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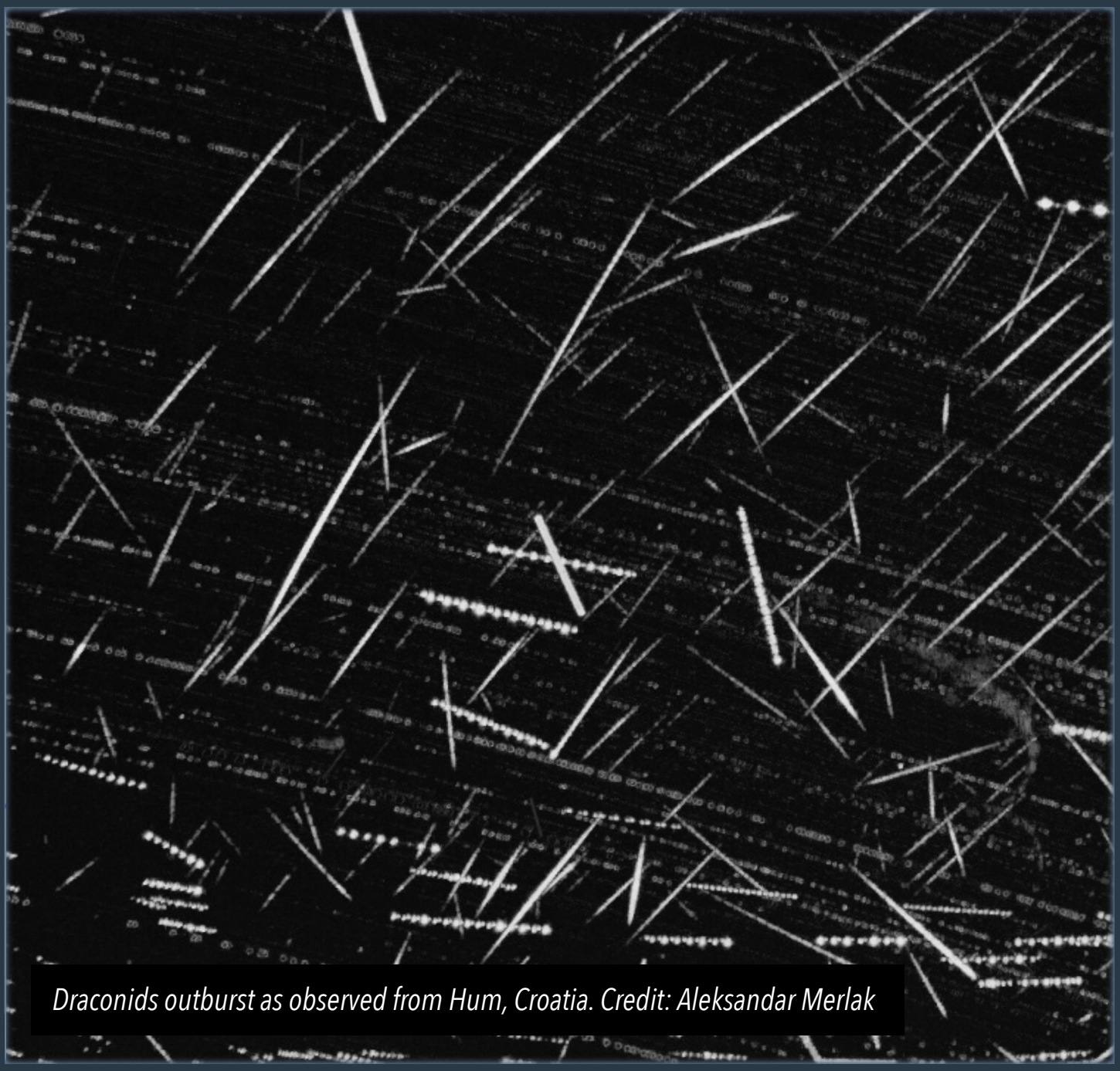

Draconids outburst as observed from Hum, Croatia. Credit: Aleksandar Merlak

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- 2017 Report BOAM
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Zeta Cassiopeiids (ZCS-444)

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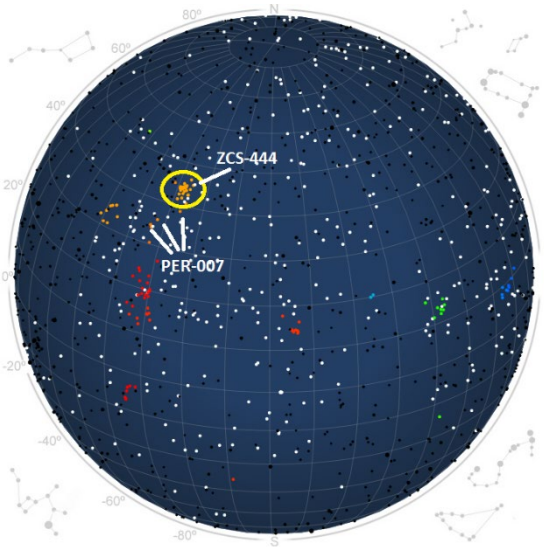
A case study on the Zeta Cassiopeiids proves that this shower qualifies all criteria to be recognized as an established shower. Yearly activity has been detected with an indication for some long-term periodicity. The time of maximum activity could be established at solar longitude 112.75° with a secondary maximum at solar longitude 114.5°. All shower characteristics are identical to the nearby Perseid shower although ζ-Cassiopeiids are likely older. Both showers may be related to a common origin.

1 Introduction

The global CAMS network results of 15 July 2018 displayed a remarkable concentration of radiants identified as Zeta Cassiopeiids (ZCS-444). The position and velocity can be easily mistaken for early Perseids, but real early Perseids have a slightly higher velocity and radiants south of these Zeta Cassiopeiids (ZCS-444), see *Figure 1*.

The remarkable large number of these Zeta Cassiopeiid radiants inspired the authors to make a case study on this shower which is still not listed as an established meteor shower in the IAU working list of meteor showers.



2 ZCS (444) history

This shower was discovered in 2012 by the Croatian Meteor Network from a radiant analysis on the 853 orbits collected in 2007 which failed association with any known meteor stream (Šegon et al., 2012). The discovery followed a detailed analysis of the 2007 CMN orbit data and CMN data of the following years as well as on the available SonotaCo orbit data. As many as 55 orbits fulfilled the Southworth and Hawkins discrimination criteria $D_{SH} < 0.15$ and allowed the computation of an accurate reference orbit, radiant drift as well as other shower characteristics.

At about the same time when the CMN-team revealed the presence of the ζ-Cassiopeiids from its orbit catalogue, the Polish Comets and Meteors Workshop published a paper with their data on this new shower (Żołądek and Wiśniewski, 2012). On July 14–15, 2005 Polish visual observers had noticed a large number of bight meteors radiating from a position slightly west of the expected early Perseid radiant, close to the star ζ-Cassiopeiae. A remarkably high number of meteors were captured on the Polish video cameras, including a spectacular fireball, with about half of all these meteors coming from a common radiant. 20 members of a potential new shower were found in the records of three PFN stations. Almost all meteors were captured after 23^h UT, some of them in the morning twilight. The Polish observers concluded in 2005 they observed an outburst of this new unknown radiant. Unfortunately, due to unfavorable geometrics no accurate orbit could be derived for the new shower.

The ZCS#444 shower was also confirmed by the shower search on the CAMS orbits obtained in 2011 and 2012 (Jenniskens et al., 2016). Strange enough, it is still waiting to be recognized as an established meteor shower despite the weight of evidence for the existence of this shower.

The photographic meteor orbit catalogue with 4873 accurate photographic orbits obtained between 1936 and 2008 resulted in only eight possible ζ-Cassiopeiids orbits, in 1953, 1956, two in 1958, 1959, 1965, 1969 and 1979. Four of these orbits match the ζ-Cassiopeiids parent orbit within a high threshold D-Criterion. The Harvard radar orbit catalogues 1961–1965 and 1968–1969 (Hawkins, 1963) contain only one orbit with a high threshold of $D_D < 0.04$. The rather small number of ζ-Cassiopeiid orbits collected before the large-scale video meteor observing networks got started explains why this shower wasn't noticed earlier.

3 The available orbit data

We have the following data, status as until July 2018, 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 257010 orbits (2007–2017). SonotaCo is an amateur video network with over 100 cameras in Japan (SonotaCo, 2009).
- CAMS with 111233 orbits (October 2010 – March 2013), (Jenniskens et al., 2011). For clarity, the CAMS BeNeLux orbits April 2013 – July 2018 are not included in this dataset because this data is still under embargo.

Altogether we can search among 686073 video meteor orbits. The methodology has been explained in a previous series of shower analyses (Roggemans and Johannink, 2018; Roggemans, 2018; Roggemans and Campbell-Burns, 2018a, 2018b, 2018c, 2018d).

4 Orbit selection

In a first approach the entire dataset was searched for orbits similar to the ZCS reference orbit from literature in order to determine the minimum and maximum values for a selection on [$\lambda_\odot$, α_g, δ_g, v_g]. This resulted in a selection of orbits within the following intervals:

- Time interval: $97° < \lambda_\odot < 125°$;
- Radiant area: $350° < \alpha_g < 22°$ & $+41° < \delta_g < +60°$;
- Velocity: $51 \text{ km/s} < v_g < 62 \text{ km/s}$.

In total 3149 orbits were selected. The median values of this first selection were used as parent orbit to calculate the discrimination criteria for all individual orbits. We apply three discrimination criteria to evaluate the similarity between the individual orbits and the parent orbit. The D-criteria used are these of Southworth and Hawkins (1963), Drummond (1981) and Jopek (1993). We consider four different threshold levels of similarity:

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

The median values of the orbits with $D_D < 0.04$ were taken as new parent orbit to recalculate the D-criteria and this procedure was repeated a second time to have a best reference orbit. The final resulting median values for the low threshold criteria is presented in *Table 1* for each sub-dataset, CAMS, EDMOND and SonotaCo and the median values for each threshold level are listed in *Table 2*.

Although all 3149 selected orbits produced meteors that would appear to be a perfect match as ζ-Cassiopeiid, with the right speed and direction for a single station observer anywhere, a remarkably high proportion of these look-a-likes fail to fulfill even the weakest D-criteria. The nearby early Perseid radiant may explain to some extent the important sporadic or rather other shower contamination of the selection. This explains why this shower remained 'invisible' for visual observers until the small outburst in 2005 caught the attention of the Polish team. It is a pity that no performant camera networks were active at the time of the reported outburst (2005).

Table 1 – The median values for each sub-set of orbits that fulfill D_D<0.105, CAMS, SonotaCo and EDMOND, all combined orbits and the final parent orbit derived for $D_D < 0.04$.

	CAMS	SonotaCo	Edmond	All	Final parent
$\lambda_\odot$	114.1°	114.6°	114.6°	114.6°	113.7°
α_g	8.2°	9.1°	9.5°	9.1°	7.7°
δ_g	+51.2°	+51.3°	+51.4°	+51.3°	+51.1°
v_g	57.2	57.4	56.9	57.1	56.9
a	13.7	12.6	9.4	10.6	13.0
q	0.992	0.992	0.991	0.992	0.995
e	0.943	0.953	0.906	0.923	0.923
ω	162.0°	161.8°	161.5°	161.7°	163.1°
Ω	114.0°	114.6°	114.6°	114.6°	113.7°
i	107.5°	107.9°	107.6°	107.6°	107.3°
N	213	357	798	1368	264

Table 2 – The median values for the final selection of orbits with four different threshold levels on the D-criteria, compared to the reference orbit from literature (Jenniskens et al., 2018).

	Low	Medium low	Medium high	High	Reference (2018)
$\lambda_\odot$	114.6°	114.1°	113.7°	113.7°	111.5°
α_g	9.1°	8.5°	7.8°	7.7°	5.1°
δ_g	+51.3°	+51.2°	+51.0°	+51.1°	+50.2°
v_g	57.1	57.1	57.1	56.9	57.1
a	10.6	11.8	12.6	13.0	12.8
q	0.992	0.994	0.995	0.995	0.996
e	0.923	0.925	0.926	0.923	0.946
ω	161.7°	162.4°	163.1°	163.1°	164.0°
Ω	114.6°	114.1°	113.7°	113.7°	111.5°
i	107.6°	107.6°	107.5°	107.3°	107.1°
N	1368	884	541	264	445
S	*57%*	*72%*	*83%*	*92%*	

With a rich sporadic background activity mixed with widely scattered early Perseids in the suspected region of the sky, the question arises if there is really another shower present, or whether this is a spurious combination of look-alike orbits? When we plot the inclination i against the length of perihelion Π for all our 3149-selected candidate ζ-Cassiopeiids orbits, we see a distinct and compact concentration (*Figure 2*), which indicates the presence of a real concentrations of similar orbits at this position.

Could these ζ-Cassiopeiids be somehow related to the Perseids which have their maximum activity about 4 weeks later? Applying our D-criteria with the Perseid reference orbit as parent orbit for the 3149-selected candidate ζ-Cassiopeiids orbits did not have any single orbit that fulfilled the D-criteria. The Perseids have an inclination about 6° higher than the ζ-Cassiopeiids, but the main difference is in the length of perihelion Π with 277° for ζ-Cassiopeiids against 289° for Perseids, with a difference in the argument of perihelion of about 14° less and 26° more in the ascending node for the Perseid orbit. The separation in time is too large between both meteor streams to find any association based on D-criteria.

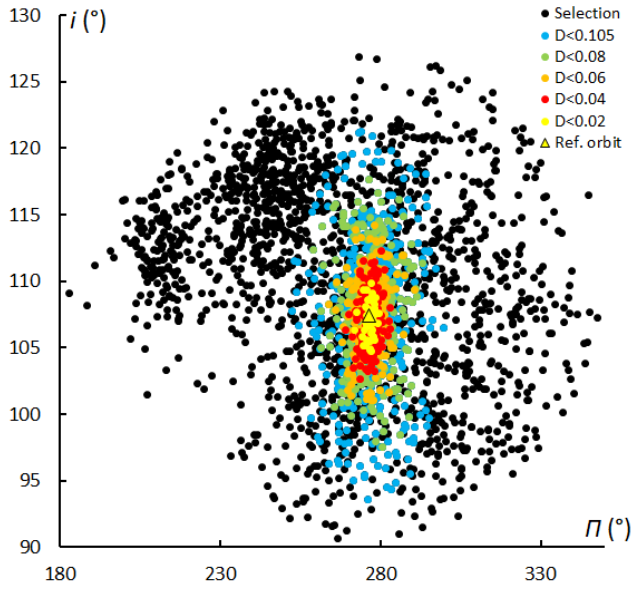


Figure 2 – The plot of inclination i (°) against the length of perihelion Π (°) for the 3149 selected possible ZCS-orbits. The colors mark the different threshold levels of the D-criteria relative to the final parent orbit listed in Table 1.

5 Case study ZCS-444: results

The 1368 probable ZCS-orbits that fulfill the minimal threshold represent only 43% of the 3149 selected orbits. In other words, less than one in two meteors that look like a ζ-Cassiopeiid for an observer has an orbit that is like the ζ-Cassiopeiid orbit while the other is a sporadic lookalike. With the early Perseid radiant nearby it is obvious why these meteors cannot be properly identified from single station observations. This implies that past single station radiant determinations for early Perseids will be strongly contaminated by these ζ-Cassiopeiids.

With the current availability of a statistically significant number of orbits the shower characteristics of the ζ-Cassiopeiids can be determined.

Activity period and maximum

The first possible ζ-Cassiopeiid orbit has been detected at $\lambda_\odot$ = 101°, the last one at $\lambda_\odot$ = 125° with the main activity detected between $\lambda_\odot$ = 110° and $\lambda_\odot$ = 118°, about July 12 and July 21. Maximum occurred at ~ $\lambda_\odot$ = 112.75° or July 15–16. The CAMS BeNeLux network had clear nights around this time and could collect plenty of ζ-Cassiopeiid orbits. In this case study we do not use any 2018 data, but the long-term orbital data obtained from 2006 until 2017 by camera networks across the globe.

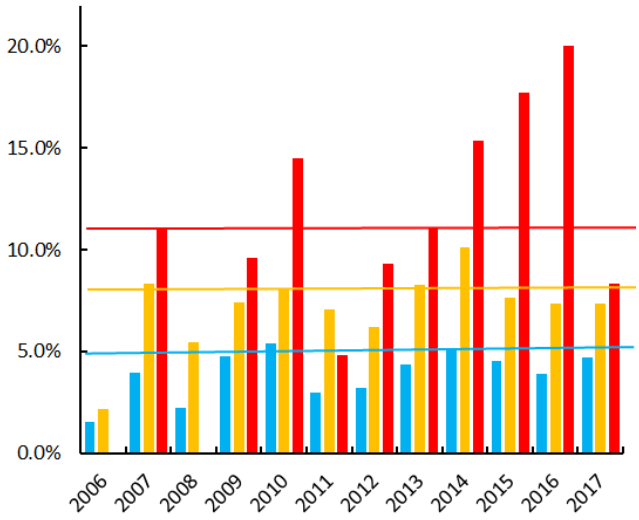


Figure 3 – The percentage of ZCS orbits relative to the total number of orbits obtained per year for different intervals of its activity period: Total activity period (D_D < 0.105, blue), the main activity period (110° < $\lambda_\odot$ < 118°, orange) and the maximum at $\lambda_\odot$ = 112.75°± 0.25° (red).

When the ζ-Cassiopeiids were noticed the very first time by dedicated visual observers in Poland in 2005 the activity level was described as an outburst. The Polish team checked its visual records 1996–2000 and did not find any activity above the level corresponding to a Zenithal Hourly Rate of 2. If the ζ-Cassiopeiids produced a real outburst in 2005 this might be an indication for some periodicity. It makes no sense to calculate ZHR values for minor showers. Counting the number of orbits identified as ζ-Cassiopeiids for each year of our dataset already confirms the annual activity. The absolute numbers are affected by variable weather circumstances and different observing capacities from year to year. To eliminate these factors, we use the total number of orbits registered per time interval to calculate the relative strength of the ζ-Cassiopeiids as a percentage of the total number of orbits registered in each period of time.

The relative activity for each year is presented in *Figure 3*. For the complete activity period 100° < $\lambda_\odot$ < 125°, with dispersed shower orbits, 3.9% of all orbits fulfill the low threshold D-criteria for the shower. For the main activity period 110° < $\lambda_\odot$ < 118°, as many as 7.5% of all orbits match with the ZCS parent orbit. Considering a period of ±6 hours around the time of maximum activity at $\lambda_\odot$ = 112.75° the percentage reached 20% in 2016 while in 2011 the relative activity level was only 4.8% of all orbits with a statistical relevant number of orbits collected that year. Such strong variation from one year to another may indicate some periodic variation in strength, however the available data does not yet allow further details to be determined. With 11.5% of all orbits during the ζ-Cassiopeiids maximum belonging to this shower the activity should easily catch the attention of any experienced meteor observer.

The number of orbits per degree of solar longitude collected by all networks worldwide over a period of 12 years offers a way to reconstruct the activity profile. In *Figure 2* we see the dispersion on the orbits in inclination against length of perihelion. The further away from the center of the stream (parent orbit), the weaker the D criteria. In *Figure 4* we display the number of orbits per degree of solar longitude for each threshold level of D-criteria. These absolute numbers based on a large mixture of data collected over a long period of time (12 years) may have smoothed out influences such as zenith distance of the radiant, different observing circumstances, etc. To eliminate the effect of observing circumstances we use the total number of orbits collected in the considered time lapse to consider the relative activity as a percentage of the total number of orbits collected. In *Figure 5* we reproduce the result for the four threshold levels. The shape of the profile is about the same as in *Figure 4* with the absolute numbers.

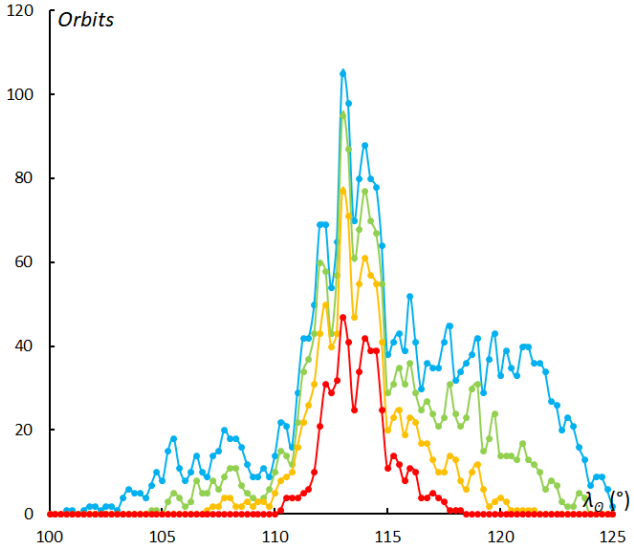


Figure 4 – The number of ζ-Cassiopeiids orbits collected per degree of solar longitude $\lambda_\odot$ during the period 2007–2017 with blue for $D_D < 0.105$, green for $D_D < 0.08$, orange for $D_D < 0.06$ and red for $D_D < 0.04$.

The profile starts with low activity with low threshold orbits with a distinct main activity from $\lambda_\odot = 110°$ until $\lambda_\odot = 118°$. Peak activity is reached at $\lambda_\odot = 112.75°$ followed by a dip and a secondary maximum at $\lambda_\odot = 114.5°$. The 'shoulder' of the activity profile after the maximum may be contaminated by early Perseids that fulfill the low and medium low threshold D-criteria for the ZCS parent orbit. In *Figure 6* we display the average value for the geocentric velocity v_g and the inclination i for each degree of solar longitude. The orbits in the right wing of the profile of *Figures 4 and 5* include more particles with a higher geocentric velocity and higher inclination. These faster particles with higher inclination are likely early Perseids that fulfill the low and medium low threshold for the ZCS parent orbit. Żołądek and Wiśniewski (2012) made a similar graphic but comparing the ZCS average geocentric velocities with those of real early Perseids. The ζ-Cassiopeiids fade away when the early Perseids move on the foreground.

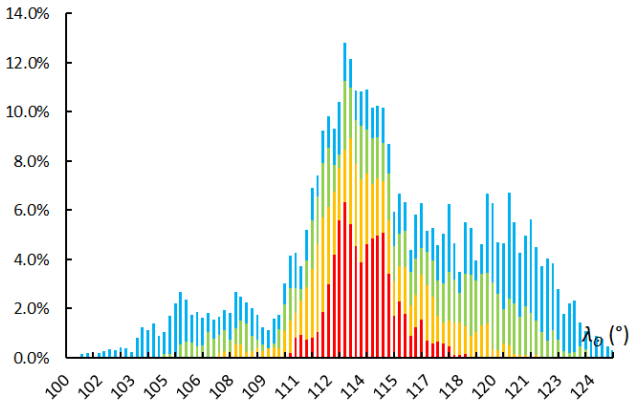


Figure 5 – The relative number of ζ-Cassiopeiids orbits collected per degree of solar longitude $\lambda_\odot$ during the period 2007–2017, with blue for $D_D < 0.105$, green for $D_D < 0.08$, orange for $D_D < 0.06$ and red for $D_D < 0.04$, as percentage of the total number of orbits collected in the same time span.

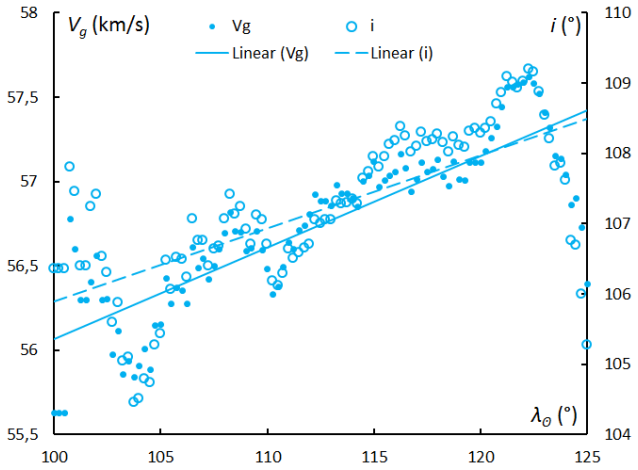


Figure 6 – The average values for the geocentric velocity v_g and the inclination i per degree of solar longitude. The increase of both values indicates contamination of the post maximum activity with early Perseids that fit low threshold D-criteria with the ZCS parent orbit.

Radiant position, size and drift

The radiant drift has been calculated for the 4 different threshold levels, the results are listed in *Table 3*, including the standard deviation. The low threshold orbits (blue) appear mainly dispersed ahead over a long period of time while the high threshold orbits are concentrated in the main activity period of the shower. The very high threshold orbits ($D_D < 0.02$) are marked in yellow (*Figures 7 and 8*).

Table 3 – Radiant drift with ± σ for the ζ-Cassiopeiids obtained from the orbits for each threshold level of the D-criteria.

Threshold level	ZCS – 444	
	$\Delta\alpha / \lambda_\odot$	$\Delta\delta / \lambda_\odot$
Low	1.27 ± 0.02	+0.36 ± 0.01
Medium low	1.32 ± 0.02	+0.36 ± 0.02
Medium high	1.40 ± 0.03	+0.30 ± 0.02
High	1.43 ± 0.05	+0.28 ± 0.05

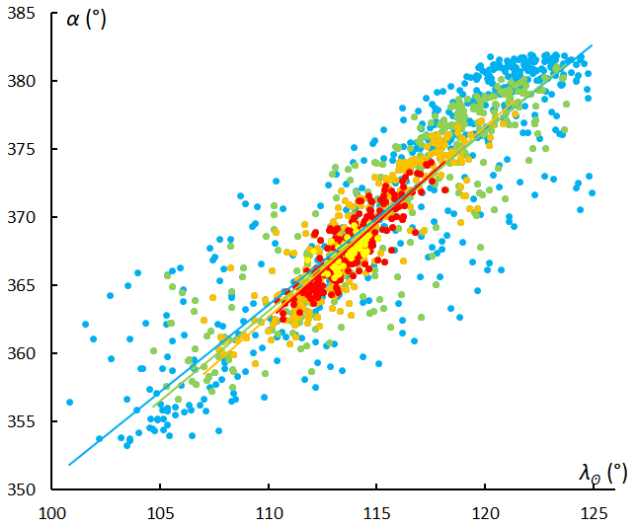


Figure 7 – Radiant drift in Right Ascension α against solar longitude $\lambda_\odot$. The different colors represent the 5 different levels of similarity, blue for $D_D < 0.105$, green for $D_D < 0.08$, orange for $D_D < 0.06$, red for $D_D < 0.04$ and yellow for $D_D < 0.02$.

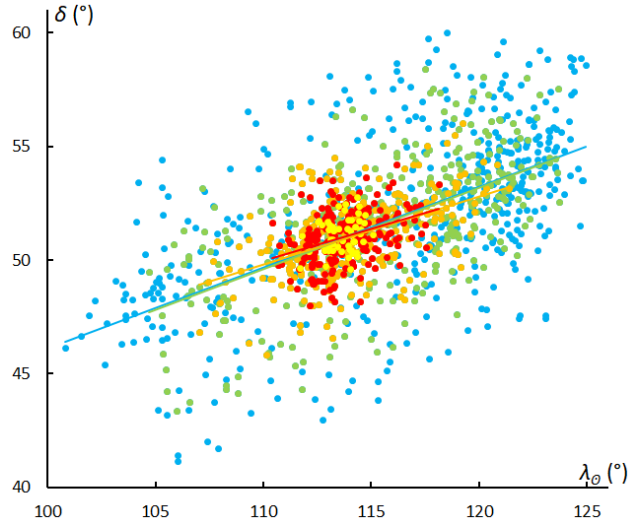


Figure 8 – Radiant drift in declination δ against solar longitude $\lambda_\odot$. The different colors represent the 5 different levels of similarity, blue for $D_D < 0.105$, green for $D_D < 0.08$, orange for $D_D < 0.06$, red for $D_D < 0.04$ and yellow for $D_D < 0.02$.

The values for radiant drift are in very good agreement with previous studies. Żołądek and Wiśniewski (2012) found $\Delta\alpha / \lambda_\odot = 1.9$ and $\Delta\delta / \lambda_\odot = +0.4$. Šegon et al. (2012) found $\Delta\alpha / \lambda_\odot = 1.4$ and $\Delta\delta / \lambda_\odot = +0.5$. Jenniskens et al. (2016) published $\Delta\alpha / \lambda_\odot = 0.95$ and $\Delta\delta / \lambda_\odot = +0.4$. These results show a radiant which moves fast north east and this is confirmed by our results in *Table 3*.

The radiant drift is effectively valid for most ZCS orbits. When we compare the scattered positions of the 3149 uncorrected radiant positions in *Figure 9* with the radiant drift corrected positions in *Figure 10*, the sporadic radiants (black) gets even more dispersed while the ζ-Cassiopeiids contract into a rather compact radiant. The same picture emerges from the plot of the ecliptic latitude β against the Sun centered longitude $\lambda - \lambda_\odot$ (*Figure 11*).

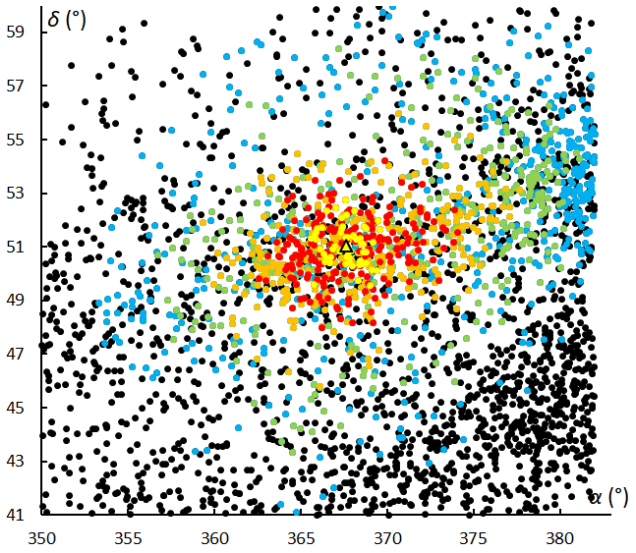


Figure 9 – Plot of the 3149 uncorrected radiant positions as selected. The different colors represent the 5 different levels of similarity according to different threshold levels in the D-criteria.

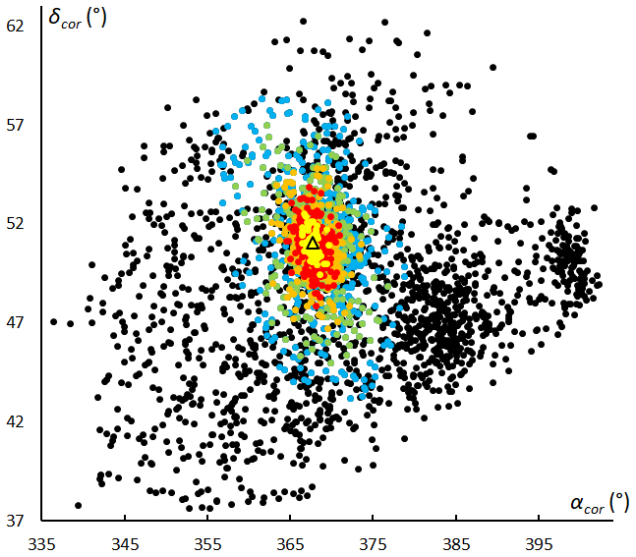


Figure 10 – Plot of the radiant drift corrected radiant positions. The different colors represent the 5 different levels of similarity.

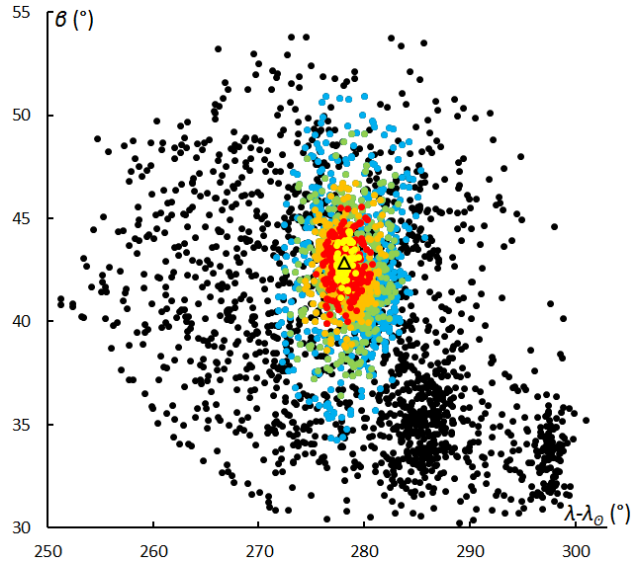


Figure 11 – Plot of the ecliptic latitude β against the Sun centered longitude λ – λ⊙. The different colors represent the 5 different levels of similarity.

Other shower characteristics

The elevation of the ablation of meteors depends mainly on two factors; the entry velocity and the structure and composition of the meteoroid particle. ZCS meteors being rather fast meteors with ~57 km/s have their ablation process starting and ending well above the average meteor elevations in the atmosphere. The results are shown in *Table 4* for different threshold levels of the D-criteria.

Table 4 – Beginning and ending heights with ± σ for the ζ-Cassiopeiids obtained from the orbits for each threshold level of the D-criteria.

Threshold level	ZCS – 444	
	H_{beg}	H_{end}
Low	107.9 ± 4.3 km	94.7 ± 5.8 km
Medium low	108.0 ± 4.2 km	94.7 ± 5.8 km
Medium high	108.3 ± 4.1 km	94.8 ± 5.8 km
High	108.3 ± 4.1 km	94.4 ± 5.8 km

The closest matching major shower with similar values are the Perseids (PER#007) with a geocentric velocity of 59.1 km/s and H_{beg} = 110.9 ± 4.0 and H_{end} = 98.0 ± 4.8 km (Roggemans, 2017). Although the ζ-Cassiopeiids are only slightly slower than Perseids, their ablation seems to happen slightly deeper in the atmosphere than what one may expect.

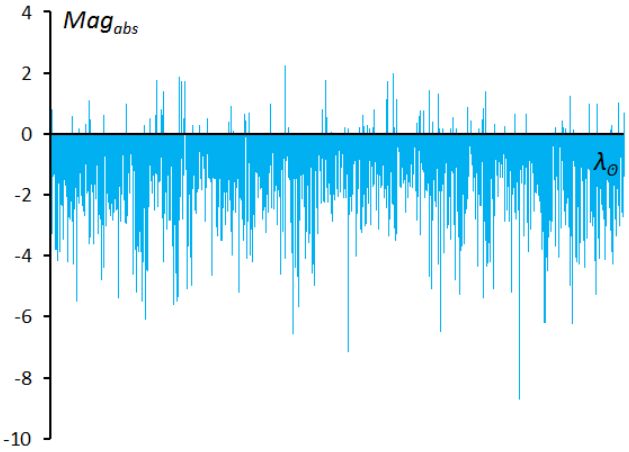


Figure 12 – The absolute magnitude of all 1368 low threshold ζ-Cassiopeiids from $\lambda_\odot$ 100° to 125°.

One explanation could be that the ζ-Cassiopeiids consist of slightly older less fragile cometary particles that manage to get a bit deeper into the atmosphere before being completely disintegrated. Another indication that the shower is rather old is the remarkable dominance of bright meteors and absence of faint meteors with m_{abs} = –1.3 [–8.7 to +2.2]. The dominance of bright meteors in the registered ζ-Cassiopeiids activity becomes very clear when we plot the magnitudes for all events collected between $\lambda_\odot$ = 100° and $\lambda_\odot$ = 125° (*Figure 12*). ZSC meteors fainter than magnitude 0 are a small minority. The strong presence of bright meteors among ζ-Cassiopeiids was already mentioned in the analysis by Šegon et al. (2012), but then a possible explanation could be that the camera networks captured mainly bright meteors and nothing much fainter than +2. Including CAMS which captures meteors of +4, the absence of faint meteors in this shower remains obvious.

Dr. Peter Jenniskens classifies the ζ-Cassiopeiids with retrograde showers of Halley type comets and suggests that the ζ-Cassiopeiids may be a component which also originates from 109P/Swift–Tuttle although the difference in inclination and difference in length of perihelion is significant (Π = 278° versus 292° according to Jenniskens et al., 2016). Peter Jenniskens also says that this fits a trend of changing Π versus $\lambda_\odot$.

Making a plot of length of perihelion Π against $\lambda_\odot$ (see *Figure 13*), displays such trend for which we find:

$$\Delta\Pi / \lambda_\odot = 0.62 \pm 0.03°$$

If we extrapolate this beyond the observed activity period of the ζ-Cassiopeiids we get at Π = 291.8° for $\lambda_\odot$ = 140° which is very close to the value of the Perseids at that time.

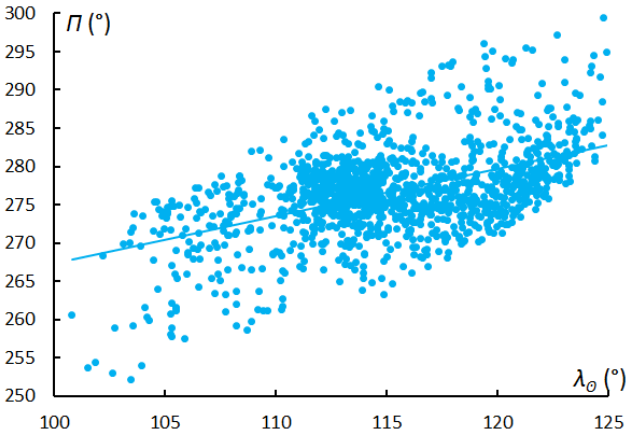


Figure 13 – The length of perihelion Π against solar longitude $\lambda_\odot$ for the 1368 low threshold orbits.

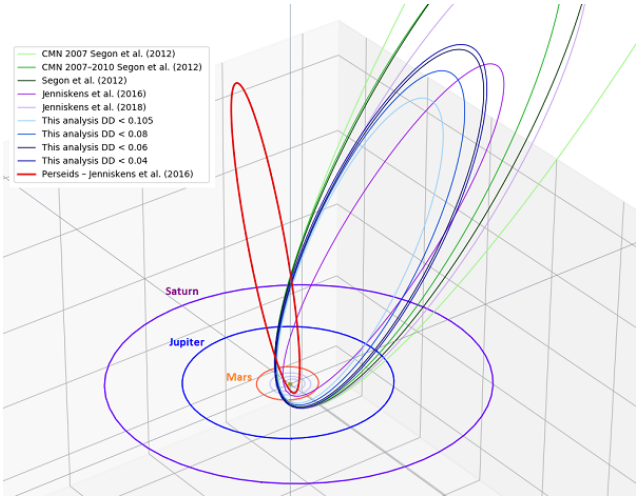


Figure 14 – The different ζ-Cassiopeiid reference orbits from Table 5 compared to the reference orbit of the Perseids. (Author Peter Cambell-Burns).

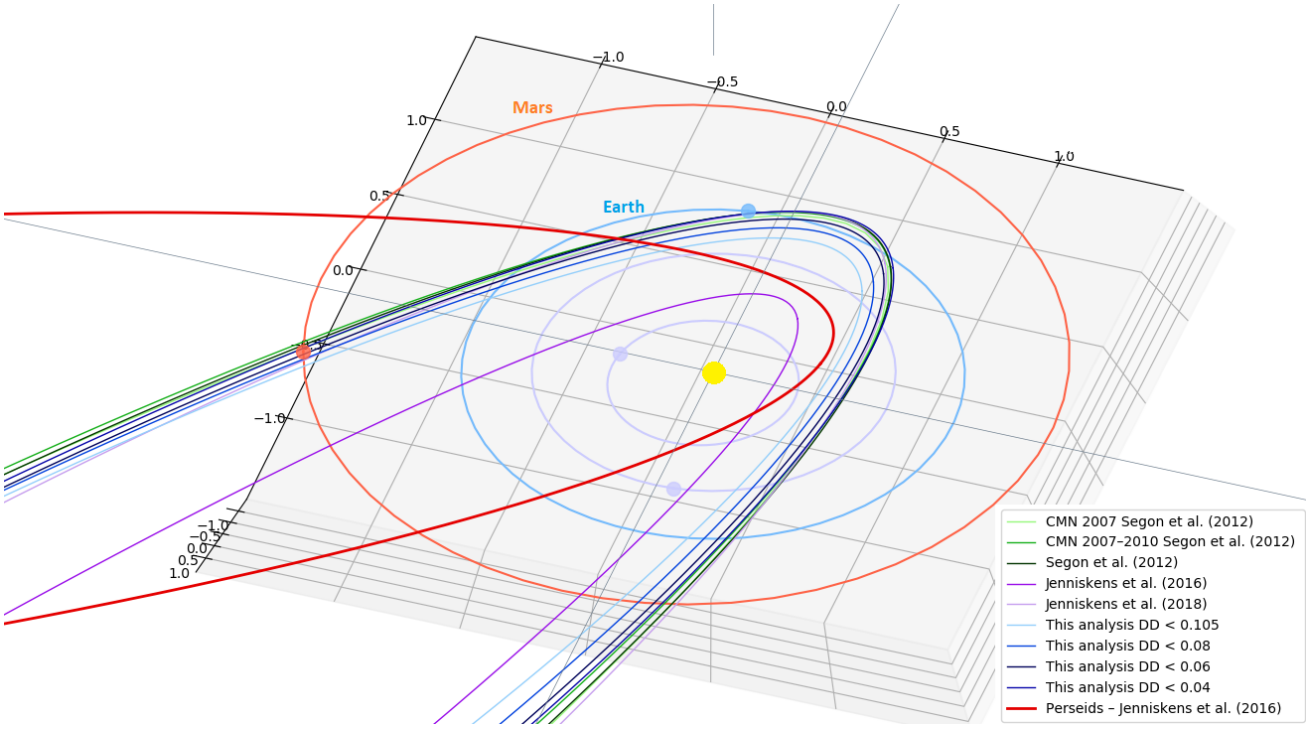


Figure 15 – The different ζ-Cassiopeiids reference orbits from Table 5, close-up near the node and perihelion, compared to the reference orbit of the Perseids (Author Peter Cambell-Burns).

Table – 5 The orbital data for the ζ-Cassiopeiids (ZCS-444) all J2000, the standard deviation σ is listed as ± where available. The orbit of the Perseids is also given.

$\lambda_\odot$ (°)	α_g (°)	δ_g (°)	$\Delta\alpha$ (°)	$\Delta\delta$ (°)	v_g km/s	a AU	q AU	e	ω (°)	Ω (°)	i (°)	N	Source
–	–	–	–	–	–	46.7	0.996 ±0.002	0.979 ±0.044	164.9 ±1.0	113.3 ±0.3	107.1 ±0.5	13	CMN 2007 Šegon et al. (2012)
–	–	–	–	–	–	18.6	0.995 ±0.001	0.947 ±0.012	163.2 ±0.5	113.7 ±0.4	107.5 ±0.5	25	CMN 2007–2010 Šegon et al. (2012)
113.2	6.9	50.7	+1.4	+0.5	57.3 ±1.0	20.3	0.997 ±0.001	0.951 ±0.008	163.9 ±0.3	113.2 ±0.2	107.5 ±0.3	55	Šegon et al. (2012)
109.0	3.1	49.5	+1.0	+0.4	57.1	12.8	1.000	0.962	165.4	112.1	106.6	118	Jenniskens et al. (2016)
111.5	5.1	50.2	–	–	57.1	18.4	0.996	0.946	164.0	111.5	107.1	445	Jenniskens et al. (2018)
114.6	9.1	51.3	+1.3	+0.4	57.1	10.6	0.992 ±0.014	0.923 ±0.077	161.7 ±5.3	114.6 ±4.6	107.6 ±4.0	1368	This analysis $D_D < 0.105$
114.1	8.5 ±5.1	51.2 ±2.1	+1.3	+0.4	57.1 ±1.2	11.8	0.994 ±0.011	0.925 ±0.064	162.4 ±4.1	114.1 ±3.4	107.6 ±3.0	884	This analysis $D_D < 0.08$
113.7	7.8 ±3.6	51.0 ±1.4	+1.4	+0.3	57.1 ±1.0	12.8	0.995 ±0.008	0.926 ±0.052	163.1 ±3.2	113.7 ±2.3	107.5 ±2.2	541	This analysis $D_D < 0.06$
113.7	7.7 ±2.3	51.1 ±1.1	+1.4	+0.3	56.9 ±0.7	13.0	0.995 ±0.006	0.923 ±0.036	163.1 ±2.2	113.7 ±1.4	107.3 ±1.8	264	This analysis $D_D < 0.04$
140	48.2	58.1			59.1	9.6	0.949	0.950	150.4	139.3	113.1	4367	Perseids – Jenniskens et al. (2016)

Figures 14 and 15 show the significant 'gap' between the ζ-Cassiopeiids orbit and the Perseids orbit. If and how the parent body of the ζ-Cassiopeiids is related to 109P/Swift–Tuttle remains a challenge for stream modelers to reconstruct the possible history of a common parent body. In such case it might be necessary to reconsider the ancient records of the Perseids if these were really Perseids or rather ζ-Cassiopeiids. With the outburst observations of this shower in 2005 in mind, the date of maximum activity of this minor shower deserves proper attention. The dust distribution along its orbit may have more surprises to come, hence observers are better prepared for outbursts.

6 Conclusion

A significant number of ζ-Cassiopeiids have been identified which allowed a detailed case study on this shower. Yearly activity has been detected with a rather large variation from year to year that may indicate some periodicity, like suggested by the outburst observed in 2005, before systematic video camera networks were operational. The time of maximum activity could be established at $\lambda_\odot$ = 112.75° with a secondary maximum at $\lambda_\odot$ = 114.5°. The post maximum wing of the activity profile includes early Perseid orbits that qualify for the ζ-Cassiopeiid parent orbit. All shower characteristics are identical to the nearby Perseid shower although ζ-Cassiopeiids are likely older. Both showers may be related to a common origin.

This shower qualifies to get listed as an established meteor shower in the IAU working list of meteor showers.

Acknowledgment

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December 2015 Geminids adventure

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An overview is given of the 2015 Geminid observation expedition by the author.

1 Introduction

As you may know, Raymond and I will go almost anywhere in North America to seek out clear skies to fulfill my passion of seeing, photographing and recording meteor shower events and for Raymond, to join me to experience them also.

So early in 2015, I told Raymond that it will be an excellent year to see December's Geminid meteor shower once again. We talked it over and decided to do another road trip to see them. The Geminids have long been my favorite annual meteor shower, with reliable displays year after year. Travelling south to see them is great not only to escape clouds, but also enjoy milder climates ☺.

The closer we were for the big day to start off on our trip, the worst it was with the cloud cover all across North America with one exception — the State of Texas! Raymond and I had not planned to travel so far out to see this meteor shower but the prospects were excellent with moonless conditions. We talked it over and decided to go way south this time. Prior to leaving Ottawa, we looked and looked for a suitable astronomy site with cloud free skies within Texas. We exchanged emails with potential locations, until I found an intriguing site and asked for Raymond's opinion. He looked at my discovery, and again we had a winner!

Our trip was to the Comanche Springs Astronomy Campus; an amateur astronomer's facility financially supported by Three Rivers Foundation for the Arts and Sciences, a private, non-profit organization which provides art and science education as well as outreach for the youth in the near and wider communities of Crowell Texas[1].

2 The observing site

So off we go to Texas, the land of ranches, cowboys and cheap T-bone steaks. And for us two; the land of big, beautiful and dark skies.

The Comanche Springs Astronomy Campus started as an original 50 acre donation from the McAdams Ranch thanks to a passion for nature conservation by the late Bettie B. Gafford. Additional land acquisitions in 2009 and 2010 expanded the campus property to its current size of 700 acres.

Located at the heart of Big Ranch Country in north central Texas, this is the home to telescopes, observatories and indoor and outdoor classroom space, the Comanche Springs Astronomy Campus serves visitors from across Texas, the U.S. and from around the globe. Visitors enjoy programs covering topics ranging from astronomy to environmental and earth science. This 700-acre facility lies in a corridor of very dark skies that stretches from outside the Dallas/Ft. Worth metroplex to Amarillo.

The buildings on campus include a roll-off observatory, a dome structure, outdoor observation platforms and an area for individual telescopes with electrical outlets. The site facilities are indoor and outdoor classrooms, four bunkhouses capable of housing up to 65 overnight guests, 12 RV spaces, 3 outdoor pizza ovens, an adjoining pavilion and a large new shower/restroom facility. The site is internet friendly due to their 150Mbps backbone to the outside world and Wi-Fi antennas throughout the grounds.

Once we arrived there, we met with Jeff Barton, Director of Astronomy. Mr Barton showed us around the site, then sat down in the spacious room for a lovely chat. Mr Barton spoke about their commitment to purchase three of each telescope types for the Foundation when possible, their mandate for education, various astronomy topics and their future plans. The Foundation wishes to expand certain facilities, increase their number of star parties and build a digital planetarium projecting round stars.

At the time of our visit, the roll-off observatory housed a 30-inch, 20-inch and two 18-inch reflecting telescopes; remember their commitment of three of each, well this 30-inch is one of three that they own. The main dome houses a 15-inch refractor, the largest telescope of this type in Texas that is used on a regular basis for public events (and of the same aperture as the one at the Science&Tech Museum here in Ottawa). Attached to it is a classroom serving school and scouts visits, as well as an alternate location for small programs in case of inclement weather.

The long trip to get there was worth it. The night sky at Comanche Spring is one of the darkest Raymond and I have seen to for a long time. As with Irvine Lake Airstrip

[1] https://www.3rf.org

(Nirvana), it is classed as a 2 on the Bortle Scale, but this place is even slightly darker than Nirvana (i.e. mag 7.0-7.5 skies).

The Bortle Scale 2 is described as:

- the zodiacal light is distinctly yellowish and bright enough to cast shadows at dusk and dawn
- airglow may be weakly visible near horizon
- clouds are only visible as dark holes against the sky
- surroundings are barely visible silhouetted against the sky
- the summer Milky Way is highly structured
- many Messier objects and globular clusters are naked-eye objects
- M33 is easily seen with naked eye
- limiting magnitude with 12.5" reflector is 16.5

Another benefit of this site is its latitude of about 34 degrees north. This latitude provides the observer a glimpse of some of the southern constellations; examples of constellations are Grus and Vela; example of star is Canopus (second brightest in the sky).

Our first and second nights were concentrated on the Geminids and they were absolutely wonderful! Both nights had intense meteor activity as we saw and photographed hundreds of meteors darting non-stop across ink black skies! Without a doubt my most productive Geminid year!!

The following nights were more casual but just as stunning — a mix of meteor observing, astro-imaging, comet hunting and casual observing, along with howls hooting, coyotes howling and deer leisurely walking around us. During one night, Raymond and I heard at least four separate bands of coyotes on their property. I sure wished the nights would not end!

Our time spent there observing was amazing! The entire facility staff was very helpful, friendly and accommodating. It was also a treat to meet David Drummond, a very well-known and respected storm chaser who works for KCBD NewsChannel 11. David stayed an additional night to observe the Geminids with us. The foundation kindly offered to lend us their TeleVue 102mm APO Renaissance and Coronado SolarMax 90 telescope for our uses while we were there.

So this is another astronomy site gem that we truly enjoyed and will no doubt re-visit in the future. If you are in the area, stop by to enjoy the Comanche Springs Astronomy Campus' accommodation, warmth and night sky. It's recommended to call ahead of time to make arrangements. (NOTE: As of 2018, the campus is currently closed for construction).

Raymond and I wish to thank the President, Brian Allen and their Director of Astronomy, Jeff Barton for their warm and open generosity.

3 December 13–14 observations

Here's a Gallery of a few images that will give you a taste of our trip experience[2]. I know that Raymond took several photos as well.

Here's the results for the first night of Geminids, which was the night of maximum activity.

The session started a bit later than planned, as we setup our cameras, aligned our tracking mounts and then had to wait for a few lingering cloudy periods to move away. Then… it was clear … and … WOW!!! … Was it EVER clear!!! The limiting magnitude topped at nearly 7.2, one of the darkest skies I've ever seen. The Zodiacal light was glowing very evidently, the Zodiacal band was visible, and the Milky Way displayed a wealth of intricate structure. The horizons were dark with the exception of a couple of very faint (barely noticeable) glows at the eastern horizon. Temperature was a very mild and dry +4C. Already, the meteors were flying right and left as I settled into my chair and I couldn't wait to get going. I started formal observing at midnight, and went on all the way to 6:30am morning dawn. Humidity and fog rose towards morning, and this caused a small drop in LM.

A total of 507 meteors was observed in the span of five hours! It was full of Geminids, with 98 seen in the first hour alone, not including the occasional sporadics and other minor showers. The second hour was even stronger with 107 Geminids! They were generally well spaced apart, but in several instances, I saw two or three Geminids appearing nearly simultaneously in the sky! Most of them were of average brightness, with occasional bright ones thrown into the mix. The brightest was a mag -4 blue-green Geminid fireball seen during the second hour. The most impressive meteor was however not a Geminid but a very slow mag -1 sporadic that travelled a length of 40 degrees, lasting several seconds and turning yellow-to-orange! On top of the very successful visual observations, this night also marked my most successful ever for meteor photography! As you will see on my Smugmug page, I've captured a plethora of Geminids!

Night of Dec 13/14 2015 photos[3] (scroll down the webpage to see each images & captions).

