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On the Uncertainty of the Annular Mode Time Scale

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The proper simulation of the annular mode (AM) time scale may be regarded as an important benchmark for climate models. Previous research demonstrated that climate models systematically overestimate this time scale. As suggested by the fluctuation-dissipation theorem, this may imply that models are overly sensitive to external forcings. Previous research also made it clear that calculating the AM time scale is a slowly converging process, necessitating relatively long time series and casting doubts on the usefulness of the historical reanalysis record to constrain climate models in terms of the AM time scale.

Here, we use a 4000-year-long control simulation with the GFDL climate model CM2.1 to study the effects of internal atmospheric variability on the stability of the AM time scale. In particular, we ask whether a model's AM time scale and climate sensitivity can be constrained from the 50-year-long reanalysis record. We find that internal variability attaches large uncertainty to the AM time scale when diagnosed from decadal records. Even under fixed forcing conditions, at least 100 years of data are required in order to keep the uncertainty in the AM time scale of the Northern Hemisphere to 10%; over the Southern Hemisphere the required length increases to 200 years. If nature's AM time scale is similarly variable, there is no guarantee that the historical reanalysis record is a fully representative target for model evaluation. We further use the model simulation to investigate the dynamical coupling between the stratosphere and the troposphere from the perspective of the AM time scale. Over the Northern Hemisphere we find only weak indication for influences from stratosphere-troposphere coupling on the AM time scale. The situation is very different over the Southern Hemisphere, where we find robust connections between the AM time scale in the stratosphere and that in the troposphere, confirming and extending earlier results of influences of stratospheric variability on the troposphere.