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IMC 2012 announcement

New meteor showers reported

July γ-Draconids confirmed

October–November video meteors

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Front cover photo

This bright fireball was captured on 2012 January 21 at $22^{h}23^{m}$ UT from Mount Pantokrator (800 m), near the town of Corfu, Greece. The author used Canon EOS 40D and 15-mm $f/2.8$ fisheye lens for this 30 s exposure at ISO 800. Photo courtesy: Vasilis Metallinos.

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

Welcome to the 40th volume of *WGN*! In these 40 years meteor science has made enormous progress. Starting from building the basis for standardized visual observations and analysis, where the International Meteor Organization (as well as its home Journal) played a crucial role, to introduction of new technologies such as the video technique for routine observations, to shower modeling and predictions. I like to think that authors publishing in *WGN* contributed a big part in this progress and I hope they will continue to do the same in the years to come.

With this issue we are clearing some of the delays that occurred with the last couple of issues and are getting back on track with publication within the title month.

Call for Draconid articles

As always, we welcome input from our readers. With a strong Draconid meteor shower outburst just behind us, I hope we can make one issue specifically devoted to this shower. Please contact us at `wgn@imo.net` if you are interested in contributing your Draconid observing report or analysis, or if you have any other meteor-related paper in the works.

Call for photographs

Of course, we also welcome photographs suitable for covers. As you know, we can publish a colour photograph on the front cover (and occasionally on the back cover as well). Black&white versions of the photographs can be published on the back cover. If you think you have an interesting or spectacular meteor photograph that would look good on the cover of *WGN*, please offer it to us.

IMO bibcode WGN-401-editorial NASA-ADS bibcode 2012JIMO...40....1K

Janus

Cis Verbeeck [1]

2011 started off very well. On February 4, a bolide was observed by the Croatian and Slovenian video networks. Careful multi-station analysis enabled the successful recovery of a meteorite near Križevci, Croatia. While many meteor showers were observed in 2011, the Draconids in particular promised to be interesting. Several modelers had predicted two Draconid outbursts on October 8: a main peak around 20^{h} UT and a secondary one around 17^{h} UT. Though no significant increase in ZHR was observed around 17^{h} UT, the main peak was prominent in both visual and video observations, with a maximum ZHR just above 300 around $20^{\mathrm{h}}15^{\mathrm{m}}$ UT.

In September, many meteor enthusiasts took the chance to meet over a hundred fellow meteor fans at the IMC in the picturesque town of Sibiu, Romania. Once again, the attendance was very large and diverse, and so were the talks, posters and other activities. As always, the IMC proved to be the perfect place to share experiences, techniques, results and plans between amateur and professional meteor workers alike. Attending an IMC is like a virus: participants inflame each other with their enthusiasm, and soon are struck by meteor fever, leaving its victims full of future meteor plans... and wanting to attend the next IMC, of course.

We were very happy to count among the participants again a North American delegation led by NASA's Bill Cooke. As in Armagh, Bill stressed the importance of IMO's observations as input for his work at NASA. Though he is using video data too, the most important criterion for NASA to study the meteor hazard to rocket launches is the meteoroid flux density derived from IMO's *visual observations*. Currently, visual observations offer an unrivaled accuracy of flux densities in the right mass interval. Bill repeated this at the IMO opening reception in front of some officials including the president of the Romanian Space Agency, and in an interview with Romanian television.

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But surely visual observations will be of far less importance within a few years, with the rising star of video observations, right?
I will bet you a Leonid storm or two that visual observations will remain important within tens of years to come! The human eye contains roughly 120 million detector rods ("pixel"), which cover a field of view $\sim 180°$ wide at a limiting magnitude of up to 6.5 and a cadence of $\sim$10 frames per second processed by the brain. Although the comparison between a biological and electronic system is complicated, observers will agree that the current generation of low-light video cameras attains the sensitivity of the human eye only in far smaller fields of view. While this problem is successfully being solved by building stations and networks which combine larger numbers of narrow-field cameras, it is unlikely that such systems will provide the same spatial coverage as visual observers in the near future. Even when other techniques will surpass visual observations in all respects, we will still want visual observations for sheer continuity of data, just like the sunspot number is still the most widely used measure of solar activity (even in the space age) because much longer time series are available than for more modern measures. Hence I see a bright future for the visual observer.

What happens to all those visual data?
Much of them are soon entered in the online form on the IMO website (`http://www.imo.net/visual/report`), and are automatically included in the online activity graphs, which feature immediate but preliminary results. Data ingestion into the Visual Meteor Database (VMDB, `http://www.imo.net/data/visual`),on the other hand, is a rather slow process, but one which guarantees high quality data. Though the online form performs a few automatic syntactic checks on the input, a human observer is capable of producing a host of possible mistakes which are not easy to detect automatically, e.g.,

- If someone enters "PER KCG SDA", does it mean that all other shower meteors are classified as sporadics, or that 0 meteors of those showers were observed?
- Although "/" is supposed to mean "shower not observed" and "0" to mean "0 meteors observed", people are often confused about this convention.
- Sometimes an observer erroneously lists observing periods similar to: 1^h00^m–1^h09^m; 1^h10^m–1^h19^m; 1^h20^m–1^h29^m, etc.

These additional mistakes require human interpretation, and sometimes even contacting the observer. Rainer Arlt and a few helpers are putting a lot of their time into this kind of quality control as observations are entered in the VMDB. While it is fortunate that so many observations are received, there is a significant backlog in entering the data. If you are willing to help Rainer and his team out and devote some time to carefully *check and enter visual observations into the VMDB*, please send an e-mail to Rainer Arlt.

Before you start thinking I'm only interested in visual observations, let us talk about video. Within the last years, the IMO Video Meteor Network has become fully mature and has been an ever growing success story. Part of this is reflected in the organization of Orbit Workshops preceding the IMC in many recent years, including 2011. The IMO Video Meteor Network has been steadily growing, and now counts over 50 cameras, yielding typically about 10 000 to 18 000 meteors and 3 000 to 5 000 effective observing hours per month. Whereas meteoroid flux densities have traditionally been obtained using visual observations, Sirko Molau's new MetRec version released in 2011 allows the calculation of meteoroid flux densities from video observations. Video observations can now be processed and uploaded to the Virtual Meteor Observatory (VMO) right after the observation. The corresponding flux densities and equivalent visual ZHRs are immediately available in Geert Barentsen's online MetRec FluxViewer (`http://vmo.imo.net/flx/`).

As some observational techniques are on the rise, other ones have virtually ceased to be. Though good old photographic observations still offer superior meteor trajectories, they will soon come to an end, as Kodak — the last manufacturer of photographic film — has recently stopped its production.

Over to my main playground now: radio observations. Concurrently with the Orbit Workshop, a one-day Radio Meteor Workshop was organized. There were many new faces among the 14 participants, which were treated to a variety of topics from beginner to experienced level: basics of radio observations, description of the BRAMS interferometer system, a demo of acquisition software SpectrumLab, meteor detection software, VHF and VLF observations, Software Defined Radio, advanced analysis of radio meteor data, and plans for observing the 2011 Draconids. Engaged in a much less direct observing technique, radio meteor observers are much less organized, and no default data reduction method has been adopted yet. But knowledge and collaboration are growing.

2012 will see the first ever IMC south of Gibraltar, on the beautiful island of La Palma, which boasts one of the best night skies and observatories in the world. We hope to meet many old and new meteor friends there!

The "Asteroids, Comets, Meteoroids 2012" conference in Niigata, Japan (May 16-20), is another good occasion to meet other (mainly professional) meteor workers.

2012 will probably also welcome three new council members, proposed at the 2011 General Assembly in Sibiu. The vote will be closed soon, and we hope we can welcome Javor Kac, Paul Roggemans and David Asher as new council members. Paul agreed to act as an IMO-IMC liaison person, and has already taken up this activity with a lot of sense for initiative. Paul's contribution solves an untenable situation, where Marc Gyssens previously combined this role with the already heavy workload of Treasurer. We would like to thank Marc for all of the good work he has put into this job. As editor-in-chief of WGN, Javor Kac is an obvious candidate for the IMO council. David Asher has provided much appreciated opinions, contributions, and *limericks* within the council for many years, and was easily bribed to join the council again after a few non-council years. Meanwhile, we are happy to report that the IMC Proceedings are back on track! In the last five years, they have suffered from a significant backlog, sometimes up to several years. At present, all past IMC Proceedings have been published up to 2009, whereas the IMC 2010 Proceedings are printed and underway to the conference participants.

Happy New Year and clear skies!

Janus *was a Roman god with two faces, one looking to the past and one to the future, called upon at the beginning of any enterprise. Today he is often a symbol of re-appraisal at the start of the year.*

Letter to WGN — Some reflections on WGN and IMO

Cis Verbeeck [1]

Thanks to the devotion of Javor and his team of editors, WGN is in good shape and covers a variety of subjects. Of course, the journal's content is shaped by the contributions submitted by the meteor community, i.e., *you*. At present, most WGN papers deal with solid scientific analyses and facts. This is great, but in addition to those articles, I would like to see more *"human factor" contributions*: reports of shower campaigns and camps by local or national teams, descriptions of meteor setups, letters to WGN reflecting your thoughts, questions, or calls for collaboration on whichever meteor topic of concern to you, ... WGN gladly welcomes such contributions as a platform to connect meteor workers.

Several visual observers have indicated to me that they would like to see more *global visual meteor shower analyses* in WGN. Rainer and a few other authors do publish such an analysis now and then, but they are already over-occupied by IMO activities such as the time-consuming task of VMDB data input and quality control, and have no time for frequent global shower analyses. Though the VMDB is available for everyone to use, it is obvious that most meteor observers do not have the experience or intent to perform such an analysis themselves. However, in the previous issue, you can enjoy an interesting and detailed analysis of 30 years of Geminid observations. Similar contributions are heartily encouraged... perhaps you want to have a go at it? IMO officers will be glad to provide advice and feedback.

A philosophical note: what is IMO? Who is it for?
IMO is an organization consisting entirely of volunteers who are not paid, who even pay any extra costs involved in their IMO tasks themselves (telephone calls, transport, ...). Some people are active IMO members because they want to contribute to meteor science and knowledge, some to share with like-minded people the joy of seeing meteors in the night sky, most of them for both reasons combined. IMO is there for you: the meteor enthusiast, wishing to share his or her *passion for meteors*. Both WGN and the IMC provide an excellent platform for this. IMO has produced several derived products, such as observational databases and tools, a handbook and other publications, but its core business is bringing you in contact with your meteor fellows. This is *your* organization, and it welcomes your ideas and input for possible improvement of IMO activities. Of course, IMO also welcomes helping hands, as a lot of work is presently shared among devoted, but rather few people. My mailbox is awaiting your response!

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Conferences

International Meteor Conference 2012 — 31st edition September 20–23, La Palma, Canary Islands, Spain

Paul Roggemans

Location and period

The 2012 International Meteor Conference (IMC) will take place on La Palma, Canary Islands, Spain, from September 20th (Thursday evening) to 23rd (Sunday lunchtime). This 31st edition of the IMC will be organized by Astro Travels in collaboration with the Cabildo of La Palma Island Authority which will sponsor this event. Astro Travels is a small business managed by Ovidiu and Gabriela Vaduvescu and is specialized in organizing astronomical events and related tourist activities.

The conference room (120 seats) at Hotel Taburiente will host the lectures and the poster session of the 2012 IMC (Figure 6). This professional lecture room offers all facilities required for a modern, professional meeting.

The IMC participants will be hosted in the 3-star Apart Hotel Las Olas (Figure 5). The hotel overlooks the Atlantic Ocean and is located in a tourist resort, Los Cancajos, 5 minutes walk from the Lecture room in Hotel Taburiente. The resort is just 5 minutes away by bus from both the airport and Santa Cruz de La Palma, the capital city of the island. The Las Olas Hotel provides apartments consisting of a large bedroom (for two persons), a living room with TV and an extensible sofa (for the third person), a bathroom, an equipped kitchenette, and a balcony or patio/terraza. Triple accommodation will be the standard at this IMC, but double and single rooms are available at a small extra cost. More information is available on the conference website, `http://www.imo.net/imc2012`.

