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Characterization of extreme years in Central Europe between 2000 and 2016 according to specific vegetation characteristics based on Earth Observatory data

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Extreme weather events frequently occur in Central Europe, affecting the state of the vegetation in large areas. Droughts and heat-waves affect all plant functional types, but the response of the vegetation is not uniform and depends on other parameters, plant strategies and the antecedent meteorological conditions as well. Meteorologists struggle with the definition of extreme events and selection of years that can be considered as extreme in terms of meteorological conditions due to the large variability of the meteorological parameters both in time and space. One way to overcome this problem is the definition of extreme weather based on its observed effect on plant state. The Normalized Difference Vegetation Index (NDVI), the Enhanced Vegetation Index (EVI), the Leaf Area Index (LAI), the Fraction of Photosynthetically Active Radiation (FPAR) and the Gross Primary Production (GPP) are different measures of the land vegetation derived from remote sensing data, providing information about the plant state, but it is less known how weather anomalies affect these measures.
We used the vegetation related official products created from the measurements of the MODerate resolution Imaging Spectroradiometer (MODIS) on board satellite Terra to select and characterize the extreme years in Central European countries during the 2000-2016 time period. The applied Collection-6 MOD13 NDVI/EVI, MOD15 LAI/FPAR and MOD17 GPP datasets have 500 m $\times$ 500 m spatial resolution covering the region of the Carpathian-Basin. After quality and noise filtering (and temporal interpolation in case of MOD13) 8-day anomaly values were derived to investigate the different years. The freely available FORESEE meteorological database was used to study climate variability in the region. Daily precipitation and maximum/minimum temperature fields at 1/12° $\times$ 1/12° grid were resampled to the 8-day temporal and 500 m $\times$ 500 m spatial resolution of the MODIS products. To discriminate the different behavior of the various plant functional types MODIS (MCD12) and CORINE (CLC2012) land cover datasets were applied and handled together. Based on the determination of the reliable pixels with different plant types the response of broadleaf forests, coniferous forests, grasslands and croplands were discriminated and investigated. Characteristic time periods were selected based on the remote sensing data to define anomalies, and then the meteorological data were used to define critical time periods within the year that has the strongest effect on the observed anomalies. Similarities/dissimilarities between the behaviors of the different remotely sensed measures are also studied to elucidate the consistency of the indices. The results indicate that the diverse remote sensing indices typically co-vary but reveal strong plant functional type dependency. The study suggest that the selection of extreme years based on annual data is not the best choice, as shorter time periods within the years explain the anomalies to a higher degree than annual data. The results can be used to select anomalous years outside of the satellite era as well.

Keywords: Remote sensing, meteorology; extreme years; MODIS, NDVI; EVI; LAI; FPAR; GPP; phenology