

Original scientific paper
UDC 551.594.5

The auroral events observed from Croatia and a part of surrounding countries

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Received 19 January 1998, in final form 26 May 1998

Descriptions of 37 auroral (or polar light) events were analysed that were published mostly since the middle of the 18th century up to present days and observed within latitudes from 42 to 45.5 °N and longitudes 13 to 19 °E (mainly on the territory of Republic of Croatia). The list of auroral events includes date, place and source of information and, for the most cases, visually observed parameters such as: colour, shape, distribution on the sky and time duration of the phenomenon. Basic statistical results allowed the conclusions about the most frequent occurrence of a particular parameter. The auroral events correlate highly with the solar activity and in mentioned latitudes they correlate also with the secular period of sunspots.

Keywords: aurora, auroral calendar, aurora and sunspots, polar light events.

1. Introduction

*The aurora** is a rare phenomenon in the whole of Central Europe, and therefore also over the territory within the latitudes 42–45.5 °N and longitudes 13–19 °E, covering most of Croatia, Slovenia and Bosnia and Herzegovina. Over this territory more than 30 auroral events were recorded in the last 250 years. Altogether 37 events were observed in 23 years concentrated around the solar activity maxima. The most recent aurora over Croatia has been observed during the last solar activity maximum i.e. twice in 1991 (on the 1 November and during the evening and night on 8/9 November). These days were cloudless and with mild temperatures. People were surprised seeing the red coloured sky over the northern horizon, which lasted for several hours, from evening over the midnight and in the morning hours of the next day, as reported by many observers. The war started in Croatia in 1991, and

* or *the polar light*, a term used in Croatian more frequently.

the red coloured skies above the northern horizon gave an impression of the big war fire over a large area, situated north from the observer. Because of the war activity it was hard to calm the panics down and to explain that it is just a natural phenomenon which can be rarely seen over the Croatian latitudes, approximately once or twice during someone's lifetime.

2. Historical review

The longest and the most numerous data on auroral events, collected until now, originate from visual observations. This is valid for the entire global data as well, regardless of the auroral probability. The oldest and the most complete auroral data come primarily from the populated polar regions of the Northern hemisphere. The Scandinavian countries gave, and are still giving, the largest contribution to the auroral (visual) data collection and research. Starting from the beginning of the 18th century their data were correlated to magnetic field disturbances, thanks to Swedish professor of mathematics, A. Celsius (1701–1744).

The paper aims to cover auroral phenomena observed primarily in Croatia, and partly in neighbouring countries for which the data were found (Slovenia, Bosnia and Herzegovina, Montenegro).

The first Croatian who wrote about the phenomenon (to the best of our knowledge) was the Jesuit Rudjer Bošković (Dubrovnik 1711–Milan 1787), a universal scientist. Besides the two well-known papers of his related to the aurora, (Bošković referred to them as debates or discussions*), Bošković made his comments about aurora, sometime in verses** also in some of his other publications. The one published in 1738 in Rome, having 12 pages and 8 sketches, written in Latin, has been inspired by polar light event probably seen by him twice in Italy (19 October 1726 and 16 December 1737)***. Bošković tried to estimate the height of the polar light, and used at the con-

* »De Aurora Boreali, Dissertatio habita in Seminario Romano ab Augustino Fanucci Academico redivivo, Jo. Bapt. Amalfitano Equite Hier. Ac. Rediv. ...«, 12 pages, 8 figures, in Latin, published twice (August 1738 printed by Komarek and again September 1738 by Antonio de Rubeis); »Dialogi sull Aurora Boreala«, del P. Ruggiero Giuseppe Boscovich, della compagnia di Jesu, Giornale de Letterati, 47 pp, in Italian, MDCCLVII (1757).

** Caroli Noceti e Societate Jesu »De Iride et Aurora boreali Carmina ...« Cum Notis Josephi Rogerii Boscovich ex eadem Societate, Romae, ex Typographia Palladis, excudebant Nicolas et Marcus Palarini, MDCCXLVII (1747), in Latin; Philosophiae recentiora a Benedicto Stay in Rom. archigymn. publ. Eloquentiae Profess., versibus traditae libri X ad Sylvium Valentium Cardinalem amplissimum, cum adnotationibus, et supplementis P. Rogerii Josephi Boscovich S.J. in Collegio Rom. publ. Matheseos profess. Tomus II, MDCCCLX (1760), in Latin.