Detailed data below:
December 13/14 2015, 06:00-12:35 UT (00:00-06:35 CST)

Location: Comanche Springs Astronomy Campus (near Crowel), Texas, USA

(Long: -99.957 West; Lat: 33.991 North)

[2] https://pmartin.smugmug.com/Astronomy/2015121317-Astronomy-Trip-to-T/Comanche-Springs-Astronomy-Cam/

[3] https://pmartin.smugmug.com/Astronomy/2015121317-Astronomy-Trip-to-T/20151213-Geminids-at-3RF-in/

Observed showers:

- Anthelion (ANT) – 06:16 (094) +23
- Monocerotids (MON) – 06:52 (103) +08
- Geminids (GEM) – 07:33 (113) +32
- Sigma Hydrids (HYD) – 08:24 (126) +02
- Dec. Leonis Minorids (DLM) – 10:08 (152) +35
- Psi Ursa Majorids (PSU) – 11:44 (176) +42
- Dec. Alpha Draconids (DAD) – 13:52 (208) +58

06:00-07:00 UT (00:00-01:00 CST); clear; 5/5 trans; F 1.00; LM 7.17; facing S50 deg; t_{eff} 1.00 hr; temp: +3C

- GEM: Ninety-eight: -1(2); 0(5); +1(8); +2(18); +3(24); +4(23); +5(17); +6(1)
- MON: three: +2; +4; +5
- ANT: two: +2; +4
- HYD: one: +5
- Sporadics: four: +2; +3; +4; +5
- Total meteors: One-hundred-eight

07:00-08:31 UT (01:00-02:31 CST); clear; 5/5 trans; F 1.00; LM 7.13; facing S50 deg; t_{eff} 1.01 hr; temp: 0C

- GEM: One-hundred-seven: -4; -2(2); -1(3); 0(5); +1(7); +2(15); +3(28); +4(23); +5(21); +6(2)
- HYD: three: +1; +3; +5
- ANT: two: -1; +5
- MON: one: +4
- Sporadics: four: +2(2); +3(2)
- Total meteors: One-hundred-seventeen

08:31-09:32 UT (02:31-03:32 CST); clear; 4/5 trans; F 1.00; LM 6.87; facing S50 deg; t_{eff} 1.00 hr; temp: -1C

- GEM: Ninety-three: -2; -1; 0; +1(7); +2(15); +3(24); +4(25); +5(19)
- MON: three: +1; +2; +4
- HYD: two: +3; +4
- DLM: one: +2
- Sporadics: nine: -1; 0; +2(2); +3; +4(3); +5
- Total meteors: One-hundred-eight

09:32-11:16 UT (03:31-05:16 CST); clear; 3/5 trans; F 1.00; LM 6.65; facing S50 deg; t_{eff} 1.00 hr; temp: -3C

- GEM: Eighty-five: -3; -2; -1(2); 0; +1(7); +2(15); +3(23); +4(24); +5(11)
- MON: five: +1; +4(4)
- HYD: four: +1; +3; +4(2)
- ANT: three: +3; +4(2)
- DAD: one: +4
- Sporadics: two: +3; +5
- Total meteors: One-hundred

11:16-12:35 UT (05:16-06:35 CST); clear; 3/5 trans; F 1.00; LM 6.52; facing S50 deg; t_{eff} 1.05 hr; temp: -4C

- GEM: Fifty-eight: -3; 0; +1(8); +2(9); +3(12); +4(15); +5(12)
- MON: one: +4
- ANT: one: +3
- Sporadics: fourteen: 0; +1; +2(2); +3(3); +4(2) +5(5)
- Total meteors: Seventy-four

Short periods (number of meteors, in 5 minutes T_{EFF} periods)

- 06:00-06:05 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: four
- 06:05-06:10 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: eleven; MON: one
- 06:10-06:15 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: four
- 06:15-06:20 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: six
- 06:20-06:25 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: nine
- 06:25-06:30 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: five; SPO: two
- 06:30-06:35 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: twelve
- 06:35-06:40 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: ten; HYD: one
- 06:40-06:45 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: nine; MON: one; SPO: two
- 06:45-06:50 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: sixteen; MON: one; ANT: one
- 06:50-06:55 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: eight
- 06:55-07:00 UT; FOV RA 081 dec -10; LM 7.17; teff 0.083; GEM: four
- 07:00-07:05 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: thirteen; SPO: one
- 07:05-07:10 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: nine; ANT: one; HYD: one
- 07:10-07:15 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: three; HYD: one; SPO: one
- 07:15-07:20 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: seven
- 07:20-07:25 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: ten; HYD: one
- 07:25-07:30 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: four; SPO: one

** BREAK 07:30-08:00 **

- 08:00-08:05 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: three; ANT: one
- 08:05-08:10 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: fifteen; MON: one
- 08:10-08:15 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: ten; SPO: one
- 08:15-08:20 UT; FOV RA 095 dec -09; LM 7.13; teff 0.077; GEM: nine
- 08:20-08:25 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: seven
- 08:25-08:30 UT; FOV RA 095 dec -09; LM 7.13; teff 0.083; GEM: fourteen
- 08:30-08:35 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: seven; HYD: one

- 08:35-08:40 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: eleven
- 08:40-08:45 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: six; SPO: one
- 08:45-08:50 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: eight; DLM: one; SPO: two
- 08:50-08:55 UT; FOV RA 111 dec -05; LM 6.87; teff 0.066; GEM: four
- 08:55-09:00 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: five; MON: two; SPO; two
- 09:00-09:05 UT; FOV RA 111 dec -05; LM 6.87; teff 0.077; GEM: four; SPO: one
- 09:05-09:10 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: six; MON: one
- 09:10-09:15 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: nine
- 09:15-09:20 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: twelve; HYD: one
- 09:20-09:25 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: ten; SPO: three
- 09:25-09:30 UT; FOV RA 111 dec -05; LM 6.87; teff 0.083; GEM: eleven
- 09:30-09:35 UT; FOV RA 124 dec -05; LM 6.87; teff 0.083; GEM: seven; MON: one
- 09:35-09:40 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: six

** BREAK 09:40-10:06 **

- 10:06-10:11 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: ten; SPO: one
- 10:11-10:16 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: seven; ANT: one
- 10:16-10:21 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: five; HYD: one
- 10:21-10:26 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: six; ANT: one; HYD: one; MON: one
- 10:26-10:30 UT; FOV RA 124 dec -05; LM 6.65; teff 0.066; GEM: four

** BREAK 10:30-10:37 **

- 10:37-10:42 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: four; MON: one

** BREAK 10:42-10:53 **

- 10:53-10:58 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: twelve; SPO: one
- 10:58-11:03 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: nine; MON: one; DAD: one
- 11:03-11:08 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: nine; HYD: one
- 11:08-11:13 UT; FOV RA 124 dec -05; LM 6.65; teff 0.083; GEM: five; ANT: one; MON: one
- 11:13-11:18 UT; FOV RA 138 dec -05; LM 6.65; teff 0.083; GEM: eight; HYD: one; SPO: two
- 11:18-11:23 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: six; MON: one; SPO: one
- 11:23-11:28 UT; FOV RA 138 dec -05; LM 6.52; teff 0.075; GEM: four
- 11:28-11:33 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: three; SPO: one
- 11:33-11:38 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: six; SPO: one
- 11:38-11:43 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: five; SPO: one
- 11:43-11:48 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: six
- 11:48-11:53 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: five
- 11:53-11:58 UT; FOV RA 138 dec -05; LM 6.52; teff 0.083; GEM: three; SPO: two
- 11:58-12:04 UT; FOV RA 138 dec -05; LM 6.52; teff 0.091; GEM: five; SPO: three

** BREAK 12:04-12:10 **

- 12:10-12:13 UT; FOV RA 138 dec -05; LM 6.30; teff 0.050; GEM: four

** BREAK 12:13-12:22 **

- 12:22-12:27 UT; FOV RA 138 dec -05; LM 6.10; teff 0.083; GEM: five; ANT: one; SPO; two
- 12:27-12:35 UT; FOV RA 138 dec -05; LM 6.05; teff 0.133; GEM: two; SPO: one

4 Second night of observing in Texas!

At sunset, we got set for another full night of observing. I am especially excited about this night for a few reasons… For one thing, the exact time of the broad maximum had occurred just a few hours before nightfall, so we anticipated that the Geminids would still be plenty active again tonight. Then, as the activity starts declining quickly, a period of BRIGHT Geminids occurs (known as the mass-sorting effect) accompanied by very bright fireballs! I was very excited about the possibility of seeing this! In many past years, I have tried and failed to see the mass-sorting effect due to the narrow window of opportunity (either missed because it occurs in the daytime, or behind cloud cover). At best, I've only seen it partially. This time, I felt I had a shot seeing it through the best part of the night!!

The sky was very clear with excellent transparency, steady mag 7 skies (after moonset), calm air, and temperature again very comfortable for us especially for a clear mid-December night (+7C at the start, down to -2C late at night, and some humidity/ground fog late at night). We enjoyed listening to several coyotes on this night!

I wasted no time, starting my watch in the early evening just as the radiant rose in the east — to check for earthgrazers. In that hour, I saw 22 Geminids, some of which had gorgeous long path lengths. Most were rather dim, so I started questioning that perhaps I had already missed the "bright meteor period" as I had on so many other occasions in previous years? So, I took a break to wait for the radiant to climb, the Moon to set, and resumed observing just

before 10pm. In the hour that followed, I saw 43 Geminids plus sporadics and other minor showers, so it was looking good! The meteors got gradually brighter and brighter!

Starting at 11pm, the Geminids suddenly started getting a LOT brighter!! WOW!!! It felt like a VERY different shower with one BRIGHT COLORFUL Geminid after another, some seen high up and many others seen very low against the flat open horizons. The rates were also surprisingly high, and easily surpassed my expectations knowing that the peak was now well behind us. The rates approached and then surpassed one meteor per minute, and that pace held up until 2:30am. It sometimes felt like this was actually the more active night, especially with all the bright meteors. 11 fireballs were seen (-7, -5 two -4s and seven -3s) along with a plethora of -1s, 0s and +1s! Lots of vivid blues, greens and yellows too!

After that, the rates dropped precipitously. I was definitely getting tired after 4:00am, but it was evident that the shower was well on its way out. Only 10 Geminids were seen in the final 40 minutes, and they were fainter now. I was absolutely pleased… what a spectacular and thrilling night!!! In 6.5 hours of viewing, I saw a total of 302 meteors! On top of the Geminids, there was also decent activity from the Monocerotids, Hydrids, anthelions and sporadics. One of these was a colorful mag 0 streak that shot 60 degrees!

It is difficult to say which of the two main nights were better… both were spectacular for different reasons! Finally, I saw the famous Geminid "mass sorting" effect… it's definitely a real thing!!! We were very lucky to see this; has the peak occurred just a few hours earlier in the day, this night would have been a lot quieter. Look at the pictures on the Smugmug below and then compare them with the ones from the previous night. You'll see the difference!

Night of Dec 14/15 2015 photos[4] (scroll down the webpage to see each images & captions):

Detailed data below:
December 14/15 2015, 01:25-10:55 UT (19:25-04:55 CST)

Location: Comanche Springs Astronomy Campus (near Crowel), Texas, USA

(Long: -99.957 West; Lat: 33.991 North)

Observed showers:

- Anthelion (ANT) – 06:16 (094) +23
- Monocerotids (MON) – 06:52 (103) +08
- Geminids (GEM) – 07:33 (113) +32
- Sigma Hydrids (HYD) – 08:24 (126) +02
- Dec. Leonis Minorids (DLM) – 10:08 (152) +35
- Psi Ursa Majorids (PSU) – 11:44 (176) +42
- Dec. Alpha Draconids (DAD) – 13:52 (208) +58

01:25-02:35 UT (19:25-20:35 CST); clear; 5/5 trans; F 1.00; LM 6.70; facing E50 deg; t_{eff} 1.16 hr; temp: +6C, crescent moon in western sky

- GEM: Twenty-two: -3; -1; 0; +1(4); +2(4); +3(4); +4(2); +5(5)
- ANT: one: +4
- Sporadics: two: +2; +4
- Total meteors: Twenty-five

03:55-04:56 UT (21:55-22:56 CST); clear; 5/5 trans; F 1.00; LM 7.00; facing SE50 deg; t_{eff} 1.01 hr; temp: +4C

- GEM: Forty-three: -2; -1(2); 0(5); +1(14); +2(8); +3(6); +4(3); +5(4)
- MON: four: +4(3); +5
- ANT: one: +4
- HYD: one: +5
- Sporadics: six: 0; +1; +4(3); +5
- Total meteors: Fifty-five

04:56-05:57 UT (22:56-23:57 CST); clear; 5/5 trans; F 1.00; LM 7.00; facing SE50 deg; t_{eff} 1.01 hr; temp: +2C

- GEM: Fifty-four: -4; -3(3); -2; -1(5); 0(4); +1(10); +2(5); +3(7); +4(11); +5(6); +6(1)
- ANT: one: +5
- Sporadics: five: +1; +2; +4(2); +5
- Total meteors: Sixty

05:57-07:28 UT (23:57-01:28 CST); clear; 5/5 trans; F 1.00; LM 7.00; facing S50 deg; t_{eff} 1.00 hr; temp: +1C

- GEM: Fifty-eight: -7; -4; -2; -1(3); 0(7); +1(8); +2(8); +3(10); +4(6); +5(13)
- MON: two: +4
- HYD: one: +4
- DLM: one: +1
- Sporadics: five: +4(3); +5(2)
- Total meteors: Sixty-seven

07:28-08:28 UT (01:28-02:28 CST); clear; 5/5 trans; F 1.00; LM 7.00; facing S50 deg; t_{eff} 1.00 hr; temp: -1C

- GEM: Forty-three: -5; -3(2); -2; -1; 0(4); +1(5); +2(7); +3(7); +4(10); +5(5)
- MON: three: +1; +4(2)
- HYD: two: +1; +4
- ANT: one: +4
- DLM: one: +4
- Sporadics: seven: +1; +2; +3; +4(4)
- Total meteors: Fifty-seven

08:28-09:00 UT (02:28-03:00 CST); clear; 4/5 trans; F 1.00; LM 6.70; facing S50 deg; t_{eff} 0.53 hr; temp: -2C

- GEM: Sixteen: -3; -2(3); -1; 0(2); +1(2); +2; +4(4); +5; +6

[4] https://pmartin.smugmug.com/Astronomy/2015121317-Astronomy-Trip-to-T/20151214l5-meteor-photos/i-v2xTXBG

- ANT: one: +3
- Sporadics: one: +6
- Total meteors: Eighteen

09:52-10:55 UT (03:52-04:55 CST); clear; 4/5 trans; F 1.00; LM 6.60; facing S50 deg; t_{eff} 0.70 hr; temp: +1C

- GEM: Ten: +1; +2(5); +3(4)
- MON: one: +3
- HYD: one: +3
- Sporadics: eight: +3; +4(6); +5
- Total meteors: Twenty

Short periods (number of meteors, in 5 minutes T_{EFF} periods)

- 01:25-01:35 UT; FOV RA 051 dec +12; LM 6.70; teff 0.166; GEM: one
- 01:35-01:45 UT; FOV RA 051 dec +12; LM 6.70; teff 0.166; GEM: five
- 01:45-01:55 UT; FOV RA 051 dec +12; LM 6.70; teff 0.166; GEM: one
- 01:55-02:05 UT; FOV RA 051 dec +12; LM 6.70; teff 0.166; GEM: four
- 02:05-02:15 UT; FOV RA 051 dec +12; LM 6.75; teff 0.158; GEM: three
- 02:15-02:25 UT; FOV RA 051 dec +12; LM 6.80; teff 0.166; GEM: four; SPO: two
- 02:25-02:35 UT; FOV RA 051 dec +12; LM 6.90; teff 0.166; GEM: four; ANT: one

** BREAK 02:35-03:55 **

- 03:55-04:05 UT; FOV RA 069 dec -03; LM 7.00; teff 0.166; GEM: six; ANT: one; SPO: one
- 04:05-04:15 UT; FOV RA 069 dec -03; LM 7.00; teff 0.166; GEM: six
- 04:15-04:25 UT; FOV RA 069 dec -03; LM 7.00; teff 0.158; GEM: eight; SPO: one
- 04:25-04:35 UT; FOV RA 069 dec -03; LM 7.00; teff 0.166; GEM: ten; MON: one; SPO: two
- 04:35-04:45 UT; FOV RA 069 dec -03; LM 7.00; teff 0.166; GEM: five; MON: two; SPO: one
- 04:45-04:55 UT; FOV RA 069 dec -03; LM 7.00; teff 0.166; GEM: eight; MON: one; HYD: one; SPO: one
- 04:55-05:05 UT; FOV RA 081 dec -08; LM 7.00; teff 0.166; GEM: eight
- 05:05-05:15 UT; FOV RA 081 dec -08; LM 7.00; teff 0.158; GEM: twelve; SPO: one
- 05:15-05:25 UT; FOV RA 081 dec -08; LM 7.00; teff 0.166; GEM: eleven
- 05:25-05:35 UT; FOV RA 081 dec -08; LM 7.00; teff 0.166; GEM: three; ANT: one; SPO: two
- 05:35-05:45 UT; FOV RA 081 dec -08; LM 7.00; teff 0.166; GEM: twelve; SPO: one
- 05:45-05:55 UT; FOV RA 081 dec -08; LM 7.00; teff 0.166; GEM: seven; SPO: one
- 05:55-06:05 UT; FOV RA 079 dec -08; LM 7.00; teff 0.166; GEM: nine; DLM: one; MON: one
- 06:05-06:10 UT; FOV RA 079 dec -08; LM 7.00; teff 0.077; GEM: five

** BREAK 06:10-06:40 **

- 06:40-06:50 UT; FOV RA 079 dec -08; LM 7.00; teff 0.161; GEM: ten; HYD: one
- 06:50-07:00 UT; FOV RA 079 dec -08; LM 7.00; teff 0.166; GEM: ten
- 07:00-07:10 UT; FOV RA 079 dec -08; LM 7.00; teff 0.166; GEM: five; SPO: two
- 07:10-07:20 UT; FOV RA 079 dec -08; LM 7.00; teff 0.166; GEM: eleven; SPO: three
- 07:20-07:30 UT; FOV RA 079 dec -08; LM 7.00; teff 0.166; GEM: eleven; MON: one
- 07:30-07:40 UT; FOV RA 104 dec -05; LM 7.00; teff 0.166; GEM: six; HYD: two; SPO: one
- 07:40-07:50 UT; FOV RA 104 dec -05; LM 7.00; teff 0.166; GEM: fourteen; MON: one
- 07:50-08:00 UT; FOV RA 104 dec -05; LM 7.00; teff 0.166; GEM: five; ANT: one; MON: one; SPO: one
- 08:00-08:10 UT; FOV RA 104 dec -05; LM 7.00; teff 0.166; GEM: ten
- 08:10-08:20 UT; FOV RA 104 dec -05; LM 7.00; teff 0.166; GEM: four; SPO: two
- 08:20-08:30 UT; FOV RA 104 dec -05; LM 6.90; teff 0.166; GEM: two; DLM: one; MON: one; SPO: three
- 08:30-08:40 UT; FOV RA 106 dec -09; LM 6.80; teff 0.166; GEM: seven; SPO: one
- 08:40-08:50 UT; FOV RA 106 dec -09; LM 6.80; teff 0.166; GEM: five; ANT: one
- 08:50-09:00 UT; FOV RA 106 dec -09; LM 6.70; teff 0.166; GEM: four

** BREAK 09:00-09:52 **

- 09:52-10:02 UT; FOV RA 116 dec -09; LM 6.60; teff 0.166; GEM: three; SPO: one
- 10:02-10:14 UT; FOV RA 116 dec -09; LM 6.60; teff 0.200; GEM: two; MON: one; HYD: one; SPO: one

** BREAK 10:14-10:55 **

- 10:18-10:55 UT; FOV RA 116 dec -09; LM 6.60; teff 0.333; GEM: five; SPO: six

Visual observations 2016

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An overview is given of the 2016 meteor observations by the author, covering the Quadrantids, Eta Aquariids, July meteor showers, Perseids, September meteor showers and December Geminids.

1 January 3–4, 2016

I had excellent success in observing and photographing the 2016 Quadrantids maximum!

Shane Finnigan joined me, and we drove to Otter Lake to setup at his cottage. Along the way, we were quite skeptical about the weather, judging by how thick the cloud cover was all above us. It was just overcast everywhere. The forecast showed a possible clearing to the north so we figured it was worth a shot. After a 1.5 hour drive, we arrived to the cottage and the sky was clear! YES!!!!! But first, we had to clear the driveway from a few feet of fresh snow accumulation, and then make ourselves a path to the back of the cottage where we wanted to observe. As we shoveled, by chance I spotted a bright mag -4 earthgrazing Quadrantid moving horizontally about 60 degrees long, behind the thick tree line. It was pretty awesome! Once we were done, we had a nice rectangular shoveled area for our chairs and cameras, as well as a path to the cottage and to the front. I then got the observing gear and cameras out, and overhead I was already seeing quite a number of Quadrantids without even trying!

It was a cold night, down to -23C but all the earlier exercise perked us up. It was also very much well worth the effort! The Quadrantids were somewhere near full tilt with excellent hourly rates of 43, 53, 66 and 47! I was impressed with these rates, especially with the rising Quarter Moon and the occasional clouds/haze during the last two hours. The Quadrantids seemed to come in various spurts and quiet spells. At times, nothing was seen for several minutes, then suddenly a burst of several quads all fanning out in different directions!

There was also a bit of everything — a very entertaining meteor watch! Here's some of the other highlights:

At 3:05am, an impressive mag -3 sporadic that fragmented into three pieces! WOW!!! Just a minute later, a mag -4 Quadrantid descended into the West with a long 30 degrees path — smack in the middle of my camera's field

At 4:57am, a -3 sporadic earthgrazer shot 60 degrees, travelling from south to north and producing a long train!

At 5:00am, as many as six Quads appeared including a point meteor seen almost exactly on the radiant! Another point meteor was seen at 5:48am.

It was a cold but wow, what very rewarding night for sure!! 240 meteors in four hours. Shane and I both really enjoyed it!

My camera managed to capture many, many Quads and some of the earthgrazers and bright sporadics too! Please see the photos on my Smugmug site[5] (scroll down the page to see all the images and a time lapse of the mag -4 Quad persistent train):

Detailed data below:
January 3/4 2016, 07:45-11:47 UT (02:45-06:47 EST) Location: Otter Lake, Quebec, Canada, (Long: -76.407; Lat: 45.829)

Observed showers:

- Anthelion (ANT) – 07:40 (115) +20
- January Leonids (JLE) – 09:52 (148) +24
- Dec. Leonis Minorids (DLM) – 11:36 (174) +24
- Quadrantids (QUA) – 15:16 (229) +50

07:45-08:45 UT (02:45-03:45 EST); clear; 3/5 trans; F 1.00; LM 6.40; facing N50 deg; t_{eff} 1.00 hr; temp: -21C

- QUA: forty-three: -4; 0; +1(5); +2(9); +3(7); +4(9); +5(11)
- DLM: four: +3(2); +4; +5
- Sporadics: four: -3; +1; +3(2)
- Total meteors: Fifty-one

08:45-09:46 UT (03:45-04:46 EST); clear; 3/5 trans; F 1.00; LM 6.30; facing N50 deg; t_{eff} 1.01 hr; temp: -22C

- QUA: fifty-three: 0(2); +1(3); +2(11); +3(9); +4(19); +5(9)
- ANT: one: +4
- JLE: one: +2

[5] [1]https://pmartin.smugmug.com/Astronomy/20160104-Quadrantids-Otter-Lake-QC

- DLM: one: +4
- Sporadics: six: +2(2); +4(2); +5(2)
- Total meteors: Sixty-two

09:46-10:46 UT (04:46-05:46 EST); clear; 3/5 trans; F 1.05 (20% clouds from 10:00-10:15 UT); LM 6.30; facing N50 deg; t_{eff} 1.00 hr; temp: -23C

- QUA: sixty-six: -1; 0; +1(4); +2(15); +3(16); +4(19); +5(10)
- ANT: one: +3
- DLM: one: +4
- Sporadics: six: -3; 0; +2; +3; +5(2)
- Total meteors: Seventy-four

10:46-11:47 UT (05:46-06:47 EST); clear; 3/5 trans; F 1.08 (10% clouds from 11:10-11:30 UT and 15% from 11:30-11:47 UT);

LM 5.94; facing N50 deg; t_{eff} 1.01 hr; temp: -24C

- QUA: forty-seven: -1; 0; +1(4); +2(18); +3(11); +4(12)
- DLM: one: +2
- Sporadics: five: +2; +3(2); +4(2)
- Total meteors: Fifty-three

Short periods (number of meteors, in 10 minutes T_{eff} periods)

- 07:45-07:55 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: six; DLM: one; SPO: one
- 07:55-08:05 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: four; DLM: one
- 08:05-08:15 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: eleven; SPO: one
- 08:15-08:25 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: six
- 08:25-08:35 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: eight; DLM: one; SPO: one
- 08:35-08:45 UT; FOV RA 192 dec +79; LM 6.40; teff 0.166; QUA: eight; DLM: one; SPO: one
- 08:45-08:55 UT; FOV RA 204 dec +80; LM 6.30; teff 0.166; QUA: eleven; ANT: one; SPO: three
- 08:55-09:05 UT; FOV RA 204 dec +80; LM 6.30; teff 0.158; QUA: nine
- 09:05-09:15 UT; FOV RA 204 dec +80; LM 6.30; teff 0.166; QUA: seven; DLM: one; SPO: three
- 09:15-09:25 UT; FOV RA 204 dec +80; LM 6.30; teff 0.166; QUA: ten; JLE: one
- 09:25-09:35 UT; FOV RA 204 dec +80; LM 6.30; teff 0.166; QUA: seven
- 09:35-09:45 UT; FOV RA 204 dec +80; LM 6.30; teff 0.166; QUA: seven
- 09:45-09:55 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: eleven; SPO: two
- 09:55-10:05 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: eleven; ANT: one; SPO: one (20% clouds)
- 10:05-10:15 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: thirteen; SPO: one (20% clouds)
- 10:15-10:25 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: eleven; DLM: one
- 10:25-10:35 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: ten; SPO: one
- 10:35-10:45 UT; FOV RA 219 dec +80; LM 6.30; teff 0.166; QUA: twelve; SPO: one
- 10:45-10:55 UT; FOV RA 234 dec +80; LM 6.30; teff 0.166; QUA: twenty; SPO: two
- 10:55-11:05 UT; FOV RA 234 dec +80; LM 6.30; teff 0.166; QUA: eight; SPO: one
- 11:05-11:15 UT; FOV RA 234 dec +80; LM 6.30; teff 0.166; QUA: five; SPO: one (10% clouds)
- 11:15-11:25 UT; FOV RA 234 dec +80; LM 6.30; teff 0.158; QUA: six (10% clouds)
- 11:25-11:35 UT; FOV RA 234 dec +80; LM 5.80; teff 0.166; QUA: five; SPO: one (15% clouds)
- 11:35-11:47 UT; FOV RA 234 dec +80; LM 5.00; teff 0.200; QUA: three; DLM: one (15% clouds)

2 May 5–6, 2016

I went out to Bootland Farm for a pre-dawn Eta Aquariids watch, and Shane Finnigan joined me. The sky was really nice, and it was wonderful to hear a chorus of birds, owls, frogs and ducks. It was a comfortable night to be out too.

Unless the Eta Aquariids are unusually active, it's uncommon to see more than a few per hour from 45 degrees latitude. The radiant is very low and by the time it starts to gain some elevation, the night is already over. Occasionally, some really nice earthgrazers can make up for the low numbers!

As it turns out, I wasn't disappointed. A number of nice long ETA's were seen; the longest was a 50 degree long earthgrazer of mag +1 orange-to-blue! Good numbers of sporadics were seen and even the Eta Lyrids made an appearance.

The brightest was a mag 0 ETA that shot into the south near the Milky Way just as the night was ending. My Canon 6D even managed to capture that one[6]!

I observed the final 20 minutes in bright morning twilight in case the ETAs would be active as the radiant came up but none were seen.

May 5/6 2016, 06:30-08:50 UT (02:30-04:50 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- Anthelion (ANT) – 15:44 (236) -20

[6] https://pmartin.smugmug.com/Astronomy/20160506-Eta-Aquariids-Bootland-Farm/

- eta Lyrids (ELY) – 19:20 (290) +43
- gamma Aquilids (GAQ) – 20:28 (307) +14
- eta Aquariids (ETA) – 22:24 (336) -02

06:30-07:30 UT (02:30-03:30 EDT); clear; 4/5 trans; F 1.00; LM 6.48; facing SE50 deg; t_{eff} 1.00 hr; temp: +5C

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

07:30-08:33 UT (03:30-04:33 EDT); clear; 4/5 trans; F 1.00; LM 6.29; facing SE50 deg; t_{eff} 1.00 hr (3 min dead time); temp: +5C

- ETA: four: 0; +2; +3; +4
- ELY: three: +1; +3; +4
- GAQ: one: +2
- Sporadics: nine: +2; +3(3); +4(2); +5(3)
- Total meteors: Seventeen

08:33-08:50 UT (04:33-04:50 EDT); clear (morning twilight); 4/5 trans; F 1.00; LM 5.10; facing SE80 deg; t_{eff} 0.28 hr; temp: +5C

- meteors: none seen

3 May 9–10, 2016

I went out to Bootland Farm on the morning of May 10th to look for late Eta Aquariids. It was a very nice night, and comfortably cool with the temperature just above the freezing mark. I only watched for an hour but I was pleased to see 11 meteors (including 3 Eta Aquariids). One of the ETAs was a wonderful mag 0, blue, 50 degrees long earthgrazer that shot into Draco and Ursa Minor.

May 9/10 2016, 07:15-08:15 UT (03:15-04:15 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- Anthelion (ANT) – 16:00 (240) -21
- eta Lyrids (ELY) – 19:23 (291) +43
- theta 2 Sagittariids (TTS) – 19:40 (295) -34
- gamma Aquilids (GAQ) – 20:28 (307) +15
- eta Aquariids (ETA) – 22:39 (340) +00

07:15-08:15 UT (03:15-04:15 EDT); clear; 4/5 trans; F 1.00; LM 6.34; facing SSE50 deg; t_{eff} 1.00 hr; temp: +1C

- ETA: three: 0; +2; +4
- ELY: two: +2(2)
- ANT: one: +1
- Sporadics: five: +2(2); +3; +4; +5
- Total meteors: Eleven

4 July 29–30, 2016

The last few days of July period has long been one of my favorite times to observe meteors! Activity kicks into high gear at this point, with several active southern radiants including the Aquariids, early Perseids and upswing in sporadic rates too! The Moon will usually either favor the Aquariids in late July or the more popular Perseids in August. For 2016, the situation was actually pretty good for both. For the Aquariids, a waning crescent Moon rose shortly before dawn, and for the Perseids, the Moon set is shortly after midnight. So, this makes it possible to enjoy a bit of each shower's best near their maximum.

I ventured out to Bootland Farm, still one of my favorite sites (nice balance of darkness, seclusion and proximity from the city). I signed on just before midnight and I observed for over 4 hours until morning twilight. It was a pristine night with above-average transparency and stars up to mag 6.6 near the zenith! The Milky Way was quite impressive too for this location. At the start of the session, I saw two brilliant satellite flares of mag -4 or so one after the other high in the south!

I saw a total 90 meteors, lots going on up there! Not surprisingly, the South Delta Aquariids was the most active shower with 25 seen, followed by the Perseids with 15. The anthelions and Beta Perseids were also active, each producing 6 meteors. Other showers weakly active included the Capricornids, July Pegasids and Gamma Draconids.

The best meteor was the mag -4 CAP in Delphinus at 3:53am. It moved slowly on a short path until it ended with a terminal flash!

The rising crescent Moon caused only a small dip in the limiting magnitude towards the end of the night.

July 29/30 2016, 03:50-08:20 UT (23:50-04:20 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- July gamma Draconids (GDR) – 18:42 (281) +51
- Alpha Capricornids (CAP) – 20:28 (307) -09
- Anthelion (ANT) – 21:20 (320) -14
- South Delta Aquariids (SDA) -22:52 (343) -16
- Piscis Austrinids (PAU) – 23:04 (346) -30
- July Pegasids (JPE) -00:20 (005) +16
- Perseids (PER) – 02:04 (031) +55
- Eta Eridanids (ERI) – 02:24 (036) -14
- beta Perseids (BPE) – 02:35 (039) +39

03:50-04:50 UT (23:50-00:50 EDT); clear; 4/5 trans; F 1.00; LM 6.60; facing S50 deg; t_{eff} 1.00 hr

- ANT: four: +3; +4; +5(2)
- SDA: three: -2; +2; +4
- PER: three: +2(3)
- GDR: one: +3

- BPE: one: +5
- Sporadics: five: +1; +3; +4(2); +5
- Total meteors: Seventeen

04:50-05:50 UT (00:50-01:50 EDT); clear; 4/5 trans; F 1.00; LM 6.60; facing S50 deg; t_{eff} 1.00 hr

- SDA: seven: 0; +1; +2; +3; +4; +5(2)
- PER: five: +1; +2; +3(2); +4
- BPE: two: -1; +3
- CAP: one: +2
- ANT: one: +5
- JPE: one: +4
- Sporadics: seven: +2; +3; +4(2); +5(3)
- Total meteors: Twenty-four

05:50-07:00 UT (01:50-03:00 EDT); clear; 4/5 trans; F 1.00; LM 6.58; facing S50 deg; t_{eff} 1.00 hr

- SDA: ten: 0; +2(2); +3(5); +4; +5
- PER: four: +2(2); +3; +5
- CAP: one: +4
- JPE: one: 0
- BPE: one: +4
- Sporadics: eight: +1; +2; +3(3); +4(2); +5
- Total meteors: Twenty-five

07:00-08:00 UT (03:00-04:00 EDT); clear; 4/5 trans; F 1.00; LM 6.53; facing S50 deg; t_{eff} 1.00 hr

- SDA: five: +2(2); +3(2); +5
- PER: two: 0; +1
- BPE: two: +2; +4
- CAP: one: -4
- ANT: one: +3
- JPE: one: +4
- Sporadics: ten: +2(5); +3(2); +4; +5(2)
- Total meteors: Twenty-two

08:00-08:20 UT (04:00-04:20 EDT); clear; 4/5 trans (morning twilight); F 1.00; LM 6.38; facing S60 deg; t_{eff} 0.33 hr

- PER: one: +1
- Sporadics: one: +2
- Total meteors: Two

5 August 1–2, 2016

A few nights later, I went out again to Bootland to enjoy an early morning session. I rushed to leave home because I slept right through my midnight alarm clock, so I quickly grabbed what I needed and left so that I could still catch a good 2-3 hours of darkness before dawn.

When I arrived at Bootland, I realized I had left my meteor bag at home! … in the street actually! This bag had all my accessories and binoculars. Fortunately, a family member was able to retrieve it for me, but it meant that I had no tape recorder or note pad. I considered aborting the meteor watch and just view the sky casually, or come back home. Instead, I improvised a way to do voice memos on my iPhone without having to look down at the screen and ruin my dark adaptation. It was tricky and a bit of a pain but it seemed to work okay so I gave it a go. Without my talking clock, this also meant that I had to look down at my watch to note the exact time for each meteor, a process that took about 5 seconds for each meteor.

So, I signed on at 1:40am and watched for almost 3 hours until morning twilight. The sky was nice and clear with average transparency. The temperature very comfortable at +14C, with just a few mosquitoes, calm night and no dew. One iridium satellite of flare of mag -5 that lit up the sky a bit – cool!

I saw 66 meteors, with the South Delta Aquariids still going strong (with 18 of them), followed closely by the Perseids (with 14 seen). The majority of the Perseids were all seen in the second hour, and then they produced almost nothing during the final 40 minutes. The brightest meteor was a mag -1 CAP seen at 3:03am very far from the radiant, down in the east. It was yellow and produced a terminal flash.

August 1/2 2016, 05:40-08:25 UT (01:40-04:25 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- July gamma Draconids (GDR) – 18:44 (281) +50
- Alpha Capricornids (CAP) – 20:28 (307) -09
- Anthelion (ANT) – 21:20 (320) -14
- South Delta Aquariids (SDA) -22:52 (343) -16
- Piscis Austrinids (PAU) – 23:04 (346) -30
- July Pegasids (JPE) -00:20 (005) +16
- Perseids (PER) – 02:04 (031) +55
- Eta Eridanids (ERI) – 02:24 (036) -14
- beta Perseids (BPE) – 02:35 (039) +39

05:40-06:42 UT (01:40-02:42 EDT); clear; 3/5 trans; F 1.00; LM 6.53; facing S50 deg; t_{eff} 1.00 hr

- SDA: eight: +1; +2; +3(3); +4(2); +5
- ANT: five: +2(2); +3; +5(2)
- PER: three: +1; +3; +4
- CAP: two: +4(2)
- GDR: one: +1
- Sporadics: seven: +1(2); +3; +4(2); +5(2)
- Total meteors: Twenty-six

06:42-07:45 UT (02:42-03:45 EDT); clear; 4/5 trans; F 1.00; LM 6.55; facing S50 deg; t_{eff} 1.01 hr

- PER: ten: +1; +2(4); +4(2); +5(3)
- SDA: six: +3; +4(3); +5(2)
- ERI: three: +2; +3(2)
- CAP: one: -1
- JPE: one: +5
- Sporadics: eight: +2; +3(3); +4(4)
- Total meteors: Twenty-nine

07:45-08:25 UT (03:45-04:25 EDT); clear; 4/5 trans; F 1.00; LM 6.47; facing S50 deg; t_{eff} 0.65 hr

- SDA: four: +3(3); +5
- ANT: one: +4
- PER: one: +3
- BPE: one: +5
- Sporadics: four: +2(2); +3; +4
- Total meteors: Eleven

6 August 10–11, 2016

Here's a pre-peak Perseids watch for the morning of August 11, 2016 at Bootland Farm. Sky had average transparency but with some cirrus clouds covering the north. It was a warm night at +20C and very humid but without any dew. I was excited when I got out of the car there, as a nice mag -2 Perseid shot to the north! It was a surprisingly noisy night with a lot of crickets all over the place

I observed for two hours, from 3:30-4:32am and I saw 68 meteors. The Perseids were going on strong in the first hour with 35 seen, but for some strange reason, the rates dropped to only 16 in second hour. I can't really explain why that occurred as I was fully awake. There seemed to be more very faint meteors in the second hour too.

The best meteor was a Perseid at 3:08am that shot over 30 degrees and flared to mag -3, leaving behind a 4 sec persistent train!

At 3:03am, a sporadic and anthelion appeared exactly at once and nearly crossed paths.

Another highlight at 3:26am: a highly foreshortened blue-green Perseid near the radiant that flared to mag -2, and left a 2 sec train.

Unfortunately, the peak night August 11/12 of the Perseids was a washout. I made an effort to chase "sucker holes" to the east of the city, and then to the south-west. The best I managed was seeing a pair of meteors through a very small brief opening. The following night August 12/13, Shane Finnigan and I drove to the Plevna and Nirvana sites to try and catch an opening between clouds, but we got caught in a heavy rain as we waited in the parking lot at Plevna. At Nirvana, the sky did clear up briefly so we could observe casually for a while and saw a few meteors before the clouds returned. Then we called it quits and came back home.

August 10/11 2016, 06:30-08:32 UT (02:30-04:32 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 18:20 (275) +55
- alpha Capricornids – 20:44 (311) -08
- Anthelion (ANT) – 21:48 (327) -13
- North delta Aquariids (NDA) – 22:52 (343) -00
- South delta Aquariids (SDA) – 23:16 (349) -14
- Piscis Austrinids (PAU) – 23:20 (350) -28
- Perseids (PER) – 02:44 (041) +56
- eta Eridanids (ERI) – 02:52 (043) -12
- beta Perseids (BPE) – 02:57 (044) +38

06:30-07:30 UT (02:30-03:30 EDT); clear; 3/5 trans (thin cirrus clouds over the north); F 1.00; LM 6.40; facing SE60 deg; t_{eff} 1.00 hr

- PER: thirty-five: -3; -2; 0(3); +1(4); +2(8); +3(8); +4(4); +5(6)
- SDA: three: +2; +4; +5
- KCG: two: +1; +5
- ANT: two: +4; +5
- Sporadics: five: +1(2); +2; +3; +4
- Total meteors: Forty-seven

07:30-08:32 UT (03:30-04:32 EDT); clear; 3/5 trans (thin cirrus clouds over the north); F 1.00; LM 6.38; facing SE50 deg; t_{eff} 1.01 hr

- PER: Sixteen: 0; +2; +3(3); +4(3); +5(8)
- SDA: one: +1
- Sporadics: four: +2; +3; +4; +5
- Total meteors: Twenty-one

7 September 3–4, 2016

I went out for a quick one hour midnight session to enjoy the sky. It was average becoming below-average transparency with haze and cirrus clouds in parts of the sky. Fortunately, my view to the south was pretty good! I saw twelve meteors (9 sporadics, 2 September Perseids and 1 anthelion). The best meteor was at 11:59pm; a mag +1 golden sporadic that moved slowly near the border of Cygnus-Cassiopeia.

September 3/4 2016, 03:45-04:45 UT (23:45-00:45 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- Anthelion (ANT) – 23:32 (353) -03
- September Epsilon Perseids (SPE) – 02:38 (039) +38

03:45-04:45 UT (23:45-00:45 EDT); clear; 2/5 trans (thin haze and cirrus clouds throughout the sky); F 1.00; LM 6.41; facing S50 deg; t_{eff} 1.00 hr

- SPE: two: +3; +5
- ANT: one: +3
- Sporadics: nine: +1; +2(3); +4; +5(4)
- Total meteors: Twelve

8 December 13–14, 2016

The 2016 Geminids peak night was unfavorable due to the Full Moon just above Orion. To make matters more challenging, the sky was hazy and full of cirrus. Normally I would skip this and stay in bed but this is among the year's best meteor showers. Even on an "off" year, I usually will make an attempt to go out.

It appeared that the clouds were breaking up on the evening of December 13th, so I drove to the RASC's FLO site near Almonte. The sky was reasonably clear when I got there I casually saw a few nice meteors including a mag -2 Geminid and a mag +1 earthgrazing sporadic. The wind was at 15-20 km but I was nicely shielded by the trees, and the temperature was a very bearable -8C. The Moon however was intensely bright, and the best I could see in the darkest part of the sky was a limiting magnitude of +4.0.

I watched from midnight to 1:00am and I saw 9 Geminids and one anthelion. Then sky quickly deteriorated and clouded over completely. I took a snooze in the comfort of my winter sleeping bag, and woke up an hour later to see if it would clear. However, the sky was fully overcast and it was snowing. I packed the cameras and headed back home.

December 13/14 2016, 05:05-06:00 UT (00:05-01:00 EST) Location: Almonte, Ontario, Canada, (Long: -76 deg 15'; Lat: 45 deg 15')

Observed showers:

- Geminids (GEM) – 07:33 (113) +32
- Monocerotids (MON) – 06:52 (103) +08
- Anthelion (ANT) – 06:16 (094) +23

05:05-06:00 UT (00:05-01:00 EST); clear; 1/5 trans (thin haze and cirrus clouds throughout the sky); F 1.00; LM 4.00; facing S50 deg; t_{eff} 0.92 hr; Temp -8C

- GEM: nine: -2; +1(2); +2(2); +3(3); +4
- ANT: one: +3
- Total meteors: Ten

Visual observations 2017

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An overview is given of the 2017 meteor observations by the author, covering the July meteor showers, Orionids and Geminids.

1 July 27–28

On this late July session at Bootland Farm, I had the company of a curious deer who'd approach and sniff the grass around me. It was mild at +15C and there was a lot of mosquitoes but the Thermacell once again worked wonders! Nice sky, with average transparency except for some passing cirrus clouds around 1:30am. A half hour later, the sky improved. Except for the occasional rustlings from the deer, it was a quiet night.

Between 1:10-3:50am (2.5 hours), I saw 58 meteors (including 20 S. delta Aquariids, 8 Perseids, 4 Capricornids, 3 Gamma Draconids, 3 Anthelions, 2 N. Delta Aquariids, 2 July Pegasids, one phi Piscid and 15 sporadics).

The best was a mag –1 sporadic at 2:02am; it was majestically slow, blue-green and faded away very gradually.

July 27/28 2017, 05:10-07:50 UT (01:10-03:50 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- gamma Draconids (GDR) – 18:44 (281) +50
- alpha Capricornids (CAP) – 20:24 (306) -09
- Anthelion (ANT) – 21:16 (319) -16
- Northern delta Aquariids (NDA) – 22:15 (334) -04
- Southern delta Aquariids (SDA) – 22:42 (340) -16
- Piscids Austrinids (PAU) – 22:56 (344) -24
- July Pegasids (JPE) – 00:16 (004) +16
- Perseids (PER) – 01:52 (028) +54
- eta Eridanids (ERI) – 02:16 (034) -16
- phi Piscids (PPS) – 02:44 (041) +35
- psi Cassiopeiids (PCA) – 00:50 (013) +64

05:10-06:10 UT (01:10-02:10 EDT); clear; 3/5 trans (some clouds in west, dissipating); F 1.00; LM 6.50; facing SSE50 deg; t_{eff} 1.00 hr; 15C

- SDA: ten: -1; +2; +3; +4(5); +5(2)
- PER: four: +1(2); +2; +3
- GDR: three: +1(2); +2
- CAP: one: +5
- PPS: one: +2
- Sporadics: five: -1; +2(2); +3; +5
- Total meteors: Twenty-four

06:10-07:10 UT (02:10-03:10 EDT); clear; 3/5 trans (a few clouds in FOV); F 1.05; LM 6.44; facing S50 deg; t_{eff} 1.00 hr; 14C

- SDA: seven: +1(2); +2(2); +3(2); +4
- PER: four: +1; +2; +4(2)
- CAP: three: +1; +2(2)
- ANT: two: +2; +5
- NDA: two: +2; +3
- JPE: two: 0; +3
- Sporadics: seven: +1; +2(2); +3; +4(2); +5
- Total meteors: Twenty-seven

07:19-07:50 UT (03:19-03:50 EDT); clear; 3/5 trans; F 1.00; LM 6.44; facing S50 deg; t_{eff} 0.48 hr; 13C

- SDA: three: +3(2); +5
- ANT: one: +4
- Sporadics: three: +2; +3; +4
- Total meteors: Seven

2 July 28–29, 2017

Here's my results for the morning of July 29th 2017. The sky was much nicer than the previous night, with above-average transparency! The Milky Way was very structured, and there was a wealth of stars all around the zenith! As always, I setup my chair facing south to keep an eye on the many active radiants in that part of the sky.

This was a very productive 3.5 hour session with 94 meteors! I saw 28 S. Delta Aquariids, 11 Perseids, 8 Capricornids, 4 phi Piscids, 3 anthelions, 3 N. Delta Aquariids, 2 psi Cassiopeiids, 2 Gamma Draconids, one July Pegasid and 32 sporadics.

The third hour was particularly busy with 35 meteors! A lot going on in just about every part of the sky! I was glad to have such a clear night since the majority of the meteors seen were quite faint.

The brightest ones were two sporadics of mag -2, one seen at 2:23am and the other at 3:08am. Also, a very nice mag –1 Capricornid was seen near the end of the night grazing through the head of Cetus. It was a beauty!

July 28/29 2017, 04:45-08:20 UT (00:45-04:20 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- gamma Draconids (GDR) – 18:44 (281) +50
- alpha Capricornids (CAP) – 20:24 (306) -09
- Anthelion (ANT) – 21:16 (319) -16
- Northern delta Aquariids (NDA) – 22:15 (334) -04
- Southern delta Aquariids (SDA) – 22:42 (340) -16
- Piscids Austrinids (PAU) – 22:56 (344) -24
- July Pegasids (JPE) – 00:16 (004) +16
- Perseids (PER) – 01:52 (028) +54
- eta Eridanids (ERI) – 02:16 (034) -16
- phi Piscids (PPS) – 02:44 (041) +35
- psi Cassiopeiids (PCA) – 00:50 (013) +64

04:45-05:45 UT (00:45-01:45 EDT); clear; 4/5 trans; F 1.00; LM 6.58; facing SSE50 deg; t_{eff} 1.00 hr; 14C

- SDA: five: +1; +3(3); +4
- PER: three: 0; +1; +3
- CAP: two: +2(2)
- GDR: one: +5
- ANT: one: +5
- PCA: one: +5
- Sporadics: six: +2; +4(5)
- Total meteors: Nineteen

05:45-06:46 UT (01:45-02:46 EDT); clear; 4/5 trans; F 1.00; LM 6.60; facing SSE50 deg; t_{eff} 1.00 hr; 13C

- SDA: nine: +2(3); +4(2); +5(4)
- PER: four: +1(2); +2; +3
- CAP: three: +1; +2; +4
- GDR: one: +3
- JPE: one: +3
- PPS: one: +5
- Sporadics: seven: -2; +2; +4; +5(4)
- Total meteors: Twenty-six

06:46-07:46 UT (02:46-03:46 EDT); clear; 4/5 trans; F 1.00; LM 6.55; facing SSE50 deg; t_{eff} 1.00 hr; 12C

- SDA: nine: +2(2); +3(2); +4; +5(4)
- PER: four: +3(2); +4; +5
- NDA: three: +1; +4; +5
- PPS: three: +2; +3; +4
- ANT: two: +4(2)
- CAP: one: 0
- Sporadics: thirteen: -2; +2(2); +3(3); +4(4); +5(3)
- Total meteors: Thirty-five

07:46-08:20 UT (03:46-04:20 EDT); clear; 4/5 trans (morning twilight); F 1.00; LM 6.20; facing SSE50 deg; t_{eff} 0.56 hr; 11C

- SDA: five: +2; +4(3); +5
- CAP: two: -1; +2
- PCA: one: +5
- Sporadics: six: +1; +3(2); +4; +5(2)
- Total meteors: Fourteen

3 July 29–30, 2017

Here's my results for the morning of July 30th 2017. Third night in a row! The sky was actually cloudy when I got there, so I slept in the car until 2am. I signed-on as soon as it cleared up and I was able to observe for a couple of hours until morning twilight. The transparency was a very decent average-quality. Between 2:10-4:10am, I saw a total of 58 meteors. This included 14 S. Delta Aquariids, 9 Perseids, 5 phi Piscids, 4 Capricornids, 2 N. Delta Aquariids, 2 July Pegasids, one Gamma Draconid, one anthelion, one Eridanid, one psi Cassiopeiid and 18 sporadics.

Both hours actually were equally active with 29 meteors.

The Eridanid at 2:43am was an impressive 60 degrees long earthgrazer that flared twice along its path up to mag +3. Seconds later, a nice slow mag –1 Capricornid flared just south of Pegasus.

At 3:33am, a mag -3 S. Delta Aquariid produced a bright flare — nice!!

At 3:58am, I saw a very fast-moving satellite that passed near the zenith from west to east. It was very dim (approx. mag +5) but was it ever cruising!! I wouldn't be surprised if this was about to re-enter the atmosphere!

July 29/30 2017, 06:10-08:10 UT (02:10-04:10 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- gamma Draconids (GDR) – 18:44 (281) +50
- alpha Capricornids (CAP) – 20:24 (306) -09
- Anthelion (ANT) – 21:16 (319) -16
- Northern delta Aquariids (NDA) – 22:15 (334) -04
- Southern delta Aquariids (SDA) – 22:42 (340) -16
- Piscids Austrinids (PAU) – 22:56 (344) -24
- July Pegasids (JPE) – 00:16 (004) +16
- Perseids (PER) – 01:52 (028) +54
- eta Eridanids (ERI) – 02:16 (034) -16
- phi Piscids (PPS) – 02:44 (041) +35
- psi Cassiopeiids (PCA) – 00:50 (013) +64

06:10-07:10 UT (02:10-03:10 EDT); clear; 3/5 trans; F 1.00; LM 6.50; facing SSE50 deg; t_{eff} 1.00 hr; 14C

- SDA: six: +2(3); +3; +4; +5
- CAP: three: -1; +2; +3
- PER: three: +1; +4; +5
- PPS: two: +1; +5
- GDR: one: +5
- ANT: one: +4
- JPE: one: +2
- ERI: one: +3

- PCA: one: +5
- Sporadics: ten: +3; +4(3); +5(6)
- Total meteors: Twenty-nine

07:10-08:10 UT (03:10-04:10 EDT); clear; 3/5 trans; F 1.00; LM 6.35; facing SSE50 deg; t_{eff} 1.00 hr; 13C

- SDA: eight: -3; +2; +3(2); +4(4)
- PER: six: -3; 0; +4(2); +5(2)
- PPS: three: +1; +4; +5
- NDA: two: +2; +3
- CAP: one: 0
- JPE: one: +4
- Sporadics: eight: +2; +4(2); +5(5)
- Total meteors: Twenty-nine

4 July 30–31, 2017

Here's my results for the morning of July 31th 2017. Fourth night in a row! Once again out at Bootland Farm for a two hour pre-dawn session. The sky was crystal clear, and it was very mild at +15C but humid. Between 2:00-4:19am (2 hours not including breaks), I saw 53 meteors. Another fun session for sure! The dominant showers were the S. Delta Aquariids (with 19 seen) and the Perseids (with 12 seen). I also saw trace activity from several other minor radiants as well as 16 sporadics. Both hours again had a very even number of meteors.

The brightest meteors were the mag -1 S. Delta Aquariid at 2:49am and the -1 sporadic at 3:54am.

No luck with the Perseids peak nights (August 11-12 2017). They were unfavorable due to the gibbous moon in Pisces, but the weather also did not cooperate. I did see one nice bright fireball from a quick glance out the bedroom window, with mostly cloudy skies. Talk about luck! August and September were spent travelling for the Solar Eclipse and then to Nova Scotia, so meteor observing took a bit of a back seat ☺.

