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Impacts of Convective Gravity Wave Drag in the Southern Hemisphere Winter Stratosphere

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Excessive cold pole and stronger polar vortex in the southern hemisphere (SH) winter stratosphere are the long-lasting problem in most general circulation models (GCMs). Recent studies show that this problem is related to the underestimated model wave drag in the SH winter extratropical stratosphere, especially by underestimated or missing gravity wave drag (GWD) in the SH. Convective GWD is one of the major missing GWDs in most current GCMs that could significantly influence on the temperature and polar vortex in the SH winter stratosphere. Cumulus convection is strong in the storm track regions of the winter extratropics as well as in the tropics, and thus convectively induced gravity waves provide substantial wave drag in the SH winter stratosphere. The non-orographic GWD parameterizations that do not consider specific sources may not realistically represent the GWD in those specific regions. In this study, we use the Whole Atmosphere Community Climate Model (WACCM) and show that the temperature and wind biases in the SH winter stratosphere of the model in the June-August (JJA) climatology are significantly alleviated by including two convective gravity wave drag (GWDC) parameterizations (a columnar scheme and a ray-based scheme). The reduction in the wind biases is due to directly the addition of GWDC in the SH midlatitudes and indirectly the enhanced resolved wave drag in response to GWDC. The enhanced wave drag also improves the springtime breakdown of the SH vortex that delayed in the simulation without GWDC. The cold temperature biases are alleviated by increased downwelling in the SH winter polar regions, which stems from an increased poleward motion due to the enhanced wave drag in the midlatitudes.