# ECMWF contribution to the SMOS mission


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## ECMWF main contributions to the SMOS mission

### Operational global monitoring of level-1C TB over land and sea

- Development of the passive microwave forward operator CMEM,
- Sensitivity of background TB to the CMEM soil roughness parametrization,
- Pre-processing of SMOS Level-1C BUFR messages,
- Implementation of passive monitoring in the IFS.

### Assimilation of SMOS TB with an EKF

- New surface EKF assimilation scheme [1],
- Development of a bias correction scheme in C-band with AMSR-E data,
- Research assimilation experiments using SYNOP, AMSR-E and SMOS data.

## The Community Microwave Emission Model (CMEM)

Modular physics ↔ Modular code structure
Allows accounting for different parametrizations 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)?
- Equivalent to L-MEB when options in red are chosen
- Website: http://www.ecmwf.int/research/ESA_projects/SMOS/cmem/cmem_index.html

Soil | Vegetation | Atmosphere

## Sensitivity of background TB to soil roughness parametrization

### Objective

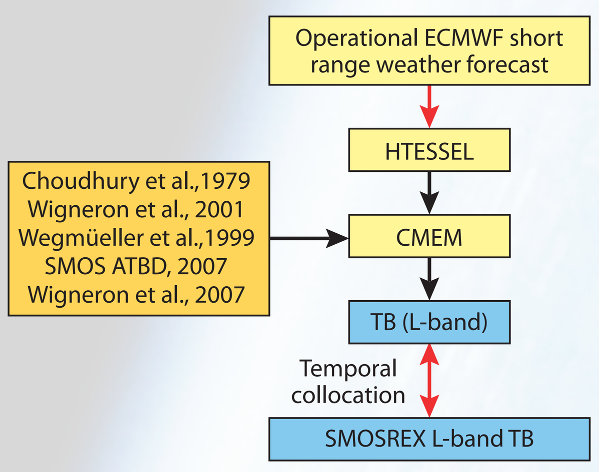
Study ECMWF TB background error sensitivity to different soil roughness parametrizations in L-band at T799 [2]. Complement studies of [3] and [4].

### Input data

- Atmospheric fields from operational short-term ECMWF weather forecast
- Vegetation cover and type from ECOCLIMAP database
- Soil texture set to medium-fine
- Soil roughness parameter set to global scale: h = 2.2 cm

### Output data

Multi-angular ECWMF background TB at H & V polarisation in L-band.




*Schema to compute background TB from CMEM and comparison with field observations.*

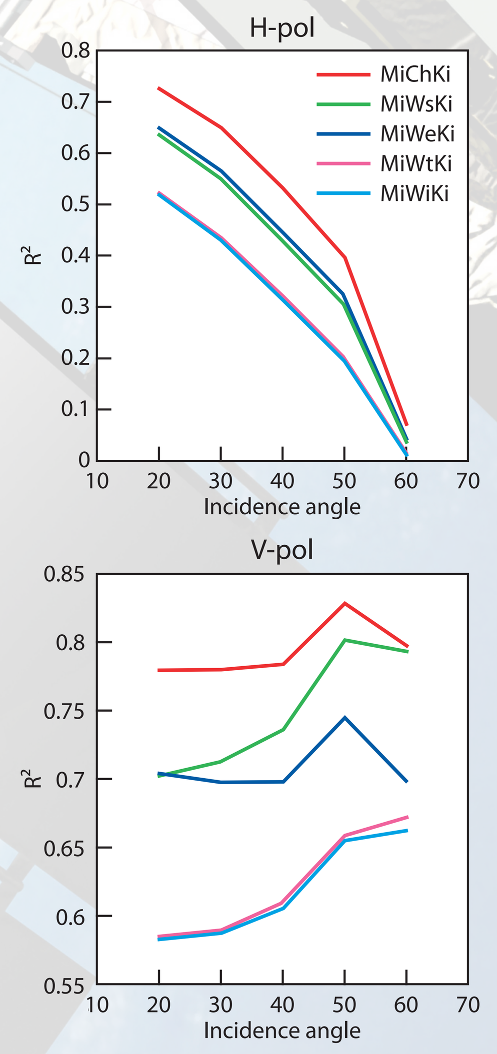



***Figure 1*** *Coefficient of determination ($R^2$) of TB background error as a function of the incident angle with different parametrizations of soil roughness.*

