TOWARDS A MEDIUM RESOLUTION BRIGHTNESS TEMPERATURE PRODUCT FROM ACTIVE AND PASSIVE MICROWAVE OBSERVATIONS

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1. INTRODUCTION

Global measurements of soil moisture are vital to understanding the global water, energy and carbon cycles. An accurate estimation of soil moisture at a spatial resolution of better than 10km will benefit the future development of regional water resource applications, such as weather forecasting, flood prediction and agricultural activities. Therefore the objective of NASA's Soil Moisture Active Passive (SMAP) mission [1], scheduled for launch in 2014, is to achieve a medium resolution (~9km) soil moisture estimate with a 0.04 m^3/m^3 accuracy in areas having a vegetation water content less than $5kg/m^2$, through combination of high resolution (~3km) but noisy radar data with accurate but lower resolution (~36km) radiometer data. However, given the novelty of the SMAP viewing configuration, the downscaling algorithms required to achieve such an intermediate soil moisture product through the synergy of active-passive data, have so far received only limited testing with real data sets (airborne or spaceborne). Consequently, this study tests the baseline downscaling algorithm developed for SMAP [2], using experimental airborne data collected by a SMAP airborne simulator and supporting ground data.

2. STUDY SITE

The study site is located in the semi-arid agricultural area near Yanco, in the Murrumbidgee Catchment, south-eastern Australia (Fig. 1). This site has been extensively monitored for soil moisture with in-situ stations since 2003, and has been the focus of several airborne field experiments. It is also listed as an official SMAP core calibration/validation site. The Soil Moisture Active Passive Experiments (SMAPEx) held in this site consist of a series of three field campaigns specifically designed to contribute to the development of radar and radiometer soil moisture retrieval algorithms for the SMAP mission [3]. The airborne data were collected using a SMAP simulator, which included the Polarimetric L-band Multibeam Radiometer (PLMR) and the Polarimetric L-band Imaging Synthetic aperture radar

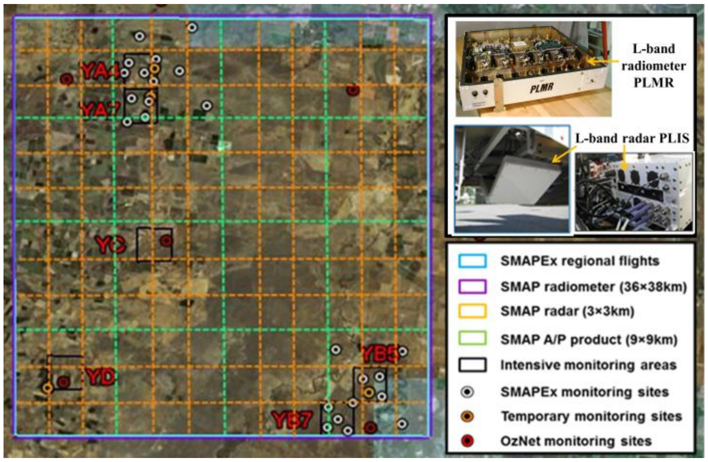

Fig. 1: Overview of the SMAPEx site and its focus areas, with a size of ~36km×38km, approximating one SMAP radiometer pixel. Inset shows the airborne sensors PLMR and PLIS.

(PLIS) aboard the same aircraft. The system provided brightness temperature and backscatter coefficient at 1km and 10m respectively from a 3,000m flying altitude. Such data can be used to replicate the SMAP data stream for validating algorithms applicable to the SMAP mission viewing configuration. The main SMAPEx flights included simulation of a time series of SMAP observations by coverage of a 36km×38km area (equivalent to a pixel of the SMAP EASE grid at 35°S latitude) with a 2-3 days revisit time. Ground sampling of soil moisture, vegetation and roughness data were conducted concurrently with the airborne flights, in order to provide ancillary and validation data. Radiometer and radar data used in this study were from the third SMAPEx campaign (SMAPEx-3, September 5-23, 2011).

3. METHODOLOGY AND RESULTS

Before testing the baseline downscaling algorithm with SMAPEx data, the airborne observations were processed to closely represent the SMAP data stream in terms of spatial resolution, incidence angle, and azimuth direction. Consequently, the PLMR brightness temperatures observed at ±7°, ±21.5°, and ±38.5° incidence angles, and the PLIS backscattering observed at incidence angles ranging from 15° to 45°, were both normalized to the 40° of SMAP [4]. Subsequently, the 10m resolution PLIS and 1km resolution PLMR were upscaled to 1km and 36km respectively, being the SMAP radar and radiometer L1 product resolution. The impact of changes in the azimuthal view angle was also assessed and found to be unimportant at these spatial resolutions. An example of the resulting radar and radiometer observations is shown in Fig. 2. These data were then used to test the baseline downscaling algorithm for SMAP, which is based on the hypothesis of a near linear relationship between radiometer brightness

