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NEWS

Satellite Constellation Monitors Global and Space Weather

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Six identical microsatellites were successfully launched into a circular low-Earth orbit from Vandenberg Air Force Base, Calif., at 0140 UTC on 15 April 2006.

Termed the Formosa Satellite 3 and Constellation Observing System for Meteorology, Ionosphere, and Climate (FORMOSAT-3/COSMIC) mission, the new constellation's primary science goal is to obtain vertical profiles in near-real time of temperature, pressure, and water vapor in the neutral atmosphere and electron density in the ionosphere. The observations will be used to support operational global weather prediction, climate monitoring and research, space weather forecasting, and ionospheric research.

The mission is a collaborative project of the National Space Organization (NSPO) in Taiwan and the University Corporation for Atmospheric Research (UCAR) in the United States. Expected to last for five years, FORMOSAT-3/COSMIC provides the first satellite constellation for observing global weather using the Global Positioning System (GPS) radio occultation technique.

Science Payloads

Each satellite houses a GPS Occultation Experiment (GOX) payload. Developed at the Jet Propulsion Laboratory (JPL, Pasadena, Calif.), the GOX receiver measures the propagation time of radio signals from a GPS satellite to a FORMOSAT-3/COSMIC satellite as it rises or sets behind the Earth relative to the GPS satellite. As the radio waves pass through the atmosphere, they are refracted and slowed, with the degree of bending related to the vertical variation of refractivity, which is a function of temperature, pressure, and water vapor in the neutral atmosphere and electron density in the ionosphere.

From the raw phase and amplitude measurements of these refracted radio waves, profiles of bending angle and refractivity can be deduced. These profiles can be assimilated into numerical weather prediction models, yielding information on temperature, pressure, and water vapor. Vertical profiles of temperature and moisture can be deduced from the refractivity profiles with the use of additional information. A special issue of the journal *Terrestrial, Atmosphere and Oceanic Sciences* (TAO) for Applications of the Constellation Observing System for Meteorology, Ionosphere and Climate (*Tao, 11*(1), 2000) presents further information on the RO technique, the science payloads, and the FORMOSAT-3/COSMIC mission.

The GOX will be making use of the advanced open-loop (OL) signal tracking, which allows the RO soundings to penetrate deep into the lower troposphere at all latitudes, observing planetary boundary layer heights and structure and providing valuable information on low-level moisture.

The GOX will provide over 2500 atmospheric soundings every 24 hours around the globe (Figure 1). This is about twice the number of daily weather balloon observations (~1500 soundings from ~850 stations), which are concentrated mostly over land. The RO soundings' high vertical resolution will complement the high horizontal resolution of conventional infrared and microwave satellite soundings.

In addition, the GOX will provide vertical profiles of electron density. The approximately 2500 electron density profiles between 90 and 800 kilometers will define the ionospheric structure, and the scintillation and electron density irregularities that contribute to satellite malfunctions.

Another instrument aboard each satellite is the tiny ionospheric photometer (TIP), which will monitor the density of emissions that result from recombination of oxygen ions with electrons at ionospheric altitudes, and will be helpful for improving the ionospheric occultation inversions. Moreover, TIP measurements will contribute to the determination of the nighttime auroral boundary.

The satellites are also equipped with a triband beacon (TBB), which will provide ionospheric observations to ground-based receivers. Data from the TBB can be used to retrieve the satellite-to-ground total electron content, allow for high-resolution tomography of the electron density distribution, and monitor phase and amplitude scintillations induced in radio waves propagating through the ionosphere.

Special Observation Campaigns and Data Management

During the first 13 months following launch, the six satellites will gradually separate as they

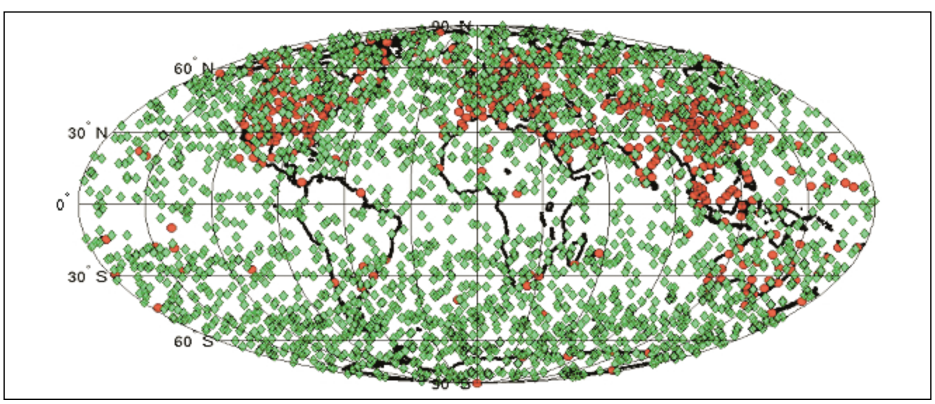

Fig. 1. More than 2500 radio occultation (RO) soundings (green dots) obtained by the GPS Occultation Experiment (GOX) each day. In comparison, radiosondes (red dots) provide only approximately 1500 soundings per day.

rise from their initial altitude of 512 kilometers to their final orbit at an altitude of ~800 kilometers, an orbit plane inclination angle of 72° and a separation angle between the neighboring orbit planes of 24° in longitude.

