Overview of the GlobSnow SWE product

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Overview of the SWE product

– Outline –

1) Detailed explanation of the product, including examples

2) The prototype SWE product for Northern Hemisphere

3) The GlobSnow SWE algorithm

4) The validation results - briefly (more details on Wednesday)

Detailed explanation of the SWE product

- SWE products (30 years + Oper.NRT product)
- Covering Northern Hemisphere for 1978 - 2010
  - Based on
    1) AMSR-E data (2002 – present)
    2) SSM/I data (1987 – 2002)
    3) SMMR data (1978 – 1987)
    4) Global weather station data (through WMO)
  - SWE Algorithm by Pulliainen (2006)

Detailed explanation of the SWE product

• Following an intercomparison of algorithms from Environment Canada, NASA, and FMI over Eurasia and Canada, the GlobSnow SWE product will be derived using the method described in Pulliainen (2006) and currently employed operationally over Eurasia by FMI.

• Methodology (FMI algorithm / Pulliainen 2006):

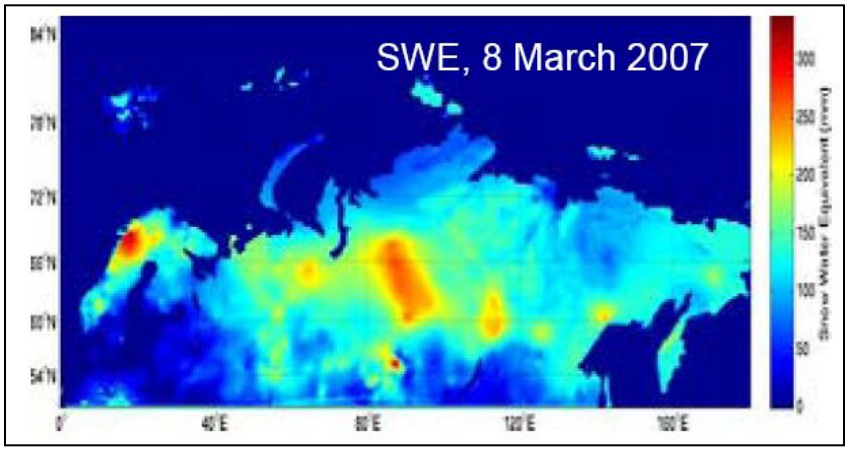
  •Assimilation of satellite data with *in situ* observations (snow depth from weather stations)

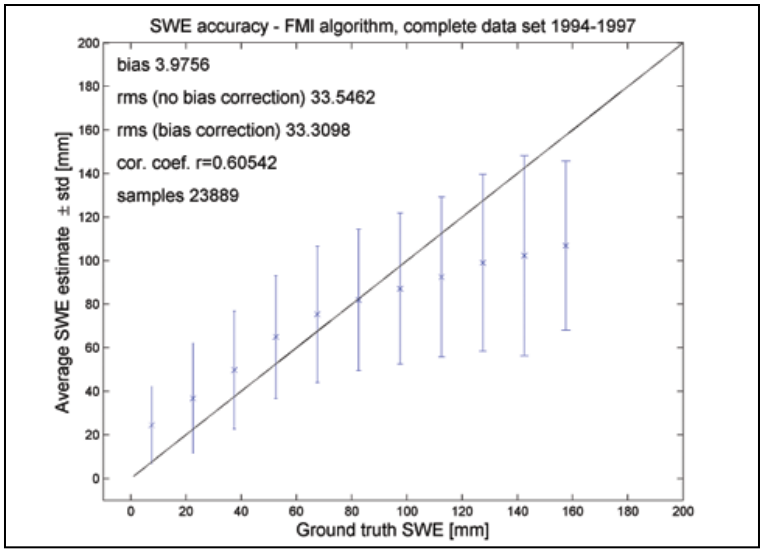
  • Kriged daily effective grain size background field (determined by adjusting HUT model to weather station SD)

  • Statistical uncertainty produced for each grid cell

• Time series will extend from 1978 to present covering Northern Hemisphere

• Operational near real time service will begin producing snow maps during 2010.



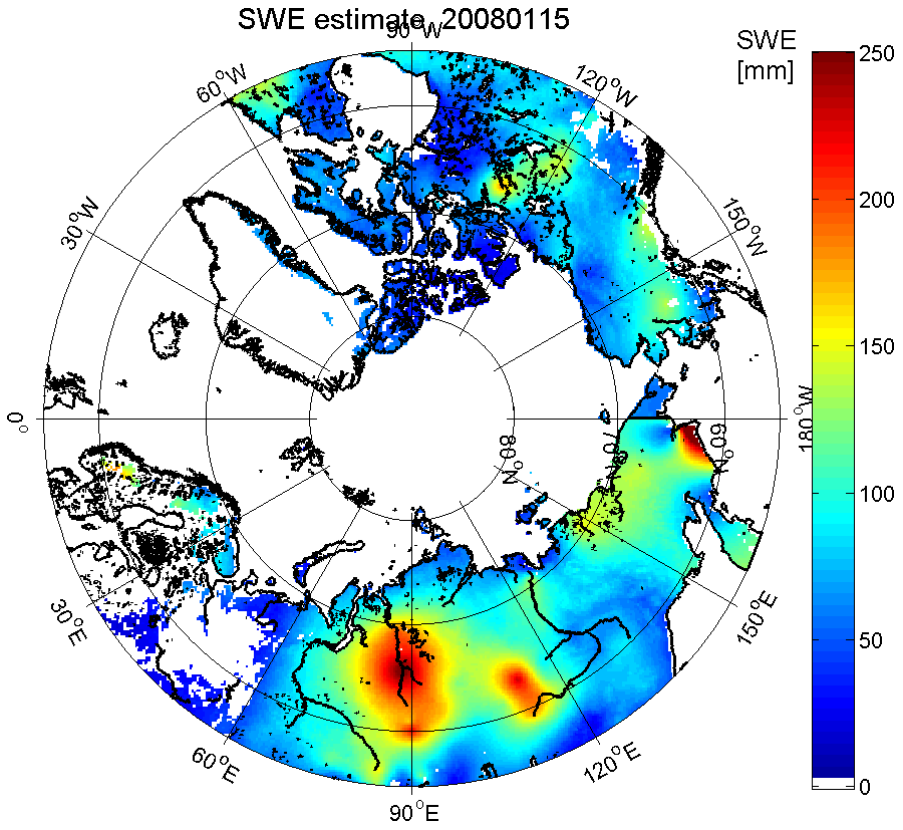


Detailed explanation of the SWE product

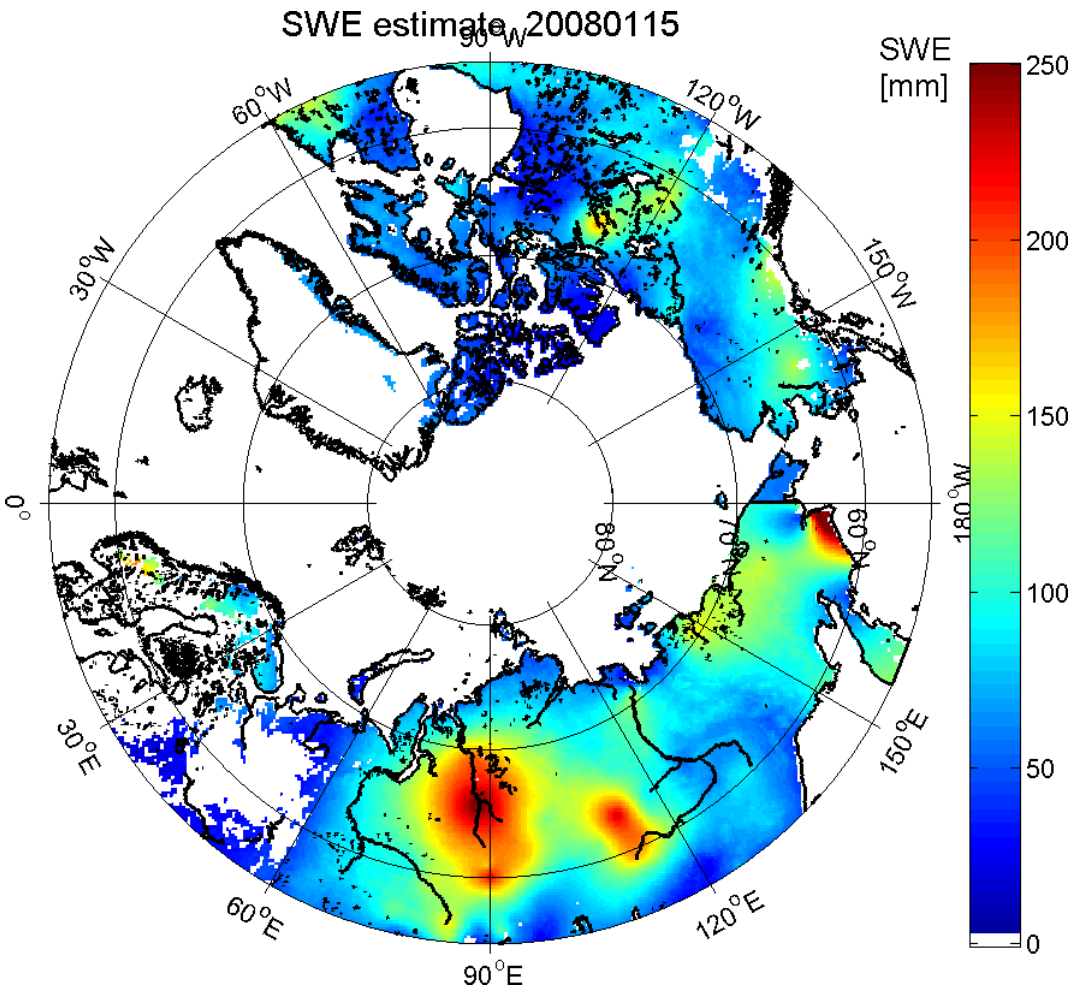
- SWE product is produced in EASE-Grid projection
- 25km x 25km grid cells
- Daily SWE estimate determined from night time radiometer observations (asc. node)
- Coverage: 35-85 degrees northern latitude
- Detection limit of 10mm

