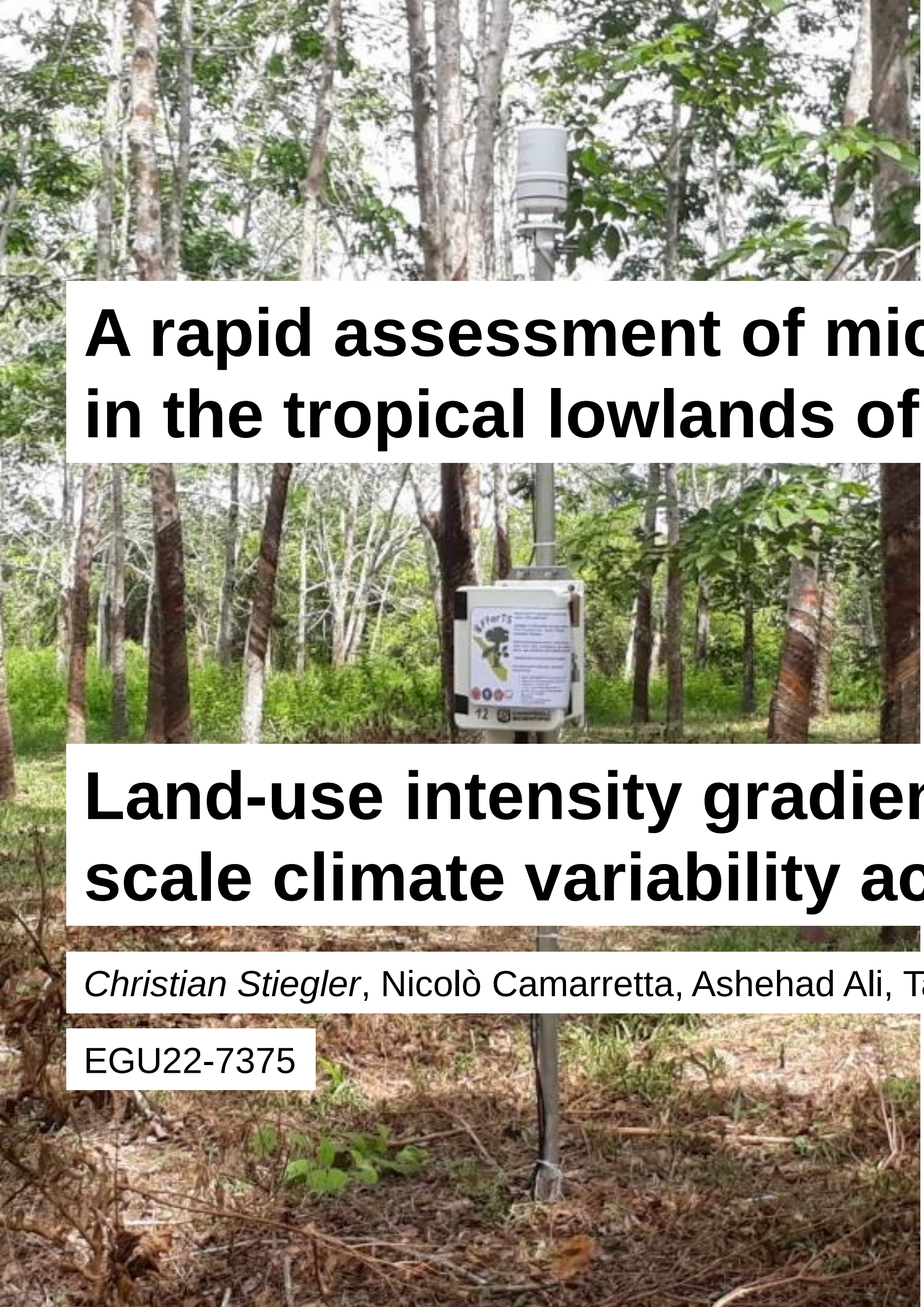
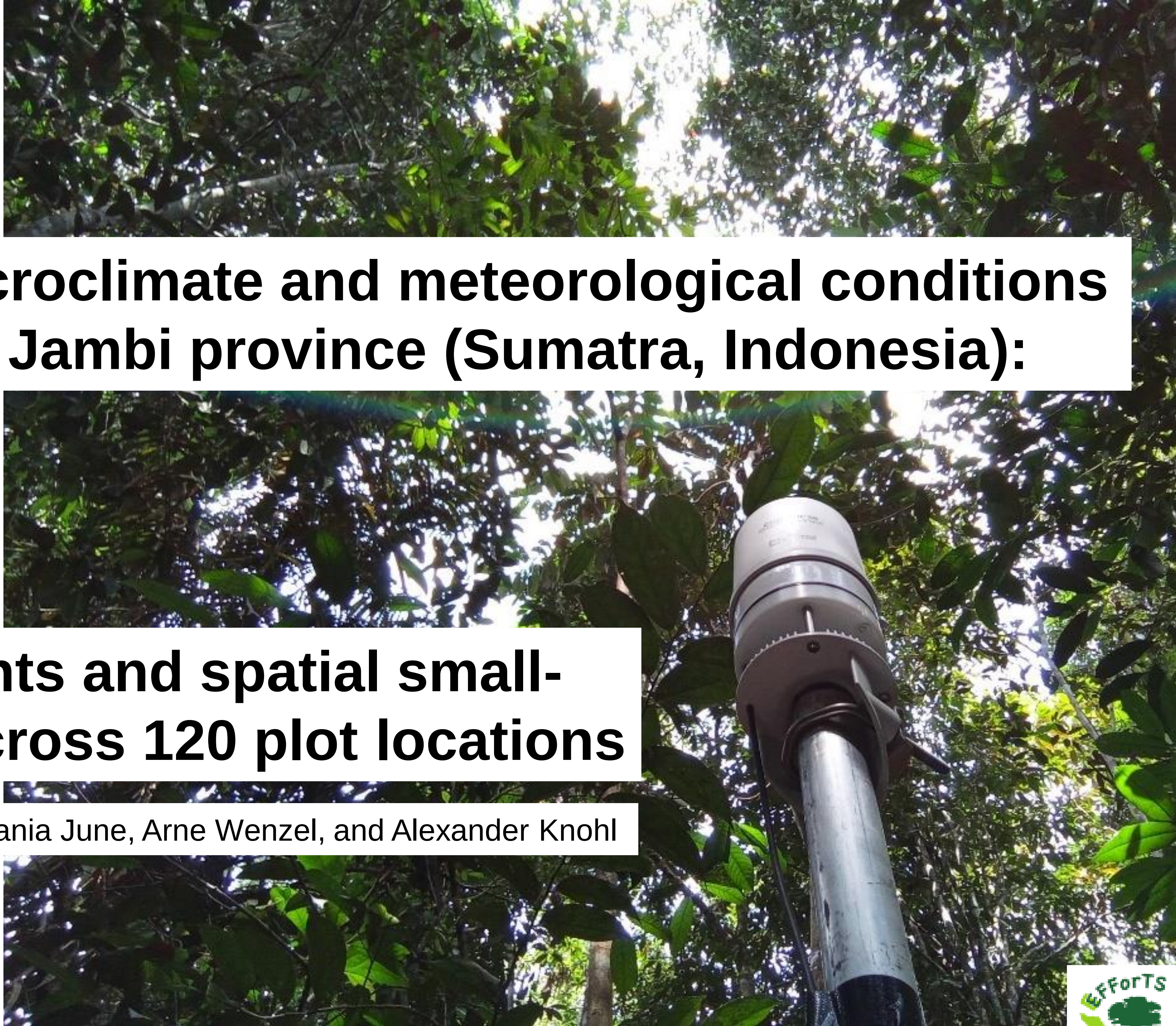
A rapid assessment of microclimate and meteorological conditions in the tropical lowlands of Jambi province (Sumatra, Indonesia):

Land-use intensity gradients and spatial small-scale climate variability across 120 plot locations

Christian Stiegler, Nicolò Camarretta, Ashehad Ali, Tania June, Arne Wenzel, and Alexander Knohl

EGU22-7375





Bogor Agricultural University
University of Jambi
Tadulako University
University of Göttingen
DFG Deutsche Forschungsgemeinschaft

