

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

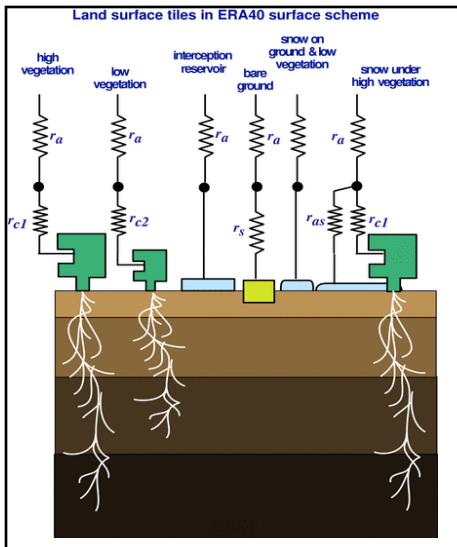
TESSEL

Van den Hurk et al. (2000)
Viterbo and Beljaars (1995)
Viterbo et al (1999)

Up to 8 tiles (binary Land-Sea mask)

GLCC veg. (BATS-like)

ERA-40 and ERA-I scheme

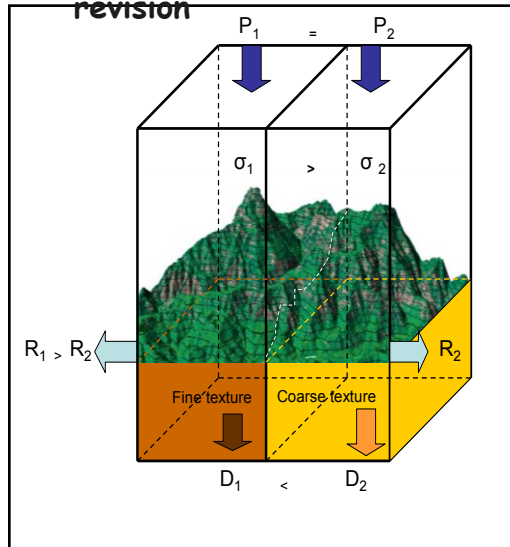


2007/11

Hydrology-**TESSEL**

Balsamo et al. (2009)
van den Hurk and Viterbo (2003)

Global Soil Texture (FAO)
New hydraulic properties
Variable Infiltration capacity & surface runoff revision

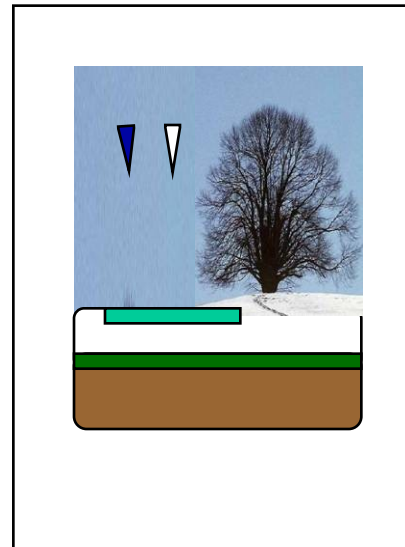


2009/03

NEW SNOW

Dutra et al. (2010)

Revised snow density
Liquid water reservoir
Revision of Albedo and sub-grid snow cover



2009/09

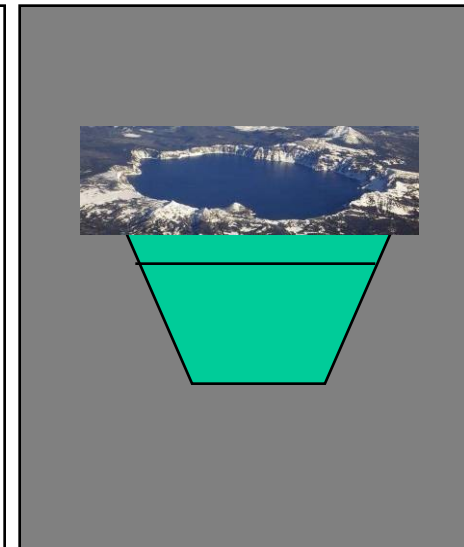
2010/2011

NEW LAI

Boussetta et al. (2010)

FLAKE

Mironov et al (2010),
Dutra et al. (2010),
Balsamo et al. (2010)
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)

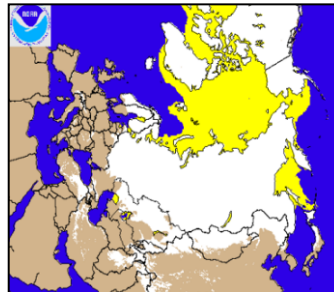
Soil moisture analysis based on
Temperature and relative humidity
analysis



Revised snow analysis

Drusch et al. (2004)

Cressman snow depth analysis using
SYNOP data improved by using
NOAA / NESDIS Snow cover
extend data



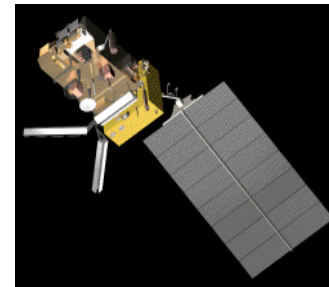
Structure Surface Analysis

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

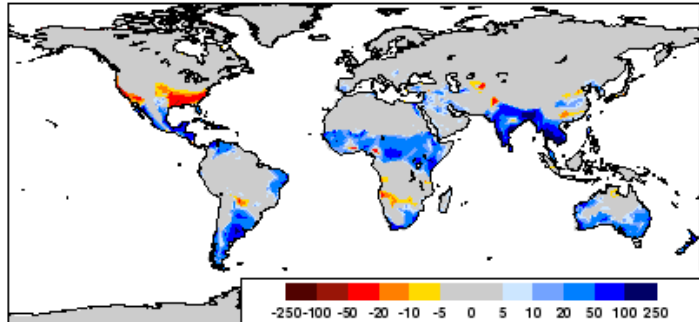
New SEKF Soil moisture analysis

Implementation in IFS cycle 36r4, operational 9 November 2010

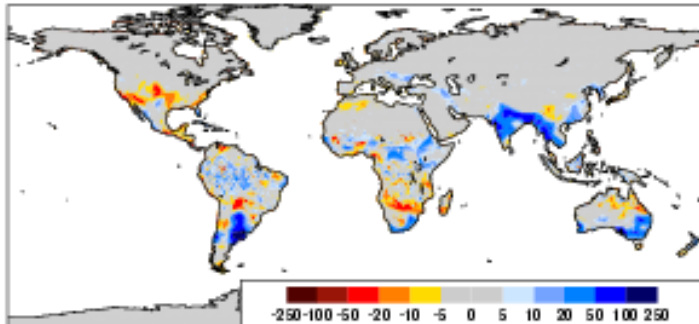
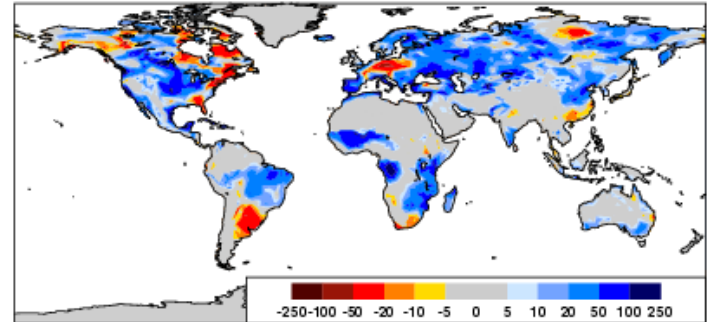
January 2009

