Quantifying drought responses in Central European grasslands with satellite time series. Current applications and future opportunities

Patrick Hostert[1,2], Akpona Okujeni[1], Katja Kowalski[1], Arasumani Muthusamy[3], Sebastian van der Linden[3]

[1] Earth Observation Lab, Humboldt-Universität zu Berlin, Germany
[2] IRI THESys, Humboldt-Universität zu Berlin, Germany
[3] Institute for Geography and Geology, University of Greifswald, Germany

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Increasing drought risk

- Climate change extremes will likely further increase
- Long-term droughts already affect water security

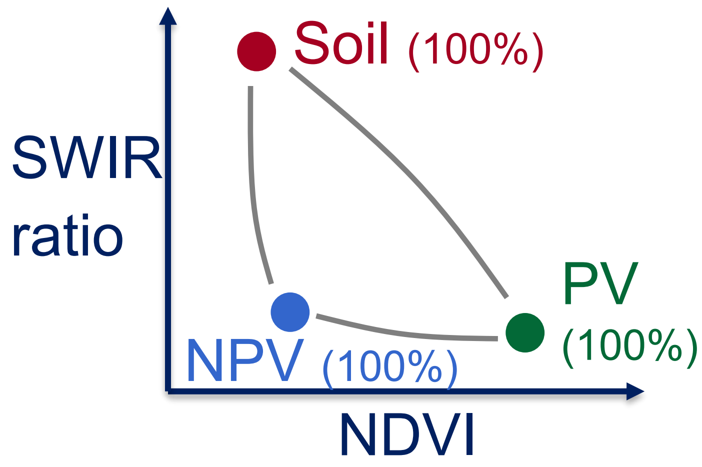
Spiegel online,7 Oct 2022
(https://tinyurl.com/22kbytj7)

Agricultural land in Zealand, Denmark, captured by Sentinel-2
(https://www.esa.int/ESA_Multimedia/Videos/2018/07/Denmark_scorched)

- Grasslands are specifically sensitive to droughts, while under-researched

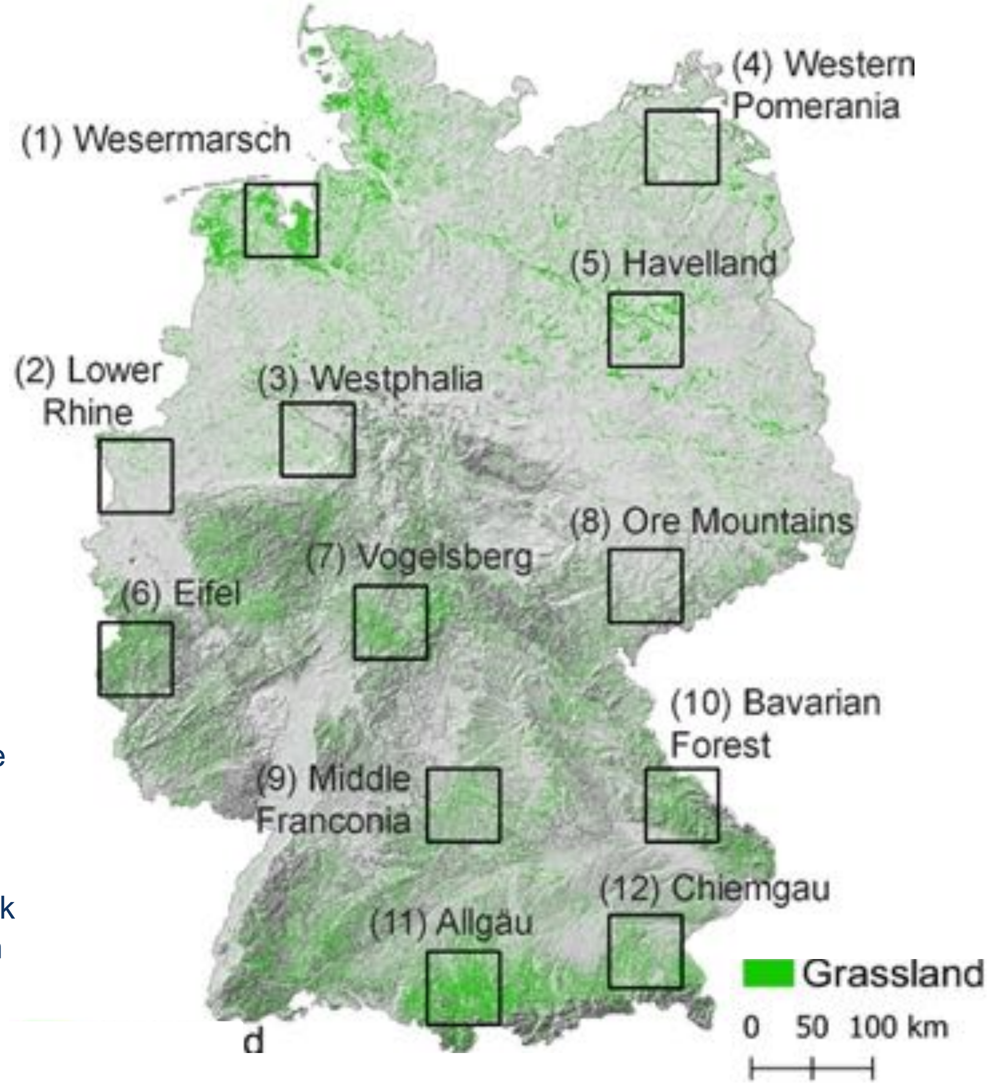
The role of NPV and soil

- Green vegetation (**PV**), dry vegetation (**NPV**), and **soil** fractional cover allow grassland drought monitoring
- Mixing space concept following Guerschman et al. (2009)



