Several studies of the upper atmosphere took place at Arecibo since the last NAIC Newsletter went to press. We begin with a more complete description of the topside ionospheric experiment that occurred in late November of last year, which we only briefly mentioned in that report.

In November, we conducted the Plasmaspheric Observations of Light Ions in the Topside Exosphere (POLITE) World Day campaign from the 22nd through the 25th. One goal of POLITE is to advance our appreciation of the topside light ion morphology and dynamics through a combination of modeling efforts and coordinated observations made by the incoherent scatter radar chain and by DMSP (Defense Meteorological Satellite Program) overflights. The use of the full latitudinal and longitudinal extent of the radar chain was critical to this campaign in that one key objective was to study the latitudinal and longitudinal variations of hydrogen, oxygen, and helium ions. Simultaneous measurements of neutral oxygen, hydrogen, and helium are also important to explore the coupling between ion and neutral species in the lower part of the topside ionosphere.

For this particular campaign, the observations during, or near to the solstices were of special interest because significant asymmetries in field-aligned ion flows are at their maximum during these periods. In the winter, the helium ion layer descends in altitude and increases in strength, making the observations easier for most other incoherent scatter radars. Because of its vast sensitivity, Arecibo, on the other hand, is well positioned to study the helium ion layer throughout the entire year. We ran the radar for about 60 hours during the core period of POLITE with optical measurements on the associated nights.

During POLITE, and for a similar adjacent study proposed by Robert Kerr et al. (Scientific Solutions, Inc.), Kerr and his student Steve Oetting installed their infrared Fabry-Perot interferometer in the Airglow Lab to observe the He 10830-Å metastable emission that originates in the thermosphere. Their instrument provided critical data on the final piece of the ion-neutral chemistry of the high-altitude ionosphere by furnishing relevant information on neutral helium to compare with He⁺ measured with the radar. We can also extract O⁺ and H⁺ concentrations from radar spectra — the neutral counterparts were determined from optical measurements of the O 8446-Å and Hα 6563-Å airglow using the Observatory’s photometers.

In addition, for these studies we reconfigured one of our own Fabry-Perot interferometers to be sensitive to Hα by...
changing the etalon plate spacing and performing a number of other instrument changes. High-spectral resolution studies of $H_\alpha$ help us determine the flux of potentially “hot” hydrogen atoms that may have sufficient energy and velocity to escape the Earth’s atmosphere. Several additional nights of observation were made throughout the rest of the year to support these winter-time high-altitude studies, even during times when radar observations were unavailable. The purpose of the extended optical runs was to gear-up for a major, early spring topside ionospheric campaign that is taking place as this Newsletter goes to press.

In mid-January, Silvia Duhau (U. of Buenos Aires) together with Michael Kelley (Cornell U.) and Mike Sulzer (NAIC) carried out several radar runs. The purpose of their experiment was to verify, or not, various rocket Langmuir probe measurements showing elevated electron temperatures in the lower part of the E-region ionosphere during winter months around noon. The specific goals of these incoherent scatter radar measurements were to:

1. make the most accurate possible E-region measurements of electron temperature ($T_e$) and ion temperature ($T_i$), preferably by more than one independent method, and
2. look for enhancements in the plasma line, possibly indicating a tail in the electron distribution.

One set of temperature measurements was obtained from coded long pulse ion line observations. Also, an independent measurement of $T_e/T_i$ was obtained by comparing the coded long pulse plasma line electron density measurements with measurements derived from the ion line power profile. Once the near field response of the radar was determined, very high quality measurements of $T_e/T_i$ became possible down to 103 km.

In the first three days of the experiment we obtained simple power profiles, as well as ion and plasma, and coded long pulse ion line measurements in order to determine the behavior of the E-region. The last two days used coded long pulse ion and plasma line measurements, recording the raw data on exabyte tape. It is these measurements that give extremely high quality plasma line profiles, but the analysis is very computationally intensive. About one fourth of the data have been analyzed, covering one of the noon periods. So far, no evidence of elevated temperatures has been found.

Analysis of the data is continuing. Duhau is developing a collision model for the lower E-region so that accurate temperature measurements can be obtained using the ion line spectra. The goal is to obtain two independent measurements of $T_e/T_i$ over the entire E region.

The use of the high quality plasma line profiles in combination with high resolution ion line measurements (made from the same radar pulses by recording two channels at once) is a new technique. Preliminary results indicate that it is possible to use the same data, which extends up to about 190 km to measure the molecular ion fraction with sufficient accuracy to make comparison with models useful. The difficulty with molecular ion fraction measurements is that the molecular and O masses are so close that it is not possible to distinguish them and simultaneously measure $T_e/T_i$ because the effects on the spectrum are very similar. With $T_e/T_i$ otherwise determined, the different masses can be seen, although it requires a lot of independent samples to obtain useful results.

