Societal Implications

Natural hazard mitigation, the effects of global warming, and optimum use of water resources are areas of major concern for humankind today. The implications of space geodesy when applied to natural hazards associated with earthquakes and volcanoes are well known in the geoscience community, but space geodesy also has an impact beyond these traditional solid Earth hazards. Sea level rise, glacial melting, and hurricane forecasts are of immediate interest to communities around the world, particularly in the context of global climate change. Geodesy can also reveal the overlapping threats from multiple hazards—for example, in areas of coastal subsidence such as Bangkok, Thailand, the effect of continued sea level rise amplifies flooding hazards.

One of the greatest global challenges of the 21st century is securing fresh water for the increasing worldwide population and for sustaining natural ecosystems. Geodetic monitoring of subsidence in depleted aquifers and water level changes in wetlands, rivers, and lakes yields important constraints for hydrological models that can serve as decision support tools for water resource managers.

The varied scales and high precision of space geodetic observations are helping to push the frontiers of knowledge regarding many Earth processes. Because space geodetic measurements have many applications, geodesy today brings scientists together for interdisciplinary research that helps mitigate the influence of the forces of nature on our growing population as well as the effect of the population on Earth's fragile surface.

For more information on space geodetic techniques and their applications, please visit http://www.unavco.org/geodesy21century.

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Author Information

Shimon Wdowinski, Division of Marine Geology and Geophysics, University of Miami, Miami, Fla.; and Susan Eriksson, UNAVCO, Boulder, Colo.; E-mail: Eriksson@unavco.org

NASA Mission to Explore Forcing of Earth's Space Environment

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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 will 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

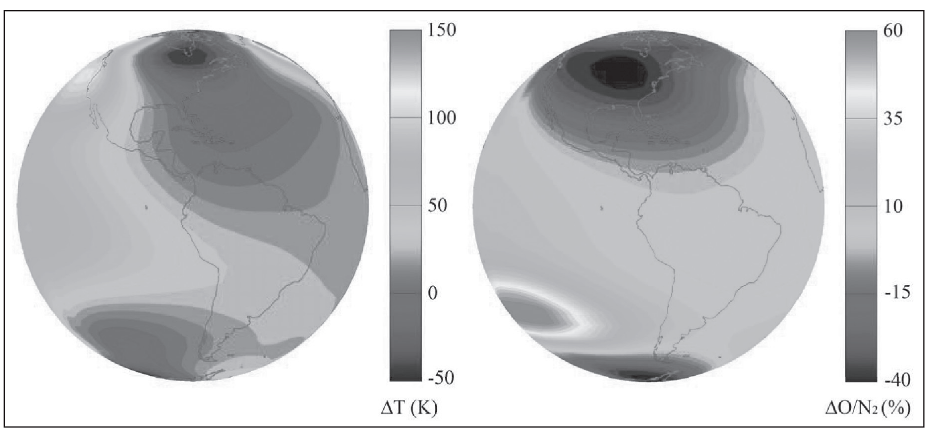

Fig. 1. Storm-time changes in thermospheric temperature and composition. Differences between storm-time and quiet-time calculations from the National Center for Atmospheric Research's thermosphere-ionosphere electrodynamics general circulation model (TIEGCM) are shown (left) for the temperature (K) and (right) for the column density ratio of atomic oxygen to molecular nitrogen (O/N_2, in percent). Both are on a constant-pressure surface at an altitude of approximately 160 kilometers. After averaging from an intrinsic, approximately 625-square-kilometer resolution to the 5°× 5° 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 and the viewing geometry used for these images approximate those of the GOLD imager. Original color image appears at the back of this volume.

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 will provide the information needed to derive the atmospheric temperatures at approximately 160 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., the column density ratio of atomic oxygen to molecular nitrogen (O/N_2)) during the day and electron densities near the F_2 region of the ionosphere (~300 to 600 kilometers in altitude) peak at night. GOLD also plans to make limb scans of the above parameters and measure molecular oxygen (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 will allow for the separation of spatial and temporal changes.

Measurements of the temperature and composition of the thermosphere will 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 previously. 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.

Acknowledgment

This article is written on behalf of the GOLD science team.

