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Meteor showers 2016: review of predictions and observations
December and January video meteors

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Front cover photo

A meteor captured on 2017 May 27 at $21^{\rm h}02^{\rm m}$ UT by a meteor camera, which is part of the UK Meteor Monitoring Network. Photo courtesy: John Maclean FRAS.

Back over photo

This Geminid Meteor was registered on 2014 December 4 in Inga Stone, Paraiba, Brazil. The Inga Stone is a rock formation covered of glyphs represent animals, fruits, humans, constellations, and other unrecognizable images. It was made by ancient civilizations that lived in the region over 3000 years ago. This same meteor was recorded by two cameras of BRAMON – Brazilian Meteor Observation Network, that made is possible to verify its association with the Geminid shower. Photo courtesy: Marcelo Zurita.

Writing for WGN This Journal welcomes papers submitted for publication. All papers are reviewed for scientific content, and edited for English and style. Instructions for authors can be found in WGN **45:1**, 1–5, and at `http://www.imo.net/docs/writingforwgn.pdf` .

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Conferences

Thirty-Seventh International Meteor Conference, Pezinok-Modra, Slovakia, August 30–September 2, 2018

Pavol Zigo, Leonard Kornoš, Juraj Tóth and Tomáš Paulech

Introduction

It is our privilege to welcome the IMC community to Slovakia for the fourth time. After visiting Smolenice (1992), Stará Lesná (1998), and Šachtička (2008), the 2018 edition will take place in Pezinok, the birthplace of the influential Slovak astronomer Dr. Ján Štohl (1932–1993). The Astronomical and Geophysical Observatory (AGO) in Modra is situated only a few kilometers away, at the eastern foothills of the Little Carpathian Mountains. It is one of the most important vitculture centers in this region.

Local Organizer

The Astronomical and Geophysical Observatory in Modra belongs to the Faculty of Mathematics and Physics of the Comenius University in Bratislava, and was officially established in 1992. A great deal of effort is focused on meteor research. Modra is a member of the European Network for fireball detection (coordinated by Ondřejov Observatory, Czech Republic). The Slovak Video Meteor Network was established to provide a year-round detection of meteors. Currently, the Network consists of four all-sky AMOS systems including spectral cameras installed throughout Slovakia. Moreover, we are running AMOS stations at the Teide and Roque de los Muchachos observatories on the Canary Islands since 2015 and in Chile since 2016. Naturally, we are collaborating with advanced amateur meteor observers from Slovakia, the Czech Republic, Poland, Hungary and other countries who joined the common EDMOND initiative. Regular weekend seminars are organized in the AGO since 2009.

Conference dates

After the IMC 2016 which took place in June of that year to allow participants to also join *Meteoroids*, the IMC 2017 returned to the traditional period, around the third weekend of September. The IMC 2018 will again deviate from this traditional period, albeit only slightly, and will take place from August 30 to September 2, 2018. The reason for this shift is the nearby XXXth IAU General Assembly in Vienna which takes place from August 20 to 31. This is of course a great opportunity to attract more IAU attendees to come to the IMC. We expect that this coupling will enrich the scientific program significantly, as well as save time and minimize travel expenses for a substantial part of the IMC participants.

Location and venue

The conference location is Pezinok, which is situated about 30 km to the northeast of the capital city of Bratislava.

The conference will be held at Hotel Rozalka On the hotel premises, which neighbor a complex of horse-riding arenas, there is a congress facility with conference hall, lobby bar and roofed terrace. Poster panels will be arranged in the conference hall.

The hotel provides accommodation in three separate residences for 130 guests in double bedrooms, a family room, or apartments with terrace. There are also a limited number of single rooms. Every room is equipped with cable TV with flat screen, internet connection, telephone, bathroom with toilet, shower cabinet, and toilet facilities. There is an indoor restaurant, where all meals will be served. It has a capacity around 80 guests, to which must be added the summer terrace with view on the horse riding parcours. If we are informed of them in advance, special food requirements can be arranged.

Program and social events

The detailed scientific program, consisting of talks and poster presentations, will be announced shortly after the end of the registration period. We are considering to invite some speakers to give review talks, which can serve for newcomers on the one hand, and professionals or advanced amateurs on the other hand. We also expect short contributed talks involving various aspects of meteor observing and data analysis. The overall goal of the conference will be to encourage mutual collaboration between amateur and professional meteor astronomers.

All presentations, both talks and posters, will be included in the IMC 2018 Proceedings as full-length papers or abstracts. A contest for the best poster and the best meteor photo started at previous IMCs will be organized in 2018 too.

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Figure 1 – Aerial view of Hotel Rozalka and surroundings.

On Saturday afternoon, there will be an excursion to two interesting places nearby the conference venue. The first is Červený kameň ("red stone") Castle situated in the Little Carpathian Mountains at only 17 km from Pezinok. We will take a guided tour which leads through the 13th-century castle with its huge underground and fortification system. Our excursion will continue to the Astronomical and Geophysical Observatory in Modram where we can take a short tour through the facility with small refreshment and socializing till late evening.

Registration

The standard conference registration fee has been set to 170 EUR which we hope will be acceptable for all interested to attend. This fee includes full board (accommodation in a double room, breakfast, lunch, and dinner) from Thursday evening August 30 (dinner included) till Sunday noon September 2 (lunch included), all lecture and poster sessions, coffee breaks, and the excursion. The price for accommodation in a single room is 240 EUR. A limited number of apartments and a family room are available at 170 EUR per occupying participant.

T-shirts and printed proceedings can be purchased separately upon registering, but electronic proceedings will be made available to all participants.

Registration is expected to open in January 2018. Detailed information concerning registration and conference program will be communicated via WGN as well as on the IMO and IMC 2018 web sites. The early registration deadline is set at June 30, 2018. After this date, an additional late registration fee of 20 EUR is charged. The final registration deadline is August 1, 2018. We would like to emphasize that registration might be closed early if maximum capacity is reached before the deadline.

Travelling to Pezinok

Pezinok is easily accessible from Bratislava by train, bus, or by car within 30 minutes. Bratislava, the country's capital, is served by its own Bratislava International Airport (BTS) having 22 regular destinations mainly in Europe. Vienna (VIE) or Budapest Ferihegy (BUD) International Airports could be used alternatively. From Vienna, there are several possibilities to use low-cost airport shuttle buses operating on a daily basis. Alternatively, you can travel between the main railway stations of Vienna and Bratislava by train (approximately a 1-hour journey). From Budapest, the best way is to use the international train from Keleti Station to Bratislava Main railway Station (approximately a 3-hour journey).

If you travel by car, the best option is to use highway D1 and take exit Pezinok-Senec some 20 km northeast from Bratislava. Follow the local road No. 503 which leads directly to Pezinok. The Local Organizing Committee (LOC) will provide assistance and individual travel recommendations if needed.

Contact

Further and more detailed information will be published in WGN following this first announcement and posted at the IMO website and IMC 2018 web pages as soon as these become available. You may contact the LOC at any time at `imc2018@imo.net`.

Meteor science

Meteor showers 2016: review of predictions and observations

Jürgen Rendtel[1,2], *Hiroshi Ogawa*[1,3], *Hirofumi Sugimoto*[1,4]

We checked the available optical data (visual, video) and radio forward scatter data for signs of peculiar activity announced in the IMO's 2016 Meteor Shower Calendar. For the Quadrantids, Perseids and Ursids, we find additional peaks in their activity profiles. The October Camelopardalids currently appears as an annual shower on October 5/6. The predicted activity of the ε-Eridanids (September 12) and α-Monocerotids are found in radio data only. No significant activity was detectable in the case of the μ-Leporids (end March), the 66-Draconids (December 2/3) and the possible meteoroids from comet P/2009 WX_{51} (Catalina) on April 21. The upcoming returns of the October Camelopardalids and the α-Monocerotids should be carefully monitored because the recent data may hint at further (minor) outbursts of these showers.

Received 2017 July 19

1 Introduction

The 2016 Meteor Shower Calendar (Rendtel, 2015) includes several predictions of possible activity of minor meteor showers and peculiarities in the activity profiles of major showers. Furthermore, some results of meteoroid stream modelling have been published and circulated later during the year. Here we present observational results for most of the events. This is meant as an overview and also as an encouragement for the observers to check future periods with possible peculiarities and as a feedback to the theoreticians to continue and improve modelling of meteoroid streams.

2 Quadrantid early peak on January 3

Model calculations of Vaubaillon provided indications that the main peak may show an (early) maximum between January 3, 22^{h}, and January 4, 02^{h}UT. This timing was optimal for European longitudes. Mass-sorting of particles across the meteoroid stream adds to the complexity of the data obtained during the passages through the stream. Hence fainter objects (radio and telescopic meteors) may reach their maximum up to hours before the brighter (visual and photographic) ones.

A detailed analysis of the 2016 Quadrantid maximum has been published in WGN (Rendtel et al., 2016), showing a short early peak in three different data samples (visual, video, radio). Interestingly, the fainter radio meteors occur about three hours earlier than the optical meteors, indicating that such an effect of strong mass segregation is present. In Figure 1 we show the summary ZHR and flux profiles derived from the total sample.

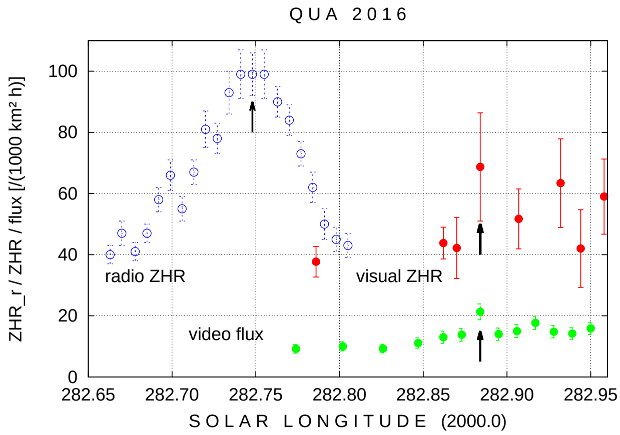

Figure 1 – Quadrantid activity profiles obtained by visual (ZHR), video (flux) and radio (ZHR_r) observations. The figure is repeated from Rendtel et al. (2016) for completeness of the 2016 events. The profiles show the minor early peak in different mass ranges indicated by the arrows.

