COSMIC / FormoSat 3
Science Payloads and Data Analysis Status - First results
Outline

• COSMIC Introduction / Status
• Early results from COSMIC
  – Neutral Atmosphere profiles
    • Refractivity, Boundary layer, Water vapor
  – Ionspheric results
    • GPS Electron Density Profiles
    • Global maps of NmF2, HmF2
    • TIP and TBB (CERTO)

• Summary
COSMIC/Formosat 3 at a Glance

- Constellation Observing System for Meteorology Ionosphere and Climate (Formosat-3)
- 6 Satellites launched in April 2006
- Orbits: alt=800km, Inc=72deg, ecc=0
- Weather + Space Weather data
- Global observations of:
  - Refractivity
  - Pressure, Temperature, Humidity
  - TEC, Ionospheric Electron Density
  - Ionospheric Scintillation
- Demonstrate quasi-operational GPS limb sounding with global coverage in near-real time
- Climate Monitoring
- Geodetic Research
Launch on April 14, 2006
Vandenberg AFB, CA

- All six satellites stacked and launched on a Minotaur rocket

- Initial orbit altitude ~500 km; inclination ~72°

- Will be maneuvered into six different orbital planes for optimal global coverage (at ~800 km altitude)

- All satellites are in good health and providing initial data
The velocity of GPS relative to LEO must be estimated to $\sim0.2$ mm/sec (velocity of GPS is $\sim3$ km/sec and velocity of LEO is $\sim7$ km/sec) to determine precise temperature profiles.

The LEO tracks the GPS phase while the signal is occulted to determine the Doppler.
The velocity of GPS relative to LEO must be estimated to $\sim 0.2\text{ mm/sec}$ (20 ppb) to determine precise temperature profiles.

The LEO tracks the GPS phase while the signal is occulted to determine the Doppler.
COSMIC Soundings in 1 Day
Occultation Locations for COSMIC, 6 S/C, 6 Planes, 24 Hrs
Ionospheric Occultation Global Coverage

• About 2500 ionospheric occultations per day
• Profiles of electron density between 100 and 800 km
• Total Electron Content to all GPS satellites in view
Getting COSMIC Results to Weather Centers

Data available to weather centers within < 180 minutes of on-orbit collection
http://www.cosmic.ucar.edu

* Select the 'Sign Up ' link under COSMIC

• Accept data use agreement

* Enter information: Name, Address, email, user_id, Password, planned use of data

• An email will be sent within 2-3 business days to indicate access has been granted.
Tropical refractivity

Polar “dry” temperature
Penetration of Planetary Boundary layer with COSMIC

Comparison of Refractivity with GFS (AVN)
Water Vapor Pressure Comparison
COSMIC (FM3 and FM4 ) vs. GFS

COSMIC Collocated Soundings, 2006.189.05.05.G17
July 8, 2006 05:05 UTC, Lat=21S, Lon=71W

COSMIC Collocated Soundings, 2006.190.09.36.G06
July 9, 2008 09:36 UTC, Lat=22S, Lon=140W
Comparison of 2 Ionospheric Profiles

(a) Comparison of altitude (km) vs. electron density (cm$^{-3}$) for COSMIC FM2 (red line) and COSMIC FM4 (blue dotted line).

(b) Graph showing the difference in electron density (cm$^{-3}$) between the two profiles.
COSMIC S4 > 0.1 between 111-233, 2006
Sub-orbit observation links during a 5-hour observation window
Ionospheric Total Electron Content Data

In addition to electron density profile information COSMIC also provides LEO - to - GPS TEC observations

We presently observe ~3100 TEC-arcs as shown here per day
Longitudinal variability of ionosphere

- Low latitude density crests and troughs are a product of photoionization, recombination, and transport.
- Electric fields interact with the Earth’s magnetic field to transport plasma vertically at the equator, which diffuses downward along the magnetic field lines.
- Meridional neutral winds also transport plasma along magnetic field lines.
- TIP reveals the complexity of these ionospheric drivers as a function of longitude.

Courtesy Clayton Coker, NRL
FM4

Courtesy Paul Bernhardt, NRL
FormoSat 3 / COSMIC Display Example for FM 3
Summary

- COSMIC was launched on-schedule and within budget.
- All 6 GPS receivers are working.
- TIP and CERTO (TBB) instruments are working.
- CDAAC automated processing is routinely providing near-real-time products.
- Obtaining good radio occultation profiles in ionosphere (~2500 /day) and neutral atmosphere (~1000 / day).
- Scintillation observations.
- About 3100 TEC-arcs / day.
- All data available for assimilation into ionospheric models and NWP models.