VALIDATION OF SMOS: SOME FIRST RESULTS

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1. INTRODUCTION

With the European Space Agency's (ESA) Soil Moisture and Ocean Salinity (SMOS) satellite successfully launched on 2 November 2009, the first long-term space-borne passive microwave observations at L-band (~ 1.4 GHz) are now becoming available. SMOS is the first satellite mission dedicated to global mapping of near-real-time surface soil moisture information. Although space-borne microwave instruments at high frequencies (e.g., C- and X-band) have been providing global coverage of data for the last 30 years, this innovative interferometric L-band radiometer is expected to provide improved soil moisture estimates due to the longer wavelength data.

Internationally there has been significant anticipation for the launch of SMOS. Moreover, there is considerable expectation that SMOS will deliver soil moisture data globally on a repeat cycle better than 3 days with an error of less than 4%v/v for areas with vegetation water content less than 4 kg/m^2 [1], and that this information will lead to improved numerical weather prediction, more accurate flood forecasting, and best-practice agricultural management, to name a few. However, SMOS has adopted a new generation technology that has never before been used on a satellite. Moreover, it is the first satellite dedicated to soil moisture measurement at L-band, and thus needs to be thoroughly tested. Consequently, airborne field campaigns are essential to validate both the brightness temperature maps and the derived soil moisture products provided by SMOS using data from i) passive microwave airborne observations at L-band using real-aperture technology, ii) detailed ground measurements of surface soil moisture content and associated environmental parameters, and iii) long-term soil moisture monitoring network data from a selection of in-situ sites (e.g. Murrumbidgee in Australia, Valencia in Spain, Upper Danube in Germany, Midi-Pyrenees in France etc.). Due to the timing of the SMOS launch (i.e., northern