3 μ-Leporids end March

Theoretical modelling of Mikhail Maslov indicated that there might be a weak activity of faint, very slow meteors (V_∞ = 15.5 km/s) on March 28–30 from a radiant near μ Leporis ($\alpha = 78°$, $\delta = -16°$). The modelled meteoroids are from comet 252P/LINEAR and were ejected in 1915, 1921 and 1926. The expected ZHR level was 5–10 at best. Conditions for optical observations were best from tropical and southern locations in the evening. Of course, radio forward scatter and radar observations had a wider window. The most probable period was given as March 28, 11^{h}–18^{h} UT.

There are no data confirming any activity within the period and from the given radiant, neither in optical nor in radio forward scatter data. The activity level derived from forward scatter observations obtained in 2016 and 2017 are shown in Figure 2. For the procedure to calculate the activity A see Ogawa et al. (2004). In both years there is no significant activity signature visible. At a first glance, the analysis in terms of a ZHR shows two peaks at $\lambda_\odot = 7\overset{\circ}{.}3$ and $9\overset{\circ}{.}7$ (Figure 3). For the definition of the given ZHR_r see section 3.4 in Rendtel et al. (2016). This low activity was observed with

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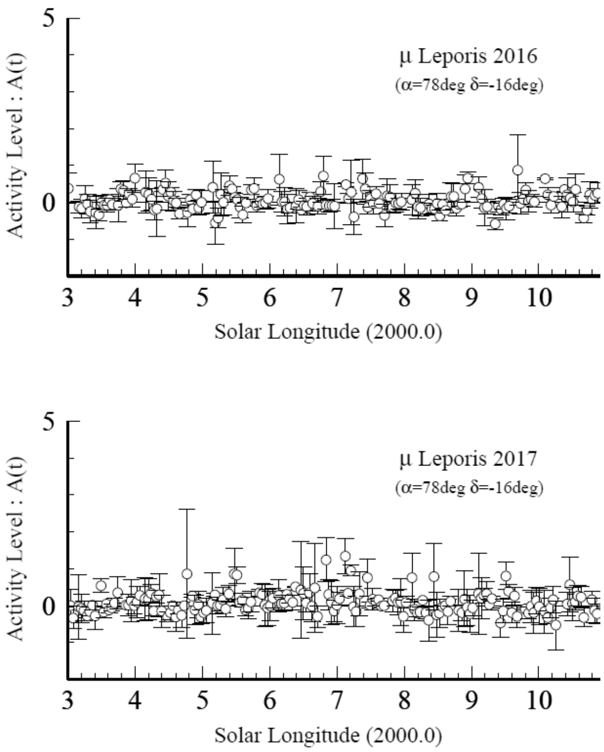

Figure 2 – Radio forward scatter activity during the suggested μ-Leporid period between March 27 and 30 (i.e. $\lambda_\odot = 6°$ to $9°$) expressed in terms of the activity level A (Ogawa et al., 2004).

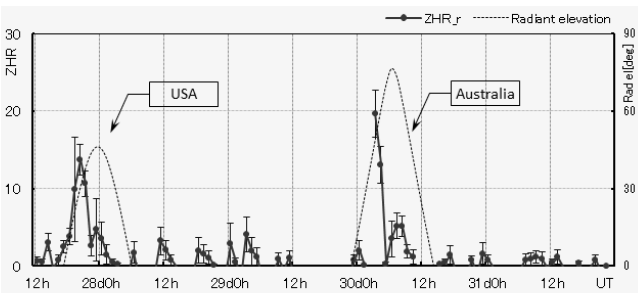

Figure 3 – This analysis may contain a very weak hint at μ-Leporids, but the data is scarce and the observing conditions are unsuited for more detailed analyses. Note that the highest ZHR__r occurs while the radiant is low in the sky (rising section of the radiant elevation curve, dashed line).

a radiant elevation of only about 20°. The later peak on March 30 was perhaps caused by an overcorrection while the activity on March 27 around 20^h UT may have a higher reliability. In the case of Activity Level Index (Figure 2), the data points scatter a lot and a peak time of 18^h UT ±5h ($\lambda_\odot$=$7\overset{\circ}{.}3$) may be vaguely identified. Generally, activity of this possible meteor shower is very difficult to analyze because of its very low level and the very slow geocentric velocity.

Furthermore, a private communication of Peter Brown confirmed that there was no sign of activity from a radiant even vaguely close to the given position found in the CMOR radar data between March 28 and 30.

Conclusion: no reliable signature of meteor activity from this radiant is detectable in the available optical and radio/radar data in the period 2016 March 28–30.

4 Meteors from comet Catalina on April 21

Mikhail Maslov found in his theoretical modelling that meteoroids released from comet P/2009 WX_{51} (Catalina) at rather high speeds may cause activity on April 21 at 02^h02^m UT. Due to the high ejection velocity, only very small particles should have reached the Earth. Since the radiant at $\alpha = 38°$, $\delta = 35°$ (close to the star 14 Tri) was only 24° west of the Sun, any activity was only observable by means of radio or radar methods. No confirming data are available by the time of writing this summary. The CMOR wavelet output for the period around the possible activity kindly provided by Peter Brown has no sign from this daytime source.

5 Perseid peaks due to dust trail passages

The mean broad maximum varied in recent times between $\lambda_\odot \approx 139\overset{\circ}{.}8$ to $140\overset{\circ}{.}3$, equivalent to 2016 August 12, 08^h to 22^h UT. Results from Mikhail Maslov and Esko Lyytinen indicated that in 2016 the Earth crosses a part of the stream which was shifted closer to the Earth's orbit by Jupiter. Therefore the background ZHR was expected to reach a level of 150–160.

Additionally, the Earth should encounter small meteoroids of the 1-revolution trail on August 11, 22^h34^m UT causing an increase of the ZHR by about 10. At 23^m23^m UT brighter meteors of the 4-revolution trail were expected.

According to calculations of Jérémie Vaubaillon, the densest part of the stream dominated by meteoroids of the 2-revolution trail was expected to be crossed between August 12, 00^h to 04^h UT ($\lambda_\odot = 139\overset{\circ}{.}49$–$139\overset{\circ}{.}66$), well before the broad nodal maximum. All together a good occasion for tests of observing and analysing procedures.

5.1 Visual data

The trail encounters in the night August 11/12 fell into the European night time and many observers successfully recorded Perseid data in this period. Figure 4 shows the calculated ZHR using a constant $r = 2.0$ for the interval. This value of r is slightly lower than the standard value of $r = 2.2$ which was applied for the broad main maximum with a ZHR of about 110 in the period centred on August 12, 23^h UT ($\lambda_\odot = 140\overset{\circ}{.}4$; not shown here). The highest peak is very close to the 4-revolution trail calculated for 23^m23^m UT. All peak positions obtained from separate data sets are summarized in Table 1.

5.2 Video data

The large sample of video data from the same period has been analysed as well (Figure 5), also using $r = 2.0$ for this period. The peak positions and flux level variations are essentially identical with the visual results (Table 1). The highest flux occurs close to the calculated 4-revolution trail position as found from the visual data.

Table 1 – Observed positions and strength of the Perseid trail encounters calculated for the night August 11/12. The activity measures are ZHR for visual, flux in $1/(10^3\ \mathrm{km}^2\mathrm{h})$, ZHR_r for Radio 1 and the Activity level A for Radio 2.

	109P 4-revolution trail			109P 2-revolution trail		
Method	Peak position	Activity	Time (UT)	Peak position	Activity	Time (UT)
Visual	$139\overset{\circ}{.}467 \pm 0\overset{\circ}{.}010$	190 ± 8	23^h19^m	$139\overset{\circ}{.}58 \pm 0\overset{\circ}{.}03$	155 ± 9	02^h15^m
Video	$139\overset{\circ}{.}466 \pm 0\overset{\circ}{.}004$	86 ± 4	23^h18^m	$139\overset{\circ}{.}64 \pm 0\overset{\circ}{.}04$	50 ± 4	03^h40^m
Radio 1	$139\overset{\circ}{.}45 \pm 0\overset{\circ}{.}01$	190 ± 10	22^h55^m			
Radio 2	$139\overset{\circ}{.}474 \pm 0\overset{\circ}{.}010$	4.21 ± 0.38	23^h30^m			

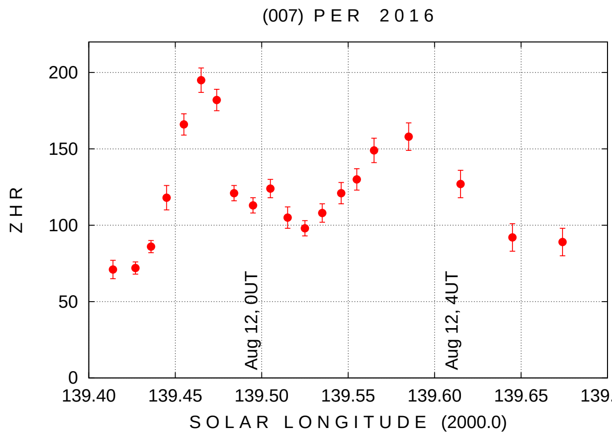

Figure 4 – Visual ZHR of the 2016 Perseids around the early dust trails encounters on August 11/12 using $r = 2.0$ for this interval.

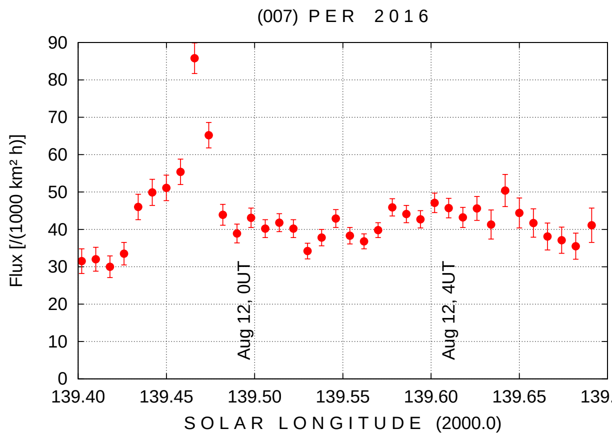

Figure 5 – Flux of the 2016 Perseids around the early dust trails encounters on August 11/12 determined by video data of the IMO Video Meteor Network, using $r = 2.0$ (like for the visual data) and $\gamma = 1.5$; minimum number of meteors per bin is 80. The interval shown in Figures 4 and 5 is identical.

