e-Zine for meteor observers meteornews.net

MeteorNews

ISSN 2570-4745 VOL 5 / ISSUE 1 / JANUARY 2020

Meteor over Hadrians Wall in Hexham, United Kingdom 24th October 23.54 UT by Julie Winn

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Meteorite-producing stream of the tau-Cetids and a meteorite dropping fireball over Poland

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PF061018 Bukienka, a meteorite dropping fireball which appeared over southern Poland (Olech et al., 2019), was caused by the known tau-Cetid fireball stream (No. 50 in Terentjeva, 1989, 1990). A description of an extraordinary fireball phenomenon is given.

1 Introduction

A fireball with a maximum absolute magnitude of –9.7 appeared in the night 2018 October 5–6, at $00^h26^m51^s$ UT over southern Poland and was observed by ten video stations of the Polish Fireball Network (Olech et al., 2019). The fireball entered the Earth's atmosphere with a velocity of 18.2 km/s and started at the height of 86.0 km. At a height of 41.5 km the fireball passed over the village of Bukienka, reaching its maximum brightness. The terminal velocity of the fireball was only 4.9 km/s at a height of 30.8 km. The authors reported that because of these conditions there is a chance for a possible meteorite fall of small fragments with a total mass of 100 ± 50 grams. The predicted area of a possible meteorite impact has been computed. The authors published the orbital elements of this PF061018 Bukienka fireball.

Usually, the fragmentation of the meteoroid body takes place in the lower atmospheric layers, in the region with strong deceleration, where the atmospheric drag and, hence, disruptive forces reach maximum values (Astapovich, 1958). Thus, meteorite droppings are usually caused by the fragmentation of a meteoroid body in the atmosphere. However, there may be meteorite falls produced by a meteoroid stream that initially enters the atmosphere as a cluster of bodies. I. S. Astapovich gives a geometric criterion allowing one to distinguish between these two types.

2 Research results

From a study of the catalogues with orbital elements of fireball and meteoroid streams, we have deduced that the Bukienka meteorite dropping fireball is related to the already known large fireball stream of the τ–Cetids active during the period September 28 – November 26 (No. 50 in Terentjeva, 1989, 1990). The fireball over the Amur river on 1982 October 7 appeared during this activity period. All the data are presented in *Table 1*.

In the catalogues of 359 minor meteor streams (Terentjeva, 1963, 1966, 1967 and 1968) no minor streams exist associated with the Bukienka fireball.

The orbital elements of the Bukienka fireball are in a good agreement with the orbital elements of the τ-Cetids fireball stream. The difference in the value of the major semi-axis is not a big problem, since large, and especially dispersed streams always contain both long- and short-period orbits. The τ-Cetids are such a wide spread stream and the Earth needs two months approximately to cross this shower.

If we apply the widely used criterion for the determination of stream membership proposed by R. B. Southworth and G. S. Hawkins, then for two orbits (see *Table 1*) we obtain a value of $D_{SH} = 0.16$, which is quite appropriate for such a wide stream as the τ-Cetids (and a large number of streams alike). For major streams such as the Orionids and the Perseids D_{SH} ranges from 0.00 to 0.24 and more (Southworth and Hawkins, 1963).

Nevertheless, we should note that there are no universal mathematical criteria. Not any criterion can take into account the whole range of orbits, individual properties and peculiarities of meteor showers and streams. The used criteria give inappropriate results for the streams, whose orbits are close to ecliptic, streams with N, S and Q branches, most of wide streams, etc. As Prof. Astapovich once said, one cannot push the vast variety of phenomena into limits of formal mathematical criterion. Thus, requiring D_{SH} to be less than 0.1 for all streams in the Solar System is incorrect. Mathematical criteria while searching, of course, help to find required orbits, though these play a subsidiary role. The main role belongs to common sense. The fireball stream of the τ-Cetids fits in the list of meteorite-producing fireball streams, found by the authors (Terentjeva and Barabanov, 2017, 2018, 2019).

This list should be permanently expanded because meteorite-producing streams are of great importance. In particular, these streams may be hazardous for Earth. Relatively large bodies hidden in these streams may even cause serious local damage when colliding with the Earth. For observers these streams may appear as a firework of bright meteors and fireballs, and even a meteorite dropping. We can, for instance, recall the Tagish Lake meteorite dropping caused by the μ-Orionid fireball stream

Figure 1 – Dust trail in the cone of the evening glow. A bright fireball over Amur (200 km from Khabarovsk down the Amur river, Russia), on 1982 October 7, at 18^h50^m (Khabarovsk' time). From the personal archive of A. K. Terentjeva. The author of the photo is unknown.

Table 1 – The orbital elements for the fireball, eq.2000.0 (Olech et al., 2019) and the τ-Cetids N°50, eq.1950.0 (Terentjeva, 1989, 1990).

Object name	Date (UT)	α_g (°)	δ_g (°)	v_∞ km/s	a AU	e	q AU	ω (°)	Ω (°)	i (°)	Π (°)
Bukienka fireball	2018 X 6	13.6	–22.9	18.2	1.62	0.510	0.793	67.2	19.45	11.36	86.65
τ-Cetids	IX 28 – XI 26	18	–19	20.4	2.442	0.667	0.791	58.4	27.4	11.6	85.8

(Terentjeva, Barabanov, 2004). Therefore, the observers should always pay attention to these meteorite-producing streams.

3 Conclusion

As a conclusion, we would like to mention one interesting and extremely rare fireball event described by I. S. Astapovich (1958) in his well-known monograph. Sometimes a big number of fireballs may be observed at once, they may appear as cluster-like formations. I. S. Astapovich recounts several events of this kind: a quasi-simultaneous appearance of 40 fireballs over Prussian Saxony on December 12–13, 1830 (the Geminids?); a large stream having contained several dozens of fireballs that passed over Scandinavia on the 9th of February 1931; and the most grand event that took place on the same day, but 18 years prior to the Scandinavian event from a different apparent radiant. On the 9th of February 1913 three large groups of a hundred of fireballs appeared within 10 minutes and travelled over 8400 km along the line from Canada over the Bermuda Isles to the equator. There are 144 records of this event taken both from boats and ashore. The groups travelled at different altitudes; the lowest passed over Ontario, at 42 km above the ground, and produced prominent noise. Two other groups flew over the Atlantic Ocean with a velocity of 14 km/s.

The observers should always keep in mind that these events, though quite rare, do take place. Thus, they should make enough efforts not to be taken by surprise.

Acknowledgment

The authors thank *Paul Roggemans* and *Elena Bakanas* for all efforts with the preparation of this article.

This work was supported by Program LP RAS 19 – 270.

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Phoenicids (PHO#254) activity in 2019

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Since the minor planet 2003 WY25 was identified as the left-over of the lost comet D/1819 W1 (Blanpain), possible encounters with several dust trails could be forecasted. Both in 2008 and in 2014, some modest Phoenicid activity could be observed. The next possible encounters with dust trails were expected in 2019. The video camera networks of CAMS BeNeLux and SonotaCo in Japan registered in total 7 and 10 possible Phoenicid orbits most of which are likely related to the 1819 dust trail. One single Phoenicid orbit registered on November 20 by CAMS BeNeLux may be related to the 1872 dust trail. The very low activity level and absence of orbits at some predicted dust trails may indicate very weak or no cometary activity of the parent body.

1 Introduction

The Phoenicids were for a long time a poorly known meteor shower, seen on 5 December 1956, observed by many observers in Australia and South Africa (Ridley, 1963) as well as by a team on the first Japanese Antarctic Research Expedition in the Indian Ocean (Huruhata and Nakamura, 1957).

The event was also registered by radio observations at Adelaide, Australia. The radio rate of 30/hr measured on an equipment of high sensitivity is much lower than expected from the visual rates of 20 to 100/hr reported from 1 to 9 hours later (Weiss, 1958). The Phoenicids had been already reported in 1887 when about one meteor per minute was seen and later again in 1938. The history of this shower has been described in detail by Jenniskens and Lyytinen (2005).

Table 1 – The December Phoenicids (PHO#254) from literature (Cook, 1973).

	Cook (1973)	Comet 1819 IV Blanpain
$\lambda_\odot$	253.5°	–
α_g	15.3°	–
δ_g	–44.7°	–
v_g	11.7	–
a	2.96 A.U.	2.96 A.U.
q	0.99 A.U.	0.892 A.U.
e	0.67	0.699
ω	359°	350.2°
Ω	74°	79.2°
i	13°	9.1°

With the 1956 data available, the shower got listed in the working list of meteor streams established by Allan Cook (Cook, 1973) and remained for long the only information available.

2 Discovery of extinct comet nucleus 2003 WY_{25}

The minor planet 2003 WY_{25} was discovered by the Catalina Sky Survey as a very faint object with a diameter of only 400 m in diameter. The orbit was very similar to the orbit of the lost comet D/1819 W_1 (Blanpain). This new information allowed researchers to integrate back in time and the better determined orbit of 2003 WY_{25} proved to fit very well with poorly determined orbit of Blanpain in 1819.

Jenniskens and Lyytinen (2005) could predict a return of the shower in the fall of 2005, but conditions were much less favorable than in 1956. Also, for the years 2019, 2034, 2039, and 2044, enhanced Phoenicids activity has been predicted, all at much lower rates than in1956.

3 Forecasts 2008, 2014 and 2019

Mikiya Sato and Jun-ichi Watanabe (2010) also predicted possible Phoenicid returns for the years 2008, 2014 and 2019. If and how much activity would be visible depends on the ejection of meteoroids at each perihelion passage and thus the cometary activity of D/1819W1 Blanpain. Unfortunately, the parent comet was observed only in 1819 and remained missing until it was rediscovered as an asteroid, 2003 WY25. This discovery allowed to reconstruct the orbit over a long period of time, but the cometary activity of the object and thus possible dust

Table 2 – Possible dust trails of D/1819W1 Blanpain which could be encountered by the Earth in 2019. (Courtesy Mikiya Sato).

Ejection			Radiant			Minimum point				
Year	Velocity (m/s)	f_M	α_g (°)	δ_g (°)	v_g (km/s)	Date	Time (UT)	Distance (AU)	α_g (°)	δ_g (°)
1819	+8.63	0.0016	7.75	–5.38	11.07	Nov. 13	12^h41^m	+0.0017	6.93	–5.87
1819	+7.38	0.0032	7.38	–6.91	10.74	Nov. 15	07^h33^m	+0.0008	7	–7.14
1814	+4.69	0.00096	7.44	–7.72	10.62	Nov. 16	05^h32^m	+0.0007	7.14	–7.91
1808	+2.31	0.0007	7.27	–8.6	10.47	Nov. 17	05^h34^m	+0.0003	7.13	–8.69
1803	+1.56	0.00058	7.22	–8.84	10.43	Nov. 17	12^h10^m	+0.00021	7.12	–8.9
1872	–13.64	0.012	7.11	–11.06	10.01	Nov. 21	17^h09^m	+0.0013	6.57	–11.39
1877	–14.2	0.0079	6.33	–12.73	9.87	Nov. 22	09^h24^m	+0.0007	6.59	–12.56
1882	–15.89	0.016	5.8	–14.23	9.76	Nov. 23	07^h04^m	+0.0019	6.52	–13.78
1898	–17.23	0.009	6.53	–28.32	9.69	Dec. 2	19^h23^m	+0.00044	6.58	–28.29

ejection remains unknown. Observing efforts to monitor the Phoenicids could provide an indirect way to find out if any dust trails have been formed. Any Phoenicids' activity observed during a predicted passage through a dust trail can reveal the existence or absence of such a dust trail.

For 2008 a possible return was predicted for the trails ejected in 1861 and 1866. Especially the 1866 offered likely activity with positive ejection velocities and a closest approach between the orbits of 0.00012 AU. Some low activity was detected in 2008 (Sato and Watanabe, 2014).

In the forecast for the 2014 Phoenicid return, many trails formed between 1771 until 1935 could encounter the Earth. Based on the most favorable geometric conditions for some trails an activity was predicted with an equivalent ZHR of 20 to 50 at best, depending on the cometary activity when the early 20th century trails had been formed (Sato and Watanabe, 2010).

The Phoenicids were effectively observed from North Carolina, USA, using video and digital cameras in the night from 2014 December 1, at 22^h30^m UT until December 2, 4^h00^m UT. The activity of the Phoenicids was confirmed as well as the predicted maximum December 2, at 0^h UT. The activity was rather modest with only 29 Phoenicids recorded. The compact radiant of the Phoenicids agreed well with what was predicted and this was significant more to the north compared to the radiant observed in 1956, the observed apparent radiant was at R.A. ~6° to 15° and decl. ~–16° (Fujiwara et al., 2017).

4 Forecast Phoenicids 2019 return

In *Table 2* Mikiya Sato lists the dust trails that might be encountered by Earth in 2019. These can be considered as three different groups. A first number of older dust trails may produce Phoenicids activity in the period 13 to 17 November, a second group could be responsible for Phoenicids between 21 and 23 November and a final dust trail of 1898 might cause activity on December 2, in spite of the negative ejection velocity the f_M value may correspond to a ZHR of 12 if the cometary activity of the parent body in 1898 was comparable to 1819. Some of these possible dust trails have been shown in *Figure 1*.

The parameter f_M value is the degree of extension of the trail, and was derived by $f_M = \Delta t_0/\Delta t$, where Δt is the time needed for a given part of the trail to pass through the ecliptic plane, and Δt_0 is the same, but at the first return. In any case, f_M is a measure of the density of the dust within the trails.

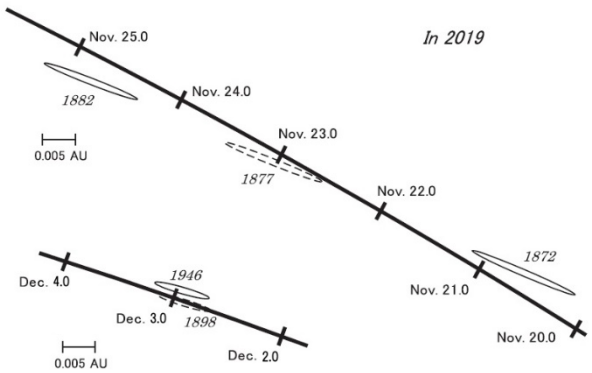

Figure 1 – Some of the theoretical dust trails of D/1819W1 Blanpain which could be encountered by the Earth in 2019, if there was any cometary activity at the return the dust trail may have been produced. (Courtesy Mikiya Sato).

Since comet D/1819W1 Blanpain was poorly observed and lost until rediscovered as minor planet 2003 WY_{25} no information is available about the cometary activity of the parent body for all computed returns since 1819. In case no dust was released at the time when the predicted dust trails were formed, then no meteor activity will occur. Most likely, any possible activity will be modest when only weak cometary occurred during the formation of the dust trails. Any positive or negative observations in 2019 could tell us more about the cometary activity of the parent body at the time the dust trails were assumed to be formed. The long period of time, weeks earlier than the 1956 Phoenicid activity and the geocentric radiant position much more to the north, in the constellation of Cetus, may confuse observers.

5 The Phoenicids 2019 return

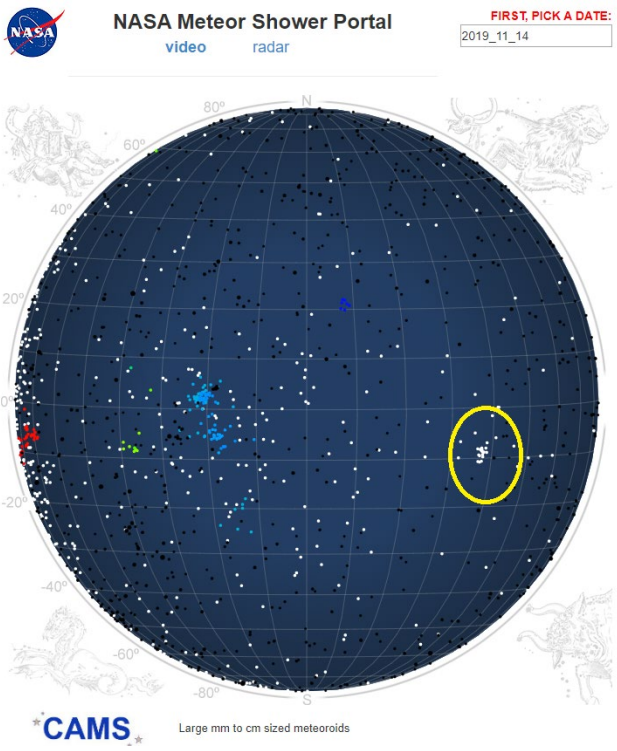

Figure 2 – The CAMS radiant map for November 14, the position of the Phoenicid radiants are in the yellow circle.

Peter Jenniskens was the first to report that based on 18 Phoenicids detected by the CAMS Chile network on 2019 November 12 to 14, we can conclude the Phoenicids did return in 2019. The outburst was also detected by most other CAMS networks (Jenniskens, 2019).

On the Global Meteor Activity website, you can find all the radiants obtained for multiple station meteors that allowed to compute an orbit. Go to CAMS website[1], pick a date (use Chrome or Firefox as browser, not IE) and you can see the shower activity on November 12, 13, 14 and 15. The Phoenicid shower is the white blob right of the antihelion source, just below the ecliptic plane.

Table 3 – The December Phoenicids (PHO#254) from the 2019 return, preliminary CAMS results, and current comet orbit (J2000) (Jenniskens, 2019).

	CAMS (2019)	Comet 1819 IV Blanpain
$\lambda\odot$	229.1 to 231.6°	–
α_g	7.3 ± 0.4°	–
δ_g	–6.9 ± 0.4°	–
v_g	11.8 ± 0.5 km/s	–
a	–	3.04 A.U.
q	0.935 ± 0.002 A.U.	0.959 A.U.
e	0.75 ± 0.04	0.685
ω	28.6 ± 0.4°	9.84 °
Ω	50.7 ± 0.2°	68.92 °
i	2.89 ± 0.16°	5.90°

[1] http://cams.seti.org/FDL/

6 CAMS BeNeLux results

Although the weather was very uncooperative, the CAMS BeNeLux network had seven candidate Phoenicid orbits, the meteors were rather faint (courtesy Carl Johannink):

- On November 9 at $21^h38^m42^s$ UT, between camera 397-Zoersel, Belgium (*Bart Dessoy*) and camera 3852-Zillebeke, Belgium (*Steve Rau*).
- On November 12 at $01^h16^m01^s$ UT, between camera 396-Gent, Belgium (*Tim Polfliet*) and camera 3830-Mechelen, Belgium (*Adriana and Paul Roggemans*) (*Figure 4*).
- On November 12 at $19^h10^m32^s$ UT, between camera 801-Burlage, Germany (*Robert Haas/Edwin van Dijk*) and camera 351-Ermelo, Netherlands (*Koen Miskotte*).
- On November 13, at $20^h32^m25^s$ UT, between camera 389-Mechelen, Belgium (*Adriana and Paul Roggemans*) (*Figure 5*) and camera 3032-Oostkapelle, the Netherlands (*Klaas Jobse*).
- On November 15, at $23^h14^m52^s$ UT, between camera 814-Grapfontaine, Belgium (*Jean-Paul Dumoulin and Christian Wanlin*) and camera 807-Mechelen, Belgium (*Luc Gobin*).
- On November 15, at $23^h17^m55^s$ UT, between camera 393-Uccle, Belgium (*Hervé Lamy*) and camera 3037-Oostkapelle, the Netherlands (*Klaas Jobse*).
- On November 20 at $22^h07^m28^s$ UT, between camera 809-Mechelen, Belgium (*Luc Gobin*), camera 3815-Genk (*Seppe Canonaco*) and camera 3831-Mechelen (*Adriana and Paul Roggemans*) (*Figure 3*).

Figure 3 – Phoenicid meteor on November 20 at $22^h07^m27.89^s$ UT, on camera 3831 (RMS BE0004) at Mechelen, Belgium (Adriana and Paul Roggemans).

The details for the Phoenicids orbits obtained by CAMS BeNeLux are listed in *Table 4*.

Most striking is the very low ablation height of these Phoenicid meteors, around 80 km, typical for such very slow meteors. Although the CAMS BeNeLux network is optimized to cover the atmospheric layer between 80 and 120 km, the variable weather and some technical problems meant that not all CAMS stations could capture meteors simultaneously. This reduces mainly the chances to get

Figure 4 – Phoenicid meteor on November 12 at $01^h16^m01^s$ UT, on camera 3830 (RMS BE0002) at Mechelen, Belgium (Adriana and Paul Roggemans).

Table 4 – The Phoenicids orbits obtained by CAMS BeNeLux in 2019 (J2000).

	2019/11/09 $21^h38^m41.52^s$	2019/11/12 $01^h16^m01.30^s$	2019/11/12 $19^h10^m31.99^s$	2019/11/13 $20^h32^m24.58^s$
$\lambda_\odot$	226.918°	229.079°	229.829°	230.892°
α_g	10.804 ± 0.04°	6.59 ± 0.03°	11.27 ± 0.06°	6.75 ± 0.03°
δ_g	–6.83 ± 0.10°	–5.97 ± 0.04°	–2.72 ± 0.20°	–7.03 ± 0.14°
v_g	11.728 ± 0.012 km/s	10.444 ± 0.006 km/s	10.837 ± 0.023 km/s	10.619 ± 0.011 km/s
H_b	87.7 ± 0.01 km	89.4 ± 0.00 km	82.5 ± 0.01 km	89.3 ± 0.02 km
He	72.7 ± 0.01km	76.8 ± 0.01km	69 ± 0.01km	73.7 ± 0.01km
a	2.957 A.U.	2.688 A.U.	2.584 A.U.	2.915 A.U.
q	0.91998 ± 0.00018 A.U.	0.93937 ± 0.00006 A.U.	0.9253 ± 0.00037 A.U.	0.94343 ± 0.00018 A.U.
e	0.6889 ± 0.0009	0.6505 ± 0.0004	0.6419 ± 0.0016	0.6763 ± 0.0008
ω	34.356 ± 0.047°	29.488 ± 0.016°	33.555 ± 0.105°	27.805 ± 0.055°
Ω	46.9225 ± 0.0003°	49.0988 ± 0.0003°	49.8284 ± 0.0005°	50.8983 ± 0.0004°
i	3.283 ± 0.027°	2.247 ± 0.012°	2.026 ± 0.048°	2.549 ± 0.036°

	2019/12/23 $03^h15^m47.48^s$	2019/12/23 $04^h45^m31.94^s$	2019/12/23 $06^h24^m01.37^s$	2019/12/23 $06^h34^m57.17^s$
$\lambda_\odot$	270.705355°	270.768851°	270.838538°	270.846272°
α_g	218.27 ± 0.46°	221.27± 0.80°	214.52 ± 0.51°	220.57 ± 0.00°
δ_g	74.94 ± 0.18°	75.58 ± 0.67°	75.08 ± 0.44°	74.87 ± 0.00°
v_g	10.197 ± 0.017 km/s	11.215 ± 0.183 km/s	10.13 ± 0.04 km/s	10.13 ± 0.04 km/s
H_b	87.3 ± 0.01 km	87.57 ± 0.04 km	94.2 ± 0.02 km	94.2 ± 0.02 km
He	74.04 ± 0.01km	78.95 ± 0.05km	77.64 ± 0.04km	77.64 ± 0.04km
a	2.834 A.U.	3.524 A.U.	3.098 A.U.	3.098 A.U.
q	0.95071 ± 0.00012 A.U.	0.94519 ± 0.00115 A.U.	0.96027 ± 0.0004 A.U.	0.96027 ± 0.0004 A.U.
e	0.6645 ± 0.0012	0.7318 ± 0.0122	0.6901 ± 0.0032	0.6901 ± 0.0032
ω	25.451 ± 0.035°	26.477 ± 0.25°	21.376 ± 0.159°	21.376 ± 0.159°
Ω	53.0378 ± 0.0008°	53.0399 ± 0.0112°	58.0322 ± 0.0017°	58.0322 ± 0.0017°
i	2.715 ± 0.047°	2.688 ± 0.484°	3.243 ± 0.112°	3.243 ± 0.112°

multiple station events for meteors that appear deep in the atmosphere where the overlapping between the FoV of the cameras at different sites is much less than for higher altitudes in the atmosphere.

Figure 5 – Phoenicid meteor on Nov. 13, at $20^h32^m25^s$ UT, on camera 389 at Mechelen, Belgium (Adriana and Paul Roggemans).

7 SonotaCo Network in Japan results

The Japanese SonotaCo network was also successful with 10 possible Phoenicid orbits registered in the period of 12 to 16 November. The Japanese results are listed in *Table 5*.

While CAMS BeNeLux registered rather faint Phoenicids, SonotaCo Network had a few bright meteors. Some nice bright meteors are shown in *Figures 6, 7* and *8*. The radiant appears to be very compact (*Figure 9*), comparable to the results of CAMS (*Figure 2*).

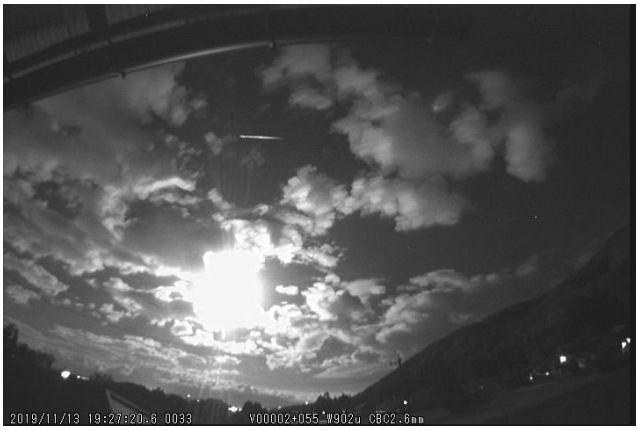

Figure 6 – Possible Phoenicid on 13 November 2019 at $10^h27^m20^s$ UT by Chikara Shimoda. (Courtesy Chikara Shimoda).

Figure 7 – Possible Phoenicid on 14 November 2019 at $17^h06^m19^s$ UT by Chikara Shimoda. (Courtesy Chikara Shimoda).

Figure 8 – Possible Phoenicid on 15 November 2019 at $23^h52^m17^s$ UT by Yasunori Fujiwara. (Courtesy Yasunori Fujiwara).

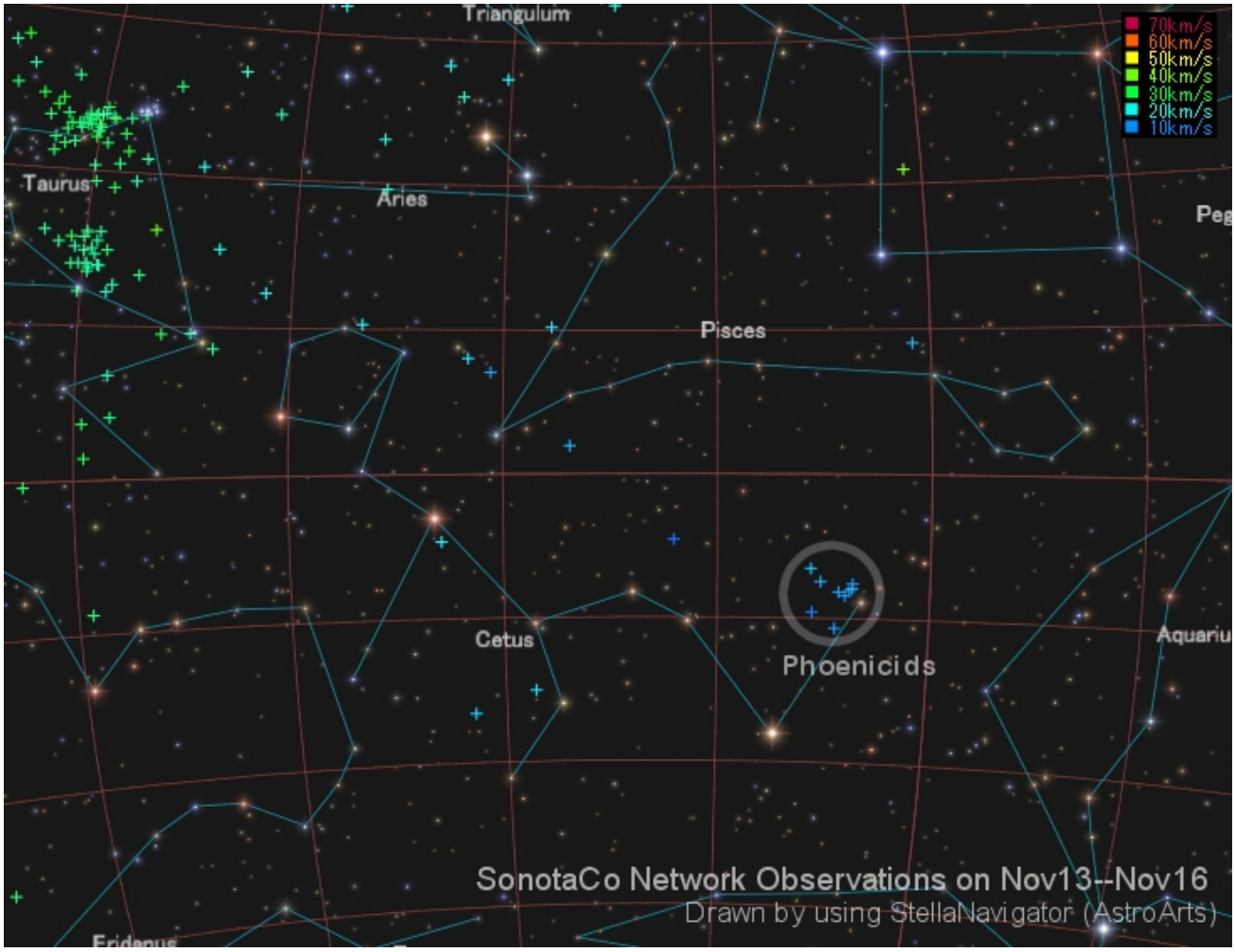

Figure 9 – Radiant plot for the orbits obtained by SonotaCo Network in Japan during the period 13–16 November. (Provided by Mikiya Sato).

Table 5 – Candidate Phoenicid meteors detected by SonotaCo Network in Japan based on SonotaCo Network observation data (Data on SonotaCo Network M.CSV exchange hub 2019[2]). (Provided by Mikiya Sato).

$\lambda_\odot$ (°)	α_g (°)	δ_g (°)	v_g km/s	e	a (AU)	q (AU)	ω	Ω	i	*Mag.*	H_b	H_e
230.470	8.2	–9.58	8.11	0.4958	1.8862	0.9511	28.0512	50.4698	2.6987	0.77	85.4	72.7
231.631	5.36	–7.61	9.63	0.621	2.5093	0.951	25.9889	51.6322	2.335	0.79	86.8	79.9
231.688	17.96	–4.58	7.42	0.4044	1.5691	0.9345	36.1529	51.689	2.4082	–5.05	80.3	73.8
231.755	5.58	–8.1	9.92	0.6418	2.6533	0.9504	25.919	51.7556	2.5329	–2.67	88.4	70.1
232.421	5.42	–7.92	11.53	0.7645	4.0234	0.9473	25.5342	52.4227	2.7752	–0.01	89.1	78.7
232.572	7.63	–7.46	10.76	0.6924	3.0727	0.9452	26.9576	52.5731	2.7754	1.46	89	79
232.650	8.31	–6.56	12.41	0.8067	4.853	0.9379	27.8792	52.6516	2.9378	1.42	89.9	74.7
232.651	5.89	–8.42	9.94	0.6469	2.6953	0.9518	25.3336	52.6527	2.6381	–3.27	85.2	72.4
232.667	6.34	–8.17	9.83	0.6363	2.6153	0.9511	25.6845	52.6692	2.6065	–3.68	69.8	59.9
233.658	6.58	–10.69	9.88	0.6466	2.7014	0.9545	24.2899	53.6597	3.2219	–0.91	87.4	73.9

8 Conclusions

The forecast for possible Phoenicid activity in 2019 has been confirmed, although the level of activity was low. A significant number of Phoenicid orbits was registered by the CAMS networks worldwide as well as by the SonotaCo Network in Japan. Most orbits were obtained in the period 9 to 16 November, spread over different nights.

CAMS BeNeLux network had one candidate Phoenicid orbit in the night of November 20–21. Preliminary results indicate that the global CAMS networks had four possible Phoenicid orbits around November 21. Visual observations

[2] http://sonotaco.jp/forum/viewtopic.php?t=4441

by Pierre Martin on November 22–23 also confirmed Phoenicid activity (Martin, 2020).

No possible Phoenicid orbits were registered by CAMS around December 2. Also, visual observations during the night 2–3 December by Pierre Martin did not detect any Phoenicid activity (Martin, 2020).

Cometary activity past two centuries must have been very poor or non-existent during most perihelion passages. A recent image of comet D/1819W1 Blanpain has been obtained on 18 November 2019 and shows no coma (*Figure 10*).

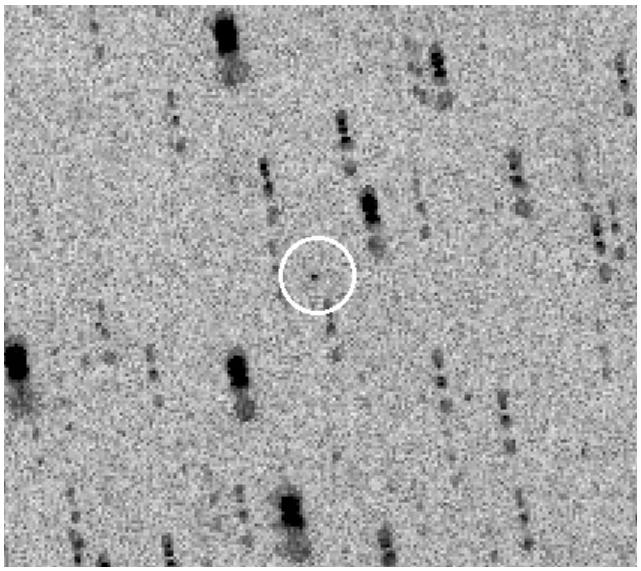

Figure 10 – 289P/Blanpain recorded on 18 November 2019 at 20^h00^m UT) recorded with the TRAPPIST-North (0.6-m) telescope in Morocco. Magnitude 20.8, no coma detected. (Courtesy: Emmanuel Jehin, Université de Liège, Belgium).

Acknowledgment

The authors wish to thank *Mr. Mikiya Sato* for providing the information about this event, we thank the SonotaCo Network members in Japan who have been observing every night for more than 10 years, and make it possible to compare their Phoenicid results with these obtained by CAMS BeNeLux. We are grateful to *Mr. Chikara Shimoda* and *Mr. Yasunori Fujiwara* for granting permission to use their photographs. We thank *Ms. Miki Kobayashi* for her help to get in contact with the authors of the Japanese results and we thank the *Administrator of SonotaCo Network* for his very helpful advises.

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Likely alpha Monocerotids (AMO#246) outburst on the morning of November 22, 2019

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There is a good chance to observe a short-lived outburst of the alpha Monocerotids in the morning of the night 2019 November 21–22. Observers are encouraged to watch for possible alpha Monocerotids in the last hours of the night, from 4h15m UT onwards. If an outburst takes place it is likely to be centered around 4h50m UT with a duration of 15 up to 40 minutes maximum.

1 Introduction

A very short outburst for the alpha Monocerotids (AMO#246) is likely on 2019 November 22, at 04^h50^m UT at the morning sky over Europe (Jenniskens and Lyytinen, 2019a). This outburst is caused by the dust released by a long period comet, but the comet itself is still unknown. The orbital data is listed in *Table 1*.

Table 1 – The alpha Monocerotids (AMO#246) data listed by the Meteor Data Center in the IAU working list of meteor showers.

	Dutch Meteor Society (2001)	Jenniskens et al. (2016)
$\lambda_\odot$	239.3°	239.0°
α_g	117.1°	116.8°
δ_g	+0.8°	+0.9°
v_g	63 km/s	63.0 km/s
a	~500 A.U.	500.00 A.U.
q	0.488 A.U.	0.488 A.U.
e	0.999	0.999
ω	90.66°	90.7°
Ω	59.322°	59.3°
i	134.13°	134.1°

2 AMO#246 history

This shower has previously produced four outbursts, in 1925, 1935, 1985 and 1995, of which 1995 was already predicted and the photographic observations revealed the exact radiant. This is important for modeling.

Because it is a long period one revolution orbit, you do not even need to know the orbital period. This is valid when the period is long enough, e.g. at least about 300 years. The period should also not be too long, for instance more than 1000 years, because then the dust trail would have been stretched too long and so diluted that it could have hardly caused any outbursts as strong as these we had before. The 1925 and 1935 outbursts reached even the level of a meteor storm with ZHRs of over 1000. In 1985 and 1995 the activity reached a level with ZHRs of about 700 and 400.

This dust trail exists for such a long time near the Earth's orbit that it can produce outbursts, for at least decades, and in this case probably for a few centuries. The width of the trail is just very narrow. The half-width is approximately the same as the distance from the center of the Earth to the geostationary satellite orbit.

The perturbations by the planets, in total, amount to about a few million kilometers so that at sometimes the trail gets close enough to the Earth. The forecast for a possible outburst was published in 2002 (Lyytinen and Jenniskens, 2003). The data concerning the alpha Monocerotids (AMO#246) has been reproduced in *Table 2*.

Table 2 – Predicted close approaches for the alpha Monocerotids (AMO#246) dust trail.

Date (UT)	Distance (A.U.)	$\lambda_\odot$ (J2000)	Comment
2019-11-22, 04h52m	–0.00036	239.306	Far
2043-11-22, 10h58m	–0.00008		

The possible 2019 outburst has a calculated "miss-distance" of –0.00036 A.U. which can be commented as "far". At such a distance the author estimates that only a weaker outburst could be produced. The trail situation for the calculation model has been fitted to agree exactly for the year 1995. As such, it is also well suited to fit with the previous outbursts.

However, I now reviewed the situation and I think it is likely possible that it could have a somewhat shorter orbital period, maybe about 600 years (somewhat shorter for the comet than for these meteors). Next, I have averaged the different outbursts and eventually putting more weight on the former outbursts because these had higher ZHRs.

As a result, I find the prediction to be more favorable for this year. I could estimate the miss-distance as –0.0002 A.U., but in this case, there would be an uncertainty of something like ±0.0002 A.U. (possible everything from zero to that value in the table of the Icarus paper).

It could produce a ZHR value of maybe only about a hundred to even storm level (with a ZHR of more than 1000). However, because the radiant is not very high and also because of the possible twilight, the actual counts will be of course well below this level. In Helsinki, the Sun rises a little less than two hours later, so the twilight somewhat disturbs. The Moon is also present at the sky, but already as a crescent, so this may not disturb significant more than the twilight.

While checking, I got the time for the outburst 2 minutes earlier than in the Icarus paper (Lyytinen and Jenniskens, 2003), e.g. 04^h50^m, even though the solar longitude became 0.002° larger now. This was valid for the center of the Earth. Because people in Europe are at the morning side and on the north side, we are a few minutes ahead of that. Otherwise, this would not be in error for many minutes. The location of the trail is more accurate in the direction of the Earth's motion than in the ecliptic perpendicular to the orbit.

Anyone who is going to try to observe should not be late at all. The strongest maximum would fit in about 15 minutes, or maybe a little bit less. It will be almost completely over in about 40 minutes. I recommend starting the observations at the latest at 04^h30^m and if you don't want to miss any meteor, then start no later than at 4^h15^m.

Another point in regard with the fairly large number of prediction lines in the table in the Icarus paper (Lyytinen and Jenniskens, 2003) is that quite a few are observed in only one outburst while assumed to be likely of long-period. Looking at the IAU database for a couple of the showers it seems that these have already been observed and that these had no long period.

As for the outburst of the DPA#120, linked to C/1907 G1 (Grigg-Mellish), it was the first time such event was observed for this comet. Although the outburst was rather weak, it was distinct enough. Earlier this year we got a new unlisted case, the 15 Bootids (FBO#923), confirmed by camera observations before and known for its weak annual activity, the parent body appears to be a long-period comet. According to Jenniskens, the candidate is the bright comet C / 539 W1. (Jenniskens, 2019b; Johannink, 2019).

Other observed meteor showers of this type are the Lyrids (LYR#006) and the Aurigids (AUR#206), for which the parent comets are known. The outburst for the latter happened in 2007 (Atreya and Christou, 2009) and was first predicted by Lyytinen and Jenniskens (2003) and later brought back to the attention of meteor observers in a separate paper (Jenniskens and Vaubaillon, 2007). While for the September epsilon Perseids (SPE#208) and the October Camelopardalids (OCT#281), the trail appears to be either wider than usual or it did not yet get the best hit.

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Alpha Monocerotids (AMO#246) outburst 2019

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The predicted alpha Monocerotids outburst did materialize. Although early visual and radio reports indicated only 'some' weak activity, several video cameras under good sky conditions recorded a significant number of alpha Monocerotids in a short time interval, exactly as predicted by Peter Jenniskens and Esko Lyytinen. Although the level of activity cannot be compared to the 1995 return and definitely no meteor storm took place like announced in some sensation media, CAMS leading scientist Peter Jenniskens concludes that this was not just 'some activity' but a real shower outburst. The outburst is also clearly shown by the results of the Global Meteor Network coordinated by Denis Vida. The lack of bright meteors explains why visual observers saw very few AMO-meteors, especially where a low elevation of the radiant, moonlight and twilight hampered observations.

1 Introduction

Predictions suggested a fair chance to observe a short-lived outburst of the alpha Monocerotids in the morning of the night 2019 November 21–22. Any activity was expected to be centered around 4^h50^m UT and the duration of the event would be limited to 15 up to 40 minutes maximum (Jenniskens and Lyytinen, 2019a; Lyytinen and Jenniskens, 2020).

The predictions got wide attention in the media worldwide. Some journalists did not pay attention to the details in the original publication and announced a spectacular meteor storm with 1000+ of shooting stars to be seen while no scientist ever predicted such spectacular event. Even if a strong outburst would have occurred, the actual numbers of meteors seen would not be so impressive because of the very short duration of the Earth transit through the dust trail. For most casual watchers with poor sky conditions, low radiant elevation, light pollution, moonlight and twilight, the number of meteors visible would be only a fraction of the actual number and certainly disappoint observers with too high expectations. Especially, the low radiant elevation at some location reduced the visible number of meteors to a fraction of what could be seen in perfect circumstances with the radiant at the zenith.

2 Preliminary results

The first reports from visual and radio observers confirmed that some alpha Monocerotids were observed, although only small numbers were seen. The activity was much less than in 1995 when many more meteors were seen. So far it seems that the alpha Monocerotids were rather faint, no particular bright meteors were reported.

The most substantial early report came from Denis Vida: "*The Global Meteor Network stations in Croatia and Russia (perhaps elsewhere as well) saw many AMOs, but it definitely was not a meteor storm. The width of the shower was indeed very small. A short analysis results in the activity profile shown in Figure 4, based on single-station data from La Palma (ES0002). From the time lapse it looks like Musk's Starlink is becoming a serious problem. AMO's start around 4^h30^m, and starlink sats start around 6^h00^m in this time lapse video*[3]."

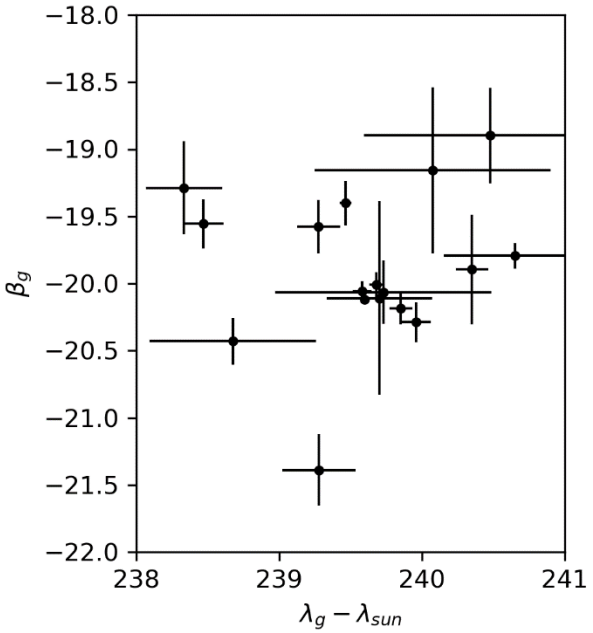

Figure 1 – The solar centered ecliptic coordinates in the $\lambda_\odot$ range 238.0 to 240.0°. Note the very compact nature of the radiant (courtesy: Denis Vida).

