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Sentinel-based FSC data combined with Northern Hemisphere SWE

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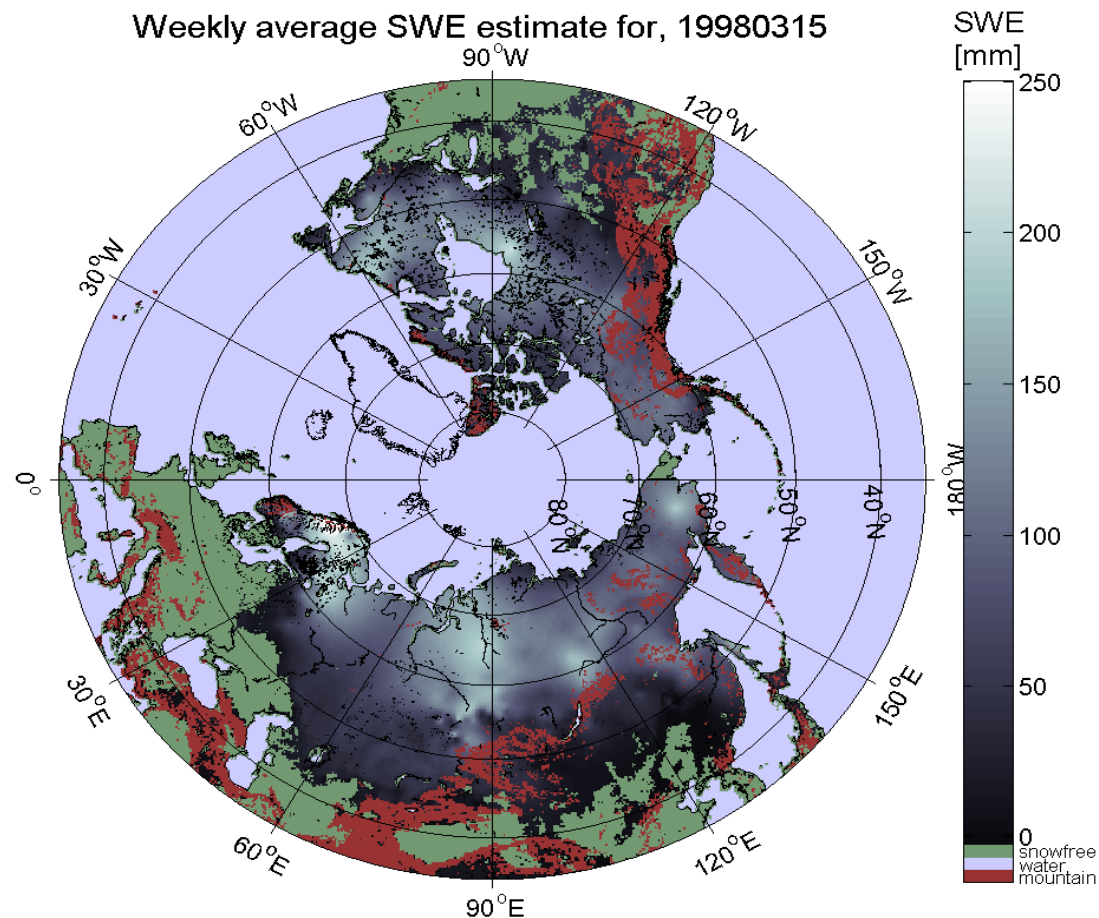
Outline

- **Northern Hemisphere SWE + FSC**
 - GlobSnow NH SWE
 - GlobSnow VIIRS NH FSC & NOAA IMS
- **Combining the SE and SWE data**
- **Pan-European High Resolution SWE**
 - Upgraded GS SWE retrieval approach
 - 5km resolution, Pan European domain



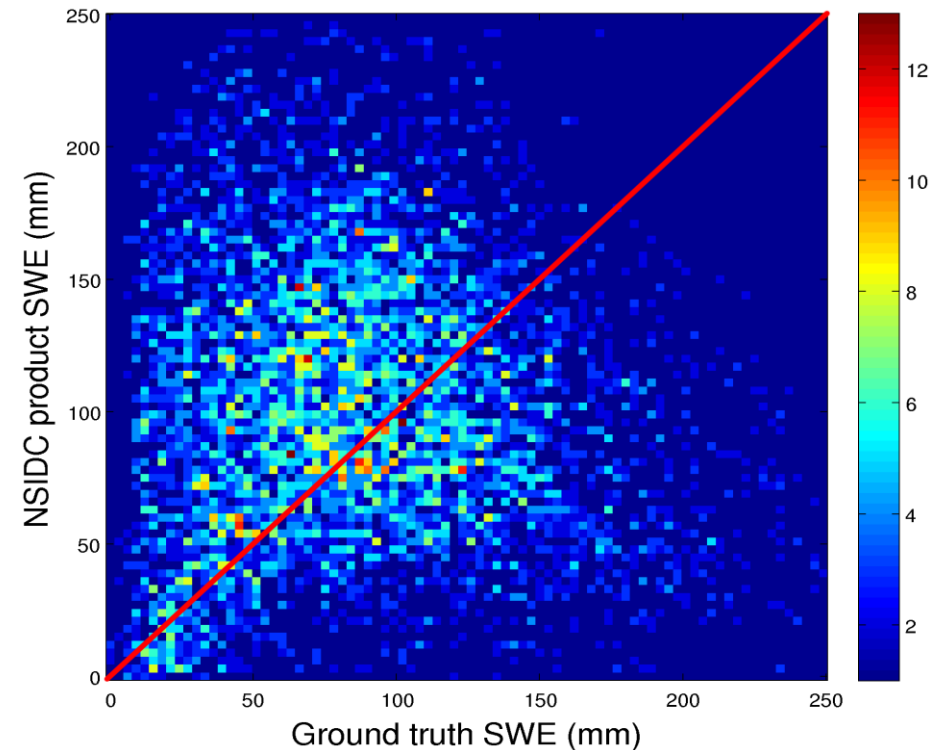
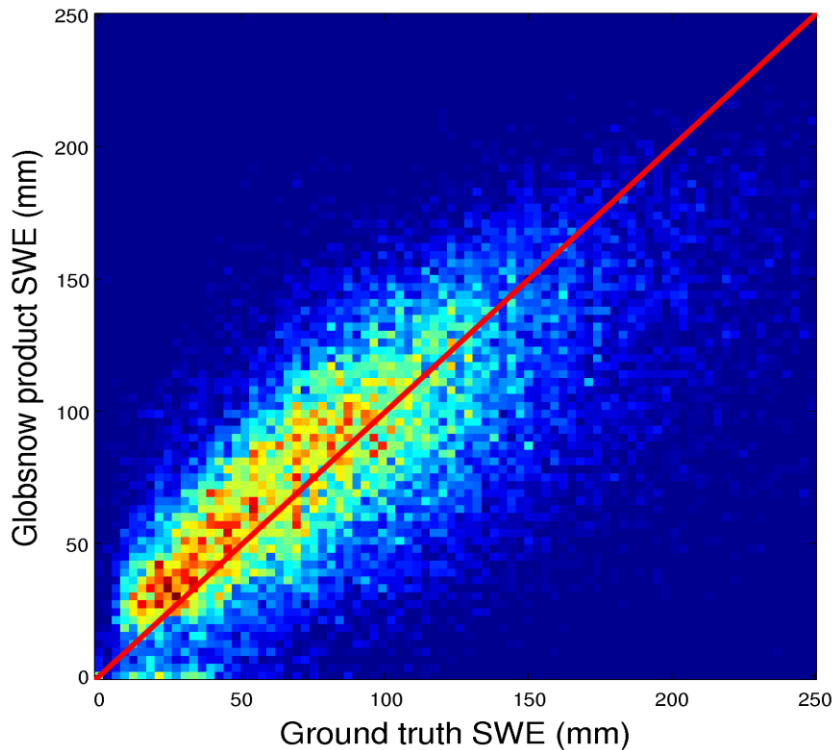
35 year-long CDR time-series on snow conditions of Northern Hemisphere

