Extreme Hot and Dry Summers in Germany
Analysis of Long-term Earth Observation Time Series of Vegetation Condition

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Introduction

As other European countries, Germany experienced several severe droughts and heat waves in the recent past. The year 2018 was an extraordinary hot and dry year in Germany with the second highest summer temperatures on record after 2003. 2018 was also characterized by strong precipitation deficits with large regional differences. In central Germany the amount of precipitation has never been so low before. [1]

It is assumed that droughts and heat waves will increase in frequency and intensity in Central Europe in the future [2], making a thorough understanding and a (early) detection of these extreme events critical.

Material & Methods

The agricultural drought of 2018 was characterized by analyzing earth observation based vegetation condition. Remote sensing vegetation indices provide a continuous information of the state of plants over time. Here, a multi-annual time series of 16-day composites of MODIS Enhanced Vegetation Index (EVI) (MOD13Q1) from 2000 to 2018 was used to investigate the vegetation conditions in Germany. For each composite the deviation from its respective long-term median was calculated. Before, the data was masked using the MODIS pixel reliability layer and the CORINE land cover/land use dataset [3]. The deviations were averaged to monthly intervals and patterns were compared to climate data and agricultural statistics.

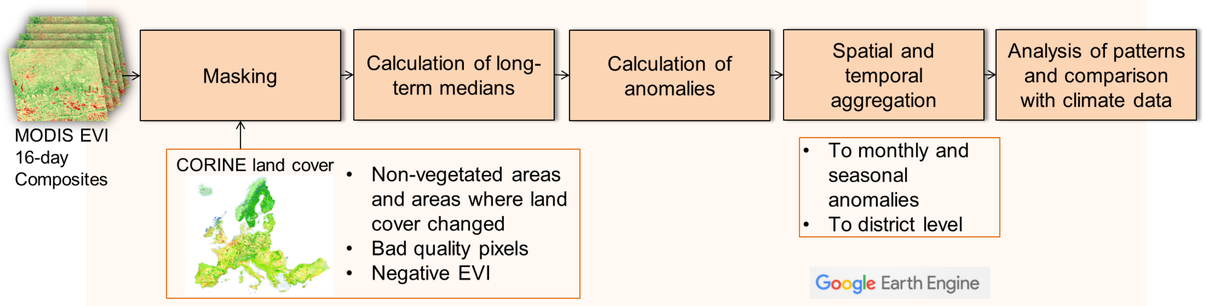

Fig. 1: Processing steps for characterization of vegetation condition.

Results – Temporal Dynamics

Figure 2 shows the monthly averaged deviations from the long-term medians for spring, summer and autumn from 2000 to 2018 for Germany. Only 2003 and 2018 show negative effects in summer and autumn when compared to the long-term median of the study period. In 2018, the state of the vegetation in spring was positive compared to the long-term median and only later in the year the conditions got relatively worse.

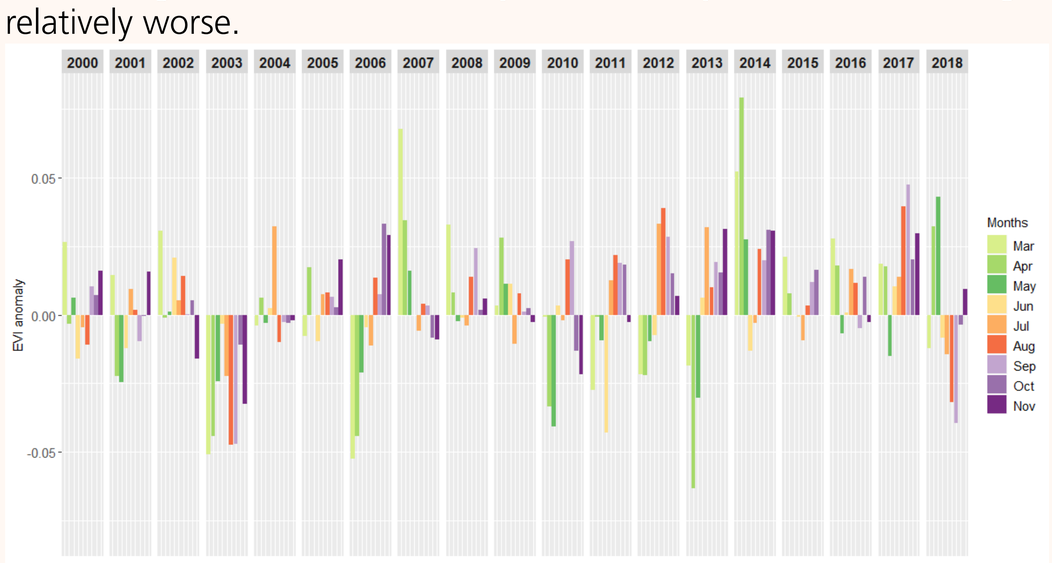

Fig. 2: Monthly deviations of EVI for spring, summer and autumn in Germany.