*** J. Torbar 1887/88, Roger Bošković and his works in astronomy and meteorology, in Croatian, Rad JAZU, Vol. 87/88/90, pages 429–470; Ž. Marković, 1968/69, Rudjer Bošković, Dio I. i II, in Croatian, JAZU, 1144 pp.

temporary mathematical methods to make the altitude estimation based on the data of one observation site only. His result of 600 miles* overestimates the presently most frequently obtained values. He also gave some recommendations for observations and discussed the causes of the phenomenon. He accepted at that time popular Mairan's theory which postulates that the polar light is a consequence of mixing between expanding solar atmosphere and the upper layers of the Earth's atmosphere, which is not very far away from the present scientific view (Fairbridge, 1967; Simmons, 1985).

The earliest known recorded descriptions of two polar light events seen over Croatia, belong to the first half of the 18th century and were discovered by Penzar and Penzar (1997) in the recently printed *Annales* of Franciscan monastery (Anonymous, 1993), situated in Dalmatian city of Makarska. Franciscan Nikola Gojak wrote it in Old-Croatian, as a part of the monastery annals. The records of about 6 other events seen at the end of the 18th century were found in an another Franciscanian monastery, situated in the Slavonian city Osijek, written by the Franciscan Marijan Lanosović in Latin (Penzar and Penzar, 1985). He described in detail the beautifully pronounced polar light seen on January the 18th, 1770, which lasted for two and half hours.

Numerous records about the polar light events that originate from the 19th century were found, most of them in the meteorological and ship diaries, as well as in the individual reports. Such different kinds of diaries and records were the source for regular reports about special events included or added to weather information, which have been usually sent to some regularly published paper or meteorological journal such as *Meteorologische Zeitschrift*, printed in Vienna.

About 20 papers were published in the last 100 years by authors from Croatia with topics related to the polar light. Some were related to a particular event, the others were describing recommendations for observations, or explaining the contemporary knowledge on the polar light (for instance as it was done before IGY 1958/59, *e.g.* Labović, 1958/59; Labović, 1959, or later Dominis, 1962; Lisac, 1996). Some were published as a chapter of a schoolbook, *e.g.* I. Potočnjak (1878). A detailed description of the magnificent polar light event on the 25/26 January 1938 including the presentation of contemporary scientific knowledge was written by J. Goldberg (1938). His description was based on about 50 answers to official questionnaires compiled in the Geophysical Institute in Zagreb and sent all over the country immediately after the event. This especially pronounced polar light was seen all over Europe, as far south as Sicily and Gibraltar. It was seen over Canada too. Goldberg (1938) mentioned that in the last 70 years (meaning approximately

* According to relations in old Italian measures: 1 geographic mile = 1855.11 m

from 1870 to 1938) there were observed and described only 4 more events seen from Croatia, as far as he was informed.

J. Mokrović (1943) made a list of the phenomena seen from Croatia, enriched with some newly found documents. Recently I. Penzar (1978) gave a comprehensive overview including his newly found records for 16 more events since 1770, which makes 22 records altogether for the time interval of 208 years (1770–1978) collected over Croatia and part of the surrounding countries.

3. The auroral or polar light events calendar

Based mostly on the data collected by the cited authors and according to several more original records that were discovered, a table was compiled (Appendix) containing the basic information on the auroral events observed over the considered territory. The table contains data for 37 polar auroral events altogether, seen over the time interval of 254 years (1737–1991).

Aurora borealis is in Croatian language mostly called »*polarna svjetlost*« (meaning the polar light). Another older, but better picked name »*sjeverna zora*« (meaning exactly aurora borealis) also exists. Finally, the expression »*sjeverna svjetlost*« or »*sjeverna luč*« (meaning the northern light) is also, but rarely, used. The most frequently used term 'polar light' is therefore used in the table.

The table contains the following data: date, duration and place of the visual observation, the name of the observer and the source of information. Original or excerpted descriptions of the phenomena include the shape, dynamics and intensity of light, colours and the distribution over the sky. The text is a free translation from Croatian or German.

