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Towards heterogeneous ice and NAT nucleation rates based on PSC observations in the Arctic winter 2009/2010

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Polar Stratospheric Clouds (PSCs) form in the winter polar stratosphere at low temperatures and play an important role in polar ozone chemistry. The nucleation mechanisms of nitric acid trihydrate (NAT) and ice particles are presently put to test by the EU-projects RECONCILE and LAPBIAT2. An extensive field campaign took place in the Arctic winter 2009/2010 with unprecedented PSC observations resulting from unusually low stratospheric temperatures from mid-December to late January.

The compact optical backscatter aerosol detector (COBALD) measured PSC backscatter (at 455 and 870 nm) in 8 sonde launches from Ny-Ålesund, Spitsbergen, and in 7 sonde launches from Sodankyla, Finland. In Sodankyla, the COBALD sondes flew as tandem with a cryogenic frost point hygrometer (CFH) and with a fluorescent Lyman-α stratospheric hygrometer (FLASH-B). Some of these soundings were coordinated with overpasses of CALIPSO (the Cloud-Aerosol Lidar and Infrared Pathfinder Satellite Observations) and with flights of the stratospheric research aircraft Geophysica.

Closely matched measurements between CALIPSO and COBALD agree well in their backscatter profiles at PSC levels. Soundings were analyzed by extensive trajectory and microphysical box model calculations. On 17 January 2010 the backscatter ratio at 870 nm above Sodankyla reaches values up to 100, which in combination with the simultaneously observed decrease in water vapor indicates an ice cloud. In contrast, temperatures only slightly below the frost point exclude the possibility of homogenous formation on synoptic scale. We show that wave clouds, not resolved in the ECMWF operational data, can reconcile the model results and the observations.

In the early phase of the winter, CALIPSO frequently observed liquid/NAT mixture PSCs with NAT particles occurring in low number densities before ice was present in the polar vortex. We will present preliminary results from backward trajectories starting from a large number of NAT clouds detected by CALIPSO in December 2009. By means of a statistical evaluation we investigate the occurrence of different PSC types with respect to a dependence on intensity and duration of supercoolings below the NAT equilibrium temperature derived from ECMWF temperatures along the trajectories. This might present a pathway to quantify the NAT nucleation rate for a heterogeneous, ice-independent nucleation mechanism, e.g. on meteoritic particles.