Soil Moisture increments (mm)

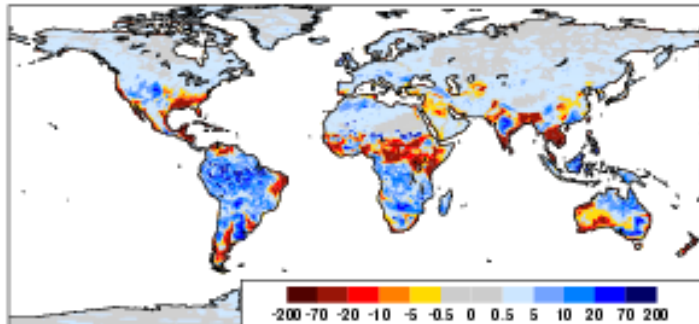
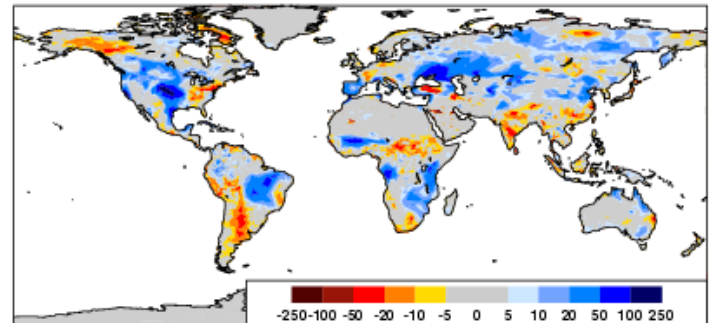
July 2009



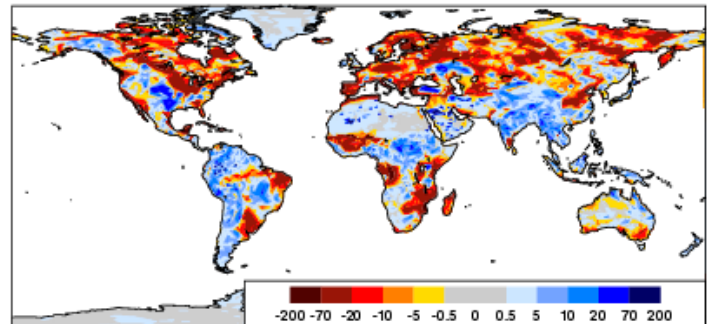
OI



SEKF



|SEKF| - |OI|



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

METOP/ASCAT Soil Moisture

ASCAT: Advanced SCATterometer

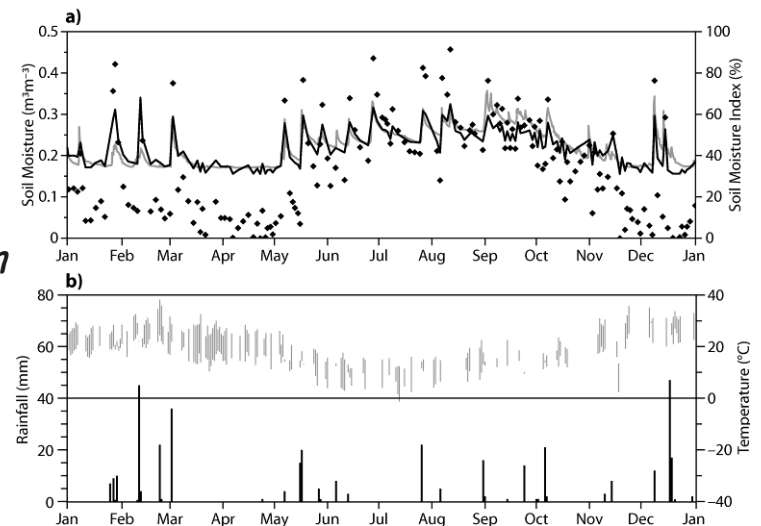
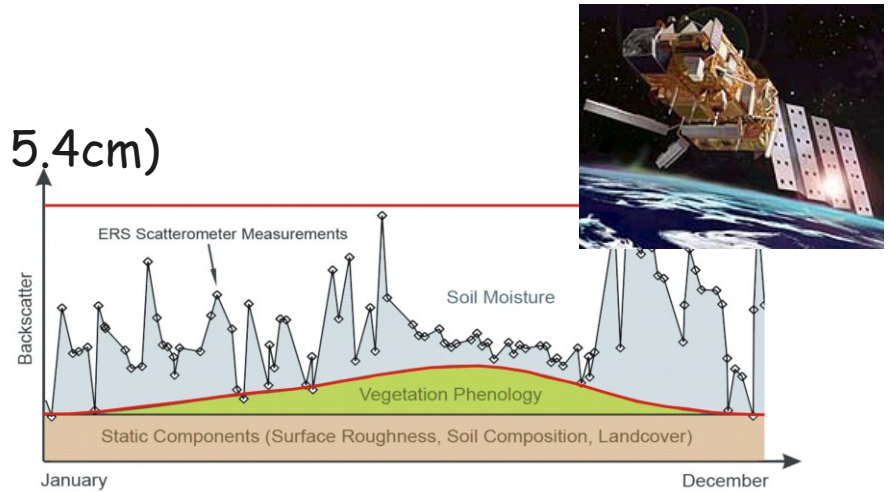
Active measurements at C-band (5.6 GHz ; 5.4cm)

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*



ASCAT monitoring

(since September 2009)

