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A network for upper atmosphere monitoring at high latitudes of the nothern hemisphere

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Abstract. L-band scintillation occurring at high latitudes can be severe during ionospheric storms. Details of the mechanisms causing the scintillation are difficult to establish if isolated instruments are affected but by operating a suite of complementary instrumentation it is possible to investigate the underlying causes. A number of GPS receivers have been deployed in northern Europe. The first was deployed in September 2003. Each receiver is networked to the home institution and monitors raw scintillation data. Scintillation events occurring during disturbances in November 2004 are related to the large-scale plasma using other instrumentation. The MIDAS imaging algorithm is used to show the spatial distribution of total electron content (TEC) in conjunction with the plasma movement detected using the SuperDARN radars. In addition, local ionospheric structures are monitored by a Navy Ionospheric Monitoring System (NIMS) receiver co-located with the European Incoherent Scatter (EISCAT) radar in Norway. The occurrence of both phase and amplitude scintillation events and their severity are examined with relation to the underlying physical structures in the ionosphere. The results are of interest to the GPS community as they provide information about potential GPS signal loss in the arctic and polar regions.

Key words. Solar-terrestrial relationships

1. Analysis of scintillation data

Eight GPS scintillation receivers are now deployed in northern Europe, collecting phase and amplitude data from GPS satellite signals. The amplitude values were divided by a 1-minute mean and the standard deviation was calculated to find the S4 index, which is the standard deviation of the received power normalised by its mean value. The S4 values obtained from Svalbard data were reduced by a value representative of the ambient noise. The phase scintillation data, 1 minute sigma phi, were detrended by the subtraction of a cubic fit and filtered to remove values below a cut-off frequency of 0.1Hz (Van Dierendonck et al. 1993, and references therein, De Franceschi et al. 2003).

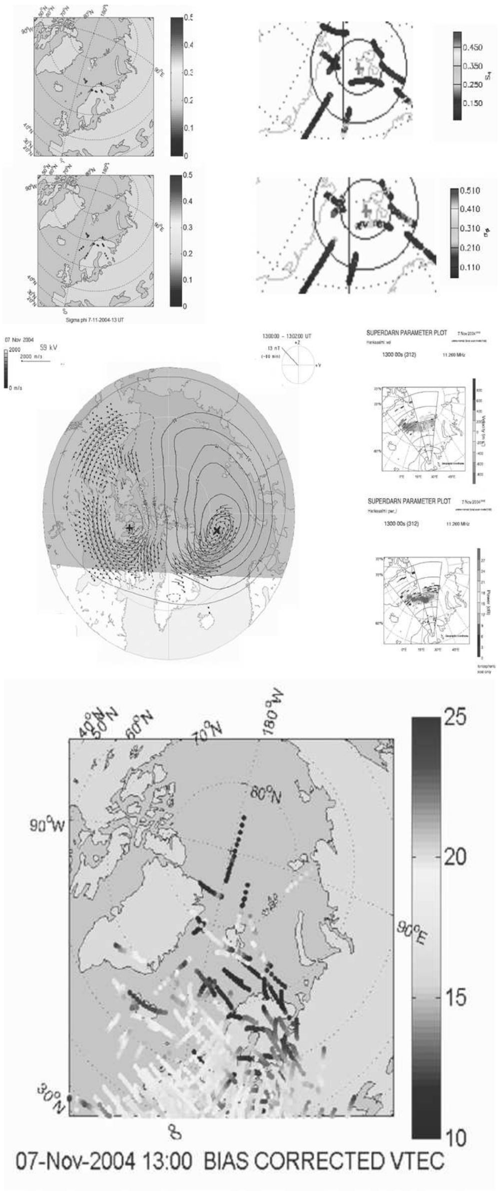

Fig. 1. Phase and amplitude scintillations from Troms and Svalbard between 13 and 14 UT on 7 November (top); convection pattern from the SuperDARN radars (centre), power and velocity components from the superDARN radar at Hankasalmi (Finland) and the equivalent vertical TEC map at 13 UT on 7 November (bottom).

2. The case study of november 2004 storm

In figure 1 phase and amplitude scintillations are projected onto a shell at 350 km altitude from Troms and Svalbard between 13 and 14 UT on 7 November (left), the convection pattern is constructed from the SuperDARN radars (centre), the power and velocity components are from the superDARN radar at Hankasalmi (Finland) and the equivalent vertical TEC map is obtained from the data of a network of GPS receivers via the MIDAS algorithm (Mitchell and Spencer 2003).

From this figure we can argue that, instead of the enhanced electron densities, TEC, and convection velocities observed over Svalbard on the edge of the dusk cell, phase and amplitude scintillations are only slightly increased.

Figure 2 shows the vertical TEC from the network of GPS receivers and the contemporaneous values of sigma phi from Tromso between 1 and 3 UT on 8th November (left), the diurnal variation of TEC, sigma phi and S4 for 8th November (centre) and evidence of phase scintillations on the edge of the dawn convection cell around 5 UT (right).

From this figure its possible to observe that on 8th November 2004 the TEC is enhanced at the edges of the dawn convection cell and that the scintillation activities associated with the edges of the cell are increased over northern Scandinavia.

