Evaluation of downscaled soil moisture and vegetation optical depth derived from the Land Parameter Retrieval Model

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Abstract: Space-borne passive microwave radiometers have great potential for observation of land surface parameters such as surface soil moisture and vegetation water content. However, the coarse resolution of the sensors limits the value of the data in hydrology. In this study, a passive microwave soil moisture and vegetation optical depth product is downscaled to ~10 km resolution and then evaluated over the Australian continent, with special attention for the Murrumbidgee and Fitzroy catchments.

First, brightness temperatures from the Advanced Microwave Scanning Radiometer (AMSR-E) are downscaled using the smoothing filter-based modulation technique. In this technique, brightness temperatures from the C-band (~50 km resolution) are adjusted based on data from the Ka-band (~10 km resolution). The downscaled brightness temperatures are then used as inputs in the Land Parameter Retrieval Model (LPRM), which produces downscaled soil moisture and vegetation optical depth products. However, the Ka-band used in the downscaling technique is more sensitive to precipitation, so as a final step a precipitation mask is introduced to improve the quality of the final products. The advantage of this method compared to other downscaling methods is that all data originates from the same sensor and platform.

The downscaled soil moisture and vegetation optical depth products show enhanced detail and have a higher spatial variability compared to the original, coarser resolution. The added value of the precipitation mask is demonstrated by comparing the soil moisture product with time series of in situ soil moisture sensors in the Murrumbidgee catchment. This shows that the precipitation mask removes extraneous values, leading to a slight, but significant increase in the correlation between these datasets.

Visually, the downscaled vegetation optical depth product sharpens the boundaries of changes in vegetation in Australia. This is confirmed by higher spatial correlations between the vegetation optical depth and the MODIS 16-day NDVI product after downscaling. This increase in correlation is significant in areas such as the Fitzroy catchment, where there are a number of distinct patches of sparse and dense vegetation.

The downscaled soil moisture product was evaluated by in situ soil moisture data and an antecedent precipitation index. Both of these methods show that correlations with the downscaled product are similar but slightly worse than correlations with the product at the original resolution. However, irrigation areas in the Murrumbidgee catchment that cannot be distinguished at the original resolution become visible in the downscaled product. On average, these irrigation areas are about 20% wetter after downscaling.

In summary, passive microwave soil moisture and vegetation optical depth products were downscaled using brightness temperatures from the same sensor and platform. Application of a precipitation mask to the downscaled products improved the quality of the products by removing extraneous values. Downscaling improves the performance of LPRM products in areas with strong gradients in vegetation or soil moisture. One important example is that irrigation areas are consistently wetter in the downscaled soil moisture product. These results show that downscaling increases the information content in the soil moisture and vegetation optical depth products, which can benefit hydrological studies at regional scales.

Keywords: *Soil moisture, Downscaling, Passive microwave radiometry, Remote sensing*