Land-use change in Indonesia

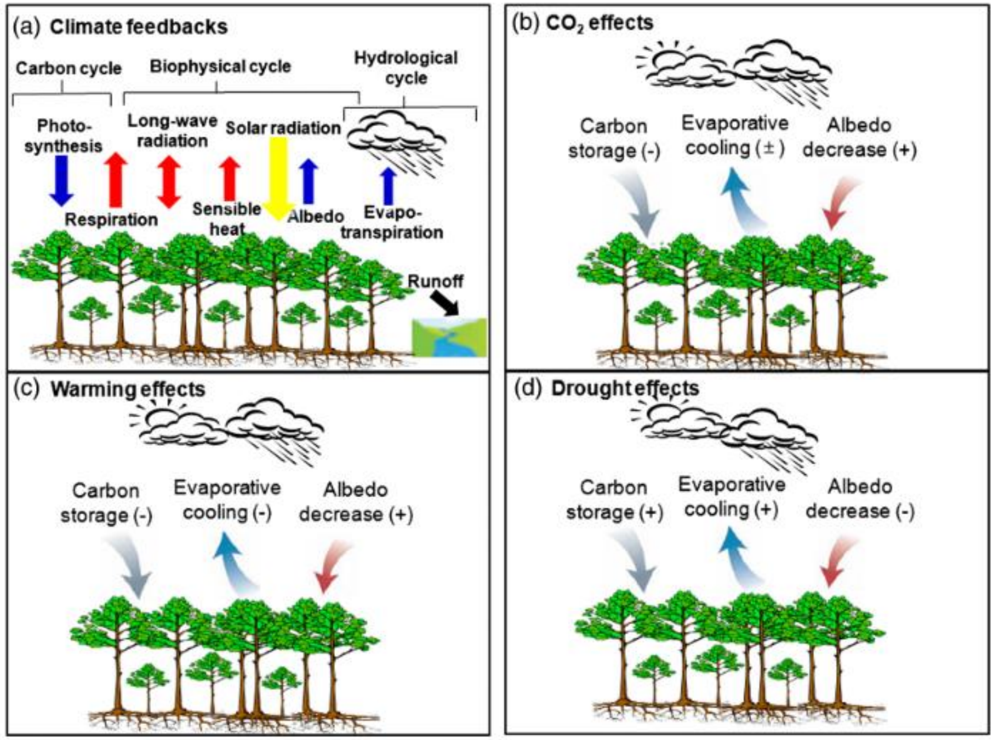
Indonesia is one of the hotspots of land transformation from forest ecosystems toward oil palm and other cash-crop monocultures.

Deforestation arising from cropland expansion in the tropics poses threats to forest ecosystem services, climate regulation and carbon stocks.

Substantial loss of primary forest cover in Indonesia:

- 2001-2016: total loss ~9.2 Mha
  (=size of Portugal, or 103 times the city of Berlin)

Picture credit: Dipa



Zhou et al. (2013)

Study aim & hypothesis

Study aim:

- Asses below-canopy microclimate and its spatial small-scale variability within the most common land-use types in tropical lowland Jambi province (Sumatra, Indonesia).
- Explore functional relationships between microclimate and vegetation characteristics.

Hypothesis:

- Agricultural land-use systems (e.g. oil palm & rubber monocultures) with their lower vegetation structural complexity, have warmer and drier microclimates and reduced microclimatic buffering capacities compared to forest systems.

Picture credit: Basri

Rapid (ecological) assessment

- A Rapid Assessment is a brief, topic-specific collection of data.
- Rapid (Ecological) Assessments are used to study an ecosystem by activities of researchers in different fields working in the same place and at the same time.
- The method provides a quick “snapshot” of an ecosystem in situations where time and financial resources are limited.
- The idea is to respect each research field’s particular methodology & foster interaction among the fields. → Obtain knowledge of the ecological relations between the various groups.

Source: EFForTS-instagram

Study area

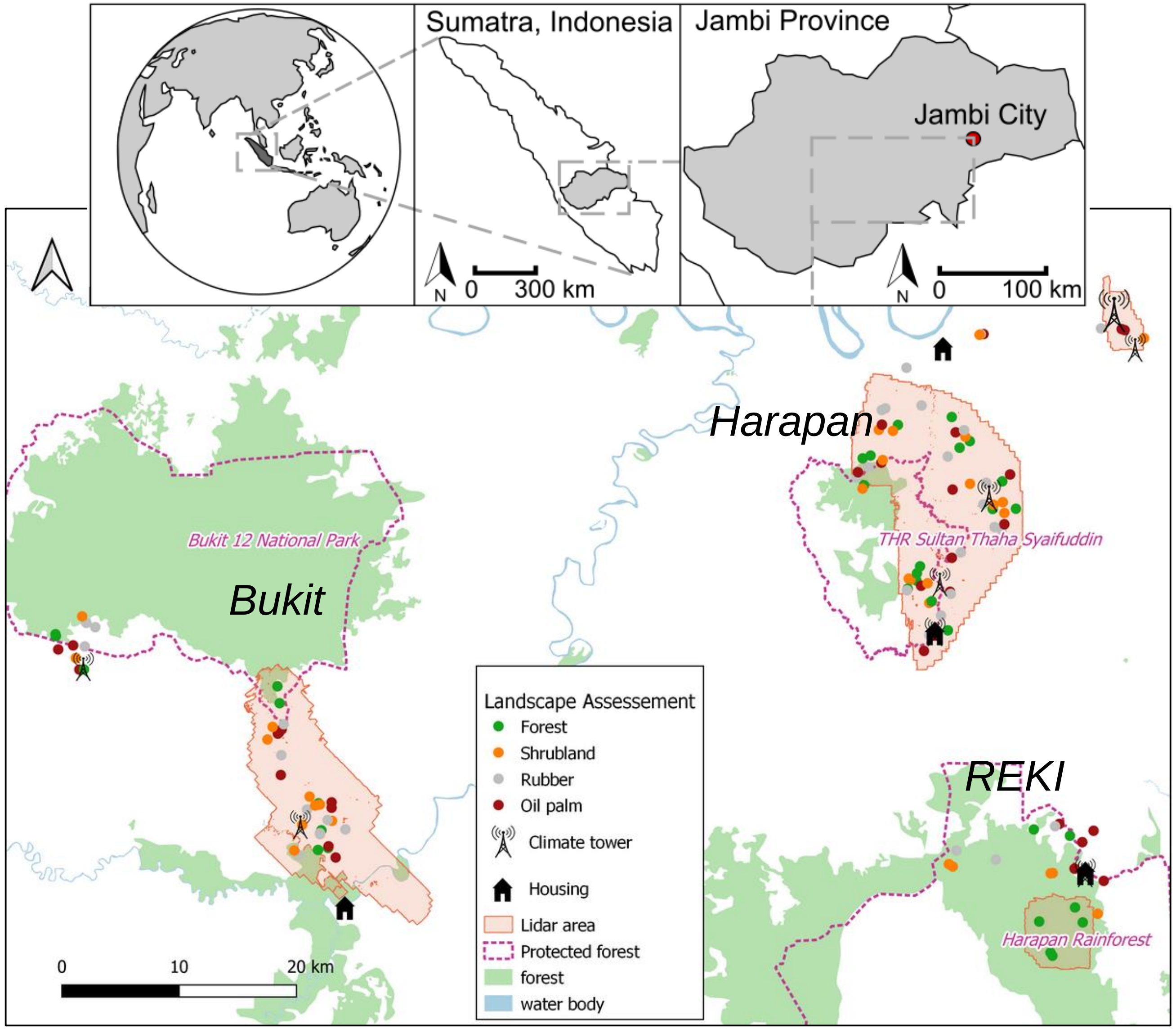
Study area:
Tropical lowland Jambi Province, Sumatra, Indonesia

3 landscapes:
"*Bukit*", "*Harapan*" & "*REKI*"

4 main land-use types:
Forest, oil palm & rubber plantations, shrub land

132 locations → "plots"

Duration:
May – November 2021



Source: Stiegler et al., 2019, EFForTS-sharepoint

Instrumentation

Micrometeorological measurements:

- “Mini meteo stations” *ClimaVUE 50 Compact Digital Weather Sensor*, Campbell Scientific; *TRIME-PICO32* soil moisture & temperature)
- Measured parameters:
  - Air temperature
  - Air relative humidity
  - Air pressure
  - Air vapor pressure
  - Wind speed
  - Wind direction
  - Solar radiation
  - Precipitation
  - Lightning (lightning strike count, lightning average distance)
  - Soil moisture
  - Soil temperature

Picture credit: Basri

Airborne laser scanning (ALS):

- Collected on seven separate days between 24 January and 5 February 2020, covering a total surface of 434,14 km^2.
- BN2T fixed-wing aircraft, *Riegl LMS-Q780* full waveform scanner.

