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Drought vulnerability quantification in Bulgaria through modeling crop productivity and irrigation requirements

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There are a lot of facts proving that Global Climate Change affects the frequency and severity of extreme events as meteorological and consequent agricultural drought. The necessity to develop methodologies and simulation tools for better understanding, forecasting and managing risk of such events is evident for society. Thus the objective of the study is to assess the vulnerability of irrigated and rainfed agriculture to drought in Bulgaria using the WINIS-AREG simulation model and seasonal standard precipitation index SPI for the period 1951-2004. This model was previously validated for maize hybrids of different sensitivity to water stress on soils of small, medium and large water holding capacity (total available water TAW) in various locations. Simulations are performed for Plovdiv, Stara Zagora, Sandanski and Sofia (South Bulgaria) and Pleven, Lom and Silistra (North Bulgaria). Results relative to Plovdiv, Thracian Lowland, show that in soils of large TAW (180 mm m-1) net irrigation requirements (NIRs) range 0-40 mm in wet years and 350-380 mm in dry years. In soils of small TAW (116 mm m-1), NIRs reach 440 mm in the very dry year. NIRs in Sofia and Silistra are about 100 mm smaller while in Sandanski they are 30-140 mm larger than in Plovdiv. Rainfed maize is associated with great yield variability (29%<Cv<73%). Considering an economical relative yield decrease (RYD) threshold of 60 and 48% of the potential maize productivity in Plovdiv and Sofia, 32 % of years are risky when TAW=180 mm m-1 in Plovdiv, that is double than in Sofia and half than in Sandanski. In North Bulgaria the economical RYD threshold is 67, 55 and 60% for Pleven, Lom and Silistra. When TAW=180 mm m-1 only 12% of the years are risky in Pleven and Silistra that is half than in Lom. If TAW is medium (157 mm m-1) the risky years rise to 19, 36 and 47% in the last three sites respectively. In Plovdiv region reliable relationships (R2 >91%) were found for seasonal agricultural drought relating the average SPI (2) for July and August with the simulated NIRs and RYD of rainfed maize. In Stara Zagora, Sandanski (R2>75%) and Sofia (R2>71%) the relationships were less accurate. The study found statistically significant correlations between High Peak Seasonal SPI (2) "July-Aug" and simulated NIRs and RYD of rainfed maize for North Bulgaria as well (R2>0.81). When rainfed maize is grown of soils of large TAW in South Bulgaria economical losses are produced when high peak season SPI (2) < 0 in Sandanski, SPI (2) < -0.50 in Plovdiv and Stara Zagora and SPI (2) < -0.90 in Sofia. Corresponding NIRs thresholds between 250 and 190mm were identified. In North Bulgaria the soil specific economical SPI threshold is smaller. If the soil water holding capacity is large SPI (2) "July-Aug" ranges between -0.75 (Lom) and -1.5 (Pleven) while the corresponding NIRs threshold is 210 and 250 mm. The derived reliable relationships and soil specific thresholds of high peak seasonal SPI (2) "July-Aug", under which soil moisture deficit leads to severe impact of drought on maize productivity and irrigation requirements, could serve to produce an early warning system and for planning damage prevention in Bulgaria, which to some extend is representative of a wider area of South East Europe.