Estimating near surface soil moisture at a high spatial resolution using an in-situ data based model

*Indishe Prabath Senanayake[1], In-Young Yeo[1,2], Natthachet Tangdamrongsub[3,4], Garry R Willgoose[1], Gregory R Hancock[5], Tony Wells[1], Bin Fang[6], Venkataraman Lakshmi[6], Jeffrey P Walker[7]

1. School of Engineering, Faculty of Engineering and Built Environment, The University of Newcastle, Callaghan, NSW 2308, Australia., 2. Department of Geographical Sciences, University of Maryland, College Park, MD 20742, USA., 3. Earth System Science Interdisciplinary Center, University of Maryland, College Park, Maryland, USA., 4. Hydrological Sciences Laboratory, NASA Goddard Space Flight Center, Greenbelt, Maryland, USA., 5. School of Environmental and Life Sciences, Faculty of Science, The University of Newcastle, Callaghan, NSW 2308, Australia., 6. School of Earth Ocean and Environment, University of South Carolina, Columbia, SC 29223, United States., 7. Department of Civil Engineering, Monash University, Clayton, Victoria 3800, Australia.

Soil moisture is a key variable in the hydrologic cycle. Therefore, soil moisture information is important for hydrologic and climatic modelling, and for agricultural applications. However, the available point-scale in-situ observations and coarse resolution (10s of km) satellite soil moisture retrievals are unable to capture the spatial variability of soil moisture at high spatial resolutions as required by many of the local and regional scale applications. The lack of high resolution soil moisture data has resulted uncertainties in the model outcomes in these applications. Downscaling coarse spatial resolution L-band microwave satellite soil moisture products using high spatial resolution optical/thermal satellite data appears to be a feasible option to estimate near surface (~top 5 cm) soil moisture at a high spatial resolution. In this study a model was developed to estimate soil moisture at 1 km spatial resolution by downscaling coarse resolution satellite soil moisture products. This downscaling model was built by using in-situ observations from a long term monitoring network (2004-2015) over two sub-catchments, Krui and Merriwa River, located in the Upper Hunter Region of south-eastern Australia. The model was based on the soil thermal inertia relationship between the diurnal temperature difference (ΔT) and daily mean soil moisture (μSM). A regression tree (RT) was built between ΔT and μSM and classified based on the season, vegetation density and soil clay content. Moderate Resolution Imaging Spectroradiometer (MODIS) land surface temperature (LST) and Normalized Difference Vegetation Index (NDVI) values at 1 km spatial resolution were input to the model to estimate soil moisture at 1 km resolution. Subsequently, SMAP-Enhanced 9 km (L3SMP-E) and SMOS 25 km grid (SMOS CATDS L3 SM 3-DAY) soil moisture products over the study area were downscaled and then compared against in-situ observations. Further, the downscaling algorithm was applied to aggregated soil moisture observations from National Airborne Field Experiment 2005 (NAFE’05) over a 40 x 40 km land area over Krui and Merriwa River catchments. The downscaled products were validated using 1 km airborne data. The SMAP L3SMP-E and SMOS CATDS L3 SM 3-DAY products show unbiased root mean square errors (ubRMSEs) of 0.068 and 0.051 cm^3/cm^3 (R^2 values of 0.40 and 0.61), respectively, against in-situ observations. The downscaled airborne soil moisture data shows an RMSE of 0.07 cm^3/cm^3 (with R value of 0.4). The model performed well in dry conditions compared to wet conditions. This method shows a good potential in developing a long time series of high spatial resolution soil moisture information over arid and semi-arid regions using SMOS and SMAP soil moisture products.

Keywords: Downscaling, remote sensing, SMAP, SMOS, soil moisture, thermal inertia

