Session: Poster

Assessment of the Local Oscillator calibration frequency impact on the SMOS Sea Surface Salinity

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Introduction

At the end of the Commissioning Phase (20-May 2010) of the European Space Agency (ESA) Soil Moisture and Ocean Salinity (SMOS) satellite, the calibration frequency of the Microwave Imaging Radiometer by Aperture Synthesis (MIRAS) instrument Local Oscillators (LO) was set to 10 minutes, while waiting for in-depth analysis of the impact of such choice.

The MIRAS instrument has a unique reference clock that is distributed to the Control and Monitoring units (CMN) located in the SMOS arms and in the hub. Each CMN uses the clock signal, provided by the Local Oscillator, to generate a reference tone and provide it to a group of six receivers. Although every CMN should generate exactly the same tone, the phase of the tones drifts due to the temperature dependency of the CMN electronics. A comprehensive analysis of the phase drifts with physical temperatures fluctuations was performed during on-ground characterisation [1]. The assessment of these phase drifts as a function of temperature changes was performed in [2], verifying that phase drifts could be mainly assigned to the LO temperature drifts. These phase drifts are adding non-coherent phase information to the measurements, therefore blurring the brightness temperature images.

For this reason LO phase tracking by correlated noise injection is required. As already mentioned, the correlated noise injection for LO calibration purposes is operationally executed every 10 minutes. Each LO phase calibration takes 5 epochs (6 seconds) [3]. As such, the LO calibration frequency is a trade-off between the very accurate brightness temperature (TB) measurements needed for Ocean Salinity retrievals and the not as much accurate measurements but with fewer gaps (i.e., the lower the calibration frequency, the lower the number of lost epochs) needed for Soil Moisture retrievals.

From the 16th to 30th of March 2010, the MIRAS instrument was set to perform a calibration of the LO every 2 minutes. At the SMOS Barcelona Expert Center (BEC-SMOS) all the half-orbits from 24th and 25th march (54 in total) were processed with the official SMOS Level 1 Prototype Processor v3.5 [4] up to Level 1c products. The SMOS Level 2 Ocean Salinity Prototype Processor v3.17 [5] was used to process the L1c up to Sea Surface Salinity (SSS) products (level 2). The L2 processing was performed with an ISEA4H8 grid, to reduce the dimension of the products (1/4 of ISEA4H9 grid). Data has been processed at three LO phase calibration frequencies: 2, 6 and 10 minutes. The last two correspond to decimated data, i.e., from the original data (2 min), only LO phase calibrations at 6 and 10 minutes intervals are used to process the 6-min and the 10-min data, respectively. Please, note that an n-minute LO calibration frequency is referred hereafter as n-min.

The objective of this work is to assess, both qualitatively and quantitatively, the impact of calibrating the LO at different intervals on brightness temperatures (TB) and on SSS. Since we use the same dataset with different LO calibration frequency, we avoid other sources of error related to e.g., different geophysical conditions or different sun direction, among others.

It is important to note that, in this work, we do not perform any validation using external data sources. We only inter-compare TB measured with different calibration frequencies and use the highest frequency mode, i.e., 2-min, as the reference since it is the optimal one, i.e. the one with least error in the LO phase.

Impact on Brightness Temperature

Figure 1 exhibits the difference between the TB with a given LO calibration frequency and the reference TB (corresponding to 2-min), in V-polarization for incidence angles between 38º to 40º. The left (right) plot shows the degradation of 10-min (6-min) data with respect to the reference. One can clearly appreciate that 10-min calibration suffers a higher degradation. Note that V-polarization data experience more degradation than H-pol data (not shown). A similar pattern is observed when analysing TB differences at other incidence angle ranges.

The left plot of figure 1 shows a clear spatial pattern of relatively strong differences (up to 0.3 K) along the sub-satellite track at different cross-track locations (see red and blue lines in the plot). Since they cannot be associated with any geophysical signal, these patterns must be artefacts produced by the de-phasing of the LO, i.e., additional errors in the 10-min TBs (w.r.t. 2-min TB errors). Moreover, these patterns change along the orbit every 10 min (see four distinct patterns in the along-track direction), further confirming our hypothesis. In the right plots, these artefacts are hardly visible, indicating that the de-phasing errors are significantly smaller in the 6-min TBs than in the 10-min TBs.

