NASA Mission to Explore Forcing of Earth's Space Environment

The Global-scale Observations of the Limb and Disk (GOLD) mission has been selected as a mission of opportunity by NASA's Small Explorer program. This mission, with an anticipated 2014 launch date, is an opportunity to significantly advance thermosphere-ionosphere (TI) science and to provide answers to key elements of an overarching question for heliophysics science: What is the global-scale response of the thermosphere and ionosphere to forcing (e.g., by geomagnetic storms or atmospheric tides) in the integrated Sun-Earth system?

Understanding the response of the TI region to forcing is important for scientific as well as societal reasons. Scientifically, understanding how Earth's TI responds to forcing provides insights into the response of similar regions on other planets. Societal impacts that arise from an inadequate understanding of this region include unnecessary delays in air travel and unanticipated interruptions in satellite services such as the Global Positioning System. The GOLD mission promises to lead to a decrease in such problems.

Scientific Objectives

The TI region contains the transition between the plasma-dominated region of the atmosphere and the neutral, fluid-dominated atmosphere at lower altitudes. External forcing by the solar extreme ultraviolet (EUV) normally dominates in this region, but internal forcing from magnetosphere-ionosphere (MI) coupling or from atmospheric tides can have a critical or even dominant influence, as MI coupling frequently does during geomagnetic storms. The relative importance of each forcing source varies with time, geographic location, and altitude; consequently, our understanding of the TI region is best advanced by considering its global-scale behavior, an approach often used in modeling.

GOLD would provide, for the first time, a near-simultaneous global-scale "snapshot" of the temperature and composition in the lower thermosphere, allowing one to see how these two major parameters, shown in Figure 1, react to external and internal forcing. Following their temporal development across a hemisphere of the Earth, GOLD measurements are expected to resolve critical aspects of the forcings that drive the transition region. Using these two key parameters, theories and models of TI forcing are tested and understanding of the system is advanced.

The GOLD mission will address the following four key science questions, which are a subset of the overarching question:

1. How do geomagnetic storms alter the temperature and composition structure of the thermosphere; how does the low-latitude nighttime ionosphere respond to geomagnetic storms; and is the initial state of the thermosphere-ionosphere system a key determinant of geomagnetic storm effects?
2. What is the global-scale response of the thermosphere to solar EUV variability?
3. Do atmospheric waves and tides have a significant effect on the thermospheric temperature structure?
4. Do vertical ion drifts, as manifested in the structure of the equatorial anomaly, affect the occurrence of ionospheric irregularities?

New Measurement Capability

An advantage GOLD has over previous TI missions is that it is expected to produce the first global-scale measurements of temperatures in the Earth's thermosphere. The GOLD instrument is an ultraviolet imaging spectrograph that will be aboard a commercial satellite in geostationary orbit over the Americas. The imager will be built by the Laboratory for Atmospheric and Space Physics (LASP) of the University of Colorado at Boulder. GOLD will produce images (1320–1620 angstroms (Å)) of the entire disk at 30-minute intervals, with either high (~1 Å) or low (~10 Å) spectral resolution. The high-resolution observations would provide the information needed to derive the atmospheric temperatures at approximately160 kilometers on the dayside disk.

While the high-resolution observations are unprecedented, similar low-resolution observations have proven invaluable for tracking changes in thermospheric composition (i.e., atomic oxygen to molecular nitrogen (O/N_2) column density ratio) during the day and electron densities near the F_2 region of the ionosphere peak at night. GOLD also plans to make limb scans of the above parameters and measure O_2 by stellar occultation. While previous investigations relied on in situ measurements and remote sensing observations from low-Earth orbit (LEO), which can cover only localized regions of space, GOLD's geostationary perspective would allow for the separation of spatial and temporal changes.

Measurements of the temperature and composition of the thermosphere would provide needed constraints for advancing space environment models. Previous missions have provided middle- and low-latitude observations from low- or medium-Earth orbit (e.g., the Thermosphere Ionosphere Mesosphere Energetics and Dynamics (TIMED) mission [*Christensen et al.*, 2003]) or have concentrated on high latitudes with highly elliptical orbits (e.g., the Imager for Magnetopause-to-Aurora Global Exploration (IMAGE) mission [*Mende et al.*, 2000]). A geostationary orbit provides a global-scale view of the subauroral regions, similar to the view provided for the high latitudes by the auroral imaging missions. However, unlike the auroral missions, continuous observations are possible from geostationary orbit.

GOLD provides an opportunity to significantly advance our understanding of the four key questions noted above. The geostationary orbit enables local time, storm onset time, and longitudinal variations to be separated. Simultaneous measurements of temperature and composition on a large scale provide a better understanding of how both respond to the major forcing processes examined in questions 1 and 2. Observing the temperatures across a hemisphere allows thermospheric tides to be determined and question 3 to be addressed. GOLD's imaging of the ionospheric depletions produced by irregularities in the equatorial ionosphere could lead to a better understanding of the relationship between vertical ion drifts and the occurrence of ionospheric irregularities considered in question 4.

GOLD observations promise to contribute significantly to our understanding of the TI system and to increase the benefit of other TI observations by providing the large-scale context for localized measurements. Other space-based TI missions—such as the Neutral Ion Coupling Explorer (NICE), currently under study as a NASA Small Explorer—could expand the opportunities for scientific discovery by measuring parameters that are not available from GOLD.

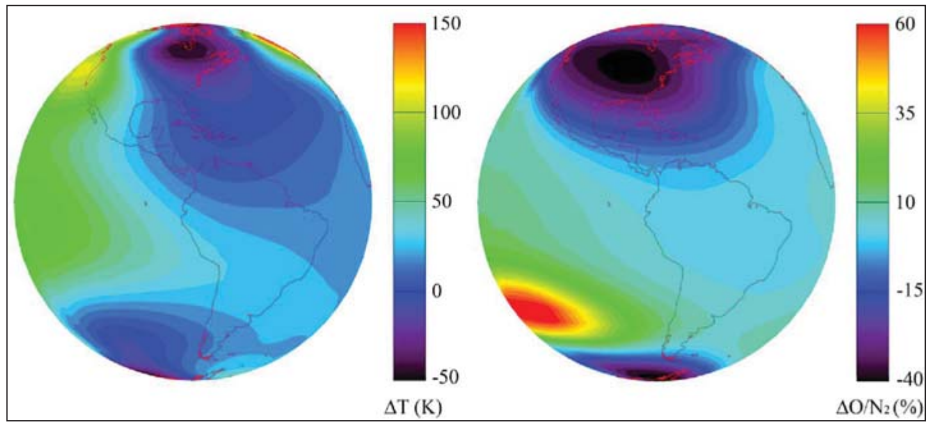

Fig. 1. Storm-time changes in thermospheric temperature and composition. Differences between storm-time and quiet-time calculations from the National Center for Atmospheric Research's thermosphere-ionosphere electrodynamics general circulation model (TIEGCM) are shown (left) for the temperature (in kelvins, K) and (right) for the O/N_2 column density (in percent). Both are on a constant pressure surface at approximately 160 kilometer altitude. After averaging from an intrinsic, approximately 25 kilometer resolution to the 5º × 5º grid typically used by the TIEGCM, the Global-scale Observations of the Limb and Disk (GOLD) mission is expected to resolve differences of less than 15 K in temperature or less than 10% in O/N_2 column density in 2-hour averages. The spatial resolution of the data and the viewing geometry used for these images approximates that of the GOLD imager.

Acknowledgment

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References

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