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FINAL REPORT FOR NASA 94-NASA-P/G-1718

TITLE

High Altitude Weather Balloons to Support Rayleigh and Sodium Lidar Studies of the Troposphere, Stratosphere and Mesosphere at the Amundsen-Scott South Pole Station

PI

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AMOUNT

$15,500

PERIOD

July 1,1995 - June 30, 1995

SUMMARY

This proposal funded 100 high altitude weather balloons costing $15,500 to support the deployment of a Rayleigh/Raman/Na lidar at the South Pole. One year of measurements have been completed and it is estimated that the balloons will provide another 1-2 years of data.

Background

This proposal funded 100 high altitude weather balloons costing $15,500 to support the deployment of a Rayleigh/Raman/Na lidar at the South Pole. The development funds for the lidar were awarded under NSF DPP90-18089 and renewed under NSF DPP92-19898. The lidar system combines a number of optical techniques to provide measurements of the Antarctic middle atmosphere from 10-110 km focusing on the characterization of Polar Stratospheric Clouds (PSCs).

The lidar system was deployed at the South Pole in November 1994 and is capable of measuring:

a) the backscatter ratio profiles of polar stratospheric clouds at the 1064 nm and 532 nm wavelengths and the depolarization ration profile at 532 nm,

b) tropospheric and stratospheric temperatures from approximately 2 km above the surface to approximately 30 km altitude using the N_2 Raman scattered signal at 607 nm,

c) middle atmospheric temperatures from 30 km altitude to approximately 70 km using the Rayleigh scattered signal at 532 nm.

The scientific goals are:

1) To completely characterize the morphology of polar stratospheric clouds and the conditions under which they form at the South Pole in winter. We are particularly interested in accurately classifying the cloud layers and in tracking any long-term changes in their characteristics.

2) To characterize the seasonal variations and long-term changes in tropospheric, stratospheric and mesospheric temperatures at the South Pole.

3) To study the vertical distribution and long-term variations in the characteristics of polar mesospheric clouds.

PSCs play a crucial role in the ozone chemistry of polar regions. Current chemical models rely on the presence of these clouds to explain the rapid destruction of ozone observed each spring in Antarctica. PSCs have been classified into three general types. [3] Type I PSCs are formed by the condensation of nitric acid trihydrate (NAT) on the particles of the background stratospheric sulfate layer. Type II PSCs are composed of water ice particles that form at colder temperatures on the pre-existing nitric acid particles. Under slow cooling conditions these ice particles grow to large sizes and sediment out of the stratosphere. This is the mechanism by which nitrogen compounds and water are removed from the Antarctic stratosphere during the winter. Both cloud types provide surfaces for heterogeneous chemical reactions that precondition the stratosphere for the subsequent ozone loss. These heterogeneous reactions are quite temperature sensitive. [4-6] Type III PSCs are the nacreous ("mother of pearl") clouds formed by rapid freezing of water during flow over topography. Toon et al. [7] subdivided Type I PSCs into two classes (Ia and Ib) based on lidar measurements in the Arctic. [8] Satellite measurements[9, 10] have revealed the continental scale and seasonal persistence of these clouds and characterized the climatology. A variety of balloon borne[11-13] and lidar[2, 14-16] experiments have been conducted in Antarctica. Ground based measurements have been limited to a few sites while satellite measurements do not observe the higher latitudes during the winter. Polarization[14, 16] lidar techniques have been used in Antarctica and show a variation of particle type and associated depolarization with altitude. Multi-wavelength measurements[2] have also shown a variation of particle type with altitude. However, no seasonal data sets have been collected that unambiguously present the detailed development of PSCs. The high altitude balloons provided by this grant provide temperatures to altitude in excess of 25 km and thus are extremely important for complete PSC characterization.

Progress to Date

A complete characterization of Antarctic PSCs throughout their seasonal development was initiated with the first lidar observations in December 1994. Despite equipment problems, more data at significantly higher signal to noise ratios (20× better than in 1990) was acquired our first year than in our previous campaign. A sample of a data set showing the combined temperature measurements of the lidar and the balloon sondes is shown in Figure 1. The derived stratospheric temperatures from the lidar signal above the PSCs are determined using hydrostatic equilbrium The high altitude temperatures from the balloons provide a "tie down" point for these calculations. Note that no effort was made to adjust the derived temperatures in Figure 1 and the small difference in the overlap region of 28-30 km indicates that the goal of complete temperature profiles throughout the year will be accomplished.

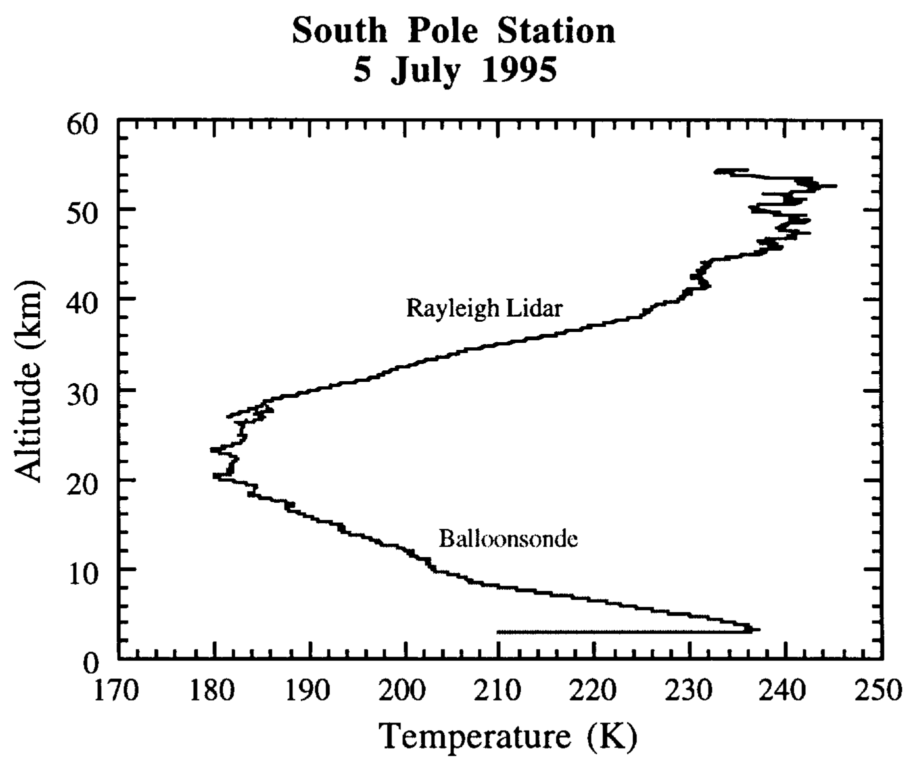

Figure 1. A complete temperature profile from 1 km to above 50 km at the South Pole station. The low altitude temperatures were derived from the balloons provided by this grant.

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