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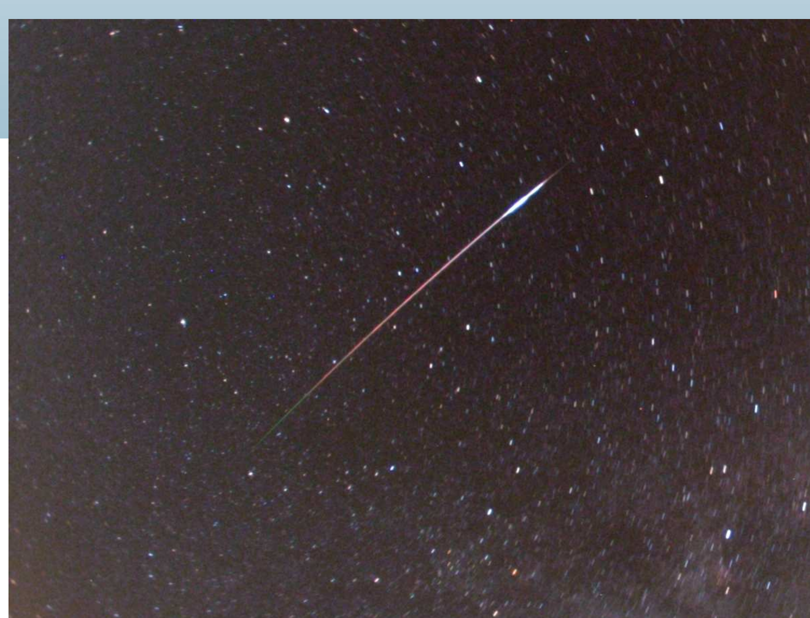

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Front cover photo

Bright Perseid fireball of about magnitude −6, photographed on 2012 August 12 at $19^{h}54^{m}30^{s}$ UT from Merenje, Croatia. The author used a modified Canon EOS 300D equipped with a Peleng 8 mm $f/3.5$ lens for a 3-minute exposure at ISO 800. Photo courtesy: Željko Andreić.

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

Cover design Rainer Arlt

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Editorial

Javor Kac

I am sorry to have to start this editorial with a sad news. I was shocked to learn about Wayne T. Hally's passing away on October 12. Among other tasks, Wayne served as WGN handling editor in the last couple of years. More about Wayne's many contributions to amateur meteor astronomy is presented in obituary by Robert Lunsford.

A much more pleasant event was the 31st International Meteor Conference which took place in La Palma in September. I arrived with four of my fellow observers from Slovenia 6 days prior to the conference to explore the island and to take advantage of the good astronomical conditions. We were able to enjoy all six clear nights on the top of the mountain, in the observatory surroundings. Unfortunately, our equipment got stuck at Canary Islands customs so we had to rent a telescope and equatorial mount from local astronomers. Still, we accomplished many observing goals, including some meteor observing. This year's conference was again a splendid one. Packed with interesting lectures covering all aspects of meteor astronomy presented by amateur and professional astronomers, the program left little time for informal discussions during daytime. This was well compensated by hanging out in the international community long into the night. The Sunday excursion was a very exciting one. It took participants to the top of the mountain for a tour of the observatories, and offered astonishing views of the Caldera de Taburiente. A conference report is presented by the first-time participant to IMC Kerem Çubuk from Turkey.

IMO bibcode WGN-405-editorial NASA-ADS bibcode 2012JIMO...40..149K

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 keeping 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-405-gyssens-renewals NASA-ADS bibcode 2012JIMO...40..149G

In Memoriam: Wayne T. Hally

Robert Lunsford

I regret to inform the readers of the passing of WGN handling editor and `MeteorObs` administrator Wayne T. Hally, age 60, of High Bridge, NJ on Friday, October 12, 2012 at home. He was born on June 17, 1952 in Plainfield, NJ. He lived in High Bridge for more than 20 years, moving from Woodbridge, NJ. He was the son of Myrtle Irving Hally Nissen of Winchester, VA and the late Thomas Hally. He attended Rutgers University and he directed a Big Band Radio Show many years ago, WRSU out of Rutgers University. He was an Electronics Technician, working for Tektronix in Woodbridge, NJ. Memberships include the NJAA (New Jersey Astronomical Association) in High Bridge, NJ and the Community Collaborative Rain Hail and Snow Network "Volunteers working together to measure precipitation across the nation." He was also a member of the C.E.R.T. Team in High Bridge. Wayne was also a long time member of the International Meteor Organization and helped in proofreading articles that appeared in WGN, the Journal of the IMO.

Wayne joined North American Meteor Network (NAMN) shortly after it was formed in 1995, and was an eager learner of anything to do with meteor observing. He immediately read all the available material on meteors early on. His first archived observation for NAMN was made on April 21/22, 1996 in which he recorded 3 Lyrids and 3 Sporadics in 0.33 hours. Through the years he was always a regular contributor of data to NAMN and tirelessly offered assistance and answered questions to new observers on `MeteorObs`.

Wayne was especially interested in minor showers and provided those interested with a huge amount of information he had gleaned from various sources in his research. His contributions to NAMN culminated when he volunteered to take over the writing of the NAMN monthly newsletter, which he wrote from October 2007 to January 2009. Wayne was so enthusiastic and bubbling over with information he wanted to share with other observers that he often had a difficult time keeping the newsletter within its length guidelines. Ultimately, computer problems, time constraints and medical problems forced Wayne to cease publishing the newsletter.

Figure 1 – Wayne T. Hally holding the rain gauge.

As far as the NJAA, Wayne was a fixture in a corner of the clubs parking lot all set up with his lounge chair for nights of meteor observing. He lived less than 5 minutes away from the club, and could have easily observed from his house. But he was always up there in case someone would come by, ask a few questions, and also become a visual meteor observer. Wayne contributed quite a bit to the club's Research Center, where you would find him giving talks (complete with his overhead charts). He was also one of the presenters (on meteors) when the Club would have their Adult Education Outreach classes. He volunteered quite often to help the Youth Center, when they had their activity evenings – whether it was in regards to meteors or not. Just recently he was chosen to the position of Honorary Life Member for all his service to the NJAA. He was the Club's Librarian, and at the time of his passing he was the NJAA's Treasurer. Wayne also traveled across the eastern U.S. and even Canada, giving his signature talks at star parties and planetariums, and observing meteors with his friends and colleagues.

Long time members of the `MeteorObs` list will remember Wayne as a no-nonsense contributor dedicated to providing clear and concise information on meteor-related topics. Wayne was one of the first members of `MeteorObs` and became a list administrator some seven years ago when Lewis Gramer began his quest of earning his PhD. During this period Wayne was the backbone of the list and it might not exist today if not for his efforts. I had the pleasure to observe meteor activity with Wayne on two occasions, once in Tallahassee, FL, and the other in San Diego during the Geminid maximum. While serious about acquiring accurate data, he had a jovial personality, making the observing sessions that much more enjoyable. He was also a passionate weather observer and loved to share stories of the wild weather he had encountered.

Survivors in addition to his mother include his step-father; Harry Nissen of Winchester, VA. His companion of 30 years; Ann M. Willard, at home; 1 step daughter; Christina O'Brien of South Brunswick, NJ; 2 granddaughters; Keelin Hally O'Brien and Ryley Kiera O'Brien.

You are invited to share your recollections of Wayne on this list and to sign his Guest Book located at: `http://www.legacy.com/guestbooks/mycentraljersey/guestbook.aspx?n=wayne-hally&pid=160393935&cid=full`.

RIP Good Buddy!

IMO bibcode WGN-405-lunsford-hally NASA-ADS bibcode 2012JIMO...40..150L

Conferences

First announcement of the International Meteor Conference 2013

Przemysław Żołądek

The 2013 International Meteor Conference will be held in Poznań, the capital of the western Poland. This conference will be organized by the Polish Comets and Meteors Workshop (CMW/PKiM) and will take place from 2013 August 22–25. This IMC will be closely connected with Meteoroids 2013 Conference organized a few days later in the same city. Such location of the IMC will help both amateurs and professionals to meet and exchange their scientific results. There are many traveling possibilities to reach Poznań; the city is very easy reachable for all European participants

Participants will be accommodated in the IOR Congress Center, the modern hotel, conference and restaurant all-in-one facility. During the weekend the IMC participant will visit the Morasko Reservoir – a group of the large meteorite impact craters located north of Poznań and the meteorites exhibition with largest, 178 kg piece of Morasko meteorite, found in 2006.

Figure 1 – The historical center of Poznań.

IMC 2013 registration fee is €150 before 31 May 2013 and €160 after this date. Participants will be accommodated in double rooms, single room option is available for an additional €50. The registration deadline is 2013 July 31. The registration form and any additional informations will be available on the IMC 2013 web site which will be soon available at `http://www.imo.net/imc2013`. The LOC can be contacted via email on `imc2013@imo.net`. This is the second time the IMC is organized in Poland. The previous was a successful IMC 2002 in Frombork. Hope to see you next time in Poland!

IMO bibcode WGN-405-zoladek-imcann NASA-ADS bibcode 2012JIMO...40..151Z

Details of the Proceedings of the International Meteor Conference, Sibiu, Romania, 15–18 September 2011

Marc Gyssens and Paul Roggemans

The IMC 2011, preceded by a Radio Meteor Workshop and a Meteor Orbit Workshop, was organized in Sibiu, Romania. It was attended by many active meteor workers from around the world. A special effort was invested to have the proceedings ready before the IMC 2012. The IMC 2011 Proceedings are also exceptionally complete. Every relevant lecture or poster contribution is represented by a paper or an abstract. Following are the abstracts of all the contributions.

Those who attended the Conference have either received the Proceedings at the IMC 2012 on La Palma or will receive them shortly in the mail. Others can order them from the International Meteor Organization: details are in the lower half of the inside back cover of this Journal and on the IMO website `http://www.imo.net/imo/publications`.

The status of the NASA All Sky Fireball Network

William J. Cooke and Danielle E. Moser

Established by the NASA Meteoroid Environment Office, the NASA All Sky Fireball Network consists of 6 meteor video cameras in the southern United States, with plans to expand to 15 cameras by 2013. As of mid-2011, the network had detected 1796 multi-station meteors, including meteors from 44 different meteor showers. The current status of the NASA All Sky Fireball Network is described, alongside preliminary results.

IMO bibcode WGN-405-gyssens-proceedings2011 NASA-ADS bibcode 2012JIMO...40..151G

Meteorite-dropping bolide over north Croatia on 4th February, 2011

Damir Šegon

On the night of 2011 February 4, a very bright bolide was observed over Slovenia and Croatia. The bolide was recorded by four cameras of the Croatian Meteor Network (CMN), by four cameras of the Slovenian Meteor Metwork (SMN) and by one European Network camera. Based on the preliminary reduction of CMN and SMN data, the meteoroid's orbit was determined, and a ground search was initiated. So far a single 292-g meteorite fragment has been recovered.

The Košice meteorite fall: atmospheric trajectory and fragmentation from videos and radiometers

Jiří Borovička

On 28 February 2010, $22^{h}24^{m}46^{s}$ UT, a huge bolide of absolute magnitude -18 appeared over eastern Slovakia. Although this country is covered by the European Fireball Network (EN) and the Slovak Video Network, bad weather prevented direct imaging of the bolide by dedicated meteor cameras. Fortunately, three surveillance video cameras in Hungary recorded, at least partly, the event. These recordings allowed us to reconstruct the trajectory of the bolide and recover the meteorites. In addition, the light curve of the bolide was recorded by several EN camera radiometers, and sonic booms were registered by seismic stations in the region. The meteorites were classified as ordinary chondrites of type H5 (see *Meteoritical Bulletin* 100).

I developed a model of atmospheric meteoroid fragmentation to fit the observed light curve. The model is based on the fact that meteoroid fragmentation leads to a sudden increase of a bolide's brightness, because the total meteoroid surface area increases after the fragmentation. A bright flare is produced if large numbers of small fragments or dust particles are released. I tried to model the whole light curve rigorously by setting up the mass distribution of fragments and/or dust particles released at each fragmentation point. The dust particles were allowed to be released either instantaneously or gradually. The ablation and radiation of individual particles were computed independently, and the summary light curve was computed. The deceleration at the end of the trajectory was taken into account as well.

Based on the approximate calibration of the light curve, the initial mass of the meteoroid was estimated to 3500 kg (corresponding to diameter of 1.2 m). The major fragmentation occurred at a height of 39 km. Only few (probably three) large compact fragments of masses 20–100 kg survived this disruption. All of them fragmented again at lower heights below 30 km, producing minor flares on the light curve. In summary, Košice was a weak meteoroid which fragmented heavily in the atmosphere and produced large numbers of small (under 10 g) meteorites. Nevertheless, some parts of the meteoroid were strong enough, so that a few relatively large (over 1 kg) meteorites exist as well.

We were lucky that the three videos and the radiometric curves enabled us to reconstruct the trajectory and atmospheric fragmentation of the Košice bolide, although the precision is, of course, lower than it would have been from regular meteor cameras. Full details will be published in the paper cited below. I am grateful to many people who collaborated in this work, especially Antal Igaz, Pavel Spurný, Juraj Tóth, Pavel Kalenda, Jakub Haloda and Ján Svoreň.

The Košice meteorite

Juraj Tóth and Ján Svoreň

The glare of the bolide on the night of February 28, 2010, illuminated streets and interiors of apartments at some location in eastern Slovakia and northern Hungary. In addition, cannon-like bursts or series of low frequency blasts were heard. Due to bad weather, cloudy skies, and scattered showers, the Central European Fireball Network (operated by Dr. Pavel Spurný of the Czech Academy of Sciences) did not take direct optical records of the bolide and the Slovak Video Meteor Network (operated by the first author) was not operational that night. So, at first sight, it seemed that there were no scientific records of this event. Fortunately, fast photoelectric sensors on seven automated fireball stations in the Czech Republic (6) and Austria (1) detected the illumination of the sky caused by the bolide, which made it possible to determine exact time and duration of the bolide and estimate its brightness. The bolide reached its maximum brightness of at least magnitude -18 in one huge flare. Later on, several surveillance camera data were published showing the moment when the night turned into day for a second, but only two videos from Hungary (Örkény village, Fazzi Daniella and Vass Gábor; Telki village, contact persons Sárneczky Krisztián, and Kiss László) actually captured the fireball itself. Thanks to calibration of videos by several members of the Hungarian Astronomical Association (MCSE, `http://www.mcse.hu`) contributing (in particular, Antal Igaz) and a trajectory analysis by Dr. Jiří Borovička of the Czech Academy of Sciences gave the hope that significant numbers of meteorite fragments reached the surface. He also calculated the impact area, near the town of Košice in eastern Slovakia. The data from the Local Seismic Network of Eastern Slovakia (project led by Professor Moczo of Comenius University) confirmed the atmospheric trajectory as well.

The expedition consisting of scientists and graduate students of the Astronomical Institute of the Slovak Academy of Sciences (under the leadership of the second author), Comenius University in Bratislava (under the leadership of the first author), and the Czech Academy of Sciences (under the leadership of Pavel Spurný) started to sweep meadows and forests at the calculated area. The first meteorite was discovered by Juraj Tóth on March 20th. By October 6th, 77 meteorite fragments were found. The heaviest fragment weighs 2.17 kg and was found by Tereza Krejčová; the smallest pieces were only about 0.5 g (finder Július Koza). The total mass recovered is 4.3 kg. There were 28 finders: Juraj Tóth, Diana Buzová, Marek Husárik, Tereza Krejčová, Ján Svoreň, Július Koza, David Čapek, Pavel Spurný, Stanislav Kaniansky, Eva Schunová, Marcel Škreka, Dušan Tomko, Pavol Zigo, Miroslav Šebeň, Jiří Šilha, Leonard Kornoš, Marcela Bodnárová, Peter Vereš, Jozef Nedoroščik, Zuzana Mimovičová, Zuzana Krišandová, Jaromír Petržala, Štefan Gajdoš, Tomáš Dobrovodský, Peter Delinčák, Zdenko Bartoš, Aleš Kučera, and Jozef Világi.

Preliminary as well as complex mineralogic analysis implies that the recovered meteorite is classified as an ordinary H5 chondrite (Dr. J. Haloda, Czech Geological Survey, D. Ozdín, and P. Uher, Comenius University in Bratislava). The authors are grateful to all collaborators mentioned above. More details about the meteorite will be published in the near future.

Fireball observations in central Europe and western Australia: instruments, methods, and results

Pavel Spurný

Penetration of larger meteoroids through the atmosphere which gives rise to spectacular luminous events—fireballs or even superbolides—is of the greatest interest. Their registrations, especially photographic and newly also photoelectric recordings, provide excellent means to examine physical properties as well as the temporal and spatial distribution of extraterrestrial matter in near-Earth space.

The most efficient tools for registration of these very scarce events are the fireball networks: systems covering large areas of the Earth's surface, with multiple camera stations designed to image a large fraction of the night sky. Such camera networks for fireball observations have been set up in several nations at various times in the past (European Fireball Network (EN) in the Czech Republic, Germany, Austria, and Slovakia; the Prairie Network in the USA; and the Meteorite Observation and Recovery Project (MORP) in Canada). Of these networks, only the European fireball network is still in operation, and this continuously since it was started up, but recently new networks were established in South-West Australia and in Ontario, Canada. The two main scientific aims of all these programs remain the same as in the very beginning—first, to constrain the flux of extraterrestrial material to the Earth over a range of masses, and second, to provide a statistically significant group of meteorites with accurate orbits.

