An in-situ data based model to downscale radiometric satellite soil moisture products

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1. INTRODUCTION

- Soil moisture (SM) information plays a vital role in a number of hydrologic, climatic and agricultural applications.
- The point-scale in-situ measurements and coarse resolution (~10s of km) satellite SM products are often unable to cater the requirement of high spatial resolution SM for catchment and regional scale applications.
- Downscaling satellite SM products can be identified as a viable solution for this problem.

(Source: NASA)

2. OBJECTVES

Improve the spatial resolution of SMAP 36 km and SMOS 25 km near surface SM products into 1 km, based on the thermal inertia relationship between the diurnal soil temperature difference (ΔT) and the daily mean SM (μSM).

3. STUDY AREA & NAFE 05 SOIL MOISTURE DATA [1]

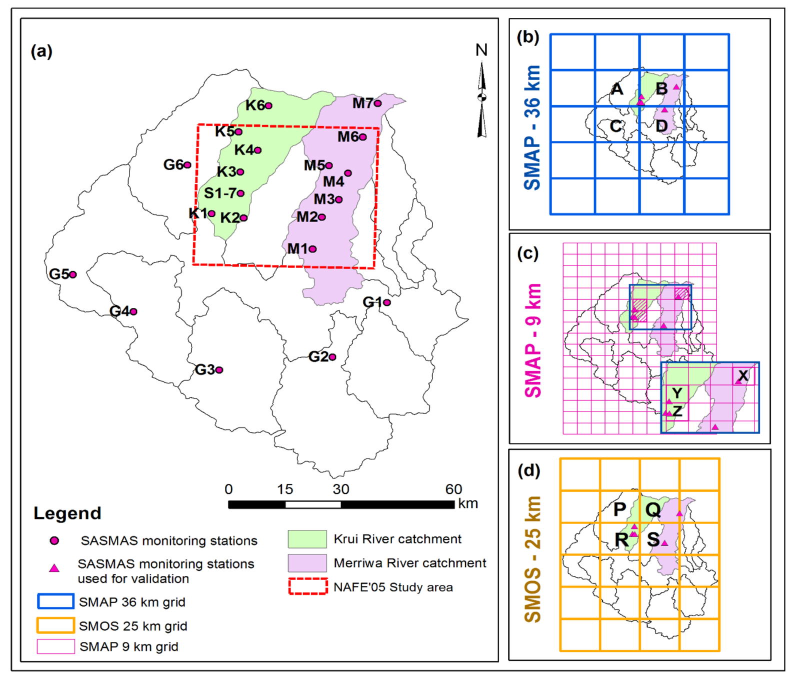
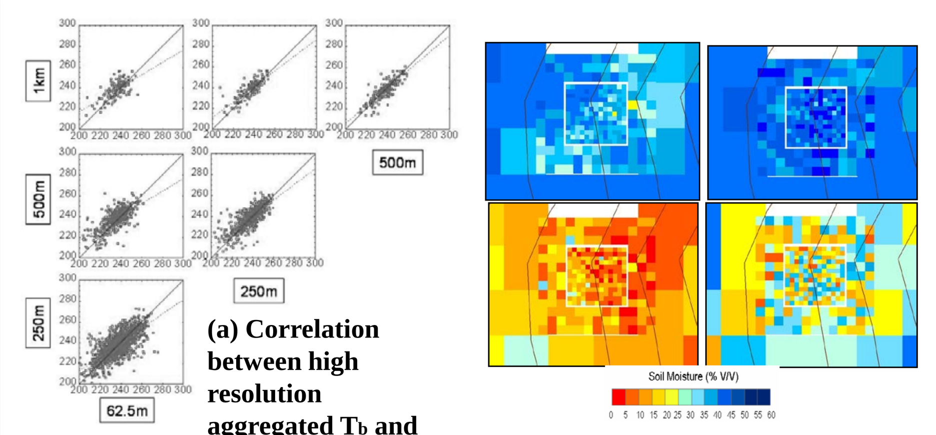


Fig. 1: The study area, Goulburn River catchment (South eastern Australia) and SASMAS soil moisture network with SMAP 36-km and SMOS 25-km grids.



