

RC4: "The description of data recovery needs more details. What is the ultimate source of information on the number of those (about 400) photographs that are not found? Maybe some observatory or personal notebooks of E. Sucksdorff (ES)."

Reply: The main sources of information about the history of auroral images taken at SGO are hand-written notebooks of Eyvind Sucksdorff for 1927–1929. There are described relevant data for each photograph (date, exposure time, orientation of camera etc.). In Appendix A there is a table showing the dates of rescued auroral photos as well as the lost ones (see below) based on Sucksdorff's notebooks.

RC4: "These source documents should all be described, scanned and made publicly available in digital format. Even better if they were read to digital tables. Now nothing of such possible development is mentioned. Similarly, the photographs should be scanned and stored in a public digital archive."

Reply: The original source information is stored in tables and auroral images available have been digitized. They are in the digital archive of the SGO. However, for the moment our policy of releasing the auroral data is restricted to individual requests only which should address to the SGO (eija.tanskanen@sgo.fi).

RC4: " How does the image timing go? Judging from the temporal time evolution of auroral forms and intensity depicted in the 6 images, a likely order is clockwise from top left to end at middle left."

Reply: The image order in the plate of six single photographs was clockwise.

RC4: "As described in the manuscript, there was a vigorous photography program in Norway, which led to the improved determination of auroral height. In this situation, I was left wondering why at all Norwegians wanted to install a station in SGO? Historical order of events is missing. "

Reply: There was a plan promoted by the scientific community in Norway that the auroral photography network will be expanded outside Norway for the coming Polar Year 1932–1933. Stations in Greenland, North-Norway (Tromsø) and on Bear Island in the Arctic Sea were set up. The SGO observatory was located far away in the east from the sites of the Norwegian auroral program and could allow a more wide observation view for the auroral photography during the Polar Year.

Eyvind Sucksdorff visited Störmer's auroral laboratory in 1938 and discussed there about auroral research but no common writings exist.

RC4: "Have SGO photographic films been saved and archived in Norway?"

Reply: According to Sucksdorff's notebooks there are comments that images from Sodankylä and from the auxiliary station were sent to Oslo for further analysis. I have been in contact to Oslo University and asked if they have auroral images from the SGO but without results.

RC4: "Visual auroral observations by ES from 1932 to 1944 are said to be archived at SGO. What does it practically mean? "

All observations with related information (observer, time, location, coding, weather info etc.) must be made publicly available with related URLs included. Similarly for the "routine" observations from 1914 until 1954. What about the auroral observations by the Danes? Are these included in the same dataset?"

Reply: Results of visual auroral observations 1932–1944 carried out at the SGO and several sites in Lapland are in hand-written notebooks only. We have plans to transcribe the results in form of tables and make summaries of the observations. There are about 10 rather unorganized notebooks available including the visual observations carried out by the Danish team.

RC4: " Line 29. Contribution by ES was pioneering probably only in Finland."

Reply: This is rewritten: In Finland, Eyvind Sucksdorff's contribution to research of auroras was a pioneering effort with minimal resources.

RC4: " Lines 83 and 89. Is frame = photograph? If yes, ignore "frame". Does 600 photographs mean 100 plates?

Reply: Yes, "frame" is changed to "photograph". Yes, c. 600 photographs mean c. 100 plates.

RC4: " Line 94. 200 photographs means about 35 paper sheets? How many exactly?

Reply: The paper copies of single photographs are larger than the originals in a plate. The size of a single paper photograph is about 4 x 4 cm. Each paper sheet consists of 10 single photographs. The number of sheets is 20.

RC4: " Statement (see lines 149-151) "The second greatest magnetic storm during this cycle, as recorded by magnetometers at Sodankylä." "The second greatest magnetic disturbance." would be a possible statement once authors define exactly, how the intensity estimate was made, perhaps based on the local K index? "

Reply: The lines 149-151 are rewritten as follows: The February 27, 1929 magnetic storm observed at the SGO and other magnetic stations at high latitudes was one of the major magnetic storms during the solar cycle 16 (1923–1933) (e.g., Goldie, 1929; Rowland, 1929).

RC4: " Also, additional evidence on storm evolution is needed to verify if the disturbance of the previous night was part of the same storms. Surely it was not "a minor storm".

Reply: Corrected: The February 27, 1929 magnetic storm at the SGO started already in the evening hours of February 26 and ended near midday of 28th (Fig. 5).

RC4: " Fig. 6 caption would read more clearly as follows: "The two top pictures show auroral lights reflected from the frozen river Kitinen. The black belt under the auroral lights, which is the tree line on the other side of the river, is seen in all pictures, most clearly in the top row." This is the setting in all 6 photographs. The exact start and end times (hh:min:sec) of each photograph should be added to the left or right of each

panel so that a rough estimate of auroral intensity and temporal order could be obtained. If these images were obtained at 30s intervals, the total time is at most 3.5 min, not 5 min as in text. "

Reply. The caption is rewritten as follows:

Figure 6. Auroral displays on February 27, 1929 as captured by a camera at the Sodankylä observatory. Each frame on the photographic plate represents auroras in intervals of about 30 seconds at about 20 h (UT) to the west. The exposure time varies between 1 to 30 seconds. The first photograph is on the top left.

