Ionospheric drifts estimated using GPS scintillation data during magnetic storm on 5-6'th of April 2010

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ABSTRACT

We have analysed the ionospheric drift pattern during disturbed geomagnetic conditions on 5-6'th of April 2010 at high geomagnetic latitudes (Hornsund). The stress in the analysis is put on drift dependence onscale size of underlying electron concentration irregularities.

The effects of interaction of electromagnetic waves with the plasma are used in various radio techniques to investigate the physical properties and dynamics of the ionosphere. In particular, satellite radio beacons are effectively applied to measure ionospheric total electron content (TEC). Beacon satellites are also used to study ionospheric irregularities. The amplitude, phase, and angle of arrival of the signals traversing the ionosphere are distorted by drifting small scale plasma density irregularities. Fluctuations of the wave parameters are called scintillations. Scintillations, when measured on the ground, provide information about the structure and motion of ionospheric irregularities (Yeh, 1982).

High-latitude ionosphere are often remarkably irregular and dynamic. For that reason, monitoring of the high-latitude scintillation is of outmost importance. With this in mind, we got involved in the MISTECS (Monitoring of Ionospheric Scintillation and Total Electron Content on Spitsbergen) project. Monitoring equipment has been installed in the Polish Polar Station in Hornsund on Spitsbergen.

One of the components of MISTECS is the spaced receivers experiment in which three GPS scintillation receivers (GISTM) are placed at the corners of the triangle (Figure 1). The aim of the spaced receivers experiment is estimation of the diffraction pattern drift velocities and anisotropy of scintillation-producing electron density irregularities.

In Figure 2 the data for three receivers are shown on the same plot - red for receiver numbered 05, green - 06, blue - 16. Remarkable features of time series are nonstationarity of individual receivers data and its mutual relation as well. This mutual relation between measurements taken at two distinct spatial position is a key property for deriving the velocity of a drifting field (Briggs, 1968).

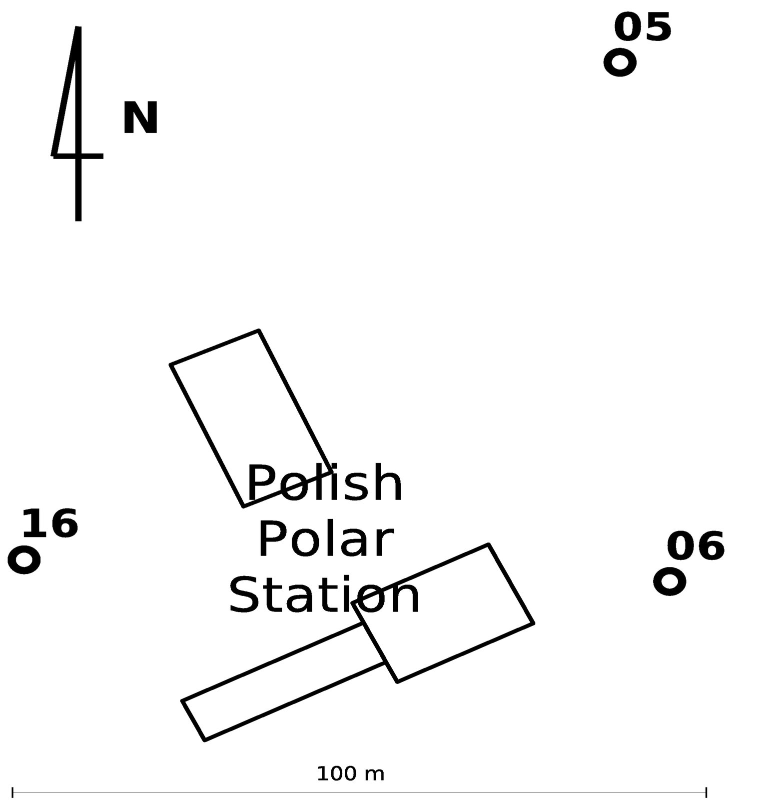

Figure 1 Placement of the GPS receivers at the Polish Polar Station In Hornsund (Svalbard)

