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New meteor showers
SPA Meteor Section results
2012 Geminids from Morocco
April–May video meteors

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Front cover photo

A fireball brighter than the Moon with aurora, photographed on 2013 March 30 at $05^{\mathrm{h}}16^{\mathrm{m}}$ UT from the Frozen lake at Patricia Beach, MB, Canada. Nikon D800 at ISO 800 was used with 24 mm $f/3.2$ lens and 8 s exposure. Photo courtesy: Shannon Bileski.

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/docs/writingforwgn.pdf` .

Cover design Rainer Arlt

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Editorial

Javor Kac

This issue is packed with content and leaves only a little space for the editorial. I therefore only want to mention my August meteor-related activities. We were finally blessed with some good weather in July and August, and I managed to observe on 13 nights in August, covering most of the Perseid activity. The observations were complemented by the excellent International Meteor Conference 2013 which took place in the later part of August in Poznań, Poland. It was really nice to meet a large number of my international friends again. The conference combined interesting lectures, poster sessions and an excursion with long evenings for informal contacts and having fun. A more detailed report will be presented in the next issue.

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From the Treasurer — IMO Membership/WGN Subscription Renewal for 2014

Marc Gyssens

Traditionally, the annual International Meteor Conference (IMC) marks the beginning of the IMO Membership/WGN Subscription “renewal season”, which started early this year, because the IMC was about a month earlier than usual. More detailed renewal information will follow in the October issue of WGN, but if it is more convenient for you to renew already now, you are welcome to do so. Membership fees/subscription rates for 2014 remain unchanged compared to this year.

Since it is also possible to renew for two or more years at a time, many IMO members/WGN subscribers are unsure when their membership/subscription expires. If you want to know for sure, consult the address label on the envelope in which you received the WGN. If the label mentions “2013” in the top right-hand corner, your IMO membership/WGN subscription expires at the end of this year, and you should renew.

For information on membership fees/subscription rates and on how to pay, please refer to the IMO website or await the more detailed instructions in the October issue!

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Call for Future International Meteor Conferences

Jürgen Rendtel, Paul Roggemans, and Marc Gyssens

After a very successful International Meteor Conference (IMC) in Poznań, Poland, which was organized in conjunction with the professional conference “Meteoroids 2013”, participants as well as those who could not make it this time are already looking forward to the next IMC, which will take place in Giron, in the French Jura Mountains, from September 18 to 21, 2014.

This leaves us with finding suitable proposals for IMCs in 2015 and beyond. To allow interested parties to prepare themselves properly, it is important to plan future IMCs well in advance. Therefore, the IMO Council invites candidate IMC organizers to present their proposal. **The IMO offers a guide to prospective IMC organizers, the *IMC Essentials*. Prospective organizers must consult this guide first.** It can be obtained by simple request from Paul Roggemans, the IMO’s IMC Liaison Officer (details on inside back cover). Typically, an IMC takes place around the third week of September, from Thursday evening (arrival of the participants) to Sunday lunch time (departure of the participants).

Proposals should be sent to the IMC Liaison Officer, Paul Roggemans (`paul.roggemans@gmail.com`), preferably in PDF format. The location for the 2015 IMC will be decided at the very latest during the summer of 2014, so prospective organizers for the 2015 IMC should aim for the spring of 2014 to leave sufficient time for discussion with the IMC Liaison Officer to finalize the proposal. Among the finalized proposals, the IMO Council will then choose the most suitable one.

From past experience, we know it is often difficult to choose between several proposals. If several proposals merit acceptance, the Council will ask the unfortunate candidates to retain their candidacy for the next edition(s). If in the next round the Council must decide between proposals of equal merit, priority will be given to the older one(s).

Before applying to become a candidate IMC organizer, make sure you can answer the following questions:

1. **Who are you?** Who is going to be the local organizers? Which local, regional, or national astronomical organization(s) is/are backing you up? What is your experience with meteor work? Have you been involved in past IMCs, as passive/active participant or as co-organizer? Do you or the organization(s) to which you belong have experience in organizing events that can be compared to an IMC? Can you rely on a coherent team to act as Local Organizing Committee? Mind that it is impossible for a single person to manage all aspects of an IMC!
2. **Why do you want to do it?** What is your motivation to be a candidate to organize an IMC?
3. **Where do you want to do it?** At what location do you want to organize an IMC? Why is this a good location? Can it easily be reached by plane, public transportation, and/or car? How many hours does it take to get there by public transport from the nearest major international airport? Can you provide a few pictures of the location, or, a weblink to such pictures?
4. **At what venue are you going to hold the IMC?** Preferably, lectures and accommodation should be under the same roof, but there is no real objection to the lecture room being at a separate location within easy walking distance from the accommodation. Do you have a faithful description of the accommodation at your disposal that gives a clear idea to other persons what you have in mind? Do you have an offer from the hotel and/or the institution providing additional accommodation to prove that the venue you propose is indeed available and that the price is within the limits of your budget (see below)? Can you provide a few pictures of the accommodation, or, a web link to such pictures? Not surprisingly, a suitable and available accommodation is the most important key to hosting an IMC.
5. **What will it cost?** Can you provide a preliminary budget for the IMC proposed, including all sources of income, in particularly sponsors or subsidies? Take into account that the price per participant should not exceed 170 EUR by much. Of this amount, 10 EUR must be reserved for producing and mailing the (post-)proceedings to the participants. With respect to the expenditures, take into account that the participants must be offered full board from Thursday evening, dinner, up to Sunday, lunch, inclusive. Of course, lecture room facilities should be accounted for, as well as a coffee break in the morning and in the afternoon. Finally, it is also customary to have a half-day excursion, usually on Saturday afternoon. Of course, future prices cannot be known at the time an IMC is planned. It is customary to start from current prices and adding to them a reasonable margin to account for price increases and, if applicable, currency exchange differences between the Euro (the currency used to set registration fees) and your local currency (in which you have to pay your providers). You should also include a margin for unforseen expenses.

   Note that, although the IMO provides the service of collecting the registration fees for you, the IMO will in principle *not* cover any negative balance that you might incur, so, please, draft your budget responsibly! A realistic budget for your proposed IMC is essential. An IMC proposal not containing a serious financial planning will not be considered.
6. **Can it also be done in a later year?** We can only have one IMC every year. It is therefore important for us to know if you can also make this offer in a subsequent year. So, ask yourself whether this is possible! If you think it is not possible, ask yourself whether your arguments are rational as opposed to emotional. It is imperative that you answer these questions honestly. Of course, we understand that you are keen to organize the next IMC to be assigned, but knowing the real time constraints of all the candidates is a serious help for the Council to make the best decision possible!

In your application, please answer all the questions above to the best of your abilities. You may of course add any additional information or considerations which you think may influence your candidacy favorably. In general, however, help the IMO Council in seeing the wood for the trees! While it is important that your application is complete and addresses all the issues mentioned above, please do so *concisely*! Avoid beating about the bush with meaningless phrases and be as factual as possible!

If you are interested in applying for the local organization of an IMC in 2015 and/or beyond, taking into account what has been said above, we ask you to please send a short declaration of intent to the IMC Liaison Officer with some summary information as soon as you know you are serious about proposing an IMC. Mind that such a declaration of intent is not a formal commitment, but it is an indication for the IMO Council as to how many formal applications may be expected. Based on this information, the Council may actively solicit additional candidacies if needed.

Several participants at the most recent IMC already expressed interest in organizing a future IMC during the IMO's General Assembly Meeting, but more offers are necessary to ensure sufficient choice for the IMO Council to make a good decision. Therefore, we hope to receive many candidacies!

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Meteor science

Ten possible new showers from the Croatian Meteor Network and SonotaCo datasets

Željko Andreić [1], *Damir Šegon* [2], *Korado Korlević* [3], *Filip Novoselnik* [4], *Denis Vida* [5] *and Ivica Skokić* [6]

The Croatian Meteor Network Catalogues of Orbits for 2007 to 2010 and the SonotaCo catalogues for 2007 to 2011 were searched for possible new showers. Altogether 133 653 orbits were included in the search that revealed 18 possible new streams. The first 8 are already described in a previous paper (Šegon et al., 2013), and the remaining 10 are described here. These 10 streams already received temporary IAU shower numbers and three-letter codes. We present here the basic orbital, radiant and activity data for them. Possible parent bodies were identified for two of these showers. Additionally, one of the newly discovered showers (520 MBC) seems to be a twin shower, associated with the previously known shower 335 XVI. Last, but not least, new data about one stream from the IAU MDC list of established showers (175 JPE) is obtained.

Received 2012 November 11

1 Introduction

The Croatian Meteor Network (CMN) was started in 2007. Further details of the network are given by Andreić & Šegon (2010) and Andreić et al. (2010) . The catalogues of orbits for 2007, 2008 and 2009 are already published (Šegon et al., 2012a; Korlević et al., 2013) and the catalogue for 2010 is available on the CMN download web page:
`http://cmn.rgn.hr/downloads/downloads.html`

The well known SonotaCo network (SonotaCo, 2012) also published catalogues for 2010 and 2011 recently, and older catalogues are already public. Combining all these datasets we compiled a database of 133 653 orbits that was systematically searched for new showers.

2 New showers

The search resulted in 18 potential new showers not yet reported to the IAU MDC database, plus a few that later on turned out to be already known. For each shower the individual orbits of meteoroids were tested with the D-criterion (Šegon et al., 2012b), employing the widely used Southworth-Hawkins method (Southworth & Hawkins, 1963), and a mean orbit was calculated from the individual orbits that satisfy the criterion $D_{SH} < 0.15$. The results are summarized in Table 4. The first 8 showers are already described in Šegon et al. (2013), and the remaining 10 are described here, along with one shower (Section 2.5) that appears to be already known. The file with all individual orbits of the new showers mentioned in this article can be obtained from the CMN download page.

All these radiants are present in the IMO Video Meteor Database (IMO, 2012). The showers were reported to the IAU, following the standard procedure (Jenniskens et al., 2009), and received temporary shower numbers. Searches for possible parent bodies (using the JPL orbit database) were also performed, and revealed possible parent bodies for three showers. They are described where appropriate.

2.1 April λ Ophiuchids – 517 ALO

This shower is active from April 1 to April 10, with maximum around April 5. Although at the moment only 20 orbits are known, the meteors of this shower

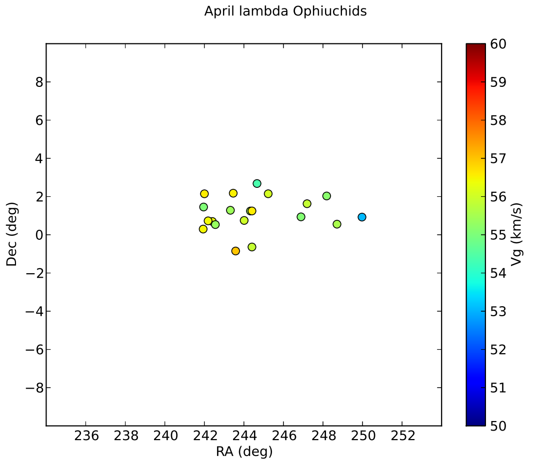

Figure 1 – Radiant plot of April λ Ophiuchids.

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were present in each year from 2007 to 2011. The radiant plot shows the effect of radiant drift clearly (Figure 1), but apart from that seems to be quite compact.

2.2 April 102 Herculids – 518 AHE

This shower is active from April 19 to 27, with maximum around April 23. Only 9 orbits for this shower are known, divided almost equally among all the years from 2007 to 2011, excepting 2008, when none was found. The radiant plot covers an area of about 2° (Figure 2). Regardless of the small number of orbits, the mean shower orbit is quite well defined, with maximal D_{SH} between the mean orbit and a single meteoroid orbit not exceeding 0.07.

Another interesting property of this shower is that meteors were all very bright, with observed magnitudes between 0 and -5.

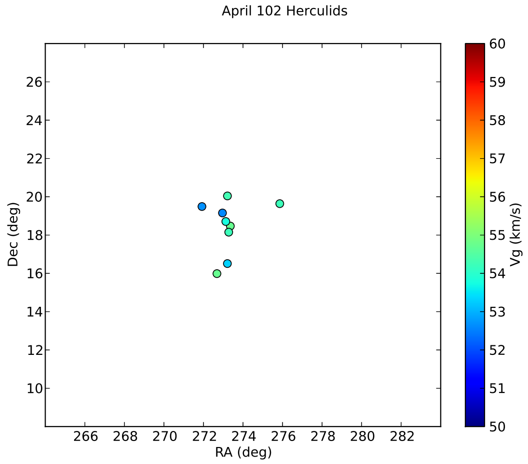

Figure 2 – Radiant plot of April 102 Herculids.

2.3 β Aquarids – 519 BAQ

This shower is active from April 23 to May 20, with maximum around May 6. 20 orbits for this shower are known. The radiant plot clearly shows effects of daily motion (Figure 3), otherwise is well defined.

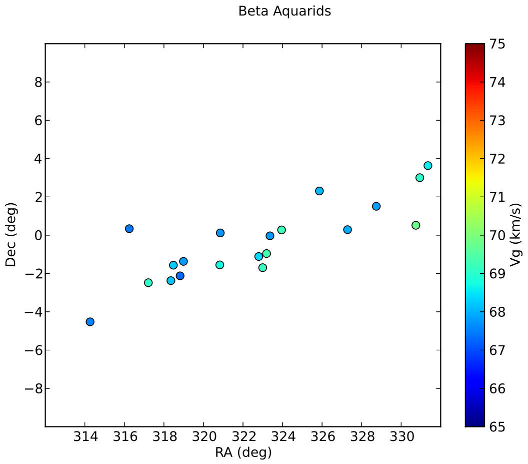

Figure 3 – Radiant plot of β Aquarids.

2.4 May β Capricornids – 520 MBC

This shower is active from May 15 to 27, with maximum around May 17. 13 orbits for this shower are known, from all 5 years. The radiant plot (Figure 4) is stretched horizontally due to the daily motion, but is compact.

This shower has an orbit very similar to the orbit of the December χ Virginids (335 XVI), but with a totally different period of activity. It is possible that it is the same shower, with two orbit intersection points. The comparison of available data is given in Table 1. As the IAU MDC lacks any orbital data for 335 XVI, we calculated them from 53 orbits we have found in our combined database. The orbital similarity is striking, with $D_{SH} = 0.08$, which strongly supports our assumption that we are dealing with the same shower that intersects the earth's orbit twice, before and after perihelion.

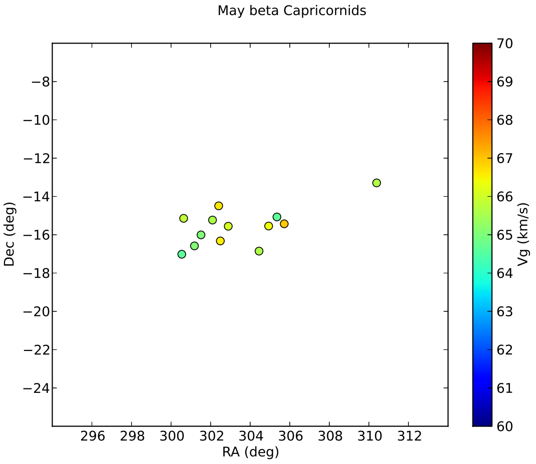

Figure 4 – Radiant plot of May β Capricornids.

Table 1 – Comparison of May β Capricornids and December χ Virginids.

parameter	520 MBC	335 XVI (IAU MDC)	335 XVI (CMN)
$\lambda_\odot$	53–66		236–261
$\lambda_\odot$ Max.	56.8	256.7	253.6
RA	303	186.8	184.8
Dec	-15.6	-7.9	-6.9
dRA	0.74	0.2	0.72
dDec	0.17	-0.14	-0.35
v_g	65.7	67.8	68.0
N	13	31	53
q	0.554		0.579
e	0.942		0.981
ω	266		280
Ω	57		74
i	171		171
D_{SH}			0.08

2.5 Southern α Pegasids – 522 SAP

This shower is active from July 3 to 23, with maximum around July 14. 93 orbits for this shower are known. The radiant plot (Figure 5) is well defined with clear evidence of daily motion, which in this case could be accurately determined, together with the mean orbit.

The IAU MDC database mentions 462 JGP with its radiant nearby ($RA = 359°$, $Dec = +14°$) and with maximum activity around $\lambda_\odot = 120\overset{\circ}{.}8$, almost 9 days later than 522 SAP. No orbital data for this shower are known, making any further conclusions impossible.

According to recent work (Ueda, 2012; Holman & Jenniskens, 2013) about the July Pegasids (175 JPE), it turns out that 522 SAP orbital elements and activity data fit very well to 175 JPE so they are almost certainly the same shower. Thus, 522 SAP should be removed from the IAU MDC list.

The search for possible parent bodies revealed C/1771 A1 (Great comet) with $D_{SH} = 0.09$, the same comet already listed as a possible parent body by Holman & Jenniskens (2013). It should be noted here that Ueda (2013) identified C/1979 Y1 (Bradfield) as a possible parent body, but we confirmed the conclusion made by Holman & Jenniskens (2013), i.e. that C/1771 A1 is a slightly better candidate for the parent body.

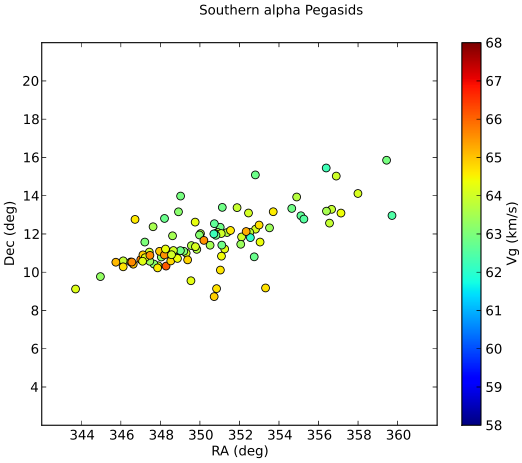

Figure 5 – Radiant plot of Southern α Pegasids.

2.6 August γ Cepheids – 523 AGC

This shower is active from August 21 to September 4, with maximum around August 28. 44 orbits for this shower are known. The radiant plot (Figure 6) is diffuse, without signs of daily motion.

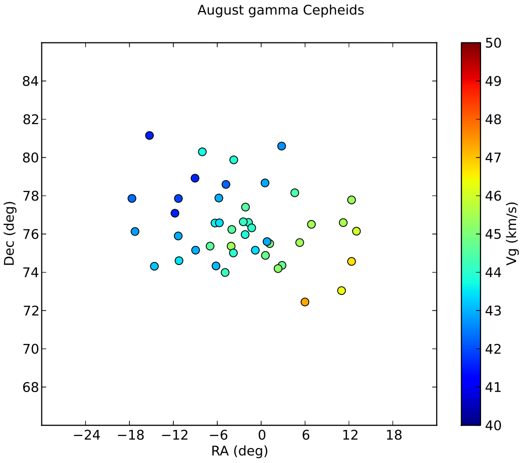

Figure 6 – Radiant plot of August γ Cepheids.

2.7 λ Ursae Majorids – 524 LUM

This shower is active from October 24 to November 1, with maximum around October 28. 29 orbits for this shower are known. The radiant plot (Figure 7) is diffuse.

The IAU MDC database mentions 339 PSU with its radiant nearby ($RA = 168°$, $Dec = +45°$) and with maximum activity around $\lambda_\odot = 253°$, about a month later than 524 LUM. Geocentric velocity is also very similar (61 versus 60.3 km/s), but due to the large difference in solar longitudes it is questionable if they are the same shower. Orbital data for this shower are not provided, making any further conclusions difficult.

Another nearby shower is 382 BUM, with radiant at $RA = 161°$, $Dec = +57°$, and $\lambda_\odot = 184°$, but the orbit is totally different so it is clearly a different shower.

The search for possible parent bodies revealed comet C/1975 T2 (Suzuki-Saigusa-Mori) with $D_{SH} = 0.14$ as a possible parent body. The comparison of orbital data of the 524 LUM and the comet is given in Table 1.

