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Preliminary results

History

Front cover photo

Fireball of about magnitude −6 to −8 as photographed on 2011 May 4 at $23^{h}10^{m}46^{s}$ UT from Erkner, Germany. The author used a Canon 40D, 180 s exposure at IS0 800, EF-S 10–22 mm $f/3.5$–4.5 USM lens set to 13 mm and $f/4.0$, all mounted on a H-EQ5 mount. Photo courtesy: Jens-Uwe Köhler.

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 **31:4**, 124–128, and at `http://www.imo.net/articles/writingforwgn.pdf` .

Cover design Rainer Arlt

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Editorial — Draconids, a future strong shower

Javor Kac

Strong meteor showers and meteor storms are one of the finest celestial displays that nature can offer. The most recent examples include the Leonid meteor storms about a decade ago. Meteor storms have always sparkled public interest in meteors and astronomy in general. They were also often the drivers for research in meteor astronomy. One of the challenges has always been predicting the meteor outbursts. This task has been attempted since the 19th century but had various success rates. The first outbursts based on dust trail models were those of the Leonids during the 1998 perihelion epoch. Such models are now used to predict numerous meteoroid streams from short-period comets.

Several studies predict that there will be an outburst of the Draconids on October 8 this year. While some studies do not anticipate a strong outburst, others predict a very strong shower with a ZHR of several hundreds. Two such studies, authored by Vaubaillon et al. (2011) and Maslov (2011) are presented in this issue of *WGN*.

Despite the strong Moon interference, all observers are urged to take part in the campaign. All modes of observations can contribute valuable data to help fully understand this meteoroid stream. Of course, if the strong shower occurs, it should present a splendid visual experience as well.

According to Jenniskens (2006), the next outburst of the Leonid is not expected until 2034. Before that, we may witness strong meteor showers or even meteor storms from the Perseids in 2016, Ursids in 2020, τ-Herculids in 2022 and Perseids in 2027 and 2028.

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Ingo Reimann (1939–2011)

WGN Editorial Team

We were informed that one of our long-time members, Ingo Reimann (1939–2011) passed away on May 18. His interests were mainly in radio observing. We offer our sincerest condolences to his family.

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Letter — Reply: Meteors in Australian Aboriginal Dreamings

Duane W. Hamacher [1]

In response to the letter by Gorelli (2010) about Hamacher & Norris (2010), he is quite right about Aboriginal people witnessing impact events in Australia. There are several oral traditions regarding impact sites, some of which were probably witnessed, as Gorelli pointed out. The Henbury craters he mentions, with a young age of only ~ 4200 years, have oral traditions that seem to describe a cosmic impact, including an aversion to drinking water that collects in the craters in fear that the fire-devil (which came from the sun, according to an Elder) would rain iron in them again. Other impact sites, such as Gosse's Bluff crater (Tnorala in the Arrernte language) and Wolfe Creek crater (Kandimalal in the Djaru language) have associated impact stories, despite their old ages (142 Ma and ~ 0.3 Ma, respectively).

In addition, many fireball and airburst events are described in Aboriginal oral traditions, a number of which seem to indicate impact events that are unknown to Western science. I have published a full treatise of meteorite falls and impact events in Australian Aboriginal culture that I would like to bring to the attention of Gorelli and *WGN* readers (Hamacher & Norris, 2009). Although our paper was published in the 2009 volume of *Archaeoastronomy*, it did not appear in print until just recently, which is probably why it has gone unnoticed. Recent papers describing the association between meteorites and Aboriginal cosmology (Hamacher, 2011) and comets in Aboriginal culture (Hamacher & Norris, 2011) have also been published, and would likely be of interest to *WGN* readers.

I heartily agree with Gorelli that oral traditions are fast disappearing, taking with them a wealth of information about not only that peoples' culture, but also about past geologic and astronomical events, such as meteorite falls and cosmic impacts (a branch of the growing field of *Geomythology*). There is an old saying that 'when a man dies, a library goes with him'. This is certainly the case in Australia, and along with Gorelli, I encourage *WGN* readers to get involved in studying meteoritic events in oral traditions. There is a lot of information regarding meteoritical events and phenomena in the literature that is still waiting to be collected and analysed ... and I applaud McBeath for his pursuit to publish this material through the successful *Meteor Beliefs Project*!

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Draconids

The coming 2011 Draconids meteor shower

Jérémie Vaubaillon[1], *Junichi Watanabe*[2], *Mikiya Sato*[3], *Shun Horii*[4] *and Pavel Koten*[5]

A detailed analysis of the coming 2011 Draconids outburst is performed with different methods. The first step was to post predict the 1933 and 1946 storms. Difficulties arise when dealing with the 1985 outburst, since no unique orbital solution is able to explain the different outbursts observed during this year. This fact emphasizes our need to better know the parent body comet 21P/Giacobini-Zinner. Fortunately, the coming outburst will be caused by the trails ejected in 1980 and 1907, already encountered in the past. No storm is expected, but the level of the shower is poorly constrained. A first highly entertaining outburst is expected on 2011 October 8 around 17^{h} UT. The second and the main outburst is expected around 20^{h} UT the same day. The level of the shower will be of a few hundreds (around 600 per hour).

Received 2011 May 30

1 Introduction

The Draconids is a meteor shower happening in early October, for which the parent body is the Jupiter family Comet 21P/Giacobini-Zinner, discovered in 1900. Both the comet and the meteor shower are peculiar. The comet is the most carbon depleted, and the meteors are known to be the slowest and the most fragile of all. In the past, the Draconids have shown several outbursts. The most famous of all happened in 1933 and 1946, there were reports then to show that there has been as many as 10 000 meteors per hour. More recently, the 2005 outburst took everybody by surprise for two reasons: first it was not expected, and second it mostly dealt with tiny particles (roughly in the range 10 to 100 μm), making the meteors mostly visible with radio techniques (Campbell-Brown et al., 2006).

In the past few years, there have been many announcements of another outburst expected in October 2011. In particular, Watanabe and Sato (2008) have shown that a change of activity of the comet is needed in order to explain the past outburst and have forecasted a level of a few hundreds of meteors per hour.

The goal of this paper is first to further investigate the coming 2011 outburst by providing a complete analysis, and second to alert the scientific community and encourage observations. Indeed, the level of a future meteor shower is one of the hardest aspects to forecast. This is usually the only trigger to motivate hundreds or even thousands of people to observe, or justify large expeditions such as the past Leonids MAC for example.

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2 Method

An approach by Sato and Horii is based on Sato (2003) and Horii et al. (2008) the simplest simulation of dust trail theory (e.g., Asher, 2000) is used. The particles of meteoroids were ejected parallel to the body motion, both ahead of and behind the comet at each perihelion. The ejection velocity was set to be within the range $[-30; +30]$ m/s, where "+" is in the direction of the body's motion and "−" in the opposite direction. We did not take into account the effect of radiation pressure. We used orbital elements calculated by Kinoshita (2008) 20 perihelion passages of the comet from 1880 until 2005 are included in it.

Vaubaillon's approach is based on (Vaubaillon et al., 2005): heavy computer simulations that mimic the ejection and the evolution of the meteoroid stream in the solar system. The downfall of this approach is that level of the shower is based on the photometric observations of the parent body. In this case, we know that the activity has drastically changed in the past, making this approach not as efficient as for the Leonids for example. Nevertheless, it is possible to calibrate the model based on past observations. The simulations were performed at the CINES supercomputer facility (France) and involved 24 perihelion passages of the comet, from 1852 until 2005. For each passage, three size bins in the range $\left[10^{-4}; 10^{-1}\right]$ m of each 50 000 particles were ejected.

3 Preliminary results: post-predictions

In order to validate the models we post-predicted the 1933 and 1946 storms. Both the models successfully predicted the storms at the right date. Figures 1 and 2 show the encounter between the stream and the Earth.

The 1933 storm was caused by the 1900 and the 1907 trails. They were respectively five and four revolutions old, that is very young. The trails were not perturbed by Jupiter, and therefore were very dense. In addition, they fall at exactly the same location on the path of the earth. In a sense, this storm was similar to the 2001 Leonids, except that the stream was coming from a Jupiter family comet.

Table 1 – Circumstances of the 1933 and 1946 Draconids storms. Negative distance to the Earth (δr) means Earth is closer to the Sun than the trail.

Year	Trail	Nrev	by JV			by MS
			δr (AU)	$\lambda_\odot$	date (UT)	date (UT)
1933	1900	5	+0.0003356	197.°00430	Oct. 9, 20^{h}12^m	Oct. 9, 20^{h}23^m
1933	1907	4	−0.0001749	196.°99369	Oct. 9, 19^{h}56^m	Oct. 9, 20^{h}08^m
1946	1900	7	−0.0007444	197.°00041	Oct. 10, 03^{h}58^m	Oct. 10, 04^{h}11^m
1946	1907	6	−0.0005646	196.°99971	Oct. 10, 03^{h}57^m	Oct. 10, 04^{h}05^m
1946	1913	5	−0.0002978	196.°99269	Oct. 10, 03^{h}47^m	Oct. 10, 03^{h}58^m
1946	1920	4	−0.0001011	196.°99020	Oct. 10, 03^{h}43^m	Oct. 10, 04^{h}05^m
1946	1926	3	+0.0000770	196.°98921	Oct. 10, 03^{h}41^m	Oct. 10, 03^{h}46^m
1946	1933	2	+0.0006207	196.°99086	Oct. 10, 03^{h}44^m	Oct. 10, 03^{h}44^m

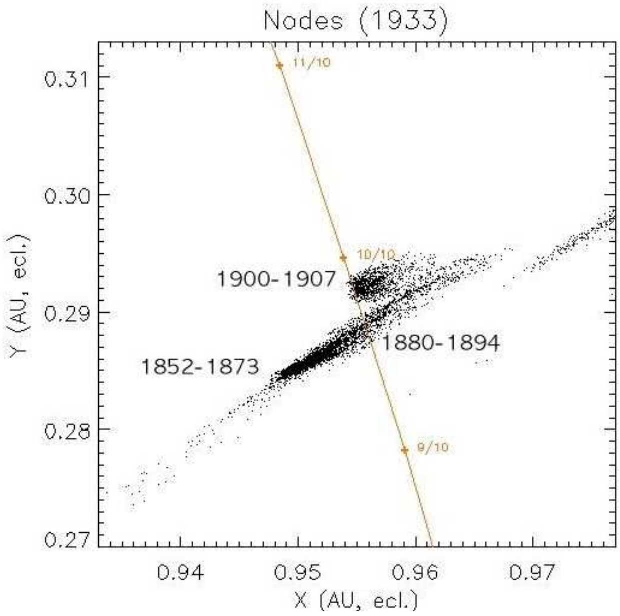

Figure 1 – General circumstances of the 1933 Draconids meteor storm.

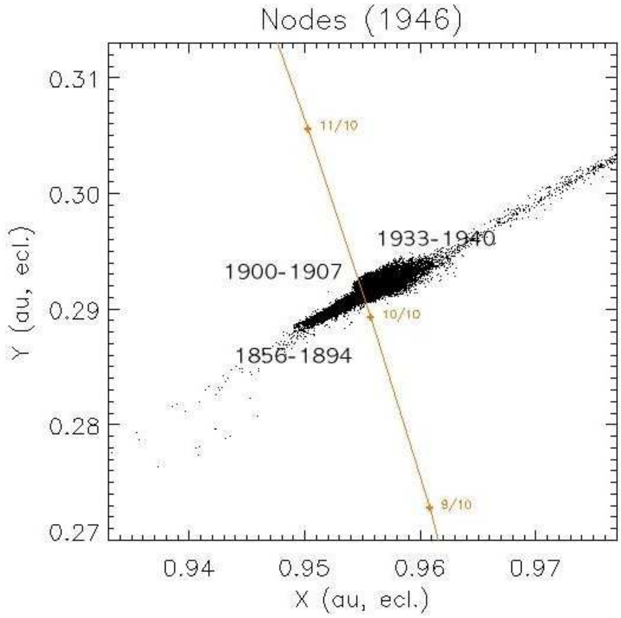

Figure 2 – General circumstances of the 1946 Draconids meteor storm.

In 1946, the exact same trails were encountered again, but this time, there were also extremely fresh trails, ejected one and two revolutions before the storm. In a sense, the 1946 Draconids meteor storm was the perfect storm.

Records in the order of 10 000 meteors per hour for those two events are found in the literature, raising hopes for a storm in 2011. However, the level of the shower is hard to determine since back then there was no standard technique to reduce the data.

It is worth mentioning that in the two cases, the models predict another outburst before each storm, caused by the trails ejected before the comet discovery (during the 19th century). However, these outbursts are very uncertain for a number of reasons. The most important is that the orbit of the comet is poorly known before its discovery in 1900, since it had had a close encounter with Jupiter in 1898. In other words, we need to solve the problem of the orbit of comet 21P.

4 The orbit of comet 21P/Giacobini-Zinner

The comet was discovered in 1900. After this, almost all passages were observed. Because the comet is a Jupiter family comet, there are today 15 recorded passages. However, we discovered that several slightly different orbital solution lead to different forecasts for the Draconids meteor showers. In Table 2 we show the details for the 1985 outburst, for the solution provided by JPL and by IMCCE. Note that the latter was used to derive the predictions published in Jenniskens (2006). Since then, several minor effects have been taken into account (e.g. first terms on special relativity) to compute the orbit of the comet. Still, the way the observations are treated is different, and it is often custom-made on a case-by-case bases by the scientists providing the cometary ephemeris. Automated methods consider all the reported observations, within a chosen matching criterion. However, the definition of outlier can also be manual. In this case, we do not know exactly how the data were reduced, but they provide significant differences in terms of Draconids showers as shown in Table 2.

We can see that the solution provided by JPL is able to explain the first outburst whereas the "IS" one is off by two hours. One could natively conclude that the JPL solution is the closest to reality. However, it does not explain the second outburst, and for which Shanov's

Table 2 – Circumstances of the 1985 Draconids from different comet solutions and models: "V-IMCCE" stands for (Vaubaillon et al., 2005) model with comet orbit provided by P. Rocher (after corrections), "V-JPL" for the same model with the comet orbit provided by JPL, "MS" stands for a model by Sato and Horii with comet orbit provided by Kinoshita; "IS" refers to I. Shanov's work published in Jenniskens (2006). Observation data are taken from the same book.

Model	Trail	δr (AU)	$\lambda_\odot$	date (UT)
V-JPL	1933	−0.01125	195.°173	Oct. 8, 07^h35^m
V-IMCCE	1933	−0.00981	195.°154	Oct. 8, 07^h06^m
MS	1933	−0.01664	195.°127	Oct. 8, 06^h27^m
MS	1940	−0.01797	195.°115	Oct. 8, 06^h10^m
IS	1933	+0.01114	195.°253	Oct. 8, 09^h45^m
observation			195.°174	Oct. 8, 07^h36^m
V-IMCCE	1894	−0.00927	195.°203	Oct. 8, 08^h18^m
V-IMCCE	1946	+0.01724	195.°391	Oct. 8, 12^h52^m
V-JPL	1946	+0.01306	195.°365	Oct. 8, 12^h15^m
MS	1946	+0.01125	195.°356	Oct. 8, 12^h01^m
IS	1946	+0.01114	195.°253	Oct. 8, 09^h45^m
observation			195.°256	Oct. 8, 09^h36^m

solution is better. The very least we can say is that this situation is puzzling, and makes forecasting difficult.