The IMC program and social events

As in previous years, the possibility is offered to organize workshops preceding the IMC, on Thursday September 20th. Any such workshop will be held at Hotel Las Olas. Conference room and participation are free of charge.

The IMC starts with a Welcome Reception in Hotel Las Olas on Thursday at 19:00. The lecture sessions will run from Friday morning till Sunday noon. Participants are encouraged to contribute with a lecture or a poster on visual, photographic, video or radio observations, fireballs, orbit determination, stream modeling, meteor physics, parent bodies, observing expeditions, or anything else related to meteors and their observation.

All lectures and posters must be announced properly, preferably on the Registration Form upon registering. In order to improve the quality of the presentations and to avoid delays with the IMC Proceedings, we ask that, for each presentation— be it a lecture or a poster—the paper is written prior to the IMC and sent to the IMO, c/o Paul Roggemans. The instructions for IMC Proceeding papers and posters can be found on the IMC 2012 website (in the menu, look under "Program" for "Lectures & Proceedings").

On Saturday, September 22nd, the IMC 2012 participants will have the opportunity to visit the Roque de los Muchachos Observatory (ORM) (Figure 7), known as the European Northern Observatory. The visit will include the Gran Telescopio de Canarias (GTC 10.4 m, the largest optical telescope in the world today, Figure 10), the William Herschel Telescope (WHT 4.2 m, Figure 8) and the gamma-ray MAGIC telescopes (2×17 m, Figure 9).

How to get to La Palma?

Please make sure to use SPC as airport code for Santa Cruz de La Palma because there are many confusions about the name! You can either fly directly to La Palma (either daily from Madrid or weekly from a few other European cities) or via the neighbouring islands of Tenerife and Gran Canaria (including low-cost air travel) from where you can take a local flight or ferry to La Palma. European travelers must expect to pay between 200 and 400 Euros round trip.

There are two airports on Tenerife: "Los Rodeos" (airport code TFN) in the North and "Reina Sofia" (TFS) in the South. They are served by many low-cost airlines (especially, the southern Reina Sofia "TFS" Airport) with direct flights from many cities in Spain, England, Germany, the Netherlands, France, Ireland, Italy, Luxemburg, Switzerland, the Czech Republic, Poland, Russia, and Portugal, to name just a few countries.

When you fly to the southern Reina Sofia "TFS" Airport, you may consider taking the ferry to La Palma from the South Harbour "Los Cristianos" (after 18:00, but not daily, circa 3-hour trip) or you may consider taking the bus to the northern Los Rodeos "TFN" Airport from where many local flights depart to La Palma (every hour or half hour, until 20:30). Notice that the Los Rodeos "TFN" Airport is only served by domestic flights! There are two local airlines in the Canaries: Binter Canarias and Islas Airlines. Both operate flights from Tenerife to La Palma, but only from the northern Los Rodeos "TFN" Airport. There are also many direct low-cost flights

Figure 1 – The Canary Islands.

Figure 2 – The IMC 2012 logo.

Figure 3 – The IMC location close to the international airport and Santa Cruz, the capital of the island.

Figure 4 – The Los Cancajos resort with the IMC host Las Olas and the lecture venue Taburiente.

to Gran Canaria (airport code LPA) from cities in European countries such as England, Germany, Netherlands, Ireland, Denmark, Norway, Finland, Switzerland, Belgium, Austria, the Czech Republic, Italy, and Russia, From the same Gran Canaria Airport you have direct flights to La Palma (17:30, 19:00, 19:20, and 20:00).

Your IMC 2012 accommodation, the workshop(s), and the accommodation for the optional tourist packages are all in the Apart Hotel Las Olas, while the actual Conference takes place in Hotel Taburiente (see Figures 3 and 4). Both hotels are very conveniently located in the tourist resort Los Cancajos, at only 5 minutes by car from both the airport and the capital city of Santa Cruz de La Palma. A taxi ride, which can be shared, costs approximately 7 Euros by taxi. Alternatively, you can take a bus for 1.30 Euro per person. Buses run every half hour during business days and every hour during weekends. Within Los Cancajos, everything is within an easy 5-minute walking distance. A detailed PDF document with traveling advice can be downloaded from the conference website `http://www.imo.net/imc2012` from the page "Getting there".

Flights are cheap if booked early. Unfortunately, many IMC participants tend to register late. Booking late for La Palma may result in considerably higher traveling costs. For 2012, we therefore strongly recommend not to postpone your registration, and book your flights as early as possible!

Figure 5 – The 2012 IMC host: Hotel Las Olas.

Figure 6 – The 2012 IMC lecture hall in the four-star hotel Taburiente, a 5 minutes walk from Hotel Las Olas.

Figure 7 – The Roque de los Muchachos Observatory (ORM).

Figure 8 – The William Herschel Telescope dome.

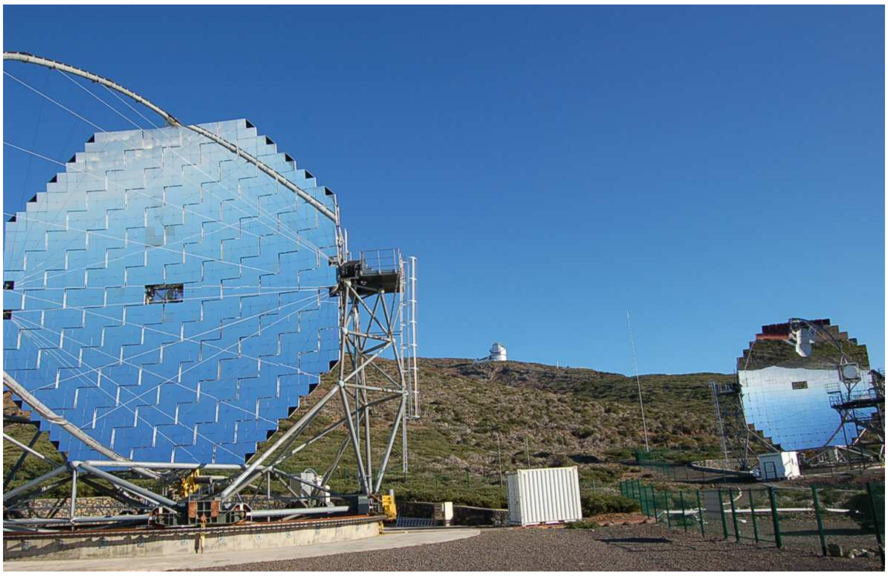

Figure 9 – The gamma-ray MAGIC telescopes (2×17 m).

Figure 10 – The GTC telescope (Gran Telescopio de Canarias, 10.4 m).

Combining the IMC with vacation, tourism and another conference

Given the fascinating beauty of La Palma, the traveling efforts for this IMC may have added value if you combine the IMC with some extra holidays. During the days before the IMC, the organizers offer several optional excursions to visit the most extraordinary places of the island. Please check the IMC website for these offers (in the menu, look under "Conference" for "Tourist Tips"). New Moon on September 16th offers plenty of observing opportunity under the fabulous sky of the Canary Islands. A night excursion for this purpose is offered too.

In addition, this IMC precedes the 2012 EPSC which is organized from September 24th to 28th in Madrid, Spain, which will be on the way home from La Palma for most participants. This offers both amateurs and professional astronomers the possibility to optimize traveling efforts and costs to attend both the IMC and EPSC. See also http://www.europlanet-eu.org.

Registration

The standard registration fee is 155 Euros (170 Euros after June 30th). This covers presentations, proceedings, the conference excursion, a T-shirt and conference materials, all meals from the Thursday evening reception to the Sunday noon lunch, and hotel accommodation for 3 nights (in principle, Thursday night till Saturday night). For this fee you will share an apartment with two other IMC participants (triple occupancy). A double room during these three nights can be requested for a supplement of only 15 Euros for the entire period and a single room for a supplement of only 65 Euros. **If you want to share your room with an accompanying person, he or she must also register and pay as a participant!**

Finally, if you wish to arrange your own accommodation, the registration fee amounts to 100 Euros (115 Euros after June 30th). It covers all the benefits of the previous options (in particular, also the lunches and dinners), except for accommodation and breakfasts.

Regardless of the option chosen, lunches and dinners are at the same place for all participants, at the buffet restaurant of Hotel Las Olas.

To register, please visit http://www.imo.net/imc2012 and fill out the registration form. You will then be automatically directed to the page with payment information. Only if you do not have internet access, you can fill out the paper registration form.

Your registration will be valid after receipt of the **full registration fee** (and at least 50% of the extras). (We do no longer accept advances on the registration fee to secure your IMC registration[1]). The required amount is due within two weeks after registering to validate your registration. You will receive system-generated confirmation e-mails for both receipt of your registration form and receipt of your payment. For further questions regarding registration and payment, please contact the IMO Treasurer, Marc Gyssens (treasurer@imo.net).

Cancellation policy for the registration fee

The cancellation policy for the registration fee (not taking into account extra nights or tourist packages ordered) is determined as follows:

- before July 1st, 2012: full reimbursement, reduced with a cancellation fee of 15 Euros;
- between July 1st, 2012, and August 19th, 2012: partial reimbursement of 75 EUR (regardless of the registration/accommodation option chosen).
- from August 20th onward: no reimbursement.

Please check the IMC website for the cancellation policy for the extras (extra nights and tourist packages).

Further information and contact details

For all further information, latest updates, etc., please check the IMC 2012 web pages:
http://www.imo.net/imc2012.

You can also contact the organizers via e-mail:
imc2012@imo.net
or:

- LOC-coordinator: Gabriela Vaduvescu, +34-677-284-622 (mobile), +34-922-107-759 (fixed line);
- Assistant coordinator: Ovidiu Vaduvescu, +34-677-284-742 (mobile), +34-922-107-759 (fixed line);

IMO bibcode WGN-401-roggemans-imcann NASA-ADS bibcode 2012JIMO...40....4R

[1]The IMC registration fee is calculated as sharp as possible. In the recent past, we witnessed an increasing amount of late cancellations or no-shows. Therefore, we had to change our payment policy to ensure that the Local Organizers can honour their commitments to the hotels and other providers of services.

International Meteor Conference
La Palma, Spain, 2012 September 20–23
Registration form

Do not use if you have internet access! Please register electronically on `http://www.imo.net/imc2012` if you can. Only if you have **no** internet access, fill out one form for each individual participant and return it to Marc Gyssens, IMO Treasurer, Heerbaan 74, B-2530 Boechout, Belgium, as soon as possible. Registration will be guaranteed only after Marc Gyssens has received the full registration fee for the option chosen. We expect this payment to arrive within two weeks after the form.

Name: ______________________ Address: ______________________

____

____

Phone: ______________ Fax: ______________ E-mail: ______________

- I wish to register for the IMC 2012 from September 20 to 23:
  - ○ I opt for the standard fee (155 EUR early/170 EUR late);
  - ○ I opt for arranging my own accommodation (100 EUR early/115 EUR late).
- I prefer a triple room (no supplement) and share a room with ______________(if applicable).
- I prefer a double room (add 15 EUR) and share a room with ______________(if applicable).
- I prefer a single room (add 65 EUR).
- T-shirt: Size (S-M-L-XL): ________ Gender: ________ (included in fee)
- Food requirements (e.g., vegetarian, nut allergy): ______________
- I intend to travel by ________, together with ______________

For participants wishing to contribute to the program:

Lecture: ______________________________

Requirements: ______________________________

Duration: ________ minutes (including a few minutes for questions and discussion)

Workshop: ______________________________

Poster(s): ______________________________ Space: ________ m^2

Comments:

○ I am paying the entire registration fee for the option selected.

