Plasma convection over Northern Scandinavia

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ABSTRACT

Measurements of ionospheric convection in the high latitude ionosphere over northen Scandinavia are made with the ground based coherent radar system STARE (= Scandinavian Twin Auroral Radar Experiment). The measurements are made continuously, and they are available in real time over the Internet. The measurements are therefore useful for assessing the current space weather.

Key words: Space weather, ionosphere, convection

1. INTRODUCTION

The interaction of the solar wind with the Earth's magnetic field and ionosphere controls the plasma environment of the Earth. The interaction induces currents and electric fields in the geomagnetic environment, which results in the formation of the magnetosphere. The ionosphere is an integral part of the magnetosphere and electric fields and currents in the ionosphere are manifestations of the solar wind interaction with our planet, i.e. manifestations of the space weather. The ionospheric convection, which is determined by the electric fields and currents in the ionosphere, can be measured from the ground. In particular ground based coherent radar systems have proven useful in this respect. A unique aspect of ground based experiments, as opposed to space born experiments, is the possibility of making simultaneous measurements over a large area to determine the instantaneous spatial variations of the convection and its temporal developments.

2. THE STARE SYSTEM

With STARE (Nielsen et al.,1998) the ionospheric convection is measured over an area of 200 000 km2 with a spatial resolution of 20x20 km and a temporal resolution of, typically, 20 s. The field of view of the experiment is shown in Figure 1. The system consists of two fully automatic unmanned coherent radar stations operating near 140MHz. The radar backscatter occurs in an altitude range from 100 to 120 km, with the most intense contribution from altitudes between 105 and 110 km. The irregularity drift velocities (convection velocities) derived from the STARE observations are extracted from Doppler velocity measurements. The Doppler velocity measured by each radar station equals the 'mean' phase velocity of the unstable plasma waves giving rise to the radar backscatter. These phase velocities are experimentally and theoretically related to the component of the electron drift velocity in the direction of the radar k-vector, i.e. in the direction of measurement (Sudan et al., 1973; Robinson, 1986; Hamza and St.-Maurice, 1993a,b). The two radar stations are used to make stereoscopic observations of plasma wave activity over a common area (the field of view of the system), and from the Doppler velocity measurements the electron drifts are estimated in a grid of points separated by 0.5 degrees in longitude and 0.2 degrees in latitude.

2.1. Examples of observations

Examples of instantaneous convection observed with STARE are shown in Figure 2. The field of view of STARE coveres about 5 degres in latitude and 12 degrees in longitude. Figure 2 shows a time where eastward drifts (westward electrojet) dominates the lower part of the field of view, while a swirl in the convection on the poleward side. Figure 3 shows a wide westward electrojet driven by strong electric fields of larger than 50 mV/m. In Figure 4 an attempt is made to illustrate the dynamics of the ionospheric convection. The latitudinal profile of flow velocities is plotted as a function of time. It demonstrates clearly the dynamic nature of the convection at this time. For example, at 0330UT the flows reverse direction from eastward to westward for about 15 minutes.

2.2. Real time access to the radar stations

In each station the radar is connected to a PC which is dedicated to communications with the outside world. The Comm-PC is accessible via the internet over an ISDN interface. At the end of each integration time (of typical 20 s duration) the data file with the observation data is send from the radar system to the Comm-PC, where it can be viewed in real time over the internet. An example is shown in Figure 5. Each radar makes measurements as a function of range in 8 antenna lobes. In the left panel the backscatter intensity is shown in relative units (increasing intensity from blue to red) as a function of antenna lobe and range. In the same coordinate system the right panel displays the sign of the Doppler velocities (red for positive, and blue for negative Doppler).

The data files for all integration times are concatenated to 24 hour files, which are ftp'ed to MPAe every morning, and the data from the previous day are available there by 1000 UT. To get an overview of the occurrence of backscatter a quick-look plot of the form of Range-Time- Intensity plot is then made, which can be viewed over internet. An example is shown in Figure 6. Data from the norwegian and the finnish radar stations are shown separately. In a coordinate system with range vs time are shown regions where backscatter occurred; the color of the regions are coded to indicate the sign of the Doppler velocity (i.e. the sign of the convection velocity component in the direction of the radar station: 'red' for flow towards and 'blue' for flow away from the station). For the norwegian data it is generally speaking valid, that the eastward electrojet is marked by 'red' signature and the westward electrojet by 'blue' signature.