In figure 3 the enhanced relative equivalent vertical TEC values are confirmed by a NIMS satellite pass recorded at Tromso (left) and phase scintillations associated with the edges of the dawn convection cell (right).

For the colour version of the figures, please visit:
http://www.spaceweather.ingv.it/alfonsi05.pdf

3. Discussions

Eight GPS scintillation receivers are now deployed in northern Europe, collecting phase and amplitude data from GPS satellite signals. In this study the Svalbard and the Tromso receivers have been used. During the November 2004 the plasma convection and TEC values evidenced by SuperDARN, MIDAS GPS and NIMS data have been related to scintillation

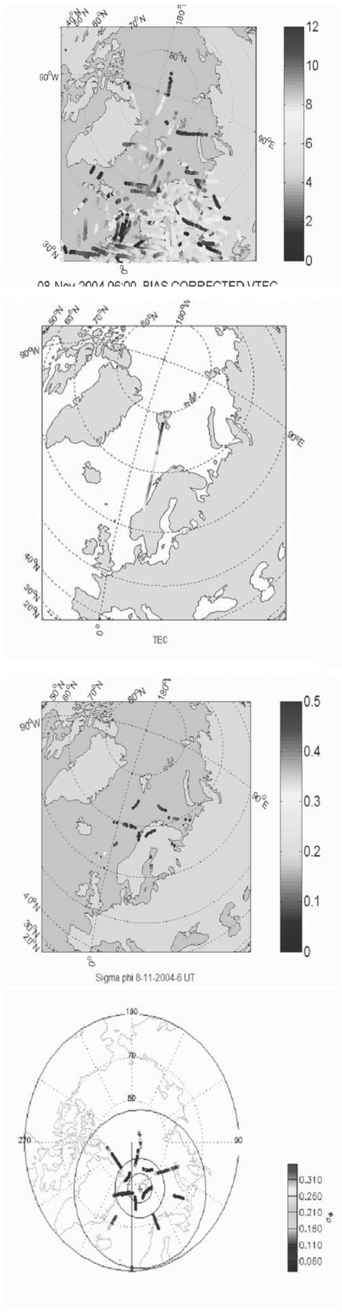

Fig. 3. Equivalent vertical TEC map, TEC as observed by a NIMS satellite pass recorded at Tromso and phase scintillations from Tromso and Svalbard on 8 November between 6 and 7 UT.

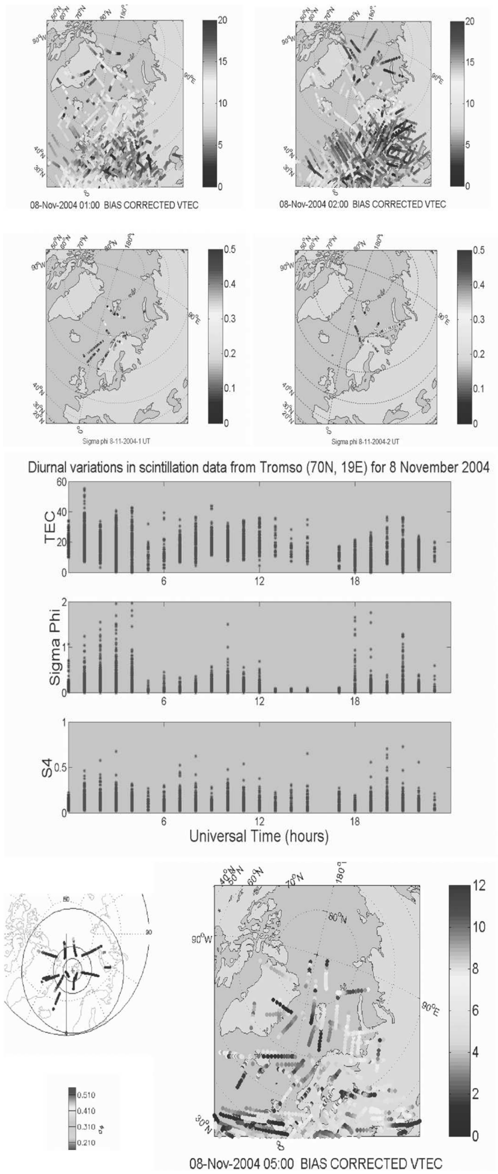

Fig. 2. Vertical TEC from the network of GPS receivers, sigma phi from Troms between 1 and 3 UT on 8 November (top), the diurnal variation of TEC, sigma phi and S4 for 8 November (centre) and the equivalent vertical TEC map around 5 UT (bottom).

events. The results show very slight enhanced scintillation activity associated with enhanced velocities in the dusk cell on 7th November. The morning of 8th November showed enhanced values of phase scintillation associated with the edges of the dawn cell. These results are complementary to those from the October 2003 storm where scintillation was associated with cross-polar convecting plasma during the evening (Mitchell et al. 2005). It is intended that further studies on these data sets from the recent solar maximum will help to explain the roles of precipitation and convection in the control of high-latitude GPS scintillation.

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