- Product includes error estimates for each SWE value

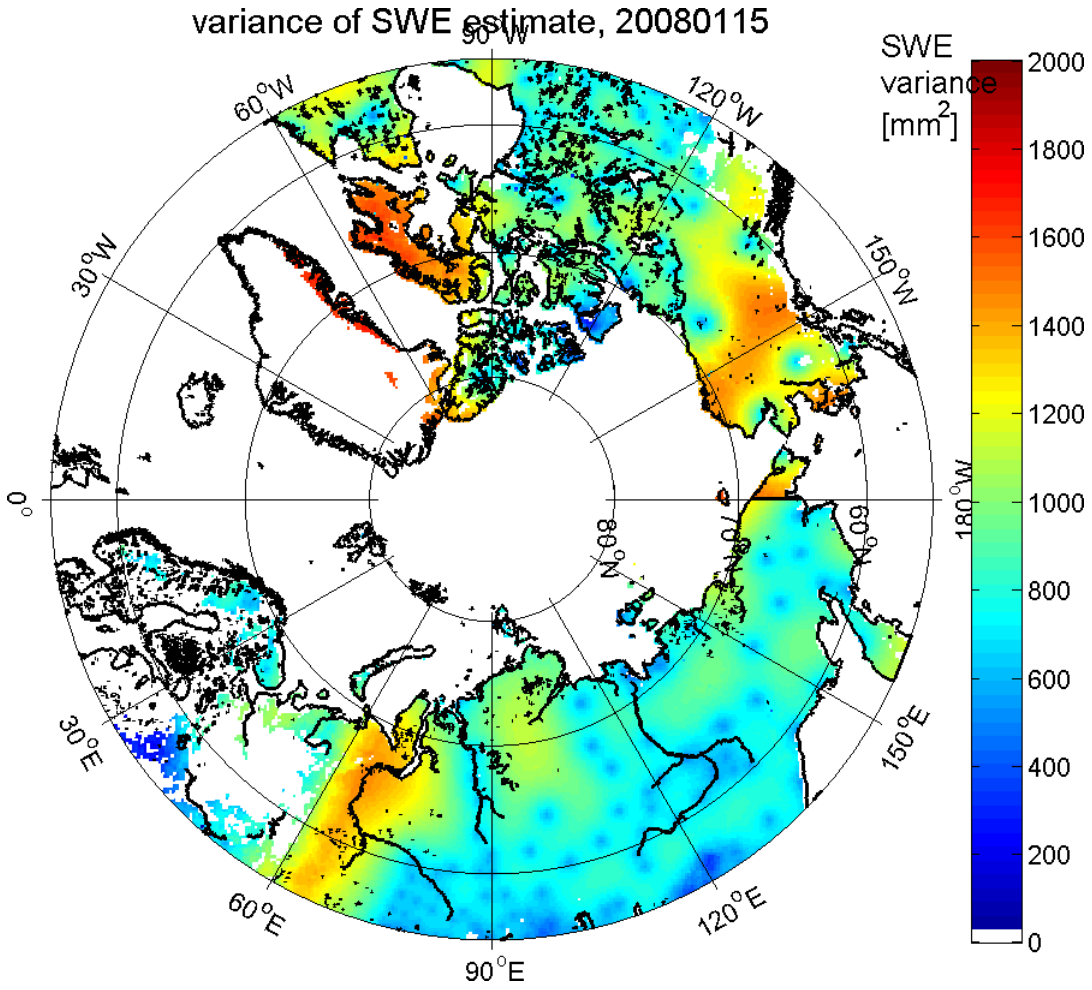
- Future product will include a “coarse resolution” background Snow Extent estimate (details in Wednesdays presentation)



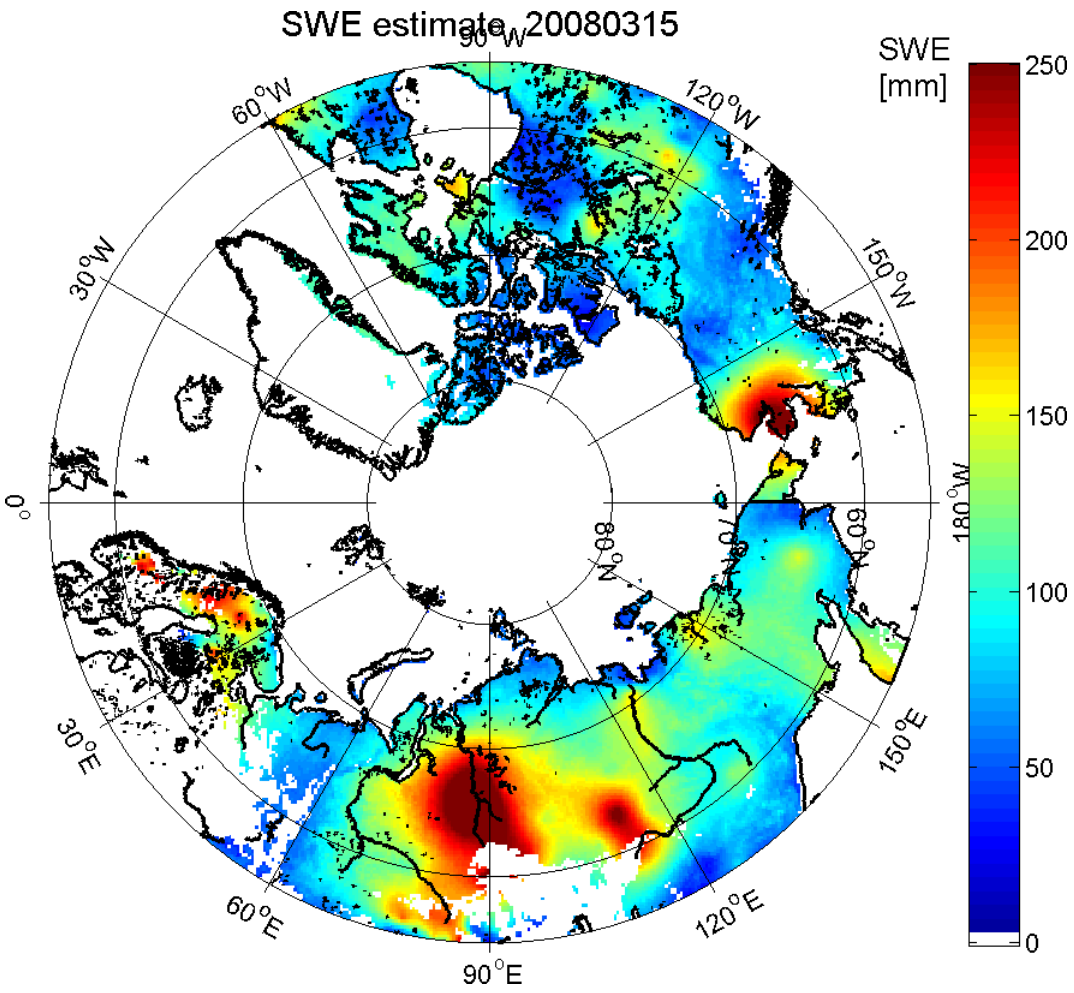
SWE estimate: 15 January 2008 (v.0.9.1)



