Data Article

Dataset on microclimate and drone-based thermal patterns within an oil palm agroforestry system

Laura Somenguem Donfacka,c,*, Alexander Röllb, Florian Ellsäßerb, Martin Ehbrectha, Bambang Irawand, Dirk Hölscherb,e, Alexander Knohle,f, Holger Krefte,c, Eduard J. Siahaand, Leti Sundawatig, Christian Stieglerf, Clara Delphine Zempc,e,h

a University of Goettingen, Silviculture and Forest Ecology of the Temperate Zones, Büsengeweg 1, Göttingen 37077, Germany
b University of Goettingen, Tropical Silviculture and Forest Ecology, Büsengeweg 1, Göttingen 37077, Germany
c University of Goettingen, Biodiversity, Macroecology and Biogeography, Büsengeweg 1, Göttingen 37077, Germany
d University of Jambi, Faculty of Forestry, Jln Raya Jambi, Jambi 36361, Indonesia
e University of Goettingen, Centre of Biodiversity and Sustainable Land Use, Büsengeweg 1, Göttingen 37077, Germany
f University of Neuchâtel, Institute of Biology, Conservation Biology Lab, Rue Emilie-Argand 11, Neuchâtel CH-2000, Switzerland
g Department of Forest Management, Bogor Agricultural University, Kampus IPB Darmaga, Bogor 16680, Indonesia
h University of Goettingen, Bioclimatology, Büsengeweg 2, Göttingen 37077 Germany

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A B S T R A C T

Microclimate and Land Surface Temperature (LST) are important analytical variables used to understand complex oil palm agroforestry systems and their effects on biodiversity and ecosystem functions. In order to examine experimental effects of tree species richness (0, 1, 2, 3 or 6), plot size (25 m², 100 m², 400 m², 1600 m²) and stand structural complexity on microclimate and Land Surface Temperature, related data were collected following a strict design. The
experiment was carried out in the Jambi province, in Sumatra (Indonesia), as part of the collaborative project EFForTS [Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems]. Microclimate data collected using miniaturized data loggers combined with drone-based thermal data were considered within an oil palm plantation enriched with six target tree species. The time-frame considered for data analysis was 20th September 2017 to 26th September 2017. The experiment data can be used for comparison with data from conventional oil palm agroforestry systems in the tropics. They can more specifically be used as reference to assess microclimate and Land Surface Temperature patterns within similar agroforestry systems.

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Specifications Table

| Subject                        | Ecology                        |
|--------------------------------|--------------------------------|
| Specific subject area          | Assessment of microclimate and land surface temperature variability within oil palm plots enriched with tree species. |
| Type of data                   | Table                          |
|                                | Image                          |
|                                | Figure                         |
| How data were acquired         | Data were obtained using miniaturized microclimate sensors (hygrochron and thermochron loggers), and an octocopter drone equipped with radiometric thermal and RGB (red-green-blue) cameras. |
| Data format                    | Raw                            |
|                                | Analyzed                       |
| Parameters for data collection | Ambient air temperature, soil temperature, relative humidity and land surface temperature data acquired over a week (20th September 2017 to 26th September 2017) and around noon were considered. |
| Description of data collection | Microclimate data were collected from 28 experimental plots and 4 control plots varying in size (25 m², 100 m², 400 m² and 1600 m²) and in diversity level (0, 1, 2, 3 and 6). Land surface temperature data were obtained from 52 experimental plots and 4 control plots. |
| Data source location           | Institution: EFForTS [Ecological and Socioeconomic Functions of Tropical Lowland Rainforest Transformation Systems] |
|                                | City: Jambi (Sumatra)           |
|                                | Country: Indonesia              |
|                                | Latitude and longitude (and GPS coordinates, if possible) for collected samples/data: 01.95° S and 103.25° E |
| Data accessibility             | With the article (Supplementary part) |
|                                | Repository name: Mendeley Data  |
|                                | Data identification number: https://doi.org/10.17632/79t4psrhwj.1 |
|                                | Direct URL to data: https://data.mendeley.com/datasets/79t4psrhwj/3 |
| Related research article       | L.S. Donfack, A. Röll, F. Ellsäßer, M. Ehbrecht, B. Irawan, D. Hölscher, A. Knohl, H. Kreft, E.J. Siahaan, L. Sundawati, C. Stiegler, D. C. Zemp, Microclimate and land surface temperature in a biodiversity enriched oil palm plantation, Forest Ecology and Management. https://doi.org/10.1016/j.foreco.2021.119480 |
Value of the Data

