PS 1 – ReS 13: GEDI

VEGETATION STRUCTURE MODELLING AND EXPLORATIVE STATISTICS BASED ON SENTINEL-1, -2 AND GEDI IN THE PARAGUAYAN CHACO

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Project: **Geo-ForPy** (05/2020-08/2022), German Aerospace Center (DLR) and Faculty of Engineering from the National University of Asunción (FIUNA)

Objective: „Understanding forest cover structure for biodiversity conservation in the Paraguayan Chaco“, https://www.geoforpy.eoc.dlr.de/index.html


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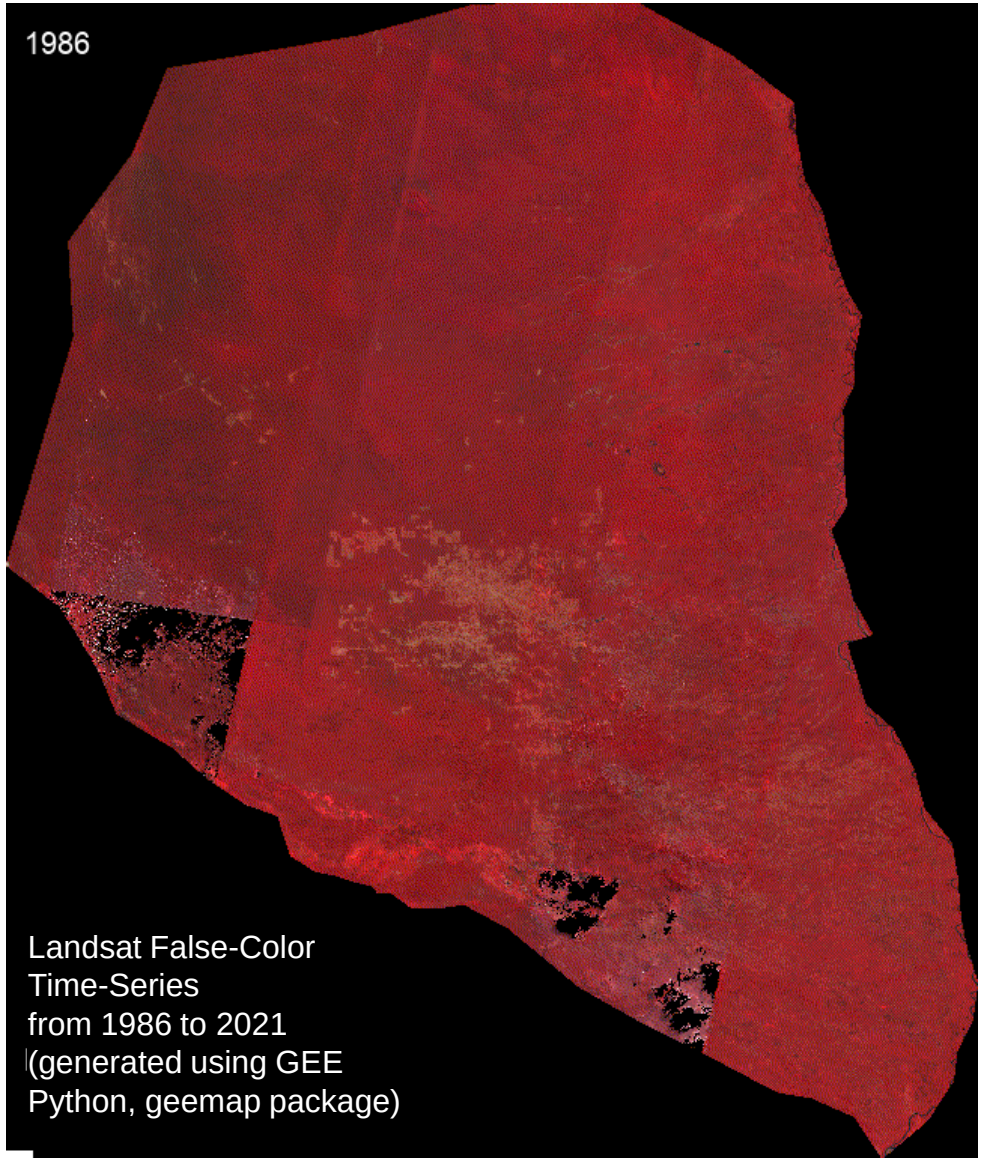
Introduction to the Paraguayan Chaco

Landsat-Based Time-Series Analysis of Forest Cover Change:

Garcia Calabrese et al. (2021), Understanding the relationship between environmental policies and deforestation activities in the Paraguayan Chaco. EGU General Assembly 2021, 19-30 April 2021, Online.

- Forest cover declined by about **66 700 km²** (35 %) from 1986 to 2020
- Significant differences in deforestation activities during **governmental periods**
- **Drivers** of forest cover change:
  - Weak implementations of **environmental policies**
  - Lack of sound **law enforcement**
  - Deficits in **financial support**
  - Inappropriate **governance**



Landsat False-Color Time-Series from 1986 to 2021 (generated using GEE Python, geemap package)

Methodology of Vegetation Structure Modelling

FIRST High-Resolution Spaceborne Forest Structure Modelling for the Paraguayan Chaco

Satellite Data

June to incl. September 2019 (dry Season)

sentinel-1
C-Band Synthetic Aperture Radar (10 m)

sentinel-2
High-resolution, multi-spectral sensor (10 m)

