



Preliminary observations of ionospheric structures using TEC measurements from the COSMIC radio beacons

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Dual Frequency Tomography Beacon Receivers



- Beacons on board LEO satellites:
 - Presently, 13 beacons including the COSMIC spacecraft
 - The ePOP and C/NFOS mission will also carry beacons
- Have a higher data rate than GPS signals
 - Up to 1 kHz (typically 1-10 Hz) compared with 10 Hz (typically 33 mHz)
 - Allows measurements of the rapid ionospheric variations
- Spacecraft move across the field of view in ~20 min.
 - Tends to measure spatial rather than temporal variations
 - Enable tomographic reconstruction
- Use an uncoded signal



CIDR Systems



Antenna



Laptop



Receiver



CIDR Measurements



- Measures the Doppler shift δf for the 150 and 400 MHz signals
 - Related to the slant ΔTEC by

$$\frac{\Delta T[\text{TECu}]}{\Delta t} = \frac{\Delta(\delta f)}{2.569 \times 10^{-16} [\text{m}^2]}$$

Where:

$\Delta(\delta f)$ is the difference between the down-converted Doppler shifts at 400 and 150 MHz

Δt is the reciprocal of the sample rate

- Relative TEC from integrating the ΔTEC

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CIDR Measurements



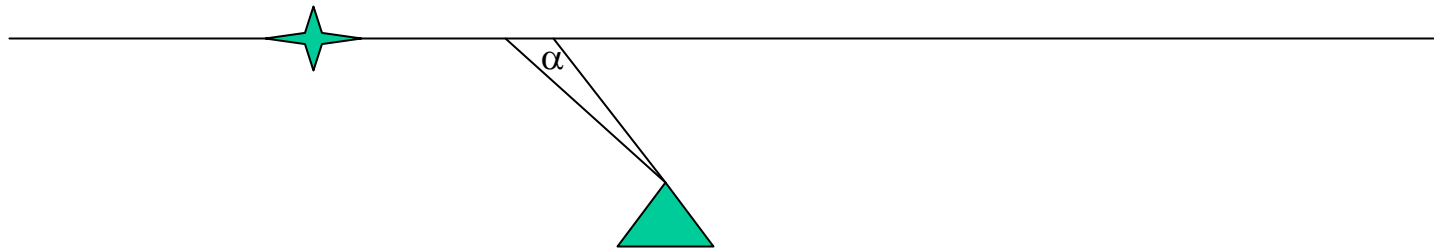
- Measures the subcycle phase difference in both channels
- The phase scintillation index σ_{ϕ} is equal to the standard deviation over a chosen time period.



Scale of CIDR measurements



- For a typical beacon satellite orbit, the satellite crosses a full field of view in 20 minutes.
 - Corresponds to an arc distance of $\sim 0.15^\circ$ in 1 second



- The CIDR are sensitive to smaller-scale structures
 - At 1 Hz: F-region structures (300 km) ~ 1570 m
E-region structures (100 km) ~ 525 m
 - At 1kHz: F-region ~ 1.57 m; E-region ~ 0.525 m



Coherent Ionospheric Doppler Receiver systems



- Diamonds indicate CIDR systems
- Alaskan CIDRs (owned by Univ. of Alaska-Fairbanks) are part of a tomography chain with similar tomography receivers developed by NWRA
- Future deployments are planned in New York and Columbia

Constellation Observing System Meteorology, Ionosphere and Climate (COSMIC)