5 2011 encounter of the Earth with the stream

For the year 2011, many different models all confirm the eventuality of an outburst. Figure 3 and Table 3 show the circumstances of this encounter. The good news is that the second and the most important outburst will be cause by trails ejected in 1900 and in 1907, already encountered in 1933 and in 1946. Figure 4 shows the 1900 trail in 2011. Even though this Jupiter family trail is 17 revolutions old, we can see that it is not highly perturbed. Those two facts give us confidence for this coming outburst. However, we have seen in the previous section that the orbit of the comet still presents some puzzling problems. The first outburst is expected a few hours before the main one. Because of the uncertainties on the orbit of the comet, this first event is highly uncertain. A further analysis shows that it will be composed of relatively large particles (that is, larger than 1 mm). As a consequence, we hope that this outburst will be the occasion to refine our knowledge on the dynamics of this comet.

As mentioned previously, the photometry of the comet is not available for the years of ejection of the trails. As a consequence the level of the shower is based on a relative comparison of the 1933 and 1946 showers. However, even those showers are not perfectly known, since the method of reduction were not well defined back in those days. Moreover, Watanabe et al. (2008) have shown that the activity of the comet has changed between passages. As a consequence, the level of the shower could be as much as a factor of two higher or lower than what it is presented here.

All the models agree that the level will be unusual, and on the order of a few hundreds per hour. No storm is expected though. The first outburst (if any) will be on the order of 200 meteors per hour at most, whereas the second will be around 600 per hour.

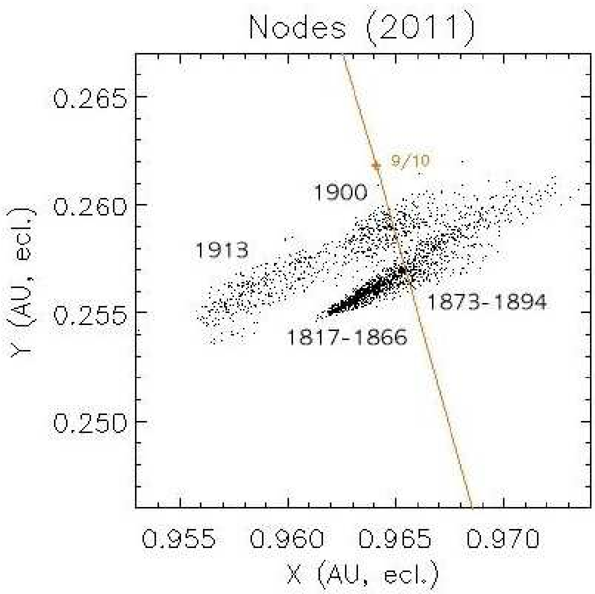

Figure 3 – General circumstances of the 2011 Draconids meteor shower.

6 Discussion

As mentioned several times throughout this paper, the level of this coming shower is not as certainly determined as in the 2002 Leonids for example. What seems the most likely is that a Draconids outburst is expected, caused by the 1900 and the 1907 trails. Note that Maslov's results only forecast a minor outburst for this year with a level of at most 50/hr (Maslov, 2011).

Why is it important to observe? To our knowledge, this coming shower is the first significant Draconids outburst to be forecasted. As a seen previously, it will be the occasion to study the orbit of the comet, especially before its discovery in 1900. Moreover, we will be able to study the disintegration of the most fragile meteoroid into Earth's atmosphere with great detail, thanks to a higher than usual activity level. This event is also potentially the most abundant in terms of number of meteors since the great days of the Leonids. We hope that this article will motivate people all around the world that they should go outside and observe these events.

Table 3 – Circumstances of the 2011 Draconids.

Year	Trail	by JV			by MS & SH	
		δr (AU)	$\lambda_\odot$	date (UT)	δr (AU)	date (UT)
2011	1866	−0.0036438	$194^\circ.87353$	Oct. 8, 16^h13^m		
2011	1873	−0.0031428	$194^\circ.88429$	Oct. 8, 16^h29^m		
2011	1880	−0.0024856	$194^\circ.90063$	Oct. 8, 16^h53^m	+0.00327	Oct. 8, 19^h04^m
2011	1887	−0.0015047	$194^\circ.92248$	Oct. 8, 17^h25^m	−0.00071	Oct. 8, 17^h05^m
2011	1894	+0.0010553	$194^\circ.97733$	Oct. 8, 18^h45^m		
2011	1900	−0.0022798	$195^\circ.02944$	Oct. 8, 20^h01^m	+0.00097	Oct. 8, 20^h36^m
2011	1907	−0.0052619	$195^\circ.00594$	Oct. 8, 19^h26^m	−0.00244	Oct. 8, 19^h59^m

Moreover, we hope that reports will be sent to the International Meteor Organization so that a global analysis will be performed and a complete view of the shower and the stream can be drawn. Comparison with what happened in 1933 and 1946 will provide us insight about the way data were analyzed back then.

7 Planned observations

Since the Draconid meteor shower is not usually very active, the predicted outbursts provide us with unique opportunity to investigate its properties. Not only can we test models of the orbital evolution of another meteoroid stream, but also we could collect more data on the meteoroids, that are the most fragile material among all the other showers (Borovička et al., 2007).

The timing of the outburst favors Middle East and eastern parts of Europe. On the other hand the meteorological conditions are not kind at this part of the year on the majority of the continent. Therefore the idea of the airborne observational campaign arose. The most promising area in terms of weather is south-eastern Europe. However the radiant might be low on the horizon (as pointed out by R. Arlt – personal communication), causing a significant decrease in the number of observed meteors. We already know of many ground-based expeditions in Mediterranean countries (Greece, Israel, Turkey and so on). As usual, the contribution of each and every country will provide the world wide view of the phenomenon. Automated analysis will be available on the website of the International Meteor Organization. Once again we would like to emphasize here the importance of the work performed by amateurs, for both the observation and the analysis.

Because the expected peaks are not expected to be observed in Japan, Japanese observers are planning to perform an expedition for the observation as National Astronomical Observatory of Japan (NAOJ). Considering the observing conditions with possible cloud coverage, the Japanese professional astronomers chose the site of Maidanak observatory, which is located at the center of the Eurasian Continent, Uzbekistan. Mount Maidanak is near the border of Afghanistan, whose time zone is GMT+5 hours, the longitude +66.89641 degree, the latitude +38.67332 degree, and the altitude 2593 m above the sea level. The Maidanak observatory has a 1.5 m telescope, a 1 m telescope and four 60 cm telescopes. Moreover the NOAJ observatory has a memorandum of understanding in the collaboration with this observatory for observation of asteroids. Several researchers in National Astronomical Observatory of Japan often visit Maidanak observatory for observing asteroids by using their telescopes under good sky condition (Ehgamberdiev et al., 2000). There are more than 200 clear nights per year, especially from July to

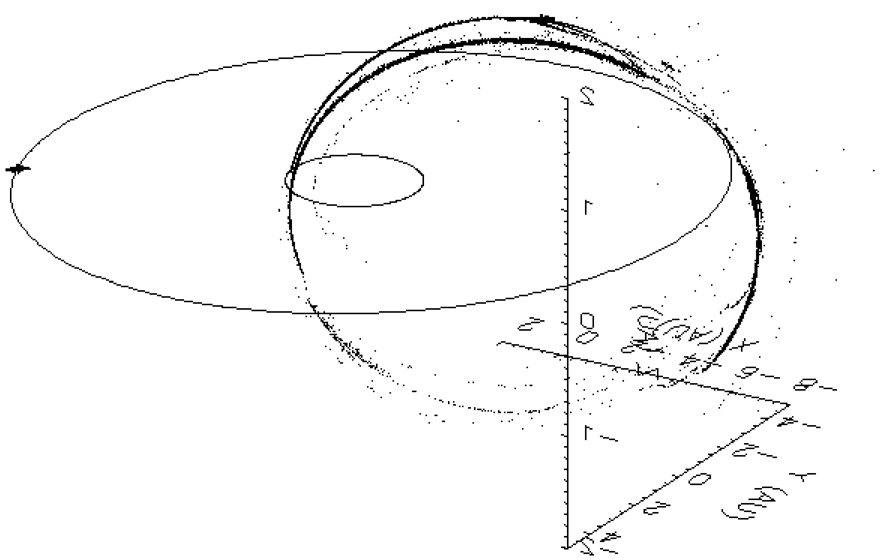

Figure 4 – 3D view of the Draconids meteoroid stream as in October 2011.

September with a probability of 90 %, although such high probability of clear nights in October is not expected. NAOJ astronomers plan to stay a few nights before and after the expected peaks, and to carry out video observation by using Watec a CCD video camera system mainly for monitoring activity of this shower.

In Europe, the plan is to use two different small planes and establish a double station observation. The French SAFIRE Falcon 20 is partly already granted and the preparations are underway. The second one would be the DLR Falcon 20, but there is still ongoing discussion with EUFAR office, whether it will financially support such a mission. If two planes are available, we plan to fly them in the same line one behind the other. Such configuration will allow us to use the instruments on both sides of the planes for the double station observations. The distance between the planes would be up to 100 km. Due to the Falcon 20 4 hours autonomy, we plan two flights to cover both predicted maxima. The base for whole mission will be Kiruna airport in northern Sweden. Between both flights the planes will land here to be refueled. Timing will be very tight so planning is essential.

Each plane will carry set of different instruments. There will be narrow (about $\simeq 40°$) and wide ($\simeq 90°$ to $\simeq 120°$) field of view video cameras with low (1 per second) and high (50 per second) frame rate as well as the spectral cameras working in visible and infrared light. SAFIRE Falcon will accommodate 10 instruments, whereas DLR Falcon will have six or seven. The goals of the mission are measurements of the population index, activity profile, flux, light curves and atmospheric trajectories and spectra of meteors. If both planes are available then the heliocentric orbits will be studied as well. Finally, NASA may also support a Gulfstream airplane to join the two European ones. However, we will not know until July 2011.

Since the event will be visible on a Saturday evening at reasonable time, this meteor shower is the perfect occasion for the broadcasting of science, astronomy and meteors. Many amateur clubs in Europe will have a public outreach event during this night. This aspect should not be neglected, since many professional astronomers became interested in the field by witnessing a meteor shower.

8 Conclusion

Most of the forecasting methods used around the world predict an outburst for the Draconids in 2011. Based on past observations, this outburst will happen on October 8 at around 20^{h} UTC. The level of the shower is hard to predict because of the peculiar orbit of the comet. Observations of the meteors as well as the comments in the coming months will provide us with insight on the structure of the meteoroid stream around 21P.

Acknowledgement

We are thankful to the National Astronomical Observatory of Japan (Mitaka, Tokyo) for partly supporting this work. The heavy computations were performed at CINES, France. We are thankful to the International Meteor Organization for their requests and help in writing this article. In the same way, where are thankful in advance to all the people who will report their observations to the IMO website, as well as those who will fully analyze the results. Heartfelt thanks also to the SAFIRE and EUFAR teams for helping us defining how the airplane campaigns might work (regardless of the results), as well as the referees granting us 100% of the French aircraft flying time.

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Future Draconid outbursts (2011 – 2100)

Mikhail Maslov[1]

Descriptions of future Draconid meteor shower outburst forecasts are presented for the period 2011 – 2100. Primary attention is paid to the closest cases of expected (possible) activity in 2011, 2012, 2014, 2018 and 2019.

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1 Introduction

The Draconids are one of the most famous meteor showers, produced by the debris of comet 21P/Giacobini-Zinner. In the past this shower gave a number of outbursts, including two storms in 1933 and 1946, when hourly rates of activity reached several thousands. In this paper we introduce the results of 21P meteoroid stream modeling aimed at the prediction of future Draconid activity. The closest interesting case is the Draconids 2011, this year, which as many researchers expect should be marked by the shower's activity. It is described below with a graph, as well as other interesting cases within the period 2011 – 2020. For the years in 2021 – 2030 only textual descriptions of what could happen are given. And finally, the characteristics of expected Draconid activity in the far future are presented in Table 1. Computations of meteor particles' orbital evolution were made with the COMET'S DUST 2.0 program by S. Shanov and S. Dubrovsky (Shanov & Dubrovski, 2005). To estimate the possible intensity of Draconid outbursts the model described on pages 158–160 of (Lyytinen & van Flandern, 2000) and adapted to the Draconid stream by the author was used. Initial orbital elements of the comet 21P were taken from (Kinoshita, 2008).

2011

In 2011 the Earth encounters a bunch of 1887 – 1926 trails. These encounters are not very close, with the closest three trails (1887, 1894 and 1900 ones) expected to pass at −0.00092 AU, +0.00107 AU and −0.00136 AU from the Earth, respectively. For this reason, we do not expect very high Draconid activity in 2011, with the ZHR reaching 40 – 50 meteors at maximum. The major part of the activity should be produced by the 1900 trail, which is several times denser than the 1887 and 1894 trails. The maximum time for the 1900 trail is 2011 October 8 at $20^{h}13^{m}$ UT; so far this time is expected to become the time of maximum activity of the overall outburst. Minimum distances to the 1887 and 1894 trails will be reached by the Earth some hours before this, on 2011 October 8 at $17^{h}04^{m}$ and $18^{h}06^{m}$ UT, respectively. At present, the first meteors of the outburst are expected to appear already at $17^{h}-18^{h}$ UT on October 8, and their brightness will generally be quite high at the beginning, but with a subsequent gradual decrease to average levels closer to the main maximum

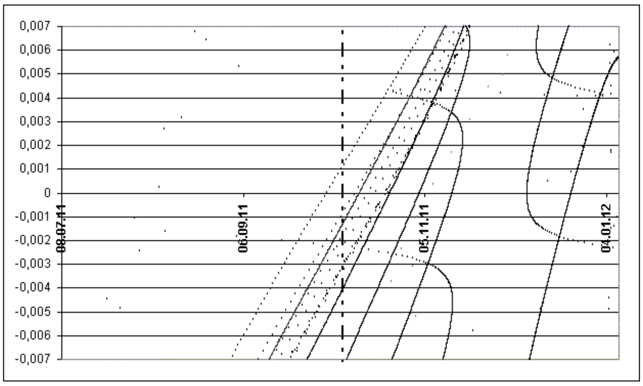

Figure 1 – 21P trails in the vicinity of the Earth's orbit around Draconid maximum time in 2011 (X-axis is time, Y-axis is distance from Earth's orbit measured in AU).

time of $20^{h}13^{m}$ UT. Also, the decrease in activity after reaching the maximum is expected to be sharper than the rise towards maximum. The theoretical radiant of the outburst is: RA = 263°.3, Dec = +55°.8, v_{g} = 20.9 km/s. Unfortunately the sky quality at the expected maximum time will be spoiled by the light of the almost full Moon in the evening time, when the Draconid radiant is at its highest altitudes. However, in the northern hemisphere the Moon will not be very high in the sky.

