CALIPSO Observations of PSCs and Cirrus during the 2015-2016 Arctc Winter

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Introduction

Polar stratospheric clouds (PSCs) have been observed by CALIPSO over vortex-wide scales during every polar winter since the satellite was launched in 2006. Although differing in detail, PSC seasons in the Antarctic exhibit a high degree of year-to-year similarity. This is not the case in the Arctic, where the extent and duration of the low temperatures required for PSC formation vary greatly from year to year. Compared to previous winters, the 2015-2016 Arctic winter was unusually cold from mid-December through January, with minimum temperatures at 50 hPa lower than observed over the past 35+ years and synoptic-scale regions of temperature below the frost point. The present Arctic winter was also exceptional from the CALIPSO perspective with more PSCs observed than in any of the nine previous Arctic seasons, including the 2010-2011 season in which significant Arctic ozone loss occurred. During the 2015-2016 winter and spring, the POLSTRACC (POLar STRAtosphere in a Changing Climate) field campaign, coordinated by the Karlsruhe Institute of Technology (Karlsruhe, Germany), is being conducted from Arena Arctica in Kiruna, Sweden, featuring a number of flights of the German HALO (High-Altitude and LOng Range) research aircraft. In this poster, we illustrate the uniqueness of the 2015-2016 season and describe the evolution of PSCs as observed by CALIPSO during December and January. We also show the first-ever comparisons of matched CALIOP PSC observations with upward-looking data from the German WALES ((Water vApour Lidar Experiment in Space) high-spectral resolution lidar system flown on the HALO aircraft.