- 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 1979-2014
- Passive microwave radiometer data combined with ground-based synoptic snow observations
 - Variational data-assimilation
- Available at open data archive (www.globsnow.info)
- **Daily NRT production** since 2010



SWE retrieval performance (benefit of data assimilation)

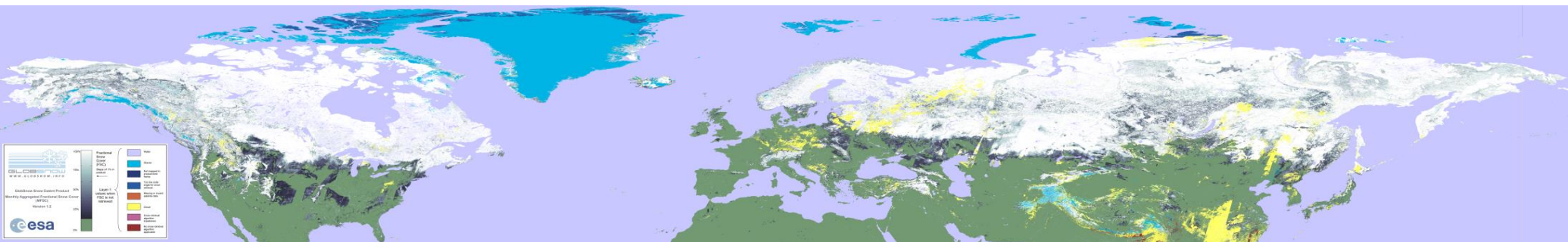
- Density scatterplot (assimilated vs. satellite only SWE)
- Russian INTAS SCCONE **SWE transect data** (distributed data) as reference





GlobSnow Snow Extent (SE) dataset

- 17 years SE data record has been produced using optical imagery from ESA ATSR-2 (1995-) and AATSR (2002-) on a hemispherical scale. NPP VIIRS from 2012-
- SYKE's *SCAmod* method for fractional snow cover mapping implemented for Northern hemisphere
- Cloud detection algorithm developed by SYKE (+ contributed by ENVEO, FMI & NR)



- Methodology developed especially for forested regions – basically a tough challenge for optical SE retrieval
- Uncertainty estimate provided for each grid cell, data available as NetCDF CF
- Operational data production at the Finnish Meteorological Institute (FMI)



GlobSnow-2, Suomi NPP VIIRS SE product

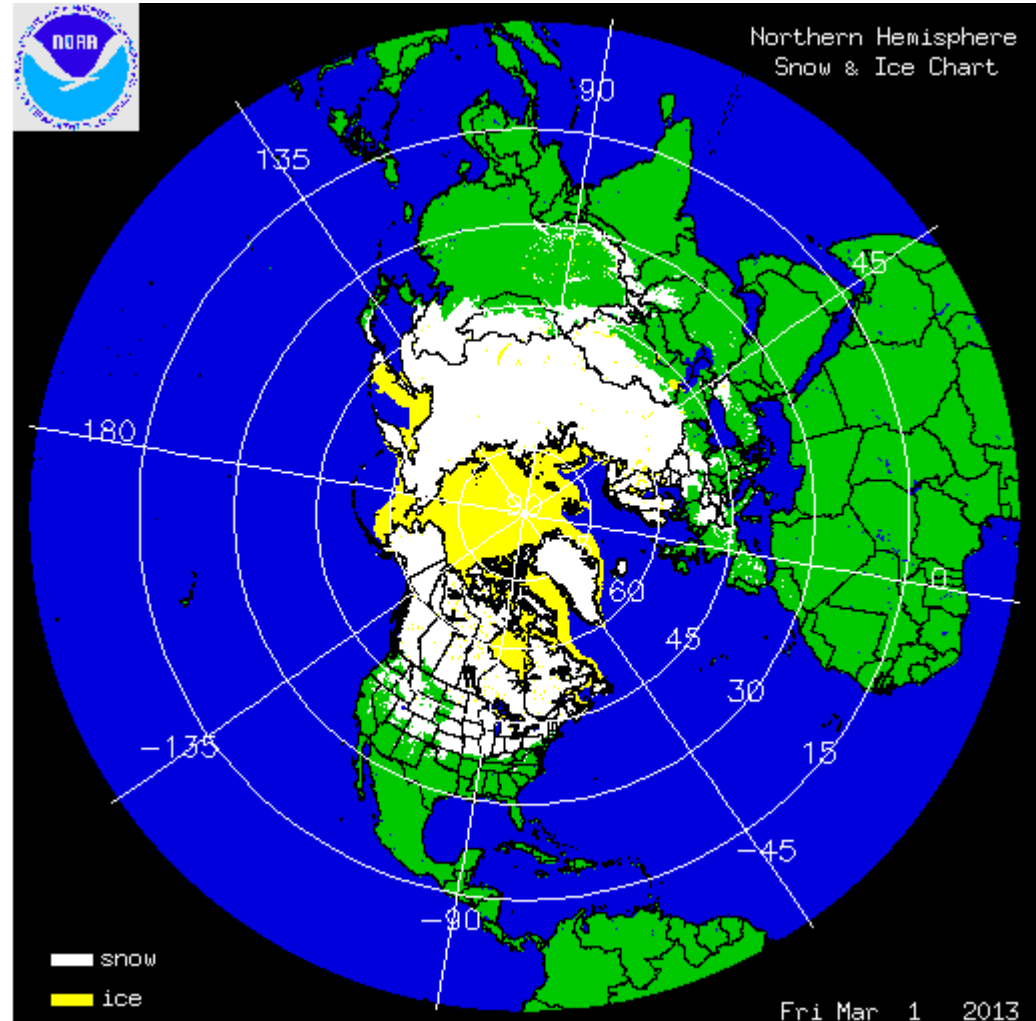
~1km spatial resolution, daily hemispherical coverage





NOAA/NESDIS IMS Snow/Ice (NRT “since 1966”)

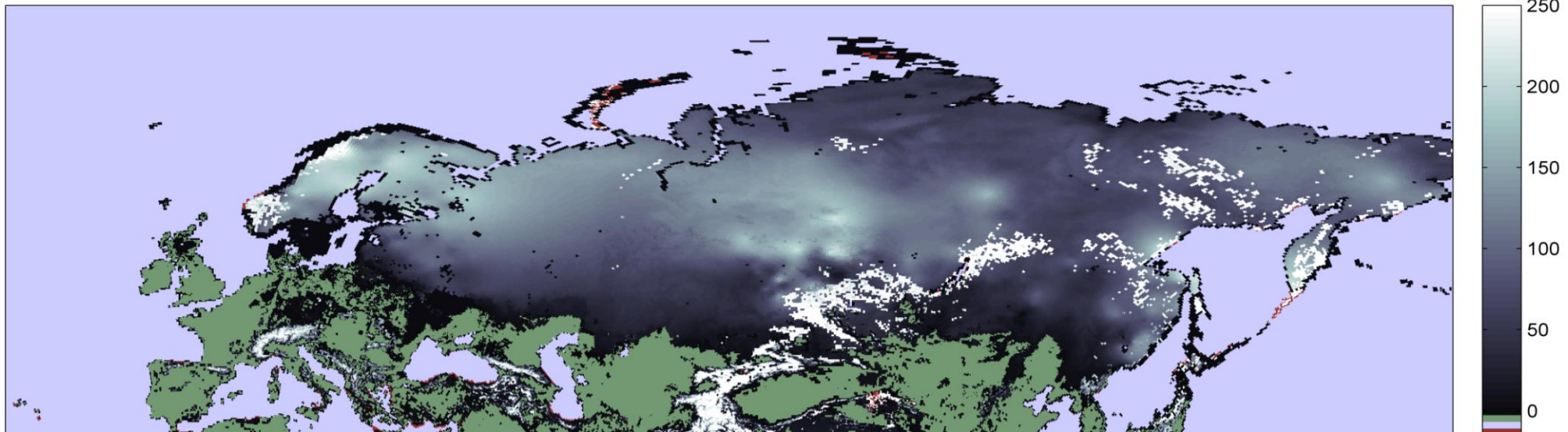
- **Daily 4km SE product based on multisensor data and human analyst interpretation**
- **Satellite + ground-based + modelled data**
- **Combines optical, PMW and SAR data**
- **Cloud filling**
- **Binary product**
- **89km / 24km / 4km / 1km**
- **Operational focus, numerous methodology improvements since 1966**





