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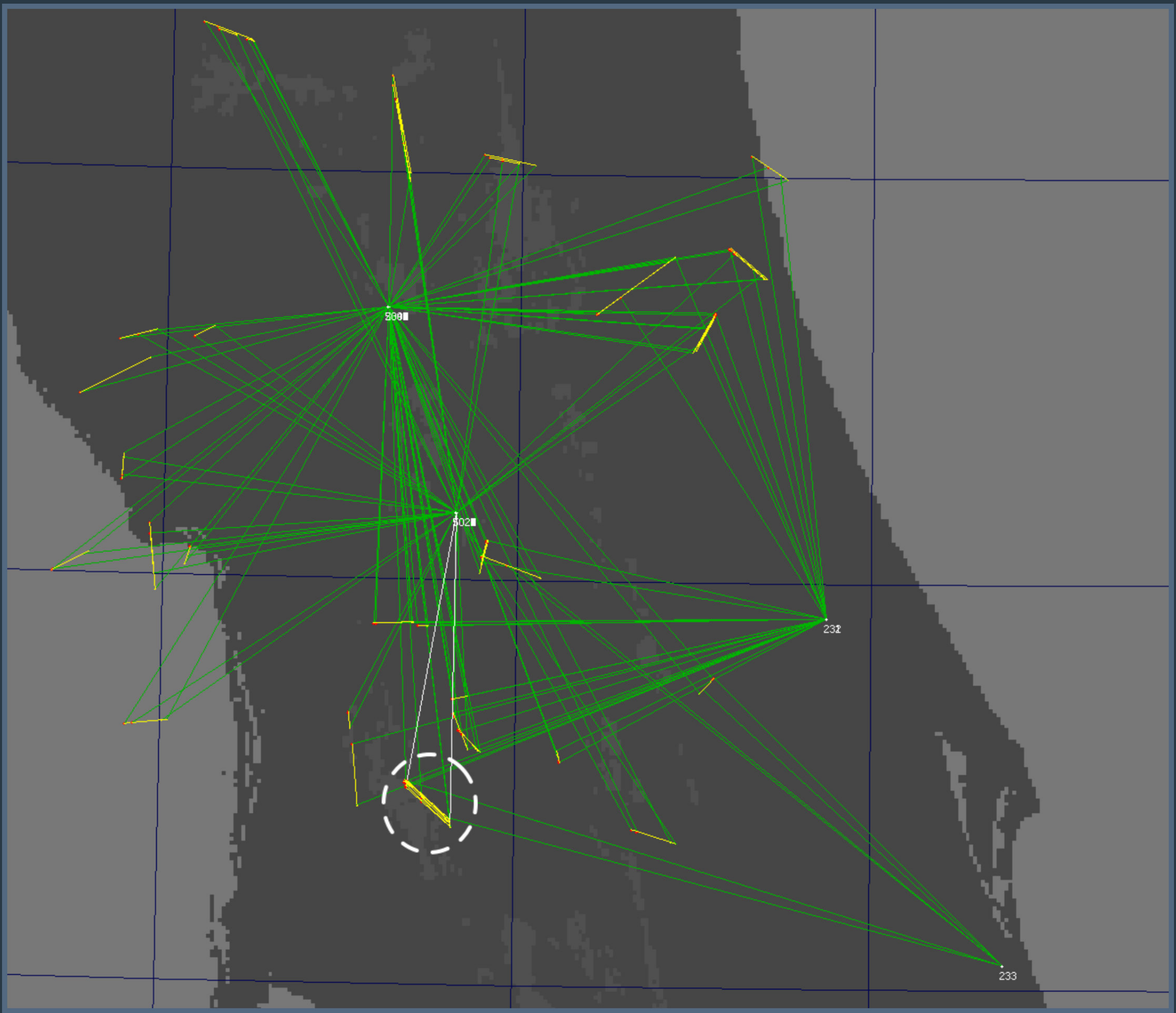

CAMS-Florida ground tracks that show 26 coincident meteors from the night of 30-31 May 2019

- Perseids 2018 analysis
- Mysteries in Taurus
- Radio observations
- Leonids 2018 analysis
- CAMS reports
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The Perseids in 2018
Analysis of the visual data

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The Perseid campaign was successful in 2018, despite the lesser weather in southern Europe. This article covers the analysis of visual data gathered during August 2018. The Perseid filament showed some extra activity on August 12 around 20-21 UT. Striking was the high Perseid activity during the night of 13 on 14 August 2018 observed in Europe.

1 Introduction

With New Moon on August 11, 2018, there was good reason to plan a decent Perseid campaign. Many observing activities were set up worldwide again: for example, a very large group of observers was active near Petnica (known from, among others, the IMC 2017). The author was part of a Belgian / Dutch team of observers who had moved into a gite in southern France with a beautiful view of the starry sky (Vandeputte 2018, 2019).

Even though southern Europe had less stable weather during the period the Perseids were active, an enormous amount of data was reported on the IMO website. The best result since 2015, in which it is striking that there were considerably fewer observers active in 2018 compared to 2015. That means that there were more observers who observed longer, a good development. In the year 2017 the numbers of Perseids observed were lower because there was a lot of moonlight around the Perseid maximum. See also *Table 1*.

Table 1 – Overview of observation data received by the IMO.

Year	N PER	N Observers
2015	37724	375
2016	21480	257
2017	6536	140
2018	32757	232

2 Predictions

There were no spectacular predictions like in 2016. Peter Jenniskens announced that some extra activity could be observable on August 12, 2018 at 20^h UT ($\lambda_\odot = 139.79°$) as the result of an encounter with the Perseid filament (Rendtel, 2017). This dust trail is a collection of old material from comet 109P Swift Tuttle trapped in a mean-motion resonance. Jeremie Vaubaillon found a very old dust trail that might give a little extra activity on August 13, 2018 at 1^h37^m UT ($\lambda_\odot = 140.030°$).

3 Collecting the data

Most of the data was collected from the IMO website in September and October. In addition, the author also received some data from observers who do not report to IMO. All data was checked on the known criteria:

- Only data from observers with a known C_p were used
- Only data with limiting magnitudes of 5.9 or higher was used
- Only observations made with a radiant height of 25 degrees or more were used.
- Extreme outliers were removed.

4 The population index r

The population index *r* could be calculated for many nights. The magnitude distributions of observers with a good C_p determination were examined. The rule here is: The difference between the average limiting magnitude and the average magnitude of the Perseids may not exceed 4.5 magnitudes. In the end, 13085 Perseids could be used to determine the population index *r*. *Table 2* and *Figure 1* is the result.

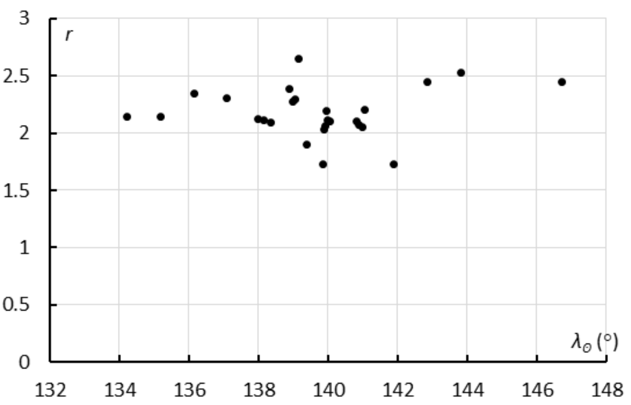

Figure 1 – Perseids 2018, population index r, 7 to 20 August 2018, graph based on Table 1.

Table 2 – The calculated population index r [–2; 5] for the Perseids in 2018. The sign ~ means that there was not enough data for a reliable population index r calculation r [–2; 5].

Date	λ⊙	r[–2;5]	nPER
5-8-2018 00ʰ UT	132.294	~	40
6-8-2018 00ʰ UT	133.252	~	40
7-8-2018 00ʰ UT	134.210	2.15	202
8-8-2018 00ʰ UT	135.168	2.15	227
9-8-2018 00ʰ UT	136.127	2.35	337
10-8-2018 00ʰ UT	137.086	2.31	411
10-8-2018 22ʰ UT	137.966	2.13	304
11-8-2018 02ʰ UT	138.126	2.12	298
11-8-2018 07ʰ UT	138.326	2.1	87
11-8-2018 21ʰ UT	138.886	2.39	281
11-8-2018 23ʰ UT	138.966	2.28	650
12-8-2018 01ʰ UT	139.046	2.3	994
12-8-2018 03ʰ UT	139.126	2.65	190
12-8-2018 05ʰ UT	139.206	~	45
12-8-2018 07ʰ UT	139.286	~	59
12-802918 09ʰ UT	139.366	1.9	57
12-8-2018 11ʰ UT	139.446	~	97
12-8-2018 20.5ʰ UT	139.826	1.73	195
12-8-2018 21.5ʰ UT	139.866	2.04	801
12-8-2018 22.5ʰ UT	139.906	2.07	824
12-8-2018 23.5ʰ UT	139.946	2.2	894
13-8-2018 0.5ʰ UT	139.986	2.12	1086
13-8-2018 1.5ʰ UT	140.026	2.11	1077
13-8-2018 21ʰ UT	140.806	2.11	156
13-8-2018 23ʰ UT	140.886	2.08	1003
14-8-2018 01ʰ UT	140.966	2.06	1415
14-8-2018 03ʰ UT	141.046	2.21	615
15-8-2018 00ʰ UT	141.887	1.73	395
16-8-2018 00ʰ UT	142.848	2.45	317
17-8-2018 00ʰ UT	143.809	2.53	223
19-8-2018 00ʰ UT	145.732	~	30
20-8-2018 00ʰ UT	146.694	2.45	46
22-8-2018 00ʰ UT	148.620	~	33

Although we did not observe at the exact same solar longitude in 2018 (but there is some overlap!) as in 2015, we did compare with the analysis from 2015 (Miskotte, 2016a, 2016b). *Figure 2* shows a comparison of the population index *r* of the Perseids as found during the two years.

It is striking that there are roughly similarities between the two years. High population index *r* values leading up to and after the maximum. There is a little more variation during the maximum. Only both nights 13–14 and 14–15 August show major differences. In 2018 the *r* values are close to each other, in 2015 there is much more variation. First the *r* values found in 2015 are considerably higher than in 2018, at the end of the night 13–14 August 2015 the *r* values suddenly fall far below the level of 2018. It should be noted that the moment 13 August 2018 21ʰ UT is the same solar longitude as 03ʰ UT on August 14, 2015.

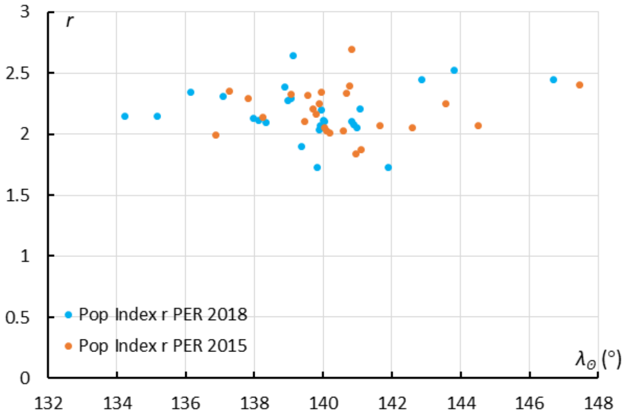

Figure 2 – Comparison of population index r of the Perseids in 2015 and 2018, period 7–20 August.

5 Zenithal Hourly Rates (ZHR)

ZHRs are always calculated in the Dutch Meteor Society according to the method of Peter Jenniskens as described in (Jenniskens, 1994).

$$ZHR = \frac{n \cdot F \cdot r^{6.5-LM}}{(\sin h)^{\gamma} \cdot C_p \cdot T_{eff}} \quad (1)$$

However, the radiant height correction γ is set to 1.0 instead of 1.4. When all the data was processed that met the criteria described in *Section 3*, 14335 Perseids remained for processing. For the nights until August 10, all ZHR values were calculated per night (weighted average). For the night August 10 on 11 we could calculate the weighted average ZHR per continent (Europe and America only!). The nights 11–12, 12–13 and 13–14 August the ZHR could be determined per hour over Europe and partly also for America. For the nights following August 14, the ZHR was again determined per night. The result is shown in *Figure 3*.

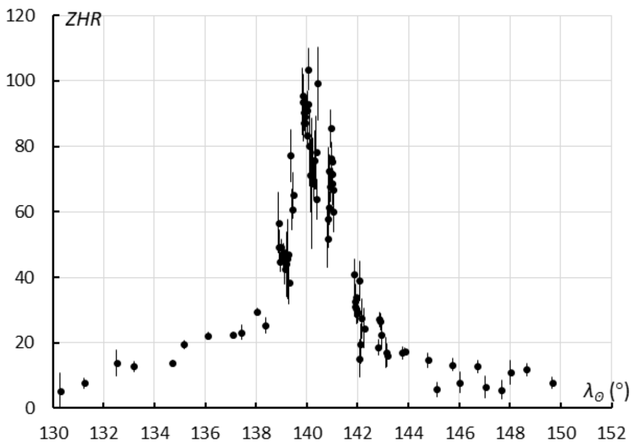

Figure 3 – ZHR of the Perseids in 2018, period 3–23 August.

At first glance, the graph shows (*Figure 3*) no strange events. The maximum ZHR found is slightly above 100.

Next, we zoom in on the individual nights 11–12, 12–13, 13–14 and 14–15 August.

11–12 August 2018

There is enough data available to zoom in on the Perseids activity in the night of 11–12 August over Europe and North America. A total of 2526 Perseids were used in the analysis for this period. The result is shown in Table 3 and *Figure 4*. These are ZHR values based on 15–30-minute counting intervals.

Table 3 – ZHR of the Perseids in the period from 11 August 2018 20^h UT to 12 August 2018 12^h UT. A total of 2526 Perseids were used for this table.

Day	UT	λ⊙	Bins	PER	ZHR	±
11	20.78	138.877	5	38	56.7	9.2
11	21.58	138.909	14	97	49.4	5.0
11	22.49	138.945	22	216	44.7	3.0
11	23.50	138.986	38	471	49.3	2.3
12	0.41	139.022	42	542	46.5	2.0
12	1.41	139.062	31	449	45.0	2.1
12	2.33	139.099	11	257	47.5	3.0
12	3.13	139.131	4	80	42.7	4.8
12	4.65	139.192	2	20	44.0	9.8
12	5.65	139.231	1	14	45.6	12.2
12	6.48	139.265	2	27	46.9	9.0
12	7.37	139.300	2	34	38.3	6.6
12	8.58	139.349	5	94	77.3	8.0
12	10.48	139.425	5	100	60.7	6.1
12	11.21	139.454	4	87	65.1	7.0

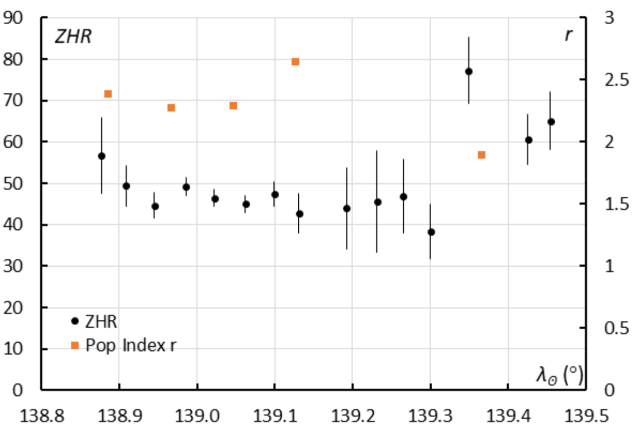

Figure 4 – The ZHR and population index r in a single graph of the Perseids for the night between August 11, 2018 20^h UT and August 12, 2018 12^h UT. There was only enough data from Europe to calculate a reliable population index r. The standard r value of 2.20 was used for America.

Noticeable are the large error bars at the beginning of the night over Europe caused by a low radiant position and too few data. Large error bars are caused by the relatively low numbers of Perseids and less observers (with known C_p!) for American observations. We see a flat curve above Europe with a ZHR of roughly between 40 and 50, above North America increasing ZHRs leading (60 to 80) up to the maximum that was expected sometime in the night 12–13 August 2018 (Rendtel, 2017).

12–13 August 2018

A somewhat difficult night, especially for southern Europe. There are relatively few data after August 13, 2018 02^h UT. These are ZHR values based on 15–20-minute counts with a weighted average. A total of 5287 Perseids were used for this night. As mentioned earlier, there were two possible events that deserve attention (Rendtel, 2017), possibly some extra activity from the Perseid filament around August 13, 2018 20^h UT ($\lambda_{\odot}$ = 139.79°) and a very old dust trail that might give a little extra activity on August 13, 2018 at 01^{h}37^m UT ($\lambda_{\odot}$ = 140.030°). According to IMO, the maximum of the Perseids would fall between $\lambda_{\odot}$ = 139.8° and 140.3°, corresponding between 12 August 2018 20^h UT and 13 August 2018 08^h UT.

The results of this night are summarized in *Table 4* and *Figure 5*.

Table 4 – ZHR of the Perseids in the period from 12 August 2018 20^h UT to 13 August 2018 12^h UT.

Day	UT	λ⊙	Bins	PER	ZHR	±
12	20.83	139.839	8	85	93.7	10.2
12	21.25	139.856	17	223	95.5	6.4
12	21.74	139.875	18	236	87.4	5.7
12	22.23	139.895	29	403	90.5	4.5
12	22.70	139.914	32	454	89.1	4.2
12	23.24	139.935	26	429	87.4	4.2
12	23.76	139.956	30	505	92.0	4.1
13	0.23	139.975	26	481	91.3	4.2
13	0.73	139.995	26	493	90.9	4.1
13	1.23	140.015	27	501	83.4	3.7
13	1.72	140.035	26	563	93.1	3.9
13	2.10	140.049	10	259	103.5	6.4
13	3.46	140.104	5	43	80.1	12.2
13	4.59	140.149	4	40	71.1	11.2
13	5.78	140.197	1	12	68.7	19.8
13	6.45	140.224	7	119	75.6	6.9
13	7.62	140.271	8	134	69.8	6.0
13	8.30	140.298	4	70	75.9	9.1
13	9.82	140.358	2	49	78.1	11.2
13	10.53	140.387	6	109	63.8	6.1
13	11.34	140.419	3	79	99.2	11.2

What is striking is a rather flat activity above Europe but at the end of the night a weak peak of activity with a ZHR of just over 100 is visible. Above North America lower ZHRs were recorded but with larger error bars due to lower numbers of Perseids and sometimes low radiant positions. The last ZHR point is rather high and is based on the observation of only one single observer.

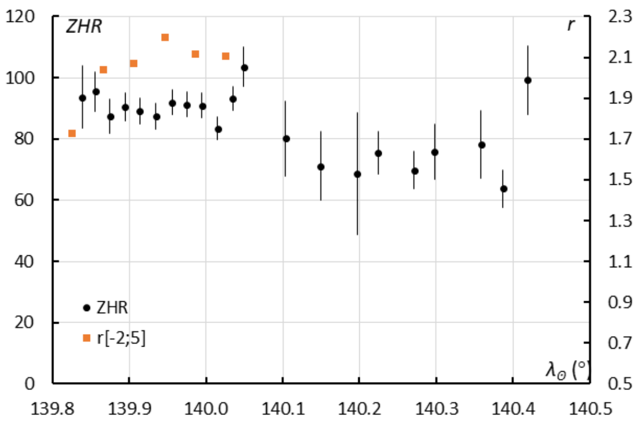

Figure 5 – The ZHR and population index r in a single graph of the Perseids for the period between 12 August 2018 20ʰ UT and 13 August 2018 12ʰ UT. There was only enough data from Europe to calculate a reliable population index r. The IMO standard value of 2.20 was used for America.

Perseid filament active?

Regarding the possible extra activity due to the Perseid filament, there are indications that this has happened. At the start of their observations on August 12, 2018 at 20ʰ UT the observers in southern France saw relatively more bright Perseids, including a beautiful earth-grazing fireball of magnitude –4 moving from Cassiopeia to Sagittarius. Unfortunately, this data was not used because the radiant position at this location was still far below 25 degrees at that time. Data from, for example, *Jakub Koukal* from the same period[1] could be used and he saw three fireballs of –4, –5 and –6 between 21ʰ05ᵐ and 22ʰ00ᵐ UT.

Indeed, we see a very small peak in activity again just after 21ʰ UT, but it is very marginal. Luckily, there is solid support by the population index *r*. The population index *r* is very low at 12 August 2018 between 20ʰ–21ʰ UT, but rises quickly after 21ʰ UT. These are things that we would expect with a Perseid filament encounter. See also the 2016 analysis when the filament was very active (Miskotte, 2016a, 2016b). Also, it seems that the filament may have already been active before 20ʰ UT, but the data from that period shows too many mutual differences between the observers and is inadequate regarding radiant heights, limiting magnitudes and/or the lack of observers with a reliable C_p.

Was the old dust trail active?

Regarding the old dust trail that would be active on 13 August 2018 at 1ʰ37ᵐ UT (Rendtel, 2017), it is much harder to substantiate this, also, because the expected extra activity adds little to the already high activity. A peak was observed around 2ʰ06ᵐ UT, about a half hour later. But this could also have been the normal maximum. The *r*-value also shows no strange behavior around that time. The "fingerprint" of an old dust trail is a temporary lower population index *r* and that has not happened.

13–14 August 2018: surprise, surprise!

Most observers in Europe observed a good Perseid activity during this night. The observers in the Provence also noticed this, the report of *Michel Vandeputte* (Vandeputte,2018;2019; Miskotte 2018) describes this very well: "*The Perseids were clearly active. The first hour was almost normal; but afterwards it went faster and faster. Perseids came in heavy flurries with sometimes multiple meteors per minute. In fact: this activity went unusually fast for a post maximum night! Most of the meteors were relatively weak, but a nice –5 also appeared in the Big Dipper: excitement among the observers. The author, for example, had a highest fifteen-minute count between 02ʰ15ᵐ–02ʰ30ᵐ UT with no less than 39 Perseids and I counted 102 Perseids in the last hour before dusk. In total even nearly 400 Perseids at 5 hours observational time! You can only see these numbers in a good (normal) maximum night!*".

Data from other parts of Europe also confirm these observations, the following message came from *Kai Gaarder* who observed from southern Crete (via FB communication): "*August 13–14 was a good night with surprisingly high activity. Hourly counts were around 90 in the morning hours. 15 minutes rates were around 10 in the early evening hours and reaching over 20 in the morning hours. I have not calculated the mean magnitudes yet but I had a feeling that the Perseids were richer in bright meteors in the range of +2 to –1, than the night before. Had to stop observing some 15 minutes earlier than normal because of an early morning flight home.*"

All this was a reason to analyze this night in detail. What is going on here? Observations were analyzed in the same way as the two previous nights. The ZHR values are based on 15–20-minute counts with a weighted average. A total of 2223 Perseids were used for this night. The result is shown in *Table 5* and *Figure 6*.

Table 5 – Perseids ZHR between 13 August 2018 21ʰ UT and 14 August 2018 04ʰ UT.

Day	UT	λʘ	Bins	PER	ZHR	±
13	21.28	140.817	3	35	51.8	8.8
13	21.72	140.835	4	42	58.0	8.9
13	22.23	140.855	8	109	72.7	7.0
13	22.69	140.873	10	139	61.2	5.2
13	23.20	140.894	12	202	72.4	5.1
13	23.69	140.913	14	224	67.8	4.5
14	0.23	140.935	10	225	85.5	5.7
14	0.72	140.955	10	217	76.3	5.2
14	1.20	140.974	12	261	75.4	4.7
14	1.66	140.993	12	260	71.5	4.4
14	2.15	141.012	8	216	68.6	4.7
14	2.65	141.032	6	199	66.8	4.7
14	3.09	141.050	3	94	60.0	6.2

[1] https://www.imo.net/members/imo_vmdb/view?session_id=77037

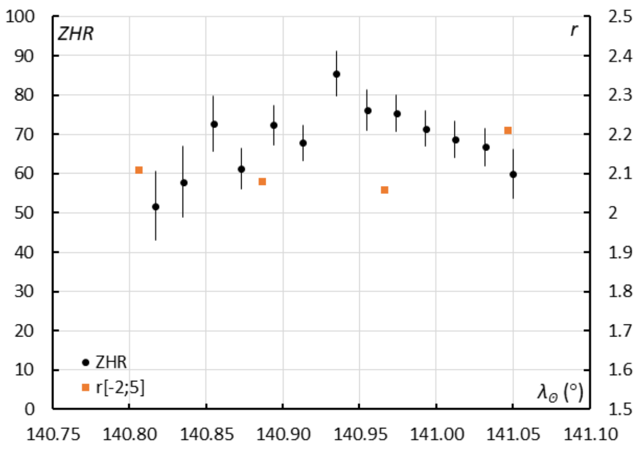

Figure 6 – The ZHR and population index r in a single graph of the Perseids for the night of August 13, 2018 21h UT to August 13, 2018 04h UT.

If we look at *Figure 6* we can speak of a spectacular activity level. There is a peak of activity on August 14 at 00h14m UT ($\lambda_\odot$ = 140.935°). The activity reached a *ZHR* of 85 at that moment! As many observers reported, there were no high numbers of bright Perseids. The population index *r* is slightly below the normal value of 2.20 for almost the entire night and at the end of the night the *r*-value was rising above the mentioned value. It is striking that the lowest population index *r* values were found around the time of maximum.

The ascending wing of the ZHR profile (*Figure 6*) looks a bit messy, this may also have to do with the somewhat lower radiant heights at the start of the night. The descending wing of the profile looks very nice with a steady decreasing activity from *ZHR* = 85 to *ZHR* = 60 at the end of the night. The population index *r* does not show crazy things, so if there really is an increase in activity then this was caused over the entire visually observable magnitude spectrum.

To determine whether and to what extent there was some increased activity, we used old observational data around the solar longitude in which we could observe in 2018. Taking into account the moon and same solar longitude the years 1986, 1994, 2002 and 2010 are good for comparing to 2018. There was of course a lot of searching in both the IMO database and the visual database of the DMS. Unfortunately, there is not that much data available from observers with a good C_p determination. Below is a brief overview.

13–14 August 1986: 3 observers MISKO (Koen Miskotte), RISBA (Bauke Rispens), ROGPA (Paul Roggemans) with good (and high C_p) determinations, one single location (Puimichel, southern France) under top conditions (*lm* 6.5–6.7) with mistral and high transparency. Impression of data: reliable, a total of 862 Perseids.

13–14 August 1994: 2 observers MISKO and LANMA (Marco Langbroek) with good C_p determinations, one single location (Biddinghuizen, NL) under top conditions (*lm* 6.7 – 6.8!), good transparency, zodiacal light was visible. The author remembers that the Perseid activity was rather disappointing compared to 1986! Impression of the data: good, but rather few meteors, only 239 Perseids.

13–14 August 2002: 5 observers ATAJU (Jure Atanackov), KACJA (Javor Kac), MISKO, LANMA and VANMC with good C_p determinations, two locations in (Slovenia), Lattrop in the Netherlands and Ellezelles in Belgium under top conditions (*lm* 6.3–7.0). Impression data: very good, personal differences in ZHRs small, a total of 851 Perseids.

13–14 August 2010: 5 observers (few DMS, most DMS observers were in Redortier, southern France and they had it clear only for the first 1.5 hours with a too low radiant position): KACJA, LEVAN (Anna Levin), WEITO (Thomas Weiland), SAVBR (Branislav Savic) and VANMC with good C_ps, five locations (Slovenia, Israel, Crete, Serbia and Belgium, good conditions (*lm* 6.2–6.7). Impression of the data: excellent, no strong mutual differences in ZHR, a total of 629 Perseids.

13–14 August 2018: Largest data set of observers with known C_p. 22 observers in good conditions, multiple locations in Europe. Impression of the data: fine, *lm* 5.9–6.8, a total of 2223 Perseids.

To be able to compare these five years with each other, a fixed population index *r* of 2.20 has been used. The result of all these calculations are shown in *Figure 7*.

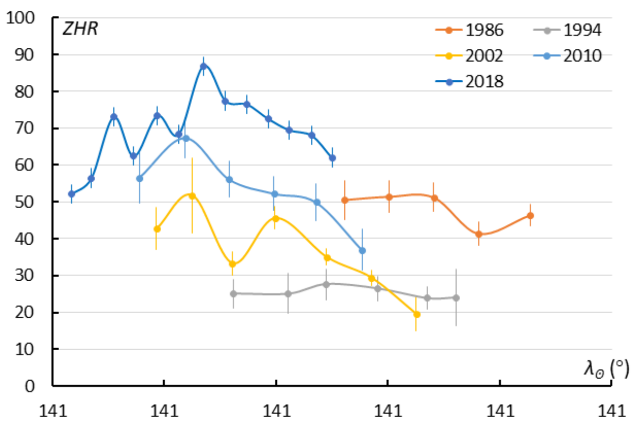

Figure 7 – Comparison of the Perseid activity during the nights of 13–14 August in 1986, 1994, 2002, 2010 and 2018. The lines between the points are to indicate more clearly to which years the ZHR points belong.

Table 6 – Maximal ZHRs and solar longitudes for the night of 13–14 August 1986–1994–2002–2010–2018.

Year	$\lambda_\odot$	ZHR
1986	141.101	51 ± 4
1994	141.045	28 ± 4
2002	140.925	52 ± 10
2010	140.919	67 ± 6
2018	140.935	87 ± 6

Table 7 – Overview of the Perseid activity between λ_{O} 140.90° and λ_{O} 140.95° for the period 2000–2040. Good years for Europe are of course 2026 and 2034, but 2025 also offers an opportunity to observe the decreasing wing of the activity, as in 2037. In 2023 the ascending wing could still be observed. The moon phases are rounded to 10 degrees and a + or – indicates whether it is an increasing or decreasing moon phase. Taken altogether, it is still possible to observe well with increasing phases of the moon up to 80+% and with decreasing phases of the moon from 40 to 50%.

Year	Solar Longitude	Date (start)	Start UT	End UT	Observed	Moon %	Best place to observe
2000	140.90–140.95	13–8–2000	08:40	09:55	~	90+	
2001	140.90–140.95	13–8–2001	14:48	16:04	~	40–	
2002	140.90–140.95	13–8–2002	20:53	22:08	21:30	30+	
2003	140.90–140.95	14–8–2003	03:06	04:22	~	96+	
2004	140.90–140.95	13–8–2004	09:20	10:34	~	10–	
2005	140.90–140.95	13–8–2005	15:26	16:41	~	0	
2006	140.90–140.95	13–8–2006	21:32	22:47	~	80–	
2007	140.90–140.95	14–8–2007	03:40	04:55	~	10+	
2008	140.90–140.95	13–8–2008	09:51	11:06	~	80+	
2009	140.90–140.95	13–8–2009	16:00	17:15	~	60–	
2010	140.90–140.95	13–8–2010	22:04	23:19	22:35	10+	
2011	140.90–140.95	14–8–2011	04:16	05:31	~	100	
2012	140.90–140.95	13–8–2012	10:30	11:45	~	10–	
2013	140.90–140.95	13–8–2013	16:37	17:52	~	40+	
2014	140.90–140.95	13–8–2014	22:44	00:00	~	85–	
2015	140.90–140.95	14–8–2015	04:56	06:11	~	0	
2016	140.90–140.95	13–8–2016	11:08	12:22	~	80+	
2017	140.90–140.95	13–8–2017	17:17	18:32	~	60–	
2018	140.90–140.95	13–8–2018	23:22	00:35	00:14	10+	Europe
2019	140.90–140.95	14–8–2019	05:30	06:15	~	100	North America
2020	140.90–140.95	13–8–2020	11:41	12:56	~	30–	Western north America, Pacific
2021	140.90–140.95	13–8–2021	17:47	19:02	~	30+	Asia
2022	140.90–140.95	13–8–2022	23:51	01:06	~	100	Europe
2023	140.90–140.95	14–8–2023	06:04	07:19	~	0	North America
2024	140.90–140.95	13–8–2024	12:13	13:18	~	60+	Western north America, Pacific
2025	140.90–140.95	13–8–2025	18:23	19:38	~	80–	Asia
2026	140.90–140.95	14–8–2026	00:30	01:45	~	0	Europe
2027	140.90–140.95	14–8–2027	06:41	07:56	~	90+	Atlantic Ocean, North America
2028	140.90–140.95	13–8–2028	12:59	14:14	~	50–	Pacific, east Asia
2029	140.90–140.95	13–8–2029	19:07	20:22	~	30+	Asia
2030	140.90–140.95	14–8–2030	01:09	02:14	~	100	Europe
2031	140.90–140.95	14–8–2031	07:21	08:36	~	10–	Atlantic Ocean, North America
2032	140.90–140.95	13–8–2032	13:28	14:43	~	40+	Pacific, east Asia
2033	140.90–140.95	13–8–2033	19:36	20:51	~	90–	Asia
2034	140.90–140.95	14–8–2034	01:42	02:57	~	0	Europe
2035	140.90–140.95	14–8–2035	07:49	08:03	~	80+	Atlantic Ocean, North America
2036	140.90–140.95	13–8–2036	14:04	15:19	~	60–	Pacific, east Asia
2037	140.90–140.95	13–8–2037	20:11	21:26	~	10+	western Asia, Eastern Europe
2038	140.90–140.95	14–8–2038	02:16	03:31	~	100	(Western) Europe
2039	140.90–140.95	14–8–2039	08:33	09:48	~	30–	Atlantic Ocean, North Amerca
2040	140.90–140.95	13–8–2040	14:42	15:57	~	30+	Pacific, east Asia

A surprising result: the years 2002, 2010 and 2018 have shown a higher ZHR since 1994. The years 2002, 2010 and 2018 also always show a maximum ZHR between λ_Θ 140.90° and 140.95°. The maximum ZHRs in the mentioned 5 years are shown in *Table 6*. The duration of this higher activity is rather long, about 5 to 6 hours.

The expectation is of course not that from now on we will get higher ZHRs between λ_Θ 140.90° and 140.95°. Because that would mean backwards in time that in the 60s or 70s there was no activity of the Perseids during the night of August 13–14. So perhaps this is a coincidence. In addition, the ZHR value from 1994 is very low and 1986 falls completely outside the solar longitude interval covered in 2018.