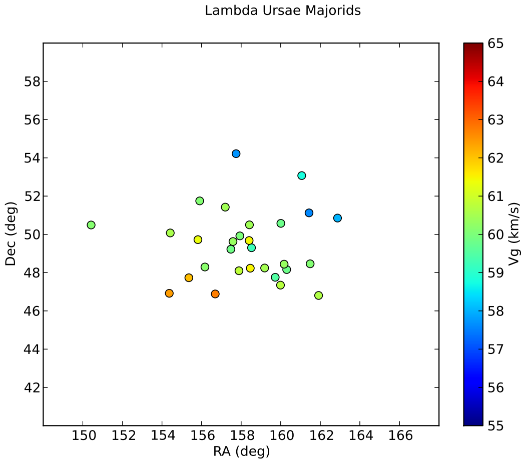

Figure 7 – Radiant plot of λ Ursae Majorids.

Table 2 – Comparison of orbits of λ Ursae Majorids and comet C/1975 T2 (Suzuki-Saigusa-Mori).

parameter	524 LUM	C/1975 T2
q	0.917	0.838
e	0.931	0.986
ω	147	152.0
Ω	215	216.8
i	115	118.2
D_{SH}		0.14

2.8 ι Cygnids – 525 ICY

This shower is active from October 16 to November 19, with maximum around October 31. 40 orbits for this shower are known. The radiant plot (Figure 8) is very diffuse. The elements of the mean orbit are similar to the two previously known showers 282 DCY ($D_{SH} = 0.22$) and 83 OCG ($D_{SH} = 0.23$). Most probably all three are just one shower, but observations accounting for deceleration are needed to make this clear.

The search for possible parent bodies revealed asteroid 2001 SS$_{287}$ with $D_{SH} = 0.16$ as a possible parent

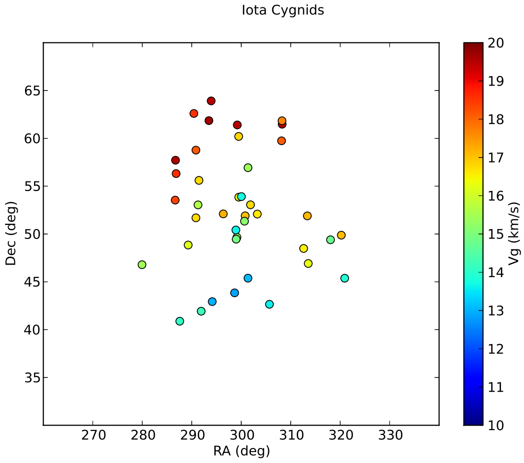

Figure 8 – Radiant plot of ι Cygnids.

body. The comparison of orbital data of the 525 ICY and the asteroid is given in Table 3. There is a whole family of asteroids with similar orbits and the next best possible candidates, with D_{SH} in parentheses, are: 2010 TK$_{167}$ (0.18), 24445 2000 PM$_8$ (0.19), 2012 UB$_{69}$ (0.20), 2001 SD$_{170}$ (0.21), 2010 TC$_{55}$ (0.21), etc.

Table 3 – Comparison of orbits of ι Cygnids and asteroid 2001 SS$_{287}$.

parameter	525 ICY	2001 SS$_{287}$
q	0.982	1.052
e	0.631	0.675
ω	190	173.9
Ω	218	230.8
i	24	18.5
D_{SH}		0.16

2.9 Southern λ Draconids – 526 SLD

This shower is active from November 1 to 5, with maximum around November 3. 26 orbits for this shower are known. The radiant plot (Figure 9) is compact and elongated by the daily motion.

The IAU MDC database mentions 383 LDR with its radiant nearby ($RA = 156°$, $Dec = +75°$) and with maximum activity around $\lambda_\odot$=196°, 3 weeks earlier than 526 SLD. Orbital elements and geocentric velocity differ a lot, so we do not consider this as the same shower.

Another nearby shower is 385 AUM ($RA = 175°$, $Dec = +65°$), with maximum activity around $\lambda_\odot$ = 209°, 2 weeks earlier than 526 SLD. Again, orbital elements and geocentric velocity differ too much for these two to be the same shower.

2.10 υ Ursae Majorids – 527 UUM

This shower is active from November 16 to 26, with maximum around November 22. 27 orbits for this shower are known. The radiant plot (Figure 10) is compact and elongated by the daily motion. The elements of the mean orbit have good accuracy.

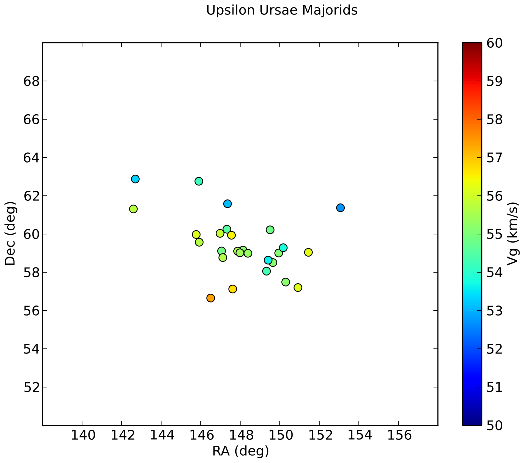

Figure 10 – Radiant plot of υ Ursae Majorids.

2.11 January ζ Draconids – 528 JZD

This shower is active from December 25 to January 11, with maximum around January 4. Only 13 orbits for this shower are known. The radiant plot (Figure 11) is quite scattered. The mean orbit of the shower is similar to orbits of Apollo asteroids which makes this shower quite interesting as it could be a genuine asteroidal stream, but more orbits are needed to refine the

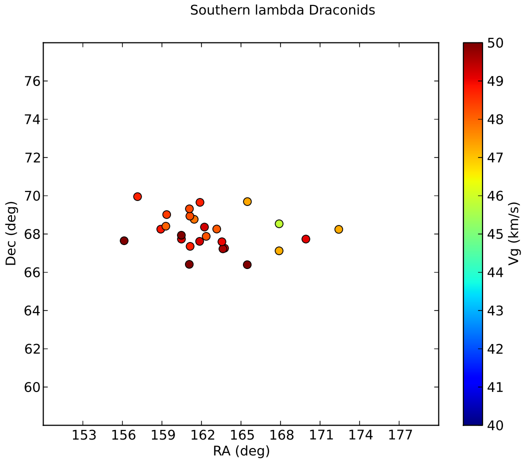

Figure 9 – Radiant plot of Southern λ Draconids.

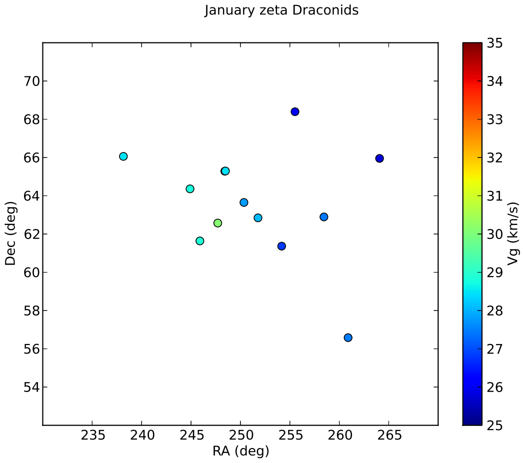

Figure 11 – Radiant plot of January ζ Draconids.

accuracy of data for this shower and make further conclusions possible.

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Table 4 – Mean orbits of the new showers. ID is the IAU identification of the shower, name the proposed name of the shower, $\lambda_\odot$ solar longitudes between which the shower was active, mean the average (mean) solar longitude of all meteors available, RA and Dec are coordinates of the mean radiant, v_g is geocentric velocity, a is the semimajor axis of the orbit, q perihelion distance, e eccentricity, ω argument of perihelion, Ω longitude of ascending node, i inclination and N is the number of known orbits belonging to the corresponding shower. The ± values are standard deviation of the meteors selected for the corresponding shower. Note that in case of RA and Dec there is a contribution of the daily motion to the standard deviations.

ID	name	$\lambda_\odot$	mean	RA	Dec	v_g	a	q	e	ω (peri)	Ω (node)	i	N
517 ALO	April λ Ophiuchids	12–21	15.5	244.6 ± 2.4	1.1 ± 0.9	55.7 ± 0.9	14	0.287 ± 0.022	0.980 ± 0.033	296 ± 3	15.5 ± 2.2	110.6 ± 1.7	20
518 AHE	April 102 Herculids	29–37	33.8	273.3 ± 1.0	18.5 ± 1.3	53.6 ± 0.8	10	0.777 ± 0.026	0.922 ± 0.048	238 ± 4	33.8 ± 1.9	98.3 ± 2.0	9
519 BAQ	β Aquarids	34–60	46.3	323 ± 5	-0.4 ± 1.9	68.4 ± 0.7	11	0.937 ± 0.027	0.914 ± 0.050	149 ± 6	46 ± 7	156.2 ± 1.8	20
520 MBC	May β Capricornids	53–66	56.8	303 ± 3	-15.6 ± 1.0	65.7 ± 0.7	5.4	0.554 ± 0.024	0.942 ± 0.045	266 ± 3	57 ± 4	171.0 ± 1.5	13
522 SAP	Southern α Pegasids	102–121	112.0	351 ± 3	11.7 ± 1.4	63.9 ± 0.9	16	0.564 ± 0.032	0.964 ± 0.044	265 ± 4	112 ± 4	148.8 ± 2.0	93
523 AGC	August γ Cepheids	149–162	155.1	358 ± 8	76.4 ± 1.9	44.0 ± 1.4	9	1.005 ± 0.003	0.892 ± 0.049	188 ± 3	155 ± 3	76 ± 3	44
524 LUM	λ Ursae Majorids	211–219	215.0	158.2 ± 2.6	49.4 ± 1.8	60.3 ± 1.2	13	0.917 ± 0.014	0.931 ± 0.052	147 ± 3	215.0 ± 1.8	115 ± 3	29
525 ICY	ι Cygnids	203–237	218.4	299 ± 10	53 ± 6	16.4 ± 2.0	2.7	0.982 ± 0.011	0.631 ± 0.049	190 ± 9	218 ± 9	24 ± 4	40
526 SLD	Southern λ Draconids	219–223	221.6	163 ± 4	68.1 ± 0.9	48.7 ± 1.1	4.0	0.986 ± 0.004	0.744 ± 0.052	189 ± 3	221.6 ± 1.2	88.0 ± 1.8	26
527 UUM	υ Ursae Majorids	234–244	240.4	148.0 ± 2.3	59.4 ± 1.5	55.1 ± 1.1	18	0.823 ± 0.020	0.954 ± 0.057	229 ± 3	240.4 ± 2.4	99.9 ± 2.4	27
528 JZD	January ζ Draconids	274–290	283.9	251 ± 7	64 ± 3	28.1 ± 1.3	2.6	0.982 ± 0.003	0.617 ± 0.054	181 ± 6	284 ± 5	46.6 ± 2.5	13

Discovery of the February epsilon Virginids (FEV, IAU #506)

Kathryn Steakley[1] *and Peter Jenniskens*[2]

Combining first week of February CAMS and SonotaCo data resulted in the detection of at least one previously unreported shower. The February epsilon Virginids radiate from R.A. = 201°.7 and Dec = +10°.4, with a mean geocentric velocity of 63.0 km/s at solar longitude 315°.3. The mean orbital elements of these meteoroids are $q = 0.488 \pm 0.021$ AU, $1/a = 0.085 \pm 0.095$ 1/AU, $e = 0.958 \pm 0.046$, $i = 138°.1 \pm 1°.3$, $\omega = 271°.2 \pm 3°.7$, and $\Omega = 315°.3 \pm 0°.9$. The shower may originate from comet C/1808 F1 (Pons), if that comet is a Halley-type comet.

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1 Introduction

February has been regarded colloquially as an uneventful month in terms of meteor shower activity, so one can imagine our surprise at the amount of activity found when examining the February data from our Cameras for All-sky Meteor Surveillance (CAMS) system. CAMS consists of three separate stations that use video surveillance cameras to automatically monitor the night sky for meteor activity. We compare data across multiple stations to produce trajectories and orbits of incoming meteors of at least +4 magnitudes (Jenniskens et al., 2011).

2 Results and discussion

Figure 1 shows the combined CAMS 2011 and 2012 data (1118 meteors) for the first week of February. Fast apex-source meteors are the cloud on the left, the slower antihelion source meteors are on the right. Each show a lot of structure, indicative of meteoroid streams. Our goal is to add new showers to the IAU Meteor Shower Working List and confirm those that are already listed.

The previously reported February Eta Draconids (FED) stand out well as a compact cluster (Jenniskens & Gural, 2011). This long-period comet shower had an outburst in 2011. In 2012, CAMS detected two additional FED orbits.

One stream not previously reported was a cluster of nine meteors in the 2012 CAMS data (marked "FEV" in Figure 1) with a geocentric radiant near the star ε Virginis.

We examined CAMS data from the year before, and the SonotaCo data (2007–2009; 773 meteors), for evidence of prior activity (SonotaCo, 2009). From these data sets, we were able to obtain 15 additional candidates.

Extending the period examined from 2012 data through February 9th also added 4. This brought the total number of meteor orbits potentially associated with this shower to 28.

Next, D-criteria calculations (Jenniskens, 2008) were performed on each of these 28 orbits. The D-criterion indicates how closely two orbits are related. By calculating the D-criterion for each individual orbit as compared to the median of the orbits (Table 1), we were able to eliminate outliers from the data set. We determined that 22 of the 28 orbits had D-criterion values of less than 0.15.

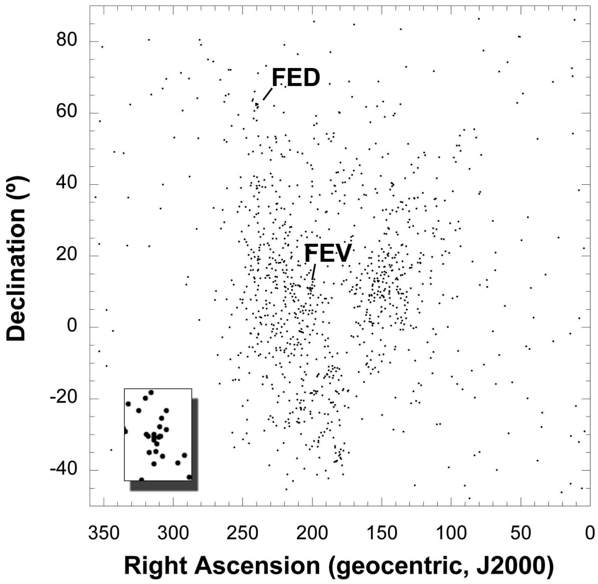

Figure 1 – CAMS meteors in the first week of February. Inset shows the FEV cluster.

The shower was reported to the IAU, assigned number 506 and named the February epsilon Virginids (FEV). It is active between 312°.9 – 320°.3, with peak activity around solar longitude 315°. On February 5, the shower radiates from R.A. = 202°, Decl. = 11°, with geocentric velocity $V_g = 63$ km/s.

The semimajor axis of $a \approx 11.8$ AU corresponds to an orbital period of $P = 40.4$ years. At face value, this implies a Halley-type parent body, although an intermediate long-period comet cannot be ruled out (Jenniskens, 2006). If this is a Halley-type stream, then there would be good prospects of future outbursts from this shower, when dust gets trapped in mean motion resonances (Jenniskens, 2006).

A search of orbital parameters of known Near Earth Objects from the Jet Propulsion Laboratory (JPL) Small Body Database produced a candidate parent body (Table 1): C/1808 F1 (Pons).

Comet Pons provides a theoretical radiant match (Table 1), if the line of apsides is rotated by precession (method "W" by Neslusan et al., 1998). The comet has

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evolved well beyond the point of passing Earth's orbit at the descending node, now having a daytime-shower node at Earth on August 20th, something expected for Halley-type comets, but perhaps not from long-period comets. With only 10 observations over 8 days, the comet orbit is not well enough determined to tell the difference.

Other potential parents exist. C/1978 T3 (Bradfield) has similar longitude of perihelion and inclination, but does not provide a matching theoretical radiant position when rotating the line of apsides (Table 1), or the nodal line.

Acknowledgements

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Table 1 – Orbital elements of 22 February Epsilon Virginids.

$\lambda_\odot$ (°)	Date (m/d/y)	Time (UT)	Source	R.A. (°)	Decl. (°)	V_g (km/s)	$1/a$ (1/AU)	q (AU)	e	i (°)	ω (°)	Ω (°)	ϖ (°)
312.86	02/01/09	$17^{\mathrm{h}}06^{\mathrm{m}}09^{\mathrm{s}}$	SonotaCo	199.61	+11.93	61.73	0.188	0.469	0.912	136.28	275.73	312.86	228.59
313.23	02/02/11	$14^{\mathrm{h}}08^{\mathrm{m}}05^{\mathrm{s}}$	CAMS	199.91	+10.95	64.74	−0.042	0.515	1.022	139.83	266.83	313.22	220.05
313.74	02/03/12	$08^{\mathrm{h}}32^{\mathrm{m}}49^{\mathrm{s}}$	CAMS	201.57	+11.19	62.57	0.160	0.507	0.919	137.57	270.79	313.74	224.53
313.86	02/03/12	$11^{\mathrm{h}}13^{\mathrm{m}}58^{\mathrm{s}}$	CAMS	201.72	+10.82	63.50	0.092	0.523	0.952	138.77	267.87	313.85	221.73
313.95	02/03/12	$13^{\mathrm{h}}21^{\mathrm{m}}13^{\mathrm{s}}$	CAMS	198.53	+11.64	60.99	0.194	0.414	0.920	135.65	282.12	313.94	236.07
314.08	02/03/11	$10^{\mathrm{h}}14^{\mathrm{m}}37^{\mathrm{s}}$	CAMS	200.33	+11.93	61.27	0.203	0.456	0.908	135.05	277.46	314.07	231.53
314.18	02/03/11	$12^{\mathrm{h}}47^{\mathrm{m}}07^{\mathrm{s}}$	CAMS	199.65	+12.78	60.09	0.250	0.425	0.894	132.36	281.83	314.18	236.01
314.20	02/03/11	$13^{\mathrm{h}}08^{\mathrm{m}}27^{\mathrm{s}}$	CAMS	200.97	+10.2	64.27	0.018	0.510	0.991	140.32	268.23	314.20	222.43
314.80	02/04/12	$09^{\mathrm{h}}30^{\mathrm{m}}46^{\mathrm{s}}$	CAMS	200.35	+10.93	63.26	0.043	0.474	0.980	137.96	272.85	314.80	227.65
314.96	02/04/12	$13^{\mathrm{h}}22^{\mathrm{m}}54^{\mathrm{s}}$	CAMS	201.61	+10.6	63.24	0.082	0.496	0.959	138.39	270.87	314.96	225.84
315.23	02/04/11	$13^{\mathrm{h}}28^{\mathrm{m}}31^{\mathrm{s}}$	CAMS	201.69	+8.24	64.10	0.078	0.497	0.961	143.48	270.67	315.22	225.90
315.30	02/04/08	$20^{\mathrm{h}}40^{\mathrm{m}}10^{\mathrm{s}}$	SonotaCo	201.64	+8.81	63.95	0.070	0.494	0.966	142.19	270.87	315.30	226.17
315.84	02/05/12	$10^{\mathrm{h}}09^{\mathrm{m}}27^{\mathrm{s}}$	CAMS	202.85	+9.33	61.88	0.238	0.477	0.887	139.42	275.70	315.84	231.54
315.93	02/04/09	$17^{\mathrm{h}}50^{\mathrm{m}}30^{\mathrm{s}}$	SonotaCo	204.50	+10.59	64.92	−0.028	0.569	1.016	138.45	260.70	315.93	216.63
315.98	02/05/12	$13^{\mathrm{h}}25^{\mathrm{m}}14^{\mathrm{s}}$	CAMS	201.14	+9.53	60.08	0.330	0.405	0.867	137.84	285.66	315.97	241.63
316.93	02/06/12	$11^{\mathrm{h}}49^{\mathrm{m}}26^{\mathrm{s}}$	CAMS	203.58	+11.2	63.52	0.019	0.513	0.990	135.94	267.92	316.92	224.84
319.16	02/08/11	$10^{\mathrm{h}}39^{\mathrm{m}}26^{\mathrm{s}}$	CAMS	204.69	+9.05	62.36	0.140	0.467	0.934	137.93	275.19	319.16	234.35
319.22	02/08/11	$11^{\mathrm{h}}55^{\mathrm{m}}23^{\mathrm{s}}$	CAMS	203.75	+8.72	61.60	0.189	0.431	0.919	138.13	280.19	319.21	239.41
319.87	02/09/12	$09^{\mathrm{h}}38^{\mathrm{m}}54^{\mathrm{s}}$	CAMS	205.93	+10.11	64.94	−0.113	0.530	1.060	136.87	264.17	319.87	224.04
319.92	02/09/12	$10^{\mathrm{h}}50^{\mathrm{m}}19^{\mathrm{s}}$	CAMS	205.51	+8.72	63.05	0.088	0.483	0.958	138.49	272.54	319.92	232.46
320.09	02/08/09	$20^{\mathrm{h}}16^{\mathrm{m}}54^{\mathrm{s}}$	SonotaCo	206.14	+9.97	62.75	0.082	0.495	0.960	135.65	270.95	320.09	231.04
320.32	02/09/11	$14^{\mathrm{h}}05^{\mathrm{m}}54^{\mathrm{s}}$	CAMS	204.81	+8.26	62.98	0.075	0.457	0.966	139.15	275.36	320.32	235.67
	Median value:			201.67	+10.40	63.02	0.085	0.489	0.959	138.05	271.75	315.26	228.12
	Standard error of median value:			±0.48	±0.28	±0.31	±0.023	±0.009	±0.010	±0.5	±1.3	±0.54	±1.4
	Dispersion of values (σ)			2.2	1.3	1.4	0.11	0.040	0.047	2.4	6.1	2.5	6.5
	C/1808 F1 (Pons)			206.38	+8.29	62.03	0.0	0.390	1.0	134.30	253.74	325.64	219.38
	C/1978 T3 (Bradfield)			237.63	−2.56	62.82	0.0	0.432	1.0	138.26	240.45	358.42	238.87

