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OCCURRENCE RATE OF SAR-ARCS DURING THE 22ND SOLAR ACTIVITY CYCLE

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The occurrence rate of the subauroral red arcs (SAR-arcs) has been studied by using photometric observations at the Maimaga station (56.5°N, 200°E, geomagnetic coordinates) at the Yakutsk meridian in the period 1988-1998. Observations have been carried out in winter-spring periods on moonless nights, under favorable atmospheric conditions. 109 events of the occurrence of SAR-arcs (557 hours), during 239 observation nights (2031 hours) were registered. The occurrence rate of SAR-arcs for each concrete year was determined as a ratio of the total registration time of SAR-arcs to the summary observation time in hours per an year. It is found that the occurrence rate of SAR-arcs is associated with the phases of the 22nd solar cycle. They occurred most commonly at the solar activity maximum (by the number of sunspots) and at the decay phase (~40%) and more rarely - in the solar activity minimum (~15%).

Introduction

After the discovery by Barbier in 1956 from Haute Provence in southern France (φ-43.9° geogr., φ-39.7° geom.) of stable auroral red arcs (SAR-arcs) [1], this unique mid-latitudinal phenomenon attracted considerable investigators' attention. From 1958 the ground-based photometric and photographic purposeful SAR-arc observations began to be carried out in the North American continent [2]. Since 1967, the most complete and reliable ground-based measurements on the network of mobile scanning photometers are carried out at the Battelle observatory in Richland (North America) since 1967 [3].

In European-Asian continent the photometric and photographic observations of SAR-arcs are carried out on in the North-East of Russia at the station of Maimaga, since 1988 [4].

Stable subauroral red arcs (SAR-arcs) are associated with the magnetic disturbances on the Earth and, therefore, with the periods of the solar activity rise. Long period trends of SAR-arc occurrence rate make it easy to follow the energy transmission in the solar terrestrial system.

On the basis of photometric observations at Fritz-Peak observatory (39.9°N, 254.5°E, geog., φ-48.5°N geom.) for 1958-1965 and analogous data, obtained at the Battelle observatory (46.4°N, 240.4°E geog. φ-52.8 geom.) during the period of 1968-1978 the conclusion was drawn: the modulation in the SAR-arc occurrence rate is associated with solar activity cycle and changes from season to season. SAR-arcs appear mostly rarely during the cycle minimum and also during summer months. Most often they appear 2-3 years after the solar activity maximum (by the number of solar spots) [5].

In this work, the photometric observation data on SAR-arc occurrence rate, obtained at Maimaga (63.0°N geogr., φ-56.5°N geom.) were used.

Observations

Observations were carried out by use of a scanning two-channel photometer in winter-autumn periods, during moonless nights under favourable atmospheric conditions. The analysis of the data, obtained in night period is a term depending on the observation duration. In [3] this value, was determined in the following way: the observation night time under nice weather conditions measured during 2-3.5 hours was considered as 0.5 of the observational period, 3.5-5 hours for 0.75 and more than 5 hours during the complete observational night time period. For 1968-1978 at Battelle Observatory from 654 observational night periods, 88 were interpreted as cases with occurrence of SAR-arc [5]. In present paper, we considered the number of hours accounted for the observation period and registration time of SAR-arc in hours for that period, not the number of night observation period. The occurrence rate of SAR-arcs for every concrete year was determined as the ratio of the total SAR-arc registration time to summary observation time.

All in all, during autumn-winter periods at moonless nights, 114 cases of SAR-arc occurrence of total duration about 570 hours, during 251 observation nights (approximately 2146 hours) at the Yakutsk meridian are registered. The mean occurrence rate of SAR-arcs during the 22nd solar cycle is about 27 per cent from the total observation time.

Figure presents the histogram of SAR-arc occurrence rate for the 22nd solar activity cycle (by the number of sun spots).

During the years of solar activity maximum (1989-1991), the most often occurrence of SAR-arcs, i.e. about 35 per cent from the total observation time (in hours) was observed; the same detection rate of SAR-arcs also continues during the solar activity decrease phase 1992-1993. During minimum of solar activity in 1994-1998 the mean registration rate of subauroral red arcs is 15 per cent.

