

CryoLand

Snow Water Equivalent (SWE) product



Kari Luojus, Matias Takala, Jaakko Ikonen, Jouni Pulliainen
Finnish Meteorological Institute

Snow melt-day and SWE based on microwave radiometry – low resolution – hemispheric scale

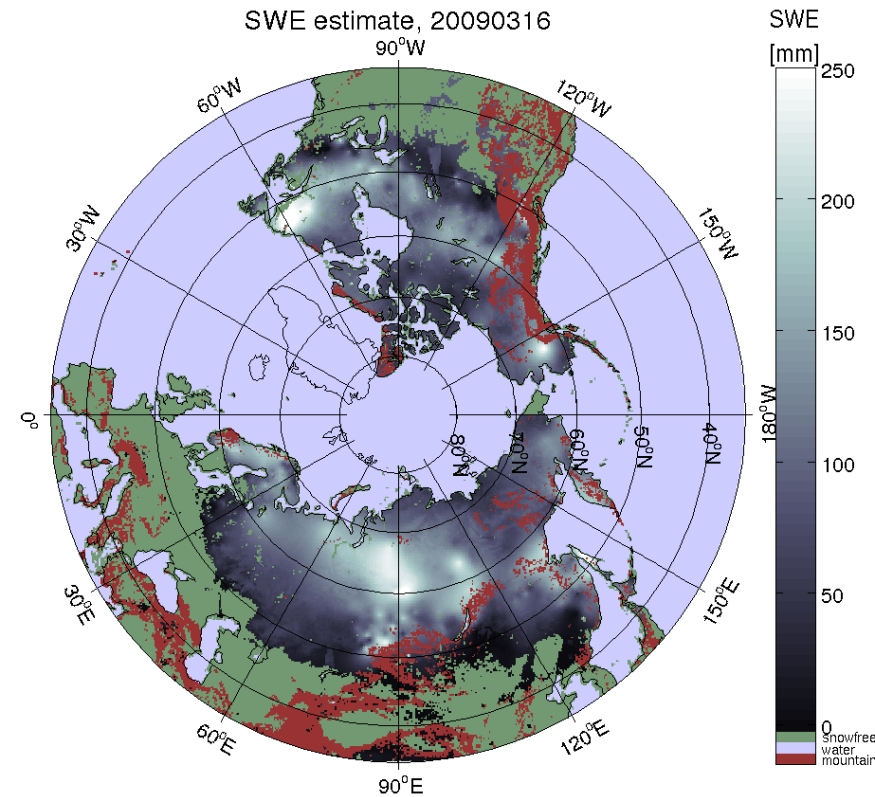


SWE Product (non-mountain areas):

- “ESA GlobSnow” -legacy
- Northern Hemisphere
- Grid size 25 km
- Daily maps
- Polar stereographic projection
- Passive MW data (DMSP SSMIS), combined with synop observations

Improvements within CryoLand:

- Regional algorithm accounting for land cover
- Higher spatial resolution (~10km)
- Delivered in lat-lon grid (0.1x0.1 cells)
- Produced at Sodankylä National Satellite Data Center FMI/ARC
- Sustainability for 2014/2015 &(2015/2016)

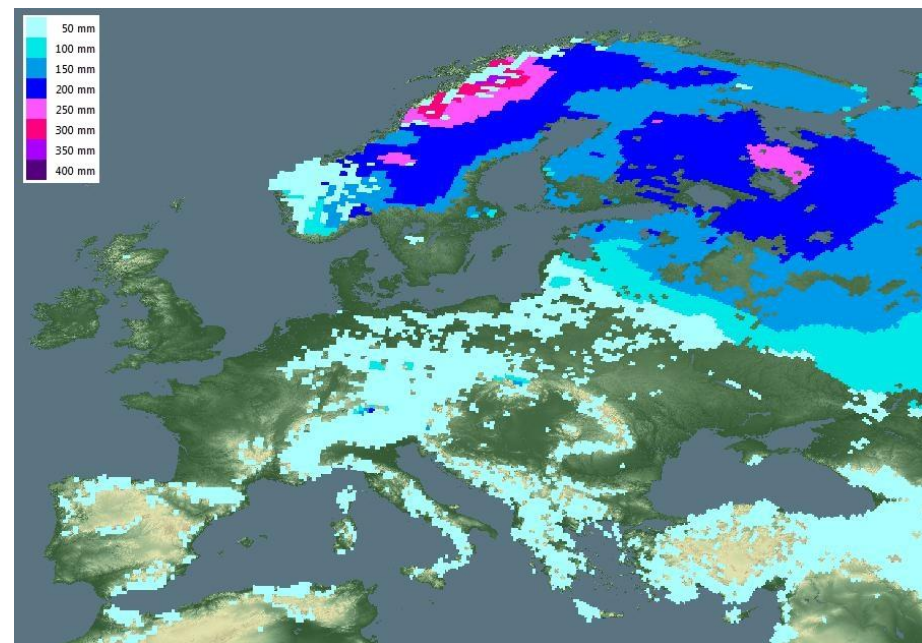


Pan-European SWE product (NRT status)



Status:

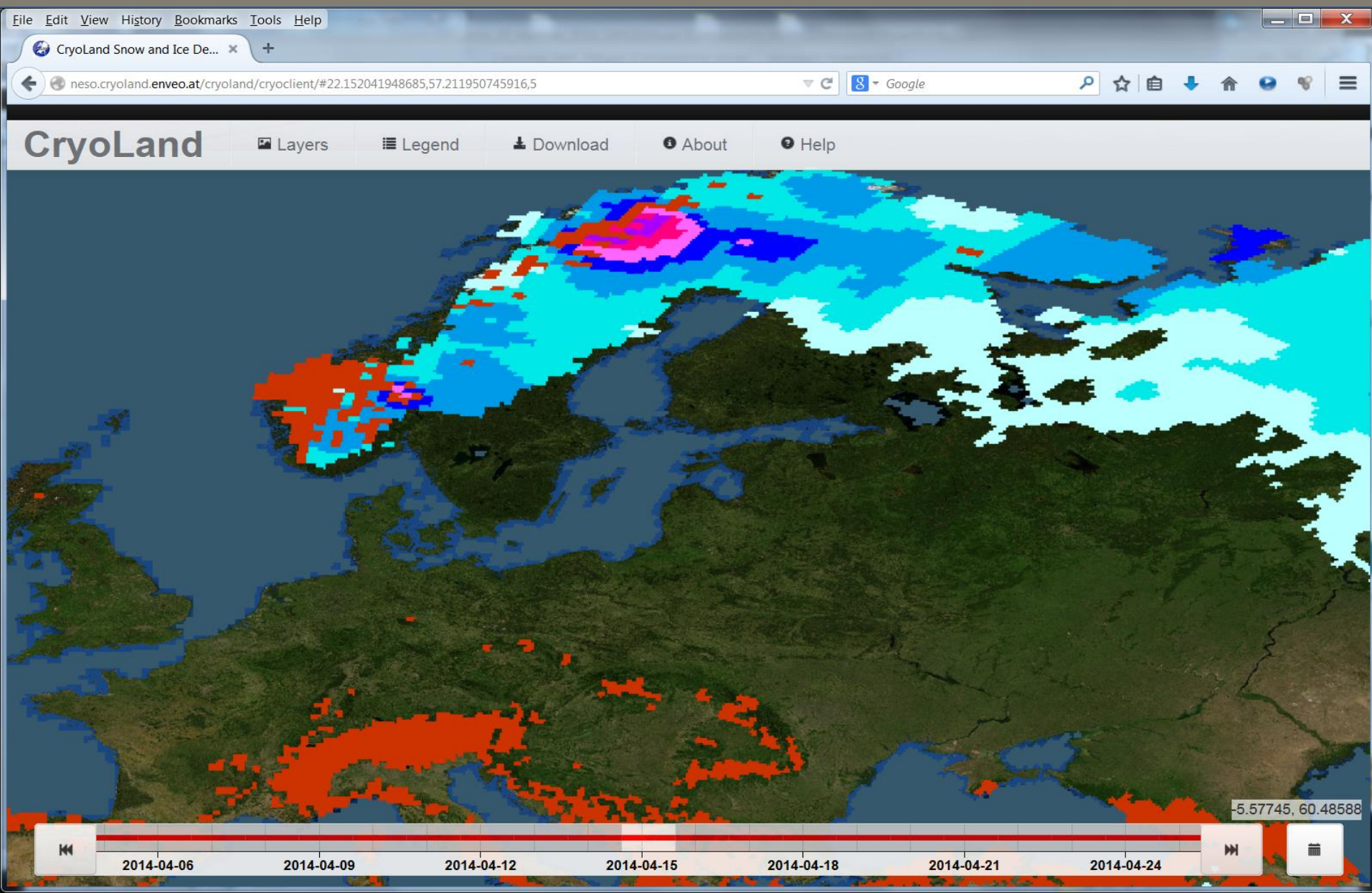
- NRT Data production & delivery begun late December 2012
 - Data packaging according to CryoLand specifications
 - Data transfer via ENVEO FTP
 - Data available from:
<http://neso.cryoland.enveo.at/cryoland/cryoclient/>
- Service guaranteed for winter 2014-2015 (& 2015-2016)



Pan-European SWE Product 15 February 2011

Parameter	Specification
Thematic variable	Snow Water Equivalent (SWE)
Thematic resolution	4% SWE up to 400 mm
Delivery time period	Winter Season: late October – June
Temporal frequency	Daily
Spatial resolution	0.1° × 0.1°
Sensor	DMSP SSMIS Radiometer Data
CryoLand status	Operational

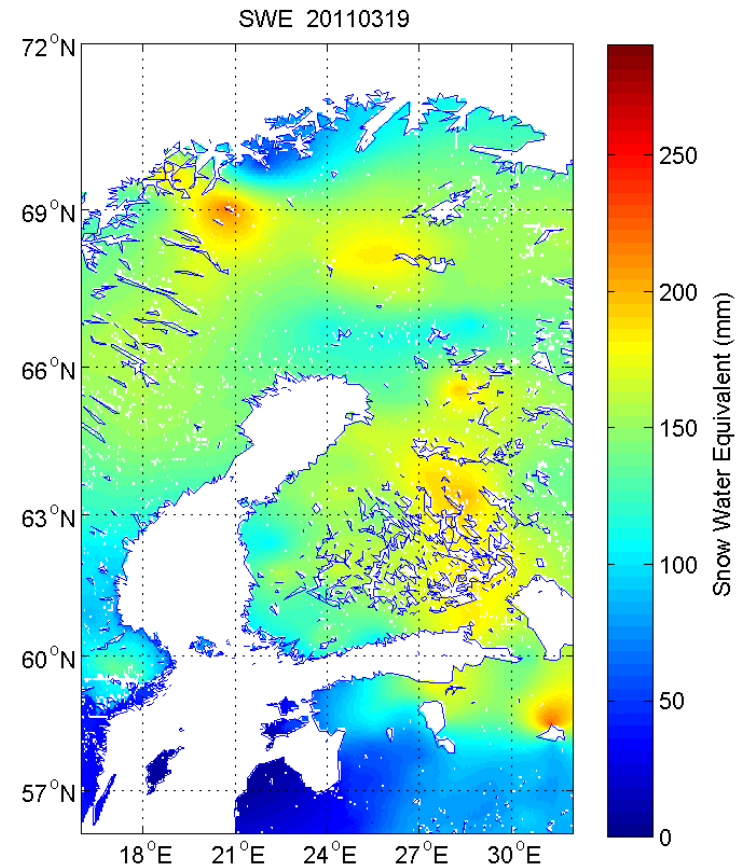
CryoLand pan-European SWE product (@ CryoLand server, 15 April 2014)



High resolution regional SWE product - production based on user demand



- Snow Water Equivalent (SWE)
 - = amount of water the snow pack contains
 - ≈ thickness (with estimated snow density)
 - + Daily product from SSMIS
 - + Assimilation of weather station obs.
 - + All weather conditions & night time
 - +/- for continuous snow cover (from Nov/Dec – Mar/Apr)
 - +/- Calculation unit $0.05^\circ \sim 5\text{km}$ (interpolations of satellite and ground truth data)
 - Possibilities for improvement:
 - Combining with higher resolution images