Ongoing meteor work

SPA Meteor Section Results: 2007

Alastair McBeath[1]

Information extracted from analyses carried out by the SPA Meteor Section from 2007 is presented and discussed. Events covered include: the radio Quadrantid maximum on January 4; a bright fireball seen from parts of England and imaged from the Netherlands at 19^h56^m UT on February 6, for which an approximate trajectory was established; radio results from the Lyrids in late April; the Perseid near-peak activity from August and a note on some daylight Perseid observing from Britain using thermal imagers; the radio α–Aurigid maximum on September 1; the Orionid return, which again provided enhanced activity over several consecutive dates in October for visual and radio observers; the radio Leonids, although the probably main peak found visually on November 19 was not recorded thus due to its timing; the typically protracted Geminid maximum period around December 13–15 as observed visually and by radio; and the Ursid outburst, primarily as detected by radio on December 22.

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1 Introduction

After an unintended hiatus in the catching-up process with the delayed SPA Meteor Section results' articles in WGN, following publication of the 2006 results (McBeath, 2010), we resume here with a review of the main events from 2007 as covered by observers reporting to the Section. Although most of the matters detailed were discussed nearer the time online in the SPA's fortnightly Electronic News Bulletins (ENBs) and on the Society's website (which with other meteoric items from the year that do not warrant more comment here, remain freely available, with indexes, on the Meteor Section pages via `www.popastro.com`), fresh discussions and previously unpublished items are now presented for the first time.

These new materials include almost all the radio analyses, as during 2007 SPA Assistant Meteor Director David Entwistle (appointed early in the year) carried out analyses of radio data received using an amended version of the 'SBV' computational method published in WGN by Steyaert, Brower & Verbelen (2006). In general, only those findings were published in the ENBs at the time. While such investigations proved a worthwhile test of the method, it became clear during the year that the final computed information was not sufficiently reliable, and attempts using this technique were abandoned by the SPA in early 2008. Consequently, I have reanalysed the radio results for this paper using the long-standing Relative Radio Rate, RRR, method as defined by (McBeath, 2012). As noted in that reference however, it is essential to appreciate the RRR is not a strictly-computed value due to the degree of subjectivity involved in its generation, so it is not the radio equivalent of the visual ZHR. Despite this, by creating normalized graphs showing both the ZHR and RRR (achieved here chiefly using separate y-axes), it is feasible to directly compare the patterns of activity detected visually and by radio, just not their absolute values. In discussing the radio results overall, it must be remembered that as these were typically binned into only one-hour segments, the minimum error for any timing estimates from such information is at least that amount. To ensure as full coverage as possible for such comparisons, published IMO visual data either from WGN analyses or the online "live" webpages for specific showers have been used, the latter only where no more detailed information was available. SPA visual results were analysed following the standard IMO ZHR calculation method as outlined in Chapter 9 of Rendtel & Arlt (2008), albeit commonly using only an assumed r-value where too few meteors were available to reliably generate this factor independently. For the first time, some computed video hourly rates (HRs) as reported in IMO sources have been included for comparisons too with the Geminids and Ursids.

2 Observing totals and observers

The year brought increases over the tallies for 2006 in visual and still-imaging observer activity (the latter somewhat marginally), but saw falls in both the quantity of radio and video work reported. Part of the increase in visual and imaging work came about through casual reports primarily during the Perseids and Geminids. While a welcome indication of continued general interest in major meteoric events, this did not convert into significant quantities of usable data. Contribution of those remained as for many years in the hands of a few long-standing, more regular observers. Table 1 shows the main 2007 totals.

The list of contributing observers follows. Abbreviations show where observations other than visual watching were provided: 'I' = still-imaging, 'R' = radio and 'Vi' = video. '+ V' indicates visual data were additionally submitted. As often in recent years, many reports arrived as summaries in publications, including the American Meteor Society's (AMS's; `www.amsmeteors.org`) journal *Meteor Trails* sent via editor Robert Lunsford, the Arbeitskreis Meteore's

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Table 1 – Visual, video and viable radio hours' totals, visual and video meteor numbers recorded (with a partial breakdown of visual types), per month. A maximum of three main showers per month plus the ANT have been listed for the visual breakdowns to conserve space. In addition to these, one meteor was thermally imaged during June and an uncertain number more during August (discussed below under the "Perseids" section), 28 meteor trails were still-imaged in 10.6 h during August, with a further 4.2 h of unsuccessful still-imaging reported from December.

Month	Visual						Video		Radio hours
	Hours				ANT	Meteors	Hours	Meteors	
		QUA							
January	29.2	17			31	225	—	—	7058
February	19.7	—			40	107	61.8	154	7108
March	50.3	—			62	291	19.8	60	7163
		LYR	ETA						
April	145.0	416	12		173	1419	87.7	208	6903
May	56.6	—	43		73	410	20.1	74	6685
		JBO							
June	53.3	1			55	349	16.7	57	5943
		SDA	CAP	PER					
July	72.1	47	59	35	90	722	119.8	593	4923
August	335.1	83	65	5962	145	9104	117.6	841	5479
		AUR	DAU						
September	150.2	157	69		155	1319	51.7	221	5774
		ORI	STA	NTA					
October	203.2	2326	138	155	—	4227	47.5	275	5767
		LEO							
November	84.2	92	100	106	—	910	107.4	605	5251
		GEM	URS	COM					
December	160.3	3151	25	112	102	4503	146.6	669	5941

(AKM's; `www.meteoros.de`) journal *Meteoros*, provided by Ina Rendtel, and the Radio Meteor Observation Bulletins (RMOBs; `www.rmob.org`), sent by their editor, Chris Steyaert. Some observers' data featured in more than one place, and some observers sent in separate reports directly or via a third person as well. Observers reporting electronically sometimes used a pseudonym, and where no other name could be established for such people, these have been given below in quotation marks. In general, where an observer submitted data to more than one place, just one option has been selected to indicate where those results may be found.

Mike Alexander (Scotland), Enric Algeciras (RMOB; R; Spain), Karl Antier (France), Rainer Arlt (AKM; Germany), "astroeddie" (England), Pierre Bader (AKM; Germany & Switzerland), Tom Banks (England), Mary Bartley (Wales), Orlando Benitez (RMOB; R; Canary Islands), Ray Berg (AMS; Indiana & New Mexico, USA), Lukas Bolz (AKM; Germany), Mike Boschat (RMOB; R; Nova Scotia, Canada), Walter Bradford (I + V; England), Ian Brantingham (Scotland), Bernd Brinkmann (AKM; California, USA & Germany), Jeff Brower (RMOB; Vi + R; British Columbia, Canada), Robert Buchheim (AMS; California, USA), Tony Buick (UK), Willy Camps (RMOB; R; Belgium), Alessandro Candolini (RMOB; R; Italy), Giuseppe Candolini (RMOB; R; Italy), Matt Chapman (Isle of Man), Mike Clarke (UK), "coldfieldboundary" (Belgium), Colin Cooper (England), Tim Cooper (South Africa), Sarthak Dasadia (Gujarat, India), Mark Davis (AMS; South Carolina, USA), Maybel Delglyn (UK), Gaspard De Wilde (RMOB; R; Belgium), Paul Domaille (Guernsey, Channel Islands), David Entwistle (RMOB; R; England), Frank Enzlein (AKM; Germany), Mike Feist (England), Daniel Fischer (AKM; California, USA), Stela Frencheva (AKM; Germany), Valter Gennaro (RMOB; R; Italy), Christoph Gerber (AKM; Germany), Thomas Giguere (AMS; Hawaii, USA), George Gliba (AMS; West Virginia, USA), Shelagh Godwin (England), Lew Gramer (AMS; Florida, USA), Robin Gray (AMS; California & Nevada, USA), "gregger" (England), Patrice Guérin (RMOB; R; France), Peter Gural (AMS; California, USA), Walter Haas (AMS; New Mexico, USA), Wayne Hally (AMS; New Jersey, USA), Dave Hancox (Scotland), Kim Hay (AMS; Ontario, Canada), Robert Hays (AMS; Indiana & Michigan, USA, Ontario, Canada), Alan Heath (R + V; England), P-M Heden (I; Sweden), Udo Hennig (AKM; Germany), Terry Holmes (England), Javor Kac (AMS; Slovenia), Mike Kelly (Isle of Man), André Knöfel (AKM; Austria, Germany & Tenerife), Marco Langbroek (Netherlands), Trevor Law (England), Thomas Lazuka (AMS; Illinois, USA), Robert Lunsford (AMS; California, USA), Hartwig Lüthen (AKM; Tenerife), Ed Majden (RMOB; R; British Columbia, Canada), Tony Markham (England), James Martin (Isle of Man), Pierre Martin (AMS; Ontario, Canada), Felix Martinez (AMS; Florida & Virginia, USA), "martinss" (I; England), Paul Martsching (AMS; Iowa, USA), Alastair McBeath (England), Conor McDonald (Northern Ireland), Tom McEwan (Scotland), Martin McKenna (Northern Ireland), Norman McLeod (AMS; Florida, USA), Patrick Mergan (RMOB; R; Belgium), Jane Mills (England), Sirko Molau (AKM; Germany), Michael Morrow (AMS; Hawaii, USA), Sven Näther (AKM; Germany), Cristian Negru (RMOB; R; Romania), Stan Nelson (RMOB; R; New Mexico, USA), Sadao Okamoto (RMOB; R; Japan), Ingo Ortmann (AKM; Germany), Mike Otte (RMOB; R; Illinois, USA), "Paul C" (I; England), Jean-Louis Rault (RMOB; R; France), Jürgen Rendtel (AKM; Germany & Tenerife), Manuela Rendtel (AKM; Germany), Jeffrey Riechmann (AMS; California, USA), Laurence Roberts (I; England), Clive Rogers (I + V; England), Frank Ryan (Ireland), William Sagar (AMS; Texas, USA), Robin Scagell (England), David Scanlan (England), Jonathan

Shanklin (England), Andy Smith (RMOB; R; England), Ulrich Sperberg (AKM; Germany), Christopher Stefan (AMS; Florida, USA), Jeff Stevens (England & Scotland), Enrico Stomeo (Vi; Italy), Magda Streicher (South Africa), Petra Strunk (AKM; Tenerife), Dave Swan (RMOB; R; England), David Swann (AMS; Oklahoma & Texas, USA), Richard Taibi (AMS; Maryland & Massachusetts, USA), Istvan Tepliczky (RMOB; R; Hungary), Danny Thomas (England), Robert Togni (AMS; Arkansas, USA), Simona Vaduvescu (AMS; Hawaii, USA), Diego Valeri (RMOB; R; Italy), Felix Verbelen (RMOB; R; Belgium), Frank Wächter (AKM; Germany), Sabine Wächter (AKM; Austria & Germany), William Watson (AMS; New York, USA), Roland Winkler (AKM; Germany), David Woodward (England), Julie Yellowley (England), Kim Youmans (AMS; Georgia, USA).

3 Radio Quadrantids

Full Moon on January 3 created the worst possible visual observing conditions for the 2007 Quadrantids, so it is scarcely surprising no usable data were collected that way, while even the IMO's video data (circulated to the IMO-News e-mail list by Sirko Molau on 2007 February 15) allowed no useful comments. David Entwistle's SBV radio analysis ran into difficulties thanks to an unhelpfully large scatter in the possible computed peak timings recorded by different radio systems between $\sim 22^{\rm h}09^{\rm m}$ to $01^{\rm h}30^{\rm m}$ UT on January 3/4. However, it was possible to suggest an average timing from those of $00^{\rm h}07^{\rm m}$ UT on January 4, $\lambda_\odot = 283\overset{\circ}{.}15$, comfortingly very close to the predicted value of $283\overset{\circ}{.}16$ in the IMO's *Shower Calendar* (McBeath, 2006, pp. 2 & 26), less than thirty minutes later. After the SBV analysis method was later strongly questioned, it became unclear how much reliance might still be placed safely upon this finding.

In trying to clarify the situation by reanalysing the available radio results for this paper, a rather different peak timing was found, between $02^{\rm h}$ to $06^{\rm h}$ UT on January 4, with a weighted mean at $\sim 03^{\rm h}30^{\rm m} \pm 1{\rm h}$ UT, $\lambda_\odot = 283\overset{\circ}{.}35 \pm 0\overset{\circ}{.}04$. See Figure 1. The general strength and consistency in this peak from the more complete reliable European and sole Japanese datasets, with its timing in relation to the radiant geometries at the various sites, would have been sufficient in previous RRR examinations to suggest this likely represented the true maximum. No peak was apparent around the proposed SBV mean maximum time. Whether the lesser RRR peak near $11^{\rm h}$ UT on January 4 may have been a recurrence of the possible secondary maximum sometimes found in SPA Quadrantid analyses from recent returns was not certain (cf. McBeath, 2010, p. 186), though it was present in three sets of the European observations, and one from North America. No other significant peaks were present for the remainder of January 4. It is intriguing that the main radio maximum was centred around three hours later than predicted, given that the visual peak in 2006 from the preliminary IMO visual data may have been five hours or more later than expected (according to Rainer Arlt's report on IMO-News from 2006 January 8). In the absence of results collected by other methods of course, the 2007 radio findings must remain somewhat tentative.

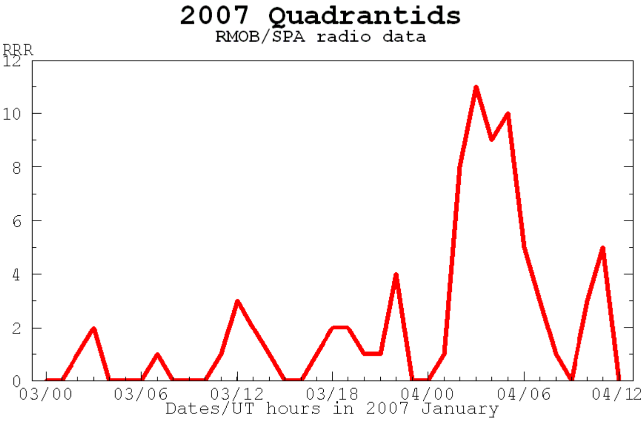

Figure 1 – The RRR graph for the Quadrantids from $00^{\rm h}$ UT on January 3 to $12^{\rm h}$ on January 4.

4 February 6/7 fireball

Although the usual healthy number of fireball sightings was received by the Meteor Section from 2007, only this event at $19^{\rm h}56^{\rm m}$ UT on February 6 was sufficiently well-observed to allow a more detailed trajectory determination. It was reported from eleven locations in England and the Netherlands, including being partly imaged by Klaas Jobse's all-sky fireball patrol camera, part of the European Fireball Network (camera EN97), located at Oostkapelle in the Netherlands. Information extracted from this image was combined with the better British visual positional data to allow a reasonable trajectory to be estimated. A sketch-map showing the projected surface track for its flight is in Figure 2.

The start of the imaged trail was probably around 80 km altitude above the North Sea $\sim$ 45 km east of North Foreland in Kent, southeast England, some 50 km north of Gravelines in northern France, at approximately $51\overset{\circ}{.}5$ N, 2° E. From there, the fireball flew

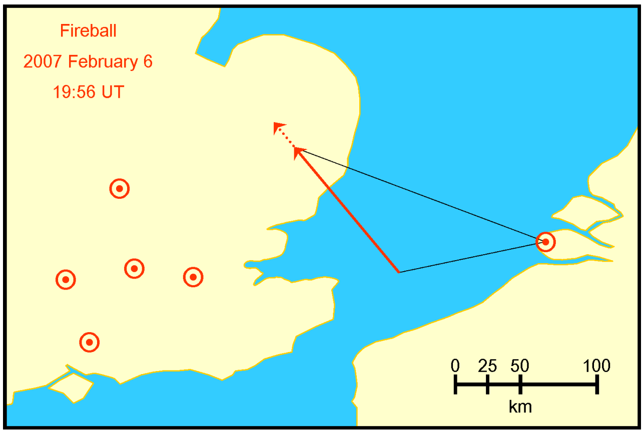

Figure 2 – A sketch map of southeast England, the adjoining seas and the coastal regions of the southern Netherlands, Belgium and northeast France, showing the projected surface track for the February 6 fireball. Target symbols indicate the main observing locations for the trajectory's determination, while the solid arrowed line shows the imaged part of the trail (attached to the Netherlands imaging site by thinner lines). The dashed extension of the arrowed line gives the likely end of the visible trail, which was not imaged.

northwest on a very shallow trajectory, only about 8° from the horizontal, crossing the English coast just north of Felixstowe in Suffolk. The last part imaged was probably at ∼ 65 km altitude above a point around 7 km northeast of Stowmarket, Suffolk, not far from Mendlesham, at circa $52\overset{\circ}{.}25$ N, 1° E. The end of the visible trail was plausibly further northwest of this point, at ∼ 61 km altitude, roughly 10 km east of Thetford, Norfolk, close to $52\overset{\circ}{.}4$ N, $0\overset{\circ}{.}8$ E, if so. This latter position was merely a best-estimate, however.

Assuming these details were correct, the imaged atmospheric path would have been some 110 km long. The photographed path duration (available thanks to the rotating shutter attached to the imaging system) was about 4.56 s, leading to a mean atmospheric velocity for the photographed part of the trail, not allowing for atmospheric deceleration, of ∼ 24 km/s. This tallied with most of the visual observations, which tended to mention the meteor was slow-moving, and relatively long-lasting. The full visible path-length was probably ∼ 135 km (thus lasting around 5.6 s). Most witnesses mentioned the object fragmented later in its flight, while the imaged trail and two witnesses suggested a short-lived persistent train may have happened after the fireball vanished.

