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

Alexander Knohl[1], A Meijide[1], Y Fan[1], D Gunawan[2], D Hölscher[3], T June[4], F Niu [3], O Panferov[5], A Ringler[1], A Röll[3], C Sabajo[1,] N Tiralla[1]

aknohl@uni-goettingen.de

GEORG-AUGUST-UNIVERSITÄT GÖTTINGEN

EFForTS

Introduction

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, e.g. albedo, surface temperature, and energy partitioning. Yet, the overall biophysical effect of such land transformations on the atmosphere at local and regional scale remains unclear.

Objective

- To quantify the biophysical impact of land transformation on the atmosphere at local scale and at regional scale

Questions

- What are the impacts at local scale (stand level)?
- What are the impacts at regional scale (province level)?

Conclusions

- Higher within-canopy air, soil, and surface temperature of all transformed systems compared to forest (1°C , 3°C respectively)
- Oil palm age has large effect on surface temperature and energy partitioning
- Large differences in transpiration across land-use types
- However, only minor air temperature effects (<0.2 °C) at the regional scale

➔ strong local scale biophysical impacts on the atmosphere, which is however mitigated at the regional level.

Site

- Jambi province, Sumatra, Indonesia
- Land-use types: Forest, jungle rubber, rubber and oil palm plantations

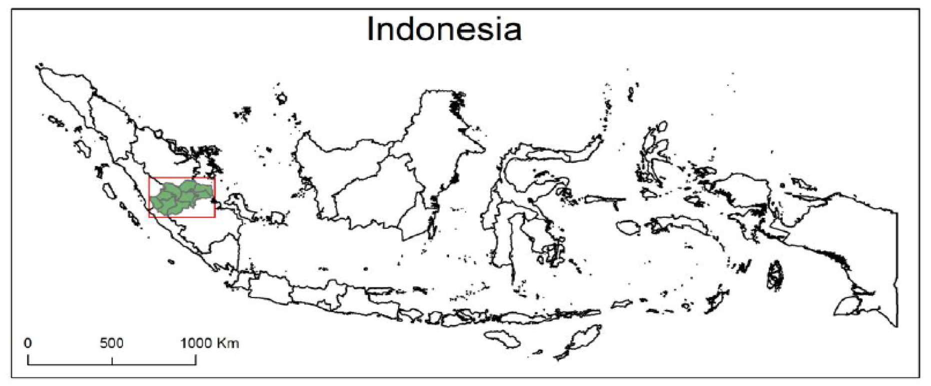

Fig. 1 Study area: Jambi province, Sumatra

Methods

- Microclimate: air (2 m, below canopy) and soil (-0.05 m) temperature at 32 plots.
- Remote sensing: canopy surface temperature derived from Landsat images (thermal band)
- Surface fluxes: eddy covariance measurements in a 2- and a 12-year old oil palm plantation
- Plant water use: sap flux measurements in 32 plots
- Land surface modelling: CLM 4.5 with new oil palm module
- Regional climate modelling: WRF 3.6 coupled to CLM 4.0, double nesting to 2 x 2 km resolution

Acknowledgements

This study was supported by a grant from the German Research Foundation (DFG, *CRC 990*, subprojects A02, A03 and Z02) and the European Commission through by the Erasmus Mundus Joint Doctorate Program *Forest and Nature for Society* (EMJD FONASO).

Affiliations

[1]Bioclimatology, Georg-August University Göttingen, Germany, [3]Agency for Meteorology Climatology and Geophysics, Indonesia, [3]Tropical Silviculture and Forest Ecology, Georg-August University Göttingen, Germany, [4]Department of Geophysics and Meteorology, Bogor Agricultural University, Indonesia, [5]Climatology and Climate Protection, University of Applied Sciences Bingen am Rhein, Germany

