Space-time monitoring of (sub) soil moisture for agricultural management: a case study

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Abstract: The expected increase in food demand will lead to increased water use in agricultural production in order to improve crop yields, maintain long-season dual-purpose crops and extend areas of perennial pastures. This combined with possible future climate shifts may mean that we will be farming drier and drier soils. One impediment to water-use efficiency and improved crop production is reliable estimates of soil moisture. Accurate estimates of soil moisture can help farmers make better decisions about what, when and how much to sow in their paddocks or when and how much to fertilise pre- and mid-season. The need to monitor soil moisture has lead to the implementation of monitoring networks as part of research projects such as OzNet (Murrumbidgee catchment) or ones developed specifically for growers by DEPI Victoria (Victoria) and FarmLink Research (southern NSW). Although space-time datasets are available the question remains about how transferable the information is to field and farms without probes. Also, remote sensing products available for soil moisture only refer to the top few cm of soil and are provided at a coarse resolution. For management of crops, soil moisture estimates for the entire profile are needed at the spatial resolution of a paddock, the order of 50-1000 m pixels. To tackle this issue we propose the development of a methodology to predict soil moisture for the entire profile at a resolution of 250 m and 7 days using a combination of in-situ measurements and remote sensing products which parameterise components of the soil water balance equation. In this work we present (i) initial modelling results (ii) a soil moisture monitoring network we have established in the Muttama creek catchment, a subcatchment of the Murrumbidgee river.

The basis of our approach is to use the water balance equation

$$S = R + I - ET - DD - RO, \qquad (1)$$

where S is the change in soil moisture, R is precipitation, I is irrigation, ET is evapo-transpiration, DD is deep drainage and RO is runoff. Eqn. 1 is used to estimate the bulk profile soil moisture content and we propose to use geostatistical inversion techniques coupled with in situ measurements of soil moisture to disaggregate the bulk profile predictions into predictions at individual depths. R and ET are estimated by readily available geospatial and remote sensing products, as an example here we use gridded SILO rainfall data (5km, 1 day) and the MODIS 16 ET product (1km, 8 days) to represent DD and RO in Eqn. 1. We have set a total profile water holding capacity of 500mm in the top 1.0 m after which water is lost from the profile. The water balance part of the approach was tested at FarmLink Research sites using daily soil moisture data from 2011 and the median correlation coefficients ranged between 0.4 and 0.7 across all sites and depths.

To understand the relative importance of our model predictions as compared to soil, terrain and weather, a Random Forest was fitted to a suite of variables (slope, aspect, soil order, land use, ET, rainfall, and soil moisture predicted from Eqn. 1). Soil moisture predictions were the 5th most important predictor, ahead of it being slope, aspect, soil order and a dummy monthly variable. This is to be expected as the soil moisture predictions are based on geospatial products with spatial and temporal resolutions coarser than the daily, point soil moisture observations. Therefore local features such as slope and aspect are not represented in the model predictions. Further work needs to consider downscaling the model predictions from Eqn. 1.

The Muttama creek subcatchment encompasses an area of 1025 km^2 and is dominated by cropping and grazing. In January 2014 a network of 26 soil moisture monitoring sites was established which monitor soil moisture at 5 depths to a depth of 1.0 m. It was established as a case study for our research on soil moisture monitoring. In the future we hope to use this more intensively monitored region to test the inversion method and downscaling approaches we intend to use for the P and ET geospatial products.

Keywords: *Soil moisture, Monitoring, Water balance, Remote sensing*