# Comparison of Co-Located TEC Observations Made By COSMIC Satellite and Mountaintop GPS Receiver

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One of the principal observations derived from GNSS (Global Navigation Satellite Systems) signals is ionospheric total electron content (TEC), which is a measure of the density of free electrons integrated along the signal path. TEC is typically computed using the difference of dual-frequency signals from a GNSS satellite, thereby taking advantage of the frequency dispersive effects of ionosphere plasma on microwave-band propagation. In turn, TEC measurements made using GNSS receivers provide valuable observations for ionosphere modeling and imaging applications [1]. It has been noted that TEC measurements made by low-earth-orbiting (LEO) satellites such as COSMIC are especially valuable to these applications since they provide complementary horizontal observations to the slant and vertical observations that ground receivers provide. However, radio occultation measurements are relatively sparse compared to those made by the vast GNSS ground receiver networks. If we can make reliable TEC estimates from ground receiver measurements of signals from very low-elevation satellites, these observations can help provide more horizontal information to ionosphere imaging and modeling applications.

Estimating TEC using low-elevation GNSS observations introduces new challenges such as increased multipath and signal attenuation. These challenges can partially be overcome with improved receiver tracking algorithms, high-gain antennas, and the use of multi-frequency (i.e. triple-frequency GPS) signals. In April 2015, a mountaintop dish experiment was performed at Mount Haleakala to collect signals from low-elevation GPS satellites. Observations of the triple-frequency GPS satellite G25 made using the high-gain dish antenna were co-located with observations made by COSMIC satellite C002. Figure 1 shows the COSMIC tangent point track and mountaintop receiver's 300 km ionosphere piercing point track. In this work, we compare TEC observations made by the COSMIC satellite with those made using the mountaintop dish. Applying the work from [2] and [3], we use G25's triple-frequency signals to optimally estimate TEC. We compare the abilities of COSMIC and the mountaintop receiver to identify the E-layer peak that is present during the time of the observation. Figure 2 shows the electron density profile, which was obtained using the C002 TEC observations and the Abel inversion technique, that indicates the E-layer presence. Ultimately, we aim to use COSMIC observations in order to demonstrate that TEC estimates from ground receivers observing low-elevation satellites can provide another valuable set of horizontal observations.

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[3] J. Spits, "Total electron content reconstruction using triple frequency GNSS signals," PhD thesis, Universit de Lige, Belgique, 2012.

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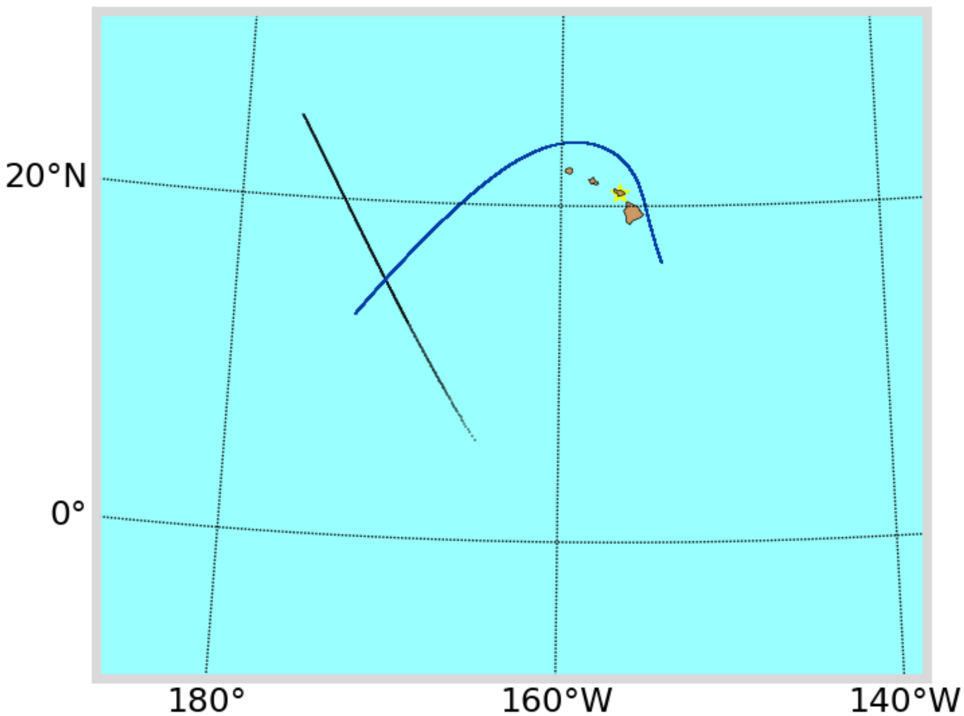


Figure 1: Shows co-located observations of GPS satellite G25 made by COSMIC satellite C002 and by the mountaintop dish. The mountaintop receiver's ionosphere piercing point track is shown in blue, while the COSMIC occultation profile tangent point coordinates are shown in black. The receiver location is given by the yellow star. The G25 satellite appears to the southwest.