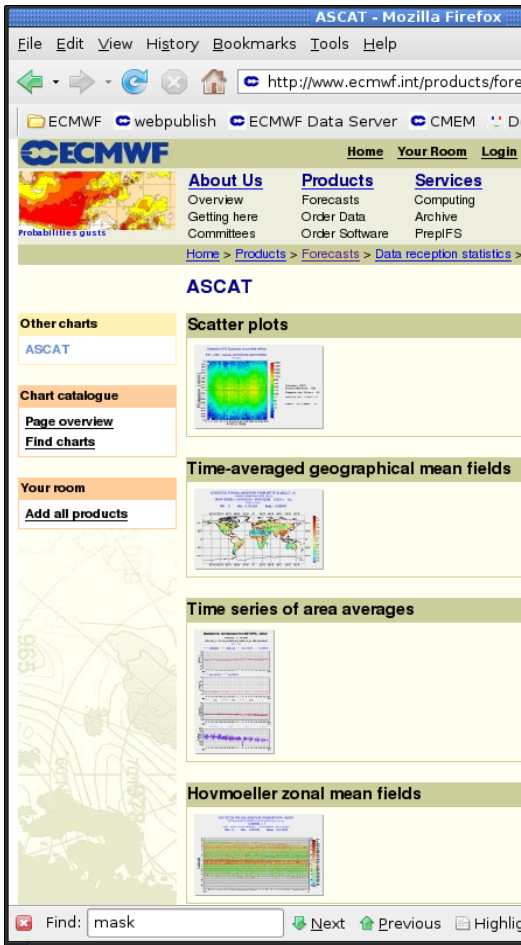
The screenshot shows a Mozilla Firefox browser window displaying the ASCAT monitoring website. The browser's address bar shows the URL <http://www.ecmwf.int/products/forecasts/d/charts/>. The website header includes the ECMWF logo and navigation links: Home, Your Room, Login, Contact, Feedback, Site Map, and Search. A secondary navigation bar lists: About Us, Products, Services, Research, Publications, and News&Events. The main content area is titled "ASCAT" and features several interactive chart categories, each with a small thumbnail image and a downward arrow:

- Other charts**: Includes a link for "ASCAT".
- Chart catalogue**: Includes links for "Page overview" and "Find charts".
- Your room**: Includes a link for "Add all products".
- Scatter plots**: Shows a thumbnail of a scatter plot.
- Time-averaged geographical mean fields**: Shows a thumbnail of a world map.
- Time series of area averages**: Shows a thumbnail of a time-series plot.
- Hovmoeller zonal mean fields**: Shows a thumbnail of a Hovmoeller plot.

The browser's search bar at the bottom contains the text "Find: mask" and includes navigation buttons for "Next", "Previous", "Highlight all", and "Match case".

Use of Active microwave data: ASCAT monitoring

(since September 2009)

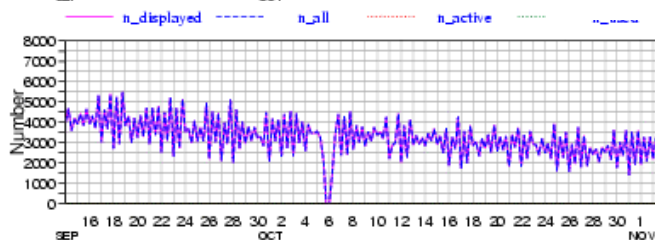
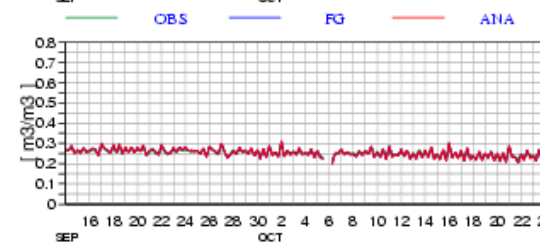
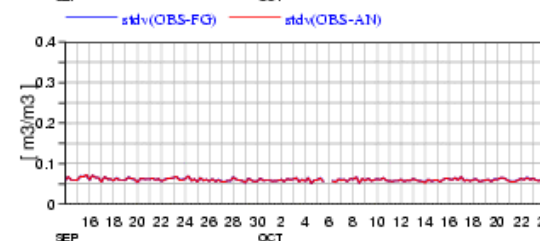
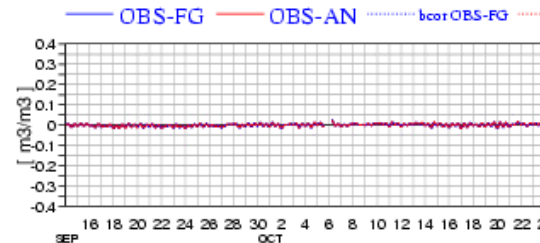


Statistics for Soil Moisture from METOP-A / ASCAT

Channel = 1, All Data

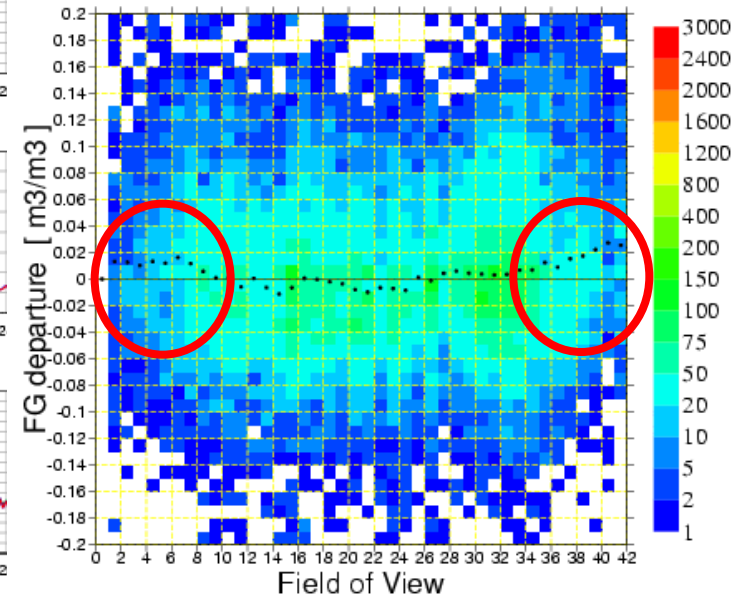
Area: lon_w= 0.0, lon_e= 360.0, lat_n= 90.0, lat_s= -90.0 (over land)

EXP = 0001



Scatterplot of FG Departures versus Field of View

EXP = 0001 ; Period = 2010110100 to 2010110300
All Data

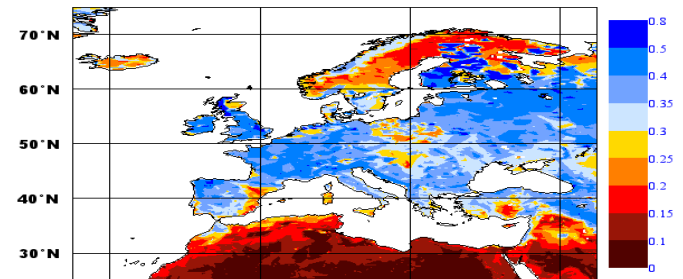


H-SAF Root zone soil moisture product based on ASCAT data assimilation

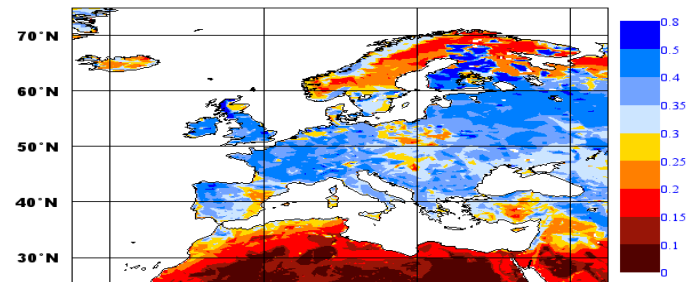
- Assimilation in the IFS using the SEKF
- July 2008 - August 2010 daily data
- H-SAF area (also available at global scale)

