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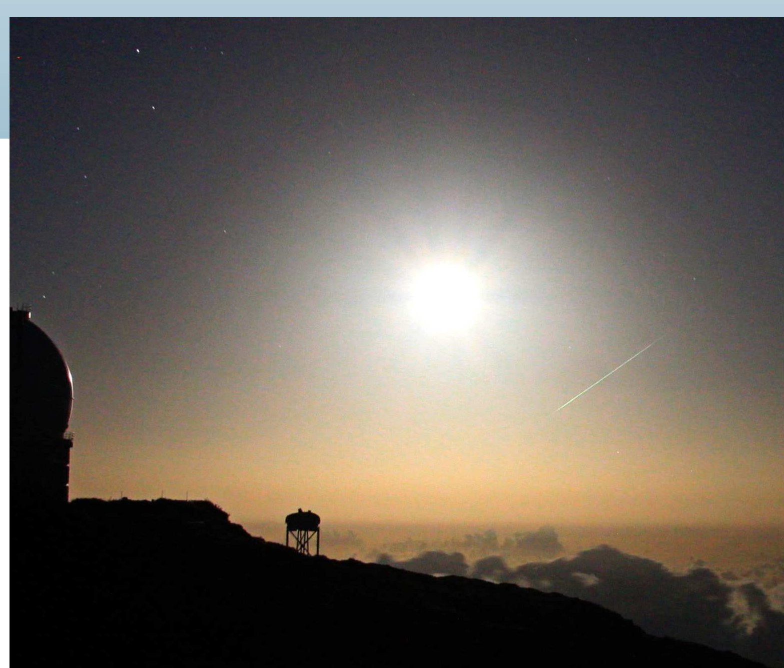

Solar longitudes 2013
Independent discoveries of the ζ-Cassiopeiids
August–September video meteors
A brief history of impact movies

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Front cover photo

A green fireball estimated at magnitude −10 appeared near the bright Moon (age 10 days) on 2012 September 26 at 02^h56^m UT as seen from La Palma, Canary Islands (Spain) at Roque de los Muchachos, 2400 m alt. The exposure of 20 s was made using a Canon 50D camera with a Tamron 17-50 mm, $f/2.8$ lens at 17 mm, $f/7.1$ (!) and ISO 1600. The dome on the left houses the William Herschel Telescope.
Photo courtesy: Valentin Grigore (SARM Romania).

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

Cover design Rainer Arlt

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From the Treasurer — IMO Membership/WGN Subscription Renewal for 2013

Marc Gyssens

We invite all our members/subscribers to renew for 2013. The fees are as tabulated below. We are happy that we can offer WGN at the same cost as last year. We also continue to offer an electronic-only subscription at a reduced rate.

IMO Membership/WGN Subscription 2013				
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, at `http://www.imo.net/payment`. Members and subscribers who have not yet renewed will find enclosed a leaflet where these payment instructions are further detailed. Please follow these instructions! Choosing the most appropriate payment method results in low or even no additional costs for you as well as the IMO. The IMO strives to keep these costs low in order to control the price of the journal!

When you renew, give a few minutes of thought to becoming a **supporting member**. As you may know, there is an IMO Support Fund. Up to now, this IMO Support Fund was exclusively used to help active meteor workers to attend the annual International Meteor Conference, who would otherwise not have been able to come. For the future, we intend to extend this support to meteor-related projects. (Details will follow shortly.) Our ability to provide this service to the meteor community 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!

One final request: every year, a lot of members renew late. As a consequence, back issues that already appeared have to be sent out to these members. Please support our volunteers in their bimonthly effort to have WGN shipped to you by renewing promptly! Thank you for your understanding and cooperation!

IMO bibcode WGN-406-gyssens-renewals NASA-ADS bibcode 2012JIMO...40..187G

Solar Longitudes for 2013

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 2013. 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-406-arlt-solarlong
NASA-ADS bibcode 2012JIMO...40..187A

Solar longitudes 2013. Dates refer to 00^h UT.

Jan	1	280.55	Mar	1	340.38	May	1	40.60	Jul	1	99.15	Sep	1	158.54	Nov	1	218.54
Jan	2	281.57	Mar	2	341.38	May	2	41.57	Jul	2	100.10	Sep	2	159.51	Nov	2	219.54
Jan	3	282.59	Mar	3	342.39	May	3	42.54	Jul	3	101.05	Sep	3	160.48	Nov	3	220.54
Jan	4	283.61	Mar	4	343.39	May	4	43.51	Jul	4	102.01	Sep	4	161.44	Nov	4	221.54
Jan	5	284.63	Mar	5	344.39	May	5	44.48	Jul	5	102.96	Sep	5	162.41	Nov	5	222.54
Jan	6	285.64	Mar	6	345.39	May	6	45.45	Jul	6	103.92	Sep	6	163.38	Nov	6	223.54
Jan	7	286.66	Mar	7	346.39	May	7	46.42	Jul	7	104.87	Sep	7	164.35	Nov	7	224.55
Jan	8	287.68	Mar	8	347.39	May	8	47.39	Jul	8	105.82	Sep	8	165.33	Nov	8	225.55
Jan	9	288.70	Mar	9	348.39	May	9	48.35	Jul	9	106.78	Sep	9	166.30	Nov	9	226.56
Jan	10	289.72	Mar	10	349.39	May	10	49.32	Jul	10	107.73	Sep	10	167.27	Nov	10	227.56
Jan	11	290.74	Mar	11	350.39	May	11	50.29	Jul	11	108.68	Sep	11	168.24	Nov	11	228.57
Jan	12	291.76	Mar	12	351.39	May	12	51.25	Jul	12	109.64	Sep	12	169.21	Nov	12	229.57
Jan	13	292.78	Mar	13	352.39	May	13	52.22	Jul	13	110.59	Sep	13	170.19	Nov	13	230.58
Jan	14	293.80	Mar	14	353.39	May	14	53.18	Jul	14	111.55	Sep	14	171.16	Nov	14	231.58
Jan	15	294.82	Mar	15	354.38	May	15	54.15	Jul	15	112.50	Sep	15	172.13	Nov	15	232.59
Jan	16	295.84	Mar	16	355.38	May	16	55.11	Jul	16	113.45	Sep	16	173.11	Nov	16	233.60
Jan	17	296.85	Mar	17	356.38	May	17	56.08	Jul	17	114.41	Sep	17	174.08	Nov	17	234.60
Jan	18	297.87	Mar	18	357.37	May	18	57.04	Jul	18	115.36	Sep	18	175.06	Nov	18	235.61
Jan	19	298.89	Mar	19	358.37	May	19	58.00	Jul	19	116.32	Sep	19	176.03	Nov	19	236.62
Jan	20	299.91	Mar	20	359.36	May	20	58.97	Jul	20	117.27	Sep	20	177.01	Nov	20	237.63
Jan	21	300.93	Mar	21	0.35	May	21	59.93	Jul	21	118.22	Sep	21	177.99	Nov	21	238.64
Jan	22	301.94	Mar	22	1.35	May	22	60.89	Jul	22	119.18	Sep	22	178.97	Nov	22	239.65
Jan	23	302.96	Mar	23	2.34	May	23	61.85	Jul	23	120.13	Sep	23	179.94	Nov	23	240.66
Jan	24	303.98	Mar	24	3.33	May	24	62.81	Jul	24	121.09	Sep	24	180.92	Nov	24	241.67
Jan	25	304.99	Mar	25	4.32	May	25	63.77	Jul	25	122.04	Sep	25	181.90	Nov	25	242.68
Jan	26	306.01	Mar	26	5.31	May	26	64.73	Jul	26	123.00	Sep	26	182.88	Nov	26	243.69
Jan	27	307.03	Mar	27	6.30	May	27	65.69	Jul	27	123.95	Sep	27	183.86	Nov	27	244.70
Jan	28	308.04	Mar	28	7.29	May	28	66.65	Jul	28	124.91	Sep	28	184.84	Nov	28	245.72
Jan	29	309.06	Mar	29	8.28	May	29	67.61	Jul	29	125.86	Sep	29	185.82	Nov	29	246.73
Jan	30	310.07	Mar	30	9.27	May	30	68.57	Jul	30	126.82	Sep	30	186.81	Nov	30	247.74
Jan	31	311.09	Mar	31	10.25	May	31	69.53	Jul	31	127.78						
Feb	1	312.10	Apr	1	11.24	Jun	1	70.49	Aug	1	128.73	Oct	1	187.79	Dec	1	248.76
Feb	2	313.12	Apr	2	12.23	Jun	2	71.45	Aug	2	129.69	Oct	2	188.77	Dec	2	249.77
Feb	3	314.13	Apr	3	13.21	Jun	3	72.40	Aug	3	130.65	Oct	3	189.76	Dec	3	250.78
Feb	4	315.15	Apr	4	14.20	Jun	4	73.36	Aug	4	131.60	Oct	4	190.74	Dec	4	251.80
Feb	5	316.16	Apr	5	15.18	Jun	5	74.32	Aug	5	132.56	Oct	5	191.73	Dec	5	252.81
Feb	6	317.17	Apr	6	16.17	Jun	6	75.28	Aug	6	133.52	Oct	6	192.71	Dec	6	253.83
Feb	7	318.19	Apr	7	17.15	Jun	7	76.23	Aug	7	134.48	Oct	7	193.70	Dec	7	254.84
Feb	8	319.20	Apr	8	18.14	Jun	8	77.19	Aug	8	135.44	Oct	8	194.69	Dec	8	255.86
Feb	9	320.21	Apr	9	19.12	Jun	9	78.15	Aug	9	136.40	Oct	9	195.68	Dec	9	256.88
Feb	10	321.23	Apr	10	20.10	Jun	10	79.11	Aug	10	137.36	Oct	10	196.66	Dec	10	257.89
Feb	11	322.24	Apr	11	21.08	Jun	11	80.06	Aug	11	138.31	Oct	11	197.65	Dec	11	258.91
Feb	12	323.25	Apr	12	22.07	Jun	12	81.02	Aug	12	139.27	Oct	12	198.64	Dec	12	259.92
Feb	13	324.26	Apr	13	23.05	Jun	13	81.97	Aug	13	140.23	Oct	13	199.63	Dec	13	260.94
Feb	14	325.27	Apr	14	24.03	Jun	14	82.93	Aug	14	141.19	Oct	14	200.62	Dec	14	261.96
Feb	15	326.28	Apr	15	25.01	Jun	15	83.88	Aug	15	142.16	Oct	15	201.61	Dec	15	262.97
Feb	16	327.29	Apr	16	25.98	Jun	16	84.84	Aug	16	143.12	Oct	16	202.60	Dec	16	263.99
Feb	17	328.30	Apr	17	26.96	Jun	17	85.79	Aug	17	144.08	Oct	17	203.59	Dec	17	265.01
Feb	18	329.31	Apr	18	27.94	Jun	18	86.75	Aug	18	145.04	Oct	18	204.59	Dec	18	266.03
Feb	19	330.32	Apr	19	28.92	Jun	19	87.70	Aug	19	146.00	Oct	19	205.58	Dec	19	267.04
Feb	20	331.33	Apr	20	29.89	Jun	20	88.66	Aug	20	146.96	Oct	20	206.57	Dec	20	268.06
Feb	21	332.34	Apr	21	30.87	Jun	21	89.61	Aug	21	147.92	Oct	21	207.56	Dec	21	269.08
Feb	22	333.34	Apr	22	31.85	Jun	22	90.57	Aug	22	148.89	Oct	22	208.56	Dec	22	270.10
Feb	23	334.35	Apr	23	32.82	Jun	23	91.52	Aug	23	149.85	Oct	23	209.55	Dec	23	271.11
Feb	24	335.36	Apr	24	33.80	Jun	24	92.47	Aug	24	150.81	Oct	24	210.55	Dec	24	272.13
Feb	25	336.36	Apr	25	34.77	Jun	25	93.43	Aug	25	151.78	Oct	25	211.55	Dec	25	273.15
Feb	26	337.37	Apr	26	35.74	Jun	26	94.38	Aug	26	152.74	Oct	26	212.54	Dec	26	274.17
Feb	27	338.37	Apr	27	36.71	Jun	27	95.33	Aug	27	153.71	Oct	27	213.54	Dec	27	275.19
Feb	28	339.38	Apr	28	37.69	Jun	28	96.29	Aug	28	154.67	Oct	28	214.54	Dec	28	276.21
			Apr	29	38.66	Jun	29	97.24	Aug	29	155.64	Oct	29	215.54	Dec	29	277.23
			Apr	30	39.63	Jun	30	98.19	Aug	30	156.60	Oct	30	216.54	Dec	30	278.25
									Aug	31	157.57	Oct	31	217.53	Dec	31	279.27

Meteor science

The new July meteor shower

Przemysław Żołądek[1] *and Mariusz Wiśniewski*[2]

A new meteor stream was found after an activity outburst observed on 2005 July 15. The radiant was located five degrees west of the possible early Perseid radiant, close to the star Zeta Cassiopeiae. Numerous bright meteors and fireballs were observed during this maximum. Analysis of the IMO Video Database and the SonotaCo orbital database revealed an annual stream which is active just before the appearance of the first Perseids, with a clearly visible maximum at $\lambda_\odot = 113.^\circ1$. Activity of the stream was estimated as two times higher than activity of the Alpha Capricornids at the same time. The activity period extends from July 12 to 17, during maximum the radiant is visible at coordinates $\alpha = 5.^\circ9$, $\delta = +50.^\circ5$, and observed meteors are fast, with $V_{\rm geo} = 57.4$ km/s. The shower was reported to the IAU Meteor Data Center and recognized as a new discovery. According to IAU nomenclature the new stream should be named the Zeta Cassiopeiids (ZCS).

Received 2012 April 7

1 Introduction

The first half of July is known as a time of rather low meteor activity. Observers' attention is focused on minor, hardly detectable meteor showers. After July 7 the weak July Pegasid (JPE) stream can be observed with maximum on July 10 (Ueda, 2012). JPE meteors are swift, with entry velocities around 68 km/s but the typical activity is very low. There is also the weak c-Andromedid (CAN) shower detected recently in video data (Molau & Rendtel, 2009) with radiant at coordinates $\alpha = 30^\circ$, $\delta = +48^\circ$. The maximum of the c-Andromedids can be observed two days after the July Pegasids, on July 12. Some well known ecliptic showers are becoming visible around this time. The Alpha Capricornids (CAP) can be observed after July 5 and Delta Aquarids (SDA) after July 12, both showers having a maximum on July 30. In the second half of July the Perseid shower becomes visible; according to the IMO Meteor Shower Calendar its activity starts on July 17 and increases slowly reaching ZHR close to 10 at the end of the month.

The July meteor streams were extensively observed by the Polish Comets and Meteors Workshop (CMW). Numerous astronomical camps were organized during summer months from 1996. After 2002, video, photographic and even radio methods were used to observe the streams mentioned above and sporadic background activity (Wiśniewski et al., 2003). Also at this time the Polish Fireball Network (PFN) was founded (Olech et al., 2006).

2 The 2005 outburst

In the year 2005 the CMW astronomical camp was held from July 1 to July 15. Most of the participants made visual observations using the drawing method, the video-telescopic experiment was done (Poleski & Szaruga, 2006), and there was also photographic and CCTV equipment installed on the observatory dome. Besides two narrow-field CCTV systems we used two video cameras with Ernitec 1.2/4 mm lenses and three DSLR cameras with Zenitars 2.8/16 mm mounted. The last night of the camp was July 14/15 and visual observers finished their observations earlier but they reported an unusual number of bright meteors and even fireballs. After quick analysis of visual drawings we found ZHR higher than 4 in the second half of night. Inspection of video and photographic data next day confirmed these reports. On the photographic images two similar bright meteors were detected, one of magnitude -2 and one with magnitude -4. The lightcurves of these meteors were characteristic, with a rapid brightness increase in the middle part. On the video cameras an unusually high number of meteors were recorded, with one spectacular fireball visible on the brightening twilight sky. This meteor appeared at $01^{\rm h}11^{\rm m}$ UT, reached magnitude higher than -6 and was recorded also by PFN03 Złotokłos video station (Figure 1). About half of registered meteors had a common radiant located north of Pegasus and Andromeda; after collecting data from all three PFN stations 20 members of a potential new shower were found.

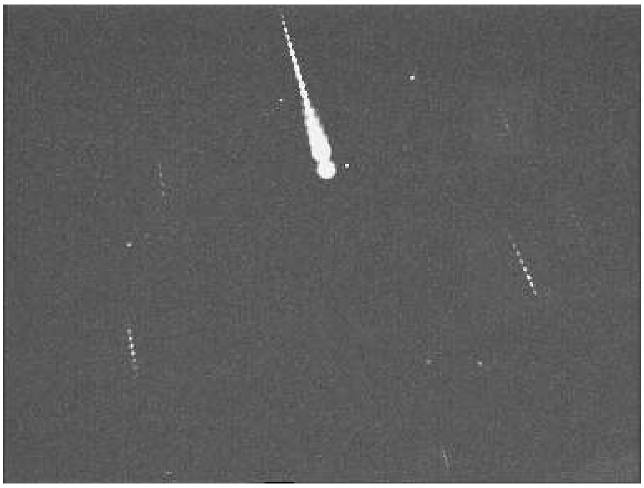

Figure 1 – Composite image created from PFN01 PAVO1 data recorded between $22^{\rm h}56^{\rm m}$ UT and $01^{\rm h}11^{\rm m}$ UT.

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NASA-ADS bibcode 2012JIMO...40..189Z

Table 1 – Radiant coordinates, velocities and orbital elements of calculated meteors. Beginning and terminal heights are presented as $H_{\rm beg}$ and $H_{\rm end}$.

Designation	mag	α_g	δ_g	$V_{\rm geo}$	q	e	i	ω	Ω	$H_{\rm beg}$	$H_{\rm end}$
20050714PFN231115	−2	7.8	45.1	55.2	1.002	0.569	112.46	163.9	112.519	111	92
20050714PFN232601	−4	2.3	51.6	56.1	0.994	0.906	105.54	162.55	112.525	105	93
20050714PFN235506	+2	5.9	49.0	56.4	1.003	0.835	108.10	166.23	112.548	102	93
20050715PFN011103	−6	3.4	51.1	58.7	1.007	1.136	106.57	169.78	112.598	114	85

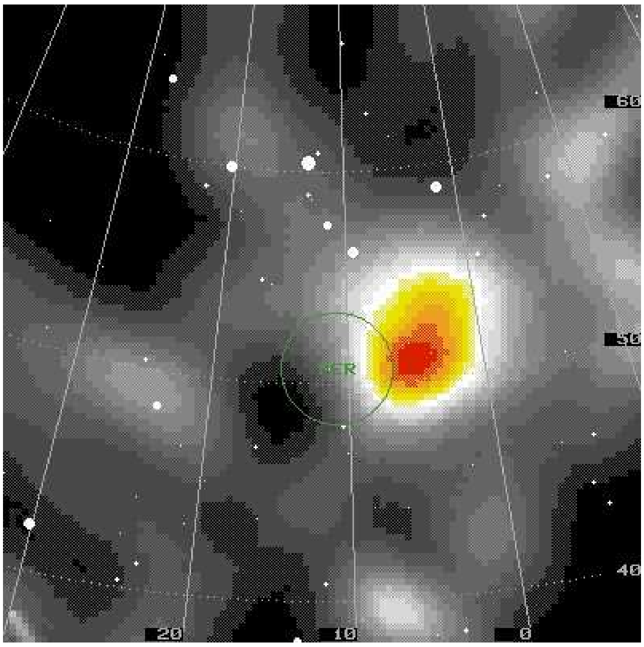

Figure 2 – Radiant calculated using PFN video data with geocentric velocity = 57 km/s.

