Advancing Southern African rangeland monitoring with hyperspectral satellite time series

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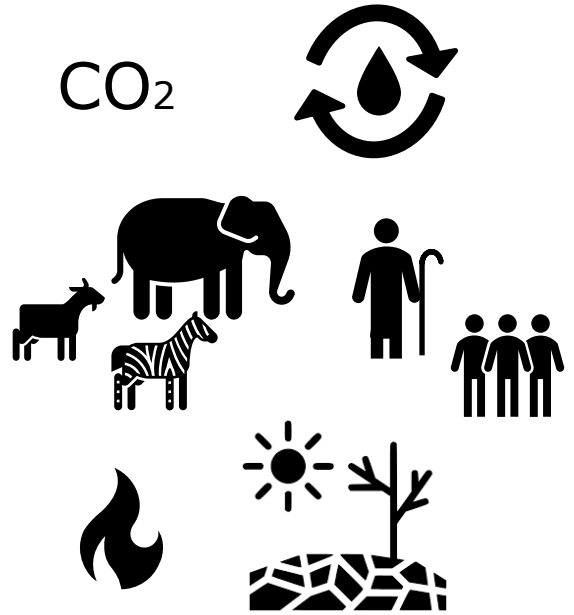
Rangeland monitoring

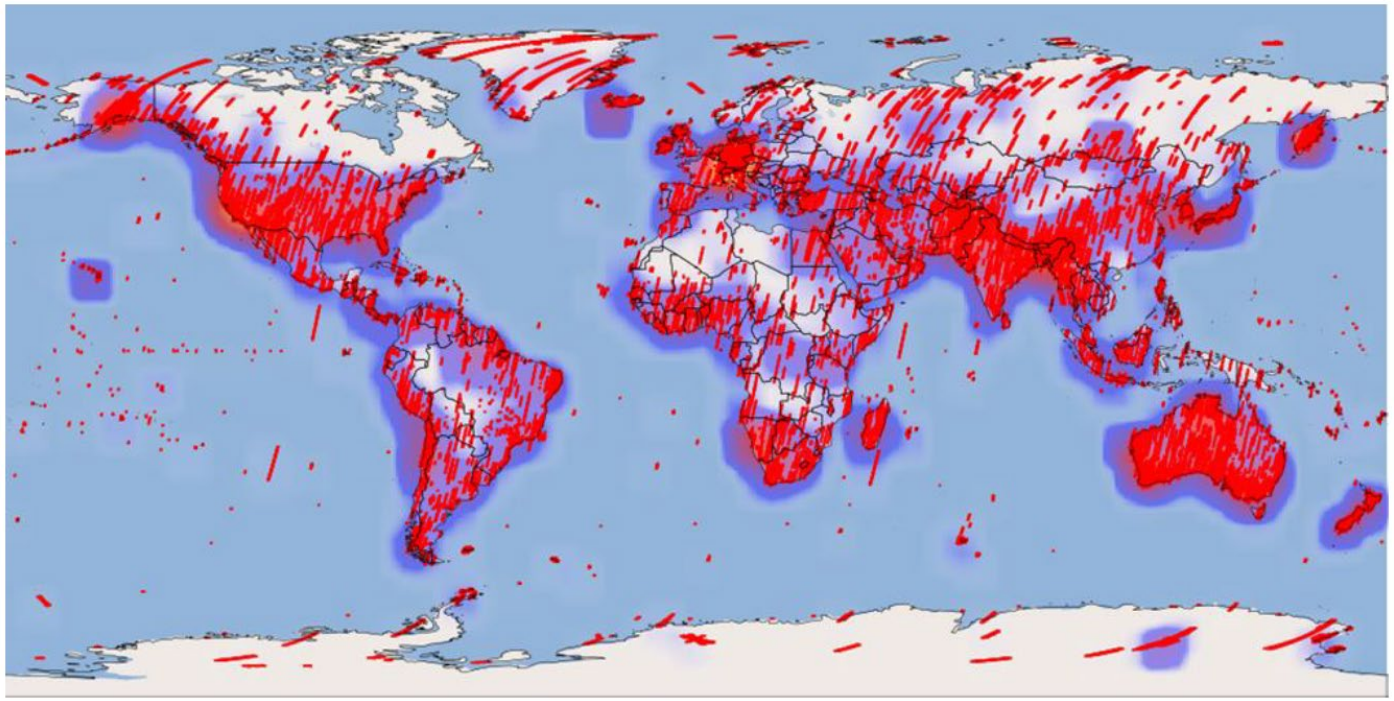
- Plant productivity, composition, health
- Green and **Non-photosynthetic vegetation** (NPV) cover/biomass
- NPV most accurate from hyperspectral data (Durante et al., 2014)



