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Front cover photo

Bright fireball recorded by the Hiroshima University allsky camera on 2015 May 18 at $02^{h}57^{m}15^{s}$ UT. The allsky camera comprises of Nikon D3200, Sigma 4.5 mm F2.8 lens and used 15 s exposure at $f/3.2$ and ISO 1600. Image courtesy: Koji S. Kawabata, Hiroshima University.

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` .

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In Memoriam: Bruce Andrew McIntosh (1929 – 2015)

Peter Brown

Received 2015 May 25

Bruce McIntosh, a long time meteor researcher, passed away February 14, 2015 in Toronto, Canada. Bruce was born in the town of Wiarton, Ontario in 1929 and did post-graduate work at the University of Western Ontario (MSc, 1953) and McGill University (PhD, 1958) in Physics. Bruce become a staff scientist in the Division of Radio and Electrical Engineering at the National Research Council soon after obtaining his MSc. He married Louise in 1954, and their first son was born in 1955. Bruce and family moved to Montreal soon afterwards, where he concentrated on completing his PhD studies, and where Louise gave birth to their second child. He returned to NRC in Ottawa in 1959, where his third and fourth children were born.

Figure 1 – Dr. Bruce McIntosh shortly after his graduation from the Physics program at McGill University.

Bruce began his scientific career focused on studies of meteors using radar, a topic of particularly great interest in Canada in the 1950s, driven initially by the practical considerations related to the development of the JANET forward-scatter radio communication system. Bruce worked in the meteor group at the NRC led by Peter Millman, first as part of the upper atmosphere research branch of the NRC and later as a member of Herzberg Institute of Astrophysics. Together with Millman and D.W.R. McKinley, he performed much of the early statistical work on meteor radar measurements made at the Springhill Observatory, including compilation and analysis of some of the first long-term radar meteor echo records (Millman & McIntosh, 1964; Millman & McIntosh, 1966).

Bruce's professional collaborations expanded in 1966 when Dr. Miloš Šimek and Dr. Jan Štohl spent an extended research visit to Ottawa (very unusual at the time), where they worked together on radar meteor interpretation. An extended reciprocal visit by Bruce and his family in 1973 to Ondřejov Observatory (in the former Czechoslovakia) cemented a lifelong friendship between Miloš and Bruce, and signaled the beginning of a long-term collaboration lasting through the remainders of both of their careers. Over the next two decades, they produced a series of long term studies of radar meteor streams using data from both the Springhill observatory and the Ondřejov radar, establishing baselines of activity for several major showers which would be later be used to help model the streams. In 1989, Bruce's contribution to science in Czechoslovakia was recognized by the Czechoslovak Academy of Sciences when they awarded him with the *Gold Medal of Merit in the Physical Sciences*.

These long term shower studies would later lead Bruce to expand his research into modeling the dynamics of the major meteoroid streams, a topic just coming of age in the 1970s and 1980s with the advent of faster computers. In particular, with the return of 1P/Halley in 1986, the topic of the Halley meteoroid streams (the Orionids and Eta Aquariids) and their evolution became a major focus for the International Halley Watch (IHW). Together with Anton Hajduk of the Astronomical Institute of the Solvak Acamedy of Sciences, Bruce developed the ribbon-model for the Halleyid streams (McIntosh & Hajduk, 1983) which was widely used in the community for understanding and interpretation of IHW meteor shower observations. Bruce's long-time interest in stream modeling, combining the best available information from comet observations and meteor measurements, culminated in a widely cited work on the enigmatic Quadrantid shower (McIntosh, 1990). The main results of this paper still form the basis for modern studies of this unusual meteor shower.

Bruce's inquisitive nature led him to explore several other areas of meteor science. These included studies of fireballs (McIntosh, 1970), and together with the late Douglas ReVelle he performed some of the earliest measurements dedicated to the detection of fireball infrasound (McIntosh et al., 1976). His study of the Leonid shower returns of the 1960s (McIntosh & Millman, 1970) proved very helpful when he participated in the 1999 global Leonid observing program, making him one of the few active meteor scientists whose research spanned an entire period of the Leonids (34 years).

Bruce's deep physical insight and quiet nature will be dearly missed by all who knew him.

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Letter — Zeng Wei Zhou (1988 – 2015)

Qinpo Zheng

Received 2015 May 27

Dear Fellow Meteor Observers,

I have a very sad news that Zeng Wei Zhou (Born on November 9, 1988, IMO Code: ZENWE) died at home 2:00 am on May 11, 2015. He loved astronomy since he was a child. He specialized in visual meteor observations, satellite observations and forecasts of asteroid occultations. Before his death, he also built a small remote control observatory at home. He provided meteor observers with a lot of help and has been recognized by everyone in China for his contributions. So all of China's astronomy enthusiasts were sadden of the news of his death. Chinese astronomy researcher Quanzhi Ye, has submitted an asteroid naming proposal, hoping to commemorate him for his contribution to Chinese astronomy. I think we should all remember his contribution.

Best regards,

Qinpo Zheng

IMO bibcode WGN-433-zheng-zhou NASA-ADS bibcode 2015JIMO...43...72Z

Call for photographs

Javor Kac

We are frequently short of photographs for the *WGN* covers that we publish in colour (front cover) or black&white (back cover). If you think you have a suitable meteor-related photograph, please offer it to us. More or less any computer image format will do. You can send your photographs to `wgn@imo.net`, but remember to put 'Meteor' in the subject line to get round the anti-spam filters.

IMO bibcode WGN-433-kac-call NASA-ADS bibcode 2015JIMO...43...72K

Conferences

International Meteor Conference 2016 in Egmond, The Netherlands — First announcement

Joost Hartman

From 2016 June 2 to 5, the International Meteor Conference 2016 will take place in Egmond, The Netherlands. It will be hosted by the Dutch Meteor Section of the Royal Dutch Association for Meteorology and Astronomy (KNVWS).

The IMC 2016 will happen just before the *Meteoroids 2016* conference, held at ESTEC, Noordwijk from June 6–10, 50 km south of Egmond, stimulating participants of both to visit each other, maximizing fertilization between amateur and professional meteor astronomers. 2016 is also the year that the KNVWS Meteor Section celebrates its 70th anniversary.

The IMC will take place in the town of Egmond, a coastal town located close to the North Sea in the municipality of Bergen (30 000 inhabitants), some 45 km north-west of the capital of The Netherlands, Amsterdam. Egmond can easily be reached by plane (via Schiphol Airport Amsterdam, Eindhoven Airport or Rotterdam Airport and is well connected to other parts of the Netherlands and the capital Amsterdam by train and bus. Egmond lies very close to motorway A9 between Amsterdam and the lovely city of Alkmaar, only 10 km away.

The conference will be held at the Stay Okay Hostel in Egmond. This Hostel will be available exclusively for the conference and will serve as host for full-board-participants. The hostel is on walking distance from the Dutch beach, has three sun-dressed terraces, bikes and numerous options, and is children friendly. For participants who do not want to stay at the Stay Okay Hostel the LOC will assist in arranging for alternative accommodation in the nearby village.

Figure 1 – The IMC 2016 logo.

On Saturday afternoon an excursion to the world Heritage site: “De Waddenzee” is planned. We will embark a big shrimp trawler and sail the shallow waters of the UNESCO and Dutch heritage site Waddenzee. During our trip the trawler catches our evening diner: Saturday night we will eat Fresh shrimp! If we are lucky we could catch even a glimpse of the many seals.

The standard registration fee for a shared 4 persons room at the Stay Okay is €175.-, when registered before 2016 February 28 and €205.- after this date. Non-accommodated participants are charged €100.- until February 28 and €130.- after this date. The registration deadline will be 2016 April 15.

In addition to the 4 person rooms, there are a limited number of 1 or 2 person rooms available. The organization is employing the principle first come first served. The registration fee for a double room is €250,- per person. The registration fee for a single room is €350,- per person.

The standard registration fee includes 3 nights of accommodation in a 4 persons room (June 2 until June 5) at the Stay Okay Hostel, full board (breakfast, lunch and diner; except (alcoholic) beverages), all IMC lectures and the poster session, coffee breaks, the excursion to the Waddenzee and the Saturday evening programme, conference material and the digital IMC proceedings. T-shirt and IMC proceedings on paper can be ordered for €10.- and €15.-, respectively.

We hope very much to see you in Egmond!

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Future IMCs and candidate organizers

Paul Roggemans[1]

The 35th International Meteor Conference has been announced (see elsewhere in this issue) and candidates to organize future conferences are invited to prepare proposals. A description how to prepare a candidacy as IMC organizer can be found on the IMO website under 'Conferences'. For people who are interested to become a candidate IMC organizer we offer also a kind of *Manual for IMC organizers* which contains a very detailed description of recommendations, numerous examples of IMC-related documents and information about all previous conferences. A copy (pdf) can be obtained at a simple request from the author. Asking for a copy does not commit you to anything.

For the 2017 IMC an excellent proposal has been made already in 2015 to have the conference in Petnica, Serbia. Because of the amount of work required for a decent IMC candidacy, it is not the purpose to have several candidates for the same year as then some candidates need to be disappointed. Nevertheless we are interested to hear from anyone interested to organize an IMC some year in the future.

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Meteor science

Draconid 2011 outburst observations from Slovenia

Javor Kac[1]

The 2011 Draconid outburst results are presented based on visual, video and photographic observations. A population index of $r = 2.6 \pm 0.1$ and a maximum zenithal hourly rate of 460 ± 60 on 2011 October 8 at 20^h11^m UT are obtained from the visual observations. Twelve double-station Draconids form an average geocentric radiant at $\alpha = 262\overset{\circ}{.}4 \pm 0\overset{\circ}{.}8$, $\delta = +55\overset{\circ}{.}4 \pm 0\overset{\circ}{.}4$, with a velocity $v_\infty = 22.4 \pm 0.4$ km/s. Single-station video observations indicate a radiant at $\alpha = 261\overset{\circ}{.}4 \pm 1\overset{\circ}{.}4$, $\delta = +55\overset{\circ}{.}8 \pm 1\overset{\circ}{.}4$, and a velocity of $v_\infty = 20.6 \pm 0.5$ km/s. A flux profile is presented based on 358 video Draconids, and a maximum flux of 87 Draconids per 1000 km^2 per hour is found on 2011 October 8 at 20^h15^m UT.

