NIEDERSÄCHSISCHE STAATS- UND
UNIVERSITÄTSBIBLIOTHEK GÖTTINGEN

Werk

Jahr: 1983
Kollektion: fid.geo
Signatur: 8 Z NAT 2148:53
Digitalisiert: Niedersächsische Staats- und Universitätsbibliothek Göttingen
Werk Id: PPN1015067948_0053
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948_0053

LOG Id: LOG_0041
LOG Titel: Experimental data on electric field and electron density dependence of auroral e-region drift turbulence and radar backscatter
LOG Typ: article

Übergeordnetes Werk

Werk Id: PPN1015067948
PURL: http://resolver.sub.uni-goettingen.de/purl?PPN1015067948
OPAC: http://opac.sub.uni-goettingen.de/DB=1/PPN?PPN=1015067948

Terms and Conditions

The Goettingen State and University Library provides access to digitized documents strictly for noncommercial educational, research and private purposes and makes no warranty with regard to their use for other purposes. Some of our collections are protected by copyright. Publication and/or broadcast in any form (including electronic) requires prior written permission from the Goettingen State- and University Library.
Each copy of any part of this document must contain there Terms and Conditions. With the usage of the library's online system to access or download a digitized document you accept the Terms and Conditions.
Reproductions of material on the web site may not be made for or donated to other repositories, nor may be further reproduced without written permission from the Goettingen State- and University Library.

For reproduction requests and permissions, please contact us. If citing materials, please give proper attribution of the source.

Contact

Niedersächsische Staats- und Universitätsbibliothek Göttingen
Georg-August-Universität Göttingen
Platz der Göttinger Sieben 1
37073 Göttingen
Germany
Email: gdz@sub.uni-goettingen.de

J Geophys (1983) 53:198–200

Journal of Geophysics

Short Communication

Experimental Data on Electric Field and Electron Density Dependence of Auroral E-Region Drift Turbulence and Radar Backscatter

M.V. Uspensky[1], W. Baumjohann[2, 3], R.J. Pellinen[4], and G.V. Starkov[1]

[1] Polar Geophysical Institute, Vladimirskaya 17, 183023 Murmansk, USSR
[2] Institut für Geophysik der Universität Münster, D-4400 Münster, Federal Republic of Germany (former address)
[3] MPI für Physik und Astrophysik, Institut für extraterrestrische Physik, D-8046 Garching, Federal Republic of Germany (present address)
[4] Finnish Meteorological Institute, Division of Geomagnetism, SF-00101, Helsinki 10, Finland

Key words: Radar aurora amplitude – Electron density

Introduction

Haldoupis et al. (1982), Uspensky et al. (1983) and Starkov et al. (1983) have recently found that the 140 MHz backscatter amplitude in the auroral ionosphere depends mainly on the mean electron density (height-integrated conductivity) in the *E*-layer. A similar relationship for the 46 MHz band was also found by Leinonen et al. (in press 1983). In principle, this can be explained by only a slight dependence of the relative level of *E*-region drift turbulence $<(\Delta N/N)^2>$ in the auroral ionosphere on ionospheric parameters, viz. electric field and mean electron density.

However, up to now, quantitative evidence for such a backscatter amplitude – electron density relationship is restricted to the few events which have so far been analyzed. Therefore, the aim of this short note is to add some more data to that data set. Furthermore; we will compare measurements made in the evening and morning sectors, where the conditions for irregularity excitation might be different.

Electron Density Fluctuations

The volume cross-section in the Born approximation, which is a quantitative measure of the auroral backscatter, is a function of the relative level of the ionospheric wave tubulence due to the Farley-Bunemann and gradient drift instabilities (Fejer and Kelley, 1980). The wave turbulence equals the mean fractional electron density fluctuations $<(\Delta N/N)^2>$ or – which is the same – the level of the ionospheric drift turbulence. Using the turbulence level the backscatter cross-section equation can be written:

$$\sigma_v(k) = 32\pi^4 r_e^2 N^2 <(\Delta N/N)^2> f(k) \tag{1}$$

where k is the wave number, $f(k)$ the fluctuation power spectra, $\iiint f(k)\, d^3k = 1$ and r_e is the classical electron radius.

