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Conferences
Aurigids
Video meteors
Solar longitudes

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Front cover photo

This composite image shows 123 Geminids extracted from 113 original images. All photos used were taken with Canon 350D camera and Peleng 8 mm fisheye lens, in the four nights between 2007 December 12–15. Since the image is a composite of several hours, meteors that are near the horizon on the composite may have been higher in the sky when they appeared. Their lengths and colors may therefore be unnatural in this image. Photo courtesy: Erno Berkó.

Writing for WGN This Journal welcomes papers submitted for publication. All papers are reviewed for scientific content, and edited for English and style. Instructions for authors can be found in WGN **31:4**, 124–128, and at `http://www.imo.net/articles/writingforwgn.pdf` .

Cover design Rainer Arlt

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Editorial – Geminids galore

Javor Kac

I have been looking forward to the 2010 Geminid maximum since the beginning of the year. In my view, the Geminids are the best annual shower, because of their high meteor rate, long-lasting maximum, and useful elevation of their radiant almost all night long. This year, observers in Slovenia were very fortunate with the weather – after a long spell of overcast sky with lots of precipitation, the nights from December 9 to 15 were at least partly clear. I took advantage of the situation and observed with several friends for five consecutive nights from December 10/11 to 14/15. The conditions were quite brutal, as expected for December nights – from temperatures dipping down to −17°C to snow-covered roads. Nonetheless, I braved the conditions for more than 13 hours of effective observing time and recorded more than 900 meteors, mostly Geminids. The most productive night for me was December 13/14 with rates up to 18 Geminids per 6-minute interval under an LM 6.4 sky. A lack of bright meteors was noted. We hoped for a brighter display the next night, but ended up under thick cirrus clouds. We did see a number of bright Geminids through the clouds, though.

I hope you will enjoy the last issue of *WGN* Volume 38. For the next Volume, I encourage you to submit your observations and results of analyses related to meteors for publication in our Journal. Also, I invite you to send in meteor-related photographs that we could use on front or back covers.

Finally, I wish all our readers delightful holidays, a happy and prosperous New Year, and clear skies!

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From the Treasurer — IMO Membership/WGN Subscription Renewal for 2011

Marc Gyssens

We invite all our members/subscribers to renew for 2011. The fees are as tabulated below. We are happy that we can offer WGN at the same cost as last year. From 2011 onwards, we also offer an electronic-only subscription at 5 euros or 10 dollars less than the standard rate.

IMO Membership/WGN Subscription 2011				
Electronic + paper with surface mail delivery:		€26		US$ 39
Electronic + paper with airmail delivery (outside Europe only):		€49		US$ 69
Electronic only:		€21		US$ 29
Supporting membership:	add	€26	add	US$ 39

It is possible to renew for two years by paying double the amount. General payment instructions can be found on the IMO's website, `http://www.imo.net`.

When you renew, give a few minutes of thought to becoming a **supporting member**. Every year, the IMO helps active meteor workers to attend the annual International Meteor Conference, who would otherwise not have been able to come. Our ability to provide this help depends primarily on the gifts we receive from supporting members! Another way to help meteor workers with limited funds is to offer them a gift subscription.

We already thank all our members that will renew for their continued trust in our Organization!

IMO bibcode WGN-386-gyssens-renewals NASA-ADS bibcode 2010JIMO...38..175G

Conferences

IMC 2011 in Sibiu, Romania

Valentin Grigore
on behalf of the Local Organizing Committee

After another very successful International Meteor Conference (IMC), in Armagh, Northern Ireland, the next IMC—the 30th edition already!—will take place in Sibiu, Romania, from 2011 September 15th (Thursday evening) to 18th (Sunday lunchtime). It will be organized by the SARM (the Romanian Society for Meteors and Astronomy), the national astronomical society of Romania, who also organized a successful IMC in 2000 at Pucioasa (see `http://www.imo.net/imo/imc/2000` for more details on that past event).

Sibiu is an important city in Transylvania (a historical region in the central part of Romania) with a population of 150,000. It is located at 280 km north-west of Bucharest and is one of the most important cultural centers of Romania. The old city of Sibiu was ranked as "Europe's 8th most idyllic place to live" by Forbes magazine and was designated as European Capital of Culture for the year 2007, in tandem with Luxembourg. A video presentation of Sibiu and its surrounding area was posted by the SARM on YouTube at `http://www.youtube.com/watch?v=GH_OgFnwwA8`. A full description of Sibiu city is available on Wikipedia at `http://en.wikipedia.org/wiki/Sibiu`. The organizers intend to organize the conference excursion on the Transfăgărăşan highway, with lunch at the Bâlea Restaurant located on Bâlea Lake, a glacier lake situated at 2034 m altitude in the Făgăraş Mountains. A short video on this famous road is posted at the following link: `http://vimeo.com/18001861`.

The participation fee for the 2011 IMC, including full board, is currently set at 155 EUR.

Further information about the IMC 2011 will be published in the February 2011 issue of *WGN* (*WGN* **39**:1) and, by that time, also posted at `http://www.imo.net/imc2011`. The Local Organizing Committee can be contacted through Valentin Grigore, e-mail: `sarm.ro@gmail.com`.

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Call for Future IMCs

Jürgen Rendtel and Marc Gyssens

Regularly, the IMO Council sends out calls for organizing future IMCs. In this way, the Council wants to avoid the situation that no spontaneous proposals is offered, with as a possible undesirable consequence that we might have a year without IMC. To give interested parties full opportunity to prepare themselves, we have decided to publish the call for the next IMC already now. It will be repeated in the February issue of WGN.

Hence, this is a formal call for organizing the 2012 IMC, as well as later editions. Typically, an IMC is supposed to take place around the third week of September, from Thursday evening (arrival of the participants) to Sunday lunchtime (departure of the participants).

Proposals are due 2011 June 1, and should be sent to the President, `president@imo.net`, preferably in PDF-format.

The IMO Council will normally decide on the proposal to be accepted in 2011 September, at the IMC in Sibiu, Romania. The Council may take advantage of the intermediate time to ask for clarifications or additional information from the candidates.

From past experience, we know it is often difficult to choose between several proposals. If multiple proposals merit the opportunity to host an IMC, the Council will contact such candidates to ask them to retain their candidacy for the next year. If in the next round the Council must decide between equally worthy proposals, priority will be given to the older one.

There are no forms to solicit for the 2012 IMC or subsequent editions, but your proposal should at least contain the following elements:

1. **Who are you?** Who is going to be the local organizers? Which local, regional, or national astronomical organization(s) is/are backing you up? What is your experience with meteor work? Have you been involved

in past IMCs, as passive/active participant or as co-organizer? Do you or the organization(s) to which you belong have experience in organizing events that can be compared to an IMC?

2. **Why do you want to do it?** What is your motivation for wanting to organize an IMC?

3. **Where do you want to do it?** At what location do you want to organize an IMC? Why is this a good location? Can it easily be reached by plane, public transportation, and/or car? How many hours is it by public transport from the nearest major international airport? Provide a few pictures of the location, or, a weblink to such pictures.

4. **At what venue are you going to hold the IMC?** Preferably, lectures and accommodation should be under the same roof, but there is no real objection to the lecture room being at a separate location within easy walking distance from the accommodation. Describe the accommodation at your disposal. Preferably, add an offer from the hotel and/or the institution providing additional accommodation to prove that the venue you propose is indeed available and that the price is within the limits of your budget (see below). Provide also a few pictures of the accommodation, or, a weblink to such pictures.

5. **What will it cost?** Draft a preliminary budget for the IMC proposed. Mention all sources of income, in particularly sponsors or subsidies. Take into account that the price per participant should not exceed 150 EUR by much. Of this amount, 10 EUR must be reserved for producing and mailing the (post-)proceedings to the participants. With respect to the expenditures, take into account that the participants must be offered full board from Thursday evening, dinner, up to Sunday, lunch, inclusive. Of course, lecture room facilities should be accounted for, as well as a coffee break in the morning and in the afternoon. Finally, it is also customary to have a half-day excursion, usually on Saturday afternoon.

   Note that, although the IMO provides the service of collecting the registration fees for you, the IMO will in principle *not* cover any negative balance that you might incur, so, please, draft your budget responsibly!

6. **Can it also be done in a later year?** We can only have one IMC every year. It is therefore important for us to know if you can also make this offer in a subsequent year. If there are reasons why the application cannot be postponed, please describe these reasons clearly! It is imperative that you answer the questions honestly. Of course, we understand that you are keen to organize next year's IMC, otherwise you would not have applied, but having a clear picture of the real time constraints of all the candidates is a serious help for the Council to make the best decision possible!

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

If you are interested in applying for the local organization of the 2012 IMC, please email the President as soon as possible that you intend to apply by the due date of 2011 June 1. Even though such a declaration of intent is not a formal commitment, it is an indication for the Council as to how many applications may be expected: based on this information, the Council may actively solicit additional candidacies.

We hope to receive many candidacies!

IMO bibcode WGN-386-rendtel-futureimcs NASA-ADS bibcode 2010JIMO...38..176R

Details of the Proceedings of the International Meteor Conference, Poreč, Croatia, 2009

Communicated by Željko Andreić and Javor Kac

In 2009, the International Meteor Conference (IMC) was for the first time held in Croatia. Those who have attended an IMC will know that they present many high-quality papers on a wide range of meteor subjects. This material is less well known outside the circle of conference-goers, however. To make it more widely available, we are publishing brief details of all IMC 2009 papers here.

IMO bibcode WGN-386-imc2009-abstracts NASA-ADS bibcode 2010JIMO...38..177A

Those who attended the Conference will already have the Proceedings. Others can order them from the International Meteor Organization: details are in the lower half of the inside back cover of this Journal and on the IMO website `http://www.imo.net/imo/publications`.

Recent shower calculations

D.J. Asher

Meteor shower predictions are now achieving considerable levels of success. Recent examples included the activity peaks in the 2009 Perseids and Leonids providing good matches to forecasts made by various meteor astronomers. It can also be shown, from orbit geometry calculations combined with knowledge of meteoroid ejection processes from cometary nuclei, that young dust trails in different streams have differently shaped cross sections, and therefore different outburst activity profiles when the Earth encounters them. Whereas Leonid trails have somewhat elliptical cross sections in the ecliptic plane, Perseid trail cross sections resemble – to those with sufficient imagination – the shape of legendary forest creatures.

Digital All-sky cameras V: Liquid Crystal Optical Shutters

Felix Bettonvil

In this fifth paper about digital All-sky cameras I present a Liquid Crystal Optical Shutter that can be used for determination of the velocity of meteors. The aim is to modulate the shutter signal with a sinusoidal function and use frequency analysis to compute the velocity.

Comparative analyses of visual and video observation of Perseid Meteor Shower in 2008

Vilena Velikić and Nevena Milutinović

Perseid Meteor Shower is shown to be the most suitable one for comparative video and visual analysis. Since the idea of calibrating these two methods exists for some period of time, our data from year of 2008 has shown to be the most practical one for analyzing in order to start answering the question – is calibration possible? After finishing with our calculations and comparing our results with ones that Japanese Meteor Network and IMO already have, we came out with results that can help leading us to our main goal – calibration of video and visual observations.

A 2009 July 28 fireball spectrum

Javor Kac and Mitja Govedič

A sensitive video CCTV camera was used with the diffraction grating to record meteor spectra. On 2009 July 28 at $22^{\rm h}59^{\rm m}39^{\rm s}$ UT, a second-order spectrum of a bright fireball was recorded. Eighteen emission lines were identified, with the major lines corresponding to magnesium, calcium, iron and sodium. Only four faint emission lines could be attributed to the atmospheric elements, probably due to the low meteor atmospheric velocity.

The Second Year of Croatian Meteor Network

Željko Andreić, Korado Korlević and Damir Šegon

Croatian Meteor Network (CMN) was first presented to international meteor community on IMC2008, and since then CMN made great progress in its work. In this paper we present achievements and developments during period between two International Meteor Conferences.

Integration of mean orbits of meteoroid streams

Radosław Poleski

Mean orbits of the meteor streams are most frequently calculated using arithmetic averages of heliocentric orbital elements. Resulting values of orbital parameters do not satisfy laws of celestial mechanics. This contribution discusses the influence of planetary perturbations on mean orbit calculated using vector orbital elements.

The 2009 Perseid Maximum – Photographic Results

Przemysław Żołądek, Mariusz Wiśniewski, Krzysztof Polakowski, Ewa Wala, Krzysztof Walczak and Radosław Poleski

An astronomical camp was organized by Comet and Meteors Workshop during the 2009 Perseids maximum. 69 meteors were photographed during four consecutive nights. We found that photographic Perseid radiant was very compact and located at $\alpha = 48\overset{\circ}{.}7$, $\delta = 58\overset{\circ}{.}6$. Our main goal was the determination of the radiant from single station photographic observations, however we also calculated two double station trajectories using additional data which were send to us by casual photographic observer from other parts of Poland. Dozens of radio reflections were observed with simple radio receiver, some of them were identified with photographic images.

Fireball Kościerzyna – 2009.05.31 20:49:38 UT

Mariusz Wiśniewski, Karol Fietkiewicz, Przemysław Żołądek, Jarosław Dygos, Mirosław Krasnowski and Krzysztof Polakowski

On the night of May 31, 2009, at 20:49:38 UT an extremely bright fireball occurred over northern Poland. Three cameras of Polish Fireball Network recorded this event. Images from PFN24 Gniewowo was completely saturated by meteor flash. We use data from PFN05 Poznań and PFN22 Czernice Borowe for calculations. We develop Meteor Identification Software (MIS) to detect meteor in series of images, estimate position and luminosity of the event. Our software is capable to analyse each sub-frame of interlaced images. Positions determined by MIS software have much smaller dispersion than estimated by MetRec. Kościerzyna Fireball have no chance to produce meteorite due to high entry speed and composition.

Terrestrial meteorite craters and their geomorphological, geological and mineralogical consequences: An overview

Arnold Gucsik, Krisztián Mihályi, Dobosi Károly, Szabolcs Nagy, Szaniszló Bérczi and Henrik Hargitai

The impact cratering as a leading process in the formation of the planetary bodies and surfaces and their geological as well as mineralogical consequences have been summarized in this review article. The purpose of this study is to provide the most important lithological and shock diagnostic features of shock metamorphism accompanied with terrestrial impact structures. The first section of this study gives a brief summary of the formation mechanism and stages of an impact structure as well as a short description of basics of the sock wave physics of an impact event. The next section deals with the types of terrestrial impact structures. The lithological shock-metamorphic indicators, diagnostic shock features in the target rocks and mass extinction aspects of the impact events are mentioned in the following sections.

Meteor Observation and the Light Pollution

Valentin Grigore

This paper propose some concrete ways and procedures made by "no light pollution" militants (astronomers, ecologists, scientific, educational and cultural institutions) to combat this type of pollution. Meteor observations is the most important field of astronomy affected by the light pollution.

Aerodynamical properties of fragments of a meteor body in the terrestrial atmosphere

N. G. Barri

There is significant evidence that some fraction of meteoric bodies is destroyed in the atmosphere. The evolution of the fragment cloud depends on a large number of factors, among them: the meteoroid's altitude and velocity at the moment of breakup, fragments sizes and properties of a body material. The interaction of shock waves forming in front of the fragments may lead to both an increase and decrease of the midsection area of the fragment cloud (Artem'eva & Shuvalov, 1996). In this work, we consider the inter action of the fragments in a supersonic flow. The configuration properties of two spherical bodies of different radii are considered. Via numerical simulations, we calculate the pressure distribution in the flow around the two bodies for different relative positions. We construct the functions of the coefficients of transverse and drag forces from the angle between the central line of the two bodies and the flow direction for different distances between the two fragments. We find the conditions for the collimation effect, i.e., fragment inclusion into the wake of the leading (usually, the largest) fragment. We systematize the simulation results for drag and forces and infer the basic aerodynamic properties of the meteoroid fragments.

Observations of Orionids from Bulgaria

Todor Dimitrov and Valentin Velkov

Presented are results from visual observations of the Orionds and other showers carried out in Bulgaria. Radiant positions of the basic active showers are obtained. Recorded is a possible new radiant in ARI.

Observations of Perseids in 2009 from Bulgaria

Daniela Urumova

Presented are results from visual observations of the Perseids and other summer showers carried out in Bulgaria. Radiant positions of the basic active showers are obtained. Recorded is a possible early activity of KCG.

Parents of meteors (4)

Andrei Dorian Gheorghe and Alastair McBeath

This essay represents the continuation of a series inspired from Romanian literature and published in IMC Proceedings. This time the authors analyse a humorous sketch, written by the greatest Romanian dramatist and humorist, Ion Luca Caragiale, about the instruction in the Romanian schools at the end of the 19th century.