## Pre-processing of SMOS BUFR files

- Check crucial header information of BUFR files
- Check geographical position of observations
- Check TB have physical values (50 K < TB value < 350 K)
- Data is thinned to reduce data volume

Ex: simulated SMOS pre-processed BUFR file 17 December 2010 from 00–06 UTC. → adapted for an experiment in 2008.

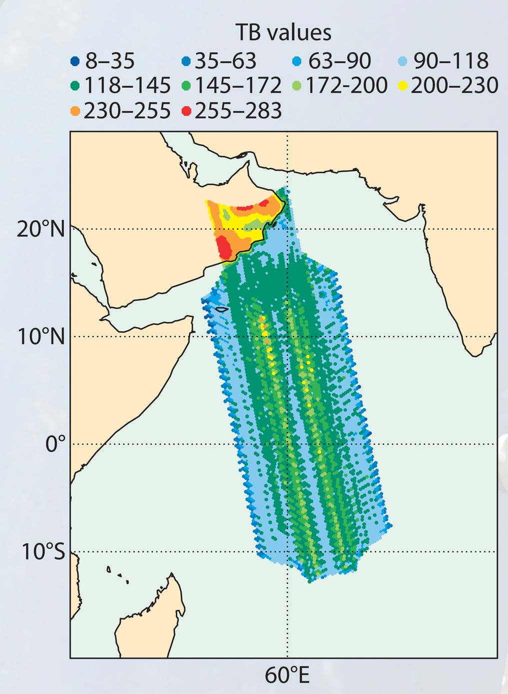



***Figure 2*** *Simulated SMOS file to test data thinning for 17 December 2010.*

### Thinning

- Keep 1 out of 10 bufr messages →~ 90% of data eliminated: from 49,893 to 4945 observations.
- Mean and STD are the same as in Figure 3, and a large number of observations will still be monitored.