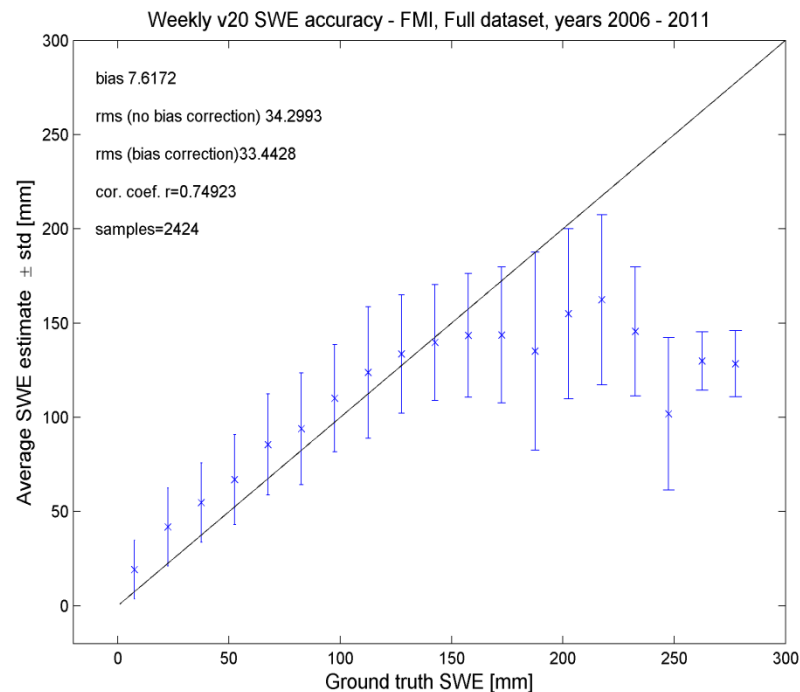
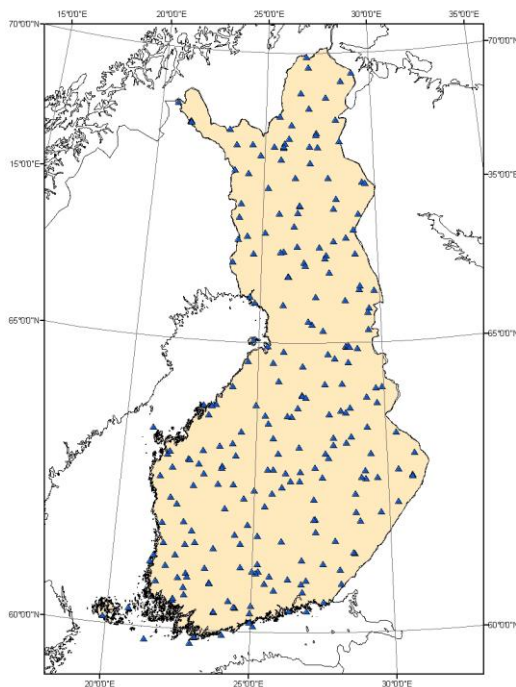
Requires dense meteorological station network
-> currently produced for land areas of Finland (for SYKE hydrological use)



Evaluation, Finnish snow courses, 2006-2011

Finnish snow survey data

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



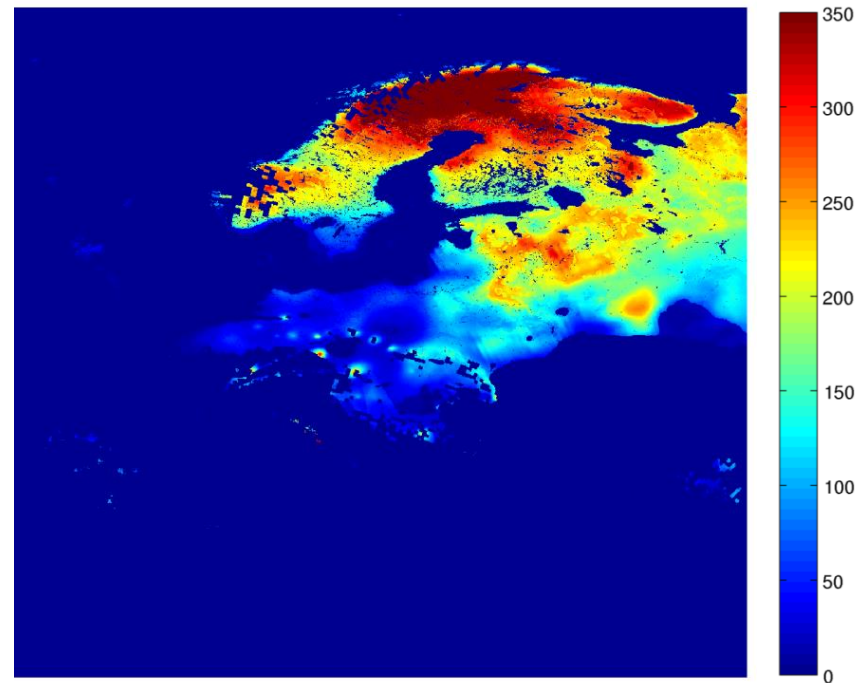
**GS-2 SWE v2.0, Bias +7.6 mm,
RMS-error: 34.3 mm,
2424 samples**

High resolution (5km) Pan-European SWE product



High resolution SWE product

- In Development Phase
- SWE retrieval based on assimilation of PMW & synop-data with enhanced high resolution auxiliary data
- Fractional snow cover info used for:
 - improved snow detection during winter snow accumulation period
 - Improved melt detection during spring
- Utilization of optical (VIIRS-based) data in combination with NOAA IMS (4km) product
- Pan-European domain (5km resolution)
- Test phase: winter 2014-2015
- Available for testing...