During the night of July 14/15 three fireball stations with four cameras were active. Almost all selected meteors were recorded after $23^{\rm h}$UT, some of them in morning twilight. PFN01 Ostrowik station detected 15 meteors on all cameras during the last two hours, PFN05 four meteors in 54 minutes. After comparison with known meteor activity for the same cameras and conditions we can roughly estimate the ZHR as 10–15. PFN video data from the night July 14/15 were analyzed using Radiant software (Arlt, 1992). We found a clearly visible radiant at coordinates $\alpha = 6°$, $\delta = +51°$ for geocentric velocity $V_{\rm geo}$= 57 km/s, five degrees west of the possible early Perseid radiant (Figure 2). After examining PFN data we found some meteors suitable for trajectory and orbit calculations including these brightest. Unluckily, the geometry was not optimal (planes' intersection angles between 5 and 10 degrees) so the precision of these trajectories is not very high. Despite this, all listed meteors look to have a common origin. The radiant coordinates, geocentric velocities and rough orbital elements are presented in Table 1. The radiant calculated from 2005 data is located close to the star Zeta Cassiopeiae. According to IAU nomenclature the new stream should be named the Zeta Cassiopeiids (ZCS). The true nature of the observed outburst was unclear for many years. Activity of such a stream was never observed by CMW visual observers before 2005. The absence of a radiant was confirmed during analysis of the CMW visual database. This database contains meteors observed using drawing method, from 1996 to 2007 (data for July 10–20 available for 1996–1999, 2001–2002 and 2004–2005). New analyses became possible recently, with use of new large video meteor datasets.

3 IMO Video data analysis

The IMO Video Network provides probably the largest available database with more than one million recorded meteors. These data can be easily analyzed using dedicated software like Radiant or RadFind. These applications can analyze large datasets of single station meteors using a statistical approach. Activity of the suspected radiant was checked using Radiant software, separately for every year, with a one day step, and the assumed geocentric velocity set to $V_{\rm geo}$= 57 km/s.

Images created using Radiant software for 2005 and 2006 present chaotic structures caused by lack of data for the activity period (Figure 3). The stream is clearly visible in the years 2007–2011. Activity starts around July 12. Between July 14 and July 16 this is the most prominent radiant in the examined area with activity well above the sporadic background. The position of the radiant is in good agreement with the results obtained for 2005 outburst, located 5° west from the possible Perseid radiant. After July 17 activity decreases: in 2007 and 2008 it disappeared completely and in 2010 diffuse structures are visible. In 2009 and 2011 activity drops after July 17 but there is a radiant visible moving into the position of early Perseids. In this case probably the new stream and early Perseids are overlapping which results in the observed unusual drift. The Perseid radiant is distinctly visible after July 20–21. We did another analysis using RadFind software (Molau, 2007) with all data from the IMO Video Network. RadFind found two streams separately – the Perseids and another one, unknown to RadFind, with radiant position expected for Zeta Cassiopeiids.

Zeta Cassiopeiids were detected at the same coordinates as during the previous calculations. Positions were calculated using half degree intervals of solar longitude. The radiant is located a bit westward from the radiant of Perseids, the right ascension drift is a bit different, and the declination drift looks quite unusual, the ZCS radiant moving significantly north during its activity period (Figure 4). This effect is probably caused by overlapping of two radiants – early Perseids and Zeta Cassiopeiids. The geocentric velocity of ZCS and early Perseids is similar but not identical. ZCS looks to be slower, with constant $V_{\rm geo}$= 57.5 km/s (Figure 5).

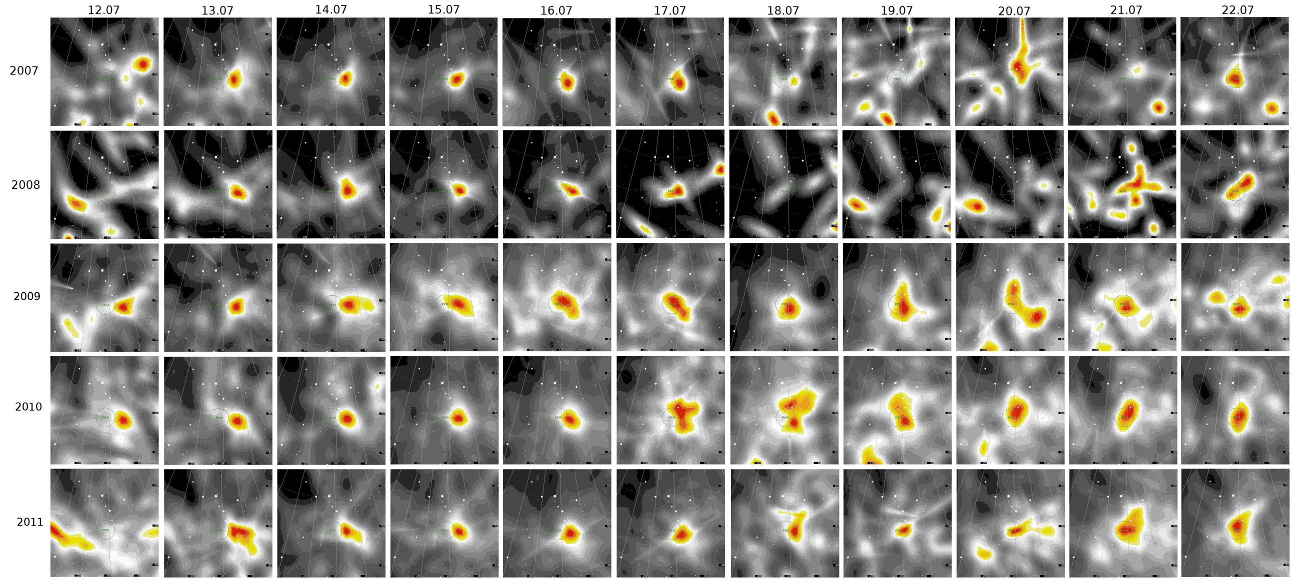

Figure 3 – Probability maps generated using Radiant software. The new radiant is the most significant structure between July 12 and 16. After July 17 activity in the area decreases. The Perseid radiant is visible after July 20. The field of view in each individual plot is the same as in Figure 2.

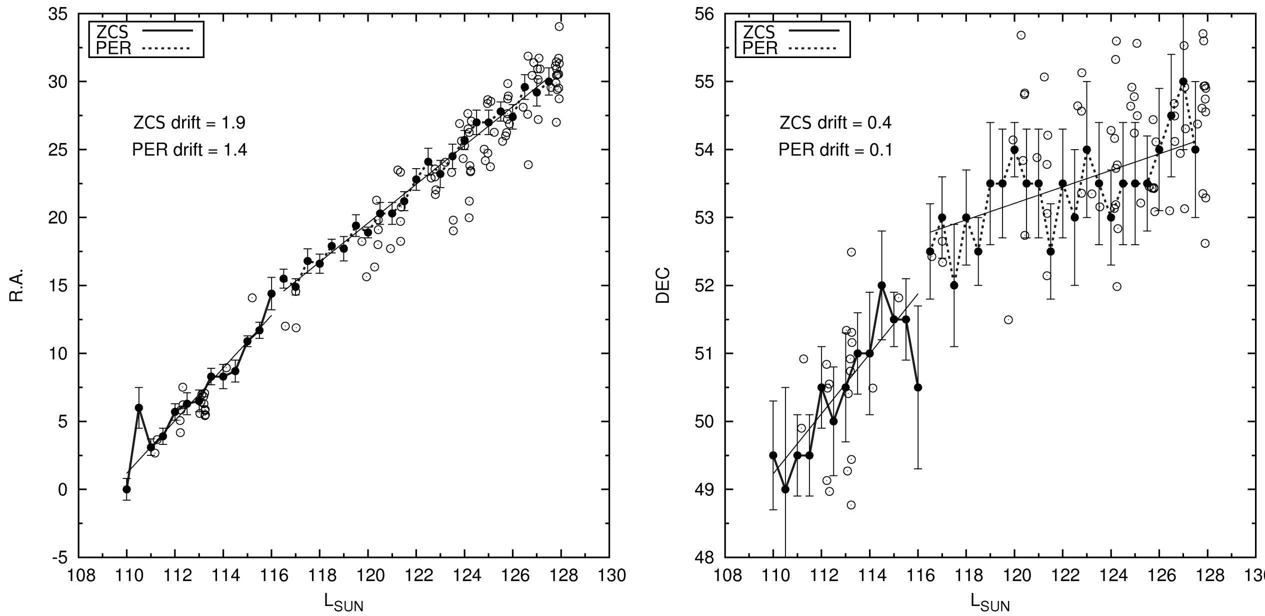

Figure 4 – Drift of the Zeta Cassiopeiids and early Perseids. Black dots represent positions calculated with RadFind, white circles represent positions of meteoroids selected from SonotaCo video database. Note an unusual ZCS radiant drift in declination caused by ZCS and PER radiants overlapping.

Using RadFind we can easily estimate the activity of all detected radiants, including Zeta Cassiopeiids. Activity of the Zeta Cassiopeiids starts along with Perseid activity at $\lambda_\odot = 109°$ and has a clearly visible maximum at $\lambda_\odot = 113°$. During the maximum, ZCS are the most active stream on the sky, with activity two times higher than activity of Alpha Capricornids at this solar longitude (Figure 6). ZCS radiant disappears at $\lambda_\odot = 117°$. The Perseids reach a similar level of activity nine days later which is consistent with results calculated using Radiant software. The observed activity profile clearly shows that there is a separate meteor stream observed in the middle of July.

4 SonotaCo database analysis

The large database of meteoroids' orbital elements were published recently by the SonotaCo video network (SonotaCo, 2009a). With over 65 000 entries this data set is very useful for searching and analyzing new meteor streams. We examined the whole database from 2007, 2008 and 2009 (SonotaCo 2009b,c, 2010) but probably due to bad weather most of ZCS were found in 2009. We selected 426 meteoroids with radiants visible between $\lambda_\odot = 100°$ and $\lambda_\odot = 127°$, with geocentric radiant coordinates in the range $(0° < \alpha < 90°)$, $(40° < \delta < 70°)$. To compare orbits of these meteoroids we used Drummond's orbital similarity criterion (Drummond, 1981). Pairwise D' comparison between all selected orbits was done. For every single mete-

Table 2 – Orbital elements, radiant coordinates and geocentric velocities of Zeta Cassiopeiids found in SonotaCo database.

Mean D'	α_g	δ_g	V_{geo}	q	e	i	ω	Ω	Designation
0.0367	5.06	50.84	57.39	0.9994	0.9891	106.77	165.06	112.21	20090715UT010406
0.0392	5.8	49.44	58.04	1.0046	0.9689	109.12	167.51	113.24	20090716UT030402
0.0393	6.43	49.27	58.32	1.0023	0.9788	109.7	166.41	113.08	20090715UT230320
0.0394	5.49	51.16	57.41	1.0017	0.9929	106.7	166.13	113.26	20090716UT032449
0.0401	6.23	48.97	58.2	1.0003	0.9634	109.81	165.38	112.33	20090715UT040440
0.0403	3.66	50.92	57.14	1.0000	0.9942	105.96	165.32	111.26	20090714UT010715
0.0415	2.67	49.9	57.27	1.0052	0.9740	106.81	167.81	111.17	20090713UT224839
0.0420	5.84	50.49	57.21	0.9972	0.9510	107.3	163.95	112.25	20090715UT020458
0.0421	5.87	51.31	56.3	0.9991	0.9059	105.89	164.59	113.25	20090716UT031934
0.0435	5.58	51.34	56.12	0.9989	0.8969	105.61	164.47	113.03	20090715UT214034
0.0436	6.3	50.74	56.9	0.9990	0.9255	107.07	164.65	113.2	20090716UT015559
0.0457	7.08	48.77	58.36	1.0017	0.9533	110.54	166.02	113.23	20090716UT024833
0.0466	6.97	50.41	58.24	0.9979	1.0139	108.55	164.53	113.11	20090715UT234706
0.0470	5.42	52.49	56.22	0.9979	0.9538	104.41	164.3	113.24	20090716UT025054
0.0471	6.83	50.92	56.55	0.9960	0.8996	106.78	163.26	113.19	20090716UT014148
0.0500	4.17	49.13	57.2	1.0060	0.9123	108.23	168.06	112.22	20090715UT012044
0.0504	6.78	51.74	57.01	1.0043	0.9585	106.47	167.39	115.33	20080718UT012720
0.0504	7.51	50.55	58.18	0.9911	1.0157	108.4	161.91	112.32	20090715UT034642
0.0511	4.04	52.57	56.13	0.9936	0.9795	103.58	162.65	111.22	20090714UT000949
0.0516	8.94	50.49	58.23	0.9946	0.9896	109.2	163.12	114.13	20090717UT011547

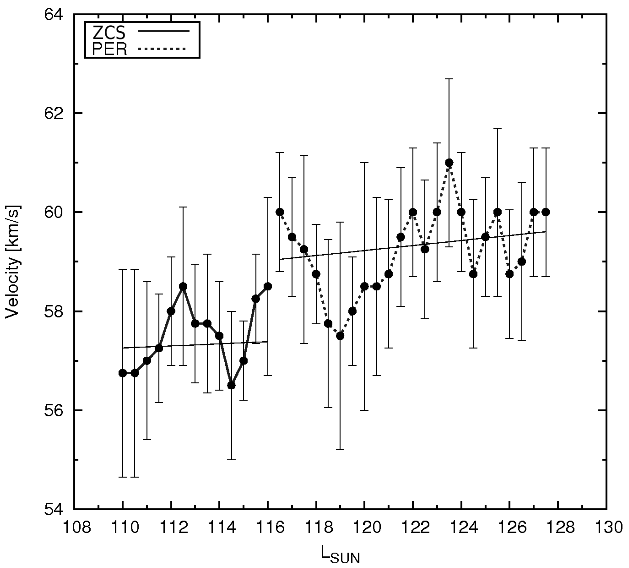

Figure 5 – Geocentric velocities of Zeta Cassiopeiids and Perseids calculated from IMO Video Network database.

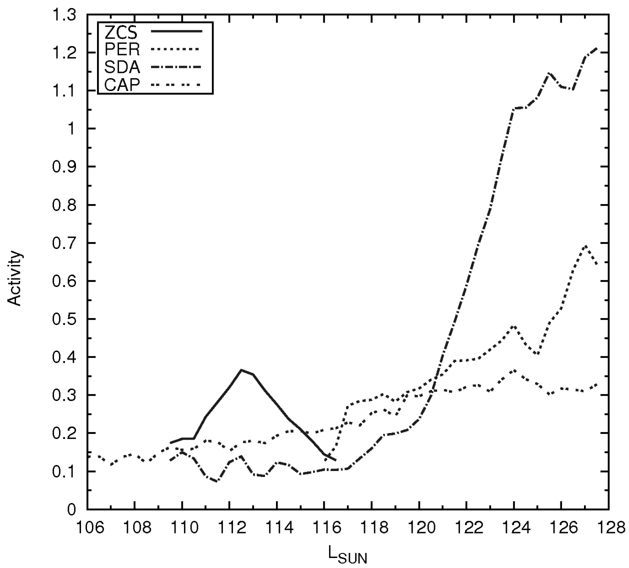

Figure 6 – Activity of all detected meteor showers from July 1 to July 31, given as fraction of sporadic background and corrected for radiant altitude. Calculated with RadFind using IMO Video Network database.

oroid a group of other similar orbits were selected using similarity threshold $D'<0.103$ and orbits exceeding this threshold were rejected. From each such created group the mean D' value is calculated and assigned to the given meteoroid compared with other orbits. This comparison is repeated for all other meteoroids. As a result we have a list of meteoroid orbits with mean D' values calculated for each meteoroid's orbital vicinity defined by the $D'<0.103$ threshold. The orbit with the lowest mean D' may be treated as most representative for the stream, then we can define stream members using comparison with this best orbit. The mean value of D' for all orbits selected this way is a useful parameter determining the consistency of such an orbital group and can be used for searching of not numerous but compact meteoroid streams. The radiant positions and calculated mean D' values are presented in Figure 7. ZCS creates a significant group at coordinates $\alpha = 7°$, $\delta = +50°$. Individual orbital elements of the Zeta Cassiopeiids are presented in Table 2. After orbital elements comparison we found that this is a well defined, distinct meteor stream with highest mean D' values greater than 0.04. The early Perseids create the second group, more numerous, visible in the center of the graph. This group is large and elongated due to radiant drift. Orbital elements are much more dispersed,

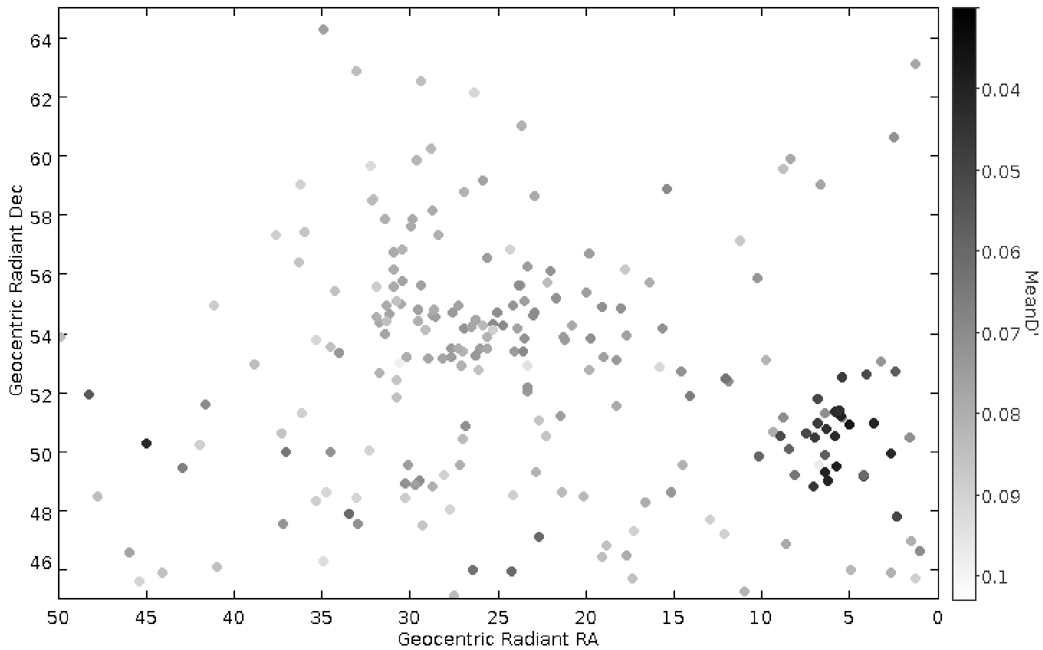

Figure 7 – Geocentric radiants and mean D' values of the selected meteoroids.

