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2008–2009 CMN orbit catalogs
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Administrative

Meteor science

Front cover photo

This fireball was recorded on 2010 August 12 at $20^{h}59^{m}$ UT from Dąbrówka, Poland. Canon EOS 450D camera equipped with 50 mm $f/1.8$ lens was used with 16 s exposure at ISO 200 (!). Photo courtesy: by Janusz Kowalski.

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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From the Treasurer—How can you support your organization?

Marc Gyssens[1]

The following people have paid at least double the normal membership fee for 2012 (but not necessarily *in* 2012):

Karl Antier	Lars Bakmann	Luc Bastiaens	Mihail Bidnichenko
Peter Brown	Raka Dabhade	Marc de Lignie	David Entwistle
Juan Antonio Gonzalez Hernandez	Marc Gyssens	Arnaud Leroy	Sirko Molau
Hans-Georg Schmidt	Walter Soto	Richard Taibi	Casper ter Kuile
Masayuki Toda	Jan Verbert	Masayuki Yamamoto	

We are very grateful to the people above for their support. At the same time, however, it must be emphasized that many other people contributed to the IMO. For instance, many members gave gifts smaller than the regular membership fee; of course, these gifts are equally appreciated. Also, several members contribute by providing a gift membership to a friend, or by paying a friend's or colleague's registration fee for the International Meteor Conference, or by a direct gift to the IMO Support Fund. We mention in particular Paul Roggemans and Casper ter Kuile, who made very generous gifts.

Thanks to the generosity of our members, the IMO was able to provide support for the 31st International Meteor Conference at La Palma, Canary Islands, Spain, to 1 participant each from Azerbaijan, Bulgaria, Greece, and Russia.

As already announced last year, the IMO Council feels that, on the one hand, the International Meteor Conference, however important it is, is too narrow a focus for IMO Support and, on the other hand, that the funds the IMO can afford to spend to help meteor workers yield much more return when invested in scientific projects. Even though the Council may still grant some support to attend an IMC on an exceptional basis, the IMO Support Fund will be redirected towards directly supporting meteor astronomy projects. You can read more about this elsewhere in this issue. As this is an important and ambitious new challenge, we encourage our members to continue providing support to our Organization by becoming a supporting member, by giving smaller donations, or a direct gift to the IMO Support Fund. Also, gift memberships and private support to IMC participants remain very welcome. Whichever you choose to provide support, the international meteor community will be very grateful for it!

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New goals for the IMO Support Fund

Marc Gyssens[1]*, Paul Roggemans and Jürgen Rendtel*

Past policies

When the IMO was founded 25 years ago, the Iron Curtain was still a reality. While most West-Europeans could travel freely to Central and Eastern Europe, people from Central and Eastern Europe faced many challenges to travel to Western Europe, one of which was that their currencies were not freely convertible. Initially, this was solved with personal gifts, loans, and other very creative solutions. For example, Czech, Hungarian, and Slovak groups offered publications to be sold by the IMO on their behalf, to generate credits in the IMO accounts in hard currency, which these groups could subsequently use to pay for memberships, IMO publications, etc. Most of the financial constraints in these early years were successfully solved in this and similar ways.

When all currencies were finally convertible, some people still relied on financial support to attend an IMC, as the registration fee to them represented more than a monthly salary. Small profits generated from selling IMO publications and support from members provided the IMO with a very healthy financial reserve part of which could be returned to the meteor community on an annual basis. It was therefore decided by the IMO Council to

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set up a Support Fund. Although it has never been the intention of the Council to limit its goals to providing IMC grants, this has been the case in practice, because, there, the greatest needs were felt. In the beginning, support went to highly active or specialized meteor workers who would otherwise not have been able to attend an IMC. When these meteor workers gradually found alternative means to pay for their registration, the focus shifted to encouraging young amateurs and newcomers to the meteor community to experience an IMC and share the benefits of international collaboration.

The total amount spent to sponsor IMC participants since 1986 is an impressive number in the order of several tens of thousands of Euros. Was it worthwhile? The answer is definitely “yes”. However, the effectiveness of the support spent raised questions in recent years. It is quite natural that as long as funds are available people will continue to apply for them, but the number of justifiable requests decreased significantly over the past few years. It therefore occurred to the IMO Council that it was time to reconsider its policies.

New policy

From 2013 onward, the available annual budget will no longer go to IMC support, but to amateur meteor research projects. These projects must

- be proposed by an IMO member;
- concern scientific and technological aspects of meteor observing;
- involve a medium- to long-term commitment of 3 years or more;
- return relevant results to the international community via the IMO;
- respect the conditions defined in a contract between the successful applicant and the IMO.

An application for a grant from the IMO Support Fund can be submitted at any time and must be addressed to the IMO President. It should include

- proper identification of the applicants, including their past realizations in meteor astronomy;
- a scientific and technological justification of the project;
- a timing to realize the project;
- references to support the competence of the applicants, and to support the feasibility of and the timing for the project proposed;
- a motivation why a grant from the IMO Support Fund is necessary to realize the project;
- a realistic budget of the costs and revenues involved, including the grant requested from the IMO Support Fund, financing by the applicants themselves or by the local, regional or national association to which they belong, and revenues from external sources;
- an explanation how the project will be managed during at least the first 3 years;
- a statement indicating whether you want to maintain your proposal for consideration during the next year should the budget for the current year be exhausted.

Successful applicants will be asked to sign a contract containing both the commitments of the applicants and additional requirements of the IMO that will constitute the terms under which the grant is provided. Under no circumstances will the IMO provide a blank check to the applicants! If the applicants do not live up to the terms specified in the contract, the IMO may withhold payment. These terms will not only refer to the content of the project and the way it is managed, but also to a proper justification of the financial means provided, via invoices of the purchases agreed in the contract.

As the available budget is relatively small, the number of projects that can be financed will be limited to two or three per year. There are no deadlines; applications will be evaluated on the basis of first come, first served, and each proposal will be considered carefully on its merits. Proposals not meeting the criteria set above will be excluded from further consideration. In particular, proposed projects must be aimed at obtaining scientific results in a sustainable manner. Projects concerning outreach or education, or events of a more cultural nature will be considered out-of-scope.

Notice that the IMO Council reserves the right to support a cause at its own discretion when it feels it can further meteor astronomy in this way. The same holds for IMC support, which can still be made available in the form of waiving the standard registration fee, on a case-by-case basis. Requests for such support should be strongly motivated from a scientific perspective (required presence at a workshop, presentation of scientific results, participation in an international project, etc.).

Outreach

As emphasized above, grants of the IMO Support Fund will *not* be provided for outreach-oriented projects. This does not imply that the IMO fails to recognize the importance of outreach. There are still many individuals who are serious about meteor astronomy, but who cannot afford IMO membership, for instance, but not exclusively, in developing countries. To encourage meteor astronomy, also in these countries, the IMO provides free membership with an electronic subscription to WGN to such individuals. Well-motivated requests for such gift memberships will be considered by the IMO Council.

Letter — Meteor stream of the large Chelyabinsk fireball

Alexandra Terentjeva[1,2] *and Elena Bakanas*[1,3]

We have revealed the meteor stream associated with the large Chelyabinsk fireball by searching the orbit database of radio meteor observations (the IAU Meteor Data Center in Lund, Sweden; see Lindblad, 1995). This stream we named Daytime Peg-Aquarids. The stream has northern (N), ecliptic (Q) and southern (S) branches. Orbital elements and the other parameters are given in Table 1.

This study is based on the orbital elements of the Chelyabinsk fireball, obtained by Jiri Borovicka, Esko Lyytinen and others (see Borovicka et al., 2013; Lyytinen, 2013). We searched all radar orbits (Harvard, Obninsk, Mogadisho, Kharkov, Adelaide) to identify the matching orbits. In this way we revealed four orbits (two from the Harvard 1968–69 survey and two from the Adelaide 1968–69 survey).

On the radiant area of the discovered meteor shower is superposed another daytime meteor shower active from February 11 till 24 with the larger velocity $v_\infty = 19 - 23$ km/s.

A relation may perhaps exist between the southern (S) branch of Daytime Peg-Aquarids and the known Daytime c-Aquariids of longer orbital period (Meteor Data Center, 2013) but specific research is required.

The detailed research about the meteor stream of the Chelyabinsk fireball will appear in another publication.

Table 1 – Meteor stream of the Chelyabinsk fireball. Orbital elements are given for the 1950.0 equinox.

No.	Date (UT)	Apparent radiant		v_∞	a	e	q	i	ω	Ω	π	Branch
		α	δ	km/s	AU		AU					
2492 H	1969 Feb 11.922	334°	+9°	17.4	1.902	0.571	0.816	7°.1	121°.5	322°.8	84°.3	(N)
2497 H	1969 Feb 11.925	337°	−16°	16.2	1.471	0.47	0.78	2°.1	290°	142°.8	72°.8	(Q)
702 A	1969 Feb 16.344	343°	−9°	16.7	1.715	0.536	0.796	0°.4	296°.4	147°.2	83°.6	(Q)
621 A	1969 Feb 14.886	346°	−22°	17.8	1.727	0.548	0.781	6°.1	294°.1	145°.8	79°.9	(S)

Note: H and A signify meteors from the databases of Harvard and Adelaide radar orbits respectively.

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Meteor science

August ι Cetids, a Possible New Meteor Shower in August

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The Croatian Meteor Network Catalogs of Orbits for 2007 to 2010 contain 19055 orbits, of which 8410 can be attributed to previously known streams. The radiant analysis of the remaining orbits, plus the orbits from SonotaCo catalogs for 2007 to 2009, revealed a possible new stream. This stream was assigned IAU shower number 505 and three-letter code AIC. The analysis was recently rerun with orbits from SonotaCo databases for the years 2010–2011, resulting in a total of 120 orbits belonging to the AIC stream with refined mean orbit, radiant position and daily motion. The stream is active in August and September.

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1 Introduction

The Croatian Meteor Network (CMN) was started in 2007. The network is described in more detail in (Andreić & Šegon, 2010) and (Andreić et al., 2010). The catalog of orbits for 2007 is already published (Šegon et al., 2012) and the catalogs for 2008–2009 are announced in this issue (Korlević et al., 2013).The analysis of the radiant plots of sporadic meteors from CMN catalogs for 2007 to 2010 and SonotaCo catalogs for 2007 to 2009 pointed to a potential new shower in august. This shower received a preliminary IAU MDC code 505 AIC and name August ι Cetids.

2 The new shower

The 23 individual orbits of meteoroids that could belong to a new shower were detected during the Višnjan School of Astronomy 2012 and were tested with the D-criterion, using the commonly used Southworth-Hawkins method (Southworth & Hawkins, 1963). The results of this analysis were presented at the IMC 2012 conference in La Palma (Vida et al., 2013) and are summarized in Table 1.

Table 1 – Results of radiant analysis for the members of the new shower, based on 23 orbits. Orbital data are given as: semi-major axis a (in A.U.), its reciprocal value $1/a$, perihelion distance q (in A.U.), eccentricity e, inclination i, longitude of the ascending node Ω and argument of perihelion ω. i, Ω and ω are given in degrees.

parameter	standard arithmetic average
a	1.96 (rough estimate)
$1/a$	0.50905 ± 0.03057
q	0.097 ± 0.004
e	0.951 ± 0.004
i	20.5 ± 1.0
Ω	322.2 ± 8
ω	156.8 ± 8
α (avg)	$0\overset{\circ}{.}4$
δ (avg)	$-6\overset{\circ}{.}4$
v_g (avg)	37.96 km/s
$\lambda_\odot$ min.	$145\overset{\circ}{.}8$
$\lambda_\odot$ max.	$154\overset{\circ}{.}0$

In accordance to the procedure of reporting new showers (Jenniskens et al., 2009) we contacted the IAU Meteor Data Center and proposed the name August ι-Cetids. In response, the shower was assigned IAU shower number 505 and tree-letter code AIC.

In the meantime, the SonotaCo catalogs for 2010 and 2011 were released and a new analysis of all available catalogs was performed, resulting in a total of 120 meteor orbits that satisfy $D < 0.15$) criterion. The radiant plot for these orbits is shown in Figure 1. The complete set of these orbits can be downloaded from the CMN web site (CMN, 2012). This analysis resulted in refined stream data, presented in Table 2. It was found that the period of activity is significantly longer than the one determined from visual analysis of radiant plots. We were also able to determine the mean daily motion of the radiant, the position of the mean radiant itself is slightly shifted in both coordinates, and the ac-

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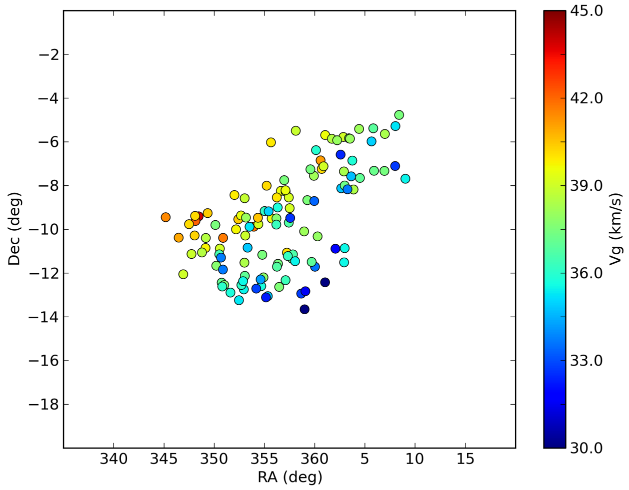

Figure 1 – Radiant plot of all AIC orbits found by the authors to date.

curacy of the radiant position is significantly improved. The radiant position can be calculated from:

$$\alpha = 0.71°(\lambda_\odot - 145\overset{\circ}{.}4) + 356\overset{\circ}{.}8 \quad (1)$$

$$\delta = 0.21°(\lambda_\odot - 145\overset{\circ}{.}4) - 9\overset{\circ}{.}6 \quad (2)$$

We also compared the mean AIC orbit with the mean Southern δ-Aquariids (SDA) orbit whose radiant is close to the AIC radiant. To do this, we first calculated the mean SDA orbit from 932 orbits in the before mentioned databases we used. We found that the mean orbits of AIC and SDA are clearly different. Only 2 orbits that would satisfy $D < 0.15$ criterion for both showers were found. UFOOrbit classified both as SDA. The mean orbits are also different, especially in the perihelion distance and the eccentricity. The mean orbits themselves differ by $D_{SH} = 0.26$, a significant but not very large difference. This could mean that both showers have a common parent body, or originate from different fragments of the same body.

Table 2 – Refined results of radiant analysis for the members of the new shower, based on all available catalogs (CMN 2007 to 2010 and SonotaCo 2007 to 2011).

parameter	refined value
a	1.825 ± 0.053 (rough estimate)
$1/a$	0.54788 ± 0.016
q	0.106 ± 0.003
e	0.942 ± 0.002
i	21.3 ± 0.3
Ω	325.4 ± 0.7
ω	148.2 ± 0.5
α (avg)	$356\overset{\circ}{.}8$
daily motion:	$+0\overset{\circ}{.}7$
δ (avg)	$-9\overset{\circ}{.}6$
daily motion:	$+0\overset{\circ}{.}2$
v_g (avg)	37.24 ± 2.6 km/s
$\lambda_\odot$ min.	128°
$\lambda_\odot$ max.	164°

Table 3 – IMO data about AIC.

