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Multi Function Heat Pulse Probes (MFHPP) to Estimate Ground Heat Flux and Reduce Surface Energy Budget Errors

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Ground heat flux plays a crucial role in surface energy budget: an incorrect estimation of energy storage and heat fluxes in soils occur when probes such as heat flux plates are adopted, and these mistakes can account for up to 90% of the residual variance (Higgins, GRL, 2012). A promising alternative to heat flux plates is represented by Multi Function Heat Pulse Probes (MFHPP). They have proven to be accurate in thermal properties and heat fluxes estimation (e.g. Cobos, VZJ, 2003) and can be used to monitor and quantify subsurface evaporation in field experiments (Xiao et al., VZJ, 2011).
We perform a laboratory experiment with controlled temperature in a small Plexiglas column (20cm diameter and 40cm height). The column is packed with homogeneously saturated sandy soil and equipped with three MFHPPs in the upper 4cm and thermocouples and dielectric soil moisture probes deeper. This configuration allows for accurate and simultaneous ground heat flux, soil moisture and subsurface evaporation measurements. Total evaporation is monitored using a precision scale, while an infrared gun and a long wave radiometer measure the soil skin temperature and the outgoing long-short wave radiation, respectively. A fan and a heat lamp placed above the column allow to mimick on a smaller and more controlled scale the field conditions induced by the diurnal cycle. At a reference height above the column relative humidity, wind speed and air temperature are collected.
Results are interpreted by means of numerical simulations performed with an ad-hoc-developed numerical model that simulates coupled heat and moisture transfer in soils and is used to match and interpolate the temperature and soil moisture values got at finite depths within the column. Ground heat fluxes are then estimated by integrating over almost continuous, numerically simulated temperature profiles, which avoids errors due to use of discrete data (Lunati et al., WRR, 2012) and leads to a more reliable estimate of this crucial term.
The surface energy balance is calculated and the residual decomposition approach described by Higgins, GRL, 2012 will be applied to estimate the contribution of the ground heat.
Results of the matching between subsurface-surface evaporation are presented, and the applicability of the MFHPP to energy balance closure problems is discussed.