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The Drought Interest Group: Uncertainties in 20th and 21st century global drought

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Reconstructions of historic drought events can help our understanding of the mechanisms of drought occurrence, put current conditions and future projections into context, and help quantify the impact of global warming. The lack of large-scale and long-term observations of terrestrial hydrological variables, however, hampers the development of reconstructions from direct observational data. A viable alternative is the use of modeling that can provide spatially and temporally consistent and continuous estimates, and provide the basis for mechanistic understanding and thence prediction. The recent development of large-scale gridded meteorological datasets that merge observational and reanalysis products has helped drive this by providing forcing for off-line land surface hydrological simulations using state-of-the-art models. When constrained through calibration to available large-scale observations of streamflow, and evaluated against remotely sensed data such as snow and total water storage change, the modeled data provide a reasonable depiction of hydrological cycle variation. We show results from a multi-model ensemble of land surface model reconstructions of global drought for the 20th and early 21st centuries and use these to evaluate changes in drought and the uncertainties. Uncertainties exist because of model errors, meteorological forcing inaccuracies and choice of drought characteristic. Forcing uncertainty is to first order dictated by uncertainty in precipitation and especially for the early 20th century in sparsely monitored regions. Independent evidence from hydrological observations and proxy sources are used to help validate these events. Uncertainty in long-term precipitation, radiation and other meteorological forcings are evaluated through analysis across multiple competing products. Errors derived from model structure are accounted for via the multi-model ensemble, which shows similarities in the overall identification of major drought events but large differences in the depiction of drought development and recovery, as mainly driven by differences in the model representation of subsurface hydrological processes. Large-scale drought events are analyzed through comparison of their joint space-time characteristics and this is used to rank events in terms of severity. Recent decadal changes suggest drying for many regions, driven by reduced precipitation. The expected influence of global warming via increased atmospheric evaporative demand and longwave radiation is difficult to discern, however, given the uncertainties in the forcing datasets. We also evaluate estimates of long-term drought events from reanalysis against our best estimates from the off-line modeling to determine whether reanalysis products are capable of providing the basis for understanding the mechanisms of drought initiation, persistence and recovery.