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The impact of surface temperature variability on the climate change response in the NH polar vortex

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The response in the high-latitude Northern Hemisphere winter stratosphere to an increase in atmospheric CO2 depends strongly on the basic state of the control climate, which in turn is largely determined by the surface temperature. The majority of CO2-doubling or IPCC-like long-term climate change experiments undertaken with stratosphere-resolving GCMs prescribe monthly mean sea surface temperatures as a boundary condition; these are then interpolated linearly to daily values. When surface temperatures are calculated interactively by a slab (or full) ocean coupled to the GCM, energy is conserved at the surface and daily variability in the surface conditions is maintained. However, practical computational considerations generally preclude this approach in state-of-the-art GCMs. We use a middle-atmosphere Chemistry-Climate Model with physics parametrizations of intermediate complexity (the IGCM-FASTOC) to investigate the effect of suppressing daily or monthly variability. Five CO2-doubling experiments are undertaken, each consisting of a control and a CO2-doubling simulation, run for 100 years (timeslice) each. Different combinations of land and sea surface temperatures are used: either calculated interactively, prescribed and interannually varying, or prescribed with a climatological seasonal cycle. The strongest response to CO2-doubling in the Northern Hemisphere high-latitude winter stratosphere is found when surface temperatures are calculated interactively by a coupled slab ocean and a land surface scheme. Both the interannual variability in ocean and land temperatures, and the adjustment of oceans and lands to the atmosphere and to one another, are important in order to maintain realistic stratospheric forcing by planetary waves and to adequately capture the stratospheric response to global warming.