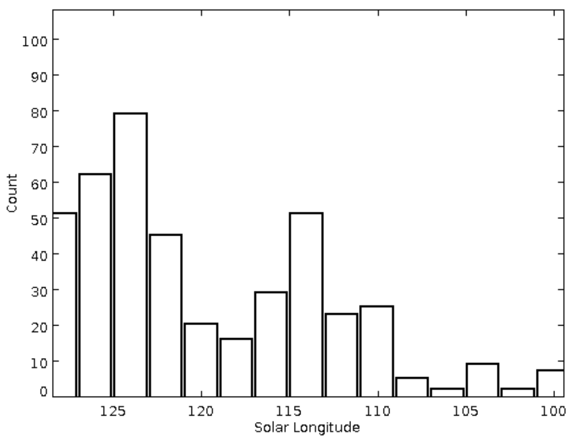

Figure 8 – Number of meteoroids observed between $\lambda_\odot = 100°$ and $\lambda_\odot = 127°$.

with typical mean D' in the range 0.07–0.09. The number of meteoroids in the selected area is presented in Figure 8. Before $\lambda_\odot = 108°$, ZCS meteors were not observed. Significant activity appeared after $\lambda_\odot = 110°$, with a peak at $\lambda_\odot \simeq 113°$. After maximum the activity drops and reaches a minimum at $\lambda_\odot = 120°$. The Perseid meteor stream is visible after that.

Figure 9 presents mean D' values calculated for selected meteoroids, showing their solar longitudes. The maximum was observed at $\lambda_\odot \simeq 113\overset{\circ}{.}1$ which corresponds to the date 2009 July 15, 14^{h} UT. Radiant coordinates were calculated as $\alpha = 5\overset{\circ}{.}9$, $\delta = +50\overset{\circ}{.}5$ and geocentric velocity was determined as V_{geo}= 57.4 km/s. These values are very similar to the other determinations of the radiant and velocity (Table 3).

5 Conclusions

A new July meteor stream was found using PFN data, IMO Video Network observations and the SonataCo orbital database, with three different methods. All results look to be consistent: a stream is located at coordinates $\alpha = 5\overset{\circ}{.}9$, $\delta = 50\overset{\circ}{.}5$, V_{geo} was determined as 57.4 km/s, maximum occurs at $\lambda_\odot = 113\overset{\circ}{.}1$ (around July 15). The shower was observed for the first time in 2005; in 2006 was not found due to lack of data; and was active every year after 2007 which makes it an annual stream active from July 12 to 17. The stream looks to be new in the July sky, never noticed before 2005. Visual analysis of CMW data from 1996–2000 does not reveal any activity higher than ZHR of 2 in this area of the sky (Kiraga & Olech, 2001). Also analysis of the CMW visual database for 2001–2002 and 2004–2005 confirmed lack of an observed ZCS radiant. Presently this radiant activity is two times higher than Alpha Capricornids observed at $\lambda_\odot = 113°$. This new stream should be observed using visual methods to estimate a reliable ZHR value and its year to year variations. It is interesting that Zeta Cassiopeiids were not noticed by present-day observers who observe mostly during activity of big and well known meteor showers. The shower was reported to the IAU MDC and recognized as a new discovery. A very interesting confirmation of the ZCS stream's existence came recently from Croatian observers. A group led by Damir Šegon independently discovered the same radiant and their publication is under preparation at the time of editing this text (Šegon et al., 2012).

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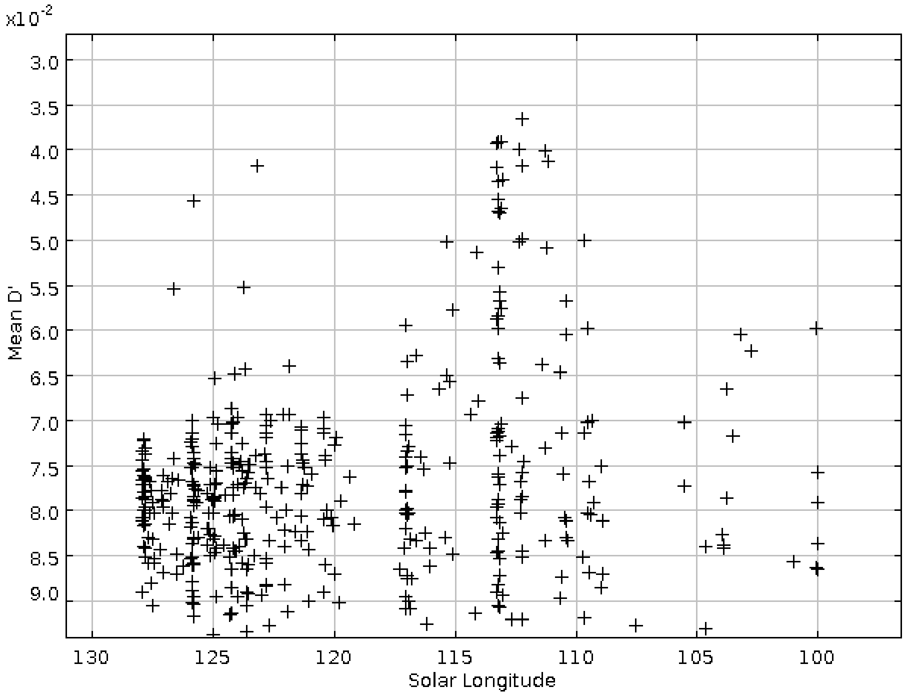

Figure 9 – Mean D' values observed between $\lambda_\odot = 100°$ and $\lambda_\odot = 127°$.

Table 3 – Geocentric radiant, velocity and solar longitude of observed maximum calculated using different methods.

Method	Data	α_g	δ_g	V_{geo}	$\lambda_\odot$
Double station analysis	PFN 2005	4.9	49.2	56.6	112.5
Radiant analysis	PFN 2005	6.0	51.0	57.0	113.0
RadFind analysis	IMO Video	6.5	50.5	57.5	113.1
Double station analysis	SonotaCo	5.9	50.5	57.4	113.1

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New shower in Cassiopeia

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The Croatian Meteor Network Catalogue of Orbits for 2007 contains 1211 orbits, out of which 358 belong to previously known streams. The radiant analysis pointed to a possible new stream with radiant in Cassiopeia, at $\alpha = 6{\stackrel{\circ}{.}}9$, $\delta = 50{\stackrel{\circ}{.}}7$ and $v_g = 57.3$ km/s. The maximum activity is around solar longitude of $113{\stackrel{\circ}{.}}2$. This stream was assigned IAU shower number 444 and three-letter code ZCS. The proposed name of the shower is Zeta Cassiopeiids. The analysis of data for the following years (2008–2011) shows that the meteors belonging to the new stream were present in each year.

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1 Introduction

The year 2007 was the first year of operation of the Croatian Meteor Network (CMN). The network itself is described in more detail in Andreić & Šegon (2010) and Andreić et al. (2010). From all double and multiple station detections in 2007 a catalogue of 1211 orbits was obtained. Out of those, 358 belong to previously known streams. The catalogue is described in detail in Šegon et al. (2012) and can be downloaded from: `http://hmm.homeip.net/home/hmm/downloads/downloads.html`.

2 New shower 444 ZCS

Radiant analysis of the remaining 853 orbits extracted 13 orbits that belong to the new shower. Individual orbits of meteoroids were tested with the D-criterion, using the commonly adopted Southworth-Hawkins method (Southworth & Hawkins, 1963). Starting from the most grouped orbits evident in the dataset, a first estimate of the shower's mean orbit was calculated. Then a D-criterion search of our database using this mean orbit gave the 13 resulting orbits summarized in Table 1.

Based on these 13 orbits, the mean orbit of the shower was recalculated with two most commonly used methods, namely the Jopek-Rudawska method for determining the mean orbit of the stream (Jopek et al., 2006, 2008) and the standard arithmetic average method (i.e. taking the arithmetic average of the orbital elements of individual meteors for the orbital elements of the mean orbit). The mean orbit of the shower determined from these data is given in Table 2. The resulting D_{SH}'s for individual orbits in the final column of Table 1 are referred to the mean orbit from Table 2.

In accordance with the procedure of reporting new showers (Jenniskens et al., 2009) we informed the IAU Meteor Data Center and proposed the name Zeta Cassiopeiids. In response, the shower was assigned IAU shower number 444 and the three-letter code ZCS.

3 CMN data on 444 ZCS shower

As the next step, we expanded our search for meteors that could belong to the Zeta Cassiopeiid stream to the complete CMN database for the next three years. Based on orbital elements given in Table 2 we ran through our databases for 2008, 2009 and 2010 and extracted all orbits that satisfy the condition $D_{SH} < 0.3$. In the last step we used only orbits that satisfy $D_{SH} < 0.15$ and used them to refine the mean orbit of the Zeta Cassiopeiids. Finally, all data were reprocessed by one of the authors (Peter Gural) using his software procedures, providing an independent check of data accuracy and versatility. These new trajectory and orbit determination procedures that were described at last year's IMC (Gural, 2012a,b) provide error estimations for resulting trajectories and dynamics, and consequently all orbital elements.

Zeta Cassiopeiids were found in each following year. Afterwards we again processed all available data which allowed us to refine the orbital and radiant data for the new stream. The CMN orbits (calculated using this multi-parameter fit method) for all years, that satisfy $D_{SH} < 0.15$, are given in Table 3 and resulting orbital parameters are summarized in Table 4.

The fact that CMN photometry calibration is not good for meteors brighter than -2 mag does not impact F-values (Koten & Borovička, 2001; Fleming et al., 1993) for ZCS light curves. We have found out that the mean F-value for 25 CMN ZCS is 0.68 ± 0.09 (1-sigma). The graph of F-values is given in Figure 1.

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Table 1 – Individual orbits of meteoroids in CMN database from 2007 that belong to the new shower. Data processing for these orbits finished with UFOOrbit software orbit calculations. ID is the identification number of the orbit in the database, $\lambda_\odot$ solar longitude corresponding to the time of impact of the meteoroid, M_{abs} absolute magnitude of the meteor, α and δ are coordinates of the radiant, v_g is geocentric velocity, q perihelion distance, e eccentricity, ω argument of perihelion, Ω longitude of ascending node, i inclination (ω, Ω and i in degrees). D_{SH} is the value of the Southworth-Hawkins distance function, calculated for each meteor as a distance from the mean orbit (Table 2) that is calculated from this same dataset.

ID	$\lambda_\odot$	M_{abs}	α	δ	v_g	q	e	Ω	ω	i	D_{SH}
67	112.897	−3.4	6.06	50.75	57.29	0.999	0.961	112.9	164.7	107.2	0.02
101	114.018	0.9	7.67	51.93	57.41	0.995	0.996	114.0	163.4	106.6	0.04
61	112.109	−5.3	4.68	50.72	56.78	1.000	0.939	112.1	165.2	106.3	0.05
87	113.932	−4.7	7.40	51.79	56.59	0.996	0.928	113.9	163.2	106.1	0.06
77	113.095	−0.5	6.72	51.10	58.22	0.997	1.044	113.1	164.4	107.7	0.07
65	112.144	−4.8	2.89	51.53	55.89	1.004	0.922	112.1	167.0	104.2	0.09
78	113.846	0.2	9.71	51.31	57.34	0.987	0.947	113.8	160.0	107.9	0.09
112	114.821	−0.9	8.02	51.65	56.11	0.997	0.872	114.8	163.6	106.2	0.11
32	110.075	−2.5	2.65	49.22	58.79	1.003	1.078	110.1	167.2	108.4	0.13
73	113.006	0.4	3.82	50.13	55.28	1.007	0.801	113.0	168.2	105.7	0.19
57	112.068	−0.4	8.71	49.70	55.66	0.981	0.773	112.1	157.0	107.9	0.24
95	113.973	1.2	9.00	42.61	59.58	1.011	0.785	114.0	171.0	119.4	0.30
102	114.019	1.0	7.85	50.41	61.40	1.001	1.271	114.0	166.7	110.9	0.30

Table 2 – Results of radiant analysis for the members of the new shower, based on CMN orbits from 2007. Orbital data are given as: semimajor axis a (in A.U.), its reciprocal value $1/a$, and q, e, i, Ω, ω as defined in Table 1.

parameter	Jopek-Rudawska method	arithmetic average
a	42.8	46.7
$1/a$	0.02335 ± 0.04437	0.02140 ± 0.04437
q	0.9960 ± 0.0022	0.9958 ± 0.0022
e	0.977 ± 0.044	0.979 ± 0.044
i	107.1 ± 0.5	107.1 ± 0.5
Ω	113.4 ± 0.3	113.3 ± 0.3
ω	164.9 ± 1.0	164.9 ± 1.0

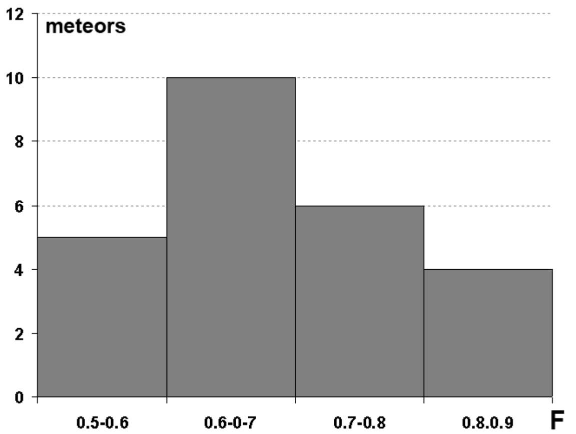

Figure 1 – Light curve F-parameter summary for ZCS. On x-axis are F-parameter bins and on y-axis respective meteor counts.

4 Other sources 444 ZCS data

A SonotaCo database search based on mean orbital data resulted in 30 orbits satisfying the $D < 0.15$ criterion, whose orbital data are presented in Table 5 and resulting mean orbital data in Table 6.

We also searched the IMO Video Meteor Database results from the analysis done for 2006 (IMO, 2007), 2009 (IMO, 2009) and 2012 (IMO, 2012; Molau, 2012).

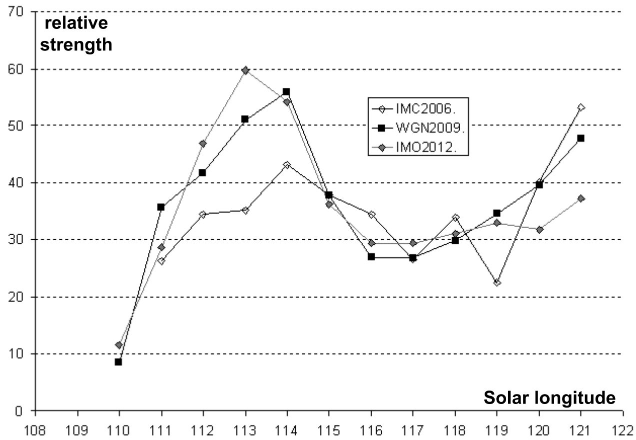

Figure 2 – IMO activity plot for $\lambda_\odot = 108-122°$ shows ZCS activity peak (at $\lambda_\odot = 113°$), followed by regular Perseid activity increase. Data presented as for 2006, 2009 and 2012 represent results from IMO analysis for respective years.

We have found that the ZCS radiant has been detected in all analysis runs, and it was the most active radiant during its activity period ($\lambda_\odot = 109-118°$) – moreover, we have found that the relative strength for this radiant has increased from 2006 to 2012 (Figure 2). Most probably due to the small number of meteors, ZCS could not be distinguished from the Perseid radiant so the analysis from 2009 (Molau & Rendtel, 2009) had recognized ZCS as PER and thus expanded the Perseid activity period as early as $\lambda_\odot = 109°$.

5 Discussion

All together, in CMN and SonotaCo databases we have found 55 orbits that satisfy $D_{SH} < 0.15$. The radiant plot of all orbits is shown in Figure 3, and the daily mean motion in Figure 4. Such a large number of orbits allows us to find average orbital elements and a good estimate of radiant position and mean daily motion (Table 7). The magnitude distribution of ZCS meteors is presented in Figure 6, showing that the average

Table 3 – Individual orbits (calculated by multi-parameter fit method) of meteoroids from 2007 to 2010 that satisfy $D_{SH} < 0.15$. Year and JD are given in the first two columns: individual meteors are identified by JD as the catalogues for years 2008–2010 are not finished yet. Remaining column headings are as in Table 1.