Results – Spatial Dynamics

Figure 3 illustrates the spatial patterns of the vegetation condition for 2003, 2004 and 2018. The EVI deviations were averaged to county scale. In 2018, northeastern parts are affected in June and July and western parts in August. The same investigation was conducted for grasslands only (Figure 4), which were extracted using the CORINE land cover layer. It shows stronger negative conditions for 2003 and 2018 especially in late summer.

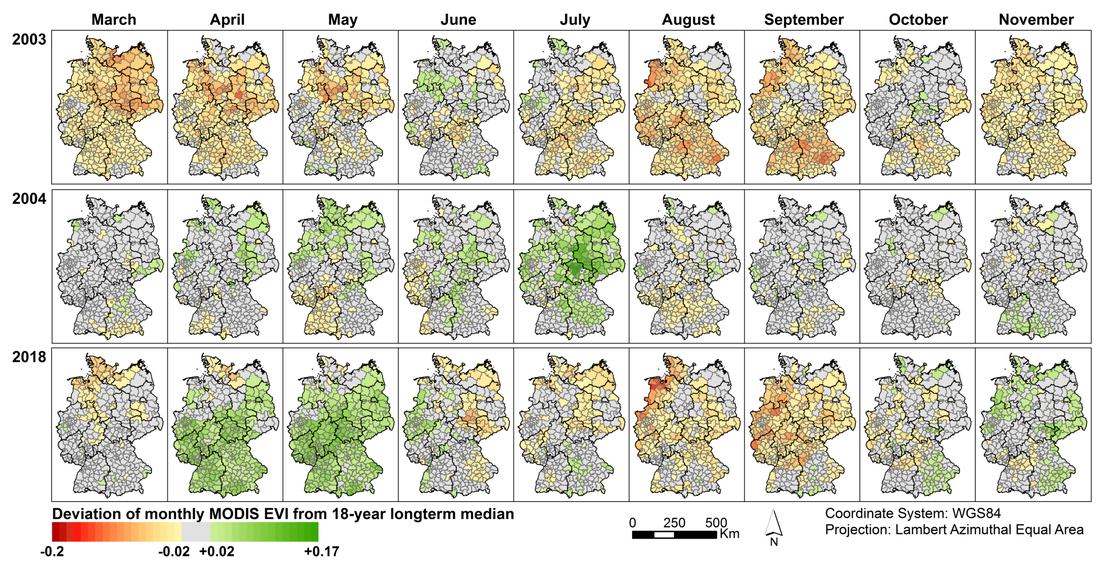

Fig. 3: EVI deviations for all land cover types.

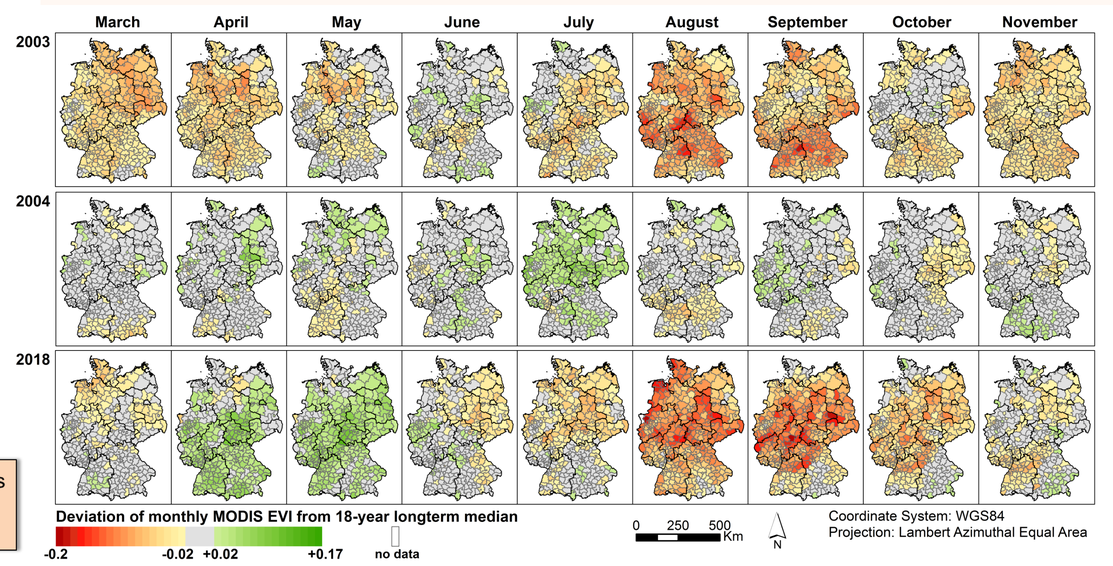

Fig. 4: EVI deviations for grasslands only.

