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Original paper

On the frequency of auroras over Germany

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Resumen

Se muestra una recopilación de 171 observaciones de auroras alemanas entre 1946 y 1964, las cuales no se habían publicado previamente. Los datos se analizaron en relación con el índice Kp, el número de manchas solares y las variaciones estacionales. También se incluye una lista completa de dichas observaciones.

Palabras clave: aurora, latitudes medias, actividad geomagnética.

Abstract

A compilation of 171 German auroral observations between 1946 and 1964, not published previously, is presented. The data are analysed with respect to the Kp-index, sunspot numbers and seasonal variation. Also we include the full list of such observations.

Key words: aurora, mid-latitudes, geomagnetic activity.

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Introduction

For readers it may be useful to have more data on the occurrence of auroras in middle latitudes. An example are the German observations between the years 1949 and 1964 which will be discussed in the present work.

The study of Auroras was among the most important research areas during the International Geophysical Year (IGY, 1957-58) and the subsequent International Geophysical Co-operation (IGC, 1959). Special efforts were made to observe auroras at mid- and low latitudes. Reports have been published on these observations (Gartlein and Sprague 1960, Lang-Hesse 1961, 1963, Lassen *et al*., 1963). These reports, however, contain only a selection of observations and comprehensive catalogues like those by Fritz (1873) and Boller (1898) do not exist for these periods.

It was suggested (Chapman, 1957, Paton, 1957) that during the IGY, older observations should also be analysed. This suggestion has led to the present compilation from German observations.

Observations

In Table 1 we present 171 auroral observations carried out in Germany, between 1946 and 1964, the observations before 1957 are taken from different newspapers and journals (e. g. from Zeitschrift für Meteorologie). Detailed reports are only available in very few cases and often only the fact of the observation of an aurora is noted. Although such observations are useful, the observations are more valuable if detailed descriptions are also given (as for example for the aurora on 25/01/49 in Table 1). These limitations mean that detailed studies of auroras in Germany are possible only after 1957. For the IGY-IGC period detailed descriptions are available which are based on the international procedures (Chapman and Bartels, 1940).

In spite of these limitations, some conclusions can be reached concerning the appearance of auroras over Germany.

Connection with the Kp-index

The connection between the appearance of auroras and geomagnetic activity (represented in the present report by the Kp-index), is well known (e.g Newell *et al*., 2009). There is an experimentally confirmed relation in the sense that in the case of a higher Kp-index, auroras can be observed at more southern regions.

As has been shown previously (Schröder 1964), auroras are much more likely to be observed when Kp=5. In fact, from 161 auroral observations, 131 (~81%) were observed at Kp=5 and 30 at Kp = 4 (~19%). These reports also show that auroras occur in Germany much more frequently than previously supposed.

This result, deduced from visual observations, can be compared with radar observations. It is found that at low Kp-values (0 - 3) no backscatter is observed. The frequency of the latter increases with increasing Kp, but in southern Germany backscatter is observed only at Kp = 6 (Lange-Hesse, 1963). Another series of observations shows that auroral echoes seldom appear at Kp = 6, at Kp = 7 they appear in 60% of cases, at Kp = 8 in 80% of the cases and at Kp = 9 in all possible cases (Lange-Hesse, 1963; Tsurutani, 1992). Barbier (1958) reported that auroras were repeatedly observed in France at Kp = 4. A noteworthy case is the aurora on October 20, 1957 (Kp = 4_0) (Barbier, 1959; Lange-Hess, 1961). Reports on auroras observed in England, even in southern England are found in Paton (1961, 1962).

The correctness of these observations is confirmed by the fact that many such auroras were observed several times and independently from one another. The explanation can be based on the outer ion belt which reacts sensitively to solar disturbances. As even very small disturbances lead to instabilities, a connection with certain auroras seems to be possible (Paton, 1965).

