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Projection of future drought conditions in Europe and North America using the relative drought indices and multiple GCMs

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Various drought indices are commonly used to assess drought conditions. In addition to the 1-month and 12-months Standardized Precipitation Index (SPI) and the Palmer Drought Severity Index (PDSI), the present contribution employs Z index, which is closely related to PDSI but does not account for the persistence - it rather characterizes the immediate (for a given week or month) conditions. While the SPI is based solely on precipitation data, the PDSI and Z indices are based on precipitation and temperature data and on the available water content of the soil. For climate change impact studies, we consider PDSI and Z to be better indicators as they account for the changes in both temperature and precipitation. The three indices are calculated by computer programs available from the National Drought Mitigation Center and Computer Science and Engineering, both located at the University of Nebraska-Lincoln. To allow assessment of the climate change impacts, we made the modification of the programs: the indices are calibrated using the present climate weather series and then applied to the future climate weather series [relative drought indices; Dubrovsky et al. (accepted)]. In assessing impacts of climate change on the drought conditions, we analyze changes in the values of the indices and in the frequency of months belonging to drought spells, which are defined here as continuous periods in which the index: (a) does not exceed the selected upper threshold value, and (b) falls at least once below the lower threshold value. Threshold values of 0 and -1 are used to define the SPI-

based drought spells, -1 and -3 are used to define PDSI-based and Z-based drought spells. The drought indices are derived from the grid-related GCM-simulated (whole globe) surface monthly weather series for 1961-2000 (present climate) and 2060-2099 (changed climate). To account for the inter-GCM uncertainties, multiple GCM simulations available from the IPCC database are used.

Results: SPI changes closely follow the precipitation changes. According to most GCMs, the SPI(12month)-based drought risk in Europe will increase towards south and decrease towards north. In North America, the SPI changes indicate that the drought risk will decrease in northern regions, several models project drought increase along Gulf Coast and Central U.S., NCAR model indicates drought increase in western U.S. As PDSI and Z-index also account for temperature, which is projected to rise in most parts of the world, the areas with increased drought stress (under a changed climate) indicated by these two indices are larger than the areas indicated by SPI. In Europe, this increase is most significantly exhibited in its southern and eastern regions. Z-index indicates that the drought stress will increase mostly in summer. Except for few regions in some GCMs, the PDSI-based drought risk will increase in all parts of Europe and North America.

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Reference: Dubrovsky et al. (accepted): Application of Relative Drought Indices in Assessing Climate Change Impacts on Drought Conditions in Czechia. Theoretical and Applied Climatology.