- This dataset provides valuable spatial and temporal temperature and humidity data obtained from permanent plots established in an agroforest stand. It might be useful to understand the effect of mixed species tree planting on microclimate and land surface temperature variability.
- These data will benefit those who are interested in agroforestry management systems, biodiversity and ecosystem functions enhancement and efficient techniques for microclimate data collection and assessment.
- The data can be used to be compared with other microclimate and land surface temperature data collected in tropical agroforestry systems or pure oil palm plantations. They can also be used to assess effect of other parameters (e.g., vapour pressure deficit, tree growth, transpiration, etc.) on thermal patterns.

1. Data Description

1.1. Microclimate data

Ambient air temperature, soil temperature and relative humidity represent the microclimate data of interest recorded. The dataset containing microclimate data is structured with text files categorized with date, Time, values (temperatures/relative humidity values) and Unit. These are raw data extracted from microclimate sensors.

1.2. Land surface temperature data

Land Surface Temperatures were measured at the surface of oil palm and tree canopy. Thermal images from 56 plots and a csv file summarizing climatic variables for these plots and their metrics (average, minimum, maximum etc.) are available in the data repository. Thermal images were stored as tif images that can be visualized in GIS software (e.g. QGIS) and their respective properties can also be checked there. Abbreviations used in the csv file named “All-Data_Humusindo_56Plots_stats.csv” are summarized (Table. 1);

1.3. Other abbreviations used in the dataset

RH: relative humidity; LST: land surface temperature

1.4. Appendices

Raw data available in the Mendeley repository include a first folder containing appendices summarized in a docx file. Appendix A contains a detailed enumeration and denomination of microclimate sensors positioned above and under the ground, in the respective plots within which they were found. It shows which sensors successfully collected data and which didn’t. Appendix B display metrics (mean, maximum, minimum, median and standard deviation) of microclimate (for 32 plots) and land surface temperature (for 56 plots) calculated considering the timeframe 10 am to 3 pm. Appendix C summarizes the proportion of microclimate sensors with available data for each investigated plot. Appendix D makes a state of all plots and categories of plot size and diversity level within which they are positioned. Appendices E and F show calculated values of mean, median, standard error of the mean, minimum/maximum values of ambient air,
Table 1
List of abbreviations in the File “AllData_Humusindo_56Plots_stats.csv”.

