SMOS Vicarious Calibration: a contribution to the Monitor Facility

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SMOS Monitor Facility

- SMOS (MF) Monitor Facility key objectives:
  - Daily monitoring of the DPGS production.
    - Statistics on the difference between sensing time and generation time
    - Gantt chart SPQC failures (Products and ADF)
    - Gantt chart Planning vs Production
    - Daily plots and maps
  - Long term trends
    - Analysis of the SPQC report
    - Generation of time series plots covering trends since beginning of the mission or specific report period
    - Generation of “Pseudo L3” products for QC (plots and maps)
  - Routine Calibration monitoring
    - Calibration parameters: G-matrix, Flat Target Transformation, Consolidated Calibration file (visibility offset, FWF)
    - Vicarious calibration
  - SM and OS long term geophysical validation monitoring
    - Comparison with on-situ or model data
MF Vicarious Calibration

• MIRAS instrument has onboard calibration systems (injection of correlated and uncorrelated noise) designed to enable calibrated brightness temperatures to be derived in the ground processing.
• SMOS satellite allows MIRAS to be calibrated also looking at the deep sky during specific calibration acquisition obtained by rotating the satellite.
• However, all satellite radiometers require fine-tuning in the post-launch overall system calibration to remove residual radiometer and antenna system calibration artifacts. These can arise from a variety of causes such as uncorrected attitude errors, instrument misalignment or pointing errors, instrument thermal gradients calibration coefficient errors, component degradation, etc.
• Post-launch calibration usually involves fine-tuning of the onboard calibration and retrieval of in-orbit calibration coefficient. These activities can be supported by suitable external targets, i.e., homogeneous Earth surface areas of large spatial extent with stable and well-known emissivity to be used as reliable references.
• MF Vicarious calibration aims to support commissioning phase in-orbit calibration activities and to provide inputs to the long term monitoring of the MIRAS calibration.
MF Vicarious Calibration

- Suitable natural targets for the calibration monitoring are the calm ocean areas that can be used as cold reference targets (80-150 K) within the typical Earth-view brightness temperature dynamic range.
- However, even if the cold end of the calibration is monitored accurately, such that ocean geophysical products can be accurately derived, the warm end of the calibration may still be inaccurate, giving rise to inaccuracies in geophysical retrievals over land.
- For those reasons the SMOS MF approach is to implements suitable vicarious calibration monitoring strategy over the full dynamic range of the measured brightness temperature.
MF Vicarious Calibration

• The study with the “Università di Tor Vergata” (part of the SM L2 ESLs) is focused on the warm/mid-range targets. This is needed because there is less knowledge about what constitutes a suitable target in the mid-range (~200 K) or warm end (250-300 K) of the scale. Ice sheets could be considered for the mid-range, and tropical forests for the warm end.
• Other studies are carried out by the SMOS Vicarious calibration team and it is expected to include their input in the operational infrastructure of the MF. In particular inputs are expected from the activities described in the SMOS Val/Retr plan regarding the experimental campaigns and studies on models and assimilation.
• The first objective of the “Università di Tor Vergata” study is to analyse the modeling accuracy, and spatial and temporal stability, of the brightness temperatures for some selected targets and understand if they are a suitable choice as external targets for SMOS calibration monitoring.
• The second objective is to derive operational algorithm and procedures for the MF
• The research is on-going and the results presented here are focused on the first objective of the study
Brazilian Rain Forest

- Stable target used to monitor the Scatterometer / SAR calibration (C-band Vpol)
- Scatterometer analysis shows a stability within 0.5 dB or 0.2 dB if the annual variation is removed (R. Crapolicchio et al “On the stability of Amazon rainforest backscattering during the ERS-2 Scatterometer mission lifetime” Ceos workshop 2003)

ERS-2 Scat fore beam image

Inter-annual variation of the gamma nought
Brazilian Rain Forest

- The same area has been monitored at C-Band using the AMSR-E radiometer data at 6.9 GHz

Tb 6.9 GHz year 2006

Polarization Index 6.9 GHz year 2006

7th SMOS Workshop: Cal/Val and commissioning 29 – 31 October 2007 ESA-ESRIN Frascati Italy
Brazilian Rain Forest

• Two small areas have been selected with small values of PI (dense vegetation) and Tb standard deviation (stable target). One measurement every 16 days.
### ZONE 1 – Lat. [1,2] Long. [-65.5,-64.5]