The screenshot shows the H-SAF Project website at ECMWF. The browser title is "H-SAF Project at ECMWF - Mozilla Firefox". The address bar shows the URL "http://www.ecmwf.int/research/EUMETSAT_projects/SAF/HS". The website features a navigation menu with links for Home, Your Room, Login, Contact, Feedback, Site Map, and Search. Below the menu, there are sections for "About Us", "Products", "Services", "Research", "Publications", and "News&Events". A sidebar on the left lists "EUMETSAT projects" and "ECMWF H-SAF" with links to "SM-ASS-1 Product", "SM-ASS-1 preview", "Operational monitoring", "References", and "Contact". The main content area is titled "H-SAF project at ECMWF" and "ECMWF contribution to the H-SAF". It describes the project's goal: "The ECMWF activities are centred around the development of a root zone soil moisture product based on the forecast from the Numerical Weather Prediction model, satellite derived surface soil moisture, and an advanced data assimilation system." A section titled "During the H-SAF development phase (2005-2010)" details the development of the volumetric root zone soil moisture SM-ASS-1 product. A list of links includes "SM-ASS-1 Product characteristics", "Algorithms and software for the SM-ASS-1 root zone soil moisture production", "SM-ASS-1 previews", "How to read SM-ASS-1 (GRIB API, Metview, Matlab)", and "ASCAT global soil moisture monitoring (under 'soil moisture') - operational at ECMWF since September 2009".

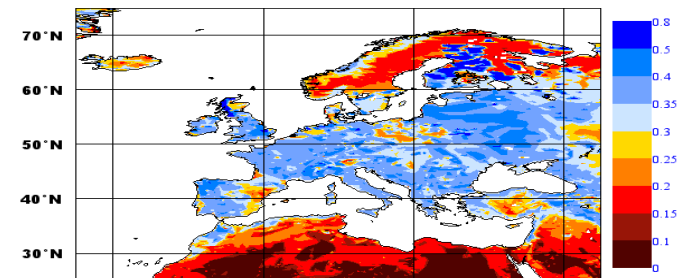
Layer 1: 0-7 cm



Layer 2: 7-28 cm



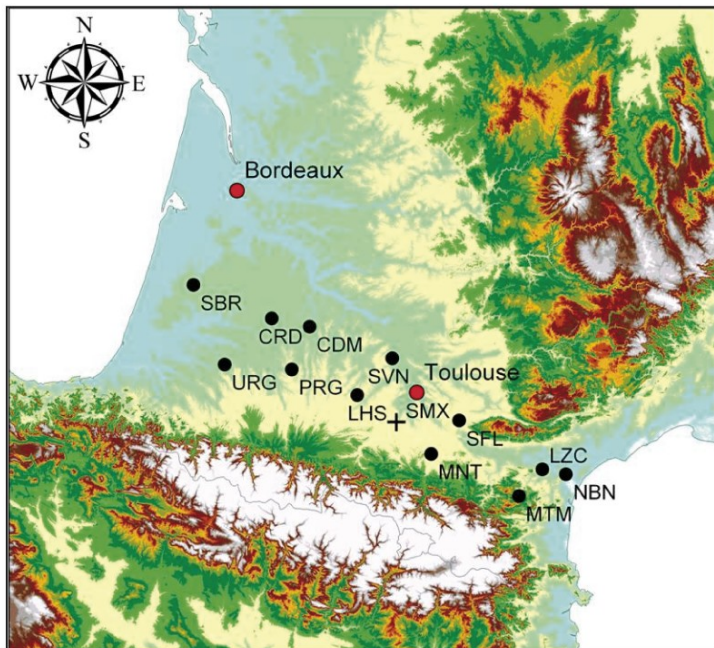
Layer 3: 28-100 cm



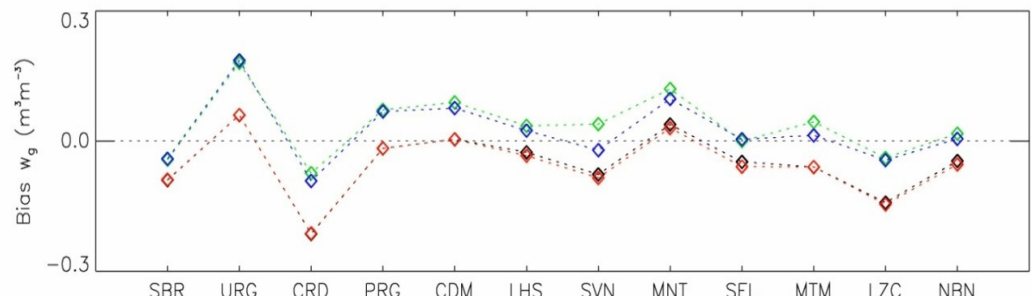
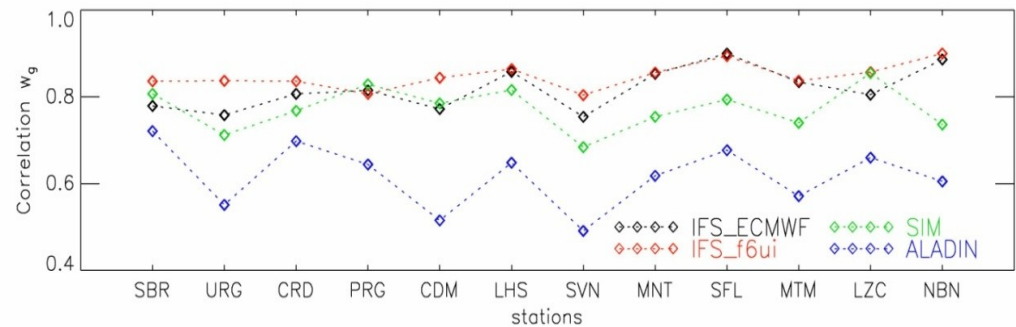
ECMWF Soil Moisture analysis verification