Namibia field campaign 2023, @Lasse Harkort

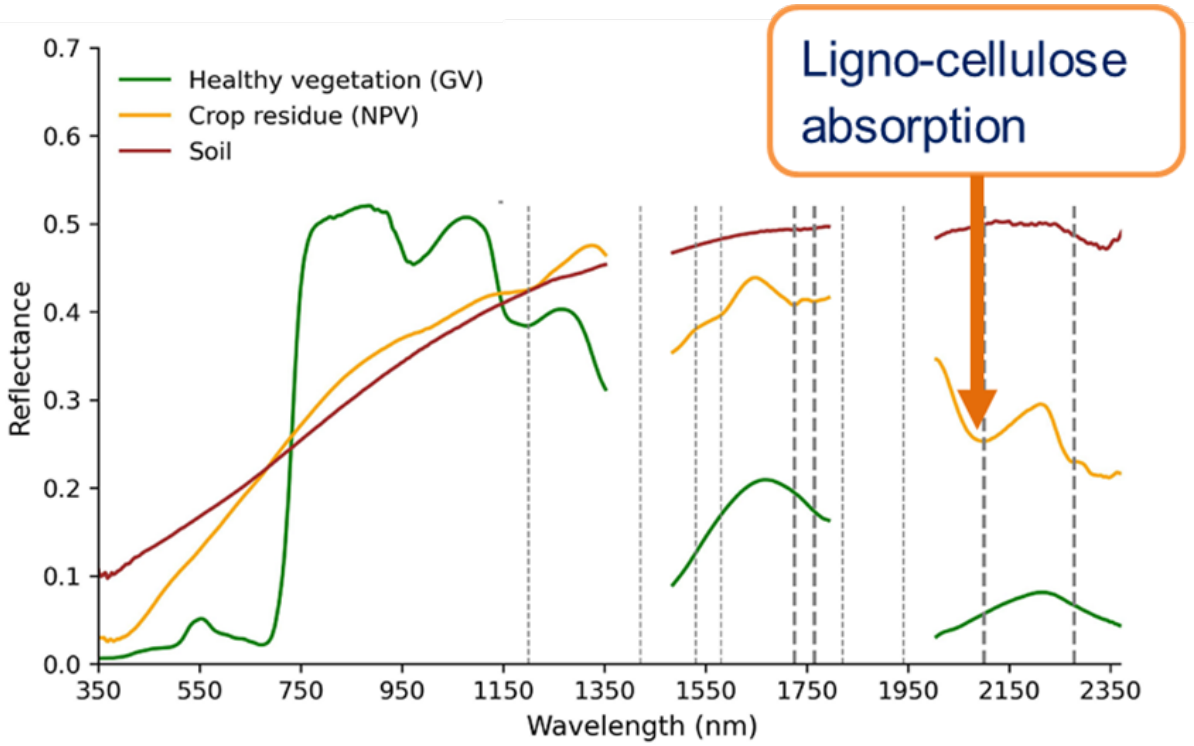
Hyperspectral Earth Observation

- Spaceborne **hyperspectral** remote sensing enhances **ecosystem monitoring** with more precise land surface and vegetation indicators
- Upcoming operational missions (e.g., **CHIME, SBG**) will provide regular global coverage
- Current precursor missions (e.g., **EnMAP**) pioneer globally sampled hyperspectral time series



Archive of EnMAP tiles until 31.03.2024.
EnMAP Ground Segment, Mission Quarterly Report (#7)

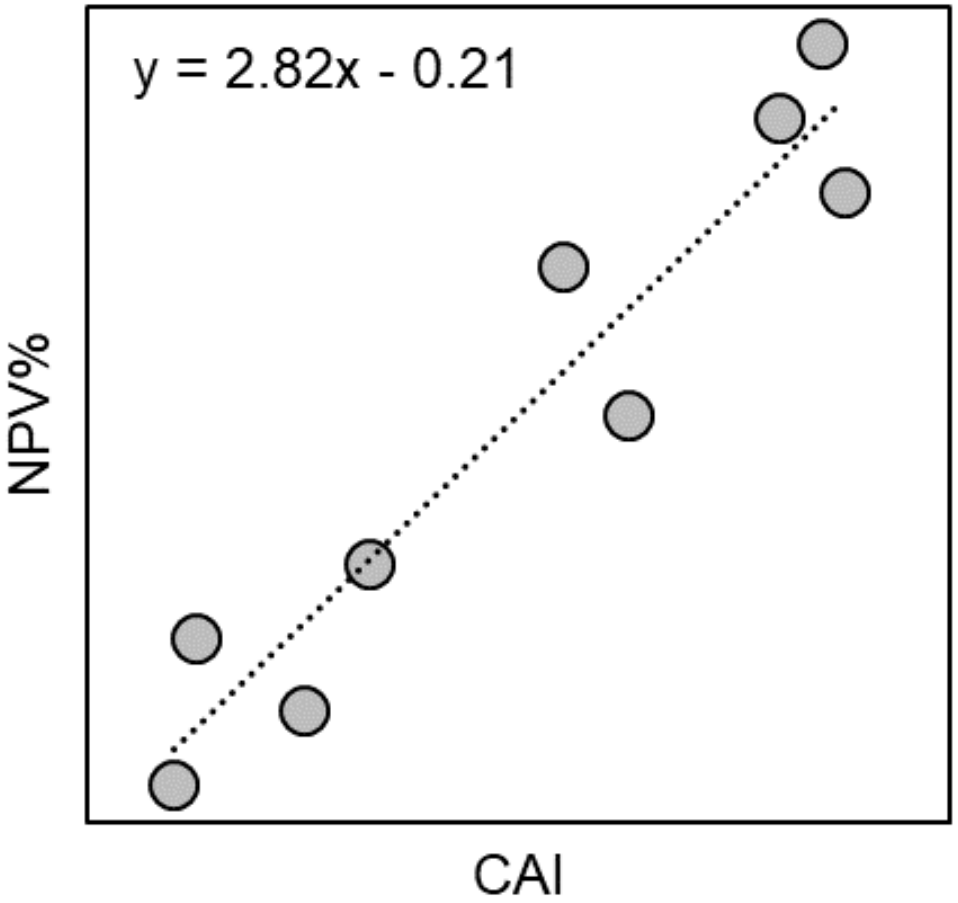
Cellulose Absorption Index (CAI, Daughtry et al. 2001)



Verrelst et al. 2023

- Hyperspectral index for non-green vegetation
- $CAI = 0.5(R_{2019\ nm}+R_{2206\ nm})-R_{2109\ nm}$
- *CAI* lacks physically meaningful units, complicating its interpretation

