International Beacon Satellite Symposium BSS-2016
Trieste, Italy

Using EISCAT incoherent scatter radar co-aligned with GPS satellites to obtain details about plasma structures and scattering mechanisms originating scintillation at L band

B. Forte*[1], F. Da Dalt[1], T. Panicciari[1], C. Mitchell[1], J. Kinrade[2], G. Bust[3], S. Skone[4], C. Coleman[5], I. Häggström[6], C.-F. Enell[6]

[1] Department of Electronic and Electrical Engineering, University of Bath, Claverton Down, BA2 7AY, Bath, UK.
(E-mail: b.forte@bath.ac.uk)

, [2] Department of Physics, Lancaster University, UK.

, [3] Applied Physics Laboratory, Johns Hopkins University, USA.

, [4] Schulich School of Engineering, University of Calgary, Canada.

, [5] Electrical and Electronic Engineering Department, The University of Adelaide, Australia.

, [6] EISCAT Scientific Association, Kiruna, Sweden.

ABSTRACT

Ionospheric scintillation originates from scattering of electromagnetic waves through spatial gradients in the plasma density distribution, drifting across a given propagation direction. In the case of satellite radio links ionospheric scintillation may reduce the overall level of the received signal, enhancing the errors in the tracking process. Ionospheric scintillation is an important space weather impact that affects the reliable and continuous operation of satellite telecommunication and navigation systems and services. The purpose of the experiment presented here was to compare profiles of electron density from EISCAT with co-located ionized structures in the ionosphere to GPS scintillation. This type of experiment allows identifying plasma structures as well as the type of scattering originating scintillation on GPS signals at auroral latitudes.

During this experiment the EISCAT UHF radar was pointed along the same line of sight of a given GPS satellite the signal of which was recorded by means of a GPS scintillation monitor co-located with EISCAT UHF transmitter at Tromso.

Structures extending between the E and F region (possibly caused by the combination of the trough and particle precipitation in the nighttime sector) were indeed identified as responsible for low-to-moderate levels of phase scintillation, while the corresponding gradients in the refractive index were not enough to trigger amplitude scintillation.

Two measurement campaigns took place in October 2013 and October 2015 when different GPS satellites were followed with the EISCAT UHF radar.
The positions of GPS satellites to be followed were determined in advance on the basis of the projection of the ephemeris in the future by using a SP3 file released the day before each of the days during the measurement campaign. Those positions were determined between 1 and 5 minute intervals to cover the entire duration of the measurement [1].

In the October 2013 campaign the EISCAT UHF radar was pointed towards the selected satellite by remaining fixed in a given position (defined in terms of azimuth and elevation) for 5 minutes, then re-positioning into the new direction in the next interval, and so on (see Figure 1). At each fixed position the GPS satellite line of sight was moving and traversing the radar line of sight in each 5-minute interval. On the other hand, in the October 2015 campaign the EISCAT UHF radar was pointed and maintained aligned towards the selected satellite every minute.

