Prospects of aurora-watching success in Poland

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Based on reports from aurora watchers in Poland in the years 2011–2018, we have developed an algorithm which should improve the quality of aurora alerts. This algorithm evaluates prospects of aurora-watching success on the basis of current values of the following parameters: planetary index, K_{p}, magnetic latitude of the observer, phase of the Moon, and number of hours after the end of nautical twilight (nautical dusk is the moment of the end of nautical twilight). Critical values of these parameters were estimated empirically using the available aurora reports.

1 Motivation

Aurorae are relatively rare phenomena in Poland. They are usually seen only above the northern horizon, which explains an alternative name, *northern lights*. Their brightness is rather faint, therefore the chance of observing an aurora depends on additional factors such as perfect weather conditions, a lack of moonlight or artificial lighting. Therefore, it is very important not to lose any opportunity to observe these phenomena.

Electronic communication media (TV, radio and the Internet) eagerly publicize information concerning alerts of geomagnetic storms, simultaneously announcing the chance of aurora-watching success. However, predictions of the strength of geomagnetic storms as well as their detailed timetable are still unsatisfactory. Moreover, aurora-watching success in mid-latitudes does not depend only on geomagnetic storm occurrence. A lack of practical knowledge concerning observing conditions needed for success can confuse and even frustrate aurora enthusiasts, leading to disregard of similar communications in the future.

In our work we attempted to specify all factors responsible for aurora visibility and to estimate their influence on aurora-watching success.

2 Survey of aurora observations

We collected reports of aurora observations in Poland in the years 2011–2018. A significant part of the reports originated from the *Polski Astrobloger* blog[1]. Altogether we found 48 aurora nights with observations from 164 locations (Figure 1). According to these reports, a strong correlation with the planetary index K_{p}, a geomagnetic parameter introduced by Julius Bartels (Bartels et al., 1939), can be seen. All observed aurorae occurred during geomagnetic storms or strong substorms. The higher values of K_{p} were connected with a higher equatorward shift in the magnetic