Exceptionally Cold and Stable Vortex

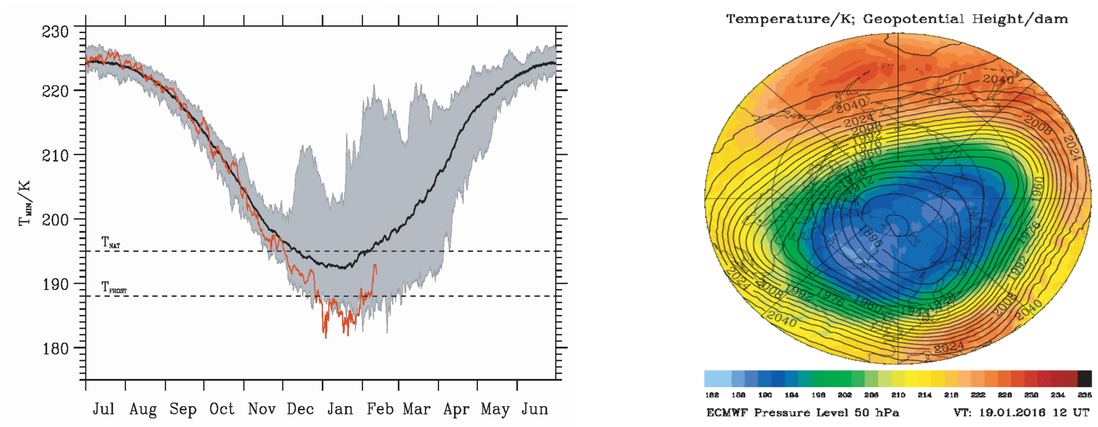
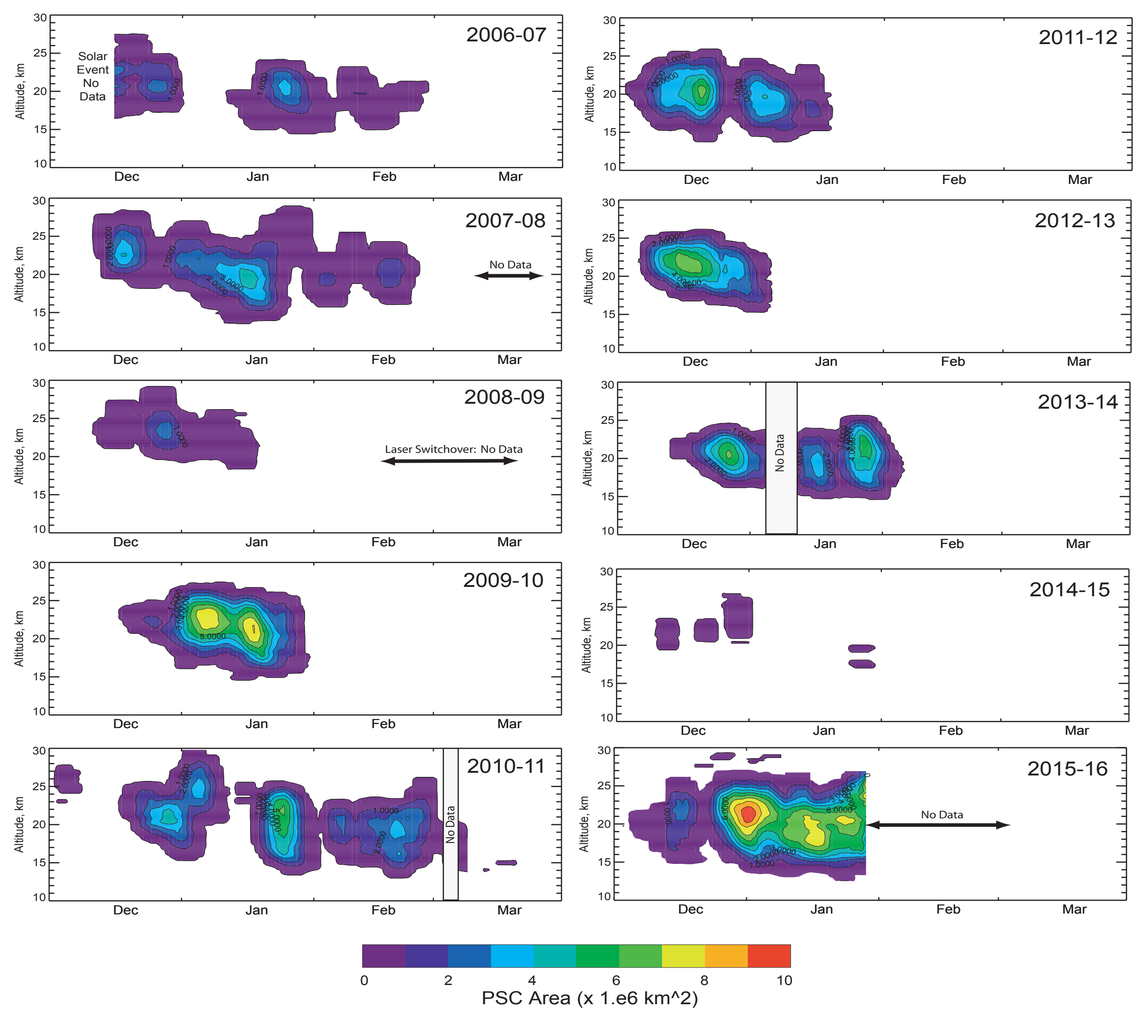


