

Interactive comment on “Formation of large NAT particles and denitrification in polar stratosphere: possible role of cosmic rays and effect of solar activity” by F. Yu

Anonymous Referee #2

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Yu presents a hypothesis that nucleation of solid nitric acid containing hydrates by interaction with cosmic rays can explain the selective nucleation of PSCs leading to denitrification [e.g. Fahey et al., 2001].

A number of previous studies have shown that a bulk nucleation rate of order $1 \times 10^{-5} \text{ cm}^{-3} \text{ h}^{-1}$ is sufficient to describe the observed particle size distribution and rate of denitrification. The simulations shown in section 3 are not terribly illuminating as they essentially reproduce these earlier studies. The real question addressed here is whether cosmic-ray induced freezing (CRIF) is a viable mechanism for the selective nucleation. I have doubts.

CRIF has been previously reviewed by Harrison and Carslaw. Yu provides greater

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physical discussion of CRIF than described by Harrison and Carslaw, and in this regard the manuscript is a contribution. The data of Detwiler and Seeley, however, suggest that this mechanism may not be viable. Clearly, further laboratory information is required to test CRIF at higher energies. The critical question is what is the value of P_2 ? Yu concludes that a value of 0.1 is required to yield the required nucleation rate. Yu provides no physical reason, however, that such a high efficiency is reasonable other than it provides sufficient nucleation to yield the observed nucleation (e.g. circular). We know, for example, that H_2SO_4 droplets remain supercooled in the stratosphere essentially forever. Clearly for these particles P_2 must be much lower. The second argument put forward are the observations by Shumilov et al. of correlations of lidar signals with solar proton events (SPE). Yu argues that Shumilov et al.'s explanation of new particle formation cannot be correct because of the lack of H_2SO_4 . This argument is not strong. We know 1) that new particles are formed in the polar vortex due to the subsidence of air from the upper stratosphere and mesosphere with high H_2SO_4 and 2) it is possible that new NAT or NAD particles are nucleated in the supersaturated (in H_2O and HNO_3) air on the large number of ions formed (not CRIF), e.g. no H_2SO_4 is involved. Finally, the suggested correlation of NO_3^- in ice cores with SPE is suggested as evidence. Unless Yu has a suggestion for how the NAT particles make it to the surface, it is hard to understand how this correlation supports his mechanism.

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