RPeterson

From: "RPeterson" <10SNE2@prodigy.net>
To: "Virginia Hawke" <virginiahawke@earthlink.net>
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CLEMSON UNIVERSITY ATMOSPHERIC AND SPACE PHYSICS

Current Projects

SPIRIT 2 (fall 2002)

Student **P**rojects **I**nvolving **R**ocket **I**nvestigation **T**echniques is a NASA sponsored student launch program which is intended to broaden undergraduate and post graduate educational opportunities using experiments built by students and flown by NASA on suborbital sounding rockets and scientific balloons. As described by NASA: "The program, initiated in 1993, provides practical experience in all aspects of planning, building, and flying a space science experiment. The projects involve a wide variety of academic disciplines to achieve the end-to-end management, publicity, design and fabrication, test and calibration, flight operations, data analysis, and the publication of final reports and/or scientific papers. The program is meant to be equally relevant to students in academic fields as diverse as science and engineering, education, business administration, industrial management, and/or public relations.

Poker Flat, Alaska (spring 2002)
"Coupling of Dynamics and Aurora."

The experimental program is designed to measure the magnitude of turbulent diffusion and other subgrid-scale dynamics. It will build on our previous Atmospheric Response in Aurora (ARIA) project with new measurements of turbulence and vertical motions and extend the observations into more intense auroral substorms expected during solar maximum. It will explore the possibility of heretofore unrecognized turbulent processes that may be driving composition and circulation changes during diffuse auroral events. The experiment is designed to achieve closure on the apparent inconsistencies between model results and observations by providing detailed information about the forcing and response of the system to Joule heating and Lorentz forcing, especially at scales that

might
be characterized as subgrid scales for the large general circulation models.

To achieve these goals, we will apply an array of in situ and ground-based techniques. They include
previously tested instrumentation and techniques to provide specification of the inputs, including time
histories of the electric fields, particle fluxes, and currents. Also, better specifications of the neutral
response will be made using multi-site, ground-based composition measurements and new in situ
measurements of wind, vertical velocity, and turbulence.

There will be a series of flights involving a total of four rockets to be launched from the Poker Flat
Research Range. The experiment will define the characteristics of the horizonal circulation, the vertical
flow field, and the magnitudes of the vertical and horizontal turbulent diffusion coefficients during a
period of heating and Lorentz forcing in the postmidnight auroral oval. A near-simultaneous launch of
three chemical release rockets and one instrumented rocket is planned.

St. Croix/Arecibo (summer 2002)
"Investigations of Sporadic E Layers and Quasiperiodic Echo Structure in Puerto Rico using Arecibo
and a Coherent Scatter Radar."

Our objective is to study quasi-periodic (QP) echoes associated with sporadic E layers using the
Arecibo Observatory incoherent scatter radar (ISR), and HF coherent scatter radar to be located on
St. Croix, and the Arecibo sodium lidar. Sporadic E and the QP echoes are the result of complex
neutral atmosphere/ionization interactions in the mesosphere and lower thermosphere (MLT) region.
The goals are (1) to determine the horizontal spatial structure of the ionization and the relationship
between that structure and the location of QP echoes observed with the coherent radar, (2) to
determine the vertical spatial extent of the ionization structures, and (3) to determine the relationship
between the motion of the ionization structures and the Doppler velocities and range rates measured by
the coherent scatter radar. To accomplish this, dual-beam azimuth scans will be carried out with the
incoherent scatter radar to provide information about the horizontal spatial variations and the vertical
extent of the electron density structure and to determine the velocity at which the structures move from
one beam to the other. The coherent scatter HF radar will be set up in a location on St. Croix so that
the beam will be perpendicular to the magnetic field lines in the E region above the Arecibo
Observatory so that the two radars have a common volume in the E region. By operating the HF

system in full interferometric imaging mode it will be possible to track the irregularities in range, azimuth,
and elevation, and to determine the range rates and Doppler shifts associated with the echoes. The
sodium lidar will be operated in dual-beam mode as well in order to provide information about the
horizontal and vertical spatial structure in the lower E region and the motions of the neutral atmosphere.
By combining the various measurements, the dataset can be used as a test of the various theories that
have been proposed to explain the initiation of the QP echoes.

Japan (summer 2002)
"A Proposal to Manufacture and Test a TMA Sounding Rocket Chemical Release Canister - SEEK
2."

We will design, manufacture, and test a trimethyl aluminum (TMA) chemical release canister to be
flown on an S310 sounding rocket as part of the SEEK-2 experiment in the summer of 2002.

Wallops Island Flight Facility, Virgina (fall 2002)
"A Sequential Rocket Investigation of Winds and Plasma Layers in the Nighttime E Region."

