ECMWF contribution to the SMOS mission

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→Monitoring
→Assimilation

Outline

- **Global Monitoring**
  - passive microwave forward operator CMEM,
  - choice of surface roughness parameterisation (SMOSREX roughness experiment),
  - SMOS pre-processing data in the Integrated Forecasted System,
  - Implementation of passive monitoring,
- **Data assimilation study**
  - ECMWF surface assimilation scheme (de Rosnay et al. presentation),
  - Development of a bias correction scheme in C-band,
  - Assimilation experiments.

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SMOS data monitoring. Objectives

- Monitoring → core activity at ECMWF for many years.
- For NWP applications, monitoring compares forecast and observed data.
- SMOS: global monitoring of L1c TB at H and V polarization.
  - Passive monitoring: modeled brightness temperatures First Guess (FG) compared to observations (OBS-FG).
  - Active monitoring: when SMOS data will be assimilated, compute analysis departure (OBS-ANA).
  - Land surfaces:
    - Firstly, passive monitoring of L1c TB.
    - Switch to active monitoring when SMOS data used in operation (only in case of positive or neutral impact on the forecasts).
  - Ocean surfaces: passive monitoring of SMOS L1c TB.
  - Results available on the ECMWF products web page
- A key component of the monitoring is the modeled forward operator that transforms model variables into observation space.

The Community Microwave Emission Model (CMEM)

- ECMWF forward model operator (from 1 to 20 GHz).
- Coded in F90, flexible I/O interface: gribex, gribAPI, netcdf, ascii.
- Highly modular, I/O interfaces for the NWP Community.
- Physics is modular, based on the parameterizations of:
  - L-Band Microwave Emission of the Biosphere (Wigneron et al., 2007).
  - Land Surface Microwave Emission Model (Drusch et al., 2007).
- References:
  - Holmes et al., IEEE TGRS, 2008
  - Drusch et al., JHM, 2009
  - de Rosnay et al. JGR, 2009
  - Sabater et al., sub Remote Sensing, 2009
- CMEM website:

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

CMEM physical parameterisation

Modular physics <-> Modular code structure
Allows accounting for different parameterisations for each component

- **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)?
- **Vegetation opacity model**
  (None / Kirdyashev / Wegmuller / Wigneron / Jackson)?
- **Atmospheric radiative transfer model**
  (None / Pellarin / Liebe / Ulaby)?