5.3 Radio forward scatter

The radio data clearly show the first peak at $\lambda_\odot = 139\overset{\circ}{.}45$, and later around $\lambda_\odot = 139\overset{\circ}{.}8$ the broad maximum (graph shown at `http://www5f.biglobe.ne.jp/~hro/Flash/2016/PER/index.html`). The values are listed in Table 1 as "Radio 1". Alternatively, we may refer to the activity measure derived from the same raw data (see `http://www.amro-net.jp/meteor-results/08_per/2016per.html`), listed in Table 1 as "Radio 2". Interestingly, the signature of the 2-revolution trail which occurs in the optical data around $02^h - 04^h$ UT is missing. According to the optical data, this trail was not significantly dominated by bright meteors and fireballs as the 4-revolution trail was. Perhaps the portion of small meteoroids which usually contribute to a strong radio signal was low.

6 ε-Eridanids: September 12

Jérémie Vaubaillon's calculations indicated that there was some activity expected from the ε-Eridanids (209 EER) on 2016 September 12 near 17^h30^m UT. The meteoroids are thought to have been released from comet C/1854 L1 (Klinkerfues). The radiant is at $\alpha = 57°$, $\delta = -14°$, and their atmospheric entry velocity of 59 km/s is similar to that of the Perseids.

6.1 Optical data

The radiant is above the horizon only after local midnight, depending on the latitude. The given timing was favourable for observers east of about 90° longitude. As usual in this time of the year, there are only a few visual reports available in the VMDB. Four observers submitted reports. Closest to the time were the reports shown in Table 2; the observers have been contacted later to confirm their counts. The available video data have no sign of the ε-Eridanids (Sirko Molau, private communication).

6.2 Radio results

The analysis of radio forward scatter data shown at `http://www5f.biglobe.ne.jp/~hro/Flash/2016/SPE/index.html` gives a small peak at $\lambda_\odot = 170\overset{\circ}{.}2$ (2016 September 12, 18^h UT). The FWHM of the EER peak is approximately $0\overset{\circ}{.}15$ or 3.5 hours. In order to calibrate the ZHR_r we may use the ZHR_r of the September ε-Perseids (204 SPE) which occurred under very similar conditions and with roughly the same entry velocity of the meteoroids just three days earlier on September 9, 19^h UT. Both peaks of similar appearance are shown in Figure 6.

The visual data of the IMO's VMDB give a maximum ZHR of 6 ± 2 (not in the sense of a pronounced peak, but the highest roughly 8-hour average) on 2016 September 9 near 09^h UT at $\lambda_\odot = 166\overset{\circ}{.}9$. For completeness, we show the respective profile in Figure 7. This is consistent with the SPE flux and ZHR derived from video data (ZHR approximately 5 ± 2 over a longer period around $\lambda_\odot = 167\overset{\circ}{.}4$). For all optical data we applied $r = 3.0$. Hence we consider the optically determined ZHR of 5–6 as a reference level.

The radio forward scatter activity (ZHR_r) of the EER is essentially as high as the SPE signal. Assuming

Table 2 – Reports of visual observations close to the predicted EER activity (the time difference Δt (hours) to the predicted peak is given). EER gives the number of meteors which can be associated to the radiant. Observers: GERCH – Christoph Gerber; MISKO – Koen Miskotte; RENJU – Jürgen Rendtel.

Date	Period (UT)	EER	Δt	Observer	Location
Sep 12	0009-0341	0	-13	MISKO	Netherlands
Sep 12	0140-0344	0	-13	GERCH	Germany
Sep 12	0255-0450	0	-12	RENJU	Spain
Sep 13	0025-0257	0	$+7$	MISKO	Netherlands
Sep 13	0130-0338	0	$+8$	GERCH	Germany
Sep 13	0315-0548	2	$+10$	RENJU	Spain

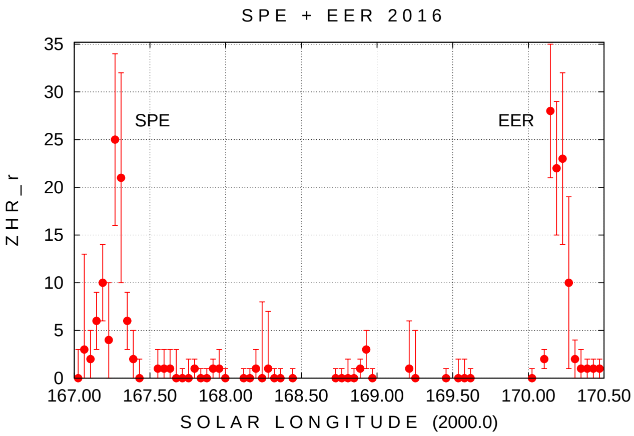

Figure 6 – Radio forward scatter ZHR data of the SPE and EER. Both peaks are similar in strength, but while the SPE show a regular return with a ZHR level of about 5 (visual and video agreeing well), there are no optical EER data available.

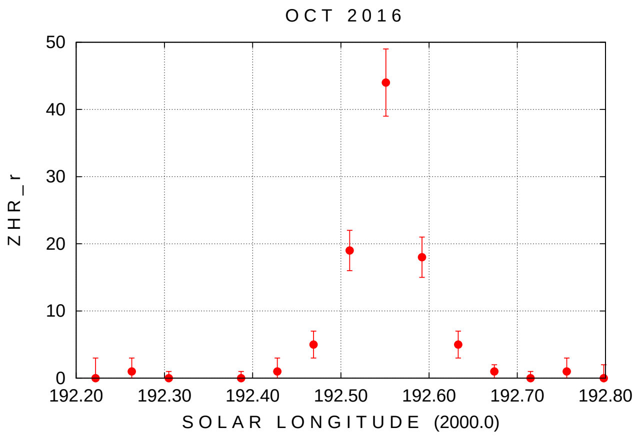

Figure 8 – Radio forward scatter ZHR_r data of the OCT. The significant peak occurred exactly at the predicted position at $\lambda_\odot = 192.^\circ56$. The peak level is discussed in the text.

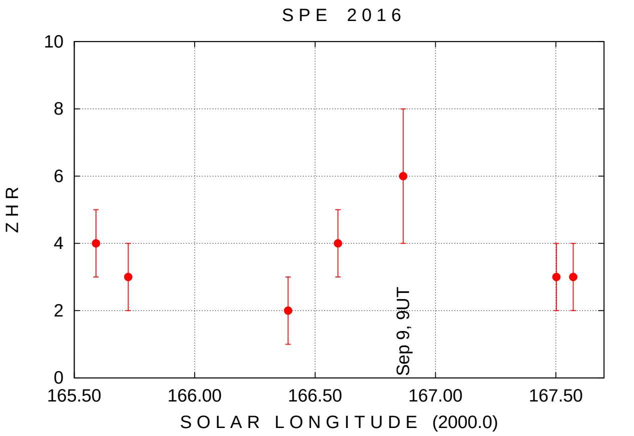

Figure 7 – ZHR profile of the September ε-Perseids obtained from visual observations. The peak position at $\lambda_\odot = 166.^\circ8$ (September 9, close to 09^h UT) is earlier and less pronounced than the profile from the radio data shown in Figure 6.

that there are no further significant effects (geometry, population index), we may then assume that the ZHR of the EER was also of the order of 5. This changes, of course, if the meteoroid size composition of the two showers had been different.

7 October Camelopardalids

In 2005 and 2006 short-lived outbursts were recorded by video cameras on October 5/6 near $\lambda_\odot = 193^\circ$. The shower has been detected annually (Molau et al., 2017) and produced a peak at $\lambda_\odot = 192.^\circ58$ repeatedly with an estimated ZHR of about 5. According to Esko Lyytinen – see the 2016 Shower Calendar – the case of the October Camelopardalids (281 OCT) is not clear. The orbit seems of long period nature. After the 2005 observation it was concluded to be an outburst of the 1-revolution trail, but now it appears to be an annual shower. Either this trail is a lot wider than a typical long period 1-revolution trail, or we have not yet encountered the trail center. Hence there might be (surprise) encounters in different years. In the year 2016 the calculated trail position is very much the same as in 2005. So Esko Lyytinen expected an about similar level outburst in 2016 than the one observed in 2005. The predicted position was at $\lambda_\odot = 192.^\circ56$, i.e. 2016 October 5, 14^h45^m UT.

Enhanced activity was indeed found on 2016 October 5 at the predicted position at 14^h45^m UT in video camera data from Finland. A clear peak is visible in the radio ZHR profile obtained (see data presented at `http://www5f.biglobe.ne.jp/~hro/Flash/2016/OCT/index.html`). The given value of the OCT peak ZHR_r is 43 (Figure 8). As shown in section 6, the radio ZHR-values for both the September ε-Perseids (208 SPE) and the ε-Eridanids (209 EER) are given as about 20 while the optical data give rather 5. It seems the radio ZHR of these weak events is overestimated. The calibration via the observed SPE (visual and video data) – applying a factor of 0.25 – yields a ZHR of approximately 10 for the OCT. This remains a

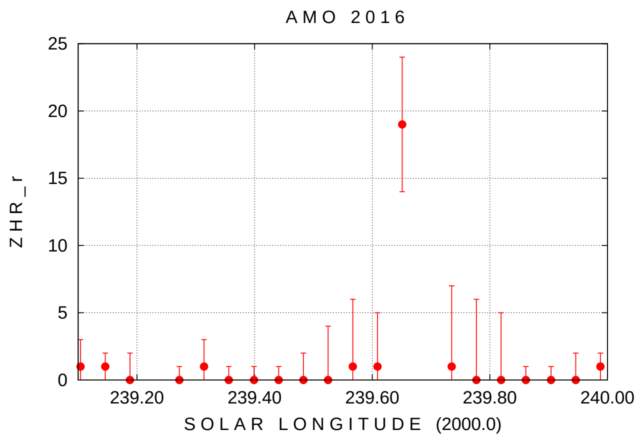

Figure 9 – Radio forward scatter ZHR data of the AMO. The significant peak at the predicted position at $\lambda_\odot = 239\overset{\circ}{.}68$ may represent an optical ZHR of about 5.

significant activity, though. More important is the fact that the peak occurs at $\lambda_\odot = 192\overset{\circ}{.}55$, exactly at the position given by Lyytinen.

