THE POLARIMETRIC L-BAND MULTI-BEAM RADIOMETER

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1. INTRODUCTION

Passive microwave remote sensing has become widely accepted as the most promising technique for remote sensing of soil moisture, with two soil moisture dedicated missions based on this technology. These are the Soil Moisture and Ocean Salinity (SMOS) mission launched by the European Space Agency in 2009 [1], and the Soil Moisture Active Passive (SMAP) mission under development by the National Aeronautical and Space Administration with a scheduled launch in 2014 [2]. While the SMAP mission will make use of radar data to downscale to 10 km the approximately 40 km spatial resolution radiometer measurements that space-borne passive microwave sensors provide, the soil moisture retrievals will still be based on interpretation of passive microwave measurements at L-band. Consequently, there has been a need for airborne passive microwave sensors to develop the pre-launch soil moisture retrieval algorithms, improve on post-launch soil moisture retrieval algorithms, independently confirm the calibration of satellite brightness temperature measurements, and verify downscaling algorithms. This paper presents an overview of the Polarimetric L-band Multi-beam Radiometer and its use for these purposes.

2. INSTRUMENT

The Polarimetric L-band Multi-beam Radiometer (PLMR) is a relatively compact and lightweight system for airborne operation using a small aircraft. The PLMR uses an 8×8 array of dual polarized microstrip patches and two Butler beam-forming matrices to receive the naturally emitted microwave energy from the earth surface at 1.413GHz central frequency with 24MHz bandwidth. An embedded computer located inside the antenna enclosure collects digital counts corresponding to scene brightness along with physical temperature of critical parts of the electronics, which are transmitted to an external data logging computer that stores the PLMR output along with a GPS one-pulse-per-second input, for time synchronization with a standalone INS/GPS unit that is used for georegistration purposes. The PLMR has 6 beams at incidence angles of ±7˚, ±21.5˚ and ±38.5˚ with an approximately 15˚ field of view for each beam, resulting in a spatial resolution of approximately one-third the flying height. The symmetrical design of PLMR means that it can be installed with the 6 beams orientated either across- or along-track, in which case multi-incidence angle data similar to that provided from SMOS may be obtained for the same points on the ground. The PLMR has recently been combined with a Polarimetric L-band Imaging Synthetic aperture radar (PLIS) to simulate data from the Aquarius and SMAP missions (Fig. 1a). The accuracy of PLMR is better than 0.7 K for H-polarization and 2 K for V-polarization including system noise and in flight calibration drift [3], using hot and cold calibrations before and after each flight utilizing a calibration target and the sky, as well as in-flight low altitude passes of a water body where water temperature and salinity are monitored (Fig 1b).

3. APPLICATIONS

The PLMR has been used in several important airborne field campaigns over the past eight years. In 2005 it was used in the National Airborne Field Experiment (NAFE’05) that was conducted together with the Cooperation for SMOS (CoSMOS) pre-launch field campaign using EMIRAD, in the Goulburn River catchment of eastern Australia [4]. An example time series of high resolution (62.5m) brightness

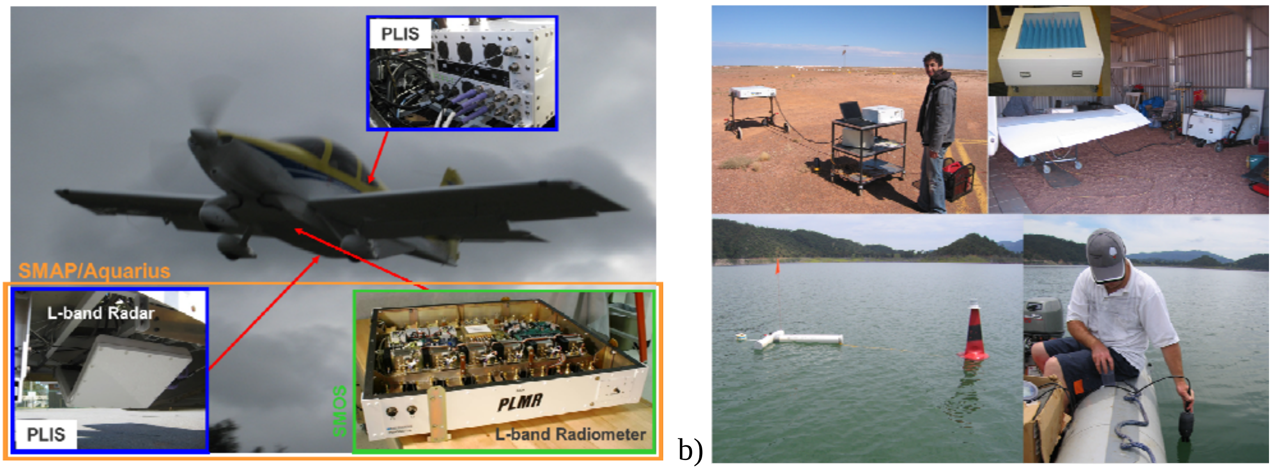
a) 

Fig. 1: Operation of the Polarimetric L-band Multi-beam Radiometer (PLMR) showing a) installation on the aircraft and b) pre- & post-flight calibrations. Also shown is the Polarimeteric L-band Imaging Synthetic aperture radar (PLIS) that converts PLMR from a SMOS simulator to a SMAP/Aquarius simulator.