Received 2015 January 20

1 Introduction

Draconids are known for their occasional outbursts. Two Draconid meteor storms were observed during the 20th century – both, the 1933 and the 1946 outbursts featured ZHRs on the order of 10 000 (Jenniskens, 1995). Further Draconid outbursts of ZHR on the order of several hundred happened in 1952, 1985 and 1998 (Jenniskens, 2006).

Several predictions of enhanced activity of Draconids in 2011 were published (Vaubaillon et al., 2011; Maslov, 2011). They all agreed on the main peak timing (predicted on 2011 October 8 at around 20^h UT, range from 19^h26^m to 20^h36^m UT), but differed in strength predictions which ranged from ZHR 50 to 750.

In the following sections we describe the visual, video and photographic observations of the 2011 Draconid outburst. Preliminary data from these observations has been presented at the International Meteor Conference at La Palma (Kac, 2013).

2 Observations and results

The weather was very unstable in central Europe around 2011 October 8, making any planning more than a couple of hours ahead impossible. One day before the expected event, potential observing locations were chosen in western Slovenia and northern Italy. Eleven observers gathered in Sežana, Slovenia, a city that served as their headquarters until the last-minute decision. As a front with thunderstorms passed the site only a couple of hours before the event, a choice was made to move to near the village of Tatre, about 20 km south-east from the headquarters. Near-perfect observing conditions persisted from team's arrival at dusk until 21^h UT.

2.1 Visual observations

Five observers contributed visual data for the outburst, observing from two different locations: Mitja Govedič observed from Središče ob Dravi in the north-east of Slovenia, whereas others observed from Tatre. A total of 634 Draconids were recorded in more than 12 hours of observations (Table 1). Draconids were distinctive for their slow speed and very short trails because of the high radiant elevation, and were dominated by fainter meteors.

Table 1 – Visual observers' statistics for 2011 October 8. t_{eff} denotes effective observing time, DRA the number of Draconids, DAU the number of δ-Aurigids, STA the number of Southern Taurids and Spor the number of sporadic meteors. A '/' denotes that observer did not did not distinguish the meteor shower and that these meteors are included in the sporadic meteors count.

Observer	t_{eff} (h)	DRA	DAU	STA	Spor
Jure Atanackov	3.346	238	/	2	15
Mitja Govedič	1.000	46	1	/	19
Javor Kac	3.571	137	0	0	10
Janez Kos	2.747	167	/	/	22
Rok Pucer	1.798	46	/	/	5
Total	12.462	634	1	2	71

A population index of $r = 2.6 \pm 0.1$ was obtained based on our observations, calculated according to Arlt (2003), and using magnitude distributions of 634 Draconids collected on 2011 October 8 between 17^h47^m and 21^h28^m UT. This population index was then used to calculate the ZHR activity profile (Figure 1). A maximum ZHR of 460 ± 60 is calculated on 2011 October 8 at 20^h11^m UT.

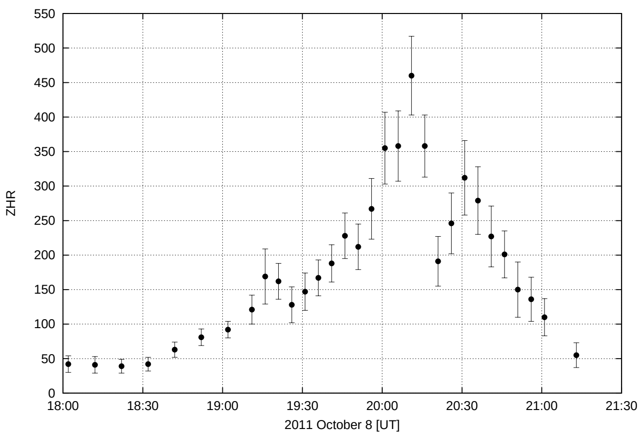

Figure 1 – Visual ZHR activity profile of the Draconids, using population index of $r = 2.6$.

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The population index fits well to values obtained by visual observations as reported in Tóth et al. (2012) and Trigo-Rodríguez et al. (2013), as well as to video results secured by narrow-field and allsky camera, operating onboard the aircraft where a mass distribution index of $s \sim 2.0$ (corresponding to $r \sim 2.6$) was obtained (Tóth et al., 2012).

The maximum timing fits to that reported on the IMO's Draconids 2011 visual data quicklook page (International Meteor Organization, 2012) as well as the peak times reported by Tóth et al. (2012), Vandeputte (2012), Trigo-Rodríguez et al. (2013) Molau & Barentsen (2014), and Koten et al. (2014). The maximum rate is somewhat higher than reported by the aforementioned sources where maximum ZHR between 113 and 371 was obtained. This could be due to different population index values that were used or the application of personal perception coefficients. Trigo-Rodríguez et al. (2013) also report other possible ZHR enhancements at $19^{\mathrm{h}}38^{\mathrm{m}}$ UT with a ZHR of 419 and at $21^{\mathrm{h}}08^{\mathrm{m}}$ UT with a ZHR of 394; and Toth et al. (2012) found additional peak of ZHR 310 at $19^{\mathrm{h}}53^{\mathrm{m}}$ UT. These peaks could not be confirmed by our observations.

2.2 Video observations

Two cameras (marked with asterisk in Table 2) were installed and calibrated on 2011 October 7, one night before the expected outburst. Three other cameras, permanently installed and affiliated to the IMO Video Meteor Network (Molau & Rendtel, 2009), also contributed observations for this study. All cameras were from Mintron, using a 1/2" Sony ExView CCD, and equipped with either 6-mm f/0.75 or 8-mm f/0.8 lenses. Typical limiting magnitudes reached with this equipment are +5 to +6 for stars and about +4 for meteors. Astrometric accuracy for all cameras is about 3'. Matrox Meteor II frame grabbers were used for image digitization. MetRec software was used for meteor detection. The program inspects camera's video signal at 25 frames per second and automatically detects meteors and other similar phenomena. Timing information, celestial coordinates and brightness are recorded for each event. In addition, the program calculates meteor's angular velocity and performs meteor shower association. A composite image of the event and individual frames (optional) are stored as well. All computers were time-synchronized via the NTP internet protocol to obtain timing accuracy better than one frame duration (0.04 s).

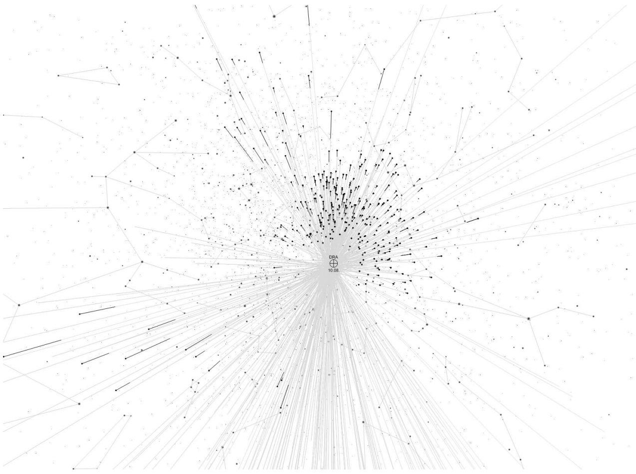

Figure 2 – Backward tracings plot in gnomonic projection based on 492 video meteors recognized as Draconids. Circle marks the radiant position according to ephemerides. Plot was created with the MetVis software.

Almost 800 meteors were recorded by the video cameras, with nearly 500 of them identified as Draconids by the MetRec software (Table 2).

2.2.1 Radiant position from single-station meteors

The radiant position based on video records was calculated using RadFind tool from the MetRec package. The first search was run at 1° positional steps and 1 km/s steps in velocity. The following radiant parameters were obtained: $\alpha = 262^\circ\!.2 \pm 1^\circ\!.3$, $\delta = +56^\circ\!.0 \pm 1^\circ\!.3$, $v_\infty = 21.0 \pm 0.5$ km/s. The second run was at $0^\circ\!.2$ positional resolution and 0.2 km/s steps in velocity, exploring only coordinates $10^\circ \times 10^\circ$ around the position obtained in the first step. The second run resulted in $\alpha = 261^\circ\!.4 \pm 1^\circ\!.4$, $\delta = +55^\circ\!.8 \pm 1^\circ\!.4$, $v_\infty = 20.6 \pm 0.5$ km/s. The radiant is well seen in the backward tracing plot from video meteors shown in Figure 2. The radiant position and velocity compare favorably to those listed in the IMO working list of meteor showers: $\alpha = 262^\circ$, $\delta = +54^\circ$, $v_\infty = 20$ km/s (McBeath, 2011) and fits perfectly to parameters obtained by the IMO Video Meteor Network observers (Molau et al., 2012). The radiant position and velocity are also in agreement with the values found in (Tóth et al., 2012; Trigo-Rodríguez et al., 2013; Borovička et al., 2014; Molau & Barentsen, 2014; Rudawska et al., 2014; Šegon et al., 2014).

Table 2 – Video camera locations and meteor detection statistics for 2011 October 8. Column DRA gives the number of Draconids as identified by MetRec. Cameras marked with asterisk are mobile cameras installed specifically for the Draconids campaign.

Camera name	Site (country code)	Latitude	Longitude	Elevation	DRA	Total
Mobcam1	Nova vas nad Dragonjo (SI) *	45.48°N	13.70°E	280 m	178	305
Orion1	Ljubljana (SI)	46.08°N	14.54°E	300 m	31	38
Orion2	Središče ob Dravi (SI)	46.40°N	16.27°E	200 m	76	116
Sraka	Velenje (SI)	46.35°N	15.10°E	440 m	15	32
Cygnus1	Sgonico/Zgonik (IT) *	45.74°N	13.75°E	280 m	192	294
				Sum	492	785

2.2.2 Draconid orbits

MetRec detection files containing positional data of meteors were converted to UFO software-compatible format. Double-station events were detected and orbits calculated by using UFOOrbit software. Q1 selection criterion was used, with additional restrictions: minimum station distance 15 km, maximal radiant difference for paired calculations 1°.