5 Lyrids

Lunar conditions were reasonably favourable for the Lyrids, with a waxing crescent Moon at first quarter on April 24, although the weather across many parts of the northern hemisphere where the Section's observers were based was often much less helpful. Despite this, and drawing on AMS and AKM data as well as reports received more directly, it was possible to generate ZHRs from every night except April 19/20 between April 14/15 to 22/23 inclusive. In common with the IMO's visual results (Rendtel & Arlt, 2007), these suggested a peak around $22^{\mathrm{h}}30^{\mathrm{m}}$ UT on April 22 ($\lambda_{\odot} = 32\overset{\circ}{.}31$). The IMO ZHR then was $\sim 20 \pm 1$. These IMO rates are illustrated, without error bars – in all cases these were of order ±1 or 2 only – in Figure 3.

As has been apparent before (see for instance, the comments on the 2004 Lyrids in McBeath, 2007, pp. 61–62), the Lyrid radio results proved less straightforward to analyse. The SBV report David Entwistle produced suggested a vague peak between $\sim 21^{\mathrm{h}}$–02^{h} UT on April 22/23, followed by a possible secondary maximum, consisting of apparently increased numbers of overdense echoes (that is, likely due to bright or very bright visual meteors) around 07^{h}–08^{h} on April 23. My initial assessment of the raw radio data concurred in general with these findings, but the more detailed re-examination of the radio results for this paper, also illustrated in Figure 3, has found a somewhat different pattern, suggestive that the $\sim 07^{\mathrm{h}}$ one-hour radio bin on April 23 was part of an apparently rising trend beginning around 02^{h} that morning, and that while activity was probably increased above normal before then too, from circa 21^{h} UT on April 22, the only peak present during the pre-midnight phase was relatively minor.

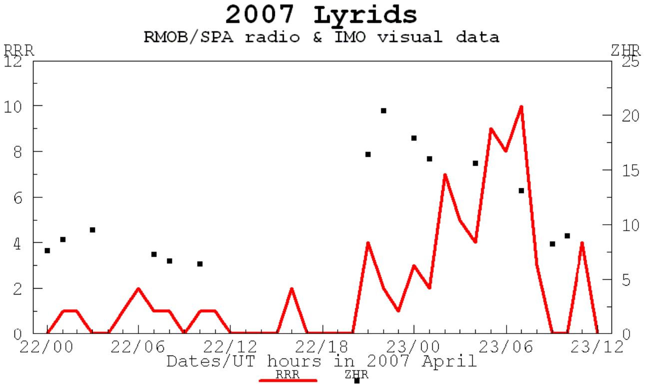

Figure 3 – A comparison of the Lyrid RRR with the IMO's ZHR data from (Rendtel & Arlt, 2007) between 00^{h} UT on April 22 to 12^{h} on April 23.

Although the radio maximum around 05^{h}–08^{h} seems dominant in Figure 3 ($\lambda_{\odot} = 32\overset{\circ}{.}58$–$32\overset{\circ}{.}70$), this must be treated cautiously, because it was detected primarily from Europe. From this region, this time of day in late April brings both one of the Lyrid radiant's most favourably-observable intervals and the diurnal sporadic peak, both of which have undoubtedly had an effect on what was observed. Despite this, it is difficult to escape the fact this interval also brought an unexpected increase in longer-duration overdense meteor echoes, which cannot be accounted for simply by geometric considerations, as no repeat was present on days to either side at the same time. While the coverage was not definitive, as just one datapoint fell within the key spell, it is curious the IMO results showed no significant difference in the Lyrid population index around this time ($r = 1.98$ at $07^{\mathrm{h}}18^{\mathrm{m}}$ UT compared to 2.02 at 04^{h} and 1.98 at $08^{\mathrm{h}}54^{\mathrm{m}}$ – Rendtel & Arlt, 2007, Table 2, p. 78). There were signs that the population index had fallen continuously, if slightly, from $\sim 22^{\mathrm{h}}30^{\mathrm{m}}$ UT, $r = 2.20$, to $\sim 07^{\mathrm{h}}$ certainly, but that drop seemed too little to account for the radio data's findings. While various explanations might be proposed, in the absence of other information, none seem especially satisfactory in resolving this apparent discrepancy.

6 Perseids

Some fine weather coincided with the moonless Perseid maximum weekend for many places, allowing plenty of people from casual watchers to dedicated meteor observers a useful view of what happened. Those reporting to the SPA confirmed the subsequent IMO view (both from the "live" online data and the more detailed near-maximum examination of Rendtel, 2008) that peak ZHRs had been a little below those expected, at best ∼ 90 on August 12/13 UT. The "live" IMO ZHRs, without error bars, are shown in Figure 4 by comparison to the Perseid RRR trace.

Three visual maxima were reported from the 2007 Perseid return by Rendtel (2008), an uncertain filamentary peak around $\lambda_{\odot} = 139\overset{\circ}{.}65 \pm 0\overset{\circ}{.}03$ (August 12, $20^{\mathrm{h}}20^{\mathrm{m}} \pm 45^{\mathrm{m}}$ UT), ZHR $\sim 78 \pm 5$, a more definite, probable resonant meteoroid, maximum at $\lambda_{\odot} = 139\overset{\circ}{.}86 \pm$

Table 2 – Global magnitude distributions for the 2007 Perseids and August sporadics seen under better sky conditions (cloud cover < 20%, LM = +5.5 or better), including mean LMs and corrected mean magnitudes. Data were collected from August 11/12 and 12/13 only.

Shower	≤ -3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$\geq +5$	Total	LM	$\overline{m}_{6.5}$
PER	15	13	15	41	57	79	74	54	30	378	+6.10	+2.27
SPO	2	0	0	1	8	15	33	28	16	103	+6.16	+3.49

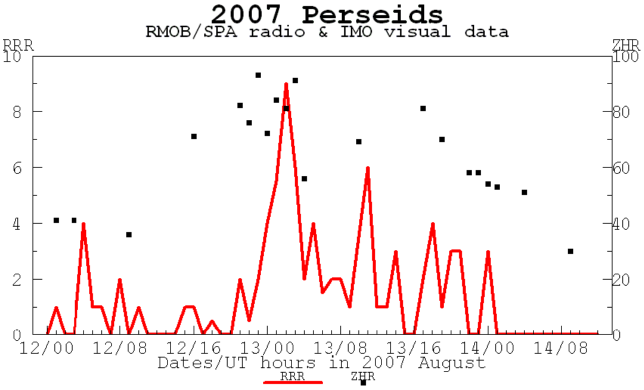

Figure 4 – A plot of the Perseid RRR and the IMO's "live" online ZHR data between 00^{h} UT on August 12 to 12^{h} on August 14.

$0\overset{\circ}{.}03$ (August 13, $01^{\mathrm{h}}35^{\mathrm{m}} \pm 45^{\mathrm{m}}$), ZHR 88 ± 6, and the mean maximum at $\lambda_\odot = 140\overset{\circ}{.}25 \pm 0\overset{\circ}{.}05$ (August 13, $11^{\mathrm{h}}20^{\mathrm{m}} \pm 75^{\mathrm{m}}$), ZHR 67 ± 8. The radio data were checked for confirmation of these aspects for this paper. There was no obvious radio maximum in time to the earliest of the three visual events, but there were quite close matches for the August 13 pair. As shown in Figure 4, the first was notably the better-detected (partly because it happened close to an ideal time for the European radio observers), peaking in the 02^{h} UT bin, likely centred around a weighted mean time of $\sim 02^{\mathrm{h}}15^{\mathrm{m}} \pm 1^{\mathrm{h}}$, $\lambda_\odot = 139\overset{\circ}{.}89 \pm 0\overset{\circ}{.}04$. The second, recorded from Europe and North America, peaked in the 11^{h} bin, so probably within thirty minutes of $11^{\mathrm{h}}30^{\mathrm{m}}$, $\lambda_\odot = 140\overset{\circ}{.}26 \pm 0\overset{\circ}{.}02$.

It is unclear whether there was any real significance to the possible weaker radio maxima in the 04^{h} bin on August 12 (if so, in the $\lambda_\odot = 139\overset{\circ}{.}01 \pm 0\overset{\circ}{.}02$ interval), or that around 18^{h} on August 13 which may have persisted through until midnight UT on the 14th (beginning at $\lambda_\odot = 140\overset{\circ}{.}52$). The latter was detected from Japan and partly from North America, albeit observing conditions were close to ideal in both places around 18^{h}. The short-term spiky nature of the RRR graph adds problems for its further interpretation, something which is not unexpected with the Perseids from previous returns. The SBV analysis by David Entwistle suggested only a generally broad and ill-defined maximum for instance, lasting from roughly 22^{h}–06^{h} UT on August 12/13, perhaps with hints of somewhat increased activity around 23^{h}–00^{h} and 01^{h}–03^{h}, and possible weaker enhancements between 10^{h}–11^{h} and 12^{h}–13^{h} on the 13th.

Magnitude and train details derived from the SPA results, while of limited extent, suggested fairly typical values. Near-peak magnitude distributions are given in Table 2. Persistent trains were left by 34% of Perseids (86 of 256 meteors) and 6.5% of sporadics (4 of 61 meteors).

One unusual event was the direct observation of the Perseids in daylight using thermal imagers, as far as could be determined for the first time. Laurence Roberts and several colleagues set up suitable equipment from their company which manufactures it in Essex, southeast England, and ran it from 03^{h}–07^{h} UT on August 12/13, collecting a total of eleven hours or so of data from the various sensors and video cameras. This followed-on from the accidental recording of a meteor crossing the daylight sky using such gear by the same team on 2007 June 21, around 08^{h} UT. Unfortunately, no further information was received concerning exactly what had been recorded, beyond an initial comment of "many meteors". It is not known either what further attempts may have been made using such equipment, although information was found suggesting a similar system had been tried overnight in 2007 May by an observer from the Siemens company in Germany, which had recorded similar activity levels to what a visual observer might have seen at the time.

7 Radio α-Aurigids

The short-lived outburst of predominantly bright meteors from the badly moonlit α-Aurigids on September 1 has naturally been discussed here before (including by Habuda, 2007 and Rendtel, 2007 both very soon afterwards, and Molau, 2008a). Confusion over the shower radiant's location as reported in observations made during the outburst, discussed by both Habuda and Molau, and other problems with the near-Auriga minor showers at this time of year led to a thorough re-evaluation, which found this shower's radiant was actually located well to the southeast of the star α Aurigae, hence the shower is now known just as the "Aurigids". Rendtel's analysis found the visual peak had occurred within three minutes of $11^{\mathrm{h}}20^{\mathrm{m}}$ UT, $\lambda_\odot = 158\overset{\circ}{.}556 \pm 0\overset{\circ}{.}003$, with an estimated ZHR based on five-minute counts of 132 ± 25.

As this timing fell poorly for most of the more active visual and imaging SPA contributors, the Section's main analytical interest centred on the radio results. It was quickly apparent from five contributors soon after the event that a strong, sharp peak had been detected in the one-hour binning interval from 11^{h}–12^{h} UT on September 1, with lesser activity surrounding that from at least $\sim 10^{\mathrm{h}}$–13^{h}. Four of these datasets gave mean peak times for the centre of the outburst between $11^{\mathrm{h}}15^{\mathrm{m}}$ and $11^{\mathrm{h}}19^{\mathrm{m}}$ UT, while Jeff Brower noted from his data and that collected from Finland by Esko Lyytinen a FWHM time of $\sim 56^{\mathrm{m}}$.

Subsequent examinations of the radio results by Brower, David Entwistle and myself (the latter in preparation for this article) have in general confirmed those early findings. Using a total of six reports that included five or ten minute echo-count data, the overall mean timing for the outburst peak was found at $11^{\mathrm{h}}18^{\mathrm{m}} \pm 10^{\mathrm{m}}$ UT ($\lambda_{\odot} = 158\overset{\circ}{.}553 \pm 0\overset{\circ}{.}007$), tolerably close to that found by Rendtel. Although such comparisons are fraught with difficulty, it seemed plausible the strongest radio activity was somewhat less than a typical Quadrantid radio maximum (of visual ZHR ~ 120), albeit dominated during the peak hour by a notably increased number of very persistent echoes, which would tally with the visual and video records of many bright to fireball-class Aurigid meteors seen during the outburst. Rendtel for instance reported a population index of 1.74 ± 0.08 for the maximum, while Brower noted his automated fireball video system had caught seven fireball events overnight on September 1, all between $10^{\mathrm{h}}55^{\mathrm{m}}$ and $11^{\mathrm{h}}59^{\mathrm{m}}$ UT. Brower found the long-duration overdense radio meteor echoes began for his system at $10^{\mathrm{h}}55^{\mathrm{m}}$ UT and lasted until $\sim 11^{\mathrm{h}}45^{\mathrm{m}}$.

Although the IMO visual data suggested Aurigid ZHRs dropped quite quickly after the maximum (the fifteen-minute ZHR graph, Figure 1 in Rendtel, 2007, suggested rates had fallen to ~ 12 by about midday UT), the radio results continued to indicate somewhat elevated count levels for an hour or more after the maximum, albeit without the probable "bright meteors" component, which may account for the drop in visual rates, as the meteors returned to the typical, fainter, Aurigid brightness regime. It is interesting too that the outburst peak was not recorded by all the RMOB observers located where the radiant should have been readily observable at the time (Europe and North America). Eight of twelve datasets showed such a clear peak, with those that did not either recording higher echo counts generally, so likely detecting a greater proportion of underdense echoes, or possibly those where system-saturation due to the large number of persistent overdense trails during the maximum had artificially reduced the counts. The former point would suggest the outburst peak had been distinctly lacking in smaller meteoroids/fainter meteors.

8 Orionids

As hoped for in advance, following the unexpectedly strong return of 2006 (cf. McBeath, 2010), enhanced Orionid activity happened again in 2007, with elevated ZHRs reported from several nights across the expected peak on October 21 (see Arlt et al., 2008). In the UK, a persistent atmospheric high pressure area meant most nights in the week leading up to the maximum provided observers with an opportunity to check on the shower. Rates were generally normal (ZHRs < 10) in what was reported up to October 17/18, but rose quickly to near-maximum levels by October 19/20, and reached ~ 40–50 by October 20/21 the last better night for many British watchers, after which fog and low cloud set in. A few lucky observers saw rates still well above usual towards dawn on October 22/23, though no further moonless watching was practical after that. While reports from overseas have boosted the SPA visual data further since the event, the IMO's report (op. cit.) remains the most detailed, and it is that which is used in comparison to the radio results here.

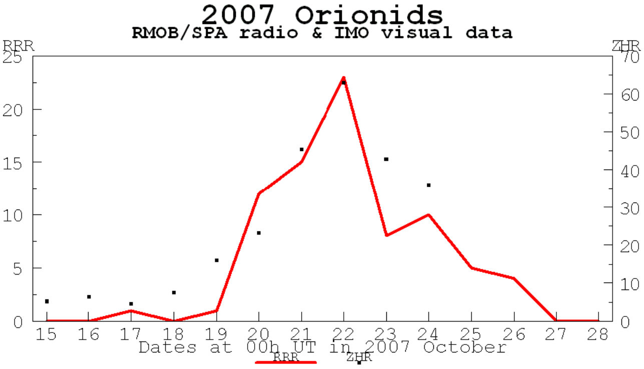

Figure 5 – A graph of the Orionid RRR and the IMO's ZHRs (from Arlt et al., 2008) between October 15 and 28. For clarity, the data have been combined into a single daily point for each, without error bars.

The Orionids, with their typically protracted activity at near-peak levels, and fairly modest ZHRs, have often proven a tricky subject to examine from forward-scatter radio results. The SBV analysis method, which was designed chiefly for identifying single, quite short, clear maxima, is unsuitable for this type of shower, so this is the first radio meteor analysis attempted for the 2007 Orionids as far as I am aware. Interference proved problematic for a number of the regular RMOB observers, and there were frequent gaps in some datasets as a result. However, a reasonably robust activity profile has been generated from October 15–28, as shown in Figure 5 with the IMO visual results.

The pattern shown by both datasets seemed remarkably similar, the greatest discrepancy apparent on October 23, one of the days of elevated activity when only a single visual ZHR point could be derived. Interestingly, and although the data available were somewhat limited, while peaks in the longer-duration radio meteor-echo counts were found from October 20–22 inclusive and again on October 24, there was apparently no repeat in unusual longer-duration meteor activity on October 23. No evidence for a lack of brighter meteors was seen in the population index examination by Arlt et al. (2008) around this time, although the r-value did seem to have been increasing slightly from its lowest near then.

Overall, this helps give a degree of confidence to the character of the declining radio rates shown after October 24 when no visual observations were available for contrast. Activity seemed to have resumed its pre-peak level in the radio results by October 27 (remembering the RRR zero level does not mean no activity, simply no significant activity was found when the given shower's radiant was most likely responsible for what was recorded). Perhaps fortunately from the visual observers' perspective, the longer-duration echo count features seemed not to have recurred after October 24!

Arlt et al. (2008) found two possible stronger Orionid maxima on October 22, around 00^{h} and 08^{h} UT, when ZHRs were 70 ± 4 and 80 ± 5 respectively. The

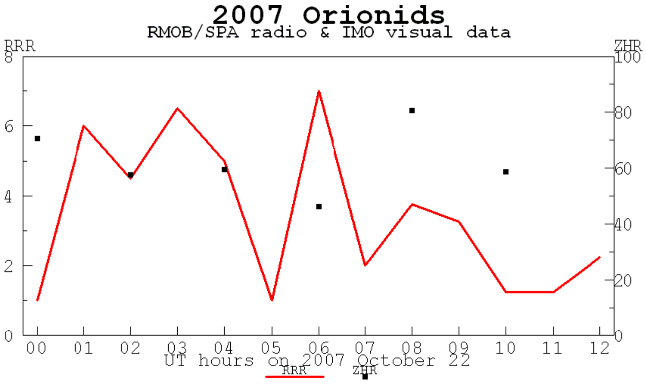

Figure 6 – The Orionid RRR and the IMO's ZHRs (from Arlt et al., 2008; shown without errors bars here) between 00^{h} and 12^{h} UT on October 22.

radio data were examined more closely for evidence that might have supported these potential sub-maxima, but as Figure 6 shows, unfortunately no such confirmation could be achieved, with what radio peaks there were that day before 12^{h} UT occurring in the one-hour bins commencing at 01^{h}, 03^{h} and 06^{h}, primarily apparent here thanks to the concentration of radio systems operated from Europe. In general, the radio reports throughout October 22, while showing stronger count levels due to the Orionids than on other days around then, were simply elevated overall, rather than concentrated at specific times.

9 Radio Leonids

The Leonids' $\lambda_{\odot} = 235.^{\circ}27$ nodal maximum was due around 03^{h} UT on November 18 (McBeath, 2006, pp. 17–18), and although modelling by Jérémie Vaubaillon (as reported via the `www.imcce.fr` website) had suggested the Earth would pass relatively close to a number of denser Leonid meteoroid trails during the 2007 return, only the 1932 AD trail was expected to be near enough to possibly create some significant interest, likely in the hour or two before midnight UT on November 18/19. Mikhail Maslov (2007, p. 7) anticipated a ZHR of ∼ 30 from this trail at $23^{\mathrm{h}}05^{\mathrm{m}}$ UT on November 18, albeit probably producing many meteors too faint for visual observers. He also proposed an earlier maximum with ZHRs of ∼ 15 for 21^{h} UT on November 17. Disappointingly, while largely Moon-free, much of the Leonid peak epoch passed behind cloudy skies for almost all the Section's visual observers. Even the IMO's "live" online results page presented many fewer data than might have been hoped-for, again primarily due to poor conditions. While the radio results suffered less interference than during the Orionid epoch in October, these were only available from Europe and North America. The near-maximum IMO visual ZHRs and the RRR are shown in Figure 7.

Three peaks seemed apparent in the visual results on November 18, around 01^{h} UT (ZHR ∼ 22, an average of two datapoints astride this time), ∼ 11^{h} (ZHR ∼ 27), and the third, the strongest so-recorded at 35 ± 5, around $23^{\mathrm{h}}50^{\mathrm{m}}$ UT. However, the first of these was not especially well-defined, as ZHRs of 20+ were found from about midnight to 04^{h} UT that day, while the second was a temporally isolated datapoint, making its importance difficult to judge. The third seemed more convincingly the main maximum, taking place roughly as predicted for the 1932 trail, although apparently not lacking in visual meteors.

