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Observation of auroral optical emissions through co-located GPS, riometers, and all-sky imager measurements

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ABSTRACT

Optical emissions from an all-sky camera at 557.7 nm and riometer images were compared with co-located GPS scintillation measurements in the case of events showing stable arc-like optical structures as well as saturating emissions affecting almost the entire field of view.

Co-located GPS scintillation measurements (1-min scintillation indices as well as 50-Hz sampling of signals intensity and phase) were compared to the optical emissions, assuming an emission altitude of 120 km that the satellite motion was also mapped to. Weak scattering [1] was assumed as a model for the scintillation observations to a good approximation owing to very low levels of measured intensity scintillation [2].

In this study it is shown that the analysis of spectral modifications of GPS signals has the potential to provide a novel and cost-effective technique for indirect detection of ionisation structures originating from particle precipitation which could be used to complement all-sky camera and riometers measurements. Specifically, we compare optical emissions from an all-sky imager at 557.7 nm, riometer images, and co-located GPS scintillation measurements (1-min scintillation indices as well as 50-Hz sampling of signals intensity and phase) during observations of stable arc-like optical structures. The comparison of the co-located measurements showed that the optical emissions and associated ionisation gradients introduced longer temporal fluctuation periods (i.e. from spatial scales larger than the Fresnel

scale) on the GPS carrier phase (as determined from phase power spectral densities), while the Fresnel frequency maintained a constant value throughout the events (as determined from intensity power spectral densities). A constant Fresnel frequency and the relative velocity associated with it did not seem consistent with a phase changing screen in the E region, while they could be plausible with one at the F region. The events presented herein justify extended use of GPS systems for more extended measurements of particle precipitation at high latitudes.

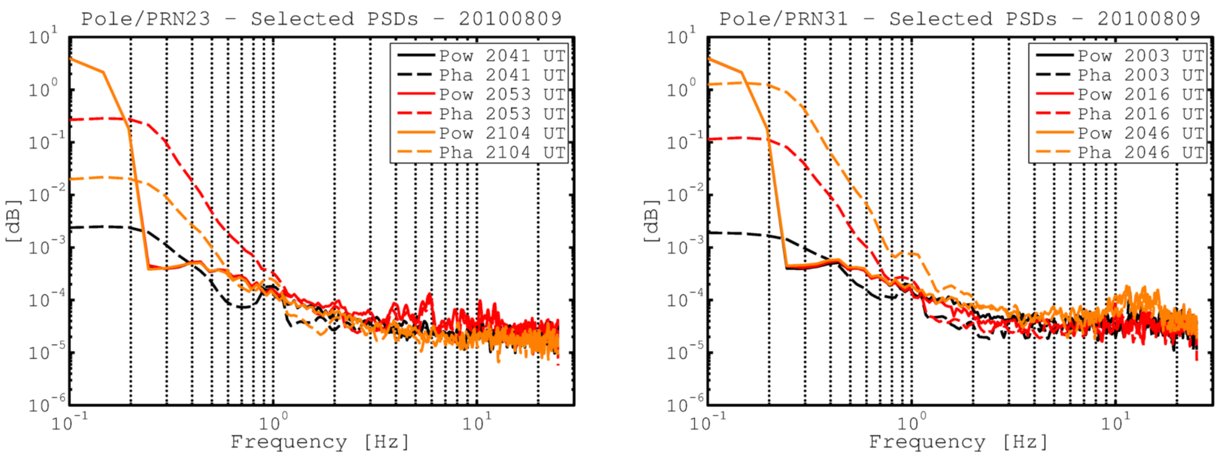

Figure 1: Example of the power spectral densities (for both intensity and phase of GPS signals) observed during optical emissions.

Key words: All-sky camera, Scintillation, GPS, Magnetometers, Riometers, Power Spectral Density.

References:

[1] Rino, C. L. (1979), A power law phase screen model for ionospheric scintillation 1. Weak scatter, Radio Sci., 14(6), 1135–1145..

[2] Forte B., C. Mitchell, J. Kinrade, S. Skone, A. J. Gerrard, A. Weatherwax, and Y. Ebihara, Identification of auroral optical emissions by means of GPS radio signals, submitted for publication to JGR.

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