Double-station meteors were detected between station pairs Ljubljana–Središče ob Dravi, Velenje–Sgonico and Ljubljana–Sgonico. Thirteen Draconid double-station meteors satisfied the selection criteria. Orbital data obtained for these meteors is listed in Table 3.

Figure 5 shows the geocentric radiant positions of double-station meteors. While most radiants form a tight cluster, meteor number 9 deviates significantly. Still, when checked for orbital similarity against the average orbital elements of other double-station meteors using D' criterion (Drummond, 1981), the D' is $D' = 0.036$, much lower than the conventional threshold $D' < 0.105$ required for orbits to match. This test confirms that the meteor was in a Draconid orbit. The average geocentric radiant position using the remaining 12 meteors is at $\alpha = 262.^{\circ}4 \pm 0.^{\circ}8$, $\delta = +55.^{\circ}4 \pm 0.^{\circ}4$, and velocity $v_\infty = 22.4 \pm 0.4$ km/s. These values are in agreement with results reported by (Tóth et al., 2012; Trigo-Rodríguez et al., 2013; Borovička et al., 2014; Šegon et al., 2014) that are based on 43, 16, 8, and 63 double-station Draconids, respectively.

2.2.3 Draconid flux

The software used for meteor detection (MetRec) measures the limiting magnitude LM for stars for each one-minute interval. The effective observing time is also recorded for each interval. These data can be used to calculate the meteoroid flux.

Only intervals with stellar $LM \geq 4.0$ were used for the flux calculation. Bin size was required to contain at least 20 Draconids and bin length was allowed to range from 10 to 60 minutes. Only four of the cameras listed in Table 2 were used for the flux calculations as the camera in Velenje did not achieve the LM criterion due to predominantly cloudy weather.

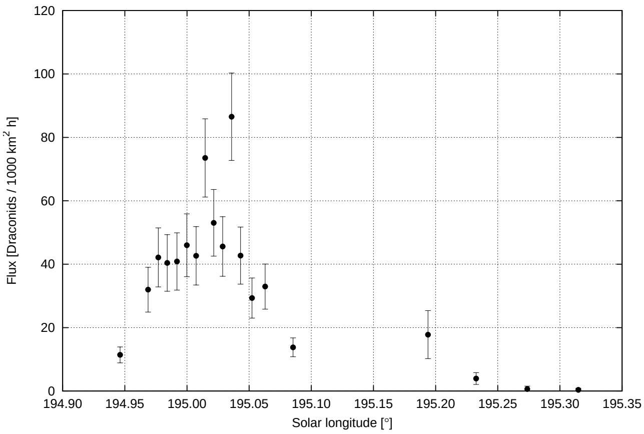

Figure 3 – Video activity flux profile of the Draconids, using a population index of $r = 2.6$.

The flux profile shown in Figure 3 is based on 358 Draconids as automatically recognized by MetRec. Two possible maximum times are found in the profile: at $19^{\mathrm{h}}52^{\mathrm{m}}$ UT with a flux of 74 Draconids per 1000 km^2 per hour and at $20^{\mathrm{h}}15^{\mathrm{m}}$ UT with a flux of 87 Draconids per 1000 km^2 per hour. The second (higher) peak in the profile coincides with the peak time as found by the IMO Video Meteor Network study (Molau et al., 2012) and fits to the visual maximum time obtained from visual observations presented in Section 2.1 of this paper.

2.3 Photographic observations

Eight observers contributed their photographic observations in this study. They are listed in Table 4 along with camera models, optics used, exposure times and meteor statistics.

2.3.1 Photographic activity profile

The Draconid photographic activity profile was constructed by counting the number of meteors detected in 15-minute bins. No corrections for camera dead time or radiant height were made. Two ill-defined peaks can be found in the profile (Figure 4). The first peak is centered at $19^{\mathrm{h}}00^{\mathrm{m}} \pm 15^{\mathrm{m}}$ UT, while the main peak occurs at $20^{\mathrm{h}}22^{\mathrm{m}} \pm 22^{\mathrm{m}}$ UT. While the second peak coincides nicely with the visual and video maxima, the first peak is not readily apparent in those data. This possibly suggests a transient decrease of population index without appreciable rise in activity, thereby producing brighter meteors that are picked up by photographic cameras.

2.3.2 Photographic radiant

Photographic images containing possible Draconids were astrometrically reduced using Astro Record 3.0 software (de Lignie, 1997). A minimum of 30 reference stars were used for field calibration in each photograph. Astrometric accuracy in measured images ranged from 0.1 arcmin (50 mm lens) to 1.7 arcmin (10 mm fish-eye lens).

The mean Draconid radiant position was calculated using the tracings environment of Radiant 1.43 software (Arlt, 1992). This function determines the number of incident meteor backward tracings in each small square that the sky is divided into. Resolution (square size) of 0.5° was used in this work to calculate the apparent

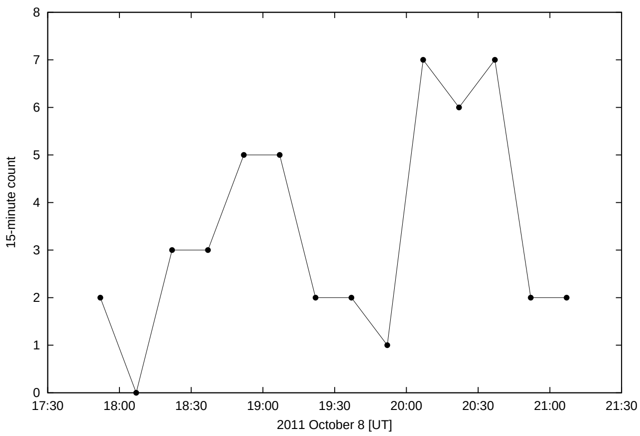

Figure 4 – Photographic meteors per 15-minute bin.

Table 3 – Radiant, velocity and orbital data for double-station Draconids detected on 2011 October 8. Meteor number 9 is excluded from the average data calculation.

No	Time (UT)	α [°]	δ [°]	v_∞ [km/s]	a [AU]	q [AU]	e	i [°]	ω [°]	Ω [°]
1	$18^h07^m53^s$	262.7	+55.4	23.1	3.22	0.9962	0.691	31.1	173.1	194.9520
2	$18^h09^m35^s$	262.8	+55.9	22.4	2.71	0.9965	0.632	30.2	173.3	194.9531
3	$18^h21^m10^s$	262.4	+56.0	22.1	2.57	0.9963	0.612	29.9	173.0	194.9610
4	$18^h46^m33^s$	263.1	+55.4	22.8	3.03	0.9965	0.671	30.6	173.4	194.9785
5	$19^h35^m04^s$	262.9	+55.7	22.1	2.66	0.9964	0.625	29.9	173.2	195.0117
6	$19^h42^m04^s$	260.3	+54.8	21.7	2.53	0.9945	0.606	29.2	171.1	195.0165
7	$19^h43^m26^s$	261.4	+54.9	22.6	2.94	0.9952	0.662	30.3	171.9	195.0174
8	$19^h43^m50^s$	262.1	+55.5	22.4	2.80	0.9959	0.644	30.3	172.6	195.0177
9	$19^h48^m38^s$	269.7	+61.9	24.1	2.69	0.9991	0.629	34.2	180.0	195.0211
10	$19^h49^m35^s$	262.6	+55.7	22.1	2.64	0.9963	0.623	29.9	173.1	195.0217
11	$19^h56^m26^s$	261.9	+55.0	22.0	2.68	0.9957	0.628	29.6	172.4	195.0263
12	$20^h50^m46^s$	263.2	+55.9	22.8	2.99	0.9965	0.667	30.9	173.5	195.0636
13	$22^h55^m51^s$	262.9	+55.1	22.3	2.82	0.9962	0.647	30.0	173.1	195.1493
	average ± SD	262.4 ± 0.8	$+55.4 \pm 0.4$	22.4 ± 0.4	2.8 ± 0.2	0.9960 ± 0.0006	0.64 ± 0.03	30.1 ± 0.5	172.8 ± 0.7	195.0141

Table 4 – Photographic camera statistics for 2011 October 8.

Operator	Camera model	Lens used	Total exposure time (min)	Total meteors
Jure Atanackov	Nikon D80	18/3.5	211	3
Javor Kac	Canon 40D	17/2.8	233	18
Janez Kos	Nikon D5000	18/3.5	265	2
Patricija Pevec	Nikon D70	18/3.5	207	3
Rok Pucer	Nikon D80	50/1.4	—	2
Matic Smrekar	Nikon D40	10/2.8	241	15
Nina Smrekar	Nikon D5000	35/1.8	222	6
Samo Smrke	Canon 350D	18/3.5	—	3

radiant from photographic records. Apparent radiant position was corrected for zenith attraction and diurnal aberration taking into account the mean time of all recorded meteors. Based on 38 measured meteors, the geocentric coordinates for mean radiant were found at $\alpha = 262\overset{\circ}{.}7$, $\delta = 56\overset{\circ}{.}2$, assuming a geocentric velocity of 20.4 km/s. If the extremes of the detection interval are taken into account instead of mean time, the geocentric radiant location differs maximally by $^{+0.1}_{-1.5}$ in right ascension and $^{+1.0}_{-1.2}$ in declination.

