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The global impact of supersaturation in a coupled chemistry-climate model

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Abstract. Ice supersaturation is important for understanding condensation in the upper troposphere. Many general circulation models however do not permit supersaturation. In this study, a coupled chemistry climate model, the Whole Atmosphere Community Climate Model (WACCM), is modified to include supersaturation for the ice phase. Rather than a study of a detailed parameterization of supersaturation, the study is intended as a sensitivity experiment, to understand the potential impact of supersaturation, and of expected changes to stratospheric water vapor, on climate and chemistry. High clouds decrease and water vapor in the stratosphere increases at a similar rate to the prescribed supersaturation (20% supersaturation increases water vapor by nearly 20%). The stratospheric Brewer-Dobson circulation slows at high southern latitudes, consistent with slight changes in temperature likely induced by changes to cloud radiative forcing. The cloud changes also cause an increase in the seasonal cycle of near tropopause temperatures, increasing them in boreal summer over boreal winter. There are also impacts on chemistry, with small increases in ozone in the tropical lower stratosphere driven by enhanced production. The radiative impact of changing water vapor is dominated by the reduction in cloud forcing associated with fewer clouds ($\sim$+0.6 Wm^{-2}) with a small component likely from the radiative effect (greenhouse trapping) of the extra water vapor ($\sim$+0.2 Wm^{-2}), consistent with previous work. Representing supersaturation is thus important, and changes to supersaturation resulting from changes in aerosol loading for example, might have a modest impact on global radiative forcing, mostly through changes to clouds. There is no evidence of a strong impact of water vapor on tropical tropopause temperatures.

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