Polar Stratospheric Clouds at Rothera and South Pole: Lidar Observations and Polar Vortex Effects

Wentao Huang[1], Xinzhao Chu[1], Shawn E. Simpson[2], Graeme J. Nott[3], and Patrick J. Espy[4]

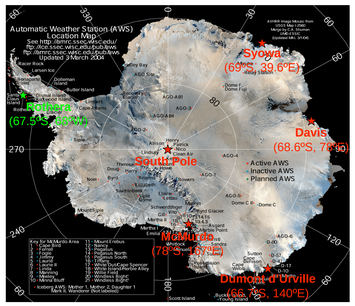
[1]University of Colorado at Boulder, [2]Columbia University, [3]Dalhousie University, [4]British Antarctic Survey

1. Introduction: Why to Study Polar Stratospheric Clouds?

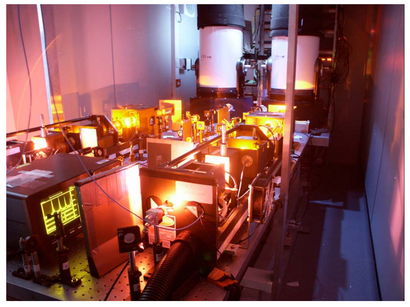
- Polar stratospheric clouds (PSC) are a critical factor of the ozone chemistry responsible for the Antarctic ozone hole.
- PSCs are strongly correlated with stratospheric temperature, aerosol injection, water vapor and tracer gas contents as well as the polar vortex activity, volcanic eruption, and mountain waves.
- Type II PSCs are possibly a significant climate forcing-factor (a winter warming mechanism) that is underestimated in current GCMs.

2. Ground-Based Lidar Observations of PSCs in Antarctica

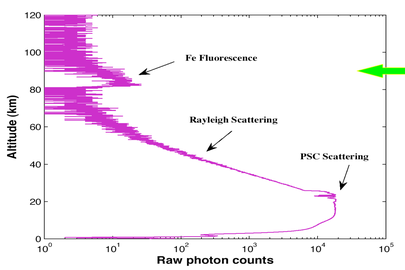
Our Observation is the First in West Antarctica



UIUC Fe Boltzmann / Rayleigh Lidar at Rothera

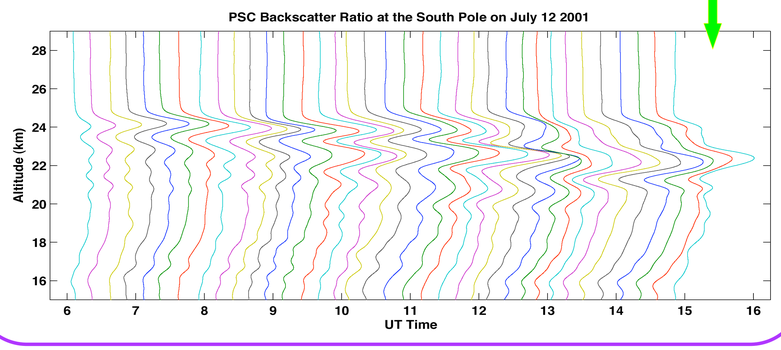


The PSC observations at Rothera and South Pole were made with the UIUC Fe Boltzmann/Rayleigh lidar, which is a dual-channel resonance-fluorescence lidar operating at 372 and 374 nm with full-diurnal coverage.



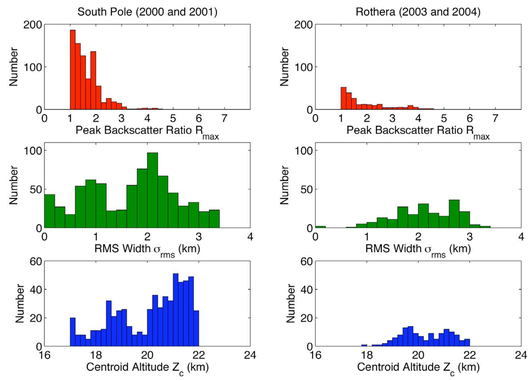
Raw data profile (15-min integration) of the range-resolved lidar signal from the 374-nm channel.

PSC backscatter ratio profile and its temporal evolution, clearly showing wave structure and propagation due to gravity wave activities.



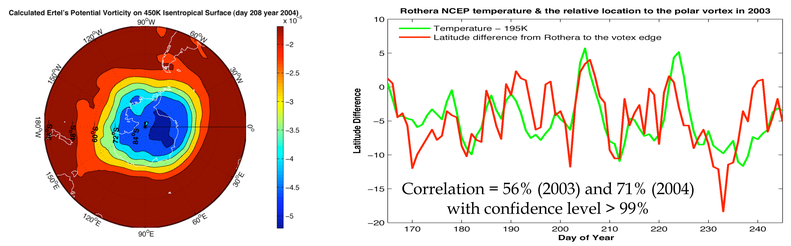
3. Mean Characteristics of PSCs at South Pole and Rothera

