The SMOS monitoring suite at ECMWF

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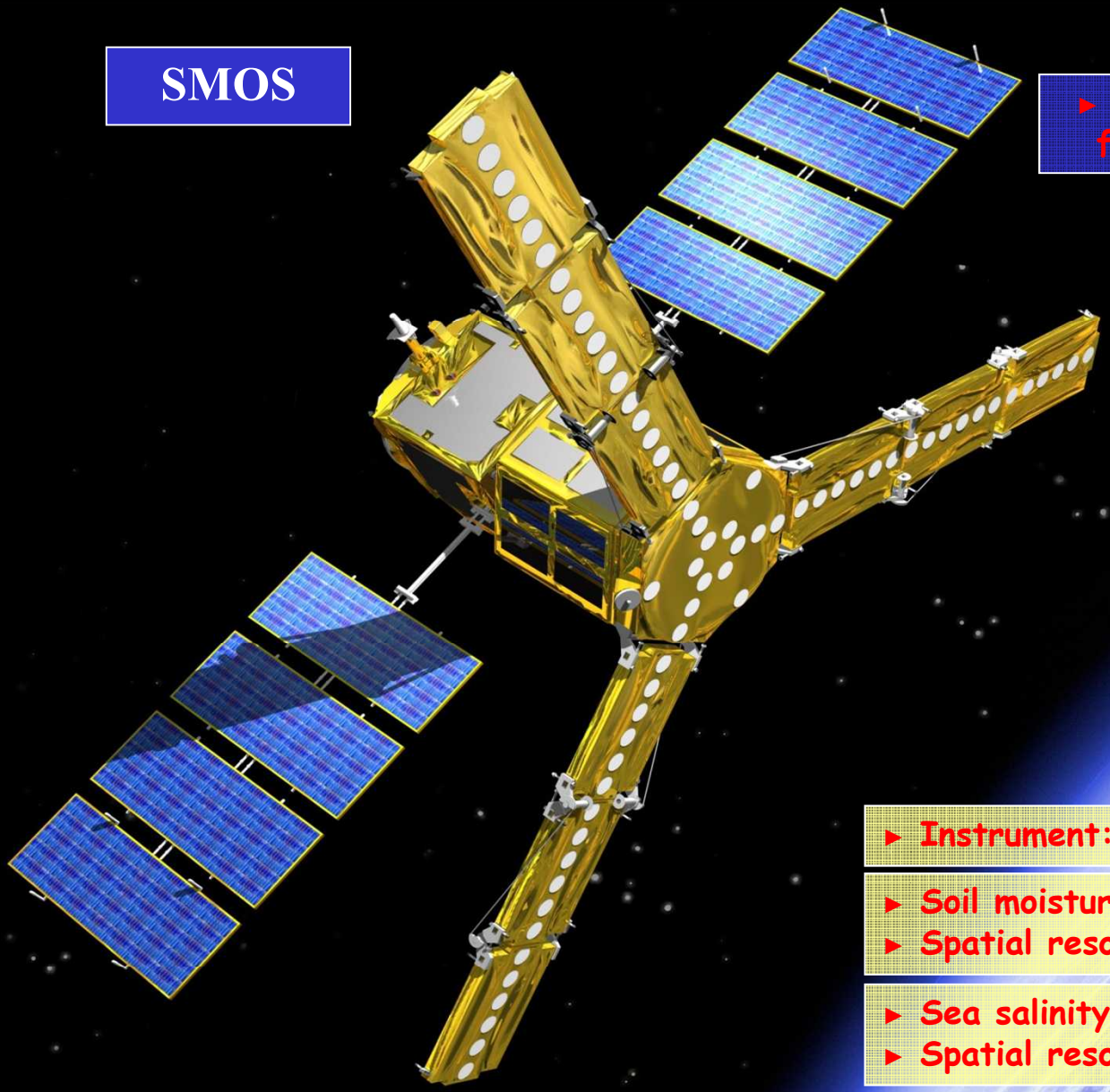
SMOS



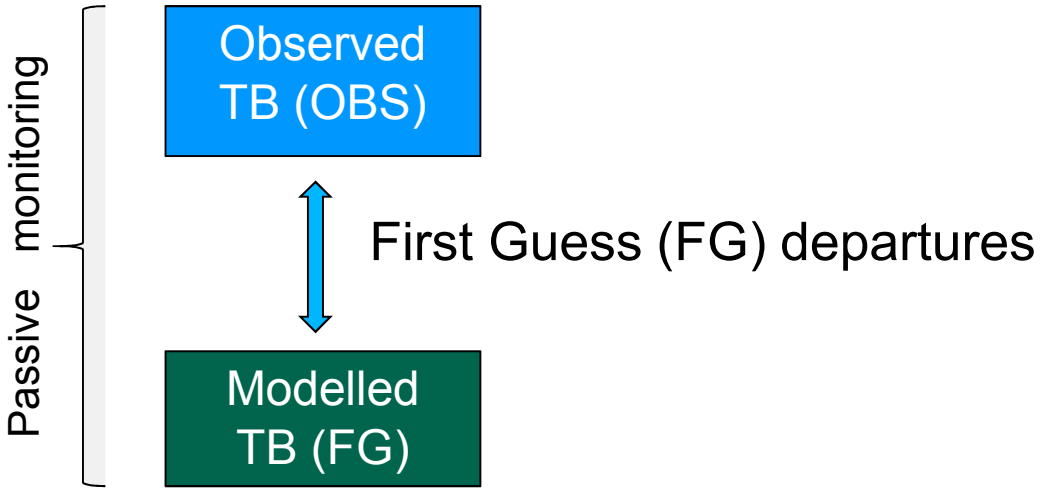
- Launch succesfully: 02-11-2009 from Plesetsk Cosmodrom, Russia.