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—RICHARD EASTES, Florida Space Institute, Kennedy Space Center, Fla.; E-mail: reastes@mail.ucf.edu

NEWS

Obama Indicates Strong Support for Science

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In remarks delivered at the U.S. National Academy of Sciences (NAS) annual meeting on 27 April, U.S. President Barack Obama indicated his administration's strong support for science and for pursuing a clean energy economy. He also announced a goal that the United States "will devote more than 3% of our [gross domestic product] to research and development."

"This represents the largest commitment to scientific research and innovation in American history," Obama said, noting that the American Recovery and Reinvestment Act already is providing the nation with its largest single boost to investment in basic research.

Obama said innovation is key in developing new technologies to produce, use, and save energy, and that "our future on this planet depends on our willingness to address the challenge posed by carbon pollution. And our future as a nation depends upon our willingness to embrace this challenge."

"There will be no single Sputnik moment for this generation's challenges to break our dependence on fossil fuels," he told the scientists gathered in Washington, D. C. "But energy is our great project, this generation's great project." Among those accompanying Obama to the NAS meeting were John Holdren, director of the White House Office of Science and Technology Policy (OSTP); Jane Lubchenco, administrator of the National Oceanic and Atmospheric Administration; Steven Chu, secretary of energy; Lawrence Summers, director of the National Economic Council; and Nina Fedoroff, science adviser at the State Department.

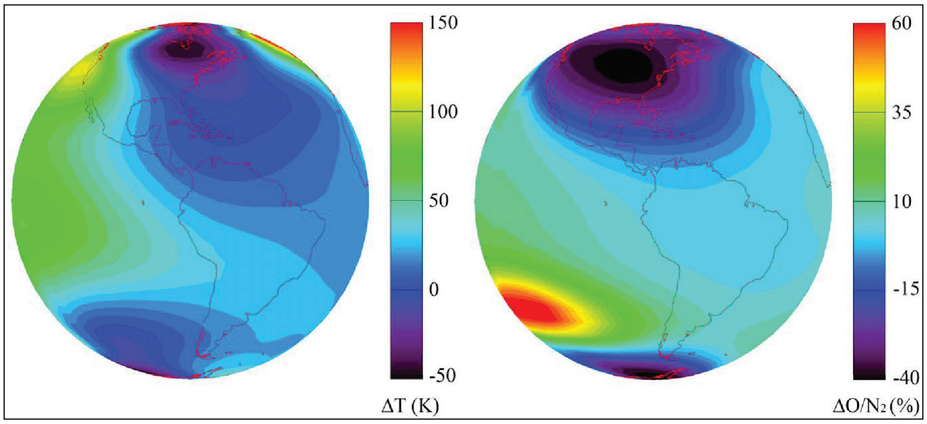
Obama also elaborated on a 9 March executive memorandum regarding scientific integrity. "Under my administration, the days of science taking a back seat to ideology are over," he said. "To undermine scientific integrity is to undermine our democracy. It is contrary to our way of life." Obama indicated that Holdren and OSTP are leading a new effort to ensure that federal policies are based on the best and most unbiased scientific information.

Obama announced that the President's Council of Advisors on Science and Technology (PCAST) will be cochaired by Holdren; Eric Lander, director of the Broad Institute of the Massachusetts Institute of Technology and Harvard University; and Harold Varmus, former head of the National Institutes of Health. Among the other members of PCAST are several AGU members: Rosina Bierbaum, dean of the School of Natural Resources and Environment at the University of Michigan; Mario Molina, professor of chemistry and biochemistry at the University of California, San Diego; and Daniel Schrag, geology professor in the Department of Earth and Planetary Sciences and professor of environmental science and engineering in the School of Engineering and Applied Sciences at Harvard University.

The president announced several new initiatives, including the Advanced Research Projects Agency for Energy, or ARPA-E. Based on the Defense Advanced Research Projects Agency (DARPA), the new agency will also seek to do high-risk, high-reward research. He also announced that states making strong commitments and progress in math and science education will be eligible to compete later this year for additional funds under the secretary of education's $5 billion "Race to the Top" program. Obama indicated he will participate in a public awareness and outreach campaign to encourage students to consider careers in science, math, and engineering.

Obama also noted that the goal of strengthening U.S. science efforts will require the efforts of the broad scientific community, and not just government. "Today I want to challenge you to use your love and knowledge of science to spark the same sense of wonder and excitement in a new generation," he said, urging scientists to spend time in classrooms and participate in educational programs.

—RANDY SHOWSTACK, Staff Writer



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