Comparison with Agricultural Statistics

The spatial patterns are in good accordance to precipitation deficits (e.g. SPI) (not shown) and are a good indicator for agricultural drought. The temporal dynamics show strong similarities to harvest statistics in Germany [4]. In 2003 and 2018 harvests were relatively low due to drought and heat. In other years (e.g. 2006, 2013) other reasons apply, as late frost events or strong and long preceding winters. Figure 5 shows potato harvests and EVI deviations only for cropland.

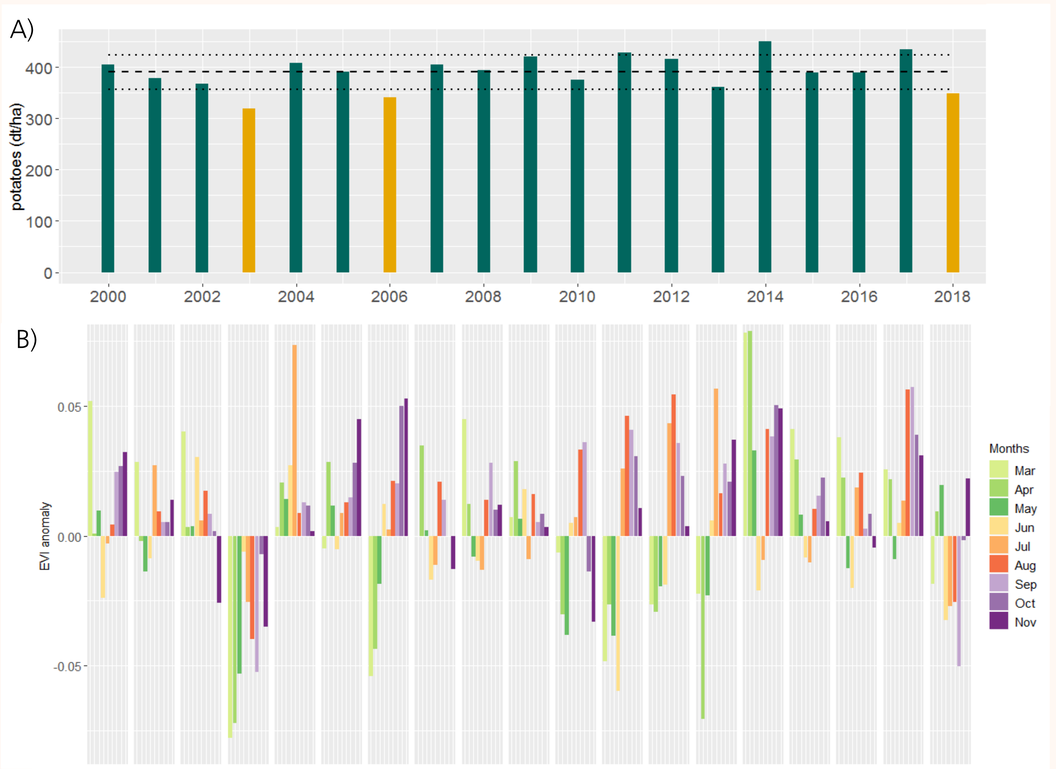

Fig. 5: Potato harvests [4] including mean (dashed) and one standard deviation plus and minus the mean (dotted) (A) and EVI deviations for cropland in Germany (B).

Conclusion

The drought event of 2018 is clearly discernable in EO data. Strong regional differences and temporal variability could be depicted. Also distinctions between land cover types are visible. Inclusion of more datasets, like soil moisture or evapotranspiration, would be an interesting next step to enable earlier detection.

[1] Imbery, F., K. Friedrich, C. Koppe, W. Janssen, U. Pfeifroth, J. Daßler, and P. Bissolli. 2018. "2018 wärmster Sommer im Norden und Osten Deutschlands." Accessed April 26, 2019.
[2] IPCC. 2018. "Global warming of 1.5°C: An IPCC Special Report on the impacts of global warming of 1.5°C above pre-industrial levels and related global greenhouse gas emission pathways, in the context of strengthening the global response to the threat of climate change, sustainable development, and efforts to eradicate poverty.".
[3] European Union, Copernicus Land Monitoring Service 2012, European Environment Agency (EEA), f.ex. in 2018: "© European Union, Copernicus Land Monitoring Service 2018, European Environment Agency (EEA)".
[4] Data Source: Statistisches Bundesamt (Destatis), Genesis-Online, accessed February 22 2019; Datenlizenz by-2-0.

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