Preparing the ESA-SMOS (Soil Moisture and Ocean Salinity) mission - Overview of the User Data Products and Data Distribution Strategy

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***Abstract*— The ESA Earth Explorer SMOS (*Soil Moisture and Ocean Salinity*) mission will carry the first polar-orbiting 2-D interferometric radiometer (*MIRAS- Microwave Imaging Radiometer using Aperture Synthesis*) acquiring data of emitted microwave radiation at the frequency of 1.4 GHz (L-band).**

The SMOS mission products will provide different data types, each with its own characteristics. SMOS products are classified according to the different levels of processing and each product will contain specific data. The aim of this paper is to highlight the innovative satellite instrument and to present to the scientific user community the content of each product type.

***Index Terms*— Microwave radiometry, interferometry, satellites products.**

I. Introduction

SMOS is the second ESA Earth Explorer mission to be developed as part of ESA's Living Planet Programme, in cooperation with CNES (France) and CDTI (*Center for Technological and Industrial Development*- Spain).

The SMOS sensor MIRAS (Microwave Imaging Radiometer using Aperture Synthesis) is a dual polarized 2-D interferometer operating at L-band (1.41 GHz) and it is the first-ever, polar-orbiting, space-borne, 2-D interferometric radiometer.

The instrument will provide records of brightness temperatures over incidence angles from 0º up to 55º across a 600 km swath, with a spatial resolution in the range of 30-50 km. Table I lists the more important MIRAS properties.

An important aspect of this mission is that it will demonstrate a new measuring technique for a spaceborne radiometer by adopting the interferometric method derived from the radioastronomy.

Map of brightness temperatures, ocean salinity and soil moisture will be derived from the visibility functions which is the feature measured by the instrument.

SMOS measurement requirements that need to be fulfilled in the product delivered by ESA are:

- Soil Moisture accuracy of 4% with a spatial resolution <50 km and a revisit time <3 days
- Ocean Salinity accuracy of 0.5-1.5 practical salinity units (psu) for a single overpass.

TABLE I
MIRAS Instrument Properties

Orbit	Sun-synchronous, dawn/dusk, circular orbit at altitude 763 km. 06.00 hrs local solar time at ascending node
Swath width	600 km (FOV has a hexagon-like shape at an orbital altitude of 763 km)
Tilt angle	32.5 degrees
Spatial resolution	35 km at centre of field of view
Grid Spacing	~15 km
Temporal Resolution	3 days revisit at Equator
Operational Mode	Dual and full polarization
Number of receivers	69 antennas (66 LICEF on the three arms and 3 NIR used as reference)
Radiometric Accuracy	1.8 K (at 180 K) 2.2 K (at 220 K)

II. SMOS Products General Features

A. Products types

The following SMOS products will be generated in the SMOS DPGS (Data Processing Ground Segment) in ESAC-Villafranca to be distributed to the users:

1. Level 1 family (obtained by applying the instrument calibration and the image reconstruction);
2. Near Real Time product; and
3. Level 2 (defined according to the surface type, land or sea, and containing geophysical parameters).

Level 1 and Level 2 data will be processed in 24 hours after the acquisition, while the NRT will be available to the weather forecast operational centers (ECMWF, MetOffice, etc.) within 3 hours from data sensing.

B. Products format

The SMOS products format follows the ESA Earth Explorer

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file format standards [1] and it is composed of two parts: a Header (in XML format) and a Datablock (in binary format). The Header contains configuration control, organizational data and product quality information, whereas the Datablock the scientific data.

C. Discrete Global Grid

SMOS geolocated products (such as Level 1C and Level 2) use an equal-area grid system called ISEA 4H9, i.e. Icosahedral Snyder Equal Area projection with *aperture* 4, *resolution* 9 and shape of cells as hexagon. The Discrete Global Grid (DGG) system ISEA 4H9 provides a uniform inter-cell distance of 15 km, i.e. all footprint centers are equispaced. This fine grid has been adopted in order to provide the correct sampling for the measurements at 30Km of spatial resolution according to the Nyquist criteria.. The Discrete Global Grid systems are described in detail in [2].

