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On the Effect of “Patchy Pulsating” Aurora and Auroral Arcs on GPS Signals

Abstract:
Aurora occurs in different well-known morphologies, or types, including the best-known arcs and patchy-pulsating aurora (PPA). Previous observational studies have demonstrated that the ionospheric effects of auroral precipitation affect the accuracy of Global Navigation Satellite Systems (GNSS), including GPS, but how different types of aurora might affect GNSS differently has not been investigated to date. In an attempt to explore the relationship between auroral type and the resulting effects on GNSS, we have used data from a THEMIS (Time History of Events and Macroscale Interactions during Substorms) All-Sky Imager (ASI) located at Sanikiluaq (~67º geomagnetic latitude), Canada. GPS data was also obtained from a Canadian High Arctic Ionospheric Network (CHAIN) GPS receiver collocated with the THEMIS ASI. This GPS receiver is a custom-made GPS scintillation receiver capable of providing high-rate GPS signal power and phase and as well as scintillation data. A list of patchy pulsating aurora and auroral arc events were catalogued from the ASI data for the years 2008-2013. Corresponding scintillation data for these time periods were obtained from the GPS receiver. In order to determine the effects of PPA and arcs on GPS signals, the number of cycle slips observed during each were calculated. Results suggests PPA affects GPS in a more adverse manner than auroral arcs given its spatial extent. Even though the magnitude of phase scintillation index (σφ) observed in auroral arcs was much higher than in PPA, receiver was able to keep lock on to the signals much better during arcs compared to patchy aurora. We have also calculated spectral slopes/spectral index for all events which had σφ _ 0.3. Although the histograms for these spectral indices seem to reveal that average spectral index for both these phenomena was ~3.5, spectral indices for auroral arcs seem to tend towards higher values compared to spectral indices of PPA. This result seems to suggest that for auroral arcs, large sized ionospheric irregularities dominate their spectral content compared to PPA, where there is also contribution from smaller sized irregularities coming into effect. Approximate size of these irregularities is also estimated in this study.