Characterization of Low-Latitude Ionospheric Scintillation of GPS Signals: An EPOP Experiment

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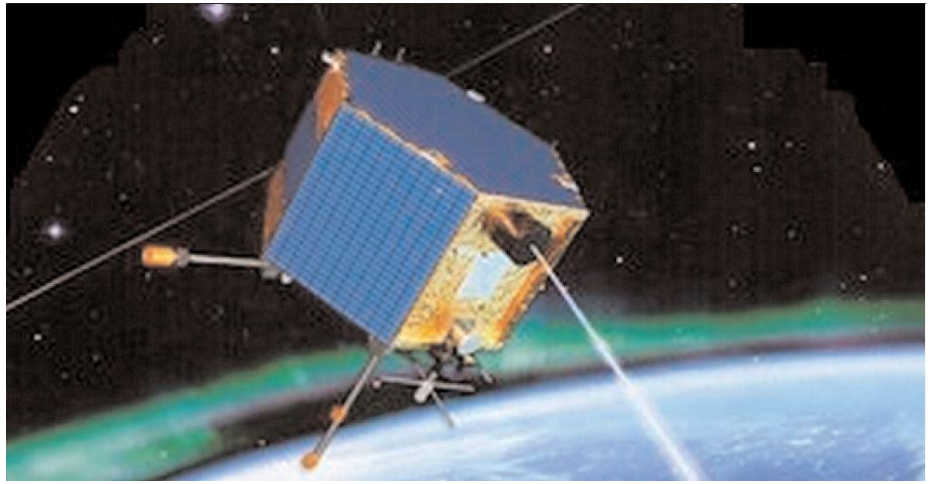
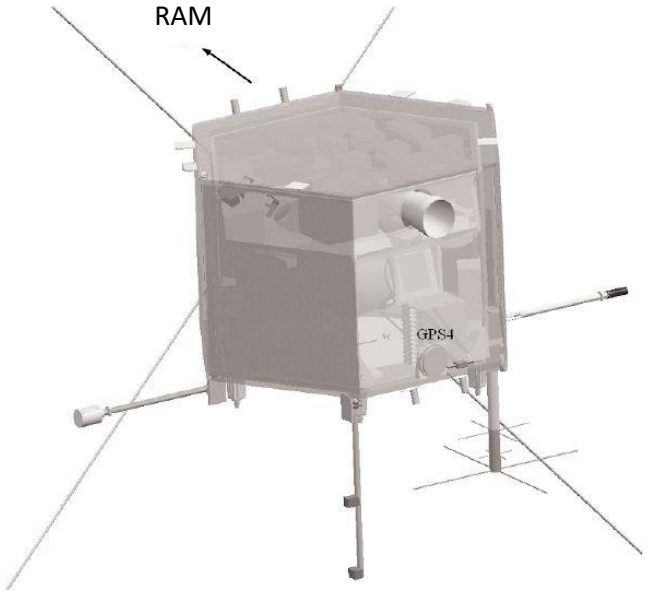
E-POP Payload on CASSIOPE

- We use the e-POP payload on the CASSIOPE spacecraft (launched in September 2013) to measure GPS signals near its perigee.
- The GAP Radio Occultation (RO) receiver on CASSIOPE offers an opportunity to measure GPS signal amplitude and phase at sampling rates of 20, 50, and 100 Hz.
- GAP RO normally points in the horizontal direction.



Artist's illustration of the CASSIOPE satellite in orbit[1].

- GAP RO measurements provide a valuable opportunity to study plasma density irregularities in the vertical dimension.
- In this experiment, we took e-POP out of its normal orientation to point the GAP RO antenna toward the zenith.
- GAP RO's high sampling rate makes it unique.



GAP RO antenna[1].

1-Kim, D., & Langley, R. B. (2010). The GPS attitude, positioning, and profiling experiment for the enhanced polar outflow probe platform on the Canadian CASSIOPE satellite. *Geomatica*, *64*(2), 233-243.

Experiment

- TEC measurements were carried out along an approximately vertical cut through the ionosphere.