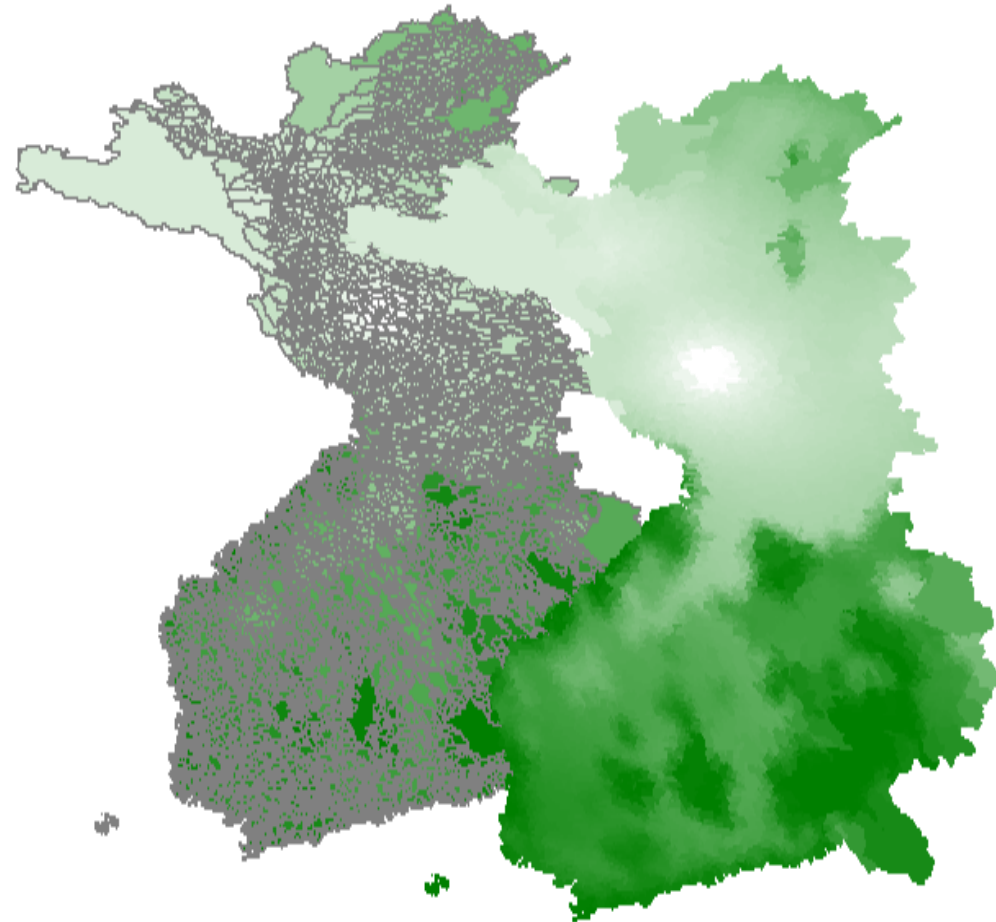
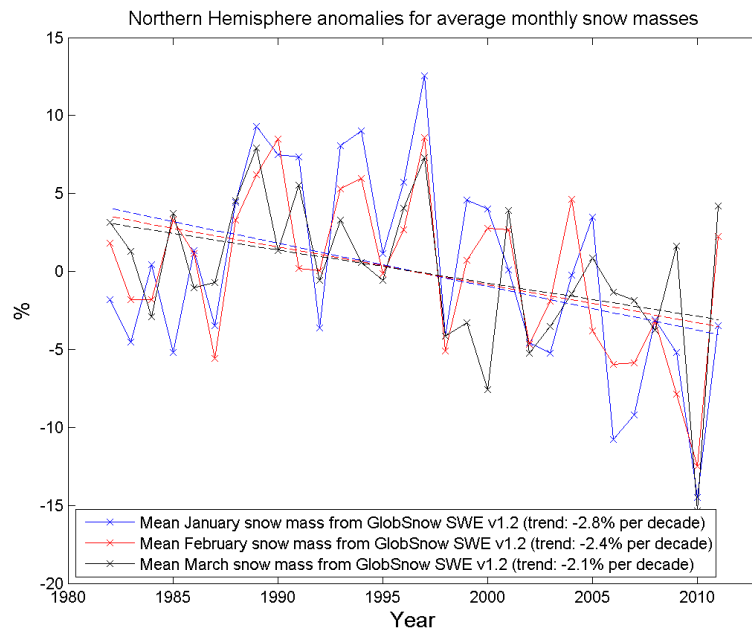
5km SWE product for 16 March 2013

Derived SWE products

Derived SWE products



- **Derived SWE products:**
 - User defined calculation areas – e.g. Finnish WSFS
 - Statistics & trend analyses based on a 30-years time-series, e.g. : monthly average SWE, Mean melting date, etc...
 - EDO/JRC SSPI



Monthly average SWE for Finnish WSFS (SYKE) drainage basins, January 2009

- Development of a end-user tailored added-value product for drought monitoring (European Drought Observatory / JRC)

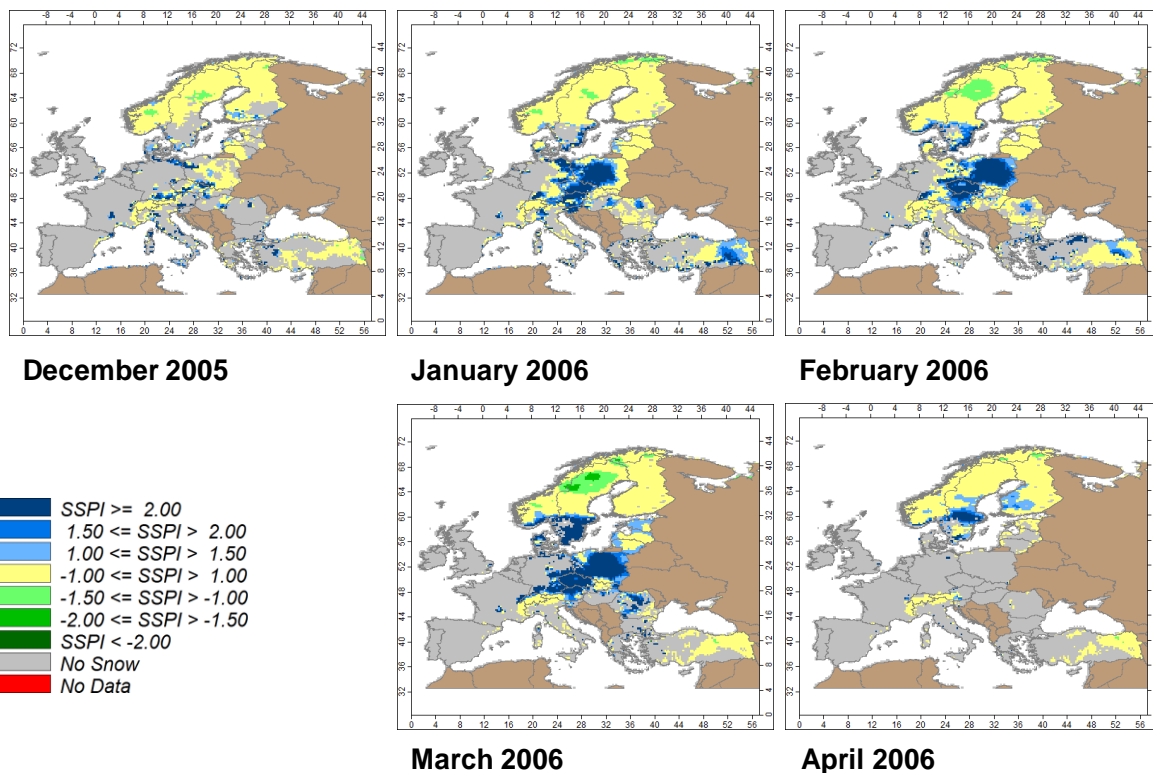
- ESA GlobSnow Long-term snow information (covering 35-years) applied for NRT drought monitoring