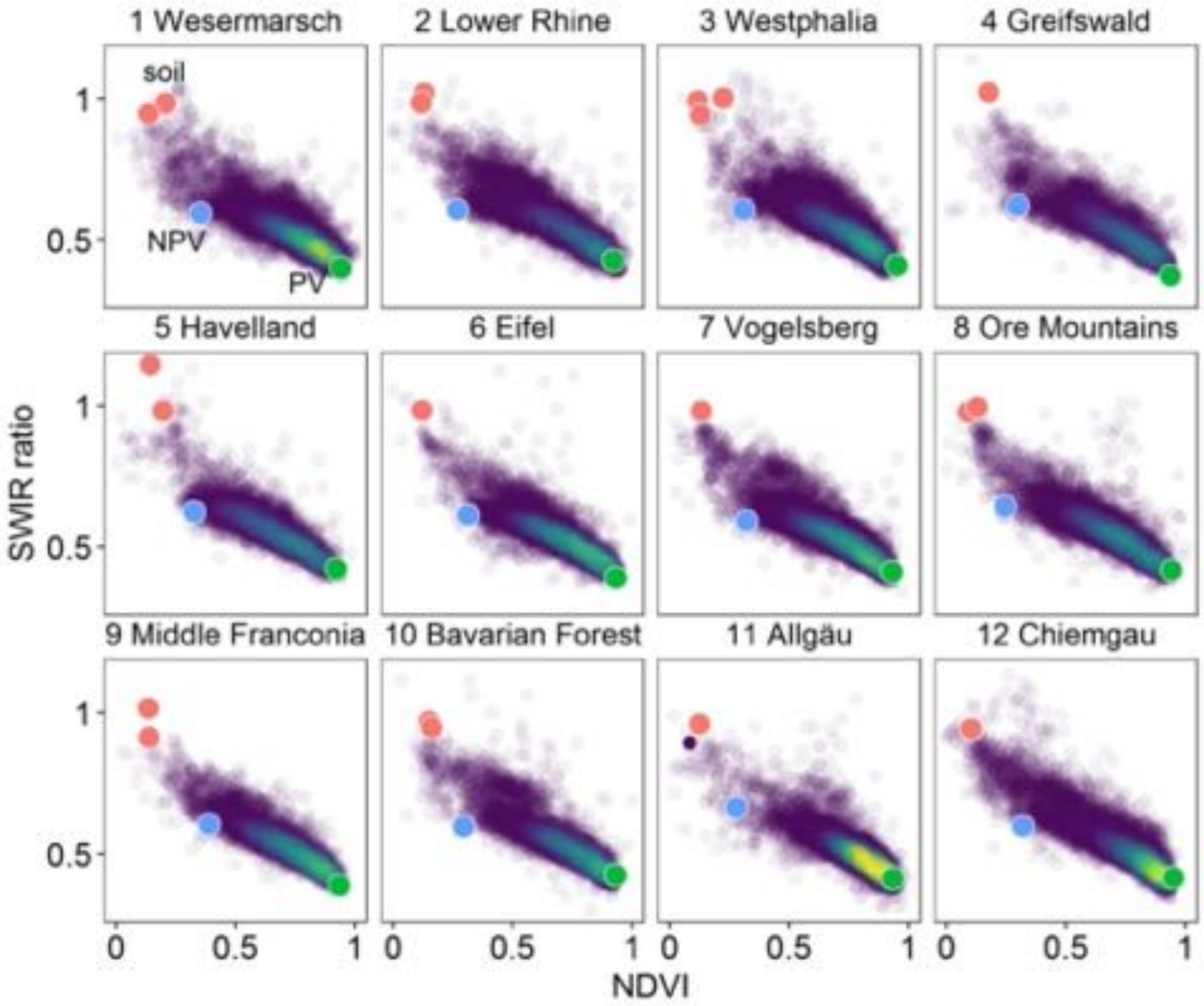
Guerschman et al. (2009). Estimating fractional cover of photosynthetic vegetation, non-photosynthetic vegetation and bare soil in the Australian tropical savanna region upscaling the EO-1 Hyperion and MODIS sensors. RSE, 113, 928-945

Kowalski et al. (in rev.). A generalized framework for drought monitoring across Central European grassland gradients with Sentinel-2 time series