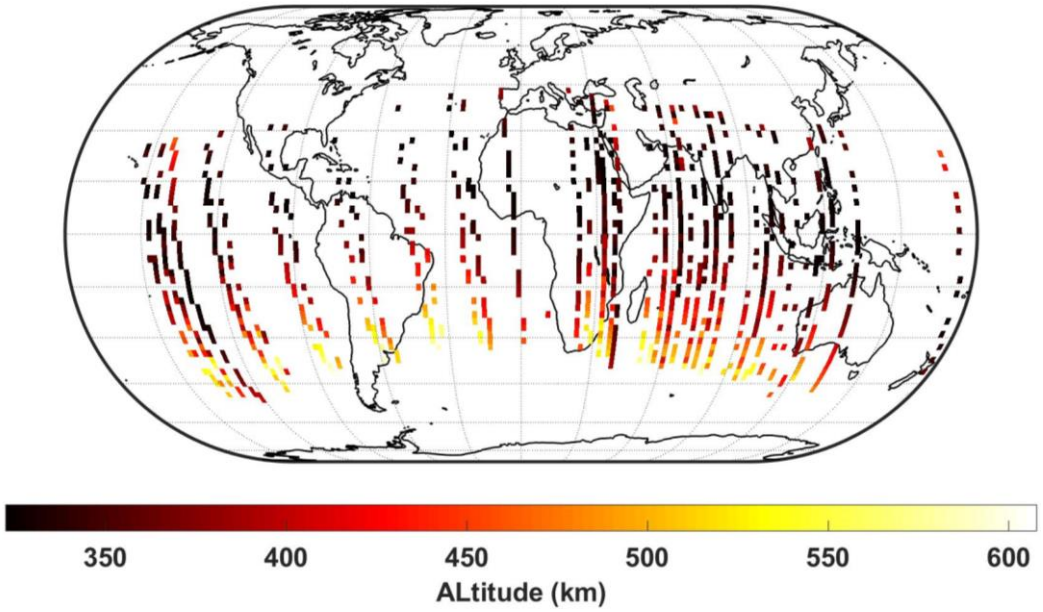
- CASSIOPE was reoriented by approximately 90 degrees daily for short periods between Nov 13 to Dec 06, 2019.

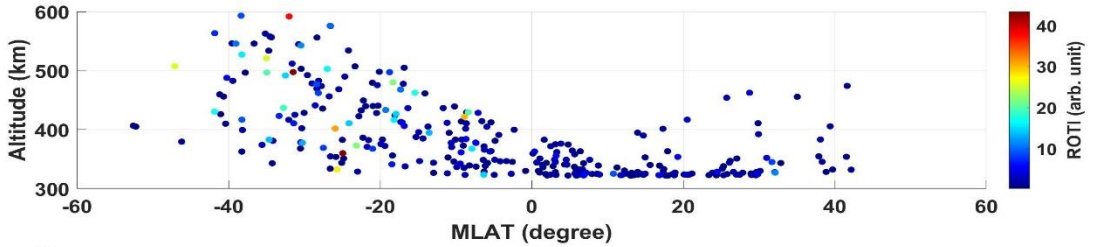
- Criteria:
  - Flying over low latitudes
  - Post-sunset local times (between 1700-2100 MLT)
  - Sampling rates of 50 and 100 Hz

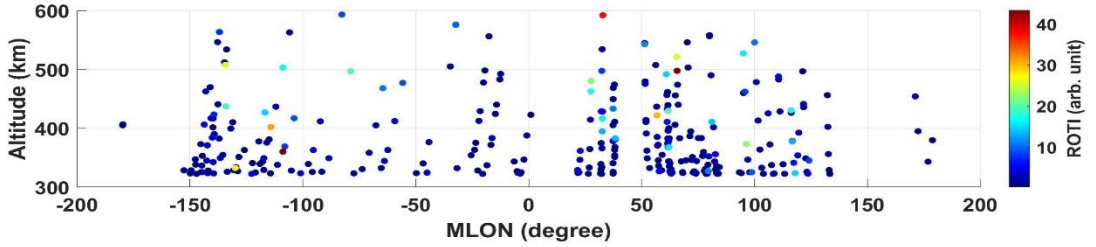
- Total number of experiments:
  - 71 experiments at 50 Hz
  - 22 experiments at 100 Hz