- Instrument: MIRAS, operating at 1.4 GHz
- Soil moisture accuracy: 4%
- Spatial resolution: 40-50 km
- Sea salinity accuracy: 0.1 psu
- Spatial resolution: 200x200 km
- Revisit time: 2-3 days
- Data stations: Svalbard (Norway) and Villafranca (Spain)

Main objectives

1. Global monitoring of NRT brightness temperatures at the satellite reference frame at several incidence angles.

   - For Numerical Weather Prediction (NWP) applications, monitoring compares forecast (or analysis) and observed data.

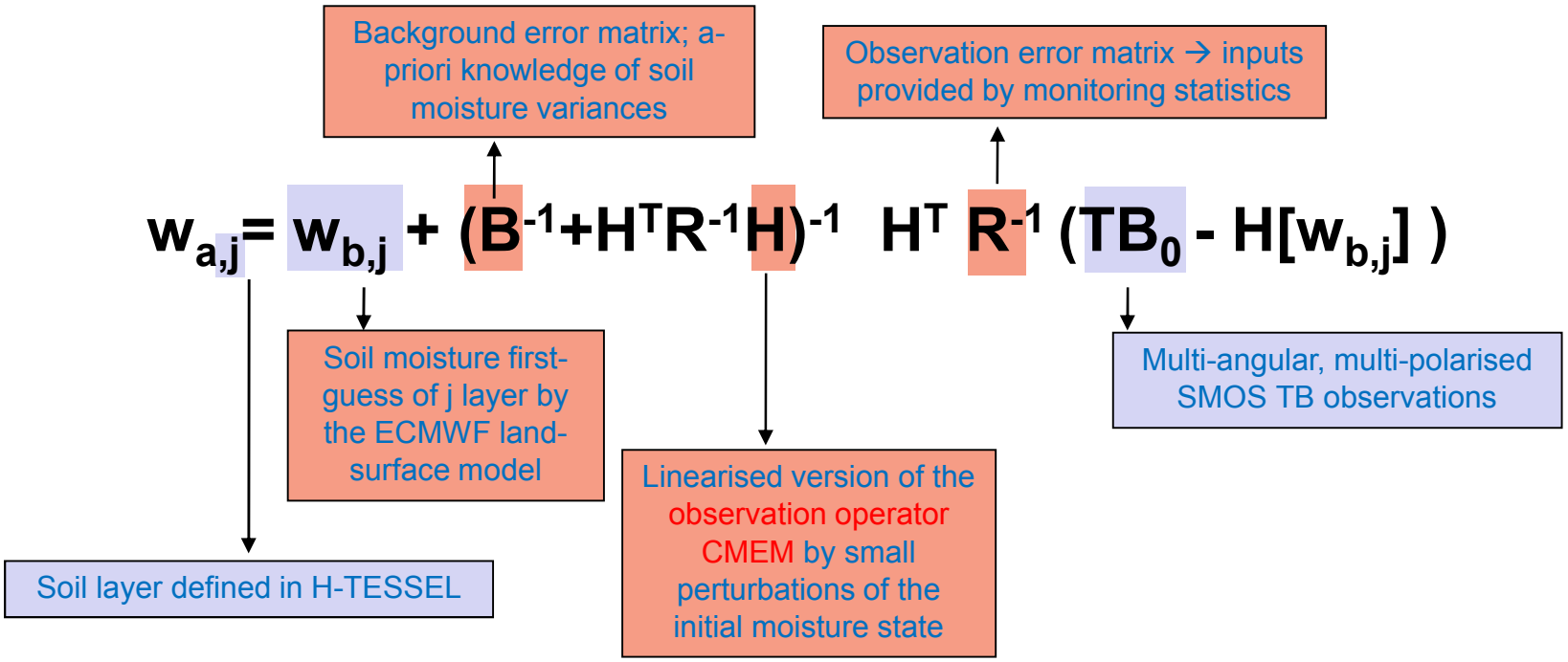


   - Results available in NRT through the ECMWF satellite monitoring webpage. **[http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite/smos]**

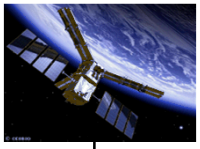
Main objectives

2. Assimilation of SMOS NRT brightness temperatures over land → investigate the meteorological impact of SMOS data assimilation.

Extended Kalman Filter (EKF) soil moisture (w_a) analysis:



Implementing SMOS data in the IFS. Last version



ESAC

NRT BUFR product

Convert to NRT ECMWF BUFR product

Store in ECMWF archives

MARS

ECFS

Pre-process data:
- Consistency checks
- Parallel data thinning per angular bins

BUFR files

Acquisition, quality control, thinning, etc.

Mapping and load data to ODB tables

Distribution per processor and grid point

Collocation, screening, forward modelling, first-guess departures, etc.

Computations in model space (gp_model)

Get SMOS data in grid point
- *call* ***smos_process***

Forward model (CMEM)
- *physics interface routines*
- *call* ***callpar***
  - *call* ***smos_screen***
  - ***CMEM interface***
  - *call* ***mwave_screen***
  - ***RTTOVS interface***

T_{atm}, ε

Back to observation space
- *call* ***smos_update***

ODB data

passive monitoring of NRT TB over land & sea

ODB: Observational Data Base used by the Integrated Forecasting System

Main obstacles (and challenges) in the implementation

- Volume of SMOS data,
  - Much computing resources and time were needed to process and test SMOS data,
  - Which data should be thinned and which data should be assimilated?
  - Some scripts showed difficulties to cope with very large files and needed re-adaptation,

- Particular measuring principle (observation of the same area with different incidence angles at different time stamps) produces very large internal data bases which are difficult to handle,
  - Structure of SMOS ODB in the IFS needs to be revised to make it more efficient and use less memory resources → Is a 'MUST' for operational purposes,
  - Independent multi-polarisation, multi-angular computations needed special treatment,

- Implementation of the CMEM observation operator in the IFS,
  - Compatibility with IFS is only guaranteed if CMEM code is adapted to a multi-thread environment

The observation operator – CMEM

Based on LMEB [Wigneron et al., 2007] & LSMEM [Drusch et al., 2007]
Available at **[http://www.ecmwf.int/research/ESA_projects/SMOS/cmem/cmem_index.html]**

- **Soil dielectric mixing model**
  (Wang & Schmugge / Dobson / Mironov)?
- **Effective temperature model**
  (Choudhurry / Wigneron / Holmes)?
- **Smooth surface emissivity model**
  (Fresnel / Wilheit)?
- **Soil roughness model**
  (None = Smooth / Choudhury / Wegmuller / Wigneron 01/07)?