[3] https://youtu.be/oHs7ljhQWPA

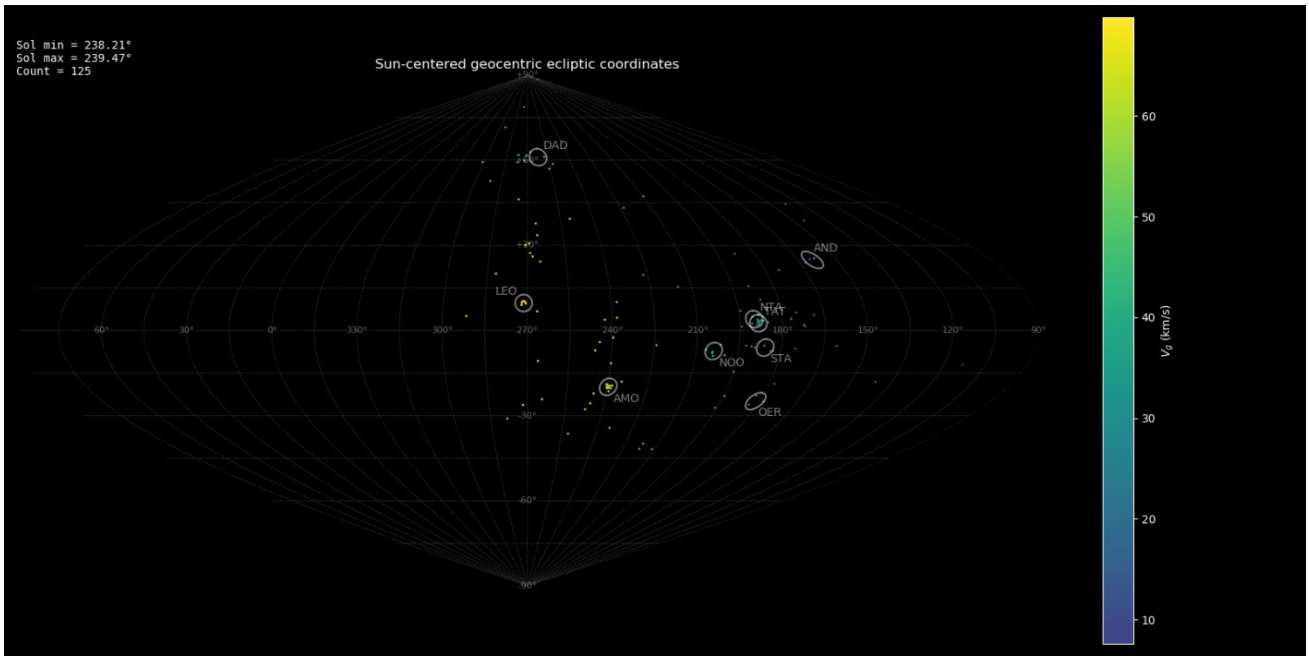

Figure 2 – The solar centered ecliptic coordinates in the $\lambda_\odot$ range 238.0 to 240.0° with color gradiant in function of the geocentric velocity v_g (courtesy: Denis Vida).

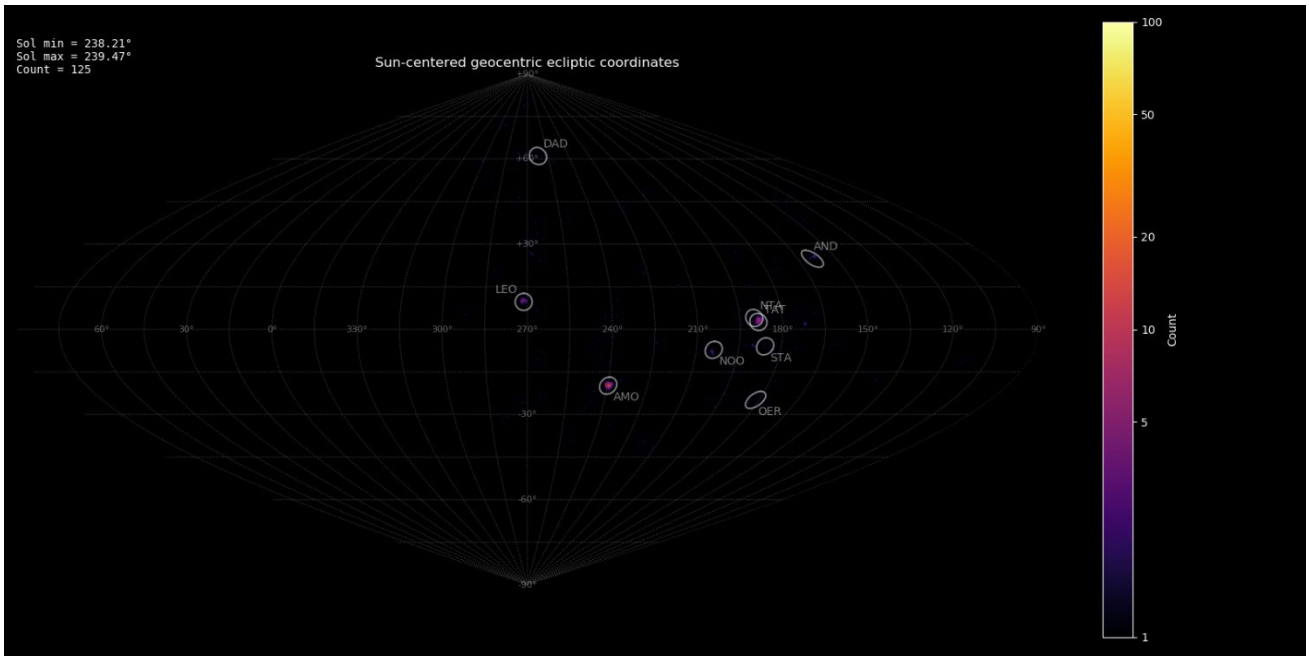

Figure 3 – The solar centered ecliptic coordinates in the $\lambda_\odot$ range 238.0 to 240.0° with color gradiant in function of the density (courtesy: Denis Vida).

Meanwhile Denis Vida shared the preliminary orbits. Denis writes: "*The shower meteors were fast and small, so there weren't many data points per meteor. The average meteor duration was around 0.3 s, which translates to only 7 points per station at 25 FPS. This makes the trajectories quite uncertain, but a tight cluster of radiants with small uncertainties around λ_g–$\lambda_\odot$ = 239.8° and β_g = –20.25 can be seen on the radiant map* (*Figures 1, 2 and 3*)".

Peter Jenniskens[4] reports that the alpha Monocerotids outburst has been confirmed by the Brazilian CAMS-EXOSS network (*Figure 5*). Meanwhile, Chile recorded 14 and Florida 32 alpha Monocerotid orbits during the outburst, as well as some that were not so precisely measured and that are not captured by the lookup table. Chile reported clouds in La Serena. Detected meteors were in +4 to +1 magnitude range, most +3 and +2. The shower clearly peaked in a short period. There was not just "activity", it was clearly an outburst (Jenniskens et al., 2019b).

The CAMS networks picked up some orbits that were identified as AMO#246 members in the night of November 21, the night before the expected enhanced activity. *Figure 6* shows the position of the AMO#246 radiants, with some other active sources marked as well. This means that

[4] http://cams.seti.org/

some dust of this shower got already well dispersed. *Figure 7* displays the map of November 22 which includes the orbits captured during the outburst.

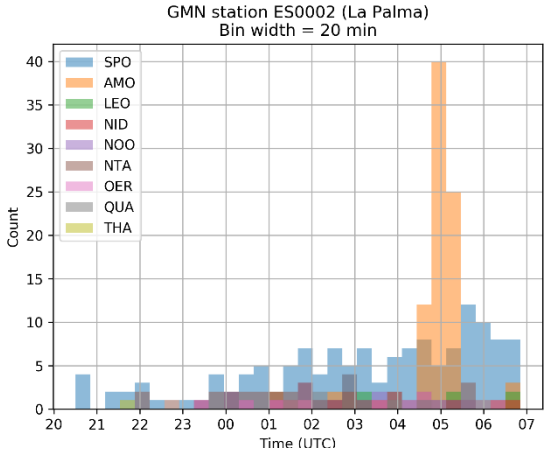

Figure 4 – Global Meteor Network station ES0002 (La Palma) shower count (courtesy Denis Vida).

Figure 5 – A composite image, made by Peter Jenniskens, of alpha Monocerotids captured at one of the CAMS-EXOSS cameras (nr. 9999) in Brazil between 04^h49^m and 05^h14^m UTC, November 22, (courtesy of Marcelo De Cicco).

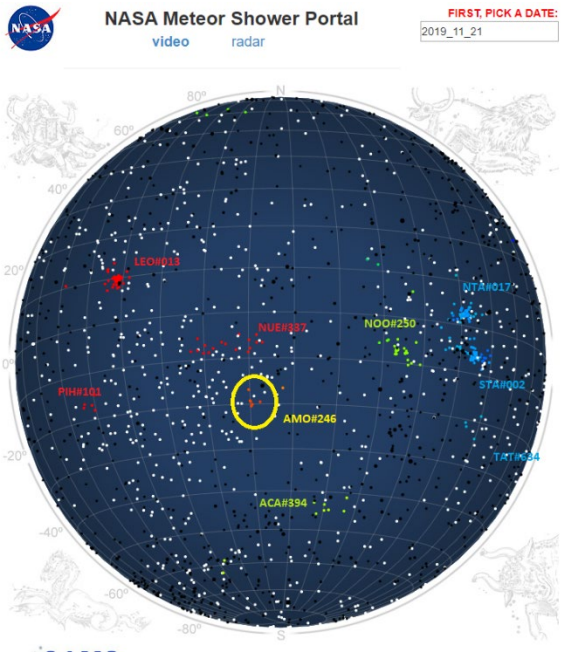

Figure 6 – The radiants of the orbits collected by the CAMS networks during the night before the predicted outburst, November 20–21. The alpha Monocerotids radiants are marked with a yellow circle.

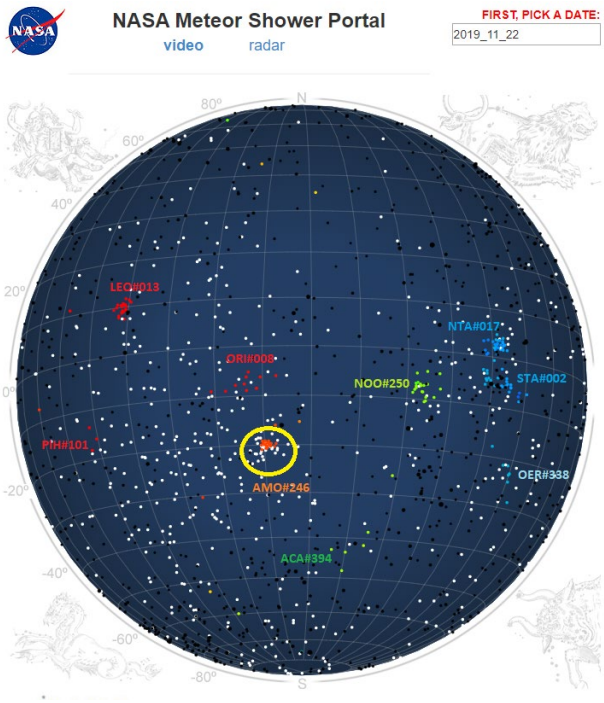

Figure 7 – The 46 radiants of the AMO#246 orbits collected by the CAMS networks during the predicted outburst, November 22. The alpha Monocerotids radiants are marked with a yellow circle.

Figure 8 – Video composite from CAMS 5001 which is located in Gainesville, Florida (courtesy J. Andreas (Andy) Howell).

J. Andreas (Andy) Howell reports: "*CAMS-Florida collected coincidences of 44 meteors from the alpha Monocerotid meteor shower during the evening of November 21–22. The radiant was 35 degrees above the eastern horizon, and skies were mostly clear. Activity spanned the time interval 04^h38^m to 05^h37^m UT with a lone meteor from this shower detected later in the night at 07^h55^m UT. The mid-point of activity occurred at 05^h02^m UT on November 22. The majority of detected meteors were magnitude +1 or +2. Figure 8 is a video composite from CAMS 5001 which is located in Gainesville, Florida. Figure 9 shows the time distribution of coincidences.*"

For the AMO meteors observed by CAMS-Florida, the mean interarrival time was 83.5 seconds (omitting the outlier AMO at 7^h55^m UT). The arrival of a half dozen meteors beginning at 5^h07^m UT with interarrival times of 3s, 4s, 46s, 20s, 6s, 2s was unusual in that they were all well

below the mean. This suggests that there was a significant uptick in activity for about 1-minute beginning at 5^h07^m UT.

Enrico Stomeo reports the observations he made during the night of 21–22 November with three cameras at his observatory near Venice. Unfortunately, the sky was almost always largely covered with clouds. It was totally cloudy when the peak of the alpha Monocerotids was supposed to happen. The observations were as follows:

- NOA38 cam
  UT 203000-045000 T_{eff} 3.93h TOT 17 = 3 AMO, 2 LEO, 12 SPO.
  Two aMONs appeared within four minutes at 044134 and 044550 UT.
- MIN38 cam
  UT 204600-044400 T_{eff} 3.38h TOT 21 = 2 NTA, 1 LEO, 1 STA, 17 SPO.
- SCO38 cam
  UT 204400-043900 T_{eff} 3.30h TOT 15 = 1 AMO, 2 STA, 1 LEO, 1 NTA, 10 SPO.

John W. Briggs reports to the Global Meteor Network: "*My family and I observed at FOAH Observatory (IAU code V23) near Magdalena, New Mexico, USA, for about 25 minutes through the maximum predicted for the alpha Monocerotids (i.e., centered on about 10^h55^m Mountain Time here in USA), and we saw two unusual meteors that I believe were associated with the shower. Both were about 3rd magnitude and travelled on very long arcs rising up from low in our eastern sky — one of them travelling nearly to zenith. Although we saw no meteor "storm" here, seeing these rather unusual meteors was well worth the effort! We were lucky to have a clear sky briefly through this period after a very rainy day.*"

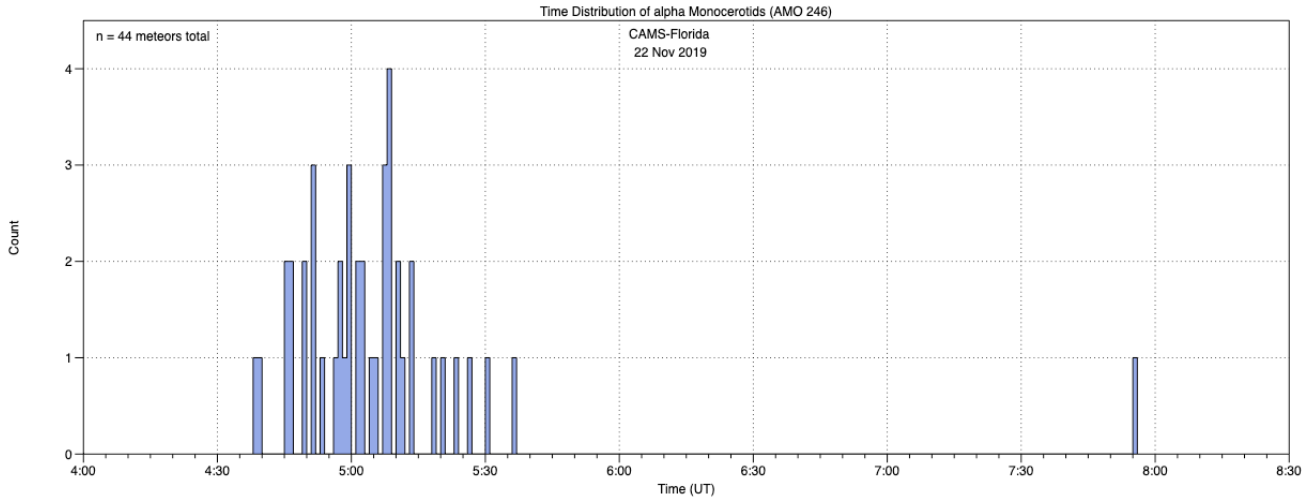

Figure 9 – The time distribution of coincidences (courtesy J. Andreas (Andy) Howell).

Figure 10 – A stack of the 23 AMO meteors captured by the RMS FR000A at Cerilly, France (courtesy: Tioga Gulon).

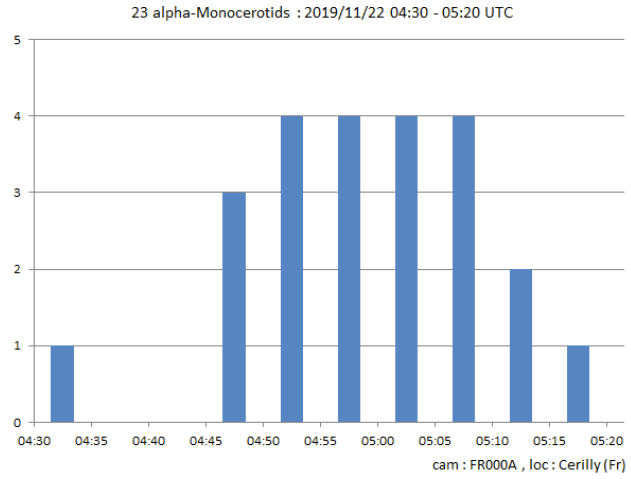

Figure 11 – Time distribution of the appearance of the AMO meteors (courtesy: Tioga Gulon).

Table 1 – CAMS single station shower association for CAMS 3900 and 3901 hosted by Société Lorraine d'Astronomie at Nancy, France, by Tioga Gulon.

Date	Time UTC	Shower	Mag	El_{rad}
11/22/2019	04:43:00.090	AMO	1.5	38.9
11/22/2019	04:47:30.330	AMO	1	38.6
11/22/2019	04:55:20.670	AMO	–0.3	37.9
11/22/2019	04:55:38.489	AMO	1.3	37.9
11/22/2019	04:56:53.969	AMO	2.4	37.8
11/22/2019	04:56:53.949	AMO	1.3	37.8
11/22/2019	04:57:14.589	AMO	2.8	37.8
11/22/2019	04:58:01.349	AMO	1.6	37.7
11/22/2019	05:00:01.069	AMO	1.1	37.5
11/22/2019	05:00:56.889	AMO	0.9	37.4
11/22/2019	05:03:16.609	LEO	0.6	59.2
11/22/2019	05:04:19.190	AMO	–0.4	37.1
11/22/2019	05:05:19.609	AMO	2.2	37
11/22/2019	05:10:33.289	AMO	1.4	36.6
11/22/2019	05:16:06.509	AMO	–0.3	36
11/22/2019	05:16:45.010	AMO	2.4	35.9
11/22/2019	05:17:08.330	AMO	1	35.9
11/22/2019	05:20:29.469	LEO	2.1	60.4
11/22/2019	05:21:07.469	AMO	–0.1	35.5
11/22/2019	06:00:29.770	LEO	1.3	61.7

Jiri Borovicka reported: "*We performed double station video observations under good skies in the south of the Czech Republic. Definite activity but much lower than in 1995. Still, experienced observer Kamil Hornoch counted 44 AMO meteors during an hour (4^h26^m–5^h23^m UT), 16 of them during the 10 minutes interval centered at 4^h50^m UT (star limiting magnitude was near 6.5 at that time).*

Preliminary inspection of our narrow field intensified video cameras revealed only few alpha Monocerotid records."

Figure 12 – Stacked image of 17 AMOs on CAMS 3900 hosted by Société Lorraine d'Astronomie, November 22 04^h43^m– 05^h21^m UT, Nancy, France (courtesy: Tioga Gulon).

Figure 13 – BRAMON SMZ1 station, Brazil (Courtesy Sergio Mazzi).

Figure 14 – BRAMON Station Maranguape Ceará, Brazil (courtesy: Lauriston de Sousa Trindade).

Ivan Sergei from Belarus reports: "*I watched the log files from my RMS (Radio Meteor System, 88.6 MHz). On the interval 04^h40^m–05^h00^m UT some increase has been registered in the level of meteor echoes. From 03^h42^m UT to 05^h00^m UT 22.11.2019 I heard 91 meteors. Brief summary: some enhancement in meteor activity in the radio range has occurred.*"

Table 2 – Radio Meteor System, 88.6 MHz operated by Ivan Sergei in Belarus.

22.11.2019		21.11.2019	
3.00-03.20 UT	10	03.00-03.20 UT	22
3.20-03.40 UT	6	03.20-03.40 UT	18
3.40-04.00 UT	6	03.40-04.00 UT	25
04.00-04.20 UT	10	04.00-04.20 UT	15
04.20-04.40 UT	8	04.20-04.40 UT	15
4.40-05.00 UT	30	04.40-05.00 UT	18
5.00-05.20 UT	19	05.00-05.20 UT	11
05.20-05.40 UT	14	05.20-05.40 UT	8
05.40-06.00 UT	14	05.40-06.00 UT	20

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Esko Lyytinen and Peter Jenniskens (2020). “Likely alpha Monocerotids (AMO#246) outburst on the morning of November 22, 2019”. *eMetN*, **5**, 11–12.

Draconids (DRA#009) video results on 8 October 2019

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A report is presented on the 2019 Draconid (DRA#009) observations made by the author.

1 Introduction

My camera detected notable Draconid activity on 08 October. So far, the DRA activity suddenly stopped after 14^h15^m UT for my camera and for the rest of the night (more than 10 hours of clear sky) only one additional Draconid meteor was detected.

It started at 12^h58^m UT and captured 11 Draconid meteors at the following time (UT):

- $13^h12^m06^s$
- $13^h39^m16^s$
- $13^h45^m58^s$
- $13^h47^m02^s$
- $13^h47^m32^s$
- $14^h00^m41^s$
- $14^h11^m48^s$
- $14^h12^m23^s$
- $14^h13^m42^s$
- $14^h15^m34^s$
- $19^h47^m16^s$

Figure 1 – This is a composite image of photographic meteors during 13^h58^m–20^h02^m UT on 8 October 2019, some meteors coming from the DRA radiant are visible, they appeared in the very beginning of the session.

Leonids (LEO#013) 2019 possible activity enhancements

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An overview is presented of possible enhanced activity for the Leonids in 2019.

1 2019 Leonid predictions

In 2019 the Leonids could produce some activity enhancements in addition to the annual maximum (Kasuo Kinoshita[5]). Potentially the most interesting one is a quite prominent peak with an expected ZHR = 27, it is related to the 1400 trail, its computed time of maximum is at 2^h35^m UT on 16 November, which is two days before the annual maximum. However, the reliability of this outburst prediction is quite low, because the Earth encounters the part of the 1400 trail that is composed by particles with negative ejection velocities (around –16 m/s). Such trail parts are depleted of particles as the smallest of these are blown away by radiation pressure. Nevertheless, we suggest that some remaining larger particles could produce a notable activity enhancement with a high portion of bright meteors.

As shown in the *Figure 1*, the annual maximum itself overlaps with a few small outbursts produced by different trails. For instance, at 13^h35^m UT on 17 November a small enhancement is possible with a ZHR = 6–7 on top of the annual maximum (total ZHR = 19). The prediction of this enhancement is much more reliable as it is caused by the encounter with the 1866 trail composed of particles with positive ejection velocities, though very high (93 m/s). This means small sizes of particles, so the share of faint meteors could increase at the given time of maximum. Also, the number of radio meteors could significantly increase.

The third small activity enhancement is visible in the *Figure 1* after the annual maximum, the computed time of this peak is 4^h13^m UT on 19 November with a ZHR = 4 while together with the annual activity the total would be ZHR = 14. This enhancement is related to the 1800 trail, but just like the first peak, with particles ejected with a high negative ejection velocity of –26 m/s, which makes the reliability of this enhancement prediction very low.

For some additional information, consult my website[6].

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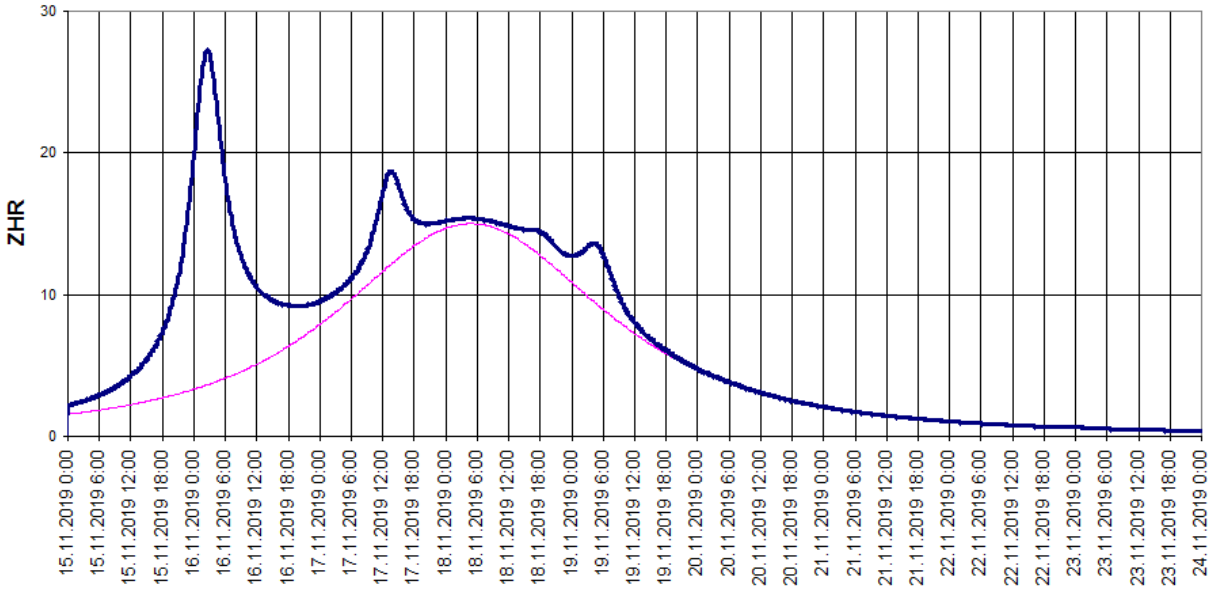

Figure 1 – Assumed profile of overall Leonid activity (blue line) and its background component (red line).

[5] http://jcometobs.web.fc2.com/ [Orbital elements of the comet 55P/Tempel-Tuttle]

[6] http://feraj.ru/Radiants/Predictions/Leonids2019eng.html

December alpha Aurigids (DAR#258)

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A case study was dedicated to the earlier discovered fireball shower, the December alpha Aurigids, listed in the IAU working list of meteor showers as DAR#258. A first search to establish the range in time, radiant and velocity resulted in a very unlikely wide range in time and radiant area. Further tests made it understood that the discrimination criteria associated mainly sporadic and other shower orbits. A second search within a narrower range in time, radiant and velocity resulted in a dataset of possible December alpha Aurigids orbits representing very weak activity and a diffuse radiant with no indication for any periodicity and no dominant presence of fireballs or bright meteors. There is no conclusive evidence for the existence of this shower.

1 Introduction

Terentjeva (1990) analyzed fireball orbits and defined 78 fireball streams. A similar search was made on over 1000 photographic orbits with meteors brighter than magnitude –3 (Porubčan and Gavajdová, 1994). One of the showers that were identified in both studies were the December alpha Aurigids (DAR#258). The orbital data has been listed in *Table 1*.

On December 12–13, 1996, Russian observers witnessed a meteor outburst from a radiant at α_g = 78.8° and δ_g = +43°. A possible association with the December alpha Aurigids (DAR#258) was suggested (Terentjeva, 1998). However, checking through CAMS orbit data of recent years, the DAR#258 meteor stream remains remarkable absent. On request of Dr. A.K. Terentjeva, I made a search for this stream based on our orbit dataset.

Table 1 – The December alpha Aurigids (DAR#258) from literature.

	Terentjeva (1990)	Porubčan and Gavajdová (1994)
$\lambda_\odot$	274°	262.2°
α_g	85°	84.9°
δ_g	+42°	+35.5°
v_g	–	19.5 km/s
v_∞	22.5 km/s	–
a	2.096 A.U.	2.279 A.U.
q	0.694 A.U.	0.668 A.U.
e	0.700	0.7069
ω	253.6°	257.7°
Ω	274.0°	270.0°
i	11.2°	7.2°

2 The available orbit data

We have the following orbit data collected over 12 years, status as until July 2019, available for our search:

- EDMOND EU+world with 317830 orbits (until 2016). EDMOND collects data from different European networks which altogether operate 311 cameras (Kornos et al., 2014).
- SonotaCo with 284138 orbits (2007–2018). SonotaCo is an amateur video network with over 100 cameras in Japan (SonotaCo, 2009).
- CAMS with 110521 orbits (October 2010 – March 2013), (Jenniskens et al., 2011, 2016). For clarity, the CAMS BeNeLux orbits since April 2013 are not included in this dataset because this data is still under embargo.

In total 712489 video meteor orbits are publicly available. Our methodology to detect associated orbits has been explained in a previous case study (Roggemans et al., 2019).

3 A preliminary search

To locate the position where December alpha Aurigids can be found we take the orbital elements given by Porubčan and Gavajdová (1994) as reference (see *Table 1*).

The D-criteria that we use are these of Southworth and Hawkins (1963), Drummond (1981) and Jopek (1993) combined. We define five different classes with specific threshold levels of similarity:

- Low: $D_{SH} < 0.25$ & $D_D < 0.105$ & $D_H < 0.25$;
- Medium low: $D_{SH} < 0.2$ & $D_D < 0.08$ & $D_H < 0.2$;
- Medium high: $D_{SH} < 0.15$ & $D_D < 0.06$ & $D_H < 0.15$;
- High: $D_{SH} < 0.1$ & $D_D < 0.04$ & $D_H < 0.1$.
- Very high: $D_{SH} < 0.05$ & $D_D < 0.02$ & $D_H < 0.05$.

This first test results in as many as 1867 orbits that fulfill the low threshold criteria class with $D_D < 0.105$. Unfortunately, the spread on the orbits is too large to represent a realistic range where December alpha Aurigids may be found:

- Time interval: $72° < \lambda_\odot < 305°$;
- Radiant area: $57° < \alpha_g < 113°$ & $+11° < \delta_g < +56°$;
- Velocity: 15 km/s < v_g < 24 km/s.

Most of these orbits are sporadics or were previously classified belonging to other meteor streams. The similarity criteria indicate only a degree of geometric similarity. Using for instance a single discrimination criterion with a low threshold will almost certainly result in pure chance orbit associations that physically have absolutely nothing in common.

Also, the medium low and medium high threshold criteria are too weak to detect a reasonable compact shower. The type of orbit in this region near the ecliptic with a large concentration of sporadic meteoroids with similar orbits makes it rather tricky to define any average orbits based on D-criteria only. To limit the contamination with pure chance similar orbits, the range found for the high threshold similarity class ($D_D < 0.04$) of the preliminary search is taken to make a selection of orbits in which December alpha Aurigids orbits can be found, adding 3° in solar longitude extra margin at either side of the activity interval:

- Time interval: $260° < \lambda_\odot < 282°$;
- Radiant area: $76° < \alpha_g < 92°$ & $+27° < \delta_g < +42°$;
- Velocity: 18 km/s < v_g < 21 km/s.

In total we have 92368 of the 712489 orbits in this time interval and only 139 fit with the limits set for radiant area and velocity range. After 3 iteration an average orbit is found for 134 orbits. *Table 2* lists the averaged orbit for each threshold level. The high threshold class has the most representative orbit.

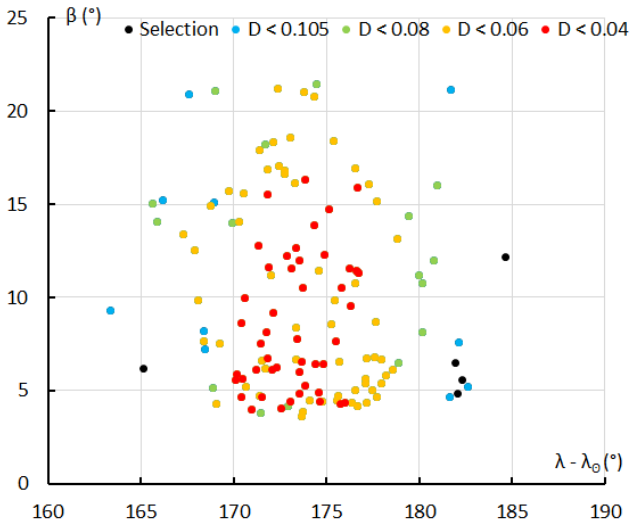

Figure 1 – Plot of the ecliptic latitude β against the Sun centered longitude λ – λ☉. The different colors represent the 4 different threshold levels of similarity.

Plotting the ecliptic latitude β against the Sun centered longitude $\lambda - \lambda_\odot$ neutralizes the radiant drift due to the movement of the Earth around the Sun. The resulting radiant distribution is rather diffuse and there is no indication of any concentration in *Figure 1*. The same image appears in the plot of inclination against the longitude of perihelion Π (*Figure 2*), no real concentration of orbits is displayed.

Table 2 – The average orbits for the four different threshold levels of the D-criteria obtained for the DAR#258 meteor stream.

	Low	Medium low	Medium high	High
$\lambda_\odot$	270.6°	270.2°	270.6°	271.6°
α_g	82.7°	82.7°	82.7°	84.5°
δ_g	+31.9°	+31.9°	+31.0°	+30.9°
v_g	19.5	19.5	19.4	19.4
a	2.3	2.3	2.3	2.4
q	0.674	0.674	0.675	0.677
e	0.711	0.709	0.707	0.713
ω	255.6°	255.7°	255.6°	255.4°
Ω	270.7°	270.7°	270.7°	271.1°
i	5.9°	5.9°	5.6°	5.2°
N	133	123	107	48

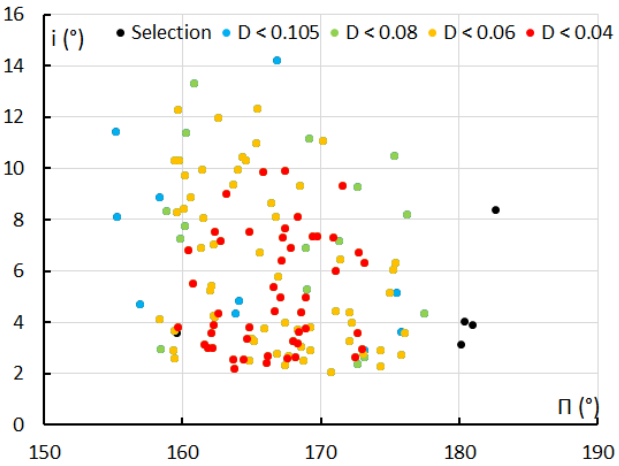

Figure 2 – The plot of inclination i (°) against the longitude of perihelion Π (°) for the 139-selected possible DAR-orbits. The colors mark the different threshold levels of the D-criteria for the reference orbit listed in Table 2.

The December alpha Aurigids were discovered using fireball orbits, meteors brighter than magnitude –3. Looking at our sample of similar orbits, there is no indication for any dominant presence of bright meteors, the brightest having $Mag_{Abs} = -4.5$, the faintest $Mag_{Abs} = +3.0$, with an average of $Mag_{Abs} = -0.2$ and only 7 cases brighter than Mag_{Abs} –3.0. This is nothing like a fireball stream.

The previously identified fireball stream (Porubčan and Gavajdová, 1994) was found from a much smaller dataset with photographic orbits of meteors. It is strange that our much bigger dataset of video meteor orbits obtained during a period of 12 years does not confirm this. It is not clear how the photographic meteor orbits were identified as possible DAR#258 orbits, unless that a stream search was

used based on the Southworth-Hawkins D discriminant only. This could explain the discrepancy in both results. These short period orbits close to the ecliptic are part of a very rich dust population. The initial attempt to detect the range to search for possible DAR#258 orbits using three different discrimination criteria combined resulted in a huge number of orbits that all fulfilled the discrimination criteria, with a huge radiant area with a northern and southern branch either side of the ecliptic. This sample included orbits that were previously identified as late Taurids and associated meteor showers and even Geminids. The explanation is very simple that the D-criteria indicate the similarity between orbits but prove no physical relationship. Short period orbits such as the DAR#258 orbit are very tricky when analyzed by D criteria.

If previous stream searches were based on the Southworth-Hawkins criteria only, it is very likely that relationships were assumed between unrelated orbits, perhaps including orbits that could also be successfully identified as Geminids, Taurids or associated showers. The question remains if it was checked that the D criterion used could also result in a positive match with other better-established meteor streams?

In order to minimize the risk of pure chance orbit association we limited the range on our selection in time, radiant position and velocity speed. The resulting sample of possible DAR#258 orbits is rather small and diffuse and leaves the doubt whether or not this sufficiently proves that this shower exists? Are there enough similar but unrelated sporadic orbits that could explain the discovery of this shower?

The orbits we identified as DAR#258 orbits were sampled in all years between 2007 and 2018, there is no indication for any periodicity. The outburst mentioned in 1996 happened near the Geminid maximum. We find no indication that this could be related to the DAR#258 shower like identified in the IAU Shower list.

4 Conclusion

This case study did not result in any conclusive evidence for the existence of the DAR#258 meteor shower. This type of short period orbits near the ecliptic is problematic to make shower associations using similarity discrimination criteria. Too optimistic assumptions to interpret orbit associations based on these D-criteria may result in selections of similar orbits by pure chance and risk to end up with spurious meteor showers.

Acknowledgment

The author is very grateful to *Jakub Koukal* for updating the dataset of EDMOND, to the SonotaCo Network members in Japan who have been observing every night for more than 10 years (Simultaneously Observed Meteor Data Sets SNM2007–SNM2018), to CAMS (2010–2013) and to all camera operators involved in these camera networks.

EDMOND[7] includes: BOAM (*Base des Observateurs Amateurs de Meteores, France*), CEMeNt (*Central European Meteor Network, cross-border network of Czech and Slovak amateur observers*), CMN (*Croatian Meteor Network or HrvatskaMeteorskaMreza, Croatia*), FMA (*Fachgruppe Meteorastronomie, Switzerland*), HMN (*HungarianMeteor Network or Magyar Hullocsillagok Egyesulet, Hungary*), IMO VMN (*IMO Video Meteor Network*), MeteorsUA (*Ukraine*), IMTN (*Italian amateur observers in Italian Meteor and TLE Network, Italy*), NEMETODE (*Network for Meteor Triangulation and Orbit Determination, United Kingdom*), PFN (*Polish Fireball Network or Pracownia Komet i Meteorow, PkiM, Poland*), Stjerneskud (*Danish all-sky fireball cameras network, Denmark*), SVMN (*Slovak Video Meteor Network, Slovakia*), UKMON (*UK Meteor Observation Network, United Kingdom*).

The CAMS BeNeLux team is operated by the following volunteers: *Hans Betlem* (Leiden, CAMS 371, 372 and 373), *Felix Bettonvil* (Utrecht, CAMS 376 and 377) , *Jean-Marie Biets* (Wilderen, CAMS 379, 380, 381 and 382), *Martin Breukers* (Hengelo, CAMS 320, 321, 322, 323, 324, 325, 326, 327, RMS 328 and 329), *Guiseppe Canonaco* (Genk, RMS 003815), *Bart Dessoy* (Zoersel, CAMS 397, 398, 804, 805, 806 and 888), *Franky Dubois* (Langemark, CAMS 386), *Jean-Paul Dumoulin / Christian Wanlin* (Grapfontaine, CAMS 814, 815 and RMS 003814), *Luc Gobin* (Mechelen, CAMS 390, 391, 807 and 808), *Tioga Gulon* (Nancy, France, CAMS 3900 and 3901), *Robert Haas* (Alphen aan de Rijn, CAMS 3160, 3161, 3162, 3163, 3164, 3165, 3166 and 3167), *Robert Haas / Edwin van Dijk* (Burlage, CAMS 801, 802, 821 and 822) , *Robert Haas* (Texel, CAMS 810, 811, 812 and 813), *Klaas Jobse* (Oostkapelle, CAMS 3030, 3031, 3032, 3033, 3034, 3035, 3036 and 3037), *Carl Johannink* (Gronau, CAMS 311, 312, 313, 314, 315, 316, 317 and 318), *Hervé Lamy* (Ukkel, CAMS 393; Dourbes, CAMS 394 and 395), *Koen Miskotte* (Ermelo, CAMS 351, 352, 353 and 354) , *Piet Neels* (Terschelling, CAMS 841, 842, 843 and 844), *Piet Neels* (Ooltgensplaat, CAMS 340, 341, 342, 343, 344 and 345, 349, 840), *Tim Polfliet* (Gent, CAMS 396), *Steve Rau* (Zillebeke, CAMS 3850 and 3852), *Paul Roggemans* (Mechelen, CAMS 383, 384, 388, 389, 399, 809, RMS 003830 and 003831), *Hans Schremmer* (Niederkruechten, CAMS 803), *Erwin van Ballegoij* (CAMS 347 and 348) and *Marco Van der Weide* (CAMS 3110).

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[7] https://fmph.uniba.sk/microsites/daa/daa/veda-a-vyskum/meteory/edmond/

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Perseids 2019: another peak in activity around solar longitude 141.0?

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Observations in August 2019 confirmed a secondary peak in the Perseid activity profile at solar longitude 141.0°, which was noticed in the 2018 Perseid activity as well as in previous years of observations. An analysis is presented of the 2019 observational data compared with the 2018 results.

Figure 1 – Composition made from images of Perseids in the night 13–14 August 2019 taken with an ASI290MM camera in combination with a 2.5 mm fish eye lens. The recordings were made by Bart Declercq from his observatory in Haaltert, Belgium. The brightest Perseid was magnitude –7 and left a persistent train that was visible for 1 minute by the naked eye.

1 Introduction

It is Tuesday morning, August 14, 2018. European meteor observers notice that the Perseids are well active that night. The first author subsequently extensively analyzed the available visual data (Miskotte, 2018a; 2018b). It showed that around the traditional maximum there was some extra activity from bright meteors caused by the Perseid filament. A bigger surprise was that a serious peak in activity was found on the night of 13–14 August! The maximum felt just before solar longitude 141.0° and had a ZHR of 85. Searching back in old data around the same solar longitude and the same moonlight conditions from 1986, 1994, 2002 and 2010 showed that there were previously peaks in activity around solar longitude 141.0°, but the ZHR was not as high as in 2018.

2 2019: another peak in Perseid activity around solar longitude 141.0?

There was excitement among the authors when the famous radio curve from Hirofumi Sigumoto was online. After the traditional maximum, a second peak in activity was found just after solar longitude 141.0°! Unfortunately, a search on the IMO website for visual observing data around solar longitude 141.0° yielded rather few observations due to moonlight and/or bad weather conditions. In this article we will take a closer look at available radio-, CAMS- and visual meteor observations.

