Geophysical Research Abstracts
Vol. 15, EGU2013-12042, 2013
EGU General Assembly 2013

First temperature measurements within Polar Stratospheric Clouds with the Esrange lidar

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In the winter stratosphere polar stratospheric clouds (PSCs) provide the surface for heterogeneous reactions which transform stable chlorine and bromine species into their highly reactive ozone-destroying states. PSCs are classified into three types (PSC Ia: nitric acid di- or trihydrate crystals, NAD or NAT; PSC Ib: supercooled liquid ternary solutions, STS; PSC II: ice) according to their particle composition and to their physical phase.

The formation of PSCs depends strongly on temperature. For a comprehensive understanding of such temperature–dependent processes in the lower stratosphere, lidar measurements using the rotational–Raman technique are most suitable. The rotational–Raman technique allows for temperature measurements without a priori assumptions of the state of the atmosphere. The technique is feasible in aerosol layers and clouds, such as PSCs. A rotational–Raman channel for temperature measurements in the upper troposphere and lower stratosphere was added to the Esrange lidar in late 2010. The Esrange lidar operates at Esrange (68°N, 21°E) near the Swedish city of Kiruna. By combining rotational–Raman measurements (4–35 km height) and the integration technique (30–80 km height), the Esrange lidar is now capable of measuring atmospheric temperature profiles from the upper troposphere up to the mesosphere. Such measurements could be used to validate current lidar-based PSC classification schemes and the current understanding of PSC formation. The new capability of the instrument furthermore enables the studies of other clouds layers, temperature variations and exchange processes in the upper troposphere/lower stratosphere. These studies will take advantage of the geographical location of Esrange where mountain wave activity in the lee of the Scandinavian mountain range gives rise to a wide range of PSC growth conditions. Although several lidars are operated at polar latitudes, there are few instruments that are capable of measuring temperature profiles in the troposphere, stratosphere, and mesosphere, as well as aerosols extinction in the troposphere and lower stratosphere.

In this study, we utilize measurements of PSCs and temperature during the winters 2010/11, 2011/12, and 2012/13 to gain insight into the temperature dependence of different PSC types.