3 Conclusions

A strong Draconid meteor shower outburst was observed by means of visual, video and photographic techniques. The maximum times with all observing modes occurred on 2011 October 8 between $20^{h}11^{m}$ and $20^{h}22^{m}$ UT. A ZHR of above 400 was calculated based on visual observations. Video observations show a maximum on 2011 October 8 at $20^{h}15^{m}$ UT with a flux of 87 Draconids per 1000 km^2 per hour. The geocentric radiant positions obtained using different techniques are summarized in Table 5. Single-station radiant parameters $\alpha = 261\overset{\circ}{.}4 \pm 1\overset{\circ}{.}4$, $\delta = +55\overset{\circ}{.}8 \pm 1\overset{\circ}{.}4$, $v_\infty = 20.6 \pm 0.5$ km/s were obtained from video data. Double-station meteors yield an average radiant at $\alpha = 262\overset{\circ}{.}4 \pm 0\overset{\circ}{.}8$, $\delta = +55\overset{\circ}{.}4 \pm 0\overset{\circ}{.}4$ and velocity $v_\infty = 22.4 \pm 0.4$ km/s. Photographic observations point at a geocentric radiant at $\alpha = 262\overset{\circ}{.}7^{+0.1}_{-1.5}$, $\delta = +56\overset{\circ}{.}2^{+1.0}_{-1.2}$. All findings are in mutual agreement as well as with other results published to date.

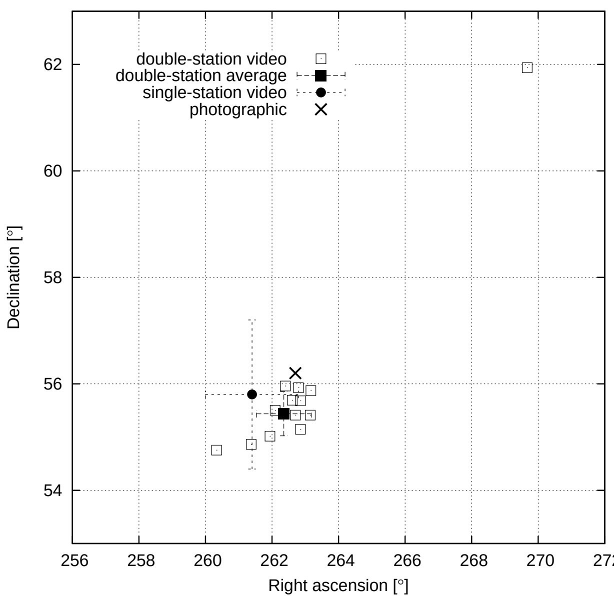

Figure 5 – Geocentric radiants of the 2011 Draconids obtained by different methods.

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Table 5 – Geocentric radiant positions of the 2011 Draconids, obtained by different techniques as presented in this work.

Technique	α [°]	δ [°]	v_g
Video (single station)	261.4 ± 1.4	$+55.8 \pm 1.4$	$v_\infty = 20.6 \pm 0.5$ km/s
Video (double station)	262.4 ± 0.8	$+55.4 \pm 0.4$	$v_\infty = 22.4 \pm 0.4$ km/s
Photographic	262.7	+56.2	n.a.

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Double station observation of meteors in Nikolaev

Nikolay Kulichenko[1,2], *Oleksandr Shulga*[1,3], *Yevgen Kozyryev*[1], *and Yevgeniya Sybiryakova*[1]

Meteor research using TV CCD unintensified techniques was started in 2011. The facilities and methods of meteor observation and initial processing are described. The initial results from both single and low-base double station observation are described in the article. The main emphasis of the research is precise astrometry and further meteoroid orbit calculations.

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1 Introduction

Meteor observation using video techniques was started at Research Institute Nikolaev astronomical observatory (RI NAO) in 2011. This was the third big meteor research campaign in Ukraine after Odessa (Gorbanev et al., 2006; Gorbanev, 2009) and Kiev (Hajdukova et al., 1995; Kozak et al., 2001). The research is based on a system of fixed telescopes equipped with TV CCD cameras for both single and double station observation. The main goals were to create a completely automated observing set up and to obtain astrometric and kinematic parameters of meteors (radiant point coordinates, velocities, orbit elements) using original software developed in RI NAO.

2 Meteor observation methods and facilities

2.1 Meteor telescopes

Video observations of meteors at the RI NAO are conducted using meteor patrol, which includes 6 optical telescopes (4 lenses: $f = 85$ mm, $f/1.8$; 2 lenses: $f = 100$ mm, $f/2.0$) equipped with a TV CCD cameras WAT-902H2 (768×576, $8.6 \times 8.3 \mu$m). The field of view is $3\overset{\circ}{.}2 \times 4\overset{\circ}{.}2$ for four of the telescopes and is $2\overset{\circ}{.}7 \times 3\overset{\circ}{.}6$ for the other two telescopes. The system does not include any intensifier. Each video system is contained in a hermetic capsule to protect it from rain and other aggressive meteorological conditions (Figure 1a,b,c). Cameras work in the interlace mode with a rate of 50 half-frames per second.

2.2 Combined observation method

The original combined observation method was developed at RI NAO for observation of objects having high apparent rates on stare telescopes (Shulga et al., 2009; Shulga et al., 2011). Originally it was used for observation of Near Earth Asteroids (NEA), comets, and artificial satellites. The primary aim is to obtain frames with stars and moving object separately in order to allow more accurate coordinate measurement. The automated meteor detection software was designed in 2010, based on the experience with real-time video stream processing.

Figure 1 – Meteor patrol: a) at RI NAO; b) at station 11.8 km distant; c) meteor telescope inner housing.

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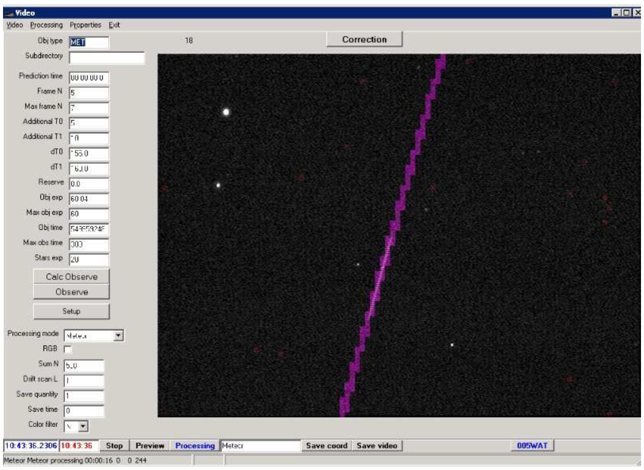

Figure 2 – Software for on-line meteor detection in video stream.

The detection algorithm works as follows:

1. averaging of pixel brightness in cells of 8×8 pixels;
2. calculation of the signal/noise ratio of each cell using the brightness of the same cell in 25 frames before and after the current frame;
3. searching for the lines of the meteor trajectory among the cells that exceed the threshold value of the signal/noise ratio (using the least-square method with exclusion of big deviations);
4. searching for objects which are uniformly moving along the detected line (using the least-square method with exclusion of big deviations);
5. exclusion of objects whose speed is less than 2 deg/s (assumed to be satellites);
6. saving the image sequence.

Parallel to the real-time detection process the star images are accumulated with a 30 s exposure using the track-and-stack technique. Accuracy of the reference system is better than 6 arc sec. Limiting magnitude for stars is $(12\text{–}13)^m$.

2.3 Time synchronization

The method of double station synchronization is based on using PPS-impulse from GPS receiver Resolution-T as reference impulse. Accuracy of time synchronization is 10^{-4} s.

2.4 Initial processing software

The modified software to process TV observations of low elliptic objects is used for the calculation of the equatorial coordinates of the meteor trajectories. There are three main steps of calculation:

1. star processing (Astrometrica 4.4.1.364 software, USNO-B1.0 reference star catalogue);
2. measuring the meteor trajectory points in frame coordinate system (software developed in RI NAO);
3. calculation of the equatorial coordinates of the meteor trajectories using results of the previous steps (software developed in RI NAO).

3 Results (single station observation)

3.1 Statistics

During 2011–2014, 4135 single station meteors were observed. Due to weather conditions, narrow field and some technical problems the meteor distribution over solar longitude is not representative. The mean duration of observed meteor trajectories was in the range 0.05–0.6 s. The distribution of meteors over meteor magnitude and arc length is shown in Figure 3.

3.2 Astrometry

The main parameter of single station meteor trajectory is the position of the pole of the meteor path's great circle (Gorbanev & Golubaev, 2009). This parameter is used in the subsequent calculation of radiant point coordinates (Astapovich, 1958). The mean accuracy of estimation of the coordinates of the pole is about (0.05–0.1)°. The difference in accuracy between systems with different focal lengths is not significant.

4 Visible radiant point estimation

Two double station observation campaigns were conducted at RI NAO: the first one was in spring 2013 (Kulichenko et al., 2014); the second started in September 2013 and it is still working. The first pair of stations observed during March–May 2013 and had a baseline of 5 km. Each station consisted of two meteor telescopes with lenses $f = 85$ mm, $f/1.8$, $FOV = 3{.}^{\circ}2 \times 4{.}^{\circ}2$ and unintensified CCD cameras WAT-902H2. Total number of observed meteors was 220, number of simultaneous observed meteor trajectories was 130. The shortness of the baseline led to there being a quite large number of double station meteors, and the fact that one meteor could be observed by both telescopes at one station meant that the number of real observed meteors was about 80. The mean accuracy of visible radiant determination is 0.7 arc sec and more than 60% of radiants have standard deviation of better than 0.2 arc sec. A plot of visual radiants for meteors observed in 2013 is shown in Figure 5.

In summer 2013, the baseline was increased to 11.8 km and a pair of telescopes was added with lenses $f = 100$ mm, $f/2.0$, $FOV = 2{.}^{\circ}7 \times 3{.}^{\circ}6$, for more accurate position measurement. During September 2013–September 2014, the total number of observed meteor trajectories was 1757, but due to technical problems two pairs of telescopes only started observing in August 2014. Number of double station meteors 328. The mean accuracy of visible radiant determination is less than 0.5 arc sec, more than 80% of radiants have standard deviation better than 0.2 arc sec. A plot of visual radiants for meteors observed in 2014 is shown in Figure 6.