SOIL

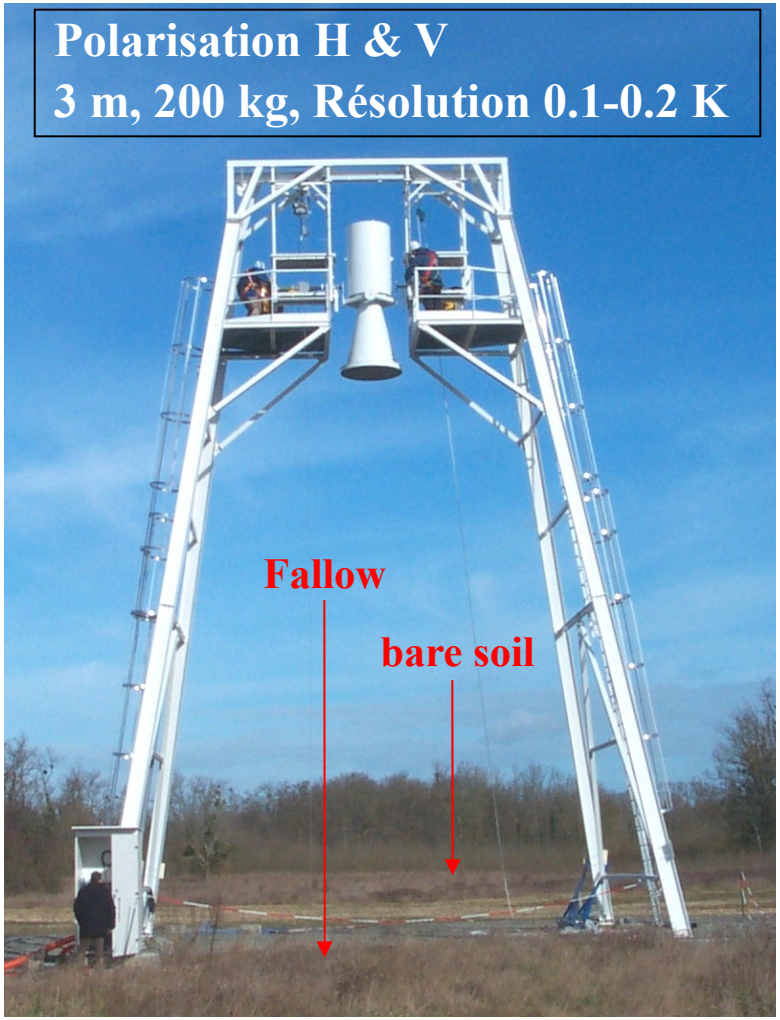
VEGETATION

ATMOSPHERE

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

SMOSREX roughness experiment

- **LEWIS – 1.4GHz (ONERA)**

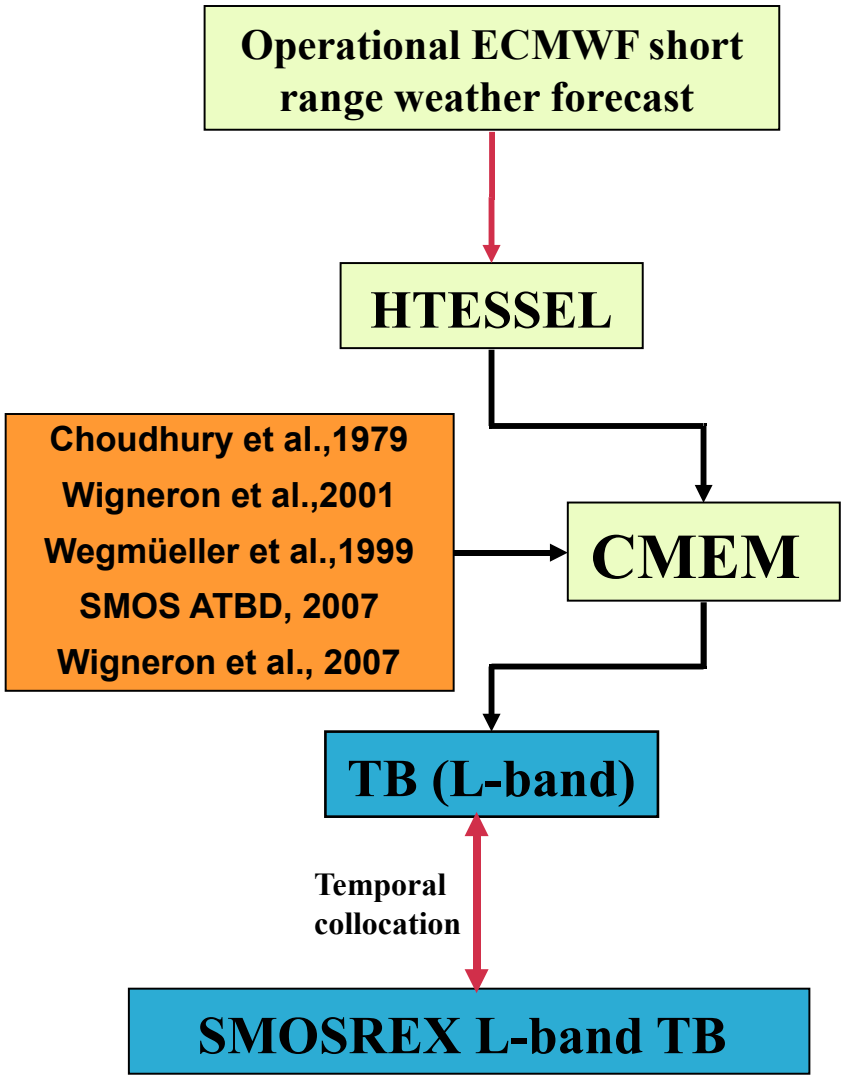


Objective:
Find a suitable soil roughness parameterisation for TB simulation in L-band.
Complement studies of [Drusch et al., 2007] and [de Rosnay et al., 2008].

SMOSREX site:
- Continuous L-band dataset from 2003 in polarization H & V (LEWIS)
- Multi-scanning angular data at 20°, 30°, 40°, 50° and 60° over fallow and bare soil.
- Continuous meteorological data.
- Soil moisture and temperature profile monitoring.

SMOSREX objectives:
- Modeling of microwave emission L-band (P. de Rosnay et al. 2006, M.J. Escorihuela, 2006)
- SMOS retrieval algorithm improvement (K. Saleh et al., 2006).
- Assimilation of multispectral remote sensing data (J.Muñoz Sabater et al., 2007-2008).

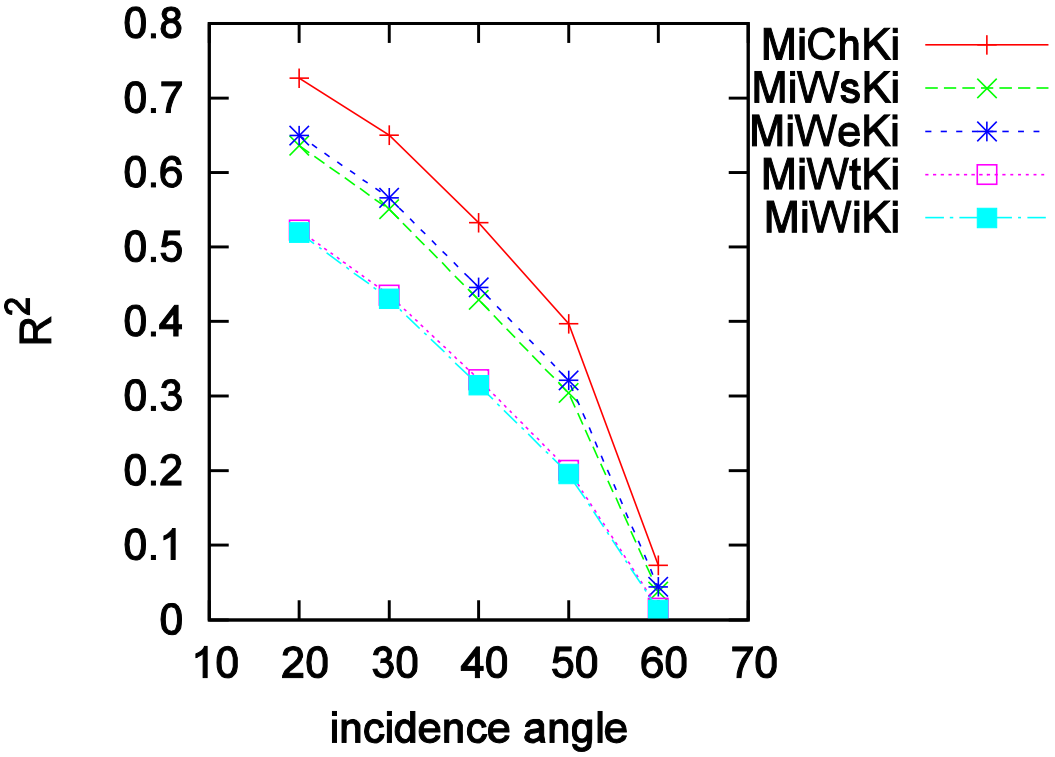
SMOSREX roughness experiment – set up

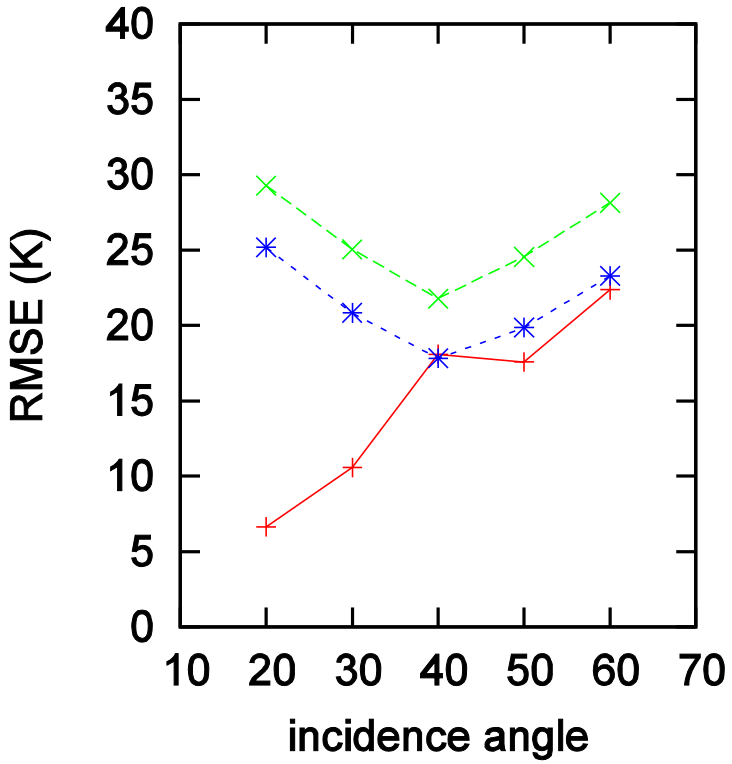


- Setup for the year 2004,
- Spatial resolution T799.
- **Input data:**
  - atmospheric fields from operational short-term ECMWF weather forecast.
  - ECOCLIMAP database for SMOSREX pixel. Vegetation cover : C3-grass (93%) and deciduous forest (4%).
  - medium-fine soil texture.
  - soil surface roughness set-up as at global scale h=2.2 cm (SMOSREX h=0.92 cm).

