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How useful are meteorological drought indicators to assess agricultural drought impacts across Europe?

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Drought monitoring and early warning (M&EW) is an important component of agricultural and silvicultural risk management. Meteorological indicators such as the Standardized Precipitation Index (SPI) are widely used in operational M&EW systems and for drought hazard assessment. Meteorological drought yet does not necessarily equate to agricultural drought given differences in drought susceptibility, e.g. crop-specific vulnerability, soil water holding capacity, irrigation and other management practices. How useful are meteorological indicators such as SPI to assess agricultural drought? Would the inclusion of vegetation indicators into drought M&EW systems add value for the agricultural sector? To answer these questions, it is necessary to investigate the link between meteorological indicators and agricultural impacts of drought. Crop yield or loss data is one source of information for drought impacts, yet mostly available as aggregated data at the annual scale. Remotely sensed vegetation stress data offer another possibility to directly assess agricultural impacts with high spatial and temporal resolution and are already used by some M&EW systems. At the same time, reduced crop yield and satellite-based vegetation stress potentially suffer from multi-causality. The aim of this study is therefore to investigate the relation between meteorological drought indicators and agricultural drought impacts for Europe, and to intercompare different agricultural impact variables. As drought indicators we used SPI and the Standardized Precipitation Evaporation Index (SPEI) for different accumulation periods. The focus regarding drought impact variables was on remotely sensed vegetation stress derived from MODIS NDVI (Normalized Difference Vegetation Index) and LST (Land Surface Temperature) data, but the analysis was complemented with crop yield data and text-based information from the European Drought Impact report Inventory (EDII) for selected countries. A correlation analysis between meteorological drought indicators and remotely sensed vegetation stress at the EU NUTS3 region level revealed a high correlation between the two types of indicators for many regions; however some spatial variability was observed in (i) strength of correlation, (ii) performance of SPI versus SPEI, and (iii) best linked SPI/SPEI time scale. We additionally explored whether geographic properties like climate, soil texture, land use, and location explain the observed spatial patterns. Our study revealed that climatically dryer areas (water limited) showed high correlations between SPI/SPEI and vegetation stress, whereas the wettest parts of Europe (radiation limited regions) showed negative correlations especially for short accumulation periods, suggesting that for these regions, short droughts could actually be beneficial for vegetation growth. These findings suggest that relying solely on meteorological indicators for agricultural risk assessment in some regions might be inadequate. Overall, such information may help to tailor agricultural drought M&EW systems to specific regions.