FORMOSAT-3/COSMIC:
Results from one year in orbit

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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 $\sim 500$ km; inclination $\sim 72^\circ$
• Currently spacecraft are being maneuvered into six different orbital planes for optimal global coverage (at $\sim 800$ km altitude)
• 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.
COSMIC ionospheric measurements

GPS receiver (GOX): \{
  TEC & S_4 scintillation index 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 allows $S_4$ index for all LEO–GPS links to be calculated)
Ionospheric profiles processed at UCAR

Processed data for cosmicrt

Date

Occultations per day

0 1000 2000 3000

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.

[Schreiner et al., GRL 2007]
Comparisons with ISR data

(a) RO (42.6N, 73.96W)  
(b) RO (41.4N, 70.69W)  
(c) RO (38.2N, 76.94W)  
(d) RO (48.4N, 73.14W)  
(e) RO (41.9N, 72.40W)  
(f) RO (41.6N, 67.29W)  

MHR

JRO

[Lei et al., JGR 2007, in press]
COSMIC, ionosondes and TIEGCM

August 2, 2006

COSMIC ionosondes model (TIEGCM)
Compared with COSMIC, TIEGCM show smaller peak density in the summer hemisphere, but larger peak density in the winter hemisphere.

TIEGCM have lower HmF2 in the polar region.
Total Electron Content data

TEC arcs from one dump on June 1st, FM3 Aft-POD antenna (2006.152.003.02.01)

GPS-COSMIC transitionospheric radio links for a period of 100 minutes on March 4, 2007
COSMIC and USU GAIM

Data collected during the first week of COSMIC operation (April 21-28, 2006)

- Good agreement of NmF2 between COSMIC and USU GAIM
- Higher peak heights from GAIM than those from COSMIC
- COSMIC should help determine vertical distribution better in data assimilation models
Recent firmware upload allows calculation of $S_4$ scintillation index for all COSMIC-GPS links.

Both high elevation angle data from POD antennas and occultation data from high-gain limb antennas.

One second $S_4$ index data are available in near-real time.

A problem with occasional outliers in the raw data remains to be solved.
Tiny Ionospheric Photometer (TIP)

135.6-nm passes Sep 14, 2006 (FM1, FM3, FM6) 21:00 LT

[Image provided by Clayton Coker, NRL]
**Tri-band Beacon (TBB)**

Samples of relative slant-path TEC data from Patrick AFB, Florida (FM1, FM5, FM6) December 21, 2006

[Image provided by Paul Bernhardt, NRL]
Summary and status

- Currently UCAR 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
- Recent firmware upload allow $S_4$ scintillation index to be calculated for all LEO–GPS links
- COSMIC data have been verified against ground-based data and models
- A variety of results have been obtained with the data collected during the first year in orbit
- TIP and TBB instruments also provide new exciting data
- We look forward to see COSMIC data being used in space weather models in the near future

COSMIC data are freely available in near real-time at http://www.cosmic.ucar.edu