"Physics of Auroral Phenomena", Proc. XXXIV Annual Seminar, Apatity, pp. 193 - 196 2011

Polar Geophysical Institute

SEASONAL VARIATIONS OF DOMINATING ARRIVAL DIRECTIONS OF REGISTERED LIGHTING SIGNALS AS AN INDICATOR OF ANNUAL MOTION OF WORLD THUNDERSTORM CENTERS

V.V. Pchelkin[1], E.N. Yakushenkov[2]

1 Polar Geophysical Institute RAS, 26a, Academgorodok St., Apatity, Murmansk region, 184200, Russia
2 Kola department of Petrozavodsk State University, Apatity, Murmansk region, 184200, Russia

Abstract Using measurements of magnetometers in Lovozero observatory (Kola peninsula) for 2006-2009 years, dominant arrival directions of lighting signals were calculated. The average azimuth distributions of registered lighting signals for each season were constructed. Systematic changes in the dominant arrival directions of lighting signals depending on season were found. Estimations of seasonal variability of the activity of the world thunderstorm centers are made.

Introduction

Irregular spacing of thunderstorm activity centers on the Earth surface (Bliokh et al., 1980; Rossi et al., 2007*)* results in an anisotropy of arrival directions of noise signals in the 6-11 Hz frequency range (near the first Shuman resonance). It might be supposed that variability of position of the thunderstorm centers (and their activity) would be accompanied by seasonal changes of dominant arrival directions of registered lighting signals (Rossi et al., 2007*)*. The main objective of the given work is the testing of this assumption. Interest of such problem, first of all, consists in check of possibilities of large-scale high-altitude monitoring of global thunderstorm activity in the given range of frequencies.

On the one hand, similar monitoring has not a great accuracy, and it isn't allowed to calculate the location of an individual lightning (Fullekrug et al., 1996, 1999; Kemp, 1971; Bliokh et al., 1980;). Many factors bring an essential error in determination of a true bearing on sources of signals (influence of a coastal line, anisotropic conductivity in the ionosphere, magnetic field of the Earth etc.). For example, according with estimations in the paper Fullekrug et al. (1999), the lightning flash bearing (Hollister, California and Silberborn, Germany) exhibits a rotational dependence ~12°, associated with the conductivity contrast between the Earth's crust and the nearby Pacific Ocean. The bearing deviation exhibit ~11° is attributed to the anisotropic conductivity in the ionosphere during day-and nighttime conditions. Given results demand accuracy of the conclusions and force to base, first of all, on observations of relative variations of the parameters, which were made in approximately identical conditions of wave propagation.

On the other hand, existing system of satellite observations (and ground based observations in VLF region) still do not give the full information about the global distribution of lightning flashes on all Earth surface with the satisfactory time resolution too (Rodger et al., 2004; Christian et al., 2003). The on-line control of global thunderstorm activity is absent now.

Let's notice, that high-latitudes observations are practically free from influence of near thunder-storms. It considerably improves possibilities of large-scale monitoring of the thunderstorm centers, which grouped mainly in equatorial latitudes. The small number of stations enough removed from each other will allow to execute the parameters fitting of large-scale model of location of lightning flashes on Earth surface. This method demands inexpensive means (in comparison with a satellite observations or VLF lightning location network).

In summary we will notice, that feature of monitoring in high latitudes is the proximity to sources of magnetosphere waves. It dictates the necessity of a very careful selection of days without magnetosphere disturbances.

Measurements and data processing

The data from the regular measurements of the horizontal component of the noise magnetic field at the frequency range of the first Schumann resonance, held at the high-latitude Lovozero observatory for the period 2006-2009, were used. The brief description of the accepting – measuring equipment is contained in papers Roldugin et al. (2003), Beloglazov et al. (2009).

The days with the observed disturbances of magnetosphere and technogenic noises, as well as the days with incomplete records were excluded from the experimental data. Thus 300 days (from 3 years) were selected for the analysis.

During the processing by the methods of digital filtering the frequency band was narrowed to about the range of 6-11 HZ.

For each measurement of the horizontal component of the magnetic inductance vector the arrival azimuth was calculated. The calculation results were presented in the form of daily distribution of azimuths. The number of signals that received in the corresponding range of angles and times was shown by color. This form is better for determining the activity of the thunderstorm centers (compared with the daily course of signal intensity).

3. Results and discussion

1) In the noise magnetic field in the frequency range near the first Schumann resonance (as it was supposed) we have detected clearly anisotropy. This fact is interpreted as a result of irregular spacing of thunderstorm activity on the Earth surface and its changers in the course of time. That leads to the occurrence of different dominant arrival directions of lightning signals during a day (see Fig. 1). (In a daily total distribution of azimuths the anisotropy of arrival directions of noise signals is revealed too – see Fig. 2).
2) We found that the dominant arrival directions of lightning signals have natural seasonal variation (Fig. 3), which is caused by the seasonal movements of the world thunderstorm centers.