The objective of the effort is to study the composition, chemistry, and electrodynamics of intermediate
ionization layers in the E region at mid latitudes. In particular, the interaction of the neutral winds and
electric fields with the layers will be studied using a combination of sounding rocket measurements and
ionosonde measurements. The Clemson University effort will include three chemical release sounding
rockets that will provide high-resolution neutral wind profile measurements in the mesosphere and
lower thermosphere in conjunction with the instrumented rocket measurements.

Poker Flat, Alaska (spring 2003)
"Multiple-Scale Study of High-Latitude Joule Heating during a Substorm Event."

Recent modeling results and studies based on limited ground-based data have suggested that the small-
scale fluctuations in the electric fields can contribute significantly to the large-scale Joule heating at high
latitudes. Since the heating is proportional to the square of the electric field, those fluctuations that
average to zero can still have a non-zero variance which will then produce an increase in the net heating. Estimates in the earlier studies of the contribution of the small-scale fluctuations to the heating
range anywhere from 25% to 100%, although those studies generally had limited data or had employed
a number of assumptions. Another important factor when estimating the Joule heating is the

a number of assumptions. Another important factor when estimating the Joule heating is the effect of
the neutral winds which alter the Joule heating and the heating profiles in particular. Since the Joule
heating is critical to the dynamics, electrodynamics, and chemistry of the high-latitude region, we plan a
detailed investigation of the contribution of small-scale fluctuations to the larger-scale Joule heating in a
substorm event when such effects are most likely to be important. Specifically, we will use a
combination of ground-based and in situ rocket measurements to estimate the contributions to the
heating over a range of scales from approximately 500 km to 5 m, i.e., over five orders of magnitude.
A total of four rockets will be launched near-simultaneously from Poker Flat, Alaska, close to the
midnight sector when horizontal gradients are expected to be large. The four rockets include two
instrumented and two chemical release rockets that will be launched as pairs along two different
azimuths. The primary measurements from the instrumented rockets will be the vertical profiles and
horizontal variations in the electron densities and the horizontal variations in the electric fields. The
primary measurements from the chemical release rockets will be the neutral wind profiles. By
combining the in situ rocket measurements with measurements from a high-resolution coherent scatter
radar interferometer, ground-based photometers, magnetometers, and SuperDARN, we will be able to
achieve the coverage of scales from a few meters.

Poker Flat Alaska (spring 2003)
"Mapping the E-Region Vertical and Zonal (Horizontal) Winds near a Stable Auroral Arc, using a
Near-Horizontal Chemical Release Trail."

We plan to address two critical aspects of thermospheric dynamics, namely, small-scale motions and
vertical mixing. The gradients of most atmospheric quantities are strongest in the vertical direction.
Thus, vertical winds disrupt the atmosphere more than horizontal winds, because they carry air parcels
directly across parameter isosurfaces. The consequences of vertical winds are poorly understood,
although some key points are:
* It appears that strong thermospheric vertical winds occur mostly at auroral latitudes, where they are
highly geographically localized.
* In-situ spacecraft observations show significantly modified thermospheric composition within such
regions of strong vertical wind.
* Ultraviolet images from space show that horizontal advection eventually causes these composition
changes to affect large geographic areas.

* Ground-based observations suggest, but cannot prove, that the large vertical wind events driving the composition changes actually originate in the E-region, just poleward of discrete auroral arcs. Here, we plan to "zoom in" on this apparent source region for large amplitude vertical wind events. To do so, we propose a novel rocket experiment, in which a chemical trail will be deployed nearly horizontally across an auroral arc, at around 160 km altitude. Photographing this trail's drift will allow measurement of vertical and horizontal zonal winds, each resolved over geomagnetic latitude. An on-board spin-scanned photometer and electron density probe will establish, in detail, the spatial relationship between the observed vertical wind field and the associated auroral structures. A smaller second rocket will be launched immediately following the first, on a conventional steep trajectory. This rocket will deploy a near-vertical trail that will map the surrounding altitudinal structure of the wind field, both above and below the previous horizontal trail.

Peru (spring 2004)
"Sounding Rocket Investigations of E-and F-Region Electrodynamics at the Magnetic Equator in Peru."

Improvements in the radar instrumentation at Jicamarca, Peru, have led to significant increases in radar resolution as well as the capability to measure new parameters. Measurements during the last five years have provided a new perspective on the complicated interactions between the neutral and ionized components of the atmosphere at the magnetic equator that had not been fully appreciated before. In spite of the enhanced capabilities of the radar at Jicamarca, further progress in understanding many of the phenomena of interest requires a combination of ground-based and in situ measurements of the type that can only be provided by sounding rockets. There will be a series of launches from the Punta Lobos site in Peru during the spring equinox period in 2004 to investigate these phenomena in more detail.

The investigations will include studies of the electrodynamics of the nighttime and daytime electrojet, the electrodynamics of the bottomside of the F layer, the electrodynamic coupling of the E-region electric fields and neutral winds, and mesospheric echoing regions.