The transient evolution of the stratospheric residual circulation response to climate change

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Models consistently simulate a strengthening of the stratospheric Brewer Dobson circulation (BDC) in response to an increase in atmospheric greenhouse gas (GHG) concentrations. One mechanism to explain the BDC response to GHGs invokes changes to the distribution of wave forcing in the lower stratosphere associated with increases in the strength of zonal winds in the subtropical upper troposphere/lower stratosphere (Shepherd and McLandress, 2011). The changes in the subtropical jets are in turn strongly linked to changes in the thermal structure of the troposphere. This implies that the increase in the BDC is strongly tied to surface and tropospheric warming, which responds to radiative forcing on time scales of months to years. However, no previous studies have attempted to separate the timescales of the residual circulation response to forcing and its link to specific atmospheric processes. This study explores the temporal response of the BDC to an imposed forcing using an ensemble of integrations with the Met Office Unified Model. We evaluate the BDC response by analyzing the Transformed Eulerian Mean (TEM) diagnostics and associated wave driving from resolved and parametrized waves. The experiments investigated include: a globally uniform increase in sea surface temperatures of 4 K without any changes to atmospheric composition (i.e. stratospheric cooling due to CO_2 is not included); a quadrupling in atmospheric CO_2 in the absence of sea surface temperature changes (i.e. stratospheric cooling occurs but the tropospheric thermal structure remains similar). These experiments enable the effects of changes in atmospheric and surface heating on the BDC to be separated. The use of ensemble simulations provides a unique opportunity to examine the transient features of the BDC response to forcing and for the associated atmospheric processes to be identified. Particular attention will be paid to the magnitude of the simulated changes in the different experiments, since developing improved quantitative constraints on predicted future changes in the BDC is important for future projections of stratospheric and tropospheric climate.

References

Shepherd, T.G. and C. McLandress, 2011, *J. Atmos. Sci.*, ***68***, *784–797*