temperature maps across the month-long campaign is shown in Fig. 2a for one of the focus farms. It was also used in the three-week long NAFE'06 campaign that was conducted in the Yanco area of the Murrumbidgee catchment in south eastern Australia [5]. Subsequently it was used in the two post-launch Australian Airborne Calibration/validation Experiments for SMOS (AACES) that were conducted in summer and winter of 2010, across the entire 80,000 km^2 Murrumbidgee Catchment [6]. A collage of 1km resolution data from the AACES-1 campaign is shown in Fig 2b. During the intervening time there has also been a deployment to Germany in the context of SMOS, and to the Australian arid zone to assess the suitability of potential on-orbit calibration targets for SMOS and SMAP. Most recently it has been used in the series of Soil Moisture Active Passive Experiments (SMAPex) over winter 2010, summer 2010 and spring 2011, for the purpose of pre-launch algorithm testing [7], and in the HiWater experiment in China during Spring 2012.

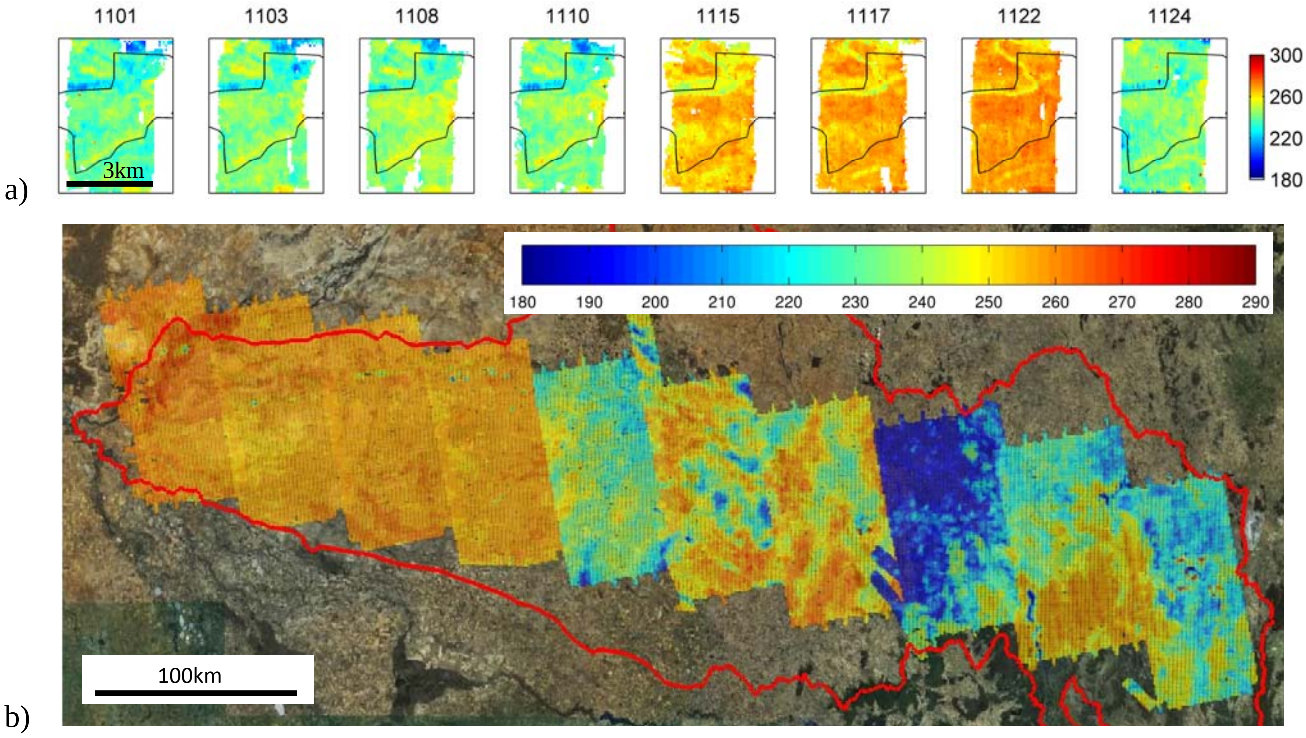


Fig. 2: Examples of PLMR brightness temperature data collected at h-polarisation with a) 62.5m spatial resolution across a focus farm during the NAFE'05 in the Goulburn Catchment (month and day of time sequence are indicated above each panel) and b) 1km spatial resolution across the Murrumbidgee Catchment during the 5-week long AACES-1 (each 50km x 100km patch is sampled on a different date). Data have been normalised to a constant 38 incidence angle in both cases.

4. CONCLUSIONS

The Polarimetric L-band Multi-beam Radiometer has been used in many airborne field campaigns over the past eight years. Consequently it has contributed significantly to pre-launch SMOS algorithm development, SMOS post-launch calibration/validation and algorithm refinement, and is currently making important contributions to SMAP pre-launch algorithm testing. Papers on the use of PLMR for these purposes are presented in other sessions of this conference, showing the results from those studies.

5. ACKNOWLEDGEMENTS

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