GPS Radio Occultation data assimilation: progress report

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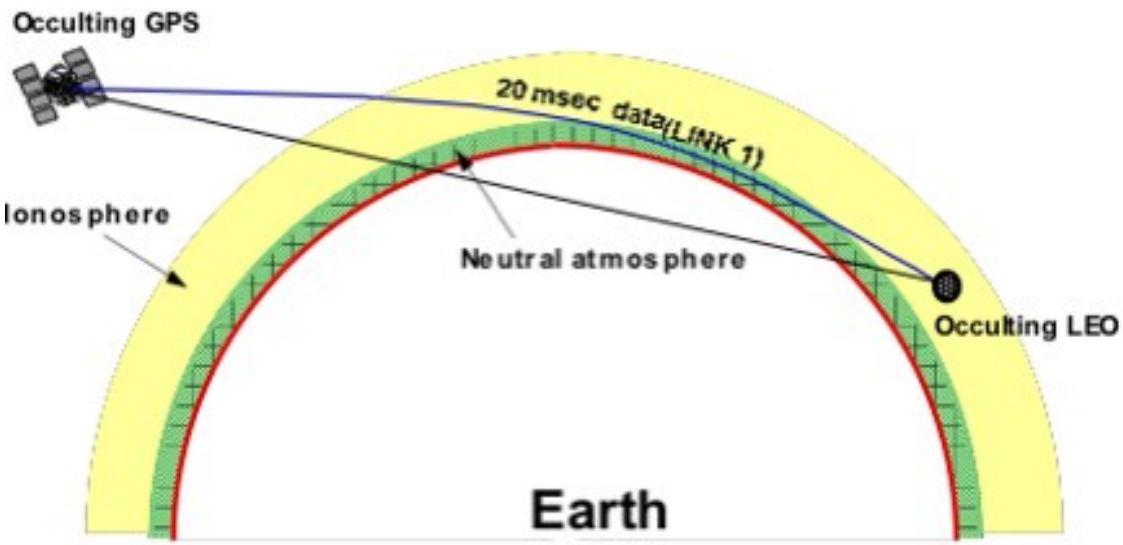
GPS Radio Occultation

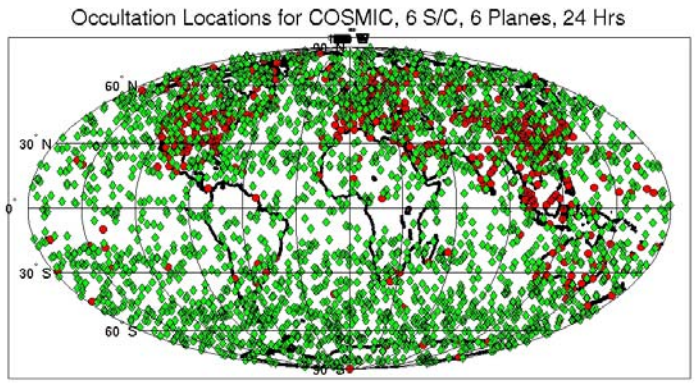
Basic measurement principle:

Deduce atmospheric properties based on
precise measurement of phase delay and amplitude.

