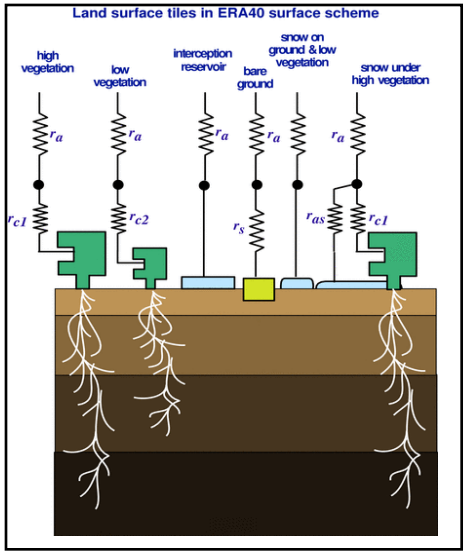
# Use of satellite data for land surface analysis at ECMWF

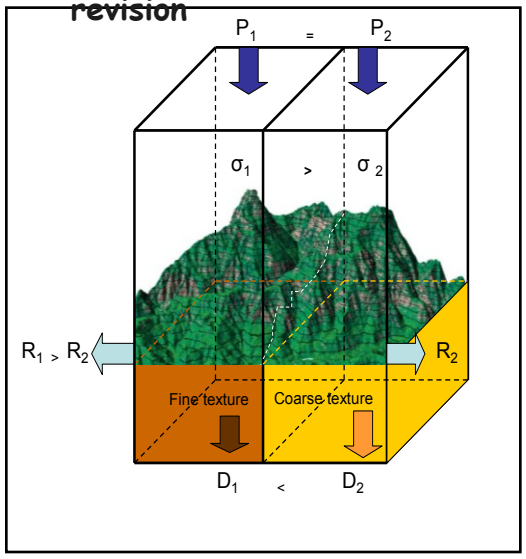
*Patricia de Rosnay*

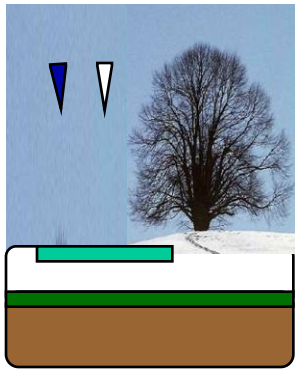
*Thanks to: G. Balsamo, J. Muñoz Sabater, M. Drusch, K. Scipal, L. Isaksen, C. Albergel*

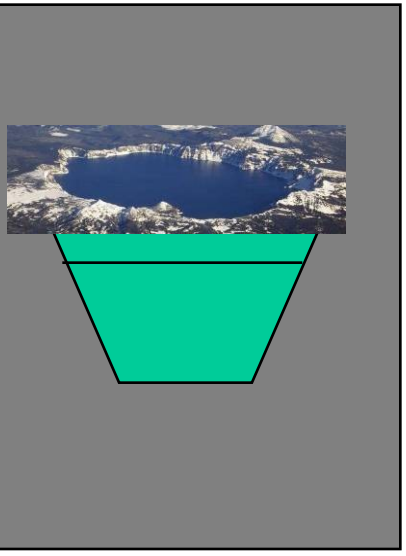
# Land surface model evolution

| 2000/06 | 2007/11 | 2009/03 | 2009/09 | 2010/2011 |
|---|---|---|---|---|
| **TESSEL**<br>Van den Hurk et al. (2000)<br>Viterbo and Beljaars (1995)<br>Viterbo et al (1999)<br><br>Up to 8 tiles (binary Land-Sea mask)<br>GLCC veg. (BATS-like)<br>ERA-40 and ERA-I scheme | **Hydrology-TESSEL**<br>Balsamo et al. (2009)<br>van den Hurk and Viterbo (2003)<br><br>Global Soil Texture (FAO)<br>New hydraulic properties<br>Variable Infiltration capacity & surface runoff revision | **NEW SNOW**<br>Dutra et al. (2010)<br><br>Revised snow density<br>Liquid water reservoir<br>Revision of Albedo and sub-grid snow cover | | **NEW LAI**<br>Boussetta et al. (2010)<br><br>**FLAKE**<br>Mironov et al (2010),<br>Dutra et al. (2010),<br>Balsamo et al. (2010)<br>Extra tile (9) to account for sub-grid lakes |





# Land surface data assimilation evolution

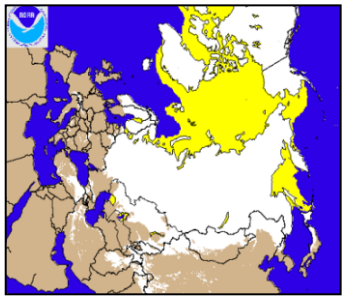
| 1999/07 | 2004/03 | 2008/09 | 2010/2011 |
|---|---|---|---|

## OI screen level analysis

Douville et al. (2000)
Mahfouf et al. (2000)
Soil moisture analysis based on Temperature and relative humidity analysis

## Revised snow analysis

Drusch et al. (2004)
Cressman snow depth analysis using SYNOP data improved by using NOAA / NSEDIS Snow cover extend data

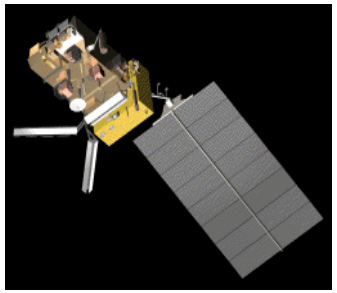


## Structure Surface Analysis

OI snow analysis and high resolution NESDIS data (4km)

SEKF Soil Moisture analysis
Simplified Extended Kalman Filter
Drusch et al. (2009), de Rosnay et al. (2010)

METOP-ASCAT



SMOS

- SEKF (Simplified Extended Kalman Filter) surface analysis
- Use of active microwave data (ASCAT soil moisture product)
- Use of passive microwave SMOS data (Brightness Temperature product)
- New snow analysis and use of NOAA/NESDIS 4km snow cover product