Objectives

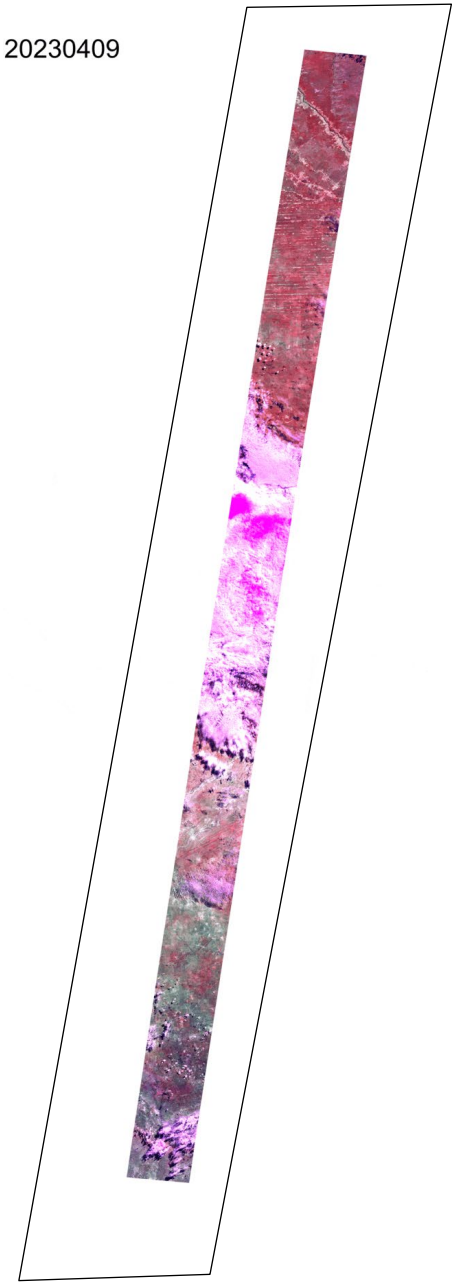


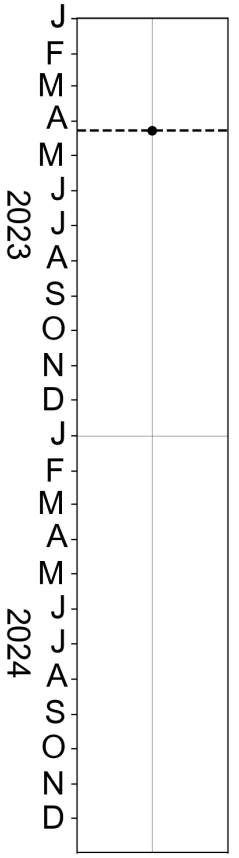
1) Develop a robust and accessible model for translating *CAI* into *NPV%*
2) Compare model derived from field-based spectral measurements vs EnMAP spectra

Study site & data

- Transect: central Namibia to Angolan border
- EnMAP time series with close to monthly acquisitions starting from 04/2023
- Data gap during the rainy season due to unfavorable weather conditions (cloud cover)
- Level-2A data organized in cube structure

Spectral range	420 – 2450 nm
Sampling distance	6.5 nm (VNIR), 10 nm (SWIR)
Geometric resolution	30 x 30 m
Swath width	30 km
Orbit repeat cycle	27 days
Revisit	21 days (±5° off-nadir) 4 days (±30° off-nadir)

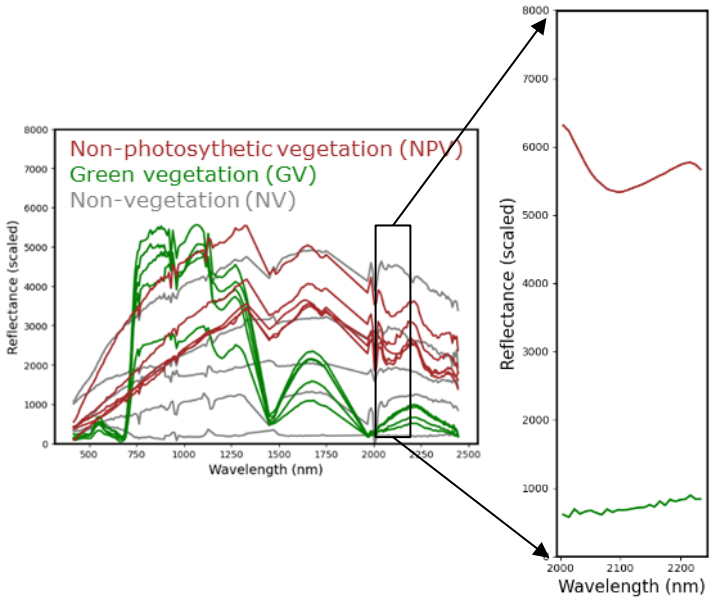




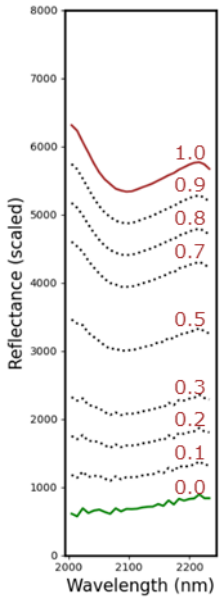
https://www.enmap.org

Workflow

Spectral library



Synthetic training data

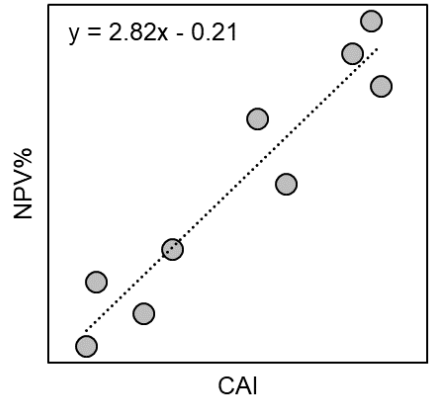


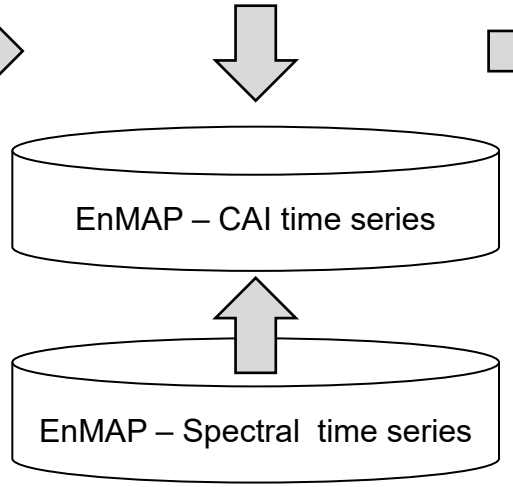
#	CAI	NPV frac
NPV	0.39	1.0
MIX	0.37	0.9
MIX	0.33	0.8
MIX	0.27	0.7
MIX	0.24	0.5
MIX	0.18	0.3
MIX	0.18	0.2
MIX	0.15	0.1
GV	0.09	0.0