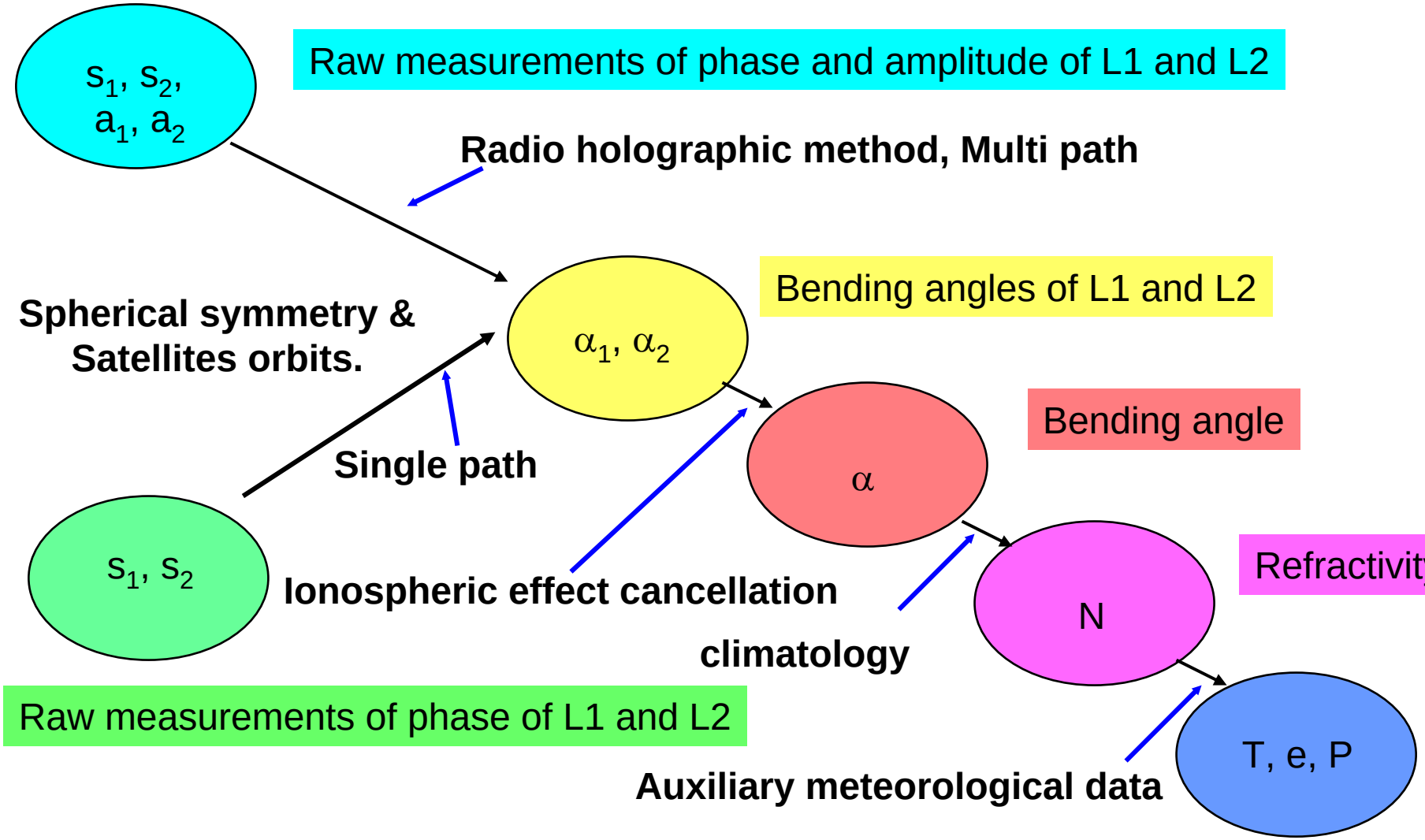


Characteristics of COSMIC observations

- Limb sounding geometry complementary to ground and space nadir viewing instruments
  - High vertical resolution (~100 m)
  - Lower horizontal resolution (~200 km)
- All weather-minimally affected by aerosols, clouds or precipitation
- High accuracy (equivalent to < 1 Kelvin from 5-25 km)
- Equivalent accuracy over ocean than over land
- Independent of radiosonde calibration
- No instrument drift
- Global coverage
- No satellite-to-satellite observational bias
- Inexpensive compared to other sensors



GPS RO: what to assimilate?