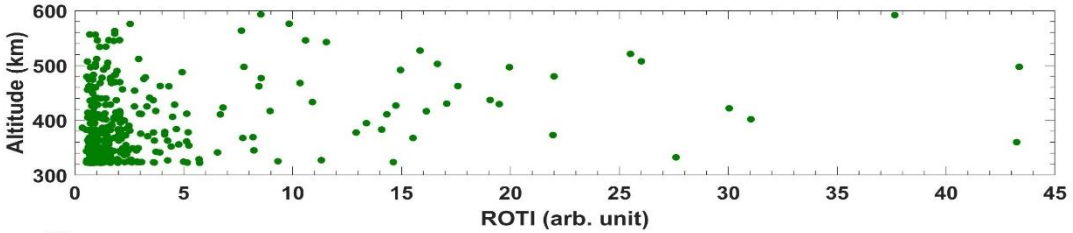
- I plan to utilize e-POP high-resolution **upward looking** GPS measurements at different altitudes to examine signal fluctuations arising from propagation through ionospheric plasma irregularities with different scale sizes.

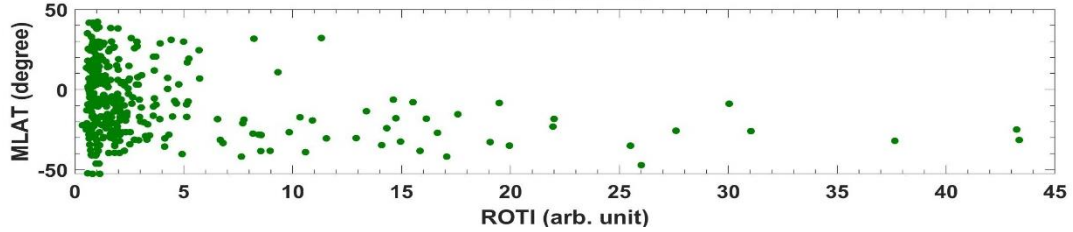
Statistical Overview of the 50 Hz Experiments (Nov 20 to Dec 06 - 2019)