Dennison et al. 2023

Okujeni et al. 2013

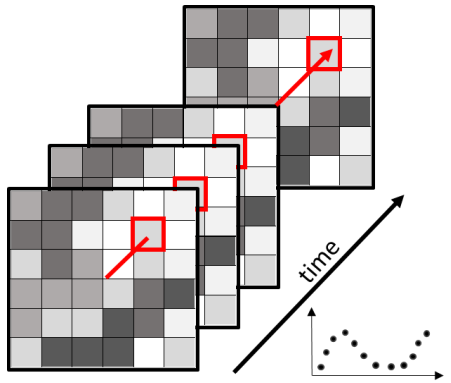
Regression modeling



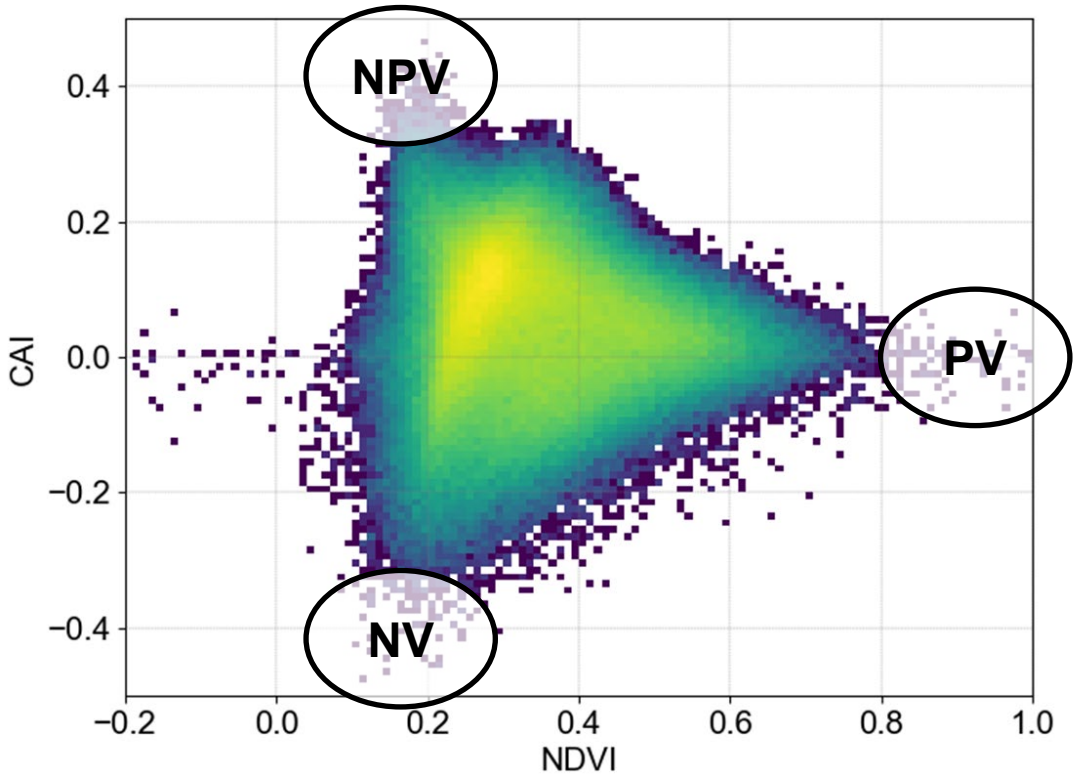


EnMAP data cube

NPV fractional cover time series

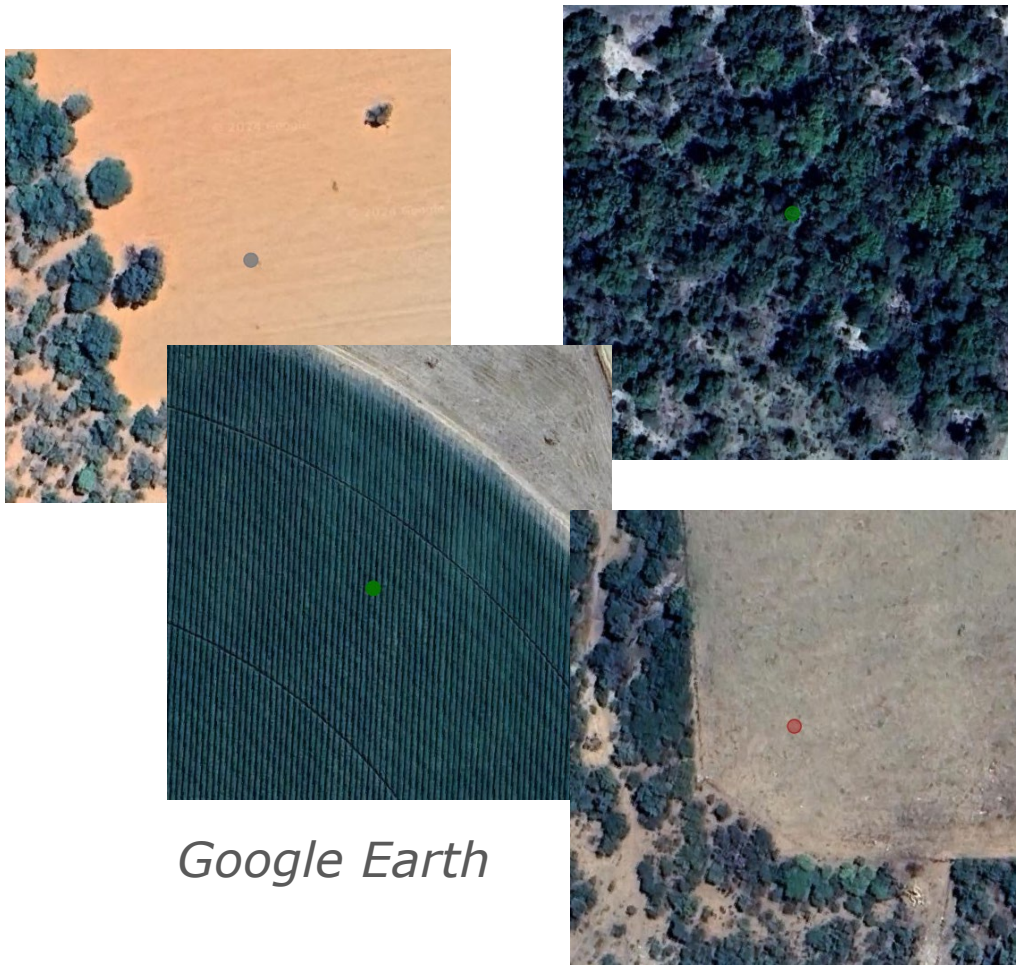


EnMAP spectral library



- Candidate image spectra from a multitemporal NDVI/CAI