Use of SMAP for Numerical Weather Prediction: monitoring of SMAP brightness temperatures at ECMWF

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Introduction

This poster presents the European Centre for Medium-Range Weather Forecasts (ECMWF) SMAP Early Adopter activities. The objective of ECMWF is to implement the SMAP data into the ECMWF Integrated Forecasting System and to monitor SMAP brightness temperature (TB) data. Before launch, the developments focus on:

- Implement the SMAP L1C TB data (based on SMAP test data sets) into the ECMWF Integrated Forecasting System, define a new BUFR template for SMAP and define a new Observation Data Base (ODB) data structure in the ECMWF system.
- Using the SMOS L1 brightness temperature observations at 40 degrees incidence angle to assess the SMAP monitoring statistics.

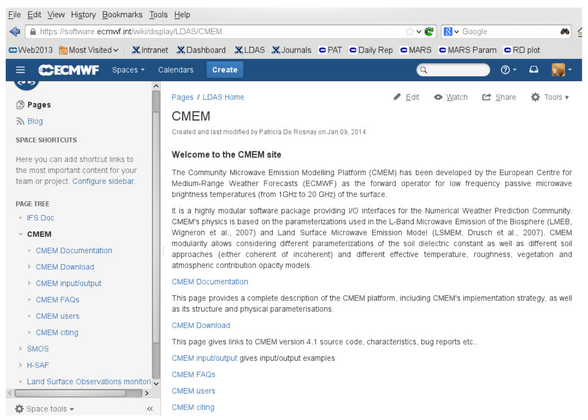
After launch, the SMAP L1C TB will be used for near real time monitoring of the observations and first guess departure, both at global scale and at regional scale.

The Community Microwave Emission Modelling Platform

CMEM

- Microwave emission modelling platform used as SMOS and SMAP forward operator
- Modular structure allows the use of a range of parameterisations of soil dielectric properties, soil roughness and vegetation opacity

https://software.ecmwf.int/wiki/display/LDAS/CMEM



Also used at CMC, CSIRO, GSFC, and others centres…

Current version 4.1

CMEM references:

- Holmes et al., TGRS 2009
- Drusch et al. JHM, 2009
- de Rosnay et al. JGR, 2009
- de Rosnay et al., ESA Report 2009
- Muñoz-Sabater et al. IJRS, 2012
- Parrens et al., RSE, 2014

https://software.ecmwf.int/wiki/display/LDAS/Publications

Forward simulations results

CMEM simulations

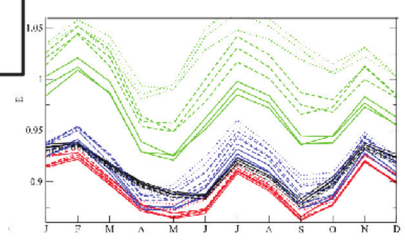
CMEM_ECMWF comparison with SMOS TB:
- 3 dielectric models (Dobson, Mironov, Wang)
- 3 vegetation opacity models (Jackson, Kirdyashev, Wigneron)
- 4 roughness models (Choudhury, Wigneron, Wsimple, Wtexture)

→ 36 configurations

Global Evaluation of CMEM against SMOS data for 2010

Evaluation Metrics:
RMSE, R, Bias, SDV, uRMSE, E (normalized uRMSE)