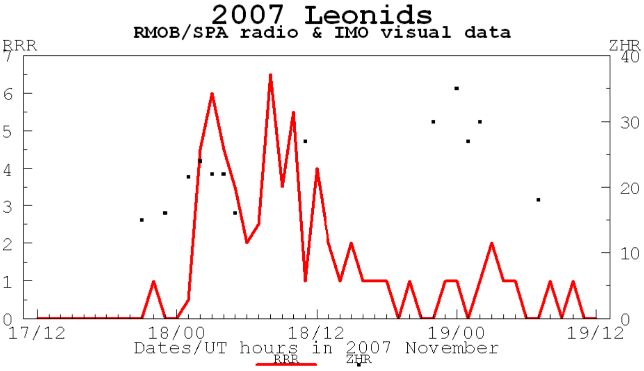

Figure 7 – The Leonid RRR compared with the IMO's "live" online ZHR data between midday UT on November 17 to the same time on the 19th.

The radio results seemed to concur with the first peak, which here lasted for several hours beginning in the 02^{h} UT bin of November 18. The second RRR maximum, seemingly the best-recorded of all, began in the 08^{h} bin and persisted in a declining form through until perhaps 13^{h} UT. The ∼ 11^{h} visual datapoint presumably resulted from part of this activity. However, despite the probable "tail" in Leonid radio rates that followed this, and with the possible exception of a quite weakly-recorded potential minor maximum around the 03^{h} UT bin on November 19, no other peaks were detected. While this may seem strange at first, given the expectations for many faint meteors in the ∼ 23^{h} peak on the 18th and the apparent strength recorded for that event visually, it happened at about the worst possible time to be detected from the radio details to-hand, as the radiant had set from most of North America by about 22^{h} UT, and had barely risen from even northern Europe by 23^{h}, so was still very low by midnight. It thus seemed possible the radio Leonid "tail" effect was due to parts of the genuinely elevated activity during this interval being detected despite these difficulties. Certainly, there seems no reason to doubt the validity of the visual findings from this radio analysis.

10 Geminids

Despite being virtually moonless, the Geminid maximum, as so often in the northern winter, ran into some poor weather for visual observers. Conditions across the British Isles, for example, were rather patchy near the expected peak, due around $16^{\mathrm{h}}45^{\mathrm{m}}$ UT on December 14 (McBeath, 2006, p. 22), although skies had been better at times in the preceding week, allowing some helpful information on the rising Geminid activity to be collected. By December 13/14 and 14/15, most places had only mist, fog and low clouds, which helped reduce observing times even for those, chiefly in Ireland and Northern Ireland, who enjoyed marginally better viewing then. The IMO's "live" webpage review too

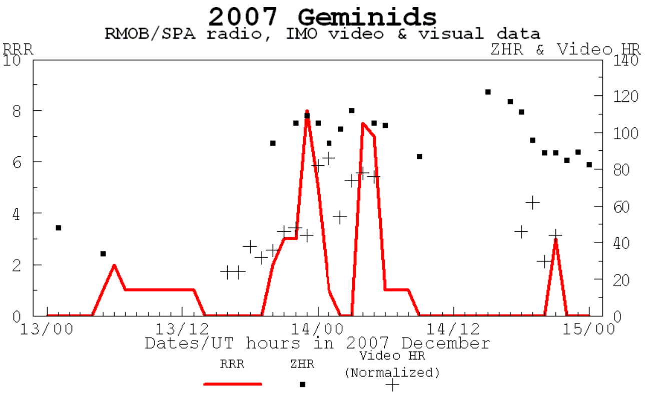

Figure 8 – The IMO's "live" online ZHR Geminid data compared with the RRR results and the radiant-altitude-corrected IMO video hourly rates (HRs; estimated by-eye from Figure 2, p. 41 of Molau, 2008b, and normalized to fit the ZHR scale here) between midnight UT on December 13 and the same time on the 15th.

was rather limited, but was at least able to provide reasonably complete coverage for much of December 14, a day when ZHRs remained apparently at or above ~ 80, with a possible peak (as it was located just after the day's longest gap in results, its reality is uncertain) at $\sim 14^{h}35^{m}$ UT with a ZHR of 122 ± 6, as illustrated by Figure 8.

In the radio results, there were difficulties because of interference, or system-saturation due to the numbers of Geminid echoes occurring relatively close together in time, which seem to have been particularly problematic for North American observers. This was compounded as the sole dataset from Japan had a lot of missing data too, which meant the predicted maximum time received effectively no usable coverage for the RRR examination. Figure 8 also shows the RRR data. Using the SBV radio analysis method based on data from six European observers, David Entwistle estimated a peak sometime between 12^{h} and 17^{h} UT on December 14, with a mean maximum time of $\sim 15^{h}39^{m} \pm 3^{h}$ UT. It is though important to appreciate that this was a purely computed estimate, because the Geminid radiant was below the horizon throughout this interval from Europe, thus it was unclear how much reliance might be placed upon it.

Given the interpretive difficulties with the other results, it was felt useful to add in the IMO's video data to Figure 8 as well. While those gave few clues to clarify the true maximum, given that the results were again from Europe, they did indicate something unusual may have transpired overnight on December 13/14. The bimodal radio "peak" on December 14 centred at about 02^{h} UT was also recorded exclusively from Europe. Under different circumstances, it might have been reasonable to assume this had most probably resulted simply from the radiant geometry, which culminated at about that central dip's time, creating a raw radio meteor activity pattern well known generally. However, it is intriguing that both the IMO visual and video results indicated something of a dip in Geminid rates near the same time (remembering both the radio and IMO video data were presented only in one-hour bins), which may

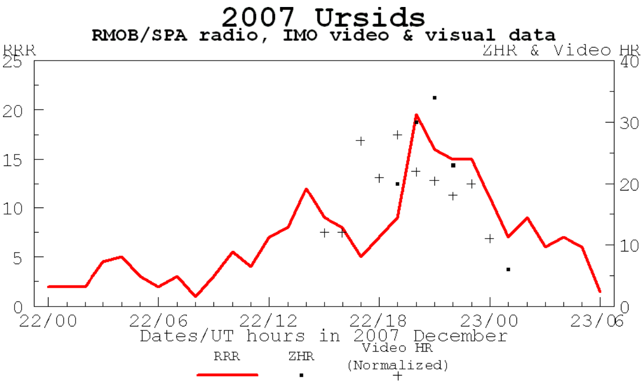

Figure 9 – "Live" IMO Ursid webpage ZHR results compared with the corrected IMO video hourly rates (HRs) and the RRR results between midnight UT on December 22 and 06^{h} on the 23rd.

suggest the drop in radio meteor activity was partly real. Other than that, the Geminids seemed to have provided a typical return in 2007, with excellent activity for those who were able to see it, if without a clearly definable peak in the information available!

11 Ursids

Following the stronger Ursid return in 2006 (cf. McBeath, 2010), and just ahead of the perihelion return of the shower's parent comet 8P/Tuttle in 2008 January, even the presence of the almost full Moon for the predicted nodal maximum around $\lambda_{\odot} = 270.^{\circ}7$, 01^{h}–$03^{h}30^{m}$ UT on December 23 (McBeath, 2006, p. 13; note the date there was given in error as December 22) was unlikely to deter observers, particularly after further predictions issued shortly before the event suggested that ZHRs of $\sim$ 40–80 might occur at some stage between $\sim 20^{h}$–22^{h} UT that day. Naturally, the weather had the final word in reducing what was practical, which with the moonlight helped create a degree of confusion as to just what had taken place in the immediate aftermath. The IMO's "live" online results page gave a possible peak ZHR of ~ 35 at $21^{h}15^{m}$ UT or so, $\lambda_{\odot} = 270.^{\circ}53$, with rates apparently better than 20 present from about $18^{h}30^{m}$ to $22^{h}10^{m}$. The IMO radiant-altitude-corrected video data (Molau, 2008b) supported a protracted period of better Ursid rates from roughly 17^{h}–23^{h}, perhaps with peaks around 17^{h} and 19^{h}. Both datasets are shown in Figure 9, the video results normalized to fit the ZHR scale, and also combined into one-hour datapoints based on the graphical thirty-minute information, converted numerically by-eye from Molau's Fig. 3, p. 41.

To try to clarify matters, a more detailed examination of the radio results covering December 20–24 inclusive was carried out, which has been revisited and slightly amended with additional data here. From this, December 22 stood out, if rather marginally, in most datasets as being the more sustainedly active radio meteor day from this interval, although it did not always produce the highest echo counts. December 22 was accordingly investigated more closely, with the RRR findings given in Figure 9 here too, expanded to cover the nodal crossing interval on December 23. Probable Ursid activity seemed to be present throughout the whole period, and several potential maxima were apparent, including one during that near-nodal time, albeit seemingly stretched from $\sim 02^{\rm h}$–$06^{\rm h}$ UT. However, the significance of this peak needs to be questioned because of a minor maximum around $03^{\rm h}$–$06^{\rm h}$ the previous day, for all that on the 23rd was recorded rather better. Two more convincing maxima were found besides these, the first centred on a weighted mean time of $14^{\rm h}04^{\rm m}$ UT, $\lambda_\odot = 270\overset{\circ}{.}23$. It perhaps persisted from roughly $12^{\rm h}$ to $17^{\rm h}$. The second seemed the more significant and substantial, lasting from $\sim 18^{\rm h}$ until $01^{\rm h}$ UT or so, with a weighted mean time of $21^{\rm h}23^{\rm m}$ UT, $\lambda_\odot = 270\overset{\circ}{.}54$, although the best concentration of positive results was in the hour commencing at $19^{\rm h}00^{\rm m}$, $\lambda_\odot = 270\overset{\circ}{.}44$.

Overall, an Ursid filament peak on December 22 between at least $19^{\rm h}$–$23^{\rm h}$ UT can be supported by the IMO and RRR results, although the video data suggested it may have begun somewhat before this time, perhaps around $17^{\rm h}$. There seems little reason to think the estimated IMO ZHRs were other than reasonably accurate, despite the moonlight problems, although more observations would have been very welcome.

12 Conclusion

Although sky conditions did little to assist the Section's visual observers at times during 2007, both within and without the UK, interest in meteor activity remained high in the Section's correspondence and online activities. The power of radio observing to circumvent difficulties posed by the weather, and still provide clues as to what was probably happening even when no other results were available, continued to help inform on such matters. As ever, my grateful thanks go to all the Section's contributors during the year, allowing this summarised analysis. Clear skies to all!

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Birth of meteor network in Morocco – Analysis for the 2012 Geminids

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Morocco is known to a region of frequent witness of meteorite falls and/or recovery. This dictate the necessity to create the first Moroccan meteor network. This paper presents the results of the 2012 Geminid observation campaign performed at the Atlas Golf Marrakesh, Marrakesh, Morocco. It was found that the Geminids duration is generally correlated to their magnitude. Moreover, we analyse a Geminid spectrum showing a normal class spectrum, with high sodium content. Morocco is found to be an excellent place for meteor observation and future work and collaboration are presented.

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1 Introduction

The monitoring of meteor shower presented in this paper illustrates one of the many aspects of the current research efforts of the University of Cadi Ayyad to characterize the flux and the nature of the interplanetary matter hitting the Earth of the moon. In this framework, the main purpose of the Oukaimenden observatory is to monitor the sky and the neighboring environment of the Earth (NEO, NEA, comets and meteors). The monitoring of lunar flashes from the Earth is another aspect of this research. A fraction of the object's pre-impact kinetic energy is released as radiation resulting in a flash above impact that can be seen from Earth using small size telescope equipped with a high speed video camera. These impact flashes have been successfully observed on the Moon by Earth-based telescopes during several showers, mainly in Japan, and the USA (Dunham et al., 2000; Ortiz et al., 2000; Cudnik et al., 2002; Ortiz et al., 2002; Yanagisawa & Kisaichi, 2002; Cooke et al., 2006; Cooke et al., 2007; Suggs et al., 2008b; Suggs et al., 2008a; Yanagisawa et al., 2008) and NASA Marshall Space Flight Center (MSFC). The Oukaimenden observatory is now pioneering this activity on the African and European continents, and is an active partner of the a Moroccan-French network of observatories involved in the survey of impact flashes on the Moon (including the Uranoscope of Ile de France and the Midi-Pyrénées Observatory). Several joint observations campaigns were achieved in the last two years, in particular during the major meteor showers high than usual rate of lunar flashes is expected (Daassou et al., 2011). It is hoped that this network will contribute to improve the current record of known impact flashes. Despite no new impact flashes have been published yet, we show that the analysis of previously published observation can be used to constrain the nature of these events and suggests several ways of improving the scientific value of this time-consuming monitoring effort.

One of the main goal of monitoring the meteors is to compute the location of meteorite falls. The desert landscapes of a large portion of the country is highly favorable to the recover of meteorite, and the fraction of recovered meteorite may be substantially improved if computation predictions of fall locations is achieved. When both trajectories, and therefore orbits are linked to a recovered objects, this allows us to link a given rock sample with a possible parent body (or a possible source region in the Solar System). As Morocco has already developed a network of collaborations permitting to conduct various analysis in the laboratory of the recovered samples (as illustrated in the case of the recent fall of the Tissint meteorite from Mars (Chennaoui Aoudjehane et al., 2012), the benefit for the Moroccan scientific community of the development of a meteor monitoring network is demonstrated.

Here we report the results from our Geminid observation campaign performed in December 2012 at the Atlas Golf Marrakesh (AGM), Marrakesh, Morocco. The Geminid meteor shower is one of the most active showers and occurs between 2012 December 4 and 17. In 2012 the maximum was expected to occur on December 13 at $23^{\mathrm{h}}30^{\mathrm{m}}$ UT, with ZHR = 120. The Geminid parent body is asteroid 3200 Phaethon. It is a 5 km in diameter asteroid, with perihelion distance of about 0.14 AU. No unusual activity of Pheathon was observed, until Jewitt and Li detected ongoing mass loss in 2009 (Jewitt & Li, 2010). Because Phaethon approaches the Sun so closely, it is exposed to very high temperatures. Thermal dehydration process can crack its surface, and with the help of electrostatic repulsion and radiation pressure the particles are swept away from the surface of the asteroid. All these processes may be responsible for the observed activity of 3200 Phaethon in 2009 (Jewitt, 2012), and additionaly supply the Geminid stream. In Section 2 we briefly describe the instruments used during the campaign. Section 3 focuses on the data reduction and analysis of the detected Geminids. In Section 4 we present our conclusions and perspectives for future scientific activities in Morocco.

2 Instruments

For the Geminid observation campaign two stations was originally planed. The first stations was located at the

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Figure 1 – Position of the stations: the Oukaimden Observatory (Station 1) and Atlas Golf Marrakesh (Station 2).

Atlas Golf Marrakesh (AGM), Marrakesh in Morocco. The second station was located 42.38 km south of AGM in Oukaimden Observatory. The positions of the stations are shown in Figure 1 and their coordinates are provided in Table 1. The second station was not operational (accidentally damaged) and could not be used during the Geminid showers. Our equipment included two Watec 902H2 cameras, a 12 mm/F1.2 lens (FOV ~ 30° × 20°), a 6 mm/F1.2 lens (FOV ~ 60° × 40°), and a 600 grooves/mm grating, mounted in front of the 12 mm lens.

Table 1 – Location of ground based video meteor stations: the Oukaimden Observatory and Atlas Golf Marrakesh.

	Station 1 (Oukaimden Obs.)	Station 2 (AGM)
Longitude	31°12′32″ N	31°37′28″ N
Latitude	7°52′52″ W	7°59′35″ W
Altitude	2700 m	466 m

Since then two wide-field cameras have been permanently installed at the Oukaimden Observatory and Atlas Golf Marrakesh (Figure 12). For the purpose of this campaign the narrow-field observations were performed on the camera provided by IMCCE.

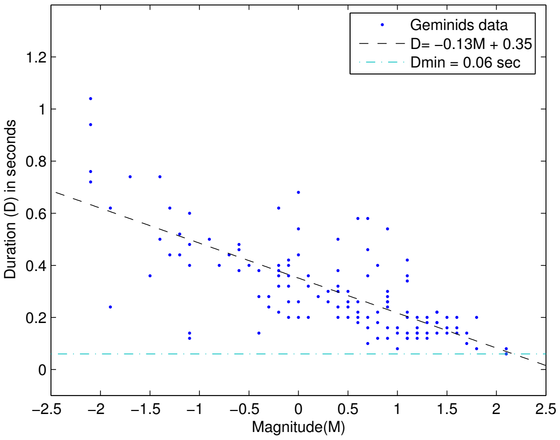

Figure 2 – Magnitude of 131 Geminids detected as a function of its duration (in seconds)

3 Observations, Data reduction, and Analysis

We performed a narrow- and wide-field video observations during the period from $20^{\mathrm{h}}30^{\mathrm{m}}$ to $04^{\mathrm{h}}00^{\mathrm{m}}$ UT on 2012 December 12-14. The meteors were detected with the UFOCapture software (SonotaCo, 2009). Next, the meteor data were processed with the UFOAnalyzer software (SonotaCo, 2009). The meteor spectra data reduction and analysis were processed with IMCCE's program SPECIES[1].

The wide-field camera detected 161 meteors, and at least 130 of them are identified as Geminids. The narrow-field camera detected 46 meteors, 27 of which showed spectra of variable quality. Only 32 meteors are observed by both cameras. The reason of this discrepancy is that the cameras were mounted on separate tripods. The two FOV did not always overlap as the pointing direction was regularly changed to follow the radiant. The narrow-field camera detected faint meteors, not detected with the wide-field camera.

Photometry

The photometry of 161 meteors was performed with the UFOAnalyser software which classifies different groups of known meteors. In order to precisely identify with a great precision the types of meteors we need to make a correct and precise adjustment between the meteor image and a sky map provided by the software. The adjustment configuration was saved, and subsequently apply to identify the meteor type. For a different pointing direction, we applied a new configuration.

UFOAnalyser gives the duration of the meteor (in seconds) and its apparent velocity. Figure 2 represents the distribution of the magnitude of 131 Geminids as a function of their durations. The magnitudes range between −2.1 and +2.1 (Table 2).

We clearly see that most magnitudes range between 0 and 1. The absence of higher than +2.1 magnitude can be explained by the detection limit of the Watec camera and lens. On the other hand, the absence of less

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[1] SPECIES (SPECtra IdEntification Software) program written in `MATLAB` and developed by Rudawska.

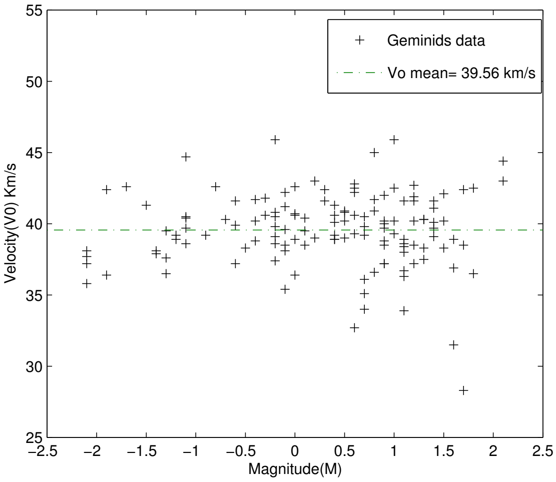

Figure 3 – Magnitude as a function of velocity of all the Geminids detected on 2012 December 13 and 14.

Table 2 – Distribution of 2012 Geminids magnitude.

magnitude	-2	-1	0	$+1$	$+2$
meteor#	7	18	38	57	11

that -2.1 magnitudes does not prevent their existence outside the FOV.