feature space with support of rainfall map *Guerschmann et al. 2009*

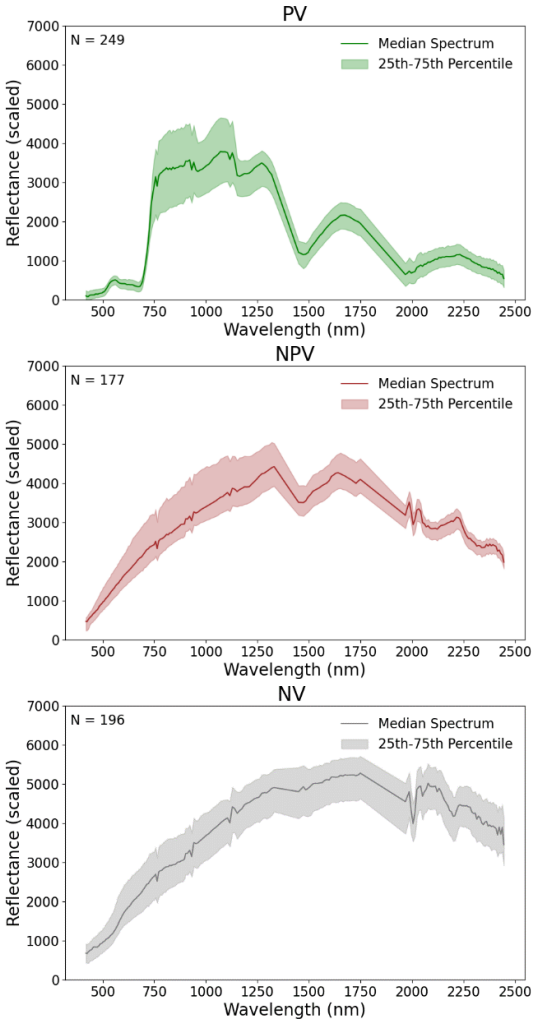
- Final library through visual quality assessment using VHR imagery



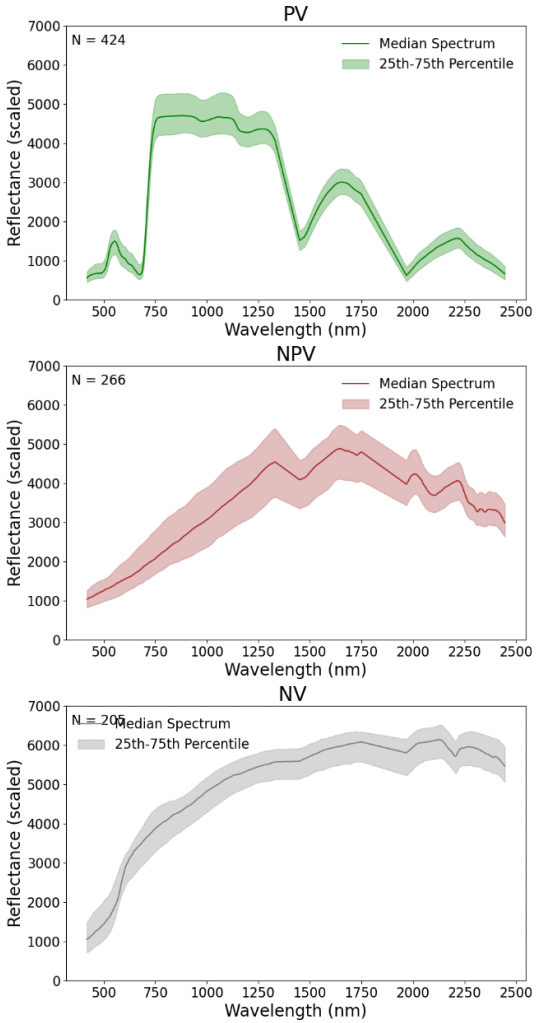
Google Earth

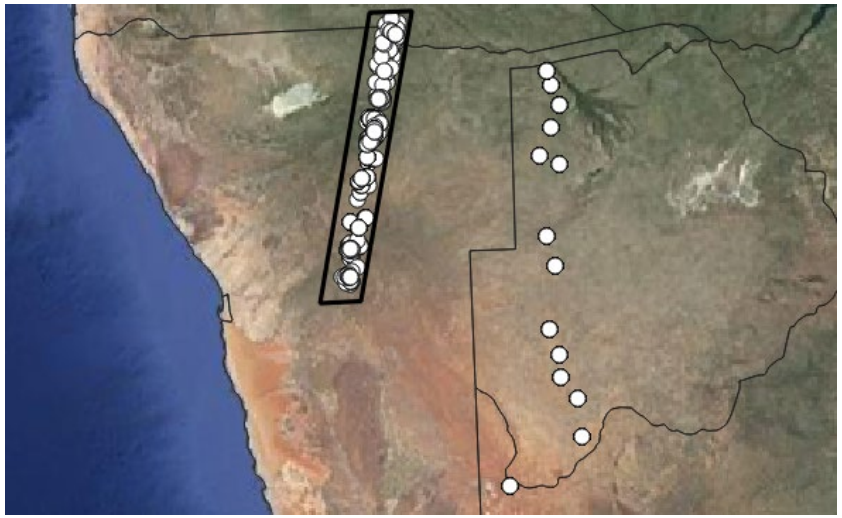
Results – EnMAP vs. field spectral library

