OVERVIEW OF SMOS LEVEL 2 OCEAN SALINITY PROCESSING AND FIRST RESULTS

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1. INTRODUCTION

Ocean salinity relates the Earth global water cycle to ocean circulation. It is modified through processes that increase or decrease the fresh water amount in the ocean surface, mainly precipitation and evaporation, but also river discharges, and freezing and melting in polar regions. These changes in surface salinity are transferred to the deep ocean and spread to other regions by advection and diffusion mechanisms. This generates slight differences in dissolved salt content between the different water masses that are sufficient to play a major role in ocean dynamics and in the relationship between the ocean and the Earth's climate. Salinity is especially relevant in some key processes like the dense water formation at high latitudes, where high salinity waters from the subtropical Northern Atlantic Ocean are brought northwards by the Gulf Stream and then, in contact with the very cold and less saline arctic waters, form dense water masses that sink and push the three-dimensional ocean conveyor belt, the global thermohaline ocean circulation. Knowing the salinity distribution at global scale and its annual and interannual variability is crucial to better understand the ocean's role in the climate system, regulated by this circulation and water and heat fluxes between atmosphere and ocean.

2. SMOS SALINITY OBJECTIVES

SMOS (Soil Moisture and Ocean Salinity), launched in November 2, 2009 is the first satellite mission addressing the salinity measurement from space through the use of MIRAS (Microwave Imaging Radiometer with Aperture Synthesis), a two-dimensional interferometer designed by the European Space Agency (ESA) and operating at L-band. SMOS aims at contributing to the following salinity remote sensing objectives:

- improving seasonal to interannual climate prediction,
- improving ocean rainfall estimates and global hydrologic budgets,
- monitoring large scale salinity events and thermohaline convection.

The mission expects being able to observe barrier layer effects on tropical Pacific heat flux, halosteric adjustment of heat storage from sea level, North Atlantic thermohaline circulation, surface freshwater flux balance, among other phenomena relevant for large-scale and climatic studies. These require an obtainable accuracy of 0.1-0.4 pss, practical salinity scale units. At L-band the polarized brightness temperature (TB) measured by a radiometer is linked to salinity in the first centimeter of the ocean through the dielectric constant of sea water. The sensitivity to salinity increases with decreasing frequency, as well as decreases the attenuation by the atmosphere, and the 1400-1427 MHz window, reserved for passive observations, has advantages for Sea Surface Salinity (SSS) remote sensing. This requires special care because of the low sensitivity of TB to SSS: from 0.8 K to 0.2 K per pss, which depends on the ocean temperature, the radiometer incidence angle, and the polarization. It is necessary to separate out the effects on TB from other parameters such as sea surface temperature (SST), the impact of ocean roughness, radiation from external sources, Faraday rotation in the ionosphere, etc.

3. SALINITY RETRIEVAL

The basic algorithmic approach selected for SSS retrieval from SMOS radiometric measurements is based on an iterative convergence scheme that compares the measured values with those provided by an L-band forward model of the sea surface emission. This model uses a guessed salinity that can be adjusted until obtaining an optimal fit with the radiometric measurement. MIRAS allows at each satellite overpass to measure a 2D image of the ocean surface under a wide range of incidence angles, then providing a series of different TB values corresponding to a single SSS at a fixed ocean location. This overdetermination is used to reduce the measurement noise and to adjust several geophysical variable parameters that characterize the sea state (for example SST, wind speed, significant wave height) and are also included in the forward model, in addition to SSS, in the iterative minimization process.

This paper presents the objectives of the ocean salinity determination by SMOS, the algorithmic approach chosen for this determination, and the results of the first tests carried out during the SMOS Commissioning Phase (6 months after launch) to evaluate the feasibility and quality of the salinity inversion. These include for example a characterization of the radiometric accuracy and the radiometric noise within the field-of-view, comparisons between the measured brightness temperatures and those derived from direct models of the ocean emission under different conditions and using different model options, verification of the full polarimetric signal contents, analysis of the dependency on the viewing angle, comparison of the retrieved salinity values to the existing climatological fields and to the distribution of independent variables from other satellite sensors, like sea surface temperature and ocean color, and impact of the proximity to the coast or sea ice in the retrieval quality.

A large number of papers has been published about salinity remote sensing and its implementation in the SMOS mission. We provide and extensive list of references, with emphasis on the different physical processes that have been considered in the SMOS salinity retrieval algorithm.

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