

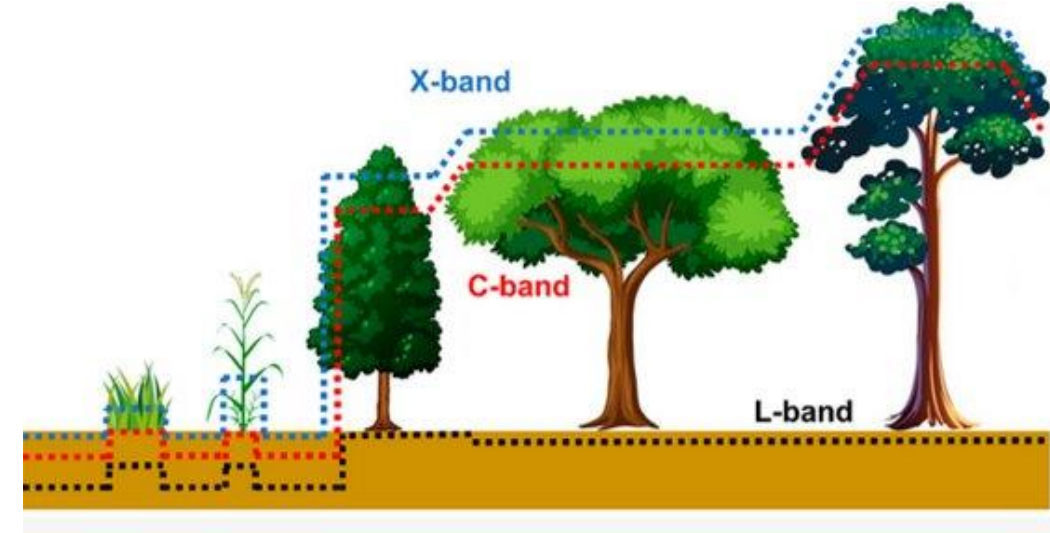
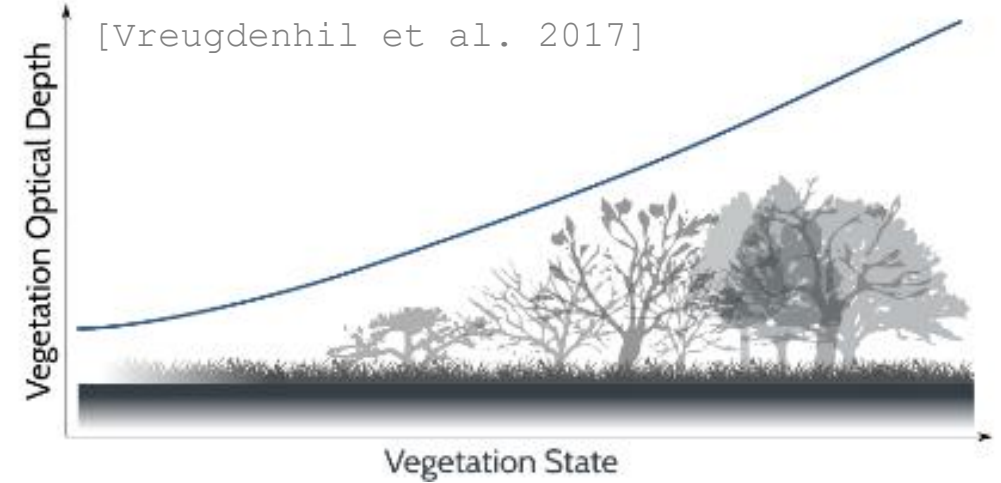
Quantifying Long-term Vegetation Dynamics and Trends From Multi-Source Passive Microwave Observations

Wouter Dorigo¹ Ruxandra Zotta¹, Leander Moesinger¹, Benjamin Wild¹, Irene Teubner², Matthias Forkel³

¹TU Wien, Austria; ²ZAMG, Austria; ³TU Dresden, Germany

Microwave remote sensing for vegetation dynamics

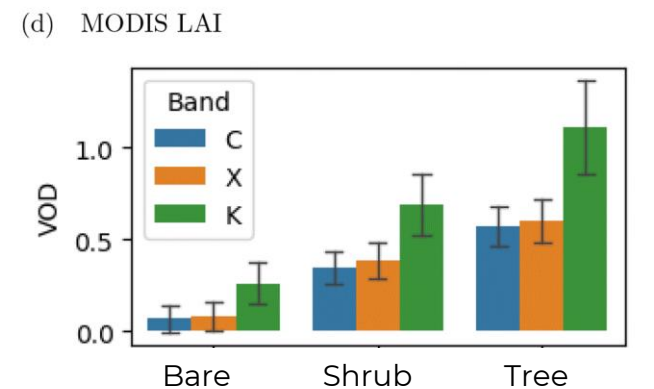
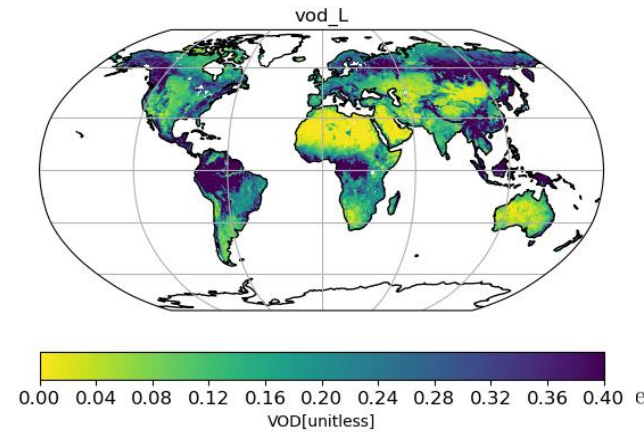
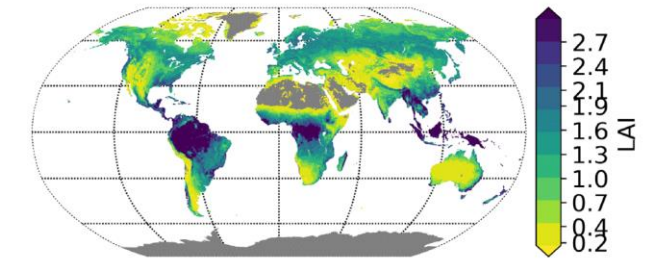
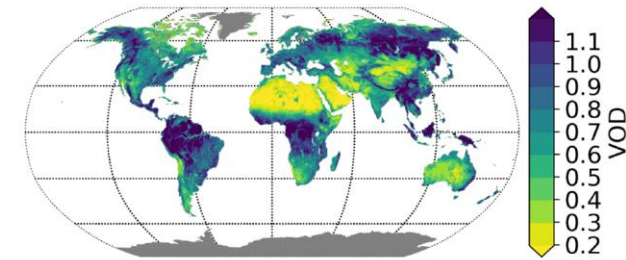
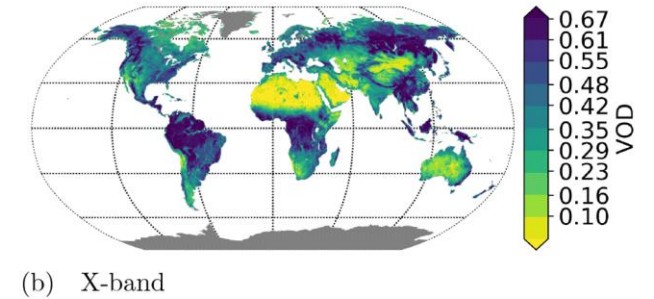
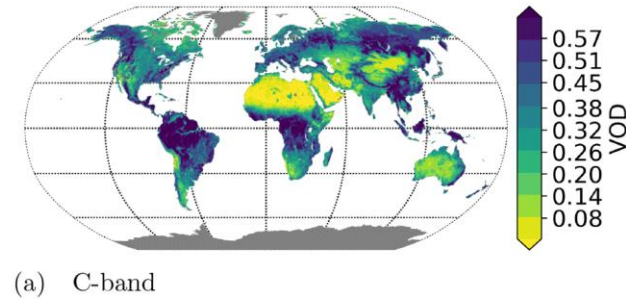
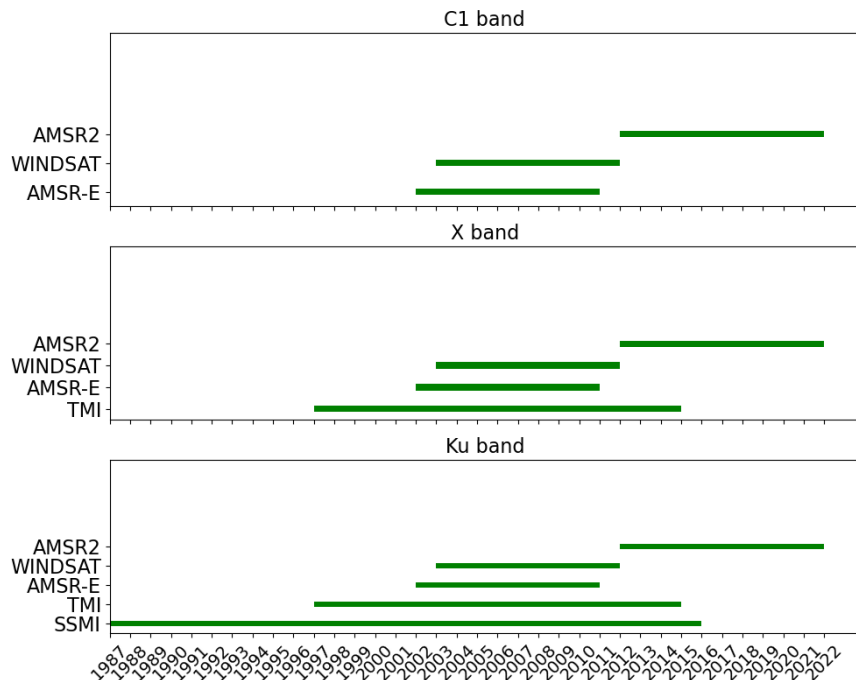
- Vegetation Optical Depth (VOD) quantifies the attenuation of (microwave) radiation by vegetation.
 - › Related to vegetation water content and biomass
 - › Depending on wavelength
- Retrieval algorithms seek to separate vegetation signal from soil signal, e.g.,
 - › **TU Wien method** for radar observations
 - › **Land Parameter Retrieval Model** (VU/NASA/VanderSat/Planet) for radiometer data