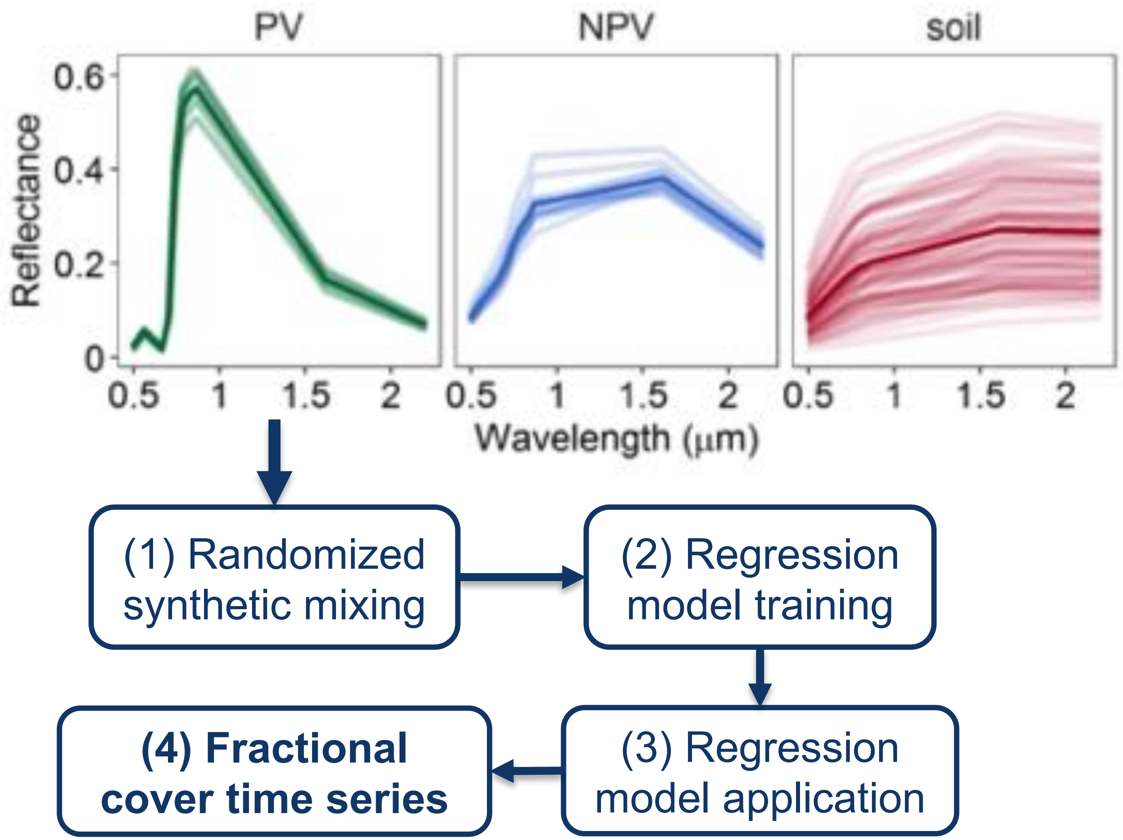


- S2-based drought index from unmixing time series of PV, NPV, and soil fractions

Fractional cover estimates



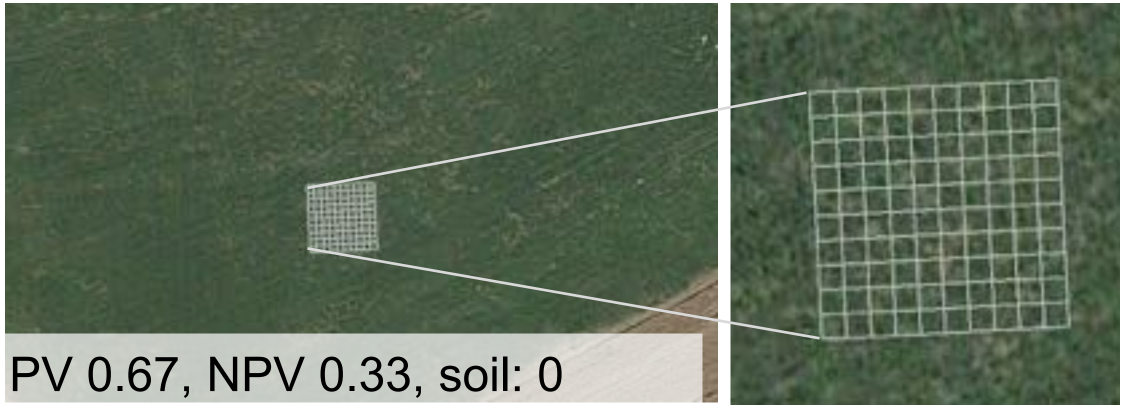
- Regression-based unmixing using synthetic training data



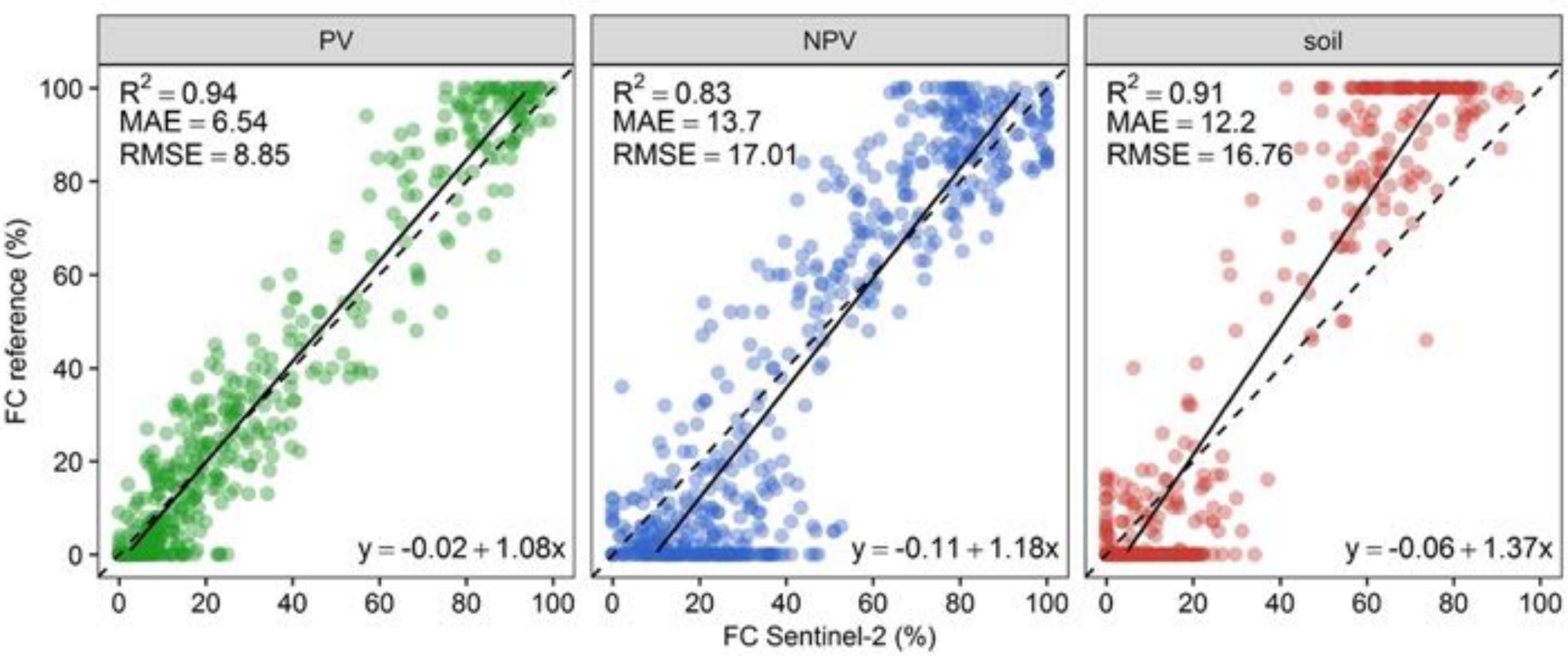
Okujeni et al. (2017) IEEE, Kowalski et al. (2022) RSE

