Early Results of Ionospheric Measurements from the FORMOSAT-3/COSMIC Mission

Stig Syndergaard
Christian Rocken
William S. Schreiner
Douglas C. Hunt

COSMIC Project Office, UCAR

Jiuhou Lei

High Altitude Observatory, NCAR

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COSMIC – A Six Satellite Constellation

Illustration courtesy of Orbital Sciences Corporation

Launched April 15, 2006, from Vandenberg AFB
All six satellites stacked and launched on a Minotaur rocket.

Initial orbit altitude \( \sim 500 \text{ km} \); inclination \( \sim 72^\circ \).

Currently spacecraft are being maneuvered into six different orbital planes for optimal global coverage (at \( \sim 800 \text{ km} \) altitude).

All satellites are in good health and providing a huge amount of high-quality data.

COSMIC data were officially released to the public on July 28, 2006.
GPS receiver (GOX): \{ Total electron content along links to GPS satellites \\
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
Overview of GOX ionospheric data

Three main products from the GPS receivers:

- Total Electron Content (TEC) along links to GPS satellites
- Electron density profiles derived from GPS occultations
- Scintillations (recent firmware upgrade should allow $S_4$ index for all LEO–GPS links to be calculated)
Processed data for cosmicrt

Ionospheric profiles processed at UCAR
April 22, 2006 – first collocated profiles

- 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.
Comparisons with ground-based data

(a) RO (42.6N, 73.96W)  
DAY: 212  
UTh: 12:33

(b) RO (41.4N, 70.69W)  
DAY: 214  
UTh: 13:06

(c) RO (38.2N, 76.94W)  
DAY: 230  
UTh: 17:56

(d) RO (48.4N, 73.14W)  
DAY: 231  
UTh: 07:40

(e) RO (41.9N, 72.40W)  
DAY: 231  
UTh: 07:40

(f) RO (41.6N, 67.29W)  
DAY: 265  
UTh: 00:57

(a) RO (11.7S, 84.76W)  
DAY: 181  
UTh: 06:35

(b) RO (9.79S, 81.67W)  
DAY: 264  
UTh: 00:58
**Event on August 9, 2006**

**15:50 UT** Enhanced electron density at 400–500 km
Event on August 9, 2006

15:50 UT  Enhanced electron density at 400–500 km

15:56 UT  Enhancement seems to propagate upward
Event on August 9, 2006

15:50 UT  Enhanced electron density at 400–500 km
15:56 UT  Enhancement seems to propagate upward
15:59 UT  Further upward
15:50 UT  Enhanced electron density at 400–500 km
15:56 UT  Enhancement seems to propagate upward
15:59 UT  Further upward
16:03 UT  Further yet
Constellation on August 26, 2006
**Event on August 26, 2006**

**13:01 UT**  F2-layer peak at $\sim 240$ km

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**PRN 14**

**FM6 13:01 UT (11:31 LT)**
**FM4 13:09 UT (11:42 LT)**
**FM3 13:09 UT (11:42 LT)**
**FM2 13:19 UT (11:58 LT)**
**FM1 13:30 UT (12:08 LT)**

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**Electron density (1/cm$^3$)**

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**Longitude (degrees)**

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**Latitude (degrees)**
Event on August 26, 2006

- **13:01 UT** F2-layer peak at \(\sim 240\) km
- **13:09 UT** F2-layer peak at \(\sim 280\) km
Event on August 26, 2006

13:01 UT  F2-layer peak at \( \sim 240 \text{ km} \)
13:09 UT  F2-layer peak at \( \sim 280 \text{ km} \)
13:19 UT  F2-layer peak at \( \sim 320 \text{ km} \)
Event on August 26, 2006

13:01 UT  F2-layer peak at ~240 km
13:09 UT  F2-layer peak at ~280 km
13:19 UT  F2-layer peak at ~320 km
13:30 UT  F2-layer peak at ~360 km
Summary and status

• Currently UCAR/CDAAC process between 2000 and 2500 electron density profiles per day

• We also process about 3000 DCB calibrated TEC arcs per day – useful for assimilation into space weather models

• New firmware (build 4.3) should allow $S_4$ scintillation index to be calculated for all LEO–GPS links (firmware uploaded to two of six satellites)

• Early results of collocated occultation measurements show excellent agreements – high degree of repeatability of measurements from different platforms

• A few electron density profiles have been verified against ground-based measurements

• Early constellation figuration allows study of ionospheric dynamics when near-collocated measurements are made a few to several minutes apart