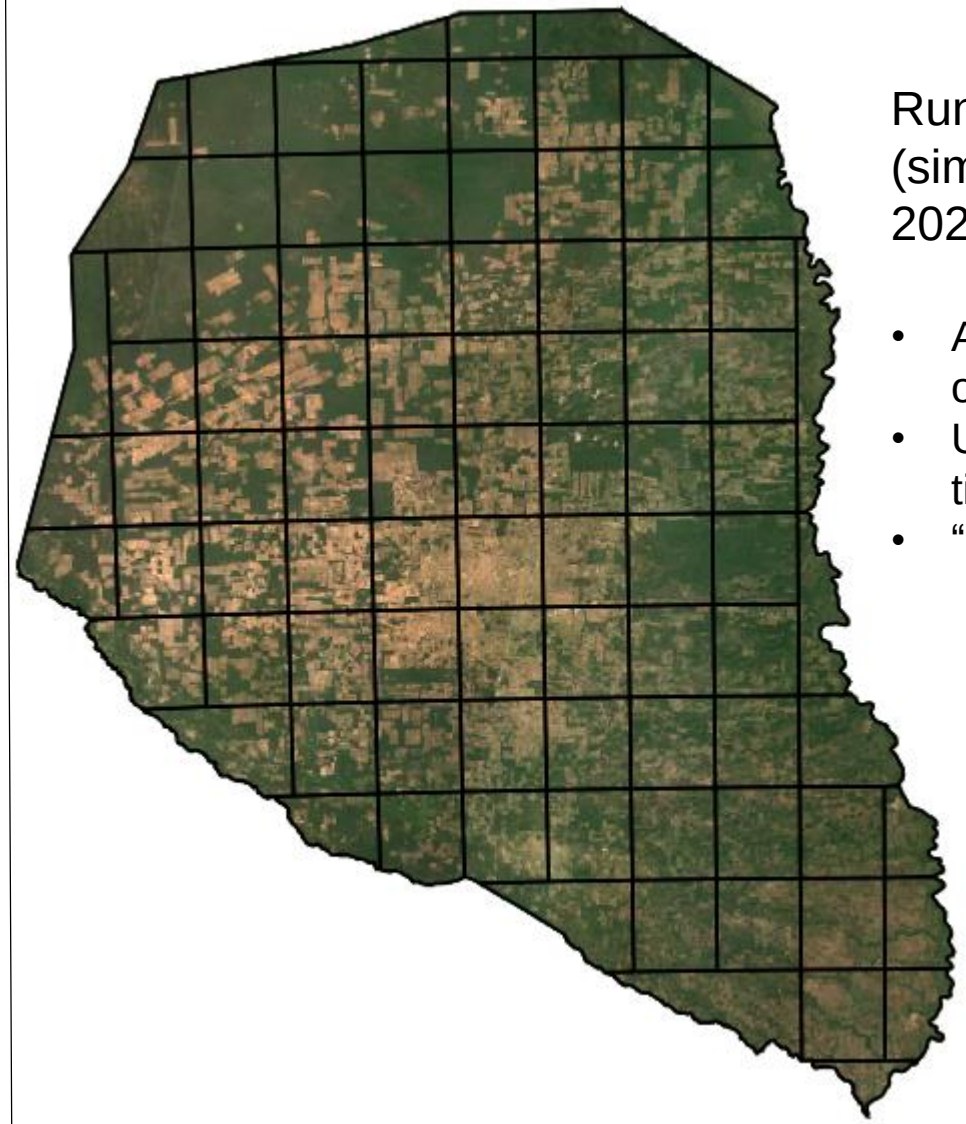
GEDI ECOSYSTEM LIDAR
Global Ecosystem Dynamics Investigation

Processing

Google Earth Engine

python 3

Tile-based processing: (0.5 x 0.5 degrees, ~ 3 000 km²)



Running one model per tile (similar to Potapov et al. 2021):

- Avoid computational limits of GEE
- Use max. 8 k samples per tile
- “Local” model learning

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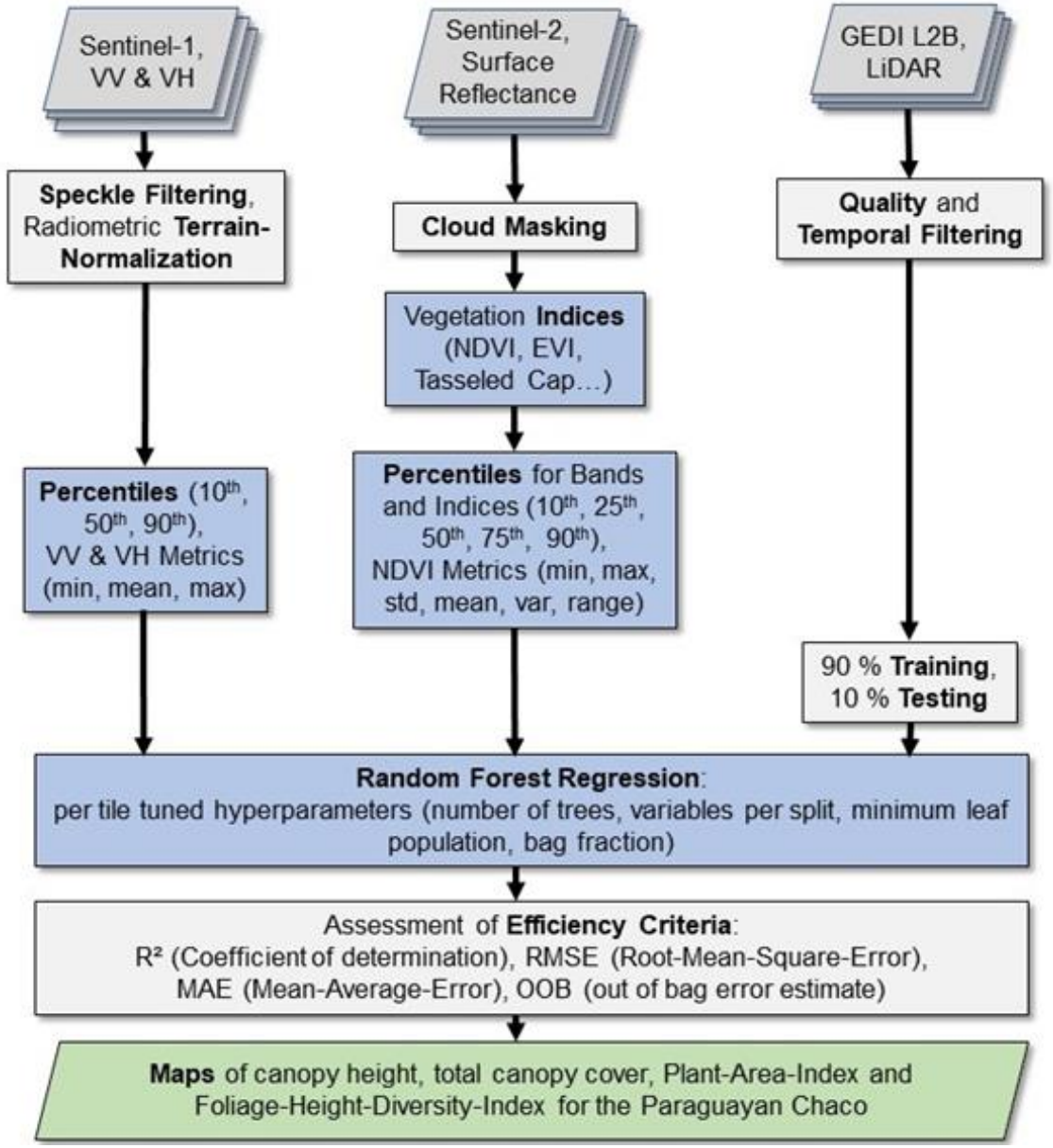
Methodology of Vegetation Structure Modelling

