TOWARDS VALIDATION OF SMOS LAND PRODUCTS USING THE SYNERGY BETWEEN MODELS, AIRBORNE AND GROUND-BASED DATA OVER THE VALENCIA ANCHOR STATION. DEFINITION OF MATCHING-UP POINTS TO SMOS OBSERVATIONS

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1. INTRODUCTION

The main goal of ESA's (*European Space Agency*) SMOS (*Soil Moisture and Ocean Salinity*) mission is to deliver global fields of surface soil moisture (SM) and sea surface salinity, with enough resolution to be used in numerical weather prediction and global climate models, using L-band (1.4 GHz) radiometry. Within the context of the preparation for this mission over land, the *Valencia Anchor Station* (VAS) experimental site, in Spain, was chosen as a preferential test sites in Europe for SMOS Cal/Val activities. Ground and meteorological measurements over the area are used as input to a Soil-Vegetation-Atmosphere-Transfer (SVAT) model, SURFEX (*SURFace EXternalisé*) - module ISBA (*Interactions between Soil-Biosphere-Atmosphere*) to simulate surface SM. Calibration as well as validation of the ISBA model was made by using *in situ* SM measurements.
The VAS is located about 80 km west of the city of Valencia, on the natural region of the *Utiel - Requena Plateau*. The region is a reasonable homogeneous area of about 50 x 50 km^2, mainly dedicated to vineyards

(75%), and other Mediterranean ecosystem species (shrubs, olive and almond trees and pine forests). The topography is generally plain (slope angle < 2%) with slightly undulated regions (8% - 15%). The temperatures range from -15ºC in winter to 45ºC in summer, with an annual mean temperature of 14ºC. Annual precipitation is about 450 mm with peaks in spring and autumn.

2. SOIL MOISURE CHARACTERIZATION OF THE VALENCIA ANCHOR STATION

Over continental surfaces, SM validation requires a realistic estimation of surface SM in different areas within a SMOS footprint. SM variability depends on soil intrinsic and extrinsic factors. It is necessary to have a sampling strategy that integrates the relationships between hydrological variables, particularly SM, and the parameters of the landscape at different spatial scales. The strategy and sampling methodology used in this work is to subdivide the landscape into environmental units related to the spatial variability of SM. These units are heterogeneously structured entities which present a certain degree of internal uniformity of hydrological parameters according to climate, soil type, topography, vegetation cover conditions, lithology and elevation and therefore, they are considered to have similar SM levels. The main assumption for each unit is that the dynamical variation of the hydrological parameters within one unit should be minimum compared to the dynamics of another unit. This paper shows the study carried out on the variables influencing SM in the VAS area to localize areas representative of the average SM of the different units inside the SMOS footprint and to estimate the potentiality and suitability of these specific points with respect to the larger area of the footprint. The ultimate objective is to maximize resources and time in the elaboration of SM maps for the validation of SMOS data.

Intensive SM sampling has been carried out in the area at different scales in the framework of different campaigns both at ground level and from aircraft to support the definition of the homogeneous land units as well the spatialisation of SM based on SVAT modeling which is explained below, with the final aim of achieving the full characterization of SM at the scale of a SMOS pixel (~ 50 km) [1].

Before launch, numerous field experiments have been conducted in order to establish the SMOS Level 2 processor L-MEB (*L-band Microwave Emission of the Biosphere*) model [2], a working emission model which is valid for different surfaces provided the appropriate parameterizations are used. L-MEB parameterizations represent semi-empirical adjustments of the radiative transfer equations that describe the propagation of L-band radiation in natural media. They describe, for instance, the attenuation properties of different canopies, or the effects of soil roughness on surface emission.

The two-parameter inversion of L-MEB also provides vegetation water content (VWC). This paper also describes the retrieval of VWC in the VAS site using MODIS data and ground based high resolution maps. A multi-scale approach has been implemented to retrieve VWC at 1 km resolution with MODIS data.