July 30/31 2017, 06:00-08:19 UT (02:00-04:19 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- gamma Draconids (GDR) – 18:44 (281) +50
- alpha Capricornids (CAP) – 20:24 (306) -09
- Anthelion (ANT) – 21:16 (319) -16
- Northern delta Aquariids (NDA) – 22:15 (334) -04
- Southern delta Aquariids (SDA) – 22:42 (340) -16
- Piscids Austrinids (PAU) – 22:56 (344) -24
- July Pegasids (JPE) – 00:16 (004) +16
- Perseids (PER) – 01:52 (028) +54
- eta Eridanids (ERI) – 02:16 (034) -16
- phi Piscids (PPS) – 02:44 (041) +35
- psi Cassiopeiids (PCA) – 00:50 (013) +64

06:00-07:11 UT (02:00-03:11 EDT); clear; 3/5 trans; F 1.00; LM 6.50; facing S50 deg; t_{eff} 1.00 hr; 15C

- SDA: eleven: -1; +1; +2(2); +3; +4(4); +5(2)
- PER: six: +1(2); +2; +4(2); +5
- CAP: one: +1
- Sporadics: eight: +3; +4(2); +5(5)
- Total meteors: Twenty-six

07:11-08:19 UT (03:11-04:19 EDT); clear; 3/5 trans; F 1.00; LM 6.35; facing S50 deg; t_{eff} 1.13 hr; 14C

- SDA: eight: +2(2); +3; +4(2); +5(3)
- PER: six: +1; +2(2); +3; +5(2)
- GDR: two: 0; +4
- ANT: one: +3
- ERI: one: +2
- PPS: one: +3
- Sporadics: eight: -1; +1(2); +2(2); +4(2); +5
- Total meteors: Twenty-nine

5 October 20–21, 2017

Continuing to catch up with old observing reports ☺

Last year, I was able to get only one night of observing for October's Orionids. This is one of my favorite annual showers, not only because of its association with Comet Halley, but also because of its "plateau like" duration and occasional enhancements. In some rare years, such as 2006-2008, there put on spectacular displays with rates that approach that of the Perseids or Geminids. Most years however, it is a moderate shower, rich in faint meteors.

2017 appeared to be a normal year. I went to Bootland Farm to observe from 1:30-6:10am and Shane Finnigan joined me as well. The sky transparency was below average, with a haze surrounding the horizons, and possibly thin cirrus clouds above us. This was evident with the larger than usual city glows from Ottawa and Renfrew, and the limiting mag above was 6.2 at best. The temperature was a mild +10C and with absolutely no bugs ☺

In the 4 hours I watched formally, I saw 92 meteors (60 Orionids, 4 N. Taurids, 3 S. Taurids, 2 Leo Minorids, 2 Andromedids, 1 chi Taurid, 1 Epsilon Geminid and 19 sporadics). Orionids hourly rates were 9, 18, 18 and 15. All in all, a pretty good night!

Without a doubt, the highlight-of-the-night was the mag -5 Orionid fireball seen in the last hour. It travelled over 30 degrees before producing a bright terminal flash, and leaving a 7 minutes persistent train! WOW!! I had time to pull out the 9×63 binocs to get a close-up view of the afterglow hanging amongst the stars, and slowly turning into an expanding "Z" shape that filled the field of view!

Here's the Orionids 2017 photography results. I had two cameras running the entire night, and I was surprised to have captured a decent number of meteors despite the slightly hazy sky:

Composite of 10 meteors[7]. Photographed with a Canon 5D and Sigma Art 35mm f/1.4 (at f/2.0), ISO 1600:

Composite of 9 meteors[8]. Photographed with a Canon 6D and Rokinon 14mm f/2.8, ISO 3200:

Composite of 3 meteors[9]. Photographed with a Canon 5D and Sigma Art 35mm f/1.4 (at f/2.0), ISO 1600:

Composite of 3 meteors[10]. Photographed with Canon 5D and Sigma Art 35mm f/1.4 (at f/2.0), ISO 1600:

October 20/21 2017, 05:30-10:10 UT (01:30-06:10 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- Southern Taurids (STA) – 02:44 (041) +11
- Northern Taurids (NTA) – 02:30 (038) +18
- Orionids (ORI) – 06:24 (096) +16
- epsilon Geminids (EGE) – 07:04 (106) +28
- Leonis Minorids (LMI) – 10:40 (160) +37
- Andromedids (AND) – 00:28 (007) +23
- chi Taurids (CTA) – 03:20 (050) +24
- nu Eridanids (NUE) – 06:54 (104) +12

05:30-06:30 UT; clear but hazy; 2/5 trans; F 1.00; LM 6.25; facing S50 deg; t_{eff} 1.00 hr; 10C

- ORI: nine: –1; 0; +1; +2; +3; +4; +5(3)
- NTA: two: +2(2)
- STA: one: +4
- AND: one: +1
- Sporadics: five: +2; +3(2); +4(2)
- Total meteors: Eighteen

06:30-07:30 UT; clear but hazy; 2/5 trans; F 1.00; LM 6.25; facing S50 deg; t_{eff} 1.00 hr; 10C

- ORI: eighteen: –1(2); 0; +1(2); +2(3); +3(5); +4(2); +5(3)
- STA: one: +1
- AND: one: +3
- CTA: one: +3
- Sporadics: four: +3; +4(2); +5
- Total meteors: Twenty-five

07:44-08:50 UT; clear but hazy; 2/5 trans; F 1.00; LM 6.25; facing S50 deg; t_{eff} 1.01 hr; 9C

- ORI: eighteen: –1; 0; +1(2); +2(3); +3(4); +4(4); +5(3)
- STA: one: +4
- NTA: one: +5
- Sporadics: six: +3(2); +4; +5(3)
- Total meteors: Twenty-six

09:01-10:10 UT; clear but hazy; 2/5 trans; F 1.00; LM 6.25; facing S50 deg; t_{eff} 1.01 hr; 9C

- ORI: fifteen: –5; +1(2); +2(3); +4(5); +5(4)
- LMI: two: +3(2)
- NTA: one: +3
- EGE: one: +4
- Sporadics: four: +2; +3(2); +4
- Total meteors: Twenty-three

6 December 13–14, 2017

The weather cooperated very nicely for last December's excellent Geminids meteor shower peak! Shane Finnigan, Raymond Dubois, Aero the dog and myself packed all our gear and off we went to Shane's cottage in Otter Lake, Quebec! It was nice that for once, the weather cooperated to see my favorite annual meteor shower without having to drive thousands of miles!

This was a VERY cold night, with a predicted overnight low of –30C (–22F). We were very well equipped with all the parkas, winter sleeping bags and chemical hand warmers that we needed to survive a whole night of meteor observing and photography. It definitely takes careful planning with this kind of temperatures, but thankfully the night was calm, and we also had a canopy of trees surrounding us to shield us from the wind. It was cold enough to hear the trees and branches emitting crackles and "pops" from contraction.

Early evening, I proceeded to setup my equatorial mount (for guided photos) and then cameras. As always, I had anti-dew strips running to keep the lenses dry and also transfer just enough heat to the camera bodies and even to the external remote triggers to prevent them from freezing completely! All of this was powered with my 1200w/hr LiFePO4 battery pack (itself in an insulated cooler with heat packs).

During setups, we saw several nice Geminids coming out of the east without even really trying! It was obvious that the activity was high even though the radiant was still quite low. Raymond was the first to be setup to watch, and from his constant "ooohs, another good one!!", I could tell that there was a good show overhead!

My hands and fingers tend to get cold fast, so I used fleece gloves and then very thick down filled mitts. These mitts don't allow much dexterity once I have them on, but they are very warm! They are also spacious enough that I could fit hand warmers and my micro-tape recorder. The fleece gloves are thin enough that I can feel the buttons on the device to record my voice memos on and off, all while keeping my hands warm. On top of that, both arms were well under my -40C rated sleeping bag. The talking clock was in one of the large pockets of my parka — I'd just hit

[7] https://pmartin.smugmug.com/Astronomy/20171021-Orionids-Bootland-Farm/i-FmQCkns/A
[8] https://pmartin.smugmug.com/Astronomy/20171021-Orionids-Bootland-Farm/i-vhwh6r2/A
[9] https://pmartin.smugmug.com/Astronomy/20171021-Orionids-Bootland-Farm/i-7d7vCd6/A
[10] https://pmartin.smugmug.com/Astronomy/20171021-Orionids-Bootland-Farm/i-FzCKZt3/A

that park of my parka. For my feet, two pairs of thick wool socks over a thinsulate, plus feet warmers. Finally, body warmers in two of my pockets. All in all, very comfy and no issues sitting out there for several hours in this kind of cold.

I signed on at 10:15pm and observed until 6:15am. I did not try to do a marathon however, I did take a number of breaks to check on the cameras, and go inside the warm cottage for a break or a snack. The effective observing time in my chair was actually over 6.5 hours. In that span of time, the Geminids were terrific!! I saw a total of 503 meteors (including 430 Geminids, 12 Monocerotids, 8 Hydrids, 6 Coma Berenicids, 3 anthelions, 2 December Leo Minorids and 42 sporadics). The observed Geminids hourly rates were 67, 92, 77, 77, 53 and 46. The final half hour of the night in rising moonlight and twilight produced 18 Geminids. I was very pleased by those rates, and I suspect we missed a number of meteors that occurred below the tree line.

As usual, the Geminids had moments of quick activity followed by quieter spells. Overall, it was active enough that I never felt there was much of a lull the entire night, although it seemed like the shower was starting to wind down towards the end. At one point after midnight, there was a single minute with as many as 11 meteors! They just kept coming and coming!!

Many bright, colorful meteors were seen but the mag –5 and -6 fireballs seen late at night were GORGEOUS!! The –5 Geminid was vivid BLUE, and had a 30 degrees long path that left a 12 sec train. I thought that was going to be the highlight until I saw the –6 at 4:26am! That one was blue-white, went 30 degrees low in the sky just above the cottage and, swelled up intensely, about 1/2 the diameter of the Moon!

All in all, a really fantastic night with the company of Shane and Raymond! It was very much well worth the effort, even though I froze a finger at the end while removing my camera. I just never seem to get tired of viewing this prolific shower A real treat also, to be able to sleep in the warm cottage at the end (thanks Shane!).

Photo results

This is a composite image of the Geminids meteor shower taken with my Canon 6D and a Rokinon 14mm lens at f2.8. I took hundreds of exposures over the night, all while tracking these stars. Then I picked all the shots with meteors in them and digitally added them together into Photoshop to create this image… a near "all night" capture of 74 Geminids. This is a really wide view, covering most of the entire sky. The Milky Way is visible across several constellations… including Orion, Taurus and Perseus. All the meteors seem to radiate from a point in Gemini, an effect due to perspective. Those tiny meteors near the radiant point are ones seen coming nearly "head on" to the camera[11].

This is another composite of the Geminids taken with my Canon 6D and a Rokinon 14mm lens at f2.8. Late at night, with Gemini crossing the zenith, and meteors seen "falling" straight down in every direction. This image contains 49 Geminids, digitally stacked in Photoshop. What is that down on the ground?! Alien? Christmas Tree? No, it's Shane who just happened to stand out there with his camera, taking pictures and using a dim light. That was completely unplanned and I didn't know Shane was going to be in the picture like that. It turns out that I liked the result[12].

This is another composite image of the Geminids taken with my Canon 6D and a Rokinon 14mm lens at f2.8. This was towards the end of the night. Some bright long meteors were captured heading down to the east. The Big Dipper is visible on the top left, oriented vertically[13].

One of the fireballs seen late at night! This one was greenish and it lit up a part of the sky. This is a single image only (not a composite). Canon 5D, Rokinon 24mm f.1.4 lens (set at f2.0)[14].

Another digital composite, this time taken with a Canon 5D, Rokinon 24mm f.1.4 lens (set at f2.0)[15].

This image is a combination of 22 unguided time exposures (each lasting 45 seconds). Unguided means untracked (i.e. camera set on a fixed tripod). Because of Earth's rotation, the objects in the sky move continuously from east to west. The resulting 20 minutes worth of unguided photos created long streaks of stars. This effect makes star colors more obvious. Seven meteors were captured too! On the upper left side, the tiny white dot is a geo-synchronous satellite. Canon 5D, Rokinon 24mm f.1.4 lens (set at f2.0)[16].

Long Geminid meteor meets a flaring artificial satellite. In reality, both were likely very far from each other… just an interesting line of sight! Taken on the morning of December 14 2017. Canon 6D, Rokinon 14mm f.2.8 lens[17].

Short time lapse video of a Geminid fireball and its persistent train (looks like a brownish expanding "puff" left by the meteor). To see it better, go to the settings below and make sure that HD is selected! The real time is 4.5 minutes (the meteor lasted about 1 second, and the glowing train lingered for much longer). Canon 5D, Rokinon 24mm f.1.4 lens (set at f2.0)[18].

[11] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-3B3hBPW/A
[12] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-r8BHkBF/A
[13] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-Hf2kHks/A
[14] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-gT7Vf9Z/A
[15] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-snfNS3S/A
[16] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-qWwdn6m/A
[17] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-JS7J8mt/A
[18] https://pmartin.smugmug.com/Astronomy/20171213-14-Geminids-Otter-Lake/i-VF63JVq

Visual results

December 13/14 2017, 03:15-11:15 UT (22:15-06:15 EST)
Location: Otter Lake, Quebec, Canada, (Long: -76 deg 23' 53"; Lat: 45 deg 49' 45")

Observed showers:

- Anthelion (ANT) – 06:00 (090) +23
- Monocerotids (MON) – 06:40 (100) +08
- November Orionids (NOO) – 06:52 (103) +15
- Geminids (GEM) – 07:20 (110) +33
- sigma Hydrids (HYD) – 08:28 (127) +02 (not until second hour)
- December Leonis Minorids (DLM) – 10:00 (150) +34 (not until fourth hour)
- psi Ursa Majorids (PSU) – 11:44 (176) +42 (not until fourth hour)
- December alpha Draconids (DAD) – 13:36 (204) +58 (not until fourth hour)
- Coma Berenicids (COM) – 11:30 (173) +20 (not until fourth hour)
- December sigma Virginids (DSV) – 13:12 (198) +07 (not until fifth hour)

03:15-04:16 UT; clear; 4/5 trans; F 1.17; LM 6.65; facing S60 deg; t_{eff} 1.01 hr; -19C

- GEM: sixty-seven: -3; -1(2); 0(5); +1(12); +2(8); +3(15); +4(18); +5(6)
- ANT: one: +1
- MON: one: +3
- Sporadics: seven: 0(2); +2(2); +3; +4; +5
- Total meteors: Seventy-six

04:16-05:17 UT; clear; 4/5 trans; F 1.17; LM 6.70; facing S60 deg; t_{eff} 1.00 hr; -21C

- GEM: ninety-two: -3(2); -2(2); -1(2); 0(8); +1(13); +2(24); +3(21); +4(12); +5(8)
- HYD: three: +2(3)
- MON: two: +2; +3
- Sporadics: five: -1; +1(2); +2; +3
- Total meteors: One-hundred-two

5:17-06:20 UT; clear; 4/5 trans; F 1.17; LM 6.70; facing S60 deg; t_{eff} 1.05 hr; -24C

- GEM: seventy-seven: -2; -1; 0(3); +1(11); +2(28); +3(15); +4(13); +5(5)
- MON: five: +2(2); +3(2); +4
- ANT: two: +3; +4
- HYD: two: -2; +4
- Sporadics: seven: +1; +3(2); +4(3); +5
- Total meteors: Ninety-three

7:40-08:43 UT; clear; 4/5 trans; F 1.17; LM 6.70; facing S60 deg; t_{eff} 1.00 hr; -26C

- GEM: seventy-seven: -5; -3; -2(3); -1(5); 0(8); +1(13); +2(16); +3(13); +4(9); +5(8)
- MON: three: +1; +4; +5
- COM: three: +4(3)
- DLM: one: +3
- Sporadics: six: +3; +4; +5(4)
- Total meteors: Ninety

8:43-09:43 UT; clear; 4/5 trans; F 1.17; LM 6.70; facing S60 deg; t_{eff} 1.00 hr; -29C

- GEM: fifty-three: -6; -3; -2(2); -1(3); 0(4); +1(11); +2(13); +3(10); +4(7); +5(1)
- HYD: two: +1; +2
- COM: two: +3; +4
- MON: one: +5
- DLM: one: +2
- Sporadics: six: 0; +3(3); +4; +5
- Total meteors: Sixty-five

9:43-10:44 UT; clear; 4/5 trans; F 1.17; LM 6.50; facing S60 deg; t_{eff} 1.01 hr; -30C

- GEM: forty-six: -2; -1(2); 0(3); +1(6); +2(4); +3(13); +4(13); +5(4)
- HYD: one: +3
- COM: one: +3
- Sporadics: seven: +2; +3(4); +4; +5
- Total meteors: Fifty-five

10:44-11:15 UT; clear; 4/5 trans (morning twilight); F 1.17; LM 6.16; facing S60 deg; t_{eff} 0.51 hr; -30C

- GEM: Eighteen: -4; -1; 0(3); +1(3); +2; +3(6); +4; +5(2)
- Sporadics: four: +3; +4(2); +5
- Total meteors: Twenty-two

Short periods (number of meteors, in 5 or 10 minutes T_{EFF} periods)

- 03:15-03:25 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; t_{eff} 0.167; GEM: nine; ANT: one; SPO: two
- 03:25-03:25 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; t_{eff} 0.167; GEM: ten; MON: one
- 03:35-03:46 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; teff 0.175; GEM: fifteen; SPO: two
- 03:46-03:56 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; teff 0.167; GEM: ten; SPO: two
- 03:56-04:06 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; teff 0.167; GEM: thirteen
- 04:06-04:16 UT; FOV RA 054 dec +18; F 1.17; LM 6.65; teff 0.167; GEM: ten; SPO: one
- 04:16-04:26 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: ten; HYD: one
- 04:26-04:36 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: sixteen; HYD: one; SPO: two
- 04:36-04:43 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.117; GEM: twelve; SPO: one

** BREAK 04:43-04:44 **

- 04:44-04:54 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: thirteen; MON: two; SPO: one

- 04:54-05:04 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: fifteen
- 05:04-05:09 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.083; GEM: eleven; HYD: one
- 05:09-05:14 UT; FOV RA 067 dec +17; F 1.17; LM 6.70; teff 0.083; GEM: eleven; SPO: one
- 05:14-05:24 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: twelve; SPO: one
- 05:24-05:34 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: eleven; MON: two; SPO: two
- 05:34-05:44 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: twenty; MON: one
- 05:44-05:54 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: nine; HYD: two
- 05:54-06:04 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: eleven; SPO: one
- 06:04-06:14 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.167; GEM: ten; ANT: two; MON: one; SPO: two
- 06:14-06:20 UT; FOV RA 082 dec +17; F 1.17; LM 6.70; teff 0.100; GEM: eight; MON: one; SPO: one

** BREAK 06:20-07:40 **

- 07:40-07:50 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: ten
- 07:50-08:00 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: eleven; MON: one; SPO: one
- 08:00-08:10 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: thirteen
- 08:10-08:20 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: sixteen; COM: three; MON: one; SPO: two
- 08:20-08:30 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: sixteen; MON: one; SPO: two
- 08:30-08:35 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.083; GEM: five; DLM: one; SPO: one

** BREAK 08:35-08:38 **

- 08:38-08:48 UT; FOV RA 116 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: nine
- 08:48-08:58 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: thirteen; MON: one
- 08:58-09:08 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: eight; HYD: one; SPO: two
- 09:08-09:18 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: twelve; SPO: one
- 09:18-09:28 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: nine; SPO: one
- 09:28-09:38 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: four; COM: one; SPO: two
- 09:38-09:48 UT; FOV RA 131 dec +12; F 1.17; LM 6.70; teff 0.167; GEM: five; COM: one; DLM: one; HYD: one
- 09:48-09:58 UT; FOV RA 146 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: eleven; HYD: one
- 09:58-10:08 UT; FOV RA 146 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: nine; SPO: one
- 10:08-10:18 UT; FOV RA 146 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: seven; SPO: two
- 10:18-10:29 UT; FOV RA 146 dec +13; F 1.17; LM 6.70; teff 0.175; GEM: six; SPO: three
- 10:29-10:39 UT; FOV RA 146 dec +13; F 1.17; LM 6.70; teff 0.167; GEM: seven; COM: one; SPO: one
- 10:39-10:49 UT; FOV RA 162 dec +14; F 1.17; LM 6.70; teff 0.167; GEM: nine
- 10:49-10:59 UT; FOV RA 162 dec +14; F 1.17; LM 6.70; teff 0.167; GEM: seven; SPO: one
- 10:59-11:09 UT; FOV RA 162 dec +14; F 1.17; LM 6.70; teff 0.167; GEM: six; SPO: three
- 11:09-11:15 UT; FOV RA 162 dec +14; F 1.17; LM 6.70; teff 0.100; GEM: one

2017 Report BOAM
October to December 2017

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A summary of the Orionid and Geminid showers and the most interesting meteor events recorded by the French network BOAM during the period of October until December 2017 is presented.

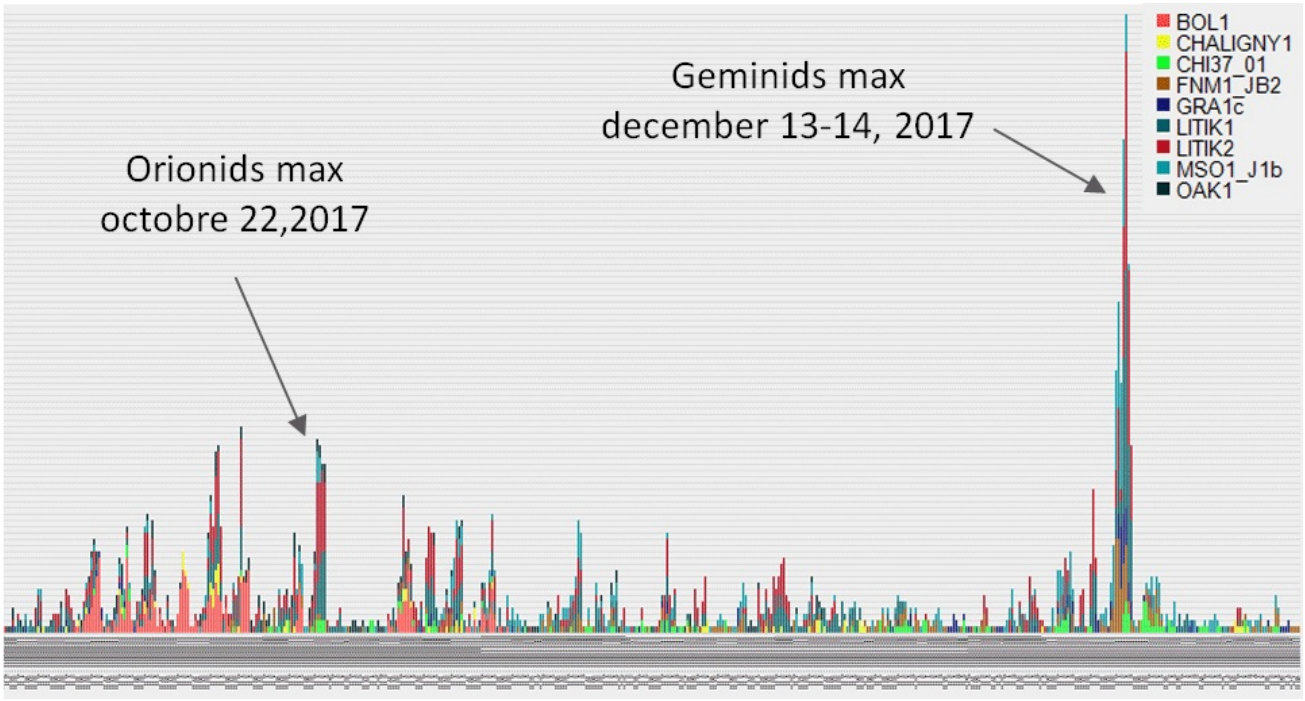

Figure 1 – Overview of the number of captures for the period October to December 2017 – GraphBoam.

1 Introduction

Each year, the period between October and December is marked by the activity of a dozen major showers. The maxima of the Orionids and the Geminids were key moments for the BOAM network and nice fireballs occurred during these three months.

2 October 2 – November 7: Orionids

Table 1 – The Orionid meteor stream characteristics.

Period of activity	October 2 – November 7
Maximum	October 21
Radiant position (max)	$\alpha = 95°$ and $\delta = +16°$
Zenithal Hourly Rate (max)	20 meteors per hour
Velocity	66 km/s
Population index *r*	2.5
Parent body	1P/Halley

Orionid meteors are dust ejected by the famous comet of Halley when it comes close to the Sun every 76 years. The Earth crosses the particle cloud released from the nucleus two times per year giving two single meteor showers: η-Aquariids in May (easily observable from the Southern Hemisphere) and Orionids in October.

We have recorded 403 Orionids during the activity period, allowing to calculate 57 orbits, radiant positions and trajectories with data from UKMON and FMA.

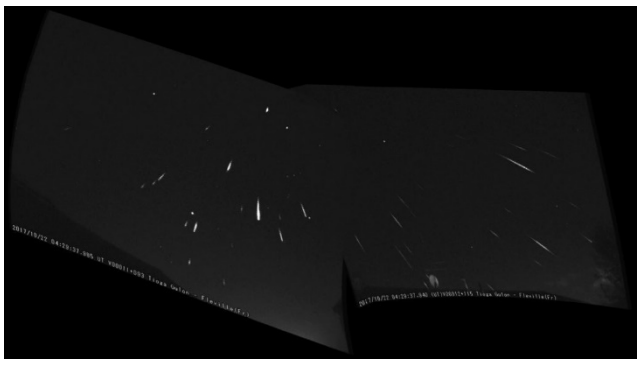

Figure 2 – Stacked picture of 48 Orionids from the stations LITIK1 and LITIK2 (Fléville – France) during the night of October 22th.

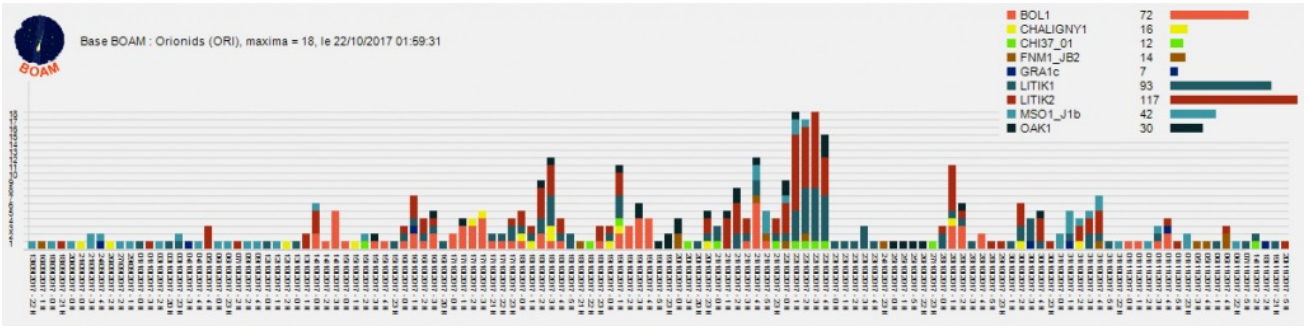

Figure 3 – Chronological distribution of the 403 single detections of Orionids – GraphBoam.

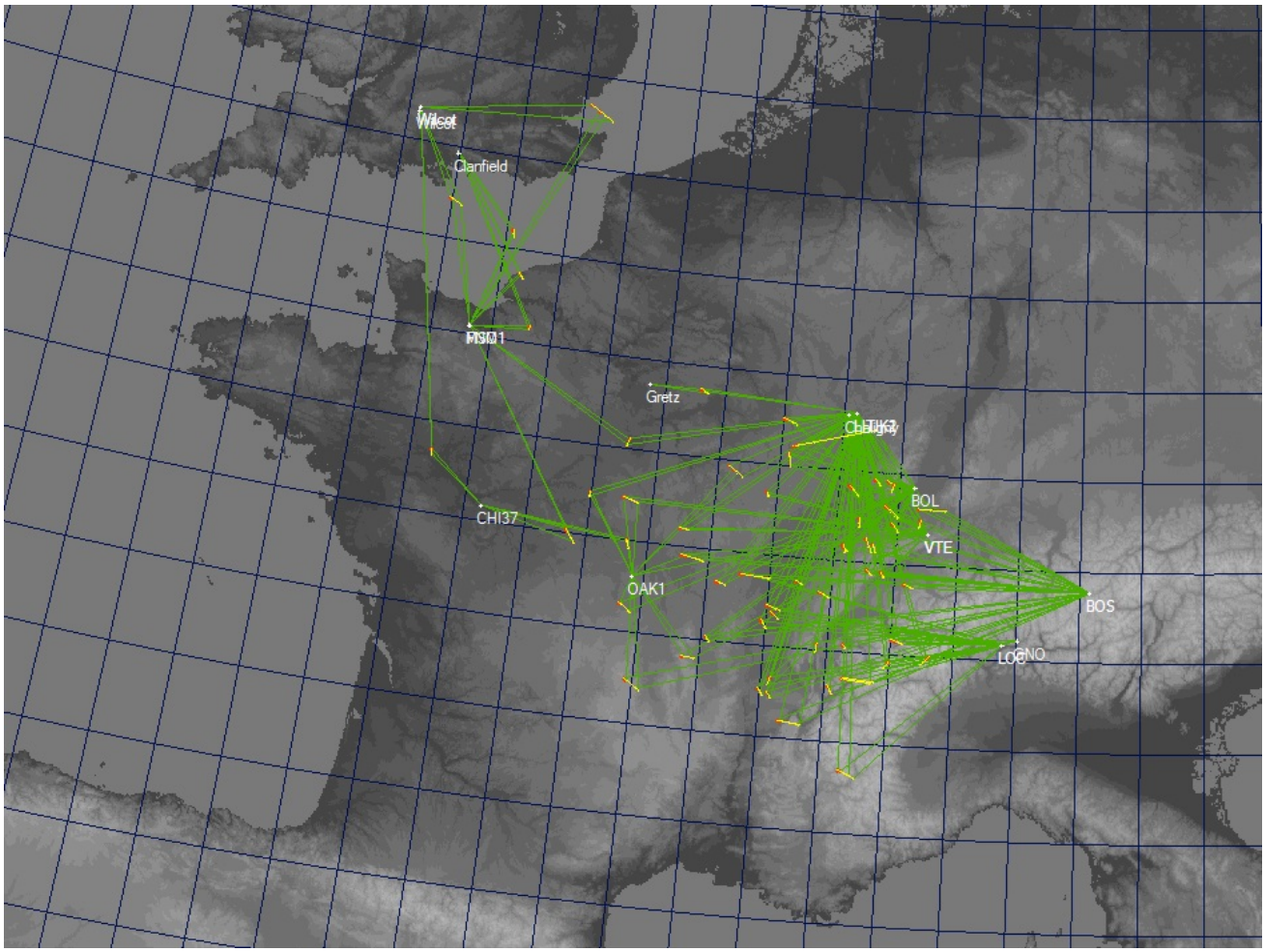

Figure 4 – 57 Orionid trajectories on a ground map – UFOorbit.

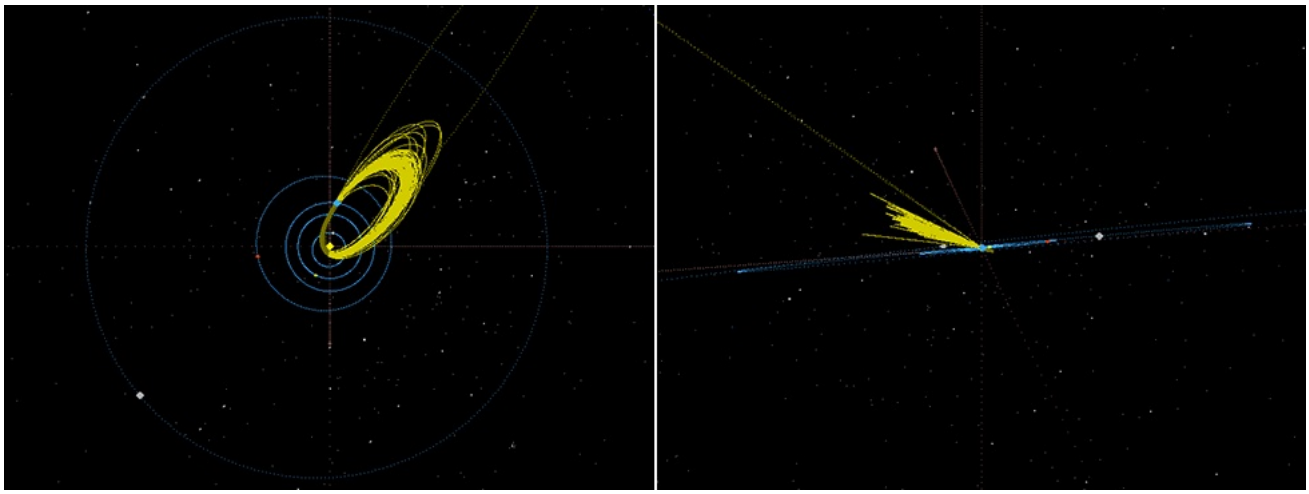

Figure 5 – 57 Orionid orbits on a solar system map : top view, side view – UFOorbit. The semi-major axis of the orbit calculated depends a lot on the velocity of the meteor, the accuracy is rather poor for this element.

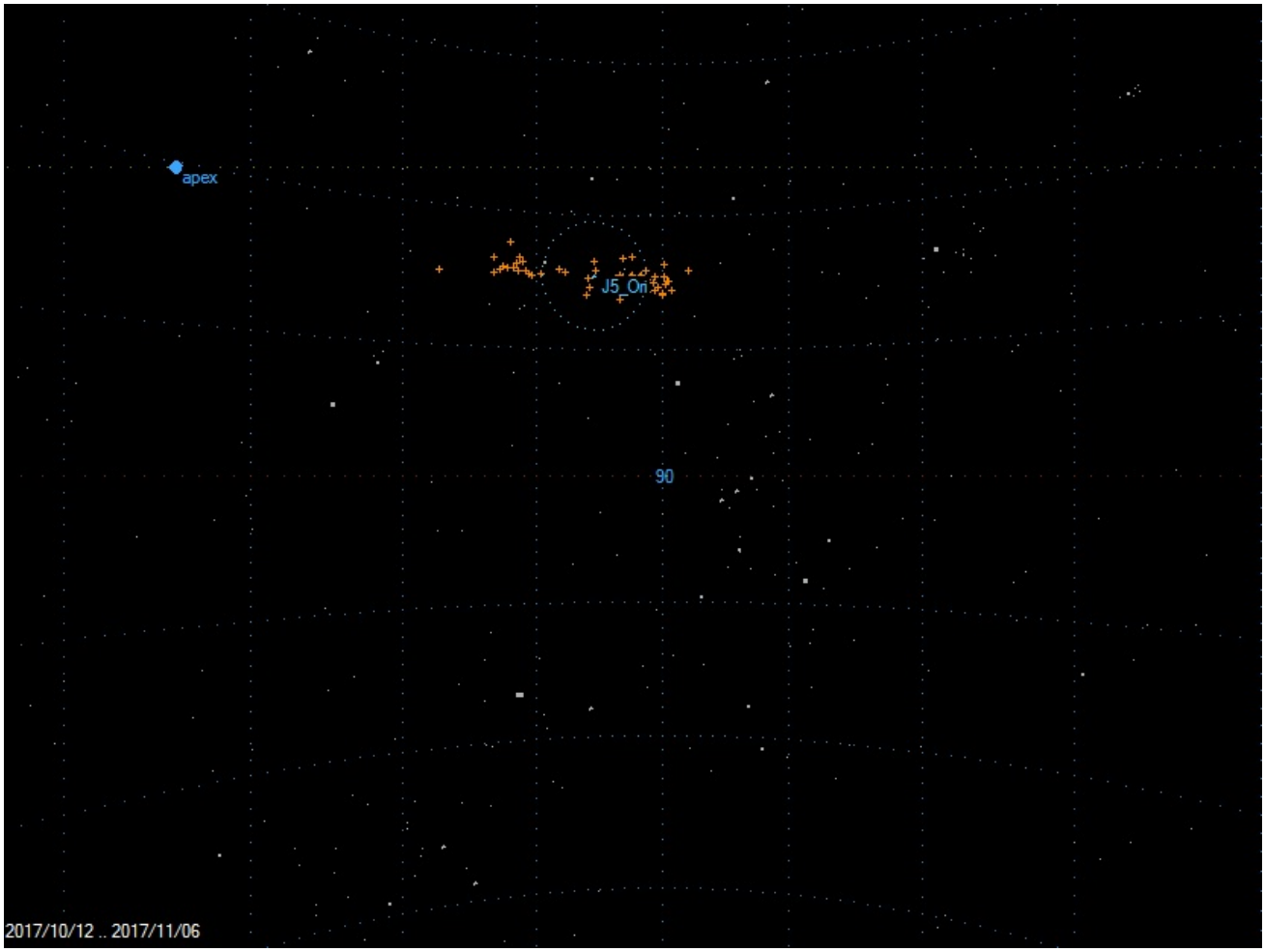

Figure 6 – 57 Orionid radiants on a gnomonic projection sky map – UFOorbit.

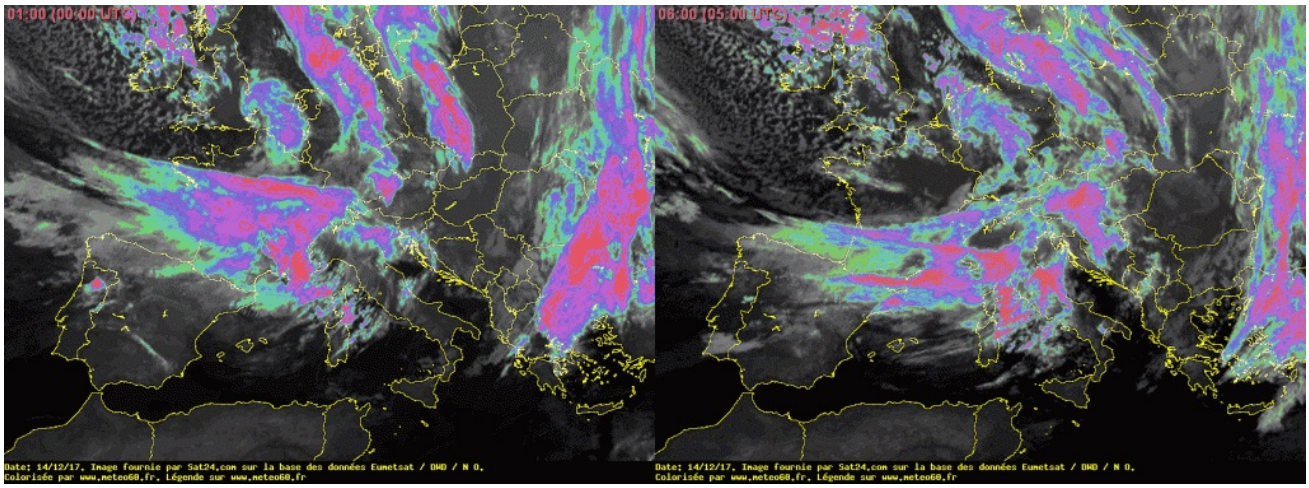

Figure 7 – IR satellite images on the night of December 13-14 ©Sat24.com / meteo60.fr.

3 December 4 – 17: Geminids

The Geminid shower is active from December 4th to 17th with a large peak during the night of December 13th to 14th, maximum ZHR around 120 meteors per hour. The meteoroids entry velocity is 35 km/s, leaving few persistent trails.

These shooting stars appeared in 1862 and their origins remained a long time unknown until 1983, date of the discovery of the parent body, the asteroid Phaethon.

Table 2 – The Geminid meteor stream characteristics.

Period of activity	December 4 – 17
Maximum	December 13–14
Radiant position (max)	$\alpha = 112°$ and $\delta = +33°$
Zenithal Hourly Rate (max)	120 meteors per hour
Velocity	35 km/s
Population index *r*	2.6
Parent body	3200 Phaeton

Figure 8 – Stacked pictures of the Geminids from the station Fleville – Left : LITIK2, 77 meteors – Right : LITIK1, 61 meteors © T.Gulon.

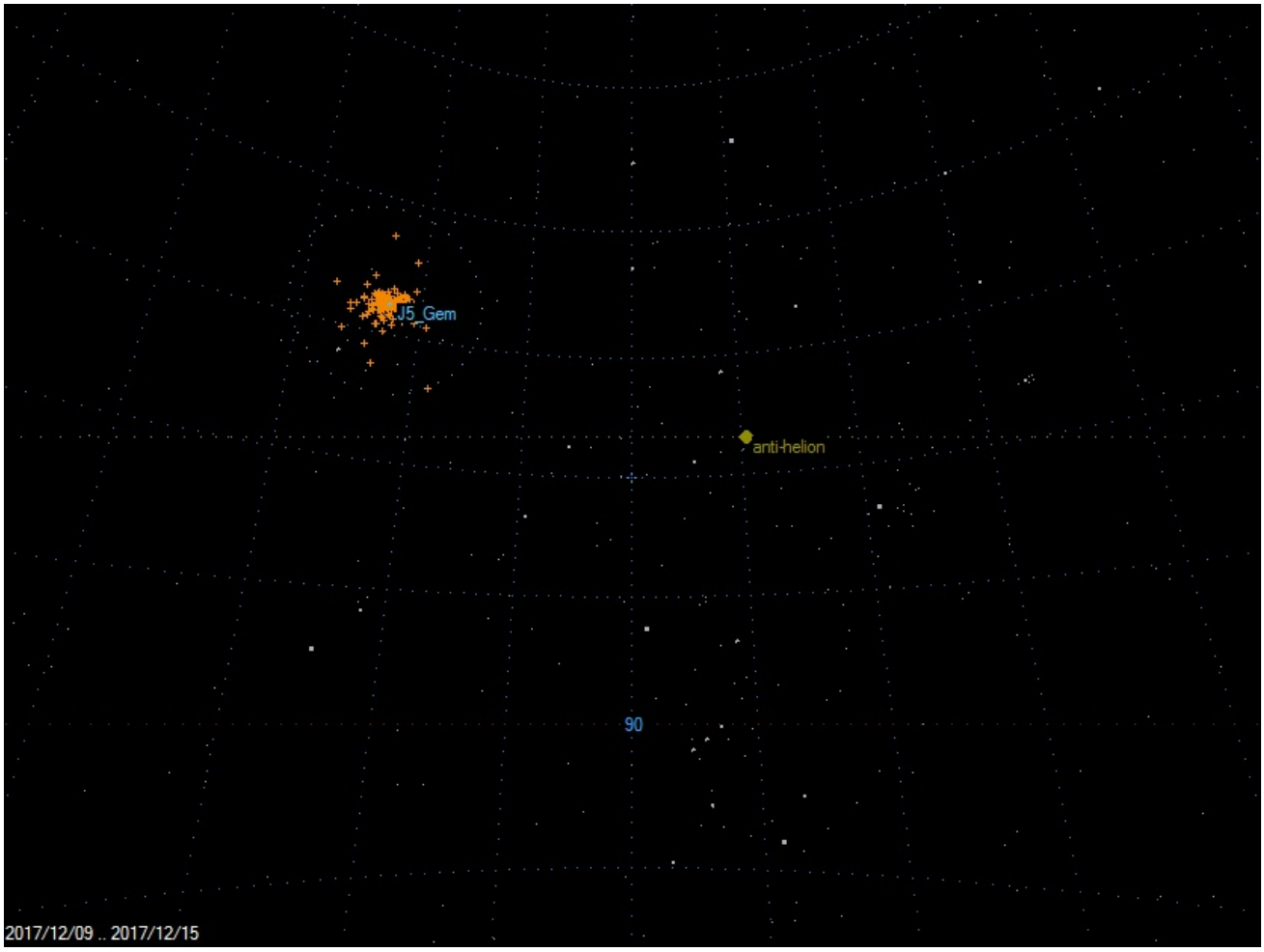

Figure 9 – 111 Geminids radiants on gnomonic projection sky map – UFOorbit.

This year, the observation conditions were optimal with an absent moon (New Moon on December 18). The maximum was predicted for December 14 around 06:30 UT but it was appropriate to be attentive between 13:50 UTC December 13 and 11:05 UTC December 14, 2017 because over the last twenty years, the most beautiful maxima observed occurred between 261.5° and 262.4° of solar longitude. The maximum visible activity was around 2–3 o'clock in the morning when the radiant is high in the sky.

The weather conditions were bad that night on France, except for the cameras of the northern third which had clear skies on the second half of the night.

We recorded 513 Geminids in 2017, allowing trajectory calculation of 111 of them thanks to data from neighboring UKMON and FMA networks.

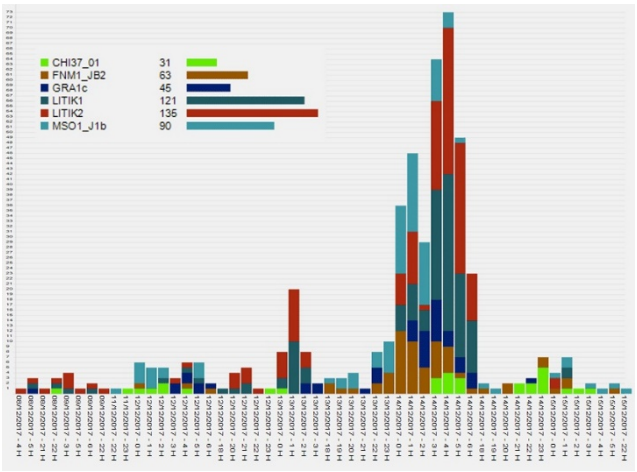

Figure 10 – Chronological distribution of the 513 single detections of Geminids – GraphBoam.

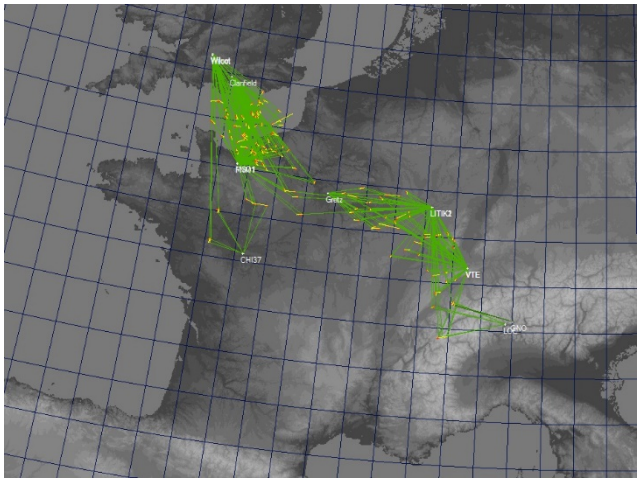

Figure 11 – 111 Geminid trajectories on the ground map – UFOorbit.

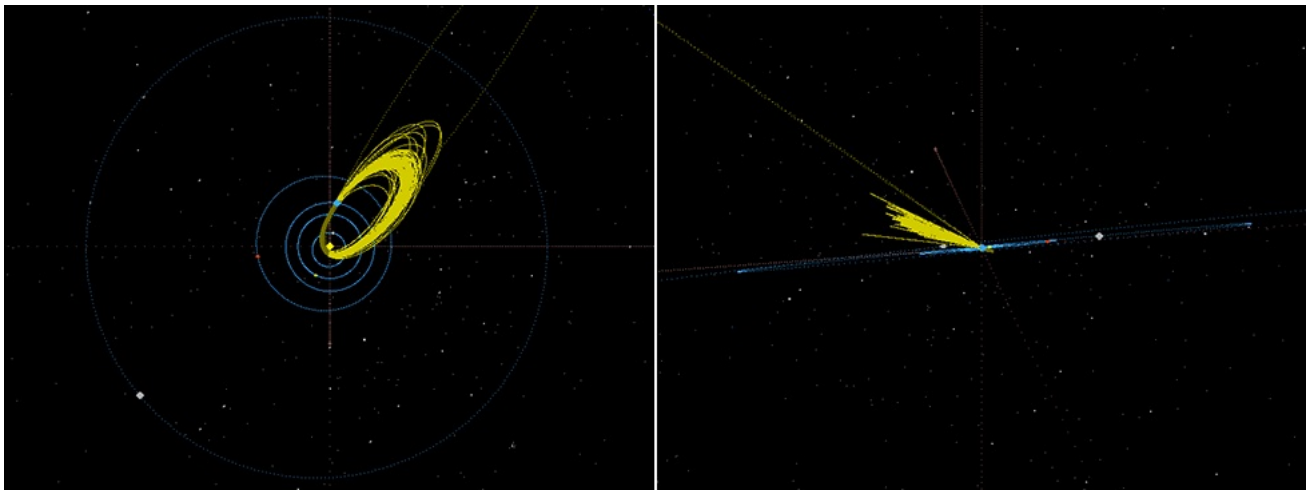

Figure 12 – 111 Geminid orbits in the solar system map : top view side view – UFOorbit. The semi-major axis of the orbit calculated depends a lot on the velocity of the meteor, the accuracy is rather poor for this element.

4 Peculiar meteor events

2017/10/05 – 03:36:16 UT: Fast and long meteor M20171005_033616

Figure 13 – M20171005_033616 – Chinon (France) – Astrochinon. link to the video.

This beautiful fireball crossed the sky through the zenith over AstroChinon observatory (station CHI37) enlightening the sky for more than 6 seconds with multiple fragmentations. On the record, the magnitude of moon at the horizon is –12 and although the fireball seems to cross mist scattering its light we can estimate the maximum magnitude around –9.

Unfortunately, we have not been able to do a triangulation calculation, 3 cameras recorded the event but only the station CHI37 is calibrated in astrometry.

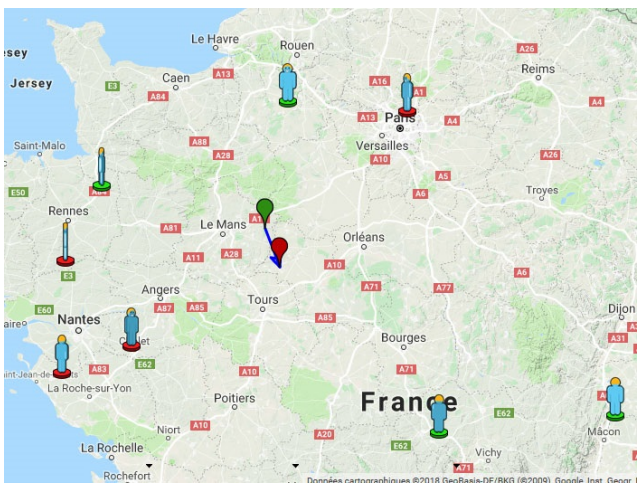

Figure 14 – 8 visual reports – IMO (Link).

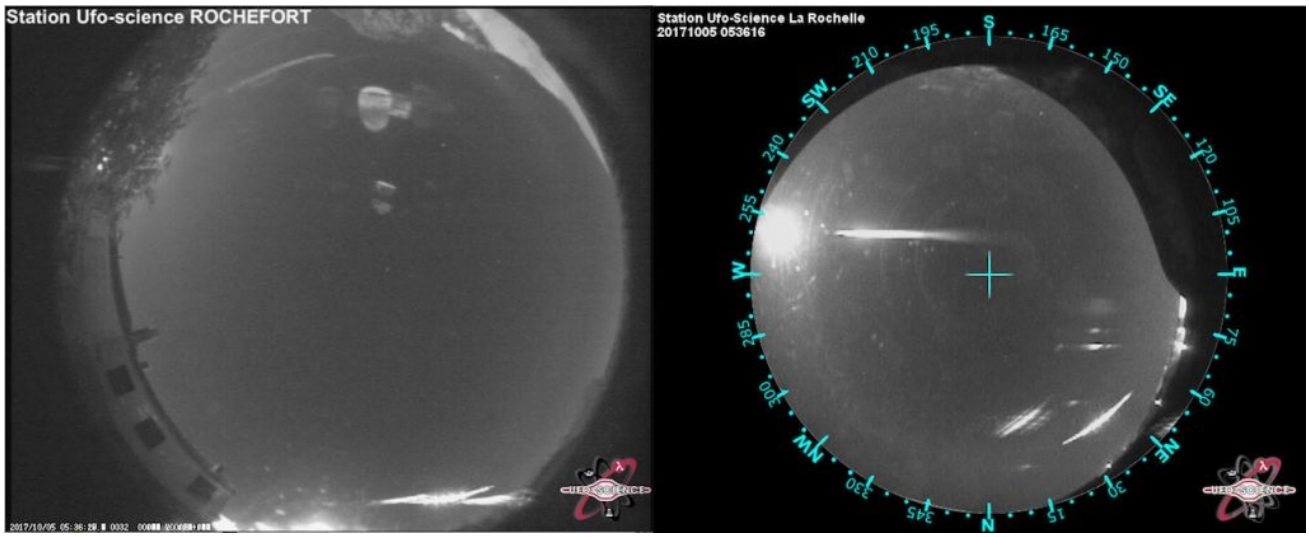

Figure 15 – M20171005_033616 from Rochefort and La Rochelle (France) © Jean-Christophe DORE – Ufo-science.

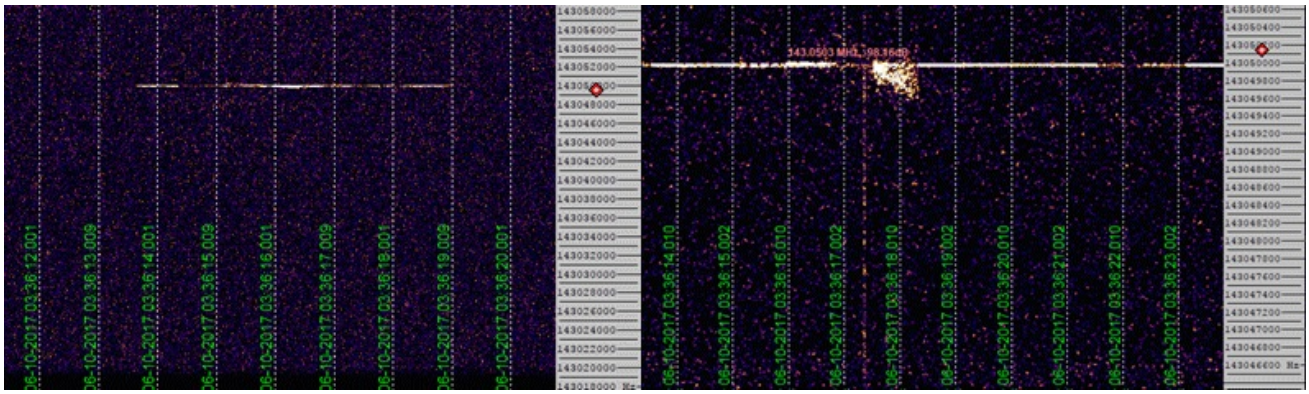

Figure 16 – GRAVE radar reflection from Brest (left) and Caen (right) © Fripon.