EnMAP-based lib. Namibia



Field-based lib. Botswana



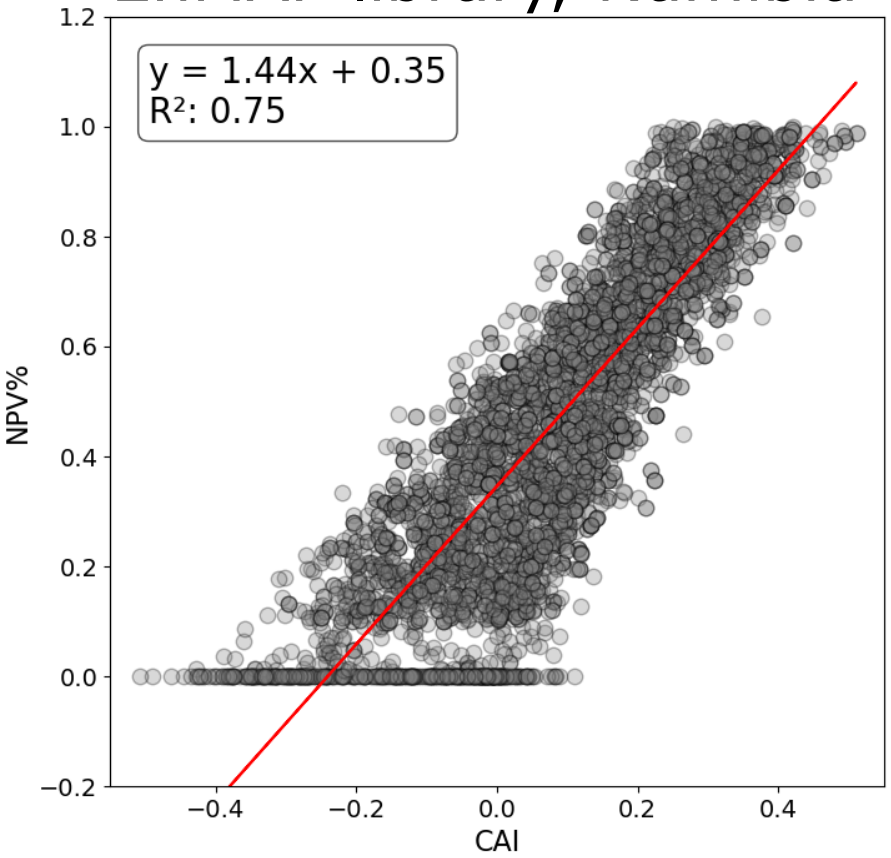


- Kalahari endmember set collected across a north-south rainfall gradient in Botswana
- Field-based (ASD FieldSpec 3)

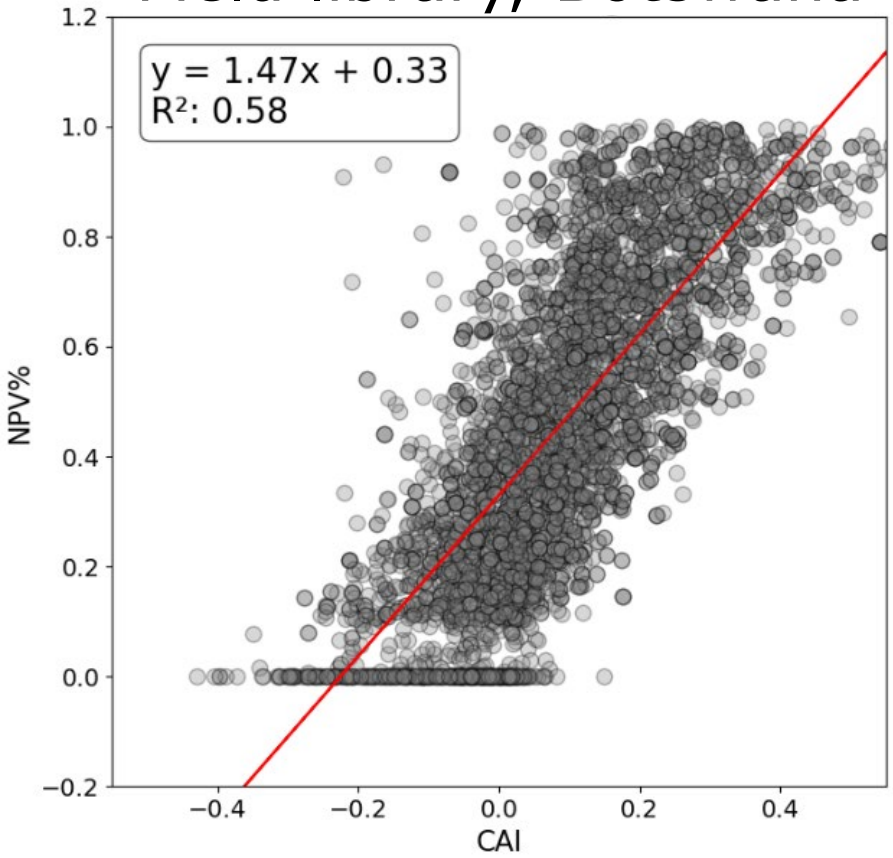
Meyer, Okin, Ochoa & Brodrick. NSF (2007-2011); NASA (2011-2016). Kalahari Ecosystem Endmember Set. Data set. Available online [http://ecosis.org] from the Ecological Spectral Information System (EcoSIS). 10.21232/fEsyLrWo