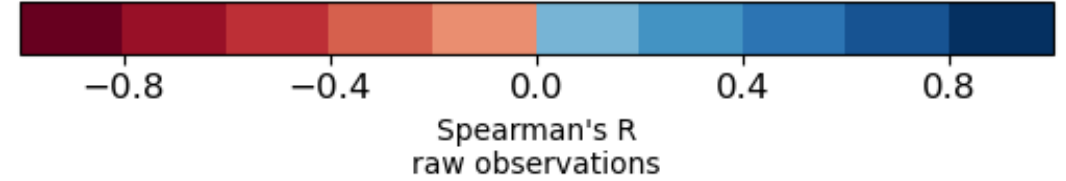
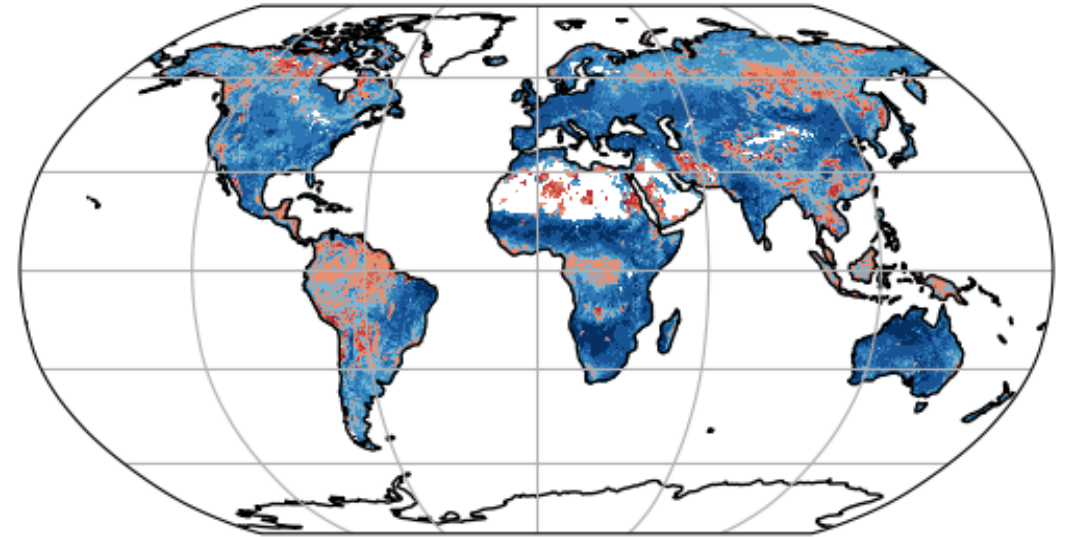
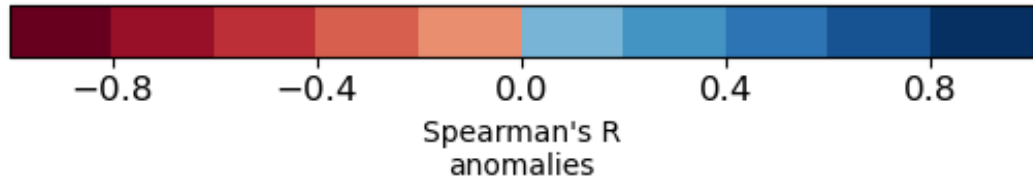
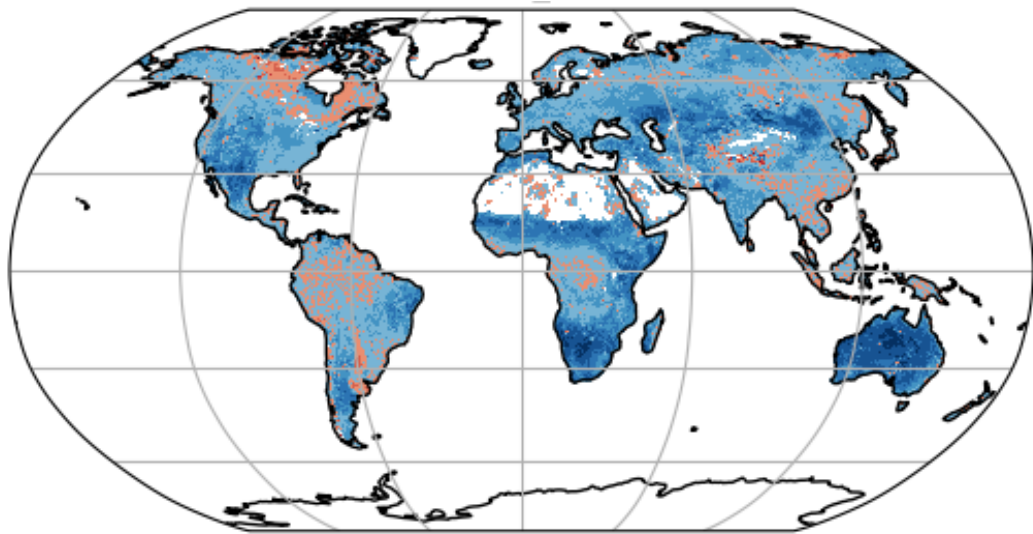
[Frappart et al. 2020]

Long-term, harmonized VOD, derived from multiple single-sensor LPRM level 2 datasets from radiometers

- Separate VODCA products for C-, X-, Ku-band
- 0.25° spatial sampling
- Daily, 1987 - 2021
- <https://doi.org/10.5281/zenodo.2575599>

