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Atlantic Meridional Overturning Circulation response to idealized solar forcing

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The response of the Atlantic Meridional Overturning Circulation (AMOC) to idealized solar forcing is studied with the Kiel Climate Model (KCM), a sophisticated coupled atmosphere-ocean-sea ice model. Analysis of KCM's internal (unforced) AMOC variability indicates that three distinct timescales can be identified: One multidecadal with a period of about 60 years, one quasi-centennial with a period of about 100 years and one multi-centennial with a period of about 300-400 years. Most variance is explained by the multi-centennial mode, and the least by the quasi-centennial. The solar constant varies sinusoidally with different period and amplitude in a number of additional runs. The AMOC response in KCM is highly nonlinear. For instance, in the experiment with a 100 year forcing period and amplitude of 2 Watts per square meter, AMOC variability becomes strongly entrained by the external forcing. While the control run depicts multi-timescale behavior, the variability is channeled into a relatively narrow band around the forcing period in the forced run. It is the quasi-centennial AMOC mode with a period of about 100 years which explains only a relatively small fraction of the variance in the control run that is strongly entrained by the forcing. This behavior indicates that it is not necessarily the most unstable (or least damped) mode which is excited by external forcing, implying that we need to understand the full modal structure of the unforced variability to understand the forced variability in a nonlinear system. This is a challenge for climate models. If the internal modes of the system are not well represented, we cannot expect that the response to external forcing is realistically captured.