| name                          | typeOfVariable | units            | description                                               |
|-------------------------------|----------------|------------------|-----------------------------------------------------------|
| Date                          | date           |                  | date and time                                             |
| Pressure_hPa                  | realNumber     | hPa              | air pressure                                              |
| Q_Pressure                    | integerNumber  |                  | quality flag air pressure                                |
| Min_Pressure_hPa              | realNumber     | hPa              | minimum air pressure                                       |
| Q_Min_Pressure               | integerNumber  |                  | quality flag minimum air pressure                         |
| Max_Pressure_hPa              | realNumber     | hPa              | maximum air pressure                                       |
| Q_Max_Pressure               | integerNumber  |                  | quality flag maximum air pressure                         |
| PrTemp_degC                  | realNumber     | °C               | pressure temperature                                      |
| Q_PrTemp                     | integerNumber  |                  | quality flag pressure temperature                         |
| Min_PrTemp_degC              | realNumber     | °C               | minimum pressure temperature                              |
| Max_PrTemp_degC              | realNumber     | °C               | maximum pressure temperature                              |
| Q_Max_PrTemp                 | integerNumber  |                  | quality flag maximum pressure temperature                 |
| UBat_var_V                   | integerNumber  | V                | battery voltage                                           |
| Min_UBat_var_V               | realNumber     | V                | minimum battery voltage                                   |
| Q_Min_UBat_var               | integerNumber  |                  | quality flag minimum battery voltage                      |
| Max_UBat_var_V               | realNumber     | V                | maximum battery voltage                                   |
| Q_Max_UBat_var               | integerNumber  |                  | quality flag maximum battery voltage                      |
| CMP3_Radiation_W_per_m       | integerNumber  | W/m²             | Global radiation                                          |
| Q_CMP3_Radiation             | integerNumber  |                  | quality flag global radiation                             |
| Min_CMP3_Radiation_W_per_m   | integerNumber  | W/m²             | minimum global radiation                                  |
| Max_CMP3_Radiation_W_per_m   | integerNumber  | W/m²             | maximum global radiation                                  |
| Q_CMP3_Radiation             | integerNumber  |                  | quality flag maximum global radiation                     |
| NR_Radiation_W_per_m         | integerNumber  | W/m²             | net radiation                                             |
| Q_NR_Radiation               | integerNumber  |                  | quality flag net radiation                                |
| Min_NR_Radiation_W_per_m     | integerNumber  | W/m²             | minimum net radiation                                     |
| Max_NR_Radiation_W_per_m     | integerNumber  | W/m²             | maximum net radiation                                     |
| 2_Max_NR_Radiation_W_per_m   | integerNumber  | W/m²             | quality flag maximum net radiation                        |
| PAR_Quantum_mol_per_ms       | integerNumber  | umol/m²s         | incoming PAR                                              |
| Q_PAR_Quantum                | integerNumber  |                  | quality flag PAR                                          |
| Min_PAR_Quantum_mol_per_ms   | integerNumber  | mol/m²s          | minimum PAR                                               |
| Q_Min_PAR_Quantum            | integerNumber  |                  | quality flag minimum PAR                                  |
| Max_PAR_Quantum_mol_per_ms   | integerNumber  | mol/m²s          | maximum PAR                                               |
| Q_Max_PAR_Quantum            | integerNumber  |                  | quality flag maximum PAR                                  |
| WS_FC_m_per_s                | integerNumber  | m/s              | wind speed                                                |
| Q_WS_FC                      | integerNumber  |                  | quality flag wind speed                                   |
| Min_WS_FC_m_per_s            | integerNumber  | m/s              | minimum wind speed                                        |
| Q_Min_WS_FC                  | integerNumber  |                  | quality flag minimum wind speed                           |
| Max_WS_FC_m_per_s            | integerNumber  | m/s              | maximum wind speed                                        |
| Q_Max_WS_FC                  | integerNumber  |                  | quality flag maximum wind speed                           |
| WD_FC_deg                    | integerNumber  | o                | wind direction                                            |
| Q_WD_FC                      | integerNumber  |                  | quality flag wind direction                               |
| Min_WD_FC_deg               | integerNumber  | o                | minimum wind direction                                    |
| Q_Min_WD_FC                  | integerNumber  |                  | quality flag minimum wind direction                       |
| Max_WD_FC_deg               | integerNumber  | o                | maximum wind direction                                    |
| Q_Max_WD_FC                  | integerNumber  |                  | quality flag maximum wind direction                       |
| Humidity1_prc                | integerNumber  | Vol.%            | air humidity, 0.5 m                                       |
| Q_Humidity1                  | integerNumber  |                  | quality flag air humidity 0.5 m                          |
| Min_Humidity1_pro            | integerNumber  | Vol.%            | minimum air humidity, 0.5 m                              |
| Q_Min_Humidity1              | integerNumber  |                  | quality flag minimum air humidity 0.5 m                  |
| Max_Humidity1_pro            | integerNumber  | Vol.%            | maximum air humidity, 0.5 m                              |
| Q_Max_Humidity1              | integerNumber  |                  | quality flag maximum air humidity 0.5 m                  |
| Temperature1_degC            | integerNumber  | °C               | air temperature, 0.5 m                                   |
| Q_Temperature1               | integerNumber  |                  | quality flag air temperature, 0.5 m                      |
| Min_Temperature1_degC        | integerNumber  | °C               | minimum air temperature, 0.5 m                           |
| 2_Min_Temperature1           | integerNumber  |                  | quality flag maximum air temperature, 0.5 m              |

