THERMOSPHERIC TEMPERATURE AND NITRIC OXIDE SPECTROGRAPH

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LONG-TERM GOAL

The long term goal for TtANOS is to develop techniques for remote sensing of the D and E regions of the earth's ionosphere. In particular TtANOS will test methods for measuring temperature and density and for monitoring variations in nitric oxide which can result from changes in the concentration of two important greenhouse species, carbon dioxide and methane

SCIENTIFIC OBJECTIVES

The TtANOS program has 4 specific science objectives:

1. To simultaneously measure middle ultraviolet limb emissions and solar soft X-rays in order to:
   a) determine day time thermospheric nitric oxide (NO) and nitrogen (N_2) densities over the altitude range 90 km to 200 km;
   b) study the relationship between solar soft X-rays and NO production rate and variability; and
   c) infer day time oxygen (both O_2 and O) densities from N_2 second positive and Vegaard Kaplan emissions;
2. To determine night time O_2 densities and temperatures by measuring the Hertzberg emission bands;
3. To infer day time lower themrospheric temperatures over the altitude range 90 km to 200 km from measurements of NO γ band shapes; and

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4. To look for signatures of the buildup of atmospheric the greenhouse gases carbon dioxide and methane.

APPROACH

TtANOS will make remote sensing observations of the D and E regions the atmosphere using a small space-borne instrument package. A telescope-spectrometer views the limb of the earth while an X-ray photometer observes the sun. The spectrometer measures altitude profiles of NO γ band (λ ~ 215 nm), N_2 Vegaard Kaplan emission (λ ~ 280 nm), and N_2 second positive (λ ~315 nm) emissions with a vertical resolution of 5.0 km and a latitudinal resolution of 6• . Temperature as a function of altitude and latitude is deduced from the spectral shape of the NO band emission (Barth and Eparvier, 1993) during the day. During the night, temperatures at a single altitude near 100 km can be calculated from the shape of the weak O_2 Hertzberg emission, also located near 280 nm. Neutral densities are deduced from emission intensities and ratios of the two N_2 band systems. Variability in the concentrations of NO will be compared to temporal changes in the solar soft X-ray flux. The correlation study requires the use of photochemical models to correct for NO concentration variations caused by seasonal atmospheric processes.

WORK COMPLETED

During the past year, we completed the design and fabrication of the TtANOS spectrograph hardware. The instrument is currently undergoing assembly and test and will be ready for flight qualification testing by March 1998. We continue to interact with the Air Force Space Test Experiment Program (STEP) to identify a flight opportunity for TtANOS. Currently we are studying the feasibility of flying TtANOS on the first launch of the Orbital Suborbital Program (OSP) which is being supported by STEP personnel at Kirkland Air Force Base in Albuquerque, New Mexico.

RESULTS

Preliminary results from out feasibility study indicate that it may be possible to fly instruments like TtANOS on simple spacecraft which have only limited pointing capability. We would accomplish this by using sensors to measure spacecraft attitude and feed back this data to a small steering mirror which controls the viewing direction of the TtANOS spectrograph. This technique would be incorporated with TtANOS in the first OSP flight.

IMPACT/APPLICATION

Both the remote sensing observations and their implementation have significant impact for future investigations. First, TtANOS will make the first global measurements of temperature and density in the D and E regions. Current techniques for estimating structure and composition in these regions rely on interpolation between values measured in the lower mesosphere ($h < 40$km) and those measured in the upper thermosphere ($h > 200$km). Understanding the dynamics of D and E region is important to our understanding of the role which trace constituents such as NO may play in ozone destruction in the upper stratosphere. In addition, because photochemical models have shown that NO densities in the D and E region are strongly dependent on concentrations of greenhouse gases such as carbon dioxide and methane, TtANOS type measurements have potential use as early indicators of global change. Second, assuming TtANOS flies on the first

OSP spacecraft, it will demonstrate the feasibility of coordinating spacecraft and instrument capabilities to achieve high resolution instrument pointing and stability. This concept of completely integrating instrument and spacecraft to produce a "sciencraft" will dramatically reduce the cost of space borne high resolution atmospheric remote sensing experiments.

RELATED PROJECTS

TtANOS is directly related to investigations funded by the Office of Naval Research PRIMER Program. It includes:

1. Long Range Thermosphere-Ionosphere-Mesosphere-Electrodynamics General Circulation Models being developed by Ray Robel at the National Center for Atmospheric Research; and
2. Models of O_2 Hertzberg emission band structure constructed by Ron Thomas at New Mexico State University.

TtANOS is also related to a number of DOD remotes sensing investigations:

1. It will test the possibility of extending measurements made by the DMSP Special Sensor Ultraviolet Limb Imager (SSULI) from the F region of the ionosphere into the D and E regions; and
2. It will be a follow on to the NRL Remote Atmospheric & Ionospheric Detection System (RAIDS) employing high resolution in the middle ultraviolet region of the spectrum.

REFERENCES

C. A. Barth and F. G. Eparvier, 1993. "A Method for Measuring the Temperature of the Lower Thermosphere," *Journal of Geophysical Research*, 98, 9437.