- **Output:** ECMWF background TB at H and V polarization.

SMOSREX roughness experiment – Results for TBH





Best parameterization : Choudhury

Best incidence angle : 20°

RMSE(K)	R^2(%)	BIAS (K)
6.6	73	-2.56

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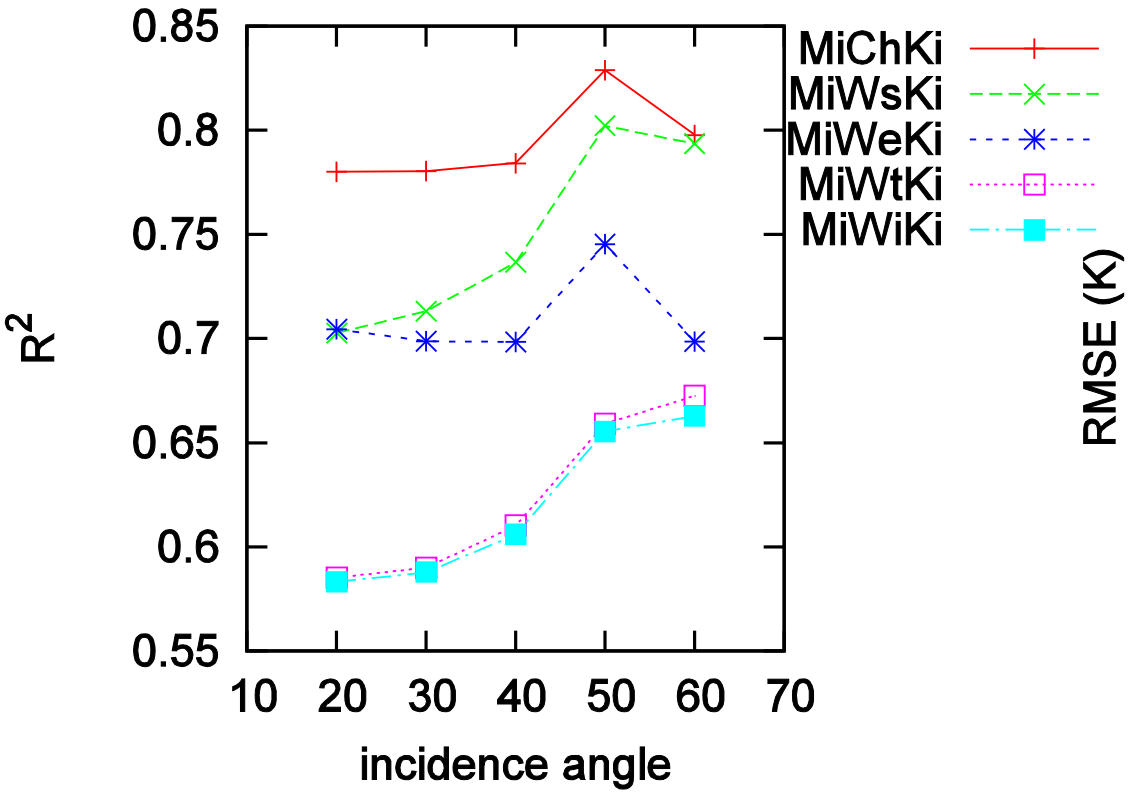
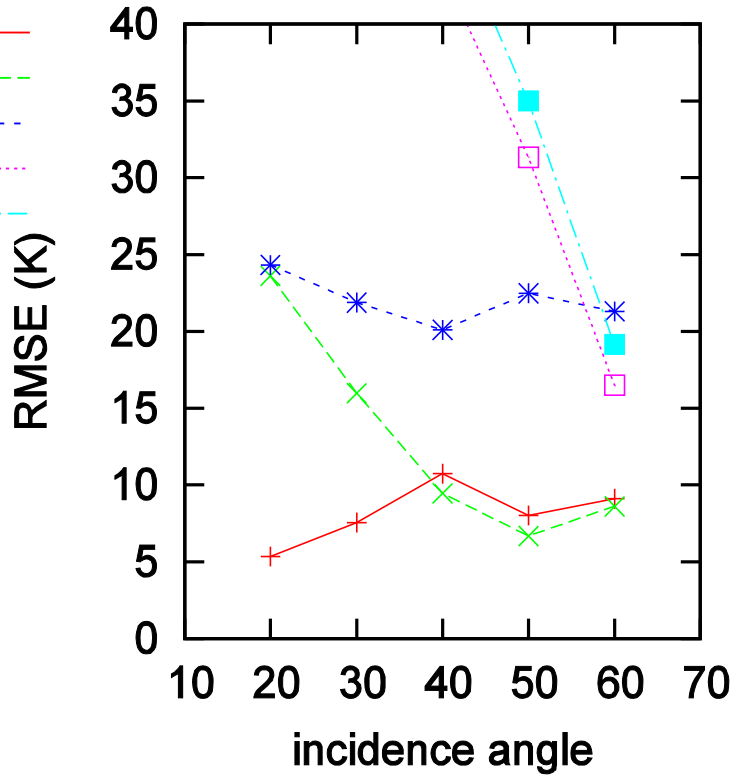
SMOSREX roughness experiment - Results for TBV

