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

Also used at CMC, CSIRO, DIFFO, and others... 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/CMEM

Forward simulations results

Global Evaluation of CMEM against SMOS data for 2010

Evaluation Metrics:
RMSE, R, Bias, SKV, uRMSE, E (normalized uRMSE)
Results at both polarizations, at 00, 06, 12, 18 UTC, for each month and year.

<table>
<thead>
<tr>
<th>Month</th>
<th>Moscow</th>
<th>Wigneron</th>
<th>Wang</th>
<th>Rms</th>
</tr>
</thead>
<tbody>
<tr>
<td>January</td>
<td>0.09 0.09 0.09 0.09</td>
<td>0.09 0.09 0.09 0.09</td>
<td>0.09 0.09 0.09 0.09</td>
<td>0.09 0.09 0.09 0.09</td>
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<tr>
<td>February</td>
<td>0.07 0.07 0.07 0.07</td>
<td>0.07 0.07 0.07 0.07</td>
<td>0.07 0.07 0.07 0.07</td>
<td>0.07 0.07 0.07 0.07</td>
</tr>
<tr>
<td>March</td>
<td>0.06 0.06 0.06 0.06</td>
<td>0.06 0.06 0.06 0.06</td>
<td>0.06 0.06 0.06 0.06</td>
<td>0.06 0.06 0.06 0.06</td>
</tr>
<tr>
<td>April</td>
<td>0.05 0.05 0.05 0.05</td>
<td>0.05 0.05 0.05 0.05</td>
<td>0.05 0.05 0.05 0.05</td>
<td>0.05 0.05 0.05 0.05</td>
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<tr>
<td>May</td>
<td>0.04 0.04 0.04 0.04</td>
<td>0.04 0.04 0.04 0.04</td>
<td>0.04 0.04 0.04 0.04</td>
<td>0.04 0.04 0.04 0.04</td>
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<tr>
<td>June</td>
<td>0.03 0.03 0.03 0.03</td>
<td>0.03 0.03 0.03 0.03</td>
<td>0.03 0.03 0.03 0.03</td>
<td>0.03 0.03 0.03 0.03</td>
</tr>
<tr>
<td>July</td>
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<td>0.02 0.02 0.02 0.02</td>
<td>0.02 0.02 0.02 0.02</td>
<td>0.02 0.02 0.02 0.02</td>
</tr>
</tbody>
</table>

Best correlation and uRMSE with Wang, Wigneron, Wsime

ECMWF SMOS and SMAP Bias correction

Bias correction parameters

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

$$ A(i) = T_{BM} - T_{BO} \times \frac{\sigma_{TB_{M}}}{\sigma_{TB_{O}}} $$

$$ B(i) = \frac{\sigma_{TB_{M}}}{\sigma_{TB_{O}}} $$

With $\sigma$ 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

<table>
<thead>
<tr>
<th>Angle (°)</th>
<th>R</th>
<th>RMSE(K)</th>
<th>Bias (K)</th>
<th>Var (K^2)</th>
</tr>
</thead>
<tbody>
<tr>
<td>40</td>
<td>0.52 0.52 16.9 13.9</td>
<td>-3.3 -1.3 123 95</td>
<td>Before BC</td>
<td></td>
</tr>
<tr>
<td>40</td>
<td>0.56 0.53 7.7 7.7</td>
<td>0.7 0.5 7 7</td>
<td>After BC</td>
<td></td>
</tr>
</tbody>
</table>

Global statistics

<table>
<thead>
<tr>
<th>Angle (°)</th>
<th>R</th>
<th>RMSE(K)</th>
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</table>

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-comparison 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.
- 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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