(a) Correlation between high resolution aggregated Tb and independent low resolution observations.

(b) High resolution soil moisture data (6.25m - 1 km) at Stanley Site (microtopography & uniform vegetation).

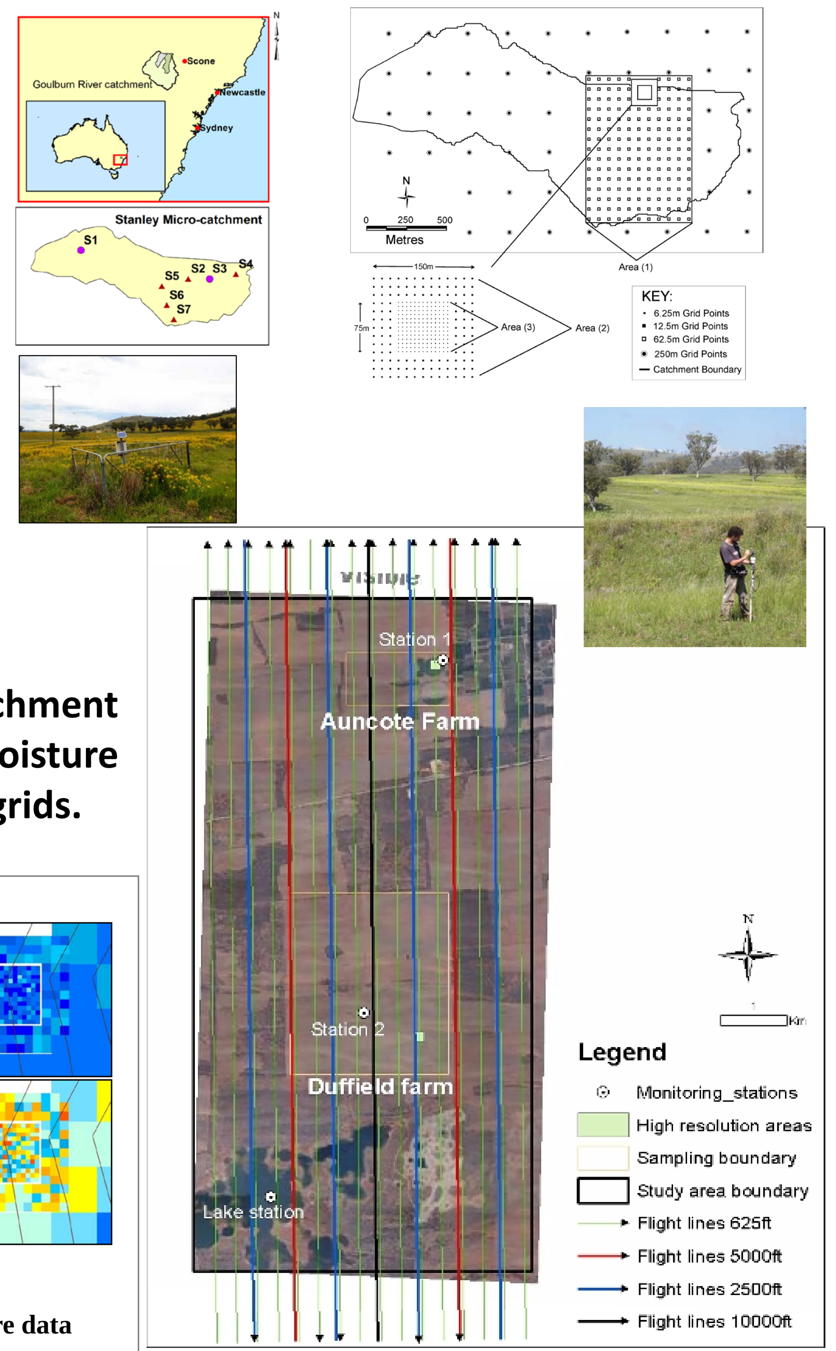


Fig. 2: NAFE 05 Soil Moisture Data [1].