→ **SOIL**

- **Vegetation opacity model**
  (None / Kirdyashev / Wegmuller / Wigneron / Jackson)?

→ **VEGETATION**

- **Atmospheric radiative transfer model**
  (None / Pellarin / Liebe / Ulaby)?

→ **ATMOSPHERE**

- **Snow emission model**
  (Pulliainen)?

→ **SNOW**

- Equivalent to L-MEB when options in red are chosen

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First - guess

- Community Microwave Emission Model (CMEM), modular radiative transfer code used to compute first-guess:

- Drusch et al., 2009, JHM
- de Rosnay et al., 2009, JGR
- Muñoz-Sabater et al., 2011, IJRS

First-guess → CMEM initial config

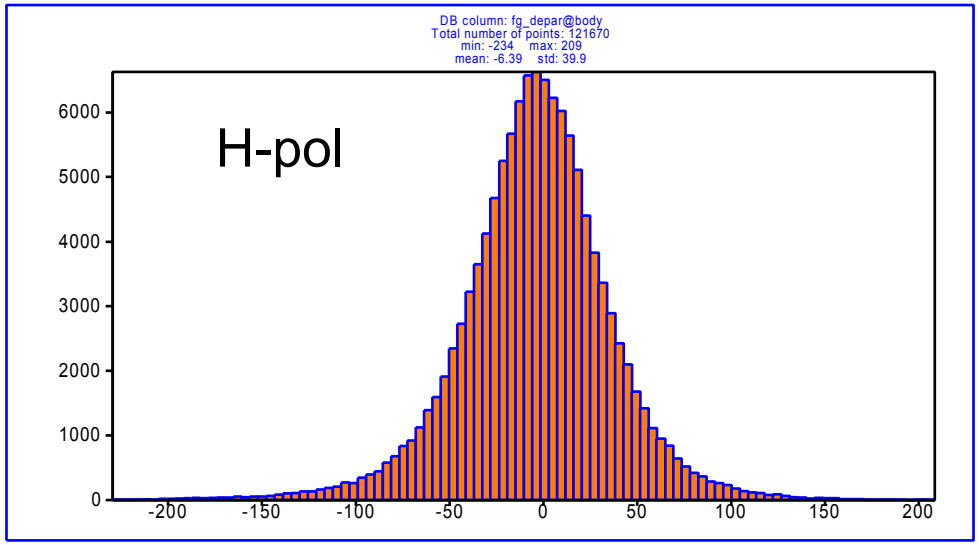
dielectric	Wang
effect. temp	Choudhury
smooth surface	Fresnel
roughness	Choudhury
vegetation	Kirdyashev
atmosphere	Pellarin

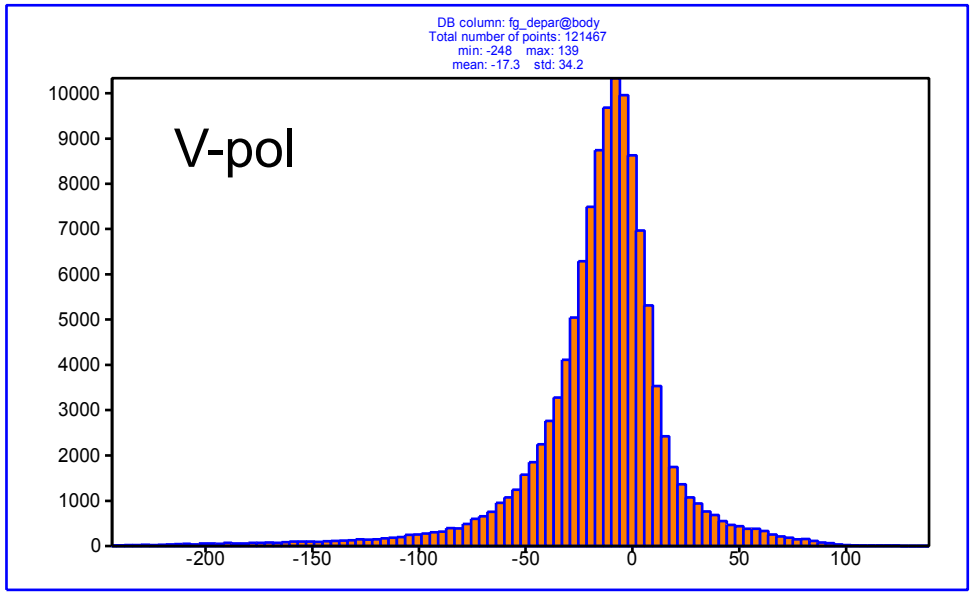
First-guess departures (obs - model)

Case Study:

- **22 January 2010,**
- **First 4D-Var 12h cycle,**
- **Global scale,**
- **All incidence angles included,**
- **No mask applied on vegetation or snow**