Bruce McCurdy's observation

The only observation around solar longitude 141.0° (= August 14, 2019 8^h00^m UT) comes from Bruce McCurdy from Canada. His time interval runs from August 14, 2019 6^h04^m to 10^h22^m UT. Unfortunately, due to the combination of moonlight and smoke from wildfires, McCurdy had a low limiting magnitude. He wrote:

"*Observed Perseids within ± 24 hours of the peak for the 32nd consecutive year. Barely. After a long run of crummy weather that wiped out the peak and several nights before, it cleared on the 13th to allow one session of post-peak viewing in the wee hours of the 14th. At that, bright moonlight interacting with incoming forest fire smoke reduced the sky at the "dark site" to urban or at best suburban quality, limiting magnitude about 4.5 at best. Just 27 Perseids observed in 4.0 hours T_{eff}, with a bias towards brighter members (9 of mag –1 or brighter). Better late than never, but better luck next year!*"

McCurdy didn't see Perseids in the first hour, but during the other hours he did. Despite the very poor circumstances, we calculated the data under the motto: better something than nothing. An assumed population index *r* of 2.00 has been used in the calculations. This resulted in ZHRs between 40 and 60.

Michel Vandeputte's observations

Michel (2nd author) was able to observe this night from Belgium (unfortunately Ermelo hometown of the first author was cloudy that night) between 23^h30^m and 03^h15^m UT (= between solar longitude 140.661° and 140.811°). He wrote:

"*This night was also clear, actually much better in quality than the previous night. There was some wind this night. First, I had to sleep a little, but I was woken up long before my alarm went off caused by a text from Simon Vanderkerken. He had seen a fireball from his car. I couldn't sleep anymore and decided to go under the starry sky a little earlier. This time I opted for a session on the ridge, given the more stable weather situation. The moonlight seemed many times more disturbing than during 12–13 August. My view was focused on the northeast. Observations were done between 23^h30^m and 3^h00^m UT. When I started immediately there appeared a grandiose –6 to –7 PER with a long persistent train across the north!! I was able to follow the persistent train for one minute. Even more bright Perseids appeared in that first hour … Perhaps I should have observed a little earlier? I am curious what the all sky cameras will show. For the rest, the activity actually continued quite well. Certainly, in the last hour it was downright good, when the Moon disappeared behind the edge of the forest. Lots of activity, lots of weak stuff! ZHR must certainly have been > 50. The end of the session was one not to forget … a combination of a green-white –2, a +0, a –1 and a –6 Perseïd!! What an end of this session!!*"

The question here is, did Michel observe this last hour of the first increase in activity to the second peak just as in 2018?

Figure 2 – The Perseid fireball of August 14, 2019 at $3^h14^m38^s$ UT (magnitude –6) recorded by Bart Declercq from Haaltert, Belgium. The fireball appeared in the constellation Auriga.

3 The radio ZHR curve from Hirofumi Sigumoto

Figure 3 shows the radio curve of the Hirofumi Sugimoto website[8]. The green line shows the ZHR curve based on radio observations from 2018. The way Sugimoto converts radio observations into a visual ZHR curve was described in his article on Meteornews (Sugimoto, 2017). The peak just after solar longitude 141.0° is clearly visible.

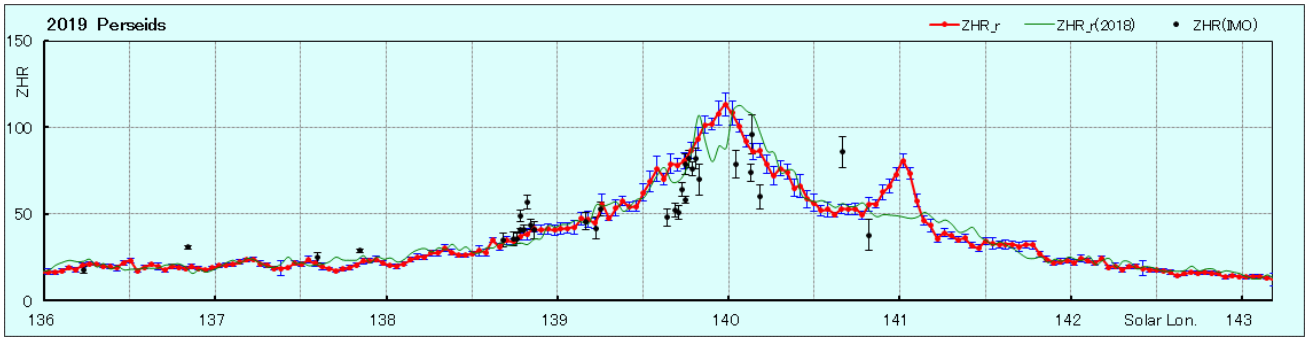

Figure 3 – The Perseid 2019 ZHR curve based on data collected worldwide by RMOB and made by Sugimoto.

[8] http://www5f.biglobe.ne.jp/~hro/Flash/2019/PER/index.html

4 Radio observations by Felix Verbelen (Belgium)

Inquiries with radio observer Felix Verbelen also yielded an interesting observation. *Figure 4* shows a comparison between 2018 and 2019. It concerns the radio reflections of more than 10 seconds (counted manually). The hour totals always relate to the past hour and were averaged according to the formula:

$$N(h) = \frac{n(h-1)}{4} + \frac{n(h)}{2} + \frac{n(h+1)}{4}$$

Felix always uses the reflections that last longer than 10 seconds because they usually correspond best with the visual observations.

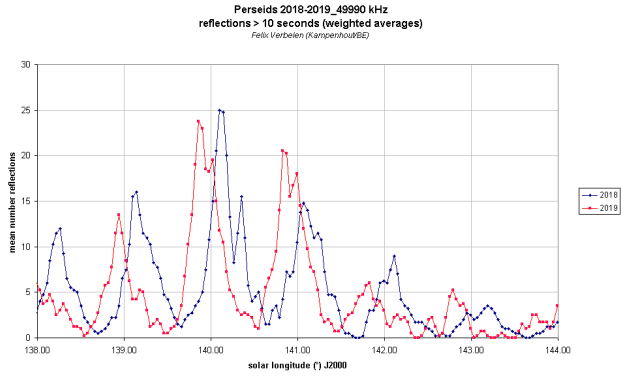

Figure 4 – Radio data from the Perseids 2019 of Felix Verbelen with reflections of 10 or more seconds. The blue curve represents 2018, the red curve 2019.

It is clearly visible that the activity of the Perseids with reflections of 10 or more seconds in 2019 was higher than in 2018. Unfortunately, his data from 2018 shows no additional activity as observed by European visual observers.

5 Comparison of CAMS data from 2018 and 2019

We also looked at the CAMS data (worldwide) from 2018 and 2019 (*Figure 5*)[9]. In 2019 we clearly see a much larger amount of Perseids. But unfortunately, this is also the case with the other meteor showers and sporadic meteors. So here unfortunately disruption due to the weather and / or influences by the new CAMS networks in the southern hemisphere plays a role here. In order to eliminate weather and new network influences, we also looked at the relationship between the numbers of Perseids and other meteor showers.

The well-known images (*Figure 5*) also have a table with the numbers of meteors for each meteor shower. This determines the ratio in percentages of Perseids compared to the other showers in the night of August 14, 2016, 2018 and 2019. Here again we encountered the problem that the new southern CAMS networks record relatively more meteors from the southern meteor showers such as e.g. the Aquariid complex or meteor showers such as the eta Eridanids (in 2016: 4 meteors; in 2018: 2 meteors; in 2019: 36 meteors) and August Omicron Aquariids (in 2016: 4 meteors; in 2018: 12 meteors; in 2019: 43 meteors). That is why calculations were made without these meteor showers. The result is shown in *Table 1*. It is noticeable that the share of the Perseids in the total amount of meteor showers is virtually the same. So, this way no additional confirmation has been found of higher Perseid activity in 2018 and 2019 compared to 2016. Unfortunately, we can't do much with the CAMS data in this case.

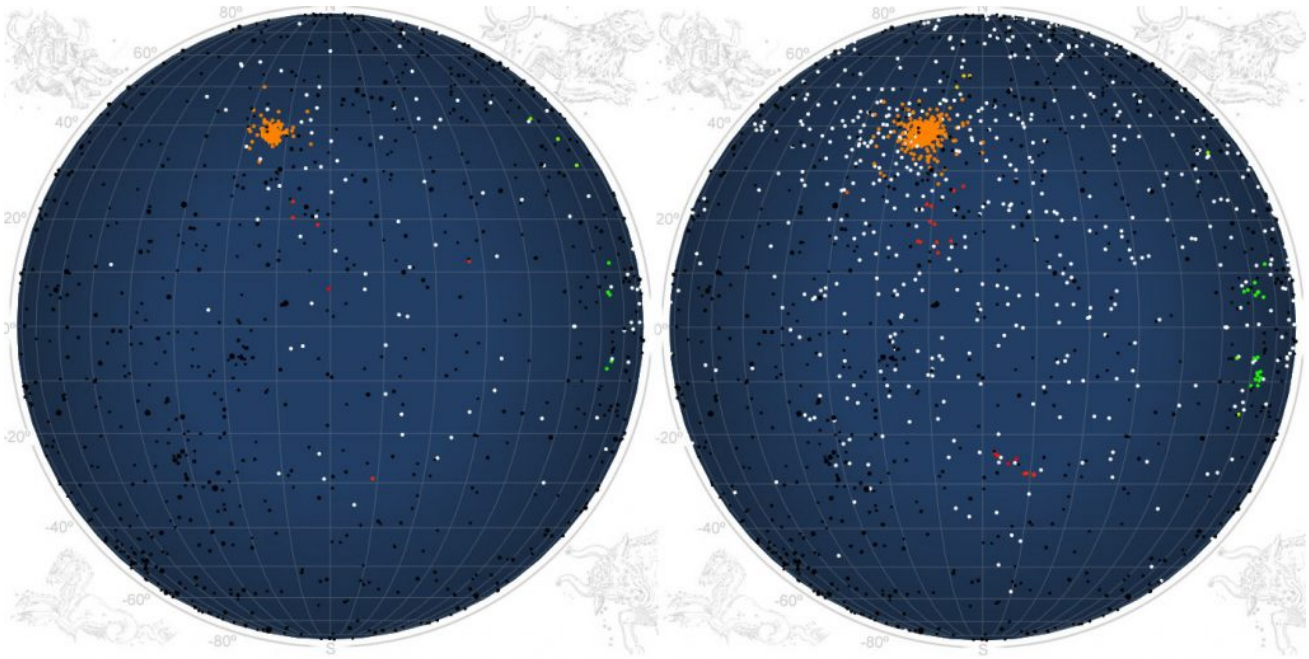

Figure 5 – CAMS data from 14 August 2018 (left) and 2019 (right).

[9] Source: http://cams.seti.org/FDL/

Table 1 – Ratio Perseids and other meteor showers on August 14, 2016, 2018 & 2019.

Date	nPer	nSHO	%PER	Date	nPER	nSHO	%PER	Date	nPER	nSHO	%PER	
14–8 2016	263	30	89.8	14–8 2018	905	73	92.5	14–8 2019	2383	234	91.1	
14–8 2016	263	22	92.3	14–8 2018	905	59	93.9	14–8 2019	2383	155	93.9	Excl. AOA &ARI

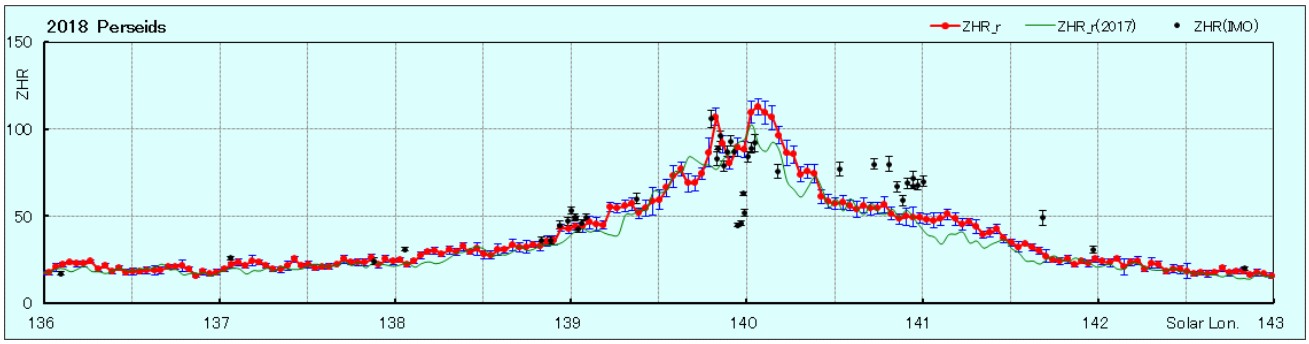

Figure 6 – Perseid ZHR curve for 2018 based on worldwide radio observations (RMOB) and made by Sugimoto.

6 What do we know now?

Unfortunately, there is hardly any visual evidence that there was a peak in activity in 2019 at solar longitude 141.0°. In 2018 this peak was well observed. The 2019 radio curve of Sugimoto indicates a significant peak in activity, comparable to the visual peak of 2018. Unfortunately, Sugimoto's curve for 2018 (*Figure 6*) does not show a peak in activity.

To see how radio ZHR values relate to individual visual ZHR values, the ZHR values found from the data of Bruce McCurdy and Michel Vandeputte were put together in one graph. The result is displayed in *Figure 7*.

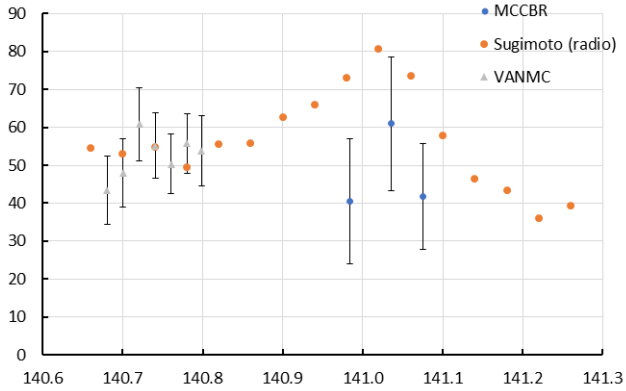

Figure 7 – The ZHR values found from the data from Bruce McCurdy from Canada (blue dots) and Michel Vandeputte from Belgium (grey triangles) compared to the radio curve from Sugimoto (orange points).

Michel Vandeputte's data fits in nicely with the radio ZHR graph of Sugimoto. The ZHR found from the observation of Bruce McCurdy does not fit well, but does have the highest ZHR around the maximum of the radio ZHR curve. The lower ZHR curve relative to the radio ZHR curve is perhaps due to the greater atmospheric extinction caused by the smoke from the wildfires.

Finally, the shape of the ZHR curve was also examined. Therefore, a graph has been made that combines the radio ZHR curve from 2019 with the visual ZHR curve from 2018. *Figure 8* shows the result.

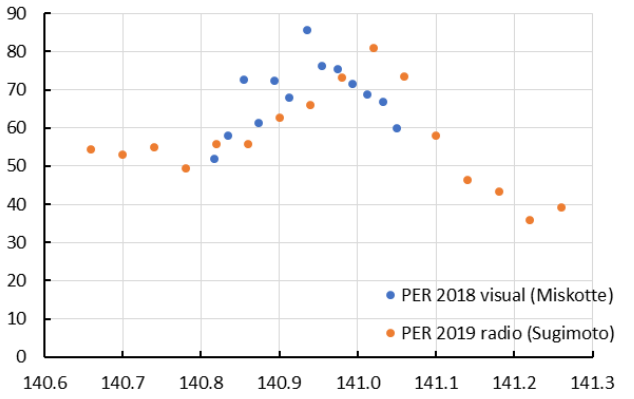

Figure 8 – Comparison of the visual Perseids 2018 ZHR graph with the radio Perseids 2019 ZHR graph.

It is striking that both peaks are reasonably in agreement in terms of appearance and height. The radio peak fell two hours later in 2019 compared to the visual peak in 2018. The question now arises as to why the radio data from 2018 shows NO peak around solar longitude 141.0°? Perhaps it can be explained by the fact that the visual observations from 2018 show that the *r* value was almost normal during that peak. The observations of Vandeputte and McCurdy from 2019 suggest brighter Perseids. The radio data from Felix Verbelen seems to support this. Perhaps an explanation is that the radio observation method picks up the bright meteors better than the weak meteors.

7 Conclusions and call for observations

It is clear that in 2019 the Perseids showed an extra peak in activity around solar longitude 141.0. This is mainly confirmed by radio data and barely by visual observations. In 2019, it seems that the peak was accompanied by somewhat brighter Perseids than in 2018. Therefore, an important call for observers in western North America, the Pacific and East Asia to continue to properly monitor Perseids beyond the traditional maximum! Perhaps another surprise is possible after 2018 and 2019.

The maximum found in 2018 (solar longitude 140.94°) will appear in 2020 on 13 August at 12^h45^m UT. It can still be observed from California until around 12^h30^m to 12^h45^m, so at a peak around 12^h45^m UT the increasing activity can still be observed well. Also, in north-east Asia it is possible to observe around that time, but the radiant will still be low. If the peak at the maximum found in 2019 (141.02° based on radio data), then this will take place at 14^h45^m UT. In that case, only the first increase to this peak is visible from California. Australia and East Asia are better locations, although the radiant in Australia remains low.

Acknowledgment

Thanks to Carl Johannink and Paul Roggemans for critically reading this article. Also, a word of thanks to Bruce McCurdy for his observation around solar longitude 141.0°. Hirofumi Sigumoto provided the source material of the Perseid radio ZHR curve.

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2019 Camelopardalid (CAM#451) outburst as seen by Global Meteor Network stations in New Mexico

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Global Meteor Network stations in New Mexico recorded three Camelopardalid (CAM#451) orbits during the predicted 2019 outburst. Here we present the details of observations and give the parameters of estimated orbits.

1 Introduction

The young Camelopardalid meteor shower, produced by the comet 209P/LINEAR, had an outburst in 2019. The main peak was predicted around 7^h44^m UT on 24 May at a very high declination geocentric radiant of RA=123.2°, Dec=+79.9°. The timing of the outburst favored observers in the western part of North America, Pacific, and Eastern Asia. A trail ejected in 1939 was predicted to cause this outburst of low activity (ZHR around 10). The modelling and prediction were done by Mikhail Maslov[10].

The Global Meteor Network (GMN)[11] is a world-wide network of low-cost meteor stations running open-source software on Raspberry Pi single-board computers. See Vida et al. (2019) for more details.

Three Camelopardalids were recorded by GMN stations in New Mexico (*Figures 2, 6* and *7*). Five different stations recorded these meteors, and observations were manually reduced using the tools in the RMS library[12] to ensure measurement quality, and the trajectories were computed using the Monte Carlo method of Vida et al. (2019).

2 Results

The three Camelopardalids were recorded in a ~4 hour window, from 04^h45^m to 09^h00^m UTC on May 24. *Figure 1* shows their orbits, and *Table 1* lists their orbital elements. We note that all observations were within ~1 degree of the predicted radiant at RA=123.2°, Dec=+79.9°, possibly indicating a tight radiant dispersion. Nevertheless, no

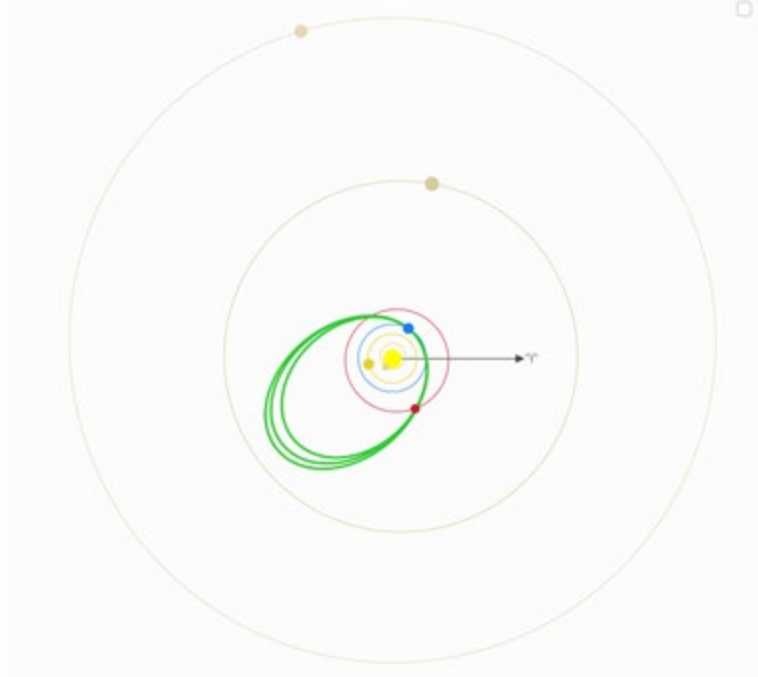

Figure 1 – Heliocentric orbits of the three recorded Camelopardalids (top view).

[10] Mikhail Maslov's predictions : http://feraj.ru/Radiants/Predictions/209p-ids2019eng.html
[11] Global Meteor Network: https://globalmeteornetwork.org/
[12] RMS library on GitHub: https://github.com/CroatianMeteorNetwork/RMS

Table 1 – The radiant and orbit data compared to recent values from literature. Note that the reported uncertainties estimate the measurement precision, not the absolute accuracy.

Orbit	$\lambda\odot$ (°)	α_g (°)	δ_g (°)	v_g (km/s)	a (AU)	q (AU)	e	ω (°)	Ω (°)	i (°)	Π (°)
20190524_044439	62.49	116.9 ±0.8	+79.7 ±0.1	15.63 ±0.05	2.57 ±0.03	0.9640 ±0.0005	0.625 ±0.004	151.1 ±0.2	62.5	20.88 ±0.06	213.57 ±0.19
20190524_072227	62.60	125.4 ±2.0	+79.6 ±0.4	14.91 ±0.06	2.41 ±0.03	0.9702 ±0.0011	0.598 ±0.005	152.6 ±0.4	62.6	20.10 ±0.17	215.22 ±0.40
20190524_085835	62.66	120.4 ±1.3	+78.9 ±0.2	15.61 ±0.03	2.68 ±0.04	0.9657 ±0.0009	0.639 ±0.004	151.8 ±0.3	62.7	20.61 ±0.07	214.46 ±0.31
2014 Jenniskens et al. (2018)	62.8	120.0	+78.7	15.3	2.59	0.966	0.627	151.5	62.8	20.2	
Annual Jenniskens et al. (2018)	62.9	119.7	+79.8	15.6	2.58	0.965	0.626	151.4	62.9	20.9	

Figure 2 – The Camelopardalid recorded at GMN station US000L on 2019-05-24 $04^h44^m39.04^s$ UTC.

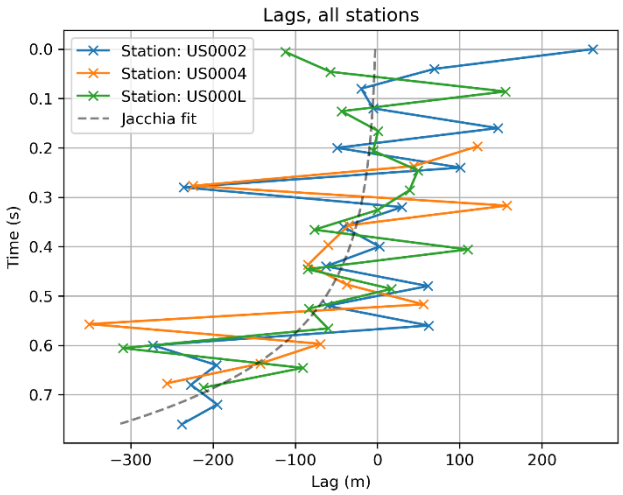

Figure 3 – Lag of the Camelopardalid recorded on 2019-05-24 $04^h44^m39.04^s$ UTC.

concrete conclusions about the dispersion can be made due to small number statistics. Our observations also agree well with values reported by other observers for the much larger 2014 outburst.

To give the readers some insight into the data, we give several plots. *Figure 3* shows the lag (the distance that the meteoroid falls behind an object with a constant velocity that is equal to the initial meteoroid velocity) of the first observed meteor. As it can be seen, the meteor shows obvious deceleration. *Figure 4* shows the ground track and the four stations that observed the second meteor, and *Figure 5* shows the spatial fit residuals for the third meteor. The average angular fit residuals for all meteors were on the order of 1 arc minute.

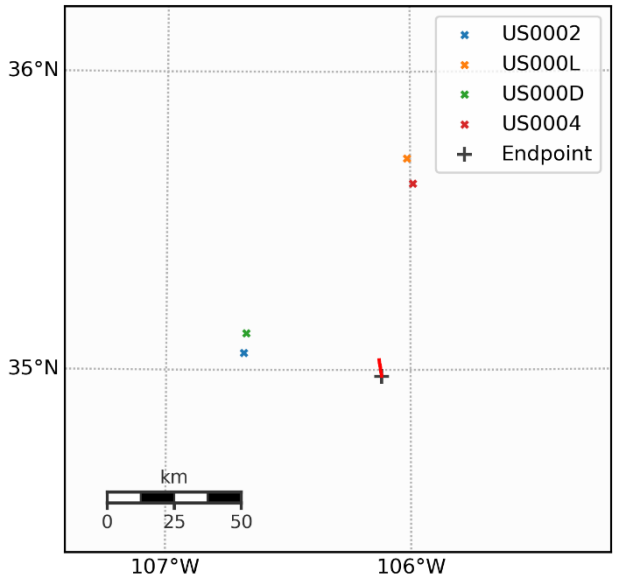

Figure 4 – Meteor ground track and stations for the meteor observed on 2019-05-24 $07^h22^m27.40^s$ UTC.

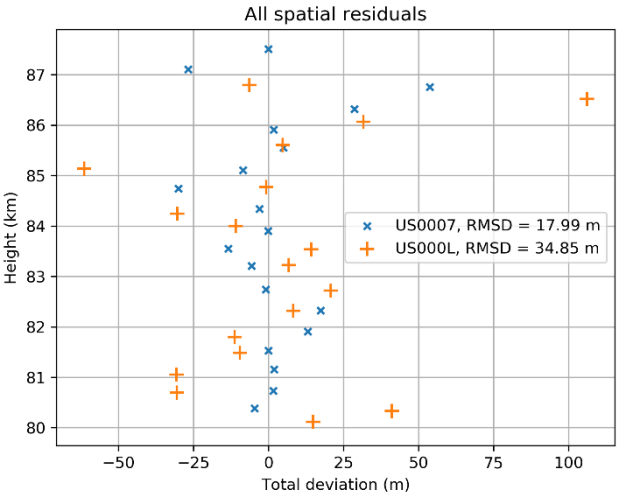

Figure 5 – Spatial residuals for the Camelopardalid 2019-05-24 $08^h58^m35.90^s$ UTC.

Figure 6 – The Camelopardalid recorded at GMN station US0007 on 2019-05-24 $08^h58^m35.90^s$ UTC.

This is a very encouraging result for the Global Meteor Network and confirmation of the main objectives that were set when the RMS project was started:

- We recorded unique outbursts.
- The data was collected and reduced in a matter of days.
- The results are consistent with models and previous work.

Acknowledgments

We would like to thank the folks operating the New Mexico Meteor Array for their hard work and dedication, and Paul Roggemans for editing this article.

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Figure 7 – The Camelopardalid recorded at GMN station US0004 on 2019-05-24 $07^h22^m27.40^s$ UTC.

The IAU working list of meteor shower

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The purpose of the IAU working list of meteor showers is to keep the literature on meteor showers transparent by attributing a unique name to each meteor shower, a three-letter code, and a number. The list has been rapidly expanded in recent years. The multitude of similar meteor shower entries, showers that were never documented in any publication, and the lack of a process to remove showers from the list, caused confusion in the meteor community. A short overview of some recent decisions and the current status is presented.

1 Introduction

Ever since observers noticed that meteors could be identified as shower members by their backwards produced path intersecting its shower radiant, this appeared to be a reliable method to determine new weak showers. The intersections produced by these single station trails resulted in large numbers of poorly documented radiant lists, most of which were just spurious and statistically not significant. Single station minor shower observations caused a lot of controversy.

A more reliable way to define meteor showers is to use orbits. Past 10 years, many video camera networks produced large numbers of orbits which allowed to search for minor meteor streams. In order to coordinate meteor shower definitions and to manage a reference list of meteor showers, the IAU dedicated a working group to take care of this task. The IAU Meteor Data Center (MDC) is responsible for the management of the IAU meteor shower Working List, under the auspices of Division F (Planetary Systems and Bioastronomy) of the International Astronomical Union.

The purpose of the list is to keep the literature transparent. That is done by attributing a unique name to each meteor shower, a three-letter code, and a number. Any newly discovered showers can be added when the discovery has been published in a paper, or if the paper has at least been submitted for publication.

2 Short historic review

A task group on meteor shower nomenclature was established in 2006 at the IAU General Assembly in Prague, Czech Republic. The task group was transformed into the Working Group of Shower Nomenclature at the IAU General Assembly in Rio de Janeiro, Brazil in 2009. The members of the committee are elected at the IAU General Assembly for a term of 3 years (Spurny et al., 2006; Jenniskens, 2006, 2007, 2008; Jopek and Jenniskens, 2011; Jopek and Kaňuchová, 2017).

The task of the working group is to establish a descriptive list of established meteor showers that can receive official names during the IAU General Assembly.

3 Decisions at Meteoroids 2019

Thursday 20 June the members present at the Meteoroids conference in Bratislava met to discuss the status of the Working list. *Dr. Peter Jenniskens* chaired the meeting and stressed that the purpose of the working list is to properly identify meteor showers described in literature and not to completely document meteor showers.

The large number of meteor showers added in recent years tend to inflate the working list and many entries might be either showers already listed with a different name or just spurious entries. The number of showers listed is not a real concern. The fact that no orbital data or incomplete orbital data were listed is also not a concern. It was not approved to remove showers based on these being insufficiently documented. Exceptionally, showers that were very well observed, but without any orbits recorded, should be included if enough evidence is available for the existence of the shower, e.g. a strong outburst.

What is a concern is that several entries were accepted in recent years which were announced to be submitted for publication while the publication never happened. It was suggested that these showers would be moved to the list of removed meteor showers or completely deleted. To avoid this situation in the future a proof of submission of the paper should be delivered in case of newly discovered meteor showers.

Another concern are the duplicates and spurious entries. At the meeting it was decided to remove meteor showers that do not exist. The arguments why a shower is considered not to exist must be published in a peer reviewed journal. Editors of amateur journals (*WGN, Journal of the IMO, MeteorNews, Radiant, etc.*) are suggested to review any such papers, perhaps by the members of the Working Group. Papers that suggest removal of meteor showers from the list should be sent to the Meteor Data Center and the proposed removal will be evaluated. The reason for removal should be mentioned. Reasons for removal can be "duplicate", "not statistically significant", etc.).

Proposed showers that were not published in a paper are deleted from the list and NOT added to the list of removed meteor showers. The codes and numbers become again available. New shower discoveries must be documented in

a paper to be submitted within half a year to the Meteor Data Center after requesting the shower name and number. These new showers will no more be listed "pro-tempore" before a paper has been submitted to a journal.

Another change concerns the shower duration, radiant and speed dispersion which were not included before. It was decided to add a look-up table listing the additional data in units of Solar Longitude, Sun-centered Ecliptic Longitude, Ecliptic Latitude, Geocentric Velocity and the IAU shower number.

As a result of these decisions, the list now contains 795 meteor showers of which 112 are established showers, 24 are shower complexes and 659 showers remaining on the working list, being documented in the scientific publications. A list of 172 removed showers remains accessible as archive of names used in the past. In total 137 showers were permanently deleted because there was no known publication that documented the discoveries.

4 What to do when a new shower is discovered?

Amateurs who run a camera network to collect orbits may detect unknown meteor showers whenever some unknown source produces an outburst when Earth passes through its previously unknown dust trail. This kind of 'discoveries' represent very valuable contributions to meteor astronomy. However, care should be taken to verify the statistical relevance of groups of similar orbits. To check the likely similarity of orbits, the so-called discrimination criteria are popular tools to check if different orbits may be part of the same meteor shower. The relevance of the D-criteria depends a lot on the type of orbits considered. For instances short period orbits embedded in the rich dust layer around the ecliptic may easily fit D-criteria although there is absolute no physical connection between the orbits. For instance, using the D-criterion of Southworth and Hawkins (1963) as only criterion will very likely result in large collections of similar orbits. Anyone may derive large numbers of showers from these types of orbits all fitting very well the D-criteria although being statistically pure chance associations and thus producing nothing else than false positives for meteor shower detections.

Before any new shower discovery is being claimed, the statistical relevance of the orbit associations should be carefully checked. In case of a reliable discovery, the facts should be documented in a paper to be submitted to a scientific journal, including online journals, which may include *eMeteorNews*.

In order to publish a paper on a newly identified meteor shower, a proper name for the shower, its IAU code and shower number should be requested. When requesting, send a draft of the manuscript that documents the discovery to the Meteor Data Center. The contact person for the IAU Working Group on Meteor Shower Nomenclature and its Working List of Meteor Showers[13] is Tadeusz Jopek (jopek at amu.edu.pl).

Acknowledgment

The author wishes to thank *Peter Jenniskens* and *Tadeusz Jopek* for reviewing this report and for the information provided.

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Northern Taurids (NTA#017) preliminary analysis based on IMO data 1989-2019

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I present a preliminary analysis of the NTA activity using visual data from 1989 to 2019. The aim of the study is to determine the peak activity intervals of the shower and the activity period of the shower. The data for this study were taken from the VMDB (IMO). Unfortunately, a substantial number of VMDB records turned out to be unreliable and had to be removed. The small numbers of meteors per hour are affected by statistical scatter, no precise time of maximum could be determined, but a flat plateau with best rates occurs in the interval 226°–232° solar longitude.

1 Introduction

A prerequisite for studying the activity of this shower was the mismatch between the maximum date in the IMO calendar (November 13) and the weekly newsletters published by *Robert Lunsford* (November 3). I decided to find out when the maximum activity of the shower actually appeared.

Here is the information from Robert Lunsford: "*According to the listing for the NTA's in the IAU Meteor Shower Center, the latest listing from CMOR (#6 Brown et al.) lists the maximum at solar longitude 219 which corresponds to November 2nd. This data was obtained between 2002 and 2008 and published in 2010. An earlier entry for the same source lists the maximum at SL 224.5 which corresponds to November 7th. Note that the earlier entry was based on 470 meteors verses 2281 for the more recent entry. A more recent study (2016) by Jenniskens lists the NTA maximum at SL 220 which corresponds to November 3rd. Although your graph displays a sharp peak on November 13th, the graph you provided by CMOR displays little change in activity from November 4th through the 16th. The range in dates for all listings in the IAU Meteor Shower Center for the NTA's are SL 214.1 October 28th to SL 234.4 November 17th. These are all reputable sources so I feel that we can safely conclude that the NTA's reach a plateau-like maximum during the first half of November and that any date within that range could possibly be the true maximum.*"

Table 1 – The NTA#017 data from the working list of meteor showers of the IAU Meteor Data Center.

$\lambda_{\odot}$ (°)	α_g	δ_g	N	Reference
224	58.6	+21.6	80	Porubcan and Kornos, 2002
224	44	+18.9	25	Kresak and Porubcan, 1970
214.1	44.7	+19.8	22	Jopek et al., 2003
224.5	53.3	+21	470	Brown et al., 2008
234.4	62	+24	475	SonotaCo, 2009
219	48.9	+17.7	2281	Brown et al., 2010
220	48.9	+20.7	509	Jenniskens et al., 2016
218.4	47.5	+19.3	3173	Jenniskens et al., 2018

2 Analyzing visual NTA data

In a first attempt ZHRs were calculated for all the NTA data found in the Visual Meteor Database (VMDB) of IMO. The result was a rather chaotic plot which did not allow to reconstruct an activity profile (*Figure 1*). It was clear that the VMDB data needs a quality check before the data can be used.

After removal of the most obvious garbage a new, much smaller selection of observing data remains. However even after removal of a lot of junk entries, the ZHR-values displayed still a huge scatter at low ZHR values (*Figure 2*).

Figure 3 shows a graph of the shower activity with the ZHR averaged in function of the Solar Longitude. The main shower activity maximum occurs in the Solar Longitude range from 226° to 231° with ZHR values of 4±1. A possible second maximum can be seen at about Solar Longitude 251° with a ZHR of about 5. At the Solar Longitude interval 214°–217° appears a slight increase in activity level to a ZHR = 4. At the beginning of the shower activity at Solar Longitudes 197° the ZHR is very low with values about 2. The shower activity starts probably earlier than Solar Longitude 196°–197°. Also, the activity of the NTA meteor stream does not end at 255° Solar Longitude. The IMO visual meteor database (VMDB) does not contain enough data to clearly define the period of shower activity. The graph in *Figure 3* shows a slight increase in shower activity at a Solar Longitude of about 241°–242° with a ZHR of 4. The activity profile of the meteor shower seems to indicate four concentrations. However, this activity profile does not really fit with the maxima obtained from previous studies (see *Table 1*).

The low ZHRs are based on small numbers of shower meteors which are to a large extend affected by statistical scatter. One or two meteors seen more or less make a big difference. Perhaps it makes no sense to try to make activity profiles when the numbers of shower meteors are too small?

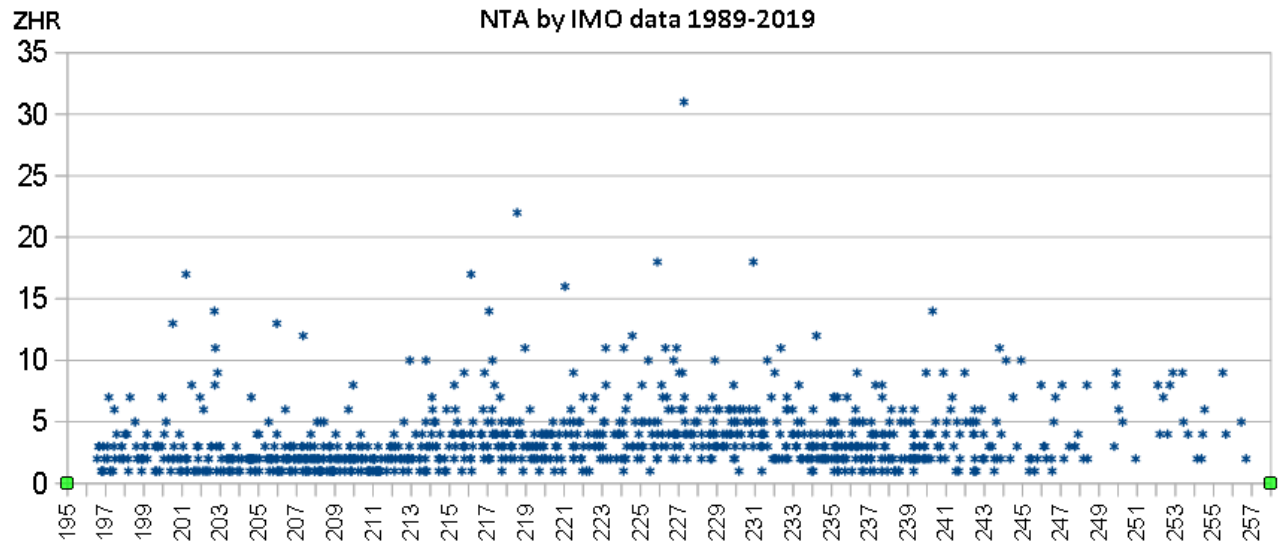

Figure 1 – All the ZHRs based on the unfiltered VMDB data.

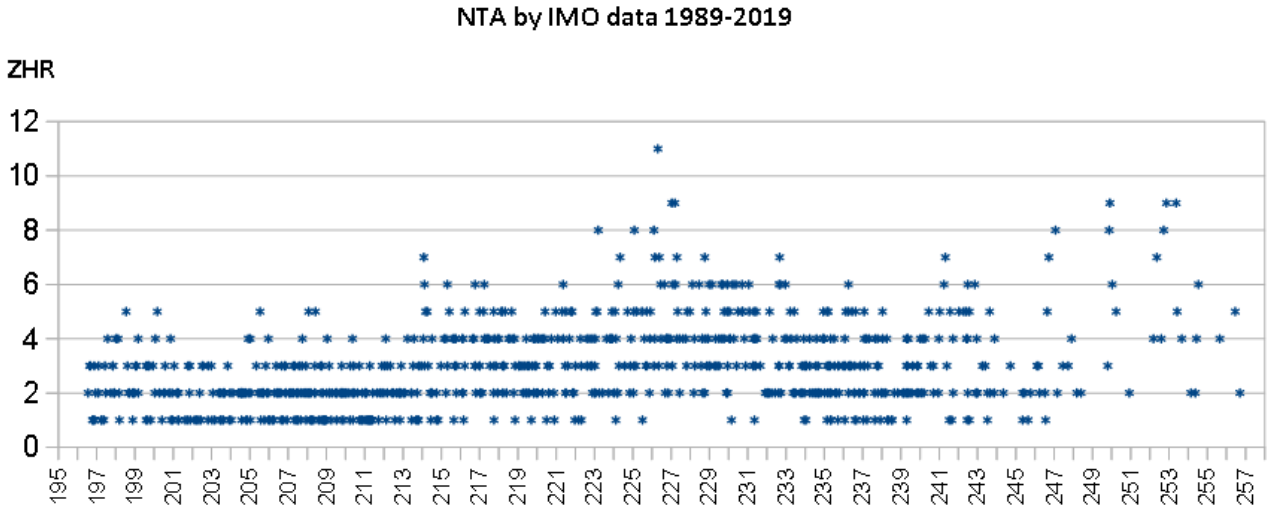

Figure 2 – NTA activity 1989-2019 based on the VMDB data after removal of obvious junk data.

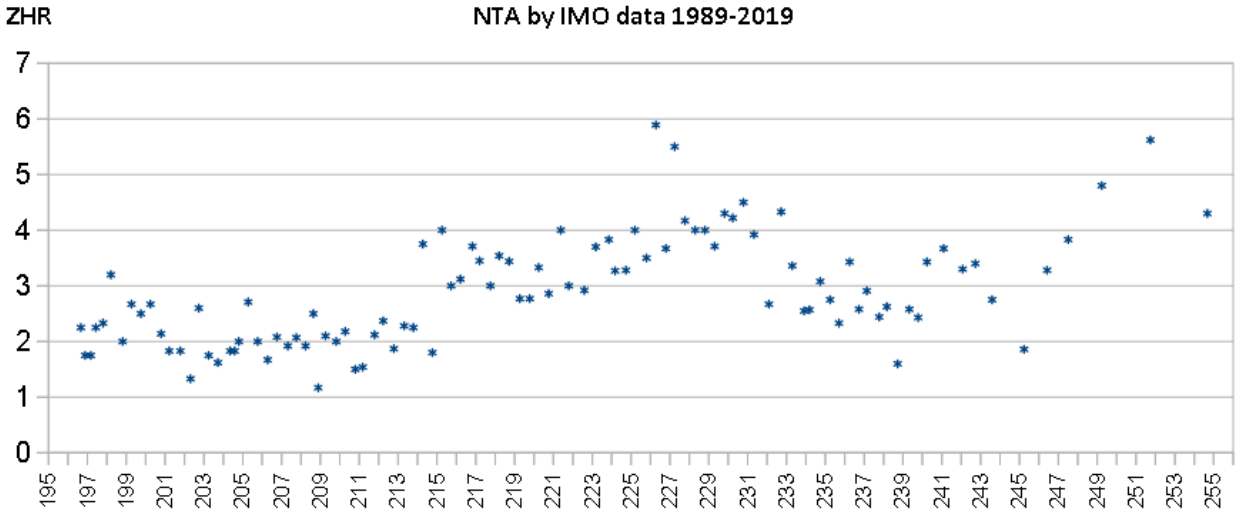

Figure 3 – The averaged ZHR values for the NTA data taken from the IMO data 1989-2019

3 Conclusion

Great care must be taken when using visual data from the IMO VMDB since a substantial amount of the records contain unreliable data. Before using any data, some quality control is essential to remove the garbage. After removal of all junk data, a much smaller amount of data can be used to average the ZHRs.