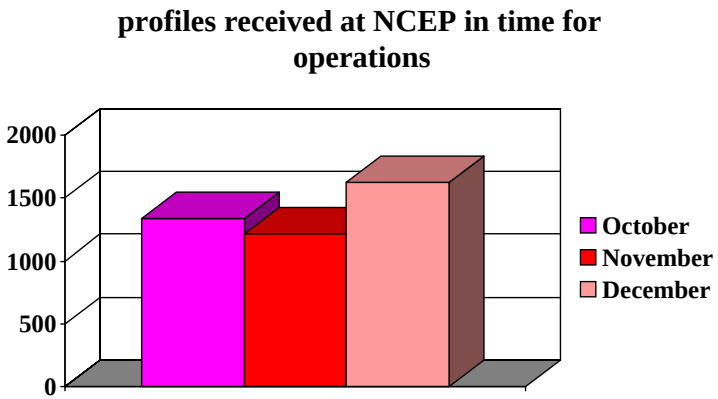
Achievements at the JCSDA

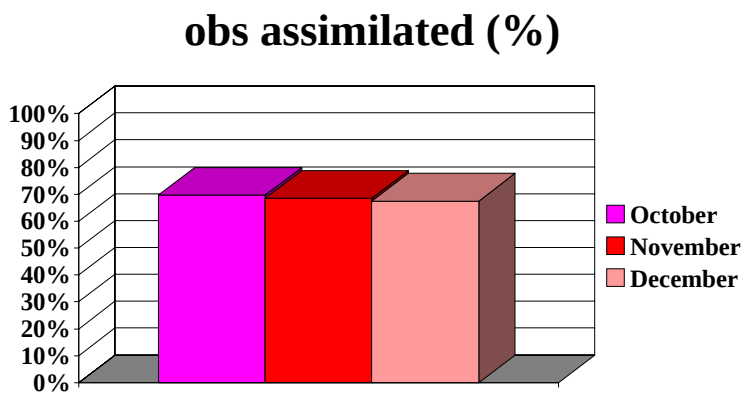
- The JCSDA developed, tested and incorporated into the new generation of NCEP's Global Data Assimilation System the necessary components to assimilate two different type of GPS RO observations (refractivity and bending angle). These components include:
  - complex forward models to simulate the observations (refractivity and bending angles) from analysis variables and associated tangent linear and adjoint models
  - Quality control algorithms & error characterization models
  - Data handling and decoding procedures
  - Verification and impact evaluation algorithms
- Pre-operational implementation runs showed a positive impact in model skill when COSMIC profiles were assimilated on top of the conventional/satellite observations.
- As a result, **COSMIC became operationally assimilated at NCEP on May 1st 2007**, along with the implementation of the new NCEP's Global Data Assimilation System (GSI/GFS). [Profiles of refractivity were selected for implementation in operations, while the tuning of the assimilation of bending angles is currently being analyzed at NCEP].
- **The assimilation of observations from the COSMIC mission into the NCEP's operational system has been a significant achievement of the JCSDA. [Operational assimilation one year after launch!].**

COSMIC observations at NCEP

- We assimilate rising and setting occultations, there is no black-listing of the low-level observations (provided they pass the quality control checks), and we do not assimilate observations above 30 km (due to model limitations).
- In an occultation, the drift of the tangent point is considered.

Average COSMIC counts/day at NCEP (2007)





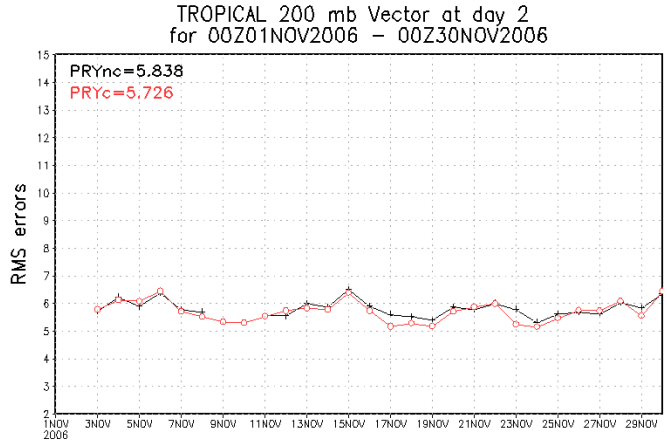
The remaining ~30% received, but not assimilated, is due to:

- Preliminary quality control checks (bad data/format)
- Gross error check (obs very different from the model)
- Statistics quality control check (obs too different from the model-obs statistics)

