



Anomaly detection for drought impact monitoring of Swiss forests

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Samantha Biegel, David Brüggemann, Francesco Grossi, Daniele Volpi, Konrad Schindler
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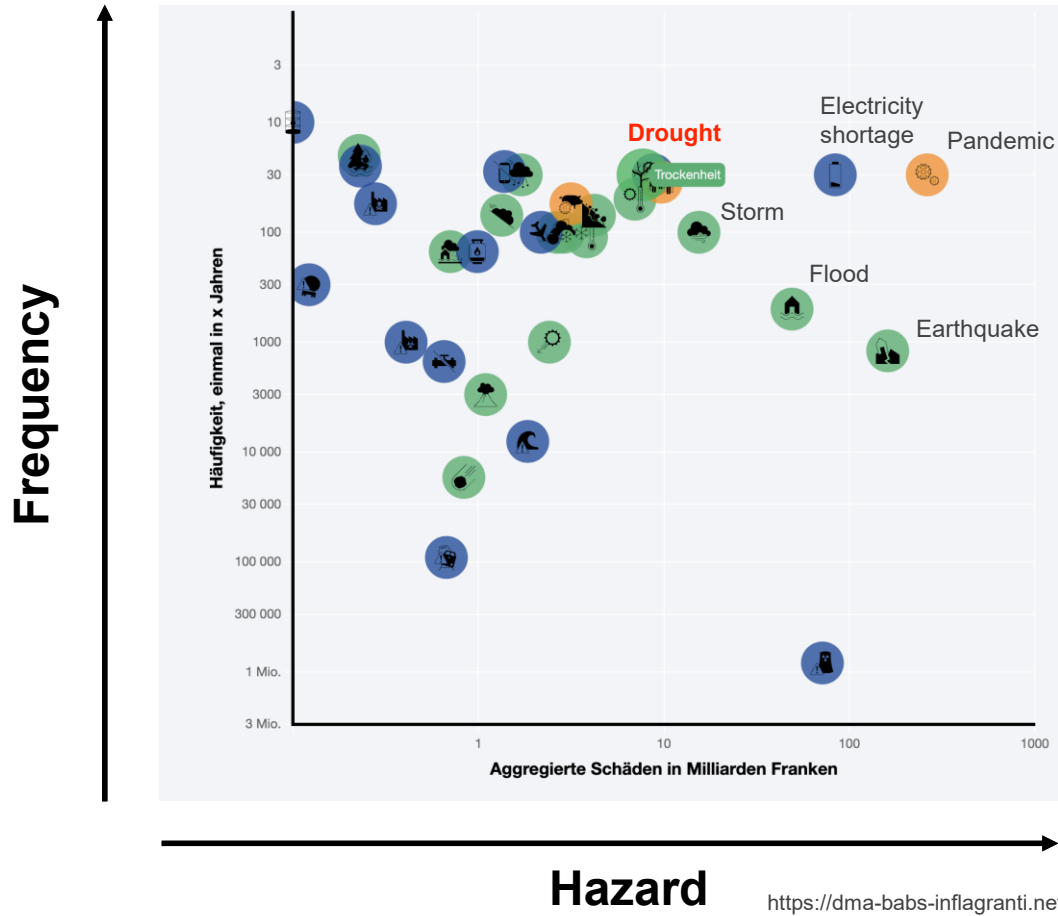
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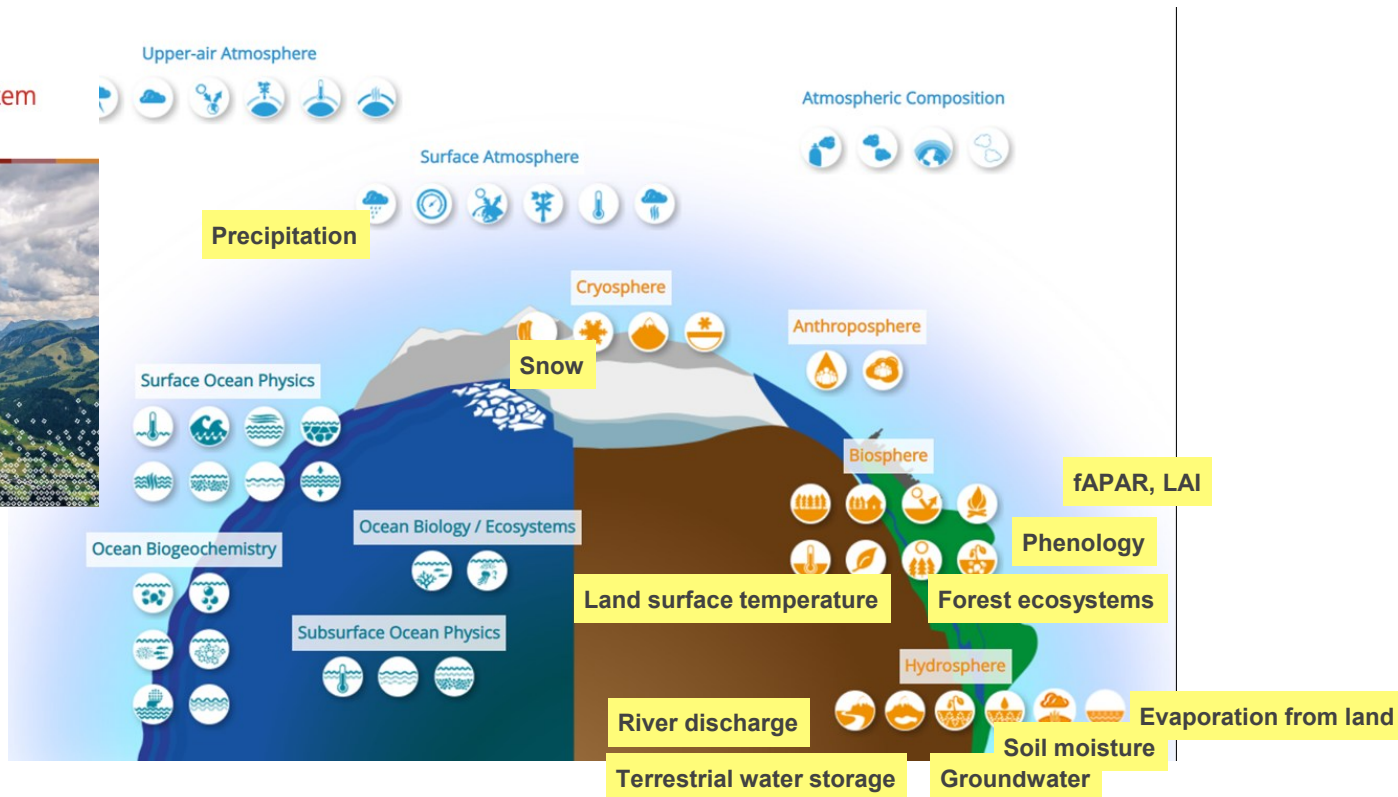
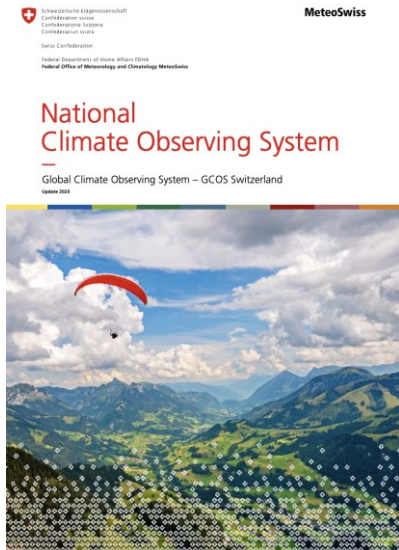