The Draconids' 2011 outburst was predicted by many authors, Jeremie Vaubaillon (2011), Esko Lyytinen, Mikiya Sato, Hartwig Luethen among them; some of their results are listed in (Jenniskens, 2006). The given prediction is in principal agreement with these works, but its activity estimates are on the conservative side.

If the outburst occurs at the times given above, the best conditions for observation will be in Europe and the north-western edge of Africa. There will also be a reasonable radiant height in the major part of the Middle East and in the northern edge of Eurasia, excluding the extreme north-east. Also, observers in that part of Eurasia will have good conditions to check the expected low Draconid activity from the 1887 and 1894 trails some hours prior to the main maximum. Very good conditions for radio observations will be in Northern America; in the very north of South America the radiant will also be high enough for radio observations.

2012

As shown in Figure 2, in 2012 two trails will be present in the vicinity of the Earth's orbit. These are the 1959 and 1966 trails. This case is quite similar to the Draconids 1999 case, when a small activity outburst with

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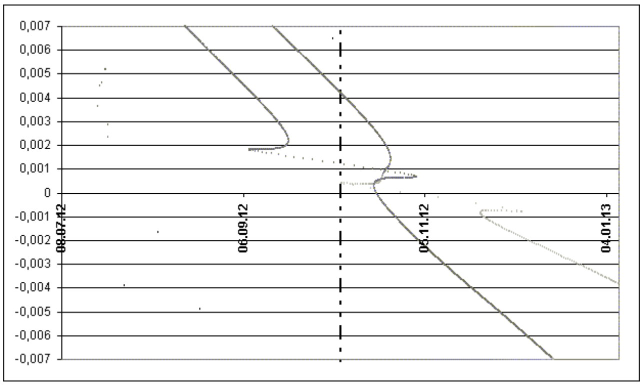

Figure 2 – 21P trails in the vicinity of the Earth's orbit around Draconid maximum time in 2012 (X-axis is time, Y is measured in AU).

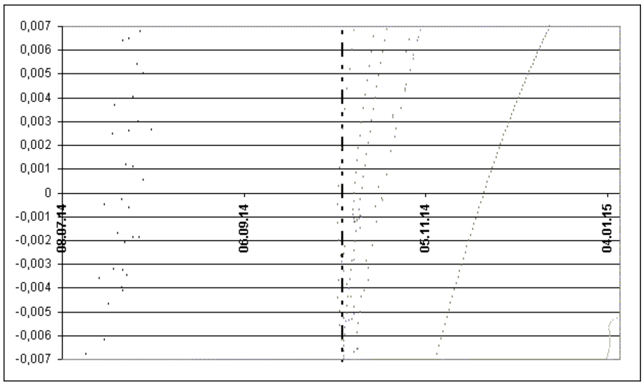

Figure 3 – 21P trails in the vicinity of the Earth's orbit around Draconid maximum time in 2014 (X-axis is time, Y is measured in AU).

ZHR of 10 – 15 occurred. However in 2012 the situation is much less auspicious. The 1959 trail, which is the closest of the two trails to the Earth, passes at 0.00121 AU (which is actually quite a large distance); moreover this part of the trail is perturbed by a previous encounter with the Earth (in 1992) and at present is several tens of times less dense than an analogous non-perturbed trail. The maximum time for this trail is 2012 October 8 at $16^{\mathrm{h}}22^{\mathrm{m}}$ UT, but any visually detectable activity is unlikely.

The 1959 trail also gives a vertical encounter with maximum time on 2012 October 8 at $16^{\mathrm{h}}54^{\mathrm{m}}$ UT. A "vertical trail", which occurs as a result of perturbations by big planets, contrasts with the usual cases of trail encounters. In a vertical trail, neighboring computed particles significantly differ in distance between their orbit and the Earth's orbit, despite extremely small differences in the times of their minimum distance passage from the Earth's orbit. Thus in plots of minimum distance value against minimum distance passage time, such trails look vertical. The computed $\mathrm{ZHR_{ex}}$ for this encounter is 0.5, so we expect to reach at best the levels of isolated meteors with very low average brightness.

Finally, the 1966 trail encounters the Earth with its non-perturbed part, but it passes at the very large distance of 0.00416 AU, which also cancels any prospects for significant activity. Maximum time for this trail is 2012 October 8 at $15^{\mathrm{h}}37^{\mathrm{m}}$ UT, computed $\mathrm{ZHR_{ex}}$ is 0.2.

As a whole we could say that in 2012 we have some chances for weak Draconid activity during the period of October 8 from 15 – 17 UT, but it is very likely that nothing will happen. Average meteor brightness (if anything occurs) is expected to be very low, and the aging Moon will not create any significant trouble for observers, at least in the evening time, when the Draconid radiant is at its highest altitudes. Considering the timings given, the best conditions for checking possible Draconid activity will be at Asian longitudes in the northern hemisphere.

2014

The Earth encounters the bunch of 1900 – 1913 trails. No direct intersections with trails are expected, but use of the "vertical trails" approach points towards chances that some particles from non-axis trail parts could collide with the Earth. The trails intersect the Earth's orbit in the period 2014 October 7 – 14. On 2014 October 6 at $20^{\mathrm{h}}10^{\mathrm{m}}$ UT a small enhancement with ZHR of 10 – 15 meteors with very low average brightness is possible. With radio observations higher activity is likely. Theoretical radiant is RA = 261.°5, Dec = +47.°4, $v_{\mathrm{g}} = 18.3$ km/s.

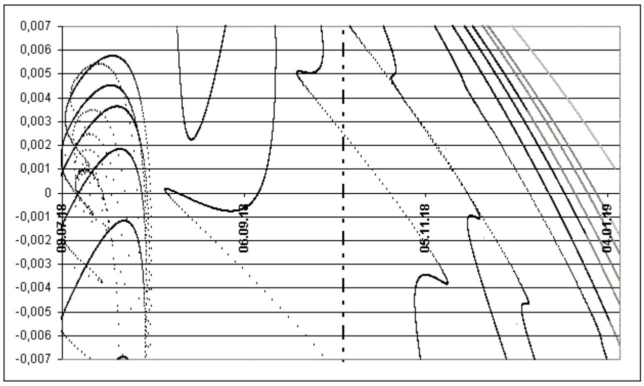

Figure 4 – 21P trails in the vicinity of the Earth's orbit around Draconid maximum time in 2018 (X-axis is time, Y is measured in AU).

2018

At first sight it is a very favorable return of the 21P comet, but it is not expected to give a strong outburst of activity, as the Earth passes through the area of strongly rarified and perturbed material within the channel (closely bunched group) of 1946 – 1959 trails. There are no close direct encounters, but the "vertical trails" approach shows the possibility of weak activity from the 1953 trail, with ZHR of 10 – 20 within the period of 2018 October 8 – 9 from $23^{\mathrm{h}} - 00^{\mathrm{h}}$ UT. Theoretical radiant is RA = 262.°8, Dec = +56.°0, $v_{\mathrm{g}} = 21.0$ km/s.

2019

Very close direct encounter with 1959 trail. Its characteristics: $V_{\mathrm{ej}} = 62.9$ m/s, fM(fMD)= 2.377, $\lambda_{\odot}$ =

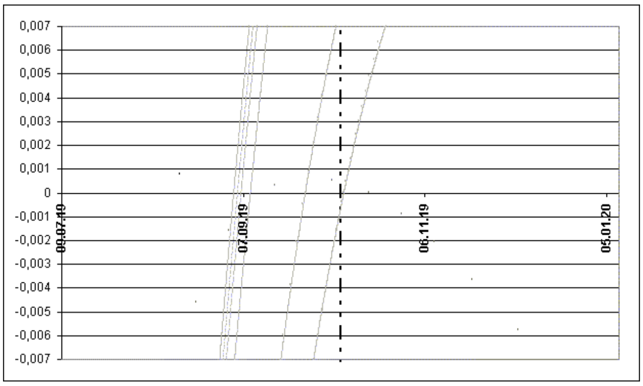

Figure 5 – 21P trails in the vicinity of the Earth's orbit around Draconid maximum time in 2019 (X-axis is time, Y is measured in AU).

$194.^{\circ}759$. Taking as a basis Draconid activity in 1999, we can expect a small visual peak not higher than ZHR $5-10$, on 2019 October 8 at $14^{\mathrm{h}}45^{\mathrm{m}}$ UT. On the other hand, radio observations could show much higher activity. Theoretical radiant: RA $= 261.^{\circ}4$, Dec $= +53.^{\circ}9$, $v_{\mathrm{g}} = 20.5$ km/s.

2023

Encounter with 1887 trail. We used the "vertical trails" approach, as this trail crosses the Earth's orbit on 2023 October 12. A notable activity enhancement is likely, up to ZHR $10-20$, on 2023 October 8 at $12^{\mathrm{h}}10^{\mathrm{m}}$ UT with a high proportion of fireballs. Theoretical radiant: RA $= 263.^{\circ}4$, Dec $= +56.^{\circ}3$, $v_{\mathrm{g}} = 21.0$ km/s.

2025

Encounter with channel of $1907-1953$ trails, intersecting the Earth's orbit at the end of September. According to the "vertical trails" approach, significant activity enhancements with lots of submaxima are likely within 2025 October 8 from $05^{\mathrm{h}} - 11^{\mathrm{h}}$ UT. Suggested time and intensity of these submaxima are the following: $05^{\mathrm{h}}01^{\mathrm{m}}$ UT, ZHR $10-15$; $07^{\mathrm{h}}25^{\mathrm{m}}$ UT, ZHR $20-25$; $09^{\mathrm{h}}06^{\mathrm{m}}$ UT, ZHR $20-25$; $10^{\mathrm{h}}17^{\mathrm{m}} - 10^{\mathrm{h}}49^{\mathrm{m}}$ UT, ZHR $50-60$. So far, we expect an oscillating increase of activity, and the first meteors can already appear at $01^{\mathrm{h}}20^{\mathrm{m}}$ UT. Meteor brightnesses will be quite high; lots of fireballs are likely. We would also like to note that due to the high density of this channel of trails and experimental character of the "vertical trails" approach used, ZHR estimates given above are quite optimistic and the real activity can be much lower. Theoretical radiant is RA $= 261.^{\circ}9$, Dec $= +54.^{\circ}8$.

Direct encounter with 2-revolution 2012 trail on 2025 October 8 at $15^{\mathrm{h}}14^{\mathrm{m}}$ UT. Ejection velocity of encountered trail particles is very high, 88.3 m/s. So far we expect visual activity at the level of only $10-40$ in ZHR, average brightness very low. However with radio observations, much higher activity is likely, up to very strong storm with tens of thousands meteors per hour. Theoretical radiant: RA $= 262.^{\circ}8$, Dec $= +55.^{\circ}9$, $v_{\mathrm{g}} = 21.1$ km/s.

2030

Direct encounter with a quite rarified channel of $1817-1859$ trails on 2030 October 8 at $21^{\mathrm{h}} - 22^{\mathrm{h}}$ UT. Activity should rise to ZHR $10-20$, perhaps with lots of submaxima. Meteor brightnesses will be high, with lots of fireballs. Theoretical radiant: RA $= 263.^{\circ}5$, Dec $= +58.^{\circ}1$, $v_{\mathrm{g}} = 21.7$ km/s.

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Table 1 – Years of expected Draconid activity in 2031 – 2100.

year	day, time (UT)	ZHR_{ex}	comments
2038	Oct. 7, $00^h - 04^h$	5	bright meteors
2038	Oct. 7, 16^h – Oct. 8, 02^h	20 – 30	faint meteors
2050	Oct. 6, 17^h03^m	4 – 5	very faint meteors
2062	Oct. 6, 08^h05^m	500 – 600	bright meteors
2064	Oct. 6, 05^h41^m	200 – 300	very bright meteors
2069	Oct. 6, $02^h - 06^h$	5 – 10	very faint meteors
2078	Oct. 4 – 5	10 – 20	bright meteors
	Oct. 6, 05^h32^m	2 – 3	very bright meteors
	Oct. 7, $11^h - 12^h$	4 – 5	very bright meteors
	Oct. 7, 23^h41^m	20 – 40	very bright meteors
2084	Oct. 6, 20^h27^m	10 – 20	bright meteors
2097	Oct. 5, $17^h - 18^h$	50 – 60	bright meteors
2098	Oct. 5, 04^h20^m	1500 – 2000, up to 10000 – 20000	very bright meteors
	Oct. 5, 07^h17^m	500, up to 5000	very bright meteors
	Oct. 5, 15^h20^m	100 – 200	bright meteors

Preliminary results

Results of the IMO Video Meteor Network — February 2011

Sirko Molau[1], *Javor Kac*[2], *Erno Berko*[3], *Stefano Crivello*[4], *Enrico Stomeo*[5] *and Antal Igaz*[6]

IMO Video Meteor Network results for 2011 February are presented. The best February record so far was attained: more than 11 000 meteors were detected, in over 3 000 hours of effective observing time. The minor π-Hydrids were less active than in 2010, reaching about 5% of the sporadic meteor count. The β-Herculids showed a similar activity as in the previous year. The δ-Leonids did not stand out of the sporadic background in 2011.

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1 Introduction

Whereas the meteor season is gaining momentum in the southern hemisphere in February, the month is rather dull for northern hemisphere observers. The hourly rate is breaking down, the nights are getting shorter and the weather is only rarely cooperative. This year the decline was less dramatic, though. The observing conditions were not really perfect anywhere, but most cameras collected around 15 observing nights, which is a fairly good result for February. In the first ten days of the month we had clear skies at many observing sites, so that during individual nights up to 36 cameras were active. In total we collected more than 11 000 meteors in over 3 000 hours of effective observing time (Table 1 and Figure 1) – significantly more than in the previously best February in 2008 (Molau, 2008).

2 Minor showers of February

Reporting on meteor showers in February soon gets boring, as the range of showers is rather modest. We therefore have taken another look at the β-Herculids (418 BHE) and the π-Hydrids (101 PIH), which we found in our 2009 analysis of the IMO Video Meteor Database (Molau & Rendtel, 2009). We added the δ-Leonids (DLE) from the IMO Working List, even though they were not recognized as an independent shower in our analysis. The result is given in Figure 2, in which we omitted nights with less than 100 sporadic meteors.

The activity interval of the π-Hydrids fell into the time period when the weather conditions were best, so that we could follow this shower well (166 shower meteors were recorded). With 5% of the sporadic meteor number, the π-Hydrids were less active than in 2010, when they shortly reached up to 10% of the sporadic count (Molau & Kac, 2010).

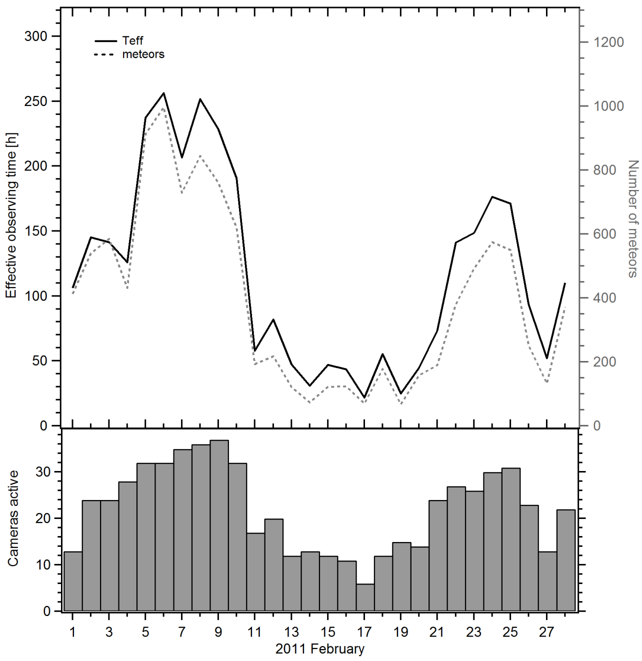

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2011 February.

