A new analysis framework to detect changes in internal variability under global warming

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Internal variability is often considered as noise in the climate system that conceals the forced response, but is itself not changing in response to the forcing. However, internal variability describes deviations from the forced response, and thus has a direct influence on the magnitude and frequency of anomalous or even extreme events. Therefore, a change of internal variability may cause a perceptible change of anomalous events in the climate system.

We introduce a method to robustly detect a change in internal variability and attribute it to a change in the external forcing. We apply this method to global mean specific humidity from the Max Planck Institute Grand Ensemble (MPI-GE).

Internal variability in the observational record or a transient climate simulation cannot be assumed to be independent of the forcing, therefore we need an analysis method to account for this. We use the ensemble dimension in a large ensemble to quantify internal variability. In contrast, the often applied approach to analyse variability in the time domain does not provide a well-defined estimate whenever internal variability is changing with time. To sample the phase space of internal variability in the ensemble dimension adequately at different forcing states, a large ensemble size is necessary. Only then can we attribute a detected change in internal variability to the external forcing change and avoid misinterpretation of apparent changes in internal variability that can arise from undersampling.

Our analysis method is presented for global mean specific humidity because an increase of the internal variability of specific humidity would be expected in a warmer atmosphere based on thermodynamic constraints. We use an idealised strong warming experiment with a prescribed increase of the atmospheric CO_2 concentration by 1% per year. This experiment from the MPI-GE consists of 100 realisations. In this strong warming scenario, we detect a robust increase in the internal variability of global mean specific humidity in response to global warming.