Observations of Ionosphere/Troposphere Coupling as Observed by COSMIC

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Introduction

- NRL Space Science Division has used the COSMIC Constellation to study the coupling between the troposphere and ionosphere
  - Sudden Stratospheric Warming impacts on the Ionosphere
  - Tidal Forcing of the EIA
  - MSTIDs driven by gravity wave forcing
  - Ionospheric Bubbles

- COSMIC radio occultation measurements of the electron density
  - Slant TEC measured horizontally through the Earth’s ionosphere
  - Electron density profiles produced by Abel inversions of the slant TEC measurements were used in the study
  - Global coverage of electron density profiles
  - 24 hour local time coverage

- This presentation focuses on the use of TIP data for ionospheric studies
  - TIP operated only during nighttime
  - Studies confined to moon down periods to eliminate red-leak
On April 14, 2006, the COSMIC/FOMOSAT-3 satellite constellation was launched.

Constellation became fully deployed in 2007 with full local time coverage.

The primary research objective of the COSMIC satellites is to improve tropospheric weather prediction.

- Uses GPS occultation to sense water vapor using refractivity.

Secondary research goal is to study the ionosphere.
SSUSI is DMSP sensor that is a copy of the GUVI sensor that flew on the NASA/TIMED satellite

COSMIC passes near ALTAIR on April 6, 2010
• ~20 LT
• Good agreement with SSUSI radiances

TIP shows smaller scale structure → ionospheric depletions
• TIP signal-to-noise ratio ~100
• SSUSI signal-to-noise ratio ~2
Studies of Ionospheric Bubbles

ALTAIR Scan
B field lines
TIP Measurements

244 MHz S4

TIP 135.6-nm Emission

- Solar minimum
- Very weak low latitude ionosphere at 23LT
- Depletion in S crest maps to depletion seen in ALTAIR scan
- N crest absent less than 10 degrees to the west – suggests longitudinal variation in pre-reversal enhancement
- Bottomside structure near equator observed in TIP data
Studies of Ionospheric Bubbles

TIP and ALTAIR show similar features – bottomside structure, no anomaly crest, poleward edge of low latitude region.

Note TIP crosses bottomside features (dark bands) on the 630.0-nm allsky image. These are seen as depressions in the TIP data at 5°, 9°, and 13°N latitude.
Climatological 4-cell pattern attributed to non-migrating tides, generally about 50% variation in anomaly crests intensity (~30% in TEC or NmF2).

Asymmetry favoring southern crest in all sectors except in American sector where magnetic equator is south of geographic equator.

Daily patterns show evidence of large scale variation (1-2 cells, hemispheric scale) –implies hemispheric scale variation of neutral winds from day to day.
TIP Ingestion Into GAIM -Improved Resolution of the EIA-

(Schunk et al.)

Horizontal gradients from adjacent TIP passes separated by a few 100 km

High resolution anomaly
Crest to trough ratio precursor to irregularity formation
Background density places upper bound on scintillation intensity
Day-to-Day EIA Variability & ESF

- Area of enhanced ionospheric anomaly formation near Christmas Island – peak of 4-cell pattern.
- Anomaly is always well formed – measured by 1356Å photometer (TIP).
- Crest magnitude and location varies.
- Trough depth varies.
- Crest to trough ratio (CTR) correlates well with ESF occurrence measured by Christmas Is Radar.
- Evidence that PRE is a driving mechanism.
Gravity Wave Coupling Into the Ionosphere

- **Combined Radio Interferometry and COSMIC Experiment in Tomography (CRICKET) campaign:**
  - September 15, 2007
  - Used VLA Radio Telescope near Socorro, NM to observe the ionosphere during a COSMIC satellite overflight

- **Experiment Goal:** Better understand gravity wave induced ionospheric perturbations (traveling ionospheric disturbances or TIDs) observed by the VLA

- **Experiment concept:**
  - Gather simultaneous measurements of ionospheric structure using VLA & COSMIC
  - Use COSMIC to put VLA measurements into global context

- **Results:**
  - First reported observation of a travelling ionospheric disturbance seen from space
  - Pathfinder for global space-based TID studies

**Very Large Array Radio Telescope**
Summary

- The Tiny Ionospheric Photometers were useful instruments for ionospheric studies
  - Very high sensitivity provided very high signal-to-noise ratio measurements of very weak ionospheres

- Science highlights
  - The detection and characterization of a Medium-Scale Traveling Ionospheric Disturbance that had a few TECU variation
  - Ability to see ionospheric bubbles that did not penetrate the F-peak
  - Observed correlation between the Crest-to-Trough ratio and the severity of Spread-F
  - Provided high resolution measurements that could significantly impact the accuracy of assimilative ionospheric models
  - High-precision, high-resolution specification of ionospheric structure near the EIA