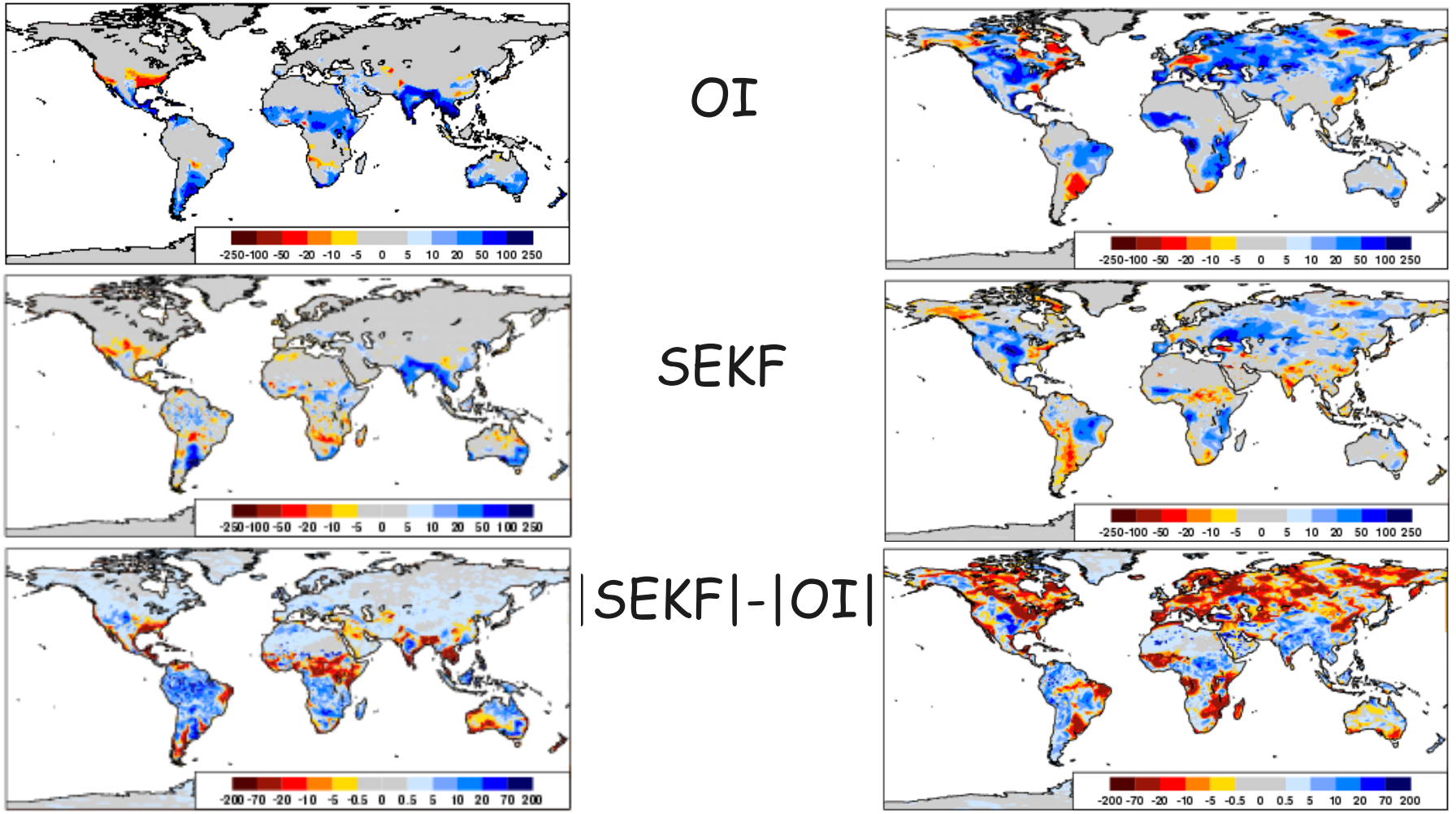
# New SEKF Soil moisture analysis

Implementation in IFS cycle 36r4, operational 9 November 2010

**Soil Moisture increments (mm)**

January 2009

July 2009

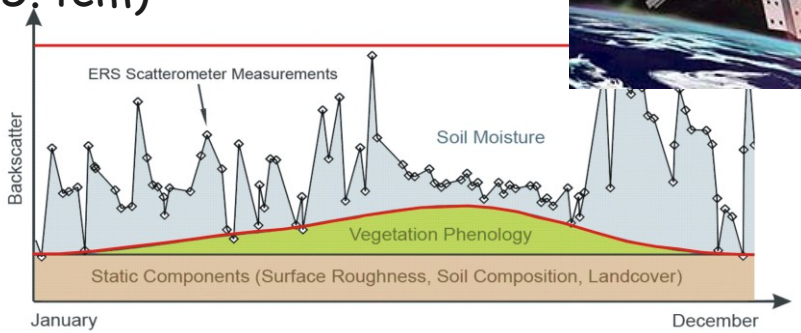



de Rosnay et al (2009), Drusch et al (2009)

# METOP/ASCAT Soil Moisture

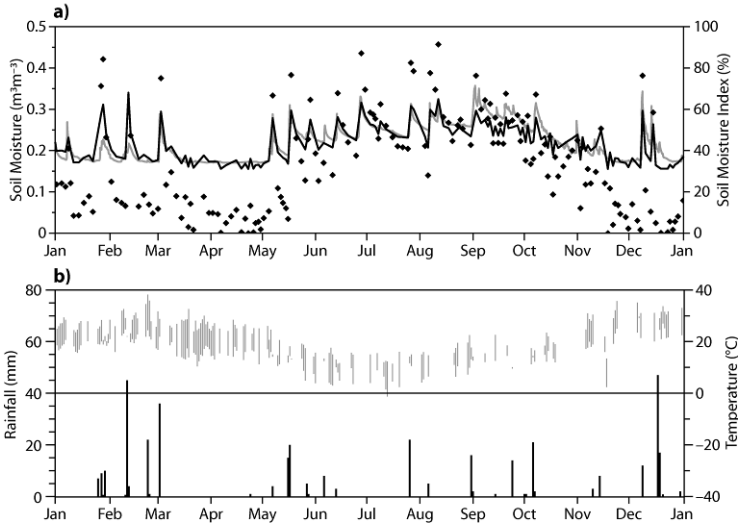
ASCAT: Advanced SCATterometer

Active measurements at C-band (5.6 GHz ; 5.4cm)




L2 soil moisture product

- *NRT data via EUMETCAST since 2008 (130 min after sensing)*
- *Relative measure*
- *ERS-1/2 heritage (since 1992)*
- *Guaranteed operation until 2020*




Bias correction

- *Simplified CDF matching – matching Mean and Range (ignoring higher order biases)*
- *Matching uses 9 years of data (1992-2000)*
- *Biases are estimated for each point separately*



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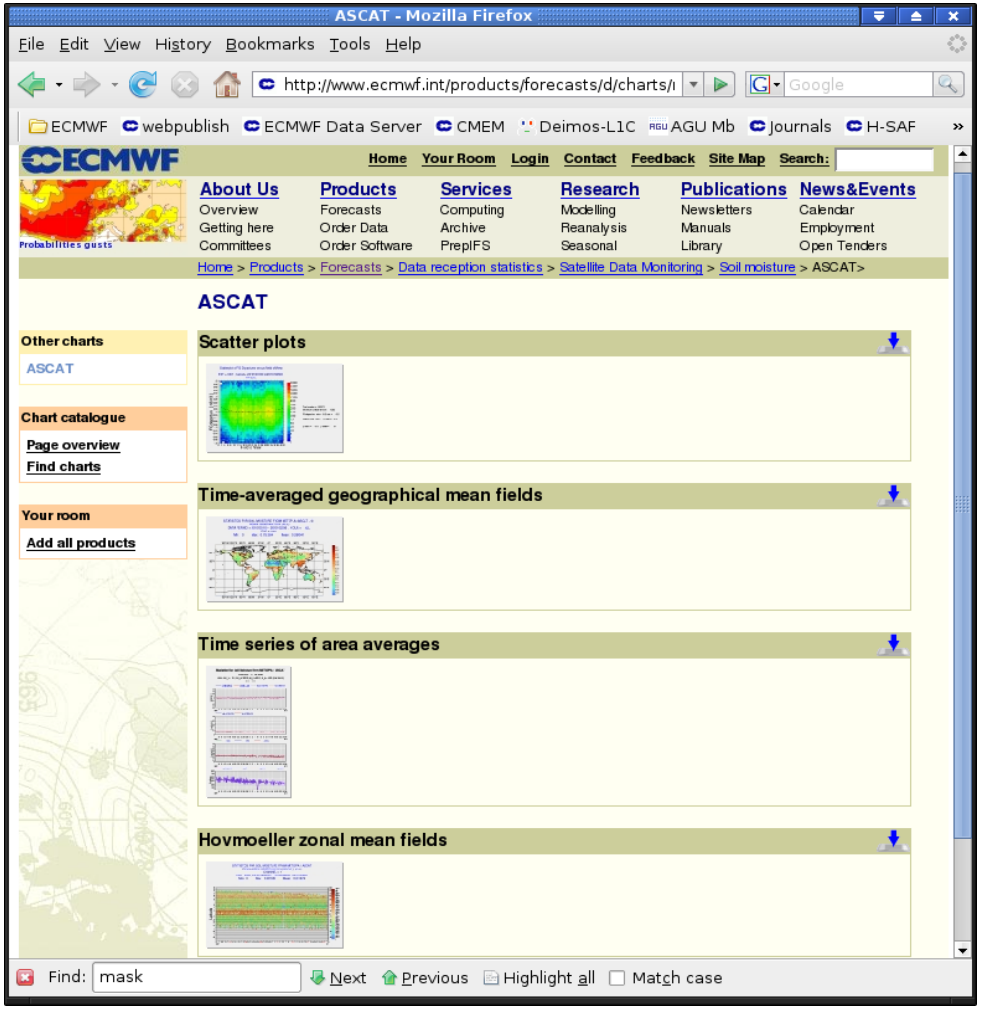
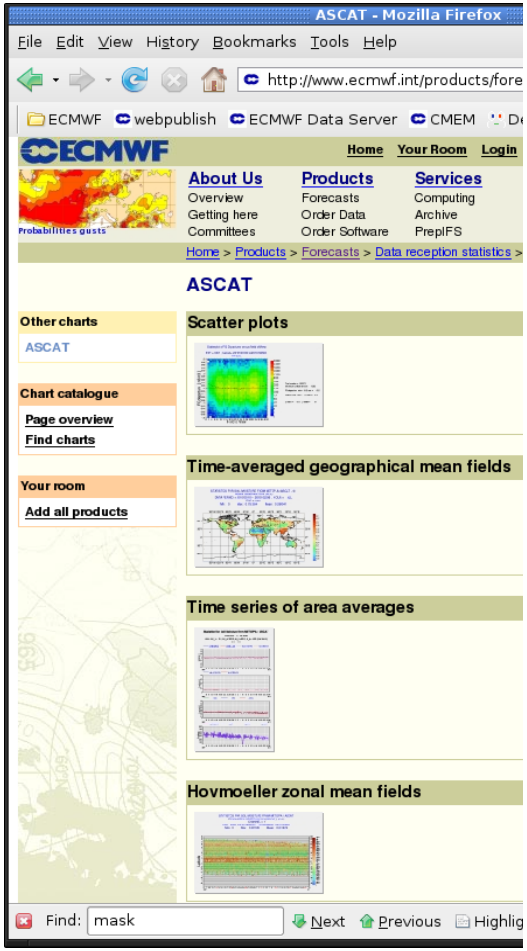
# ASCAT monitoring