- The SSPI is defined as the unit standard normal deviate associated with the percentile of snowpack accumulated over a specific duration

- Normalized values between -2 and below to 2 and above
- ten-day and monthly averages of GlobSnow SWE product used

- Intermediate end-user: EDO/JRC (Joint Research Center)

Monthly Average SSPI Winter 2005 - 2006





Application for Hydrological Modelling in Finland

- **Operational hydrological activities in Finland by SYKE (the Finnish Environmental Institute)**
- **FMI activities focus on research and support for operational hydrology in Finland and Baltic Sea drainage basin**

Current status

- Development of FMI Hydrologic Modelling and Forecasting Capability - **H**ydrological **O**perations and **P**redictions **S**ystem (HOPS)
- Conceptual models with physically based parameterization schemas as a basis
- The modelling system's is currently under testing – initial results available / promising
- Testing of physically based a-priori parameterization schemas
- Testing of satellite based snow cover data (SWE) assimilation on model performance

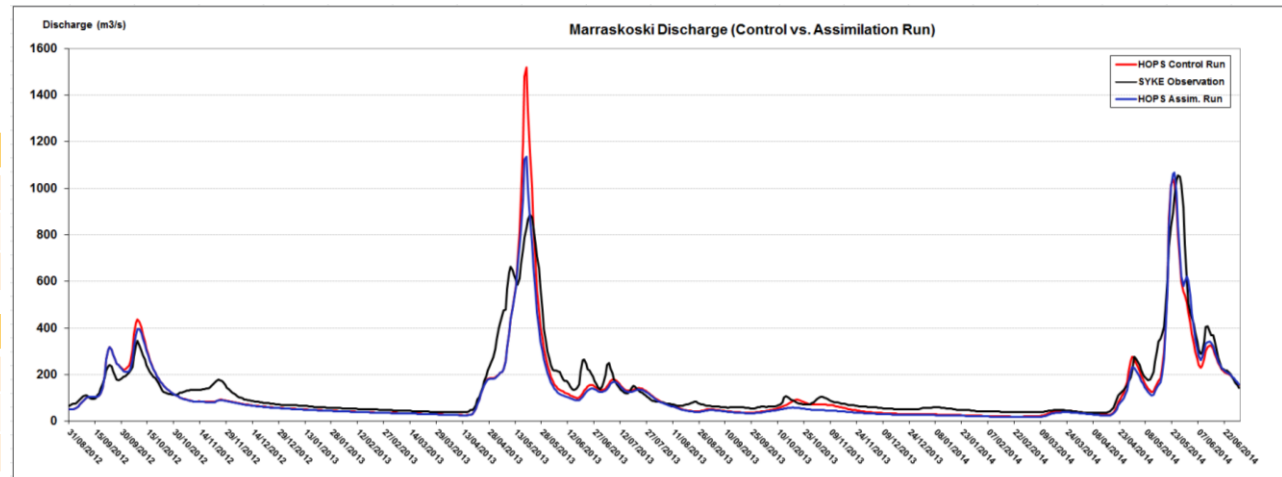
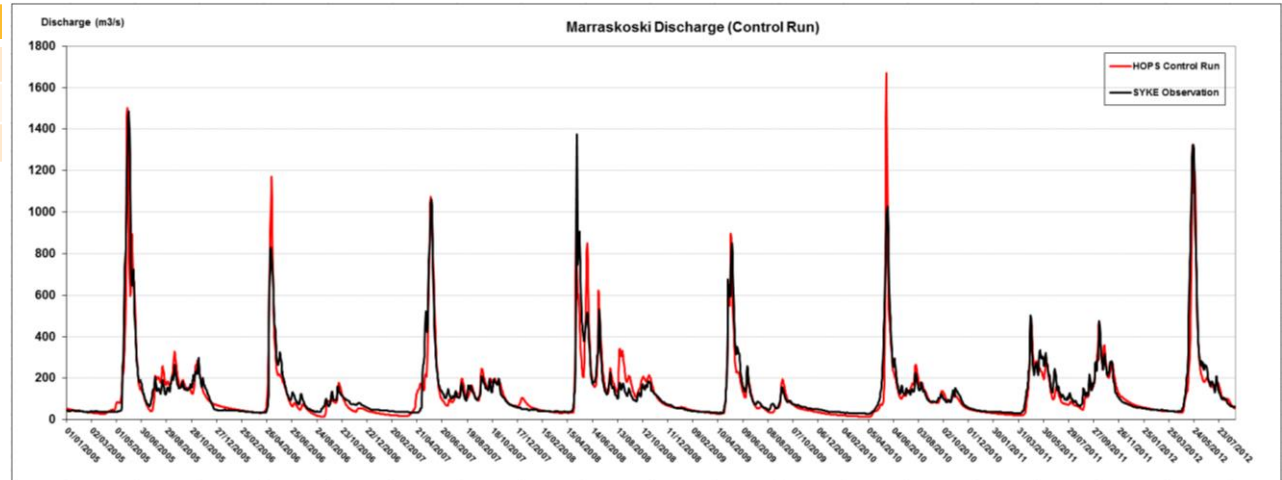
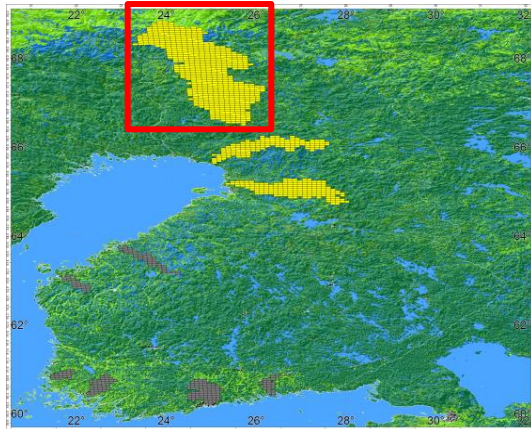
Future outlook