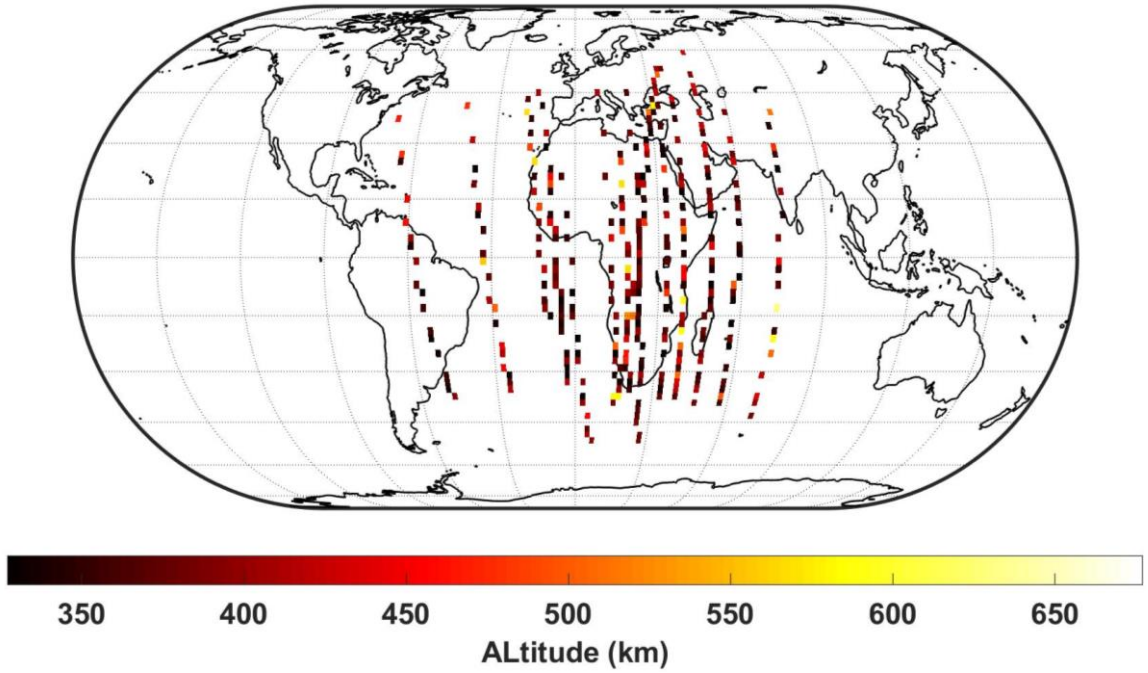


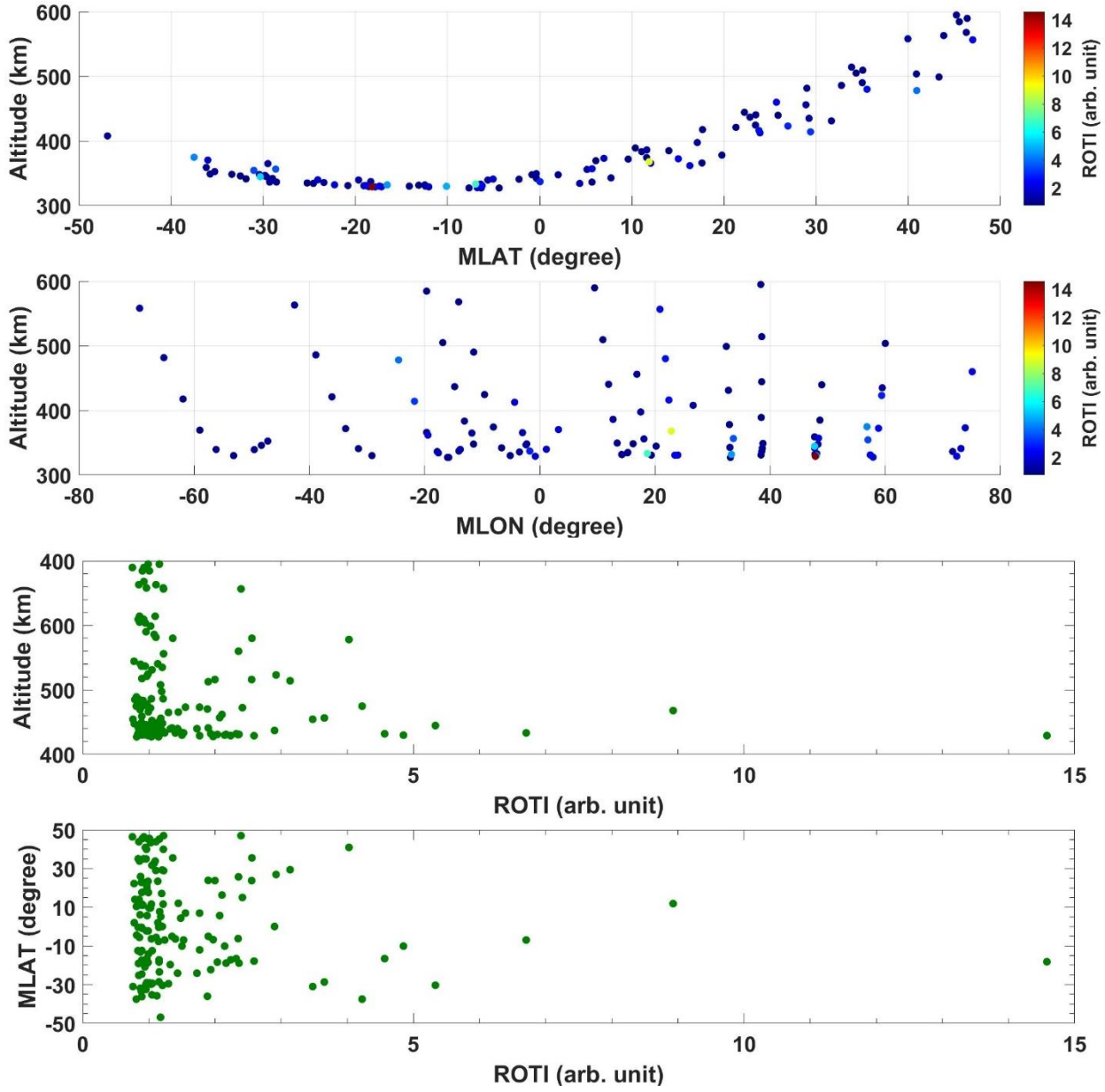




- **ROTI calculation method: Standard deviation of time derivatives of STEC calculated in 3 min time bins.**
- **All measurements took place between 1700 to 2100 MLT using GPS satellites at an elevation angle of > 50 degrees above e-POP.**
