Near Real-time Ionospheric Data Products from COSMIC

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COSMIC Project Office
University Corporation for Atmospheric Research

Collaborators

Bill Kuo  Chris Rocken
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COSMIC – A Six Satellite Constellation

Launched April 14 2006 – 11 days ago
All six satellites stacked and launched on a Minotaur rocket.

Initial orbit altitude $\sim 500$ km; inclination $\sim 72^\circ$.

Will be maneuvered into six different orbital planes for optimal global coverage (at $\sim 800$ km altitude).

All satellites are in good health and providing initial data.
GPS receiver: \{ Total Electron Content (TEC) to all GPS satellites in view \\
Ionospheric radio occultations (profiles) & scintillations \}

Tiny Ionospheric Photometer (TIP): Ultra-violet emission from ionosphere

Tri-Band Beacon (TBB): TEC & scintillations on satellite-to-ground links
Total Electron Content measurements:

- High-resolution (1 Hz) TEC to all GPS satellites in view at all times
- Can track up to 12 GPS satellites at the same time (9 aft + 4 fore)
- Useful for global ionospheric tomography and data assimilation
Ionospheric GPS occultation measurements:

- High-resolution (1 Hz) occultation TEC below orbit altitude
- Ionospheric electron density profiles from orbit altitude and down
- Ionospheric scintillations using the two limb antennas (50 Hz)
Tiny Ionospheric Photometer measurements:

- Emission (1356 Å) due to recombination of oxygen ions and electrons
- Nadir intensity along sub-satellite track – proportional to $\int N_e^2 dz$
- High quality data on night-side – uncertainty about day-side quality
Tri-Band Beacon measurements:

- Radio signals transmitted from COSMIC at 150, 400, and 1067 MHz
- TEC between the COSMIC satellites and chains of ground receivers
- Amplitude and phase scintillations on the satellite-to-ground links
• About 2500 ionospheric occultations per day
• Profiles of electron density between 100 and 800 km
• Total Electron Content to all GPS satellites in view
First COSMIC ionospheric profiles

C001.2006.111.09.19.G13 (lat = 19N, lon = 53W)
C001.2006.111.09.21.G23 (lat = 24N, lon = 41W)
First Ionospheric Profiles

More COSMIC ionospheric profiles

Altitude (km) vs. Electron density (1/cm³)
Total Electron Content

LEO-GPS Total Electron Content, Flight Module 4, aft antenna

Time in minutes since 23-APR-06, 20:10 UTC

TEC (TECU)
Some Amazing First Comparisons...  

Same occultations from two different COSMIC satellites

- FM2 and FM4 within 30 km of each other
- FM2 about 4 seconds behind FM4
- Four seconds later, FM2 is within 1 km of where FM4 was 4 seconds earlier
- FM2 and FM4 orbit altitudes differ by a few hundred meters.
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Summary and Instrument Status

• Three instruments on board each COSMIC satellite will provide ionospheric data:
  – GPS receiver: TEC, electron density profiles, and scintillations
  – TIP: Nadir intensity from radiative recombination emission along the sub-satellite track
  – TBB: TEC and scintillations on satellite-to-ground links

• COSMIC is in early check-out phase
  – All GPS receivers working; SNRs looking good; about 50 ionospheric profiles acquired so far
  – S/C attitude is currently not optimal; limits initial GPS data collection and data processing
  – Attitude expected to stabilize in a few days when solar arrays are switched to slow speed mode
  – TIP instruments performing well, but apertures not opened yet
  – TBB transmitters not yet turned on

• We anticipate that COSMIC will provide an unprecedented large amount of ionospheric data useful for data assimilation into space weather models and ionospheric research in general
Prospects for COSMIC II

• The expected lifetime of COSMIC is about five years
• COSMIC’s latency is not optimal for space weather forecasting
• UCAR has been discussing with NOAA about a possible COSMIC follow-on mission (COSMIC II)
• This would provide the opportunity to design a system that would better support the space weather community needs
• It would be good to receive input from the community with regard to the requirements for such a follow-on mission