A new focused World Day experiment was initiated this past February, called the Global Ionosphere-Thermosphere Coupling Study (a.k.a. GITCS). It was a three-day study proposed by Mike Kosch (Max Planck Institut für Aeronomie) and Chantal Lathuillere (Centre National de la Recherche Scientifique - CNRS). The objectives of this multi-radar, multi-optical experiment were twofold. First, simultaneous radar and optical measurements of key ionospheric and thermospheric parameters, such as, electron concentration, ion and electron temperatures, and ion velocities observed parallel to the Earth’s magnetic field, will be used to constrain global models of the thermosphere. Two key models used in this study are the University College of London 3D Thermospheric model and the Grenoble TRANSCAR model. A second objective of GITCS is to determine ion-neutral collision frequencies in the F-region ionosphere between O and O using meridional neutral winds either measured directly via optical interferometry, or inferred from incoherent scatter radar measurements of ion drifts. The atomic oxygen concentration and neutral temperature needed to determine O-O collision frequencies will be taken from models of the neutral atmosphere or from direct measurement where available.

During the month of February, the Arecibo 430 MHz radar ran for nine consecutive nights (Feb. 12-20). This was part of a combined effort by Kelley and Erhan Kudeki (U. of Illinois) to investigate the effects of geomagnetic storms and substorms in the ionosphere over Arecibo, as well as E-region layer formation, dynamics and plasma instabilities. The Arecibo radar measurements were complemented by several other instruments, including two coherent radars.
from Cornell (CUPRI, run by Wes Swartz) and Illinois (Kudeki), two imagers from Cornell (Francisco García) and Los Alamos (Tom Armstrong), and the Arecibo sodium resonance lidar and photometers. Several nights were quite active in the E-region. In particular, the night of February 20-21 had a spectacular event near 100 km altitude which was observed almost coincidentally by all three radars and the lidar (see Fig. 2). At nearly the same time a very disturbed F-layer drifted overhead with structure quite similar to an event observed in June 1998. Moreover, we were treated to a geomagnetic storm during February 18-19. This storm prevented the usual midnight collapse during the night of the 18th and also raised the height of the F-peak by about 100 km. This storm resulted in spectacular airglow images showing plasma depletions surging pole-ward at high velocity. The success of the project was much aided by the willingness of astronomer Carl Heiles (UC Berkeley) to trade time on the telescope on an active night for time later in the week.

As mentioned above, we supported Kudeki et al.’s study with optical observations of the lower thermosphere and upper mesosphere. Craig Tepley (NAIC) and Eva Robles (NAIC) carried out Fabry-Perot measurements of neutral winds and photometric observations of various upper mesospheric airglow emissions, such as, O(1S), OH, and O₂. The neutral temperature at different heights in the atmosphere are extracted from these airglow data. Ann Chojnacki (Cornell U.) and Jonathan Friedman (NAIC) also operated our resonance fluorescence lidar on many of the nights of the experiment measuring the structure of the mesopause region between approximately 80 and 105 km altitude using the sodium layer as a tracer. An interesting example of the detailed dynamics present at this altitude range is shown in Fig. 2b, also from the night of Feb. 20-21, where we see the influence of pronounced atmospheric gravity waves that

![Image 1](image1.png)

![Image 2](image2.png)

![Image 3](image3.png)
strongly reveal their presence in the Na layer. The enhanced Na layer near 101 km was very unusual in that it was long lived. These layers normally last on the order of an hour, while on this particular night it was apparent throughout the 7+ hour observation period.

A four-day World Day, Lower Thermosphere Coupling Study (LTCS) occurred in early March. This particular experiment was somewhat of a merger between two different scientific focuses — the “standard” tidal study characteristic of LTCS observations in the past, with the influence of magnetic storms on ionospheric conditions. Generally, the effects of magnetic storms on the ionosphere are more pronounced at higher altitudes and are believed to have very little influence deep within the atmosphere.

With the hope of catching an intense geomagnetic disturbance by flexibly scheduling a “floating” observation window for this experiment, the March 1999 LTCS attempted to quantify whether or not there is a major, or even minor, storm effect on the lower thermosphere. Unfortunately, initial results are somewhat inconclusive because only a small amount of magnetic activity was observed during the experiment. This study was a pilot project for the upcoming CEDAR-TIMED investigations that begin next year after the launch of the NASA TIMED satellite that will study the upper mesosphere and lower thermosphere.