This contribution was focused on the current work and some particular recent results from the European Fireball Network, especially from its Czech part (current status is described, for example, by Spurný et al., 2006) and from the Desert Fireball Network in the Nullarbor Plains of South-West Australia (Bland, 2004; Spurný et al., 2012; and Bland et al., 2012). The mode of operation of both networks and the analysis methods used were described in detail and illustrated by some examples. Similarly, the most important recent results, especially from the Desert Fireball Network, such as the Bunburra Rockhole and Mason Gully meteorite falls, were presented in detail. These results are already published by Spurný et al. (2011, Mason Gully; 2012, Bunburra Rockhole) and Bland et al. (2009, Bunburra Rockhole).

Automated camera station

Maxim Matvei

An automated camera station is described.

Effect of "terminal explosion"

Lidia Egorova

We consider the entry into the Earth's atmosphere of a cosmic body at hypersonic speeds. Large aerodynamic charges, the forces of inertia, and heat flow to the body surface lead to mass loss or even destruction of the body. The movement of the fragment cloud caused by the destruction of the body is a separate problem. From observations, we know that the flight of a cosmic body often ends with a terminal flare. We present one possible estimate of the energy in the final stages of the destruction of the body, confirming the possibility of the observed effect of the "terminal explosion" of the meteoroid.

Determination of atmospheric velocity of bright meteors on the basis of high resolution light curves

Lukáš Shrbený and Pavel Spurný

We introduce a new method for determination of atmospheric velocity of bright meteors (fireballs). The method uses high-time resolution light curves of fireballs and photographic or digital records of the fireballs where dynamical data are not available, i.e., rotating shutter was not used. Simultaneous identification of flares or other unambiguous events is needed both on the light curve and the photographic or digital record. These events, flares for instance, serve as time-marks and substitute the artificial rotating shutter time-marks. We studied the method on 9 selected fireballs which fulfill the above conditions, occupy a wide interval of possible initial velocities (from 14.5 to 50 km/s), and are of a different orbital origin (cometary and asteroidal). The method provides correct velocities with few km/s scatter around the average value that corresponds to the rotating shutter velocity. The method was used for one fireball without dynamics data and probable meteorite fall was excluded in this case on the basis of the determined velocity.

Dark flight calculations: how accurate can they be?

Željko Andreić

Dark flight calculations rely on accuracy of input data. The resulting uncertainties are analyzed and illustrated on an example of a simulated meteorite fall. It turns out that the biggest problem is uncertainty in the deceleration of the incoming body, together with meteorological data about wind velocity (speed and direction). The expected uncertainty in the calculated coordinates of the impact point defines a probability ellipse which is highly stretched in the direction of the average wind direction, with a semi-major axis of a few kilometers, and a semi-minor axis of a few hundred meters in size.

Near-earth asteroids as source of meteors

Mirel Birlan

Asteroids are considered as being at the origin of some meteor showers and some meteorites. Initially, the genetic link is established by a dynamical approach. Subsequently, this dynamical approach is validated or invalidated by additional studies which require observations of asteroids' physical parameters. Spectroscopy is the technique which relates the mineralogy of meteorites (and meteors) with the mineralogy of their parent bodies. An example of this technique applied to the asteroid (4486) Mithra, as well as the mineralogical modeling of its spectrum is presented. Mithra's surface is covered by a layer of fine particle which do not exceed 25 μm in size.

Evolution of Comet Halley and the Orionid stream

Aswin Sekhar

Many previous works have shown the active role of mean motion resonances in the long term dynamical evolution of meteoroid streams. It would be interesting to look at the orbital evolution of Comet 1P/Halley in the near past and try to develop a comprehensive ejection model which can correlate the existing observations of the Orionids wherever possible. This paper aims to present a few interesting aspects related to this.

Leonid meteoroids from different filaments

Pavel Koten

The perihelion passage of Comet 55P/Tempel-Tuttle in 1998 was followed by several strong storms and other periods of enhanced activity between 1998 and 2009. Double-station video data were collected in 1999, 2000, 2001, 2006, and 2009. This sample of several hundreds of meteors is covering filaments of different age. We investigated the atmospheric trajectories, especially the beginning heights of the meteors. The beginning height depends on the meteor photometric mass. It was found that the slope of this dependence is different for each filament. Higher slope means more fragile particles. It seems that there is a correlation between the age of the filament and the slope of the above-mentioned dependence: the older filaments show a higher slope than the younger ones.

The coming 2011 Draconids meteor shower

Jérémie Vaubaillon, Junichi Watanabe, Mikiya Sato, Shun Horii, and Pavel Koten

A detailed analysis of the coming 2011 Draconids outburst is performed with different methods. The first step was to post predict the 1933 and 1946 storms. Difficulties arise when dealing with the 1985 outburst, since no unique orbital solution is able to explain the different outbursts observed during this year. This fact emphasizes our need to better know the parent body comet 21P/Giacobini-Zinner. Fortunately, the coming outburst will be caused by the trails ejected in 1980 and 1907, already encountered in the past. No storm is expected, but the level of the shower is poorly constrained. A first highly entertaining outburst is expected on 2011 October 8 around 17^{h} UT. The second and the main outburst is expected around 20^{h} UT the same day. The level of the shower will be of a few hundreds (around 600 per hour).

Draconid meteor storms

David J. Asher and Duncan I. Steel

Outbursts and storms in the October Draconid meteor shower occur because meteoroids from the parent periodic comet, 21P/Giacobini-Zinner, are not dispersed uniformly around the stream. The comet's orbital evolution has allowed meteoroidal material to be fed into the stream for the past few centuries and to be supplied for the next thousand years or more, but this depends on the nucleus continuing to be physically active. Various shower outbursts can be linked to the comet's observed activity during the past century.

Comparison of ASGARD and UFOCapture

Rhiannon Blaauw and Katherine Sarah Cruse

The Meteoroid Environment Office is undertaking a comparison between UFOCapture/Analyzer and Asgard (All Sky and Guided Automatic Realtime Detection), both software used to detect meteors. To accomplish this, video output from a Watec video camera on a 17 mm Schneider lens (25° field of view) was split and input into two computers, one running UFOCapture and the other running Asgard. The purpose of this study is to compare the sensitivity of the two systems, false alarm rates, and ease of use.

The parent body search

Regina Rudawska, Prakash Atreya, Sylvain Bouley, Jérémie Vaubaillon, François Colas, and Thierry Silbermann

Meteor Observation Networks, such as the double-station meteor network developed in the CABERNET project (PODET-MET), will soon provide a vast amount of observational data with the aim to calculate the orbits of the meteoroids. For 12 and 13 December 2010, we had 100 meteors observed by the double-station CABERNET systems. Data were processed and accurate orbits were computed. In order to retrieve the parent body from such collected data set, we used already existing procedures aiming to determine the origin of meteoroid streams. In the survey, some questions arose, such as which dissimilarity function to use in order to find a parent body for the observed meteors. Can we determine the exact moment of the meteoroid ejection from the surface when we associate the meteor with a parent body? We would like to provide insights on these (and other) questions.

Narrow-band photometry of meteors

Francisco Ocaña, Jaime Zamorano, and Jesús Gallego

Using photometric filters improves the detection of fireballs and meteors, especially under skies with heavy light pollution like at the Observatorio UCM. We have developed a simulation and pipeline software, and tested the feasibility of this technique. An experimental device has been designed and developed. We propose the use of photometric filters centered on the emission lines to measure several meteor properties more efficiently than by others spectroscopic methods using prisms or gratings. Several scientific purposes which this photometric system can serve are summarized.

PyFN—multipurpose meteor software

Przemysław Żołądek

The new software used by the Polish Fireball Network is presented. The most important feature of this program is its ability to determine quickly and semi-automatically the trajectories and orbits. The entire process and the quality of the data can be controled by the user. This application was written in Python using additional scientific modules. PyFN is a terminal application without GUI, and can easily be extended in the future.

A new method of meteor trajectory determination applied to multiple unsynchronized video cameras

Peter S. Gural

A new approach has been formulated to solve for the straight line trajectory of a meteor through the atmosphere when given multiple camera views of the meteor's luminous track. Using a motion propagation model in three-dimensional space plus time, and iteratively solving for all free model parameters simultaneously, one can obtain a fully coupled solution to the apparent radiant direction, three-dimensional begin position, atmospheric entry speed, deceleration terms, and timing offsets when using data from unsynchronized video cameras. A Monte Carlo component adds empirical error estimation for each of the key model parameters computed. This multi-parameter fitting method extends the allowable collection geometries for meteor trajectory estimation to lower convergence angles between camera-meteor-camera lines of sight and smaller site separation distances.

What happened at ESA's Meteor Research Group in 2010/11?

Detlef V. Koschny, Jonathan Mc Auliffe, Felix C. M. Bettonvil, Maria Gritsevich, Cornelis van der Luijt, Francisco Ocaña González, Hans Smit, Håkan Svedhem, and Joe J. Zender

A lot of activities took place in 2010/11 in the Meteor Research Group (MRG) of the European Space Agency's (ESA) Research and Scientific Support Department. Both special observing campaigns as well as continuous observations were performed, mainly with intensified video cameras, but also still with CCD cameras. This paper gives an overview of the activities.

Delta-Aquariid expedition to Namibia, July 2011

Carl Johannink

For many years, members of the Dutch Meteor Society (DMS) observed the Southern δ-Aquariid (SDA) meteor shower from different European countries. This year, DMS members traveled to Namibia to make observations under excellent conditions. ZHR profiles and r values obtained from this expedition's results confirm earlier results. The stream peaks with a maximal ZHR of around 25, which makes it a very attractive stream for meteor observers in the southern hemisphere.

Meteors Without Borders: a global campaign

Thilina Heenatigala

"Meteors Without Borders" is a global project, organized by *Astronomers Without Borders* and launched during the Global Astronomy Month in 2010 for the Lyrid meteor shower. The project focused on encouraging amateur astronomy groups to hold public outreach events for major meteor showers, conduct meteor-related classroom activities, photography, poetry and art work. It also uses social-media platforms to connect groups around the world to share their observations and photography, live during the events. At the International Meteor Conference 2011, the progress of the project was presented along with an extended invitation for collaborations for further improvements of the project.

Epsilons: we need more theories

Christian Steyaert

In this paper, we present new observational results regarding epsilons, and propose a very different physical mechanism that causes them.

More on ELF, VLF, and meteors

Jean-Louis Rault

In the frame of an electrophonic meteors study during the 2009 Perseids shower, preliminary results were presented during the 2009 International Meteor Conference in Poreč, Croatia. Further data gathering, including VHF and ELF/VLF radio and photographic records, was performed at the Pic du Midi observatory and at the Guzet ski station during the 2010 Geminids shower. Correlations between radio and photo data, and the influence of a large meteor on the propagation of some VLF radio transmissions are presented here.

BRAMS : status of the network and preliminary results

Stijn Calders and Hervé Lamy

Recently, the Belgian Institute for Space Aeronomy has been developing a Belgian network for observing radio meteors using a forward scattering technique. This network is called BRAMS (Belgian RAdio Meteor Stations). A radio transmitter emits a circularly polarized pure sine wave toward the zenith at the frequency of 49.97 MHz. This beacon is located in Dourbes (southern Belgium) and emits a constant power of 150 W. The receiving network consists of about 20 stations hosted mainly by radio amateurs. Two stations have crossed-Yagi antennas measuring horizontal and vertical polarizations of the waves reflected off meteor trails. This will enable a detailed analysis of the meteor power profiles from which physical parameters of the meteoroids can be obtained. An interferometer consisting of 5 Yagi antennas is installed at the site of Humain in order to determine the angular detection of one reflection point, allowing to determine meteoroid trajectories. We describe this new meteor observing facility and present the goals we expect to achieve with the network.

Radio-physical model of a meteor trail with specular reflection point

Helen V. Kharchenko

A radio-physical model for the estimation of the coherent and incoherent components of the signal scattered by a meteor trail with specular reflection point is proposed.

SDR—radio meteor affordable approach

C. Leşanu and A. Drăgoiu

A software-defined radio system, or SDR, is a radio communication system where components that have been typically implemented in hardware (e.g., mixers, filters, amplifiers, modulators/demodulators, detectors, etc.) are instead implemented by means of software on an embedded computing device or a personal computer. While the concept of SDR is not new, the rapidly evolving capabilities of digital electronics render practical many processes which used to be only theoretically possible. A basic SDR system may consist of a personal computer equipped with a sound card, or other analog-to-digital converter, preceded by some form of RF front end. Significant amounts of signal processing are handed over to the general-purpose processor, rather than being done in special-purpose hardware.

Slovak Video Meteor Network—status and results: Lyrids 2009, Geminids 2010, Quadrantids 2011

Juraj Tóth, Leonard Kornoš, Roman Piffl, Jakub Koukal, Štefan Gajdoš, Martin Popek, Ivan Majchrovič, Martin Zima, Jozef Világi, Dušan Kalmančok, Peter Vereš, and Pavol Zigo

Since 2009, double station meteor observations by the all-sky video cameras of the Slovak Video Meteor Network (SVMN) resulted in hundreds of orbits. Thanks to several amateur wide field video stations of the Central European Meteor Network (CEMeNt) and despite a not-ideal weather situation, we were able to observe several Lyrid 2009, Geminid 2010, and Quadrantid 2011 multi-station meteors during their maxima. The presented meteor orbits derived by the UFOOrbit software may be qualified as quite precise.

The French Video Meteor Network

Arnaud Leroy, Jehan Chrétien Ferrez, Tioga Gulon, Jean Brunet, Stéphane Jouin, Marc Herrault, Jean Paul Godard, and Christophe Demeautis

The French Video Meteor Network was first presented to the international meteor community during the IMC 2011. In this paper, we present the structure and the tools developed by our network and the results of the first complete year of operation (2010).

Beware of silently assuming linear intensity in meteor images

Tom Roelandts

Computer screens, projectors, and television sets are nonlinear devices. Many digital images are pre-compensated for this. This can lead to errors when certain computations are performed on these images, since their intensity is no longer encoded linearly. We present two use cases, together with suggestions on how to avoid the problem.

Results of Orionid observations with the FAVOR camera

Anna P. Kartashova

The results of single-station TV observations of the Orionids for the period from 2006 to 2008 are presented. The high-sensitive TV camera FAVOR (FAst Variability Optical Registrator) was used for observations of meteors up to magnitude +8.5. In total, 3713 single-station meteors were obtained, 449 of which were associated with the Orionid meteor shower. The distribution of the influx rate to the Earth (IMA or Index of Meteor Activity) of the Orionids for the period from 2006 to 2008 is given. In 2006, the peak of activity of the Orionids was reached on 20 October, and the IMA at that moment was 135×10^3 (particles to the Earth per hour). In 2007 and 2008, the IMA during maximum activity (October 20-21) was 4–6 $\times 10^3$. The magnitude distributions of the Orionids for the period from 2006 to 2008 are presented and discussed. Most Orionids caught have magnitudes between +5.0 and +7.0.

First results on video meteors from Crete, Greece

Grigoris Maravelias

This work presents the first systematic video meteor observations from a, forthcoming permanent, station in Crete, Greece, operating as the first official node within the International Meteor Organization's Video Network. It consists of a Watec 902 H2 Ultimate camera equipped with a Panasonic WV-LA1208 (focal length 12mm, f/0.8) lens running MetRec. The system operated for 42 nights during 2011 (August 19–December 30, 2011) recording 1905 meteors. It is significantly more performant than a previous system used by the author during the Perseids 2010 (DMK camera 21AF04.AS by The Imaging Source, CCTV lens of focal length 2.8 mm, UFO Capture v2.22), which operated for 17 nights (August 4–22, 2010) recording 32 meteors. Differences—according to the author's experience—between the two softwares (MetRec, UFO Capture) are discussed along with a small guide to video meteor hardware.

Development of the camera network in Hungary

Antal Igaz

The significant growth of the Hungarian video meteor network since the spring of 2009 is described.

Geminids 2002, 2009, and 2010: a brief report on an experiment with visual and photographic observations and images of all-sky cameras

Ivan S. Bryukhanov, Stanislav A. Korotkiy, Zakhar Lapitsky, Leonid Molchanov, Kirill Ushakov, Aleksey Gain, Roman Grabovsky, Dmitry Starovoytov, Maksim Chernyavsky, Aleksey Chernik, Matvey Nazaruk, Ilya Nazaruk, Sofia Poluyanova, Lyubov Tumash, Aleksandr Semenkov-von Zdorrfe, Andrey Prokopovich, Dmitry Akulich, and Elena Zaritskaya

In 2009 and 2010, an experiment to search for radiants of meteor showers on images of online all-sky cameras was attempted. In 2009, only two cameras of the Tzec Maun project were used: one near Pingelly in Australia and one in New Mexico in the United States. In 2010, two more cameras, one all-sky camera at the SAO in Nizhny Arkhyz, Russia, and the one in Kiruna, Finland, brought the total to four.

For comparison purposes, photographic meteor images made by Stanislav Korotkiy at the SAO during the Geminids' maximum in 2010, as well as visual observations carried out by a group of observers from the town of Maryina Horka in Belarus in 2002, were used. The goal of this attempt was to find out whether meteor images of all-sky cameras are suitable in practice for the determination of the radiants of meteor showers. This was a new astronomical project called *All-Sky Beobachter*, "Beobachter" being the German word for "observer".

Orbits of meteoroids under the influence of gravitational and nongravitational forces

Julia A. Snetkova

We discuss the problem of dust particle (meteoroid) motion under the forces of the Sun's gravity, light pressure, and solar wind plasma pressure. It is shown that the orbit of a meteoroid significantly changes under the influence of nongravitational forces due to a decrease of the orbit's semi-major axis and eccentricity. Expressions for the light pressure force and the solar wind plasma force are presented.