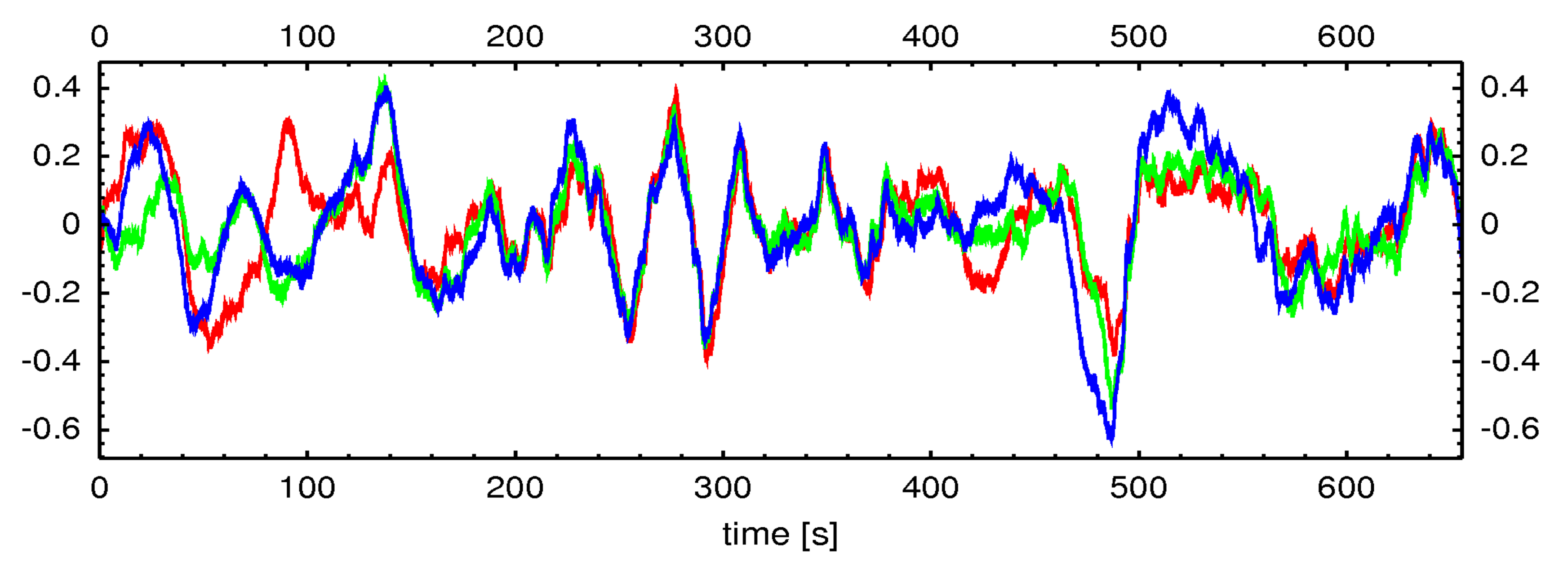

Figure 2 Detrended GPS phase for three receivers: red - 05, green - 06, blue - 16.

In a paper (Grzesiak & Wernik, 2009) we proposed a new method of analysis of spaced receivers data, which uses the windowed Fourier transform (WFT) to take care of possible nonstationarity of data, and Radon transform (RT) that can capture characteristic linear dependence of the cross-spectrum phase on frequency, provided the scintillation pattern on the ground is drifting. The advantage of the method is that it allows to obtain frequency variations of the drift velocity even for non-stationary data.

In Figure 3 we presented the results of the dispersion analysis of ionospheric drifts of during magnetic storm on 5-6.10.2010 - the strongest in 2010. Each of the drawings illustrates the distribution of mutual phase spectrum of GPS signal phase for a couple of receivers and its Radon transform below. Portions of the data analyzed come from various phases of the storm and the results show a large variation in the nature of the drift. These are fragments of a large coherence in the distribution of the phase and well-defined drift (a) and (c) as well as noisy and apparently nonstationary drifts in (b) and (d). We attribute this variability to the very dynamic nature of the phenomenon under investigation.