Fractional cover estimates

- Multi-season validation database from VHR imagery

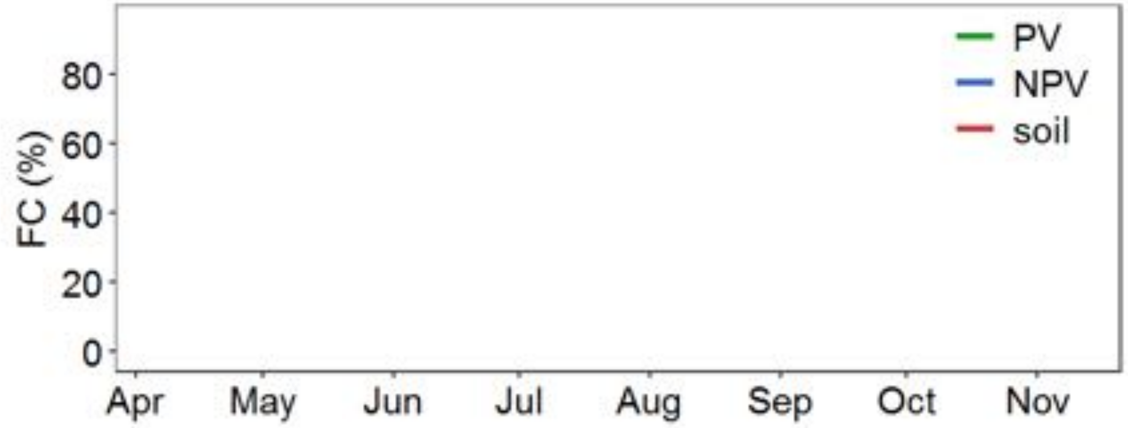


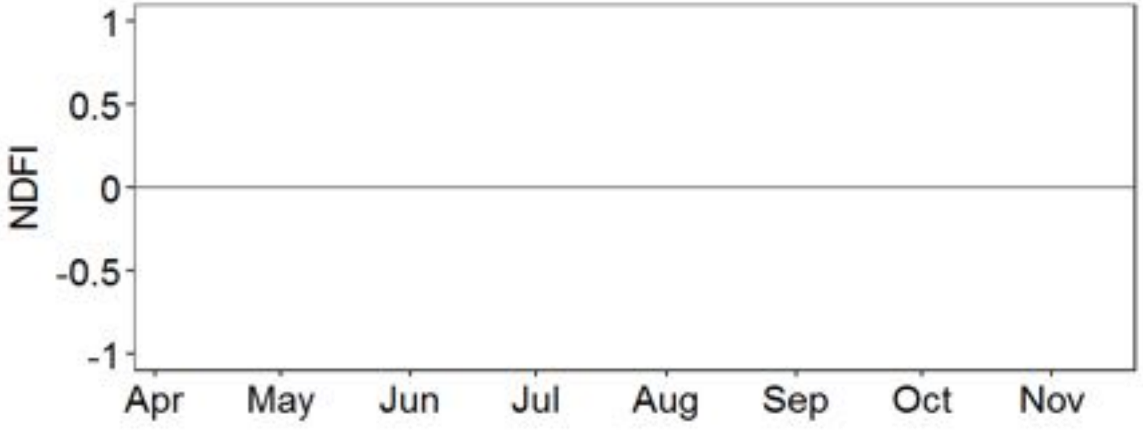
Example of 10x10 pixel grid (100m²) for reference data generation



PV, NPV and soil fractional cover estimates as input for NDFI calculation

NDFI-based grassland drought index



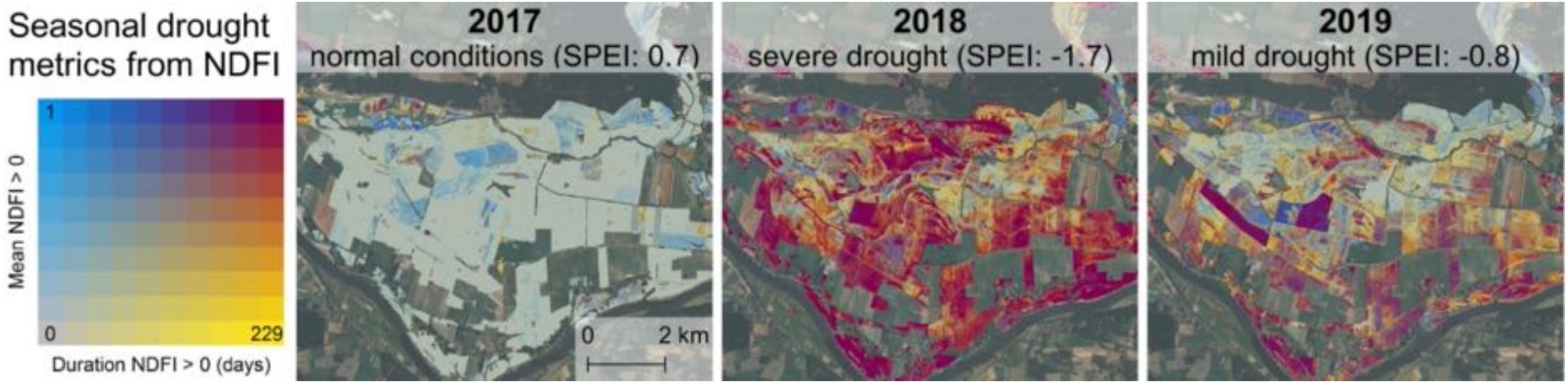


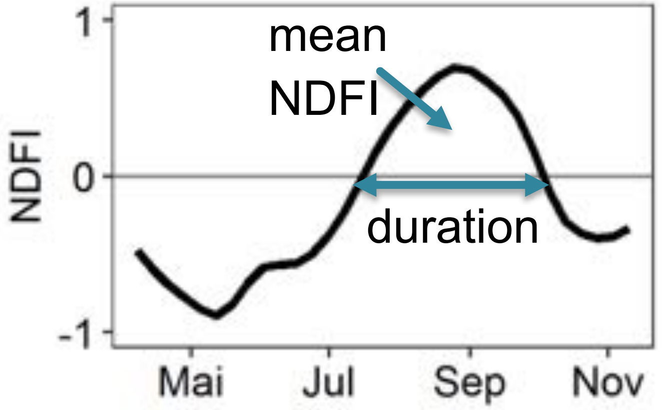
$$NDFI = \frac{((f_{NPV} - f_{NPVbase}) + f_{soil}) - f_{PV}}{(f_{NPV} - f_{NPVbase}) + f_{soil} + f_{PV}}$$