$\lambda_\odot$ [°]	α [°]	δ [°]	rel. strength
147	357.5	−8	8.5
148	358.8	−6.5	7.8
149	359.4	−9	5.8
150	359.4	−9.5	7.5
151	0.5	−9.5	8
152	1.5	−9.5	5.2
153	2.5	−6	6.5
154	3	−6.5	8.9
155	3.5	−6.5	10.2
156	4.5	−7	7.2
157	5	−6	6.2
158	6	−6	5.2
159	7	−4.5	8.1
160	7	−5	8.7
161	9	−3	6.6
162	10	−3	7.7
163	10.5	−4	6.5
164	11	−3	5.6
165	12.5	−2	3.1

Finally we checked the IMO Million Meteors pages (Molau, 2012), and found that this radiant has been detected during the last analysis, too. Radiant positions fit pretty well with our observations, and relative strength (activity) show that the maximum could be somewhere around $\lambda_\odot = 155°$, but that cannot be confirmed since the actual activity cannot be seen during the period of SDA activity. Results obtained by IMO are presented in Table 3.

3 Discussion

All together in the CMN and SonotaCo databases we found 120 AIC orbits that satisfy $D_{SH} < 0.15$. Such a large number of orbits allows refining the average orbital elements and a good estimate of radiant position and mean daily motion (Table 2).

Parent body search for AIC yields no known object at their average orbit. There are some obvious thoughts/questions jumping out at this point. The AIC parent body could be an unknown comet, could be a long separated fragment of the SDA parent body, or the AIC could be in fact a heavily perturbed SDA filament.

Despite similarity of SDA and AIC orbits, our strong opinion is that these two groups of meteoroids should be considered as two separate meteor showers. In order to confirm such statement, more detailed analysis of SDA and AIC should be done.

4 Conclusions

Altogether, 120 orbits fitting mean orbital parameters by D-criteria inside $D_{SH} < 0.15$ in CMN catalogs for 2007 to 2010 and SonotaCo catalogs for 2007 to 2011 have been found. The available data show that the radiant is active from 128–164° solar longitude, corresponding roughly to August 1 – September 6, with maximum very roughly around 155° solar longitude (August 27). Radiant position at the middle of the activity period ($\lambda_\odot = 145\overset{\circ}{.}4$) is at $\alpha = 356\overset{\circ}{.}8$, $\delta = -9\overset{\circ}{.}6$ with $v_g = 37.2$ km/s. The mean daily motion was found to be $+0\overset{\circ}{.}71$ in right ascension and $+0\overset{\circ}{.}21$ in declination. IAU MDC named the shower August ι-Cetids with the temporary number 505 and a tree-letter code AIC.

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Discovery of the Upsilon Andromedids (UAN, IAU #507)

David Holman[1] *and Peter Jenniskens*[2]

During routine low-light level video observations with CAMS (Cameras for Allsky Meteor Surveillance) made from 2011 June 2 to August 7, a weak shower with a radiant near Upsilon Andromedae was discovered. In that same section of the sky, the Phi Piscids (PPS) were detected, listed as #372 in the IAU Working List of Meteor Showers. The Alpha Triangulids (ATR, IAU #414) and August Piscids (AUP, IAU #415) are activity from the same stream and should be removed from the list. Radiant and speed of the July Pegasids (JPE, IAU #175) match the Great Comet of 1771 (C/1771 A1) as well as earlier identified comet C/1979 Y1 Bradfield.

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1 Introduction

The IAU Working List of Meteor Showers contains more than 300 unconfirmed showers that need verification. The Cameras for Allsky Meteor Surveillance (CAMS) project was established to do so. CAMS is a three-station 60-camera meteor surveillance system using Watec Wat902 H2 cameras equipped with 12-mm focal length lenses. CAMS is based in northern California and was operated during the summer of 2011 from Fremont Peak Observatory, Lick Observatory, and a winery in Lodi (Jenniskens et al., 2011).

Here we report on observations of the Northern Apex region from June 2 through August 7, 2011 (Figure 1). The Canadian Meteor Orbit Radar (CMOR) identified the Phi Piscids (PPS, IAU#372) in this region (Brown et al., 2010). Single-station video observations collected in the IMO Video Meteor Network (VMN) suggested activity from showers labeled numbers 26 (PPS, IAU #372), 31 (JPE, IAU #175), 39 (ATR, IAU #414), 41, and 46 (AUP, IAU #415) (Molau, 2010; Molau & Rendtel, 2009). Nearby are the c-Andromedids (CAN) and Northern June Aquilids (NZC), which are not discussed here.

2 Stream search

We use three D-criteria distance functions in our analysis: $D_{SH}/2$, D_D, and $D_H/2$, each normalized according to (Jopek & Froeschlé, 1997). We found similar results from each using a threshold of $D_c = 0.054$, scaled to $D_{SH}/2$ and the other distance functions for 99% reliability at $M \geq 10$ (Jopek & Froeschlé, 1997), where M is the number of linked stream members found using a given D_c value. Our search algorithm was to take each orbit in the sample set and use it as the comparison orbit for all other orbits in the same sample set. The number of orbits in the sample set that matched the comparison orbit was tabulated. We found that graphing these counts as a function of various orbital elements revealed sharp spikes, each identified with a meteoroid stream. One such graph is shown in Figure 2. Each symbol is the count for one of 1311 orbits.

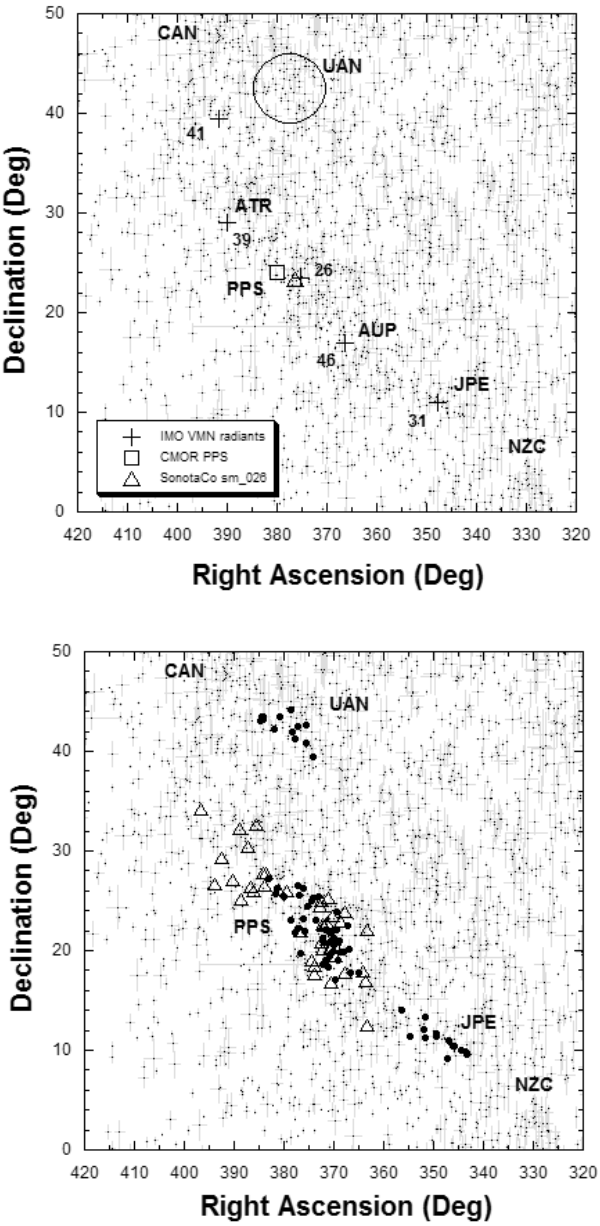

Figure 1 – CAMS geocentric radiants detected in the Northern Apex region between 2011 June 2 and August 7. Top: meteor showers identified in previous orbit surveys (see text). Bottom: members of the Phi Piscids (PPS, IAU #372), the July Pegasids (JPE, IAU #175), and the new Upsilon Andromedids (UAN, IAU #507). CAN are the c-Andromedids. NZC is the subject of another paper.

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NASA-ADS bibcode 2013JIMO...41...43H

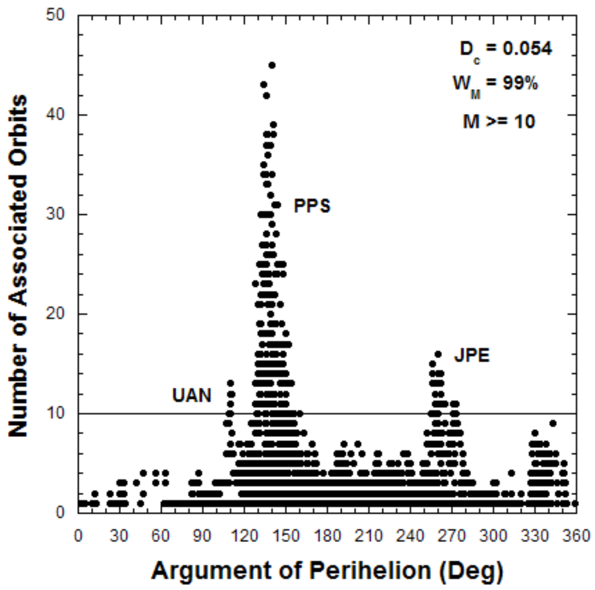

Figure 2 – Number of associated orbits as a function of the argument of perihelion of the orbit.

3 Confirmation of the Phi Piscids

The central radiant in Figure 1 is the Phi Piscids (PPS), first included in the IAU list as number 372 from observations by the CMOR system (Brown et al., 2010) using radar data from 2001 to 2008. CMOR detected this shower, with a peak at 106° solar longitude, during only three days. Using the CMOR mean PPS orbit as a comparison, only 2 matches to the CAMS data were found.

SonotaCo (2010) also identified a stream at this location, designated as sm_026 (abbreviated for Sirko Molau (2010), shower 26) in their 2007–2009 on-line databases, but active over a longer period of time. The CMOR geocentric velocity (and correspondingly the orbital elements a and e) are lower than those found by SonotaCo. The SonotaCo sm_026 mean orbit produced 43 matched CAMS orbits. The resulting average radiant, velocities and orbital elements (Table 1) agree well between the two datasets.

The radiant and peak activity for shower 26 from VMN data (Molau, 2010) also agree well, but the velocity is higher (Table 1). These PPS orbits are shown in Figures 1 and 3. In both figures, SonotaCo's orbits for sm_026 are shown with open triangles.

The Phi Piscids have a wide and asymmetrical activity curve with a peak on June 26 at $\lambda_\odot = 94°$ (Figure 4), which agrees well with the peak at 95° observed by SonotaCo. The change of argument of perihelion as a function of solar longitude ($0.39°/1°\lambda_\odot$) suggests this shower's long duration is due to precession of the orbit, similar to the July-tail of the Perseid shower (Jenniskens, 2006).

The magnitude range of all detected PPS meteors is −0.8 to +3.0. The magnitude distribution index averages $\chi = 3.17$ for the interval from −1 to +2 magnitude ($N = 43$). The PPS radiant does not rise at Fremont Peak Observatory (our standard observer) until 07^h37^m UT, so we use the interval from 07^h37^m to 12^h18^m UT (the beginning of civil twilight), or 4.68 hours as our $t_{\rm eff}$ value, and the values $N = 9$, $h_r = 15.79$, $\chi = 1.75$, $\gamma = 1.26$, and $L_m = 5.4$. With this, the peak ZHR for the PPS stream on June 26 is ZHR is 8.4 ± 2.8, using the formula by (Jenniskens, 1994). The radiant passes closest to the zenith during the daytime, around 7 hours local time, and sets around 14 hours local time.

The mean heliocentric distance to the point of ascension for the PPS meteoroids is 5.30 AU, with a one sigma dispersion of 0.97 AU, so many PPS meteoroids have a node at the orbit of Jupiter. Their mean orbital period, with 4 long-period outliers removed, is 49.0 ± 5.6 years, which is 4.1 times the mean period for Jupiter. The mean period suggests that the potential parent body is a Halley-type comet, possibly with meteoroids in a 1:4 mean-motion resonance. Such accumulation of dust in resonances can lead to meteor outbursts such as, for example, seen with the Orionids of comet 1P/Halley. There is no likely parent body candidate among known comets.

4 Confirmation of the July Pegasids (JPE)

The July Pegasids are distinct from the PPS stream, even though they share the same inclination. There are 14 JPE orbits similar to the mean orbit by Ueda (2012), identified in Figures 1 and 3. The radiant, geocentric velocity, and orbital element drifts all agree with the results by (Ueda, 2012). Rates never exceeded 3 per degree of solar longitude.

Among the JPL/NASA (JPL/NASA, 2012) list of 3158 comet orbits, the July Pegasids are a good match with comet C/1979 Y1 (Bradfield), as identified by Ueda (2012). D_H shows the lowest distance function match at 0.054. However, we also find that comet C/1771 A1 (Great Comet) matches our data at 0.032 for D_H, which is a slightly better fit (Table 1). Both could perhaps be the same comet or, perhaps, they originated from one parent body at the time of the formation of the July Pegasid shower.

The JPE stream ascends near the Earth's orbit, but outside of it by 0.4 AU. The mean orbital period, with 4 long period outliers removed, is 45.4 ± 9.6 years, which also suggests that the potential parent body is a Halley-type comet. Comet C/1979 Y1 (Bradfield) has an orbital period just over 300 years, which makes this a long-period comet similar to comet Thatcher, parent of the Lyrid shower.

