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Demonstration of the assimilation of the future SMOS data by using field and airborne campaigns

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I- Introduction

The SMOS project (ESA/CNES), to be launched in 2007, aims at developing a space-borne L band interferometric radiometer able to provide global estimates of surface soil moisture with a sampling time of 2-3 d. Passive microwave remote sensing may provide quantitative information about the water content of a shallow near-surface soil layer (ws). However, the variable of interest for applications such as short and medium term meteorological modeling and hydrological studies over vegetated areas is the root-zone soil moisture (w2), which controls plant transpiration. Since near-surface soil moisture is related to root-zone soil moisture through diffusion processes, assimilation algorithms may enable one to retrieve w2 content from observed ws. Field or airborne campaigns can be used to validate the coupled land surface/microwave emission models and the assimilation algorithms. In order to test the assimilation of the future SMOS data, dual-polarized, multiangular measurements of L-band brightness temperatures (Tb) need to be collected in contrasting soil moisture conditions, i.e. over a long period of time. Field experiments of several years are feasible provided a lot of efforts are made to build an automatic measurement and data acquisition system. Airborne experiments are expensive but regular observations during a few months are feasible provided the flights are not too long. Once the SMOS data will be available at a global scale (spatial resolution of 30-50 km), ground truth measurements of soil moisture, covering large aridity gradients (several hundreds of km), will permit to validate the SMOS products (ws), and the corresponding analysed w2. Establishing such transects is feasible at a relatively low cost by using existing operational, automatic,

surface networks of meteorological stations.

II- SMOSREX: 3 year field radiometric measurements

In order to validate assimilation algorithms based on time series of L-band Tb, a long data set (at least one annual cycle) must be obtained and a microwave emission model coupled with a land surface model. Moreover, a long-term experiment is required to assess the effects of factors such as dew, frost, rainwater interception by leaves, changes in soil roughness, etc., on the use of the Tb. The SMOSREX field campaign (2003-2006) consists of continuous measurements of Tb over a vegetation canopy and over a bare soil surface, on the PIRRENE site of ONERA, near Toulouse. These observations are performed along with continuous, automatic measurements of the soil moisture and temperature profiles. Soil moisture is measured with probes using frequency domain reflectometry. The local climate is measured continuously: wind speed (at 10 m height), air temperature and humidity (2 m), incident solar and infrared radiation. Vegetation biomass and leaf area index are determined by destructive measurements. Surface temperature is measured by using an infrared radiometer. The L-band radiometer LEWIS made by ONERA (Lemaître et al., IEEE TGRS, 42(8), 1666-1676, 2004) was installed in January 2003. A system permitting automatic multiangular measurements of Tb (3 times per day over the two surface types: fallow and bare soil) including sky calibrations, was developed. The LEWIS radiometer was mounted on a 15-m scaffolding and is able to rotate automatically in order to view two surface types. Two reference sites representative of the studied fallow and bare soil surface were equipped with micrometeorological instruments. The site was equipped with infrared pyrometers (Heitronics) and a multi-band VIS, MIR, PIR instrument (CIMEL) measuring the reflectances. This system permits to assess the assimilation of multi-spectral data. SMOSREX (Météo-France, CESBIO, ONERA, INRA) is supported by CNES.

III- CoSMOS-Toulouse: a 3 month airborne campaign

CoSMOS is an ESA airborne campaign. It will be carried out in April-May-June 2005. Most flights will be performed in the region of Toulouse and opportunity flights will be made in Spain and over the Atlantic Ocean. The objectives of CoSMOS-Toulouse are to - Improve the representativeness of local field campaigns (e.g. SMOSREX) dedicated to the assimilation of remote sensing data, by observing several surface types, - Validate the assimilation algorithms of SMOS data in preoperational conditions, - Assess the use of SMOS data at the regional scale, - Continue the research effort on the L-band emission of forests started after Eurostarrs (2001). The L-band Tb will be measured from the Convair-580 of Environment-Canada by using a radiometer built by the Technical University of Denmark: - fully polarimetric Tb and 2 angles (0 and

40°) - One flight of about 250 km every 3 days (= SMOS sampling time) - Long term (3 months, a total of about 30 flights) - Contrasted conditions of soil moisture (wet to dry) - Dense weather station network available - 7 ground validation sites (Météo-France, CESBIO, INRA, ONERA) - Existing operational products (SIM hydrometeorological system of Météo-France). - Time: before sunrise - Low altitude (500 m).

IV- SMOSMANIA: a soil moisture network for SMOS

SMOSMANIA (Soil Moisture Observing System - Meteorological Automatic Network Integrated Application) is a project aiming at integrating soil moisture measurements in the automatic ground station network of Météo-France (the RADOME network). A 300 km transect in South-western France, including 12 automatic weather stations, will be equipped with ThetaProbes. For the first time, automatic measurements of soil moisture will be integrated in an operational meteorological network. These data will be used to validate the SMOS products and the operational products of the SIM system of Météo-France. They will contribute to analyse and reduce the bias between the SMOS products and the operational models, a first step before assimilating the SMOS data.

V- Conclusion

A validation/demonstration experimental effort is made in South-Western France to assess the assimilation of the future SMOS data into land surface models used in meteorology and hydrology.