Figure 2 reveals a correlation between the duration D and the magnitudes M. The regression line shows that the fainter Geminids (from $+2.1^{\mathrm{m}}$ to 0^{m}) last from 0.06 s to 0.38 s, whereas the brightest Geminids (from 0^{m} to -2.1^{m}) last from 0.12 s to 1.04 s. This distribution shows that brightest Geminids have longer duration than fainter Geminids, with some exceptions.

To explain this particular case, we draw the velocity diagram of all 131 Geminids detected as function of the magnitude (Figure 3). This diagram shows that the velocity distribution varies between 28.3 and 45.9 km/s, with an average velocity equal to 39.56 km/s. It is greater by 4.56 km/s than the value cited in the literature (Suggs et al., 2011). We also note that for the same magnitude we have different velocities. The following equation represents the mass of the Geminids on Earth, can explain this difference in velocity (Hughes, 1995):

$$\log\, m = 14.7 - 4.0\, \log\, V - 0.4\, M\,,$$

where V is the Geminid velocity (in km/s), m its mass (in kg) and M its magnitude. We see that for a same magnitude we have two different velocities of Geminids corresponding to two different mass. Therefore, the brightest Geminids with short durations (shown in Figure 2) have relatively high velocity and relatively low mass.

The Figures 4 and 5 represent the number of Geminids as a function of the time with no correction for the radiant elevation. On the first night, the maximum occurred between $23^{\mathrm{h}}00^{\mathrm{m}}$ and $00^{\mathrm{h}}00^{\mathrm{m}}$ UT, while on the second night it occurs between $02^{\mathrm{h}}00^{\mathrm{m}}$ and $04^{\mathrm{h}}00^{\mathrm{m}}$ UT. The ZHR was calculated assuming a population index of $r = 1.51$ based on the magnitude distribution of our data set. The ZHR profile shows Figure 6.

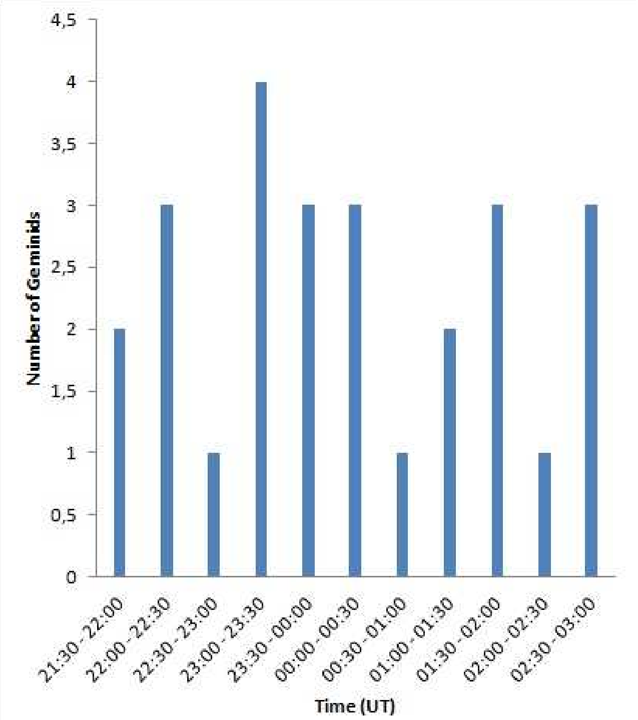

Figure 4 – Bar plot of number of Geminids as a function of the time (UT) for the night 2012 December 12-13.

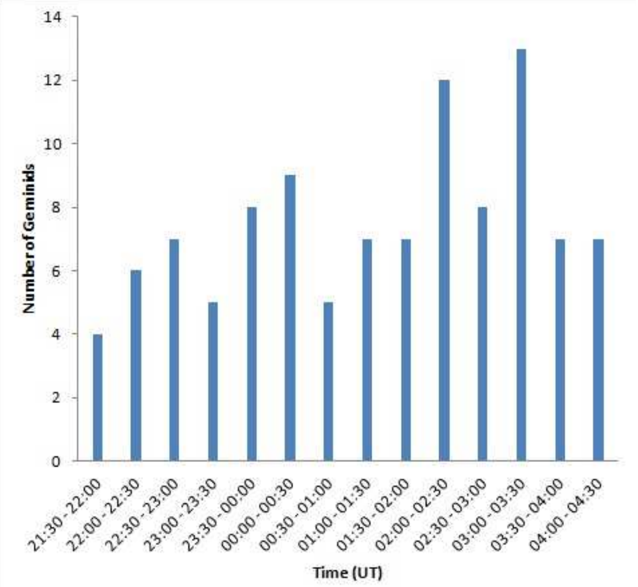

Figure 5 – Bar plot of number of Geminids as a function of the time (UT) for the night 2012 December 13-14.

Meteor spectroscopy

We captured 27 spectra from $+2.1$ to -2.1 magnitude meteors. Here we present the results for the brightest meteor, which spectrum reveals the most features.

Before analyzing the spectrum we reduced the recorded video. First, we subtracted the dark frame from all video frames. Next, we divided them by the flat-field image. We also created the background image as median of the seven first frames, before the meteor appears. We subtracted this background image from all frames reducing the noise and removing fixed stars. The spectrum profile of the Geminid was extracted from each frame using the `ImageJ` program.

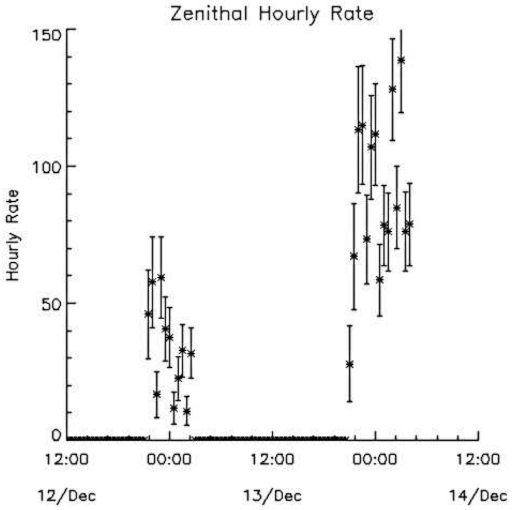

Figure 6 – ZHR profile based for the Geminids 2012.

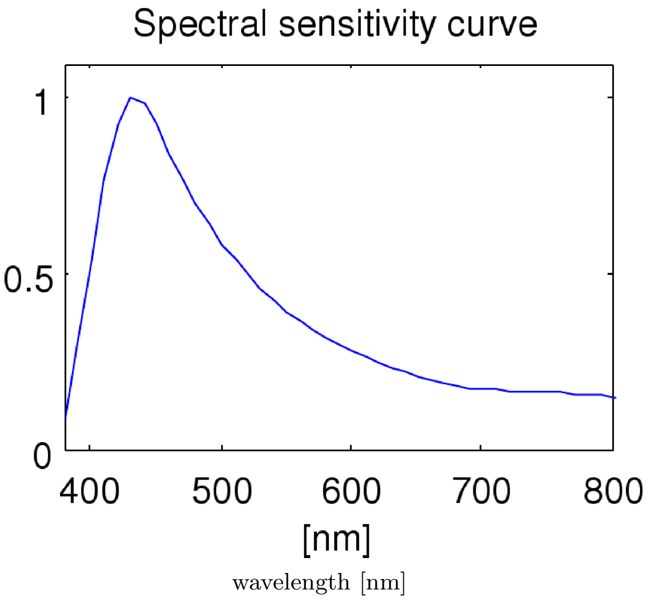

Figure 7 – Spectral sensitivity curve of the Watec 902H2 camera.

The wavelength scale was determined by means of known lines in the calibration spectrum. For this purpose we used LED lights of known wavelengths (480 nm, 505 nm, 539 nm, 594 nm, 615 nm, 630 nm, 645 nm). The effective spectral sensitivity curve of the Watec 902H2 camera was obtain by measuring the spectrum of a lamp imitating the black body radiation at 2700 K. The sensitivity curve is shown in Figure 7. The calibration curve covers the range of 350–800 nm, with a maximum at 450 nm.

The analysed meteor was observed on 14 December 2012 at $03^{\mathrm{h}}33^{\mathrm{m}}39^{\mathrm{s}}$ UT (Figure 8). It was detected both by narrow- and wide-field camera. The UFOAnalyser identified it as a meteor of magnitude −2.1.

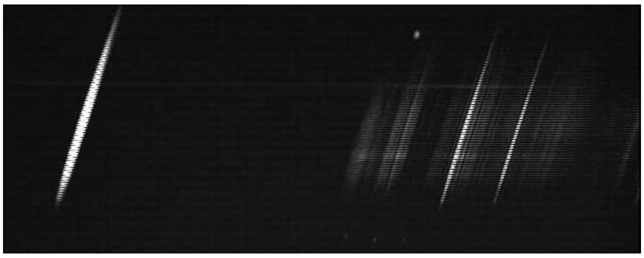

Figure 8 – The Geminid observed at $03^{\mathrm{h}}33^{\mathrm{m}}39^{\mathrm{s}}$ UT on 2012 December 14.

First, we identified the main spectral lines in each video frame, i.e. Fe I (438 nm), Mg I (518 nm), and Na I (589 nm). Next, in order to relate the instrumental lengths to wavelengths, a 2nd degree polynomial fit was used. Having calibrated the wavelengths, we identified other spectral lines.

The Figure 10 shows the time evolution of the meteor spectrum. The time interval between the video frames is 0.039 s. We captured zero (meteor) and first order spectrum. There are three distinctive lines from the beginning to the end of the meteor flight: iron (438 nm), magnesium (518 nm), and sodium (589 nm). The following additional chemical elements were also identified along the meteor trajectory: calcium (422 nm), iron (429 nm), iron (496 nm, 511 nm, 528 nm, 533 nm), and calcium (559 nm). The nitrogen (742 nm) appears in the second phase of the flight, while the forbidden oxygen line (777 nm) emerges near the end. In the meantime the spectrum consists of other overlapping emission lines (Table 3).

At $03^{\mathrm{h}}33^{\mathrm{m}}40\overset{\mathrm{s}}{.}35$ UT about 38 emission lines are seen in the 380–750 nm range (Figure 9). The lines identification was performed using Table 1 in (Borovička et al., 2005), and the NIST [2]. The identified species are listed in Table 3.

Figure 11 shows the relative intensities of the sodium, magnesium, iron, and calcium. Comparing to the magnesium line, the other lines are faint. Magnesium, iron and calcium follow a profile similar to sodium. As pointed out by (Borovička, 2010), brighter meteors tend to have brighter sodium line. In our case, the sodium line is bright during most of the meteor's trajectory, with the most probable intensity ratios Na/Mg = 0.48. Together with the ratio Fe/Mg = 0.47, the spectra is of a normal class, according to the classification in (Borovička et al., 2005).

4 Conclusions

Equipped with two cameras (wide- and narrow-field), on 2012 December 12-14, we conducted a Geminid observation campaign in Marrakesh, Morocco. Because of a technical problem we conducted single-station observations. In total we detected 175 meteor, among which 155 are Geminids. University of Cadi Ayyad is equipped with two AllSky cameras, one settled in the Oukaimeden Observatory and the other one in the Atlas Golf Marrakesh observatory of Marrakesh. At the night of Geminid maximum the AllSky camera at Oukaimeden observatory caught a few meteors (Figure 4).

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[2] NIST Atomic Spectra Database Lines Data, `http://physics.nist.gov/PhysRefData/ASD/lines_form.html`

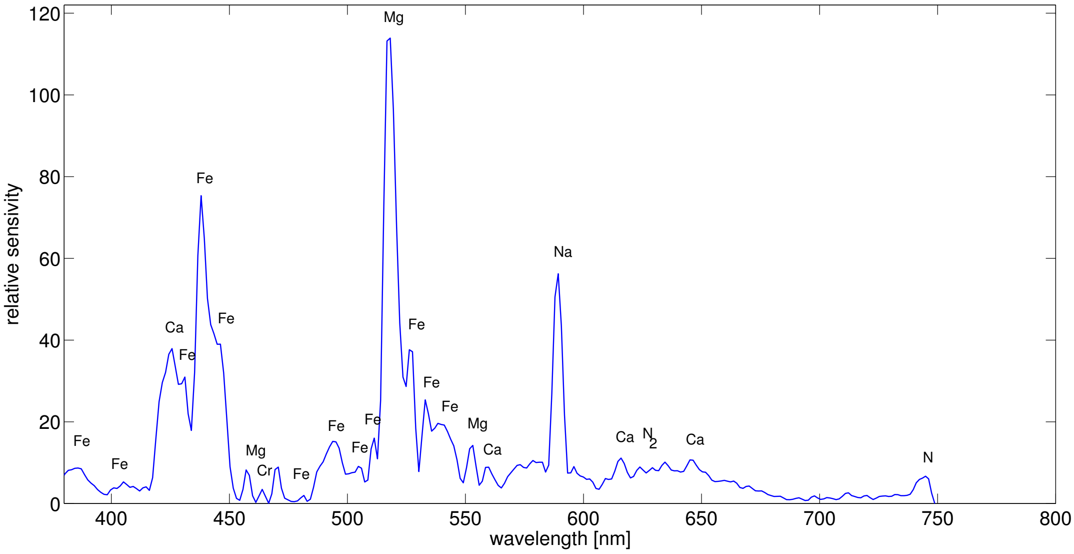

Figure 9 – The Geminid meteor spectrum at $03^{\mathrm{h}}33^{\mathrm{m}}40\overset{\mathrm{s}}{.}35$ UT ($t = 0.351$ s) after sensitivity correction.

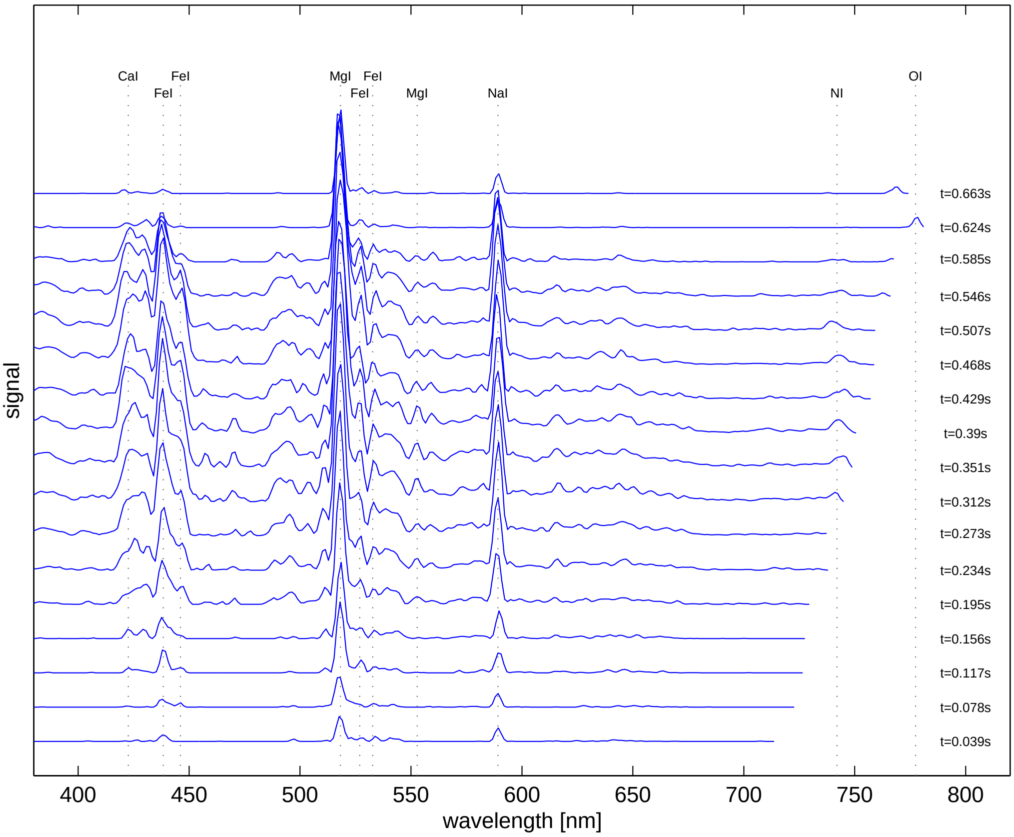

Figure 10 – Time variation of the spectra of the Geminid after sensitivity correction. The time interval is 0.039 s.

We showed that the Geminids duration is generally correlated to their magnitude, where the brightest Geminids have longer duration than the fainter one. Moreover, the measured average velocity of Geminids is greater by 4.56 km/s relative to the value in the literature. The analysis of one of our Geminid spectrum shows normal class spectrum, with higher sodium content, that would support a cometary origin for 3200 Phaethon pointed by (Borovička, 2010).

In order to measure the trajectories of meteors, and thereafter seek their origin, the future vision of the meteor network in Morocco is to perform continuous meteor observations. For this purpose since December 2012 we have equipped ourselves with two permanent meteors stations. The equipment includes two Watec 902H2 cameras with 12 mm/F1.2 lens protected in a housing (Figure 12), and placed in the same two sites that were used during the Geminid campaign (Table 1). It is important to note that both stations are manageable through distance via internet network.

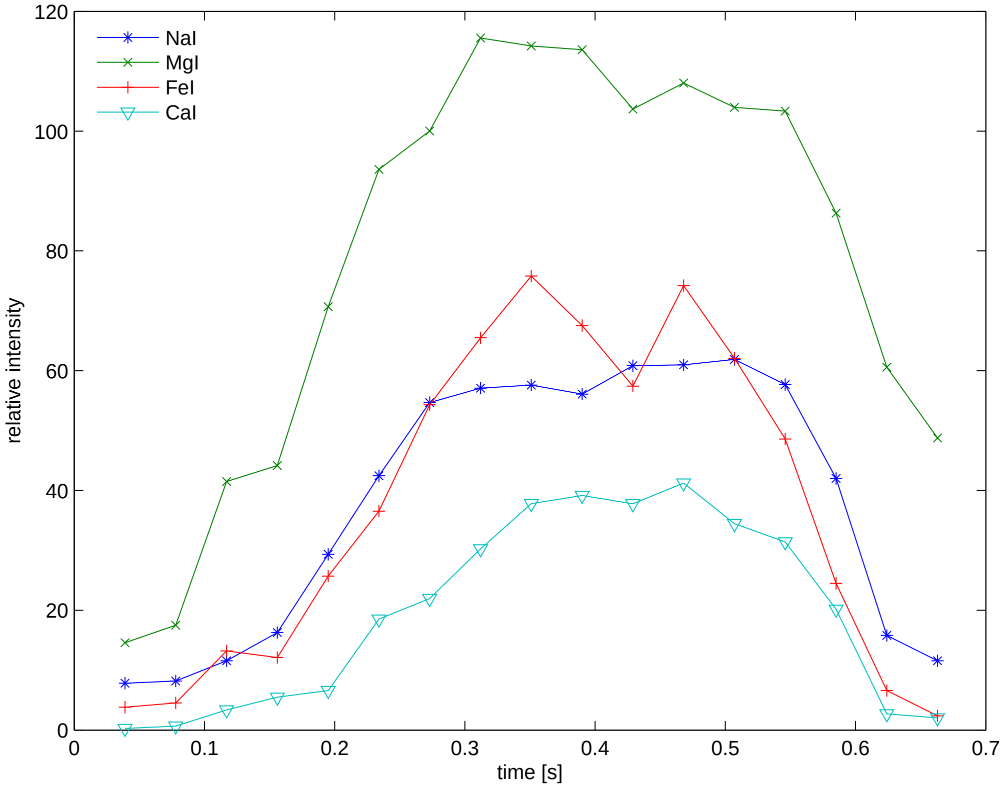

Figure 11 – Relative intensities of sodium, magnesium, iron, and calcium of Geminid spectrum; corrected for spectral response of the instrument.

Acknowledgement

We are grateful to the Mr Hila Omar and his company Atlas Golf Marrakech for putting at our disposal the means of their observatory to conduct the Geminids observation campaign. We also thank Rainer Arlt and Javor Kac for their help in the ZHR profile calculation.

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Table 3 – The list of spectrum lines identified in the Geminid spectrum captured at $03^{\rm h}33^{\rm m}39^{\rm s}$ on 2012 December 14.

