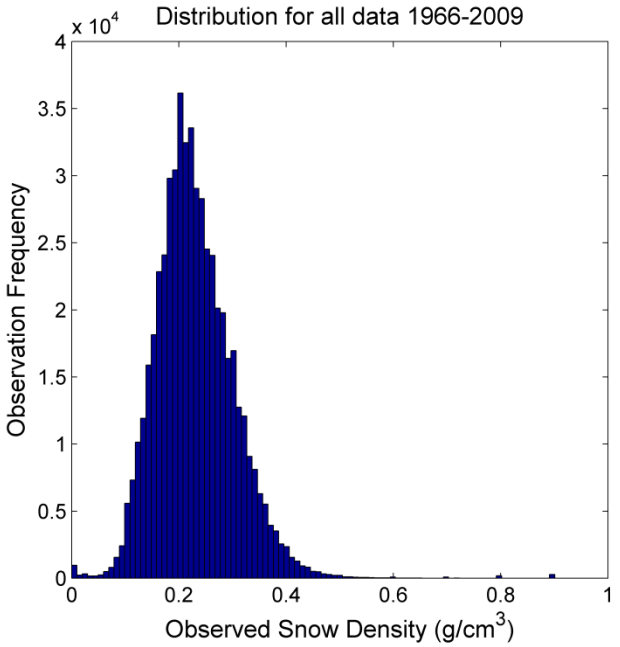
Proposed prototype SWE dataset: Distribution for all data 1966-2009

- Total number of WMO weather stations over 1300
- Time period 1966-2009 (10 stations in Finland until 2014)
- Total number of observations over 700 000
- Variables
  - Snow Water Equivalent (SWE)
  - Snow Dept (SD)
  - Snow Density







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Prototype point-wise SD dataset: Distribution for all data 1881-2001

- Total number of WMO weather stations 223
- Total number of observations over 5 million
- Variables
  - Snow Dept (SD)
  - Fractional Snow Cover information
- Data origin: Former Soviet Union (FSU)
- Currently archived in FMI database