D. Visualization Tools

Different tools are developed to visualize the different SMOS products (see Table II). The SMOSView tool is the most complete, it can visualize, plot and map all SMOS products. Beam is more oriented towards the mapping of geolocalized data (Level 1C and Level 2). The Land Cover Tool has been developed to compare L2 Soil Moisture data with the auxiliary files used to retrieve the Soil Moisture and containing the soil properties.

TABLE II
SMOS VISUALIZATION TOOLS

Tool (Developer)	Properties
SMOSView (Vega)	Display all the SMOS data products (L1 and L2) and auxiliary file generated in the SMOS ground segment. Data browsing, plotting, mapping and extraction functions are available. Specific features to represent L1a and L1b data in the so called "star-domain"
SMOS Beam (Brockman C.)	Extension of the Beam tool already used for Meris and AATSR to display SMOS L1c and L2 data. Features to correlate L1c and L2 data for the same grid point
Land Cover Tool (GMV)	Maps of Soil Moisture (SM) products and auxiliary files used by the SM processor (i.e. ECMWF, land fractions, sand and clay fractions,…)

E. Product dissemination

The correct procedure to get SMOS data is to be registered as Category-1 (for research and applications there is the Fast Registration service EOHelp@esa.int, to get free of charge and systematically generated data). After the registration and the notification of acceptance by ESA, the selected users will be contacted with detailed information on how to access the requested data.

Two different methods are foreseen for the data delivery:

1) Fast delivery where only current generated products are sent to the user;

2) order the data set needed through the User Service, which will prepare the data set that will be sent to the user (by FTP or media).

For more information on how to access to Earth Observation Data visit the web site: http://earth.esa.int/dataproducts/accessingeodata/

III. SMOS PRODUCTS

A. Level 1A Product Type

Level 1A product contains both calibration and scientific measurements from the MIRAS instrument. Calibration products include the in-orbit measurements of the PMS gain and offset, the visibility offset and the Fringe washing function shape, whereas the scientific products contain the calibrated visibilities in dual or full polarization mode when the instrument is pointing to the Earth or to external target (deep sky). These scientific products (Fig. 1) are the input for the image reconstruction process [3, 4]. Level 1A products are physically consolidated in pole-to-pole time-based segments.

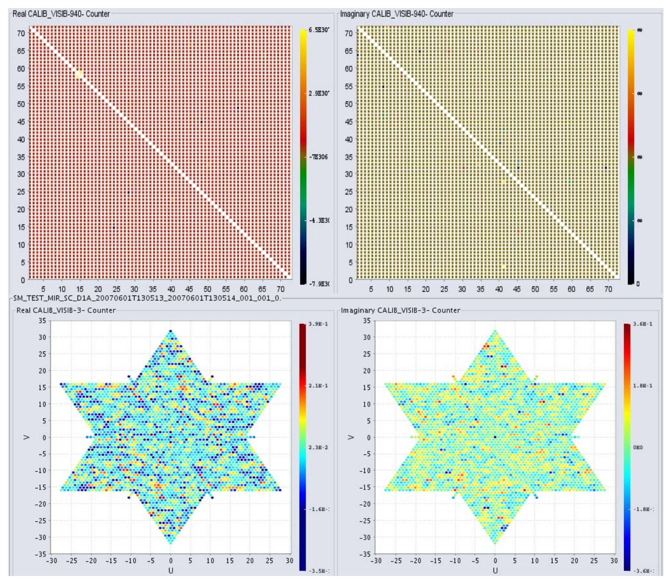

Fig. 1. Top row: Calibrated visibilities real (left) and imaginary part (right) for one L1a snapshot (single integration time). Each point in the plots corresponds to the correlation between each receiver in the three arms. Bottom row: Calibrated visibilities in the U, V domain (data generated at Deimos Engenharia– Portugal)