4. THEORY

The downscaling model is based on the soil thermal inertia (TI). TI is the resistance of an object to the changes in surrounding temperature [2].

$TI = \sqrt{\rho k c}$, where ρ is the bulk density (kg m^{-3}), k is the specific heat capacity (J kg^{-1} K^{-1}) and c is the thermal conductivity (W m^{-1} K^{-1}) of the material

$$\Delta T = f(1/_{TI}) \qquad \Delta T \approx T_{PM} - T_{AM}$$

Water has high specific heat capacity, hence a high thermal inertia compared to the dry soil. Therefore, when the SM content is increasing, the diurnal temperature difference of soil (ΔT) is decreasing. **This relationship between ΔT and daily mean SM ($\theta\mu$) [3] was used to build the downscaling algorithms.**

5. DATASETS

- SMAP (L3_SM_P) SM Products [4]
36 km resolution – 2015/2016
National Snow and Ice Data Center (NSIDC)

- SMOS (L3 SM 3-DAY) SM Products [5]
25 km resolution – 2015/2016
Centre Aval de Traitement des Données SMOS (CATDS)

- SASMAS in-situ data
Hourly soil temperature and daily SM at 0-5 cm profile – 2003-2014.
http://www.eng.newcastle.edu.au/sasmas/SASMAS/sasmas.htm

- MODIS Aqua daily land surface temperature data (MYD11A1) 1 km resolution - 2005
Land Processes Distributed Active Archive Center (LP DAAC)

- MODIS 16-day NDVI composites (MYD13A2)
1 km resolution - 2003-2014, *LP DAAC*

- The National Airborne Field Experiment 2005 (NAFE'05) SM data
1 km resolution -31 Oct, 07, 14 and 21 Nov 2005
http://www.nafe.monash.edu

- National Soil and Landscape Grid
Clay content - 90 m resolution
CSIRO (Commonwealth Scientific and Industrial Research Organisation)