Year	JD	$\lambda_\odot$	α	δ	v_g	q	e	Ω	ω	i	D_{SH}
2007	2454298.457505	113.932	7.66	51.44	57.38	0.996	0.974	113.9	163.6	107.1	0.02
2007	2454297.579870	113.095	6.47	50.85	57.17	0.998	0.950	113.1	164.3	107.2	0.02
2007	2454299.389098	114.820	8.73	51.82	57.39	0.995	0.974	114.8	163.3	107.2	0.03
2007	2454297.372443	112.895	5.75	50.93	57.30	1.000	0.973	112.9	165.2	106.9	0.04
2010	2455392.543153	112.326	5.63	50.51	56.99	0.998	0.935	112.3	164.4	107.0	0.04
2007	2454298.367210	113.844	9.20	51.60	57.23	0.988	0.955	113.8	160.6	107.3	0.05
2007	2454298.548669	114.019	9.71	51.05	57.62	0.989	0.957	114.0	160.7	108.4	0.05
2007	2454298.547440	114.018	7.76	52.90	56.38	0.992	0.955	114.0	161.8	104.9	0.06
2010	2455392.548651	112.332	4.67	52.10	56.28	0.998	0.956	112.3	164.2	104.5	0.06
2010	2455393.599077	113.334	6.53	50.88	56.46	0.998	0.892	113.3	164.1	106.7	0.07
2009	2455027.451945	112.479	4.35	51.28	57.11	1.002	0.991	112.5	166.2	105.9	0.07
2009	2455029.582944	114.514	9.05	51.56	58.23	0.994	1.031	114.5	163.0	108.1	0.08
2010	2455394.583478	114.273	7.92	51.18	58.28	0.998	1.032	114.3	164.7	108.1	0.08
2009	2455031.397587	116.244	11.13	53.70	56.80	0.987	0.974	116.2	160.4	105.5	0.09
2009	2455026.540393	111.611	4.36	48.39	58.29	1.005	0.972	111.6	167.8	109.8	0.10
2010	2455391.514169	111.344	4.91	49.74	56.37	0.998	0.868	111.3	163.7	107.1	0.10
2009	2455029.541139	114.474	8.23	53.19	55.50	0.990	0.889	114.5	160.9	104.1	0.10
2010	2455393.567368	113.303	9.09	47.58	59.72	0.998	0.995	113.3	164.5	113.5	0.11
2010	2455393.568925	113.305	7.54	50.38	56.30	0.995	0.849	113.3	162.4	107.4	0.11
2008	2454664.515121	114.693	11.82	50.18	59.20	0.986	1.026	114.7	160.3	111.2	0.11
2010	2455389.385128	109.311	4.89	46.02	58.86	0.998	0.928	109.3	164.3	112.8	0.12
2010	2455393.599900	113.335	4.46	52.38	54.81	1.001	0.848	113.3	165.2	103.2	0.14
2007	2454297.486554	113.005	4.31	50.30	55.71	1.005	0.836	113.0	167.4	106.0	0.14
2008	2454667.510702	117.551	13.95	52.72	56.57	0.983	0.881	117.6	158.5	107.5	0.14
2009	2455032.513815	117.310	15.29	51.69	59.00	0.981	1.023	117.3	158.5	110.6	0.15
Average:					57.24	0.995	0.947	113.7	163.2	107.5	
st. dev.:					1.18	0.006	0.058	1.7	2.4	2.4	

Table 4 – Results of radiant analysis for the members of the new shower, using 25 CMN orbits from 2007 to 2010. Symbols for orbital data a, $1/a$, q, e, i, Ω, ω as in Table 2.

parameter	Jopek-Rudawska method	arithmetic average
a	18.0	18.6
$1/a$	0.05544±0.01184	0.05371±0.01184
q	0.9930±0.0013	0.9949±0.0013
e	0.945±0.012	0.947±0.012
i	107.5±0.5	107.5±0.5
Ω	113.7±0.4	113.7±0.4
ω	163.2±0.5	163.2±0.5

observed ZCS is a bright −1 mag meteor. Last, but not least, the beginning and ending heights of ZCS meteors, plotted as a function of their absolute magnitude are shown in Figure 5.

From Table 4 and Table 6 it can be seen that data obtained with different capture and astrometry software, as well as trajectory and orbit calculation methods, result in very similar average orbits. Higher values of standard deviations for v_g and inclination in CMN data are most probably due to the fact that CMN uses 4 mm lenses and (in this dataset mostly) 384×288 camera resolution (typically 6 mm full D1 for SonotaCo data), otherwise the agreement is very good for all orbital parameters. Results found in the IMO database are showing that there seems to be a constant growth of relative activity during the observed period. While analysis from 2006 shows ZCS at 40% of relative strength, one may see an increase to 56% (2009) and 60% (2012), respectively. Deeper analysis and future observation will show if this is a correct assumption.

A parent body search for ZCS yields no resulting object at their average orbit. The closest comet (as one may suspect) is the Perseids' parent body, comet 109P/Swift-Tuttle. But the D-criterion value is of the order of 0.4, similar to Perseid mean orbits, meaning that at the moment we cannot consider it as the ZCS parent body. There are some obvious thoughts and questions jumping out at this point. The ZCS parent body could be an unknown comet (approaching the Sun, if the activity increase is to be confirmed), the parent body could be a fragment of Swift-Tuttle (due to similar orbital parameters), or ZCS could in fact be a heavily perturbed Perseid filament.

6 Conclusions

As for now, we found more than 55 orbits fitting mean orbital parameters by D-criteria with the limit $D_{SH} < 0.15$. First orbits are dating from 2007, but we found new shower members in our database for the next three years and in SonotaCo catalogues too, which helped in confirming the existence of the new shower, and in refining radiant position and orbital parameters.

Table 5 – Individual orbits of meteoroids from 2007 to 2009 that satisfy $D_{SH} < 0.15$ found in SonotaCo database (SonotaCo 2009, 2010). Column headings as in Table 3.

Year	JD	$\lambda_\odot$	α	δ	v_g	q	e	Ω	ω	i	D_{SH}
2009	2455026.668999	112.210	5.06	50.84	57.39	0.999	0.989	112.2	165.1	106.8	0.03
2009	2455027.767234	113.258	5.49	51.16	57.41	1.002	0.993	113.3	166.1	106.7	0.03
2009	2455026.711793	112.251	5.84	50.49	57.21	0.997	0.951	112.3	164.0	107.3	0.03
2009	2455027.616052	113.114	6.97	50.41	58.24	0.998	1.014	113.1	164.5	108.5	0.05
2009	2455025.671709	111.259	3.66	50.92	57.14	1.000	0.994	111.3	165.3	106.0	0.05
2008	2454664.685657	115.333	6.78	51.74	57.01	1.004	0.958	115.3	167.4	106.5	0.05
2009	2455027.705544	113.199	6.30	50.74	56.90	0.999	0.925	113.2	164.6	107.1	0.05
2009	2455027.585657	113.085	6.43	49.27	58.32	1.002	0.979	113.1	166.4	109.7	0.05
2009	2455028.677628	114.126	8.94	50.49	58.23	0.995	0.990	114.1	163.1	109.2	0.05
2009	2455026.794915	112.330	6.23	48.97	58.20	1.000	0.963	112.3	165.4	109.8	0.05
2009	2455027.743681	113.235	5.42	52.49	56.22	0.998	0.954	113.2	164.3	104.4	0.05
2009	2455027.752801	113.244	5.80	49.44	58.04	1.005	0.969	113.2	167.5	109.1	0.06
2009	2455027.742058	113.234	7.08	48.77	58.36	1.002	0.953	113.2	166.0	110.5	0.07
2009	2455026.782431	112.318	7.51	50.55	58.18	0.991	1.016	112.3	161.9	108.4	0.07
2009	2455025.575451	111.167	2.67	49.90	57.27	1.005	0.974	111.2	167.8	106.8	0.07
2009	2455027.763597	113.254	5.87	51.31	56.30	0.999	0.906	113.3	164.6	105.9	0.07
2009	2455025.631829	111.221	4.04	52.57	56.13	0.994	0.979	111.2	162.7	103.6	0.08
2009	2455027.695694	113.190	6.83	50.92	56.55	0.996	0.900	113.2	163.3	106.8	0.08
2009	2455027.528176	113.030	5.58	51.34	56.12	0.999	0.897	113.0	164.5	105.6	0.08
2009	2455026.681068	112.222	4.17	49.13	57.20	1.006	0.912	112.2	168.1	108.2	0.09
2007	2454300.726042	116.574	12.01	52.42	57.83	0.989	0.992	116.6	161.2	108.0	0.10
2009	2455027.777439	113.268	10.13	49.79	58.45	0.986	0.974	113.3	159.9	110.4	0.10
2008	2454658.704619	109.630	2.35	47.77	58.40	1.005	0.990	109.6	168.0	109.6	0.11
2009	2455024.754306	110.384	2.44	52.65	56.59	0.996	1.043	110.4	163.9	103.2	0.11
2009	2455027.581852	113.081	8.49	50.03	56.95	0.990	0.880	113.1	160.9	108.6	0.12
2009	2455027.671187	113.166	6.38	49.86	56.49	1.000	0.856	113.2	164.8	107.8	0.12
2009	2455031.709511	117.020	11.89	52.34	56.52	0.991	0.881	117.0	161.2	107.2	0.14
2009	2455024.761519	110.391	4.25	49.17	56.22	0.997	0.846	110.4	163.2	107.3	0.14
2009	2455027.679282	113.174	8.14	49.15	56.88	0.995	0.840	113.2	162.3	109.4	0.15
2009	2455028.574896	114.028	5.42	51.11	58.92	1.006	1.114	114.0	168.6	107.8	0.15
Average:					57.32	0.998	0.954	112.9	164.6	107.5	
st. dev.:					0.83	0.005	0.060	1.6	2.3	1.8	

Table 6 – Results of radiant analysis for the 30 orbits from SonotaCo database. Symbols for orbital data a, $1/a$, q, e, i, Ω, ω as in Table 2.

parameter	Jopek-Rudawska method	arithmetic average
a	21.3	21.9
$1/a$	0.04703±0.01116	0.04568±0.01116
q	0.9970±0.0001	0.9982±0.0001
e	0.953±0.011	0.954±0.011
i	107.5±0.3	107.5±0.3
Ω	112.9±0.3	112.8±0.3
ω	164.6±0.4	164.6±0.4

So far the available data show that the radiant is active from 107–120° Solar longitude, corresponding to roughly July 9th to July 21st. Radiant position at the maximum of $\lambda_\odot = 113^\circ\!.2$ is at $\alpha = 6^\circ\!.9$, $\delta = +50^\circ\!.7$ with $v_g = 57.3$ km/s. The mean daily motion was found to be $+1^\circ\!.4$ in right ascension and $+0^\circ\!.5$ in declination.

Independent confirmation of our results and of the existence of this shower as a separate one just came from the Polish Comets and Meteors Workshop – their results are presented in this very WGN issue (Żołądek & Wiśniewski, 2012).

Table 7 – Results of final radiant analysis for the 55 CMN and SonotaCo orbits that satisfy $D_{SH} < 0.15$. Symbols for orbital data a, $1/a$, q, e, i, Ω, ω as in Table 2. Finally, radiant position and mean daily motion are also specified. Geocentric velocity is given in km/s. The stream was active for $\lambda_\odot = 109^\circ\!.3 - 117^\circ\!.6$.

parameter	Jopek-Rudawska method	arithmetic average
a	19.6	20.3
$1/a$	0.05093±0.00807	0.04933±0.00807
q	0.9951±0.0008	0.9967±0.0008
e	0.949±0.008	0.951±0.008
i	107.5±0.3	107.5±0.3
Ω	113.2±0.2	113.2±0.2
ω	163.6±0.3	163.9±0.3
	radiant position:	mean daily motion:
α	6.9	+1.4
δ	50.7	+0.5
v_g	57.3±1.0	

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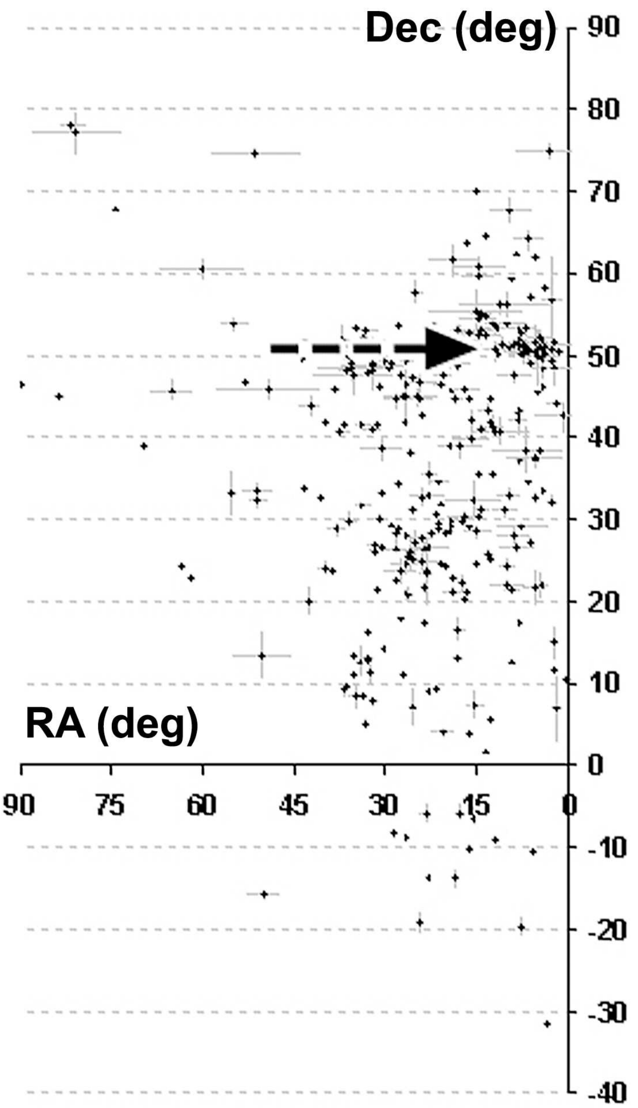

Figure 3 – Radiant plot of all radiants from CMN databases for years 2007–2010 in the part of sky where the new stream was found, for $\lambda_\odot = 108 - 122°$.

Petar Rohlik; Makarska–Robert Zovko; Mali Lošinj –Dorian Božičević; Merenje, Zagreb (RGN) – Željko Andreić; Osijek–Dario Klarić; Petrovsko–Krunoslav Vardijan; Pula–Damir Šegon; Rijeka–Ivica Ćiković; Rovišće–Denis Štogl; Sisak–Zvonko Prihoda, Daribor Brdarić; Šibenik–Berislav Bračun; Šolta–Dejan Kalebić; Višnjan – Maja Crnić, Reiner Stoss; Valpovo – Filip Novoselnik, Denis Vida; Varaždin–Alan Pevec; Velika Pisanica – Luka Oskoruš; Zagreb (Titus) – Sonja Janeković; Žrnovnica–Filip Lolić. Also, to Igor Terlević, for many contributions to the CMN software suite and to Filip Lolić for modifications of the hardware of CMN cameras.

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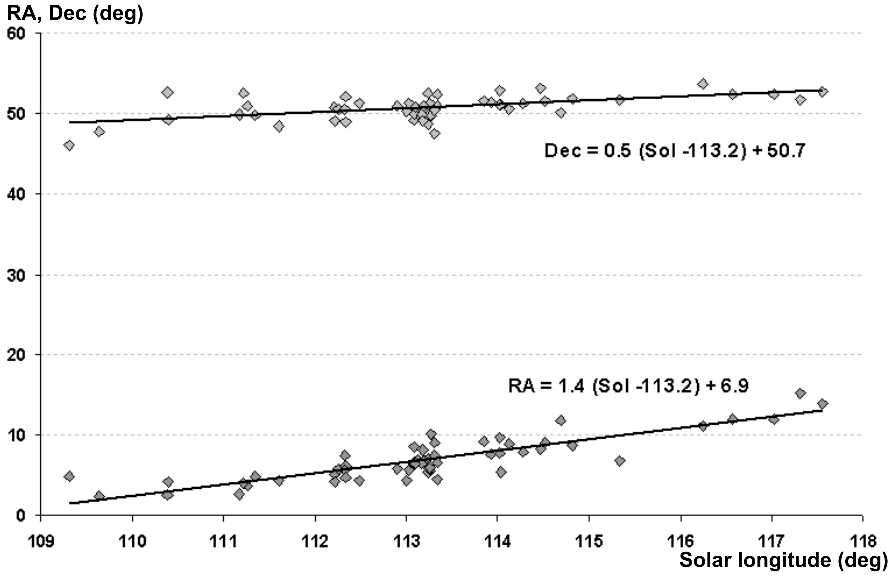

Figure 4 – Determination of radiant mean daily motion from all datasets available (CMN+SonotaCo).

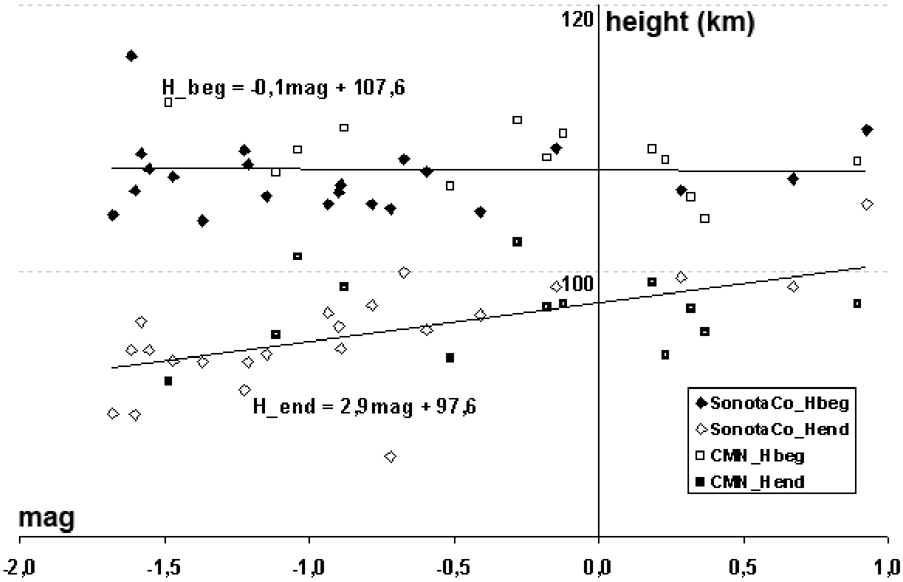

Figure 5 – Beginning and ending heights of ZCS meteors as a function of their magnitude.

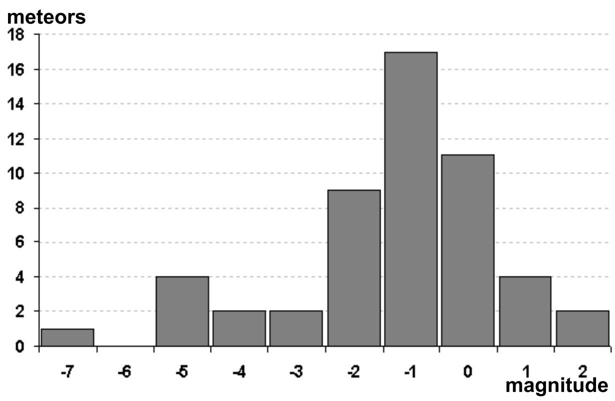

Figure 6 – Magnitude distribution of ZCS meteors.

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Preliminary results

Results of the IMO Video Meteor Network — August 2012

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A record number of more than 10 000 hours of effective observing time was obtained by 74 cameras that recorded more than 74 000 meteors in 2012 August. The activity profile of the Perseids is presented, based on more than 30 000 shower meteors. The zenith exponent γ was analysed, and a best fit of $\gamma = 1.9$ was obtained for 2012 Perseids. Shower parameters of κ-Cygnids, Southern ι-Aquariids, Northern ι-Aquariids and Aurigids from the 2012 analysis are presented. A new meteor shower of θ-Piscids (508 TPI) is reported and three other shower candidates are indicated.

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1 Introduction

Once again we obtained a monthly total that outperformed all previous records. This is because August 2012 presented two things: A high number of observers (40 observers with 74 camera systems) and perfect observing weather at almost all sites – even though there was a Perseid maximum without Moon interference on the agenda. Sixty-one cameras, in other words almost every camera in automated operation, yielded twenty or more observing nights. Fourteen cameras even managed to obtain 30 or 31 nights. Stefano Crivello broke his own record with Bilbo by observing 86 nights in a row without a break (from June 7 to August 29).