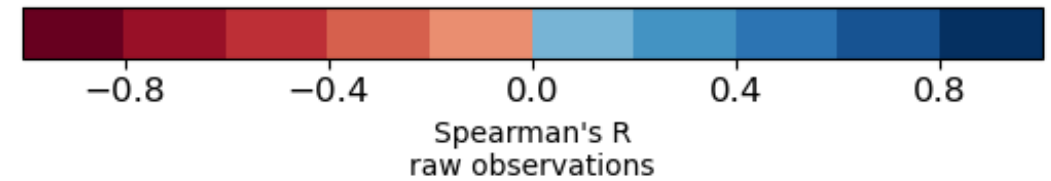
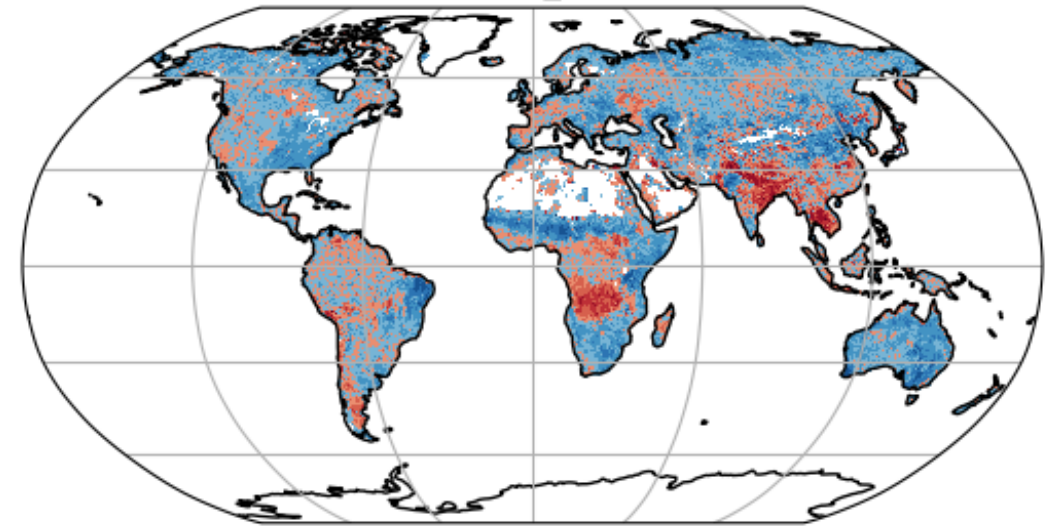
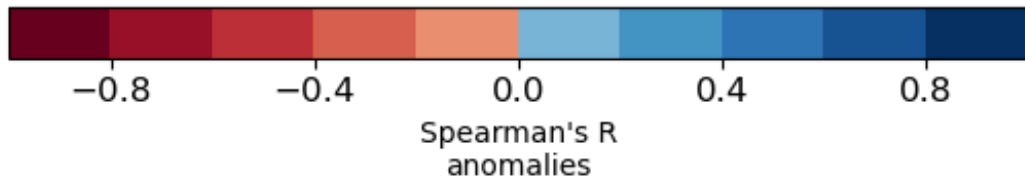
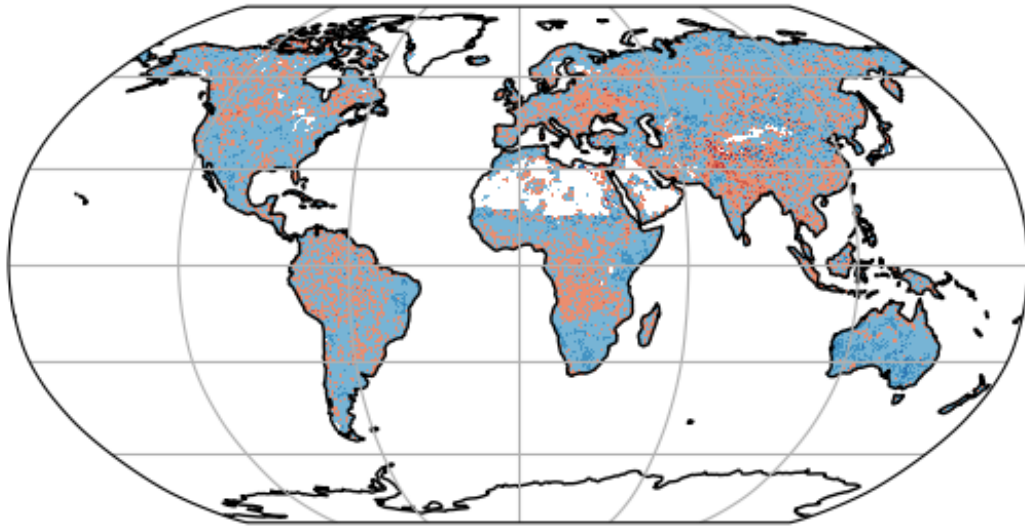


[Moesinger et al. 2020; 10.5194/essd-12-177-202]



(2002-2017)

[Moesinger et al. 2020; 10.5194/essd-12-177-202]

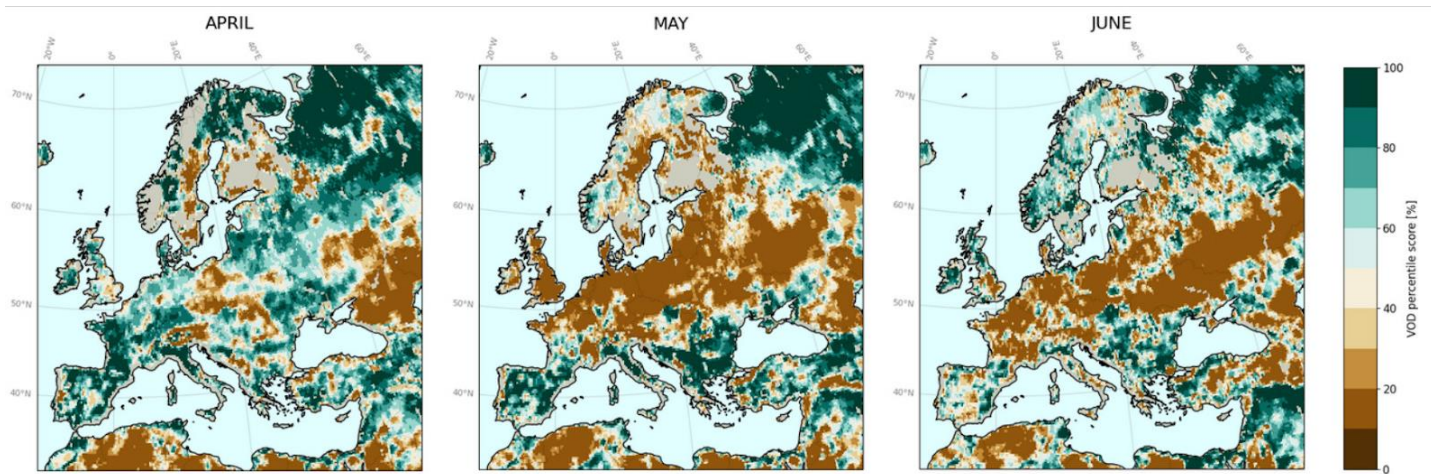


(2010-2019)

[Moesinger et al. 2020; 10.5194/essd-12-177-2021]

C3S European State of the Climate 2021

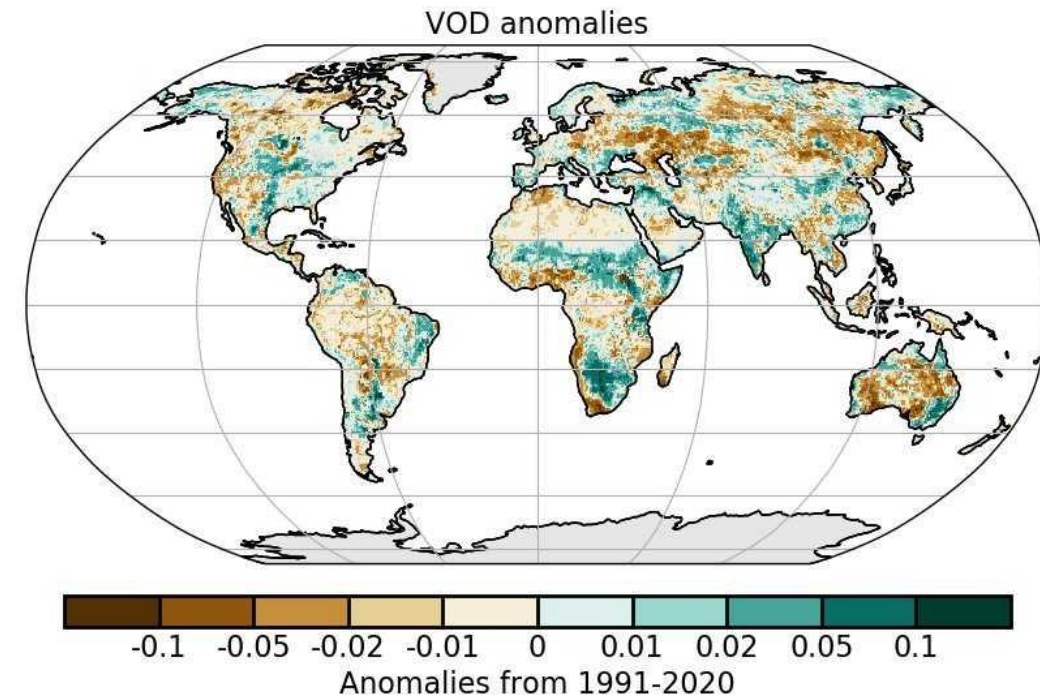
- Impact of late spring frost on vegetation