2017/10/15 – 00:50:53 UT: M20171015_005053

Sporadic, absolute magnitude: –5.0, duration time: 4.54 s, velocity: 15 km/s, height of start: 74 km, height of end: 35 km, trajectory length: 67 km, inclination: 35°, radiant ra.: 323° dec.: +39°.

Figure 17 – M20171015_005053 – Cérilly (France) – T. Gulon.

Figure 18 – M20171015_005053 – Bollwiller (France) – C. Demeautis.

Figure 19 – M20171015_005053 – Val Terbi (Switzerland) – R. Spinner.

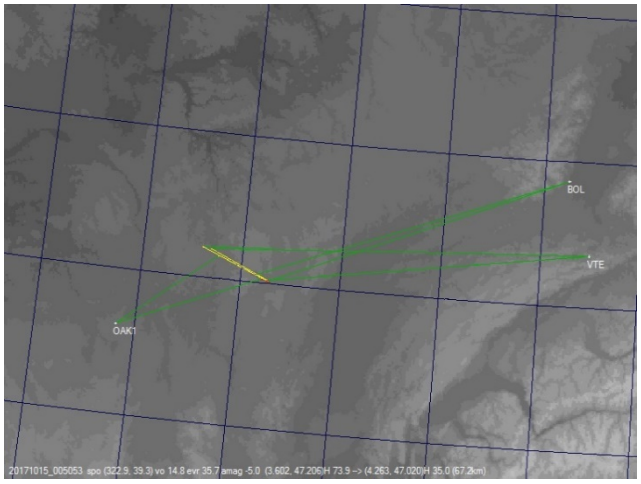

Figure 20 – M20171015_005053 trajectory on ground map Stream.

2017/10/15 – 22:11:06 UT: M20171015_221106

Figure 21 – M20171015_221106 – Bollwiller (France) – C. Demeautis.

Figure 22 – M20171015_221106 – Val Terbi (Switzerland) – R. Spinner.

Figure 23 – M20171015_221106 – Fleville (France) – T. Gulon.

Figure 24 – M20171015_221106 – Bos-Cha (Switzerland) – J. Richert.

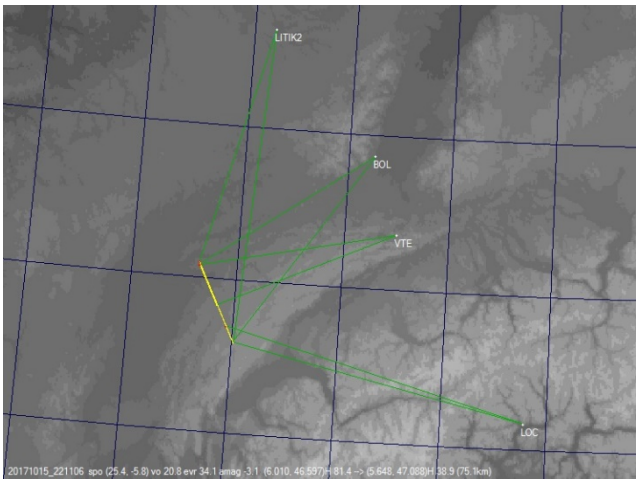

Figure 25 – M20171015_221106 trajectory on ground map.

Sporadic, absolute magnitude: –3.1, duration: 3.61 s, velocity: 21 km/s, height of start: 82 km, height of end: 39 km, trajectory length: 75 km, inclination: 35°, radiant ra.: 25° dec.: –6°.

2017/10/18 – 00:10:03 UT : Southern Taurid M20171018_001003

Southern Taurid, absolute magnitude: –6.7, duration: 2.48 s, velocity: 27 km/s, height of start: 107 km, height of end: 56 km, trajectory length: 65 km, inclination: 52°, radiant ra. : 38° dec. : +11°.

Figure 26 – M20171018_001003 – Bollwiller (France) – C. Demeautis.

Figure 27 – M20171018_001003 – Fleville (France) – T.Gulon.

Figure 28 – M20171018_001003 – Val Terbi (Switzerland) – R.Spinner.

Figure 29 – M20171018_001003 – Chaligny (France) – Marco.

Figure 30 – M20171018_001003 – Cérilly (France) – T.Gulon.

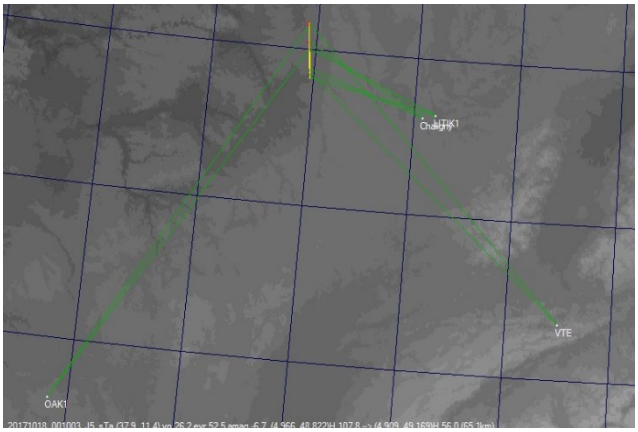

Figure 31 – M20171018_001003 trajectory on ground map.

2017/11/20 – 03:32:06 UT: Northern Taurid M20171120_033206

Figure 32 – M20171120_033206 – Fléville (France) – T.Gulon.

Figure 33 – M20171120_033206 – Val Terbi (Switzerland) – R.Spinner.

Figure 34 – M20171120_033206 – Bos-Cha (Switzerland) – J. Richert.

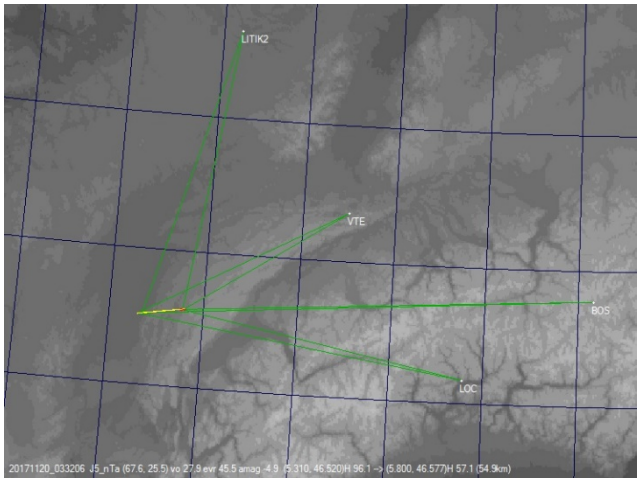

Figure 35 – M20171120_033206 trajectory on the ground map.

Northern Taurid, absolute magnitude: –4.9, duration time: 1.97 s, velocity: 28 km/s, height of start: 96 km, height of end: 57 km, trajectory length: 54 km, inclination: 45°, radiant ra.: 68° dec.: +25°.

2017/11/22 – 00:16:50 UT: M20171122_001650

Nice multi-detection between Norman stations MSOI_J1, FNM1_JB and the Swiss station VTE-6 located 550 km from the fireball.

Figure 36 – M20171122_001650 – May-sur-Orne (France) – S. Jouin.

Figure 37 – M20171122_001650 – Fontenay (France) – J. Brunet.

Figure 38 – M20171122_001650 – Val Terbi (Switzerland) – R.Spinner.

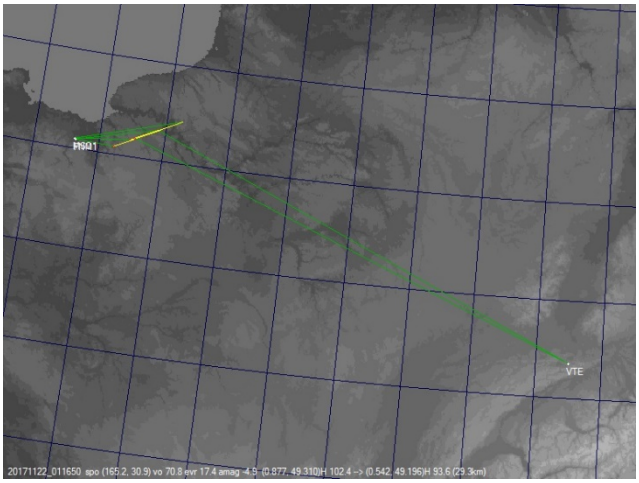

Figure 39 – M20171122_001650 trajectory on the ground map.

Sporadic, absolute magnitude: –4.9, duration time: 1.00 s, velocity: 71 km/s, height of start: 102 km, height of end: 94 km, trajectory length: 29 km, inclination: 16°, radiant ra.: 165° dec.: +31°.

2017/11/25 – 18:08:32 UT: M20171125_180832

Sporadic, absolute magnitude: –2.9, duration time: 5.39 s, velocity: 14 km/s, height of start: 80 km, height of end: 46 km, trajectory length: 77 km, inclination: 26°, radiant ra.: 310° dec.: –11°.

Figure 40 – M20171125_180832 – Fontenay (France) – J.Brunet.

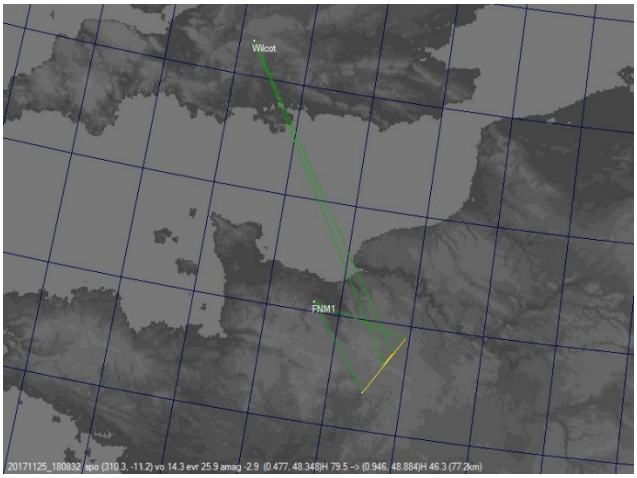

Figure 41 – M20171125_180832 trajectory on the ground map.

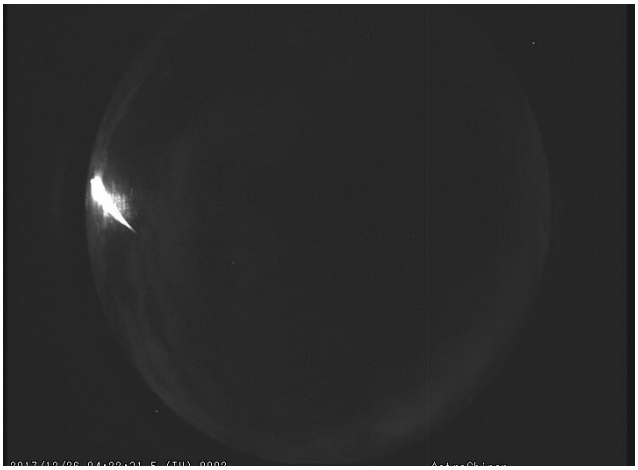

Figure 42 – M20171226_042231 – Chinon (France) – Astrochinon.

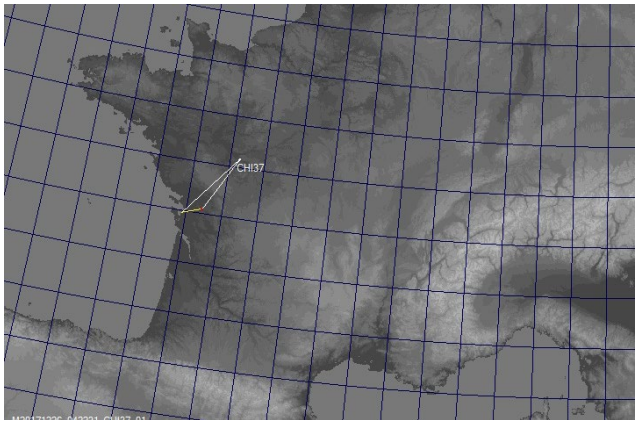

Figure 43 – M20171226_042231 approximative position.

2017/12/26 – 04:22:31 UT: M20171226_042231

On IMO fireball event, Nicolas H., a newspaper deliverer at work reported to have observed a kind of "mini Sun" burst in 4 or 5 explosive light points then turning into new explosive fragments.

The fireball lighted up the sky over Vendée, a region of the Atlantic cost of France, and was recorded by three video networks and 8 radio receivers. The image from UFO-science network's camera at La Rochelle, just below, shows an unusual bright event but no one has enough information to calculate an accurate trajectory.

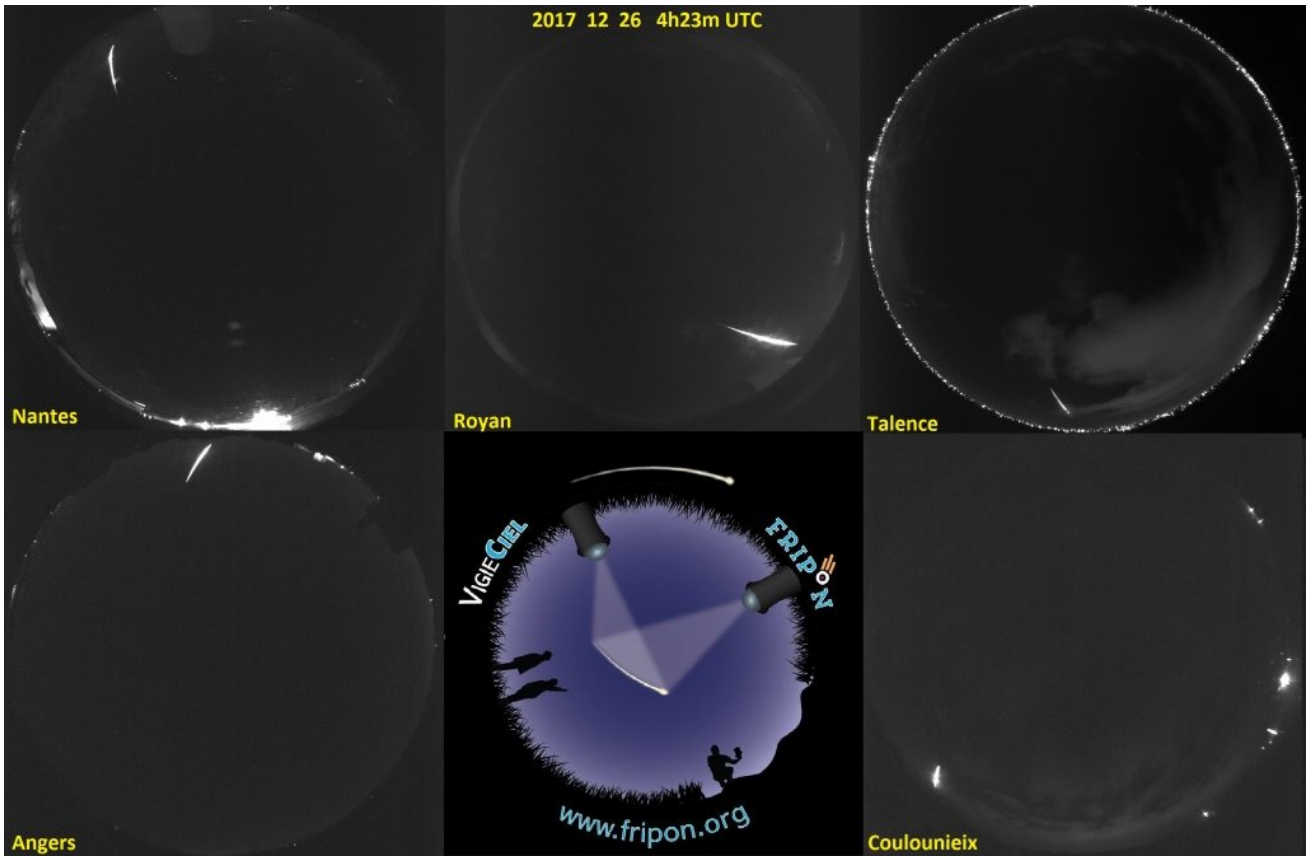

Figure 44 – Record from Nantes, Royan, Talence, Angers et Coulounieix © Fripon.

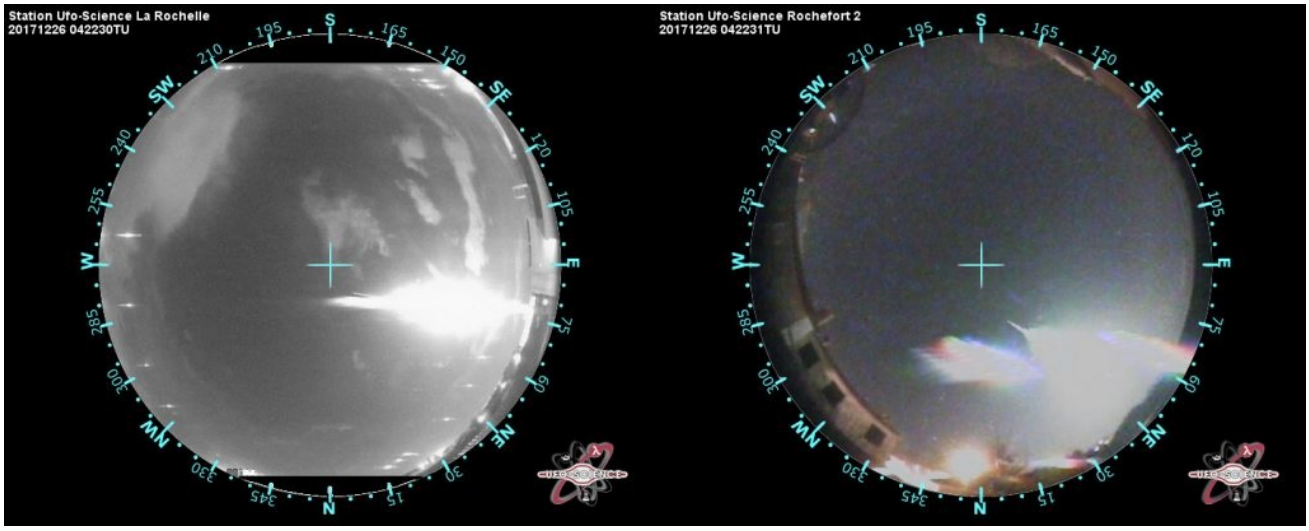

Figure 45 – M20171226_042231 from Rochefort and La Rochelle (France) © Jean-Christophe DORE – Ufo-science.

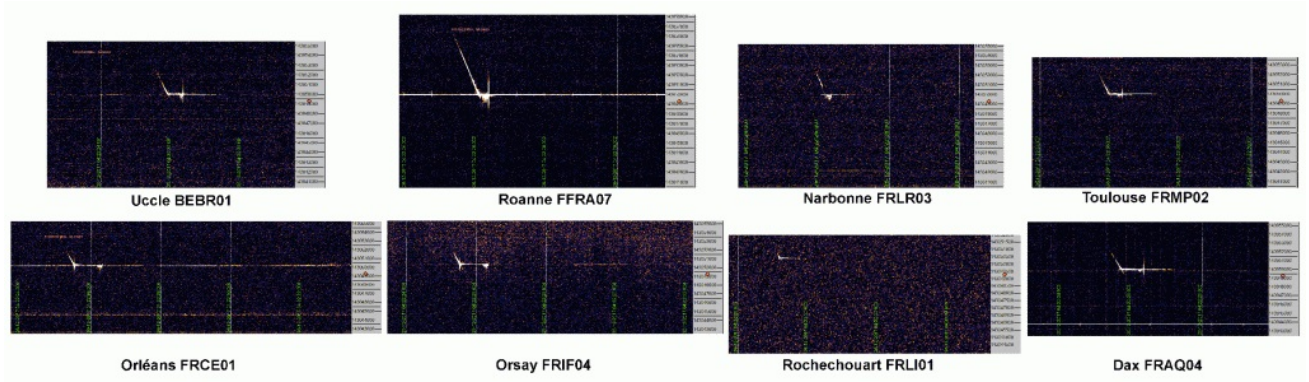

Figure 46 – GRAVE radar reflection from 8 stations © Fripon.

2018 Perseid expedition to Crete

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A report is presented on the visual observing nights by the author during the Perseids 2018.

1 Introduction

The first half of August only allows a limited time each night for meteor observations under dark circumstances at my home place in Norway. The sky gets dark enough for about two to three hours in the zenith but is still quite bright closer to the horizon. Weather conditions is also generally unstable around the time of the Perseid maximum, usually only allowing one or two nights of observations during the week of peak activity. The favorable lunar conditions this year, inspired me to raise my stakes and plan for a meteor expedition. My target was a place that hopefully could provide a week of good weather conditions and dark skies during the week of main Perseid activity. After some considerations I decided to head for the island of Crete, thus allowing to combine the meteor expedition with a week of sun and sea with the rest of my family.

Figure 1 – My rented house in the village of Agia Paraskevi, situated on a hillside some 200 meters above the Libyan Ocean.

After consulting with *Koen Miskotte* from the Dutch Meteor Society, I decided to choose a location on the southern side of island. Koen had experience from an earlier meteor expedition to this part of the island and talked warm about the excellent sky conditions far away from the busy tourist resorts on the northern side. Weather statistics for August also seemed favorable, and my choice fell on the little village of Agia Paraskevi, situated on a hillside about 200 meters over the Libyan Ocean. After a thrilling ride over the mountain on steep and narrow roads, I arrived at Vrachos Villas in the afternoon on August 6. My rented house was built of stones, perfectly fit in the surroundings of mountains, grey earth and olive trees. The sunset over the Libyan ocean was breathtaking, and after enjoying a tasty meal of homemade food in the onsite restaurant, I was more than ready for a night of meteor observations under foreign skies.

2 First night, August 6–7

Strong gusts of wind down the mountainside made me choose an observation site partially protected from the wind, in a field of olive trees within walking distance from my house. This was closer to the local light pollution than I liked, but because of my camera equipment, I did not want to be openly exposed to the strong gusts of wind either. I decided to start observations early, to check activity from the CAP, KCY and NDA, before the Perseid radiant reached a useful altitude. I started observations 19:00 UT. Sky was clear, but the Lm only reached +6.2, a bit hampered by the lights from a nearby house. By 20:30 UT I had seen a total of 17 meteors, of which 10 were SPO, 2 CAP, 2 KCY, 2 NDA and 1 ANT.

19:00 UT – 20:30 UT, T_{eff}:1.50, F:1.00, Lm:6.20, RA:292, DEC: +40

- SPO: 10 meteors: –1(1), 0(1), 2(1), 3(3), 4(2), 5(1), 6(1).
- CAP: 2 meteors: 0(1), 4(1)
- KCG: 2 meteors: –1(1), 4(1)
- NDA: 2 meteors: 1(1), 5(1)
- ANT: 1 meteor: 4(1)

After a 30 minutes break, I was eager to check out Perseid activity, after witnessing a beautiful –1 mag earth grazer during the break. Activity during the first hour was quite good with 8 Perseids, despite the radiant was still low at the sky. I had decided to look in a northern direction where the sky was at its darkest. This made it impossible to make certain shower associations of the showers in the southern sky, like the SDA and the CAP. These meteors were therefore counted as SPO. From 22:00 UT the sky suddenly

got a lot darker. An automatic timer had switched of the most annoying lights from the nearest house, leaving the sky black as coal with a Lm close to +6.5. Despite a darker sky, Perseid rates were constant with 7 meteors observed.

The third hour between 23:00 UT and 00:00 UT turned out to be the best, with 18 Perseids observed. Highlights in this period was a stunning, yellow –3 mag Perseid in UMA, leaving a persistent trail for a couple of seconds. Shortly after an even more impressive, bluish, –2 mag, slow moving meteor caught my attention in the outskirts of my observing field, continuing for about 3 seconds before extinguishing over the sea. This was probably a meteor belonging to the Capricornid shower. The last hour Perseid rates declined to 5, but sporadic activity was still good with 14 meteors. A tired but happy meteor observer decided to call it a night at 01:05 UT, knowing he had 7 more nights of rising meteor activity to come!

21:00 UT– 22:00 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.23, RA: 300, DEC: +40

- PER: 8 meteors: –2(1), 0(1), 1(2), 2(1), 4(2), 5(1)
- SPO: 6 meteors: 1(2), 4(2), 5(2)
- KCG: 1 meteor: 3(1)

22:00 UT – 23:00 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.48, RA: 300, DEC: +40

- PER: 7 meteors: 2(1), 4(2), 5(3), 6(1)
- SPO: 13 meteors: 1(1), 2(1), 3(5), 4(1), 5(3), 6(2)
- KCG: 1 meteor: 5(1)

23:00 UT – 00:05 UT, T_{eff}: 1.050, F: 1.00, Lm: 6.48, RA: 300, DEC: +40

- PER: 18 meteors: –3(1), –1(1), 0(1), 1(2), 2(4), 3(6), 4(1), 5(1), 6(1)
- SPO: 11 meteors: –2(1), 3(1), 4(5), 5(3), 6(1)
- KCG: 1 meteor: 0(1)

00:05 UT – 01:05 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.46, RA: 300, DEC: +40

- PER: 5 meteors: 2(1), 3(1), 4(1), 5(2)
- SPO: 14 meteors: 2(3), 3(3), 4(6), 5(2)
- KCG: 1 meteor: 3(1)

3 August 7–8

Observations 20:45 UT – 22:45 UT

After a successful first night of observations, I was looking forward to checking out what the next night would bring. Weather forecast was good for the whole week, and my only concern was the strong gusts of wind threatening to blow down my camera equipment. I therefore chose the same observation site as last night, but decided to delay observations until 20:45 UT, when the Perseid radiant had reached a useful altitude.

The first two hours gave Perseid rates slightly above the night before, with counts of 11 Perseids each hour. No fireballs were seen this first session, the brightest Perseid being a short, –1 mag, rather slow-moving meteor in Cassiopeia. Sporadic rates were good, with respectively 14 and 20 meteors observed in the two first hours.

20:45 UT – 21:45 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.31, RA: 315, Dec: +50

- SPO: 14 meteors: 1(1), 2(1), 3(4), 4(2), 5(4), 6(2)
- PER: 11 meteors: 0(1), 1(4), 2(3), 3(1), 4(1), 5(1)
- KCG: 0 meteors.

21:45 UT – 22:45 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.41, RA: 315, Dec: +50

- SPO: 20 meteors: 1(1), 3(4), 4(5), 5(7), 6(3)
- PER: 11 meteors: –1(1), 1(1), 2(2), 3(2), 4(2), 5(3)
- KCG: 0 meteors

Observations 23:05 UT – 02:10 UT

After a short break, changing the batteries in my camera and getting something to eat, I was ready for three more hours of observations. The session started 23:05 UT, and shortly after a -1 mag Perseid streaked through Cepheus at 23:11 UT. Two more bright Perseids of mag -1 and -2, also made this first hour a memorable event. Perseid rates the first hour were 12, followed up by respectively 13 and 20 the next two hours. A beautiful -2 Mag Perseid near the rising crescent moon in the eastern sky, rounded up the observations of another successful night. A total of 156 meteors had been observed in 5,05 hours, among them 67 Perseids.

23:05 UT – 00:05 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.48, RA: 337, Dec: +55

- SPO: 18 meteors: 2(1), 3(4), 4(9), 5(4)
- PER: 12 meteors: –2(1), –1(2), 1(2), 2(2), 4(2), 5(2), 6(1)
- KCG: 0 meteors

00:05 UT – 01:10 UT, T_{eff}: 1.05, F: 1.00, Lm: 6.48, RA: 337, Dec: +55

- SPO: 22 meteors: 0(2), 1(2), 2(5), 3(5), 4(5), 5(3)
- PER: 13 meteors: 0(3), 2(4), 4(3), 5(2), 6(1)
- KCG: 0 meteors

01:10 UT – 02:10 UT, T_{eff}: 1.00, F: 1.00, Lm: 6.40, RA: 337, Dec: +55

- SPO: 14 meteors: 0(1), 2(4), 3(4), 4(2), 5(3)
- PER: 20 meteors: –2(1), 1(4), 2(2), 3(2), 4(2), 5(8), 6(1)
- KCG: 1 meteor: 5(1)

4 August 8–9

A windy night with bright meteors!

The third night of my Perseid expedition to Crete, was going to be a very memorable one. When walking towards my observation site, I realized that the gusts of wind were

even stronger than the previous night. Just walking straight forward with my camping bed was difficult because the wind used the bed as a sail. Setting up my observation equipment was a nightmare. One foot was placed on the camping bed, holding it still while setting up my camera tripod. Just when everything seemed up and running, my pillow borrowed from the apartment owner, blew away into some bushes 15 meters away. I could not leave my camping bed and camera equipment without holding on to it, so I had to pack it down again, and run for the pillow! Starting all over again, I was finally ready to start observing 21:00 UT under clear skies.

Observations 21:00 UT – 00:00 UT

After only 6 minutes of observing, a beautiful, yellow, –3 mag Perseid started out in Cassiopeia and ended its flight in Cygnus, leaving a short persistent trail. The first half hour, activity was good, with 7 Perseids and 9 Sporadics observed, with the Perseid radiant still quite low at the sky. After that, Perseid rates declined sharply, with half hour counts of respectively 2 and 4 the next hour. From 22:30 UT the dull activity was over, and Perseid activity kicked back into high gear. The next 1.5 hour yielded half hour counts of 9, 10 and 9. Also the Sporadics put up a good show, with a –4 mag meteor at 23:56 as a highlight. This meteor was probably an Alpha Capricornid and made a stunning appearance over the sea in the western sky. This bluish, slow moving fireball made a perfect end to a 3 hour long memorable observing session. Rates and magnitude distribution were as follows:

21:00 UT – 21:30 UT, T_{eff}: 0,500, F: 1.00, Lm: 6.23, RA: 322, Dec: +55

- SPO: 9 meteors: 1(1), 2(2), 3(3), 4(1), 5(1), 6(1)
- PER: 7 meteors: –3(1), 1(1), 2(2), 3(1), 4(2)
- KCG: 0 meteors

21:30 UT – 22:00 UT, T_{eff}: 0,500, F: 1.00, Lm: 6.23, RA: 322, Dec: +55

- SPO: 4 meteors: 3(1), 4(1), 5(2)
- PER: 2 meteors: (1), 5(1)
- KCG: 0 meteors

22:00 UT – 22:30 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 322, Dec: +55

- SPO: 6 meteors: 4(2), 5(3), 6(1)
- PER: 4 meteors: 2(1), 3(1), 4(2)
- KCG: 2 meteors: 4(2)

22:30 UT – 23:00 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 322, Dec: +55

- SPO: 7 meteors: 2(1), 3(2), 4(2), 5(1), 6(1)
- PER: 9 meteors: 2(2), 3(2), 4(2), 5(2), 6(1)
- KCG: 1 meteor: 5(1)

23:00 UT – 23:30 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 322, Dec: +55

- SPO: 14 meteors: 1(1), 2(2), 3(3), 4(2), 5(4), 6(2)
- PER: 10 meteors: 1(3), 2(1), 3(1), 4(1), 5(3), 6(1)
- KCG: 1 meteor: 2(1)

23:30 UT – 00:00 UT, T_{eff}: 0,500, F: 1.00, Lm: 6.44, RA: 322, Dec: +55

- SPO: 9 meteors: -4(1), 0(1), 2(1), 3(1), 4(1), 5(3), 6(1)
- PER: 9 meteors: 0(2), 1(1), 2(1), 3(2), 4(1), 5(1), 6(1)
- KCG: 0 meteors

Some practical wind problems…

After 3 hours of observations, I had to take a short break to eat a couple of energy bars and take a pee. The latter was a very difficult task in the strong wind! I will not go into details, but when you at the same time must hold on to your sunbed, camera equipment, and pillow, you just don't have enough hands. With my left leg over the sunbed and pillow, my right knee on the ground, left hand on the camera equipment, and the right hand (you know where), I just had to pray that the strongest gusts of wind would stay away for a little moment. Some moments of relief later, I was ready for another two hours with the Perseid radiant high in the sky.

Observations 00:10 UT – 02:10 UT

The first hour I got half hour counts of 12 and 6 for the Perseids. This was a phenomenon that lasted the whole night. The Perseids came in batches, leaving long periods without any activity. Most of the meteors were faint, only 1 being brighter than +2. This was a 0 magnitude, white, slow moving meteor near the radiant in Perseus at 00:49 UT. The last hour turned out to be more exciting. The wind was now even stronger, and a couple of times my camera equipment tipped over in the wind. Luckily, I was aware of the danger, and was able to grab it before it hit the ground. One such moment came 01:26 UT when my camera tripod blew over, but I was able to grab it. Some seconds later a beautiful –1 mag Perseid appeared in my camera field. I was wondering whether I had started a new exposure before or after I stabilized the camera. If it was started before the wind gust, the exposure would be shaky and blurred. When thinking about this, a stunning –5 mag Perseid suddenly lit up the sky right in the middle of my camera field! If I had started the exposure after the wind gust, I would now have both these meteors on the same picture! I had to wait until the next day to check the memory card, and the lucky result you can see in *Figure 2*. 10 minutes later it was time for another mini outburst of bright Perseids, with a –2 mag at 01:36, a –1 at 01:38, and a 0 mag at 01:39. Half hour counts for the Perseids this last hour were 13 and 8. Total numbers for the whole night was 80 Perseids, 85 Sporadics, and 4 Kappa Cygnids in 5 hours observing time.

00:10 UT – 00:40 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 330, Dec: +55

- SPO: 12 meteors: 0(1), 1(1), 3(1), 4(6), 5(2), 6(1)
- PER: 12 meteors: 2(2), 3(3), 4(5), 5(2)
- KCG: 0 meteors

00:40 UT – 01:10 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 330, Dec: +55

- SPO: 8 meteors: 1(1), 3(3), 4(3), 5(1)
- PER: 6 meteors: 0(1), 2(3), 3(1), 4(1)
- KCG: 0 meteors

01:10 UT – 01:40 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 330, Dec: +55

- SPO: 6 meteors: 1(1), 2(2), 4(1), 5(2)
- PER: 13 meteors: –5(1), –2(1), –1(2), 0(2), 1(1), 2(1), 3(2), 5(3)
- KCG: 0 meteors

01:40 UT – 02:10 UT, T_{eff}: 0.500, F: 1.00, Lm: 6.44, RA: 330, Dec: +55

- SPO: 10 meteors: 2(1), 3(4), 4(1), 5(3), 6(1)
- PER: 8 meteors: 0(1), 1(1), 2(2), 3(1), 4(2), 5(1)
- KCG: 0 meteors

Figure 2 – A –5 mag Perseid and a –1 mag Perseid captured 01:36 UT. The red light in the low, right corner, is the light of a windmill on the mountain top. Picture taken with a Nikon D 3100 camera, with a Samyang 16mm F 2.0 lens. 20 seconds exposure time, with ISO 1600 settings.

August 2018 visual observations

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An overview is given of the 2018 August meteor observations by the author, covering the Perseids and August meteor showers.

1 August 4–5, 2018

Despite some hazy nights, I was able to have a successful 2018 Perseids observing campaign with several nights of observing. Here are my results, starting with the night of August 4/5…

I took up Shane Finnigan's offer to setup and observe at his new house near Renfrew for the first time. It is a big, quiet, beautiful farm property in a natural setting, with a wide-open sky view, surrounded by a low tree line (which nicely blocks out passing car lights). The night sky presents only two small light domes, one from Ottawa to the east and another from Renfrew to the north-west. The other horizons are dark. I have no doubt that Shane will love the access to mag 6th skies from the comfort of his backyard. Shane and I spent some time viewing the planets and a few DSO's with an 80ED, then I took my chair and sleeping bag out into the field to setup for a meteor watch. It was a humid night with hazy horizons and some cirrus clouds. The transparency was only about 2/5 so I did not see the sky at its full potential there. But the Milky Way was still nicely visible, and some casual meteors (early PERs and late SDAs) were seen.

I signed on formal meteor observing just after midnight, and I stayed on for two hours. I faced south, looking generally about halfway up to have the best and darkest sky. The Quarter Moon rose at 12:30 and reduced the sky darkness. The tree line worked in my favor by delaying the moon's visibility/glare for another half hour. The limiting magnitude was around 6.0, so it's definitely a very nice location!

I saw 29 meteors (break down: 12 Perseids, 4 South Delta Aquariids, 3 North Delta Aquariids, 1 Kappa Cygnid, 1 Capricornid, 1 anthelion and 7 sporadics). The Perseids were mildly active but already the most active meteor source in the sky. The brightest one was a mag -1 PER but the mag 0 KCG was also very nice. It was yellow-orange and moved slowly among the stars.

August 4/5 2018, 04:15-06:25 UT (00:15-02:25 EDT) Location: Renfrew, Ontario, Canada, (Long: -76° 38' ; Lat: 45° 25')

Observed showers:

- kappa Cygnids (KCG) – 18:40 (280) +45
- alpha Capricornids (CAP) – 20:42 (310) -08
- Anthelion (ANT) – 21:40 (325) -14
- Northern delta Aquariids (NDA) – 22:36 (339) -01
- Southern Delta Aquariids (SDA) – 23:04 (346) -14
- Piscids Austrinids (PAU) – 23:18 (350) -22
- Perseids (PER) – 02:26 (037) +56
- eta Eridanids (ERI) – 02:36 (039) -14
- psi Cassiopeiids (PCA) – 03:54 (059) +78

04:15-05:15 UT (00:15-01:15 EDT); clear; 2/5 trans; F 1.00; LM 6.13; facing S60 deg; t_{eff} 1.00 hr; 22C

- PER: eight: -1; 0; +2(2); +3; +4(2); +5
- SDA: three: +3; +4(2)
- NDA: one: +2
- KCG: one: 0
- Sporadics: four: +3; +4(2); +5
- Total meteors: Seventeen

05:15-06:25 UT (01:15-02:25 EDT); clear; 2/5 trans; F 1.00; LM 5.90; facing S70 deg; t_{eff} 1.08 hr; 20C

- PER: four: +3(3); +5
- NDA: two: +3; +4
- SDA: one: +3
- CAP: one: +2
- ANT: one: +2
- Sporadics: three: +4(2); +5
- Total meteors: Twelve

2 August 9–10, 2018

The next opportunity came a few nights later, when the sky cleared after a cold front swept through and a high-pressure system started settling into Ontario. I noticed that the sky would clear up completely at about midnight, so I went to Bootland Farm.

WOW!!! The sky was fantastic and beyond my expectation! The Milky Way was thick and structured! The sky was full of faint stars, right up there among the best nights that I've seen at this location! I quickly setup as several meteors were seen flying left and right. An RASC member, Dan, joined in. He arrived shortly after to observe meteors with me.

What a difference a few nights can make. The Perseids were going on strong, and Dan noticed several meteors in

all parts of the sky. I signed on at 12:45am, and watched for 3 hours until near 4am. Limiting mag 6.5–6.6. I faced the south-east sky, looking halfway up. This allowed to keep the Perseid radiant on the far left edge of my field of view, while being in a good position to view activity coming from the southern radiants.

In 3 hours of time, I saw 116 meteors (breakdown: 58 Perseids, 11 South Delta Aquariids, 4 anthelions, 3 Eridanids, 2 Kappa Cygnids, 1 Capricornid, 1 North Delta Aquariid and 36 sporadics). Perseids hourly rates were 17, 15 and 26. A very active night with a lot of highlights!

The session definitely started with a bang! Barely one minute into my watch, a monster mag –5 Perseid fireball came out of nowhere and shot over 30 degrees high in Pegasus, ending with a BRIGHT terminal flash! WOW, a beauty!!! It left a persistent train for 12 seconds!

Just four minutes later, another Perseid fireball, this time a –4, shot 30 degrees, ending near Mars. This one left a 10 seconds train!

Then at 1:40am, a lovely –4 PER fireball shot 40 degrees in the south before flaring and leaving behind a 20 seconds train!

Later on, at 2:40am, a gorgeous –2 Eridanid earthgrazer climbed out of the south-east, persisting through a 50 degrees path! It had a thick appearance and was vivid blue! It may not have been as bright as the earlier fireballs, but it sure was beautiful! Dan was impressed by this one.

Towards the end, at 3:41am, a long 30 degrees –3 Perseid with a 5 sec train delighted us yet again!

As if all this wasn't enough, just as I signed-off, a –5 iridium satellite flare went by in Cygnus, bright enough to light up part of the sky. What an entertaining night!! I was surprised at the number of fireballs well before peak night. I really enjoyed the meteor activity and Dan certainly agreed as well. It was one of those nights that you wish it wouldn't end!

August 9/10 2018, 04:45-07:50 UT (00:45-03:50 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Anthelion (ANT) – 22:08 (332) -12
- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern Delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

04:45-05:45 UT (00:45-01:45 EDT); clear; 4/5 trans; F 1.00; LM 6.54; facing SE50 deg; t_{eff} 1.00 hr

- PER: seventeen: -5; -4(2); +1(4); +2(2); +3(3); +4(4); +5
- SDA: seven: +1; +3; +4(3); +5(2)
- KCG: two: +2; +3
- ANT: one: +3
- Sporadics: ten: 0; +2; +4(4); +5(4)
- Total meteors: Thirty-seven

05:45-06:45 UT (01:45-02:45 EDT); clear; 4/5 trans; F 1.00; LM 6.60; facing SE50 deg; t_{eff} 1.00 hr

- PER: fifteen: -1; 0(2); +1(2); +2(3); +3(4); +4(2); +5
- ERI: two: -2; +3
- CAP: one: +4
- NDA: one: +3
- SDA: one: +5
- Sporadics: eleven: +3(2); +4(5) +5(4)
- Total meteors: Thirty-one

06:45-07:50 UT (02:45-03:50 EDT); clear; 4/5 trans; F 1.00; LM 6.63; facing SE50 deg; t_{eff} 1.08 hr

- PER: twenty-six: -3; 0(3); +1(2); +2(5); +3(5); +4(6); +5(3); +6
- ANT: three: +2; +3(2)
- SDA: three: +1; +3(2)
- ERI: one: +1
- Sporadics: fifteen: +2; +3(5); +4(6); +5(2); +6
- Total meteors: Forty-eight

3 August 10–11, 2018

The following night, I was out again at Bootland Farm to observe. I went with a full load of camping gear, as the weather looked favorable for the next few nights. I decided to sleep there at the end, and then decide where I wanted to go next without requiring a trip back home ☺

This time, I had the company of Dan and Jim Sofia, setup with 8" SCT and MallinCam. The sky was clear but not quite as transparent as the previous night. Some effects of forest fire smoke were visible, reducing sky clarity a bit near the horizons, but the sky was still very nice high up! The temperature was a comfortable 10-11C but it was very damp. Jim was already in action when I got there but he was struggling with dew affecting the corrector plate of his scope (12v hair dryer to the rescue!). Once he got going again, Jim treated us with impressive MallinCam views of M51, M13 and M57 on the monitor. He also showed some previous processed images that looked very good!

I settled into my chair shortly after midnight and observed for nearly four hours until 4:15am. I saw 126 meteors (breakdown: 80 Perseids, 9 South Delta Aquariids, 3 Capricornids, 3 anthelions, 3 Eridanids, 1 Kappa Cygnid, 1 North Delta Aquariid and 26 sporadics). Perseids were similar to the previous night with hourly rates 17, 22, 22 and 19. However, no significant fireballs were seen. The Perseids also seemed to produce more of the faint, short path variety on this night. I felt as though I could easily miss these meteors if I wasn't sharp or paying full attention.

The brightest was a –3 PER that flared and left an 8 seconds train.

I noticed a few possible Beta Perseids, radiating from a point near Algol.

The fourth hour was cut a bit short (by 10 min) due to clouds increasing above 20% in my field.

I really enjoyed viewing with Jim's fine Celestron 8×50 binoculars… The North American nebula, M31, the Andromeda galaxy, M33 and the Double Cluster were all real beauties! Thank you Jim!

August 10/11 2018, 04:20-08:15 UT (00:20-04:15 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Anthelion (ANT) – 22:08 (332) -12
- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern Delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

04:20-05:25 UT (00:20-01:25 EDT); clear; 3/5 trans; F 1.00; LM 6.48; facing SSE50 deg; t_{eff} 1.00 hr

- PER: seventeen: -3; -2; 0; +1(3); +2(2); +3(2); +4(4); +5(3)
- CAP: two: -1; +2
- SDA: two: +5(2)
- Sporadics: five: +2; +3; +4(2); +5
- Total meteors: Twenty-six

05:25-06:25 UT (01:25-02:25 EDT); clear; 3/5 trans; F 1.00; LM 6.51; facing SSE50 deg; t_{eff} 1.00 hr

- PER: twenty-two: -2; +1(3); +2(3); +3(5); +4(3); +5(4); +6(3)
- SDA: three: 0; +4; +5
- ANT: one: +4
- ERI: one: +2
- Sporadics: five: +1; +3(2); +4(2)
- Total meteors: Thirty-two

06:25-07:25 UT (02:25-03:25 EDT); clear; 3/5 trans; F 1.00; LM 6.55; facing SSE50 deg; t_{eff} 1.00 hr

- PER: twenty-two: 0(2); +1(2); +2(4); +3(3); +4(6); +5(4); +6
- ANT: two: +3; +4
- SDA: two: +3; +4
- ERI: two: +1; +3
- KCG: one: +3
- NDA: one: +4
- Sporadics: nine: +2; +3(2); +5(5); +6
- Total meteors: Thirty-nine

07:25-08:15 UT (03:25-04:15 EDT); 10-20% clouds during last 15 min; 3/5 trans; F 1.05; LM 6.40; facing SSE50 deg; t_{eff} 0.83 hr

- PER: nineteen: 0(2); +1(6); +2(3); +3(2); +4(3); +5(3)
- SDA: two: +4; +5
- CAP: one: +2
- Sporadics: seven: -1; 0; +2; +3; +4(2); +6
- Total meteors: Twenty-nine

4 August 11–12, 2018

I spent the morning sleeping in at Bootland Farm, then relaxing in Arnprior before Raymond Dubois joined me there. We looked at the weather and discussed on the location to go for the next two nights. We decided to stay put for the pre-max night, and then re-evaluate the weather the next morning. After relaxing under Raymond's large truck awning, we went to the Antrim Truck Stop, then back again to the site (quite handy, just a few minutes from Arnprior to Bootland Farm). Back to the site, we were greeted by Al Robinson who came with his astronomy-themed camper van and was ready to photograph and observe with his 8" dob. A short time later, Dan arrived as well.

At sunset, several clouds threatened but just as the CSC predicted, they dissipated. The sky was then clear all night, but was more hazy and smoke from the forest fires out west caused reduced visibility near the horizons. The transparency would later improve a bit overnight. As I was setting up, a -4 Capricornid fireball flared in the west! Nice one! After a short nap, I signed on near 11pm and I watched until 4am, taking a few breaks though during the night. For some reason, my allergies were really acting up and I often found myself with watery eyes, sneezing, and completely plugged up sinuses. There were a few instances during the night that forced me to stop observing and get up. Eventually, things eased up and I was fine.

In almost 4.5 hours, I saw 147 meteors (breakdown: 107 Perseids, 6 South Delta Aquariids, 5 Kappa Cygnids, 5 Capricornids, 3 Eridanids, 1 anthelion, 1 North Delta Aquariid and 19 sporadics). Perseids felt a bit slow early in the night with several long lulls without any meteors, but they picked as the night went on. The last hour hour period had 39 Perseids alone. The CAPs were a surprise so far from their late July peak. Sporadics were a bit lower than expected, but many dim meteors probably went unseen in the hazy lower portions of the sky. At 11:26pm, a nice -4 PER with a 6 sec train was seen in Pegasus. At 3:30am, another -4 PER this time with a 20 sec train! I thought that would be the highlight of this night but…

At 3:45am, a monster approx. –8 PER fireball lit up the sky!! I was facing the opposite direction so I missed the actual meteor. What I saw was like a flash of lightning. However, Raymond was observing the northern sky, and he saw it perfectly. I won't forget his reaction, in Raymond's

words below: “Whoa!!!! THAT was STRONG!! It looked like an atomic bomb went off in space”. I turned around, and sure enough, there was a brilliant persistent train hanging vertically and slowly starting to twist. Quickly, I called “break” from visual watching into my tape recorder, grabbed my 9×63 binocs and went for a close-up view. The train was starting to fade to the naked eye but still plainly visible. In the binocs, it looked like a large “Z” shaped cloud, wow! To make matters even more interesting, a dim Perseid was then seen shooting across the field of view of the binocs! After a full 2 min, the fireball train was finally out of sight. I’m glad that Raymond decided to switch his field of view to the north prior to the fireball – this way at least one of us saw it! Unfortunately, this meteor can’t be officially counted in my report as I did not see it directly.

I went to sleep in my car just after 4am, and part of me wished I had stayed up as I was now seeing lots of meteor activity. But I wanted to be awake and ready for the peak night.

Figure 1 – Composite image (digital combination) of Perseid meteors captured around the Summer Milky Way on this night. The meteors are co-added by combining multiple images together in Photoshop. Canon 6D and Rokinon 14mm f/2.8 lens, ISO 3200.

August 11/12 2018, 02:55-08:05 UT (22:55-04:05 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29’; Lat: 45 deg 23’)

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Anthelion (ANT) – 22:08 (332) -12
- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern Delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

02:55-03:55 UT (22:55-23:55 EDT); clear; 2/5 trans; F 1.00; LM 6.31; facing SE50 deg; t_{eff} 1.00 hr

- PER: twelve: –4; 0; +1(4); +2(3); +3(2); +5
- CAP: three: +1(2); +2
- ANT: one: +5
- SDA: one: +4
- Sporadics: four: +1; +2; +4; +5
- Total meteors: Twenty-one

04:11-05:06 UT (00:11-01:06 EDT); clear; 2/5 trans; F 1.00; LM 6.35; facing SE50 deg; t_{eff} 0.92 hr

- PER: twenty: 0(4); +1(4); +2(2); +3(2); +4(4): +5(4)
- Sporadics: three: +3; +4; +5
- Total meteors: Twenty-three

05:24-06:34 UT (01:24-02:34 EDT); clear; 3/5 trans; F 1.00; LM 6.40; facing SE50 deg; t_{eff} 1.00 hr

- PER: twenty-eight: –2(2); 0; +1(5); +2(5); +3(6); +4; +5(7); +6
- KCG: three: +1(2); +2
- SDA: three: +2; +3; +4
- CAP: two: +2; +5
- Sporadics: six: +1; +3; +4(2); +6(2)
- Total meteors: Forty-two

06:34-07:36 UT (02:34-03:36 EDT); clear; 3/5 trans; F 1.05; LM 6.42; facing SE50 deg; t_{eff} 1.00 hr

- PER: thirty-nine: –4; –1; 0(7); +1(4); +2(10); +3(6); +4(6); +5(4)
- ERI: three: –1; +1; +5
- KCG: two: +4(2)
- SDA: one: +4
- NDA: one: +5
- Sporadics: one: +4
- Total meteors: Forty-seven

07:36-08:05 UT (03:36-04:05 EDT); clear; 3/5 trans; F 1.00; LM 6.42; facing SE50 deg; t_{eff} 0.48 hr

- PER: eight: +1(2); +2(2); +3(2); +4; +5
- SDA: one: +3
- Sporadics: five: +4(4); +5
- Total meteors: Fourteen

5 August 12–13, 2018

During the day, Raymond Dubois and I discussed where to go for the peak of the Perseids. We found the possibility of

clouds encroaching from the south overnight, so we decided to drive 3 hours north into Quebec to La Verendrye Forest Reserve. Once at the airstrip, we saw people at the other end so we checked it out. We were greeted by a small group of Quebec observers setup with their scopes for a few nights. They were also there for the Perseids. We proceeded to setting up our cameras and equipment, then having supper. The sky overhead was clear but very hazy due to forest fire smoke from the fires out west. It looked like we were not going to be able to enjoy very a transparent night as was forecasted, but thankfully clouds were not an issue! Later in the evening, another car pulled in and it was the Director of Programming for the Montreal Planetarium. He came to do some 360 degrees meteor imaging/video work with a new very high-end Canon camera! Fascinating!!

Indeed, the haze remained all night, maxing out the limiting magnitude at 6.4-6.5 or 2/5 transparency. On a really good night, this site can produce mag 7.1-7.5 skies. Around the horizons, faint stars were difficult to see. Furthermore, there was some ground mist around the tree line. This caused really strong glows and light shows of sorts whenever a truck came by on the highway (Raymond captured this well on his cameras). The glare from traffic lights couldn't be seen — thankfully the tree line blocked them off. A few cars from locals drove in and out in the evening, but it was quiet later on. Once I had the cameras running, I signed on at 10:50pm and watched until 4:45am for a total of nearly 5 hours. I took a couple of long breaks to attend my cameras. Visual rates averaged at or slightly over one meteor per minute. My total count was 279 meteors (breakdown: 231 Perseids, 8 Kappa Cygnids, 5 Capricornids, 3 antihelions, 3 South Delta Aquariids, 3 Eridanids, 1 North Delta Aquariid and 25 sporadics). Perseids hourly rates were 37, 47, 66 and 62. I was surprised to see CAPs still active. There was also pretty KCGs rates that would seem to support a peak a few nights earlier than what was previously believed. The highlight was a -4 PER at 3:54am that shot 30 degrees high in the south, flared and left a 25 sec train!!

It was also my first serious use of my new Skywatcher Star Adventurer compact equatorial mount. What a nice mount that provided smooth, accurate tracking all night long, and without any issues. The counterweight that came with the kit allowed both cameras to be mounted. Doing a correct polar alignment using the phone app was also easy and quick. I highly recommend this mount for light loads and portability. Raymond was also running two of these mounts.

According to the IMO, this year was a normal or slightly below average peak (max ZHR=91). Furthermore, it looks like the highest rates occurred several hours earlier during daylight. In recent memory, 2015 was a more active year. Still, it was a very nice display and you simply can't go wrong with the peak night of the Perseids, especially near New Moon! Here's my photo results:

Figure 2 – Composite image (digital combination) of 51 Perseid meteors. The brightest meteor on the bottom right was mag –3. Canon 6D and Rokinon 14mm f/2.8 lens, ISO 3200.