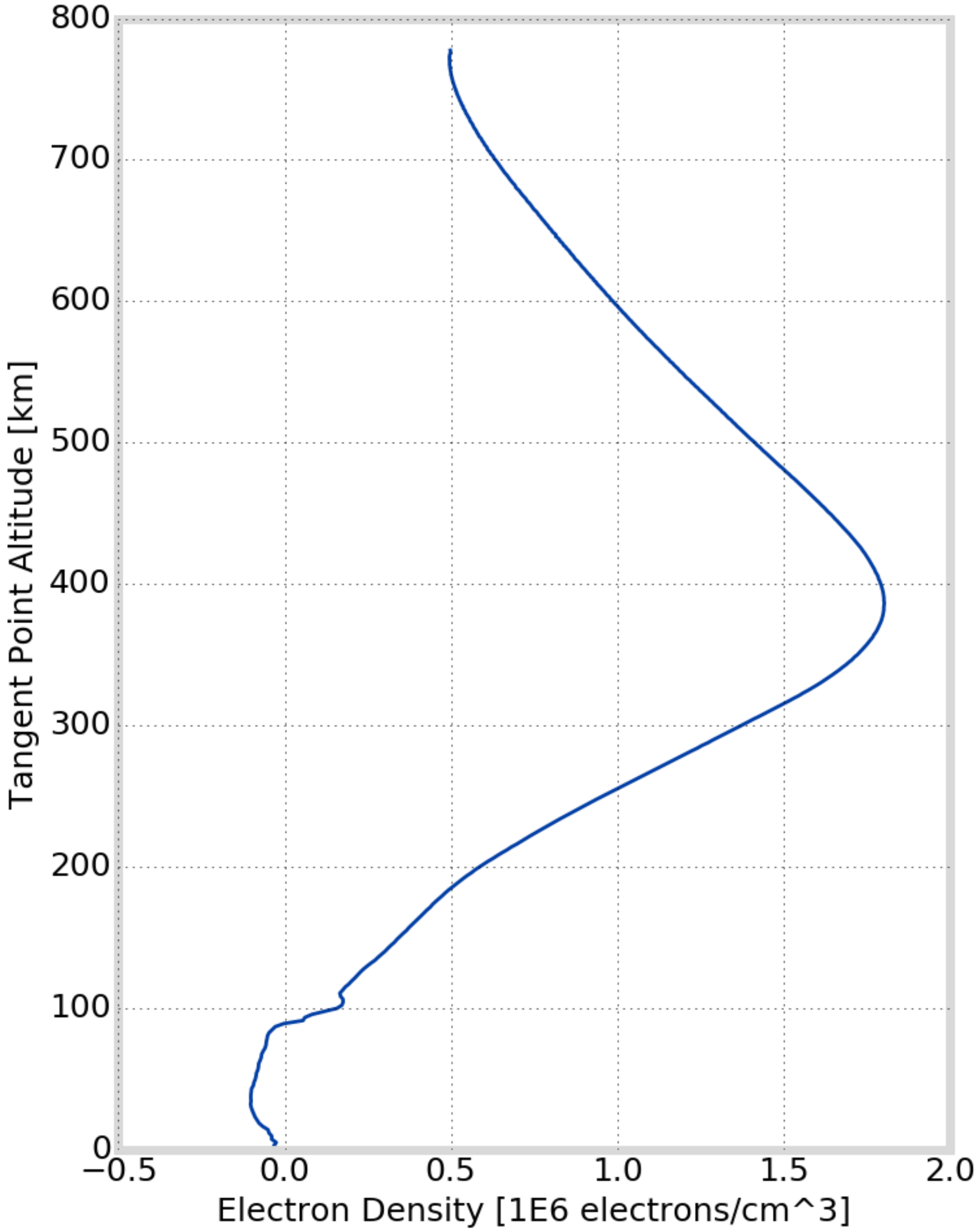


Figure 2: Shows electron density profile made by the COSMIC C002 satellite using the Abel inversion technique. Data was obtained from the CDAAC website [4]. The E-layer is visible near 100 km altitude. Lower observations show non-physical negative electron density values due to the limitations of the Abel inversion method.