Therefore, it is not clear to indicate what caused this extra activity. Here are some possible explanations given by *Michel Vandeputte* and *Paul Roggemans*:

- Michel Vandeputte: "*It is rather to be considered whether this is the 'higher' activity from 2010 & 2018. It also is close to the cycles with increased Perseid activity: 2008–2010 are there the effects of the Saturn perturbation and 2018 the after effects of the last Jupiter perturbation? Perhaps a higher and wider background component is active in that period. According to the Maslov website, after 2018 we will start with normal to even lower Perseid activity. 2026 is then a good year to compare the observations with the years mentioned above. It will not be the moon affecting the observations with a solar eclipse on August 12 that year. In 2027 and 2028 we can prepare ourselves again for a Perseid show ala 2016!*"
- Paul Roggemans: "*The Perseid maximum is slowly shifting due to the regression of the line of nodes, but this cannot explain this 'off–set'. In the second half of the 1980s we saw a bump appear on the ZHR profile that grew in 1988 to a second maximum just before the traditional maximum. This was then wiped off the table because at that time I was the only one combining data from Europe, America and Japan. Nothing was visible in ZHR profiles based on only 6–7 hours observation intervals. With the Perseid outburst in 1991, it was clearly proven and when the parent comet was discovered, this new sharp peak turned out to be a fresh dust trail related to the perihelium passage of Swift Tuttle, a temporary phenomenon that was observed for several years.*

  The bump that now appears after the traditional maximum is, in my opinion, an older dust trail that has now revolved around the Sun more than 25 years after the perihelium passage parallel to the core of the Perseid meteor shower. Apparently, the density of this dust trail is still increasing year after year. The question is how far this will continue to increase? Maybe some nice surprises are coming? This dust trail will probably disappear again after some time. This kind of parallel dust flows is exactly what one can expect from the development of meteor streams. The nice thing is that every year this turns into a surprise party with the question whether or not activity will get more or less."

It is therefore clear that this interesting development must be further observed. In *Table 7* I give the times and locations where you must be to be able to observe this 2nd maximum. Of course, only if this secondary maximum is a permanent phenomenon!

14–15 August 2018: many bright Perseids?

This night it was certainly fun watching the Perseids. For this night, 15–30-minute counts were used for which weighted averages were calculated. A total of 658 Perseids were used for this night. The ZHR values this night are between 30 and 40 above Europe and between 15 and 25 above North America. See also *Figure 8*. Striking was the population index *r* this night over Europe: with 1.70 it was very low compared to the nights before and after.

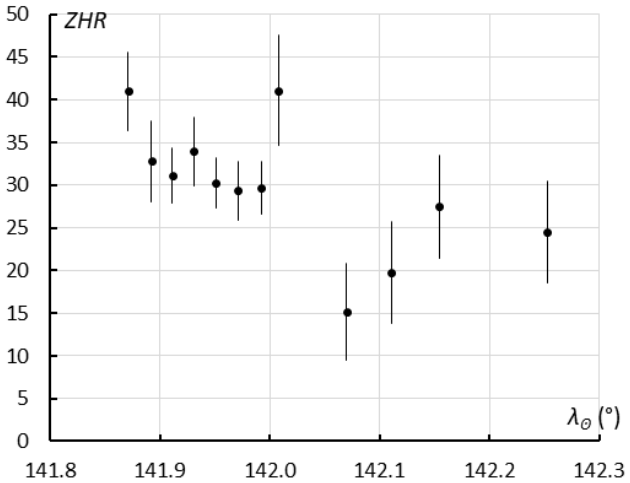

Figure 8 – ZHR of the Perseids between 14 August 2018 23^h UT and 15 August 2018 10^h UT.

6 Conclusions

A nice Perseids campaign in 2018, despite the bad weather in southern Europe. The Perseids filament showed some extra activity on August 12 around 20^h–21^h UT. What also was striking in 2018 was the high Perseid activity in the night of 13–14 August 2018 above Europe.

Furthermore, I recommend the observers to observe at least 15 or more hours between July 25 and August 31. That way we can determine reliable C_p values for more observers. And the more observers we have with good C_p, the more data we can use in the analyzes and the more reliable the results become.

Acknowledgment

A word of thanks goes to *Michel Vandeputte*, *Carl Johannink* and *Paul Roggemans* for critically reviewing and providing suggestions for this analysis. And a very big word of thanks to all observers who observed the Perseids of 2018, these are: *Ioan Adam, Rainer Arlt, Pierre Bader, Fodor Balazs, Ognjen Bašić, Orlando Benitez Sanchez, Felix Bettonvil, Dina Blagojevic, Maša Bogojević, Steve*

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References

Jenniskens P. (1994). "Meteor Stream activity 1. The annual streams". *Astron. Astrophys*., **287**, 990–1013.

Miskotte K. (2016a). "Perseïden 2015, een globale analyse". *eRadiant*, **2016**, 23–33.

Miskotte K. (2016b). "Perseids 2015, a global analysis". e*MetN*, **1**, 42–51.

Miskotte K. (2018). "Preview: Perseid observations from Aubenas Les Alps, Southern France". *eMetN*, **3**, 277–279.

Rendtel J. (2017). IMO Meteor Shower Calender 2018, International Meteor Organisation.

Vandeputte M. (2018). "Perseiden actie te Aubenas les Alpes, Provence". *eRadiant*, **2018**, 138–143.

Vandeputte M. (2019). "Perseid campaign at Aubenas Les Alpes, Haute Provence". *eMetN*, **4**, 83–88.

The Leonids in the off-season Part 2 – 2018: two small outbursts?

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A comprehensive analysis of the Leonids 2018 is presented based on visual observational data sent to the International Meteor Organization and to the author. After the 2017 analysis of the Leonids a second one could be done based on visual meteor data. This article presents the results of this analysis. It seems there was a normal nodal Leonid maximum, but on 19 and 20 November there were two (possible) small outbursts of the meteor shower. On November 19 a bit higher as usual activity was recorded (ZHR ± 12), but with unusual numbers of bright Leonids, also on November 20 with a ZHR of 20 also with bright Leonids.

1 Introduction

It is already 16 years ago that the last major outbursts of the Leonids took place. After that year outbursts were more often observed, but these were only a fraction of the strength of the big outbursts. This lasted until 2009, when a last outburst took place with a ZHR of 100. After this, it seemed to be quiet. In 2018, the author made a first analysis of the Leonids, based on visual observations from 2017. Even though there was not so much data available, the result was nice with two possible outbursts on 17 and 20 November 2017 (Miskotte, 2018). The result of this analysis was a reason, if there was enough data, to do an analysis on the Leonids 2018 with the available Leonid observations.

The Leonids are only sparingly visible from the BeNeLux. This has nothing to do with the astronomical conditions, but with the weather conditions. Very often it is cloudy in November. This was very different in 2018. High pressure over Northern Europe led to NO / SE winds during the period of 15–20 November. That resulted in the Benelux in four clear nights in a row between 15 and 19 November. The author for example, was able to observe the Leonids in the mornings of the 16^{th}, 17^{th} and 18^{th} November for the first time since 2007!

2 Predictions

The 2018 Meteor Shower Calendar of the IMO (Rendtel, 2017) contains a summary of all the predictions made by various astronomers. It is interesting to see if there has been something observable visually. *Table 1* gives an overview. Peter Jenniskens gives no extra activity for the Leonids in 2018 in his book (Jenniskens, 2006).

3 IMO's on the fly graph

The author also looked on the IMO website at the well-known ZHR-on-the-fly curve (*Figure 1*). There, 27 observers had observed during 55 sessions, in which observations were collected for 135 count periods. The result was a graph based on 432 Leonids. The graph on the IMO website also contains an error, which is removed in *Figure 1*. It concerns a ZHR point at $\lambda_{\odot}$ 229.336° (12 November 2018 at 01^h08^m UT: ZHR 7 ± 7 based on 0 Leonids. The graph of the IMO is based on data with a limiting magnitude of 5.0, and an assumed r value of 2.50.

A single ZHR point of 24 ± 5 found at $\lambda_{\odot}$ 237.699° (November 20, 2018 at 08^h21^m UT) is remarkable. This looks like an error or an observation where the radiant height is very low. However, further research shows that this is indeed an accurate observation!

Table 1 – Overview of predictions for the Leonids in 2018 (from Rendtel, 2017).

Modeller	Date	Time (UT)	$\lambda_{\odot}$	Trail	Remarks
Nodal passage	17 Nov. 2018	22^h30^m	235.267	~	
Vaubaillon	18 Nov. 2018	23^h27^m	236.316	~	?
Sato	19 Nov. 2018	22^h20^m	237.277	1069	Rate increase 10<
Vaubaillon	19 Nov. 2018	23^h59^m	237.347	1069	?
Sato	20 Nov. 2018	07^h04^m	237.642	1433	Rate increase 10<
Maslov	20 Nov. 2018	09^h30^m	237.747	1466	Bright meteors
Vaubaillon	21 Nov. 2018	00^h54^m	238.394	~	?
Vaubaillon	25 Nov. 2018	23^h26^m	243.384	1567	?

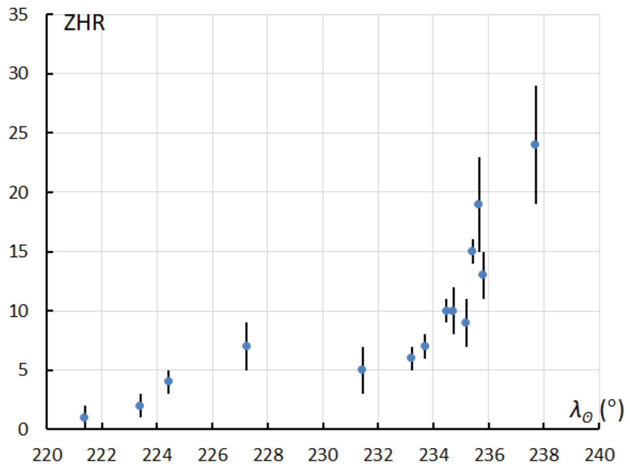

Figure 1 – The on-the-fly ZHR profile of the IMO for the Leonids 2018.

4 Collecting the meteor data

The necessary Leonid data was downloaded from the website of the International Meteor Organization. The author also received some Leonid observations from observers who did not report to IMO.

Just like in 2017 rather few observations were done. The cause may be the bad weather conditions in November and the low activity of the Leonids. The workflow: first, of course, the available observational data were critically examined. Radiant height (observations below 25 degrees radiant height were not used), limiting magnitude (limiting magnitude 5.9 or less was not used), extreme outliers were removed and only data from observers with a reliable C_p were used.

After selecting all the data that met the requirements described above, 507 Leonids remained for the analysis. These are 201 Leonids more than for the analysis of 2017.

5 Leonids 2018: population index r

In contrast to 2017, a population index value could be determined for 2018 for the period from 16 to 18 November 2018 and this only based on the European data. The results are shown in *Table 2*. A total of 367 Leonids were used for the determination of the population index *r*. Because the interval r [0; 5] yields the best numbers during the three nights, meteors were chosen for that selection.

Table 2 – Population index r for the Leonids 2018. In the ZHR calculations r [0; 5] was used.

16 November			17 November			18 November		
	r	n LEO		r	n LEO		r	n LEO
r[–2;5]	~	~	r[–2;5]	2.75	92	r[–2;5]	2.33	246.5
r[–1;5]	~	~	r[–1;5]	3.08	90.5	r[–1;5]	2.39	242.5
r[–1;4]	~	~	r[–1;4]	2.84	77.5	r[–1;4]	2.14	225.5
r[0;4]	2.81	25	r[0;4]	2.59	76.5	r[0;4]	2.20	206.5
r[0;5]	3.02	28.5	r[0;5]	2.98	89.5	r[0;5]	2.53	233.5
r[1;5]	3.14	27.5	r[1;5]	3.11	85	r[1;5]	2.68	218

Table 3 – Calculated ZHR values based on 507 Leonids.

Year	Month	Day	t/m UT	$\lambda_{\odot}$	Periods	n LEO	ZHR	±	r[–2;5]
2018	11	4	4.10	221.427	1	1	0.4	0.4	2.50
2018	11	6	3.26	223.397	4	4	1.9	1.0	2.50
2018	11	7	3.59	224.414	4	8	3.7	1.3	2.50
2018	11	10	3.21	227.411	5	18	7.4	1.8	2.50
2018	11	14	5.95	231.550	6	18	7.2	1.7	2.50
2018	11	15	4.25	232.486	2	5	2.8	1.3	2.50
2018	11	16	3.77	233.457	8	29	6.2	1.1	3.02
2018	11	17	4.75	234.456	15	74	10.2	1.2	2.98
2018	11	17	11.04	234.786	3	19	8.5	1.9	2.98
2018	11	18	2.25	235.425	28	228	13.8	0.9	2.53
2018	11	18	10.70	235.780	8	56	13.6	1.8	2.53
2018	11	19	2.75	236.454	2	20	12.5	2.8	2.50
2018	11	20	8.36	237.809	2	27	26.9	5.2	2.50

6 Leonids 2018: ZHR

The ZHR was determined by the method of Peter Jenniskens as described in Jenniskens (1994) and in Miskotte and Johannink (2005) with the radiant height correction set at 1.0 instead of 1.4 to make a comparison with the IMO curve. For the nights 15–16 (maybe too low numbers), 16–17 and 17–18 November 2018, enough data was available for a population index *r* determination r [0; 5]. Values for the population index *r* as equal to 3.02, 2.98 and 2.53 were used respectively for the nights 15–16, 16–17 and 17–18 November. With a strong number of bright meteors during the morning of November 19, the author assumed a *r* value of 2.40 and for all other nights the IMO value of 2.50 was used. For the ZHR determination a total of 507 Leonids could be used, this resulted in *Table 3* and *Figure 2*.

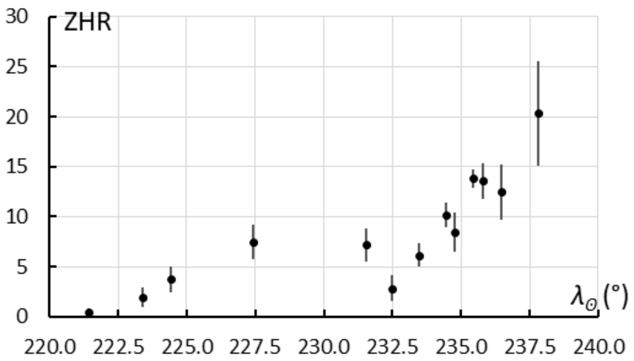

Figure 2 – ZHR graph Leonids 2018 based on Table 2 (507 Leonids). The period shown is from 4 to 21 November 2018. The ZHR is calculated with a variable population index r.

There is little difference between the ZHR curves from this analysis and the IMO ZHR-on-the-fly curve (*Figures 1 and 2*). The differences are caused, among other things, because not all IMO data has been used, data from observers have been used who do not report to IMO and an assumed population index $r = 2.50$ has been used for the IMO curve. See also *Figure 3* that combines the IMO chart and that of the author. Very small differences in the first nights but in the period 16–19 November we notice somewhat larger differences.

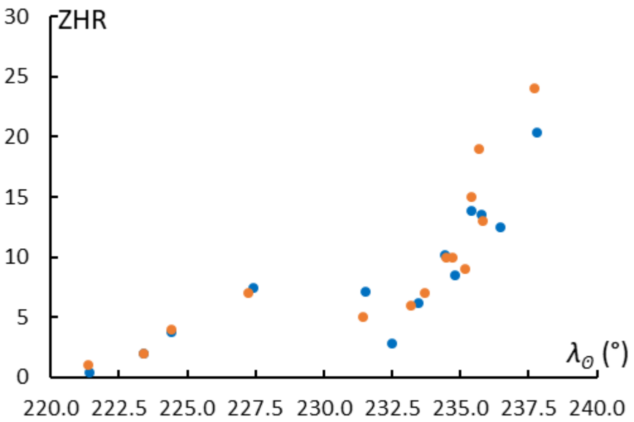

Figure 3 – Comparison Leonids ZHR 2018 between this analysis (blue dots) and the IMO ZHR-on-the-fly curve (orange dots). The ZHR is calculated with a variable population index r.

16–17 November 2018

We zoom in on the ZHR values found per hour in the night 16–17 November. This resulted in *Figure 4*. According to the IMO Meteor Shower Calendar 2018 (Rendtel, 2017) the nodal passage in 2018 was at $\lambda_\odot = 235.27°$ (17 November 2018 at 22^h30^m UT). As expected, we see a slightly increasing ZHR from 8 to 12 over Europe that night, these are the first four ZHR points. This European part of the graph is based on 93 Leonids (12 periods, 7 different observers). This mainly concerns weak Leonids, but it is striking that several observers also see a relatively large number of 0 to –3 Leonids, few of +2 but again a lot of +3 and +4.

We see declining ZHRs over the American continent. However, caution is required here, it concerns three ZHR points based on only 2 individual observers, namely *Terence Ross* (5th ZHR point) and *Wesley Stone* (6th and 7th ZHR points).

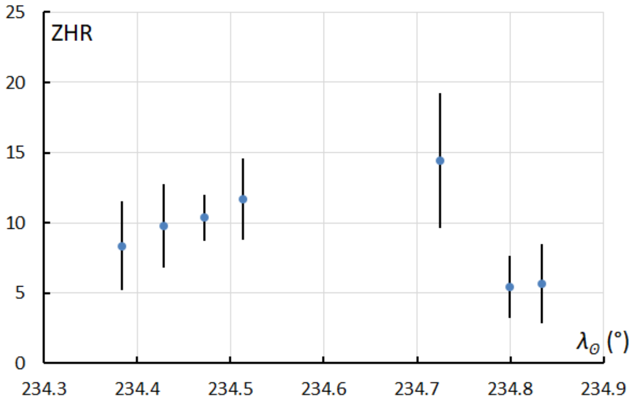

Figure 4 – ZHR Leonids in the period November 17, 2018 between 01^h and 13^h UT. The ZHR is calculated with a population index r = 2.98.

17–18 November 2018

Of course, we also zoom in on the ZHR during this night. As mentioned earlier in this article, nodal passage took place on 17 November at $\lambda_\odot = 235.27°$ (17 November 2018 at 22^h30^m UT. The ZHR above Europe (the first 6 ZHR points) decreases from 15 to 10–13, exactly what was to be expected. The first point above America seems to be high, the other three are more in line with what to expect.

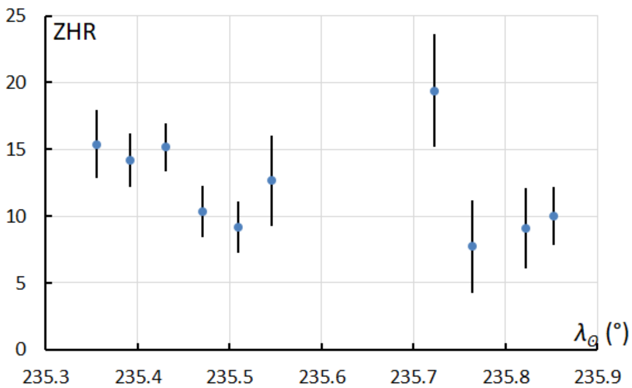

Figure 5 – ZHR Leonids in the period November 18, 2018 between 00^h and 13^h UT. The ZHR is calculated with a population index r = 2.53.

Outburst Leonid activity in 2018?

After the maximum night of November 17–18, we enter the "interesting area" of the Leonids (Rendtel, 2017). Unfortunately, the weather barely cooperated. There are few Leonid data in the IMO database after November 18th. There are three observations of "suspicious" Leonid activity.

18–19 November 2018

Only one observer could observe in this night. *Michel Vandeputte* reported relatively high activity of bright Leonids. He wrote: "*At 01^{h}45^m UT I was installed in the backyard and tsjakka: immediately an impressive –2 Leonid with persistent train moving to the southern parts of the sky! Immediately countered by a not much less beautiful –1 sporadic meteor from Canis Minor. More of it please! Here and there, there was a small cumulus-cloud, but they did not really bother. I could observe for two hours before the clouds re-appeared. The night sky was better at times than last night: more transparent and less hectic. But the wind blew a lot more and it felt pretty cold. The Leonids were much more attractive to my surprise! A whole battery of nice bright meteors between –2 and +2, certainly hourly counts of 10. Only in the end of my session the activity decreased a bit.*"

For those two hours a ZHR is calculated of 12 ± 4 with an assumed population index *r* of 2.40. The ZHR found is somewhat higher than the American ZHR values from *Figure 5* of November 18, 2018. The magnitude distribution is also strange, see *Table 4* below. Unfortunately, Michel was the only observer who observed this event. The lack of weak Leonids is striking with as a result the high average magnitude of 1.15.

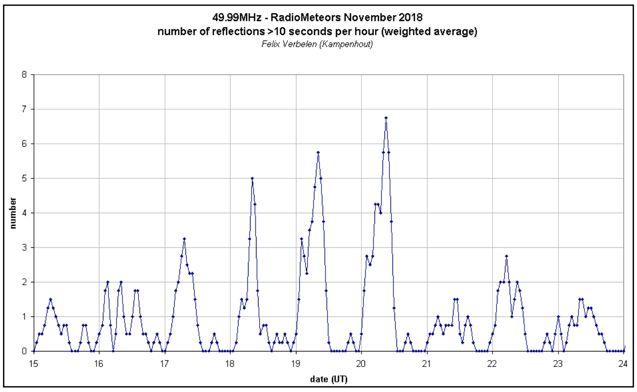

Figure 6 – Graph based on radio observations of the Leonids by Felix Verbelen of all overdense reflections longer than 10 seconds. These can be best compared with visual data because of the bright meteors.

Vandeputte's observations are supported by radio observations published by *Felix Verbelen*, he wrote the following on the VVS mailing list: "*Yesterday (20181118) it seemed that the Leonid activity this year would be moderate … Not so. Today, since 01^h UT, many strong and long-lasting reflections! Attached are some eye-catchers on the frequency of our VVS beacon (49.99 MHz), here in Kampenhout.*"

If we look at the graph of overdense reflections longer than 10 seconds of Felix (*Figure 6*) then we see indeed an increasing activity in the nights 16–17, 17–18, 18–19 and 19–20. Although the ZHR was lower in the night 18–19 than in the previous night, the number of bright Leonids turned out to be higher on the night of November 18–19 than on the previous night. See also Felix's article in Meteornews (Verbelen, 2019).

A second confirmation of the nice activity of bright Leonids on the morning of November 19 was on the well-known website of *Hirofumi Sigumoto* (*Figures 7 and 8*). The way in which Sigumoto performs his calculations is described in Meteornews (Sugimoto, 2017). The prediction of Jeremie Vaubaillon is the closest to this particular observation. So perhaps Michel has seen some activity from the associated dust trail.

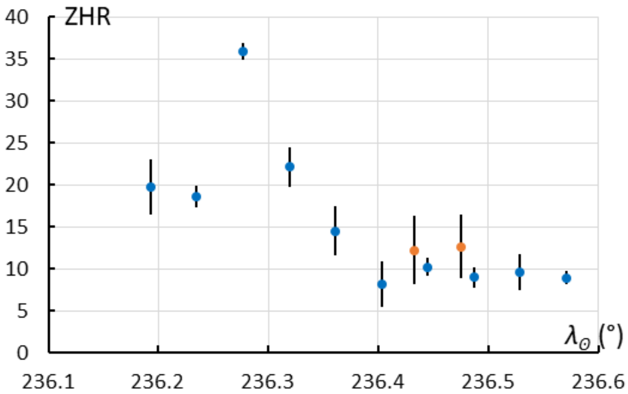

Figure 7 – A part of the Leonids radio ZHR curve of Hirofumi Sugimoto (blue dots), combined with the visual data (ZHR) by Michel Vandeputte (orange dots). The graph suggests that there may have been some more Leonid activity in the period before Michel did his observations.

Table 4 – Observation of the night 18–19 November 2018 by Michel Vandeputte.

Date	Period UT	Lm	–2	–1	0	1	2	3	4	5	LEO	Mm
19-11-2018	01^{h}45^m-03^{h}45^m	6.3	1	2	2	6	6	3	0	0	20	1.15

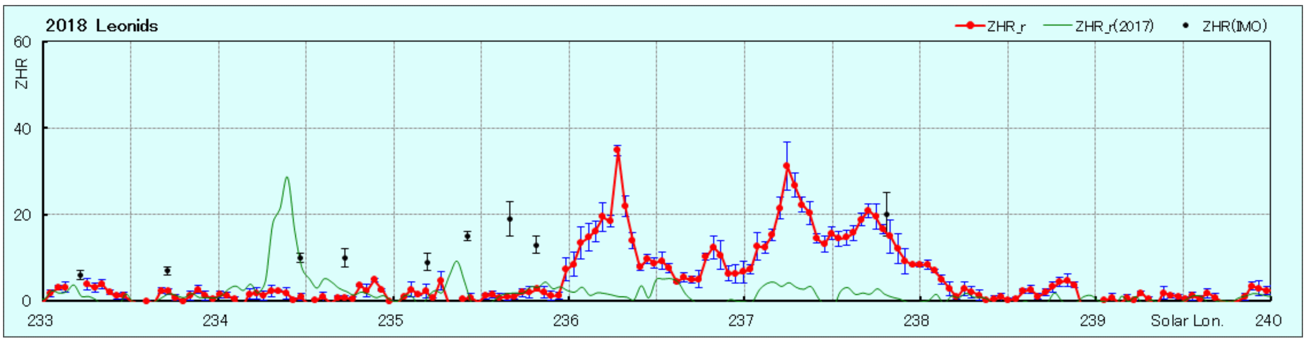

Figure 8 – Leonid ZHRs determined based on radio observations from RMOB (Sugimoto, 2017).

November 20, 2018

In both the IMO ZHR-on-the-fly graph (*Figure 1*) and the graph of this analysis (*Figure 2*) we see the fairly high ZHR point around November 20 ($\lambda_{\odot}$ = 237.80). This appears to be a ZHR point based on an observation reported by the active American observer *Terrence Ross*. His observation was done from Alpine, Texas on November 20 between 10^{h}26^m and 11^{h}30^m UT with a radiant height of 62 degrees. It yields a ZHR of 20. His observation can be found online[2].

The number of bright Leonids is also striking, somewhat comparable to the observation by *Michel Vandeputte* of November 19, 2018. Unfortunately, Ross is the only observer who has observed this.

However, there is another observation that was done earlier on the 20th by *Pedro Pérez Corujo* from the island of Cran Canaria. His observation can be found online[3].

His observation could unfortunately not be used in this analysis because of the too low limiting magnitude. But because of Ross's observation, it is used to compare the observations. Corujo sees 12 Leonids with a limiting magnitude of 5.5 between 05^{h}15^m and 06^{h}15^m UT and a radiant height of 70 degrees. This yields a ZHR of 33 ± 9.7. Unfortunately, this observer did not provide any magnitude distributions. His observation is roughly 5 hours before the observation of Ross and seems to be an indication that a possible small outburst happened on November 20th.

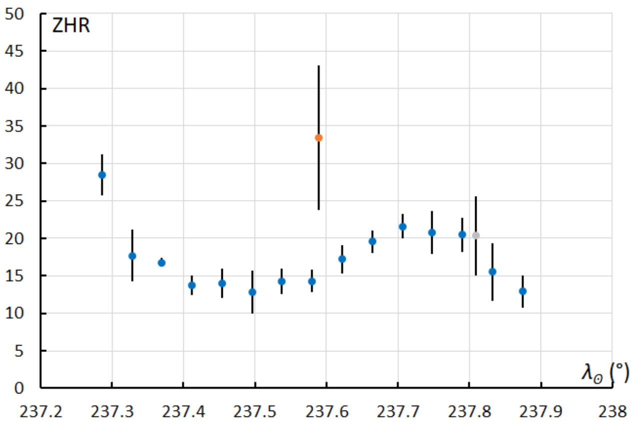

Figure 9 – The radio ZHR graph of Hirofumi Sugamoto (blue dots) compared with visual observations (ZHR) from Pedro Pérez Corujo (CORPE – orange dot) and Terrence Ross (ROSTE – grey dot).

The observations of Ross and Corujo are also supported by the graphs of *Hirofumi Sugimoto* (*Figure 9*) and *Felix Verbelen* (*Figure 6*). The ZHR on November 20 was higher than on November 19 and indeed the graph of *Felix Verbelen* also shows higher activity on November 20 than on November 19. All three modellers Sato, Vaubaillon and Maslov give candidates for this possible outburst: the observation of Corujo fits best with Sato (1433 dust trail), that of Ross with Maslov (1466 dust trail). The radiograph of Sigumoto (*Figure 8*) shows two broad peaks on November 20th. It is therefore very unfortunate that not more observers were active during this period.

7 Conclusions

Like the analysis of the Leonids for 2017, this analysis also shows that the Leonids between 15 and 25 November can be very interesting with sometimes small "outbursts". Therefore, I make a call to actively observe this meteor shower visually! And also, in 2019 when the conditions are moderate because of the Moon, the shower should be monitored. Who knows what surprises we will get to see?

I would also like to urge all observers to observe more in the period at the end of July and during entire August. This way I can calculate more reliable C_p's and add more data in the analyzes.

Acknowledgment

First of all, a huge word of thanks to the observers who observed the Leonids in 2018. These are: *Alexandre Amorim, Shrinivas Aundhkar, Pierre Bader, Steve Brown, Tim Cooper, Tibor Csorgei, Kai Gaarder, Glenn Hughes, Paul Jones, Javor Kac, Adam Marsh, Ken Marsh, Pierre Martin, Koen Miskotte, Rafael Neumann, Pedro Pérez Corujo, Ina Rendtel, Jürgen Rendtel, Terrence Ross, Kai Schutze, Ben Sharp, Ulruch Sperberg, Wesley Stone, Hanjie Tan, Michel Vandeputte, Roland Winkler, Frank Wächter* and *Sabine Wächter*.

A word of thanks also goes to *Paul Roggemans*, *Carl Johannink* and *Michel Vandeputte* for a critical review of this article and for the suggestions given. *Felix Verbelen* and *Hirofumi Sigumoto* are thanked for providing radio data and useful discussions.

References

Jenniskens P. (1994). "Meteor Stream activity 1. The annual streams". *Astron. & Astrophys.*, **287**, 990–1013.

Jenniskens P. (2006). Meteor showers and their Parent Comets. Cambridge Univ. Press., 790 pages.

Miskotte Koen (2018). "The Leonids during the off-season period: Part 1 – 2017: a small outburst!". *eMetN*, **3**, 148–152.

Rendtel J. (2017). "2018 Meteor Shower Calendar". IMO.

Sugimoto H. (2017). "The new method of estimating the ZHR using radio meteor observations". *eMetN*, **2**, 109–110.

Verbelen F. (2019). "Radio meteors – November 2018". *eMetN*, **4**, 44–48.

[2] https://www.imo.net/members/imo_vmdb/view?session_id=77963

[3] https://www.imo.net/members/imo_vmdb/view?session_id=78032

Zeta Taurids (ZTA#226) or phi Taurids (PTA#556)?

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This case study focuses on fast moving meteors with radiants in the constellation of Taurus during late September until begin of October. The Zeta Taurids (ZTA#226) seem to be an erroneous combination of early Orionid orbits with a weak concentration of distinctly different types of orbits, listed in the IAU Working List of Meteor Showers as the Phi-Taurids (PTA#556). In total 173 orbits were identified as PTA#556 shower members within the activity interval in solar longitude from 175° until 206°. These orbits are characterized by a small perihelion distance q of ~ 0.24 ± 0.02 AU and an eccentricity of ~0.95 ± 0.04. Based on this case study it is recommended to remove the ZTA#226 entry from the IAU Working List of Meteor Showers.

1 Introduction

Browsing the IAU Working List of Meteor Showers, I noticed an entry that raised questions because the two shower orbits mentioned are very different. Only the inclination *i* is similar. The data from the IAU Meteor Data Center is summarized in *Table 1*.

Table 1 – The data as listed in the IAU working list of meteor showers for the Zeta Taurids (ZTA#226 status May 2019).

	Jenniskens (2006)	Sekanina (1976)
$\lambda_{\odot}$	196°	193.5°
α_g	86.1°	71.5°
δ_g	+14.7°	+28.2°
v_g	67.2 km/s	56.5 km/s
a	21.3 AU	1.632 AU
q	0.715 AU	0.231 AU
e	0.966	0.858
ω	70.9°	311.8°
Ω	16.5°	193.5°
i	162.4°	163.1°
N	3	6

The online shower list mentions a third entry without any orbital elements to support the existence of this shower. This source is based on single station video observations (Molau and Rendtel, 2009). The use of single station data is inappropriate for detections of weak minor meteor streams for which orbits are essential to identify a more reliable shower association. The authors mention that their radiant is based on 294 meteor trails. However, the rich meteor activity around that time and the presence of early Orionid radiants nearby will generate many meteor paths with a suitable angular velocity lined up with an assumed radiant just by chance. The real radiant for single station meteor paths cannot be determined.

The difference between the two orbits is that large, that if the Zeta Taurids exist, only one of both reference orbits can be valid for this shower. The number of orbits on which both reference orbits are based are too few to define any statistical relevant reference orbit. This case study was made to clarify this confusion.

2 Available orbit data to search

We have the following orbit data collected over 13 years, status as until May 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). 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 The ζ-Taurids reference by Jenniskens

Dr. Peter Jenniskens mentioned this shower without providing further details (Jenniskens, 2006). He associates the ζ-Taurid orbit he obtained from 3 orbits with the orbit published earlier by Sekanina (*Table 1*) as well as a third orbit published by Kashcheyev and Lebedinets (1967):

- α_g = 88°
- δ_g = +12°
- v_g = 57 km/s
- a = 1.48 AU
- q = 0.38 AU
- e = 0.74
- ω = 119°
- Ω = 23°
- i = 152°

This third reference orbit has been omitted when the shower was listed in the IAU Working List of Meteor Showers. The ζ-Taurid shower has not been detected in later meteor shower searches neither on CAMS orbits (video) nor on CMOR orbits (radar) which may be an indication that this stream perhaps does not exist at all.

To verify if this reference orbit is similar to any known other meteor stream we calculate the discrimination criteria according to Hawkins (1963), referred to as D_{SH}, Drummond (1981) referred as D_D and Jopek (1993) referred as D_H. The results are listed in *Table 2*.

If we search the 712489 orbits available to find orbits that fulfil the similarity criteria with this ζ-Taurid reference orbit of Jenniskens, we find as many as 8298 orbits with a low threshold, 1963 with medium low, 431 with medium high and 90 with a high threshold similarity. However, most of these orbits were identified before as either Orionids or Eta Aquariids.

The reference orbit mentioned by Jenniskens (2006) for the ζ-Taurids (ZTA#226) seems to be based on 3 early Orionid orbits which were not recognized as Orionids. If the ζ-Taurids (ZTA#226) exist as a distinct meteor shower, this orbit is probably not related to it.