Meteor Beliefs Project: Musical Meteors, meteoric imagery as used in near-contemporary song lyrics

Alastair McBeath and Andrei Dorian Gheorghe

Items collected from contemporary song lyrics featuring meteoric imagery, or inspired by meteors, are given, with some discussion. While not a major part of the Meteor Beliefs Project, there are points of interest in how such usage may become passed into popular beliefs about meteors.

Solar Longitudes for 2011

Compiled by Rainer Arlt

A conversion table of dates to solar longitudes using (Steyaert, 1991) is given as every year. The longitudes are given on the next page; they are only valid for 2011. The conversion formulae for any time of the day are repeated here for your convenience.

If you want to calculate the solar longitude $\lambda_\odot$ of a specific time of the day, you may use a linear interpolation between two dates. Suppose you have a certain *Date* and the *Time* in hours (UT), you get the solar longitude by

$$\lambda_\odot = \lambda_{\odot,\mathrm{Date}} + (\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}}) \times \frac{\mathrm{Time}}{24^{\mathrm{h}}}.$$

Alternatively, if you want to convert a certain solar longitude $\lambda_\odot$ into a time of the day, look up the *Date* with the next-smaller solar longitude in the table and calculate

$$\mathrm{Time} = \frac{(\lambda_\odot - \lambda_{\odot,\mathrm{Date}})}{(\lambda_{\odot,\mathrm{NextDay}} - \lambda_{\odot,\mathrm{Date}})} \times 24^{\mathrm{h}}.$$

The solar longitudes of 1988–2020 are given in two-hour increments and with three decimals at `http://www.imo.net/data/solar`.

References

Steyaert C. (1991). "Calculating the solar longitude 2000.0". *WGN, Journal of the IMO*, **19:2**, 31–34.

IMO bibcode WGN-386-arlt-solarlong
NASA-ADS bibcode 2010JIMO...38..180A

Solar longitudes 2011. Dates refer to 00^{h} UT.

Jan	1	280.05	Mar	1	339.89	May	1	40.14	Jul	1	98.69	Sep	1	158.07	Nov	1	218.05
Jan	2	281.07	Mar	2	340.90	May	2	41.11	Jul	2	99.64	Sep	2	159.04	Nov	2	219.05
Jan	3	282.09	Mar	3	341.90	May	3	42.08	Jul	3	100.60	Sep	3	160.00	Nov	3	220.05
Jan	4	283.11	Mar	4	342.90	May	4	43.05	Jul	4	101.55	Sep	4	160.97	Nov	4	221.05
Jan	5	284.13	Mar	5	343.91	May	5	44.02	Jul	5	102.50	Sep	5	161.94	Nov	5	222.05
Jan	6	285.15	Mar	6	344.91	May	6	44.99	Jul	6	103.46	Sep	6	162.91	Nov	6	223.05
Jan	7	286.17	Mar	7	345.91	May	7	45.96	Jul	7	104.41	Sep	7	163.88	Nov	7	224.06
Jan	8	287.19	Mar	8	346.91	May	8	46.92	Jul	8	105.36	Sep	8	164.85	Nov	8	225.06
Jan	9	288.21	Mar	9	347.91	May	9	47.89	Jul	9	106.32	Sep	9	165.82	Nov	9	226.06
Jan	10	289.23	Mar	10	348.91	May	10	48.86	Jul	10	107.27	Sep	10	166.79	Nov	10	227.07
Jan	11	290.25	Mar	11	349.91	May	11	49.83	Jul	11	108.22	Sep	11	167.76	Nov	11	228.07
Jan	12	291.27	Mar	12	350.91	May	12	50.79	Jul	12	109.18	Sep	12	168.74	Nov	12	229.08
Jan	13	292.29	Mar	13	351.91	May	13	51.76	Jul	13	110.13	Sep	13	169.71	Nov	13	230.08
Jan	14	293.30	Mar	14	352.91	May	14	52.72	Jul	14	111.08	Sep	14	170.68	Nov	14	231.09
Jan	15	294.32	Mar	15	353.90	May	15	53.69	Jul	15	112.04	Sep	15	171.65	Nov	15	232.09
Jan	16	295.34	Mar	16	354.90	May	16	54.65	Jul	16	112.99	Sep	16	172.63	Nov	16	233.10
Jan	17	296.36	Mar	17	355.90	May	17	55.61	Jul	17	113.94	Sep	17	173.60	Nov	17	234.11
Jan	18	297.38	Mar	18	356.89	May	18	56.58	Jul	18	114.90	Sep	18	174.58	Nov	18	235.12
Jan	19	298.39	Mar	19	357.89	May	19	57.54	Jul	19	115.85	Sep	19	175.55	Nov	19	236.13
Jan	20	299.41	Mar	20	358.88	May	20	58.50	Jul	20	116.81	Sep	20	176.53	Nov	20	237.13
Jan	21	300.43	Mar	21	359.87	May	21	59.47	Jul	21	117.76	Sep	21	177.51	Nov	21	238.14
Jan	22	301.45	Mar	22	0.87	May	22	60.43	Jul	22	118.71	Sep	22	178.49	Nov	22	239.15
Jan	23	302.46	Mar	23	1.86	May	23	61.39	Jul	23	119.67	Sep	23	179.46	Nov	23	240.16
Jan	24	303.48	Mar	24	2.85	May	24	62.35	Jul	24	120.62	Sep	24	180.44	Nov	24	241.18
Jan	25	304.50	Mar	25	3.84	May	25	63.31	Jul	25	121.58	Sep	25	181.42	Nov	25	242.19
Jan	26	305.51	Mar	26	4.83	May	26	64.27	Jul	26	122.53	Sep	26	182.40	Nov	26	243.20
Jan	27	306.53	Mar	27	5.82	May	27	65.23	Jul	27	123.49	Sep	27	183.38	Nov	27	244.21
Jan	28	307.55	Mar	28	6.81	May	28	66.19	Jul	28	124.44	Sep	28	184.36	Nov	28	245.22
Jan	29	308.56	Mar	29	7.80	May	29	67.15	Jul	29	125.40	Sep	29	185.35	Nov	29	246.24
Jan	30	309.58	Mar	30	8.79	May	30	68.11	Jul	30	126.36	Sep	30	186.33	Nov	30	247.25
Jan	31	310.60	Mar	31	9.78	May	31	69.07	Jul	31	127.31						
Feb	1	311.61	Apr	1	10.77	Jun	1	70.03	Aug	1	128.27	Oct	1	187.31	Dec	1	248.26
Feb	2	312.63	Apr	2	11.75	Jun	2	70.99	Aug	2	129.23	Oct	2	188.29	Dec	2	249.28
Feb	3	313.64	Apr	3	12.74	Jun	3	71.95	Aug	3	130.18	Oct	3	189.28	Dec	3	250.29
Feb	4	314.66	Apr	4	13.73	Jun	4	72.91	Aug	4	131.14	Oct	4	190.26	Dec	4	251.30
Feb	5	315.67	Apr	5	14.71	Jun	5	73.86	Aug	5	132.10	Oct	5	191.25	Dec	5	252.32
Feb	6	316.68	Apr	6	15.70	Jun	6	74.82	Aug	6	133.06	Oct	6	192.23	Dec	6	253.33
Feb	7	317.70	Apr	7	16.68	Jun	7	75.78	Aug	7	134.01	Oct	7	193.22	Dec	7	254.35
Feb	8	318.71	Apr	8	17.67	Jun	8	76.73	Aug	8	134.97	Oct	8	194.20	Dec	8	255.36
Feb	9	319.72	Apr	9	18.65	Jun	9	77.69	Aug	9	135.93	Oct	9	195.19	Dec	9	256.38
Feb	10	320.74	Apr	10	19.63	Jun	10	78.65	Aug	10	136.89	Oct	10	196.18	Dec	10	257.39
Feb	11	321.75	Apr	11	20.61	Jun	11	79.60	Aug	11	137.85	Oct	11	197.17	Dec	11	258.41
Feb	12	322.76	Apr	12	21.60	Jun	12	80.56	Aug	12	138.81	Oct	12	198.15	Dec	12	259.43
Feb	13	323.77	Apr	13	22.58	Jun	13	81.51	Aug	13	139.77	Oct	13	199.14	Dec	13	260.44
Feb	14	324.78	Apr	14	23.56	Jun	14	82.47	Aug	14	140.73	Oct	14	200.13	Dec	14	261.46
Feb	15	325.79	Apr	15	24.54	Jun	15	83.42	Aug	15	141.68	Oct	15	201.12	Dec	15	262.47
Feb	16	326.80	Apr	16	25.51	Jun	16	84.38	Aug	16	142.65	Oct	16	202.11	Dec	16	263.49
Feb	17	327.81	Apr	17	26.49	Jun	17	85.33	Aug	17	143.61	Oct	17	203.10	Dec	17	264.51
Feb	18	328.82	Apr	18	27.47	Jun	18	86.29	Aug	18	144.57	Oct	18	204.10	Dec	18	265.53
Feb	19	329.83	Apr	19	28.45	Jun	19	87.24	Aug	19	145.53	Oct	19	205.09	Dec	19	266.54
Feb	20	330.84	Apr	20	29.42	Jun	20	88.20	Aug	20	146.49	Oct	20	206.08	Dec	20	267.56
Feb	21	331.85	Apr	21	30.40	Jun	21	89.15	Aug	21	147.45	Oct	21	207.08	Dec	21	268.58
Feb	22	332.85	Apr	22	31.38	Jun	22	90.10	Aug	22	148.42	Oct	22	208.07	Dec	22	269.60
Feb	23	333.86	Apr	23	32.35	Jun	23	91.06	Aug	23	149.38	Oct	23	209.07	Dec	23	270.62
Feb	24	334.87	Apr	24	33.33	Jun	24	92.01	Aug	24	150.34	Oct	24	210.06	Dec	24	271.64
Feb	25	335.87	Apr	25	34.30	Jun	25	92.97	Aug	25	151.31	Oct	25	211.06	Dec	25	272.66
Feb	26	336.88	Apr	26	35.27	Jun	26	93.92	Aug	26	152.27	Oct	26	212.05	Dec	26	273.68
Feb	27	337.88	Apr	27	36.25	Jun	27	94.87	Aug	27	153.24	Oct	27	213.05	Dec	27	274.69
Feb	28	338.89	Apr	28	37.22	Jun	28	95.83	Aug	28	154.20	Oct	28	214.05	Dec	28	275.71
			Apr	29	38.19	Jun	29	96.78	Aug	29	155.17	Oct	29	215.05	Dec	29	276.73
			Apr	30	39.17	Jun	30	97.74	Aug	30	156.13	Oct	30	216.05	Dec	30	277.75
									Aug	31	157.10	Oct	31	217.05	Dec	31	278.77

Meteor science

Visual Alpha-Aurigids in Trenčín

Jozef Drga [1]

The article deals with visual observation of the 2005 α-Aurigid meteor shower observed from the location of Kykula near Trenčín, IMO observation site code 23711, Slovakia. In this contribution, the observed zenithal hourly rates, the population index, the average visual magnitude and the occurrence of persistent trains are presented and discussed. The results are compared with previous publications.

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1 Introduction

The visual meteor database of the IMO presents the α-Aurigid shower as the most active meteor shower in September. The shower was discovered by C. Hoffmeister and A. Teichgraeber (Sonneberg, Germany) in 1935. They observed 30 meteors per hour from a radiant at $\alpha = 84\overset{\circ}{.}2$ and $\delta = +42\overset{\circ}{.}0$. The meteors had an average magnitude of +2.62. They found that 74 per cent of the meteors with magnitudes brighter than +3.5 had peristent trains (Hoffmeister, 1936).

2 Background information on the α-Aurigids

The α-Aurigids have an average zenithal hourly rate (ZHR) of about 7 meteors per hour at maximum. The shower is active from August 25 to September 8. Enhanced activity of the shower with about 30 meteors per hour was observed in 1935, 1986 and 1994 (McBeath, 2004). The shower maxima appear in the interval of solar longitudes $158\overset{\circ}{.}42$–$158\overset{\circ}{.}83$ (Dubietis & Arlt, 2002), and in 2005 the maximum was expected to appear at the solar longitude of $158\overset{\circ}{.}6$ corresponding to 2005 September 1, $00^{h}00^{m}$ UT (McBeath, 2004). The parent comet is probably C/1911 N1 (Kiess). The comet has a very long period of about 2000 years. The meteor outbursts are probably caused by perturbations of Jupiter and Saturn (Jenniskens, 1997). Meteoroids of this stream are fast, the entry velocity into the Earth's atmosphere is $v_\infty = 66$ km/s. Their population index varies between 2.3 and 3.1 (Dubietis & Arlt 2002), as shown in Table 1. The radiant location in right ascension is 84° and in declination +42° (McBeath, 2004).

Table 1 – Profile of the population index r after Dubietis & Arlt (2002) where $\lambda_\odot$ is the solar longitude for equinox J2000.0.

$\lambda_\odot$	r
$150\overset{\circ}{.}5$	2.9
$152\overset{\circ}{.}5$	3.1
$153\overset{\circ}{.}5$	2.6
$154\overset{\circ}{.}5$	2.3
$155\overset{\circ}{.}5$	2.4
$156\overset{\circ}{.}5$	2.6
$157\overset{\circ}{.}5$	2.7
$158\overset{\circ}{.}5$	2.5
$159\overset{\circ}{.}0$	2.4
$160\overset{\circ}{.}0$	2.6
$161\overset{\circ}{.}0$	2.6
$162\overset{\circ}{.}5$	2.6

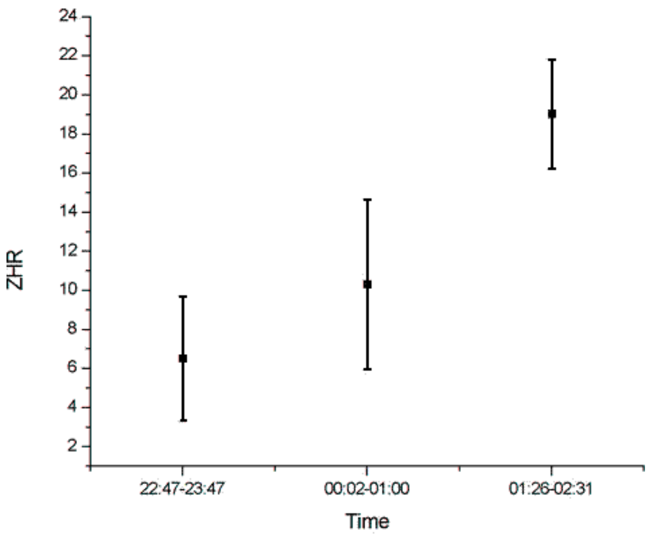

Figure 1 – The ZHR profile.

3 Observations

In this contribution, we present visual observations of the shower at Kykula (near Trenčín, IMO observing site code 23711, Slovakia) performed by a group of six observers near the expected peak of the shower's activity. The observations were carried out during the night of 2005 August 31/September 1, between $22^{h}47^{m}$ and $02^{h}31^{m}$ UT. The period was divided into three time intervals: $22^{h}47^{m}$–$23^{h}47^{m}$ UT, $00^{h}02^{m}$–$01^{h}00^{m}$ UT, and $01^{h}26^{m}$–$02^{h}31^{m}$ UT. Out of the total of 131 records, we identified 30 meteors as α-Aurigids. The average limiting magnitude during the observation was +6.04. The solar longitude in Table 3 is calculated for the the center of each interval.

For the computation of the Zenithal Hourly Rate (ZHR), we used the equation

$$\mathrm{ZHR} = \frac{NFr^{6.5-\mathrm{Lm}}}{T_{\mathrm{eff}} \sin h}, \qquad (1)$$

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NASA-ADS bibcode 2010JIMO...38..182D

Table 2 – Fraction of persistent trains.

Trains	N	Percentage
duration < 1 s	3	10.0%
duration = 1 s	14	46.7%
without trail	13	43.3%

where N is the number of shower meteors, F is the cloud correction factor, r is the population index, Lm is the stellar limiting magnitude, T_{eff} is the effective observing time, and h is the radiant altitude. The average ZHR is computed by

$$\overline{\text{ZHR}} = \frac{1}{n_{\text{obs}}} \sum_i \text{ZHR}_i, \tag{2}$$

where n_{obs} is the number of intervals used for the average. The error of the individual ZHRs is computed by

$$\Delta\text{ZHR} = \text{ZHR}/\sqrt{N} \tag{3}$$

The errors were averaged by

$$\overline{\Delta\text{ZHR}} = \frac{1}{n_{\text{obs}}} \sqrt{\sum_i \Delta\text{ZHR}_i^2}. \tag{4}$$

4 Conclusion

The ZHR profile is shown in Figure 1 while Table 2 lists the occurrence of persistent trains in the meteor shower. An average ZHR of the meteor shower derived from our observation is 11.9 ± 3.0. The ZHR was calculated assuming a population index of the shower of $r = 2.6$ (2005 Meteor Shower Calendar of the IMO by McBeath 2004). Our ZHR is a bit higher than the value of ZHR = 7 given by IMO and derived for the maximum by Dubietis and Arlt (2002). The population index value obtained from our observations ($r = 2.3 \pm 0.3$) is consistent with the value expected around the activity peak which is about 2.3–2.6 (Dubietis & Arlt, 2002).