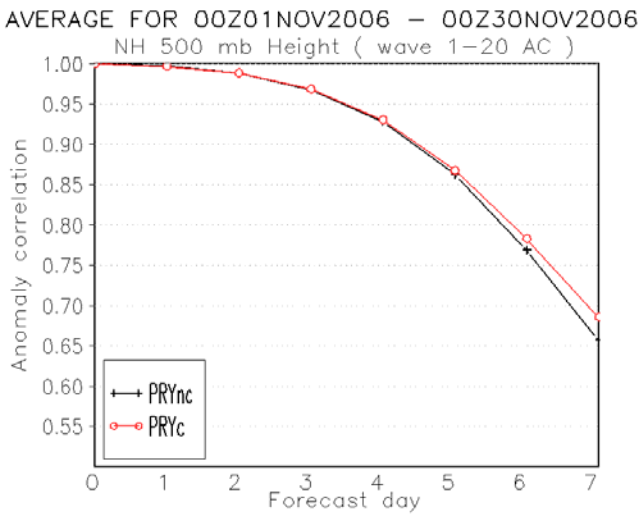
Pre-operational implementation run

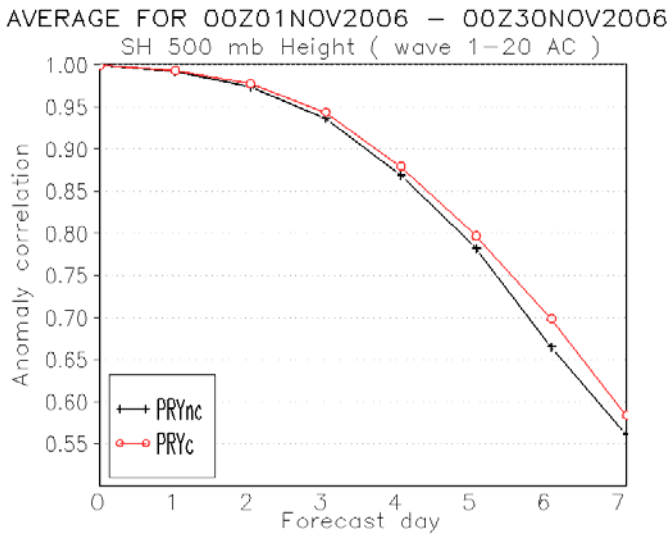
- PRYnc (assimilation of operational obs),
- PRYc (PRYnc + COSMIC refractivity)
- We assimilated around 1,000 COSMIC profiles per day

rms error (wind)