Table 2 – The five reference orbits found in the IAU working list of meteor showers that fulfill the similarity discrimination criteria for association with the ZTA reference orbit given by Jenniskens.

	ORI	ETA	SOO (1)	SOO (2)	SOO (3)
λ_O	207.5°	46.9°	185.6°	185.7°	187°
α_g	94.7°	338°	79.2°	80.4°	80.9°
δ_g	+15.5°	–2°	+12.1°	+10.6°	+12.5°
v_g	66.4	–	67.6	66.9	67.6
a	9.71	36	10.8	6.4	8.1
q	0.597	0.612	0.774	0.792	0.777
e	0.9385	0.983	0.928	0.876	0.911
ω	80.1°	101.5°	58.1°	56.5°	57.6°
Ω	27°	45.8°	5.6°	5.7°	7.7°
i	163.6°	165.5°	159.3°	156.5°	159.9°
N	1297	11	18	20	40
D_{SH}	0.13	0.19	0.12	0.18	0.13
D_D	0.09	0.09	0.05	0.09	0.06
D_H	0.11	0.17	0.11	0.17	0.13

The first orbit (ORI) resulted from the CMOR stream search (Brown et al., 2008) as reference orbit for the Orionids. The second orbit (ETA) was found from photographic orbits as reference for the Eta Aquariids (Lindblad, 1990). The remaining three orbits are for the September omicron Orionids (SOO#479) a not yet confirmed shower. The first SOO (1) reference orbit based on 18 orbits has the best similarity criteria (Rudawska and Jenniskens, 2014). The second SOO (2) reference orbit based on 20 orbits was obtained from the EDMOND database (Kornoš et al., 2014). The third SOO (3) reference orbit based on 40 orbits was obtained from CAMS orbits 2010–2013 (Jenniskens et al., 2016).

The first reference orbit for the ZTA#226 seems to be more related to the unconfirmed SOO#479 shower, and most likely all these orbits are nothing else than early Orionids. The tendency to split out main meteor showers into several minor showers inflated the number of shower entries in the IAU Working List of Meteor Showers. The confusion and inconsistencies in the IAU Working List have been discussed by Masahiro Koseki (2016, 2018).

4 The ζ-Taurids reference by Sekanina

Sekanina mentions this orbit as tau Taurids, a result of a shower search on radar orbits obtained during the Radio Meteor Project at Havana, Illinois, U.S. in 1961–1965 and 1968–1969. For a correct interpretation of the stream search the limited accuracy of these radar orbits should be taken into account. Moreover, the threshold of the similarity criterion of Southworth and Hawkins (1963) has been taken very optimistic. For instance, from all similar radar orbits only one fulfils the low threshold in our analyzes, mainly because several orbits that pass the test with Southworth and Hawkins fail on the Drummond (1981) test.

Checking the ZTA reference orbit of Sekanina with all other reference orbits listed in the IAU Working List results in two matches with two reference orbits listed for the phi Taurids (PTA#556). The orbits are compared in *Table 3*. All three orbits have no similarity with the Orionids.

Table 3 – The two reference orbits found in the IAU working list of meteor showers that fulfill the discrimination criteria for association with the ZTA reference orbit given by Sekanina.

	ZTA Sekanina 1976	PTA Andreic et al., 2014	PTA Jenniskens et al., 2018
λ_O	193.5°	193°	188.8°
α_g	71.5°	63.9°	58°
δ_g	+28.2°	+29.1°	+28°
v_g	56.5	60.2	60.1
a	1.632	8.7	12.3
q	0.231	0.234	0.22
e	0.858	0.973	0.984
ω	311.8°	303.7°	305.2°
Ω	193.5°	193.1°	188.8°
i	163.1°	156.3°	155.6°
N	6	22	38
D_{SH}		0.21	0.19
D_D		0.09	0.09
D_H		0.21	0.19

The weak similarity between the ZTA reference orbit as given by Sekanina (1976) and the PTA reference orbits suggests that these are related. The orbit obtained by Sekanina is based on orbits that fulfil the discrimination criteria with the PTA orbit as reference. It is very likely that both are physically related to each other.

5 Is there any meteor shower?

To make an independent check for possible similar orbits among our database with 712489 orbits with the reference orbit given by Sekanina for the ZTA#226 shower, we check if and how many similar orbits we have. As many as 115 orbits fulfil the low threshold criteria when we take the orbit of Sekanina as reference. These similar orbits are distributed over the following interval in solar longitude, radiant area and velocity range:

- Time interval: $172° < \lambda_{\Theta} < 210°$;
- Radiant area: $45° < \alpha_g < 100°$ & $+21° < \delta_g < +34°$;
- Velocity: 50 km/s < v_g < 62 km/s.

Next, we select all 89573 orbits we have in this time interval and from these we take the orbits with a radiant and velocity within the above-mentioned range. This results in a selection of 1097 orbits. In a first approach we calculate the average orbit for this set, using the calculation method explained by Jopek et al. (2006). For all 1097 orbits we calculate the discrimination criteria according to Southworth & Hawkins (1963), referred to as D_{SH}, Drummond (1981) referred as D_D and Jopek (1993) referred as D_H and we consider the following similarity threshold classes:

- 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: $D_{SH} < 0.1$ & $D_D < 0.04$ & $D_H < 0.1$.

Table 4 – The average values for the final selections of orbits for the four different threshold levels on the D-criteria, compared to the orbit for the shower PTA#556, with their similarity values for D_D listed below each average orbit.

	Low	Medium low	Medium high	High	PTA Andreic et al., 2014h
λ_{Θ}	188.1°	188.2°	187.4°	187.7°	193°
α_g	60.4°	60.4°	59.4°	59.3°	63.9°
δ_g	+28.5°	+28.3°	+28.3°	+28.6°	+29.1°
v_g	60.0	60.2	60.5	60.6	60.2
a	4.3	5.0	6.2	7.0	8.7
q	0.257	0.258	0.262	0.264	0.234
e	0.940	0.948	0.958	0.962	0.973
ω	301.4°	301.1°	300.3°	299.9°	303.7°
Ω	187.8°	188.0°	187.2°	187.5°	193.1°
i	157.0°	157.8°	157.5°	156.7°	156.3°
N	164	94	42	13	22
D_D	0.05	0.05	0.06	0.06	

We select the orbits that fulfil the medium high criterion, recalculate the average orbit and repeat this process. After some iteration we have an average orbit. The results are shown in *Table 4* for the different thresholds of similarity.

The sample of orbits which we selected on bases of the orbit given by Sekanina for the ZTA#226 shower effectively include a concentration of orbits that define a meteor shower. However, the average orbit for this shower is similar to the orbit listed for PTA#556 with medium high threshold levels.

Assuming that the orbit given by Sekanina is likely not the best starting point, the selection interval was slightly changed, based on 193 orbits which are similar to the PTA#556 orbit among our 712489 orbits.

- Time interval: $174° < \lambda_{\Theta} < 210°$;
- Radiant area: $43° < \alpha_g < 85°$ & $+22° < \delta_g < +35°$;
- Velocity: 56 km/s < v_g < 65 km/s.

Table 5 – The average orbital elements at each iteration while approaching the most likely average orbit for the concentration included in the sample.

q	*e*	*ω*	*Ω*	*i*
0.302272	0.887987	294.2602	188.2856	159.372
0.298632	0.919714	296.526	189.02	158.9835
0.293532	0.928027	296.8326	187.9376	158.528
0.288686	0.931124	297.3361	187.1088	157.9038
0.285071	0.933901	297.7646	186.9801	157.3177
0.280027	0.934187	298.4372	186.8108	156.7733
0.273227	0.93638	299.265	186.7455	156.2642
0.268345	0.937086	299.878	187.0397	156.2198
0.265031	0.938128	300.2929	187.0279	156.3707
0.260453	0.940173	300.857	187.2763	156.5485
0.256141	0.940977	301.3942	187.3674	156.6071
0.253252	0.940951	301.7957	187.5985	156.4208
0.251696	0.941017	302.0131	187.7667	156.493
0.250212	0.94182	302.1847	187.9417	156.6415
0.249229	0.942413	302.2956	188.0193	156.6136
0.24823	0.9427	302.4522	188.2577	156.5657
0.246357	0.94339	302.6816	188.4263	156.6904
0.244159	0.943669	303.0149	188.914	156.7515
0.24335	0.943486	303.0961	189.0144	156.9089
0.242471	0.943893	303.1838	189.2693	157.0215
0.241615	0.944677	303.2316	189.4679	157.04
0.241149	0.945055	303.2613	189.4819	157.0684
0.240392	0.945186	303.37	189.4996	157.131
0.23928	0.94489	303.5443	189.7237	157.2393

86069 orbits are available in this time bin, and 1093 orbits have the radiant and velocity in the selected range. We start with the average orbit for these 1093 orbits using the method by Jopek et al. (2006). Next, we calculate the discrimination criteria for all 1093 orbits. Then the average orbit is calculated based on those orbits that fulfill the low threshold criteria and again new discrimination criteria are calculated for all 1093 orbits. This way we approach the concentration of similar orbits using an iterative procedure. At each step a better representative average orbit is obtained, outliers are rejected, more similar orbits included and this until the result converges to a final average orbit. This happens after the 23rd recombination. The intermediate steps are listed in *Table 5* to show how the best fitting selection of orbits is approached.

After 23 iterations we cannot find any better selection of orbits. For the final orbit we consider the different average orbits for each threshold level in *Table 6*. Each of these orbits fulfils the high threshold similarity criterion with the PTA#556 orbit as reference (Andreic et al., 2014).

Table 6 – The average values for the final selections of orbits for the four different threshold levels on the D-criteria, compared to the reference orbit for the shower PTA#556, with its similarity values for D_D listed below each average orbit.

	Low	Medium low	Medium high	High	PTA Andreic et al., 2014
λ_O	189.7°	190.2°	189.8°	189.5°	193°
α_g	61.3°	61.9°	61.4°	60.3°	63.9°
δ_g	+28.5°	+28.5°	+28.8°	+28.7°	+29.1°
v_g	59.9	60.1	60.2	60.6	60.2
a	4.3	4.8	5.3	7.2	8.7
q	0.239	0.240	0.241	0.241	0.234
e	0.945	0.950	0.954	0.967	0.973
ω	303.5°	303.5°	303.3°	303.0°	303.7°
Ω	189.7°	190.1°	189.3°	189.3°	193.1°
i	157.2°	156.9°	156.6°	156.2°	156.3°
N	173	102	46	11	22
D_D	0.03	0.02	0.03	0.02	–

6 The φ Taurids (PTA#556) shower

Our search for orbits similar to the ZTA#226 resulted in a selection of orbits that confirm the PTA#556 meteor shower. With the available information we can try to obtain some more characteristics of this shower.

PTA orbits were detected in the time interval in solar longitude λ_O [175°, 206°], or September 19 until October 20. This is much longer than what Andreic et al. (2014) published with [187°, 198°]. The Right Ascension of 61.3° and Declination +28.5° is close to the position given by Andreic et al. (2014).

Andreic et al. (2014) mention a rather compact radiant, but that does not really emerge from this case study. *Figure 1* shows the radiant plot for different threshold levels of the D-criteria. *Figure 2* shows the sporadic background. The region near the ecliptic is very rich in dust which means there is a risk to find similar orbits that have no physical relationship. We reduce this risk by combining three different similarity criteria. Our selection includes 97 orbits that were identified as PTA#556 meteors by UFOCapture as these fulfil the Southworth & Hawkins criteria with D_{SH} < 0.25, but fail in our Drummond criterion with D_D > 0.105. Our selection contains probably more orbits that belong to the PTA meteor shower, but which were not identified because of the rather strict selection criteria we apply. Using only the Southworth & Hawkins criteria is not recommended as such less strict criterion could include unrelated sporadics.

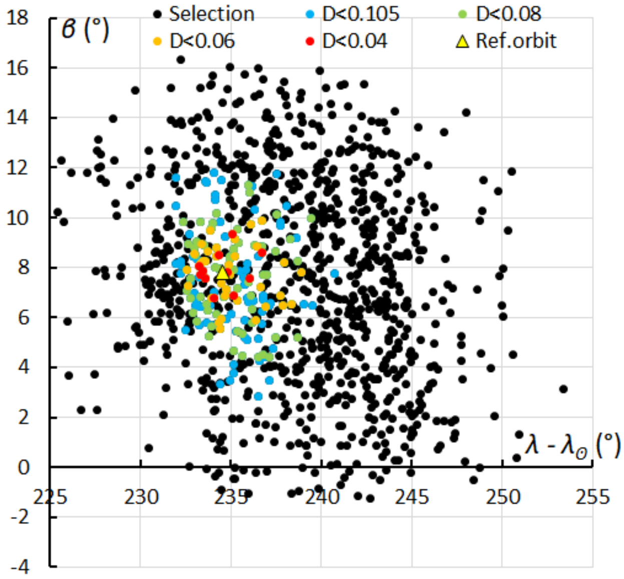

Figure 1 – Plot of the ecliptic latitude β against the Sun centered longitude λ – λ⊙. The different colors represent the 4 different levels of similarity.

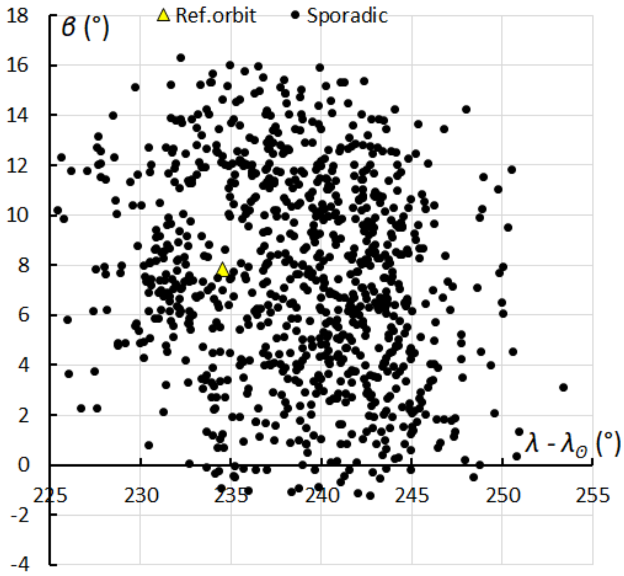

Figure 2 – Plot of the ecliptic latitude β against the Sun centered longitude λ – λ⊙ for the 921- orbits from the selection that failed in the similarity criteria.

All the sporadic radiants in *Figure 2* produced meteors that for a perfect single station observer or video station would line up with the assumed radiant position, showing the right angular velocity although most of the orbits fail in all discrimination criteria. Therefore, single station meteor shower searches are not reliable for too weak showers.

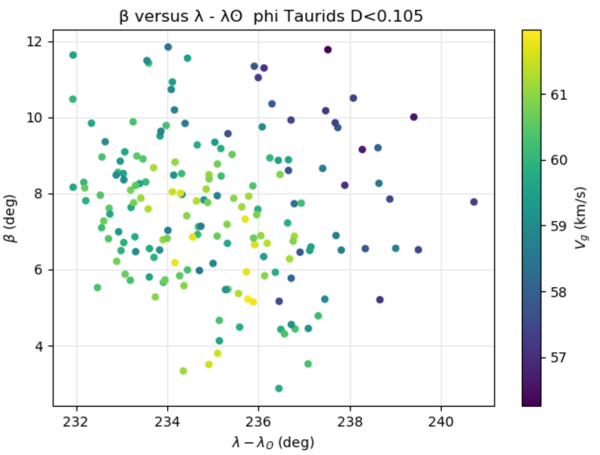

Figure 3 – Plot of the ecliptic latitude β against the Sun centered longitude λ – λ⊙ (°) for the 173 PTA orbits that fulfill the low threshold similarity criteria with a color gradient to display the variation in the velocity v_g.

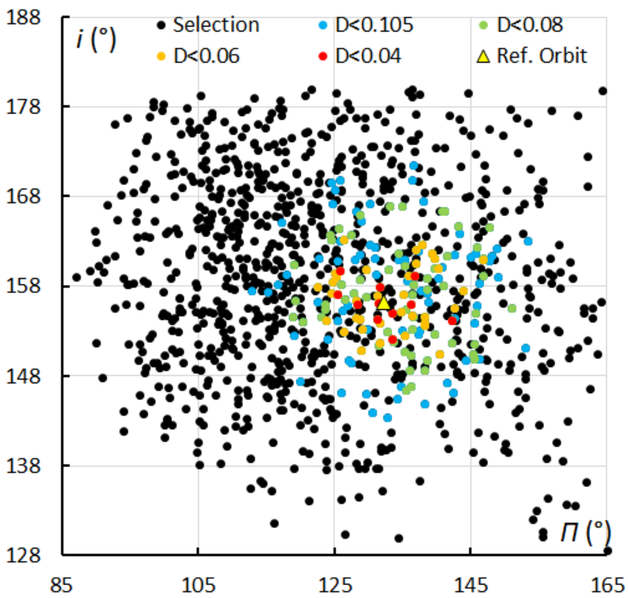

Figure 4 – The plot of inclination i (°) against the length of perihelion Π (°) for the 1093-selected possible PTA-orbits. The colors mark the different threshold levels of the D-criteria.

Figure 3 shows the velocity variation on the orbits in the radiant plot for the 173 PTA orbits that fulfil our criteria. All these orbits are characterized by a short perihelion distance *q* and high eccentricity *e*.

Figures 4, 5 and 6 show the same distributions but for inclination *i* (°) against the length of perihelion *Π* (°).

The number of orbits allows to look at the radiant drift. *Table 7* lists the results for all four threshold levels. The number of orbits with the high threshold level is too small, but the radiant drift for the three other levels is in perfect agreement with Andreic et al. (2014).

The activity period given by Andreic et al. (2014) differs from this case study. We have orbits for this shower during a longer period with $\lambda_\odot$ = 190° about at the middle. The entire period of time is very well documented with an average of about 2000 orbits available for each degree in solar longitude. The percentages of PTA orbits in these datasets are very small, less than 1%. Looking at these percentages in time bins of 1° in solar longitude to reconstruct the activity profile, strong fluctuations are visible which is most likely just statistical flutter due to the low number of PTA orbits detected. No distinct maximum is visible.

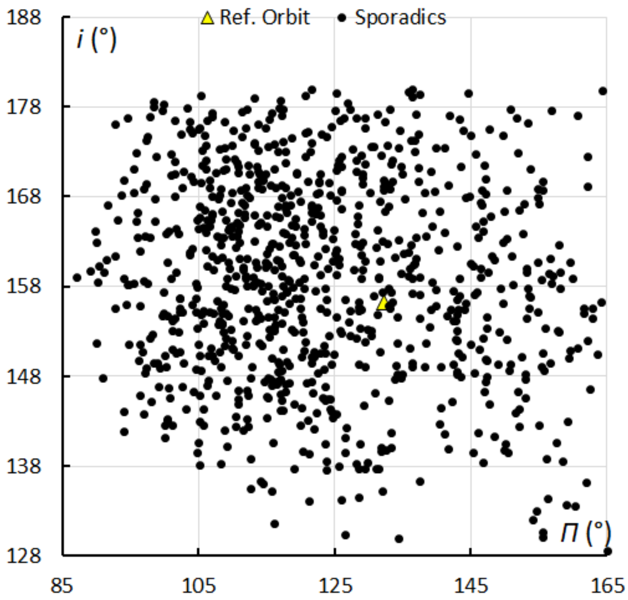

Figure 5 – The plot of inclination i (°) against the length of perihelion Π (°) for the 921 orbits from the selection that failed in the similarity criteria.

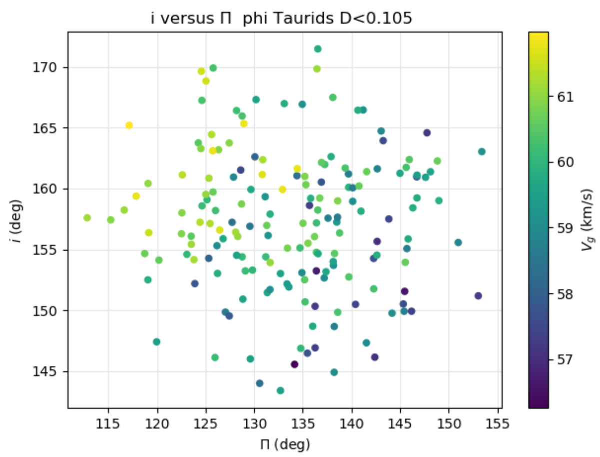

Figure 6 – Close-up on the plot of inclination i (°) against the length of perihelion Π (°) for the 173 PTA orbits that fulfil the low threshold similarity criteria with a color gradient to display the variation in the velocity v_g.

Table 7 – Radiant drift with ± σ for the φ Taurids obtained from the orbits for each threshold level of the D-criteria compared with a reference from literature (Andreic et al., 2014).

Threshold/source	PTA – 556	
	Δα / λ⊙	Δδ / λ⊙
Low	1.12 ± 0.02	+0.18 ± 0.02
Medium low	1.16 ± 0.03	+0.19 ± 0.03
Medium high	1.23 ± 0.09	+0.33 ± 0.08
High	1.39 ± 0.35	–0.04 ± 0.29
Andreic et al. (2014)	1.15	+0.20

Looking at the number of PTA orbits detected each year it is obvious this is an annual shower (*Figure 8*). The numbers vary between 0.2% and 0.4% of all available orbits during the activity period 175° < λ_Θ < 206°. Most of the orbit data comes from EDMOND and SonotaCo. Only for 2011 and 2012 CAMS data is publicly available and no EDMOND data is available for 2017 and 2018.

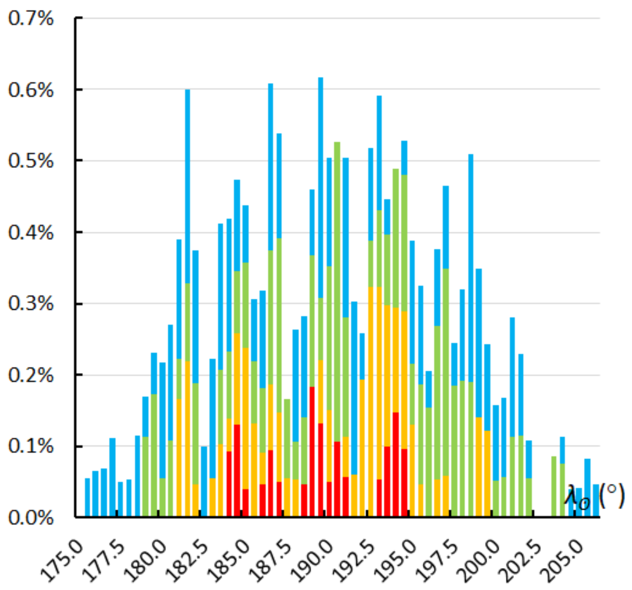

Figure 7 – The relative number of PTA orbits collected per 1° of solar longitude in steps of 0.5° during the years 2007–2018, with blue for D_D < 0.105, green for D_D < 0.08, orange for D_D < 0.06 and red for D_D < 0.04, as percentage compared to the total number of non-PTA orbits without any Orionids, collected in the same time span.

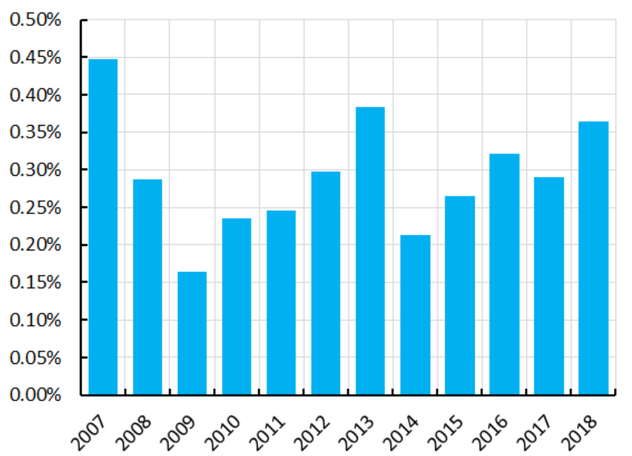

Figure 8 – The percentage of PTA orbits relative to the total number of non-PTA orbits obtained during the activity period 175° < λ_Θ < 206.5° (blue).

7 Conclusion

The ζ-Taurids (ZTA#226) are most likely an erroneous combination of a few early Orionid orbits that were linked to another minor shower, τ-Taurids, with a different type of orbit. A stream search among all available orbits indicates that there is a weak concentration of similar orbits that are related to the τ-Taurids detected by Sekanina (1976), which is already listed in the IAU Working List of Meteor Showers as the φ-Taurids (PTA#556) detected by Andreic et al. (2014).

Based on this case study, we recommend removing the record of the ZTA#226. The PTA#556 data is confirmed by this case study, with a longer activity period 175° < λ_Θ < 206°, centered around λ_Θ = 190° without a distinct maximum.

Acknowledgment

The author is very grateful to *Jakub Koukal* for the dataset of EDMOND with the data until 2016, to SonotaCo Network (Simultaneously Observed Meteor Data Sets SNM2007–SNM2018), to CAMS (2010–2013) and to all camera operators involved in these camera networks.

I thank *Denis Vida* for providing a tool to plot a color gradient to show the dispersion in velocity and an algorithm to calculate the average meteor shower orbit according to the method published by Jopek et al. (2006).

EDMOND[4] 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*).

References

Andreic Z., Gural P., Segon D., Skolic I., Korlevic K., Vida D., Novoselnik F. and Gostinski D. (2014). "Results of CMN 2013 search of new showers across CMN and SonotaCo databases". *WGN, Journal of the International Meteor Organization*, **42**, 90–97.

Brown P., Weryk R. J., Wong D. K. and Jones J. (2008). "A meteoroid stream survey using the Canadian Meteor Orbit Radar". *Icarus*, **195**, 317–339.

Drummond J. D. (1981). "A test of comet and meteor shower associations". *Icarus*, **45**, 545–553.

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

Jenniskens P. (2006). Meteor Showers and their Parent Comets. ISBN 0521853494. Cambridge, UK: Cambridge University Press. Page 728.

Jenniskens P., Gural P. S., Grigsby B., Dynneson L., Koop M. and Holman D. (2011). "CAMS: Cameras for Allsky Meteor Surveillance to validate minor meteor showers". *Icarus*, **216**, 40–61.

Jenniskens P., Nénon Q., Albers J., Gural P. S., Haberman B., Holman D., Morales R., Grigsby B. J., Samuels D. and Johannink C. (2016). "The established meteor showers as observed by CAMS". *Icarus*, **266**, 331–354.

Jenniskens P., Baggaley J., Crumpton I., Aldous P., Pokorny P., Janches D., Gural P. S., Samuels D., Albers J., Howell A., Johannink C., Breukers M., Odeh M., Moskovitz N., Collison J. and Ganjuag S. (2018). "A survey of southern hemisphere meteor showers". *Planetary Space Science*, **154**, 21–29.

Jopek T. J. (1993). "Remarks on the meteor orbital similarity D-criterion". *Icarus*, **106**, 603–607.

Jopek T. J., Rudawska R. and Pretka-Ziomek H. (2006). "Calculation of the mean orbit of a meteoroid stream". *Monthly Notices of the Royal Astronomical Society*, **371**, 1367–1372.

Kashcheyev B. L. and Lebedinets V. N. (1967). "Radar studies of meteors". *Smithsonian Contributions to Astrophysics*, **11**, 183–199.

Kornoš L., Matlovič P., Rudawska R., Tóth J., Hajduková M. Jr., Koukal J. and Piffl R. (2014). "Confirmation and characterization of IAU temporary meteor showers in EDMOND database". In Jopek T. J., Rietmeijer F. J. M., Watanabe J., Williams I. P., editors, *Proceedings of the Meteoroids 2013 Conference*, Poznań, Poland, Aug. 26-30, 2013. A.M. University, pages 225–233.

Koseki M. (2016). "Research on the IAU meteor shower database". *WGN, Journal of the International Meteor Organization*, **44**, 151–169.

Koseki M. (2018). "Different definitions make a meteor shower distorted. The views from SonotaCo and CAMS". *WGN, Journal of the International Meteor Organization*, **46**, 119–135.

Lindblad B. A. (1990). "The orbit of the Eta Aquariid meteor stream". In, C. I. Lagerkvist, H. Rickman and B. A. Lindblad, editors, *Asteroids, comets, meteors III*, Proceedings of a meeting (AMC 89) held at the Astronomical Observatory of the Uppsala University, June 12-16, 1989, Uppsala: Universitet, pages 551–553.

Molau S. and Rendtel J. (2009). "A comprehensive list of meteor showers obtained from 10 years of observations with the IMO Video Meteor Network". *WGN, Journal of the International Meteor Organization*, **37**, 98–121.

Roggemans P., Johannink C. and Cambell-Burns P. (2019). "October Ursae Majorids (OCU#333)". *eMetN*, **4**, 55–64.

Rudawska R. and Jenniskens P. (2014). "New meteor showers identified in the CAMS and Sonotaco meteoroid orbit surveys". In Jopek T. J., Rietmeijer F. J. M., Watanabe J., Williams I. P., editors, *Proceedings of the Meteoroids 2013 Conference*, Poznań, Poland, Aug. 26-30, 2013. A.M. University, pages 217–224.

Sekanina Z. (1976). "Statistical model of meteor streams. IV. A study of radio streams from the synoptic year". *Icarus*, **27**, 265–321.

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

Southworth R. R. and Hawkins G. S. (1963). "Statistics of meteor streams". *Smithson. Contrib. Astrophys.*, **7**, 261–286.

Visual meteor observations and All-sky camera results for October and November 2018

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An overview is given of the author's observations during October and November 2018.

1 Introduction

After the successful Draconid observations (Miskotte, 2019) the moderate weather permitted me to observe sporadically during October and early November. There were quite a few clear nights, but often there were too many cirrus clouds. I give an overview of my observations.

2 October 10–11, 2018

Figure 1 – A nice capture: a sporadic fireball of magnitude –6 on October 10, 2018 at 21^{h}14^{m}15^s UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 12 breaks per second. Many all sky- , FRIPON- and CAMS stations captured this event.

This was a nice session from the flat roof of my dormer. I could observe between 23^{h}40^m and 2^{h}40^m UT. I stopped because I had to go to work. The transparency was good, but the sky background was rather light, which resulted in slightly lower SQMs as usual around 20.12. The *lm* was good with a 6.3. During 3.00 hours of effective observation time I counted 6 ORI, 5 DAU, 6 STA, 5 NTA and 3 EGE. Some nice appearances:

- 01^{h}07^m UT: a magnitude +1 SPO with persistent train in Pegasus, it could possibly have been an October Ursa Majorid.
- 01^{h}28^m UT: a very beautiful and very slow yellow magnitude 0 sporadic meteor in Perseus with a long wake of a half degree.
- 02^{h}37^m UT: a magnitude +1 EGE seen in Monoceros.

Figure 2 – Bright sporadic meteor in Ursa Major recorded on October 12, 2018 at 23^{h}06^m UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 12 breaks per second.

3 October 13–14, 2018

Because of incoming cirrus, a short session between 00^{h}57^m and 01^{h}59^m UT. *Lm* 6.2 and a cloud coverage of *F* 1.12 yielded 12 meteors of which 2 are ORI, 1 STA and 1 NTA.

4 October 18–19, 2018

This session was also short because of cirrus clouds. I counted 4 ORI, 1 STA, 1 DAU and 5 SPO for 1 hour effective with a limiting magnitude of 6.1 (SQM 20.11).

5 October 19–20, 2018

Again, a short session due to cirrus. Between 00^h15^m and 01^h25^m I observed during 1.133 hours effectively 6 ORI, 2 STA, 1 NTA, 1 DAU and 9 SPO.

6 November 3–4, 2018

This night I enjoyed a nice visual session at the Groevenbeekse Heide (a heath field) near Ermelo. The nights 2–3 and 3–4 November were expected to be clear according to the Dutch Meteorological Institute. The first night I skipped because of a bad cold. And looking back on images from the all sky camera it also turned out that there was a lot of cirrus most of the time. Only two periods of just one hour were completely cloudless.

The night 3–4 November was much better. Fortunately, the cold was already getting better and I went for a session in the early morning. The Moon would rise after an hour, but it did not disturb too much the observations anymore.

Clock alarm went off at 1^h10^m UT, all the observational stuff loaded on the bike and a last sat24 check. Ok… I see a large patch of cirrus appearing above the province of Zeeland and it is moving very quickly northwards. I hope it stays away from my location during the session. When I arrived at the Groevenbeekse Heide a lot of cirrus was visible low in the southwest. The rest of the sky was very clear. At 1^h36^m UT the observations started, SQM 20.40 and *lm* 6.4. In the second hour some patches of very thin cirrus were passing through my field of view. During the third hour the cirrus disappeared. At that moment I also had to take a break to reposition myself to keep the rising Moon out of the field of view.

All in all, a very nice session: between 1^h36^m and 4^h37^m UT I counted during 3.00 hours (*lm* decreasing from 6.4 to 6.2) 2 STA, 6 NTA, 9 ORI, 1 LEO and 30 SPO, in total 48 meteors. Two beautiful Taurids were seen: a magnitude 0 and –2. The ISS was also seen near the Moon (a second passage at dusk was beautifully captured by the all sky camera) and a particularly bright satellite with a flare of –7 in the constellation of Taurus at 4^h34^m UT.

7 All sky camera EN-98 in October

The all sky camera also scored quite well in October 2018 with very nice captures on 8, 10 and 14 October. The re-entry burn of a Space-X rocket was also recorded.

Figure 3 – Possible Taurid on October 7, 2018 at $23^h57^m17^s$ UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 12 breaks per second.

Figure 4 – The beautiful magnitude –6 sporadic fireball of 8 October at $00^h30^m34^s$ UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 12 breaks per second.

Figure 5 – Re-entry burn of the Falcon-9 rocket from Space-X on October, 2018. It is visible as a blue glow in north-eastern direction. The image is a stack of 4 images that were obtained between $03^h39^m30^s$ and $03^h45^m28^s$ UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens.

References

Miskotte Koen (2019). "The outburst of the Draconid meteor shower in 2018: an analysis". *eMetN*, **4**, 74–78.

Finally, good weather conditions in the Netherlands during the Leonids 2018!

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An overview is given of the author's observations during the Leonids 2018.

