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Spatial and temporal patterns of large-scale droughts in Europe: model dispersion and performance

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Droughts are regional events that have a wide range of environmental and socio-economic impacts and thus, it is vital that models correctly simulate drought characteristics in a future climate. In this study we explore the performance of a suite of off-line, global hydrological and land surface models in mapping spatial and temporal patterns of large-scale hydrological droughts. The model ensemble consists of seven global models run with the same simulation setup (developed in a joint effort within the WATCH project). Daily total runoff (sum of fast and slow component) simulated for each grid cell in Europe for the period 1963-2000 constitute the basis for the analysis. Simulated and observed daily (7-day backward-smoothed) runoff series for each grid cell were first transformed into nonparametric anomalies, and a grid cell is considered to be in drought if the runoff is below q20, i.e. the 20% non-exceedance frequency of that day. The mean annual drought area, i.e. the average of the daily total area in drought, is used to characterize the overall dryness of a year. The annual maximum drought cluster area, i.e. the area of the largest cluster of spatially contiguous cells in drought within a year, is chosen as a measure of the severity of a given drought. The total number of drought events is defined as runs of consecutive days in drought over the entire record. Consistent model behavior was found for inter-annual variability in mean drought area, whereas high model dispersion was revealed in the weekly evolution of contiguous area in drought and its annual maximum. Comparison with nearly three hundred catchment-scale streamflow observations showed an overall tendency to overestimate the number of drought events and hence, underestimate drought duration, whereas persistence in drought affected area (weekly mean) was underestimated, noticeable for one group of models. The high model dispersion in temporal and spatial persistence of drought identified implies that care should be taken when analyzing drought characteristics from only one or a limited number of models unless validated specifically for hydrological drought.

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