5 Summary

Regular single station meteor observation in automatic mode began in 2011. The first double station meteors were observed in 2013, using a short baseline. The accuracy of visible radiant estimation is 0.7 arc sec with

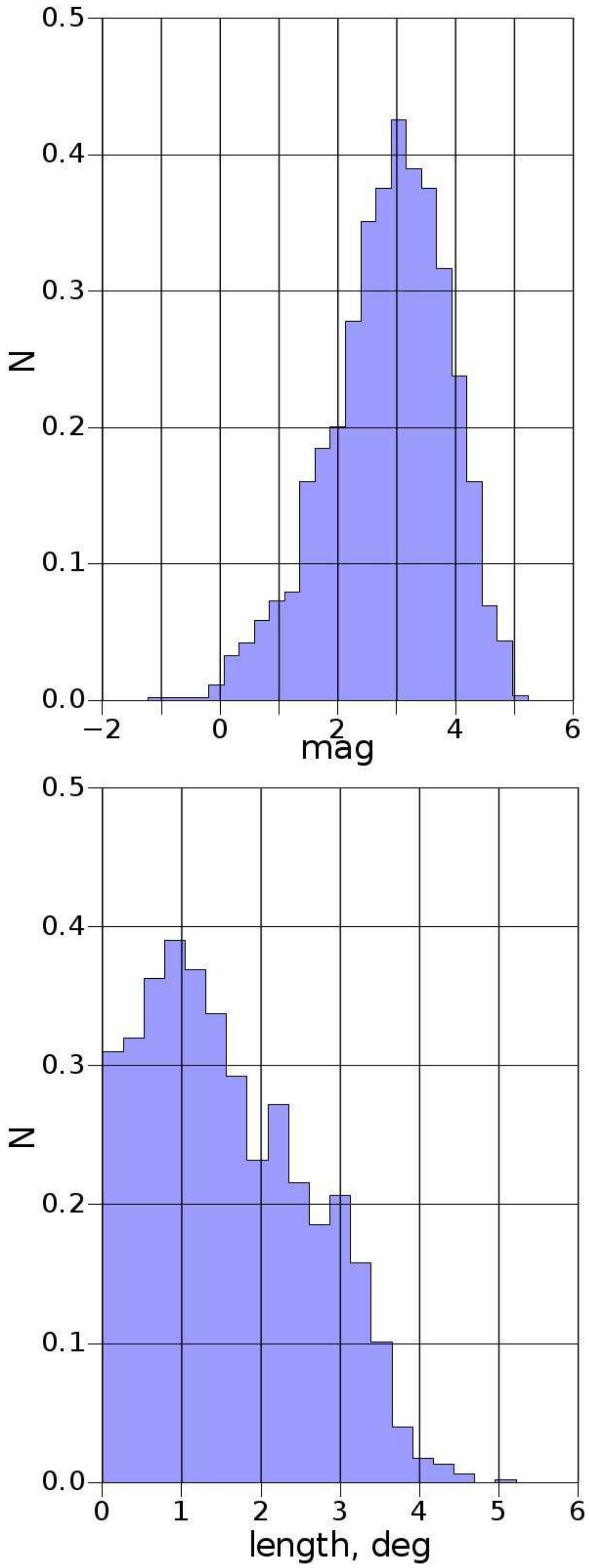

Figure 3 – a) Meteor magnitude distribution; b) meteor arc length distribution.

baseline 5 km, and better than 0.5 arc sec with baseline 11.8 km. Software for the calculation of double station meteor parameters is under construction.

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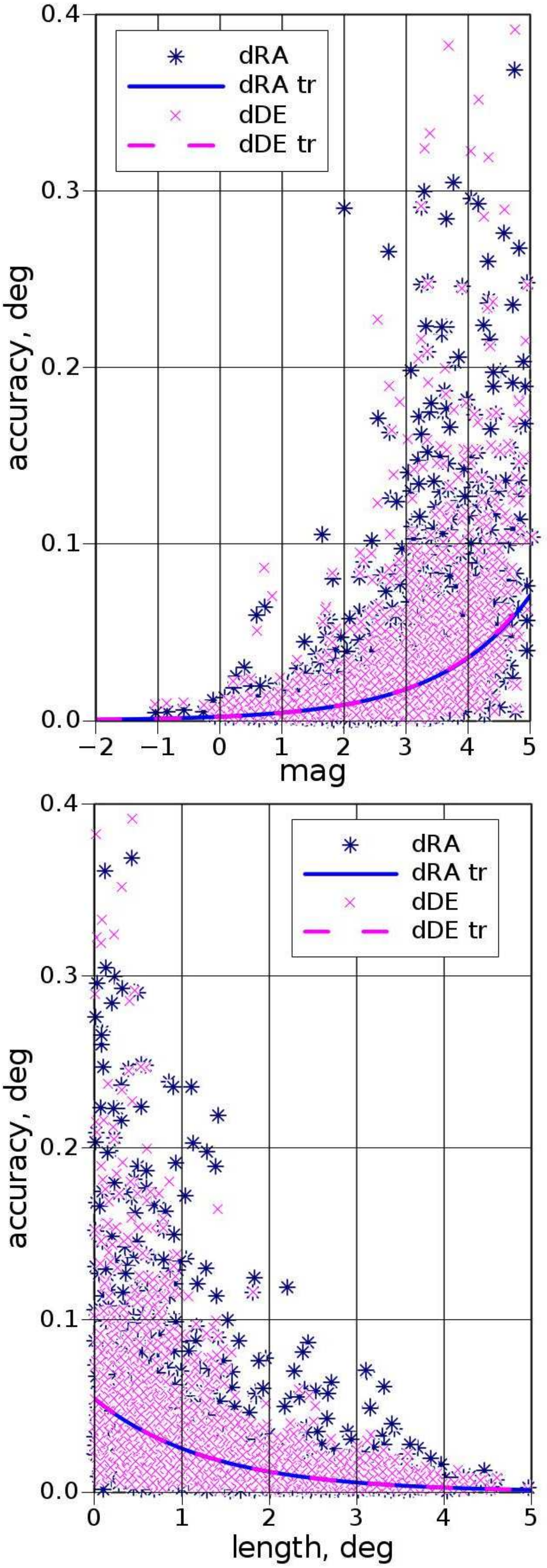

Figure 4 – Accuracy of calculation of the pole position of the meteor's great circle pole: a) dependence on meteor magnitude; b) dependence on meteor arc length.

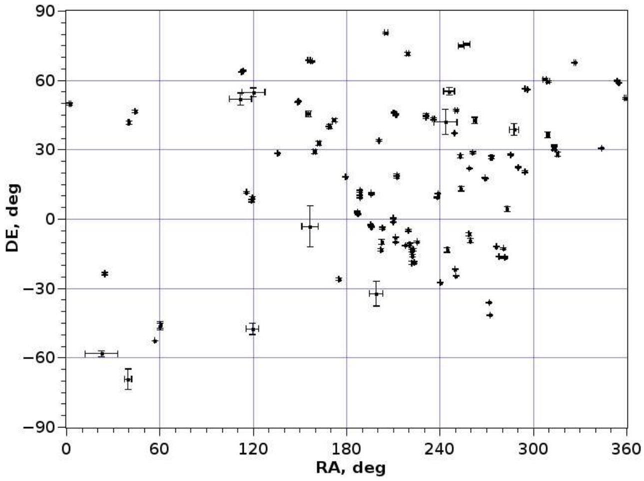

Figure 5 – Radiant plot, with uncertainties, of meteors observed in 2013.

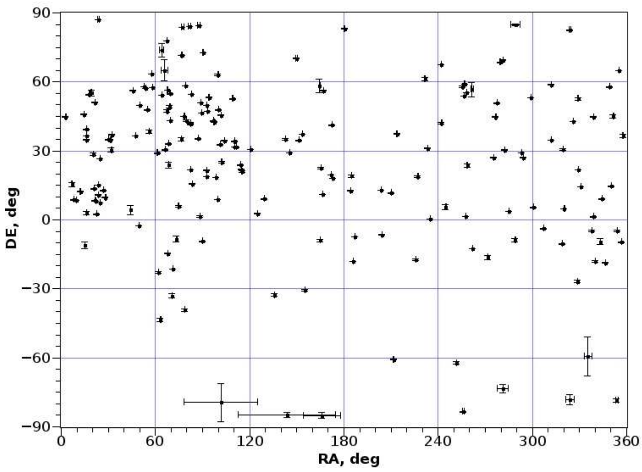

Figure 6 – Radiant plot, with uncertainties, of meteors observed in 2014.

Preliminary results

Results of the IMO Video Meteor Network — January 2015

Sirko Molau[1], *Javor Kac*[2], *Stefano Crivello*[3], *Enrico Stomeo*[4], *Geert Barentsen*[5], *Rui Goncalves*[6], *Carlos Saraiva*[7], *Maciej Maciejewski*[8], *and Mikhail Maslov*[9]

Eighty-four cameras of the IMO Video Meteor Network recorded more than 25 000 meteors in over 9 500 hours of observing time. Flux density profiles are presented for the Quadrantids, covering the period around the maximum for the years 2012 to 2015. It is found that the flux density at the maximum in 2015 was a factor of 2–4 lower than for the years 2012–2014. The population index for the Quadrantids on the night of the maximum was $r = 1.8$, in good agreement with the values from 2013 and 2014.

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1 Introduction

January is not renowned for pleasant weather. Despite this the first month of 2015 was quite acceptable, with southern European observers enjoying better observing conditions than their northern companions, as happens most of the time in winter. Whereas the first half of the month was quite balanced – 54 cameras were active during the Quadrantid peak – there were larger observation gaps in the second half. The night of January 29/30 was one of the worst in the last few years with only 12 active cameras that recorded altogether about 150 meteors in over 50 observing hours.

35 out of 84 cameras active in January obtained twenty or more observing nights. The effective observing time totaled over 9 500 hours, which is a few percent less than the record-breaking year 2012, but much more than the years 2013 and 2014. 25 000 meteors are also by far the second-best January result of the IMO Network (Table 1 and Figure 1).