Let us consider here $f(k)$ as a stable statistical function of its parameters, viz. aspect angle, azimuth or propagation angle (André, 1980) and wave number (Chestnut, 1968). Then one can study the behaviour of the ionospheric turbulence level by utilizing radar backscatter data

$$<(\Delta N/N)^2>^{1/2} \sim \sqrt{\sigma_v}/N \tag{2}$$

if one knows the mean electron density N in the backscatter region.

To solve Eq. (2) Uspensky et al. (1983) substituted N by the height-integrated Hall conductivity Σ_H. The latter was derived by dividing the upward continued external magnetic field (calculated from the Scandinavian Magnetometer Array data; Küppers et al., 1979) by the ionospheric electric field from the STARE measurements (Greenwald et al., 1978). The same method is used in the present paper. The backscatter amplitude used is that measured by the Finland STARE radar corrected for aspect and azimuth angle and slant range dependence.

Data from Morning and Evening Sectors

We will show data for two intervals: 15 March 1978, 0100-0119 UT (morning sector) and 16 March 1978, 1800-1814 UT (evening sector). A full geophysical description of these events can be found in Uspensky et al. (1982, 1983), but we should note that both events occur during pre-substorm and thus relatively smooth and stable ionospheric conditions.

Figure 1 shows two histograms for the ionospheric electron density turbulence as a function of electric field amplitude in the morning and evening sectors. These histograms were constructed from STARE electric field and backscatter amplitudes averaged over a four point meridional strip running along the x-axis of the Kiruna coordinate system (Küppers et al., 1979). The mean longitude of this strip is 19 °E and the longitudinal range covers 2°. The backscatter amplitudes have been corrected for the 7.5 dB/deg aspect angle anisotropy and slant range dependence. The aspect angle changes along the strip equally for morning and evening events from 0° to 0.6°. The average azimuth angle is always close to 90°. However, the data have still been corrected for azimuth angle dependence by using Eq. (2) of Starkov et al. (1983).

From Fig. 1 one can easily see that there is no strong dependence of ionospheric electron density turbulence on electric field amplitude and that there is at least no simple

---

Offprint requests to: W. Baumjohann

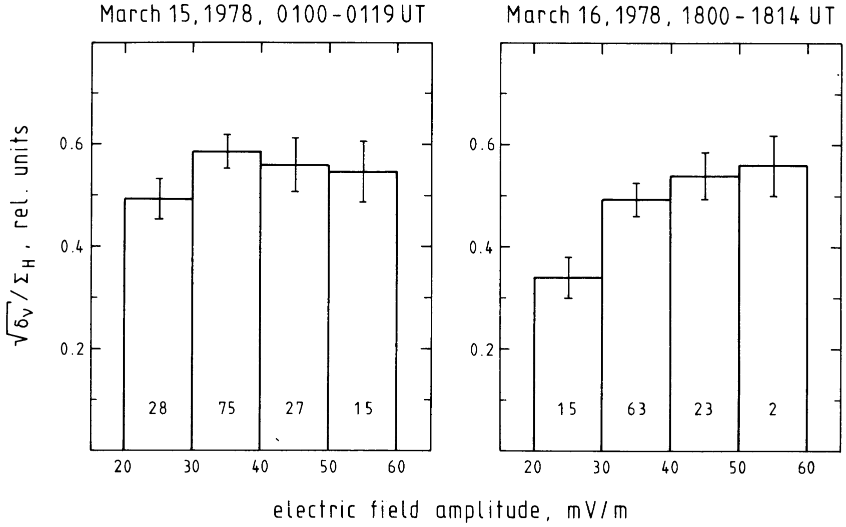

Fig. 1. Corrected STARE backscatter amplitudes from the Finland radar normalized by the height-integrated Hall conductivities as a function of electric field amplitude for the two events discussed. The bars give standard deviations and the numbers in the histogram boxes give the number of associated data samples

