Towards medium-resolution brightness temperature retrieval from active and passive microwave observations

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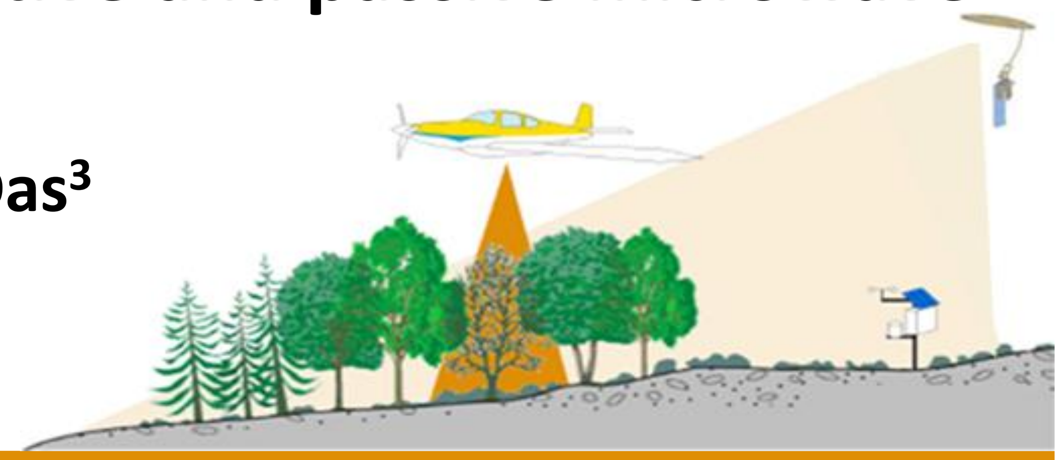

Study Objective

This research tests a proposed baseline downscaling algorithm for the SMAP mission, which is based on the synergy between active and passive microwave observations. Specific aims include:

➢Evaluating the skill of this downscaling algorithm using experimental data sets collected from the Soil Moisture Active Passive Experiment (SMAPEx) field campaigns in Australia;

➢Providing a data set of medium-resolution brightness temperature in order to retrieve a soil moisture product at ~9km in future study.

Methodology

The downscaling algorithm tested in this research is based on the near-linear relationship between radar backscatter and brightness temperature at the same scale, and includes:

- β Estimation: derived by a linear regression of radar and radiometer observations at the same time *t* and at the same resolution (36km, naming *C scale*),

$$TB(C,t) = \alpha(C) + \beta(C) \times \sigma^{\circ}(C,t).$$

- Downscaled TB: obtained by merging low resolution (*C* scale) PLMR TB with finer resolution (1km, 3km or 9km, naming *F* scale) PLIS σ˚,

$$TB(F,t) = TB(C,t) + \beta(C) \times (\sigma^{\circ}(F,t) - \sigma^{\circ}(C,t)) .$$

- Evaluation: downscaled results at different resolutions (1km, 3km and 9km) are compared with PLMR TB at 1km, 3km and 9km, respectively.

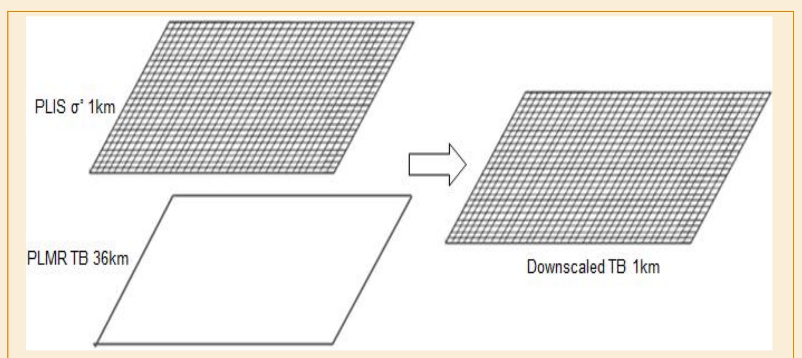

Fig. 4: Diagram of synergy between 36km resolution PLMR TB and 1km resolution PLIS σ˚ to produce 1km TB.

Data Set

SMAPEx field campaigns were held in the Yanco area of the Murrumbidgee Catchment (Fig. 1), in order to provide experimental data to develop and validate the algorithms for the SMAP mission.

Airborne observations (Fig. 2) were conducted over the SMAP test-bed simulating the SMAP prototype data stream.