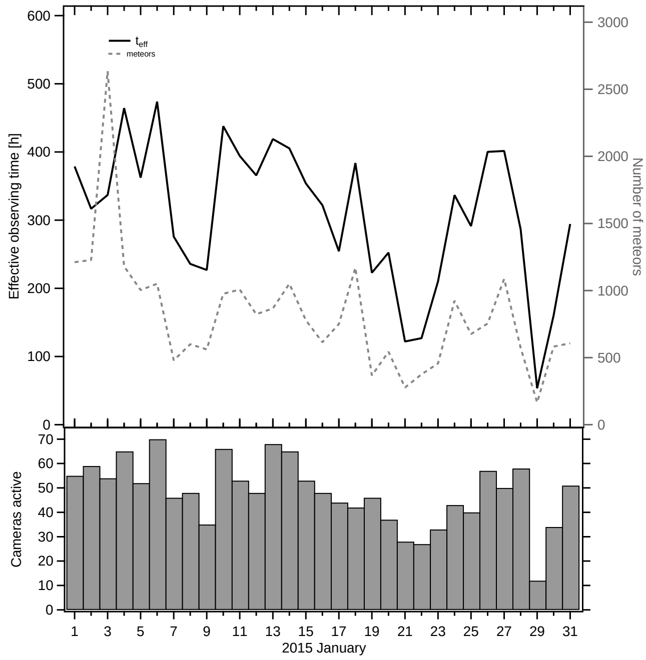

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2015 January.

2 Quadrantids

During the analysis of the Quadrantid peak of 2013 we learnt that this shower does not fit into the usual scheme (Molau et al., 2013). In the case of other showers, the activity graphs of individual years typically fit together well and yield a smooth overall profile. Not so for the Quadrantids and you err if you believe the picture would become clearer with the new data set. In fact, the opposite is true. This year, the maximum was expected for 02^{h} UT of January 4, when the radiant had already reached a sufficient altitude for European observers. We did in fact measure the highest flux densities at about that time, but the level was a factor two to four lower than in the previous three years (Figure 2). So we did

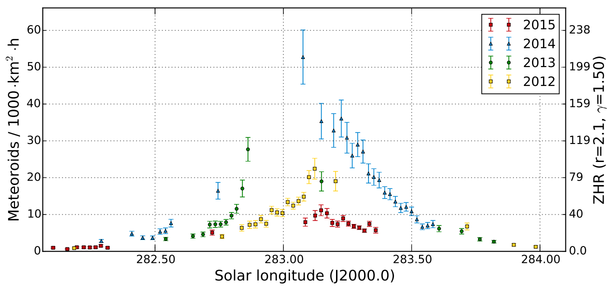

Figure 2 – Activity profile of the Quadrantids, derived from data of the IMO Video Meteor Network 2012–2015.

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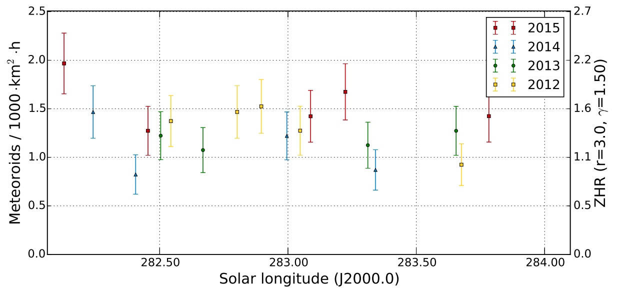

Figure 3 – Activity level of the Antihelion source near the Quadrantid maximum, derived from data of the IMO Video Meteor Network 2012-2015.

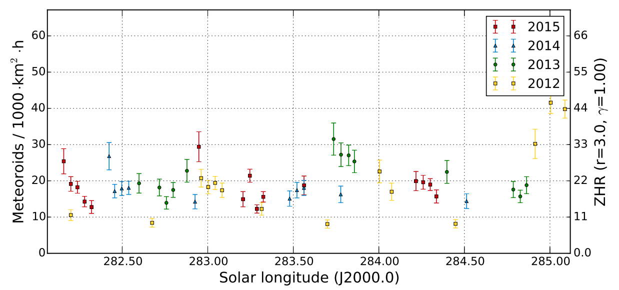

Figure 4 – Activity level of the sporadic meteors near the Quadrantid maximum, derived from data of the IMO Video Meteor Network 2012–2015.

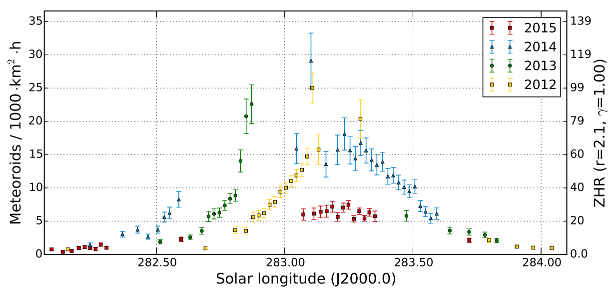

Figure 5 – Activity profile of the Quadrantids, obtained with a zenith exponent of $\gamma = 1.0$.

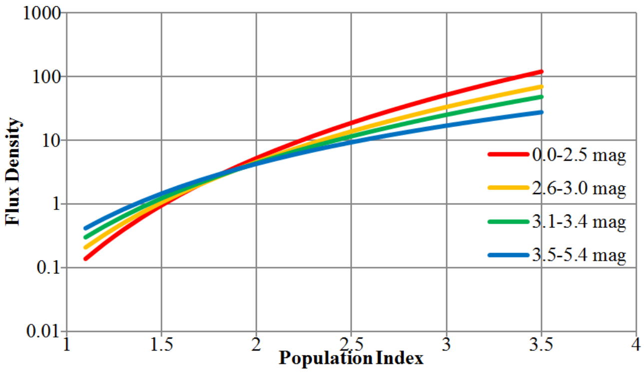

Figure 6 – Dependency of the flux density from the population index, calculated for different meteor limiting magnitudes on 2015 January 3/4.

not experience an outburst this year, but rather a collapse.

This is obviously a rather bold claim that should be substantiated by other observations. Unfortunately there are no data from IMO quick look analyses available, probably because the data set was too sparse. In the AKM Jürgen Rendtel managed to catch a few cloud gaps of less than one hour in total in the morning of January 4. In this short interval he obtained a ZHR below 50 and speculated that this might be the previously discussed "full moon effect" in visual observations. Similar result were obtained by Javor Kac observing from Slovenia during the last two hours before the dawn on January 4. Indeed, the miserable conditions just one day before full moon might also systematically influence the limiting magnitude calculation of video cameras. However, this is rather unlikely since many cameras observed away from the Moon. The only option we currently have is to look at Antihelion and sporadic meteors, which should have been affected in a similar way. Figures 3 and 4 show that this was not the case. As always there are some fluctuations, but in both cases we see the flux density at the same level as in the previous years.

Finally, one could argue that the profile of the sporadic meteors is only so smooth because Figure 4 was obtained with an unusually low zenith exponent of $\gamma = 1.0$, but that is not a valid argument either. If the flux density of the Quadrantids is plotted with the same γ-value, the profiles of 2012 and 2014 fit better with one another, but the unusually low activity level of 2015 remains (Figure 5). The Quadrantids were this year literally rained out!

What about the population index? Here we find a value of $r = 1.8$, whereby the individual graphs show a well-defined intersection point despite the large number of more than 1 000 meteors (Figure 6). In the nights before and after the peak, the r-value was clearly above two. In this respect, the Quadrantids are quite reliable, since we obtained exactly the same value of $r = 1.8$ in the peak nights of 2013 (Molau et al., 2013) and 2014 (Molau et al., 2014).

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Molau S., Kac J., Berko E., Crivello S., Stomeo E., Igaz A., Barentsen G., and Goncalves R. (2013). "Results of the IMO Video Meteor Network – January 2013". *WGN, Journal of the IMO*, **41:2**, 61–66.

Molau S., Kac J., Crivello S., Stomeo E., Barentsen G., Goncalves R., and Igaz A. (2014). "Results of the IMO Video Meteor Network – January 2014". *WGN, Journal of the IMO*, **42:2**, 83–86.

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Table 1 – Observers contributing to 2015 January data of the IMO Video Meteor Network. Eff.CA designates the effective collection area; the overall number of nights is the number of nights with at least one camera operating, the overall observing time and number of meteors are sums over all cameras.

Code	Name	Location	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig2 (0.8/8)	1475	6.2	3779	19	87.2	364
BANPE	Bánfalvi	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	7	21.3	35
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	1	3.0	4
BERER	Berkó	Ludányhalászi/HU	Hulud1 (0.8/3.8)	5542	4.8	3847	8	62.4	309
			Hulud3 (0.95/4)	4357	3.8	876	8	57.2	87
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	25	179.4	585
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	13	77.1	116
BRIBE	Klemt	Herne/DE	Hermine (0.8/6)	2374	4.2	678	21	96.1	227
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	19	78.2	207
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	24	227.4	613
			Bmh2 (1.5/4.5)*	4243	3.0	371	23	198.7	508
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	27	187.1	691
			C3P8 (0.8/3.8)	5455	4.2	1586	23	141.1	369
			Stg38 (0.8/3.8)	5614	4.4	2007	24	188.6	1007
CSISZ	Csizmadia	Baja/HU	Huvcse02 (0.95/5)	1606	3.8	390	11	24.1	108
DONJE	Donani	Faenza/IT	Jenni (1.2/4)	5886	3.9	1222	25	204.7	883
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	17	125.2	433
FORKE	Förster	Carlsfeld/DE	Akm3 (0.75/6)	2375	5.1	2154	8	26.3	56
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	25	207.7	534
			Templar2 (0.8/6)	2080	5.0	1508	24	209.5	463
			Templar3 (0.8/8)	1438	4.3	571	23	230.4	317
			Templar4 (0.8/3.8)	4475	3.0	442	26	200.2	411
			Templar5 (0.75/6)	2312	5.0	2259	27	231.3	596
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	23	151.5	337
			Orion3 (0.95/5)	2665	4.9	2069	21	87.7	157
			Orion4 (0.95/5)	2662	4.3	1043	23	126.3	159
HERCA	Hergenrother	Tucson/US	Salsa3 (0.8/3.8)	2336	4.1	544	27	234.1	462
HINWO	Hinz	Schwarzenberg/DE	Hinwo1 (0.75/6)	2291	5.1	1819	13	58.8	157
IGAAN	Igaz	Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	10	68.9	92
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	14	71.6	91
		Budapest/HU	Hupol (1.2/4)	3790	3.3	475	8	64.4	40
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	16	126.2	172
KACJA	Kac	Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	19	77.2	105
		Kamnik/SI	Cvetka (0.8/3.8)*	4914	4.3	1842	16	77.8	233
			Rezika (0.8/6)	2270	4.4	840	19	104.1	437
			Stefka (0.8/3.8)	5471	2.8	379	15	71.7	194
		Kostanjevec/SI	Metka (0.8/12)*	715	6.4	640	2	15.3	20
KISSZ	Kiss	Sülysáp/HU	Husul (0.95/5)*	4295	3.0	355	15	111.7	77
KOSDE	Koschny	La Palma/ES	Icc9 (0.85/25)*	683	6.7	2951	24	180.2	1285
		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	19	75.4	197
LOJTO	Łojek	Grabniak/PL	Pav57 (1.0/5)	1631	3.5	269	2	14.9	21