5 The August Piscids and Alpha Triangulids

VMN radiant 46, listed as the August Piscids (IAU #415), lies between the PPS and JPE radiants (Figure 1), and shares a similar velocity to PPS. We used a radiant/velocity distance function to find orbital elements for the VMN radiant data in our data. A very

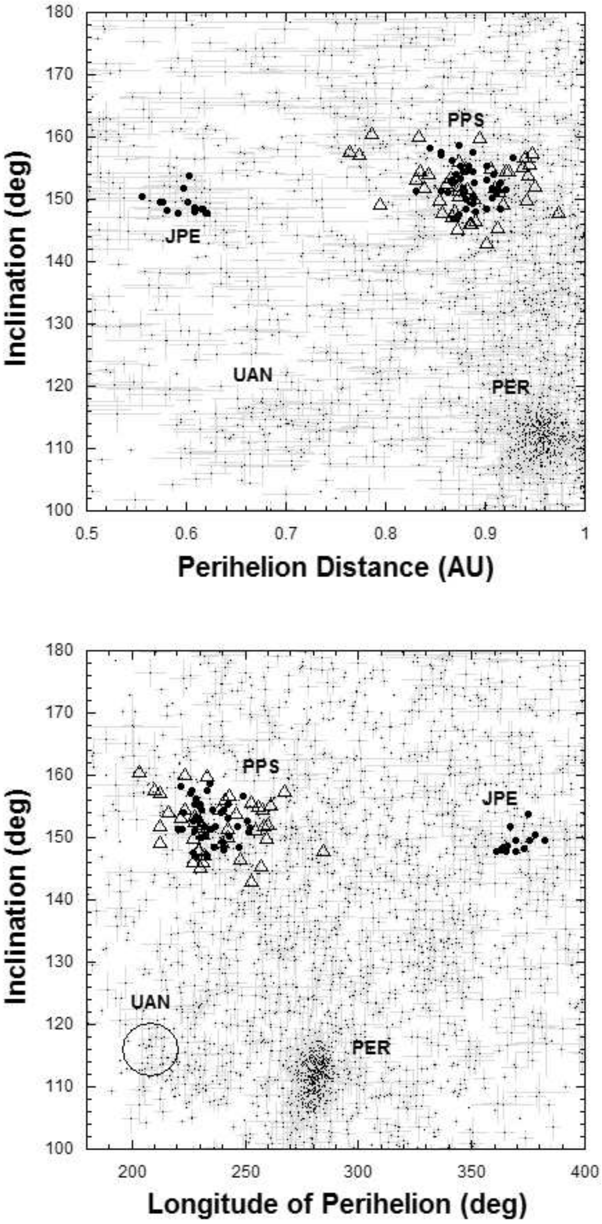

Figure 3 – Showers in meteoroid orbital element space.

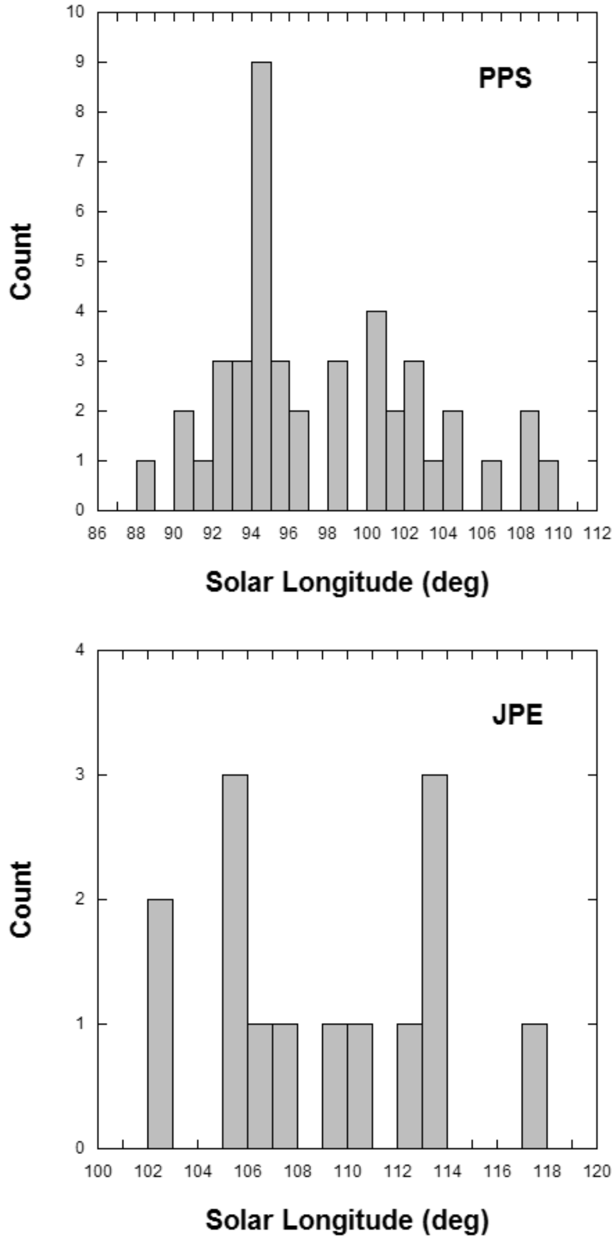

Figure 4 – Activity curves of the PPS and JPE showers.

high D_c value of 0.18 was needed for any detection to occur using the established distance functions, and those orbital elements are sufficiently similar to the PPS that a separate shower is not recognized.

Similarly, the radiant for VMN shower 39, listed as the Alpha Triangulids (IAU #414), lies on the other side of the PPS radiant from VMN shower 46 (Figure 1), and also shares a similar velocity to PPS. We also found that ATR orbits matching with cut-off value $D_c = 0.13$ tended to overlap those found for PPS at the same cut-off level.

The meteors reported by VMN for the shower 41 radiant also share a similar velocity to PPS. All of this suggests that activity observed from these three radiants is actually an extension of PPS activity.

6 The Upsilon Andromedids

Figure 2 shows a spike indicating an active stream with $\omega \approx 110°$ that is above our chosen reliability level. We found the same spike for other orbit elements and were able to identify 13 members of this stream listed in Table 2. Based on the IAU Shower List, this stream appears to be previously undetected, and we use the name Upsilon Andromedids.

This stream has orbital elements (Table 2) that are distinct from the mean for PPS, JPE, and VMN showers 46 (AUP), 39 (ATR), and 41. While the rates are low, the orbits form a compact cluster in Figures 1 and 3. We detect radiant drifts of $1.18°/1°\lambda_\odot$ and $+0.35°/1°\lambda_\odot$ in right ascension and declination, respectively. The activity profile is symmetrical, and runs from $\lambda_\odot = 93°$ to $\lambda_\odot = 101°$ (June 25 – July 4) never exceeding a count of 3 per night. The shower is rich in bright meteors. The magnitude distribution is flat from 0 to +3 with 3

Table 1 – The radiant at the peak of the shower and median orbital elements. Error bars are standard errors. Dispersions are in terms of standard deviation of the distribution. Possible parent body elements are also shown.

Survey	α_g [°]	δ_g [°]	v_g [km/s]	q [AU]	$1/a$ [AU^{-1}]	i [°]	ω [°]	Ω [°]
PPS (IAU #372):								
CAMS	12.9 ± 0.7	22.0 ± 0.4	67.1 ± 0.1	0.883 ± 0.003	0.09 ± 0.01	152.6 ± 0.5	136.7 ± 0.6	97.7 ± 0.8
Disp.	4.4	2.7	0.6	0.021	0.04	3.14	3.7	5.40
SonatoCo	16.3 ± 1.4	23.4 ± 0.7	66.6 ± 0.3	0.882 ± 0.008	0.20 ± 0.02	152.2 ± 0.7	136.2 ± 1.4	101.6 ± 1.7
Disp.	9.1	4.7	1.8	0.049	0.13	4.31	9.3	11.0
CMOR	20.1	24.1	62.9	0.856	0.48	152.6	125.02	106.0
VMN	15.3	23.5	69.1	-.-	-.-	-.-	-.-	-.-
JPE (IAU #175):								
CAMS	348.8 ± 1.1	11.1 ± 0.4	64.5 ± 0.2	0.598 ± 0.005	0.07 ± 0.02	149.3 ± 0.5	260.5 ± 0.7	109.1 ± 1.2
Disp.	4.1	1.4	0.6	0.020	0.05	1.7	2.7	4.4
Ueda	351.7	11.8	63.4	0.531	0.09	148.8	268.7	114.00
VMN	347.9	11.0	66	-.-	-.-	-.-	-.-	-.-
C/1979 Y1 (Bradfield)				0.565	0.02	146.4	264.0	108.6
C/1771 A1 (Great Comet)				0.528	(0.00)	148.6	260.4	111.9

meteors in each bin (plus one -1.8 meteor), resulting in $\chi = 1.0$. The F-skew values range from 0.26 to 1.00, with a mean value of 0.62 ± 0.07, indicating that these meteoroids are somewhat durable.

The UAN stream ascends just beyond 2 AU, well beyond the orbit of Mars. The mean orbital period, with 2 long period outliers removed, is 107.4 ± 31.2 years, which again suggests that the potential parent body is a Halley-type comet. The parent body of such showers can have evolved well beyond an orbit intersecting Earth's orbit.

7 Conclusions

We confirm the existence of the PPS and JPE streams, and find that JPE may be related to comet C/1771 A1

Table 2 – The geocentric radiant, speed, and orbit for the 13 Upsilon Andromedids in June/July 2011.

Day/UT	α_g [°]	δ_g [°]	v_g [km/s]	q [AU]	$1/a$ [AU^{-1}]	i [°]	ω [°]	Ω [°]
25 09:24:59	14.2 ± 1.3	39.5 ± 1.2	60.2 ± 0.7	0.712 ± 0.024	-0.03 ± 0.08	119.3 ± 2.0	113.9 ± 3.3	93.34 ± 0.0
25 09:49:48	15.6 ± 0.6	40.9 ± 0.6	59.8 ± 0.3	0.691 ± 0.010	-0.06 ± 0.03	116.9 ± 0.9	111.9 ± 1.4	93.36 ± 0.0
27 09:02:34	15.5 ± 0.5	42.7 ± 0.5	57.8 ± 0.1	0.707 ± 0.008	0.08 ± 0.02	113.8 ± 0.7	111.9 ± 1.2	95.24 ± 0.0
28 08:54:39	17.9 ± 0.8	41.3 ± 0.9	59.5 ± 1.5	0.694 ± 0.023	0.00 ± 0.14	117.6 ± 1.7	111.4 ± 4.3	96.18 ± 0.0
28 09:26:05	18.3 ± 0.4	41.9 ± 0.4	58.9 ± 0.5	0.684 ± 0.008	0.02 ± 0.04	116.2 ± 0.7	109.9 ± 1.4	96.21 ± 0.0
28 10:29:49	17.3 ± 0.2	42.6 ± 0.2	58.1 ± 0.1	0.695 ± 0.003	0.07 ± 0.01	114.7 ± 0.3	110.5 ± 0.4	96.25 ± 0.0
1 08:40:12	21.9 ± 0.4	42.3 ± 0.3	59.4 ± 0.4	0.675 ± 0.008	0.01 ± 0.03	117.6 ± 0.6	109.0 ± 1.2	99.04 ± 0.0
1 11:57:49	20.9 ± 0.1	43.4 ± 0.4	58.3 ± 0.5	0.688 ± 0.007	0.06 ± 0.05	115.2 ± 0.8	109.8 ± 1.5	99.17 ± 0.0
2 07:24:54	18.7 ± 0.3	44.2 ± 0.2	58.3 ± 0.2	0.738 ± 0.005	0.07 ± 0.02	114.6 ± 0.4	115.8 ± 0.8	99.95 ± 0.0
3 08:38:45	24.5 ± 0.3	43.4 ± 0.3	58.3 ± 0.3	0.660 ± 0.006	0.04 ± 0.03	116.4 ± 0.5	106.8 ± 1.0	100.94 ± 0.0
3 09:14:57	24.1 ± 1.3	43.5 ± 1.5	58.6 ± 0.4	0.667 ± 0.025	0.05 ± 0.07	116.4 ± 2.3	107.5 ± 3.5	100.97 ± 0.0
3 12:02:30	24.3 ± 0.3	43.2 ± 0.4	58.5 ± 0.3	0.662 ± 0.007	0.07 ± 0.03	116.7 ± 0.6	106.6 ± 1.1	101.08 ± 0.0
4 08:43:43	24.6 ± 0.8	43.1 ± 0.7	59.2 ± 0.9	0.676 ± 0.017	0.04 ± 0.08	117.9 ± 1.3	108.8 ± 2.9	101.90 ± 0.0
mean	19.8 ± 1.0	42.5 ± 0.4	58.8 ± 0.2	0.688 ± 0.006	0.03 ± 0.01	116.4 ± 0.4	110.3 ± 0.8	97.97 ± 0.8
Disp.	3.8	1.3	0.7	0.022	0.041	1.5	2.7	3.0

(Great Comet) as well as comet C/1979 Y1 (Bradfield). We show that activity from AUP and ATR is related to PPS, and should be removed from the IAU MDC list. Finally, we show the existence of a new weak stream, the Upsilon Andromedids (UAN, IAU#507).

8 Acknowledgements

Peter Gural and Dave Samuels provided helpful advice. Peter Gural developed the CAMS software algorithms. CAMS stations are hosted by the Fremont Peak Observatory Association (Rick Morales), Lick Observatory (Bryant Grigsby), and Heritage Oaks Winery in Lodi (Tom and Carmela Hoffman). CAMS is supported by the NASA Planetary Astronomy program.

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Croatian Meteor Network Catalogues of Orbits for 2008 and 2009

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The Croatian Meteor Network catalogues of meteor orbits that resulted from data gathered by CMN during 2008 and 2009 are described. The 2008 catalogue contains 4026 orbits and the 2009 catalogue 4382 orbits. The catalogues can be accessed via the CMN web page.

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1 Introduction

The years 2008 and 2009 were the second and third year of operation of the Croatian Meteor Network (CMN). The network is described in more detail in (Andreić & Šegon, 2010; Andreić et al., 2010). The already published catalogue for 2007 is described in (Šegon et al., 2012). All CMN catalogues can be downloaded from the download page of the CMN: `http://cmn.rgn.hr/downloads/downloads.html`.

The SkyPatrol program (Vornhusen, 2003) was used for image acquisition. Images were reduced afterwards, with the help of software written especially for this purpose by Peter Gural. This software is described in detail in (Gural & Šegon, 2009). The software automatically scans through the images from a given night collected by SkyPatrol. The MTP driver program scans through an entire night's collected data in a single sweep automatically and provides frame-by-frame focal plane positions of each meteor track. It also estimates positions of stars in each BMP for astrometric calibration and it can operate under partly cloudy conditions. All data gathered is stored in appropriate data files that are used in the next processing step. For details of the data reduction process see (Šegon et al., 2012).

The catalogue compilation process starts by combining the data on meteor tracks obtained from individual cameras to identify meteors recorded by two or more cameras. During this procedure the clock error of each camera is determined and accounted for (Vida & Novoselnik, 2011).

There is an important point that should be noted: while all meteors published in the CMN 2007 catalogue have been manually re-checked, from 2008 onwards some CMN stations started with fully automatic data processing. In order to minimize eventual coincidence of non-meteor events which could be recognized as meteors, CMN 2008 and later catalogues to follow have also been processed with UFOOrbit Q1 settings but enforced with an additional rule of the meteor trajectory overlap to be at least 2%.

The data in the catalogue is stored in the UFOOrbit *.csv R80 format (SonotaCo, 2008) with the only difference to the standard R80 format of UFOOrbit being that the column "LocalTime" is used for storing the CMN meteor identification code, not the local time of the meteor appearance.