Data Source: VOD Climate Archive (VODCA) Credit: TU Wien/ VanderSat B. V. Reference period: 1991-2020

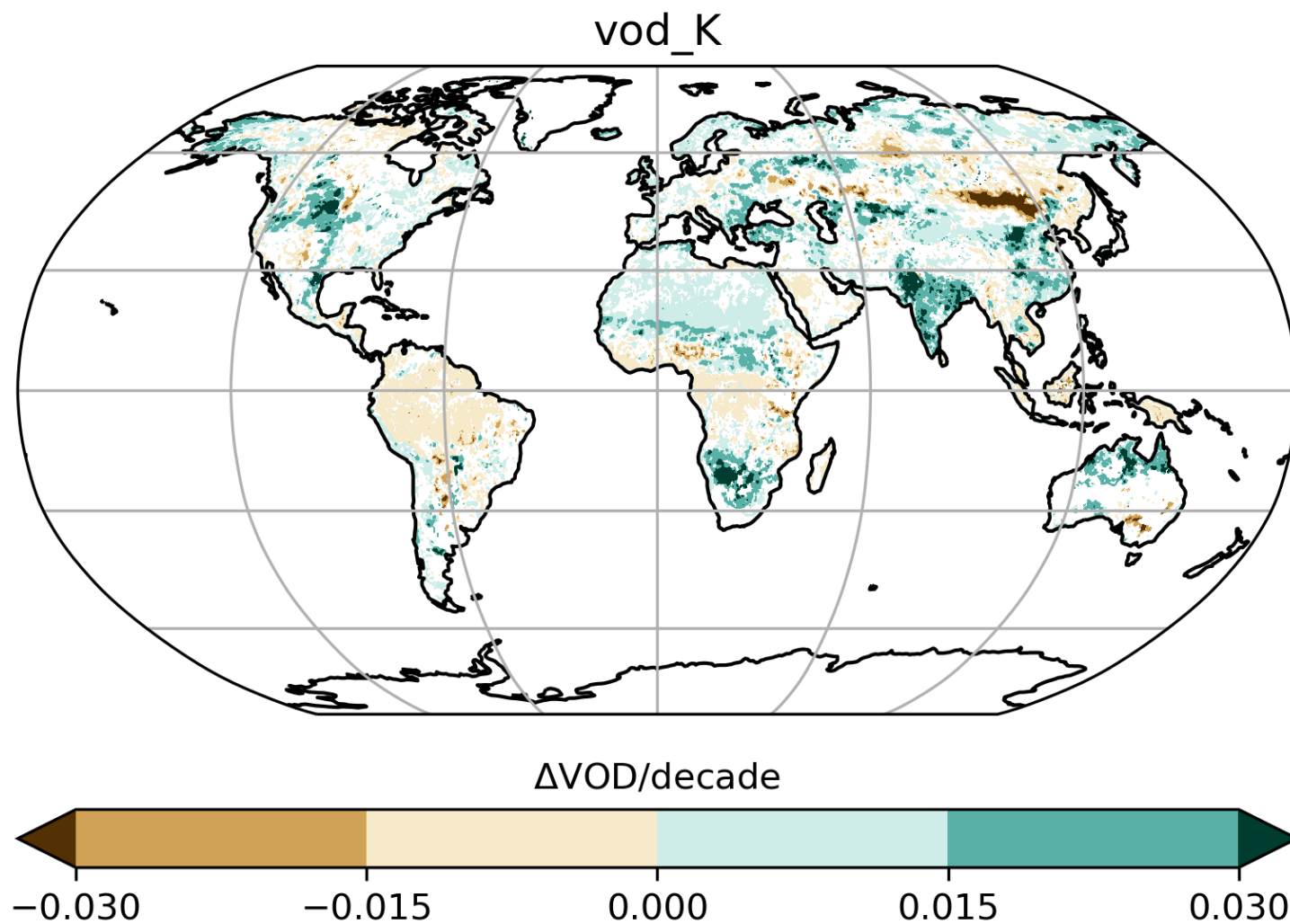


NOAA/BAMS State of the Climate 2021



Monthly ranking of VOD for April, May and June 2021, relative to 1991-2020, expressed in percentiles

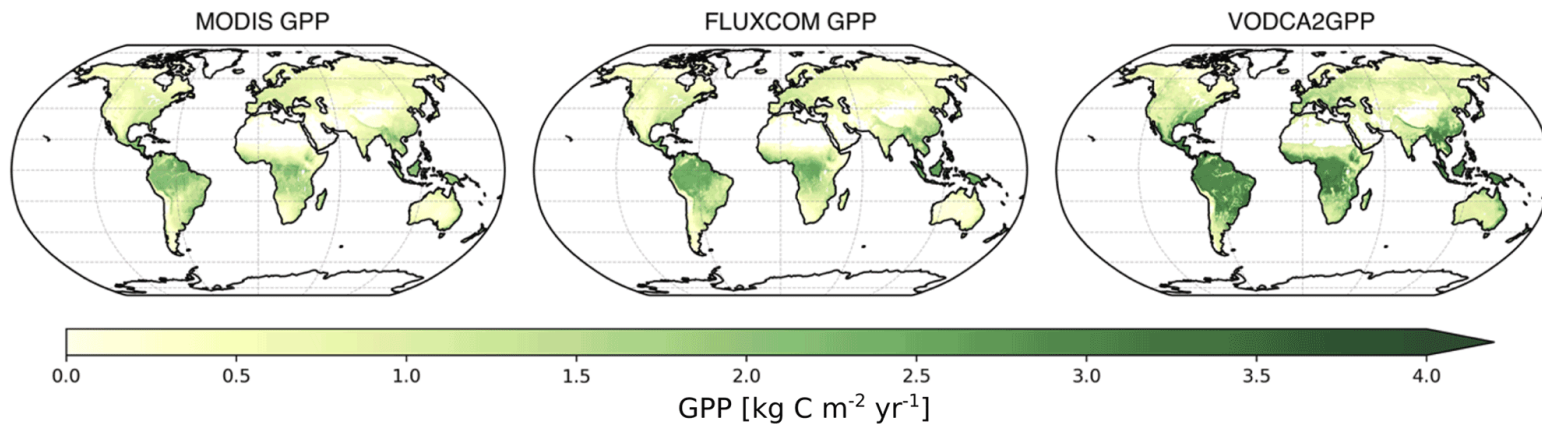
[Dorigo et al., 2021;
10.1175/2022BAMSStateoftheClimate.1]



[Moesinger et al., 2020; 10.5194/essd-12-177-202]