This is the first tabular presentation of the main auroral parameters, visually observed over Croatia and its closer surroundings. The table enables comparison of the data with similar data from other regions, in order to derive conclusions about patterns of the phenomenon in regions atypical for the regular auroras. In other words, the data may help determine the boundaries of auroral appearance.

4. Conclusions

The characteristics of the polar light events over Croatia, derived from the data listed in the Appendix are the following:

- There are three weakly expressed time intervals in a year which seem favourable for the polar light event: the end of spring (26% of events), in fall (35% of events) and in the second part of winter (39% of the events); the time intervals include the spring and fall equinoctia.
- During a day the polar light could begin shortly after a sunset, or any time after it, until early hours after midnight, and could last from about

10 minutes up to several hours, lasting from the evening until the morning of the next day.

- The illuminated area is mostly diffuse or arc shaped, rarely drapery- or fan-shaped, very rare as observed as corona (seen only once); illuminated area in a form of triangle and the bands, homogeneous or ray structured, and differently oriented but spreading mostly perpendicular to the horizon, is superimposed on the diffuse backlight area.
- In the majority of cases all shades of red and grades of glow and light intensity prevail, seen close to the horizon or spreading over the sky over its north-western or northern quadrant. Rarely, green and yellowish colours were observed.
- The well known fact is that the shades of red in the polar light emissions may be caused by excited monatomic oxygen (at the altitude from 200 km extending up to many hundreds of km), and by the excited molecular nitrogen (altitudes around 80 km). The auroral redness prevailing on the higher altitudes could be observed from the more distant regions (mid-latitudes) as in the cases of extended auroral zone during the high solar activity. The polar light data from Appendix were collected exactly from such mid-latitude regions and therefore the most frequently observed polar light colour was redness.
- The result on the polar light altitude (seen from Italy in 1726) as obtained by Rudjer Bošković should be taken with caution, and it is likely to be overestimated.

According to the description of the light intensity, there were very pronounced events in 1770, 1870 and 1938. According to the beauty and details in descriptions of a particular event the attention should be paid especially to descriptions written by M. Lanosović (1770 – cited in Bösendorfer, 1910), J. Torbar (1871), G. Bušić (1870, 1872), V. Rivoseki (cited in Goldberg, 1938), F. Margetić (1951) and V. Martinolić (1992).

The polar light is a rare event in Croatia occurring only a few times in several decades. Fig. 1 presents the sun-spot number together with markers for the years in which the polar light was observed (each solid dot indicates one event in a year). Most of the events are grouped close to the Sun's activity maxima, and only few were observed in between two maxima (*e.g.* in 1921).

The time curve in Fig. 1 points to a dependence of the phenomena on selected solar activity cycles which are grouped into three consecutive maxima. It seems that there exist favourable and unfavourable solar activity intervals with the regard to potential of auroral occurrence. The groups of three consecutive maxima when auroras occur over our latitudes, repeat in the secular period of sunspot maxima of 80 years (Gleissberg's cycle): 1790, 1870, 1950 (Fairbridge, 1967).

If one counts the number of solar activity cycles since the Maunder's minimum (ended around 1710), there were 26 whole solar activity cycles. The