First years of the Polish Fireball Network

Przemysław Żołądek

The first attempts of video and photographic meteor observations in Poland are presented. The Polish Fireball Network (PFN) was estabilished in 2004 after a succesfull Leonid campaign and the appearance of the Łaskarzew fireball. Typical fireball stations were equiped with CCTV systems, with METREC software running. The first digital fireball stations has been created in 2005. Currently, PFN consists of 20 fireball stations and uses 54 CCTV cameras.

Radio observations of meteor showers in 2008–2009

Ivan Sergey

The results of radio observations of meteor showers carried out in Belarus by the author in 2008 and 2009 are presented and dicusssed.

Activity of video meteors between 2009 and 2011

Ivan Sergey, Sergey Dubrovsky, and Vitaliy Mechinsky

The results of video meteor observations carried out in Belarus by Ivan Sergey and Sergey Dubrovsky between 2009 and 2011 are presented and dicusssed.

Review of meteor shower activity in 2000–2007

Ivan Sergey

On the basis of the visual meteor database of the Belarussian Network Of Meteor Monitoring in the period from 2000 to 2007, an overview is given for the activity of 18 meteor showers for which a satisfactory amount of observational data was available.

On two bright fireballs over Hungary

Tibor Hegedűs, Antal Igaz, and István Tepliczky

Two extremely bright fireballs have been observed from multiple sites by the newly established Hungarian Video Meteor Network in 2011. One of them even exceeded the brightness of the Full Moon, and both of them came from high ecliptic latitude. We present the results of the calculations of their atmospheric paths, Solar System orbits, and mass estimations. Some notes are added about search opportunities for possible meteorite droppings.

Video observations of meteors in Bulgaria

Antoaneta Avramova

In this paper, we present the results of our observations made during the National Astronomy and Astrophysics Summer School Belite Brezi in 2010–2011.

The astronomy festival "Nights of the Perseids"

Dimitrie Olenici

A festival dedicated to the meteor shower enthusiasts took place between 9 and 14 August since the year 2006 at the private astronomical observatory of the author, a place without disturbing light pollution in the village Horodnic de Jos in Suceava County.

Tunguska, 1908: the gas pouch and soil fluidization hypothesis

Ioan Nistor

The Siberian taiga explosion of 30 June 1908 remains one of the great mysteries of the 20^{th} century: millions of trees put down over an area of 2200 km^2 without trace of a crater or meteorite fragments. Hundred years of failed searches have followed, resulting in as many flawed hypothesis which could not offer satisfactory explanations: meteorite, comet, UFO, ... In the author's opinion, the cause is that the energy the explorers looked for was simply not there! The author's hypothesis is that a meteoroid encountered a gas pouch in the atmosphere, producing a devastating explosion, its effects being amplified by soil fluidization.

Meteor Beliefs Project: meteoritic weapons

Kristine Larsen, Alastair McBeath, and Andrei Dorian Gheorghe

A discussion of meteoritic iron weapons and weapon-like tools is given, drawing on fictional, mythological, and real-world examples. The evidence suggests that no great significance was attached to such metal purely because of its "heavenly" provenance prior to the early 19th century AD, despite later assumptions, including during the period of increased interest in meteorites, cratering events and the early usage of meteoritic iron, beginning in the early 20th century.

International Meteor Conference 2012 report

Kerem Osman Çubuk [1]

Received 2012 October 16

The International Meteor Conference 2012 was my first IMC experience but before telling you about my impressions during the IMC, I first would like to tell you about my pre-IMC feelings and experiences: How I found out about the IMC and why I wanted to become a participant.

Radio astronomy studies in Turkey started in 1960's. But these studies have never been in order and efficient. Among these studies the most exciting and the major one was the construction of a 13-meter radio dish at Erciyes University in late 2008. However, due to the lack of technical knowledge and funding, this telescope is still not operational today.

As an astronomy student who is willing to study radio astronomy, this was upsetting. With a group of friends, we thought about supporting the studies on radio astronomy when we realised the lack of awareness about it, thus, started working. Our goal was to work in cooperation with educational institutions to teach radio astronomy to the new generation and to make semi-professional observations and analysis in order to accelerate radio astronomy studies in the country. All these reasons led to the establishment of a team called Radio Wave Hunters (RWH, `www.radiowavehunters.com`), which immediately started working.

We focused on the studies that are simple and can be executed with low budgets, taking into consideration our lack of knowledge on the topic. Among those, the most suitable topic for our team was radio meteor observations. With a fast research and efficient work, we produced our first antenna in a short time. Getting some proper data took around a year for us. But still, there were lots of missing and unclear points. Right at that moment, we heard about the IMC 2012, a conference that unites amateurs and professionals on the topic from all around the world. It was the exact event for us to direct our questions and make friends who are working on the same field.

I wanted to participate at the IMC 2012 with the support of Erciyes University. I have participated in national congresses several times but that was about to be my first international conference. That is why I had no idea about the atmosphere which I would encounter. To be honest, at first, I was concerned about our poster presentation. Since many of the IMC attendees are far above our level of meteor observations, I thought our studies would not be minded enough.

On the 20th of October, I was at the Hotel Las Olas. Marc Gyssens, Paul Roggemans and Ovidiu Vaduvescu were the first people around that I have met. After a warm welcoming, I completed my check-in and went to my room. One thing which I should not skip is that, the organizers have chosen a very nice hotel. The hotel had a stunning view, good meals and well designed rooms.

My roommate Matej Korec has participated in many IMCs and he has great experience about the conference. Thanks to Matej, I could ask him a lot of questions and meet other participants easily. I really liked the arrangement of the rooms so that the new and former participants are sharing the rooms together.

Opening reception and the dinner were so good that I felt, I have known all those people not just for a couple of hours but for months. I no longer felt like a stranger. The conversations and entertainments at the bar in the following nights were so fun.

Lectures were held in the other hotel, Hotel Taburiente. I liked that because that way we had small walks at least four times a day and had the chance to interact with the locals of La Palma. At first, I was worried about the levels of presentations, but as a matter of fact, I understood the presentations without the technical details (cams, optics, lenses, etc.) with ease. Especially the presentations about radio meteor observations were great for me.

The conversations during coffee breaks and poster sessions were so interesting. Listening to the knowledge of the best meteor observers in the world and drinking coffee with them was a great experience. Especially, despite the fact that our study was basic for most of the people, the respect and the support were great.

The excursion to the Roque de los Muchachos Observatory (ORM) was just unbelievable! Seeing the world's largest telescopes from a few meters was a special moment only a small number of people could have had. I would like to thank LOC for this amazing excursion!

We were talking with Marc and Paul about a possible meteor network in Turkey. When I came back to Turkey, I discussed this topic with my friends from

Figure 1 – The author discussing radio meteors with Jeffrey Brower and Jean-Louis Rault. Photo courtesy: Ovidiu Vaduvescu.

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Figure 2 – Group photo in front of the 17-m MAGIC telescope mirrors. Photo courtesy: Ovidiu Vaduvescu.

RWH and Ferhat Fikri Özeren, who is the director of UZAYBİMER. Upon everyone's positive feedback, I gave a seminar at Erciyes University Astronomy and Space Sciences Department on October 11. There were about 50 participants. Eight of them were academics and the rest of them were grad and undergrad students. At the end of the seminar, we had long discussion on what to do next. Together with everyone's comments the final decision was to establish a national meteor network in Turkey with the lead of Erciyes University, and to work in cooperation with the IMO.

All in all, I am extremely happy about joining the IMC and also about being the first Turkish person, who ever joined an IMC. I met a lot of wonderful people and learnt a lot about meteor observations which cleared the question marks on my mind. Of course, new information brings more questions, but in time, I am sure I will solve these ones with the support I have, from all around the world. First of all I would like to thank the IMO for organizing the 31st edition of such an important conference and also to everyone who had made any contribution to IMC 2012. Everything was spectacular! I hope, next year, we will come to Poznań upon succeeding many challenges. "Nice to meet you and see you next year! ☺"

Acknowledgements

I would like to thank H. Aziz Kayıhan and Can Terzioğlu for their help with translation.

Handling Editor: Javor Kac

Meteor science

A simple model of spatial structure of meteoroid streams

Masahiro Koseki [1]

A meteor activity profile is determined by the encounter conditions of its orbit with the Earth. We can estimate a profile on the basis of a simple model; the size and the axis of meteoroids remain stable for a long time. The derived profiles are consistent with observations except for the extreme case of the Leonids.

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1 Introduction

Meteor particles are dispersed by celestial perturbations and by non-gravitational forces. We are likely to suppose a longer period of activity for a stream means it is of an older origin but this is not so. The conditions of the intersection between a meteoroid's orbit and the Earth strongly influence the meteor activity profile.

The Quadrantids show short-duration and strong activity every year and may be thought a younger stream while the α-Capricornids are active for a longer duration and assumed to be older. However this is a misunderstanding and the author intends to explain why on the basis of a simple model of a meteor stream presented in this paper.

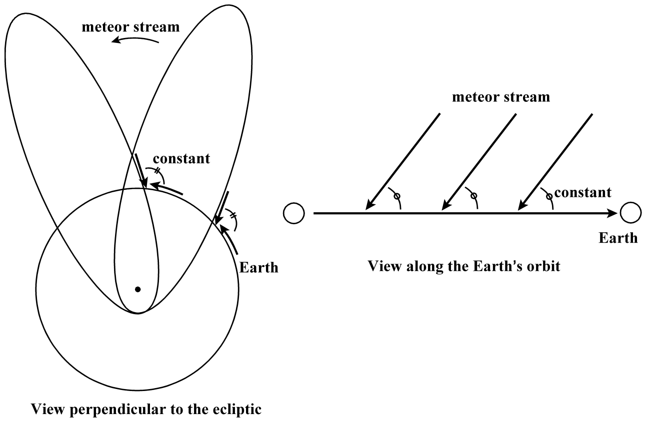

Figure 1 – Commonly used figures for explanation of radiant drift. Circles (rotation) are calculated rates in case that its orbital plane rotated on the axis of ecliptic pole.

2 Steps of meteor stream evolution

We observe many meteor showers at different stages of their history. Some occur for a short duration and show a sharp maximum. Many others have a long period of activity but no noticeable peak. It is suggested that a meteor stream might develop from its birth to extinction as follows.

Stage 1 Meteor particles are ejected from a parent body with a small velocity and move together in close proximity of the parent source.

Stage 2 Particles then spread along the parent orbit and make a thin stream around the entire orbit.

Stage 3 Particles might be perturbed by planets, mainly Jupiter, and the stream widens.

Stage 4 The spatial density of the meteor stream become comparable to sporadic meteors and the stream becomes a minor shower.

Stage 5 Meteor particles become dispersed into the sporadic background and no longer recognized as a shower.

It is necessary to compute a large number of ideal particles for the prediction of an outburst from a young meteor stream (Stage 1-2). We can expect regular meteor activity year to year in Stage 3 and can calculate its profile by considering the conditions of the encounter between the stream and Earth's orbit on the basis of the simple model of its spatial structure.

3 Calculation of meteor shower profile

A radiant drifts eastward and the reason is often explained by the rotation of its orbital plane on the axis of ecliptic pole (Figure 1). The inclination and the argument of the perihelion, in this case, remain constant and the radiant moves along the ecliptic latitude. However this does not fit the observations. The author has shown that radiants move on the coordinates ($\lambda - \lambda_{\odot}$, β) (Koseki et al., 2010), though the rotation makes the radiant stay on those coordinates. Such rotation causes small changes in orbital elements and the profile estimated from the difference between the orbits shows a slower shift with time (circles with dotted line in Figure 2). There is no reason why perihelion should rotate on the axis of the ecliptic.

We can suppose planetary perturbations, especially from Jupiter, affect a meteor stream in the same manner as comets and asteroids. It is reliable enough to assume next two hypotheses (Koseki, 1975): 1. The axis of a meteoroid orbit remains the same as the parent body (or the center of the stream). 2. The size of a meteoroid orbit, i.e. the semi-major axis, is kept at the same size. We might estimate a meteor shower activity as follows on these assumptions. It is necessary to calculate a series of meteoroid orbits, which have a fixed axis (λ_0, β_0) and the same size as the initial orbit, at different intersection positions. At first, we consider the changes

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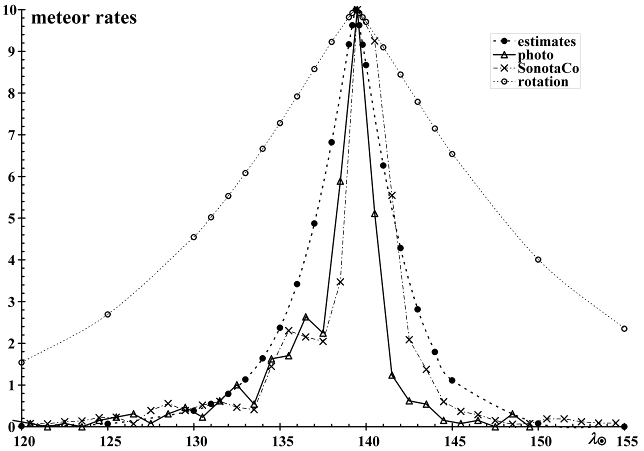

Figure 2 – Estimated Perseids rates comparing with CCD and photographic observations.

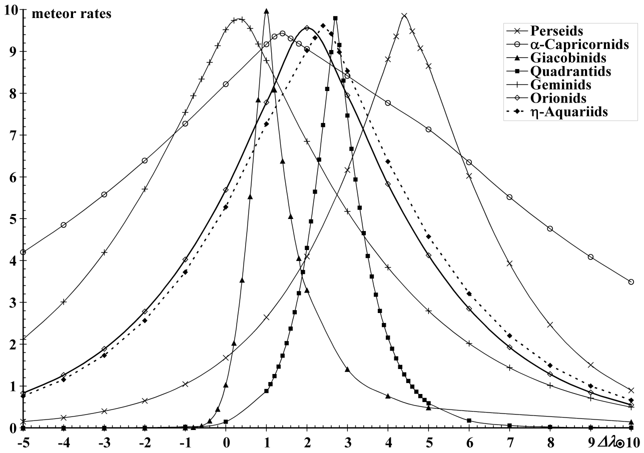

Figure 3 – Estimated profiles of some notable showers.

in the argument of the perihelion and the inclination when the intersection node varies from Ω to Ω'.

$$\lambda'_0 = \lambda_0 - \Omega' \tag{1}$$

$$\cos\omega' = \cos\lambda'_0 \cos\beta_0 \tag{2}$$

$$\cot i' = \sin\lambda'_0 \cot\beta_0 \tag{3}$$

Secondly, we hold the semi-major axis of the meteoroid, which intersects the Earth's orbit, unchanged. An ellipse is expressed as following formulae:

$$R = \frac{q\,(1+e)}{1+e\cos\theta} \tag{4}$$

and,

$$q = a(1-e) \tag{5}$$

therefore,

$$ae'^2 + (R\cos\theta)e' + (R-a) = 0 \tag{6}$$

We can get the modified eccentricity e'

$$e' = \frac{(R\cos\theta) \pm \sqrt{(R\cos\theta)^2 - 4a\,(R-a)}}{2a} \tag{7}$$

R is the radius of the Earth's orbit and θ is the encounter angle between Earth and the meteor shower's perihelion; $\theta = 180 - \omega'$ (before perihelion) or $\theta = \omega'$ (after perihelion). In case of the hyperbolic orbit, we apply the plus-minus sign as minus. Intersection angle (I) between the mean orbit and modified orbit is given as following formula.

$$I = \frac{\sin\Delta\Omega \sin i}{\sin\omega'} \tag{8}$$

It is natural to expect that the space densities of meteoroids decrease exponentially from the initial orbit.

$$N = N_0 \exp\{-\left(A\sin|I| + B|e-e'|\right)^C\} \tag{9}$$

N_0 is the maximum meteor rate and A, B and C could be determined empirically from observations. If we adopt $A = 10$, $B = 30$ and $C = 1.2$, we would get fine profile of major meteor showers (Figures 2 and 3).

4 An example of estimated profiles

For example, Figure 2 shows an estimated Perseids profile and recorded rates from photographic and CCD observations. Details for CCD data, see SonotaCo (2010) and photographic data list is given in Koseki (2009). Mean Perseid orbits are derived from photographic observations shown as Table 1, and photographic and CCD rates are counted in the period mentioned in Table 1 as $\lambda_\odot$. If we calculated the portion rates to sporadic meteors, i.e. Perseids to sporadic ratios, instead of raw Perseids rates, the observed profiles for both photo and CCD increase and widen. Magnitude ratio (population index) of the Perseids is considerably lower than for sporadic meteors and the portion rates might be raised from real ones. We, therefore, do not use the portion rates but could expect observed rates to be higher than those shown in Figure 2.

The ascending node used in Figure 2 is modified to $\Omega = 139.4$, because the mean Ω value of the Perseids does not represent the maximum. All three profiles are standardized to 10 at the maximum but the estimated value of the Perseids can not reach 10 because their average orbit does not exactly intersect the Earth's orbit.

The estimated profile of the Perseids in Figure 2 is good enough to show its observed activity. It has been suggested that Perseid activity is seen in early July, but this is not so because as shown in Figure 2 rates of Perseids are less than the detected level during that period. So-called early Perseids are from other meteor activity.

5 Discussion

We see the simple model works well for major showers in Figure 3 except for the Leonids (Figure 4). First we discuss the Leonids and then examine 6 other meteor shower profiles. Basic data are from Table 1 as in the case of the Perseids.

