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Analysis of high resolution land surface temperature patterns and related estimates of evapotranspiration

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Despite the importance of evapotranspiration (ET) for the Earth's water and energy cycle, quantifying the amount of evapotranspiration along with its variability in space and time is still difficult. At the field scale, Eddy Covariance or scintillometer systems deliver ET fluxes with high temporal resolution, albeit as an integrated signal over the footprint area. Spatially distributed ET estimates, in contrast, are mostly based on exploiting land surface temperature (LST) information acquired from thermal sensors mounted on satellite or airborne platforms. Especially for satellite data, the spatial resolution is limited to at best 90 m and thus does not support the analysis of in-field variability of LST.

In July 2016, high resolution LST information was collected by using an octocopter UAV (unmanned aerial vehicle) with a dual camera setup, consisting of a thermal imager and a regular digital camera. The setup allows for collecting information with high spatial detail (ground resolution of the thermal imagery of 5 cm) that reveals small scale variability in land surface temperature and vegetation properties.

The acquired dataset includes maps of land surface temperature and corresponding optical imagery for different dates, times of day as well as radiative and moisture conditions. Based on these images and data from a meteorological station, we model evapotranspiration using two energy balance based approaches as well as a simple contextual model. Model results are compared against turbulent energy fluxes measured by an Eddy Covariance (EC) system that is installed permanently at the site as part of the TERENO network and operated by the IMK-IFU. The importance of considering the correct EC footprint for the comparison of measured and modelled fluxes (even over a uniform land cover type) is addressed by evaluating the agreement between model estimates and measured values separately for areas in- and outside of the footprint (from up- and downwind fields). Since we conducted UAV flights under different environmental conditions, e.g. different times of day, weather and moisture conditions, the robustness of the model's performances under varying conditions can be evaluated.

In summary, this study aims at exploring the suitability of different ET algorithms that are typically run with coarser thermal imagery over larger areas for the estimation of high resolution, spatially distributed evapotranspiration rates at the field scale. The study has been carried out as part of the ScaleX field campaign (in the TERENO-prealpine observatory) at a grassland site in Fendt, Germany.