○ I acknowledge having read and I agree with the cancellation policy.

The indicated amount should be sent to IMO Treasurer, Marc Gyssens. The following payment options are available:

- **International bank transfer** to the International Meteor Organization, Mattheessensstraat 60, B-2540, Hove, Belgium, IBAN account number: BE30 0014 7327 5911, BIC bank code: GEBABEBB (Fortis Bank, Belgium). This is recommended for people living in the European Union, as it is no more costly than a domestic bank transfer when done correctly.
- **PayPal payment** to `payment@imo.net`. In that case, we must ask you to add the costs involved in the transaction (3.4% of the total sum including costs, plus 0.35 EUR).
- **Other arrangements**. Please contact the IMO Treasurer for information.

Financial support for IMC 2012 participants

Jürgen Rendtel, Paul Roggemans, and Marc Gyssens

As during previous years, IMO is making limited funds available to support participation in the *IMC* 2012. To apply for support, please e-mail your application to IMC Liaison Officer Paul Roggemans at `paul.roggemans@gmail.com`.

In order to be eligible for support, the following conditions must be satisfied:

1. The application must be submitted by an IMO member, but may also request support for other meteor workers.
2. The proposal must state that all the candidates for whom support is requested are committed to attend the *IMC* (except for unforeseen circumstances) if the requested support is granted in full.
3. Each person for whom support is requested must fill out an *IMC* Registration Form (preferably electronically) prior to filing the application. In the "Comments" box of the application, the person must specify that support will be requested as well as the name of the IMO Member who will file the application.
4. For each person for whom support is requested, a brief curriculum vitae must be included, focusing on aspects relevant to meteor work.
5. Each person for whom support is requested is expected to present either a talk or a poster at the *IMC*. He or she should indicate and detail this on the Registration Form.
6. The application must contain the full paper of each talk and/or each poster intended for presentation, in PDF format.
7. The application must explain the motivation for participating in this *IMC* and the importance of this participation to the person or group of persons for whom support is requested.
8. The application must include a budget for travel costs and registration, and the amount of support requested. Other sources of external support, or their absence, must be mentioned. The proposal must also indicate to what extent IMO support is essential to attend the *IMC*.

Failing to address in full detail each and every of the above items in the application will result in its rejection without further consideration.

The applications should reach Paul Roggemans no later than Tuesday, 2012 May 1. The IMO cannot be held responsible for applications which are lost or arrive late.

The IMO Council will endeavor to communicate its decision within two to three weeks after this deadline. If the requested support is granted in full, the registration of all candidates involved becomes final. If the requested support is not granted, or only partially granted, the candidates involved should inform Paul Roggemans within two weeks after notification of the IMO Council's decision if they want to sustain or withdraw their registration. Most likely, the support will consist of waiving registration fees, which will be settled directly between the IMO and the Local Organizers. Any additional support, if granted, will be paid in cash at the *IMC*. It is not possible to get an advance on such additional support before the *IMC*.

Should the application be turned down, the 'early' registration fee (i.e., without the surcharge for a late application) will still apply provided the applicant settles this fee within two weeks after the notification of the rejection.

We strongly encourage all serious meteor workers who want to attend the *IMC* 2012, but who are prevented from doing so by financial considerations, to apply for support.

IMO bibcode WGN-401-rendtel-imcsupport NASA-ADS bibcode 2012JIMO...40....9R

Call for Future International Meteor Conferences

Jürgen Rendtel, Paul Roggemans, and Marc Gyssens

The IMO Council invites candidate International Meteor Conference (IMC) organizers to present their proposal. To give interested parties the full opportunity to prepare themselves properly, it is important to plan future IMCs well in advance. For this purpose, the IMO offers a guide to prospective IMC organizers, the *IMC Essentials*, which describes in detail all aspects of organizing an IMC. First and foremost, potential organizers should use this guide to discern what is essential in organizing an IMC from what is secondary or even undesirable. In addition to a scenario for organizing an IMC, the *IMC Essentials* contain useful documents, templates, and detailed statistics on past IMCs answering most questions future IMC organizers may encounter.

The 2012 IMC will take place from 20 to 23 September on the island of La Palma of, which is one of the Canary Islands, an archipelago belonging to Spain. It is the IMO Council's intention to have the 2013 IMC organized in conjunction with the professional conference "Meteoroids 2013" at the end of August 2013 in Poznan, Poland. However, international conferences require careful planning long in advance. So, proposals for 2014 and beyond can already be made now! Remember that the earlier we know of your plans, the better we can assist you in the preparation should your offer be accepted by the IMO Council!

Typically, an IMC takes place around the third week of September, from Thursday evening (arrival of the participants) to Sunday lunch time (departure of the participants).

Proposals should be sent to the IMC Liaison Officer, Paul Roggemans (`paul.roggemans@gmail.com`), preferably in PDF-format, no later than 1 June, 2012. Typically, proposals for a future IMC are discussed at the General Assembly Meeting at each IMC, so in this case in September at the 2012 IMC on La Palma. The IMO Council will take advantage of the intermediate time between 1 June and the IMC to ask for clarifications and/or additional information from the candidate organizers, so that all the necessary information is available before the start of the 2012 IMC.

From past experience, we know it is often difficult to choose between several proposals. If several proposals merit acceptance, the Council will ask the unfortunate candidates to retain their candidacy for the next edition. If in the next round the Council must decide between proposals of equal merit, priority will be given to the older one(s).

Organizing an IMC involves a wide range of organizational and financial responsibilities. All these aspects are described in full detail in the *IMC Essentials*. In it, you will find complete examples of past IMC proposals and budgets. Once again, make sure you carefully read these *IMC Essentials* before offering your candidacy to organize a future IMC! Before applying to become a candidate IMC organizer, make sure you can answer the following questions:

1. **Who are you?** Who is going to be the local organizers? Which local, regional, or national astronomical organization(s) is/are backing you up? What is your experience with meteor work? Have you been involved in past IMCs, as passive/active participant or as co-organizer? Do you or the organization(s) to which you belong have experience in organizing events that can be compared to an IMC? Can you rely on a coherent team to act as Local Organizing Committee? Mind that it is impossible for a single person to manage all aspects of an IMC!

2. **Why do you want to do it?** What is your motivation to be a candidate to organize an IMC?

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

4. **At what venue are you going to hold the IMC?** Preferably, lectures and accommodation should be under the same roof, but there is no real objection to the lecture room being at a separate location within easy walking distance from the accommodation. Do you have a faithful description of the accommodation at your disposal that gives a clear idea to other persons what you have in mind? Do you have an offer from the hotel and/or the institution providing additional accommodation to prove that the venue you propose is indeed available and that the price is within the limits of your budget (see below)? Can you provide a few pictures of the accommodation, or, a web link to such pictures? Not surprisingly, a suitable and available accommodation is the most important key to hosting an IMC.

5. **What will it cost?** Can you provide a preliminary budget for the IMC proposed, including all sources of income, in particularly sponsors or subsidies? Take into account that the price per participant should not exceed 150 EUR by much. Of this amount, 10 EUR must be reserved for producing and mailing the (post-)proceedings to the participants. With respect to the expenditures, take into account that the participants must be offered full board from Thursday evening, dinner, up to Sunday, lunch, inclusive. Of

course, lecture room facilities should be accounted for, as well as a coffee break in the morning and in the afternoon. Finally, it is also customary to have a half-day excursion, usually on Saturday afternoon. Of course, future prices cannot be known at the time an IMC is planned. It is customary to start from current prices and adding to them a reasonable margin to account for inflation and, if applicable, currency exchange differences between the Euro (the currency used to set registration fees) and your local currency (in which you have to pay your providers).

Note that, although the IMO provides the service of collecting the registration fees for you, the IMO will in principle *not* cover any negative balance that you might incur, so, please, draft your budget responsibly! A realistic budget for your proposed IMC is essential. An IMC proposal not containing a serious financial planning will not be considered.

6. **Can it also be done in a later year?** We can only have one IMC every year. It is therefore important for us to know if you can also make this offer in a subsequent year. So, ask yourself whether this is possible! If you think it is not possible, ask yourself whether your arguments are rational as opposed to emotional. It is imperative that you answer these questions honestly. Of course, we understand that you are keen to organize the next IMC to be assigned, but knowing the real time constraints of all the candidates is a serious help for the Council to make the best decision possible!

If you are interested in applying for the local organization of the 2013[1] or 2014 IMC, or for later editions of the IMC, please email your intention to the IMC Liaison Officer as soon as possible, and before 1 June, 2012. Even though such a declaration of intent is not a formal commitment, it is an indication for the IMO Council as to how many applications may be expected. Based on this information, the Council may actively solicit additional candidacies.

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

We hope to receive many candidacies!

IMO bibcode WGN-401-rendtel-futureimcs NASA-ADS bibcode 2012JIMO...40...10R

[1]But mind what has been said about the 2013 IMC above!

Details of the Proceedings of the International Meteor Conference, Armagh, Northern Ireland, 2010

D.J. Asher, A.A. Christou, P. Atreya and G. Barentsen

The IMC 2010, preceded by the Fireball Data Workshop, was organized in Armagh. It was attended by many active meteor workers from around the world. Finally the Proceedings are ready. The volume contains many papers on observational projects and their results, and additionally papers in the nature of reviews, theory and more. Following are the abstracts of all the contributions.

Those who attended the Conference will receive the Proceedings shortly. 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.

Cascading fragmentation of comet 73P/Schwassmann-Wachmann 3

A. Abedin and T. Bonev

We present results from numerical backward integrations of the fragments' orbits of the comet 73P/Schwassmann-Wachmann 3 (SW3). The main purpose of the work is to identify the progenitors, fragmentation sequence and hierarchy of "second-generation" fragments, produced during the 2006 outburst of the comet. We first compare our results for "first-generation" fragments (produced during the 1995 apparition of the comet) with the results of Sekanina (2005) and then proceed forward with the identification of the parent bodies of ten major "second-generation" fragments, namely G, H, J, K, L, M, N, P, Q and R. We then build the fragmentation tree for SW3 upon Sekanina's, derived by his multi-parameter model (Sekanina, 2005) for the 1995 outburst of the comet. This could be considered as a continuation of Sekanina's fragmentation tree for fragments produced during the 2006 outburst of the comet.

French Meteor Network For High Precision Orbits of Meteoroids

Prakash Atreya, Jeremie Vaubaillon, Francois Colas, Sylvain Bouley, Boris Gaillard, Ivan Sauli, Min-Kyung Kwon

The French meteor team have developed a new large CCD camera with electronic shutter system. The large size of the CCD gives better spatial resolution, and the electronic shutter gives higher temporal resolution, and with the combination of both, provides better accuracy in orbits of meteoroids. Precise orbits are necessary to compute the dust flux in the Earth's vicinity, and to estimate the ejection time of the meteoroids accurately by comparing them with the theoretical evolution model. Various problems faced due to the use of a large CCD, such as increasing the spatial and the temporal resolution at the same time and computational problems in finding the meteor position, are illustrated.

Perseids and Geminids 2009

Rafael G. Barrios B.

Observers from ALDA (Asociación Larense de Astronomía) obtained visual data during the 2009 Perseid and Geminid showers, contributing to the activity profiles determined from observations worldwide. Several hundred meteors were visually classified by colour and these results are presented here. In the future we aim to increase the participation of observers in Venezuela.

Digital All-sky cameras VI: Camera design

Felix Bettonvil

In this sixth paper about the development of a digital All-sky camera the final design is described. The camera is based on a Canon EOS 350D, Sigma 4.5mm/F2.8 EX DC fisheye lens and a LC-TEC liquid crystal optical chopper.

IMO bibcode WGN-401-asher-proceedings NASA-ADS bibcode 2012JIMO...40...12A

Visual Observation of Meteors in Nepal

S. Bhattarai

This paper deals with the meteor works and the leading role of Nepal Astronomical Society (NASO) for meteor astronomy in Nepal.