- **Some departures are still too cold or too warm.**





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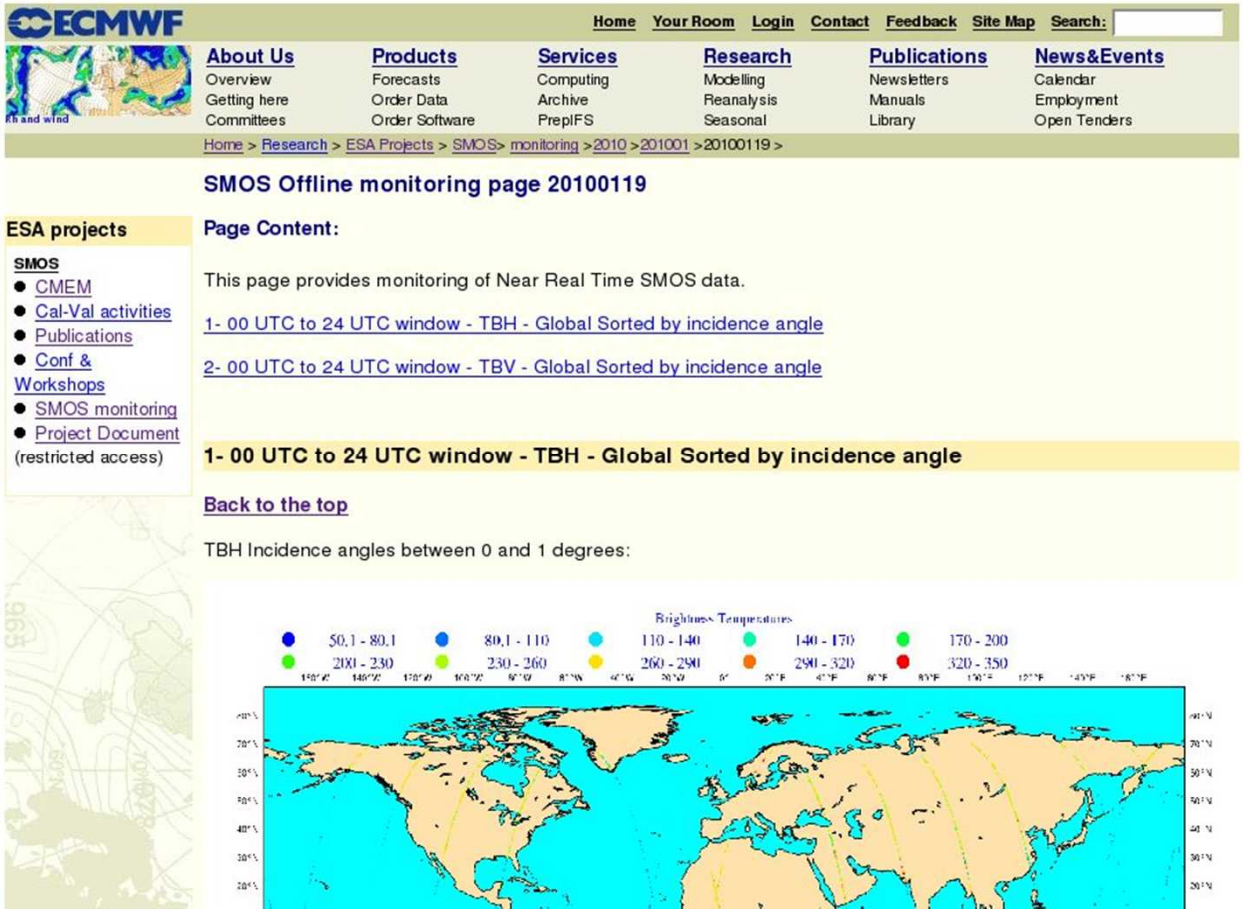
SMOS offline data monitoring webpage

- Available since November-2009,
- Since January-2010 only “NRT” data is monitored and published,
- Global maps of 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



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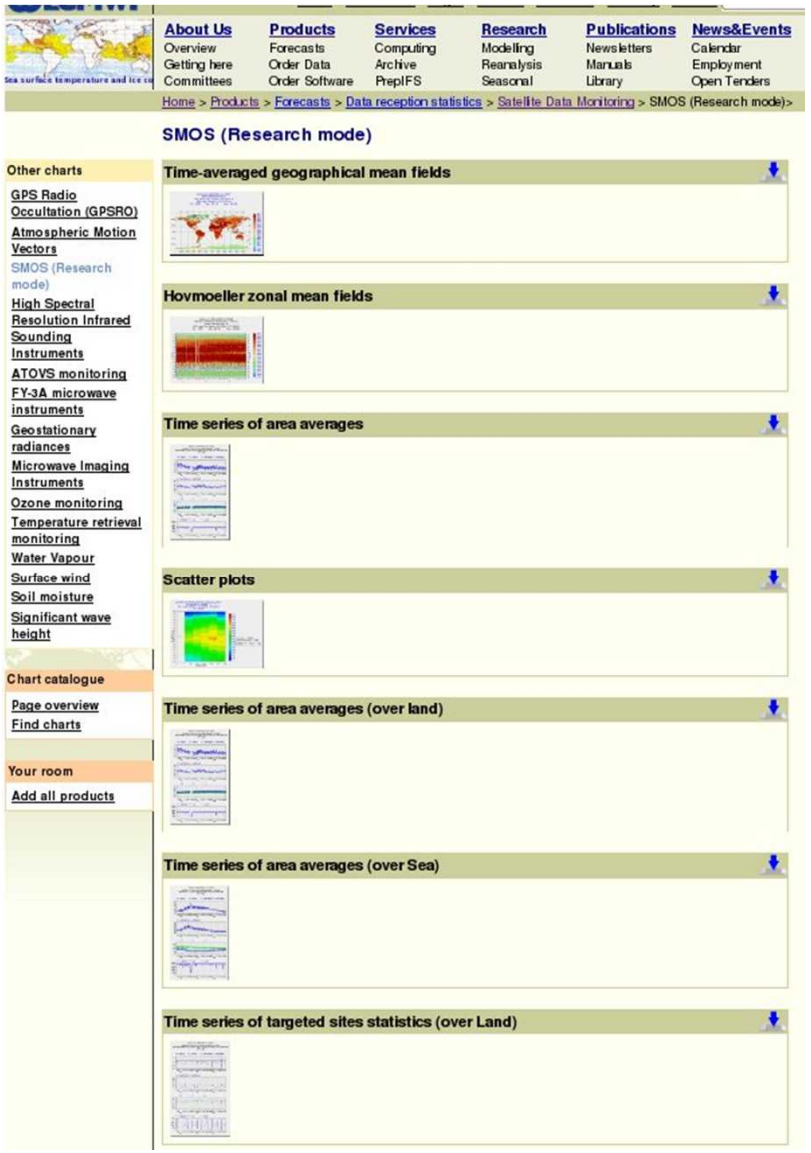
SMOS monitoring suite – current state

- Currently running under an RD expt.
- Since Nov. 2010 statistics available in NRT:
  - Global scale,
  - Land and oceans separately,
  - Several incidence angles,
  - Two polarisations states,
- Statistical products:
  - Time series of area averages,
  - Time-averaged geographical mean fields,
  - Hovmoeller zonal mean fields,
  - FG departures as function of incidence angle.
- Support to CAL/VAL by adding targeted areas.