OESCHGER CENTRE
CLIMATE CHANGE RESEARCH

High risk from summer droughts in Switzerland



Essential Climate Variables for drought (impact) monitoring



Drought monitoring and early warning for Switzerland



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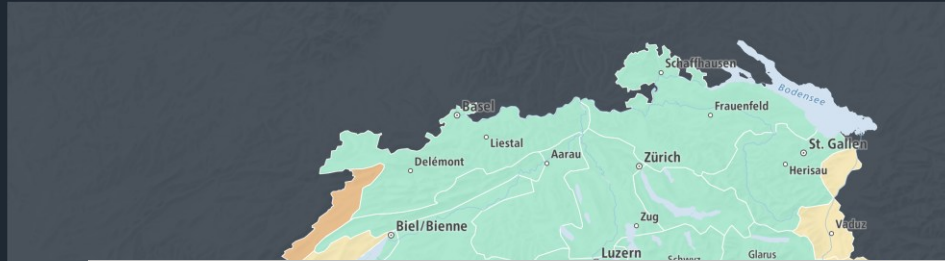
National drought platform

Home Influencing factors About drought Further information About the platform

Drought Situation until 03/22/2026

Select a region for further information.

Not dry Slightly dry Dry Very dry Extremely dry Key



Talk by Fabia Hüsler

Session *Earth System Data for Impactful Applications*

Thursday afternoon

Precipitation

River discharge

Soil moisture

Snow

Groundwater

Vegetation Health Index (NDVI, LST)

Vegetation in the spotlight

- Impacts of droughts through productivity loss in grasslands and croplands.
- Impacts of droughts through tree water stress, growth reduction, and mortality.



Need for spatial-temporal information on drought impacts.

Earth observation modalities for drought impact monitoring



- **Multispectral reflectances** fAPAR, LAI Phenology
- **Thermal** Land surface temperature Evaporation from land
- **Passive microwave** Soil moisture
- **Gravimetric** Terrestrial water storage

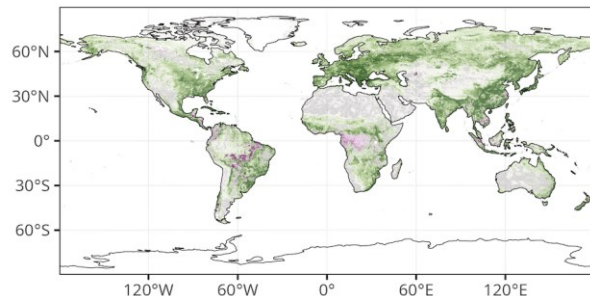
Our research in GECO



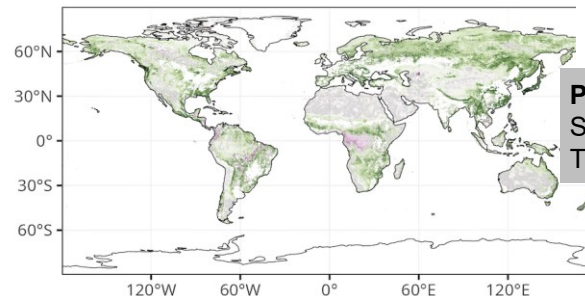
Multispectral reflectances

- Indices, hyperspectral imaging
- Non-parametric regression
- Mechanistic modelling