We are currently working to realise the possibility of combining the observations from the two stations in real time, to allow real time access to the convection velocities as shown in Figures 2,3 and 4.

3. GENERAL

Information about the STARE system and open access to the Range-Time-Intensity plots is at the address: http://www.mpae.gwdg.de/mpae-projects/STARE/STARE.html
http://www.geo.fmi.fi/PLASMA/RADAR/STARE/
The two participating institutes have an open data policy, striving to provide 'easy' access and use of the data. Access in real time to the STARE station in Midtsandan is possible after submitting the "id" of the computer to be used (to: nielsen@linmpi.mpg.de).

4. Acknowledgements

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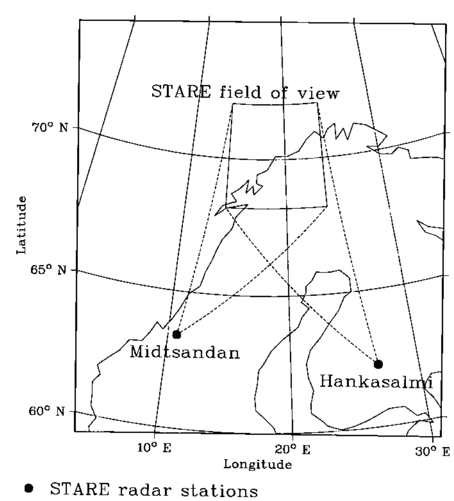


Figure 1. The field of view of the STARE radar stations in Norway and Finland. The field of view covers the geomagnetic latitude range from 65 to 70 degrees