For meteors with magnitudes brighter than +3.5, we observed persistent trains in 56.7 per cent of the cases (10.9 per cent of these were trains of a duration of about 1 second, 50.9 per cent of the trains with a duration shorter than 1 second and 38.2 per cent of meteors were without a persistent train). This is smaller than the value obtained by Hoffmeister (74 per cent) for meteors with magnitudes brighter than +3.5 (Hoffmeister, 1936).

Table 3 – The ZHR profile.

Interval	Observer	N	ZHR	Error
$22^{\text{h}}47^{\text{m}}$–$23^{\text{h}}47^{\text{m}}$	SUSMA	6	17	
	SUSMI	1	3	
	PELOW	0	0	
	BAKPE	2	6	
	Average	2.2	6.5	3.3
$00^{\text{h}}02^{\text{m}}$–$01^{\text{h}}00^{\text{m}}$	SUSMA	7	14	
	SUSMI	0	0	
	PELOW	6	18	
	Average	4.3	10.7	4.4
$01^{\text{h}}26^{\text{m}}$–$02^{\text{h}}31^{\text{m}}$	SUSMA	14	23	
	DRGJO	6	15	
	Average	10	19	2.8
	Total	5.0	11.9	3.3

The meteors with magnitudes from the interval −0.5 to +4.0 had an average magnitude of +1.98. The average magnitude found by Tepliczky (1987) is +0.5 and the one found by Hoffmeister (1936) is +2.62. Tepliczky uses the interval of meteor magnitudes ranging from −4.0 to +4.0.

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Handling Editor: Rainer Arlt

SPA Meteor Section Results: 2006

Alastair McBeath [1]

A summary of the main analyzed results and other information provided to the SPA Meteor Section from 2006 is presented and discussed. Events covered include: the radio Quadrantid maximum on January 3/4; an impressive fireball seen from parts of England, Belgium and the Netherlands at $22^h53^m51^s$ UT on July 18, which was imaged from three EFN stations as well; the Southern δ-Aquarid and α-Capricornid activity from late July and early August; the radio Perseid maxima on August 12/13; confirmation that the October 5/6 video-meteor outburst was not observed by radio; visual and radio findings from the strong, bright-meteor, Orionid return in October; another impressive UK-observed fireball on November 1/2, with an oil painting of the event as seen from London; the Leonids, which produced a strong visual maximum around $04^h - 05^h$ UT on November 18/19 that was recorded much less clearly by radio; radio and visual reports from the Geminids, with a note regarding NASA-observed Geminid lunar impact flashes; and the Ursid outburst recorded by various techniques on December 22.

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1 Introduction

This paper continues the process of catching-up with the postponed SPA Meteor Section results articles in *WGN*, begun with (McBeath, 2010), dealing this time with an overview of the main events during 2006. In doing so, material previously unpublished is given, as well as updating some of the preliminary information published earlier online in the SPA's fortnightly Electronic News Bulletins (ENBs). Indexes linked to the archived ENBs and other reports on the SPA's website are freely available to anyone who wishes to see them, via the Section's homepage, at: `www.popastro.com/sections/meteor.htm`. Analyses were carried out on the results received as described in (op. cit.).

2 Observing totals and observers

Overall, 2006 saw increases in observer activity compared to 2005 for the Section. August (where the Perseids were a difficult target because of the Moon) and September were the main exceptions, with mostly poorer visual results than in the previous year. October to December were significantly better, by contrast. The difficulties due to the decline in visual observers, and the lack of radio data much outside European and North American longitudes, persisted, but the amount of video data continued to rise significantly throughout the year, while the amount of radio data also rose. Table 1 gives the year's main totals.

The list of contributing observers follows. Abbreviations indicate where observations other than visual watching were provided: 'I' = still-imaging, 'R' = radio and 'Vi' = video. '+ V' indicates visual data were additionally submitted. Many of the reports arrived in the form of summaries in publications, including in the American Meteor Society's (`www.amsmeteors.org`) journal *Meteor Trails* made available via its editor Robert Lunsford, the Arbeitskreis Meteore's journal *Meteoros*, (`www.meteoros.de`) provided by Ina Rendtel, and the Radio Meteor Observation Bulletins (RMOBs), sent in by its editor, Chris Steyaert. Some observers' data featured in more than one place, and some observers sent in separate reports directly or via a third person as well, with Richard Taibi particularly helpful in forwarding useful results from other people. Observers who reported electronically sometimes used a pseudonym, and where no other name could be established for such people, these have been given below within quotation marks. In general, where an observer submitted data to more than one place, just one option has been selected to indicate where those results may be found.

Alice Adams (Missouri, USA; AMS), Enric Algeciras (Spain; R, RMOB), Megan Argo (England; R), "Aspicio Astrium" (UK), Jure Atanackov (Slovenia; AMS), "@@" (England), Pierre Bader (Germany; AKM), Kacem Bankih (Algeria; AMS), "barf" (England), Basingstoke Astronomical Society (England; 5 observers), Orlando Benitez (Canary Islands; R, RMOB), Ray Berg (Indiana, USA; AMS), Mike Boschat (Nova Scotia, Canada; R, RMOB), Jeff Brower (British Columbia, Canada; R, RMOB), Geoff Burt (England), Alessandro & Giuseppe Candolini (Italy; R, RMOB), Mike Clarke (England; I), Tim Cooper (South Africa), Brian Cudnik (Texas, USA; AMS), Mike Dale (Scotland), Sarthak Dasadia (Gujarat, India), "DaveP" (England), Maurice de Meyere (Belgium; R, RMOB), Gaspard De Wilde (Belgium; R, RMOB), John Drummond (New Zealand; AMS), Audrius Dubietis (Lithuania), David Entwistle (England; R + V, RMOB), Frank Enzlein (Germany; AKM), Steve Evans (England; Vi), Leslie Ewan (Scotland), Mike Feist (England), Pam Foster (Scotland), "G1ZmO" (Scotland), Dave Gavine (Scotland), Valter Gennaro (Italy; R, RMOB), Christoph Gerber (Germany; AKM), Ghent University (Belgium; R, RMOB), George Gliba (Virginia & West Virginia, USA; AMS), Bill Godley (Oklahoma, USA), Robin Gray (California & Nevada, USA; AMS), "Gregger" (England), Valentin Grigore (Romania; I), Patrice Guérin (France; R, RMOB), Wayne Hally (New Jersey, USA; AMS), "Hampshire Astronomer" (England), Robert Hays (Illinois & Indiana, USA; AMS), Howard Hendrix (California, USA), "HippyChippy" (England), Martin Hörenz

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NASA-ADS bibcode 2010JIMO...38..184M

Table 1 – Visual, video and radio hours' totals, visual and video meteor numbers recorded (with a partial breakdown of visual types), per month. Only up to three main showers per month, plus the Antihelions, ANT, have been listed for the visual breakdowns to conserve space. Though the ANT were not recognised as such in 2006, various near-ecliptic sources that now form part of the ANT were, and these have been simply combined here. In addition to these totals, 0.7 h of still-imaging for 3 trails was reported from August, plus another 8 h (12 trails) from November, and 0.2 h (1 trail) in December.

Month	Visual						Video		Radio
	Hours				ANT	Meteors	Hours	Meteors	hours
		QUA							
January	31.1	168			13	334	46.1	451	8282
February	37.2	–			33	214	46.4	183	7788
March	57.0	–			61	331	35.4	113	8046
		LYR	ETA						
April	35.1	80	0		25	202	83.8	295	8057
May	90.2	–	70		72	646	70.2	356	7274
		JBO							
June	85.4	9			96	625	97.1	344	6208
		SDA	CAP	PER					
July	183.7	290	162	285	158	2155	88.2	408	4661
August	140.0	56	35	854	75	1948	154.8	1247	5989
		AUR	DAU						
September	107.3	25	114		96	1137	182.8	1005	7645
		ORI	STA	NTA					
October	239.5	3541	278	197	–	6012	159.0	2294	8723
		LEO							
November	181.6	786	97	141	–	2609	185.5	1155	8088
		GEM	URS	COM					
December	170.0	4114	130	68	–	5689	291.5	2710	9097

(Germany; AKM), "jeremy1133" (Germany), Carl Johannink (Netherlands & Spain; AMS), Edwin Jones (Arkansas, USA; AMS), Javor Kac (Slovenia; AMS), Szabolcs Kiss (Hungary; R, RMOB), André Knöfel (Czech Republic & Germany; AKM), Peter Knol (Netherlands; R, RMOB), Ralf Koschack (Germany; AKM), Ralf Kuschnik (Germany; AKM), Pete Lawrence (England; I), Tony Lawson (England), Thomas Lazuka (Illinois, USA; AMS), Robert Lunsford (California, USA; Vi + V, AMS), Hartwig Lüthen (Germany; AKM), Tony Markham (England), Jack Martin (England), Nick Martin (Scotland), Pierre Martin (Ontario, Canada & Tennessee, USA; AMS), Paul Martsching (Iowa, Missouri, Nevada & Wisconsin, USA; AMS), Mike Maunder (Channel Islands), Alastair McBeath (England), Bruce McCurdy (Alberta, Canada), Tom McEwan (Scotland), Jim McGraw (Iowa, USA; AMS), Gary McGrory (Scotland), Norman McLeod (Florida, USA; AMS), Cliff Meredith (England), "Mike" (England), Jane Mills (England), Sirko Molau (Germany; Vi + V, AKM), "Montpelier 42" (England), "moonie" (England), Steven Morrison (England), Mike Morrow (Hawaii, USA; AMS), Sven Näther (Germany & Turkey; AKM), Cristian Negru (Romania; R, RMOB), Stan Nelson (New Mexico, USA; R, RMOB), Paul Nicholson (England; R + V), Sadao Okamoto (Japan; R, RMOB), Mike Otte (Illinois, USA; R, RMOB), Peter Phillips (Northern Ireland), "Pictobug" (Scotland), Thomas Rattei (Austria; AKM), Jean-Louis Rault (France; R, RMOB), Jürgen Rendtel (Canary Islands, Germany & Greece; AKM), Gilberto Renner (Brazil; R), Clive Rogers (England; I), Tom Russell (UK), William Sager (Texas, USA; AMS), Robin Scagell (England; I + V), Jonathan Shanklin (England), Andy Smith (England; R, RMOB), Lawrence Smith (England), Ulrich Sperberg (Germany, AKM), Jeff Stevens (England), Enrico Stomeo (Italy; Vi), Wesley Stone (Oregon, USA), Magda Streicher (South Africa), Dave Swan (England; R, RMOB), David Swann (Oklahoma & Texas, USA; AMS), Istvan Tepliczky (Hungary; R, RMOB), Robert Togni (Arkansas, USA; AMS), Dave Turner (England), Michel Vandeputte (Belgium), Felix Verbelen (Belgium; R, RMOB), Frank Wächter (Germany; AKM), Sabine Wächter (Czech Republic; AKM), Derek Ward-Thompson (France), William Watson (Arizona & New York, USA; AMS), Thomas Weiland (Austria), Linda Wilson (Hawaii, USA; AMS), Roland Winkler (Germany; AKM), Graham Winstanley (England), Kim Youmans (Georgia, USA; AMS).

3 Radio Quadrantids

Given the expected moonless observing circumstances for the 2006 Quadrantid maximum, due around 18^h20^m UT on January 3 (McBeath, 2005a, p. 3), it was disappointing to find many visual observers had struggled with some very poor weather, collecting far fewer data than might have been hoped. Arlt (2006) for example, somewhat tentatively suggested peak ZHRs of 85 ± 17 were achieved substantially later than expected, around 23^h40^m UT on January 3, possibly with a lesser maximum around 19^h UT when ZHRs were $\sim 60 \pm 17$.

Brower (2006) carried out a numerical analysis of various radio meteor data near the expected Quadrantid peak. He found a raised level in activity significantly above the sporadic rate between $10^{\rm h}$ UT on January 3 and $06^{\rm h}$ UT on January 4, with the strongest sustained activity from $19^{\rm h} - 22^{\rm h}$ UT on January 3. The more likely maximum time from the echo-count results fell in the $19^{\rm h} - 20^{\rm h}$ UT interval ($\lambda_{\odot} \sim 283\overset{\circ}{.}19 - 283\overset{\circ}{.}23$), but the echo-duration results suggested a peak in the $18^{\rm h} - 19^{\rm h}$ UT period instead ($\lambda_{\odot} \sim 283\overset{\circ}{.}15 - 283\overset{\circ}{.}19$), perhaps with a brief secondary peak around $22^{\rm h}$. Longer-duration radio echoes are typically thought due to increased rates of brighter meteors, thus perhaps were indicative of the more likely visual maximum times.

After becoming SPA Assistant Meteor Director in early 2007, David Entwistle carried out an investigation of the RMOB results from the 2006 Quadrantid period (personal communications, March 2007), using an amended version of the 'SBV' computational method published earlier in *WGN* (Steayert et al., 2006a). His findings were that Quadrantid activity was above the background sporadic level from $14^{\rm h}$ UT on January 2 to $22^{\rm h}$ UT on January 4, with a mean peak time of $18^{\rm h}51^{\rm m}$ UT on January 3 ($\lambda_{\odot} = 283\overset{\circ}{.}183$). There was however considerable scatter between the individual calculated maximum timings, from $13^{\rm h}37^{\rm m}$ to $22^{\rm h}10^{\rm m}$ UT on January 3.

Using the established SPA method for examining the raw radio data, I had already found three possible radio maxima during the Quadrantid epoch in 2006 (McBeath, 2006a), with enhanced echo-counts persisting in at least some of the datasets from $00^{\rm h}$ UT on January 3 to $11^{\rm h}$ UT on January 4. The first possible peak was recorded by most of the European and one of three North American systems, between $\sim 12^{\rm h} - 16^{\rm h}$ UT on January 3, probably centred within an hour of $\sim 14^{\rm h}$ UT ($\lambda_{\odot} \sim 282\overset{\circ}{.}98 \pm 0\overset{\circ}{.}04$). This centre put it soon after one of the radiant's best-detectable intervals from Europe and during one over North America, so may simply have been an artefact of the observing geometry. The second peak was detected from all three main geographic regions available, Japan, Europe and North America. It occurred between $\sim 19^{\rm h} - 22^{\rm h}$ UT on January 3, and was probably at its best within an hour of $20^{\rm h}$ UT ($\lambda_{\odot} \sim 283\overset{\circ}{.}23 \pm 0\overset{\circ}{.}04$). This seemed plausibly the main Quadrantid maximum, because it was found even in some of the European results, despite the radiant being very low from such sites then. There was no good indication found suggesting stronger echo-counts around the $\sim 18^{\rm h}20^{\rm m}$ UT predicted peak time. The third possible peak was again recorded from all three geographic areas, albeit weakest in Japan and most strongly from Europe, around $\sim 03^{\rm h} - 07^{\rm h}$ UT on January 4, probably at best in the one-hour interval either side of $05^{\rm h}$ UT ($\lambda_{\odot} \sim 283\overset{\circ}{.}61 \pm 0\overset{\circ}{.}04$). Though this timing fitted to one of Europe's best-observable periods for the shower, it also coincided with one of the poorest times for North American radio observations, thus raising its potential significance. A $\sim 05^{\rm h}$ peak would have followed the $\sim 20^{\rm h}$ one by around nine hours, perhaps indicative of a recurrence of the secondary maximum some nine to twelve hours after the main peak. Although this was not found in 2005, it had been suggested as a possibility by some previous recent SPA results (see McBeath, 2010 for references).

Using the video data from Enrico Stomeo, crudely corrected for sky conditions and radiant elevation as noted in (op. cit.), possible peaks were found around $19^{\rm h} - 21^{\rm h}$ UT on January 3, $00^{\rm h} - 01^{\rm h}$ and $02^{\rm h} - 05^{\rm h}$ UT on January 4. The first and third intervals were particularly interesting compared to the radio results (remembering that the start of morning twilight from Enrico's site was around $05^{\rm h}$ UT in early January). Three of the eight viable European radio datasets hinted at a possible weak sub-maximum around $01^{\rm h} - 02^{\rm h}$ UT on January 4 too, but although the initial visual reports submitted to the Section from January 3/4 also suggested a possible weak maximum centered near $01^{\rm h}$ UT, this was much less apparent when more data became available subsequently.