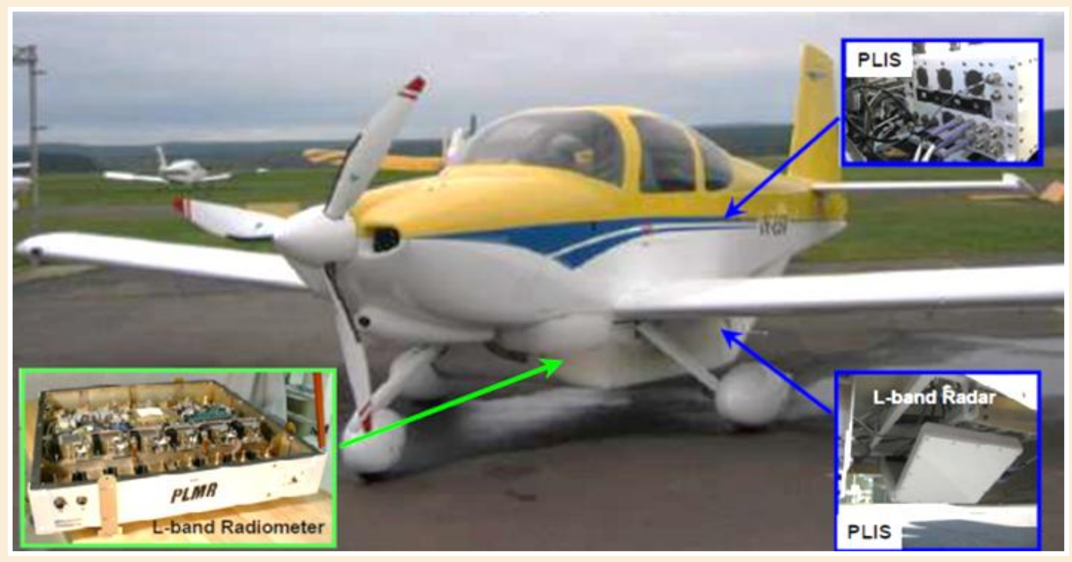

Fig. 2: Airborne simulator including Polarimetric L-band Multibeam Radiometer (PLMR); and the Polarimetric L-band Imaging Synthetic aperture radar (PLIS).

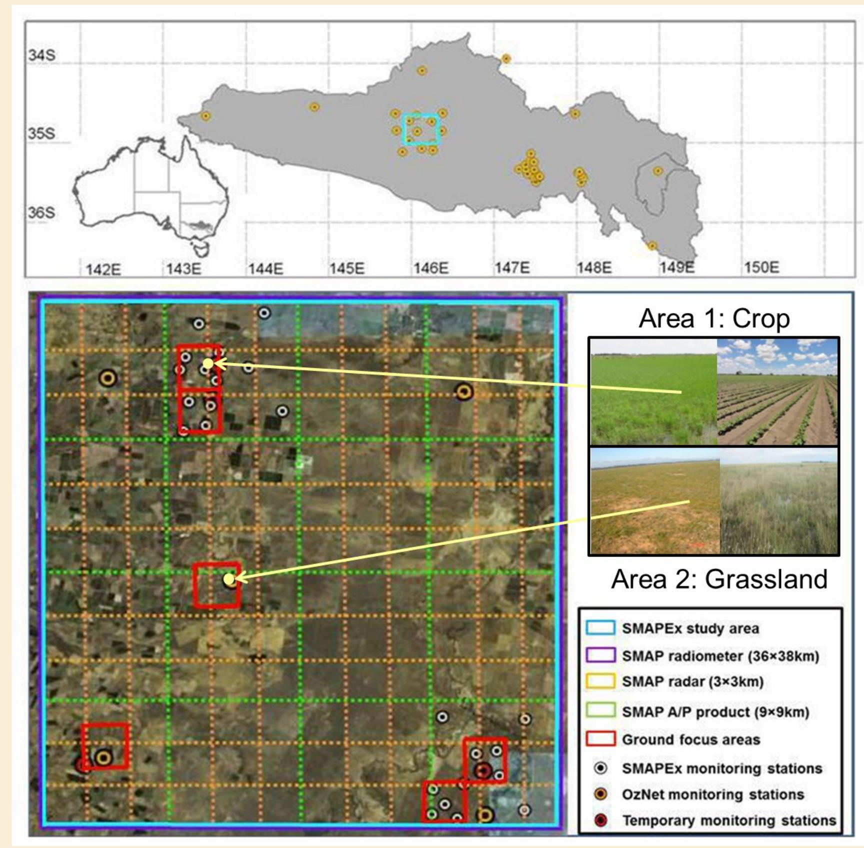

Fig. 1: Overview of the SMAPEx site showing the SMAP pixel size study site, the ground validation sites and the focus areas.

