Validation of Ørsted-GPS Occultation Data in the Lower Atmosphere

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The Ørsted-GPS Experiment

- Receiving L1 and L2 GPS signals (0.1, 1 and 10 Hz)
- First data collected April 17 1999
- ~6 hours/day August–December 1999
- 24 hour campaign February 2000 (20 days)
GPS Radio Occultation concept
Data products

Ørsted orbit determination
- Position
- Velocity

Neutral atmospheric profiling
- Refractivity
- Pressure
- Temperature
- Water vapor

Ionospheric profiling
- Total Electron Content
- Electron density
Data quality

- L1 - L2 difference can not generally be trusted
- 1–2 second data gaps every 10 second
- Noise on C/A (0.3–1 m) limits the accuracy
- Smoothed L1 - C/A difference used for ionosphere correction
- Orbit accuracy: 2–50 m (2–50 mm/s)
Data processing

Input data
- Ørsted phase and pseudo-range (L1 and CA)
- Ground-station phase and pseudo-range (L1, L2, and CA)
- Ørsted position and velocity fix (every 10 sec)

Pre-processing
- Data de-compression and formatting
- Orbit determination using GIPSY
- Cycleslip detection and correction (only on 1 Hz data)
- Filtering, interpolation and data gap filling

Orbit arc construction
- Interpolation to 10 Hz
- Correction for signal travel time

Phase corrections
- Double differencing (clock correction)
- Tropospheric correction
- Relativistic correction
- Ionospheric correction

Bending angle calculation
- Bending angle bias correction (model constrained)

Abel transform and hydrostatic integration
Comparison of temperature profiles with ECMWF analysis

Profiles at 38°N, 115°E

Profiles at 69°N, 111°W
Statistics for ~1200 profiles (20 days in February 2000)

- Mean difference \( \sim 1 \) K between 500 and 30 mb (5–25 km)
- Standard deviation 2–4 K in same interval
- “Negative N-bias” probably due to spurious tracking in the lower troposphere
Statistics separated into Northern and Southern hemispheres

- Stratospheric bias (~1K) in Southern hemisphere—but smaller st.dev. (~3K)
- Bias around tropopause heights may indicate poor ECMWF resolution
Statistics for water vapor retrievals (~190 profiles)

- ECMWF temperature used as *a priori*
- Mean difference less than 1 mb above 850 mb (1-2 km)
- Standard deviation ~2 mb or less
- Data affected by negative N-bias
Comparison of water vapor profiles with ECMWF analysis

Profiles at 39°N, 78°W

Profiles at 41°N, 154°E
Example of spurious tracking in the lower troposphere

Profiles at 41°N, 154°E

Conclusions

Main problem: poor L2 data quality
- Affects orbit determination
  - accuracy $\sim 50$ m at present— but can be improved
  - Mitigated by bending angle bias correction
- Affects ionosphere correction
  - Mitigated by smoothing L1 - C/A difference
  - limits accuracy of bias correction
- Limits accuracy of retrieved profiles

Minor problems: high-rate data gaps; spacecraft attitude; power limitations
- Data gaps affects resolution in the neutral atmosphere
- Attitude problems affects quantity and quality of occultations

Neutral atmospheric profiles
- Individual profiles can be significantly biased
- Mean accuracy as good as GPS/MET between 5 and 25 km
- Standard deviation is a little larger than GPS/MET
- Negative N-bias probably due to spurious tracking in the lower troposphere