Only the first part of the β-Herculids could be observed (99 shower meteors recorded) this year – the second half of the activity interval fell victim to the poor weather. The β-Herculids showed a similar activity to the previous year, but once more no pronounced activity profile. To obtain better profiles of such weak showers it is mandatory to average over different years.

With less than 5% of the sporadic meteor count, the δ-Leonids (75 shower meteors recorded) did not stand out of the sporadic background for most of their activity interval. Only in a single night (February 21/22) did they reach about 10% of the sporadic count, but the data set of that night was rather limited. In our long-term analysis of 2009, the radiant was noticeable between February 23 and 27 (Molau & Rendtel, 2009).

The Antihelion source (1011 shower meteors) reached about 12% of the sporadic meteor counts throughout most of February.

Finally, we present an image of the spectacular meteor of February 6 at $04^{\rm h}21^{\rm m}$ UT, which was recorded

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NASA-ADS bibcode 2011JIMO...39...68M

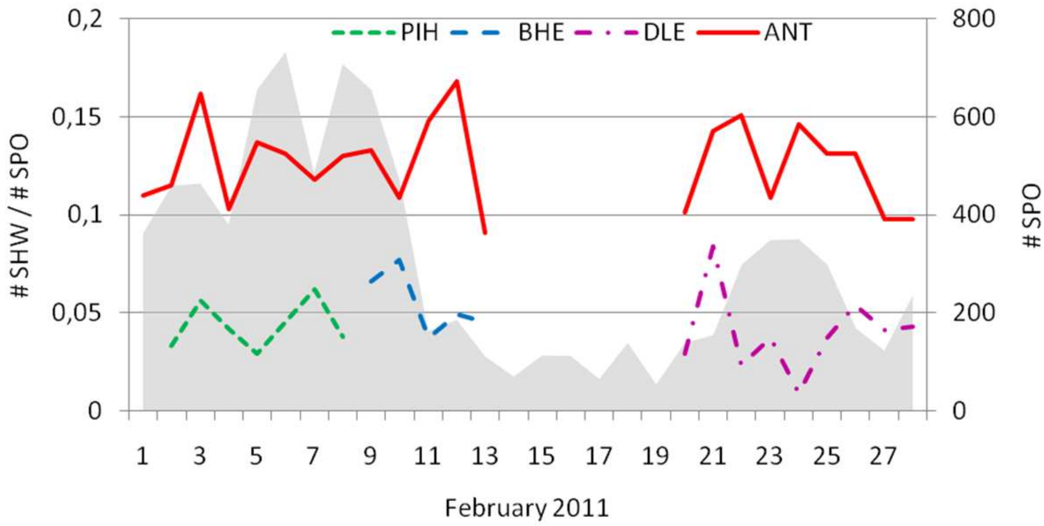

Figure 2 – Activity profiles of the π-Hydrids, β-Herculids, δ-Leonids and the Antihelion source in February 2011. Depicted is the number of shower meteors divided by the number of sporadics in the same night (keyed to the left-hand y-axis). The absolute number of sporadic meteors per night is given in the background (keyed to the right-hand y-axis).

by Antal Igaz with his camera Huhod (Figure 3). The picture on the right side shows the development of the meteor in steps of 0.2 seconds (five video frames) from top to bottom. Already at the start of detection, the meteoroid had broken into two pieces, each of which later fragmented on its own again.

Figure 3 – Meteor fragmenting into four pieces recorded on 2011 February 6 at $04^{h}21^{m}$ UT by Huhod camera. Photo courtesy Antal Igaz.

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Handling Editor: Javor Kac

Table 1 – Observers contributing to 2011 February data of the IMO Video Meteor Network. Eff.CA designates the effective collection area and Tot.CA the total collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
BENOR	Benitez-S.	Las Palmas	Times4 (1.4/50)	2359	3.2	492	12	23.2	—	70
BERER	Berko	Ludányhalászi	Hulud1 (0.95/3)	6500	3.8	2209	14	55.1	—	143
			Hulud2 (0.75/6)	2258	4.7	1348	14	91.3	208.6	284
BRIBE	Brinkmann	Herne	Hermine (0.8/6)	2374	4.2	1084	12	43.5	96.2	123
		Bergisch Gladbach	Klemoi (0.8/6)	2386	5.4	2781	13	44.5	—	125
CASFL	Castellani	Monte Baldo	Bmh1 (0.8/6)	2350	—	—	19	137.2	—	434
			Bmh2 (1.5/4.5)*	4243	—	—	17	91.5	—	292
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	5575	4.2	2525	15	73.4	194.8	268
			Stg38 (0.8/3.8)	5593	4.3	2810	21	116.0	434.4	529
CSISZ	Csizmadia	Zalaegerszeg	Huvcse01 (0.95/5)	2439	3.0	249	17	45.7	31.0	121
CURMA	Currie	Grove	Mic4 (0.8/6)	1471	5.2	3008	8	24.9	17.7	56
ELTMA	Eltri	Venezia	Met38 (0.8/3.8)	5620	4.3	1778	14	95.3	328.1	272
GONRU	Goncalves	Tomar	Templar1 (0.8/6)*	2188	5.3	2331	19	139.5	299.8	516
			Templar2 (0.8/6)*	2303	5.0	2397	20	108.6	319.6	385
GOVMI	Govedič	Središče ob Dravi	Orion2 (0.8/8)	1471	6.0	3916	15	83.9	—	238
HERCA	Hergenrother	Tucson	Salsa3 (1.2/4)*	4332	4.0	1471	24	224.3	263.2	284
HINWO	Hinz	Brannenburg	Akm2 (0.85/25)*	754	5.7	1306	11	97.2	—	338
IGAAN	Igaz	Baja	Hubaj (0.8/3.8)	5600	4.3	3338	13	62.8	59.7	175
		Hódmezővásárhely	Huhod (0.8/3.8)	5609	4.2	3031	13	35.2	50.9	99
		Budapest	Hupol (1.2/4)	3929	3.5	1144	16	38.4	89.2	94
JOBKL	Jobse	Oostkapelle	Klara2 (1.2/85)*	1564	—	—	1	11.9	—	45
KACJA	Kac	Kostanjevec	Metka (0.8/8)*	1381	4.0	2246	9	55.7	35.9	196
		Ljubljana	Orion1 (0.8/8)	1420	5.3	2336	15	54.3	47.2	155
		Kamnik	Rezika (0.8/6)	2307	5.0	2293	10	75.6	52.6	323
			Stefka (0.8/3.8)	5540	4.2	2882	11	52.9	72.5	180
KERST	Kerr	Glenlee	Gocam1 (0.8/3.8)	5238	4.2	2637	15	98.2	—	654

Table 1 – Observers contributing to 2011 February data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
LUNRO	Lunsford	Chula Vista	Bocam (1.4/50)*	1860	5.1	1719	15	101.5	141.7	350
MOLSI	Molau	Seysdorf	Avis2 (1.4/50)*	1771	6.1	4182	9	74.7	201.9	705
			Mincam1 (0.8/8)	1477	4.9	1716	13	82.1	46.6	234
		Ketzür	Remo1 (0.8/3.8)	5592	3.0	974	15	96.4	91.3	93
MORJO	Morvai	Fülöpszállás	Huful (1.4/5)	2522	3.5	532	14	47.9	—	117
OTTMI	Otte	Pearl City	Orie1 (1.4/5.7)	3837	—	—	13	58.5	—	177
PERZS	Perko	Becsehely	Hubec (0.8/3.8)*	5448	3.4	1500	20	93.8	319.6	336
ROTEC	Rothenberg	Berlin	Armefa (0.8/6)	2369	4.8	1801	16	51.4	121.7	131
SCHHA	Schremmer	Niederkrüchten	Doraemon (0.8/3.8)	5537	3.0	846	13	21.1	—	61
SLAST	Slavec	Ljubljana	Kayak1 (1.8/28)	604	6.5	1849	12	74.2	—	205
STOEN	Stomeo	Scorze	Min38 (0.8/3.8)	5631	4.1	2407	17	119.0	—	498
			Noa38 (0.8/3.8)	5609	4.9	5800	16	94.2	—	363
			Sco38 (0.8/3.8)	5598	5.0	4416	17	119.4	—	526
STRJO	Strunk	Herford	Mincam2 (0.8/6)	2357	4.7	1380	7	31.9	122.8	93
			Mincam3 (0.8/12)	728	6.1	2271	10	32.6	—	98
			Mincam5 (0.8/6)	2344	5.2	2535	7	41.2	238.6	163
TEPIS	Tepliczky	Budapest	Humob (0.8/6)	2375	4.9	2258	8	50.7	105.8	144
TRIMI	Triglav	Velenje	Sraka (0.8/6)*	2222	—	—	13	48.0	—	168
YRJIL	Yrjölä	Kuusankoski	Finexcam (0.8/6)	2337	5.5	3574	18	91.5	410.6	234
						Overall	28	3 310.2	—	11 095

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — March 2011

Sirko Molau[1], *Javor Kac*[2], *Erno Berko*[3], *Stefano Crivello*[4], *Enrico Stomeo*[5] *and Antal Igaz*[6]

March 2011 was the best March in the history of the IMO Video Meteor Network. Over 11 000 meteors were recorded in more than 4 500 hours of effective observing time. New functionalities of MetRec are discussed.

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1 Introduction

March 2011 was an unusual month. For the first time in a long while, the more northern observers were privileged again. Whereas cameras in southern Europe obtained about 15 observing nights under normal conditions, it was often 20 and more nights for the more northern stations. In the US, Carl Hergenrother enjoyed again perfect conditions and missed only a single night (by the end of the first quarter of 2011, Carl gave already a competitive edge of 14 nights to his two chasers known from the previous year), whereas the weather "down under" was rather poor.

It is no surprise that we clearly surpassed the previous best March totals. With more than 4 500 hours of effective observing time in the otherwise rather modest spring month, we achieved the third best monthly result of the IMO network ever. With respect to the meteor number, March cannot compare with August or October, of course, as it is the time of the year with the lowest hourly meteor counts. Still, more than 11 000 meteors in 2011 is more than twice the best March outcome to date (Table 1 and Figure 1).

With Karoly Jonas from Hungary, we gained another observer for the IMO Video Meteor Network. Karoly is living in Budapest and underlines once more that Watec and Mintron do well even in light polluted cities.

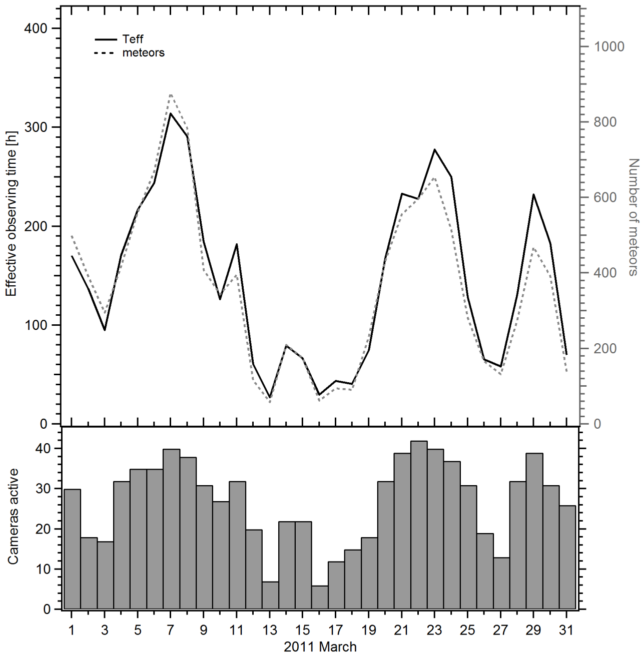

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2011 March.

2 Metrec new developments

In March, the administrators of the IMO network tested a new version of the MetRec software. It goes beyond the calculation of shower-independent effective collection areas by providing flux density measures of meteor showers. As presented at the 2010 IMC (Molau, 2011), MetRec computes at first pixel-wise the size of the field of view in square degrees. Based on that figure and the observing direction of the camera, the atmospheric surface (at an altitude of 100 km) monitored by the camera is computed next. If the camera is pointing lower to the horizon, the surface is increasing dramatically, but also the distance to the meteors grows so that they are getting fainter at the same time. This loss in brightness compared to a standard distance of 100 km (absolute meteor magnitude) is accounted for by proportionally reducing the collection area. The population index is assumed to be 3.0.

As MetRec is computing the limiting magnitude once per minute, also the difference between the observed and the standard limiting magnitude of +6.5 can be converted into a reduction of the collection area. Finally, the normalized area is multiplied with the effective observing time, which is also determined every minute, and is accumulated to obtain the effective collection area for the night.

In the new software version, this effective collection area is determined individually for each shower, whereby a number of shower-specific parameters are introduced:

- The population index, which is used to correct for the limiting magnitude and meteor distance, is not fixed at 3.0 but taken from the average value for each shower given in the IMO working list.
- The mean meteor altitude is not fixed at 100 km, but computed for each shower based on the meteor shower velocity and the radiant altitude.
- Instead of the limiting magnitude for stars, MetRec uses the limiting magnitude for meteors. At first, the distance of the radiant from the field of view, and from that the angular meteor velocity

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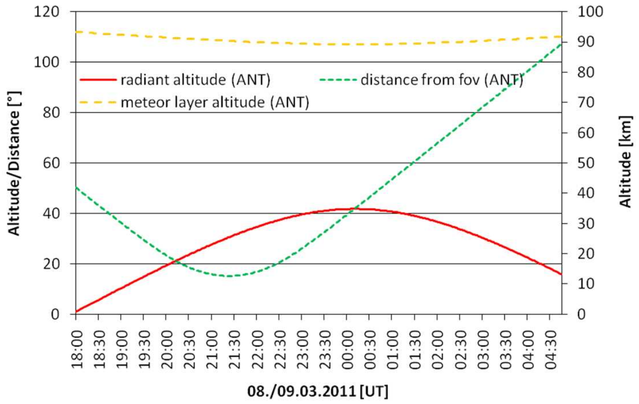

Figure 2 – Distance from the field of view, radiant altitude and meteor layer altitude of the Antihelion source, calculated for MINCAM1 on 2011 March 8/9.

