HIGH RESOLUTION SOIL MOISTURE ESTIMATES OVER THE MURRUMBIDGEE CATCHMENT USING AIRBORNE AACES DATA

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1. INTRODUCTION

The Murrumbidgee River catchment in south-eastern Australia has one of the most diverse climate conditions in the country, ranging from the alpine areas in the East with elevations up to 2,000 m, through to shrublands and grasslands in the semi-arid plains of the West with elevations as low as 50 m. The wide range of climatic, topographic and land cover variability within an approximately 500×100 km^2 area makes this catchment an excellent location for the validation of remote sensing data.

After the launch of the European Space Agency's Soil Moisture and Ocean Salinity (SMOS) mission in November 2009 [1], its products required a thorough validation at scales similar to the satellite footprint (~42km), and the proposed downscaling techniques had to be assessed. To provide a benchmark for these analyses, the Australian Airborne Cal/val Experiments for SMOS (AACES) were undertaken across the Murrumbidgee catchment during the Australian summer and winter season of 2010, respectively. The data set includes airborne L-band (1.413 GHz) brightness temperature, thermal infrared and multi-spectral observations at 1 km resolution, as well as intensive ground observations of soil moisture and ancillary data, such as soil temperature, soil texture, surface roughness, vegetation water content, dew amount, leaf area index and spectral characteristics of the vegetation [2].

In this paper, the retrieval of soil moisture from AACES airborne brightness temperatures using the L-band Microwave Emission of the Biosphere (L-MEB) model will be presented. L-MEB assembles a set of equations describing the emission and scattering of the surface, vegetation and atmosphere at L-band and constitutes the core of the SMOS L2 algorithm [3; 4]. L-MEB has been used in previous studies using airborne field data under Australian conditions [5; 6], but not at such a large scale as in the AACES experiments, nor for such a diverse environment. Soil moisture maps at 1 km over the Murrumbidgee River catchment using the default and calibrated parameterization of L-MEB will be presented and discussed.

2. THE AACES DATA SET

The AACES experiment comprises two field campaigns: AACES-1, conducted over five weeks in January/February 2010, and AACES-2, conducted over three weeks in September 2010. The AACES-1 summer campaign focused on all ten patches of the 500×100 km^2 transect outlined in Fig. 1, whereas the AACES-2 winter campaign was reduced in terms of spatial coverage and ground sampling to the five central patches. Data from AACES is available through the website http://www.moisturemap.monash.edu.au/aaces.

2.1. Airborne data

The airborne instruments operated in both AACES campaigns were the Polarimetric L-band Multi-beam Radiometer (PLMR), supported by six thermal infrared sensors. The PLMR operates at 1.413 GHz providing dual polarization observations at three incidence angles (±7, ±21.5, and ±38.5 degrees) at a nominal 1 km spatial resolution (at 3000 m flight altitude above ground level). All flights were nearly coincident with SMOS overpasses. A total of 85 (45) flight hours were conducted during AACES-1 (AACES-2).

Figure 2 shows an example of dual polarization L-band brightness temperature collected during the summer campaign. The progression of the flight patches was from west to east. The low brightness temperatures observed in the east of the catchment are due to significant rainfall in the area during the experiment. These weather conditions in summer, together with a remarkably wet winter in 2010, provide a good opportunity to assess the performance of L-MEB over a broad range of soil moisture conditions [7].

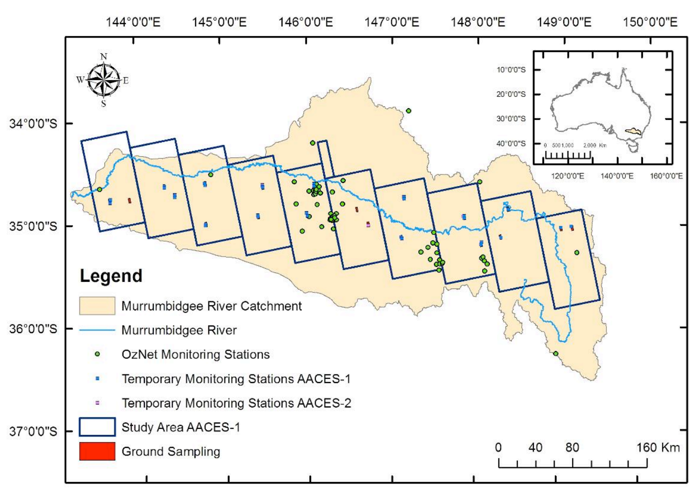

Figure 1. Overview of the Murrumbdigee River catchment, NSW, Australia. Each of the ten flight patches covered during AACES-1 as well as the location of the long-term (OzNet) and temporary soil moisture sites and ground sampling areas are indicated in the map.