Figure 3 – Perseids Through Milky Way. Composite image (digital combination) of 7 Perseid meteors. Mars is the bright object at the bottom left. Canon 5D and Rokinon 24mm f/1.4 lens (at f/2.0), ISO 1600.

Figure 4 – Perseids in the Eastern Sky. Composite image (digital combination) of 41 Perseid meteors captured on the night of August 12-13 2018. The Pleiades (M45) are visible bottom left of centre. The faint greenish bands are a combination of fog, airglow and forest fire smoke at the time that the stars background image was taken. Canon 5D and Rokinon 24mm f/1.4 lens (at f/2.0), ISO 1600.

August 12/13 2018, 02:50-08:45 UT (22:50-04:45 EDT) Location: La Verendrye Forest Reserve, Quebec, CANADA, (Long: -76deg 29'; Lat: 46 deg 59')

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Antihelion (ANT) – 22:08 (332) -12
- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern Delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

02:50-03:55 UT (22:50-23:55 EDT); clear; 2/5 trans; F 1.00; LM 6.38; facing SE60 deg; t_{eff} 1.08 hr

- PER: thirty-seven: –1; 0(4); +1(6); +2(9); +3(5); +4(6); +5(3); +6(3)
- KCG: four: +2(3); +3
- ANT: two: +4(2)
- CAP: one: +3
- Sporadics: four: +3(2); +4; +5
- Total meteors: Forty-eight

03:55-05:05 UT (23:55-01:05 EDT); clear; 2/5 trans; F 1.00; LM 6.50; facing SE60 deg; t_{eff} 1.16 hr

- PER: forty-seven: -3(2); -2; 0(5); +1(8); +2(7); +3(8); +4(10); +5(4); +6(2)
- CAP: three: -3; +3; +4
- ANT: one: 0
- SDA: one: +4
- Sporadics: five: +4(2); +5(2); +6
- Total meteors: Fifty-seven

05:39-06:48 UT (01:39-02:48 EDT); clear; 2/5 trans; F 1.00; LM 6.53; facing SE60 deg; t_{eff} 1.15 hr

- PER: sixty-six: –1; 0(7); +1(9); +2(11); +3(9); +4(13); +5(14); +6(2)
- KCG: two: +1; +5
- CAP: one: +3
- SDA: one: +1
- ERI: one: +3
- Sporadics: seven: +2; +3(3); +4(3)
- Total meteors: Seventy-eight

07:19-08:19 UT (03:19-04:19 EDT); clear; 2/5 trans; F 1.00; LM 6.50; facing SE60 deg; t_{eff} 1.00 hr

- PER: sixty-two: –4; –3; –1(2); 0(8); +1(13); +2(8); +3(13); +4(9); +5(7)
- KCG: two: +2; +4
- ERI: two: +3: +5
- NDA: one: +4
- SDA: one: +3
- Sporadics: eight: +3(3); +4; +5(3); +6
- Total meteors: Seventy-six

08:19-08:45 UT (04:19-04:45 EDT); clear; 2/5 trans; F 1.00; LM 5.98; facing SE60 deg; t_{eff} 0.43 hr

- PER: nineteen: –1; 0(2); +1; +2(5); +3(4); +4(5); +5
- Sporadics: one: +5
- Total meteors: Twenty

For the IMO report form with shorter and more detailed data sets, please see online[19].

6 August 14–15, 2018

After some much needed sleep, I went out two nights after the peak, this time on my own. The sky was hazy due to forest fire smoke but clear. I setup at midnight, and observed for 3 hours. I saw 66 meteors during that time (breakdown: 39 Perseids, 6 South Delta Aquariids, 2 North Delta Aquariids, 2 antihelions, 1 Capricornid and 39 sporadics). I was quite pleased with the numbers of PERs (with 21 in the third hour alone). The SDAs were still mildly active even two weeks after their maximum. The best meteor was a swift –1 blue-green sporadic that left a 3 sec train. It was well seen in the middle of my field of view just as I was concentrating in doing a limiting magnitude star count.

August 14/15 2018, 04:05-07:15 UT (00:05-03:15 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Anthelion (ANT) – 22:08 (332) -12

[19] https://www.imo.net/members/imo_vmdb/view?session_id=77301

- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern Delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

04:05-05:05 UT (00:05-01:05 EDT); clear; 2/5 trans; F 1.00; LM 6.23; facing S60 deg; t_{eff} 1.00 hr

- PER: seven: +2(3); +3; +4(3)
- ANT: two: +5(2)
- SDA: one: +1
- CAP: one: +4
- Sporadics: three: +2(2); +5
- Total meteors: Fourteen

05:05-06:06 UT (01:05-02:06 EDT); clear; 2/5 trans; F 1.00; LM 6.24; facing S60 deg; t_{eff} 1.01 hr

- PER: eleven: 0(3); +1(2); +2; +3(3); +4: +5
- NDA: two: +4(2)
- SDA: two: +1; +4
- Sporadics: seven: –1; 0; +3(2); +4(2); +5
- Total meteors: Twenty-two

06:06-07:15 UT (02:06-03:15 EDT); clear; 2/5 trans; F 1.00; LM 6.30; facing S60 deg; t_{eff} 1.15 hr

- PER: twenty-one: –1; 0(2); +1(5); +2(2); +3(5); +4(2); +5(4)
- SDA: three: +3; +4(2)
- Sporadics: six: +1; +3; +4(3); +5
- Total meteors: Thirty

7 August 15–16, 2018

I nearly skipped the following night because the sky took a lot longer to clear and I was tired from all the observing. But it was finally looking like the west end would clear up at about 2am. I'm very glad I took a chance and went! When I arrived at Bootland, the sky was a glorious canopy of stars all over; the clearest sky since August 9! The sky transparency was above-average transparency (4/5) and the Milky Way was thick and structured. Temperature a little cooler too at 14C. It was also one of those rare dry nights with almost no dew or fog. I signed on at 2:25am and watched for 2 hours until dawn. I saw 64 meteors (breakdown: 27 Perseids, 8 Eridanids, 4 South Delta Aquariids, 2 North Delta Aquariids, 1 Kappa Cygnid, 1 Antihelion and 21 sporadics).

The highlight was actually just a few minutes after I signed off. I took one last glance at the sky, and I saw a very slow Capricornid earthgrazer, mag +1, blue white with a nice "tail" behind the meteor.

I find meteor rates are especially quite a bit better when the sky is very clear!

August 15/16 2018, 06:25-08:30 UT (02:25-04:30 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 18:59 (285) +50
- alpha Capricornids (CAP) – 21:10 (317) -05
- Antihelion (ANT) – 22:08 (332) -12
- Northern delta Aquariids (NDA) – 23:04 (346) +02
- Southern delta Aquariids (SDA) – 23:30 (353) -12
- Piscids Austrinids (PAU) – 23:44 (356) -19
- Perseids (PER) – 03:12 (048) +57
- eta Eridanids (ERI) – 03:00 (045) -12

06:25-07:25 UT (02:25-03:25 EDT); clear; 4/5 trans; F 1.00; LM 6.58; facing SSE50 deg; t_{eff} 1.00 hr

- PER: fourteen: 0; +1(3); +2(2); +3(3); +4(4); +5
- ERI: two: +4(2)
- KCG: one: +2
- NDA: one: +4
- Sporadics: eleven: +1; +2; +3(3); +4(2); +5(3); +6
- Total meteors: Twenty-nine

07:25-08:30 UT (03:25-04:30 EDT); clear; 4/5 trans; F 1.00; LM 6.58; facing SSE50 deg; t_{eff} 1.07 hr

- PER: thirteen: +1; +2(5); +3(3); +4(3): +5
- ERI: six: +2; +4(2); +5(3)
- SDA: four: +2; +3; +4(2)
- NDA: one: +4
- ANT: one: +6
- Sporadics: ten: 0; +1(2); +2; +4(2); +5(3); +6
- Total meteors: Thirty-five

8 August 18–19

A few nights later, Dan joined me and we met up with Jim Sofia at Bootland Farm. Jim had his beautiful 18" and I set out my 12.5" PortaBall. The sky was very humid with poor transparency, but the seeing was remarkably good. I spent a good part of the night observing globular clusters and small, bright planetary nebulae (Blue Snowball, Saturn nebula, Eskimo, Blinking, and others — they all looked sharp and well defined). The steady seeing allowed the central star in M57 to be quite readily visible at times through Jim's scope! Jim also treated us to Uranus and Neptune; they both have such beautiful colors! I especially loved comparing views and exploring what the sky had to offer. The highlight was 21P/Giacobini-Zinner — my first ever good look at this comet. At low power, we could see a broad faint tail and definite motion against the stars after just a few minutes. Lots of fun!

I then observed meteors for over an hour near dawn. I saw 14 of them (breakdown: 6 Perseids, 2 Eridanids, 1 antihelion, 1 North Delta Aquariid and 4 sporadics).

August 18/19 2018, 06:45-08:00 UT (02:45-04:00 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada,

(Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 19:16 (289) +55
- Antihelion (ANT) – 22:36 (339) -09
- Northern delta Aquariids (NDA) – 23:28 (352) +04
- Southern Delta Aquariids (SDA) – 23:58 (359) -09
- eta Eridanids (ERI) – 03:24 (051) -10
- Perseids (PER) – 03:46 (057) +59

06:45-08:00 UT (02:45-04:00 EDT); clear; 1/5 trans; F 1.00; LM 6.19; facing S60 deg; t_{eff} 1.23 hr

- PER: six: 0; +2; +3(2); +4; +5
- ERI: two: +4; +5
- ANT: one: +5
- NDA: one: +3
- Sporadics: four: +1; +2; +4; +5
- Total meteors: Fourteen

9 August 19–20

On the late evening of August 19, I picked up Nicholas Zuger, we loaded all the scope and camera gear in my car, and off we went to Bootland Farm. This night was more of test run of equipment, and doing some casual imaging. The sky was affected by poor transparency (1/5) due to forest fire smoke, but I managed to capture 21P/Giacobini-Zinner (3 weeks before perihelion), M31, Double Cluster and M45. I was not doing any guiding, so these are very short exposures at quite a high ISO setting on my Canon 6D. Details under each photo[20].

I also did a short one hour meteor watch before dawn. The Perseids were weakly active, below the sporadic background.

August 19/20 2018, 07:45-08:45 UT (03:45-04:45 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- kappa Cygnids (KCG) – 19:16 (289) +55
- Anthelion (ANT) – 22:36 (339) -09
- Northern delta Aquariids (NDA) – 23:28 (352) +04
- Southern Delta Aquariids (SDA) – 23:58 (359) -09
- eta Eridanids (ERI) – 03:24 (051) -10
- Perseids (PER) – 03:46 (057) +59

07:45-08:45 UT (03:45-04:45 EDT); 10% clouds during last 30 min; 1/5 trans; F 1.05; LM 6.09; facing S60 deg; t_{eff} 1.00 hr

- PER: four: +2; +3(2); +5
- KCG: one: +4
- Sporadics: six: +3; +4(4); +5
- Total meteors: Eleven

It was really nice heaving Nicholas company on this outing! Nicholas managed to get a really good close-up shot of 21P with a 100ED refractor and a Canon 7D II. It was also Nicholas' first outing with scope and imaging gear in a dark sky!

[20] https://pmartin.smugmug.com/Astronomy/20180819-Astro-imaging-Bootland-Farm/

Perseids 2018 report from northern Italy

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A summary report is presented of the Perseid registrations with video cameras by the author.

1 Introduction

This year we can conclude we have a positive balance for the Perseids of August 2018. The Moon almost to the New Moon phase has guaranteed a series of perfectly dark nights, although unfortunately here in the plain of northern Italy the level of humidity has always been considerable being a disadvantage for the transparency.

2 The observational data

My three cameras have filmed 4015 meteor trails, of which 2181 associated with the radiant area of the Perseids in the night hours from 1 to 18 August, except on the night of August 14/15, thanks to the fact that the sky was for mostly always cloudless. The night of the maximum (12/13 August) was successful with as many as 976 meteors, 793 of which were Perseids.

The preliminary graph in *Figure 1* shows for each cam the evolution of the average daily hourly frequency, corrected to the zenith for my position and for an optimal limiting magnitude.

This year Perseids probably showed a higher than usual population index, with few bright events and in general a stable average magnitude.

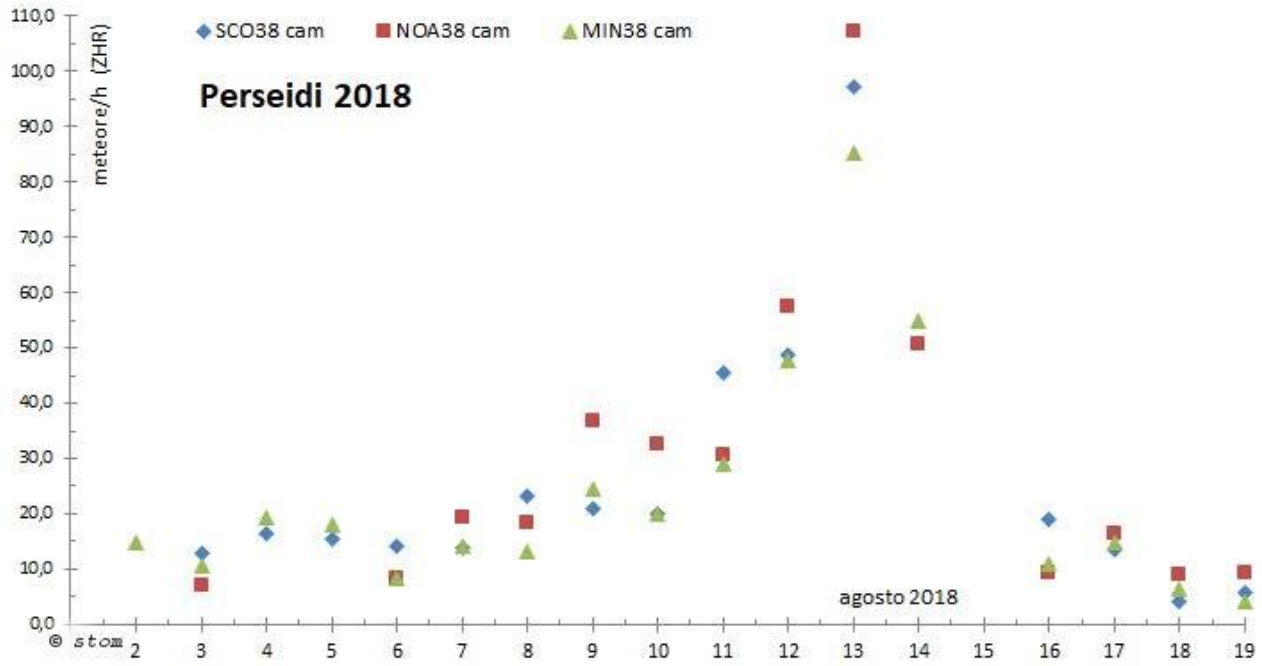

Figure 1 – The average daily hourly frequency, corrected to the zenith for my geographic position and for an optimal limiting magnitude, for each camera.

Perseids observed using low-cost Raspberry Pi based meteor stations

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The RMS (Raspberry Pi Meteor Station) has been tested in Canada during the 2018 Perseids.

1 Introduction

The Raspberry Pi Meteor Station (RMS) project has been in development since 2015 and in the last year final development and tests were done. Individual stations perform automated fireball and meteor detection, astrometric calibration, data management, and data uploading to the central server (Vida et al., 2018). There are about 10 stations operational around the world, in Brazil, Canada, Croatia and France, with future plans to expand the network to other countries as well.

At the end of 2017 tests were done using low-cost CMOS IP cameras. They have shown to be good replacements for analog cameras and are even much more sensitive. A camera with an IMX291 sensor (operated at 1280×720 resolution) and a 4mm f/1.2 CS lens sees +5 magnitude stars at 25 FPS under light polluted skies, and the meteor limiting magnitude is about +3.5. Read more about the Global Meteor Network[21].

2 Perseids 2018

The big test for the system were the 2018 Perseids. In the night of the maximum every camera detected from 300 to 400 meteors. The following images show stacks of all meteor detections in the night of the maximum (*Figures 1, 2 and 3*).

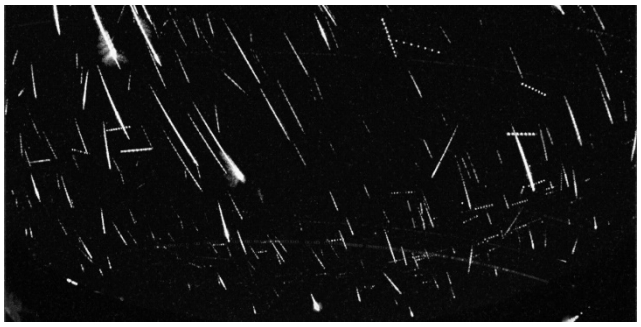

Figure 1 – Perseids from Hum, Croatia. A Hikvision Full HD camera with a 90×50 deg FOV was used.

Figure 2 – Perseids detected from Elginfield, Ontario, Canada.

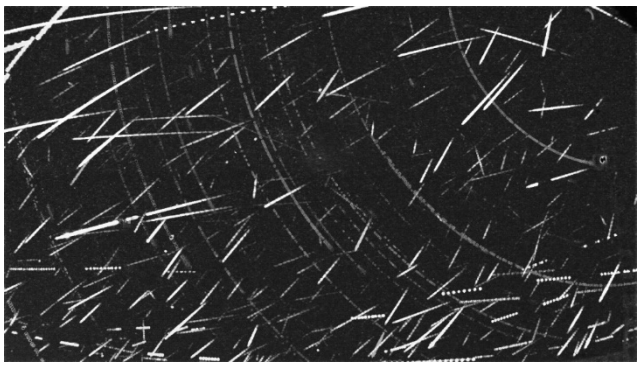

Figure 3 – Perseids detected from Tavistock, Ontario, Canada.

Elginfield and Tavistock stations have overlapping fields of view and soon the analysis of observations and orbit estimation will be performed and published.

References

Vida D., Mazur M. J., Šegon D., Zubović D., Kukić P., Parag F. and Macan A. (2018). "First results of a Raspberry Pi based meteor camera system". *WGN, Journal of the International Meteor Organization*, **46**, 71–78.

[21] https://gmn.duckdns.org/

Preview: Perseid observations from Aubenas Les Alps, Southern France

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A preview is presented of the 2018 Perseid observing expedition to the South East of France.

1 Introduction

Every now and then, *Michel Vandeputte*, his family and *Koen Miskotte* travel to the Provence (Southern France) in August to observe the Perseids. In 2016 they witnessed a very beautiful Perseids outburst in the night of 11/12 August. In 2017, only Michel was observing in the Provence, while Koen observed that year in Crete around the period of the southern delta Aquariids (SDA).

In 2016 we decided to observe the Perseids in the Provence in 2018. Because of the good conditions in which the Perseids would be visible (no moonlight during their maximum), a few more persons joined the team. In addition to Michel, his family and the author, *Jos Nijland*, *Karin Nijland*, *Carl Johannink* and *Casper ter Kuile* joined the group. So, a total of 9 persons participated. This group stayed in Aubenas Les Alps from Saturday 4 until Friday 17 August.

2 Location

Since 2013 we have an observation location at 3 km from the small Provencal village Revest du Bion. In September 2017, it turned out that the house was removed from the rental list, due to a planned major renovation in the summer of 2018. Finding a house for at least 9 people was not an easy task. Eventually we found a large house at a km distance from the tiny village of Aubenas Les Alps. This village is located a few km from the famous

Figure 1 – Group picture in front of our rented house. Fltr: Casper ter Kuile, Rientje, Koen Miskotte, Boris, Inneke Vanderkerken, Karin Nijland, Jos Nijland, Michel Vandeputte and Carl Johannink. Picture credits: Carl Johannink.

Table 1 – Individual results of the team observers at Aubenas Les Alps, Provence, France.

Date	Obs-code IMO	Period UT Start–End	T_{eff}	Mean Lm	Meteor showers					SPO	TOT
					PER	SDA	CAP	KCG	ANT		
06–07/08/2018	JOHCA	21:12-23:12	2.00	6.5	8	4	0-	-	-	17	29
	MISKO	21:20-00:31	3.08	6.6	31	7	1	-	1	34	74
	VANMC	21:35-01:35	4.00	6.6	39	2	3	1	-	45	90
07–08/08/2018	NIJJO	23:00-01:18	1.82	6.3	18	3	0	1	-	22	44
	VANMC	23:25-01:25	2.00	6.5	28	3	0	2	-	31	64
08–09/08/2018	JOHCA	22:45-00:30	1.75	6.5	16	4	2	-	-	17	39
	MISKO	23:00-02:12	2.73	6.5	33	4	3	0	1	29	70
	NIJJO	23:20-01:18	1.83	6.3	16	1	1	1	-	17	36
	VANMC	22:55-02:15	3.00	6.5	34	0	2	3	-	25	64
09–10/08/2018	MISKO	00:54-03:15	2.29	6.7	54	4	1	0	2	40	101
	VANMC	00:45-03:15	2.50	6.8	59	2	0	1	-	59	121
10–11/08/2018	JOHCA	23:00-02:15	3.08	6.5	60	7	3	-	-	51	121
	MISKO	22:51-03:15	4.20	6.7	129	2	1	2	4	56	195
	NIJJO	22:53-03:15	4.17	6.6	120	2	3	10	-	74	209
	VANMC	22:45-03:15	4.50	6.7	128	1	2	8	-	84	223
11–12/08/2018	JOHCA	23:23-02:53	3.50	6.5	95	4	2	-	-	78	179
	MISKO	22:49-03:18	4.37	6.7	234	4	3	2	-	46	292
	NIJJO	22:49-03:15	4.32	6.5	162	3	4	17	-	64	250
	VANMC	22:15-03:15	5.00	6.6	236	4	2	5	-	53	300
12–13/08/2018	JOHCA	20:15-23:00	1.63	6.5	44	4	0	1	-	34	83
	MISKO	20:02-23:00	2.52	6.5	71	0	2	2	0	29	104
	NIJJO	20:10-22:45	2.00	6.4	56	1	3	6	-	29	95
	VANMC	20:00-23:00	3.00	6.5	128	0	1	1	-	22	152
13–14/08/2018	JOHCA	01:55-03:10	1.25	6.5	65	3	1	0	-	23	92
	MISKO	22:20:03:20	4.93	6.7	365	4	3	3	0	65	440
	NIJJO	23:20-03:24	4.07	6.7	316	1	5	20	-	93	435
	VANMC	22:15-03:15	5.00	6.7	393	-	1	7	-	60	461
14–15/08/2018	JOHCA	23:55-02:45	2.83	6.5	62	2	2	0	-	52	116
	MISKO	23:14-03:18	4.00	6.7	125	3	0	8	3	61	198
	NIJJO	23:08-03:20	4.17	6.7	128	2	5	18	-	81	234
	VANMC	23:10-03:10	4.00	6.7	134	-	3	9	-	78	224
15–16/08/2018	MISKO	23:15-02:50	3.52	6.6	72	2	3	4	3	53	137
	NIJJO	23:44-02:50	3.00	6.4	42	4	3	18	-	50	117
	VANMC	00:10-02:10	2.00	6.6	41	-	1	0	0	40	82
16–17/08/2018	MISKO	00:19-03:20	3.00	6.6	45	2	3	3	3	43	99
	VANMC	00:16-03:16	3.00	6.7	36	-	4	4	-	75	119
Totals	*4*		*114.06*		*3623*	*89*	*73*	*157*	*17*	*1730*	*5689*

St Michel Observatoire. This location is about 60 km south of Revest du Bion. The disadvantage is that there is some more light pollution near Aubenas than in Revest du Bion. The advantage is that the southern location is less sensitive to orographic clouds.

3 The weather in the Provence

There has been a particularly beautiful, warm and dry summer in Western Europe since April 2018, with generally very stable weather with regularly clear nights. This is of course an advantage for observations we make in the BeNeLux. However, the very stable weather in the BeNeLux did result in a very unstable weather pattern in the Provence: rain and thunderstorms were very active there. So, we could make the first observations during the night of 6/7 August. And also, the first nights after 6/7 August had trouble with unstable weather. This often manifested itself in heavy thunderstorms during the day and in the evening remained often some remnants of those showers. But, the

"wonder of the Provence" often happened: the very rapid disappearance of the clouds resulting in very clear skies, sometimes in a time span of only 10 minutes. This often happened much earlier than predicted by the weather services!

4 The meteor observations

An overview is given in *Table 1* of all observations made from Aubenas Les Alps. Despite the unstable weather we had a good run with the Perseids this year. The four observers logged 110 hours and counted 5689 meteors. Note: the observers were at a considerable distance from each other so that they did not disturb each other.

This shows that even in unstable weather conditions, in the Provence a nice data series can be collected! And stay tuned, there will be a very extensive report about our campaign in MeteorNews later on!

Figure 2 – Nice Perseid fireball magnitude -6 captured on August 15, 2018 at 23:58 UT. Camera: Canon EOS 40D with a Canon EF 8-15 mm zoom fish eye. Camera settings: F=9.0 mm, F 5.0, exposure time 58 seconds.

Figure 3 – Nice Perseid fireball magnitude -6 captured on August 15, 2018 at 23:58 UT. Camera: Canon EOS 40D with a Canon EF 8-15 mm zoom fish eye. Camera settings: F=9.0 mm, F 5.0, exposure time 58 seconds.

Autumn 2018 observations

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An overview is given of the 2018 Autumn meteor observations by the author, covering the September and early October meteor showers.

1 September 6–7, 2018

I managed to get out on a few clear nights during September's dark window. My main goal was to check out the September Epsilon Perseids, as this shower has produced some brief outbursts with bright meteors in recent years. Although no special activity was predicted to occur this year, there is always the possibility for surprises. Otherwise, any night under a clear dark sky is always time well spent even when meteors are less active.

On the morning of Sept 7, I went to Bootland Farm and the sky conditions were excellent. It was very damp on the ground and possibly it had rained there earlier in the evening. While setting up, I saw a nice Sept. Epsilon Perseids (SPE) of mag +1 in the west that left a train. Temperature started at +11C but was only +4C at the end. It felt cold after warm summer-like weather just a few days prior. I heard several coyotes through the session which made it quite interesting.

It two hours (2-4am EDT), I saw 34 meteors (9 September Epsilon Perseids, 5 antihelions, 3 nu Eridanids, 1 eta Eridanid and 16 sporadics). A very entertaining session! The SPEs were more active than I expected, a few nights away from their predicted peak. The first hour was especially rich in sporadics, but the second hour was slower, and had a 16 minutes lull without any meteors seen. The best meteor was a highly foreshortened ERI at 3:42am EDT that flared brightly at mag 0 with a blue/green color, left a 2 secs train but only travelled 3-4 degrees.

September 6/7 2018, 06:10-08:10 UT (02:10-04:10 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- chi Cygnids (CCY) – 19:48 (297) +30
- Antihelion (ANT) – 23:56 (359) -00
- September Epsilon Perseids (SPE) – 03:06 (047) +39
- nu Eridanids (NUE) – 04:12 (063) +04
- eta Eridanids (ERI) – 04:36 (069) -04

06:10-07:10 UT (02:10-03:10 EDT); 3/5 trans; F 1.00; LM 6.55; facing S60 deg; t_{eff} 1.00 hr

- SPE: five: +1(2); +2; +3; +4
- ANT: four: +2; +3; +4(2)
- NUE: two: +4(2)
- Sporadics: eleven: +1; +2(3); +3; +4(3); +5(2); +6
- Total meteors: Twenty-two

07:10-08:10 UT (03:10-04:10 EDT); 4/5 trans; F 1.00; LM 6.60; facing S60 deg; t_{eff} 1.00 hr

- SPE: four: 0; +2(2); +3
- ANT: one: +3
- NUE: one: +3
- ERI: one: 0
- Sporadics: five: 0; +1; +3; +4; +5
- Total meteors: Twelve

2 September 7–8, 2018

I was out again the following night and Dan joined me to hunt for meteors. It was another very pleasant late night session, with temps around +10C to start and +6C near the end. I watched for 3 hours, starting at 1:25am EDT and it was a productive session. During that time, I saw 45 meteors (10 Sept Epsilon Perseids, 4 antihelions, 3 nu Eridanids, 2 eta Eridanids and 26 sporadics).

The SPEs were most interesting during the second hour with bright mag –2 and –3 meteors seen just a few minutes apart; the brighter of the two produced a terminal flash and left behind a 5 secs train! Another highlight was the -1 sporadic at 3:52am EDT that moved slowly down in the east, produced a flash and briefly fragmented into several tiny pieces before vanishing. Very nice!

September 7/8 2018, 05:25-08:25 UT (01:25-04:25 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- chi Cygnids (CCY) – 19:48 (297) +30
- Antihelion (ANT) – 23:56 (359) -00
- September Epsilon Perseids (SPE) – 03:06 (047) +39
- nu Eridanids (NUE) – 04:12 (063) +04
- eta Eridanids (ERI) – 04:36 (069) -04

05:25-06:25 UT (01:25-02:25 EDT); 3/5 trans; F 1.00; LM 6.45; facing S50 deg; t_{eff} 1.00 hr

- SPE: three: +1(2); +5
- ANT: one: +4

- NUE: one: +5
- Sporadics: eight: -1; +1; +2; +3(3); +4(2)
- Total meteors: Thirteen

06:25-07:25 UT (02:25-03:25 EDT); 3/5 trans; F 1.00; LM 6.54; facing S50 deg; t_{eff} 1.00 hr

- SPE: five: -3; -2; +3(2); +4
- ANT: two: +3(2)
- NUE: one: +1
- ERI: one: +2
- Sporadics: nine: 0; +1(2); +3(2); +4(2); +5(2)
- Total meteors: Eighteen

07:25-08:25 UT (03:25-04:25 EDT); 3/5 trans; F 1.00; LM 6.52; facing S50 deg; t_{eff} 1.00 hr

- SPE: two: 0; +4
- ANT: one: +6
- NUE: one: +1
- ERI: one: +1
- Sporadics: nine: -1; +3(3); +4(4); +5
- Total meteors: Fourteen

3 September 8–9, 2018

On this night, I decided to go to Shane Finnigan's place near Renfrew (a little more than an hour's drive from home). Joining me was Todd Weeks and Raymond Dubois. We made the most out of another clear and very transparent sky. I brought my 12.5" PortaBall and Todd had his excellent 10" dobsonian. Shane was out at an event for part of the evening, and then he joined us out in the field. It was really nice getting the scopes setup under dark skies again, and we spent a few hours enjoying a variety of deep sky objects (many of the usual Messier objects, as well as some bright and more challenging NGCs). It was especially fun to compare views.

I signed on for meteors at 1:35am EDT, and observed for 3 hours. I saw 52 meteors (18 Sept Epsilon Perseids, 4 antihelions, 1 nu Eridanid, 1 eta Eridanid and 28 sporadics). The SPEs were quite active, clearly the most active meteor source in the sky even a day or two before their predicted peak! No fireballs were seen, but the brightest SPE was a mag –1 that shot 20 degrees and left a 3 secs train. The third hour was very rich in sporadics with 14 of them seen — a large number were faint mag +4's.

Before packing up, I took one more glimpse at the pre-dawn sky with my 12.5". The comet 21P/Giacobini-Zinner was very high up and looked impressive at low magnifications (22mm Panoptic) with a tail that stretched across the entire field-of-view, and a large greenish coma. This was my best view ever of it! Then, I turned my attention to Orion and M42 was fantastic — it displayed a rich wealth of details that looked almost three dimensional, and I could see faint reddish-pink hues near the core, WOW!! It was well worth staying up for this, even despite the cold 0C or –1C with layers of frost!

Thanks to Shane for having us over at his beautiful, quiet rural property. It was an excellent night, and the company was enjoyable too!

September 8/9 2018, 05:35-08:35 UT (01:35-04:35 EDT) Location: Renfrew, Ontario, Canada, (Long: -76° 38' ; Lat: 45° 25')

Observed showers:

- chi Cygnids (CCY) – 19:48 (297) +30
- Antihelion (ANT) – 23:56 (359) -00
- September Epsilon Perseids (SPE) – 03:06 (047) +39
- nu Eridanids (NUE) – 04:12 (063) +04
- eta Eridanids (ERI) – 04:36 (069) -04

05:35-06:35 UT (01:35-02:35 EDT); 4/5 trans; F 1.00; LM 6.55; facing S50 deg; t_{eff} 1.00 hr

- SPE: seven: +2; +3(2); +4(2); +5(2)
- Sporadics: eight: +2(2); +3(2); +4(2); +5(2)
- Total meteors: Fifteen

06:35-07:35 UT (02:35-03:35 EDT); 4/5 trans; F 1.00; LM 6.55; facing S50 deg; t_{eff} 1.00 hr

- SPE: six: 0; +3; +4(3); +5
- ANT: three: +3; +4; +5
- NUE: one: +5
- ERI: one: +4
- Sporadics: six: 0; +2; +3; +4(3)
- Total meteors: Seventeen

07:35-08:35 UT (03:35-04:35 EDT); 4/5 trans; F 1.00; LM 6.55; facing S50 deg; t_{eff} 1.00 hr

- SPE: five: -1; +2(2); +4; +5
- ANT: one: +6
- Sporadics: fourteen: +3(3); +4(8); +5; +6(2)
- Total meteors: Twenty

4 September 14–15, 2018

The predicted peak night of the SPEs was clouded out, but I was able to get out a few nights later. I attended a very busy public sidewalk session in the west end, and after that, I took a drive to Westmeath Lookout. It has been a few years since I've last been to this site, and I enjoy its elevated 360 degrees views. It really is a nice spot to do meteor observing and worth the 1.5 hour drive.

This is the kind of night that I probably should have stayed home. A small cloud had parked itself over Ottawa but I was confident that the skies were clearer further to the west. As I drove, I could see some stars overhead so I figured that it would be good. But it seemed that the further I went, the cloudier it got, and as I passed Renfrew and turned on Storyland road, a few drops of rain started. Then, it got worse. It rained. And then it poured. A few minutes later, it calmed a bit. As I drove on Queens Line road (2/3 of the way to the site), the rain suddenly came down so hard that I could barely see anything. It was like a torrential

downpour! This went on and off past Beachburg and I contemplated aborting the observing attempt as it looked so dismal. But I pressed on as I was so close anyway. About 5 minutes to arrival at the Look-out, the rain stopped and I could see a few stars. I pulled into the parking lot, and out of the car, I looked up… WOW! It was a glorious canopy of stars all over the north-east. So many stars, it was absolutely stunning! In the south-east, I could see the cloud that was responsible for all that rain. Thankfully, that was behind me now. So, I grabbed my chair, meteor accessories and walked up to the top of the hill. Up there, it is a breathtaking view. I sat back in my chair and I enjoyed the light but steady easterly breeze. A few clouds hung around so I just observed casually for a while and then took a short snooze because I was so tired. The short nap energized me and I started a two hours of meteor observing. At the end of the first hour, something strange happened. The wind picked up and along with it came one of the THICKEST fogs that I've ever seen. The wind seemed to push it right in and within minutes, all the stars were disappearing around the horizons. Down below in the valley, I saw almost nothing — it was all white! All I could do was look straight up to the zenith where I could still see the sky, but it looked like it wouldn't last. It was also getting so incredibly humid and very much dismal. Just as I was about to call it a night, the wind calmed down and the fog … went away! Just like that! Such a strange night! As a result, I was able to complete my second hour.

In all, I saw 22 meteors (5 antihelions, 2 Sept Epsilon Perseids, 2 nu Eridanids and 13 sporadics). With those variable conditions, I can't complain too much. Just after I signed off, I saw what appeared to be a fireball behind a cover of approaching clouds. It was just a halo of sorts shooting across!

At 4:30am, I setup my Adventurer EQ mount and camera to capture 21P/Giacobini-Zinner's conjonction with M35, along with the compact and more distant NGC 2158 visible to the right. I found that the comet is already quite a bit fainter than it was a week ago, but this was very cool! A green fuzz ball overlapping a rich star cluster, just as morning twilight was starting. Certainly, a unique sight that we don't see every day (see *Figure 1*).

September 14/15 2018, 06:00-08:15 UT (02:00-04:15 EDT)
Location: Westmeath Lookout (White Water Region), Ontario, Canada, (Long: -76.859 West; Lat: 45.793 North)

Observed showers:

- chi Cygnids (CCY) – 20:12 (303) +32
- Antihelion (ANT) – 00:28 (007) +03
- September Epsilon Perseids (SPE) – 03:40 (055) +40
- nu Eridanids (NUE) – 04:38 (070) +05
- eta Eridanids (ERI) – 05:00 (075) -02

Figure 1 – Here's an image done with my Canon 6D and 400mm f/5.6 lens and 1.4 TC (at f/8.0), ISO6400, stack of five 30 sec exposures.

06:00-07:06 UT (02:00-03:06 EDT); 3/5 trans; F 1.05; LM 6.50; facing SE50 deg; t_{eff} 1.00 hr, 20% clouds from 06:45-06:50 and 20% from 06:56-07:06

- ANT: three: 0; +4(2)
- NUE: one: +4
- Sporadics: five: +3(2); +5(3)
- Total meteors: Nine

07:15-08:15 UT (03:15-04:15 EDT); 1/5 trans; F 1.10; LM 6.30; facing SE70 deg; t_{eff} 1.00 hr, 10% clouds from 07:15-07:30, 20% from 07:30-07:40 and 20% from 08:05-08:15

- SPE: two: +3; +5
- ANT: two: +4(2)
- NUE: one: +4
- Sporadics: eight: +2(2); +3; +4; +5(3); +6
- Total meteors: Thirteen

5 October 4–5, 2018

Here's my results for a quick outing this past Friday morning at Bootland Farm. The sky was quite nice – average transparency. It was on the cool side, just a few degrees above freezing so I was glad to have my winter gear and tuque.

I observed for only an hour (2-3am EDT) and it was as much as I could stay awake for after a very busy day. I did see a good number of South Taurids, and my first Orionid. The nu Eridanids are definitely a long-lasting minor shower – they produced a couple of meteors.

No early Draconids were seen.

October 4/5 2018, 06:00-07:00 UT (02:00-03:00 EDT) Location: Bootland Farm (Stewartville), Ontario, Canada, (Long: -76 deg 29'; Lat: 45 deg 23')

Observed showers:

- Northern Taurids (NTA) – 01:28 (022) +14
- Southern Taurids (STA) – 01:44 (026) +07
- Orionids (ORI) – 05:26 (081) +17
- nu Eridanids (NUE) – 05:58 (090) +09
- epsilon Geminids (EGE) – 05:57 (089) +28
- October Camelopardalids (OCT) – 11:13 (167) +78

06:00-07:00 UT (02:00-03:00 EDT); 3/5 trans; F 1.00; LM 6.34; facing S50 deg; t_{eff} 1.00 hr

- STA: five: +2(2); +4(2); +5
- NUE: two: 0; +2
- ORI: one: +4
- Sporadics: four: +3(2); +4; +5
- Total meteors: Twelve

The thin rising crescent moon and earthshine were beautiful!

Meteor detection by infrasound method

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The infrasound observing set up of the Swiss Meteor Network is introduced and the infrasound detection for a bright meteor over Switzerland on October 9, 2018, at 01:48:51 UT is discussed.

1 Introduction

Sound waves are changes of pressure (fluctuations of density) in a medium. In the medium of the terrestrial atmosphere, sound waves spread out as so-called longitudinal waves, by forwarding of the pressure change in the propagation direction. Infrasound is the part of the sound spectrum below the human hearing threshold, at frequencies below 20 Hz. The causes of infrasound in the atmosphere are many: animals, wind turbines, earthquakes, volcanoes, sea waves, thunderstorms, wind, trucks, helicopters, nuclear weapons tests, etc. Even bright meteors and fireballs create a sound wave when they collide with the Earth's atmosphere.

2 Infrasound recording stations

Currently (October 2018), the following stations of the Swiss Meteor Network are recording and analyzing infrasound signals (*Table 1*).

Table 1 – Stations of the Swiss Meteor Network are recording and analyzing infrasound signals[22].

Station ID	Operator	Equipment	Software
BOS Observing station Bos-cha	Jochen Richert	Infra20 Rasperry Boom	jAmaseis Winquake
ENT Observing station Entfelden	Jonas Schenker	Infra20	jAmaseis Winquake
GNO Osservatorio Astronomico di Gnosca	Stefano Sposetti	Infra20	jAmaseis Winquake
VTE Observatoire géophysique Val Terbi	Roger Spinner	Infra20	jAmaseis Winquake

3 Noise reduction

Usually infrasound waves caused by meteor events are weak signals. Often, a meteor event generates an amplitude, which is similar to the noisy signals. Most of the noise is generated by the wind. That's why it is necessary to apply an effective wind noise reduction.

According to the literature, the use of a noise averaging system is proposed. After some tests, the stations of the FMA apply different equipment. This allows to compare the different methods of noise reduction.

3.1 Noise averaging system of station BOS:

Figure 1 – BOS, Observing station Bos-cha.

[22] For the location, please visit: http://meteorastronomie.ch/images/Karte_Beobachtungsstationen.jpg

Instead of the commonly used non-UV-resistant tubes, the noise averaging system was built in a more robust way. The noise averaging system consists of a center part and 18 pcs. of radial tubes, all made of aluminum. The tubes have a length of 2.00 m and the ends are still open. In the future, the ends will be covered with a kind of filtering material.

Further, the center part is equipped with two output tubes: One for the Infiltec Infra20 sensor and another one for the Raspberry Boom sensor.

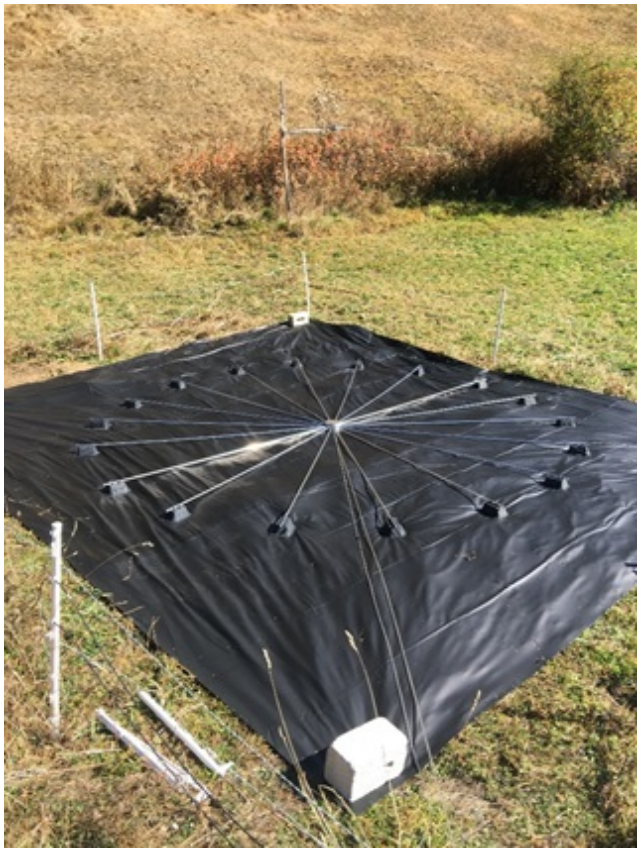

Figure 2 – BOS, Observing station Bos-cha.

Figure 3– BOS, Observing station Bos-cha, the center part with two output tubes: One for the Infiltec Infra20 sensor and another one for the Raspberry Boom sensor.

3.2 Noise averaging system of station GNO:

The noise averaging system was realized by the use of a porous tube from Claber (item no. 90350[23])

The length of the tube is 15 m, internal diameter is 16 mm. One end of the tube is closed, the other end is attached to the Infra20 device.

Figure 4 – GNO, Osservatorio Astronomico di Gnosca with the Claber tube on the ground.

Figure 5 – GNO, Osservatorio Astronomico di Gnosca with the Claber tube on the ground.

3.3 Noise reduction system of station ENT:

Figure 6 – ENT, Observing station Entfelden and its noise reduction system.

[23] https://www.claber.com/uk/cod/90350/Tubi-irrigatori/1-2-Soaker-hose---15-m

Instead of an averaging system, a noise reduction system was applied. It consists of a microphone fur, as often used from street reporters during windy weather conditions. The end of the infra20 tube is open and is simply plugged into the fur.

3.4 Noise averaging system of station VTE (similar to the recommended array from infiltec):

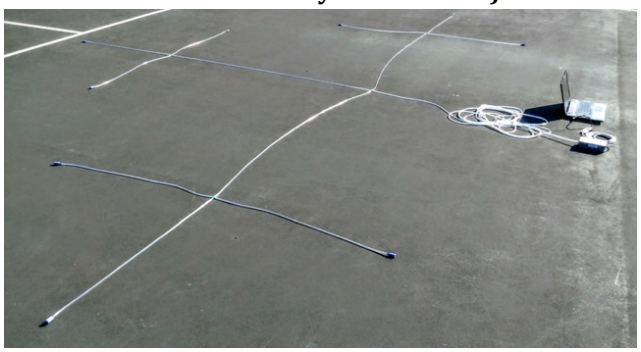

Figure 7 – VTE, Observatoire géophysique Val Terbi.

4 Meteor event

On October 9, 2018, at 01:48:51 UT, a bright meteor occurred over Switzerland. Numerous stations of the Swiss Meteor Network recorded the meteor by different methods: All-sky pictures, video sequences, audio signals (forward scattering) and spectroscopic recordings.

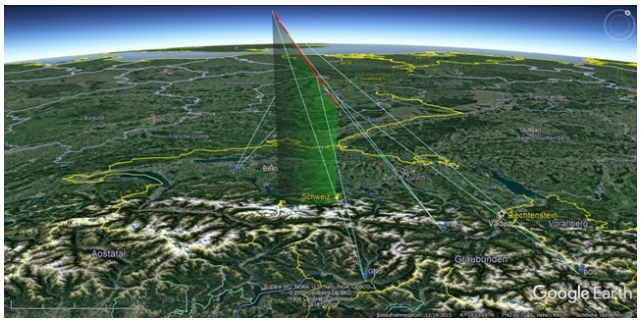

Figure 8 – Meteor event October 9, 2018, at 01:48:51 UT, starting at 118 km and ending at 72.6 km elevation.

Figure 9 – Meteor event October 9, 2018, at 01:48:51 UT, had its trajectory entirely over Switzerland.

Due to the numerous observations from different observing sites, Beat Booz was able to triangulate the trajectory of the meteor. According to the calculations, the fireball entered the Earth's atmosphere with a velocity of 38 km/s and a tilt angle of 56°. The meteor started at the height of 118 km. At an altitude of about 72.6 km, it exploded in a bright double flash. The remaining parts and the afterglow could be recorded down to height of 63 km. The trajectory occurred completely over Switzerland. The meteor ended because the material was completely ablated. That is why no mass fall is expected.

The recordings and calculations are available online[24].

5 Detection of a meteor by infrasound signal

At the end of the visual recording, a bright double flash was detected. It is assumed, that the double flash occurred by an explosive fragmentation of the meteoroid, shortly before it disappeared. The explosion was timed at 01:48:52.8 UT. At this time, the meteoroid was located on 46.73° N, 8.27° E, in a height of 72.6 km above sea level.

According to the calculations of Beat Booz, the explosion is localized at 46.73°N, 8.27°E, height 72.6 km. It is further assumed, that the sound waves started from this "point of explosion" in a spherical shape in all directions. It is also assumed, that the sound waves spread in a straight line (no refraction of the sound waves was considered). During the meteor event, the infrasound recording stations BOS, GNO, VTE and ENT were in operation too. It was suspected, that the explosion generated some infrasound waves. Depending on the distance between the "point of explosion" and the observing station, the infrasound signals should arrive at the stations at different time.

The following results in *Table 2* show the expected delay of the arrival of the sound. The base of the calculations is the standard model of the atmosphere referred to the velocity of sound in dependence of the temperature in different heights.

Table 2 – Times of expected arrival: (1) Station, (2) Calculated delay, (3) Expected arrival of the signal, (4) Resulting average speed of sound, (5) Recorded event time (main signal) and (6) Difference.

(1)	(2) sec.	(3) UT	(4) m/s	(5) UT	(6) sec.
BOS	509	01:57:22	310.635	01:57:24	+2
VTE	370	01:55:03	310.956	01:55:03	0
GNO	345	01:54:38	311.109	01:54:36	-2
ENT	327	01:54:20	311.024	–	

6 Detection of a meteor by seismic signal

Because it seemed possible, that the infrasound waves could have been recorded by the seismic sensors of the Schweizerischer Erdbebendienst (SED), we asked for the data of the nearest stations, see *Table 3*.

Near stations of the Schweizerischer Erdbebendienst (SED) can be found online[25].

[24] http://meteorastronomie.ch/detaildatafk.php?id=112

[25] http://www.seismo.ethz.ch/de/home

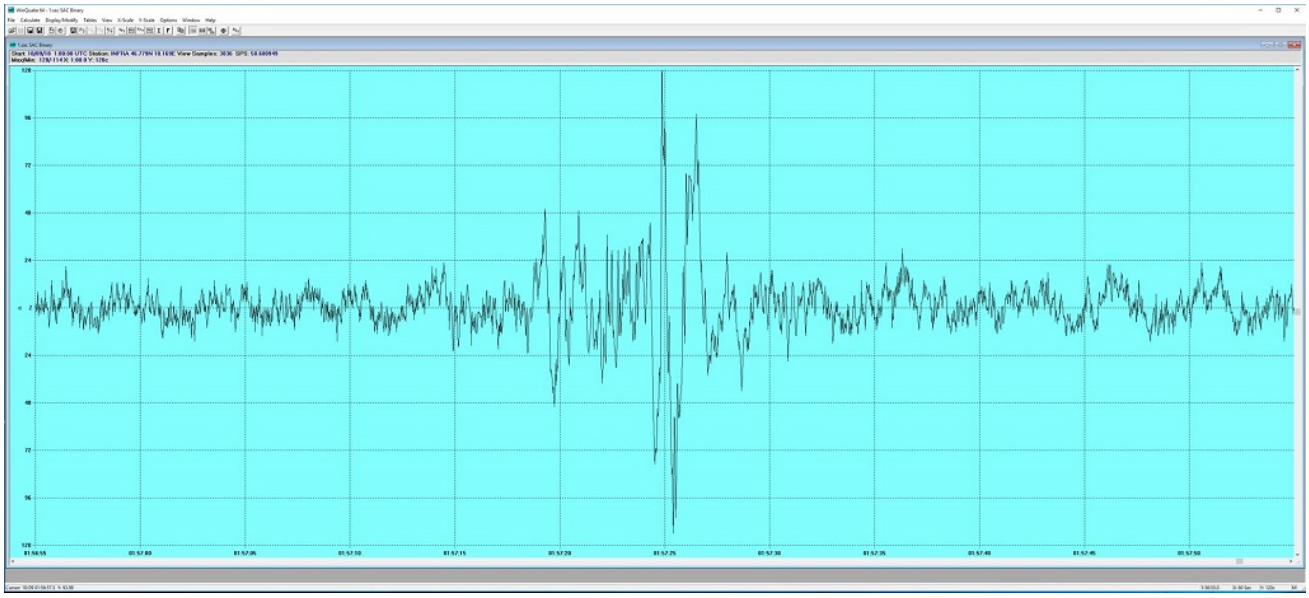

Figure 10 – The infrasound recording of station BOS: expected time: 01:57:22 UT.

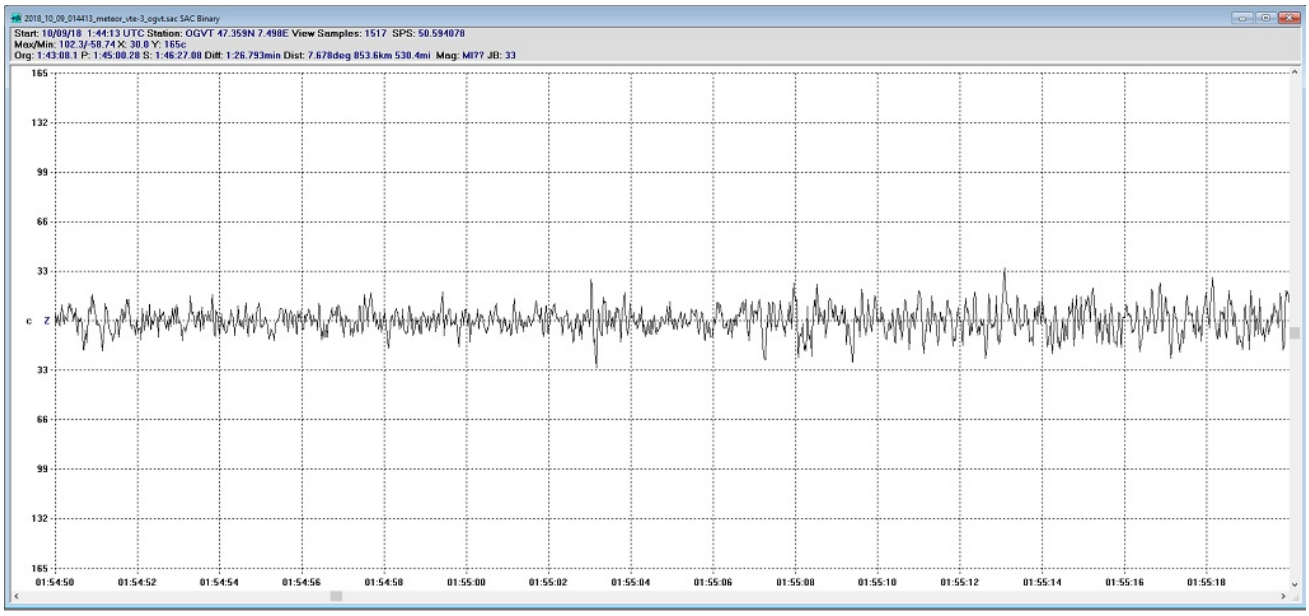

Figure 11 – The infrasound recording of station VTE: expected time: 01:55:03 UT.