Results

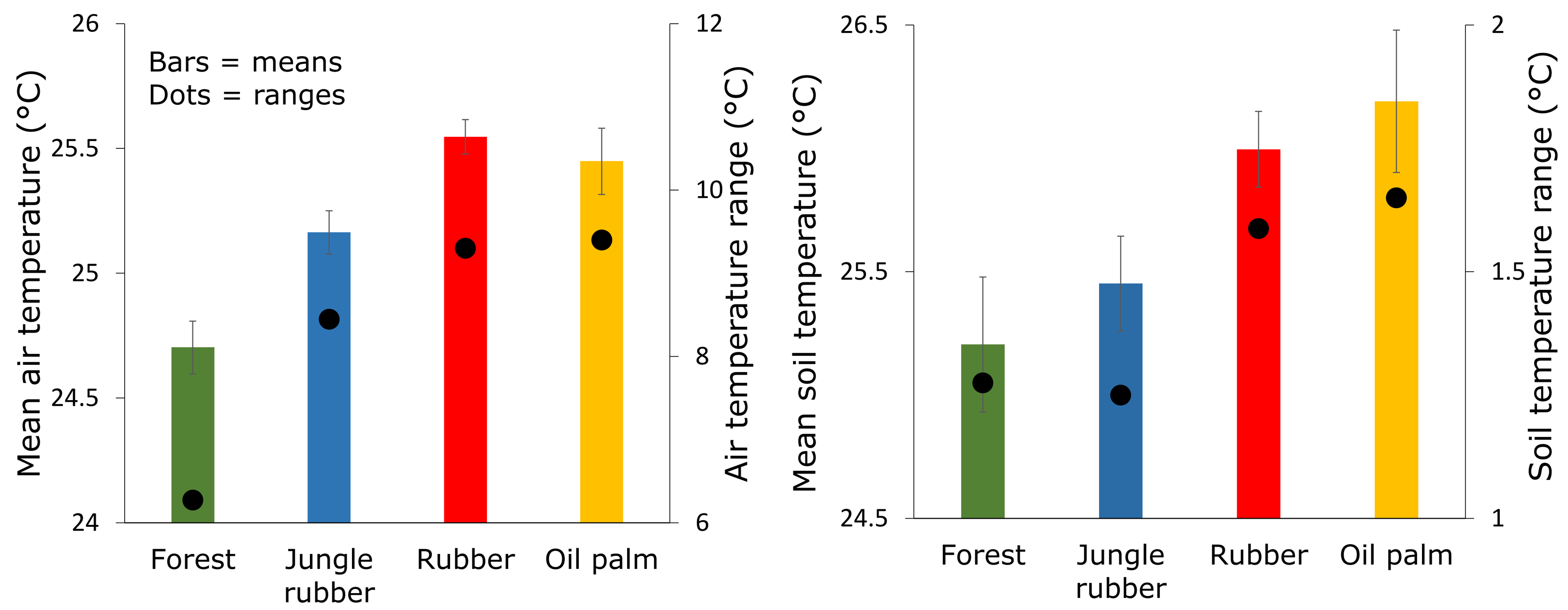

Fig.2: Measured air (left) and soil (right) temperature across different land-use systems. Bars = means ± std, Dots = ranges between percentiles 5 and 95

➔ **Canopy air temperature and soil temperature** about 1°C higher in plantations compared to forest