Hence any future observation may help to solve the open questions whether it is an annual shower, whether the Earth is close to the trail center, and, finally, what is the parent object. Assuming a long-period parent, and using the 2005 outburst as reference point, we might see similar activity on 2018 October 06, $02^{\mathrm{h}}16^{\mathrm{m}}$ UT ($\lambda_\odot = 192\overset{\circ}{.}529$).

8 α-Monocerotids

Recent modelling by Esko Lyytinen has indicated that the main trail of the α-Monocerotids (246 AMO) will not cross the Earth's *orbit* again until 2017 and 2020. However, the Earth will not be near those points in November, so nothing is likely to happen then. A weak return may occur in November 2019, ahead of the 2020 encounter, depending on how broad the trail may be. The next strong AMO outburst is unlikely before 2043. A note from Mikiya Sato after the 2017 shower calendar was published indicates – from his very recent modelling – a possible dust trail approach in 2017 *if some activity occurs a year ahead on 2016 November 21,* $18^{\mathrm{h}}30^{\mathrm{m}}$ *UT.* The possible rates were announced to be lower than in 1985 and 1995. Hence the attention to the 2016 return of the AMO.

There is a clear activity visible in radio data, showing a ZHR of about 20 at $\lambda_\odot = 239\overset{\circ}{.}68$, i.e. near 18^{h} UT (Figure 9). Similar to the suggested calibration of the EER and OCT using the optically observed ε-Perseid data, we apply the same to the AMO ZHR = 20. Doing this, the AMO visual ZHR may have been approximately 5 – thus recognizable, but not obvious.

Neither the available visual data nor the video data cover the respective interval, so there is no confirmation of the activity by another data sample. Nevertheless, the reported radio rate should be used as a good motivation to check for the calculated AMO activity on 2017 November 21, $21^{\mathrm{h}}26^{\mathrm{m}}$ UT and then hope for the 2019 return.

9 66-Draconids

A paper of Šegon et al. (2016) dealing with the association of newly found meteor showers and their possible parent bodies included the 66-Draconids meteor shower and asteroid 2001XQ. According to dynamical modeling results for 2016 by Jérémie Vaubaillon, some enhanced activity of the 66-Draconids meteor shower might have happened on 2016 December 2 around $21^{\mathrm{h}}30^{\mathrm{m}}$ UT and on December 3 around $07^{\mathrm{h}}00^{\mathrm{m}}$ UT. The theoretical radiant position was at $\alpha = 310°$, $\delta = 64°$, i.e. between Draco and Cepheus in a circumpolar position for most mid-Northern latitudes. There were good chances to spot any activity enhancement from Europe (first time) and from Western North America (second occasion). The calculated entry velocity of the meteoroids was 21 km/s. Hence any possible shower meteors should have appeared very slow in the sky.

There was no real outburst predicted, but any reported sign (or absence) of activity from this source was highly welcome for further studies on the topic – but the data yield no significant sign of the shower.

For a moment, the appearance of another shower with a radiant also in the far northern region of the sky caused some confusion, particularly because this activity was apparently higher. While the 66-Draconids remained well under the detection limit, the December kappa Draconids (336 DKD) with a radiant at $\alpha = 186°$, $\delta = 70°$ (Jenniskens et al., 2016) produced detectable activity and were also seen in the orbital data.

10 Ursid rate enhancements December 22/23 and 23/24

No unusually strong activity had been forecast for the 2016 shower when the IMO meteor Shower Calendar was being prepared. However, Jérémie Vaubaillon's modelling has hinted that weak activity could be present in the nights December 22/23 (more likely) and 23/24 close to 00^{h} UT on each occasion. The longitudes are near $\lambda_\odot = 271\overset{\circ}{.}35$ and $\lambda_\odot = 272\overset{\circ}{.}35$, respectively.

The usually poor weather conditions at many northern locations did not allow us to obtain a complete ZHR profile (Figure 10). The video data cover the first given period quite well (Figure 11) but an enhancement may be found rather at an earlier position. The highest video flux occurs on Dec 22 near $16^{\mathrm{h}}32^{\mathrm{m}}$ UT ($\lambda_\odot = 271\overset{\circ}{.}0$) and is more than $0\overset{\circ}{.}35$ before the calculated time. The period of the first given peak is well covered by the video data, but the flux profile does not show enhanced values. Both the video data as well as the visual data indicate a generally higher flux/rate near or after $\lambda_\odot = 271°$ than in the interval before.

Radio forward scatter data show enhanced activity at $\lambda_\odot = 270\overset{\circ}{.}46$ and $\lambda_\odot = 270\overset{\circ}{.}77$ (Figure 12), both well ahead of the modelled times, but nothing significant at either of the above mentioned positions. The Ursids often produced some enhancement, but in 2016 the activity peaks occurred at positions deviating from the predicted times. Whether the time difference between the highest flux/rates in the optical and radio data hints at mass sorting effects or is just an artifact

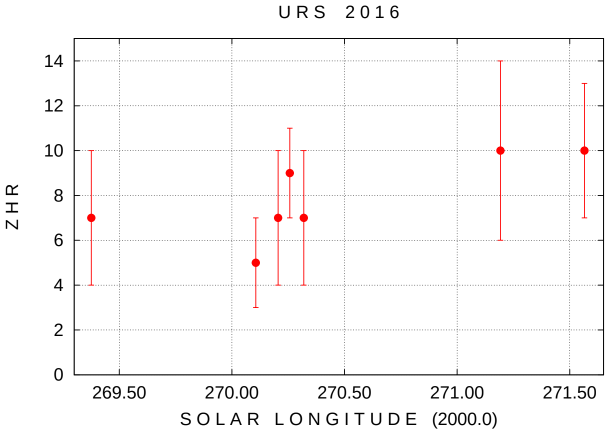

Figure 10 – Visual data do not allow to derive a complete Ursid ZHR profile. The theoretically possible enhancement near $\lambda_\odot = 271\overset{\circ}{.}35$ cannot be found in the data.

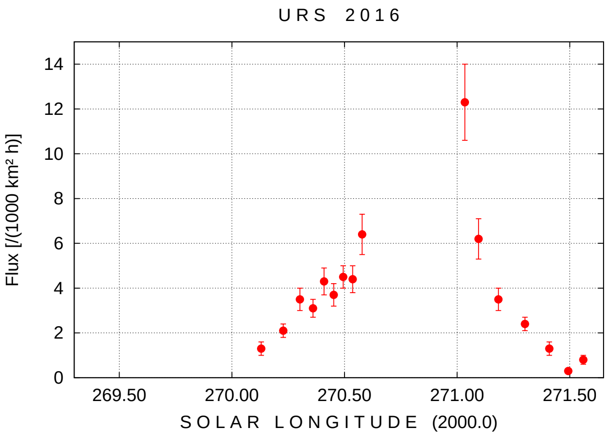

Figure 11 – Video data show enhanced Ursid flux around $\lambda_\odot = 271\overset{\circ}{.}0$ (with a gap before the highest value, so that a maximum timing cannot be derived from this sample). The theoretically possible enhancement near $\lambda_\odot = 271\overset{\circ}{.}35$ cannot be found in the data.

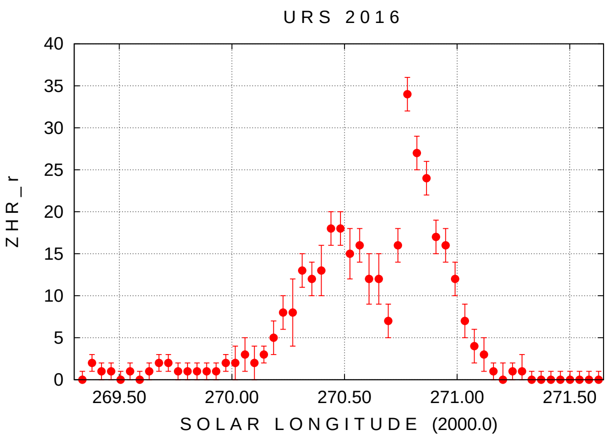

Figure 12 – The ZHR_r data derived from radio forward scatter observations of the Ursids during the same interval as shown in Figures 10 and 11. Enhanced activity occurs before the predicted time with the highest ZHR_r at $\lambda_\odot = 270\overset{\circ}{.}77$.

due to the insufficient data samples cannot be answered from the available information.

11 Conclusions

We find observational evidence from optical (visual, video) and radio forward scatter data for several activity enhancements announced for 2016 based on various model calculations.

The Quadrantids showed an additional early peak on January 3, detectable in visual, video and radio data. Several trail encounters during the Perseid peak period between late August 11 and August 12 can be distinguished and associated with the predictions. The case is less clear for the Ursids where enhancements are obvious but not close to the expected positions. Concerning the minor showers we see that the October Camelopardalids currently appear as an annual shower on October 5/6 with a ZHR of the order of 5. Activity predicted for the ε-Eridanids (September 12) and α-Monocerotids (November 21) was found in radio data only. The theoretical μ-Leporids (March 27–30) as well as the 66-Draconids (December 2/3) remained undetectable in all data sets. This also holds for the possible meteoroids from comet P/2009 WX_{51} (Catalina) on April 21 which are a pure daytime event.

The next returns of the October Camelopardalids and the α-Monocerotids in the years 2017–2019 need to be carefully monitored. Recent data and the corresponding modelling hints at further (minor) outbursts of these showers. Observers are encouraged to apply all available techniques and also to try to cover unfavourable periods. All information may help to improve our understanding of the meteoroid stream dynamics and to establish connections between parents and streams.