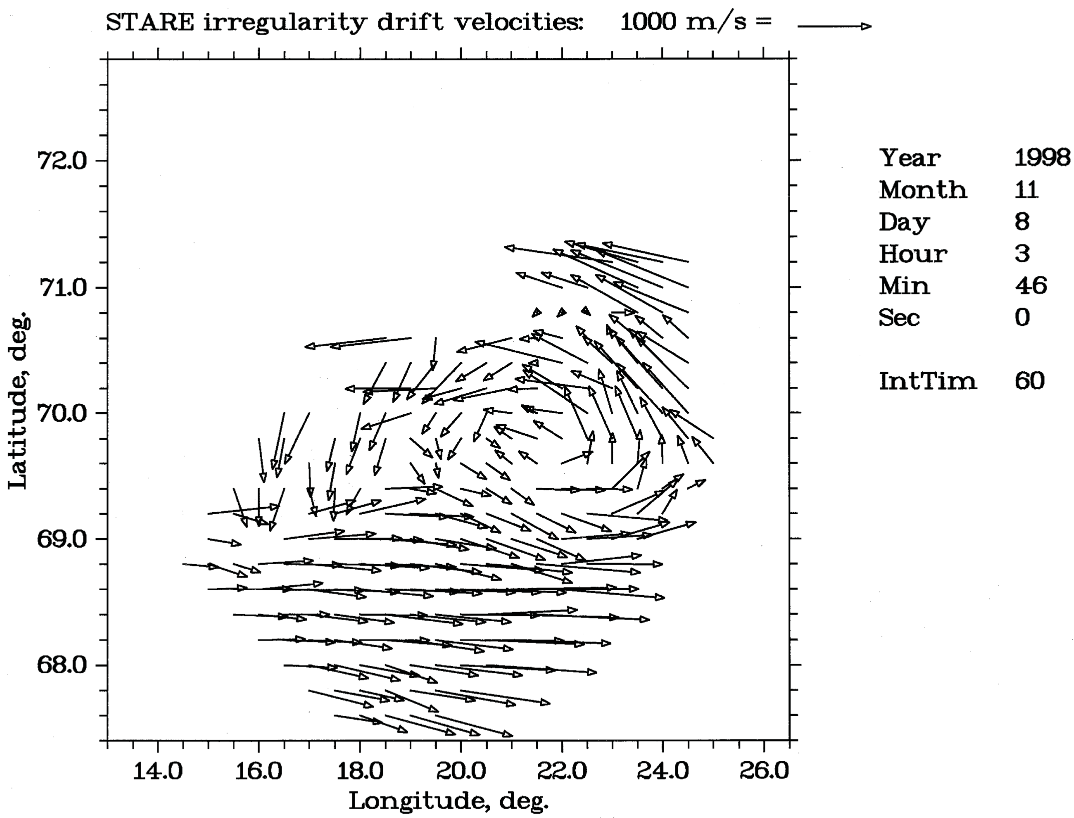


Figure 2. The field of view in longitude and latitude of the STARE system. Ionospheric flow velocities are estimated in a grid of about 20*20 km, corresponding to 0.5 degrees in longitude and 0.2 degrees in latitude. The velocities are shown, in magnitude and direction, by a vector starting in each grid point. The vectors are calculated by assuming that the Doppler velocity observed in two independent directions (towards the radar stations) equals the component of the total drift velocity on these two directions. Since the electron drift is an ExB drift in the E-region, it is further concluded that the swirl is associated with a strong divergence of the ionospheric horizontal electric field. The equivalent electric fields are determined by turning the drift velocity 90 degrees clockwise and setting 1000m/s equal to 50mV/m.

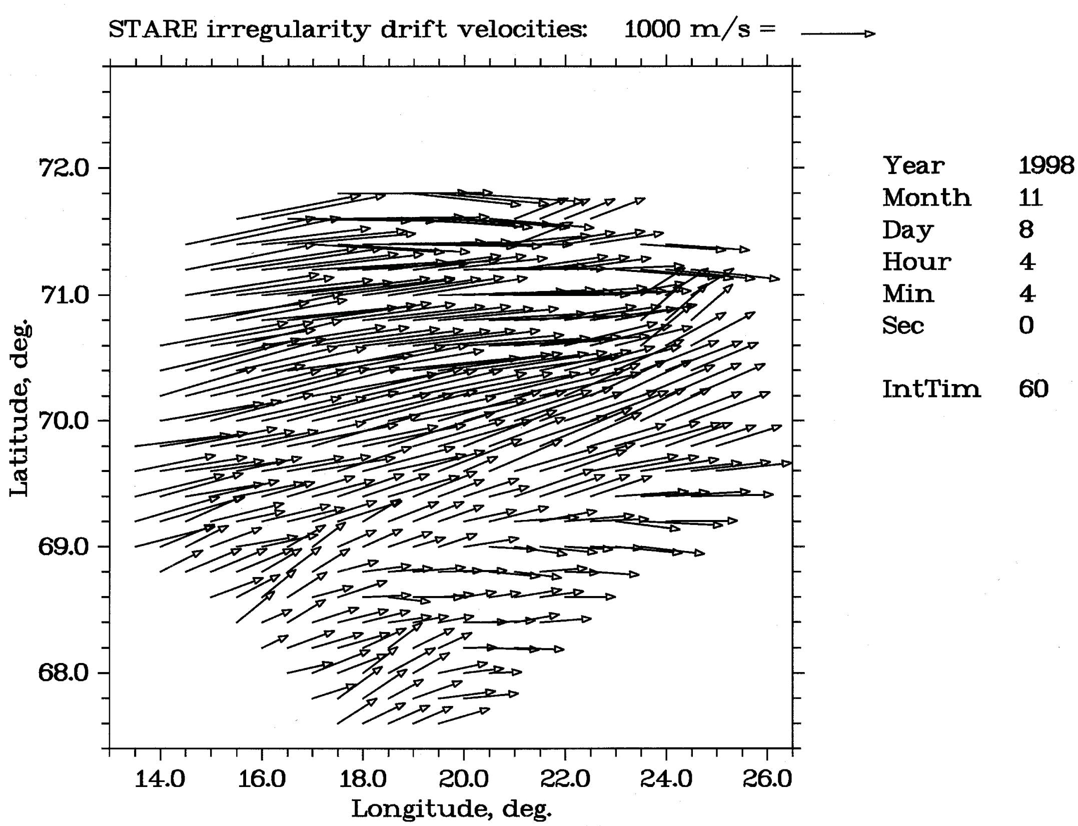


Figure 3. See Figure 2.