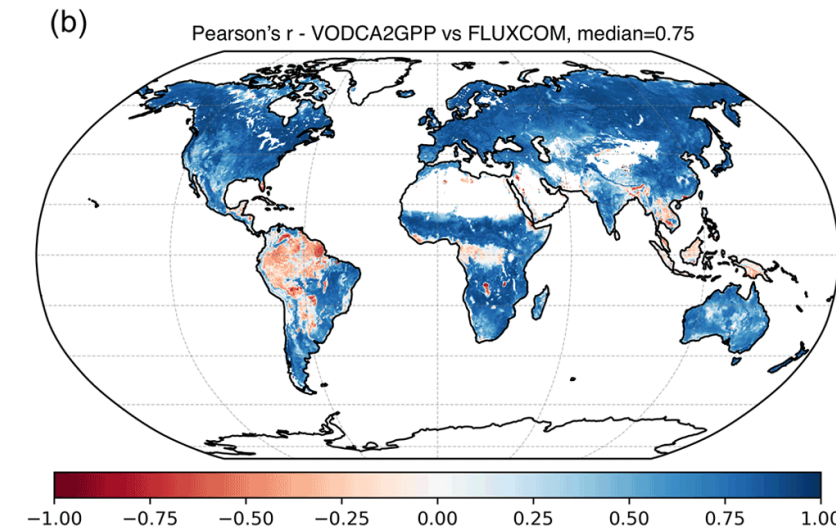
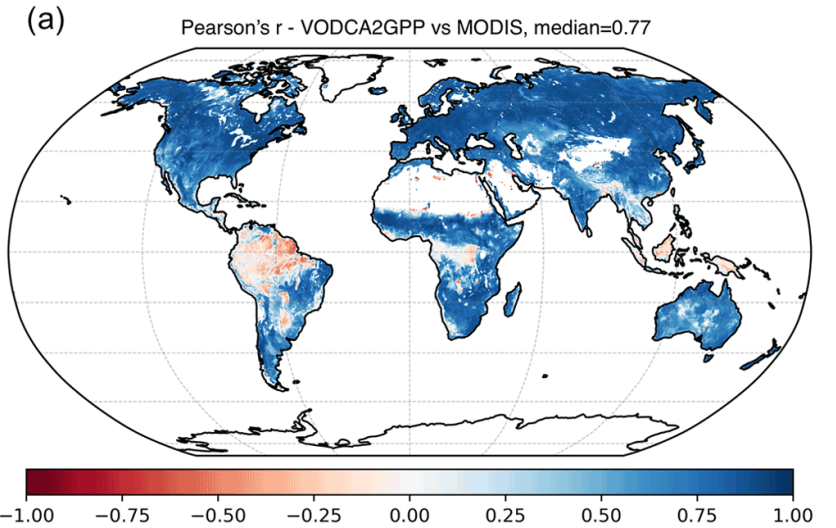
Long-term (1988-2020) GPP estimated from VODCA:

- **Generalised Additive Model**
 - Maintenance respiration
 - Growth respiration
 - Differences in vegetation type
 - Temperature dependency
- C-, X- and Ku-band from VODCA
- In situ observations from FLUXNET2015
- Air temperature from ERA5-Land

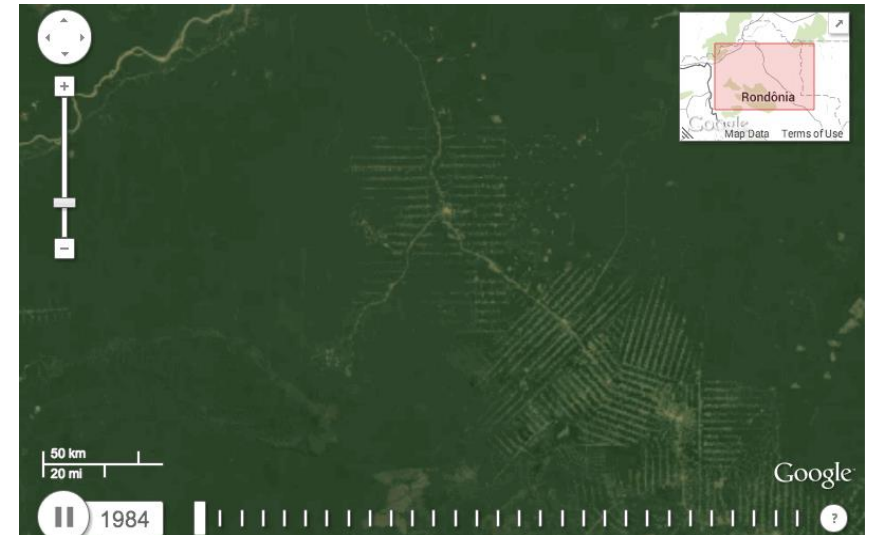
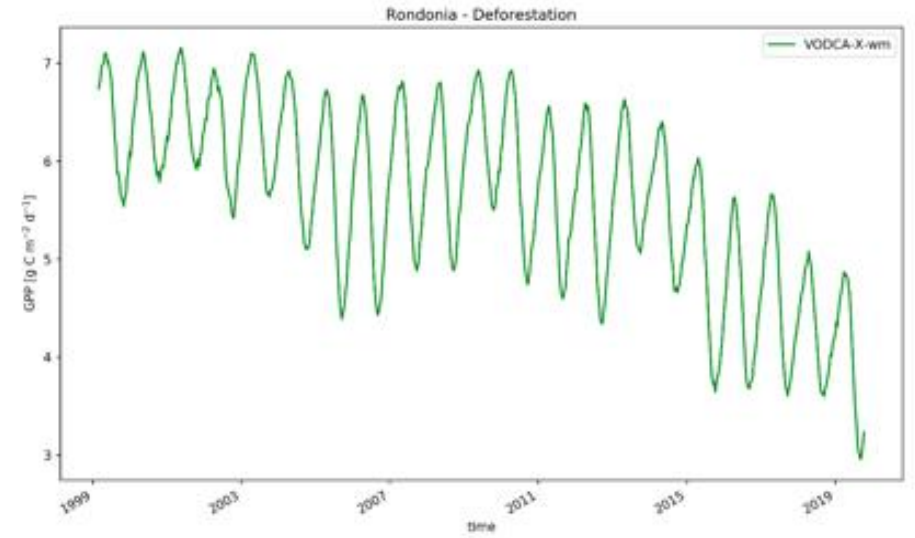
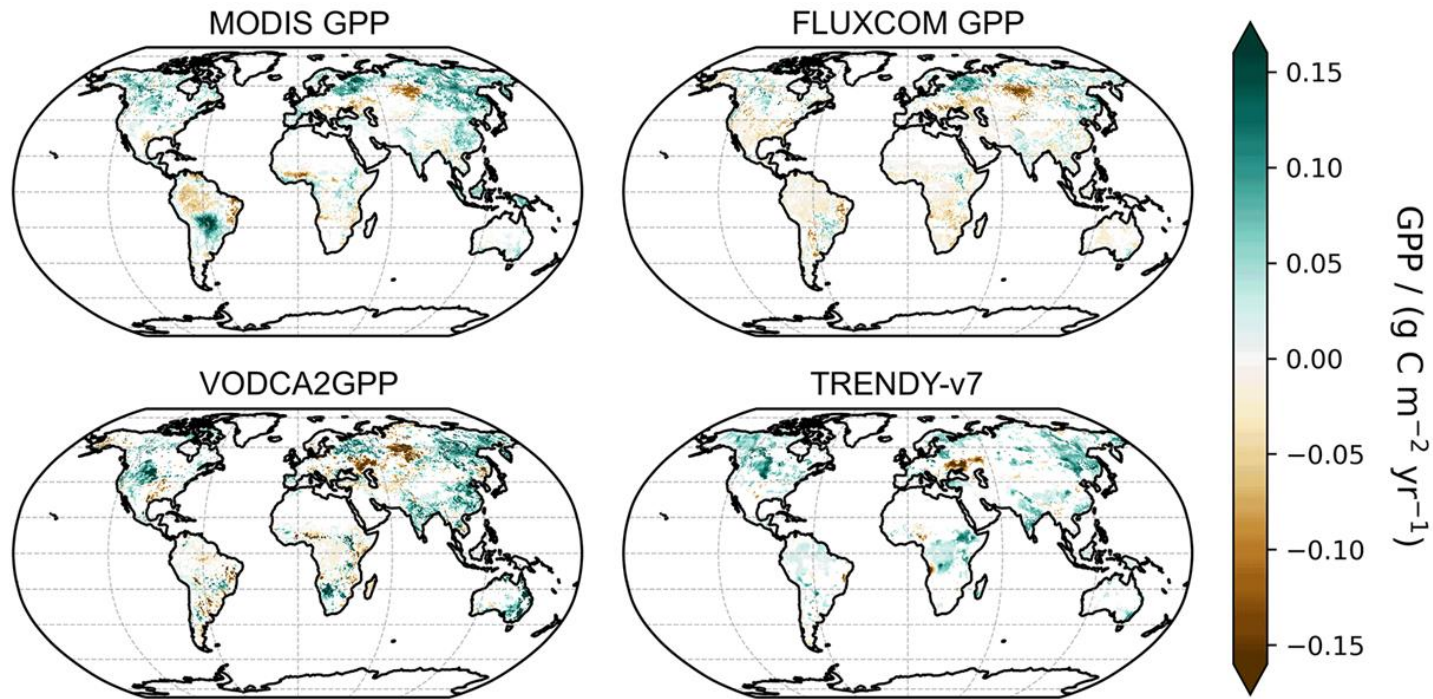