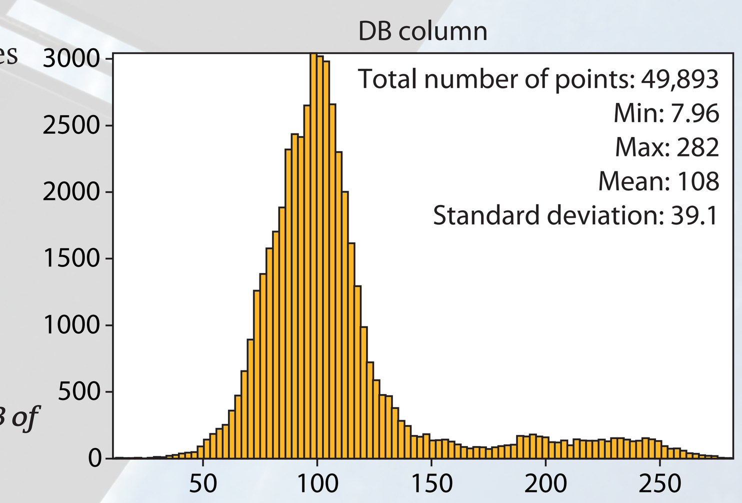
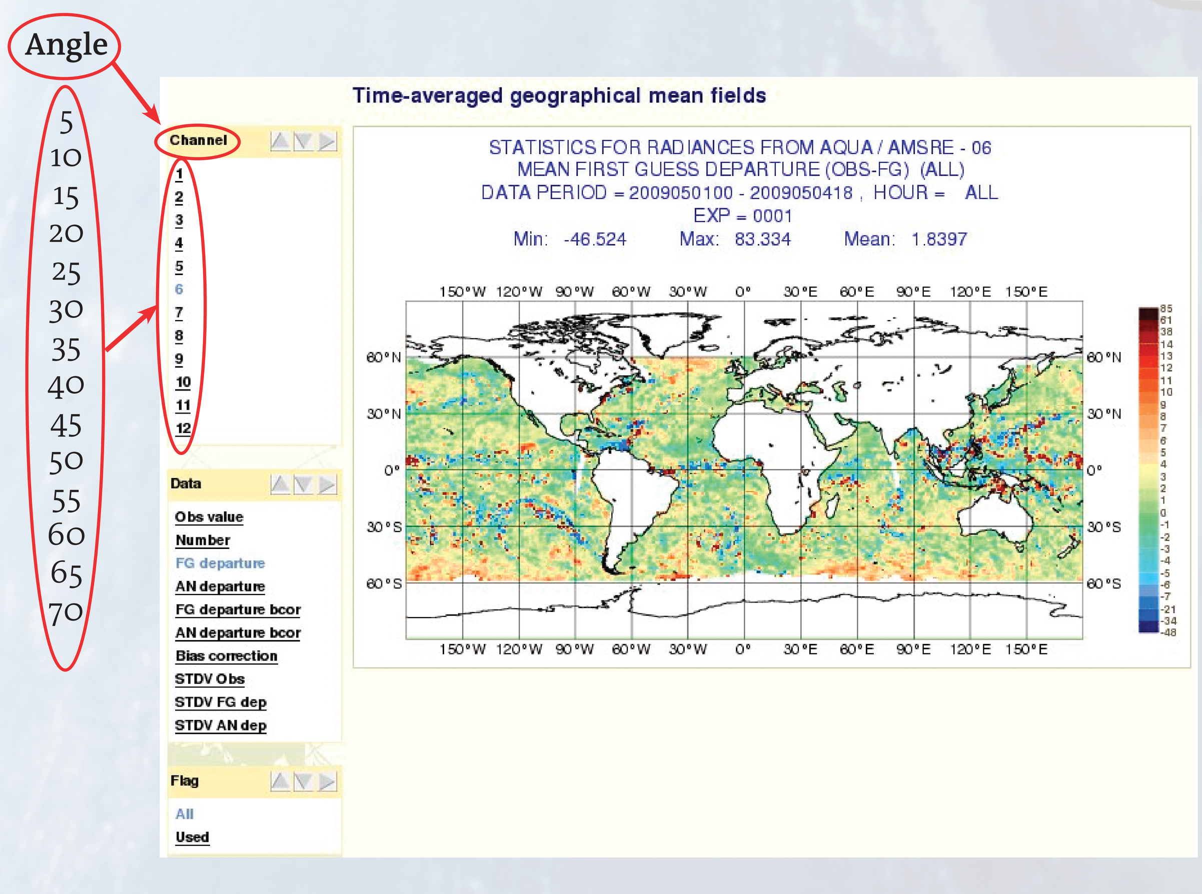



***Figure 3*** *Histogram of TB of simulated SMOS data.*

## Implementation of SMOS TB passive monitoring

- Diagnostic tool to evaluate the quality of Level-1C SMOS TB by computing first-guess departures. Monitoring products are: time-averaged geographical mean fields, Hovmoeller zonal mean fields, time series of area averages, etc.
- Example from AMSR-E data (but applicable to SMOS future data) except that instead of monitoring by channel, monitoring will be done by incident angle.




## C-band AMSR-E background departures study

- Offline system to compute TB background departures in 2008,
- Observations come from AMSR-E channels 1–2 (6.9 GHz),
- Forward model operator CMEM and analysed atmospheric fields to compute C-band background TB