4 July 18/19 fireball

Sightings from at least eleven places in England, Belgium and the Netherlands reached the SPA on a spectacular magnitude −9 fireball at $22^{\rm h}53^{\rm m}51^{\rm s}$ UT on July 18, one of 57 meteors of magnitude −3 and brighter reported from UK and nearby sites during 2006, away from the major shower maxima. Among the reports was an impressive image by Klaas Jobse at Oostkapelle in the Netherlands, from his all-sky automated meteor camera system, operating as part of the European Fireball Network (EFN). Two other EFN stations were lucky in catching the trail as well, both in Germany, one at Herford near Bielefeld, the other at Daun in Rheinland-Pfalz. Various detailed descriptions were subsequently published, including by the Belgian VVS meteor group in print (Steayert et al., 2006b; Steayert, 2007) and online, with a detailed report on the object's pre-atmospheric orbit and intra-atmospheric trajectory prepared by Dieter Heinlein and Pavel Spurny (2007). These published details confirmed the initially-suggested trend of the object's trajectory, from roughly south-southeast to north-northwest over western Belgium to the southern North Sea. Heinlein & Spurny (loc. cit.) indicated the start was around 100 km altitude above a point about 30 km east of Lille ($50\overset{\circ}{.}67$ N, $3\overset{\circ}{.}67$ E), and the end roughly 75 km east-southeast of Orford Ness in Suffolk, England ($51\overset{\circ}{.}92$ N, $2\overset{\circ}{.}33$ E), at 45 km above the North Sea. The object's atmospheric velocity was around 36–38 km/s.

5 Southern δ-Aquarids and α-Capricornids

As commonly in years when the Perseid maximum in August is badly moonlit, the attention of the keener observers switched primarily to covering the much less moonlit late-July shower maxima in 2006. A particular examination was possible of these two main sources, among those mostly minor near-ecliptic showers still recognised as separate from the ANT then, for the first time since 2003 (McBeath, 2005b). Figures 1 and 2 give ZHR graphs for the Southern δ-Aquarids, SDA,

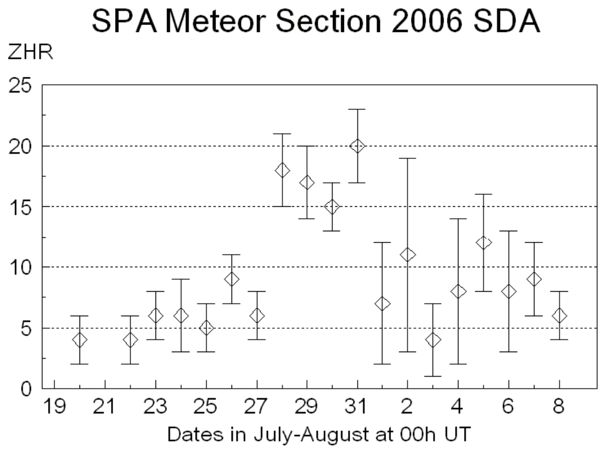

Figure 1 – Nightly mean ZHRs for the SDA during 2006 July–August.

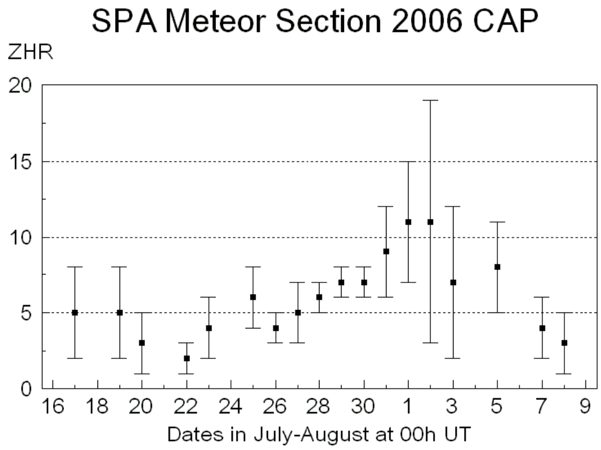

Figure 2 – Nightly mean ZHRs for the CAP during 2006 July–August.

and α-Capricornids, CAP, respectively, in both cases computed using an assumed $r = 2.5$.

In both graphs, the increased scatter into early August seemed to reflect both a drop in observer interest once the predicted maxima were past, and the decreasing amount of overnight Moon-free conditions, as full Moon approached on August 9. The SDA graph, while picking-out the predicted maximum on July 28 (McBeath, 2005a, p. 10) gave a less clear response than found in either 2003 or the twenty-year-average IMO graph in (Rendtel & Arlt, 2008, Fig. 8.26, p. 141). Perhaps the most curious element was the unexpectedly late, strongest, phase of the July 27–31 protracted peak, on July 31 ($\lambda_\odot \sim 128°$), although the IMO long-term study did suggest a very much weaker sub-maximum was present around $\lambda_\odot \sim 130° - 131°$, that might be related.

The CAP appeared to be rather more active than normal, with ZHRs nearer 10 than the ~ 5 of the 1997–2002 IMO results illustrated in (op. cit., Fig. 8.25, p. 140), or those found in the SPA analysis for 2003. The scatter involved in many of the near-maximum datapoints made this rather uncertain, but activity did seem to be protractedly at or above ZHRs of ~ 5 for significantly longer than usual in 2006. The peak timing, suggested by this as around July 31–August 2, $\lambda_\odot \sim 128° - 130°$, fitted with both the IMO graphs, and the 2003 results, rather than the $\lambda_\odot = 127°$, 2006 July 30 date stated by (op. cit., p. 139) and (McBeath, 2005a, p. 10).

Radio results during the northern summer of 2006 were badly affected by interference, especially Sporadic-E, and while some of the more-complete surviving data sets suggested the typical increased radio counts were present in late July and early August, it proved impossible to determine a clearer pattern beyond this with any confidence.

6 Radio Perseids

Bright moonlight greatly hindered visual Perseid observations in 2006, though what were possible suggested a relatively weak return in the IMO results (Rendtel, 2008, especially pp. 72–73), with ZHRs no better than ~ 60 around $\lambda_\odot = 140\overset{\circ}{.}3$ (2006 August 13, 06^h30^m UT). The SPA visual data unsurprisingly concurred with these findings. Interference reduced the available viable radio-meteor data too across the shower's expected peak, due around $23^h - 01^h30^m$ UT on August 12/13 (McBeath, 2005a, p. 9). Those eight datasets that mostly survived (five in Europe, two in North America, one in Japan) generally showed enhanced echo counts from August 11–13, and while the Perseid signature was not particularly pronounced, which often seems to happen with this shower, a clearer peak was apparent in most on August 12/13 than is sometimes the case. In detail, three possible UT peak intervals were revealed, around August 12, 19^h (all three geographic areas; $\lambda_\odot \sim 139\overset{\circ}{.}84$), August 13, $01^h - 03^h$ (Europe only; $\lambda_\odot \sim 140\overset{\circ}{.}08 - 140\overset{\circ}{.}16$) and $07^h - 08^h$ (North America & Europe; $\lambda_\odot \sim 140\overset{\circ}{.}32 - 140\overset{\circ}{.}36$). The $\sim 19^h$ peak on August 12 was apparently quite sharp, and the fact it was recorded by some systems in all three regions available might suggest it as the more significant, but the limited IMO data indicated relatively flat ZHRs near and just after this time, with ZHRs only ~ 45. The $\sim 02^h$ interval coincided with one of the better-detectable times from Europe, reducing that peak's significance considerably, while the observing geometry around $07^h - 08^h$ was not particularly favourable for any of the three geographic areas, so its importance can be considered somewhat magnified. Overall, the $\sim 06^h - 08^h$ UT period on August 13 probably represented the main visual-radio Perseid peak, but the 19^h UT radio peak the previous day remains an intriguing feature. It is interesting too that none of the results favoured a maximum particularly near the predicted $23^h - 01^h30^m$ UT period on August 12/13.

7 October 5/6 meteors

Three notices on *IMO-News* for 2006 October 6 alerted observers to the fact another weak burst of video activity had occurred from a similar source to that found in 2005, with a radiant in Draco around $\alpha = 162°$, $\delta = +79°$. Of these, Molau (2006b) included most of

Table 2 – Global magnitude distributions for the 2006 Orionids and October sporadics seen under better sky conditions (cloud cover < 20%, LM = +5.5 or better), including mean LMs and corrected mean magnitudes. Data were collected between October 19–27.

Shower	≤ -3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$\geq +5$	Total	LM	$\overline{m}_{6.5}$
ORI	18	7	24	43	58	129	116	87	21	503	+6.44	+2.04
SPO	2	1	0	7	9	22	57	47	17	162	+6.45	+3.06

the early detail, indicating the event was again brief, lasting a few hours, as detected from three sites in central Europe. He also seemed to consider this sufficient evidence to claim the source was an annually-active, brief shower, and subsequently claimed (Molau, 2006a) the source had been "quite clearly detected by radio in all the previous years", without indicating what years this 'all' might include. Unfortunately, my own investigations into radio meteor activity had already shown no evidence for a radio-detectable source exhibiting this kind of activity pattern around October 5 or 6 in the available evidence back to 1993. The 2005 event, as noted before (McBeath, 2005a), was extremely minor in the radio results, and without the video reports, would have passed unnoticed among the usual daily radio-meteor 'noise'. It is thus possible a similarly 'unnoticeable' radio signature may have been present in earlier years. However, no convincing evidence was found to support a recurrence in 2006, even after an abnormally close inspection of the RMOB data, and following detailed discussions with some of the active radio observers involved. It is of course important that the key interval identified from the video data so far, around $\lambda_\odot = 192\overset{\circ}{.}55 - 192\overset{\circ}{.}64$, should continue to receive regular coverage by all observing techniques – as has been highlighted in the more recent IMO Meteor Shower Calendars – to identify any subsequent events. Naturally, the radio results will be routinely checked too, without prejudice, as part of that on-going process.

8 Orionids

With new Moon on October 22 falling almost perfectly for the expected Orionid maximum on October 21 (McBeath, 2005a, pp. 14–15), and a much stronger, protracted maximum than normal having taken place (IMO results in (Rendtel, 2007)), it was disappointing weather conditions across the UK for the shower were remarkably poor, and only limited observing was possible from here. Thanks to overseas contributors however, it was practical to construct a ZHR graph across the shower, as shown in Figure 3. Originally, the ZHRs for this were calculated using an assumed r of 2.5, but it was clear from even some of the early observers' comments, that unusual numbers of brighter Orionids were present in the shower, and after consideration of the magnitude data available, this was eventually reduced to $r = 2.2$. The IMO findings suggested this might have been reduced still more, to 2.0 or 1.9 as a general value, which overall would have reduced the SPA ZHRs somewhat, but would not have substantially altered the character of Figure 3 (e.g. the strongest peak ZHR was ~ 79 in the SPA results and ~ 59 in the IMO). Table 2 has a global magnitude distribution for the shower and the October sporadics.

Sub-maximum features between October 20–24 were much as found in Rendtel's IMO analysis, the only missing main element in the SPA results the sharp sub-peak rising to ZHRs of ~ 47 near $\lambda_\odot = 211\overset{\circ}{.}79$ (October 25, 10^h45^m UT), due to a gap in the available data. Two outlying, lesser peaks were suggested on October 17 and 29 in the SPA results, of which only the latter was also found in the IMO data.

Interference and equipment problems bedevilled the radio coverage again, but as in 2005, the Orionid profile was generally clearly apparent in the surviving results, especially between October 20–24 or 25, with the main maximum likely on October 21, and a secondary peak around October 23. Figures 4 and 5 show two of the more complete sets of radio results across the Orionids. Only two North American radio observers were placed and able to usefully cover the $\sim 10^h - 11^h$ UT interval on October 25, and of those only Jeff Brower recorded a strong spike in echo-counts in both the 10^h and 11^h UT recording periods, at a level for both hours marginally higher than his otherwise best counts, in the 10^h and 12^h UT one-hour counting intervals on October 21. Stan Nelson was the other observer, but as Fig. 4 demonstrates, his counts had dropped back to near-normal quantities by October 25. Jeff's data (see RMOB 159) were for count levels including more underdense echoes, so due to fainter meteors, compared to Stan's, so it is interesting that (Rendtel, 2007) found the r-value had risen to 2.82 during this October 25 peak, whereas it had been ~ 1.8 at the same time the previous day, as estimated from Rendtel's Figure 1 graph.

The Figures 4 and 5 graphs here were chosen partly

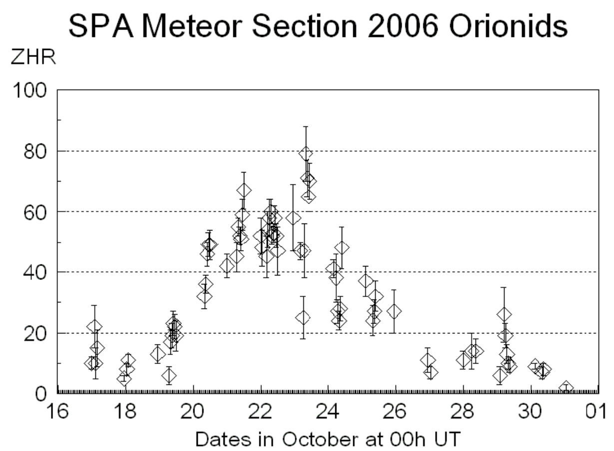

Figure 3 – Mean Orionid ZHRs during October 2006, calculated using $r = 2.2$.

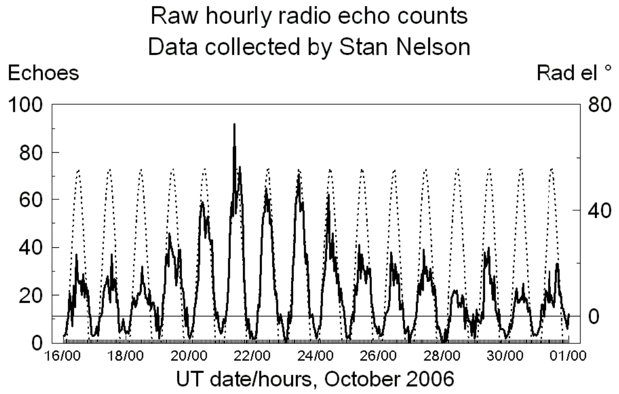

Figure 4 – Raw hourly radio echo counts from the second half of October, extracted from data collected by Stan Nelson, as given in RMOB 159, October 2006. The thicker, irregular line, keyed to the left-hand y-axis, shows the raw hourly echo count values, while the thinner, daily-symmetrical, curve (keyed to the right-hand y-axis) gives the Orionid radiant elevation for his site. Note that this graph (only) has been corrected to show the echo counts in UT, whereas the original RMOB report, though claiming to have shown the time-base in UT, had actually given it in local time instead.

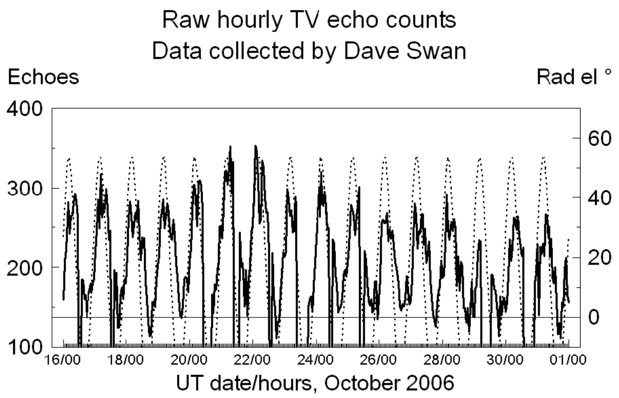

Figure 5 – As Figure 4, but giving all-echo raw TV counts from data collected by Dave Swan. Drops in the echo-count line to zero were times when interference or equipment problems prevented observing.

because they gave some support for the possible minor maxima around October 29 and 17 respectively, shown in Fig. 3. Overall however, aside from the minor echo-count peak in Dave Swan's results on October 17, there was little else to confirm this possible visual event. As it was not found in the fuller IMO analysis, the likelihood of its significance was reduced further, so a repeat of the Orionid sub-peak found around this date occasionally in the past (e.g. 1993 and 1998 recently), was unconfirmed. There was somewhat better support for the October 29 minor peak in the radio results however, with those in Fig. 4 giving one of the clearer responses. The radio data did not support this peak being especially strong however, which the IMO ZHR of ~ 15 would tend to agree with.