2 The CMN Catalogue of Orbits for 2008

Fifteen CMN cameras were in operation in 2008 (see Table 3). They covered most of the sky above the northern

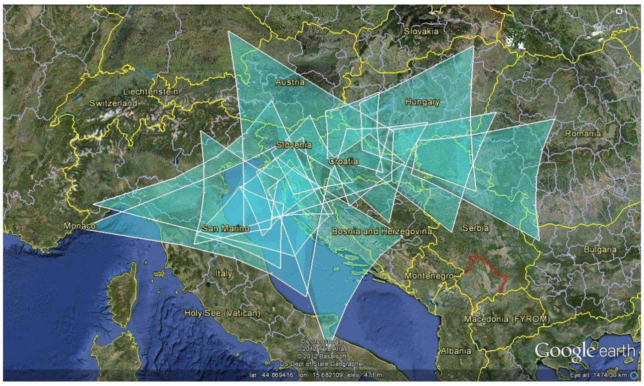

Figure 1 – Locations of CMN cameras that were in operation in 2008, and their fields of view at the typical meteor height of 100 km.

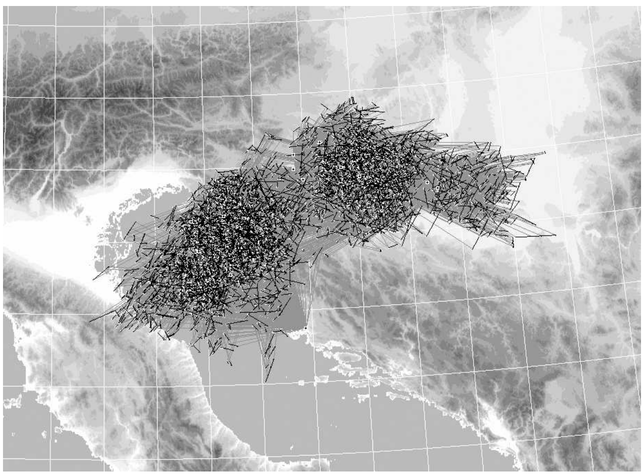

Figure 2 – Plot of ground tracks of meteors from the CMN Catalogue of Orbits for 2008.

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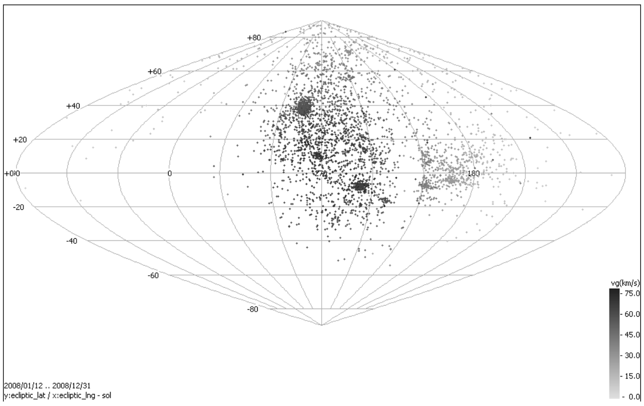

Figure 3 – Radiant plot of orbits from the CMN Catalogue of Orbits for 2008, in ecliptic coordinates. Longitude is given relative to the sun. Geocentric velocities are color coded.

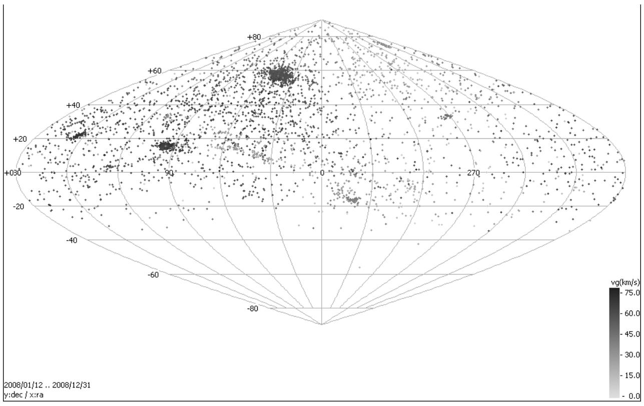

Figure 4 – As Figure 3, but in equatorial coordinates.

part of Croatia (Figure 1). Altogether 8673 double or multiple sightings were recorded, from which 4026 orbits are derived. About half of the orbits (1913) can be attributed to known streams (see Table 1).

The ground tracks of observed double station meteors follow quite closely the sky coverage of CMN cameras (Figure 2). Radiant plots of all orbits are given in ecliptic (Figure 3) and equatorial coordinates (Figure 4).

3 The CMN Catalogue of Orbits for 2009

Twenty-two CMN cameras were in operation in 2009 (see Table 4). In this year most of the sky over Croatia was successfully covered by at least two cameras (Figure 5). Altogether 9538 double or multiple sightings were recorded from which 4382 orbits were derived, half of which (1767) attributed to known streams (see Table 2).

The ground tracks of observed double station meteors follow quite closely the sky coverage of CMN cameras (Figure 6). Finally, radiant plots of all orbits in ecliptic (Figure 7) and equatorial coordinates (Figure 8) are also given here.

Table 1 – Double station stream statistics for 2008. The first column gives the IAU stream code, the second the IAU three-letter code and the third the number of orbits in the database.

IAU No.	Code	No.	IAU No.	Code	No.
266	ACC	1	6	Lyr	19
199	ADC	1	142	MDR	1
331	aHy	1	19	Mon	7
18	And	1	229	NAU	4
55	ASC	1	33	NIA	2
197	AUD	3	250	noO	8
206	AUR	4	67	NSA	1
210	BAU	2	66	NSC	1
232	BCN	1	167	NSS	2
190	BPE	10	17	nTa	31
26	NDA	24	337	nuE	2
1	Cap	24	164	NZC	1
20	Com	24	281	oCt	2
38	CUR	1	333	ocU	4
334	daD	12	182	OCY	1
224	DAU	4	228	OLY	3
47	DLI	1	227	OMO	1
9	DRA	2	8	Ori	325
34	DSE	4	241	OUI	1
221	dSx	1	183	Pau	4
23	EGE	7	7	Per	981
145	eLy	5	101	PIH	3
234	EPC	2	10	Qua	3
191	Eri	18	5	sdA	52
31	etA	7	113	SDL	2
186	EUM	1	208	sPe	6
4	Gem	24	2	sTa	80
343	hVi	1	340	tPy	1
16	Hyd	32	192	TRI	1
248	IAR	1	194	UCE	1
	jug	4	15	Urs	30
12	kCg	11	205	XAU	4
380	kDr	3	242	XDR	1
13	Leo	75	335	xVi	1
22	Lmi	8	193	ZAR	4
49	LVI	1	40	ZCY	1
				spo	2113
				Total	4026

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Our thanks go to all members of the Croatian Meteor Network, as listed in Tables 3 and 4. Also, to Peter Gural for the MTP detection software and its adaptation

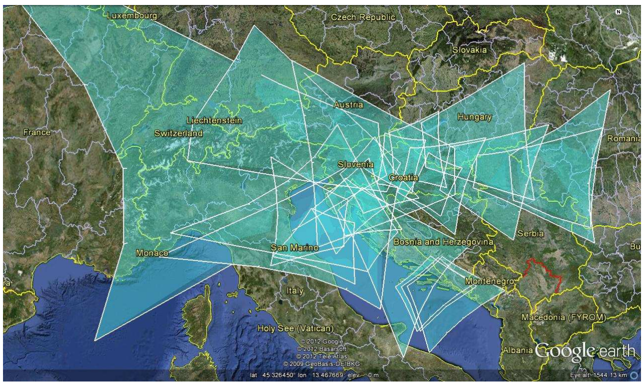

Figure 5 – Locations of CMN cameras that were in operation in 2009, and their fields of view at the typical meteor height of 100 km.

Table 2 – Double station stream statistics for 2009. The first column gives the IAU stream code, the second the IAU three-letter code and the third the number of orbits in the database.

IAU No.	Code	No.	IAU No.	Code	No.
138	ABO	1	19	Mon	4
231	ACM	2	229	NAU	3
199	ADC	2	96	NCC	1
331	aHy	3	112	NDL	1
18	And	2	245	NHD	1
211	AOR	1	33	NIA	2
197	AUD	4	250	noO	7
206	AUR	9	215	NPI	1
210	BAU	8	67	NSA	1
177	BCA	3	167	NSS	1
232	BCN	1	17	nTa	28
190	BPE	1	337	nuE	3
26	NDA	27	83	OCG	1
1	Cap	31	333	ocU	3
20	Com	22	182	OCY	1
38	CUR	1	88	ODR	1
334	daD	11	227	OMO	2
224	DAU	3	8	Ori	236
34	DSE	3	241	OUI	1
221	dSx	1	244	PAR	1
23	EGE	5	183	Pau	2
145	eLy	4	7	Per	730
234	EPC	2	101	PIH	1
191	Eri	4	89	PVI	2
31	etA	19	10	Qua	141
11	eVi	14	125	SAL	1
65	GDE	1	179	SCA	1
4	Gem	84	5	sdA	107
236	GPS	1	113	SDL	1
343	hVi	2	81	SLY	3
16	Hyd	14	150	SOP	1
319	JLE	2	225	SOR	2
175	JPE	2	208	sPe	8
91	JZA	1	2	sTa	61
12	kCg	24	124	SVI	1
380	kDr	5	192	TRI	4
235	LCY	1	194	UCE	4
13	Leo	36	15	Urs	1
22	Lmi	4	205	XAU	1
49	LVI	1	242	XDR	1
6	Lyr	27	193	ZAR	3
127	MCA	1	43	ZSE	2
				spo	2615
				Total	4382

for CMN images and for extensive discussions about all aspects of video meteor detections, to Igor Terlević for many contributions to the CMN software suite and to Filip Lolić for hardware modifications of the CMN cameras.

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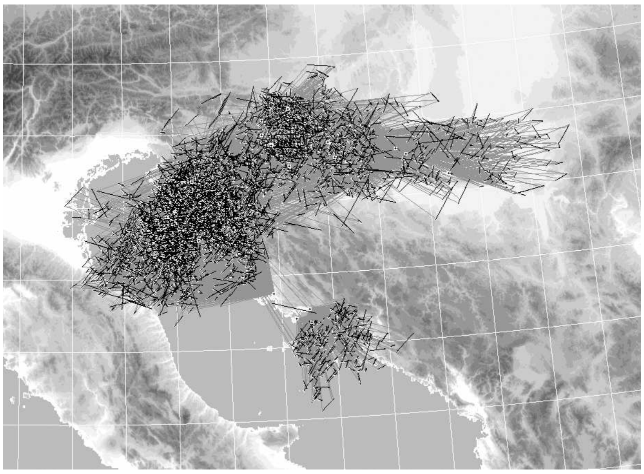

Figure 6 – Plot of ground tracks of meteors from the CMN Catalogue of Orbits for 2009.

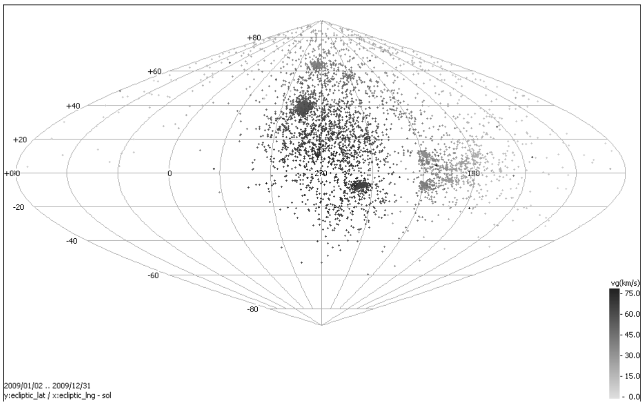

Figure 7 – Radiant plot of orbits from the CMN Catalogue of Orbits for 2009, in ecliptic coordinates. Longitude is given relative to the sun. Geocentric velocities are color coded.

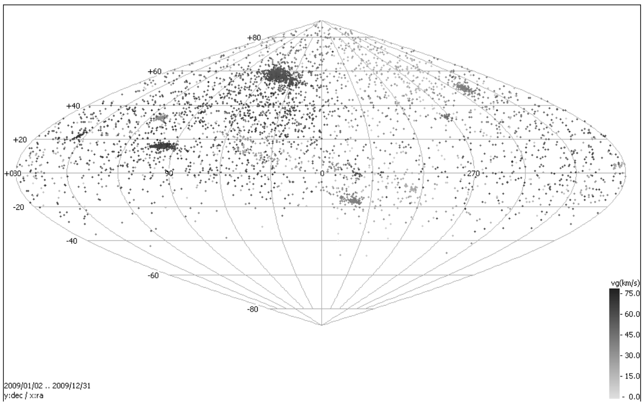

Figure 8 – As Figure 7, but in equatorial coordinates.

Table 3 – List of CMN cameras that were in operation in 2008. The first two columns give the CMN camera label, its location and principal operator. Coordinates of the camera location are provided in the next three columns. The last column shows the number of double station meteors detected by the particular camera in the corresponding year.

code	location and operator	longitude	latitude	z (m)	no. meteors
CMN_BJA	Rovišće: Denis Štogl, Luka Osokruš	16.7313	45.9464	134	155
CMN_MEA	Merenje: Željko Andreić	15.7825	45.9581	194	910
CMN_MLA	Mali Lošinj: Dorian Božičević	14.4691	44.5313	10	477
CMN_OSA	Osijek: Dario Klarić	18.6167	45.5693	84	933
CMN_PET	Petrovsko: Krunoslav Vardijan	15.7932	46.1589	255	503
CMN_PUA	Pula: Damir Šegon	13.8520	44.8691	15	609
CMN_PUB	Pula: Damir Šegon	13.8463	44.8655	28	925
CMN_RIA	Rijeka: Ivica Ćiković	14.3705	45.3472	98	580
CMN_RIB	Rijeka: Ivica Ćiković	14.3705	45.3472	98	473
CMN_SIB	Šibenik: Berislav Bračun	15.8763	43.7567	33	169
CMN_VAA	Varaždin: Željko Andreić	16.3339	46.3094	172	362
CMN_VID	Višnjan: Maja Crnić, Reiner Stoss, Korado Korlević	13.7217	45.2760	227	1017
CMN_VLA	Valpovo: Denis Vida, Filip Novoselnik	18.4225	45.6588	91	214
CMN_VPI	Velika Pisanica: Luka Osokruš	17.0942	45.8083	171	511
CMN_ZGR	Zagreb: Željko Andreić	15.9640	45.8071	117	835
				Total	8673

Table 4 – List of CMN cameras that were in operation in 2009. The first two columns give the CMN camera label, its location and principal operator. Coordinates of camera location are provided in the next three columns. The last column shows the total number of meteors detected by the particular camera in the corresponding year.