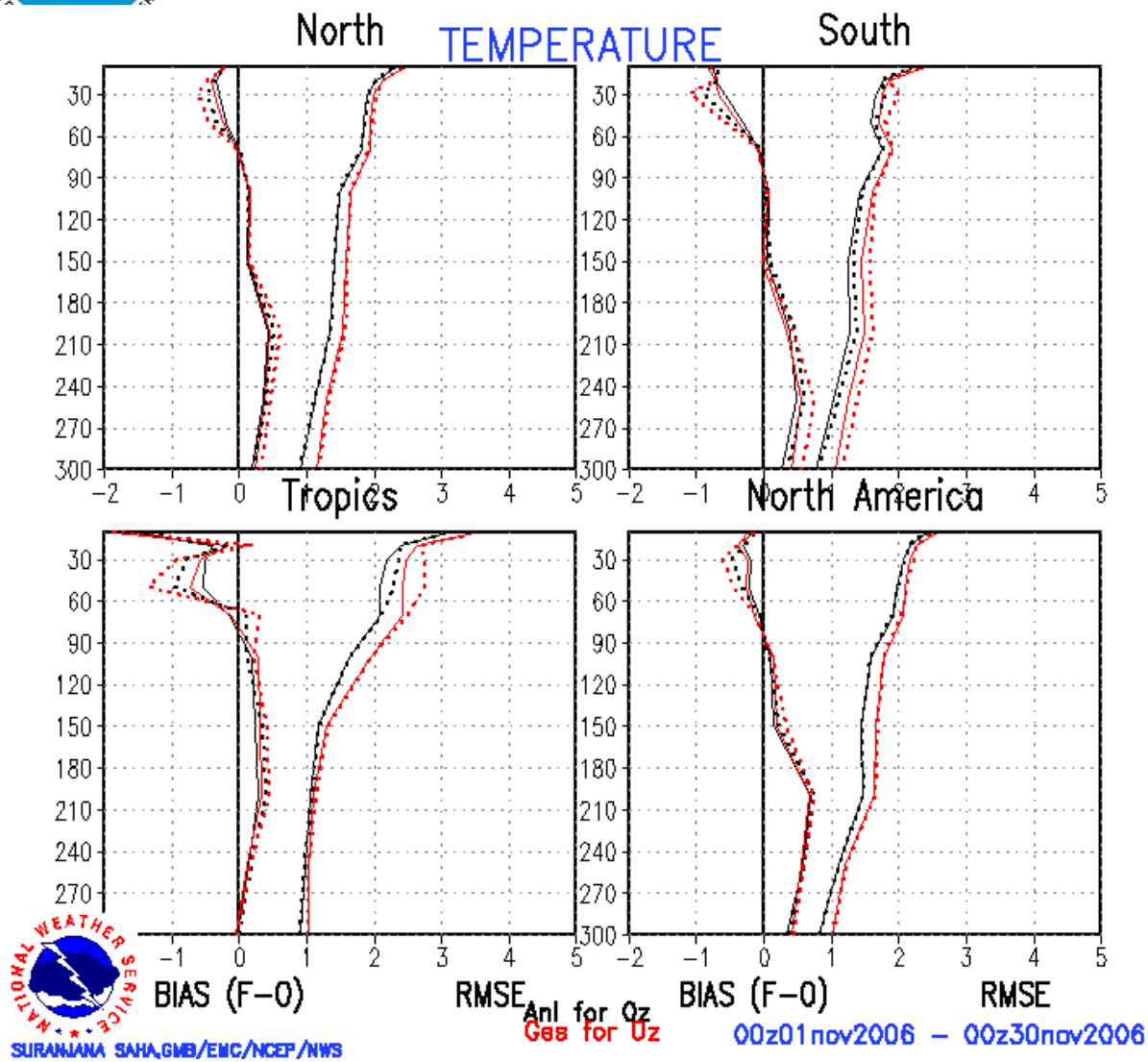


Anomaly correlation as a function of forecast day (geopotential height)





Pre-operational implementation run (cont)



- Dashed lines: PRYnc
- Solid lines: PRYc (with COSMIC)

- Red: 6-hour forecast
- Black: analysis

Recent achievements

- Monitor transition of COSMIC data into operations.
- Improve diagnostic files for GPS RO in the GSI code.
- Generalize the GPS RO code in GSI to use any vertical coordinate system.
- Analysis of more impact studies with COSMIC for different areas and periods. (The use of COSMIC improves model skill).
- Improve assimilation of GPS RO over areas of complex topography.
- Testing, evaluation and feed-back to UCAR on stratospheric bug-fixed profiles. (UCAR improved the quality of the profiles in the stratosphere in November 2007).
- Correct weights associated to the vertical levels surrounding a GPS RO observation in GSI.
- Transition of (GFZ) CHAMP & GRACE-A data into the operational tanks.

On the side …

- Evaluation & assimilation of GPS RO data into the new reanalysis system (CFSRR project; NCEP/EMC).
- Assess the use of COSMIC data to retrieve PBL heights for assimilation into the real-time mesoscale analysis system (RTMA). [Co-I in a NASA-funded Homeland Security project (within the Air Quality Group at NCEP/EMC)].
- POC within NOAA/NESDIS to use GPS RO derived products of temperature and water vapor to validate other satellite instrument data and to extend the NOAA/NESDIS 1dvar capability to include GPS RO.
- Evaluation of the requirements needed to add the GPS RO capability to conduct OSSEs within the international Joint OSSE project (PI for CEOS Category 1 action WE-07-1_3).
- Provide guidance to the Navy in their COSMIC assimilation efforts.
- POC at NESDIS/OSD & NWS (and EMP) for user requirements for GPS RO data.
- Involved in evaluation/planning for a possible GPS RO follow-on mission.

Current and future plan

- Update quality control checks & observation error characteristics for GPS RO data within GSI/GFS. (Some parallel runs are underway).
- Improve (refractivity) forward operator for GPS RO data in the GSI.
- Evaluation, testing, tuning and (likely) assimilation of GPS RO from (GFZ) CHAMP & GRACE-A (in pre-operational mode) and MetOp/A GRAS (when available). [Possible availability of SAC-C data in real-time as well. Negotiations are underway].
- Develop the necessary code infrastructure to monitor the GPS RO statistics (perl-based statistics tool developed in collaboration with Doug Hunt from UCAR/CDAAC) and transition to operations.
- Assimilation of COSMIC observations (and other GPS RO missions) into the regional model (NAM).
- Improve the performance of the assimilation of observations of bending angle (switch to bending angle in operations? Global and regional systems?).
- Explore more complex forward operators to take into account horizontal gradients of refractivity (2D forward operators).