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Spatial distribution of evapotranspiration and turbulent heat fluxes in a mature oil palm plantation using thermal imagery from UAV and two-source energy balance models

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Ongoing land transformation and the expansion of oil palm (Elaeis guineensis Jacq.) plantations change the face of tropical lowland areas in Indonesia and alter atmosphere-ecosystem interactions such as greenhouse gas exchange, turbulent heat fluxes, surface energy balance and evapotranspiration. Tropical ecosystem and land surface properties still lack in-depth understanding due to scarce direct observational and modelling studies. However, accelerated expansion and expected future areal increase of oil palm plantations, due to increasing global demand for vegetable oils as well as ongoing climate change, require a better understanding of evapotranspiration in oil palm plantations and its spatial and temporal variability for water resource and crop management.

In this study we use land surface temperature (LST) measurements obtained by an unmanned aerial vehicle (UAV) equipped with a radiometric thermal camera during a 5-day campaign to estimate turbulent fluxes of sensible and latent heat as well as evapotranspiration at a conventional oil palm plantation in the Jambi province (Sumatra, Indonesia). A total of 61 utilizable flights were carried out during the field survey. The acquired surface energy balance components are validated with on-site eddy covariance and meteorological measurements and used as an input for the two-source energy balance (TSEB) and dual-temperature-difference (DTD) model. UAV thermal images were recorded in 12 Bit radiometric resolution and cover an area of 160 x 140 m in size, which is within the flux footprint area of the eddy covariance system. Further, we created a digital elevation model from UAV imagery and investigate the effects of terrain on turbulent heat fluxes estimated from TSEB and DTD models and measured by eddy covariance.

The generated digital elevation model covers an area of 49 ha and is merged from 2720 single RGB images resulting in a ground resolution of 3.24 cm per pixel. Flux footprint analysis shows that turbulent heat fluxes originate from southeast and uphill directions. During the UAV flight campaign, daytime sensible and latent heat fluxes from eddy covariance measurements reach, on average, 51.5 W m-2 and 241.2 W m-2, respectively. Midday Bowen ratio reaches 0.25 and midday evapotranspiration is 0.51 mm h-1.