COSMIC: Constellation Observing System for Meteorology, Ionosphere and Climate: Overview, Status, and Results


UCAR / COSMIC Program - Boulder CO

COMET's NPOESS/GOES-R Training Resources Development Workshop
12-14 May 2009
Overview

• Radio Occultation (RO) introduction
• COSMIC Program Overview
• Research/Operational Highlights
• Ground Based GPS Water Vapor Observations
RO Technique
GNSS (Global Navigation Satellite System)

- GPS (USA), GLONASS (Russia), GALILEO (EU), COMPASS (China)

Yunck, 2004
Presentation of first results from COSMIC/FORMOSAT-3 appears in Bulletin of American Meteorological Society, March 2008

COSMIC / FORMOSAT - 3
Profiling the Atmosphere by Radio Occultation
Characteristics of GPS RO Data

- Limb sounding geometry complementary to ground and space nadir viewing instruments
- Global 3-D coverage 40 km to surface, full local time sampling
- High accuracy
- Demonstrated high precision (~0.2 K between 10 and 20 km)
- High vertical resolution (0.1 km near surface – 1 km above tropopause)
- Low horizontal resolution (200-300km)
- All weather-minimally affected by aerosols, clouds or precipitation
- Independent height and pressure
- No instrument drift
- No satellite-to-satellite bias
- Compact sensor, low power, low cost
COSMIC Program Overview
COSMIC at a Glance

- Constellation Observing System for Meteorology Ionosphere and Climate
- Joint US, Taiwan Mission (FORMOSAT-3)
- 6 Satellites launched in Apr 2006
- Orbits: alt=800km, Inc=72deg, ecc=0, ∆Ω=30deg
- Weather + Space Weather data
- Global observations of:
  - Pressure, Temperature, Humidity
  - Refractivity
  - TEC, Ionospheric Electron Density
  - Ionospheric Scintillation
- Demonstrate quasi-operational GPS limb sounding with global coverage in near-real time
- Climate Monitoring
- Useful for CAL/VAL studies (Rsondes, AMSU, SSMI, NWPs)
COSMIC Operational Processing

Data available to weather centers within < 180 minutes of on-orbit collection
Global coverage in all weather
2458 soundings

2458 Matches
1.7 Million Profiles in Real Time
4/21/06 – 5/6/2009

Total atmospheric occultations: 1,738,970
http://www.cosmic.ucar.edu

- Select the 'Sign Up ' link under COSMIC
- Accept data use agreement
- E-mail will be sent within 2-3 business days to indicate access has been granted
- N, P, T, wv profiles in NetCDF format
- On-line SQL database, analysis tools and data download
Research/Operational Highlights
Temperature profiles near England

At about 95-4-25:00:00 UTC

**RO and Radiosonde Profiles**

- Temperature profiles near England
- At about 95-4-25:00:00 UTC
- Pressure, mbar
- Temperature, K
- Occultation at 52.6N. 355 E.
- Radiosonde at 54.5 N. 353.9 E.
- Radiosonde at 53.5 N. 357 E.
Comparison of Collocated Profiles
Statistical comparison of FM3-FM4 Soundings separation < 10 km

0.2% precision between 10-20 km

Schreiner et al. 2007 GRL
Detection Of Boundary Layer With RO

FM-4, 04/09/2006
31.8S, 89.1E
06:27 UTC

FM-2, 27/09/2006
23.1S, 106.6E
23.04 UTC
Global Distribution and Height of ABL on a single day

Sokolovskiy et al., GRL 2007
Impact of COSMIC on Hurricane Ernesto (2006) Forecast

Results from Hui Liu, NCAR
Impact of COSMIC on Hurricane Ernesto (2006) Forecast

With COSMIC

GOES Image

GOES Image from Tim Schmitt, SSEC
Neutral in the troposphere, but some improvement in the stratospheric temperature scores. *Obvious improvement in time series for operational ECMWF model.*

Dec 12, 2006 Operational implementation represented a quite conservative use of data. No measurements assimilated below 4 km, no rising occultations.

Nov 6, 2007 Operational assimilation of rising and setting occultations down to surface

Sean Healy, ECMWF
NCEP Impact study with COSMIC

- 500 hPa geopotential heights anomaly correlation (the higher the better) as a function of forecast day for two different experiments:
  - PRYnc (assimilation of operational obs ),
  - PRYc (PRYnc + COSMIC)
- Assimilated ~1,000 COSMIC profiles per day
- Assimilated operationally at NCEP 1 May 2007
- Assimilating refractivities from rising and setting occultations at all levels (including low level), provided they pass QC
- Results with COSMIC “very encouraging”

Lidia Cucurull, JCSDA
First collocated Ionospheric profiles

From presentation by Stig Syndergaard, UCAR/COSMIC
3-D structure of the feature during daytime (constant LT)

Weaker EIA  Stronger EIA  Weaker EIA  Stronger EIA  Weaker EIA

12:00 LT

Tiger Liu, NCU
Main Results So Far from COSMIC

◆ General
  – 1500–2500 globally distributed profiles per day
  – 80% observations available within 3 hr
  – 1.74M Neutral Atmospheric profiles, 1.89M Ionospheric profiles
  – All spacecraft and payloads functioning with minor degradation
  – Operations funded through 2011
  – Working with NOAA on planning for COSMIC-II

◆ Weather/Ionosphere/Climate:
  – Significant positive impact on skill scores of operational NWP
  – Large impact in individual forecasts (e.g. Hurricane Ernesto 2006)
  – Observations of tropical boundary layer from space for 1st time
  – Ionospheric DA and modelling studies
  – Conducting inter-agency climate trend study, ~0.03%/5 years

◆ Community
  – Free and open data policy
  – 1043 registered users from 50 countries as of May 8, 2009
  – With EOL, COSMIC making near real-time and predicted data available for field campaigns (VOCALS, T-PARC, TiMREX)
  – Planning 4th COSMIC Data Users WS, 27-29 October 2009, in collaboration with JOSS
Ground-based GPS
Precipitable Water Vapor (PWV) and Slant Water Vapor

- SW is the integrated water vapor along single GPS ray paths
- PWV is “the average of all SW observations in a cone scaled to zenith”
- Simultaneous observations along 8-12 GPS ray paths
- GPS and WVR sensed SW and PWV agree to ~1.5 mm rms
COSMIC PWV Networks
Six-Hour Forecast Using GPS PW

GFS

BMB+PW

Observations
PWV Data Access and Availability

• COSMIC processes stations in North America in hourly batches (and daily), using a 30 minute piecewise linear estimation strategy.
• Global stations are processed in daily batches.
• All data processed by the COSMIC program are available via the following methods
  – LDM distribution (see http://www.suominet.ucar.edu/suomiQuestions.html#Get%20LDM )
  – Web distribution http://www.suominet.ucar.edu/data/index.html
  – Including NetCDF, ASCII download by network, and ASCII download by individual station.
• There is also a database interface that allows time series plotting and download queries
  – http://www.suominet.ucar.edu/dataQuery/suomidata.html