GNSS Radio Occultation Sampling Analysis

Stephen Leroy, Jim Anderson (Harvard)
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Background

• Inter-annual variability in dry pressure near tropopause is 0.1%, detection times \( \sim 10 \) yrs

• First indicator of climate change as seen in RO is poleward migration of mid-latitude baroclinic zones. Require \( \sim 5^\circ \) meridional resolution

• **Design:**
  – Dry pressure from NCEP reanalysis, 2000-2007
  – Compute truth from gridded NCEP reanalysis
  – Simulate occultation distribution for 8-yr period and interpolate NCEP reanalysis to locations and times
  – Generate annual averages of interpolated data by simple binning in 5\(^\circ\) latitude bins
  – Analyze difference between NCEP reanalysis truth and binned data
Radio Occultation Geometry

• Active microwave limb sounding with MEO transmitters and LEO receivers

• Transmitters:
  – GPS: 12-hr orbits (20,000km altitude), 55° inclination, six orbits separated 60° in ascending node, four satellites per orbit.
  – Galileo: 12-hr orbits, 56° inclination, three orbits separated 120° in ascending node, nine satellites per orbit.

• Receivers:
  – Three in 90° inclination orbits
  – One in 13:30 sun-synchronous orbit
  – One in prograde precessing orbit (81.5° inclination)
  – COSMIC (Six at 72° inclination)
Example distribution, one month (1)
Example distribution, one month (2)
Annual binning–truth difference (1)

Single polar LEO, GPS only, fore and aft (../y2000)
Annual binning–truth difference (2)
Cumulative sampling error

- Single polar LEO, GPS only, fore and aft
- Single polar LEO, GPS and Galileo, fore and aft
- Single sun-sync LEO, GPS only, fore and aft
- Single sun-sync LEO, GPS and Galileo, fore and aft
- Three polar LEOs, GPS only, fore and aft
- Three polar LEOs, GPS and Galileo, fore and aft
Sampling density

![Sampling density](image-url)

**Graph Details:**
- **X-axis:** Latitude
- **Y-axis:** Annual Counts
- **Labels:** Polar LEO, Sun-sync LEO

**Legend:**
- **Polar LEO**
- **Sun-sync LEO**
Local time sampling (1)

Single Polar LEO, GPS only

Latitude

Local Time [hrs]
Local time sampling (2)

Single Sun-synch LEO, GPS only

Latitude vs Local Time [hrs]
Rapidly precessing orbits

82-degree LEO, GPS only, fore and aft

75-degree LEO, GPS only, fore and aft
Preliminary conclusions

- Polar orbit yields large sampling error at high latitudes. Substantial improvement when Galileo tracking is added. Tripling the number of polar orbiters improves little (?)
- Sun-synchronous orbit yields much smaller sampling error at high latitudes but degraded performance in tropics.
- Sun-synchronous LEO orbits are preferred. Yet to determine how well rapidly precessing orbits perform.

Near future work...

- Find the cause of the polar vs. sun-synchronous performance difference.
- Investigate the sensitivity to orbit deviations.
- Test the simulator against actual COSMIC and CHAMP distributions.
- Hope to recruit Tony to verify findings.