5.1 Leonids

The Leonids are very unique in the condition of their intersection, that is, their perihelion is very close to Earth's orbit, $\omega = 175.3$ and $q = 0.974$. If we strictly

Table 1 – List of major meteor showers. Orbital elements are referred to B1950.

	$\lambda_\odot$	$\lambda - \lambda_\odot$	β	e	q	i	ω	Ω
Perseids	115∼155	275∼295	+30∼+45	0.992	0.948	112.9	150.4	138.0
Leonids	200∼265	260∼285	0∼+20	0.891	0.974	162.2	175.3	234.5
Giacobinids	165∼215	40∼140	+50∼85	0.700	0.999	25.0	177.0	196.0
Quadrantids	280∼290	260∼285	+60∼+70	0.633	0.977	71.7	171.7	282.7
η-Aquariids	30∼65	285∼300	0∼+15	0.955	0.603	164.7	98.9	46.3
Orionids	185∼225	240∼255	−15 ∼0	1.005	0.577	161.9	81.6	27.8
α-Capricornids	95∼155	165∼195	−10 ∼+25	0.760	0.592	7.1	267.9	125.4
Geminids	240∼275	200∼215	0∼+20	0.900	0.142	24.9	324.0	260.1

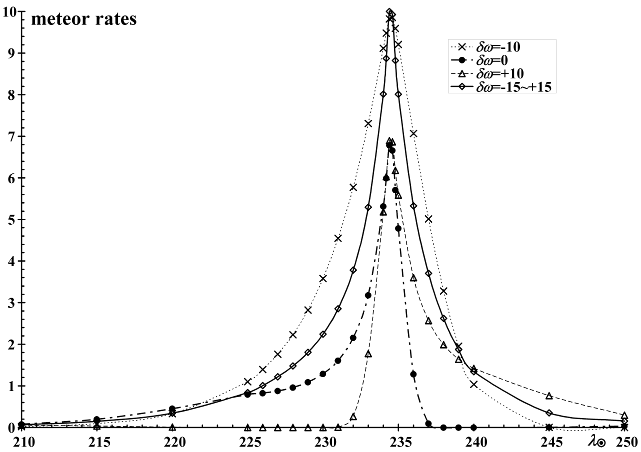

Figure 4 – Estimated profiles of Leonids based on modified calculations.

adopt the above two hypotheses, the estimated profile shows a curious shape. The profile indicated by $\delta\omega = 0$ (filled circles with dash-dotted line in Figure 4), which is calculated based on the mean Leonids orbit, shows a sudden fall-off after maximum. Figure 5a shows the cause of the curious profile as a result of the necessary change in the intersection angle in order to intercept Earth. The Leonid orbital plane should rotate between wide ranges when we would consider the fixed apsides. Figure 4 shows Leonids profiles for other modified conditions.

If we move the perihelion of the Leonids backward, i.e. $\delta\omega < 0$ (see P_1 in Figure 5b), the intersection angle between the Leonids and Earth's orbit decreases and the profile becomes more symmetric (see $\delta\omega = -10$ in Figure 4). Nevertheless, if we move the perihelion forward, i.e. $\delta\omega > 0$ (see P_2 in Figure 5b), the intersection angle must be changed by an extremely wide amount and the profile becomes asymmetric (see $\delta\omega = +10$ in Figure 4). The rate increases sharply and falls slowly contrary to the case of $\delta\omega = 0$.

The profile indicated by $\delta\omega = -15 \sim +15$ in Figure 4 gives the accumulated estimates by rotating the perihelion between $\delta\omega = -15$ and $\delta\omega = +15$ and we can accept this as being most comparable to the observations. Such accumulation is necessary in the case of the Leonids because the perihelion of the shower is near the Earth's orbit. The position of perihelion might be naturally spread in extent. As a result, the estimated activity derived from tight conditions might differ from the real profile. The Leonids are an extreme case and we can get satisfactory meteor shower profiles for many other showers by the method described in this paper.

5.2 Giacobinids (October Draconids)

The encounter condition of the Giacobinids is very similar to the Leonids (see above), but much more extreme, i.e., its perihelion is closer to the Earth's orbit, $\omega = 177.0$ and $q = 0.999$. Both showers cross the Earth' orbital plane at a similar angle, though the Leonids has a retrograde motion and the Giacobinids prograde, i.e., the inclination of the former $i = 162.2$ and the later $i = 25.0$.

The estimated profile (black triangles in Figure 3) suggests a short duration that coincides well with the observations. It is necessary to consider the dispersion of the perihelia as in the case of the Leonids but the estimation calculated from the stationary perihelia is enough for presenting the observations. This suggests the perihelia of Giacobinid meteoroids are distributed in narrow area and it might be a younger shower than the Leonids.

5.3 Quadrantids

The perihelion of the Quadrantids is near the Earth's orbits similar to the Leonids, $\omega = 171.7$ and $q = 0.977$. It is natural that the estimated profile becomes narrower than others. Moreover, the activity period of the Quadrantids is shorter than the Leonids both before and after the maximum, because the Quadrantid orbits are highly inclined, $i = 71.7$. The estimated profile is very consistent with observations and suggests the Quadrantids are not so old.

5.4 η-Aquariids / Orionids

This pair is called a twin meteor shower because they come from a common celestial body, Comet 1P/Halley. The η-Aquariids occur at the descending node of the comet and the Orionids are at the ascending node. The argument of perihelion of the former is $\omega = 99$ and the latter is $\omega = 81$. A twin shower may happen, when the argument of perihelion lies around $\omega \sim 90$ or $\omega \sim 270$ and both radii are at nodes near the Earth's orbit. The η-Aquarids (filled black diamond) and Orionids (empty diamond) in Figure 3 show very similar profiles because the encounter conditions are similar.

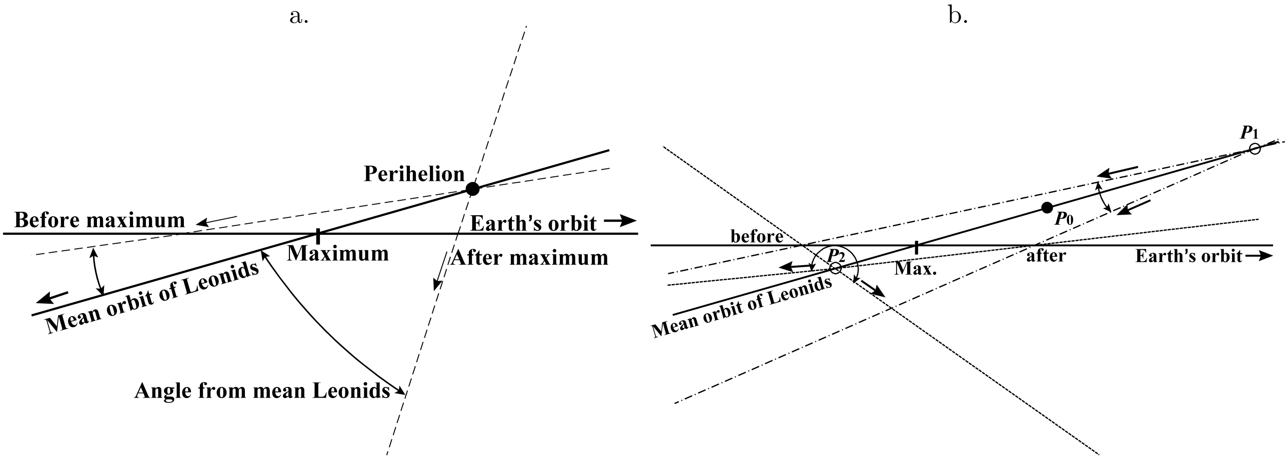

Figure 5 – Schematic encounter condition between Leonids and Earth's orbit.
a: Difference of the encounter conditions between the earlier Leonids activity and the later ones. Meteor particles, which meet after the maximum, should move highly inclined orbital plane to mean Leonids', if they have the same apsides as mean Leonids,
b: Changes of the encounter condition by rotating the perihelion on the Leonids orbital plane. P_0 points at the mean perihelion, P_1 and P_2 indicate the rotation of the perihelion by $\delta\omega = -10$ and $\delta\omega = +10$ respectively.

Both streams cross the Earth's orbital plane at small angles just as short comets do, and the argument of perihelion lies around $\omega \sim 90$ or $\omega \sim 270$. Encounter conditions are more similar to the α-Capricornids than the Leonids or Perseids. The η-Aquariids and Orionids have long intervals of activity not only because of their age but also the encounter condition.

5.5 α-Capricornids

Estimated profile of the α-Capricornids (circle in Figure 3) shows longer activity than any other streams mentioned here. Its argument of perihelion is near $\omega = 270$ and its eccentricity is smaller than the Geminids and Perseids (cross and x marks in Figure 3, respectively). These conditions make it possible to observe α-Capricornid meteors over a longer period.

5.6 Geminids

The estimated profile of the Geminids (cross in Figure 3) resembles that of the Orionids and η-Aquariids, though the Geminids have quite different encounter conditions from them. The perihelion distance of the Geminids is the smallest of the listed streams (Table 1), i.e., the perihelion is far from the Earth's orbit. Such meteor streams as the Geminids and δ-Aquariids show similar profiles.

This estimation gives the proper activity period for observations but the profile differs from observations after maximum. The observed profile falls more quickly after maximum than the estimation. It might be suggested that the Geminid meteoroids are distributed asymmetrically to its orbital plane.

6 Conclusions

1. Estimations from the simple model give good meteor activity profiles. They are affected mainly by the encounter conditions between the orbit of the meteor streams and of the Earth, and less from the age of meteor streams.
2. It is better to consider the variation of the argument of the perihelion, but most meteor showers do not need such treatment except for the extreme case such as the Leonids.

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Confirmation of the Northern Delta Aquariids (NDA, IAU #26) and the Northern June Aquilids (NZC, IAU #164)

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This paper resolves confusion surrounding the Northern δ-Aquariids (NDA, IAU #26). Low-light level video observations with the Cameras for All-sky Meteor Surveillance project in California show distinct showers in the months of July and August. The July shower is identified as the Northern June Aquilids (NZC, IAU #164), while the August shower matches most closely prior data on the Northern δ-Aquariids. This paper validates the existence of both showers, which can now be moved to the list of established showers. The August β-Piscids (BPI, #342) is not a separate stream, but identical to the Northern δ-Aquariids, and should be discarded from the IAU Working List. We detected the Northern June Aquilids beginning on June 14, through its peak on July 11, and to the shower's end on August 2. The meteors move in a short-period sun grazing comet orbit. Our mean orbital elements are: $q = 0.124 \pm 0.002$ AU, $1/a = 0.512 \pm 0.014$ AU^{-1}, $i = 37\overset{\circ}{.}63 \pm 0\overset{\circ}{.}35$, $\omega = 324\overset{\circ}{.}90 \pm 0\overset{\circ}{.}27$, and $\Omega = 107\overset{\circ}{.}93 \pm 0\overset{\circ}{.}91$ ($N = 131$). This orbit is similar to that of sungrazer comet C/2009 U10.

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1 Introduction

There is some confusion regarding the nature of the Northern δ-Aquariids (NDA, IAU #26). The shower was discovered by Wright et al. (1957), who photographed two meteors north of the ecliptic plane with orbital elements very similar to the Southern δ-Aquariids. Those meteors were photographed on 1952 August 18, and on 1953 August 5. They had low perihelion distances of 0.065 and 0.075, respectively, and inclinations of $23\overset{\circ}{.}8$ and $16\overset{\circ}{.}9$.

The IAU Working List puts the peak of the Northern δ-Aquariids at solar longitude $123\overset{\circ}{.}4$, based on visual observations, when the radiant is said to be at $\alpha = 344\overset{\circ}{.}7$, $\delta = +0\overset{\circ}{.}4$, $v_g = 40.5$ km/s. Jenniskens (2006) provides orbital element data from eight sources that agree well and nearly all put the peak around solar longitude 140°, near the peak of the Perseids. These mean orbits have inclinations in the range $18\overset{\circ}{.}0 - 23\overset{\circ}{.}0$, slightly lower than those of the Southern δ-Aquariids ($\approx 26°$), while the longitude of perihelion is in the range $\varpi = 104\overset{\circ}{.}9 - 112\overset{\circ}{.}2$. In comparison, the Southern δ-Aquariids have a longitude of perihelion $\varpi = 97\overset{\circ}{.}3 - 101\overset{\circ}{.}8$, just slightly lower. This suggests that both showers could be part of the Machholz complex. When the nodal line rotates, the inclination and perihelion distance change a lot, but the longitude of perihelion stays much the same (Jenniskens, 2006).

SonotaCo (2009) put the activity period for the Northern δ-Aquariids from solar longitude $118\overset{\circ}{.}4$ to $128\overset{\circ}{.}4$ in late July, based on the SonotaCo video observations, and identified a separate shower active in August. The new shower was named the "August Beta Piscids", subsequently included in the IAU Working List as #342 (BPI), with a peak at solar longitude $140\overset{\circ}{.}0$, $\alpha = 346\overset{\circ}{.}4$, $\delta = +1\overset{\circ}{.}4$, $v_g = 38.3$ km/s, active from solar longitude $128\overset{\circ}{.}8$ to $151\overset{\circ}{.}17$. This position, however, is the same as that of photographed Northern δ-Aquariids.

The Canadian Meteor Orbit Radar (CMOR) project (Brown et al., 2009; Brown et al., 2011) also put the peak of the Northern δ-Aquariids at the time of the Perseid maximum (solar longitude 139°). In addition, they detected a shower in June and July active from solar longitude 71° to 123° (a 53-day period), with a maximum at 101°. At maximum, the radiant was at $\alpha = 310\overset{\circ}{.}4$, $\delta = -4\overset{\circ}{.}2$, moving at $+0.845°/°$ (degrees of coordinate change per degree of solar longitude) in Right Ascension and $+0.182°/°$ in Declination, with geocentric speed $v_g = 37.5$ km/s. This translates to orbital elements $q = 0.116$ AU, $i = 39\overset{\circ}{.}5$, $\omega = 327.49°$, and $\Omega = 101\overset{\circ}{.}0$ ($\varpi = 68\overset{\circ}{.}49$).

This June–July shower was already in the IAU Working list as the Northern June Aquilids (NZC). The shower was so named because Sekanina (1976) detected it before in Harvard radar data in much of June, but CMOR extended the activity range much further into July.

Observations made during the months of June, July, and August of 2011 by the Cameras for All-sky Meteor Surveillance (CAMS) video system confirm the presence of two distinct showers in July and August. The radiants are well separated from those of the α-Capricornids (CAP) and Southern δ-Aquariids (SDA), but the nature of the two showers is very different. The July shower is that identified by CMOR as the Northern June Aquilids. That shower was also recognized from IMO single-station video observations (Molau, 2010) and identified in the latest SonotaCo video observations as an unnamed shower with provisional designation "sm_025".

2 CAMS: Cameras for All-sky Meteor Surveillance

CAMS is a three-station 60-camera meteor surveillance system using Watec Wat902 H2 cameras equipped with 12-mm focal length lenses. During the summer of 2011 the CAMS network stations were located at Fremont Peak Observatory, at Lick Observatory, and at a low

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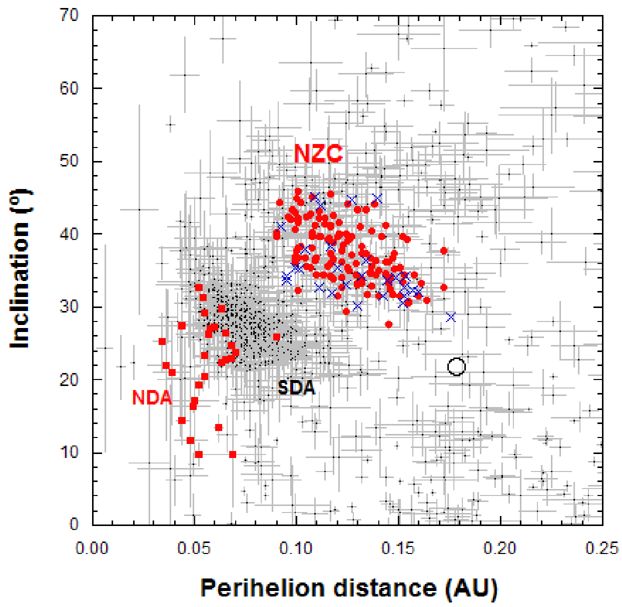

Figure 1 – NZC (dots) and NDA (squares) orbital elements relative to other meteors in the period 2011 June 14 to August 2. The crosses without error bars are SonotaCo sm_025 orbits from 2007 to 2009. The open circle are orbital elements from radar observations by Nilsson (1964).

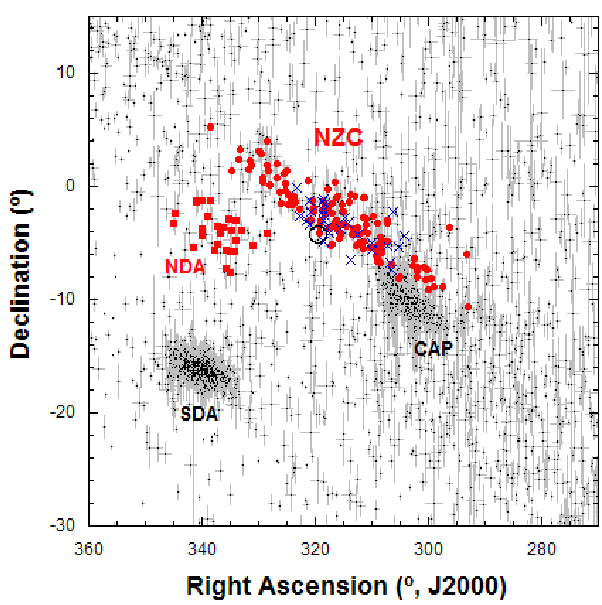

Figure 2 – As Figure 1: NZC (dots) and NDA (squares) radiant positions relative to other meteors in the period 2011 June 14 to August 2. The crosses without error bars are SonotaCo sm_025 orbits from 2007 to 2009.

altitude site near Lodi, California. The CAMS video system has been described in detail in previous works (Jenniskens et al., 2011), and more information about the CAMS network can be found on the project web-site at: `http://cams.seti.org`.