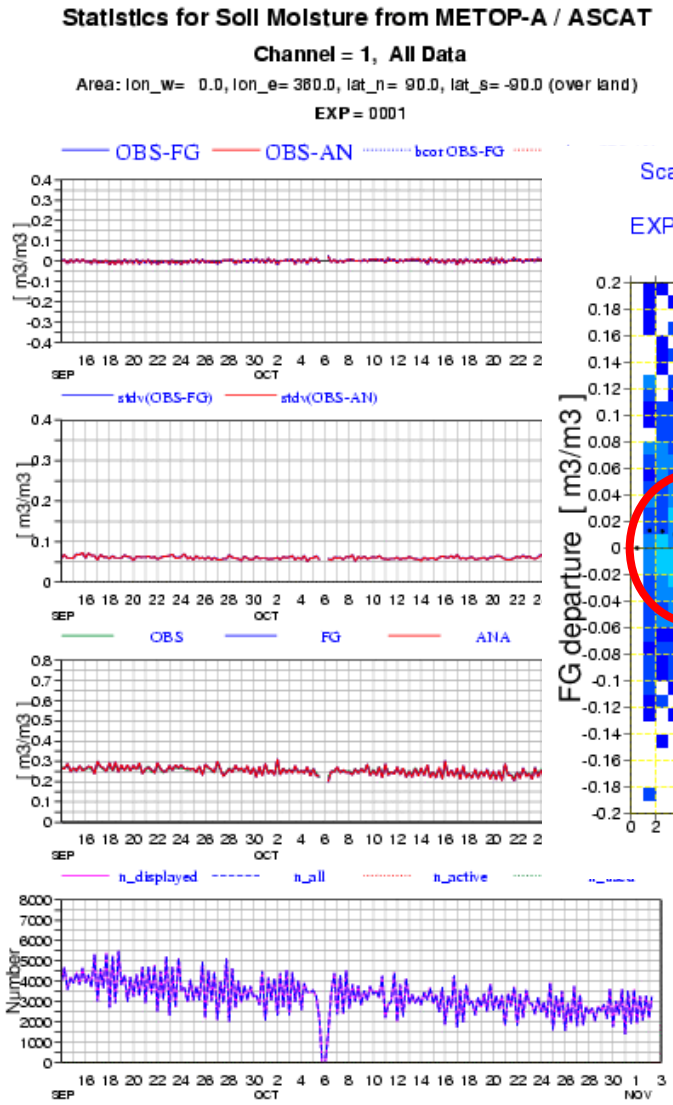
## (since September 2009)