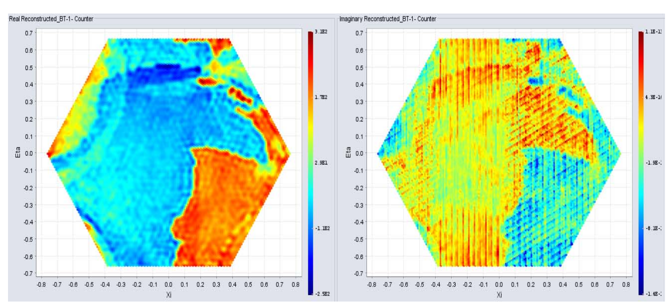

Fig. 2. Fast Fourier Transformation (on the left the Real part and on the right the imaginary part) of the Level 1B Brightness Temperature Fourier Components for one snapshot obtained with the SMOS data viewer (data generated at Deimos Engenharia– Portugal).

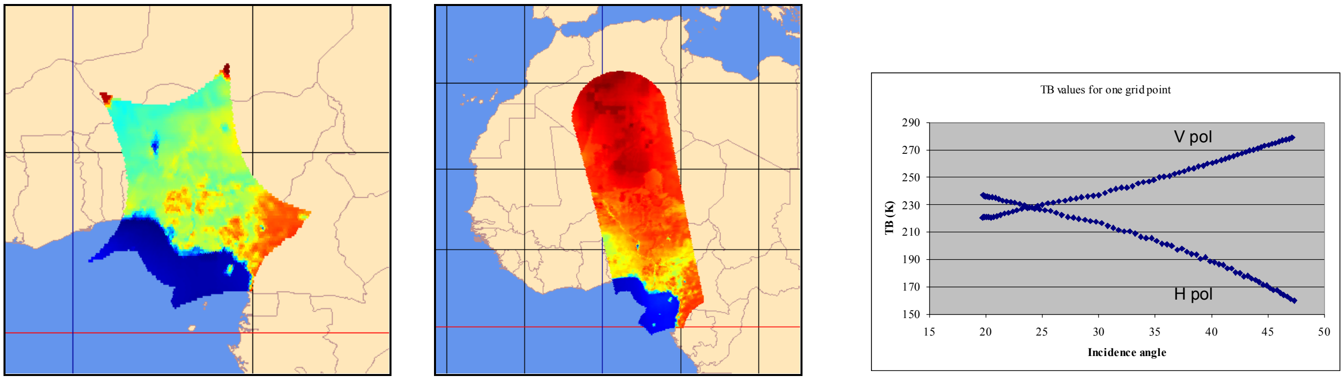

Fig. 3. Left: One "snapshot" (i.e. simultaneous observation) from the Level 1c product (H polarization). Center: With the SMOS Data Viewer it is possible to visualize the half-orbit overpass selecting one incidence angle (~ 40 ° V polarization in the image). Right: the Brightness Temperatures for one grid point (142 Brightness Temperature not measured at the same time). Data generated at CESBIO-France.

B. Level 1B Product Type

The Level 1B product contains the output of the image reconstruction process: the Fourier component of the differential brightness temperature in the antenna frame. The differential brightness temperature is derived by removing from the visibility all the elements that produce high contrast in the scene: namely the Sky, the Land and the Sea. This new approach is still under refinement and will provide a better image reconstruction by minimizing the Gibbs and alias effect in the final image. More details can be found in [4]. An example of the L1b data is given in Fig.2.

