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Comparison of different methods for estimation of drought impacts on crop yield on the field scale in Austria

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Agriculture is probably the most vulnerable economic sector to extreme weather events such as drought. Because of climate changes that could change climatic variability including precipitation pattern, extreme weather events such as drought are likely to occur more frequently in different spatial and time scales in future (e.g. IPCC, 2001). Severe agricultural drought periods occurred during the past decades in middle and south-east Europe (Alexandrov and Eitzinger, 2003). The year 2003 clearly pointed out the vulnerabilty of agricultural crop production in Austria through extreme drought periods and diclosed the need for methods to estimate drought imapact on crop production under Austrian conditions (e.g. for a drought monitoring system).

For the above mentioned reasons our project compares various drought estimation methods and their relation to crop yields (wheat, barley and maize) in 2003 at the field scale at selected agricultural regions in Austria. The selected regions were seriously affected by drought damage in 2003. The tested methods contain meteorological drought indices (Discrete and Cumulative Precipitation Anomalies (Foley, 1957), Rainfall Deciles (Gibbs and Maher, 1967), Rainfall Anomaly Index (Van Rooy, 1965), Standardized Precipitation Index (SPI), (McKee et al., 1993, 1995), Hydrothermal indices (TI, KI), (Harlfinger and Kees (1999)), agrometeorological drought indices (Palmer Moisture Anomaly Index (Z index) and Palmer Drought Severity Index (PDSI), (Karl, 1986; Palmer, 1965), Crop Moisture Index (CMI), (Palmer, 1968),

Crop Specific Drought Index (CSDI), (Meyer, 1993a,b)), a simple water balance model (FAO Method, (Allen et al., 1998)), remote sensing indices (Normalized Difference Vegetation Index (NDVI), (Kogan, 1995; Peters et al., 2002)) and crop models (DSSAT – models (Tsuji et al., 1994, 1998)).

Meteorological indices, based mainly on only precipitation or temperature and precipitation did not correlate well ($R^2 <0.30$) to yield depression of the investigated crops by drought when they were applied only for the main growing period (3 month) of the crops. Through the application of agrometeorological methods or indices the correlation could be improved significantly ($R^2 >0.30$), because they consider information about soil water storage capacity and crop status. The best correlation of R^2=0.67 (based on the year 2003 only) was found by using a relative available soil water depletion value from the simplified soil water balance model (FAO model), related to the 3 month main growing period. These results also disclose a high spatial variability of actual drought stress levels due to the high spatial variability of soil conditions, which are not considered by meteorological indices. Remote sensing indices showed a very good relationship to yield depression in 2003 at the field scale (R^2=0.82), whereby the adaptation to the most sensitve crop specific phenological phases is important. Also a few meteorological indices showed good results, when they were related to the full vegetation period of 2003, however this result could change in years with different drought pattern. The DSSAT crop models showed a good relationship to relative yield changes between different soils, however for absolute yields there was an significant overestimation of yield depression. Therefore a better model calibration is needed for that locations and crops. A combination of methods could further improve the results at the field scale, and improve the interpretation about the reasons of yield depressions (especially in distinguishing between the effects of hight temperatures and drought stress).

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