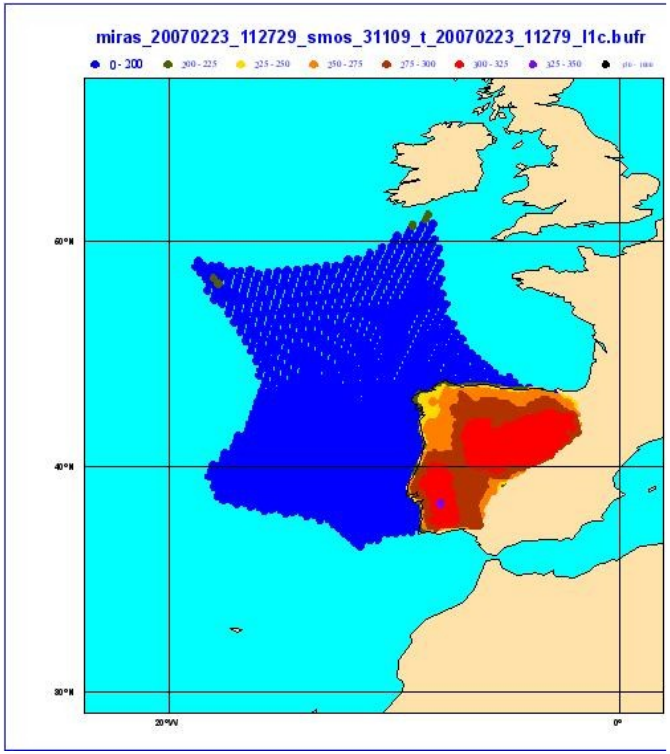




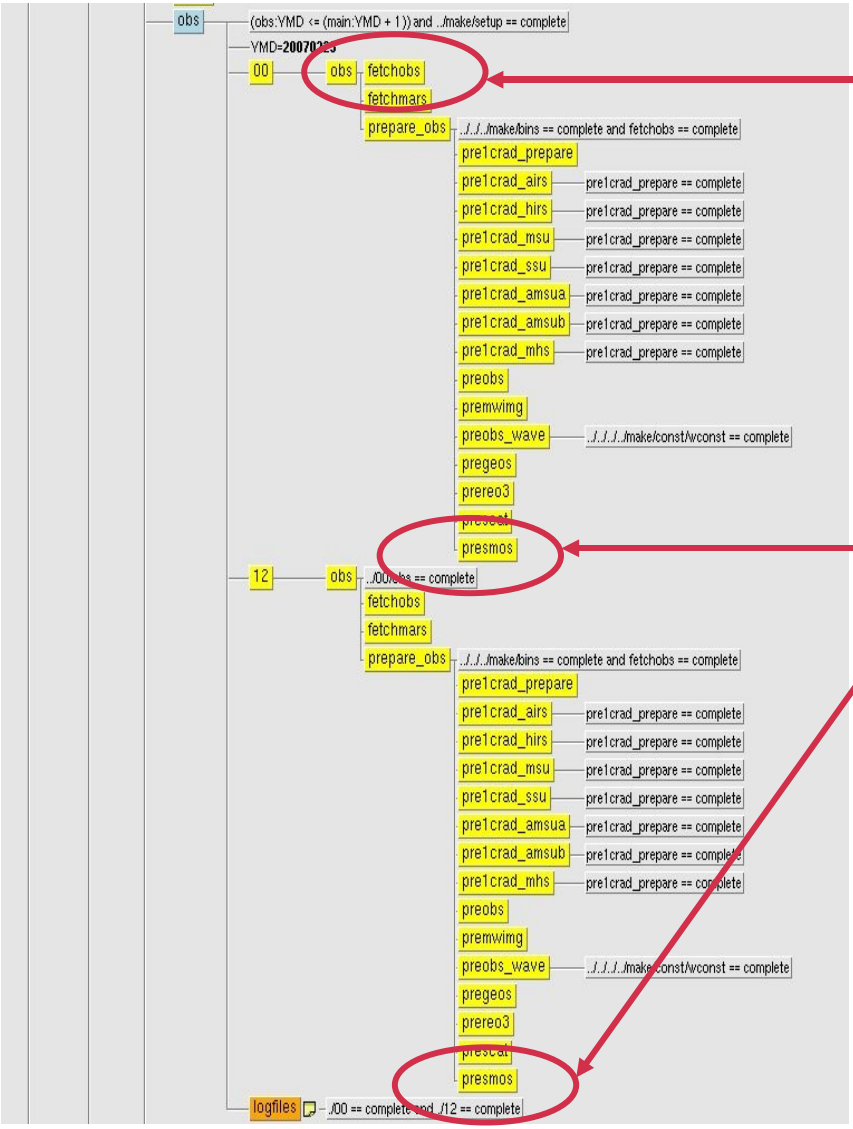
	RMSE(K)	R^2(%)	BIAS (K)
Choudhury 20°	5.34	78	-1.58
Wigneron simple 50 °	6.68	80	-1.05

Implementation of SMOS data in IFS

- Technical implementation to transform raw SMOS bufr data in IFS internal format + filtering jobs,
- Testing data: 2 demonstration files (19 bufr messages, 54 sec.)



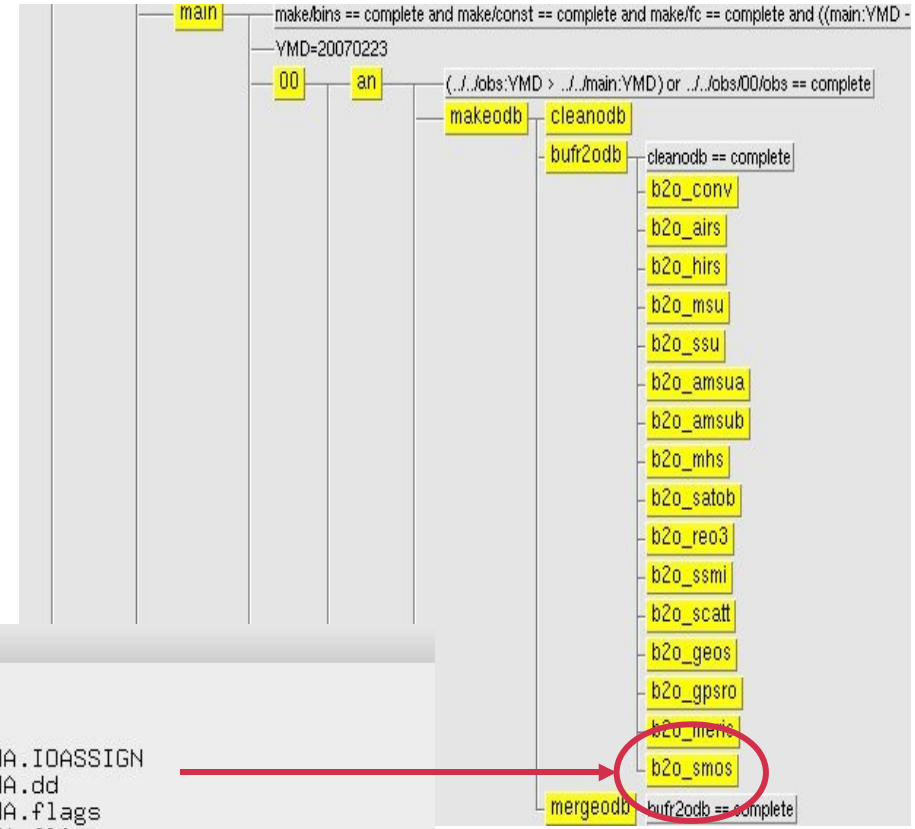
Implementation of SMOS data in IFS – fetchobs/prejobs



- All archived data is stored and retrieved from MARS or ECFS.
- In average data size estimation
  - ~ 3.6 Gby,
    - daily data need to be reduced,
  - prejobs
    - thinning (filtered X out of Y bufr messages),
    - routinely checks