code	location and operator	longitude	latitude	z (m)	no. meteors
CMN_BPA	Bačka Palanka: Janko Mravik	19.4139	45.2500	79	58
CMN_BRA	Brač: Tomislav Sorić	16.5608	43.4306	307	117
CMN_DAR	Daruvar: Aleksandar Borojević	17.2148	45.5902	156	66
CMN_MEA	Merenje: Željko Andreić	15.7825	45.9581	194	743
CMN_MLA	Mali Lošinj: Dorian Božičević	14.4691	44.5313	10	456
CMN_OSA	Osijek: Dario Klarić	18.6167	45.5693	84	398
CMN_PET	Petrovsko: Krunoslav Vardijan	15.7932	46.1589	255	693
CMN_PUA	Pula: Damir Šegon	13.8520	44.8691	15	845
CMN_PUB	Pula: Damir Šegon	13.8463	44.8655	28	1252
CMN_RIA	Rijeka: Ivica Ćiković	14.3705	45.3472	98	316
CMN_RIB	Rijeka: Ivica Ćiković	14.3705	45.3472	98	686
CMN_SIB	Šibenik: Berislav Bračun	15.8763	43.7567	33	676
CMN_SIS	Sisak: Dalibor Brdarić, Zvonko Prihoda	16.3014	45.5088	104	39
CMN_SOA	Šolta: Dejan Kalebić	16.2825	43.3929	110	40
CMN_VAA	Varaždin: Željko Andreić	16.3339	46.3094	172	71
CMN_VAB	Varaždin: Alan Pevec	16.3295	46.2976	171	18
CMN_VID	Višnjan: Maja Crnić, Reiner Stoss, Korado Korlević	13.7217	45.2760	227	1661
CMN_VLA	Valpovo: Denis Vida, Filip Novoselnik	18.4225	45.6588	91	136
CMN_VPI	Velika Pisanica: Luka Osokruš	17.0942	45.8083	171	189
CMN_ZGR	Zagreb: Željko Andreić	15.9640	45.8071	117	382
CMN_ZGT	Zagreb: Sonja Janeković	15.9746	45.8157	173	539
CMN_ZRA	Žrnovnica: Filip Lolić	16.5403	43.5215	25	157
				Total	9538

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Results of the IMO Video Meteor Network — December 2012

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A summary of the 2012 December results of the IMO Video Meteor Network is presented, based on almost 40 000 meteors collected in over 6 800 hours of observing time. Flux density profiles of the Geminids and Ursids are presented. The Geminids peaked on December 13/14 and their activity could be followed between November 30 and December 17. No activity from meteors associated with comet 46P/Wirtanen could be detected. Shower parameters for ψ-Ursae Majorids, December α-Draconids, December κ-Draconids, Comae Berenicids, ρ-Leonids, χ-Orionids, December σ-Virginids, α-Hydrids, and December χ-Virginids are presented. The 2012 IMO Video Meteor Network observations are also summarized.

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1 Introduction

The year 2012 ended with moderate weather conditions. In the first half of the month and after Christmas the observing conditions were quite fine, but in between there was a larger gap where we obtained only a few observations. Only 15 out of 73 cameras managed to obtain twenty or more observing nights. Last December, however, the weather was far from perfect as well, so that we could increase the effective observing time compared to 2011 by ten percent to over 6 800 hours. The number of recorded meteors increased even by twenty percent to almost 40 000 (Table 16 and Figure 1).

With Péter Bánfalvi, a new video observer from Hungary found his way to our network. He, Szilárd Csizmadia and Zoltán Zelko are each now operating one of the Huvcse video systems, which are arranged in a multi-station configuration.

2 Geminids

For the meteor count in December there is just one important factor – the weather during the Geminids. Observers with clear skies near December 13 can improve their totals significantly towards the end of the year. In 2012, we recorded 8 000 meteors in the night of December 12/13 alone. If the two adjacent nights are considered as well, the sums increases to 15 000 meteors. One reason was that the Geminid peak matched perfectly with new moon. Also the weather was quite cooperative these nights, so that most observers could observe at least on December 12/13 or 13/14. Those 691 meteors that Erno Berkó recorded with Hulud1 are unbeatable, but there are several other observers with over 400 meteors in a single night. Maciej Maciejewski, for example, recorded far more meteors with his cameras during the 2012 Geminids than in any previous night.

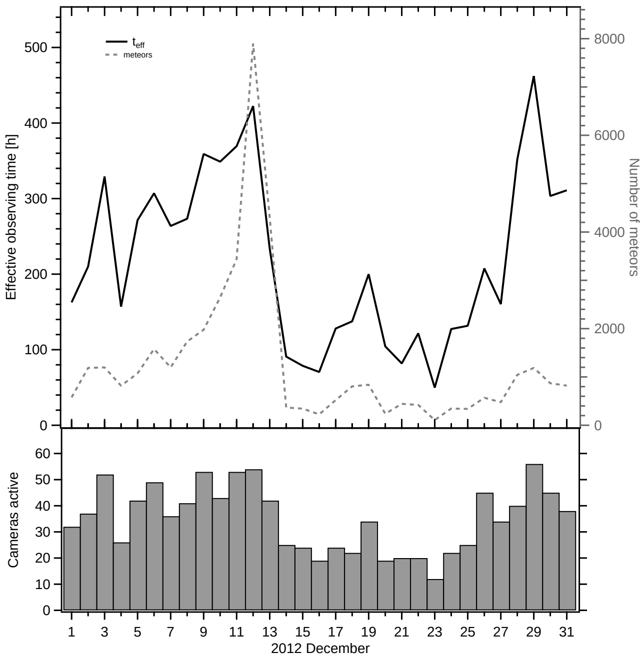

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2012 December.

Figure 2 presents an overview of the Geminids' activity profile. Up to a solar longitude of 261° there was only a moderate rate increase. Thereafter the activity rose dramatically in the night of December 12/13. In the following night, the flux density was a bit higher still and reached a peak value of about 60 meteoroids per 1 000 km^2 per hour. That is slightly more than we measured during the 2012 Perseid maximum. Already one night later, the rates had dropped by about a factor of six, and after another day the Geminids could hardly be discerned anymore from the sporadic background.

Figure 3 shows the Geminid peak between 261 and 263° solar longitude in detail, presenting also data from 2011. Also here we see a consistent picture and we can assume that the increase of rates on December 12/13

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Table 1 – Parameters of the Geminids 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	262	—	113.2	+1.02	+32.5	−0.15	36.3	—
IMO 2012	261.5	248–265	113.3	+1.07	+32.4	−0.09	35.5	0

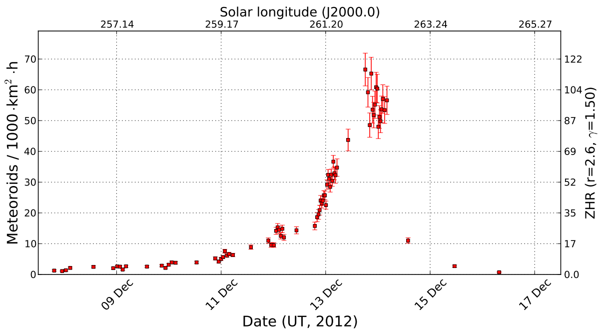

Figure 2 – Flux density profile of the Geminids from data of the IMO Network in 2012.

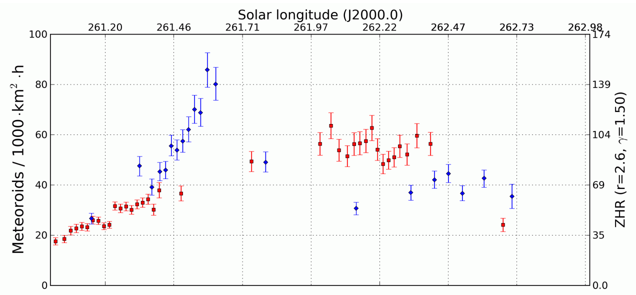

Figure 3 – Detailed activity profile of the Geminids from data of the IMO Network in 2011 (blue diamonds) and 2012 (red squares).

was only the beginning and continued towards later solar longitudes. The solar longitude interval with highest rates may in fact be missing in both years.

In the IMO video meteor database, the Geminids (4 GEM) represent the third strongest shower with over 36 000 meteors. If we consider that the activity of the even more frequent Perseids and Orionids extends over a much longer time interval it becomes clear that there is no shower with more meteors in a single solar longitude interval than the Geminids. Figure 2 shows that the very active period of the Geminids lasts no more than three days. So it was particularly interesting how long the shower would stand out from the sporadic background in our long-term analysis from spring 2012 (Molau, 2012). The answer is given in Table 1: Between November 30 and December 17 the Geminid radiant can be detected undoubtedly. As expected, the quality of the meteor shower parameters is high thanks to the large number of meteors, and there are only minor deviations from the MDC list values.

3 Minor showers

3.1 Meteors from 46P/Wirtanen

Mikhail Maslov had predicted meteors from comet 46P/Wirtanen (the original target of the Rosetta spacecraft) around the time of the Geminids (Maslov, 2012). They would result from four dust trails between 1927 and 1947. The analysis of our data, however, revealed only about five possible shower members in each relevant night. Since at the same time a few hundred sporadic meteors were detected, these shower meteors are chance alignments only, so that we could not measure any activity from this comet.

3.2 December ϕ-Cassiopeiids

Vaubaillon had forecast a possible outburst of the December ϕ-Cassiopeiids (446 DPC) for the early evening hours of December 31 (16^h10^m UT), caused by a close encounter with the 1969 dust trail (IMCCE, 2012). Several visual observers reported immediately after the events that they could observe only single shower members at best. An analysis of our video observations was conducted to support that result, but the analysis was more difficult than expected. The first question was: Where is the radiant located? Both the IMCCE website of Vaubaillon and other web pages referred to the MDC list. There the following shower parameters are given for a solar longitude of 252° (i.e. early December): $\alpha = 19\overset{\circ}{.}8$, $\delta = 58\overset{\circ}{.}0$ and $v_\infty = 19.8$ km/s.

Unfortunately, there is no radiant drift given. Our own analysis from October 2012 detected this shower in early December as well, but we found a quite strong drift in declination by $1\overset{\circ}{.}7$ per day. Now if we use that value to calculate the radiant position we end up at a declination of 104°, which is impossible of course. In addition there was confusion about the timing of the outburst. Beside the predicted time mentioned above, the IMCCE website also mentions a solar longitude of $279\overset{\circ}{.}4584$, which translates to 2012 December 30, 22^h17^m UT.

Under these conditions, we started a radiant search in the solar longitude intervals 280.0–280.4° (New Year's Eve with 119 meteors) and 279.25–279.65° (one evening earlier with 456 meteors). There was no prominent radiant in the expected region of sky. In the first test, 4 out of 119 meteors formed a radiant at $\alpha = 46\overset{\circ}{.}7$, $\delta = 66°$, $v_\infty = 20$ km/s, and the second tests did not yield any sensible radiant at all. So we cannot completely rule out activity from the December ϕ-Cassiopeiids, but the shower was definitely no eye catcher at the end of December 2012.

3.3 Ursids

Finally we can see from the Ursids how a year with enhanced activity like 2011 compares to a 'normal' year like 2012. Whereas the flux density reached values up to 15 meteoroids per 1 000 km^2 per hour in 2011, the value was only close to 4 at the same solar longitude in 2012 (Figure 4).

Table 2 – Parameters of the Ursids 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	271	—	219.4	—	+75.3	—	34.8	—
IMO 2012	270.5	266–272	218.1	+1.8	+75.1	−0.3	32.0	—

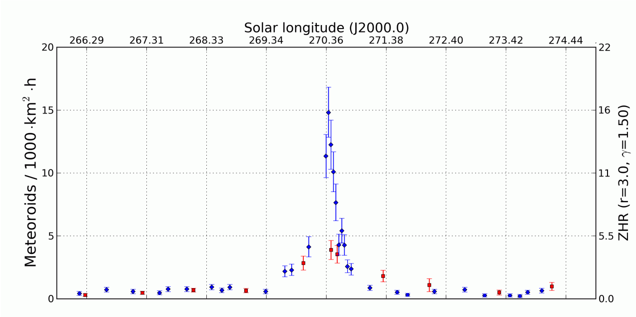

Figure 4 – Activity profile of the Ursids from data of the IMO Network in 2011 (blue diamonds) and 2012 (red squares).

The long-term analysis of the Ursids (15 URS) in based on more than 1 700 meteors. The shower could be safely detected between December 18 and 24. Just before Christmas it is the strongest source in the sky. Also for this shower, there is good agreement between our meteor shower parameters (Table 2) and the values from the MDC list.

3.4 ψ-Ursae Majorids

December is also rich in minor meteor showers. There are the ψ-Ursae Majorids (339 PSU), for example. Our meteor shower parameters based on 1 300 shower meteors are presented in Table 3. Even though the shower has a rank of four at the peak, and below 20 at the borders of the activity interval, it can be detected remarkably well between December 1 and 16. There is only little scatter in the parameters and the shower has a compact profile with maximum on December 4. The agreement with the MDC values is very good.

3.5 December α-Draconids

The case of the December α-Draconids (334 DAD), which are present with 1 400 meteors in our database between December 5 and 18 is not so comfortable. For several days the shower reaches a rank of eight and there is noticeable scatter in the meteor shower parameters during the full activity interval. Once more, the agreement with the MDC values is excellent (Table 4), if the difference in solar longitude is taken into consideration.

3.6 December κ-Draconids

Shortly before – between December 2 and 6 – we can detect the December κ-Draconids (336 DKD) in the data set. Our parameters presented in Table 5 were derived from 700 meteors. Even though the shower is only active for a short amount of time, it is the second strongest source in the sky at times. There is only little scatter in the meteor shower parameters during the short activity period, and once more there is very good agreement with the parameters given by MDC.

3.7 Comae Berenicids

The Comae Berenicids (20 COM) are detected twice in our data – or maybe we shall better say: We find two meteor showers which resemble the Comae Berenicids.

The first shower is safely detected between December 6 and January 18 with minimal scatter in the shower parameters. The well-shaped, slightly asymmetric activity profile (steeper increase than decrease) shows a maximum between December 17 and 22. Apart from a short break during the Ursids, this shower is the strongest source in the sky from mid to end December. Al-

Table 3 – Parameters of the ψ-Ursae Majorids 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	253	—	167.8	—	+44.5	—	61.7	—
IMO 2012	252	249–264	169.0	+1.1	+43.7	−0.5	61.5	—

Table 4 – Parameters of the December α-Draconids 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	257	—	207.9	—	+60.6	—	43.1	—
IMO 2012	255	253–266	205.1	+0.8	+60.1	−0.3	42.8	—

Table 5 – Parameters of the December κ-Draconids 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	250	—	186.0	—	+70.1	—	44.8	—
IMO 2012	251	250–254	185.4	+1.3	+70.4	−0.8	42.9	—

Table 6 – Parameters of the Comae Berenicids and the December Leonis Minorids 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/DLM	262		156.1		+32.7		63.3	
MDC/COM	274	—	175.2	—	+22.2	—	64.7	—
IMO 2012	269	254–298	162.5	+0.88	+30.0	−0.43	64.1	0
	280	272–283	185.7	+1.3	+11.7	−0.7	70.6	0

Table 7 – Parameters of the ρ-Leonids 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	262	—	155.6	—	+5.2	—	66.5	—
IMO 2012	256	253–259	152.5	+0.1	−5.6	−1.3	68.7	—

Table 8 – Parameters of the Northern χ-Orionids 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	257	—	83.9	—	+25.5	—	27.3	—
IMO 2012	257	256–263	82.8	+0.8	+25.6	+0.2	26.3	—

Table 9 – Parameters of the Southern χ-Orionids 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	260	—	78.7	—	+15.7	—	24.2	—
IMO 2012	263	261–267	75.1	−0.2	+18.0	−1.8	21.4	—

Table 10 – Parameters of the December σ-Virginids 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	267	—	205.1	—	+5.5	—	66.9	—
IMO 2012	272	265–279	208.7	+0.8	+4.0	−0.2	69.4	—

Table 11 – Parameters of the α-Hydrids 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	286	—	127.6	—	−7.9	—	45.0	—
IMO 2012	280	270–288	125.0	+0.7	−7.4	−0.2	44.4	—

Table 12 – Parameters of the December χ-Virginids 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	256.7	—	186.8	+0.2	−7.9	−0.14	68.7	—
IMO 2012	265	256–272	192.8	+0.7	−11.2	−0.3	70.1	—

most 7 000 meteors from our database were assigned to that shower, whose average parameters are given in Table 6.