Acknowledgement

Thanks to Peter Brown, UWO London, Canada, for providing CMOR results concerning the period of the daytime comet Catalina meteors and the comments on the possible μ-Leporids end March. Sirko Molau has checked the video data for signs of possible ε-Eridanids in September.

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Preliminary results

Results of the IMO Video Meteor Network — December 2016

Sirko Molau[1], Stefano Crivello[2], Rui Goncalves[3], Carlos Saraiva[4], Enrico Stomeo[5], and Javor Kac[6]

In 2016 December, 81 cameras of the IMO Video Meteor Network recorded over 64 000 meteors in more than 13 700 hours of observing time. The flux density profile is presented for the November Orionids. The peak activity is found at $\lambda_{\odot} = 248°$. The flux density profiles are presented for the Ursids of 2011, 2015 and 2016. While the peak activity is comparable in those years, the time of maximum varies by up to one day. The annual summary of the 2016 IMO Video Meteor Network observations is presented. More than 474 000 meteors were recorded in almost 114 000 hours of observing time.

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1 Introduction

A year with unusually nice weather ended with an unusually successful December. The statistics show a few gaps in the second half of the month, but overall there are a number of dense observing intervals which – in connection with the long winter nights – led to a record-breaking outcome. 81 video cameras participated in the IMO Network in December, whereby 51 of these managed to observe in twenty or more observing nights (Table 4 and Figure 1). The overall effective observing time increased by more than 30% compared to the previously best December of 2015, and it fell only 3% short of the all-time high month of September 2016. Because of the full moon, which ruined the most important shower, we saw "only" an increase of 5% in meteor counts compared to December 2015.

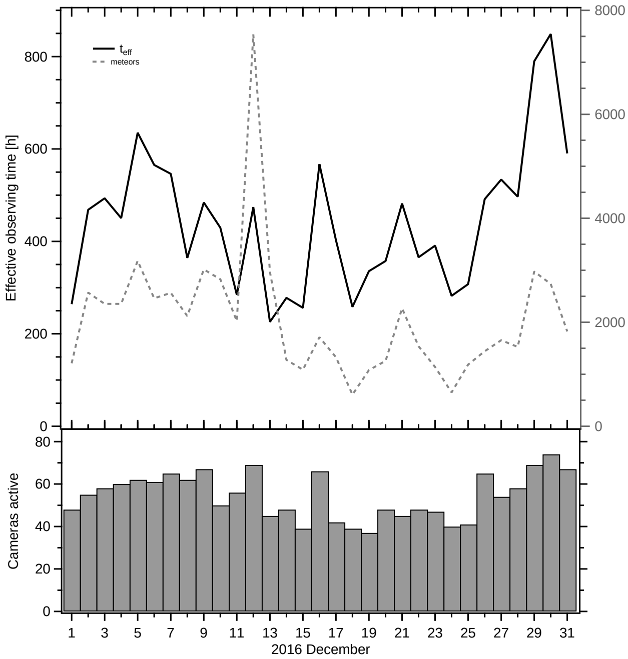

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2016 December.

2 November Orionids

Let us start the detailed analysis with the November Orionids (250 NOO) that were added only recently to the IMO working list of meteor showers (Rendtel, 2015). In our 2012 meteor shower analysis (Molau et al., 2013), we safely detected this shower between November 14 and December 7. At the end of November it is the strongest source in the sky. We re-processed all data since 2011 to obtain an activity profile of this shower. Figure 2 compares the average profile of 2011–2015 with 2016. As in the case of many showers, the ascending branch is somewhat shallower than the descending branch. The average profile shows a continuous increase up to the peak exactly at the end of November ($\lambda_{\odot} = 248°$). The flux density reaches 2 meteoroids per 1 000 km^2 per hour, which is equivalent to a ZHR of about 10. Thereafter the activity is declining, however, the shower could probably still be detected a few days after December 7.

In 2016, the shower behaved similarly – only the peak activity was somewhat lower.

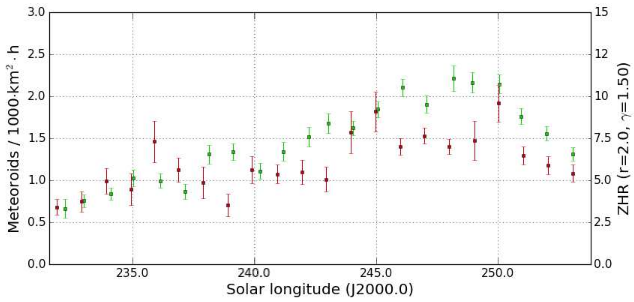

Figure 2 – Comparison of the flux density of the November Orionids 2016 (red) with the average of the years 2011–2015 (green), derived from video data of the IMO Video Meteor Network.

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NASA-ADS bibcode 2017JIMO...45...56M

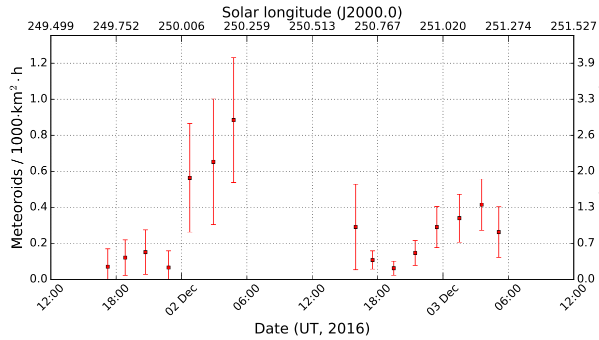

Figure 3 – Flux density profile of the 66 Draconids 2016, derived from video data of the IMO Video Meteor Network.

3 66 Draconids

The second possibly interesting shower is the 66 Draconids (541 SSD). Based on Croatian investigations to link meteoroid streams to parent bodies and a simulation of J. Vaubaillon, there was a chance that this shower would show slightly enhanced activity in the evening of December 2 and morning of December 3 (Šegon et al., 2017). Even though the first date was within the European observing window, the shower was practically untraceable (Figure 3). In the morning hours of December 2, we see indeed a minor increase in rates, but that is one day earlier than predicted and not significant, anyway, since every data point is comprised of only about ten shower members. Thus, we could not confirm any relevant activity of the 66 Draconids.

4 Geminids

Let us turn to the 2016 Geminids which happened to coincide with full moon (Figure 4). Here we see an interesting result. Not only the high peak activity of up to 200 meteoroids per 1 000 km^2 per hour is exceptional, but there is also a double-maximum with peaks on December 13 near $21^{\mathrm{h}}00^{\mathrm{m}}$ UT (solar longitude $262^{\circ}\!.06$) and December 14 near $02^{\mathrm{h}}00^{\mathrm{m}}$ UT (solar longitude $262^{\circ}\!.28$). In-between we see a “minimum” at $23^{\mathrm{h}}30^{\mathrm{m}}$ UT (solar longitude $262^{\circ}\!.17$) that nearly matches the usual Geminid peak activity.

A comparison with past maxima confirms that the 2016 activity exceeds the fluctuations of previous years significantly (Figure 5).

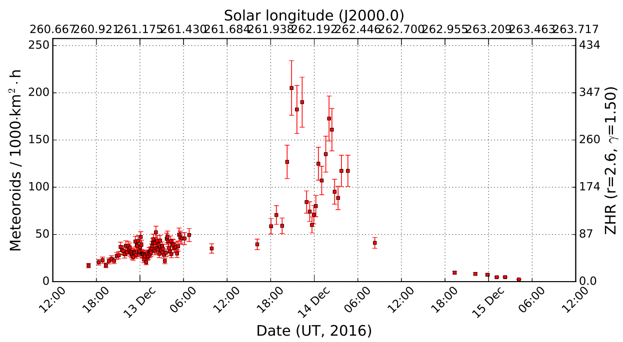

Figure 4 – Activity profile of the 2016 Geminid peak, derived from video data of the IMO Video Meteor Network.

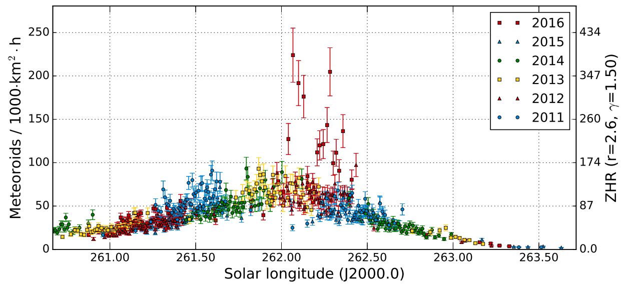

Figure 5 – Activity profiles of the Geminid peaks 2011–2016.

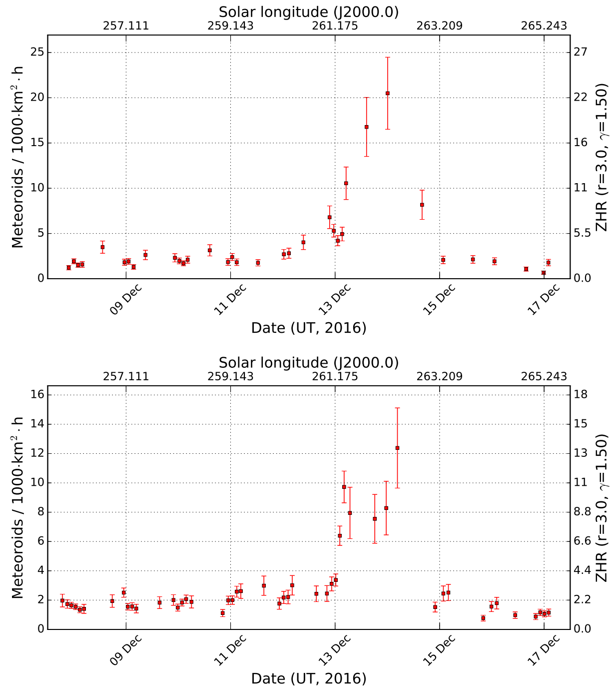

Figure 6 – Flux density profile of the Monocerotids (top) and the Antihelion source (bottom) in December 2016, derived from video data of the IMO Video Meteor Network.