- Data
- Preprocessing
- Spectral Indices
- Temporal-spectral Metrics
- Split Samples
- Modelling
- Model Validation
- Outputs



Results: Explorative Statistics and Maps of Vegetation Structure

Accuracy of Forest Structure Modelling

- Models of **Canopy Height** and **Total Canopy Cover** present higher accuracies than Plant-Area-Index and Foliage-Height-Diversity-Index

- R^2 accuracies of Canopy Height and Total Canopy Cover models are similar to studies from **Pereira-Pires et al. 2021** and **Potapov et al. 2021**

Forest Structure Model Accuracies according to Mean-Average-Error (MAE), Coefficient of determination (R^2) and Root-Mean-Square-Error (RMSE).

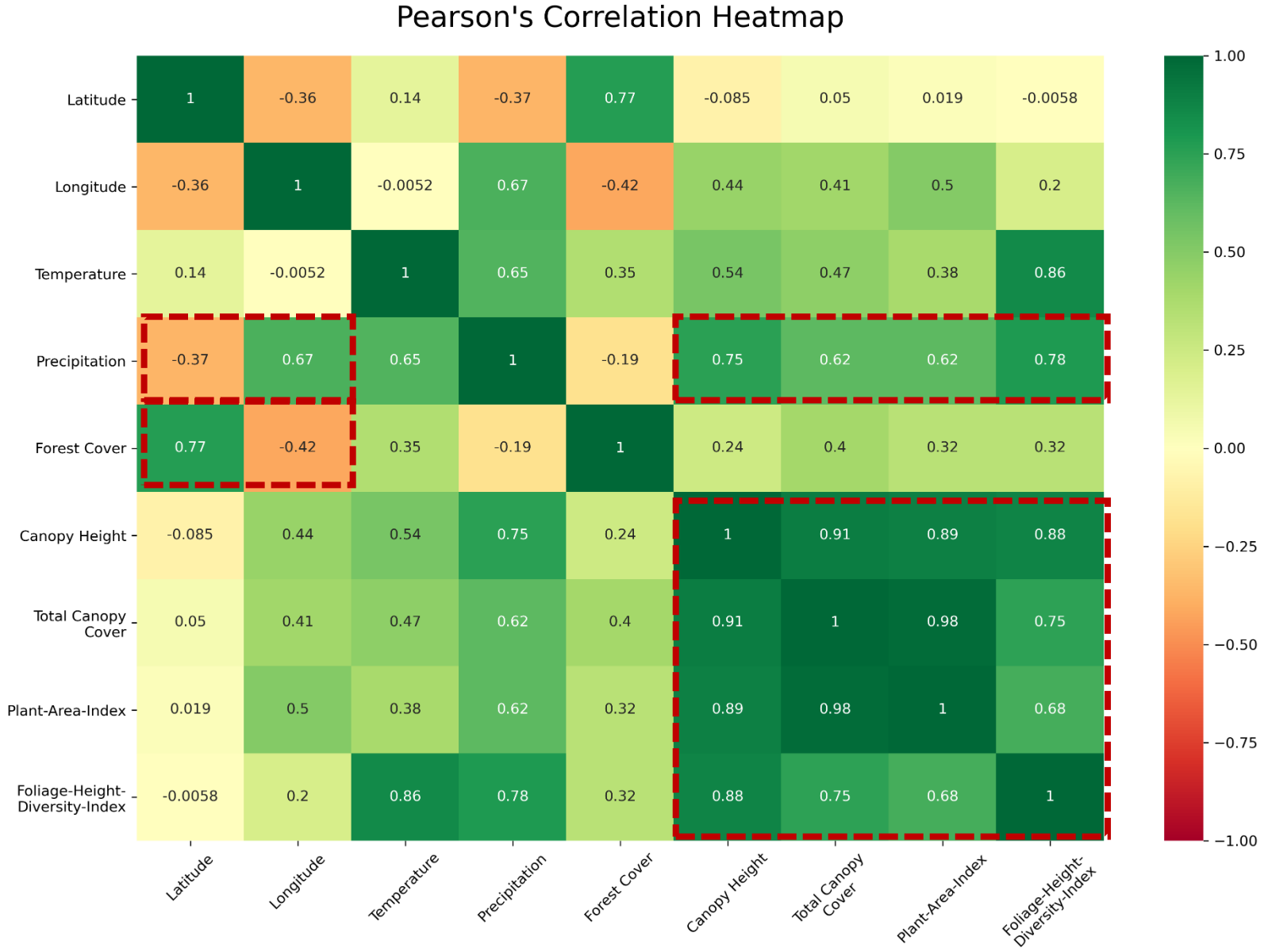
Error Criteria	Canopy Height (rh95)	Canopy Height (rh100)	Total Canopy Cover	Plant-Area-Index	Foliage-Height-Diversity-Index
MAE mean	1.1 m	1.4 m	6.2 %	0.2	0.2
MAE median	1.1 m	1.5 m	6.0 %	0.2	0.2
R^2 mean	60.0 %	57.1 %	61.8 %	50.1 %	47.4 %
R^2 median	64.0 %	60.7 %	61.4 %	50.6 %	48.0 %
RMSE mean	1.6 m	1.9 m	9.4 %	0.3	0.3
RMSE median	1.6 m	2.0 m	9.1 %	0.3	0.3

Results: Explorative Statistics and Maps of Vegetation Structure

Tile-Based Correlation Statistics

Comparison of environmental variables with modelled forest structure in forested areas:

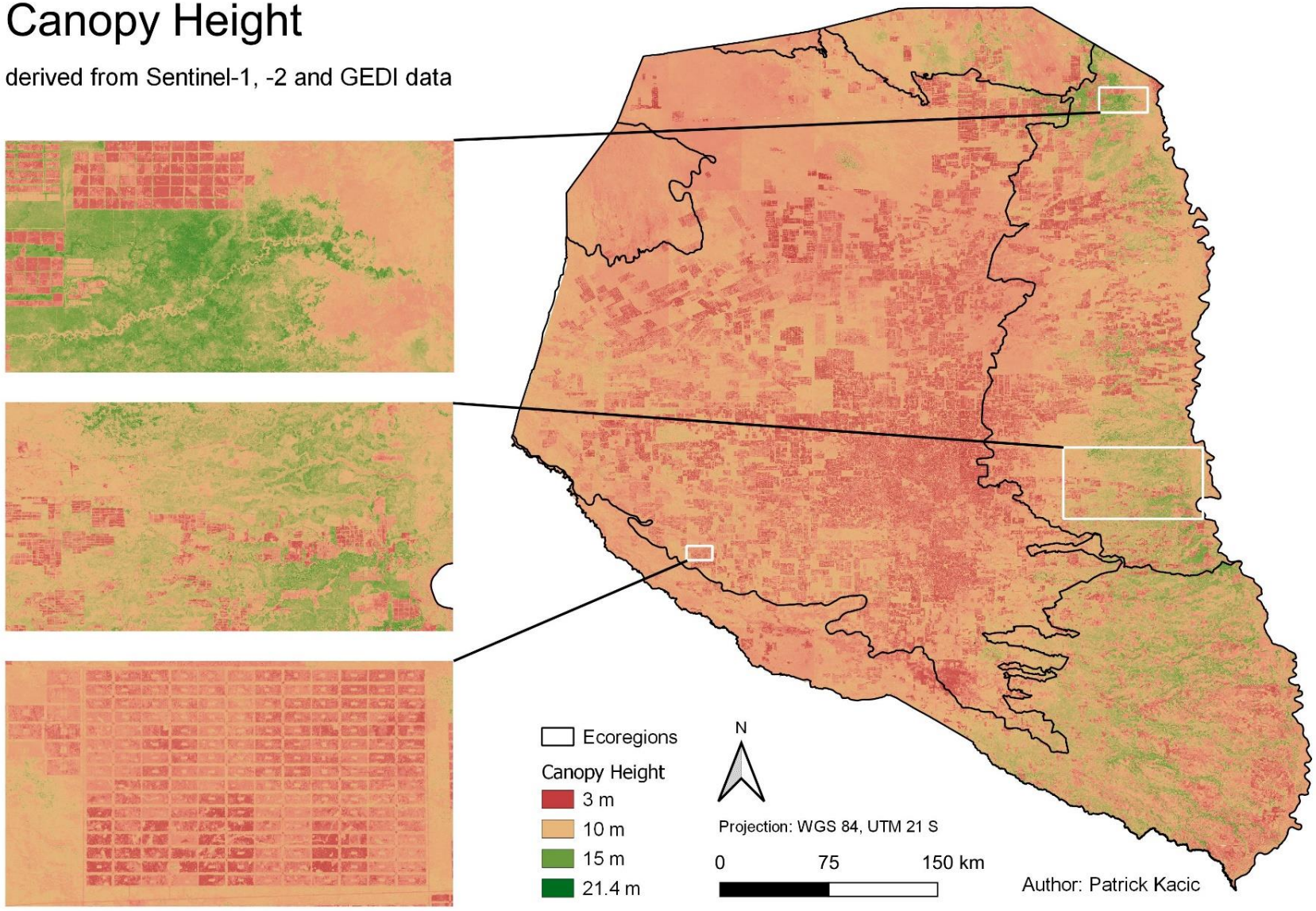
- Highest **precipitation** rates in South-East
- Elevated **forest cover** in North-West
- Modelled **forest structure** presents strong **positive correlations** between each other
- Moderate to strong positive correlations between precipitation and modelled forest structure



Results: Explorative Statistics and Maps of Vegetation Structure

Modelled Canopy Height (10 m):

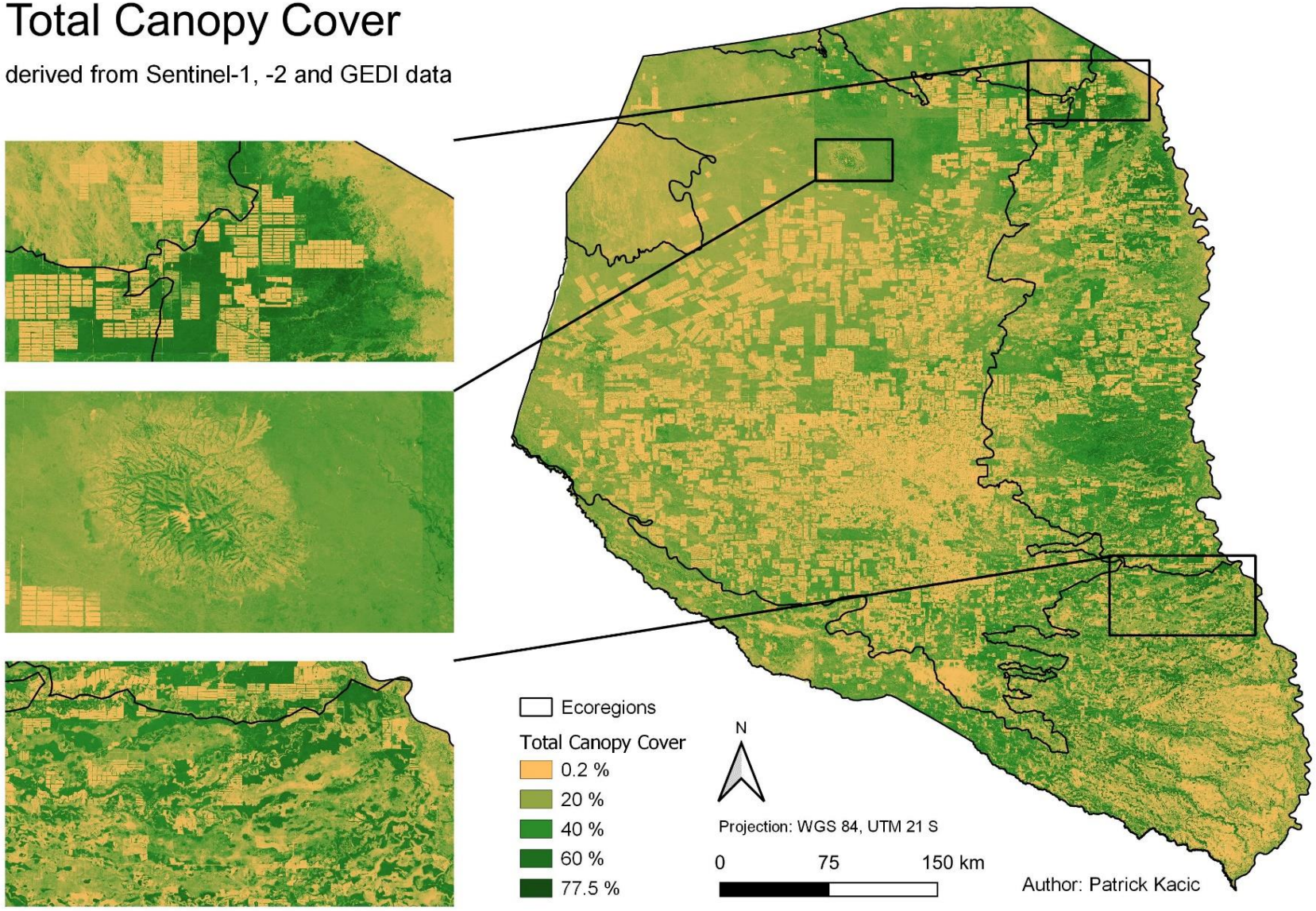
- Highest canopy heights in north-east (18 m)
- Agricultural fields are well detected with low canopy heights
- Riparian forests and savannahs in the east and south-east with canopy heights of 10 to 14 m
- Lowest canopy heights outside agricultural fields in north-west (arid climate)