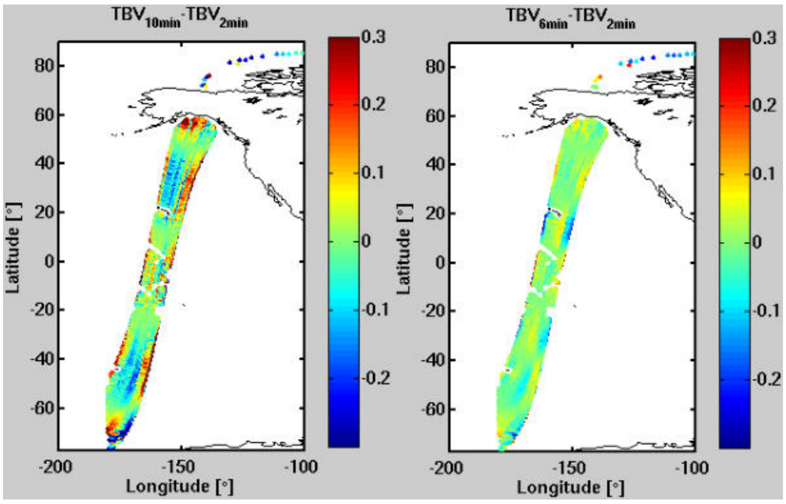

Figure 1: Differences between TB calibrated at 10 minutes and at 2 minutes (left), and between TB calibrated at 6 minutes and at 2 minutes (right), in V-pol and for incidence angles between 38º and 40º.This is the half orbit: 20100325T040821.

Scatter plots of the TB differences between 10-min and 2-min (left) and between 6-min and 2-min (right), at H-pol (top) and V-pol (bottom), are shown in figure 2 as a function of latitude (which is proportional to time), for the portion of the orbit shown in figure 1. The time intervals of the LO calibration are clearly discernible (i.e., points of minimum scatter). Note that the scatter is large for 10-min data, indicating substantial errors in TB when using a 10-min LO calibration frequency. The scatter is substantially reduced when using 6-min data instead of 10-min data.

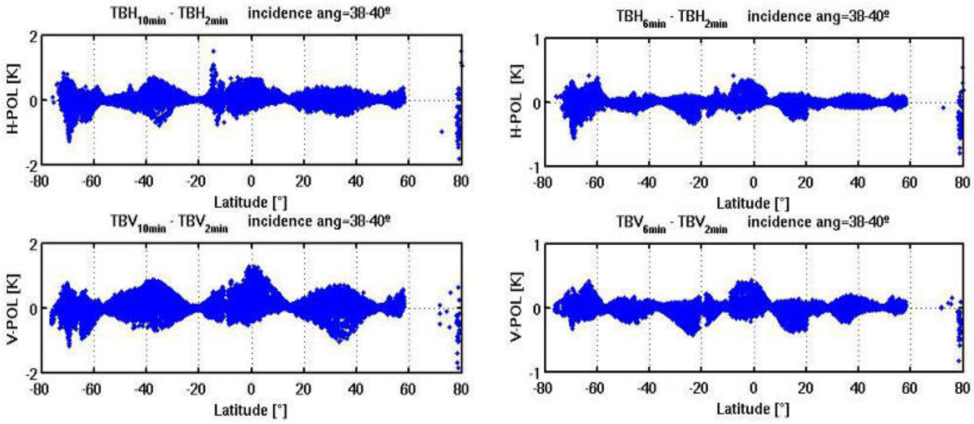

Figure 2: Scatter plots of TB differences between 10-min and 2-min (left) and between 6-min and 2-min (right), for H-pol (top) and V-pol (bottom). Only incidence angles between 38º and 40º are considered. Note that the Y-axis range of the left plots is twice that of the right plots.

The standard deviation of the TB differences between 10-min and 2-min is 0.47 K and that of 6-min minus 2-min is 0.14 K. About 4% of the points have TB differences between 10-min and 2-min higher than 0.5K, while this value decreases to 0.6% for the differences between 6-min and 2-min.

Impact on Sea Surface Salinity

The impact of the different LO calibration frequencies on the retrieved SSS is shown in figure 3 for the complete set of orbits from 24th and 25th March 2010. The figure shows the level of degradation of the retrieved SSS due to the different LO calibration frequencies, using 2-min SSS as reference. In line with the results on brightness temperatures, the quality of the retrieved SSS is substantially higher for 6-min data than for 10-min data. Also, a similar along- and across-track error pattern of SSS differences to that of TB differences is discernible. Note that measurements in the entire FOV (i.e., the Extended Alias Free FOV) measurements have been used to retrieve the SSS.