The other shower is active in parallel between December 25 and January 4. Also this shower reaches a rank of three to four, whereby our shower parameters are based on more than 1 000 meteors. The scatter in the shower parameters is a little larger and the activity profile shows only a minor peak on January 1.

If we compare both showers with the MDC list values we find that none of them matches well to the Comae Berenicids. The first shower fits from the velocity, but it deviates in the radiant position by more than ten degrees. The radiant deviation of the second meteor shower is only about five degrees, but the velocity is clearly higher.

A more thorough check reveals that there is one shower missing in the MDC list, which was there in the past: The December Leonis Minorids (32 DLM) were removed, because they are supposed to be the same shower as the Comae Berenicids. Looking at Table 6, however, we find that the December Leonis Minorids fit much better to our first shower. In fact, if the difference in solar longitude is taken into account, there is perfect agreement in position and velocity. That underlines the finding in our 2009 analysis, that the December Leonis Minorids are the dominating and one and a half months long active meteor shower, whereas the Comae Berenicids rather fit to the second, less active shower at the end of year.

3.8 ρ-Leonids

The detection of the ρ-Leonids (442 RLE) in our data is on the borderline. The shower is found between December 5 and 11 with about 600 shower members. At no time does it reach a rank above ten and there is also no clear activity profile. Still, the scatter of the shower parameters is at an acceptable level.

For this shower the deviation of our data from the MDC values (Table 7) is so high that we have to ask ourselves whether it is indeed the same meteor shower.

3.9 χ-Orionids

The Northern and Southern χ-Orionids can also be found in the IMO video data. The northern branch (256 ORN) is active between December 8 and 15 and with more than 1 200 meteors present in our database. The rank is between seven and eight and the scatter is moderate. The agreement with the MDC values is once more quite good (Table 8).

Less comfortable is the situation with the southern component (257 ORS), which is detected with about 600 meteors between December 13 and 19. Its rank stays below ten all the time, and the scatter in the shower parameters is slightly larger. The agreement between our shower parameters and the MDC values is worse (Table 9).

3.10 December σ-Virginids

The December σ-Virginids (428 DSV) are present in our database with 1 200 meteors between December 17 and 31. Maybe their activity even extends until the Quadrantids, but these intervals were rejected because of larger scatter.

The December σ-Virginids do not show a clear activity profile, but reach a rank of four to five at Christmas time. The parameters of this shower, which are all in good agreement with the MDC values except the velocity, are given in Table 10.

3.11 α-Hydrids

About 700 α-Hydrids (331 AHY) are found in our database between December 22 and January 8. The highest level of activity is reached on January 1 with a rank of five. The scatter is moderate. Table 11 shows that our shower parameters agree well with the MDC list values if the difference in solar longitude is taken into account.

3.12 December χ-Virginids

Finally, also in December, a shower with 900 members between December 8 and 24 was declared as unknown. On December 17, at maximum, it reaches a rank of five. Otherwise its rank is most of the time below ten. Still there is only little scatter in the meteor shower parameters so that it appeared unlikely that the shower was not yet detected before. Indeed, a comparison with the latest shower list yielded the December χ-Virginids (335 XVI) that fit well to our data (Table 12).

4 Summary of 2012 observations

Let us come to the obligatory review of the year 2012. It was not just *one* successful year, but as in the last few years it was *the* most successful year in the history of the IMO Video Meteor Network. Forty-six observers with an overall of 80 video systems contributed to the Network – both figures are unchanged from last year. With 17 video systems each, the German and Hungarian observers were most active, followed by Italy and Slovenia (each 11). Further cameras were operated in Portugal (7), Poland, Spain and Belgium (each 3), the Czech Republic (2) as well as Australia, the Netherlands, Greece, Finland, France and the USA (each 1).

We could record meteors in all 366 nights with a range of 15 to 69 active cameras per night (Table 13). The camera network did not grow in 2012, but the degree of automation has further increased and also the weather was quite comfortable. Thus, the effective observing time grew to well above 93 000 hours (2011: 69 000). We recorded more than 10 000 meteors in all months, whereby April performed worst with "only" about 13 000 meteors, and August was the highlight of the year with 75 000 meteors. Overall we could record more than 350 000 meteors in 2012 – a plus of 13% compared to the previous year. The average hourly rate was only 3.8 meteors (2011: 4.5) which is clearly below the average of previous years. In fact, only in 2004 was the yield lower (3.4 meteors per hour).

Table 13 – Monthly distribution of video observations in the IMO camera network in 2012.

Month	Observing Nights	Eff. Observing Time	Meteors	Meteors / Hour
January	31	9 778.8	29 885	3.1
February	29	7 764.7	16 330	2.1
March	31	9 711.0	18 992	2.0
April	30	5 683.7	12 838	2.3
May	31	6 076.7	15 127	2.5
June	30	5 652.0	14 529	2.6
July	31	6 892.1	28 165	4.1
August	31	10 616.9	75 387	7.1
September	30	9 080.6	32 316	3.6
October	31	8 755.2	42 975	4.9
November	30	6 599.8	27 108	4.1
December	31	6 826.3	39 572	5.8
Overall	366	93 437.8	353 224	3.8

In general, the weather was fine until summer, with particularly fine conditions between January and March and in August. In the last quarter, the observing conditions were rather poor.

Many observers obtained the best result of their career. Four observers managed to collect more than 300 observing nights. On top is Antal Igaz of Hungary, who smashed the previous record of 2008 (336 nights) with a total of 346 nights. At a little distance he is followed by Rui Goncalves (Portugal, 328 nights), Sirko Molau (Germany, 323 nights) and Stefano Crivello (Italy, 316 nights). But also below the 300 nights limit the observers are densely packed. In 2005 you would have been on top with 250 nights – in 2012 you are just in midfield with that figure.

Similar names in a slightly different order are found in the effective observing time ranking: Here Rui Goncalves takes the lead with 7 200 hours, followed by Antal Igaz with 6 300 and Carlos Saraiva with 6 100 observing hours. These figures clearly reflect the better observing conditions in the south.

With respect to the number of meteors, there is no deviation from the 2011 order. Just as in 2010 and 2011, Enrico Stomeo is far on top with over 34 000 meteors, followed by Sirko Molau with 29 000 meteors and Stefano Crivello with over 26 000 meteors. At this point, cameras with high sensitivity and yield are dominating.

In the long-term statistics of the IMO Network, there were also some jubilees. Some observers managed to get their 1000th observing night in 2012 (Stefano Crivello, Rui Goncalves, Mihaela Triglav-Čekada, Detlef Koschny and Antal Igaz), and Javor Kac even collected his 2000th night. With respect to the meteor count, Enrico Stomeo became the second observer to collect more than 100 000 meteors, and Sirko Molau jumped beyond the line of 200 000 meteors.

Table 15 summarizes the details for all active observers of the IMO Video Meteor Network in 2012. The number of cameras and stations refers to the majority of the year.

There were also some changes in the list of the most successful video systems. The Top-10 is now almost exclusively occupied by cameras from south and southeast European countries. Whereby the best camera in 2011 yielded 277 nights, you had to collect at least 279 nights in 2012 to be among the ten best cameras (Table 14)!

Two more cameras with over 10 000 meteors did not make it into the Top-10 list: Stg38 (275 nights / 10 651 meteors) and Hubec (274 nights / 10 327 meteors).

Finally, we would like to thank all observers for their efforts. With a lot of enthusiasm they managed to obtain this marvelous result. Sirko Molau specially thanks Stefano Crivello, Enrico Stomeo, Erno Berkó, Antal Igaz, Bernd Brinkmann and Rui Goncalves, who

Table 14 – The ten most successful video systems in 2012.

Camera	Observing Site	Observer	Observing Nights	Eff. Observing Time [h]	Meteors	Meteors / h
Templar3	Tomar (PT)	Rui Goncalves	311	2 295.2	5 878	2.6
Sco38	Scorze (IT)	Enrico Stomeo	291	1 996.4	12 596	6.3
Bilbo	Valbrevenna (IT)	Stefano Crivello	291	1 928.5	9 193	4.8
Ro1	Carnaxide (PT)	Carlos Saraiva	285	2 047.1	4 323	2.1
Ro2	Carnaxide (PT)	Carlos Saraiva	284	2 101.6	4 855	2.3
Noa38	Scorze (IT)	Enrico Stomeo	283	1 932.5	9 337	4.8
Min38	Scorze (IT)	Enrico Stomeo	283	1 941.2	12 335	6.4
Hudeb	Debrecen (HU)	Antal Igaz	282	1 705.4	5 252	3.1
Hubaj	Budapest (HU)	Antal Igaz	282	1 393.9	4 505	3.2
Remo1	Ketzür (DE)	Sirko Molau	279	1 594.4	11 698	7.3

Table 15 – Distribution of video observations over the observers in 2012.

Observer	Country	Observing Nights	Eff. Observing Time [h]	Meteors	Meteors / h	Cameras (Sites)
Antal Igaz	Hungary	346	6 355.9	19 508	3.1	4 (3)
Rui Goncalves	Portugal	328	7 206.0	23 394	3.2	3 (1)
Sirko Molau	Germany	323	5 039.1	28 930	5.7	4 (2)
Stefano Crivello	Italy	316	5 286.4	26 286	5.0	3 (1)
Carlos Saraiva	Portugal	296	6 110.5	12 579	2.1	3 (1)
Enrico Stomeo	Italy	294	5 860.0	34 268	5.8	3 (1)
Mitja Govedič	Slovenia	288	4 360.1	14 311	3.3	3 (1)
Bernd Brinkmann	Germany	284	2 539.9	8 019	3.2	2 (2)
Flavio Castellani	Italy	278	2 074.6	7 587	3.7	2 (1)
Mike Otte	USA	277	1 401.7	5 375	3.8	1 (1)
Zsolt Perkó	Hungary	274	1 612.1	10 327	6.4	1 (1)
Maciej Maciejewski	Poland	271	3 216.5	8 228	2.6	3 (1)
Rok Pucer	Slovenia	271	1 643.9	6 231	3.8	1 (1)
Szofia Biro	Hungary	270	1 647.0	4 839	2.9	1 (1)
Karoly Jonas	Hungary	266	1 592.8	4 002	2.5	1 (1)
Szabolcs Kiss	Hungary	265	1 722.4	1 783	1.0	1 (1)
Istvan Tepliczky	Hungary	265	1 703.5	7 410	4.3	1 (1)
Leo Scarpa	Italy	262	1 551.3	4 740	3.1	1 (1)
Detlef Koschny	Netherlands	260	2 077.5	12 213	5.9	2 (2)
Javor Kac	Slovenia	258	5 117.9	20 807	4.1	5 (3)
Jörg Strunk	Germany	254	3 746.4	8 857	2.4	4 (1)
Maurizio Eltri	Italy	253	1 875.8	7 617	4.1	1 (1)
Hans Schremmer	Germany	247	1 325.5	4 078	3.1	1 (1)
Mihaela Triglav	Slovenia	244	972.4	3 610	3.7	1 (1)
József Morvai	Hungary	238	1 436.6	3 759	2.6	1 (1)
Grigoris Maravelias	Greece	237	1 400.9	5 485	3.9	1 (1)
Martin Breukers	Belgium	233	2 142.7	5 594	2.6	2 (1)
Erno Berkó	Hungary	223	3 411.9	16 411	4.8	3 (1)
Steve Kerr	Australia	221	1 500.1	8 788	5.9	1 (1)
Szilárd Csizmadia	Hungary	206	814.4	2 182	2.7	1 (1)
Mario Bombardini	Italy	191	1 108.3	5 402	4.9	1 (1)
Francisco Ocaña González	Spain	174	958.4	1 218	1.3	1 (1)
Eckehard Rothenberg	Germany	171	875.8	1 912	2.2	1 (1)
Paolo Ochner	Italy	158	341.2	1 743	5.1	1 (1)
Arnaud Leroy	France	155	814.6	858	1.1	1 (1)
Ilkka Yrjölä	Finland	139	510.9	2 112	4.1	1 (1)
Stane Slavec	Slovenia	137	441.0	1 277	2.9	1 (1)
Wolfgang Hinz	Germany	121	570.7	4 326	7.6	1 (1)
Rainer Arlt	Germany	68	348.3	413	1.2	1 (1)
Zoltán Zelko	Hungary	53	239.9	559	2.3	1 (1)
Rosta Štork	Czech Rep.	18	191.2	5 112	26.7	2 (2)
Luc Bastiaens	Belgium	17	85.7	69	0.8	1 (1)
Péter Bánfalvi	Hungary	13	97.1	667	6.9	1 (1)
Orlando Benitez-Sanchez	Spain	8	68.0	60	0.9	1 (1)
Ulrich Sperberg	Germany	8	47.6	320	6.7	1 (1)
Gregor Kladnik	Slovenia	5	32.5	199	6.1	1 (1)

checked and corrected the data month by month together with him and thereby ensured the high quality of the database.