Mean yearly GPP from MODIS, FLUXCOM and VODCA2GPP for 2002-2016

[Wild et al. 2022; 10.5194/essd-14-1063-2022]



Correlation (2002-2016) between VODCA2GPP and (a) MODIS and (b) FLUXCOM

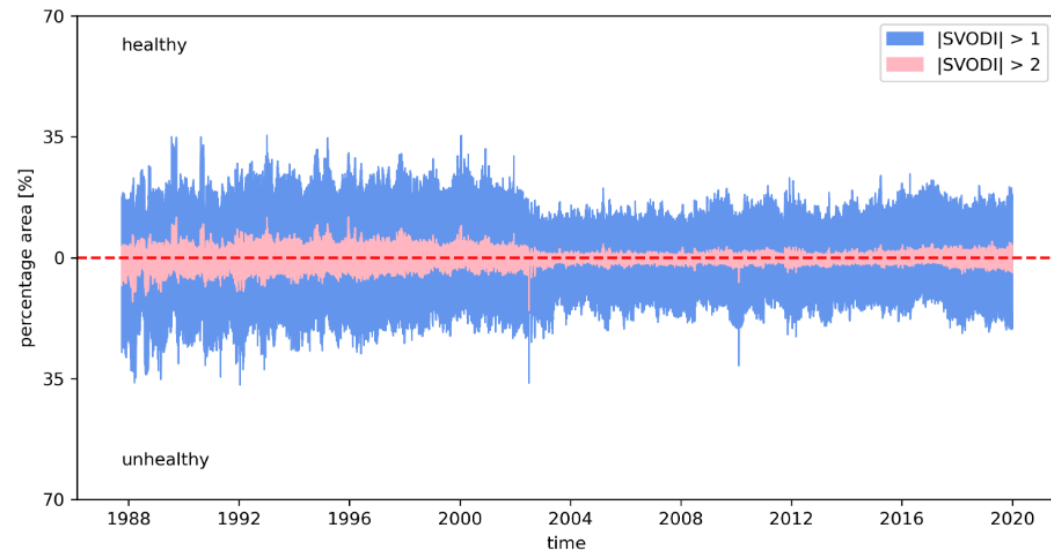
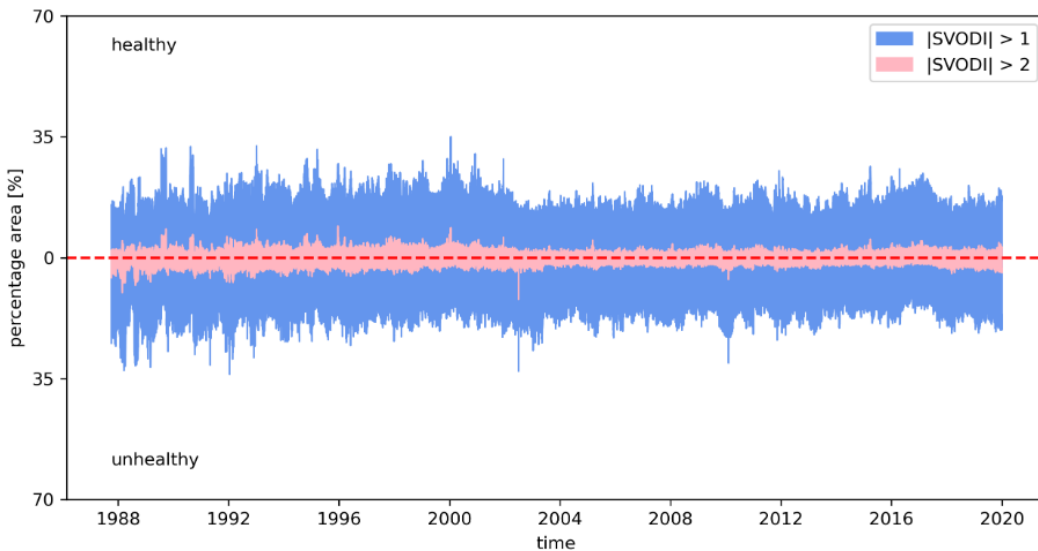


Trends in yearly median GPP for the period 2003-2015

[Wild et al. 2022; doi: 10.5194/essd-14-1063-2022]

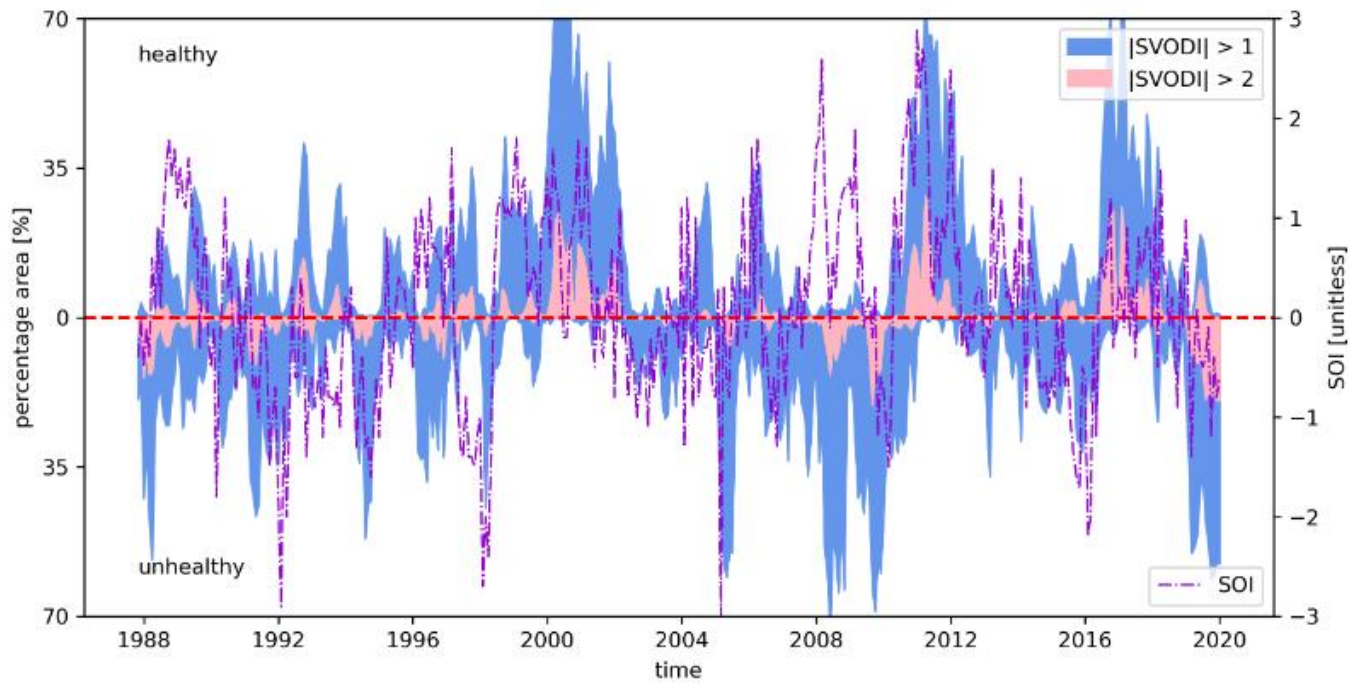
SVODI is a long-term (1987 - present), daily, global vegetation condition monitoring dataset combining on C-, X- and Ku-band VOD from multiple sensors

- Improves spatio-temporal sampling
- Uses a probabilistic merging method to deal with the heteroscedasticity of data.



