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Polar Stratospheric Cloud Composition Studies Using CALIPSO Data

Michael Pitts (1), Lamont Poole (2), and Larry Thomason (3)

(1) NASA Langley Research Center, Science Directorate, Hampton, United States (Michael.C.Pitts@nasa.gov), (2) Science Systems and Applications, Incorporated, Hampton, United States (Lamont.R.Poole@nasa.gov), (3) NASA Langley Research Center, Science Directorate, Hampton, United States (l.w.thomason@nasa.gov)

After more than two decades of study, much has been learned about polar stratospheric clouds (PSCs) and how they perturb stratospheric chemical cycles and catalyze ozone depletion. However, the observational database of PSCs is actually relatively sparse and there is still considerable uncertainty in their formation mechanisms. With the advent of the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations (CALIPSO) mission in 2006, new insight into PSC morphology is becoming available. The polarization-sensitive CALIOP (Cloud-Aerosol LIdar with Orthogonal Polarization) lidar system onboard the CALIPSO spacecraft is acquiring, on average, over 300,000 profiles per day at latitudes poleward of 55^o (including the polar night region up to 82^o), providing a unique opportunity for PSC studies. Our second-generation CALIPSO PSC algorithm utilizes both the CALIOP 532-nm scattering ratio (ratio of total to molecular backscatter coefficients) and 532-nm perpendicular backscatter coefficient for cloud detection and an innovative successive horizontal averaging scheme which enables the detection of strongly backscattering PSCs at fine (5-km) resolution and more tenuous clouds at increasingly coarser scales. Including the perpendicular backscatter measurements enhances the detection of tenuous PSC mixtures containing solid particles (presumably nitric acid trihydrate, or NAT) in low number densities. In addition, we have implemented a scheme for classifying PSCs by composition in terms of their ensemble backscatter and depolarization in a manner analogous to that used in previous ground-based and airborne lidar studies. Based on optical model calculations for mixtures of liquid aerosol droplets with oblate NAT or ice spheroids, we have defined four CALIOP-based PSC composition classes: supercooled ternary solution (STS), ice, Mix1, and Mix2, with the latter two denoting mixtures of liquid aerosol with NAT particles in lower or higher number densities/volumes, respectively.

In this paper, we present example results for PSC coverage and composition for the four Antarctic and Arctic seasons probed by CALIOP to date, illustrating interannual variability in PSC areal coverage and the well-known contrast between the Antarctic and Arctic. We also show distinctive seasonal and altitudinal variations in Antarctic PSC composition, which can be related to changes in HNO_3 and H_2O observed by the Microwave Limb Sounder on the Aura satellite. Finally, we explore potential NAT PSC nucleation mechanisms through example case studies of CALIOP data using a PSC microphysics/optics model. Examples from the recent RECONCILE field campaign will be shown if available.