Meteor Shower observations from the Indian Sub-Continent (Visual, Photographic and Radio)

Raka Dabhade, Vaibhav Savant and Jaydeep Belapure

We review the present status of meteor shower observing from the Indian sub-continent. Some amateur groups are active in visual observations, although they are restricted by the lack of good observing sites. Ham radio appears to be promising as a technique to monitor the major meteor showers in this region. We present radio observations of the 2006 Quadrantids.

Modern models of meteoroid fracture

L. Egorova

A body moving in a planetary atmosphere is under the influence of the aerodynamic loads, the forces of inertia and the heat flux. As a result, the body undergoes ablation and even could be completely destroyed. In the present investigation we start by determining the stress state within the body. We use an analytical solution to calculate the stress state, and we assume that destruction starts at the moment when the stress achieves the critical value within the body. The thermoelastic state is also evaluated, and turns out to be significant for small particles or for the debris of a body. Finally, *thermal explosion* phenomena due to the rapid evaporation of a cloud of small fragments, with a typical range of sizes of fragments, were considered.

The California All-sky Meteor Surveillance (CAMS) System

Peter S. Gural

A unique next generation multi-camera, multi-site video meteor system is being developed and deployed in California to provide high accuracy orbits of simultaneously captured meteors. Included herein is a description of the goals, concept of operations, hardware, and software development progress. An appendix contains a meteor camera performance trade study made for video systems circa 2010.

Determination of meteor influx (Index of meteor activity) for August–December 2006

A. P. Kartashova

The results of single station TV observations for the period from August to December 2006 are presented. The high-sensitivity hybrid TV camera FAVOR (with 1380 × 1024 pixel CCD giving field of view $20^\circ \times 18^\circ$) was used for observation of meteors up to 9^{m}. There were 3734 meteors detected during that period. The distributions of the meteor influx rate (Index of meteor activity) to the Earth for August to December 2006 are calculated. IMA varies from $84{*}10^5$ to $1{*}10^5$ (particles to the Earth per hour) during this period. The distributions of strong shower meteors by brightness are presented.

Measurements of celestial coordinates of meteor events registered by TV systems

A. P. Kartashova

We present a simple method for accurate calculations of equatorial coordinates of any point in the single frame of wide-field TV systems. This method can be used for measuring of equatorial coordinates of meteor tracks under difficult conditions during the observations such as partial cloudiness, small number of stars, and large distortions of the coordinate grid in the frame.

Computer Vision in Meteor Research

Eliška Anna Kubičková

The Astronomical Institute of the Academy of Sciences of the Czech Republic requires a development of software for detection of meteors in astronomical snaps. The first step of this task is to find a suitable mathematical method for detection of meteors. Hough transformation for detection of straight lines in digital images is such a suitable method. The MATLAB processor named Image Processing Toolbox is used for implementation of the Hough transformation. The graphic user interface designed on the basis of Image Processing Toolbox is used for handling the database of meteoric snaps.

Hellenic Amateur Astronomy Association's activities: Preliminary results on Perseids 2010

G. Maravelias

Preliminary results on the Perseids 2010 are presented. Visual and video observations were obtained by the author and a first reduction of the visual data shows that a maximum of ZHR ∼120 was reached during the night 12-13 of August 2010. Moreover, a video setup was tested (DMK camera and UFO Capture v2) and the results show that, under some limitations, valuable data can be obtained.

Results from the 2010 Perseids meteor campaign using the SPOSH cameras

A. Margonis, S. Elgner, A. Christou, J. Flohrer, J. Oberst

During the Perseid meteor shower in 2010, two SPOSH cameras were deployed in the Peloponnese peninsula in Greece, monitoring meteor events for four consecutive nights starting on the 10^{th} of August. Favored by the new moon which occurred at the first observing session, the camera systems recorded 5254 single meteor events. In this paper first results from the day of the maximum meteor activity are presented, regarding trajectories and radiant positions of Perseid meteors.

RANBO: An N-Body Simulator for Radiant Determination

Julia Marín-Yaseli de la Parra

We present the RAdiant N-Body Orbit (RANBO) tool for the determination of the pre-atmospheric orbital parameters of meteors. RANBO uses an N-Body Runge Kutta integrator to determine the true radiant of the meteor. The motivation for the development of RANBO was the lack of agreement between other methods of radiant determination such as the 'standard' zenithal attraction method (Gural, 2001) or the 'Gravitational Sphere of Influence' method (Díaz del Río & Koschny, 2004). The software has been designed to interface with the Virtual Meteor Observatory, but also to function as a stand-alone tool. The architecture of the software is presented as well as initial comparative results.

A History of the SPA Meteor Section

Alastair McBeath

Details from the history of meteor observing within what is now the Society for Popular Astronomy and its Meteor Section are presented and discussed, along with the background leading to the Society's formation in 1953.

Meteor Beliefs Project: False Meteorites in Britain

Alastair McBeath and David Entwistle

An examination is made of nine prominently-located boulders in Britain which have had the belief attached to them that they originated in space, regardless of their true geological nature. Possible explanations for such a belief are noted, and a call is made for additional examples of such boulders to be reported to the authors, to help carry the investigation forwards. Some comments are also made regarding other types of pseudometeorites claimed as fallen onto the British Isles since the 7th century.

The meteor work of Ernst Öpik at Armagh Observatory

John McFarland and David Asher

Ernst Öpik was one of the principal organizers of the Harvard-Cornell Arizona Expedition for the Study of Meteors in the early 1930s. Öpik took the lead in the analysis of the observations, first at Tartu Observatory and finally at Armagh Observatory. We present here details of the observational method employed, a summary of the main results on meteor radiants, velocities, heights and directions, a description of the Vibrating Meteor Camera devised later by Öpik at Armagh, and some personal recollections about Öpik by one of the authors.

Wide-Angle TV-Observations of Bright Perseids in 2007-2009 and Risk in Space

A. Murtazov

Results of the 2007-2009 bright Perseids CCD-observations are presented. Collision risk with space vehicles is calculated.

Meteoroid spatial number density and flux calculation with video meteor observation. I.

F. Ocaña, J. McAuliffe and D. Koschny

An algorithm to compute meteoroid flux densities and spatial number densities from video observation data is presented. It expands on the photographic method of Bellot Rubio (1994, WGN, 22, 118) which itself is adapted from the visual method of Koschack and Rendtel (1990, WGN, 18, 44). An analysis of the different sources of errors is performed in an attempt to standardise the calculation of incoming fluxes. Initial results are presented and areas in need of focused investigation are discussed.

Setting-Up a Fireball Detection Station at UCM Observatory

F. Ocaña, J. Zamorano, A. Sánchez de Miguel, J. Izquierdo, E. Manjavacas, P. Ramírez-Moreta, R. Ponce

UCM Observatory is the urban teaching observatory of Universidad Complutense de Madrid. In 2010 a fully-equipped fireball detection station has been completed as a node in the SPanish Meteor and Fireball Network (SPMN). The station is quasi-automatic and covers the whole sky with 6 cameras during night and day with a plate scale of ~7 arcmin/pixel. We introduce here the Fireball Research Group, its facilities and some results of our first 2 years of activity.

The Colorado All-Sky Camera Network

C. Peterson

We report on nine years of operation of a video all-sky camera network in Colorado, USA, with cameras hosted by schools and operated by student volunteers. The system utilises readily available and inexpensive instrumentation and software, and provides numerous educational opportunities for the operators as well as returning valuable meteoritic data.

OASES "Over us All is the SElfsame Sky"

M. D. Popescu

This is a short review of the OASES science, art and peace educational programme, highlighting its astronomy aspects and the children's meteor-inspired performance and exhibition shown at the International Meteor Conference held in Armagh in 2010.

Croatian Meteor Network: data reduction and analysis

Denis Vida and Filip Novoselnik

During 2010, the Croatian Meteor Network's software and data reduction pipeline was greatly improved by introducing new processing software. In this paper we describe how the processing software works, and what the current results are, illustrated with an analysis of the Southern Delta Aquarids.

Meteor science

Four Meteor Showers from the SonotaCo Network Japan

John Greaves[1]

The SonotaCo Network Japan meteor orbit database is examined using D-criterion methods to both cross match it against comet orbits and itself revealing four possible showers.

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1 Introduction

The existence of the SonotaCo Network Simultaneously Observed Meteor Data Sets[a] was first noted in Vereš and Tóth (2010). The dataset was obtained and orbital elements were analysed according to the Jopek (1993) modification of Southworth & Hawkins' (1963) D-criterion formulation.

The entirety of the orbital elements was tested against a database of comet orbits[b] (for details see the example of Greaves (2000), when a similar analysis was conducted using the meteor orbits database of the Dutch Meteor Society for the period 1991 to 1999). A small subset was tested against themselves. In order to reduce confusion generated by the major meteor showers and also to reduce computational overhead, one to two week time periods centered upon the maxima of showers such as the Geminids, Perseids, Leonids and others were removed prior to the testing of the SonotaCo orbits against themselves. This substantially reduced the number of orbits to be checked against themselves and the number of radiants to be plotted. The number of orbits to be tested was greatly reduced from over 65000 to around 5000.

Instead of the typical D-criterion threshold of 0.15, a threshold of 0.10 was used for testing against the known comet orbits as a seed and 0.06 was used for the mutual meteor cross matching to ensure that only the best candidates were retained. Also only orbits identified as sporadic in the SonotaCo catalogues (SonotaCo, 2009) were used in the tested subset.

For the comets, each comet orbit was used as a seed against which the meteor orbits could be tested one by one. For the self-test of the meteor orbits against themselves, every orbit is tested against every other orbit. Multiple pairings can occur, such that if orbit a matched to orbit b and orbit b is matched to orbit c, not only will the match of orbits b to a and orbits c to b occur, but matches between orbits a to c and orbits c to a are also likely. However, in fact only orbits a, b and c (i.e., three individual results), were returned in the final data. This was achieved by importing the D-criterion matched orbital pairs into a relational database management package and indexing upon the local time log of each event, and then cross indexing this against a copy of itself such that only unique matches would be returned via the package's indexing function. This could then be linked back to all the data of interest for each resulting object and stored in a full database imported version of the SonotaCo dataset with the local time parameter as indices.

Objects had their observed Right Ascension and Declination, Solar Longitude, Geocentric Velocity, Perihelion Distance, Eccentricity, Inclination, Argument of Perihelion, Ascending Node, Magnitude and "local-time" logged. Some of these details were used to plot orbit diagrams whilst others were used for radiant chart plots. In the analysis each object's local time as per the SonotaCo catalogue was utilised as the object identifier.

It is reiterated that relatively more stringent criteria than usual were utilised in the analysis in order to reduce false alarms and coincidences as much as possible while still leaving a reasonable chance of not missing a weak shower. Thus it is possible that the objects listed here represent a subset of the total number of objects for each shower that can be found in the full SonotaCo database.

An attempt at assessing Zenithal Hourly Rates was initially made but abandoned since using the canonical figure of $r = 2.5$ when dealing with an unknown population index gave very large numbers. This was likely because the limiting magnitude for SonotaCo is around 2[c] with many meteors being zero magnitude and brighter. The number of bright meteors for known weak showers as well as candidate showers within the database was something of a concern but there were no means with which to assess the data for magnitude calibration accuracy.

D-criterion analyses upon orbital elements enabled an objective assessment of meteor relationships. Plotting of orbits also added an extra dimension to the space and time plotting of radiant positions upon the sky, allowing comparative assessments.