Results – EnMAP vs. field spectral library

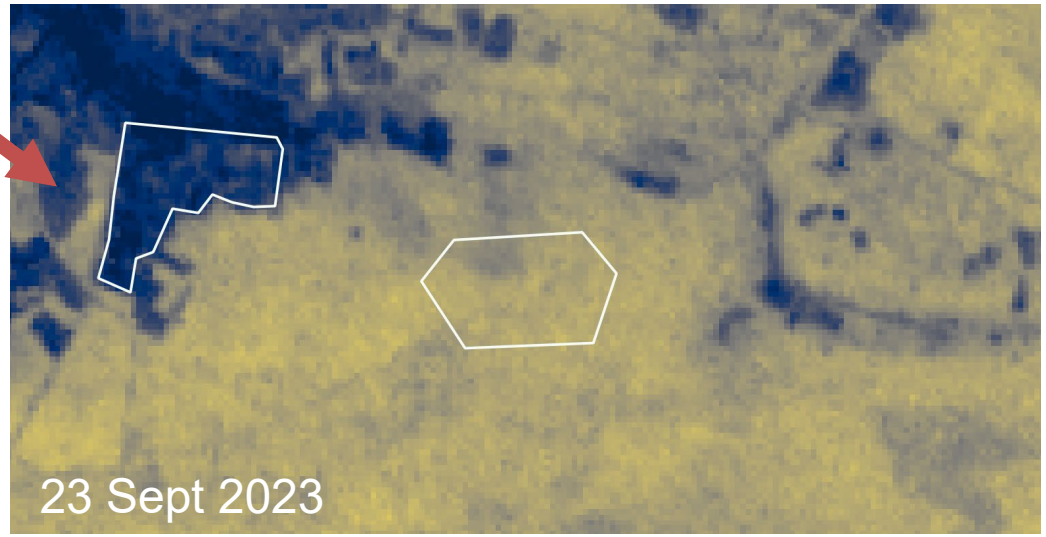
EnMAP library, Namibia

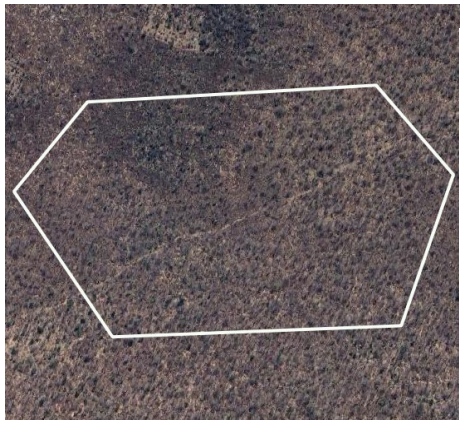


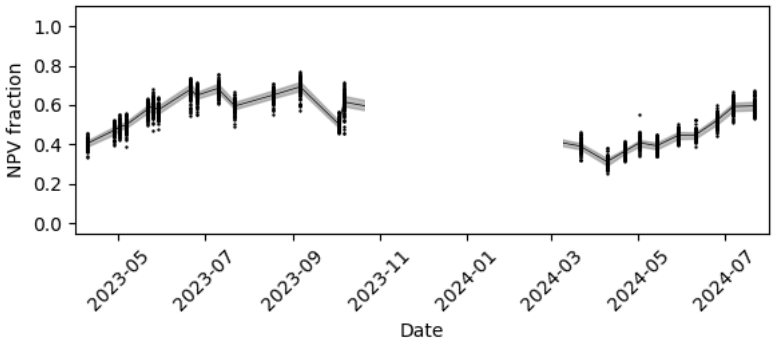
Field library, Botswana

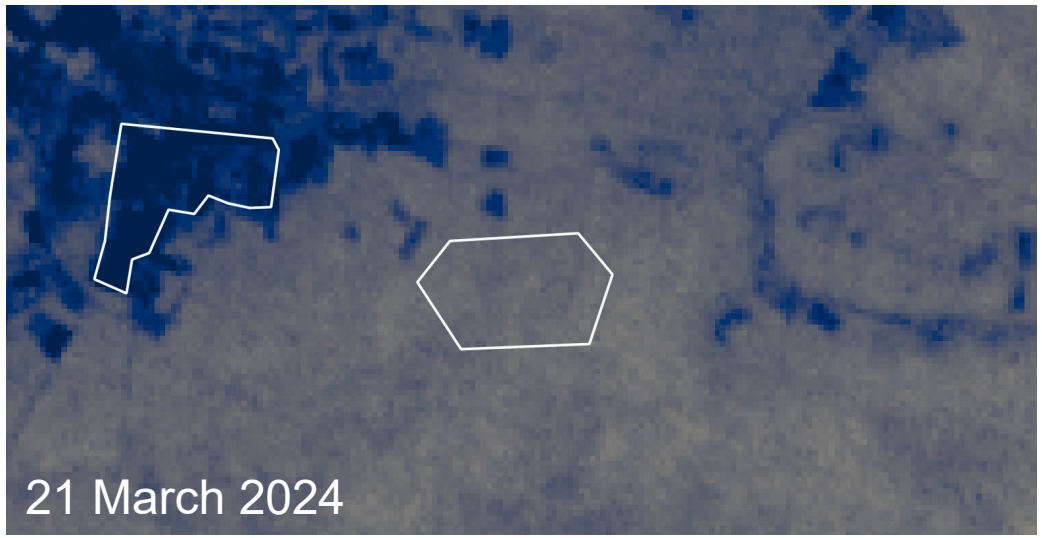


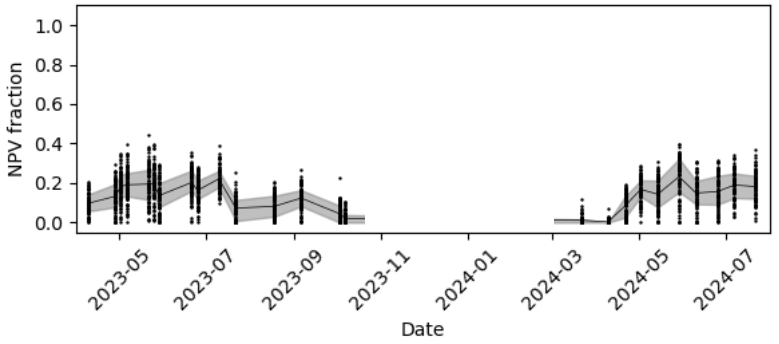
Results – NPV time series











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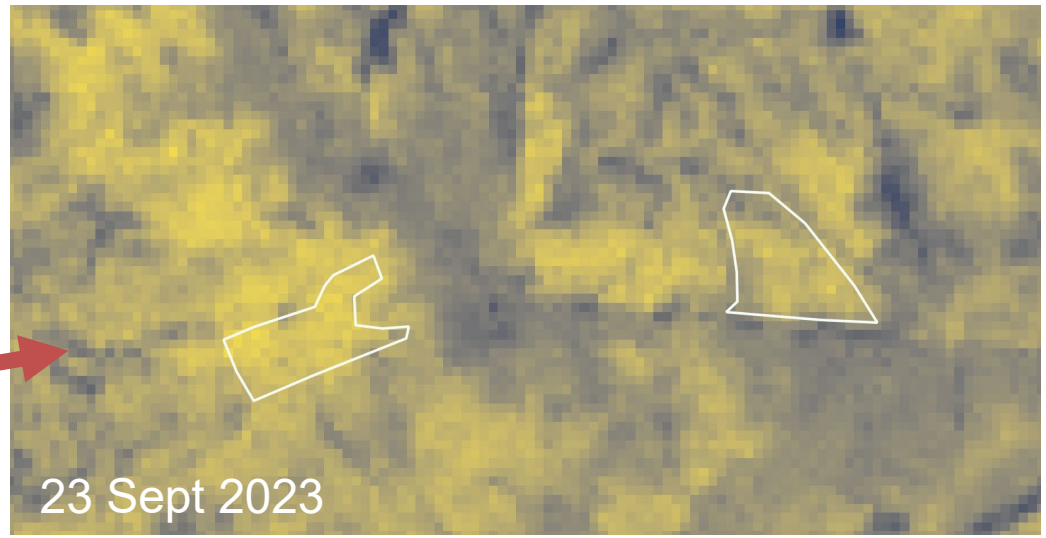

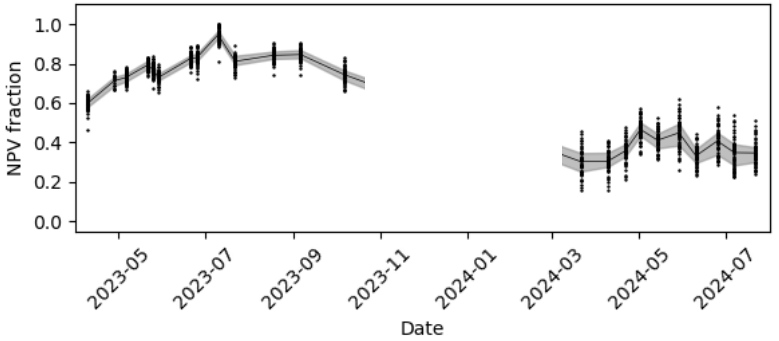

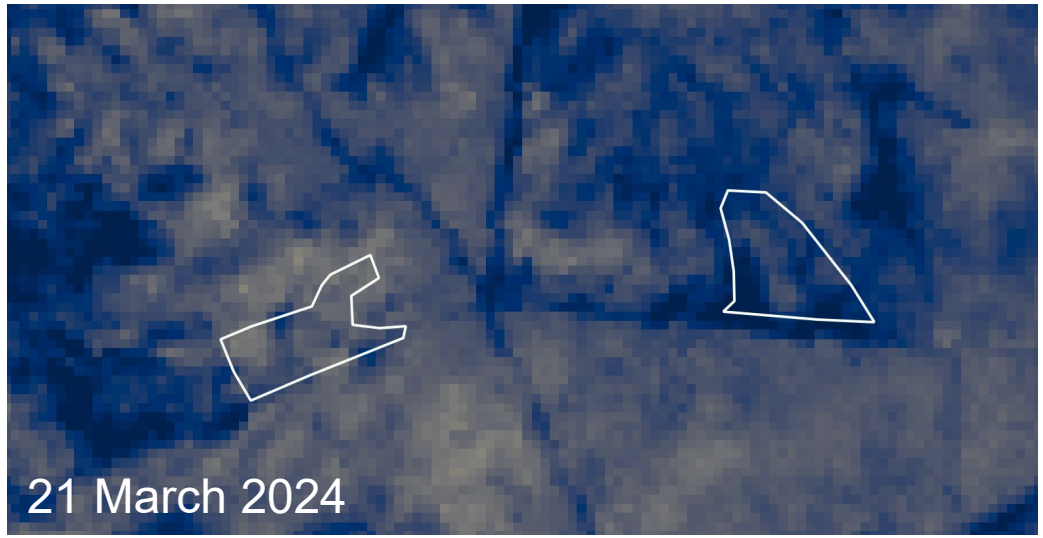