- 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



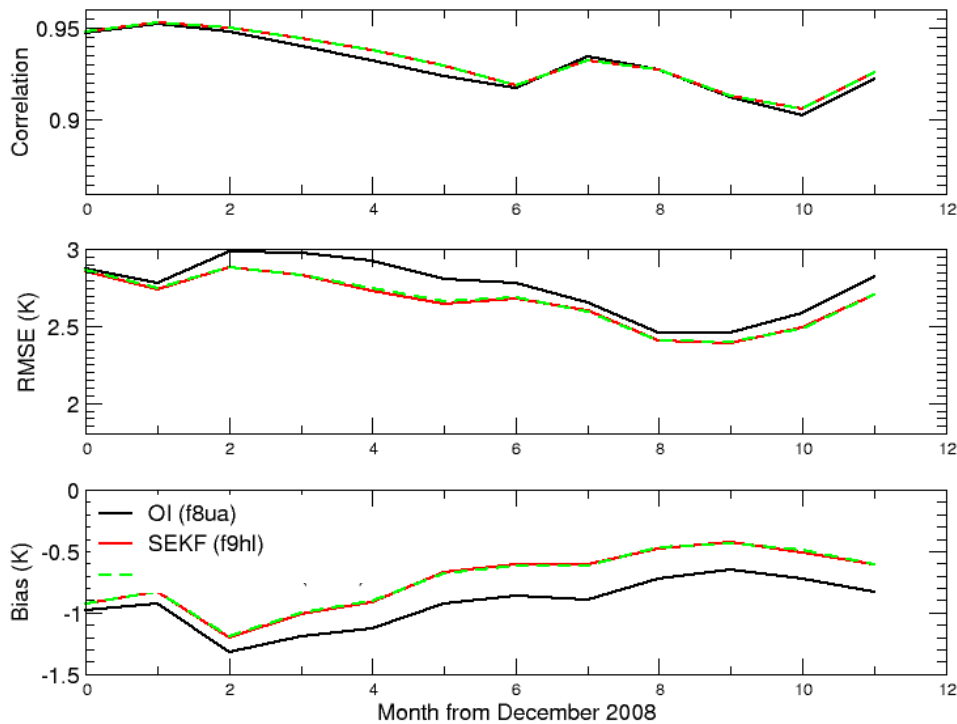
— ECMWF Operational SM (R=0.82)
— ECMWF-H-SAF product (R=0.85)
— SIM (Météo-France forced system (R=0.77)
— ALADIN (Meteo-France operational SM (R=0.63)



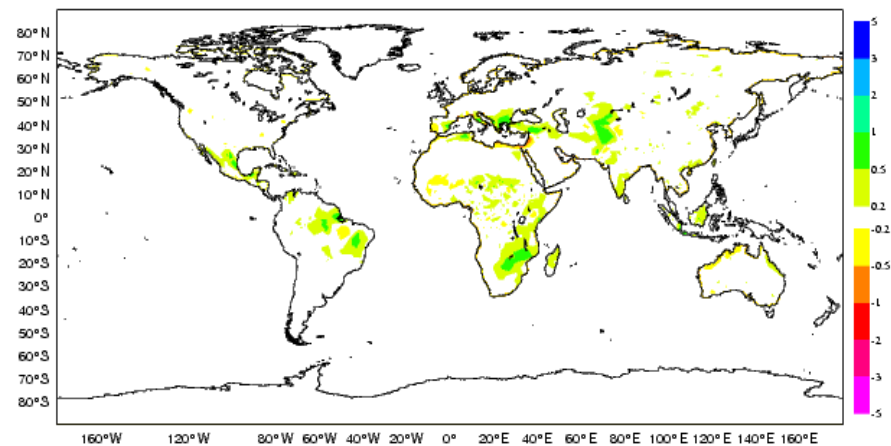
Impact on Temperature

T2m verification against analysis

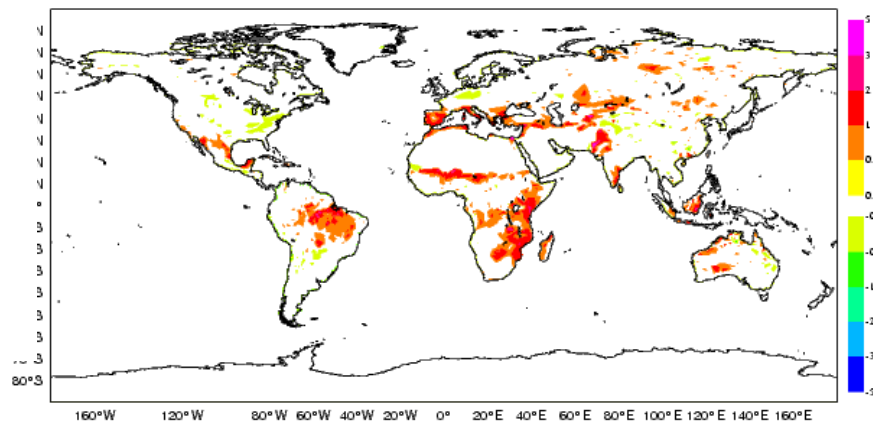
2m Temperature Africa Step 48 from 00UTC



T2m impact (SEKF improve T2m)



T2m Sensitivity (SEKF warmer)



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:

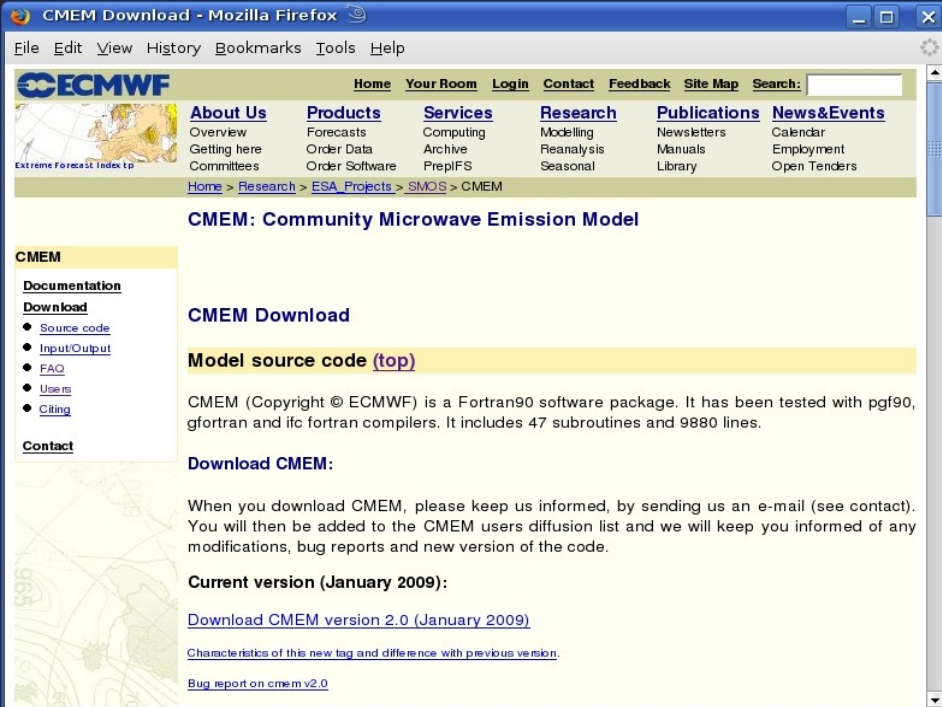
- A Forward operator, that transforms model variables into observed variables. For SMOS, the CMEM forward model has been developed, validated and implemented in the IFS.
- Data Assimilation will rely on the EKF soil moisture analysis.