PLMR and PLIS provides brightness temperature (TB) at 1km and backscatter (σ˚) at 10m, respectively (Fig. 3).

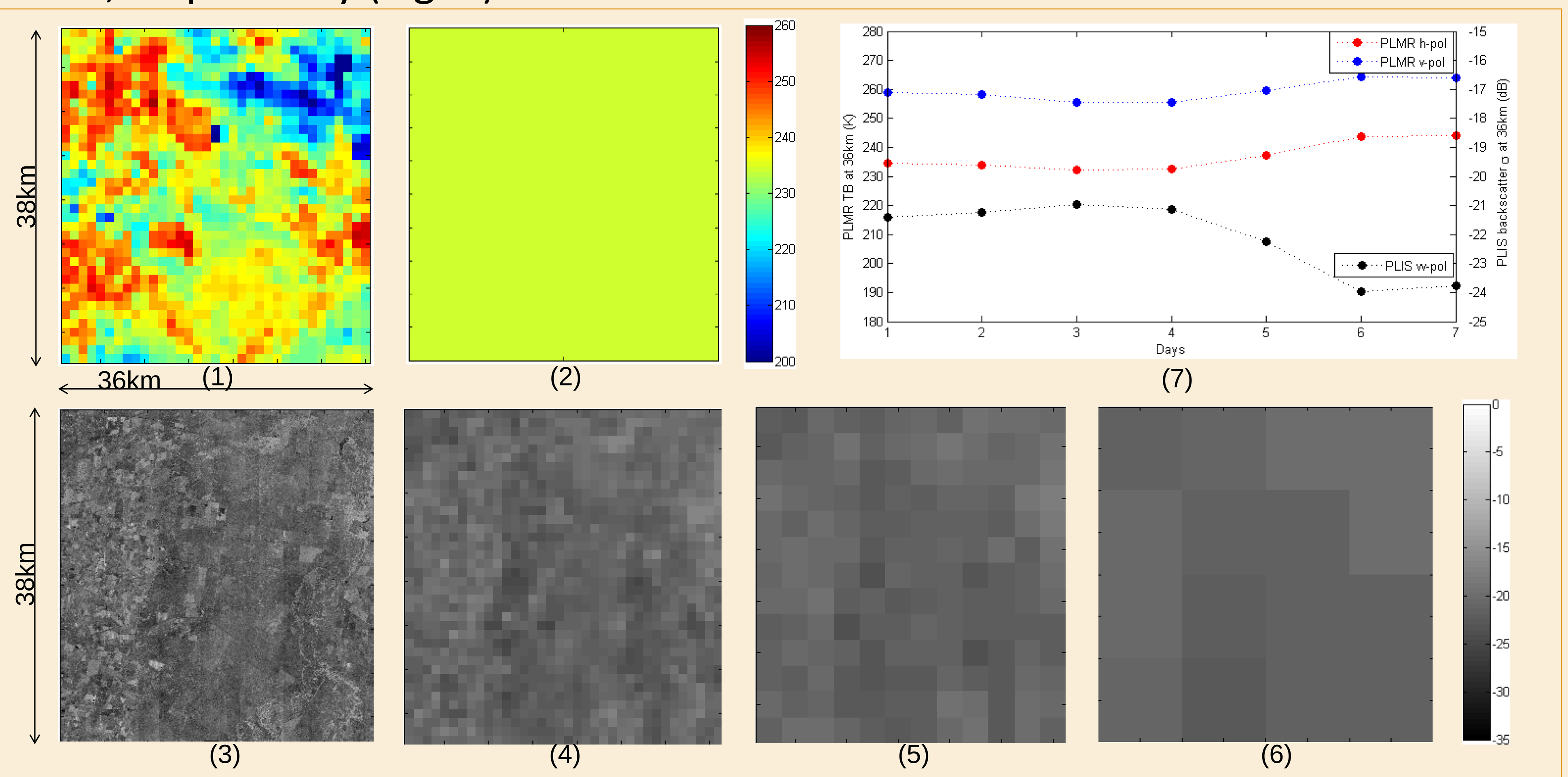

Fig. 3: An example of PLMR (h-pol) and PLIS (vv-pol) data observed concurrently from SMAPEx-3: (1) PLMR TB observed at 1km; (2) PLMR upscaled to 36km; (3) PLIS σ˚ observed at 10m, and then upscaled to (4) 1km, (5) 3km and (6) 9km; (7) time-series of PLMR and PLIS data at 36km across 7 days.

Result and Conclusion

1. β estimation from linear regression based on PLMR TB (h- and v-pol; 36km) and PLIS σ˚ (vv-pol; 36km) across 7 days during SMAPEx-3.