9 November 1/2 fireball

A brilliant fireball of magnitude at least -8 to -10 was reported from five locations in England south of Derbyshire on November 1. Timing estimates suggested it probably occurred between $17^{\rm h}30^{\rm m}$ – $17^{\rm h}45^{\rm m}$ UT that evening, while the sky was still twilit after sunset. Most of the sightings suggested the meteor was following a track between roughly northeast-southwest to east-west, and may have passed high above the Berkshire region or nearby. Two observers reported hearing a sonic boom some minutes later, apparently from the general end direction, while one witness in Hyde Park, London mentioned hearing a distinct buzzing sound simultaneously with the meteor's flight too. Although the available information could not be fitted comfortably to a single solution, it seems possible the fireball extinguished at about 30 km altitude above the Fleet–Camberley area, near the borders of Hampshire, Surrey and Berkshire, as a best-estimate. Ordinarily, such an uncertain possible flight path would not warrant mentioning here, but for one fortunate thing: the Hyde Park observer, Garry Harwood, is an artist. He prepared a series of annotated sketches immediately after the event, and was later able to construct the painting shown here as Figure 6. The original was done in oils on canvas, and is about 40×30 cm in size.

Garry also provided the following comments about his painting:

"I have attempted to convey an impression of the 1st November 2006 fireball as observed at dusk from Hyde Park in central London. While I have seen many fireballs in four decades of observing, this event was unique in my experience as it represents the first time I have heard any kind of sonic effects associated with a fireball's flight. Perhaps most unusual were the quite distinct humming or buzzing sounds heard simultaneously with the passage of the fireball. These sounds appeared to emanate from all directions at once and only stopped when the fireball extinguished. They were followed some minutes later by a muted sonic boom. These simultaneous, so-called electrophonic, sounds, were analogous to what I imagine a recording of the 'clean' hum generated by high tension power lines or a transformer might sound like, if fed through a distorting amplifier and played back at medium volume via a loudspeaker!"

10 Leonids

Figure 7 illustrates the visual Leonid results provided to the Section. Despite the shower enjoying excellent lunar circumstances, the coverage possible was rather patchy away from the expected main peaks on November 18/19 unfortunately. The strongest activity was reported from November 19, around $04^{\rm h}$ – $05^{\rm h}$ UT, when ZHRs were fairly consistently $\sim 48 \pm 5$, without a clearer peak being apparent. Although $r = 2.5$ was used to compute these rates, the actual values were rather below the best IMO ZHRs from this same interval, which were of order 60–75 (Arlt & Barentsen, 2006). Information for the SPA magnitude distribution was rather limited too, but suggested the Leonids may have been somewhat fainter than normal. The relatively small number of meteors involved gave this aspect less reliability how-

Figure 6 – An oil painting by Garry Harwood of the 2006 November 1 fireball, as seen by him from Hyde Park in London. More examples of his work (including other astronomical paintings), can be found at: `www.nataraja.demon.co.uk`. ©Garry L. Harwood, 2006. Reproduced by permission.

ever, while the IMO findings were for a fairly typical magnitude distribution overall. Table 3 has the SPA Leonid epoch magnitude details. Trains were reported from 58 of 166 Leonids, $\sim 35\%$, compared with 6 of 134 sporadics, $\sim 5\%$.

The radio results showed no clear evidence for a nodal-crossing peak on November 17 at $\sim 21^{\rm h}$ UT (McBeath, 2005a, pp. 15–16), but increased activity

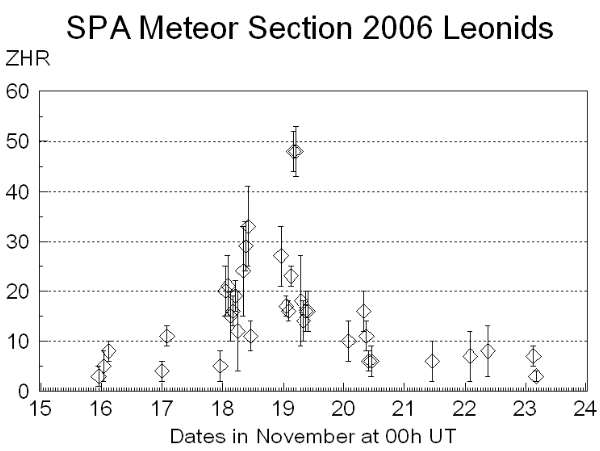

Figure 7 – Mean Leonid ZHRs during November 2006, calculated using $r = 2.5$.

very probably due to the Leonids was apparent between November 17–19 generally, often at a surprisingly similar level on all three dates. Activity was somewhat better overall in most of the viable datasets on November 19, but not all the results agreed on this. Even for those systems which did show a positive difference on this date, it was frequently quite marginal. A close inspection of the $04^{\rm h} - 06^{\rm h}$ UT period on the 19th provided at best just weak evidence for a Leonid peak during that time. Only Gaspard De Wilde's 10-second echo counts gave an unequivocally strong response then, particularly around $05^{\rm h} - 06^{\rm h}$ UT. Examining such a timing was complicated because solely the European observers had the shower's radiant above the horizon, from where the early part of this period also coincided with the latter stages of one of the Leonid radiant's best-observable times, plus the diurnal sporadic peak usually falls within this time-band for Europe, through till $\sim 08^{\rm h}$. After allowing for this, the poor response from most systems, but with one showing a clear peak, was still unexpected. There was no consensus suggesting the radio results had picked up any unusual meteoroid mass distribution during the early morning UT hours on November 19, which might have accounted for some systems preferentially ignoring the event, and interference seemed not to be present at the time in those

Table 3 – Global magnitude distributions for the 2006 Leonids and November sporadics, seen under better sky conditions (cloud cover < 20%, LM = +5.5 or better), including mean LMs and corrected mean magnitudes. Data were collected between November 17–22.

Shower	≤ -3	-2	-1	0	$+1$	$+2$	$+3$	$+4$	$\geq +5$	Total	LM	$\overline{m}_{6.5}$
LEO	1	5	10	17	24	55	49	31	10	202	+5.80	+2.84
SPO	1	1	3	8	21	30	56	35	17	172	+5.83	+3.39

datasets considered viable. Consequently, this odd response remains puzzling. It is of course possible there was a fainter-meteor component the visual observers were unable to detect, and which helped even-out the radio counts, but it is at least as likely this was simply one of the unhelpful vagaries which sometimes occur with radio meteor work.

11 Geminids

Storms across the British Isles for the near-maximum nights meant observers here had little opportunity to hunt for the better Geminid rates in near-moonless skies. Those elsewhere reporting to the Section were sometimes more fortunate, and Figure 8 indicates what visual coverage was possible during the shower. The maximum clearly fell on December 14, as expected (McBeath, 2005a, p. 17), with the strongest activity, ZHR $\sim 135 \pm 10$, persisting through both the 09^{h} and 10^{h} UT one-hour averaging intervals (a period equivalent to $\lambda_{\odot} \sim 262\overset{\circ}{.}10 - 262\overset{\circ}{.}19$), perhaps a little earlier and slightly higher than anticipated. However, and much as usual, Geminid ZHRs persisted very near or above ~ 100 for all 15 hours on which data was reported to the SPA on December 13/14. Similar temporal coverage on December 14/15 allowed one of the best determinations of the post-maximum activity 'cliff' of steeply-falling ZHRs the Section has been able to amass.

Geminid activity gave a clear radio response, with increased echo counts for two or three days across the expected visual peak, and most, though not all, systems enjoyed their stronger counts during the shower on December 13/14, usually coincident with one of the shower's best-detectable times. There was no strong consensus on a definite maximum time beyond this, so the visual results could not be confirmed this way.

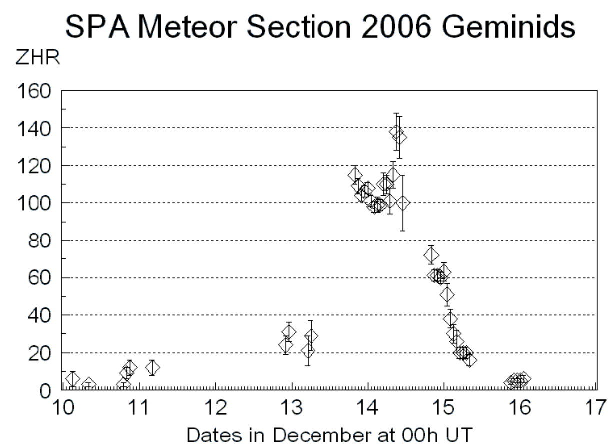

Figure 8 – Mean Geminid ZHRs from December 2006, calculated using $r = 2.5$.

One of the more interesting additional aspects of the 2006 Geminid maximum was the detection and recording of five 'definite' and one 'probable' Geminid lunar impact flashes on December 14 by NASA's Meteoroid Environment Group in Alabama, USA. This was at a rate of about one such impact event per hour, with the Moon around two days past last quarter on that date. Details can be sourced via their website `http://science.nasa.gov`.

12 Ursids

Predictions issued electronically shortly before the event added to IMO expectations for the perfectly moonless Ursid maximum, due between $\sim 19^{\mathrm{h}} - 21^{\mathrm{h}}$ UT on December 22, with ZHRs ~ 10 (McBeath, 2005a, pp. 18–19). Esko Lyytinen and Markku Nissinen predicted a possibly stronger peak on that date, thanks to Comet 8P/Tuttle's 996 AD dust trail, with ZHRs perhaps up to ~ 35 expected around $19^{\mathrm{h}}27^{\mathrm{m}}$ UT. They further indicated parts of the dust trail might be encountered at any stage from $\sim 18^{\mathrm{h}} - 21^{\mathrm{h}}$ UT, and that many of the meteors might be faint, with a sporadic-like magnitude distribution. Peter Jenniskens of the NASA SETI Institute also suggested a possible broad filament of Ursid dust might be present for some hours surrounding the normal IMO peak interval, and indicated a probable maximum at about $17^{\mathrm{h}}38^{\mathrm{m}}$ UT, with ZHRs ~ 40 of generally brighter meteors.

As usual in 2006, most of Britain managed to miss out on this shower too, with low cloud and fog for many people, and indeed only a handful of observers across Europe were able to report-on the event at all visually or by video. A few more elsewhere were able to add to this from other times, along with the radio observers. I gave detailed reviews of the observers and what had been reported by late December (McBeath, 2006b) and early January 2007 previously (McBeath, 2007), to which can now be added a further set of video results from Enrico Stomeo, plus more radio results from RMOB 161, December 2006.

The analysis was somewhat tentative, because of the results being so relatively few. However, the overall impression was of a stronger than normal Ursid maximum, probably peaking in the hour centred at $18^{\mathrm{h}}35^{\mathrm{m}} \pm 5^{\mathrm{m}}$ UT on December 22 ($\lambda_{\odot} = 270\overset{\circ}{.}678 \pm 0\overset{\circ}{.}003$), with mean ZHRs of $\sim 30 \pm 10$, set against a background of rates at least equal to the typical 'normal' peak. These were present from perhaps $12^{\mathrm{h}} - 23^{\mathrm{h}}$ UT that day, as far as the available results allowed. Activity seemed only marginally lower in the hour following this identified maximum, but seemed to have more definitely dropped, to ZHRs of $\sim 25\pm10$, in the hour centred on $20^{\rm h}45^{\rm m}$ UT, and fell further thereafter. The radio results concurred with this general pattern, with the viable results giving the most probable peak for December 22 in the $18^{\rm h}$ UT one-hour data-bin, continuing at a lower level into the $19^{\rm h}$ interval. There were suggestions in some datasets for possible peaks earlier as well, between $\sim 12^{\rm h} - 17^{\rm h}$ UT, particularly around $13^{\rm h}$ and $15^{\rm h}$ UT, a period for which there was little to no visual data available for correlation. Enrico Stomeo's video results did suggest an Ursid peak in the $30^{\rm m}$ interval centred at $17^{\rm h}42^{\rm m}$ UT, but the visual data then showed ZHRs $\sim 10 \pm 5$ (whether using $r = 2.5$ or 3.0), so its significance was unclear. This all seemed to support the idea that a broad Ursid dust filament was indeed present during the second half of December 22, but without clear maxima around $17^{\rm h}38^{\rm m}$ or $19^{\rm h}27^{\rm m}$ UT. Instead, a less-defined peak was apparent roughly halfway between these two predictions, with additional, if perhaps lesser, maxima earlier on the UT afternoon of December 22 in the radio results.

13 Conclusion

While the UK weather did its best to spoil things, as so often, the second half of 2006 produced plenty of meteoric interest, and the year overall was another busy one for the Section, with a good crop of casual fireball sightings. As always, my fulsome thanks go to all our contributing observers and correspondents for their efforts throughout the year, and in helping these analyses to continue. Good luck and clear skies for all your observing!

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History

Meteor Beliefs Project: Meteorite Veneration in the New World

Alastair McBeath [1]

Examples of meteoritic objects from the Americas, primarily Central and North America, which were apparently revered or otherwise considered supernaturally important by the native peoples there, are discussed, with which to compare previous Meteor Beliefs Project examinations of Old World meteorite veneration.

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1 Introduction

In earlier Meteor Beliefs Project articles, we have examined examples of veneration of meteorites, or other objects believed to have fallen from the skies, from the Old World, primarily within the Classical European civilizations (McBeath & Gheorghe, 2004; McBeath & Gheorghe, 2005; McBeath & Gheorghe, 2009). We have also discussed the practical reuse of meteoritic iron as ornaments, tools and weapons from various parts of the world (Hendrix et al., forthcoming; Larsen et al., forthcoming), and whether this might sometimes have included a degree of supernatural belief, if not true worship, concerning the objects involved. Here, I wish to tackle examples of meteorite veneration and other potentially supernatural meteorite reuse from the New World, particularly by the native peoples of Central and North America, to complement those previous papers.

2 Items already discussed

Figure 1 gives a sketch-map of part of northern America, to illustrate the general distribution of significant meteorite sites involved in this article and earlier ones. To recap, the objects and sites described before (all from Hendrix et al., forthcoming), included:

- The reuse of metal from the Brenham, Kansas, USA, pallasites by the Hopewell culture ($\sim$ 500 BC to $\sim$ 500 AD) as ornaments, tools and weapons, as recovered from various of their burial mounds in the Ohio, USA area;
- One $\sim$ 1500 kg octahedrite found in a ruined temple at Casas Grandes in Mexico, and a second, much smaller and now lost, iron from there, which had been wrapped and buried like a human mummy bundle. This was apparently similar to depictions and descriptions of the Aztec god Huitzilopochtli (though Casas Grandes was never part of the Aztec cultural area);
- A ten-tonne octahedrite near Morito, Mexico, said in 1619 AD to have been venerated since the natives first moved south to settle in Mexico; and
- An octahedrite strewnfield near Toluca, Mexico, in the former Aztec heartland, whose fragments were recovered and made into tools by the natives for many generations, worked with considerable skill by the local smiths when first recorded by non-natives in $\sim$ 1776 AD, if not apparently revered beyond this.

To these might be added:

- The Campo del Cielo octahedrite strewnfield in Argentina, South America, which was still believed to have fallen from the sky in fire by the natives in 1576 AD, though the actual event probably occurred in $\sim$ 2000 BC (ibid.);
- The, in some cases immense, Cape York irons around the shores of Melville Bay in northwest Greenland, which the Inuit had used for many generations as a source of metal for tools and weapons, the Inuit having settled Greenland in $\sim$ 1000 AD (Larsen et al., forthcoming). Two of the meteorites, The Woman (three tonnes) and The Dog ($\sim$ 400 kg) were named by the Inuit, but they do not seem to have been revered beyond that action; and
- A metal axe-head made from a single kamacite crystal, from an unknown date and location, but found in a native ruin somewhere in New Mexico, USA (ibid.)

The remainder of this article introduces and discusses material new to the Project.

3 Meteorites wrapped and buried

Figure 1 shows an apparent concentration of sites near Meteor Crater (formed $\sim$ 50 000 years ago) in the Canyon Diablo region of Arizona, USA, comprising those at Camp Verde, Navajo and Winona, all in Arizona too. This is somewhat misleading, as the Navajo and Winona meteorites were unrelated to those near Meteor Crater, leaving only the Camp Verde object directly connected, identical in chemistry and structure to those irons from the Canyon Diablo strewnfield, if quite different in having a smoothly-rounded physical appearance, and its associations. Winona however, also had strong links in its find-circumstances to the object at Camp Verde.