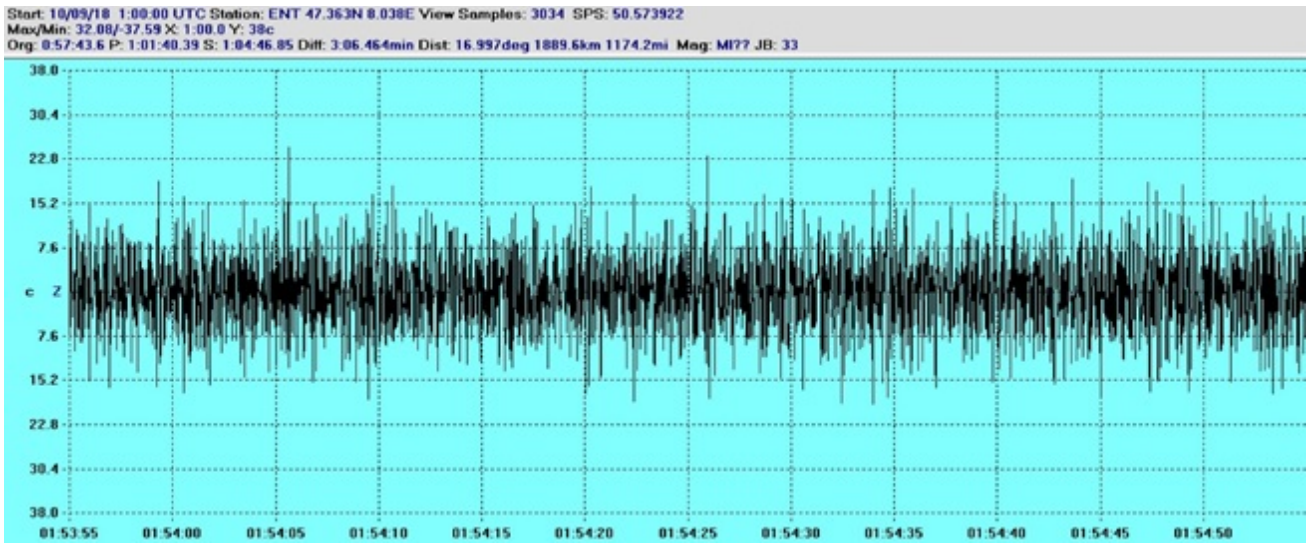

Figure 12 – The infrasound recording of station ENT: expected time: 01:54:20 UT (no detection but noise).

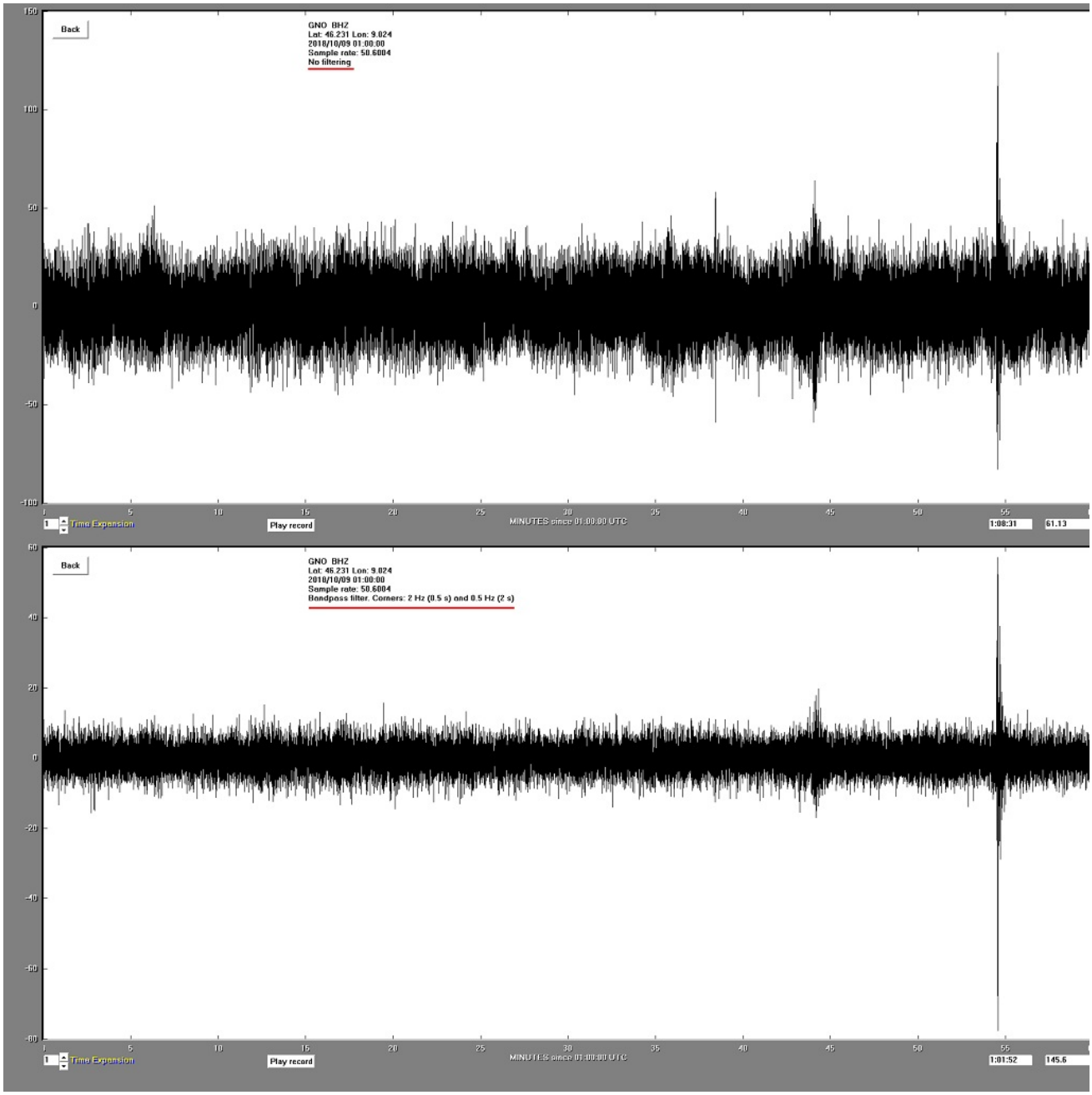

Figure 13 – The infrasound recording of station GNO: expected time: 01:54:38 UT.

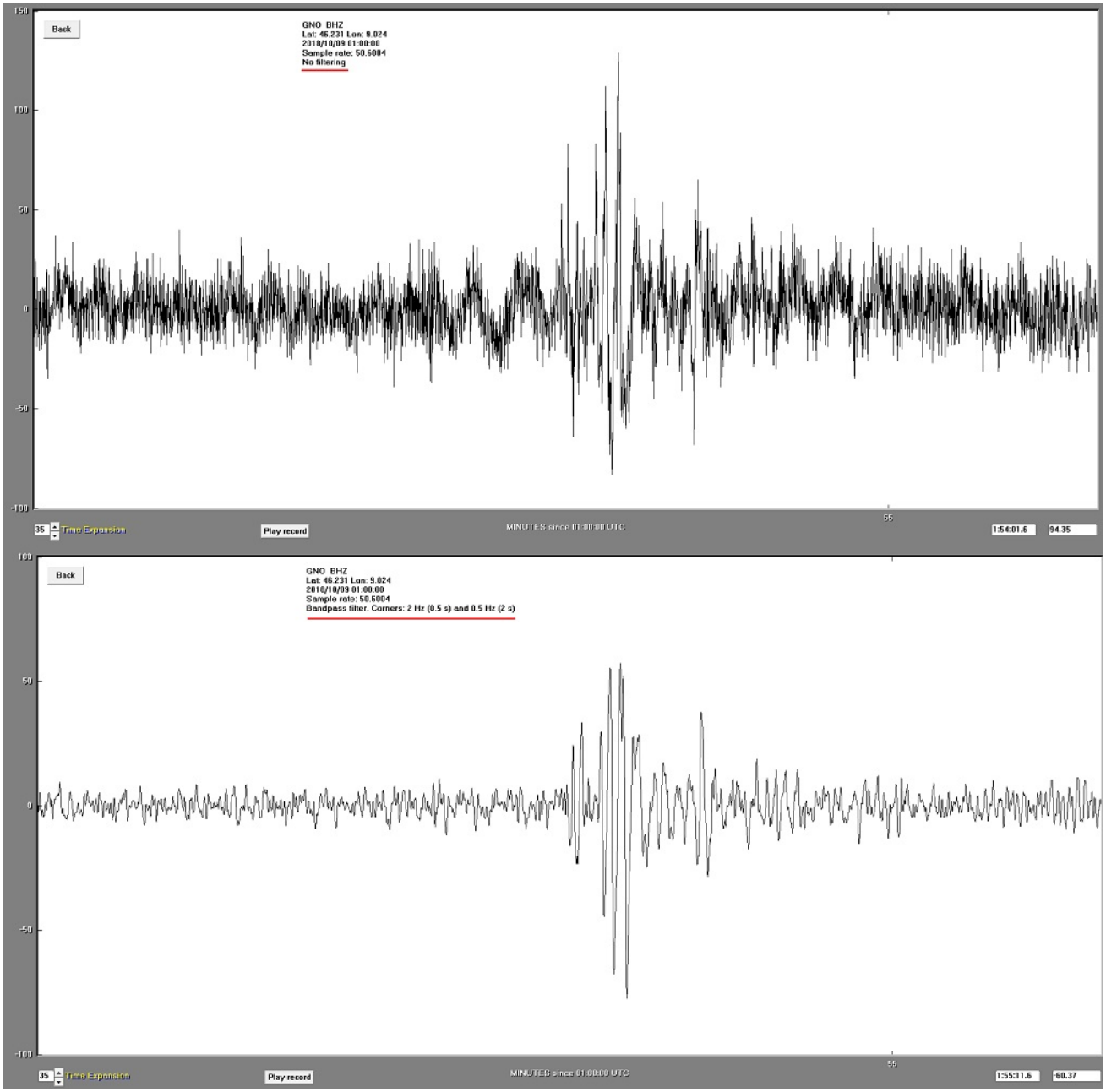

Figure 14 – The infrasound recording of station GNO (zoomed): expected time: 01:54:38 UT.

Table 3 – Near stations of the Schweizerischer Erdbebendienst (SED): (1) Calculated delay, (2) Expected arrival of the signal, (3) Resulted average speed of sound[26].

Station	(1) sec.	(2) UT	(3) m/s
FIESA	253	01:53:06	310.429
HASU	232	01:52:45	310.733
SINS	253	01:53:06	310.973
SARK	240	01:52:53	311.064
SENGL	236	01:52:49	310.864
BNALP	238	01:52:51	310.686
SSTS	247	01:53:00	310.968
SALTS	255	01:53:08	311.015
SEFS	252	01:53:05	310.992

Mr. Diehl of SED remarked: “In that time window I don’t see any (coherent) signal in the seismic network. Maybe the infrasound signal is therefore too weak to be recorded by the seismic network. In addition, many permanent stations are in deeper vaults and therefore infrasound signals might not be recorded.”

Many thanks to *Mr. John Clinton* and *Mr. Tobias Diehl* from SED for the seismic data.

[26] See the map or http://www.seismo.ethz.ch/de/home/

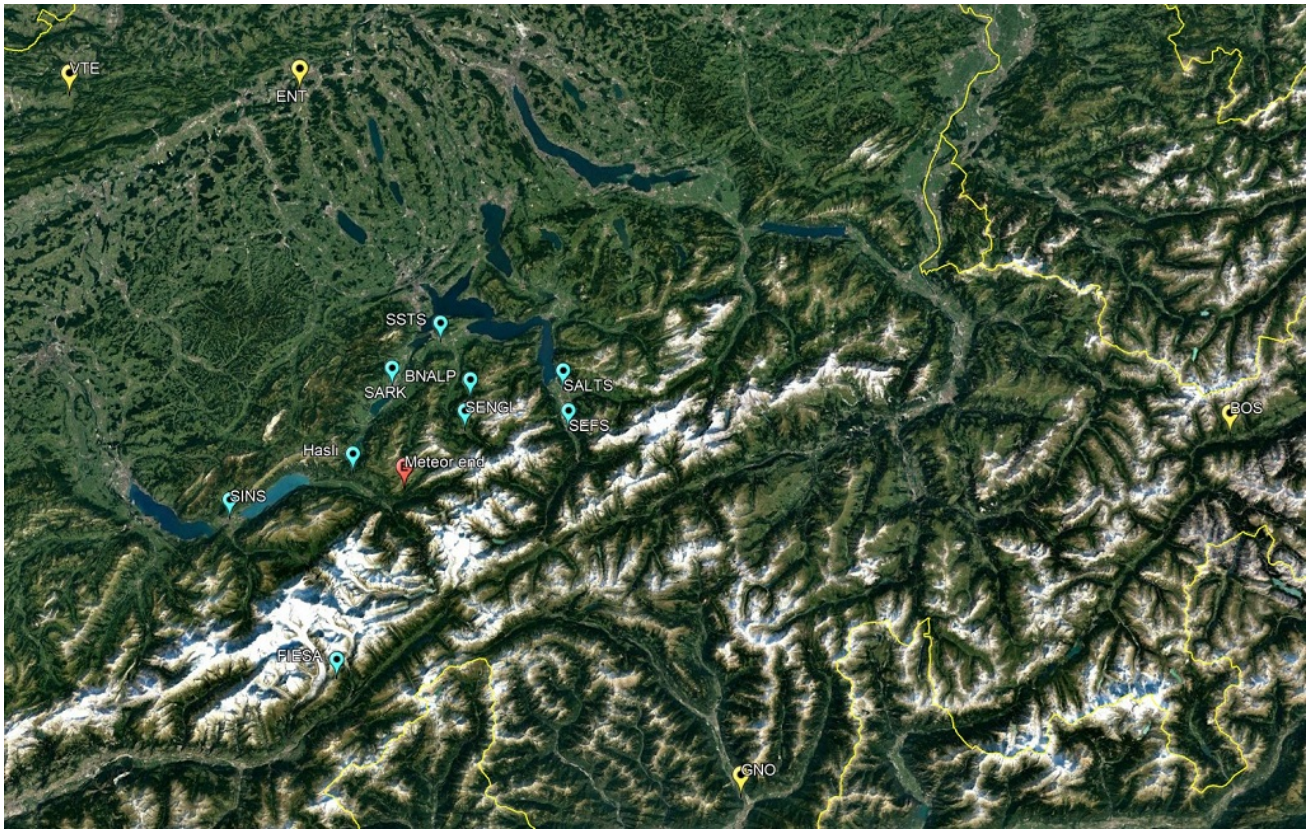

Figure 15 – Overview about the involved recording stations: Stations of FMA (yellow marks), Stations of SED (blue marks)and end of the meteor (height 72.6 km) (red mark).

Figure 16 – Overview about the involved recording stations: Stations of FMA(yellow marks), Stations of SED (blue marks)and end of the meteor (height 72.6 km) (red mark).

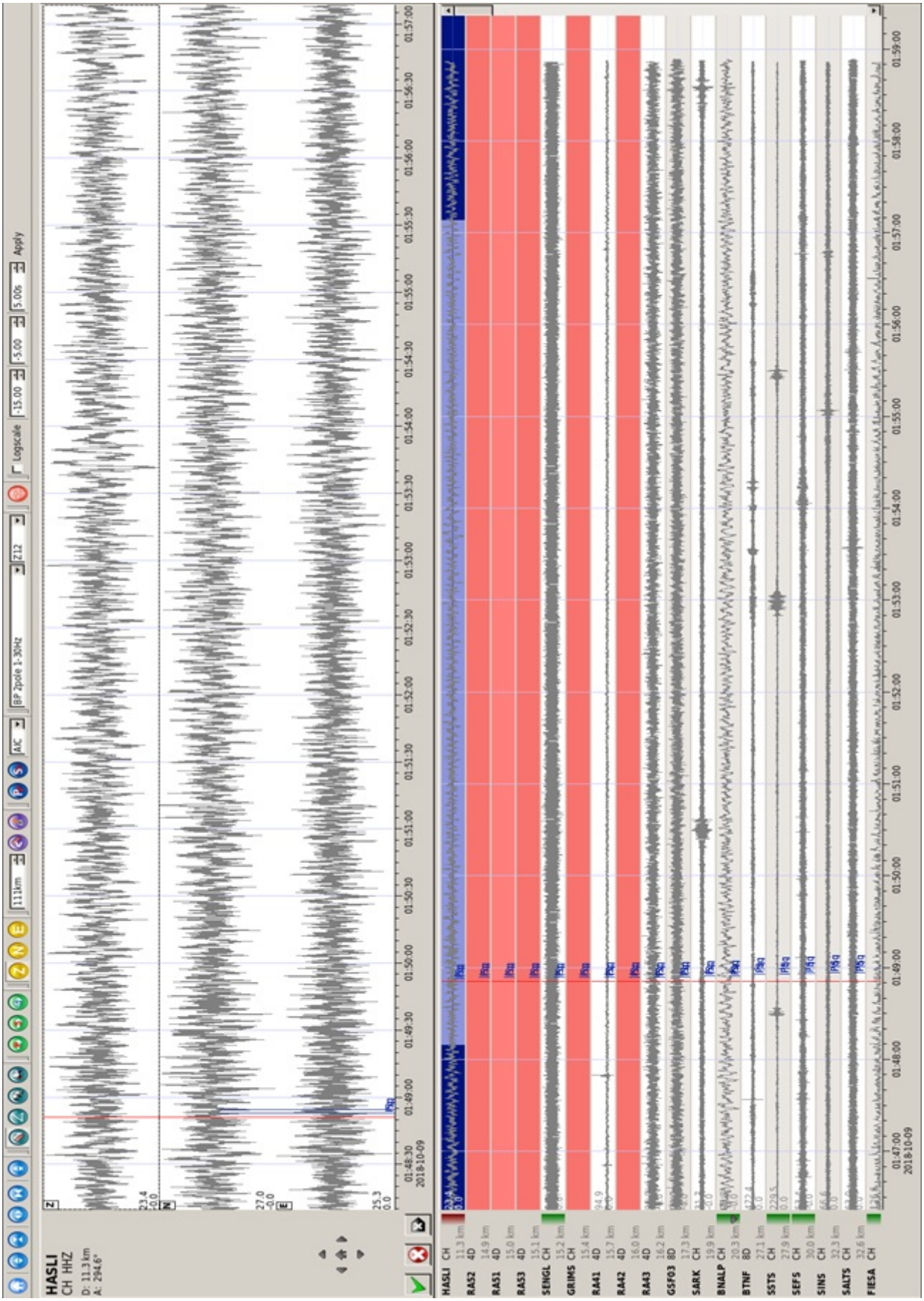

Figure 17 – Seismic recordings of the nearest stations of Schweizerischer Erdbebendienst (SED).

7 Discussion

1) The present meteor event was accompanied by a bright (double) flash at the end of the visible trajectory. In fact, this flash marks an explosive fragmentation, which causes the spread out of sound waves in a wide audio frequency spectrum, including infrasound range.

2) The existence of an explosion allows to determine a single point as the starting point of the sound waves (instead of the line path along the meteor's trajectory). And further, it can be assumed, that the sound waves start from this "point of explosion" in a spherical shape in all directions.

3) The comparison between the expected and recorded time shows, that the applied calculation method (iteration of the way of sound wave from the starting point to the observing site; by steps of 1 sec.) is well usable for a rough estimation. Hereby, the different velocity of sound waves, depending on the temperature in different heights, was considered. The result of the calculation is the delay between the time of explosion and the time of arrival of the sound wave at the observing site.

4) For the present case, the accuracy is about ± 1% resp. ± 2 seconds resp. ± 620 m in distance. This is in line with the accuracy of the position, determined out of the video sequences.

5) The herein applied calculation doesn't consider the influence caused by atmospheric sound refraction. Separate calculations show, that the length of the sound path will be prolonged by atmospheric refraction as follows:

- Station GNO: +0.6 sec.
- Station VTE: +0.3 sec.
- Station BOS: + 1.6 sec.

6) In a first approach, the herein applied calculation doesn't consider the influence caused by wind. Further investigations are necessary to estimate the influence of the wind.

7) Because of the limited accuracy of the localization of the "point of explosion" and the relative short distances, the calculation were made considering a flat surface of the Earth. For further calculations, the spherical shape of Earth shall be considered.

8) Further, the present meteor event shows also, that it is possible to make some rough triangulation out of the infrasound data. This circumstance can be important in cases where no visual or video data are available. Examples are meteor events during daytime or when skies are clouded out.

9) Depending on the distance to the observing site, the amplitude of the signal is decreasing in an exponential way. An effective noise reduction or averaging system is eminent important. It allows to distinguish better between noise and signal also in a far distance.

10) Base of all recordings and calculations is an accurate time keeping system of all participating stations.

Acknowledgment

Credits to:

- *Beat Booz* (calculations)
- *Jochen Richert* (data and equipment of station BOS)
- *Prof. Stefano Sposetti* (data and equipment of station GNO)
- *Roger Spinner* (data and equipment of station VTE)
- *Dr. John Francis Clinton* (seismic data of Schweizerischer Erdbebendienst SED)
- *Dr. Tobias Diehl* (seismic data of Schweizerischer Erdbebendienst SED)

First impressions of the 2018 Draconids outburst

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During and immediately after the appearance of the Draconid outburst impressions and reports were shared on social media. To preserve a selection of these spontaneous first impressions, a summary report has been compiled.

1 Introduction

The predictions for the Draconid activity were rather skeptical to get anything of an outburst[27] (Egal et al., 2018), so the question was if we would see any Draconids at all or if some activity would be visible, then at what level?

2 First Draconid orbits

Already 6–7 October a first Draconid was identified from the orbit obtained by the CAMS BeNeLux network. A preliminary data reduction by *Carl Johannink* of the 7–8 October CAMS BeNeLux data had over 400 orbits of which 13 proved to be Draconid orbits. What would bring 8–9 October?

3 The night of the outburst

The weather forecast for once was very good for many places in Europe although at many sites thick cirrus clouds threatened to interfere with the observations. The stations of the CAMS BeNeLux network started when the Sun was 8° below the horizon, the cirrus clouds disappeared somewhat. Around 20^h UT camera operators noticed a remarkable number of meteors on the CAMS monitor while normally it is rather rare to see any meteors directly on the snapshots of the monitor. Visual observers were hampered by cirrus clouds while it was obvious that an outburst was going on, being covered by the CAMS network. Soon the messages started to circulate on the social media. We cite some first impressions from different well-known amateurs:

Koen Miskotte (the Netherlands): "Observing between 23^h15^m and 1^h45^m UT. Nice activity despite poor observing conditions and a low position of the radiant. I estimate I saw about 30 or more with two time a magnitude +1 and one of magnitude 0."

Michel Vandeputte (Belgium): "A lot of faint stuff; but also, nice events, sometimes nice very white appearances with flares: the typical 'fragile' Draconid. The activity remained long time stable and modest until suddenly activity started to pick up; a period when about one per minute appeared. The outburst had materialized well in advance of the predicted observing window. However, it did not remain with just short pulses. The activity increased further out of nothing, multiple meteors were seen per minute, even two or three at the same instance! Yes, this was going hard: probably getting at a ZHR of about 100, certainly considering the low position of the radiant! Everywhere nice long meteor trails at the sky thanks to the decreasing radiant position. Not only faint stuff, but sometimes very nice meteors up to –2, even one small fireball!"

Tioga Gulon (France): "A little feedback from last night. I went out with two amateur astronomers on the hill of Sion south of Nancy. At the beginning of the evening 21^h local time, some high-altitude clouds were present, a few meteors appeared, and we took advantage of it to make large-field photos. We were not paying attention to occasionally watching our devices and until 00^h we saw only 5 to 6 meteors. But from 00^h to 00^h30^m (the time we left) it was pretty, we could observe an intensity with 1 or 2 meteors per minute. I do not know if it is an effect, but we had the impression specially to see them, in the sky, at the azimuth opposite of the radiant at the same elevation. (*Figure 8*)"

Mariusz 'Marand' Wiśniewski (Poland): "We had an outbreak of Draconids shower activity last night! The shower at maximum probably exceeded 100 meteors / h. More details soon."

Jure Atanackov (Slovenia): "Observed 22^h40^m–00^h44^m UT under mediocre conditions, LM about 6.5 and variable cloud cover (0 to 40%). Peak seemed to be around 23^h00^m-23^h20^m UT. Rates were probably >100/h, even with the radiant below 30 degrees. Will be surprised if peak ZHR is not around several hundred. Possible secondary peak around 00^h00^m UT."

Istvan Tepliczky (Hungary): "Last night we saw the shower of Giacobinids, unfortunately only through video meteor cameras, because we did not organize a campaign for the event. We don't have to expect to see a spectacular display. The activity has produced a lot of not-so-bright meteors, as it was in history."

[27] https://www.meteornews.net/2018/09/21/news-from-the-meteor-library-draconids-2018/

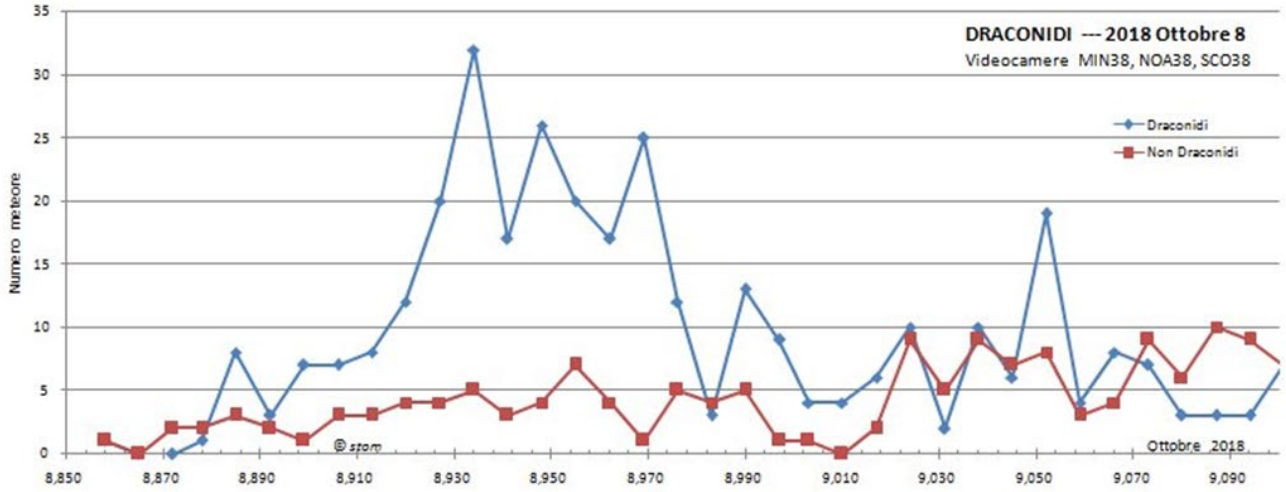

Figure 1 – Draconids 2018, results by Enrico Stomeo.

Paul Jones (Florida, USA): "October Draconid Meteor Shower OUTBURST 2018!!! WOW!! I just came back in from observing with several other members of the ACAC down at Matanzas Inlet, Florida and we saw and confirmed an amazing and unexpected outburst of this meteor shower tonight! Despite clouds that at times took over 75% of the sky, we were able to observe for 1 hour and 45 minutes (7:30 p.m. to 9:15 p.m. EDT) in between clouds and saw a total of 35 Draconid meteors during that time before the sky clouded over on us! Several were fairly bright, and all were slow-moving. It was an awesome and unexpected observation to say the least! The ACAC strikes again!!! I will prepare a report for the American Meteor Society on what we saw. I am SO very proud of our club right now!!!"

Kai Gaarder (Norway, observing from Germany): "Just a short report written on my cellphone at the bus station on my way home to Norway. I observed the outburst some 40 km South-East of Dresden, Germany. Started observations 18^h00^m UT. From 18^h00^m to 21^h00^m activity was modest, with HR around 4. From about 21^h05^m activity picked to a HR of 34. From 22^h05^m to 23^h05^m activity increased even further, to an uncorrected HR of 57. From 23^h05^m to 00^h05^m, activity was still good, with an HR of 53. From 00^h05^m to 01^h05^m activity declined to a HR of 32. The last 10 minutes I observed until 01^h15^m, I saw 2 Draconids. Observing conditions were good. Some thin cirrus clouds in periods, but also long periods with clear skies. Lm was between 6.0 and 6.2. I am really happy that I was able to observe this outburst. Sometimes 4 to 5 Draconids appeared at the same time, making this year's Draconid shower a very memorable event!"

Ferruccio Zanotti (Italy): "I am attaching the analysis for 8/9 October with some Draconids for the IMTN Ferrara NW video station. You can download the data here[28]."

Enrico Stomeo (Italy): "On the night of 8/9 October, despite some clouds, I recorded the outburst of the Draconids well. With three video cameras in all-sky I filmed 553 meteors, of which 349 Draconids. The highest frequency of Draconids appeared to me between 22^h20^m and 23^h20^m UTC with a maximum peak at 22^h25^m UTC (*Figure 1*)."

Also radio observers had plenty of meteor echos from the Draconids (see *Figure 2*).

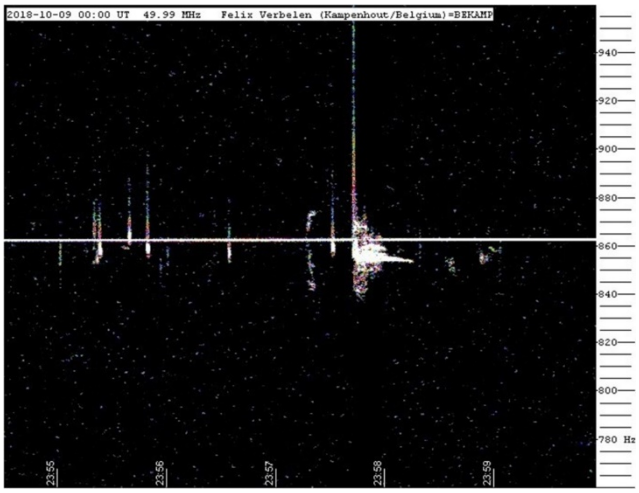

Figure 2 – Draconid radio echos recorded by Felix Verbelen, at Kampenhout, Belgium.

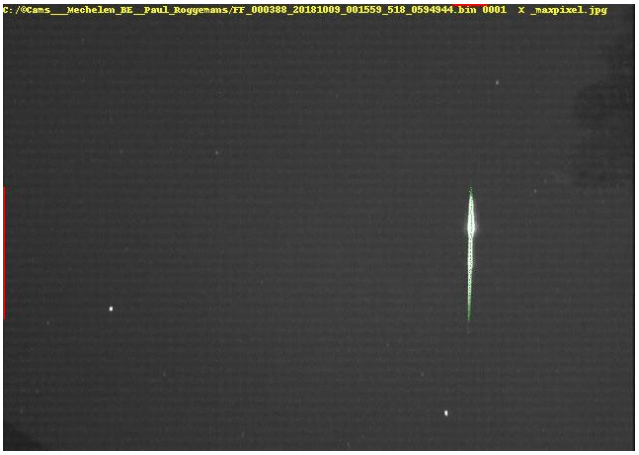

Figure 3 – Draconid with end flare on CAMS 388. The bright star at left is Polaris, constellation UMi.

[28] https://www.meteornews.net/wp-content/uploads/2018/10/M20181008_18_001_Ferrara_NW.csv

The author and *Luc Gobin* together operate in total 10 Watec Ultimate video cameras with 1.2/12mm Pentax lenses to cover all of the sky at about 40° elevation, ignoring the zenith where too little volume of atmosphere can be covered, also avoiding the horizon where only bright meteors appear which are too distant for good triangulations. In the night of 8–9 October the 10 cameras had 1219 meteors of which almost 900 were Draconids. The data of all CAMS stations is collected during the day and first results are expected from the network coordinator later on. The presence of a very active radiant was immediately evident during the manual confirmation to remove the false detections caused by planes, birds and insects. A few pictures from the CAMS cameras in Mechelen, Belgium are shown in *Figures 3, 4, 5, 6 and 7*.

Figure 4 – Often frames had 2 or 3 meteors recorded in less than 10.24 seconds, the time to capture 256 frames at 25 frames per second. Here two of these faint Draconids east of the constellation Perseus on CAMS 384.

Figure 5 – The presence of a very active radiant becomes obvious with many meteor trails parallel to each other, here on CAMS 384 with the constellation of Auriga.

Figure 6 – The presence of a very active radiant becomes obvious with many meteor trails parallel to each other, here on CAMS 384 with the constellation of Auriga.

Figure 7 – The presence of a very active radiant becomes obvious with many meteor trails parallel to each other, here on CAMS 384 with the constellation of Auriga.

Figure 8 – Composed image of the camera of Tioga Gulon at Fléville in Lorraine, France.

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Egal A., Wiegert P., Brown P. G., Moser D. E., Moorhead A. V., and Cooke W. J. (2018). "The Draconid meteoroid stream 2018: prospects for satellite impact detection". Arxiv.

Draconid outburst observed October 8th 2018 by CAMS BeNeLux

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More than 1000 orbits were collected during this night, including about 630 Draconid orbits.

1 Preliminary results

Plot based upon data by *Tioga Gulon* (Nancy), *Martin Breukers* (Hengelo), *Klaas Jobse* (Oostkapelle), *Robert Haas* (Alphen aan de Rijn), *Hans Betlem* (Leiden), *Jean-Marie Biets* (Wilderen), *Paul Roggemans* (Mechelen), *Luc Gobin* (Mechelen), *Steve Rau* (Zillebeke), *Hervé Lamy* (Ukkel), *Tim Polfliet* (Gent), *Robert Haas* (Burlage), *Robert Haas* (Texel), *Robert Haas / Piet Neels* (Terschelling), *Koen Miskotte* (Ermelo), *Erwin van Ballegoij* (Heesh), *Bart Dessoy* (Zoersel), *Hans Schremmer* (Niederkrüchten), *Christian Wanlin / Jean Paul Dumoulin* (Grapfontaine), *Marco van de Weide* (Enschede) and *Carl Johannink* (Gronau).

Acknowledgment

Thanks to all observers who sent in their data so quickly.

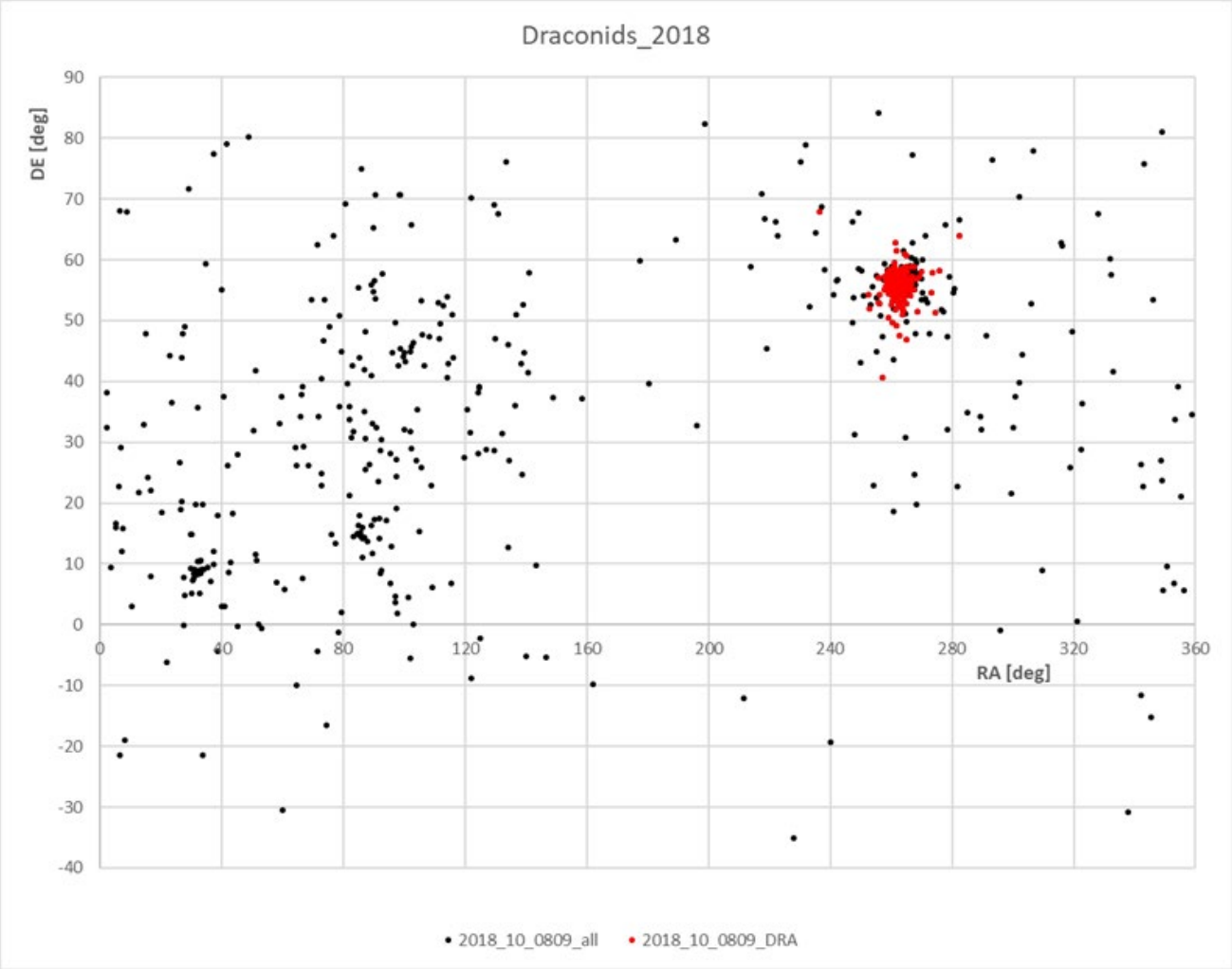

Figure 1 – All radiants; in red correspond to orbits with D < 0.105 (Drummond) compared to the reference orbit by Jenniskens (2016).

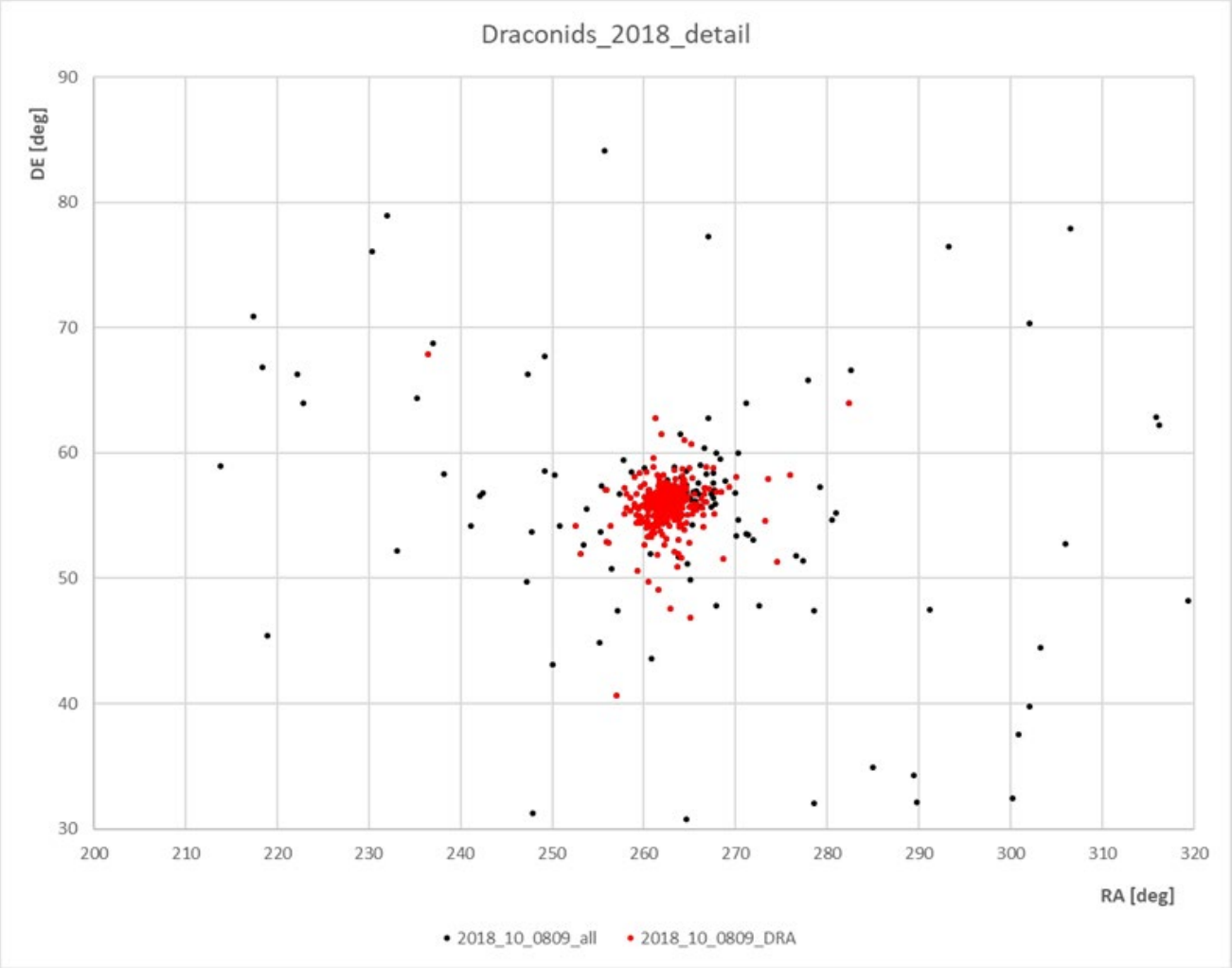

Figure 2 – Detailed radiant plot; in red positions for orbits with D < 0.105 (Drummond) compared to the reference orbit by Jenniskens (2016).

References

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

2018 Draconids as seen by a low-cost RPI based meteor camera

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The RMS (Raspberry Pi Meteor Station) registered the 2018 Draconids outburst.

1 Draconids 2018

The low-cost Raspberry Pi based meteor camera[29] located in Elginfield, Ontario, Canada observed the 2018 Draconid outburst in a short time window from 00^h30^m to 01^h30^m UTC, after which the site was clouded out.

In that period, 124 meteors were recorded using a 3.6 mm f/0.95 lens and an IMX291 based camera. This setup achieved a stellar limiting magnitude beyond +6M at 25 FPS, and the field of view was 87×45 deg.

Figure 2 shows the stack of detected Draconids in that short period of time, *Figure 1* shows one FTP compressed image with 3 Draconids (the Milky Way and Deneb are in the center of the image).

Finally, *Figure 3* shows a stack of 344 Draconids recorded from Hum, Croatia with the same setup as the one described above, but over a period of the whole night. The camera was pointing towards south west.

Read more about the Global Meteor Network[30].

Figure 1 – Three Draconids recorded around $00^h49^m51^s$ UTC on October 09, 2018. Credit: Denis Vida, Michael Mazur.

[29] https://github.com/CroatianMeteorNetwork/RMS

[30] https://gmn.duckdns.org/

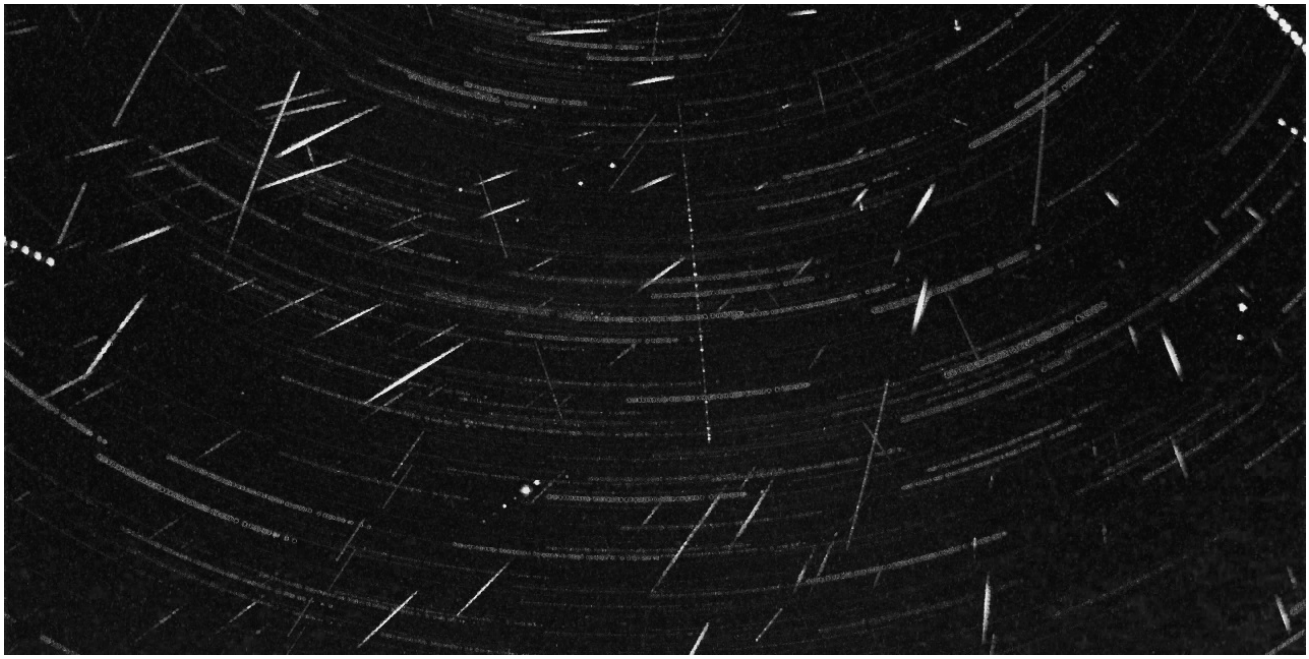

Figure 2 – The stack of detected Draconids in the short period of time from 00^h30^m to 01^h30^m UTC.

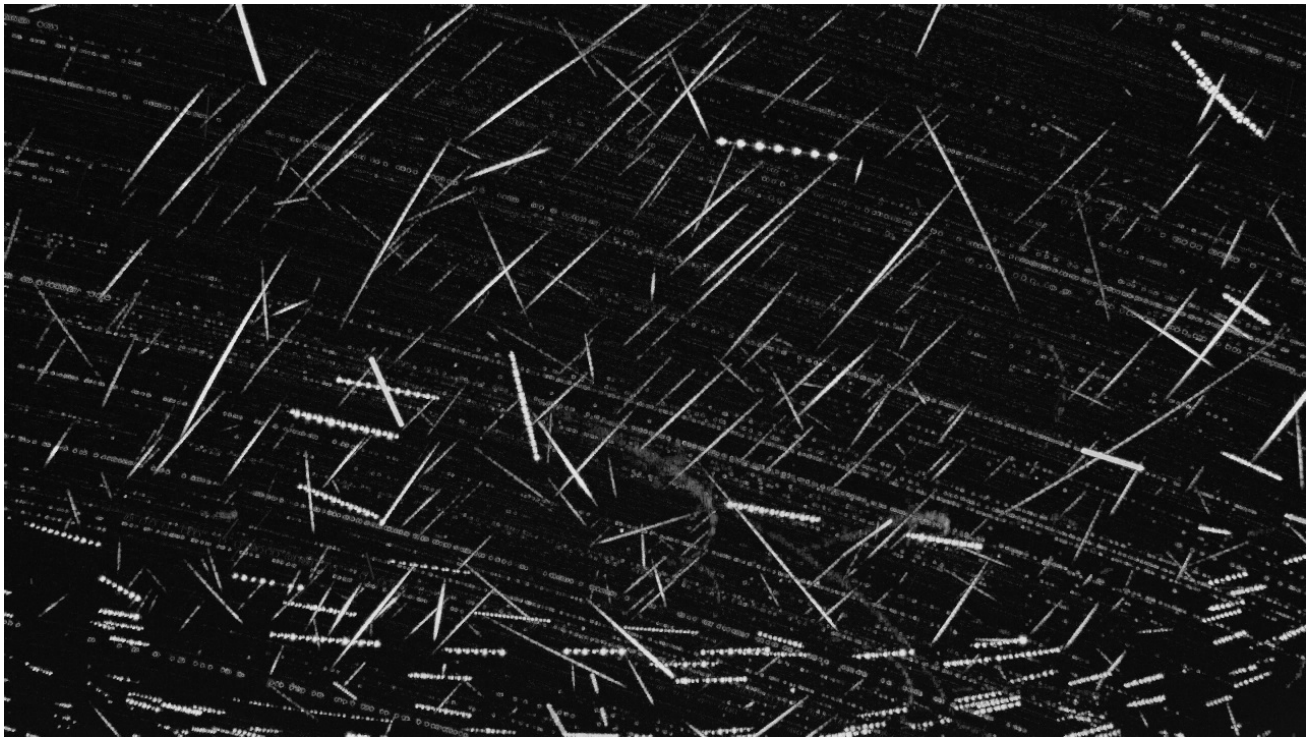

Figure 3 – Draconids outburst as observed from Hum, Croatia. Credit: Aleksandar Merlak.

Fireball over BeNeLux
10 October 2018, $21^h14^m11^s$ UT

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A summary is presented with the trajectory and orbit data obtained by CAMS BeNeLux. The fireball started exceptionally high in the atmosphere at 153.8 km elevation. The orbit has a very good match with the minor shower 31 Lyncids (TLY-613).

1 Introduction

Exceptional clear sky over the BeNeLux during the night 10–11 October allowed the registration of a fast moving, bright fireball by several cameras of the CAMS BeNeLux network as well as all-sky cameras. The appearance in the evening sky around 23^h15^m local time with a clear starry sky allowed many casual witnesses to enjoy this celestial firework. Luckily the fireball was also captured by many meteor cameras which allowed an accurate trajectory calculation.

2 Trajectory and orbit

The first results are based upon calculations from CAMS stations 802 Burlage, Germany, 807 Mechelen Belgium, 3033 Oostkapelle, the Netherlands and 814 Grapfontaine Belgium. With 156.8 km the fireball started at a remarkable high level in the atmosphere.

Figure 1 – Trajectory of this fireball 10 October 2018 based on results based upon calculations from CAMS stations 802_807_3033_814 (Burlage DE _ Mechelen BE _ Oostkapelle NL _ Grapfontaine BE).

- H_b = 156.8 km at φ = 52.5° north / λ = 5.65° east
- H_e = 87.6 km at φ = 50.0° north / λ = 3.34° east

Table 1 – The orbit solutions: (1) exponential on CAMS 807-814 and 3034, (2) linear on CAMS 807-814 and 3034, (3) based on CAMS 3033, 3166, 814 and 807 compared to the 31 Lyncids (TLY-613) (Jenniskens et al., 2018).

	(1)	(2)	(3)	TLY
RA_g (°)	118.79	118.8	118.89	125.0
Dec_g (°)	+42.97	+42.19	+43.09	+42.3
v_g (km/s)	68.57	67.85	68.07	67.4
q (AU)	0.9844	0.9836	0.9837	0.968
a (AU)	∞	24.57	65.71	17.2
e	1.0261	0.9600	0.9850	0.944
i (°)	142.94	142.75	142.54	141.6
ω (°)	166.4	165.79	165.95	160.1
Ω (°)	197.2578	197.2578	197.2578	200.4
Π (°)	3.662	3.045	3.211	

The long trajectory started above the Netherlands, crossed the entire atmosphere above Belgium and ended north of the French city of Saint-Quentin at 87.6 km elevation, excluding any possible meteorite dropping.

The CAMS software offers two approaches to calculate the orbit, a linear and an exponential. CAMS is designed to collect orbits of meteors in the range of visual observations. The system is not designed neither for too bright events nor for exceptional long trajectories such as this one. Not all cameras which registered this fireball could be used in the orbit solution. The different results, depending on the selected solution, are listed in *Table 1*. The orbit of the 31 Lyncids minor shower is listed too.

The orbit is similar to the orbit of the poorly known minor shower, the 31 Lyncids (TLY-613) fulfilling the D-criteria D_D = 0.06 and D_{SH} = 0.16. This shower is active around $\lambda_\odot$ = 200.4° with a radiant at α_g = 125° δ_g = +42.3° and v_g = 67.4°.

Figure 2 – All-sky picture by Klaas Jobse (Oostkapelle NL), All Sky is a Canon 5D 8mm f 4 iso 800, 90 sec exposure.

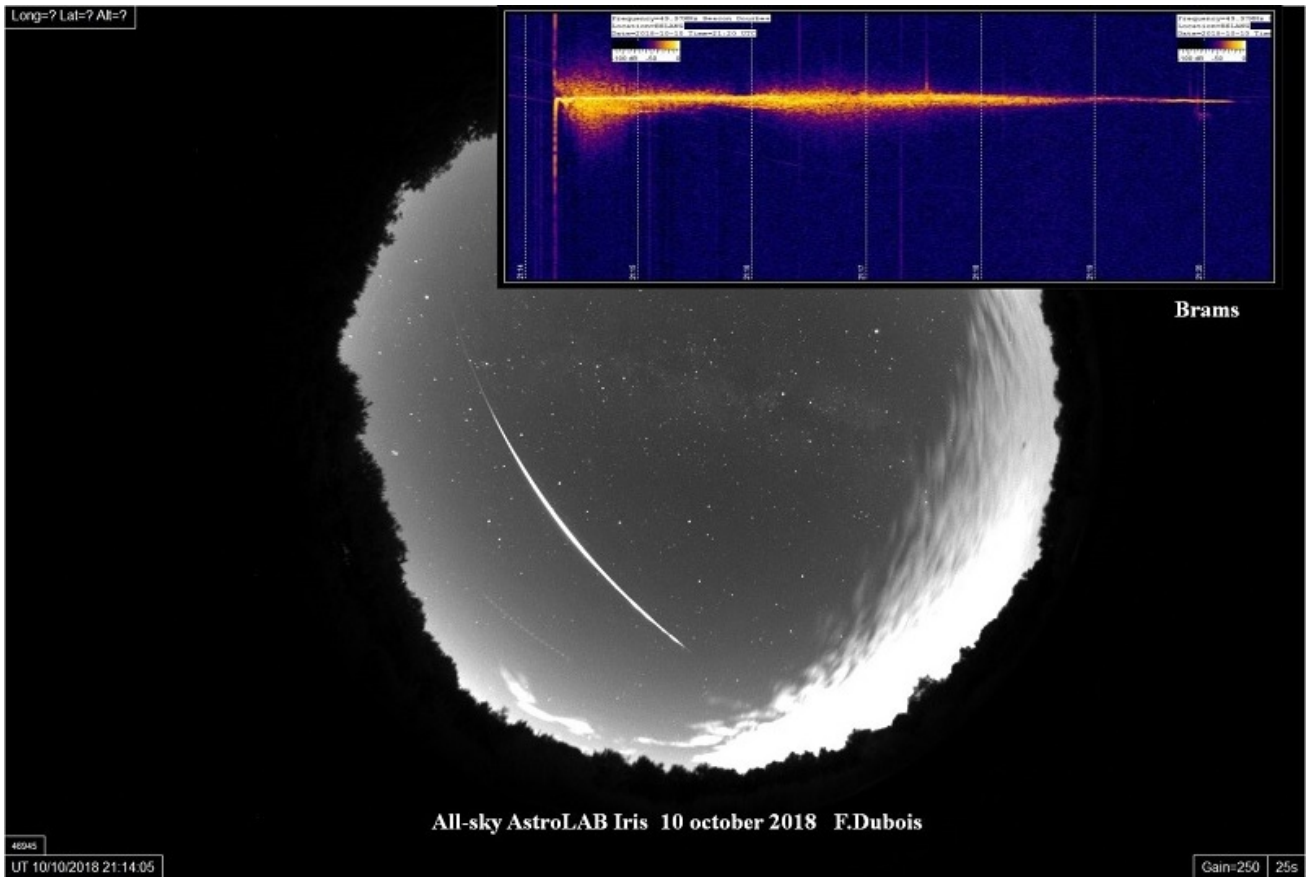

Figure 3 – All-sky AstroLab Iris and an inset with the spectrogram of the BRAMS receiver, F. Dubois, Langemark (BE).