Rui Goncalves took Templar4 into operations, so he became the fifth observer with four or more cameras. Ulrich Sperberg, a "veteran of the first hour" (in fact, he was the second IMO Video Meteor Network observer) reactivated his camera for the Perseids 2012.

And what is the result when there are so many cameras observing under perfect conditions? A record-breaking effective observing time, of course! For the second time after October 2011 we managed to obtain more than 10 000 observing hours, which is 250 more than in October 2011 and even 3 000 hours more than in August 2011. Whereas we recorded 53 000 and 59 000 meteors, respectively, in those months, it was more than 74 000 meteors in August 2012 (Table 5 and Figure 1)! The average of 7.2 meteors per hour matched almost perfectly to the values of 2011 (7.3) and 2010 (7.1).

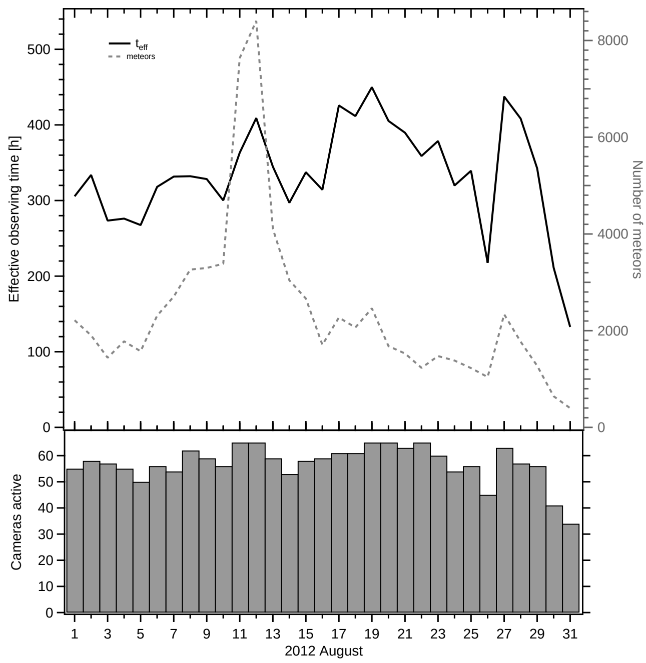

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2012 August.

2 Perseids

Let us switch immediately to the Perseids. The overall activity profile (Figure 2) obtained from over 30 000 Perseids shows the typical shape, and also the little "bump" at 133° solar longitude (August 5) is there

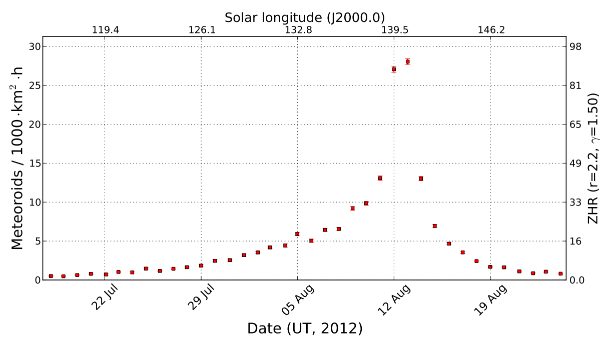

Figure 2 – Flux density profile of the Perseids in the full activity interval 2012.

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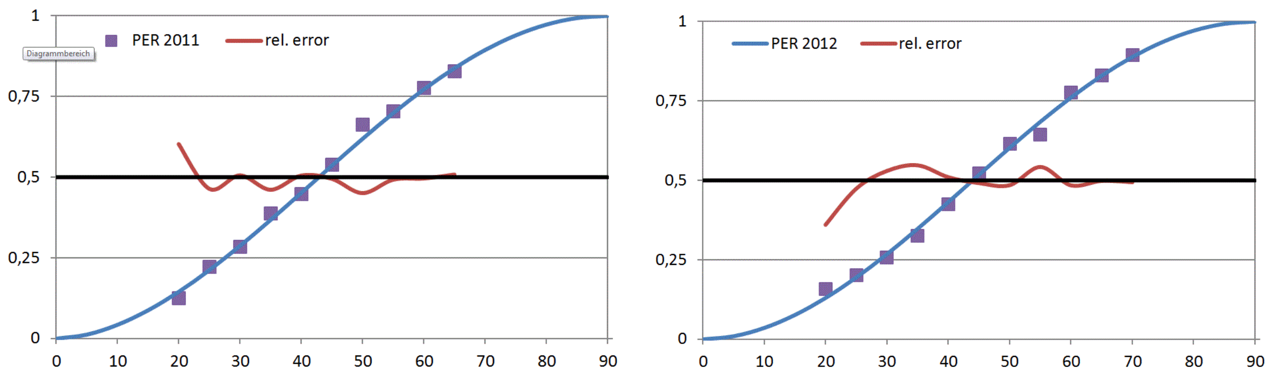

Figure 3 – Dependency of the flux density from the radiant altitude, determined from Perseid observations of 2011 and 2012. The blue line gives the best fitting correction function with a zenith exponent of $\gamma = 1.8$ (2011) respectively 1.9 (2012). The red line represents the relative error.

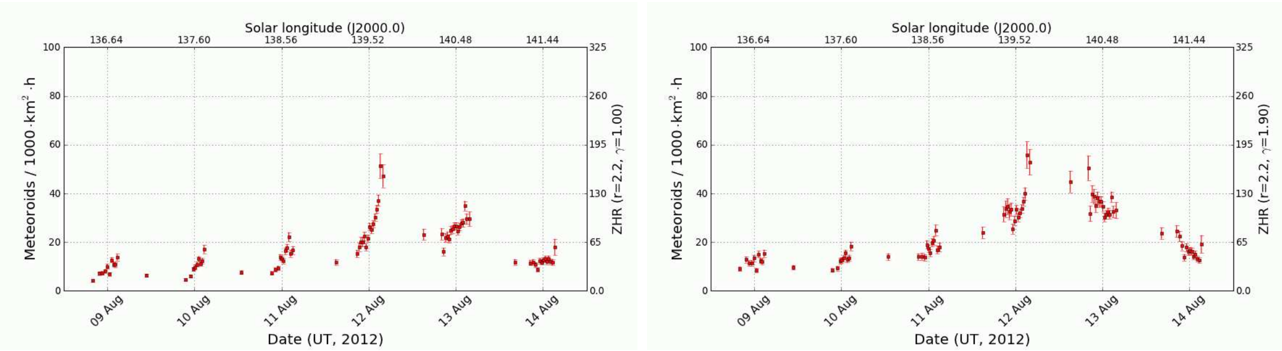

Figure 4 – Detailed flux density profile of the Perseid maximum 2012 with a zenith exponent of $\gamma = 1.0$ (left) respectively 1.9 (right).

again. Looking at the Perseid maximum in detail, the same phenomenon as in 2011 (Molau et al., 2011) can be seen: Instead of a smooth activity profile, there is a strong increase in flux density in every single night towards the local morning hours, which can be attributed to the zenith exponent. In this year we have chosen a different approach to determine the proper radiant altitude correction, which was presented in detail at the IMC 2012 (Molau, 2013).

The flux density measurements, which are uploaded by the observers to the VMO server, contain the usual correction by the sine of the radiant altitude (i.e. with a zenith exponent of $\gamma = 1.0$). During the analysis, this correction was at first reverted, and the observing intervals were grouped by radiant altitude. That is, the effective collection area and number of shower meteors were summed up in the interval 0° to 5°, 5° to 10°, etc. In the ideal case, when the flux density would have been constant all the time, this would have directly given us the dependency of the flux density from the radiant altitude. In practice, however, the Perseid flux density varies significantly in August. At the ascending activity branch, it is systematically higher at the end of the observing night with large radiant altitude when compared to the beginning of the night. In addition, some nights with more observing time have a larger impact than others. Our analysis showed, however, that both effects can be neglected. Conditions are reverted at the descending activity branch, and even if the nights are normalized to get the same weight each, nothing changes at the overall picture.

Next we can check, which function fits best to the determined dependency of the flux density from the radiant altitude. We found that the typical sine function with a zenith exponent fits very well to our data, whereby an exponent of $\gamma = 1.9$ minimizes the mean squared error. Figure 3 shows the measurements (purple rectangles), the adapted correction function calculated with $\gamma = 1.9$ (blue line) and the relative error between measurement and correction function (red line). The same procedure was applied to the 2011 Perseid data, which gave a best fit for a zenith exponent of $\gamma = 1.8$.

Figure 4 compares the uncorrected activity profile ($\gamma = 1.0$) with the best profile ($\gamma = 1.9$). The improvement is particularly obvious at the 2012 post-maximum Perseid nights.

Figure 5 is an overlay of the flux density profiles of 2011 and 2012 between 136 and 142° solar longitude. The data sets fit amazingly well to one another.

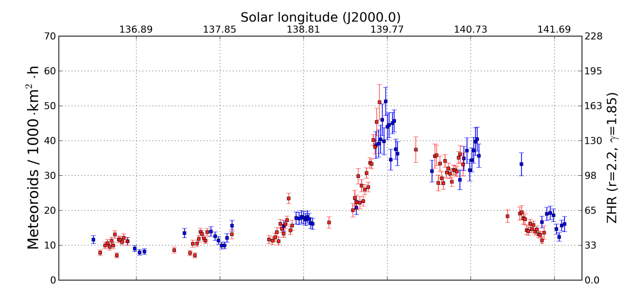

Figure 5 – Flux density profile of the Perseid maximum 2011 (blue) and 2012 (red), calculated with a zenith exponent of 1.85.

Table 1 – Parameters of the κ-Cygnids from the MDC Working List and the analysis of the IMO Network in 2012. Both the mean values for the overall activity interval, and the detailed values for the two subsection until 142 and starting from 143° solar longitude are given.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	145	—	278.2	+0.3	+54.0	+0.1	24.1	—
	145	132–156	272.6	−0.9	+57.6	+0.8	22.7	+0.08
IMO 2012	137	132–142	280.3	+1.0	+50.1	+0.6	22.0	+0.19
	150	143–156	267.3	−1.7	+61.6	+0.5	23.1	0.00

Table 2 – Parameters of the Northern ι-Aquariids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	148	—	328	—	−4.7	—	29.8	—
IMO 2012	142	140–144	334.0	+0.4	−8.3	−0.5	29.4	—

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

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	158	—	89.8	+1.0	+38.7	−0.2	66.6	—
IMO 2012	159	153–166	91.8	+1.00	+39.0	−0.01	67.7	−0.15

In the following sections we will discuss once more further showers which have been found in our recent comprehensive meteor shower analysis in spring 2012.

3 κ-Cygnids

The established shower κ-Cygnids (12 KCG) shows a weakly developed profile with a maximum on August 18 (in this year, the flux density was virtually constant between August 3 and 20). With 2 900 members, this shower can be detected between 132 and 156° solar longitude. In the past we noticed already, that the radiant drift of the κ-Cygnids is not uniform (Molau & Rendtel, 2009). That was confirmed by our new analysis. Whereas both declination and meteor shower velocity show a constant development, we can split the right ascension in two intervals: Up to a solar longitude of about 142° the radiant drifts by an average of $+1\overset{\circ}{.}0$ per day, thereafter by $-1\overset{\circ}{.}7$ per day. Table 1 shows the parameter set for the full activity interval as well as for both subsections.

4 Southern ι-Aquariids

The Southern ι-Aquariids (3 SIA), which are also listed as established shower by the MDC, cannot be detected with certainty in our long-term data. There are a few radiants between August 3 and 8, which look somehow similar to the MDC values, but they show strong variations from one day to the next, and the mean radiant is about 8° north of the expected position.

5 Northern ι-Aquariids

The Northern ι-Aquariids (33 NIA) are in a little more comfortable position. This shower can be identified between 140 and 144° solar longitude. The meteor shower parameters derived from 850 meteors are given in Table 2.

6 Aurigids

The Aurigids (206 AUR), which are also among the established meteor showers, can first be observed on August 26 at 159° solar longitude. The shower parameters in Table 3 were obtained from 1 700 meteors. The radiant position shows virtually no scatter in the full activity interval, only the velocity varies a little. The agreement with the MDC values is excellent.

That was about it with the known meteor showers in August. Further showers from the MDC working list the β-Cassiopeiids (177 BCA) or μ-Perseids (435 MPR) have been detected as well, but their identification remains questionable. Surprisingly, the Orionids can be traced back until end of August (!) but will be discussed in detail at some later analysis.

7 New shower candidates

Last but not least, Table 4 presents a few candidates for new meteor showers again.

7.1 θ-Piscids

The first shower is active from August 8 until the end of the month and can be regarded as a safe detection. The presented parameters were obtained from over 4 500 meteors and the scatter in the full activity interval is very small. In the whole second half of August, this shower is the second or third strongest source in the sky, even stronger than the κ-Cygnids. For this reason, the shower was immediately reported to MDC, where it got the designation θ-Piscids (508 TPI).

Table 4 – Parameters of four possibly new showers from the analysis of the IMO Network in 2012. The first one received the MDC designation θ-Piscids (508 TPI).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
IMO 2012	147	135–158	352.0	+0.78	+4.1	+0.36	60.6	−0.16
	155	149–158	0.6	+0.3	+77.5	−0.0	42.4	—
	155	153–157	106.5	+1.8	+40.0	−0.3	55.6	—
	160	153–166	70.4	0.0	+41.5	+0.4	70.0	—

7.2 Other shower candidates

1350 meteors were assigned to a second candidate, which is active between August 22 and September 1. Maybe the activity interval extends even three to four more days, but in the given interval it presents the lowest radiant scatter. The shower shows a weak activity profile with maximum at 155° solar longitude. As the radiant is close to the north celestial pole, larger variations in right ascension are quite normal.

The third candidate is less prominent. The parameters given in Table 4 are based on 500 meteors. The suspected shower is active in the last few days of August and shows an acceptable scatter in the parameters.

Finally also the last candidate is quite safe, as it represents the strongest source in the sky in early September. Almost 2 000 meteors can be assigned to that fast shower candidate. Its weak activity profile shows a peak in early September at 160° solar longitude.

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Figure 6 – A sporadic fireball with the Moon, recorded on 2012 August 8 at $02^h29^m42^s$ UT by Bilbo. Photo courtesy: Stefano Crivello.)

Figure 7 – Perseid fireball recorded on 2012 August 12 at $02^h28^m00^s1$ UT by Loomecon. Photo courtesy: Grigoris Maravelias.

Table 5 – Observers contributing to 2012 August data of the IMO Video Meteor Network. Eff.CA designates the effective collection area.

Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig1 (0.8/8)	1488	4.8	726	7	47.0	89
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	30	205.6	2892
			Hulud2 (0.75/6)	4860	3.9	1103	30	184.6	1012
			Hulud3 (0.75/6)	4661	3.9	1052	28	167.7	877
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	29	195.0	1233
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	29	212.4	1730
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	27	119.0	715
			Mbb4 (0.8/8)	1470	5.1	1208	25	116.6	605
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	27	121.2	795
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	28	123.3	1029
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	23	140.9	675
			Bmh2 (1.5/4.5)*	4243	3.0	371	28	139.5	645
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	30	207.8	1930
			C3P8 (0.8/3.8)	5455	4.2	1586	31	195.3	1426
			Stg38 (0.8/3.8)	5614	4.4	2007	27	195.7	2650
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	20	63.7	349
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	27	198.7	1518
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	29	224.1	1427
			Templar2 (0.8/6)	2080	5.0	1508	30	226.4	1191
			Templar3 (0.8/8)	1438	4.3	571	30	209.6	983
			Templar4 (0.8/3.8)	4475	3.0	442	4	32.2	108
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	30	194.3	1440
			Orion3 (0.95/5)	2665	4.9	2069	30	181.8	937
			Orion4 (0.95/5)	2662	4.3	1043	29	183.7	1006
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	9	27.3	268
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	27	178.3	1146
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	30	201.6	1316
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	29	204.2	1276
		Sopron/HU	Husop (0.8/6)	2031	3.8	460	29	164.5	1637
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	29	200.6	911
KACJA	Kac	Kostanjevec/SI	Metka (0.8/8)*	1372	4.0	361	11	75.7	199
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	29	172.8	852
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	23	141.2	1501
			Rezika (0.8/6)	2270	4.4	840	20	128.3	1550
			Stefka (0.8/3.8)	5471	2.8	379	19	121.0	1060
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	20	162.7	788
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	10	51.5	405
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	16	61.4	624

Table 5 – Observers contributing to 2012 August data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	16	52.6	216
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	26	129.3	404
			Pav36 (1.2/4)*	5732	2.2	227	26	143.6	858
			Pav43 (0.95/3.75)*	2544	2.7	176	25	138.7	391
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	26	158.3	1076
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	10	40.7	1246
			Mincam1 (0.8/8)	1477	4.9	1084	27	142.7	949
		Ketzür/DE	Remo1 (0.8/8)	1467	6.0	3139	25	128.2	1912
			Remo2 (0.8/8)	1475	5.6	1965	25	126.0	900
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	24	140.8	854
OCAFR	Ocaña Gonzáles	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	26	182.8	341
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	27	61.4	407
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	26	125.1	741
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	30	197.8	2090
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	23	146.8	1328
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	23	118.1	306
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	30	202.3	687
			Ro2 (0.75/6)	2381	3.8	459	29	190.4	818
			Sofia (0.8/12)	738	5.3	907	29	194.3	593
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	27	172.4	987
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	28	113.2	876
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	23	113.0	406
SPEUL	Sperberg	Salzwedel/DE	Adam (0.8/6)	2292	—	—	8	47.6	320
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	30	202.4	2336
			Noa38 (0.8/3.8)	5609	4.2	1911	30	215.0	1988
			Sco38 (0.8/3.8)	5598	4.8	3306	30	213.2	2308
STORO	Stork	Kunzak/CZ	Kun1 (1.4/50)*	1913	5.4	2778	5	31.9	1327
		Ondrejov/CZ	Ond1 (1.4/50)*	2195	5.8	4595	6	35.5	1672
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	24	98.7	445
			Mincam3 (0.8/12)	728	5.7	975	24	90.5	415
			Mincam4 (1.0/2.6)	9791	2.7	552	22	90.8	420
			Mincam5 (0.8/6)	2349	5.0	1896	29	115.2	772
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	29	199.2	1713
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	25	152.1	772
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	21	58.1	431
ZELZO	Zelko	Budapest/HU	Huvcse02 (0.95/5)	1606	3.8	390	4	15.3	102
						Overall	31	10 361.3	74 202

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — September 2012

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The cameras of the IMO Video Meteor Network recorded more than 32 000 meteors in almost 9000 observing hours in 2012 September. Flux density profiles are presented for the Aurigids, September ε-Perseids and δ-Aurigids. Parameters for six other minor showers are presented and three candidates for new meteor showers are indicated.