- Contrasts NPV and soil increase relative to PV
- Captures intra-annual changes in drought susceptibility

Souza et al. (2005) RSE, Kowalski et al. (2022) RSE

Grassland drought index





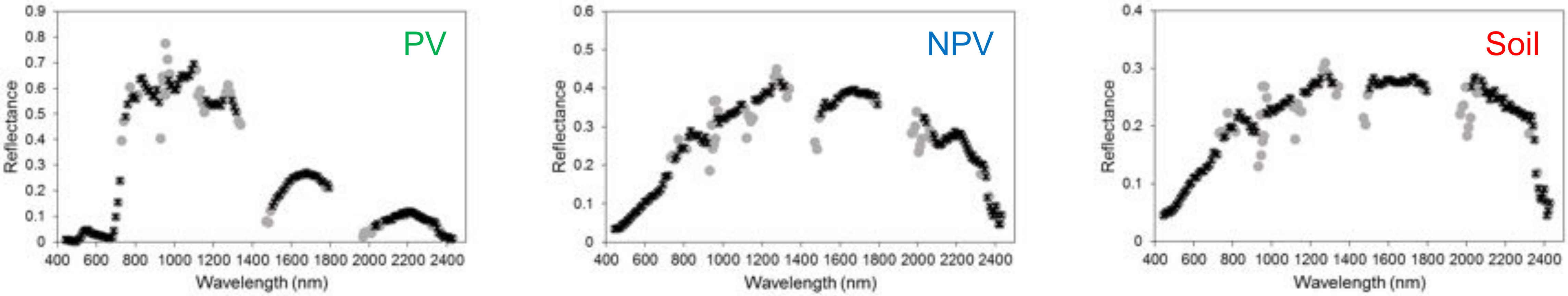
Kowalski, K., Okujeni, A., Brell, M., & Hostert, P. (2022). Quantifying drought effects in Central European grasslands through regression-based unmixing of intra-annual Sentinel-2 time series. *Remote Sensing of Environment, 268.* *https://doi.org/10.1016/j.rse.2021.112781*

PRISMA vs. S2 vs. Landsat Next

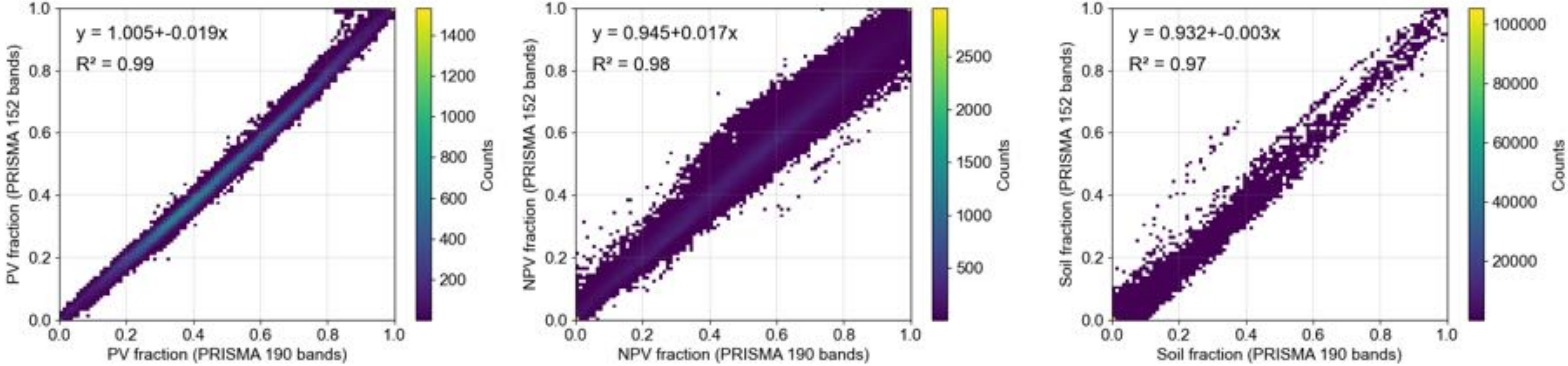
- Multitemporal PRISMA acquisitions in 2021 over NE-Germany ("Demmin site")
- Compare S2-based unmixing with PRISMA-based drought monitoring