Implementation of SMOS data in IFS – BUFR to ODB

- "Filtered" data is converted to internal ECMWF format
- b2o_smos → ECMA.smos



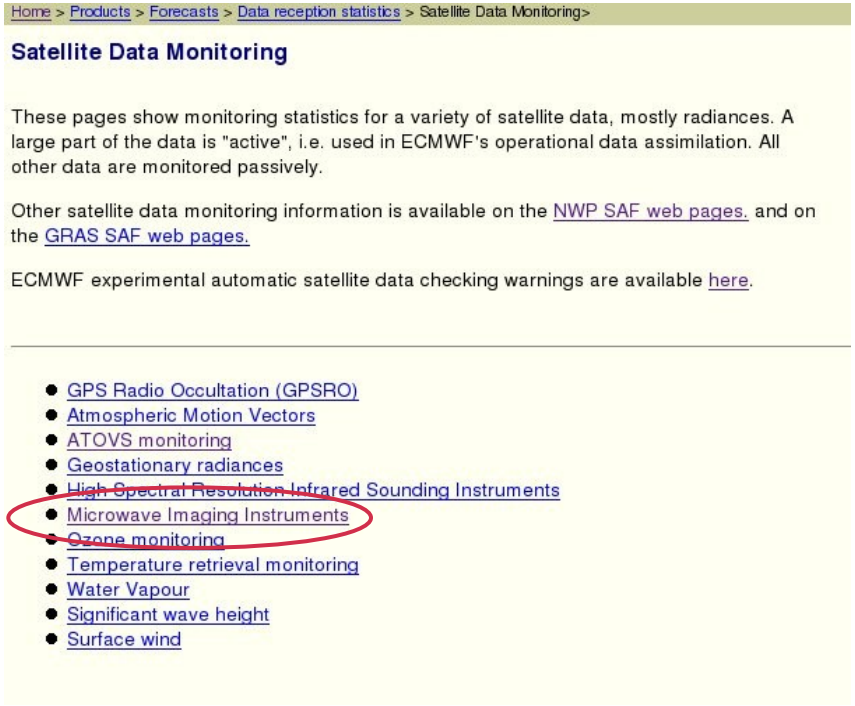
hpcf

```
hpcf0105{/fdb_2/f6pb/2007022300/an/ECMA.smos}:28$ l
total 1024
drwxr-xr-x   2 rdx      rd            32768 May 19 20:15 1/
-rw-r-----   1 rdx      rd             8540 May 19 19:52 ECMA.IOASSIGN
-rw-rw-rw-   1 rdx      rd            34952 May 19 20:58 ECMA.dd
-rw-rw-rw-   1 rdx      rd              204 May 19 19:52 ECMA.flags
-rw-r-----   1 rdx      rd              395 May 19 20:59 ECMA.flist
-rw-rw-rw-   1 rdx      rd            55065 May 19 20:58 ECMA.iomap
-rw-rw-rw-   1 rdx      rd            26878 May 19 19:52 ECMA.sch
lrwxrwxrwx   1 rdx      rd               13 May 19 19:52 IOASSIGN@ -> ECMA.IOASSIGN
lrwxrwxrwx   1 rdx      rd               13 May 19 19:52 IOASSIGN.ECMA@ -> ECMA.IOASSIGN
drwxr-x---   2 rdx      rd            32768 May 19 20:59 dca/
hpcf0105{/fdb_2/f6pb/2007022300/an/ECMA.smos}:29$
```

SMOS online monitoring

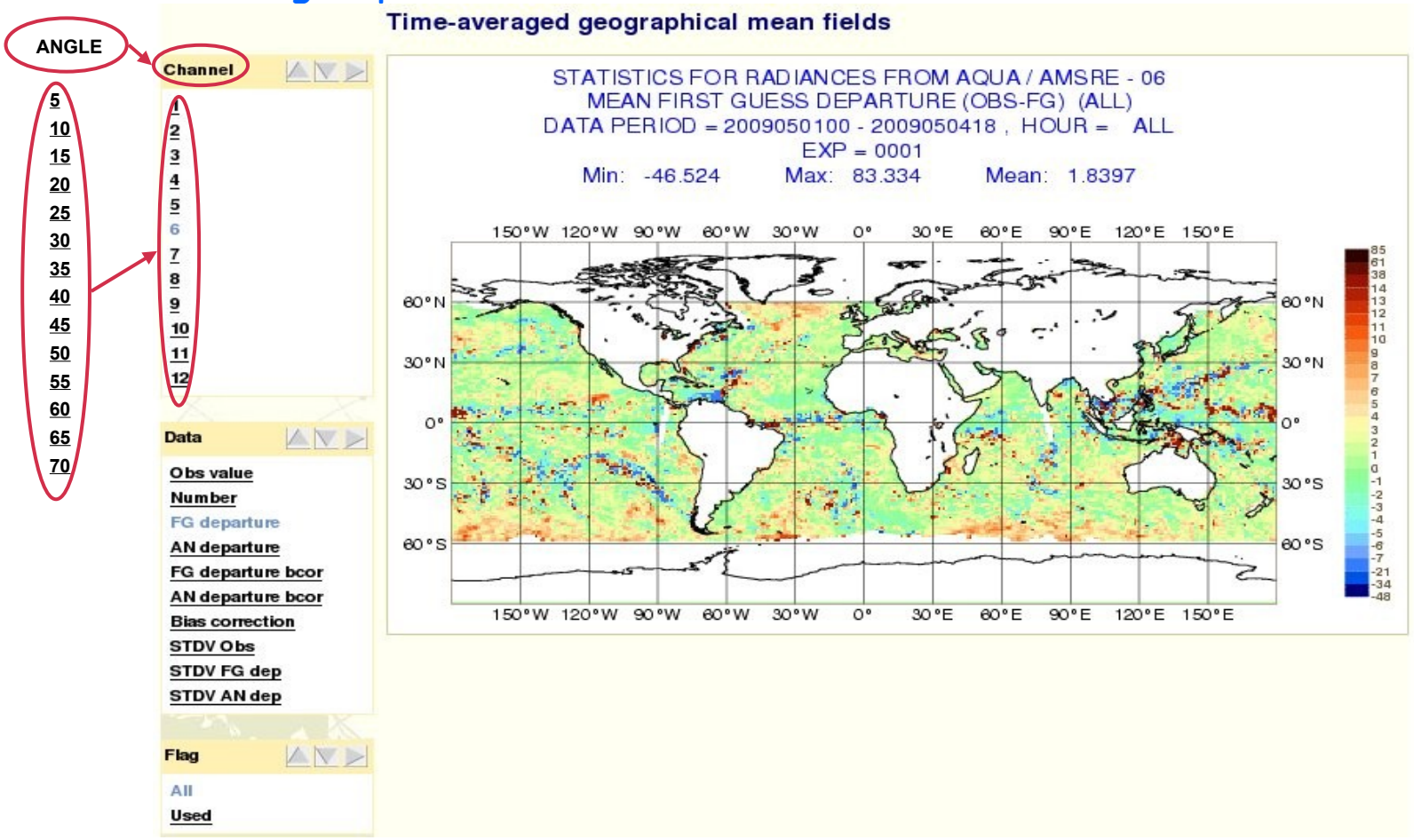
- Passive monitoring: check usefulness of SMOS data.

