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Maintenance of polar stratospheric clouds in a moist stratosphere

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Abstract. Previous work has shown that polar stratospheric clouds (PSCs) could have acted to substantially warm high latitude regions during past warm climates such as the Eocene (55 Ma). Using a simple model of stratospheric water vapor transport and polar stratospheric cloud (PSC) formation, we investigate the dependence of PSC optical depth on tropopause temperature, cloud microphysical parameters, stratospheric overturning, and tropospheric methane. We show that PSC radiative effects can help slow removal of water from the stratosphere via self-heating. However, we also show that the ability of PSCs to have a substantial impact on climate depends strongly on the PSC particle number density and the strength of the overturning circulation. Thus even a large source of stratospheric water vapor (e.g. from methane oxidation) will not result in substantial PSC radiative effects unless PSC ice crystal number density is high compared to most current observations, and stratospheric overturning (which modulates polar stratospheric temperatures) is low. These results are supported by analysis of a series of runs of the NCAR WACCM model with methane concentrations varying up to one thousand times present levels.

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