1 Introduction

It was already 11 years ago (2007) when I had clear and stable weather around a Leonid maximum! The grumbling of me in the Orionid report 2017 in *eRadiant* ("Where are the Scandinavian high-pressure areas?") did apparently help as since April it has been a coming and going of high-pressure areas above Northern Europe, resulting in good weather conditions throughout 2018.

As early as around November 10, there were signs that the weather in the Netherlands between 15 and 19 November would be very favorable for visual observations. Well, it didn't quite work out that way, but hey, I could observe three nights in a row!

2 November 15–16, 2018

I had to work on Friday, so I planned a session a little earlier in the night than usual. Observations were done from the "meteor-observatory platform" on the dormer of my roof. There I could observe between 23^{h}50^m and 02^{h}50^m UT. In the second and third hours, the sky got a bit hazy, resulting in lower *lm* (6.3 to 6.0) and SQMs (20.18 to 20.06). On the images recorded by the all-sky camera that night, it was clearly visible that haze and fog increased after 02^{h}50^m UT and after 4^{h}00^m UT the sky was completely clouded out.

But what a nice session: many meteors and a lot of bright ones. In total I counted in t_{eff}. 3.00 hours effectively 45 meteors amongst them 4 Leonids and 11 Taurids.

The most spectacular meteors:

- 00^{h}32^m UT: orange magnitude –1 Taurid with –2 end flare in Monoceros. Captured with the all-sky camera.
- 00^{h}50^m UT: the first meteor after this time is a very slow meteor of magnitude +3 straight through Perseus. The meteor also shows a wake. Coming roughly from in the northern Pisces and Andromeda area. Would it have been an Andromedid?
- 01^{h}03^m UT: –1 SPO with 3 seconds persistent train moving from Taurus to Cetus. I classified the meteor as a Leonid, but from CAMS observations it turned out to be a sporadic meteor. The radiant was located in the northern part of Hydra and is therefore also in line with the Leonid radiant. The all sky camera also caught this meteor.
- 01^{h}33^m UT: –1 sporadic meteor in Eridanus to Orion
- 02^{h}11^m UT: a brilliant –3 Taurid which moved nice and steady through Perseus. Also captured with the all sky camera.
- 02^{h}37^m UT: +1 Taurid from Taurus to Cetus.

Figure 1 – Crop of an all sky image with a Taurid of magnitude –2 or –3 in Perseus on November 16, 2018 at 02^{h}11^m UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set to 14 breaks per second.

3 November 16–17, 2018

Fortunately, I had a lot of overtime at work and when on Wednesday a clear night for 16–17 November was expected, I took a day off on Saturday morning November 17. So, I could observe nicely until the morning twilight (otherwise I had to stop at 02^{h}50^m UT). In the afternoon the sky cleared up more and more, although there was a bit of haze the first hours. But after a short sleep in the evening, the sky turned out to be pretty clear! I quickly cycled to the Groevenbeekse Heide (a heath field) and at 01^{h}10^m UT the observations started. The SQM was 20.43 at 1^h43^m UT but rose a bit further to a nice 20.48. Not a top sky (I have ever reached 20.62 at this location), but very good. Of course, and as expected, this night gave nice numbers of meteors and again some bright ones too.

I could observe between 01^h10^m and 05^h30^m UT. There was a weak eastern wind which decreased over the period. The last hour there was some very thin haze that appeared above the heath. *Lm* first was 6.4 and the last hour 6.3. In total I counted in effectively 4.22 hours 82 meteors including a disappointing number of only 13 Leonids, 11 Taurids and 2 AMOs. Another very slow meteor was seen of +2 with a long wake, again from the surroundings of the Northern part of Pisces and Andromeda. As said, the numbers of Leonids were disappointing with hourly counts of respectively 2, 2, 3 and 6.

The bright meteors:

- 01^h26^m UT: the session only lasted 16 minutes when a nice –4 Leonid appeared in Gemini with a persistent train of 6 seconds. The meteor was also beautifully captured with the all-sky camera.
- 02^h11^m UT: WOW, a beautiful Taurid with three short flares at the end. I estimated the brightest flare at magnitude –4. This meteor was also beautifully recorded with the all sky camera.
- 03^h20^m UT: a beautiful orange 0 Taurid moved just under the star Betelgeuse.

In addition to the meteors mentioned, a few +1 Leonids were also seen. The temperature decreased during this session from –1 to –3 degrees Celsius at ground level. A very successful session!

Figure 2 – Leonid of magnitude –4 in Gemini on November 17, 2018 at 01^h26^m UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 30 breaks per second.

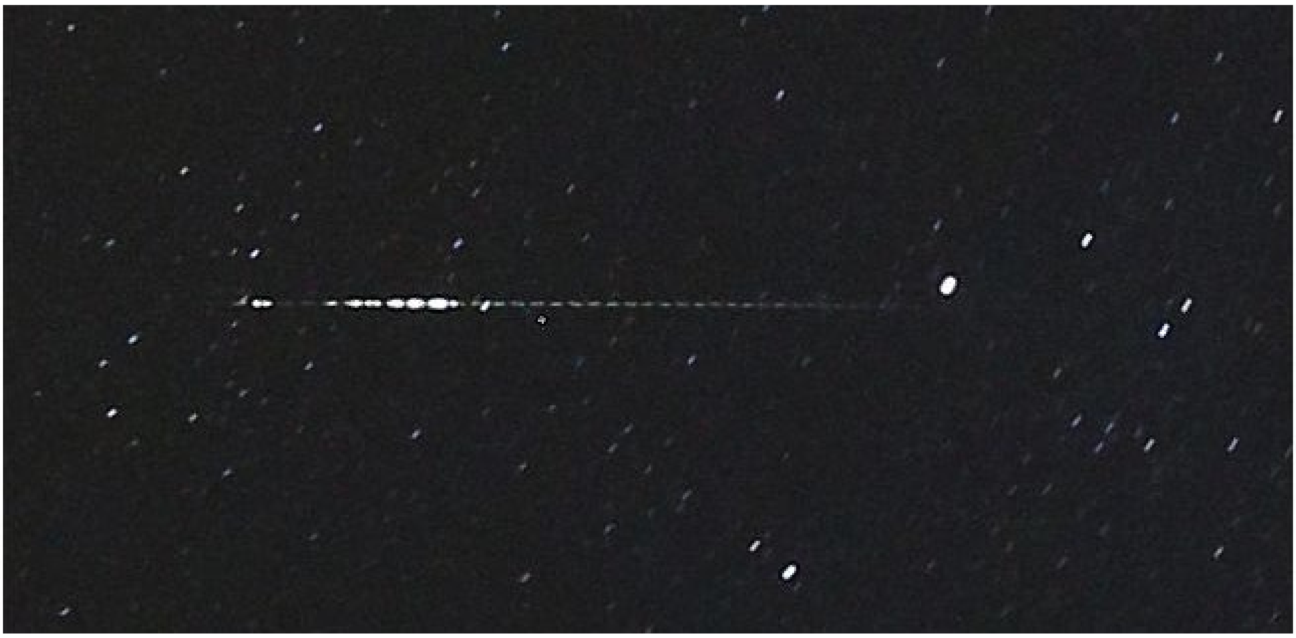

Figure 3 – Beautiful Taurid with multiple flares up to magnitude –4 on November 17, 2018 at 02^h11^m UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 30 breaks per second.

4 November 17–18, 2018

After the successful previous night, we got a third night on a row with a clear sky! There was a fast-eastern wind blowing so it would be a very cold session. The maximum of the Leonids was expected in the evening of 17 November. I started my observations at 00^h48^m UT and I managed to observe until 05^h37^m UT. There was a crystal-clear sky during the first three hours with the *lm* around 6.4 and SQM touching 20.53! However, during the fourth period there was very thin cirrus moving in from the east which caused the *lm* to drop slightly. That did not much affect the night sky. But during the last period 04^h54^m to 05^h37^m UT, more thick cirrus moved in from the northeast. The cirrus caused the *lm* to drop to an average of 6.1 and the sky obstruction *F* was 1.18.

In total I counted in 4.72 hours of effective time exactly 100 meteors, of which 35 were Leonids, 11 Taurids and 4 alpha Monocerotids. The Taurids only showed weak meteors this night. The bright meteors:

- After a few +1, +2 Leonids the first real beautiful meteor was seen at 02^h56^m UT: a 0 magnitude Leonid in the north.
- 03^h46^m UT: a –2 Leonid moving from Gemini to Orion. This meteor was also observed by Michel Vandeputte from Ronse, Belgium.
- 05^h13^m UT: a nice –1 Leonid in Virgo, persistent train 3 seconds.

All in all, fewer spectacular meteors than in the previous night, but definitely a successful session. The temperatures dropped from –2 to –5 degrees Celsius with a moderate eastern wind.

The night 18–19 November was cloudy from 20^h00^m UT in Ermelo. That is very unfortunate because quite a few bright meteors and fireballs were reported this night (visually by Michel Vandeputte and by Felix Verbelen via radio). But, all in all, I am very satisfied and happy with the result! For the first time since 2007, I could observe a lot again during the Leonids. Hopefully I do not have to wait another 11 years.

5 All-sky camera EN-98 in November 2018.

The all sky camera also scored extremely well in November, not less than 19 meteors were recorded. The best hits were a slow –6 sporadic meteor on 6 November, a –6 Leonid on 20 November and a sporadic fireball on 30 November.

Figure 4 – Leonid fireball of magnitude –6 moving from Perseus to Triangulum on November 20, 2018 at $01^h45^m18^s$ UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 30 breaks per second.

Figure 5 – The beautiful sporadic fireball of November 30, 2018 at 23^h35^m UT moving from Cancer to Hydra. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter was set at 10 breaks per second.

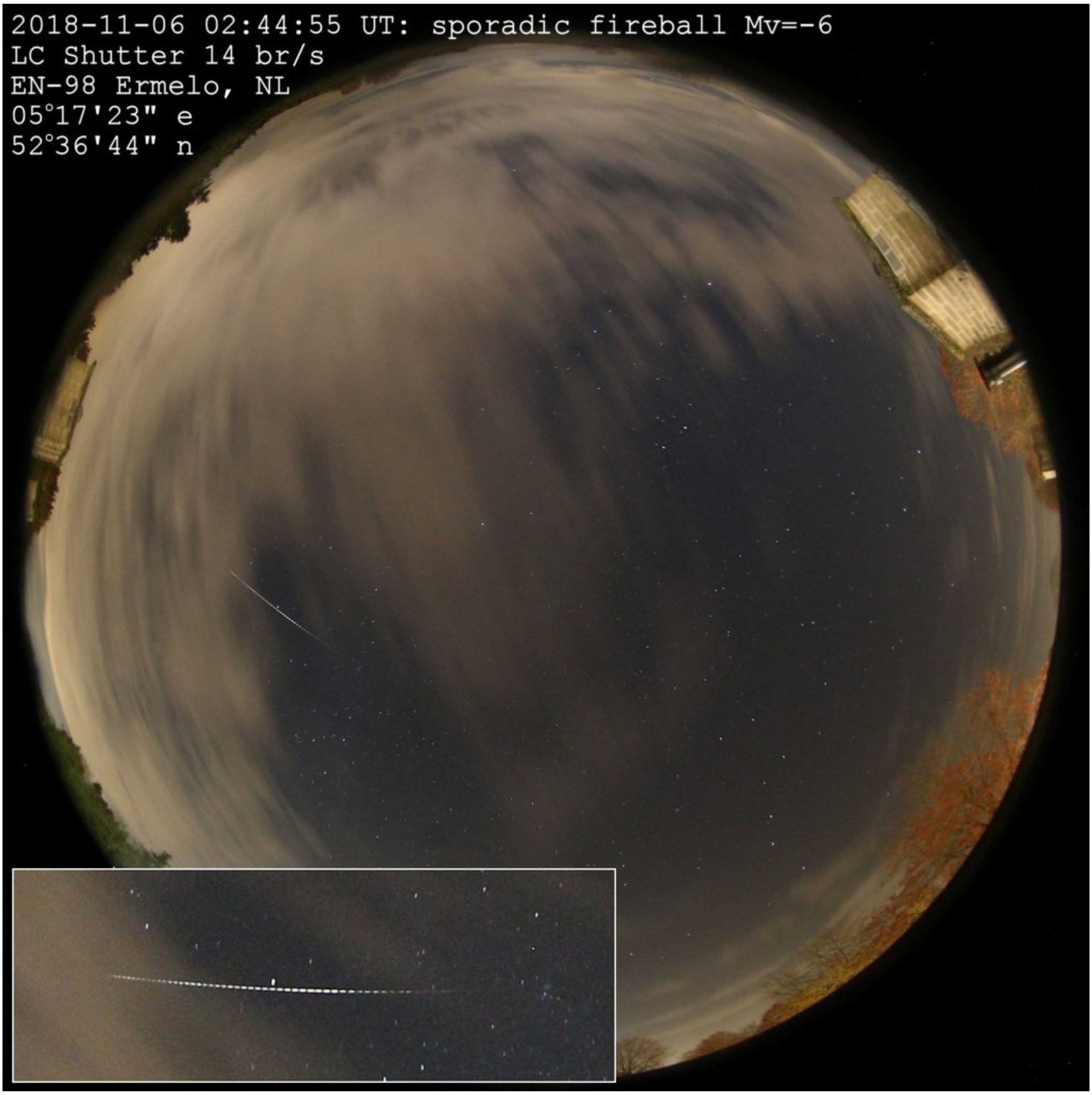

Figure 6 – Slow sporadic meteor on 6 November 2018 at $02^h44^m55^s$ UT. Camera: Canon 6D. Lens: Sigma 8 mm F 3.5 fish eye lens. The Liquid Crystal Shutter set at 14 breaks per second.

Visual observations April 6–7 from Norway Looking for Zeta Cygnids

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A report is presented on the visual observations during the night April 6-7 to observe possible Zeta Cygnids. Few candidate Zeta Cygnids were noticed.

1 Introduction

On the night between April 6 and April 7, I made visual observations from my home place Brokerudshagen in Norway. This was my first visual observation since January, due to a lot of snow and bad weather. I was therefore eager to see what the night would bring, when I walked out the door at 22^h00^m UT. The sky was clear and transparent, and I looked forward to see if I could spot any activity from the Zeta Cygnids, a minor shower listed with a maximum on April 6 in Robert Lunsford's "*Meteor Activity Outlook for 6-12 April 2019*". During 3 hours of observation I saw 21 Sporadic meteors, 2 Zeta Cygnids, and 1 Antihelion meteor. 6 meteors were also captured with my Nikon D3100 camera with a Samyang 16mm, F 2.0 lens. Details of the observation is presented below.

2 22^h30^m – 23^h30^m UT

T_{eff}: 1.00, *F*: 1.00, *Lm*: 6.11, RA: 255, Dec: +65

- Spo: +1(1), +2(2), +3(1), +5(1), +6(1) – A total of 6 meteors.
- Ant: +3(1) – A total of 1 meteor.
- Zcy: 0 meteors.

The observing session started out with a faint +6-mag sporadic meteor in Draco, followed up by a +5-mag in Ursa Minor 9 minutes later. At 22^h50^m UT the first bright meteor appeared in Draco, a second magnitude, slow moving, white sporadic meteor right in the middle of my camera field. 4 minutes later a +3-mag, reddish, medium- to slow moving Antihelion meteor was also captured by camera in the constellation of Corona Borealis. The next half hour produced another +2-mag and +3-mag sporadic, bringing the total number of meteors the first hour to seven.

3 23^h30^m – 00^h35^m UT

T_{eff}: 1,03, *F*: 1.00, *Lm*: 6.19, RA: 255, Dec: +65

- Spo: +2(2), +3(2), +4(3), +5(1) – A total of 8 meteors.
- Ant: 0 meteors
- Zcy: +4(1) – A total of 1 meteor.

The next hour started good, with 3 sporadic meteors of mag +2, +4, and +5, the first fifteen minutes. Then a dull period of almost 20 minutes, before a nice +2-mag sporadic streaked the sky near Albireo in Cygnus. At first, I thought I may have seen my first Zeta Cygnid but being in the outskirts of my field of view, I was a bit uncertain with the radiant line-up, and chose to note it as a sporadic. Checking the camera, the next day, that proved to be a right decision. After yet 3 more sporadic meteors, my first real candidate to be a Zeta Cygnid, came 00^h28^m UT. This +4-mag meteor in Draco lined perfectly up with the radiant, and both velocity and length seemed just right in the distance it appeared from the radiant! After another sporadic meteor, the hour ended with a total of 8 sporadics and 1 Zeta Cygnid.

4 00^h35^m – 01^h40^m UT

T_{eff}: 1.03, *F*: 1.00, *Lm*: 6.19, RA: 270, Dec: +55

- Spo: 0(1), +1(1), +3(3), +4(2) – A total of 7 meteors.
- Ant: 0 meteors.
- Zcy: +5(1) – A total of 1 meteor.

The last hour started with a beautiful, reddish, and very slow-moving meteor in Virgo. Then two more sporadics of mag +3 and +4, before my next likely Zeta Cygnid candidate appeared at 01^h08^m UT. This +5-mag meteor was very similar to the first Zeta Cygnid, right in the center of my field of view, and just the right velocity and length to be regarded as such. Three minutes later a nice +1-mag sporadic seemed to flash out from the star Deneb towards the horizon. This one made a nice photo, being reddish in color, and with a visible flash at the end of the flight. Three more sporadic meteors were seen the next half hour, one of them being a possible April Lambda Ophiuchid (ALO) but noted in the observation as a sporadic. Observation ended 01^h40^m, after a successful 3-hour session under a clear and transparent April sky.

Observations May 2019

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An overview is given of the 2019 May meteor observations by the author, covering the Eta Aquariid meteor showers.

1 Observations 4–5 May

I enjoyed two beautiful nights of observing the Eta Aquariids (ETA) meteor shower near its peak activity, this past weekend, during the last two hours towards dawn. From my location near Ottawa (Ontario), my latitude is 45 degrees, so I typically get to see just a few of these meteors but these can appear as colorful earth grazers.

In two hours (May 4–5, 06^h51^m-08^h51^m UT), I saw 9 ETA (just one in the first hour, but as many as 8 during the second hour). It appeared that a peak was occurring as bright morning twilight was starting. The brightest ETA, at 4^h41^mam (local time) was a mag –2 with a one second train near the zenith. I also saw two possible Eta Lyrids.

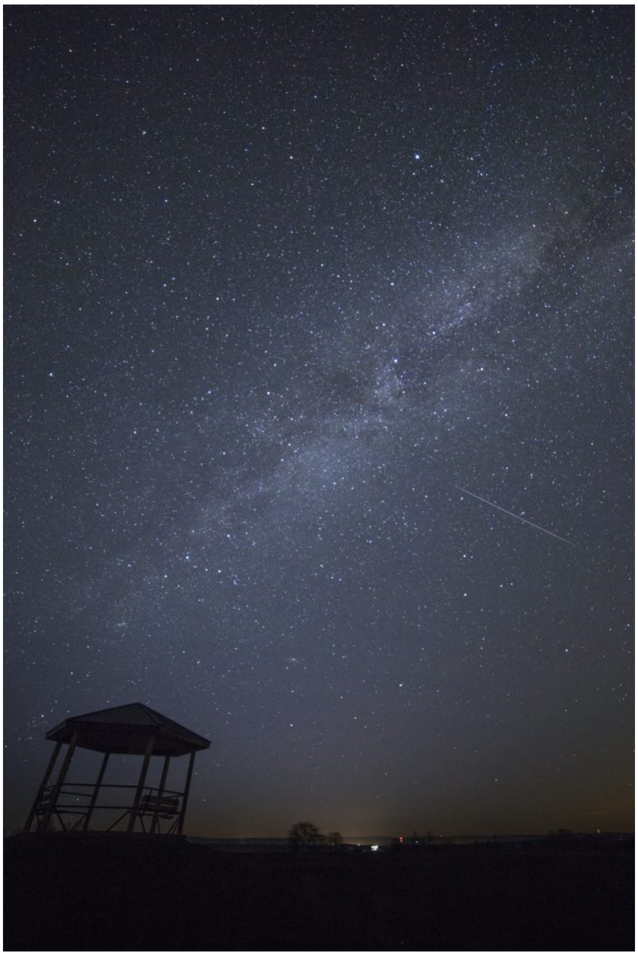

Figure 1 – Eta Aquariid meteor and Milky Way above Westmeath Lookout, Whitewater Region, Ontario. Morning of May 5, 2019. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens.

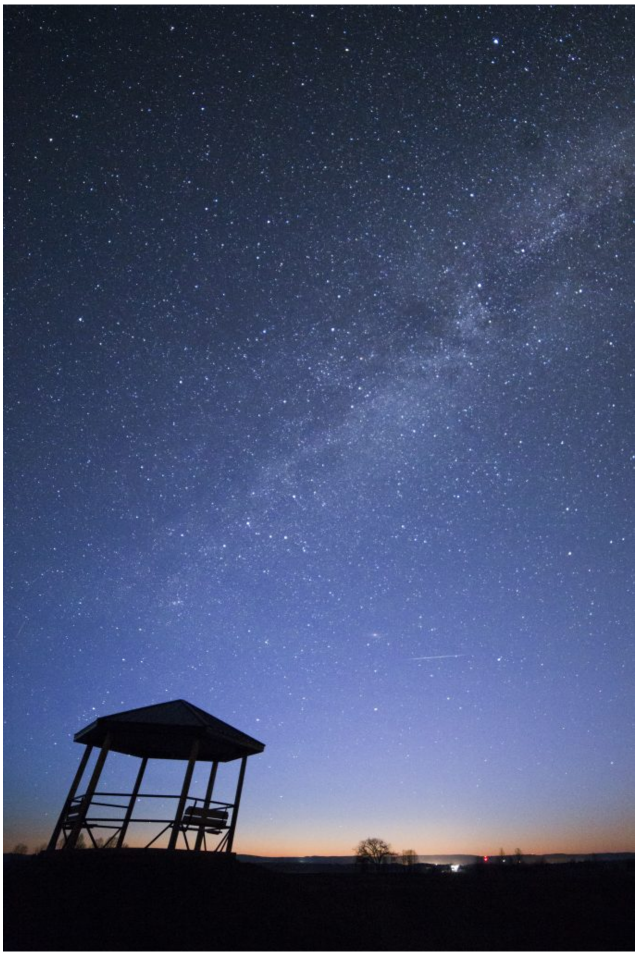

Figure 2 – Eta Aquariid meteor near the Andromeda galaxy. Westmeath Lookout, Whitewater Region, Ontario. Morning of May 5, 2019. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens.

May 4–5 2019, 06^h51^m-08^h51^m UT (02^h51^m-04^h51^m EDT) Location: Westmeath Lookout, Ontario, Canada, (76.859 W 45.793 N).

Observed showers:

- Antihelion (ANT) – 15^h48^m (237) -20
- eta Lyrids (ELY) – 19^h04^m (286) +43
- eta Aquariids (ETA) – 22^h25^m (336) -02

06^h51^m-07^h51^m UT (02^h51^m-03^h51^m EDT); clear; 3/5 trans; *F* 1.00; *lm* 6.30; facing SE50 deg; t_{eff} 1.00 hr, temp +3C

- ANT: two: +3; +4
- ELY: two: +2; +5

- ETA: one: +4
- Sporadics: two: +1; +3
- Total meteors: Seven

07^{h}51^m-08^{h}51^m UT (03^{h}51^m-04^{h}51^m EDT); clear; 3/5 trans; *F* 1.00; *lm* 5.78; facing SE65 deg; t_{eff} 1.00 hr, temp +1C

- ETA: eight: –2; 0(2); +1; +3(2); +4; +5
- ELY: one: +4
- Sporadics: two: +3; +4
- Total meteors: Eleven.

Figure 3 – This bright sporadic meteor was captured only a few minutes before sunrise! Westmeath Lookout, Whitewater Region, Ontario. Morning of May 5, 2019. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens.

2 Observations 5–6 May

On the following morning (May 6), I observed for two hours under a crystal-clear sky. It was a comfortable night with only the sound of spring peeper frogs and nocturnal birds! The Eta Aquariids (ETA) seemed a bit less active with 5 seen. The first ETA was an impressive 50 degrees long earth grazer that moved horizontally near the tree line through the Milky Way and below Jupiter. The brightest was a mag –2 ETA at 4^{h}11^m am (local time) — a gorgeous yellow-green meteor that had a 30 degrees path and left a 3 sec train! The Eta Lyrids (ELY) were again active in small numbers along with the Antihelion source. The highlight was the appearance of the International Space Station (ISS) with SpaceX Dragon resupply spacecraft. Both objects were seen flying in close formation just hours before docking!

Figure 4 – Bright sporadic meteor passes below Jupiter. Morning of May 6, 2019. Stewartville, Ontario. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens. By Pierre Martin.

May 5–6 2019, 06^{h}54^m-08^{h}52^m UT (02^{h}54^m-04^{h}52^m EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (45°23'N 76°29'W).

Observed showers:

- Antihelion (ANT) – 15^{h}48^m (237) -20
- eta Lyrids (ELY) – 19^{h}04^m (286) +43
- eta Aquariids (ETA) – 22^{h}25^m (336) -02

06^{h}54^m-07^{h}54^m UT (02^{h}54^m-03^{h}54^m EDT); clear; 3/5 trans; *F* 1.00; *lm* 6.30; facing SE50 deg; t_{eff} 1.00 hr, temp +8C

- ETA: two: +1; +5
- ANT: two: +2; +4
- ELY: two: +3; +5
- Sporadics: four: +3(2); +4(2)
- Total meteors: Ten

07^{h}54^m-08^{h}52^m UT (03^{h}54^m-04^{h}52^m EDT); clear; 3/5 trans; *F* 1.00; *lm* 5.75; facing SE65 deg; t_{eff} 0.97 hr, temp +6C

- ETA: three: –2; +3; +4
- ANT: one: -2
- ELY: one: +4
- Sporadics: none
- Total meteors: Five

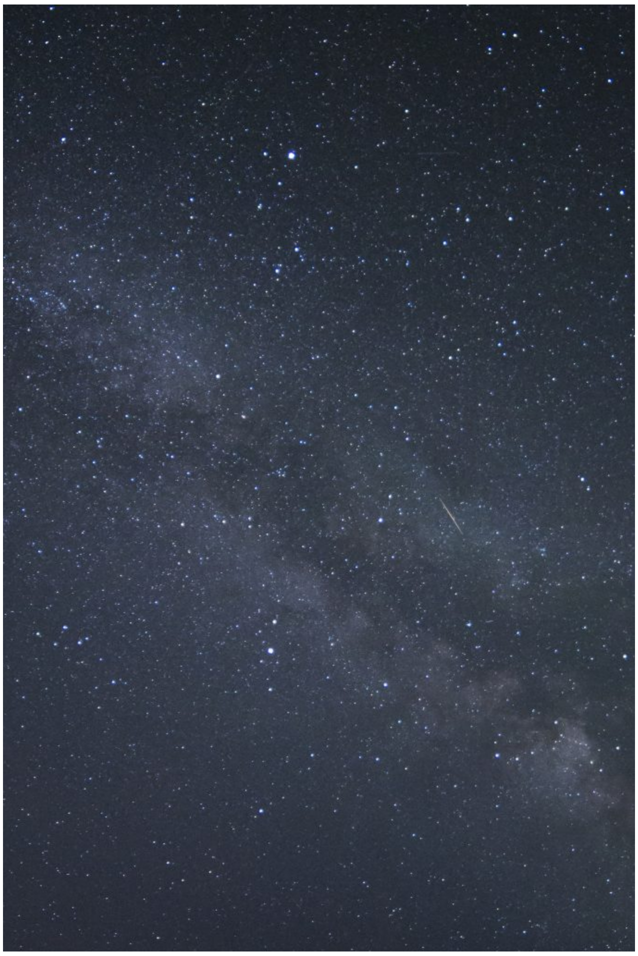

Figure 5 – Possible Eta Lyrid meteor. Morning of May 6, 2019. Stewartville, Ontario. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens. By Pierre Martin.

Figure 6 – Bright Eta Aquariid meteor shooting up in the morning twilight into the "Summer Triangle"! Morning of May 6, 2019. Stewartville, Ontario. Photographed with a Canon 6D (15 sec exposure, ISO 3200) and Rokinon 14mm f/2.8 lens. The halos around stars are due to the lens starting to fog up. By Pierre Martin.

Radio meteors February 2019

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

1 Introduction

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

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

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

As expected, the meteor activity was fairly calm during this month. No echoes longer than 1 minute were observed. There were few local interferences, no registered "sporadic E" (Es) nor lightning activity.

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

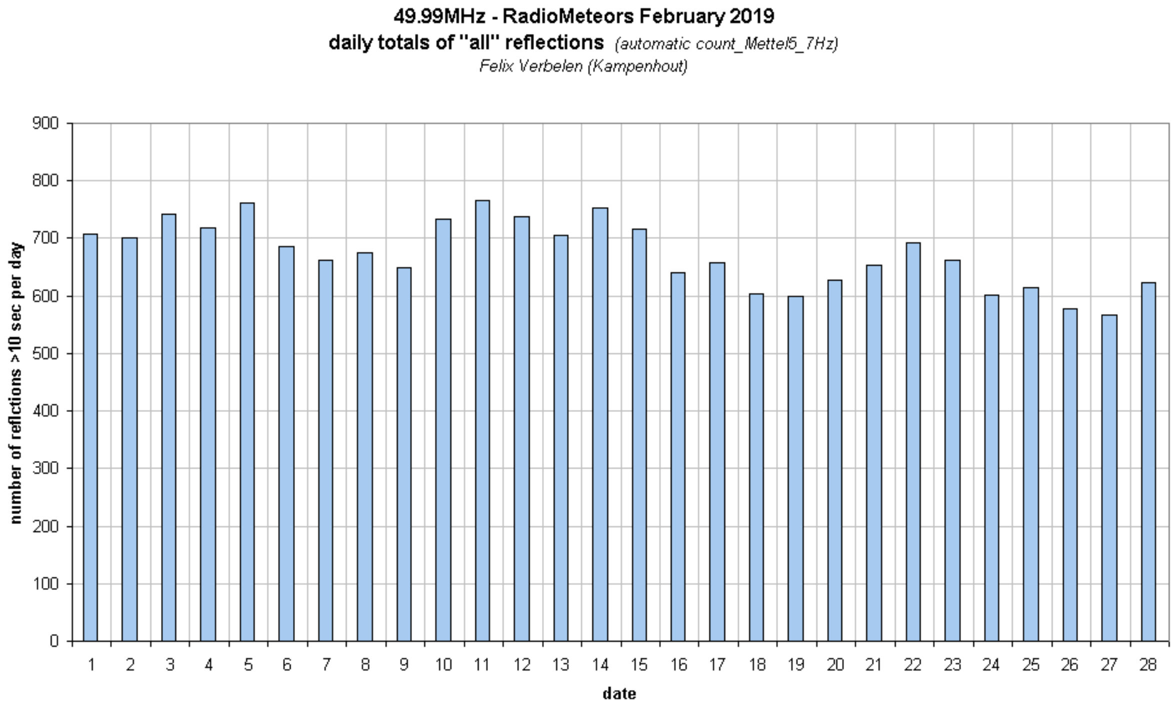
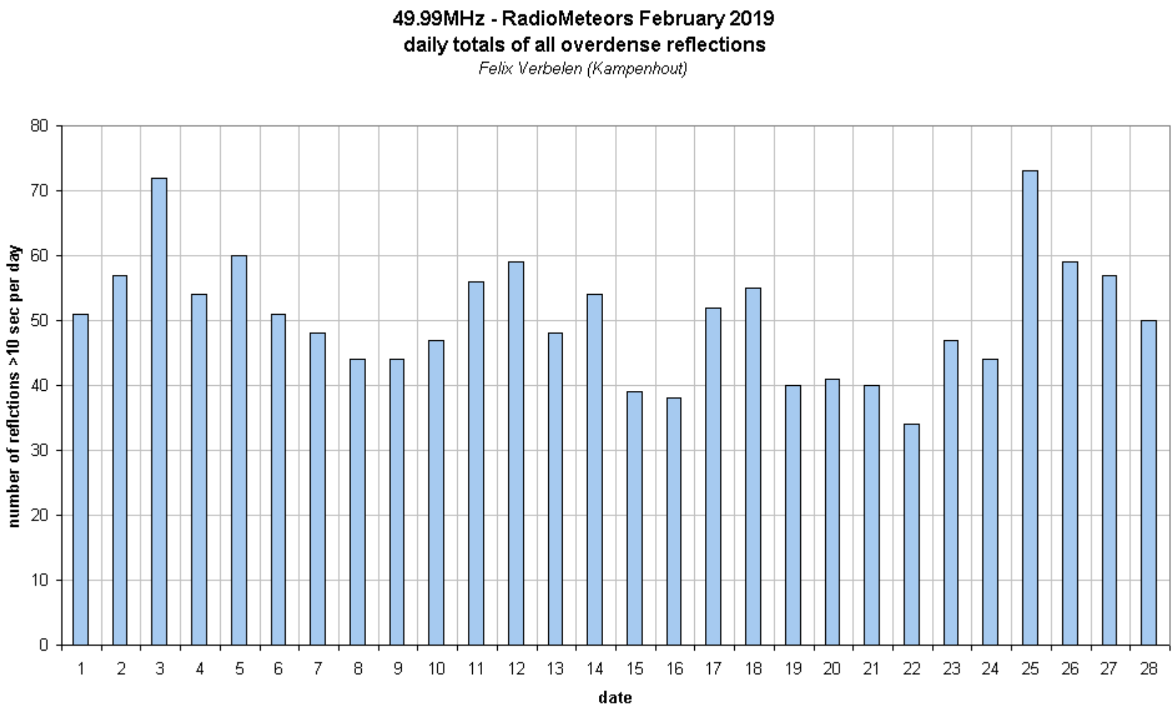


Figure 1 – The daily totals of "all" reflections counted automatically, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during February 2019.