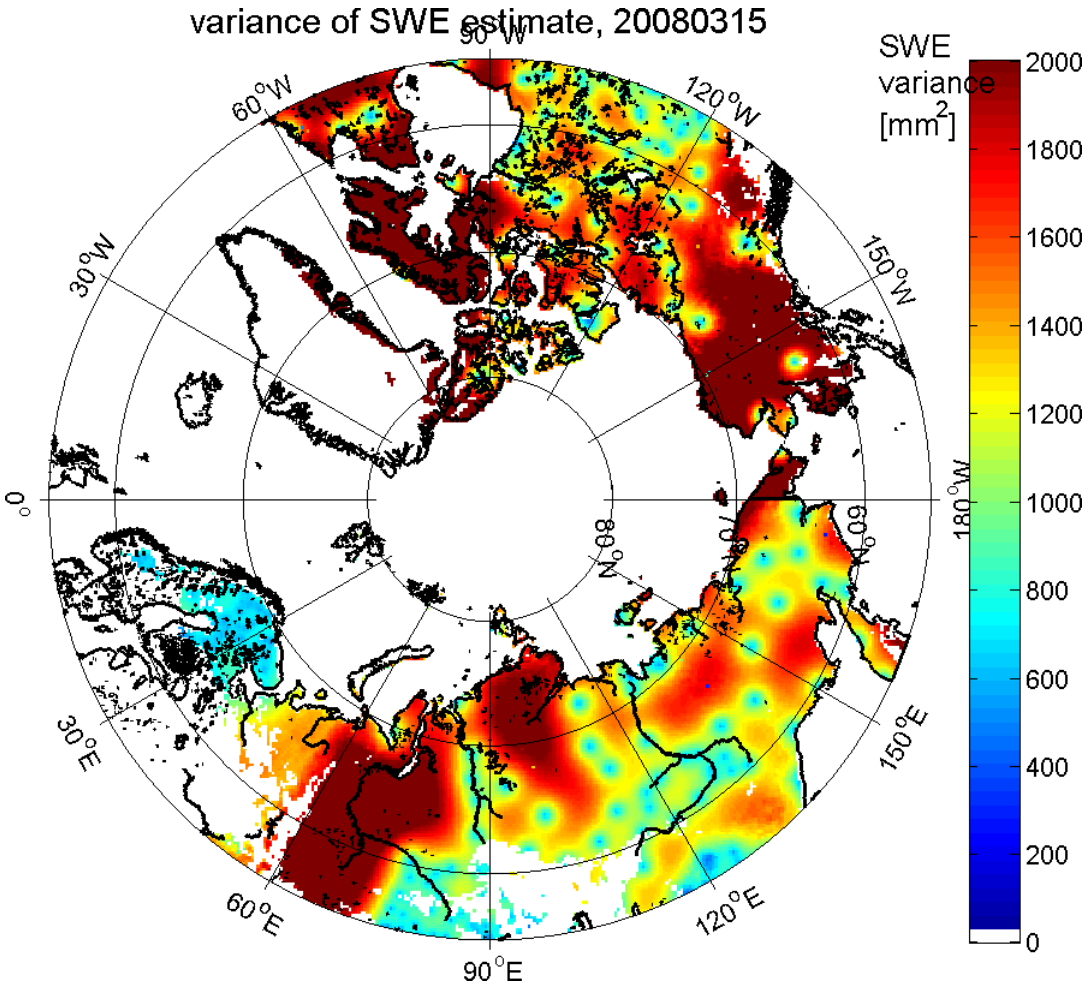
SWE error estimate: 15 January 2008 (v.0.9.1)



SWE estimate: 15 March 2008 (v.0.9.1)

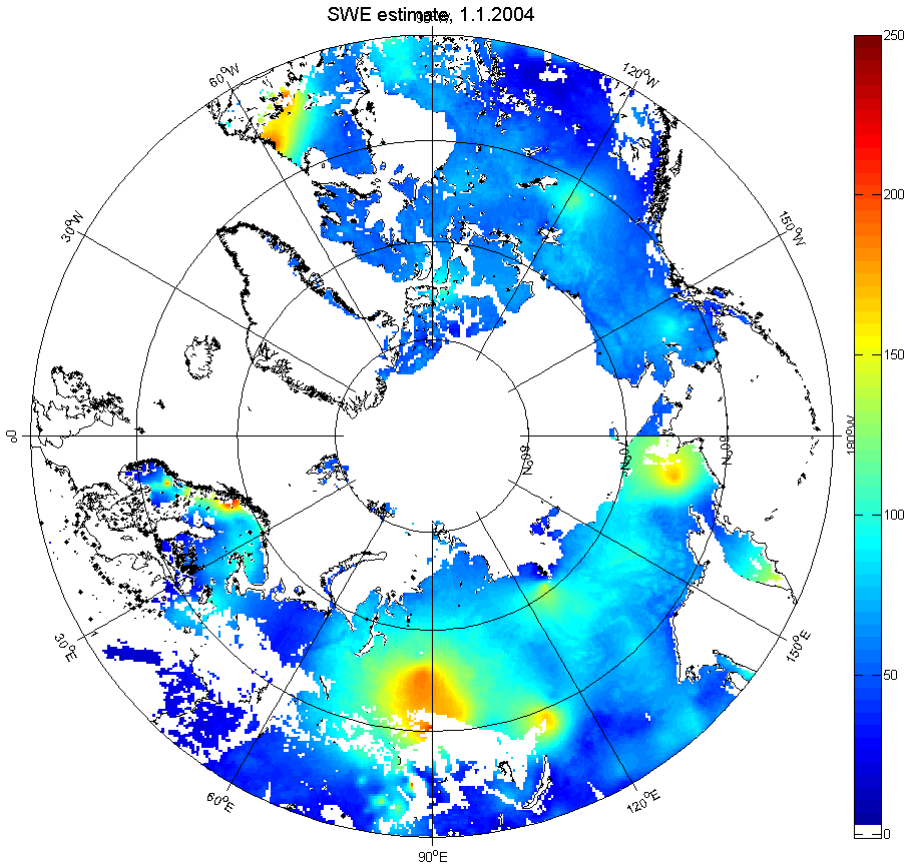


SWE error estimate: 15 March 2008 (v.0.9.1)

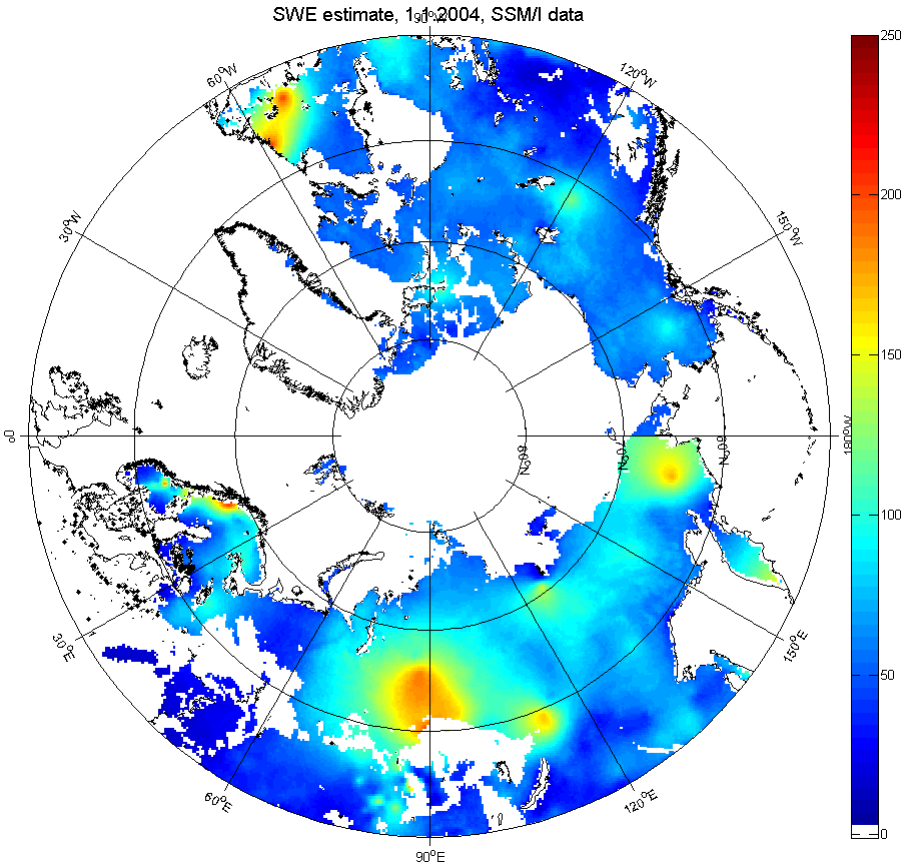


SWE for 1 January 2004: AMSR-E vs. SSM/I data

Baseline: AMSR-E derived SWE product
(both AMSR-E and SSM/I data available from 2002->)