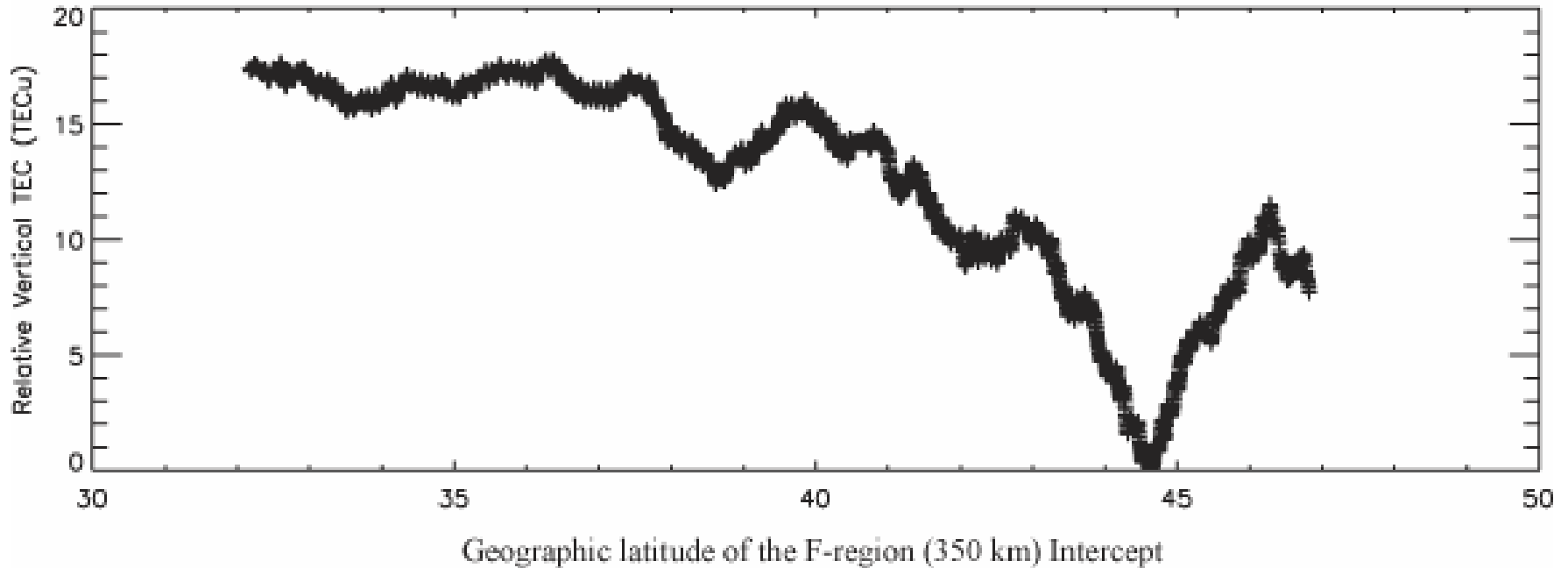


- Joint Taiwanese-US satellite program
- Constellation of 6 microsatellite
- Launched April 14, 2006
 - Operational since June-July
- 3 Instrument payloads
 - GPS occultation receiver
 - Tiny Ionospheric Photometer (TIP)
 - CERTO radio beacon (150, 400 and 1066 MHz)
- Orbit
 - Inclination ~72 deg
 - Altitude: initially- 400 km, final ~800 km
 - Spacecraft separation: final ~ 23 deg apart