Table 1 – Observers contributing to 2015 January data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Location	Camera	FOV [°²]	Stellar LM [mag]	Eff.CA [km²]	Nights	Time [h]	Meteors
MACMA	Maciejewski	Chełm/PL	Pav35 (0.8/3.8)	5495	4.0	1584	10	50.3	79
			Pav36 (0.8/3.8)*	5668	4.0	1573	16	72.2	226
			Pav43 (0.75/4.5)*	3132	3.1	319	11	71.8	141
			Pav60 (0.75/4.5)	2250	3.1	281	11	68.8	183
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	17	145.2	181
MARRU	Marques	Lisbon/PT	Cab1 (0.8/3.8)	5291	3.1	467	12	89.9	253
			Ran1 (1.4/4.5)	4405	4.0	1241	25	204.5	501
MASMI	Maslov	Novosibirsk/RU	Nowatec (0.8/3.8)	5574	3.6	773	13	74.0	280
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	17	84.0	390
			Escimo (0.6/130)	21	10.0	3507	4	24.2	35
			Mincam1 (0.8/8)	1477	4.9	1084	16	76.5	248
		Ketzür/DE	Remo1 (0.8/8)	1467	6.5	5491	22	99.9	508
			Remo2 (0.8/8)	1478	6.4	4778	19	91.3	397
			Remo3 (0.8/8)	1420	5.6	1967	18	108.7	298
			Remo4 (0.8/8)	1478	6.5	5358	22	99.6	401
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	16	126.0	127
MOSFA	Moschner	Rovereto/IT	Rover (1.4/4.5)	3896	4.2	1292	26	224.0	384
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	23	116.0	369
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	19	140.6	209
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	17	98.2	326
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	19	120.0	256
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	10	57.4	59
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	22	187.7	375
			Ro2 (0.75/6)	2381	3.8	459	25	219.3	516
			Ro3 (0.8/12)	710	5.2	619	27	238.7	781
			Sofia (0.8/12)	738	5.3	907	25	216.7	409
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	24	94.2	223
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	19	119.4	111
			Kayak2 (0.8/12)	741	5.5	920	16	110.6	84
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	28	157.6	703
			Noa38 (0.8/3.8)	5609	4.2	1911	26	168.9	637
			Sco38 (0.8/3.8)	5598	4.8	3306	28	193.1	838
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2354	5.4	2751	19	93.0	189
			Mincam3 (0.8/6)	2338	5.5	3590	22	108.0	198
			Mincam4 (1.0/2.6)	9791	2.7	552	17	73.4	134
			Mincam5 (0.8/6)	2349	5.0	1896	20	93.1	175
			Mincam6 (0.8/6)	2395	5.1	2178	20	93.4	161
TEPIS	Tepliczky	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	18	111.3	196
			Humob (0.8/6)	2388	4.8	1607	17	109.5	225
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	20	69.6	218
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	5	40.3	95
ZELZO	Zelko	Budapest/HU	Huvcse03 (1.0/4.5)	2224	4.4	933	5	22.2	48
			Huvcse04 (1.0/4.5)	1484	4.4	573	7	21.4	44
* active field of view smaller than video frame						Overall	31	9 566.3	25 370

Results of the IMO Video Meteor Network — February 2015

Sirko Molau[1], *Javor Kac*[2], *Stefano Crivello*[3], *Enrico Stomeo*[4], *Geert Barentsen*[5], *Rui Goncalves*[6], *Carlos Saraiva*[7], *Maciej Maciejewski*[8], *and Mikhail Maslov*[9]

In 2015 February, 83 cameras of the IMO Video Meteor Network recorded almost 20 000 meteors in more than 10 000 hours of observing time. An attempt to confirm the possible outburst of radio meteors from a radiant near γ Lyrae on 2015 February 5 was not successful.

Received 2015 April 20

1 Introduction

February is another winter month of the northern hemisphere that only occasionally presents nice observing conditions for observers. That seems to be confirmed by a quick glimpse at the statistics, which show bigger "holes". However, that impression is misleading, since particularly in the middle of February there were also a number of nights where most cameras were in operation. There were three nights with more than 70 of the 83 cameras active, and thus it was the by far best February result ever. For the first time we collected more than 10 000 hours of effective observing time, which is the third best total if we take into account that this month only has 28 nights. We missed a total of 20 000 meteors by a small margin (Table 1 and Figure 1), which is 20% more than in the previous best month of February 2012. As in 2012 through 2014, the average rate dropped to 2.0 meteors per hour which is close to the minimum that typically occurs in March.

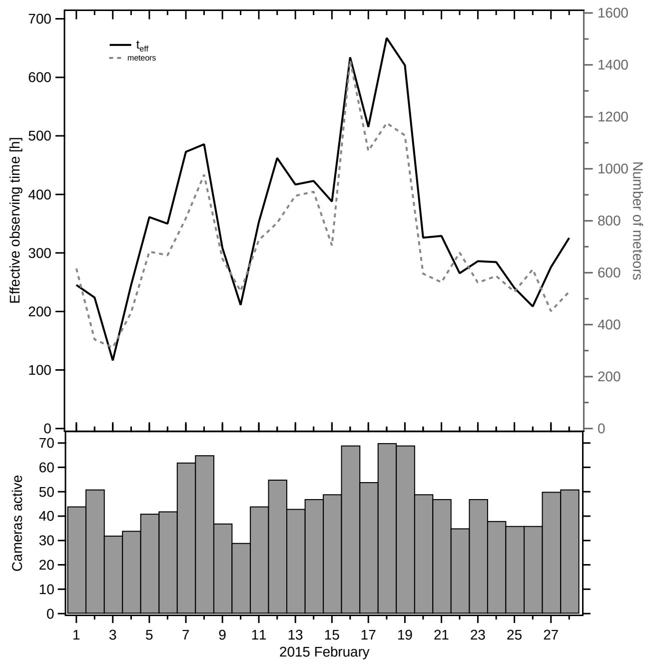

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2015 February.

2 Activity from a radiant near γ Lyrae

There are no interesting meteor showers in February, only a minor shower that sparked some discussions in this year. Chris Steyaert informed us that Lucas Pellens and other observers of the RMOB radio network experienced enhanced activity just before noon (UT) of 2015 February 5 (Steyaert, 2015). The radiant was supposed to be high in the European skies by that time, but there was no optical confirmation from American observers.

In return Christoph Gerber reported that he had noticed unusual activity from a radiant near γ Lyrae in the publicly available data of the Canadian CMOR radar (Gerber, 2015). In his subsequent search for confirmation he found at least one fireball recorded during the time in question by the NASA network that fitted nicely to the radiant. Last but not least he also found a weak radiant in the IMO Network video data. However, that was based on an old radiant list from 2009, composed of nine single-station meteors only, which should be interpreted as chance alignments.

Our two American video observers enjoyed partly clear skies in the night of 2015 February 5. The limit-

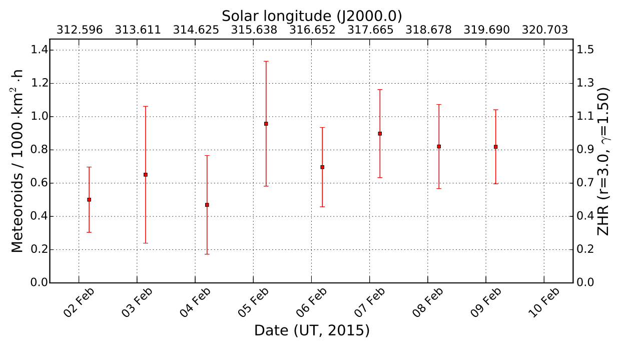

Figure 2 – Flux density profile of meteors from a radiant near γ Lyrae that was found in radar data just before noon (UT) of 2015 February 5.

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[3]Via Bobbio 9a/18, 16137 Genova, Italy. Email: stefano.crivello@libero.it
[4]via Umbria 21/d, 30037 Scorze (VE), Italy. Email: stom@iol.it
[5]NASA Ames Research Center, M/S 244-30, Moffett Field, CA 94035, USA. Email: hello@geert.io
[6]Urbanizacao da Boavista, Lote 46, Linhaceira, 2305-114 Asseiceira, Tomar, Portugal. Email: rui.goncalves@ipt.pt
[7]Rua Aquilino Ribeiro, 23 - 1 Dto. 2790028 Carnaxide, Portugal. Email: carlos.saraiva@netcabo.pt
[8]Wolynska 24, 22-100 Chelm, Poland. Email: mazziek@gmail.com
[9]16 Bronny, 90, Novosibirsk, Russia. Email: ast3@ngs.ru

IMO bibcode WGN-433-molau-vidfeb
NASA-ADS bibcode 2015JIMO...43...89M

ing magnitude of Salsa3 from Carl Hergenrother was about magnitude +4, but the radiant was located only about 10° above the horizon during the time in question. With an elevation of 25° it was higher up in the sky for Orie1 of Mike Otte, but that camera suffered from clouds between 10^h and 11^h UT. None of the 24 meteors recorded in total fitted to the given radiant. Based on the effective collection area we can estimate that the shower needed to be about four times as strong as the Antihelion source to be noticed by the two cameras.