Summary & further work

- ECMWF main objectives using SMOS data are: monitoring and data assimilation,
- Implementation of SMOS data in the IFS was complex and challenging,
- The 'SMOS chain' depends critically on the NRT product latency,
- An offline data monitoring webpage was available from Dec.09 – Nov.10,
- Since Nov. 2010 statistics using SMOS and CMEM first-guess brightness temperatures are computed and published in NRT: [http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite/smos]

- On going activities:
  - Activities aimed at preparing SMOS data for the analysis: advanced data thinning, noise filtering, bias correction.
  - Implementation of SMOS data in the SEKF.

Thank you for your attention !

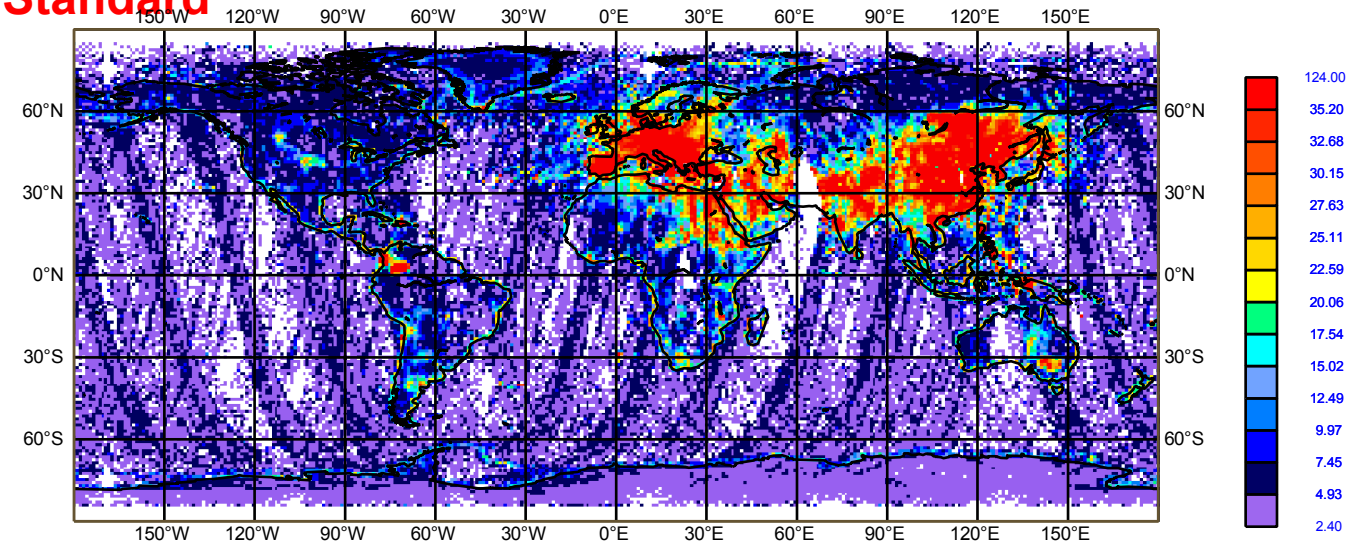
Back up slides

Global statistics: standard monitoring maps

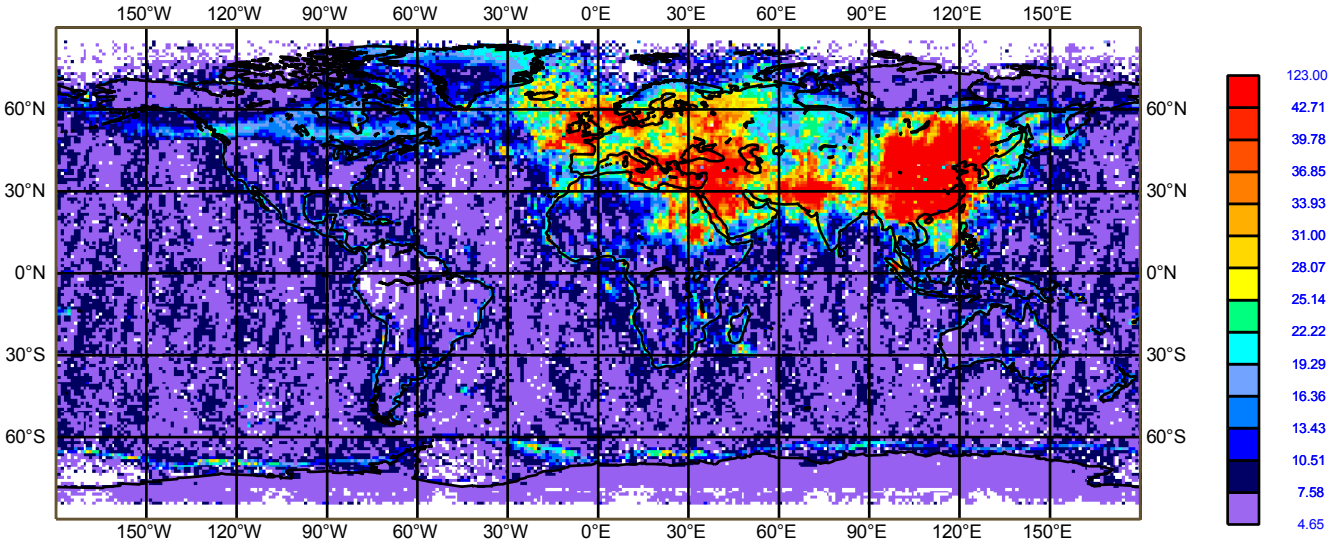
Maps of Observations Standard Deviation (STD)

