Final Progress Report

NASA Geospace Sciences SR&T award NAG5-12648

Studies of polar mesospheric clouds from observations by the Student Nitric Oxide Explorer

Scott M. Bailey, PI
January, 7, 2005

Abstract: The Geospace Sciences SR&T award NAG5-12648 "Studies of polar mesospheric clouds from observations by the Student Nitric Oxide Explorer" has been completed. The project was very successful in completing the proposed objectives and brought forth unexpected results in the study of Polar Mesospheric Clouds (PMCs). This work has provided key results to the community, provided valuable experience to two students, and inspired new research and collaborations with other research groups. Here we briefly summarize the progress and the scientific results.

Program Overview:

The primary goal of the project was to determine the climatology of Polar Mesospheric Clouds (PMCs). This objective is being carried out through analysis of data from the Student Nitric Oxide Explorer (SNOE) satellite that began making observations in 1998 and continued to make observations through December 13, 2003. The SNOE observations were compared with similar observations by the Solar Mesosphere Explorer (SME) satellite that observed during the period 1981 – 1985.

The project had the following goals:

- To determine the current climatology of PMC occurrences. The SNOE data is used to determine the frequency of occurrences of PMCs as a function of time and location.
- To determine the long-term variability of PMC climatology. The SNOE climatology will be compared to a similar climatology based on SME data. The difference in climatology will be indicative of changes in the rate of occurrence of PMCs.

SNOE PMC Database:

Because PMC observations are made serendipitously on SNOE rather than a planned observation, special changes to the data reduction software had to be implemented in order to determine the presence and strength of PMCs. In particular the algorithm that registers the measured UV radiance profile in altitude was found to break down when PMCs that were bright relative to the UV Rayleigh peak were encountered. A new algorithm was developed and implemented for the entire 6 year SNOE database.

It was discovered that a significant contribution from high altitude NO emissions contaminated the SNOE determinations of PMC brightness. A new algorithm was developed to remove this signal. The algorithm has been implemented and the entire SNOE PMC data base has been reprocessed.

Achievements:

The following new scientific results have been obtained:

- With the data processing improvements, the SNOE observed PMC brightness have become more similar and in fact brighter than the SME observed brightnesses, this has validated the result of other researchers that PMCs have in fact become brighter since SME. This is a new indication of global change in the mesosphere.

- A graduate student who is part of the SNOE PMC team has discovered the signature of planetary waves in the SNOE data. In her dissertation, which was completed at the end of the second year of this program, she demonstrated the sensitivity of PMC formation to small dynamically produced changes in temperature. These results were published in *Geophysical Research Letters*, see below for reference.

- One of the most fascinating new results from the SNOE data is the suggestion of a contribution to PMC formation from rocket launches. Stevens et al. from Naval Research Laboratory (NRL) have made the provocative suggestion that H_2O from large rockets and the space shuttle exhaust may be transported to high latitudes where it can make a significant contribution to PMC formation. SNOE data have provided preliminary support to for this idea by showing some correlation to the timing of rocket launches. A paper to *Geophysical Research Letters* appeared on this topic and future work will explore these results in detail.

- SNOE has showed that there are significant differences between Northern and Southern PMC morphology. Southern clouds also show a greater influence from dynamics. This topic has been of key interest to the community and was the subject of several invited talks by the PI at international conferences. It is discussed in the recently accepted paper by Bailey et al. and is the topic of a new publication in development.

- SNOE has revealed that dynamical influences are key drivers in PMC variability. In addition to the planetary wave signatures published earlier, other signatures of dynamics have been discovered. The sources of these signatures have not yet been identified but have also recently been discovered in other data sets. SNOE has provided crucial guidance in the question of dynamical influences on PMCs. In this way it has played an important role in the community.

Programmatic Achievements:

- The program partially supported one graduate student to complete her dissertation and provided assistance in her post doctoral fellowship: Aimee Merkel (now working at NCAR).

- One UAF undergraduate student, Justin Carstens, was supported by this grant. His research resulted in an AGU presentation with the student as lead author.

- New collaborations have been begun that have resulted in both scientific presentations and new proposals. These include collaborations with NRL looking into PMC formation from rocket exhaust, University of Colorado looking at PMC water content, NCAR looking at dynamical influences on PMCs, and University of Alaska (Richard Collins) looking at comparisons between

satellite and LIDAR observations. In addition, new collaborations are being developed with Franz-Josef Lüebken in Germany. We are particularly proud of the new research that SNOE PMC observations have inspired.

- Numerous talks at scientific meetings have been given (AGU, LPMR, COSPAR).

- Two papers have been published:

Bailey, S. M., A. W. Merkel, G. E. Thomas, and J. N. Carstens, Observations of Polar Mesospheric Clouds from the SNOE satellite, 20004JD005422, Accepted to *J. Geophy. Res.*, 2004.

Merkel, A. W., G. E. Thomas, S. E. Palo, and S. M. Bailey, Observations of the 5-day planetary wave in PMC measurements from the Student Nitric Oxide Explorer Satellite, *Geophys. Res. Lett.*, 30 *(4)*, 10.1029/2002GL016524, 2003.

I would be pleased to send copies of the papers or to provide any further details on the results of this program. We take great pride in the SNOE mission and the insight we've been able to gain into PMC morphology and physics.

Sincerely,

Scott BE

Dr. Scott M. Bailey
Assistant Professor, Space Physics and Aeronomy
Department of Physics, Geophysical Institute
University of Alaska Fairbanks
903 Koyukuk Dr., PO Box 757320
Fairbanks, Alaska 99775-7320 USA
(V) 907-474-7741
(F) 907-474-7290
scott.bailey@gi.alaska.edu