6. METHODS

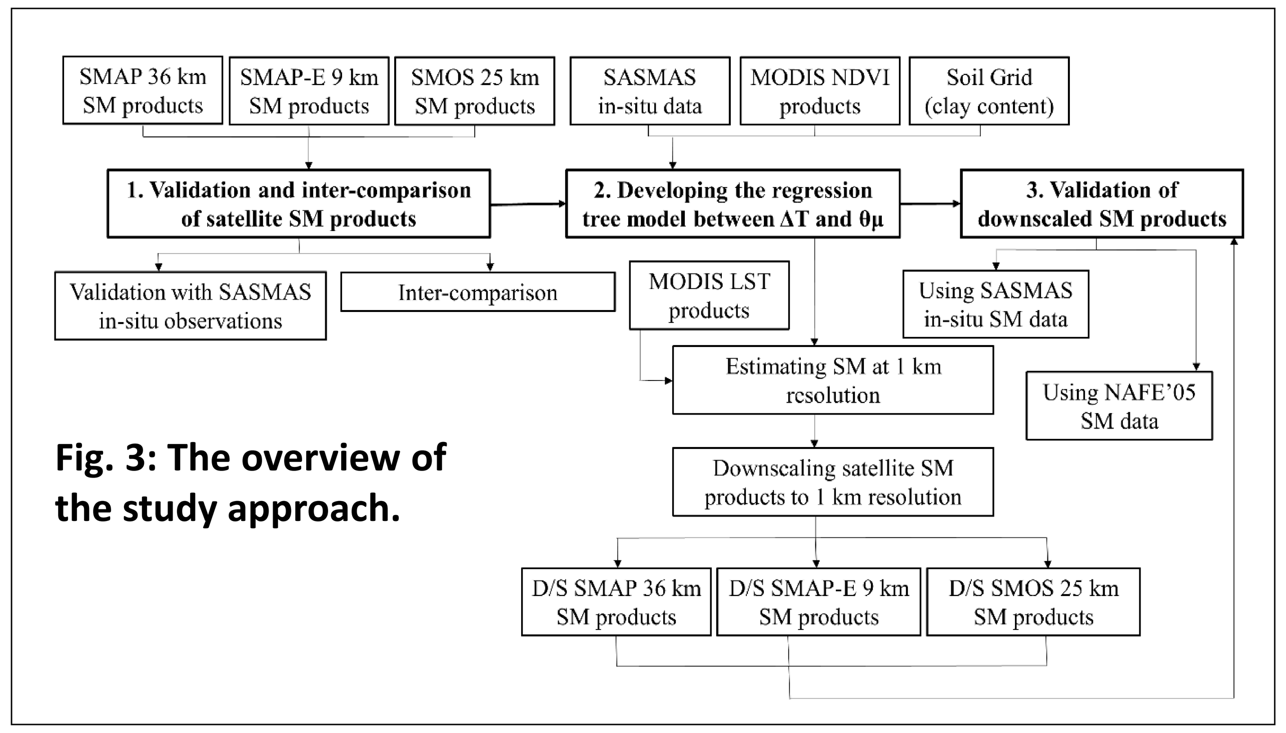


Fig. 3: The overview of the study approach.

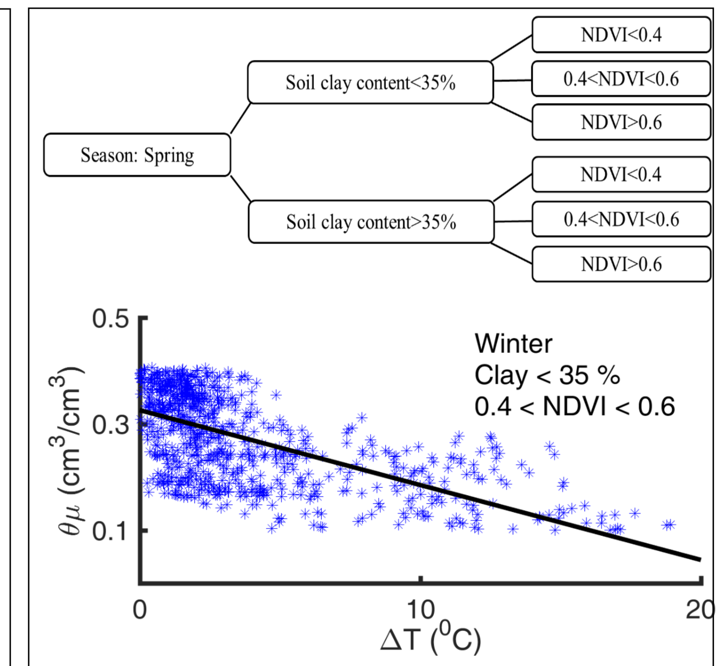


Fig. 4. The regression tree model.

