Variability of surface climate in simulations of past and future

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It is virtually certain that the mean surface temperature of the Earth will continue to increase under realistic emission scenarios. Yet comparatively little is known about future changes in climate variability. We explore changes in climate variability over the large range of climates simulated in the framework the Coupled Model Intercomparison Project Phases 5 and 6 (CMIP5/6) and the Paleoclimate Modeling Intercomparison Project Phases 3 and 4 (PMIP3/4). This consists of time slice simulations for the Pliocene, Last Interglacial, Last Glacial Maximum, the Mid Holocene and idealized warming experiments (1% CO₂ and abrupt 4xCO₂), and encompasses climates with a range of 12°C of global mean temperature change. We examine climate variability from different perspectives: from local interannual change, to coherent climate modes and through compositing extremes. The change in the interannual variability of precipitation is strongly dependent upon the local change in the total amount of precipitation. Meanwhile only over tropical land is the change in the interannual temperature variability positively correlated to temperature change, and then weakly. In general, temperature variability is inversely related to mean temperature change - with analysis of power spectra demonstrating that this holds from intra-seasonal to multi-decadal timescales. We systematically investigate changes in the standard deviation of modes of climate variability. Overall, no generalisable pattern emerges. Several modes do show, sometimes weak, increasing variability with global mean temperature change (most notably the Atlantic Zonal Mode), but also the El Niño/Southern Oscillation indices (NINO3.4 and NINO4). The annular modes in the Northern (Southern) hemisphere show only weakly increasing (decreasing) relationships. By compositing extreme precipitation events across the ensemble, we demonstrate that the atmospheric drivers dominating rainfall variability in Mediterranean climates persist throughout palaeoclimate and future simulations. The robust nature of the response of climate variability in model simulations, between both cold and warm climates and across multiple timescales, suggests that observations and proxy reconstructions could provide a meaningful constraint on climate variability in future projections.