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Assessing GFDL-ESM4.1 Climate Responses to CESM2-WACCM6 Geoengineering Forcing for 2.0°C Warming Target

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In this work we apply GFDL Earth System Model (GFDL-ESM4.1) to explore the climate responses to a geoengineering scenario that aims to restrict global warming to 2.0°C above pre-industrial levels (1850–1900) under the CMIP6 overshoot scenario (SSP534-OS) . Simulations of this geoengineering scenario with the CESM Whole Atmosphere Community Climate Model (CESM2-WACCM6) showed nearly unchanged interhemispheric and pole-to-Equator surface temperature gradients relative to present-day conditions around 2020, and reduced global impacts, such as heatwaves, sea ice melting, and large shifts in precipitation patterns (Tilmes et al 2020). Here we implement the identical stratospheric forcing in the GFDL-ESM4.1 model and find excessive global surface cooling and reduced precipitation responses, compared to those projected in CESM2-WACCM. Notably, the Southern Hemisphere experiences more substantial cooling compared to the Northern Hemisphere, accompanied by a north-ward shift in the Intertropical Convergence Zone (ITCZ). These distinct climate responses between GFDL-ESM4.1 and CESM2-WACCM6 can be traced back to their different climate feedback parameters. Furthermore, our analysis reveals that spatially heterogeneous forcing within the geoengineering scenario results in diverse climate feedback parameters even just in one model, through varying surface warming and cooling patterns. This research highlights the importance of considering model structure uncertainties and spatial forcing patterns for a comprehensive evaluation of future scenarios and geoengineering strategies.