	South Pole			Rothera		
Year	**2000**	**2001**	**Overall**	**2003**	**2004**	**Overall**
R	1.9±0.7	1.5±0.4	1.6±0.5	1.7±0.6	2.2±1.1	1.9±0.8
σ_{rms} (km)	2.5±0.8	1.5±0.9	1.9±1.0	2.0±0.7	2.3±0.5	2.1±0.6
Z_C (km)	19.7±1.9	20.8±2.0	20.4±2.0	20.4±1.3	22.5±1.1	21.2±1.6
Total Obs hour	95.4	217.3	312.7	138.9	138.9	277.8
Total PSC hour	72.3	142.3	214.6	39.5	18.8	58.3
Occurrence	75.7%	65.5%	68.6%	28.4%	13.5%	21.0%
PSC Start	May 28	Jun 11		Jun 16	Jul 12	
PSC End	Sep 6	Oct 11		Oct 5	Aug 24	

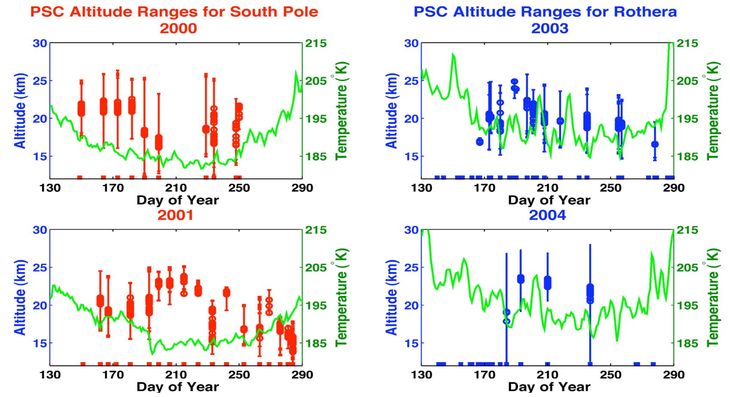


- PSC backscatter ratio, centroid altitude, and RMS width are comparable at Rothera and South Pole.
- PSC occur much more frequently and with longer season at the Pole than at Rothera, which is consistent with the longer persistence of colder stratospheric temperature at the Pole through the winter/spring.

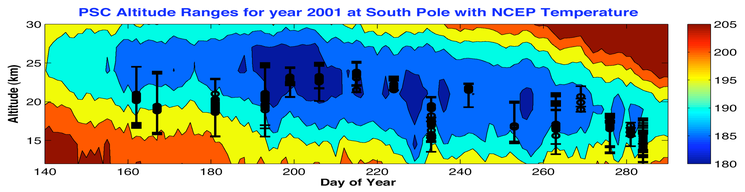
4. Polar Vorticity (NCEP) and Temperature - Vortex Correlation



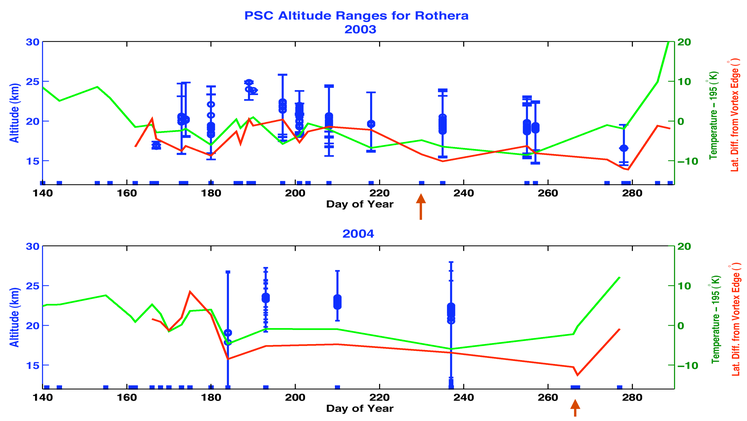
5. Correlations of PSC with Temperature and Polar Vortex



PSCs were observed in the altitude range of 12-28 km at both Rothera and South Pole, showing a very good correlation with the stratospheric temperature (< 194 K) at 50 mbar (~21 km) excluding a few exceptions.



PSC centroid altitudes show a downward trend from mid-winter to spring, following the downward progression of the coldest stratospheric temperature - stratosphere warmed from the top downwards in spring.



Rothera distance from the polar vortex edge correlates with temperature at 50 mbar well - inside vortex giving lower atmosphere, favorable for PSC formation. However, polar vortex may prevent tracer gas and water vapor transportation across the boundary - unfavorable for PSC.

6. Discussion and Conclusions

- Rothera on 11 June 2003 (193.5 K), 6 July 2003 (193.2 K), 18 June 2004 (193.5 K): T(@50 mbar) < 194 K but no PSCs observed (following a sharp decrease of T > 196 K within 1-2 days) ⇨ the atmosphere is not cold long enough for PSC formation?
- Rothera on 18 August 2003 (190.2 K) and 22 September 2004 (192.8 K): T < 194 K, Rothera is about 10° inside polar vortex but no PSCs observed (temperature dropped below 194 K at least 3 days before the observations) ⇨ polar vortex preventing tracer gas and water vapor being transported from the outside when the stratosphere is already denitrified and dehydrated in the spring?
- Overall PSC are observed in the altitude range of 12-28 km from May/June to September/October at both Rothera (67.5°S) and South Pole with comparable characteristics. PSCs occur much less frequently and in shorter season at Rothera.
- PSC occurrence correlates well with local temperature that is strongly affected by the Antarctic polar vortex at Rothera. However, polar vortex may prevent the supply of tracer gas and water vapor, which could reduce the chance of forming new PSC when denitrification / dehydration occur in the stratosphere in the spring.