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



The screenshot shows a Mozilla Firefox browser window displaying the 'CMEM Download' page. The page header includes the ECMWF logo and navigation links: Home, Your Room, Login, Contact, Feedback, Site Map, and Search. A secondary navigation bar lists: About Us, Products, Services, Research, Publications, and News&Events. The main content area is titled 'CMEM: Community Microwave Emission Model' and features a sidebar with 'Documentation' (Download, Source code, Input/Output, FAQ, Users, Citing) and 'Contact'. The main text includes 'CMEM Download', 'Model source code (top)', and a description: 'CMEM (Copyright © ECMWF) is a Fortran90 software package. It has been tested with pgf90, gfortran and ifc fortran compilers. It includes 47 subroutines and 9880 lines.' Below this, it says 'Download CMEM:' and provides instructions: 'When you download CMEM, please keep us informed, by sending us an e-mail (see contact). You will then be added to the CMEM users diffusion list and we will keep you informed of any modifications, bug reports and new version of the code.' The current version is 'January 2009', with a link to 'Download CMEM version 2.0 (January 2009)'. There are also links for 'Characteristics of this new tag and difference with previous version.' and 'Bug report on cmem v2.0'.

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
- Polarisation 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

The screenshot displays the EC-MWF website interface for the SMOS Offline monitoring page. At the top, there is a navigation bar with links for Home, Your Room, Login, Contact, Feedback, Site Map, and a search box. Below this, a menu lists various sections: About Us, Products, Services, Research, Publications, and News&Events, each with sub-links. The main content area is titled "SMOS Offline monitoring page 20100119" and includes a "Page Content:" section. This section provides an overview of the data and lists three monitoring windows: "1- 00 UTC to 24 UTC window - TBH - Global Sorted by incidence angle", "2- 00 UTC to 24 UTC window - TBV - Global Sorted by incidence angle", and "1- 00 UTC to 24 UTC window - TBH - Global Sorted by incidence angle". A "Back to the top" link is also present. Below the text, a global map shows "Brightness Temperatures" with a color-coded legend. The legend includes ranges such as 50.1 - 80.1, 80.1 - 110, 110 - 140, 140 - 170, 170 - 200, 200 - 230, 230 - 260, 260 - 290, 290 - 320, and 320 - 350. The map shows a global distribution of these temperatures, with higher values (red/orange) concentrated in the mid-latitude oceans and lower values (blue/cyan) in the high-latitude regions.

SMOS Near-Real-Time monitoring

$\Theta = 40^\circ$

20-Nov-09

20-Dec-09

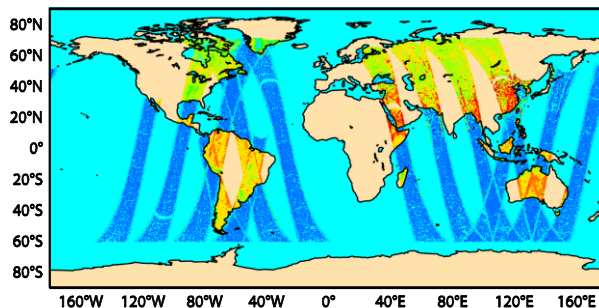
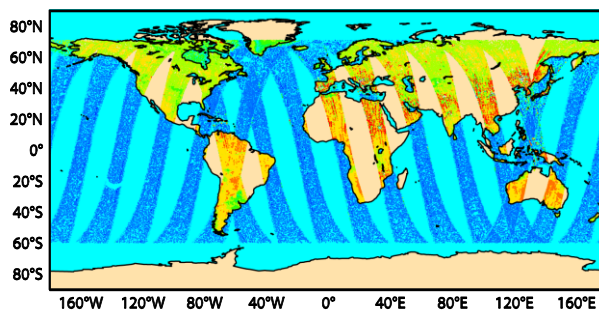
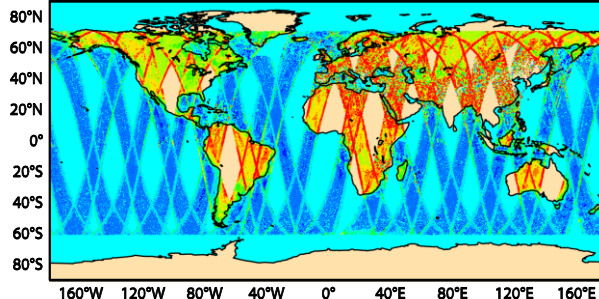
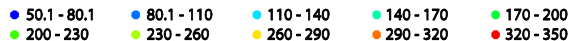
NRT

16-Jan-10

NRT

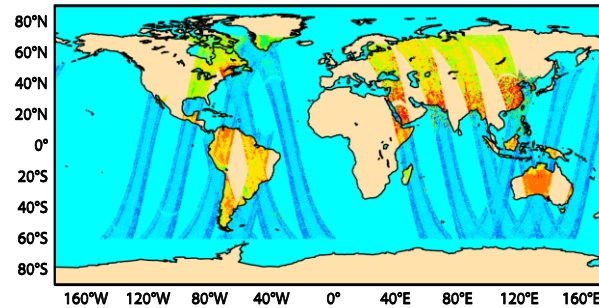
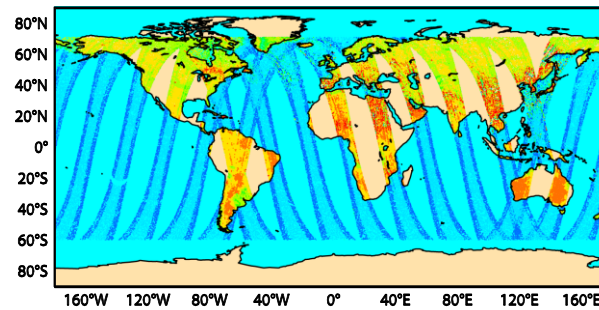
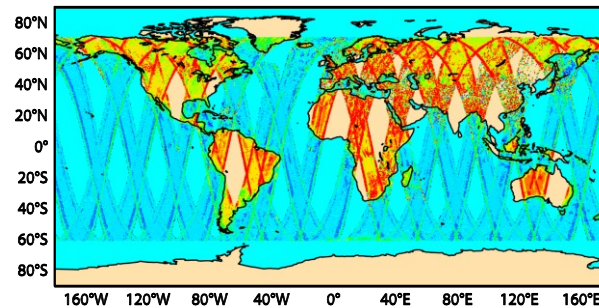
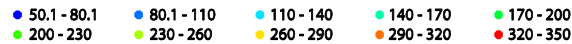
TBh