http://www.ecmwf.int/products/forecasts/d/charts/monitoring/satellite/



Implementation of SMOS data in IFS – Passive monitoring

- Passive monitoring (some results):
  - fg departures



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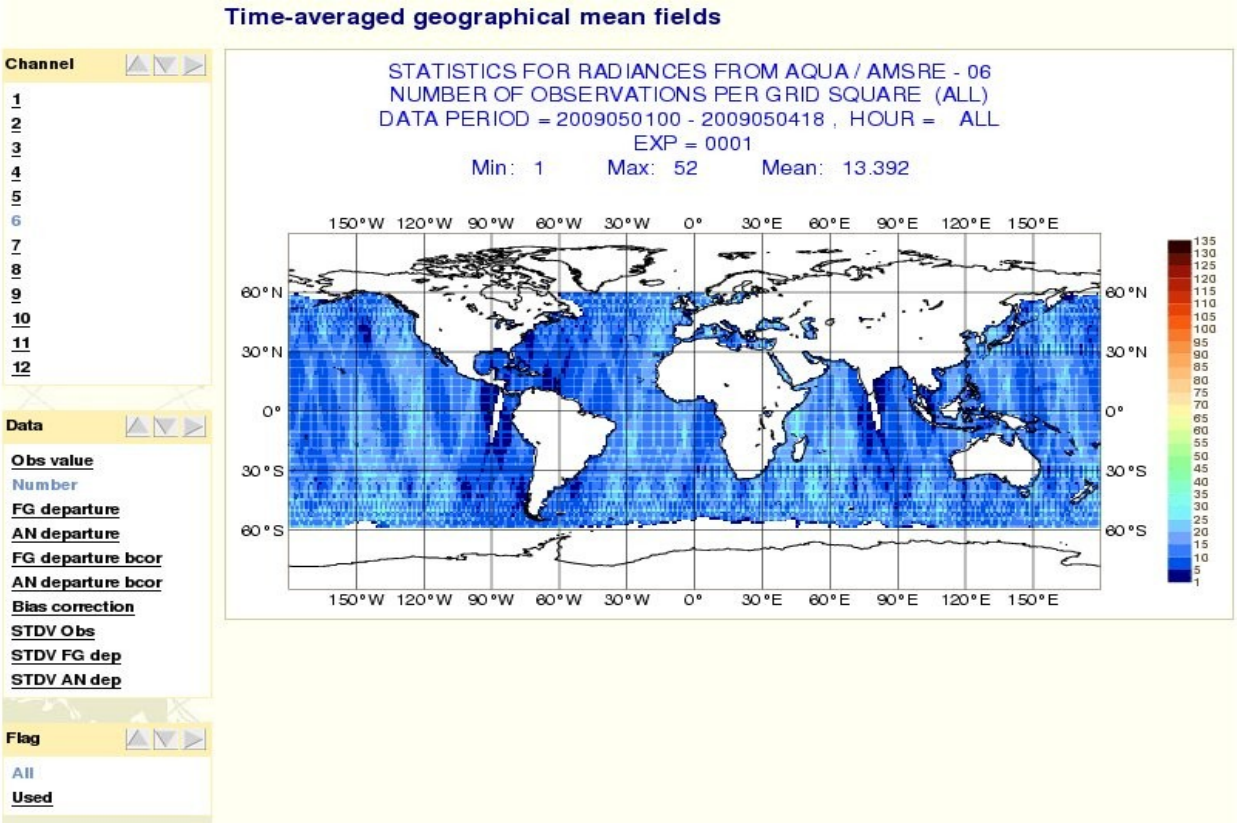
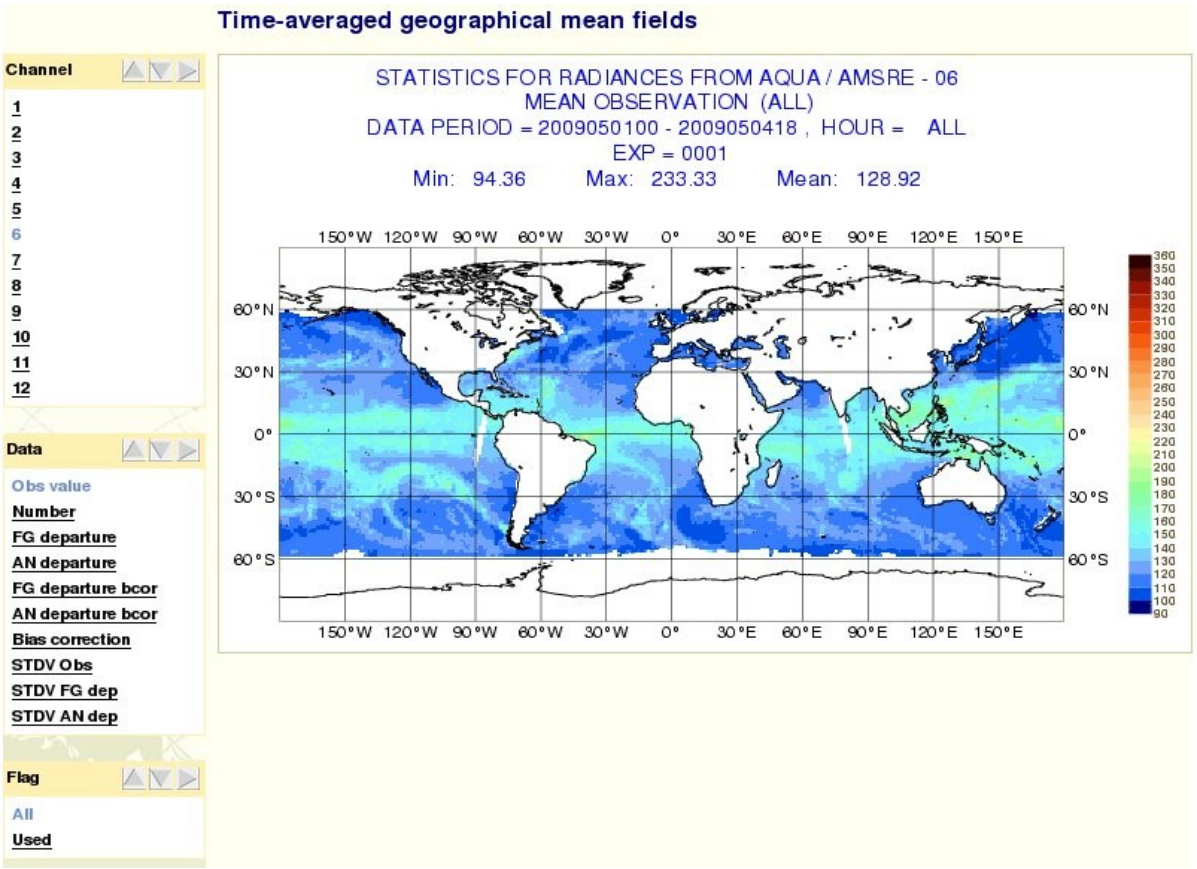
Implementation of SMOS data in IFS – Passive monitoring