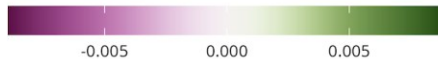
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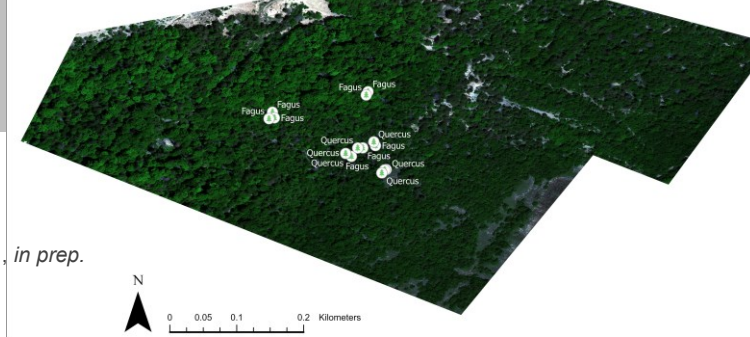
Masked



LAI Slope ($\text{m}^2 \text{m}^{-2} \text{yr}^{-1}$)



El-Meijaouy et al. *in prep.*



Detecting soil moisture drought impacts on ecosystem physiology from earth observation data



Yousra El-Meijaouy^{1,2}, Benjamin D. Stocker^{1,2} et al.

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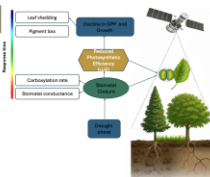


Background

• Key physiological traits (e.g., V_{max} , stomatal conductance) respond more rapidly to environmental stress, but are mostly measured at site level and poorly captured at large scales.

• Remote sensing indicators (SIF, PRI, microwave) provide direct insights into vegetation physiological responses, yet are limited by coarse resolution, coverage, and reliance on narrow-band sensors.

☑ Develop an Earth observation approach integrating spectral, thermal, and meteorological data to detect early drought stress before changes in canopy greenness appear.



Poster by Yousra El-Meijaouy
 Session *Earth System Data for Impactful Applications*
 Thursday noon

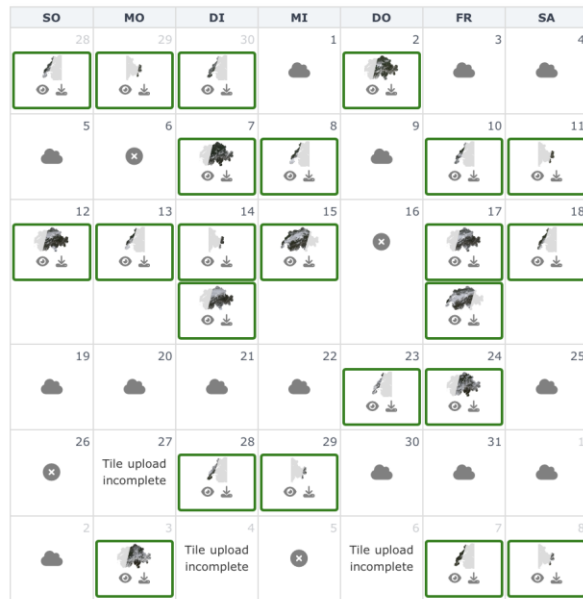
Kurth et al., *in prep.*

Drought impact monitoring with multispectral reflectance data

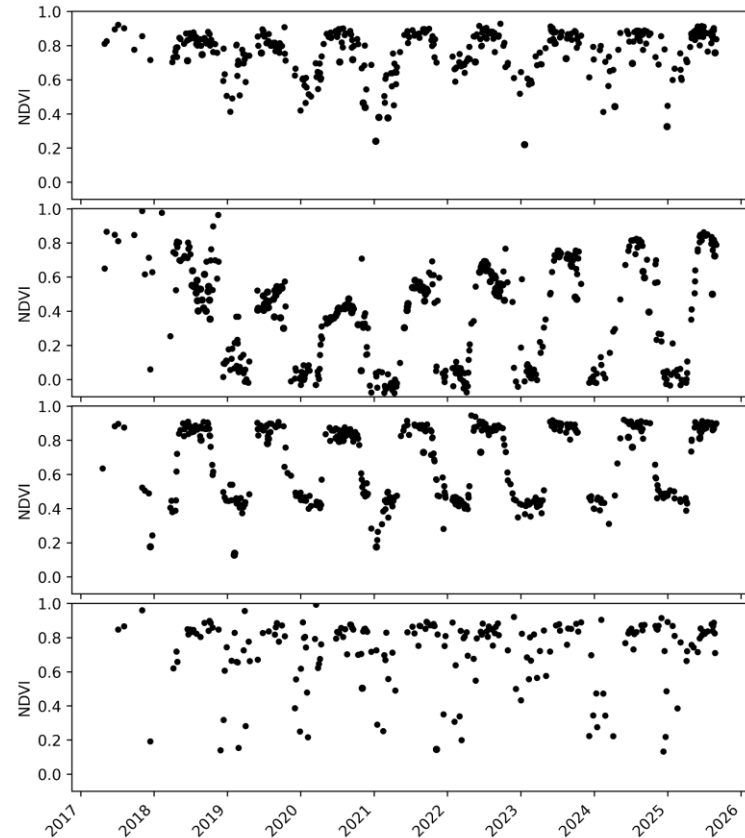
- Using NDVI
- Sentinel-2, Swisstopo S2-SR
- Focus on forests