Two more problems appear. First of all, after removal of the unreliable data, too few data are left and several time intervals without data appear. Furthermore, the small numbers are very sensitive to statistical fluctuations. The single station observations, either visual or video have a high risk to include sporadic meteors that 'seem' to line up with the NTA radiant area. Such contamination of the low number of NTA meteors with sporadic chance-lined-up meteors make the hourly rate counts very uncertain.

The activity of the shower is low and prolonged in time (more than a month), no pronounced peak can be defined. The peak activity varies from year to year. Sometimes two or even three similar peaks of activity are observed during the shower activity period. Unfortunately, the data of IMO has gaps during which no observational data is available, the behavior of the shower during such interval is unknown. The date of the main shower maximum can be the interval in solar longitude 226°–232°.

All in all, seen the poor reliability of the VMDB data, the statistical fluctuations on small number hourly rates and the risk for contamination of these small numbers with sporadics, it may be recommended to study this shower rather based on orbit data.

Acknowledgment

I thank Robert Lunsford for his feedback and Paul Roggemans for the help to edit this article.

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Infrasound detection of bolide 20191013_221816

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A bright meteor appeared above central Switzerland on 13 October 2019. The geometrical trajectory analysis was made by Beat Booz of the FMA group. The bolide emitted a flash (brighter than -5 mag) at $22^h18^m17.8^s$ UT and a luminescent remnant was also visible in some later video frames. The calculated height of this flash was 66.5 km.

1 Introduction

Beat Booz analyzed the whole event[14]. He calculated the arrival times of possible infrasound waves produced by the interaction of the meteoroid with the atmosphere along its path and particularly the waves generated by the flash. In a successive step, infrasound signals have been searched in helicorders of infrasound ground detectors. In Switzerland four stations are equipped with such devices at the locations Bos-cha (BOS), Entfelden (ENT), Locarno (LOC) and Val

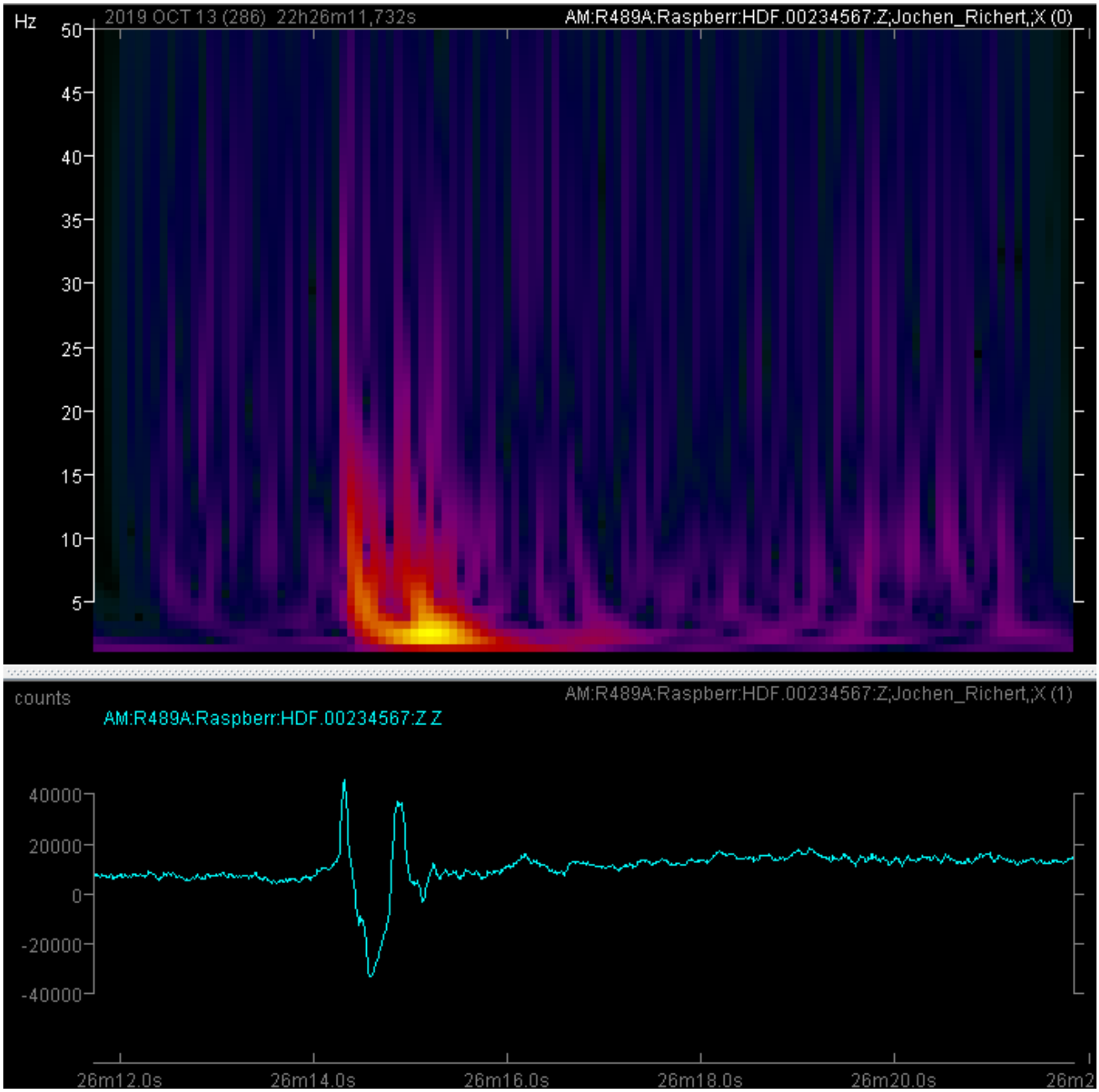

Figure 1 – Spectrogram (Butterworth filter) and signal recorded at BOS (Seisgram2K).

[14] http://www.meteorastronomie.ch/detaildatafk.php?id=139

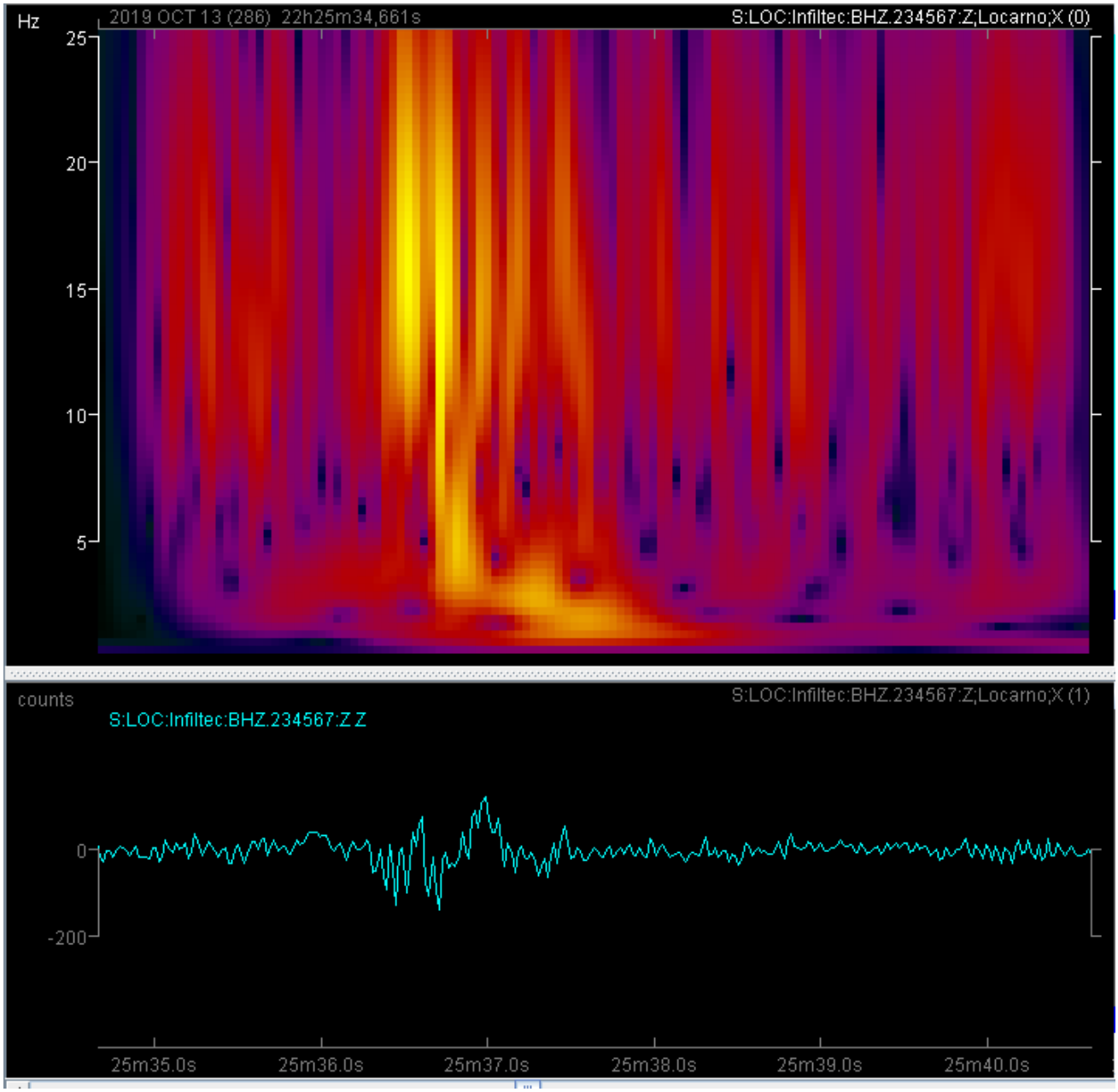

Figure 2 – Spectrogram (Butterworth filter) and signal recorded at LOC (Seisgram2K).

de Terbi (VTE). The helicorders of the stations ENT and VTE do not have evident signals and their spectrograms do not show any predominant frequency. Around the calculated times, the stations BOS and LOC detected small signals with peaks of ~0.5 Pa and ~0.2 Pa respectively.

Their spectrograms (Butterworth method) show a similar pattern with a dominant frequency of ~2 Hz. Both signals lasted ~1 s. (*Figures 1* and *2*). The BOS signal matches the Class I (single N-wave) of the taxonomic classification of Silber and Brown (2014). The measured LOC's arrival time agrees with the calculus. In the case of the BOS station, sound waves apparently arrived about 20 s too early.

Times were calculated assuming an average sound speed of 312 m/s in calm air but winds do influence that speed by some amount. So, we searched for data (speed and direction) of high-altitude winds. Such information is available online[15].

Table 1 – Calculated (without wind correction) and measured arrival times of sound waves emitted by the meteor flash at $22^h18^m17.8^s$ UT.

	Calculated arrival time [UT]	Measured arrival time [UT]
BOS infrasound station	$22^h26^m34.8^s$	$22^h26^m15^s$
ENT infrasound station	$22^h22^m18.0^s$	–
LOC infrasound station	$22^h25^m36.4^s$	$22^h25^m37^s$
VTE infrasound station	$22^h23^m34.6^s$	–

We downloaded data measured with balloons sent from Milano, Italy and Muenchen, Germany at the date

[15] http://weather.uwyo.edu/

20191014_000000. These data were measured from the ground to about an altitude of 30 km. An average of all the data was calculated. (*Table 2* and *Figure 3*).

Table 2 – Average wind data from the ground to an altitude of 30 km.

	Average windspeed [m/s]	Average wind direction [deg]
Milano	10.1	239
Muenchen	11.8	266

For the signal recorded at BOS, high altitude winds should have increased the speed of sound. When we add the influence of (supposed horizontal) winds projected in the direction of the (supposed linear) propagation of the signal (along the whole line-of-sight) we get the following sound speeds: 319.8 m/s in the BOS direction and 311.9 m/s in the LOC direction.

The results are summarized in *Table 3*. Calculated and measured times agree within some percentage.

Table 3 – Calculated (with wind correction) and measured arrival times of sound waves emitted by the meteor flash at $22^h18^m17.8^s$ UT.

	Calculated arrival time [UT]	Measured arrival time [UT]	Difference [s]	Difference in % of the measured travelling time
BOS station	$22^h26^m21.8^s$	$22^h26^m15^s$	–6.8	1.4
LOC station	$22^h25^m35.8^s$	$22^h25^m37^s$	+1.2	0.3

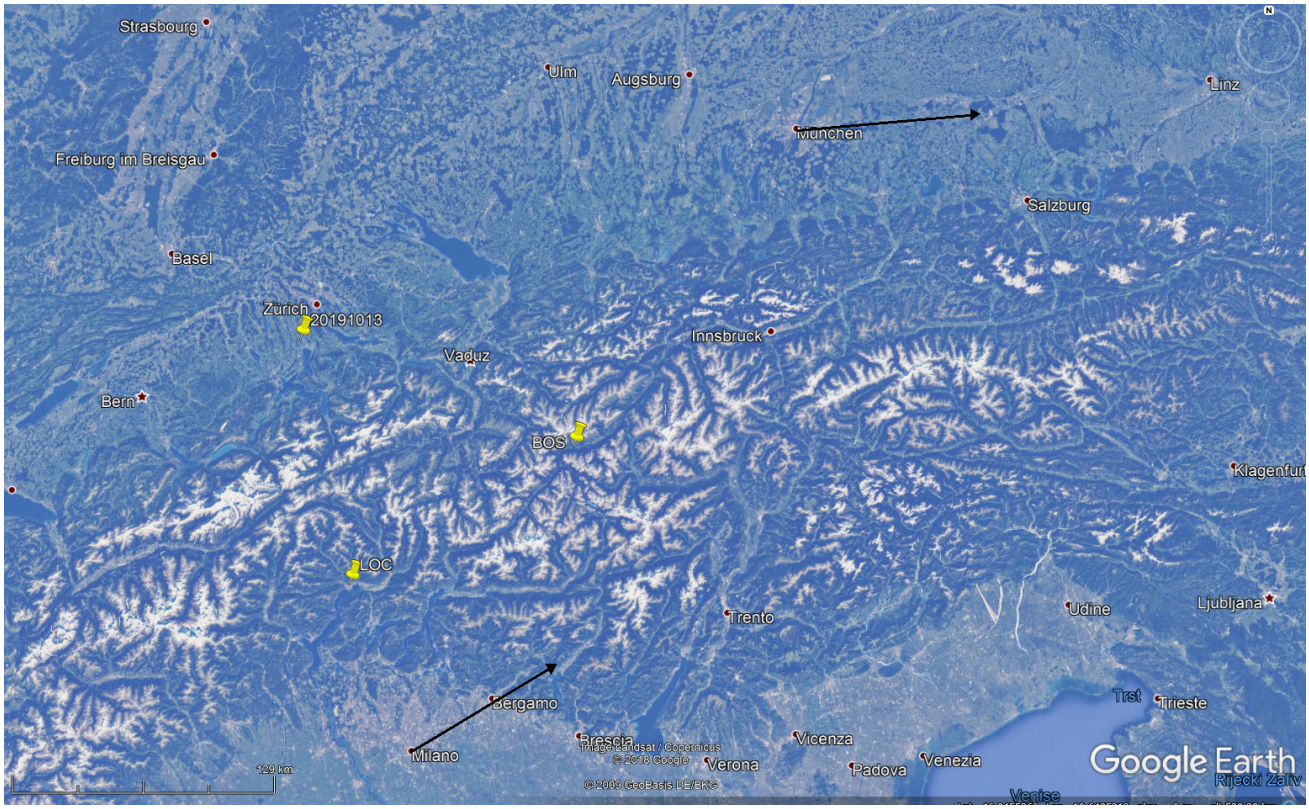

Figure – 3 Wind directions above Switzerland in the night of the bolide (GoogleEarth).

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Bright fireball over North-East of France on 2019 October 13

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A spectacular -10 magnitude fireball appeared 2019 October 13 at 4h50m13s UTC. The video recordings allowed to calculate the trajectory of the fireball.

1 Introduction

On Sunday morning, October 13th, a bright fireball appeared over the French districts Champagne and Lorraine at $06^h50^m13^s$ CEST ($04^h50^m13^s$ UTC).

It started to brighten at an elevation of 90 km near Châlons-en-Champagne and finished its path near the German border after passing over Thionville (25 km south of Luxembourg).

The event was recorded by an all-sky camera of the BOAM network, a French amateur meteor video network, located at Chaligny, 80 km South of the trajectory (*Figure 1*). It was also recorded by a station of the Swiss Fachgruppe Meteorastronomie at Val Terbi (Jura, Switzerland). Two cameras of the CAMS BeNeLux network, close by at the Société Lorraine d'Astronomie observatory in Nancy had there CCD saturated by the brightness of the fireball (*Figures 2 and 3*).

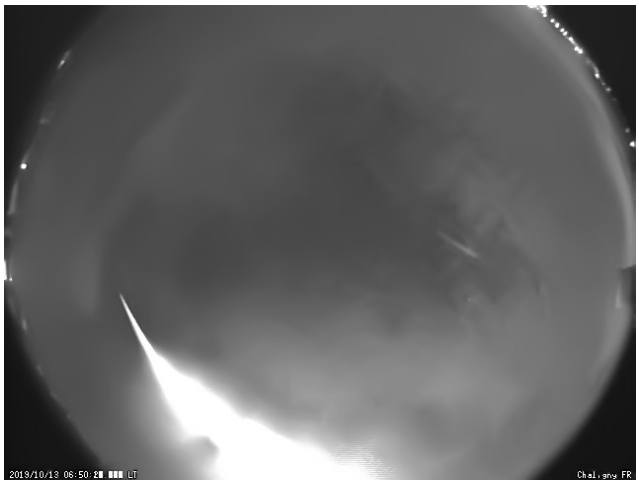

Figure 1 – Fireball 2019 October 13, $4^h50^m13^s$ UT, BOAM all-sky camera at Chaligny, France.

2 The observational data

More than 150 observations from France, Germany, Belgium, the Netherlands, Switzerland and even Italy were reported on the IMO fireball event page.

A trajectory could be calculated from two cameras working on UFOsuite software, Marco's camera at Chaligny and Roger Spinner's camera at Val Terbi. They recorded the fireball during 5 seconds and the initial velocity of the object was close to 27 km/s. It started to brighten at 90 km elevation and ended at 55 km with a maximum magnitude close to –10. The atmospheric entry angle was low, around 14°.

The FRIPON network computed the trajectory from as many as 12 stations. Results have been published on the IMO website: duration: 6s, start elevation: 90 km, end elevation 45 km, entrance angle: 19° initial speed: 27.31 km/s and the initial mass 2 kg.

Figure 2 – 20191013_045013 Fireball as captured on CAMS 3900 at Nancy, France – S.L.A.

Figure 3 – 20191013_045013 Fireball as captured on CAMS 3901 at Nancy, France – S.L.A.

UFOorbit results give a geocentric velocity of 24.4 km/s and a radiant position at R.A.: 30.6°, dec : –4.4°.

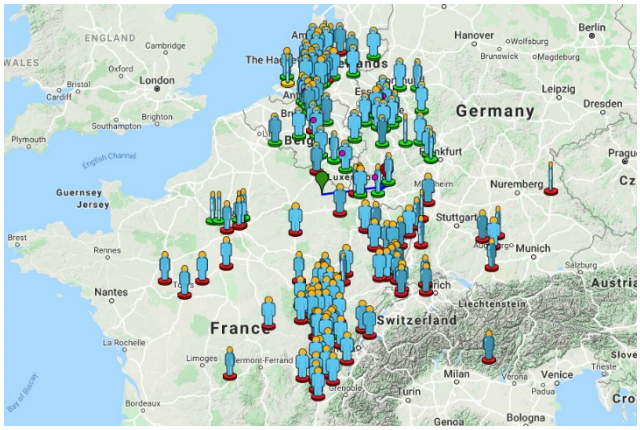

Figure 4 – Map of 153 witnesses – IMO event 5026-2019.

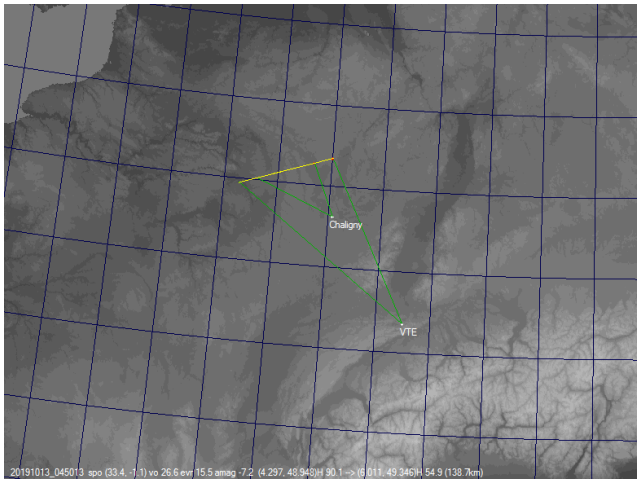

Figure 5 – 20191013_045013 fireball trajectory on the ground map – UFOobit.

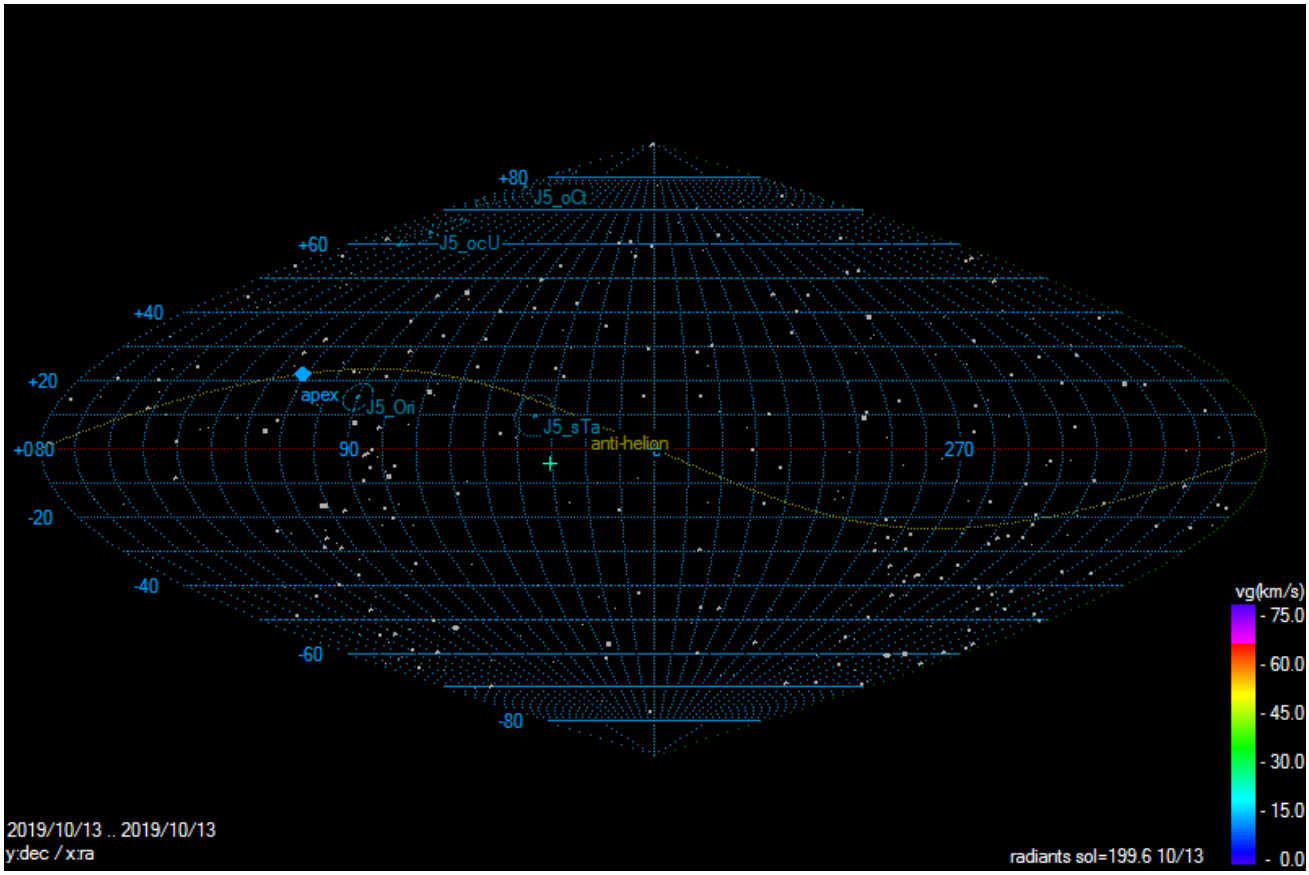

Figure 6 – 20191013_045013 fireball radiant on sinusoidal projection sky map – UFOorbit.

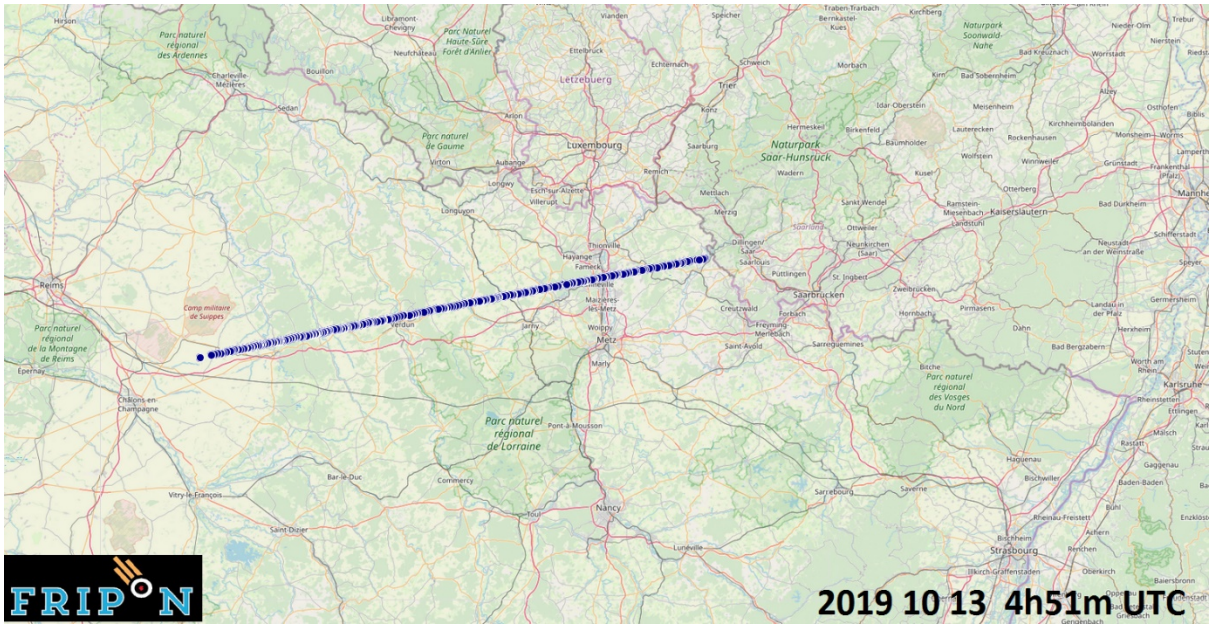

Figure 7 – Trajectory of the fireball as computed by FRIPON.

3 Webcam registrations

The fireball was recorded by many surveillance cameras:

- Dashcam's video from Utrecht, Netherland[16]
- Webcam and Meteocam's pictures provided on the AKM forum[17]
- Dornbirn / Karren[18]
- Fachhochschule Westblick Innenstadt[19]
- Heinrich-Schwaiger-Haus Kaprun Hochgebirgsstauseen[20]
- Seilbahn Zugspitze – Weltrekpord-Stütze[21]
- Schröcken[22]
- Meilerhütte – Wetterstein[23]
- Pendlinghaus – Kufstein[24]
- Röthis -Metzler[25]
- Feldkirch[26]

[16] https://youtu.be/2_-k-Yniokw
[17] https://forum.meteoros.de/viewtopic.php?f=8&t=58965
[18] https://www.foto-webcam.eu/webcam/dornbirn/2019/10/13/0650
[19] https://forum.meteoros.de/download/file.php?id=15842&sid=123b64ef688bdb8a4bce7acde33189a1&mode=view
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[26] https://www.foto-webcam.eu/webcam/feldkirch/2019/10/13/0650

Midsummer meteor observations from the Netherlands

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A report is presented of the author's meteor observing sessions in late June 2019.

1 Introduction

After the two successful nights in northern France (Miskotte, 2019), a number of clear nights followed in June in the Netherlands. As I sometimes suffer from hay fever, I could not observe every clear night. In addition to observing meteors, I have also seen 5 NLC displays, but unfortunately not the big outbreak of 21 June. Here follows a summary of the night reports.

2 The observations

22–23 June 2019

A Full Moon on June 17 means that observations become soon possible again. The evening of June 22 was clear, so the observations started at 22^h30^m UT. Location: Groevenbeekse Heide (a heath). Unfortunately, the sky was very hazy so the limiting magnitude did not exceed 6.1, the SQM reached only 19.98. The moon would rise around 23^h20^m UT, so the session ended after exactly one hour. This resulted in only three meteors, 2 sporadics and one possible early July Pegasid (+3).

28–29 June 2019

The sky cleared up nicely in the evening of the 28th of June. I went to bed early that evening to be able to observe well-rested later that night. When I was awake and looked at my phone, the messages about the big daylight fireball from earlier that evening also came in. My neighbors had also seen and heard it from the heath nearby and it must have been an impressive event. I still thought: why not a few hours later?

This night the sky was very transparent and despite the "gray nights" I achieved a limiting magnitude of 6.3 and a maximum SQM value of 20.25. During this time of the year the observing window is always very small. I could count meteors between 22^h27^m to 00^h35^m UT. During this 2.10 hour I observed 18 meteors. Some nice meteors appeared. At 23^h34^m UT a beautiful blue white magnitude 0 sporadic meteor appeared moving through Cygnus. Five seconds later followed by another weak meteor. And a slow +4 ANT was, despite the brightness, also worth the sight.

A successful night, the starry sky was beautiful with a beautiful Milky Way visible from Cassiopeia to the northern parts of the constellation of Sagittarius. Every now and then a large owl came flying by low, also some small bats. Unfortunately, there was noise coming from the village, there are always parties with live artists on Saturday evenings in the summer.

29–30 June 2019

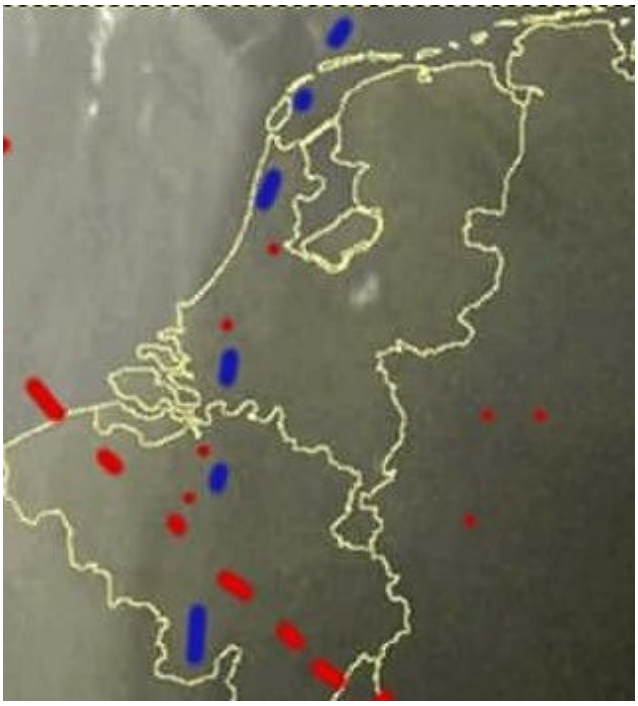

Figure 1 – On 28 June 2019, Sahara sand hung above the southwest of the Netherlands and above the North Sea.

Again, a clear sky. I was surprised when I looked outside around 20^h30^m UT, I saw elongated bands of yellow clouds hanging in the west. They were also visible on the SAT24 website. It turned out later that it was Sahara sand that was blown to western Europe with southern winds.

An hour later there was nothing left to see. At 22^h20^m UT I cycled to the heath and the circumstances were just a little less and only at very low altitude compared to the previous

night. Our Dutch Meteorological Institute KNMI expected minimum temperatures of 18–20 degrees Celsius tonight. However, when I cycled up the heath it felt much colder, it turned out to be 14 degrees Celsius. This dropped further to 12 degrees, but in the last half hour a southeastern wind came up firmly and the temperature rose again to 17 degrees at 00^h35^m UT.

This night the great owl also flew over again and sometimes also bats. There were also two other events that were noticeable.

When I arrived at my observing location, I saw a LED light on in the heather bushes next to my observing place. I thought what is it there, an electronic device with burning voltage indicator? Had I something forgotten from the previous night? I already saw it from a few meters away. Upon closer inspection it turned out to be a firefly. However, these are not real flies but beetles. I have heard many times that people have seen fireflies on the Groevenbeekse Heide, especially on the forest edges at dusk. But for me this was the first time. Such a small insect gives a lot of light, because the surrounding heather twigs and grasses were dimly lit. The insect remained visible until around 23^h30^m UT. Days later, after a hot summer day, I cycled again with my wife Lizzie along the edge of the forest during dusk. We saw two fireflies then. This is something we want to do more often because it gives a mysterious touch to the forest and the twilight.

Figure 2 – The fireball of 29 June 2019 23^h04^m UT. Camera: Canon 6D, lens Sigma 8 mm F 3.5.

And the meteors? Observations were made between 22^h24^m and 00^h36^m UT (t_{eff} 2.17 hours). Despite the fact that the sky was slightly less at a very low altitude, the sky background seemed slightly darker. Indeed, SQM values were slightly higher compared to previous night: 20.30. Limiting magnitude was 6.3 at most. In total I counted 15 meteors.

At 23^h04^m UT, very slowly a bright greenish light moved southwards in the constellation Aquila. For a moment I thought about an Iridium flare, but it went too fast. So, it had to be a bright fireball of about magnitude –6, very beautiful, especially the color. The fireball was photographically captured with my all sky camera, but (as I already expected) most breaks were molted due to the very slow velocity of the fireball. All in all, a successful night.

30 June – 1 July 2019

Third night in a row! During the long evening twilight, a short visit was first made to a family in Harderwijk who had recorded the daylight fireball of June 28 on video. Some pictures of the starry sky were made for Marco Langbroek. Unfortunately, the images from my camera could not be matched with the video recording of the fireball.

Afterwards, I went immediately into the field. During this bicycle ride to Ermelo and later to the heath, the all sky camera captured two fireballs of magnitude –4 very low in the south, but unfortunately, I did not see any of both of them.

The quality of the night was just a little less than the two previous ones. I observed between 22^h35^m and 00^h10^m UT. Indeed, observations were stopped earlier, this due to incoming clouds that entered my field of view from the north.

Only 12 meteors counted during this session. The most striking were the first meteor (a slow +3 Antihelion) and a +2 sporadic meteor.

References

Miskotte K. (2019). “Meteor observations from the very dark village of Buzancy in northern France”. *eMetN*, **4**, 241–243.

Figure 3 – This fireball was captured on 30 June 2019 between $22^h25^m30^s$ and $22^h26^m58^s$ UT.

Figure 4 – The fireball of 29 June 2019 23^h04^m UT. Camera: Canon 6D, lens Sigma 8 mm F 3.5.

The Perseids 2019 from Ermelo, the Netherlands

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A report is presented of the author's meteor observations during the month of August 2019.

1 Introduction

The Perseids of 2019 were very unfavorable in terms of moonlight. During the nights of 11–12 and 12–13 August, the moon would considerably disturb the observations with respectively a 2- and 1-hour period of moonless conditions in the late night. I regularly travel to southern locations such as France or Crete at the end of July and August to observe the southern delta Aquariids. For some reasons this year I was not able to go to southern locations and therefore I observed the Perseids from my home country.

2 The observations

29–30 July, 2019

A short session this night. The sky was very hazy and after an hour I stopped. In 1.067 hours, I only counted 7 meteors, including 1 Capricornid, 1 Perseid, 1 gamma Draconid and 4 sporadic meteors. All this with a limiting magnitude of 6.1 and SQM 20.11.

At the end of July, I got a surgical operation at my hand and started a long way of recovery and physio. As a result, I could not observe the first week of August. There were a number of clear nights during that period. The CAMS video cameras and all sky work continued. During the night of 8–9 August the all sky camera captured three meteors.

Figure 1 – Perseid magnitude –3 recorded in Cygnus on 8 August 2019 at 23^h37^m UT. Camera: Canon 6D, lens: Sigma 8 mm F 3.5 fish eye lens, ISO 2500, exposure time 88 sec. Liquid Crystal Shutter: 10 breaks per second.

As time went by it turned out that there were chances for one or more clear nights in the period 10–14 August. Sky cleared on Saturday 10 August.

Figure 2 – Beautiful kappa Cygnid recorded in Cepheus and Cassiopeia on 9 August 2019 at 00^h28^m UT. Camera: Canon 6D, lens: Sigma 8 mm F 3.5 fish eye lens, ISO 2500, exposure time 88 sec. Liquid Crystal Shutter: 10 breaks per second.

10–11 August 2019

After a walk to the Groevenbeek Heide (a heath), this session started at 23^h10^m UT. The sky was beautifully clear and transparent, but it was not a top sky. There was too much moisture in the atmosphere for that. The last hour some thin cirrus also appeared in the southeast, but it moved almost outside the field of vision to the east.

At the start of the observations, the Moon was still above the southwestern horizon. One hour later the Moon set. The observations started with a limiting magnitude of 5.9, which rose to 6.3 after moonset. I did 30-minute counts this session. The number of Perseids rose from 7 to 16 per half hour this night. So, I was enjoying myself with the Perseids and also the peace and surroundings. There were also a couple of bright Perseids:

- 01^h21^m UT: –2 Perseid from Pisces to Pegasus.
- 02^h22^m UT: –2 Perseid in Perseus
- 02^h42^m UT: a few seconds before the end of the watch, a nice –3 Perseid in the south was seen through the thin cirrus. A nice way to end observing! A number of Perseids of –1 and 0 had also been seen.

In total, this night provided 3.47 hours of effective observation time resulting in 81 Perseids, 2 southern delta Aquariids, 1 Capricornid, 1 kappa Cygnid, 4 Antihelions

and 26 sporadic meteors. So, in total 115 meteors. I have good feeling about this night.

CAMS recorded 249 meteors this night, the all sky camera captured nothing.

Figure 3 – Perseid of magnitude –4 recorded in Camelopardalis on August 10, 2019 around 2^h04^m UT. Camera: Canon 6D, lens: Sigma 8 mm F 3.5 fish eye lens, ISO 2500, exposure time 88 sec. Liquid Crystal Shutter: 10 breaks per second.

11–12 August 2019

During the day clouds came in again but in the course of the evening it cleared up completely again. The same scenario as the previous night followed. The observations started at 23^h30^m UT. The almost Full Moon remained visible until 00^h50^m UT so only two hours left without moonlight. The limiting magnitude rose from 5.8 to 6.3 and then dropped somewhat again. The circumstances were slightly less than the previous night. The sky was a bit hazy.

The Perseids were only a little bit more active than in the previous night. I worked with 15-minute counts and counted between 5 and 9 Perseids each period. Observing meteors was a pleasure again, with a quiet Groevenbeekse Heide with the owl and lots of bats.

Less bright Perseids than the night before. A –2 Perseid at 02^h20^m UT appeared in Perseus and it was the brightest meteor of this night.

In total I observed 85 Perseids, 4 southern delta Aquariids, 3 Antihelions and 2 kappa Cygnids in a total of 3.12 hours, together with 17 sporadic meteors, a total of 111 meteors. The all sky camera captured two Perseids, the CAMS systems recorded 247 meteors. The fact that CAMS scored less than the previous night was due to the fact that during the first 1.5 hours of the night there were still many clouds moving over Ermelo.

Unfortunately, 12–13 August was clouded out. The weather forecast for 13–14 August was a complete clear night, but the sky was mostly covered with clouds.

After August 21 the Moon would disturb less night after night. And so, thanks to high pressure areas, I was able to observe 5 nights in a row at the end of August.

But before that, the all sky camera captured a nice sporadic fireball of magnitude –6 low in the northwest on August 18, 2019 at $23^h36^m08^s$ UT (timing from Klaas Jobse at Oostkapelle, NL).

Figure 4 – Partly behind clouds: the nice fireball of 18 August 2019 $23^h36^m08^s$ UT. Camera: Canon 6D, lens: Sigma 8 mm F 3.5 fish eye lens, ISO 2500, exposure time 88 sec. Liquid Crystal Shutter: 10 breaks per second.

21–22 August, 2019

I did a short session from the meteor roof at home because only an hour would be moonless. It was possible to observe between 20^h30^m and 21^h40^m UT under hazy conditions. SQM maximum 19.98 and limiting magnitude reached 6.1. During 1.167 hours, I counted 11 meteors of which 1 Perseid, 1 kappa Cygnid and 1 Antihelion. The Perseid was a real beauty!! At the end of this session a nice –2 Perseid moved from Draco to Hercules with a persistent train of 3 seconds. It was also captured by the all sky camera.

22–23 August, 2019

Every night after August 22, the Moon was rising later and later, allowing me to observe longer. This session was between 20^h25^m and 22^h11^m UT (1.75 hours effective) from the meteor roof again and under slightly hazy conditions (limit magnitude 6.2 and SQM 20.07). This resulted in 19 meteors of which 1 Perseid, 2 kappa Cygnids and 1 Antihelion. The most beautiful meteors were a Perseid of +1 and a sporadic meteor of magnitude 0.

23–24 August, 2019

3rd clear night in a row, again from the meteor roof. I was able to observe between 20^h23^m and 22^h32^m UT (2.15 hours effectively). Unfortunately, the sky was slightly hazier than the previous night, so the limiting magnitude did not exceed 6.1 and the SQM did not exceed 20.03.

A total of 20 meteors were counted. Striking was the number of Perseids despite a low radiant position and so late in the period: 4 Perseids (with magnitudes +1, +3, +3 and +4). There may be of course occasional "pollution" between Perseids and sporadic meteors coming from the same area of the sky. The sporadic meteors stole the show this session with two meteors of magnitude +1 and 0, both with long persistent trains.

24–25 August 2019

4th clear night in a row. The sky was again a bit hazy but better than August 23–24. This night, I decided to observe from the Groevenbeekse Heide (a heath). It was possible to observe between 20^h23^m and 23^h04^m UT (2.58 hours effectively). The limiting magnitude increased to 6.3 at most and the SQM reached 20.30 (at a location where I once measured 20.65).

A total of 25 meteors were seen, so this number was a bit disappointing compared to the previous nights. Of those 25 there were 3 Perseids, 1 Aurigid, 3 kappa Cygnids and 3 Antihelions. Surprisingly, no bright meteors were seen. That is unusual, because the end of August is known for the beautiful meteors that often appear. Yet one interesting meteor: a beautiful Aurigid (?) earthgrazer was seen from +2 moving from Cepheus to Scutum.

25–26 August 2019

The 5th night in a row and finally a really nice night. Although the limiting magnitude was at the same level as the previous night (6.3), the transparency was much better, especially at a lower altitude. The SQM now reached a maximum of 20.31. Observations were done between 20^h28^m and 23^h51^m UT (3.32 hours effectively). A total of 34 meteors were counted, including 1 Aurigid, 1 Perseid, 3 kappa Cygnids and 3 Antihelions. This time beautiful meteors, two kappa Cygnids of magnitude –1 and 0 were seen. It should be noted that the –1 kappa Cygnid had a rather long path in relation to the distance of the radiant. This white meteor did show a flickering appearance with a wake.

The highlight was of course the beautiful sporadic fireball of 21^h44^m UT (*Figure 5*). I was just recording some SQM measurement when a fast-green fireball of magnitude –6 was seen near the "mercedes" of Aquarius. WOW: what a bright persistent train (starting at magnitude +1), which unfortunately weakened very quickly. After 10 seconds there was nothing left to see. The all sky camera has also caught this meteor. Friend and fellow observer Michel Vandeputte, observing from Ronse, Belgium, had also seen this fireball. This was the last night of 5 clear nights in a row, the second heat wave in the Netherlands was coming to an end, which would be accompanied by clouds, rain and thunder.