Figure 4 – All-sky picture by Koen Miskotte (Ermelo NL).

Figure 5 – All-sky picture from Bussloo (NL).

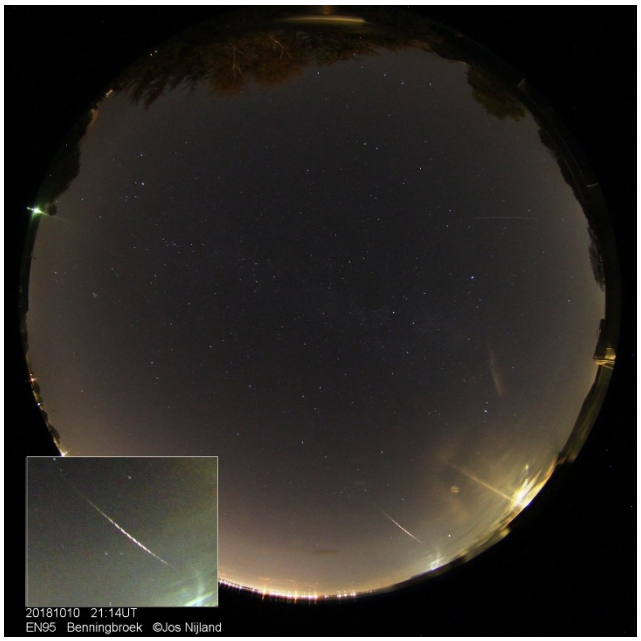

Figure 6 – All-sky picture by Jos Nijland (Benningbroek NL).

Figure 7 – Picture from Johan Pieper (Kerkrade NL).

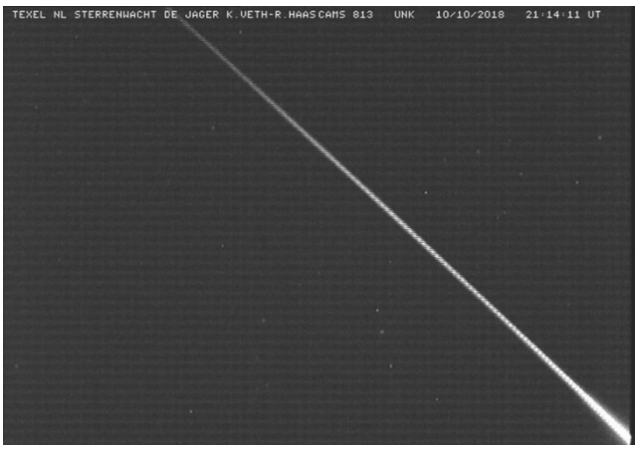

Figure 8 – CAMS 813 Robert Haas- K. Veth (Texel NL).

Figure 9 – CAMS 3166 Robert Haas (Alphen aan de Rijn NL).

Figure 10 – CAMS 3034 Klaas Jobse (Oostkapelle NL).

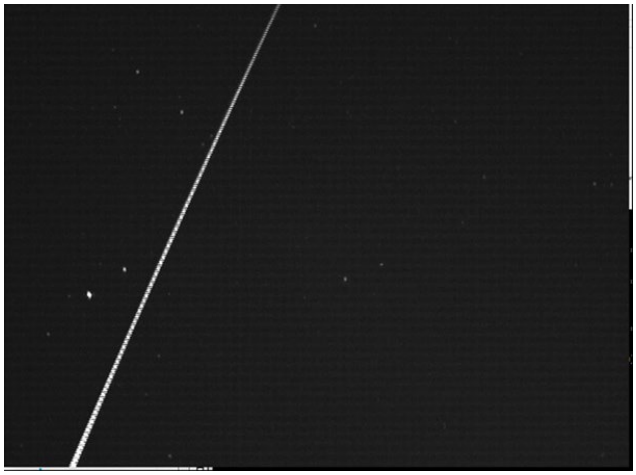

Figure 11 – CAMS 313 Carl Johannink (Gronau DE).

Figure 12 – CAMS 802 Robert Haas (Burlage DE).

Figure 13 – CAMS 807 Luc Gobin (Mechelen BE).

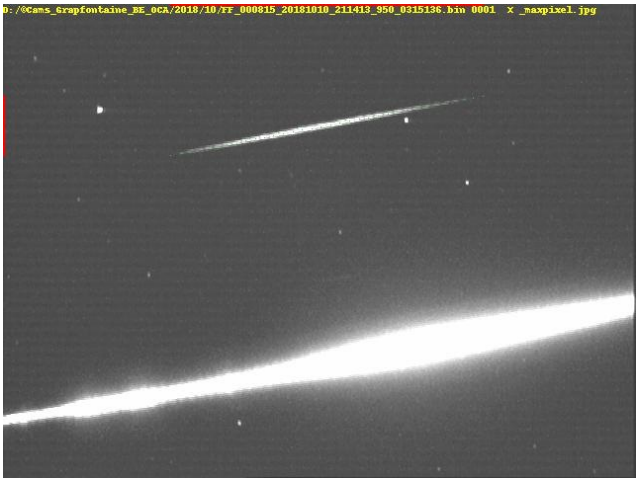

Figure 14 – CAMS 815 Christian Wanlin / Jean-Paul Dumoulin (Grapfontaine BE).

Figure 15 – CAMS 814 Christian Wanlin / Jean-Paul Dumoulin (Grapfontaine BE).

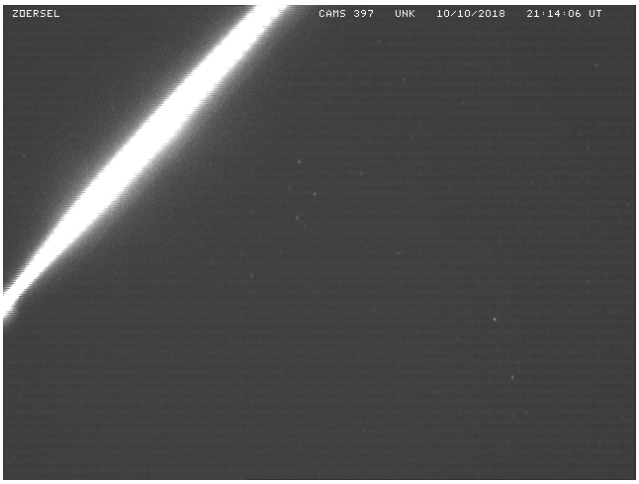

Figure 16 – CAMS 397 Bart Dessoy (Zoersel BE).

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Fireball over Northern Europe, 10 October 2018, $21^h14^m11^s$ UT

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17 stations of the FRIPON network registered the fireball of 10 October 2018, 21h14m11s UT over the BeNeLux. The trajectory and orbit solution obtained independently by FRIPON is presented and compared with the solution found by CAMS BeNeLux.

1 Introduction

An interesting news was published on MeteorNews about a fireball over the Benelux on 10 October 2018 (Johannink, 2018).

This fireball was also seen by 17 FRIPON cameras! Registrations were obtained from the Netherlands, Belgium, France, Germany and Switzerland. *Table 1* lists the orbital parameters close to these of CAMS but with an eccentricity lower than 1. This was an object with a very low entrance angle that remained high in the atmosphere. The speed was rather fast and constant until the catastrophic end.

2 Trajectory and orbit

Table 1 – Comparing the orbit obtained by FRIPON with the result for CAMS BeNeLux.

	FRIPON	CAMS
v_∞ (km/s)	68.974 ± 0.064	
v_g (km/s)		68.07
a (AU)	25.6 / 39.5	65.71
q (AU)	0.9848 ± 0.0007	0.9837
e	0.968 ± 0.007	0.9850
i (°)	142.76 ± 0.09	142.54
Ω (°)	197.2579 ± 0.0004	197.2578
ω (°)	166.4 ± 0.4	165.95

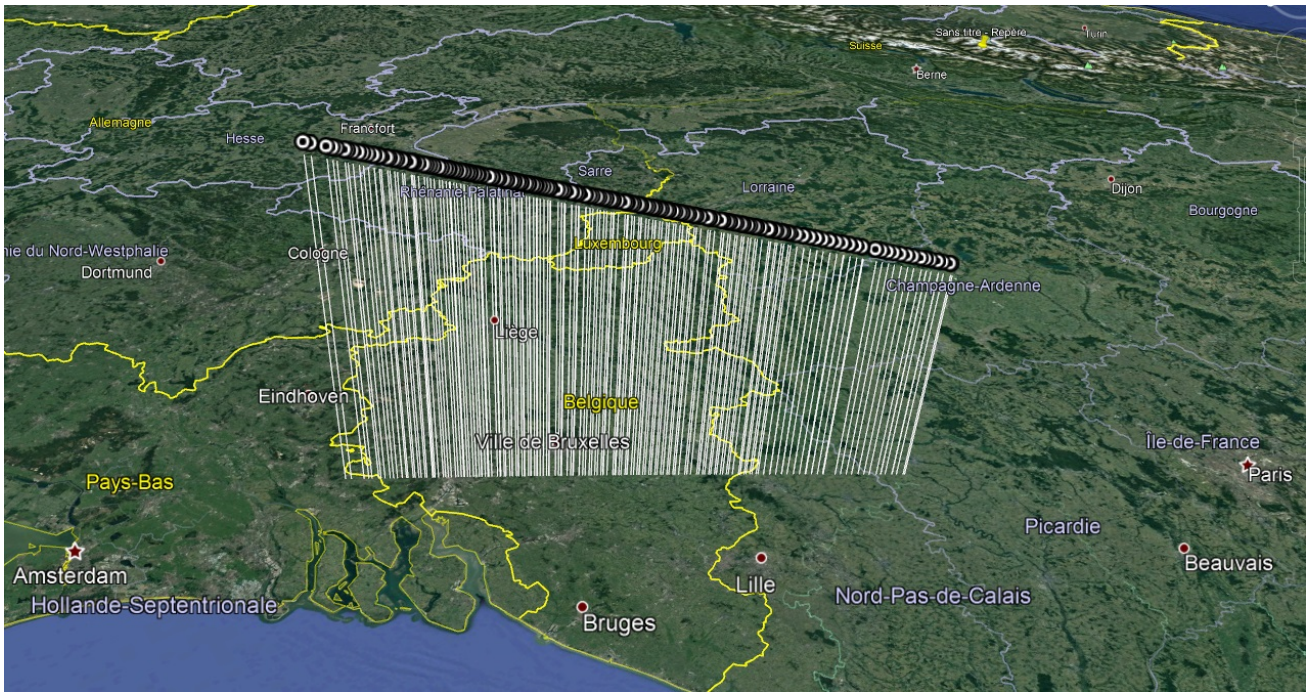

Figure 1 – FRIPON Trajectory solution.

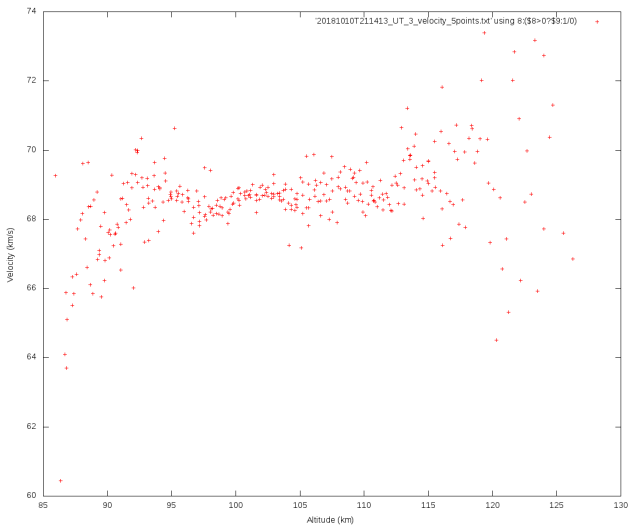

Figure 2 – Velocity measurements.

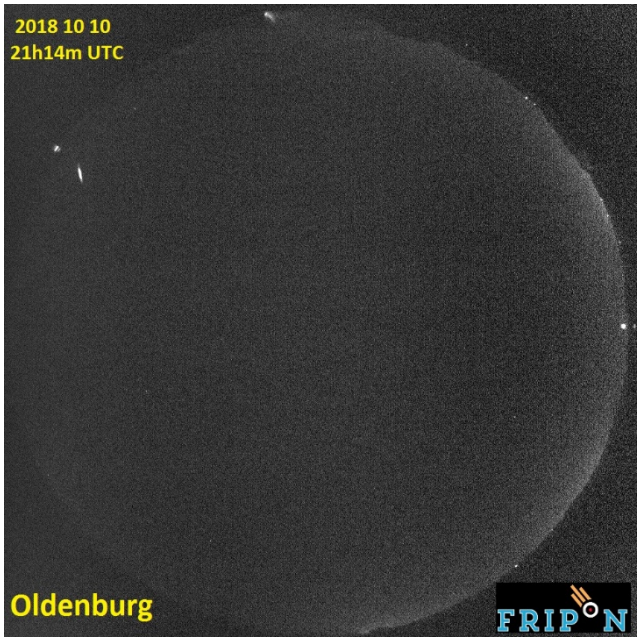

Figure 3 – FRIPON Oldenburg, Germany, low on the horizon.

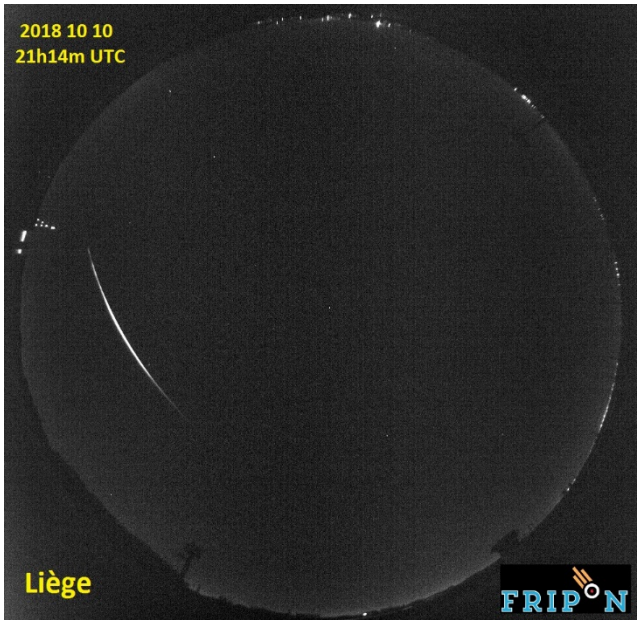

Figure 4 – FRIPON Liège, Belgium.

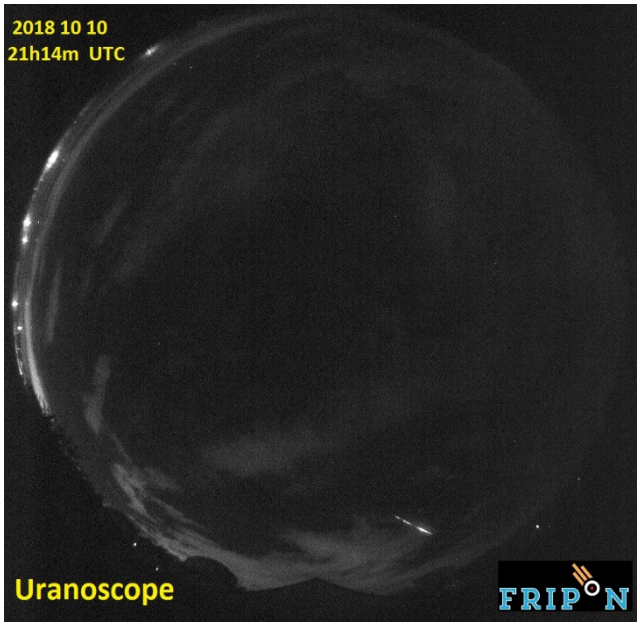

Figure 5 – FRIPON Uranoscope.

Figure 6 – FRIPON Uccle, Belgium.

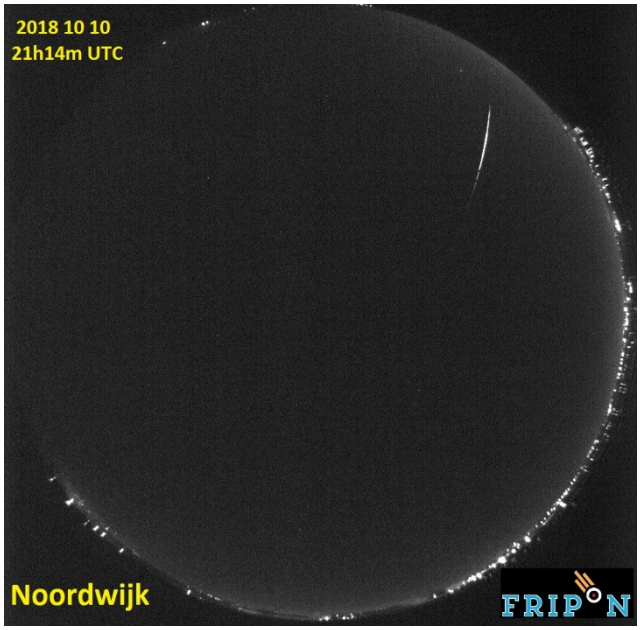

Figure 7 – FRIPON Noordwijk, the Netherlands.

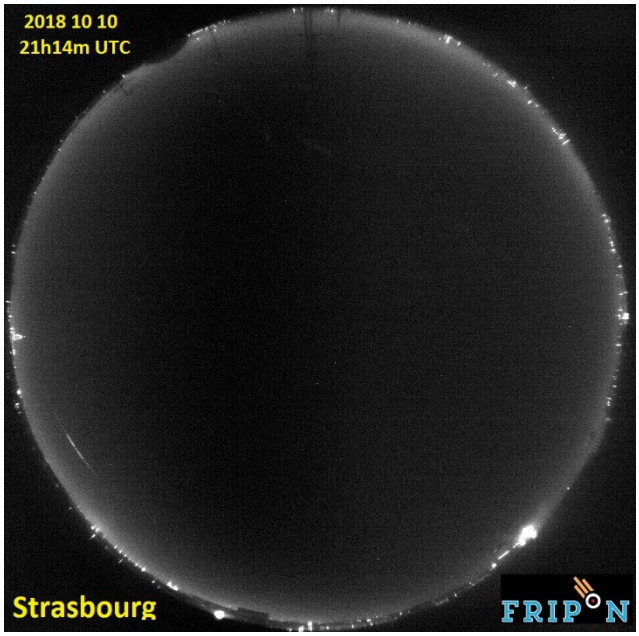

Figure 8 – FRIPON Strasbourg, France.

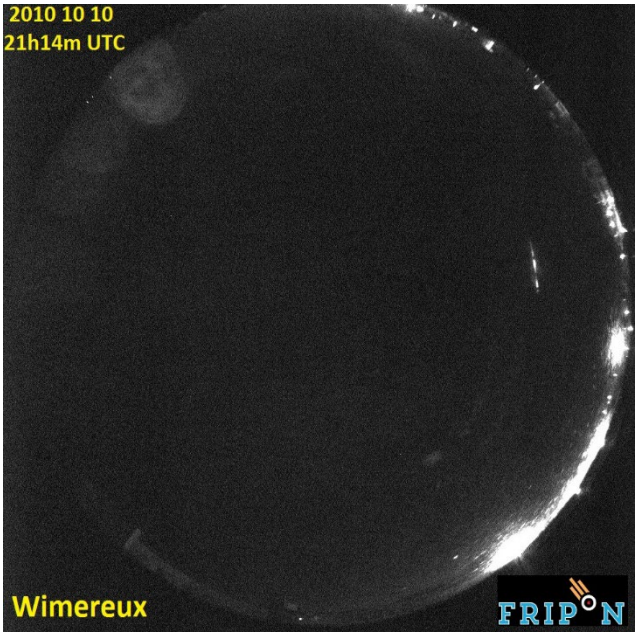

Figure 11 – FRIPON Wimereux, France.

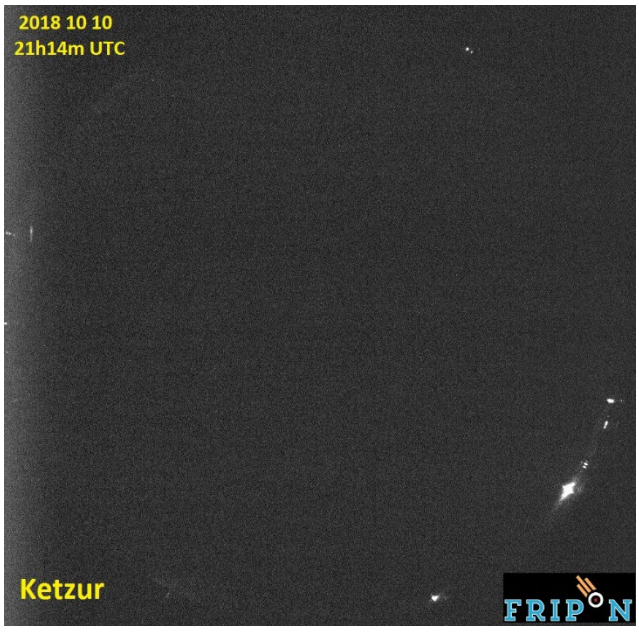

Figure 9 – FRIPON Ketzur.

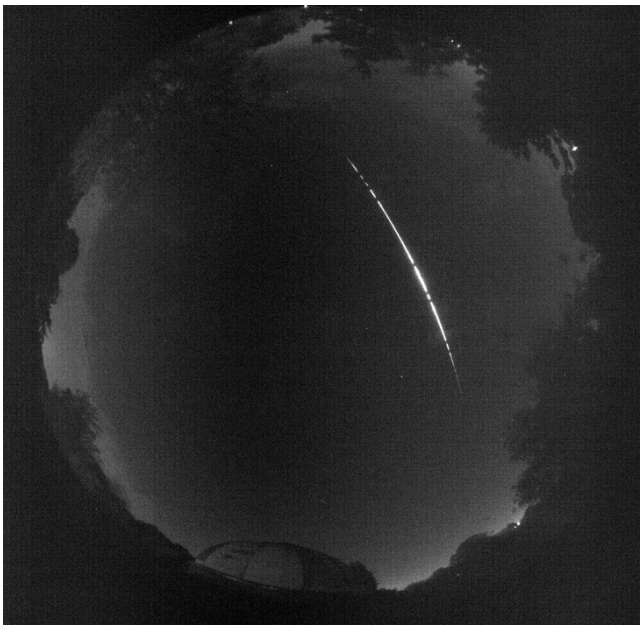

Figure 12 – FRIPON Lille, France.

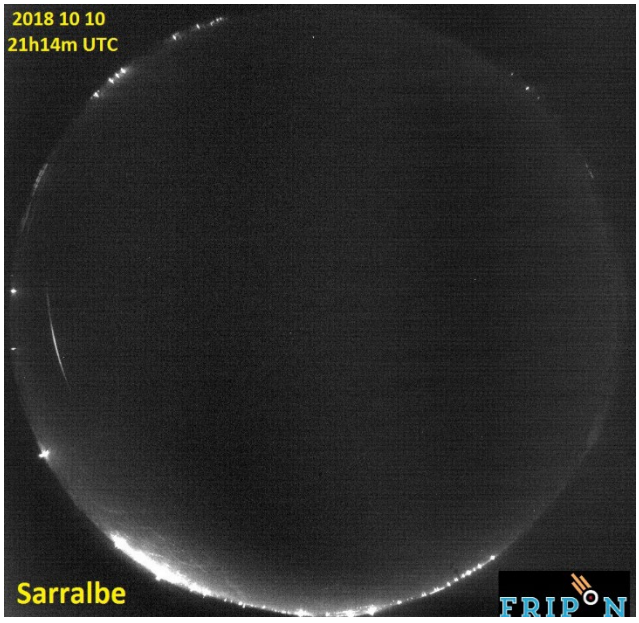

Figure 10 – FRIPON Sarralbe, France.

Figure 13 – FRIPON Oostkapelle, the Netherlands.

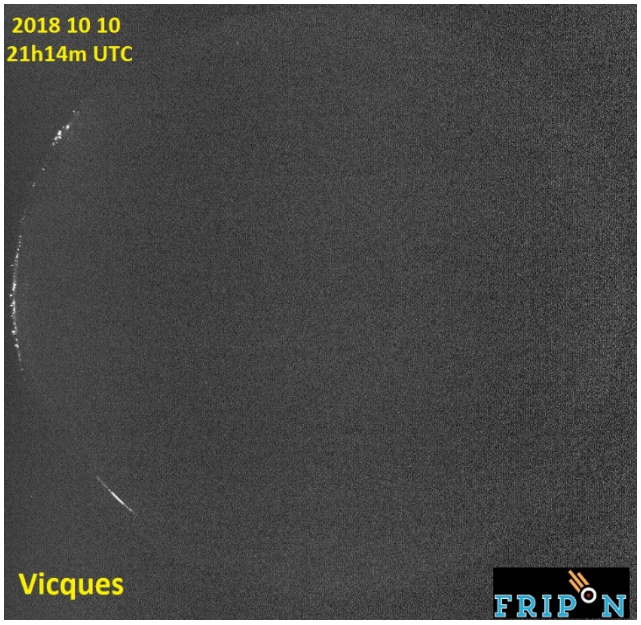

Figure 14 – FRIPON Vicques, France.

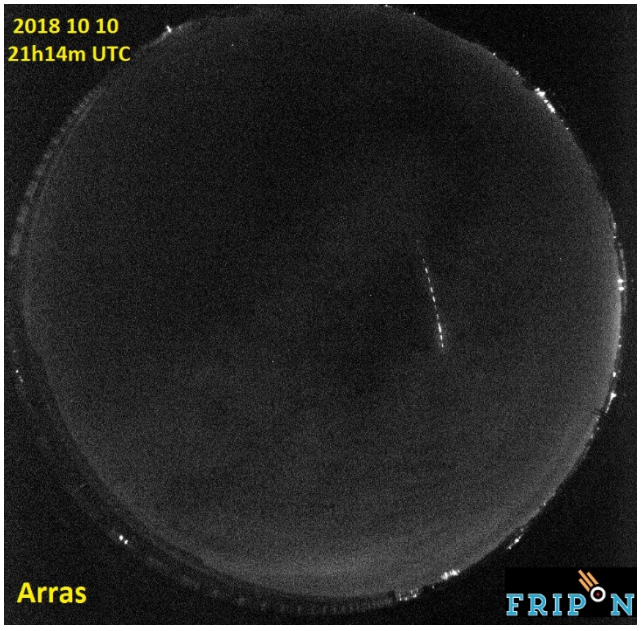

Figure 15 – FRIPON Arras, France.

Figure 16 – FRIPON Pleumeur Bodou.

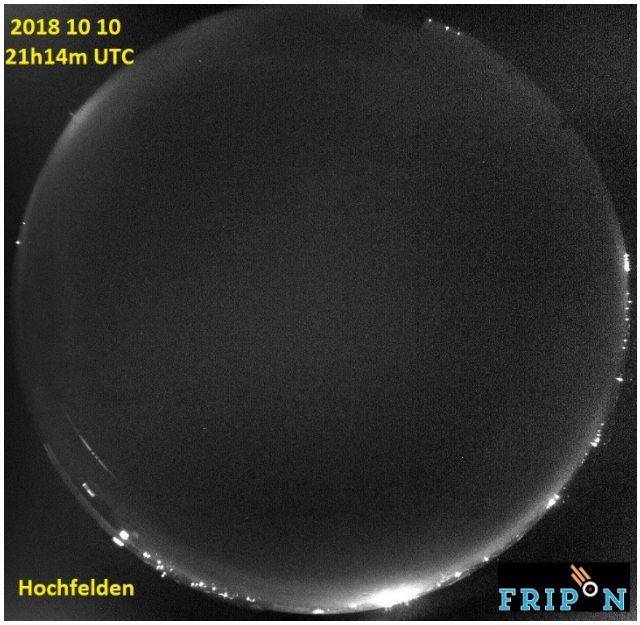

Figure 17 – FRIPON Hochfelden.

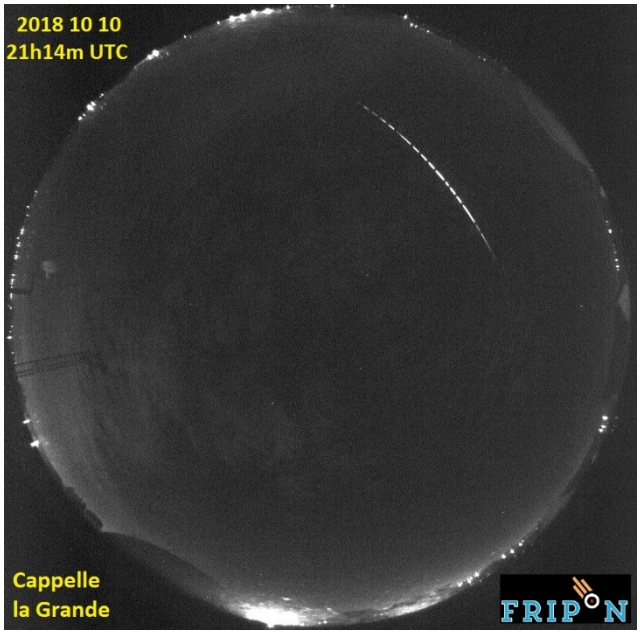

Figure 18 – FRIPON Dunkerque.

Radio meteors – July 2018

Felix Verbelen

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felix.verbelen@skynet.be

An overview of the radio observations during July 2018 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, 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 July 2018.

On several days automatic counts were quite problematic due to (local) interference, thunderstorms (6 days with lightning activity) and sometimes strong sporadic E (10 days with Es).

Strong lightning activity in the direction of our VVS-beacon made it even impossible to manually count underdense meteors on 20180727 from 16:00 to 20:00 UT; in addition, our beacon was "OFF" on 20180711 (18:02-19:06 UT) and on 20180728 (02:19-12:04 UT), so that data for those periods are missing.

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

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

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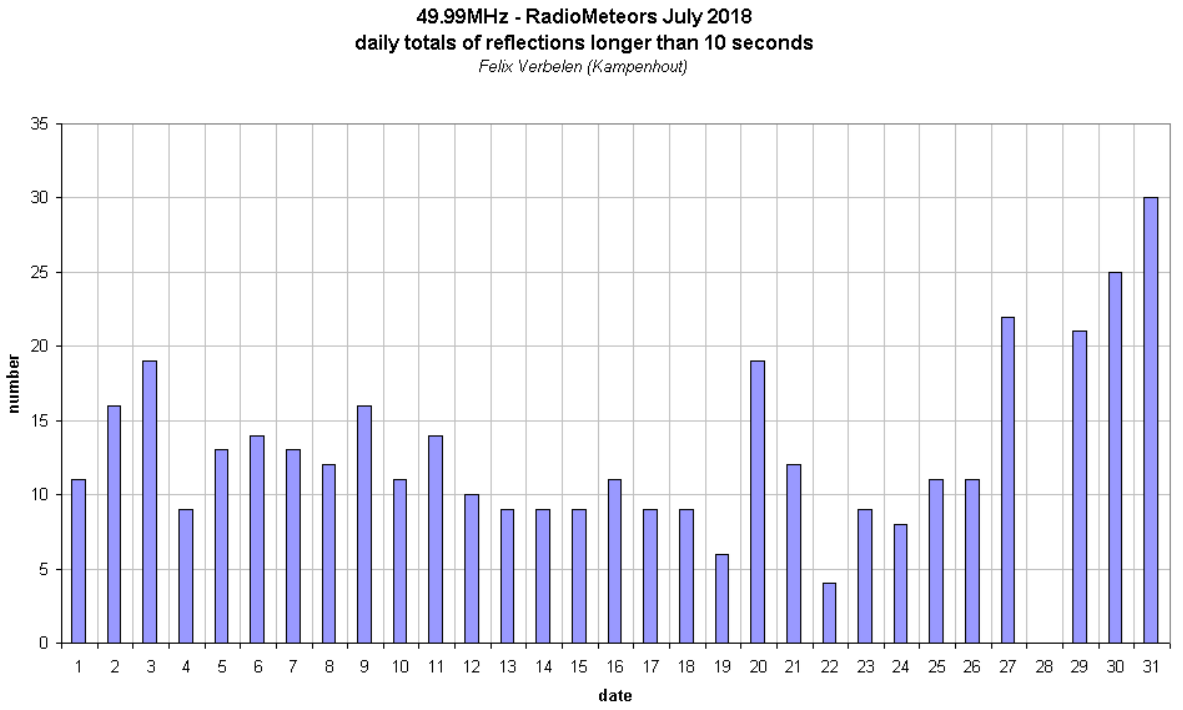

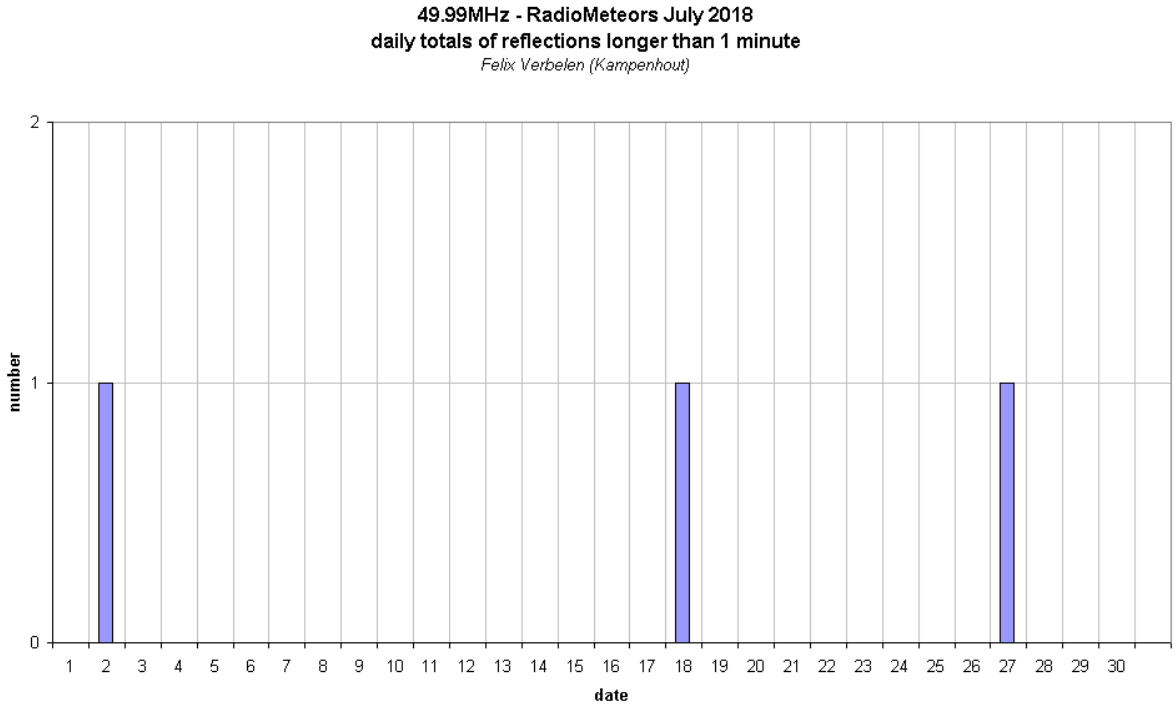

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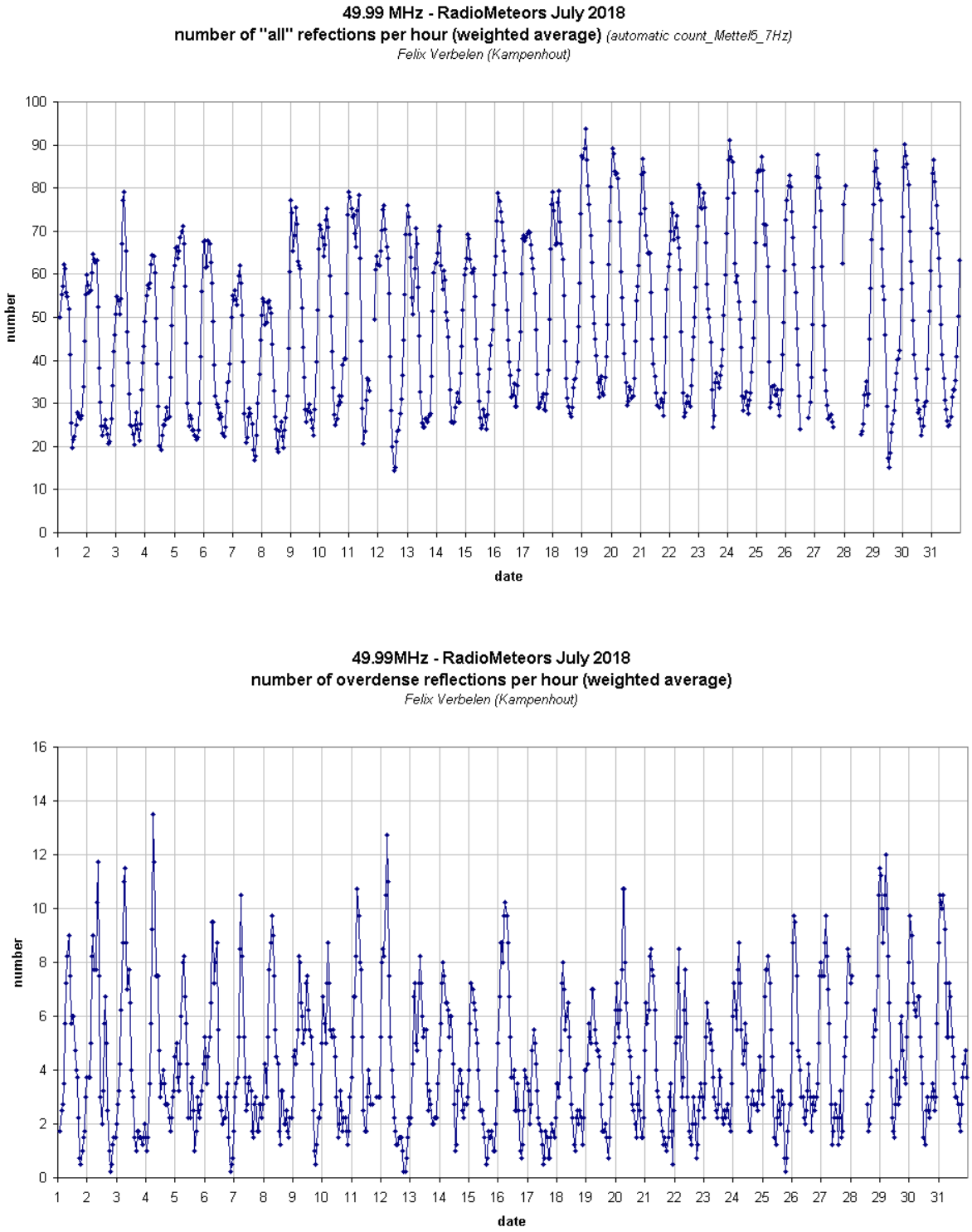

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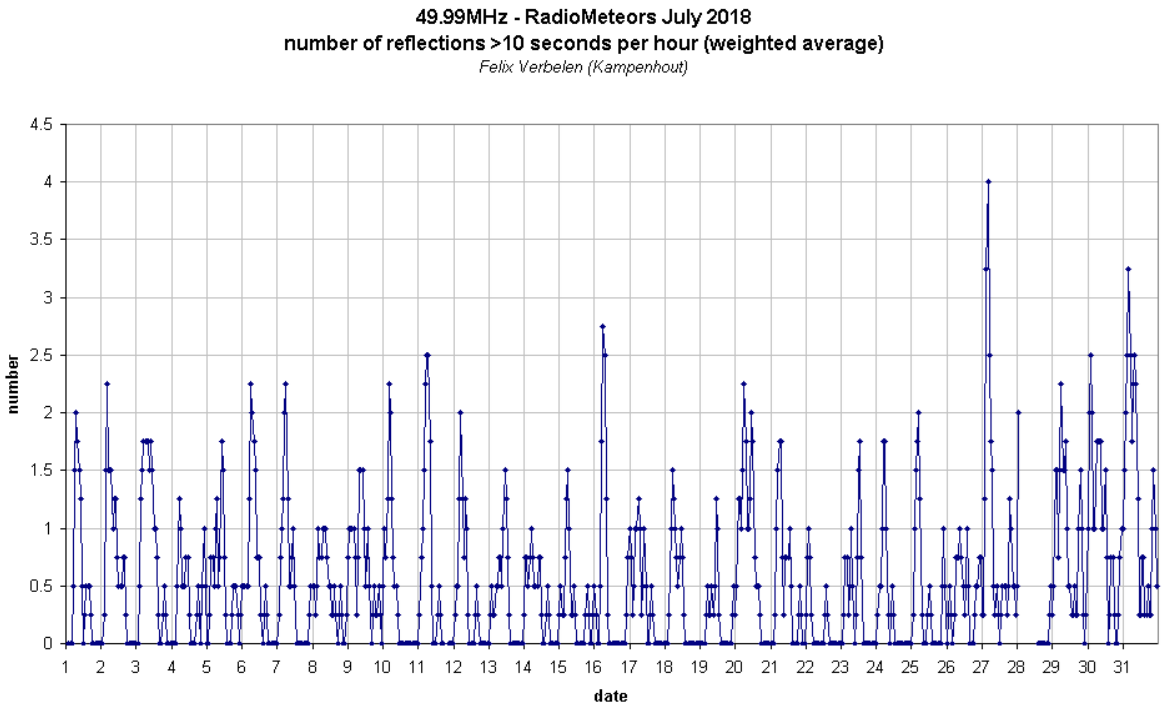

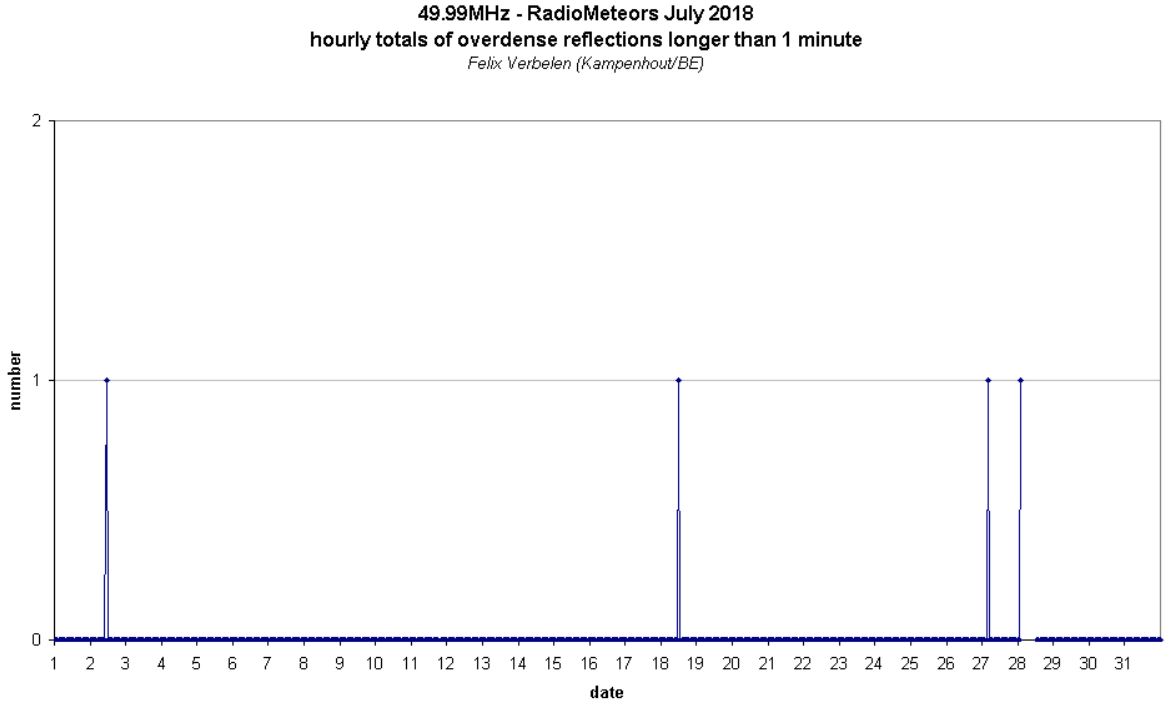

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Radio meteors – August 2018

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An overview of the radio observations during August 2018 is given.

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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, 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 August 2018.

Especially the automatic counts were hampered a few times by (local) interference, by thunderstorms (on 8 days with sometimes strong lightning activity) and by sporadic E (7 days with Es), but most of these counting errors have been corrected manually.

Eye-catchers were of course the Perseids with their maximum around 13 August: they not only provided numerous long-lasting echoes, but also determined the much stronger activity during the first half of the month compared to the second half.

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

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

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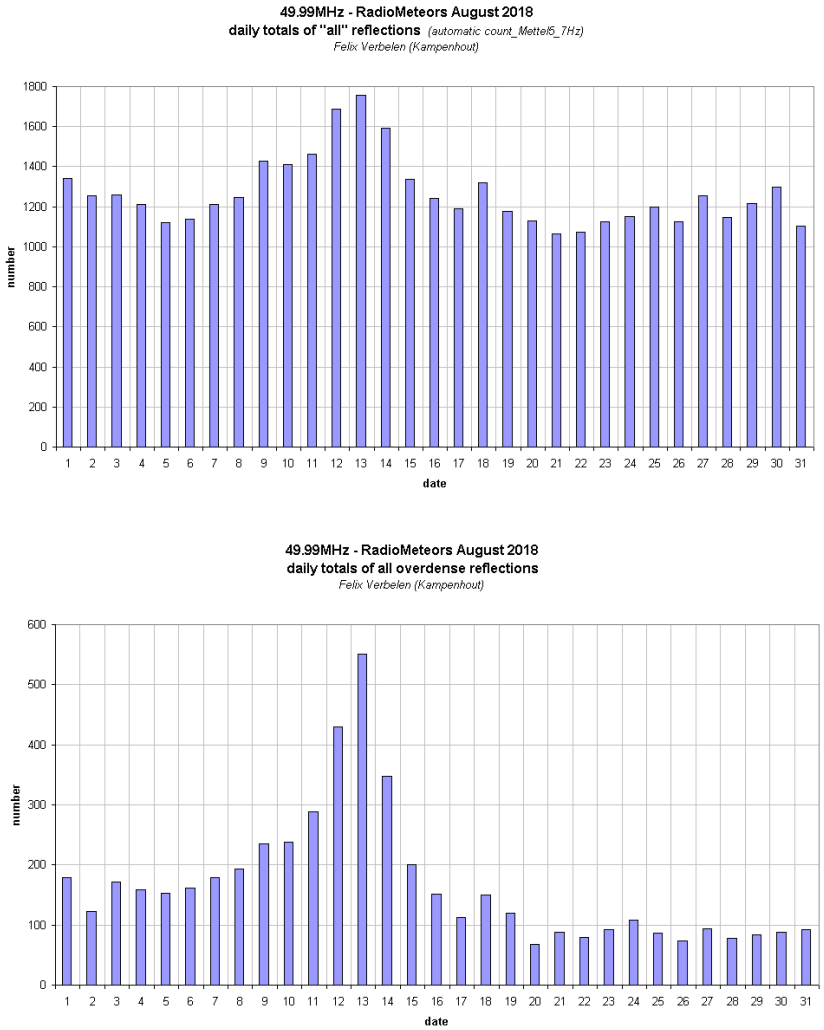

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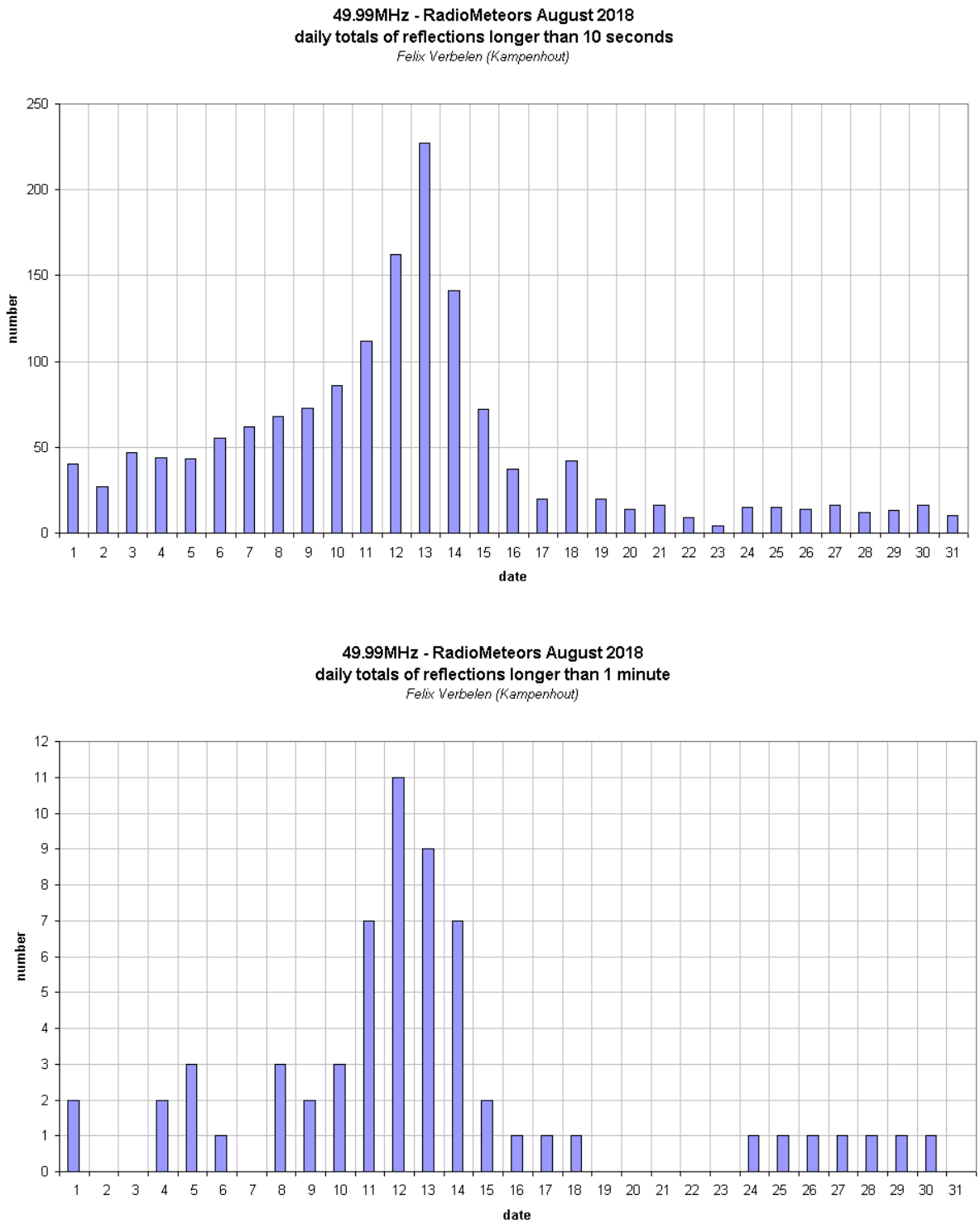

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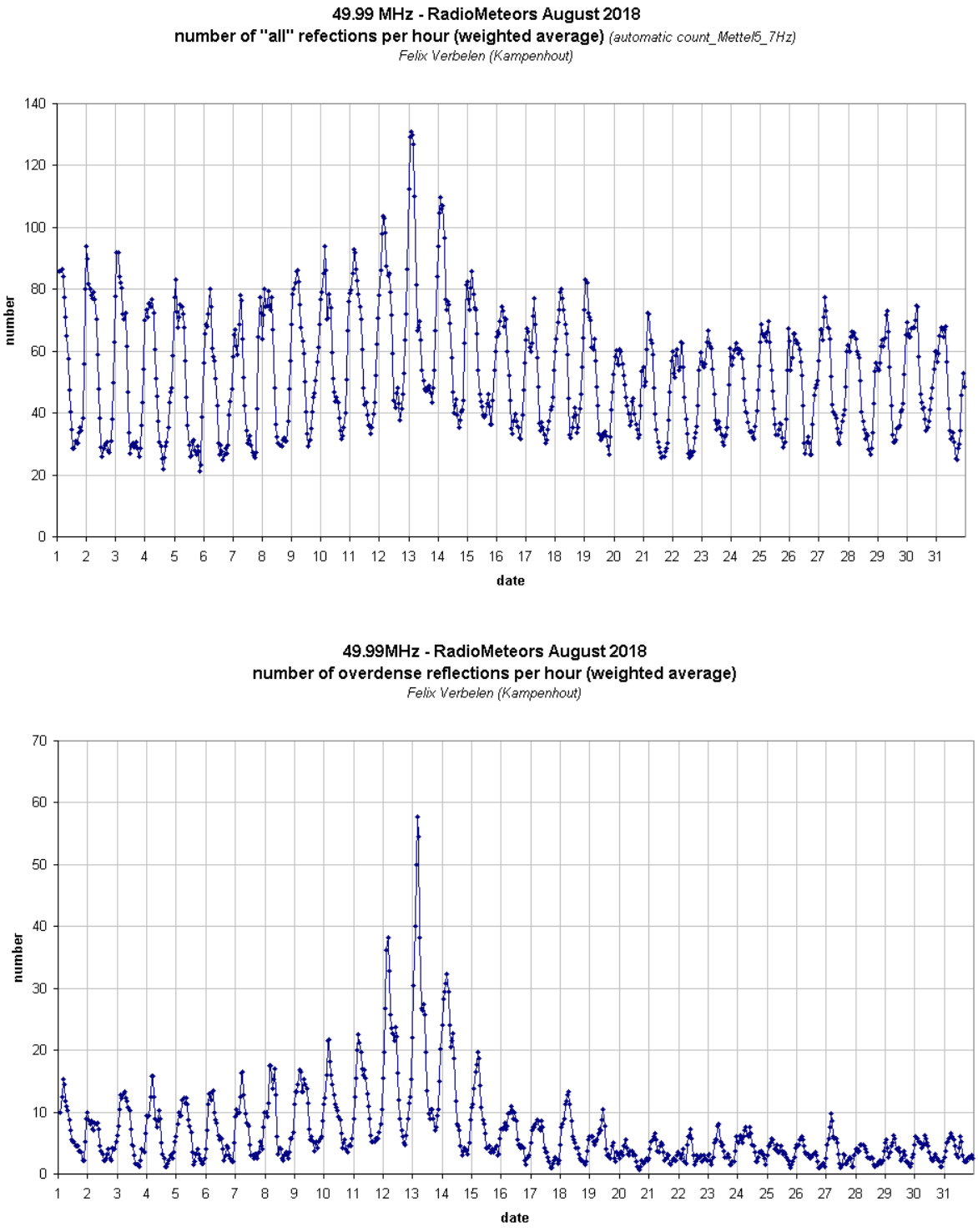

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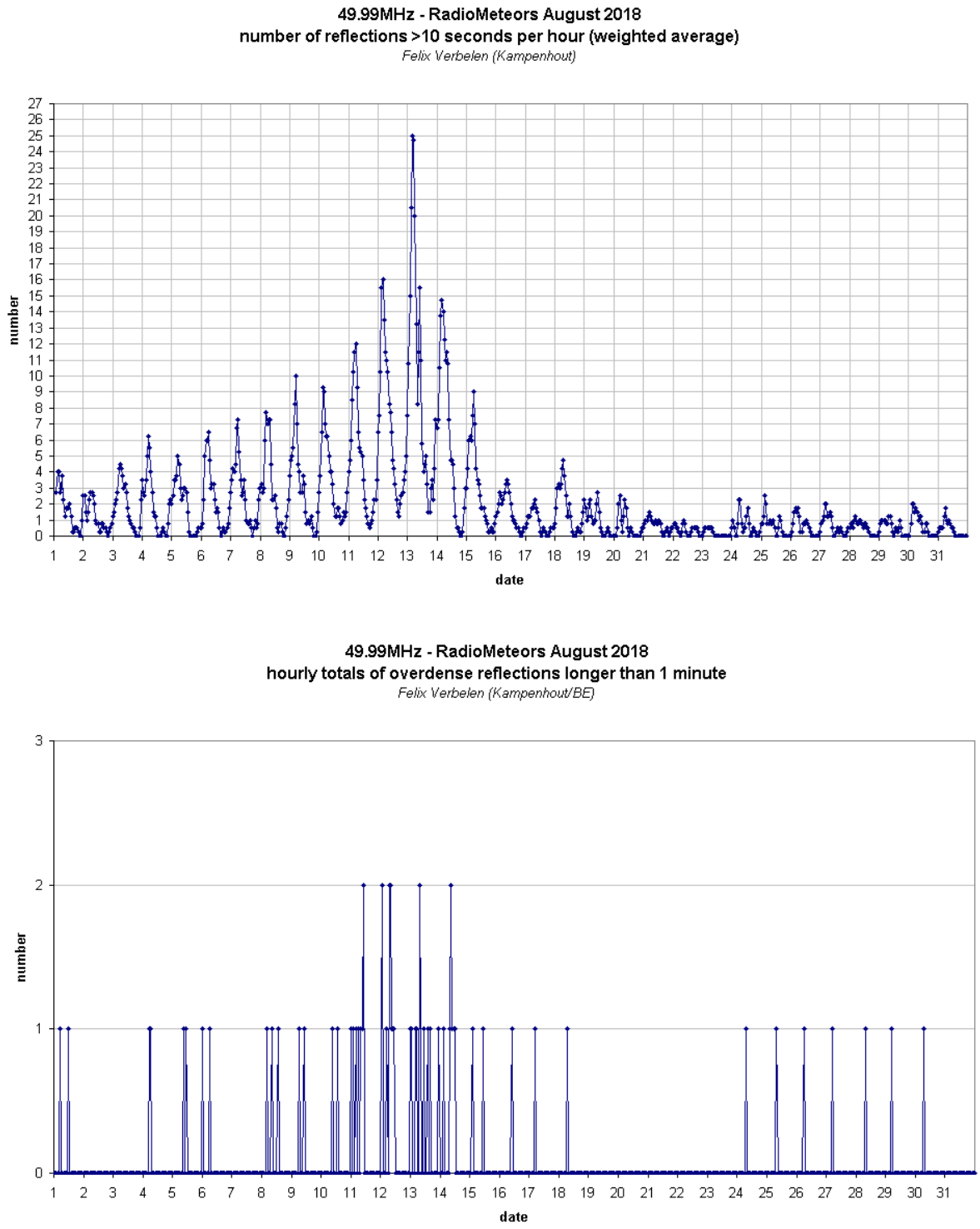

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Radio meteors – September 2018

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During this month our registrations were fortunately almost free of strong local interference, there was no registered "sporadic E" (Es) and only on September 5th there were thunderstorms with strong lightning activity.