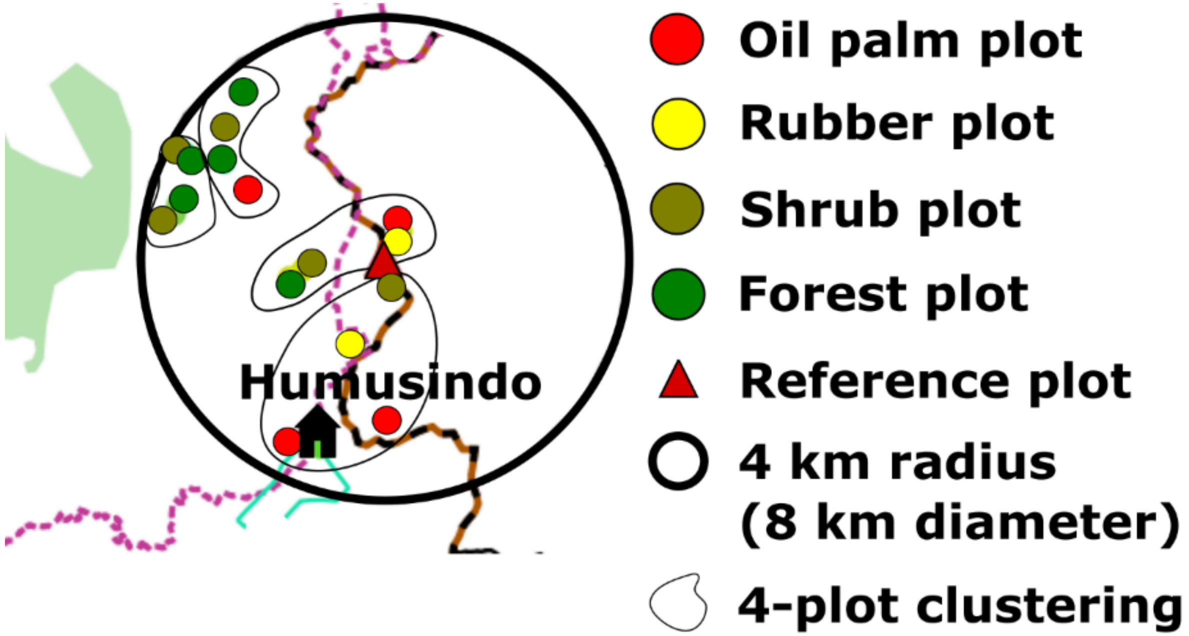
Picture credit: Riegl.com

- For each individual site, a suite of ALS-derived metrics was computed, e.g.:
  - Vegetation height
  - LAI, NDVI
  - Complexity/heterogeneity measures (rumple index, etc.)
  - Measures of vertical (e.g. foliage height diversity) and horizontal structure (e.g. canopy gaps)

Measurement design

- The entire study region is divided into 16 micro-regions.
- Each micro-region has a radius of 4 kilometers.
- Within each micro-region, a reference meteorological station is installed in an open area.
- During one set of measurements (4-plot clustering), one station is installed at each of the 4 plots. After 2 days of measurements, the meteo stations are moved to 4 new plots.

Example of a micro-region



Reference (open-land)