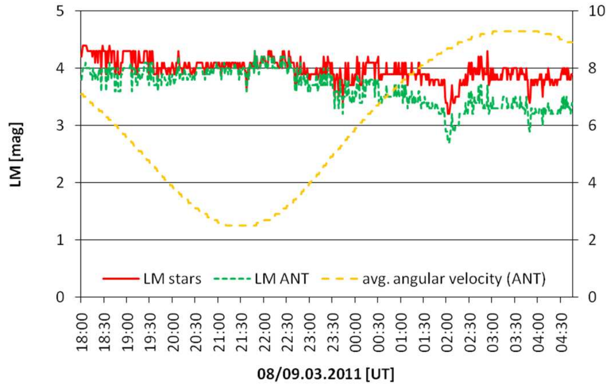

Figure 3 – Angular velocity of Antihelion meteors, as well as the stellar and the Antihelion limiting magnitude for MINCAM1 on 2011 March 8/9.

in °/s is computed. Together with the size of the field of view and the integration time, that velocity is converted to pixel per video frame. From this figure, the loss in limiting magnitude by the meteor motion is derived. Pixels with a meteor velocity of less than 2 °/s are fully omitted from the collection area, as the software filters out such slow meteors (and satellites).

- Last but not least, the radiant altitude is taken into account as one of the key parameters for the flux density. The zenith distance of the radiant is transformed once more into a reduction of the collection area.

The value of some parameters is given as an example in Figures 2 and 3, obtained for MINCAM1 and the Antihelion source on 2011 March 8/9. Figure 2 shows the radiant altitude, the average distance of the radiant from the field of view, and the meteor layer altitude. The radiant rises in the evening hours and culminates close to midnight UT. The meteor layer altitude is slowly decreasing by a few kilometers, and later increasing again. The average radiant distance from the field of view is getting smaller until about $21^{h}30^{m}$ UT and growing continuously thereafter.

Figure 3 depicts the average angular velocity of the Antihelion meteors, which is as expected lowest when the radiant is near the field of view, and increasing up to a maximum when the radiant is 90 degrees away. Furthermore, the stellar limiting magnitude determined by METREC and the corresponding limiting magnitude for Antihelion meteors is given. When the angular velocity is small, both values hardly differ from each other, but at a distance of 90 degrees the loss amounts to more than half a magnitude.

By taking all these parameters into consideration, a meteor-shower dependent effective collection area normalized to a limiting magnitude of +6.5 and radiant position at zenith is obtained. In the end, the number of recorded shower meteors is divided by this figure to derive the flux density.

Of course, there are still certain approximations in the algorithm. It is unlikely, for example, that the software will have a meteor detection probability of 100% down to the limiting magnitude of the camera. Similar to human observers, the detection probability will deteriorate towards fainter meteors, even though the effects will be smaller than for human observers.

The loss in meteor limiting magnitude derived from the angular velocity is a new terrain as well, as we are using a formula that is hitherto unknown and which is further investigated by Pete Gural.

Last but not least, the real population index will actually differ from the average value used for each shower. Only time will tell whether the corrections are still good enough to combine data from completely different video meteor cameras into a meaningful flux density profile (without normalization by the number of sporadic meteors).

Unfortunately, there was no stronger meteor shower in March, so we could only check for the sporadic flux density in the software testing phase. That is particularly challenging, as there is no defined sporadic radiant with a fixed velocity. This is why METREC assumes an average angular velocity of 14 °/s (which is the long-term average over all sporadic meteors) and a constant radiant altitude of 30 degrees (which is the average altitude over all possible radiant points above the horizon). Some effects like the increase of sporadic activity towards dawn cannot be modeled this way, but at least the sporadic flux density is then better comparable to flux densities of meteor showers.

Finally, the software was augmented by a function to automatically upload the flux density data to the central VMO server after the observation was checked with POSTPROC.

The results obtained in the testing phase were encouraging. After some bugs were fixed, the software was released to all observers by the end of March. The aim was to obtain during the 2011 Lyrids the first flux density profile of a meteor shower in near real-time based on video data. If and how we reached that goal will be presented in the next monthly report.

References

Molau S. (2011). “Towards flux rates from video meteor observations”. `http://www.imo.net/imc2010/talks/Molau.pdf` . (presented at the IMC held in Armagh, 2010 September 16–19, to be published in Proceedings of the conference).

Handling Editor: Javor Kac

Table 1 – Observers contributing to 2011 March data of the IMO Video Meteor Network. Eff.CA designates the effective collection area and Tot.CA the total collection area.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Tot.CA [10³km²h]	Meteors
BENOR	Benitez-S.	Las Palmas	Times4 (1.4/50)	2359	3.2	492	8	17.6	30.6	45
BERER	Berko	Ludányhalászi	Hulud1 (0.95/3)	6500	3.8	2209	24	73.0	—	182
			Hulud2 (0.75/6)	2258	4.7	1348	24	128.0	—	356
BRIBE	Brinkmann	Herne	Hermine (0.8/6)	2374	4.2	1084	22	95.6	179.7	270
		Bergisch Gladbach	Klemoi (0.8/6)	2386	5.4	2781	22	84.7	243.4	265
CASFL	Castellani	Monte Baldo	Bmh1 (0.8/6)	2350	—	—	21	96.6	—	271
			Bmh2 (1.5/4.5)*	4243	—	—	15	62.2	—	163
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	5575	4.2	2525	19	126.1	151.1	267
			Stg38 (0.8/3.8)	5593	4.3	2810	15	109.4	—	285
CSISZ	Csizmadia	Zalaegerszeg	Huvcse01 (0.95/5)	2439	3.0	249	21	39.0	—	93
CURMA	Currie	Grove	Mic4 (0.8/6)	1471	5.2	3008	13	82.9	135.6	169
ELTMA	Eltri	Venezia	Met38 (0.8/3.8)	5620	4.3	1778	13	98.9	158.0	192
GONRU	Goncalves	Tomar	Templar1 (0.8/6)*	2188	5.3	2331	13	65.5	94.6	222
			Templar2 (0.8/6)*	2303	5.0	2397	15	68.9	194.9	213
GOVMI	Govedič	Središče ob Dravi	Orion2 (0.8/8)	1471	6.0	3916	24	105.4	—	269
HERCA	Hergenrother	Tucson	Salsa3 (1.2/4)*	4332	4.0	1471	30	251.0	285.6	277
HINWO	Hinz	Brannenburg	Akm2 (0.85/25)*	754	5.7	1306	18	136.5	151.2	286
IGAAN	Igaz	Baja	Hubaj (0.8/3.8)	5600	4.3	3338	22	118.9	103.0	224
		Hódmezővásárhely	Huhod (0.8/3.8)	5609	4.2	3031	18	74.3	75.8	115
		Budapest	Hupol (1.2/4)	3929	3.5	1144	22	90.2	129.7	163
KACJA	Kac	Kostanjevec	Metka (0.8/8)*	1381	4.0	2246	17	88.8	—	189
		Ljubljana	Orion1 (0.8/8)	1420	5.3	2336	20	119.4	30.3	155
		Kamnik	Rezika (0.8/6)	2307	5.0	2293	16	118.2	71.8	412
			Stefka (0.8/3.8)	5540	4.2	2882	15	101.6	—	224
KARJO	Karoly	Budapest	Husor (0.95/4.0)	5262	3.9	1159	20	67.1	231.9	174
KERST	Kerr	Glenlee	Gocam1 (0.8/3.8)	5238	4.2	2637	8	42.4	—	232

Table 1 – Observers contributing to 2011 March data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
LUNRO	Lunsford	Chula Vista	Bocam (1.4/50)*	1860	5.1	1719	11	72.7	—	269
MOLSI	Molau	Seysdorf	Avis2 (1.4/50)*	1771	6.1	4182	18	162.2	426.2	995
			Mincam1 (0.8/8)	1477	4.9	1716	23	193.2	104.0	376
		Ketzür	Remo1 (0.8/3.8)	5592	3.0	974	21	189.0	81.2	152
			Remo2 (0.8/3.8)	5635	4.3	2846	19	132.3	82.9	211
MORJO	Morvai	Fülöpszállás	Huful (1.4/5)	2522	3.5	532	22	132.8	53.9	160
OTTMI	Otte	Pearl City	Orie1 (1.4/5.7)	3837	—	—	17	56.3	138.3	150
PERZS	Perko	Becsehely	Hubec (0.8/3.8)*	5448	3.4	1500	22	166.2	391.0	343
ROTEC	Rothenberg	Berlin	Armefa (0.8/6)	2369	4.8	1801	16	80.9	174.6	155
SCHHA	Schremmer	Niederkrüchten	Doraemon (0.8/3.8)	5537	3.0	846	23	51.7	160.5	139
SLAST	Slavec	Ljubljana	Kayak1 (1.8/28)	604	6.5	1849	14	62.3	—	170
STOEN	Stomeo	Scorze	Min38 (0.8/3.8)	5631	4.1	2407	17	115.5	202.6	416
			Noa38 (0.8/3.8)	5609	4.9	5800	15	92.2	137.8	230
			Sco38 (0.8/3.8)	5598	5.0	4416	18	134.3	236.1	449
STRJO	Strunk	Herford	Mincam2 (0.8/6)	2357	4.7	1380	20	78.0	—	223
			Mincam3 (0.8/12)	728	6.1	2271	22	87.1	171.6	266
			Mincam5 (0.8/6)	2344	5.2	2535	18	111.7	—	393
TEPIS	Tepliczky	Budapest	Humob (0.8/6)	2375	4.9	2258	9	54.9	87.9	118
TRIMI	Triglav	Velenje	Sraka (0.8/6)*	2222	—	—	22	64.6	—	169
YRJIL	Yrjölä	Kuusankoski	Finexcam (0.8/6)	2337	5.5	3574	16	75.2	190.7	184
						Overall	31	4 575.3	—	11 281

* active field of view smaller than video frame

History

History of Meteor Observing Project: An overview of British meteor observing, Part II, 1861 to 2010

Alastair McBeath[1]

The second of a two-part examination of the history of meteor observing in Britain since 1563 is presented, detailing information about the peiod 1861–2010.

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1 Introduction

This article continues and concludes the discussion of the history of British meteor observing since 1563 begun previously (McBeath, 2011). References and abbreviations not given here can be found in that earlier paper.

2 The period 1861–1890

The BAAS Luminous Meteor Committee in the Report 1861 (1862, pp. 1–44) consisted of the same four men, Glaisher, Gladstone, Greg and Lowe, as in 1860, when they took on the task of reporting matters meteoric to the BAAS from the Reverend Baden Powell, who had died in mid 1860. The amount of data received had still not recovered from its drop in the closing stages of Powell's time, and the Committee urged observers to submit more, and more complete, meteor details, in their opening remarks. Indeed, although the annual BAAS Committee Reports were the main published compilation of British meteor results at this time, analyses and some witness-data continued to feature elsewhere, such as in Phil. Mag. Even back in Powell's day, occasional notes on meteors appeared in other parts of the BAAS Reports, including the first description of James Challis's "meteoroscope" in 1848 (see McBeath, 2004).

However, the Committee had changed its composition by the BAAS Report 1862 (1863, pp. 1–88 and Errata, p. 527). Glaisher and Greg remained, but Gladstone and Lowe were gone (albeit Lowe continued to be active observationally), replaced by E. W. Brayley, whom we met briefly in the previous article, and complete newcomer to the subject, Alexander Stewart Herschel (1836–1907). Herschel was to become the major driving-force in meteor work in Britain after this, almost to the end of the BAAS Committee's luminous meteor reports in 1881. More observations had been received too, with several multiple-observer fireballs and substantial data collected from the "August meteors". Meteor watching and analyses were now back to much healthier levels, something that continued for several years, thanks in part to this revitalized Committee. Meteor heights and velocities were obtained from 20 of the 1863 "August meteors", as reported in the BAAS Report 1863 (1864, pp. 209–339), which featured among a lively summary of observations ancient and modern, meteor science paper reviews, and a number of other related topics, including some sketches of meteor trains as viewed telescopically.

Eighteen-sixty-four brought still more fascinating developments. The concept and pursuit of meteor shower radiants was taken-up in earnest by the BAAS as is evident from the Report 1864 (1865 pp. 1–101): "This inquiry should be promoted with the aid of maps especially provided for the purpose" (p. 1), with a view to such observations being accumulated over the years to allow radiants to be determined accurately. Radiants were so-determined from 1863 November 30 and December 12, 1864 January 2, and April 10, 13 and 20, using "plane perspective" (i.e., gnomonic projection) charts, radiants "which it is feared would otherwise have escaped attention. The number of radiant-points that yet remain to be determined appears to be strictly measured by the zeal of the observers" (loc. cit.). Greg produced a list of 56 radiants from the BAAS data collected in the period 1845–1863, with which to compare a similar number of radiants independently identified by Professor Eduard Heis (1806–1877) of Münster, Germany, which had been then recently published in MNRAS (**24**, 212–215, 1864), a comparison given on pp. 98–101 of the 1864 Report. The forthcoming close-approach of the 1866 "November meteors" was also anticipated (pp. 3 and 97).

Much of this fresh enthusiasm for meteor work came from Herschel, who became the chief author of future BAAS Reports, and who began publishing meteor papers elsewhere in 1864 too, notably in MNRAS, where his "State of Meteoric Science" article (**24**, 133–135, 1864) was the first meteor-related item to feature in that journal since 1857, judging by the list compiled by Roggemans (1987, p. 27). Herschel published three MNRAS papers on radiants before the 1866 Leonids, and a summary of the progress of meteor astronomy during 1863–64 (MNRAS, **25**, 158–162, 1865), while the leading name from the BAAS Luminous Meteor Committee, James Glaisher, contributed a piece on the hoped-for Leonid storm (MNRAS, **26**, 53–57, 1866). This storm was anticipated as well in the BAAS Report 1865 (1866, pp. 57–142), along with a report of healthy "November star-shower" activity on 1864 November 14, as seen from the ship *Ellora* off the island of Malta (op. cit., p. 122).

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Preparations for the storm included something new. "The British Association in the past year [i.e., 1864] having sanctioned a set of Maps to be printed for the use of the Committee, which are now completed and are presented with this Report, every means will be provided to Members of the Association willing to take part in the observations of this shower, to enable them to record their observations with facility" (op. cit., pp. 57–58). The use of such maps was demonstrated at the BAAS meeting in 1865, where a radiant in Orion was illustrated, following "A shower of remarkable meteors observed on the 18th of October [1864]" (p. 58), while a summary by Herschel on p. 59 of this BAAS Report noted, "Sky-maps prepared especially for observations of shooting-stars, and particularly of their radiant-points, have been placed for constant use in the hands of observers".

Unfortunately, these gnomonic projection meteor-plotting maps have proven entirely elusive. They were not bound with the BAAS Report 1865, nor could they be traced separately (even by the modern BAAS). However, in Herschel's subsequent MNRAS paper, "Radiant Point of the November Meteors 1866" (**27**, 17–19, 1867), he described the radiants he had deduced from his own and a further sixteen observers' work, as all discovered using a gnomonic map. The essential information was that this was not one of the BAAS maps, but instead was one from an atlas of six, published by the *Society for the Diffusion of Useful Knowledge* (SDUK), edited by Sir John Lubbock.

The SDUK was set-up in the year 1826 by Henry Peter Brougham (1778–1868; later first Baron Brougham and Vaux) to make scientific knowledge more widely-available and intelligible, especially for mechanics. Its publications included a regular *Penny Magazine* and a host of beautiful maps, many of cities ancient and modern. Disappointingly, the SDUK went bankrupt in 1846, though its maps continued to be reprinted at times for the rest of the century. Lubbock was involved with various SDUK projects, the last of which was this gnomonic star atlas, in 1830, for which he wrote an accompanying text, together titled "The Stars, in Six Maps, on the Gnomonic Projection". This was not designed originally for meteor work, but was intended to show the stars as they would have been seen if using a camera lucida. Much of this information came from Matthew & Harrison (2004), vol. 7, p. 975 (Brougham) and vol. 34, p. 653 (Lubbock).