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Handling Editor: Javor Kac

Table 16 – Observers contributing to 2012 December 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	2	5.9	9
BANPE	Bánfalvi	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	13	97.1	667
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	2	11.8	24
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	12	90.9	1319
			Hulud2 (0.95/4)	3398	3.8	671	12	88.1	388
			Hulud3 (0.95/4)	4357	3.8	876	12	84.5	358
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	18	137.2	582
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	12	59.5	826
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	2	2.9	6
			Mbb4 (0.8/8)	1470	5.1	1208	5	28.9	82
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	15	49.6	130
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	14	46.5	179
CASFL	Castellani	Monte Baldo/IT	Bmh2 (1.5/4.5)*	4243	3.0	371	19	215.1	747
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	24	231.3	1434
			C3P8 (0.8/3.8)	5455	4.2	1586	24	221.7	946
			Stg38 (0.8/3.8)	5614	4.4	2007	23	192.8	1521
CSISZ	Csizmadia	Baja/HU	Huvcse02 (0.95/5)	1606	3.8	390	13	57.9	191
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	16	151.6	1126
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	17	115.8	434
			Templar2 (0.8/6)	2080	5.0	1508	18	131.2	466
			Templar3 (0.8/8)	1438	4.3	571	21	143.6	430
			Templar4 (0.8/3.8)	4475	3.0	442	16	97.7	324
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	18	143.5	1103
			Orion3 (0.95/5)	2665	4.9	2069	17	107.9	612
			Orion4 (0.95/5)	2662	4.3	1043	17	112.9	616
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	21	102.0	579
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	18	72.8	256
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	18	92.0	433
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	17	80.2	144
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	16	101.8	455
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	8	26.9	24
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	10	65.7	396
			Rezika (0.8/6)	2270	4.4	840	11	77.0	766
			Stefka (0.8/3.8)	5471	2.8	379	11	57.1	419
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	9	47.1	368
KISSZ	Kiss	Sülyśap/HU	Husul (0.95/5)*	4295	3.0	355	14	108.6	166
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	26	212.2	2015
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	16	57.6	221

Table 16 – Observers contributing to 2012 December 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
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	18	80.6	173
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	15	84.7	407
			Pav36 (1.2/4)*	5732	2.2	227	17	98.8	674
			Pav43 (0.95/3.75)*	2544	2.7	176	14	102.2	367
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	18	113.6	577
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	7	42.5	839
			Mincam1 (0.8/8)	1477	4.9	1084	20	122.1	544
		Ketzür/DE	Remo1 (0.8/8)	1467	5.9	2837	21	87.7	724
			Remo2 (0.8/8)	1478	6.3	4467	23	94.7	648
			Remo3 (0.8/8)	1420	5.6	1967	16	72.2	206
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	19	123.8	380
OCAFR	Ocaña González	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	14	101.7	145
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	19	30.6	209
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	13	76.2	605
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	20	151.9	1668
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	11	60.9	375
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	13	53.7	146
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	19	133.8	402
			Ro2 (0.75/6)	2381	3.8	459	20	159.9	520
			Sofia (0.8/12)	738	5.3	907	18	154.9	374
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	15	106.7	647
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	17	72.9	340
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	4	17.7	32
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	22	177.1	1952
			Noa38 (0.8/3.8)	5609	4.2	1911	22	179.7	1475
			Sco38 (0.8/3.8)	5598	4.8	3306	23	182.7	1982
STORO	Štork	Kunžak/CZ	Kun1 (1.4/50)*	1913	5.4	2778	2	15.7	209
		Ondřejov/CZ	Ond1 (1.4/50)*	2195	5.8	4595	2	7.2	47
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	8	35.4	124
			Mincam3 (0.8/12)	728	5.7	975	15	61.3	170
			Mincam5 (0.8/6)	2349	5.0	1896	18	61.7	299
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	20	136.2	920
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	18	47.9	445
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	3	31.0	129
ZELZO	Zelko	Budapest/HU	Huvcse03 (1.0/4.5)	2224	4.4	933	4	21.2	69
						Overall	31	6 827.8	39 585

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — January 2013

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The January 2013 report of the IMO Video Meteor Network is presented, based on more than 13 000 meteors recorded by 71 cameras in nearly 5 000 hours of observing time. The flux density profile of the Quadrantids is presented which peaked on January 3. Shower parameters for December α-Draconids, January Leonids, Northern δ-Cancrids, ξ-Coronae Borealids, January ξ-Ursae Majorids, γ-Ursae Minorids, January Comae Berenicids, α-Coronae Borealids, and February ε-Virginids are presented. A possible new shower η-Corvids is announced, being active between January 20 and 26.

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1 Introduction

The new year did not start very encouraging for most video observers. In Germany, for example, the winter 2012/13 was the one with least sunshine hours since the beginning of regular weather recordings. Hence, the observers enjoyed only few observing nights. Whereas the first half of January was still acceptable, the second half was almost a total loss. Also other north and east-European observers shared the same fate – only observers in southern Europe could collect more observations. It is therefore no surprise that only seven of the 71 cameras in operation managed to obtain twenty or more observing nights. With less than 4 900 hours, the effective observing time reduced by 50% compared to 2012 (Molau et al., 2012), and those 13 000 meteors are even only a third of the January 2012 outcome (Table 12 and Figure 1).

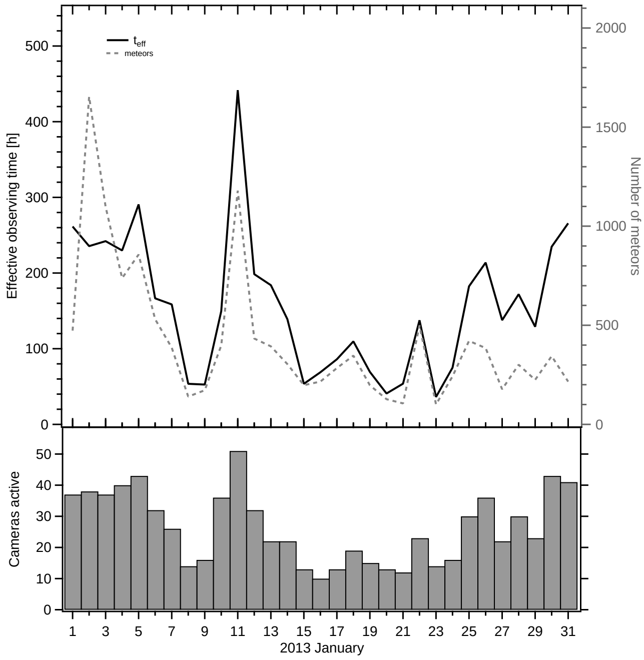

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2013 January.

2 Quadrantids

With the Quadrantids at the begin of year, the meteor season ends. The nights are getting shorter and meteor activity is clearly diminishing. The Quadrantids themselves have a strong, short peak, but only once in a few years can they be well perceived. Three prerequisites are necessary: Clear skies, a peak in the local morning hours, and no Moon. In central Europe, you may find these conditions every ten years or so – certainly not in 2013. The weather was mediocre, the maximum was predicted for daytime (UT) of January 3, and the waning Moon was located high in the sky. Still we could obtain a fair activity profile. It shows a clear increase in flux density in the morning hours of January 3 with up to 25 meteoroids per 1 000 km^2 per hour. Both the shape of the profile and the peak density match to the values of the previous year – the peak occurred only 0°3 earlier in solar longitude (Figure 2). Unfortunately, visual observations are too sparse in this year to confirm the result.

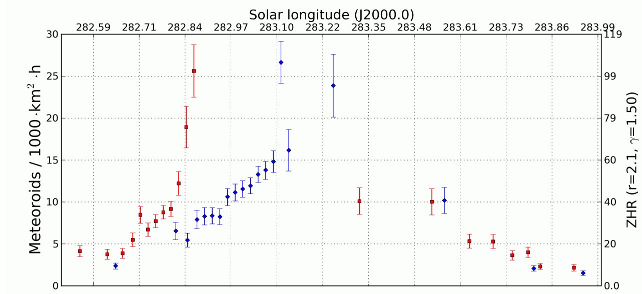

Figure 2 – Activity profile of the Quadrantids from data of the IMO Network in 2012 (blue diamonds) and 2013 (red squares).

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Table 1 – Parameters of the Quadrantids 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	283.3	—	230.0	+0.4	+49.5	−0.2	42.9	—
IMO 2012	283	278–293	230.9	+0.1	+48.7	+0.0	42.4	0

The spring 2012 long-term analysis revealed activity of the Quadrantids (10 QUA) between December 30 and January 12. From January 2 to 9 they are the strong meteor source in the sky (Table 1).

Still, there is significant scatter in the shower parameters, in particular towards the edges of the activity interval. It is particularly strange that the radiant can be found unequivocally with a little different position on December 28 and 29, then it almost disappears over New Year's Eve, and on January 2 it is clearly back. Analysing the situation in more detail we found that there are in fact two similar showers with slightly overlapping activity interval.

2.1 December α-Draconids

The second shower can be traced between December 26 and January 2. At this time, it is equally strong as the early Quadrantids, has the same velocity – only the radiant position is some 7° north-west. The scatter in the shower parameters is even lower than for the Quadrantids, and with a rank of two for five days, there is no doubt about the reality of this shower. In the MDC list there is no entry with similar parameters at the given time of year. However, the shower resembles the December α-Draconids (334 DAD), whose maximum is 20° in solar longitude earlier in time. When extrapolating the radiant position we find a good agreement, and also SonotaCo (2009) reported activity up to 278° solar longitude for this shower.

Note that we detected this shower already between 249° and 264° solar longitude as described in our December report (Molau et al., 2013). If both sections of the shower are linked, they are in good agreement – only the drift in right ascension has a different sign, which is difficult to explain. Still we currently believe that these are two segments of the same shower. The parameters are given in Table 2.

3 Other minor showers

Of course, there are further minor showers in January. They seem to stand out stronger from the background than at other times – maybe because sporadic activity is generally somewhat lower in January.

3.1 January Leonids

The first shower are the January Leonids (319 JLE), which could be detected with 250 meteors between New Year's Eve and January 6. At maximum on January 2, the shower has a rank of four and the shower parameters show only little scatter. There is perfect agreement with the MDC parameters with respect to the radiant position, but the meteor shower velocity deviates strongly (Table 3). The MDC data were obtained from Canadian radar data, and there were cases of similar large deviation in the past (e.g. for the Daytime Arietids in June). Similar differences between velocities was noted in the CMOR simultaneous radar and video meteors study (Weryk & Brown, 2012).

3.2 Northern δ-Cancrids

The Northern δ-Cancrids (96 NCC) can be found between January 10 and 28. An overall of 900 meteors from our database are assigned to that shower. Normally it would be omitted due to the large scatter in meteor shower parameters, but we report the shower anyway, because it is the second strongest source in the sky for a longer amount of time. Furthermore, according to the MDC there are also the Southern δ-Cancrids (97 SCC) active at the same time, which cannot be detected separately by us. Maybe the scatter is just a side effect of this second radiant? At least our shower parameters fit well to the MDC values (Table 4).

3.3 ξ-Coronae Borealids

Very little scatter is present in the data of the ξ-Coronae Borealids (323 XCB), even though their rank is only

Table 2 – Parameters of the December α-Draconids 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	256.5	—	207.9	+0.4	+60.6	−0.14	43.1	—
IMO 2012	255	253–266	205.1	+0.1	+60.1	−0.3	42.8	—
	278	274–281	222.8	−0.7	+53.5	−0.1	43.0	—

Table 3 – Parameters of the January Leonids 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	282.5	—	148.3	+0.66	+23.9	−0.14	53.9	—
IMO 2012	281	279–285	146.6	+0.6	+24.3	−0.2	60.4	—

Table 4 – Parameters of the Northern δ-Cancrids 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	296.3	—	130	—	+20	—	28.3	—
IMO 2012	299	290–308	131.4	+0.4	+17.6	−0.2	29.9	—

Table 5 – Parameters of the ξ-Coronae Borealids 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	294.5	—	244.8	+0.69	+31.1	−0.11	45.6	—
IMO 2012	295	291–298	249.0	+0.1	+29.8	+0.0	49.9	—

Table 6 – Parameters of the January ξ-Ursae Majorids 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	300.6	—	169.0	−0.13	+33.0	+0.01	41.7	—
IMO 2012	298	296–300	169.2	+0.3	+32.6	−0.5	45.6	—

Table 7 – Parameters of the γ-Ursae Minorids 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	299	—	231.7	+0.7	+66.8	−0.57	33.7	—
IMO 2012	300	298–304	228.5	+1.0	+67.3	−0.7	31.6	—

Table 8 – Parameters of the January Comae Berenicids 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	301	—	188.9	+1.3	+16.8	−0.3	64.9	—
IMO 2012	304	301–307	192.7	+0.8	+15.0	−0.2	65.7	—

shortly below ten. About 200 meteors can be assigned to this shower between January 11 and 18. It shows a weakly pronounced activity profile with maximum on January 15. The shower parameters derived by us are given in Table 5. Once more, there is significant deviation in the meteor shower velocity, and once more the MDC data are from the Canadian radar data analysis published in 2008. It looks as if these deviations are of systematic nature as was suggested by Weryk & Brown (2012).

3.4 January ξ-Ursae Majorids

There is also no doubt about the January ξ-Ursae Majorids (341 XUM), which are represented by 340 meteors in our database. The shower is active between January 16 and 20, and is the strongest source in the sky on January 18 and 19. The shower parameters show almost no scatter and the activity profile has a clear peak, which leaves no doubt about the detection. A comparison with the MDC list values (Table 6) shows a good agreement. Once more, our velocity is higher that the MDC values – this time the reference data come from Japanese video observations, though.

3.5 γ-Ursae Minorids

The γ-Ursae Minorids (404 GUM) are detected with 250 meteors between January 18 and 24. The shower presents moderate parameter scatter – only the shower velocity shows large scatter. At their maximum on January 20, the γ-Ursae Minorids are the strongest source in the sky. Our shower parameters match well to the MDC values (Table 7). This time there is also no discrepancy in the meteor shower velocity.

3.6 January Comae Berenicids

Another safe detection are the January Comae Berenicids (90 JCO). They are active between January 21 and 27, and during all that time there is no stronger meteor source in the sky. Almost 400 meteors are assigned to that shower. The scatter in shower parameters is moderate, but the agreement with the MDC values is excellent (Table 8).

3.7 α-Coronae Borealids

The α-Coronae Borealids (429 ACB) are detected with almost 500 meteors in our data between January 27 and February 5. End of January, they are the strongest source in the sky. There is significant scatter in the meteor shower parameters, but we have no doubt about the detection because of the strong activity. There is good agreement with the MDC values (Table 9).

3.8 February ε-Virginids

Finally we do also find the February ε-Virginids (506 FEV) in our data. Between January 29 and February 9, almost 600 meteors from our database are assigned to that shower, and the shower is the second or third strongest source in the sky all time long. There is only little scatter in the radiant position, but significant scatter in the velocity. Overall the agreement with the MDC values is excellent (Table 10).

3.9 Possible new shower η-Corvids

In the end we would like to introduce a possibly new meteor shower, which is present in our data between January 20 and 26. There is a chain of radiants in the southern hemisphere which yields a rank of up to four. An overall of 300 meteors were assigned to the shower candidate, which present moderate scatter in the shower parameters (Table 11). After publication of the shower candidate in the Internet we got a fast response from Damir Šegon of the Croatian Meteor Network, that he could confirm this shower based on data of the SonotaCo network and their own observations. Thus, we reported this candidate to the MDC, where it was added to the working list of meteor shower under the designation η-Corvids (530 ECV).

Beyond that, our meteor database shows signs of the Canum Venaticids (403 CVN) and the ν-Bootids (432 NBO), but both shower are too weak for a safe detection.

