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Investigation of heterogeneous NAT nucleation mechanisms using polar stratospheric cloud backscatter measurements onboard the CALIPSO satellite

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In the past 25 years since it became evident that polar stratospheric clouds (PSCs) play a major role in the springtime depletion of polar ozone, their detailed composition and morphology has been an area of interest. Although our knowledge on PSCs is substantial, there is still considerable uncertainty in specific key areas related to their composition and formation. Probably the least well understood of these is the nucleation process responsible for the formation of nitric acid trihydrate (NAT) particles and the circumstances under which NAT formation and growth leads to stratospheric denitrification. Backscatter measurements onboard the CALIPSO satellite have already produced an extensive set of PSC observations with unprecedented spatial and temporal resolution covering five winters. These observations are providing new insight into the key remaining questions regarding PSC composition and formation mechanisms. Here we examine CALIPSO PSC observations in combination with a microphysical model in attempt to better understand the underlying physical mechanisms for NAT nucleation. Of particular interest is the early phase of the 2009-2010 Arctic winter when CALIPSO frequently observed extended regions of tenuous NAT clouds, clearly before ice was present in the polar vortex. This provides unprecedented large-scale evidence that ice particles are not the only nuclei on which NAT may form. Microphysical model calculations along backward trajectories from these CALIPSO NAT cloud observations are used to investigate possible ice-independent, heterogeneous NAT nucleation mechanisms. These analyses will then be expanded to other winters to assess the overall significance of an ice-independent nucleation mechanism for NAT PSCs.