The meteor activity was, as expected, quiet with only modest meteor showers, but with nonetheless a number of fairly spectacular "fireballs" in the period 7–18 September (see *Figures 5 to 8*).

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

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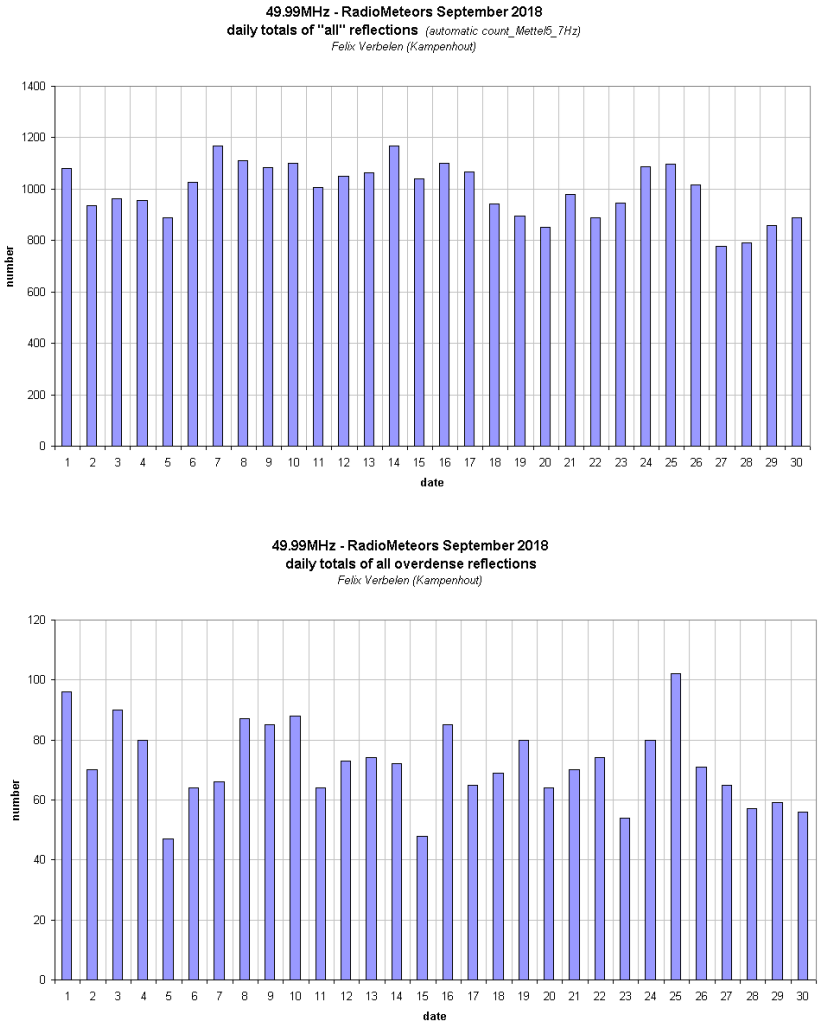

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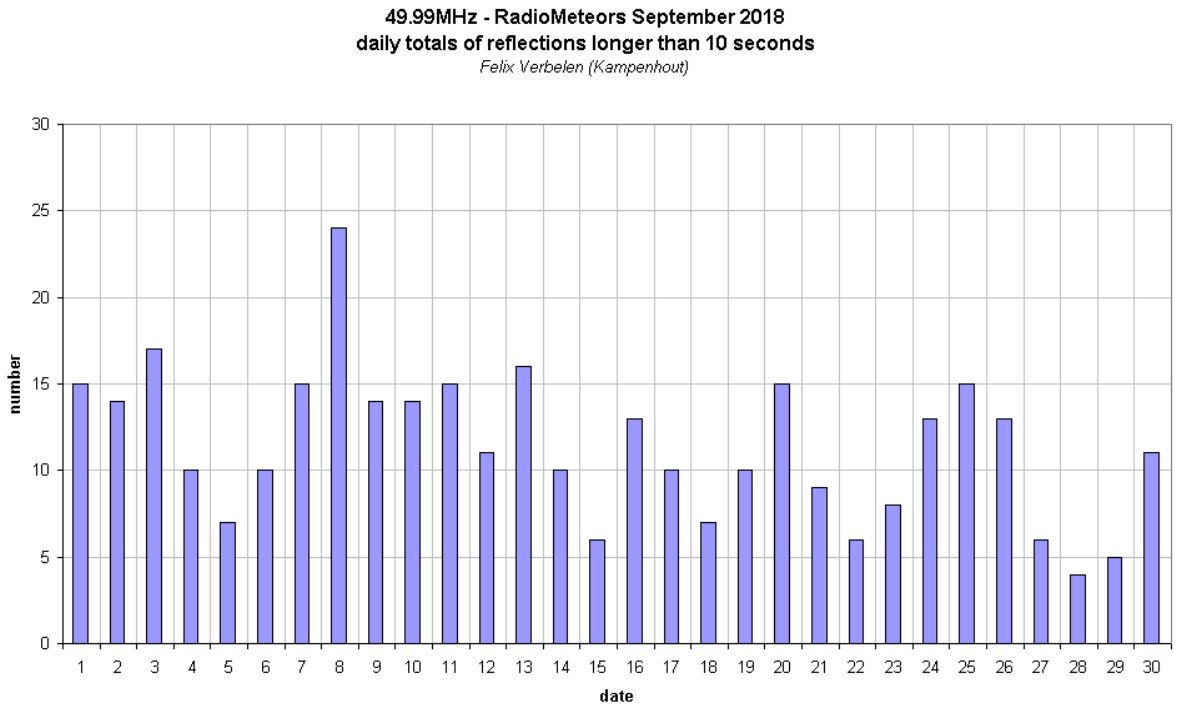

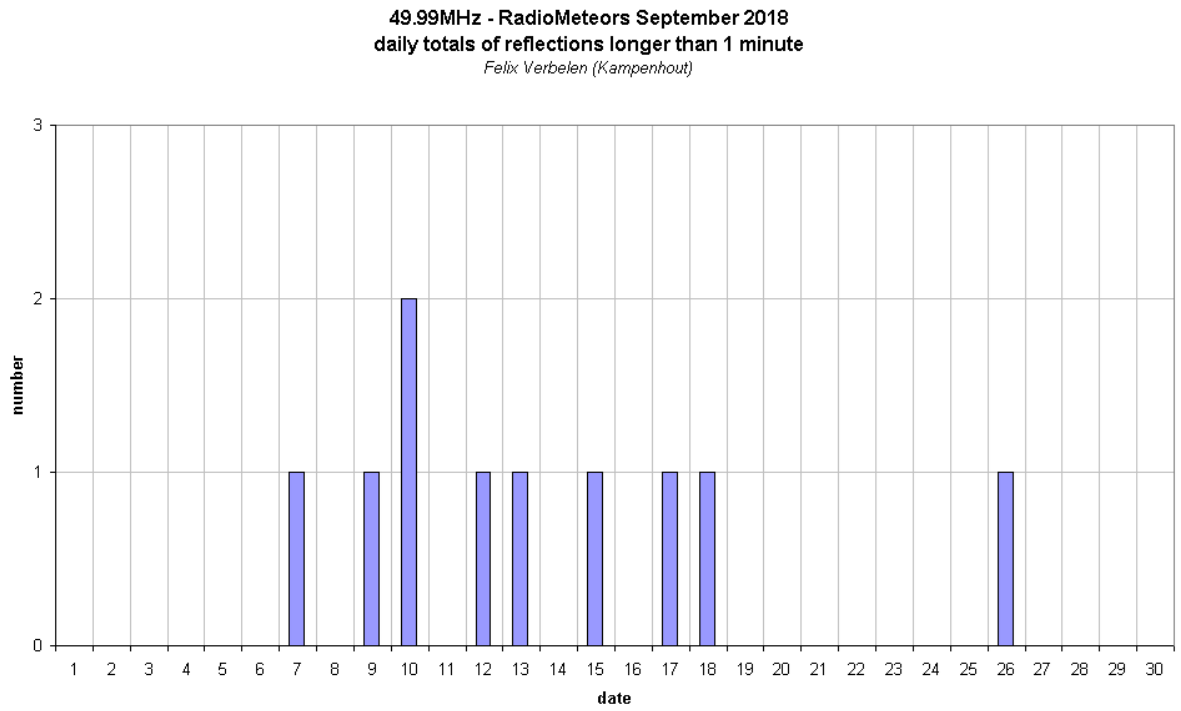

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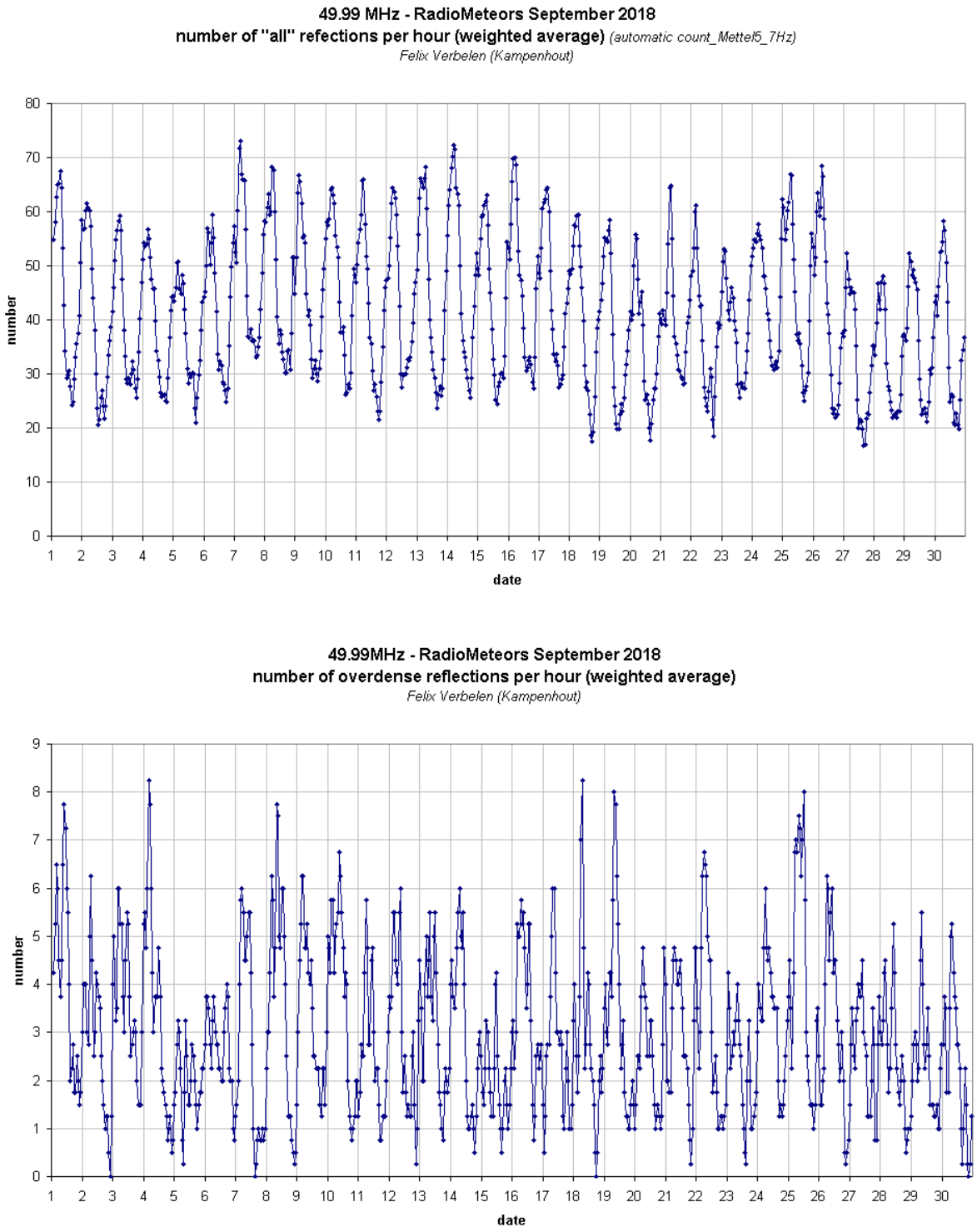

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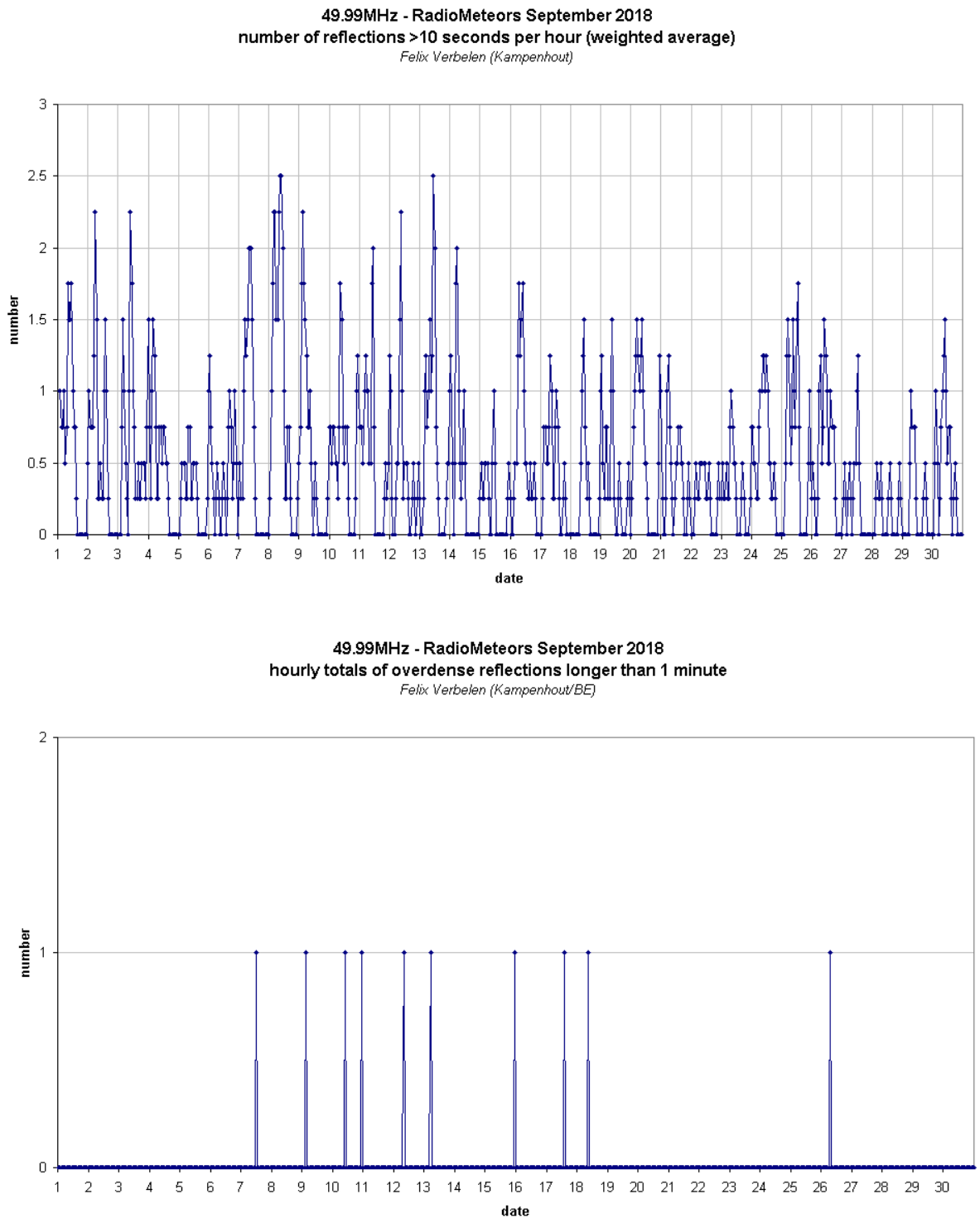

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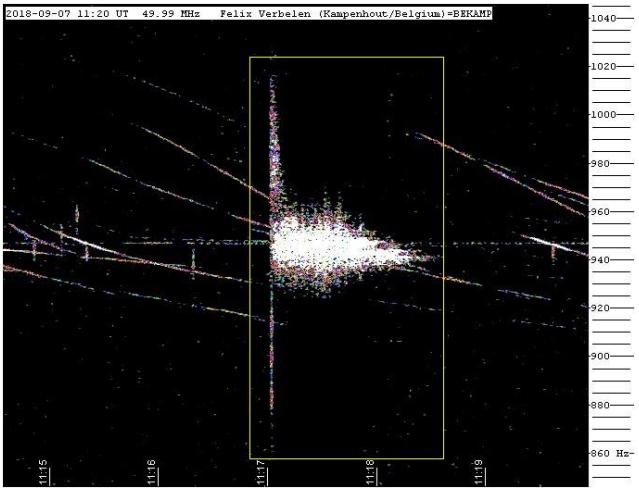

Figure 5 – Spectacular fireball on 2018 September 7, 11^h20^m UT.

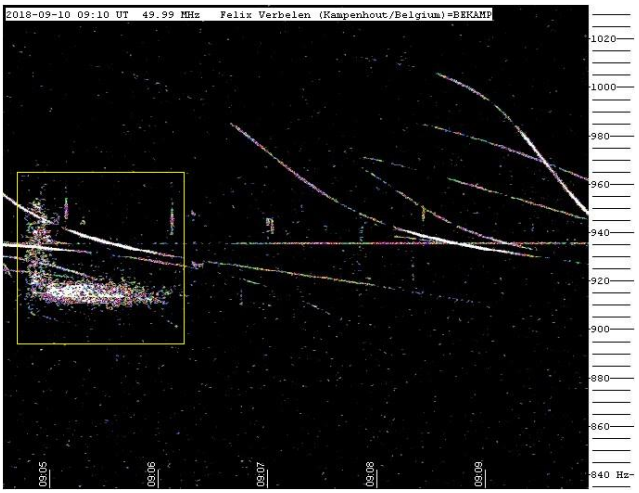

Figure 6 – Spectacular fireball on 2018 September 10, 09^h10^m UT.

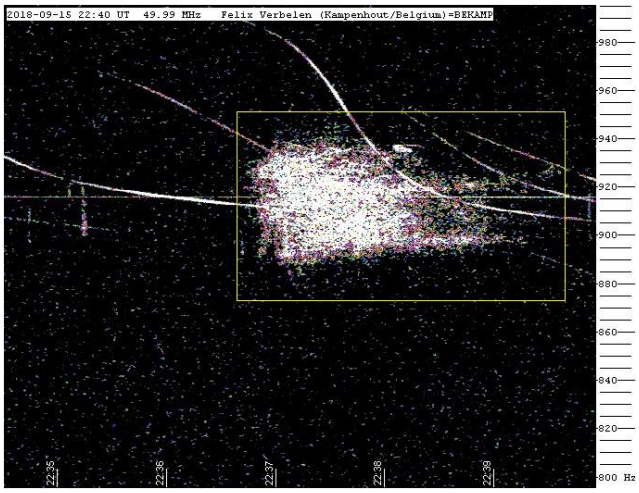

Figure 7 – Example of a spectacular fireball on 2018 September 15, 22^h40^m UT.

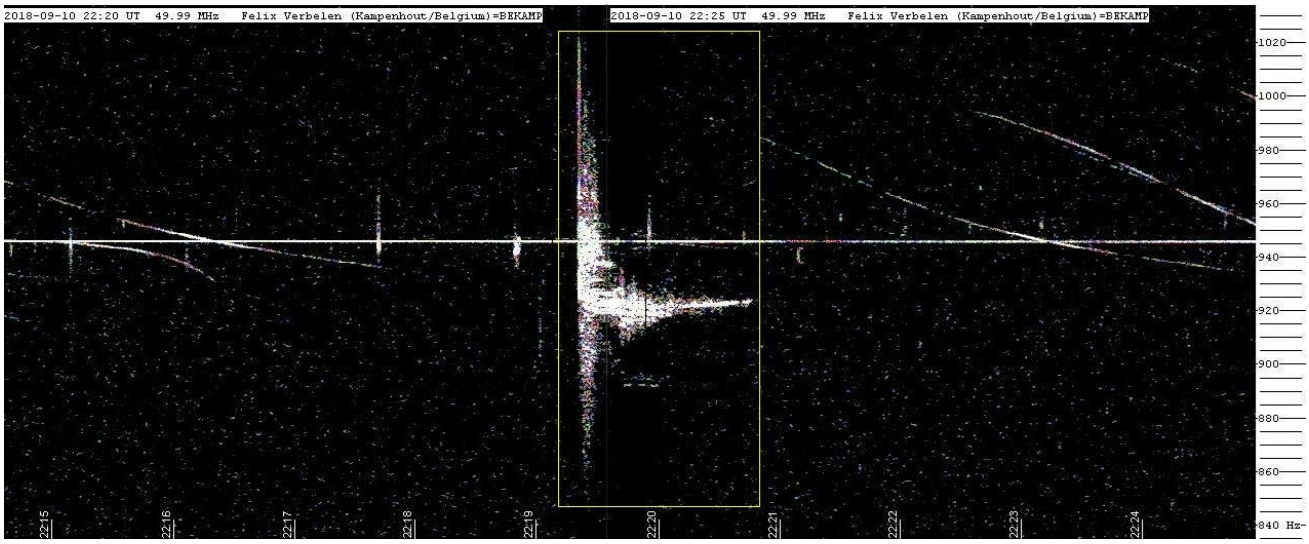

Figure 8 – Spectacular fireball on 2018 September 10, 22^h20^m UT and 22^h25^m UT.

Radio meteors – October 2018

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During this month our registrations were fortunately almost free of strong local interference, there was no registered "sporadic E" (Es) and only on October 11th there were thunderstorms with moderate lightning activity.

Highlights of the month were mainly:

- the eruption of the Draconids on 201810_08-09, with many radio echoes but relatively few overdense reflections lasting longer than 10 seconds (*Figure 3*);
- the Orionids that were not exceptionally numerous this year, but still showed a nice number of long-lasting reflections, which can mainly be seen in the daily total of overdenses longer than 10 seconds on 20181023;
- radio echoes lasting more than 1 minute, with the most spectacular on 20181010_21:14 UT (*Figure 4*). Also, during the period 201810_27-31 there were several powerful and long-lasting reflections (see *Figures 5, 6 and 7*).

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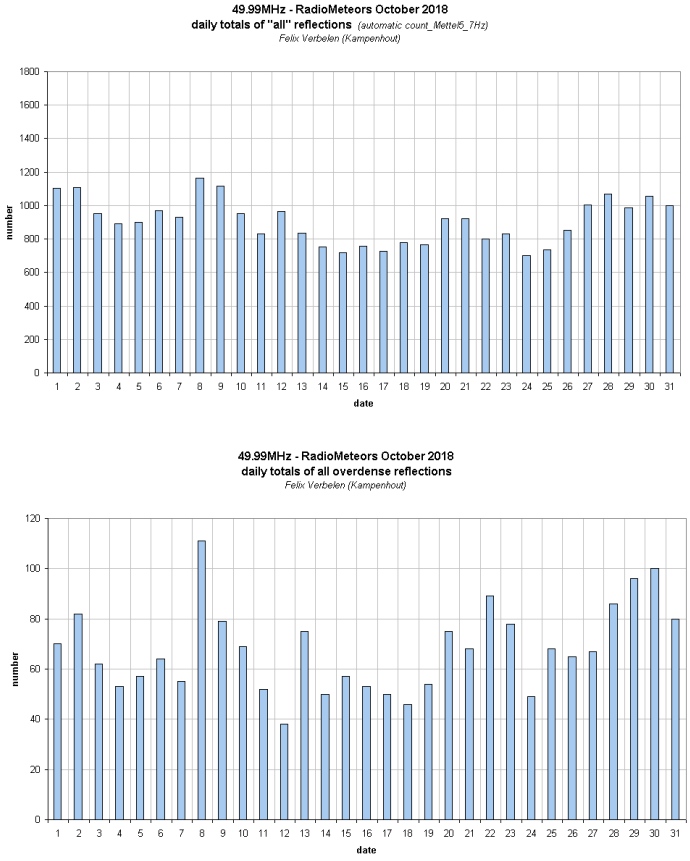

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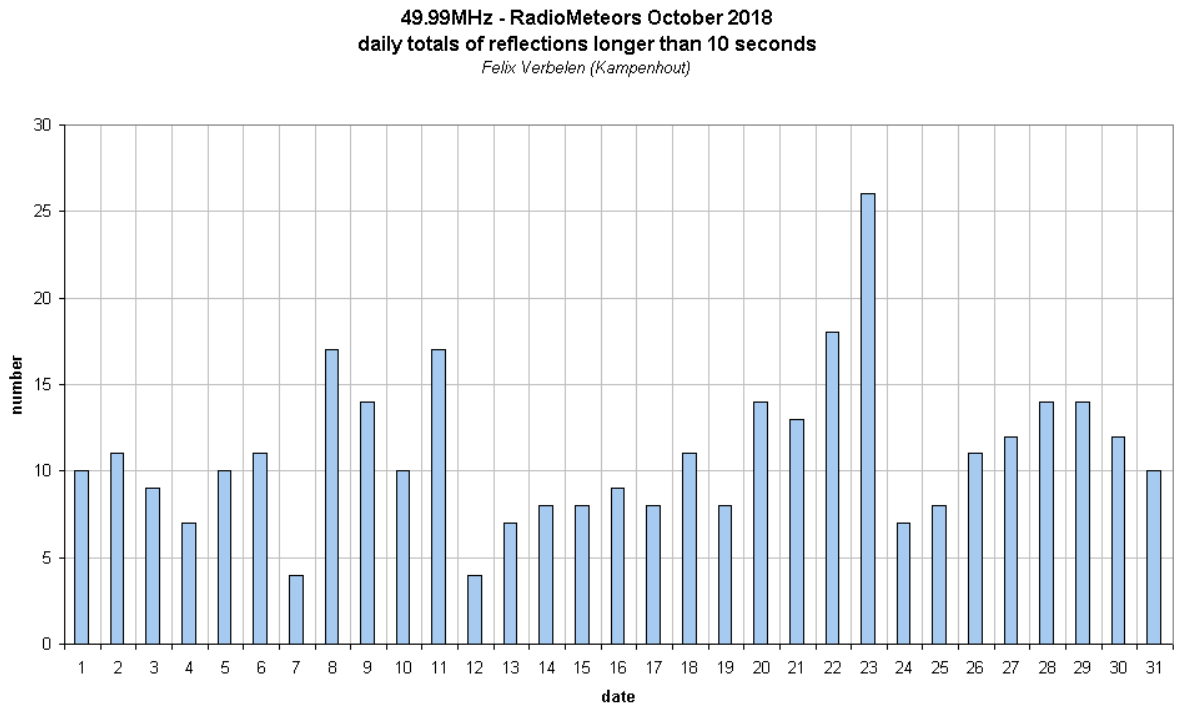

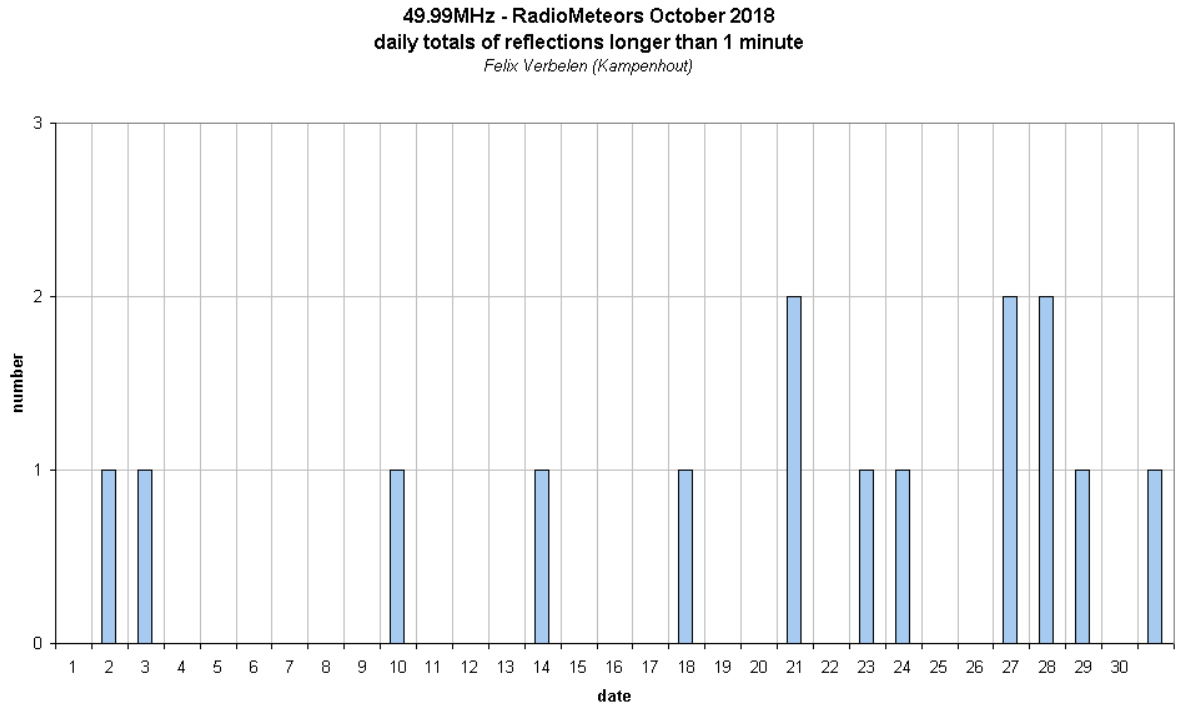

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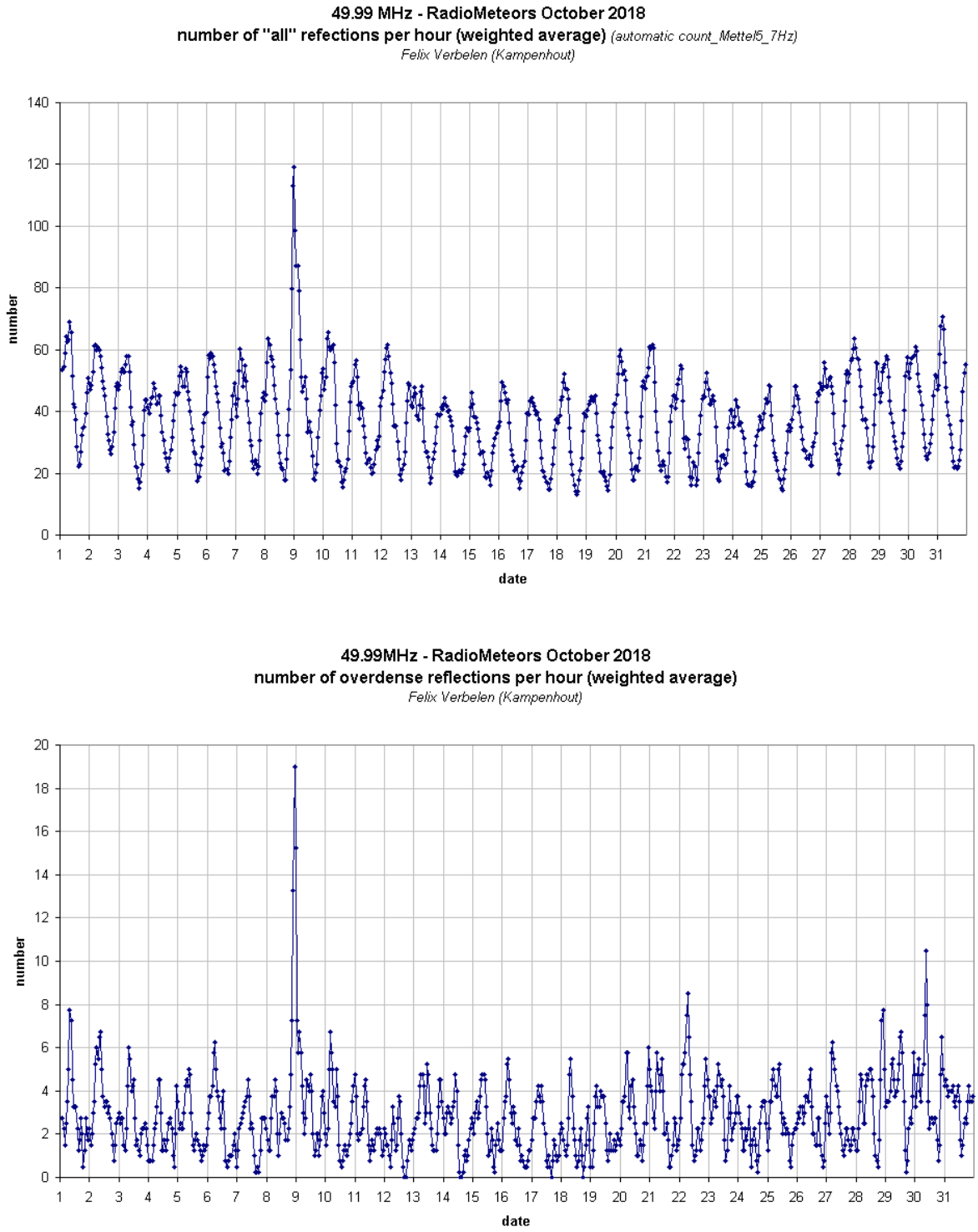

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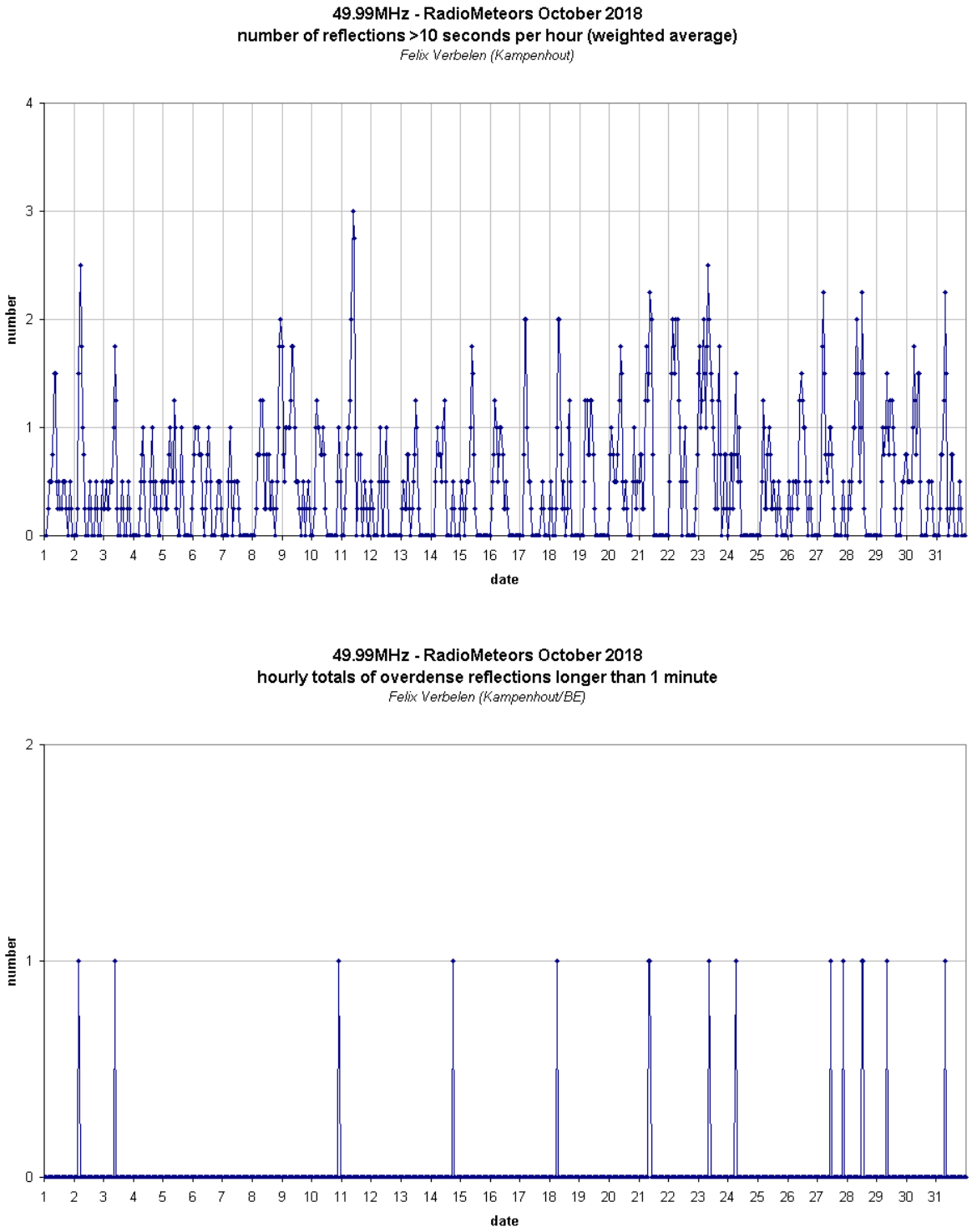

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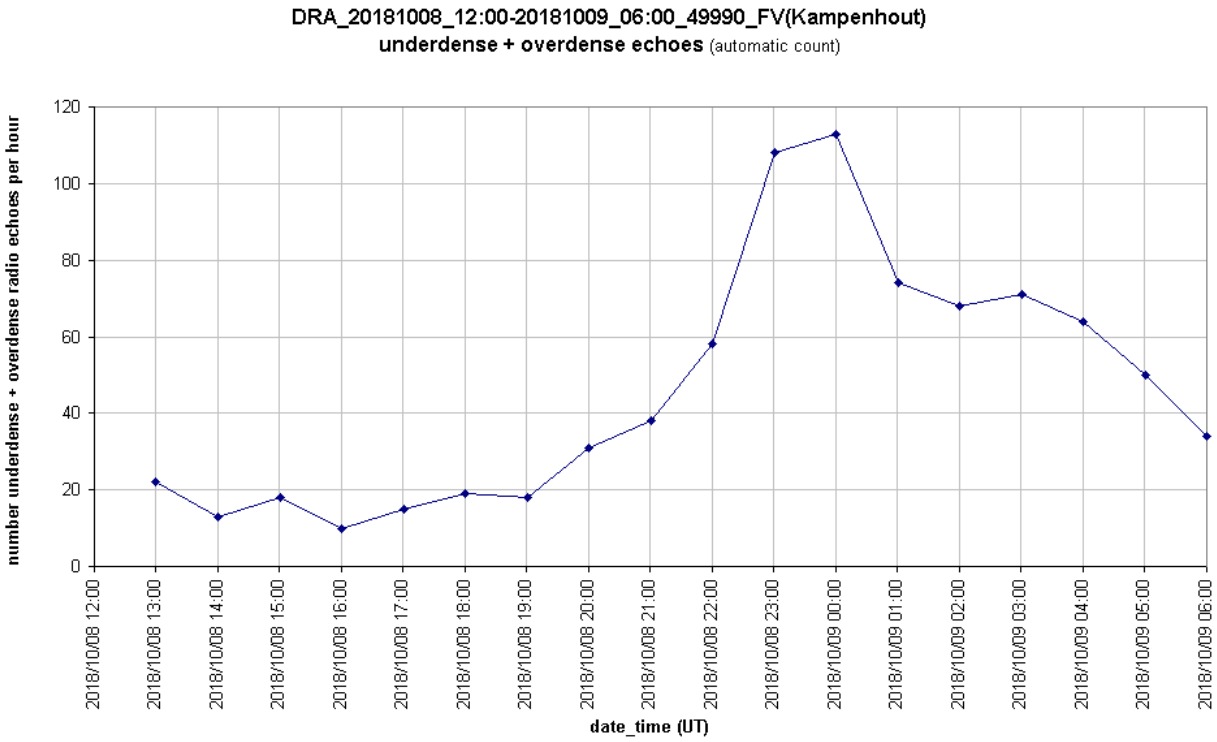

Figure 5 – The eruption of the Draconids on 201810_08-09.

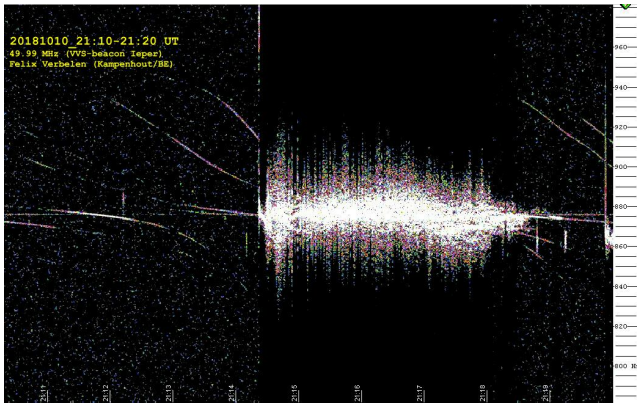

Figure 6 – Radio echoes lasting more than 1 minute, the most spectacular on 20181010_21:14 UT.

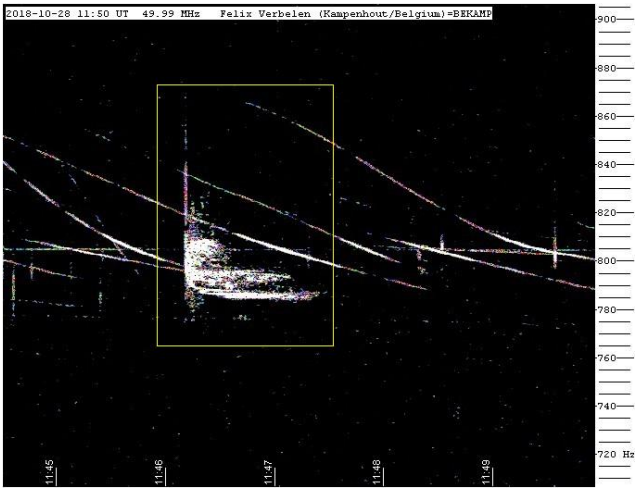

Figure 7 – A powerful and long-lasting reflection during the period 201810_27-31.

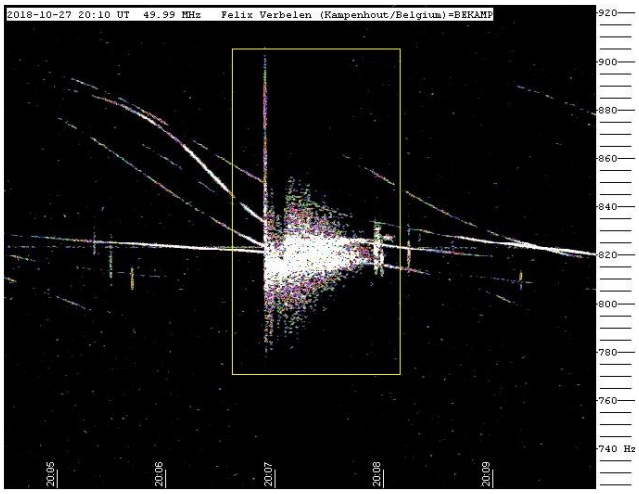

Figure 8 – A powerful and long-lasting reflection during the period 201810_27-31.

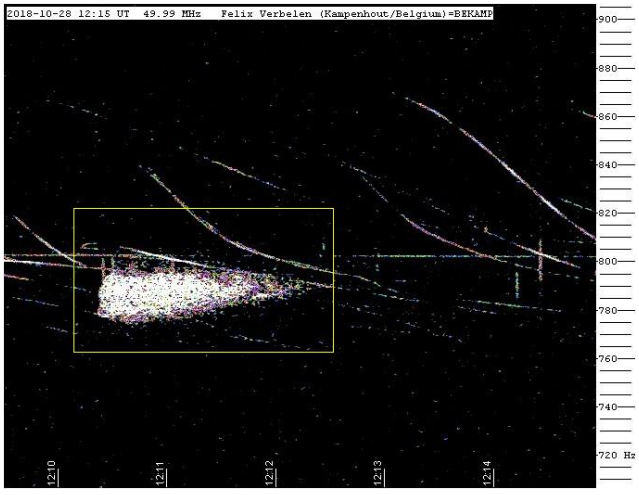

Figure 9 – A powerful and long-lasting reflection during the period 201810_27-31.

CAMS-Florida report, 19-20 October 2018

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A summary report is presented on the CAMS-Florida results for 19-20 October 2018.

1 Introduction

The night of October 19/20, 65 orbits were determined through simultaneous observation by two or more CAMS-Florida sites. Half of the orbits were Orionids that radiated from a concentrated area in the sky between Orion and Gemini. Orionids are debris from Comet 1P/Halley.

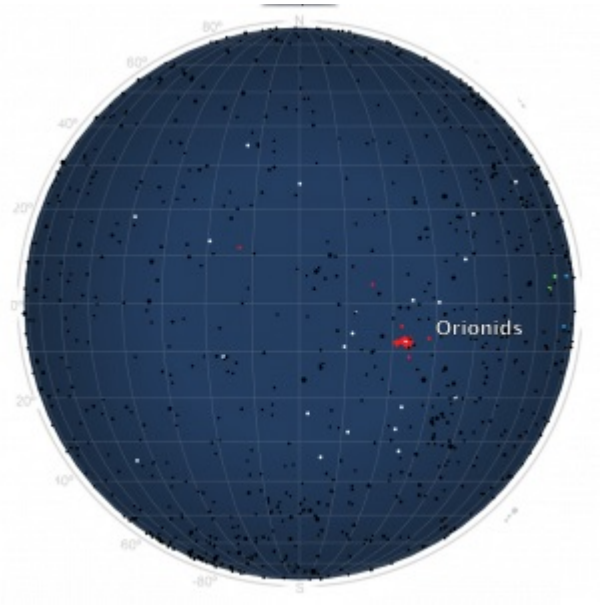

Figure 1 – The radiants for the orbits obtained by CAMS-Florida.

Florida Tech's CAMS 233 contributed to 24 of the 65 orbital determinations.

The new 8-camera CAMS in Gainesville detected 442 meteors, but just 32 of them were coincident with other CAMS-Florida sensors. What's needed are more sites to get improved overlapping coverage. Plans are underway to install another 8-camera system, to be situated in the Melbourne area.

2 Last night's activity

Meteors (w/ orbital determinations):

- CAMS 000230 – 20
- CAMS 000231 – 30
- CAMS 000232 – 34
- CAMS 000233 – 24
- CAMS 000234 – 28
- CAMS 005005 – 23
- CAMS 005006 – 8
- CAMS 005007 – 1

The previous night's data are available after 1:45pm ET at the CAMS-Florida web page[31] (*Figure 1*).

Each plotted point on the celestial map is the radiant of one meteor. Moussing over a radiant reveals the solar longitude ($\lambda_\odot$) at time of observation, the radiant's sun-centered ecliptic coordinates (λ, β), and geocentric velocity (v_g). The meteor's geocentric radiant is (l, b) where $l = \lambda_\odot - \lambda$ and $b = \beta$. If $l < 0$, add 360.

If the meteor is associated with a known meteor stream, its IAU number is shown. In that case, clicking on the point brings up an interactive simulation of CAMS-derived orbits from that stream. IAU No. = 0 means that the meteor is a sporadic, one that is not associated with a known meteor stream.

Sensor Outages:

- None

Fireballs (UT, Peak Mag, Integrated Mag, Sites):

- None noted

Mission Statement: CAMS-Florida is an independent citizen science group, a contributor to the NASA-CAMS project led by Peter Jenniskens, whose purpose is to identify meteor streams and their parent objects.

Contributing Sensors:

- CAMS 000230 – Gainesville (A. Howell)
- CAMS 000231 – New Smyrna Beach (B. Harris)
- CAMS 000232 – New Smyrna Beach (B. Harris)
- CAMS 000233 – Florida Tech (V. Jenne, M. Marquart, A. Zlotak)
- CAMS 000234 – Gainesville (A. Howell)
- CAMS 005000-005007 Gainesville (A. Howell)

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

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