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Uncertainties in Historical Changes and Future Projections of Drought

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Precipitation, streamflow and drought indices suggest drying since 1950 over many land areas, and models project more frequent and intense drought in the 21st century. Here, we examine the uncertainties in estimating historical drought changes, and further compare the model-simulated drought changes with observation-based estimates since 1900 and their future projections using the self-calibrated Palmer Drought Severity Index with the Penman-Monteith potential evapotranspiration (PET) (sc_PDSI_pm) based on the simulations from both the Coupled Model Intercomparison Project Phase 3 (CMIP3) and Phase 5 (CMIP5). Consistent with our previous analyses, precipitation and streamflow data and the calculated sc_PDSI_pm all show consistent drying during 1950-2012 over most Africa, East and South Asia, southern Europe, eastern Australia, and many parts of the Americas. Furthermore, long-term changes in global and hemispheric drought areas from 1900-2014 are consistent with the CMIP3 and CMIP5 model-simulated response to historical greenhouse gas and other external forcing, with the short-term variations within the model spread of internal variability, despite that historical changes over many regions are still dominated by internal variations. Based on the sc_PDSI_pm, both the CMIP3 and CMIP5 models project continued increases (by 50-200% in a relative sense) in the 21st century in global drought frequency and area even under low-moderate emissions scenarios, resulting from a decrease in the mean and flattening of the probability distribution functions (PDFs) of the sc_PDSI_pm. This flattening is especially pronounced over the Northern Hemisphere land, leading to increased drought frequency even over areas with increasing sc_PDSI_pm. While warming-induced ubiquitous PET increases and precipitation decreases over subtropical land are responsible for the sc_PDSI_pm decrease, the exact cause of its PDF flattening needs further investigation.