- Development of a prototype NRT reservoir inflow forecasting data service for further basins in Sweden and/or Norway



Initial Control and Assimilation Runs (Ounasjoki)

Performance Stats	Control Run (2005 - 2012)
NASH SUTCLIFFE:	0.86
CORRELATION:	0.93
RMSE:	343.19

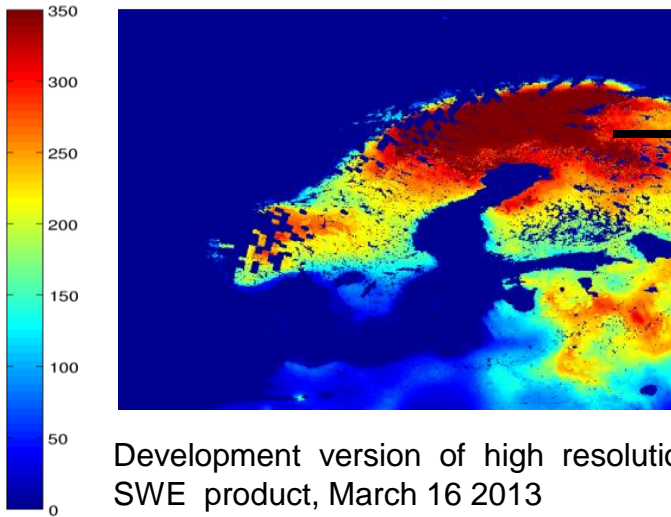


Performance Stats	Control Run (2012 - 2014)
NASH SUTCLIFFE:	0.81
CORRELATION:	0.92
RMSE:	229.41

Performance Stats	Assim. Run (2012 - 2014)
NASH SUTCLIFFE:	0.86
CORRELATION:	0.94
RMSE:	327.9