Brightness Temperatures



TBv

Brightness Temperatures

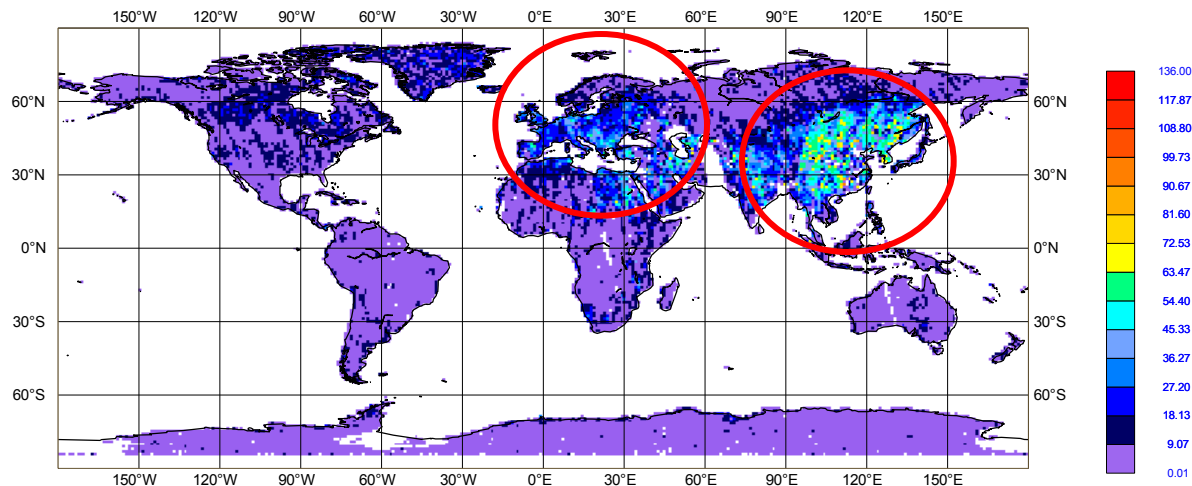


Global statistics: Standard monitoring maps

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



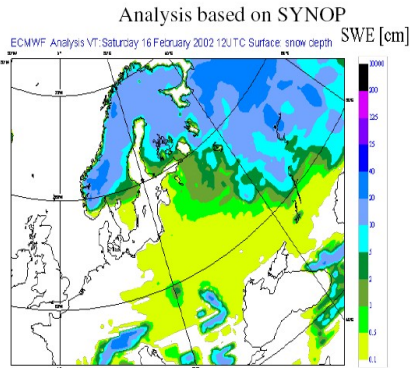
A new snow analysis

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

NOAA/NESDIS Snow extent

Analyses vs Satellite Data

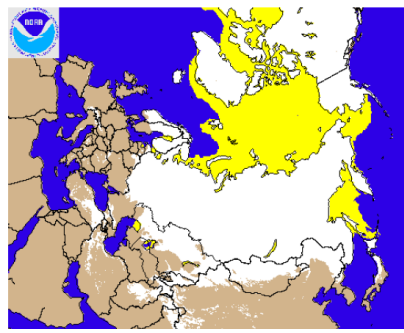
MODIS 16/02/2002



Snow extent is overestimated in the analysis when it is ba

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

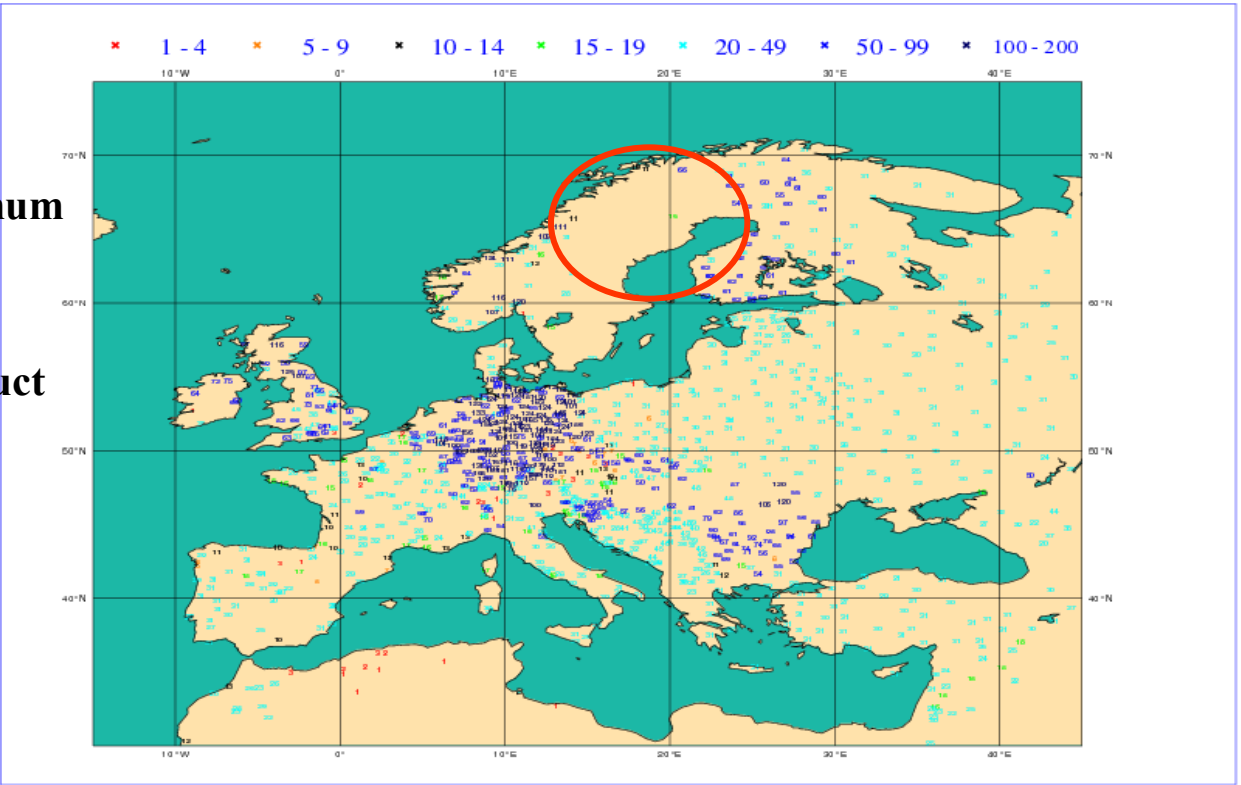
- real time
- polar stereographic projection
- 1024 x 1024 elements