The calculations of the dominant arrival directions of lightning signals at different times showed that the average bearing of the Asian World Center varies about 25 degrees from winter to summer, the bearing of the African Centre remains practically unchanged, the bearing of the American center varies about 45 degrees (see Fig . 3). This agrees well with the meteorological information about the seasonal changes of location of the world thunderstorm centers (Christian et al., 2003). According to this information remarkable increasing of “American” direction activity and its change in depending on time (the time of maximum increases by 1,5-2 hours) can be explained by widening territory of thunderstorm activity towards North America in summer. But the change of location of African center consists of the “South-North” motion. It doesn’t result in changes of azimuth on source signals in the observation place (Fig 3). The territory of Asia thunderstorm activity widens in summer towards West, and it results in a change of “Asian” bearing about 25 degrees.

3) Activity of the thunderstorm centers increases in the summer period in a different degree in comparison with winter. The approximate estimates of the number of signals coming from different centers show that the activity of the Asian Centre increases more than the activity of African and American Centers.

The method of the estimates was based on the approximate calculation of the number of signals within the boundaries of different bright spots, correlated with the activity of the world thunderstorm centers (see Fig. 3).

Acknowledgements. Author would like to thank M.I. Beloglazov, A.N. Vasiliev, S.P. Noskov and A.I. Voronin for equipment preparation, and to the personnel of the Lovozero Observatory for the measuring control. This work was supported by the Fundamental Research Program of Department Physical Sciences of the Russian Academy of Sciences (project № 4.5 - Atmospheric electricity in the lower atmosphere of the polar latitudes).

References

Bliokh, P. V., Nikolaenko, A. P., and Filippov, Yu. F.: Schumann Resonances in the Earth-Ionosphere Cavity, Peter Perigrinus, London, 1980.

Beloglazov, M. I., Akhmetov, O. I., Vasil’ev, A. N., and Kosolapenko V. I.: Variations of global thunderstorm activity from observations of the first Schumann resonance intensity in the Arctic, Russian Meteorology and Hydrology, 34, 12, 784-788, doi:10.3103/S1068373909120024, 2009.

Christian, H. J., Blaceslee, R. J., Bossippio, D. J., Boek, W. I., Buechler, D. E., Driscoll, K. T., Goodman, S. J., Hall, J. H., Koshak, W. J., Mach, D. M., and Stewart, M. F.: Global frequency and distribution of Lighting as observed from space by the Optical Transient Detector, J. Geophys. Res., 108(D1), 4005, doi: 10.1029/2002JD002347, 2003.

Fullekrug, M., Reising, S. C., and Lyons, W. A.: On the accurasy of arrival azimuth determination of sprite – associated lightning flashes by Earth – ionosphere cavity resonances, Geophysical Research Letters, 23, 25, 3691-3694, 1996.

Fullekrug, M., and Sukhorukov, A. I.: The Contribution of Anisotropic Conductivity in the Ionosphere to Lighting Flash Bearing Deviations in the ELF/ULF Range, Geophysical Research Letters, 26, 8, 1109-1112, 1999.

Kemp, D. T.: The global location of large lightning discharges from single station observations of ELF disturbances in Earth-ionosphere cavity, J. of Atmospheric and Terrestrial Physics, 33, 919-927, Pergamon Press.,1971.

Rodger, C. J., Brundell, J. B., Dowden R. L., and Thomson, N. R.: Location accuracy of long distance VLF lightning location network, Ann. Geophys., 22, 747-758, 2004.

Roldugin, V. C., Malsev, Y.P., Vasiljev, A. N., Shvets, A. V., and Nikolaenko A. P.: Changes of Shumann resonance parameters during the solar proton event of 14 July 2000, J. Geophys. Res., 108(A3), 1103, doi: 10.1029/2002JA009495, 2003.

Rossi, C., Palangio, P., and Rispoli, F.: Investigations on diurnal and seasonal variations of Schumann resonance intensities in the auroral region, Ann. Geophys., 50, 301-311, 2007.