3 Confirmation of the Northern June Aquilids

We first noticed this shower on orbital element plots of our July 2011 observations (Figure 1). The meteors are well separated from the Southern and Northern δ-Aquariids by having a higher perihelion distance and higher inclination. They were initially mistaken for the Northern δ-Aquariids, but daily plots of the radiant position show clearly a shower in late July and early August with a radiant consistent to the Northern δ-Aquariids, and a separate shower that is active during most of July. Figure 2 shows the radiant position of this July shower during the period June 14 to August 2.

The extended period of activity and the daily radiant drift causes the radiants to spread out as they do in Figure 2. At all times, however, the shower is well separated from the α-Capricornids (CAP). It is recognized as a compact cluster of radiants from 88° solar longitude to 130°.

4 D-Criterion Testing

To determine shower association with the Northern June Aquilids using dissimilar D-criteria methods D (Southworth & Hawkins, 1963) and D_D (Drummond, 1981), we define an appropriate cut-off level, D_c, using the definition from (Lindblad, 1971):

$$D_c = 0.80N^{-0.25} \tag{1}$$

With $N = 350$, we get $D_c = 0.185$, and so use values of $D \leq 0.18$ as evidence of association within our sample area. The mean orbit against which all other orbits were tested was determined by taking the mean of the 11 orbits in our preliminary data set that occurred on the peak night of July 11. These orbits were compared to their own mean, and two of those orbits were eliminated as outliers. The resulting mean of the remaining 9 orbits was used to test the association of all other NZC candidates. D-criterion tests were performed on all orbits occurring during the NZC activity period in our sample area. The resulting set of verified NZC orbits ($N = 131$) are those shown by dot symbols in Figures 1 and 2. The number of detected shower members as a function of solar longitude is shown in the histogram of Figure 3. We observed the peak to occur on July 11 ($\lambda_\odot = 108°$) in 2011. The activity profile is broad and symmetric.

This extends the range of activity further into July and early August compared to the CMOR activity period of 71° to 123°, with a peak at 101° solar longitude. There is a hint in the radiant plot of Figure 2 that activity might extend to even later times. The activity profile is symmetrical in time (57.6% appearing before the maximum). Days with no activity occurred on clear nights, but reflect the low-number statistics of detected rates.

We also tested the SonotaCo "sm_025" data ($N = 38$) using the same mean orbit and D_c, and as a result removed 10 orbits from that data set. The reduced set is shown in Figures 1 and 2 with crosses, and listed in Table 1. All orbits in the vicinity of the NDA radiant ($N = 57$) were similarly D-tested using $D_c = 0.29$ from equation (1), and the mean radar orbit of (Kashcheyev & Lebedinets, 1963). The resulting set of verified NDA

Table 1 – The mean orbital elements for NZC from various observers are listed. Error tolerances are given in standard error. Two possible parent comet orbits are also shown.

Observer	Obs. Type	Shower	$\lambda_\odot$	α	δ	v_g	q	a	i	ω	ϖ	Year
CAMS	MS video	NZC (All)	108.09	315.35	−3.07	38.33	0.124	2.11	37.60	324.94	73.03	2011
			±0.91	±0.81	±0.27	±0.19	±0.002	±0.06	±0.34	±0.27	±0.27	
CAMS	MS video	NZC (Peak)	108.55	315.49	−3.58	38.20	0.125	2.06	36.01	324.59	73.14	2011
			±0.02	±0.59	±0.39	±0.72	±0.007	±0.16	±1.39	±1.11	±1.11	
SonotaCo	MS video	sm_025	108.08	315.10	−3.56	37.68	0.129	2.00	35.34	324.52	72.60	2007–9
			±1.37	±1.11	±0.35	±0.36	±0.004	±0.14	±0.88	±0.80	±0.80	
CMOR	BSc radar	NZC	101	310.4	−4.2	37.5	0.1160	1.55	39.5	327.49	68.49	2002–6
Harvard	BSc radar	"June	85.8	297.1	−7.1	36.3	0.114	1.348	39.3	329.5	55.3	1968–9
		Aquilids"	±0.7	±0.6	±0.5	—	±0.004	—	±0.6	±0.6	±0.7	
Nilsson	FSc radar	61.7.9	121.4	319.6	−4.2	36.9	0.179	3.57	21.8	311.2	72.60	1961
			—	±1.9	±1.5	±1.4	—	—	±3.0	±4.0	±4.0	
IMO VMN	SS video	Shower 25	102.5	312.2	−5.0	43	—	—	—	—	—	1993–08
	2009 U10		100.32	306.6	−7.1	38.2	0.0544	∞	32.24	323.46	63.78	
	1997 H2		103.44	310.6	−22.3	36.1	0.1361	∞	18.32	201.47	67.29	

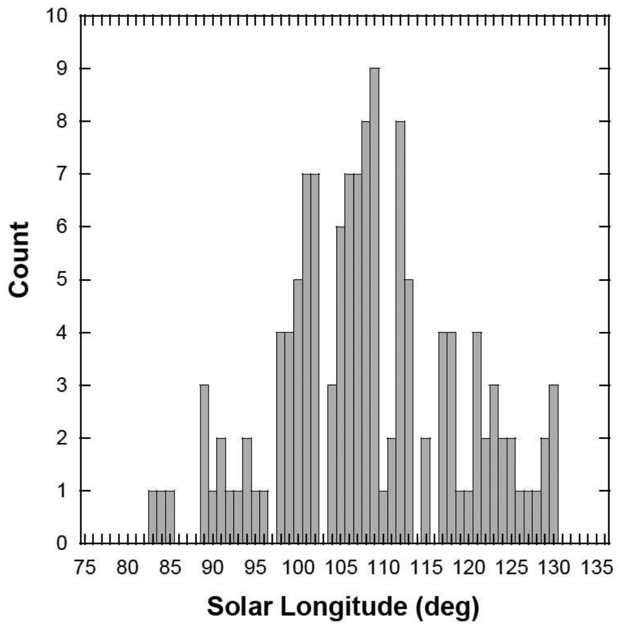

Figure 3 – The number of detected NZC shower members from CAMS data for each solar longitude in 2011.

orbits ($N = 12$) are those shown by "black square" symbols in Figures 1 and 2.

5 Orbital Elements and Drift Rates

In Table 1 we compare the various observations of this shower. CAMS data is shown for both the peak night and the entire activity period, and the SonotaCo data is shown after our D-criterion testing. The SonotaCo data agree well with our data in all respects. This is also shown in Figures 1 and 2, where NZC candidate orbits are plotted with SonotaCo orbits in α vs. δ and perihelion distance vs. inclination. The IMO Video Meteor Network (VMN) detected this shower's radiant using single-station observations made from 1993 July to 2008 July, and an automated radiant detection process. In the first analysis of the VMN data by Molau (2007), the NZC shower was split into three parts with a total of ca. 350 orbits that were designated as showers 16, 19, and 24. Shower 24 was thought to be the descending branch of shower 19 in the 2006 analysis. A second improved analysis made in 2008 combined the three previous showers into one, with ca. 900 orbits, designated as shower 25 (Molau, 2010). The radiant is a good match, but their v_g is somewhat higher than in our data.

The earliest detection we found are 3 orbits identified by Nilsson (1964) using short baseline forward-scatter radar observations made during 1961 from Adelaide, Australia, which he designated as Group 61.7.9. The forward-scatter radar observations match our radiant very well (open circles in Figures 1 and 2), but some orbital elements differ significantly. The values given for mean $\lambda_\odot$ and Ω are dependent on his observation periods, which all occurred after the peak of activity we observed, so they cannot be compared here to the other observed values of $\lambda_\odot$ and Ω. Of interest is that in addition to the observations made on July 22–29 and August 1–3, during which his 3 orbits were recorded, the radar was also operating from July 11–15 but detected no NZC meteors during that interval. Nilsson does not specify the date and time of appearance of his 3 orbits. Nilsson's radiant, v_g, and eccentricity are all good matches to our data, but q and a are both somewhat larger. The values for q and a shown in Table 1 are both calculated from Nilsson's given values of e and $1/a$. Most troublesome is Nilsson's calculated mean inclination of $21\overset{\circ}{.}8$, which is much lower than the mean value found in our data, and also far lower than the lowest inclination orbit found in our data (30°). The detected inclination drift in our data is not enough to reduce the mean inclination to Nilsson's value, even including his large error tolerances.

The NZC meteors intercept the Earth's orbit at the streams descending node. The stream then continues on past the sun to its perihelion point. After perihelion the stream quickly ascends at about a third of the mean distance of Mercury's orbit from the sun, after which the meteoroids move out towards Jupiter. The mean aphelion point is 4.11 AU from the sun, just inside of Jupiter's orbit, and 1.71 AU above the ecliptic plane, at some distance from Jupiter.

Table 2 shows the measured drift rates for our NZC data compared to those reported by SonotaCo, CMOR, and VMN. Nilsson was not able to detect reliable drift rates from only three orbits. The radiant drift rates we measure have very good regression coefficients, and generally agree with SonotaCo and CMOR. These drift rates confirm a normal radiant drift. The radiant drift rates from VMN are in rough agreement.

Our data shows the most statistically significant orbital element drift rates are in q, i, ω, ϖ, and the heliocentric distance to the ascending node, $r+$, but do not always agree well with SonotaCo's drift rates, which may be due to the lower numbers of NZC meteors recorded by SonotaCo. All other orbital element drift rates measured by CAMS have low regression coefficients combined with low drift rates, so we assume those elements to be constant during the activity period. The regression coefficients for each orbital element from both CAMS and SonotaCo are similar, even when the element values disagree. SonotaCo data show possibly significant drifts in magnitude and geocentric velocity that CAMS does not.

6 Physical Properties and Zenith Hourly Rate

All 12 871 meteors observed by CAMS with entry velocities between 30 and 50 km/s have a magnitude distribution index of $\chi = 2.96$ between +1 and −5. Assuming the actual distribution is according to χ^m, the fraction observed provides the following probability function for detection as a multi-station meteor. Above +1, the count is incomplete, detecting approximately fractions of $P(m) = 0.78$ at +1, 0.42 at +2, 0.15 at +3, 0.019 at +4 and 0.0002 at +5. Based on these probabilities, the observed magnitude distribution for NZC averages to $\chi = 2.7$.

The light curves are fairly symmetric, suggesting relatively frail meteoroids. The F-skew mean is a relatively low 0.53, typical for symmetric light curves that peak slightly after the middle of their trajectory, but with a range from $F = 0.13$ to 0.94. Seventy-six NZC meteors, or 58% of the sample, have F-values of 0.50 or greater.

The beginning and end heights of the NZC fall in the same height range of other meteors of similar velocity. The beginning heights range from 91.3 to 103.6 km with a mean of 96.8 km. The end heights range from 82.1 to 93.9 km with a mean of 86.9 km. For both beginning and ending heights, the lower height range is the same for NZC meteors and all other meteors, but the higher height range of NZC meteors is about 3 – 4 km less than that for all other meteors.

From the magnitude distribution index, the peak Zenithal Hourly Rate (ZHR) for the NZC can be calculated. The ZHR is calculated using the formula given by Jenniskens (1994):

$$\mathrm{ZHR} = \frac{N}{t_{\mathrm{eff}}} \chi^{6.5-L_m} C_{\mathrm{p}} \sin(h_{\mathrm{R}})^{-\gamma} F \qquad (2)$$

where N is the number of meteors counted during t_{eff}, the effective time interval in hours. h_{R} is the radiant height at the middle of the t_{eff} period, $\gamma = 1 + 1.08\log(\chi) = 1.47$, and C_p is the observer's perception coefficient ($C_{\mathrm{p}} = 1.0$). The extra factor "F" accounts for the relative efficiency for detecting meteors above 32° by a visual observer compared to that by CAMS.

We use the permanently installed Fremont Peak Observatory (FPO) station as our standard observer. For the peak night of July 11, 9 meteors were detected during the $t_{\mathrm{eff}} = 5.53$ hours when the sun was more than 18° below the horizon and the camera $L_m = 5.4$ at FPO. CAMS is capable of accurately recording orbits during twilight periods when the sun is only about 9° below the horizon. However, on the peak night no NZC meteors occurred during twilight. The radiant altitude at the middle of this time interval is $h_{\mathrm{R}} = 45\overset{\circ}{.}8$. To estimate the relative area covered by the cameras to that covered by a visual observer, we first multiply the video rate to that which would have been detected for a visual limiting magnitude of +6.5 above 30° elevation (limit of CAMS system), by multiplying with $\sum_m P(m)\chi^m$ (factor 10.6), then divide by that which a visual observer sees over the same region (strictly above 32° elevation), a factor of 19.1. Hence, $F = 0.55$. This results in a peak $\mathrm{ZHR} = 4.7 \pm 1.6$ /h.

7 Parent Body

The short perihelion distance suggests looking for potential parent bodies among the anomalous sun-grazing comets found among the many SOHO and STEREO comet discoveries. We searched for a prograde moving comet with $q \leq 0.2$ AU and $\varpi \approx 73°$. The large spread in node suggests that there was time for the parent to evolve at a different rate than the meteoroids by rotating the nodal line, or by changing the perihelion distance from perturbations by Jupiter at aphelion.

One object, C/2009 U10, is a promising candidate. Its parabolic orbit has $\varpi = 64°$, a little lower than expected, but the node is still close to that of the observed meteoroids (Table 1). If we assume that the perihelion distance was adjusted to the observed value, and the semi-major axis of the comet is that of the present meteoroids ($a = 2.10$ AU), then the theoretical radiant given in Table 1 follows from method "Q" of Neslusan et al. (1998). The predicted radiant is at slightly lower declination than observed, but that may merely reflect uncertainty in the comet orbit.

Another comet, C/1997 H2, has a better agreement in longitude of perihelion, but would need to be much more evolved along the nutation cycle if responsible for this stream. This makes the predicted radiant position (using method "H" of Neslusan et al. (1998)) more uncertain.

Table 2 – Drift rates for the NZC orbital elements and correlation coefficient R.

	$\Delta\alpha$	$\Delta\delta$	Δv_g	Δv_h	Δq	$\Delta 1/a$	Δi	$\Delta\omega$	$\Delta\varpi$	$\Delta r+$	ΔM_v	ΔF_{max}
CAMS	+0.866	+0.253	−0.032	+0.020	+0.00067	−0.0015	−0.172	−0.123	+0.877	+0.00083	+0.0040	+0.0020
R	0.98	0.87	0.15	0.10	0.37	0.10	0.45	0.41	0.96	0.38	0.04	0.12
SonotaCo	+0.766	+0.183	−0.085	+0.038	+0.0016	−0.0030	−0.484	−0.267	−0.733	—	+0.0289	—
R	0.95	0.72	0.33	0.15	0.49	0.15	0.76	0.46	0.81	—	0.23	—
CMOR	0.845 ±0.01	0.182 ±0.01	—	—	—	—	—	—	—	—	—	—
IMO VMN	+0.7	+0.1	—	—	—	—	—	—	—	—	—	—

8 Conclusions

We have solved confusion regarding the identity of the Northern δ-Aquariids, which can now be moved to the list of established showers, and confirm the existence of the Northern June Aquilids (NZC, IAU #164). We have shown that this stream is distinct from the Southern and Northern δ-Aquariids, and α-Capricornids. The orbital data, beginning and ending heights, and F-skew values of the NZC meteors indicate a cometary origin from a short-period sungrazer. Two such comets, C/2009 U10 and C/1997 H2, are presented as possible parent bodies, C/2009 U10 being the most similar in orbit to the meteoroids observed at Earth.

9 Acknowledgements

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A rare opportunity: Observing the 2011 Quadrantid maximum from Austria

Thomas Weiland [1]

After more than ten years of waiting, fine observing conditions in Austria during the 2011 Quadrantid maximum allowed collecting a reasonable amount of data even by a single observer. During 5.45 hours of effective observing time 188 Quadrantids were recorded on January 3/4. Calculations of the population index yielded values varying between $r = 1.89 \pm 0.21$ and 2.48 ± 0.43 (mean $r = 2.08 \pm 0.14$), whereas the activity profile shows a peak ZHR of 88 ± 13 between 02^h00^m and 03^h00^m UT, most likely at 02^h50^m to $02^h55^m \pm 15^m$ UT ($\lambda_\odot = 283.^\circ 23 \pm 0.^\circ 01$; eq. 2000.0), about 1.7 hours later ($\Delta\lambda_\odot = +0.^\circ 07$) than predicted. An impression of the maximum night together with a summary of the results is given.

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1 Introduction

With their strong, brief appearance the Quadrantids are one of the most impressive meteor showers currently visible and not only of interest for amateur observers but for theoreticians as well. The latter is due to the fact that for a long time no parent body was found. First comet 96P/Machholz was a possible candidate, being probably responsible for the Southern δ-Aquariids and the daytime Arietids. More recent research suggests a relative young age of the main component of the stream, which likely originated after the breakup of a comet not more than ca. 500 years ago. It is now widely accepted that this was the case with comet C/1490 Y1, and a remnant of it, asteroid 2003 EH_1 (which can be designated as an inactive comet as well), is the parent of the Quadrantids (Jenniskens, 2004).

