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Estimating evapotranspiration from thermal infrared data : extension of the two source SPARSE model to a four source representation in order to account for the sun-earth-sensor configuration

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Dual source energy balance models are often used in estimating and partitioning evapotranspiration between the soil and vegetation. The use of multi-angular remotely-sensed thermal data in such methods makes them susceptible to directional anisotropy (hotspot) effects that may result from the satellite's geometry, relative to the sun, at overpass time. It is therefore important to have these effects accounted for to ensure realistic flux retrievals irrespective of sensor viewing position. At present, dual source models generally interpret surface temperature according to two sources, which may be insufficient to adequately represent the limiting temperature conditions that not only depend on the source type but also their exposure to the sun. Here, we present an extended SPARSE (Soil Plant Atmosphere Remote Sensing Evapotranspiration) scheme, wherein the original SPARSE is extended to incorporate sunlit/shaded soil/vegetation elements and coupled with a radiative transfer model that links these four component emissions to out-of-canopy radiances as observed by remote sensors. An initial evaluation is carried out to check the model's capability in retrieving surface fluxes over diverse environments instrumented with in-situ thermo-radiometers. When run with nadir-acquired thermal data, which have no hotspot signal influence, both algorithms show, as expected, no observable difference in their retrieval of total fluxes. We nonetheless show that by incorporating the solar direction and discriminating between sunlit and shaded elements, the partitioning of these overall fluxes between the soil and vegetation can be improved especially in water stressed environments. We also test the sensitivity of flux and component temperature estimates to the viewing direction of the thermal sensor by using two sets of TIR data (nadir and oblique) to force the models and show that angular sensitivity is reduced. This is key particularly when using high spatial and temporal data from earth observation missions that inherently have to consider a wide-range of viewing angles in their design.

Keywords: Evapotranspiration, thermal infrared (TIR), Soil Vegetation Atmosphere Transfer (SVAT), temperature inversion.