AN AIRBORNE SIMULATION OF THE SMAP DATA STREAM

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ABSTRACT

Once launched in late 2014, NASA's Soil Moisture Active Passive (SMAP) mission will use a combination of a four-channel L-band radiometer and a three-channel L-band radar to provide high resolution global mapping of soil moisture and landscape freeze/thaw state every 2-3 days. These measurements are valuable to improved understanding of the Earth's water, energy, and carbon cycles, and to many applications of societal benefit. In order for soil moisture and freeze/thaw to be retrieved accurately from SMAP microwave data, prelaunch activities are concentrating on developing improved geophysical retrieval algorithms for each of the SMAP baseline products using data from simulations, from existing satellite missions such as SMOS, and from field campaign data, such as the SMAPEx airborne study in Australia discussed in this paper.

Keywords (Index Terms) *-- soil moisture, microwave, geophysical retrievals, airborne data, SMAP, Australia.*

1. INTRODUCTION

The Soil Moisture Active Passive (SMAP) mission [1] under development by NASA is scheduled for launch in late October, 2014. This soil moisture and freeze/thaw dedicated mission will be the first to provide soil moisture globally at ~9 km spatial resolution with a 2-3 day repeat, by combining L-band radiometer data at ~36 km resolution with L-band radar data at ~3 km resolution (Fig. 1). The rationale is that an improved spatial resolution and accuracy can be achieved through the unique combination of high resolution but noisy radar data with the more accurate yet lower resolution data from the radiometer. However, given that this is the first satellite mission to take this approach, the algorithm developments to date have been largely based on synthetic studies and a few airborne data sets, typically for areas smaller than a SMAP radiometer pixel. Consequently, this study will simulate the expected SMAP data stream using airborne simulator flights of an entire SMAP radiometer pixel, for use in pre-launch algorithm validation under a range of conditions.

2. SMAP ANCILLARY DATA

The site chosen for this study is the Yanco area of the Murrumbidgee Catchment located in south-eastern Australia (Fig. 2), extensively monitored for soil moisture with *in situ* stations since 2003 (see www.oznet.org.au). The site has a total of 13 profile soil moisture (top 90 cm) stations, and was recently augmented with a further 24 surface-only soil moisture sensors. These additional sensors were distributed across the site such that there were multiple sensors at the radar pixel scale (3 km), the radar-radiometer pixel scale (9 km), and the radiometer pixel scale (36 km), while also representing the diversity of land cover. This SMAP "Test-Bed" is characterized by flat topography with grassland and a mix of irrigated and non-irrigated crops.

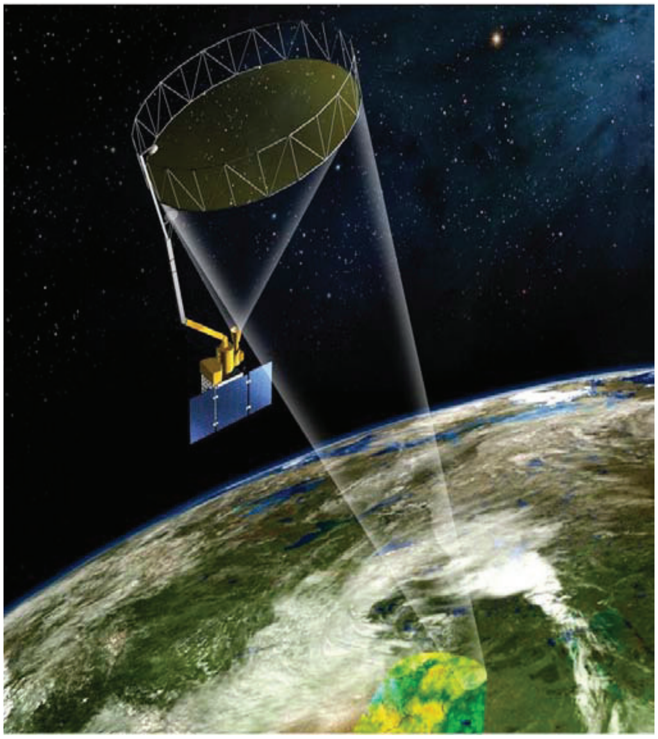

Figure 1. The SMAP mission concept consists of an L-band radar and radiometer sharing a single spinning 6-m mesh antenna in a sun-synchronous dawn/dusk orbit.

3. DATA

The radar and radiometer data used to simulate the SMAP data stream have been acquired by the SMAP simulator shown in Fig. 3 through a series of seasonal field campaigns (Soil Moisture Active Passive Experiments, SMAPEx) across approximately a year: SMAPEx-1 from 5th to 10th July 2010, SMAPEx-2 from 4th to 8th December 2010, and SMAPEx-3 from 5th to 23rd September 2011 [2]. The flights simulating the SMAP mission were conducted at a 3000 m flying height across the entire 36 km SMAP pixel with a 2-3 day temporal repeat, giving a total of 3 flights for each of SMAPEx-1 and 2, and 9 flights for SMAPEx-3. Additional target flights were also conducted to deal with the issues of incidence angle normalization, spatial scaling, and azimuth variations. Moreover, extensive ground data on soil moisture and vegetation were collected concurrently with the flights for validation of soil moisture retrieval studies.