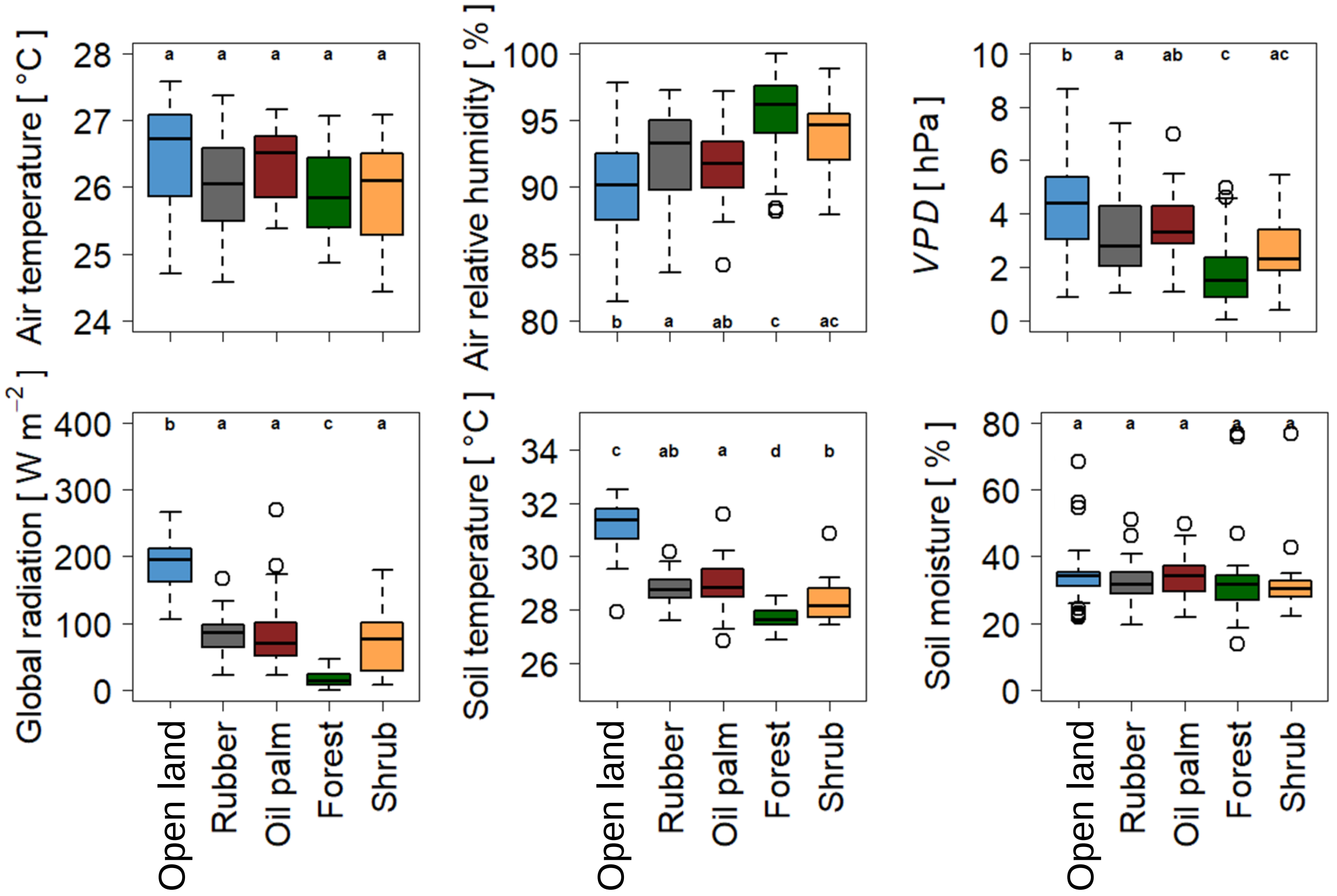
Oil palm plot

Shrub plot

Forest plot

Rubber plot

Average microclimatic conditions

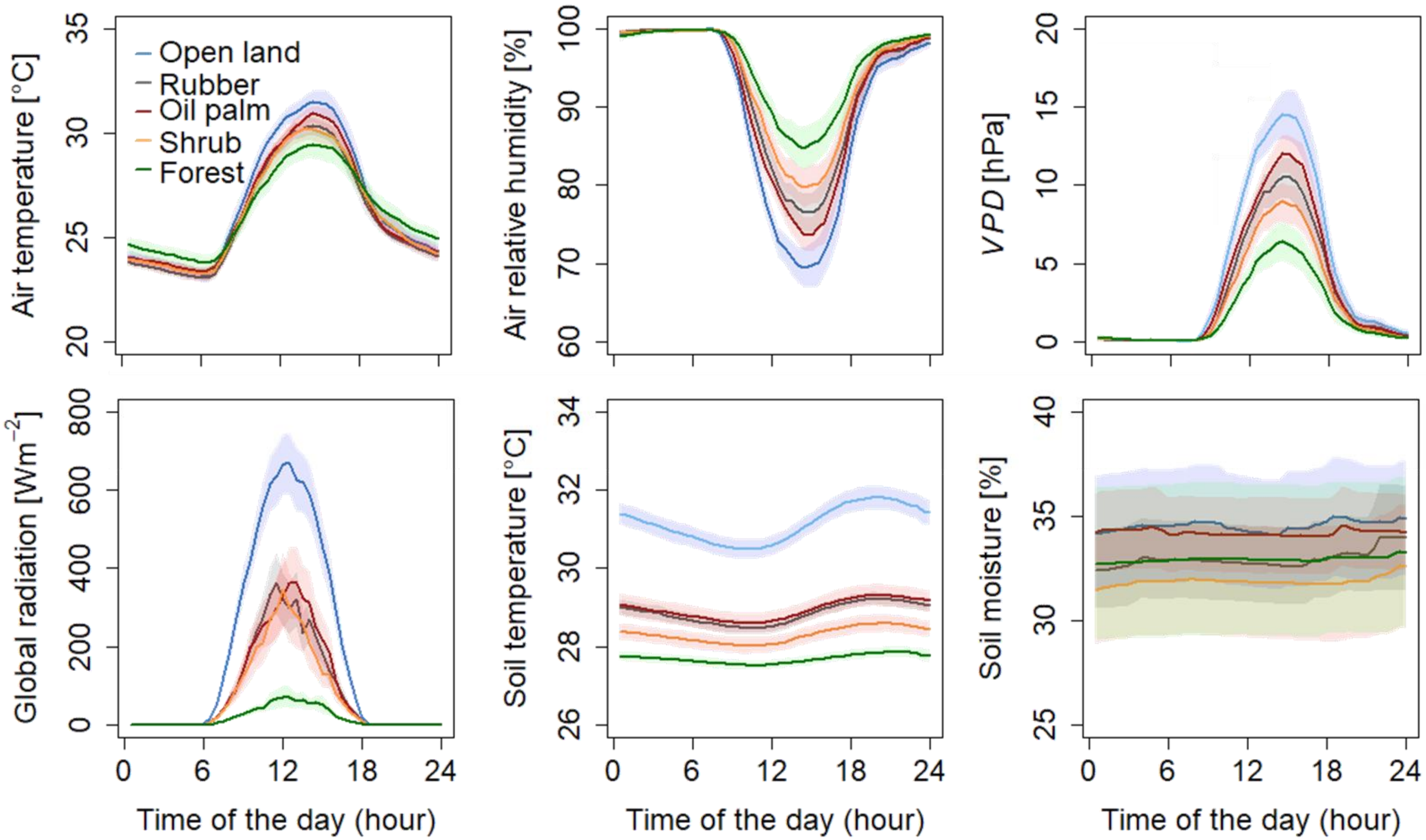


Forests and shrub (fallow) land sites are generally cooler, wetter, and receive lower radiation compared to agricultural systems and open land.

Sample size:

- Forest: 32
- Oil palm: 29
- Shrub: 29
- Rubber: 28
- Open-land locations: 41

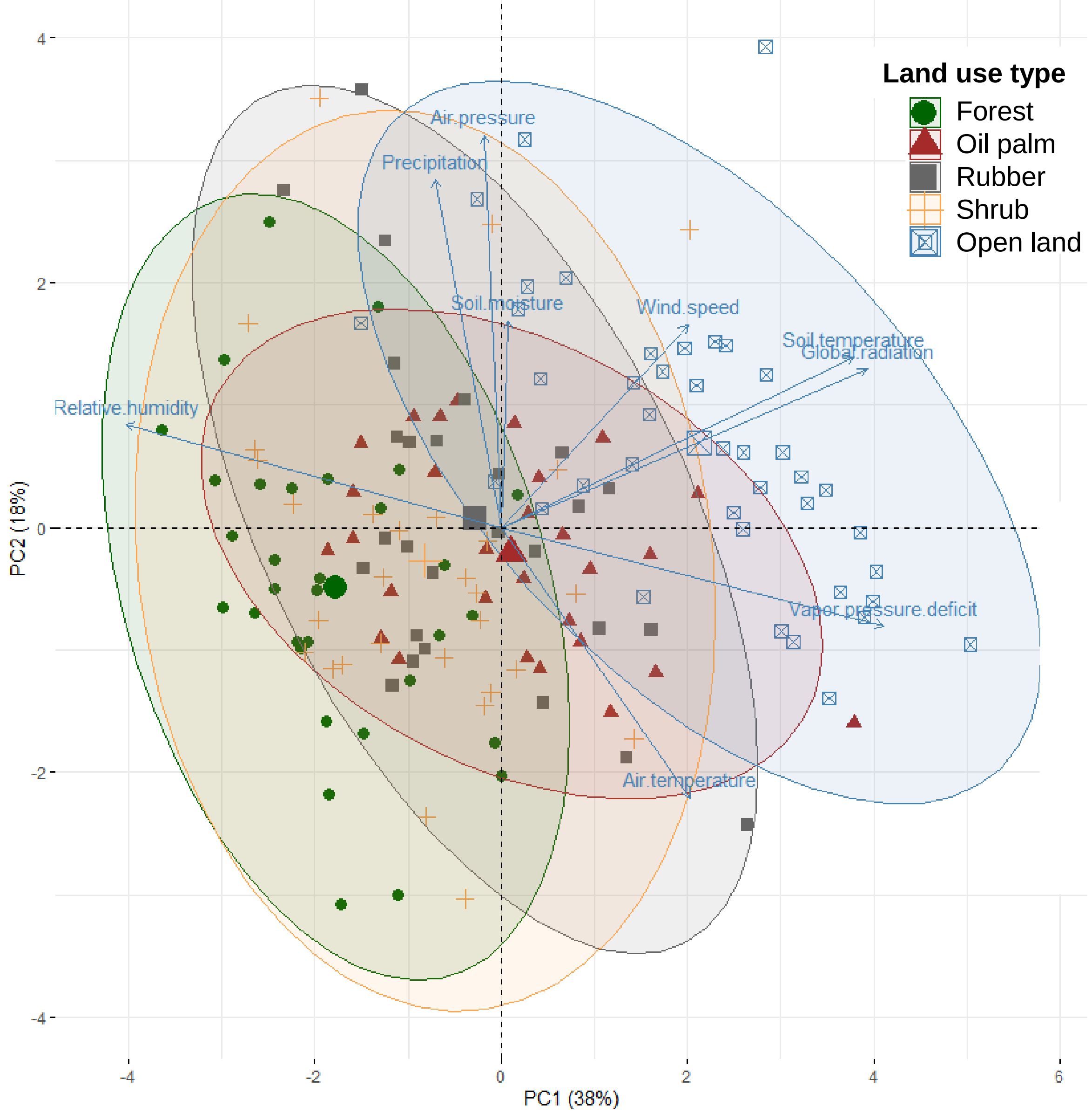
Diel microclimatic patterns



On a diel scale, differences in meteorological conditions are most pronounced around noon and in the afternoon hours.

Forests have lower amplitudes compared to agricultural systems and open land.

