Earth Observation Summer Term 2025

Project Topic 2

Satellite-derived tree cover in forest-savanna ecosystems - when is a forest a savanna?

Reference

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At intermediate precipitation (MAP 750-2000 mm), tropical forests and savannas are believed to represent alternative stable states that coexist via stabilizing feedback processes involving fire and herbivory. From a vegetation structural perspective, savannas often resemble the physiognomy of forests, yet species composition, plant functional traits, process regimes, and ecosystem services often differ considerably between these ecosystems. While a clear distinction between forests and savannas requires an ecological, physiological, and evolutionary perspective, vegetation structure remains an important indicator for assessing ecosystem state and dynamics. 'Tree cover' in particular is a widely used measure that is being used for a multitude of assessments, including characterising forest extent, deforestation processes, or forest restoration potential. As such, much ecological and socio-ecological research (and thereof derived policies) make use of remote sensing derived tree cover products that are available at global scale. However, 'forest' definitions vary and reflect historic, cultural and subject specific perceptions of what a forest actually is. Additionally, global products on tree cover are inevitably less accurate at regional to landscape scale, and their application in heterogeneous forest-savanna landscapes remains contested.

Here, the goal is to explore the potential of deriving tree cover from a regionally-calibrated model and compare it to the performance of globally available products. The primary (methodological) aim of this study is to investigate the potential of deriving tree cover from multispectral Sentinel-2 (20m) data for an area around the Gilé National Park in central Mozambique, an area covering a heterogenous mosaic of grasslands, savannas, croplands, coastal mangroves, and dense woodlands. A secondary, thematic focus may be put on the varying forest definitions (e.g. tree cover thresholds), the potential of forest-savanna differentiation, and the implications of using a particular tree cover product and definition to define 'forest' extent. The regression models to predict tree/woody cover may be built either using synthetic unmixing of image endmembers, and/or by exploring the potential of using reference fractions of tree/woody cover available from the Global Ecosystem Dynamics Investigation (GEDI) spaceborne-lidar mission. The generated fraction cover maps should be validated, and based on this assessment, a comparative exercise to existing global products performed. Validation data in turn is already partly available in the form of a high-resolution airborne laserscanning (ALS) based tree cover dataset, and may be complemented using VHR image interpretation.

Provided data

- Sentinel-2 20m multispectral interpolated time-series for 2021-2022
- Existing tree cover products by Hansen et al. (2013), Sexton et al. (2013), Brandt et al. (2023), Reiner et al. (2023)
- Vegetation cover and canopy height metrics from the Global Ecosystem Dynamics Investigation (GEDI) mission (spaceborne lidar)
- ALS-derived tree cover product at 25m resolution

Selected literature

Thematic on forest-savanna ecology and forest definitions

Ratnam et al. (2011): When is a "forest" a savanna, and why does it matter? Global Ecology and Biogeography 20, 653–660. https://doi.org/10.1111/j.1466-8238.2010.00634.x

Oliveras & Malhi (2016): *Many shades of green: the dynamic tropical forest–savannah transition zones.* Philosophical Transactions of the Royal Society B: Biological Sciences 371, 20150308. https://doi.org/10.1098/rstb.2015.0308

Briske et al. (2025). It's time to assign nonforested, nonagricultural lands a global designation. Camb. prisms Drylands 2, e5. https://doi.org/10.1017/dry.2025.2

Remote sensing of vegetation structure in forest-savanna landscapes

Kahiu et al. (2024): *Satellite-based woody canopy cover for Africa: Uncovering bias and recovering best estimates across years.* Science of Remote Sensing 9, 100124. https://doi.org/10.1016/j.srs.2024.100124

Pletcher et al. (2024): Evaluating global vegetation products for application in heterogeneous forest-savanna landscapes. International Journal of Remote Sensing 45, 492–507. https://doi.org/10.1080/01431161.2023.2299278

Abdi et al. (2022): Satellite Remote Sensing of Savannas: Current Status and Emerging Opportunities. Journal of Remote Sensing 2022. https://doi.org/10.34133/2022/9835284

References to existing tree cover products

Hansen et al. (2013): High-resolution global maps of 21st-century forest cover change. Science 342, 850–853. https://doi.org/10.1126/science.1244693

Sexton et al. (2013): *Global, 30-m resolution continuous fields of tree cover: Landsat-based rescaling of MODIS vegetation continuous fields with lidar-based estimates of error.* International Journal of Digital Earth 6, 427–448. https://doi.org/10.1080/17538947.2013.786146

Brandt et al. (2023): *Wall-to-wall mapping of tree extent in the tropics with Sentinel-1 and Sentinel-2.* Remote Sensing of Environment 292, 113574. https://doi.org/10.1016/j.rse.2023.113574

Reiner et al. (2023): More than one quarter of Africa's tree cover is found outside areas previously classified as forest. Nat Commun 14, 2258. https://doi.org/10.1038/s41467-023-37880-4