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1 Introduction

September 2012 was not a record-breaking month, but it still presented a nice outcome to the IMO Network. Spells of clear skies between September 6 and 11, and on September 20/21, interleaved with periods of poor weather conditions. Other than usual, the observers in northern central Europe enjoyed better weather conditions than the southern European observers, which are typically preferred. Two third of all camera systems obtained twenty and more observing nights. Compared to the previous year, the overall effective observing time increased by 200 to 8 850 hours, whereas the number of meteors decreased by 4 000 to overall 32 000 (Table 10 and Figure 1). With 3.6 meteors per hour, the average was as low as hardly ever before in September.

September has no major meteor showers to offer. Beside the upcoming Orionids and the Antihelion / Taurids, there are only three minor showers which belong to the Perseid / Aurigid complex.

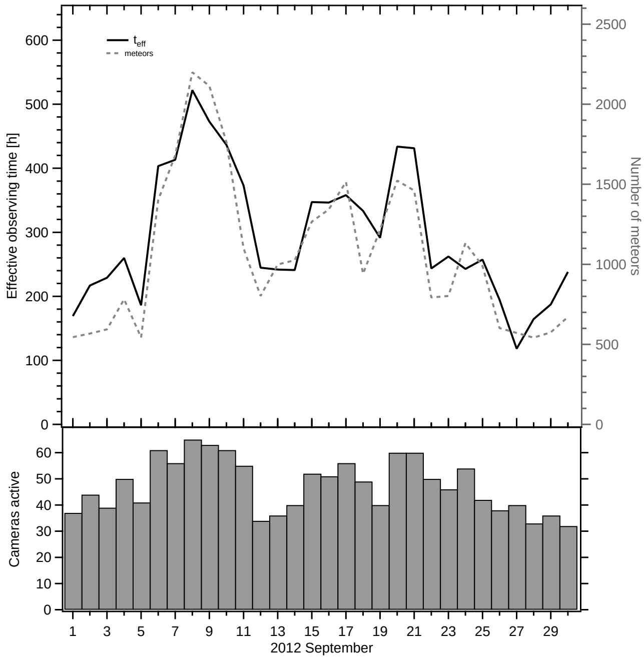

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2012 September.

2 Aurigids

The Aurigids (206 AUR) reach their maximum at the beginning of September. Figure 2 shows the activity profile of that shower in 2012. We obtained an almost constant flux density of 1.5 meteoroids per 1 000 km^2 per hour without a clear maximum.

3 September ε-Perseids

According to the IMO working list of visual meteor showers (McBeath, 2011), the September ε-Perseids (208 SPE) reach their peak on September 9. Our 2012 activity profile shows a weak plateau between September 8 and 14 with a peak flux density of almost three meteoroids per 1 000 km^2 per hour (Figure 3).

In the last meteor shower analysis from spring 2012, we could trace the September ε-Perseids with almost 5 000 shower members all month long, and almost all the time they were the strongest source of meteors in the sky. Only few showers are that dominant! The radiant position shows only little scatter, whereas the variations in velocity are a little higher. Overall the parameters fit excellently to the values from the MDC shower list (Table 1).

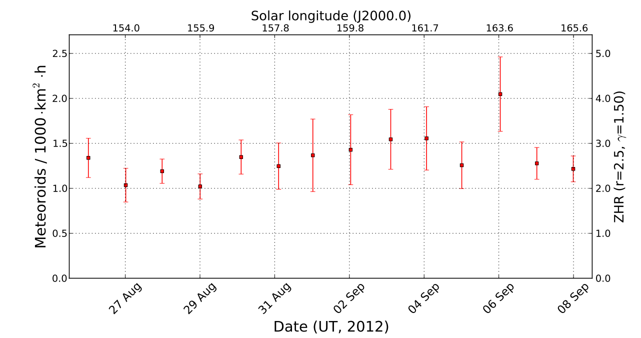

Figure 2 – Flux density profile of the Aurigids from data of the IMO Network in 2012, calculated with a zenith exponent of $\gamma = 1.5$.

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NASA-ADS bibcode 2012JIMO...40..207M

Table 1 – Parameters of the September ε-Perseids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	170	—	50.2	—	+39.4	—	65.5	—
IMO 2012	167	162–185	47.9	+1.19	+39.6	+0.06	65.5	—

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

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	191	—	83.5	—	+50.4	—	65.9	—
IMO 2012	184	182–186	76.6	−0.9	+56.7	−1.0	62.4	—

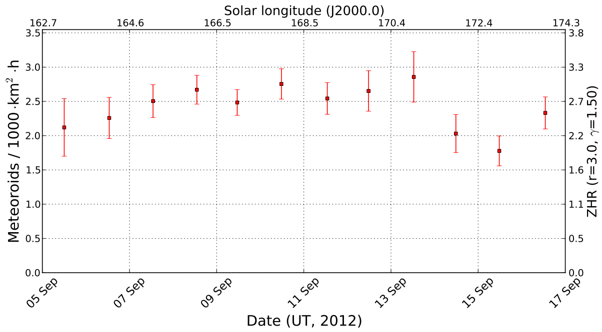

Figure 3 – Flux density profile of the September ε-Perseids from data of the IMO Network in 2012, calculated with a zenith exponent of $\gamma = 1.5$.

4 δ-Aurigids

Then there are the δ-Aurigids (224 DAU), which begin in the second half of September and reach their peak early October. Our 2012 activity profile shows slightly higher rates between September 28 and October 3 with peak flux densities of above three meteoroids per 1 000 km^2 per hour (Figure 4).

In our 2012 analysis, this shower cannot be identified without doubt. There is a candidate with almost 1 000 shower members, but it is only active for five nights and ends well before the peak date given in the MDC list. The scatter in the shower parameters is mediocre. If the radiant position is extrapolated to the peak solar longitude of 191° given by MDC, there is good agreement in declination, but the right ascension differs by almost 10° from the MDC value (Table 2).

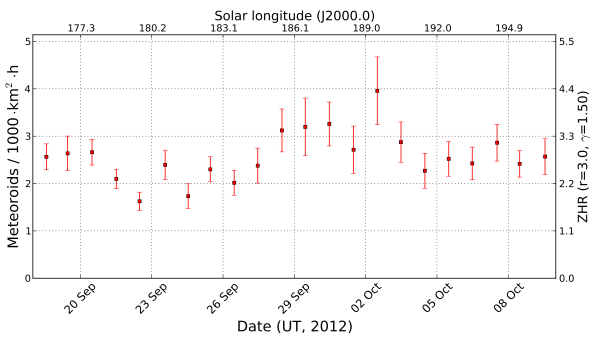

Figure 4 – Flux density profile of the δ-Aurigids from data of the IMO Network in 2012, calculated with a zenith exponent of $\gamma = 1.5$.

5 Other minor showers

As September is rich in minor meteor showers, we could identify a number of further showers in our spring 2012 analysis.

5.1 Southern October δ-Arietids and ω-Piscids

The most interesting candidate starts directly at the begin of September and can be traced in our data set until early December (!). 21 000 meteors are assigned at that time to the Southern October δ-Arietids (28 SOA). Even though the name of this shower is not really well-known, it belongs to the strongest three meteor sources in the full activity interval and end of September / early October it is even stronger than any other meteor shower.

The picture is getting still more interesting, if the meteor shower parameters are analysed in detail. It then becomes clear that there are in fact two independent meteor showers. The second one starts at the same time when the first one ends, and if there was not a displacement by 8° in right ascension and 5° in declination, both showers could be regarded as one (just as the analysis software did).

The first shower can be traced between 161° and 177° solar longitude. The peak is reached on September 11 at 168° solar longitude, and there is only little scatter in the meteor shower parameters.

The second shower is active between 179° and 246° solar longitude. Peak activity of that shower occurs mid-October at 201° solar longitude. Whereas right ascension increases linearly at that time, the declination describes a parabola shaped curve over solar longitude. First it grows by half a degree per day, then the growth is getting smaller and in the end it is zero. At the same time, the meteor shower velocity decreases significantly from 30 to 25 km/s. Table 3 shows the average values for the full activity interval.

If both showers are compared with the values from the MDC list, we find a very good agreement between the second shower and the Southern October δ-Arietids – both with respect to the time of maximum and the meteor shower parameters (Table 4). So the first meteor shower is obviously a hitherto unknown meteor shower. As the scatter in the shower parameters is low and the shower belongs to the most active meteor sources in the

Table 3 – Parameters of the ω-Piscids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	166.8	—	2.1	—	+2.4	—	—	—
IMO 2012	168	161–177	3.3	+0.85	+5.1	+0.25	30.8	−0.02

Table 4 – Parameters of the Southern October δ-Arietids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	199	—	33.1	—	+10.6	—	27.9	—
IMO 2012	201	179–246	35.7	+0.74	+8.9	+0.18	29.2	−0.09

sky at that time, we reported it directly to the MDC. There it was found, that only recently a new meteor shower with similar radiant position was found. Even though there is no velocity given for the ω-Piscids (504 OPI), the radiant position agrees so well (Table 3) that it is most probably the same meteor shower.

5.2 September Lyncids

The September Lyncids (81 SLY) are detected between 165° and 192° solar longitude in our meteor shower analysis. A detailed analysis, however, shows once more that there are in fact at least two sources. The first interval between 165° and 175° solar longitude with almost 1 000 meteors is well-defined and agrees nicely to the values from the MDC list (Table 5). In the interval thereafter, the radiants show a different position, drift and higher velocity. The scatter from one day to the next is so big, that they cannot be regarded as an own meteor shower.

5.3 September π-Orionids

Also the case of the September π-Orionids (430 POR) is not clear. The meteor shower analysis of spring 2012 yields two showers that fit roughly to the MDC values. Here we give only the values for the first shower, derived from well above 400 meteors (Table 6). The radiant is located 15° east of the MDC position. At 178° solar longitude, the second shower lies south-west, but also here the scatter in the meteor shower parameters is so big, that it cannot be regarded as a safe identification.

5.4 β-Aurigids

The detection of the β-Aurigids (210 BAU) is close to the limits. This shower is found between 178° and 182° solar longitude with over 1 100 meteors. Even though the β-Aurigids are one of the strongest meteor sources in the second half of September with a rank of three to four, their radiant position shows quite some scatter from one day to the next. The agreement with the MDC list values is reasonable (Table 7).

5.5 Northern δ-Piscids

Finally, there are the Northern δ-Piscids (215 NPI) with more than 900 meteors between 180° and 184° solar longitude. The quality of the shower parameters is mediocre – in particular the declination values scatter significantly. There is, however, a very good agreement with the MDC values (Table 8). Only the velocity is a little smaller than expected.

5.6 Further minor showers

Further minor showers from the MDC list, like the ν-Eridanids, September ι-Cassiopeiids, September μ-Arietids and σ-Orionids have been detected partly in our data, but only with large scatter in the meteor shower parameters. So at this time their identification is questionable. Maybe the picture changes in one or two years time, when even more data are available for analysis.

5.7 New shower candidates

As in the previous months, there were a few candidates for new meteor showers (Table 9).

The first candidate is based on 760 shower members. The radiants show only little scatter between 166° and 171° solar longitude. The slow shower has a rank of almost 10 and reaches peak activity on September 9 at 166° solar longitude.

The second candidate is even slower. Between 168° and 173° solar longitude, about 370 meteors are assigned to it, reaching a rank of 6. Highest activity is observed in mid-September.

More than 1 100 meteors are assigned to the third candidate between 177° and 185° solar longitude. It is at the upper end of the velocity scale and the rank is all the time above 15, which hints rather on a chance alignment of radiants than on a true meteor shower. However, as the scatter in the individual parameters is quite low, we still report it as a possible new meteor shower with maximum on September 23.

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Table 5 – Parameters of the September Lyncids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	167	—	107.4	—	+55.0	—	62.0	—
IMO 2012	167	165–175	107.5	+2.0	+55.7	+0.1	59.7	—

Table 6 – Parameters of the September π-Orionids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	178	—	74.9	—	+8.4	—	68.9	—
IMO 2012	176	174–177	62.1	+0.4	+6.4	+0.5	66.6	—

Table 7 – Parameters of the β-Aurigids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	179	—	86	—	+43	—	67.4	—
IMO 2012	180	178–182	87.6	−0.2	+47.9	−0.1	70.0	—

Table 8 – Parameters of the Northern δ-Piscids from the MDC Working List and the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	184	—	9.2	—	+7.7	—	33.1	—
IMO 2012	182	180–184	9.9	+0.8	+6.5	+1.0	27.8	—

Table 9 – Parameters of three possibly new showers from the analysis of the IMO Network in 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
	168	166–171	346.8	+0.3	+0.4	+1.5	23.9	—
IMO 2012	171	168–173	302.3	−0.0	+32.1	+0.9	17.7	—
	180	177–185	112.7	+0.8	+30.3	+0.0	70.6	—

Table 10 – Observers contributing to 2012 September data of the IMO Video Meteor Network. Eff.CA designates the effective collection area.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig1 (0.8/8)	1488	4.8	726	9	58.2	83
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	18	118.7	949
			Hulud2 (0.75/6)	4860	3.9	1103	17	112.2	272
			Hulud3 (0.75/6)	4661	3.9	1052	16	104.4	212
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	25	153.6	421
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	24	142.7	579
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	26	145.0	397
			Mbb4 (0.8/8)	1470	5.1	1208	27	160.3	374
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	29	178.4	551
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	28	152.7	630
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	16	84.4	294
			Bmh2 (1.5/4.5)*	4243	3.0	371	16	76.0	253
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	24	147.8	773
			C3P8 (0.8/3.8)	5455	4.2	1586	23	142.1	505
			Stg38 (0.8/3.8)	5614	4.4	2007	22	134.5	891
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	17	104.6	250
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	17	111.2	415
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	24	191.4	794
			Templar2 (0.8/6)	2080	5.0	1508	25	208.5	672
			Templar3 (0.8/8)	1438	4.3	571	27	202.6	609
			Templar4 (0.8/3.8)	4475	3.0	442	23	193.4	614
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	23	155.3	652
			Orion3 (0.95/5)	2665	4.9	2069	18	119.6	282
			Orion4 (0.95/5)	2662	4.3	1043	22	152.3	436
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	13	71.7	711
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	26	159.3	423
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	25	126.8	390
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	20	164.0	442
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	22	15.0	93
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	22	154.3	384
KACJA	Kac	Kostanjevec/SI	Metka (0.8/12)*	715	6.4	640	5	36.9	211
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	17	58.7	130
		Kamnik/SI	Rezika (0.8/6)	2270	4.4	840	10	65.3	601
			Stefka (0.8/3.8)	5471	2.8	379	10	62.9	288
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	29	229.0	915
KOSDE	Koschny	Izana Obs./ES	Icc7 (0.85/25)*	714	5.9	1464	21	167.8	1242
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	22	85.6	298

Table 10 – Observers contributing to 2012 September data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	15	57.9	62
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	21	149.6	302
			Pav36 (1.2/4)*	5732	2.2	227	26	166.5	630
			Pav43 (0.95/3.75)*	2544	2.7	176	21	160.0	282
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	22	142.3	578
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	8	41.4	569
			Mincam1 (0.8/8)	1477	4.9	1084	22	167.2	558
		Ketzür/DE	Remo1 (0.8/8)	1467	6.0	3139	27	171.8	1557
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	17	134.8	324
OCAFR	Ocaña Gonzáles	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	20	87.2	99
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	16	19.3	114
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	27	194.0	608
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	24	161.6	938
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	25	127.0	577
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	20	129.4	245
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	25	190.0	329
			Ro2 (0.75/6)	2381	3.8	459	23	187.6	335
			Sofia (0.8/12)	738	5.3	907	22	183.1	271
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	16	83.8	231
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	29	172.5	708
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	15	70.5	182
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	21	118.1	825
			Noa38 (0.8/3.8)	5609	4.2	1911	20	108.9	397
			Sco38 (0.8/3.8)	5598	4.8	3306	24	134.8	835
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	24	154.4	243
			Mincam3 (0.8/12)	728	5.7	975	27	162.1	339
			Mincam4 (1.0/2.6)	9791	2.7	552	22	130.4	152
			Mincam5 (0.8/6)	2349	5.0	1896	26	153.2	447
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	22	154.7	662
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	18	118.0	230
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	18	80.2	391
						Overall	30	8 859.5	32 056

* active field of view smaller than video frame

History

Meteor Beliefs Project: Meteoric Imagery in SF, Part VI – A brief history of impact movies, 1906–1999

Alastair McBeath[1] *and Andrei Dorian Gheorghe*[2]

An examination is made of 25 movies featuring impacts or collisions between extraterrestrial objects and, frequently, the Earth. These are set in a chronological sequence from 1906–1999 to illustrate changes in how such events were portrayed, and thus give clues as to what effects they may have had on the public perception of meteors and impacts during that time.

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1 Introduction

When we announced the Meteoric Imagery in SF strand of the Project (McBeath & Gheorghe, 2005), we had already identified that a significant proportion of the films and TV programmes with meteoric content fell into a class where the plot centred around the impact of some large extraterrestrial body with the Earth. Our original list of 13 impact movies, plus two early 20th century 'comet' ones, has here been expanded to 25, each presented with some discussion below to form a chronological series to highlight changes in how these matters were presented on screen between 1906 and 1999. We have relied heavily on written synopses and critiques for our information in some cases, where locating viewable copies of the items proved difficult, or where some appeared to be very similar to those we were able to see. In the section subheadings following, those items one or other of us managed to watch at least part of, are marked with an asterisk.[a]

We do not pretend this selection is a comprehensive review of all such impact movies. Even the better synopses did not feature all our chosen items in one text, while some works included comments that other SF films were known to exist, especially from Asian countries (including Japan and Korea), but that these were virtually unknown to the English-speaking world. If anyone is able to add to the notes here, particularly with details of other impact-related films, we would welcome any fresh information.

As a rule in the Project, we have advised anyone interested in what we have discussed to go and read or watch the originals of what we have provided minor extracts from, with occasional caveats. Here too, we would advocate repeating this approach, but we feel it worth noting that although most SF movies require some suspension of disbelief to accommodate unlikely or inaccurate scenarios, this appears to be still more necessary with impact-related films. Factual accuracy seemed to be invoked in some of these only when it fitted the plot, and ignored at other times (even when this sacrificed internal story consistency!).

With this warning in mind, we cue the swirling harp music and water-on-lens effect, to help take us back in our imaginations more than a century…

2 *Le Dirigeable Fantastique* (1906)*

A Star production, this three-minute black-and-white silent film by the famous French cinema pioneer George Méliès is also known by English titles, including the near-literal translation *The Fantastical Airship*, or *Inventor Crazybrains and His Wonderful Airship*. It featured the first space collision we have found in movies so far, albeit the collision was not with the Earth. Instead, an exhausted inventor fell asleep at his workbench, over his plans for an airship able to fly into space. He dreamed of success, where his balloon rose on its motors quickly above the atmosphere, taking him with it, caught in the net over the balloon. Once in space, a fiery-tailed comet (one of the typical painted stage-prop moving board effects of the period) rushed across and collided with the balloon in a huge, showy explosion, whereupon the inventor woke in a panic in his workshop, destroyed his plans, and jumped out the window! The film is typical of Méliès' other fantasy short films from around the turn of the 20th century, made purely as an entertainment, but with an inventiveness that still retains interest now. Most details here were from (Hardy, 1986, p. 26), plus one viewing of the original by AM more than 15 years ago.