Combination of SE & SWE products for the generation of concise snow cover information

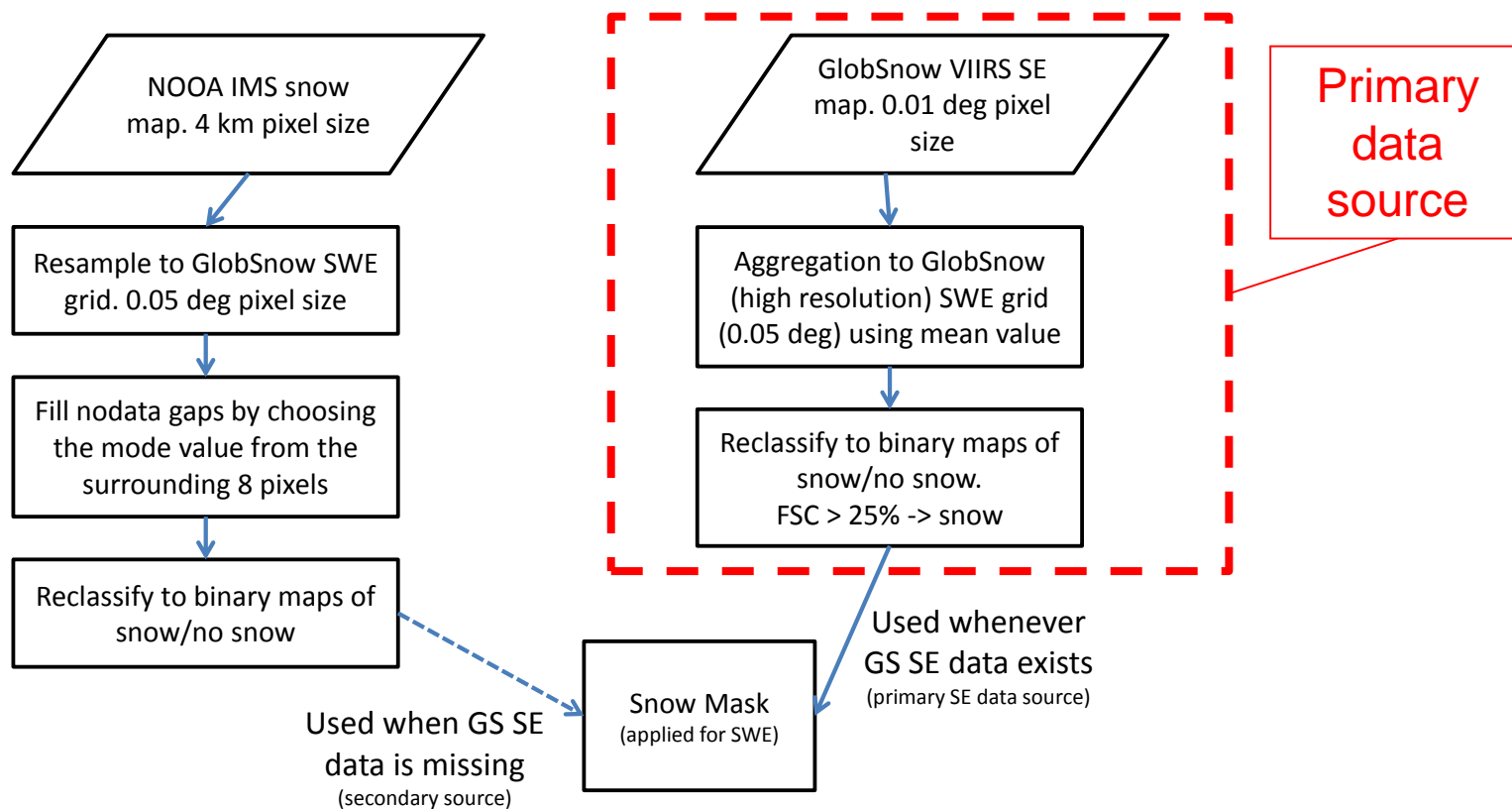
- NRT north-hemisphere daily snow monitoring product combining GlobSnow SWE and SE products (based on SSMI-S and VIIRS+Sentinel-3)
- SE information from VIIRS & NOAA IMS applied for (NRT) SWE production