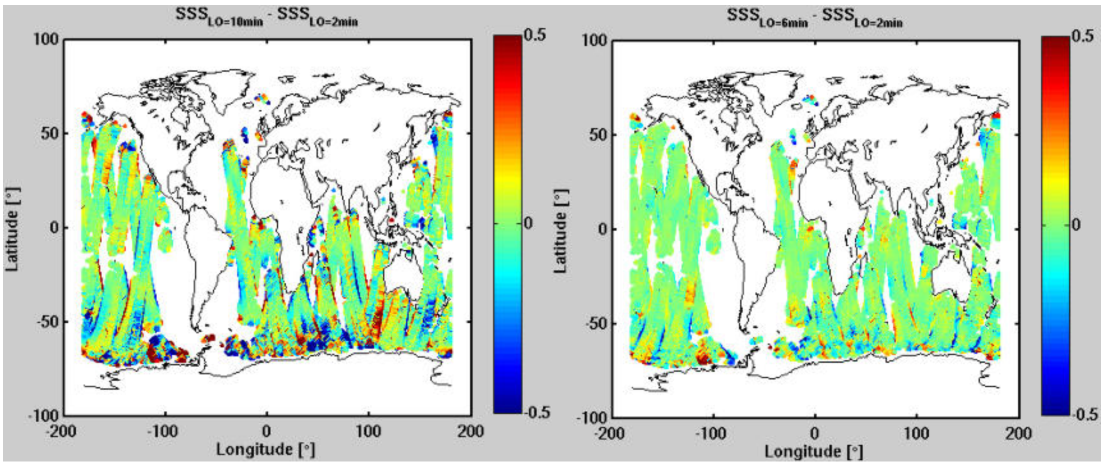

Figure 3: Retrieved SSS differences between 10-min and 2-min data (left) and between6-min and 2-min (right).

Figure 4 shows the histograms of the retrieved SSS differences between 10-min and 2-min data and between 6-min and 2-min data. The width of the distribution of the left plot is substantially higher (about twice) than that of the right plot, indicating the larger data quality degradation at 10-min calibration as compared to 6-min. Note that the expected accuracy for L2 SSS is around 1-2 psu and the 10-min LO calibration frequency can represent up to 0.5 psu of additional error, relative to 2-min data. Moreover around 3.8% of the points have SSS differences between 10-min and 2-min higher than 0.5 psu, while these SSS differences in the 6-min and 2-min is around 0.4%.

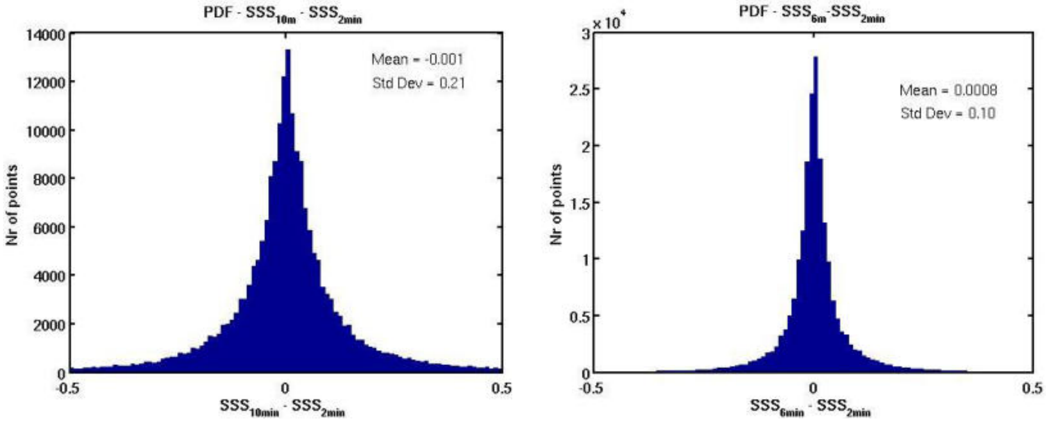

Figure 4: Histograms of the retrieved SSS differences between 10-min and 2-min data (left), and between 6-min and 2-min data (right).

Conclusion and prospects

Using a LO calibration frequency of 10 minutes results in substantial degradation of TB (larger in V-pol) and SSS, as compared to data with a LO calibration frequency of 6 minutes.

Further analysis will be performed with a larger dataset, when two weeks of data acquired with a LO calibration every 2 minutes will be available (expected in November 2011), using the latest versions of the prototypes processors (L1ppv5.0 + L2ppv5.0) recently installed in the DPGS. In addition, a simulation is envisaged to determine whether these artefacts (both the error magnitudes and patterns found with real data) are expected from the theoretical point of view.

References:

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[4] Gutierrez, A., Barbosa, J., Almeida, N., Catarino, N., Freitas, J., Ventura, M., & Reis, J. SMOS L1 Processor Prototype: from digital counts to brightness temperatures. Proc. IEEE International Geoscience and Remote Sensing Symposium, IGARSS 2007.
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