Numerical particle simulations further revealed that the core of the stream was probably ejected during a single major perihelion outburst around the year 1800 (Wiegert & Brown, 2005), whereas the "annual" background component should be 3000–4000 years old (Jenniskens et al., 1997; Wiegert & Brown, 2005). Since the aphelia of the meteoroids lie close to Jupiter's orbit they are, despite an inclination of about 72°, prone to frequent but short perturbations by that planet. This further causes different particle densities along Earth's annual passage through the stream as has been modelled by Vaubaillon (cf. Jenniskens, 2006, fig. 20.17, p. 375), though variations may be less prominent than suggested (Jenniskens, 2006). According to calculations by Vaubaillon an average Quadrantid maximum was expected to happen in 2011.

Nevertheless, New Moon (coinciding with a partial solar eclipse) about seven hours after the predicted Quadrantid peak (January 4, 01^h10^mUT, $\lambda_\odot = 283.^\circ 16$, eq. 2000.0; (McBeath, 2010)) created almost perfect astronomical circumstances for central Europe. Unfortunately, humid air usually dominates early January in Austria, resulting in cloudy skies and high altitude fog respectively. 2011 seemed to be no exception. After the passage of a cold front on January 2 and a low pressure trough one day later things improved somewhat on the evening of January 3, but not enough. To escape the incoming clouds I went to the leeward side of the Alps. Close to Lembach (near Riegersburg, Styria, Austria; 15°57′ E, 47°01′ N, 370 m altitude; field obstruction 5%) I finally found unspoiled skies for 5.5 hours. Despite some mist at the end of the night, limiting stellar magnitudes were all time better than +6.0 before morning twilight began, but with temperatures dropping down to −8.5°C it got pretty cold!

2 The maximum night (January 3/4)

I started my observations at 23^h45^m UT. By that time the radiant had an elevation of $h_R = 21°$ and conditions were nearly ideal, no clouds and wind at all, with a limiting stellar magnitude of +6.2 (Table 1).

The first 15 minutes saw only 2 QUA, but after then the stream became more active as 25 QUA were logged between 00^h00^m and 01^h00^m UT, followed by 30 QUA between 01^h00^m and 02^h00^m UT. During the third observing hour (02^h00^m to 03^h00^m UT) the shower's activity was still on the rise (45 QUA). The highest count per 15-minute interval (02^h30^m to 02^h45^m UT) yielded 19 QUA, approximately coinciding with brighter shower members and even fireballs up to magnitude −4, some of them appearing more or less simultaneously. Despite the radiant's increasing altitude, observed rates showed no further rise between 03^h00^m and 04^h00^m UT (43 QUA), suggesting that Quadrantid activity was going down again, as proved by calculations later (see Section 3.3). The bulk of the QUA meteors had now shifted to the 0 to +5 magnitude range, borne out by the population index as well (see Section 3.2). To some extent this could be found during the last observing hour (04^h00^m and 05^h00^m UT), too, as were rates continuously declining (35 QUA). At 04^h51^m UT astronomical twilight began (limiting stellar magnitude +6.0), but Quadrantids were still visible. Within the last 15 minutes 8 QUA appeared, highlighted by a fireball of magnitude −4 travelling on a 10–15° long path through Leo. At 05^h15^m UT I stopped my observations since the limiting stellar magnitude had dropped to +5.7 (Sun 14° below the horizon).

During 5.45 hours of effective observing time, I had logged 188 QUA, together with 6 Comae Berenicids (usual COM; shower association according to the Hand-

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NASA-ADS bibcode 2012JIMO...40..171W

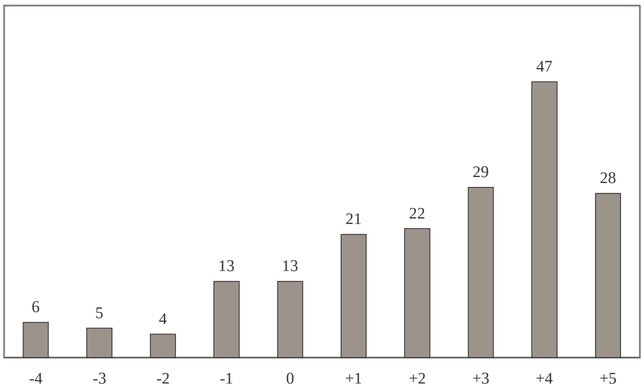

Figure 1 – Magnitude distribution of 188 Quadrantids logged on 2011 January 3/4.

book for Meteor Observers, 2nd ed., p. 173, Fig. 8.82 (Rendtel & Arlt, 2009)) and 80 sporadic meteors.

3 Discussion

3.1 Magnitude distribution

In general the magnitude distribution of the 2011 Quadrantids fits a standard function, showing a maximum in the +4 magnitude class (Table 1 and Figure 1).

15 % of the recorded QUA, more or less comparable to other major annual streams, fell within the negative magnitude range; the bulk (85 %) equalled magnitude 0 or fainter. Fireballs (per definition of magnitude -3 at least) contributed to 6% of the observed QUA number, the brightest ones reaching magnitude -4. Respectable 46% occurred during the peak ZHR interval ($02^{\rm h}00^{\rm m}$ to $03^{\rm h}00^{\rm m}$ UT; Figure 3) and still 36% approximately coincided with the highest 15-minute interval count ($02^{\rm h}30^{\rm m}$ to $02^{\rm h}45^{\rm m}$ UT). On the other side, percentages of faint meteors (magnitudes +4 and +5) reached their maxima after $03^{\rm h}00^{\rm m}$ UT.

As for sporadics, few meteors with negative magnitudes were recorded (5%), the brightest ones equalling -2. The bulk of the sporadic meteors (64%) turned out to be faint (magnitude +4 and +5).

3.2 Population index profile

Population indices were derived using the magnitude difference between the meteors and the limiting stellar magnitudes, based on table 9.2, p. 178 and the table on p. 179 in the Handbook for Meteor Observers, 2nd ed. (Rendtel & Arlt, 2009). This yielded values varying somewhat between $r = 1.89 \pm 0.21$ and 2.02 ± 0.33 before $03^{\rm h}00^{\rm m}$ UT and rising up to $r = 2.48 \pm 0.43$ after that. During the last observing hour it went down to $r = 2.30 \pm 0.42$ again (Figure 2).

The profile shown here (mean $r = 2.08 \pm 0.14$) generally corresponds to earlier results that found lowest r-values during Earth's passage through the densest parts (main component and core respectively) of the stream (Rendtel et al., 1993). In the same way, the steep rise of r around $03^{\rm h}00^{\rm m}$ UT seems to be real, because of its abrupt character, and is therefore not regarded as an artifact due to steadily increasing radiant altitudes, as has been argued in case of the 1992 Quadrantids (Rendtel et al., 1993).

For comparison, calculation of the population index of the sporadic background yielded a mean r of 2.88 ± 0.39.

3.3 ZHR profile

ZHR calculation followed the procedure given in the Handbook for Meteor Observers, 2nd ed. (Rendtel & Arlt, 2009), based on individual population indices found earlier (see Section 3.2). The zenith exponent was assumed to be $\gamma = 1.0$. No perception coefficient was applied.

During the first observing hour (from $00^{\rm h}00^{\rm m}$ to $01^{\rm h}00^{\rm m}$ UT) ZHR-values started out with 72 ± 14 and stayed at that level during the next hour ($01^{\rm h}00^{\rm m}$ to $02^{\rm h}00^{\rm m}$ UT; 70 ± 13). Then a significant rise up to 88 ± 13 ($02^{\rm h}00^{\rm m}$ to $03^{\rm h}00^{\rm m}$ UT) was seen, followed by a decrease to 80 ± 12 between $03^{\rm h}00^{\rm m}$ and $04^{\rm h}00^{\rm m}$ UT and further to 59 ± 10 between $04^{\rm h}00^{\rm m}$ and $05^{\rm h}00^{\rm m}$ UT (Figure 3).

At this point it seemed worth examining whether the activity profiles of bright and faint meteors were following the same trend. For that purpose separate ZHR-values for QUA within the negative magnitude range and those of magnitude 0 or fainter have been calculated. As Figure 4 shows, rates of bright QUA stayed more or less constant until $03^{\rm h}00^{\rm m}$ UT and went down to low levels after that. Faint QUA instead were steadily rising in number throughout the night, with a remarkable backdrop after $04^{\rm h}00^{\rm m}$ UT. The partly adverse behaviour of bright and faint meteors may reflect, though there has been argued against it (Rendtel et al., 1993; Jenniskens et al., 1997), some mass segregation effect as is borne out by the population index as well (see Section 3.2).

In order to determine the maximum time more clearly, ZHR-values based on 15-minute intervals and an average population index of $r = 2.08$ (see Section 3.2) have been calculated. Of course this results in larger fluctuations (Figure 5). Nevertheless a prominent peak between $02^{\rm h}30^{\rm m}$ and $02^{\rm h}45^{\rm m}$ UT becomes visible, approximately coinciding with the highest proportion of fireballs seen (see Section 3.1). Additionally three of overall four simultaneous events (e.g. at least two stream members appearing within 2 seconds) were noted during that time.

To smooth the profile, in a third step ZHR-values were averaged using a sliding mean of 5 bins per step (A5), yielding an activity curve seen in Figure 6. This puts the time of maximum a bit later (around $02^{\rm h}50^{\rm m}$ to $02^{\rm h}55^{\rm m} \pm 15^{\rm m}$ UT), quite in agreement with the corresponding IMO live ZHR profile (International Meteor Organization, 2011; page finally generated on 2011 March 26) which gives a peak time around $02^{\rm h}50^{\rm m}$ UT (ZHR 74 ± 4; based on 333 QUA in 33 intervals; r assumed to be 2.1; author's data included).

In order to answer the question at what time the maximum occurred it must be stated, however, that the IMO profile actually shows an earlier, even higher peak around $22^{\rm h}35^{\rm m}$ UT (ZHR 90 ± 9; based on 103

Table 1 – Magnitude distribution of 188 Quadrantids logged on 2011 January 3/4.

shower	UT	lm	−6	−5	−4	−3	−2	−1	0	+1	+2	+3	+4	+5	+6	∑
QUA	23:45–00:00	6.20	0	0	0	0	0	1	0	0	0	1	0	0	0	2
QUA	00:00–01:00	6.20	0	0	0	1	1	4	2	2	3	2	7	3	0	25
QUA	01:00–02:00	6.20	0	0	1	0	2	2	2	3	3	7	5	5	0	30
QUA	02:00–03:00	6.15	0	0	3	2	1	3	3	3	8	7	10	5	0	45
QUA	03:00–04:00	6.13	0	0	1	1	0	1	1	7	4	6	14	8	0	43
QUA	04:00–05:00	6.10	0	0	0	1	0	2	4	4	3	5	11	5	0	35
QUA	05:00–05:15	5.85	0	0	1	0	0	0	1	2	1	1	0	2	0	8
	mean	6.14	∑ 0	0	6	5	4	13	13	21	22	29	47	28	0	188

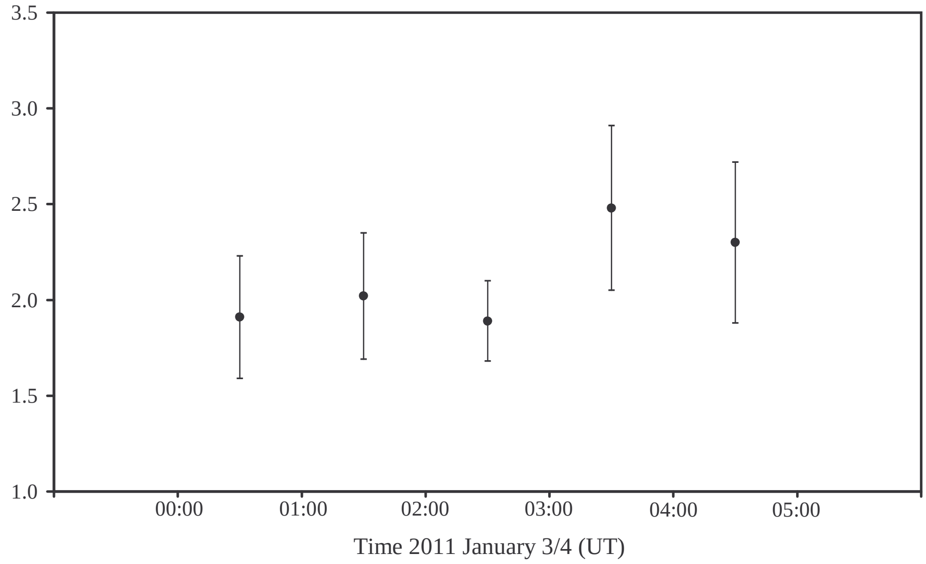

Figure 2 – Population index profile of the Quadrantids on 2011 January 3/4.

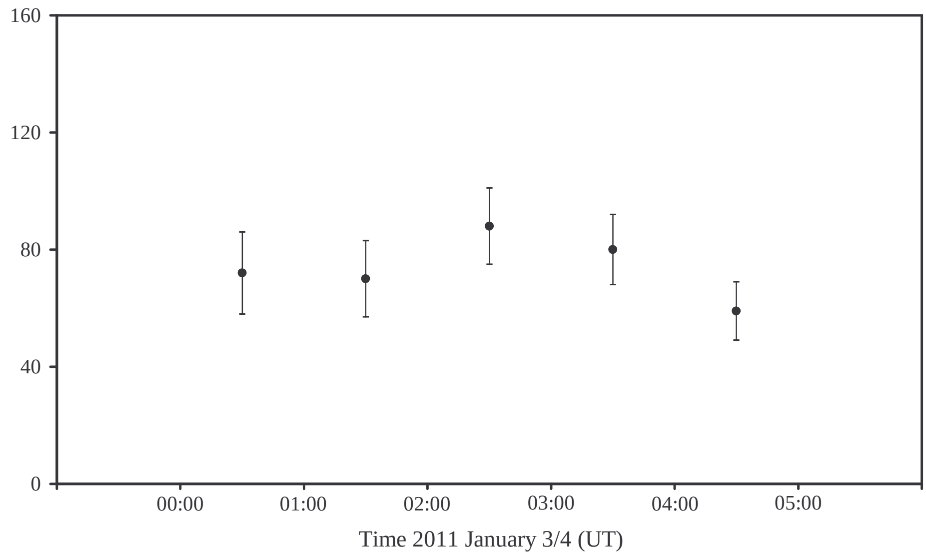

Figure 3 – Quadrantids ZHR profile on 2011 January 3/4.

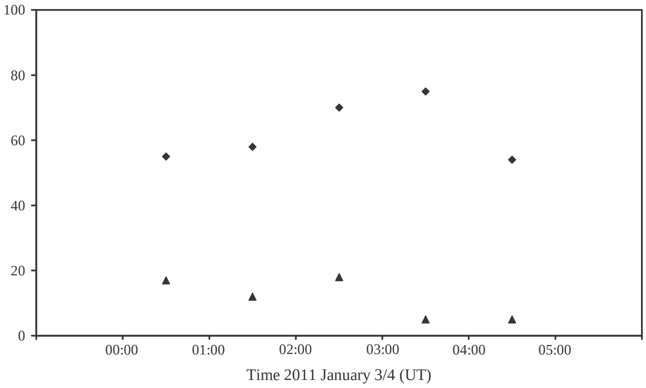

Figure 4 – Quadrantids ZHR profile on 2011 January 3/4, for QUA meteors brighter than magnitude 0 (▲) and for QUA meteors of magnitude 0 or fainter (⧫).

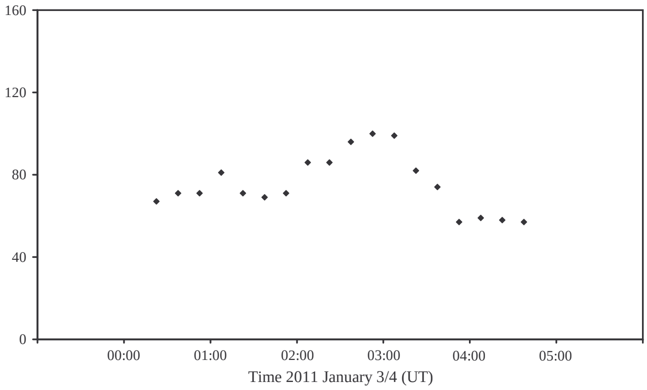

Figure 6 – Quadrantids ZHR profile on 2011 January 3/4, based on 15-minute intervals averaged over 5 bins (A5). Population index of $r = 2.08$ was used for calculation.

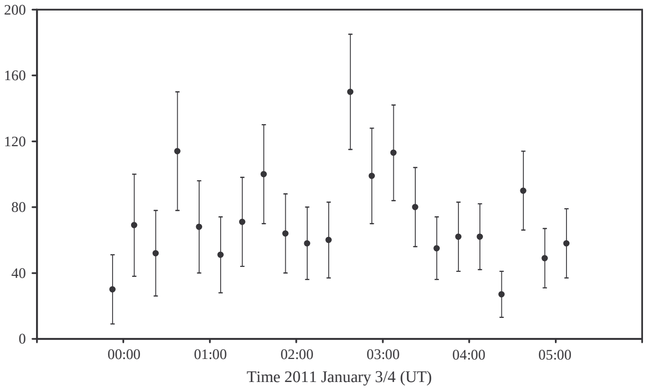

Figure 5 – Quadrantids ZHR profile on 2011 January 3/4, based on 15-minute intervals. Population index of $r = 2.08$ was used for calculation.