Oktober 2025

Heute < >



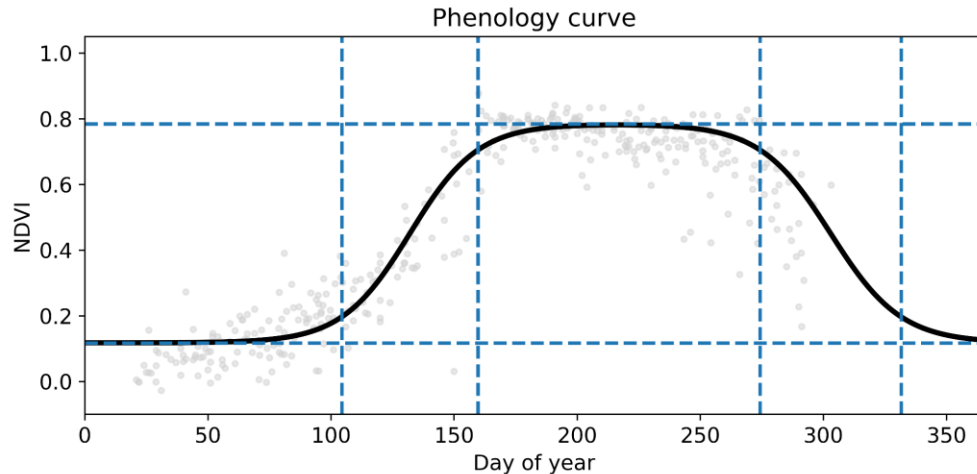
<https://www.swisstopo.admin.ch/en/satelliteimage-swisseo-s2-sr>



Forest greenness anomaly

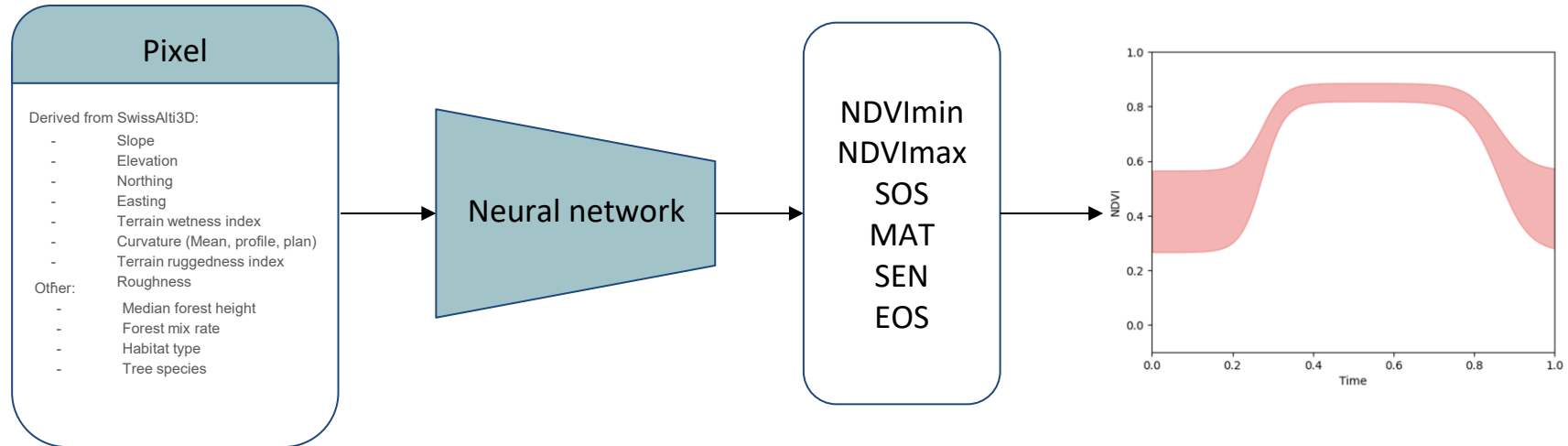
Our definition: A deviation from an expected, normal level of greenness (NDVI) given the day of the year and a set of static features for a given location

Approach: Single learned model predicting expected **mean seasonal cycle** given the static feature values at each pixel. Agnostic to periods or drivers of forest NDVI anomalies.