(continued on next page)
| name                                      | typeOfVariable | units       | description                                           |
|-------------------------------------------|----------------|-------------|-------------------------------------------------------|
| Max_Temperature1_degC                    | realNumber     | °C          | maximum air temperature, 0.5 m                        |
| Q_Max_Temperature1                       | integerNumber  |            | quality flag maximum air temperature, 0.5 m           |
| Humidity2_pro                            | realNumber     | Vol.%       | air humidity, 2 m                                     |
| Q_Humidity2                              | integerNumber  |            | quality flag air humidity 2 m                         |
| Min_Humidity2_prc                        | realNumber     | Vol.%       | minimum air humidity, 2 m                             |
| Q_Min_Humidity2                          | integerNumber  |            | quality flag minimum air humidity 2 m                 |
| Max_Humidity2_prc                        | realNumber     | Vol.%       | maximum air humidity, 2 m                             |
| Q_Max_Humidity2                          | integerNumber  |            | quality flag maximum air humidity 2 m                 |
| Temperature2_degC                        | realNumber     | °C          | air temperature, 2 m                                 |
| Q_Temperature2                           | integerNumber  |            | quality flag air temperature, 2 m                     |
| Min_Temperature2_degC                    | realNumber     | °C          | minimum air temperature, 2 m                          |
| Q_Min_Temperature2                       | integerNumber  |            | quality flag minimum air temperature, 2 m             |
| Max_Temperature2_degC                    | realNumber     | °C          | maximum air temperature, 2 m                          |
| Q_Max_Temperature2                       | integerNumber  |            | quality flag maximum air temperature, 2 m             |
| HeatFluxPlate_W_per_m                   | realNumber     | W/m²        | heat flux plate                                        |
| Q_HeatFluxPlate                          | integerNumber  |            | quality flag heat flux plate                           |
| Min_HeatFluxPlate_W_per_m               | realNumber     | W/m²        | minimum heat flux plate                                |
| Q_Min_HeatFluxPlate                     | integerNumber  |            | quality flag minimum heat flux plate                   |
| Max_HeatFluxPlate_W_per_m               | realNumber     | W/m²        | maximum heat flux plate                                |
| Q_Max_HeatFluxPlate                     | integerNumber  |            | quality flag maximum heat flux plate                   |
| Precipitation1_mm                       | realNumber     | mm          | precipitation1                                        |
| Q_Precipitation1                         | integerNumber  |            | quality flag precipitation1                           |
| Precipitation2_mm                       | realNumber     | mm          | precipitation2                                        |
| Q_Precipitation2                         | integerNumber  |            | quality flag precipitation2                           |
| Moisture1_Vol_prc                       | realNumber     | Vol.%       | soil moisture 1, 30 cm                                 |
| Q_Moisture1                             | integerNumber  |            | quality flag soil moisture 1, 30 cm                    |
| Min_Moisture1_Vol_prc                   | realNumber     | Vol.%       | minimum soil moisture 1, 30 cm                         |
| Q_Min_Moisture1                         | integerNumber  |            | quality flag minimum soil moisture 1, 30 cm           |
| Max_Moisture1_Vol_prc                   | realNumber     | Vol.%       | maximum soil moisture 1, 30 cm                         |
| Q_Max_Moisture1                         | integerNumber  |            | quality flag maximum soil moisture 1, 30 cm           |
| SoilTemp1_degC                          | realNumber     | °C          | soil temperature 1, 30 cm                             |
| Q_SoilTemp1                             | integerNumber  |            | quality flag soil temperature 1, 30 cm                 |
| Min_SoilTemp1_degC                      | realNumber     | °C          | minimum soil temperature 1, 30 cm                      |
| Q_Min_SoilTemp1                         | integerNumber  |            | quality flag minimum soil temperature 1, 30 cm         |
| Max_SoilTemp1_degC                      | realNumber     | °C          | maximum soil temperature 1, 30 cm                      |
| Q_Max_SoilTemp1                         | integerNumber  |            | quality flag maximum soil temperature 1, 30 cm         |
| Moisture2_Vol_prc                       | realNumber     | Vol.%       | soil moisture 2, 30 cm                                 |
| Q_Moisture2                             | integerNumber  |            | quality flag soil moisture 2, 30 cm                    |
| Min_Moisture2_Vol_prc                   | realNumber     | Vol.%       | minimum soil moisture 2, 30 cm                         |
| Q_Min_Moisture2                         | integerNumber  |            | quality flag minimum soil moisture 2, 30 cm            |
| Max_Moisture2_Vol_prc                   | realNumber     | Vol.%       | maximum soil moisture 2, 30 cm                         |
| Q_Max_Moisture2                         | integerNumber  |            | quality flag maximum soil moisture 2, 30 cm            |
| SoilTemp2_degC                          | realNumber     | °C          | soil temperature 2, 30 cm                             |
| Q_SoilTemp2                             | integerNumber  |            | quality flag soil temperature 2, 30 cm                 |
| Min_SoilTemp2_degC                      | realNumber     | °C          | minimum soil temperature 2, 30 cm                      |
| Q_Min_SoilTemp2                         | integerNumber  |            | quality flag minimum soil temperature 2, 30 cm         |
| Max_SoilTemp2_degC                      | realNumber     | °C          | maximum soil temperature 2, 30 cm                      |
| Q_Max_SoilTemp2                         | integerNumber  |            | quality flag maximum soil temperature 2, 30 cm         |
| Moisture3_Vol_prc                       | realNumber     | Vol.%       | soil moisture 3, 30 cm                                 |
| Q_Moisture3                             | integerNumber  |            | quality flag soil moisture 3, 30 cm                    |
| Min_Moisture3_Vol_prc                   | realNumber     | Vol.%       | minimum soil moisture 3, 30 cm                         |
| Q_Min_Moisture3                         | integerNumber  |            | quality flag minimum soil moisture 3, 30 cm            |
| Max_Moisture3_Vol_prc                   | realNumber     | Vol.%       | maximum soil moisture 3, 30 cm                         |
| Q_Max_Moisture3                         | integerNumber  |            | quality flag maximum soil moisture 3, 30 cm            |
| SoilTemp3_degC                          | realNumber     | °C          | soil temperature 3, 30 cm                             |
| Q_SoilTemp3                             | integerNumber  |            | quality flag soil temperature 3, 30 cm                 |
| Min_SoilTemp3_degC                      | realNumber     | °C          | minimum soil temperature 3, 30 cm                      |
| Q_Min_SoilTemp3                         | integerNumber  |            | quality flag minimum soil temperature 3, 30 cm         |
| Max_SoilTemp3_degC                      | realNumber     | °C          | maximum soil temperature 3, 30 cm                      |
| Q_Max_SoilTemp3                         | integerNumber  |            | quality flag maximum soil temperature 3, 30 cm         |
soil temperatures, relative humidity and land surface temperature, considering plot size categories and species diversity levels respectively. Appendix G contains two tables (table G.1 and G.2), displaying calibration results of temperature and relative humidity variables. To support these statistics, appendix J presents an illustrative figure of the distance effect on microclimate variables. Appendix H summarizes statistics explaining the effect of distance variation from plot centre on microclimatic values. Appendix I contains two figures showing microclimate patterns over the period of data acquisition, for microclimate variables ambient temperature, relative humidity and soil temperature. Appendix K illustrates the specific design of miniaturized microclimate sensors disposition within varying-sized plots. Appendix L presents an illustrative image of field installations (sensors and hand-made protection shields).