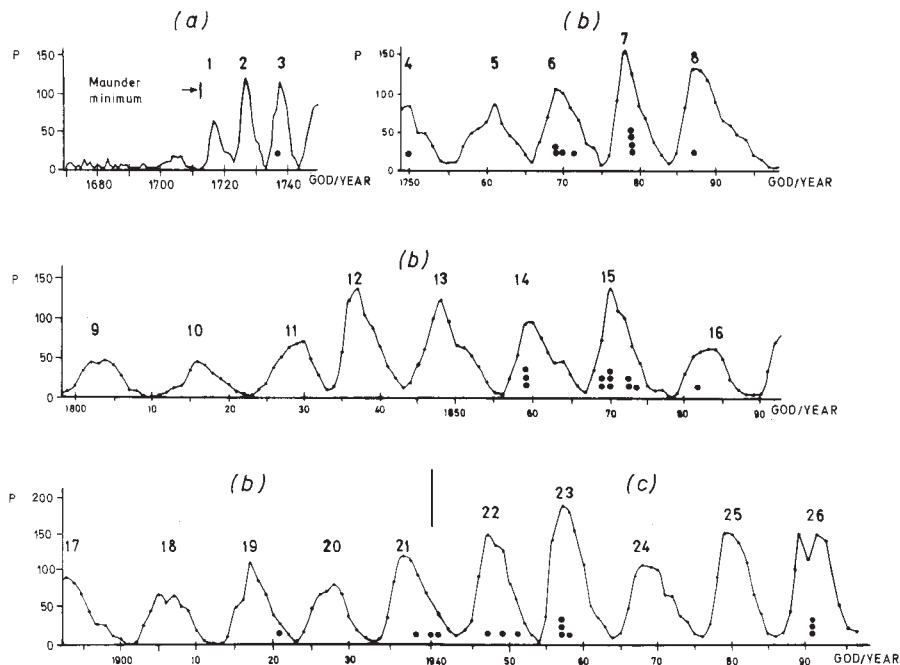


Figure 1. Annual mean sun-spot (P) time curve: a) Time interval 1675–1745 including the Maunder's minimum according to Brekke and Egeland (1983); b) Time interval 1750–1940 according to C. F. M. Stoermer in Brekke and Egeland (1983); c) Time interval 1940–1996 according to contemporary data bank on the Internet. The black points mark the years in which the polar light has been seen over Croatia and in parts of neighbouring countries, according to the table in the Appendix.

last one in 1991 was the 26th solar cycle. The 6th, 7th and 8th solar cycles have been favourable for aurora observation (therefore recorded 8 polar light events). The 14th, 15th and 16th cycles were again favourable (second favourable time interval) with 11 events recorded, followed the third favourable time interval, including the 21st, 22nd and 23rd favourable solar maxima with 9 recorded polar light events. The favourable intervals lasted over three whole solar cycles in all three cases. The event reported on the 14/15 January 1921, which was very well pronounced, falls in the period of solar minima (between the 19th and the 20th cycles). Strong sun flares can cause magnetic storms associated with polar light in the Earth's atmosphere any time between two solar activity maxima.

The first two polar light events (1737 and 1750) do not fit into the hypotheses of favourable cycles, but they fall into periods shortly after the Maunder's minimum. That fact might pose further questions on the character of the first phase of the Sun's activity cycles as well as the question of the record quality in the beginning of the 18th century.

The first of the »unfavourable« time intervals included 5 cycles with no auroras (the 9th to 13th), the second included 4 such cycles and the most recent interval without auroras includes only 2 cycles. The question is how significant is this decrease in duration of the »unfavourable«, auroraless intervals? Furthermore, is the 26th solar cycle (with 3 events of polar light observed in 1991) a sign for the start of a new aurora-favourable interval, in which case the approaching favourable interval would consist again of three solar cycles with auroras? Positive answer would mean that observers living in the lower latitudes might have opportunity to experience more polar light events. With an 80-year (Gleissberg's or secular) cycle assumed, events during the 26th cycle are not to be considered as introduction to further appearances.

The data presented in the auroral calendar might contribute to the equatorial auroral boundary identification.

Acknowledgements – We would like to thank Professor Ivan Penzar who kindly found time for valuable discussions. We would also like to thank Zlatko Matica for the carefully drawn figure. We would especially like to thank to all anonymous reviewers whose suggestions improved the main message of the paper.

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Appendix

*Data on the polar light observed from Croatia and from parts of the neighboring countries (according to the literature cited and to the original notes). n – number of days with polar light events in the year; * free translation from Old-Croatian, ** free translation from Croatian, *** free translation from German. The table continues for 7 consecutive pages.*