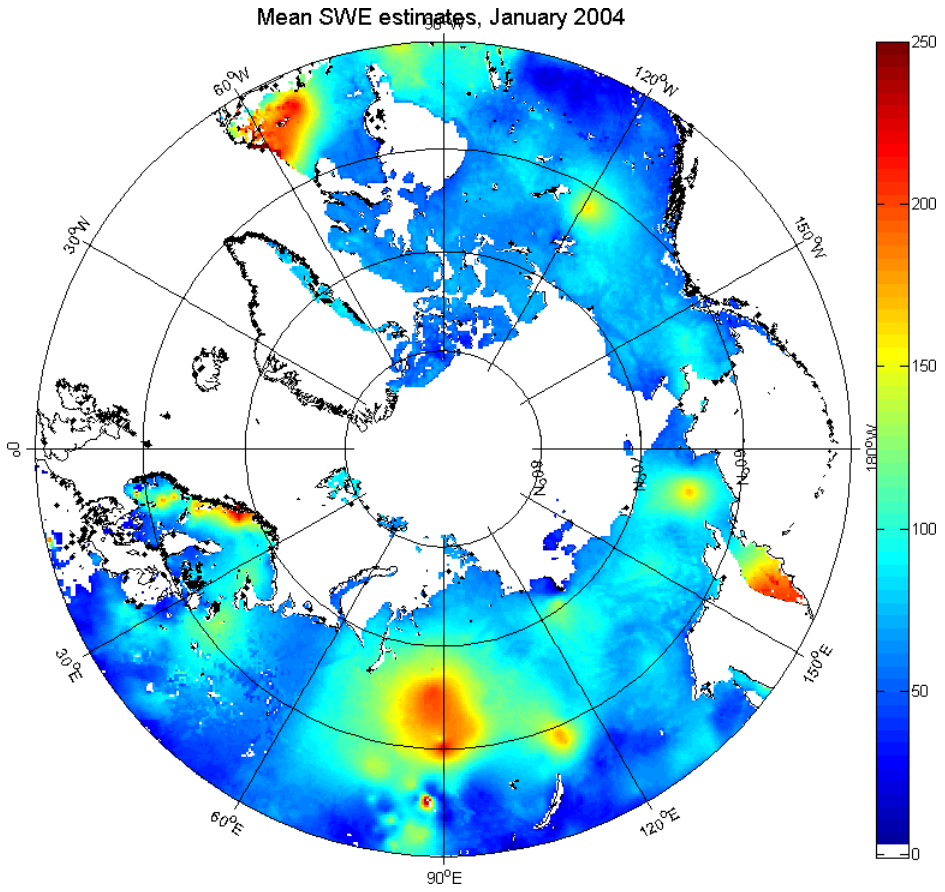


SSM/I derived SWE product
(SSM/I data used for 1987-2002)

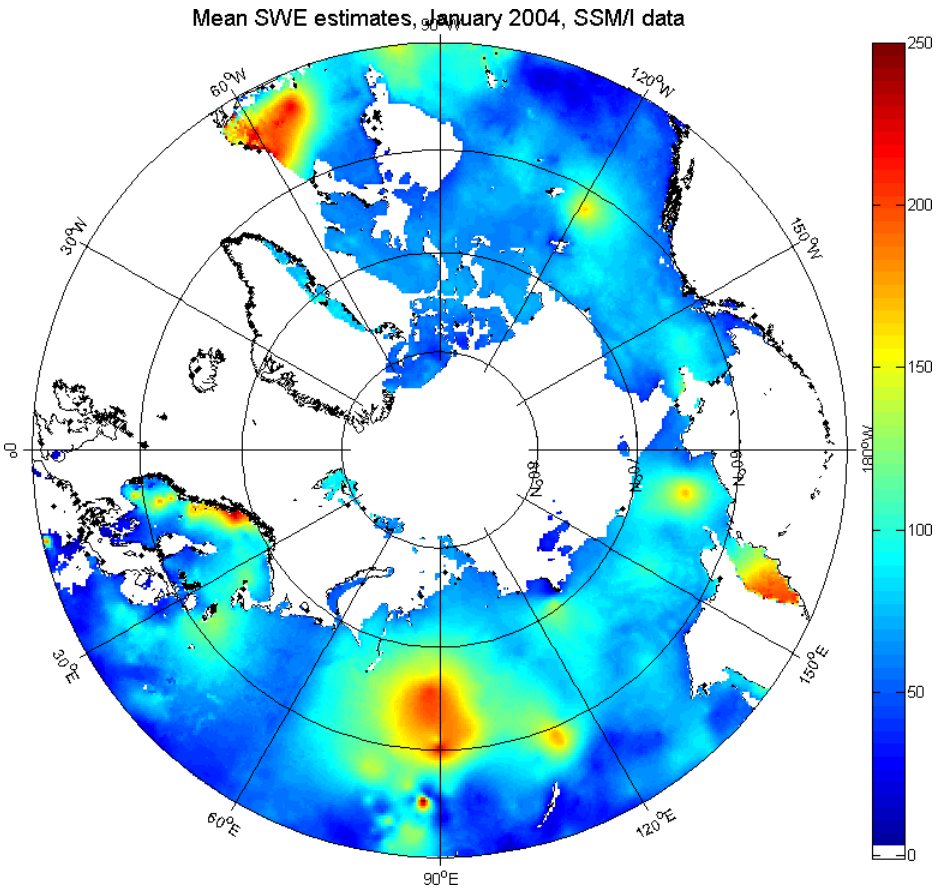


Mean SWE for January 2004: AMSR-E vs. SSM/I data

Baseline: AMSR-E derived SWE product
(both AMSR-E and SSM/I data available from 2002->)

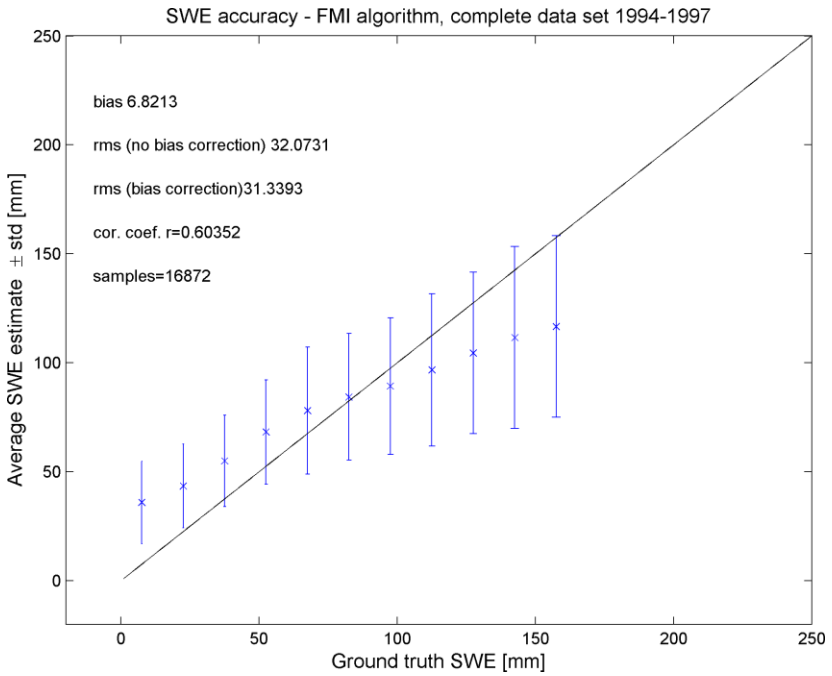


SSM/I derived SWE product
(SSM/I data used for 1987-2002)

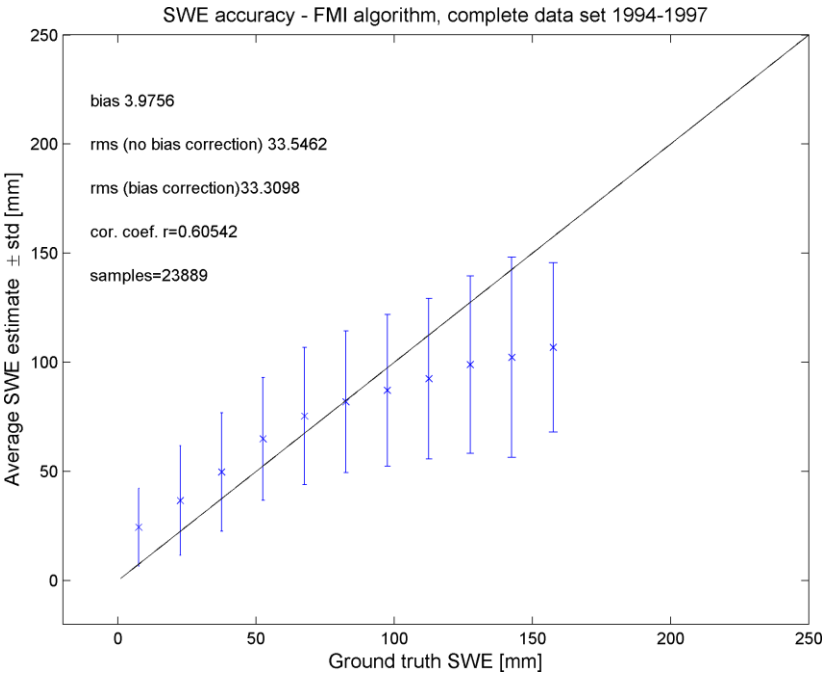


SWE for January 1994: WMO vs. INTAS-SSCONE data

Baseline: WMO synop derived SWE product



INTAS-SSCONE derived SWE product

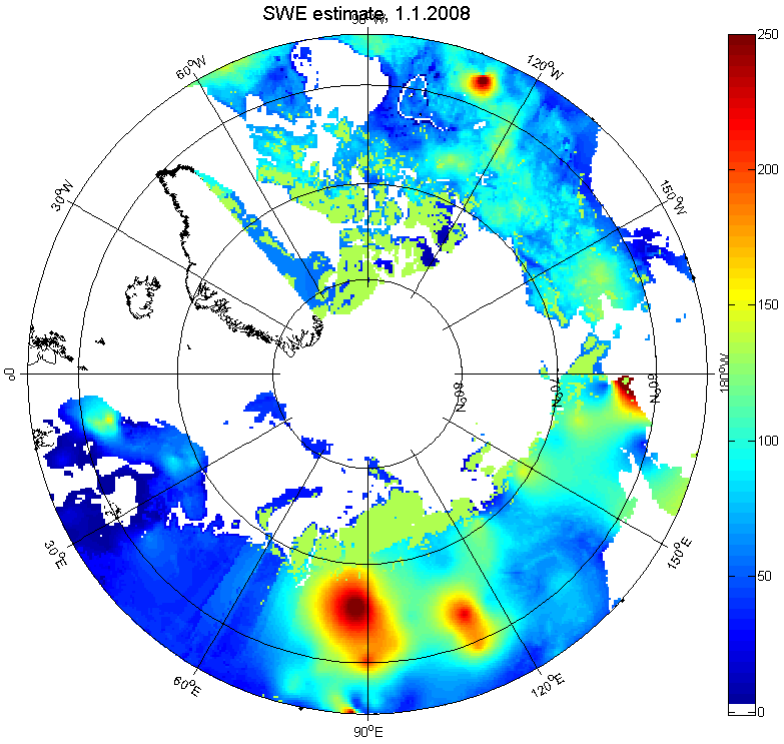


- Basically no difference in performance
  -> WMO synop data will be utilized to ensure a consistent product

