Asynchrony of recent European soil moisture and vegetation droughts

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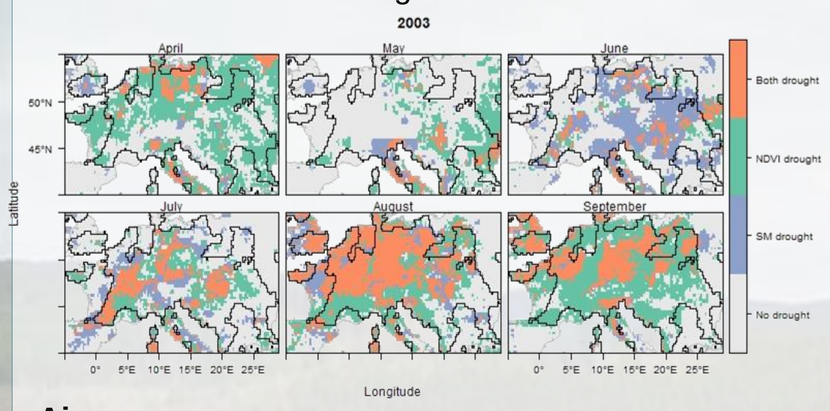
1. CONTEXT & AIM

Context

- Agricultural droughts are defined as a soil moisture deficit severe enough to hamper vegetation growth;
- It is important to quantify impacts of drought on vegetation;
- Taking soil moisture as a proxy for its impact on vegetation does not always suffice, as illustrated here for the 2003 drought.



Aim

The aim of this study was to definitively quantify the (a)synchrony between droughts in soil moisture and vegetation, to determine whether taking soil moisture droughts as a proxy for its impacts on vegetation is a valid assumption

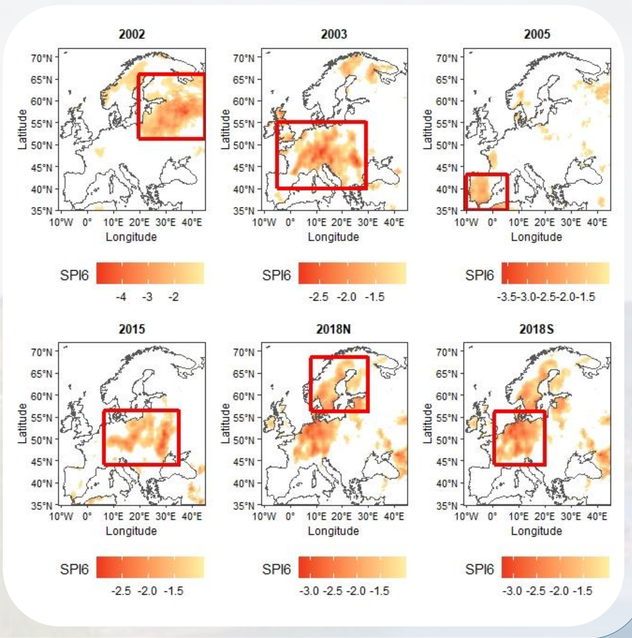
2. DATA & METHODS

Data

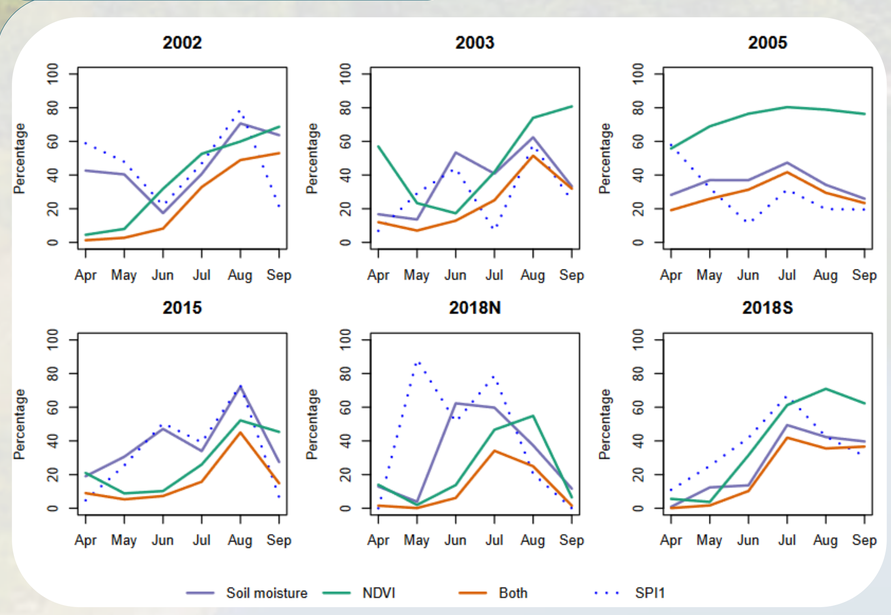
- **Precipitation**: Global monthly NASA GPM Integrated Multi-SatellitE Retrievals for GPM (IMERG) “Final Run” (Huffmann et al., 2019), 0.10˚ resampled to 0.25˚ resolution, available from 2000 to present.
- **Soil moisture**: ESA Climate Change Initiative (CCI) v04.5 combined active & passive long term blended volumetric soil moisture time series (Gruber et al., 2019)
- **Vegetation canopy greenness**: Monthly MODIS MOD13C2 Normalized Difference Vegetation Index (NDVI) 0.05˚ resampled to 0.25˚ resolution

Methods

- **Drought event selection**: Six drought events between 2000 and 2018 were selected based on the rainfall anomaly over the growing season, as shown in the figure.
- **Data preparation**: Soil moisture and NDVI data were normalized to allow for a consistent comparison. Pixels in the drought events were extracted, and identified as in a drought when the anomaly decreased below -1.
- **Drought (a)synchrony determination**: Fraction of area in drought per variable was determined first to detect differences. Then, correlation between the anomalies in soil moisture and NDVI was calculated for each drought event. Lastly, the prediction skill was calculated, were the soil moisture anomaly to be used as a proxy for an anomaly in NDVI. Five different skill scores were calculated, based on hits, misses, false alarms and correct rejections.