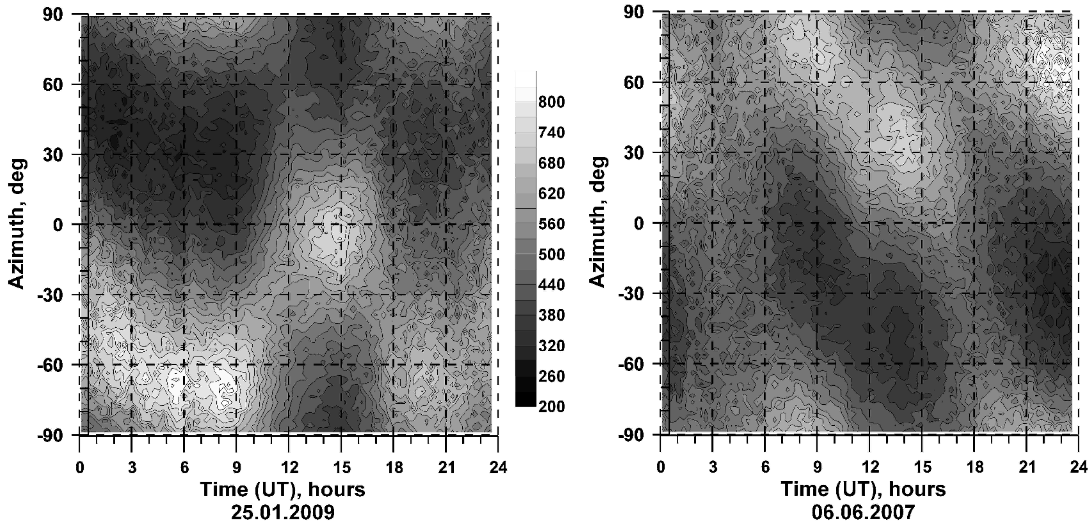

Fig. 1. Two examples of daily distribution of azimuths.

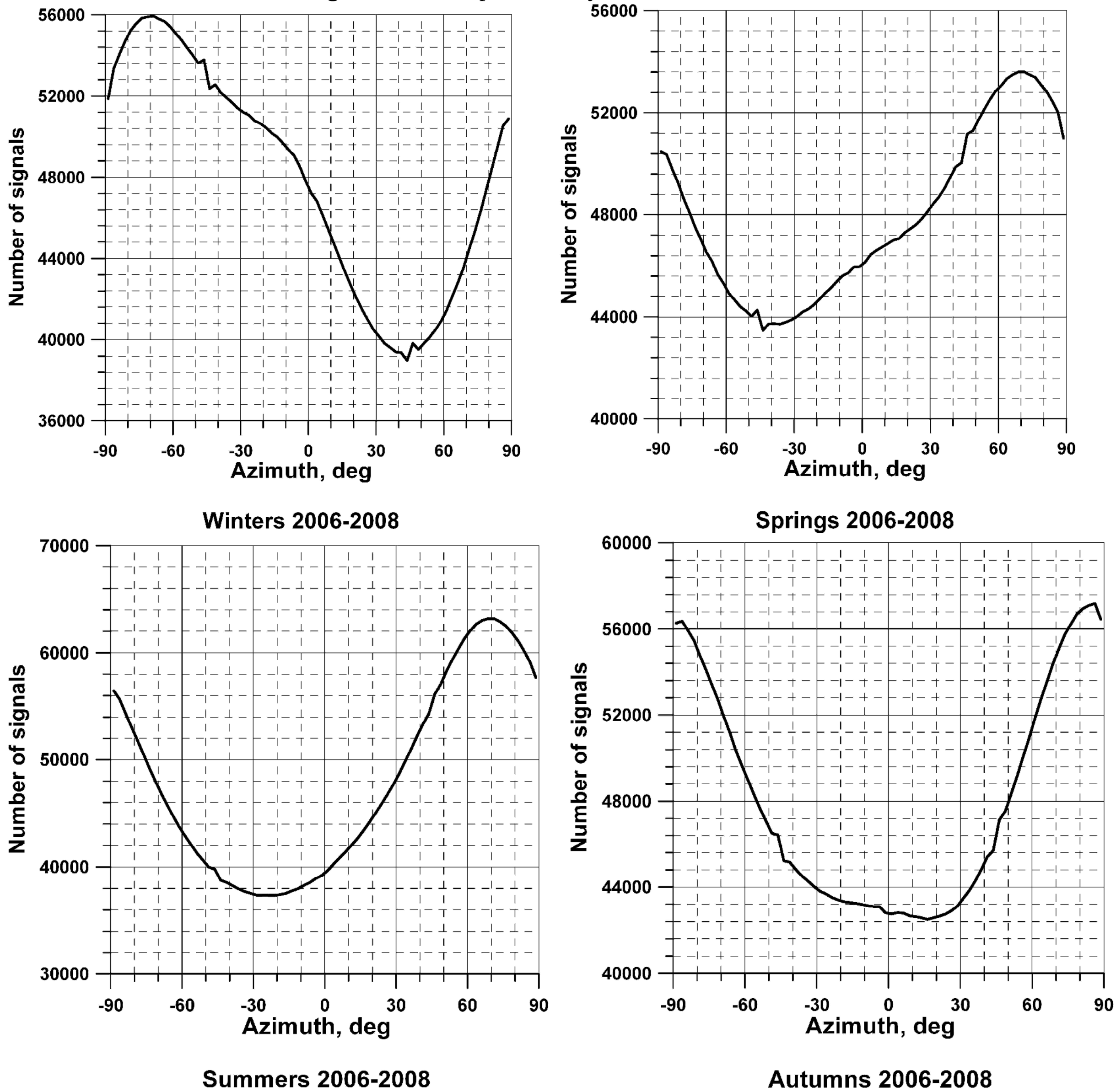

Fig. 2. Distributions of arrival azimuth of signals, registered for day (averaged for each season).