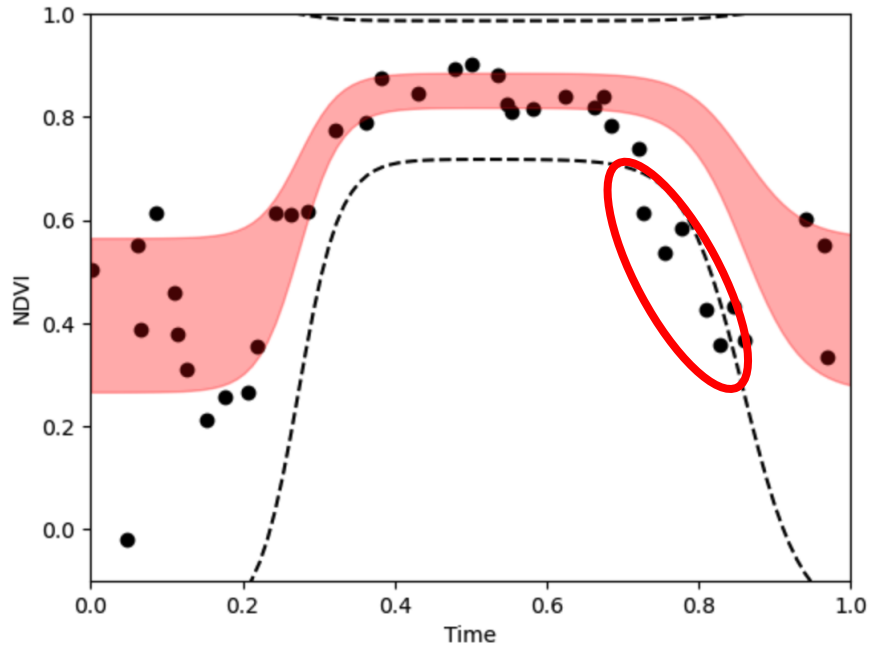
Estimating the expected mean seasonal cycle

Method: Quantile regression using pinball loss.

