APPLICATIONS OF SMOS DATA IN AUSTRALIA

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1. INTRODUCTION

The European Space Agency-led Soil Moisture and Ocean Salinity (SMOS) satellite [1] was successfully launched in November 2009 and has provided continuous brightness temperature and derived products since. As Australia was found to be unaffected by Radio-Frequency-Interference (RFI) [2] in contrast with Asia, Europe and certain parts of North America, it was seen as the most suitable continent to conduct extensive and large scale experiments using the available data sets. To date, the studies conducted across Australia range from Level 1C brightness temperature calibration and validation efforts to Level 3 soil moisture analyses and instrument intercomparisons. The particular focus for these studies has included the entire Australian continent, the Murray-Darling Basin, and the Murrumbidgee River catchment. A summary of these studies is presented, outlining the methodologies and briefly discussing the results and outlook.

2. DATA SOURCES AND STUDY AREAS

The studies have all been conducted across Australia with a particular focus on the 1.1 million km^2 Murray-Darling basin, a key catchment on the continent. With in excess of 70% of the country's agricultural products coming from this river basin, it serves as the "food bowl" of Australia. The validation campaigns were conducted in the southern-most subcatchment of the Murray-Darling basin, the 80,000 km^2 Murrumbidgee River catchment, which is equipped with over 60 monitoring stations, continuously providing precipitation, as well as soil profile temperature and moisture down to a depth of 90cm (see [3] for detailed a description of the catchment and the monitoring equipment). In 2010, two large airborne field campaigns were conducted across the Murrumbidgee catchment (see [4] for a full experiment description), providing a high-resolution (1km) brightness temperature observations across a 50,000 km^2 transect of the catchment.

The SMOS data used in those studies include different processing levels: i) the brightness temperature validation studies are based on a comparison of the airborne 1km product and the gridded SMOS Level 1C v.5.04, 2nd re-processing, data release; ii) the Level 2 gridded soil moisture product for the data assimilation and soil moisture validation; and iii) the Level 3 soil moisture product for the product intercomparison study. Land surface model estimates were obtained from the European Centre for Medium-Range Weather Forecasting (ECMWF) operational soil moisture analysis and the Australian Bureau of Meteorology's ACCESS NWP model.

3. APPLICATIONS

3.1. Brightness temperature validation across the Murrumbidgee River catchment

The brightness temperature validation was performed using 15 flights across the Murrumbidgee River catchment, coinciding with the morning overpasses of SMOS at ~6am. The PLMR data were normalized to a reference angle of 38° and corrected to the 6am reference for diurnal soil temperature drifts during the flight. The SMOS data were taken from the Level 1C (v.5.04) data set and filtered according to flags and incidence angles. The four flags were: i) alias-free zone, ii) no border, iii) no suntail, and iv) no sun point. After the initial filtering, data from incidence angles between 37° and 39° were selected and linearly averaged to provide the 38° reference brightness temperature. The two main analyses performed using those data were a comparison between SMOS footprint-size (~42km) aggregated airborne data with the actual SMOS footprint value, and also an analysis of spatial effects, ie. using the gridded representation of SMOS data on a 15km grid and comparing those against the airborne data at the same scale. It was found that a persistent warm bias exists between SMOS and the airborne data of 2.2-4.6K and a de-biased root mean square difference of 1.6-6.2K (both ranges depending on the incidence angle and polarization). Moreover, it was discovered that the use of SMOS at the 15km scale only marginally degraded the overall accuracy of the observation (Fig. 1), which may have significant implications for data assimilation applications

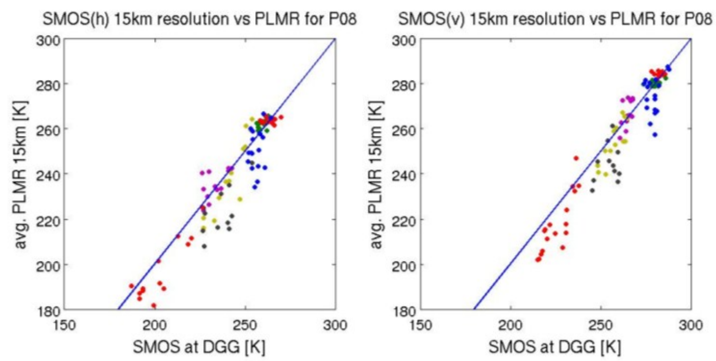

Fig. 1 Scatterplots of H- and V-polarized SMOS data at 15km against aggregated PLMR data.

