Observing Tides in the Earth’s Lower Thermosphere from a Geostationary Orbit: A Key Measurement for Understanding Thermosphere-Ionosphere Variability


I. The Thermosphere-Ionosphere System

- The thermosphere-ionosphere is a boundary between regions dominated by plasma and fluid processes
  - This transition is common to planetary atmospheres
  - Neutral and ion composition are strongly coupled
  - Variations in either affect technological systems we depend on

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II. GOLD Mission

- GOLD would fly on a commercial communications satellite in geostationary orbit (first use of commercial, geostationary flight for NASA science instrument)
- Effects of tidal, solar and geomagnetic forcing can be followed, allowing effects of each to be isolated
- Orbit and operations provide continuous coverage over the Americas
- Repeated observations of same locations allows separation of changes in time and space
- Provides, for the first time, response of the thermosphere to tidal forcing across a hemisphere

GOAL: Understand the role of tidal forcing on global changes in the thermosphere and ionosphere

METHOD: Far Ultraviolet (FUV) images of the Earth from geostationary orbit to observe global-scale temporal and spatial changes in temperature, composition and density of the thermosphere and ionosphere

RESULT: Observations of neutral density tides in thermosphere to answer critical scientific questions about their influence on variability in the thermosphere-ionosphere system

III. Calculated Tidal Effects in Thermosphere

- Temperatures and densities in the thermosphere are calculated using the TIEGCM model
  - For lines-of-sight from geostationary orbit, temperatures and densities from the TIEGCM results are combined with emission profiles derived using AURIC to calculate the N2, O2 and O3 abundance
  - The synthetic spectra are run through an instrument simulator to account for instrument sensitivity, instrumental line shape, and statistical counting noise (instrument sensitivity is determined by factor of 2)
  - The simulated spectra are then fit using a modified Levenberg-Marquardt scheme to perform Discrete Inverse Theory retrievals of the temperature

- GOLD mission will provide the data necessary for understanding the role of tidal forcing on global changes in the thermosphere and ionosphere

IV. Simulated Observation of Tidal Effects on Thermosphere by GOLD Imager

- Observations are simulated by using temperature, brightness, and O2 density profiles along lines-of-sight from geostationary orbit to produce synthetic LBH spectra
- The synthetic spectra are run through an instrument simulator to account for instrument sensitivity, instrumental line shape, and statistical counting noise (instrument sensitivity is determined by factor of 2)
- The simulated spectra are then fit using a modified Levenberg-Marquardt scheme to perform Discrete Inverse Theory retrievals of the temperature

V. Effects of Tides on Thermospheric Temperatures

- Temperature changes due to tides in the thermosphere are clearly distinguishable in the simulated and calculated images
- Amplitudes of tides at the altitudes GOLD would observe (near 160 km) are unknown, due to a lack of measurements
- At other altitudes the temperature changes calculated using the TIEGCM model are typically lower than is observed

VI. Effects of Tides on Equatorial Ionosphere at Night

- Nighttime ionosphere is coupled with the thermosphere, which changes more slowly (the time constant is hours) than the thermosphere
- GOLD can continue observing same locations after sunset in order to determine the influence of diurnal tides on the nighttime ionosphere

VII. Summary

- GOLD provides new capabilities for understanding the thermosphere-ionosphere system
- GOLD will provide unprecedented temperature measurements across the daynight disk
- GOLD will allow tracking of temporal and spatial changes across the disk during the day
- GOLD will provide almost continuous data across American sector from geostationary orbit
- GOLD mission will provide the global scale images of neutral temperatures and composition that are critical to advancing our understanding of the Thermosphere-Ionosphere system
- GOLD will provide the data necessary for understanding the role of tidal forcing on global changes in the thermosphere and ionosphere