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Stratospheric Final Warming Events and their Surface Impact

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In both hemispheres, stratospheric polar vortices form in the fall, reach maximum strength in midwinter, and decay in late winter-spring. The breakdown of these vortices is known as the Stratospheric Final Warming (SFW). In the first part of this study, we investigate stratospheric final warming events in a simplified GCM forced by specified equilibrium temperature distributions. We use a dry, hydrostatic, primitive equation model with T42 resolution in the horizontal and 40 levels in the vertical. The bottom boundary includes topography, which causes variability in the timing of final warming events. Seasonal variations in the equilibrium temperature distribution are included in the model stratosphere only, so as to demonstrate explicitly the effect of the stratospheric seasonal cycle on the model troposphere. The model produces qualitatively realistic final warming events whose influence extends down to the surface, much like what has been reported in previous observational analyses.

In the Southern Hemisphere, a tendency towards an increase in the positive phase of the Southern Annular Mode has been reported, which is associated with a poleward shift of the midlatitude jet and storm tracks. It has been suggested that these changes are primarily due to the effects of stratospheric ozone depletion. Stratospheric ozone depletion cools the polar stratosphere, causing the polar vortex to persist longer, thus delaying stratospheric final warming events. In the second part of this study, we examine stratospheric final warming events in the Southern Hemisphere using data from the NCEP/NCAR Reanalysis. Our results confirm a statistically significant trend towards later final warming events over the last several decades. We also test the hypothesis that the observed trends in surface winds are directly consequent on this trend towards later final warming events. To do this, we examine composite differences between years of large ozone depletion and the pre-ozone-hole years. Our results indicate that the observed changes in surface winds cannot be attributed to the trend towards later final warming events.