Geophysical Research Abstracts
Vol. 14, EGU2012-12752, 2012
EGU General Assembly 2012

Polar Stratospheric Clouds in SD-WACCM4

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Polar stratospheric clouds (PSCs) play an important part in the processes causing the depletion of ozone in the polar stratosphere. These clouds provide reactions sites for heterogeneous chemistry and some cloud particles grow big enough to sediment out of the stratosphere efficiently denitrifying and dehydrating the lower stratosphere thus delaying the deactivation of photochemically active chlorine species. PSCs are composed of nitric acid trihydrate (NAT), water ice and supercooled ternary solutions (STS) which form when nitric acid and water vapor condense on the background aerosol. Despite their importance the formation mechanism is still not completely understood and current atmospheric models rely on simplified parameterizations and assumptions to simulate these clouds.

We investigate the composition and occurrence of PSCs in the Specified Dynamics version of the Whole Atmosphere Community Climate Model (SD-WACCM). SD-WACCM assumes all PSCs are in thermodynamic equilibrium. This leads to a sharp onset of PSCs in the model when the specified supersaturation for NAT nucleation is reached. As temperatures decrease further NAT transitions into STS with mixed PSCs occurring only over a small temperature range.
We use observations of gas-phase HNO_3 from MLS for May and June 2005 over the Antarctic to evaluate PSC formation in SD-WACCM. Removal of gas-phase HNO_3 can be seen as an indicator of PSC formation and the temperature dependence of HNO_3 removal as indicator which type of PSC was present. Observations suggest most of the initial removal of gas-phase HNO_3 is due to the formation of STS and recent studies using CALIPSO show mixed PSCs occurring over the whole winter.

While overall denitrification in SD-WACCM agrees with observations PSC composition differs from observations. With small changes to the existing PSC scheme we improve their representation in the model without changing the extent of denitrification. NAT still forms at a specified supersaturation but only a prescribed fraction of HNO_3 is allowed to nucleate to NAT. With decreasing temperature the remaining fraction condenses to form STS. This causes STS to be the dominant PSC type while NAT is present throughout the whole winter, essentially forming mixed PSCs.
Dehydration in SD-WACCM is stronger than observations show. Therefore, we changed the treatment of ice PSC improving the agreement with observations.