2 Results

Four showers were sufficiently well defined to likely be real. These do not appear in the full list of the International Astronomical Union AU Meteor Data Centre[d] (IAU MDC) and are summarised below. Of the many

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NASA-ADS bibcode 2012JIMO...40...16G

[a]http://sonotaco.jp/doc/SNM/

[b]Guide 8.0 CDROM (www.projectpluto.com) from a public data file of Jost Jahn

[c]http://sonotaco.com/soft/UO2/UO21Manual_EN.pdf

[d]http://www.astro.amu.edu.pl/~jopek/MDC2007/Roje/roje_lista.php?corobic_roje=0&sort_roje=0

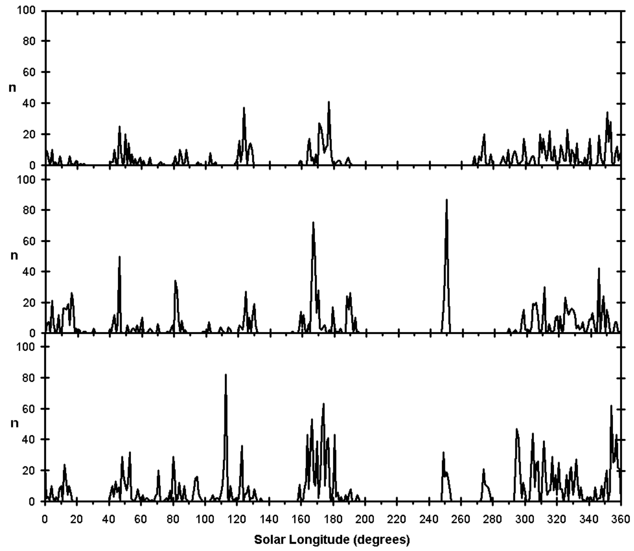

Figure 1 – For each of the years 2007, 2008, and 2009 the count per one degree bin of Solar Longitude is given with respect to the dataset of near 5000 objects analysed. In this way some idea can be gained as to whether showers absent some years yet not others were simply missed due to lack of observations.

successful cross matches against comet orbits only one appeared to be unknown previously as well as supported by a number of meteor orbits. Two further showers were of sufficient number to appear real and possessed candidates spanning more than one year. One final shower at first sight seemed real but as the number of objects was lower and only one of the three years (2007 to 2009) worth of data gave meteors it was a somewhat more tentative candidate shower.

There is also the possibility that some of the showers were only observed during a single year simply because there were no observations taken on that date for other years, whether due to no observing being done, clouds or equipment problems. Accordingly Figure 1 presents a plot for each of the individual years derived by doing a count per one degree bin of Solar Longitude. The actual count value is retained despite not being necessarily meaningful. The attempt is to demonstrate the times during each year that actually had some data and to allow some assessment of whether any of the candidate showers noted could merely have been absent just because no observations were being taken at those times.

One common feature of all four showers was their retrograde orbits, reflected in their geocentric velocities being around the 60 to 70 km/s region. Most orbits for the following showers also had aphelia extending into the outer Solar System.

The details for each particular shower are given below, complete with shower names, acronyms and number as provided by the International Astronomical Union Meteor Data Centre's Nomenclature Committee (Jenniskens, 2008). Orbit diagrams are given for each shower. The associated meteor radiants for the showers are also charted showing the local constellations, and in some cases the radiant position of any nearby IAU list meteor shower is also plotted, labelled with its IAU identity code and Solar Longitude value.

For each shower a table giving their "localtime" identifier listing the Japanese Local Time of the meteor in YYYYMMDD_hhmmss format, observed radiant Right Ascension (α) and Declination (δ) in degrees, Solar Longitude ($\lambda_{\odot}$) in degrees, Geocentric Velocity (V_g) in kilometres per second and magnitude (mag.) from SonotaCo is presented, with the D-criterion value (D_0) of the meteor shower relative to C/1846 J1 also included for the first noted shower (Table 2). Also given is a table showing their "localtime" identifier and orbital elements in the order of q (perihelion), e (eccentricity), i (inclination), ω (argument of perihelion) and Ω (ascending node) for each shower.

The mean Right Ascension, Declination and Solar Longitude are given for each shower, and the mean of each orbital element for the orbits (Tables 1 to 8). In the case of the σ-Virginids the value of D_0 given is that for the mean orbit of the meteors in comparison to that of the comet, and not a mean of the other D_0 values.

3 December σ-Virginids and C/1846 J1

The only comet orbit found to have a strong match to those of the meteor orbits while also being an unpublished association and unknown shower as far as the IAU MDC was concerned was C/1846 J1 (Brorsen) (1846 VII old style). SonotaCo also classified all the meteor orbits as being sporadic meteors. All three years of 2007 to 2009 provided several meteors in roughly equal amounts.

Their radiant generally drifts from the region of σ Virginis to τ Virginis and the main concentration of meteors appears to occur between December 20 to 22 between Solar Longitudes 267 to nearly 270 degrees (Figure 3 and Tables 1–2). The IAU MDC number is 428 and the code is DSV.

4 α-Coronae Borealids

Appearing in late January examples from all three years were found for this shower, however the predominant year by far was 2009. Examination of Figure 1 suggests that it was possible that the time period was underobserved in the previous years. A higher rate in 2009 could not be ruled out especially as roughly a quarter of the total meteors (four) appeared within two hours of each other on the 2009 January 29, with each being around zero magnitude or brighter (Table 3). The IAU MDC number is 429 and the IAU MDC code is ACB.

5 September π-Orionids

Appearing around the time of the Northern Autumnal Equinox this shower is reasonably well represented in all three years of data, despite Figure 1 suggesting that 2009 was the better observed year of the three around the time of Solar Longitude 177 to 178 degrees.

The radiants lie just east of the arc of π^1 to π^4 Orionis (Figure 7), which form part of the asterism of Orion's Bow. For simplicity the shower is name the π-Orionids. The IAU MDC number and code are 430 and

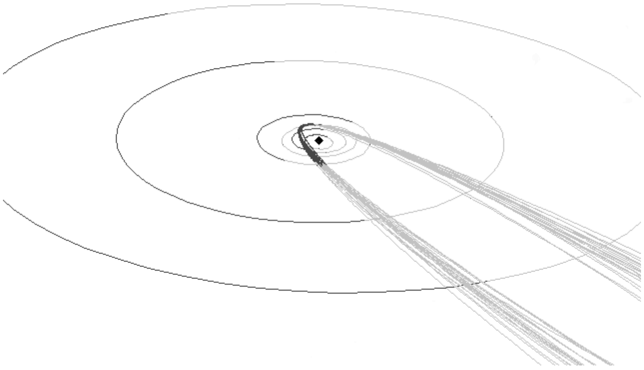

Figure 2 – Orbit Plots for the SonotaCo meteor orbits having D-criterion threshold of less than 0.10 relative to the orbit of C/1846 J1. The orbits of the planets out to that of Saturn are also shown.

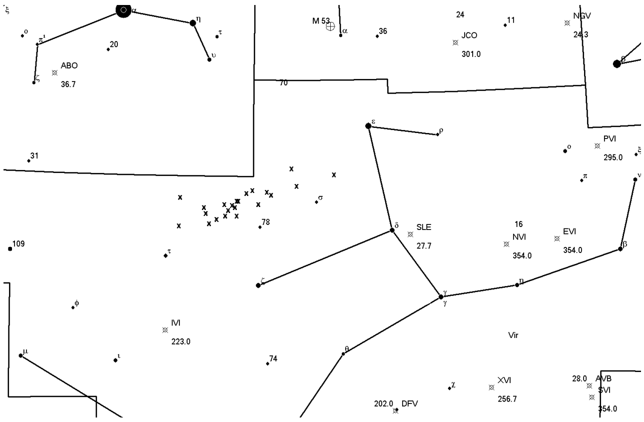

Figure 3 – Radiant Plots for the SonotaCo meteor orbits having D-criterion threshold of less than 0.10 relative to the orbit of C/1846 J1. Plots for radiants from the IAU meteor database are also given labelled with their identifying acronyms. Numerical labels for all radiants are for their Solar Longitude in degrees.

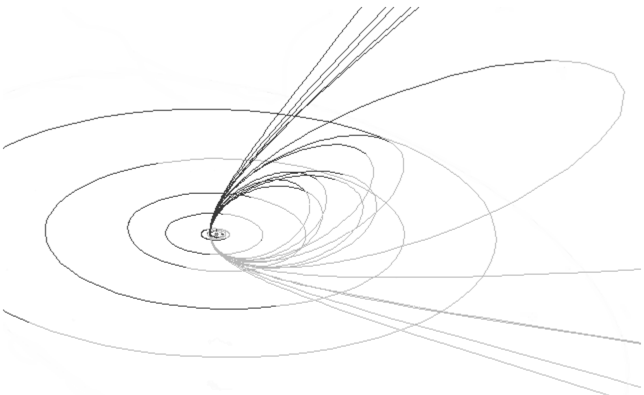

Figure 4 – Orbit Plots from SonotaCo for the α-Coronae Borealid shower. Planetary orbits out to that of Neptune are also shown.

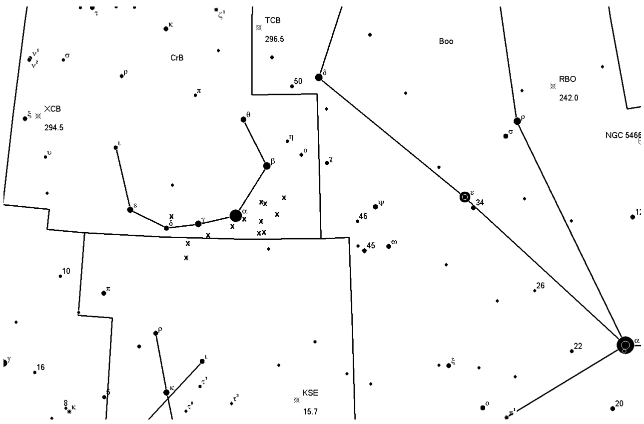

Figure 5 – Radiant Plots from SonotaCo for the α-Coronae Borealid shower.

Table 1 – SonotaCo Radiant Particulars for the December σ-Virginids.

LOCALTIME	α	δ	$\lambda_{\odot}$	V_g (km/s)	mag.
20071215_043648	200°.8668	+6°.6662	262°.322	65	+0.45
20071216_032750	201°.2448	+7°.9325	263°.291	66	+0.05
20071218_042126	203°.0490	+6°.2146	265°.364	66	−3.08
20071218_045352	202°.7508	+6°.0379	265°.387	67	−2.15
20071220_044915	204°.5392	+6°.1428	267°.419	67	−0.73
20071220_055029	205°.2622	+4°.4902	267°.462	66	−0.45
20071221_031950	205°.3700	+5°.1169	268°.374	67	−1.40
20071225_055049	209°.4751	+3°.7297	272°.553	67	−1.66
20081218_032735	203°.6642	+5°.3570	266°.076	67	−2.17
20081219_050334	205°.2103	+5°.5762	267°.161	66	+1.60
20081221_030959	206°.1672	+5°.3158	269°.117	67	−0.10
20081221_040655	206°.0988	+4°.5003	269°.158	67	−0.10
20081221_060310	207°.2677	+3°.9291	269°.240	67	+2.85
20091212_053613	198°.1051	+7°.4794	259°.804	66	−1.45
20091219_031553	204°.1017	+6°.3322	266°.828	67	−0.53
20091220_051934	205°.1753	+5°.5644	267°.933	66	−0.18
20091220_054225	205°.5557	+5°.2424	267°.949	66	+0.11
20091220_055507	205°.8649	+4°.9221	267°.958	67	+0.39
20091222_022025	209°.3800	+5°.8432	269°.843	65	+0.73
20091222_031839	206°.7428	+4°.2686	269°.885	66	+1.40
20091222_053907	207°.6411	+5°.1027	269°.984	66	+0.23
20091222_060659	207°.4771	+4°.6865	270°.004	67	+0.70
Mean Position	205°.0459	+5°.4750	267°.414	66	

Table 2 – SonotaCo Orbital Elements for the December σ-Virginids.