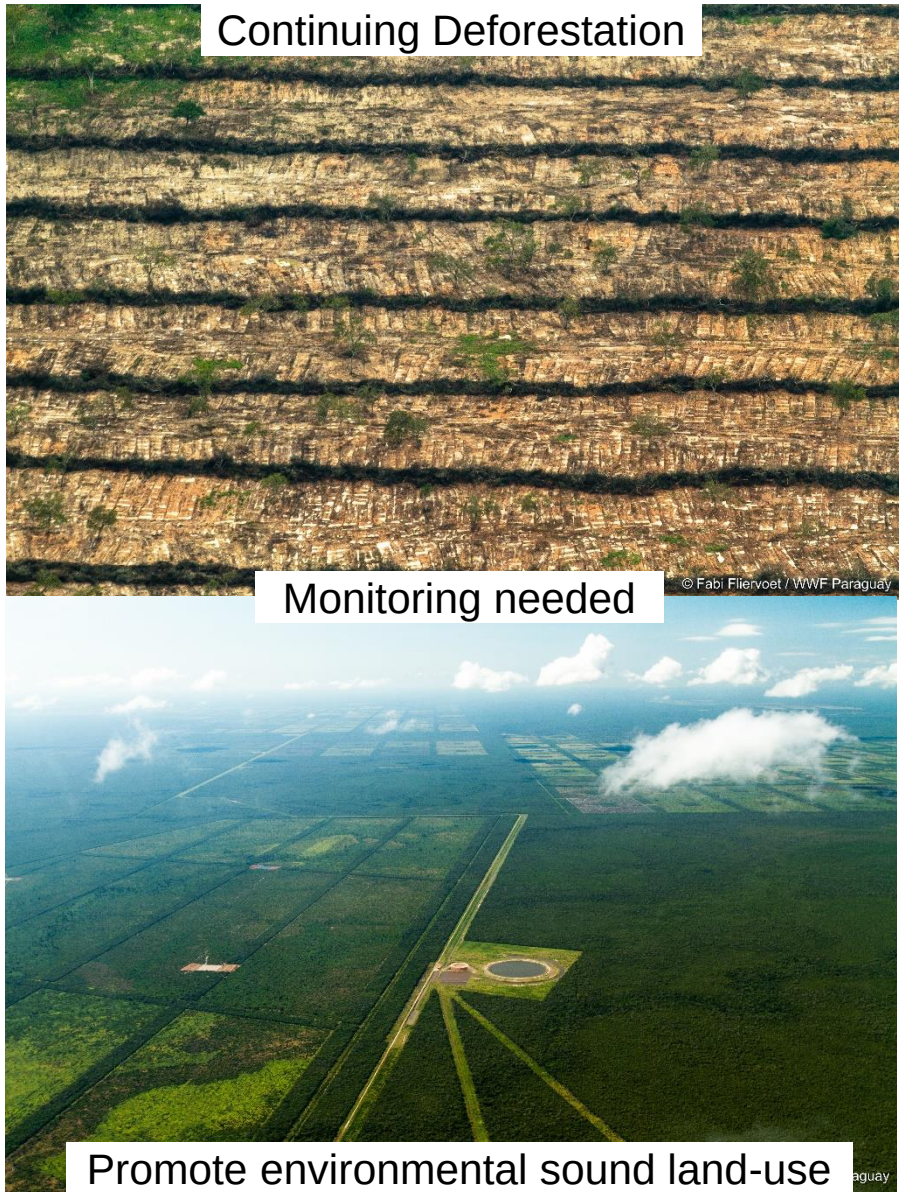
Results: Explorative Statistics and Maps of Vegetation Structure

Modelled Canopy Cover (10 m):

- Densest canopy covers in area of highest canopy heights (north-east)
- Agricultural fields show least dense canopy covers
- Most sparse canopy covers outside agricultural fields in arid region (north-west)



Conclusion and Outlook of the Geo-ForPy Project



Outlook of the Geo-ForPy Project (05/20-08/22):