Measured [nm]	Atom or ion	Laboratory [nm]	Remarks
383.6	Fe I	383.42	
400.8	Fe I	400.97	
422.6	Ca I	422.67	strong line
429.2	Fe I	429.41	strong line
437.8	Fe I	437.59	very strong line
446.1	Fe I	446.16	strong line
456.4	Cr I/ Fe I	456.42/ 456.48	
458.7	Mg I	457.11	
469.8	Cr I	469.84	
470.0	Fe I?	470.01	
488.6	Fe I?	488.63	blended
495.3	Cr I/ Fe I	495.48/ 495.76	blended
503.5	Cr I/ Fe I	503.46/ 503.67	blended
511.4	Fe I	511.58	
518.0	Mg I	518.36	very strong line
526.5	Fe I	526.95	
533.0	Fe I	533.28	
539.1	Fe I	539.71	
544.5	Fe I?	544.50	
553.0	Mg I?	552.84	
559.9	Ca I/ Fe I?	558.87/ 560.29	
570.6	Fe I/ Si II?	570.60/ 570.64	
573.2	Fe I?	573.08	blended
578.6	Si II/ Cr I?	578.57/ 578.58	
581.9	Fe I/ Mn I?	581.63/ 581.68	
589.2	Na I	589.59	very strong line
595.9	Fe I	595.82	
615.6	Ca I	615.60	
625.3	Fe I?	625.25	
631.9	Fe I	631.80	
643.9	Ca I	643.91	
650.5	Fe I?	650.17	
658.4	Fe I?	659.29	
666.3	Fe I	666.34	
672.9	Fe I	672.67	
743.0	Fe I	743.08	
745.5	N I	745.09	disappears at the end
778.4	O I	777.42	appears at the end

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Figure 12 – The wide-field camera installed at the Atlas Golf Marrakesh.

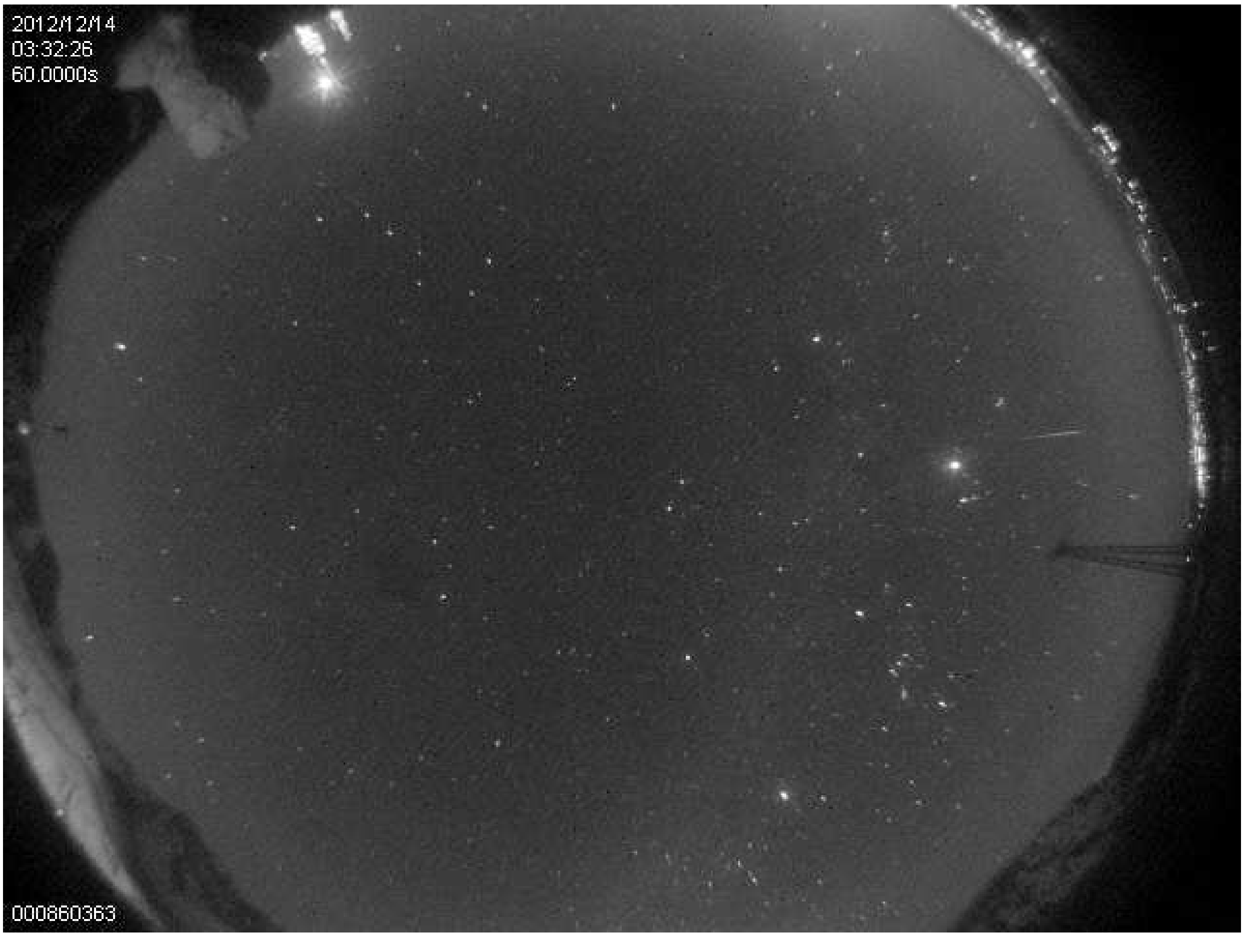

Figure 13 – Examples of Geminid detected at Oukaimeden observatory (Morocco Oukaimeden Sky Survey, MOSS), Morocco, on 2012 Dec. 14 at 03:32:26 UT.

Preliminary results

Results of the IMO Video Meteor Network — April 2013

Sirko Molau[1], *Javor Kac*[2], *Erno Berko*[3], *Stefano Crivello*[4], *Enrico Stomeo*[5], *Antal Igaz*[6], *Geert Barentsen*[7] *and Rui Goncalves*[8]

The 2013 April observations of the IMO Video Meteor Network are presented. The 2013 flux density profile is presented for the Lyrids, creating a consistent profile when combined with profiles of previous two years. An orthographic projection of Lyrid detections from two nights and three cameras is shown, using the new Panorama tool.

Received 2013 June 21

1 Introduction

Starting with the second quarter of 2013, the observing conditions finally improved. Whereas there are still big gaps in the observing statistics early April, we enjoyed fine observing conditions at most sites in the rest of the month. Observers in Hungary, Germany and at the Iberian Peninsula were particularly successful, whereas there were fewer clear nights in Slovenia and Italy, for example. In the end, 30 out of 75 video cameras obtained twenty or more observing nights. The overall effective observing time in April increased by a thousand hours to almost 7 000 hours compared to last year (Table 2 and Figure 1). The meteor yield was still slightly below the result of 2012, because a few particularly sensitive cameras are currently inactive.

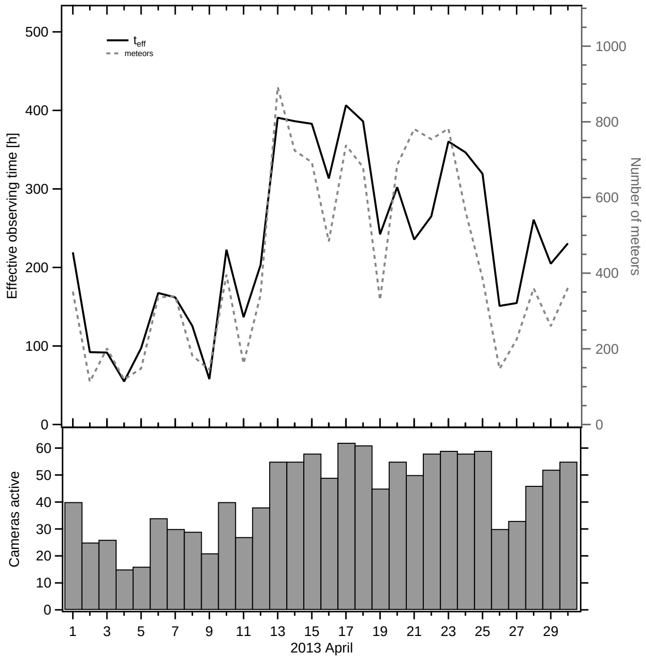

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2013 April.

2 Lyrids

After a long winter break, April presented the first shower that clearly stands out from the sporadic background, which is low at this time of year, anyway. The boundary conditions for the Lyrids were "sub-optimal", though. The maximum was forecast for the noon hours (UT) of April 22, i.e. at the European daytime three days before full Moon. This is reflected by the activity profile that we derived from 840 shower members. Neither on April 21/22 nor in the following night did we see a clear peak. Alternatively we compare the flux density profile of 2011 (green), 2012 (blue) and 2013 (red) over two degrees of solar longitude around the maximum (Figure 2).

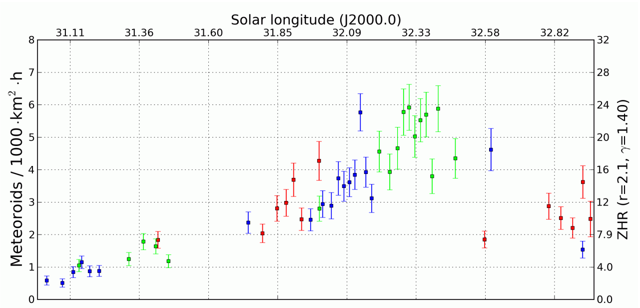

Figure 2 – Flux density profile of the Lyrids around their time of maximum, derived from data of 2011 (green), 2012 (blue) and 2013 (red).

The subjectively best picture was obtained with a relatively small zenith exponent of $\gamma = 1.4$. All three data sets give a consistent picture – only in 2013 was the activity at the ascending branch somewhat higher. One more year, and we get for the first time a complete flux density profile for this shower.

Even though the overall number of recorded Lyrids was quite small this year, it is sufficient to create nice

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Table 1 – Parameters of two possibly unknown meteor shower from the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
IMO 2012	22	19–25	266	+0.5	−15	+0.3	67	—
	23	22–25	278	+1.0	−6	+0.1	70	—

shower images with the new Panorama tool. The program, which is still in test, supports different projection types by now. As an example, Figure 3 shows meteors from the cameras Remo1 to Remo3 on April 21/22 and 22/23. The combined image is presented in orthographic projection.

3 Other showers

With respect to the meteor shower analysis of spring 2012, we published already in the last April report results for the Lyrids (6 LYR), ν-Cygnids (409 NCU), δ-Aquilids (131 DAL), σ-Leonids (136 SLE), the Southern May Ophiuchids (17 SOP) and the April χ-Librids (22 XLI) (Molau et al., 2012). According to the MDC list, these showers are either established or have working list status.

Here we complete the analysis by two candidates for unknown meteor showers. Both are located in the southern hemisphere and at the upper end of the velocity scale (Table 1). The first candidate is visible between April 8 and 15 with roughly 200 shower members in our database. The second candidate is represented by almost 150 meteors between April 12 and 15. Even though the scatter in right ascension and declination is relatively small, none of the two can be regarded as a safe detection because they never reach a rank above 10. Thus we do not report them to the MDC until there is independent confirmation for one or the other.

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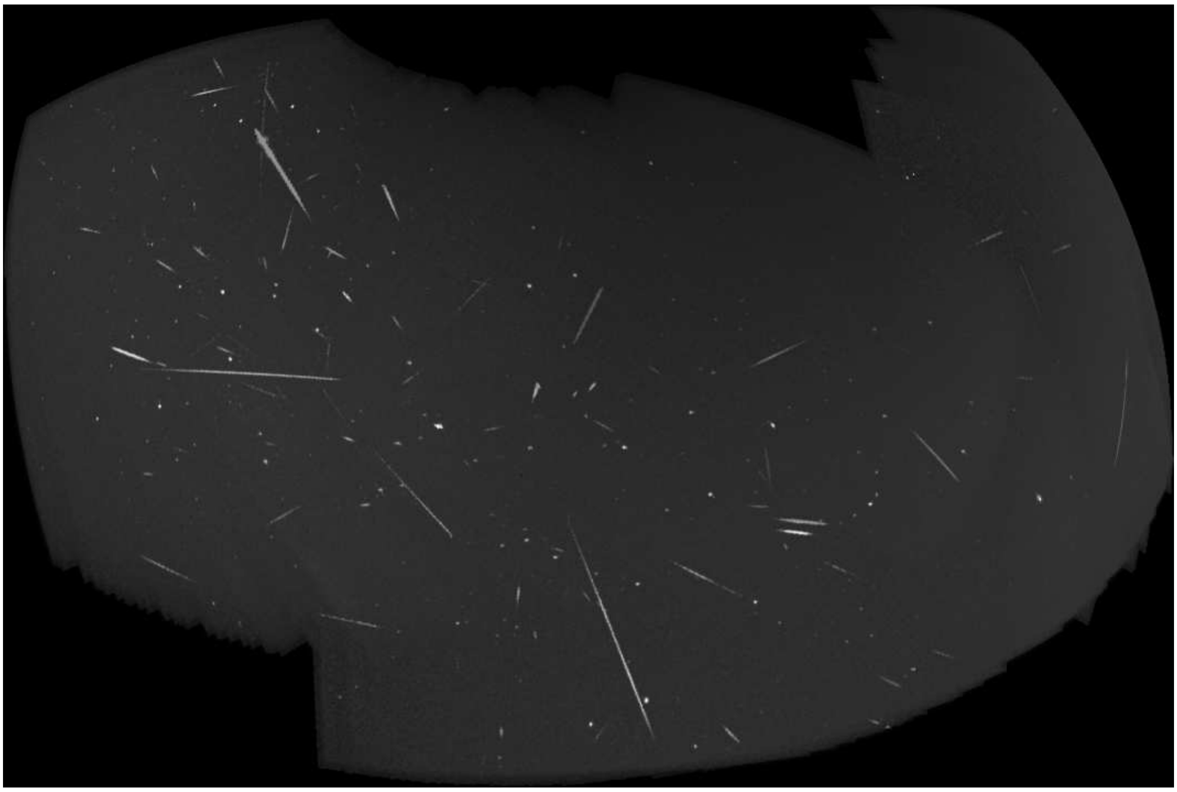

Figure 3 – Shower image of the Lyrids from recordings of Remo1, Remo2 and Remo3 on 2013 April 21/22 and 22/23.

Table 2 – Observers contributing to 2013 April data of the IMO Video Meteor Network. Eff.CA designates the effective collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig1 (0.8/8)	1488	4.8	726	1	6.9	7
BANPE	Bánfalvi	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	14	80.5	72
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	2	9.0	6
BERER	Berkó	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	20	143.4	509
			Hulud2 (0.95/4)	3398	3.8	671	19	137.3	123
			Hulud3 (0.95/4)	4357	3.8	876	20	145.1	137
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	20	120.6	122
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	12	64.0	180
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	21	113.5	143
			Mbb4 (0.8/8)	1470	5.1	1208	17	87.7	117
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	18	83.6	134
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	16	74.7	74
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	18	96.1	138
			Bmh2 (1.5/4.5)*	4243	3.0	371	15	78.1	107
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	22	108.2	206
			C3P8 (0.8/3.8)	5455	4.2	1586	20	98.1	136
			Stg38 (0.8/3.8)	5614	4.4	2007	22	122.1	287
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	15	32.9	210
GANKA	Gansel	Dingden/DE	Daro01 (1.4/3.6)	7141	3.1	652	18	75.9	80
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	24	170.9	467
			Templar2 (0.8/6)	2080	5.0	1508	25	175.3	335
			Templar3 (0.8/8)	1438	4.3	571	24	172.2	237
			Templar4 (0.8/3.8)	4475	3.0	442	24	165.2	305
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	13	70.8	120
			Orion3 (0.95/5)	2665	4.9	2069	23	70.4	132
			Orion4 (0.95/5)	2662	4.3	1043	22	78.7	152
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	24	148.8	229
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	24	169.8	192
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	23	160.8	177
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	19	135.8	61
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	21	154.2	164
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	14	62.1	36
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	7	43.3	92
			Rezika (0.8/6)	2270	4.4	840	7	47.1	169
			Stefka (0.8/3.8)	5471	2.8	379	7	38.7	79
		Kostanjevec/SI	Metka (0.8/12)*	715	6.4	640	10	62.5	127
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	16	46.5	283
KISSZ	Kiss	Sülysáp/HU	Husul (0.95/5)*	4295	3.0	355	20	150.3	81

Table 2 – Observers contributing to 2013 April data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	18	132.2	682
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	16	83.7	145
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	8	20.9	28
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	18	85.3	96
			Pav36 (1.2/4)*	5732	2.2	227	18	90.2	143
			Pav43 (0.95/3.75)*	2544	2.7	176	11	59.3	52
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	21	93.3	192
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	12	68.6	371
			Mincam1 (0.8/8)	1477	4.9	1084	16	92.0	105
		Ketzür/DE	Remo1 (0.8/8)	1467	5.9	2837	24	121.1	444
			Remo2 (0.8/8)	1478	6.3	4467	25	142.0	368
			Remo3 (0.8/8)	1420	5.6	1967	19	102.3	95
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	24	164.4	189
OCAFR	Ocaña González	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	21	163.1	119
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	9	2.6	16
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	16	49.8	142
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	23	142.9	363
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	16	104.6	174
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	12	47.1	59
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	24	122.9	192
			Ro2 (0.75/6)	2381	3.8	459	23	157.4	200
			Sofia (0.8/12)	738	5.3	907	25	157.9	157
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	5	2.1	11
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	23	101.1	174
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	13	51.1	72
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	23	86.5	279
			Noa38 (0.8/3.8)	5609	4.2	1911	18	84.5	190
			Sco38 (0.8/3.8)	5598	4.8	3306	19	108.8	303
STORO	Štork	Ondřejov/CZ	Ond1 (1.4/50)*	2195	5.8	4595	1	6.1	73
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	15	62.5	68
			Mincam3 (0.8/12)	728	5.7	975	17	72.7	85
			Mincam4 (1.0/2.6)	9791	2.7	552	11	43.8	47
			Mincam5 (0.8/6)	2349	5.0	1896	18	78.1	132
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	21	115.3	325
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	14	14.4	92
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	19	94.7	210
ZELZO	Zelko	Budapest/HU	Huvcse03 (1.0/4.5)	2224	4.4	933	8	42.4	62
						Overall	30	6 968.8	12 681

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — May 2013

Sirko Molau[1], *Javor Kac*[2], *Erno Berko*[3], *Stefano Crivello*[4], *Enrico Stomeo*[5], *Antal Igaz*[6], *Geert Barentsen*[7] *and Rui Goncalves*[8]

About 9 300 meteors were recorded by 69 cameras of the IMO Video Meteor Network in May 2013. Flux density profile and shower parameters for the η-Aquariids are presented. Significantly higher maximum activity was found when compared to previous years. Flux density profile and shower parameters are also presented for the η-Lyrids. The Southern May Ophiuchids are explored and four segments of activity identified. Shower parameters are presented for all segments. The June μ-Cassiopeiids are also detected and their shower parameters presented.

Received 2013 July 25

1 Introduction

In this year, the weather feels no pity for the meteor observers: After we obtained much fewer observations in the first three months of this year compared to the first quarter of 2012, it seemed in April as if the weather would return to normal. That turned out to be wrong, as in May it was catastrophic once more. Compared to 2012, the effective observing time was reduced by more than a quarter to 4 500 hours, and the number of recorded meteors by a third to about 9 300 (Table 5 and Figure 1). Once more, we did not reach 10 000 meteors and can only hope that we still reach that target with a few late reports as happened with February. Otherwise the string of consecutive months with 10000+ meteors observed will be broken.

There were a few nights with up to fifty of the 69 active cameras in operation. During the last 10 days of May, however, there was a large decrease in the number of cameras active. The geographical distribution was relatively fair. The 24 camera systems with twenty or more observing nights are scattered over all regions.