- Compare sensitivity of simulated L8/9 and LNext for drought monitoring

PRISMA original vs. cleaned

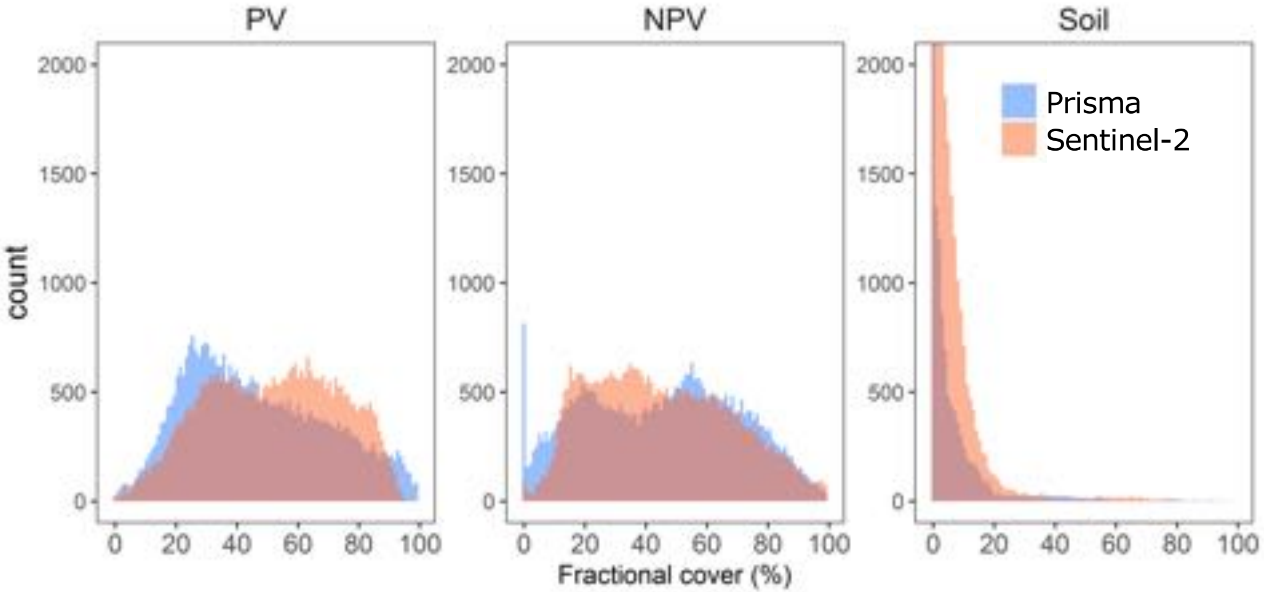


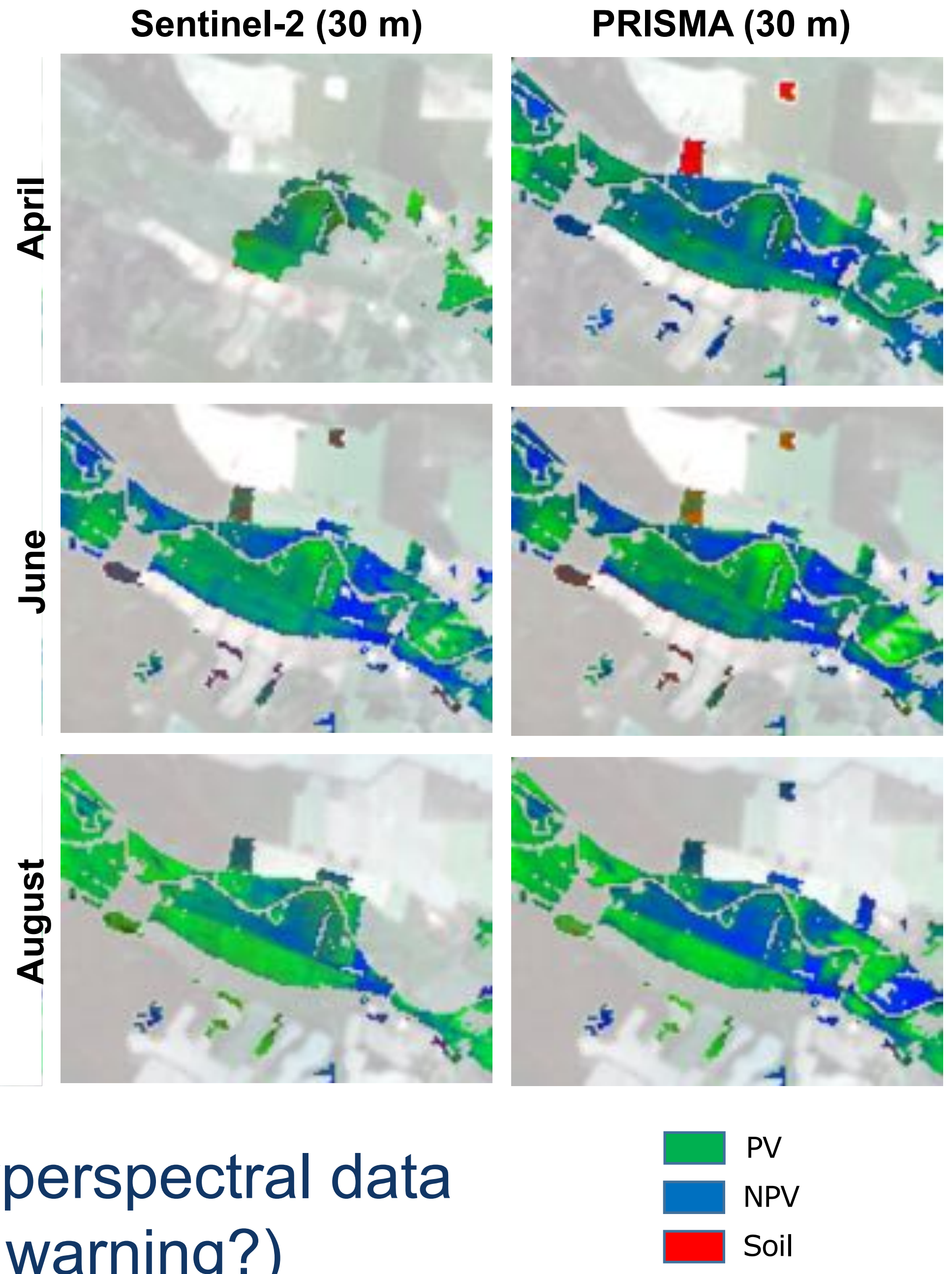
- library spectra full range (gray) and quality-screened (black) Verrelst et al. 2021