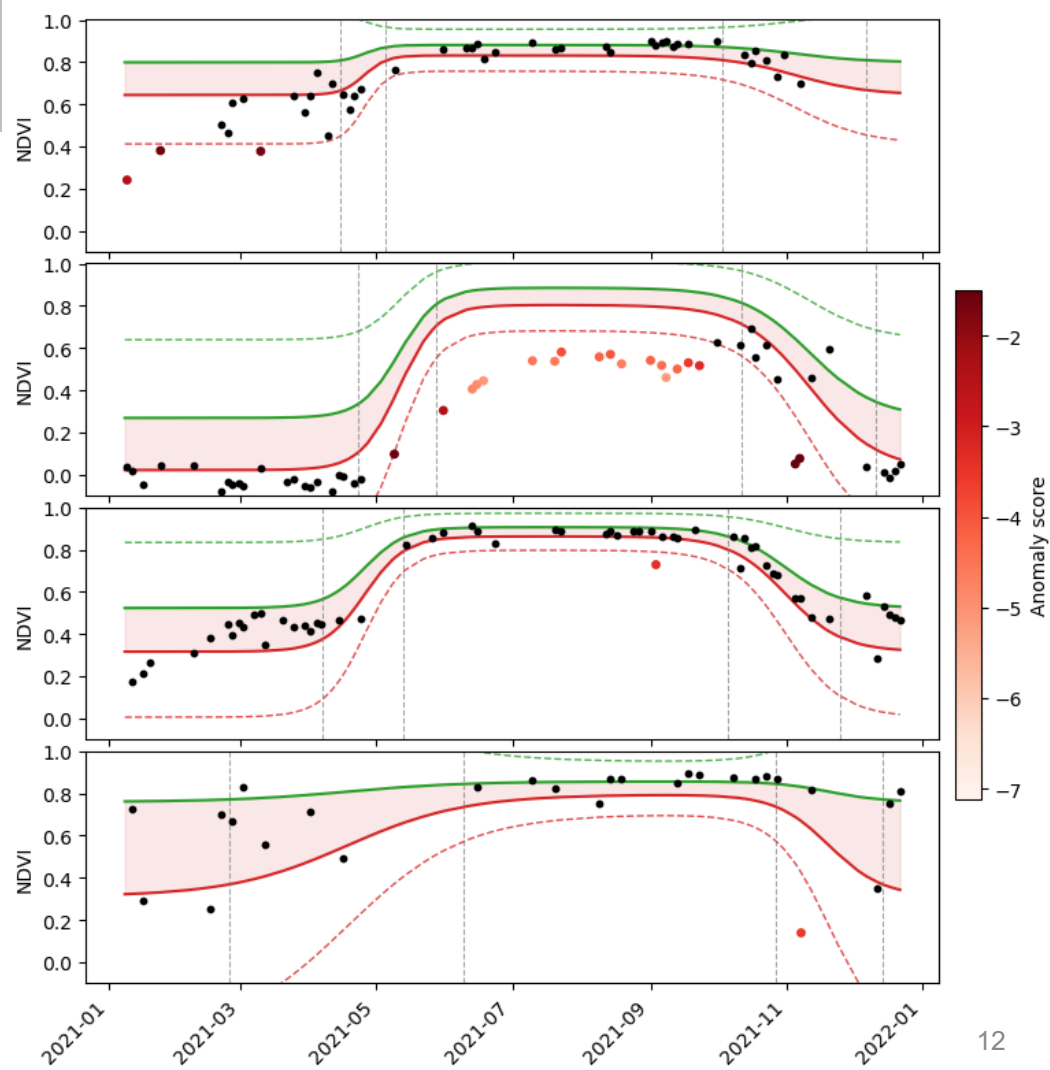


Anomaly score

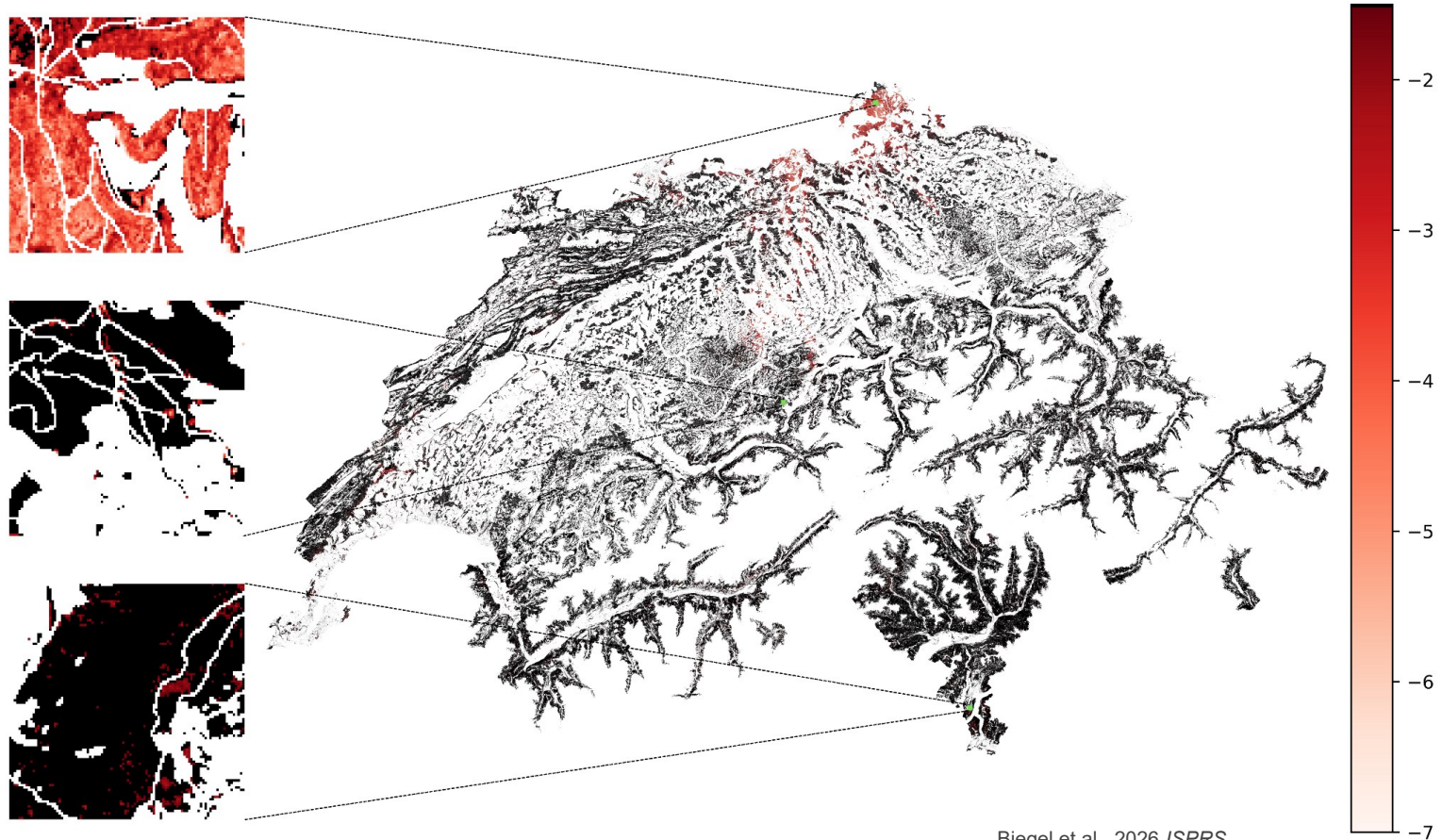
Definition: $A(t) = (\text{NDVI}(t) - Q_{25(75)}(\text{DOY})) / \text{IQR}(\text{DOY})$