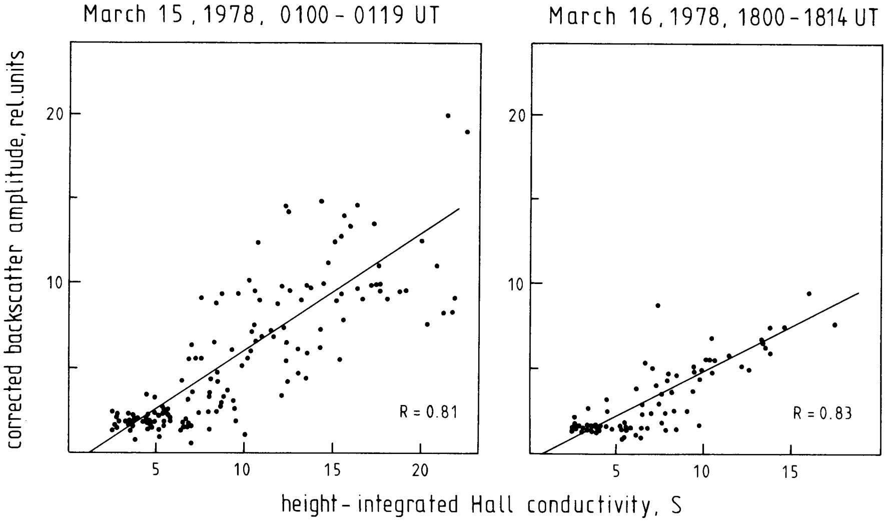

Fig. 2. Corrected Finland STARE backscatter amplitudes as a function of the height-integrated Hall conductivities. The heavy line gives the linear regression line. Note that both data sets exhibit a conductivity/electron density threshold for radar backscatter of about 1 S/0.25 · 10^5 cm^{-3}

linear relationship between those two quantities. For both events there is a saturation of the turbulence when the electric field amplitude reaches 30–40 mV/m. Note that the saturation level is approximately the same in the morning and evening ionopshere.

Note further, that the independence and saturation of the *E* region turbulence becomes even more pronounced if we take into account the recent findings by Nielsen and Schlegel (in press 1983). These authors found that the electric fields estimated from the STARE data are increasingly too low when the real ionospheric electric field exceeds 35 mV/m.

Figure 2 gives a scatter diagram of the STARE backscatter amplitudes as a function of height-integrated Hall conductivities (the latter being averaged in a similar way to the STARE quantities). In spite of some scatter there is a clear linear dependence of the backscatter amplitude on the height-integrated Hall conductivity and thus mean electron density with a correlation coefficient of about 0.8. The regression lines have very similar slopes for both morning and evening sector events. Both data sets also exhibit a similar electron density threshold (about $0.25 \cdot 10^5$ cm^{-3} for the regression line crossing the abscissa and $0.5 \cdot 10^5$ cm^{-3} for the existence of radar backscatter). A similar threshold was found earlier by Tsunoda and Presnell (1976) for 398 MHz backscatter data ($0.5 \cdot 10^5$ cm^{-3}). We believe that these electron density thresholds are an inherent property for the *E* region Farley-Buneman turbulence.

In conclusion our results confirm that the recently observed (nearly) linear relationship between backscatter amplitude and mean electron density, as well as the independence of the fractional electron density variations from the electric field magnitude (Haldoupis et al., 1982; Uspensky et al., 1983; Starkov et al., 1983; Leinonen et al., in press 1983) hold both in the evening and morning sector ionosphere. This is also supported by the linear relationship found earlier between radar amplitude and ionospheric current density (e.g. Greenwald et al., 1975; Siren et al., 1977; Baumjohann et al., 1978; Mareschal et al., 1979) which is apparently a special case of the more common linear relationship between radar amplitude and mean electron density in the backscattering region.