PRISMA vs. S2

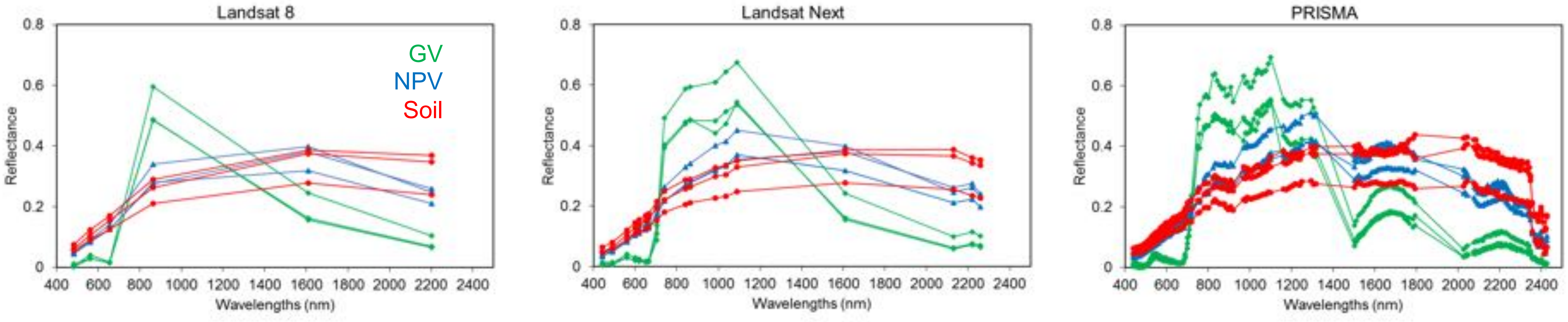
- Fractions from multitemporal PRISMA and S2 across the season compare well
- PRISMA better differentiates upper and lower bounds of fractional cover estimates





- Hypothesis: improved fraction estimates from hyperspectral data will also improve grassland drought maps (early warning?)

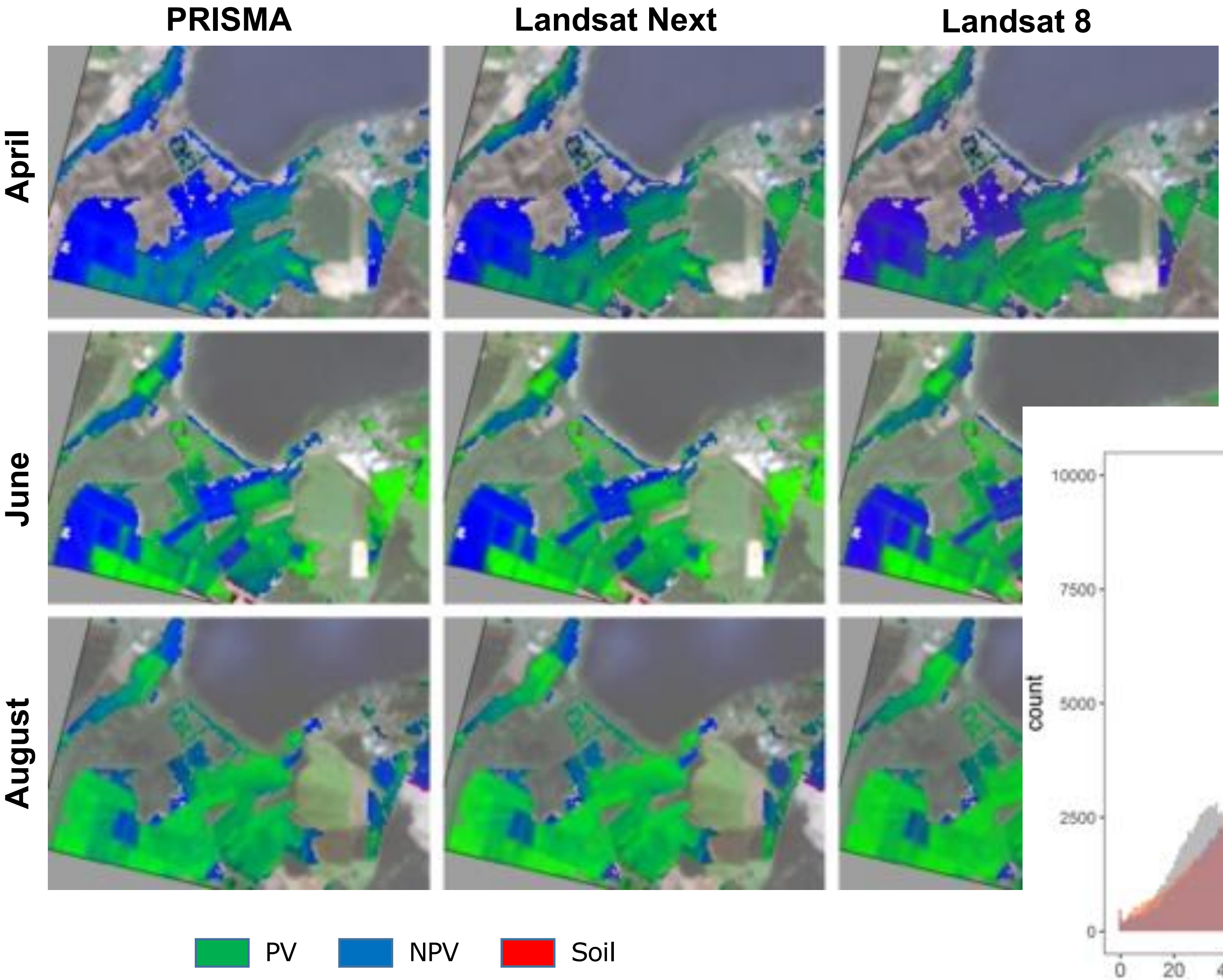
Multispectral – Superspectral – Hyperspectral