[1] `http://www.polskiastrobloger.pl/`

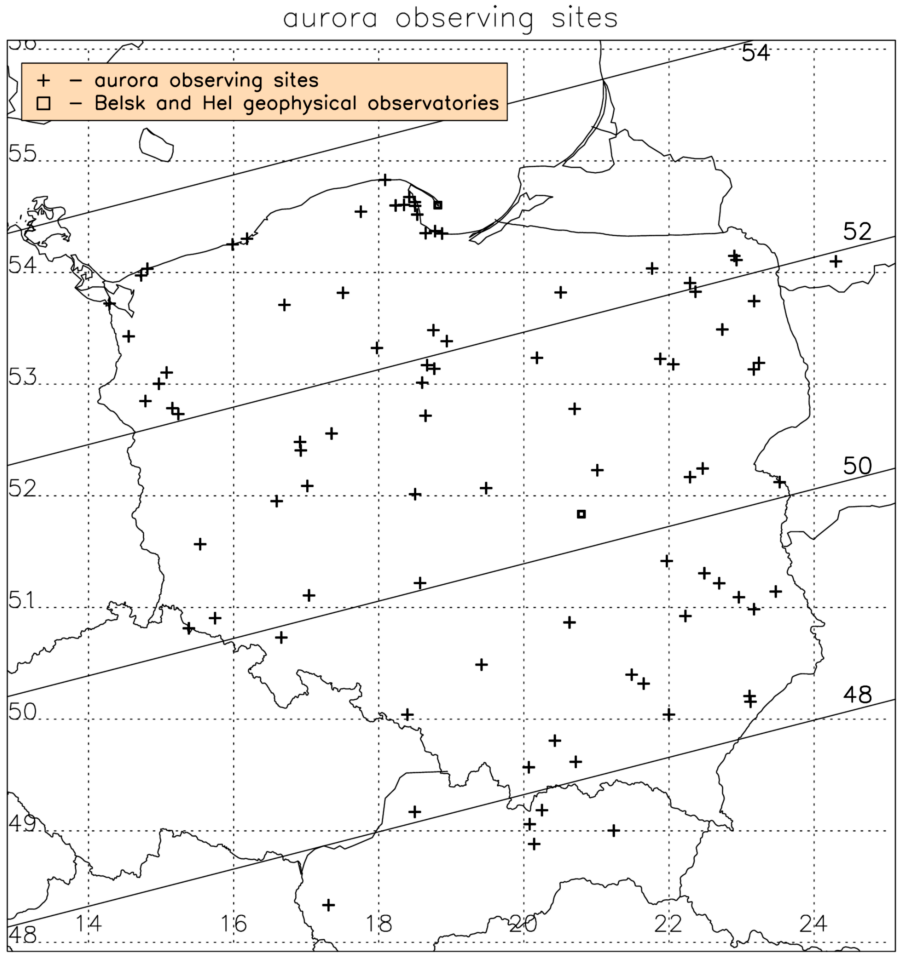

Fig. 1: Locations, from which aurorae were watched and reported in the years 2011–2018. The grid of geographical coordinates (dashed lines) and four magnetic latitudes (straight lines) are plotted.

latitude of locations from which the aurora was observed. Particulary, there were no reports of the aurora being watched below $\theta = 51°$ for $K_\mathrm{p} \leq 5$o. Moreover, the higher value of K_p was associated with a higher number of locations from which the aurora was watched, on average.

We estimated that the majority of events were seen from locations with magnetic latitudes between 2°–8° southward of the boundary of the Feldstein-Starkov aurora oval (Sigernes et al., 2011) and that they occurred 80–400 km above the Earth's surface.

3 Analysis and conclusion

Our purpose was to use the survey of aurora observations to establish a set of detailed conditions specifying the visibility of aurorae in Poland. We noticed that, on every night during which an aurora was observed, the maximal value of the planetary index K_p reached at least level 4+. However, during the years 2011–2018, we found as many as 337 nights with $K_\mathrm{p}\geq$4+, i.e. almost 7 times more than the number of reported aurora nights.

We consider the following factors to explain a lack of aurora reports during a geomagnetic storm night:

1. Brightness of the sky too high to identify the subtle auroral light, due to twilight or when the phase of the Moon was too high.
2. Weather conditions excluded any observations due to heavy overcast.
3. Some episodes with $K_\mathrm{p}\geq$4+ were associated with lower fluctuations of the magnetic field in Poland.
4. Some aurorae could have been overlooked due to low quality of alerts.

In order to verify how these factors limit the success of aurora-watching we carried out the following tasks:

1. Checking the phase of the Moon and elevation of the Sun and the Moon.
2. Verification of cloud cover data originating from MODIS satellite observations.
3. Comparison of values of K_p with local index, K, (Nowożyński et al., 1991) calculated on the basis of records of the two magnetometers localized in Belsk and Hel[2].

According to conditions existing during the aurora nights included in our survey, we defined empirical limits on the factors being considered which could justify a lack of aurora reports despite the occurrence of a geomagnetic storm:

1. Elevation of the Sun higher than -12° or the phase of the Moon higher than 0.3 for $K_\mathrm{p} \leq$ 5o and higher than 0.7 for $K_p \leq$ 6o.
2. High cloud cover in the majority of locations from which aurorae were routinely watched.
3. Values of local index K equal to 4 or below for both Polish geophysical observatories.

In summary, 78–84% of storm nights without any aurora reports can be explained by any of the considered factors, thus 16–22% of events were probably overlooked.

The empirical limits of the factors being considered allowed us to develop an algorithm with detailed relations between planetary index, magnetic latitude, lunar phase, and number of hours after the end of nautical twilight in the context of aurora visibility. We hope that our algorithm allows aurora hunters to more efficiently

[2] `https://pub.igf.edu.pl/`

use the predictions of the planetary index announcing a geomagnetic storm. Particularly it will limit confusion due to a lack of aurora-watching success despite the occurrence of a geomagnetic storm. Basing on these rules, an application alerting to the possibility of an aurora will be developed.

Detailed description of our algorithm will be soon submitted to the *Journal of Space Weather and Space Climate*.

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Participants of the XXXIX Congress of the Polish Astronomical Society. Photo by J. Pająk.