Results at both polarizations, at 00, 06, 12, 18 UTC, for each month and yearly

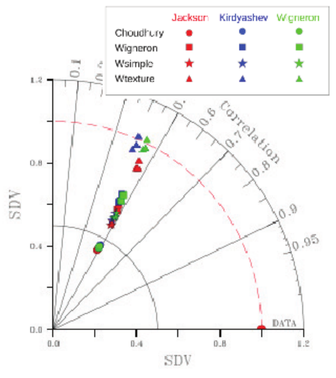


(d) TBH 00 E

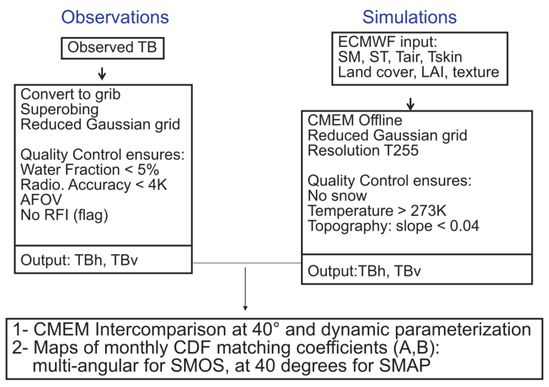
E TBx 06utc	Dobson		Mironov		Wang		Ro
Jackson	0.90	0.89	0.89	0.88	0.89	0.89	Ch Wi
	0.88	0.96	0.87	0.97	0.87	0.99	Ws Wt
Kirdyashev	0.88	0.90	0.88	0.90	0.88	0.91	Ch Wi
	0.87	1.04	0.87	1.06	0.88	1.08	Ws Wt
Wigneron	0.89	0.89	0.88	0.87	0.88	0.87	Ch Wi
	0.87	0.99	**0.86**	1.01	**0.86**	1.03	Ws Wt

Wtexture good for stdv, but not for R

Best correlation and uRMSE with Wang, Wigneron, Wsimple



ECMWF SMOS and SMAP Bias correction



Forward simulations

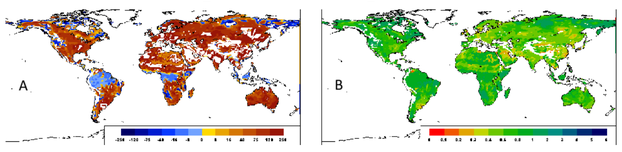
- CMEM input: ERA-Land soil moisture & temperature, air temperature from ECMWF land surface model H-TESSEL, Balsamo et al., ERA report n13, 2012
http://www.ecmwf.int/publications/library/ecpublications/_pdf/tm/601-700/tm605.pdf

Quality control:
- Slope index larger than 4% (use ECMWF parameter)
- Snow covered areas
- Freezing temperature areas
- Wetland: water fraction larger than 5%
- Areas where Effective temperature is larger than TB

Bias correction parameters

- Based on SMOS brightness temperature observations (2010-2011)
- Monthly CDF matching using a 5-month moving window
- CDF matching parameters computed for each incidence angle
- For SMAP, using 40 degrees incidence angle
- Matching parameters to be adjusted after SMAP launch, when one year of data is available

SMOS_matched = A + B * SMOS_data



For each grid point, and for each month i, CDF matching coefficients $A(i)$ and $B(i)$ are computed as:

$$A(i) = \overline{TB_M} - \overline{TB_O} \times \frac{\sigma_{TB_M}}{\sigma_{TB_O}}$$

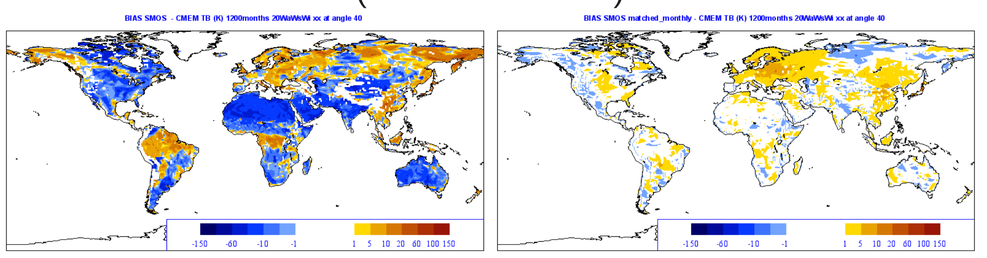
$$B(i) = \frac{\sigma_{TB_M}}{\sigma_{TB_O}}$$

With σ the standard deviation, subscripts M for model and O for observations. Matching coefficients are computed once and then used as:
$TB_O^* = A(i) + B(i)\,TB_O$

