Ionospheric Signatures in Radio Occultation Data

Anthony J. Mannucci
Chi Ao
Byron A. Iijima
E. Robert Kursinski

1. Jet Propulsion Laboratory, California Institute of Technology
2. Broad Reach Engineering

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Outline

1. Motivation
2. Single Frequency Method
   • Testing phase using COSMIC
3. Summary and Conclusions
The Radio Occultation Data Set

- Density, temperature and pressure profiles
- Relatively “sparse” data set with global coverage
- Unaffected by clouds and surface properties

http://www.cosmic.ucar.edu/gpsmet/over/septsumm_top.html
Achieving a Climate Record to 1995

Number of High Rate Occultations per Month

- Not Processed
- Processed

Different trends found for October than February

Processed in Steiner et al., 2009

Rocken et al., 1997
Achieving Records From 1995-1997

- Overcome limitation of the data: only one GPS frequency available, non-prime periods
- Develop a method of calibrating ionosphere delay that uses a single-frequency
- Reprocess GPS/MET 1995-1997 dataset using single frequency

- Philosophy: monitor latitudinal and diurnal signatures

See also:
Ionospheric refractive index for phase and range signal types

\[ N_{\text{Phase}} = 1 - \frac{40.3n_e}{f^2} \]
\[ N_{\text{Range}} = 1 + \frac{40.3n_e}{f^2} \]

Subtract and divide by two. Perform low-order fit.
Ionospheric Estimates of Delay

L1-L2 phase
CA-L1 phase-range

2008-01-01-00:44cosmic4_gps24
2008-01-01-00:05cosmic4_gps38
2008-01-01-00:09cosmic4_gps27
Processing Strategy

- Calculate CA-L1 (range – phase observable)
- Fit linear or low-order polynomial – smoothing
- Correct L1 phase with polynomial
  - Not bending angle
- Perform retrieval
- Partition results according to diurnal signature and other factors
Examples of Fitted Ionospheric Bending Angle

“Optimistic” — No C/A noise

“Pessimistic” — Bending angle instead of delay

Errors here due to L2 tracking difficulties
Line Fit Parameters Vs Local Time

Solid line: median, 2 hr bins; Dashed line: 25, 75 percentiles
Green: high-lat (> 60) Red: mid-lat (30-60) Blue: tropics (< 30)

COSMIC Jan 2008
Residuals to the Linear Fit

40-45 km

COSMIC Jan 2008

30-35 km
Refractivity Retrieval Error
Linear Fit Vs Dual-Frequency Correction

Goal: 0.03%
• Data from 50-120 km altitude contains signatures of ionospheric structure – atmospheric structure is nearly absent.

• Monitor phase and amplitude fluctuations on a per-profile basis
• Aggregate according to fluctuation intensity and other factors
• Compare retrieved bending angles between affected and unaffected profiles
• Determine upper bound of bias as a function of fluctuation intensity
  • Use profile altitude to reduce bias
Summary and Conclusions

• We can extend robustly the radio occultation data record by 6 years (+60%) by developing a single-frequency processing method for GPS/MET data

• We will produce a calibrated data set with profile-by-profile data characterization to determine robust upper bounds on ionospheric bias

• Part of an effort to produce a calibrated RO data set addressing other key error sources such as upper boundary initialization

• Planned: AIRS-GPS water vapor cross validation (water vapor climatology and trends)