- Passive monitoring (some results):
  - number of observations per grid,



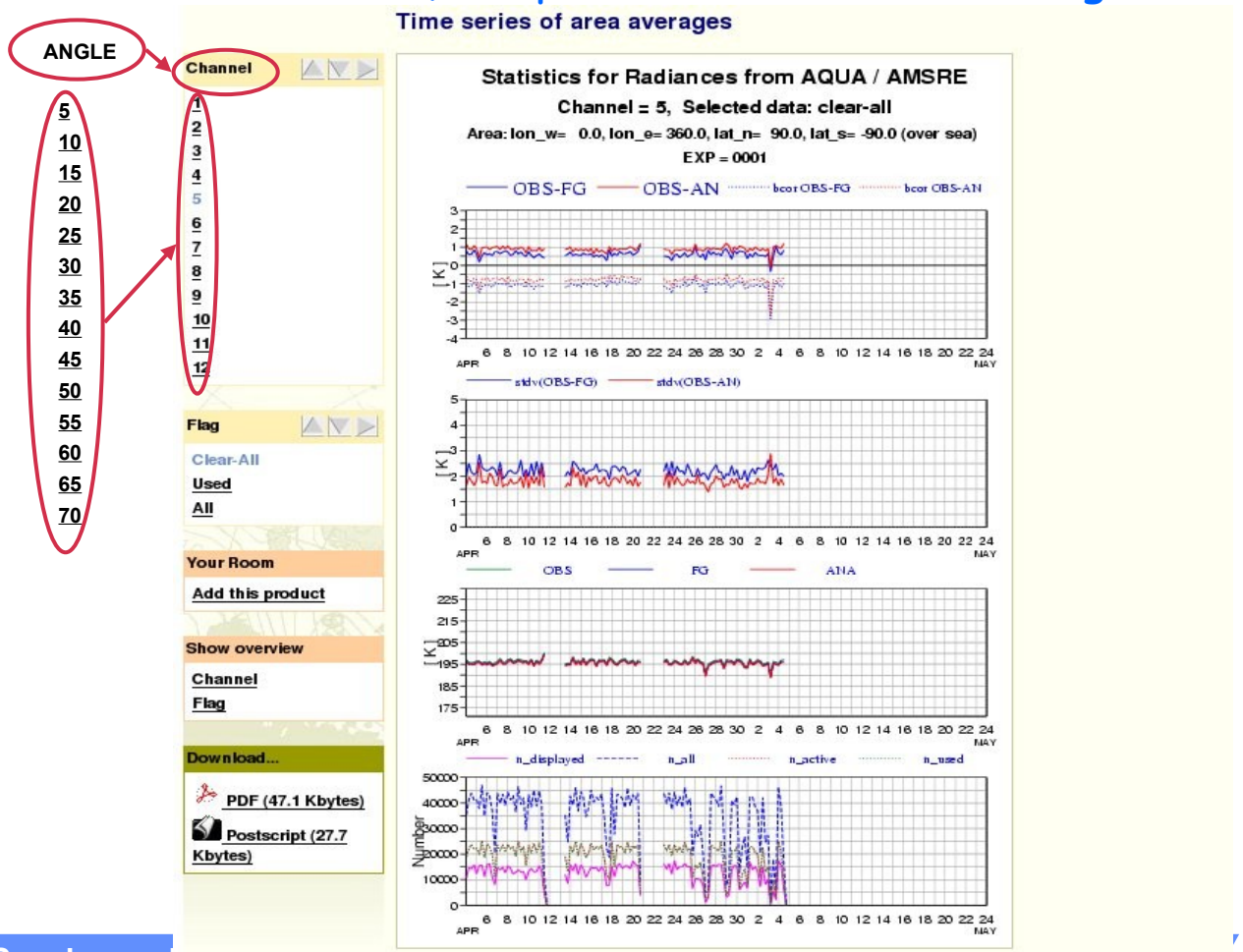
Implementation of SMOS data in IFS – Passive monitoring

- Passive monitoring (some results):
  - time-averaged geographical mean values,



Implementation of SMOS data in IFS – Passive monitoring

- Passive monitoring (some results):
  - time series (also possible for different regions and flags).



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Offline system for AMSRE C-band background departures

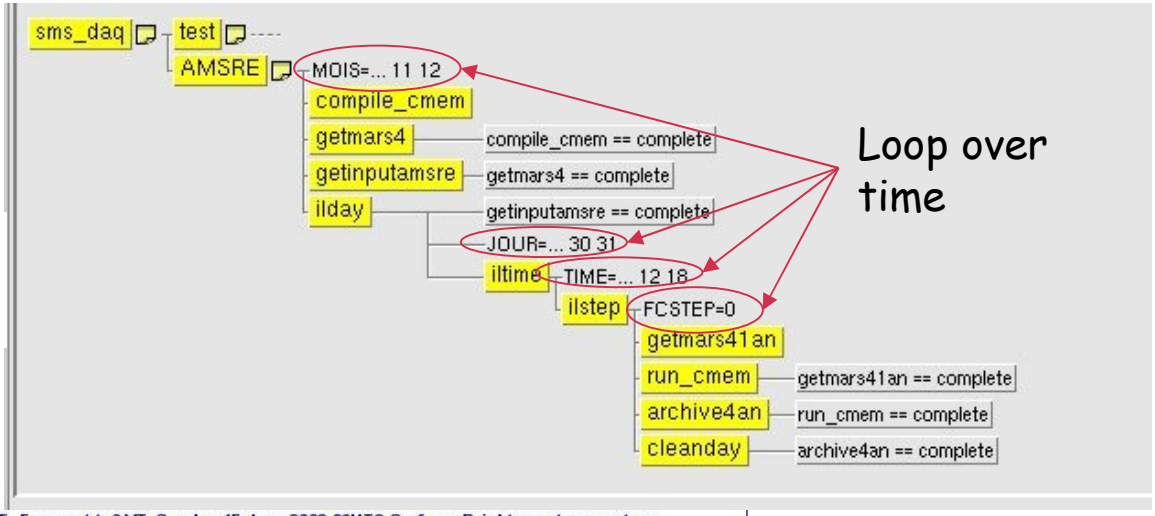
- Development of an offline system to monitor C-band departures for the year 2008,
  - Compute background TB from CMEM,
  - Fetch observations from operational database,
  - Interpol model background to observation location,
  - Compute departures
- TB simulation for 2008,
  - T511 resolution,
  - operational atmos forcing for 2008,
  - dynamic data: soil moisture, soil temperature, snow density and snow water equivalent from operational HTESSEL,
  - Static data: LAI, clay and sand fraction from ECOCLIMAP; vegetation type and cover fraction from HTESSEL

