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Multi-model analysis of global droughts in the second part of the 20th century

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Drought is a natural hazard that occurs all over the world and can have large economic, social, and environmental impacts. Drought is caused by a below average natural water availability due to low precipitation and/or high evaporation rates. It is characterized as an anomaly in the transient behaviour of the physical system (climate and hydrology), which is reflected in hydro-meteorological variables such as precipitation, soil moisture, groundwater, and streamflow. Often, the long time series of these variables needed for drought analysis are not available, particularly not at global scale. Large-scale combined observational-modelling frameworks are implemented for that reason. Off-line approaches have been developed over the last decades, which include Global Hydrological Models (GHMs) and Land Surface Models (LSMs) that simulate the global and continental terrestrial water cycle. These models are forced with global re-analysis meteorological datasets to simulate the past water cycle. It is not clear whether large-scale models are suitable to analyse hydrological extremes, e.g. drought, at global scale. Therefore, in this study, a multi-model analysis of droughts has been carried out to test how well these models can reproduce major droughts. The focus was on hydrological drought, so time series of monthly total runoff from four LSMs and four GHMs have been used. The models have a resolution of 0.5° x 0.5° and include land points only. They were run with the WATCH forcing data within the framework of the EC-FP6 project WATCH for the period 1963-2001. The variable threshold method was used with a monthly threshold to identify droughts and its characteristics from the monthly runoff for each grid cell. The global distributions of average drought duration derived from the different large-scale models were compared. Furthermore, the temporal development of the area in drought for the globe and various continents was investigated. This provides information about the ability of the models to capture the timing as well as spatial extent of major droughts. A comparison between the outcome from the large-scale models and documented major drought events was made to verify the results of the drought analysis with the large-scale models. In this way, the study gives insight in how well these large-scale models are able to simulate droughts.