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Table 9 – Parameters of the α-Coronae Borealids 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	309.9	—	233.3	—	+27.0	—	59.1	—
IMO 2012	308	307–316	231.5	+1.8	+26.0	−1.0	57.8	—

Table 10 – Parameters of the February ε-Virginids 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	315	—	201.7	—	+10.4	—	64.0	—
IMO 2012	315	309–320	201.0	+0.9	+10.6	−0.3	65.0	—

Table 11 – Parameters of an unknown meteor shower from the analysis of the IMO Network in 2012, designated by MDC as the η-Corvids (530 ECV).

Source	Solar Longitude		Right Ascension		Declination		v_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
IMO 2012	303	300–306	193.8	+0.5	−17.0	+0.6	70.3	—

Table 12 – Observers contributing to 2013 January 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	4	13.5	9
BANPE	Bánfalvi	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	8	48.8	41
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	3	15.6	3
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	7	58.5	451
			Hulud2 (0.95/4)	3398	3.8	671	7	61.4	181
			Hulud3 (0.95/4)	4357	3.8	876	7	56.8	153
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	13	62.8	155
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	9	32.6	267
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	7	46.4	57
			Mbb4 (0.8/8)	1470	5.1	1208	8	49.2	58
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	10	55.0	84
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	10	57.4	95
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	11	106.1	202
			Bmh2 (1.5/4.5)*	4243	3.0	371	9	88.1	164
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	22	177.8	598
			C3P8 (0.8/3.8)	5455	4.2	1586	22	132.8	380
			Stg38 (0.8/3.8)	5614	4.4	2007	21	163.1	616
CSISZ	Csizmadia	Baja/HU	Huvcse02 (0.95/5)	1606	3.8	390	9	24.2	72
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	7	45.0	150
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	16	134.3	367
			Templar2 (0.8/6)	2080	5.0	1508	18	150.1	368
			Templar3 (0.8/8)	1438	4.3	571	21	168.8	360
			Templar4 (0.8/3.8)	4475	3.0	442	18	141.3	366
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	8	36.8	62
			Orion3 (0.95/5)	2665	4.9	2069	7	31.9	41
			Orion4 (0.95/5)	2662	4.3	1043	11	36.7	79
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	15	52.6	98
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	14	33.0	104
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	9	41.1	48
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	9	55.7	142
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	8	46.9	37
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	9	51.9	130
			Rezika (0.8/6)	2270	4.4	840	13	59.3	164
			Stefka (0.8/3.8)	5471	2.8	379	12	57.0	131
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	21	102.2	491
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	22	189.5	1328
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	9	47.4	71

Table 12 – Observers contributing to 2013 January 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
LERAR	Leroy	Gretz/FR	SAPHIRA (1.2/6)	3260	3.4	301	5	33.7	22
MACMA	Maciejewski	Chelm/PL	PAV35 (1.2/4)	4383	2.5	253	7	41.9	45
			PAV36 (1.2/4)*	5732	2.2	227	12	50.1	94
			PAV43 (0.95/3.75)*	2544	2.7	176	11	56.6	51
MARGR	Maravelias	Lofoupoli-Crete/GR	LOOMECON (0.8/12)	738	6.3	2698	15	96.9	342
MOLSI	Molau	Seysdorf/DE	MINCAM1 (0.8/8)	1477	4.9	1084	10	40.4	76
		Ketzür/DE	REMO1 (0.8/8)	1467	5.9	2837	15	69.5	271
			REMO2 (0.8/8)	1478	6.3	4467	16	69.0	227
			REMO3 (0.8/8)	1420	5.6	1967	11	60.3	55
MORJO	Morvai	Fülöpszállás/HU	HUFUL (1.4/5)	2522	3.5	532	9	56.6	98
OCAFR	Ocaña González	Madrid/ES	FOGCAM (1.4/7)	1890	3.9	109	18	129.7	134
OCHPA	Ochner	Albiano/IT	ALBIANO (1.2/4.5)	2944	3.5	358	17	29.9	207
OTTMI	Otte	Pearl City/US	ORIE1 (1.4/5.7)	3837	3.8	460	21	158.9	449
PERZS	Perko	Becsehely/HU	HUBEC (0.8/3.8)*	5498	2.9	460	14	52.6	172
PUCRC	Pucer	Nova vas nad Dragonjo/SI	MOBCAM1 (0.75/6)	2398	5.3	2976	13	99.3	251
ROTEC	Rothenberg	Berlin/DE	ARMEFA (0.8/6)	2366	4.5	911	5	17.5	7
SARAN	Saraiva	Carnaxide/PT	RO1 (0.75/6)	2362	3.7	381	13	96.3	177
			RO2 (0.75/6)	2381	3.8	459	19	156.5	281
			SOFIA (0.8/12)	738	5.3	907	19	146.3	250
SCALE	Scarpa	Alberoni/IT	LEO (1.2/4.5)*	4152	4.5	2052	8	39.4	56
SCHHA	Schremmer	Niederkrüchten/DE	DORAEMON (0.8/3.8)	4900	3.0	409	12	64.3	122
SLAST	Slavec	Ljubljana/SI	KAYAK1 (1.8/28)	563	6.2	1294	7	13.6	57
STOEN	Stomeo	Scorze/IT	MIN38 (0.8/3.8)	5566	4.8	3270	16	94.7	405
			NOA38 (0.8/3.8)	5609	4.2	1911	15	84.6	247
			SCO38 (0.8/3.8)	5598	4.8	3306	16	100.5	376
STORO	Štork	Kunžak/CZ	KUN1 (1.4/50)*	1913	5.4	2778	1	1.9	69
		Ondřejov/CZ	OND1 (1.4/50)*	2195	5.8	4595	1	1.5	27
STRJO	Strunk	Herford/DE	MINCAM2 (0.8/6)	2362	4.6	1152	7	41.4	68
			MINCAM3 (0.8/12)	728	5.7	975	10	51.4	54
			MINCAM5 (0.8/6)	2349	5.0	1896	11	50.2	114
TEPIS	Tepliczky	Budapest/HU	HUMOB (0.8/6)	2388	4.8	1607	6	41.9	162
TRIMI	Triglav	Velenje/SI	SRAKA (0.8/6)*	2222	4.0	546	14	18.2	118
YRJIL	Yrjölä	Kuusankoski/FI	FINEXCAM (0.8/6)	2337	5.5	3574	8	53.9	144
ZELZO	Zelko	Budapest/HU	HUVCSE03 (1.0/4.5)	2224	4.4	933	3	19.0	68
						Overall	31	4 870.1	13 419

* active field of view smaller than video frame

Entropy and time: A search for Denning's resting place

Martin Beech [1]

The interminable scientific literature reveals William Frederick Denning (1848–1931) as one of the great practitioners of meteor astronomy: he wrote widely on the subject and dedicated innumerable hours to his observations. But who was Denning? What can we learn of his life, living and death. Glimpses of Denning the man do exist, but he is largely a man of translucency and unknowns. The journey recounted here reflects upon a recent search for Denning's final resting place, but, once again, it is found that time and circumstance have erased virtually all of the physical history.

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1 Introduction

Sometimes, not often, but sometimes there are private silences that can be made vocal – a public unveiling of a mourning for someone admired, but never actually met. Indeed, I am not sure that I truly like the idea of searching out the resting ground of the long dead; it seems somehow macabre and intrusive – the crossing of some threshold that should not be crossed. In spite of such feelings, on an overcast, gray-sky day this past summer I set out to see if the grave and final resting place of William Frederick Denning could be found.

Denning's many contributions to meteor and planetary astronomy are well known and even legendary, but his private life is obscure and veiled from view (Beech, 1998). Virtually nothing is known of his early life, and what is known of his later life is fragmentary and often anecdotal. Strangely, in terms of known facts, it is Denning's death that provides us with the most exact information about his family and friends. Denning died of atrial fibrillation on Wednesday 9$^{\text{th}}$ June in 1931 – he was 83 years old. His death was announced in the Times newspaper for June 10$^{\text{th}}$ under the headline "famous astronomer dead", to which was added, "Mr. William Frederick Denning, the world famous astronomer and discoverer of five new comets died at Bristol last night". The Times ran a special article on Denning the following day, June 11$^{\text{th}}$. Indeed, the article provides us with about all that we know of Denning's later life, writing, "Denning was unmarried. He lived a secluded life, and his communications with the astronomical world was almost entirely by correspondence (Beech, 2010b). His means were slender. . . " The June 11$^{\text{th}}$ copy of the Times also ran a picture of Denning with the caption, "the well known amateur astronomer, discoverer of the new star in Cygnus whose death is announced". Denning's death was also announced in the New York Times on June 10$^{\text{th}}$. Run as a 'special cable to the NYT', the article ran with the cover line, "discoverer of five comets and new nebulae succumbs in England at 82 [sic]". The announcement of Denning's death was on page 25 of the NYT, but the front page of the paper carried a story about the work of Albert Einstein – again, as a special cable, this time from Berlin, the column begins, "Einstein tells of advance in his field theory in unifying gravity and electromagnetism".

Denning's interment took place on the 13$^{\text{th}}$ of June, and the Western Daily Press newspaper tells us that, "the service was of a simple nature indicated by his retiring mode of life and held at St. Michael and Angels". The service was conducted by Rev. D. H. Hall, assisted by Denning's nephew Rev. A. A. Cockle, rector of Aston Sommerville. It was the Rev. Cockle who took the committal at the graveside in Brunswick Square cemetery. The principal mourners were, "Mrs. Willetts, Norman Denning, Mrs. C. F. Denning, Mr. and Mrs. Ernest Denning, Mrs. Katie Norman, Mr. James Norman, Miss Daisy Denning, Mr. Vicars Webb, Miss Graveley, Mr. Wallets, Mr. and Mrs. Norman, Miss Denning and Mr. H. W. Cockle". We are also told that the Royal Astronomical Society sent a wreath. Many of these same people attended the plaque unveiling ceremony held at 44 Egerton Road on 18 December 1931 (see Figure 5 of (Beech, 2010a)).

I arrived at Bristol Temple Meads station by mid-morning. The sky still overcast, and even threatening rain. From the train station I had about a mile walk to Brunswick Square. The roads were heavy with traffic, the noise seemed almost overpowering. The buildings were new, and tall and obscure, giving no indication of what business or trade the people inside might be plying. I walked through Cabot Circus, an aptly named mall alive with the commerce of bling. Moving closer towards Brunswick Square the traffic diminished, reduced to a sibilant background rush, quiet began to descend and a small amount of peace settled on the air. I saw fewer and fewer people and the houses began to look ever more worn and less cared for, and a sense of the real City, the bit that people actually live in as opposed to simply rush through, started to evolve before me. Upon entering Brunswick Square itself a sad feeling of urban decay overpowered me. The houses were old, tall and clearly built in a era now long past and glaringly at odds with the newer buildings that have grown up around them – a changing landscape they no longer recognized. The past confronted the modern-now at the Square's boundary and it was clear that the new would soon overpower the old. The grass in the center of the Square was cut, but not especially cared for. The trees seemed subdued, overburdened by their environment and less than hale.

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Figure 1 – Gravestones at Brunswick Square cemetery. The glass- topped building (image center) is the Surrey Lodge Unitarian chapel and meeting house.

Founded in the 1750's, the Brunswick Square cemetery is no longer in active use. Indeed, it was turned into a public park in 1988. A white marble stone located close to the entrance way informs the visitor that, "burial took place during the period 1768 – 1963... Many original monuments having been removed (in 1988) to permit the laying out of the site as open space for the benefit of the citizens of Bristol". It is not an overtly pleasant park and it exuded a sense of rejection and detachment – the public had seemingly not come to enjoy the space. The walls around the cemetery were actually topped with barbed and razor wire and bright yellow signs warning that, "the public consumption of alcohol is forbidden". The gravestones and monuments have all been moved to the periphery of the park; they are mostly old, weather worn and broken (Figure 1). Many of the headstones have been entirely warn smooth by the elements, the names of those commemorated now lost to our gaze. Some of the text has moss and lichen growing in the cut marks, providing the would be reader with an embossed living font. I search for about a hour. There are perhaps only fifty gravestones, but none bear witness to the resting place of William Frederick Denning. Indeed, no gravestones reveal his family name at all. Denning's final resting place is now lost to us and even his headstone has been removed. [On returning to Canada an inquiry to the Bristol City Archives revealed that Denning's headstone had not been kept, being destroyed along with the other ones removed, and that no specific information concerning the location of grave plots had been kept.]

The park is quiet during my visit. I hear bird song for the first time and I meet just a few people using the park to walk their dogs. It is inherently a peaceful place by day, but not a place in which to dwell at nighttime. Most people walk straight through, neither looking to the left or right – the presence of their fore bearers being of no apparent interest. One section of the park contains a multi-component sculpture, commissioned in 2010, by artist Hew Locke – it is incongruous and jars with its surroundings. With due respect to the artists, I can't say that I liked the piece. The sculpture, however, has some resonance with the park setting since its title is Ruined. A plaque explains that the sculpture was composed to reflect the boom and bust cycle of Bristolian industry. The rusting of the various iron pieces, symbolic gravestones, seems poetic as if the very elements want to erase their presence from the park – the slight rain that begins to fall also adds to the general sense of wanting to wash the park clean of this modern day intrusion. As I leave the park I am stopped by a young man, an earnest Jehovah's witness, who hands me a pamphlet with the title Would you like to know the truth? It seemed a poignant moment.

Denning remains an enigmatic figure – a figure from a world now long past. In life he attained national and international fame, and his death was recorded in headlines published across the world (Beech, 2010b). While Denning's publication legacy will live-on as long as there are astronomical records, the record of his life and the measure of the man has passed into shadow. The house in which he lived during the later part of his life, 44 Egerton road, still stands – the bricks and mortar having held-up against the entropy of time, war and endless British rain. The remembrance plaque that was erected at the house, with due reverence and respect, was removed sometime in the past and is now lost. Even the church where Denning's funeral service took place is no more – the church of St. Michael and all Angels was demolished in 1997.

And so, as the day began to close I found myself on the train back to London: through the window the trees and green fields are motion blurred – there is an hypnotic passing of the near landscape. The sky had been overcast all day; looming and overarching. The weather enhanced the mood and abstraction; contemplative, out of focus and far away. Denning, the person, it seems is a disappeared entity, a shadow being, his life obscured by lost records; an uncertain birth place, an uncertain childhood, an obscure personal life, a lost graveside, a removed headstone and a displaced commemorative plaque. Perhaps, I wondered, however, as the train hurried away from Bristol this was how the story should end, even though it left me with a deep sense of non-closure. Denning, the man, has passed into an unreachable realm and our only fixed point, indeed the focus of our initial gaze, is that of his many contributions to the astronomical literature.

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Perseid radiant and antiradiant

Top image shows composite of 28 photos containing Perseids, imaged on 2012 August 11/12 between 23^h06^m and 00^h27^m UT. Bottom image is a composite of nine photos with Perseids, imaged on 2012 August 12/13 between 22^h01^m and 00^h27^m UT. Nikon D3 was used for both images, equipped with 24-mm $f/1.4$ lens. Observations were done from Schachen, Swabian Alb, Germany. Photos courtesy of Till Credner / Progymnasium Rosenfeld.