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Swarm-E GPS observations of ionosphere electron content and multi-scale plasma structures

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The Global Positioning System (GPS) Attitude, Positioning, and Profiling (GAP) instrument [1,2] is one of eight components of the scientific instrument suite onboard the Swarm-E satellite (previously CASSIOPE/e-POP). The Swarm-E instrument suite was designed to primarily study the physical processes coupling the polar ionosphere to the solar wind and magnetosphere, and the ionospheric structure and dynamics associated with this coupling. The GAP instrument consists of three GPS antennas oriented towards spacecraft zenith and one antenna oriented in the anti-ram direction, along with associated GPS receivers. This configuration allows for both radio occultation and topside ionosphere measurements, which are collected at data rates of up to 100 Hz. The elliptical, polar orbit of Swarm-E and high data rate of GAP allows for unique radio occultation and topside ionosphere observations, which is particularly useful for polar regions where much of the ionosphere structure and dynamic behaviour associated with SW-M-I-T coupling are not well observed or understood.

The presentation will discuss recent reprocessing of GAP data and ongoing research projects employing the GAP dataset. Eight years of GAP data (starting in September 2013) have been reprocessed, with calibrated line-of-site total electron content (TEC) currently available on the epop-data website (https://epop.phys.ucalgary.ca/data/). Higher level products for topside vertical TEC and electron density profiles will be available in the near future. Topside TEC measurements of GAP are currently used to observe the topside electron content in the polar regions, including the statistical study of high altitude (>1000 km) topside TEC enhancements. Concurrent observations of the Imaging and Rapid-scanning ion Mass spectrometer (IRM) of Swarm-E may provide insight into possible plasma upflow/downflow associated with these enhancements. Also ongoing are statistical studies of ionospheric plasma structures with 100s of kilometer down to sub-kilometer spatial scales. This includes analysis of topside irregularities using the zenith-oriented GAP receivers, as well as observation of the vertical structure of irregularities using the GAP occultation receiver. Climatology of observed irregularities, including links to solar wind and geomagnetic activity levels will be discussed.

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

2. C. Watson, R. B. Langley, D. R. Themens, A. W. Yau, A. D. Howarth and P. T. Jayachandran, "Enhanced polar outflow probe ionospheric radio occultation measurements at high latitudes: Receiver bias estimation and comparison with ground-based observations," in *Radio Science*, **53**, 2, Feb. 2018, pp. 166-182, doi: 10.1002/2017RS006453.