<table>
<thead>
<tr>
<th></th>
<th>Mean($T_B$) = 277.6719 K</th>
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<tr>
<td></td>
<td>Std($T_B$) = 0.4326 K</td>
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<td>Mean($E_{mTskt}$) = 0.9451</td>
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<td>Std($E_{mTskt}$) = 0.0016</td>
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<td>Mean($E_{mTsll1}$) = 0.9377</td>
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<td>Std($E_{mTsll1}$) = 0.0020</td>
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<td>Mean($E_{mTskt}$) = 0.9511</td>
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<td>Std($E_{mTskt}$) = 0.0015</td>
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<td>Mean($E_{mTsll1}$) = 0.9436</td>
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<td>Std($E_{mTsll1}$) = 0.0020</td>
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<tr>
<th></th>
<th>$T_{b_{eq}} = \text{Std}(E_{mTskt}) \times \text{Mean}(T_{skt}) = 0.47$ K (skin)</th>
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<td>$T_{b_{eq}} = \text{Std}(E_{mTsll1}) \times \text{Mean}(T_{ssll1}) = 0.59$ K (soil)</td>
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<th>$T_{b_{eq}} = \text{Std}(E_{mTskt}) \times \text{Mean}(T_{skt}) = 0.44$ K (skin)</th>
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<td>Mean(T_B) = 277.9638 K</td>
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<td>Std(T_B) = 0.4616</td>
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<td>Mean(Emi_{Tskt}) = 0.9433</td>
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<td>Std(Emi_{Tskt}) = 0.0016</td>
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<td>Mean(Emi_{Tstl1}) = 0.9362</td>
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<td>Std(Emi_{Tstl1}) = 0.0017</td>
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<td>H POL</td>
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<td>T_{Beq} = Std(Emi_{Tstl1}) * Mean(T_{stl1}) = 0.50 K (soil)</td>
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<td>V POL</td>
<td>T_{Beq} = Std(Emi_{Tskt}) * Mean(T_{skt}) = 0.44 K (skin)</td>
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ZONE 2 – Lat. [0,1] Long. [-66.5,-65.5]

Mean(T_B) = 277.9638 K
Std(T_B) = 0.4616
Mean(Emi_{Tskt}) = 0.9433
Std(Emi_{Tskt}) = 0.0016
Mean(Emi_{Tstl1}) = 0.9362
Std(Emi_{Tstl1}) = 0.0017
Mean(T_B) = 280.0926 K
Std(T_B) = 0.4413
Mean(Emi_{Tskt}) = 0.9505
Std(Emi_{Tskt}) = 0.0015
Mean(Emi_{Tstl1}) = 0.9434
Std(Emi_{Tstl1}) = 0.0016
T_{Beq} = Std(Emi_{Tskt}) * Mean(T_{skt}) = 0.47 K (skin)
T_{Beq} = Std(Emi_{Tstl1}) * Mean(T_{stl1}) = 0.50 K (soil)
T_{Beq} = Std(Emi_{Tskt}) * Mean(T_{skt}) = 0.44 K (skin)
T_{Beq} = Std(Emi_{Tstl1}) * Mean(T_{stl1}) = 0.47 K (soil)
• L-Band space-radiometer measurements are not available to assess the variability of the rain forest emission (apart from 2 passes of the Sky-Lab).

• The approach is to analyse the variation of the emissivity using the Tor Vergata model. The main parameters in the model are the wood-biomass, the leaf area index and the soil moisture.

• The emissivity of the rain forest has been estimated by running the model at C-band and comparing the model emissivity with the AMSR-E values. INPUTS: biomass=250 t/ha, LAI=4,6,8, SMC in the range 5%-30%
• The typical rain-forest wood biomass is about 250 ton/ha and the LAI is about 6
• The emissivity is almost independent from the leaf area, a difference of emissivity of 0.01 (2.7K) is the maximum variation in case the LAI ranges between 4 and 8. This is an unlikely case over the rain forest
• Monitoring of Tb statistics on selected areas over the rain-forest could make sense

• The usage of the emissivity computed using ECMWF data does not improve the accuracy (at least in C-band) of the statistics

• In case of SMOS it will be important to correct the Tb for the Faraday rotation

• An operational procedure will be defined in the next months.

• The number of areas (1x1 deg) is still TBD. If the areas are really homogeneous and with the same vegetation the increase in the number will give more accuracy in the statistics.

• There are some ideas to collect statistics: average profile per incidence angle along the time, Tb histograms peak position monitoring.
Antarctica - ICE

- A recent study from G. Macelloni (IEEE TGRS July07) has identified a stable area around Dome-C using AMSR-E data
- Scatterometer data can be also used to characterize the stability of that area and to better understand the properties in term of different incident and azimuth angles (see R. Drinkwater papers)
Questions?

Thanks