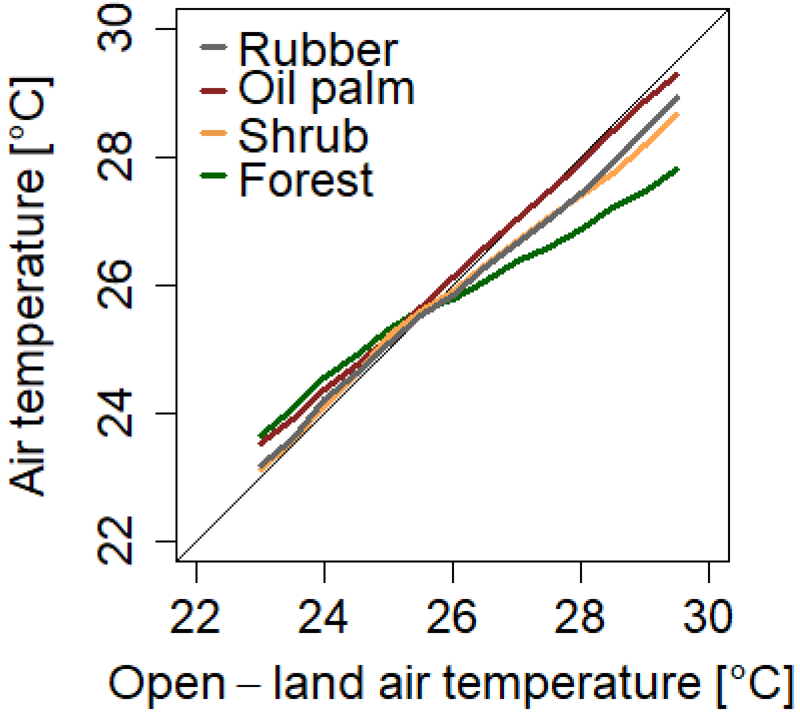
PCA of microclimatic conditions

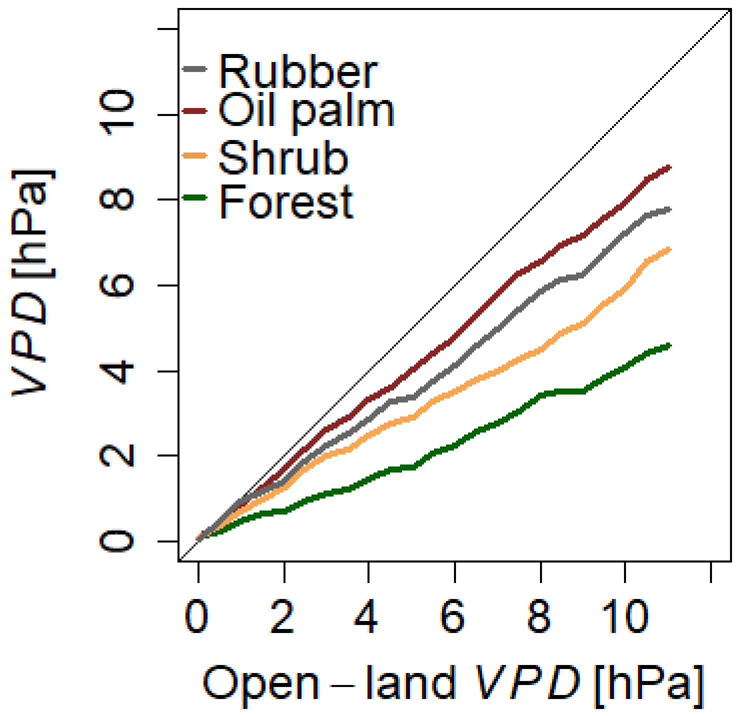


The variability of microclimatic parameters is well represented by the two principal components.

There is a clear difference in microclimatic conditions between forest and open-land locations and between agricultural systems (oil palm & rubber) and forests.

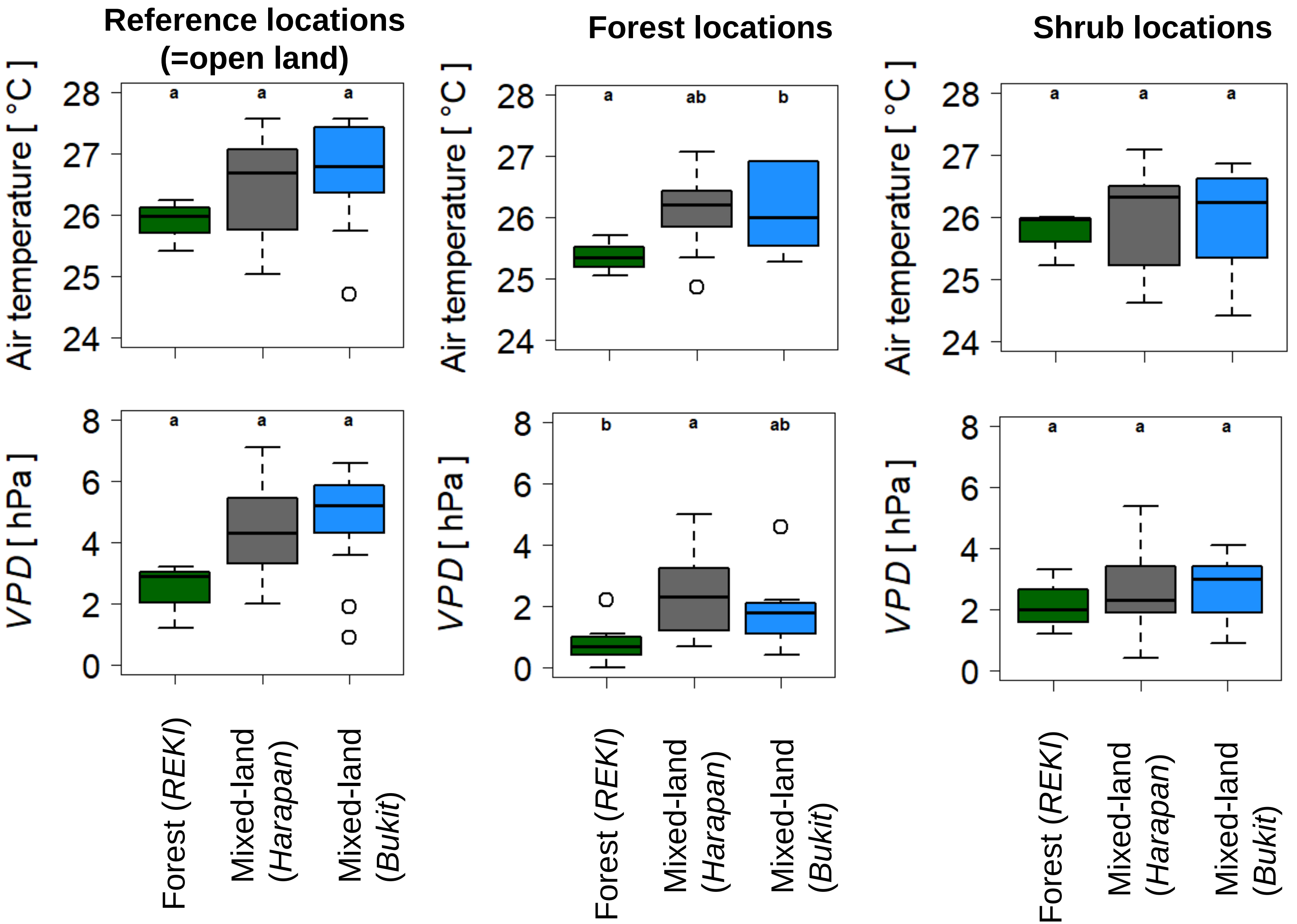
Buffering effects of land use types





Compared to open-land and agricultural systems, forest systems tend to buffer increases in air temperature and atmospheric vapor pressure deficit (*VPD*).