QUA in 13 intervals; r as above; author's data not included). Close inspection of the observational parameters revealed that only four of the ten observers active around that time both had limiting stellar magnitudes beyond +5.0 and a radiant elevation of $h_{\mathrm{R}} \geq 20°$. As a consequence the given ZHR-value may be too high and therefore regarded as an artifact. This further leads to the opinion that, although double maxima probably have been encountered at times in the past (McBeath, 2005), only one visual peak occurred in 2011.

Overall it may be concluded that a peak ZHR in the order of 90 happened on 2011 January 4, $02^{\mathrm{h}}50^{\mathrm{m}}$ to $02^{\mathrm{h}}55^{\mathrm{m}} \pm 15^{\mathrm{m}}$ UT ($\lambda_{\odot} = 283\overset{\circ}{.}23 \pm 0\overset{\circ}{.}01$; eq. 2000.0), about 1.7 hours later ($\Delta\lambda_{\odot} = +0\overset{\circ}{.}07$) than predicted (McBeath, 2010), but in good agreement with the average value of $\lambda_{\odot} = 283\overset{\circ}{.}28 \pm 0\overset{\circ}{.}01$ (eq. 2000.0) given in Jenniskens (2006).

3.4 General aspects

The Quadrantids seem to be less homogenous in their appearance compared to other major annual streams. Bright Perseids for instance often leave (persistent) trains behind; Geminids resemble "falling stars". The 2011 Quadrantids instead displayed different features, some blazed up as "Sternschnuppen" (short streaks of light in the strict sense of that German word) or as "falling stars", others developed maximum luminosity halfway on their trail. One QUA showed a bulbous and another a spear-shaped head.

Interestingly, no flares or terminal bursts were seen, contrary to earlier observations (Grigore & Berinde, 1998) and to Jenniskens (2006), who found that typical for bright Quadrantids and considered it, together with the flat light curves, as an indication of fragile cometary material.

As for trains, a non-homogenous behaviour with respect to earlier observations (Grigore & Berinde, 1998; McBeath, 1998) was observed as well (Table 2, Table 3). Only 2% of all Quadrantids, and only within the negative magnitude range, showed trains. An additional 1% has been found for persistent trains, only seen with two fireballs of magnitude −4 and of short duration (2–3 s) each.

On the other side, 23% of all QUA left short trains behind of which 84% were QUA of magnitude 0 or fainter versus 16% with magnitudes brighter than 0; with the highest percentage in the +1 magnitude class. It seems remarkable that the occurrence of short trains was not confined to bright shower members and that even meteors of magnitude +5 showed that feature.

Finally the colour(s) were recorded for all QUA of magnitude 0 and brighter, mainly yielding yellow, orange and white together with blues and greens to a much lesser extent.

Based on observed features of Quadrantid meteors in the sky, one may conclude that the meteoroids of the main component, and the core respectively, probably represent ejecta from different parts of their source and of different age, too. It further suggests that the Quadrantids are made up of particles with medium bulk density compared to other major annual streams, resembling more the Geminids than the Perseids in that respect (Babadzhanov, 2002; Borovička et al., 2009). It seems worth examining whether the behaviour of future maxima is accompanied by special features like flares and trains.

4 Conclusions

Fine observing conditions in Austria during the 2011 maximum allowed the registration of a reasonable number of Quadrantids. Population indices were comparable to those found during previous returns, whereas the activity profile (peak ZHR within the order of 90) sug-

Table 2 – Train distribution on 2011 January 3/4: %-values refer to the total QUA number recorded ($\sum$ QUA) and %-values per magnitude range refer to the number of QUA within each type of trains.

Type of train	$\sum$ QUA	Magnitude range	< 0	≥ 0
		% (number per type of trains = 100)		
short trains	22.9	short trains	16.3	83.7
trains	1.6	trains	100.0	0.0
persistent trains	1.0	persistent trains	100.0	0.0

Table 3 – Train distribution on 2011 January 3/4: %-values per magnitude class refer to the number of QUA logged in each class.

Magnitude class	−4	−3	−2	−1	0	+1	+2	+3	+4	+5
% (number per class = 100)										
short trains	16.7	20.0	25.0	30.8	30.8	61.9	27.3	17.2	10.6	10.7
trains	0.0	40.0	0.0	7.7	0.0	0.0	0.0	0.0	0.0	0.0
persistent trains	33.3	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0

gests a weaker activity than on average (ZHR $120-130$ (Jenniskens, 2006; Rendtel & Arlt, 2009)). The time of the maximum can be determined as January 4, $02^{\rm h}50^{\rm m}$ to $02^{\rm h}55^{\rm m} \pm 15^{\rm m}$ UT ($\lambda_\odot = 283\overset{\circ}{.}23 \pm 0\overset{\circ}{.}01$; eq. 2000.0), about 1.7 hours later ($\Delta\lambda_\odot = +0\overset{\circ}{.}07$) than predicted (McBeath, 2010).

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Preliminary results

Results of the IMO Video Meteor Network — June 2012

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The 2012 June report for the IMO Video Meteor Network is presented. More than 14 000 meteors were recorded by 67 cameras in over 5 500 hours of effective observing time. The June Boötids were barely detected this year. The Daytime Arietids were detected and the shower parameters are presented. Several other minor showers were detected as well and their activity interval, radiant position and drift, and velocity are presented. These showers include the ϕ-Piscids, Northern June Aquilids, σ-Capricornids, δ-Piscids, and the c-Andromedids.

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1 Introduction

In June we managed once more to improve our observing results from the previous year significantly. The month which still ranks last in our database due to the short northern hemisphere nights, presented mediocre weather in its first half. Starting from mid-June, however, almost all observers obtained long series of clear observing nights. In twelve June nights, more than 50 out of the 67 camera systems were active. On June 17, even 63 cameras were in operation.

Thirty-seven cameras managed to obtain twenty or more observing nights in June. Grigoris Maravelias did not even miss a single night with his camera LOOMECON in Greece.

In total, we accumulated over 5 500 observing hours and recorded more than 14 000 meteors (Table 8 and Figure 1), which is a plus of almost 50% compared to June 2011 (Molau et al., 2011). So we recorded already more than 100 000 meteors in the first half of 2012, and the meteor season is only about to begin!

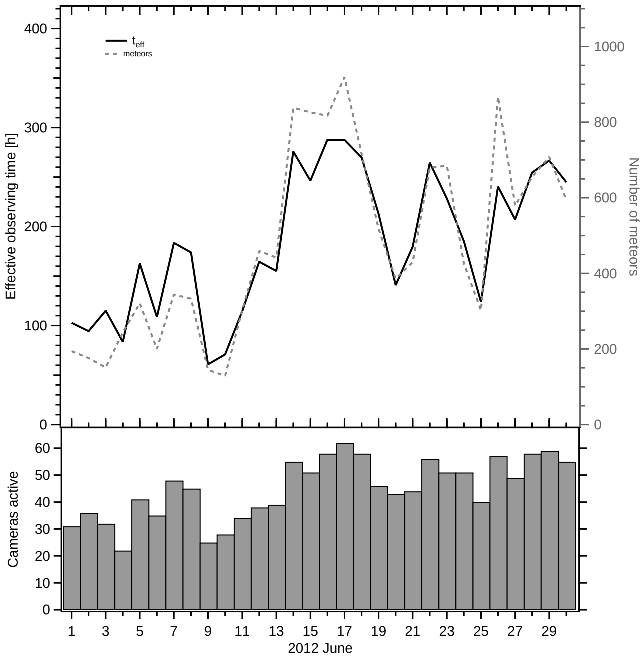

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2012 June.

2 June Boötids

June is poor of strong but rich in minor meteor showers. Probably the most famous are the June Boötids (170 JBO), which presented a number of unexpected outbursts (most recently in 1998 and 2004). In normal years, however, this shower is almost non-existent. Those 120 June Boötids that we recorded in their activity interval of 2012, yield a flux density of less than a tenth of a meteor per 1 000 km^2 per hour, which corresponds to a ZHR of well below one (Figure 2). Thus, the shower was practically invisible in this year.

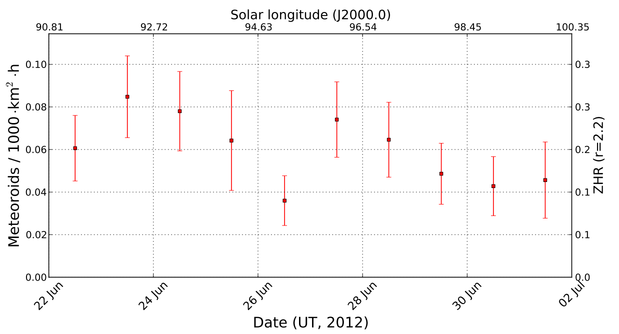

Figure 2 – Flux density profile of the June Boötids in 2012.

3 Daytime Arietids

More interesting is the case of the Daytime Arietids (171 ARI), one of the best-known daytime meteor showers, active in the first third of June. You err if you believe

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NASA-ADS bibcode 2012JIMO...40..176M

Table 1 – Parameters of the Daytime Arietids from the MDC Working List (Meteor Data Center, 2012), CAMS results (Jenniskens et al., 2012), and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	77	—	40.2	+0.7	+23.8	+0.6	37.4	—
CAMS 2012	81	—	46.5	+0.87	+23.7	+0.07	43.8	—
IMO 2012	77	74–79	44.0	+1.0	+23.5	+0.1	43	—

Table 2 – Parameters of the ϕ-Piscids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	106	—	20.1	—	+24.1	—	63.9	—
IMO 2012	101	80–122	15.1	+0.8	+25.1	+0.5	68.5	0.0

Table 3 – Parameters of the Northern June Aquilids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	86	—	298.3	—	−7.1	—	38.0	—
IMO 2012	81.5	79–84	292.0	+1.0	−11.7	−0.4	43	—

that a daytime shower is only relevant for radar observers. This shower can also be detected in our video meteor database! In the recent analysis, the shower was found between June 5 and 10 with a rank of 27. Usually a shower with only 70 meteors would be regarded as a chance alignment of radiants. In this case, however, the low meteor count meets our expectations, as the Daytime Arietids can only be observed for about an hour at dawn. The radiant position shows only little scatter and the average position matches well to the MDC values (Meteor Data Center, 2012). Only the velocity obtained by us is clearly larger than the reference value (Table 1).

However, our values agree perfectly with results of the CAMS network (Jenniskens et al., 2012). Between 2011 June 10 and 15, the three CAMS stations in California recorded four Daytime Arietids. The mean position and velocity of three meteors is given in Table 1, too. The radiant drift was obtained from video data of Fujiwara (2004), SonotaCo (2009) and Jenniskens (2012). These values fit much better to our data than the MDC values – in particular, the discrepancy in meteor shower velocity disappears. Jenniskens (2012) discussed different reasons why the MDC data (which are based on radar observations) have a lower velocity than observations in the optical domain, without getting to a conclusive explanation, though.

4 Other minor showers

In the following we want to briefly discuss further showers that were obtained by our recent analysis based on more than a million video meteors.

4.1 ϕ-Piscids

The ϕ-Piscids (372 PPS) are detected between June 6 and July 31. From June 11 to July 25 the scatter in radiant position is small enough to assume a safe detection of this shower. Table 2 compares the parameters, which were obtained from more than 4 000 shower meteors, with the reference values from the MDC list. The fast shower reaches highest activity in early July, and between mid-June and mid-July the ϕ-Piscids represent almost uninterruptedly the strongest source in the sky. Only in the second half of July, the shower is outnumbered by the α-Capricornids, Southern δ-Aquariids and Perseids.

4.2 Northern June Aquilids

Between June 10 and 15, the Northern June Aquilids (164 NZC) can be found. With a rank of 14 this shower is close to the limits, but the small scatter in position and velocity are a clear sign for its existence. The basic parameters are given in Table 3. They match only moderately to the MDC values – in particular the velocity does not fit well.

4.3 σ-Capricornids

Another long-lasting shower starts on June 18 and ends on July 24. It resembles to the σ-Capricornids (179 SCA), but in particular the declination and velocity of our analysis (based on 2 400 meteors) deviate significantly from the MDC values (Table 4). Between end of June and mid-July, the shower belongs to the most active sources in the sky. We found a small but consistent decrease of velocity in the activity interval. The highest activity is observed in the first third of July.

4.4 δ-Piscids

In the last third of June, the fast shower of the δ-Piscids (410 DPI) is active. With a rank of 7 the δ-Piscids do not belong to the strongest sources, but the small scatter in the meteor shower parameters (based on 220 meteors) and the perfect match with the MDC values (Table 5) make this shower a safe detection.

Table 4 – Parameters of the σ-Capricornids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	110	—	311.1	—	−14.5	—	29.1	—
IMO 2012	105	88–121	313.2	+0.83	−4.5	+0.23	41.6	−0.12

Table 5 – Parameters of the δ-Piscids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	92	—	10.9	—	5.5	—	70.9	—
IMO 2012	92	89–95	11.1	+0.4	5.1	+0.4	69.8	—

Table 6 – Parameters of the c-Andromedids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	110	—	32.4	—	48.4	—	60.1	—
IMO 2012	106	95–118	28.1	+1.13	46.3	+0.38	60.1	−0.11

4.5 c-Andromedids

The c-Andromedids (411 CAN) are active for almost a month. Their activity interval starts on June 27 and ends on July 21. Our shower parameters are based on more than 1 800 shower meteors. They agree well to the MDC values (Table 6). Also for this shower we found a small but consistent decrease in velocity. The highest activity is reached in the first third of July.

4.6 Other detected showers

The following four weak showers were detected as well:

- Between May 29 and June 3, the Northern ω-Scorpiids (66 NSC) are active. At the turn of the month, they are the strongest source in the sky.
- In early June, the June μ-Cassiopeiids (362 JMC) can be detected. The shower has a rank of 17 and a large scatter in its parameters, but the good agreement to the MDC values supports the existence of this shower.
- The Northern μ-Sagittariids (67 NSA) are also active in the first half of June. Even though they have a rank of two and belong to the strongest sources between June 2 and 6, their parameters show strong variations from one night to the next. They are probably more like a diffuse radiation area.
- In the middle of June, the Southern σ-Sagittariids (168 SSS) can be found, which are the strongest source at the Summer solstice.

5 Possible new shower

Finally we would like to point to a possibly new shower, that is found at the turn of June/July with a rank of 7. Table 7 lists the basic parameters, based on 350 shower meteors. Please give us feedback if you can confirm this shower by other observations, before we will report it to MDC.

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Table 7 – Parameters of a possibly new meteor shower from the analysis of the IMO Network 2012.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
IMO 2012	100	96–104	252.5	—	53.6	—	23	—

Table 8 – Observers contributing to 2012 June data of the IMO Video Meteor Network. Eff.CA designates the effective collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
ARLRA	Arlt	Ludwigsfelde/DE	Ludwig1 (0.8/8)	1488	4.8	726	2	7.4	5
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	20	76.5	271
			Hulud2 (0.75/6)	4860	3.9	1103	18	59.7	175
			Hulud3 (0.75/6)	4661	3.9	1052	18	53.1	108
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	24	106.1	189
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	27	145.3	437
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	14	39.1	72
			Mbb4 (0.8/8)	1470	5.1	1208	15	33.7	47
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	21	59.0	128
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	17	42.2	84
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	24	81.9	209
			Bmh2 (1.5/4.5)*	4243	3.0	371	23	60.0	166
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	27	121.6	369
			C3P8 (0.8/3.8)	5455	4.2	1586	17	69.1	176
			Stg38 (0.8/3.8)	5614	4.4	2007	29	107.3	588
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	21	31.2	121
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	25	137.3	342
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	20	129.6	412
			Templar2 (0.8/6)	2080	5.0	1508	20	129.2	343
			Templar3 (0.8/8)	1438	4.3	571	26	141.1	250
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	25	127.0	336
			Orion3 (0.95/5)	2665	4.9	2069	23	90.9	100
			Orion4 (0.95/5)	2662	4.3	1043	26	125.6	204
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	9	30.8	202
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	27	111.3	191
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	27	120.3	225
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	29	137.1	216
		Sopron/HU	Husop (0.8/6)	2031	3.8	460	25	81.8	287
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	28	123.4	196
KACJA	Kac	Kostanjevec/SI	Metka (0.8/8)*	1372	4.0	361	12	55.2	43
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	24	105.8	167
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	19	91.0	340
			Rezika (0.8/6)	2270	4.4	840	16	82.0	387
			Stefka (0.8/3.8)	5471	2.8	379	19	92.4	235
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	12	70.5	535
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	13	48.7	33

Table 8 – Observers contributing to 2012 June data of the IMO Video Meteor Network – continued from previous page.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	13	27.4	36
			Pav36 (1.2/4)*	5732	2.2	227	19	63.7	134
			Pav43 (0.95/3.75)*	2544	2.7	176	18	62.6	63
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	30	174.5	514
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	11	39.2	299
			Mincam1 (0.8/8)	1477	4.9	1084	19	80.0	162
		Ketzür/DE	Remo1 (0.8/8)	1467	6.0	3139	19	63.6	303
			Remo2 (0.8/8)	1475	5.6	1965	20	63.2	156
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	26	129.9	240
OCAFR	Ocaña Gonzáles	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	27	146.7	134
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	17	27.5	87
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	25	70.7	279
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	23	109.6	417
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	23	67.6	197
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	10	26.2	26
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	23	123.8	174
			Ro2 (0.75/6)	2381	3.8	459	21	112.1	158
			Sofia (0.8/12)	738	5.3	907	19	82.3	115
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	27	111.4	218
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	13	40.7	65
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	588	—	—	17	55.2	42
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	27	128.9	602
			Noa38 (0.8/3.8)	5609	4.2	1911	28	131.3	460
			Sco38 (0.8/3.8)	5598	4.8	3306	28	130.7	585
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	7	23.2	21
			Mincam3 (0.8/12)	728	5.7	975	15	34.5	51
			Mincam4 (1.0/2.6)	9791	2.7	552	10	25.2	23
			Mincam5 (0.8/6)	2349	5.0	1896	18	40.3	78
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	24	103.9	330
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	24	73.2	202
ZELZO	Zelko	Budapest/HU	Huvcse02 (0.95/5)	1606	3.8	390	4	12.9	26
						Overall	30	5 506.2	14 386

* active field of view smaller than video frame

Results of the IMO Video Meteor Network — July 2012

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In 2012 June, 68 cameras of the IMO Video Meteor Network were active. Nearly 28 000 meteors were recorded in almost 6 800 hours of effective observing time. The flux density profile of the α-Capricornids is presented and compared to one from 2011. The maximum in 2012 was reached at $\lambda_{\odot} = 130°$, which is 5° later than in 2011. The Southern δ-Aquariids reached a plateau of activity between $\lambda_{\odot}125°$ and 130°, with about twice as high flux as in 2011. Several other minor showers were detected as well and their activity interval, radiant position and drift, and velocity are presented. These showers include the Microscopids, July Pegasids, July γ-Draconids, Southern ι-Aquariids, η-Eridanids, and α-Triangulids.