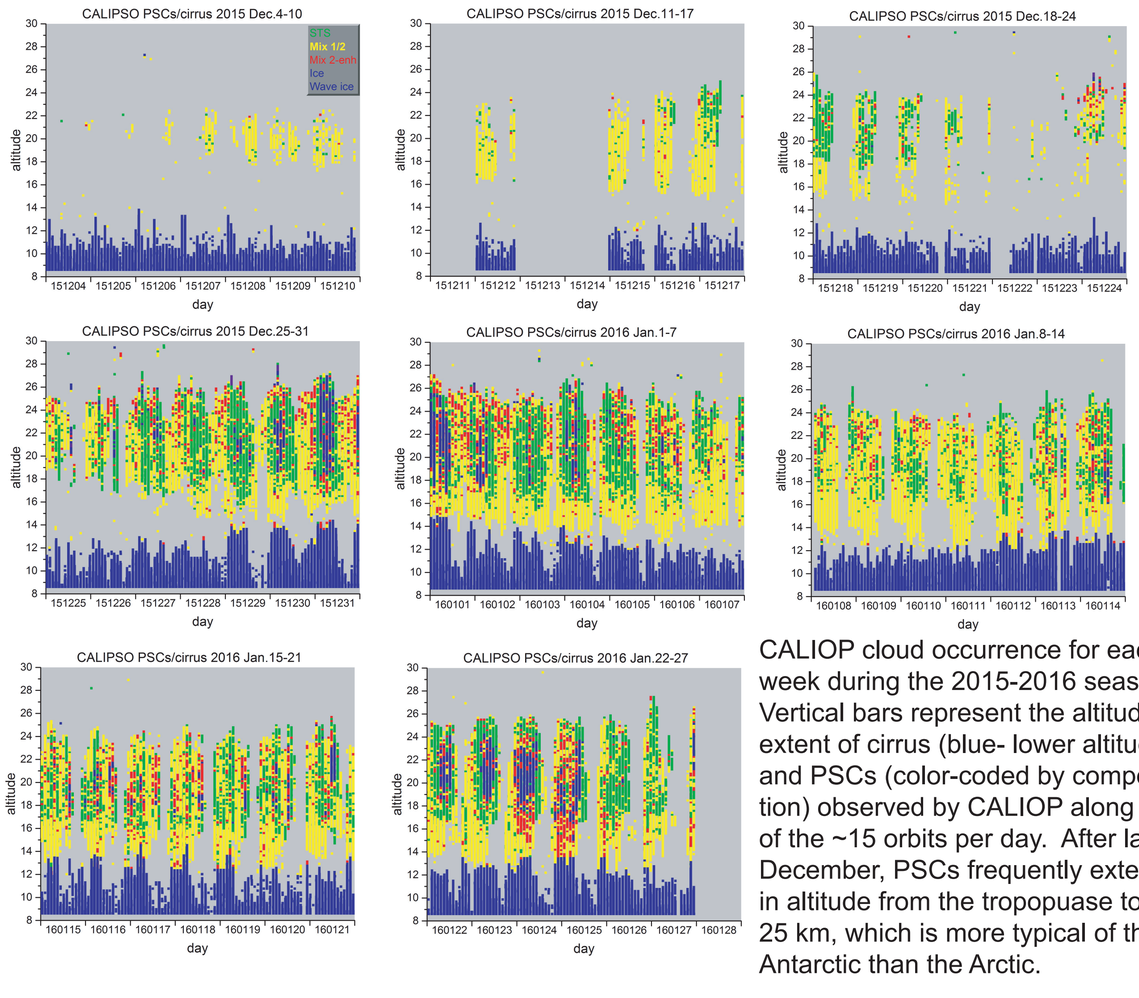
Figure on left: minimum temperature between 65°N to 90°N on the 50 hPa pressure surface. Black line: mean value from 1979-2015; red line: evolution of T_{min} from July 2015 through mid-February 2016; shaded area encompasses the minimum/maximum T_{min} between 1979-2015. Source: ECMWF reanalyses interim (ERA interim) data. Figure on right: typical structure of vortex at 50 hPa during the winter.

CALIOP PSC Areas



Time series of the spatial extent of PSCs observed by CALIOP during each of the ten Arctic PSC seasons from 2006 through 2016. The spatial coverage and altitude extent of PSCs during the 2015-2016 season are significantly larger than any of the previous nine seasons.