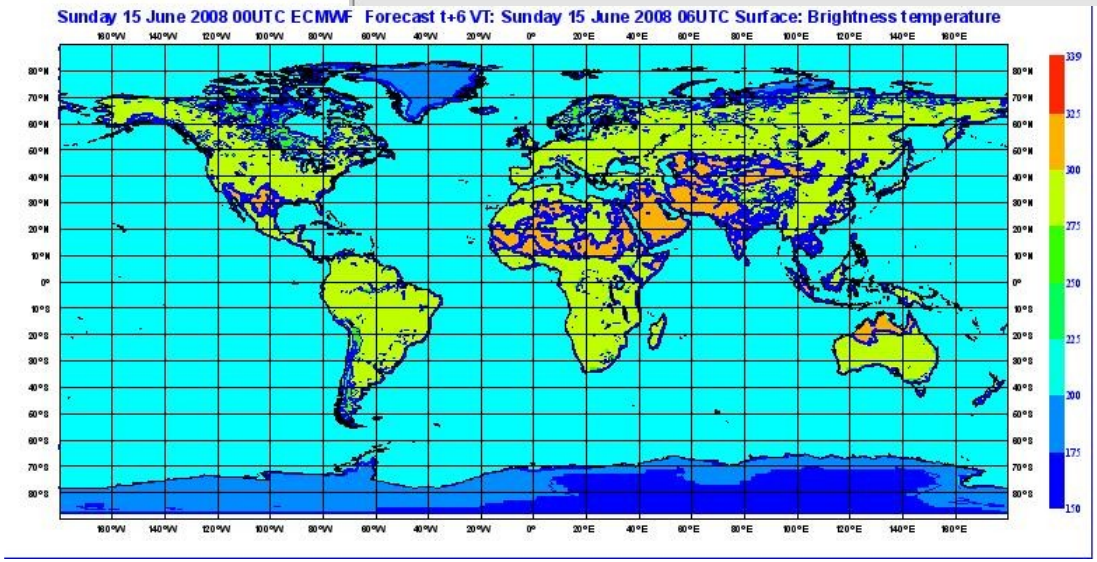
CMEM configuration in C-band	
dielectric	Wang
effect. temp	Choudhury
smooth surface	Fresnel
roughness	Choudhury
vegetation	Kyrdyashev
atmosphere	Pellarin

α = 55° - f=6.9 GHz (C-band)

AMSRE C-band background departures

- Suite AMSRE





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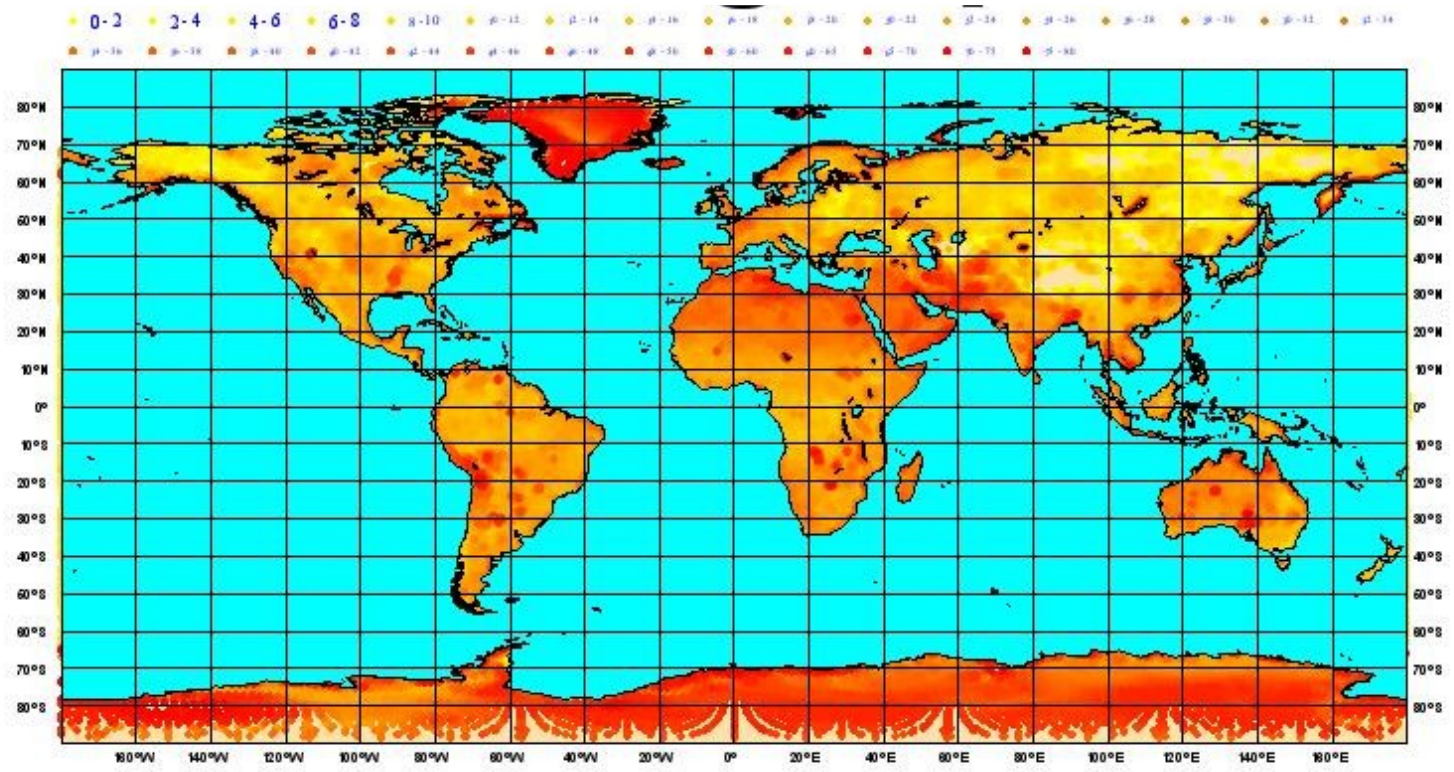
AMSRE C-band background departures

- Very preliminary result

0 K ⟷ 50 K



AMSRE C-band background departures

- Still to do
  - Apply the system to 2008,
  - Apply a bias correction scheme,
    - empirical parameters of vegetation and roughness,
    - CDF,
  - Unbias C-band data prior to assimilation experiments.

assimilation experiments at global scale

- Control experiment:
  - assimilation of screen variables,
- Research experiments :
  - assimilation of unbiased C-band observations,
  - combined assimilation of screen variables and unbiased C-band,
- Repetition of the experiments with SMOS data.

Summary

- ECMWF contribution to SMOS includes two main components:
  - SMOS data monitoring,
  - SMOS data assimilation,

- For both of them the CMEM forward model has been developed, validated, and it is being implemented in the IFS.

- For the data monitoring study,
  - on-going implementation and processing of SMOS incoming observations in the operational Integrated Forecasts System.
  - online implementation of passive monitoring.

- For the data assimilation study,
  - implementation of a new assimilation scheme,
  - bias correction study with AMSR-E C-band data.

- More information on the ECMWF contribution to the SMOS project on: http://www.ecmwf.int/research/ESA_projects/SMOS/