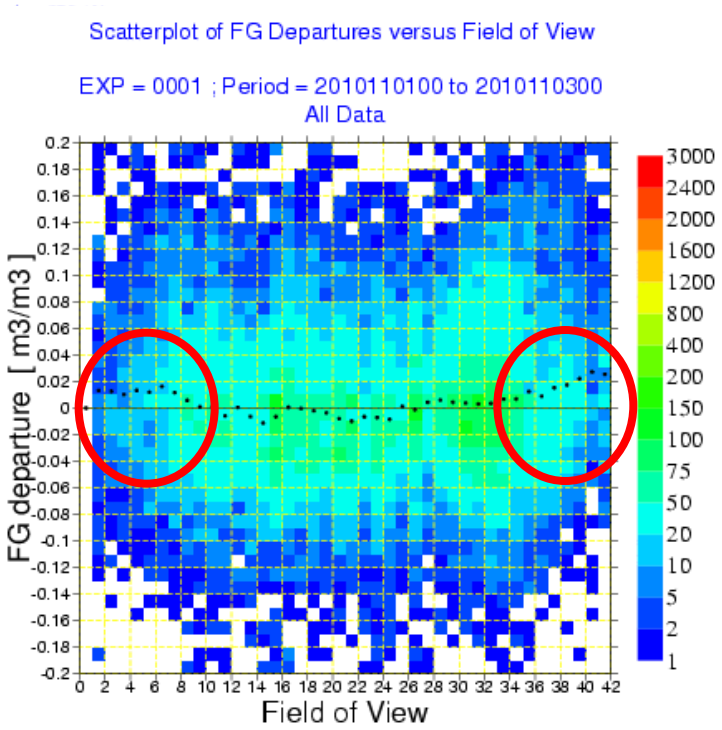


# Use of Active microwave data: ASCAT monitoring

## (since September 2009)

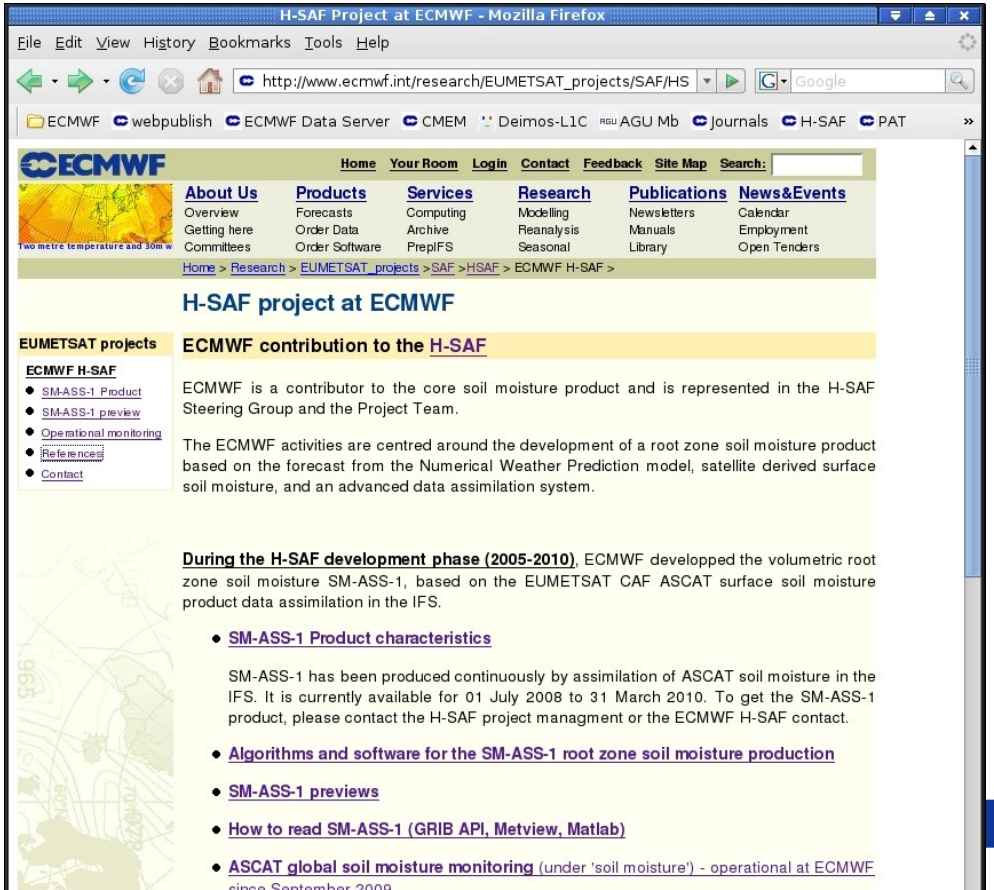


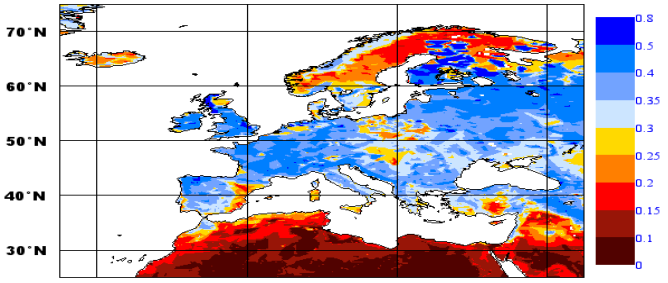



# H-SAF Root zone soil moisture product based on ASCAT data assimilation

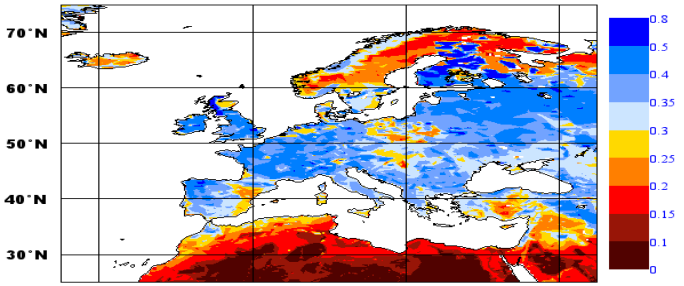
- Assimilation in the IFS using the SEKF
- July 2008 - August 2010 daily data
- H-SAF area (also available at global scale)



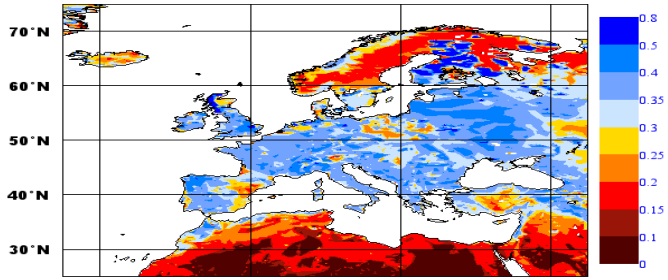

Layer 1: 0-7 cm




Layer 2: 7-28 cm




Layer 3: 28-100 cm

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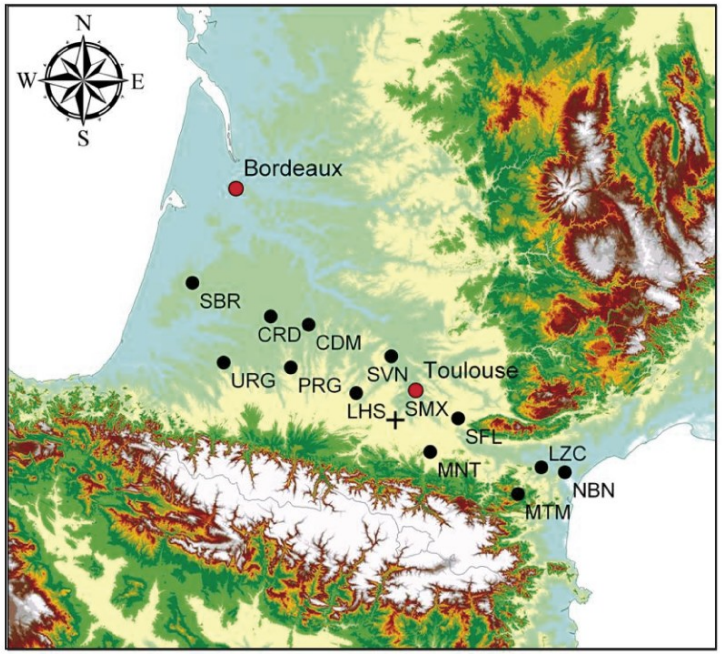
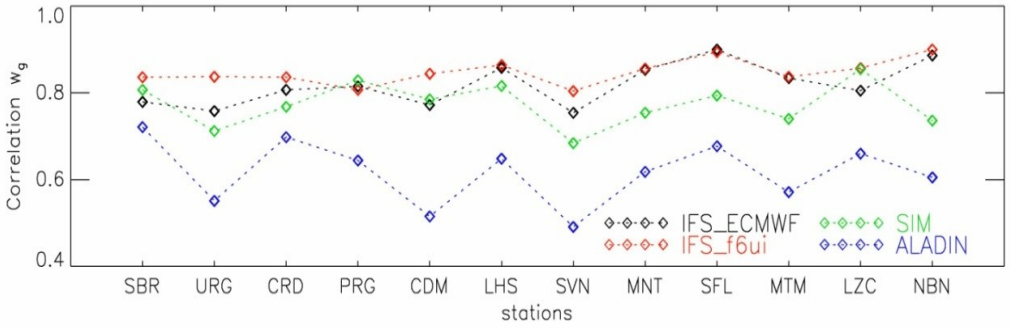
# ECMWF Soil Moisture analysis verification

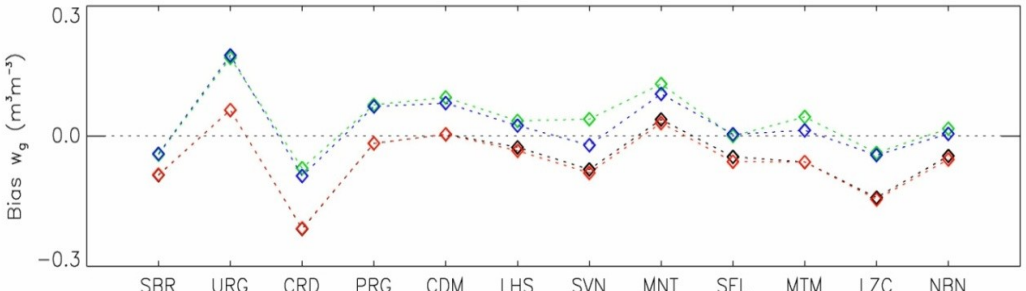
- Necessary step for the EKF implementation
- Validated for several sites across Europe (Italy, France, Spain, Belgium).
- Results in France (Albergel et al., 2010):