Like the Canyon Diablo meteorites, the 61.5 kg Camp Verde was a coarse octahedrite. It was found

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NASA-ADS bibcode 2010JIMO...38..193M

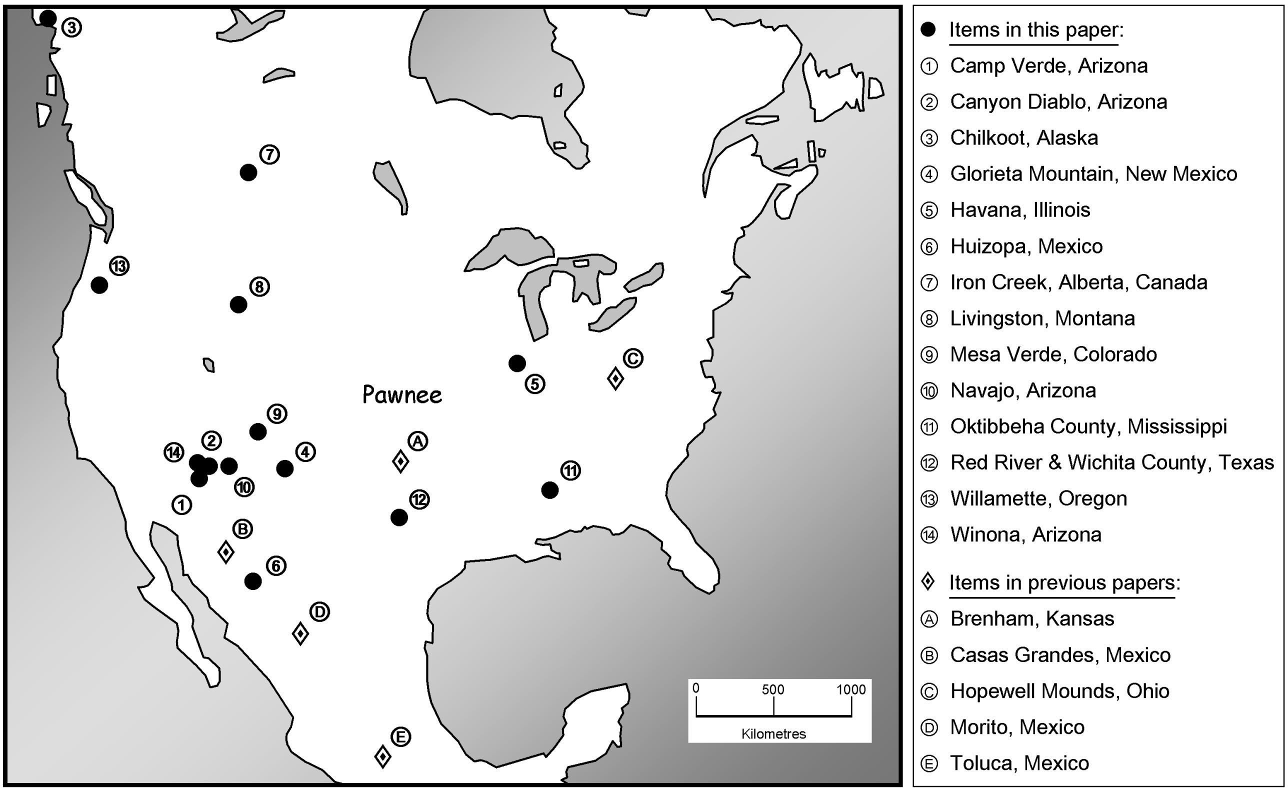

Figure 1 – A sketch-map of part of northern America, giving approximate locations for the find-sites of material discussed in this paper, and earlier Project ones where similar topics were investigated.

by an itinerant construction worker and amateur archaeologist, George E Dawson, while he was digging for treasure in the ruins of a native pueblo-style dwelling near Camp Verde in 1915. In what seemed at first a child's stone burial cist under the floor, he discovered the meteorite wrapped in a blanket of feathers. Subsequent investigations found pottery that could be dated to roughly 1100–1200 AD associated with the burial. Initially thought that the pueblo was likely inhabited by the native Sinagua then, a more recent suggestion is it was built by people from the Salado culture, originally from the Salt River valley, around 75 km southeast of Camp Verde. Why the meteorite was treated with such reverence is unknown. It has been speculated that it may have been a fragment that spalled-off and landed in this region as the Meteor Crater main body came through the atmosphere originally, since it is difficult otherwise to imagine how, or why, such a substantial object would have been deliberately carried so far from the Canyon Diablo area, just to be buried intact. (See: Buchwald, 1975, Vol. 2, pp. 399–401; Burke, 1986, p. 224. On the more recent information, several online news and discussion forums confirmed the general findings, cf. Ayers, 2009, for a useful, if journalistic, summary. Ayers gave the date of Dawson's find as 1927, however.)

It is though possible the Camp Verde meteorite was so transported, because there were native dwellings found close to Meteor Crater, including some dating to the circa twelfth century AD on the southern slope of the Crater's rim. How much, if any, use was made of the iron meteorites there, which are still to be found scattered over the countryside near the Crater, cannot be judged, as there are no surviving archaeological examples of meteorite reuse there, but it seems "The place was not taboo to the Hopi Indians, and it is quite unlikely that they witnessed the fall" (Buchwald, 1975, Vol. 2, p. 382). Despite this, it seems very probable the Hopi were aware of such a handy source of iron, readily-available on the surface near their homes.

At Winona, a few kilometres northeast of Flagstaff, Arizona, in 1928, another meteorite was found in a similar stone cist to that at Camp Verde, again buried under the floor of a native, probably this time Sinaguan, pueblo ruin. This was an egg-shaped achondrite, what became the type-stone for the rare 'winonaite' class. Although intact when first uncovered, it fell apart on attempting to remove it, but ~ 24 kg of meteoritic fragments were eventually still saved and preserved. Based on the dating of associated pottery, the pueblo site overall was probably occupied from the late eleventh to the thirteenth centuries AD (Heineman & Brady, 1929).

Considerably further south, one of the two Casas Grandes, Mexico irons was apparently wrapped and buried like a body too, perhaps suggestive of a general practice among the pueblo-dwellers in this part of southwest North America. Several different cultures have been recognised here archaeologically, often only approximately dated (cf. Bahn, 2000, pp. 164–165; Haywood, 2000, both pp. 3.26). If this was so, perhaps the concept was carried further south as people migrated into more of Central America, leading to tales of the Aztec god Huitzilopochtli being perceived as a wrapped meteorite bundle as well.

Whether all such objects were genuinely meteoritic cannot be confirmed. Burke (1986, p. 224) reported tales from the Skidi Pawnee tribe – whose former home range is roughly demonstrated by the "Pawnee" label on Figure 1 – that suggested "They wrapped objects believed to be meteorites in bundles that they considered sacred and that belonged either to individuals or to the tribe." This degree of uncertainty also reflected the fact there were no surviving potentially meteoritic objects known from Pawnee contexts available for modern identification. Burke noted the Pawnee named meteorites 'the children of Tirawhat', their leading deity, and that one legend foretold a marvellous being called Pahokatawa would come from the sky in the form of a turtle-shaped stone. The regmaglyptic markings often seen on larger meteorites due to the melting and recrystallisation of the surface during the object's atmospheric flight, could certainly give a patternation reminiscent of that seen on a turtle's shell, while meteorites can be almost any shape, of course. A conical or lenticular form, something like a turtle, would not be unusual. When such an object duly fell, the tribe carried it with them wrapped in a bundle. Afterwards, to ensure success in battle, the warriors offered prayers and smoke to the meteorite, and it was said there was no disease in the camp while the stone was with them. When they were made to relocate to Indian Territory in the nineteenth century (modernly the area of Oklahoma, USA, just east of the Brenham and Wichita sites on Figure 1), they left the stone on a high hill in western Nebraska, west of their earlier homelands in east-central Nebraska, a site and object that have not been located, regrettably. The Pawnee area was a long way northeast of the pueblo-dwelling peoples who also wrapped meteorites in bundles, so whether such beliefs may have been linked is unprovable.

4 Sacred meteorites

Wrapped and/or buried meteorites were clearly regarded as objects of significance to be treated with such reverence, even if we now cannot tell exactly why this was so. Other meteorites, including those too massive to be moved, were treated as sacred objects, sometimes noted as presented with tribute gifts. One of the better-recorded examples was the Iron Creek octahedrite in Alberta, Canada. It was first reported by William F Butler, who saw it in 1871 at the mission station of Victoria, around 140 km east-northeast of Edmonton, apparently a turtle-shaped, somewhat conical, mass, weighing ~ 175 kg. He noted it had been moved there not long before he saw it, from its original site on a hilltop somewhere south of Victoria, and related the tale "that it had been known by the Cree and Blackfoot Indians longer than any man could say. The mass was highly venerated, and tribute was paid in form of beads, trinkets or knives" (Buchwald, 1975, Vol. 2, p. 686). Burke (1986, p. 225) called it a "medicine-stone", and remarked that the local tribes believed it had fallen from heaven. He also reported an old medicine-man as having predicted its removal would bring sickness, shortage and war, and that these warnings seemed to have been fulfilled within a few months. Buchwald (loc. cit.) mentioned the tribes were plagued by smallpox soon afterwards.

In Texas, USA, the ~ 150 kg Wichita County octahedrite 'defeated' the Comanche tribe before they chose to venerate it, although it seemed to have been first discovered during the Spanish exploration of the modern Texas-Oklahoma areas in the sixteenth and seventeenth centuries. The Spaniards had tried to move it with pack mules, but to little effect, and it was some time later that the Comanche encountered the iron, and tried to melt it with huge fires, unsuccessfully. They then attacked it with tools to try to break it up, again ineffectually, and following this failure, they decided it was a powerful medicine-stone, and left it alone. "They regarded it with the highest veneration, and it was the custom of all who passed by to deposit upon it beads, arrowheads, tobacco, and other articles as offerings" (Buchwald, 1975, Vol. 3, p. 1305). Burke (1986, pp. 224–225) described the nearby Kiowa and Apache tribes as venerating the Wichita County meteorite too, believing it had come from the Great Spirit, while well-worn trails led to the site, suggesting it was very frequently visited. Buchwald related it was moved south to San Antonio in 1836, and then to Austin in 1859, where it was kept in the Capitol building. When that building burnt down in 1881, the meteorite dropped into the basement, where it was sheltered from the rubble and heat, until it was later rescued. It was then taken to the University of Texas elsewhere in Austin, where it still resides.

Somewhere nearby in Texas, Buchwald (1975, Vol. 3, pp. 1010–1012) noted that a ~ 800 kg octahedrite was found by a Pawnee tribesman around 1800, now called the Red River meteorite. Its find-location in that area is not known, and it had been taken to New York already by 1810, so although Buchwald (1975, Vol. 1, Appendix 6, p. 165) stated tribute had been paid to it by the local native tribes, it is unclear whether this was really the case, or if someone had conflated tales of the Wichita County iron with that at Red River. There is the possibility both were so-venerated, as it seemed when Western prospectors first went to the area in 1810, there were known to be three 'platinum ore' (actually meteoritic iron) masses in this region, Red River and two smaller ones. Buchwald suggested one may have been Wichita County, and that the other could have been the $\sim$ 18 kg Denton County octahedrite, first found in Texas in 1856 (Vol. 2, pp. 530–531). No such tales seemed to have been recorded in respect of Denton County, however.

The Navajo, Arizona, USA, coarse octahedrite was too massive to move at ~ 1500 kg, which may be why it was reported as buried in scree at the foot of a sandstone ridge, when it was initially found by a Westerner, R K Thomas, in 1921. He indicated the rocks had been piled over it apparently deliberately, to prevent its accidental discovery by others, and that this had been done by the Navajo tribe. Thomas suggested the Navajo had known of the object, and considered it sacred, perhaps since as early as 1600 AD. In the 1927 "Appendix to the Catalogue of Meteorites" in the British Museum, G T Prior recorded a letter as having stated Native American beads had been found with the meteorite. Another octahedrite weighing 685 kg was located less than 50 m northwest of the larger mass in 1926, buried in soil washed off an adjacent ridge, but seemingly deliberately marked with an upright rock standing by it (Buchwald, 1975, Vol. 3, p. 878). It was thus less clear how strong the veneration was in this case, nor was it obvious why such huge masses needed to be concealed at all, perhaps merely reflecting a different local custom.

If the native meteorite beliefs were uncertain at Navajo, those associated with the still-more massive Willamette, Oregon, USA, octahedrite, which weighed about fourteen tonnes, were dismissed in a court-case. It was located in 1902 by a miner originally from Wales, Ellis Hughes, but on land owned by the Oregon Iron and Steel Company. Working secretly for months, he uncovered the whole object, an enormous cone-shaped mass, very heavily pitted, and in a further three months, with a good deal of ingenuity, Hughes and his fifteen-year-old son managed to move the meteorite the 1.2 km to his own house and land. He then announced his find in 1903 October, and charged people who came the five kilometres out from nearby Oregon City twenty-five cents each to see it. A lawyer for the Oregon Iron and Steel Company was among them. He spotted the cleared track leading to Hughes' house from the Company's land, and by the end of November, Hughes was defending a court case over ownership of the object.

Hughes' defence revolved around it having been an abandoned Indian relic, and thus personal property, not part of the land it had been found on. If this was so, the meteorite would have been his, as its finder. He called two Native American witnesses in his favour, one from the Klicktat tribe, seventy years old, the other a forty-seven-year-old Wasco tribesman. They both testified that the meteorite had been sacred to the, by 1903 extinct, Clackamas tribe, who knew it as "Visitor from the Moon" (*Tomanowos*). Apparently, the Clackamas' washed their faces in water collected in the pits in the meteorite, and dipped their arrows in the water before a battle. It was said to have been owned by the tribe's medicine-men, who had continued to use it to practice various beliefs until about 1870. The jury rejected the native tales, and found in favour of the Company, however, a decision which was upheld by the US Supreme Court in 1905 July, ruling that all meteorites in the USA were the property of the land-owner where they were found (Buchwald, 1975, Vol. 3, pp. 1311–1313). Interestingly, the Supreme Court ruling made no comment regarding the veracity of the claimed native beliefs, but it remains uncertain how much reliability may be placed upon them regarding this meteorite.

Other meteorites had still vaguer claimed Native American reverence associated with them, such as the Morito iron previously discussed, or the Chilkoot, Alaska, USA, $\sim$ 43 kg medium octahedrite, first recorded in 1881, but whose fall was said to have been witnessed by the natives around 1780, and who preserved it afterwards (Buchwald, 1975, Vol. 2, p. 457). Buchwald (1975, Vol. 1, p. 165) regarded tales of these as convincing enough to include them in his listing of "26 Venerated Iron Meteorites", though it was less obvious if the finding of five fine octahedrites in a native ruin dating to circa 1400 AD near Huizopa, Mexico were necessarily in such a class, despite his listing them as venerated too. The largest was around 108 kg, but the other four were much smaller, weighing between $\sim$ 5–10 kg each, three of which are now lost, while neither of the two surviving ones are still intact (Buchwald, 1975, Vol. 2, pp. 668–670). He gave there as well the $\sim$ 114 kg Caperr, Argentina octahedrite, likely known long before $\sim$ 1871, but as an object regarded "with superstitious awe" by the native Patagonians, rather than straightforwardly venerated. The outer surface showed signs of having been damaged by hammering, which too might imply less-than-reverential treatment for the meteorite (Buchwald, 1975, Vol. 2, pp. 409–410).

By contrast to these, the Canyon Diablo meteorites near Meteor Crater seemed to have attracted neither positive nor negative native attention like this, while although the 3.5 kg Mesa Verde, Colorado, USA medium octahedrite was found in a native shrine house being restored by archaeologists in 1922, it seemed to have been left there quite disregarded, among a number of discarded rocks. It was estimated the iron and other rocks were probably placed in the building by the cliff-dwelling natives when it was initially constructed, likely in the thirteenth century AD, but it presumably had no especial significance for them (Buchwald, 1975, Vol. 3, p. 826).

5 Grave goods

Archaeologists have long debated why some human burials were accompanied by a variety of objects, and others not. Much of the reasoning originally seemed to have related to beliefs in a supernatural afterlife, where such objects would retain their utility. While the objects themselves might not have been venerated directly, they were clearly considered important enough to the dead person to need to be kept with their physical remains. Thus they gained a degree of 'proxy sanctity' simply by being buried with the corpse.

In the case of the manufactured objects and the raw iron from the Brenham pallasites, brought almost halfway across the continent to their eventual home, and subsequent burial sites in the Hopewell Mounds of Ohio, the difficulties in obtaining the metal alone suggested a probable degree of significance in itself. This seemed further indicated because it would almost certainly have been better for the tribe to have recycled and reused the iron, not to have disposed of it permanently, having already carried it so far.

Some objects were perhaps small enough to be more readily expended this way. The Hopewell-age burial mounds at Havana, Illinois, USA, radiocarbon-dated to $\sim$ 336 BC ± 250 years, were found to have contained twenty-two heavily-oxidised iron beads in Burial 10 of Mound 9, each around 0.5–1.5 cm in diameter, with more than a thousand similar-sized beads of shell and pearl. The iron beads had been cold-worked, the metal first beaten into thin sheets, then bent into cylinders, before being heated to ∼ 650°C to anneal them. The internal dimensions of the holes through the cylinders suggested they had once all been carefully strung, and likely graded by size. Analysis further suggested the originating meteorite had been a fine octahedrite (Buchwald, 1975, Vol. 2, pp. 635–637).