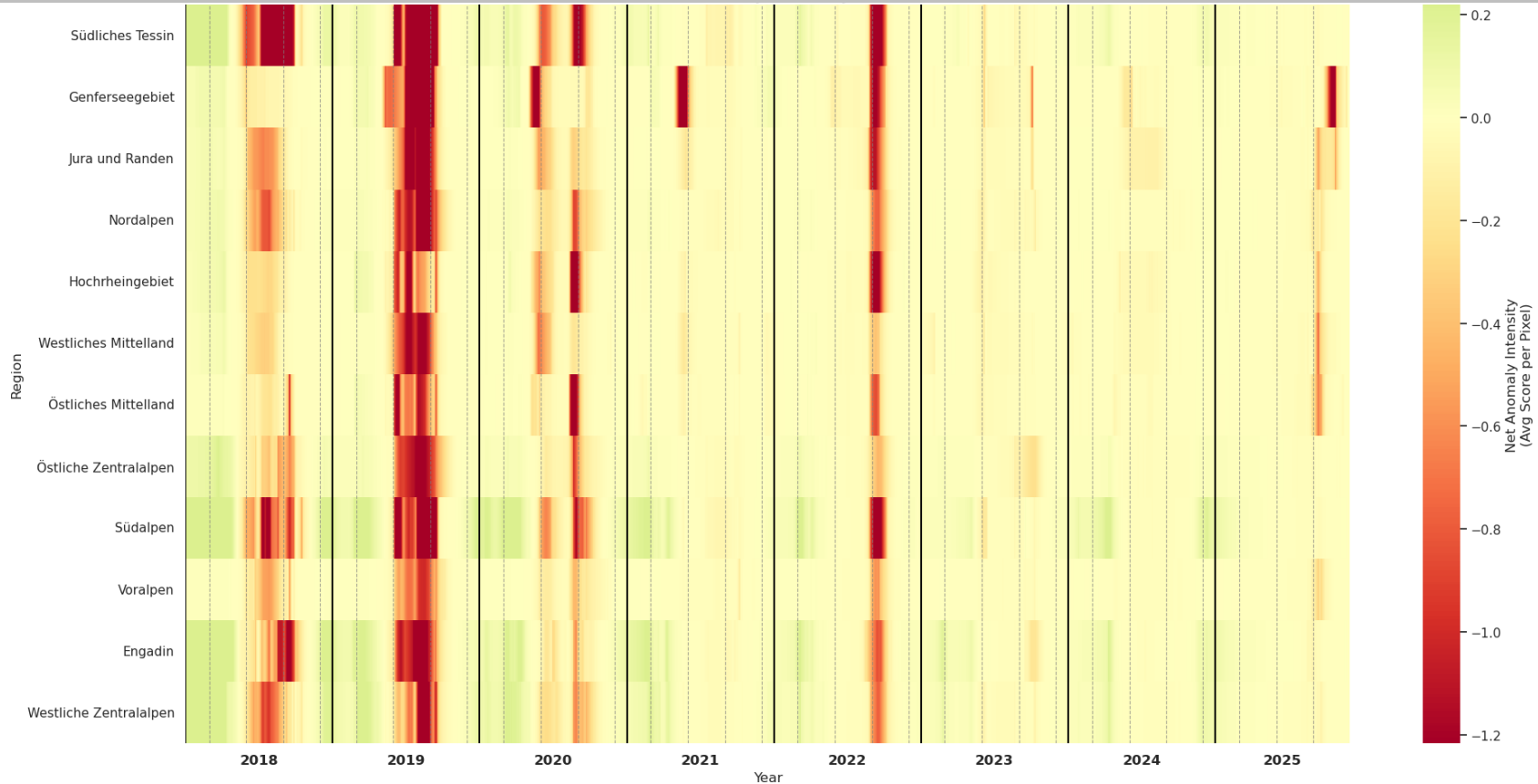
Anomaly examples



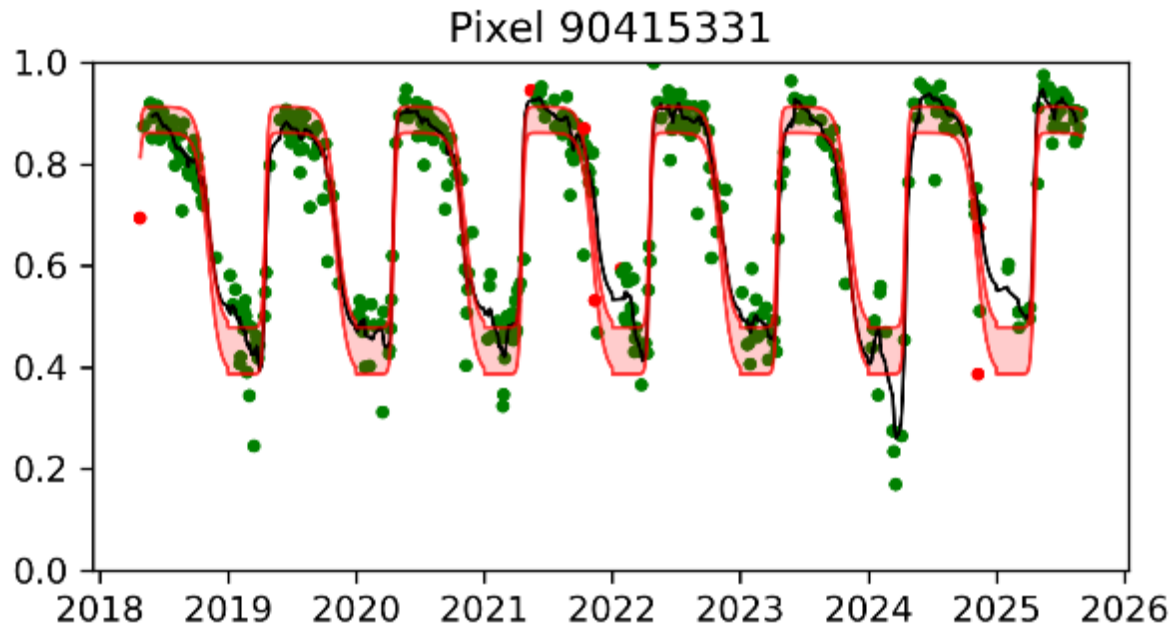
Anomaly map for 22/24 Aug. 2023 (example)



