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The Southern Hemisphere atmospheric circulation response to volcanic eruptions in coupled climate models

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Explosive volcanic eruptions that deposit aerosols into the stratosphere are one of the most important natural climate forcings. The eruptions provide an opportunity to validate climate models. Volcanic aerosols that remain in the stratosphere for a few years after the eruptions reflect solar visible radiation, causing cooling at the Earth's surface, and absorb solar near-infrared and terrestrial radiation, causing warming of the stratosphere. Known impacts of large eruptions also include a strengthening of the Northern Hemispheric (NH) stratospheric polar vortex and the tropospheric mid-latitude westerly winds in the winters following the eruption. The strengthened extratropical zonal circulation corresponds to a positive phase of the Northern Annular Mode. The NH dynamical response is reproduced by climate models, albeit with a weaker magnitude. Whether or not a dynamical response to large volcanic eruptions exists in the Southern Hemisphere (SH) remains unclear. Here we study the response of the SH circulation to the 1982 eruption of El Chichón and 1991 eruption of Pinatubo volcanoes in a suite of up-to-date coupled climate models. We find a significant response in austral spring and fall in the years following the eruptions, which consists of a stronger stratospheric polar vortex and lowered sea level pressure over the Antarctic, both consistent with the positive phase of the Southern Annular Mode. The seasonality of the response may be explained in terms of zonal flow-planetary wave interactions. This dynamical response is inconsistent with the observational reanalyses in the polar stratosphere in spring, but not in the troposphere where the internal variability representing the noise is large. Mechanisms that may explain the inconsistency are tested and the results are discussed.