C. Level 1C Product Type

The Level1C products are multi-angular brightness temperature top of the atmosphere geolocated on the DGG ISEA grid (Fig.3). Typically about one hundred measurement per polarization at different incidence angle will be available for each grid point (see plot in Fig.3). The L1c data are derived by processing the L1b differential Brightness Temperature and adding back the contribution of the Sky, Land and Sea removed during the image reconstruction processing [5]. For the same half-orbit two different L1c products are generated according to a filter mask that identify the grid points that will be archived in the two separate file: one containing mostly sea grid points and another one with mostly land grid point. Associated to each L1c product there is also the Browse product, where only the TBs values for the incidence angle interpolated at 42.5° are stored.

D. Level 2 Soil Moisture Product Type

The L2 Soil Moisture (SM) product contains not only the Soil Moisture retrieved, but also a series of ancillary data derived from the processing (nadir optical thickness, surface temperature H and V polarization, roughness parameter, dielectric constant and brightness temperature retrieved at top of atmosphere and on the surface) with the corresponding uncertainties (Fig.4). As for the Level 1C, the product is geolocated on the DGG ISEA grid. Details on the Level 2 Soil Moisture Algorithm can be found in [6].

E. Level 2 Ocean Salinity Product Type

The L2 Ocean Salinity (OS) product contains three different

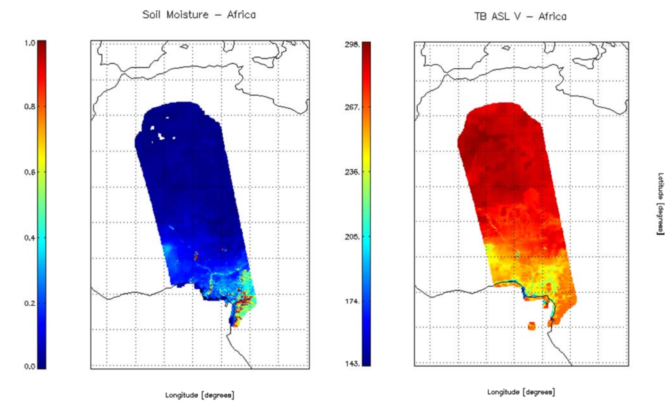

Fig. 4. Left: Soil Moisture retrieved over Africa from a simulation. Right: retrieved V polarization Brightness Temperatures on the surface at 42.5 ° for the same overpass (data generated at CESBIO-France).

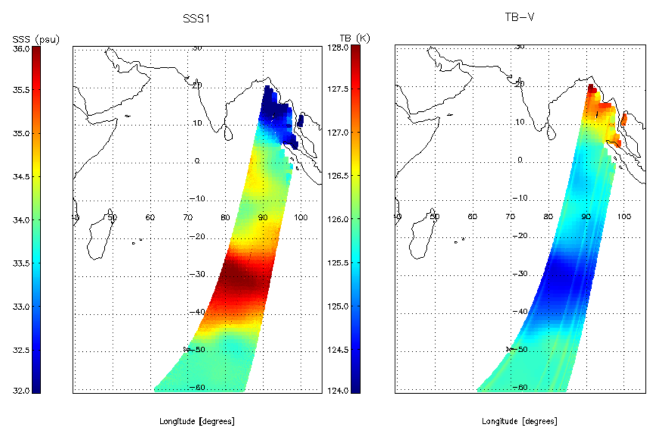

Fig. 5. Left: Ocean Salinity retrieved with the two-scale model from a simulation. Right: retrieved V polarization Brightness Temperatures on the surface at 42.5 ° for the same overpass (data generated at ACRI-ST-France).

Ocean Salinity values derived from three different retrievals implemented in the processing [7, 8, 9] and the brightness temperature retrieved at top of atmosphere and on the surface (Fig. 5) with the corresponding uncertainties. As the Level 1C product and the L2 SM product is geolocated on the DGG ISEA grid.

F. Near Real Time Product Type

The Near Real Time product is under development and will be available to the weather forecast operational centers within

3 hours from the data sensing.

This product will contain Brightness Temperature at top of atmosphere on a DGG ISEA grid with a reduced space resolution.

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