Regionally aggregated anomaly intensity over time



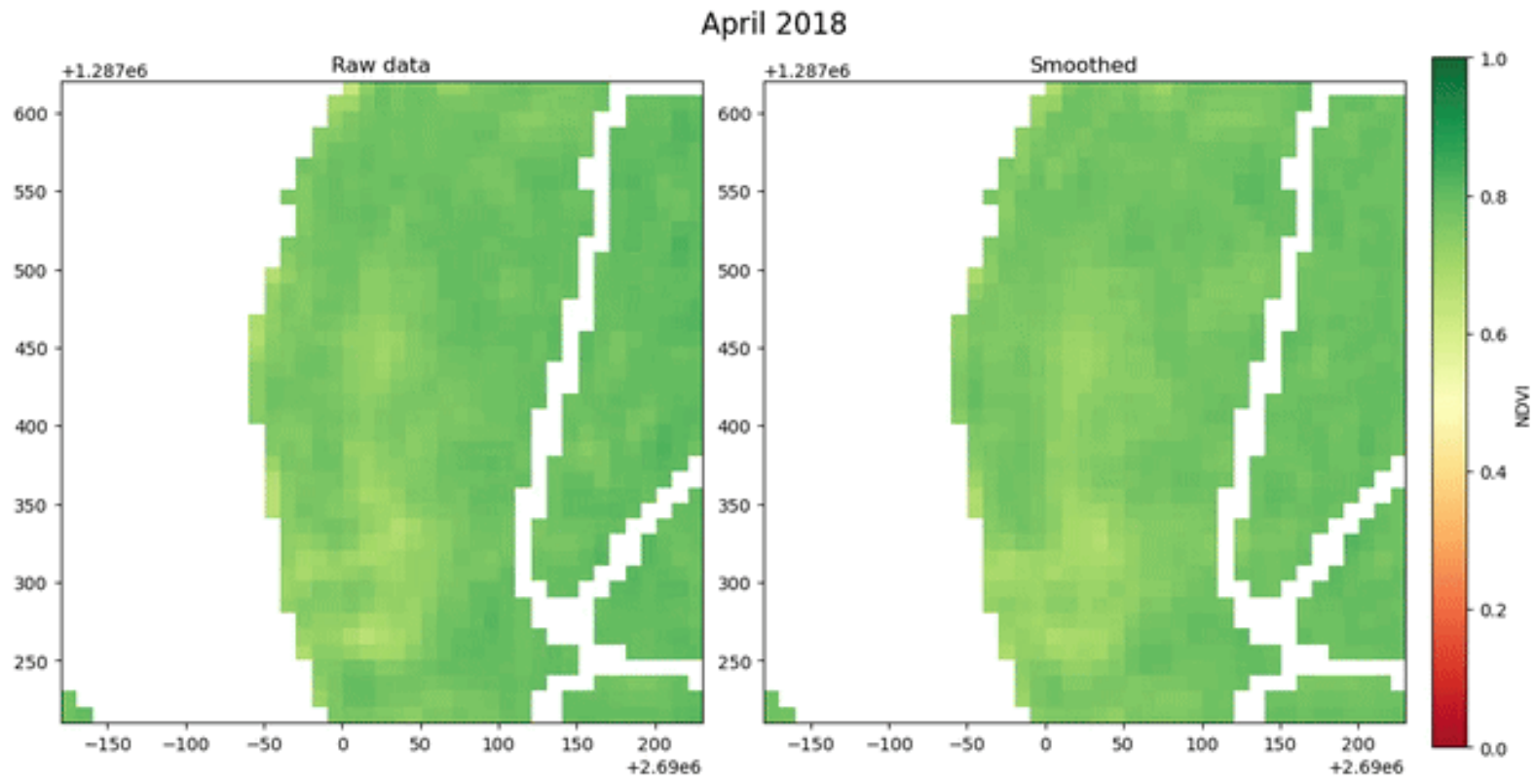
Cleaning and gap-filling



- Good observation
- Bad observation
- Smoothed and gap-filled

Anomaly map animation, Mar. 2018 - Dec. 2019

(Drought impact example)



Concluding thoughts

- **Greenness (NDVI, LAI, fAPAR, ...) is closely related to vegetation productivity, relevant for measuring climate impacts, and observable from space.**
- **Current monitoring measures drought based on multiple variables from different cycles/spheres.**
- **Still far from a physically consistent state estimation for climate impact monitoring on multiple (connected) variables.**
- **Basis for communicating drought monitoring is built.**
- **Now needs partnerships for specific objectives to provide spatial and stakeholder-relevant information, e.g., for:**
 - Climate impact monitoring for grassland and croplands.
 - Land surface state estimation and near-term forecasting at high resolution (mountains!)
 - Multi-modal EO data for “spatialising” based on local measurements (e.g., evapotranspiration, photosynthesis)

Acknowledgments



Samantha Biegel

PhD Student, co-hosted ETH AI-Center

Country-wide, high-resolution monitoring of forest browning with Sentinel-2

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