2. Experimental Design, Materials and Methods

Microclimate data were obtained from 28 plots systematically varying in size and tree species diversity, while land surface temperature data were collected from 52 plots. Microclimate data represent environmental variables recorded above (ambient air temperature and relative humidity) and below (soil temperature) the ground. Four additional control plots differently considered for microclimate and land surface temperatures data were also investigated. 198 miniaturized microclimate sensors (100 thermochron and 98 hygrochron iButtons, Maxim integrated, USA) to measure ambient air temperature, relative humidity, and soil temperature, which were acquired in 10-minutes intervals all over considered days. Due to a limited number of available sensors, we selected from the 56 initial plots, 32 that represented a great variability in vegetation structure and with varying species diversity level and plot size, including the four control plots.

Within each plot, mini microclimate sensors were positioned on each sampling point located at increasing distance on a logarithmic scale (1, 2, 4 and 8 m distant from each other) oriented along three main directions: North, South-East, and South-West. The purpose of this fractal design was to account for spatial variations in temperature and humidity values [1] and to have comparable data across plot sizes. We used two types of mini microclimate sensors: hygrochron temperature/humidity loggers (DS1923-F5#), installed 1.5 m above the ground to measure both the ambient air temperature and relative humidity and thermochron temperature loggers (DS1922L-F5#), placed 10 cm under the ground to measure soil temperature. The mini microclimate sensors were protected from water and direct solar radiations using hand-made multi-plate radiation shields (Fig. 1).

Precision and accuracy as provided by the manufacturer are 0.063°C and 0.5°C, respectively for hygrochron and thermochron loggers. When measured values were negative, these were considered as aberrant and therefore excluded from the analysis to prevent any bias. We validated the mini microclimate sensors by applying a linear regression of the measured values with reference values (air temperature and relative humidity measured with Hygro-Thermo Transmitter, Thies Clima, Göttingen, Germany; soil temperature measured with Trime-Pico32, IMKO, Ettingen, Germany) across a range of controlled microclimatic conditions (from 25 to 35°C), indicating no systematic biases (mean slope = 0.86, mean intercept = 5.68°C, mean R² = 0.91 for temperature, mean slope = 0.96, mean intercept = 3.56%, mean R² = 0.91 for relative humidity). Collected data were saved as txt. files.