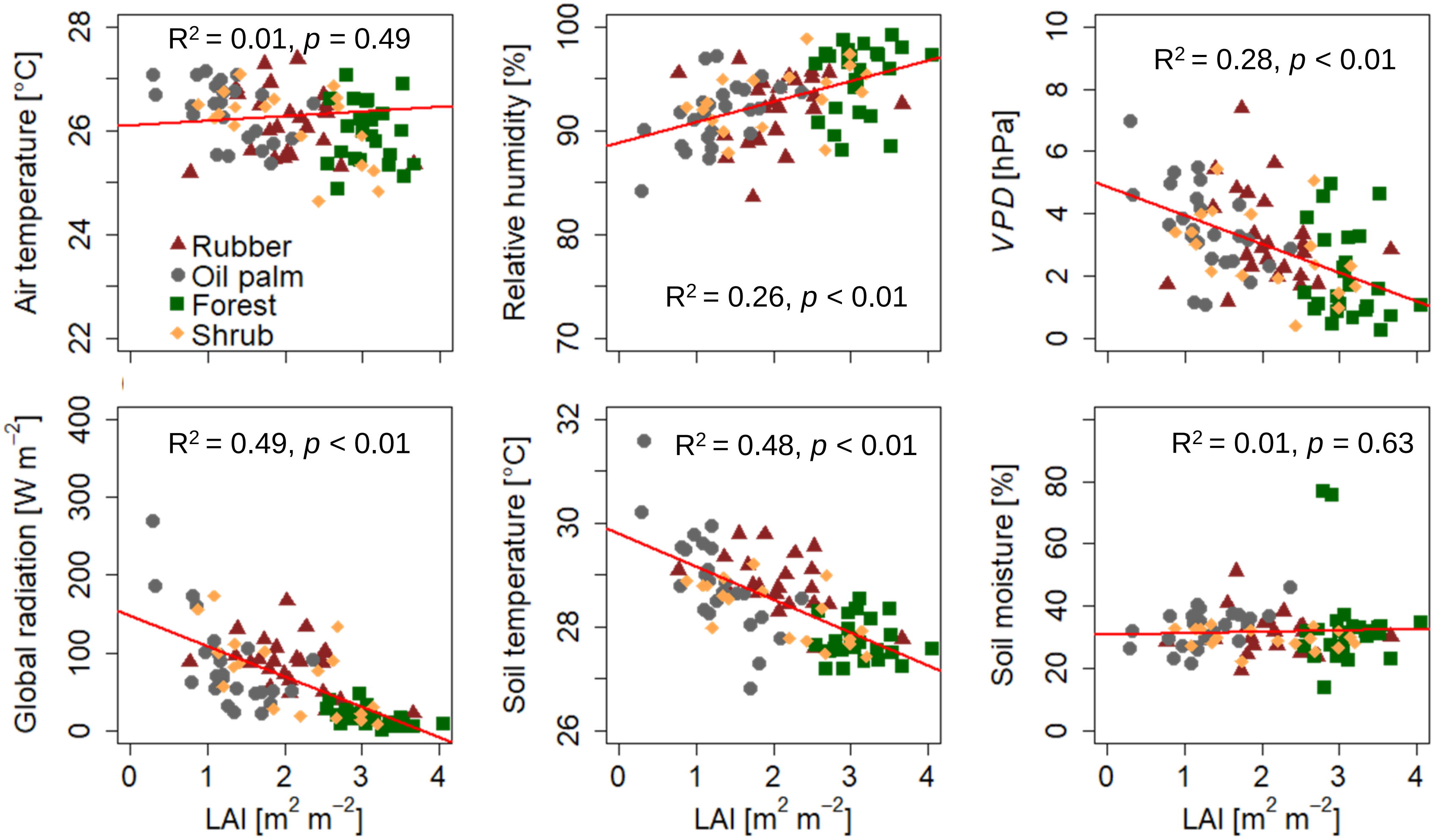
Differences between land systems (REKI, Harapan, Bukit)



Mixed-land systems (*Harapan, Bukit*) tend to be slightly warmer and drier compared to forest-dominated land systems (*REKI*).

Within the mixed-land systems, forests tend to be warmer and drier compared to forests in the forest-dominated land systems (*REKI*)

Leaf area index (LAI) and microclimatic conditions

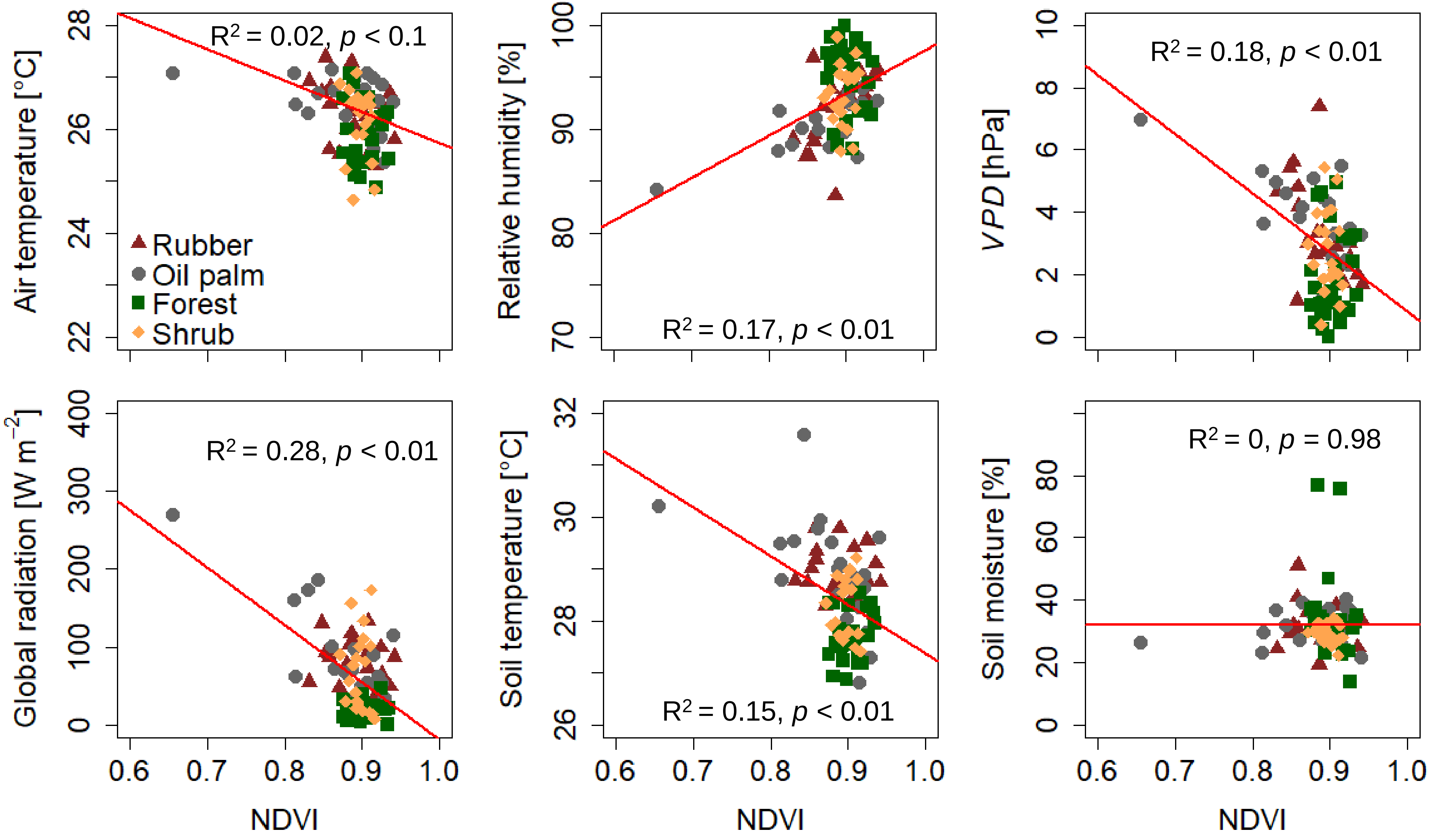


LAI, with higher leaf area density in forest ecosystems than agricultural systems, showed significant impact on air moisture, below-canopy light, and soil temperature conditions.