## Verification of ECMWF SM over the SMOSMANIA Network



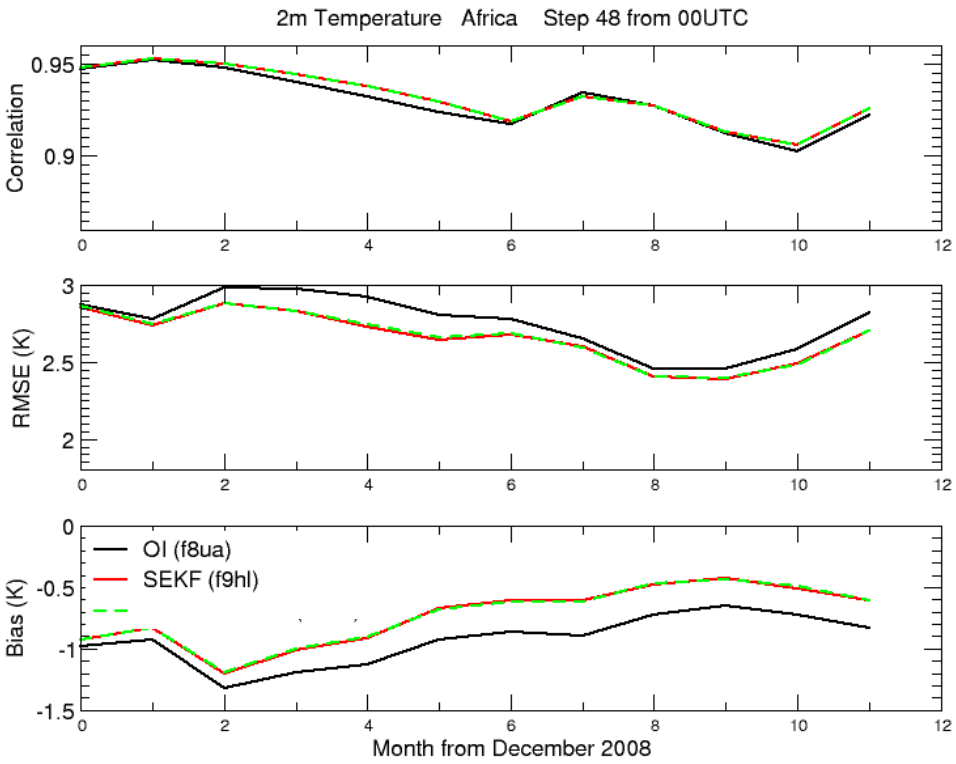

ECMWF Operational SM (R=0.82)
ECMWF-H-SAF product (R=0.85)
SIM (Météo-France forced system (R=0.77)
ALADIN (Meteo-France operational SM (R=0.63)



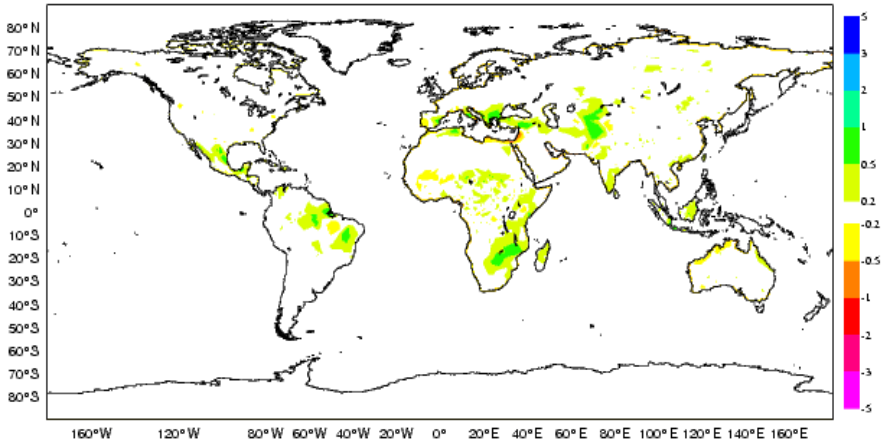



# Impact on Temperature

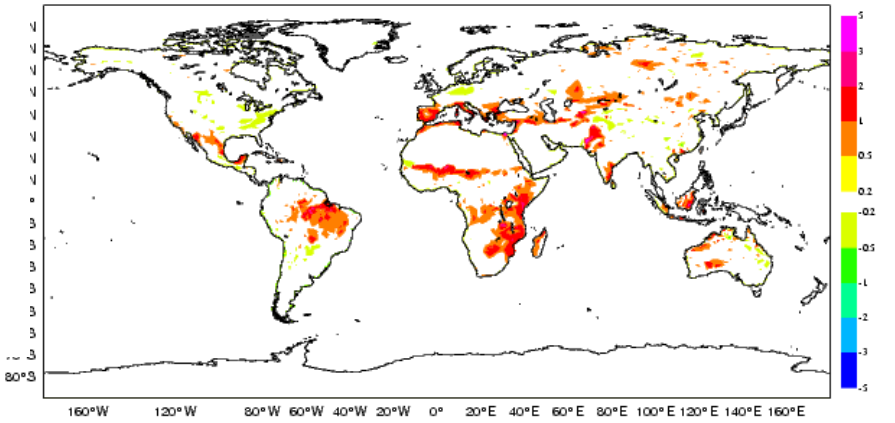
## T2m verification against analysis




## T2m impact (SEKF improve T2m)




## T2m Sensitivity (SEKF warmer)



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# SMOS project at ECMWF:
# "Global Monitoring and Data Assimilation Study"

SMOS: Soil Moisture and Ocean Salinity
Passive measurements at L-band (1.4GHz; 21cm)

## Monitoring:

- Monitoring of L1c Brightness Temperatures (TB) performed globally since Nov 2009 and results made available on the ECMWF SMOS web page.

## Data Assimilation:

- Assimilation of SMOS TB will be implemented in the IFS in order to investigate the impact of SMOS data assimilation on soil moisture and atmosphere.

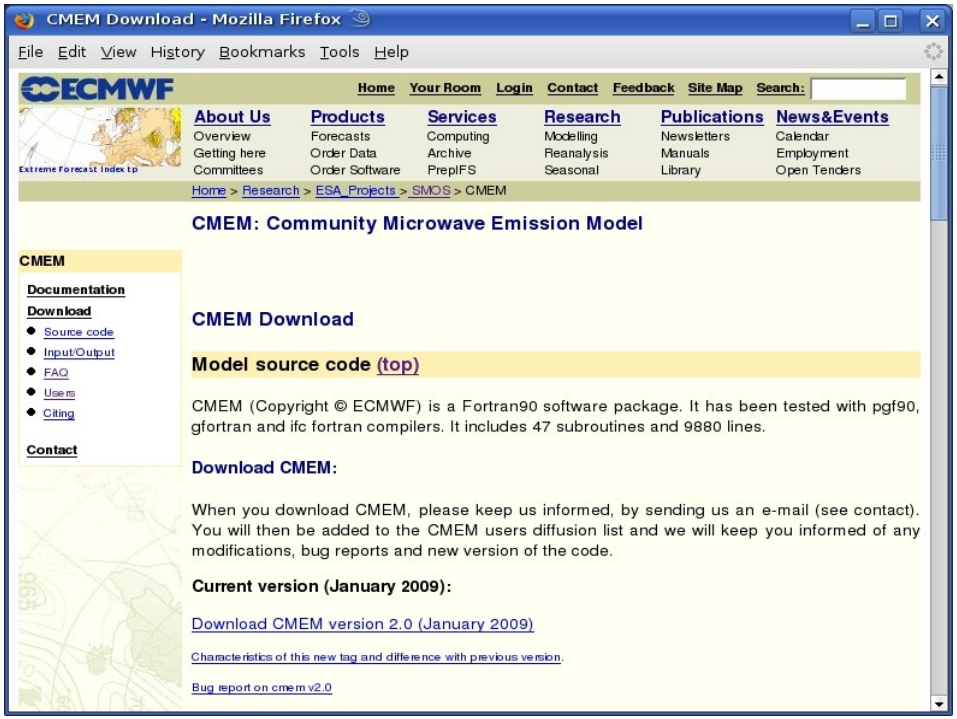
## Monitoring and assimilation of SMOS data rely on:

- A Forward operator, that transforms model variables into observed variables. For SMOS, the CMEM forward model has been developed, validated and implemented in the IFS.
- Data Assimilation will rely on the EKF soil moisture analysis.