- Comprehensive Analysis of
  - **Multi-temporal forest cover change** based on Landsat from 1987 – 2020 (Da Ponte et al. 2022)
  - **Vegetation Structure Modelling** based on Sentinel-1, -2 and GEDI (Kacic et al. 2021)
  - Multi-temporal Forest **Fragmentation Analysis**
  - **Deep Learning** to identify incomplete **Windbreaks** (Kriese et al. 2022)
  - Understanding **forest cover dynamics** in different **governmental periods** (Salinas et al., in peer-review)

- All methods and results shared and discussed with institutions in Paraguay during **Training-Workshops**


Thank you very much for your attention!
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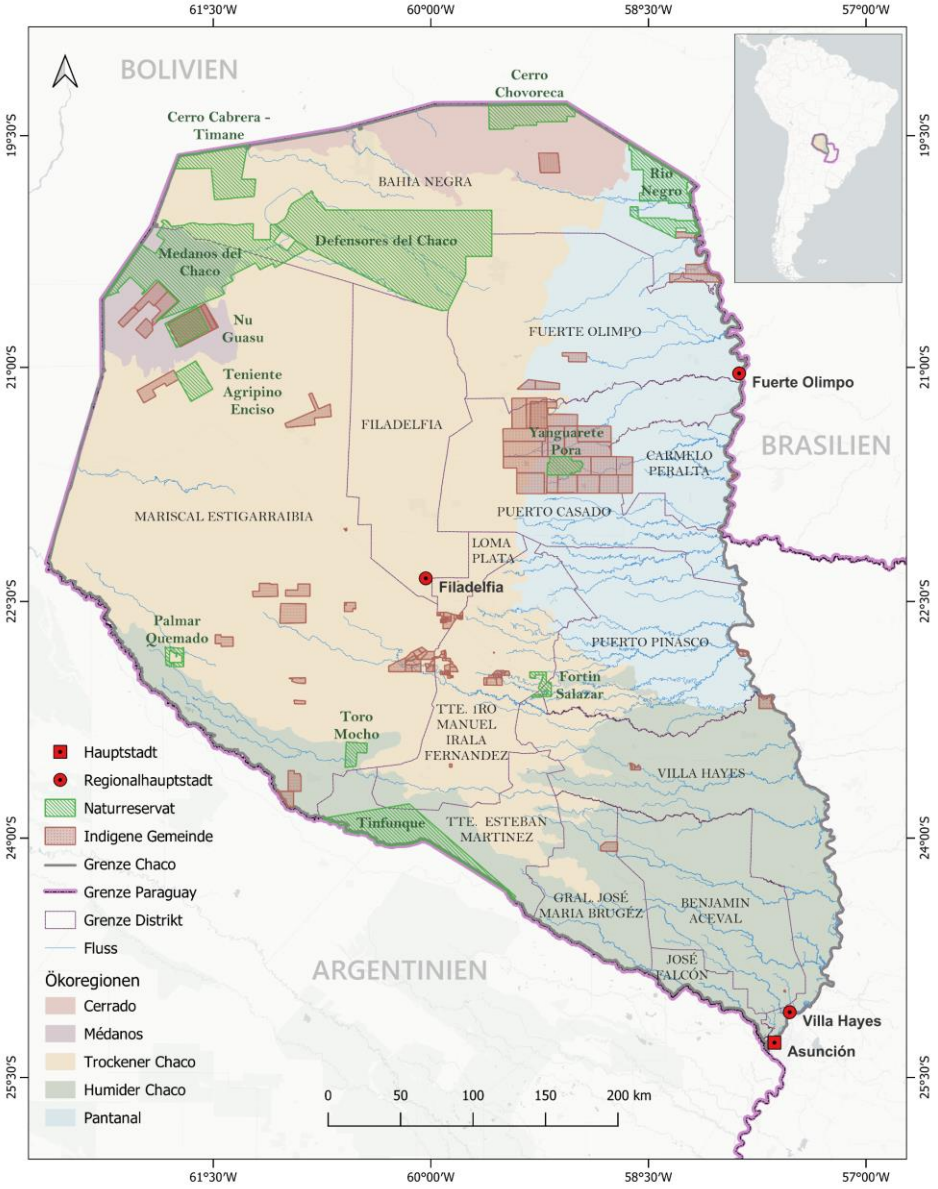
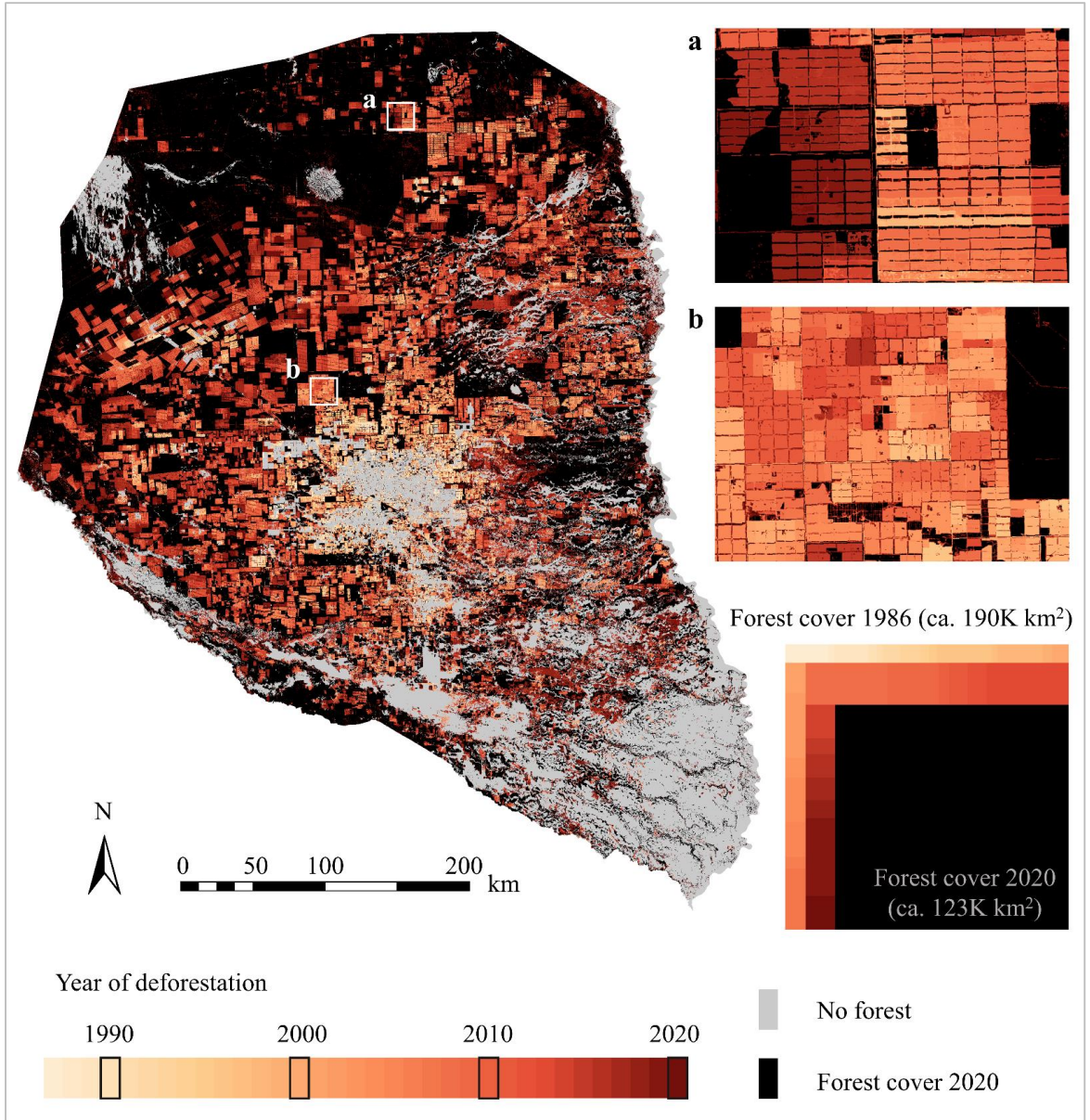
https://geoforpy.eoc.dlr.de/index.html