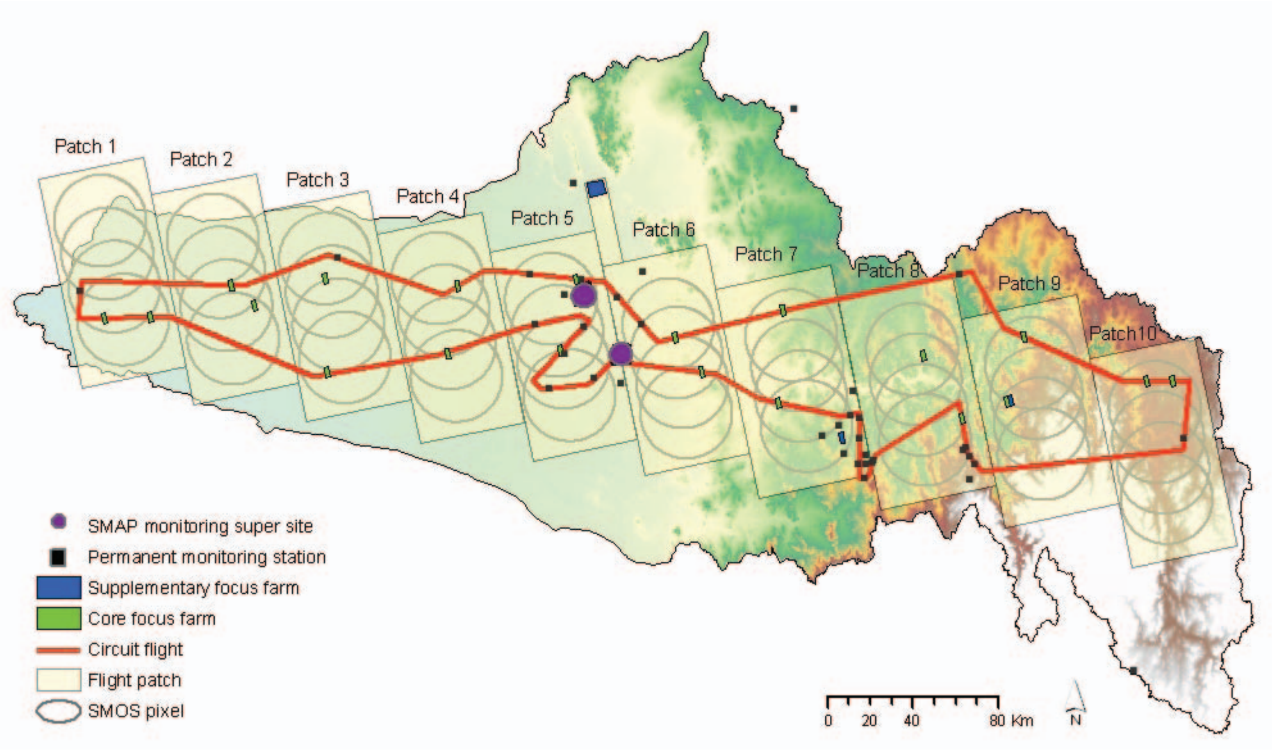

Figure 1: AACES overview showing the location of the 10 intensive flight domains (yellow boxes) and a continuous circuit flight path (red line) overlaying the SMOS pixels (circles), locations of core (green rectangles) and supplementary (blue rectangles) focus farms, permanent in-situ monitoring locations (black squares) and in-situ monitoring super sites (purple circles) within the Murrumbidgee catchment. The background shows topographic variation from low and flat in the west (light green) to alpine in the east (white).

hemisphere autumn), Australia is well positioned to conduct the first intensive SMOS validation campaign during its growing season.

The Australian Airborne Cal/val Experiments for SMOS (AACES) are expected to provide one of the most comprehensive assessments of SMOS world-wide, due to its combined airborne and in-situ data collection strategy across an extensive transect of the Murrumbidgee catchment in south-eastern Australia (Fig. 1). This area is unique as it comprises a wide variety of topographic, climatic and land cover characteristics, and therefore represents an excellent validation site for the land component of this satellite mission. This paper outlines the airborne and ground monitoring for the Australian SMOS validation campaigns. Results from the first campaign to be conducted in January-February 2010 will be presented.

2. STUDY AREA

The AACES are being conducted across the entire Murrumbidgee River Catchment located in south-eastern Australia (-33° to -37°S, 143° to 150°E). As illustrated in Fig. 1, there are a total of 38 soil moisture profile stations distributed across the catchment (see also http://www.oznet.unimelb.edu.au), with clusters of 5 or more surface soil moisture probes at several of these in the Yanco monitoring area (SMAP "super sites"). Moreover, parts of the catchment (Yanco and Kyeamba) have already been the focus of a previous and very successful campaign in 2006, called the National Airborne Field Experiment (NAFE; see http://www.nafe.unimelb.edu.au), which tested amongst other things the suitability of the area for SMOS calibration and validation purposes [2, 3].

Due to its distinctive topography, the Murrumbidgee catchment exhibits a significant spatial variability in climate, topography, soil, vegetation and land cover. Moreover, the diversity within this confined area, the large amount of complementary data from long-term monitoring sites, and the past airborne field experiment, this region is an ideal test-bed for the comprehensive validation of SMOS described here, and is highly complementary to the current study sites in other countries. Considering the size of the satellite footprint, there are still regions that are relatively homogeneous (especially the western part of the catchment) in regards to climate, soil type and vegetation when compared to other study sites in Europe and the United States. Further details on the study areas can be found in [4].

3. FIELD CAMPAIGNS

Compared to the planned European validation campaigns, which will comprise a single SMOS pixel, or transects through a few SMOS pixels with a number of repeat flights over a few months, the Australian campaigns will focus on accurately mapping the spatial variability across an area comprising about 20 independent SMOS pixels with temporal variability assessed according to season. Thus, features such as climatic, topographic and seasonal changes will be mapped on a much larger spatial and temporal scale than the equivalent campaigns elsewhere. Consequently, these experiments will contribute to comprehensive validation of SMOS brightness temperature and soil moisture, and are highly complementary to the planned activities in other countries.