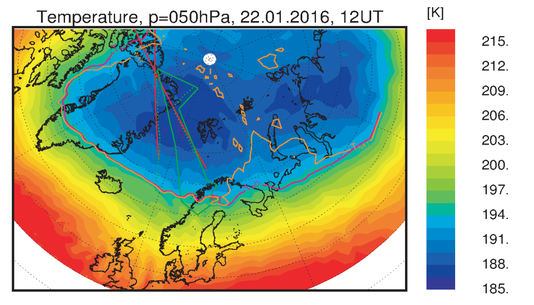
Evolution of 2015-16 PSC Season

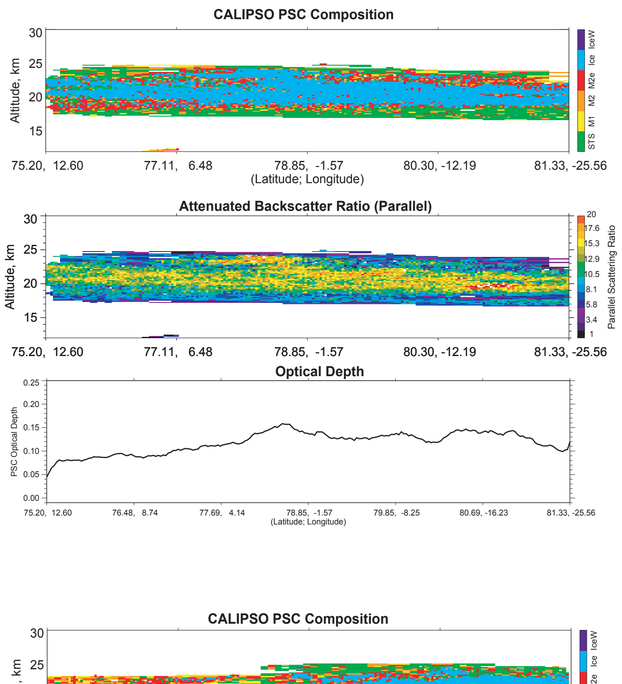


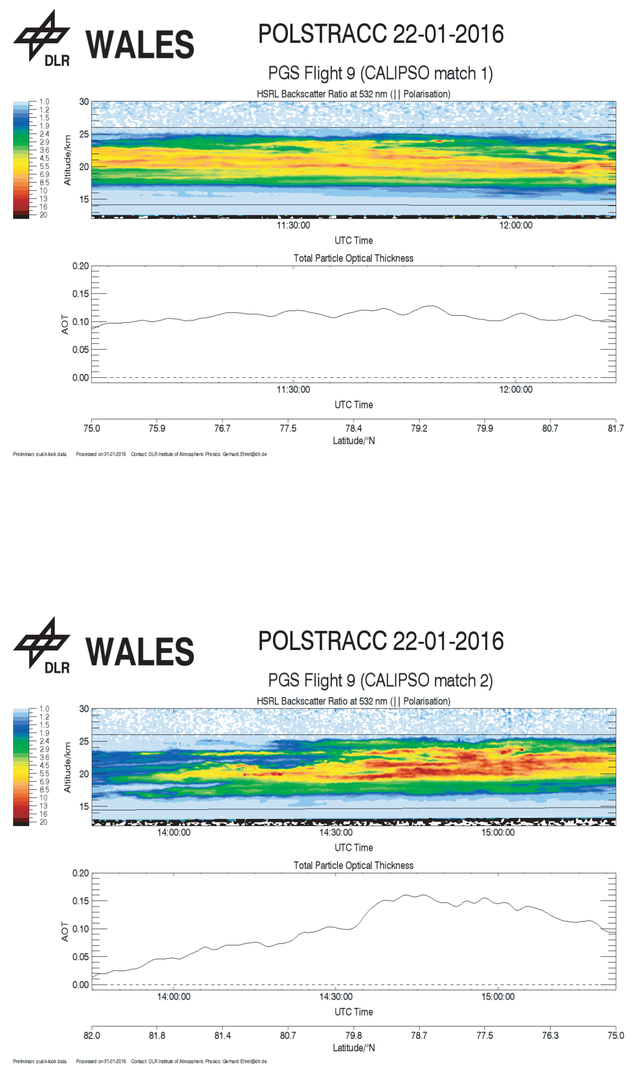
CALIOP cloud occurrence for each week during the 2015-2016 season. Vertical bars represent the altitude extent of cirrus (blue- lower altitudes) and PSCs (color-coded by composition) observed by CALIOP along each of the ~15 orbits per day. After late December, PSCs frequently extended in altitude from the tropopuase to 25 km, which is more typical of the Antarctic than the Arctic.