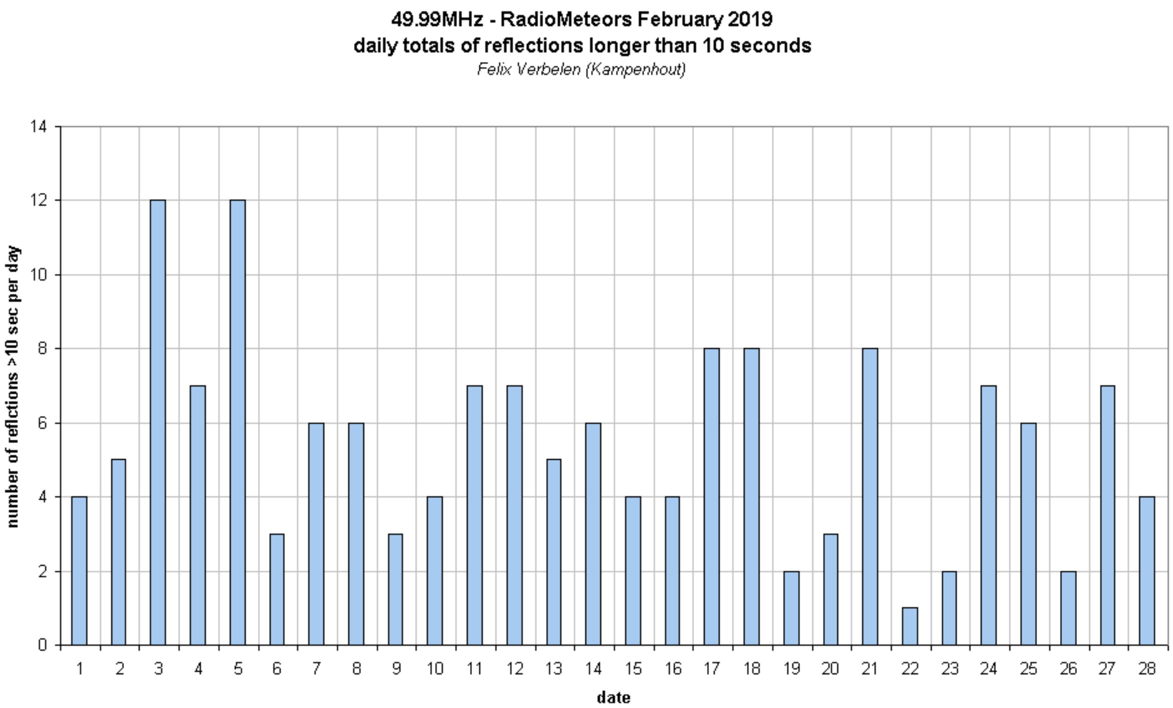
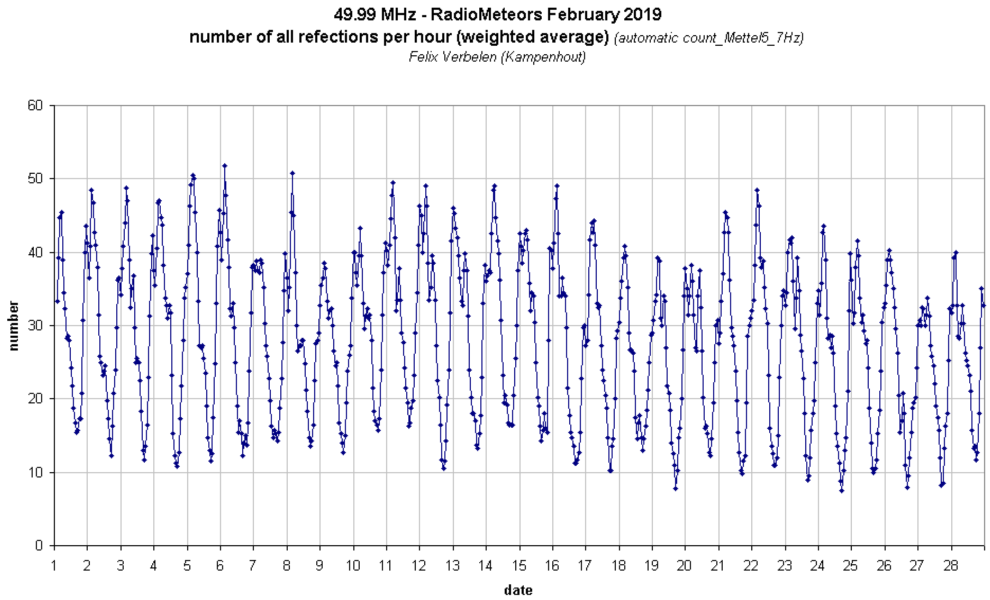
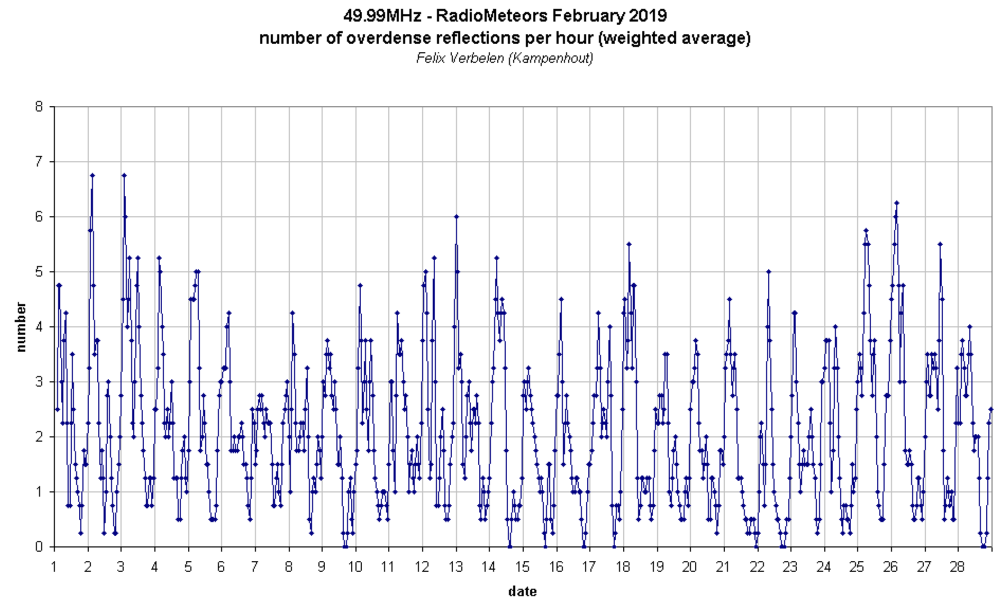


Figure 2 – The daily totals of manually counted “overdense” reflections, and daily totals of overdense reflections longer than 10 seconds as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during February 2019.





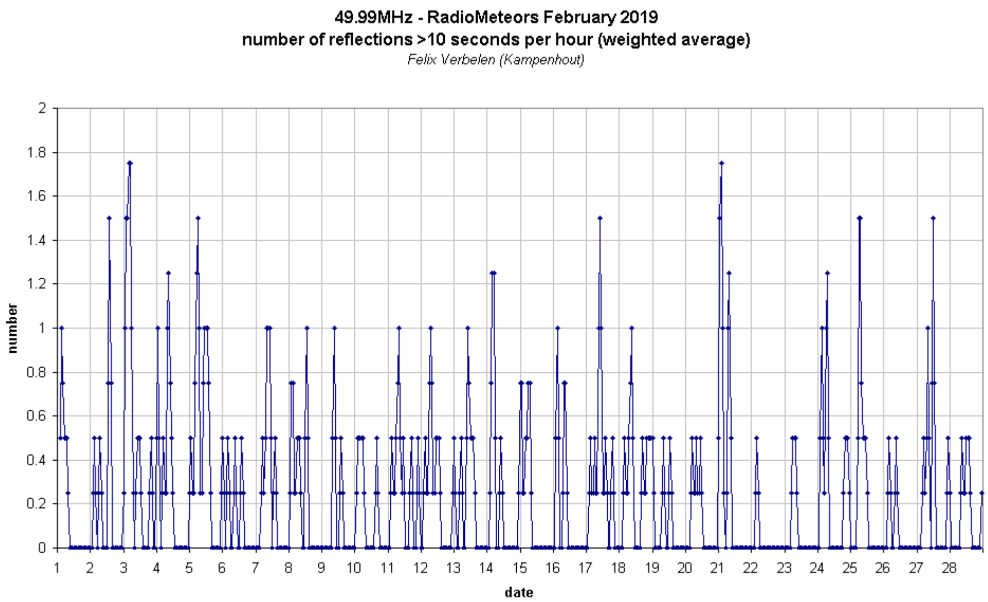


Figure 3 – The hourly numbers of "all" reflections counted automatically, and of manually counted "overdense" reflections and overdense reflections longer than 10 seconds, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during February 2019.

Radio meteors March 2019

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

1 Introduction

The graphs show both the daily totals (*Figures 5 and 6*) and the hourly numbers (*Figure 7 and 8*) of "all" reflections counted automatically, and of manually counted "overdense" reflections and overdense reflections longer than 10 seconds, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during March 2019.

Unfortunately, data are missing for several days, due to technical problems (see *Figures 5–8*). During this month there were few local disturbances and no registered "sporadic E" (Es), but lightning activity was noted on 5 days (7+10+11+13+17[th] of March).

As expected, the meteor activity was fairly low, but nevertheless a number of nice smaller meteor showers (to be analyzed in detail).

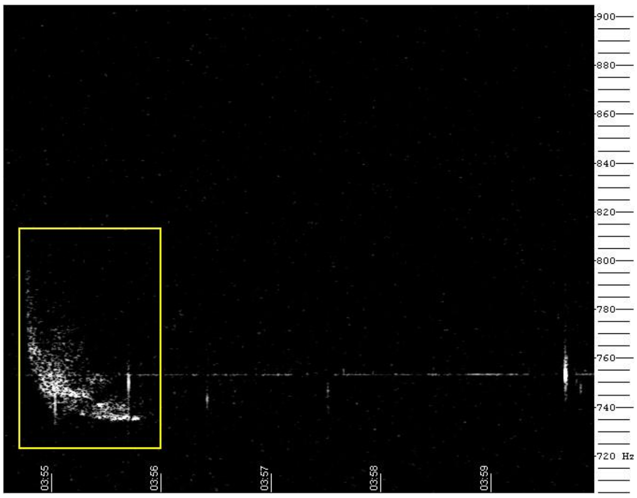


Figure 1 – 4 March 2019, 04^h00^m UT.

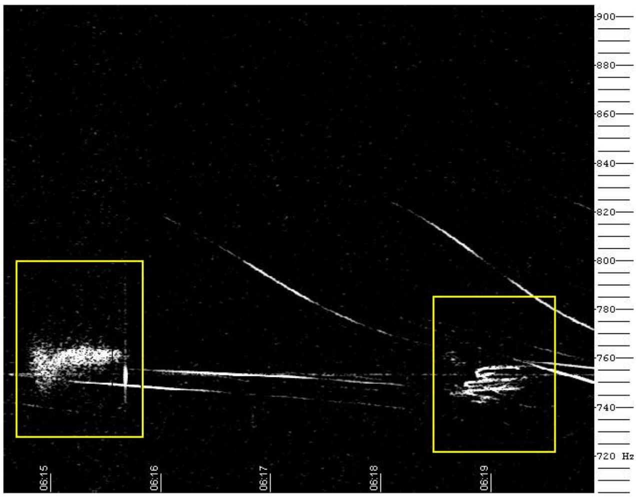


Figure 2 – 4 March 2019, 06^h20^m UT.

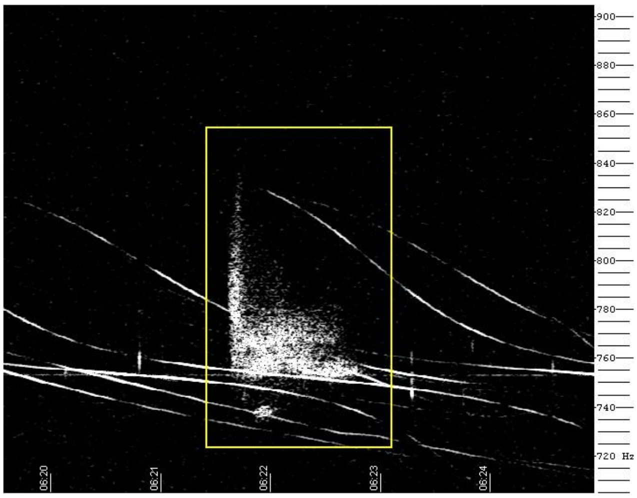


Figure 3 – 4 March 2019, 06^h20^m UT.

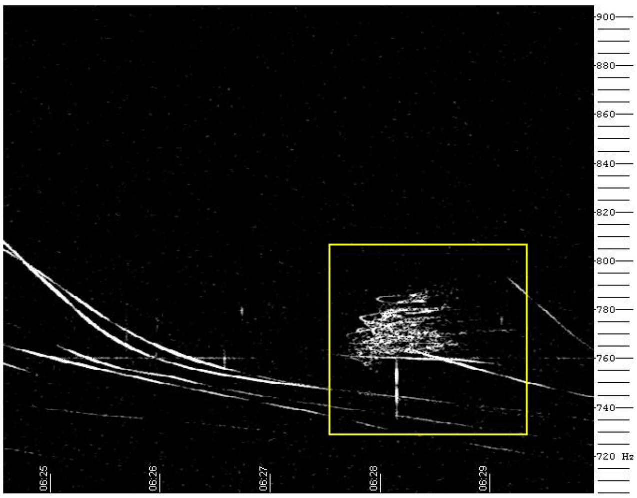
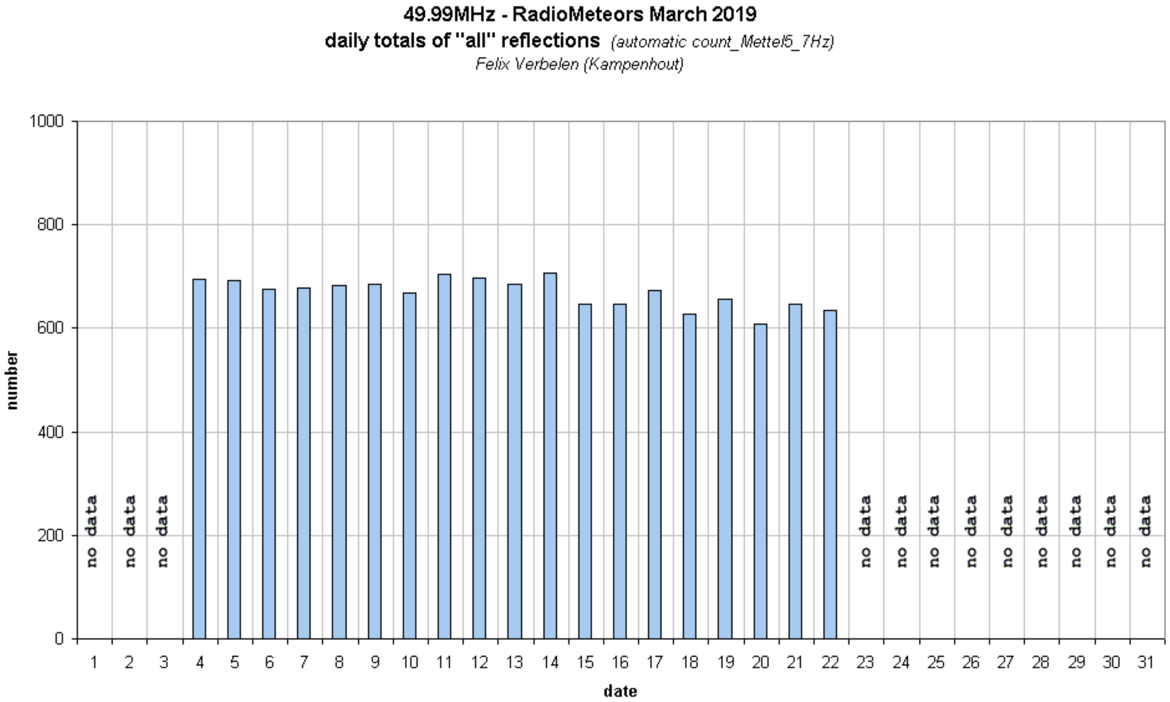


Figure 4 – 4 March 2019, 06^h30^m UT.

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

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

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



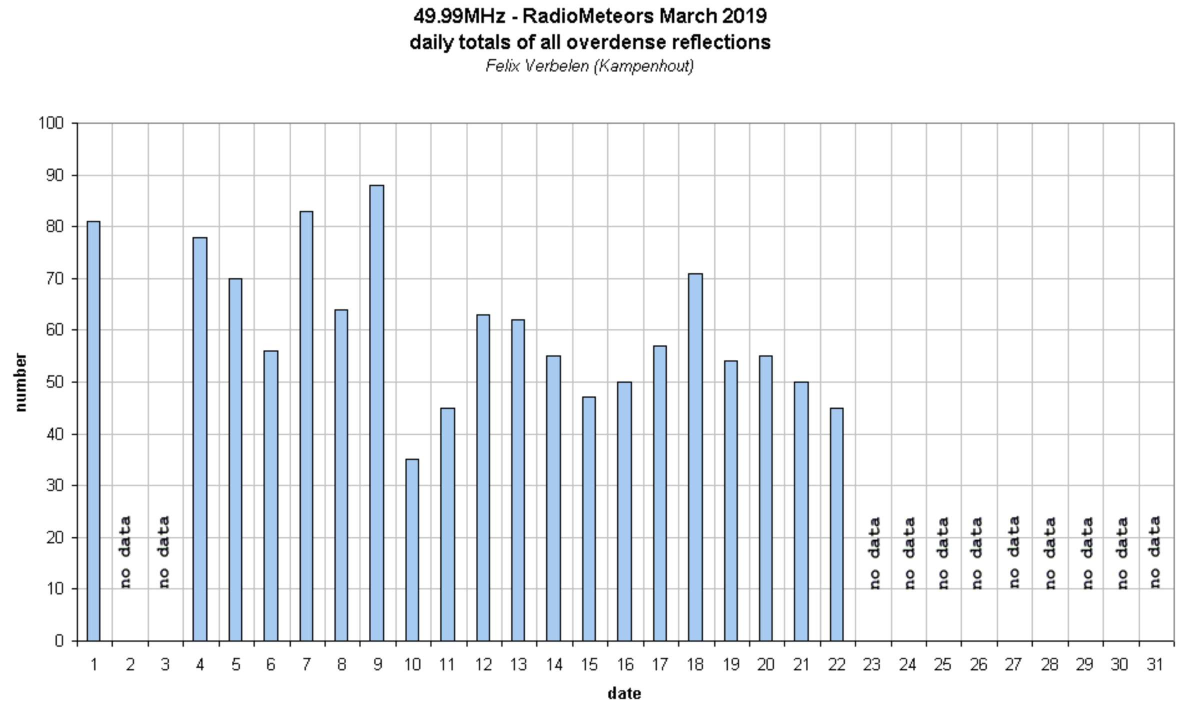
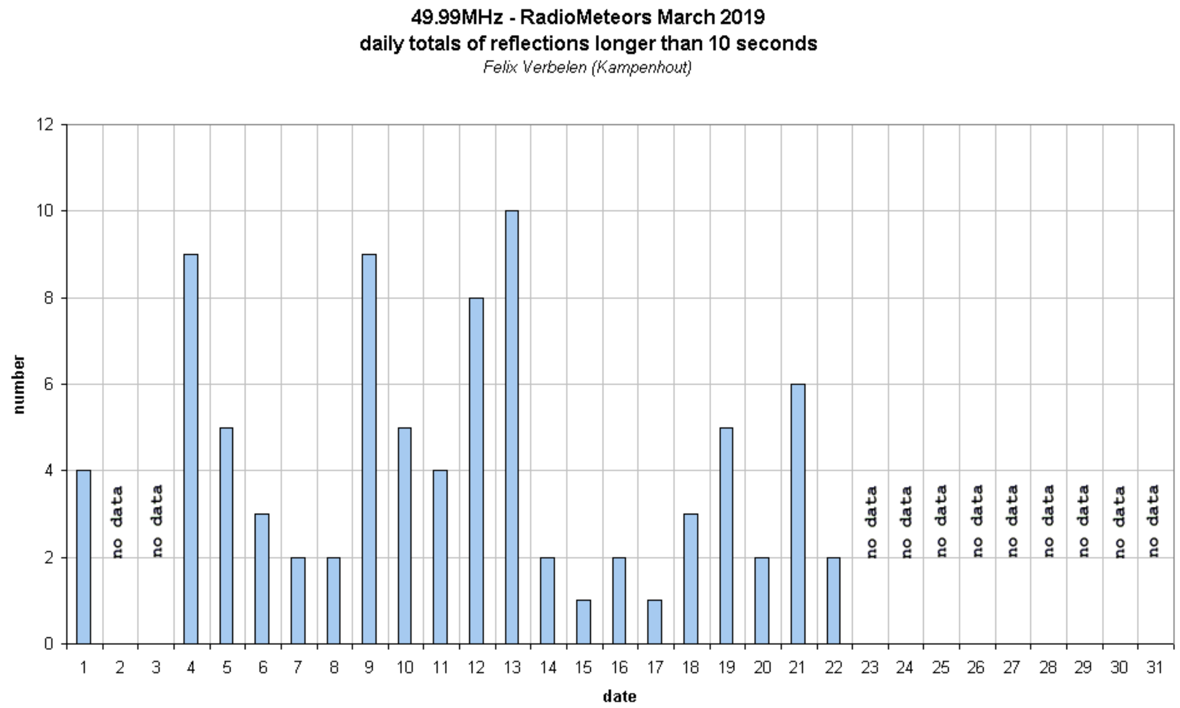


Figure 5 – The daily totals of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during March 2019.



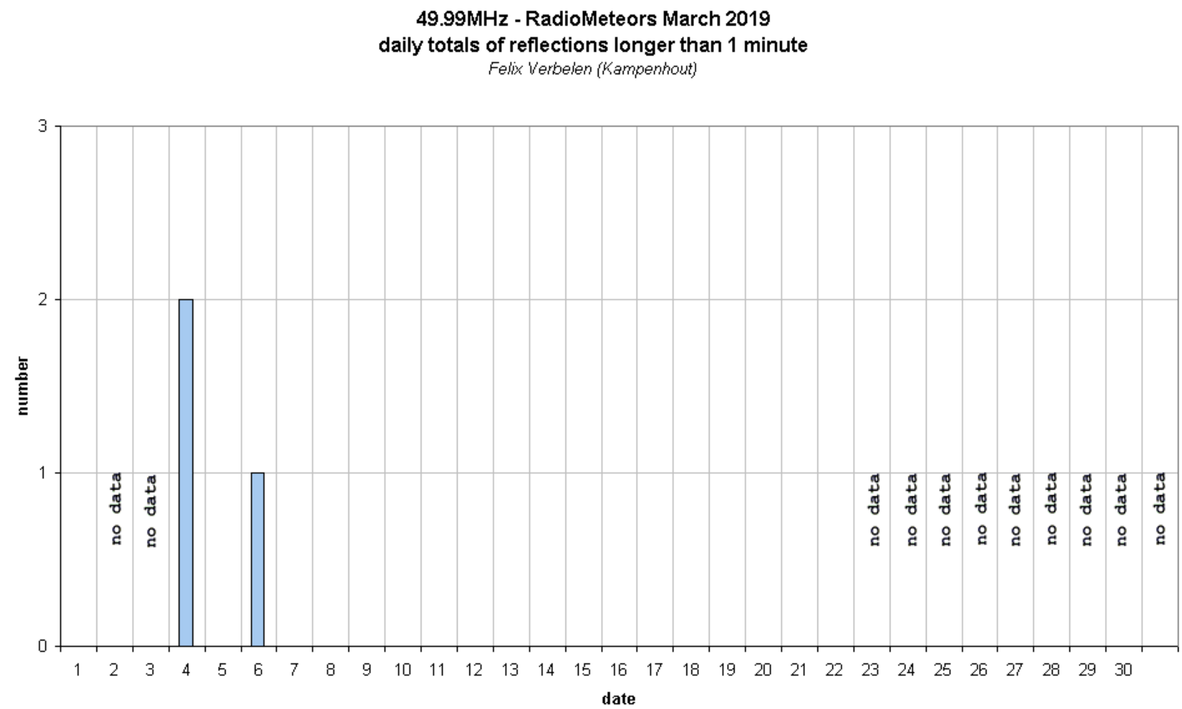
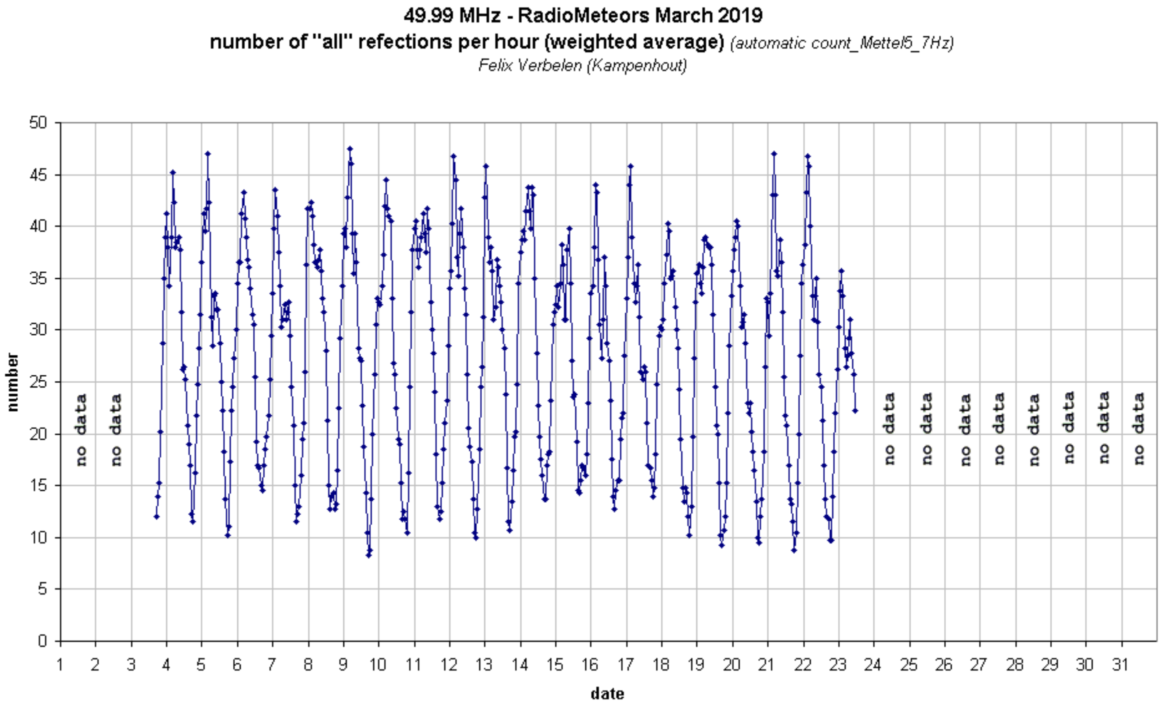


Figure 6 – The daily totals of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during March 2019.



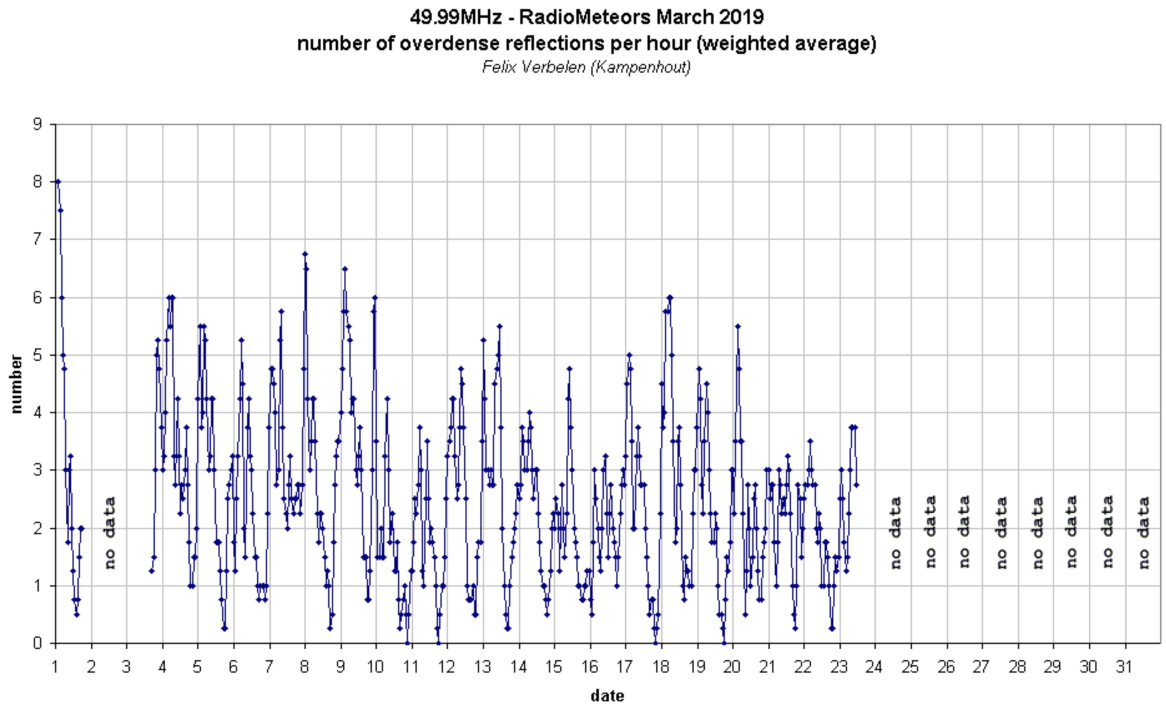
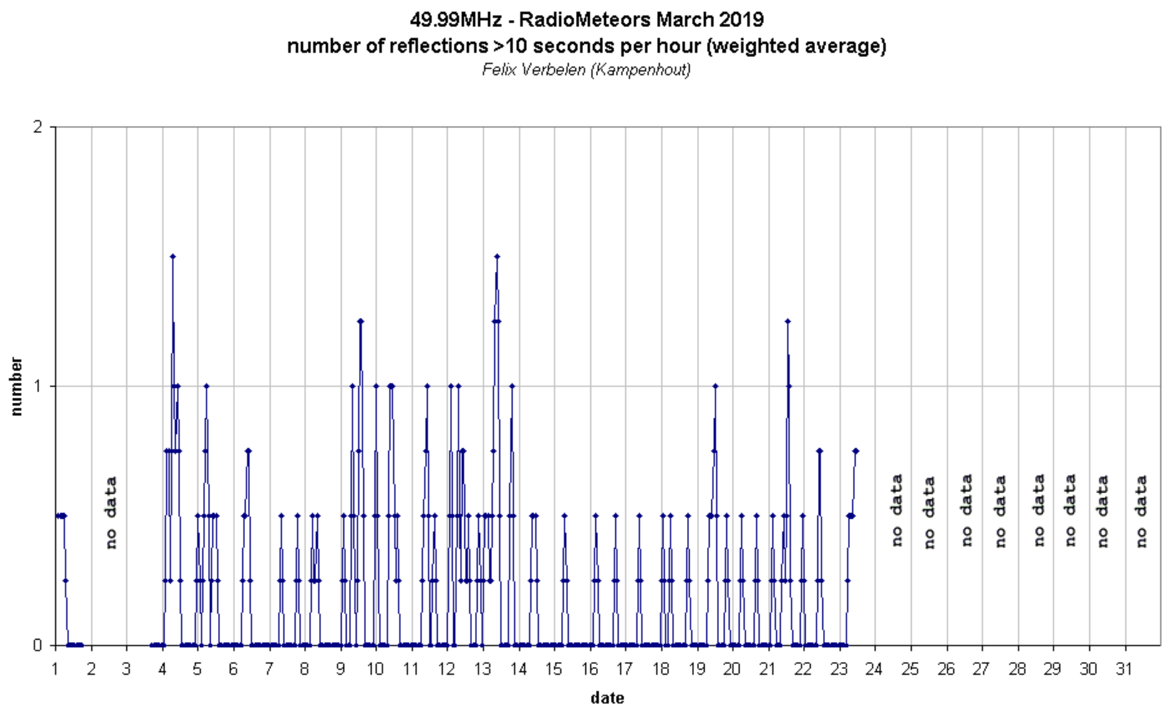


Figure 7 – The hourly numbers of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during March 2019.



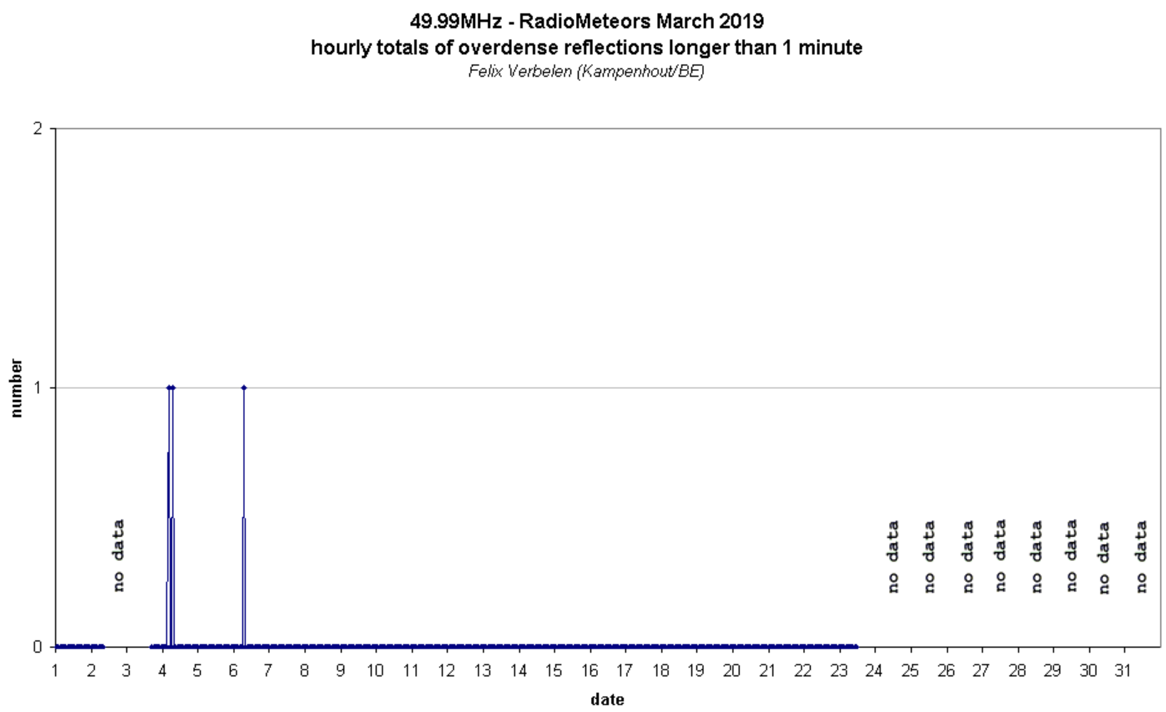


Figure 8 – The hourly numbers of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during March 2019.