The commissioning phase of SMOS is scheduled to last only 6 months, after which the mission will be considered "operational". It is thus important that at least one extensive validation campaign be conducted during the post-launch commissioning phase. Moreover, the first 8 weeks post-launch are dedicated to switching on and commissioning the payload itself, so the optimal time for a campaign is after 4 January 2010. During the commissioning, data will be acquired all the time but with dual and full polarisation alternating week about. At the end of the commissioning period a decision must be made by ESA to measure either dual or full polarisation data only. Consequently, the optimal time for a SMOS validation campaign is January/February 2010.

The first of the planned series of four AACES campaigns, scheduled for 20 January to 20 February 2010, is able to meet these requirements, because of its location in the southern hemisphere and that the campaign is designed to cover a large transect with significant variability in conditions. The campaigns are planned to cover a

100 km x 500 km (more than 20 independent SMOS pixels) transect of the Murrumbidgee catchment in its entirety at 1 km spatial resolution using an L-band radiometer, with flights timed to coincide with SMOS overpasses. The primary airborne instruments will include the Polarimetric L-band Multibeam Radiometer (PLMR), thermal infrared and multi-spectral sensors, supported by surface soil moisture content, soil temperature, and rainfall data from the Murrumbidgee (OzNet) monitoring network. This will be further complemented by short-term soil moisture and temperature monitoring stations with additional leaf wetness and thermal infrared measurements, intensive soil moisture observations with the Hydraprobe Data Acquisition System (HDAS), and extensive vegetation characterisation, at a number of focus farms.

4. SUMMARY

The Australian Airborne Cal/val Experiments for SMOS (AACES) are planned take place across the entire Murrumbidgee catchment during four separate month-long campaigns over a two year timeframe, enabling the effects of seasonal variation in vegetation condition and land cover change to be assessed in addition to soil moisture. Consequently, issues related to snow cover, litter, vegetation dynamics etc will be assessed in relation to soil moisture retrieval. Results from the first campaign, to be undertaken in January and February 2010 will be presented.

5. REFERENCES

[1] Kerr, Y.H., P. Waldteufel, J.P. Wigneron, J.M. Martinuzzi, J.M. Font and M. Berger (2001), Soil moisture retrieval from space: The Soil Moisture and Ocean Salinity (SMOS) mission. *IEEE Trans. Geosci. Rem. Sens.*, **39**(8): 1729−1735. .

[2] Merlin, O., Walker, J. P., Kalma, J. D., Kim, E., Hacker, J., Panciera, R., Young, R., Summerell, G., Hornbuckle, J., Hafeez, M., and Jackson, T., 2008. The NAFE'06 Data Set: Towards Soil Moisture Retrieval at Intermediate Resolution. *Adv. Wat. Resour.*, **31**(11):1444-1455.

[3] Azcurra, C. and Walker, J.P., 2009. Towards SMOS Validation in South-eastern Australia. In Anderssen, R.S., R.D. Braddock and L.T.H. Newham (eds) *18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation*. Modelling and Simulation Society of Australia and New Zealand and International Association for Mathematics and Computers in Simulation, July 2009, pp. 3675-3681.

[4] Peischl, S., Walker, J.P., Allahmoradi, M., Barrett, D., Gurney, R., Kerr, Y., Kim, E. LeMarshall, J., Rüdiger, C., Ryu D., and Ye N., 2009. Towards Validation of SMOS Using Airborne and Ground Data Over the Murrumbidgee Catchment. In Anderssen, R.S., R.D. Braddock and L.T.H. Newham (eds) *18th World IMACS Congress and MODSIM09 International Congress on Modelling and Simulation*. Modelling and Simulation Society of Australia and New Zealand and International Association for Mathematics and Computers in Simulation, July 2009, pp. 3733-3739.