Figure 5 – The beautiful sporadic fireball of 25 August 2019 21^h44^m UT. The fireball appeared in Aquarius. Camera: Canon 6D, lens: Sigma 8 mm F 3.5 fish eye lens, ISO 2500, exposure time 88 sec. Liquid Crystal Shutter: 10 breaks per second. A rather noisy recording due to the high night temperatures at the end of August 2019.

29–30 August, 2019

Trying to catch some Aurigids! After the alarm went off, the sky was clear. When I arrived at the heath at 23^h20^m UT I was shocked: a number of enormous blue light beams were spinning around and a large part of it was lit up. I soon realized that these were the preparations for the Classical Groevenbeekse outdoor concert that always takes place at the end of August. On all sky pictures made during earlier editions I saw that it usually ends around 23^h30^m UT. Indeed, after fifteen minutes the light beams went out and started the session at 23^h38^m UT.

However, there was also a lot of fog, there was no wind, so gradually the sky became foggy. After more than an hour I had to stop, because the limiting magnitude dropped to 6.1 with a rapid decline towards the horizon. In total I saw 10 meteors in 1.1 hours effectively, of which 1 Aurigid, 1 kappa Cygnid and 1 Antihelion.

30–31 August, 2019

Fortunately, this night was very clear. This session started at 00^h00^m UT and ended at 03^h03^m UT with the limiting magnitude increasing to 6.4 and the SQM reached 20.41. In the low east there was some cirrus visible, and also some cirrus was coming from the west, but it dissolved completely before entering my field of view. This was also visible on Sat24 which I consulted before I left for the heath. An outermost ambience night with the owl, bats and fog benches almost all the time lower on the heath.

During 3.00 hours effectively I counted 39 meteors of which 4 Aurigids, 1 September Perseid, 2 kappa Cygnids and 4 Antihelions. Most of them were weak. Only three meteors of +1 being an Aurigid, kappa Cygnid and a sporadic meteor were the highlights this session. Despite the lack of bright meteors, this was a beautiful night thanks to the dark starry sky.

Autumn observations 2019

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An overview is given of the 2019 October, November and December meteor observations by the author, covering the autumn meteor showers.

1 October 25–26

Here's my report for the Orionids. I was only able to observe on one morning, four days after the peak. Fortunately, the Orionids have a "plateau" of near-maximum rates that can last for a few days. The morning of the 26th cleared, so I drove to Bootland Farm to setup for a few hours until morning dawn. It was raining as I drove, but when I arrived at the site, the sky was all clear with a nice transparency! A fast Orionid and a long, slow Taurid were casually seen in the north as I setup my chair. A possible very weak aurora was visible, but without any discernible structure. The temperature was cool near 0C, but comfortable.

Unfortunately, the sky was clear for only 20 minutes (with five Orionids seen) before a fast-moving cloud completely obstructed the sky. I took a look at the satellite imagery on my phone, and it appeared to be quite small, so I decided to wait and have a short snooze. My patience paid off as 35 minutes later, just after 4am EDT, the sky was once again all clear, and I could resume observing. I was treated to some nice activity.

The Orionids were surprisingly active over the next two hours until dawn, without visual hourly rates of 13 and 16. Many were on the faint side, but a few reached the mag –1 to +1 range. The nicest Orionid was seen at 5:02am EDT – a foreshortened mag 0 blue-green streak near the radiant that left a two seconds train.

The forty degrees long +1 Leo Minorid seen at 3:20am EDT, also with a two seconds train, was also quite memorable.

Observation October 25–26 2019, 07^h10^m–10^h05^m UT (03^h10^m–06^h05^m EDT)

Location: Bootland Farm (Stewartville), Ontario, Canada, (45°23'N 76°29'W)
Observed showers:

- Andromedids (AND) – 00:43 (011) +24
- Northern Taurids (NTA) – 02:50 (043) +19
- Southern Taurids (STA) – 03:04 (046) +12
- chi Taurids (CTA) – 03:42 (055) +25
- Orionids (ORI) – 06:44 (101) +16
- nu Eridanids (NUE) – 07:14 (109) +13
- Leonis Minorids (LMI) – 11:00 (165) +35

07^h10^m–07^h30^m UT (03^h10^m–03^h30^m EDT); clear; 3/5 trans; F 1.00; LM 6.30; facing SE50 deg; t_{eff} 0.333 hr

- ORI: five: +1; +4; +5(3)
- STA: one: +4
- LMI: one: +1
- Sporadics: none
- Total meteors: Seven

08^h05^m–09^h05^m UT (04^h05^m–05^h05^m EDT); clear; 3/5 trans; F 1.00; LM 6.30; facing SE50 deg; t_{eff} 1.00 hr

- ORI: thirteen: 0; +1(2); +2(3); +3; +4(4); +5(2)
- STA: three: +3; +4(2)
- LMI: three: 0; +4; +5
- NTA: two: +1; +3
- NUE: one: –1
- Sporadics: nine: +2; +3(5); +4(2); +5
- Total meteors: Thirty-one

09^h05^m–10^h05^m UT (05^h05^m–06^h05^m EDT); clear; 3/5 trans; F 1.00; LM 6.30; facing SE50 deg; t_{eff} 1.00 hr

- ORI: sixteen: –1; 0; +1(2); +2(2); +3; +4(6); +5(3)
- NTA: one: +5
- STA: one: 0
- Sporadics: seven: +3(4); +4; +5(2)
- Total meteors: Twenty-five

I packed it in just as the thin crescent moon with earthshine was clearing the tree line. It was quite beautiful!

2 November 22–23

Here's my report for the possible December Phoenicids (PHO) activity on the evening of November 22. This is a rare, periodic meteor shower that produced only one impressive display in 1956. Its parent object is 289P/Blanpain, which is gradually transforming from a comet to a dormant object. The Phoenicids were predicted and detected again in 2014, but at a much weaker level.

Meteor forecasters Mikiya Sato and Jun-ichi Watanabe (2010) previously predicted that the Phoenicids would return in 2008, 2014, and 2019. For 2019, there's at least two separate groups of dust trails predicted to encounter Earth, around November 23 and December 2.

The 2014 shower was successfully predicted and detected but at a much weaker level than in 1956 (Fujiwara et al., 2017). Already this year, the Phoenicids were confirmed to be active by the meteor camera networks between November 12 to 14, 2019 from a much more northerly radiant at 01:00 (015) –07, just below the ecliptic, near Cetus. This is very different than the 1956 radiant, and makes this shower more accessible to northern hemisphere observers (Roggemans et al., 2020).

Here's another interesting article on this fascinating meteor shower:[27]

Certainly, this shows that a lot can learned about a particular comet, by just looking at its meteor shower!

With a clear sky on the evening of November 22, I went to Renfrew (west of Ottawa) to observe for a few hours in the early evening. I kept me expectations low (even a negative –no meteor– result can be useful, although I was hoping perhaps to see something more). Dan Vasiu joined me as well, and it was a nice night with average transparency and a limiting magnitude of 6.3. I began observing at 01^h20^m UT (8^h20^m pm EST) and I continued for four and a half hours. It was nice for a change to observe meteors so early in the evening. A total of 47 meteors were seen (including 6 South Taurids, 3 North Taurids, 3 December Phoenicids, 3 November Orionids, 1 theta Aurigid, 1 Orionid and 30 sporadics. The 3 December Phoenicids were plotted and fit the correct parameters to be Phoenicids (i.e. alignment, path length and speed). They radiated from near the same radiant detected by the camera network between November 12 to 14. The December Phoenicid seen at 04^h57^m UT was impressive… an extremely slow +1 yellow meteor that moved through Eridanus for several seconds. It had a very gradual and unique light curve, showing no flares nor any visible wake. It looks just like an "ultra-slow motion Geminid". What a sight! Dan also saw another similar slow-moving meteor that I missed; he drew it on a piece of paper and it would seem to be a good PHO candidate as well. It appears that the December Phoenicids were indeed very weakly active on the November 22/23 night. Although my three observed PHO's isn't much, the extremely slow speed makes these meteors very distinctive.

Two other highlights from this night: A –4 north Taurid fireball at 02^h58^m UT (21^h58^m EST) with multiple flares low in the south-west, and a +2 near point sporadic at 05^h12^m UT (00^h12^m EST).

Observation November 22–23 2019, 01^h20^m–05^h50^m UT (20^h20^m–00^h50^m EST). Location: Renfrew, Ontario, Canada (45°25'48″N 76°38'24″W)

Observed showers:

- December Phoenicids (PHO) – 01:00 (015) -07
- Northern Taurids (NTA) – 04:46 (072) +26
- Southern Taurids (STA) – 04:54 (074) +20
- November Orionids (NOO) – 05:44 (086) +16
- November theta Aurigids (THA) – 06:13 (093) +35
- alpha Monocerotids (AMO) – 07:55 (119) +01
- Orionids (ORI) – 08:40 (130) +14
- Leonids (LEO) – 10:43 (161) +19

01^h20^m–02^h20^m UT (20^h20^m–21^h20^m EST); clear; 3/5 trans; F 1.00; LM 6.30; facing S50 deg; t_{eff} 1.00 hr

- STA: two: 0; +2
- NOO: one: +3
- Sporadics: six: +2; +4(3); +5(2)
- Total meteors: Nine

02^h20^m–03^h22^m UT (21^h20^m–22^h22^m EST); clear; 3/5 trans; F 1.00; LM 6.30; facing S50 deg; t_{eff} 1.00 hr

- NTA: three: –4; +2; +3
- STA: two: +3; +4
- PHO: one: +4
- NOO: one: +4
- THA: one: +1
- Sporadics: ten: –1; +1(2); +3(3); +4(3); +5
- Total meteors: Eighteen

03^h22^m–04^h22^m UT (22^h22^m–23^h22^m EST); clear; 3/5 trans; F 1.00; LM 6.30; facing S50 deg; t_{eff} 1.00 hr

- NOO: one: +4
- Sporadics: four: +2; +4(2); +5
- Total meteors: Five

04^h22^m–05^h24^m UT (23^h22^m–00^h24^m EST); clear; 3/5 trans; F 1.00; LM 6.35; facing S50 deg; t_{eff} 1.00 hr

- PHO: one: +1
- STA: one: +4
- Sporadics: seven: +2; +3(2); +4(3); +5
- Total meteors: Nine

05^h24^m–05^h50^m UT (00^h24^m–00^h50^m EST); clear; 3/5 trans; F 1.00; LM 6.35; facing S50 deg; t_{eff} 0.42 hr

- PHO: one: +3
- STA: one: +3
- ORI: one: +4
- Sporadics: three: +3; +4(2)
- Total meteors: Six

[27] https://www.sciencealert.com/scientists-may-have-solved-the-mystery-of-the-disappearing-phoenicids-meteor-shower

3 December 2–3

On Monday December 2, I setup at a dark sky site west of Ottawa to look for a possible early evening Phoenicids encounter with the dust trail released in 1898 by comet D/1819 W1 (Blanpain). The projected radiant for this activity would be located at 00^h26^m (007°) –28° which lies in northern Sculptor, but little was known on what might actually be seen. This area of the sky is best placed as soon as evening twilight ends. This part of the sky is very low as seen from this latitude, but any activity would be distinct since these meteors move very slowly at only 12 km/sec. Moreover, I succeeded in seeing very weak activity on November 23 (near the time of the 1877 trail encounter), and video camera networks around the world detected more significant Phoenicids activity between November 12 to 14. This appeared to be one of those unique years when a meteor shower could possibly produce separate activity over the span of a few weeks. There was also special interest in the Phoenicids this year, as these trail encounters could give some more insight on the parent comet's dust production in its "dying" stages. Even a negative (no meteor) result can be useful.

On this occasion, I observed for four hours, starting soon after the end of twilight. The sky was clear and of decent transparency (LM=6.2) with a near First Quarter Moon in the western sky. To minimize the glare, I positioned myself close to a tree line, keeping the moon out of sight and I faced the south-east, and then later on, the south. In all, I saw 21 meteors (3 November Orionids, 2 Geminids, one Northern Taurid and 15 sporadics). I saw absolutely no signs of the Phoenicids.

Dan Vasiu joined me to observe as well, and I enjoyed having his company. He saw only one meteor that could possibly fit the parameters of being a Pheonicid.

The best meteor was seen as I was setting up, before my "official start". It was a 40 degrees long sporadic that reached mag 0 and fragmented. All in all, even with the absence of Phoenicids, it was quite a nice night.

Observation December 2–3 2019, 22^h50^m–03^h15^m UT (17^h50^m–22^h15^m EST). Location: Renfrew, Ontario, Canada. (45°25'48"N 76°38'24"W).

Observed showers:

- December Phoenicids (PHO) – 00:26 (007) -28
- Northern Taurids (NTA) – 05:15 (079) +28
- Southern Taurids (STA) – 05:22 (081) +21
- Monocerotids (MON) – 06:06 (091) +09
- November Orionids (NOO) – 06:14 (093) +16
- Geminids (GEM) – 06:43 (101) +35
- sigma Hydrids (HYD) – 08:00 (120) +04

22^h50^m–23^h50^m UT (17^h50^m–18^h50^m EST); clear; 3/5 trans; F 1.00; LM 6.25; facing SE55 deg; t_{eff} 1.00 hr

- GEM: one: +1
- Sporadics: one: +3
- Total meteors: Two

23^h50^m–01^h05^m UT (18^h50^m–20^h05^m EST); clear; 3/5 trans; F 1.00; LM 6.25; facing SE55 deg; t_{eff} 1.00 hr

- GEM: one: +3
- NOO: one: +3
- Sporadics: four: +1; +2; +3; +5
- Total meteors: Six

01^h05^m–02^h05^m UT (20^h05^m–21^h05^m EST); clear; 3/5 trans; F 1.00; LM 6.25; facing S55 deg; t_{eff} 1.00 hr

- Sporadics: six: +2; +3(2); +4(2); +5
- Total meteors: Six

02^h05^m–03^h15^m UT (21^h05^m–22^h15^m EST); clear; 3/5 trans; F 1.00; LM 6.38; facing S55 deg; t_{eff} 1.16 hr

- NOO: two: +4; +5
- NTA: one: +2
- Sporadics: four: +3(2); +4; +5
- Total meteors: Seven

References

Fujiwara Yasunori, Nakamura Takuji, Uehara Satoshi, Sagayama Toru, Toda Hiroyuki, the NHK Cosmic Front TV Crew (2017). "Optical observations of the Phoenicid meteor shower in 2014 and activity of comet 289P/Blanpain in the early 20th century". *Publications of the Astronomical Society of Japan*, **69**, 60-1–60-9.

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Radio meteors September 2019

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An overview of the radio observations during September 2019 is given.

1 Introduction

The graphs show both the daily totals (*Figure 1 and 2*) and the hourly numbers (*Figure 3 and 4*) of "all" reflections counted automatically, and of manually counted "overdense" reflections, overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during the month of September 2019.

The hourly numbers, for echoes shorter than 1 minute, are weighted averages derived from:

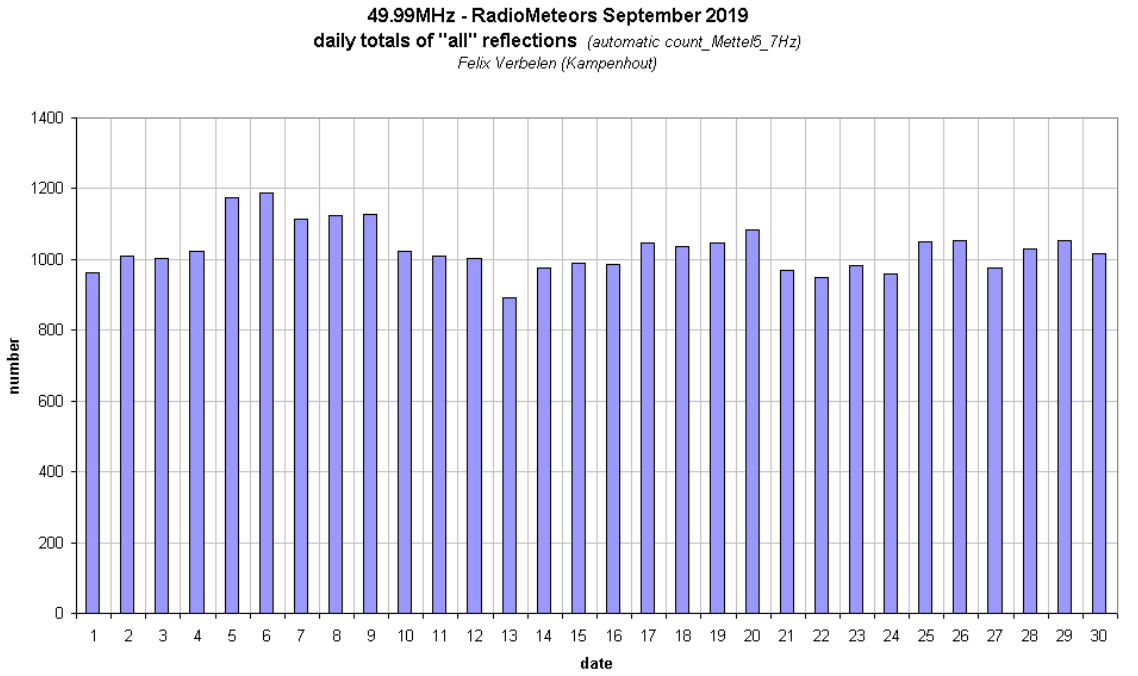
$$N(h) = \frac{n(h-1)}{4} + \frac{n(h)}{2} + \frac{n(h+1)}{4}$$

During this month our registrations were quite often affected by moderate local interference, but no "sporadic E" (Es) or lightning activity.

The automatic countings were manually corrected in order to eliminate the effects of the disturbances.

The registrations show no great outbursts this month, but nevertheless enhanced activity around September 10th and a number of minor showers, with also a number of eye-catching long duration reflections (*Figures 5 to 18*).

If you are interested in the actual figures, please send me an e-mail: felix.verbelen at skynet.be.



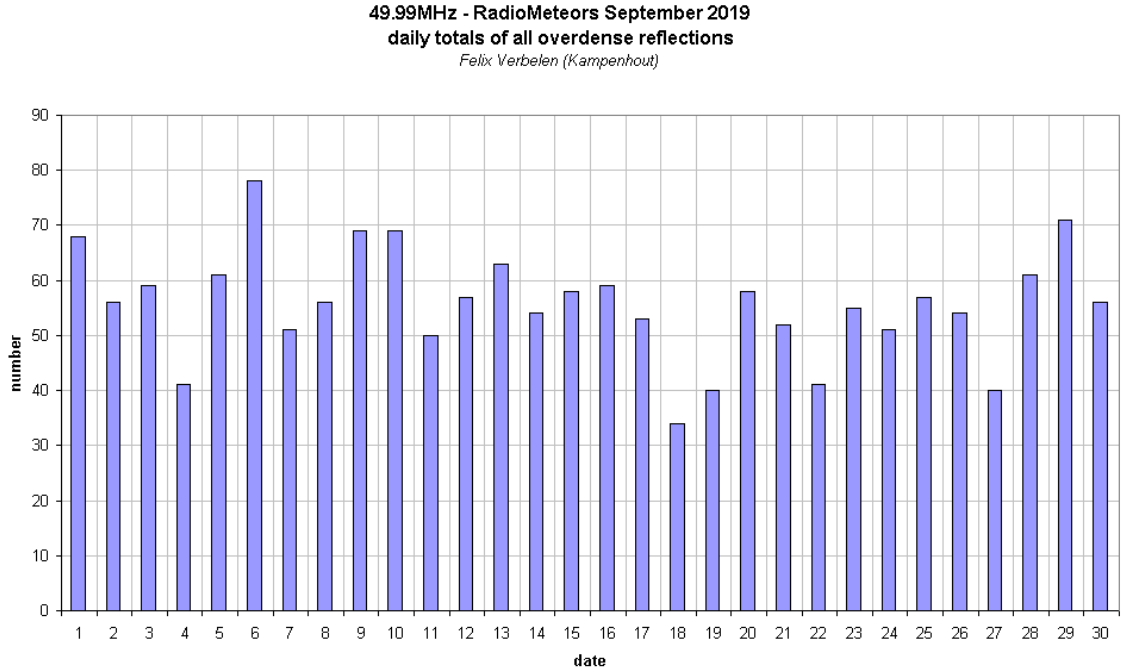
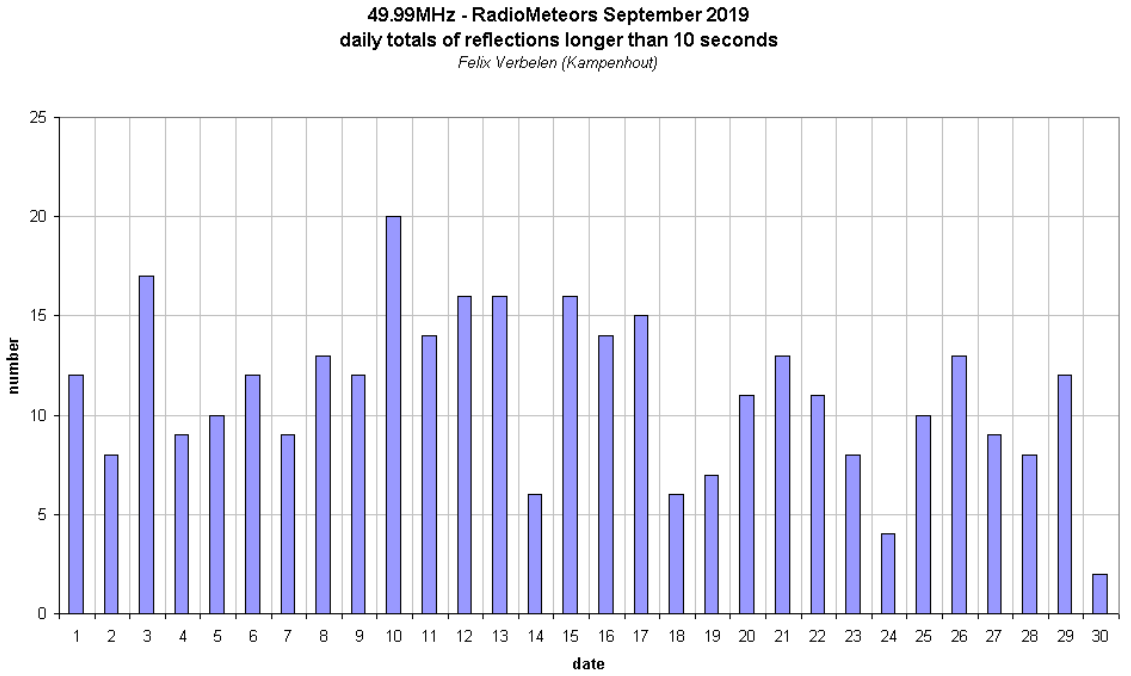


Figure 1 – The daily totals of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during September 2019.



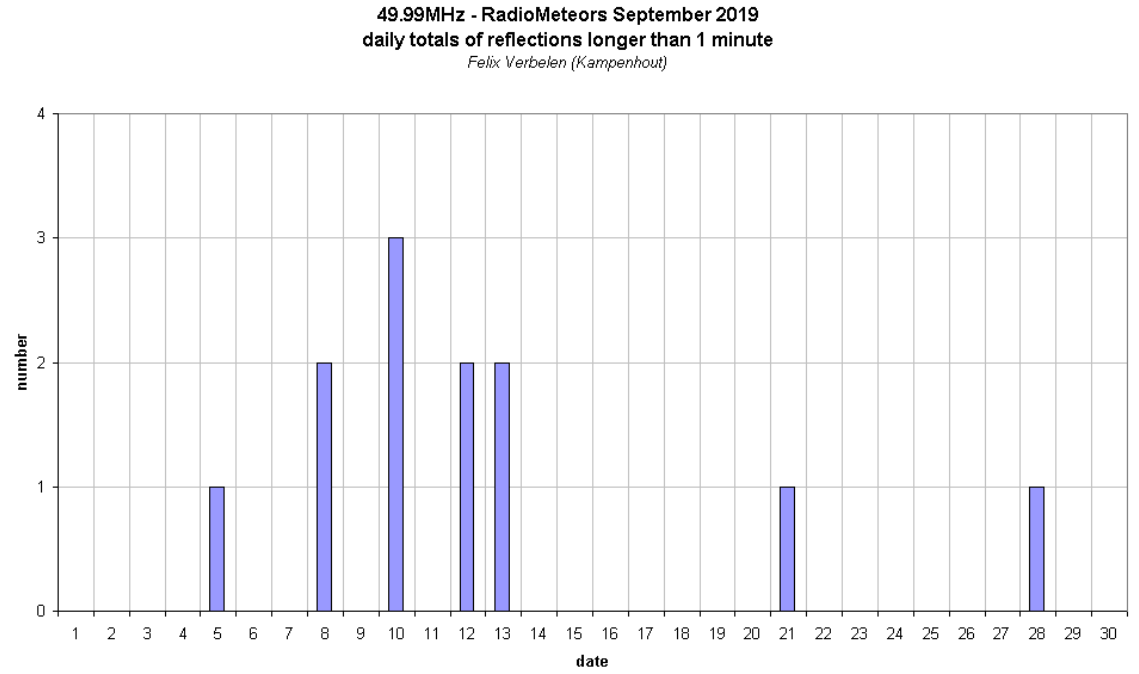
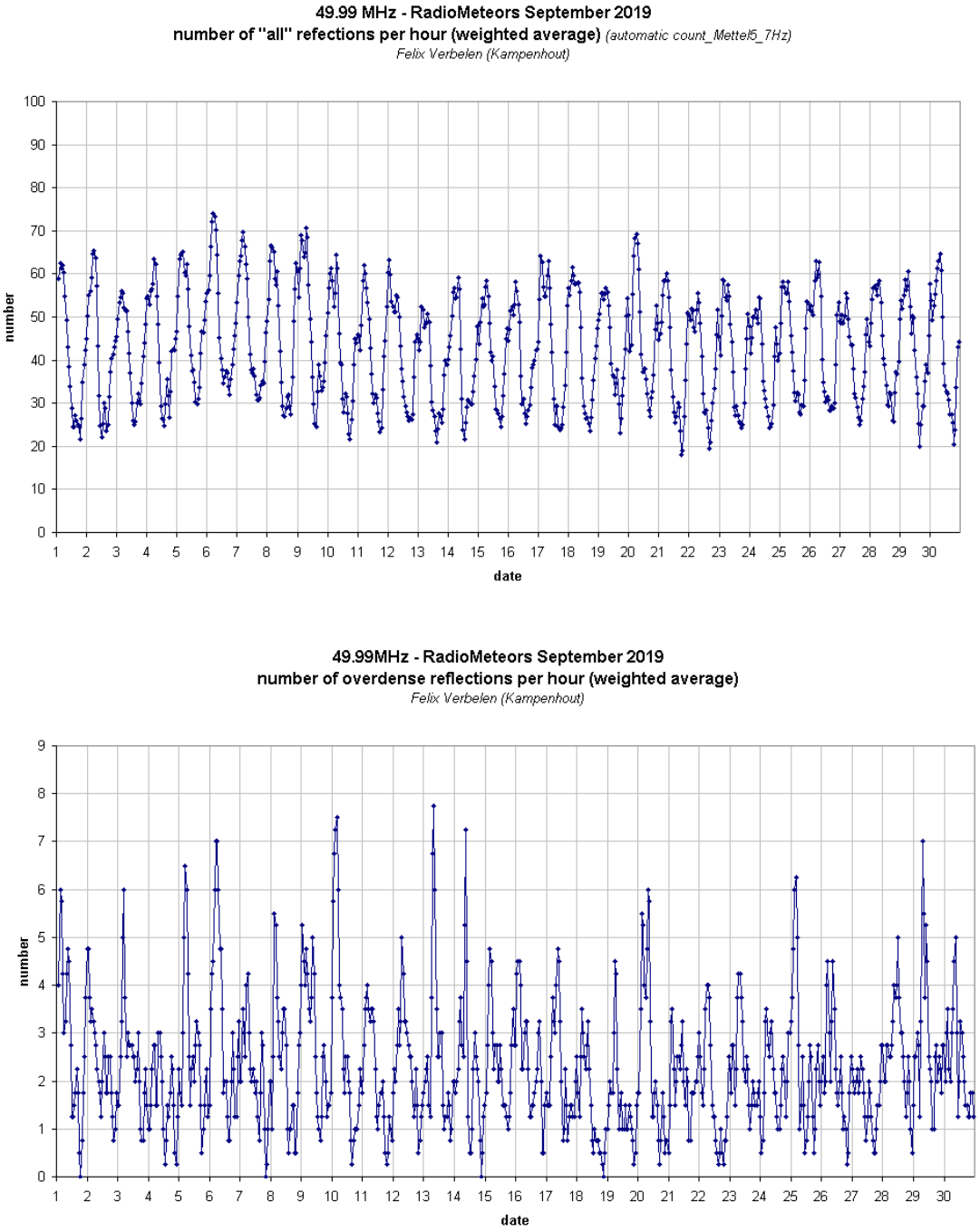


Figure 2 – The daily totals of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during September 2019.



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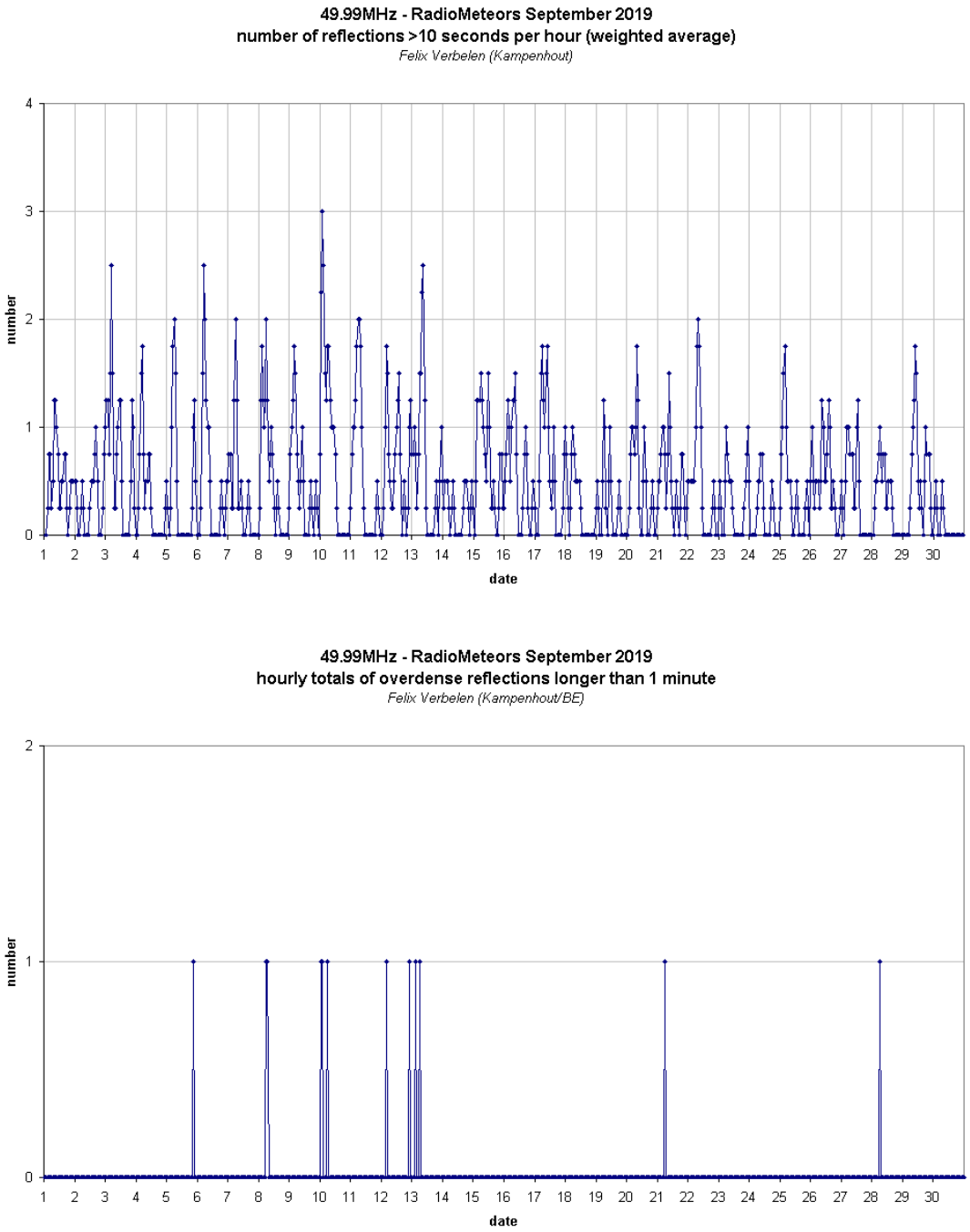

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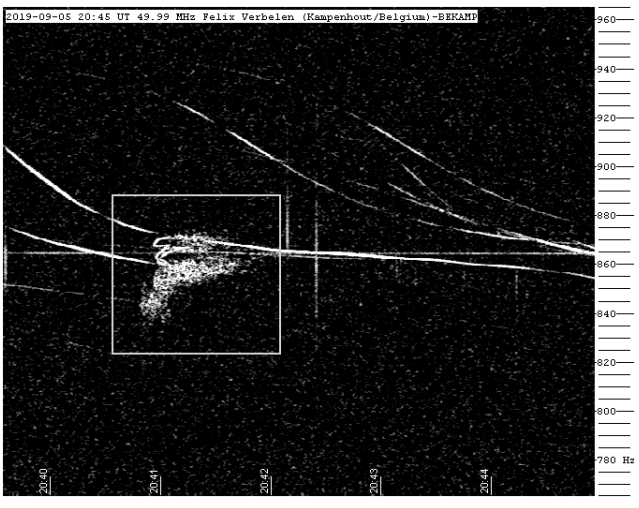

Figure 5 – 2019 September 5 at 20^h45^m UT.

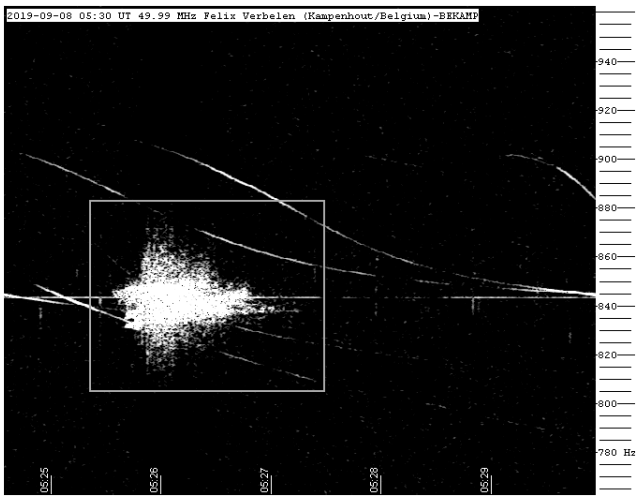

Figure 6 – 2019 September 8 at 05^h30^m UT.

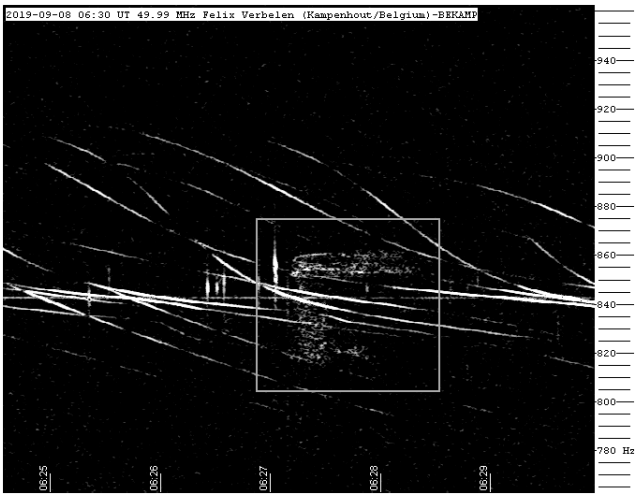

Figure 7 – 2019 September 8 at 06^h30^m UT.

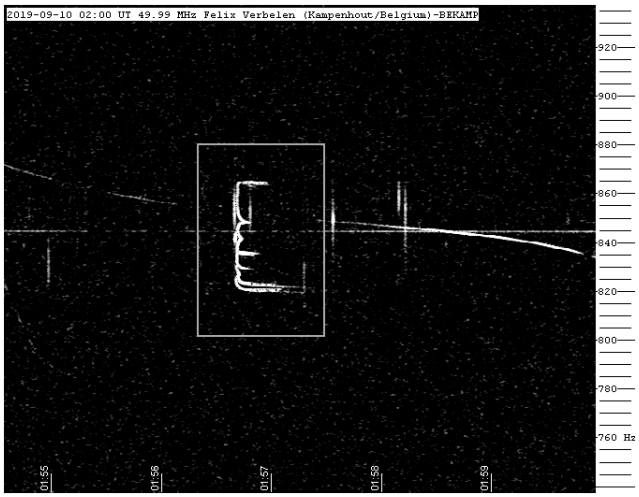

Figure 10 – 2019 September 10 at 02^h00^m UT.

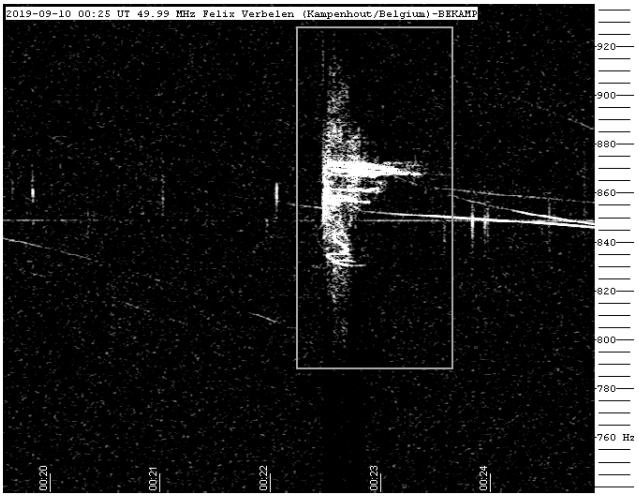

Figure 8 – 2019 September 10 at 00^h25^m UT.

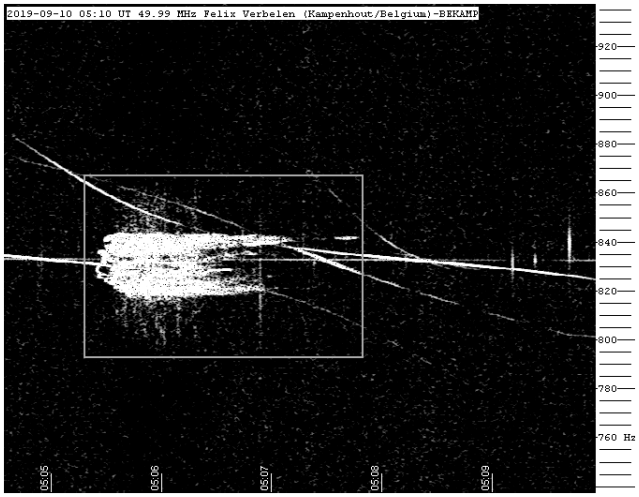

Figure 11 – 2019 September 10 at 05^h10^m UT.

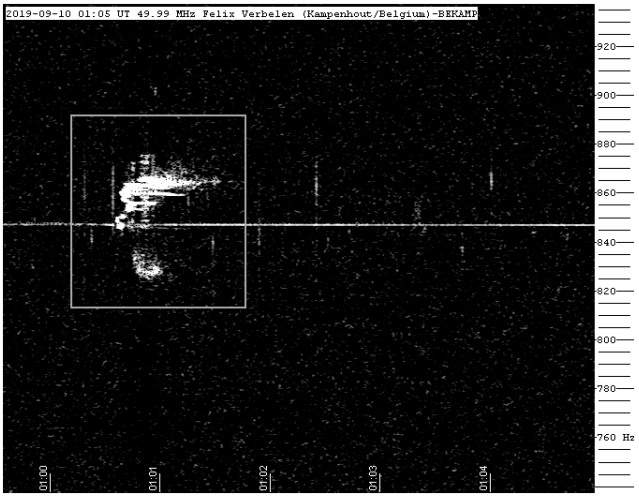

Figure 9 – 2019 September 10 at 01^h05^m UT.

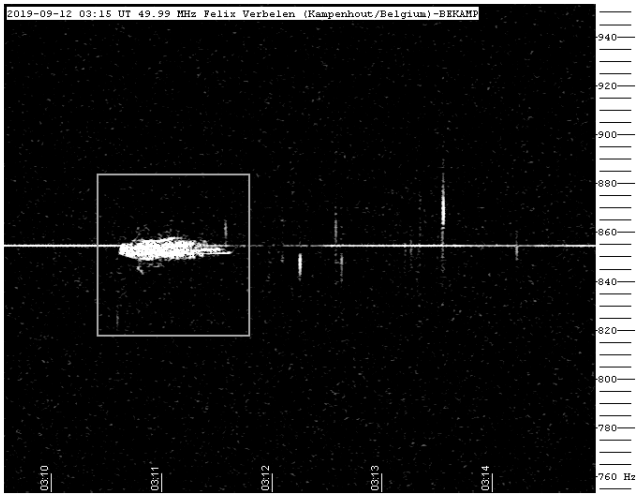

Figure 12 – 2019 September 12 at 03^h15^m UT.

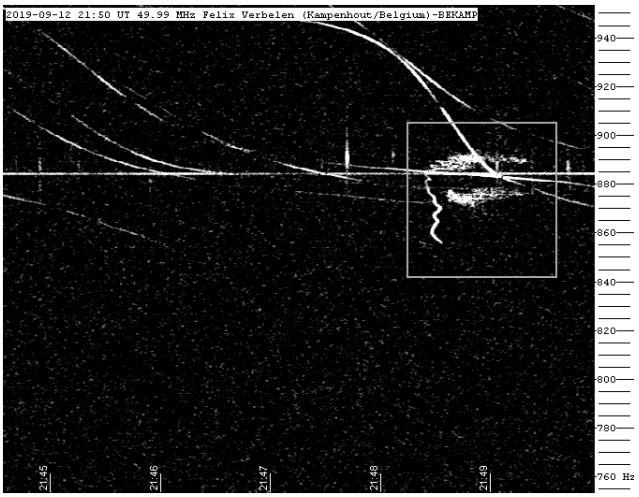

Figure 13 – 2019 September 12 at 21^{h}50^{m} UT.

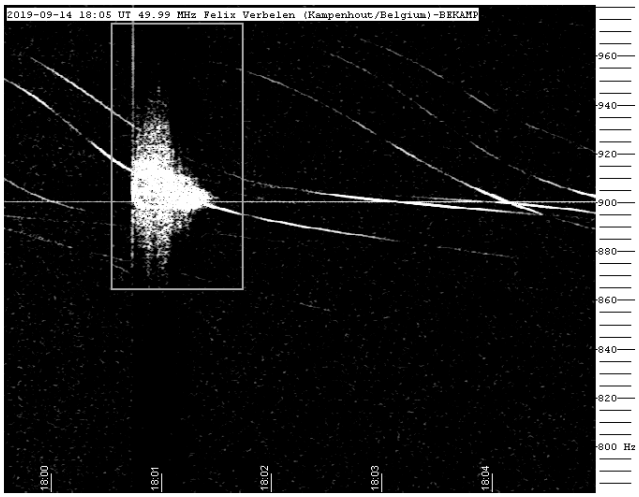

Figure 16 – 2019 September 14 at 18^{h}05^{m} UT.