3. RESULTS

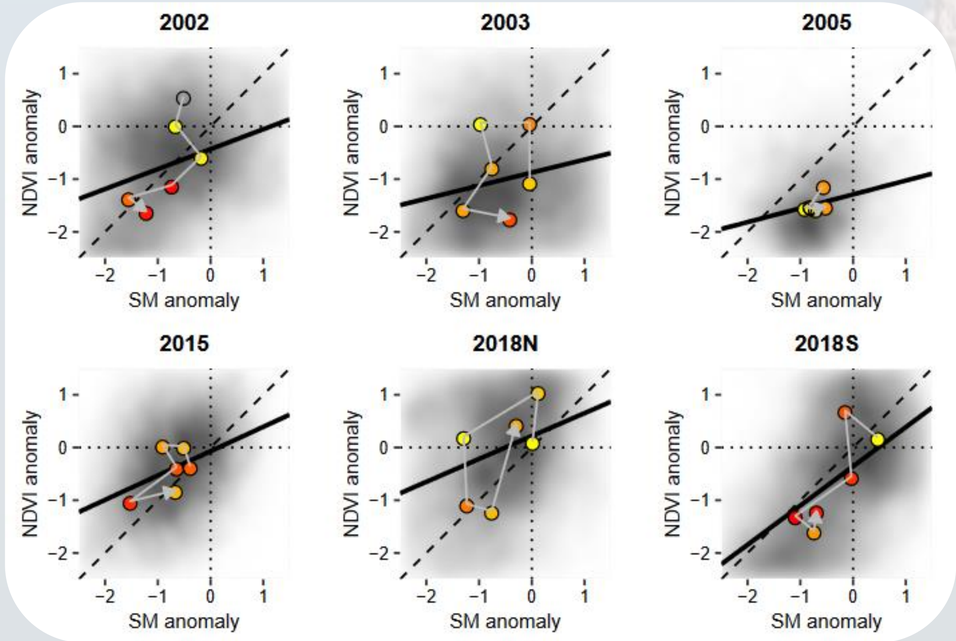


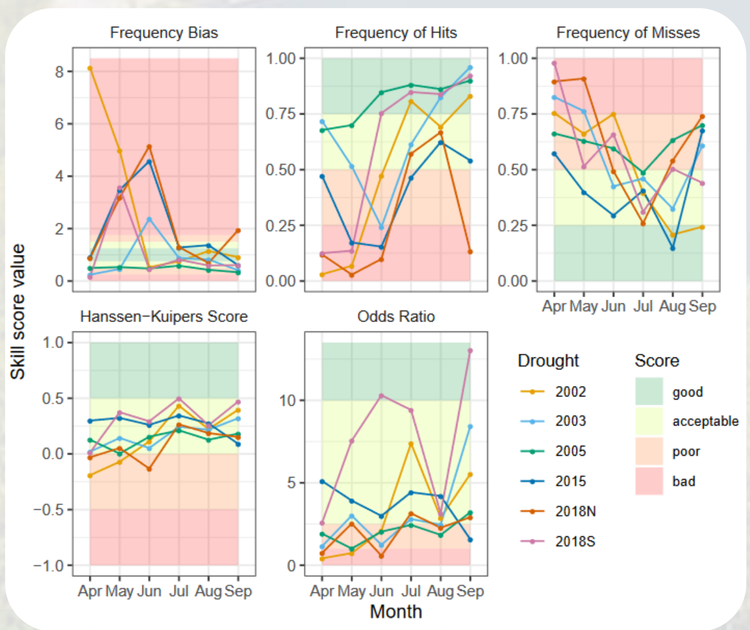
Drought affected areas

The top left figure shows time series of SM and NDVI anomalies, which behave asynchronously in each of the studied events: it generally takes time before a negative anomaly in soil moisture propagates into the vegetation. Interestingly, in 2005 and 2018S, there are areas that have vegetation deficits in absence of a SM drought. Such a signature would be expected in areas where vegetation is limited by energy, but it seems unlikely that this was the case here, due to their southern location. Moreover, a SM deficit lasting for longer time periods will increase the impact on vegetation as it also affects deep-rooted plants, rather than only shallow-rooted vegetation.

Correlation

The middle figure shows scatter density plots for each selected pixel in the six studied drought events, and correlations for each month in the growing season, connected by arrows (yellow=low correlation, red=high correlation). Low correlations in the start of the growing season indicate that the soil moisture anomaly is likely not a great predictor for NDVI anomaly. Although the correlation increases towards the end of the growing season, we expect the usefulness of end-of-season NDVI anomaly prediction using soil moisture anomalies to be limited for agricultural purposes.





Skill scores

The result of the skill score analysis is shown in the bottom figure. From the low density of lines in the parts of the plots shaded green, it is clear that the overall skill of NDVI anomaly prediction using soil moisture anomalies is rather low. Secondly, skill scores generally improve in August, confirming the conclusion drawn from the correlation analysis.

4. CONCLUSIONS

Though agricultural droughts are generally quantified using soil moisture anomalies, results of this study showed a clear asynchrony between these anomalies and their impacts on vegetation. Studies on agricultural drought quantification should therefore consider the effects of drought on vegetation, and, where possible, include vegetation data.

ACKNOWLEDGEMENTS

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