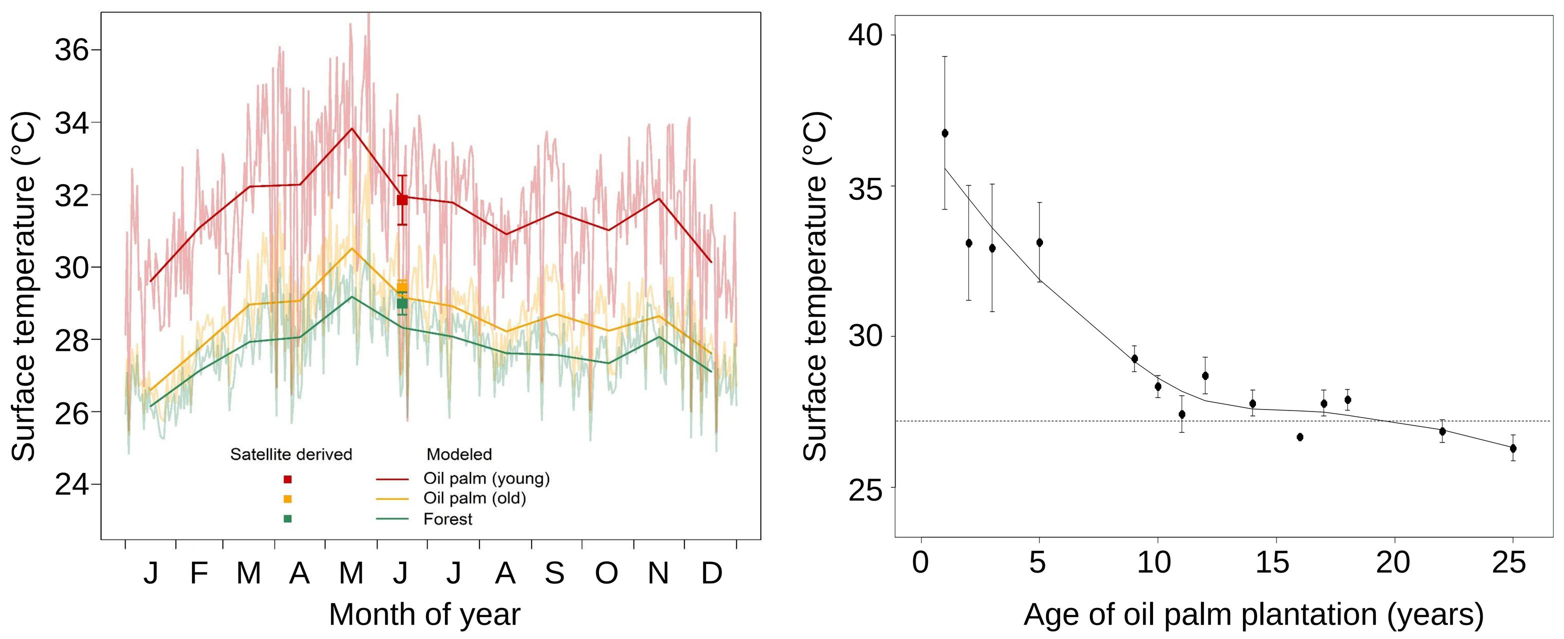

Fig. 3: Modelled (left, lines, tick reflects monthly, thin daily 10-11 a.m. means) and satellite derived surface temperature (left, squares) of oil palm plantations and forests. Satellite derived surface temperature of oil palm plantations versus age (right). Horizontal line reflects forests, fit based on Local Polynomial Regression Fitting (LOESS)

➔ **Surface temperature** of oil palm plantation about 3°C higher than of forest. Young oil palm plantations up to 10°C higher, mature oil palm plantations approach forest