# The Community Microwave Emission Model

- SMOS forward operator at ECMWF.
- I/O interfaces for the Numerical Weather Prediction Community.
- CMEM Input/Output interface is flexible: grib (gribex, gribAPI), netcdf, ascii.
- CMEM is a Fortran 90 software, portable for unix/linux systems
- Web interface available

http://www.ecmwf.int/research/ESA_projects/SMOS/cmem/cmem_index.html




Tool for the ESA SVRT (SMOS Validation and Retrieval Team)

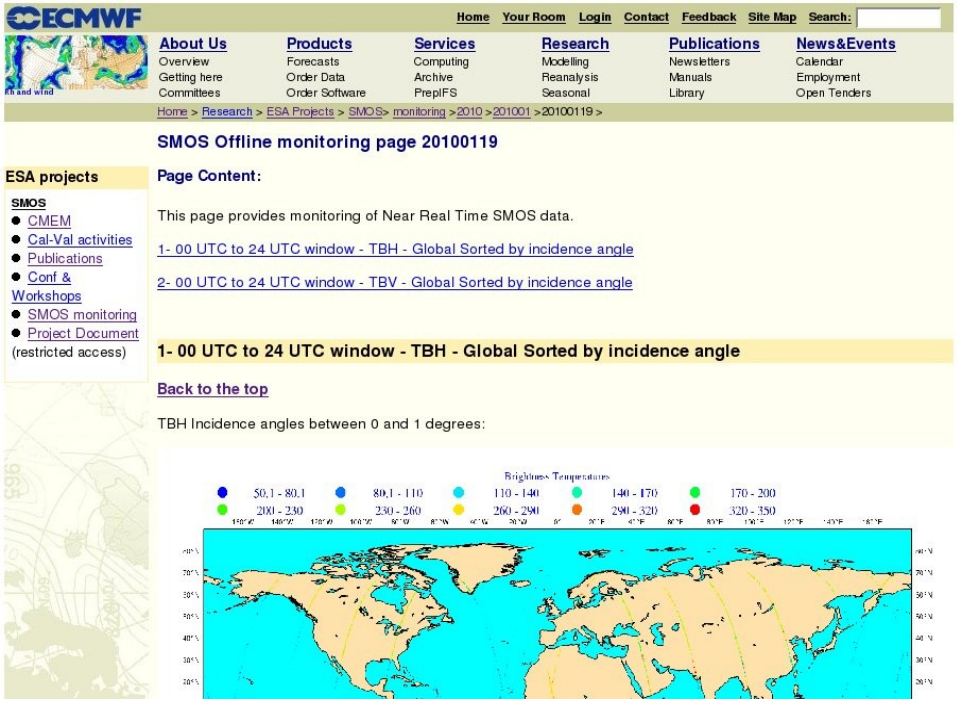
**References:**


Drusch et al. JHM, 2009
de Rosnay et al. JGR, 2009
Muñoz Sabater et al., IJRS 2010

# SMOS offline data monitoring webpage

- Available since November 2009
- Since January 2010 only "NRT" data is monitored and published
- Global maps of Level-1C NRT product
- Polarisations in the antenna reference frame at 0°, 10°, 20°, 30°, 40°, 50° and 60°

