CAN WE DERIVE NEAR DAILY EVAPOTRANSPIRATION MAPS AT FIELD SCALE RESOLUTION WITH THE AVAILABLE SPACEBORNE SYSTEMS?

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Over the last several decades, there has been a major effort to develop methods for deriving spatially-distributed evapotranspiration (ET) maps over landscapes by using remote sensing imagery in the visible–near-infrared (VIS/NIR) and the thermal infrared (TIR) bands in surface energy balance models. The spatial resolution of the resulting ET maps is determined by the spatial resolution of the coarsest input, and the temporal frequency is determined by the revisit time of the acquiring satellite system. For water management applications and other agricultural purposes, ET maps would be optimally produced daily at fine spatial resolution (< 100 m). However, a trade-off exists between the spatial and temporal resolutions of current remote sensing systems, such that they typically have either high-spatial/low-temporal or low-spatial/high-temporal resolution. This tradeoff is particularly significant for satellite-based thermal imaging instruments, which have 2-10 times coarser resolution than do co-located VIS/NIR sensors. Provided that a method for thermal image sharpening (TsHARP) produces reliable estimates of the real temperature field, near daily ET maps at scales marginally resolving the typical field size can potentially be produced.

In this study, a Two-Source-Model (TSM) of surface energy balance was used to derive ET maps using TIR data at different spatial resolutions. The utility of TsHARP for TSM flux evaluations was examined over two agricultural regions in the U.S.: a rainfed corn and soybean production region in central Iowa, and an irrigated agricultural area in the Texas Panhandle. The goal was to estimate errors in ET incurred by using sharpened thermal imagery in place of imagery acquired at fine-scale native resolution.

The TSM is a land-surface parameterization of the radiation and turbulent energy exchanges between the soil, vegetation and lower atmosphere. Given an estimate of fractional vegetation cover, the TSM partitions the surface temperature and energy/water fluxes into soil and canopy contributions. The TsHARP algorithm uses high-resolution information of vegetation cover fraction, derived from NDVI, to sharpen temperature maps from coarser-resolution thermal bands, with the implicit assumption that fractional vegetation cover, which is related to NDVI, is one of the primary factors affecting LST variations across a given scene.

A subset from a Landsat ETM+ scene acquired on July 1, 2002 for the Walnut Creek Watershed (WCW) and a subset of a Landsat ETM+ scene acquired on September 22, 2002 for the Texas High Plains (THP) regions were used, representing rainfed and irrigated agricultural areas, respectively.

It was found that the use of sharpened thermal inputs to the TSM produced inconsistent results between the two sites in estimating fine-resolution sensible (H) and latent (LE) heat fluxes. For the THP, the sharpened thermal imagery only marginally improved TSM-derived H and LE compared to the non-sharpened fluxes. However, applying TsHARP over the WCW region reduced errors in H and LE estimation by 30-60% and significantly increased the correlations with the reference fields.

It is therefore concluded that in the absence of satellite systems providing fine resolution (<100m) thermal satellite data with frequent (every few days) revisit times, TsHARP provides a valuable tool for monitoring ET at field scales over the Walnut Creek Watershed, representing rainfed agricultural areas. In contrast, over the Texas High Plains, representing irrigated agricultural regions, TIR data sharpened from 1km resolution and used by the TSM are unable to produce accurate high resolution ET maps due to sub-pixel variability in moisture patterns that are not captured by the thermal sharpening algorithm. Consequently, for precision management and decision support systems designed for irrigated agricultural areas, there is still a need for high resolution (<100 m) thermal imagery in order to provide important field-scale crop water use information.

While further study is required to generalize these conclusions, the results from these two sites are likely to be representative of typical rainfed and irrigated agricultural regions during the growing season when such information would improve water management decisions.