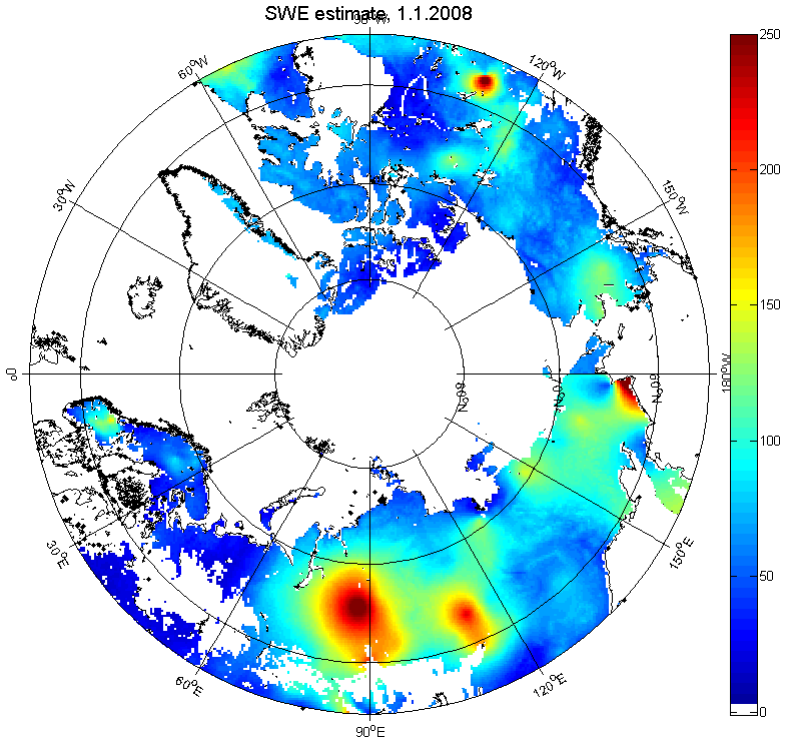
The prototype SWE product Northern Hemisphere 2003 to 2008 (v.0.9.1)

The prototype SWE product

- **The prototype SWE product v.0.9.1 (2003-2008)**



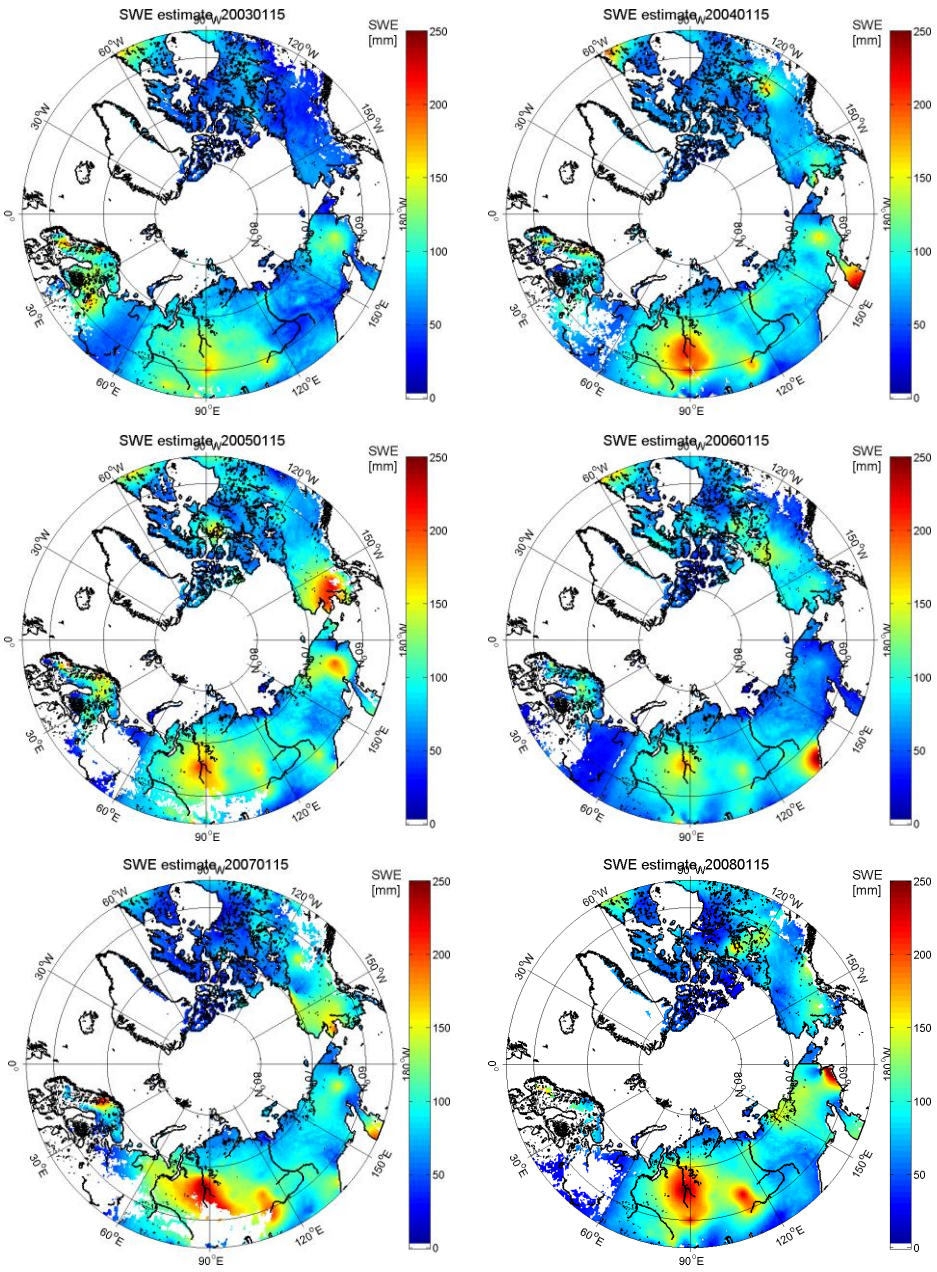
v.0.9



v.0.9.1

The prototype SWE product

- **The prototype SWE product v.0.9.1**
  - Released on 12/2009, improved temporal coverage when compared with v.0.9 data
  - Covers Northern Hemisphere from 2003 to 2008
    - Based on AMSR-E data
  - Includes error estimates (variance of the SWE estimate in mm^2)
  - Includes the SWE estimates also for mountains
  - Data format HDF4
  - Wet snow presented as SWE 0mm (needs to be flagged in future versions)



The prototype SWE product

In addition to the SWE estimates, the data used in the algorithm evaluations were also released:

- INTAS-SSCONE data (1994 - 1997)
- Finnish snow course measurements 2005 - 2008
- Canadian reference data (4 different data sets)

All the data are accessible through the “litdb.fmi.fi” –ftp server (username “globsnow_user” / pw “5jjhbsg7”)

SWE product: metadata and coding

DATA CONTENTS and METADATA

- Data content, field 1: 'Snow Water Equivalent (mm)'
- Data content, field 2: 'Variance of SWE estimate (mm)'

- Sensor
- Processing date
- Coordinate system
- Latitude range
- Longitude range
- Spatial Resolution
- Processing software name
- Processing software version
- Processing organisation
- Weather station data date
- Auxiliary data, land mask name
- Auxiliary data, land mask version
- Auxiliary data, mountain mask name
- Auxiliary data, mountain mask version
- Auxiliary data, forest mask name
- Auxiliary data, forest mask version

CODING

• Values >1	SWE [mm]
• 0	no Snow
• -1	wet snow
• -2	no data
• -3	water

AUXILIARY MASKS

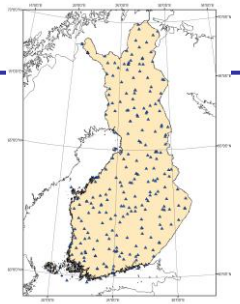
- Mountain mask: (not applied in v.0.9.1)
- Land/Water mask: GLC 2000-derived
- Forest mask: GLC 2000-derived