http://www.ecmwf.int/research/ESA_projects/SMOS/monitoring/smos_monitor.html



# SMOS Near-Real-Time monitoring

Θ = 40°

TBh

TBv

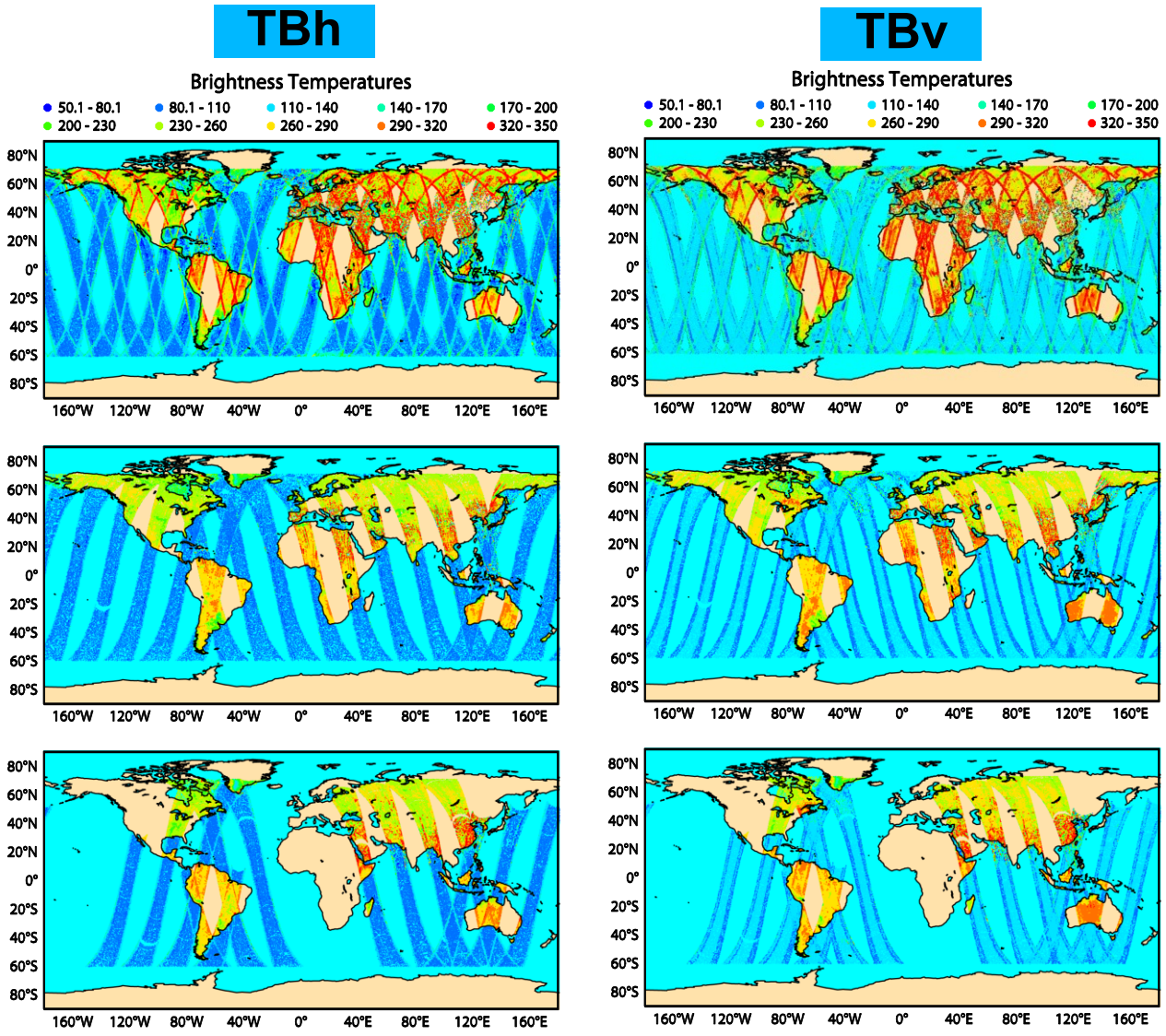
20-Nov-09

20-Dec-09

NRT

16-Jan-10

NRT



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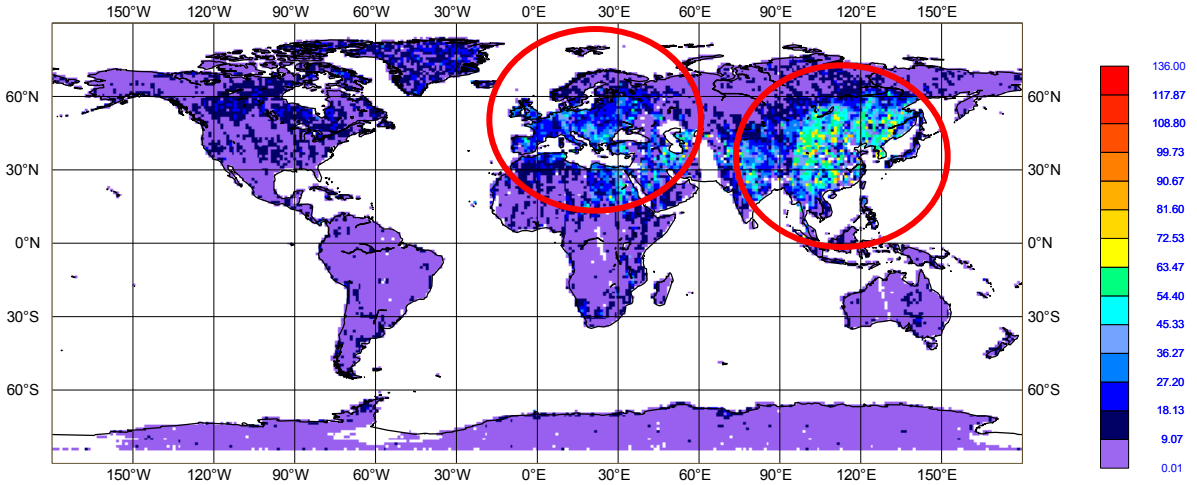
# Global statistics: Standard monitoring maps

Map of STD of First Guess Departure over land (Obs – Model), 01-07 March

- RFI (Radio Frequency Interference) impact on FG departures STD is large,
- Excluding RFI contaminated areas, most of first-guess departures STD are below 9 K. Larger values are found in snow, boreal forests and dry areas.

STATISTICS FOR RADIANCES FROM SMOS
STDV OF FIRST GUESS DEPARTURE [ ] (ALL)
DATA PERIOD = 2010-03-01 12 - 2010-03-07 12 , HOUR= ALL
EXP = FC5I, CHANNEL = 2 (FOVS: 55-60)
Min: 0.0220971 Max: 135.746 Mean: 13.3676

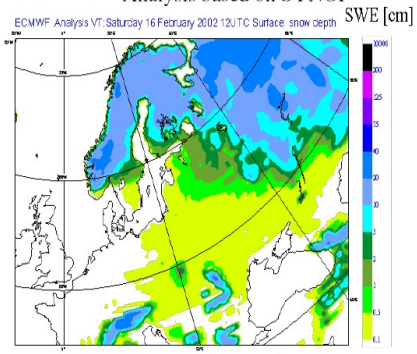


# A new snow analysis

## Analyses vs Satellite Data

MODIS 16/02/2002

Analysis based on SYNOP




Snow extent is overestimated in the analysis when it is ba

## 2004: use of the IMS 24km product (Drusch et al.)

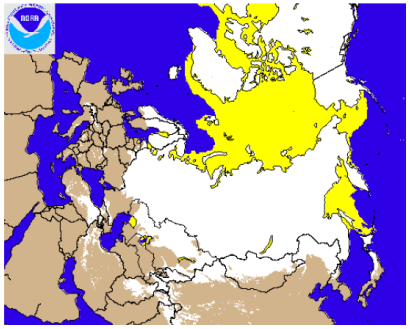
### NOAA/NESDIS Snow extent

Interactive Multisensor Snow and Ice Mapping System:

- time sequenced imagery from geostationary satellites,
- AVHRR,
- SSM/I,
- station data,
- previous day's analysis