3 *The Comet* (1910)*

An 11-minute long, silent, black-and-white, Kalem film. "This remarkable and dramatic cinematic vision of Halley's comet breaking its orbit and crashing into the Earth was unique in early American cinema, and stands as a remarkable prediction, not of fact, but of films to come" (*op. cit.*, p. 40). The return of Halley's Comet in 1910 generated a lot of interest, so it was inevitable the early cinema would latch onto it too. The film, which despite its brevity, we have only managed to see short extracts of, began with a family in a mansion, anxious at news of the comet's approach. They went at once to a conveniently nearby observatory, where the

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[a] As with Hendrix et al. (2012, especially, p. 80), this article too should have been published in the *2008 IMC Proceedings*, but was not. We have presented it here with minimal changes.

chief astronomer explained and showed them the comet with a large telescope (one good idea at least, given the unfavourable view of Halley the Earth had in 1910). This was followed by shots of panicking city-dwellers racing off in cars to some kind of 'safety' elsewhere. The comet's near-approach was dramatized as the Earth becoming very hot, with spontaneous fires breaking out, and the oddity of an old miser's coin hoard melting – though he remained healthy, if distressed and rather hot! The populace sought shelter in ever-deeper caves, but eventually the comet missed the Earth, and swung away back into space. The closing scene was a disturbing panorama of the devastated surface (*op. cit.*, pp. 40–41).

4 *The Comet's Comeback* (1916)

Despite the title of this Beauty, black-and-white, silent film, and that it too was American, it was not a sequel to the 1910 *Comet.* Instead it was a 15-minute long comedy, a plea against the craze for ever-increasing vehicular speed of the time, with pun-named characters such as the driver 'Fuller Speed' (played by John Sheehan). Professor Peedeeque (from the initials 'PDQ' for 'Pretty Darn Quick', a popular phrase of the period) saw an unexpected comet through his telescope, and found that an ancient Chinese astronomer Ho Kem (from the American colloquialism 'hokum', meaning melodrama, or nonsense) had predicted this comet's return 1000 years in his future, and that gases from it would slow the world down. The Professor observed these gases being emitted by the comet from inside his sealed laboratory with its own oxygen supply (how fortunate!), and rescued his daughter and her two suitors who lay gassed in his garden. From the lab, they watched as the city slowed down (achieved using trick photography, which had its humorous points apparently), but the ending was quite downbeat, as the gas seeped in, and with too little oxygen left, Fuller Speed drew the short straw and had to leave, so the others could survive at 'normal speed' (*op. cit.*, p. 53).

5 *Verdens Undergang* (1916)

The first feature-length impact movie, at 65 minutes, this Danish black-and-white, silent film produced by Nordisk (also known as *The End of the World*) was written and directed by August Blom, his last as Nordisk's leading director, though he remained as the studio's general artistic supervisor until 1918. This was an elaborate view of the breakdown of social order following the discovery of a comet that would collide with the Earth. The rich indulged in orgiastic excesses, while the poor were outraged at such behaviour and took up arms in a violent confrontation, set against a background of riots, power struggles and natural disasters, including what seemed to be footage of the film's heroine being carried to safety over genuine floodwaters. The photography, by Axel Graatkjaer, was apparently impressive generally, but the special effects of the actual collision were not, consisting "largely of sparklers bouncing across a tabletop model of a village" (Strick, 1976, p. 83). The film ended with the hero and heroine surviving, Adam-and-Eve-like (*ibid.*; Hardy, 1986, pp. 55–56).

These initial four films, reinforcing the very negative view of comets, seem simply a continuation of the ancient comet fears overall, moved into then-modern settings, and expanded to allow some physical contact to occur with the impactor, even when it did not make landfall on the planet. Despite this, there was the gleam of future hope, in that in all cases at least some people survived the calamity to reclaim whatever remained of the Earth afterwards. A quite lengthy hiatus in impact movies followed *Verdens Undergang*, yet the next film was as if it had not been so, even to its title.

6 *La Fin du Monde* (1930)

This is a confusing film to try to review succinctly, as there seem to have been three (or more) versions of it, issued between 1930–1934, and although it was originally shot as a silent movie, sonorized versions, including an English language one, as *The End of the World* in 1934, were subsequently put out. Made by L'Ecran D'art as a French black-and-white film, it was based on a story by astronomer Camille Flammarion (whom we have met in the Project before), reworked by the film's director Abel Gance, who also took one of the starring roles, as Jean Novalic, a religious maniac, ultimately portrayed as a Christ-like figure. André Lang was credited as the screenplay's co-author, but this may have been only for the later English version(s?) The plot was effectively that of *Verdens Undergang*, in that the film detailed the likely events of social collapse when the world's population became aware that a comet was soon to hit the planet. As with the earlier film, this involved hedonistic orgies, riots and various catastrophes, but now Jean Novalic and his scientist brother Martial (played by Belgian actor Victor Francen, usually the only cast member to receive a positive review) attempted to instil some moral fibre into humanity. They did so in a distinctly fascistic, totalitarian fashion, which again, if understandably, has tended to count against the film in the minds of post-war reviewers. Starting out at either 91 or 93 minutes in Gance's original version (which may not survive modernly – Craven, 2001), his producers sacked him and re-edited the whole into rather a mess by all accounts, reducing Gance's appearances in the film drastically, if not necessarily to its detriment (Hardy, 1986, p. 83). A five-minute 'explanatory' prologue was added (possibly only to the English version(s), though one commentary suggested the French version of the 1934 edition ran to 105 minutes – Wannen, 1999), but the whole film was cut to just 55 (or 54) minutes for the 1934 Anglo-American release. Unfortunately, none of the commentaries mentioned how the comet or any impact-related events were portrayed, nor did any give a clear indication as to its ending, though one (Craven, 2001) said enough to suggest it may have been a positive one, with disaster just averted, and some of humanity surviving. In addition to the cited sources above, see also (Fane-Saunders, 2001, p. 115).

7 *Flash Gordon* (1936)*

Originally a 1930s American comic strip by Alex Raymond, Universal used the strip as a basis for this 13-part black-and-white cinema serial, later shown on TV with the title *Flash Gordon: Space Soldiers*, directed by Frederick Stephani (also one of the scriptwriting team of four). Each episode was about 15 to 20 minutes long. It is generally reckoned this was the best of the three 'Flash Gordon' serials Universal made, the storyline essentially the simple one from the cartoon strip. It revolved around the three heroes, clean-cut innocent Flash (played by Larry 'Buster' Crabbe), virginal innocent Dale Arden (Jean Rogers), and the more worldly, slightly devious, Doctor Zarkov (Frank Shannon) setting off in a rocket ship for the wandering planet Mongo, which was apparently on a collision course with the Earth. It was of course really all a dastardly plot by evil, self-styled 'Ruler of the Universe', Ming the Merciless (Charles Middleton), who had usurped the throne of the rightful ruler Prince Barin (Richard Alexander). A series of rapidly-paced (and occasionally badly edited!) adventures, 'cliff-hanger' episode endings, disasters and triumphs ensued, played out with gusto, if often rather inadequate special effects, across the strange landscapes of Mongo, with its aerial and underwater cities, subterranean tunnels and caverns, till the heroes finally set all to rights, defeated Ming and saved the Earth. Meteorically, the first episode had Flash and Dale in a commercial passenger aircraft flying through a 'meteor shower', of sparks and flames falling down right past the model Ford Trimotor, set against a stormy cloud scene, to illustrate the effects the rapid approach of Mongo was having on Earth, forcing all the passengers and crew to bale out. Plausibility was never an essential in such serials, intended primarily for an audience of youngsters, so it is difficult to be too harsh in judging it, and instead enjoy it as it was meant – as simple entertainment. It is interesting here though, as it was the earliest film we have found that replaced the comet as a potential impactor with a planetary body (however strange the planet).

Another lengthy hiatus in impact movies followed, largely because in the interim the real world went through a global catastrophe of its own making, with the 1939–45 war, and the mechanized conflicts which preceded and followed it. As with the 1916–30 hiatus, curiously, the same basic theme of a planetary collision revived the impact movie concept.

8 *When Worlds Collide* (1951)*

The 1950s are well known as a 'golden age' for science fiction movies, with a degree of inventiveness in some scarcely seen since the 1930s. Using statistics derived only from (Hardy, 1986), the quantity of such films also shot up to an unprecedented level, far outstripping the numbers released in the early heyday from 1907–16, when 133 such films were issued. Not till 1947–56 (132 films) was this decadal total achieved again, with 243 films put out between 1951–60. This interest reflected the rapid development in rocketry which led to the launch of the first Earth-orbiting satellite, the Soviet Sputnik 1 on 1957 October 4.

When Worlds Collide featured in the first tranche of 1950s SF movies, combining rocketry with its reworking of a planetary collision scenario. Directed by George Pal for Paramount in the USA, for the first time, an impact movie was made in colour. It ran to 83 minutes, and was based on the 1932 novel of the same name by Philip Wylie and Edwin Balmer (who jointly published a sequel, 'After Worlds Collide' in 1934), greatly assisted by the visions created by the noted American space artist Chesley Bonestell. A wandering dying star, Bellus, entered the Solar System on a collision course for Earth, towing an earth-like planet, Zyra, which, after the Earth's destruction, would apparently settle into the Earth's old orbit. Given eight months to prepare, only a single large rocket could be readied to carry a lottery-chosen select band to settle on the new world. Unlike previous orgiastic world's end movies, societal collapse was here portrayed in a less frenzied fashion, but the special effects illustrating the natural disasters preceding the collision were much superior to anything done before, including the wholesale flooding of a model of New York City (however clichéd such ideas may have become now). The ending too was far more satisfactory, with the rocket-borne survivors tentatively exploring their new world. Their view of a distant futuristic city at the film's end was taken by some as rather unsettling, implying that the planet was already inhabited, but it may simply have been a vision of their own possible future (Strick, 1976, pp. 82–84 & 88–89; Hardy, 1986, p. 133).

One item from Jack Moffitt's original screenplay which did not survive into the eventual movie was the discovery that meteors heralding the approach of the new world contained a metal that could be reused to successfully line the rocket tubes in the escape craft. The need for widespread meteor special effects to accommodate this probably would have been beyond the film's budget, however (Warren, 1982, pp. 62–63).

9 *Uchujin Tokyo ni Arawaru* (1956)

Variously titled in English *The Mysterious Satellite*, *The Cosmic Man Appears in Tokyo*, *Space Men [Spacemen] Appear over [in] Tokyo*, *Warning from Space* (US TV release), or *Unknown Satellite over Tokyo* (international release), this was a Daiei Motion Picture Company film, 87 minutes long (81 minutes in the US releases), made in colour. It featured large, upright, starfish-shaped aliens, each with a large single eye in the middle of the body, who arrived on Earth in flying saucers that resembled meteors, an interestingly literal 'falling star' connection. The beings were from the planet Paira, which circled the Sun directly opposite the Earth on the same orbit (thus it could never be seen from Earth). After terrifying a few Earthlings, the seemingly not-too-bright Pairans agreed between themselves to change their forms to human to communicate with the Earth people, in order to warn them of the perils of nuclear weapons (in case the humans could not work that out for themselves. . .), and also to mention that, "a flaming, runaway comet (thereafter referred to as Planet R) [was] on a collision course with the Earth" (Galbraith, 1994, p. 21)! Oddly, the Earthlings had failed to spot that little problem sooner. As the comet/Planet R drew nearer, the Earthlings vacillated, while the world heated up, causing a variety of natural disasters. A nuclear strike on Planet R failed, but luckily the Pairans rescued one Dr Matsuda and his formula for a superexplosive, 'Urium 101', from an earthquake, which material was duly launched on a rocket that destroyed the threat, "and everyone emerges from the rubble" (*op. cit.*, p 22). The critical consensus was that the special effects in the film overall were good, though we could trace no specific comments on the meteor or comet/fiery planet depictions. Other points of interest included the non-human, if unfortunately somewhat comical, aliens, and the fact they were friendly and helpful for once. Especially useful sources for the above were (Hardy, 1986, pp. 163–164) and (Galbraith, 1994, pp. 21–23 & 308).

10 *La Morte Viene Dalla Spazio* (1958)

A less-than-impressive joint Italian-French co-production by Royal and Lux films, made in black-and-white, and running to either 85 or 82 minutes in its continental European form, or 80 minutes in its English language version, the film was also called *Le Danger Vient de L'Espace* (French release, 1959), *Death from Outer Space* or *The Day the Sky Exploded* in its English versions (*circa* 1961). The tale started with the first combined US-USSR-UK launch of an atomic-powered rocket from Australia, which had to be aborted in the high atmosphere. The piloting astronaut returned safely, but the rest of the rocket continued on and hit the Sun, exploding and massively disrupting the solar surface. This in turn caused huge climatic disruptions on Earth (via extensive use of stock footage), and sent a shower of asteroids towards Earth too. Amid the expected widespread panic, the astronaut galvanized the world's governments into shooting the planetary nuclear missile arsenal at the asteroids, destroying them. So: job done, world saved, film ends! Commentators agreed that the best part of the film was Mario Bava's cinematography, and that the worst part was pretty well everything else – script, direction, acting. . . We may guess the special effects too fell into this latter category (Hardy, 1986, p. 182; Warren, 1986, pp. 507–508; Fane-Saunders, 2001, p. 90).

11 *Il Pianeta degli Uomini Spenti* (1961)

Also known as *Battle of the Worlds*, *Planet of the Lifeless Men* or *Guerre Planetari*, this was an Ultra Film/ Sicilia Cinematographica production, made in colour in Italian, and running to either 95 or 84 minutes. By contrast to the previous entry here, it was director Antonio Margheriti (credited as Anthony Dawson) who was singled out for particular praise, "effortlessly transcending the crudities of the script, the acting and the special effects" (Hardy, 1986, p. 211 – all subsequent quotes on this film from this page). Claude Rains played Professor Benson ("Rains appears to be the only one capable of enjoying his role") who was scornful of his colleagues' claim that a large 'meteorite' was about to hit the Earth. "He is proved right when the thing stops and appears to launch flying saucers against the Earth"! Discovering that the crew had died, and this was now just an automated craft carrying out its last instructions, Benson boarded the 'meteorite' to learn its secrets, but was blown up along with it when the Earth's governments attacked it with missiles! With use of intelligent irony and black humour, "The film is an object lesson in how to let cinema triumph over both script and acting, allowing visual style and imagination to carry their own corrosively fascinating meanings."

12 *Yosei Gorasu* (1962)

Gorath, or more literally, *The Suspicious Star Gorath*, was produced in colour in Japan by the Toho Company, most famous for its many giant monster movies, beginning with *Gojira* (*Godzilla*) in 1954. It ran to 89 minutes. This was not a regular monster movie, though Gorath was monstrous enough, a wandering star on a collision course with Earth, of 6000 Earth-masses, but only half the Earth's size. Two possible solutions were proposed, to try and destroy it, or move the Earth out of its way! The sight of it gravitationally sucking up all in its path (including Saturn's rings, but oddly not Saturn itself or its atmosphere) was enough to abort the Gorath destruction attempt, leaving only the neat swerve manoeuvre. Thus the film progressed until the giant rockets the world's disbanded armies had built at the South Pole were fired. For reasons that were never explored, they succeeded in slowly moving the Earth out of Gorath's path, while the usual climatic heating effects occurred on the planet, including, as in most of the Japanese monster movies, the near-obligatory destruction of Tokyo, here submerged by a gigantic wave caused by the star's gravity. The Moon was absorbed, but the Earth escaped, and there were positive effects, such as the world's nations cooperating with one another, so that "together they promise to return the planet to its former orbit and rebuild what was lost in its close brush with Gorath" (Galbraith, 1994, p. 73). Such as the Moon, perhaps? Despite the ludicrous plot, which passed curiously uncommented upon in published discussions of the film, there was innovation here, and the modelwork special effects have been generally praised. Moving the Earth, were it feasible, would be an anti-collision strategy, for instance, and the populace initially met the threat of its impending doom with resignation and apathy, though not for long. Details on the film came from (Hardy, 1986, pp. 218–219) and (Galbraith, 1994, pp. 72–76 & 354–355; see pp. 7–14 & 347–349 for *Gojira*).

13 *Il Pianeta Errante* (1966)

A 77-minute long Italian colour film, also called *War Between the Planets*, produced by Mercury Film International, this got only a brief, generally negative, review in (Hardy, 1986, p. 256), where the plot was described as about yet another wandering asteroid on a collision course with the Earth, and the team of brave men sent out to blow it up – just in time, as ever – though in fact, as we have seen, till this film, asteroids were rather a rarity as the potential impactor. Hardy concluded: "Characterization, dialogue and plot are uniformly bad, only the asteroid itself, visualized as a living being into whose heart the heroes must travel, is at all impressive." Sadly, while this description is intriguing, we cannot expand upon it, as we could find no other useful additional information.

14 *Gamma Sango Uchu Daisakusen* (1968)

Variously titled in English as *The Green Slime*, *Battle Beyond the Stars* or *Death and the Green Slime* (though the Japanese title is translated literally in Galbraith (1994, p. 326) as, *After the Creation of Space Station Gamma: Big Military Operation*), this was either a Japanese-American (Hardy, 1986, p. 272) or a Japanese-American-Italian (Galbraith, 1994, pp. 169 & 327) co-production, made by Ram Films, Southern Cross Films, the Toei Company and Lum Film, in colour, and ran to 77 (Japan) or 90 (USA) minutes. Set at some vague future time, an asteroid called Flora (looking very similar to Gorath from the 1962 film *Yosei Gorasu* above) was discovered only twelve hours from Earth-impact. A mission was ordered from Earth to collect part of a crew from Space Station Gamma 3, a wheel-shaped station in Earth orbit, and destroy it. So far, so routine. However, green pulsating blobs of living matter were discovered on the asteroid's surface as the crew were laying the explosive charges, and despite all efforts to prevent it, some of this material was carried accidentally on board the rocket. Once there, this 'green slime' grew into improbable, small, bipedal, tentacular monsters. Galbraith (1994, pp. 169–172) gave an extensive, scathing description/critique of them, including that they were "some of the most laughably ridiculous monsters in screen history" (p. 169). They electrically attacked the crew, but not before the asteroid was successfully destroyed in an unimpressive special effects shot. The remainder of the film was taken up with finding a way to destroy the creatures, after they spread to the orbital Space Station, which was eventually achieved by self-destructing the Station in the atmosphere, immolating all the creatures in a controlled re-entry meteoric burn-up. Unfortunately, neither of our main cited sources for this movie commented on how this was shown, but from Galbraith's comments, we may guess the answer was 'not very convincingly'. Other reviews cited in these sources were generally negative too, though the film was an unusual combination of the 'impact' and 'monster accidentally retrieved from space' SF themes.