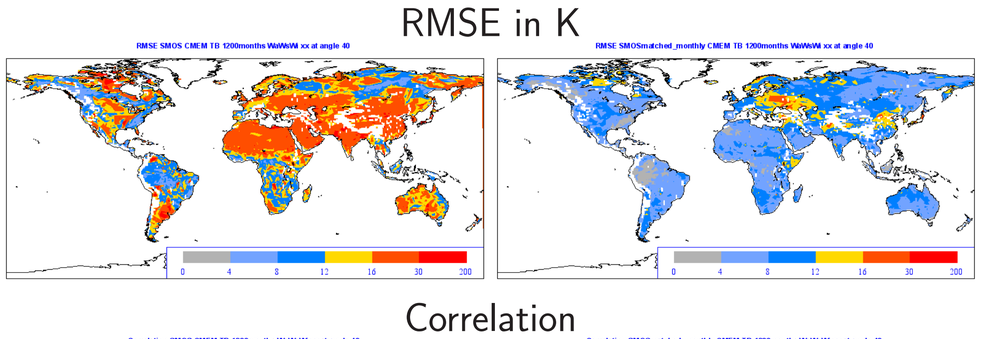
Results for 2012

Annual scale evaluation

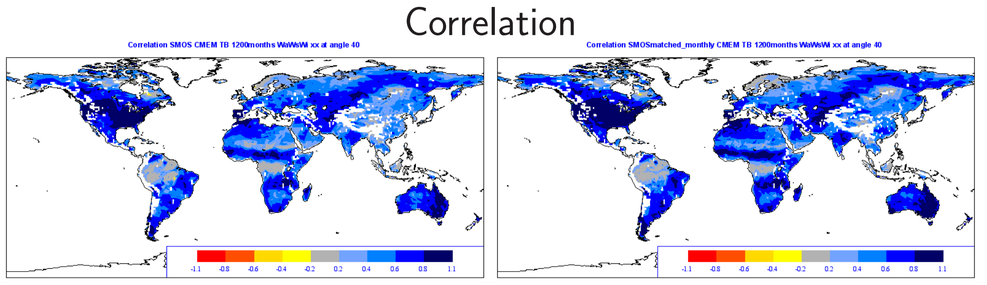
Bias (OBS - MODEL) in K



RMSE in K

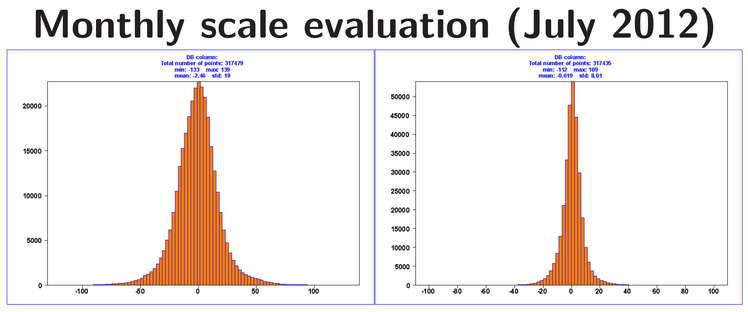


Correlation



Before BC After BC

Monthly scale evaluation (July 2012)



Before BC After BC

Global statistics

Angle (^{o})	R		RMSE(K)		Bias (K)		Var (K^2)		
40	0.52	0.49	16.9	13.9	-3.3	-1.3	123	95	Before BC
40	0.56	0.53	7.7	7.7	0.7	0.5	7	7	After BC

Table: Comparison between observed and simulated L1 TB (both polarizations).

Conclusion

- Technical work to implement SMAP data in the ECMWF Integrated Forecasting System is ongoing.
- CMEM best configuration identified by inter-comparision and evaluation against the SMOS data at 40 degrees incidence angle.
- Using SMOS L1 TB at 40 degrees to obtain SMAP-like observations, statistics of model departure are computed at global scale, before and after bias correction.
- Monthly CDF-matching efficiently reduces systematic errors between SMOS and CMEM. The global RMSE is reduced from 16.9 K to 7.7 K for 2012.
- Seasonal cycle correction leads to improved correlation from 0.52 before bias correction, to 0.56 after bias correction.
- SMOS-based bias correction parameters will be used immediately after first SMAP is available for monitoring.

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