Later Carl Johannink checked the CAMS Benelux dataset for possible "background activity" the night before and after but found none. That is confirmed by our IMO video data. In the first third of February, only about 10 meteors per night fit to the radiant, which yields a flux density of below one meteoroid per 1 000 km^2 per hour (Figure 2). Since the alignment with the radiant was typically poor, these are also most probably just chance alignments.

So we are left with two interpretations: Either it was a short one-time outburst without a background component that was at best a little stronger than the Antihelion source, or is was made of faint meteors beyond the optical range.

References

Gerber C. (2015). ""Februar-Lyriden" am 5.2.2015". `http://forum.meteoros.de/viewtopic.php?f=8&p=201062` .

Steyaert C. (2015). "[radiometeoren] High activity Feb 5 10h UT". `http://lists.meteorobs.org/pipermail/meteorobs/2015-February/017601.html` . (meteorobs mailing list).

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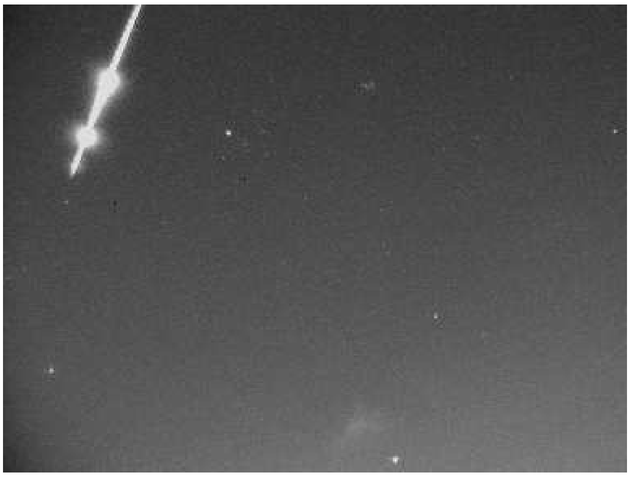

Sporadic meteor recorded on 2015 February 5 at $18^h58^m36^s$ UT by Mincam2 camera.

Sporadic meteor recorded on 2015 February 20 at $03^h51^m43^s$ UT by Hinwo1 camera.

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		Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	18	113.2	149
LOJTO	Łojek	Grabniak/PL	Pav57 (1.0/5)	1631	3.5	269	11	77.1	66

Table 1 – Observers contributing to 2015 February data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Location	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
MACMA	Maciejewski	Chełm/PL	Pav35 (0.8/3.8)	5495	4.0	1584	9	73.5	124
			Pav36 (0.8/3.8)*	5668	4.0	1573	16	109.2	276
			Pav43 (0.75/4.5)*	3132	3.1	319	12	90.7	129
			Pav60 (0.75/4.5)	2250	3.1	281	13	103.4	243
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	12	75.4	64
MARRU	Marques	Lisbon/PT	Cab1 (0.8/3.8)	5291	3.1	467	18	147.4	295
			Ran1 (1.4/4.5)	4405	4.0	1241	18	172.0	258
MASMI	Maslov	Novosibirsk/RU	Nowatec (0.8/3.8)	5574	3.6	773	15	108.8	232
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1230	6.9	6152	11	67.0	343
			Mincam1 (0.8/8)	1477	4.9	1084	17	99.7	260
		Ketzür/DE	Remo1 (0.8/8)	1467	6.5	5491	22	169.3	623
			Remo2 (0.8/8)	1478	6.4	4778	20	170.2	526
			Remo3 (0.8/8)	1420	5.6	1967	21	162.5	318
			Remo4 (0.8/8)	1478	6.5	5358	21	173.7	639
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	13	136.7	109
MOSFA	Moschner	Rovereto/IT	Rover (1.4/4.5)	3896	4.2	1292	19	154.9	190
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	14	99.8	176
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	21	120.5	174
PERZS	Perkó	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	15	124.5	237
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	17	129.5	199
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	17	153.3	152
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	18	163.8	212
			Ro2 (0.75/6)	2381	3.8	459	19	164.2	258
			Ro3 (0.8/12)	710	5.2	619	20	176.4	379
			Sofia (0.8/12)	738	5.3	907	20	181.4	186
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	20	130.3	293
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	563	6.2	1294	10	56.0	47
			Kayak2 (0.8/12)	741	5.5	920	7	58.8	44
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	19	139.1	393
			Noa38 (0.8/3.8)	5609	4.2	1911	20	141.2	359
			Sco38 (0.8/3.8)	5598	4.8	3306	19	148.8	435
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2354	5.4	2751	18	131.7	227
			Mincam3 (0.8/6)	2338	5.5	3590	20	136.3	199
			Mincam4 (1.0/2.6)	9791	2.7	552	18	109.5	134
			Mincam5 (0.8/6)	2349	5.0	1896	18	137.3	211
			Mincam6 (0.8/6)	2395	5.1	2178	21	144.7	202
TEPIS	Tepliczky	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	17	139.5	182
			Humob (0.8/6)	2388	4.8	1607	16	152.6	304
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	15	40.3	92
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	9	75.9	94
ZELZO	Zelko	Budapest/HU	Huvcse03 (1.0/4.5)	2224	4.4	933	10	35.8	79
			Huvcse04 (1.0/4.5)	1484	4.4	573	10	29.8	58
* active field of view smaller than video frame						Overall	28	10 041.8	19 963

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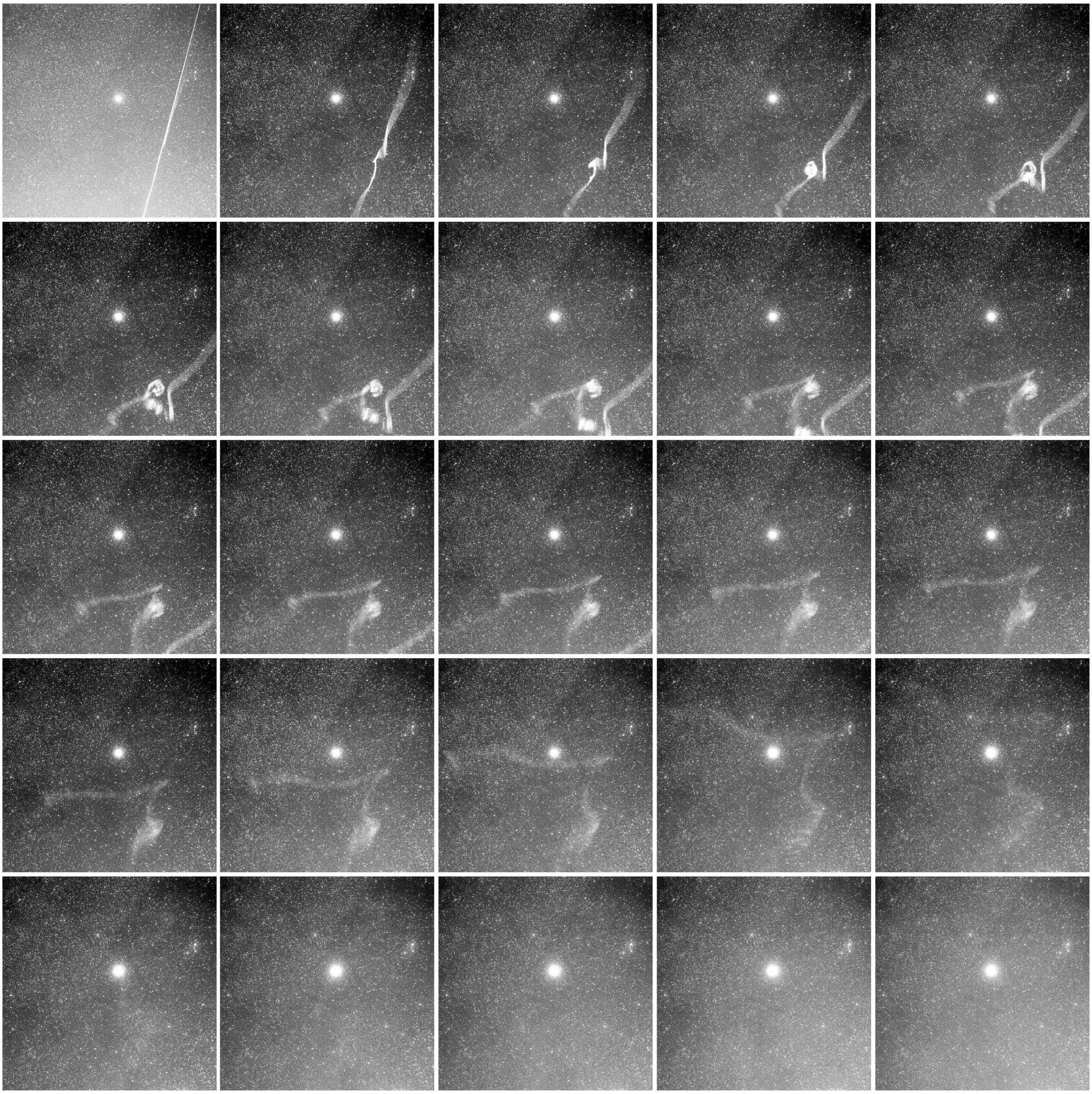
2015 March 15 Switzerland/Germany fireball train



This beautiful sequence of the persistent train left by a bright fireball was captured on 2015 March 15 from near Bamberg, Bavaria, Germany. The sequence goes from upper left to lower right. Each single photograph was taken with a Canon EOS 1100D camera and 59 s exposures. The entire series comprises almost exactly one hour. Image courtesy: Hans Hopf.
The IMO received 284 reports about the fireball that produced that train (see `http://fireballs.imo.net/imo_view/event/2015/657` for details).