Note that the weather was quite poor at the night of maximum which can be seen from less dense data points than in the night before (Figure 4). Whereas we recorded almost 10 000 meteors in the Geminid peak night of 2015, it was only 3 000 meteors this time.

Unfortunately, we cannot check visual observations for comparison, since hardly any observer was active under those conditions. However, both the activity profile of the Monocerotids (Figure 6, top) and the Antihelion source (Figure 6, bottom) show similarly unusual activity at the same time. Hence, we can be quite sure even without visual confirmation, that the unusual activity is an artifact of poor observing conditions.

5 Ursids

Just before Christmas, the Ursids sometimes present unexpected activity peaks. There was no prediction for very high activity in 2016, but model calculations by J. Vaubaillon hinted at possibly enhanced rates close to midnight UT of December 22/23 and 23/24 (Rendtel, 2015). On the other hand, the activity increased clearly

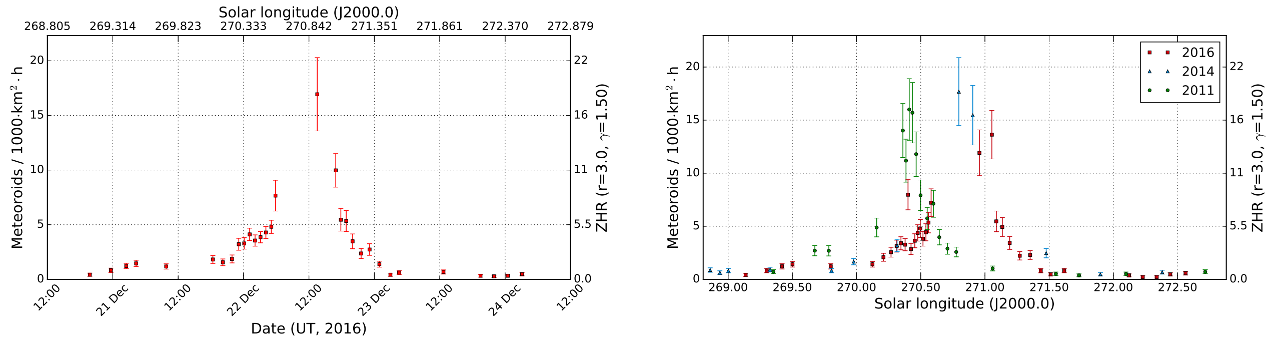

Figure 7 – Flux density profile of the Ursids 2016 (left) and comparison between 2011, 2014 and 2016 (right), derived from video data of the IMO Video Meteor Network.

towards dawn of December 22 and dropped significantly in the evening of that same day (Figure 7, left). The data point in-between is not significant, since we have only two cameras in that time zone. A comparison with the profiles of previous years (Figure 7, right) shows that the activity of 2016 was in fact not unusual. In 2011 and 2014 we observed similar or even higher peaks – only the time of maximum varies by up to a day.

6 2016 summary

As usual we want to review the last year at the end of the December report. For the first time in many years, the number of observers and video cameras decreased clearly, which can be attributed mainly to the loss of Hungarian observers. 44 observers (2015: 48) from 12 countries (2015: 14) with a total of 85 meteor cameras (2015: 92) contributed to the IMO Network in 2016. Whereas in Germany the number of cameras increased by one to 20, we see Hungary (9 cameras) relapse to fifth place behind Portugal (14), Italy (13) and Slovenia (11). They are followed by Poland (5) and Spain (4), Holland and the USA (each 2) as well as Greece, Finland, and Russia with one camera each.

In 366 observing nights (2015: 365) and 113 937 hours of effective observing time (2015: 121 853) we recorded a total of 474 658 meteors (2015: 480 362). The decrease in the number of cameras lead to a reduction of effective observing time by almost 7% but the meteor count remained effectively the same. Indeed, the balance of 2016 was for a long time better than in the year before. It was October/November and the poor lunar phase for all relevant showers in fall and winter which changed the game. In the end, we owe the great output to the unusually pleasant weather and to the four video cameras of Detlef Koschny in the Canary Islands, which were remarkably successful. The average hourly meteor rate in the IMO Network increased from 3.9 in 2015 to 4.2 in 2016.

Table 1 shows the monthly distribution of observations. The average number of observing hours per month dropped below 10 000 again, but September, December and August 2016 rank first, second and fourth in the long-term statistics of the IMO Network. Also, those almost 100 000 meteors we collected in August (Molau et al., 2017) were by far the best monthly output ever.

Eight observers managed to collect over 300 observing nights in 2016. For most of the time, Detlef Koschny spearheaded the statistics and was on track to top his own record from the year before (351 nights). However, in the middle of December all of his four cameras broke down due to a technical problem so that he had to surrender to his closest rival in the home straight and finished with 340 nights. Sirko Molau pushed his best result by five to a total of 347 observing nights, and

Table 1 – Monthly distribution of video observations in the IMO Network 2016.

Month	Observing Nights	Eff. Observing Time	Meteors	Meteors / Hour
January	31	9 087.7	27 969	3.1
February	29	7 024.8	15 526	2.2
March	31	8 296.6	17 512	2.1
April	30	7 717.5	16 606	2.2
May	31	7 013.1	17 402	2.5
June	30	6 977.6	21 916	3.1
July	31	8 742.2	42 142	4.8
August	31	12 251.8	98 386	8.0
September	30	14 146.1	62 458	4.4
October	31	9 184.1	47 491	5.2
November	30	9 774.9	42 776	4.4
December	31	13 720.5	64 474	4.7
Overall	366	113 936.9	474 658	4.2

Table 2 – Distribution of video observations over the observers in 2016.

Observer	Country	Observing Nights	Eff. Observing Time [h]	Meteors	Meteors / h	Cameras (Stations)
Sirko Molau	Germany	347	9 309.0	50 677	5.4	7 (2)
Detlef Koschny	Netherlands	340	7 804.9	75 865	9.7	4 (2)
Rui Goncalves	Portugal	339	11 669.6	37 588	3.2	6 (1)
Rui Marques	Portugal	319	4 082.5	14 101	3.5	2 (1)
Carl Hergenrother	USA	318	2 711.1	6 932	2.6	1 (1)
Enrico Stomeo	Italy	316	4 939.0	30 025	6.1	3 (1)
Stefano Crivello	Italy	315	5 405.0	29 811	5.5	3 (1)
Carlos Saraiva	Portugal	310	7 867.5	19 733	2.5	4 (1)
Jörg Strunk	Germany	293	6 344.8	19 230	3.0	5 (1)
Bernd Klemt	Germany	292	2 690.5	8 808	3.3	2 (2)
Rainer Arlt	Germany	288	1 401.8	8 480	6.0	1 (1)
Jenni Donati	Italy	282	1 800.8	10 682	5.9	1 (1)
Mario Bombardini	Italy	282	1 754.1	8 969	5.1	1 (1)
Istvan Tepliczky	Hungary	279	3 218.9	9 092	2.8	2 (1)
Flavio Castellani	Italy	278	2 681.9	8 521	3.2	2 (1)
Mitja Govedič	Slovenia	273	3 092.2	7 861	2.5	3 (1)
József Morvai	Hungary	272	1 797.8	3 296	1.8	1 (1)
Antal Igaz	Hungary	271	1 622.7	3 696	2.3	2 (2)
Maciej Maciejewski	Poland	267	4 989.2	20 959	4.2	4 (1)
Martin Breukers	Netherlands	260	1 475.2	3 654	2.5	1 (1)
Hans Schremmer	Germany	259	1 381.2	4 487	3.2	1 (1)
Karoly Jonas	Hungary	257	2 987.3	6 776	2.3	1 (1)
Mike Otte	USA	247	1 386.9	2 675	1.9	1 (1)
Zsolt Perkó	Hungary	236	1 216.9	6 364	5.2	1 (1)
Leo Scarpa	Italy	232	1 249.8	2 496	2.0	1 (1)
Fabio Moschini	Italy	233	258.8	1 713	6.6	1 (1)
Stane Slavec	Slovenia	231	2 353.8	4 919	2.1	2 (1)
Javor Kac	Slovenia	227	5 102.2	25 726	5.0	5 (3)
Maurizio Eltri	Italy	220	1 350.0	5 752	4.3	1 (1)
Mihaela Triglav	Slovenia	219	928.9	2 231	2.4	1 (1)
Alvaro Lopes	Portugal	214	1 333.4	1 622	1.2	1 (1)
Kevin Förster	Germany	193	1 111.0	4 526	4.1	1 (1)
Eckehard Rothenberg	Germany	176	672.9	1 776	2.6	1 (1)
Grigoris Maravelias	Greece	151	886.9	1 809	2.0	1 (1)
Tomasz Lojek	Poland	146	845.3	3 342	4.0	1 (1)
Mikhail Maslov	Russia	146	592.4	3 269	5.5	1 (1)
Ilkka Yrjölä	Finland	144	735.9	2 305	3.1	1 (1)
Erno Berkó	Hungary	116	844.7	6 567	7.8	1 (1)
Maurizio Carli	Italy	114	724.8	2 789	3.8	1 (1)
Péter Bánfalvi	Hungary	100	246.2	627	2.5	1 (1)
Wolfgang Hinz	Germany	93	606.3	2 674	4.4	1 (1)
Wala Węgrzyk	Poland	78	440.9	1 726	3.9	1 (1)
other	—	2	6.3	492	78.1	1 (1)
Paolo Ochner	Italy	2	15.6	15	1.0	1 (1)

with 339 nights Rui Goncalves had two nights less on his balance than in the year before. There was only minor motion in the following ranks, but Rui Marques, Carl Hergenrother, Enrico Stomeo, Stefano Crivello and Carlos Saraiva all managed to cross the 300 nights' mark.

Regarding the effective observing time, the picture of the past few years has not changed. Rui Goncalves collected over 10 000 observing hours, and he was followed again by Sirko Molau and Carlos Saraiva.