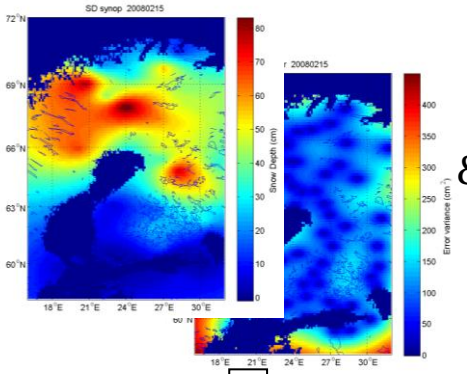
The GlobSnow SWE algorithm

The GlobSnow SWE algorithm

- **An Algorithm published in Remote Sensing of Environment by Prof. Pulliainen (2006)**
- **The method utilizes**
  - Microwave Radiometer data
    - 19 GHz (V-pol) & 37 GHz (V-pol and H-pol)
  - Weather station data
    - Acquired through WMO
  - HUT snow emission model (Pulliainen et al. 1999)

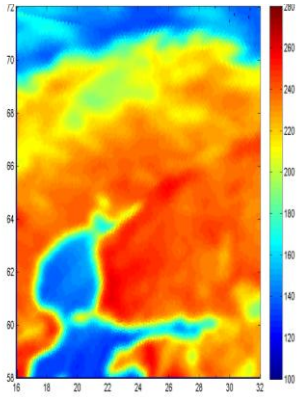
(2) Weather station obs. (SD)