7. RESULTS

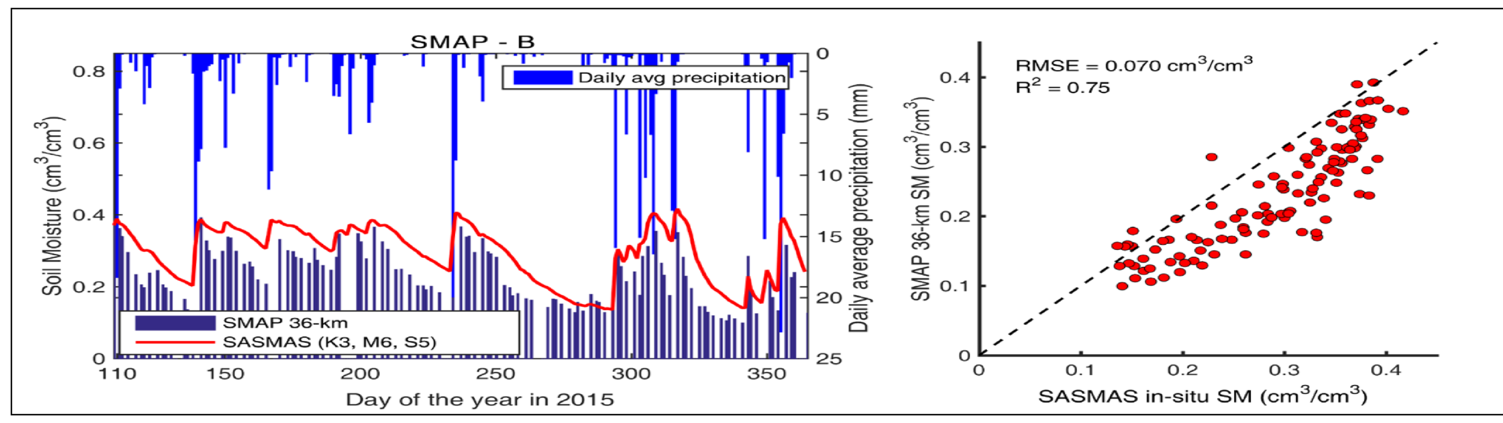


Fig. 5: Comparison between SMAP 36-km SM products and SASMAS in-situ data.

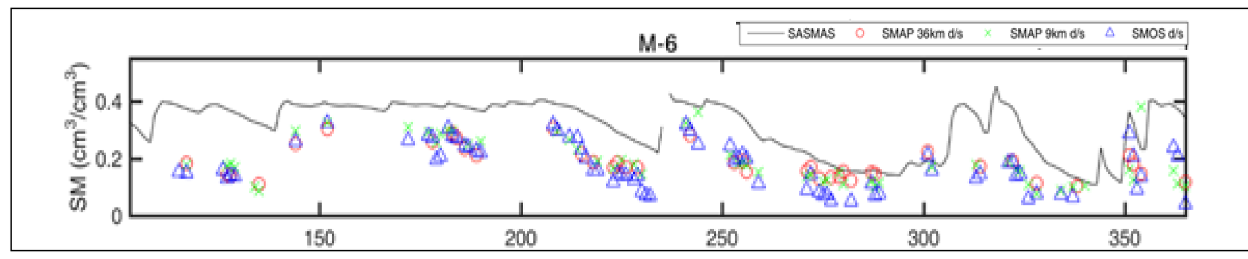


Fig. 6: Temporal variability of SM (SMAP 36 km, SMAP 9 km, and SMOS 25 km with respect to SASMAS in-situ data.