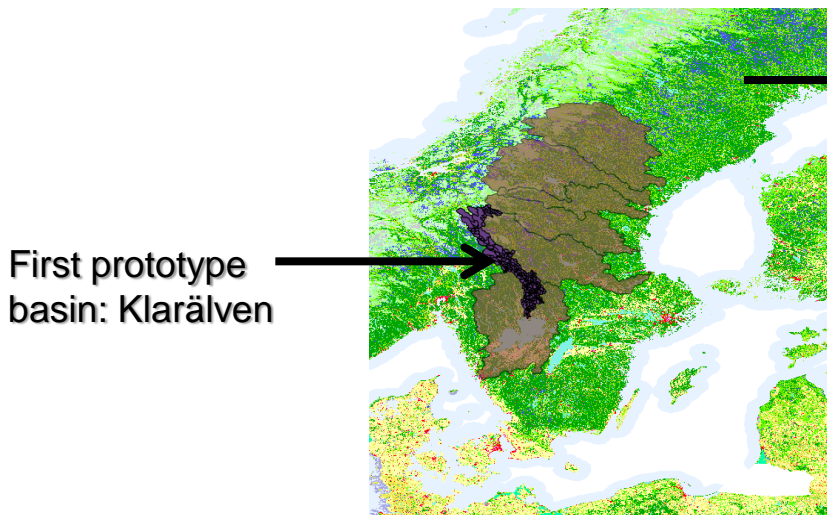


NRT Snow and Inflow Forecasting Delivery System

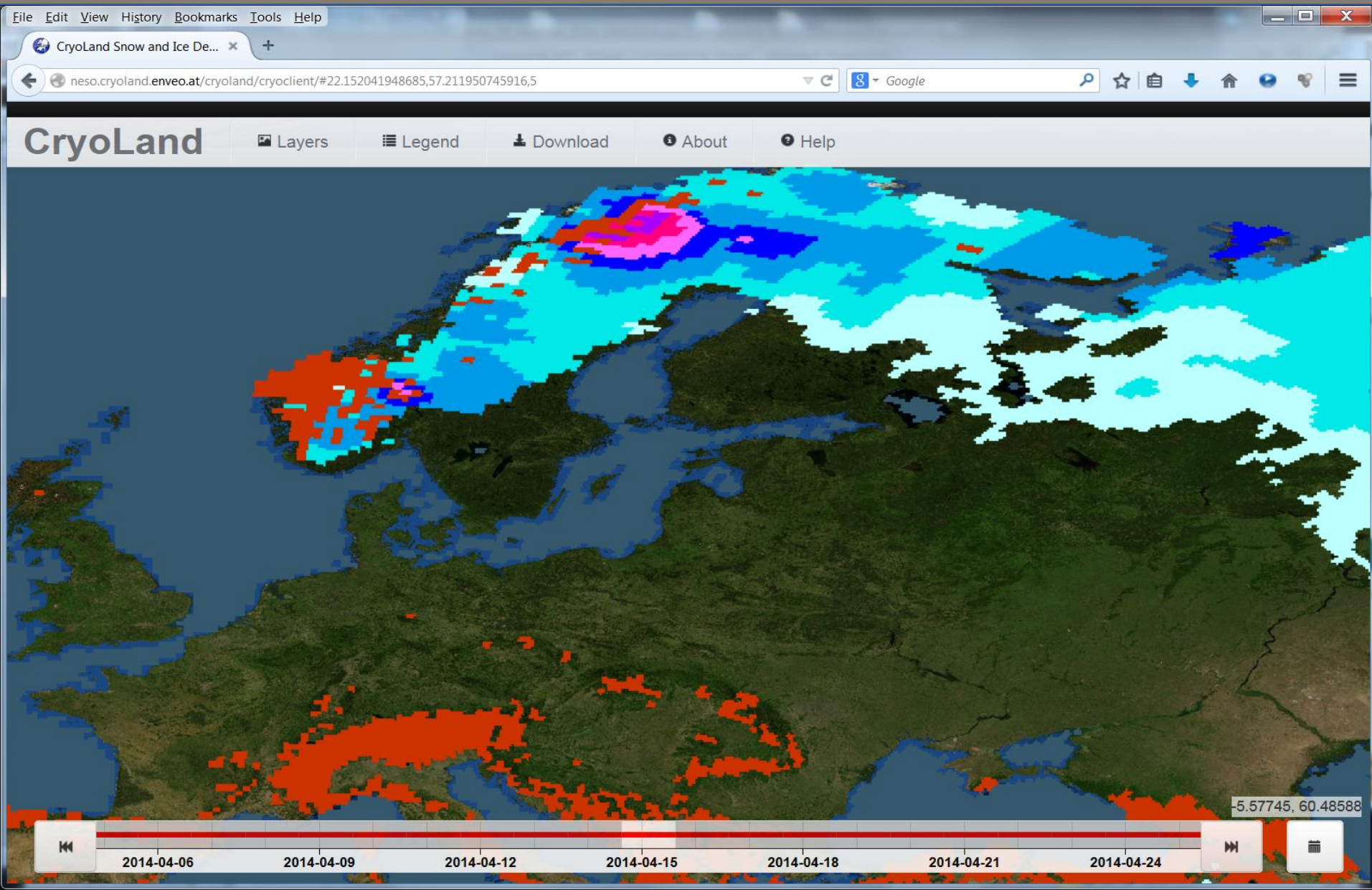


Objectives for winter 2014-2015:

- Development of an operational NRT EO snow cover data delivery system for a selected area: Sweden/Norway
 - High resolution (5km) SWE map
 - Fractional snow cover map
 - Statistical Snow depth (SWE) data for sub-basins
- Development of a NRT reservoir inflow forecasting data service
 - Based on FMI (HOPS) System
 - Satellite based snow cover data (SWE) assimilation
 - ECMWF / HIRLAM forecasts to drive the operational hydrological forecast service



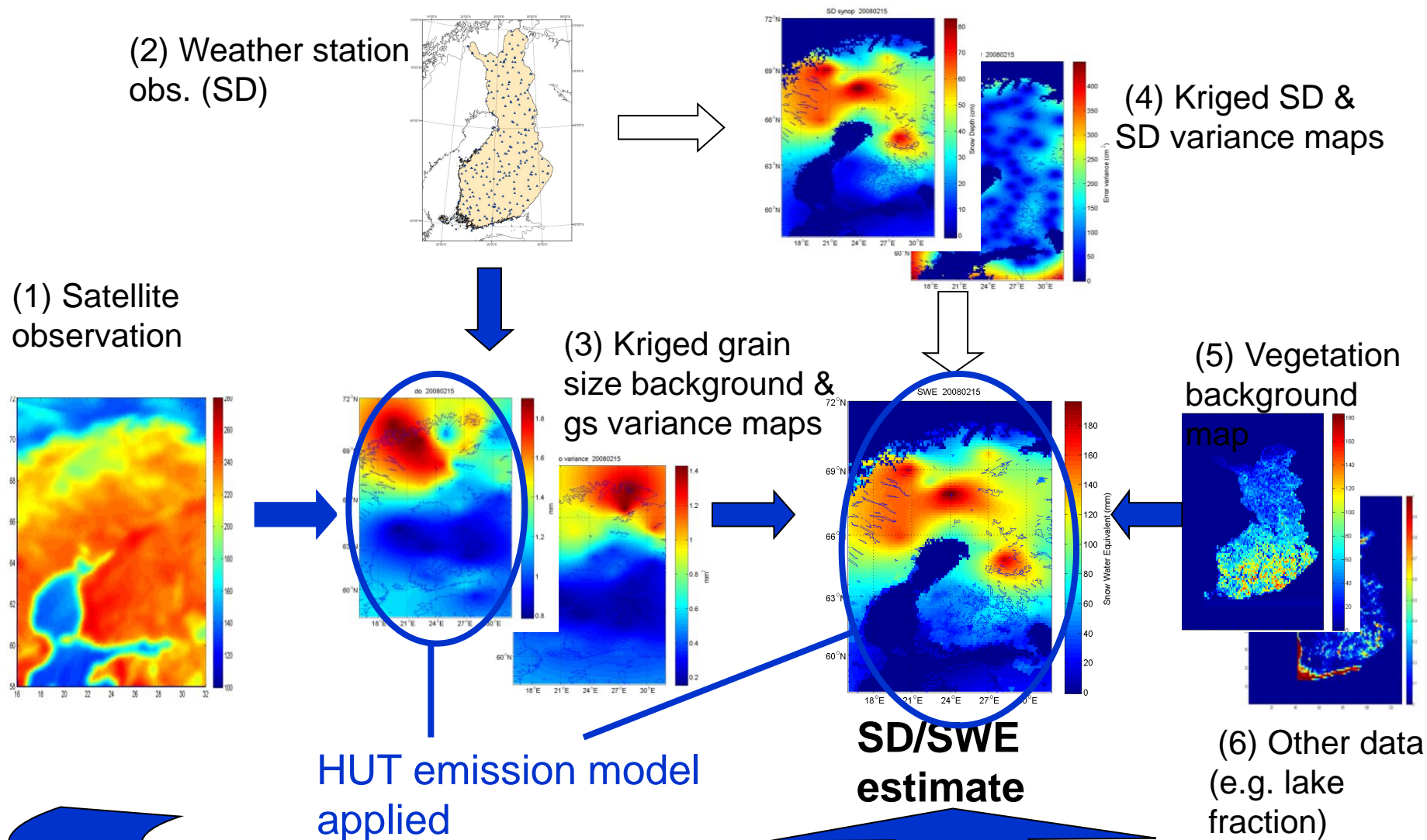
SWE product -CryoLand server- (15.4.2014)





Backup Slides Processing chains...