- **For this period, e-POP perigee was north of the equator, so measurements in the southern hemisphere were taken at higher altitude.**
- **In general, larger ROTI values were observed in the southern hemisphere.**

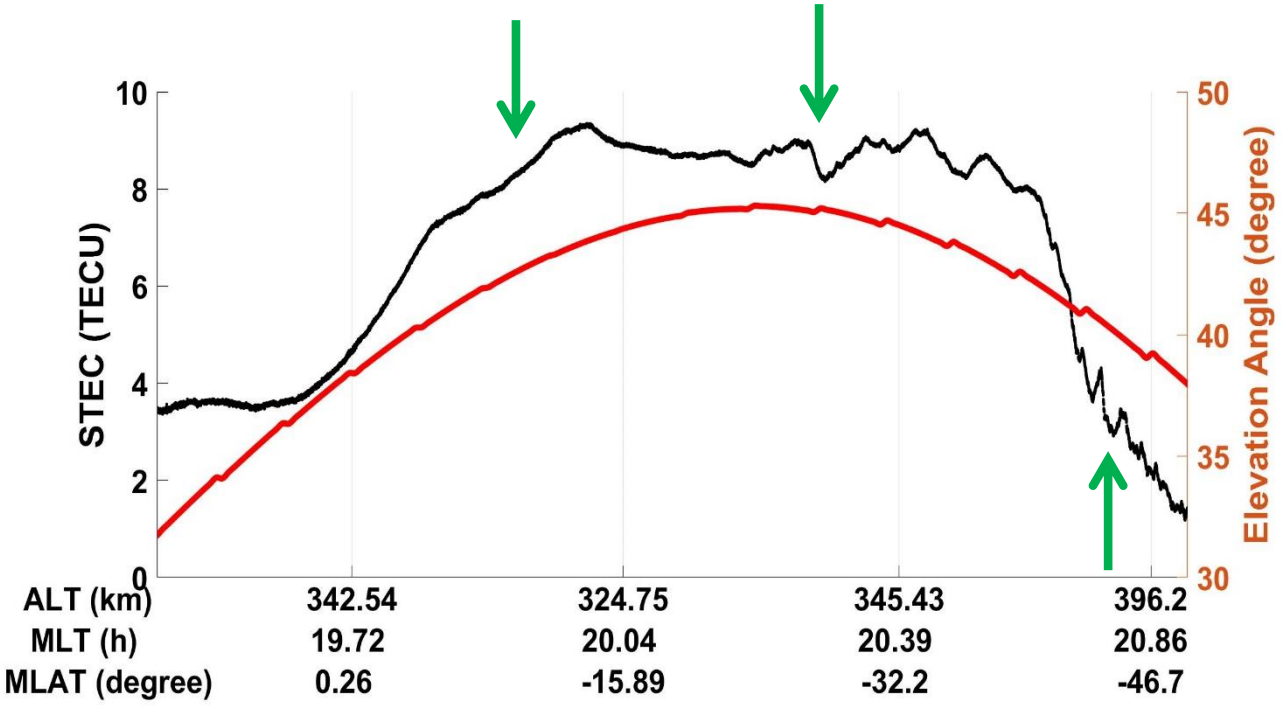
Statistical Overview of the 100 Hz Experiments (Nov 13-20)