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
1	16/10/1737	Around 02 h	Makarska	On the clear night and W-wind the air was illuminated fiery-red; the light was distributed into three parts: towards Split, towards Island of Hvar and towards the mountains. (*)	Fra Nikola Gobjak, annalist in Francisc. Makarska.	Extracted from the Franciscan monastery annals in Makarska (Anonymous, 1993) and listed in Penzar and Penzar (1997).
1	3/2/1750	Around 02 h	Makarska	Two pronounced phenomena appeared from the direction of mountains, one from Vršac and the other from the Vrujka direction. (*)	Ivan Lovrić	According to translation from Italian by M. Kombol in 1948 (Lovrić, 1776) and noticed by Penzar and Penzar (1997).
2	31/10/1769 17/11/1769 (estimated by I. Penzar)	No records	Šinj	The northern light has been seen several times towards the site from which the bora wind is blowing; later it changed the position moving northward and westward. (**)		
1	18/1/1770	08:30–21:00		Diffuse redness, which has been converted into an arc spreading from the Great Bear to the Wing of Cygnus ... There appeared also auroral elements in form of bands spreading toward zenith and reddish fan-shaped light patches, which tended to fade and re-appear, and join and decompose themselves. The phenomenon in 1779 was similar to the one in 1770. (**)		Extracted from the Franciscan monastery annals in Latin (Bösendorfer, 1910) and presented by Penzar and Penzar (1985), listed in Mokrović (1943) and I. Penzar (1978).
4	10/2/1779 13/2/1779 15/2/1779 19/9/1779	No records	Osijek		Fra Marijan Ladanović, annalist in the Franciscan monastery in Osijek.	
1	12/5/1787	20 h–22 h	Našice	The polar light was seen to spread from the eastern to the northern side of the sky. (**)		
1	7/1/1831	No records	No records	Citation: "... aurora over our area is very rare ... but the most beautiful was noticed, as it has been said, on January the 1st, 1831 ..." (**)	Unknown	Ivan Potočnjak (1878), the note is indefinite rel. to the name of the observation place and person.

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
3	21/4/1859	21:30–23 h	Ljubljana	The polar light appeared as fiery-redness on the northern side of the sky, almost reaching zenith. After 23 h the phenomenon was covered by the clouds. (**)	Karlo Dežman, museum custodian and meteor. observer.	According to Bučić et al. (1872) and cited in Penzar (1978).
	3/9/1859	Around 20 h	Ljubljana Celje	No description		
	12/10/1859	duration 12 min.	Ljubljana	The polar light was beautiful, but it lasted for a short time and was preceded by the telegraph-pointer pulsation. (***)		
2	13–14/5/ 1869	Short	Hvar	Polar light appeared weak and of short duration (on the 14th of May, 1869 at 6:45 a.m. an earthquake occurred). (**)	G. Bušić, telegraphist and meteorological observer.	According to G. Bučić (Bučić and Paugger, 1869) and listed by Penzar (1978)
		20:30–21:45 23:45–00:15	Pula	Aurora appeared two times repeatedly, being dark reddish and arc-shaped, with both arc sides reaching the horizon. The middle lower edge was about 15° and the upper edge about 45° above the horizon. The middle of the arc corresponded to magnetic meridian. The phenomenon faded around 21:45, but it reappeared again two hours later, developing faster to the same intensity. (***)	Mariners J. Wachtel and F. Laschober on the warship <i>Brig Saida</i> in Pula.	Informed by dr. F. Paugger, hydrographist, extracted from an extensive record (Bučić and Paugger, 1869).

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
	24/10/1870	18:30–08 h	Vis	Aurora appeared in the evening over the NE-, N- to NW-part of the sky in the form of active bands, which faded and reappeared. The next evening the phenomenon appeared again in its full beauty with fiery-red bands spreading from E to NW. Both evenings the phenomenon has been pronounced mostly northward. (***)	A. Morelli, garrison commander of the castle of Island Vis.	Report written by A. Morelli (Bučić et al., 1870) and listed in Penzar (1978).
	25/10/1870	18–20:30 h				
	25/10/1870	18 h–21 h	Zagreb	Above the Medvednica mountain, to the left of the Great Bear, the arc of glowing redness on the sky spreaded, with its top corresponding to magnetic meridian. On the arc rays appeared, three of them distributed in the pyramid-shape, changing the color from bloody reddish to light yellow. (**)	Prof.dr. Josip Torbar, member of the Academy.	Paper written by Torbar (1871), listed in Goldberg (1938) and Penzar (1978).
3	24–25/10/1870	Twilight–20h	Hvar	That evening illumination was so strong that making notes in open did not make any difficulties. Over the red glowing arc the glowing rays spreaded and in whitish. The phenomenon faded and reappeared three times, moving at the same time from E over N toward W. A cloud layer covered the view around 20 h.	G. Bučić	Extracted from the record written by G. Bučić (Bučić et al., 1870) and listed in Penzar (1978).
	25/10/1870	18:30–22:03	Herceg-Novi	An active phenomenon appeared on the sky towards NW, spreading horizontally about 60° and reaching about 45° above the horizon. With pulsating light intensity aurora weakened after about 19 h, but around 20 h it reappeared. The glow of illumination was magnificent toward the N side and alike to a big fiery flame, moving toward E and finally fading toward ESE. (***)	Matteo Merssa	Report written by M. Merssa (Bučić et al., 1870).
	28/11/1870	Around 16 h	Karlovac	Aurora appeared in the shape of corona. (**)	Martin Sekulić, school professor	According to Sekulić (1872).