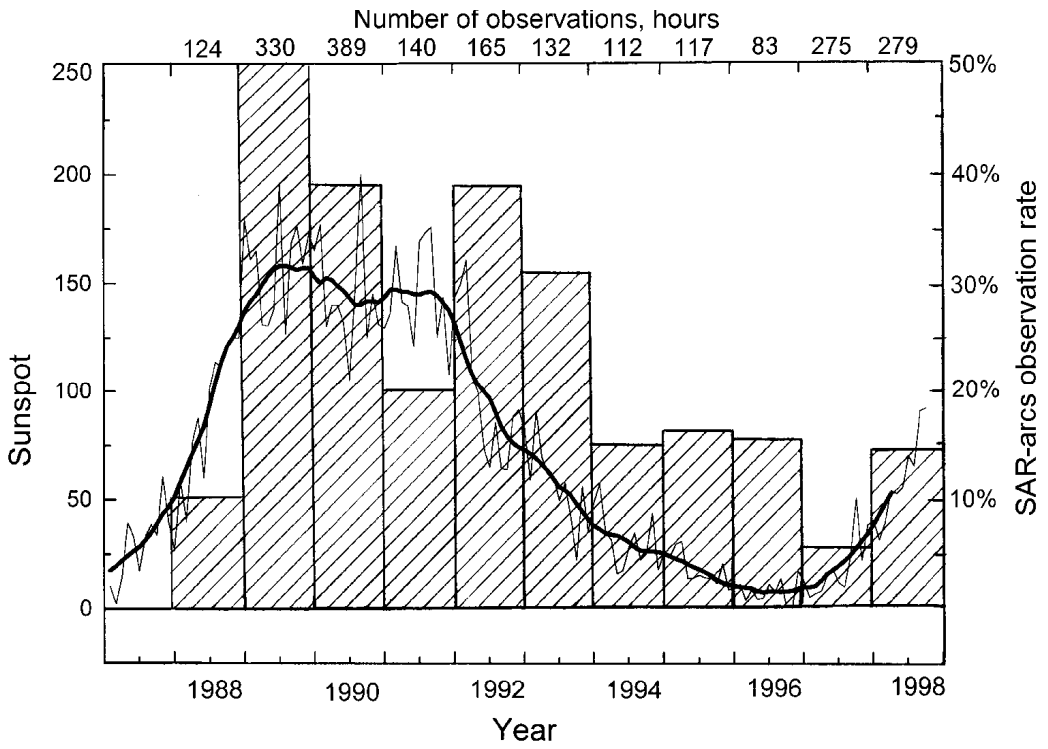

Fig.1. Histogram of observation rates of SAR-arcs during the period of 1988–1998. Also depicted are the smoothed monthly mean sunspot numbers, that indicate the solar activity level. The total number of photometric observations are shown on top for every year in hours.

In [5], the count of the red arc occurrence rate for the period of 1968-1978 was carried out. The most often occurrence of SAR-arcs in the 20th solar activity cycle at the decrease phase of solar activity 2-3 years after the maximum was, on the average, 17 per cent and at the minimum - about 8 per cent.

Considering that the period of night observations in 1968-1978 at the Richland observatory also covers autumn-summer period, where the least observation rate is registered and observations in Maimaga were carried out only in winter-spring period in December-March, when the elevated occurrence rate of SAR-arc is marked, probably, this fact explains the observed higher rate of SAR-arc occurrence approximately by a factor of 2 during the 22nd solar cycle at the Yakutsk meridian in relatively equal cases of 88 red arcs in [3] and 114 ones in 1988-1998 during photometric observations in Maimaga.

It should be mentioned that during the 22nd solar activity cycle the highest occurrence rate of SAR-arcs was observed at the maximum and decay phase without 2-3 years delay relatively to the maximum in 19 and 20 cycles.

In [5], it is shown that the maximum of occurrence rate is 2-3 year delay relative to the solar activity maximum in the 20th cycle. The same delay was for geomagnetic activity in this cycle [6].

By data of the Yakutsk magnetic station, the geomagnetic activity for 1988-1998 by a number of K-indices coincides with solar activity. Therefore, the SAR-arc occurrence rate by observation in Yakutia during the 22nd solar activity cycle corresponds to the geomagnetic activity.

Conclusion

The analysis of photometric observation data at the Yakutsk meridian during the 1988-1998 showed that stable subauroral red arcs were registered every year during the maximum as well as in minimum of the solar activity cycle (according to the number of sunspots), the average occurrence rate of SAR-arcs in these years was 27 per cent from the total number of observations. All in all, in spring-winter periods on moonless nights, 114 cases of SAR-arc occurrence of total duration, 570 hours during 251 observation nights were registered. The highest occurrence rate of SAR-arcs is marked in years of maximum and decay phase of solar activity cycle, approximately 35 per cent of total observation number in hours and most rarely in years of minimum (15 per cent).

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