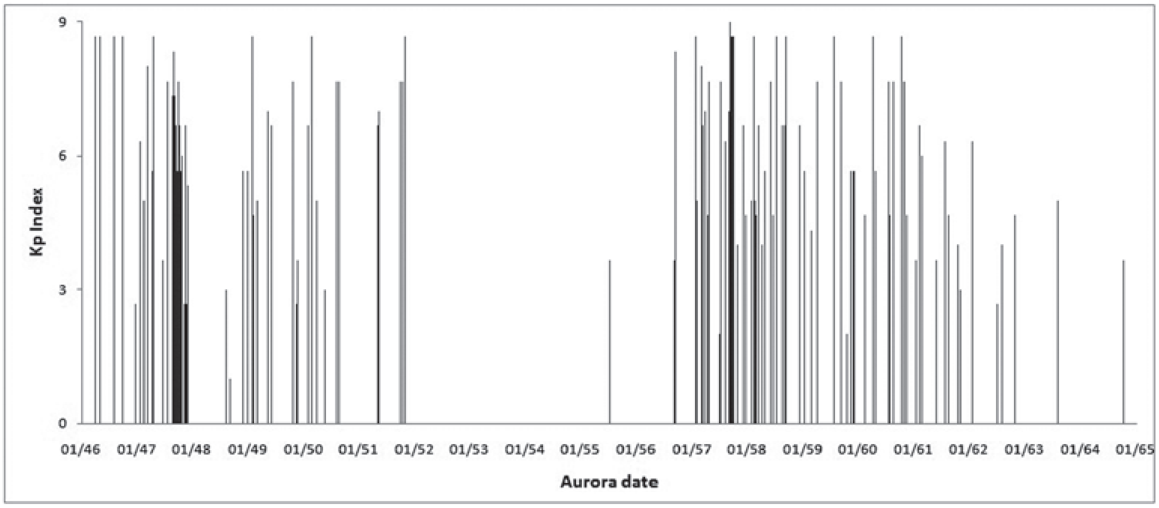
From Figure 1 and Table 1, our data indicates that from 171 observations, for Kp < 5 we detected 23 (~13%) auroras, in agreement with reports that at mid-latitudes (55-50 N°) auroras can sometimes be observed at low Kp-values. In particular, remarkable observations of auroras at very low Kp-values are as follows: 26/08/48 (Kp = 1) and 25/09/46, 29/06/57 and 10/10/59 (Kp = 2). On the other hand, extremely *active* auroras were also observed with Kp = 9, some examples are: 17/04/47, 20/02/50, 28/10/51, 21/01/57, 13/09/57, 29/09/57, 11/02/58, 08/07/58 and 15/07/59.

Seasonal distribution

The seasonal distribution of auroras is well known from observations at higher latitudes. This seasonal distribution is also present in the data of the years 1956 - 1960 (Schröder 1964; 1965a; 1965b). From the present material taken over a longer period of observation, Table 2 confirms maximum occurrence in the equinoxes:

Table 1. Observations of 171 auroras. The dates indicated the night of the observation. The format is day/month/year. The corresponding Kp refers to 0000-2400 UT.

Date	Kp	Date	Kp	Date	Kp
23/03/46	6+	15/09/47	6-ssc	03/05/49	7_0ssc
25/03/46	9-	16/09/47	5_0	30/05/49	7-ssc
28/03/46	9-	17/09/47	6-	14/10/49	8-ssc
23/04/46	9-	18/09/47	5+	15/10/49	8-ssc
26/07/46	9-	22/09/47	5-	14/11/49	3-
22/09/46	9-	23/09/47	6-ssc	15/11/49	3-
23/09/46	8-	24/09/47	7+	19/11/49	4-
25/09/46	2-	25/09/47	8-ssc	24/01/50	7-ssc
18/12/46	3-	26/09/47	4_0	20/02/50	9-ssc
16/01/47	6+ssc	27/09/47	4-	21/03/50	5_0
08/02/47	5_0	02/10/47	7-ssc	19/05/50	3_0
03/03/47	8+	07/10/47	5-	20/05/50	3-ssc
09/04/47	6-	11/10/47	6-	07/08/50	8-ssc
17/04/47	9-ssc	19/10/47	6+	18/08/50	5-ssc
15/06/47	4-	31/10/47	3-	19/08/50	8-
17/07/47	8-ssc	07/11/47	3-	20/08/50	8-
15/08/47	7+ssc	09/11/47	7-ssc	01/05/51	7-
16/08/47	7+	10/11/47	7-	02/05/51	7+
19/08/47	6+	12/11/47	5+	25/09/51	8-
20/08/47	6-	22/11/47	3-	07/10/51	8-
22/08/47	8+ssc	24/11/47	5+ssc	28/10/51	9-ssc
23/08/47	7_0	05/08/48	3+	07/07/55	3+
25/08/47	5+	26/08/48	1+	08/07/55	4-
29/08/47	4-	20/11/48	6- ssc	04/09/56	4-
03/09/47	7+ssc	25/12/48	6-ssc	08/09/56	8+ssc
07/09/47	7-	24/01/49	7+ssc	21/01/57	9- ssc
11/09/47	5ssc	25/01/49	9-	29/01/57	5_0ssc
12/09/47	4-	03/02/49	5-ssc	01/03/57	5-ssc
13/09/47	6-	21/02/49	5_0ssc	02/03/57	8+
04/03/57	-4	17/02/58	5-	02/11/59	6-
10/03/57	7-ssc	18/02/58	5_0	23/11/59	6-
21/03/57	-5	20/02/58	5-	30/11/59	6-
27/03/57	7_0ssc	11/03/58	5-	06/02/60	5-
09/04/57	-5	12/03/58	7-	31/03/60	8-
17/04/57	8-ssc	13/03/58	6-	01/04/60	9-
29/06/57	2	07/04/58	4_0	17/04/60	6-
30/06/57	8- ssc	16/04/58	5-	15/07/60	8-
03/08/57	6+ssc	17/04/58	6-	20/07/60	5-
29/08/57	7-ssc	18/04/58	5+	16/08/60	8-ssc
31/08/57	7_0ssc	31/05/58	8-ssc	06/10/60	9-
02/09/57	8-ssc	14/06/58	5-ssc	25/10/60	8-
03/09/57	-9	07/07/58	4-	11/11/60	5-
04/09/57	9_0ssc	08/07/58	9-ssc	08/01/61	4-
05/09/57	-9	17/08/58	7-ssc	04/02/61	7-ssc
13/09/57	9-ssc	18/08/58	5-	17/02/61	6_0
22/09/57	8+ssc	03/09/58	7-ssc	26/05/61	4-
23/09/57	-9	04/09/58	9-	17/07/61	6+ssc
29/09/57	9-ssc	05/09/58	8-	11/08/61	5-
30/09/57	-6	04/12/58	7-ssc	11/10/61	4_0
20/10/57	4_0	05/01/59	6-	28/10/61	3_0ssc
26/11/57	7-ssc	22/02/59	4+ssc	10/01/62	6+ssc
28/11/57	5_0	27/03/59	8-	29/06/62	3-
30/11/57	-3	28/03/59	7+	28/07/62	4+
12/12/57	-5	15/07/59	9-ssc	24/10/62	5-
20/01/58	5	03/09/59	8-ssc	29/07/63	3-
10/02/58	-5	04/09/59	7+	30/07/63	5_0
11/02/58	9-ssc	10/10/59	2+	03/10/64	4-ssc