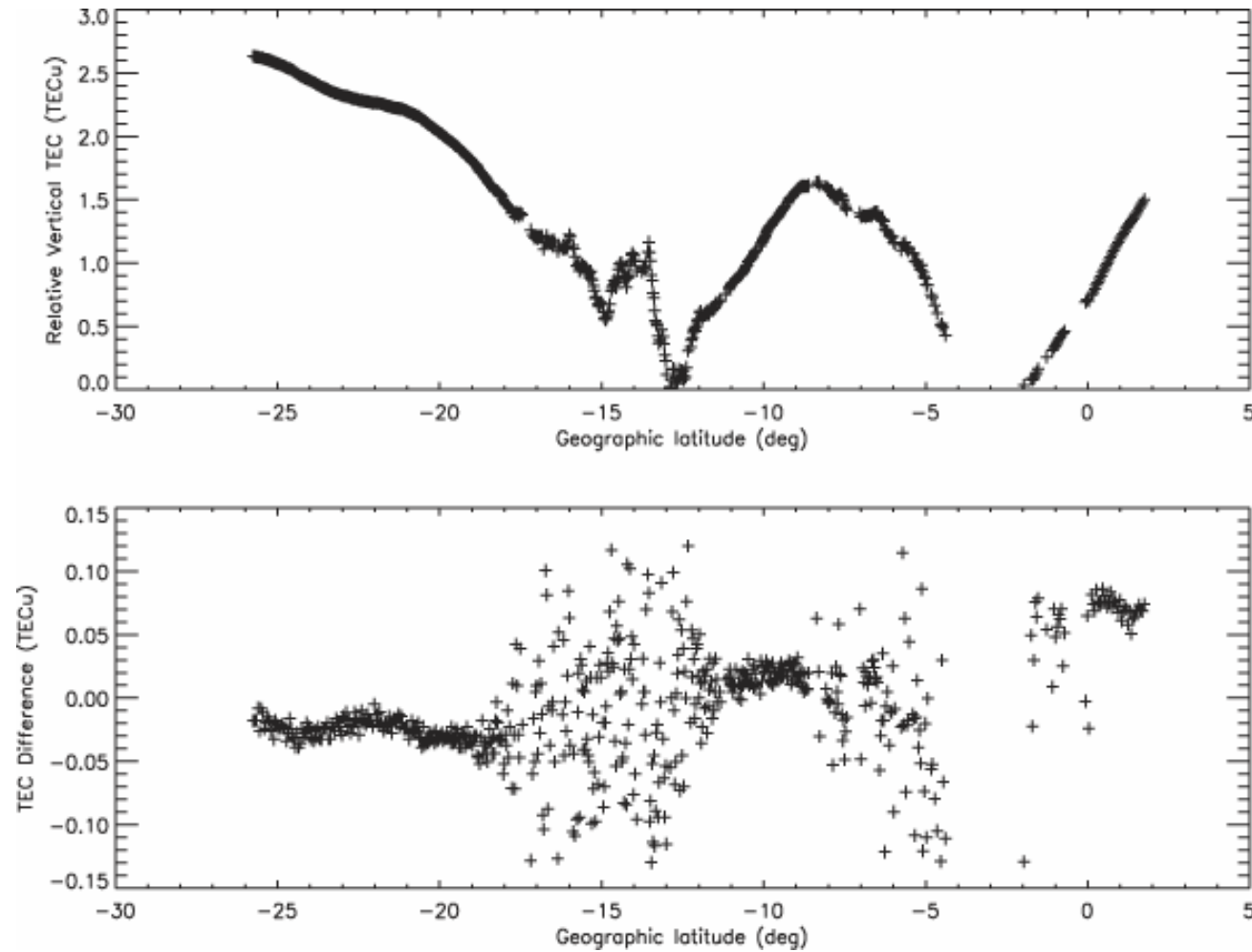
Observation of the Ionospheric Trough

Oneonta CIDR-FORMOSAT F (2006-118-10.6)



The measured slant TEC has been converted to vertical and given as a relative measurement. The receiver bias is unknown. This pass began at UT1038 (0538LT). The nightside trough is observed between 44 and 45 deg GLAT (roughly 57 deg MLAT).

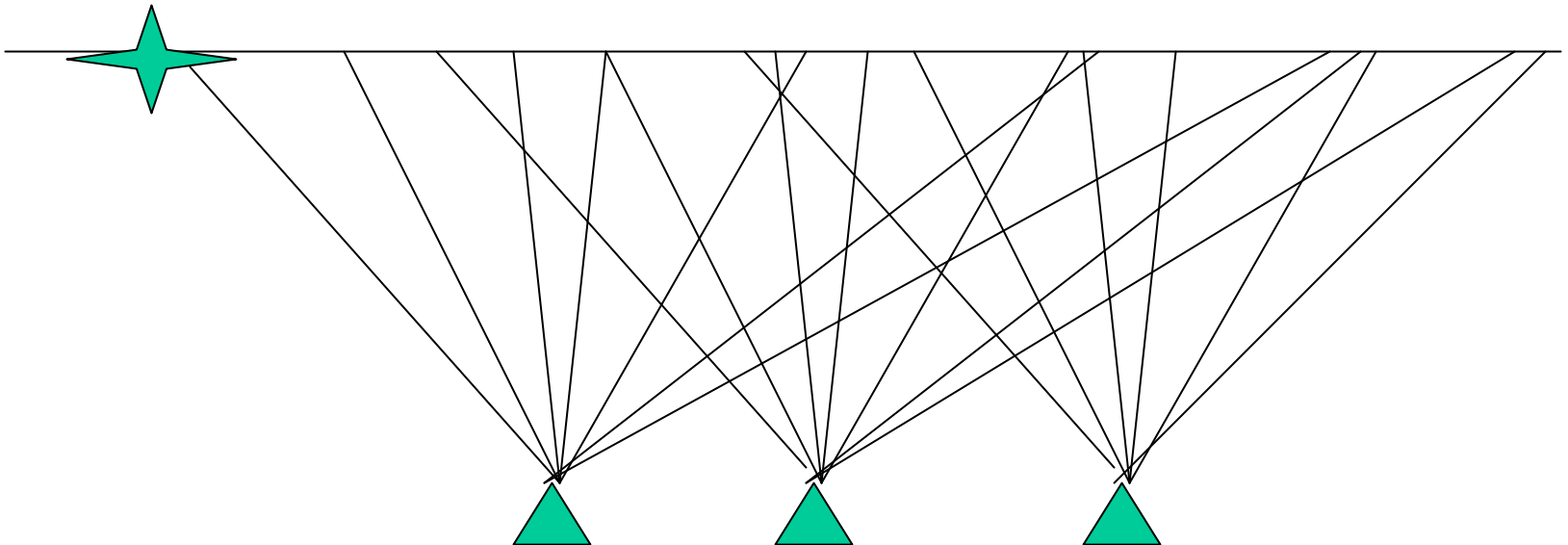
Equatorial Fountain Observations



CIDR data taken at Ancon, Peru on August 20, 2006 (Day 232) starting at UT0810 (0301LT). The Δ TEC was taken at 1 Hz

Ionospheric Tomography

- Traditional usage of the CIDR-like measurements
- Utilizes crossing ray paths
 - Typically 3-5 receivers along aligned with the orbit
- Assumes a slowly varying ionosphere
 - Typically 15 minute time steps



Status of CIDR beacon measurements



- 11 deployed CIDR systems have been deployed in the American sector with 2 more to be deployed in the next few months
- These systems are presently measuring slant TEC from the COSMIC-CERTO beacon signals in addition to the other radio beacons
- 4 more CIDRs are available for future deployments
- Efforts are underway to put the data on a public database
- For case studies and to discuss future collaborations, please contact garner@arlut.utexas.edu for slant TEC data



Possible future deployments



- Examination of the equatorial anomaly and equatorial physics in different longitudinal sectors
 - Two latitudinal chains of 3-4 CIDRs around the magnetic equator
- Investigation of the mid-latitude conjugate features
 - Two different chains at similar magnetic latitudes in the southern and northern hemispheres

