EGU23-3650, updated on 23 Apr 2024
https://doi.org/10.5194/egusphere-egu23-3650
EGU General Assembly 2023

Effects of denitrification on the distributions of trace gas abundances in the polar regions: Comparison of the Whole Atmosphere Community Climate Model with observations

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Polar stratospheric clouds (PSCs) play a key role in the polar chemistry of the stratosphere. Nitric acid trihydrate (NAT) particles have been shown to lead to denitrification of the lower stratosphere. While the existence of large NAT particles (NAT "rocks") has been verified by many measurements, especially in the Northern Hemisphere (NH), most current chemistry-climate models use simplified parametrizations, often based on evaluations in the Southern Hemisphere where the polar vortex is stable enough that accounting for NAT rocks is not as important as in the NH. Here, we evaluate the probability density functions of various gaseous species in the polar vortex using one such model, the Whole Atmosphere Community Climate Model (WACCM), and compare these with measurements by the Michelson Interferometer for Passive Atmospheric Sounding onboard the Environmental Satellite (MIPAS/Envisat) and two ozonesonde stations for a range of years and in both hemispheres. Using the maximum difference between the distributions of MIPAS and WACCM as a measure of coherence, we find better agreement for HNO_3 when reducing the NAT number density from the standard value of 1 x 10^{-2} cm^{-3} used in this model to 5 × 10^{-4} cm^{-3} for almost all spring seasons during the MIPAS period in both hemispheres. The distributions of $ClONO_2$ and O_3 are not greatly affected by the choice of NAT density. The average difference of WACCM to ozonesondes supports the need to reduce the NAT number density in the model. Therefore, this study suggests using a NAT number density of 5 × 10^{-4} cm^{-3} for future simulations with WACCM.