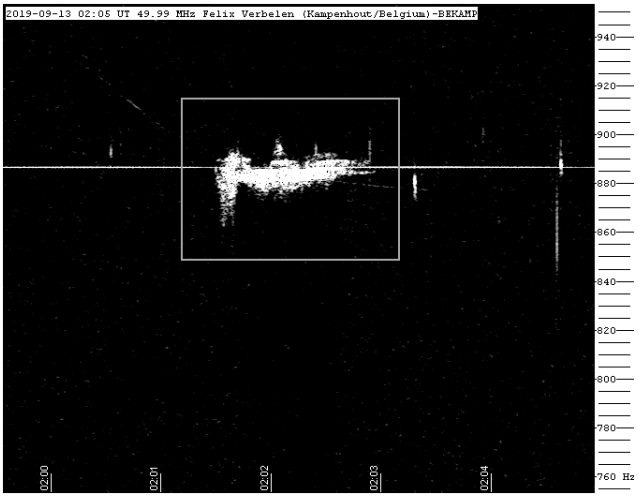

Figure 14 – 2019 September 13 at 02^{h}05^{m} UT.

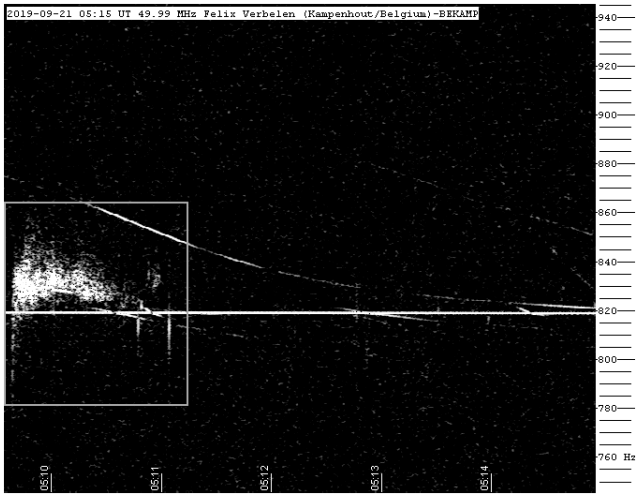

Figure 17 – 2019 September 21 at 05^{h}15^{m} UT.

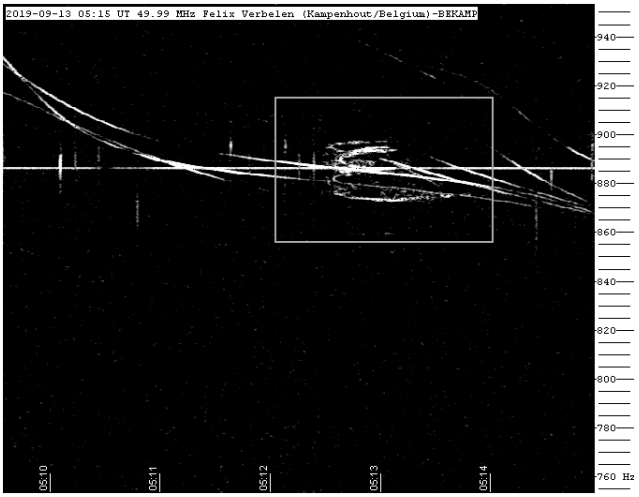

Figure 15 – 2019 September 13 at 05^{h}15^{m} UT.

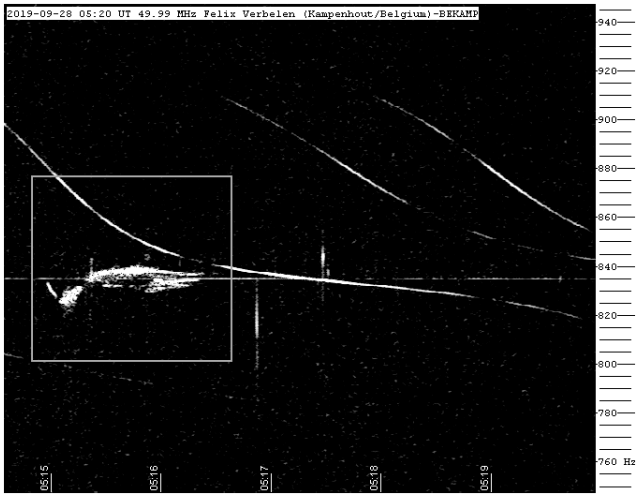

Figure 18 – 2019 September 28 at 05^{h}20^{m} UT.

Radio meteors October 2019

Felix Verbelen

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felix.verbelen@skynet.be

An overview of the radio observations during October 2019 is given.

1 Introduction

The graphs show both the daily totals (*Figure 1 and 2*) and the hourly numbers (*Figure 3 and 4*) of "all" reflections counted automatically, and of manually counted "overdense" reflections, overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during the month of October 2019.

The hourly numbers, for echoes shorter than 1 minute, are weighted averages derived from:

$$N(h) = \frac{n(h-1)}{4} + \frac{n(h)}{2} + \frac{n(h+1)}{4}$$

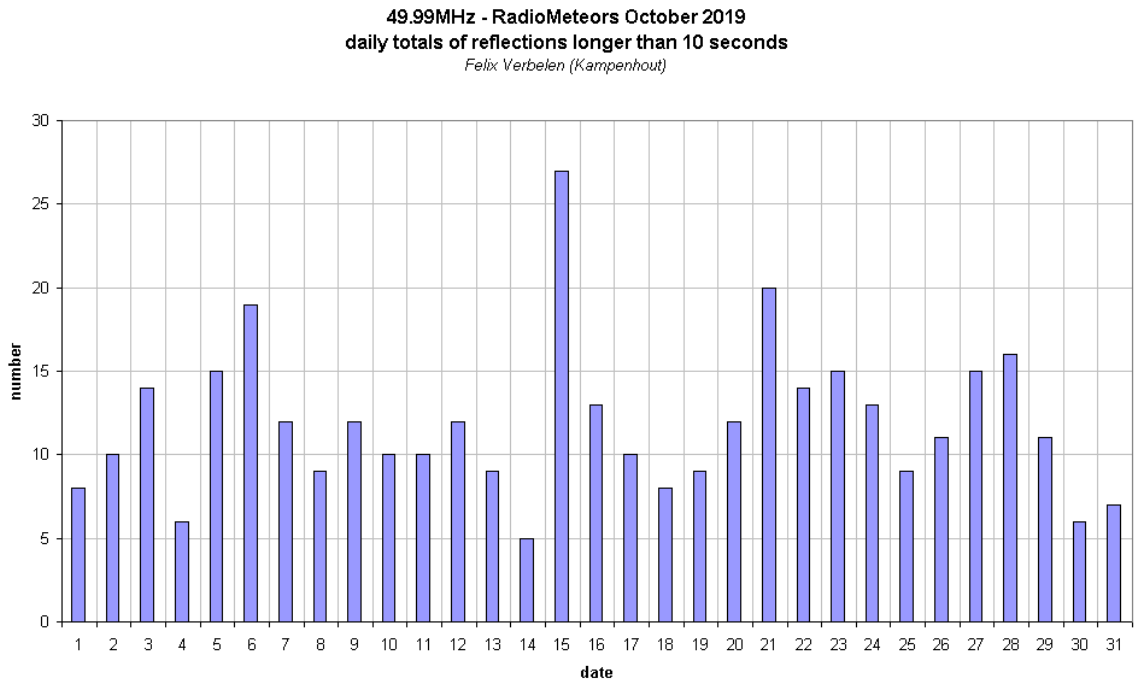
During this month our registrations were quite often affected by moderate local interference and on 4 days by lightning activity, but no observed "sporadic E" (Es).

The automatic countings were manually corrected in order to eliminate the effects of the disturbances.

Some screen-dumps of a selection of eye-catching long duration reflections are displayed (*Figures 5 to 17*).

If you are interested in the actual figures, please send me an e-mail: felix.verbelen at skynet.be.

Figure 1 – The daily totals of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during October 2019.



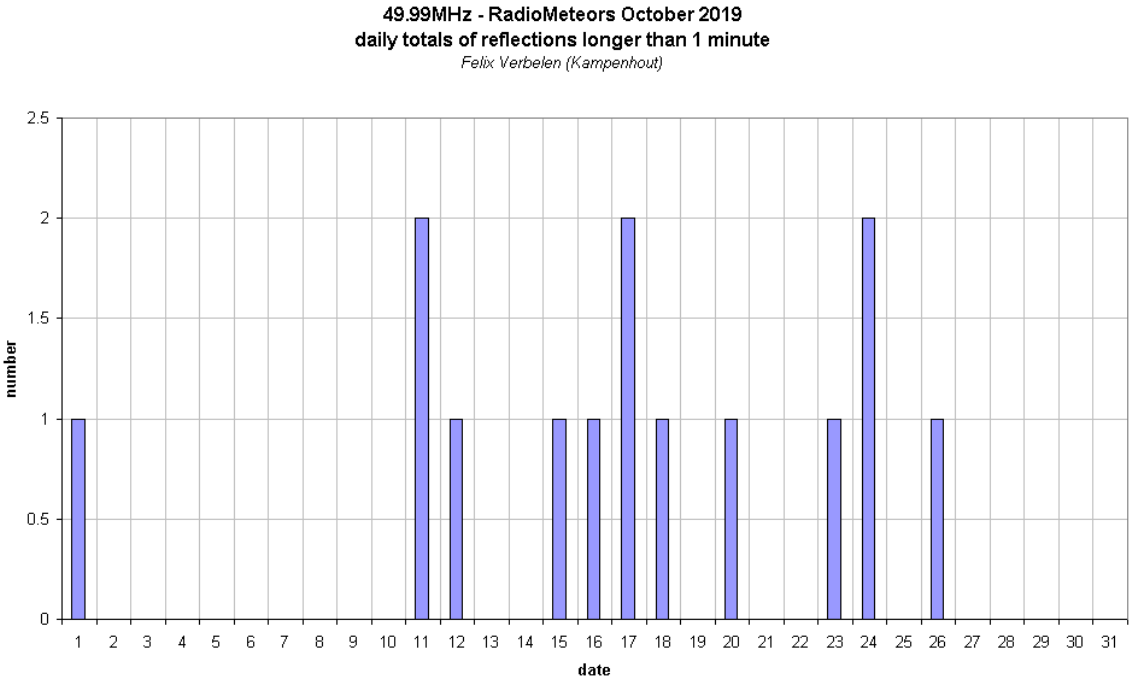
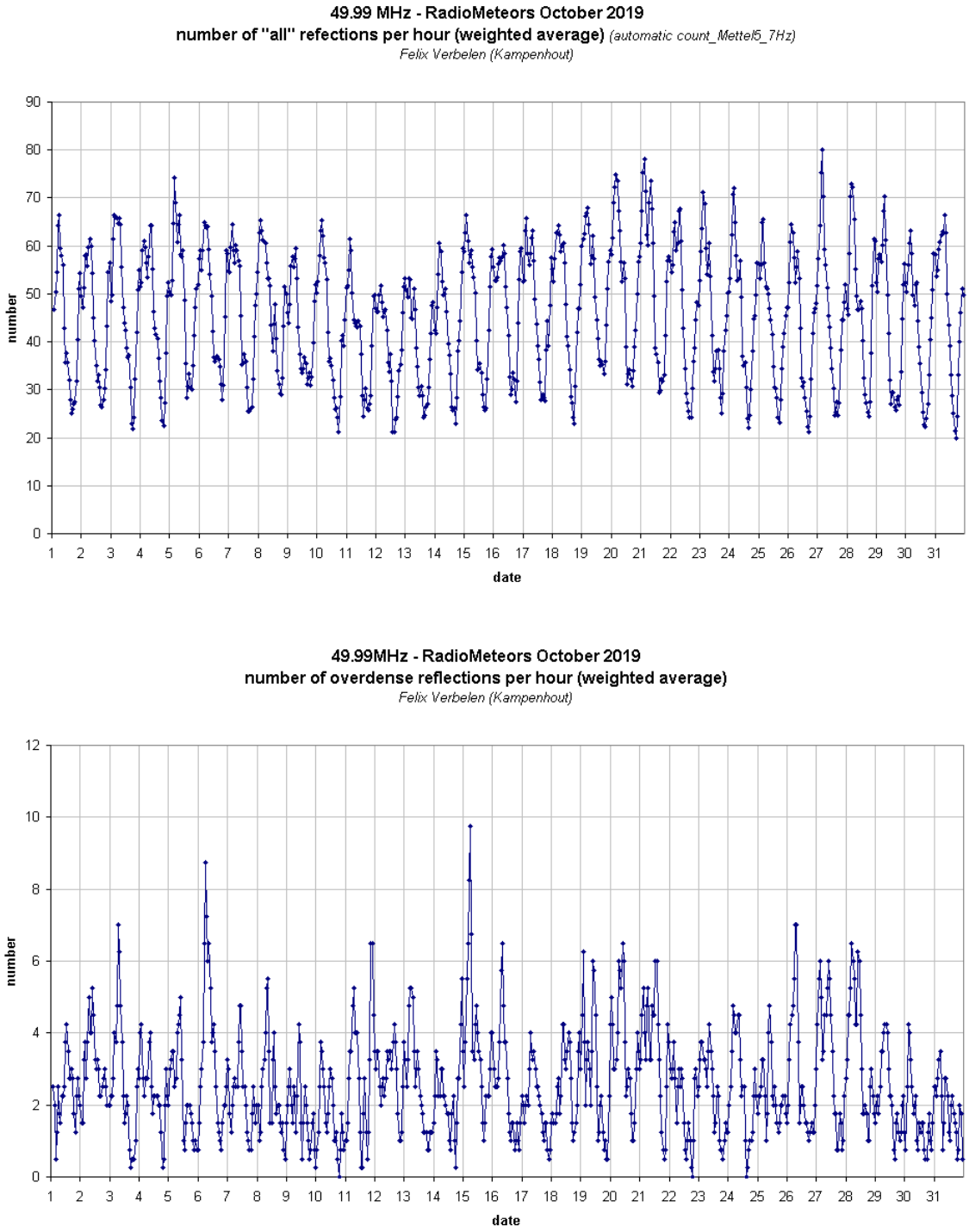


Figure 2 – The daily totals of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during October 2019.



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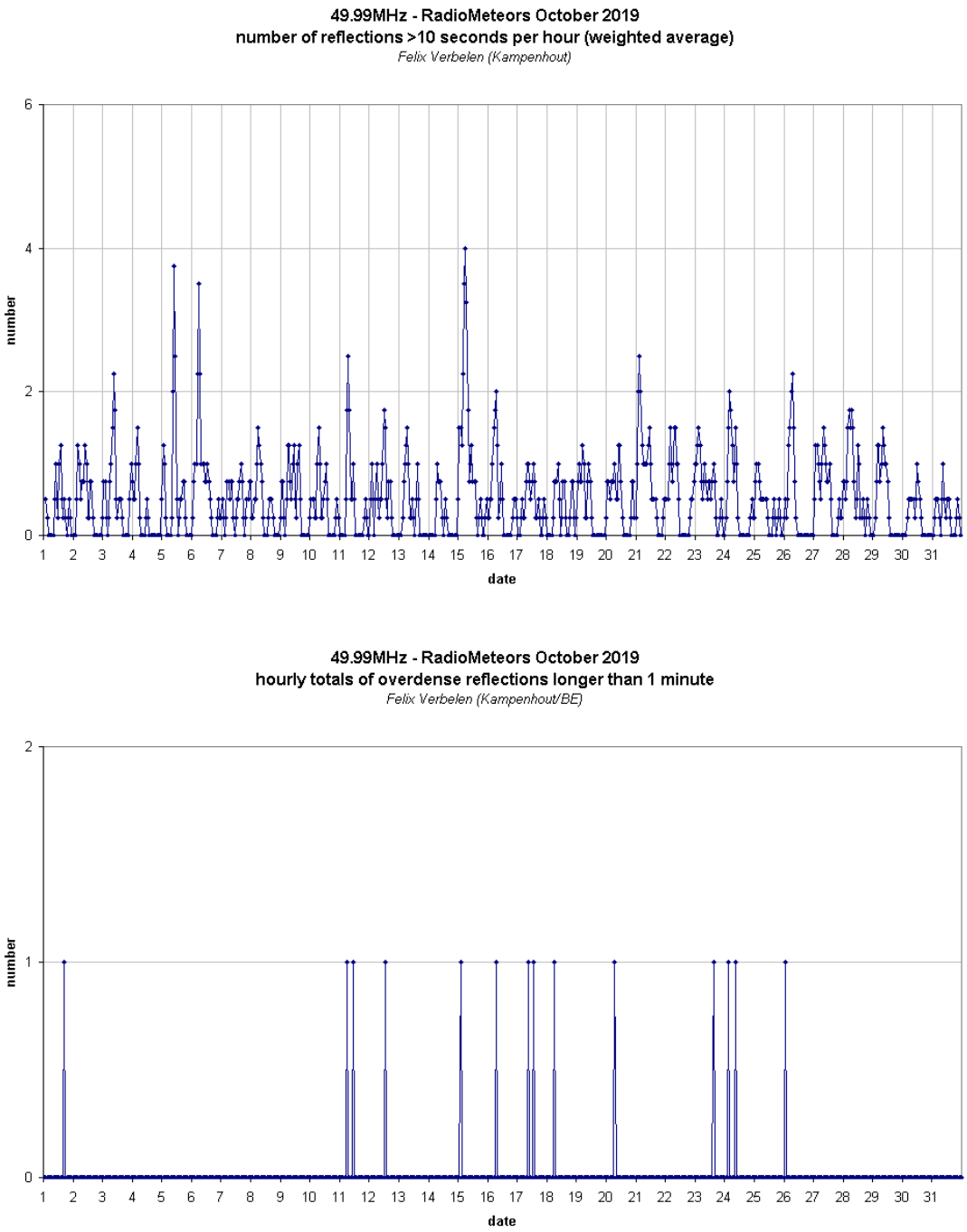

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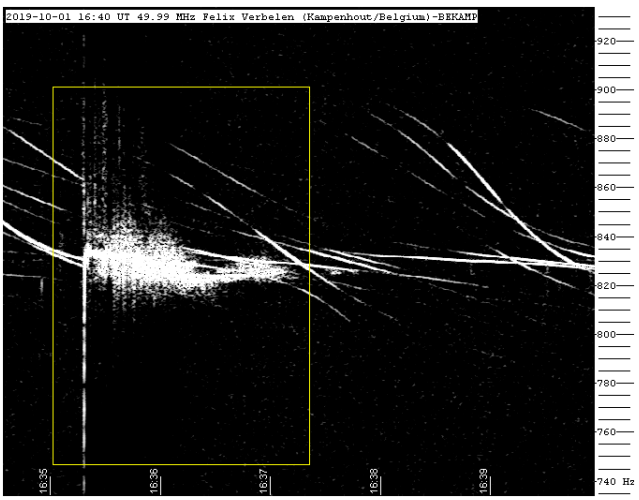

Figure 5 – 2019 October 1 at 16^h40^m UT.

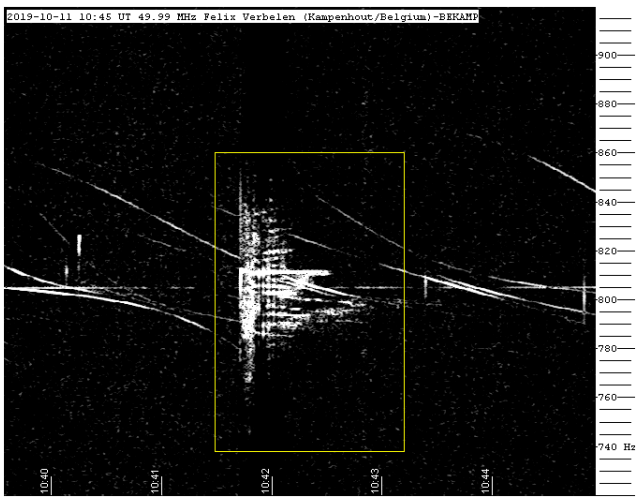

Figure 6 – 2019 October 11 at 10^h45^m UT.

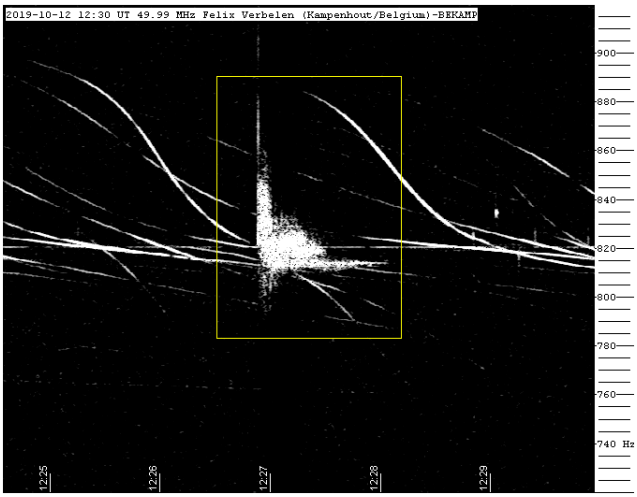

Figure 7 – 2019 October 12 at 12^h30^m UT.

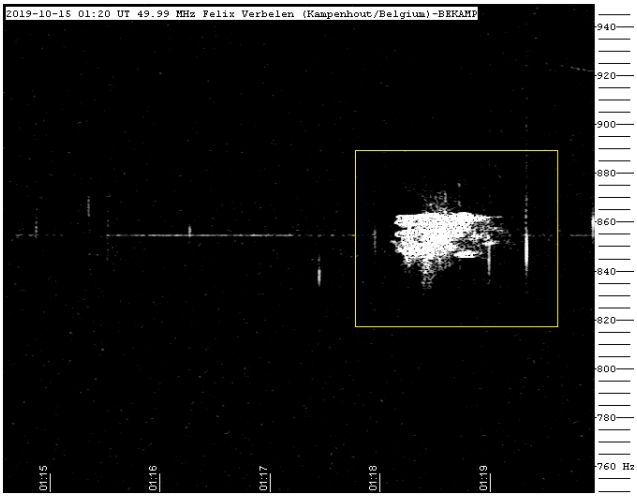

Figure 8 – 2019 October 15 at 01^h20^m UT.

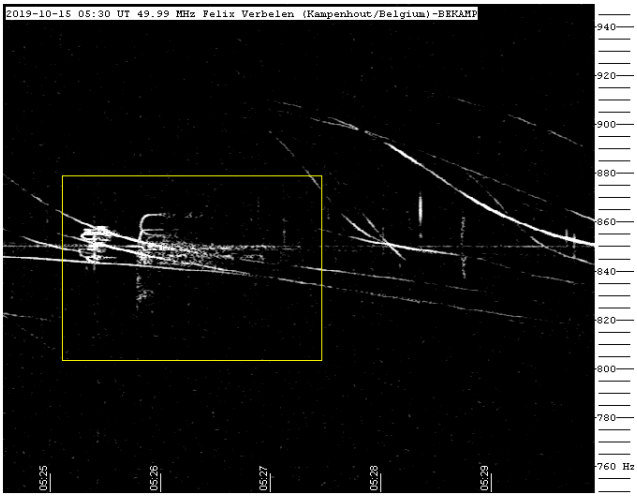

Figure 9 – 2019 October 15 at 05^h30^m UT.

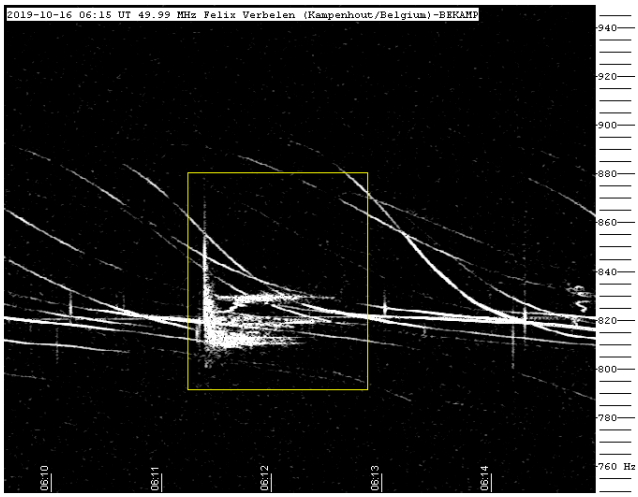

Figure 10 – 2019 October 16 at 06^h15^m UT.

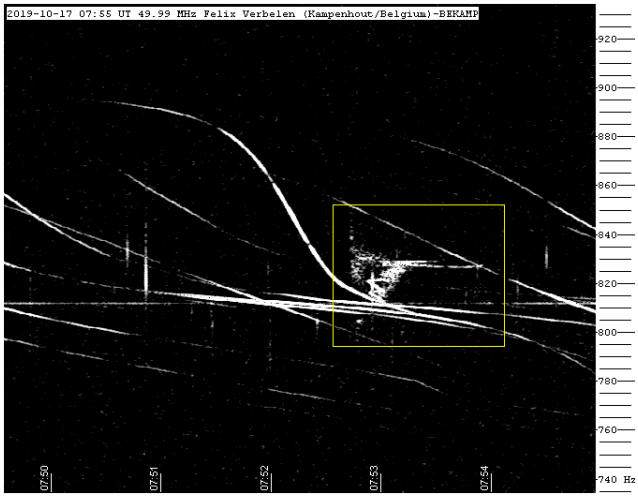

Figure 11 – 2019 October 17 at 07^h55^m UT.

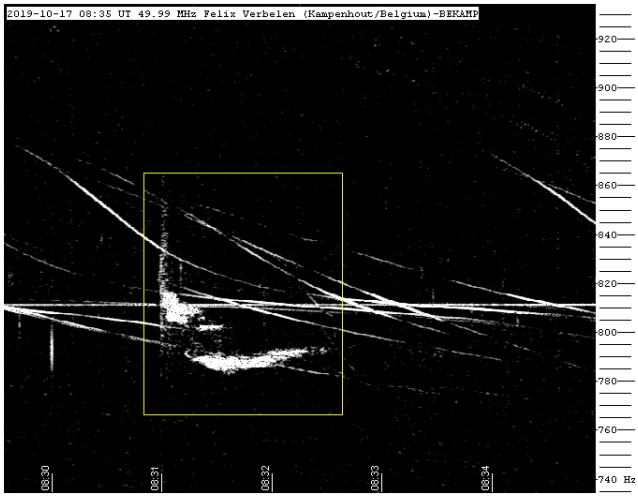

Figure 12 – 2019 October 17 at 08^h35^m UT.

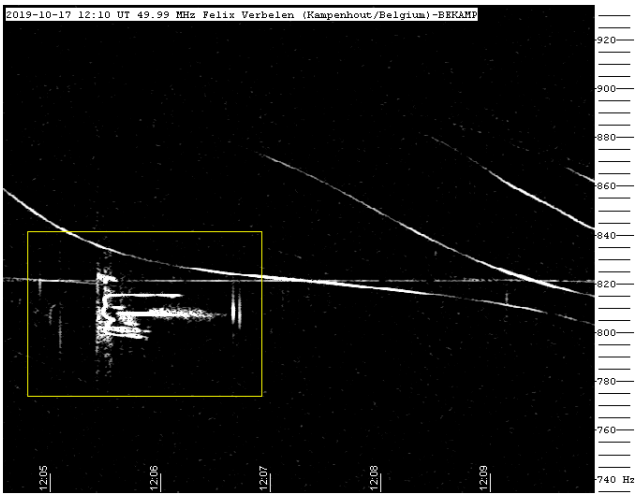

Figure 13 – 2019 October 17 at 12^h10^m UT.

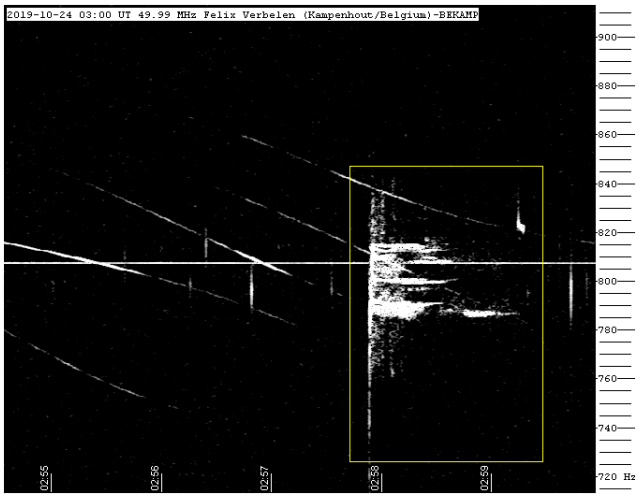

Figure 16 – 2019 October 24 at 03^h00^m UT.

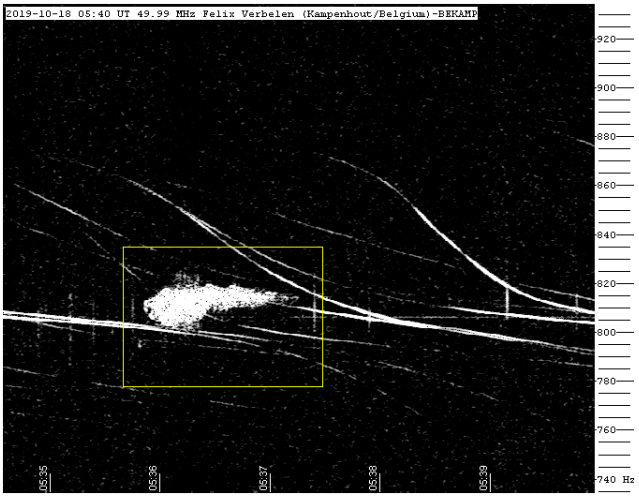

Figure 14 – 2019 October 18 at 05^h40^m UT.

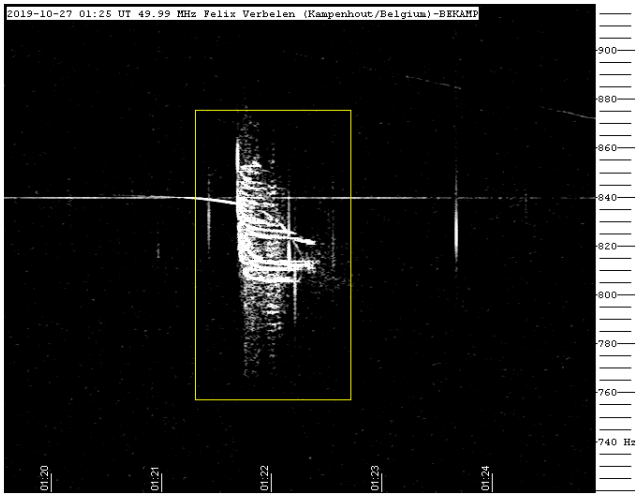

Figure 17 – 2019 October 27 at 01^h25^m UT.

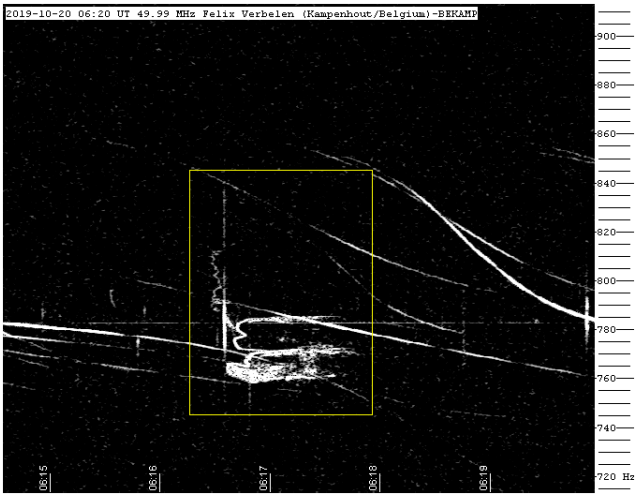

Figure 15 – 2019 October 20 at 06^h20^m UT.

Radio meteors November 2019

Felix Verbelen

Vereniging voor Sterrenkunde & Volkssterrenwacht MIRA, Grimbergen, Belgium
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An overview of the radio observations during November 2019 is given.

1 Introduction

The graphs show both the daily totals (*Figure 1 and 2*) and the hourly numbers (*Figure 3 and 4*) of "all" reflections counted automatically, and of manually counted "overdense" reflections, overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during the month of November 2019.

The hourly numbers, for echoes shorter than 1 minute, are weighted averages derived from:

$$N(h) = \frac{n(h-1)}{4} + \frac{n(h)}{2} + \frac{n(h+1)}{4}$$

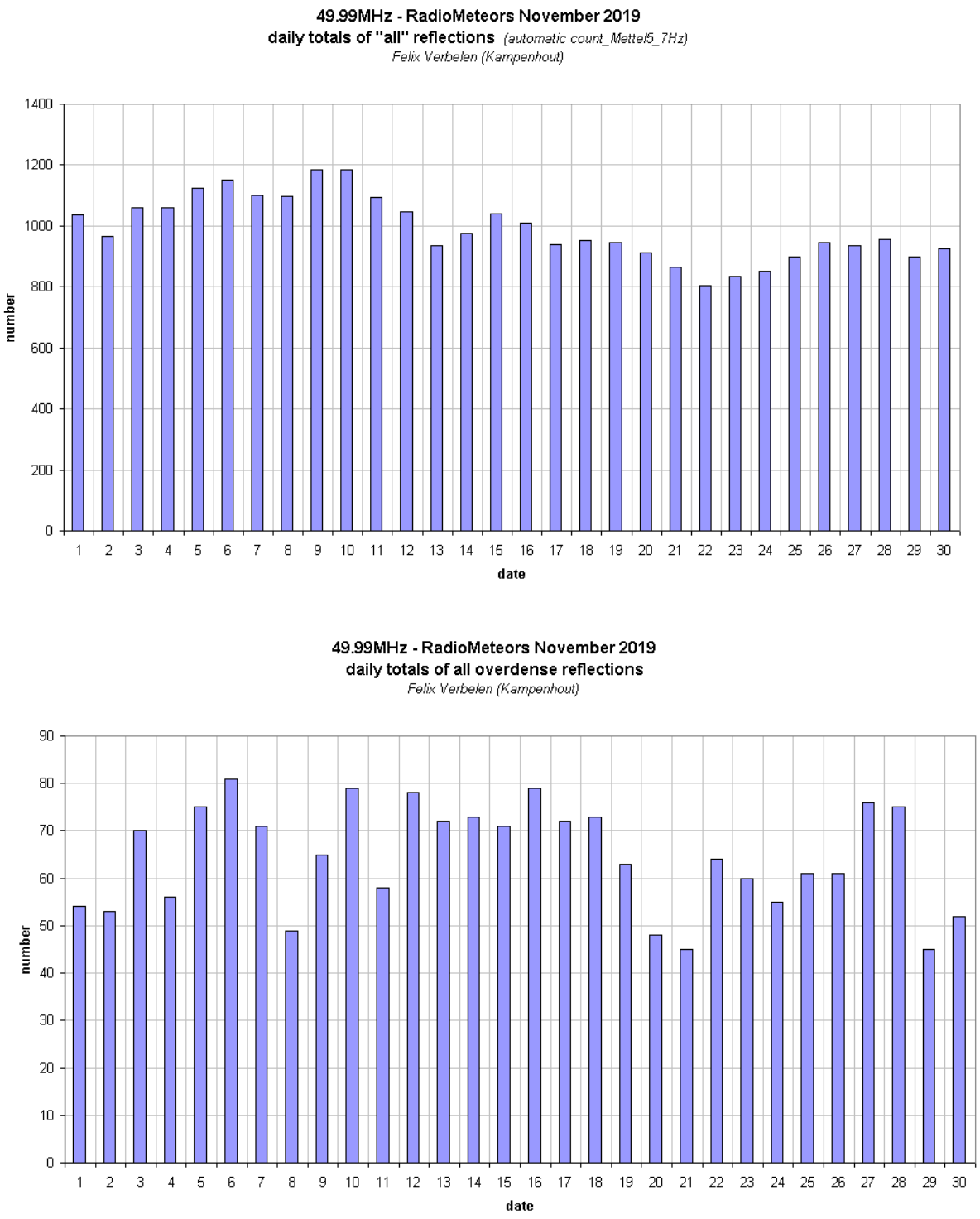
During this month there were few local disturbances (apart from sometimes quite strong background noise), no registered "sporadic E" (Es) nor was there lightning activity.

As expected, highlights of the month were the Leonids. The number of reflections of this swarm remained relatively low, but several overdense echoes longer than 10 seconds were observed. As on previous years, shorter overdense echoes came earlier than the longer, especially the overdenses longer than 1 minute, that peaked on November 19th.

Many other swarms were also active, showing quite a number of reflections longer than 10 seconds. Particularly interesting was the period 27-29th of November for which the IAU-meteor list prominently points to the November Orionids (NOO), but these can hardly be the source of the peaks shown by our graphs, since at the time of our maxima the NOO-radiant was under the local horizon. – To be further examined.

Some screen-dumps of a selection of eye-catching long duration reflections are displayed (*Figures 5 to 14*).

If you are interested in the actual figures, please send me an e-mail: felix.verbelen at skynet.be.



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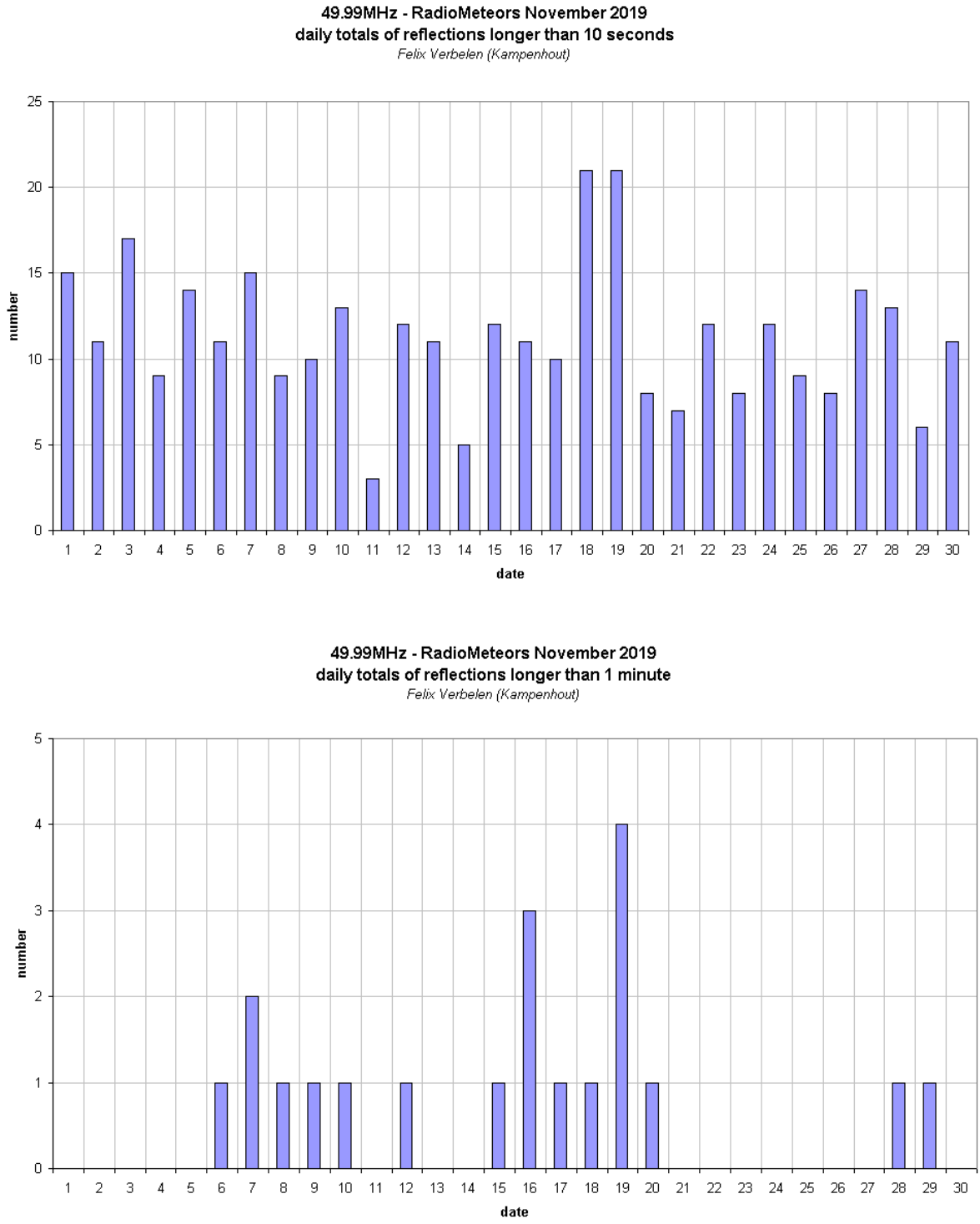
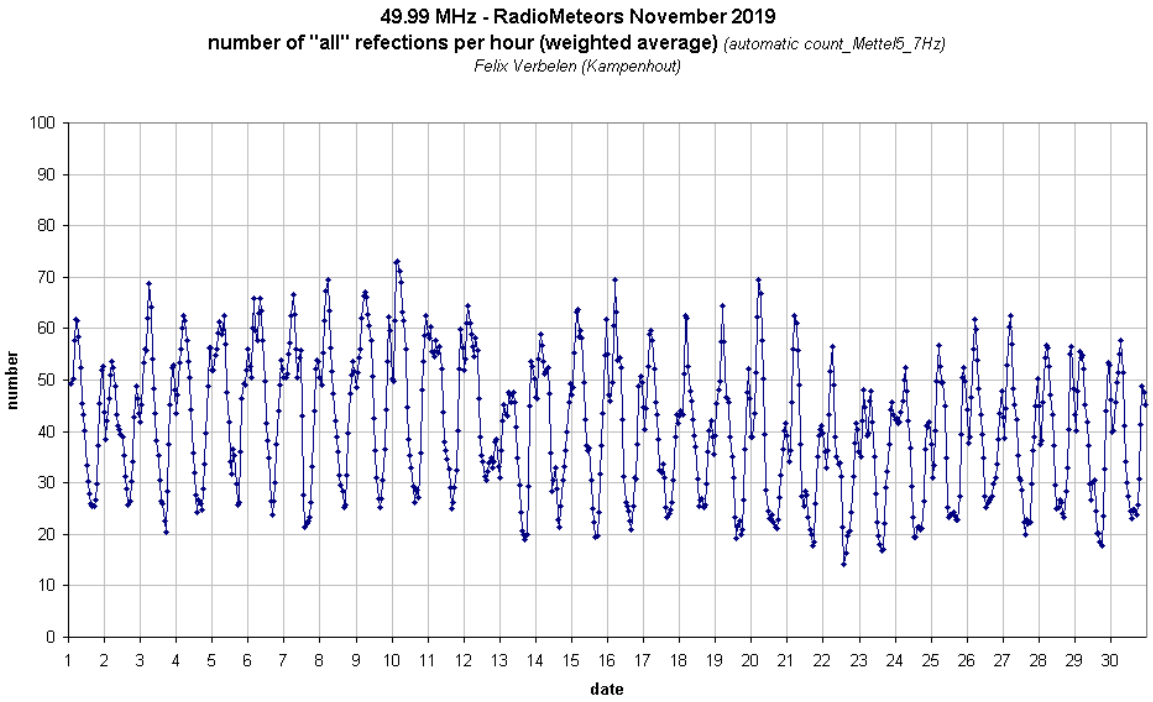


Figure 2 – The daily totals of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during November 2019.