### Calibration of CMEM in C-band

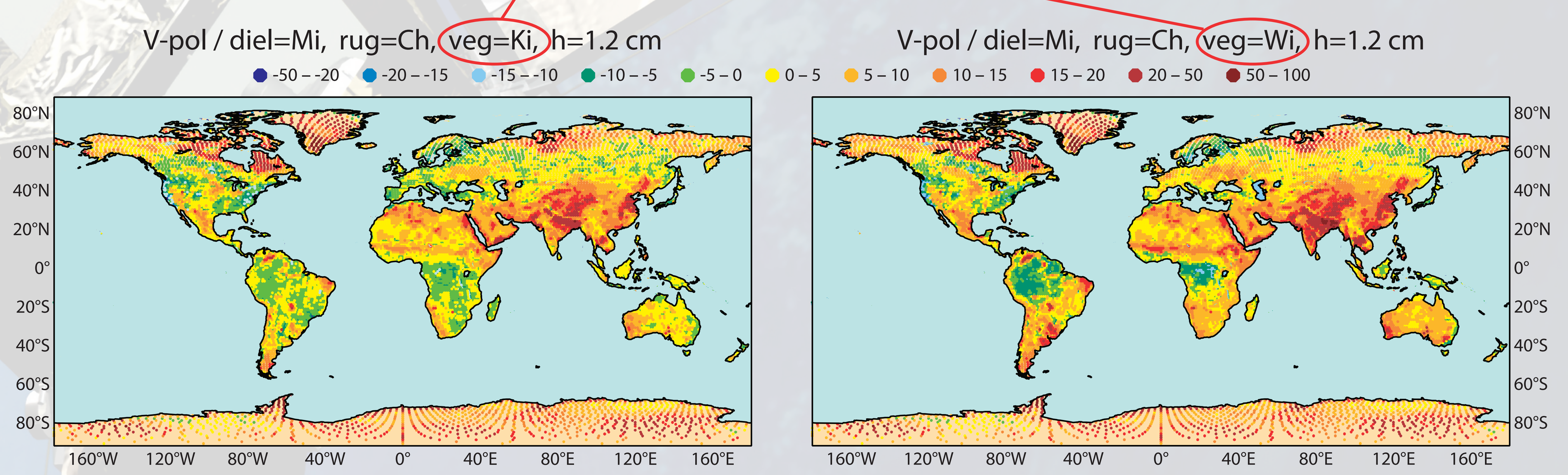
- TB sensitivity study to the main contributions (and parameterisations) of the soil emission,
- Fine tuning of vegetation and soil roughness main driving parameters.

| | | |
|---|---|---|
| Dielectric mixing model | a) Wang and Schmugge, 1980<br>b) **Mironov et al., 2004** | Very low sensitivity. |
| Effective temperature | Choudhury et al., 1982 | |
| Smooth surface | Fresnel et al., 1977 | |
| Vegetation opacity model | a) **Kirdyashev et al., 1979**<br>b) Wigneron et al., 2007 | |
| Vegetation structure parameter [a_geo] | a) **$a_{geo}$ (low/high) = [0.33,0.66]**<br>b) $a_{geo}$ (low/high) = [0.33,0.33] | $\tau_{veg}$ in C-band is large and no sensitivity to $a_{geo}$ is shown. |
| Surface roughness | Choudhury et al., 1979 | |
| Soil roughness STD of height | a) h = 0.2 cm<br>b) **h = 0.4 cm**<br>c) h = 0.8 cm<br>d) h = 1.2 cm | h > 0.8 cm shows no sensitivity. |
| Atmosphere | Pellarin and Calvet, Tech. note | |

*CMEM runs in February and July 2008, H & V pol, to study the sensitivity of the TOA TB to different parametrizations of the soil emission components in CMEM .*