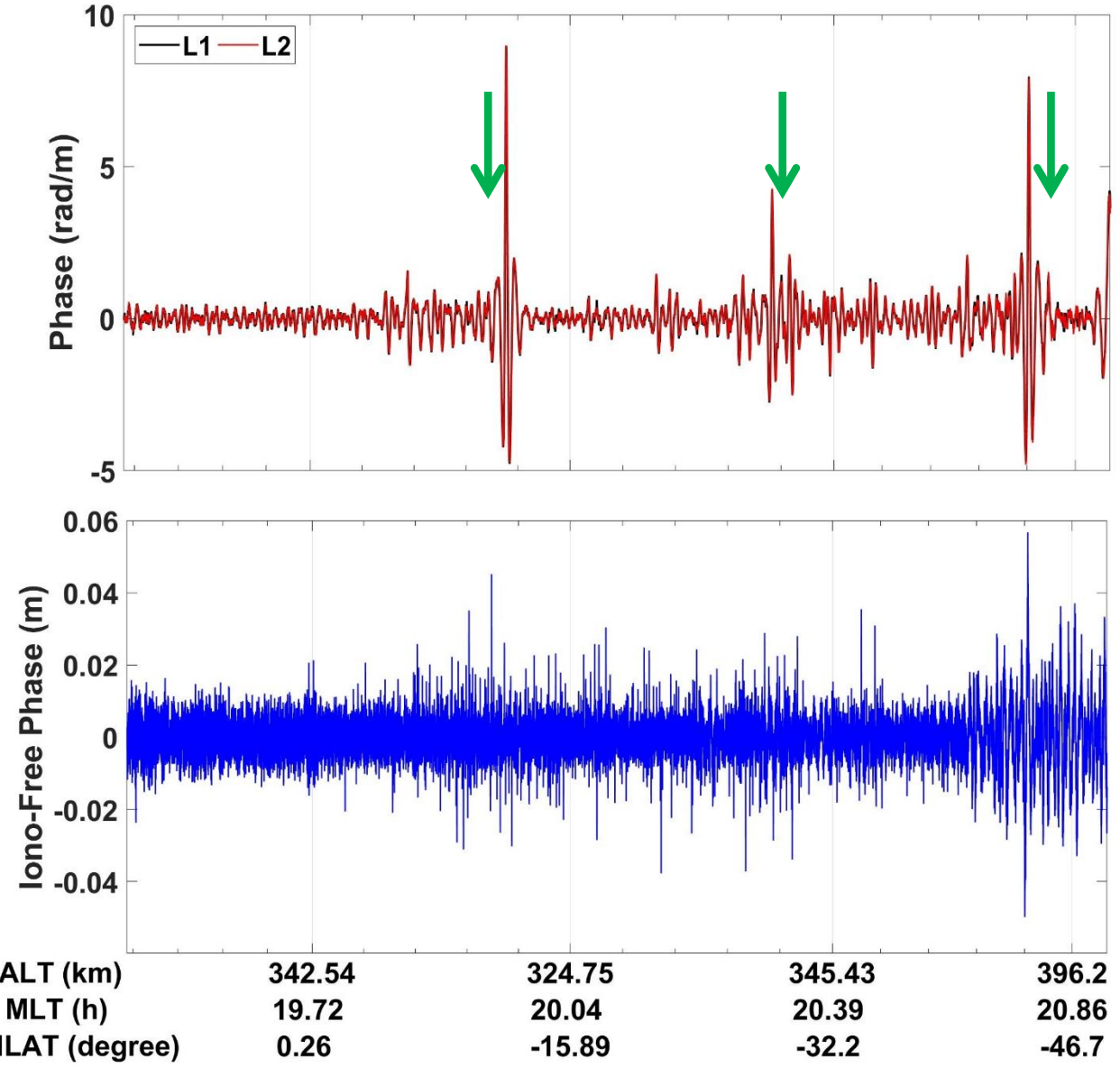




- **The same ROTI calculation method and criteria were applied for the 100 Hz data sets.**
- **Fewer experiments were carried out at 100 Hz than at 50 Hz.**
- **More 100 Hz experiments were conducted in the northern hemisphere.**
- **The same trend in ROTI (larger values in the southern (summer) hemisphere) was observed in the 100 Hz experiments.**