Sample size:

- Forest: 26
- Oil palm: 25
- Shrub: 18
- Rubber: 24

NDVI and microclimatic conditions

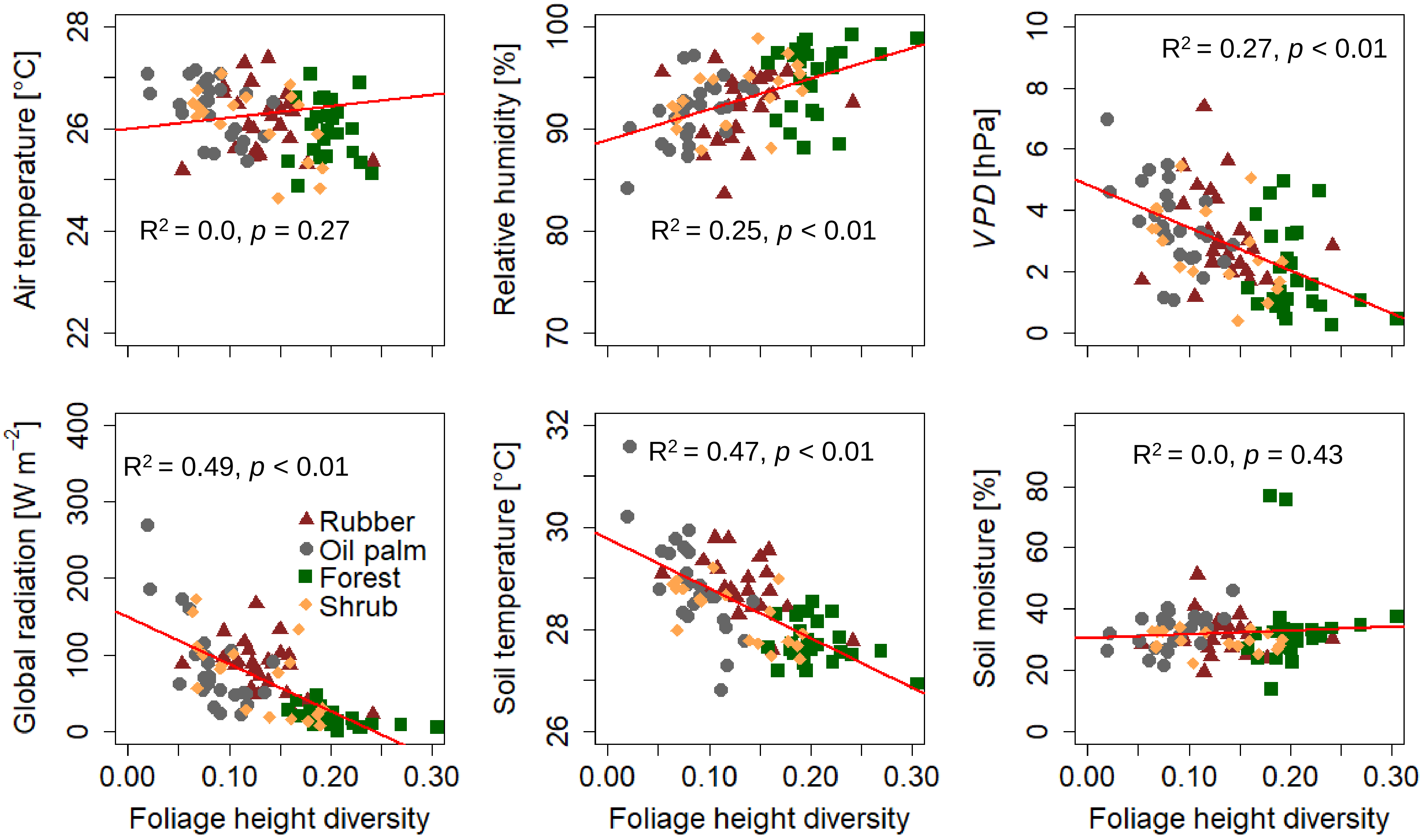


Micrometeorological parameters showed relatively weak correlations with NDVI.

Sample size:

- Forest: 26
- Oil palm: 25
- Shrub: 18
- Rubber: 24

Foliage height diversity (FHD) and microclimatic conditions

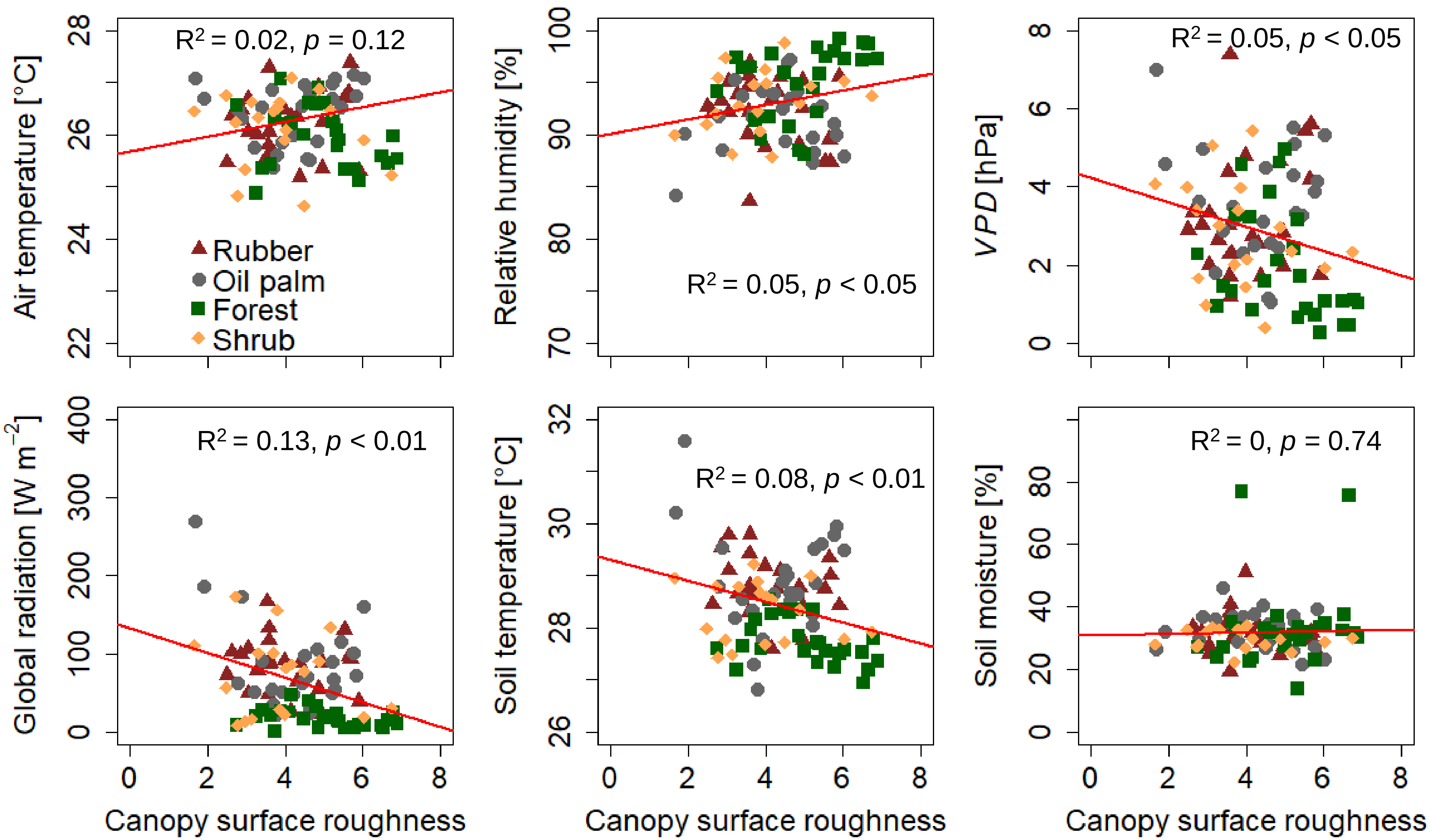


Foliage height diversity, with higher diversity in forest ecosystems than agricultural systems, showed significant impact on air moisture, below-canopy light, and soil temperature conditions.