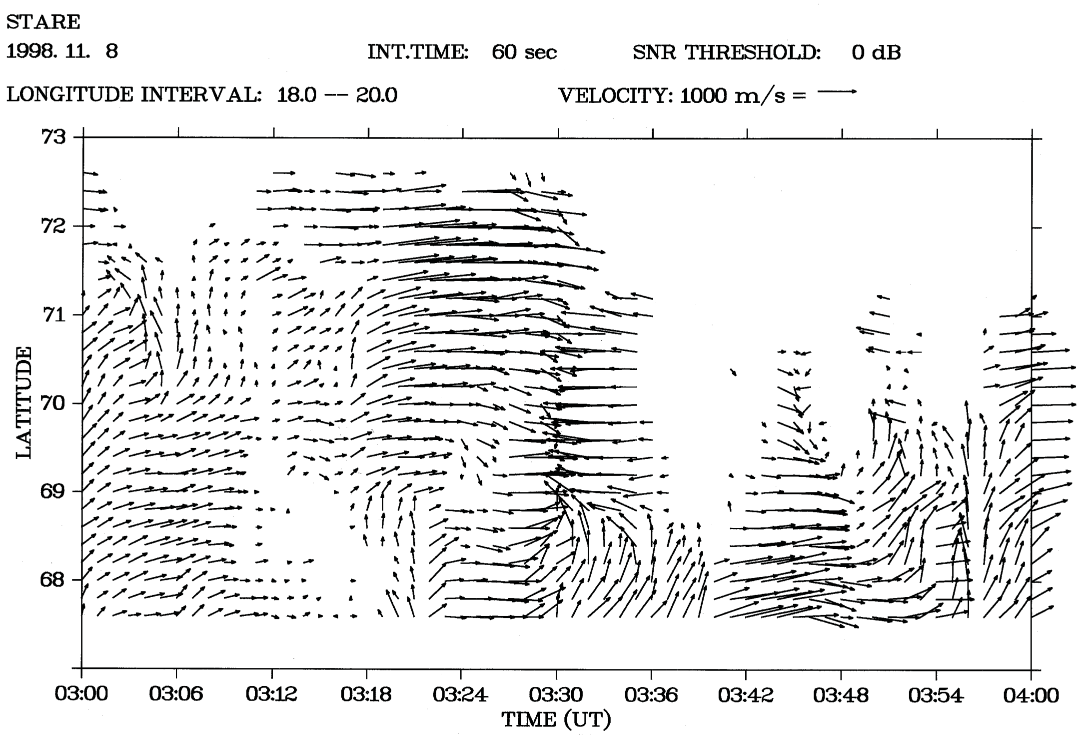


Figure 4. Drift velocities are averaged over the longitude range from 18 to 20 degrees and the latitudinal variation is plotted as a function of time to reveal how the spatial flows develop with time

