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Long-Range Memory in Millennium-Long ESM and AOGCM Experiments

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Northern-hemisphere (NH) temperature records from a reconstruction and a number of millennium-long climate-model experiments are investigated for long-range memory (LRM). The models are two Earth-system models (ESMs) and two atmospheric-ocean general circulation models (AOGCMs). The periodogram, detrended fluctuation analysis and wavelet variance analysis are applied to examine scaling properties and to estimate a scaling exponent of the temperature records. A simple linear model for the climate response to external forcing is also applied to the reconstruction and the forced climate model runs and compared to unforced control runs to extract the LRM generated by internal dynamics of the climate system. With one exception the climate models show strong persistent scaling with power-spectral densities of power-law form with exponent $0.8<p<1.0$ on time scales from years to several centuries. The relationship between the spectral exponent p and the more familiar Hurst exponent is $H=(p+1)/2$. This is somewhat stronger persistence than found in the reconstruction ($p=0.7$). The exception is the HadCM3 model, which exhibits $p=0.6$. We find no indication that LRM found in these model runs is induced by external forcing, which suggests that LRM on sub-decadal to century time scales in NH mean temperatures is a property of the internal dynamics of the climate system.