| BIAS (K) | RMSE (K) |
|---|---|
| 4.4 | 11.5 |

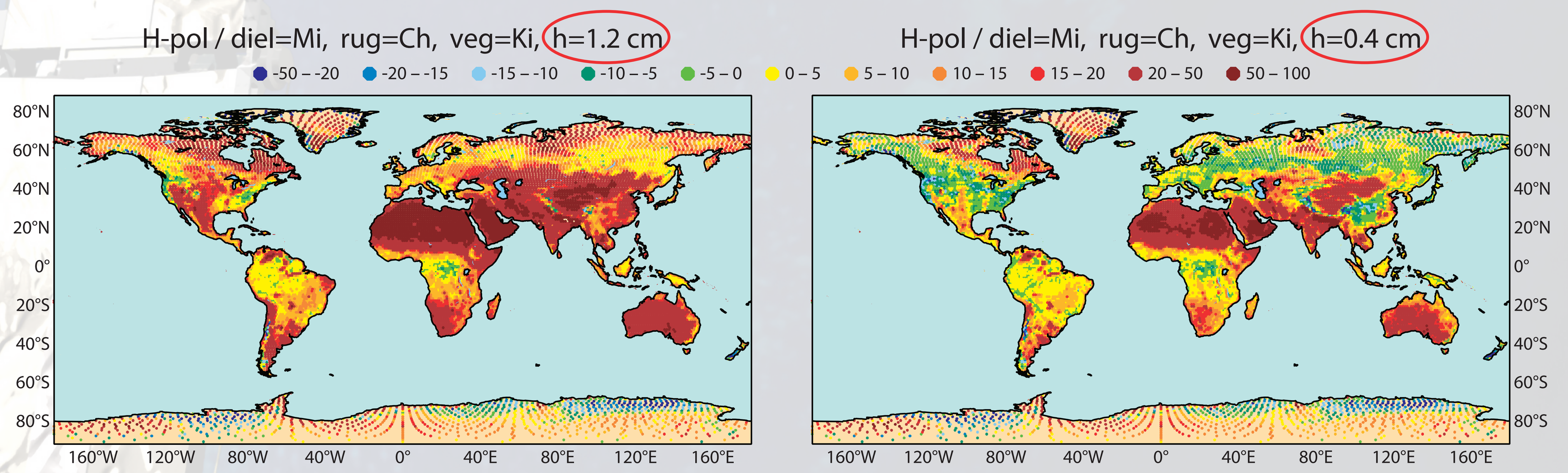
| BIAS (K) | RMSE (K) |
|---|---|
| 6.0 | 13.3 |




*C-band background departures sensitivity to the vegetation parametrization for July 2008 (V-pol).*

| BIAS (K) | RMSE (K) |
|---|---|
| 21.4 | 30.0 |

| BIAS (K) | RMSE (K) |
|---|---|
| 10.3 | 19.5 |




*C-band background departures sensitivity to the soil roughness parameter for July 2008 (H-pol).*

## Future plans

- Operational implementation of SMOS Level-1C passive monitoring
- Contribution to key decision points during SMOS commissioning phase
- Apply bias correction scheme to AMSR-E C-band data
- Research assimilation experiments of SYNOP, AMSR-E C-band and SMOS data to improve soil moisture estimation

## Bibliography


1 **Drusch M., K. Scipal, P. de Rosnay, G. Balsamo, E. Andersson, P. Bougeault, P. Viterbo** (2009): "Towards a Kalman filter based soil moisture analysis system for the operational ECMWF Integrated Forecast System", *Geophys. Res. Let.* doi: 10.1029/2009GL037716.

2 **J. Muñoz Sabater, P. de Rosnay** and **G. Balsamo** (2009): "Sensitivity of L-band NWP forward modelling to soil roughness", Submitted to *Int. Journal of Remote Sensing*.

3 **Drusch M., T. Holmes** and **P. de Rosnay** and **G. Balsamo** (2009): "Comparing ERA-40 based L-band brightness temperatures with Skylab observations: A calibration / validation study using the Community Microwave Emission Model", *Journal of Hydromet.* doi: 10.1175/2008JHM964.1.

4 **de Rosnay, P., M. Drusch, A. Boone, G. Balsamo, B. Decharme, P. Harris, Y. Kerr, T. Pellarin, J. Polcher** and **J.-P. Wigneron** (2009): "AMMA Land Surface Model Intercomparison Experiment coupled to the Community Microwave emission Model: ALMIP-MEM", *Journal of Geophysical Research,* doi: 10.1029/2008JD010724.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