- TB STD [K]
- H-pol
- 45°-50°

- 01-07 March 2010



- 03-10 May 2010



Areas affected by RFI → large STD of TB

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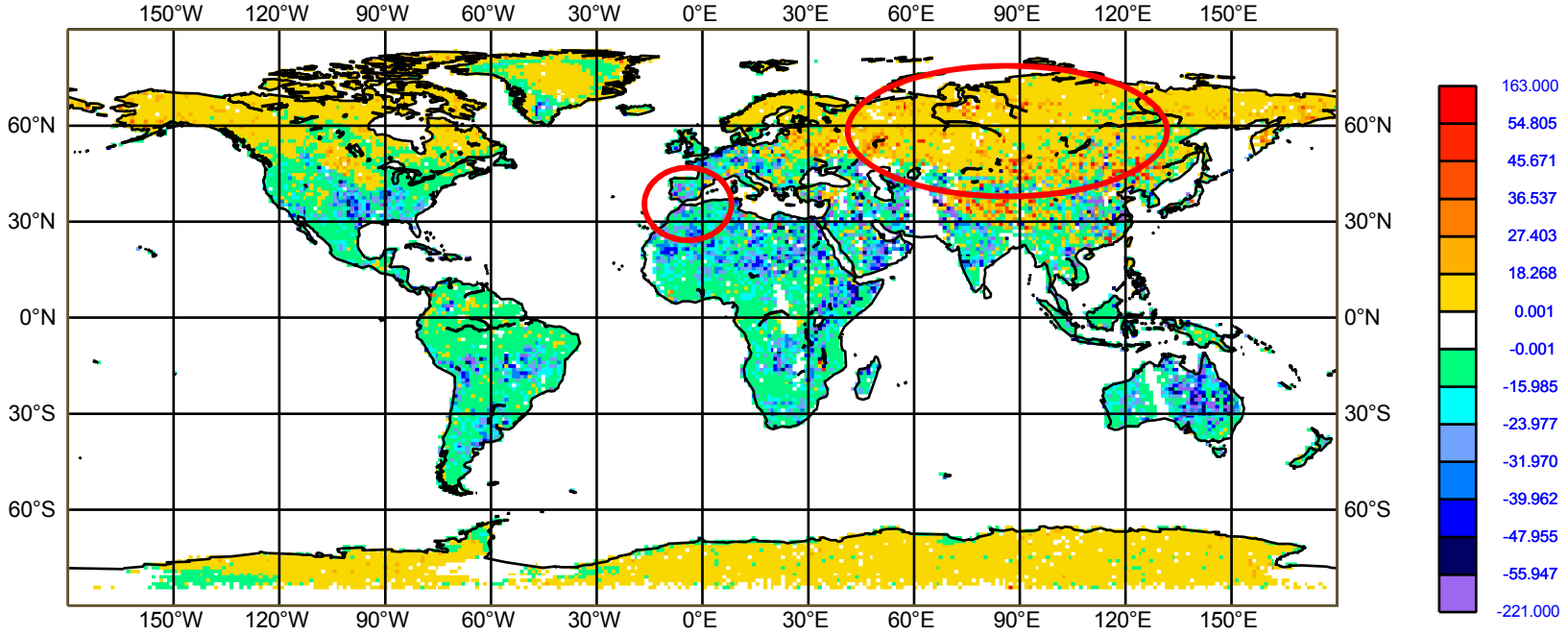
Global statistics: Standard monitoring maps

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

STATISTICS FOR SMOS RADIANCES
MEAN FIRST GUESS DEPARTURE (OBS-FG) [K] (ALL)
DATA PERIOD = 2010-03-01 12 - 2010-03-07 12 , HOUR= ALL
EXP = FC5I, CHANNEL = 1 (FOVS: 45-50)
Min: -220.042 Max: 162.398 Mean: -0.184426



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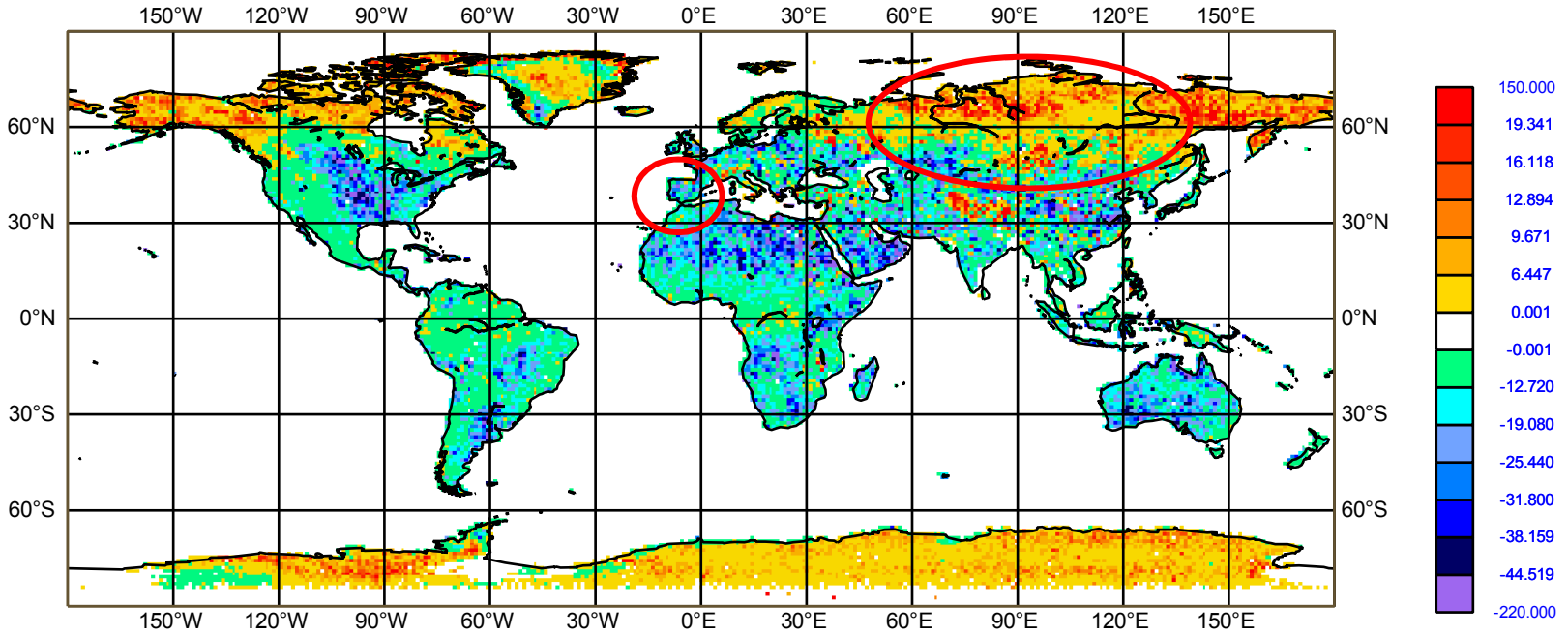
Global statistics: Standard monitoring maps