15 *City Beneath the Sea* (1970)*

Also called *One Hour to Doomsday*, this American colour film by Kent Productions/Motion Pictures International, ran to either 93 or 120 minutes in different versions. Its alternate title seemed rather ironic, as it was only about an hour into a fairly tedious plot set in 2053 about an undersea storage facility called 'Pacifica' (no prizes for guessing its location!), that we finally, and wholly unexpectedly, learnt that an "incredibly dense neutron planetoid" was on collision course for Earth. Despite being at Pluto's distance, this potential impactor was already causing earthquakes, volcanic eruptions and weather phenomena on Earth, and was approaching rapidly. The facility held the entire US gold reserve, plus numerous containers of the incredibly unstable, glowing, explosive power source 'H 128'. Discovering the planetoid would strike near the facility (what incredible bad luck), it was evacuated, presumably because the crew would prefer to be on dry land when the Earth was vaporized (no other explanation was offered), allowing a risible sub-plot about stealing the gold to develop. The impactor in space was a glowing red and white rough sphere, which smoked and crackled, and emitted the sound of whistling wind. The 'H 128' substance smoked and crackled similarly. Ten minutes before impact, the missiles from this undersea city, seemingly all-but forgotten earlier, were launched, deflecting the planetoid past the Earth. So that was alright then... It was directed and produced by Irwin Allen, who re-used some footage of a flying submarine in his TV series *Voyage to the Bottom of the Sea* from the same period. He went on to specialize in similarly less-than-gripping 'disaster' movies. Our notes here came from viewing the film, plus additional points in Hardy (1986, p. 291).

16 *Na Komete* (1970)

An 88-minute Czech colour film from Studio Barrandov, directed by Karel Zeman, in English called *On the Comet* or *Hector Servadac's Ark*, the latter as the film was an adaptation of Jules Verne's 1877 novel, *Hector Servadac*, a fantasy story set in 1888 of how part of the Earth became a comet and drifted through space, yet still bearing all its inhabitants alive and well. Ultimately, the comet was to collide with the Earth again. Hardy (1986, pp. 294–295) heaped praise on the film, while describing much less than we found helpful, summing up that, "the film is a spectacular yet charming piece of work with memorable scenes of meteorological phenomena." Hardy concluded by comparing it to Abel Gance's 1930 *La Fin du Monde*, suggesting it covered similar ground, but better, and with more humour.

A further break in impact movies followed, until 1979. While the 1960s had continued the proliferation of science-fiction films as a whole, their inventiveness seemed to have declined, with many sequels or minor variant copies, and although the number of films per year listed in Hardy (*op. cit.*) held up through to the early 1970s, a drop began from 1967 which continued to 1973. With Apollo 8 the first manned craft to orbit the Moon and return to Earth safely in late 1968, science-fiction appeared to be becoming reality. After that, apart from 1979, till 1985 (when Hardy's text concluded), the number of such films produced annually remained at levels better than most years before 1951, but they never recovered back to the high points of the late 1950s to late 1960s.

17 *Meteor* (1979)*

This Palladium Pictures, American-made, colour movie, running to 107 minutes, was roundly criticized at the time and subsequently for its poor script, worse special effects and abysmal science, despite casting several big-name actors, including Sean Connery, Natalie Wood, Henry Fonda, Martin Landau, Karl Malden and Trevor Howard. The impact plot centred around a crazy-paving-surfaced, dry-ice-mist-emitting 'comet', routinely referred to as the 'meteor', discovered approaching the Earth on a collision course "from behind the Sun" (presumably missing the Sun's gravitational effects *en route*). A manned Mars probe sent to the asteroid belt to investigate took a mere two days to get there from Mars (helpfully, communication with Earth was instantaneous). The probe 'parked' beside the asteroid Vesta, and watched as the 480 km-diameter comet, now with the added sound of a rocket engine, smashed apart a 30 km diameter asteroid Orpheus, a chunk of which flew off and destroyed the Mars probe. Due to a continuity error, the time-stamp on the images received at Earth showed this occurred as the comet-asteroid impact happened, not some time later! So, a cluster of one large and many smaller fragments, not just one comet, was left still heading for Earth. The scale of the Solar System continued to be greatly reduced, such that the asteroid belt was apparently a mere 8 to 9 million km from Earth, rather than the 1–2 astronomical units of our reality, so only six days remained to save the Earth. Forced into reluctant cooperation, US and USSR space missile batteries were turned on the approaching swarm. One day later, the view from the comet was of the eclipsed Sun, yet another two days elapsed before the first, very slow, comet-like 'meteor' appeared in the atmosphere, as a glowing rock-like object crashed with a simultaneous boom behind some distant mountains, as viewed from the surface. Later 'meteors' were far worse, shown as ovals of light moving across the sky, completely unlike genuine 'shooting stars'. More minor hits followed, "striking the ground with no more impact than your average 1000-pound bomb" (Anderson, 1985, p. 234), one of which smashed the Twin Towers of New York City, an understandable, if particularly unfortunate, decision in light of more recent actual events. Ultimately, enough missiles hit the large chunk in space to reduce it to sparkly dust. Thus, danger passed, world saved, all returned to normal. Aside from the burning, devastated NYC. Sources of information besides the movie itself were Anderson (1985, pp. 233–235), Hardy (1986, p. 350) and Fane-Saunders (2001, pp. 218 & 220).

We have given as much detail here largely because this film formed the template for the raft of US impact movies in the late 1990s, particularly in terms of the non-hypervelocity impacts on Earth. Such 'glowing meteorite strikes' were typically shown as like, and no more effective than, a small military missile or shell hit, and having a similar apparent speed. A car might be wrecked, but someone standing nearby might be unharmed, for instance.

18 *Night of the Comet* (1984)*

Made by Atlantic 9000 in the USA, this was a 95-minute colour film, an entertaining pastiche of the American zombie movie genre, set in Los Angeles, California. Here, the Earth's population who saw the light from a nearby comet either crumbled to dust or became murderous zombies. The survivors, chiefly teenagers, were left to battle the zombies, and then re-lay the foundations of civilization. One nice touch was to have the heroine and her boyfriend survive as they were indoors making a pirate copy of the film *It Came From Outer Space* from 1953 (itself a meteorically-relevant movie we hope to examine in a future article). *Night of the Comet* at least proved it was possible to make an end-of-the-world movie on a low budget, given enough common sense and an inventive flair (Hardy, 1986, p. 388). While this comet's 'impact' was rather indirect, we have included the film as a little light relief from some of the other, more earnest, but far poorer, 'real' impact films.

19 *Gojira vs. Mosura* (1992)

The 19th Godzilla movie made by the Toho Company, this ran to 104 minutes, in colour. Its English title translated as *Godzilla versus Mothra*, so setting it among the numerous monster versus monster films produced since the 1950s in Japan. It began with a large 'meteor' plunging into the Ogasawara Sea off the Bonin Islands south of Japan. The impact's force caused a tremendous storm, which uncovered an enormous egg on Infant Island, near Indonesia. It also awoke a monstrous caterpillar-like creature called Battra, which had long been hibernating in Siberia, along with the sleeping Godzilla elsewhere. Various of these and other plot elements were discovered by an 'Indiana Jones' type treasure-seeker and his team, before (for no definable reason) Battra, Godzilla and the giant moth Mothra, newly hatched from its egg, were battling one another across Japan. Ultimately, Battra and Godzilla fell from a great height into the sea, though it transpired that Battra had been meant to wake only in the distant future, to protect the Earth from an even greater object on a collision course, and that Mothra would have to take Battra's place at that time instead. Galbraith's commentary (1994, pp. 293–296 & 353–354) did not describe the meteoric effects specifically, but he did say the effects generally were very good, a more positive assessment than he gave the confused screenplay!

20 *Without Warning* (1994)

An American made-for-TV colour movie, presented as how the TV news would handle the 'live' story of huge asteroidal fragments striking different parts of the world. From the reviewer's comments, apparently this was a well-made example of television imitating itself for dramatic effect, and seemingly so finely-crafted that "thousands" of US viewers called in to check it was just a fictional presentation (Fane-Saunders, 2001, pp. 372–373). Unfortunately, we have little other information on it, so cannot judge how the meteoric and impact effects – if any were actually shown – were handled.

21 *Asteroid* (1997)*

This seemed to have started out as a TV mini-series of two 105-minute episodes, but we have seen only the, presumably cut-down, single film version, which even so ran to around 150 minutes. The items of meteoric interest occurred from the start, but petered out as the whole deteriorated into a more standard earthly disaster movie. The film opened on a large, apparently self-luminous, comet, which hit a fairly large asteroid, shattering it to fragments. The comet continued unperturbed, making a light roaring sound, now followed by a trail of glittery bits of former asteroid. Welcome to "the Fletcher Comet", which returns every 4000 years, but this time with added sparkle... The comet was to miss the Earth (for once!) but two larger chunks of asteroid, 'Helios' and 'Eros', would be potential impactors. The atmospheric meteor effects were plausibly done for the 'other' smaller fragments, but the impacts of those that reached the surface (where shown) were the usual 'missile'-standard ones, too puny for anything with extraterrestrial velocity. Occasionally, the incoming meteors were less impressive, with firework like sub-meteors flung out on 'starburst', right-angle vectors. The larger 'Eros' fragment was blown up by airborne lasers, creating a 12-hour long debris field, called here a "meteor shower", despite it being of meteorites, the larger ones of which seemed unerringly attracted to cities (the smaller 'Helios' fragment had earlier hit a dam, for instance). Despite the destruction, these impactors left sufficient rubble for the humans watching events unfold nearby to struggle over for far too long in the following scenes. At the end, we saw the comet trailing smoke, moving across the daytime sky, just passing-by... Though poorly-paced, *Asteroid* has been reckoned as one of the more believable SF dramas of its type (Fane-Saunders, 2001, p. 30, plus our own viewing notes).

22 *Doomsday Rock* (1997)

Resisting the temptation to simply write here 'ditto', this too was a US TV movie, but apparently with poorer/cheaper special effects, centred on an astronomer and his daughter in a nuclear silo trying to warn the world about a potential impacting giant comet (Fane-Saunders, 2001, p. 108). Perhaps the world would not have noticed otherwise.

23 *Armageddon* (1998)*

If you feel the need to watch at least one of the late-millennium US-made impact movies, you could do worse than choose this one, which is best viewed as a black comedy, never taking itself very seriously, starring Bruce Willis. 'Science' takes a left turn during the opening credits, leaving the film to go its own way mostly. The meteors-in-the-atmosphere special effects were fine enough, but the impacts were just the typical human-speed missiles with explosive effect for entertainment value alone. In New York City during one of various nods to the past, the top of the Empire State Building was knocked burning into the street where the Willis O'Brien animated King Kong had fallen in the 1933 movie, for instance. Grand Central Station took a strike too, as another familiar NYC landmark other than the Statue of Liberty. These were just precursors to the main event, however. With 18 days till an asteroid "the size of Texas" would hit the Earth, following an unseen comet-asteroid collision in the asteroid belt some while before (saving on the effects budget, as well as being more plausible for what might have been detected from Earth), there was just time to fetch Bruce Willis and his team from an oil rig, fly them out to the somewhat cometary asteroid, plant nuclear bombs, and blow it in two, so it would miss the planet. Shanghai in China got blown up itself by a small fireball that plunged into its harbour (maybe hitting the unmentioned undersea oil reservoirs there – no other reason was given for it!), while Paris had its traffic problems solved permanently by being completely redesigned as a smoking crater. An orbiting NASA Space Shuttle was destroyed by repeated unusually realistic high-speed meteor strikes as the film opened, and Willis & Co. managed to accidentally destroy the Russian Mir space station after refuelling there on the way to the asteroid. After a predictable, but still entertaining, series of adventures, Bruce Willis' character had to sacrifice himself to save the world, and destroy the projectile. All good fun, tautly told!

24 *Deep Impact* (1998)*

A critically better-received copy of *Armageddon*, but taking itself much too seriously, this was a circa two-hour-long US colour movie. The plot: comet discovered on collision course with Earth; space mission sent to blow up comet – fails; smaller comet fragment hits near eastern coast USA, creating devastating tsunami, etc.; space mission crashed suicidally into larger fragment of comet and blew it up; panic over (sort of...). Most of the early story was the slow discovery of the comet-approach information by a reporter, information which had been kept from a public seemingly devoid of amateur astronomers. This made for a VERY long wait till something meteoric (or even astronomical) appeared. When we reached that point, the various meteor effects were quite impressive, if not wholly convincing at times. Although we were told the spectacular meteor display from the exploded larger fragment lasted an hour, barely five seconds of it featured on-screen, for example.

25 *Meteorites!* (1998)*

This circa 80-minute US movie was a curious mixture of fantasy and reality, set against the usual backdrop: comet hits asteroid; fragments hit Earth; plus various standard disaster-movie sub-plots. On the positive side, an understanding of the velocity-mass equation in relation to crater size was noted, as was the differentiation between the terms 'meteor' and 'meteorite', while many of the meteor effects were believable enough. Less positively, we had 'astronomers' watching the strong to storm meteor activity only with telescopes, while the impacts were of the standard 'missile' forms, in one cartoon-like instance vaporizing a tabloid newspaper reporter at a UFO convention, while leaving his smoking boots standing upright on an untouched path! Oddest of all was the concept that the impacts only occurred days apart, in a single, narrow, straight line across the USA "the orbital line of the Shu-Pan Comet", and that by moving only a short way off this 'line' everyone would be safe. So when an 'astronomer' found that the comet's orbit had altered, meaning it too would hit the Earth, and said "It's goin' to get worse!", we wondered if he meant the level of impacts, or the nature of the film. As the blazing projectile numbers increased, the featured town's population took shelter in a conveniently nearby mine, returning to normal life in a devastated landscape immediately after the impacts stopped, at the end of the movie.

26 *Judgment Day* (1999)

Not having seen this US colour film, we can judge it only by the comments of Fane-Saunders (2001, pp. 185–186), which indicated it had poor special effects, and while the film overall rose above that problem, it lacked tension. The story, which we can all probably recite together by now, was of a giant asteroidal impactor heading for Earth, with only one scientist able to save the planet. However, he had been kidnapped by a cult leader, who believed the impact was god's will. There was no reviewer's comment on how any meteoric or impact effects were illustrated, regrettably.

27 Conclusion

Impact scenarios in movies have a long, if generally undistinguished, pedigree, despite improvements in the quality of their special effects with time (in some cases, at least). It is curious no films so far seem to have been able to reconcile believable impact science with a strong and well-performed storyline, but the more recent clutch have certainly filtered through into popular belief, with concern about impacts now occurring occasionally when inexperienced witnesses report an ordinary fireball sighting, not an especially welcome influence.

All the way through, we have seen movies reflected the general societal concerns of their times, such as the global conflicts and economic problems in the first half of the twentieth century, and how rocketry and space exploration might affect the rest of society in the 1950s and 60s. The late 1990s films seemed to have originated in a combination of the unusual run of strong returns from the Perseids and what was expected from the Leonids, with the series of interesting, sometimes naked-eye, comets, including Hyakutake and Hale-Bopp, in conjunction with the calendrical millennium. The attraction of such celestial impact movies seems to have waned more recently, but on past evidence, it will likely return, doubtless once more reinforcing public (mis-)conceptions about such events!

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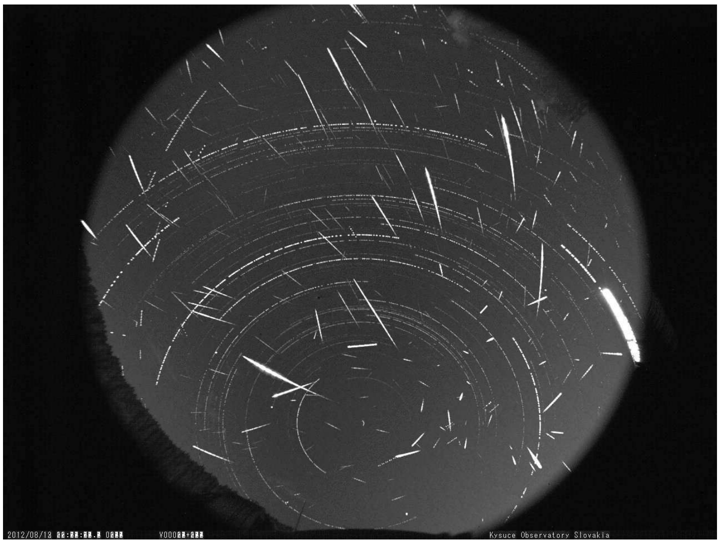
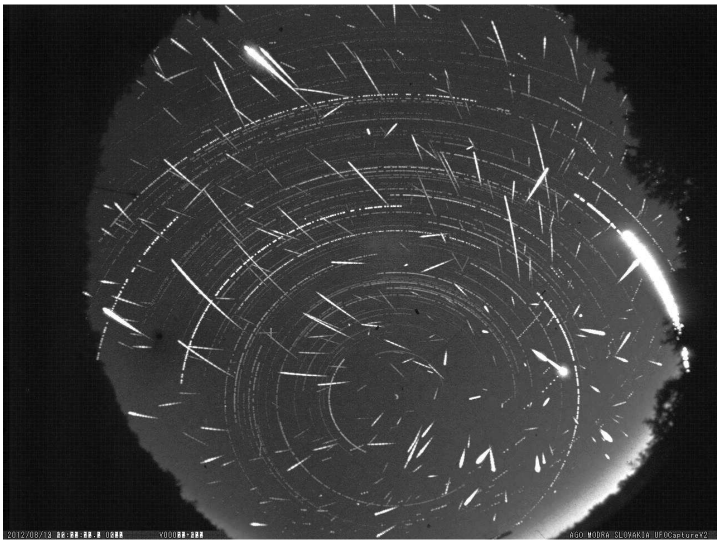
2012 Perseids in Slovakia

Arborétum Mlyňany



Public observatory in Kysucké Nové Mesto



AGO Modra

Composite images of the 2012 Perseids detected by three AMOS stations are based on data acquired on the night of 2012 August 12/13 ($19^{h}25^{m} - 02^{h}40^{m}$ UT). Each station detected more than 200 Perseids within 3.3 hour interval in the brightness range between magnitudes $+3.5$ and -6.0. The trail of the rising Moon is visible on the right, the North faces down. AMOS (All-Sky Meteor Orbit System) is a video detection system currently residing at three permanent locations – AGO Modra, Arborétum Mlyňany and Public observatory in Kysucké Nové Mesto – and creates the Slovak Video Meteor Network (PI Juraj Tóth). Observer: Š. Gajdoš; Image processing: J. Tóth [AGO/SVMN archive, AGO Modra, Slovakia].