Use of satellite data for land surface analysis at ECMWF

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Thanks to: G. Balsamo, J. Muñoz Sabater, M. Drusch, K. Scipal, L. Isaksen, C. Albergel
# Land surface model evolution

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<tr>
<td></td>
<td>Up to 8 tiles (binary Land-Sea mask)</td>
<td>Global Soil Texture (FAO) New hydraulic properties Variable Infiltration capacity &amp; surface runoff revision</td>
<td>Revised snow density Liquid water reservoir Revision of Albedo and sub-grid snow cover</td>
<td>FLAKE</td>
<td>Mironov et al (2010), Dutra et al. (2010), Balsamo et al. (2010)</td>
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**New improvements in 2000/06**
- **TESSEL**
- **Hydrology**
- **NEW SNOW**
- **NEW LAI**

**New improvements in 2007/11**
- **Global Soil Texture (FAO)**
- **Variable Infiltration capacity & surface runoff revision**

**New improvements in 2009/03 and 2009/09**
- **REVISED SNOW**
- **FLAKE**

**New improvements in 2010/2011**
- **FLAKE**
- Extra tile (9) to account for sub-grid lakes
# Land surface data assimilation evolution

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<td><strong>OI screen level analysis</strong></td>
<td><strong>Revised snow analysis</strong></td>
<td><strong>Structure Surface Analysis</strong></td>
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<td>Douville et al. (2000)</td>
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<td>OI snow analysis and high resolution NESDIS data (4km)</td>
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<td>Mahfouf et al. (2000)</td>
<td>Cressman snow depth analysis using SYNOP data improved by using NOAA / NSEDIS Snow cover extend data</td>
<td>SEKF Soil Moisture analysis</td>
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<td>Soil moisture analysis based on Temperature and relative humidity analysis</td>
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<td>Simplified Extended Kalman Filter</td>
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<td>METOP-ASCAT</td>
<td>SMOS</td>
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- 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|

METOP/ASCAT Soil Moisture

ASCAT: Advanced SCATterometer
Active measurements at C-band (5.6 GHz; 5.4 cm)

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)
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)
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

Correlation

RMSE (K)

Bias (K)

Month from December 2008

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

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/smос_monitor.html
SMOS Near-Real-Time monitoring

$\Theta = 40^\circ$

20-Nov-09

TBh

20-Dec-09

TBv

NRT

16-Jan-10

NRT
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: 13.367
A new snow analysis

Analysis vs Satellite Data

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
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)