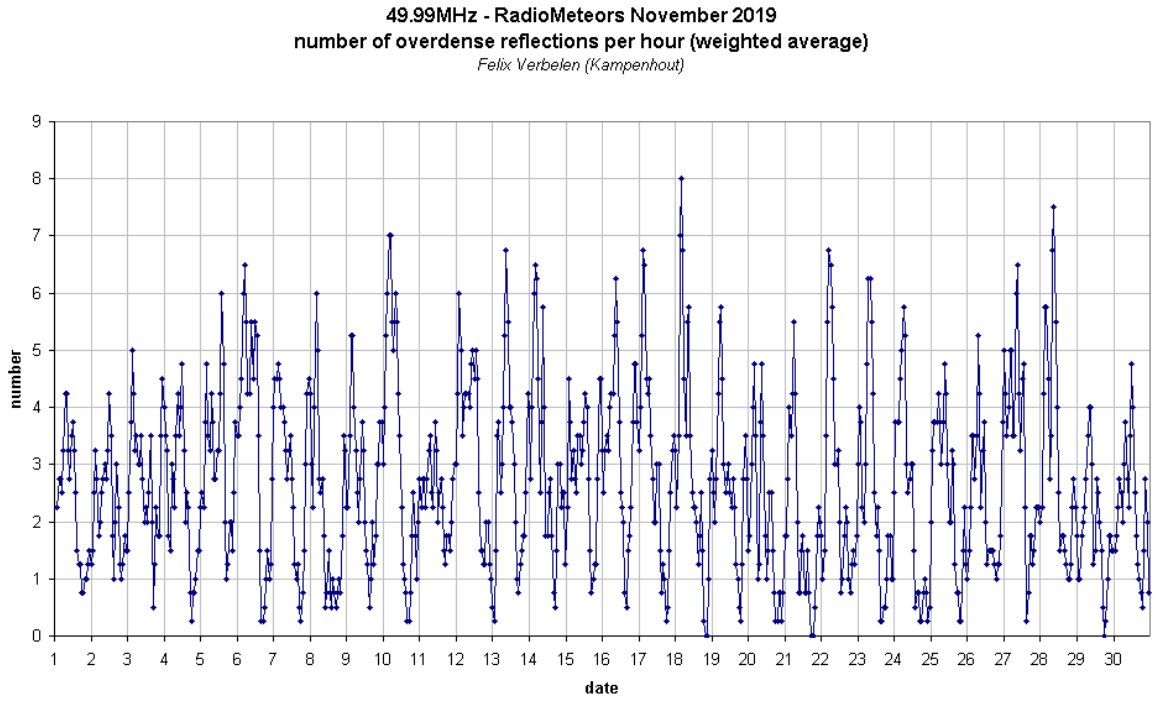


Figure 3 – The hourly numbers of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during November 2019.

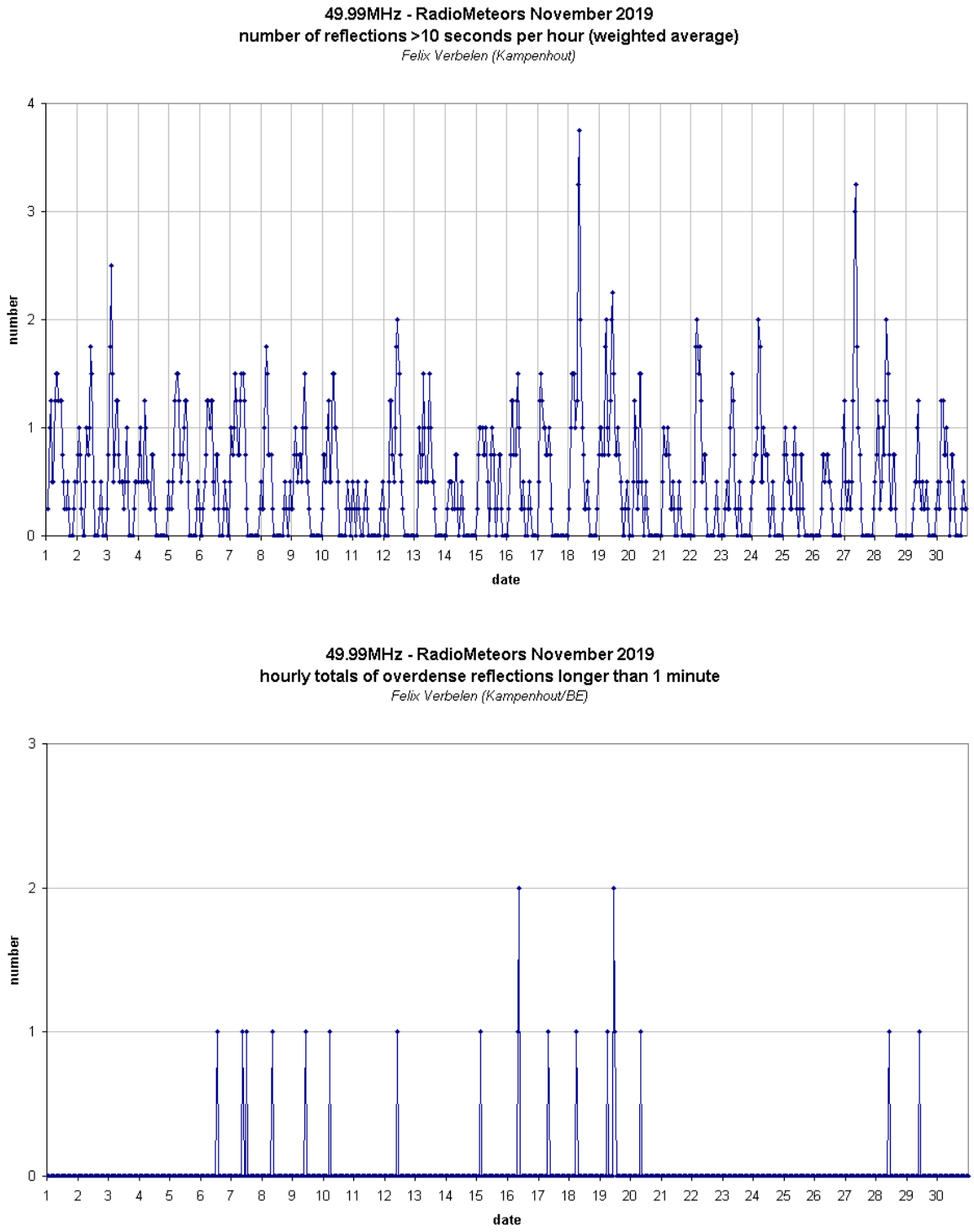


Figure 4 – The hourly numbers of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during November 2019.

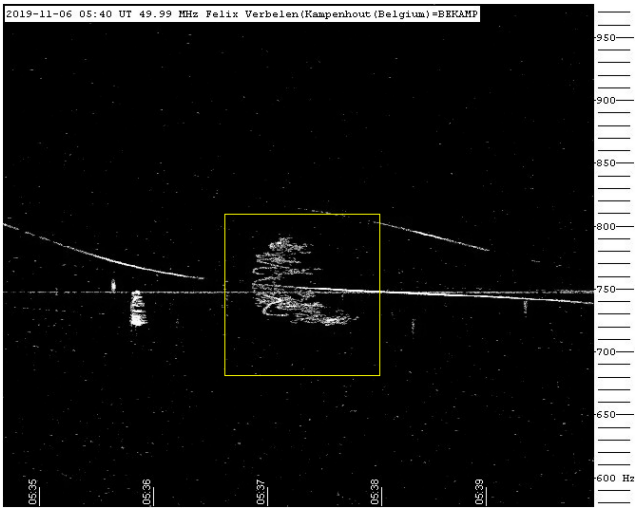


Figure 5 – 2019 November 06 at 05^{h}40^{m} UT.

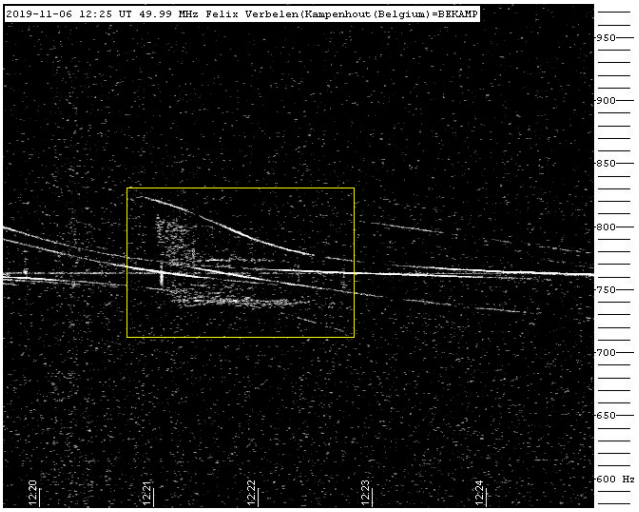


Figure 6 – 2019 November 06 at 12^{h}25^{m} UT.

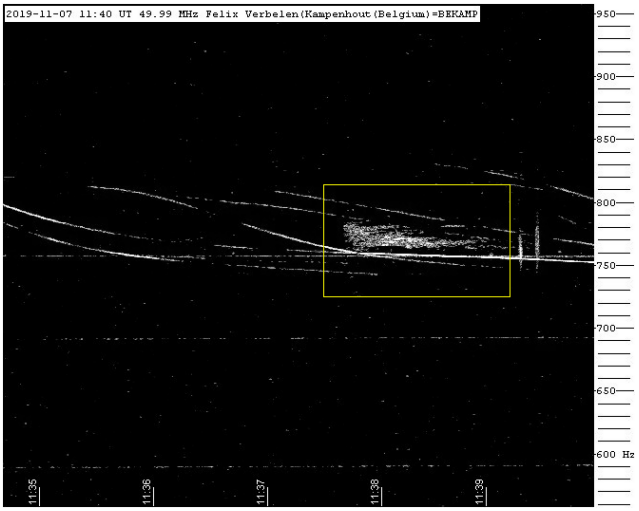


Figure 7 – 2019 November 07 at 11^{h}40^{m} UT.

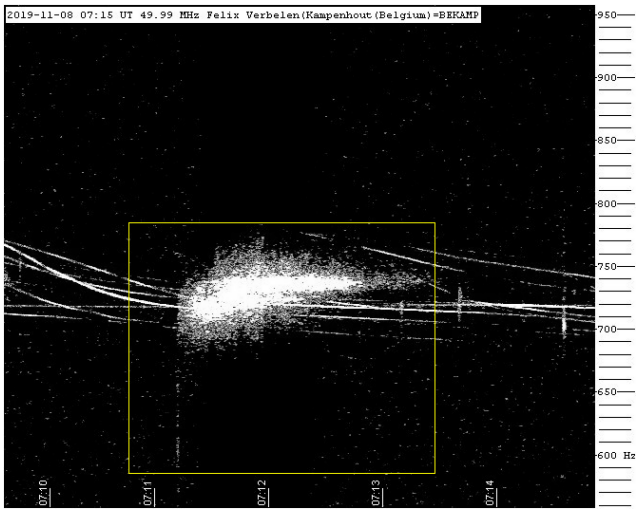


Figure 8 – 2019 November 08 at 07^{h}15^{m} UT.

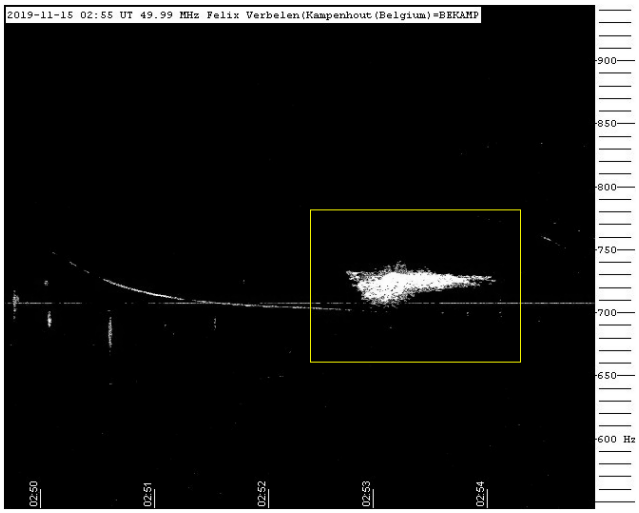


Figure 9 – 2019 November 15 at 02^{h}55^{m} UT.

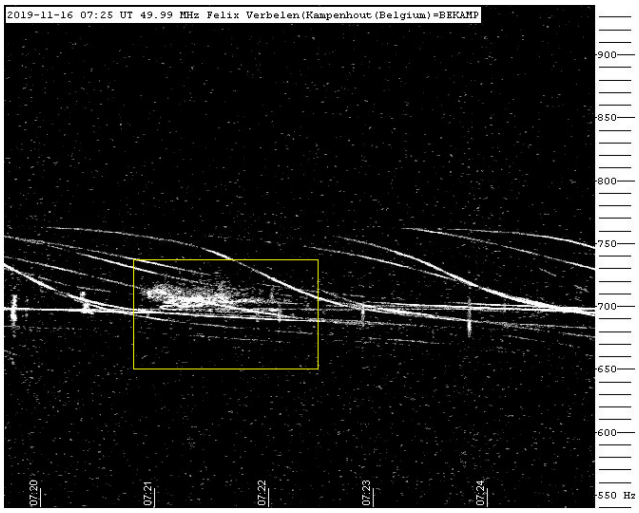


Figure 10 – 2019 November 16 at 07^{h}25^{m} UT.

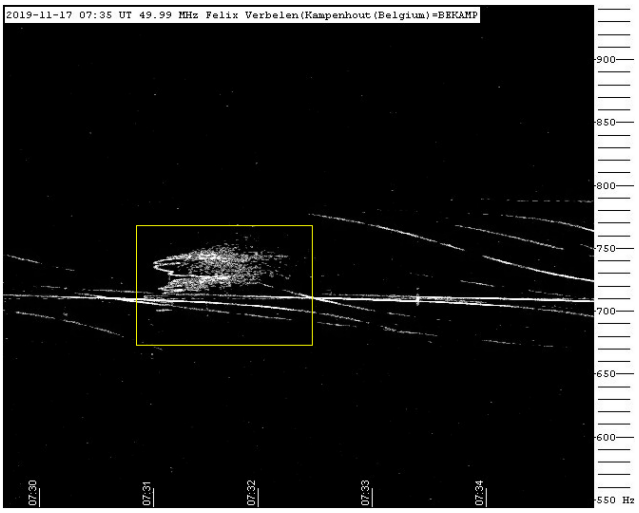


Figure 11 – 2019 November 17 at 07^{h}35^{m} UT.

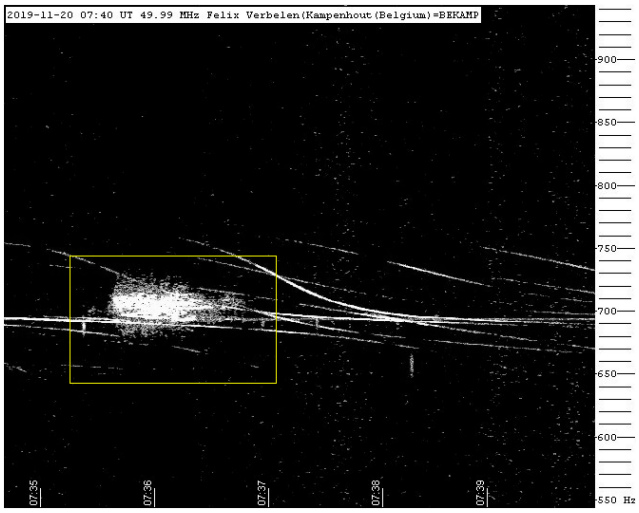


Figure 13 – 2019 November 20 at 07^{h}40^{m} UT.

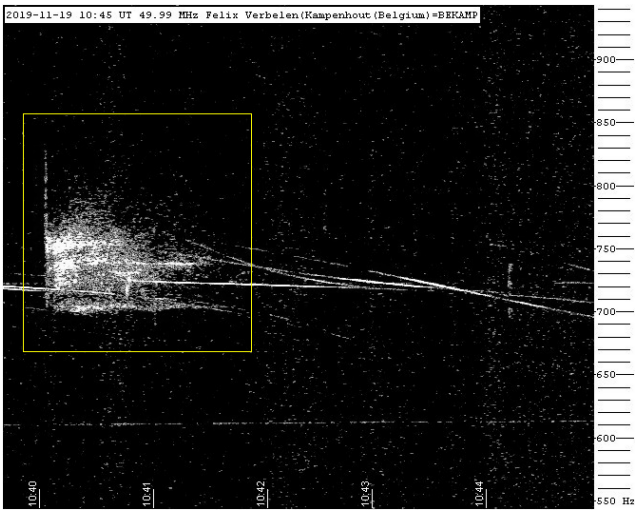


Figure 12 – 2019 November 19 at 10^{h}45^{m} UT.

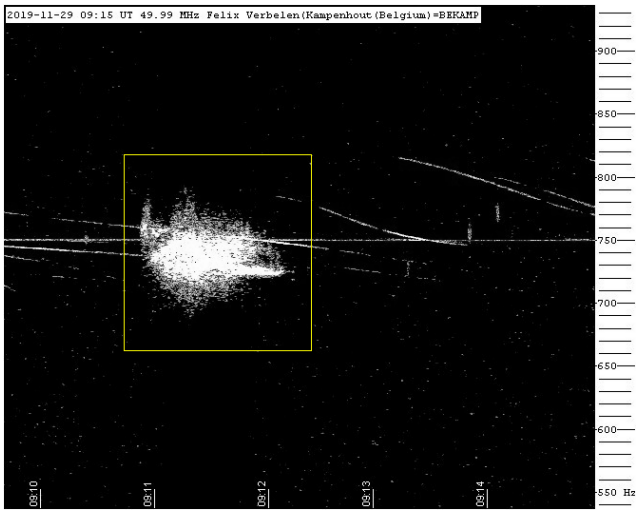


Figure 14 – 2019 November 29 at 09^{h}15^{m} UT.

Radio and photographic meteor monitoring in September 2019

Ivan Sergei

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A report is presented with the photographic and radio meteor observations of the author during September 2019 in Belarus.

1 Introduction

In the first part of the month, the increased meteor activity is probably related to the average activity of small meteor showers such as the AUR and SPE. According to CMOR data, the following minor showers were detected in the first half of September: KDR, ZCA, NIA, SDA, SAQ, SLY, KLE and the Aries-Triangulids. The second half of the month is calmer. Of the noticeable minor showers, only the Piscids had fairly average activity. The Canadian CMOR radar recorded activity of the following small meteor streams: KLE, DPL, SIC, NDR, SIA, ICE, SRP, DSX, STA and OPS.

I used a 5-element antenna pointing westward at my astronomical observatory in Polyani 8 km from the city of Molodechno (Belarus). Observations are conducted round the clock operating at a frequency of 88.6 MHz The detection program of the signals is Metan (Autor: Karol from Poland), using a laptop with an Intel Atom CPU N26000, 1.6 GHz processor. The graph in blue shows the average activity of meteors (*Figure 1*). The marks, in black indicate weak meteor activity according to MDC data. The program for displaying the results is RAMEDA (*Figure 2*) (author: Sergey Dubrovsky).

I also report results of the activity of bright meteors per night on the all-sky camera, using the Canon 350D. The most beautiful meteor was recorded in the constellation of Auriga on September 27 at 01^h29^m UT (*Figure 4*).

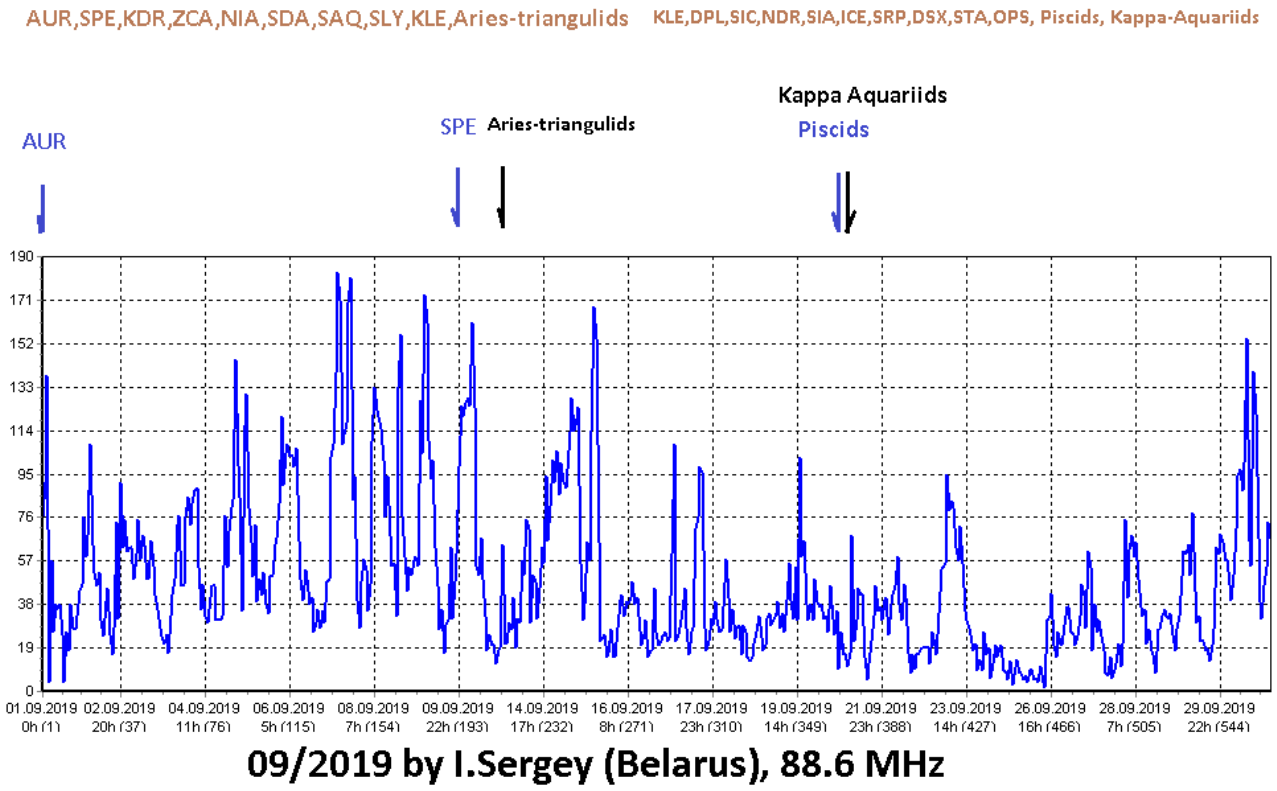

Figure 1 – Radio meteor echo counts at 88.6 MHz for September 2019.

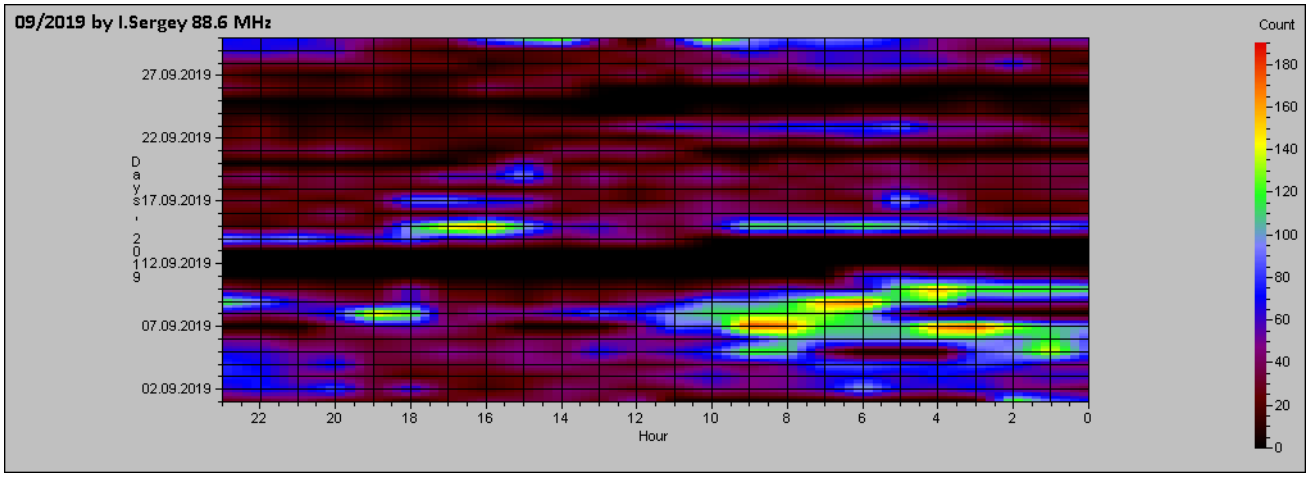

Figure 2 – Heatmap for radio meteor echo counts at 88.6 MHz for September 2019.

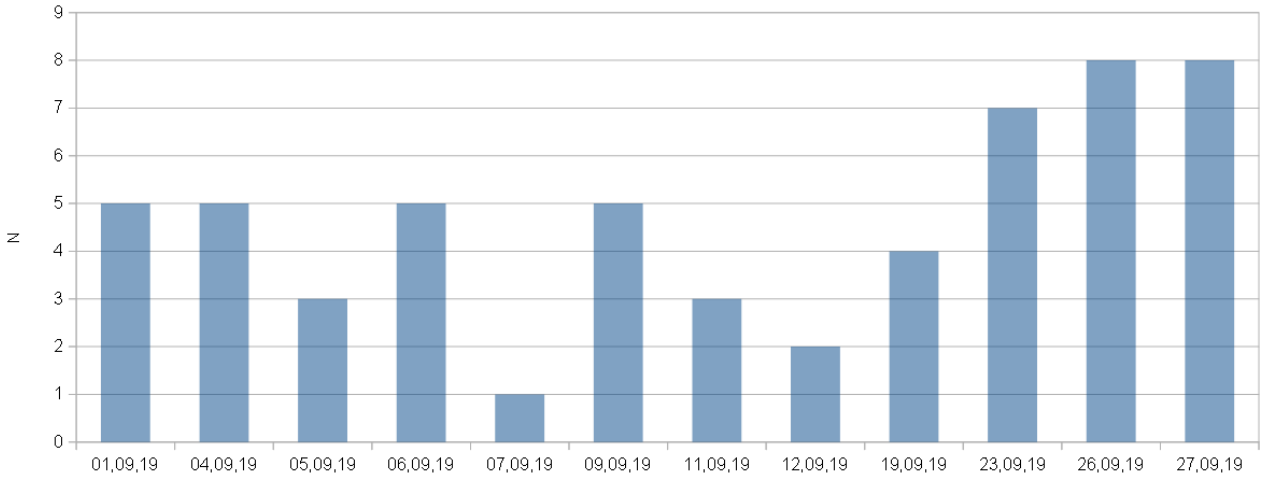

Figure 3 – Photograpic meteor count on the All-sky camera for September 2019.

Figure 4 – Bright meteor recorded in the constellation of Auriga on September 27 at $01^{h}29^{m}$ UT.

Radio and photographic meteor monitoring in October 2019

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A report is presented with the photographic and radio meteor observations of the author during October 2019 in Belarus.

1 Introduction

Results of radio and photographic meteor observations are presented, based on a private astronomical observatory 8 km north-west of the city Molodechno (place – Polyany, Latitude +54°16'46", Longitude 26°44'38"). The first half of the month was rather calm. A slight increase in meteor activity on October 8 and 9 was caused by the presence of the peak activity of the Draconids and the October Arietids. In the first half of the month, according to the CMOR data, activity of the following streams was recorded: KLE, DSX, STA, ZTA, DSX, DRA, LCY, SOR, LDR, EPC, OLP and DAU. The second half of the month had more activity with the wide maximum of Orionids during the period from 20 to 25 October with a maximum at about 22 October and an hourly activity of about 170 signals. The following CMOR streams were active during this period: LMI, AUM, EGE, LDR, OUI, AUM, ODC, STA, ORI, CTA, XDR and OER.

The graph in blue shows the average activity of meteors (*Figure 1*). The marks, in black indicate weak meteor activity according to MDC data. The program for displaying the results is RAMEDA (*Figure 2*) (author: *Sergey Dubrovsky*).

Photographic observations also show an increase in the activity of bright meteors and fireballs from 20 to 26 October, which agrees with the radio surveillance. The peak activity was reached on 23 October (9 meteors per hour). Bright meteor activity (signals greater than 10 seconds):

- October 20 – 18 signals per day;
- October 21 – 19 signals per day;
- October 22 – 20 signals per day;
- October 23 – 39 signals per day.

The activity of bright meteors was 39 signals per day on October 25 (duration of signals more than 10 seconds). The cause for the increased activity of bright meteors in the radio observations on October 15 is unknown. At the beginning of the month the activity was 12 signals per day for October 1 (*Figure 4*).

The RMS (Radio Meteor System) recorded a powerful radio signal lasting for about 26 seconds on October 25 at 00^h13^m UT. According to local reports in the media a bright fireball passed over Braslov at 00^h12^m UT (provided by Braslov Department of Internal Affairs).

I also report results of the activity of bright meteors per night on the all-sky camera, using the Canon 350D.

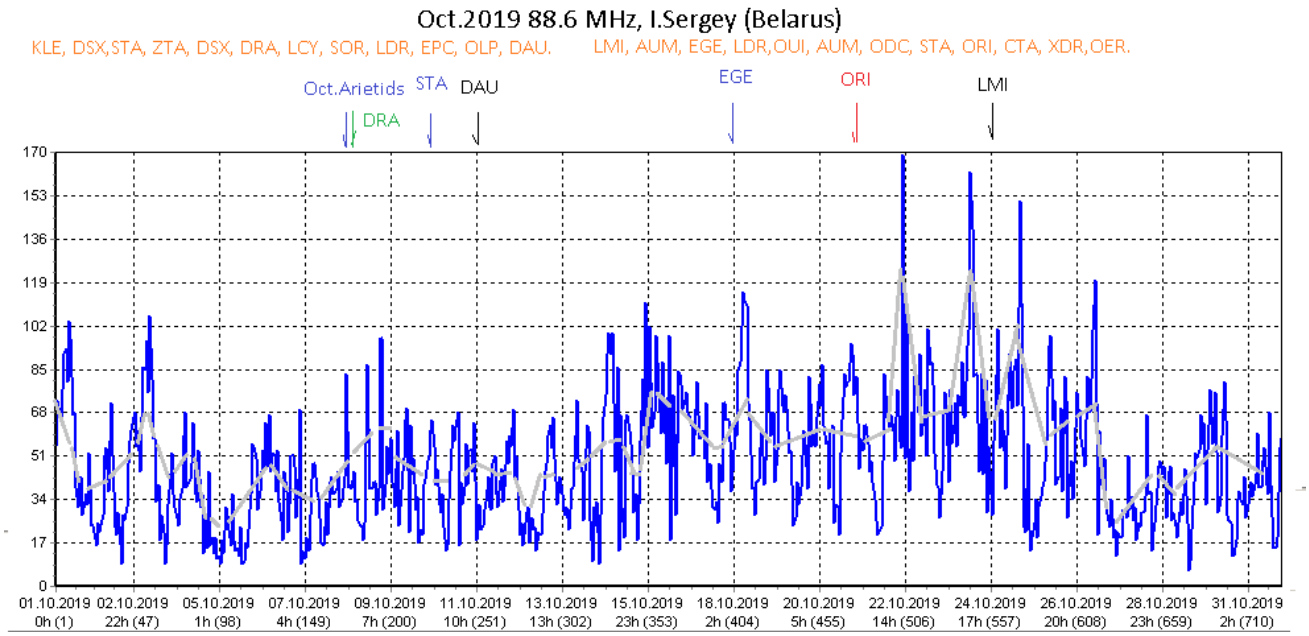

Figure 1 – Radio meteor echo counts at 88.6 MHz for October 2019.

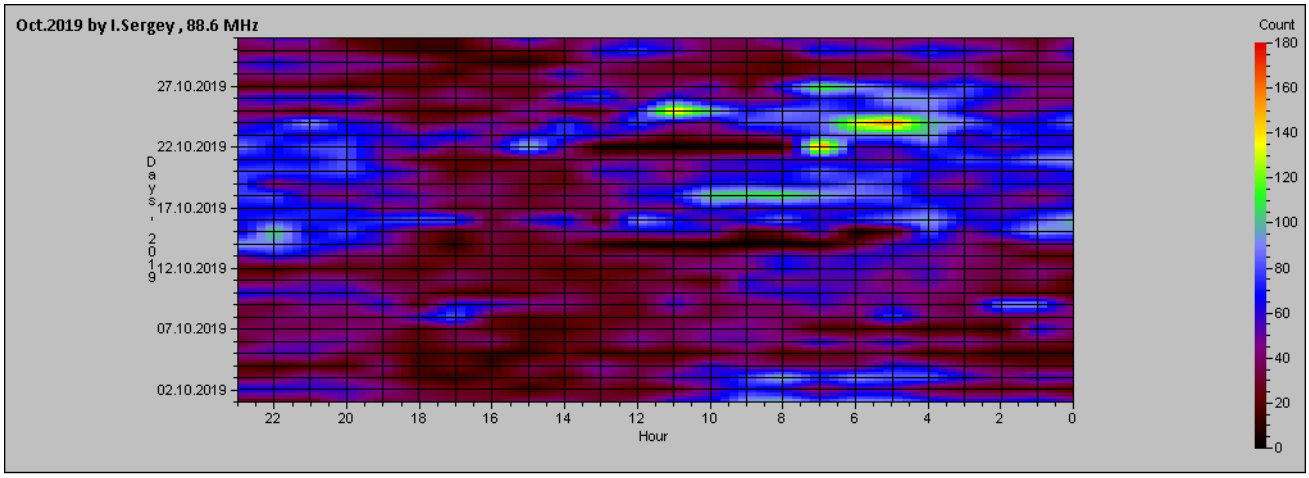

Figure 2 – Heatmap for radio meteor echo counts at 88.6 MHz for October 2019.

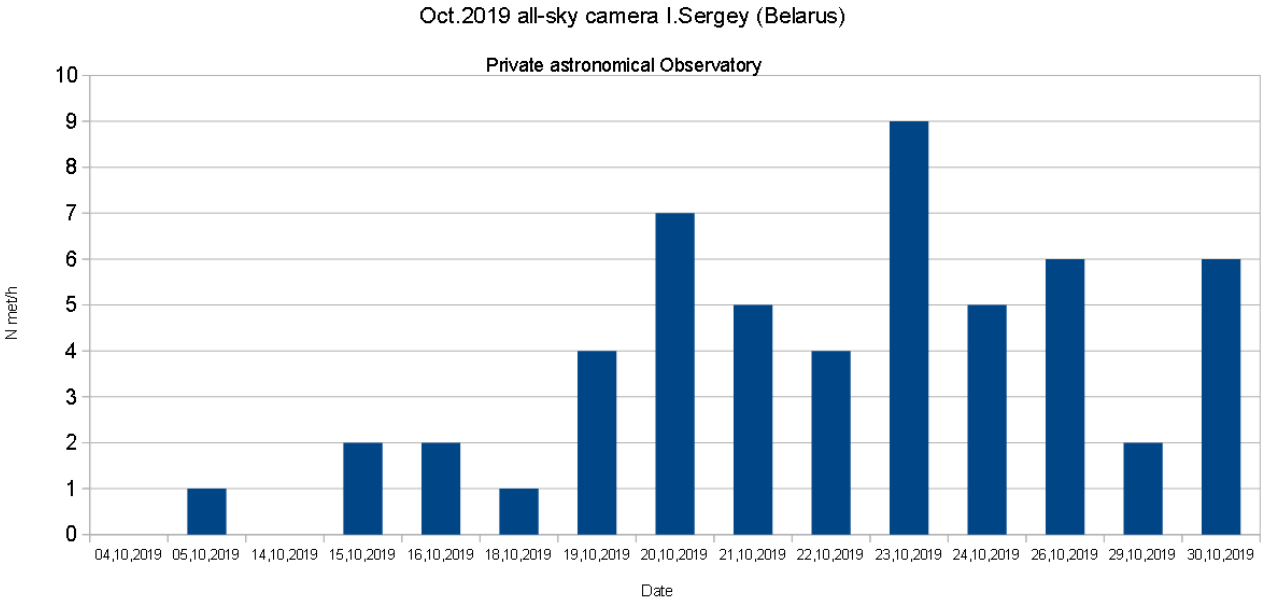

Figure 3 – Photographic meteor count on the All-sky camera for October 2019.

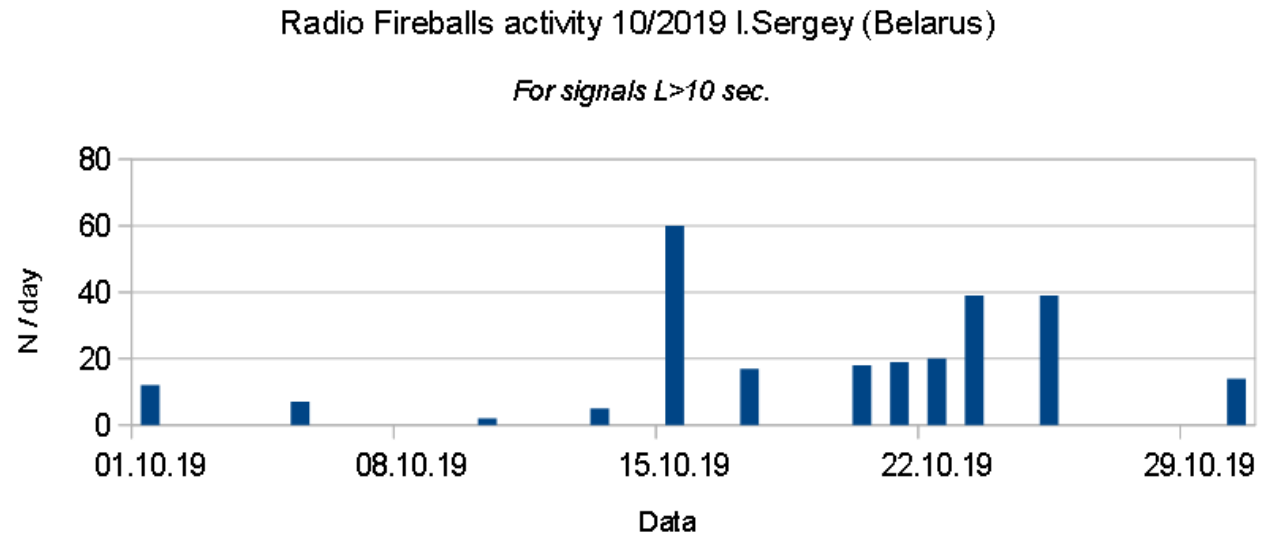

Figure 4 – Bright meteor echo count for October 2019.

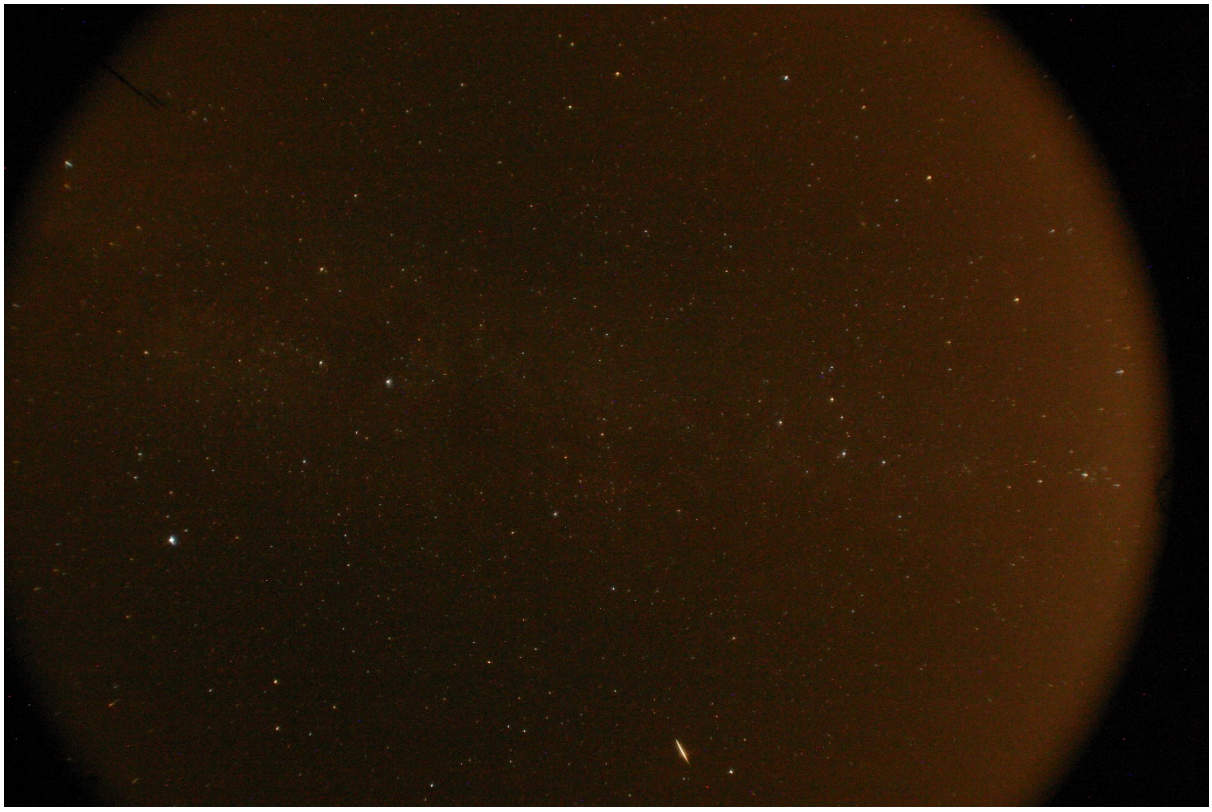

Figure 5 – A –4 fireball was recorded on October 21 at 17^h46^m UT, presumably from the LDR meteor shower which left a train that lasted for several minutes.

Figure 6 – On October 23 at 18^h30^m UT, a bright meteor from the STA meteor shower was recorded.

Figure 7 – A bright and beautiful Orionid meteor was registered on October 25 at 00^h13^m UT.

Figure 8 – A beautiful bright STA meteor was recorded on October 30 at 23^h27^m UT.

Radio meteor monitoring in November 2019

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The results of the author's radio meteor observations for November 2019 are presented, as well as the first observing results of the meteor showers of the Leonids and the Northern Taurids (NTA) according to the Canadian Meteor Orbit Radar (CMOR).

1 The November observations

The observations were carried out at a private astronomical observatory near the town of Molodechno (Belarus) at the place of Polyani. A 5 element-antenna directed to the west was used, a car FM-receiver was connected to a laptop with as processor an Intel Atom CPU N2600 (1.6 GHz). The software to detect signals is *Metan* (author - Carol from Poland). A feature of my RMS (Radio Meteor System) is the reception of signals from the smallest meteoroids that generate signals, I've created some scale to relate the signal level of meteors in the radio echoes and the photographic star brightness from my all sky camera. The scale turned out to be is very approximate. up to about 6 to 7 magnitude stars.

There was more activity during the first half of the month because of the Orionids and also the Southern Taurids (STA) are still active in early November. In the first half of the month, the following meteor showers ae active: CTA, NTA, OKD, OER, ORI, STA, NID, NOO, OER, ZCN, NAS, IAR, LEO and AND. The second half of the month is calmer. The total number of small showers is larger than in the first half of the month, but their total activity results in lower rates than in the first half of the month. During this period of time, the following showers display activity: ORI, LEO, NOO, NOO, IOA, QUA, STA, NAS, AND, THA, OER, OME, NAR, FTA, AMO, NZT, NZP, NLD, GCP, NLY, GEM, NSU and ZLE. CMOR incorrectly shows two NTA radiants. In fact, the southern radiant marked on the radar images as "NTA" is the STA shower. Interestingly enough, the radar has detected the start of the main QUA shower activity one and a half months before the start of the shower activity!

The arrows on the graph (*Figure 1*) show the maximum activity of meteor shower, the shower code refers to the IAU working list of meteor showers managed by MDC. Black indicates weak activity, blue is average activity, red is strong activity, green stands for variable activity. Some minor meteor showers which are active according to the CMOR data are also indicated.