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

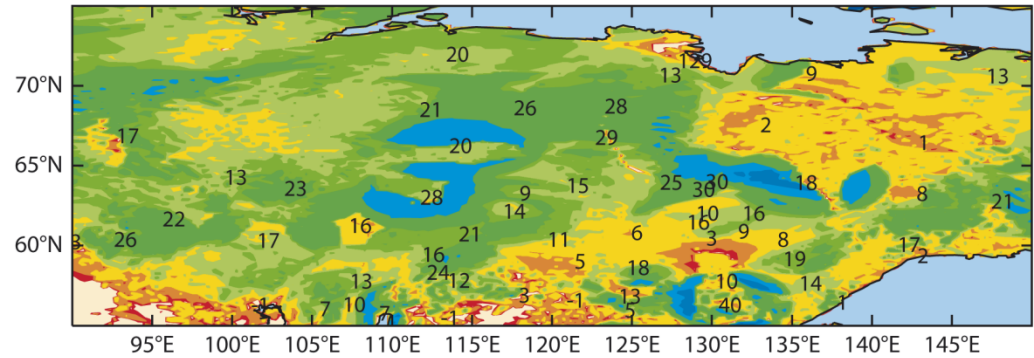
- Improved QC (monitoring, Blacklisting)



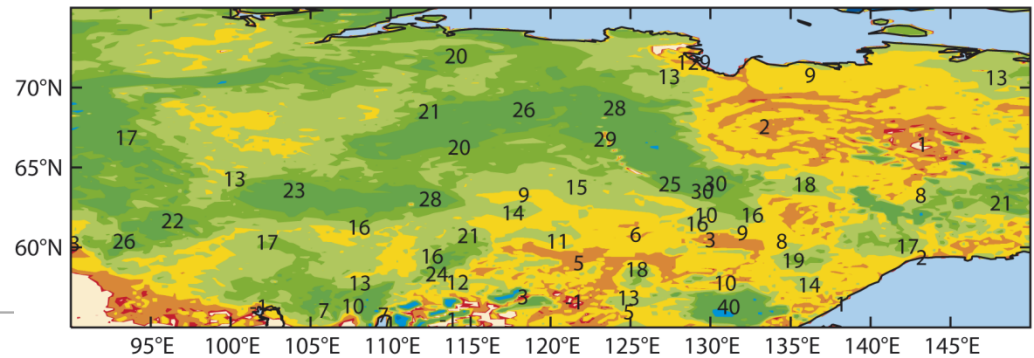
A new snow analysis

Snow depth (cm) analysis and SYNOP reports on 30 October 2010 at 00 UTC

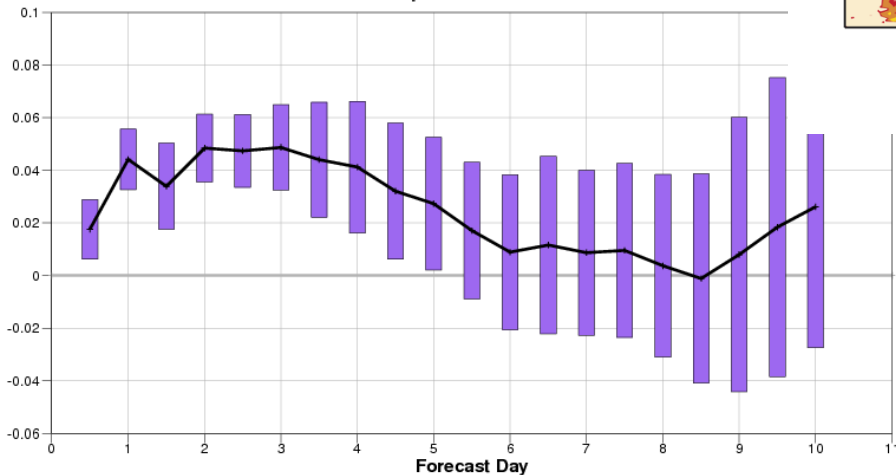
a 36r2 osuite



b 36r4 esuite



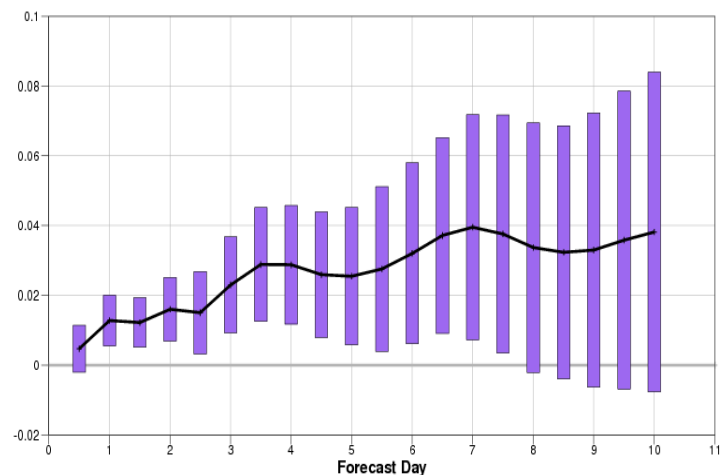
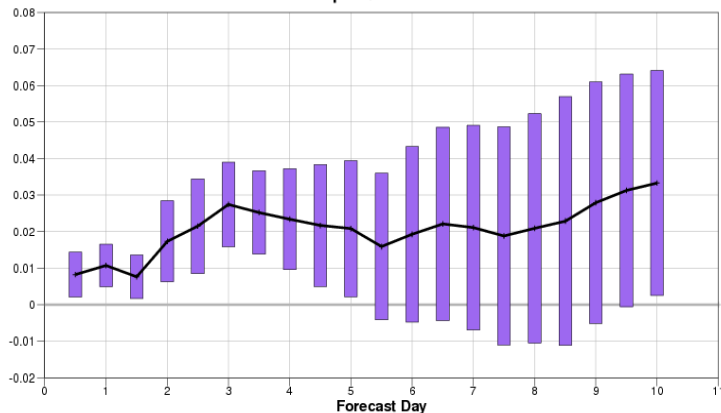
control normalised ffxs minus ffpt
 Root mean square error forecast
 E.asia Lat 25.0 to 60.0 Lon 102.5 to 150.0
 Date: 20091202 00UTC to 20100110 00UTC
 500hPa Geopotential 00UTC
 Confidence: 90%
 Population: 40



- OI has longer tails than Cressman and considers more observations.
- Model/observation information optimally weighted by an error statistics.

A new snow analysis – Impact

control normalised fdfc minus fdog
Root mean square error forecast
N.hem Lat 20.0 to 90.0 Lon -180.0 to 180.0
Date: 20091202 00UTC to 20091231 00UTC
500hPa Geopotential 00UTC
Confidence: 90%
Population: 30



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)