Appendix

Appendix A: Study Area and Deforestation

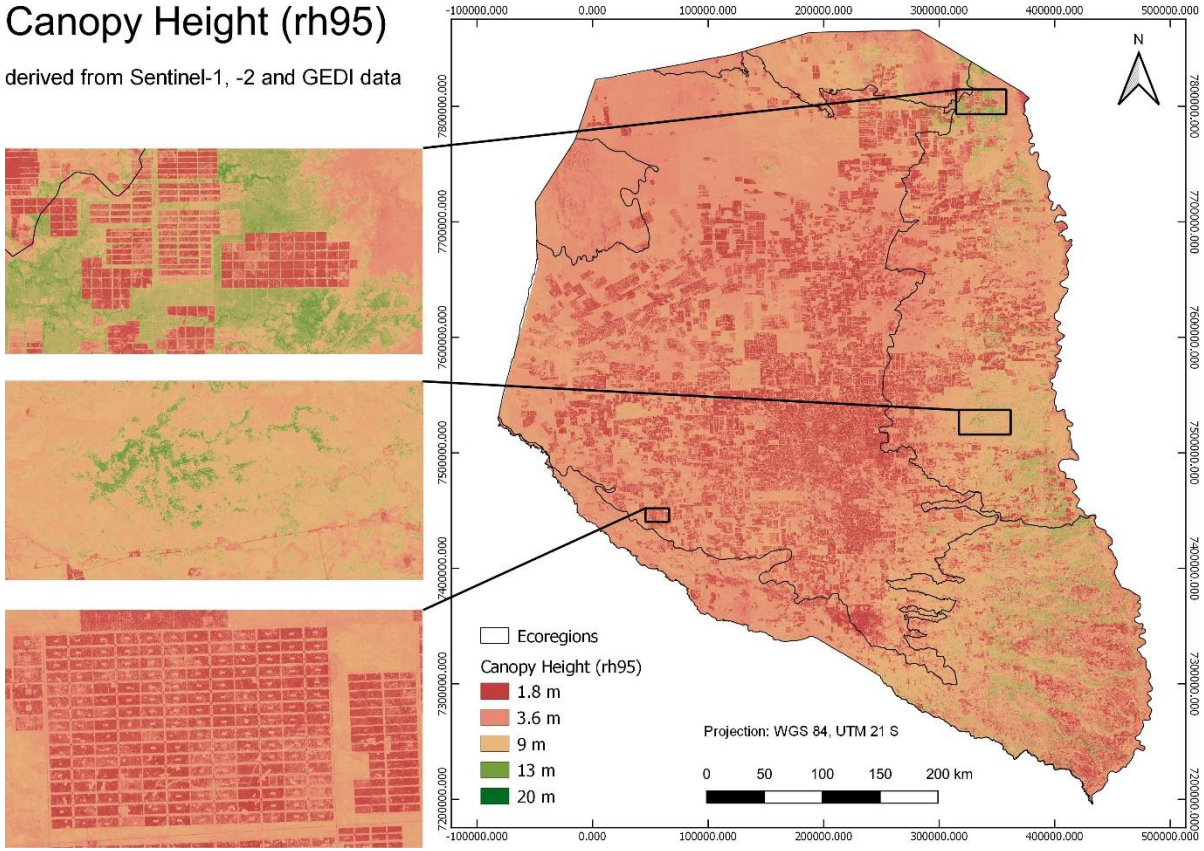




Appendix B: Canopy Height and Canopy Cover

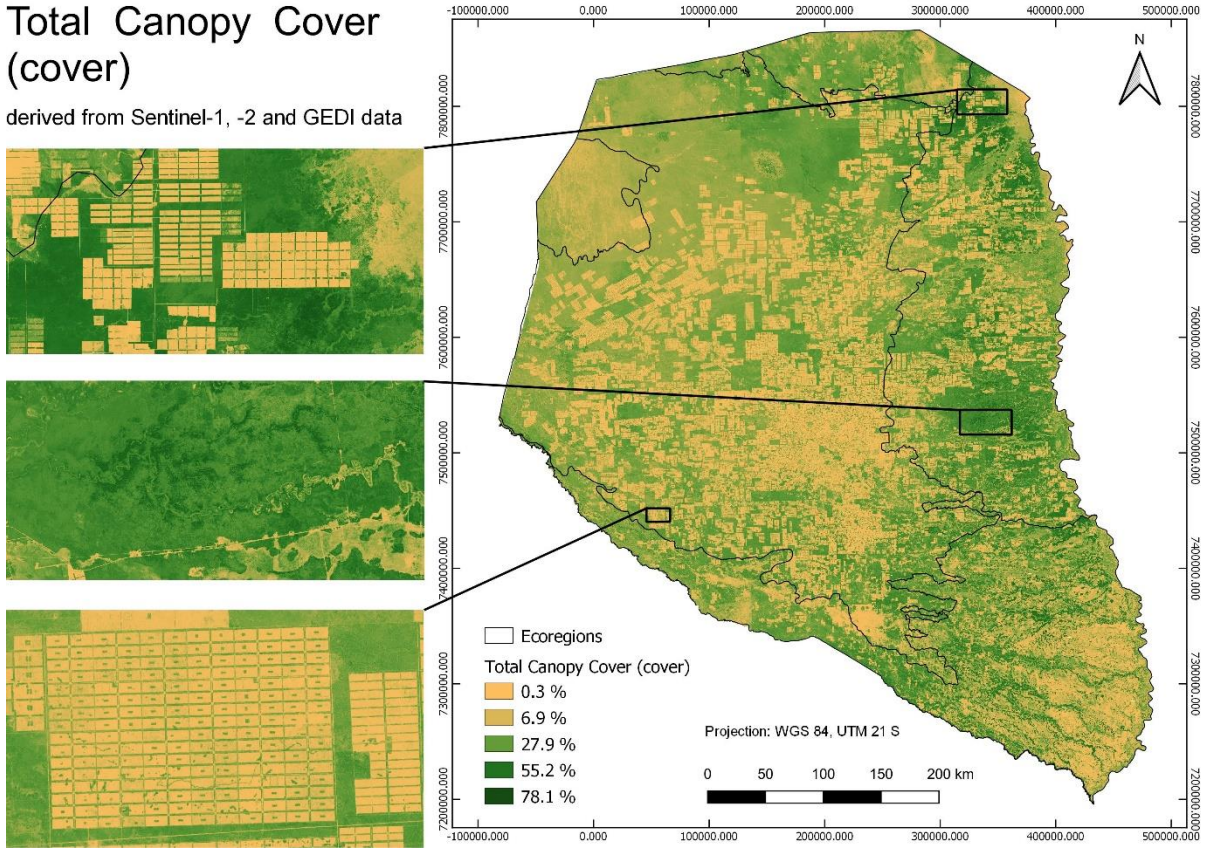
Canopy Height (rh95)

derived from Sentinel-1, -2 and GEDI data



Total Canopy Cover (cover)