NSPO will conduct an Intensive Observation Period (IOP) campaign to cross validate RO data with other observations, and to assess the impact of FORMOSAT-3/COSMIC observations on predictions of typhoon intensity and track as well as heavy rainfall events over eastern Asia. The IOP campaign will be held during May–October 2006. Two field campaigns will be conducted in the vicinity of Taiwan, one to study the Mei-Yu front and associated disturbances during May and June and the other to study typhoons during July–October. Researchers around the world are invited to participate in the IOP campaign.

Two data centers will receive and process the satellites' raw data: (1) the COSMIC Data Analysis and Archive Center (CDAAC, which developed the data processing algorithms) located at UCAR and (2) the Taiwan Analysis Center for COSMIC (TACC) at the Central Weather Bureau in Taiwan. The processed results will be ready for distribution within 3 hours from the time of data collection. All FORMOSAT-3/COSMIC data and products will be made freely and openly available to the international science and operational communities from CDAAC or TACC. Data product users are required to register at the TACC Web site at http://tacc.cwb.gov.tw/

With the demonstration of real-time operational use of RO observations, FORMOSAT-3/COSMIC will complement other Earth-observing systems and improve global weather analyses and prediction. The success of the FORMOSAT-3/COSMIC mission will inaugurate an age of operational GPS sounding for weather forecasting, climate analysis and research, ionospheric monitoring, and a suite of related Earth science pursuits.

Additional information about the FORMOSAT-3/COSMIC mission may be found at http://www.nspo.org.tw/2005e/projects/project3/intro.htm and http://www.cosmic.ucar.edu/

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SPRING MEETING PREVIEW

Joint Assembly Sessions Focus on Urbanization

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The urban environment has grown to encompass not just the downtown area of a city but also the suburbs and rapidly growing exurban areas. This growth can affect a wide range of geological, physical, and biological processes. Several sessions at the 23–26 May 2006 Joint Assembly in Baltimore, Md., will explore this topic.

Two union sessions on the "Impact of Urbanization on Environmental Systems" (U31A and U32A) will take place on Wednesday morning, 24 May, at 8:30 A.M. and 10:45 A.M. The sessions are designed to be a wide-ranging exploration of the different, multiple roles that urbanization, and the changes in the environment that accompany urbanization, have on biological and geophysical processes, said session co-convener Larry Band. Brand is Voit Gilmore distinguished professor and chair of the department of geography at the University of North Carolina, Chapel Hill.

In these sessions, "rather than specializing, we are looking at a fairly broad range of interactions in the natural and built environment," Band said. Topics will include the history of environmental impacts, changes in the ecological community in urban areas, land-atmosphere interactions, mesoscale climate interactions with urbanization, and biogeochemistry. A final synthesis discussion will look for common denominators among the various areas of research because none of these research topics can be approached in isolation, Band explained.

Band said that the sessions would feature talks about the two urban Long-Term Ecological Research (LTER) sites—Phoenix, Ariz., and Baltimore, Md.—which represent a contrast in city age, rate of growth, and hydrology. In addition, besides examining how urbanization has affected environmental systems, presentations will also look at the impact of the environment on urbanization, Band said.

One of the session presenters, Peter Groffman, a senior scientist at the Institute of Ecosystem Studies, Millbrook, N.Y., will focus on the interactions between humans and their environment. Groffman said, "[Many] environmental problems will never be solved unless…we start to understand why do humans do things they do, how do they perceive the environment, how do their perceptions influence their values, and how do their values influence their actions and decision-making processes. This is a very difficult topic because it involves an interface between social science, physical science, and biological science."

Groffman will continue this focus in two related biogeosciences sessions for which he is a co-convener: "A Unique Urban Biogeochemistry?" (B23A and B24A), which will be held Tuesday afternoon, 25 May, at 2:00 P.M. and 4:15 P.M. One of the goals for this session is to hear from not only the two urban LTER sites but also about other locales, such as Louisville, Ky., and Binghamton, N.Y., where this area of research began flowering after the LTER sites were funded, Groffman said.

In addition to the focus on human-environment interactions, other presentations will highlight how the watershed approaches that have been used for studying natural and agricultural systems are now being transferred to urban systems, Groffman said. For example, the Baltimore LTER has several years of data on the area's watershed that can be used to evaluate the effect of a sewer system upgrade on the areas streams and waterways, Groffman noted.

Urban systems research can have more immediate impact than work done on natural systems, Groffman said, because "if we work in urban ecosystems, we learn interesting things about biogeochemistry, but the results are used and evaluated by decision-makers much more immediately." Using Baltimore again as an example, Groffman noted that the city has recently approved an urban tree canopy goal that incorporates research done in the region.

Two hydrology sessions on "Aerosols, Pollution, and Urbanization Effects on Precipitation" (H51A and H52B)—held on Friday morning, 26 May, at 8:30 A.M. and 10:45 A.M.—will have an overarching theme of how human activities affect precipitation, said session co-convener Thomas Bell, a senior research scientist in the Laboratory for Atmospheres at NASA Goddard Space Flight Center, Greenbelt, Md.

Several presentations will focus on how pollution and aerosols affect clouds and precipitation. For example, session co-convener J. Marshall Shepherd, from the University of Georgia, Athens, will present an urban growth model for the city of Houston, Tex., and examine the potential effects of urban growth from 1992 to 2025 on regional clouds, precipitation, and temperatures.

In another talk, Bell will present data showing a mid-week pattern of precipitation in the southeast United States, which could be related to patterns of particulate pollution from sources such as diesel trucks. Other presentations will focus on efforts to incorporate the growing understanding of aerosols into climate models.

Further information about the 2006 Joint Assembly is available at http://www.agu.org/meetings/ja06/

—Sarah Zielinski, Staff Writer