3.2. Data assimilation study

In the data assimilation study, an Evolutionary Extended Kalman Filter was used to test the added value to the land surface model states of the Joint UK Land Environment Simulator (JULES) model. This work is still under progress at the current stage, but initial results suggest that a gain in the model performance is achieved, when compared to the in-situ observation sites of the Murrumbidgee River catchment.

3.3. Level 2 soil moisture validation

A soil moisture validation was performed using the SMOS Level 2 gridded soil moisture product, gridded ASCAT soil moisture retrievals, the ECMWF soil moisture analysis from the atmospheric model runs (SM-DAS-2), and 38 of the in-situ monitoring stations in the Murrumbidgee River catchment. It was found that all data products showed a similarly good range of correlations to the respective ground stations, despite ASCAT and

SMOS having different observation depths. Fig. 2 shows a Taylor diagram of the results with the normalized standard deviation (SDV; the standard deviation of the satellite/model divided by that of the in-situ reference) and the correlation. The lower SMOS SDV suggests that SMOS has a lower dynamic range than the in-situ data, whereas ASCAT and SM-DAS-2 are closer to that of the in-situ data on average.

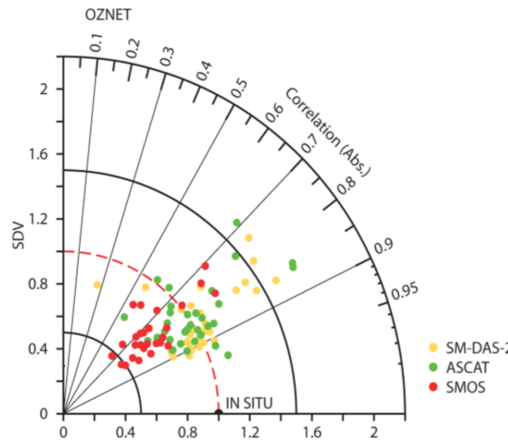

Fig. 2. Taylor diagram of SMOS, ASCAT, and SM-DAS-2 soil moisture agains the in-situ observations (figure adapted from [5]).

A further study investigated the downscaling of the coarse scale soil moisture data using high-resolution thermal observations (notably the evaporative fraction) [6]. A qualitative comparison shows a good resemblance of the vegetation and soil moisture patterns within the SMOS footprint. A comparison with the in-situ measurements of the Murrumbidgee River catchement is currently under way.

3.4. Brightness temperature evaluation across the Murray-Darling Basin

In order to extend the validation of the SMOS Level 1C brightness temperature product, the Community Microwave Emission Model has been set up to be run in the current SMOS-configuration (Mironov soil model). A timeseries of brightness temperature data are being produced and compared against the SMOS products. The land surface information for the input into the radiative transfer model will be provided by the operational data sets of the AWRA model. This study is also still in progress and will eventually provide information on the quality of the spatial information contained in SMOS data.

3.5. Soil moisture product intercomparison across Australia

An intercomparison of continent-wide modelled surface soil moisture estimates from the ACCESS NWP model of the Australian Bureau of Meteorology with ASCAT surface soil wetness and the Level 3 SMOS surface soil moisture products shows a good overall temporal correlation for both data sets, particularly in the sparsely vegetated areas of northern Australia. The temporal correlations are reduced in the southern regions, where vegetation plays a more dominant role, as well as in more mountainous terrains. Overall, it is found that the SMOS ascending passes show a slightly better result than the descending passes. To account for differences between the shallow sensing depth of the remotely sensed products and the model topmost soil layer thickness (10 cm) an exponential filter is used [6], with assumed time constant T of 3 (SMOS) and 5 (ASCAT) days. Further work is planned to determine more optimal values of the exponential filter time constant T.

4. CONCLUSIONS

A number of studies involving various SMOS data products have been presented. The SMOS Level 1C data were shown to relate well with the airborne data collected across the Murrumbidgee River catchment. Moreover, it was shown that the SMOS T_B data may be used at its gridded 15km resolution, with minimal loss in the data accuracy. Soil moisture studies showed a good correlation of SMOS data with in-situ measurements, giving confidence in the SMOS Level 2 data quality, despite the lower dynamic range displayed in the satellite data. An Australia-wide study showed a high level of correlation, particularly in the savannah regions of northern Australia for both SMOS and ASCAT data with the modelled soil moisture estimates. With the good correlation between SMOS and the in-situ data within the Murrumbidgee River basin, it may be assumed that the data quality in the more sparsely vegetated areas of central and northern Australia are of equally good quality. Thus it may be postulated that the high correlations give confidence in both, the modelled and the remotely sensed soil moisture data sets.

5. ACKNOWLEDGMENT

The AACES campaigns were funded by ARC DP0879212.

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