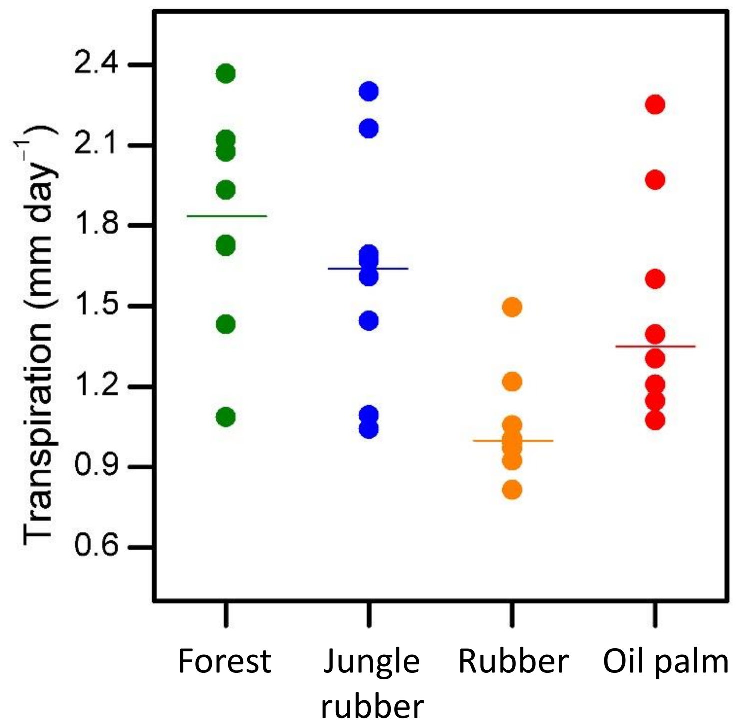

Fig. 4: Transpiration (sap flux) across land-use systems

➔ **Transpiration** is lowest in rubber plantation. Oil palm on average also has lower transpiration compared to forest. Large transpiration in mature and highly fertilized oil palm plantations (not shown).

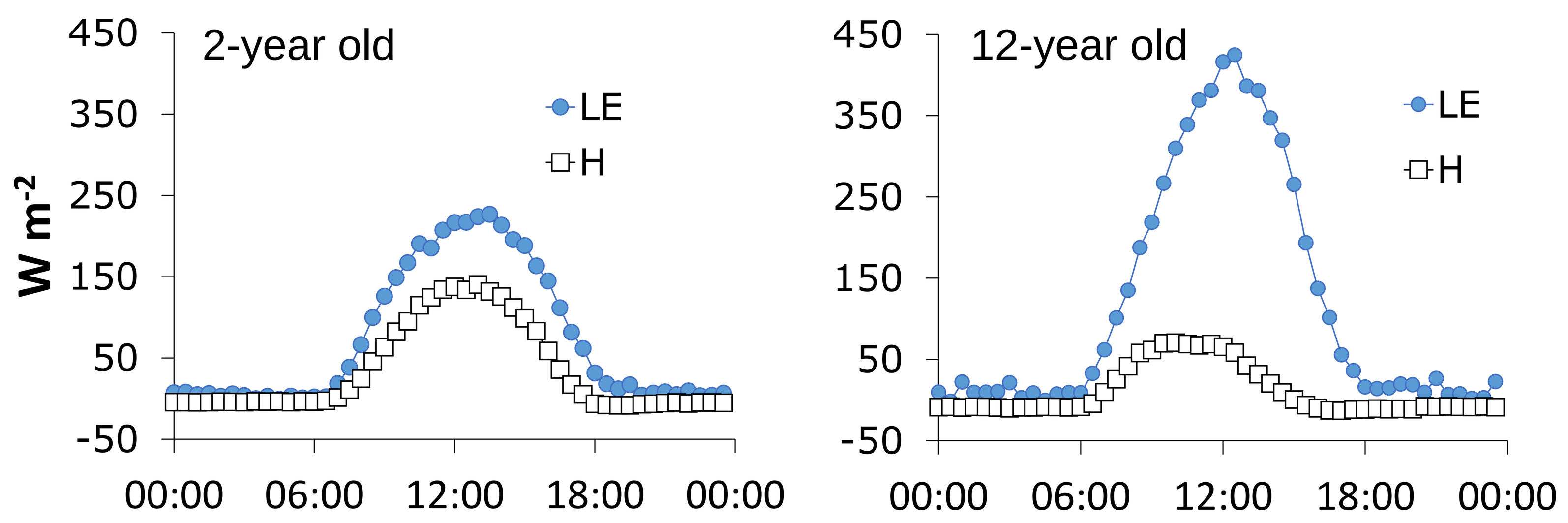

Fig. 5: Latent (LE) and sensible (H) heat fluxes (mean diurnal cycle) of 2-year old and 12-year old oil palm plantation based on eddy covariance measurements.

➔**Energy partitioning** of oil palm stands changes strongly with age

Table 1: Modelled effect of land transformation on regional air temperature at 2 m (ΔT_{air}) based on regional climate model simulations using current climate (ERA-Interim 2000-2005)

	Mean T	Min T	Max T
ΔT_{air} (K)	<0.2	<0.5	<0.5

➔**Mean regional warming effect** due to land transformation is small (< 0.2°C).