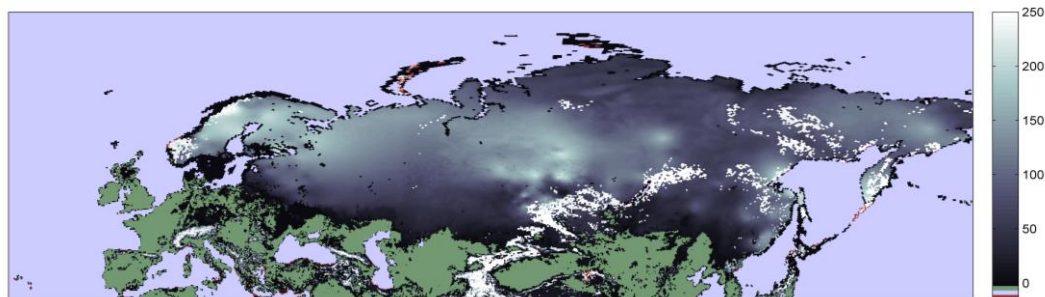
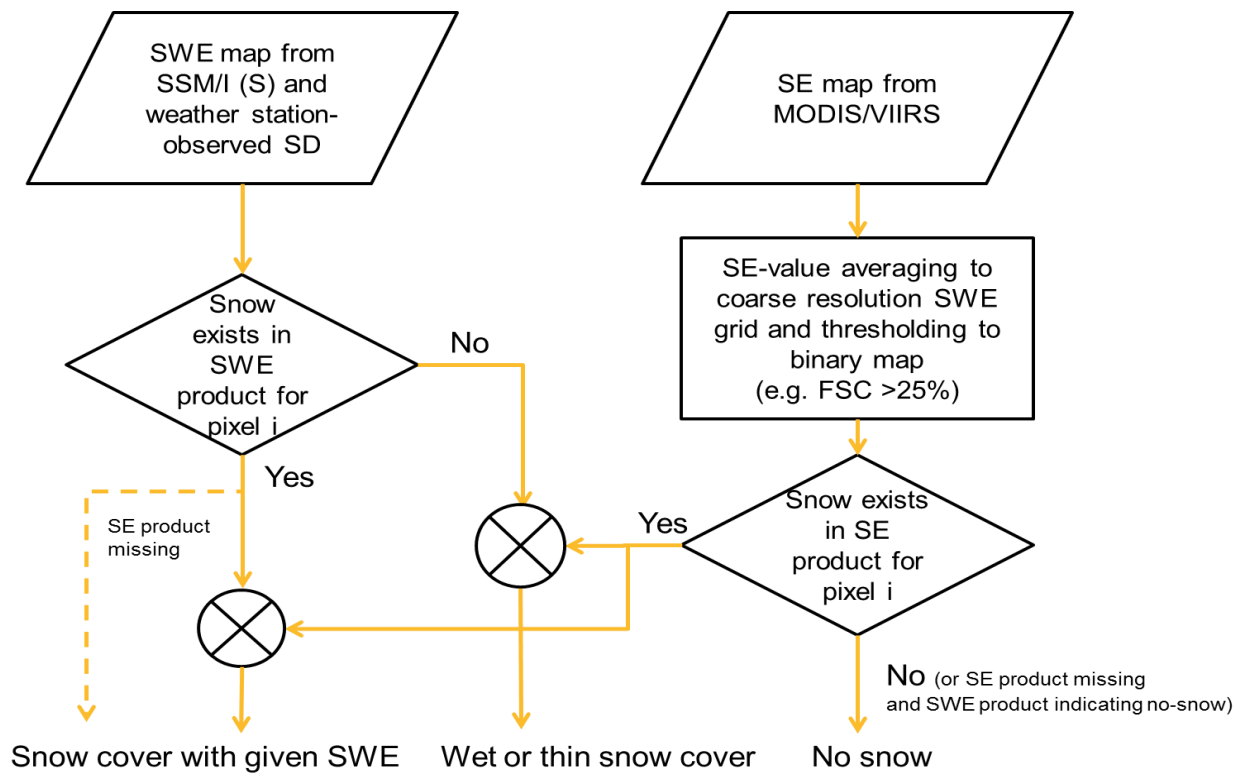
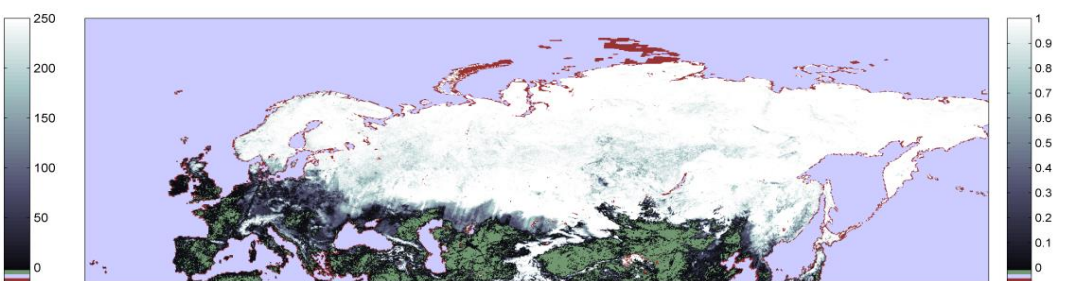
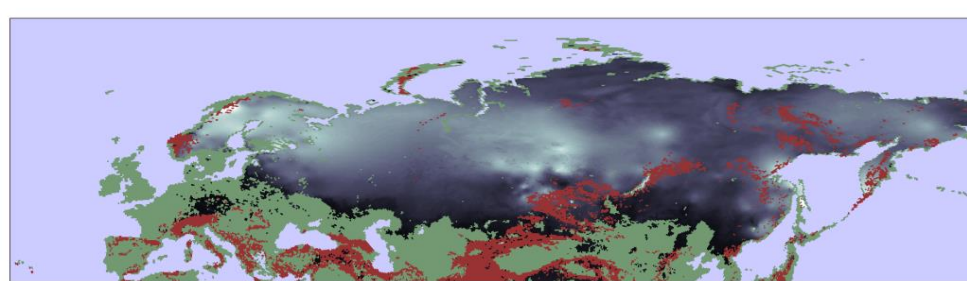




Combination of SE & SWE products for the generation of concise snow cover information