The six SDUK maps included stars, graticules and artistic constellation illustrations, in some cases printed in full colour, and, as such, are impressive works of art. Four equatorial charts and two polar ones covered the entire sky in the set, each about 28 × 26 cm in size. Copies can sometimes be found in online salerooms. Whether the BAAS simply reused the SDUK maps, or a variant of them (perhaps without the elaborate figurative artwork) is unknown, but it may be suggestive that Herschel used and credited the SDUK map for his MNRAS paper. Much later, Prentice (1948, p. 108), indicated the BAAS maps continued in use with most observers till 1915, but commented that they "were on too small a scale and did not contain enough stars; moreover there were errors in some of the star positions and in the polar curves", though he made no mention of any artistic constellation figures.

Other fresh initiatives came about thanks to the 1866 Leonids, including the collection and publication of a huge number of observations, as witnessed by the quantity of papers in the 1867 volume of MNRAS, for instance (cf. Roggemans, 1987, p. 28). James Challis "reinvented" his meteoroscope for measuring meteor sky-positions for the event (McBeath, 2004), while visual spectroscopy was employed too. The BAAS Report 1866 (1867, pp. 16–146) described how John Browning (1830/31–1925), Glaisher and Herschel had used binocular spectroscopes to view spectra of some "August meteors" earlier in 1866 (see also Browning's paper on Leonid spectra in MNRAS, **27**, 77–79, 1867). The Leonid storm of November 13/14 was naturally commented upon in detail in the BAAS Report 1867 (1868, pp. 288–430), with observers having worked to define the radiant, and to attempt double-station recording of the same meteors, to derive their heights. There were fascinating descriptions and sketches showing the behaviour of numerous persistent trains seen visually and telescopically on the storm night, lasting ten minutes or more each at times, plus examinations of the observed meteor brightnesses and colours, as well as the spectroscopic reports. The BAAS Committee of Glaisher, Greg, Brayley and Herschel was joined by Charles Brooke (1804–1879), Secretary to the *Meteorological Society*, in this presentation, who remained a member in most years up to his death.

In the BAAS Report 1868 (1869, pp. 344–428), much space was devoted to discussions and lists of meteor shower radiants, including from the works of Schiaparelli regarding the "August meteor-ring" (i.e., the Perseid meteoroid stream), and that for the "November meteors". A series of charts showing these radiant-points were printed and bound in an atlas, which was sent to individuals and groups at the end of 1867 by the BAAS. A fresh version of this "Meteor Atlas", with three new charts and other improvements, was published in 1868, featuring all the known or suspected northern-hemisphere radiants. While copies of this Atlas have not been traced, the 1868 Report included a list of the radiants involved on pp. 401–403, with some discussion, and a list of southern hemisphere showers on p. 405. This work was continued and expanded by the Committee's tenth anniversary Report 1869 (1870, pp. 216–308), and on into the 1870s, but the period 1868–69 saw the emergence of perhaps the most famous of all British meteor astronomers, Bristol-based William Frederick Denning (1848–1931; see his detailed biography by Martin Beech – Beech, 1998a, 1998b, 1998c; also, Beech, 2010a).

Although concerned with Jupiter's satellites, not meteors, Denning's first publication was in the *Astronomical Register* (AR), a journal begun in 1863 January, intended to collect items not important enough to warrant featuring in MNRAS, along with other astronomical information, aimed particularly at amateur observers

(Dreyer & Turner, 1923, p. 134). Numerous meteor notices appeared in the AR throughout its existence (1863–1886), in some cases duplicating material from elsewhere, such as the BAAS Reports. In 1869, Denning was one of the founders of the first attempt to create a dedicated, national amateur astronomy group in Britain, the *Observational Astronomical Society* (OAS), whose reports featured in the Astronomical Register. Meteors were naturally part of the OAS's interests – see for example the notes on the "August meteors" (AR, **9**, 237, 1871), – though not an especially major one.

Unfortunately, the OAS disbanded in mid 1872, most likely due to a lack of support from its membership. This was particularly poorly-timed, as the first, strong meteor activity associated with Comet 3D/Biela was predicted for, and occurred in, late November 1872. This Andromedid storm of November 27 was well-seen from Britain, as the vast array of short papers in MNRAS (**33**, 1873) demonstrated (listed in Roggemans, 1987, pp. 29–30). It was also discussed by the BAAS Report 1873 (1874, pp. 349–403), of course, though the Luminous Meteor Committee had been reduced by the death of E. W. Brayley on 1870 February 1 (BAAS Report 1870; 1871, pp. 76–102). The 1870 BAAS Report had indicated a change in observing policy too, requesting that observers should concentrate on covering the well-known and long-established annual meteor shower nights, following the example of the Italian meteor observers led by Schiaparelli. In light of the Andromedids of 1872, not a recognised annual shower, this was perhaps a little premature in implying how "well understood" meteor behaviour was.

Encouraged by regular correspondence with Herschel from 1869 to 1874 (cf. Beech, 2010b, p. 85, on the rift between the two at this time), Denning's meteor publications first peaked in number in the late 1870s (Beech, 1998a, Fig. 1, p. 23), and he was able to show observationally the diurnal drift in the Perseid radiant from his own data in 1877, a significant contribution to the subject. The following year though, he published his initial paper in MNRAS, which suggested some radiants might be stationary, a belief he continued to hold until his death. Arguments over this seem to have blighted his later life, and may have contributed to his frequent ill-health and depression from about 1890 onwards (op. cit., pp. 22–24 and references therein). He provided much data to the BAAS Luminous Meteor group during the 1870s, but was never on the Committee, perhaps deterred by his experiences with the OAS, for all his importance to the subject was clearly growing.

By the mid 1870s, showers in the BAAS Reports and elsewhere might still be called after their month of peak occurrence, but the potential for confusion due to the two "November" showers after 1872 seemed to have helped promote the notion of using the constellation the radiant lay in to name the shower – such as the "Perseids". The "-ids" suffix was not exclusively preferred however, as the term "Andromedes", used in the BAAS Report 1878 (1879, pp. 258–377), for instance, was favoured instead of "Andromedids" in Britain through until the shower had ceased to be especially sought during the first quarter of the 20th century, suggesting practical use, not linguistic pedantry, was from the start of greater bearing on how showers might be named in English.

Despite the continued strong interest in meteors and their analyses, plus the fact the BAAS Committee had expanded its numbers to six, it is clear the Luminous Meteor group was struggling by 1877. The BAAS Report 1877 (1878, pp. 98–193) noted the Committee had hoped to review the shower radiant list and improve the available observing instructions, but had been unable to do so, due to the time involved in the analysis work. Most of this was done instead by the time of the 1878 Report, which formed a watershed in the life of the BAAS efforts regarding meteors. Greg and Denning's analyses had shown the key point of needing high-quality meteor plots to make progress, and the observing directions were revised and reissued there accordingly. The shower analyses included comparisons with similar data prepared elsewhere in Europe, while the meteor observing instructions were the most detailed published in Britain to that time, on pp. 370–377, including notes on visual and telescopic observing, fireballs and meteorites. Much of the information requested has remained largely unchanged since.

This proved to be the last really detailed meteor review of the BAAS. The Report 1879 (1879, pp. 76–131; unusually published in the same year as the meeting) noted Greg had retired from his analysis work with the Committee, and that Brooke had sadly died. Although E. J. Lowe had returned (a fact that passed oddly uncommented upon), the details published were somewhat lessened, and much was mentioned as having to be deferred to a future year for discussion. The latter never happened. The Report 1880 (1880, pp. 39–55) was short, and largely a review of what the previous twenty Reports had achieved, with little new material, while the Report 1881 (1882, pp. 290–293) was the Committee's last, little more than a few brief notes. Presumably, the aging Committee members had had enough, perhaps coupled with the failure of the predicted Andromedid return, expected in the previous year, which "proved to be only a source of disappointment, as no marked abundance of Andromedes during the last week of November 1880 was anywhere noticed by observers." Despite attempting some more positive comments on the Leonids seen from America, and the Quadrantids from England (observed by Denning), it was a somewhat sad end to this once-vital facet of British meteor work.

It may be that a new monthly British publication, *The Observatory* (TO), intended to "aim at presenting in a popular form a general review of the progress of Astronomy, and at promoting the activity of observers by affording early intelligence of recent advances in the Science" (Dreyer & Turner, 1923, p. 198), and first published in 1877 April, was able to provide a much more immediate forum than the annual BAAS reviews, often not published for up to two years after the events they described, which contributed to the end of the BAAS's close involvement with meteor astronomy.

Denning published frequently in TO from the first volume onwards (see Roggemans, 1987, pp. 47–48), while the amount of items appearing there and in journals such as MNRAS and AR, written by Denning and others, demonstrated clearly that much meteor observing continued in Britain during the early 1880s, as it had before. Indeed, interest in the subject showed another especial peak thanks to the strong Andromedes return of 1885, a focal point for the decade, which saw more meteor-related papers published in MNRAS for 1886, than in any year since 1873 (op. cit., pp. 32–33).

More changes followed. Members of the old BAAS Luminous Meteor Committee rapidly ceased to feature as meteor-astronomy authors after the early 1880s. Even Herschel, though he continued to observe and to correspond frequently with Denning, largely dropped from view after he retired as Professor of Physics at Newcastle-upon-Tyne in the late 1880s, leaving Denning as the prime motivator of meteor observing in Britain. Denning's standing was further confirmed in 1887, when he was elected President of the *Liverpool Astronomical Society* (LAS). This flourishing Society, founded in 1881, and based at Liverpool in northwest England, had largely amateur astronomical members, but scattered across Britain and other parts of the world, and held its meetings in different parts of the country, effectively as a national astronomical society in all but name. Denning also served as Director to its Meteor and Comet-Seeking Section, and its Jupiter Planetary Section. After his year-long Presidency, he continued as Vice-President during 1888 (Beech, 1998a, pp. 22–24). However, by 1890, the LAS was in difficulties, and could no longer sustain its national role.

In July of that year, another active observer of the period, W. H. S. Monck (1839–1915), published a letter in the weekly *English Mechanic* newspaper (1885–1926), already noted for encouraging beginners to astronomy through its letters column, suggesting a genuinely national astronomical society be founded, based in London. This was not intended to rival the RAS, but to supplement it, for those who could not afford the RAS subscription fee, or who found the RAS papers too technical, and which women – excluded entirely by the RAS then – could join (Kelly, 1948, p. 7). Progress in forming the new society was rapid. Its first general meeting was held on 1890 October 24, and its first ordinary meeting a month later. This was the British Astronomical Association (BAA), and following the pattern of the LAS, it immediately established a series of eight observing sections, including one for meteors. David Booth was appointed its first Meteor Director (op. cit., p. 8), and thus was created virtually the sole focus for organized amateur meteor astronomy in Britain through to 1964.

Almost from the first, discussions of meteors took place at the BAA's regular London meetings. The Association's instigator, Monck, raised a discussion at the 1890 December meeting which showed nearly 25 years after Schiaparelli's discovery, how much uncertainty still remained regarding the link between comets and meteor showers. "That there is some connection between Comets and Meteors in the case of *great displays*, seems highly probable, but I am inclined to think that the Comet does not produce any Meteor Shower, but only intensifies those which emanate from points in the vicinity of the Cometary radiant" (Monck, cited in Kelly, 1948, p. 10). The notable rising star in meteor astronomy and other branches, as well as in the field of meteorology, Thomas William Backhouse (1842–1920), replied to Monck's presentation, summarizing the beliefs on the topic of the period.

3 The period 1891–1945

The Monck and Backhouse discussions from late 1890 featured in the inaugural volume of the *Journal of the BAA* (JBAA), for 1890–91, along with coverage of more practical subjects, such as meteor photography, still very much in its infancy, through to speculative contemplation of meteoric dust falling onto the Moon. Denning joined the BAA in 1891, and was almost immediately co-opted into directing its Cometary Section, to whose observing programme he added telescopic meteors. He contributed occasional meteor papers to the JBAA from its second volume, and by the third, it seemed even Monck was probably satisfied of the meteor-comet connection's reality, after several anonymous notes on "The Andromedes (Bielids)" had appeared. The BAA also began publishing bound, annual *Memoirs* from 1891, which included summary reviews of meteor activity that were quite similar, if considerably less extensive, to what the BAAS had formerly done up to a decade before, prepared by the Meteor Directors. For meteors, this continued every year until 1906, but then there was a gap, and only two more featuring meteors were published later, in 1923 and 1936. The annual *Memoirs* were stopped due to wartime paper shortages in 1940, and never resumed. Although a few one-off texts were published subsequently under this title, none concerned meteors. The meteoric items featured there were listed by Roggemans (1987, pp. 167–168).

From its inception through to the 1939–45 war, the BAA Meteor Section's programme revolved around determining meteor radiants and atmospheric trajectories, all requiring high-precision positional data. Initially, there were a dozen or more British observers capable of generating such information regularly, including Backhouse, Denning and Herschel, building on the expertise created during the later BAAS years. However, the quantity of data obtained was never great, and was wholly insufficient to answer key questions, such as that regarding stationary radiants. In addition, there were errors in the analysis methods used for obtaining atmospheric meteor paths, and further problems were caused by the inadequate maps and celestial globes used for plotting meteors prior to the publication of Backhouse's set of 14 gnomonic maps covering the whole sky in 1915. Figure 4 in Beech, 1998a (p. 28), and Figures 3 and 7 in Beech, 2010a (pp. 44 and 47), showed Denning with his 18-inch (about 46 cm) diameter plotting globe, for instance. Backhouse had been planning the new star charts since 1886, and had spent many years compiling the "Catalogue of 9842 Stars Visible to the Naked Eye" from which to generate them. This Catalogue was finally published by Hills & Co. in his home town of Sunderland in 1911, and the charts were prepared as 110°-diameter circles on 30-inch (about 76 cm) square sheets, showing stars down to magnitude +6.4 in 0.2-magnitude steps. (Prentice, 1948, discussed various aspects of the programme and problems of the early BAA Meteor Section, while parts of the Backhouse information came from Matthew & Harrison, 2004, vol. 3, p. 103.)

The late 1890s brought much anticipation of the Leonids in 1899, with Denning's book "The Great Meteoric Shower of November" published in 1897. Numerous journal, newspaper and magazine articles followed it, but, of course, no storm occurred then. While some astronomers were quick to point out this "failure" was entirely as expected, one has to wonder why notes on the shower's disappointing non-appearance were still published in TO (**22**, 454–456, 1899) and JBAA (**18**, 135, 1899–1900). It is hard to assess if this had any wider effects on British meteor observing. The amount of meteor and meteorite papers published in JBAA and elsewhere continued at a generally healthy level until the Great War (1914–18), with Denning an especially prolific author, certainly.