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1 Introduction

July 2012 was once more an unusually successful month. Even though you did not get the impression of a sunny Summer month in northern Europe, the observing statistics is unequivocal. Only a short glimpse on the tables reveals that there were hardly any observing breaks. And that first impression is indeed correct: In fifteen nights there were fifty or more cameras in operation – on July 26 it was even 63 out of 68 cameras. Overall there were record-breaking fifty cameras with twenty and more observing nights. With almost 6 800 hours of effective observing time and 28 000 meteors (Table 10 and Figure 1), July cannot compete with top-class months like August or October, but that is still much more observing data than we ever obtained in a July before.

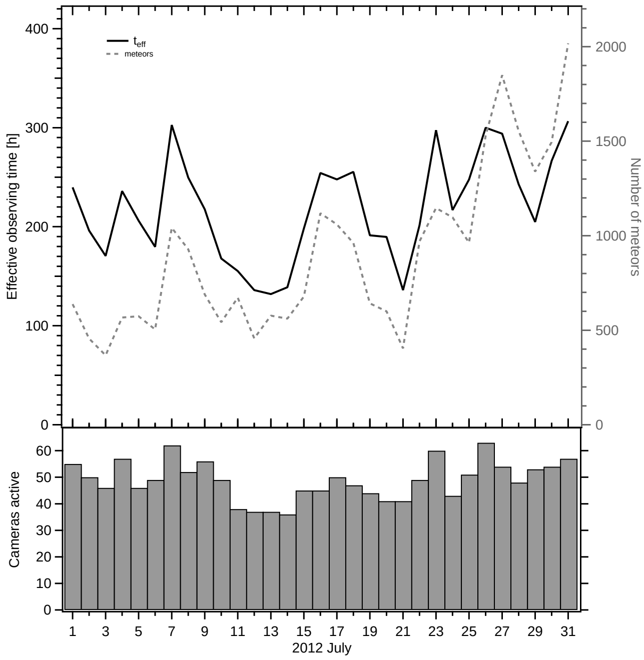

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2012 July.

2 α-Capricornids

With the α-Capricornids and Southern δ-Aquariids, two well-known showers reached their maxima end of July. From both of them we already got nice flux density profiles in the year before (Molau et al., 2011), so that we could compare the results from 2011 and 2012 directly.

Figure 2 shows the flux density profile of the α-Capricornids between July 17 and August 7 (115–135° solar longitude), calculated with a zenith exponent of 1.5. The result is remarkable: Until 123° solar longitude, both profiles are virtually identical. Thereafter, however, the profiles look different. Last year, the maximum occurred already at 125° solar longitude (July 28) (Molau et al., 2011). In 2012 the activity further rose until 130° solar longitude (August 2) and then declined much faster than in the previous year. At 132° solar longitude, both graphs matched well again. In the long-term statistics, the maximum occurs at 125°, so it is 2012 where the maximum actually deviates from the long-term average.

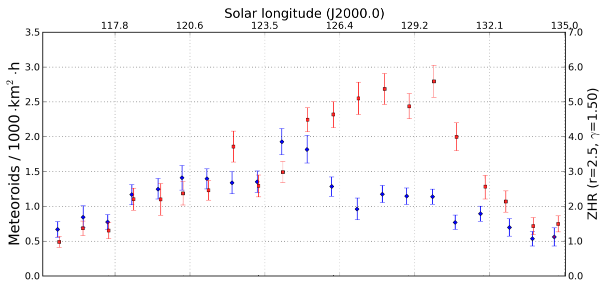

Figure 2 – Comparison of the α-Capricornid flux density profiles of 2011 (blue diamonds) and 2012 (red squares).

In the recent analysis of the IMO Video Meteor Database based on over one million meteors (Molau, 2012), the α-Capricornids (1 CAP) were detected between June 25 and August 12. However, the first days

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NASA-ADS bibcode 2012JIMO...40..181M

Table 1 – Parameters of the α-Capricornids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	127	—	305.6	+0.5	−8.7	+0.3	24.9	—
IMO 2012	125	113–137	305.3	+0.52	−10.0	+0.24	24.1	−0.19

Table 2 – Parameters of the Southern δ-Aquariids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work). Given are average values for the whole activity interval, and values for the two segments up to and after 138° solar longitude.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	126	—	341.6	+0.9	−13.9	+0.3	42.0	—
IMO 2012	126	117–165	339.7	+0.83	−16.6	+0.34	43.8	−0.15
IMO 2012	126	117–138	339.7	+0.80	−16.4	+0.21	44.1	−0.34
IMO 2012	152	139–165	1.3	+0.82	−7.7	+0.41	41.0	−0.04

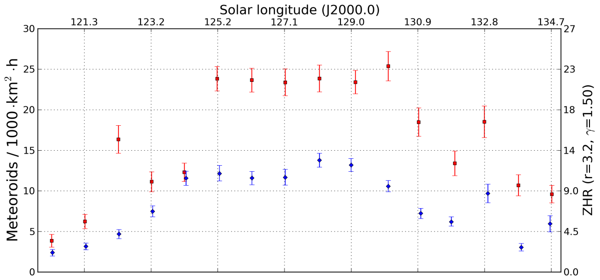

Figure 3 – Comparison of the Southern δ-Aquariid flux density profiles of 2011 (blue diamonds) and 2012 (red squares).

are quite uncertain – only between July 16 and August 10 can the shower be identified unequivocally. The parameters in Table 1 were derived from over 6 000 shower members. Already in the 2009 analysis (Molau & Rendtel, 2009) we had found a significant reduction of meteor shower velocity by 0.18 km/s per day (or more precise: per degree in solar longitude). That values is confirmed by our latest analysis.

3 Southern δ-Aquariids

Also in case of the Southern δ-Aquariids there are large deviations in the 2011 and 2012 data sets (Figure 3). Even though the activity plateau between 125° and 130° solar longitude can be found in both years, the peak flux density in 2012 is about twice as high as in the year before. We do not yet have any reasonable explanation for this phenomenon. Given the size of the data sets, individual cameras like the Australian Gocam1 (which had to pause in 2012) cannot have such a strong influence. Also when zenith exponent other than 1.5 is chosen, the result is still the same.

In the current meteor shower analysis, the Southern δ-Aquariids (5 SDA) can be safely detected between July 20 and September 8 (Table 2). At this time, both the radiant position and the meteor shower velocity yield a consistent picture with almost no scatter. Thanks to the large data set of over 13 000 meteors, we can even detect fine structures within the activity interval. The declination, for example, is not growing constantly, but by 0.2° per day between 117° and 138° solar longitude, and by twice that amount thereafter. Also the shower velocity is not constant. The details for both segments are given in Table 2 as well.

4 Minor showers of July

Let us now have a look at further meteor showers that we found in our recent analysis. We only list showers which can be regarded as save detections based on their parameters. Additional candidates of more questionable nature can be found at `http://www.imonet.org/showers`.

4.1 Microscopids

As their name suggests, the Microscopids (370 MIC) are a southern meteor shower. We can track them from end of June until mid-July with only little scatter in the parameters. The activity profile shows no clear peak – the highest flux density is reached at the beginning of the activity interval. Table 3 compares our data from more than 500 meteors derived parameters with the values from the MDC list. They are in very good agreement.

4.2 July Pegasids

The activity interval of the July Pegasids (175 JPE) starts on July 5. Already five days later the shower reaches highest activity, but it still can be tracked until early August in our data. Based on more than 2 100 shower meteors, we see some variation in the meteor shower velocity, but almost none in the Right Ascension and Declination values. So it is even more remarkable that there is significant deviation from the values given in the MDC list (Table 4).

4.3 July γ-Draconids

The slow July γ-Draconids (184 GDR) can be detected in an interval of 6 days only, but still more than 700 meteors were assigned to that shower. Peak activity is reached on July 28/29. The radiant shows almost no drift in the activity interval, and our parameters match very well to the values from the MDC list (Table 5).

Table 3 – Parameters of the Microscopids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	104	—	320.3	—	−28.3	—	39.6	—
IMO 2012	105	98–111	320.0	+1.1	−26.7	+0.15	40.8	−0.07

Table 4 – Parameters of the July Pegasids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	108	—	340.0	—	+15.0	—	62.3	—
IMO 2012	108	103–131	347.6	+0.82	+11.0	+0.23	67.5	−0.03

4.4 Southern ι-Aquariids

Given that the Southern ι-Aquariids (3 SIA) are an established MDC meteor shower, it is quite difficult to detect them in our data. In fact, there are two different showers which are similar to SIA. One of them is active between July 21 and August 8. Our more than 1 000 shower meteors, the derived parameters deviate significantly from the MDC data (Table 6). The maximum occurs earlier, the shower is slower and the radiant lies north-west of the expected position. The second shower, which is based on 500 meteors, shows a better agreement with respect to peak date and velocity, but it still lies eight degrees north of the expected position. Both showers show significant scatter in their parameters. Maybe they represents a rather diffuse radiation area.

4.5 η-Eridanids

The η-Eridanids (123 ERI), another established shower in the MDC list, can be detected between July 26 and August 15. The radiant appears even two to three days earlier and later in our data, but with strong deviations. There is no clear activity peak, which is why the data in Table 7 are given for the center of the activity interval. The radiant position, which is derived from over 1 900 shower meteors, shows only little scatter. The velocity varies a little stronger, but a systematic drift during the activity interval is not found.

4.6 α-Triangulids

We have no unequivocal detection of the α-Triangulids (414 ATR) in our data. There is, however, a shower between July 26 and August 20 which shows some similarities. The activity profile shows no clear peak, which is why the shower data in Table 8 derived from over 4 100 meteors are given for the center of the activity interval. While the right ascension is equally growing, there is stronger scatter in declination and meteor shower velocity. With a rank of 6, however, this shower can be regarded as a safe detection.

Possible new showers

Finally there are once more two new shower candidates (Table 9). The first shower is derived from about 450 meteors and active at the middle of the month. It has only a rank of 18, but just small scatter in the shower parameters. The second shower is based on over 600 meteors and occurs in the last third of July.

Both showers are fast and show no sign of a drift in meteor shower velocity. As soon as there is independent confirmation for these, we will report them to the MDC.

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Table 5 – Parameters of the July γ-Draconids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	125	—	280.1	—	+51.1	—	29.6	—
IMO 2012	125	122–127	280.6	+0.0	+50.8	+0.1	26.6	−0.06

Table 6 – Parameters of the Southern ι-Aquariids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work). Neither of the two shower candidates fits particularly well to the MDC data.

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	132	—	333.9	+1.1	−16.5	+0.2	36.6	—
IMO 2012	127	118–135	316.1	+0.58	−10.6	+0.26	29.1	+0.26
IMO 2012	132	130–135	329.1	—	−8.3	—	32.4	—

Table 7 – Parameters of the η-Eridanids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	138	—	45.0	—	−12.9	—	65.0	—
IMO 2012	133	123–142	40.1	+0.82	−12.3	+0.41	66.6	+0.03

Table 8 – Parameters of the α-Triangulids from the MDC Working List (Meteor Data Center, 2012) and the analysis of the IMO Network 2012 (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
MDC	120	—	28.9	—	+28.1	—	71.9	—
IMO 2012	135	123–147	44.3	+1.10	+37.6	−0.22	67.9	+0.07

Table 9 – Parameters of two possible new meteor showers from the analysis of the IMO Network 2012. (this work).

Source	Solar Longitude		Right Ascension		Declination		V_∞	
	Mean [°]	Interval [°]	Mean [°]	Drift [°]	Mean [°]	Drift [°]	Mean [km/s]	Drift [km/s]
IMO 2012	110	106–115	33.8	+0.8	+7.9	+0.3	68.9	—
	121	118–129	42.2	+0.73	+10.0	+0.25	69.0	—

Table 10 – Observers contributing to 2012 July 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	13	46.2	31
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	20	98.0	493
			Hulud2 (0.75/6)	4860	3.9	1103	20	79.9	293
			Hulud3 (0.75/6)	4661	3.9	1052	20	65.1	225
BIRSZ	Biro	Agostyán/HU	Huago (0.75/4.5)	2427	4.4	1036	23	103.4	315
BOMMA	Bombardini	Faenza/IT	Mario (1.2/4.0)	5794	3.3	739	31	188.5	937
BREMA	Breukers	Hengelo/NL	Mbb3 (0.75/6)	2399	4.2	699	19	62.5	231
			Mbb4 (0.8/8)	1470	5.1	1208	20	65.7	193
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	25	77.3	234
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	21	75.2	271
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	29	145.6	501
			Bmh2 (1.5/4.5)*	4243	3.0	371	27	99.1	365
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	31	158.7	825
			C3P8 (0.8/3.8)	5455	4.2	1586	25	95.9	454
			Stg38 (0.8/3.8)	5614	4.4	2007	27	132.7	1189
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	17	35.4	176
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	29	169.9	797
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	29	182.0	945
			Templar2 (0.8/6)	2080	5.0	1508	29	183.8	741
			Templar3 (0.8/8)	1438	4.3	571	29	172.9	511
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	26	133.9	555
			Orion3 (0.95/5)	2665	4.9	2069	23	111.8	291
			Orion4 (0.95/5)	2662	4.3	1043	26	112.9	327
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	7	27.3	356
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	26	125.0	336
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	30	152.1	481
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	29	164.1	395
		Sopron/HU	Husop (0.8/6)	2031	3.8	460	22	92.3	588
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	28	124.1	314
KACJA	Kac	Kostanjevec/SI	Metka (0.8/8)*	1372	4.0	361	6	30.7	38
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	23	97.4	199
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	15	70.3	430
			Rezika (0.8/6)	2270	4.4	840	14	64.1	455
			Stefka (0.8/3.8)	5471	2.8	379	14	64.7	366
KOSDE	Koschny	Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	17	51.0	240
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	11	16.0	55

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

Code	Name	Place	Camera	FOV [°^{2}]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Meteors
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	22	89.3	170
			Pav36 (1.2/4)*	5732	2.2	227	26	114.4	484
			Pav43 (0.95/3.75)*	2544	2.7	176	22	100.0	197
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	17	85.2	447
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	13	55.8	671
			Mincam1 (0.8/8)	1477	4.9	1084	25	95.8	386
		Ketzür/DE	Remo1 (0.8/8)	1467	6.0	3139	27	89.8	759
			Remo2 (0.8/8)	1475	5.6	1965	24	90.0	371
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	26	135.7	319
OCAFR	Ocaña Gonzáles	Madrid/ES	Fogcam (1.4/7)	1890	3.9	109	25	128.3	214
OCHPA	Ochner	Albiano/IT	Albiano (1.2/4.5)	2944	3.5	358	24	49.7	247
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	27	79.1	417
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	27	134.8	847
PUCRC	Pucer	Nova vas nad Dragonjo/SI	Mobcam1 (0.75/6)	2398	5.3	2976	28	132.1	438
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	19	36.3	141
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	27	185.7	471
			Ro2 (0.75/6)	2381	3.8	459	28	189.2	502
			Sofia (0.8/12)	738	5.3	907	21	117.0	243
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	30	137.7	460
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	22	76.2	193
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	588	—	—	17	39.0	133
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	29	163.7	1191
			Noa38 (0.8/3.8)	5609	4.2	1911	28	156.6	913
			Sco38 (0.8/3.8)	5598	4.8	3306	30	162.8	1211
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	15	57.3	114
			Mincam3 (0.8/12)	728	5.7	975	24	65.9	133
			Mincam4 (1.0/2.6)	9791	2.7	552	17	61.2	79
			Mincam5 (0.8/6)	2349	5.0	1896	22	68.5	250
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	22	101.1	491
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	23	82.8	281
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	1	2.3	15
ZELZO	Zelko	Budapest/HU	Huvcse02 (0.95/5)	1606	3.8	390	6	19.4	57
						Overall	31	6 778.2	27 998

* active field of view smaller than video frame

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