Geophysical Research Abstracts
Vol. 15, EGU2013-3463, 2013
EGU General Assembly 2013

The Brewer-Dobson Circulation in a changing climate: Trend versus natural variability

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The vast majority of recent modelling studies finds a strengthening of the stratospheric meridional overturning circulation, the Brewer-Dobson Circulation (BDC), under increasing greenhouse gas concentrations. Although there is a large spread in magnitude and source of the BDC trend among models and model configurations, the positive sign of the trend is found to be a robust response. However, observational datasets covering 10 to 30 years of measurements at different locations do not reveal any significant trend. This contradiction between modelling studies and observations could possibly be due to low-frequency variability of the BDC. In both observational datasets as well as model simulations BDC trends could be masked by or confused with long-term variability.

In this study, long model simulations are analysed to identify the low-frequency modes of natural BDC variability. Possible connections to other sources of long-term variability in the Earth System, particularly the tropical sea surface temperatures (SSTs), are investigated. The amplitude of the low-frequency natural BDC variability is compared to trends derived from both model and observational datasets, and thus it is assessed if the available observational datasets are adequate to allow for a detection of a robust trend in the BDC.

In order to derive the natural BDC variability a 1000-year preindustrial control run, performed with the coupled atmosphere-ocean General Circulation Model MPI-ESM, is analysed. By applying a wavelet analysis the low-frequency modes of natural variability are obtained. As previous studies found that tropical SSTs play an important role in driving the BDC, the covariance of the BDC and the NINO 3.4 index is investigated by calculating cospectra and wavelet coherence. It turns out that also low-frequency modes of variability are mediated from the surface to the stratosphere. BDC trends derived from both observational datasets as well as transient historical model runs and different future scenario simulations, performed with MPI-ESM, are compared to the amplitude of the derived natural modes of variability.