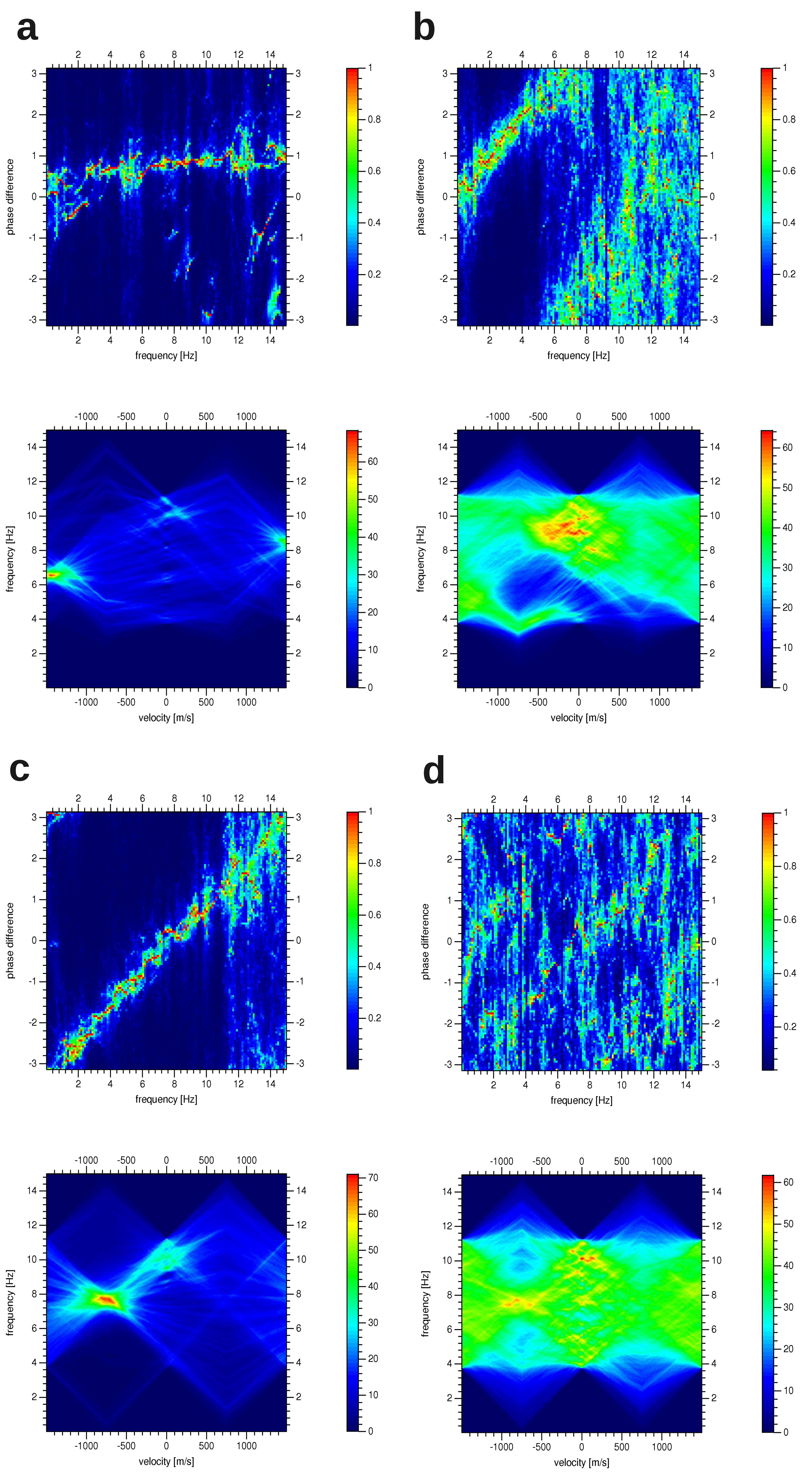

Figure 3 The results of the dispersion analysis of ionospheric drifts of during magnetic storm on 5-6.10.2010 - the strongest in 2010. Each of the drawings illustrates the distribution of mutual phase spectrum of GPS signal phase for a couple of receivers and its Radon transform below. Portions of the data analyzed come from various phases of the storm.

Acknowledgments
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