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Wintertime biases in the EC-EARTH stratosphere: CMIP6 version

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The aim of this study is to comprehensively assess the boreal winter climatology of the European Consortium Earth-system model (EC-EARTH), specifically the contributing version to CMIP6, v3.3. To identify model biases, the climatological stratospheric circulation of a 100-year long simulation with prescribed climatological boundary conditions and fixed radiative forcing, representative of present-day climate, is compared to reanalysis data. An important issue is found in the vertical distribution of stratospheric temperature from the tropics to mid-latitudes in EC-EARTH, which is seemingly linked to radiative processes of ozone, leading to a biased warm middle-upper stratosphere. Consistent with this bias, the Brewer-Dobson circulation at middle/lower levels is weaker than reanalysis while the polar vortex in EC-EARTH is stronger at the upper-stratosphere. The amplitude of Planetary waves is overall underestimated, but the magnitude of the background wave injection from the troposphere into the stratosphere is overestimated in relation to a weaker polar vortex at lower-stratospheric levels and thus less effective wave filtering. The overestimation of the background wave driving is maximum in early-winter and consistent with an increase of sudden stratospheric warmings at this time, as compared to reanalysis. When the wave injection climatology is decomposed spatially, a distinctive role of the planetary waves is revealed: while large-scale waves (wavenumbers 1-2) dominate the eddy heat flux over the North Pacific, small-scale waves (wavenumbers 3-4) are responsible for the doubled-lobe structure of the eddy heat flux over Eurasia. EC-EARTH properly simulates this climatological feature, although overestimates its amplitude over central Eurasia.