There were though problems for the BAA Meteor Section. Directors had come and gone throughout the 1890s, with no real negative impact. David Booth had continued as Director till 1892, followed by Henry Corder, 1892–99, Denning, 1899–1900, and Walter E. Besley after Denning, but Besley's ill health and death in 1905 apparently caused a total collapse in the Section's activities, not helped by Herschel's death in 1907. Prentice (1948, p. 105) characterised the period 1905–11 as one in which "very little meteor work was done in Britain", and made no comment whatsoever concerning the "Miss C. O. Stevens" he listed as the Meteor Director during that time.

Prentice, however, seemed willing to criticise the perceived failings of many of those involved in BAA meteor observing before his own time as Director, from Denning downwards, and it was disingenuous of him to make so sweeping a statement, given the unabated number and variety of meteor-related papers published in MNRAS, TO and JBAA across this supposed hiatus. The work may not all have been done under the auspices of the BAA, but meteor work did indeed continue, likely as actively as ever, in Britain then.

In fact, Catherine Octavia Stevens (1864–1959) came to her BAA Directorship as a complete meteoric novice, having been a more active solar, auroral and halo observer since joining the Association in 1891. While she determined to set the Section on a more scientifically-useful course observationally, she struggled to cope with the responsibility of the post, and her lack of knowledge, not helped by being ill for much of the late stages of her time as Meteor Director. This led to the Section being relatively inactive overall, albeit this problem recurred for several other BAA sections in the opening decade of the twentieth century (Larsen, 2006, p. 77).

The Reverend Martin Davidson (1880–1968) was appointed Meteor Director in 1911. He was particularly knowledgeable regarding the more theoretical aspects of meteor science, but was strongly aided observationally by people such as Denning, musician and enthusiastic astronomer Fiammetta Wilson (1864–1920), and Alice Grace Cook (died 1958). From 1912 to 1919, 500 true meteor atmospheric paths were obtained, a number which had previously been amassed only from 1882 to 1911. Davidson went into the army as a chaplain on Europe's Western Front in 1915, which halted his involvement with meteor astronomy until 1919, and though nominally still Director, it was actually Wilson and Cook, as joint Interim Directors, who continued the Section's work and limited publications during the War. Indeed, women were not required to serve in the armed forces then. Wartime paper shortages meant the BAA *Memoirs* could not be published, and even the JBAA was reduced in size (Kelly, 1948, pp. 23 and 27; Larsen, 2006, pp. 79–80; Prentice, 1948, p. 105). What should have been a particular highlight of this period, the June Boötid outburst on 1916 June 28, and its association with Comet 7P/Pons-Winnecke, suggested by Denning and later confirmed by C. P. Olivier in America, was reported by far fewer British observers than might otherwise have been expected under peacetime circumstances. It featured more heavily in TO (Denning's papers in **39**, 1916, pp. 353–357 and 396–397, and **40**, 1917, pp. 95–96) and MNRAS (Denning again, **76**, 1916, pp. 740–743) than in JBAA, where, aside from a few notes nearer the event, the first dedicated paper on the shower and its comet did not feature until Davidson's discussion after the War (**31**, 270–271, 1920–21).

Scarcely had Davidson returned from the army and resumed his BAA activities, when Wilson died unexpectedly in 1920 July, a loss which largely halted all work on multiple-station meteor observations, in which she had been so active in previous years (Prentice, 1948, p. 105). Indeed, her enthusiasm and energy for meteor observing since joining the BAA in 1910 led both to her cooperating with Denning in obtaining more double-station meteor paths than any other pair of observers had ever previously achieved, and also to her making herself ill, to the point of being ordered to cease observing for a time by her doctor. By the time of her death, she had plotted paths for most of the 10 000+ meteors she had observed since 1910. This decade, during which Cook, Denning and Wilson were so very actively dominant, was later regarded as a "golden age" in British meteor astronomy (Larsen, 2006, p. 78).

Shortly before F. Wilson's untimely death, in 1920 April, Davidson had reinvented the meteoroscope again, "An Apparatus for the Observation of Meteor Paths", as his initial JBAA paper title subsequently identified it (**30**, 223–226, 1920). The detailed description, with a photograph of the instrument on Plate III (facing p. 223) of the same JBAA volume, showed it was quite similar to the Challis meteoroscope, last used in the 1860s. Davidson failed to mention Challis's name in regard to it, and apparently had developed it entirely independently. He displayed an improved version of the device at the BAA's Conversation Meeting in 1921 March, before resigning as Director later that year, leaving it to his successor, Grace Cook, to report on the "new" meteoroscope's trial usage in May to the 1921 December Meeting (see A. G. Cook, "First report on the meteoroscope", JBAA, **32**, 98–99, 1921–22). This was not a great success. Cook noted that recording a meteor's path with the straight edge of a stick (the "meteor wand" Denning was photographed with) took her 30 seconds. With practice, she reduced the time to do the same using the meteoroscope from five to two *minutes*! She added, "It is doubtful if this can be improved upon." However, using the instrument, 143 of 535 meteors seen from 1921 June 1 to September 8 were recorded by her. It is not difficult to see why, like the Challis version, the "Davidson" meteoroscope was not used much beyond these trials, and it never featured so prominently again.

Cook stood-down as Meteor Director in 1923, and was replaced by the, still, longest-serving BAA Meteor Director, J. P. Manning Prentice (1903–1981), from 1923 to 1954. Although he actually resigned in 1937, he was persuaded to continue in-post without a significant break (Kelly, 1948, p. 44). Prentice took time to settle into his new role, and published scarcely anything of note on meteors in JBAA or elsewhere until 1929. These early years were taken-up with experiments intended to improve the quality of visual meteor observing and its analyses, and his gaining familiarity with meteor science overall. In this, he was particularly heavily influenced by the writings of Olivier, founder of, and primary driving force behind, the *American Meteor Society*. This helped ground the BAA Section more firmly in a rigorous scientific methodology and discipline than had been sometimes apparent before. One early result was the rejection of the idea of stationary radiants, which Prentice had been a supporter of when he took on the Section, having learnt his early observing under Denning and Cook. Invaluable assistance came from observer George Alcock (1913–2001), and observer-analyst Alphonso King (1882–1936), who took over from Denning as the main author of meteor information in TO from 1927 until King's death (cf. the list in Roggemans, 1987, pp. 56–62). Denning by then was elderly and becoming frail, though he continued to observe and publish on meteors until shortly before his own death at 83, on 1931 June 9 (Beech, 1998a, p. 28).

Among the BAA's experiments was meteor photography using automated plate cameras with small, short focal-ratio lenses, notably by H. H. Waters and Edward Howard Collinson (1903–1990). The work was frustrating, however. For example, from 411 hours of exposures between 1929 and 1934, 452 plates were used, but just 20 meteor trails were photographed. Even working in conjunction with Prentice and King's visual observations enabled a total of only six meteor atmospheric paths to be obtained. Consequently, the main emphasis remained on visual watching. Rejecting the use of plotting maps and globes, apparently as early as 1920 according to Prentice, by the 1930s, the BAA relied on observers having memorized every star in the entire visible sky from Britain, and being able to give a purely written description of where each meteor's path had begun and ended in relation to the stars. This description used a complex shorthand notation, and the example Prentice cited in his official history of the Meteor Section (1948, p. 108) was given with no explanation, and was entirely meaningless to anyone not directly involved in the work. In conjunction with improved and simplified mathematical analyses, thanks to his close cooperation with the BAA's Computing Section under its new Director, appointed in 1936, John Guy Porter (1900–1981), this greatly improved the accuracy of the results collected, and markedly speeded-up the analysis process, but it also meant scarcely any observers had the necessary skills to produce the data (Kelly, 1948, p. 41; Prentice, 1948, pp. 106–108).

Meteoric event of the 1930s was the Draconid storm on 1933 October 9. It was observed from various places in Britain, aside from elsewhere in the world, as the papers by King in TO (**56**, 348–349 and 379–381, 1933; **57**, 38 and 288, 1934) and JBAA (**44**, 111–115, 1933–34) demonstrated. Prentice also discussed it in the same JBAA volume (pp. 108–111), yet he failed to mention it in his review of the Meteor Section's history (Prentice, 1948), where instead he seemed far more intent on describing the complexities involved in his newly-devised observing programme. He also managed to credit himself there with the discovery of the association between the Draconids and Comet 21P/Giacobini-Zinner in 1926 (op. cit., p. 110), ignoring the fact this link had been proposed by Davidson back in 1915 (JBAA, **25**, 292–293, 1914–15), and which radiant Denning suggested he had observed meteors from between 1900 and 1913 later in the same JBAA volume (p. 348). Further predictions and observations by these same men followed in 1920, and it was only at the 1926 return that Prentice was among the British observers who covered the shower, along with Denning and King.

Following the Great War, the worldwide economic depression had created chaos at times through much of the 1920s and 1930s, and this culminated in the 1939–45 global conflict. While meteor work continued much as before in Britain during 1939, by late 1940, the increasing call-up to military service of able-bodied men and women, coupled with shortages of all kinds of supplies, left the BAA in difficulties, along with many other organizations not essential to the war-effort. As a result, hardly any organized British meteor observing was possible from 1940 to 1945. Prentice was virtually the sole watcher reporting to the BAA, although he and Porter continued their collaborative analysis efforts, which provided further evidence against, the concept of hyperbolic sporadic meteor velocities, the main contentious topic after the stationary radiant debate had been laid to rest (Spalding, 1990, p. 87). In many ways, things would never be the same again once this war ended.

4 The period 1946–1980

The process of demobilizing the armed forces after the war led to large quantities of technical gear becoming surplus to requirements, much of which was sold-off very cheaply. In Britain, for example, this led to professional astronomers gaining access to equipment that enabled the setting-up of the Jodrell Bank radio astronomy group in Cheshire, part of the University of Manchester, as it still is. Heading the group was Bernard Lovell, who turned to the BAA for advice on meteor observing. Prentice, busy rebuilding his visual observing team, with Porter's computational skills, was happy to oblige, and, by-chance, the 1946 October 9/10 Draconid storm happened in perfect time to be recorded visually, photographically and by radar from Britain, a remarkably fortunate coincidence. Papers on the event followed in MNRAS (**107**, 164–175, 1947, by Lovell, C. J. Banwell and J. A. Clegg), TO (**67**, 3–8, 1947, by Prentice) and JBAA (**57**, 86–91, 1946–47, by Prentice again). At the BAA's 1947 November meeting, Porter spoke on the radar discovery of the first daytime meteor showers from Jodrell Bank, and more papers in JBAA through to 1950 continued the theme of radar meteor developments. However, such changes were not welcomed by all, with complaints from BAA members that too much time at Meetings and JBAA space was being occupied by this new work, instead of "real astronomy" (Beet, 1990, pp. 12–14)!

Regardless of such views, the pace of technological change in astronomy could not be halted, and by the 1950–51 session, the BAA was considering publishing two journals, one for technical papers, the other more popularly-written, but was stopped by the cost. Amateur authors in Britain had ceased writing generally in "professional" journals like MNRAS and TO by the 1950s, as the separation between "amateurs" and "professionals" in science became increasingly entrenched, and the complexity of the published material rose. As the problem worsened, an alternative concept was to start a Junior Section in the BAA, to help those youngsters struggling with the JBAA's more technical content. The detailed proposal to form such a Section by Ernest Beet and Patrick Moore was rejected by the BAA Council in 1952. This led to several BAA members, including Moore, taking matters into their own hands, and they formed the separate *Junior Astronomical Society* (JAS) in 1953 March (Moore, 1990, p. 18). Originally intended as a means of training young people prior to entry into the BAA, by the mid 1960s, the JAS was becoming gradually more independent, a slow process which led in 1994 to it changing its name to the *Society for Popular Astronomy* (SPA), and it continues today as an independent, less technical, alternative national British amateur astronomical society to the BAA.

As well as the success of radar meteor work, photographic work was massively boosted by the professional Harvard Super-Schmidt programme. Radar studies rapidly ended the hyperbolic-velocity theory for sporadics, while the Super-Schmidt data produced thousands of high-accuracy meteor orbits and atmospheric paths. In just a few years, all the aims of the highly complex visual technique Prentice and Porter had so laboriously constructed and employed before the war, and to which they had returned afterwards, had been achieved thanks to these professional methods alone. The amateur work in these fields was redundant, and a disillusioned Prentice resigned finally as BAA Meteor Director in 1954. Porter hung-on as Computing Director till 1959 (Moore, 1990, pp. 20–22; Spalding, 1990, p. 88).

Harold Ridley (1919–1995) took on the Meteor Section after Prentice quit, having been one of the keen, new, post-war meteor observers Prentice had trained. He tackled the problem of the redundant visual technique by switching to statistical methods to obtain rate and magnitude results from various shower meteors and the sporadics, while abandoning meteor plotting entirely. Prentice's apparent disdain for such a technique (1948, p. 104) may help explain why he was so unable to adapt. The basic ideas Ridley set-down formed the foundation for most subsequent British meteor observing, though meteor plotting was later used occasionally as well, commonly employing gnomonic maps for special projects, by both the BAA and JAS/SPA. Ridley also embraced those instrumental methods amateurs could use relatively easily, including photography, and to a lesser extent photographic spectroscopy. Collinson, so active photographically between the wars, now pounced on the cheap war-surplus lenses and new, fast, photographic film emulsions to upgrade rapidly the abilities of amateur meteor photographers. As early as 1956, Ridley had available 23 Perseid trail images allowing the derivation of the shower's radiant that summer, while additionally using the visual data to determine the time of shower maximum, both results which still stand-up compared to modern values (see Ridley's "The Perseid meteor shower 1956", JBAA, **67**, 235–239, 1956–57). The photographic radiant found was quite compact too, in complete contrast to the large, diffuse radiant Prentice's earlier visual plotting analyses had indicated.

Spectroscopically, successes were fewer, since only bright fireballs stood any chance of recording with the systems available, but from 1954–65, five BAA observers recorded 37 individual meteor spectrograms, 17 of those by Ridley alone between 1954–58. Various JBAA papers discussed these, such as Ridley's first capture in **65**, 70–71, 1954–55, his summary paper on the Section's spectra in **76**, 229–230, 1965–66, and the immediately following article by the Lloyd-Evans brothers (who together had imaged 17 more spectra from 1958 to 1965), 231–243.

One of Ridley's last major activities as Director was making advance publicity for the 1966 Leonids, for the first time using TV as well as printed media to get the message over. The failure of the shower to produce storms in 1899 and 1932–33 meant expectations for 1966 were not especially high, but clearer skies over parts of Britain allowed many people a view of the activity on November 16/17 or 17/18. Rates at best were similar to a good Perseid maximum, far better than the typical Leonid drizzle, albeit not the great storm seen over the western USA (cf. Spalding & McBeath, 1998). Ridley's interests were turning towards comet photography however, and having thoroughly revitalized British amateur meteor work, he stepped-down as BAA Meteor Director in 1968. (Notes on Ridley's Directorship here, where not otherwise indicated, largely came from Spalding, 1990, pp. 88–89.)