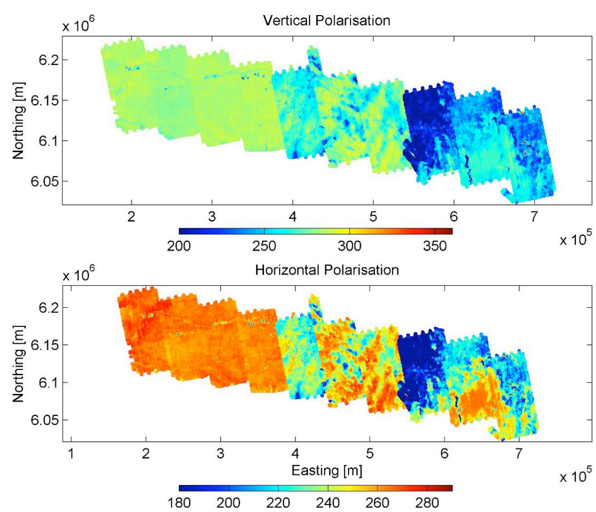

Figure 2. Example of PLMR airborne brightness temperature at vertical (top) and horizontal (bottom) polarisation during AACES-1. Each of the rectangular patches corresponds to a different flight day (from [7]).

2.2. Ground data

The in situ sampling was conducted in areas representative of the conditions of each flight patch and comprised:

- the OzNet monitoring network, with 62 stations throughout the entire Murrumbidgee River catchment ([8]; http://www.oznet.org.au) soil profile temperature and moisture observations and rainfall data;
- temporary monitoring stations, recording soil moisture, soil temperature (both to a depth of 25cm), rainfall, leaf wetness, and skin temperature using a thermal infrared sensor, and
- intensive high resolution surface soil moisture and vegetation measurements at 20 different 2×5 km^2 focus farms [2].

3. METHODOLOGY

Prior to retrieving high resolution soil moisture from the PLMR brightness temperatures, AACES-1 airborne measurements have been compared against simulated L-MEB brightness temperatures using in situ ground sampling data from all focus farms. The L-MEB predictions using the default parameters of the model were close to the PLMR observations for dry conditions, whereas up to 25 K difference was found under wet conditions, particularly on days after rain, with L-MEB overestimating the land emission [2]. A similar study is being performed with AACES-2 data.

The retrieval of soil moisture will be undertaken for specific flight patches in the central and western areas of the catchment, where the impact of topography is expected to be lower, using the default L-MEB settings in [3] and a 3-Parameter configuration (ie., soil moisture *SM* will be estimated together with the effective roughness *HR* and optical thickness of vegetation at nadir τ). Additional 3-P retrieval will be performed using parameters calibrated in the focus areas instead of the default ones. As vegetation water content plays a significant role in the retrieval mechanisms of L-MEB, the days having a large difference between predictions and observations will be of particular focus. Ground data are available on both leaf wetness and integrated vegetation water content (ie. plant water and leaf wetness) through the ground data collection. First, the sensitivity of L-MEB to vegetation water content for various vegetation types will be assessed, followed by a modeling of L-MEB with both integrated water content and plant water only. This will provide a further insight into the importance of leaf wetness and eventually dew.

4. CONCLUSIONS

This paper presents a study on high-resolution soil moisture maps across the 50,000km^2 Murrumbidgee River catchment, making use of the extensive brightness temperature data collected during AACES-1 and -2.

The applicability of the radiative transfer model's default parameterization is assessed and the model calibrated using the ground-based observations of the campaigns. The sensitivity of L-MEB to certain model parameters is also investigated (in particular vegetation water content), to determine the accuracy to which they need to be known for accurate soil moisture retrieval at large scale. The high-resolution soil moisture map over the Murrumbidgee catchment will be crucial for further hydrologic analysis, including comparisons with high resolution maps derived from SMOS by [9].

5. ACKNOWLEDGMENTS

The AACES campaigns were funded through the Australian Research Council (ARA) project DP0879212 as part of the MoistureMap project. The airborne instrumentation has been developed through ARC infrastructure grants (LE0453434, LE0560930).

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