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# Climatology of ionospheric perturbations associated with Pc3-6 ULF waves, as observed using ground-based GPS total electron content measurements

Chris Watson*(1), P.T. Jayachandran (1),
(1) University of New Brunswick, Fredericton, Canada, e-mail: chris.watson@unb.ca

Several case studies have revealed fluctuations in ionospheric total electron content (TEC) associated with ultra-low frequency (ULF) magnetic field variations [1,2]. At this point, the TEC response to ULF waves is considered unpredictable and intermittent, and the mechanisms that drive the variations in TEC are still unresolved. In addition, the sharp ionospheric density gradients associated with ULF-driven plasma perturbations may lead to detrimental impacts on radio communication and navigation systems relying on trans-ionospheric signal propagation. We have conducted a survey of the TEC response to ULF waves in the Pc3-6 (up to 200 mHz) frequency range using high-data-rate Global Positioning System (GPS) receivers of Sanikiluaq (56.54ºN, 280.77ºE) and Fort Simpson (61.76ºN, 238.77ºE) stations, located in the auroral region of the Canadian Arctic. In-situ ULF activity was monitored using magnetometer measurements of the GOES 13 and 15 satellites, which have magnetic footprints near Sanikiluaq and Fort Simpson, respectively, while corresponding ULF activity on the ground was monitored by Sanikiluaq and Fort Simpson ground magnetometers.

A survey of ULF wave events during the year 2015 revealed 801 narrow-band Pc3-6 ULF waves observed by the GOES magnetometers, during periods where simultaneous GPS TEC and ground magnetometer measurements were also available. Cross-spectral analysis of GOES satellite magnetic field fluctuations with those of GPS TEC and ground magnetic field was used to determine whether variations observed in the respective measurements were linked. ULF wave events were observed on a near daily basis through all MLT sectors, with discrete, Pc-band dependent peaks in GOES ULF wave occurrence in the morning and afternoon sectors. Simultaneous, coherent fluctuations in GPS TEC were observed up to 47% of the time in the case of lower frequency Pc6 events, 39% of the time for Pc5 events, 15% for Pc4 events, and 2% for Pc3 events. A coherent TEC response was more commonly observed that that of a ground magnetometer response, while the ULF wave polarization was a significant factor in the intensity of the TEC and ground magnetometer response. This statistical survey is currently being expanded to cover a 10-year duration. We will discuss the statistical results and the implications for unravelling the mechanisms governing the TEC response to ULF waves.

1. C. Watson, P. T. Jayachandran, H. Singer, R. Redmon, and D. Danskin, “GPS TEC response to Pc4 “Giant Pulsations””, in *J. Geophys. Res. Space Physics*, **12**, 2, 2016, pp. 1722-1735, doi:10.1002/2015JA022253.

2. C. Watson, P. T. Jayachandran, H. Singer, R. Redmon, and D. Danskin, “Large-amplitude GPS TEC variations associated with Pc5-6 magnetic field variations observed on the ground and at geosynchronous orbit”, in *J. Geophys. Res. Space Physics*, **120**, 2015, doi:10.1002/2015JA021517.