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Global hydrological drought analysis for the second part of the 20th century

M.H.J. van Huijgevoort, P. Hazenberg, and H.A.J. van Lanen

Wageningen University, Hydrology and Quantitative Water Management Group, The Netherlands
(marjolein.vanhuijgevoort@wur.nl)

Drought is a natural hazard that occurs all over the world and can have large economic, social, and environmental impacts. Large-scale models, Global Hydrological Models (GHMs) and Land Surface Models (LSMs), have been developed over the last decades to simulate the global and continental terrestrial water cycle. It is not clear whether these models provide suitable data for the analysis of hydrological extremes on a global scale, e.g. drought. Therefore, in this study, a multi-model analysis has been carried out to evaluate if a suite of these models can reproduce major drought events. Time series of monthly total runoff from five LSMs and five GHMs (0.5° x 0.5°) have been used to focus on hydrological drought. They were run with identical forcing (WATCH forcing data) within the framework of the EC-FP6 project WATCH for the period 1963-2001. A new drought identification tool that combines the variable threshold level method and the consecutive dry period method was used to characterize drought events in the ensemble median of the ten global models. After the temporal drought identification per cell, a clustering method was applied to determine the spatial extent of drought events and exclude small spatial events. From the ensemble median, the temporal development of area in drought for the globe and various subregions was investigated. The results show that known major drought events in all continents were identified. From the time series of drought occurrence, several severe drought events were selected, which were studied in the spatial domain. Duration and spatial extent of these events can substantially differ with documented studies. Considering the individual models especially the spatial extent of major drought events differed, however all models did capture them. In general, the modelled runoff shows a fast response to rainfall, which leads to deviations from observed drought events in slowly responding systems. By taking the multi-model ensemble median, this effect is somewhat reduced, however the response time remains too fast. Overall, the study shows that the median of the large-scale models is able to identify major hydrological drought events, but the spatial extent and duration of these events is less reliable compared to observations.