Radio meteors April 2019

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

1 Introduction

The graphs show both the daily totals (*Figures 2 and 3*) and the hourly numbers (*Figure 5 and 6*) of "all" reflections counted automatically, and of manually counted "overdense" reflections and overdense reflections longer than 10 seconds, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during April 2019.

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

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

Unfortunately, due to technical problems, data were lost on April 1st and partially on April 2nd (see *Figures 2, 3, 4 and 5*). During this month there were some local disturbances and interference, but no registered "sporadic E" (Es). Lightning activity was noted on 3 days (2+3+7th of April).

As expected, the Lyrids shower peaked on April 23rd, which is readily shown by the graphs of reflections longer than 10 seconds.

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

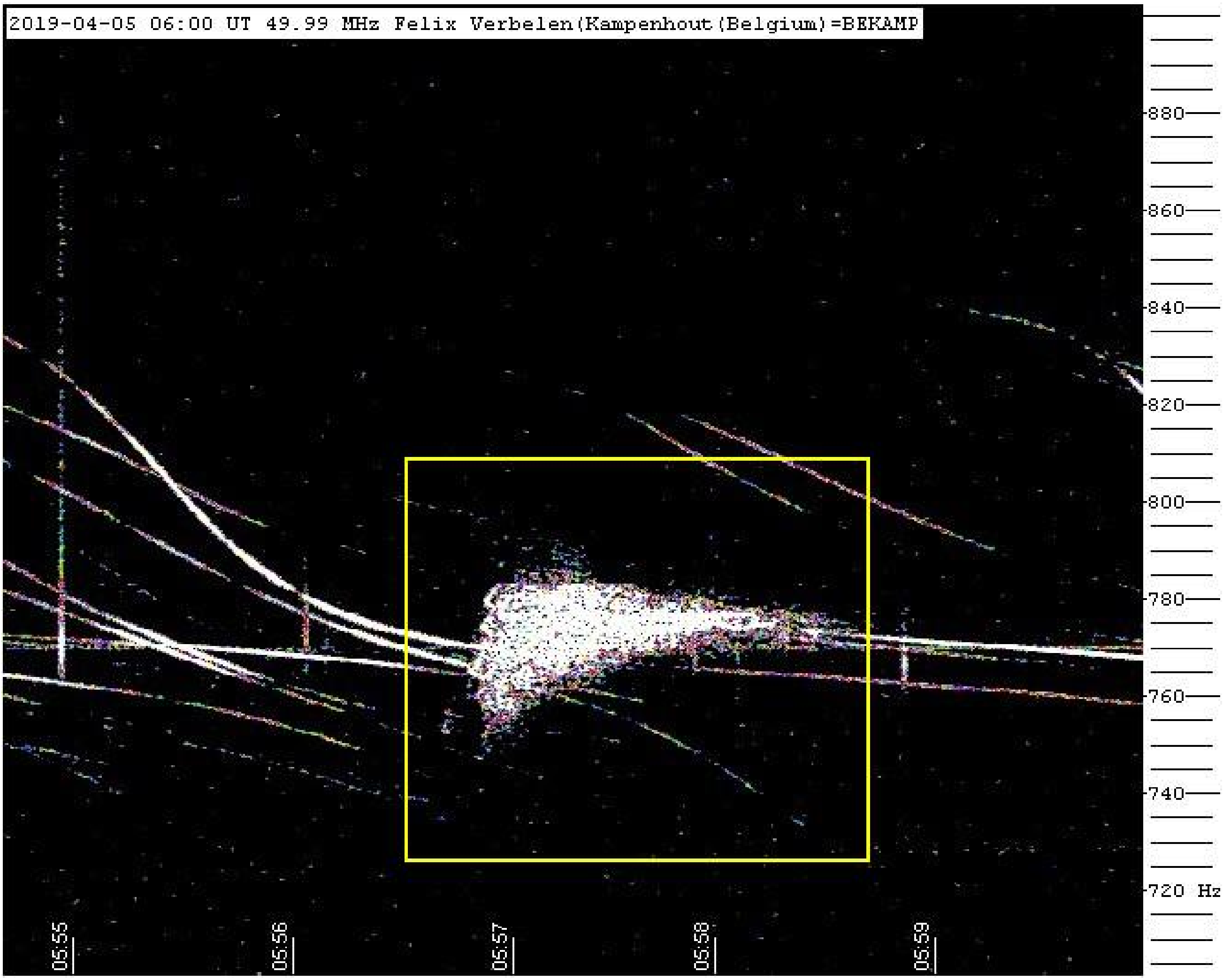
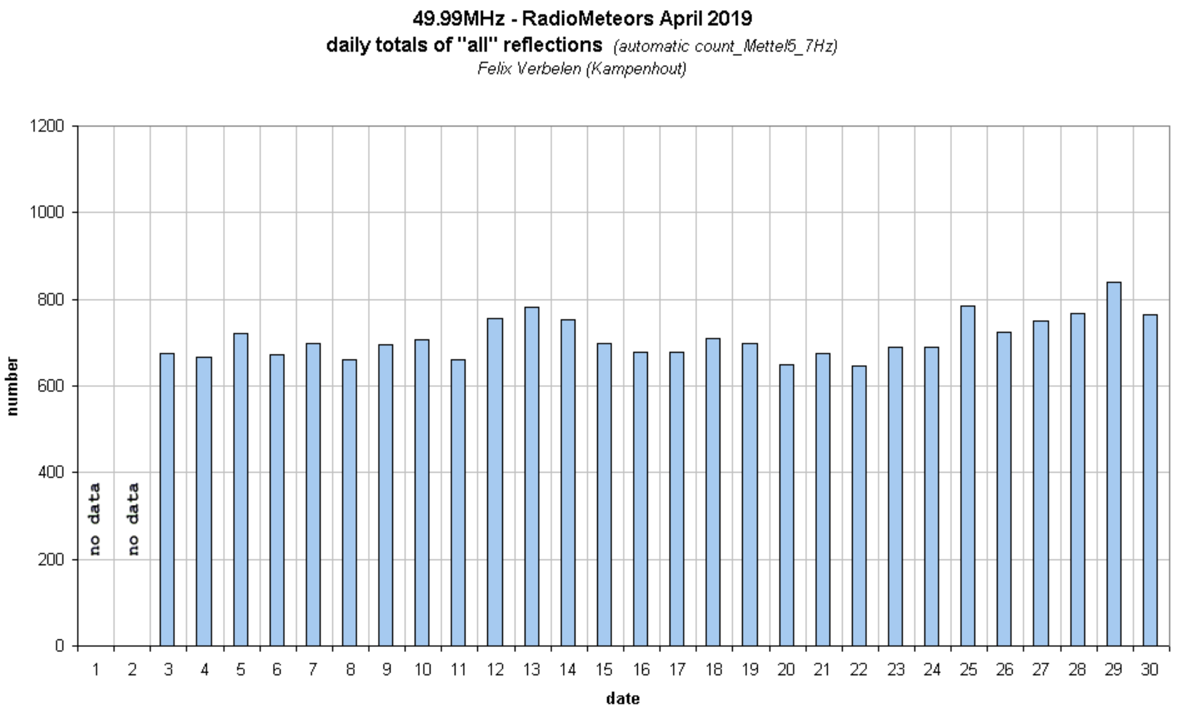


Figure 1 – Echo registered on 5 April 2019 at 6^h00^m UT.



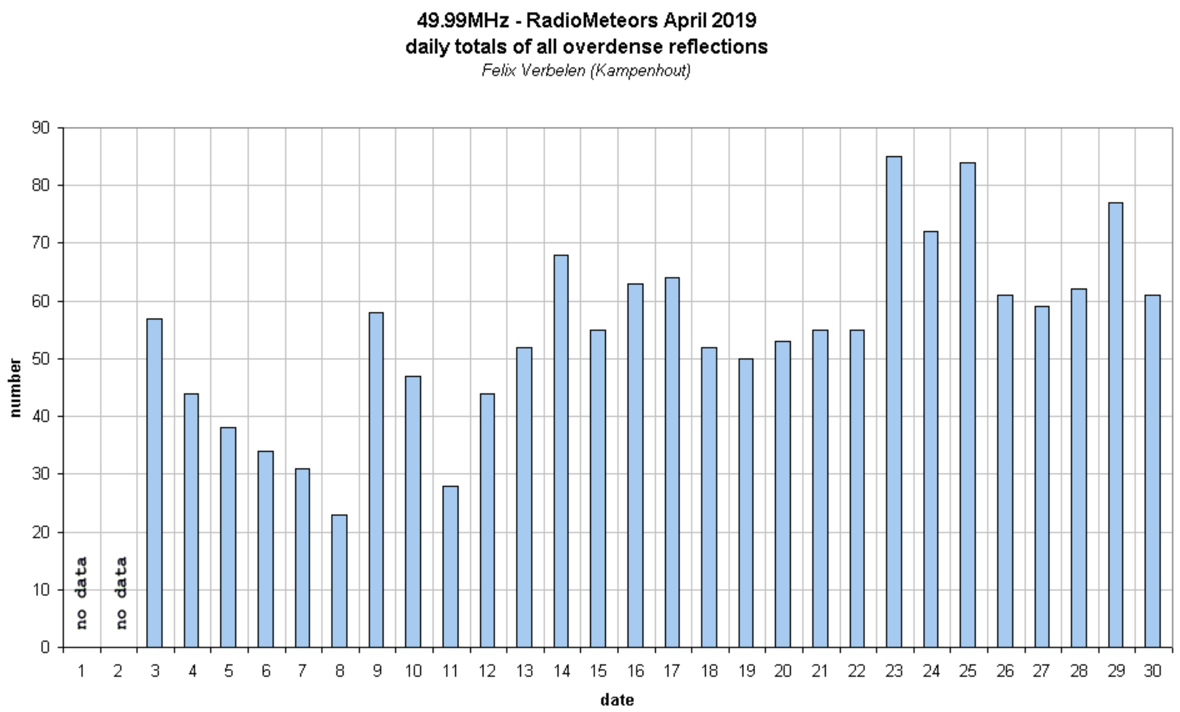
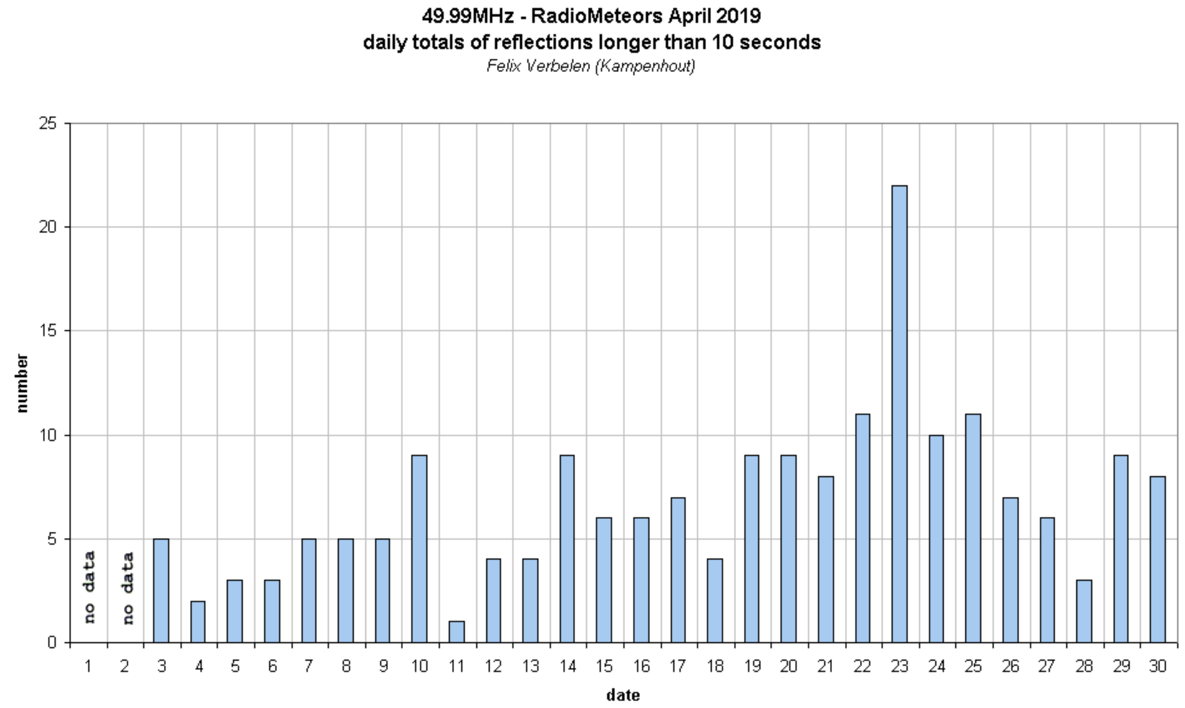


Figure 2 – The daily totals of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during April 2019.



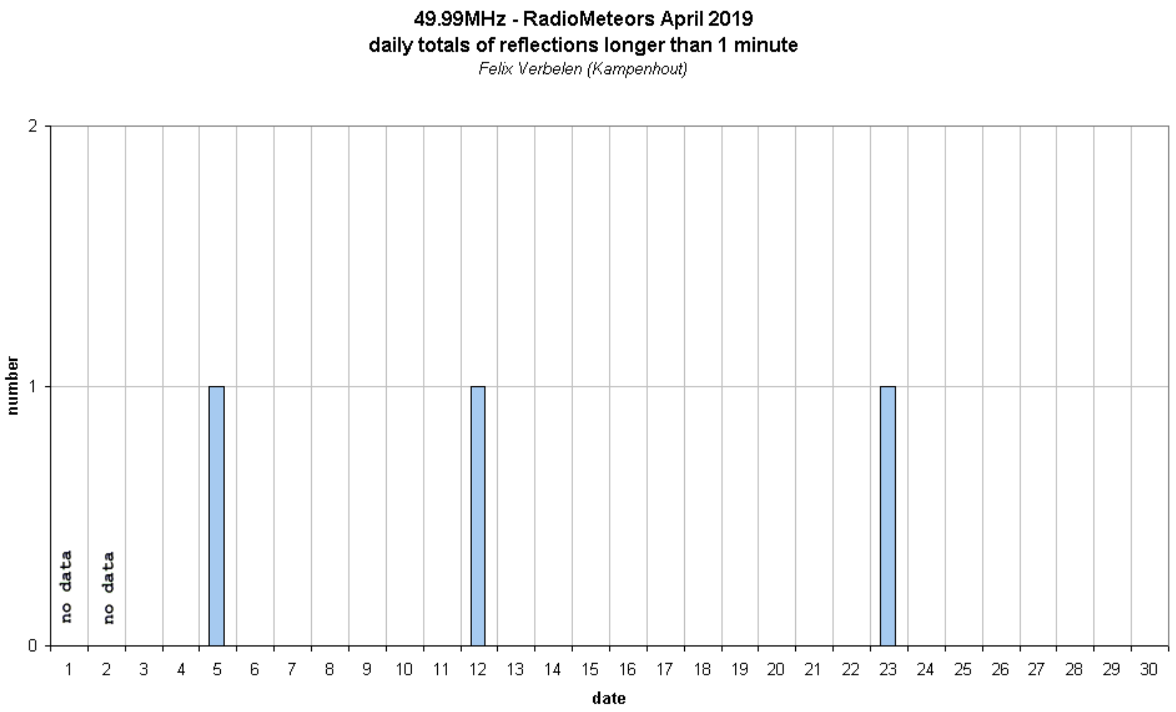
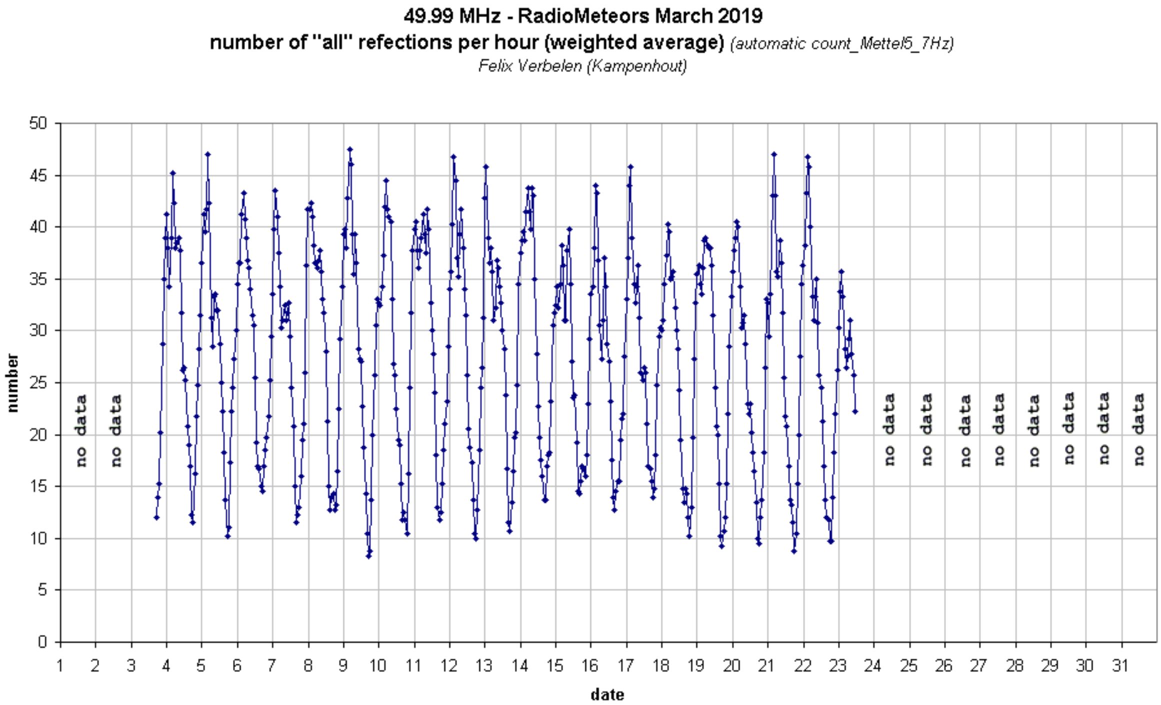


Figure 3 – The daily totals of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during April 2019.



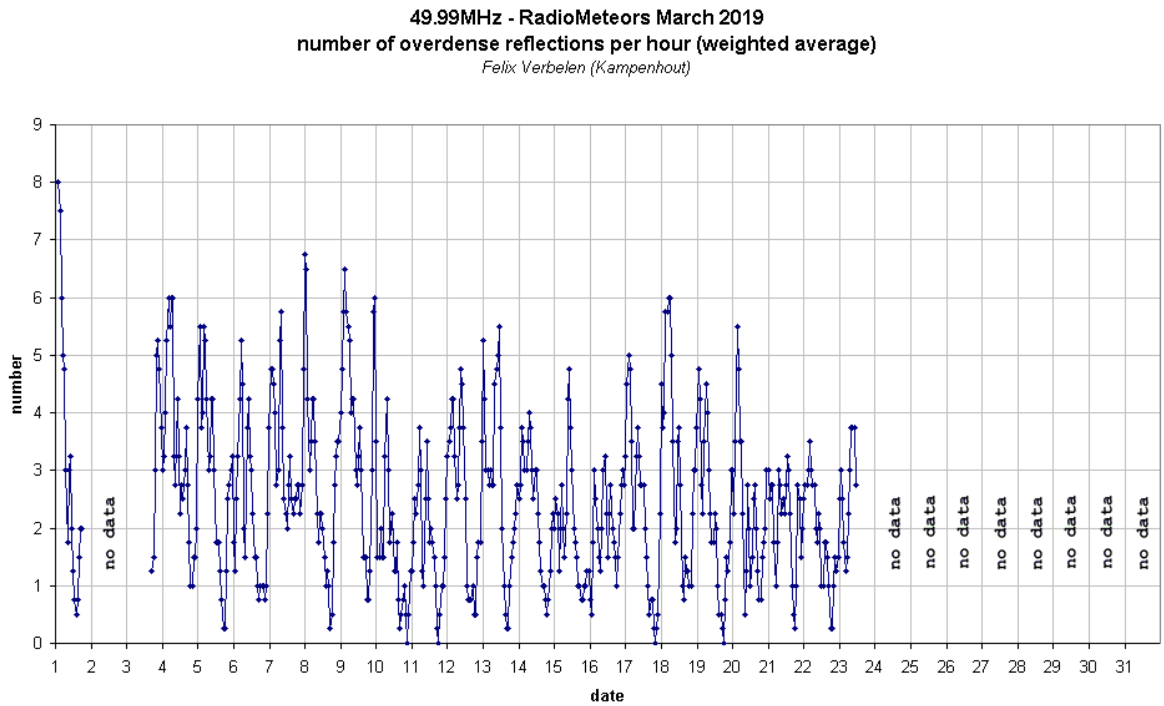
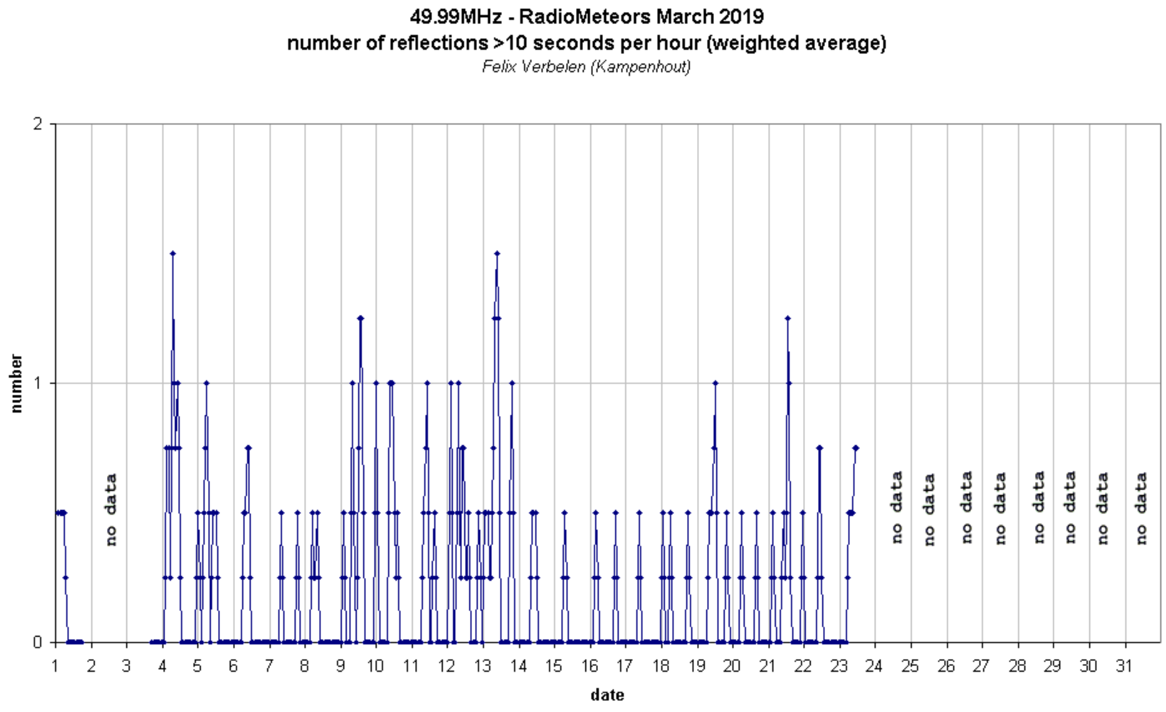


Figure 4 – The hourly numbers of "all" reflections counted automatically, and of manually counted "overdense" reflections, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during April 2019.



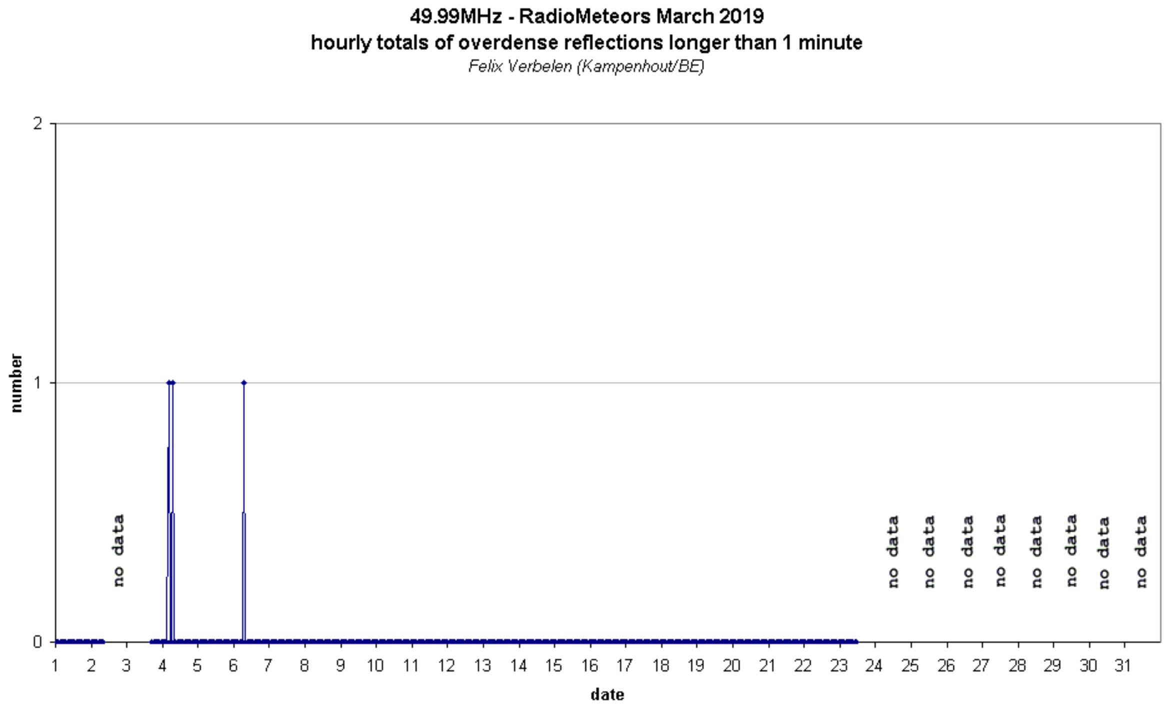


Figure 5 – The hourly numbers of overdense reflections longer than 10 seconds and longer than 1 minute, as observed here at Kampenhout (BE) on the frequency of our VVS-beacon (49.99 MHz) during April 2019.

February 2019 report CAMS BeNeLux

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A summary of the activity of the CAMS BeNeLux network during the month February 2019 is presented. This month offered many clear nights, 8 nights with more than 200 orbits, 2 nights had over 300 orbits. In total 17784 meteors were recorded, 10570 of which proved multiple station, or 59%. In total 3485 orbits were collected during this month, 20% less than in February 2018.

1 Introduction

December 2018 and January 2019 brought mainly unfavorable nights, worse than what these winter months normally could offer. The first half of February 2019 brought reasonable circumstances while the second half of February counted exceptional many clear nights. This way we can compare two exceptional good months of February in two consecutive years.

2 February 2019 statistics

The weather followed a similar pattern as previous year, with a series of clear nights after a long period of rather unfavorable weather. 8 nights resulted in more than 200 orbits (against 11 nights in 2018), 2 nights of these had over 300 orbits. Overall the weather was slightly less favorable than previous year, but still far better than what one may expect for this winter month.

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

Year	Nights	Orbits	Stations	Max. Cams	Min. Cams	Mean Cams
2013	9	38	6	5		2.3
2014	21	601	12	29		20.3
2015	21	777	14	39		27.4
2016	24	1075	17	51	13	36.9
2017	16	717	18	53	20	38.6
2018	26	4147	22	91	48	81.7
2019	24	3485	18	74	50	68.8
Total	141	10840				

CAMS BeNeLux managed to collect 17784 meteors (23439 in 2018) with 74 cameras (91 in 2018) capturing at 18 participating stations (22 in 2018) during the best nights. 10570 or 59% of these meteors were multi-station meteors, good for 3485 orbits (4147 in 2018). With the 2019 results the total number of orbits for February obtained by CAMS BeNeLux got at 10840 orbits collected in 141 successful nights. The statistics for February 2019 are compared in *Table 1* with all previous February months since the start of the CAMS BeNeLux network. Although the weather was comparable with previous year, less results were obtained due to a significant lower number of operational cameras.

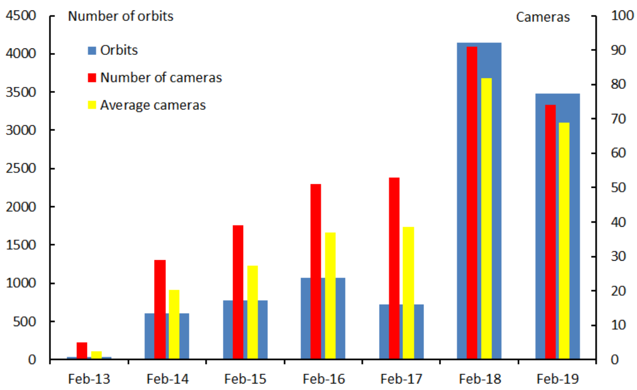

Figure 1 – Comparing February 2019 to previous months of February in the CAMS BeNeLux history. The blue bars represent the number of orbits, the red bars the maximum number of cameras running in a single night and the yellow bars the average number of cameras running per night.

On average 68.8 of the available 74 cameras were capturing per night (81.7 of 91 in 2018). This high average corresponds to 93% of the maximum number of cameras available. Especially in the first years, before AutoCams was available in the BeNeLux, many cameras remained switched off when the weather did not look good in the evening. This way the chances to obtain double station meteors for those cameras that remained active were rather small. 4 nights did not yield any orbit and only one night remained without a single meteor recording. AutoCAMS kept a minimum of 50 cameras active on all nights, even on completely overcast nights. On as many as 24 nights orbits have been collected. *Figure 1* shows the decline in camera capacity compared to 2018. This combined with exceptional good weather resulted in a nice total number of orbits for this winter month.

On 2018 February 14, the CAMS BeNeLux network recorded a few similar orbits which were identified with a new minor shower listed as the February Hydrids (FHY-1032) in the IAU Working List of Meteor Showers (Jenniskens et al., 2018), (Roggemans and Cambell-Burns, 2018). Not any single orbit of this shower was detected in 2019.

3 Conclusion

The exceptional favorable weather in the second half of February 2019 resulted in another successful month of February for a second year in a row.

Acknowledgment

Many thanks to all participants in the CAMS BeNeLux network for their dedicated efforts. The data on which this report is based has been taken from the CAMS website[5]. The CAMS BeNeLux team is operated by the following volunteers:

Hans Betlem (Leiden, CAMS 371, 372 and 373), *Jean-Marie Biets* (Wilderen, CAMS 380, 381 and 382), *Martin Breukers* (Hengelo, CAMS 320, 321, 322, 323, 324, 325, 326 and 327), *Bart Dessoy* (Zoersel, CAMS 397, 398, 804, 805 and 806), *Jean-Paul Dumoulin and Christian Walin* (Grapfontaine; CAMS 814 and 815), *Luc Gobin* (Mechelen, CAMS 390, 391, 807 and 808), *Robert Haas* (Alphen aan de Rijn, CAMS 3360, 3361, 3362, 3363, 3364, 3365, 3366 and 3367), *Robert Haas* (Texel, CAMS 810, 811, 812 and 813), *Robert Haas / Edwin van Dijk* (Burlage, CAMS 801, 802, 821 and 822), *Klaas Jobse* (Oostkapelle, CAMS 330, 331, 332, 333, 334, 337, 338 and 339) , *Carl Johannink* (Gronau, CAMS 311, 312, 313, 314, 315, 316, 317 and 318), *Hervé Lamy* (Dourbes, CAMS 395), *Hervé Lamy* (Humain, CAMS 816), *Hervé Lamy* (Ukkel, CAMS 393),*Koen Miskotte* (Ermelo, CAMS 351, 352, 353 and 354), *Steve Rau* (Zillebeke, CAMS 3850 and 3852), *Paul Roggemans* (Mechelen, CAMS 383, 384, 388, 389, 399 and 809), *Hans Schremmer* (Niederkruechten, CAMS 803) and *Erwin van Ballegoij* (CAMS 347 and 348).

[5] http://cams.seti.org/FDL/index-BeNeLux.html

CAMS results in February and March 2019

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A summary is presented of the results obtained by CAMS BeNelux during the months of February and March 2019.

1 February 2019

February 2019 was more or less a month with two faces. In the first decade, most stations were only able to work almost cloudless on one night. After this period, it got much better again. The nights of 14–15 and 15–16 February resulted each in more than 300 multiple station meteors. After a short dip a period with beautiful spring weather during the day and very transparent clear nights at night followed in the period 22–27 February.

The last day of the month was the turning point to a very volatile period, which we would still experience further in March.

Only 4 nights went completely without any orbits: 4–5, 6–7, 9–10 and the last night of the month. Fifteen nights had more than 100 orbits, the absolute toppers being the aforementioned nights in the middle of the month. A total of 3485 orbits were recorded this month (see *Figure 1*).

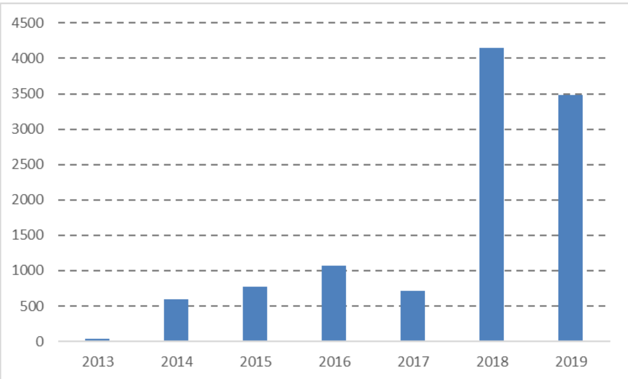

Figure 1 – Overview of the number of orbits recorded in February by CAMS BeNeLux.

Assuming that this year the period with the really clear nights almost coincided with the Full Moon period, this is a very good result. No major showers are active in February and the sporadic activity is clearly less than it used to be the months before.

Figure 2 shows the radiant positions of all recorded orbits. Also, the meteors are divided into groups based on their geocentric velocity.