Developments were underway elsewhere. In the early 1960s, the JAS was starting to set-up dedicated observing sections. Previously, things had been much more informal, but interest generated by an article "Who's for watching the Perseid meteors?" in the 1964 July issue of the JAS's quarterly magazine *Hermes* led to the Meteor Section being formed in late 1964, directed until 1968 by the article's author, Geoff White. In fact, White seemed to have been first involved in JAS meteor work from the late 1950s, including at a Perseid observing camp on Farthing Downs, near Coulsdon on the southern outskirts of London in 1959. The JAS was still quite small in the 1960s, with many members living in or near London, and such meteor observing camps at Farthing Downs were an occasional feature of White's tenure as Director. Also in 1964, a new independent magazine was set-up, to rapidly publish and publicise astronomical observations and news, often within a few days or weeks of the event, *The Astronomer*. Many of Britain's leading meteor amateurs have contributed data for inclusion there down the years, and some continue to do so. Though never a major source of meteor analyses, it did add to interest in the subject from its early days, and there have been some lively debates in it, as long-standing Meteor Editor and observer Tony Markham has discussed before (e.g., Markham, 1995).

It would be easy to get the impression from this condensed historical sketch that fireballs had ceased to have much importance after the BAA was founded, but as the continued supply of reports published on individual, British-witnessed fireballs throughout the 20th century showed (cf. the MNRAS, TO and JBAA article lists in Roggemans, 1987) that was not so. Perhaps the most significant of the last 50 years was that associated with the Barwell meteorite fall in Leicestershire, on 1965 December 24, an L6 olivine-hypersthene chondrite, which was widely-seen – and heard – across parts of Britain, and whose analysis, along with that of its meteorite fragments, was well-discussed by both the professional and amateur press (cf. items in *Nature*, **210**, 983, 1966 by H. G. Miles and A. J. Meadows, or the commentaries in JBAA, **76**, 331–335, 1965–66; and **77**, 60–61, 1966–67; plus Howard Miles's detailed review on pp. 177–195 of this latter volume).

Keith Hindley, then a Chemistry PhD student at Liverpool University, became JAS Meteor Director in early 1968. Already known for his telescopic meteor work, a technique he introduced to the JAS, he brought a more professional approach to the topic generally, while continuing and expanding the previous visual observing campaigns, especially for particular showers. By late 1968, having gained his doctorate, he was also appointed BAA Meteor Director. Successful visual observations of the 1969 Lyrids and June Lyrids followed for both Sections, but wishing to concentrate on the BAA in what spare-time his post-doctoral work allowed, he resigned as JAS Meteor Director in mid 1969, and was replaced by one of his two assistants, Robert Mackenzie.

Mackenzie was young and enthusiastic, but lacked the scientific knowledge and experience of Hindley. Beginning with a small committee to run the Section, he soon followed Hindley's model, by retaining just two assistants, Martin Ince (who had been Hindley's other assistant), and later Sandy Allan, and for a time, all seemed to be going smoothly.

Regrettably, controversy soon arose, initially in regard to some of Mackenzie's telescopic planetary observations submitted to the BAA, which were at their most polite described as "imaginative", in what remains of the correspondence from that period. Claims and counter-claims followed in other astronomical fields with which Mackenzie was involved, including meteors, casting doubts over all his meteor work. He was expelled from both the BAA and JAS in a series of poorly-documented official actions by the two organizations, and was replaced as JAS Meteor Director in late 1970 by his assistant Ince.

Too little detail has survived on this whole sorry affair to say who, if anyone, was in the right, but no one came out of it well, and it seems likely that the BAA and JAS should have handled the matter rather differently, as the reactions of both seem very heavy-handed now.

Mackenzie set-up the *British Meteor Society* (BMS) in late 1970, immediately after being expelled from the two national societies, and Allan became his assistant there subsequently. The BMS was intended to rival the BAA and JAS Meteor Sections, publishing a regular magazine *Meteoros* and other information. However, the acrimonious events surrounding Mackenzie tarnished its reputation from the beginning, something that was not helped by some of the claims made from BMS data, which either seemed too precise for the results on which they were based, or at times failed to tally with what observations by non-BMS contributors elsewhere had found. Thanks to this, the BMS was never more than a minor player in British meteor observing, and it finally disbanded in 1990.

The JAS Meteor Section quickly recovered under Ince's leadership, with a mixture of continuity and innovation. Continuity came from publishing duplicated-sheet *Bulletins* reporting on observed meteor activity, and sent to Section members several times a year, which had begun in Hindley's day, and which ceased only in 1983. (These were then replaced by a single annual *Report* or *Review*, from 1996 until 2004, by when regular fortnightly updates were being published online in the SPA's *Electronic News Bulletins*.) Innovation was in the form of an eight-page, offset-printed booklet, which gave all the essentials for getting started in amateur meteor work, *Observing Meteors*, written by Martin Ince and Robin Scagell, first published in 1971 August. Updated and expanded several times since, this has remained the title of the Section's observing instruction "manual". Now in its fifth edition, and in printed format running to twelve pages, since 2009, this has been available in PDF format online (authored by Alastair McBeath, Shelagh Godwin, David Entwistle, and Robin Scagell).

In the BAA, Hindley had still greater ambition, when in 1971 he set-up the International Meteor Data Centre, intended to collect and analyze visual meteor results from amateurs worldwide, funded entirely by the BAA. Unfortunately, problems with contacts, coordination, and handling the volume of data involved, when all had to be done by-hand, meant it failed quite quickly, and no similar attempt was made on a global scale again before the IMO was formed. After this disappointment, Hindley spent most of the latter years of his directorship attempting to establish and operate a network of all-sky fireball cameras across Britain, for multi-station fireball observations that might have allowed the recovery of any resultant meteorites. Regrettably, of a theoretical 50 or so camera-stations, scarcely any operated routinely, and the number of multi-station meteors recorded was accordingly very small, hindered further by poor-quality all-sky equipment, and, as with the Meteor Data Centre, insurmountable administrative problems. Hindley battled on until 1980, perhaps for too long, before passing the directorship to his Visual Coordinator, George Spalding, late that year (Spalding, 1990, pp. 89–90).

During this time at the JAS Meteor Section, Ince had handed-over to another professional scientist, with a PhD in physics and astronomy, Alison Brown, in mid 1972. She continued in-post until late 1974, producing regular quarterly *Bulletins*, but she was gradually drawn into non-astronomical spheres that took up most of her time. Robert McNaught's appointment in 1975 helped revitalize the Section once more, with his great enthusiasm for, and knowledge of, meteor science. An especial highlight of his time in office was the 1977 Perseid campaign, visually and photographically, which, thanks to some well-timed good weather, was a great success with observers. McNaught moved-on in 1978, and was replaced by George Spalding. Spalding went to much trouble in clearing the backlog of unpublished JAS meteor results from 1974, and 1977 onwards, in his early years in-post (completed in 1980), aside from maintaining the Section's visual activities. He was aided particularly in this latter by the excellently strong Perseid return of 1980, which the weather again allowed many observers in Britain to enjoy. After rather turbulent times in the post-war era, 1980 was to begin a much more stable spell for British amateur meteor astronomy.

5 The period 1981–2010, and the future

Spalding's first tasks as BAA Meteor Director revolved around re-energising its visual programme, which had been allowed to lapse rather by the late 1970s. To help in this, various coordinators for geographic regions in Britain and for different techniques - including photography and telescopic work - were appointed, and fresh examinations of some of the Section's archival datasets were carried-out, of which perhaps the most significant was "The time of Geminid maximum as a function of visual meteor magnitude", published in JBAA, **93**, 109–112, 1982–83, drawing on results compiled between 1968 and 1980. He also expanded the visual *Newsletters*, begun by him in late 1979, to cover all aspects of the Section's activities, and these continue to be issued to Section members a few times in most years. However, this attention to the BAA meant the JAS Section received progressively less input, and began to suffer badly. In late 1983, Spalding stood-down as JAS Director in favour of the current author, who has run the Section ever since. As with Spalding at the BAA in 1980, McBeath's initial tasks centred on restarting the JAS Section, rewriting its observing instructions, and setting up a programme of, primarily visual, observing.

Significant meteoric events in the 1980s included the 1985 Draconids, though these were detected only by a single experimental BAA radio system from Britain, and the Orionid returns nearest Comet 1P/Halley's most recent perihelion, observed as part of the International Halley Watch in 1985–86. Again, the BAA was most heavily involved in collecting and analysing meteor results, from the 1985 Orionids, which activity seemed fairly normal (Spalding, 1990, pp. 90–91).

International collaboration during this Orionid campaign was disappointingly limited however, so when the concept of an *International Meteor Organization* began to seem a real possibility in the late 1980s, decisions had to be made regarding whether, and if so how best, to support it. McBeath was very enthusiastic from the start, and began publishing items in the then proto-IMO's journal *WGN* in 1988 ("JAS Meteor Section Visual Results: 1988 Perseids", WGN **16**, 195–197, 1988). A steady stream of JAS, since 1994 SPA, articles continued thereafter, through to the present, and he served five consecutive terms as IMO Vice-President, ending in 2009. Spalding's approach was a great deal more cautious, perhaps remembering too well how very badly things had gone for Hindley's failed attempt to create a similar body nearly twenty years before, a policy continued by his successors. To date, the BAA has never been more than peripherally involved with the work of the IMO.

Spalding though was finding too many other calls on his time by the early 1990s, and unable to continue as he would have wished, he stood-down as BAA Meteor Director in 1992, to be replaced by Neil Bone (1959–2009). Bone proceeded with the programmes of visual and photographic observing that Spalding had built-up, though it was primarily the efforts of Steve Evans (1953–2008), the BAA's photographic meteor coordinator from 1985 and throughout the 1990s, that promoted the photographic, and, as the 1990s progressed, video, work within the Section.

In 1994, the newly-renamed SPA Meteor Section first became involved in attempts at radio meteor examinations and analyses, and publishing these in various places, including WGN. That still continues too, and indeed has grown into a more routine and significant part of the Section's activities over time, drawing on results from around the world via the Belgium-based Radio Meteor Observation Bulletins run by Chris Steyaert, which began in 1993, as well as contacts built-up over the years.

Although both Meteor Sections continued to promote visual meteor observing in Britain as vigorously as ever, by the mid 1990s, there were definite problems emerging. The amount of routine meteor watching from UK sites was falling, and many fewer new, young observers were coming into the subject. A number of reasons for this were apparent, such as increased light pollution preventing easy access to suitable observing sites, and lack of time or interest because of other spare-time activities, particularly the increasing burden of after-school coursework for youngsters. While interest in, and observed numbers of, fireballs seen from Britain remained high – indeed they appear to have been increasing through the first decade of the 21st century, judging by such sightings submitted to the SPA – too few observers have made routine visual meteor watches to allow UK-only analyses of anything other than occasional major shower peaks to be practical for some years.

This situation was alleviated for a time by the huge interest created due to the strong to storm Leonid returns around 1998–2002, while statistics from the SPA's meteor webpages since 2000, have demonstrated a great many people have remained fascinated by meteors, and wish to be better informed about them. A development in 2009 was an independent British initiative by the *Newbury Astronomical Society* in Berkshire, in setting-up Twitter Meteor Watches for the Perseids and Geminids. These created a degree of up to global interest and participation. Electronic communication is thus liable to be the key way forward in the next few years at least, as, while systems like Twitter may generate meteor results that are too far from the essential scientific observations we really need to progress the subject, the clear willingness of people to be involved in such things *en masse* should not be ignored as a means to help attract those who could be persuaded to take a more useful and active role in meteor astronomy. The BAA was peripherally involved in the 2010 Twitter Perseid Meteor Watch, for instance.

A greater problem may be the aging organizers of amateur meteor work. Following Neil Bone's death in early 2009, still in-post as BAA Meteor Director, John Mason was appointed only "Acting Director" due to too many commitments elsewhere.

Despite such difficulties, it is clear that British amateur meteor astronomers continue to be enthusiastic in looking out for meteors and fireballs, much as they have enjoyed doing for the last nearly 450 years. As organizers of such efforts, what we need to continue doing is recognise and guide that enthusiasm, so amateur scientific meteor astronomy in some form can continue here for the next 450 years and more!

6 Conclusion

The increasingly abbreviated notes in the latter part of this paper have reflected the fact this period falls within many people's recent living memory, and much of it, particularly the activities of the JAS, then SPA, Meteor Section, has been fully-documented in this journal already, and, since 2000, online. Many of the details before 1980 were much less well-known outside a small circle of those most closely-involved, parts of which can be recovered now only from what materials – published papers and correspondence – have survived. Information concerning the early JAS Meteor Section through to the late 1970s, has never been published anywhere before, for instance. There is much more that might have been written, while some of the items discussed above and in the previous paper, such as the BAAS Reports from the 19th century, would benefit from further study, as large parts of them had been apparently forgotten, even barely a few years later. As always with history, there are lessons to be learnt from it, so long as we retain the wit to appreciate them before it is too late!

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Postscript

After this article was submitted, the author prepared a more detailed history of the JAS/SPA Meteor Section, which was presented as a poster at the 2010 IMC in Armagh, and which text is expected to be published in the forthcoming *Proceedings* from that meeting.

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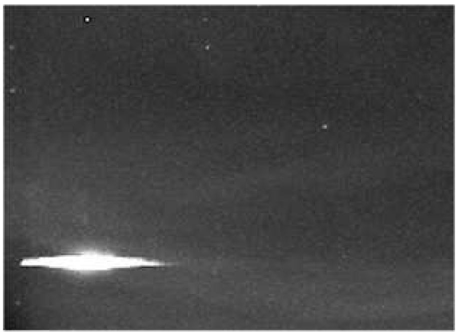
2010 August meteor captures from Italy

Magnitude −4 Perseid
2010 August 2 at $00^h21^m50^s$ UT
Author: Enrico Stomeo, Scorzè



Magnitude −4 Perseid
2010 August 4 at 22^h01^m UT
Author: Enrico Stomeo, Scorzè

Magnitude −9 sporadic
2010 August 5 at $00^h53^m23^s$ UT
Author: Maurizio Eltri, Venezia Lido

Magnitude −9 sporadic
2010 August 5 at $00^h53^m23^s$ UT
Author: Enrico Stomeo, Scorzè

Magnitude −5 Perseid
2010 August 7 at 01^h34^m UT
Author: Stefano Crivello, Valbrevenna

Magnitude −3.5 Perseid
2010 August 7 at $02^h15^m19^s$ UT
Author: Enrico Stomeo, Scorzè

Magnitude −8.5 sporadic
2010 August 8 at $22^h27^m13^s$ UT
Author: Enrico Stomeo, Scorzè

Magnitude −8.5 Perseid
2010 August 8 at $22^h27^m13^s$ UT
Author: Maurizio Eltri, Venezia Lido

Magnitude −3.5 Perseid
2010 August 9 at 00^h59^m UT
Author: Stefano Crivello, Valbrevenna

Magnitude −7.5 Perseid
2010 August 9 at $01^h24^m53^s$ UT
Author: Ferruccio Zanotti, Ferrara

Magnitude −6.5 Perseid
2010 August 9 at $01^h24^m52^s$ UT
Author: Enrico Stomeo, Scorzè

Magnitude −9 Perseid
2010 August 9 at 02^h17^m UT
Author: Enrico Stomeo, Scorzè

Fireballs captured by cameras of the Italian Astronomical Union Meteor Section members prior to the 2010 Perseid maximum.