Until December 2016, Detlef Koschny had already recorded so many meteors that the technical defect of his cameras did not cost him the first place with respect to the meteor count. In fact, with over 75 000 meteors he was at such a distance that he recorded almost as many meteors as second ranked Sirko Molau and third ranked Rui Goncalves together. Another eight observers contributed more than 10 000 meteors to the overall output.

Table 2 gives the details for all active IMO Network observers. The number of cameras and stations refers to the main part of 2016.

Looking at the list of the ten most successful cam-

Table 3 – The ten most successful video systems in 2016.

Camera	Location	Observer	Observing Nights	Eff. Observing Time [h]	Meteors	Meteors / h
Templar5	Tomar (PT)	Rui Goncalves	320	2 100.4	7 927	3.7
Templar1	Tomar (PT)	Rui Goncalves	317	2 369.8	9 615	4.1
Salsa3	Tucson (US)	Carl Hergenrother	316	2 711.1	6 932	2.6
Templar2	Tomar (PT)	Rui Goncalves	314	2 369.7	7 922	3.3
Templar4	Tomar (PT)	Rui Goncalves	312	2 234.0	7 846	3.5
Stg38	Valbrevenna (IT)	Stefano Crivello	307	2 002.1	14 100	7.0
Sco38	Scorze (IT)	Enrico Stomeo	300	1 707.3	11 288	6.6
Remo2	Ketzür (DE)	Sirko Molau	299	1 593.5	9 135	5.7
Noa38	Scorze (IT)	Enrico Stomeo	297	1 654.2	8 719	5.3
Remo1	Ketzür (DE)	Sirko Molau	297	1 557.3	10 744	6.9

eras of 2016, we see almost the same entries as in the year before (Table 3). Meanwhile a camera has to collect almost 300 observing nights to rank in the Top-10!

The following cameras are not listed in Table 3, but still recorded more than 10 000 meteors each: Lic2 (24 520), Icc9 (20 888), Lic1 (18 244), Icc7 (12 014), Jenni (10 682) and Min38 (10 018).

The complete data set from 1993 to 2016 is available for download at the IMO Video Meteor Network homepage `http://www.imonet.org`. Currently the database contains 3 088 953 meteors from 748 283 hours of effective observing time in 6 104 nights.

As always, we like to thank our observers for their passion, which is the basis for the success of the IMO Network. Special thanks to Stefano Crivello, Enrico Stomeo, Rui Goncalves, Carlos Saraiva and Maciej Maciejewski, who check every month together with Sirko Molau the data consistency and guarantee the high quality of the database.

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Table 4 – Observers contributing to 2016 December data of the IMO Video Meteor Network. Eff.CA designates the effective collection area; the overall number of nights is the number of nights with at least one camera operating, the overall observing time and number of meteors are sums over all cameras.

Code	Name	Location	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig2 (0.8/8)	1475	6.2	3779	24	143.2	1051
BANPE	Bánfalvi	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	9	50.3	90
BERER	Berkó	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	16	151.9	1408
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	22	184.2	864
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	19	158.1	483
BRIBE	Klemt	Herne/DE	Hermine (0.8/6)	2374	4.2	678	23	186.9	733
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	22	189.1	720
CARMA	Carli	Monte Baldo/IT	Bmh2 (1.5/4.5)*	4243	3.0	371	11	109.4	441
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	21	238.8	1354
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	28	256.0	1809
			C3P8 (0.8/3.8)	5455	4.2	1586	26	224.4	1205
			Stg38 (0.8/3.8)	5614	4.4	2007	25	239.1	2309
DONJE	Donani	Faenza/IT	Jenni (1.2/4)	5886	3.9	1222	21	188.8	966
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	19	168.1	642
FORKE	Förster	Carlsfeld/DE	Akm3 (0.75/6)	2375	5.1	2154	21	171.4	888
GONRU	Goncalves	Foz do Arelho/PT	Farelho1 (1.0/2.6)	6328	2.8	469	10	111.0	100
		Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	30	298.7	1376
			Templar2 (0.8/6)	2080	5.0	1508	30	308.8	1271
			Templar3 (0.8/8)	1438	4.3	571	28	298.3	570
			Templar4 (0.8/3.8)	4475	3.0	442	30	294.6	1208
			Templar5 (0.75/6)	2312	5.0	2259	30	288.5	1286
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			Orion4 (0.95/5)	2662	4.3	1043	20	132.0	399
HERCA	Hergenrother	Tucson/US	Salsa3 (0.8/3.8)	2336	4.1	544	27	233.6	863
HINWO	Hinz	Schwarzenberg/DE	Hinwo1 (0.75/6)	2291	5.1	1819	22	193.2	799
IGAAN	Igaz	Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	17	119.2	485
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	21	146.6	269
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	20	164.2	680
			Husor2 (0.95/3.5)	2465	3.9	715	20	175.0	629
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1399	3.8	268	25	217.4	544
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			Rezika (0.8/6)	2270	4.4	840	26	233.7	2368
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		Kostanjevec/SI	Metka (0.8/12)*	715	6.4	640	20	180.2	527
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	12	84.7	637
			Lic1 (2.8/50)*	2255	6.2	5670	15	122.1	1118
		La Palma/ES	Icc9 (0.85/25)*	683	6.7	2951	10	72.0	825
			Lic2 (3.2/50)*	2199	6.5	7512	11	79.0	808
LOJTO	Łojek	Grabniak/PL	Pav57 (1.0/5)	1631	3.5	269	10	66.1	331
LOPAL	Lopes	Lisbon/PT	Naso1 (0.75/6)	2377	3.8	506	2	11.9	18

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			Pav36 (0.8/3.8)*	5668	4.0	1573	18	105.9	444
			Pav43 (0.75/4.5)*	3132	3.1	319	19	56.2	394
			Pav60 (0.75/4.5)	2250	3.1	281	17	97.3	696
MARRU	Marques	Lisbon/PT	Cab1 (0.75/6)	2362	4.8	1517	31	321.7	1415
			Ran1 (1.4/4.5)	4405	4.0	1241	28	281.2	1171
MASMI	Maslov	Novosibirsk/RU	Nowatec (0.8/3.8)	5574	3.6	773	3	15.3	49
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	17	108.2	1228
			Escimo2 (0.85/25)	155	8.1	3415	16	108.8	454
			Mincam1 (0.8/8)	1477	4.9	1084	16	102.9	979
		Ketzür/DE	Remo1 (0.8/8)	1467	6.5	5491	25	141.8	1209
			Remo2 (0.8/8)	1478	6.4	4778	25	148.4	1148
			Remo3 (0.8/8)	1420	5.6	1967	24	156.6	753
			Remo4 (0.8/8)	1478	6.5	5358	6	39.3	268
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	17	160.2	523
MOSFA	Moschini	Rovereto/IT	Rover (1.4/4.5)	3896	4.2	1292	29	63.7	463
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	18	125.5	305
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	22	130.9	807
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	18	122.7	278
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	26	260.7	679
			Ro2 (0.75/6)	2381	3.8	459	27	263.3	1069
			Ro3 (0.8/12)	710	5.2	619	28	244.6	1163
			Ro4 (1.0/8)	1582	4.2	549	25	250.6	531
			Sofia (0.8/12)	738	5.3	907	29	269.2	787
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	17	130.6	234
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	25	190.4	650
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	24	194.5	746
			Kayak2 (0.8/12)	741	5.5	920	22	194.2	282
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	26	213.9	1202
			Noa38 (0.8/3.8)	5609	4.2	1911	26	217.0	1121
			Sco38 (0.8/3.8)	5598	4.8	3306	26	217.0	1370
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2354	5.4	2751	24	175.3	1061
			Mincam3 (0.8/6)	2338	5.5	3590	23	159.7	542
			Mincam4 (1.0/2.6)	9791	2.7	552	15	129.7	143
			Mincam5 (0.8/6)	2349	5.0	1896	23	170.9	543
			Mincam6 (0.8/6)	2395	5.1	2178	22	159.0	561
TEPIS	Tepliczky	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	20	199.2	867
			Humob (0.8/6)	2388	4.8	1607	20	188.6	1016
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	24	171.0	429
WEGWA	Wegrzyk	Nieznaszyn/PL	Pav78 (0.8/6)	2286	4.0	778	24	175.0	653
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	13	97.9	363
* active field of view smaller than video frame						Overall	31	13 720.5	64 474

Results of the IMO Video Meteor Network — January 2017

Sirko Molau[1], *Stefano Crivello*[2], *Rui Goncalves*[3], *Carlos Saraiva*[4], *Enrico Stomeo*[5], *and Javor Kac*[6]

The IMO Video Meteor Network collected over 33 000 meteors in almost 11 900 hours of observing time in 2017 January. The maximum of the Quadrantids occurred during the daytime hours for the Network cameras and consequently the flux density profile only shows the ascending and descending branches. The flux density profiles are presented for the γ-Ursae Minorids of 2016 and 2017, which show a maximum near solar longitudes 299° and 300°.

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1 Introduction

The year starts with long nights for the IMO video observers, but also with typically poor observing conditions. This year the weather was mediocre but still above par for January which led to the best January output in the history of the IMO Network. We counted a total of 77 active cameras, half of which with twenty or more observing nights. On January 6 and 21 we had 65 cameras in operation (Table 1 and Figure 1). The effective observing time totalled almost 11 900 hours, which is 2 000 more than in the previously best January of 2012. With over 33 000 meteors, we recorded 10% more than in 2012.

There were no new cameras, but operation of the Italian camera Jenni was taken over by Francesca Cineglosso at the begin of year.

2 Quadrantids

To get a nice display from the most important meteor shower of January, which is also the last major shower for half a year, you need three prerequisites: a convenient lunar phase, pleasant weather and a peak during the European night time hours. The first two conditions were met in 2017, but the peak occurred during the noon hours UT of January 3. Hence we could only observe the increase in rates on the night before, and the decrease on the night after the peak. The peak activity as such could not be recorded by us (Figure 2).

It is difficult to estimate the strength of the peak from these data, but the ascending and descending branches were similar to the data set of 2012 and 2015, when the activity was below the average (Figure 3). That fits in with visual observations. The automated analysis of visual data at the IMO homepage (IMO, 2017) yields a peak ZHR of 80 – in vintage years the ZHR may reach values twice as high!