The two top pictures show auroral lights reflected from the frozen river Kitinen. The black belt under the auroral lights, which is the tree line on the other side of the river, is seen in all pictures, most clearly in the top row. Next four pictures show rapidly changing auroral forms, veils and spirals. Two bright spots are planets Jupiter (upper) and Venus (lower) in the west and about 15° from the horizon. (Photo: E. Sucksdorff's collection SGO).

The total time (about 5 min) is corrected: about 3.5 minutes.

RC4: " The exact start and end times (hh:min:sec) of each photograph should be added to the left or right of each panel so that a rough estimate of auroral intensity and temporal order could be obtained. "

Reply: They will be given later. There are some problems with Sucksdorff's time writings during the storm.

RC4: " Figure 8. While the number of auroral nights gives some information about the occurrence of auroras, the more correct way is to present the fraction of the nights with auroras to the number of all nights that were "available" for auroras to be observed. So, in addition to the figure of absolute numbers, authors should present these fractions. Otherwise, the study is rather futile. As seen in the figure, there are times when auroral occurrence and magnetic activity are very different, even differently located over the cycle. Also, the multi-decadal rise is dubiously large in auroras. These differences are, very likely, due to the variable weather conditions, which would be corrected by the above fractions."

Reply: We have added new data to the auroral data shown in Fig. 8 (see below) The data is taken from the compilation of visual auroral data by Legrand and Simon (1987). The data collection comprises of several thousands auroral records from sub-auroral latitudes in the northern hemisphere from the years 1780–1979. This data series correlates reasonable well with the time variation of auroras obtained from the SGO during 1914–1954. However, there are certain anomalies in the SGO curve when magnetic activity and auroral occurrence are quite different due probably varying weather and cloudy conditions. The original conclusion that there has been an increasing trend in the occurrence of aurora 1914-1954 at SGO is still valid.

[Legrand, J.-P. and Simon, P.A., 1987. Two hundred years of auroral activity (1780–1979). *Annales Geophysicae*, 5, 161–167].

There is a picture attached in the end of the reply sheet showing the correlation between global *aa*-index and auroral occurrence number derived by Legrand & Simon. The linear correlation for the years 1914–1954 is +0.79.

RC4: "Mention in text and in caption what is the magnetic activity index used here."

Reply: The magnetic activity index is the annual mean of daily Ak number taken from the magnetic yearbooks of the SGO.

RC4 line 205. "Line 205. Mention which observatories."

Reply: The two temporary observatories during the Polar Year 1932-1933 were Petsamo (69.5°N; 31.2°E) near the coast of the Arctic Sea, now in the territory of Russia, and Kajaani in East-Finland (64.2°N; 27.7°E).

RC4: " Line 241-242. This is an odd sentence. Auroral occurrence studies are also part of auroral studies."

Reply: This sentence is now: ~~Independent from auroral studies~~, Visual observations of the occurrence of auroras were made in connection with daily meteorological observations at the Sodankylä observatory since the founding of the observatory in 1914.

RC4: " Line 156. Ref to Fig. 5 must be earlier in text.

Reply: Corrected

RC4: " Line 254. It is multi-decadal, not decadal."

Reply. Ok. Corrected.

RC4: " Line 272. Write: auroras obtained almost one hundred years ago are the first ones in Finland."

Reply: Ok. Corrected

RC4: " References are relevant except for all the three papers by Tanskanen. Neither Tanskanen et al., 2005, nor Tanskanen, 2009, deals with auroral observations. "

Reply: Tanskanen et al. (2005) and Tanskanen (2009) found that the largest substorm numbers and peak amplitudes were found during the declining solar cycle phases. Their analysis was derived using magnetic data from the solar cycle 1993–2003. This similar to conclusion here that auroral occurrence rate is generally enhanced during the declining phase of a solar cycle.

RC4: " Tanskanen, 2022, is not even a scientific paper. "

Reply: Ok. This reference is deleted.

RC4: " The centennial increase in geomagnetic activity was found by Mayaud in 1972".

Reply: Yes. The reference Mayad (1972) is added in the reference list.

Mayaud, P.N.: The *aa* Indices: A 100-Year series characterizing the magnetic activity. *Journal of Geophysical Research*, 77, 6870–6874, <https://doi.org/10.1029/JA077i034p06870>, 1972.

Appendix A

Table 1a. Dates¹ of available auroral photographs at the SGO 1927–1929

Date	Number of single photos
1927	
Nov 18	24
Nov 19	6
Dec 13	33
Dec 14	3
Dec 18	6
Dec 28	42
1928	
Jan 27	46
Mar 11	18
Mar 13	30
1929	
Feb 27	18
Total	226

Table 1b. Dates¹ of photographs lost in the war 1944

Date	Number of single photos
1928	
Dec 6	9
1929	
Jan 29	18
Feb 17	11
Feb 27	147
Mar 7	12
Mar 8	40
Mar 11	42
Mar 14	78
Mar 27	27
Total	384

¹ The data is based on original hand-written notebooks by E. Sucksdorff