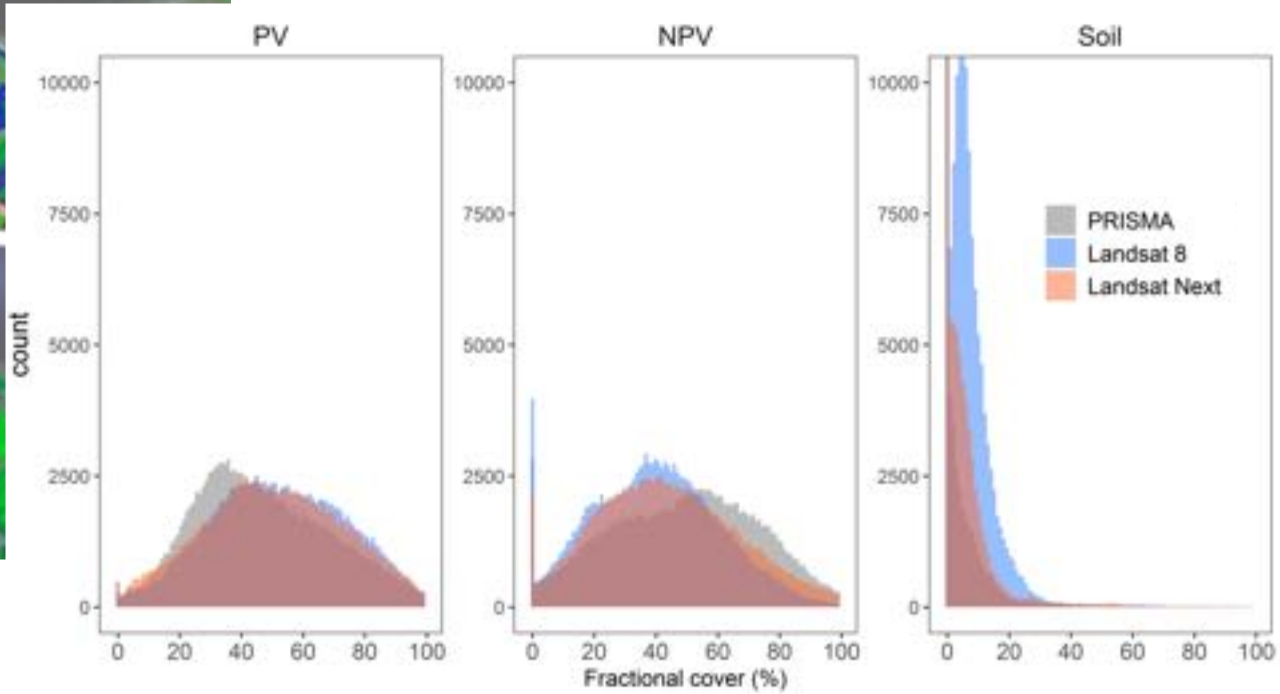
- Today‘s operational systems are great (archives!), while not perfect
- Today‘s hyperspectral systems are close to perfect, while not operational

- Here: simulation of Landsat 8 and Landsat Next from PRISMA data
- Goal: deeper understanding of SWIR-bands in different spectral resolutions for drought mapping in grasslands

PRISMA vs. Landsat vs LNext

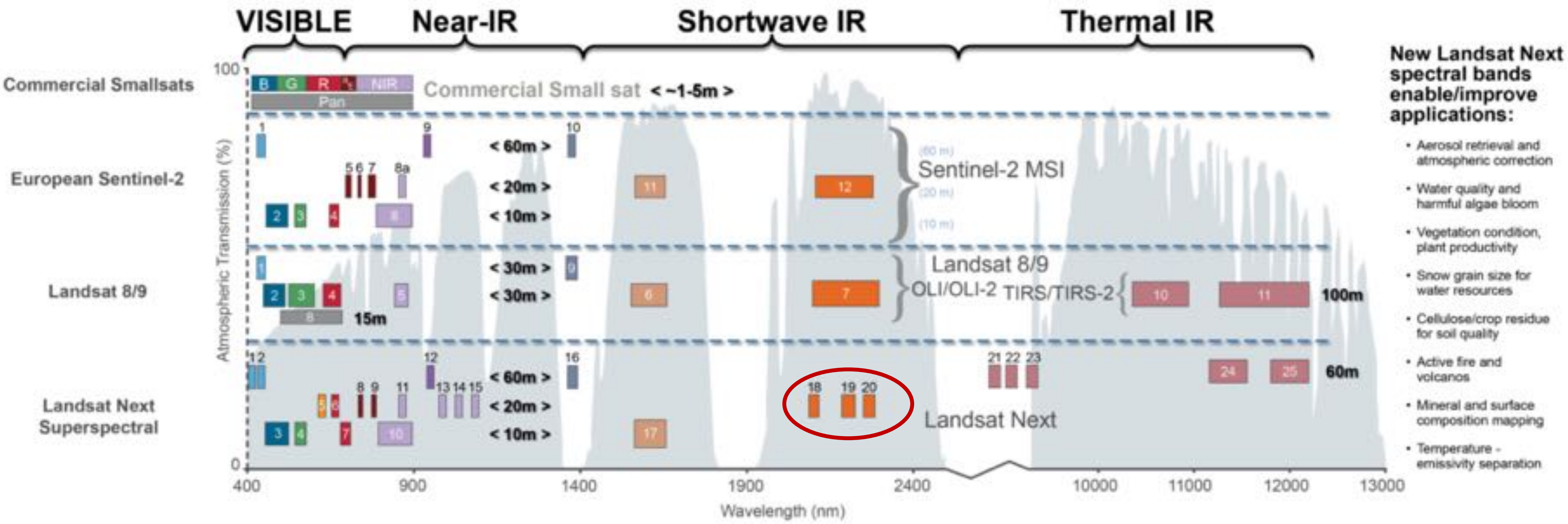


- LNext comes close to hyper-spectral PRISMA estimates
- Specifically, low soil values are missed by Landsat-8



LNext
Landsat Next

Spectral Band Comparisons Between Commercial Smallsats, European Sentinel-2, Landsat 8/9, and Landsat Next (Superspectral)



Wu et al. 2019. User needs for future Landsat missions. *Remote Sensing of Environment*, 231, 111214
Hively et al. 2021. Evaluation of SWIR Crop Residue Bands for the Landsat Next Mission. *Remote Sensing, 13, 3718*

- It will converge – while there‘s a role for both – superspectral and hyperspectral

Image Credit:
NASA/NOAA/GSFC/
SuomiNPP/VIIRS/
Norman Kuring

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@HumboldtRemSens

patrick.hostert@geo.hu-berlin.de
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- **Landsat Science Team**: https://www.usgs.gov/landsat-missions/2018-2023-landsat-science-team