# GNSS Radio Occultation: progress report

Lidia Cucurull

NOAA GPSRO Program Scientist
NOAA & JCSDA

UMBC, Maryland, May 2010

# Outline

- Recent accomplishments and ongoing work

    - Assimilation code

    - Evaluation of current and new RO sensors

    - Other RO-related ongoing activities

# Assimilation code

- Improvement of the GPS RO algorithms in GSI
  - More accurate forward operator for refractivity
  - Update of the quality control procedures
  - Optimal observation error characterization

- Changes resulted in an improvement in model skill in SH (mass fields) and reduction of the low- and high-level tropical wind errors

- The changes were implemented operationally at NCEP in Dec 2009

- Detailed description of the changes and results can be found in Cucurull 2010, *Weather and Forecasting* (doi 10.1175)

- GPS RO algorithms are used by anyone using/developing GSI code.

- Delivery of a perl-based software to monitor GPS RO statistics in real time at NCEP (in collaboration with D. Hunt, UCAR). The code can also be used in research mode. Statistics for the operational NCEP model can be found at:

  http://www.emc.ncep.noaa.gov/gmb/wx20cl/STATS_GPSRO/OPS/

# Assimilation code (cont'd)

- The assimilation of COSMIC (and other RO sensors) into NAM is under parallel testing

- Current development work focuses on improving the forward operator

  - Transitioning from refractivity to (1D) bending angle
    » Description of the code can be found in Cucurull et al. 2007, MWR
    » Enhancement of assimilation in lower troposphere (eg., super-refraction conditions)
    » Enable assimilation of high-level observations

  - Sensitivity of the forward operator (refractivity) to compressibility factors (collaborative project with CWB, Taiwan)
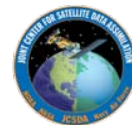
# GPS RO sensors

- UCAR upgraded the processing of the COSMIC observations. The changes modified the statistics of the data (bias and standard deviation in stratosphere). A rigorous testing and evaluation of the impact of the new data was conducted. The new processing became operational in October 2009

- Observations from Metop/GRAS and GRACE-A instruments were evaluated and QC algorithms in GSI were updated accordingly. The data was added to the operational observing system at NCEP in February 2010

- Preliminary evaluation of SAC-C (Argentinean mission) sample data for possible transition to real-time -currently delivered in non-real time and TerraSAR-X (German mission)

- Proposal submitted to evaluate ROSA (Italian RO receiver) on Oceansat-2 has been approved. Negotiations with ASI (Italian Space Agency) are underway

- Collaboration project with Spain IEEC for launch of a COSMIC-type receiver for RO and modified antennas (multi polarized) to detect heavy precipitation (recently funded by Spanish Government)

# GPS RO sensors (cont'd)

- Working with NOAA/OSD on a follow-on capability beyond COSMIC. This involves NESDIS, NWS and other NOAA line offices.
- NOAA is moving forward on a replacement to COSMIC
- "COSMIC 2" (conceptual)
  - 12 satellites
  - Homogeneous global coverage
  - GPS and Galileo signals (minimum)
  - Higher gain antennas for lower SNR
  - 8000+ soundings per day
  - ~30 minutes data latency - from sounding to data delivery to the weather/ionospheric centers

- Preliminary evaluation of PBL heights from COSMIC for future assimilation into the RTMA system (UCAR and EMC/RTMA group)

- Use of RO for validation of re-calibrated radiances and evaluation of the impact of RO observations on the bias correction of nadir sensors into the CFSRR system (Re-analysis).

# Outlook

- Monitor current GPS RO observations (maintain operational effectiveness)

- Evaluate future RO sensors (as early as possible) to enable operational assimilation of the new data as soon as possible.

- Future development work with GPS RO will focus on improving the forward operator (and consequently QC and error characteristics)

- **Participate in International RO Working Group (IROWG), recently formed by CGMS** (CoChair David.Ector@noaa.gov)

  **http://www.irowg.org/** **(September 10-11 2010, Graz, Austria)**

- Support the design & requirements for a COSMIC follow-on mission

- We might want to consider to create a JCSDA "sounding" group, rather than three independent WG (MW, IR, GPSRO)