Map of Mean First Guess Departure over land (Obs – Model)
01-07 April

STATISTICS FOR RADIANCES FROM SMOS
MEAN FIRST GUESS DEPARTURE (OBS-FG) [K] (ALL)
DATA PERIOD = 2010-04-01 00 - 2010-04-07 00 , HOUR= ALL
EXP = FDHK, CHANNEL = 1 (FOVS: 45-50)
Min: -219.294 Max: 149.69 Mean: -0.170418



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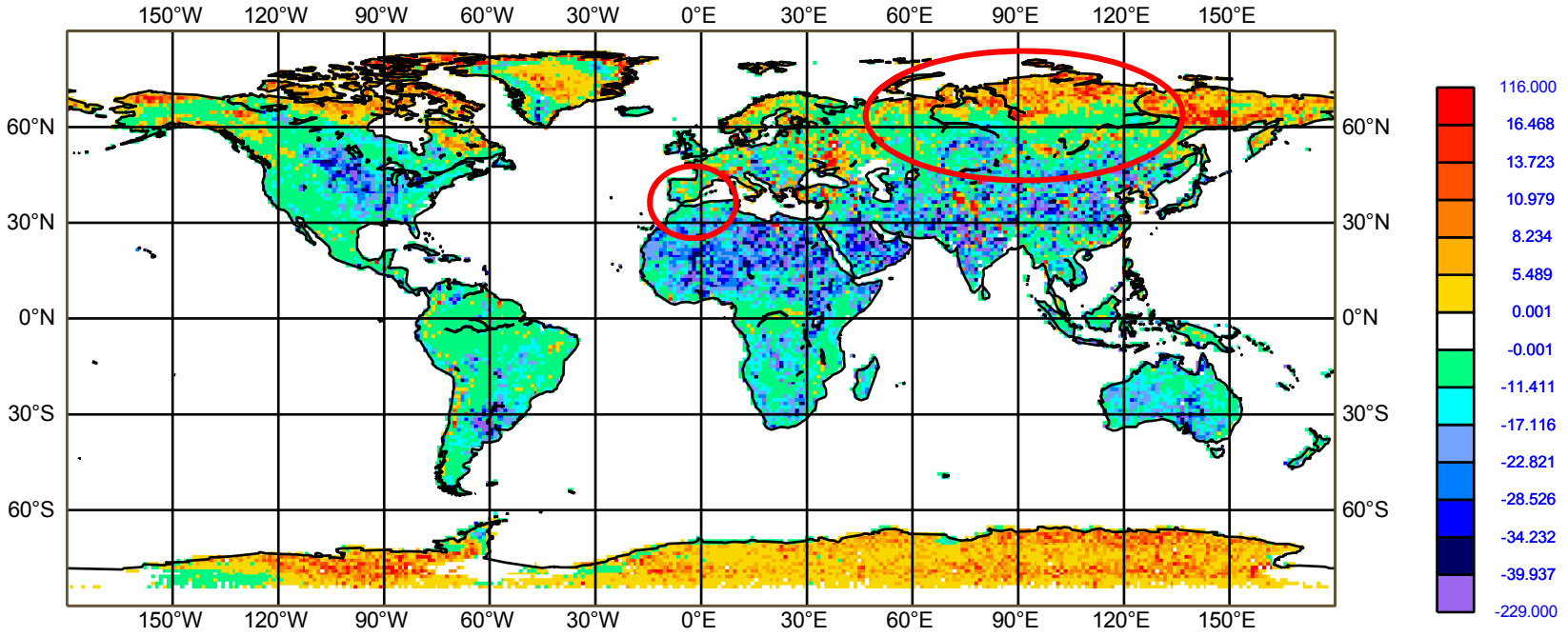
Global statistics: Standard monitoring maps

Map of Mean First Guess Departure over land (Obs – Model)
03-10 May

STATISTICS FOR RADIANCES FROM SMOS/
MEAN FIRST GUESS DEPARTURE (OBS-FG) [K] (ALL)
DATA PERIOD = 2010-05-03 00 - 2010-05-10 00 , HOUR= ALL
EXP = FDJ4, CHANNEL = 1 (FOVS: 45-50)
Min: -228.203 Max: 115.375 Mean: -0.158591