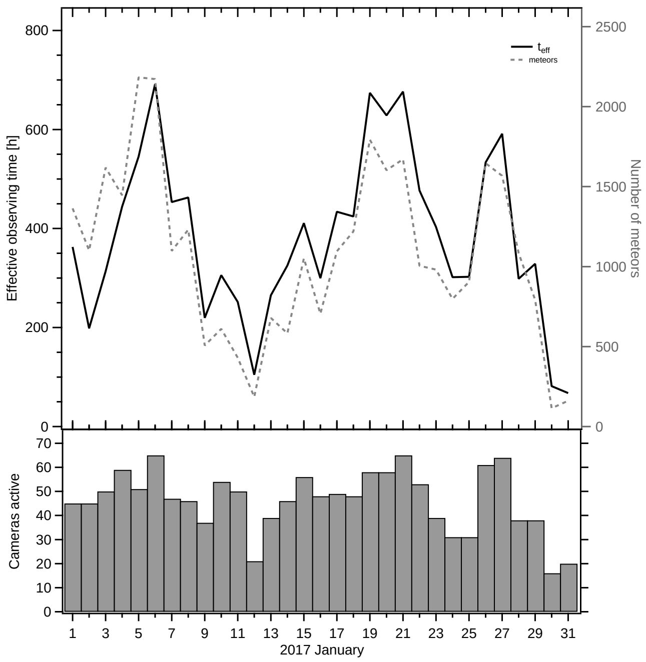

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2017 January.

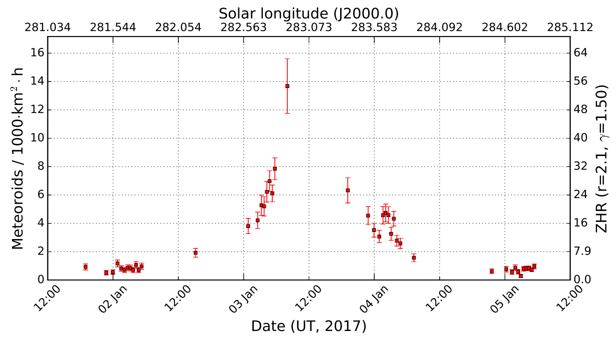

Figure 2 – Flux density profile of the Quadrantids in 2017 January, derived from video data of the IMO Network.

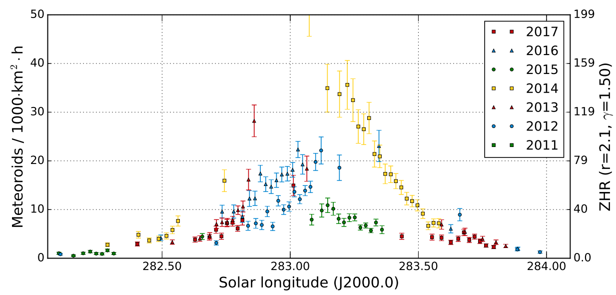

Figure 3 – Comparison of the flux density profile of the Quadrantids 2011 to 2017.

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[2] Via Bobbio 9a/18, 16137 Genova, Italy. Email: `stefano.crivello@libero.it`

[3] Urbanizacao da Boavista, Lote 46, Linhaceira, 2305-114 Asseiceira, Tomar, Portugal. Email: `rui.goncalves@ipt.pt`

[4] Rua Aquilino Ribeiro, 23 - 1 Dto. 2790028 Carnaxide, Portugal. Email: `carlos.saraiva@netcabo.pt`

[5] via Umbria 21/d, 30037 Scorze (VE), Italy. Email: `stom@iol.it`

[6] Na Ajdov hrib 24, 2310 Slovenska Bistrica, Slovenia. Email: `javor.kac@orion-drustvo.si`

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NASA-ADS bibcode 2017JIMO...45...63M

3 κ-Cancrids

In 2015, the Canadian CMOR radar detected a short, but intense outburst of the κ-Cancrids (Brown, 2016). Unfortunately, the peak of this shower, at 289°.3 solar longitude, also occurred during European daytime hours. Nevertheless, we still re-calculated the meteor shower assignment during January 9 and 10 but the activity of the shower remained negligible as expected.

4 γ-Ursae Minorids

The γ-Ursae Minorids were also checked in detail. This minor shower was discovered by CMOR in 2010 (Brown et al., 2010) and could be detected visually last year, despite video observations only revealing low activity level near the detection limit (Molau et al., 2016). That picture did not change in 2017. Once more we measured a flux density below one meteoroid per 1 000 km^2 per hour at 299° and 300° solar longitude (Figure 4). That is equivalent to a ZHR below one.

Surprisingly even such a weak shower presents a high-quality activity profile with little scatter only. It is not so much the absolute activity level but rather the effective collection area of the camera network that is essential here, and in this respect the shower seems well positioned with its circumpolar radiant and the long January nights. How favourable the conditions really are was verified via this simple analysis. We compared the typical effective collection area of the γ-Ursae Minorids with that for some major showers (QUA, ETA, PER, GEM). In order to get a representative picture, we calculated the total collection area of the four cameras Remo1–4 (which point in all four directions at about 45° altitude) near Berlin under normalized observing conditions (constant limiting magnitude of 6.3 mag) for the peak night of each shower.

It is no surprise that the Geminids yield a perfect result, since their radiant is well positioned during the long December nights. Surprisingly, however, the Quadrantids perform a few percent better, despite typically not being observed before midnight. At 52° northern latitude, the radiant is circumpolar and has an altitude of more than 10°, even at the lower culmination. It is not too far away from the center of field of view of the cameras, which causes a lower angular meteor velocity, and at dawn the radiant lies close to the zenith.

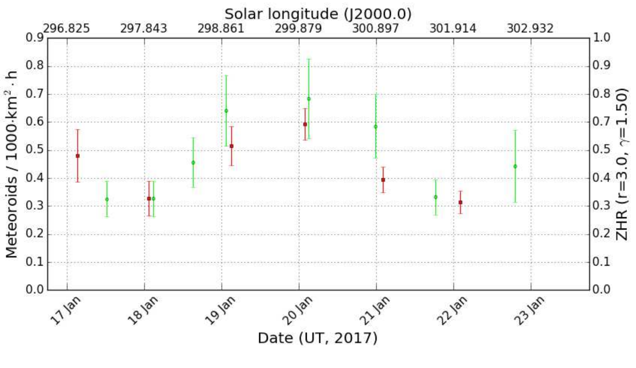

Figure 4 – Comparison of the flux density profile of the γ-Ursae Minorids in 2016 (green) and 2017 (red).

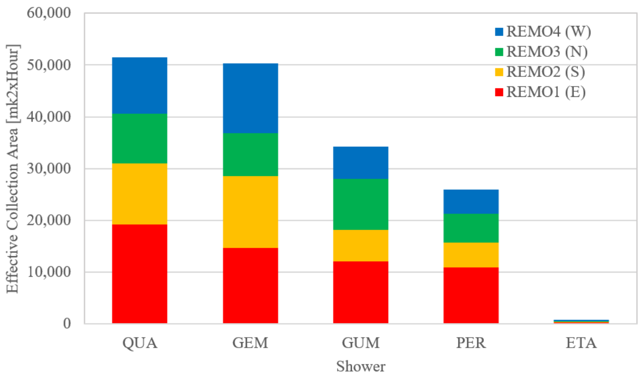

Figure 5 – Effective collection area of the cameras Remo1, Remo2, Remo3 and Remo4 per night under normalized conditions (same limiting magnitude) for the peaks of different meteor showers.

With over 34 000 km^2 per hour, the collection area of the γ-Ursae Minorids is by 1/3 smaller than that of the Geminids, and the collection area of the Perseids only half that of the Geminids. For comparison: the η-Aquariids accumulated less than 1 000 km^2 per hour in this experiment!

It is also noteworthy how the cameras perform in comparison to each other. Remo1 observing eastward has always the biggest effective collection area, since the combination of radiant altitude and distance from center of field of view is best here. In case of the Quadrantids, Perseids and η-Aquariids, the other three cameras each have roughly the same collection area. During the Geminids, the northward directed camera Remo3 is clearly inferior to the southward oriented Remo2 and westward oriented Remo4, and in case of the γ-Ursae Minorids it is just the other way around (Figure 5).

Overall the γ-Ursae Minorids are well positioned for IMO Network video observers and this explains the fine quality of the data set.

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			Remo3 (0.8/8)	1420	5.6	1967	20	146.4	323
			Remo4 (0.8/8)	1478	6.5	5358	21	143.9	574
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	17	148.9	180
MOSFA	Moschini	Rovereto/IT	Rover (1.4/4.5)	3896	4.2	1292	4	9.0	59
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	11	72.4	91
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	21	134.8	439
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	18	104.5	145
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	26	219.7	336
			Ro2 (0.75/6)	2381	3.8	459	23	216.5	486
			Ro3 (0.8/12)	710	5.2	619	24	222.6	637
			Ro4 (1.0/8)	1582	4.2	549	22	207.4	229
			Sofia (0.8/12)	738	5.3	907	24	237.1	381
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	25	195.3	296
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	20	171.8	333
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	11	89.6	221
			Kayak2 (0.8/12)	741	5.5	920	15	133.4	136
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	27	243.8	1145
			Noa38 (0.8/3.8)	5609	4.2	1911	28	253.0	1070
			Sco38 (0.8/3.8)	5598	4.8	3306	27	253.8	1298
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2354	5.4	2751	18	115.6	495
			Mincam3 (0.8/6)	2338	5.5	3590	15	109.2	222
			Mincam5 (0.8/6)	2349	5.0	1896	15	113.2	209
			Mincam6 (0.8/6)	2395	5.1	2178	16	108.8	249
TEPIS	Tepliczky	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	15	128.8	229
			Humob (0.8/6)	2388	4.8	1607	17	180.0	312
WEGWA	Wegrzyk	Nieznaszyn/PL	Pav78 (0.8/6)	2286	4.0	778	16	148.3	243
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	12	98.7	213
* active field of view smaller than video frame						Overall	31	11 877.8	33 403

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