SWE product – thematic processing chain



CryoLand pan-European SWE product - processing chain



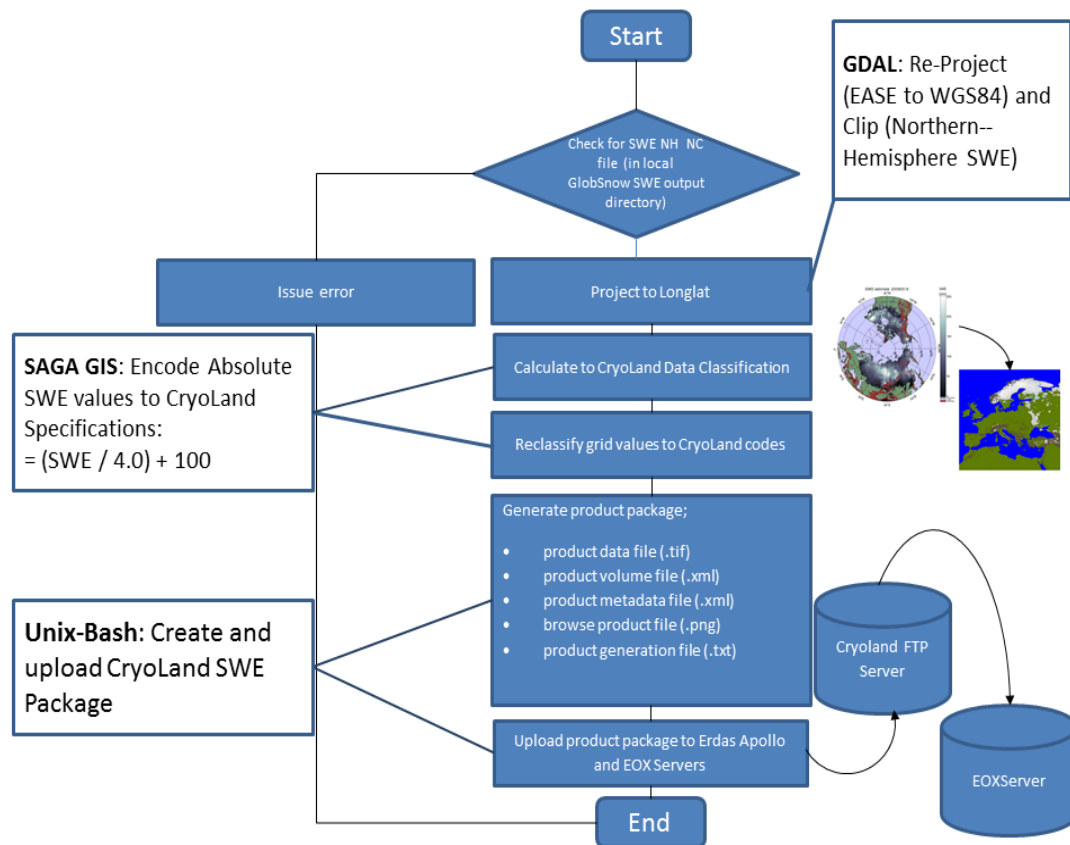
- “Raw” GlobSnow data (.Netcdf) from Litdb-database (www.glosnow.info)
- Unzip and convert GlobSnow packages to Geotiffs
- SAGA GIS used to re-code grid values according to CryoLand specifications
- SAGA GIS used to re-project from EASE-grid to WGS84, mask and resample to 0.10 and 0.25 degree grids
- create metadata xml files
- processed data (incl. metadata) moved to storenet archive
- data in storenet archive catalogued and made available on FMI internal ERDAS Apollo server
- Getting data to CryoLand-server:
 - FMI pushes data to EOX server using FTP



Pan-European “Lat/Lon” SWE 1.1. 2009

Pan-European SWE Service:

- **Re-projection:** The Northern Hemispheric 25km EASE grid SWE maps are re-projected to geodetic Lat/Lon WGS-84.
- **Re-sampling and Clipping:** The re-projected grids are clipped to correspond to the CryoLand SWE service domain and resampled to a resolution of 0.1 degrees.
- **Reclassification:** The resampled grid values are reclassified according to CryoLand SWE service encoding.
- **Product packing:** Service product packages containing a data file, xml metadata files, a snap shot file and product generation text file are generated.
- **Uploading:** Completed packages are simultaneously uploaded to FMI's Erdas Apollo Map server and Compressed packages (tar.gz) are uploaded to the EOX ftp-server geoportal directory.

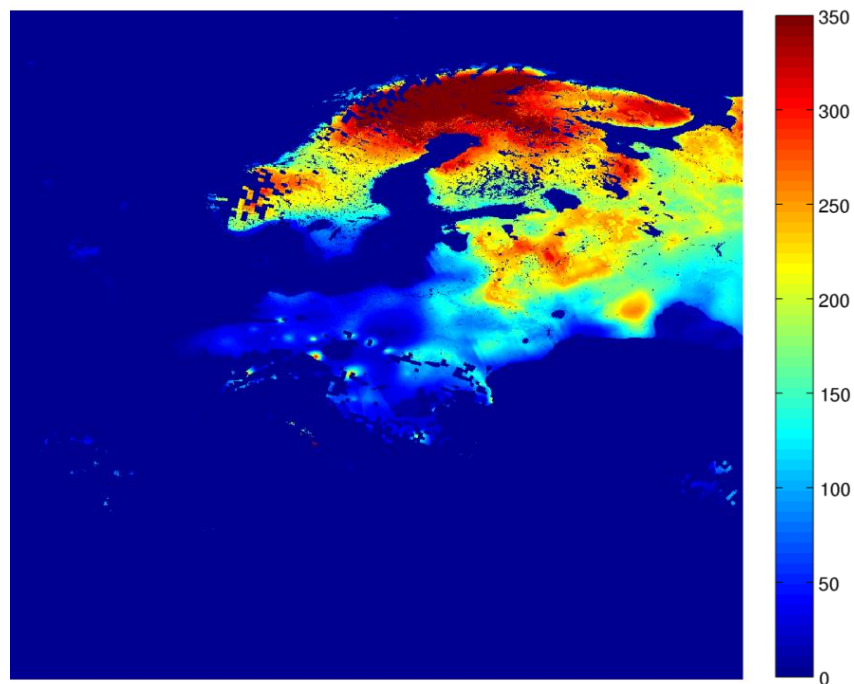


Enhancing the spatial resolution of SWE retrieval



- High resolution SWE product for Europe $\sim 5\text{km}$ (0.05×0.05 degree lat/lon grid)
- Improved aux data; additional WS data; DMSP SSMIS PMW data; snow extent from NOAA IMS snow product & NPP VIIRS
- Covering pan-Europe, longitudes: 25W - 45E & latitudes: 25N - 75N

16 March 2013



15 March 2014

