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Downward Wave Coupling between the Stratosphere and the Troposphere: the Role of Sea Surface Temperatures

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The dynamical coupling between the stratosphere and the troposphere is dominated by planetary waves that are generated in the troposphere by orography and ocean-land heating contrasts. These waves travel upward into the stratosphere where they either dissipate or are reflected downward to impact the troposphere again. The latter is called downward wave coupling. In the Northern Hemisphere, downward wave coupling mainly occurs during January, February and March whereas in the Southern Hemisphere it occurs from September to December.

The occurrence of downward coupling is tied to a so-called „bounded wave geometry“ of the stratospheric basic state, meaning a well-defined high-latitude meridional waveguide in the lower stratosphere that is bounded above by a vertical reflecting surface. It can be analyzed using the wave geometry diagnostic developed by Harnik and Lindzen (2001) which separates the widely used index of refraction into vertical and meridional wavenumber contributions to determine whether the stratospheric basic state allows wave propagation in the vertical and meridional directions.

We use the wave geometry diagnostic by Harnik and Lindzen (2001) to investigate the impact of Sea Surface Temperatures (SST) on downward wave coupling. We thereby compare two simulations of NCAR's Community Earth System Model (CESM), a coupled model system including an interactive ocean (POP2), land (CLM4), sea ice (CICE) and atmosphere (NCAR's Whole Atmosphere Community Climate Model (WACCM)) component. The first experiment is a 140-year simulation with the fully coupled atmosphere-ocean version of CESM, and the second one a 50-year simulation with only CESM's atmospheric component WACCM, a fully interactive chemistry-climate model extending from the Earth's surface through the thermosphere (about 140 km), with underlying climatological SSTs obtained from the first, coupled CESM run. Both simulations develop under conditions where greenhouse gases are held constant at the 1960 level. From the difference of the two simulations we can estimate the role of the SSTs for wave propagation and coupling. The model results are validated with the Modern Era Retrospective-Analysis for Research and Applications (MERRA) dataset, which has been shown to be consistent with ECMWF reanalysis data (ERA-40).