Sample size:

- Forest: 26
- Oil palm: 25
- Shrub: 18
- Rubber: 24

Canopy roughness (rumple index) and microclimatic conditions



$R^2 = 0.01$, $p < 0.01$

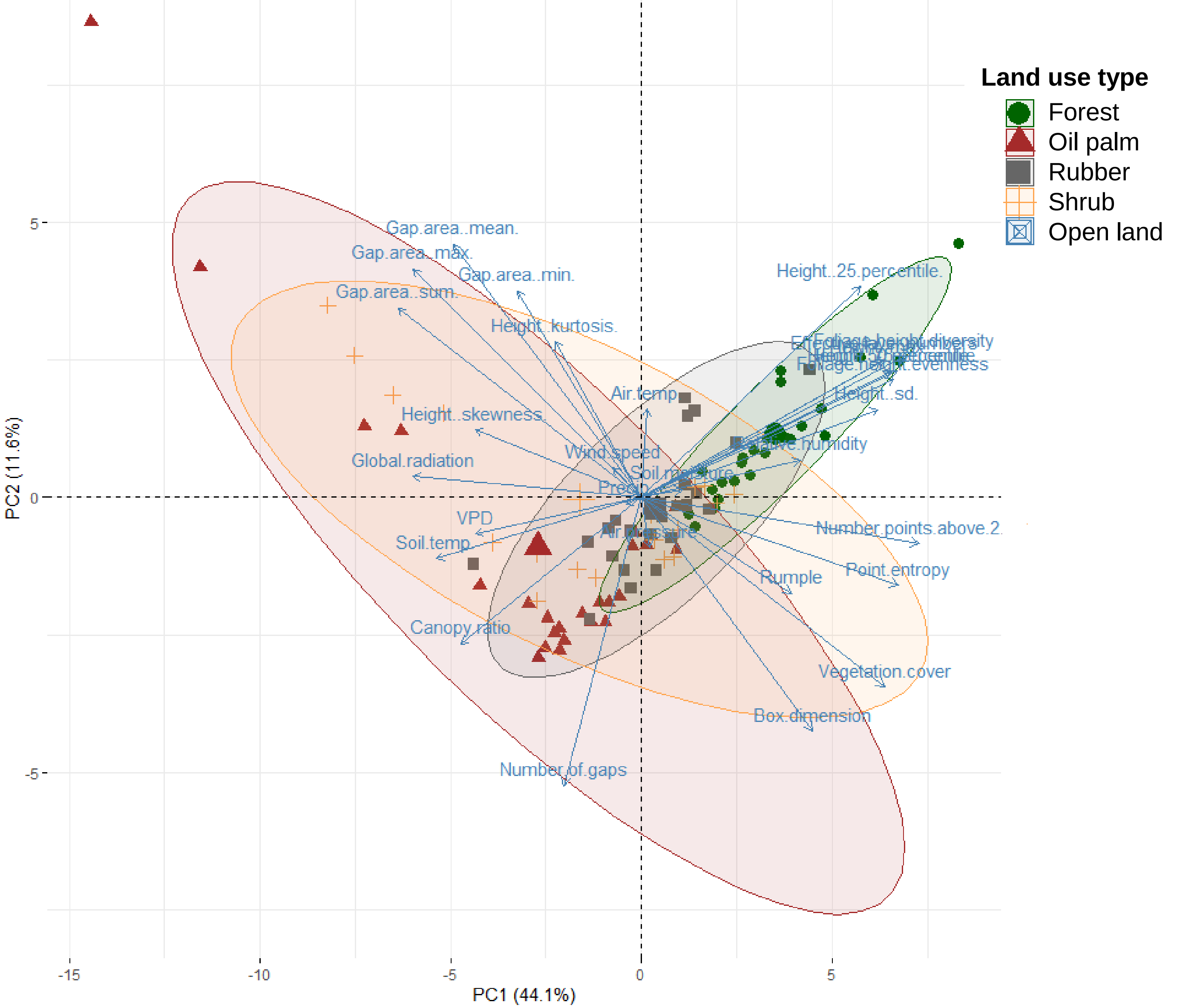
$R^2 = 0.01$, $p = 0.63$

Canopy roughness showed relatively little variation between the different land use types and no clear impact on meteorological parameters.

Sample size:

- Forest: 26
- Oil palm: 25
- Shrub: 18
- Rubber: 24

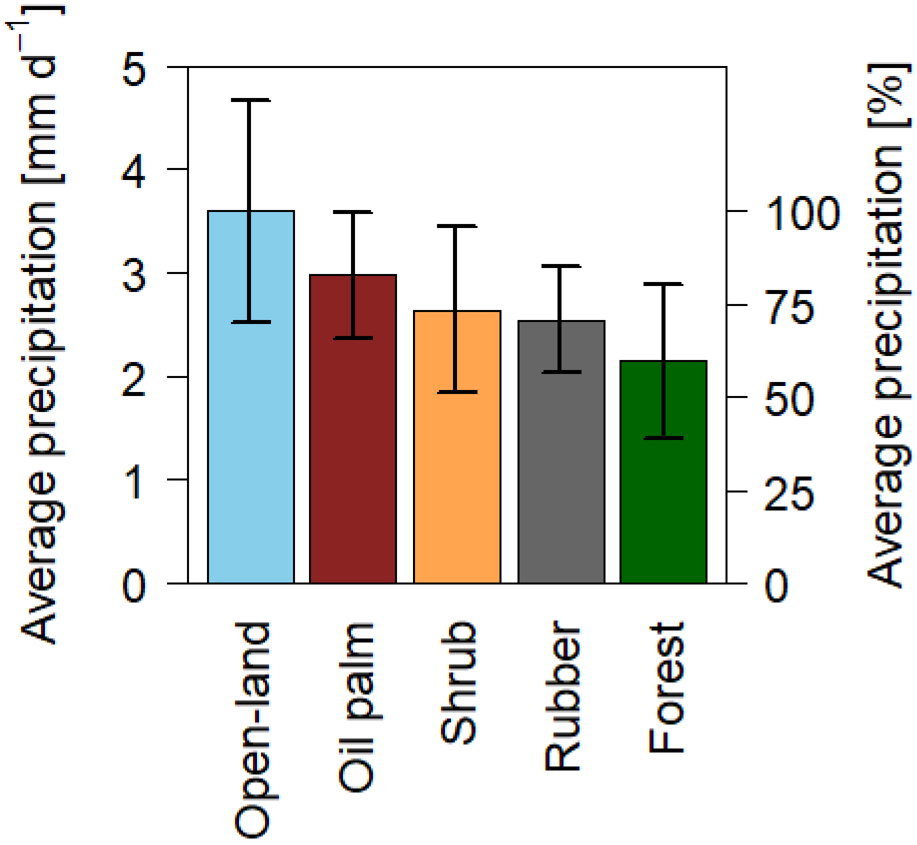
PCA of ALS metrics and microclimatic conditions



Stand summary statistics (e.g. LAI), measures of vertical structure (e.g. height, FHD), measures of complexity/heterogeneity (e.g. rumple), air humidity and air temperature seemed to be mostly related to forest and partly to rubber locations.

Metrics of vegetation gaps and below-canopy global radiation were mainly related to oil palm plantations and shrub (fallow) lands.

Precipitation and interception



Interception is highest in forests, with forest floors receiving ~41% less precipitation compared to open-land locations.

In contrast, interception in oil palm is relatively low, with oil palm floors receiving ~17% less precipitation compared to open-land locations.

Summary & conclusion

- We sampled 118 plots and 15 open-land locations.
- Forest sites are generally cooler and wetter compared to the other land-use types.
- We observed a relatively high variability of meteorological parameters even within the same land-use types and micro-region.
- Structural complexity of vegetation (e.g. foliage height diversity, vegetation gap areas, leaf area index) has strong impact on below-canopy microclimates and buffering effects of meteorological extremes.
- Mixed-land systems (*Harapan, Bukit*) tend to be slightly warmer and drier compared to forest-dominated land systems (*REKI*). Within the mixed-land systems, forests tend to be warmer and drier compared to forests in the forest-dominated land systems.
- Compared to other land-use types, interception is high in forest ecosystems and low in oil palm monocultures.

Source: EFForTS-instagram

A BIG THANKS TO OUR INDONESIAN ASSISTANTS!!!!

Basri	Bayu	Wisda (Tika)	Alifian
			

THANK YOU FOR YOUR ATTENTION!

christian.stiegler@biologie.uni-goettingen.de

@BioclimGoe
@efforts_crc990
@stiegler_chr

Bogor Agricultural University   University of Jambi   Tadulako University   University of Göttingen

DFG Deutsche Forschungsgemeinschaft

EFForTS