Determination of CASSIOPE Topside Ionospheric Total Electron Content Using GPS Precise Point Positioning Techniques (in development)

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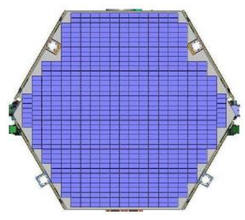
Introduction

Since the advent of satellite technology, there has been an increased need for accurate information on plasma density variation within the ionosphere. This information has many applications including:

- Providing accurate estimations of ionospheric propagation delays for space missions and navigation systems
- Advancing the understanding of plasma density variations, irregularities, and scintillation
- Furthering our knowledge of the coupling between the sun, magnetosphere, thermosphere, and ionosphere
- Improving spatial resolution for ionospheric modeling and forecasting under various states of plasma activity
- Natural hazard detection
- Monitoring space weather



CASSIOPE model - note GAP-A contains:
4 NovAtel OEM4-G2L dual-frequency receivers with
Sensor Systems S67-1575-14 microstrip patch antennas

Method

As part of the Enhanced Polar Outflow Probe (e-POP) payload on the Canadian CAScade, Smallsat, and IOnospheric Polar Explorer (CASSIOPE) small satellite, the GPS Attitude, Positioning, and Profiling (GAP) experiment's dual-frequency GPS receivers and associated zenith-facing antennas (GAP-A) can be utilized to derive plasma density variation estimates above the satellite using the following method:

Preprocessing
- Outlier and cycle slip detection (Blewitt, 1990)
- Cycle-slip correction (Banville and Langley, 2010)
- Carrier-phase integer ambiguity resolution

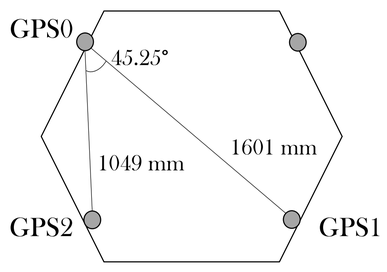
Calibration
- Application of systematic corrections (relativity, phase wind up)
- Estimation of satellite and receiver differential code biases and total electron content (TEC)
- Determination of receiver coordinates

Assimilation
- Analysis and validation of estimated TEC
- Assimilation of calibrated TEC into physics-based model of the ionosphere (JPL/USC GAIM)
- Combination with data from additional space- and ground-based equipment

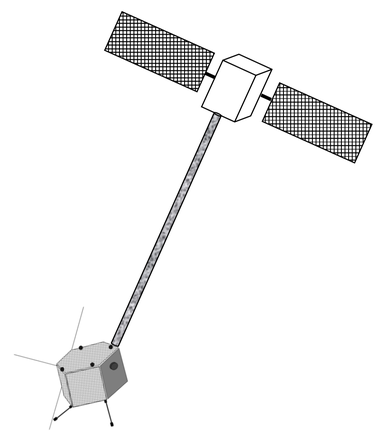
Techniques

To provide TEC estimations a specialized software package is under development that will make use of both the standard precise point positioning (PPP) and array-aided PPP techniques.

	PPP (Kouba and Héroux, 2001)	Array-aided PPP (Teunissen, 2012)
Input	Pseudorange and carrier-phase observations from a single, dual-frequency receiver	Pseudorange and carrier-phase observations from multiple, collocated dual-frequency receivers
Products	Precise reference satellite orbit and clock products	Precise reference satellite orbit and clock products
TEC	Contains receiver differential code biases	Estimates receiver differential code biases leading to calibrated (absolute) TEC



Configuration of the GAP-A payload on the CASSIOPE satellite utilized for array-aided PPP



TEC - number of free electrons in a column (1 m^2 cross section), extending from the satellite to the receiver. In this experiment, TEC is estimated along the ray path between a GPS satellite and the GAP-A antennas on the CASSIOPE satellite.

Forthcoming Research

(1) Provide reliable TEC estimations, which can be used to improve the spatial resolution of existing datasets

(2) Improve our understanding of the solar-terrestrial impact of the ionosphere on navigation systems with a focus on the polar regions

(3) 3D Modeling/reconstruction of high-latitude ionospheric plasma in order to study the detailed morphology of the polar region

(4) Combination of TEC derived from CASSIOPE and the Canadian High Arctic Ionospheric Network (CHAIN) to take advantage of their different spatial and temporal distributions

(5) Assimilation of calibrated TEC into a physics-based model of the ionosphere

References

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Further Information

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