Northern Hemisphere product

- real time
- polar stereographic projection
- 1024 × 1024 elements

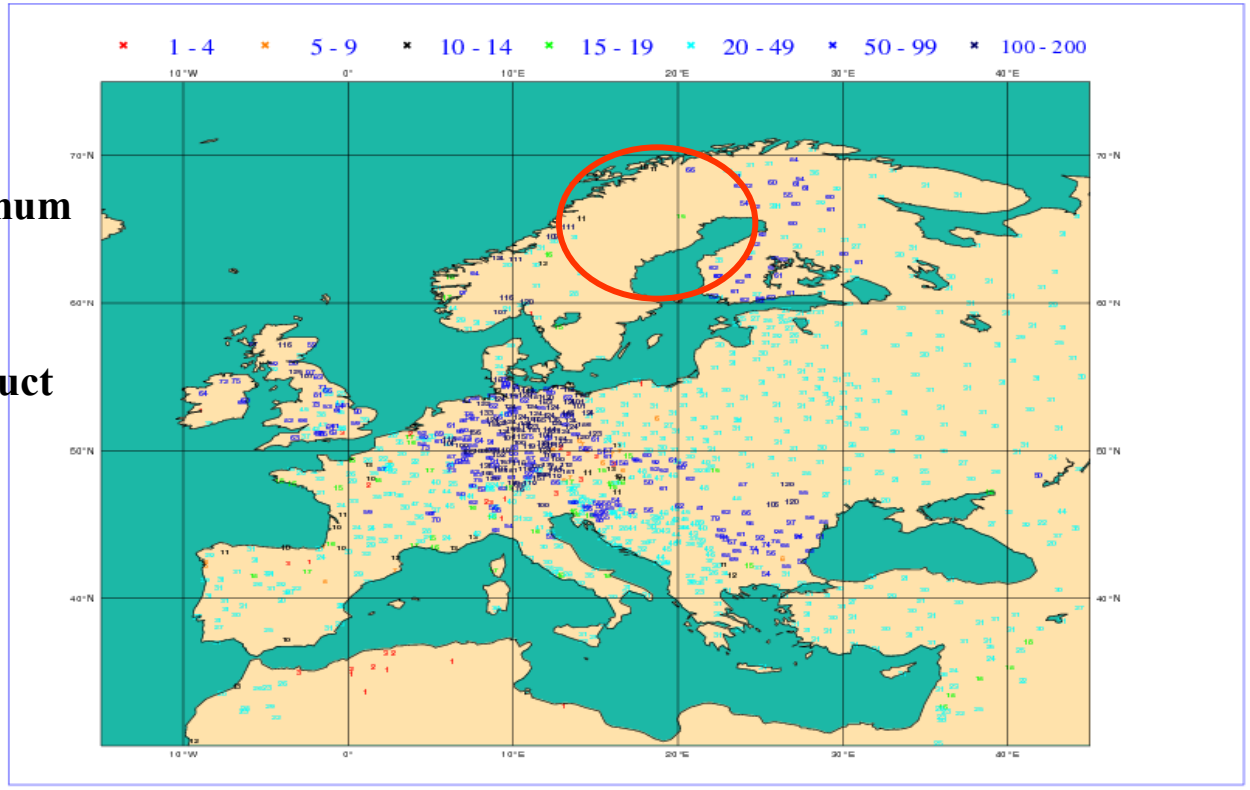


## 2010:

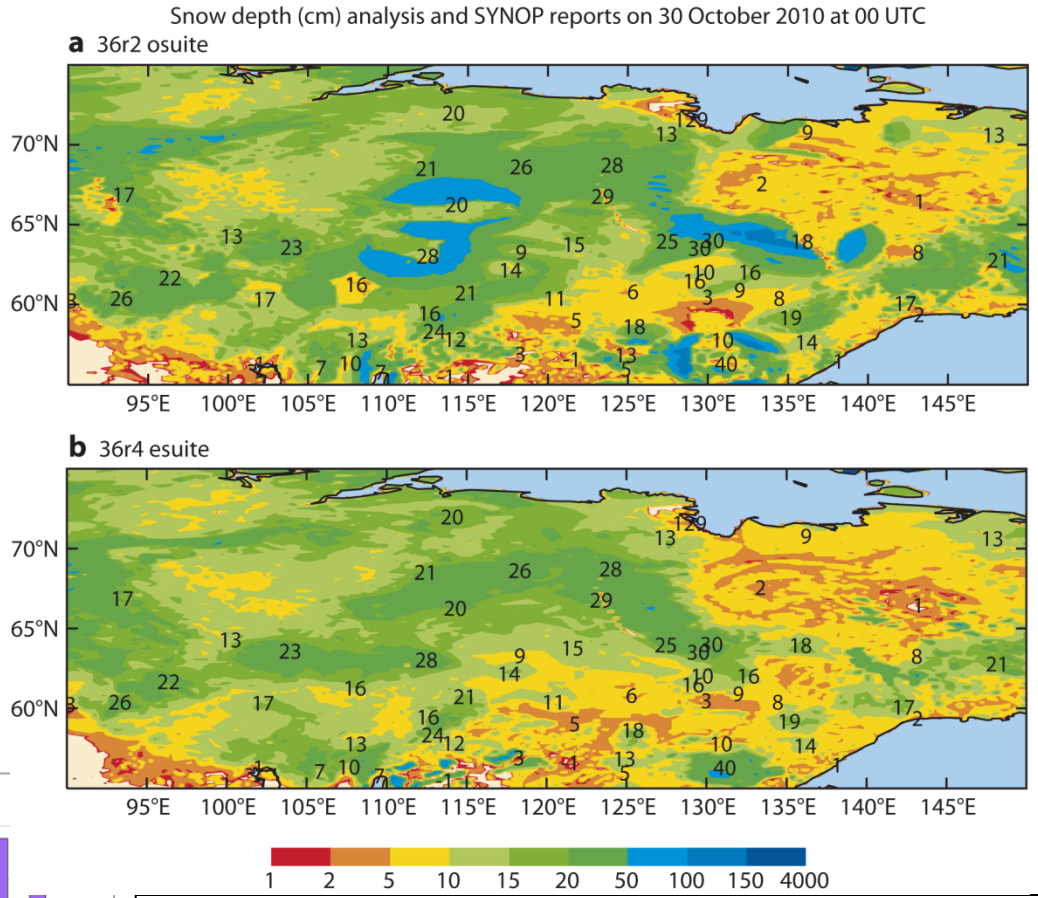
**-Snow analysis based on the Optimum Interpolation with Brasnett 1999 structure functions**

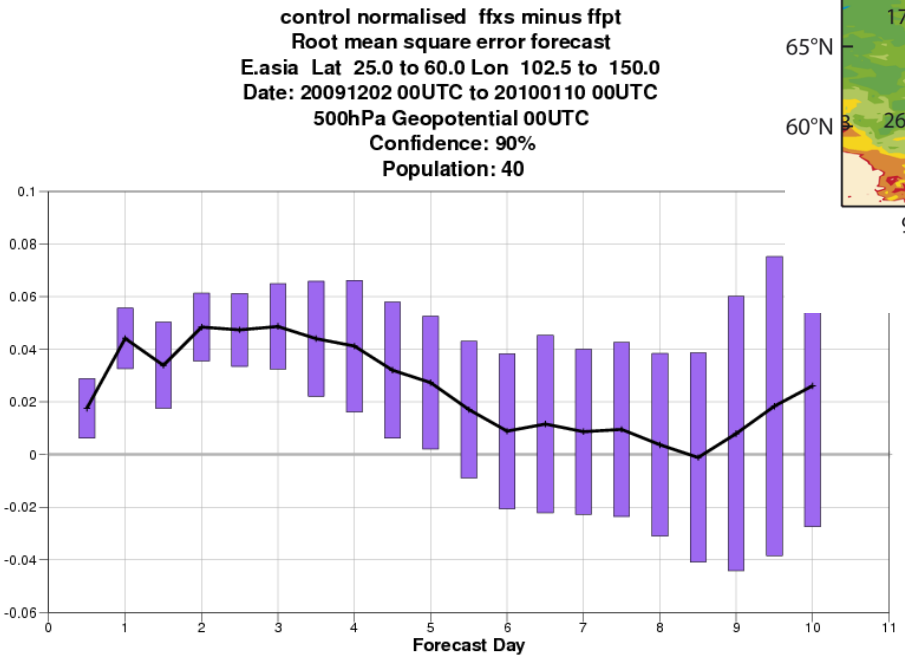
**-A new IMS 4km snow cover product to replace the 24km product**

**- Improved QC (monitoring, Blacklisting)**



# A new snow analysis

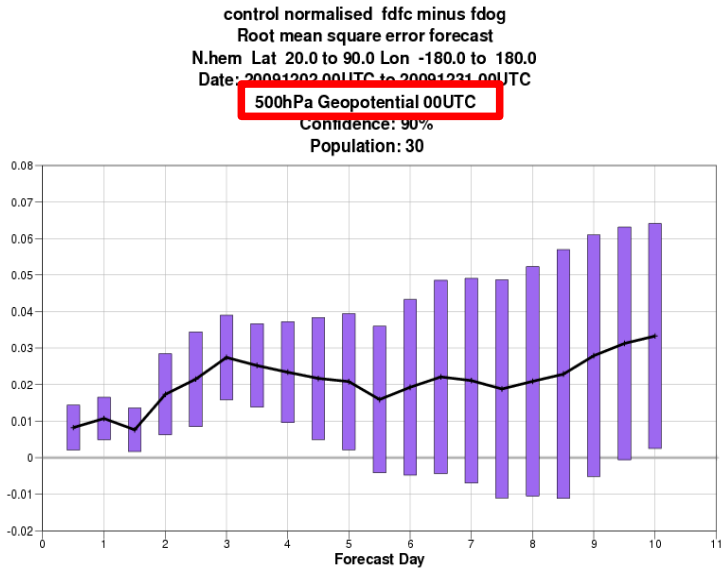


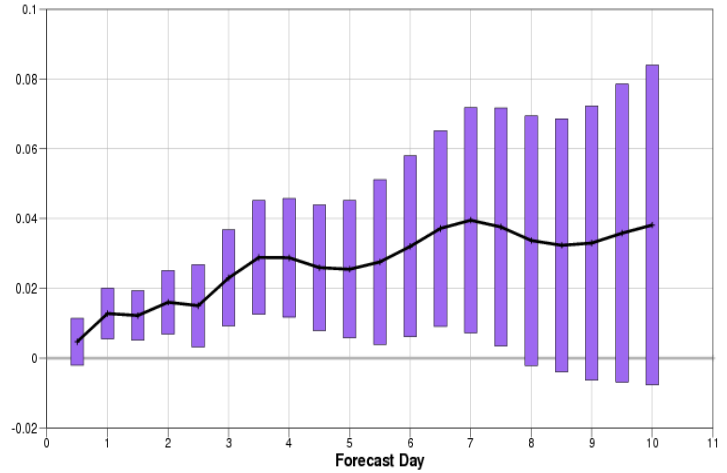




- OI has longer tails than Cressman and considers more observations.

- Model/observation information optimally weighted by an error statistics.

# A new snow analysis – Impact




Northern Hemisphere

OI impact

OI+new IMS 4km impact

Significant improvement of circulation until FC day +7

# Summary

**Recent operational implementation:**

- 2009
  - New structure of the surface analysis (independent from 4D-Var)
  - ASCAT soil moisture operational monitoring
- 2010
  - EKF soil moisture analysis, based on SYNOP screen level parameters analysis
  - Development and implementation of the OI snow analysis, based on Brasnett 1999 and use of high resolution snow cover data from NOAA/NESDIS, improved QC (blacklisting and monitoring possibilities).

**Ongoing research:**

2009-2010

- ASCAT data assimilation and global root zone production for H-SAF.
- ECMWF soil moisture validation - Very good skills for several sites across Europe (Italy, SMOSMANIA, Spain, Belgium)
- Implementation of SMOS data in the IFS and data monitoring
- Stand alone surface analysis (delayed due to snow priorities)