4. METHODS

Data collected by the SMAP simulator have a ~10 m and 1 km resolution for the radar and radiometer, respectively. Flight lines were undertaken in a north-south direction, meaning a constant east-west azimuth for the sensor looking directions but a range of across-track incidence angles. As SMAP uses a conical scanning mechanism to map out its swath at a constant 40° incidence angle with spatial resolutions of 3 km and 36 km for the radar and radiometer respectively, it is necessary to (i) normalize the incidence angle of the simulator data, (ii) upscale the spatial resolution from 10 m to 3 km for the radar and 1 km to 36 km for the radiometer, and (iii) confirm that no azimuth effects are expected relative to the conically scanned radar data. Consequently, procedures are being developed and

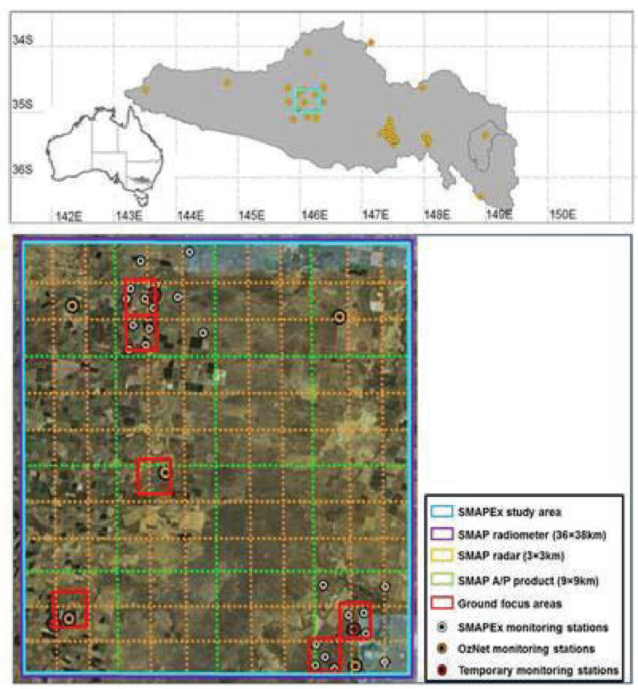

Figure 2. Overview of the SMAP pixel simulated by airborne data showing a ~36 km resolution radiometer pixel, the 3 km radar pixels, and 9 km radar-radiometer downscaled pixels.

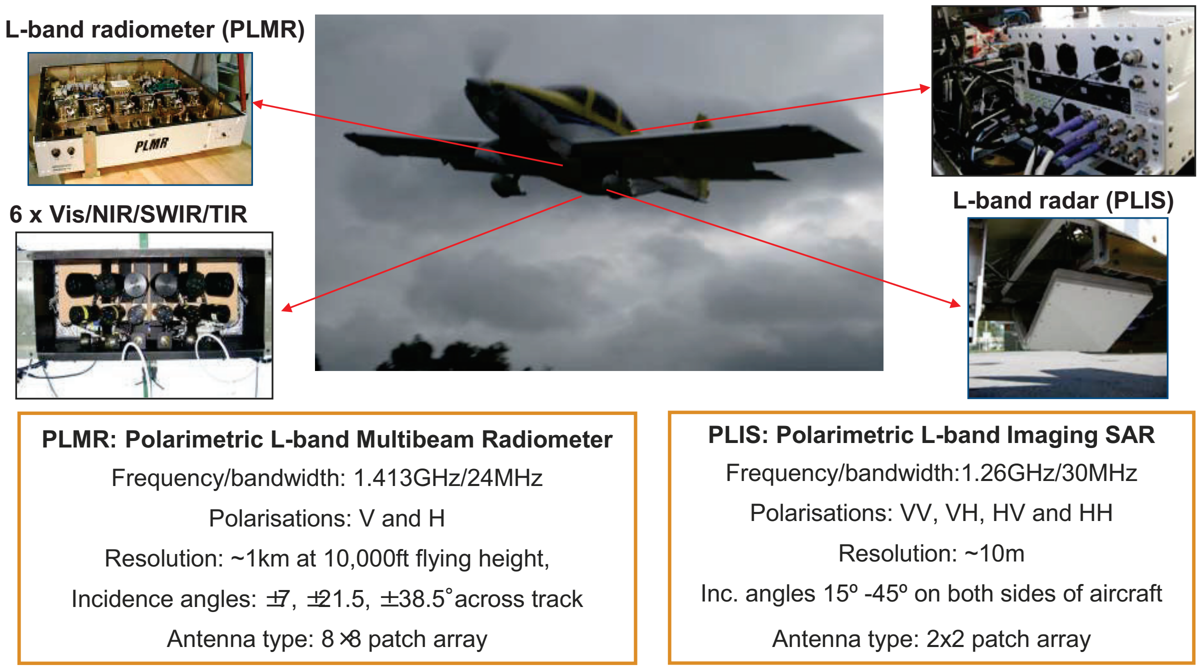

Figure 3. The Australian airborne SMAP simulator.

tested using data from a series of target flights undertaken specifically for this purpose. A series of 1 km resolution soil moisture maps derived from the radiometer data are also under development for validation of soil moisture products (radar-only, radiometer-only, and radar-radiometer) derived from this simulated SMAP data stream using the SMAP mission algorithms.

5. CONCLUSIONS

An airborne data stream is being developed to simulate that expected from the SMAP mission, both in terms of spatial resolution and temporal repeat. This data set covers a 1-week period in winter, a 1-week period in summer, and a 3-week period in the spring growing season. A soil moisture product at 1 km resolution is also being derived from the passive microwave radiometer observations for use in development and testing of the SMAP mission algorithms for radar-only, radar-radiometer and radiometer-only soil moisture products.

6. ACKNOWLEDGEMENTS

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7. REFERENCES

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