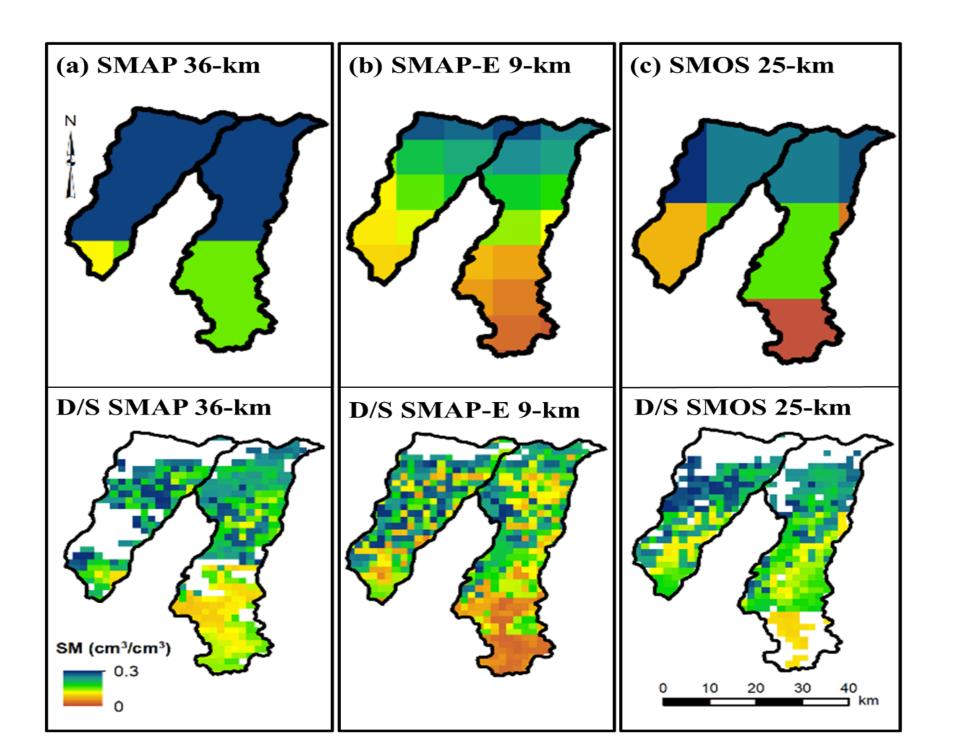


Fig. 7: Spatial variability of SM across Krui and Merriwa River catchments as captured by (a) SMAP 36-km (b) SMAP-E 9 km and (c) SMOS 25 km and their downscaled counterparts on 28th June 2015.

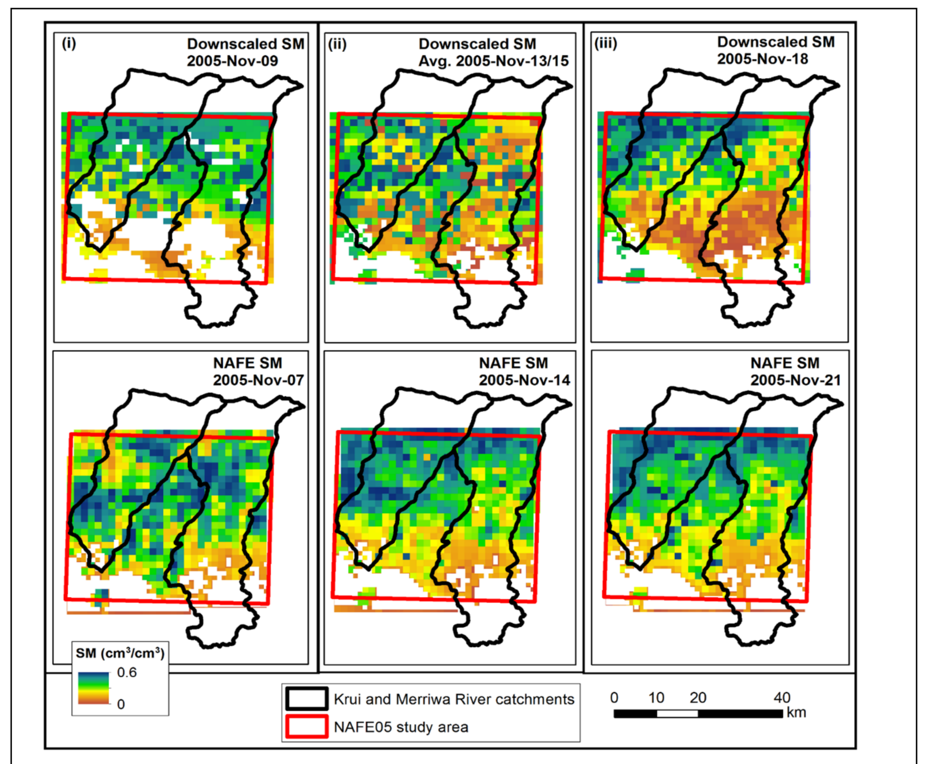


Fig. 8. Comparison of the downscaled soil moisture products with NAFE'05 airborne dataset.

SUMMARY

1. The downscaled SMAP 36 km, SMAP-Enhanced 9 km and SMOS 25 km soil moisture products showed unbiased root mean square errors of 0.06, 0.07 and 0.05 cm^3/cm^3, respectively, against the in-situ data.

2. An RMSE of 0.07 cm^3/cm^3 was observed when comparing the downscaled soil moisture against the passive airborne L-band retrievals.

3. The findings here auger well for the use of satellite remote sensing for the assessment of high resolution soil moisture.

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