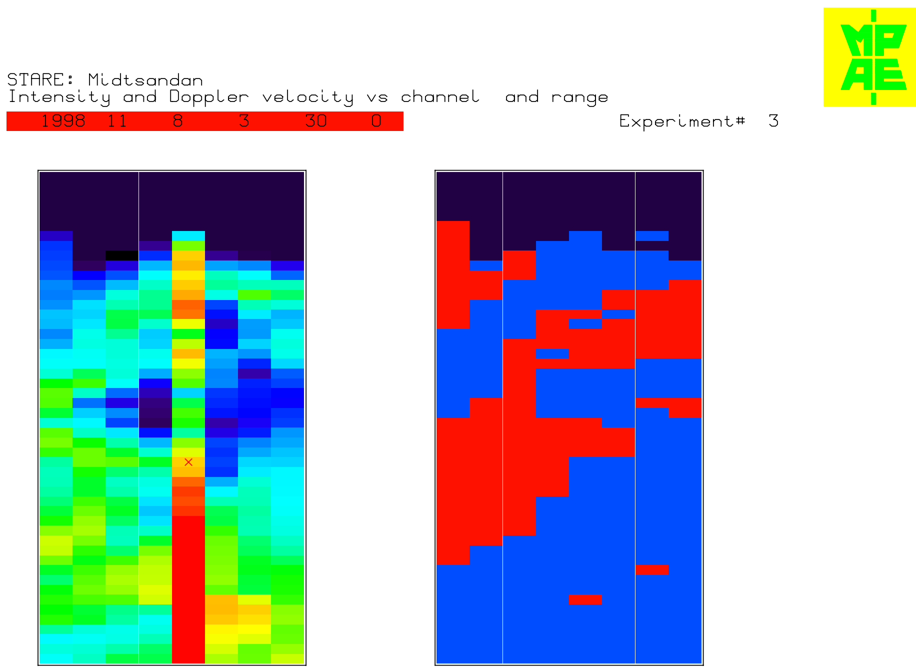
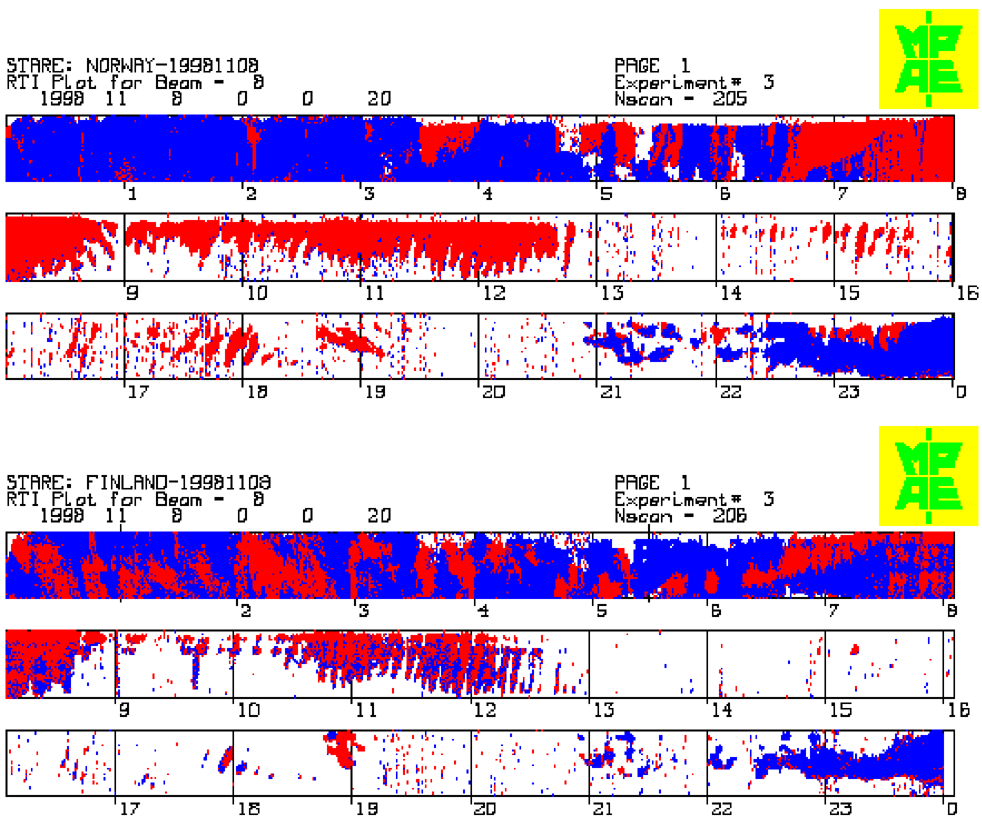


Figure 5. In an (antenna lobe, range)-coordinate system are shown: the backscatter intensity (left panel) and the sign of the Doppler velocity (right panel). The backscatter threshold is at about 15mV/m, and , thus, a backscattedred signal indicates that the electric field in the ionosphere is larger than this threshold. The sigh of the Doppler velocity indicates that the convection is towards (red) or away (blue) from the radar station.

STARE RTI Data Plots



STARE at MPAe

Figure 6. Selecting backscatter intensity data from a single antenna lobe, the ranges for which the signal intensity is above background are marked by 'red' where the convection is positive (towards the radar station), and by 'blue' where the convection is negative (away from the radar station).