March (17 auroras) and September (35 auroras), and minimum during solstices: December (4 auroras) and June (5 auroras). The July maximum obtained from the 1957 - 1960 data (Schröder, 1964; 1965a; 1965b) is not confirmed here in the longer series.

The equinoctial maxima are also present in the radar observations in Germany. Such data have been discussed for the period January 1957 to February 1962 (Lange-Hesse, 1963).

An apparent shift in the months of maximum occurrence should be mentioned here. Maximum occurrence frequencies were observed with the radar in the months of April and October whereas the maxima of visual observations, occurred in the months of March and September. A comparison is possible as in both cases (Figure 2 and Figure 10 of Lange-Hesse, 1963) data are presented without reference to hours of the day. The difference remains even when only visual observations for the years 1956 - 1960 are used for a more rigorous comparison (see Figure 2 of Schröder, 1964).

Earlier observations in Denmark and Norway (Harang, 1940) showed maxima in the months of March and October (see Figure 10 of Harang, 1940).

The maximum in September appears also in the Danish observations of the years 1957 - 1960 (latitude 58°N) (see Figure 1 of Lassen *et al*., 1963). It is interesting to note in this Danish data that about 40% of nights with red auroras also occurred in September in the period 1957 - 1960 (see Figure 12 of Lassen *et al*., 1963).

Finally it should be stressed that the German observations are subjective estimations of the observers, and due to cloudy nights etc., less comprehensive than others. These deficiencies, however, cannot be eliminated in individual cases from the visual observations.

Connection with sunspot numbers

The difficulties of the analysis of the present material are appreciated. They stem from the short data series, the inhomogeneity of the data as well as from factors which cannot be eliminated in the usual way (e. g. method of reporting, estimation etc.). It is, however, still interesting to compare these data with the traditional knowledge of the phenomenon.

In the period of observations, maximum (RM) and minimum (Rm) solar activity occurred in the following years: RM: 1947 and 1957, Rm: 1954 and 1964.

Figure 2 and Table 2 show that maximum numbers of auroras were observed around the maximum sunspot number years: 1947 and 1957-58. Minimum numbers of auroras were observed around the years of minimum sunspot numbers: 1952-54 and 1963-64; moreover, these events were mostly faint and short-lived. Thus, even in case of low solar activity, auroras may appear, but their occurrence frequency is very low.

Table 2. Monthly distribution of auroral observations.

	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	TOTAL
1946			3	1			1		3			1	9
1947	1	1	1	2		1	1	8	15	5	6		41
1948								2			1	1	4
1949	2	2			2					2	3		11
1950	1	1	1		2			4					9
1951					2				1	2			5
1952													0
1953													0
1954													0
1955							2						2
1956									2				2
1957	2		6	2		2		3	9	1	3	1	29
1958	1	5	3	4	1	1	2	2	3			1	23
1959	1	1	2				1		2	1	3		11
1960		1	1	2			2	1		2	1		10
1961	1	2			1		1	1		2			8
1962	1					1	1			1			4
1963							2						2
1964										1			1
TOTAL	10	13	17	11	8	5	13	21	35	17	17	4	171

Conclusions

Here we present a previously unpublished historical observations of 171 auroras in Germany. We confirm that: Most auroras appear for Kp > 5, although some auroras are observed also with low Kp indices of 1 and 2. Maximum auroral occurrence is during the equinoxes and minimum during the solstices. Finally, maximum auroral occurrence is around the sunspot maximum and minimum around sunspot minimum.

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