Preliminary Comparisons of CALIOP and WALES HSRL

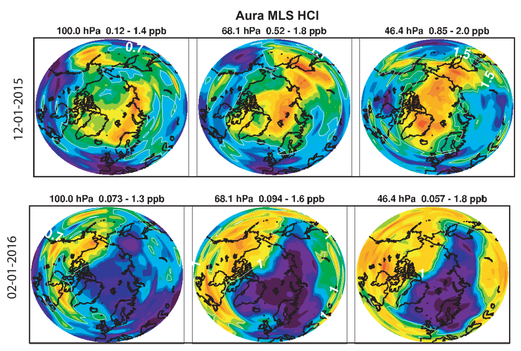
Figure on right: CALIPSO orbit tracks (red) and HALO flight path (green) from HALO flight on 22 January 2016. Dashed green lines represent back trajectories from the HALO flight path to the two CALIPSO orbits at time of overpass. Figures below show preliminary comparisons of CALIOP (left) and WALES (right) quicklook data products from the two matched segments. PSC optical depths are integrated over the vertical extent of the clouds.

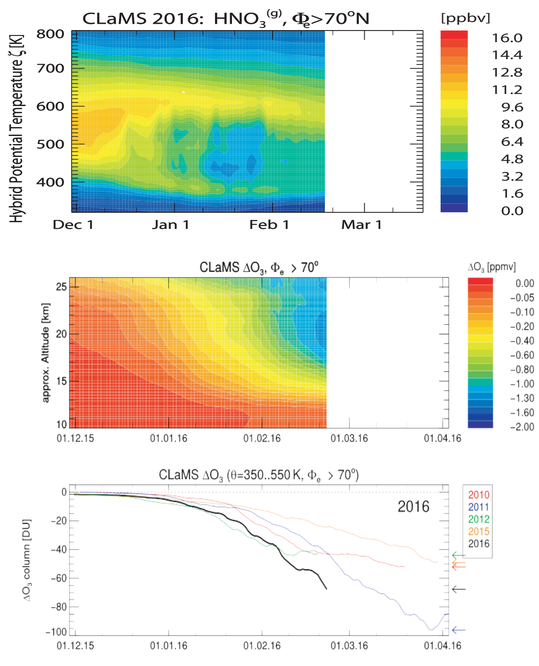






PSC processing setting the stage for record O_3 loss?





Above: Aura MLS HCl maps for December 1, 2015 (top row) and February 1, 2016 (bottom row) at three different pressure levels. Right top:Time evolution of stratospheric HNO_3 from the CLaMS model. Right middle: Time evolution of stratospheric O_3 from the CLaMS model. Right bottom: CLaMS column O_3 loss for this season to date. Widespread PSCs led to almost complete chlorine activation and redistribution of HNO_3, resulting in unprecedented late winter O_3 loss.

Summary

- Exceptionally cold and stable vortex led to unusually active PSC season with cloud occurrence on unprecedented horizontal and vertical scales
- Frequent high tropopause events occurred with cirrus/PSCs extending from troposphere to > 25 km
- Widespread NAT particle sedimentation led to significant redistribution of HNO_3 to z<14 km
- Extensive PSCs led to almost complete chlorine activation by late January possibly setting stage for record Arctic O_3 loss
- Preliminary comparions of CALIOP PSC backscatter and optical depth with matched uplooking airborne HSRL data indicate excellent agreement

Acknowledgements

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WALES lidar data provided by Martin Wirth, DLR, Institut für Physik der Atmosphäre Oberpfaffenhofen, Germany