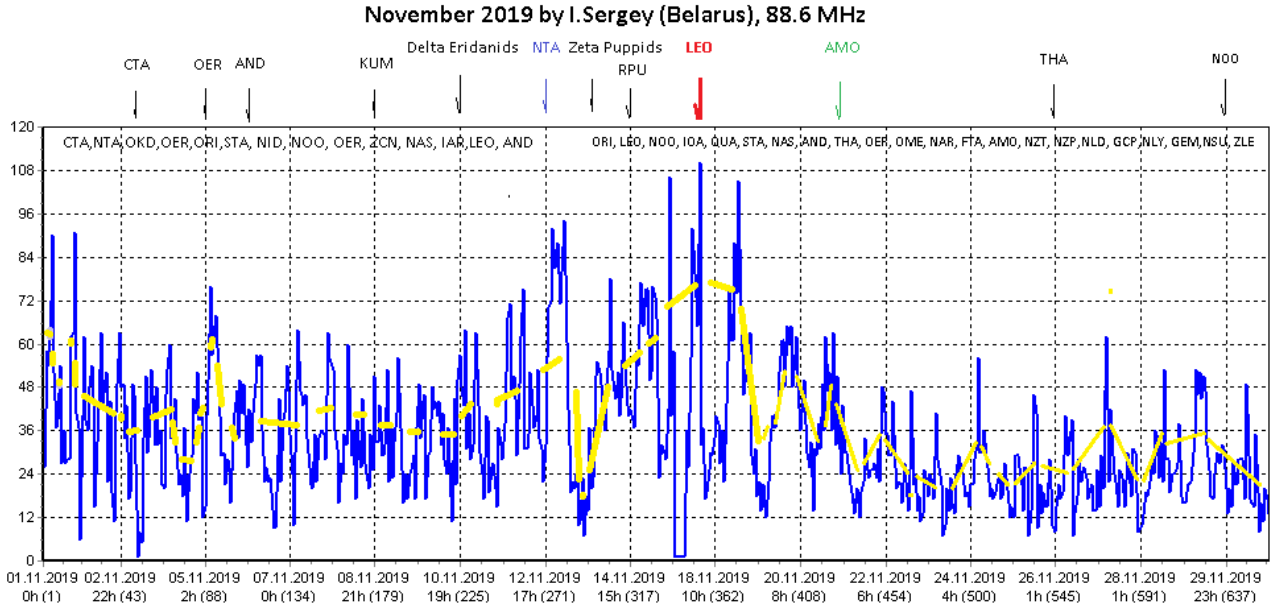

Figure 1 – Radio meteor echo counts at 88.6 MHz for November 2019.

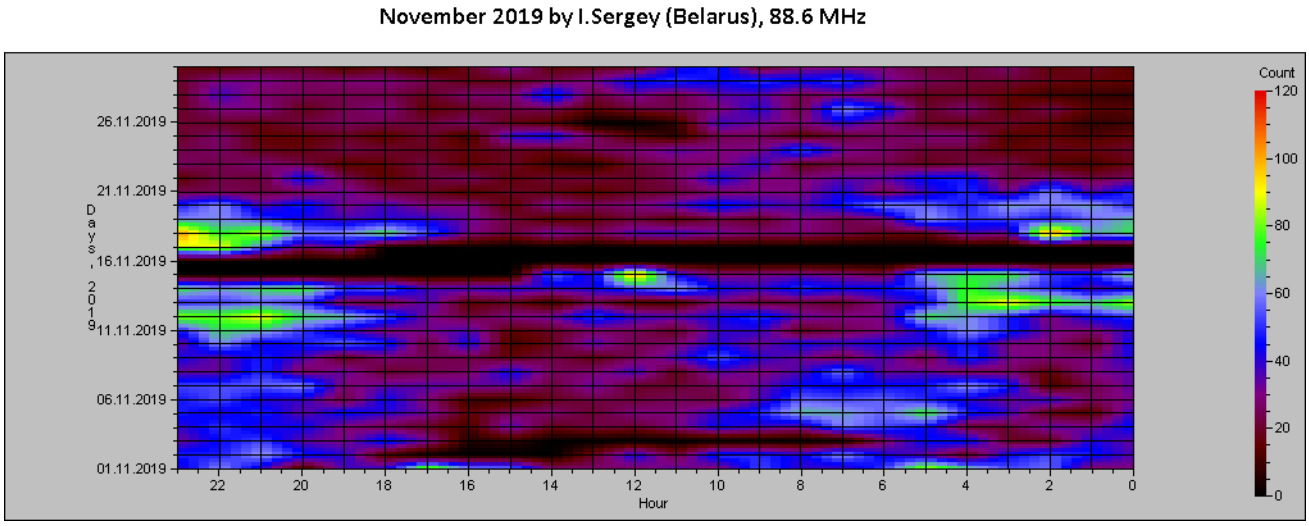

Figure 2 – Heatmap for radio meteor echo counts at 88.6 MHz for November 2019.

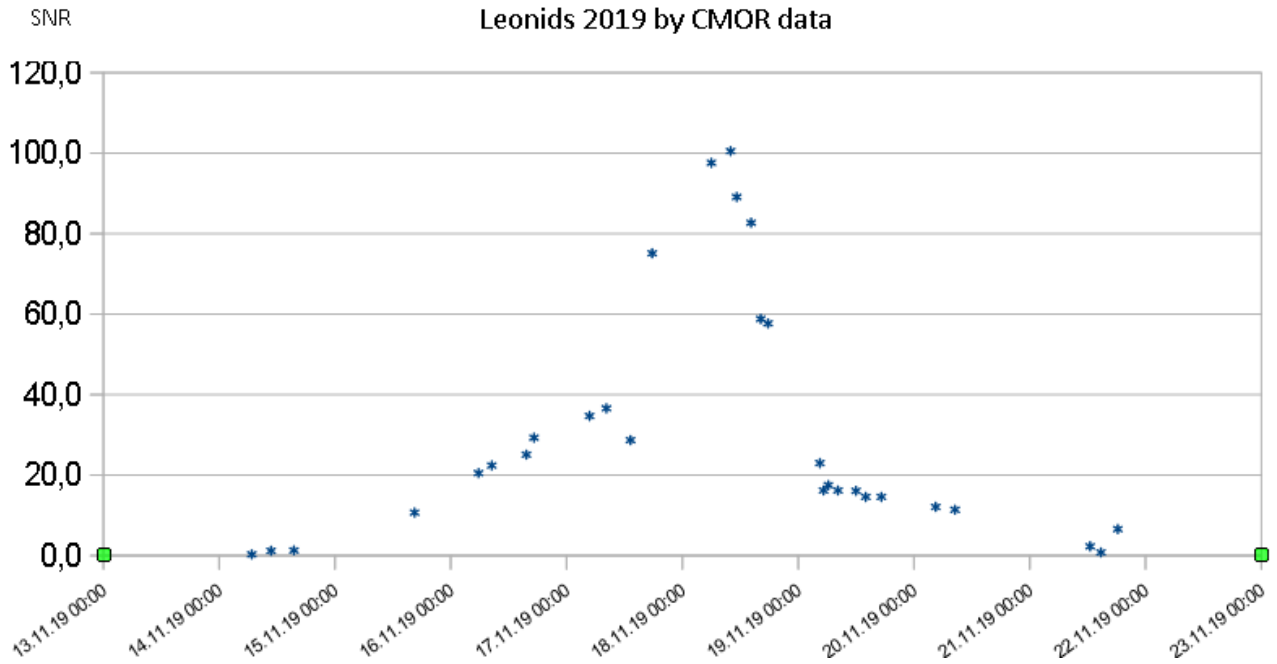

Figure 3 – The Leonid activity according to CMOR. (Signal-to-Noise Ratio - SNR is defined as the ratio of signal power to the noise power).

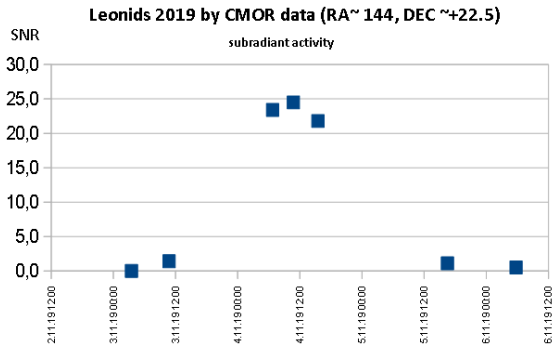

Figure 4 – Activity of the Leonid sub-radiant in 2019.

I present the first results of a study of the Leonid meteor shower activity based on the Canadian Meteor Orbit Radar (CMOR) data (Jones et al., 2005). Radiant images were analyzed using Maxim DL photometry software. The optimal SNR level for the sub-radiant was determined manually (determining while moving the cursor over the image) with a radius of 1.5 degrees at (R.A.~144° DEC ~ +22.5°) (see *Figures 4 and 5*), and with a radius of 3.5 degrees for the main radiant at (R.A.=153° DEC = +22°) (see *Figure 6*). The sub-radiant appeared on the radar on November 14th and disappeared on November 16th.

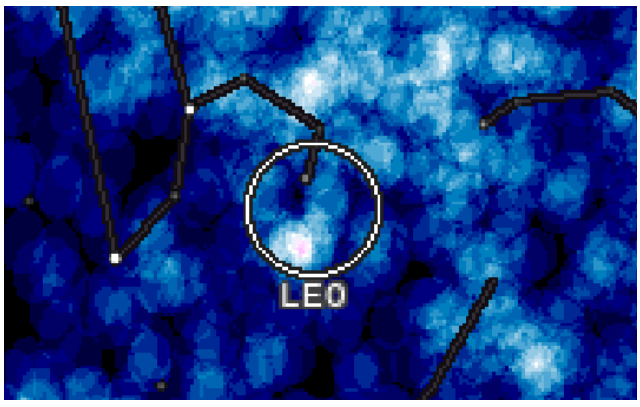

Figure 5 – Position of the Leonid sub-radiant according to CMOR data.

The maximum activity was short-lived and appeared around 11^{h} UT on 14 November. The main shower radiant appeared on the radar on November 14 and disappeared on November 21. The peak activity occurred at the interval of 06^{h}00^{m}–10^{h}00^{m} UT on November 18 (*Figure 3*), which coincides with the data announced by Robert Lunsford (Meteor Activity Outlook for November 2019, IMO-News)[28]: The annual Leonids were predicted to peak at about 05^{h}00^{m} UT on November 18th.

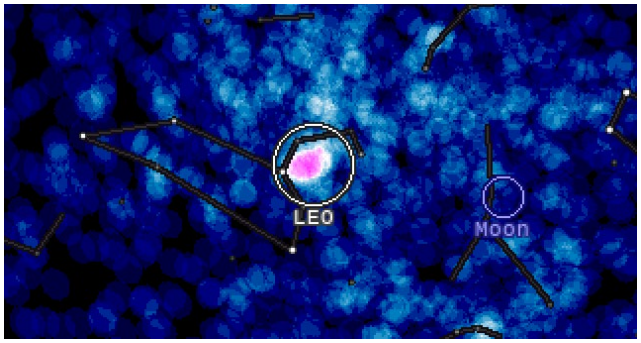

Figure 6 – Leonids radiant position according to CMOR.

According to IMO data, the peak activity occurred a day earlier, i.e. on November 17 about 06^{h}30^{m} UT with a ZHR of about 29. However, in IMO there are no observations for November 18, so it is impossible to determine the exact moment of the peak activity of the shower, based on the visual data of IMO.

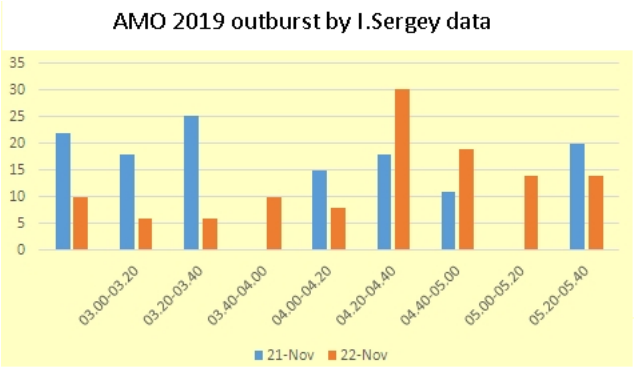

Figure 7 – Increased AMO activity from my RMS data.

Table 1 – Overview of the AMO activity according to RMS data for 2016–2018, all times in UT.

2016				2017				2018			
21.11.2016	N	22.11.2016	N	21.11.2017	N	22.11.2017	N	21.11.2018	N	22.11.2018	N
03.00-03.20	19	03.00-03.20	13	03.00-03.20	14	03.00-03.20	21	03.00-03.20	9	03.00-03.20	15
03.20-03.40	23	03.20-03.40	16	03.20-03.40	16	03.20-03.40	20	03.20-03.40	25	03.20-03.40	13
03.40-04.00	12	03.40-04.00	20	03.40-04.00	16	03.40-04.00	19	03.40-04.00	25	03.40-04.00	6
04.00-04.20	14	04.00-04.20	15	04.00-04.20	24	04.00-04.20	19	04.00-04.20	19	04.00-04.20	14
04.20-04.40	18	04.20-04.40	20	04.20-04.40	21	04.20-04.40	22	04.20-04.40	22	04.20-04.40	11
04.40-05.00	23	04.40-05.00	16	04.40-05.00	32	04.40-05.00	18	04.40-05.00	21	04.40-05.00	13
05.00-05.20	–	05.00-05.20	21	05.00-05.20	20	05.00-05.20	20	05.00-05.20	17	05.00-05.20	8
05.20-05.40	–	05.20-05.40	14	05.20-05.40	16	05.20-05.40	16	05.20-05.40	12	05.20-05.40	15
05.40-06.00	–	05.40-06.00	32	05.40-06.00	17	05.40-06.00	12	05.40-06.00	21	05.40-06.00	8
06.00-06.20	8	06.00-06.20	16	06.00-06.20	21	06.00-06.20	16	06.00-06.20	20	06.00-06.20	8
06.20-06.40	19	06.20-06.40	15	06.20-06.40	18	06.20-06.40	20	06.20-06.40	10	06.20-06.40	17

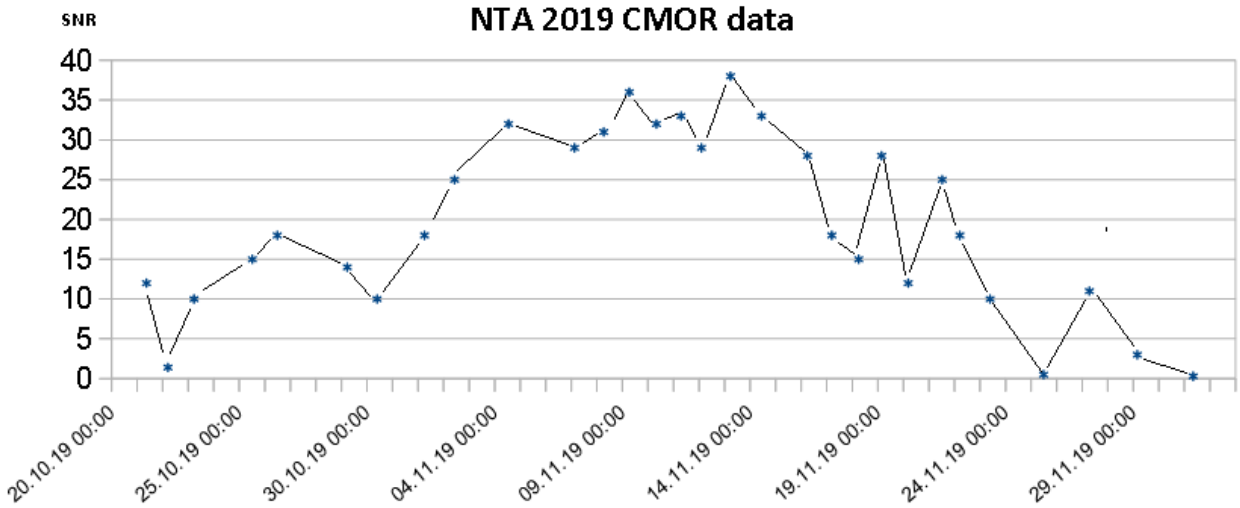

Figure 8 – NTA activity according to CMOR data.

[28] https://www.meteornews.net/2019/11/15/meteor-activity-outlook-for-16-22-november-2019/

According to my data, some increase in AMO activity occurred in the interval 04^h40^m–05^h00^m UT on November 22, 2019. because of the higher activity of the meteor shower (radar sensitivity is a bit rough). During the interval 04^h40^m–05^h00^m UT some increase in the level of meteor signals was recorded.

In 2016, there was a brief spike in meteor signal activity at 05^h40^m–06^h00^m UT 22.11.2016. In 2017 and 2018 there were no short-term bursts in the morning of November 22.

The IMO Newsletter for NTA shows the peak of this meteor shower on November 3. And the IMO calendar shows the peak activity of the shower on November 13 (Rendtel, 2018). I decided to do a little research on this topic when this shower peaks. To do this, I analyzed images from CMOR (Canadian Meteor Orbit Radar).

I did a radiant flux photometry (radiant intensity measurement) and drew up a SNR (Time) graph. The graph and even the images show that the radiant is very intense (there is redness) around November 13, but on November 9, the double structure is visible (*Figure 9*).

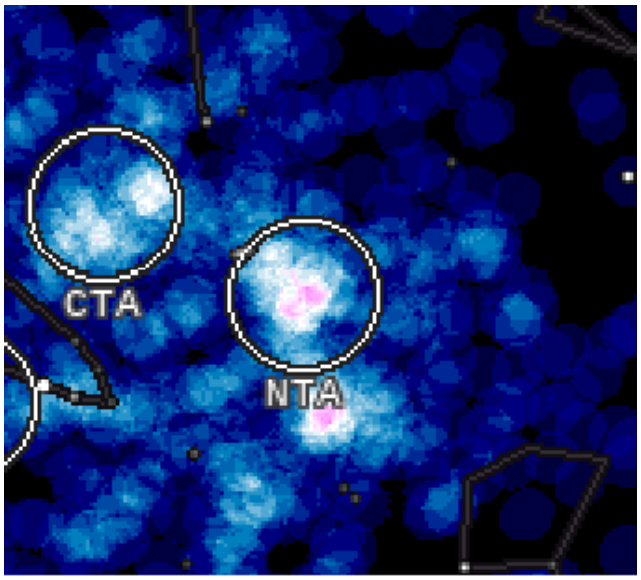

Figure 9 – Double NTA structure according to CMOR data.

But from November 2 to November 4, the radiant is less intense, rather white without reddish color. So, the maximum NTA is around November 13, not November 3, as mentioned on the mailing list by Robert Lunsford. Interestingly, on November 9, a double radiant structure appeared.

2 Conclusion

CMOR observations allow us to determine the periods of activity of the most noticeable meteor showers, the peak interval of the activity, radiant drift over time and the activity range of the showers. Personal radio observations allow you to monitor the overall level of activity, also to monitor the short-term outburst activity of the showers and to study the activity of the fireballs. The advantage of radio observations is the 24/24 hours monitoring and the independence from weather conditions.

Acknowledgment

I would like to thank Sergey Dubrovsky for the software they developed for data analysis and processing of radio observations. Thanks to Paul Roggemans for his help in the lay-out and the correction of this article. Thanks to, Christian Steyaert, for his help with the data processing.

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Rendtel Jürgen (2019). “Meteor Shower Calendar”. IMO.

CAMS Florida events Autumn 2019

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A remarkable Earth grazing meteor on 2019 October 25 and an exceptional early Leonid on 2019 November 5 are described.

1 Earth-grazer on October 25

Every now and then, we see an Earth-grazing meteor with exceptionally long ground track. Such was the case with a 1st-magnitude meteor over northern Florida, traveling NE to SW early on the morning of October 25.

Figure 1 – CAMS 5002 image with Earth-grazer, 2019 October 25, $06^h29^m50^s$ UT.

Observed ground track was 225km before it disappeared over the Gulf of Mexico. Initial height was 115km, descending to 111km, after being tracked for 3.6 seconds by CAMS-FL sites. The object's orbital parameters computed by UFOOrbit:

- $a = 7.61$
- $e = 0.922$
- $i = 123.6$

UFOOrbit correlated this earth-grazing meteor with the Leonis Minorid meteor shower (LMI#022), which peaked during the night of October 24–25. As seen from north Florida, the shower's radiant rose above the eastern horizon at 06^h21^m UT. Appearing just 8 minutes later at $06^h29^m49^s$ UT, the tangential approach of the meteoroid through Earth's atmosphere accounted for the long trail.

Seven cameras of the CAMS-FL network captured this object as it streaked by: Gainesville (5002, 5003, 5007), College of Central Florida (5023, 5024), Ocklawaha (5043, 5044).

Fall and Winter typically bring good weather to north Florida, and we look forward to more excitement like this!

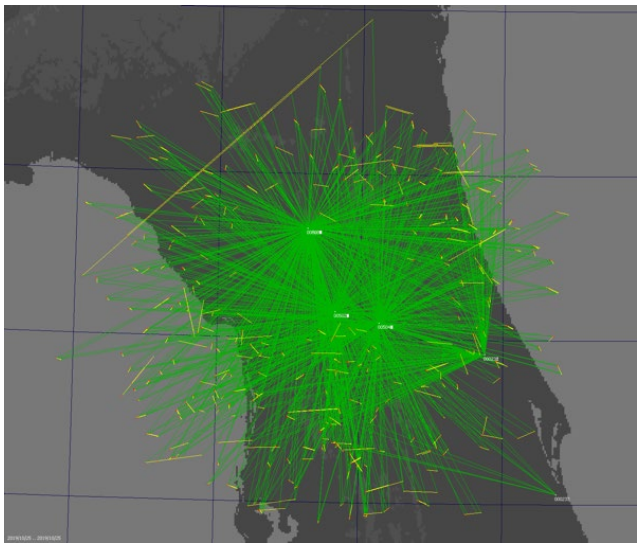

Figure 2 – Ground plots of all meteors with that of the Earth-grazer.

2 An early Leonid on November 5

Although the peak of the Leonid meteor shower is still 2 weeks away, CAMS-Florida captured a bright one last night, at magnitude –2.9. Contributing sites were CAMS 233 (Florida Institute of Technology) and CAMS 5004 (Gainesville).

Date & Time were 5 November $09^h38^m02^s$ UT.

UFOOrbit initially failed to identify it as a Leonid. However, inspection of the radiant plot and CSV file show that the radiant was very close to the predicted position, with orbital parameters that match what would be expected of a Leonid meteor.

September 2019 report CAMS BeNeLux

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A summary of the activity of the CAMS BeNeLux network during the month of September 2019 is presented. September 2019 counted many clear nights. 30389 meteors were recorded,14826 of which proved multiple station, or 49%. A total of 4609 orbits were collected during this month.

1 Introduction

In general September tends to be a very favorable month for meteor observations with a rich activity although no major showers are active this month. The only uncertainty remains the weather which has been favorable in recent years during this month. What would September 2019 bring?

2 September 2019 statistics

CAMS BeNeLux collected 30389 meteors of which 14826 or 49% were multi-station, good for 4609 orbits. This is about 20% less than previous year. This month counted as many as 15 nights with more than 100 orbits. The best September night was 20–21 with as many as 456 orbits in a single night. Only one night remained without any orbits. The statistics of September 2019 are compared in *Figure 1* and *Table 1* with the same month in previous years since the start of CAMS BeNeLux in 2012. In 8 years, 209 September nights allowed to obtain orbits with a grand total of 24013 orbits collected during September during all these years together.

The weather was very favorable and September 2019 allowed to register more than 1000 meteors extra compared to September 2018. However, the return in number of orbits was finally almost 1000 orbits less than what we got during the 2018 record month for September. The northern part of the CAMS BeNeLux network suffered less good coverage as some of the CAMS stations were temporarily inactive or unable to contribute for various reasons. While the first three weeks of September had favorable weather, from September 22 onwards the BeNeLux got rather very poor weather circumstances.

The volume of atmosphere monitored by the CAMS BeNeLux cameras is huge. If all or most cameras are kept operational, most of the meteors registered will help to obtain an orbit. However as soon as several cameras, or some stations drop out for whatever reason, the remaining cameras have less chance to get multi-station results. The difference in number of orbits between 2019 compared to 2018 shows how much the success of a camera network depends on a common effort by the different stations.

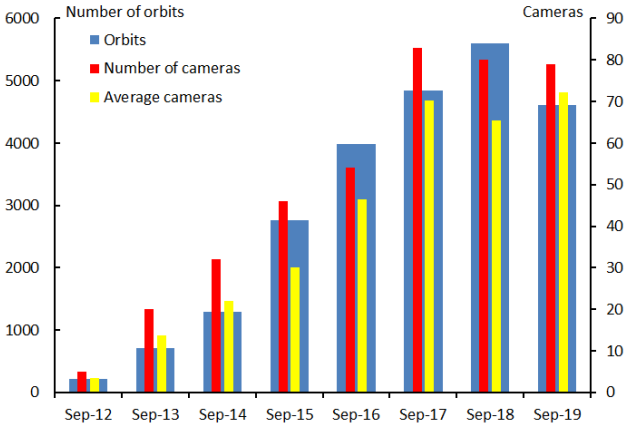

Figure 1 – Comparing September 2019 to previous months of September in the CAMS BeNeLux history. The blue bars represent the number of orbits, the red bars the maximum number of cameras running in a single night and the yellow bar the average number of cameras running per night.

Table 1 – September 2019 compared to previous months of September.

Year	Nights	Orbits	Stations	Max. Cams	Min. Cams	Mean Cams
2012	18	209	5	5	-	3.4
2013	19	712	9	20	-	13.7
2014	27	1293	14	32	-	22.0
2015	29	2763	15	46	-	30.0
2016	30	3982	19	54	32	46.5
2017	29	4839	22	83	47	70.2
2018	28	5606	20	80	57	65.4
2019	29	4609	20	79	64	72.3
Total	209	24013				

3 Conclusion

September 2019 confirmed the reputation of this month with a very rich background meteor activity and favorable weather. The smaller number of orbits compared to September 2018 can be explained by the fact that a few camera stations were not available for different reasons.

Acknowledgment

Many thanks to all participants in the CAMS BeNeLux network for their dedicated efforts. Thanks to *Martin Breukers* for providing all the data on which this report is based. The CAMS BeNeLux team was operated by the following volunteers during the month of September 2019:

Hans Betlem (Leiden, Netherlands, CAMS 371, 372 and 373), *Jean-Marie Biets* (Wilderen, Belgium, CAMS 379, 380, 381 and 382), *Martin Breukers* (Hengelo, Netherlands, CAMS 320, 321, 322, 323, 324, 325, 326 and 327, RMS 328 and 329), *Guiseppe Canonaco* (Genk, RMS 3815), *Bart Dessoy* (Zoersel, Belgium, CAMS 397, 398, 804, 805, 806 and 888), *Jean-Paul Dumoulin and Christian Walin* (Grapfontaine, Belgium, CAMS 814 and 815, RMS 003814), *Luc Gobin* (Mechelen, Belgium, CAMS 390, 391, 807 and 808), *Tioga Gulon* (Nancy, France, CAMS 3900 and 3901), *Robert Haas* (Alphen aan de Rijn, Netherlands, CAMS 3360, 3361, 3362, 3363, 3364, 3365, 3366 and 3367), *Robert Haas* (Texel, Netherlands, CAMS 810, 811, 812 and 813), *Robert Haas / Edwin van Dijk* (Burlage, Germany, CAMS 801, 802, 821 and 822), *Klaas Jobse* (Oostkapelle, Netherlands, CAMS 3030, 3031, 3032, 3033, 3034, 3037, 3038 and 3039), *Hervé Lamy* (Dourbes, Belgium, CAMS 394 and 395), *Hervé Lamy* (Humain Belgium, CAMS 816), *Hervé Lamy* (Ukkel, Belgium, CAMS 393), *Koen Miskotte* (Ermelo, Netherlands, CAMS 351, 352, 353 and 354), *Tim Polfliet* (Gent, Belgium, CAMS 396), *Steve Rau* (Zillebeke, Belgium, CAMS 3850 and 3852), *Paul and Adriana Roggemans* (Mechelen, Belgium, CAMS 383, 384, 388, 389, 399 and 809, RMS 003830 and 003831), *Hans Schremmer* (Niederkruechten, Germany, CAMS 803) and *Erwin van Ballegoij* (Heesch, Netherlands,CAMS 347 and 348).

October 2019 report CAMS BeNeLux

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A summary of the activity of the CAMS BeNeLux network during the month of October 2019 is presented. October 2019 had exceptional poor weather conditions. Despite the uncooperative weather a total of 3344 orbits were collected during this month.

1 Introduction

October is one of the best months of the year for meteor observing. However, weather in autumn in the BeNeLux region tends to be rather unstable. October 2019 would be the 8th month of October since the CAMS BeNeLux network has started in 2012. For instance, a good coverage of the Orionids might be most interesting. Would this be possible in 2019?

2 October 2019 statistics

CAMS BeNeLux experienced exceptionally poor weather circumstances in October 2019. Still 3344 orbits could be collected which is far less than the 9611 orbits obtained in 2018. In 2018 we were exceptionally lucky with many clear nights and the Draconids outburst as a bonus. This year, the exceptional dry weather of previous months suddenly changed into a cloudy and rainy weather pattern. This month counted 11 nights with more than 100 orbits. The best October night was 27–28 with as many as 518 orbits in a single night. Only two nights remained without any orbits. The statistics of October 2019 are compared in *Figure 1* and *Table 1* with the same month in previous years since the start of CAMS BeNeLux in 2012. In 8 years, 199 October nights allowed to obtain orbits with a grand total of 25485 orbits collected during the month of October during all these years together.

Some CAMS stations were not operational due to technical problems or other reasons. October 2018 had a maximum of 82 cameras, 73.0 on average available while October 2019 had 76 cameras at best and 67.5 on average. The impact of the exceptional poor weather resulted in about the same number of orbits as in October 2016 when at best only 54 cameras and on average 41.3 cameras were available.

A favorable weather for the Orionids did not happen in 2019. Stable clear nights during the Orionid activity happened the last time during the testing period of CAMS in the BeNeLux after the Draconid 2011 project, months before the official start of the CAMS BeNeLux network. Anyway, unfavorable weather ruined weeks or months of observing time every now and then. The CAMS BeNeLux weather pattern is known for its rather astronomy unfriendly character. In fact, it is remarkable that CAMS BeNeLux overall managed to collect so many orbits.

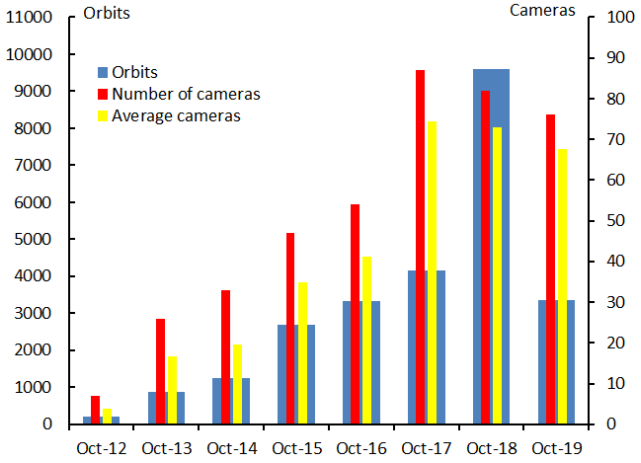

Figure 1 – Comparing October 2019 to previous months of October in the CAMS BeNeLux history. The blue bars represent the number of orbits, the red bars the maximum number of cameras running in a single night and the yellow bar the average number of cameras running per night.

Table 1 – October 2019 compared to previous months of October.

Year	Nights	Orbits	Stations	Max. Cams	Min. Cams	Mean Cams
2012	16	220	6	7		3.9
2013	20	866	10	26		16.8
2014	22	1262	14	33		19.7
2015	24	2684	15	47		34.8
2016	30	3335	19	54	19	41.3
2017	29	4163	22	87	45	74.4
2018	29	9611	21	82	52	73.0
2019	29	3344	20	76	47	67.5
Total	199	25485				

3 Conclusion

October 2019 was a rather poor month for CAMS BeNeLux because of the unfavorable weather circumstances during most nights.

Acknowledgment

Many thanks to all participants in the CAMS BeNeLux network for their dedicated efforts. Thanks to *Carl Johannink* for providing all the data on which this report is based. The CAMS BeNeLux team was operated by the following volunteers during the month of October 2019:

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November 2019 report CAMS BeNeLux

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A summary of the activity of the CAMS BeNeLux network during the month of November 2019 is presented. 21142 meteors were recorded, 9339 of which proved multiple station, or 44%. In total 3237 orbits were collected during this month. Unfavorable weather and technical problems at a number of CAMS stations reduced the results during this month.

1 Introduction

November is a typical autumn month with rather unstable weather over the BeNeLux. Completely clear nights are rare during this time of the year. However, during the long nights with 13 to 14 hours dark sky, it is also rare that clouds remain all night present. Very often clear gaps appear during which meteors can be registered. To be successful in a month like November is a matter of having the cameras operational. With most stations running Auto CAMS seven days on seven, still a lot of double station meteors can be registered during periods with unexpected clear sky.

2 November 2019 statistics

CAMS BeNeLux collected 21142 meteors of which only 9339 or 44% were multi-station, good for 3237 orbits. This is far less than last year when 53% of all meteors were multiple station and 6916 orbits were collected. November 2018 was an exceptional favorable month while this year we got a more or less normal month of November. To make things worse several CAMS stations struggled with hardware problems or were not operational. For instance, the major CAMS station Gronau, Germany with 8 cameras has been temporary unavailable since August because of renovation work. Terschelling with 4 cameras is still unavailable since a computer failure in January. Technical problems at the CAMS stations Heesch, Alphen a/d Rijn, Genk, Dourbes and Zoersel further reduced the chances to record multiple station meteors. All in all, with 3237 orbits obtained in these circumstances, it is still a success.

This month counted 10 nights with more than 100 orbits (16 in 2018). Only one night produced more than 500 orbits in a single night (6 in 2018). The best November night in 2019 was 7–8 with as many as 2556 meteors registered, 1585 of which were multi-station, good for 502 orbits in this single night. Only three nights remained without any orbits. The statistics of November 2019 are compared in *Figure 1* and *Table 1* with the same month in previous years since the start of CAMS BeNeLux in 2012. In 8 years, 179 November nights allowed to obtain orbits with a grand total of 19795 orbits collected in November during all these years together.

While November 2018 had 85 cameras at best and 75.3 on average, November 2019 had 77 cameras at best and 71.1 on average.

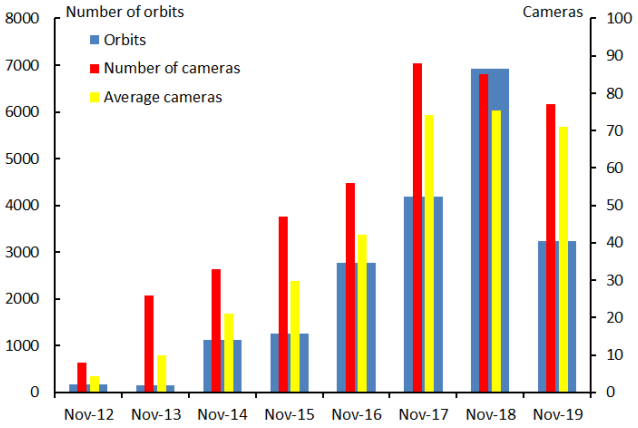

Figure 1 – Comparing November 2019 to previous months of November in the CAMS BeNeLux history. The blue bars represent the number of orbits, the red bars the maximum number of cameras running in a single night and the yellow bar the average number of cameras running per night.

Table 1 – November 2019 compared to previous months of November.

Year	Nights	Orbits	Stations	Max. Cams	Min. Cams	Mean Cams
2012	14	165	6	8	-	4.4
2013	13	142	10	26	-	9.8
2014	24	1123	14	33	-	21.1
2015	23	1261	15	47	10	29.8
2016	24	2769	19	56	19	42.2
2017	26	4182	22	88	57	74.2
2018	28	6916	21	85	59	75.3
2019	27	3237	20	77	60	71.1
Total	179	19795				

3 Conclusion

November 2019 brought the usual autumn weather for the BeNeLux. Unfortunately, some major CAMS stations remain unavailable while several other stations had major

or minor technical problems that prevented either to capture meteors, or to use the data of the meteors. Poor weather and technical problems resulted in a rather modest number of orbits.

Acknowledgment

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An ordinary Geminid fireball

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A bright -7 magnitude Geminid fireball appeared above Southern Hungary on 15 December, 2019 at 5h21m UT. The event was registered by dedicated meteor cameras and the trajectory and orbit could be calculated.

1 Introduction

On 15 December, 2019 at 5^h21^m UT the biggest fireball of the 2019's Geminid meteor stream lighted up the sky above Hungary. There were some meteorological cameras across the country which could catch the event, but because of copyright issues I cannot attach any of them. Three dedicated meteor cameras recorded successfully the phenomenon from the following places: Soroksár (by Jónás Károly, *Figure 1*), Veszprém (Landy-Gyebnár Mónika, *Figure 4*) and Kelenföld (by the author, *Figure 2*) I used only the first two in this calculation.

2 Trajectory and orbit

Figure 1 – The 2019 December 15, 5^h21^m UT bolide's snapshot from Soroksár (by Jónás Károly).

Figure 2 – The 2019 December 15, 5^h21^m UT fireball's beginning from Kelenföld (by the author).

The fireball began to emit light at an elevation of 101 km. The trajectory was 55.3 km long with an average speed of 32.8 km/s and an entrance angle of 39 degree. Its peak brightness was around –7 absolute magnitude. The last bits of it ablated totally at 42.2 km high in the atmosphere. I used the UFO software package to estimate these values. (Sonotaco, 2009).

Because the measurable deceleration – about 2 km/s along the trajectory – I had to manually change the UFOOrbit import values to obtain a more reliable orbit in the solar system. The resulting orbital elements are:

- $\alpha_\odot = 113.9°$
- $\delta_\odot = +31.4°$
- $a = 1.1$ A.U.
- $q = 0.167$ A.U.
- $e = 0.853$
- $\omega = 323.6°$
- $\Omega = 262.7°$
- $i = 18°$

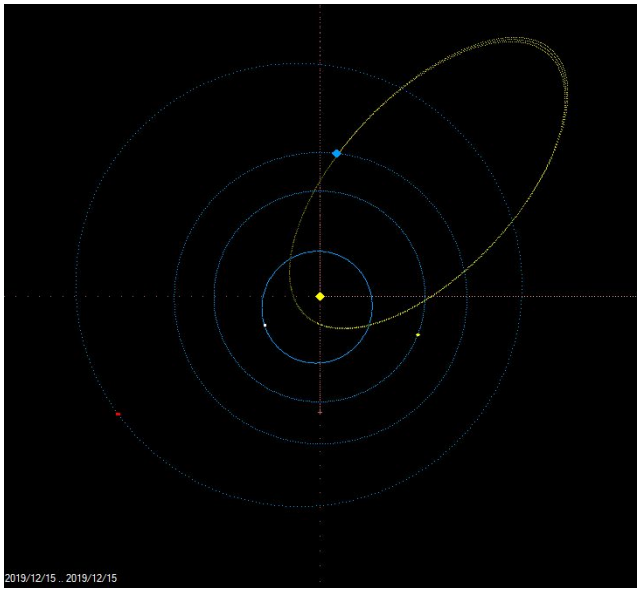

Figure 3 – The Geminid like orbit in the solar system.

References

SonotaCo (2009). "A meteor shower catalog based on video observations in 2007-2008". *WGN, Journal of the International Meteor Organization*, **37**, 55–62.

Figure 4 – The 2019 December 15, 5^h21^m UT fireball at Veszprém (by Landy-Gyebnár Mónika).

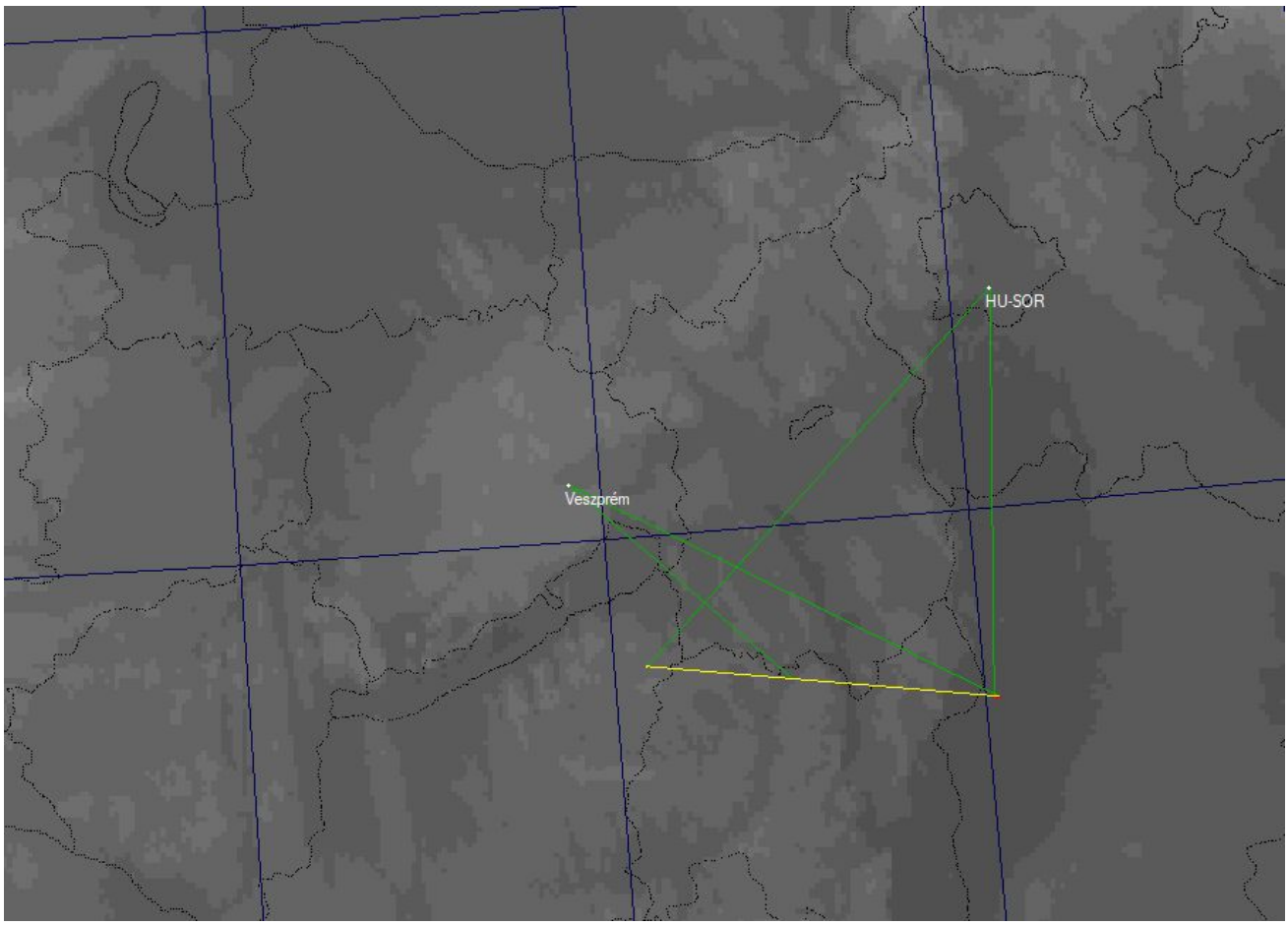

Figure 5 – The 2019 December 15, 5^h21^m UT fireball's trajectory over the southern part of Hungary.

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ISSN 2570-4745 Online publication https://meteornews.net

Listed and archived with ADS Abstract Service: https://ui.adsabs.harvard.edu/search/q=eMetN

MeteorNews Publisher:

Valašské Meziříčí Observatory, Vsetínská 78, 75701 Valašské Meziříčí, Czech Republic