LOCALTIME	q (AU)	e	i	ω	Ω	D_0
C/1846 J1	0.633760	0.990414	150°.6809	99°.7253	263°.9889	—
20071215_043648	0.569595	0.925616	149°.8195	97°.0931	262°.3219	0.089
20071216_032750	0.615408	0.959967	147°.8727	103°.5874	263°.2906	0.097
20071218_042126	0.603168	0.955856	149°.6777	102°.0085	265°.3638	0.051
20071218_045352	0.616221	0.975933	150°.5729	104°.0784	265°.3867	0.059
20071220_044915	0.631587	0.984977	149°.3022	106°.1687	267°.4191	0.071
20071220_055029	0.587831	0.964208	151°.1529	100°.3720	267°.4624	0.069
20071221_031950	0.614889	0.985264	150°.1863	104°.1505	268°.3738	0.043
20071225_055049	0.616414	0.979218	150°.0181	104°.2168	272°.5531	0.092
20081218_032735	0.591726	0.961941	150°.6023	100°.7763	266°.0755	0.050
20081219_050334	0.598744	0.975734	149°.1823	101°.9685	267°.1611	0.051
20081221_030959	0.620437	0.992027	149°.2860	104°.9754	269°.1171	0.054
20081221_040655	0.617605	1.000196	150°.9822	104°.8145	269°.1573	0.048
20081221_060310	0.590461	1.000594	150°.7995	101°.5765	269°.2395	0.075
20091212_053613	0.588135	0.937879	150°.9218	99°.6682	259°.8037	0.095
20091219_031553	0.624445	0.989298	149°.0031	105°.3824	266°.8276	0.068
20091220_051934	0.617171	0.964782	149°.6200	103°.9418	267°.9334	0.050
20091220_054225	0.603088	0.959101	149°.7052	102°.0878	267°.9496	0.058
20091220_055507	0.600122	0.985918	150°.0675	102°.3753	267°.9585	0.047
20091222_022025	0.566372	0.979757	144°.4203	98°.2028	269°.8436	0.079
20091222_031839	0.603187	0.963410	150°.5586	102°.2162	269°.8848	0.077
20091222_053907	0.611157	0.974057	148°.5237	103°.4395	269°.9841	0.074
20091222_060659	0.621133	1.012775	149°.7951	105°.5119	270°.0039	0.060
Mean Orbit	0.604950	0.974023	149°.6395	102°.6642	267°.4141	0.045

Table 3 – SonotaCo Radiant Particulars for the α-Coronae Borealids.

LOCALTIME	α	δ	$\lambda_\odot$	V_g (km/s)	mag.
20070202_032122	236°.3113	+24°.6946	312°.414	58	−0.60
20080128_053145	232°.2706	+27°.3945	307°.169	57	−0.70
20080201_042137	236°.2217	+25°.3734	311°.183	58	−0.22
20090128_023106	231°.0367	+27°.5904	307°.796	58	+2.50
20090128_032120	231°.4365	+26°.7880	307°.831	58	+2.25
20090128_041708	232°.0668	+27°.3007	307°.871	60	+0.27
20090129_030621	232°.1539	+25°.9364	308°.837	60	−2.00
20090129_033629	232°.4114	+25°.8759	308°.858	59	−0.15
20090129_043731	232°.2919	+26°.4847	308°.901	59	−1.85
20090129_045857	233°.8488	+26°.2206	308°.917	60	+0.10
20090129_054619	233°.2042	+26°.5809	308°.950	57	+1.40
20090201_031653	237°.1444	+26°.6725	311°.892	57	+1.60
20090201_053410	235°.1486	+25°.7880	311°.989	59	+0.95
20090202_022615	231°.5717	+30°.3649	312°.871	57	+0.45
20090202_022742	232°.1111	+32°.0430	312°.872	57	+0.90
Mean Position	233°.2820	+27°.0072	309°.890	58	

Table 4 – SonotaCo Orbital Elements for the α-Coronae Borealids.

LOCALTIME	q (AU)	e	i	ω	Ω
20070202_032122	0.978857	0.885206	106°.5682	170°.3874	312°.4142
20080128_053145	0.981480	0.900618	104°.6787	173°.2873	307°.1693
20080201_042137	0.977128	0.924561	105°.8402	169°.3990	311°.1830
20090128_023106	0.983853	0.928833	105°.0627	176°.3786	307°.7958
20090128_032120	0.983096	0.939804	106°.2043	175°.1497	307°.8313
20090128_041708	0.983023	1.096985	106°.4249	175°.2282	307°.8707
20090129_030621	0.982994	1.062162	108°.1207	175°.0002	308°.8371
20090129_033629	0.982492	0.971101	107°.3783	174°.2578	308°.8584
20090129_043731	0.983668	1.022560	107°.0764	175°.9180	308°.9015
20090129_045857	0.980414	1.083236	107°.0651	172°.3826	308°.9166
20090129_054619	0.982272	0.879612	105°.3129	173°.8347	308°.9500
20090201_031653	0.977163	0.917551	103°.1936	169°.3342	311°.8919
20090201_053410	0.983505	1.057291	107°.1335	175°.1460	311°.9887
20090202_022615	0.981311	1.067447	101°.7078	187°.3032	312°.8713
20090202_022742	0.981323	1.105569	99°.2949	187°.2318	312°.8724
Mean Orbit	0.981505	0.989502	105°.4041	175°.3493	309°.8901

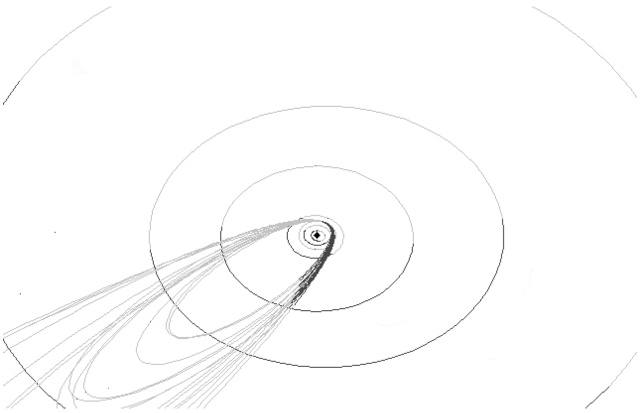

Figure 6 – Orbit Plots from SonotaCo for the September π-Orionid shower. Planetary orbits out to that of Uranus are also shown.

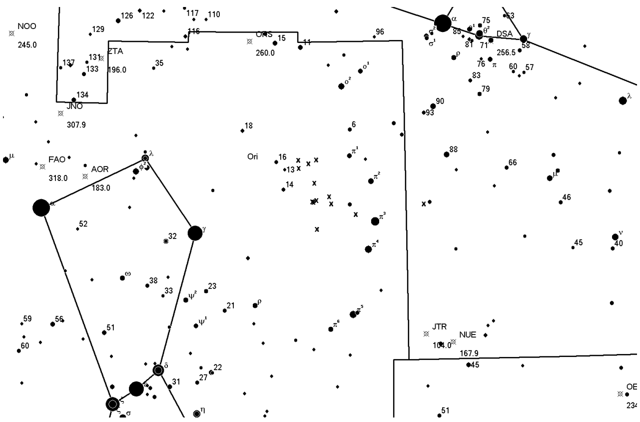

Figure 7 – Radiant Plots from SonotaCo for the September π-Orionid shower.

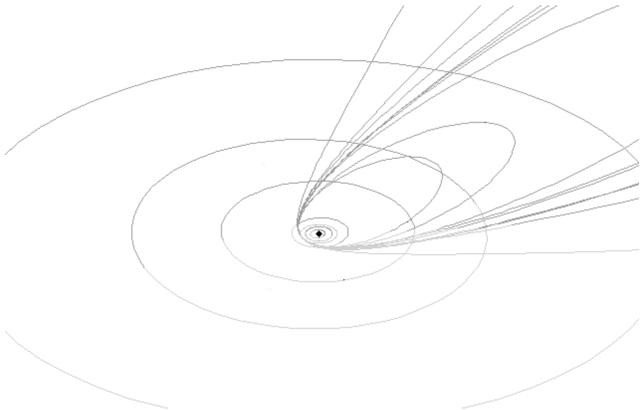

Figure 8 – Orbit Plots from SonotaCo for the June ι-Pegasid shower. Planetary orbits out to that of Uranus are also shown.

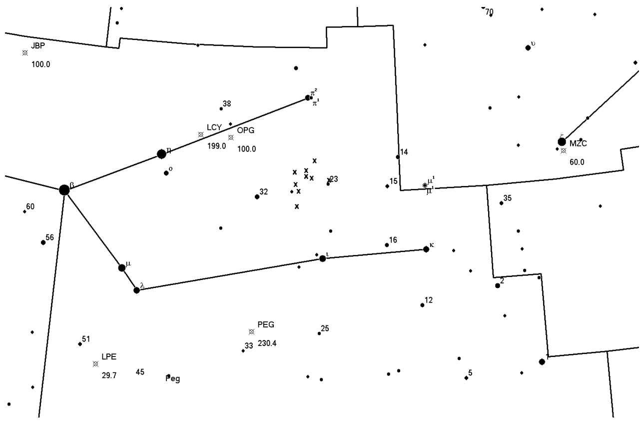

Figure 9 – Radiant Plots from SonotaCo for the June ι-Pegasid shower. Nearby IAU shower radiants and their Solar Longitudes are also shown.

POR respectively. Given its location this is a shower for both Hemispheres,and an Equinoctial shower too, providing all observers a similar night length.

6 June ι-Pegasids

The radiants lie near 23 Pegasi and are concentrated around 2009 June 26, Solar Longitude 94.15 degrees, and barely lasted two hours in total at that time (Figure 9 and Tables 7–8). This shower was not present in the other years, nor much outside the roughly two hour window in 2009. However, Figure 1 shows that other meteors were detected around this time in 2007 and 2008 suggesting the lack of June ι-Pegasids is real. The IAU MDC number is 431 and the IAU MDC code given is JIP.

7 Conclusion

Multiple station meteor orbit observations allow the examination of Earth impacting objects and their orbital evolution from a ready supply of impinging objects, i.e. meteors. Despite the New Zealand AMOR radar experiment (Galligan & Baggaley, 2005) and the more recent Canadian CMOR orbit research (Brown et al., 2008), itself radar based, little recent work has occurred of this nature.

SonotaCo is a welcome exception, and in tandem with D-criterion tests can be seen to give tangible results. In this analysis four new candidate showers, one with a previous unsuspected parent comet to a meteor shower, were presented based on that data. Other papers (e.g. Vereš and Tóth, 2010) have revealed that not only traditional showers can be examined with the data, but also new things can be revealed about those showers.

The D-criterion test upon meteoroids enables a somewhat independent test of relationship between groups of meteoroids, and although not totally independent (orbits are derived from radiant positions and time of event for instance) can give information on meteors which were only classified as being sporadic by radiant clustering techniques.

Future work that can be applied to this data includes examining the data around the times of major showers for showers contemporaneous yet independent of them, often lost in the flood of the major shower meteors. Also possible is the confirmation of IAU Working List showers (for instance, in the same D-criterion analysis, evidence of meteors associated with the γ-Ursae Minorids, the x-Herculids, possibly the β-Hydrids (or an adjacent new shower), and with less certainty the ζ-Serpentids exist, although still pending a refined anal-

Table 5 – SonotaCo Radiant Particulars for the September π-Orionids.