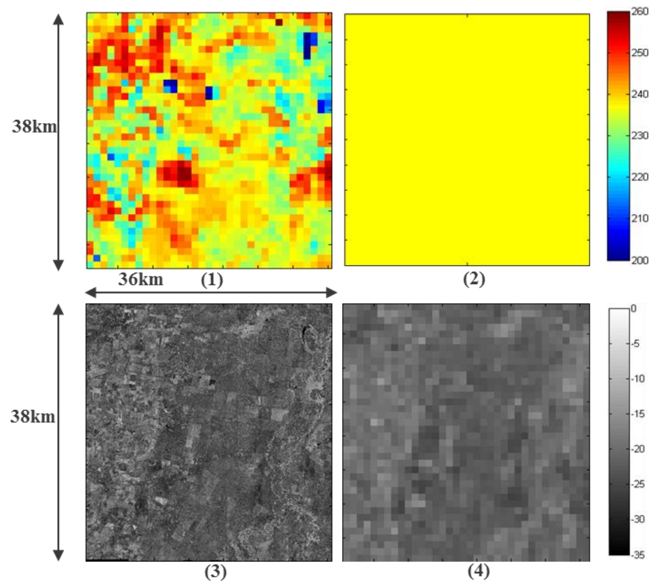

Fig. 2: Example of the simulated SMAP prototype data from PLMR and PLIS observations, with incidence angle normalized to 40°: (1) PLMR observed at 1km & at h-pol; (2) PLMR upscaled to 36km & at h-pol; (3) PLIS observed at 10m & at vv-pol; and (4) PLIS upscaled to 1km & at vv-pol.

temperature and radar backscatter observations at the same resolution [5, 6]. Application of the algorithm involves three main steps: 1) estimation of a parameter β using a time-series of vv-pol radar and h-pol radiometer data at coarse scale; 2) estimation of a parameter γ using the same time-series of radar data but at hv-pol and at vv-pol; and 3) estimation of vegetation conditions by the respective variation of radar backscatter at hv- and vv-pol across the entire area. Fig. 3 shows an example of the downscaling results at 1km resolution obtained from this downscaling algorithm. The Root-Mean-Square-Error (RMSE) of the downscaled brightness temperatures with respect to the PLMR observed brightness temperatures is approximately 8-9K at 1km resolution and 2-4K at 9km resolution.

4. CONCLUSIONS

Medium resolution (9km) brightness temperature can be derived through the combination of radiometer and radar observations. This study has tested the baseline active passive downscaling algorithm that has thus far received quite limited evaluation using experimental data. Based on an airborne simulation of the SMAP data stream from the SMAPEx field campaigns, the downscaling algorithm was found to yield an accuracy of downscaled brightness temperature between 8 and 9K at 1km for h-pol. The accuracy improved to between 2 and 4K when applied at 9km resolution. The performance of the algorithm was slightly better at v-pol (improvement of 0.7K) than at h-pol at 9km. Results also indicated that the error of downscaled brightness temperature is generally smaller in grassland than in crop areas

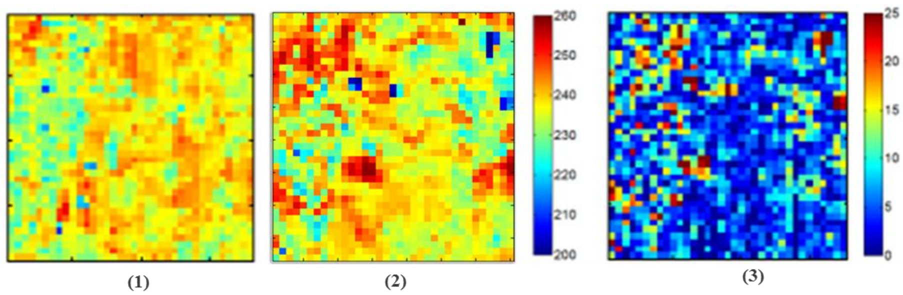

Fig. 3: Example of the downscaling results at 1km resolution: (1) downscaled brightness temperature at h-pol; (2) PLMR brightness temperature observations at h-pol as the reference; (3) difference between downscaled result and PLMR observations in each pixel.

by about 1K at 9km. The accuracy of the downscaled brightness temperature from this study also depends on the robustness of β and γ estimates derived from the SMAPEx data. Based on the downscaled brightness temperature results, it should be possible to achieve a soil moisture product at medium resolution within the specified accuracy requirement.

5. ACKNOWLEDGEMENTS

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