Future study will include the additional 2 days for parameterization of β.

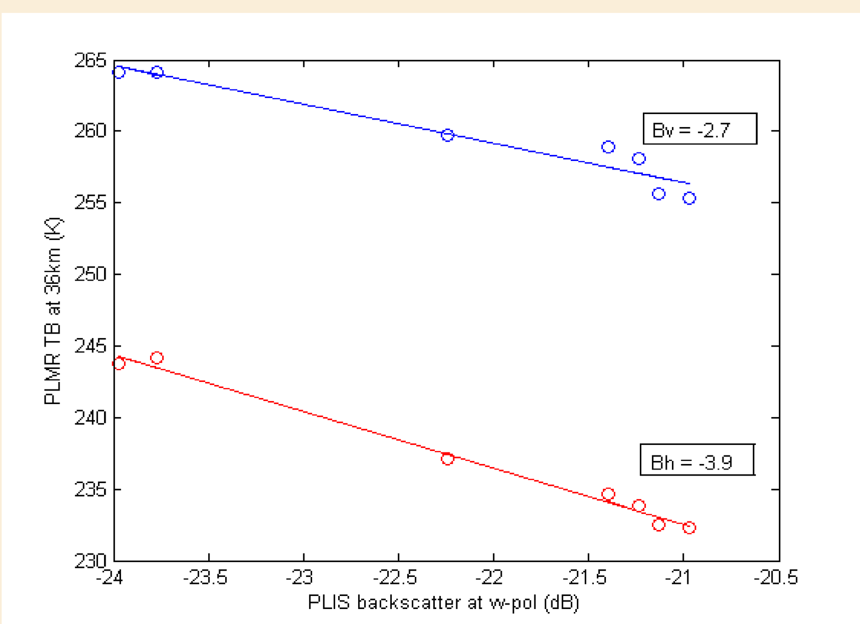

Fig. 5: β estimation from linear regression: β=-3.9 from TB at h-pol and σ˚ at vv-pol; β=-2.7 from TB at v-pol and σ˚ at vv-pol.