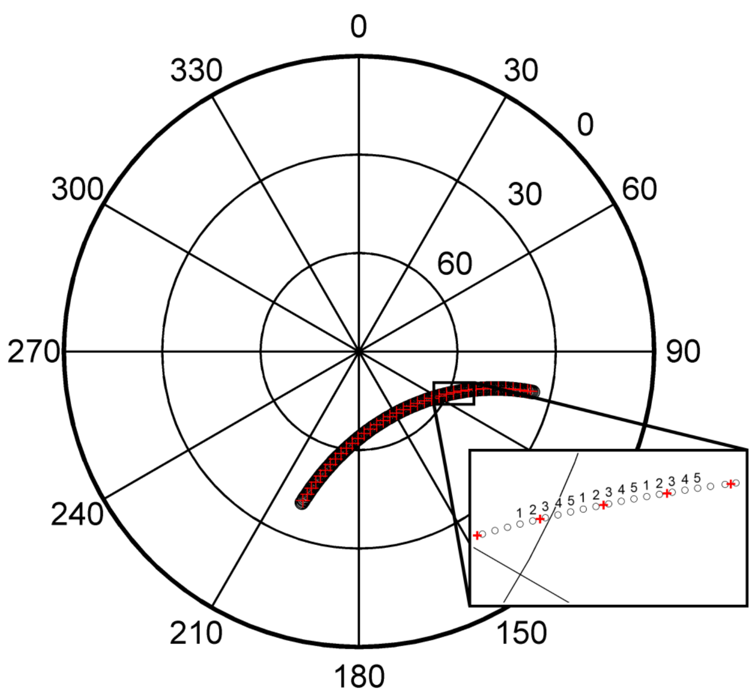

Figure 1: Example of the experiment geometry for the October 2013 campaign.

Within the limitation to the spatial resolution of the experiment, plasma structures forming at auroral latitudes as a consequence of particle precipitation were associated with signatures on the carrier phases of the GPS satellites which were followed.

The results obtained provide details about the scattering mechanisms responsible for the observed ionospheric scintillation at L band, which can be discussed in view of well established theories for auroral latitudes problems [2-3]. The interpretation is also based on the observation of modifications to power spectral densities measured through GPS signals.

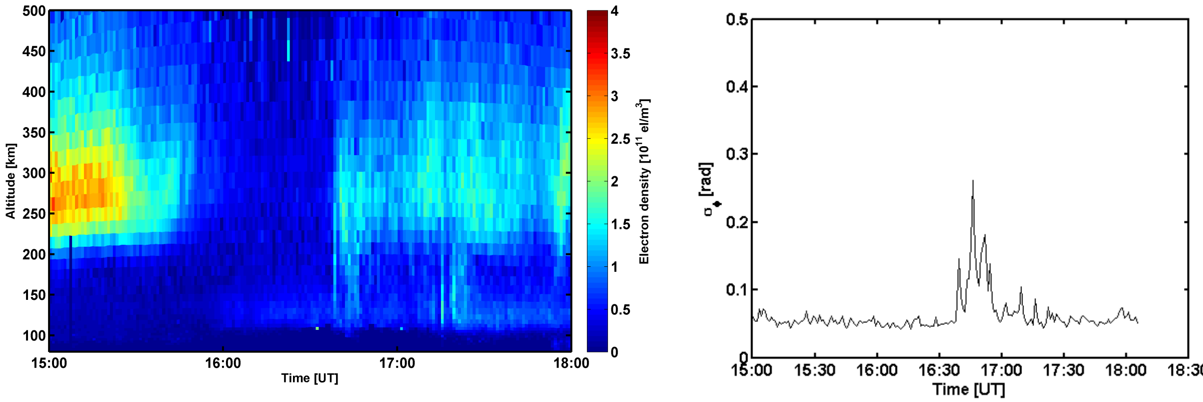

Figure 2: Example of the results obtained during the October 2013 campaign [4].

Key words: EISCAT, Scintillation, GPS.

References:

[1] Forte, B., Smith, N. D., Mitchell, C. N., Da Dalt, F., Panicciari, T., Chartier, A. T., Stevanovic, D., Vuckovic, M., Kinrade, J., Tong, J. R., Häggström, I., and Turunen, E.: Comparison of temporal fluctuations in the total electron content estimates from EISCAT and GPS along the same line of sight, Ann. Geophys., 31, 745-753, doi:10.5194/angeo-31-745-2013, 2013.

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

[3] Booker, H. G. (1981), Application of refractive scintillation theory to radio transmission through the ionosphere and the solar wind, and to reflection from a rough ocean, J. Atmos. Terr. Phys., 43(11), 1215–1233.

[4] Forte B., C. Mitchell, F. Da Dalt, T. Panicciari, J. Kinrade, G. Bust, S. Skone, C. Coleman, I. Häggström, and C.-F. Enell, Identification of scintillation signatures on GPS signals originating from plasma structures detected with EISCAT incoherent scatter radar along the same line of sight, submitted for publication to JGR.

Acknowledgements: The EISCAT campaigns were funded through the EISCAT International Peer Review Programme. The research leading to these results was also supported through the European Union Seventh Framework Programme (FP7/2007-2013) under grant agreement n° [607081].