Acknowledgements. The authors are indepted to Drs. R.A. Greenwald and E. Nielsen for the STARE data. This work was financially supported by the Deutsche Forschungsgemeinschaft (W.B.) and the Finnish-Soviet Committee on cooperation in science and technology (M.U., R.P., G.S.).

References

André, D.: Radarmessungen von Plasmawellen in der polaren Ionosphäre. Dissertation Math.-Naturwiss. Fak., Georg-August-Universität, Göttingen, 1980

Baumjohann, W., Greenwald, R.A., Küppers, F.: Joint magnetometer array and radar backscatter observations of auroral currents in Northern Scandinavia. J. Geophys. **44**, 373–383, 1978

Chestnut, W.: Low frequency waves and irregularities in the auroral ionosphere as determined by radar measurements. In: Low frequency waves and irregularities in the ionosphere, N. D'Angelo, ed.: pp. 173–191. Dordrecht: D. Reidel 1968

Fejer, B.G., Kelley, M.C.: Ionospheric irregularities. Rev. Geophys. Space Phys. **18**, 401–454, 1980

Greenwald, R.A., Ecklund, W.L., Balsley, B.B.: Radar observations of auroral currents. J. Geophys. Res. **80**, 3635–3641, 1975

Greenwald, R.A., Weiss, W., Nielsen, E., Thomson, N.F.: STARE: A new radar auroral backscatter experiment in northern Scandinavia. Radio Sci. **13**, 1021–1039, 1978

Haldoupis, C., Nielsen, E., Goertz, C.K.: Experimental evidence on the dependence of 140-Megahertz radar auroral backscatter characteristics on ionospheric conductivity. J. Geophys. Res. **87**, 7666–7670, 1982

Küppers, F., Untiedt, J., Baumjohann, W., Lange, K., Jones, A.G.: A two-dimensional magnetometer array for ground-based observations of auroral zone electric currents during the International Magnetospheric Study (IMS). J. Geophys. **46**, 429–450, 1979

Leinonen, J., Kangas, J., Kustov, A.V., Stepanov, G.S., Uspensky, M.V.: PiC magnetic pulsations and variations of ionospheric electric field and conductivity. J. Atmos. Terr. Phys. **45**, in press 1983

Mareschal, M., McDiarmid, D.R., McNamara, A.G.: Some properties of diffuse radio aurora at high aspect angles. J. Geophys. Res. **84**, 6687–6690, 1979

Nielsen, E., Schlegel, K.: A first comparison of Stare and Eiscat electron drift velocity measurements. J. Geophys. Res. **88**, in press 1983

Siren, J.C., Doupnik, J.R., Ecklund, W.L.: A comparison of auroral currents measured by the Chatanika radar with 50 MHz backscatter observed from Anchorage. J. Geophys. Res. **82**, 3577–3584, 1977

Starkov, G.V., Oksman, J., Uspensky, M.V., Kustov, A.V.: On the dependence of radar amplitude on ionospheric electron density. J. Geophys. **52**, 49–52, 1983

Tsunoda, R.T., Presnell, R.I.: On a threshold electric field associated with the 398-MHz diffuse radar aurora. J. Geophys. Res. **81**, 88–96, 1976

Uspensky, M.V., Greenwald, R.A., Kaila, K., Kustov, A.V., Pellinen, R.R., Pudovkina, E.V., Raspopov, O.M., Starkov, G.V.: Eastward motion of radar aurora and auroral loops in the morning sector. In: Studies of the high-latitude ionosphere and magnetosphere, O.M. Raspopov, ed.: pp. 41–55. Leningrad: Nauka 1982 (in Russian)

Uspensky, M.V., Pellinen, R.J., Baumjohann, W., Starkov, G.V., Nielsen, E., Sofko, G., Kaila, K.U.: Spatial variations of ionospheric conductivity and radar auroral amplitude in the eastward electrojet region during pre-substorm conditions. J. Geophys. **52**, 40–48, 1983

Received March 18, 1983; Revised version June 1, 1983
Accepted June 1, 1983