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SMOS INSTRUMENT PERFORMANCE AND CALIBRATION AFTER 6 YEARS IN ORBIT

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ABSTRACT

ESA's Soil Moisture and Ocean Salinity (SMOS) mission has been in orbit for over 6 years, and its Microwave Imaging Radiometer with Aperture Synthesis (MIRAS) in two dimensions keeps working well. The data for almost this whole period has been reprocessed with the new fully polarimetric version (v620) of the Level-1 processor which also includes refined calibration schema for the antenna losses. This reprocessing has allowed the assessment of an improved performance benchmark, a better understanding of the observations, and the preparation of a new version (v700) of the Level-1 processor with further potential.

Index Terms— SMOS, aperture synthesis, radiometry, interferometryhttp://www.ieee.org/organizations/pubs/ani_prod/keywrd98.txt

1. INTRODUCTION

The deployment of version v620 of the SMOS Level-1 processor in Spring 2015 and the corresponding reprocessing of all mission data, has provided an over 6 year period data set, long enough to throw new light and further insight into MIRAS observations, summarized in this paper.

2. SYSTEMATIC SPATIAL RIPPLE

A consolidated result is the existence of a noise floor limit in the amplitude of systematic spatial ripple in SMOS images, below which, it is not possible to reach. The noise floor is determined by the combination of element spacing and antenna pattern similarity. The further away the element spacing is from that one for which no aliases can appear (0.58 times the central wavelength of the radiation in the case of hexagonal sampling, as it is SMOS), and the more dissimilar the antenna patterns are from each other, the larger the amplitude of the systematic spatial ripple is.

A second contributor to spatial ripple is the lack of perfect knowledge of the antenna patterns. Currently the SMOS Calibration and Level-1 team is working on techniques to reduce this contribution, such as the Initial Guess based Techniques (dubbed 'Gibbs' approaches), the Floor Error Mask, the Pre-Distorted G-matrix and the Average Pattern

Reconstruction.

3. SUN AND RFI TAILS

The side lobes from the Sun and strong Radio Frequency Interference (RFI) sources degrade SMOS images. To correct for them some methods have been put in place, and are subject of continuous improvement. These techniques used either an estimated point source instrument response, a real Sun acquisition or a variety of RFI source detection algorithms to mitigate their impact or, at least, flag images or pixels contaminated by them. The preliminary correction of the Sun effect when it is located in the back of the antenna array has been quite successful. Recently new developments, like the nodal sampling, based on the image covariance matrix have given a new insight into the instrument impulse response, with the potential to improve the performance of SMOS in RFI contaminated seas.

4. LAND-SEA CONTAMINATION

Land-sea contamination refers to an excess of brightness temperature measured around continental masses. An important contributor to this signal has been identified, this being an unbalance of about 2% between the amplitude of the visibility at the origin and any other. The most recent v700 of the Level-1 processor has implemented the so-called ALL-LICEF branch, with which the correction of such unbalance has successfully been demonstrated. In parallel, at Level-2 (sea surface salinity retrieval), an empirical technique built up using the whole mission data set, has been devised to remove the land sea contamination also very effectively.

5. ORBITAL VARIATIONS

Orbital variations are studied by comparing SMOS brightness temperature observations in ascending and descending passes over the same ocean area. With the new v620 Level-1 processor orbital variations are well constrained within ±0.4 K, except for the eclipse season, when they can reach 3 times that much. Accordingly the efforts are directed to finding a correction for the eclipse season. A critical parameter is the amplitude of the noise injection generated by the 3 Noise Injection Radiometer (NIR) units of MIRAS, which appears affected by the physical skin temperature and its gradient.

6. SEASONAL VARIATIONS

The Hovmöller plots over ocean of SMOS descending passes of the (Stokes 1)/2 parameter had always shown some warm deviation around October. The 6 year long data record has allowed the computation of correlation factors with high confidence level, and the best candidate for the mentioned deviation has turned to be the reflected galaxy signal. That is, the instrument is more stable than initially thought, the October variation being due to a geophysical miss-modelled effect.

7. YEARLY VARIATIONS

Yearly variations are assessed against the cold sky, the ocean and Antarctica. They all show a very high stability of SMOS, with slopes under 0.01 K/year. This is achieved thanks to the high stability of the NIR units and the more correct in-orbit estimation of the antenna loss, by comparison to the ground characterization data.

8. IN-ORBIT CALIBRATION STRATEGY

The in-orbit calibration strategy of SMOS has changed very little since the start of its operational phase in June 2010. However, a more precise analysis of the external calibration manoeuvers has shown the impact of thermal effects. There is evidence that these effects happen when the skin temperature of the antenna is colder than about 0°C. To avoid the impact of cold temperatures, external manoeuvers have been programmed, since October 2014, at a moment such that the Sun has some positive elevation angle over the antenna to keep it warm enough. These 'Warm' calibrations are providing more consistent noise injection calibration temperatures since they were introduced.

9. IMAGE RECONSTRUCTION

Improvements in image reconstruction are continuous. The current work includes the implementation of the 'Gibbs-2' technique, which should reduce land sea contamination, and a better correction of the Sun and RFI sources effects. A new version of the Level-1 processor (v710) should be ready by October 2016 with this technique implemented.

10. CONCLUSIONS

This paper will present the most recent status of SMOS instrument performance and calibration after over 6 years in orbit.