Combined snow mask from GS VIIRS SE and NOAA IMS

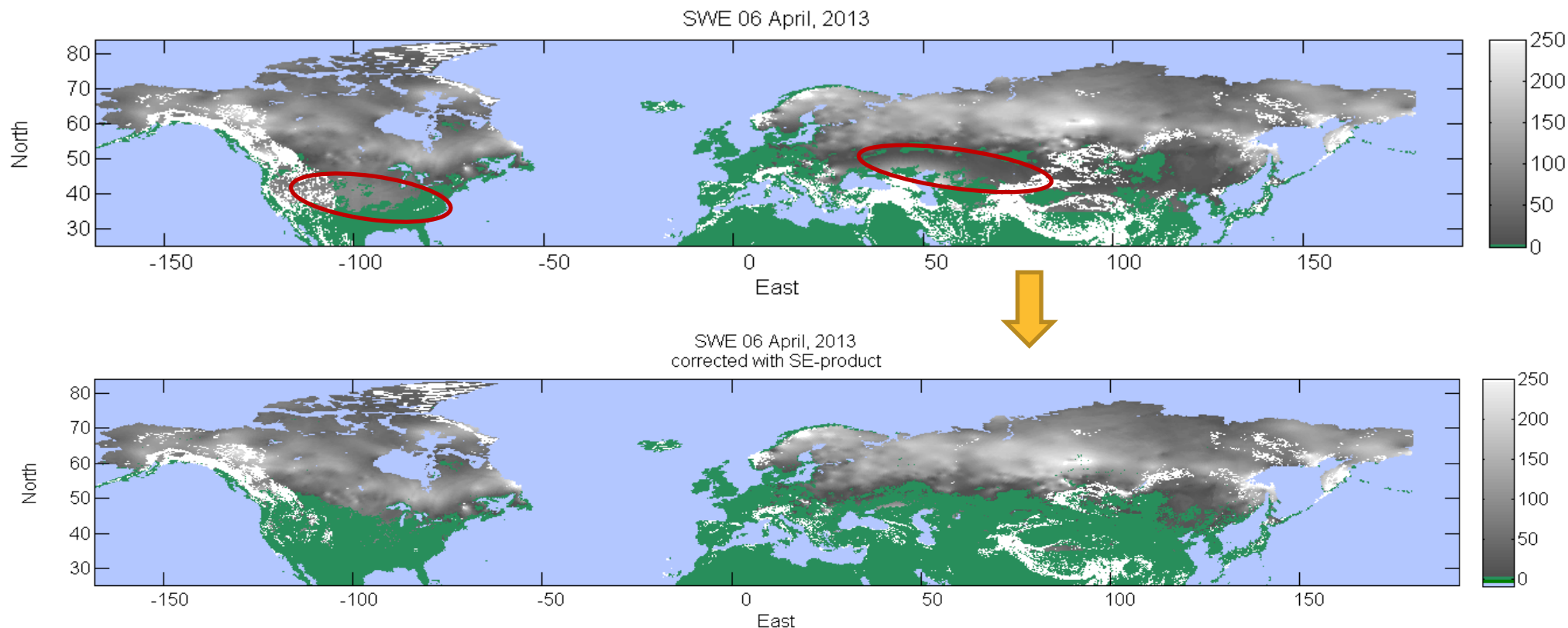






Fusion of GlobSnow SE and SWE

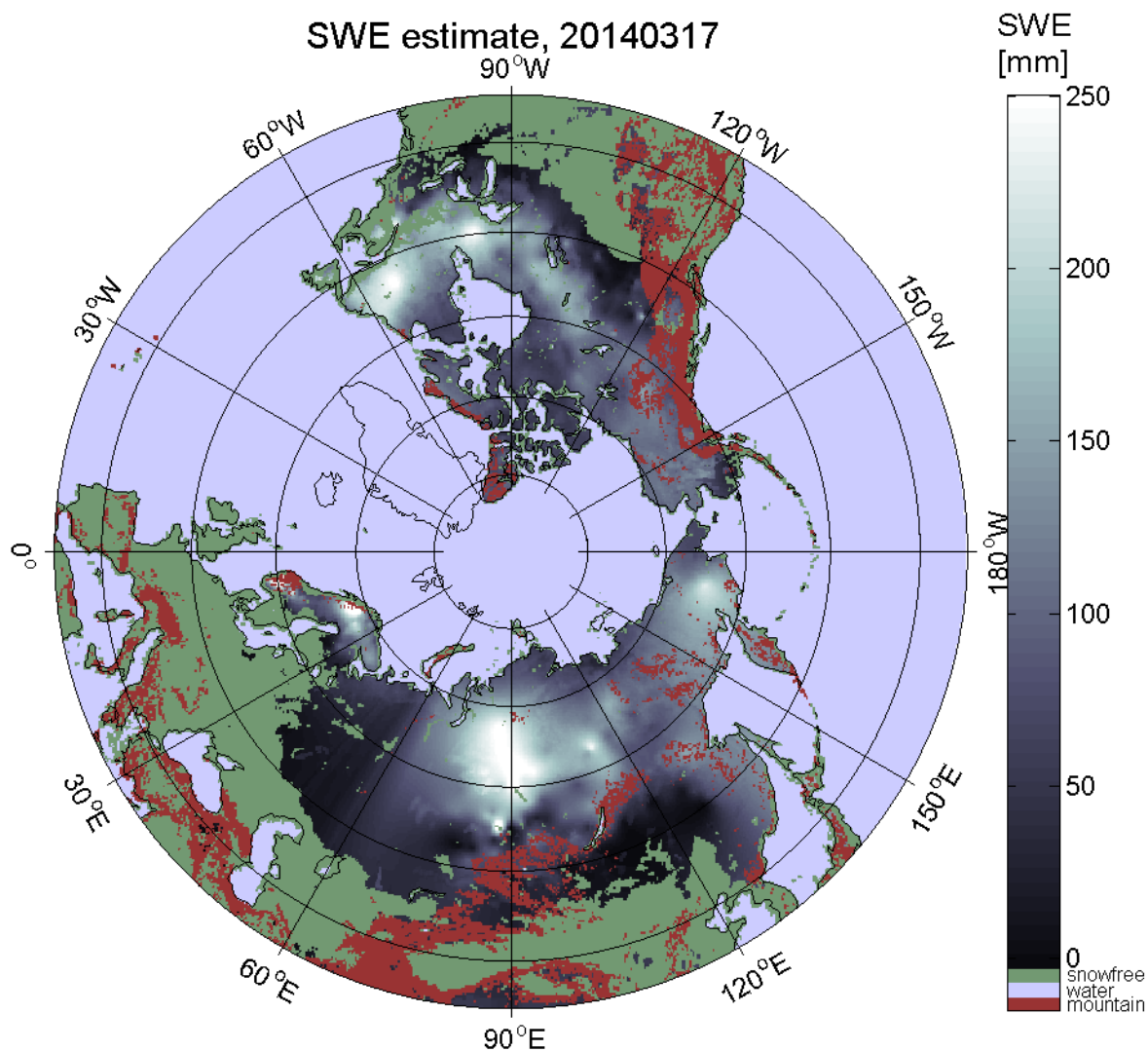
GlobSnow SWE NRT-product has difficulties in detecting snow line during spring melt season -> snow line identification from SE-product



Winter 2013-2014 processed & analysed

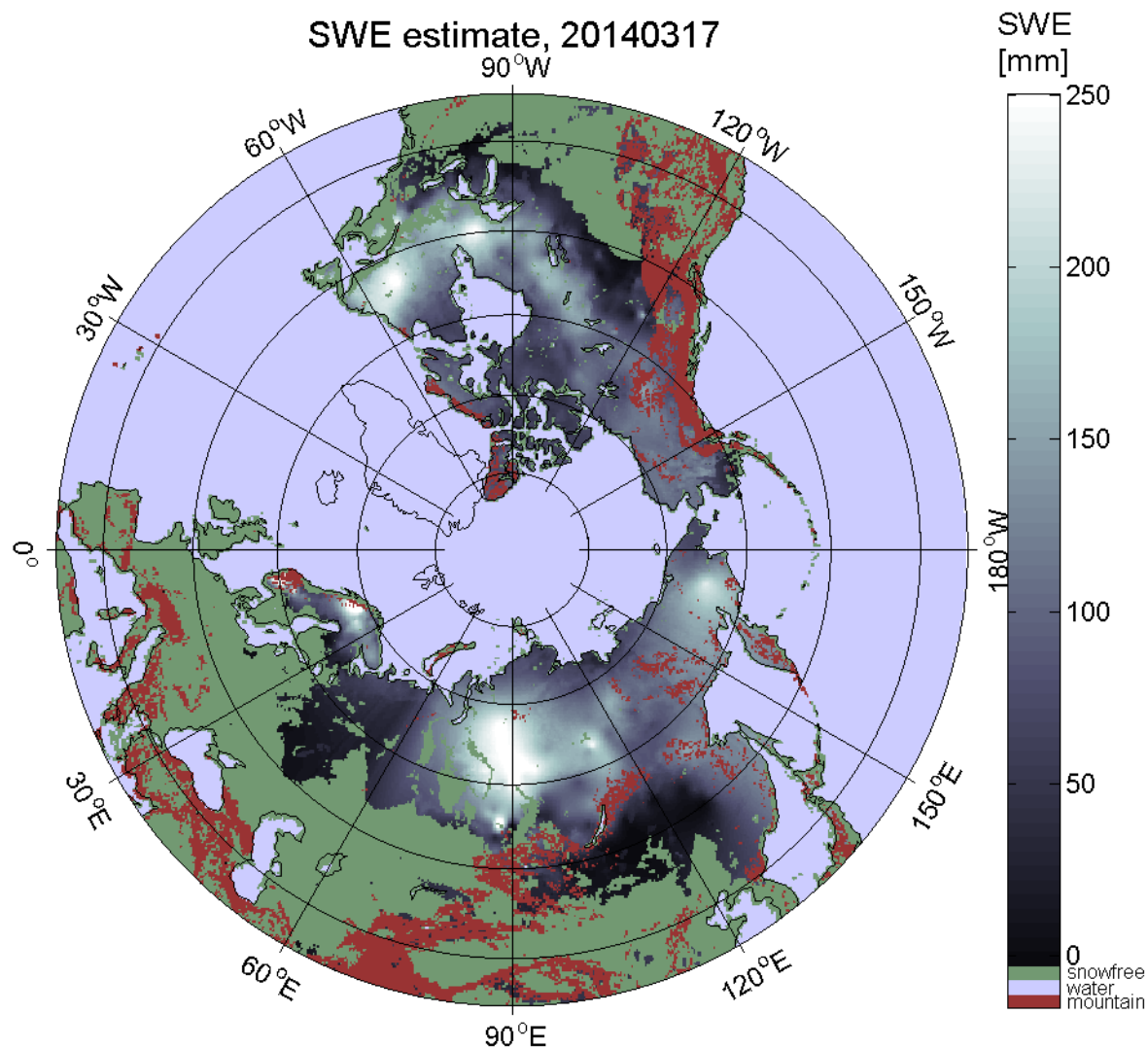


Original GlobSnow SWE (17 March 2014)