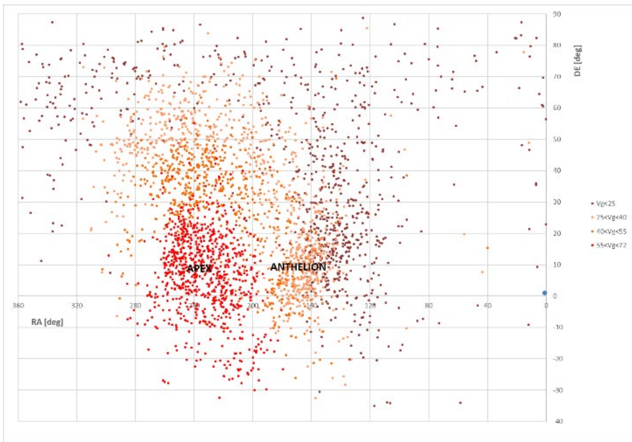

Figure 2 – Radiant plot, in function of v_g, for all orbits in February 2019.

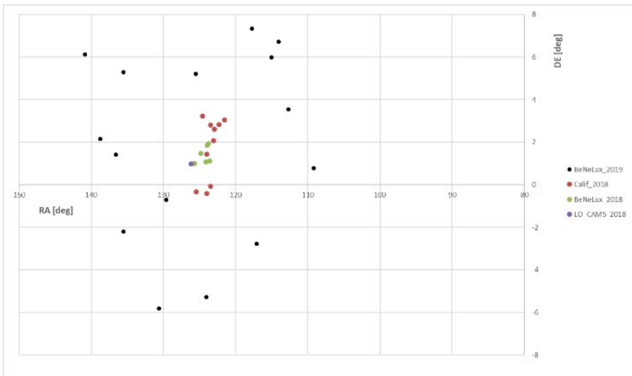

Figure 3 – Radiant plot of the February Hydrids (2018) and of meteors recorded by CAMS BeNeLux in 2019 in the same region of the sky.

In 2018, CAMS California, LO-CAMS and CAMS BeNeLux registered activity around 13 February from a region near RA ~ 124 degrees and Decl. ~ +1 degree, in the border region of the constellations Canis Minor and Hydra. The night of 13–14 February was largely clear for all posts in the BeNeLux. However, no activity was observed from this region at the same solar longitude this year.

Figure 3 shows radiant positions of the meteors that were captured by the various networks in 2018, as well as what CAMS BeNeLux recorded in this year.

2 March 2019

A total of 1217 orbits were recorded in March. Especially in the first decade it was mostly cloudy, so that in that period less than 100 orbits could be registered.

The monthly score was nevertheless hardly lower than the best March score so far in our network: 1280 orbits in March 2018.

From this kind of numbers, it appears that the meteor activity in March is really at the annual dip.

Perhaps partly due to the mostly cloudy weather our network could not provide confirmation for an observation of increased activity from Bootes (571 TSB) in the night of 4–5 March 2019 (report P. Jenniskens via email).

Acknowledgment

Finally, many thanks to all the people who keep our network up and running!

Hans Betlem (Leiden-NL, CAMS 371 – 373), *Felix Bettonvil* (Utrecht-NL, CAMS 376–377), *Jean-Marie Biets* (Wilderen-B, CAMS 380 – 382), *Martin Breukers* (Hengelo-NL, CAMS 320 – 329), *Bart Dessoy* (Zoersel-B, CAMS 397, 398, 804 – 806 and 888), *Jean-Paul Dumoulin / Christian Wanlin* (Grapfontaine-B, CAMS 814 , 815), *Luc Gobin* (Mechelen-B, CAMS 390, 391, 807 and 808), *Robert Haas* (Alphen aan de Rijn-NL, CAMS 3160 – 3167), *Robert Haas / Edwin van Dijk* (Burlage-D, CAMS 801, 802, 821 and 822), *Tioga Gulon* (Nancy-FR, CAMS 3900) , *Robert Haas* (Texel-NL, CAMS 810 – 813), *Klaas Jobse* (Oostkapelle-NL, CAMS 3030 – 3037), *Carl Johannink* (Gronau-D, CAMS 311 – 318), *Hervé Lamy* (Ukkel-B, CAMS 393; Dourbes-B, CAMS 394 and 395), *Koen Miskotte* (Ermelo-NL, CAMS 351 – 354) , *Jos Nijland* (Terschelling-NL, CAMS 841 – 844), *Tim Polfliet* (Gent-B, CAMS 396), *Steve Rau* (Zillebeke-B, CAMS 3850 and 3852), *Paul Roggemans* (Mechelen-B, CAMS 383, 384, 388, 389, 399 and 809), *Hans Schremmer* (Niederkrüchten-D, CAMS 803), *Erwin van Ballegoij* (Heesh-NL, CAMS 347 and 348) and *Marco van der Weide* (Losser-NL, CAMS 3110).

References

Jenniskens P., Gural P. S., Grigsby B., Dynneson L., Koop M. and Holman D. (2011). "CAMS: Cameras for Allsky Meteor Surveillance to validate minor meteor showers". *Icarus*, **216**, 40–61.

Jenniskens P., Johannink C. and Moskovitz N. (2018). "February Hydrids outburst (IAU#1032, FHY)". *WGN, Journal of the International Meteor Organization*, **46**, 85–86.

CAMS BeNeLux results April 2019

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Weather offered very good observing conditions around the traditional Lyrid maximum. More than 2500 orbits were collected in 29 (partial) clear nights. 322 orbits could be identified as members of the Lyrid stream. The drift in R.A. was +0.92 degrees per day and –0.22 degrees per day in declination, based upon the 149 Lyrid orbits fulfilling the similarity criterium of Drummond with D < 0.04 obtained in the period between April 18–19 and April 23–24.

1 Introduction

The month of April was extremely sunny. In De Bilt it was even the fourth-sunniest April month since 1901. No surprise that many orbits could be added by our network during almost all the April nights.

The nights around the traditional Lyrids maximum were mostly clear, which resulted in a nice collection of Lyrid orbits.

2 The data

Only the night of 5–6 April remained without multiple station meteors during the month of April. In total more than 2500 orbits were recorded by our network, again a new record for this spring month. The nights in the period 18 to 23 April in particular were very clear.

Therefore, it is no surprise that most multi-station meteors were captured in the nights around the Lyrid maximum. In *Figure 1* we see the radiant positions for all the orbits obtained in the period from 15–16 to 23–24 April. The large concentration around R.A. = 270 and decl. = +30 degrees, already indicates the Lyrids.

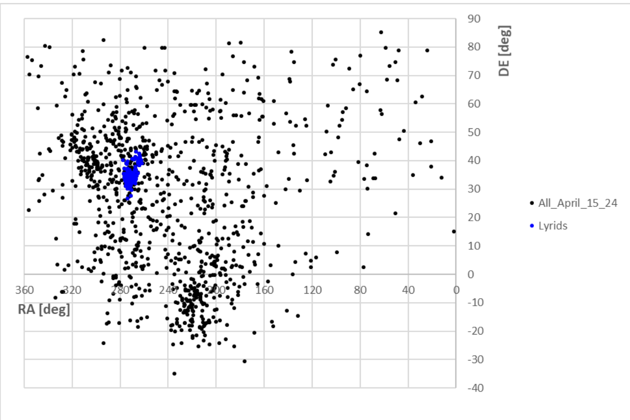

Figure 1 – Plot of all radiants recorded in the period of 15–16 until 23–24 April (blue radiants are Lyrids).

In *Figure 2* we zoom in on the area around the Lyrid radiant. Sporadic meteors and Lyrids were distinguished by means of the discrimination criterion of Drummond (1981). The different colors of the radiants indicate the degree of similarity of the orbits compared to the reference orbit given by Jenniskens (2016).

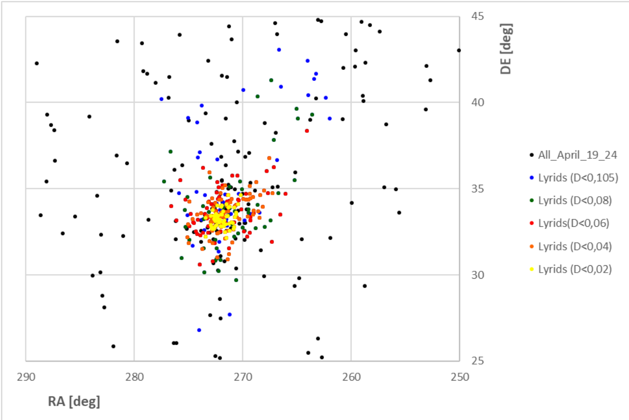

Figure 2 – The area of the Lyrid radiant with sporadic meteors (black) and Lyrids split into different steps of the Drummond criterion.

For the 149 Lyrid orbits with the discrimination criterion $D_D < 0.04$, the median of the radiant position and of the orbital elements was determined. The results are listed in *Table 1*. The results are compared with the values published by Jenniskens (2018).

Table 1 – Median values for the radiant position and the orbital elements for 149 Lyrids with $D_D < 0.04$ determined by CAMS BeNeLux compared with Jenniskens (2018).

	CAMS BeNeLux (2019)	Jenniskens (2018)
α_g	272.0°	272.1°
δ_g	+33.4°	+33.6°
v_g	46.8 km/s	46.7 km/s
$\lambda_{\odot}$	32.3°	31.7°
q	0.920 AU	0.923 AU
a	23.9 AU	25.6 AU
i	79.6°	79.3°
ω	214.2°	213.6°
Ω	32.3°	31.7°

The similarities are good. Of course, it must be kept in mind that we have only used data from our network, so we have only taken "snapshots" from the entire activity period.

The number of Lyrids with $D_D < 0.04$ is so large around the maximum that we were able to determine the radiant drift for the period from 17 to 24 April ($\lambda_\odot$ ~ 25 - 33 degrees). We found a drift of +0.92 degrees / day for the Right Ascension. That is almost identical to the value we found in 2018 (Roggemans and Johannink, 2018). For the declination we find a drift of –0.22 degrees / day. This value is also close to the value we found in 2018. However, it does deviate from the value that Jenniskens published (+0.02 degree / day).

Figure 4 shows for each of the nights 15–16 to 23–24 April the percentage of Lyrids from the above set in relation to the number of other meteors from the same night. We see a nice activity profile, which, just like in 2018, corresponds well with the known profile with a maximum activity around solar longitude of 32 degrees.

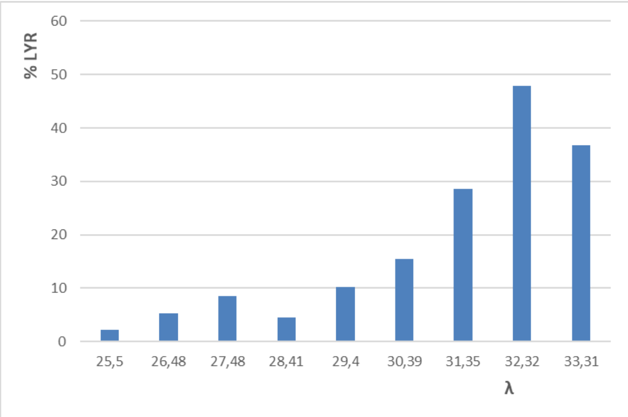

Figure 4 – Percentage of Lyrids in relation to the other meteors during the nights 15–16 to 23–24 April 2019. (source: CAMS BeNeLux data).

References

Drummond J. D. (1981). "A test of comet and meteor shower associations". *Icarus*, **45**, p. 545–553.

Jenniskens P., Gural P. S., Grigsby B., Dynneson L., Koop M. and Holman D. (2011). "CAMS: Cameras for Allsky Meteor Surveillance to validate minor meteor showers". *Icarus*, **216**, 40–61.

Jenniskens P., Nénon Q., Albers J., Gural P. S., Haberman B., Holman D., Morales R., Grigsby B. J., Samuels D. and Johannink C. (2016). "The established meteor showers as observed by CAMS". *Icarus*, **266**, 331–354.

Jenniskens P., Baggaley J., Crumpton I., Aldous P., Pokorny P., Janches D., Gural P. S., Samuels D., Albers J., Howell A., Johannink C., Breukers M., Odeh M., Moskovitz N., Collison J. and Ganjuag S. (2018). "A survey of southern hemisphere meteor showers". *Planetary Space Science*, **154**, 21–29.

Roggemans P. and Johannink C. (2018). "CAMS BeNeLux: resultaten 2018". *eRadiant*, **40**, 115–118.

CAMS-Florida has a new meteor camera system operating at College of Central Florida

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A brief description is given of the new meteor camera system for CAMS-Florida.

1 Introduction

CAMS-Florida has a new meteor camera system operating at College of Central Florida (Ocala, Florida). The system, which is installed on the roof of the science building, has camera numbers CAMS 5020–5027. Physics Professor Kisvarsanyi writes: "*It comes at a time when the college is just getting an introductory astronomy course up and running, so the project has been great to share with my students!*"

Figure 1 – The newly installed camera system for CAMS-Florida.

2 The equipment

The eight miniature video cameras, purchased online, use the Sony ICX810 CCD. The camera enclosure is a polycarbonate utility box 18 inches (45 cm) long, 14 inches (36 cm) wide, and 8 inches (20 cm) high. The power receptacle uses a GPS LightLock timer[6] that automatically turns camera power on after sunset and off before sunrise. The LightLock adjusts to location and time of year, and resets automatically after a power outage. The camera box has two small, watertight vents to equalize pressure inside & outside. The 7-inch optical window is TruVue Optium acrylic which blocks 97% of UV light, is anti-reflection coated, and has a hard coat that makes it similar to glass. Acrylic has the same coefficient of thermal expansion as the polycarbonate box, to minimize stress on the sealant at the interface. The TruVue Optium acrylic was purchased at a picture framing store. A 10W heater inside the box gives just enough warmth to prevent dewing.

The first full night of operation was April 22–23, one night after the peak of the Lyrid meteor shower. CAMS-Florida contributed 142 meteoroid orbits, with the new camera system at College of Central Florida contributing to 122 of those orbits!

3 Current CAMS Florida situation

CAMS-Florida currently has cameras at four locations: Gainesville, Ocala, New Smyrna Beach, and Melbourne. We have plans to install another 8-camera system at Ocklawaha later this year. The network provides good coverage of central Florida, but we need more coverage in south Florida and also the panhandle (northwest part of Florida).

[6] http://www.gpslightlock.com

Clear nights May 2019 are yielding many coincident meteors at CAMS-Florida

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A summary report is presented about the large numbers of multiple station meteors collected by CAMS-Florida during May 2019.

1 Introduction

Clear nights have been yielding 30–40 coincident meteors each night for the past week. Attached is a map of CAMS-Florida ground tracks that show 26 coincident meteors from the night of 30–31 May 2019.

Of interest is the bolide at $09^h21^m21^s$ UT seen by four cameras: CAMS 234 & 5000 (Gainesville), CAMS 5020 (College of Central Florida), and CAMS 233 (Florida Institute of Technology). Traveling in a northwesterly direction, the meteor's duration was slightly more than 1/2 second. It popped into view at 110 km altitude and then disappeared at 79 km.

The object had perihelion barely inside Earth's orbit and aphelion just inside Jupiter's orbit; evidently, it belonged to the Jupiter family of comets & debris with inclination i = 144 degrees (i.e., retrograde orbit). The meteoroid encountered Earth at 63.2 km/sec. UFOOrbit makes it possible to do these calculations using CAMS data.

The main CAMS web page[7] lists each night's coincident events with meteor radiants plotted on the celestial sphere.

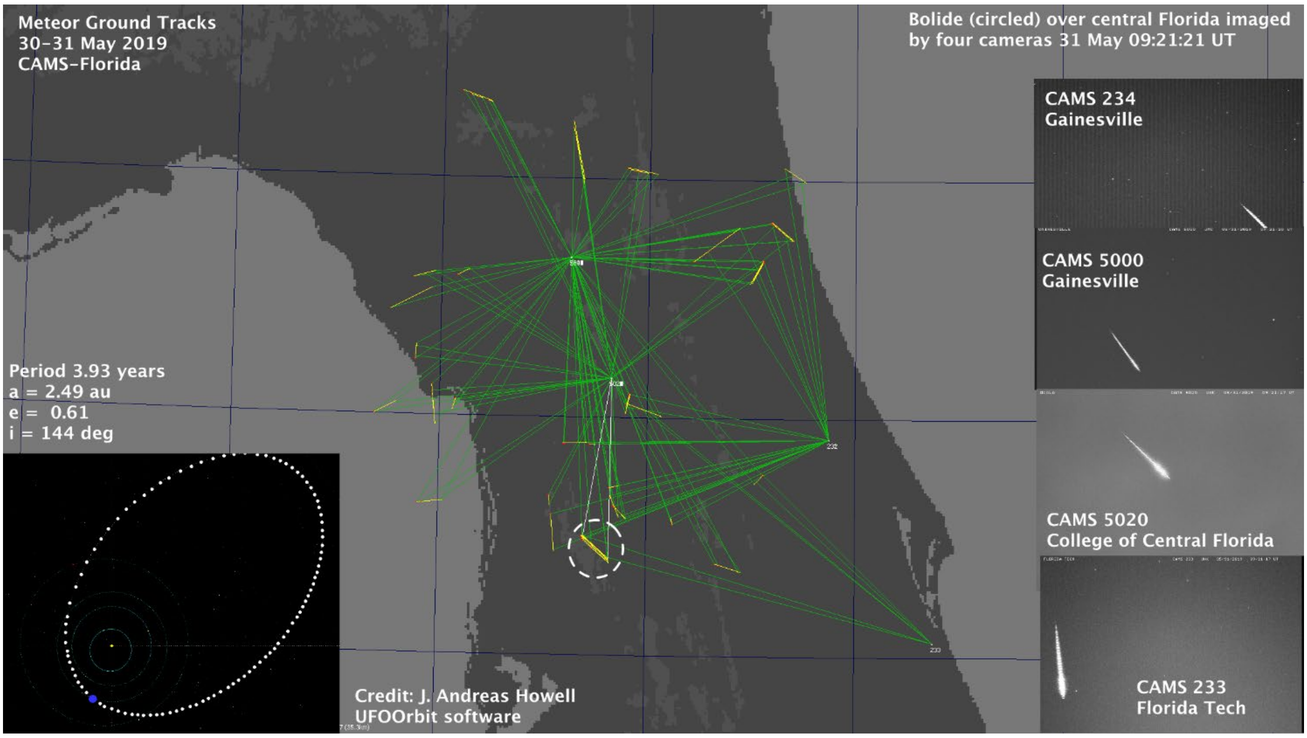

Figure 1 – Florida ground tracks that show 26 coincident meteors from the night of 30–31 May 2019, with details for the fireball at $09^h21^m21^s$ UT.

[7] http://cams.seti.org/FDL/index-FL.html

Fireball of 24 January 2019 over north-west Italy

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A brilliant meteor was observed in northern Italy at $20^h59^m07^s$ UT on 24 January 2019. The bolide was recorded by 7 cameras and 4 radio stations. The trajectory of the meteoroid over north-west Italy was calculated together with the orbit in the Solar System.

1 Introduction

At $20^h59^m07^s$ UTC on Thursday, January 24th, many people throughout northern Italy observed a large meteoric fireball which crossed the sky showing a bright trail in prevalence over the Ligurian Sea.

There have been many reports and visual testimonies from northern Italy and from neighboring countries, some of which through the IMO fireball platform[8]. Among the useful observational data there were also video and radio records.

2 Observational reports

The brilliant meteor was filmed by seven video stations that collaborate with the Italian Meteor Group (IMG) /UAIsm[9], which captured different parts of the fireball path (*Table 1*).

Table 1 – List of video stations that captured this fireball.

Camera	Site	φ° N	λ° E	Observer
ARCI e BILBO cams	Caserza (GE)	44.55	9.04	Stefano Crivello
AAB cam	Medelana (BO)	44.36	11.15	Giulio Busi
CH1 e CH2 cams	Chioggia (VE)	45.18	12.31	Matteo Fuolega
NOA38 cam	Scorze'(VE)	45.56	12.11	Enrico Stomeo
ROVER cam	Rovereto (TN)	45.86	11.01	Fabio Moschini

Some useful indications have been selected from the visual reports, among the most accurate not affected by errors due to the distance of the meteor or the poor experience of the observer. The visual reports indicated a very strong maximum apparent brightness, at least as bright as the quarter lunar phase (–10m) if not more.

From the visual reports it appears that the flight was visible for a few seconds during which the meteor displayed, according to some witnesses, fragmentation and a change in color from blue green to yellow red. Nobody reported hearing any noise.

Figure 1 – Central part of the fireball captured by CH1.

Figure 2 – Central part of the fireball captured by CH2.

The best observational conditions were for the BILBO and ARCI video cameras that saw the event near the zenith. Unfortunately, the proximity of the bolide to these two stations has created a serious problem, because in the second part of the path the flare of maximum brightness has completely saturated the field of view and therefore the recognition software was unable to detect, calculate and record the many astrometric positions, as well as

[8] https://fireball.imo.net/members/imo_view/browse_events

[9] Italian Meteor Group / UAI Meteor Section, http://meteore.uai.it

unfortunately to save in real-time all the sequences of the images of the individual frames.

Figure 3 – Initial part of the fireball captured by NOA38.

Figure 4 – Final part of the fireball captured by AAB.

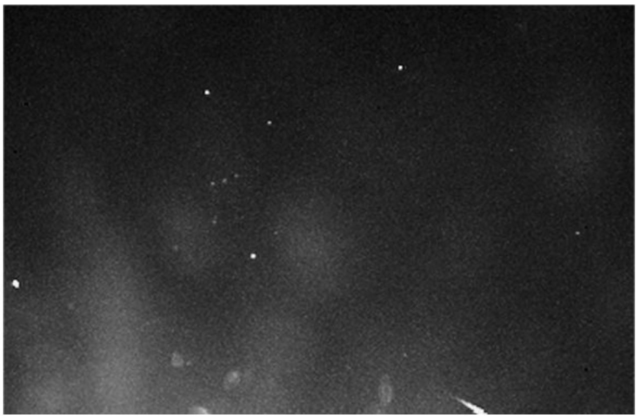

Figure 5 – Initial part of the fireball captured by ROVER.

The NOA38 and ROVER stations, hundreds of kilometers away from the event, only filmed the fireball in the first part of the path, when the object was at its highest altitude. The availability of video data captured in the vicinity of the event (ARCI and BILBO) has changed the preliminary results initially deduced only from these two distant stations, results that assumed a trajectory a little more south-west of the real one and ending above French territory.

On the opposite, the AAB station has seen the fireball appearing practically from the edge of the field of view, between obstructions, only in its terminal phase.

Regarding the two cameras CH1 and CH2, it should be considered that they are surveillance instruments pointed on the horizon and that, moreover, they are not particularly sensitive. Given the considerable distance from the event, both have not seen the beginning of the meteor and have not captured the actual end of the bolide.

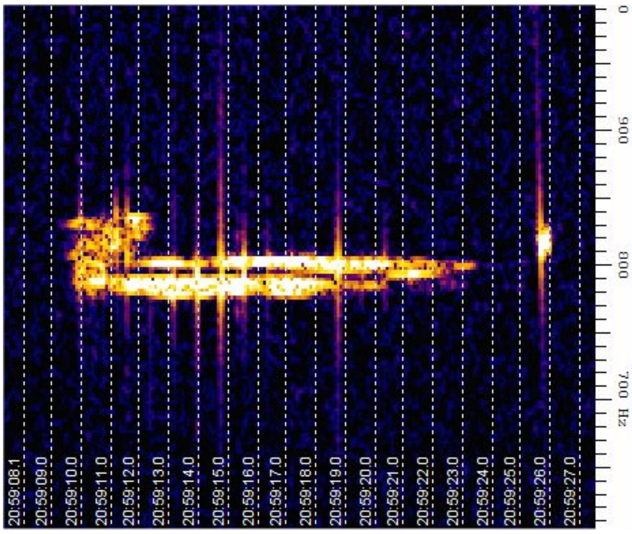

Figure 6 – Spectrogram of the event recorded by ®FAEN.

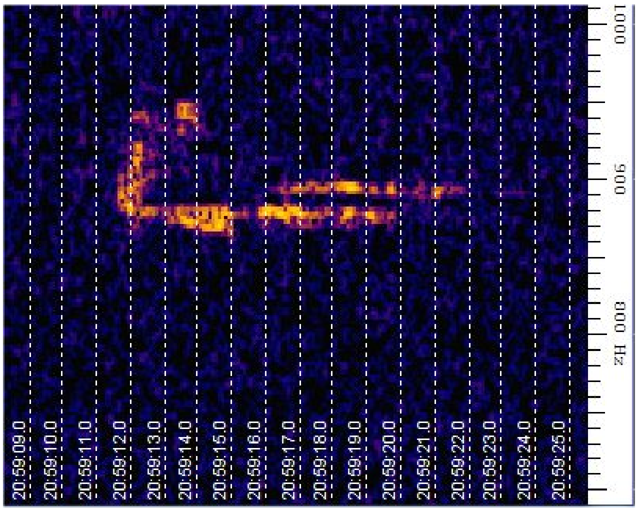

Figure 7 – Spectrogram of the event recorded by ®VENL.

Table 2 – List of radio stations that registered this fireball.

Station	Site	φ° N	λ° E	Observer
®FAEN	Faenza (RA)	44.28	11.90	Mario Bombardini
®VENL	Venezia Lido (VE)	45.42	12.38	Venice Planetarium
®ROVE	Rovereto (TN)	45.86	11.01	Fabio Moschini
®RECH	Latina (LT)	41.43	12.88	Massimiliano Recchia

The bolide was also recorded by four radio stations collaborating with IMG, oriented in the direction of the radar Graves[10] (central France) so as to receive the pulses transmitted on the frequency 143.05 MHz in the case of meteoric events (*Table 2*).

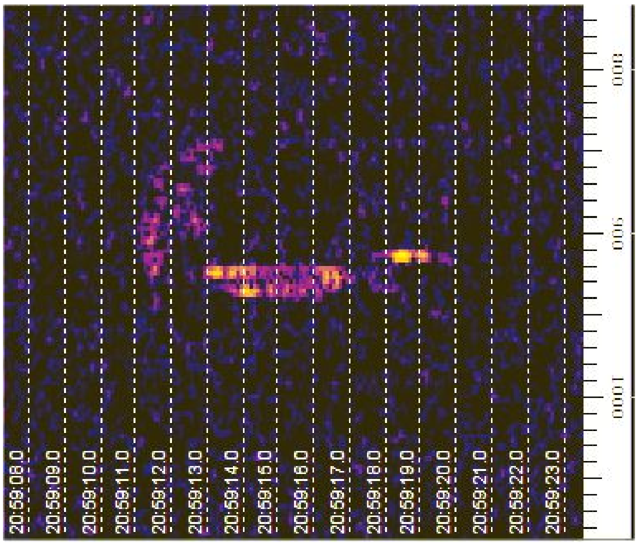

Figure 8 – Spectrogram of the event recorded by ®ROVE.

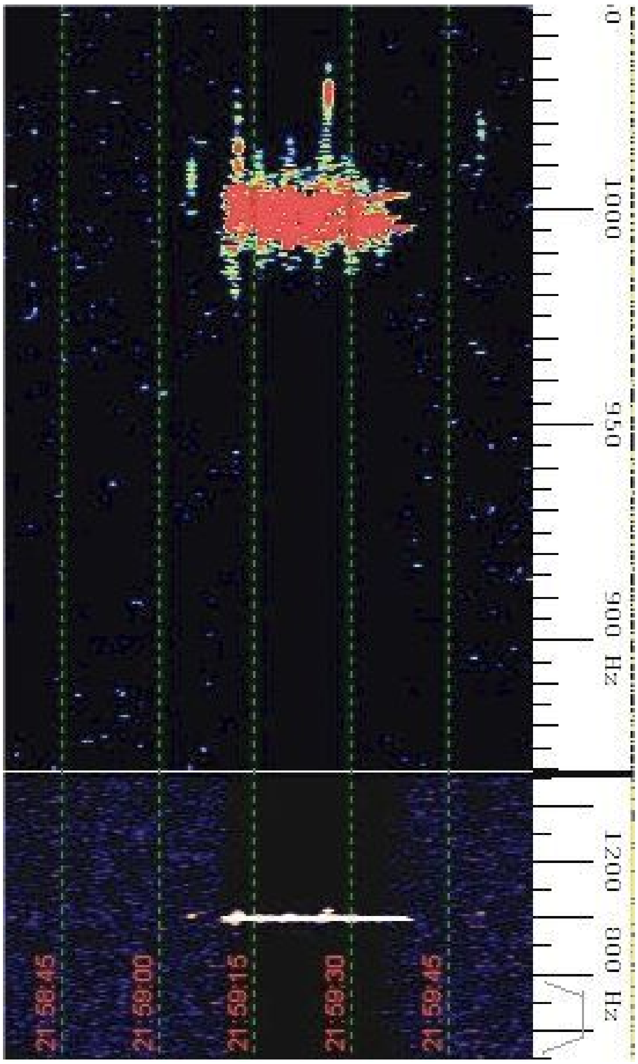

Figure 9 – Spectrogram of the event recorded by ®RECH.

The radio signal was reflected to the ground as long as the atmospheric layers were ionized by the impact of the meteoroid with the Earth's atmosphere. In *Figures 6, 7, 8 and 9* the turbulence of the trail and the persistence of the echo of the hyperdense trail are visible, the yellow and red zones indicate the signal intensity at that frequency and the doppler shift of the monitored Graves radar. In the case of the ®ROVE radio station the spectrogram is specular with respect to the others as the reception is set in LSB instead of USB.

3 The atmospheric trajectory

The astrometric measurements were either checked or even performed again in the case of the surveillance cameras. The calculations were done using different methods by the IMG team software. Only velocity differences of less than 4 km/sec between stations and triangulations with convergence angles greater than 10 degrees were considered, because small convergence angles can generate large positional errors. All triangulations were also weighed against the convergence angle taking into consideration whether or not produced by calibrated cameras or by surveillance cameras with wide-angle lenses.

By combining the video data available, it appears that the bolide became visible in the atmosphere at a height of 105.6 km over the Ligurian Sea (44.009°N, 9.265°E) and ended at 26.2 km in the sky just north-west of the city of Mondovì in Piemonte (44.429°N, 7.684°E). The map (*Figure 11*) shows, in addition to the pointing directions of the individual video stations, the projection on the ground (yellow points) of the atmospheric trajectory of the meteoroid. *Figure 10* instead shows the geometry of the atmospheric trajectory of the bolide.

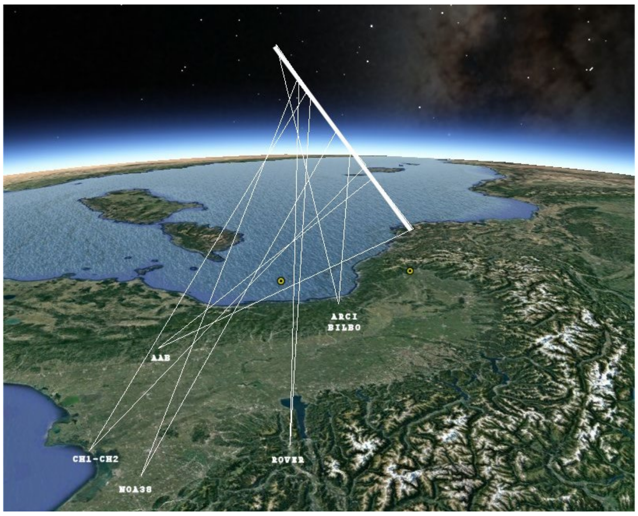

Figure 10 – Geometry of the atmospheric trajectory of the fireball as seen from the north-east.

Combining (and weighting) all the data shows that the body entered the atmosphere along the trajectory with an average speed of 33.5 km/sec, an average inclination of 32.5° with respect to the ground and an average azimuth, seen from the end point, of N_113.1°E. During the long 4.4 second path the velocity showed a progressive slowdown of about 2–3 km/sec.

[10] Graves Radar TX 47.348°N 5.516°E

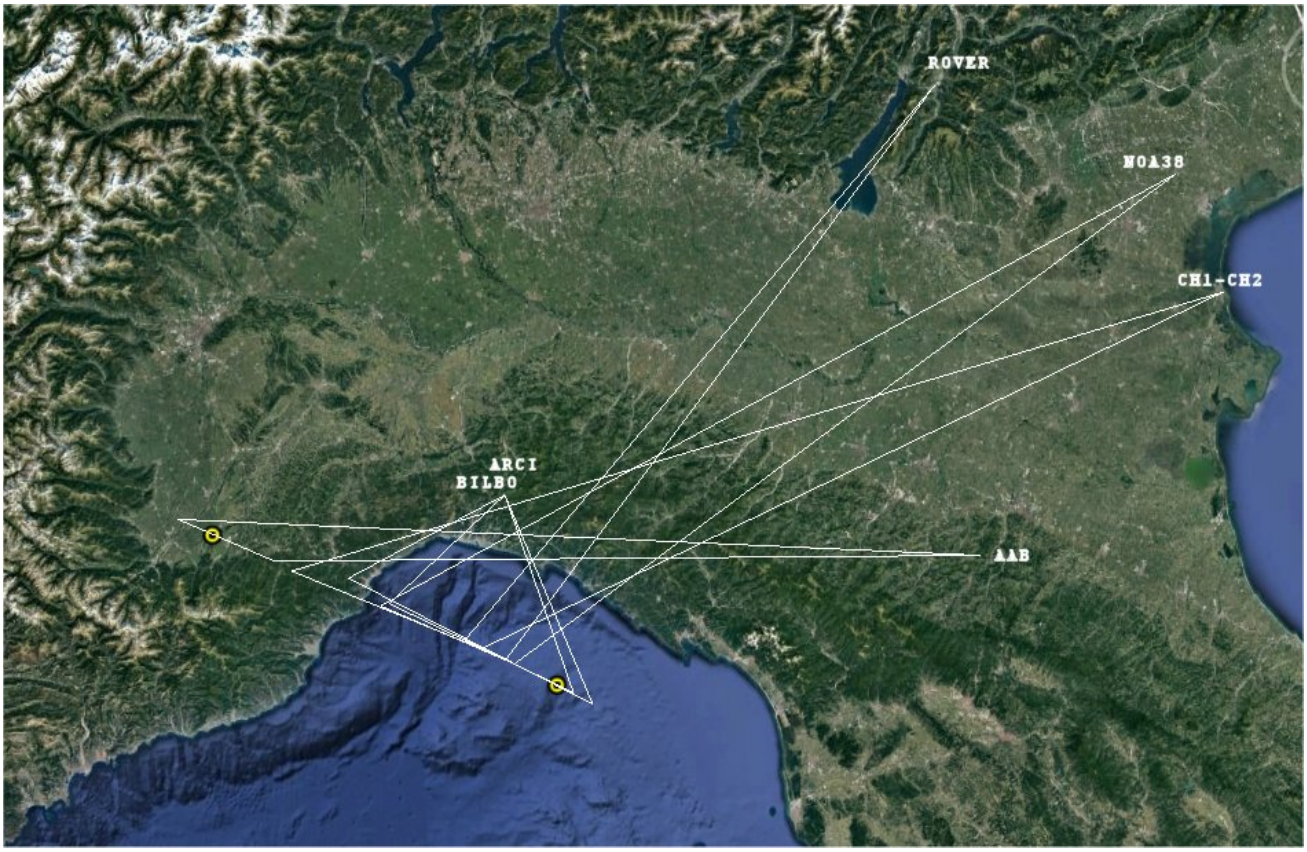

Figure 11 – Ground projection of the atmospheric trajectory of the fireball.