Another was a small pallasite fragment weighing 128 g, found buried in a pottery bowl, whose worn, bright exterior suggested perhaps that it had been long handled, maybe carried in the pouch of a medicine-man. Its chemistry and structure identified it as being part of the nearby Glorieta Mountain meteorites. It was found in a pueblo ruin near Pojoaque in New Mexico, USA, probably dated to ∼ 1200 AD, and for a while after its discovery, it was called Pojoaque as a result. The Glorieta Mountain area hosts one of world's more important iron strewnfields, around four kilometres long by one kilometre wide, and from which twenty-eight pallasitic octahedrites have been recovered, up to ∼ 67 kg in weight. The total weight of all the meteorites located there was ∼ 190 kg (Buchwald, 1975, Vol. 1, Table 11, p. 28 & Vol. 2, pp. 597–601). As noted when discussing the Brenham pallasites previously, the nature of pallasites makes the iron much easier to extract and reuse than that from a solid iron meteorite. In the case of Glorieta Mountain, this extraction was still easier, because the original object seemed to have fragmented in the air, the veins of iron breaking apart into 'finger'-shaped individual pieces. Buchwald (Vol. 1, Fig. 35, p. 48 & Vol. 2, Figs. 793–796, pp. 597–598) showed photographs of several of these shaped roughly like knife blades, ∼ 10–30 cm long, though none had been reworked at all.

A tumulus in Oktibbeha County, Mississippi, USA, contained an extraordinarily high-nickel-content probable meteorite (∼ 60% nickel, more than twice the quantity found in other nickel-rich meteorites). From the surviving 156 g piece, it was clear about half the original mass had been cut-off and removed before burial, while the remaining piece had been artificially reheated since its formation. Why only part of it had been, presumably, used before it ended in this burial is unknown (Buchwald, 1975, Vol. 3, p. 947).

The most substantial of these native-grave-buried meteorites was found in 1936, about ten kilometres south of Livingston, Montana, USA, where a medium octahedrite weighing 1.6 kg was discovered with human remains plus various objects and weapons, all entombed in a deliberately-piled cairn of rocks. There seemed to have been no other burials nearby, certainly not of comparable type, so it is not known why this cairn was there, who made it, nor why such a significant meteorite should have accompanied the burial (Buchwald, 1975, Vol. 2, pp. 776–777).

6 Discussion

In general, the quantity and distribution of the items detailed above, and previously for North America, is about what would be expected from a simple consideration of the random nature of meteorite falls. The somewhat greater concentration of items in the southwest of North America seemed to reflect a practice of deliberately burying meteorites by the people who dwelt in pueblos around the twelfth to fourteenth centuries AD there. Presumably, those meteorites were chosen because there was some particular significance about them, perhaps their size or shape, or perhaps because they had been witnessed to fall.

The lack of meteorites revered from parts of the Americas south of modern Mexico City, by contrast to places to its north, is very striking. It is not clear why this should have been so, but it may have related to differences in burial customs, the preservation of oral tales and beliefs, or simply that there has been insufficient detailed examination of sites and recording of tales in the southern half of the Americas.

Perhaps the most unusual aspect was the great predominance of meteoritic irons among the venerated objects, with scarcely any stony meteorites involved at all. Given that stones seen to fall vastly outnumber the irons so-observed (Buchwald, 1975, Vol. 1, Table 19, p. 37 suggested just ∼ 5% of all witnessed meteorite falls were irons) seemed to argue strongly against any kind of importance in a perceived heavenly provenance for meteorites overall, perhaps excepting a few specific cases. Irons are far more often found without being seen to fall (ibid. gave ∼ 49%), largely because their survival times against earthly weathering processes are significantly longer compared to stony meteorites, plus they have much greater reuse potential, and are easier to identify as unusual compared to earthly surface rocks.

Too few cases here had tales recorded about them to indicate whether their celestial origins were generally even known, let alone if they played a role in helping select the objects for veneration and preservation. Sometimes, it was reasonably definite that the objects could not have been seen to fall, judging by their estimated arrival times. Overall, it seems likely that, as has been identified in the Project before, simple pragmatism in taking advantage of a readily-available surface source of iron, was of greater moment than where the material may once have come from.

However, there have been a number of reports of stony meteorites found on Native American campsites. Nininger (1938) mentioned having recovered four from such locations during 1936–37 alone, two each in eastern Colorado and western Kansas, USA, for example, though he approximately located only the two in Colorado as found near Karvel, Lincoln County, and Springfield, Baca County. The latest British Natural History Museum's "Catalogue of Meteorites" (Grady, 2000) listed just three objects found in similar locations, but two of those – from Apex Gulch, Jefferson County, Colorado, an L6 chondrite found in 1938, and Leslie, Hall

County, Texas, an H5 chondrite found in 1968 – were different to those Nininger had found. The third was one of Nininger's 1936 finds, from Rolla, Morton County in Kansas, another H5 chondrite. Quite what significance can be attached to such finds, whose locations in the campsites, and dating or associative evidence, was typically unrecorded, is unclear. As Nininger himself stated (ibid., p. 39), "it must be admitted that without additional evidence, these associations could be regarded as accidental."

7 Conclusion

In contrast to the examples of ancient Old World meteorite veneration, where there were many tales describing the objects and sometimes the rituals associated with them, but no surviving objects to confirm the nature of any, in the New World, there were plenty of confirmed meteoritic objects found in contexts suggestive of religious or supernatural significance, but often supported by vague or uncertain tales regarding what practices they may have been involved with. That meteorites were among the objects considered sacred in both regions has been well-confirmed, although it is less certain their heavenly origins were always known, or even necessarily thought important, in the New World.

8 Acknowledgements

Particular thanks go to David Entwistle for helping to trace details regarding the Camp Verde, Red River and Winona meteorites, and for general discussions regarding others of the objects covered above, including those found on native campsites.

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Preliminary results

Results of the IMO Video Meteor Network — September 2010

Sirko Molau [1] *and Javor Kac* [2]

In September 2010, 46 cameras of the IMO Video Meteor Network were active with more than 3 700 hours of observations and almost 19 000 meteors recorded. Minor showers active in September were explored. Activity profiles of the September ε-Perseids, ν-Eridanids and ι-Cassiopeiids are presented. Signs of early activity of the Orionids were searched for. A small increase could be detected from September 25, and convincing rates could be observed from September 30.

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1 Introduction

In September, the weather conditions in Europe slightly reversed: the more northern observers enjoyed better conditions than in the month before, whereas most observers south of the Alps collected fewer clear nights. Thirteen out of 46 cameras recorded meteors in twenty or more nights. With more than 3 700 hours, the effective observing time reduced by 350 hours compared to 2009. The number of meteors, however, increased by more than 3 000 to almost 19 000 (Table 1 and Figure 1). Once more, the camera network grew slightly: Klaas Jobse started observation with his second intensified camera Klara2 in September.

By the end of the month, about half of all cameras had switched to the new version of MetRec, so that the effective collection area could be calculated. The total collection area, however, is given in Table 1 only for those cameras that provided reliable limiting magnitudes and therefore effective collection areas in the full month. In addition we abstained from listing the same field of view for all cameras with the same lens contrary to what was announced in the last report (Molau & Kac, 2010a). A closer analysis had revealed that the small deviations between the cameras are not only measurement errors, but represent also real differences due to tiny variations in the focal length.

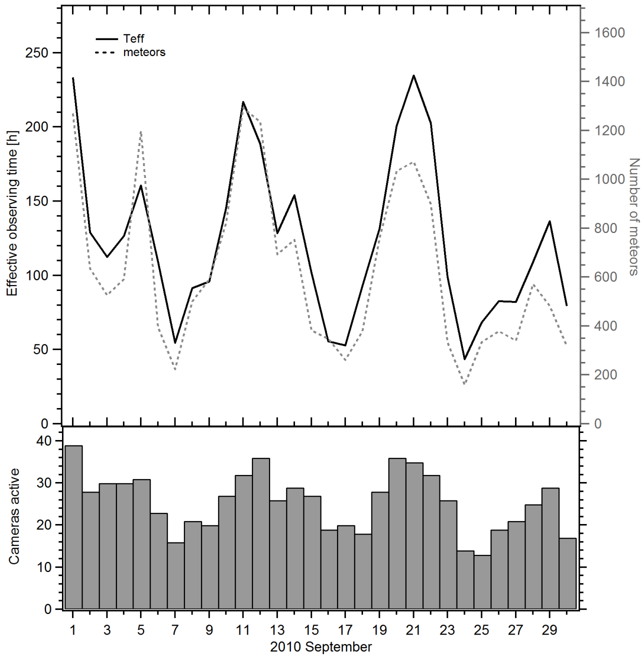

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2010 September.

2 September showers

With a long-term average of 4.5 meteors per hour, September is a transitional month between the peak months of August (7.0) and October (5.9). The latest analysis of meteor showers in the Perseus-Auriga region showed that there is a bunch of minor showers near the northern Apex source (Rendtel & Molau, 2010). With the September ε-Perseids (208 SPE), one of these shall be analyzed here in more detail. Only recently the SPE were corrected in the IMO working list and "shifted" into the right position. In addition, we have a closer look at the ν-Eridanids (337 NUE) and September ι-Cassiopeiids (416 SIC) as in the last year. The analyses are based on data of 677 SPE, 91 SIC and 893 NUE atop of 14 000 sporadic meteors. As usual, the ratio of the shower and sporadic meteor counts per night was used as an activity measure.

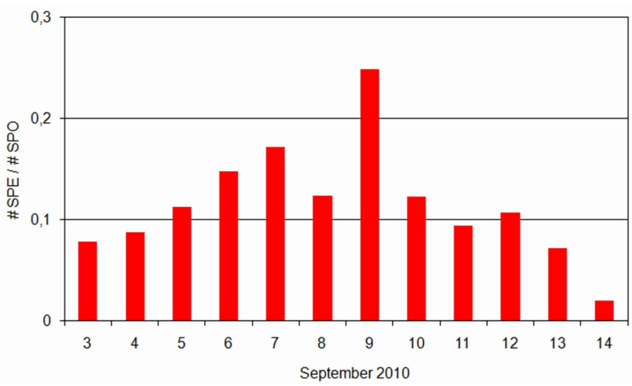

Figure 2 – Activity profile of the September ε-Perseids in September 2010. The ratio of shower and sporadic meteors is plotted for each night.

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IMO bibcode WGN-386-molau-vidsep
NASA-ADS bibcode 2010JIMO...38..199M

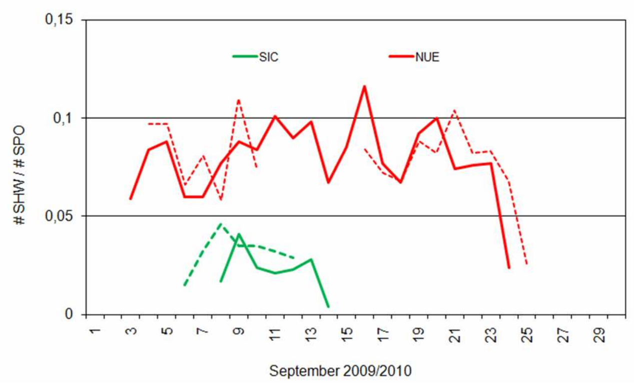

Figure 3 – Comparison of the activity profiles of the ν-Eridanids (NUE) and the September ι-Cassiopeiids (SIC) in September 2009 (dashed line) and 2010 (solid line).

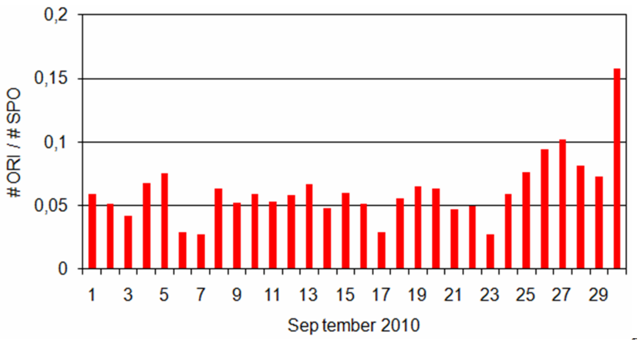

Figure 4 – Percentage of sporadic meteors that match to the extrapolated Orionid radiant. Starting from September 25, there is a small increase in rates that hints on the real shower.

2.1 September ε-Perseids

In this year, the September ε-Perseids show a classical profile with a distinct maximum of about 25% of the sporadic meteors in the night of September 9/10 (Figure 2). That date matches perfectly to the value found in the last long-term analysis (Solar longitude 167°). It is also consistent that rates at the ascending branch are slightly higher than at the descending branch – only the maximum is more pronounced than in the long-term analysis.

2.2 ν-Eridanids and September ι-Cassiopeiids

The ν-Eridanids and September ι-Cassiopeiids are even weaker showers. To assess whether their activity graphs show real structures or only random fluctuations, the profile from the monthly analysis in September 2009 was plotted in parallel to the new 2010 values (Figure 3).

In both years, the ν-Eridanids show an approximately constant activity of 7–8% of the sporadic meteor count. The highest rate was observed on 2010 September 16, but the profile shows also a few sub-maxima. It is amazing that even these structures match reasonably well in both years.

The September ι-Cassiopeiids reached again only about 4% of the sporadic meteor count. Their maximum (September 9) occurred one day later than in the year before.

The good agreement between both years is encouraging. It indicates that activity profiles of even such weak showers do not only show random fluctuations.

3 Early Orionids

Finally we want to check at what time the activity interval of the Orionids starts. The long-term analysis of 2009 showed first signs of this shower as early as September 26. However, the real start date was set to October 3, since only then the radiant position was determined reliably enough. In the recent analysis of the Perseus Auriga complex, which incorporated additional data from fall 2009, the shower could even be traced to mid-September (Rendtel & Molau, 2010).

Now we extended the activity interval artificially to September 1 and tested how many meteors would fit to the extrapolated radiant position. A fairly constant rate of 5% of the sporadic meteors matched to that radiant in all of September (Figure 4). Only starting from September 25, there was a marginal increase in meteors which could reflect the onset of the Orionids in 2010. On September 30 the increase became prominent. The shower activity in October is covered in Molau & Kac (2010b).

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Table 1 – Observers contributing to 2010 September data of the IMO Video Meteor Network. Eff.CA designates the effective collection area and Tot.CA the total collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
BENOR	Benitez-S.	Las Palmas	Times4 (1.4/50)	2359	—	—	16	62.1	—	186
			Times5 (0.95/50)	33	7.0	261	14	17.3	—	44
BRIBE	Brinkmann	Herne	Hermine (0.8/6)	2374	4.2	1074	22	114.7	—	471
CASFL	Castellani	Monte Baldo	Bmh1 (0.8/6)	2350	—	—	19	82.6	—	262
			Bmh2 (1.2/4.5)*	4243	—	—	22	104.2	—	424
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	5575	—	—	22	140.4	—	729
			Stg38 (0.8/3.8)	5593	—	—	28	182.1	—	1431
ELTMA	Eltri	Venezia	Met38 (0.8/3.8)	5620	—	—	13	93.7	—	342
GONRU	Goncalves	Tomar	Templar1 (0.8/6)*	2188	5.3	2331	25	173.4	276.0	856
			Templar2 (0.8/6)*	2303	5.0	2397	25	154.8	299.1	628
GOVMI	Govedič	Središče ob Dravi	Orion2 (0.8/8)	1471	6.0	3916	22	101.7	—	403
HERCA	Hergenrother	Tucson	Salsa3 (1.2/4)*	4332	4.0	1471	28	169.9	—	662
HINWO	Hinz	Brannenburg	Akm2 (0.85/25)*	754	5.7	1306	13	65.3	79.8	327
IGAAN	Igaz	Baja	HuBaj (0.8/3.8)	5600	4.3	3338	12	57.7	109.2	174
		Hodmezovasarhely	HuHod (0.8/3.8)	5609	4.2	3031	19	107.8	268.4	420
		Budapest	HuPol (1.2/4)	3929	3.5	1144	18	56.8	57.2	136
JOBKL	Jobse	Oostkapelle	Betsy2 (1.2/85)*	1725	—	—	4	21.3	—	558
			Klara2 (1.2/85)*	1564	—	—	5	29.6	—	309
KACJA	Kac	Kostanjevec	Metka (0.8/8)*	1381	4.0	2246	10	44.5	37.5	136
		Ljubljana	Orion1 (0.8/8)	1420	5.3	2336	20	56.4	51.3	218
		Kamnik	Rezika (0.8/6)	2307	5.0	2293	12	50.1	73.5	373
			Stefka (0.8/3.8)	5540	4.2	2882	11	43.4	71.5	137
KERST	Kerr	Glenlee	Gocam1 (0.8/3.8)	5238	4.2	2637	17	98.2	228.7	571
KOSDE	Koschny	Noordwijkerhout	Lic4 (1.4/50)*	2027	—	—	14	62.9	—	687
			Tec1 (1.4/12)	741	5.6	1133	19	28.8	—	89
LUNRO	Lunsford	Chula Vista	Bocam (1.4/50)*	1860	—	—	14	74.5	—	365