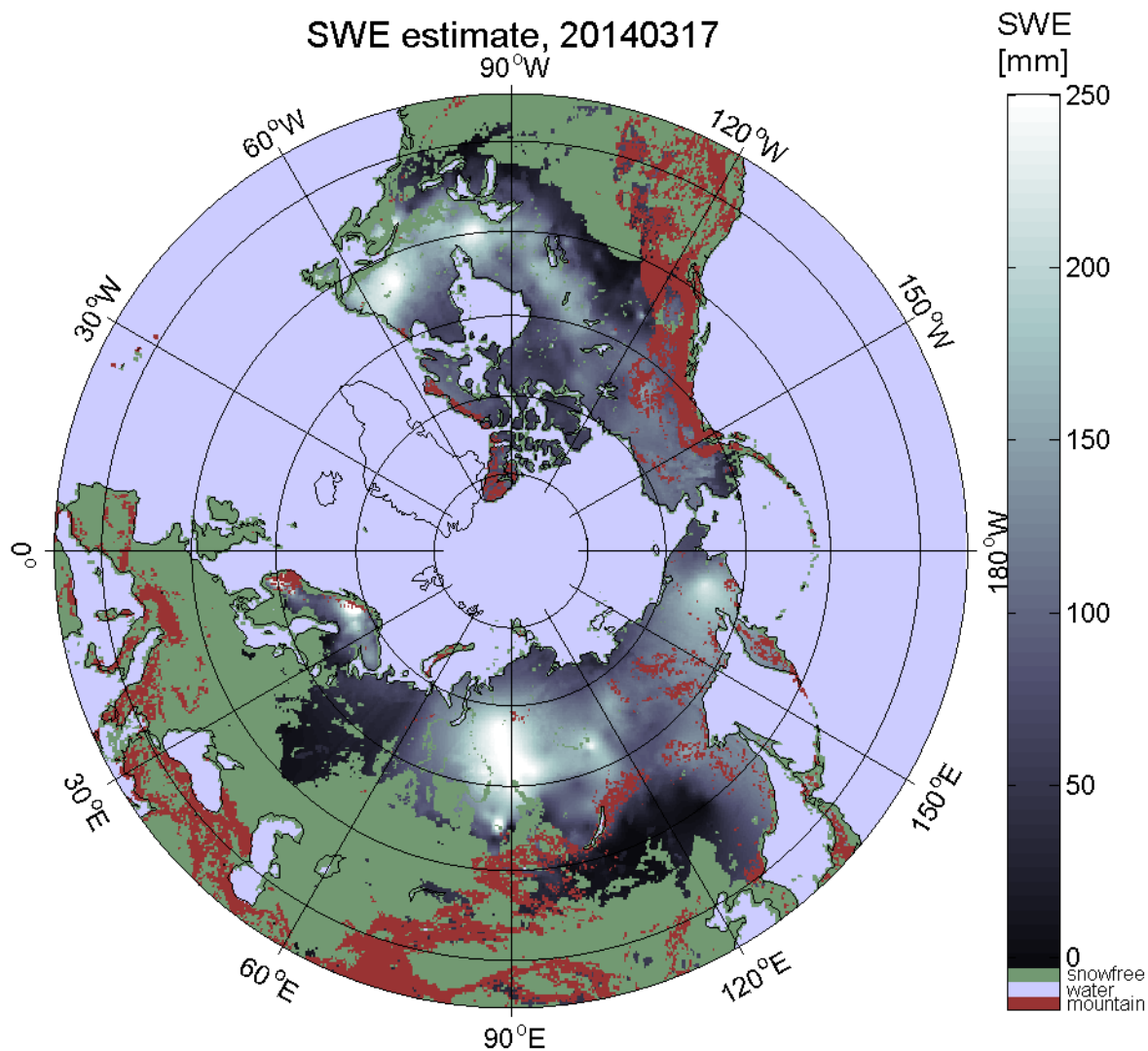


IMS masked SWE (17 March 2014)





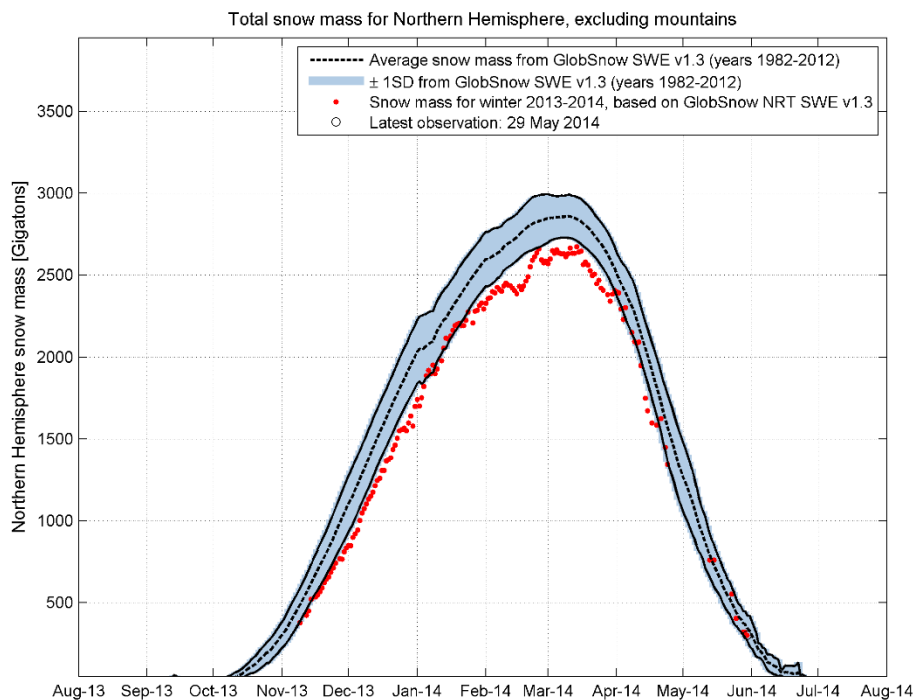
IMS+VIIRS masked SWE (17 March 2014)