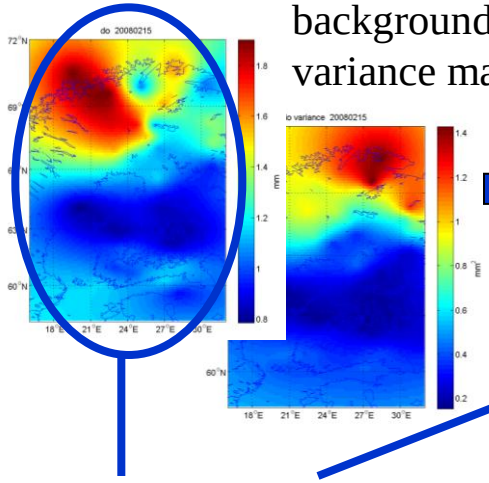


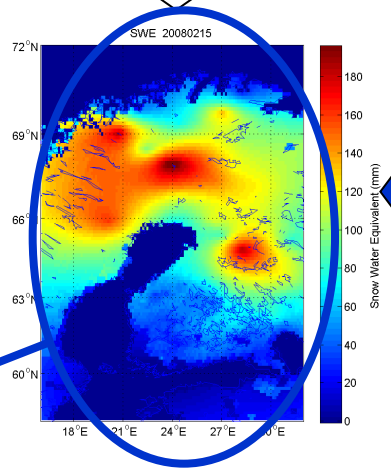
(4) Kriged SD map & SD variance map

(1) Satellite observation

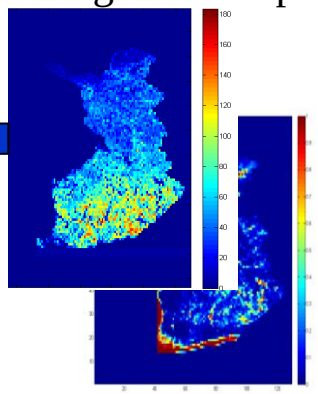


(3) Kriged grain size background & gs variance map



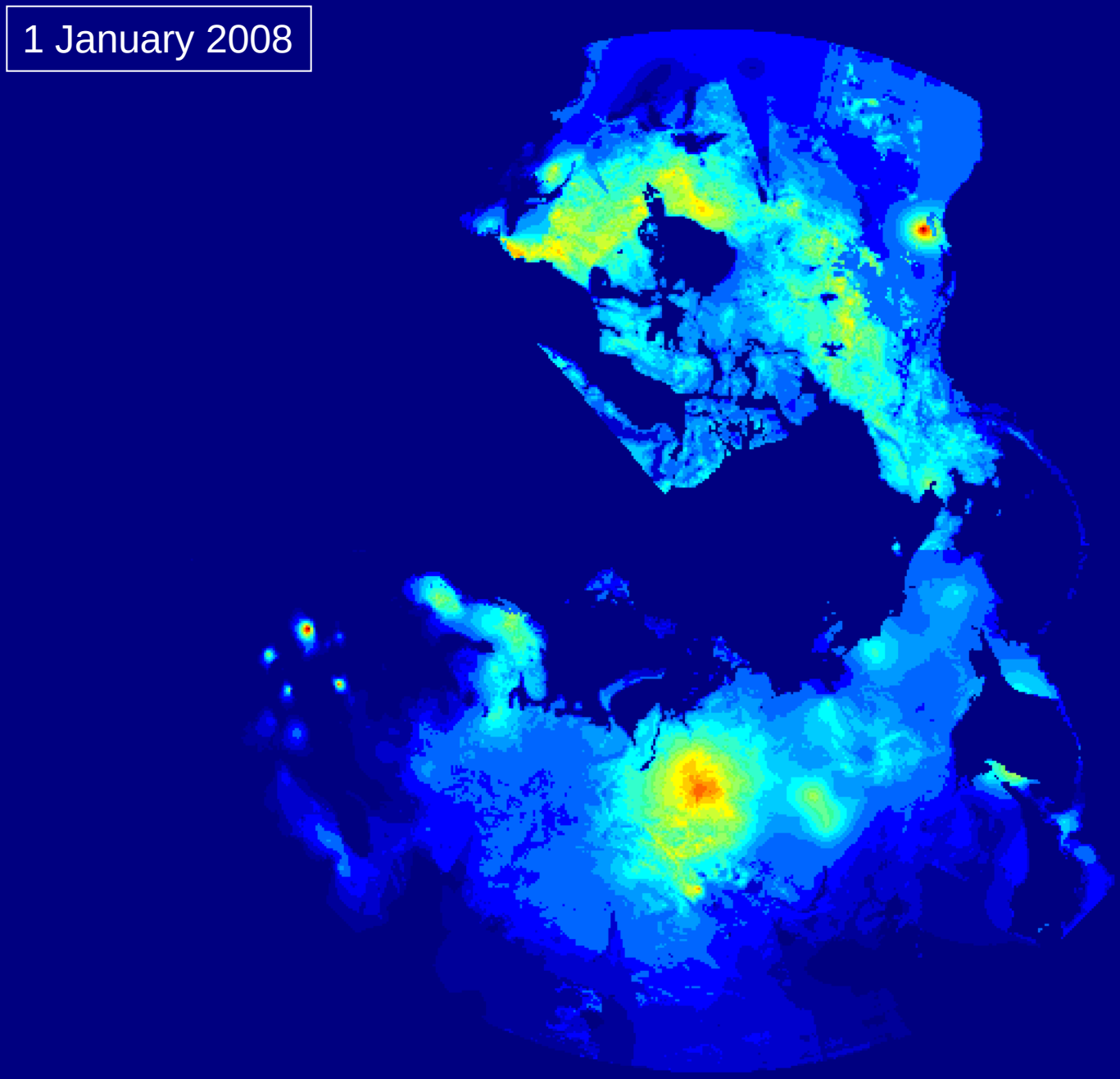


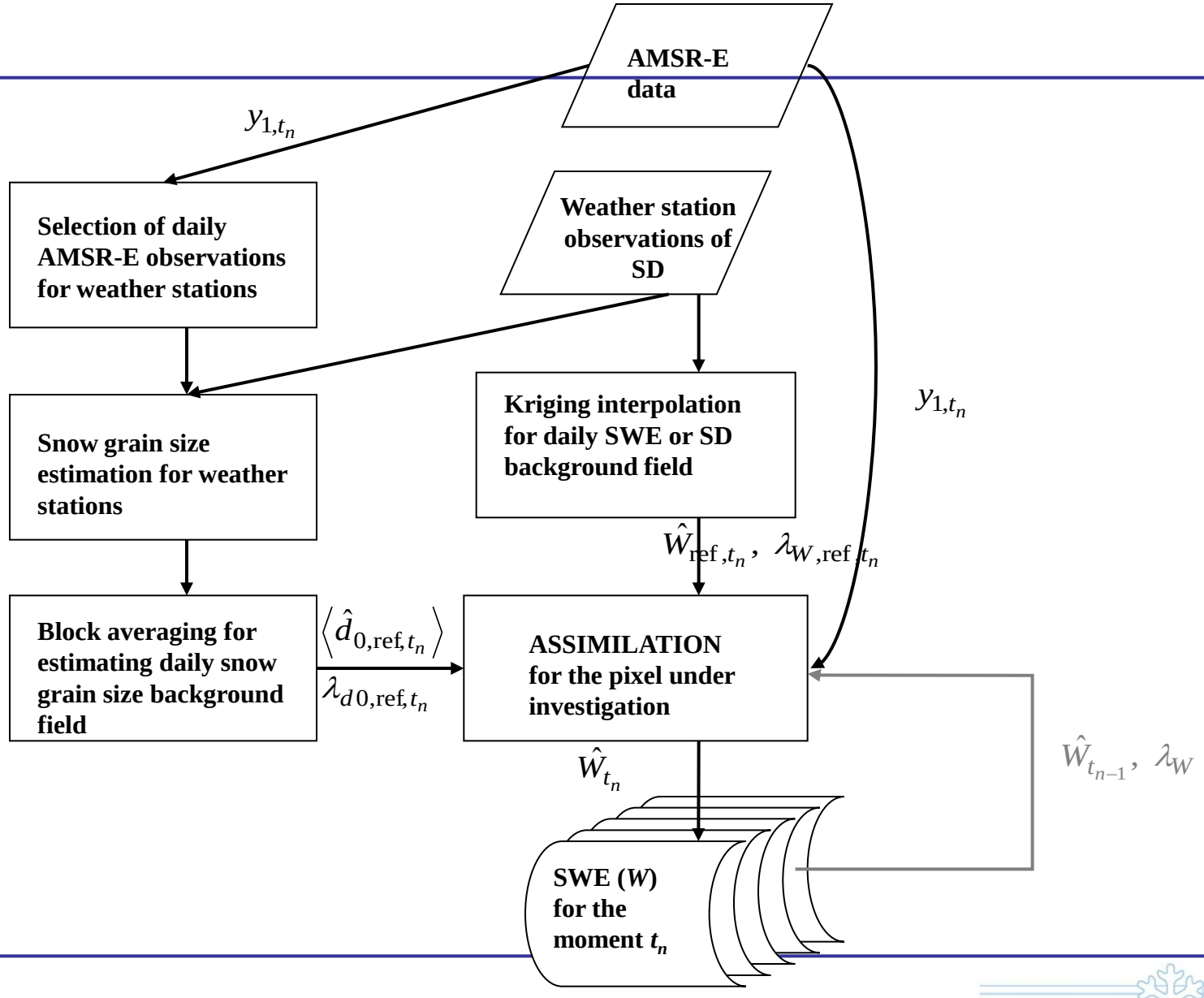
(5) Vegetation background map



HUT emission model applied

SD/SWE estimate


1 January 2008


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

Overview of the SWE validation results

(focusing on Eurasia, additional details on Wednesday)

Overview of the SWE validation activities

- 5 different SWE algorithms tested for three separate test regions
- Test regions: Eurasia, Canada and Finland cover nearly all the areas of the Northern Hemisphere with seasonally varying snow cover

- One of the most detailed algorithms evaluations for satellite-derived SWE datasets

Overview of the SWE validation results - Eurasia

Daily SWE estimates acquired with 5 different algorithms evaluated for Eurasia (1994-1997)

- FMI Assimilation algorithm (Pulliainen 2006)
- EC SWE suite (Goodison, Walker, Goita, Derksen et al. 1993-2009)
- Chang et al. 1987 (original channel difference algorithm)
- SPD-algorithm (Asbacher 1989)
- Armstrong and Brodzik 2001-algorithm (Improved channel difference)

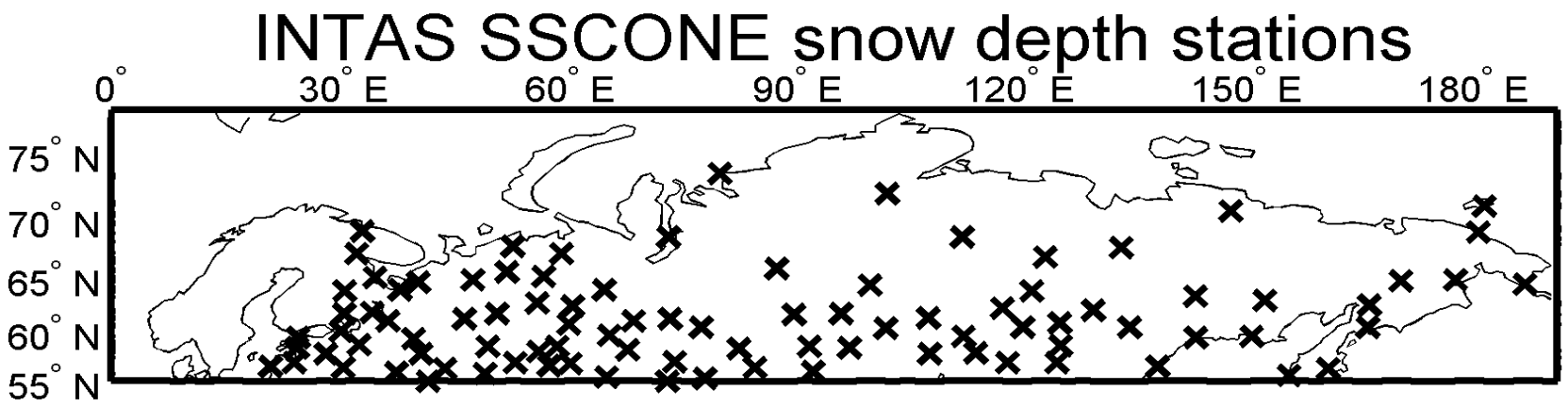
SWE estimates computed between 09/1994 and 12/1997 (SSM/I data)

- Chang, SPD and Armstrong –algorithms were evaluated for both asc & desc nodes; FMI uses desc node data complemented with asc node data
- Evaluations for complete data set and separately for different seasons

Validation data – INTAS SSCONE path data

INTAS SSCONE data (from the former USSR and Russia)

- There are 223 snow depth stations in INTAS SSCONE dataset
  - Data used in the FMI algorithm - kriging interpolation (not used for validation)
- There are 1294 snow path stations (separate from snow depth stations)
  - Used as the validation data for the GlobSnow evaluations
  - There were 450 path stations with data for 1994-1997
- Snow path and depth station data are independent!



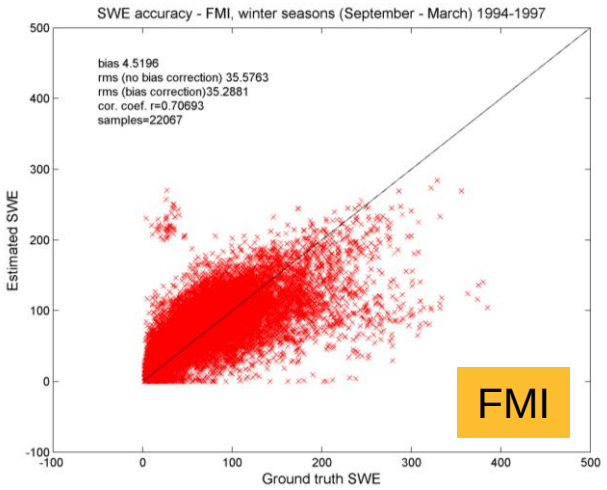
Overall performance of the SWE algorithms
Eurasia 09/1994 – 12/1997

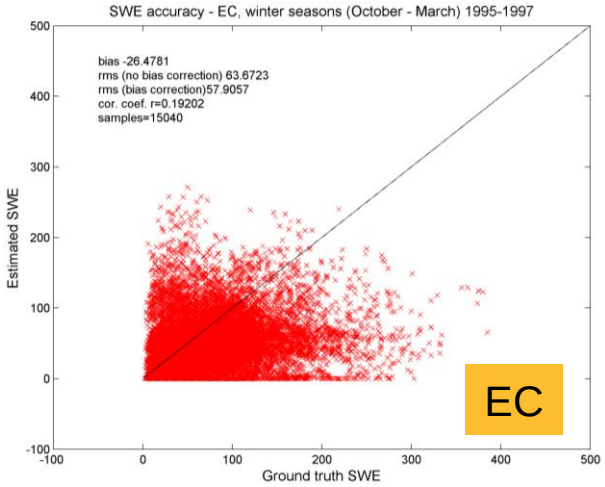
Evaluations against 450 INTAS path stations - ”snow courses”

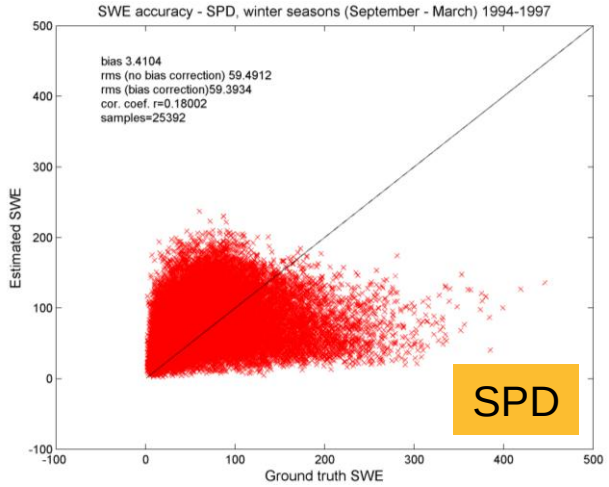
Name	***RMSE***	***bias***	***Corr.coeff***	***Unbiased RMSE***	***Samples***
FMI algorithm	43.2 mm	-3.1 mm	0.611	43.1 mm	26063
EC algorithm	67.6 mm	-28.2 mm	0.210	61.5 mm	18109
Chang et al. 1987 (asc node) Chang et al. 1987 (desc node)	71.6 mm 70.7 mm	-8.4 mm 1.6 mm	0.011 0.029	71.1 mm 70.8 mm	26726 27521
SPD algorithm (asc node) SPD algorithm (desc node)	67.1 mm 63.9 mm	-12.7 mm -3.1 mm	0.052 0.121	65.9 mm 63.9 mm	29559 29451
Armstrong et al. 2001 (asc node) Armstrong et al. 2001 (desc node)	72.3 mm 73.7 mm	-44.1 mm -42.9 mm	0.044 0.029	57.3 mm 59.9 mm	21796 24791