Table 1 – Observers contributing to 2010 September data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
MOLSI	Molau	Seysdorf	AVIS2 (1.4/50)*	1771	6.1	4182	17	93.1	215.3	1122
			MINCAM1 (0.8/8)	1477	4.9	1716	24	112.1	149.2	593
		Ketzür	REMO1 (0.8/3.8)	5592	3.0	974	23	89.6	93.1	297
			REMO2 (0.8/3.8)	5635	4.3	2846	22	90.7	177.8	289
MORJO	Morvai	Fülöpszallas	HUFUL (1.4/5)	2522	3.5	532	20	83.1	44.5	209
OCHPA	Ochner	Albiano	ALBIANO (1.2/4.5)	1971	—	—	13	53.4	—	107
OTTMI	Otte	Pearl City	ORIE1 (1.4/5.7)	3837	—	—	13	59.3	—	247
PERZS	Perko	Becsehely	HUBEC (0.8/3.8)*	5448	3.4	1500	12	48.2	34.9	141
ROBBI	Roberto	Verona	FIAMENE (0.8/3.8)	5632	—	—	12	60.1	—	174
ROTEC	Rothenberg	Berlin	ARMEFA (0.8/6)	2369	—	—	18	85.6	—	332
SCHHA	Schremmer	Niederkrüchten	DORAEMON (0.8/3.8)	5537	—	—	16	59.6	—	195
SLAST	Slavec	Ljubljana	KAYAK1 (1.8/28)	596	—	—	11	35.2	—	107
STOEN	Stomeo	Scorze	MIN38 (0.8/3.8)	5631	—	—	19	122.8	—	876
			NOA38 (0.8/3.8)	5609	—	—	18	118.6	—	795
			SCO38 (0.8/3.8)	5598	—	—	19	124.0	—	1056
STRJO	Strunk	Herford	MINCAM2 (0.8/6)	2357	—	—	9	33.8	—	125
			MINCAM3 (0.8/12)	728	—	—	18	62.4	—	233
			MINCAM5 (0.8/6)	2344	—	—	9	48.6	—	234
TEPIS	Tepliczky	Budapest	HUMOB (0.8/6)	2375	4.9	2258	13	79.3	99.1	405
YRJIL	Yrjölä	Kuusankoski	FINEXCAM (0.8/6)	2337	—	—	17	65.5	—	299
						Overall	30	3 719.2	—	18 774

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — October 2010

Sirko Molau [1] *and Javor Kac* [2]

Fifty cameras of the IMO Video Meteor Network were active in 2010 October. Almost 40 000 meteors were recorded in about 5 600 hours of observations – a record month in the Network history. The activity profiles of the Orionids as well as the Northern and Southern Taurids throughout the month are presented. October Camelopardalids could again be reliably detected, their maximum occurring on October 5/6. Their activity profile is presented along with activity profiles from the October Ursae Majorids and Leonis Minorids.

Received 2010 December 9

1 Introduction

October came with all prerequisites for a splendid monthly result. As in August, a total of 50 video cameras were active. The fine weather presented many observing nights to most observers, and Carl Hergenrother once more did not miss even a single night. Highlights of the month were October 9 and 21, when about 40 cameras collected a total of 300 observing hours. In addition, October is one of the most interesting seasons with the Orionids, Taurids and a number of minor showers active. Even though the weather deteriorated just at the Orionid maximum and the sky became moonlit by that time (full Moon on October 23), we simply had to break the record again. And how we did it! With almost 5 600 hours we collected 20% more effective observing time than in August 2010 (Molau & Kac, 2010a), and also the meteor count increased by 20% to almost 40 000 (Table 1 and Figure 1). On average, we recorded 7.1 meteors per hour – just as many as in August and one meteor per hour more than the long-term October average.

In October, another camera (HuLud1, operated by Erno Berko) started regular observation in Hungary. In addition, we could welcome an English observer in our midst again. Malcolm Currie contributed the first Orionid observations with his camera Mic4.

At the same time we received the sad news that the British amateur astronomer Andrew Elliot passed away on November 28 after a long illness. He was a technology aficionado, and a versatile and always helpful amateur that used his video equipment not just for lunar occultations (his primary hobby-horse), but occasionally also for meteor observation. With Andrew we lose a valuable advisor and good friend.

October has once more shown a limit. A single person is overstretched when collecting, checking and archiving such large data sets alone. For this reason we are about to establish a new collaboration model, where a number of experienced observers will contribute to the verification of observations.

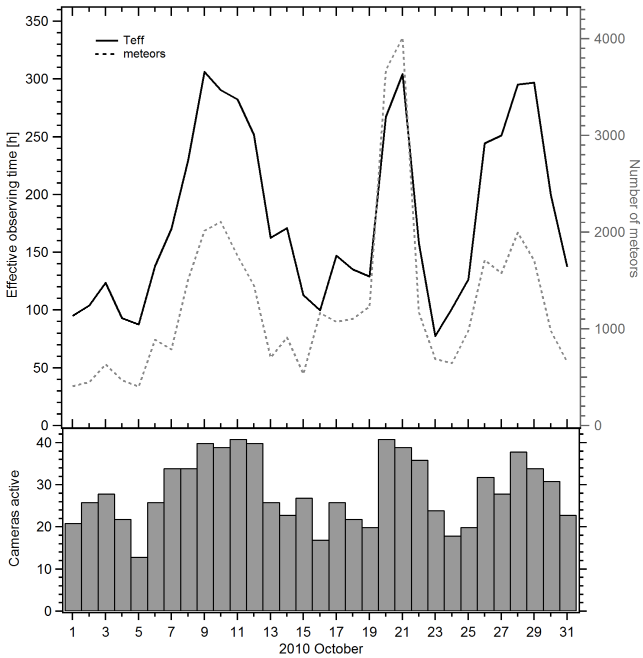

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2010 October.

2 Orionids

October was as expected dominated by the Orionids. The analysis of last month had shown that their activity started already around September 25 (Molau & Kac, 2010b). Now we could extend the activity profile by the full month of October (Figure 2). The graph is based on 12 300 Orionids and 21 000 sporadic meteors, recorded between 2010 September 25 and October 31. Until about October 10, the Orionid activity remained at a constantly low level. Thereafter it rose day by day and reached a peak on October 22/23. In that night, 2.7 Orionids were recorded for each sporadic meteor which is the same ratio as at last year's maximum (Molau & Kac, 2009).

3 Taurids

Let's have a look at the Taurids next. The long-term analysis of 2009 (Molau & Kac, 2009) revealed that the southern branch is active first, reaching its maximum on October 10. The northern branch peaks about one month later on November 13. That was confirmed by the 2010 data set (Figure 3). In the beginning, the Southern Taurids were slightly dominating. They

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NASA-ADS bibcode 2010JIMO...38..203M

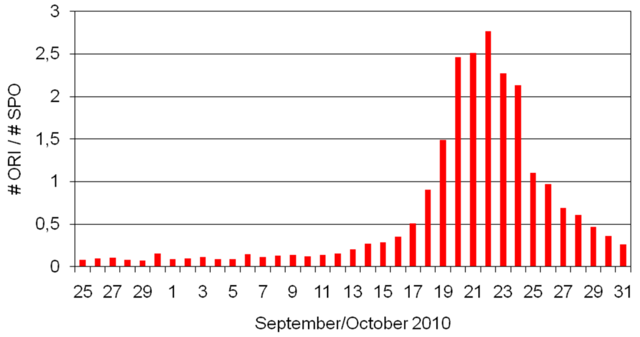

Figure 2 – Activity profile of the Orionids in 2010. In this and all following figures, the ratio between the number of shower meteors and sporadics is displayed for each night.

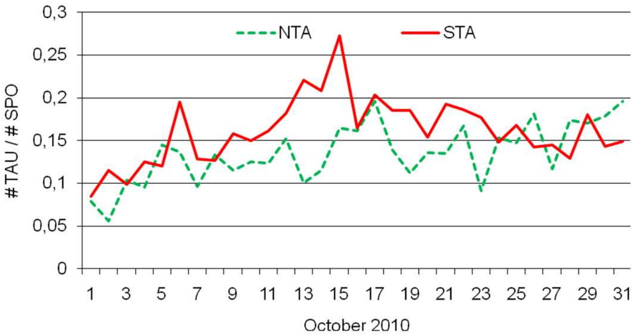

Figure 3 – Activity profiles of the Northern (NTA) and Southern Taurids (STA) in 2010.

reached their maximum on October 15 and thereafter the rate slowly declined. The activity of the Northern Taurids, however, increased slowly but constantly in all of October. By the end of the month, the northern branch had overtaken the southern.

4 Minor showers of October

There was no sign of the Draconids in the first ten days of October. Also the October Ursae Majorids remained within the sporadic background with a total of 240 shower meteors (Figure 4). Only on October 15/16 they were clearly noticeable with about 15% of the sporadic meteor count. That date matches exactly to the maximum found in the 2009 shower analysis (Molau & Rendtel, 2009).

In the final third of October we recorded more than 300 Leonis Minorids. They were slightly above the sporadic background for a couple of days and reached their maximum with only about 10% of the sporadic count at the same date that the Orionids were at their maximum. Also that agrees with the 2009 analysis, when the maximum was determined at October 23.

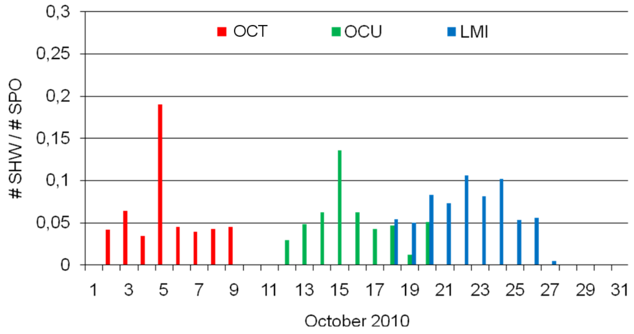

Figure 4 – Activity profiles of the October Camelopardalids (OCT), October Ursae Majorids (OCU) and Leonis Minorids (LMI) in 2010.

Still, the October Camelopardalids remain our favorite minor shower thanks to their extremely short duration. Last year's analysis revealed a maximum at solar longitude 192.6 degrees with a full width at half maximum (FWHM) of about six hours (Molau & Kac, 2009). This year, this corresponded to 03^{h} UT on October 6. As expected, we observed highest rates with 46 shower meteors in the night of October 5/6. Their count was 20% of the sporadic count with most shower meteors occurring in the half hour intervals $01^{h}00^{m}$–$01^{h}30^{m}$ UT and $03^{h}00^{m}$–$03^{h}30^{m}$ UT. Hence, the October Camelopardalids were the most active shower in that night. In the nights before and after October 5/6, their activity was lower by a factor of five – the shower could not be recognized any more in the sporadic background.

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Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [$10^3 km^2 h$]	Meteors
BENOR	Benitez-S.	Las Palmas	TIMES4 (1.4/50)	2359	3.2	492	17	79.5	—	346
			TIMES5 (0.95/50)	33	7.0	261	12	18.4	—	52
BEREE	Berko	Ludányhalászi	HULUD1 (0.95/3)	6500	—	—	9	75.2	—	335
			HULUD2 (0.95/2.8)	5977	4.2	2978	20	141.1	—	610
BRIBE	Brinkmann	Herne	HERMINE (0.8/6)	2374	4.2	1074	10	77.7	—	398
CASFL	Castellani	Monte Baldo	BMH1 (0.8/6)	2350	—	—	20	126.0	—	522
			BMH2 (1.2/4.5)*	4243	—	—	20	158.9	—	1019
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	5575	4.2	2525	24	161.0	—	1157
			STG38 (0.8/3.8)	5593	—	—	25	164.0	—	1503
CURMA	Currie	Grove	MIC4 (0.8/6)	1471	5.2	3008	7	40.8	—	625
ELTMA	Eltri	Venezia	MET38 (0.8/3.8)	5620	—	—	21	166.7	—	953
GONRU	Goncalves	Tomar	TEMPLAR1 (0.8/6)*	2188	5.3	2331	19	151.3	271.1	1180
			TEMPLAR2 (0.8/6)*	2303	5.0	2397	20	150.2	285.8	999
GOVMI	Govedič	Središče ob Dravi	ORION2 (0.8/8)	1471	6.0	3916	23	155.0	125.5	800
HERCA	Hergenrother	Tucson	SALSA3 (1.2/4)*	4332	4.0	1471	31	181.3	—	839
HINWO	Hinz	Brannenburg	AKM2 (0.85/25)*	754	5.7	1306	11	75.8	88.7	439
IGAAN	Igaz	Baja	HUBAJ (0.8/3.8)	5600	4.3	3338	6	51.4	—	436
		Hódmezővásárhely	HUHOD (0.8/3.8)	5609	4.2	3031	24	144.7	—	881
		Budapest	HUPOL (1.2/4)	3929	3.5	1144	22	100.1	97.4	392
JOBKL	Jobse	Oostkapelle	BETSY2 (1.2/85)*	1725	—	—	12	104.6	—	2691
			KLARA2 (1.2/85)*	1564	—	—	14	118.4	—	1767
KACJA	Kac	Kostanjevec	METKA (0.8/8)*	1381	4.0	2246	9	63.9	33.9	323
		Ljubljana	ORION1 (0.8/8)	1420	5.3	2336	21	91.0	80.6	456
		Kamnik	REZIKA (0.8/6)	2307	5.0	2293	12	97.6	44.7	875
			STEFKA (0.8/3.8)	5540	4.2	2882	12	76.7	42.5	381
KERST	Kerr	Glenlee	GOCAM1 (0.8/3.8)	5238	4.2	2637	20	125.1	364.7	1020
KOSDE	Koschny	Noordwijkerhout	LIC4 (1.4/50)*	2027	5.3	2782	21	91.4	—	610
			TEC1 (1.4/12)	741	5.6	1133	16	22.8	—	87

Table 1 – Observers contributing to 2010 October data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
LUNRO	Lunsford	Chula Vista	Bocam (1.4/50)*	1860	—	—	4	19.5	—	143
MOLSI	Molau	Seysdorf	Avis2 (1.4/50)*	1771	6.1	4182	18	136.5	321.4	2055
			Mincam1 (0.8/8)	1477	4.9	1716	24	148.2	183.2	1025
		Ketzür	Remo1 (0.8/3.8)	5592	3.0	974	27	117.8	114.0	524
			Remo2 (0.8/3.8)	5635	4.3	2846	26	114.1	192.5	416
MORJO	Morvai	Fülöpszállás	HuFul (1.4/5)	2522	3.5	532	22	143.2	—	586
OCHPA	Ochner	Albiano	Albiano (1.2/4.5)	1971	—	—	2	5.6	—	16
OTTMI	Otte	Pearl City	Orie1 (1.4/5.7)	3837	—	—	24	167.7	—	1001
PERZS	Perko	Becsehely	HuBec (0.8/3.8)*	5448	3.4	1500	23	174.4	157.8	1134
ROBBI	Roberto	Verona	Fiamene (0.8/3.8)	5632	—	—	17	86.1	—	313
ROTEC	Rothenberg	Berlin	Armefa (0.8/6)	2369	4.8	1801	19	111.8	126.9	575
SCHHA	Schremmer	Niederkrüchten	Doraemon (0.8/3.8)	5537	3.0	846	23	106.3	—	407
SLAST	Slavec	Ljubljana	Kayak1 (1.8/28)	596	—	—	16	102.6	—	365
STOEN	Stomeo	Scorze	Min38 (0.8/3.8)	5631	—	—	22	196.3	—	1811
			Noa38 (0.8/3.8)	5609	—	—	22	187.8	—	1669
			Sco38 (0.8/3.8)	5598	—	—	22	195.1	—	2142
STORO	Stork	Ondřejov	Ond1 (1.4/50)*	2195	5.8	4595	2	9.9	—	361
STRJO	Strunk	Herford	Mincam2 (0.8/6)	2357	—	—	20	79.4	—	310
			Mincam3 (0.8/12)	728	—	—	21	92.4	—	441
			Mincam5 (0.8/6)	2344	—	—	21	135.8	—	809
TEPIS	Tepliczky	Budapest	HuMob (0.8/6)	2375	4.9	2258	18	160.7	213.6	1153
YRJIL	Yrjölä	Kuusankoski	Finexcam (0.8/6)	2337	—	—	18	88.6	—	446
						Overall	31	5 590.4	—	39 398

* active field of view smaller than video frame

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