2. GROUND-BASED RADIOMETRY EXPERIMENTS

In recent years, the VAS has hosted various radiometry experiments. These were performed at different scales, from the plot scale to the regional scale (up to 50 km), using ground-based and airborne-based radiometry. The main results are discussed in this communication.

MELBEX-I (*Mediterranean Ecosystem L-Band characterisation Experiment*) was a ground-radiometry experiment run in 2005 using the L-band radiometer EMIRAD over a plot of shrub land. We will present results from this experiment [3] that highlighted the small effect of Mediterranean shrub land at L-band, and investigated the role of exposed rocks in the surface emission.

MELBEX-II was a ground-radiometry experiment run in 2007 using again the EMIRAD L-band radiometer over a plot of vineyards throughout the whole vegetation cycle. Vineyards are the main land use at the VAS site, therefore vineyard parameterizations are crucial for the validation of SMOS data at the VAS. This communication will discuss, in particular, changes in surface roughness throughout the crop year, and changes in the canopy microwave properties throughout the plant growing cycle.

MELBEX-III is the third ground-based radiometry experiment of this series which started in September 2009 using the ESA L-band radiometer ELBARAII-3 mounted on a 15 m tower and fully dedicated to monitoring validation activities at the VAS site during SMOS life time. Since then, the instrument has been measuring brightness temperatures at horizontal and vertical polarization of thermal radiation from the MELBEX-II vineyard area. Measurements are performed automatically at nadir angles between 30° and 70° in steps of 5° every 30 min. At 45°, brightness temperatures are recorded every 5 min. Additional calibration of the radiometer is performed every day around midnight by means of sky brightness measurements at 150°.

Simultaneously with the passive radiometer measurements, *in-situ* SM is measured at representative locations within the respective observed footprints. The common objective of these experiments, besides retrieving surface SM from the tower-based measurements, is to upscale the field-scale data to the VAS scale for calibrating and validating the radiance measured with the overflying MIRAS radiometer on board the SMOS satellite.

2. AIRBORNE-BASED EXPERIMENTS

Airborne measurements at L-band are used to improve the parameterization of the L-MEB model in the area, to improve the match between measured brightness temperatures by SMOS and simulations using ground SM[4].

ESA *SMOS Validation Rehearsal Campaign*, 2008. A control area of 10 x 10 km^2, mostly dedicated to vineyards in winter-like conditions and with significant patches of matorral and shrub land, was flown on four days using the EMIRAD radiometer. SM could be retrieved with good accuracy but only after surface roughness was determined. In fact, the campaign highlighted that close to specular modelling of the surface reflectivity using 0-6 cm measurements of SM underestimated surface emission. This was also observed in other airborne data sets [5].

CNES CAROLS (*Cooperative Airborne Radiometer for Ocean and Land Studies*) campaigns. In 2009, the L-band CAROLS radiometer, similar to the EMIRAD radiometer, was flown on three occasions over an area of 1500 km^2

covering vineyards, shrub land and Mediterranean pine forests. Main results of CAROLS 2009 will be presented in this communication, and the emphasis will be on comparing local to regional scale results given that CAROLS flights were performed at 4000 m above the surface.

MODELLING

This paper also shows the use of surface variables from the VAS site to simulate passive microwave brightness temperature in order to have satellite "match ups" for Cal/Val and to test retrieval algorithms.

Ground and meteorological measurements from the VAS site are used to simulate SM using the SURFEX model with the ISBA module. The validation of this approach was made by means of a point to point comparison with ground measurements from which we obtained good agreement between simulated and measured SM. The spatialization method proposed uses all the available data in order to have SM estimates representative of a SMOS pixel. The second step consists in using output data from the ISBA model to simulate surface emission by using the L-MEB model that helps to better understand the exact signification of the SMOS signal thus giving a first insight of SMOS data. Finally, the results of the above mentioned experiments will be the basis for comparisons between simulated brightness temperatures (TB) and SMOS measured TBs at the VAS site. These exercises will be conducted in order to have an assessment of the L-MEB performance in a highly studied and monitored area, and to help pinpointing future areas of investigation in microwave radiometry.

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