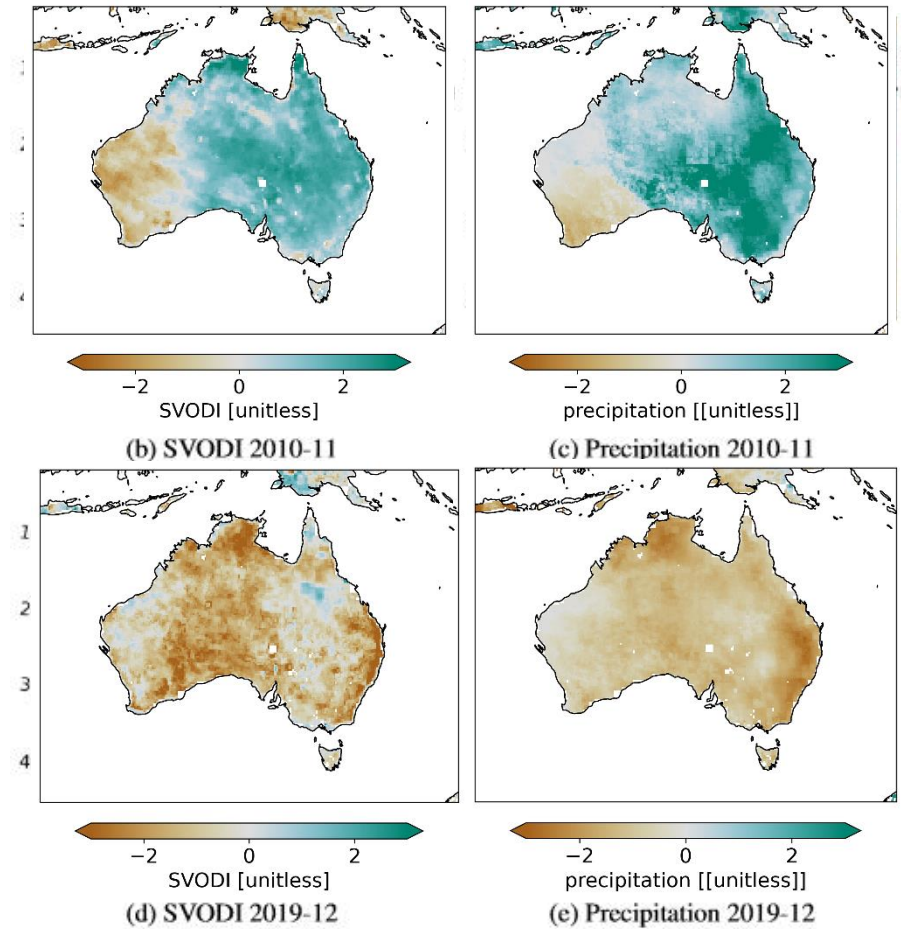
Example of abnormal and extreme counts for probabilistic (left) and non-probabilistic (right) merging

[Moesinger et al., 2022; 10.5194/bg-2021-360]

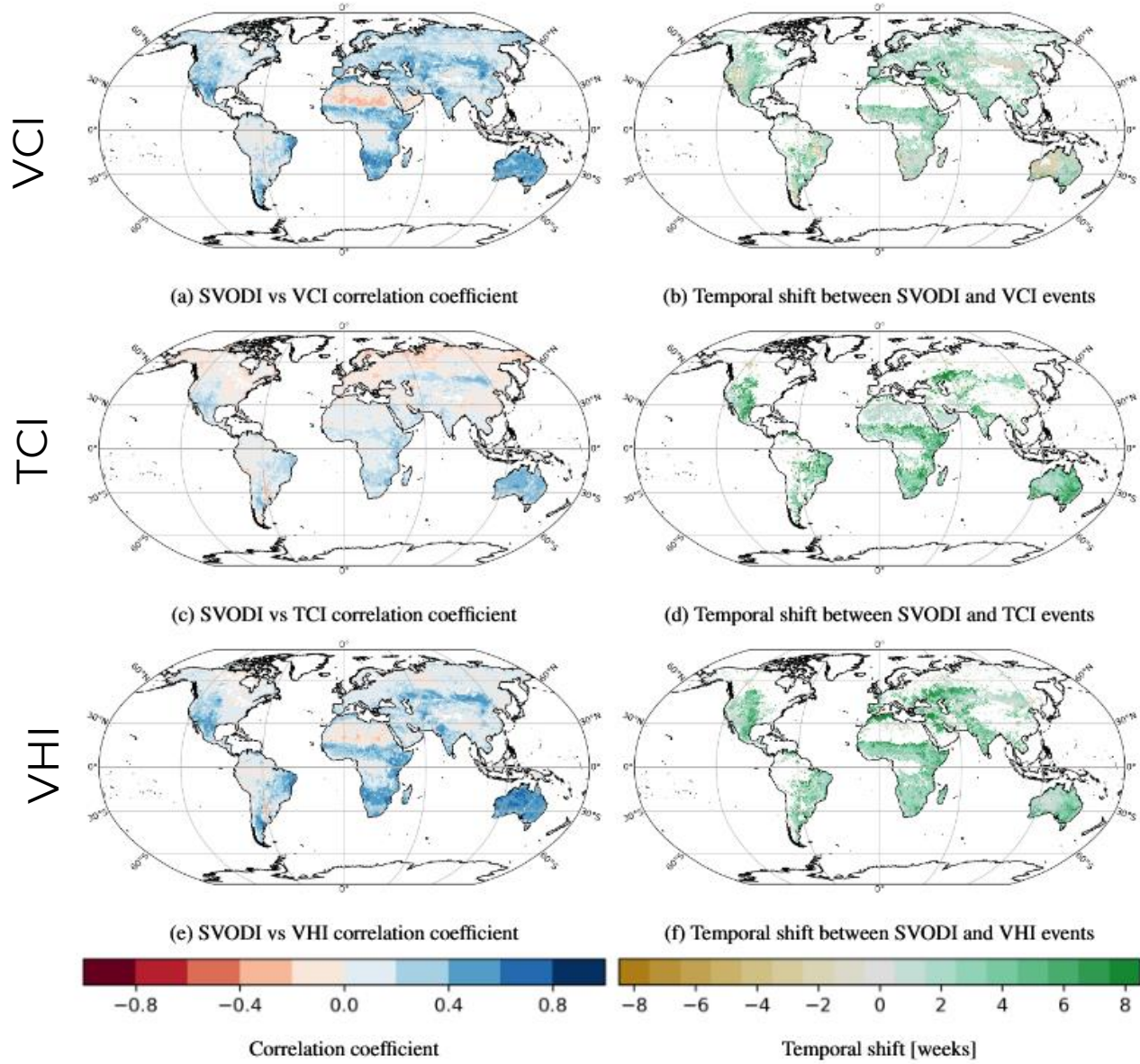


Fraction of percentage area of $|SVODI| > 1 > 2$ for central Australia in conjunction with Southern Oscillation Index

[Moesinger et al., 2022; 10.5194/bg-2021-360]



SVODI and standardized precipitation anomalies for 2010-11 and 2019-12



Correlation and temporal shift (in weeks) between SVODI and **vegetation indices**:

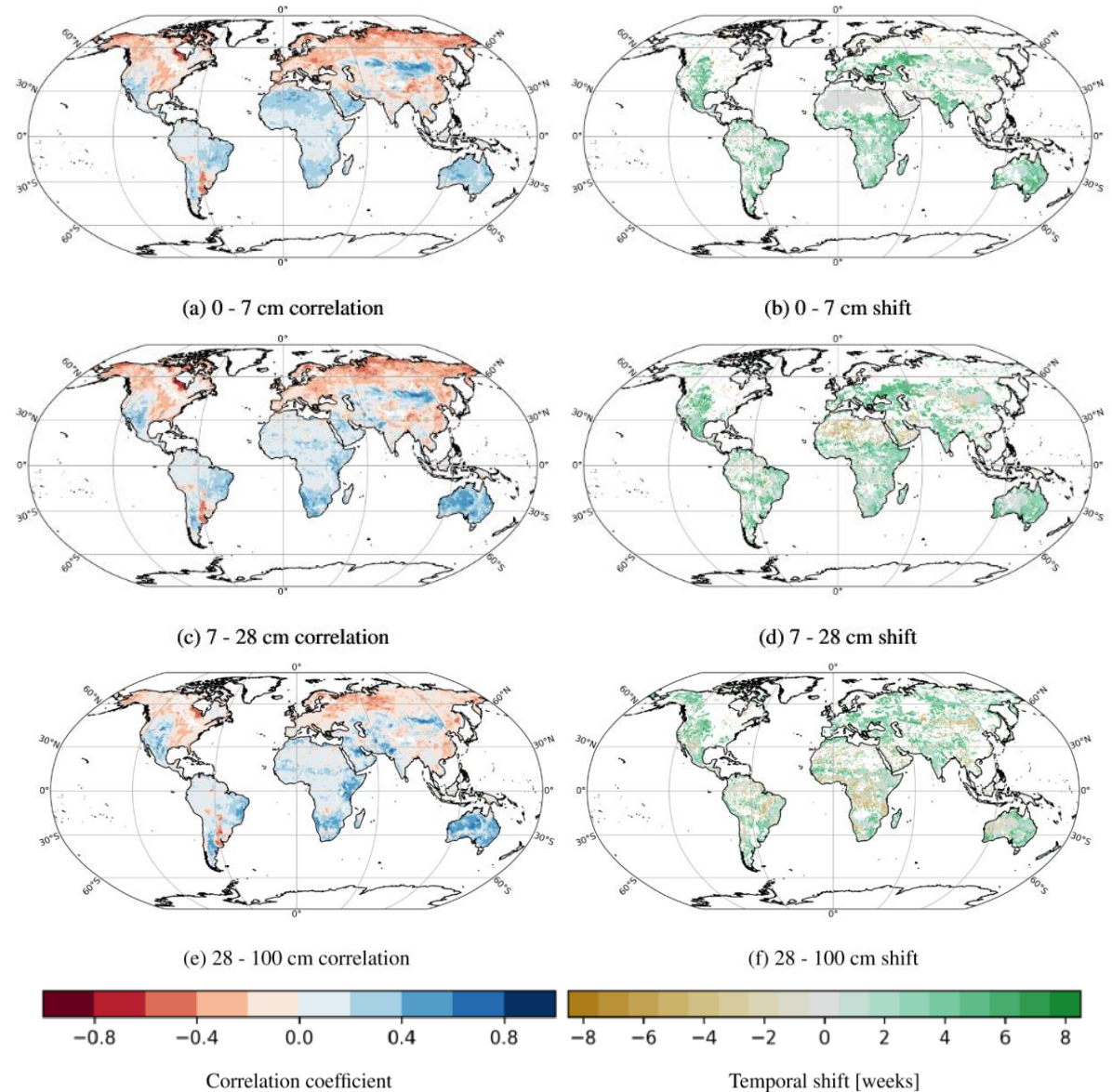
- Vegetation Condition Index (optical)
- Temperature Condition Index (thermal)
- Vegetation Health Index (optical + thermal)

[Moesinger et al., 2022; 10.5194/bg-2021-360]

Correlation and temporal shift (in weeks) between SVODI and **ERA5 Soil Moisture**:

- 0-7 cm
- 7-28 cm
- 28-100 cm

[Moesinger et al., 2022; 10.5194/bg-2021-360]



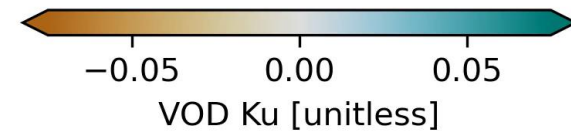
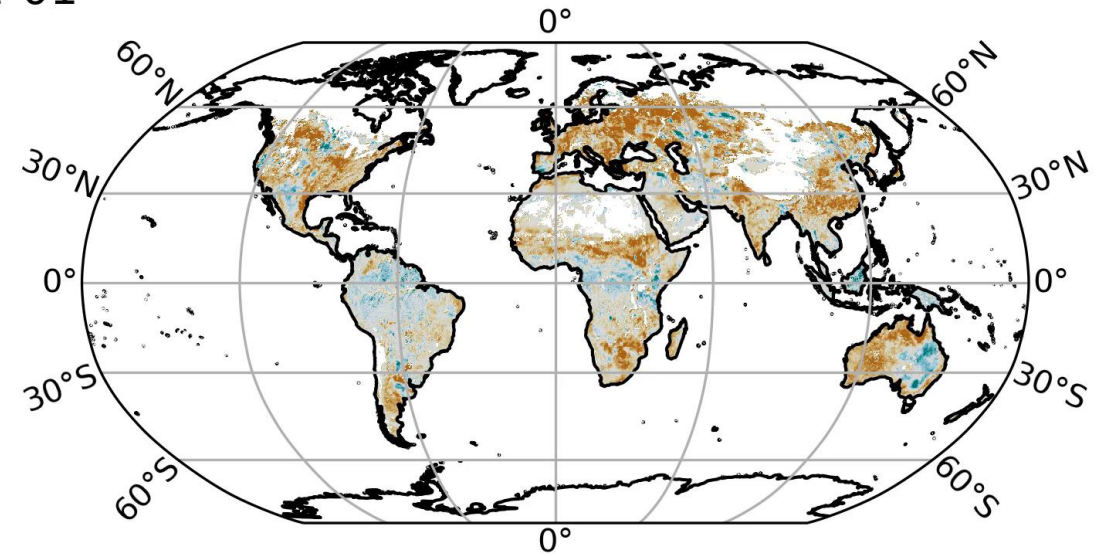
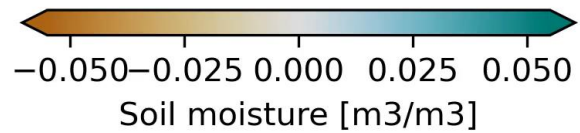
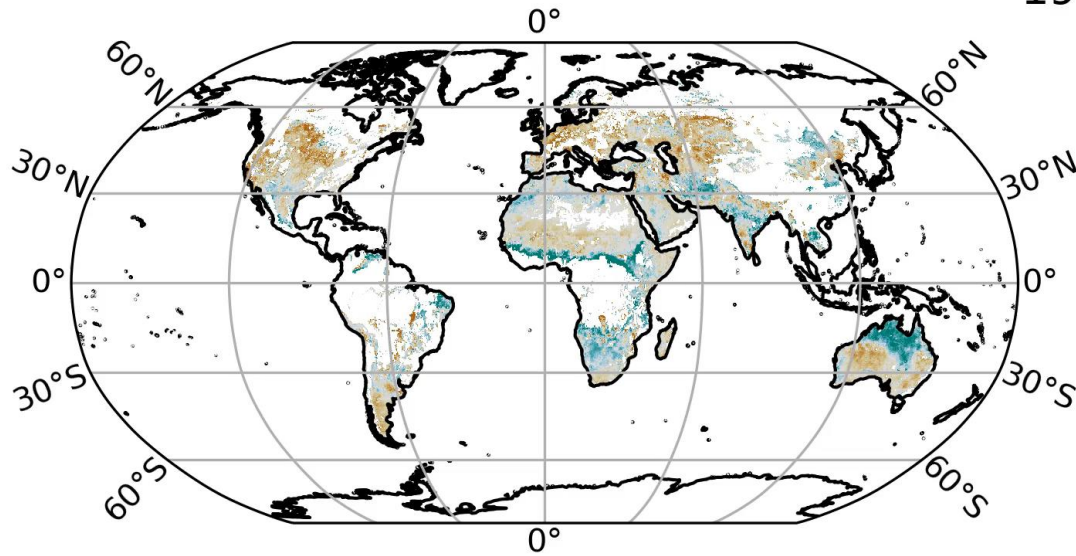
- **VOD** profits from long heritage of high frequency (C-, X-, Ku) microwave missions, making it a powerful source for climate and carbon cycle research

- **VODCA** allows monitoring temporal and spatial dynamics in above-ground biomass
 - › More sensitive to foliage biomass than L- and P-band
 - › Drylands, agriculture, pastures

- **VODCA2GPP** valuable independent GPP source
 - › data-sparse regions
 - › Long-term trends

- **SVODI** allows to assess the impact of extreme events and water cycle variability on global vegetation dynamics

1991-01



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