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Downward Wave Coupling Changes in Response to Future Climate Change, Two Way Atmosphere/Ocean Coupling and QBO

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Wave reflection in the stratosphere can impact the troposphere via a well-defined, high latitude meridional waveguide that is bounded above by a vertical reflecting surface. Such wave reflection is known as downward wave coupling (DWC). Recent studies have shown that stratospheric ozone affects DWC, affecting wave propagation and subsequent wave-mean flow interaction in the Southern Hemisphere. However the factors controlling DWC in the Northern Hemisphere are still unclear. There is new evidence that the frequency of Major Stratospheric Warming (MSW) is significantly influenced by the QBO and two-way ocean/ atmosphere interaction. However the resulting impact on DWC has thus far not been investigated. Here we examine the impact of future climate change, two way atmosphere/ ocean coupling, and the QBO on wave geometry and DWC using different CESM-WACCM model experiments.

A transient simulation of present and future climate (1955-2099), with green house gases (GHG) and ozone depleting substances (ODS) following the RCP 8.5 scenario, shows the largest reduction in the DWC over last few decades of the simulation. This reduction is associated with an absence of the vertical reflecting surface and statistically insignificant downward wave reflection. Comparison to an experiment with GHG/ODS fixed at 1960s levels, shows no indication of DWC-changes. The lack of a DWC response is associated with insignificant changes of the background wind states, whose vertical structure directly impacts the DWC. The comparison of this experiment with simulations with and without QBO nudging shows that the QBO strengthens the DWC. This can be explained by the fact that our nonQBO simulation has a permanent, strong QBO-like east phase, which dampens the DWC. Comparison of experiments with dynamically-coupled and fixed SSTs shows that the background zonal wind is strengthened significantly when the ocean/atmosphere interaction is removed. However, no apparent strengthening of DWC is seen in association with SST-coupling, which suggests that the vertical wind shear does not entirely explain the DWC differences.