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Sensitivity of the stratospheric circulation to the latitude of thermal surface forcing

Barbara Winter[†]; Michel Bourqui
[†] McGill University, Canada
Leading author: barbara.winter@mail.mcgill.ca

Using a Chemistry Climate Model, we analyze the response in the Northern Hemisphere winter stratosphere to idealized thermal forcing imposed at the surface. The forcing is a 2K temperature anomaly added to the control surface temperature at all gridpoints within a latitudinal window of 10 or 30 degrees. The band-wise forcing is applied systematically throughout all latitudes of the Northern Hemisphere. Thermal forcing applied anywhere equatorwards of 20N, or continuously from the equator to 30N, increases planetary-wave generation in the troposphere and enhances the flux of wave activity propagating vertically into the stratosphere. Consequently, a greater flux of wave activity breaks in the polar vortex, increasing the Brewer-Dobson circulation and leading to a warm anomaly in the polar stratosphere. Ozone concentration increases at high latitudes and decreases at low latitudes. Thermal surface forcing imposed between 30N and 60N has the reverse effect - decreased planetary-wave generation in the lower troposphere and reduced vertically propagating wave flux entering the stratosphere - and leads to a stronger and colder vortex. Thermal forcing applied polewards of 60N has little effect on the tropospheric mean state, but nonetheless decreases the planetary-scale eddy heat flux from the surface to the tropopause, resulting in a sufficient decrease of the vertical flux of wave activity for the vortex to be anomalously strong and cold. When surface forcing is imposed only polewards of 30N, ozone concentration decreases at high latitudes but is not affected at low latitudes. Combining the forcing in an equatorial and an extra-tropical band leads to a response similar to that of the equatorial forcing, demonstrating that the subtropical surface temperature changes determine the sign of the surface-driven response in the vortex.