The radiant was found to be near the ecliptic at RA 138.7° and Dec. +8.0° (eq.2000) between the constellations of Cancer and Hydra. No known meteor shower could be associated. *Figure 12* shows the most likely orbits of the meteoroid, resulting from the best triangulations.

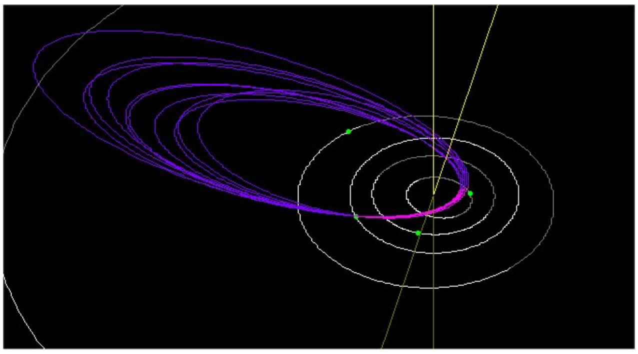

Figure 12 – Most likely orbits resulting from best triangulations.

The most probable values that describe the atmospheric trajectory and heliocentric orbit of the meteoroid are summarized below (all eq. 2000):

- Apparent radiant: RA 137.67° Decl. +8.01° (Cancer)
- Geocentric radiant: RA 138.74° Decl. +6.67°
- Apparent velocity: v_{obs} 34.18 km/sec
- Geocentric velocity: v_g 32.30 km/sec
- Heliocentric velocity: v_h 38.27 km/sec
- Semi major axis a = 2.61 AU
- Perihelion distance q = 0.302 AU
- Eccentricity e = 0.884
- Argument of perihelion ω = 118.50°
- Ascending node Ω = 124.59°
- Inclination i = 12.58°

A preliminary comparison of the orbits found with those of known cometary or asteroidal objects indicates a possible probability (D-Criterion = 0.175) of similarity with the asteroid 356394-2010QD2.

Fireball over Switzerland and Italy 2019 February 22, 02h07m34s UT

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A fireball with a trajectory of over 150 km has been registered by video cameras of the Swiss Fachgruppe Meteorastronomie as well as by FRIPON stations. The event did not match the orbital elements of any known shower and was classified as sporadic.

1 Introduction

A fast fireball appeared over Northern Italy and ended above Switzerland after travelling over 150 km through the atmosphere. The event escaped from public attention as it appeared at 3^h local time in the night. Cameras of the Swiss Fachgruppe Meteorastronomie and the French and Italian FRIPON cameras captured the fireball.

2 The available data

Clear sky allowed a good coverage of the event from many camera stations. Apart from video registrations radio meteor observers detected the echo reflection. The fireball was peculiar because of its speed and long trail and not so much for its brightness which barely reached –4 (*Figure 1, 2 and 3*). Although a moderate brightness many FRIPON stations registered the fireball allowing to calculate a very accurate orbit.

Figure 1 – The 2019 February 22, $02^h07^m34^s$ UT fireball as captured on LOC5 (West) at Locarno, Switzerland.

Figure 2 – The 2019 February 22, $02^h07^m34^s$ UT fireball as captured on LOC4 (SouthWest) at Locarno, Switzerland.

Figure 3 – The 2019 February 22, $02^h07^m34^s$ UT fireball as captured Saint-Luc, France, by FRIPON (François Colas).

List of FRIPON stations that captured this fireball (*Figure 4*):

- Sormano (22/02/2019 02:07:15 UTC)
- Aurillac (22/02/2019 02:07:16 UTC)

- Dijon (22/02/2019 02:07:16 UTC)
- Alessandria (22/02/2019 02:07:15 UTC)
- Lyon (22/02/2019 02:07:15 UTC)
- Grenoble (22/02/2019 02:07:15 UTC)
- Saintluc (22/02/2019 02:07:15 UTC)
- Barolo (22/02/2019 02:07:15 UTC)
- Au busson (22/02/2019 02:07:16 UTC)
- OHP (22/02/2019 02:07:15 UTC)
- Aubenas (22/02/2019 02:07:16 UTC)
- Chalon (22/02/2019 02:07:15 UTC)
- Moulins (22/02/2019 02:07:16 UTC)
- Lusernasangiovanni (22/02/2019 02:07:15 UTC)
- Cuneo (22/02/2019 02:07:15 UTC)
- Saintlupicin (22/02/2019 02:07:15 UTC)
- Pontarlier (22/02/2019 02:07:15 UTC)
- Lignan (22/02/2019 02:07:15 UTC)
- Lesangles (22/02/2019 02:07:16 UTC)
- Beaumontlesvalence (22/02/2019 02:07:16 UTC)
- Bedonia (22/02/2019 02:07:15 UTC)
- Sutrieu (22/02/2019 02:07:15 UTC)
- Roanne (22/02/2019 02:07:16 UTC)

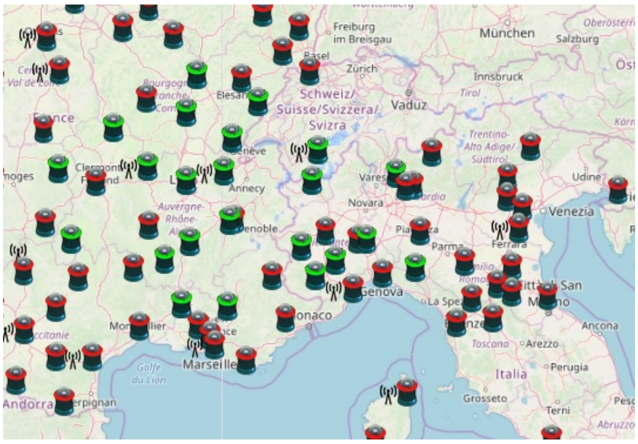

Figure 4 – The FRIPON stations that captured this fireball are marked in green.

3 The atmospheric trajectory

This fireball got in the atmosphere at an entrance angle of barely 10°. The exceptional high velocity of 64 km/s suffered rather little deceleration. The event happened between 128 km and 74 km of elevation. The beginning height is exceptional high.

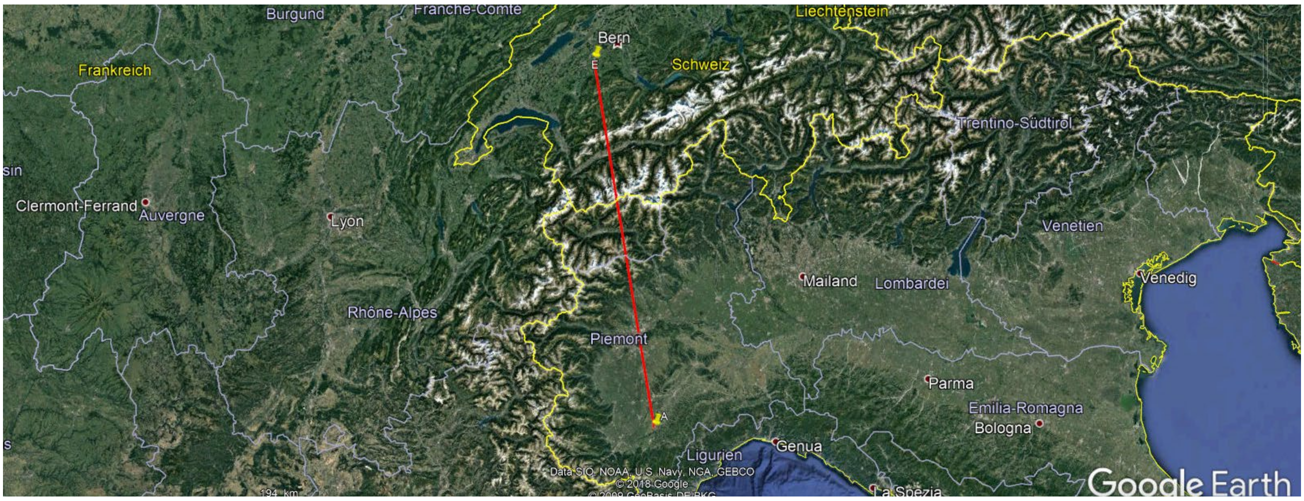

Figure 5 – The trajectory of the 2019 February 22, 02^{h}07^{m}34^s UT fireball as calculated from the FMA data.

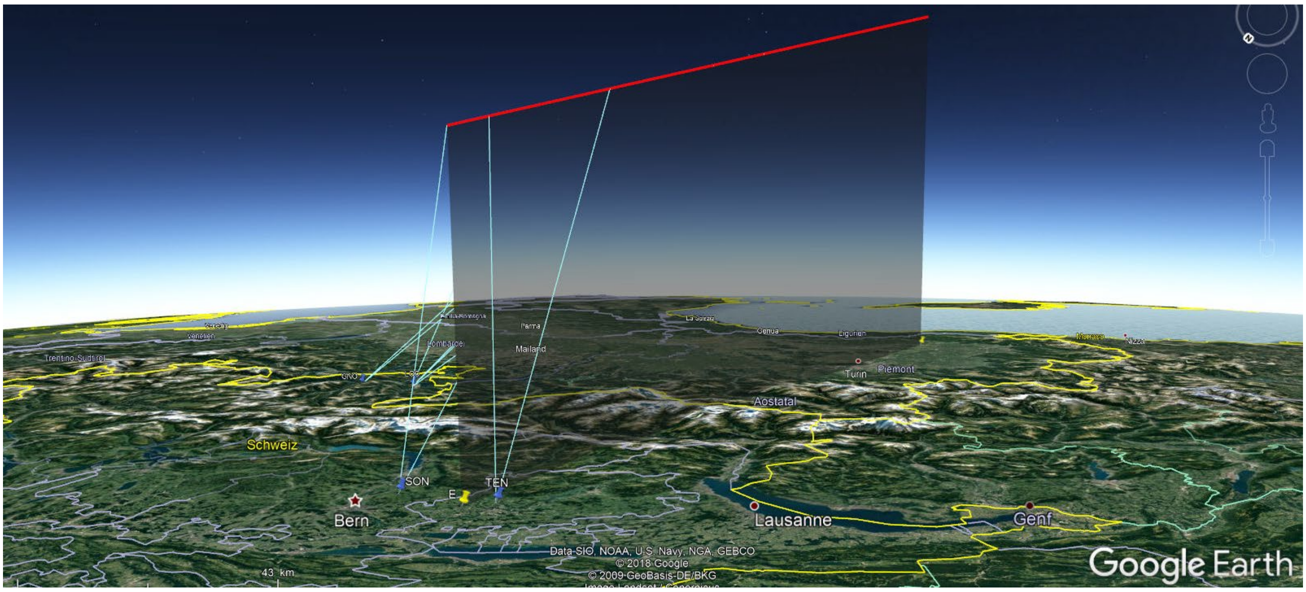

Figure 6 – The trajectory of the 2019 February 22, 02^{h}07^{m}34^s UT fireball as calculated from the FMA data.

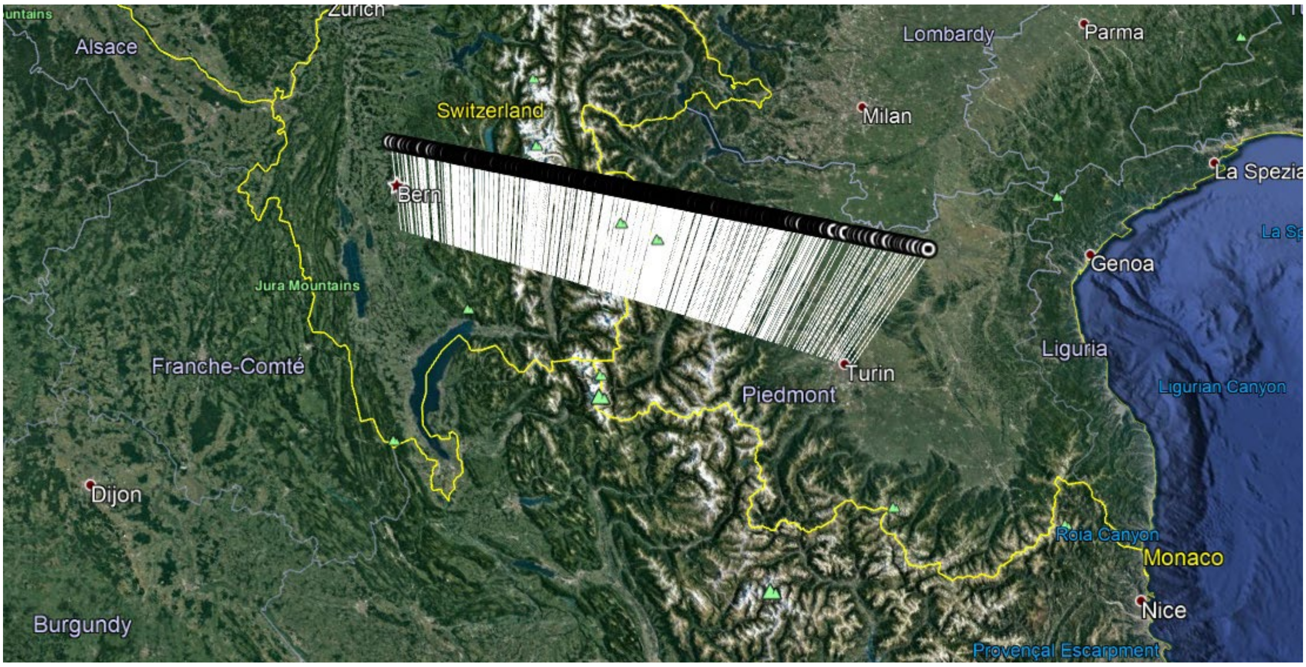

Figure 7 – The trajectory of the 2019 February 22, 02^{h}07^{m}34^s UT fireball as calculated from the FRIPON data (François Colas).

4 The orbit

The orbit calculation of the FMA data resulted in a slightly hyperbolic orbit, which may be explained because of the error margin on the velocity measurement. The FRIPON orbit has an eccentricity e just less than 1. The results are compared in *Table 1*. The fireball was most likely caused by a cometary fragment.

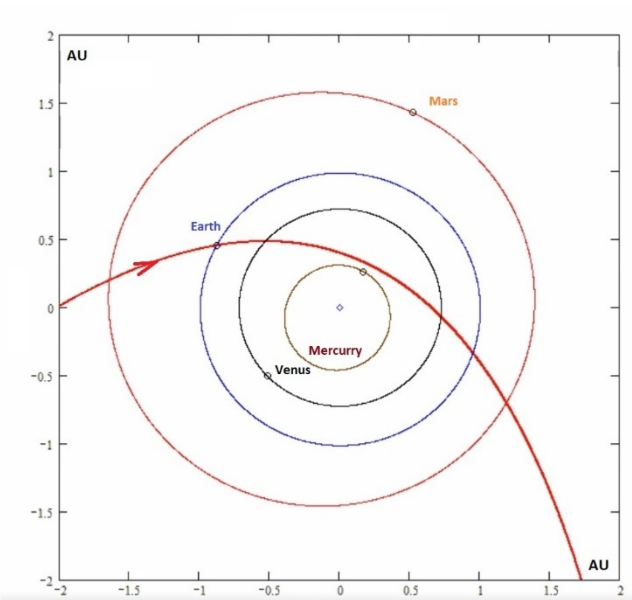

Figure 8 – Plot of the orbit based on the FMA calculations, relative to the inner planets.

The geocentric radiant based on the FMA data resulted in α_g = 202.9° and δ_g = –31.3° with a geocentric velocity v_g = 63.2 km/s. There is not any known meteor shower from the IAU Meteor shower list that matches with the orbit of this fireball and therefore it can be classified as a sporadic.

Table 1 – The orbital elements obtained by FMA compared to the result obtained by FRIPON.

	FMA	FRIPON
a	–	87.4 AU
q	0.552 AU	0.5513 AU
e	1.0004	0.9937
ω	83.32°	83.58°
Ω	152.89°	152.89°
i	131.97°	131.95°

Acknowledgment

The authors thank the FRIPON camera network for their data. The FMA results are based on the data of the following camera operators:

- *Stefano Sposetti*, Swiss Fachgruppe Meteorastronomie (FMA), Osservatorio Astronomico di Gnosca (GNO) and Locarno (LOC).
- *Dr. Thomas K. Friedli*, Swiss Fachgruppe Meteorastronomie (FMA), Observatory Sonnenturm Uecht.
- *Roger Spinner*, Swiss Fachgruppe Meteorastronomie (FMA), Observatoire géophysique Val Terbi (VTE).
- *Jochen Richert*, Swiss Fachgruppe Meteorastronomie (FMA), Observing station Bos-cha (BOS).
- *Peter Kocher*, Swiss Fachgruppe Meteorastronomie (FMA), Observing station Tentlingen (TEN).

Two fireballs over Denmark

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Two slow fireballs appeared in a week of time over Denmark, on April 8 and 15. Both orbits proved to be sporadic events. The April 15 event may have dropped a meteorite, if this was the case it must have fallen into the sea.

1 Fireball 8 April 2019

A slow moving, bright fireball appeared above Denmark on 2019, April 8 at $19^h32^m31^s$ UT. The event was seen by many casual witnesses in Denmark, Germany, Norway and the northern part of the Netherlands. Unfortunately, these reports did not allow to compute a reliable trajectory. Luckily, the meteor was recorded at four different camera stations which allowed a more accurate calculation of the trajectory in the atmosphere and its orbit[11].

Figure 1 – Image from the camera in Silkeborg, Denmark (N. Sorensen).

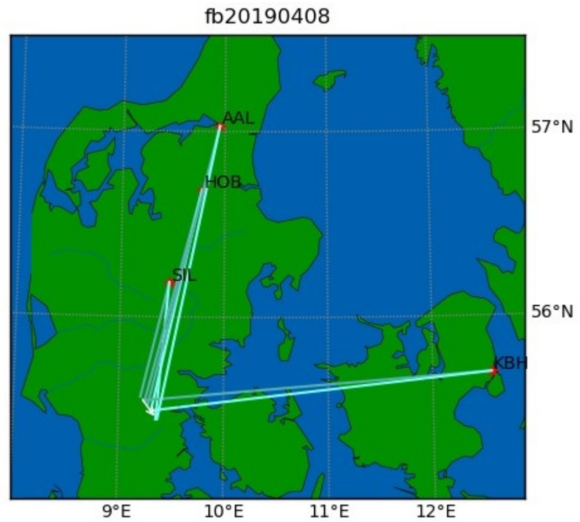

Figure 2 – The positions of the 4 cameras of the Danish Fireball Network that captured this fireball, together with the ground projected path of the meteor.

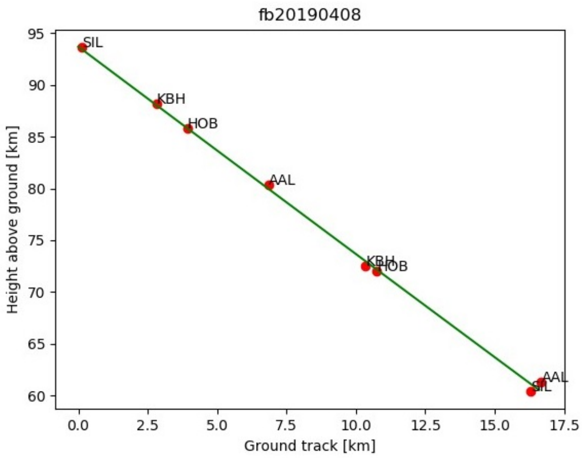

Figure 3 – The meteor height above the ground along the trajectory. Each red dot corresponds to where the track crosses a line of sight in the map (Figure 2).

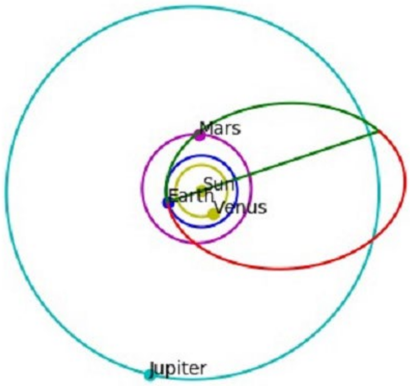

Figure 4 – Solar system with the meteoroid orbit. The green part of the orbit is above the ecliptic and red part below.

It started at 94 km and ended at 61 km altitude. The radiant position was found to be at R.A. 73.5° and decl. +69.5°, the velocity 17 km/s. The entrance angle of 63° and the end height at 61 km exclude that any meteorite survived the passage through the atmosphere. The orbit does not match with any meteor shower listed in the IAU Meteor Shower list.

- q = 0.986 A.U.
- e = 0.705
- ω = 164.3°
- Ω = 18.4°
- i = 13.7°

[11] http://www.stjerneskud.info/fireball/event2019-04-08-21-32-31/

2 Fireball 15 April 2019

A very slow moving, bright fireball appeared above Denmark on 2019, April 15 at $00^h35^m39^s$ UT. The event was recorded at three different camera stations which allowed an accurate calculation of the trajectory in the atmosphere and to obtain the orbit[12].

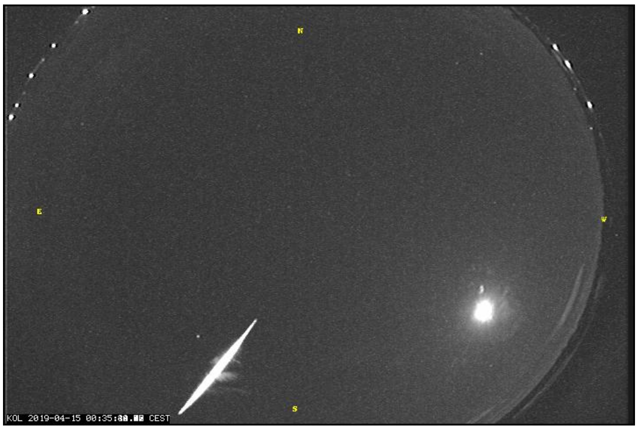

Figure 5 – Image from the camera in Kolding, Denmark.

Figure 6 – Image from the camera in Søndervig, Denmark.

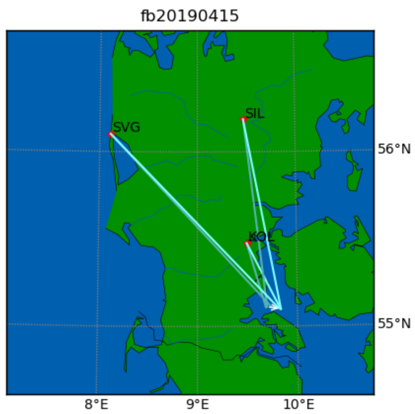

Figure 7 – The positions of the 3 cameras of the Danish Fireball Network that captured this fireball, together with the ground projected path of the meteor.

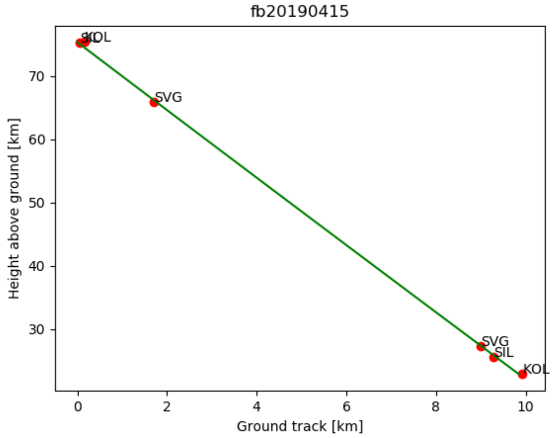

Figure 8 – The meteor height above the ground along the trajectory. Each red dot corresponds to where the track crosses a line of sight in the map above (Figure 7).

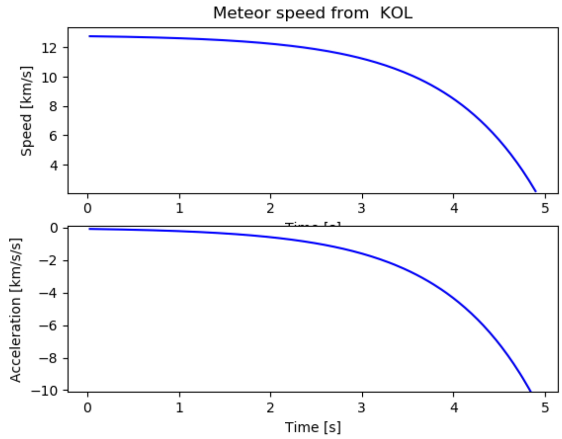

Figure 9 – The variation of the velocity in km/s, during the flight of the fireball (top). The deceleration in km/s/s during the flight of the fireball (bottom).

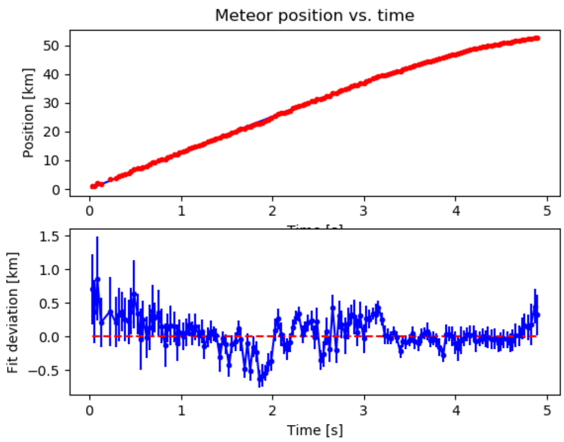

Figure 10 – The position of the fireball in function of time during its flight (top), the error margins on the measured positions relative to the linear fit (bottom).

[12] http://www.stjerneskud.info/fireball/event2019-04-15-00-35-39/

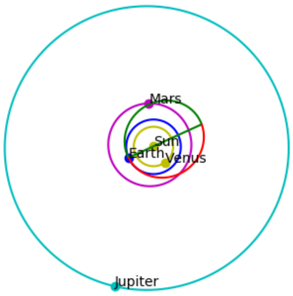

Figure 11 – Solar system with the meteoroid orbit. The green part of the orbit is above the ecliptic and red part below.

It started at 75 km and ended at 23 km altitude. The radiant position was found to be at R.A. 163.2° and decl. +56.0°, the velocity 13 km/s. The steep entrance angle of 80°, the low velocity and the end height at 23 km suggest that a meteorite may have survived the passage through the atmosphere. If this was the case, it must have dropped in the sea. The orbit does not match with any meteor shower listed in the IAU Meteor Shower list.

- q = 1.000 A.U.
- e = 0.324
- ω = 189.4°
- Ω = 24.4°
- i = 7.5°

Bright daylight fireball April 6, 2019 above Krasnoyarsk, Russia

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A description of the fireball event is given based on several witness reports.

1 Introduction

Galina Ryabova pointed our attention at a recent daylight fireball event in Russia[13,14,15]. On Saturday, April 6, 2019 around 18^h50^m local time the residents of Krasnoyarsk noticed a bright fireball moving through the sky. Some witnesses heard a noise like the sound of an airplane. The fireball dissolved in the sky and apparently nothing reached the ground. A few weeks ago, on March 15, a similar fireball was observed in the same region over Evenkia.

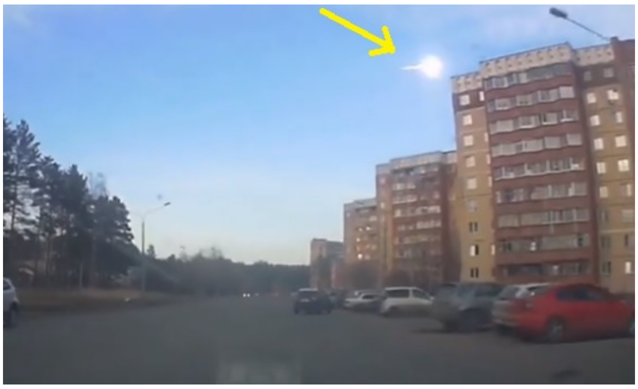
2 Some witness reports

The event was recorded on many mobile phones and dash cams. People were wondering what they saw and discussed the videos they shared on social networks. Most people were aware that it was an exceptional bright meteor, and some recalled the Evenki meteorite that fell in March.

Astronomer Vladimir Surdin, an associate professor at Moscow State University, commented that the luminous object was indeed a celestial body, a large meteoroid that entered the Earth atmosphere as a bright meteor. Thanks to the many video cameras, not a single meteor like this can pass unnoticed. The information collected by cameras is very important for science.

According to the testimony of Andrey Brownovsky in Krasnoyarsk, the object crossed the sky with great speed and had a long tail. Another resident of Krasnoyarsk, Dmitry Dmitriev, says that the object displayed a greenish light. The fireball moved so fast that most eyewitnesses had no time to take a camera to make a video or to take photos. "*I thought maybe it is a plane that was on fire. While I was getting the phone out of my pocket, it already disappeared. Most likely, it must have been a meteor*" concluded Tatiana Stanovova, a resident of Solnechny.

The fireball was also observed by residents of Kansk and the Ilan district. In social networks, residents of these settlements mentioned: "*It appeared blinding comparable to a welding arc. Before disappearing, it broke up into small objects.*" Sergey Kulishnev, a resident of Kansk, says that the fall of the object was accompanied by sound. Svetlana Sorokina reported: "*It flashed and burned in the sky in front of my eyes. A very bright white and green ball, fiery, followed by a dotted line – three parts of the tail, just as bright, parallel to the ground. It did not fall but all burned. I realized that I saw it, but I hadn't the time to record it.*"



The cosmic guest was also noticed in other cities of the region, in Lesosibirsk and Zheleznogorsk. A bright white dot, then a flash of fire – it all took a fraction of a second. "*We were leaving the Planet shopping center,*" said Komsomolskaya Pravda, "*and it flew right over our heads at a gigantic height. I saw this only on the Internet, but here it happened live … it flew from the north, in the direction of the right bank of the Yenisei.*"

[13] https://www.krsk.kp.ru/daily/26963.5/4017729/
[14] https://www.gismeteo.ru/news/proisshestviya/31238-v-nebe-nad-krasnoyarskom-zametili-meteorit-video/?utm_source=gismeteo&utm_medium=rss_feed&utm_campaign=news
[15] https://ngs24.ru/news/more/66045061/

Virginid fireball over Spain

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An overview is presented of the exceptional fireball events by the meteor observing stations operated by the SMART Project (University of Huelva) from Sevilla and Huelva during April 2019.

1 Fireball 2019 April 12

On 2019 April 12, at $3^h06^m47^s$ UT, a fireball was spotted over Spain. It was produced by a meteoroid from the Virginids that hit the atmosphere at about 65000 km/h. The peak absolute magnitude of the bolide was of about –10. It began over the province of Cáceres at an altitude of about 91 km, and ended over the province of Ávila at a height of around 35 km.

The event was recorded in the framework of the SMART project (University of Huelva)[16], operated by the Southwestern Europe Meteor Network (SWEMN), from the meteor-observing stations located at La Hita (Toledo) and Sevilla.

Figure 1 – The fireball of 2019 April 12, at $3^h06^m47^s$ UT.

[16] https://youtu.be/QSOywclDUhg

I still can’t believe we’ve got a meteor camera on our roof!

Anita Kapila

Leader of the Elite Scientists, William Perkin Church of England High school, Greenford, Middlesex, United Kingdom

UKMON teamed up with Natural History Museum and helped young scientists discover astronomy and introduced a meteor detection camera to William Perkin school.

1 Introduction

That’s the thought I have all the time when I think about what we have at William Perkin Church of England High School. A few years ago, I met Dr Ashley King from the Natural History Museum (NHM), who had seen some of the students work at the Imperial Festival in the summer of 2016. We applied for a Royal Society Partnership grant of £1,500 together and subsequently won that. That then enabled our school to buy all the equipment needed to set up a meteor camera on the roof of our school!!! AMAZING!! Dr Ashley King, Richard Kacerek (UKMON), Helena Bates (NHM), Peter Campbell Burns (UKMON) and Enrica Bonato (NHM), came to set up the camera, and since then we have had beautiful pictures and films of meteors and fireballs. Subsequently, the photos were analyzed using special UFO (still makes me laugh!), software, the chosen 15 Elite Scientist students (aged 11-14), had to learn how to analyze the data, which was a great skill for them to acquire. All of the above mentioned, were so wonderful to us, giving us their time, expertise, and help whenever we had problems. To this very day, I still ask for help from Richard, Peter, and Ashley, and they never turn me away, always willing to help me get the system back on track. Just this week, I was complaining about the fact that we had not seen any meteors since January, and Richard helped us with the settings, and we are seeing beautiful meteors again. My dream is that our school get a giant fireball that is seen around the world!

Figure 1 – Introducing students to the meteor project.

Figure 2 – UKMON and NHM teams at William Perkin school installing the camera.

The students got to present their work, at the Royal Society Partnership grant conference, Natural History Museum, and the Imperial Festival 2017. These kinds of experiences of which there are many will help the students in their future when they apply for college and university places and jobs. To this very day, we are still taking pictures of meteors, although we are not able to analyze the data at the moment, as the students are currently working on a long project which is very different! We do however share our data of fireballs with NHM and UKMON if we get any! I am still keen to get the other three schools in The Twyford Trust involved with UKMON so that they can also experience what we have. I’m also keen for our data to be shared within a countrywide/ Europewide network, and vice versa. I am sure that will happen one day. Thank you to all of the Natural History Museum and UKMON teams for all the richness you have brought our school.

We look forward to continuing our work with you in the future.

Figure 3 – From left Helena Bates (NHM), Enrica Bonato (NHM), Richard Kacerek UKMON), Peter Campbell-Burns(UKMON), Anita Kapila (William Perkin school), Dr. Ashley King (NHM).

Figure 4 – Elite scientists at the school talking about the project.

Figure 5 – Peter Campbell-Burns from UKMON is explaining meteors to students.

Figure 6 – Anita Kapila and the elite students from William Perkin school.

Figure 7 – Dr. Ashley King giving a talk on what are meteors.

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