LOCALTIME	α	δ	$\lambda_\odot$	V_g (km/s)	mag.
20070920_032502	75°.7316	+9°.7597	176°.335	68	−0.15
20070921_024714	75°.5239	+7°.9531	177°.286	68	−0.40
20070921_032641	73°.4067	+7°.3376	177°.313	68	+0.85
20070921_035613	75°.3657	+7°.9869	177°.333	67	+0.33
20080923_011605	75°.3477	+9°.9596	179°.902	68	−0.35
20080923_012837	75°.4521	+8°.8274	179°.911	69	+2.50
20080923_023333	75°.5113	+7°.9363	179°.955	67	+1.50
20090920_040504	74°.7151	+8°.1846	176°.841	67	−0.57
20090921_015837	74°.6176	+7°.8420	177°.732	67	+0.77
20090921_030907	76°.2522	+9°.9570	177°.780	68	+1.73
20090921_034052	75°.2998	+6°.5990	177°.805	67	+1.05
20090921_034534	70°.0620	+7°.8133	180°.599	70	+0.45
20090924_031013	76°.2157	+9°.5464	180°.717	68	−0.40
Mean Position	74°.8847	+8°.4387	178°.424	68	

Table 6 – SonotaCo Orbital Elements for the September π-Orionids.

LOCALTIME	q (AU)	e	i	ω	Ω
20070920_032502	0.895048	0.894718	156°.4287	39°.7200	356°.3349
20070921_024714	0.877189	0.936818	153°.1094	42°.4054	357°.2860
20070921_032641	0.841588	1.022539	152°.2060	47°.1868	357°.3128
20070921_035613	0.862318	0.862551	152°.8796	45°.9879	357°.3328
20080923_011605	0.827017	0.962532	156°.2198	50°.1052	359°.9014
20080923_012837	0.836615	1.023459	154°.3926	47°.8425	359°.9099
20080923_023333	0.823756	0.944396	152°.4241	50°.8610	359°.9541
20090920_040504	0.855242	0.835985	153°.1694	47°.6363	356°.8408
20090921_015837	0.847250	0.893393	152°.5250	48°.0225	357°.7325
20090921_030907	0.878830	0.901675	156°.5474	42°.5407	357°.7803
20090921_034052	0.867757	0.896079	157°.8022	44°.5522	357°.8019
20090921_034534	0.861128	0.938155	150°.4784	45°.1079	357°.8051
20090924_031013	0.827247	0.995914	155°.4485	49°.5835	0°.7165
Mean Orbit	0.853922	0.931401	154°.1255	46°.2732	358°.2084

Table 7 – SonotaCo Radiant Particulars for the June ι-Pegasids.

LOCALTIME	α	δ	$\lambda_\odot$	V_g (km/s)	mag.
20090626_015125	331°.2860	+29°.1779	94°.128	62	−0.70
20090626_023635	333°.2110	+28°.9767	94°.158	60	+0.55
20090626_024721	333°.1318	+27°.9278	94°.165	60	+0.60
20090626_025341	332°.3210	+29°.2853	94°.169	59	−1.45
20090626_031852	332°.6257	+29°.3893	94°.186	57	−0.85
20090626_034154	332°.1428	+30°.1221	94°.201	59	−1.50
20090626_234937	332°.6141	+29°.6467	95°.001	59	−2.17
20090627_005602	333°.2585	+29°.6033	95°.045	58	−0.44
20090627_010714	333°.0444	+28°.6408	95°.053	60	+1.20
Mean Position	332°.6261	+29°.1967	94°.456	59	

Table 8 – SonotaCo Orbital Elements for the June ι-Pegasids.

LOCALTIME	q (AU)	e	i	ω	Ω
20090626_015125	0.908359	1.241787	114°.1918	216°.1069	94°.1281
20090626_023635	0.909513	1.000905	114°.4773	217°.8550	94°.1580
20090626_024721	0.894732	0.978189	115°.4206	220°.7365	94°.1651
20090626_025341	0.899465	0.946350	112°.6234	220°.2552	94°.1693
20090626_031852	0.889735	0.807746	111°.3804	223°.8736	94°.1860
20090626_034154	0.909202	1.007885	111°.9390	217°.8442	94°.2013
20090626_234937	0.903890	0.980183	113°.0068	219°.0942	95°.0014
20090627_005602	0.899195	0.871049	112°.4808	221°.2342	95°.0454
20090627_010714	0.899458	1.058645	114°.9742	219°.1034	95°.0528
Mean Orbit	0.901505	0.988082	113°.3883	219°.5670	94°.4564

ysis). In such cases, the finding of a shower via D-criterion methods from SonotaCo that coincides with a shower found from an independent survey and one not necessarily using orbital data is strong evidence for the reality of such a shower, as it is repeatability via an independent team using independent equipment.

Whilst preparing this paper a new shower (the February η-Draconids) was found using the upcoming and developing CAMS system (Jenniskens & Gural, 2011), showing that something of an outburst in this area of observation may well be underway. Certainly confirmation of showers will be easier with a multil-ongitude approach, not just because weather may be better in one place than another, but also there is some suggestion from the SonotaCo data that some showers have very short lived and tight presences, making observer location even more crucial than usual in the detection of shower outbursts, or "mini-outbursts".

This does not necessarily mean the passing of more traditional or even other modern methods of meteor observing. Targets need confirming, and other methods may well be more suited to determination of shower display nature and Zenithal Hourly Rates and population indices, and more able to go down to fainter magnitudes. As well as also providing more showers spread around the year for visual observers to enjoy, because decent skies, suitable moon phase and predicted meteoric events rarely have the good grace to all three coincide.

There is also some circumstantial evidence, given the nature of these showers, and from data in SonotaCo for showers like the η-Lyrids (associated with comet IRAS-Araki-Alcock), that a number of discrete retrograde orbits of some inclination may mean a number of long lived Earth crossing showers where no necessarily recognisable parent may exist, and that they may be common. Examination of databases like SonotaCo and the future CAMS data will lead to an accumulation of information and nature of such showers should they be shown to be common. Such objects would have implications in terms of Earth impact studies, for if they exist in any number they will reveal that material on the orbits of retrograde comets are likely minimally affected by perturbations. As a result the material can take a very long time to be dispersed.

Taking this analysis as an example, the December σ-Virginids seem to repeat from year to year, as do the September π-Orionids, with the latter being a target for both Northern and Southern Hemispheres and presenting itself at a time of year when meteor showers are normally at a minimum.

All four showers had orbits inclined and retrograde which if not purely a selection effect (i.e., such showers may be the easiest to detect) is at least suggestive of some background of fossil orbit showers from comets long gone from our neighbourhood.

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Meteor shower catalog based on 3 770 triangulation analyses of double-station Image-Intensified video observations over Japan

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The D-criterion and D'-criterion were used to cross-check against the IAU meteor shower list, 3 770 simultaneous meteors that we observed between December 1992 and October 2009 by double-station observation with an image intensifier (II) and for which orbits were determined. As a result, we detected 22 known and 12 unknown meteor showers. There are 295 showers recorded on the IAU list (as of June 2009), but we were aware that only a few appear regularly each year. Since an II targets faint meteors with magnitudes as faint as 8, many of the unknown meteor showers we found were fast, faint meteor showers close to the apex. The number of meteor showers on the IAU list is so large that it is hard to grasp the full picture. Therefore, in this paper, we made it easier for the reader to understand by plotting the meteor showers on a star chart. It was important for this study to accurately show the radiant error. Hence, we introduced and investigated the concept of using error ellipses for radiants. We recorded the double-station video images and orbital data from the independent II observations used in the study in catalog form so the data can be used by other researchers.

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1 Introduction

In December 1992, we began double-station video observation using an image intensifier (II). By October 2009, we had recorded 3 770 meteors and produced a number of observational reports (e.g., Shigeno et al., 1997; Shigeno & Shigeno, 2004).

In traditional reports, a number of references are used to cross-check against known meteor showers. Cook's list (1971) refers to observational results, such as those of McCrosky and Posen (1961), listing details such as the radiants and orbital elements of 58 meteor showers. This can be considered the classic type of list, which is from photographic observation. The volume by Kronk (1988) drew together an extremely large number of references to describe 119 showers, becoming a true compilation of meteor showers. Meanwhile, the IMO Handbook (Rendtel et al., 1995) presents 38 main showers, in addition to explaining observation methods.

Most recently, the IAU Meteor Data Center published a list of meteor showers (Jenniskens et al., 2009). Because there are as many as 295 showers, it is no easy task to check them against observational results. Therefore, we began by plotting the radiants obtained from the 3 770 double-station observations we made, together with the radiants from the IAU list, on a star chart. Then, we determined which meteor showers were known and which were unknown, following a number of lines of inquiry, which we shall introduce below.

2 Observational equipment

Figure 1 shows a photograph and block diagram of the equipment used in the observations. The IIs used were the Hamamatsu Photonics K.K. V3287P and the Delft High Tech Corporation XX1470. These are referred to as second-generation IIs and have amplification factors of approximately 50 000. The best observation acqusition method possible at the time in 1992 involved images taken with a 410 000 pixel CCD, recorded to Hi8 video tape. In 2005, we began recording to PC using the DV format.

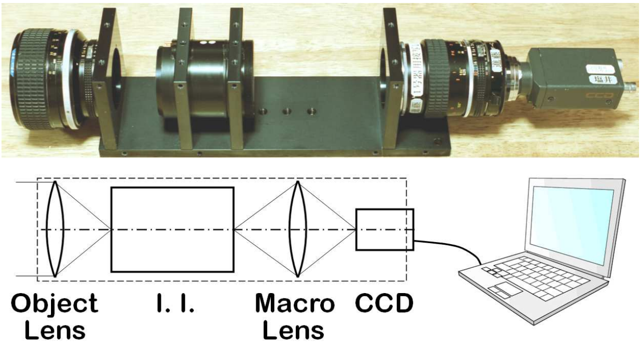

Figure 1 – Video equipment using II and block diagram.

The objective lens was a replaceable type. Our primarily lens was a Canon 85 mm $f/1.2$, with a 12° × 9° field of view, limiting stellar magnitude of approximately 9.5 and limiting meteor magnitude of approximately 8. The mean measurement error of position was approximately 70 arc seconds (standard deviation), and the mean error in calculation of radiants by triangulation was approximately 0.6° (standard deviation). Around 50 units of our observational equipment were produced and distributed to observers around Japan.

The main observation sites for the authors group were at Mount Akagi in Gunma Prefecture, Japan (139°11′33″ E, 36°28′42″ N) and Chichibu District in Saitama Prefecture, Japan (139°06′10″ E, 36°05′56″ N), arranged roughly North-South, with a baseline of 42.9 km. The field of view was narrow, so a star chart was drawn up, and the field of view set with a precision of approximately 0.5° in order that the maximum rate of concurrency could be achieved.

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NASA-ADS bibcode 2012JIMO...40...24S

3 Method of detecting meteor showers

The IAU meteor shower list, which boasts as many as 295 showers, can be considered a compilation of all meteor observations to date. Therefore, using this as a basis, we examined our observation results and identified the known meteor showers. We then searched out the as-yet-unknown meteor showers from among any activities that we suspected might be meteor shower activity but that did not correspond to any known meteor showers.

3.1 Detection of showers by the D/D' Criteria

Our basic procedure was to follow the process outlined in 1-1) to 1-4) below to pick out the meteor showers from the overall data.

1-1) To detect meteors associated with the objective meteor showers (orbit elements), we first classified them using the D-criterion (Southworth & Hawkins, 1963) and the D'-criterion (Drummond, 1979). Because each of detection based on orbital elements can differ, we considered a shower identified if the detection was made with either the D-criterion or the D'-criterion. We then used a screening method to further narrow down the detected meteors. We will now explain the D-criterion and D'-criterion in simple terms.

- The D-criterion is a means of investigating the degree of similarity between two orbital elements that can be summarized in the form of equation (1). When it is applied to a large quantity of raw data, the result is taken to indicate an identified shower when the D value is 0.2 or lower, based on experience.

$$D^2 = (\Delta e)^2+(\Delta q)^2+(2\sin(\Delta i))^2+(2\sin(\Delta\varpi))^2 \quad (1)$$

where Δe is the difference in eccentricity, Δq the difference in perihelion distance, Δi the angle between the orbital planes and $\Delta\varpi$ the difference between longitudes of perihelia.