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
		Evening to midnight	Hvar Cetinje Skadar	Over a red background the white little clouds were seen, some of them similar to comets. White arcs were temporarily mixed together, making one cloudy area. The rays converged into one point. Noted were disturbances in telegraphic links during the phenomenon. (***)	G. Bučić	Extracted from the record written by G. Bučić (Bučić et al., 1872) and listed in Penzar (1978).
	4/2/1872	17:45–21:45	Herceg-Novi	At the twilight northern light appeared, which became arc-shaped around 18:30, spreading about 110° horizontally and reaching about 35 above the horizon. The arc was of an intensively red color. (***)	Matteo Merssa	Record written by M. Merssa (Bučić et al., 1872).
2		18 h–21 h	Mostar	The northern light covered 1–4 quadrant s of the sky. The sky was pale as in a twilight. Gradually the light intensified becoming stronger than the moonlight, becoming also bloody reddish. The phenomenon changed its shape over several hours, appearing in glowing rays and spreading from NW to NE, converging into zenith. (***)	P. Reglia, k.k. consul	Report written by P. Reglia (Bučić et al., 1872).
	4-5/2/1872	17:50–00:30	Pula	Around 17:50 a weak redness appeared on the sky; its intensity became stronger and around 18:20 the NW, N to NE part of the sky appeared purple-red in color and arc-shaped; there were visible bands and rays of light, the clouds had redish glow. (***)	Joh. Palisa and Director Mueller	Extracted from an extensive report written by J. Palisa and Dr. Mueller (Bučić et al., 1872).
	7/7/1872	22:30–01 h	Ljubljana	A redish glow appeared around midnight, over the NE part of the sky, spreading up to lower stars in the Plough; the phenomenon moved towards NNW and oscillated becoming more and more pale. (***)	K. Dežman and several firemen.	Reported by K. Dežman (1861) listed in Bučić et al. (1872).
1	7–8/1/1873	23 h–03 h after mid- night	Pula	Weakly pronounced aurora, positioned at 13°55'E and below 44°40'N; previously the sky had dark almost dirty outlook, and then appeared the reddish arc-shaped form spreading from NW to NNE and about 20° high. The phenomenon has been pronounced mostly at about 2 h after midnight. The rays were not seen this time. (***)	Mariner F. Laschober, on the warship <i>Brig Said</i> in Pula.	Reported by Joh. Palisa, director of Marine-astronomical station in Pula and based on the ship diary (Palisa, 1873).
1	17/11/1882	18 h–18:30	Zagreb	A bright arc on the N-NW part of the appeared and became more luminous, and the stars were visible through it. On the opposite side the Moon came out from clouds and spread the reflected redish light in a beautiful glow. The phenomenon lasted shortly because of increased cloudiness. (**)	Ivan Stožir, school professor and director of the Meteor. ob- serv. in Zagreb.	Report by I. Stožir (1883) and listed in Goldberg (1938), Mokrović (1943) and I. Penzar (1978).