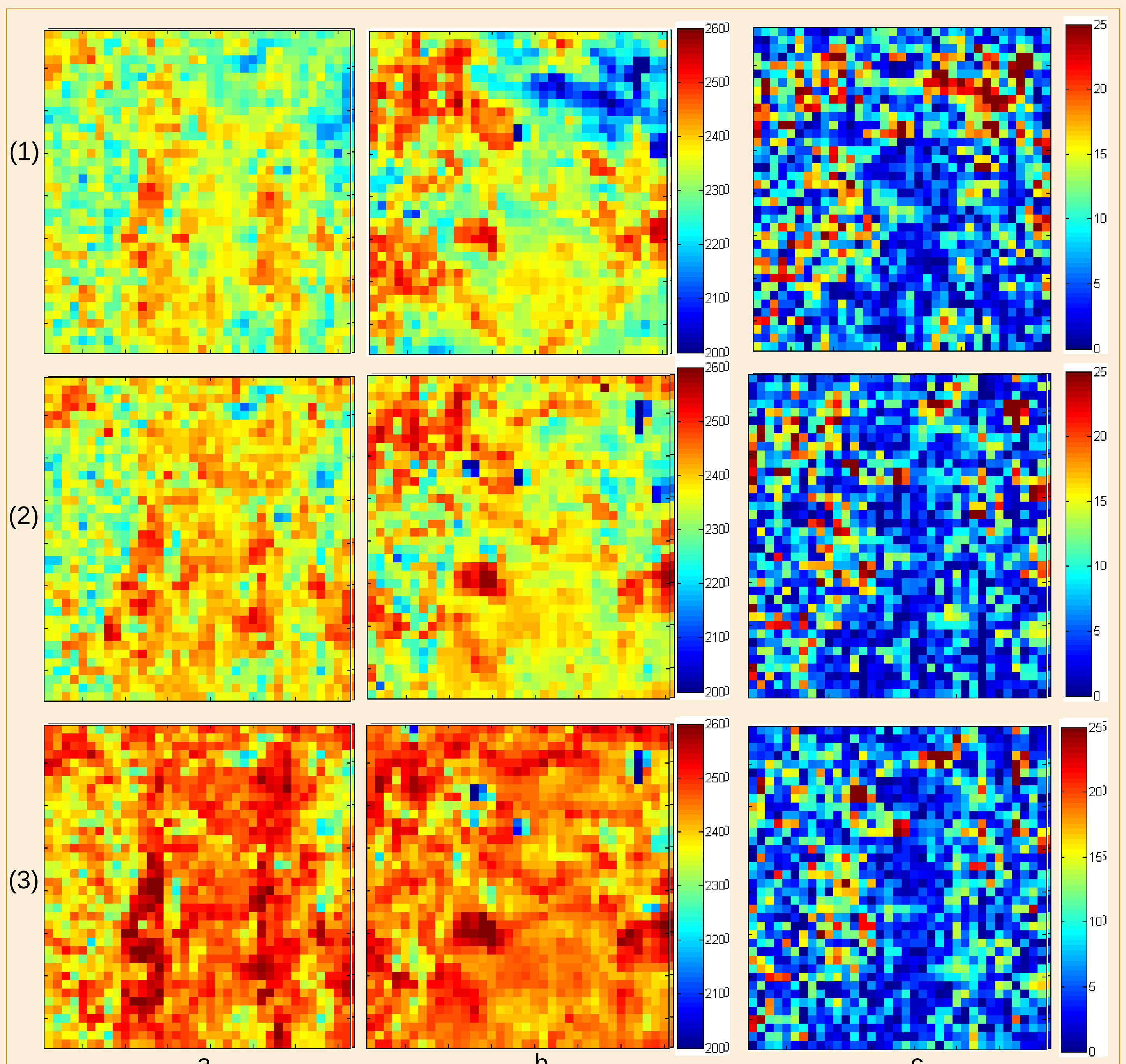

Fig. 6: Comparison between (a) downscaled TB and (b) PLMR observations at h-pol and 1km resolution; The difference of each 1km pixel results for 3 days: Day2 (1), Day5 (2) & Day9 (3) is shown in (c).

2. Downscaling results in Fig. 6 & Fig. 7 show that the error of downscaled TB is generally smaller in grassland (middle) than in crop area (side). RMSE at v-pol has an overall improvement of ~2K over h-pol according to Table 1, and decreases from approximately 8K to 4K when upscaling from 1km to 9km.

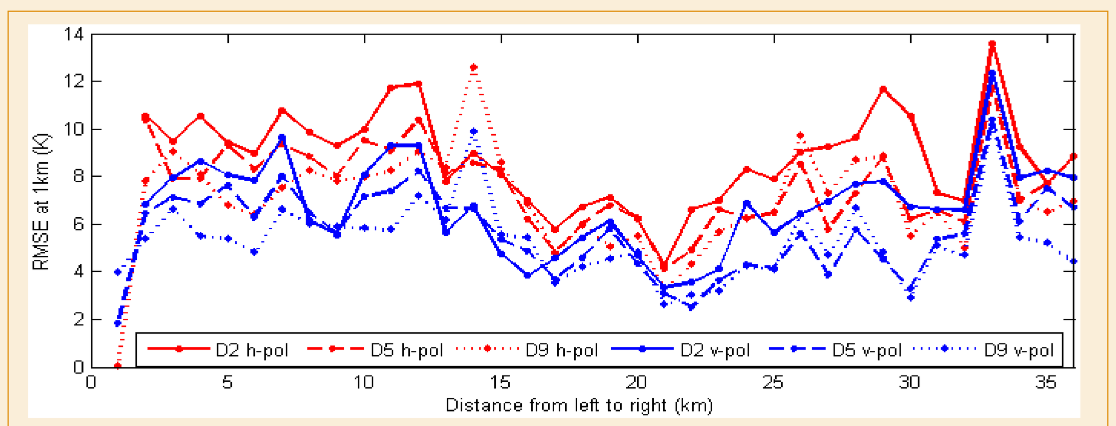

Fig. 7: RMSE of each 1km strip of Day2, Day5 & Day9 vs the distance starting from left to right: red lines are RMSE of downscaled results at h-pol, while the blue lines are RMSE of downscaled results at v-pol.

Table 1: RMSE of downscaled TB for each of the 7 days across the entire SMAPEx area at different polarization and at different resolution.

	D1		D2		D3		D4		D5		D8		D9		Average	
	h	v	h	v	h	v	h	v	h	v	h	v	h	v	h	v
1km	11.6	9.8	10.5	8.8	9.7	8.5	11.1	9.3	9.3	7.8	10.4	8.2	8.9	7.6	10.2	8.6
3km	8.8	7.3	8.2	6.9	7.9	6.6	8.2	6.8	6.7	5.8	8.0	6.4	5.5	4.6	7.6	6.3
9km	5.8	4.9	5.5	4.5	5.6	4.7	5.1	3.8	3.2	2.9	5.1	4.0	2.7	2.2	4.7	3.8

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SMAPEX

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