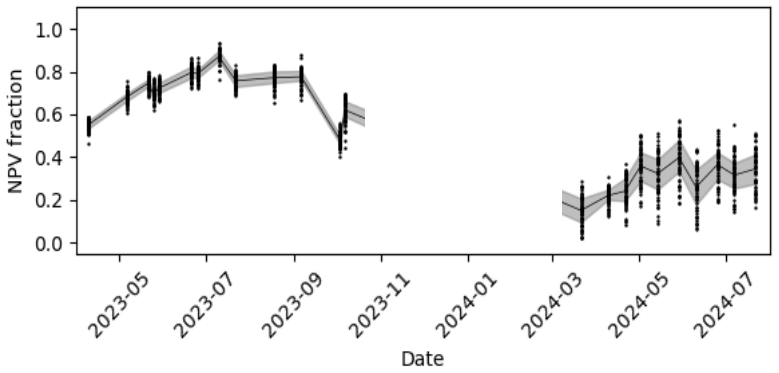

Conclusions

- Straightforward and reproducible approach for NPV time series retrieval from spaceborne imaging spectroscopy
- Image-based spectral library development strategy compensates absence of in-situ spectral databases
- NPV validation requires standardized protocol and community driven effort for collecting fractional cover field data
- EnMAP time series showcase benefits of future operational hyperspectral satellite missions (CHIME, SBG)

Thank you!

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