Thermal images were acquired with an octocopter drone (MK EASY Okto V3; HiSystems, Moormerland, Germany) equipped with radiometric thermal and RGB (red-green-blue) cameras, to capture thermal and RGB images of all the 56 study plots. We used the thermal camera Flir Tau 2 640 with TeAx ThermoCapture module attached; the focal length 13 mm covers spectral bands ranging from 7.5 to 13.5 μm. RGB camera was based on an Omni vision OV12890 CMOS-Sensor 148 (Omni vision, USA) with a 170 °FOV fish-eye lens [2]. For each day considered, flights were operated at noon (12 pm local time) at the average height of 50 m above the starting point, but varying up to 20 m over plots. Thermal images were recorded and only images falling within plot dimensions were cropped and saved as rgb tif files. The resulting plot thermal
images were used to compute minimum, maximum and average values of temperature in degree Kelvin per plot, using thermal pixels. Thermal values per plot were saved as csv file.

We derived the stand structural complexity from terrestrial laser scans in October and November 2016 based on a procedure described by Ehbrecht et al. (2021) [3]. A FARO Focus terrestrial laser scanner (Faro Technologies Inc., Lake Mary, USA), placed at the centre of each plot was used to obtain three-dimensional point clouds of each plot for the computation of the Stand Structural Complexity Index (SSCI). SSCI is an integrated measure of the three-dimensional arrangement of the vegetation above the herbaceous layer and quantifies the heterogeneity of biomass distribution in three-dimensional space [4]. Index values increase with increasing efficiency of canopy space occupation and vertical stratification. Further details on SSCI construction and functioning can be found in Ehbrecht et al. (2021). Control plots considered to assess stand structural complexity, Land Surface Temperature (LST) and microclimate were all different, and correlations between the three variable categories were therefore performed considering 28 plots instead of 32.

We used R version 3.6.3 to calculate different metrics (mean, median, maximum/minimum, standard error of the mean and range) of each variable (ambient air temperature, relative humidity, soil temperature and LST). Microclimate metrics calculation took into consideration microclimate sensors at equivalent distance away from central sensor (1 meters) for all plots, so as to cancel the distance effect.

Ethics Statement

None
Declaration of Competing Interest

The authors declare that they have no known competing financial interests or personal relationships which have or could be perceived to have influenced the work reported in this article.

CRediT Author Statement

**Laura Somenguem Donfack:** Conceptualization, Methodology, Data curation, Formal analysis, Writing – original draft; **Alexander Röll:** Writing – review & editing, Supervision; **Florian Ellsäßer:** Methodology, Investigation, Software, Writing – review & editing; **Martin Ehbrecht:** Methodology, Writing – review & editing; **Bambang Irawan:** Project administration, Methodology; **Dirk Hölscher:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing; **Alexander Knohl:** Data curation, Writing – review & editing; **Holger Kreft:** Conceptualization, Funding acquisition, Methodology, Writing – review & editing; **Eduard J. Siahaan:** Methodology, Data curation; **Leti Sundawati:** Project administration, Methodology; **Christian Stiegler:** Methodology, Writing – review & editing; **Clara Delphine Zemp:** Conceptualization, Funding acquisition, Methodology, Investigation, Visualization, Writing – review & editing, Supervision.

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References

[1] S.R. Hardwick, R. Touni, M. Pfeifer, E.C. Turner, R. Nilus, R.M. Ewers, The relationship between leaf area index and microclimate in tropical forest and oil palm plantation: Forest disturbance drives changes in microclimate, Agric. For. Meteorol. 201 (2015) 187–195, doi:10.1016/j.agrformet.2014.11.010. PM - 28148995.

[2] F. Ellsäßer et al., Predicting evapotranspiration from drone-based thermography - a method comparison in a tropical oil palm plantation. 2021.

[3] M. Ehbrecht et al., “Global patterns and climatic controls of forest structural complexity,” 2021, doi:10.1038/s41467-020-20767-z.

[4] M. Ehbrecht, P. Schall, C. Ammer, D. Seidel, Quantifying stand structural complexity and its relationship with forest management, tree species diversity and microclimate, Agric. For. Meteorol. 242 (2017) 1–9, doi:10.1016/j.agrformet.2017.04.012. M4 - Citavi.