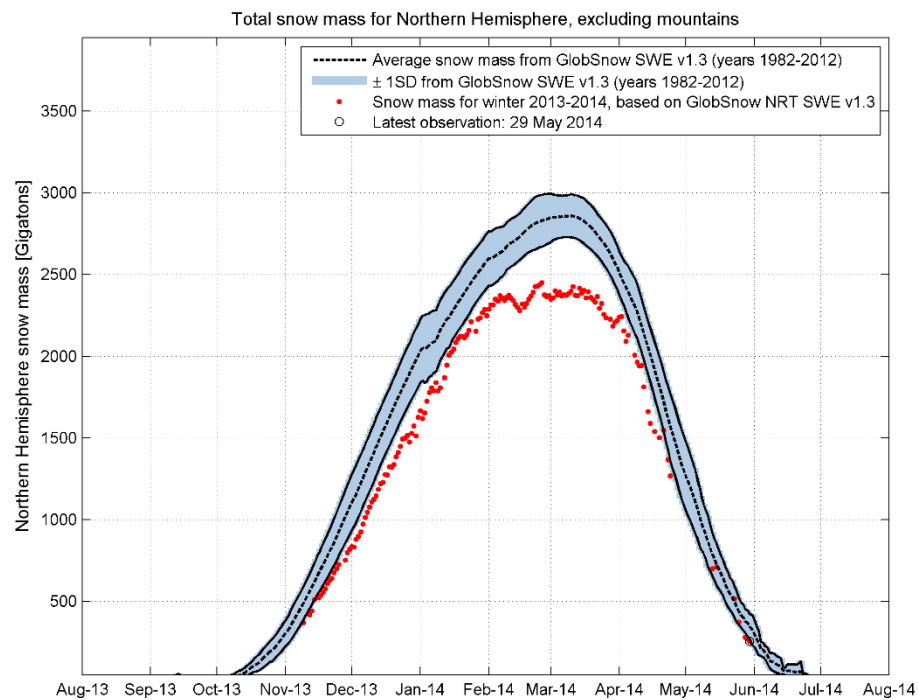


Total integrated NH snow mass 2014

Original GS SWE



IMS & VIIRS masked SWE





Pan-European High Resolution SWE

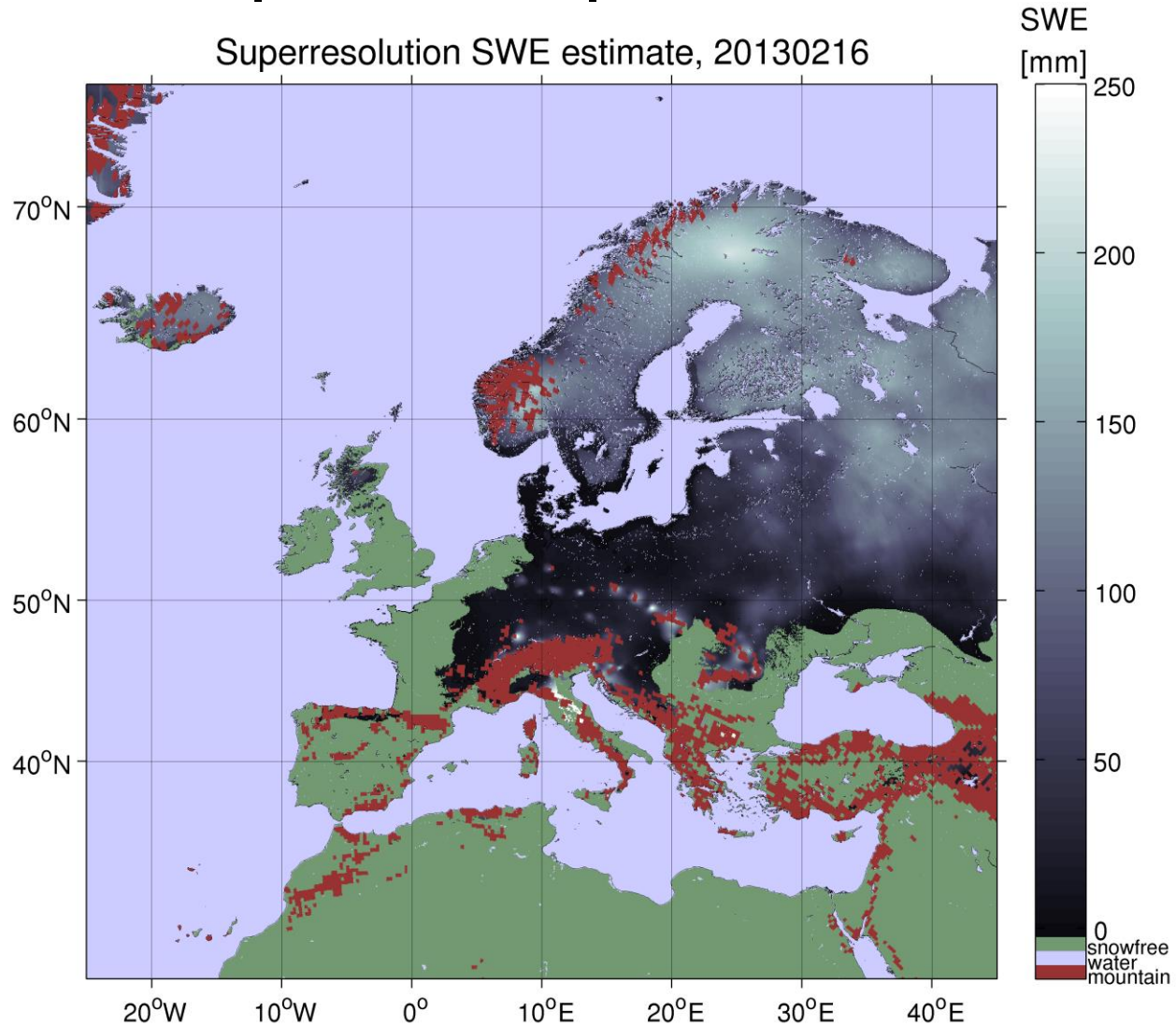


Super-SWE vs. GlobSnow CDR

- **Improved resolution by assimilating in a higher resolution grid (variation within footprint is dealt with simple convolution)**
- **Snow grain size and variance are interpolated using nearest neighbor interpolation with low pass filtering to reduce artefacts**
- **Auxiliary files are all overhauled (to the higher resolution grid), especially forest stem volume map (based on forest transmissivity map by Finnish Environment Institute SYKE)**
- **Snow covered area determined using IMS data for fall-winter season**
- **IMS+VIIRS used for the spring melt season**



Example of Super-SWE



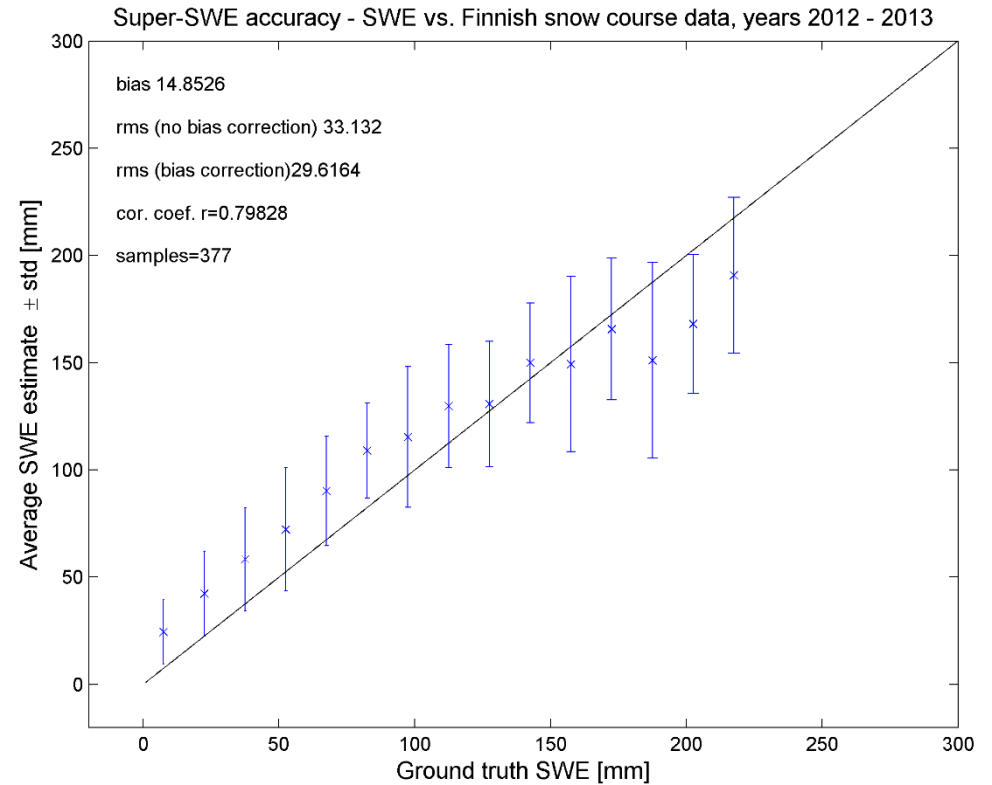
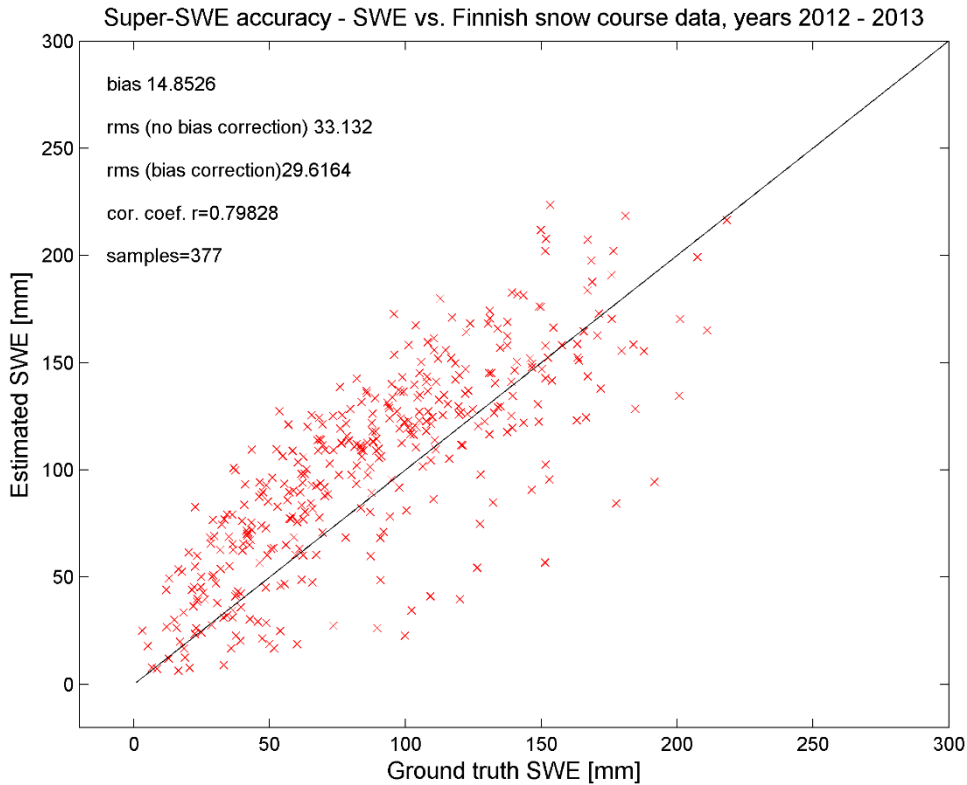