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
1	14–15/1/ 1921	After mid- night to 02 h.	Zagreb	Unusual redness of the northern sky gradually converted into a fan-shaped bands with sharp edges and colored in different nuances of redness (pink to dark red), reaching about 45° above the horizon. The bands width and brightness varied; the light was breaking through clouds, causing the reddish frames around them. (**)	Franjo Kos, school professor.	Listed in Goldberg (1938), Mokrović (1943) and I. Penzar (1978).
1	25–26/1/ 1938	Evening to after mid- night	Zagreb and many other cit- ies in Croatia and all over the Europe	The phenomenon appeared arc-shaped with a ray structure, fading and re-appearing three times; the reddish glow spread over the northern horizon from NE to NW, reaching above the Great Bear constellation; the redness was gentle and transparent, so the stars could be seen through it; the silverish and green flocks breached through, the patches of redness, reminding on the rays of one reflector below the horizon; the glowing arc primarily reminded on a giant drapery, and later on accumulated clouds, illuminated from above; the sea surface gave an impression of a grant dish filled with glowing lava, causing a fright to sailors and fishermen which turned their ships and boats towards the coast. (***)	About fifty records collected over Croatia, between which the prof. V. Rivošeki's, the school director in Senj, was the most distinguished.	According to the paper written by J. Goldberg (1938), and based on questionnaires, prepared by about fifty observers all over Croatia. The originals are kept in Geophysical Institute archive (1938). The data are listed in Mokrović (1943) and Penzar (1978).
1	24/3/1940	No record	Zagreb	No description.	Prof.dr. A. Gilić and many others.	Listed in Penzar (1978).
1	3/3/1941	No record	Ivanec	No description.	N. Blumschein	According to Prof. Dr. J. Mokrović (Miljak, 1991) and listed in Penzar (1978).
1	17/5/1947	No record	Virje	No description.	I. Caganović	
1	26/1/1949	00:10–00:25	Zagreb	The reddish cloud was situated in meridian; the upper part of the glowing cloud was white and brights and its lower part showed redness typical for nitrogen; through the illuminated cloud the Al-deramin in Cepheus constellation could be seen. (**)	Vladimir Glumac school professor, and others.	Paper with a sketch, written by V. Glumac (1949) and listed in Penzar (1978).

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
1	28/6/1951	20:36-20:52 (about 15 min)	Poreč	On the dark, starry sky and below the polar star, close to the horizon, a weak redness appeared, spreading over the whole Great Bear constellation. All stars were visible through the reddish area. The illuminated area had a triangular shape with its base on the horizon and with its top about 20° below the Polar star; brick-reddish color spread towards the both sides of the horizon, but more toward the W. The intensity and nuances of redness were permanently variable; the rays in a shape of a bundle as created by a reflector appeared; the rays faded over one place on the sky and reappeared on the other; the play of light lasted so long the phenomenon lasted; when it started to weaken the bands (rays) first and after them the rest of redness. (**)	Prof. Franjo Margetić, director of the Hidrometeor. Institute of Croatia.	Paper written by F. Margetić (1951) and listed in Penzar (1978).
	21-22/1/ 1957	20 h-03:25 after mid- night	Zagreb, Sljeme, Zavižan and numerous meteor. stations in Croatia, B&H	The reddish drapery was crossed over by bright rays; the illumination reached the height of 50 above the horizon; many TV and radio emissions were disturbed during the night. (**)	D. Kovačić, M. Brajković and observers on many meteor. stations.	Paper written by Dr. Dražen Poje (1957) and listed in I. Penzar (1978).
3	25/1/1957	22:10-22:50 duration of observation	Rijeka Opatija	The pronounced rays of light were spread over a reddish cloud, vertically above the horizon. Nearby there were seen some less pronounced rays, changing in color from pink to blue-yellowish. Through illuminated cloud the stars were visible. (***)	Prof. V. Glumac, who mentioned also J. Miletić from Rijeka and K. Penkala temporarily in Opatija, as observers.	Report with a sketch written by V. Glumac (1957), typewritten manuscript.
	29/9/1957	23:15-23:50 duration of observation	From the ship sailing Lapad to Dubrovnik	The illumination appeared over the northern sky westward about 30 from the Cassiopea constellation and eastward for about 40° from the Great Bear const. and about 40° to 45° above the horizon. The light was dark redish being darker near the horizon and disappearing towards zenith. There light-yellow bands were also seen. (***)	Pavle Kapičić, captain on a Yugoslav warship	According to P. Kapičić's report (1957).
	29/9/1957	No records	Zagreb	No description	O. Wittasek, student and meteor. observer	Meteorological diary of the Zagreb-Grič Observatory.
	29/9/1957	20:45-21:15	Dubrovnik	The sky become bright over its northern part giving impression that a giant fire existed behind the mountains. (**)	Ivan Tutman	I. Tutman's record (1957).
1	10-11/2/ 1958	No records	Zagreb	No description	O. Wittasek	Meteorological diary, Zagreb-Grič Observatory