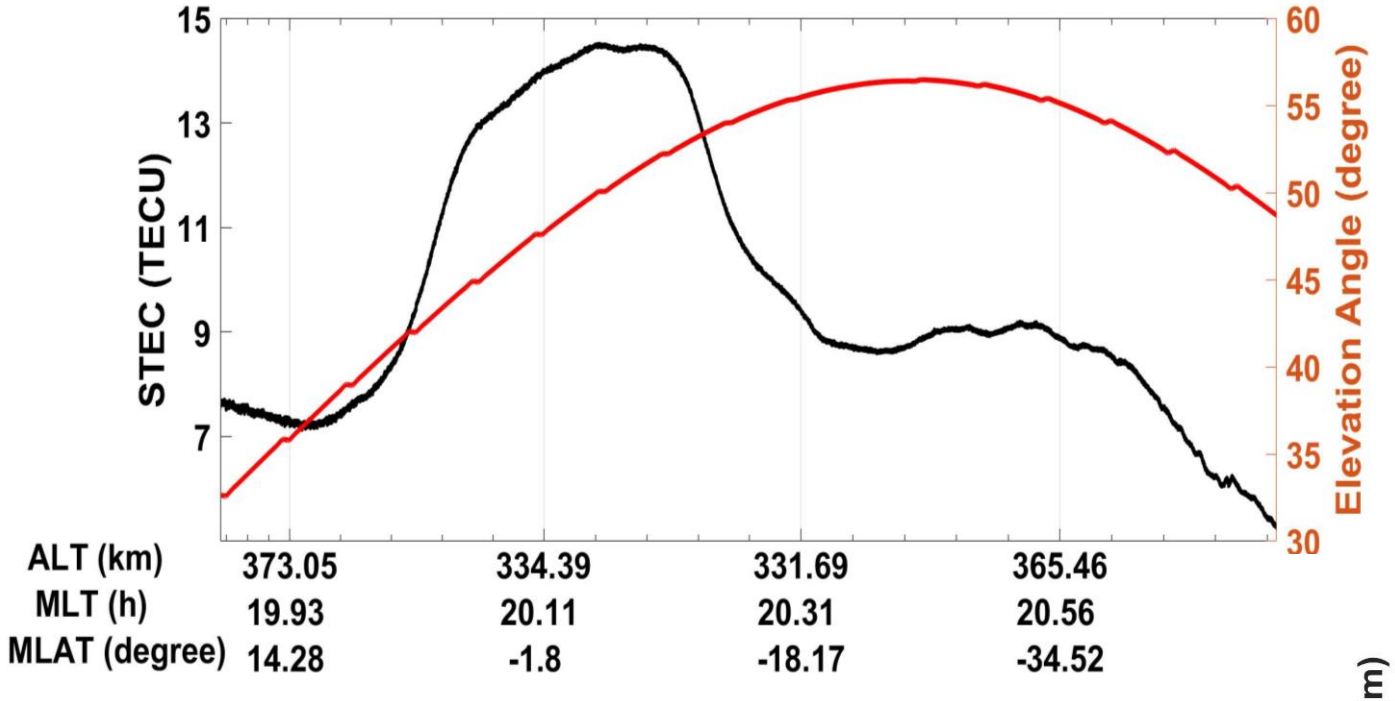
Observations on 2019-11-22 form PRN=10

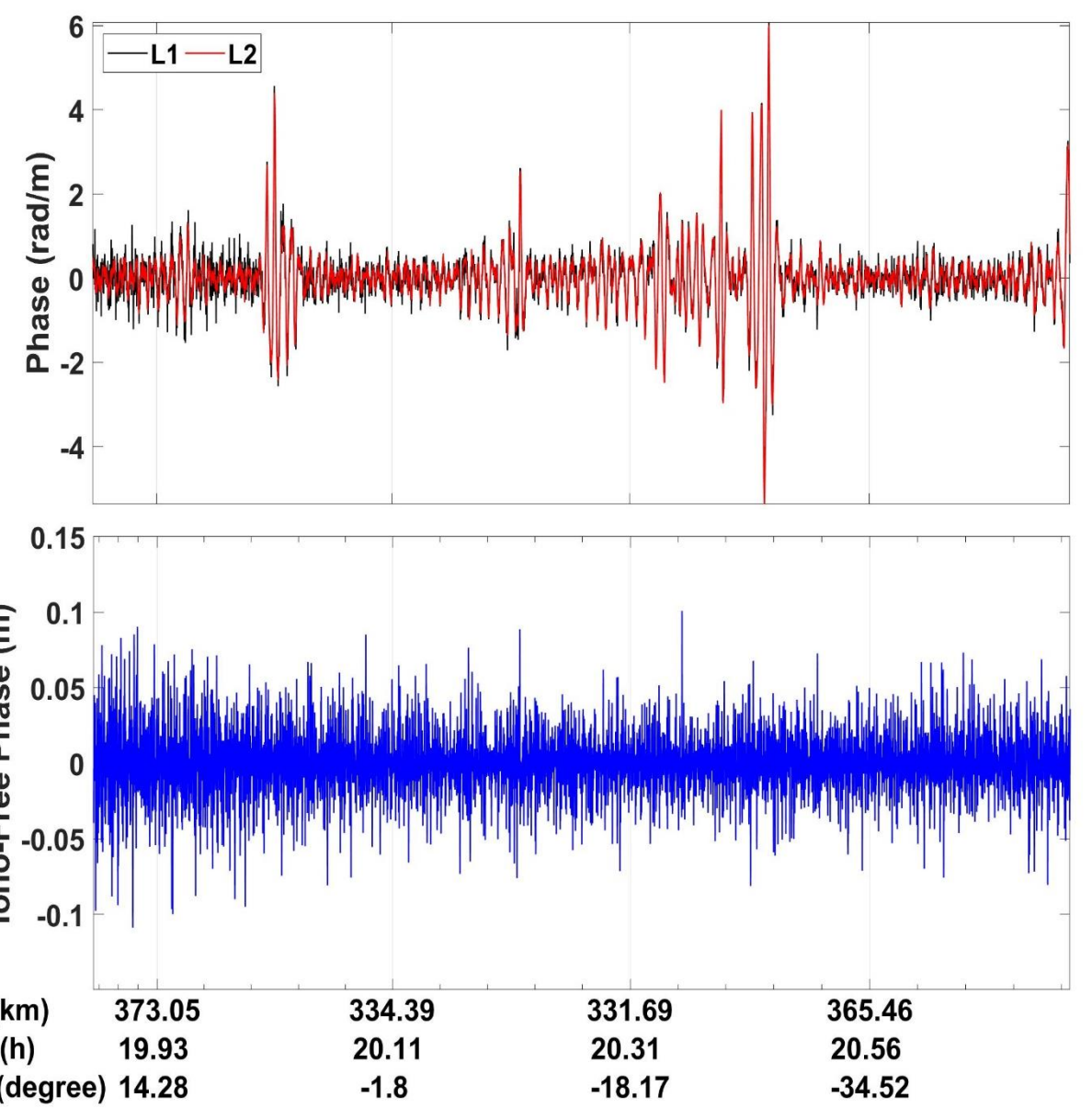




- Sampling rate: 50 Hz.
- Sharp changes in STEC are associated with an increase in residual error in ionospheric-free combination phase.

Observations on 2019-11-18 form PRN=14





- Sampling rate: 100 Hz.
- Residual errors in ionospheric-free combination phase are larger than those in previous case.

Summary

- In this experiment, upward looking GAP-RO measurements provide new high-resolution (50 and 100 Hz) observations that enable us study GPS signal fluctuations which result from ionospheric plasma irregularities with different scale sizes.
- Preliminary analysis shows significant TEC fluctuations originating well above e-POP's perigee of 350 km.
- These observations will be used to study characteristics of ionospheric irregularities which cause GPS signal scintillations.

Acknowledgements

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