In May, the IMO Network grew further east. Mikhail Maslov started observations with his camera NOWATEC (whereby NO does not stand for the opposite of *yes* but rather his home town) from Novosibirsk in Russia. He operates a "standard setup" with a Watec 902H2 camera and a 3.8 mm $f/0.8$ Computar lens. Of course, a single observer at this longitude cannot provide the same data quality as the dense camera network in central Europe, but the observations of Mikhail extend our data set (e.g. flux density profiles) significantly. Maybe Mikhail can even gain further observers for our network in the years to come?

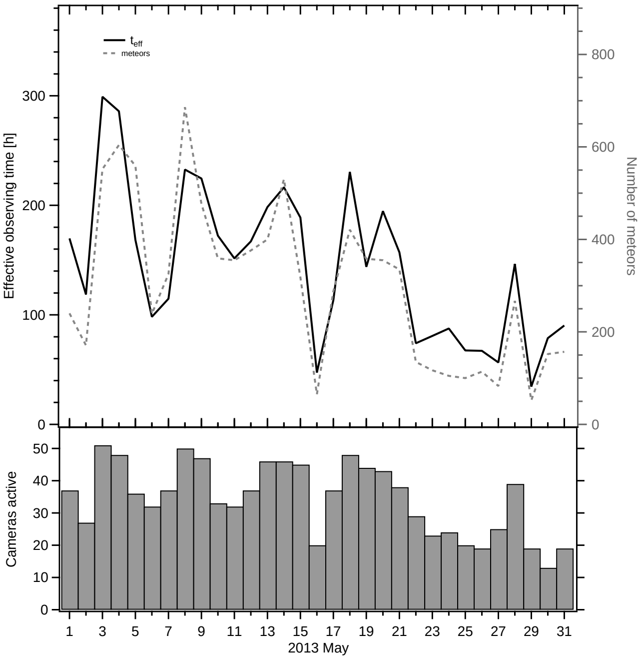

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2013 May.

2 η-Aquariids

Highlight of May are the η-Aquariids. As always it is difficult to obtain an accurate activity profile of this shower, as most observations are obtained in central Europe, where there is only a small observing window of one or two hours combined with a low radiant altitude. Figure 2 presents the flux density profiles of the years 2011 to 2013, whereby each night is represented by a single data point. A higher temporal resolution is not possible due to the short observing windows. There is good agreement in the ascending and descending branches, but this year the peak is a factor of two to three times higher than the previous years. The absolute value depends significantly on the chosen zenith exponent γ due to the low radiant altitude. The peak flux density varies between almost 50 ($\gamma = 1.0$) and almost 100 ($\gamma = 1.5$).

Overall our data confirm the visual observing results: The IMO quick look analysis yielded a peak ZHR

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NASA-ADS bibcode 2013JIMO...41..133M

Table 1 – Parameters of the η-Aquariids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	46.9	—	338.8	+0.8	−0.4	+0.4	66.9	—
IMO 2012	47	38–59	339.1	+0.64	−0.5	+0.33	67.4	+0.1

Table 2 – Parameters of the η-Lyrids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	49.1	—	292.5	—	+39.7	—	46.7	—
IMO 2012	50	45–52	291.3	+0.15	+43.4	+0.0	44.0	—

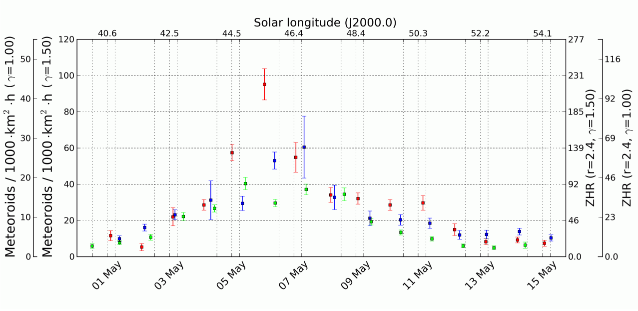

Figure 2 – Flux density profile of the η-Aquariids, derived from data of 2011 (green), 2012 (blue) and 2013 (red). Left and right of the graph are individual scales for zenith exponents γ of 1.0 and 1.5.

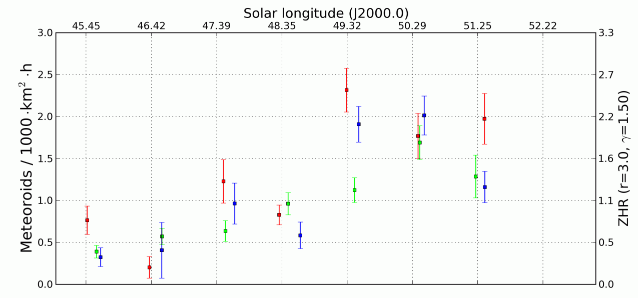

Figure 3 – Flux density profile of the η-Lyrids, derived from data of 2011 (green), 2012 (blue) and 2013 (red).

of 50 to 60 in 2011 (International Meteor Organization, 2011) and 60 to 70 in 2012 (International Meteor Organization, 2012). On May 6 of this year, however, a peak ZHR of 135 was determined (using $\gamma = 1.0$) (International Meteor Organization, 2013). The high activity comes as a surprise: In the past, some variations at a 12-years-scale were observed, but the next peak was only expected for 2014 to 2016 according to the IMO Meteor Shower Calendar (McBeath, 2012). So it seems that enhanced rates of the η-Aquariids were a bit early.

In the long-term analysis of spring 2012, the η-Aquariids (31 ETA) can be detected between April 29 and May 20. The IMO video meteor database contains a total of 3 800 shower members. The η-Aquariids always have a rank of one, which can be explained easily: If a shower can be detected at all with such a small observing window and low radiant altitude, those factors will be weighted by the observability function so that no other shower can compete.

In fact, there are already radiants starting from April 24 and until June 3 at the expected position, but in these intervals the shower velocity sometimes deviates significantly, which is why they were omitted.

Table 1 lists the shower parameters obtained for the η-Aquariids. They are in perfect agreement with the MDC list values.

3 η-Lyrids

The η-Lyrids reach maximum activity between May 10 and 11 with a peak flux density of 2 meteoroids per 1 000 km^2 per hour (Figure 3).

In the long-term analysis, the η-Lyrids (145 ELY) can be found between May 7 and 13. There are an additional two intervals before and four after with similar radiants, but these were not credited to the shower due to the larger scatter in parameters. Even without these, the η-Lyrid radiant shows quite some scatter even though it has a rank of three during almost the full activity interval. The shower parameters which were obtained from about 800 meteors are summarized in Table 2. In particular in declination there is a stronger deviation from the MDC list values.

4 Other showers

The χ-Capricornids (76 CCA) where discussed already in the monthly report of May 2012 (Molau et al., 2012). Here we complete the list with two additional showers from May.

4.1 Southern May Ophiuchids

The Southern May Ophiuchids (150 SOP) are an odd case. The shower can be detected safely between May 5 and June 6 with almost 1 600 shower meteors. Its rank is never lower than four, and even though it is the strongest source in the sky for an extended period of time, it is not possible to obtain sensible shower parameters. The day-to-day variation is reasonable, but there are times where the parameters are increasing and times where they are decreasing. The shower parameters can only be approximated by a set of four segments (Figure 4).

A quick check reveals that the radiant is located only few degrees north of the nominal Antihelion position.

Table 3 – Parameters of the Southern May Ophiuchids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	57	—	258	—	−24	—	30.0	—
IMO 2012	47	44–50	238.9	−0.1	−15.2	+0.4	30.4	—
	54	51–57	247.3	+2.5	−16.9	−2.1	34.7	—
	61	58–64	251.7	−2.5	−15.4	+1.1	31.0	—
	70	65–75	248.2	+0.8	−10.8	+0.2	24.3	—

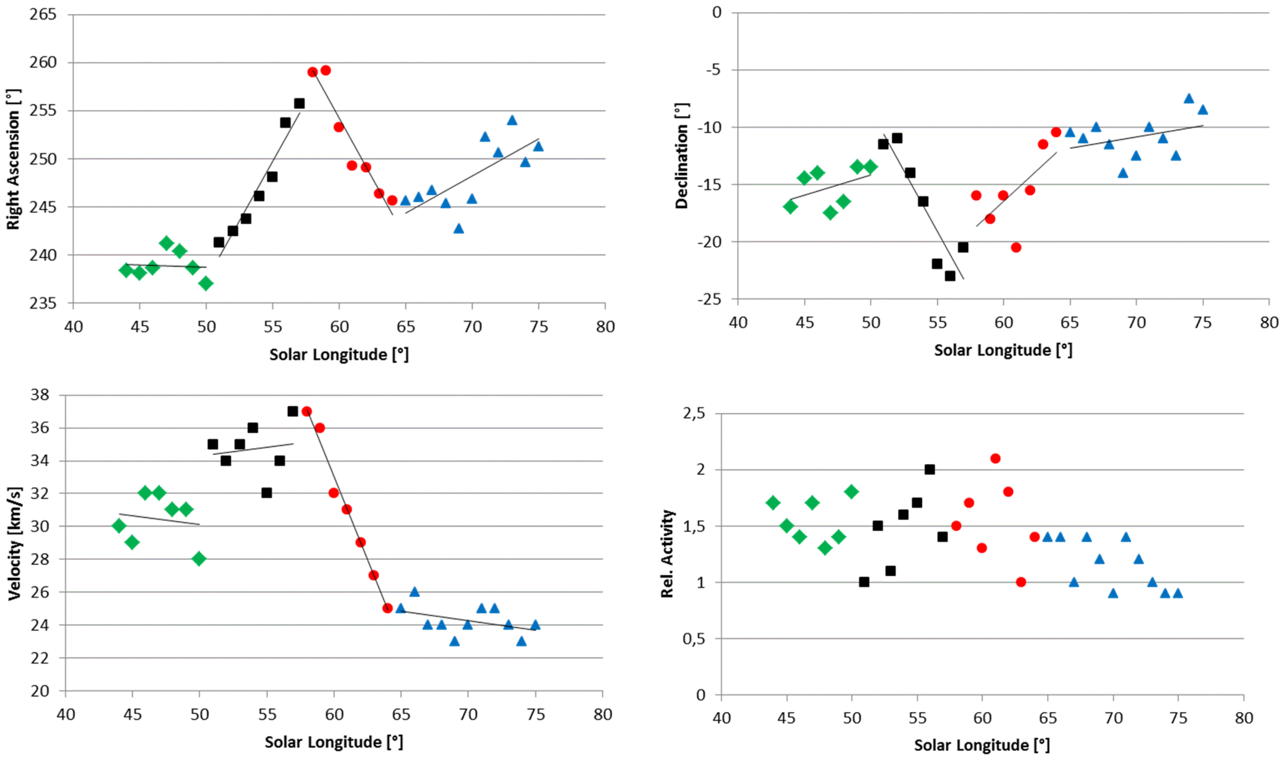

Figure 4 – Shower parameters of the Southern May Ophiuchids plotted over the solar longitude: Right ascension (upper left), declination (upper right), velocity (lower left) and relative activity (lower right).

The Antihelion source is presumably dominated by different sub-radiants at times, or the activity center inside this diffuse source is drifting. The MDC list values in Table 3 originate from the 1996 IMO visual handbook (Rendtel et al., 1996). Later the shower was subsumed together with other showers of the IMO working list as the Antihelion source. Table 3 separately lists the mean parameters of the four individual segments.

4.2 Northern ω-Scorpiids

Between May 29 and June 1, the Antihelion radiant can be recognized once more – this time as Northern ω-Scorpiids (66 NSC). It is the richest source in the sky during that time, but we cannot confirm the MDC shower for sure, because our position and velocity deviate strongly from the MDC values. For this reason we do not further pursue this shower.

4.3 June μ-Cassiopeiids

The June μ-Cassiopeiids (362 JMC), however, are safely detected in our database between May 31 and June 5 with 150 meteors. The rank of this shower is only somewhere between ten and twenty, but the activity profile shows a clear peak on June 2 and the scatter of parameters is acceptable. Table 4 compares our parameters with the MDC list values. Taking the difference in solar longitude into account, there is an amazingly good agreement for such a minor source.

At this point we have completed the latest meteor shower analysis, which was started in spring 2012 and documented in the recent monthly reports. A consolidated list of the identified showers will be prepared for the next IMC.

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International Meteor Organization (2012). “eta-Aquariids 2012: visual data quicklook”. `http://www.imo.net/live/eta-aquariids2012/` .

Table 4 – Parameters of the June μ-Cassiopeiids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	74	—	17.5	+0.91	+53.9	+0.28	45.0	—
IMO 2012	71	69–74	11	+2.8	+53	+0.5	43	—

International Meteor Organization (2013). "eta-Aquariids 2013: visual data quicklook". `http://www.imo.net/live/eta-aquariids2013/`.

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Handling Editor: Javor Kac

Figure 5 – Panoramic view of the recordings by Remo1 and Remo2 on 2013 May 5/6. In the morning hours, a bunch of η-Aquariids could be recorded, which yielded the long trails visible in the left part of the image. Note also the flurry of meteors which seem to radiate from the north eastern part of Hercules (right of the image center). There is no known meteor shower at this position. However, a radiant search revealed that this is just a chance alignment of meteors which do not really converge to a reliable radiant solution.

Table 5 – Observers contributing to 2013 May data of the IMO Video Meteor Network. Eff.CA designates the effective collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig1 (0.8/8)	1488	4.8	726	8	34.2	30
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	1	0.2	1
BERER	Berkó	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	14	75.3	243
			Hulud2 (0.95/4)	3398	3.8	671	12	69.4	92
			Hulud3 (0.95/4)	4357	3.8	876	11	68.5	70
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	17	80.2	92
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	13	50.6	119
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	15	57.3	73
			Mbb4 (0.8/8)	1470	5.1	1208	15	62.0	66
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	19	64.8	115
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	16	65.4	96
CASFL	Castellani	Monte Baldo/IT	Bmh2 (1.5/4.5)*	4243	3.0	371	13	64.1	101
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	23	99.2	259
			C3P8 (0.8/3.8)	5455	4.2	1586	23	84.1	153
			Stg38 (0.8/3.8)	5614	4.4	2007	23	108.3	339
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	16	26.5	200
GANKA	Gansel	Dingden/DE	Daro01 (1.4/3.6)	7141	3.1	652	10	44.4	42
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	21	135.1	353
			Templar2 (0.8/6)	2080	5.0	1508	22	153.9	315
			Templar3 (0.8/8)	1438	4.3	571	28	158.3	228
			Templar4 (0.8/3.8)	4475	3.0	442	23	149.4	331
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	19	74.6	139
			Orion3 (0.95/5)	2665	4.9	2069	17	51.4	87
			Orion4 (0.95/5)	2662	4.3	1043	20	52.6	115
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	15	41.9	66
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	13	67.7	35
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	22	99.1	100
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	8	39.6	24
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	9	38.5	120
			Rezika (0.8/6)	2270	4.4	840	9	46.1	197
			Stefka (0.8/3.8)	5471	2.8	379	7	28.9	60
		Kostanjevec/SI	Metka (0.8/12)*	715	6.4	640	4	24.1	82
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	5	9.4	62
KISSZ	Kiss	Sülysáp/HU	Husul (0.95/5)*	4295	3.0	355	18	85.1	43
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	11	16.7	32

Table 5 – Observers contributing to 2013 May data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	21	88.4	107
			Pav36 (1.2/4)*	5732	2.2	227	22	96.1	163
			Pav43 (0.95/3.75)*	2544	2.7	176	19	93.6	72
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	22	102.3	163
MASMI	Maslov	Novosibirsk/RU	Nowatec (0.8/3.8)	5574	3.6	773	5	9.7	26
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	7	31.6	231
			Mincam1 (0.8/8)	1477	4.9	1084	19	71.1	144
		Ketzür/DE	Remo1 (0.8/8)	1467	5.9	2837	23	90.1	359
			Remo2 (0.8/8)	1478	6.3	4467	24	95.7	313
			Remo3 (0.8/8)	1420	5.6	1967	22	82.7	92
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	23	91.2	90
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	9	8.4	50
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	13	56.1	153
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	23	90.3	266
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	21	72.1	158
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	8	30.3	35
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	20	133.3	194
			Ro2 (0.75/6)	2381	3.8	459	22	147.0	225
			Sofia (0.8/12)	738	5.3	907	20	124.9	147
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	11	12.2	55
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	19	77.2	156
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	6	11.1	25
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	16	63.3	318
			Noa38 (0.8/3.8)	5609	4.2	1911	22	71.7	223
			Sco38 (0.8/3.8)	5598	4.8	3306	21	82.8	290
STORO	Štork	Kunžak/CZ	Kun1 (1.4/50)*	1913	5.4	2778	1	6.1	55
		Ondřejov/CZ	Ond1 (1.4/50)*	2195	5.8	4595	3	10.1	124
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	12	48.0	54
			Mincam3 (0.8/12)	728	5.7	975	13	42.2	53
			Mincam4 (1.0/2.6)	9791	2.7	552	14	41.5	57
			Mincam5 (0.8/6)	2349	5.0	1896	15	49.6	90
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	24	80.9	187
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	14	15.4	99
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	10	23.3	41
						Overall	31	4 477.2	9 295

* active field of view smaller than video frame

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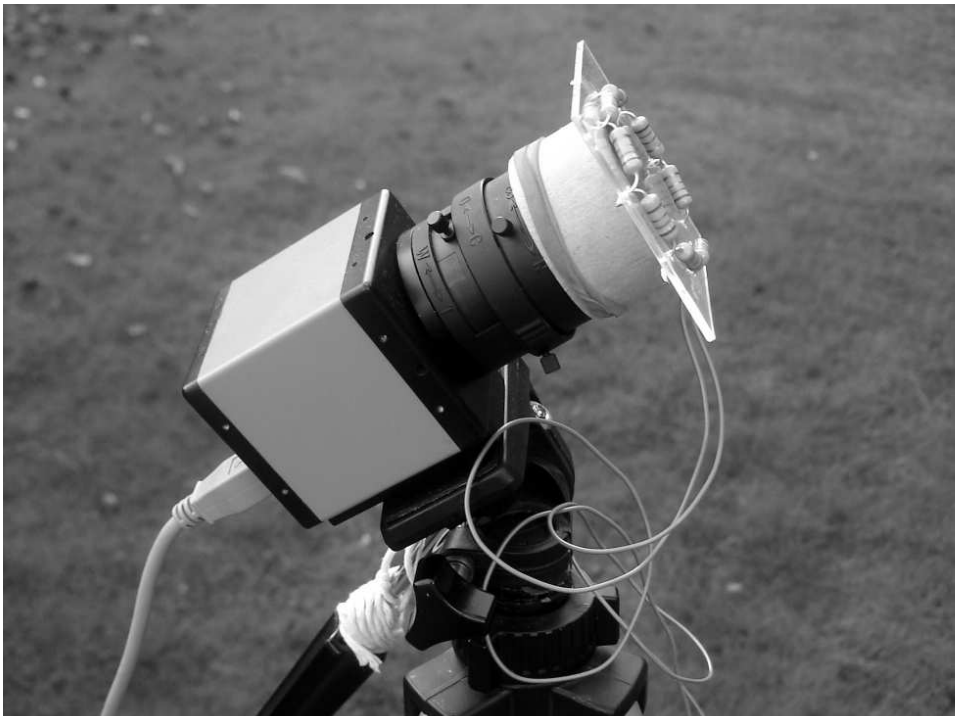
2013 Perseid from England



Top: Perseid meteor at the Cygnus–Pegasus-Lacerta border imaged on 2013 August 13 at 01$^{\mathrm{h}}$47$^{\mathrm{m}}$14$^{\mathrm{s}}$ UT using an Imaging Source monochrome DMK AU03 Camera with an Opticstar 2.8–12.0 mm $f/1.4$ Lens an a 9.7 s exposure from Chelmsford, England.

Left: Camera setup used to capture the image above. Photos courtesy of Peter Meadows.