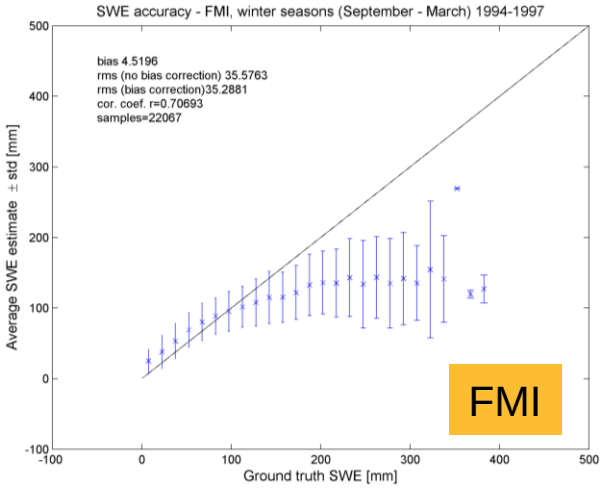
SWE Eurasia winter seasons (Sept–March)

	RMSE	bias	Corr.coeff	Samples
FMI	35.6 mm	4.5 mm	0.707	22067
EC	63.7 mm	-26.5 mm	0.192	15040
Chang	66.5 mm	6.2 mm	0.083	23840
SPD	59.5 mm	3.4 mm	0.180	25392
Armstrong	68.6 mm	-41.1 mm	0.063	19988









Compliance with the User Requirements

	EC	NSICD/Chang et al + derivates	FMI
Finland			
	Good agreement for SWE < 100 mm Low overall bias	Poorest sensitivity to increasing SWE Systematic underestimation Low bias, RMSE only for shallow snow (SWE< 50 mm)	Good performance up to SWE < 150 mm
Eurasia			
	High RMSE values for all seasons; decreased sensitivity to increasing SWE compared to Finnish test area	Good agreement up to SWE < 90 mm. Reversed sensitivity for higher values. Poor overall performance.	Good performance up to SWE < 100 mm. Meets criteria for SWE < 150 mm
Canada			
Tundra	Performed well across lake rich sub-Arctic tundra.	Systematic underestimation.	Low RMSE and bias, but poor correlation with observations.
Northern Boreal	Performed well up to 200 mm SWE.	Poor correlation with observations, even for shallow snow cases.	Significant improvement in performance when SWE <150 mm.
Southern Boreal	Low RMSE and bias, but only moderately strong correlations.	Performed well.	Performed well.
BERMS	Problems with shallow to deep snow transition.	Performed well.	Performed well. Appears to have some problems in determining snow off date.
Prairie	Performed well.	High RMSE and weak correlation.	Performed well.
CMC	Weak correlation and high RMSE, particularly late in the season.	Weak correlation and high RMSE, particularly late in the season.	Relatively low RMSE and high correlation; retains snow cover too long in the spring.
Meets GlobSnow Criteria:			
Yes			
With Conditions			
No			

Conclusions for the SWE validation work

- Current long term datasets on Global scale: Monthly from 1978, daily from 2002

  GlobSnow: Daily 30 years (… from launch of SMMR 1978)

- Thematic accuracy for the current methods
  - On global scale 40mm – 200mm & on regional scale 20mm – 50mm
  - GlobSnow RB: Target accuracy of 25 – 40 mm on global scale (SWE < 150mm)

  FMI Algorithm: RMSE of 43.2 mm for Eurasia (complete dataset with 26063 samples)

  FMI Algorithm: RMSE of 33.5 mm for Eurasia (for SWE < 150mm; 23889 samples)

- Error estimates (error bars)
  - Current methods do not provide information on estimation error

  FMI algorithm: Error estimates for each SWE estimate (through assimilation)

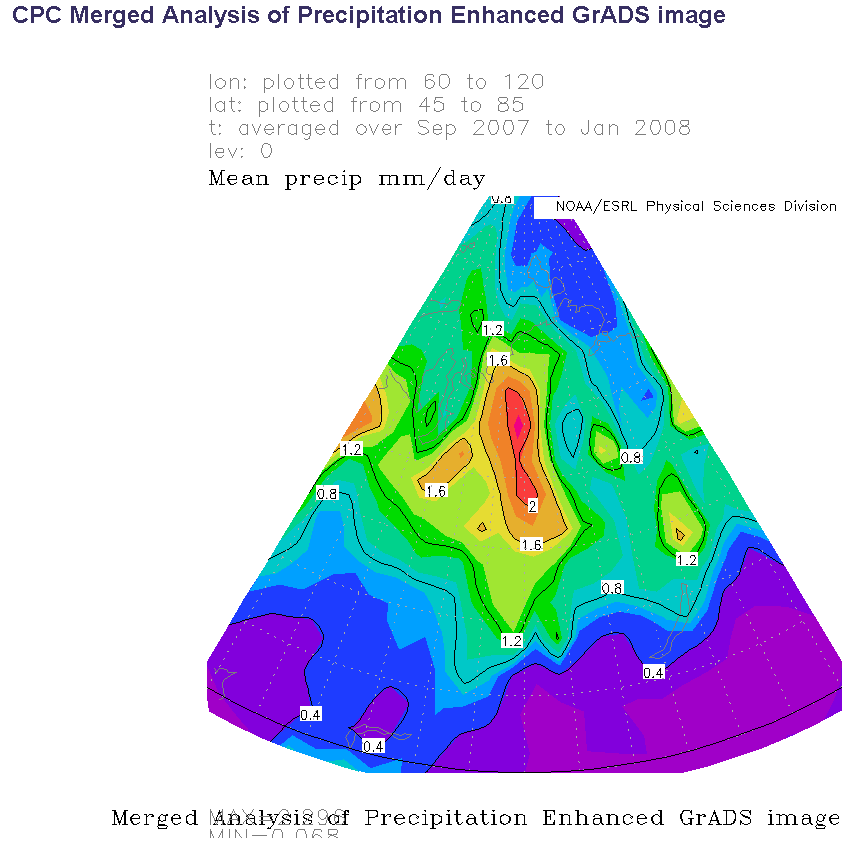
- Based on the analyses for Eurasia:

  FMI algorithm is the strongest candidate for GlobSnow SWE

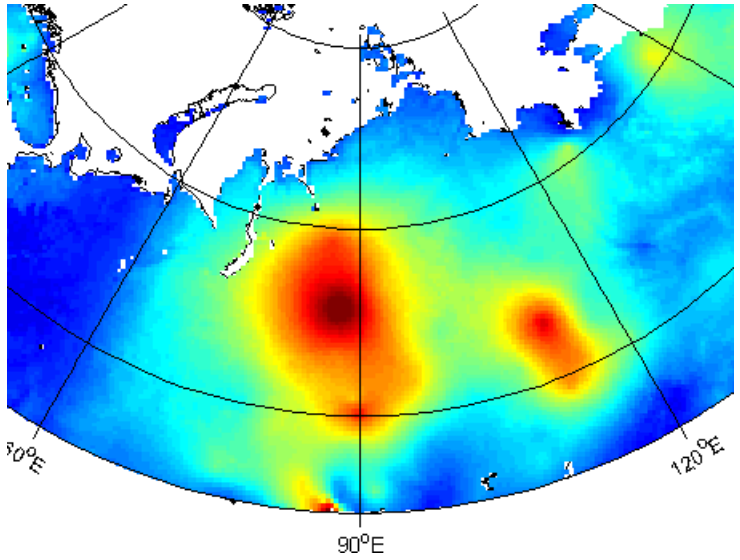
Comparing CMAP precipitation map with SWE maps

- first results -

CMAP monthly mean precipitation
September 2007 - January 2008



Mean SWE for January 2008
Northern Eurasia



Summary for the SWE product

- **GlobSnow SWE product**
  - Northern Hemisphere, starting from 1978
  - Based on radiometer and weather station data
  - Both SWE estimates and error estimates

- **Prototype product and validation data <u>available now</u>**

- **30 years SWE time series to be produced by 08/2010**
- **Oper. NRT SWE data will be produced starting 10/2010**

Open issues

- **Final processing parameters (presentation on Wednesday)**
- **Aggregation (presentation on Wednesday)**
- **User feedback needed:**
  - User experiences on the utilization of the SWE product in real-life applications
  - Comparison with other reference data
    - Additional ground truth data
    - Other comparable products
    - Climate model data

The prototype SWE product v.0.9.2

- **The prototype SWE product v.0.9.2 (next version)**
  - To be released in late January 2010
  - Addition of data for 1994 to 1997 (SSM/I sensor) and SWE estimates for 2004 from both SSM/I & AMSR-E
    - Preliminary versions (v.0.9.1) uploaded to FTP on 11 January 2010
  - Wet snow flagged with a suitable value
  - Quicklook images (png)
  - Filtering of suspicious weather station data
    - presentation tomorrow by J. Pulliainen

+ Other modifications based on user requests!

The End

- **Thank you for your attention!**