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Biophysical Impacts of Tropical Land Transformation from Forest to Oil Palm and Rubber Plantations in Indonesia

Alexander Knohl (1), Ana Meijide (1), Yuanchao Fan (1), Dodo Gunawan (2), Dirk Hölscher (3), Tania June (4), Furong Niu (3), Oleg Panferov (5), Andre Ringeler (1), Alexander Röll (3), Clifton Sabajo (1), and Nina Tiralla (1)

(1) Georg-August University Göttingen, Bioclimatology, Göttingen, Germany (aknohl@uni-goettingen.de), (2) Climate Change and Air Quality, Badan Meteorologi, Klimatologi, dan Geofisika, Jakarta, Indonesia, (3) Georg-August University Göttingen, Tropical Silviculture and Forest Ecology, Göttingen, Germany, (4) Bogor Agricultural University (IPB), Department of Geophysics and Meteorology, Bogor, Indonesia, (5) University of Applied Sciences, Climate protection and adaptation, Bingen, Germany

Indonesia currently experiences rapid and large-scale land-use changes resulting in forest loss and the expansion of cash crop plantations such as oil palm and rubber. Such land transformations are associated with changes in surface properties that affect biophysical processes influencing the atmosphere. Yet, the overall effect of such land transformations on the atmosphere at local and regional scale remains unclear.

In our study, we combine measurements of microclimate, transpiration via sap-flux, surface energy fluxes via eddy covariance, surface temperature via remote sensing, land surface (CLM) and regional climate modeling (WRF) for Jambi Province in Indonesia.

Our microclimatic measurements showed that air temperature within the canopy was on average 0.7-0.8°C higher in monoculture plantations (oil palm and rubber) compared to forest. Remote sensing analysis using MODIS and Landsat revealed a higher canopy surface temperature for oil palm plantations (+1.5°C) compared to forest, but only little differences for rubber plantations. Transpiration (T) and evapotranspiration (ET) as well as the contribution of T to ET of oil palm showed a strong age-dependent increase. The sensible to latent heat flux ratio decreased with age. Overall, rubber plantations showed the lowest transpirations rates (320 mm year-1), oil palm intermediate rates (414 mm year-1), and forest the highest rates (558 mm year-1) indicating substantial differences in water use.

Despite the differences in water use and the higher within-canopy and surface temperatures of the plantations compared to the forest, there was only a minor effect of land transformation on the atmosphere at the regional scale (<0.2 °C), irrespectively of the large spatial extend of the transformation. In conclusion, our study shows a strong local scale biophysical impact affecting the conditions at the stand level, which is however mitigated in the atmosphere at the regional level.