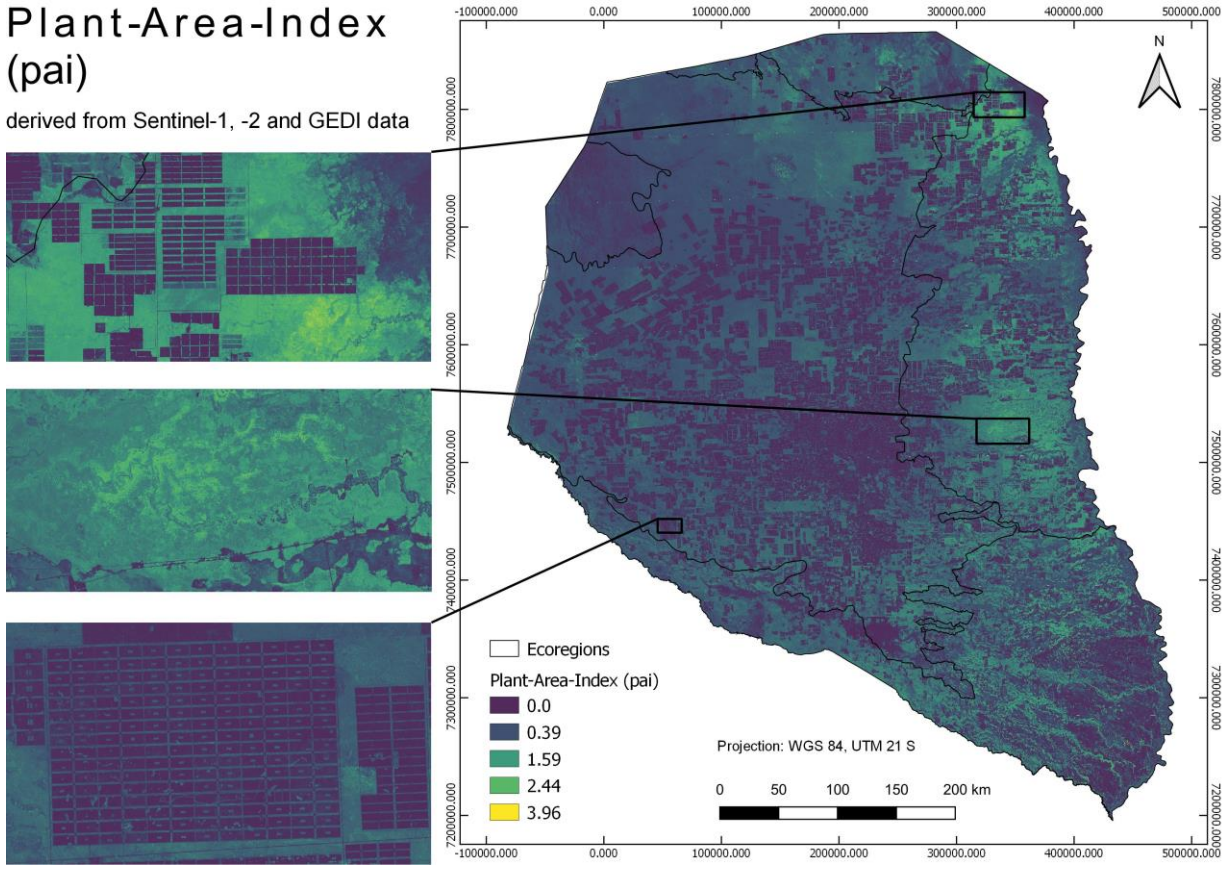
derived from Sentinel-1, -2 and GEDI data



Appendix C: PAI and FHDI

Plant-Area-Index (pai)

derived from Sentinel-1, -2 and GEDI data



Foliage-Height-Diversity-Index (FHDI)

derived from Sentinel-1, -2 and GEDI data