n	Date (day/ mon/year)	Time	Site of observation	Description of the events (shape, color, light intensity and other characteristics)	Observer	Source of information
	1/11/1991	20 h–21:45	Mali Lošinj	Citation: "... Around 20 h I noticed a redishness pretty low above the NW horizon; the twilight past long time already (these last days I have observed on the Sun big group of sunspots and therefore I thought about the polar light); It was seen below the Great Bear constellation spreading parallel to the horizon, but it was not too bright; at 21:05 there appeared two branches, proceeded behind the northern horizon, and the other spreaded parallel towards NNE; at 21:35 the phenomenon weakened with the position lowering to 6-15° above the horizon only, and faded after 10 minutes ..." (**)	Valter Martinolić, astronomer amateur	According to the V. Martinolić's record (1992) including two sketches.
	8-9/11/ 1991	After sunset and 2 hours in duration	Zagreb, Bijenik	The bands of light and arcs similar to clouds of light, illuminated stronger in the middle and behind the edges the strong orange light at the start was mixed with the sunset colors. (**)	Mario Šobar, technician in Geophysical Institute Zagreb.	According to the questionnaire compiled in Geoph. Institute Zagreb by I. Lisac).
	8-9/11/ 1991		Samobor	Reddish illumination of the sky. (**)	Lovorka Sokolić, secretary in Geophysical Institute Zagreb.	
3	8-9/11/ 1991	Around 23 h	Varaždin, Ludbreg	Reddish illumination in the arc- and band-shape. (**)	Telephone calls to the weather forecast service at Hydrological and Meteorological Service of Croatia.	Report made by Ivan Čačić, M.Sc, weather forecaster on a duty in Hydrological and Meteorological Service of Croatia.
	8-9/11/ 1991	Around mid- night and later	Zagreb, Ogulin, Delnice, Rijeka, Is. Pag, Zadar, Šibenik, Split, Dubrovnik	The observers were sending only the phone messages about the pronounced redness over the northern part of the sky, not describing the details, asking for the explanation only (because it was the time of the war in Croatia, with numerous and big battle fires. (**))		
	8-9/11/ 1991	21 h-02 h	Split	Citation: "... It was a clear, calm and stary sky; around 21 h the northern part of the sky appeared to glow reddish, and around 23 h the light spreaded up to almost half of the sky; the glow was diffuse, but varied in intensity, density and position, forming band, as somewhere behind the coast (north direction) giant fires burnt ..." (**)	Jurica Mijak, B.Sc., weather forecaster in Marine-Meteorological Center in Split.	J. Mijak (1991).
	9/11/ 1991/	After mid- night until 04 h	Mali Lošinj, Višnjan	The polar light was seen in the whole beauty: glowing redness, or purple, with temporary white bands in the direction from SW-W over zenith towards E-NE and N. From Višnjan the phenomenon was seen too, but the strongly illuminated cities (Kopar and Trieste) disturbed a good view. (**)	Several observers.	

SAŽETAK

Polarna svjetlost viđena iz Hrvatske i dijela susjednih zemalja*Inga Lisac and Antun Marki*

Analizirani su zapisi o 37 pojava polarne svjetlosti, viđene od sredine 18. stoljeća do danas, nad područjem od 42 do 45,5 °N širine i od 13 do 19 °E dužine (pretežno područje današnje Republike Hrvatske). Izrađen je popis svih pojava u obliku povijesnog kalendara polarne svjetlosti, koji sadrži datum i mjesto viđenja, izvor informacije te opis opaženih parametara kao što su boja, oblik, raspodjela na nebu i trajanje pojave, gdje je to bilo moguće odrediti. Kalendar pojava je omogućio zaključke o najčešćim i bitnim značajkama polarne svjetlosti viđene iz naših krajeva. Pokazalo se da je čestina pojave povezana sa Sunčevom aktivnošću.

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