Super-SWE validation (winter 2012-2013)

- **Season 2012-2013 is validated in Finland using Finnish Environment Institute (SYKE) snow course data**
- **Validation data is independent of input SD data**
- **Super SWE: bias is 14.9 mm, RMSE 33.1 mm and RMSE with bias correction 29.6 mm**
- **H-SAF H13: bias 16.1 mm, RMSE 27.8 mm, and RMSE with bias correction 22.6 mm**



Super-SWE validation data scatterplot



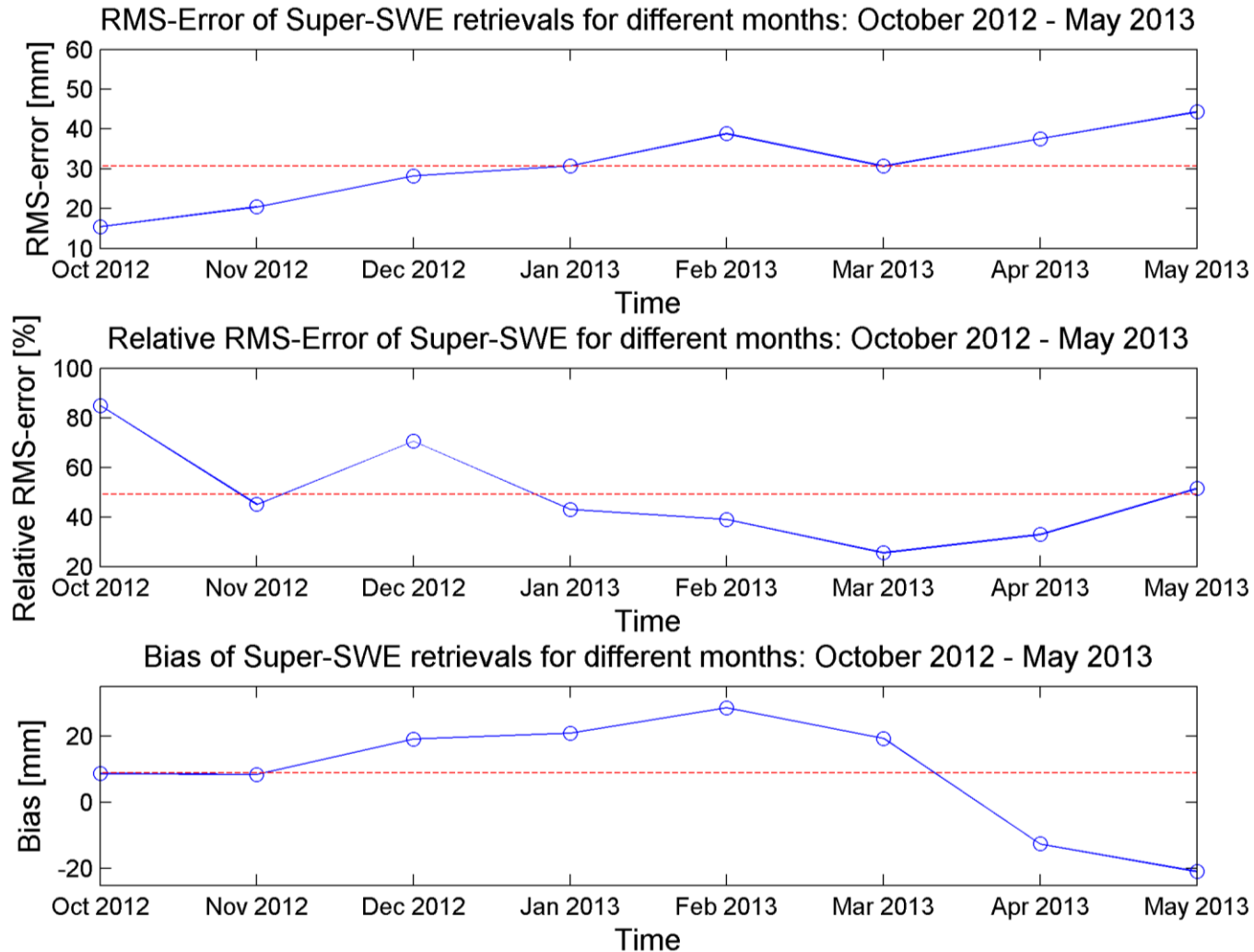


Interpretation of validation results

- **Higher resolution SWE product is in par with other products such as H-SAF H-13 and GlobSnow SWE**
- **Bias and RMSE slightly improved, when compared with GlobSnow CDR SWE**
- **RMSE plotted as a function of month, the peak SWE month has the lowest relative RMSE**



Monthly RMSE, relative RMSE & bias





Conclusions

Combination of SE & SWE products demonstrated

- Information on SWE and SE fused into a single layer
- Potential to produce a 2-layer product, showing SWE & SE data on independent layers (end user preference?)

Common user request concerning SWE products is the spatial resolution:

- Data assimilation can be used to estimate SWE in a finer resolution despite the radiometer instrument footprint
- Results are validated and in par with other SWE products

Production on-going for the SEN3APP project, both

- NH IMS/VIIRS augmented SWE product
- High-resolution Pan-European SWE product