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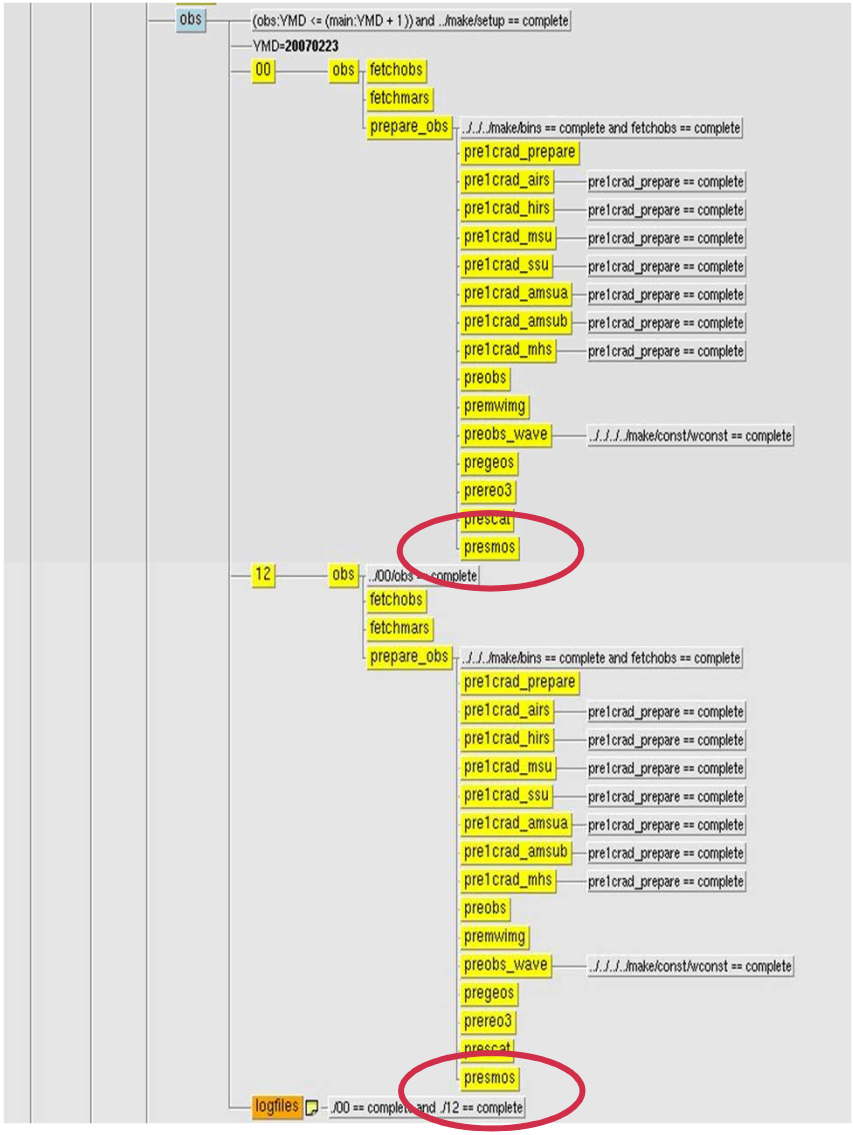
SMOS data pre-processing



SMS Supervisor Monitor Scheduler

- Routinely checks,
- Validity of data,
- Data thinning,
- Others checks can potentially be implemented at this level (noise filtering, RFI mitigation algorithms, etc.)

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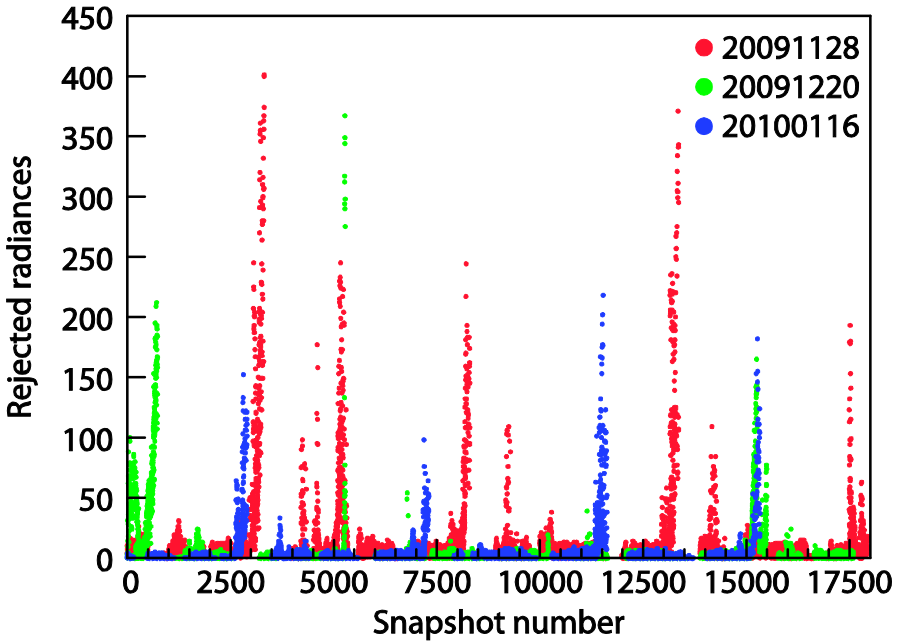
Implementation of SMOS data in the IFS

- routinely checks:
  - header corresponds to SMOS data,
  - geographical coordinates not missing,
  - date and time complete, etc.

- Validity of data checks:
  - data has a correct position,
  - TBs are within physically bounds, etc.



- Data thinning,

Volume of SMOS daily data is very large (~4 Gby for dual-pol, ~8 Gby for full-pol), comparable to IASI data! → thinning is necessary to reduce amount of data and redundancy.

- Others checks, pre-tasks, can potentially be implemented here… (RFI filtering, data thinning based on angular criteria, etc.)

Main tasks in model space

- Collocation of SMOS observations to a ECMWF model grid.

- Observations screening (flags are given for land, ocean, active observations, etc.)

- Forward computation is carried out at model grid-point with the IFS version of the Community Microwave Emission Model (CMEM),

- First-guess departures are computed at model grid-point, by comparing model background and the nearest SMOS observation to the grid-point.

- All the information (flags, forward computation, first-guess, etc.) is stored in an internal database for further use.