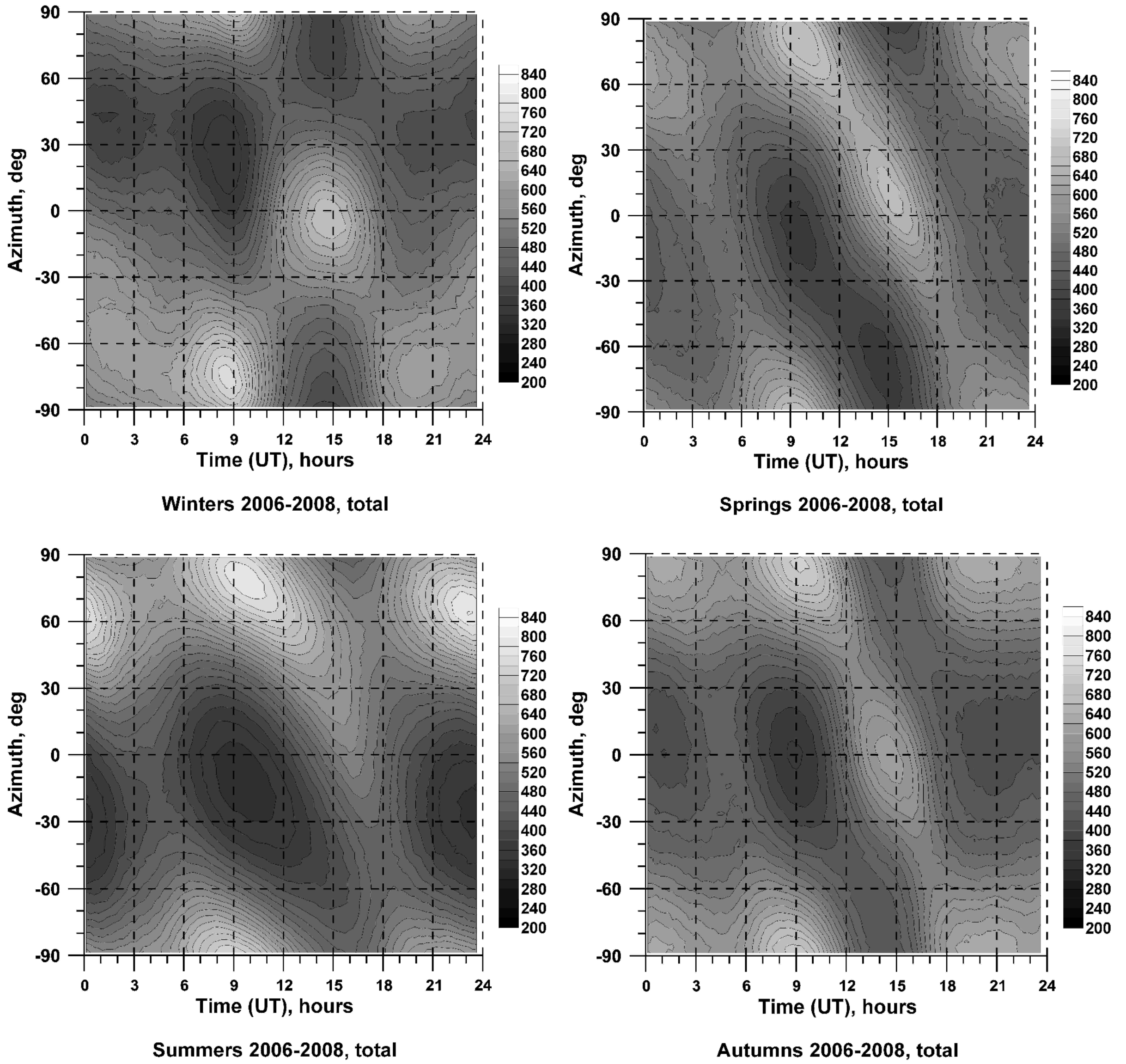

Fig. 3. Daily distribution of azimuths (averaged for each season). The number of signals that received in the corresponding range of angles and times was shown by color.