- The D'-criterion is an improvement upon the D-criterion method and is expressed as equation (2).

$$D'^2 = (\Delta e)^2 + (\Delta q)^2 + \sin(\Delta i)^2 + \sin(\varphi)^2 \quad (2)$$

where φ is the actual angle between the perihelion points.

The points of improvements in the D'-criterion are as follows.

- Instead of the difference between longitudes of perihelia, it uses the actual angle between the perihelion points.
- The formulae used to calculate each of the four items in the equation has been devised to ensure that it takes a value between 0 and 1, thus making them have an equal effect on the determined value. In the D-criterion, on the other hand, the difference in eccentricity and the difference in perihelion distance took values between 0 and 1, while $2\sin(\Delta i)$ and $2\sin(\Delta\varpi)$ took values between 0 and 2. The effects on the determined value therefore differed depending on the item.
- It is common for the D'-criterion to be around 1/2 of the D-criterion; based on experience, a D' value of 0.1 or lower has been adopted as a criteria for an identified shower.

1-2) In determining the mean of a meteor shower, we used only our video observation data.

1-3) In cases in which the observation stretched over multiple days and the number of meteors was large, the mean was determined using the observation data of the day that had the largest number of meteors.

1-4) In searching our entire observation data for meteors that appeared to have a connection, we referred to the observational data of McCrosky & Posen (1961) (hereinafter referred to as M&P data), from which we determined the number of meteors thought to be an identified shower. We learned the following from comparisons between the two sets.

- M&P data were from photographic observation made between 1952 and 1954. Therefore, finding the same shower in our video observation meant that the shower in question had been active for at least 50 years.
- The photographs in M&P data targeted bright meteors of magnitude 4 and brighter, while our video observation targeted faint meteors as faint as roughly magnitude 8. It is clear that both bright meteors and faint meteors are observable.

3.2 Method of identifying known meteor showers using the IAU list

The problem that we encountered when comparing data obtained via the process outlined in the previous section with the IAU list was that the IAU list did not deal with the orbital elements of meteor showers. Hence, we adopted the technique outlined in 2-1) to 2-4) below.

2-1) We determined the orbital elements from the solar longitude of the maximum shower date, radiant and velocity.

2-2) The orbital elements so determined were taken as parent data, and we searched the observation dataset using the D-criterion and D'-criterion for meteors that appeared to be related.

2-3) From the meteors found, we determined the day of observation, and the mean and standard deviation (σ) of the radiant. Taking 2σ as our criteria, we discarded any which were 2σ or more from the mean. We then determined the mean radiant, velocity and orbital elements.

2-4) By following this process, we identified 22 known meteor showers. As shown in Table 1, these appear to correspond to meteor showers on the IAU list in the range 001 to 342.

3.3 Method of identifying unknown meteor showers

We will now discuss the technique we used to identify the unknown meteor showers that were detected from our data but that did not correspond to any of the 295 showers on the IAU list according to the comparison of data described in Section 3.2.

3-1) On the star chart, we plotted the radiants of the IAU list, our observations and the M&P data, month by month. The M&P data we received was a version which Hiroyuki Shioi had organized (Shioi, 1994, private communication) from the M&P paper (McCrosky & Posen, 1961).

3-2) We visually searched for clusters of unknown radiants that were not included in the radiants from the IAU list and determined their approximate right ascension and declination.

3-3) We picked out the individual meteors which had radiants close to the determined right ascension and declination and which had closely matching velocities. Then, we determined the mean radiant, velocity and orbital elements. 15 showers were detected using this method.

3-4) The orbital elements so determined were taken as parent data, and with the method outlined in 2-2) to 2-3) above for known meteor showers, the mean radiant, velocity and orbital elements were determined.

3-5) Even when the radiants were almost the same, small differences in velocity would lead to orbits that could differ dramatically. Consequently, 3 showers were excluded, leaving 12. For example, when the velocity differed by 3% in the case of a meteor with a radiant close to the apex, the eccentricity changed by 0.1, which was outside the range of the D'-criterion. In the case of video observation, there is a large error in velocity. Therefore, making judgments about meteor showers with high velocities requires caution. The results are shown in Table 2, using numbers assigned by IAU from 432 to 443.

4 Evaluation of radiants by error ellipses

When a meteor shower is identified, it is of the utmost importance to evaluate the error in the radiants. Hence, in this report, we used the error ellipses shown in Figure 2 (Shigeno et al., 2003) to determine the radiant errors.

4.1 Method of determining error ellipses

If the points of observation of the meteor path are taken as P_1, P_2, ..., P_n, as shown in Figure 2, then their errors are as indicated by the ellipses. Here, σ_1, σ_2, ..., σ_n are the errors (standard deviation) which are orthogonal to the meteor path at each respective point of observation. In this case, the error which translates the meteor path parallel σ_u and the error which inclines the meteor path σ_t can be represented by

$$\sigma_u = \frac{1}{\sqrt{\sum_{i=1}^{n} \frac{1}{\sigma_i^2}}}, \sigma_t = \frac{1}{\sqrt{\sum_{i=1}^{n} \frac{x_i^2}{\sigma_i^2}}} \tag{3}$$

where x_i is the distance (radians) measured along the meteor path from the mean position of all the measurement points on that meteor path to the i-th measurement point.

On the pole of the great circle along the meteor path, the error ellipse has size σ_u in the direction facing the mean measurement point and size σ_t in the orthogonal direction. When the same meteor is observed at two or more points, the pole of the great circle along each meteor path and its error ellipse can be determined. When the radiant is determined from multiple poles of great circles along the meteor path, then it is possible to determine the error ellipse of the radiant using the same method as above.

4.2 Extent and error of observed radiants

An example of the error ellipses of radiants obtained by observation is shown in Figure 3. The small error ellipses are gathered near the center, while the large error ellipses are spread out around the outside. It is clearly evident that the long axes of the error ellipses are oriented radially outward from the center, and that the radiants are shifted from the center due to the error.

5 Comparison of radiant distributions

5.1 Distribution and comparison of Radiant

In Figure 4, the month by month radiant distributions are shown. The $\times$'s of left figure indicate radiants we observed, the $+$'s indicate radiants from the M&P data, and the Double circles indicate the apexes. The solid-lined ellipses (radius 6°) represent the radiants of the IAU list. 65 of which are defined as the established meteor shower in the IAU list, are represented using bold lines.

The right figure represent meteor showers identified using our observations. The solid-lined ellipses (radius 6°) represent the radiants of known meteor showers. The dotted-lined ellipses (radius 7°) represent the radiants of unknown meteor showers detected in this study. The meteors used to determine averages are indicated by $\times$'s. (Due to the circumferential stretch produced by projecting a star chart onto a plane, which is propor-

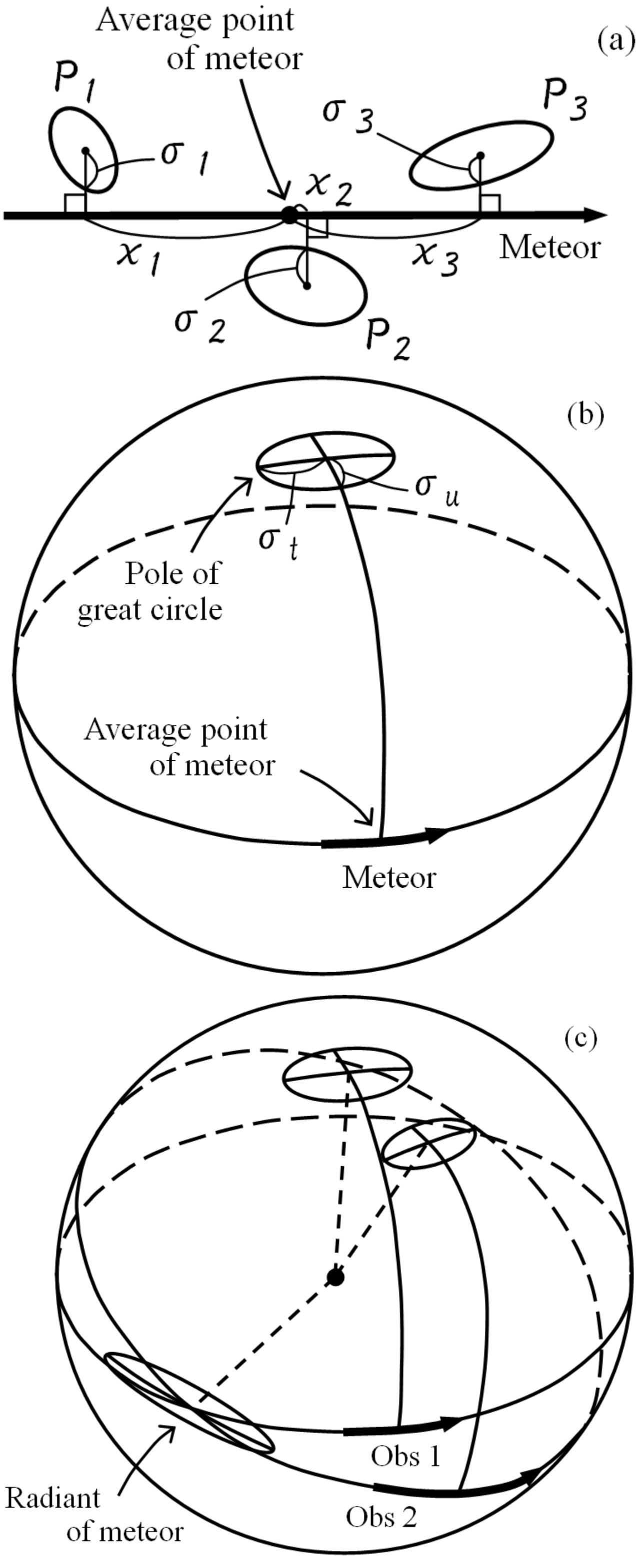


Figure 2 – (a) Meteor path and measurement points with errors shown by ellipse. (b) Meteor path and its pole of great circle. The error translating the meteor path parallel to itself is labeled σ_u and the error inclining the meteor path is labeled σ_t. (c) The radiant and error ellipse determined from the pole of the great circles along each of the meteor paths measured at two points.

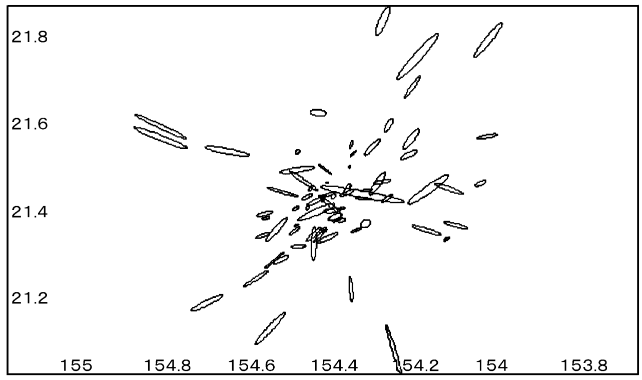


Figure 3 – Distribution of error ellipses of radiants obtained via double-station photographic observation on 2001 November 18. Size of ellipses reduced by 1/5 for ease of viewing.

tional to the distance from the center, these appear as non-circular ellipses but represent circles with correct radii).

Circles of radius 6° were used to represent the IAU list meteor showers because for many such showers almost all the results of radiant calculations were distributed within a circle of 6°. For these known meteor showers, we have added the meteor shower code. Circles of radius 7° were used to indicate the radiants of unknown meteor showers because these had a slightly wider radiant distribution than the known meteor showers. For the previously unknown meteor showers, the IAU has assigned numbers from 432 to 443.

The sizes of the ×'s on the graph are proportional to the geocentric velocity (V_G): the faster the V_G, the larger the ×. The sizes of the +'s are similarly proportion to the V_G's. The influence of the orbital motion of the earth is reflected by the high velocities of the meteors near the apex and by V_G decreasing with distance.

5.2 Error in the results of identification of known meteor showers in Table 1

For each meteor shower, the top row shows the mean value and the bottom shows the spread of data in terms of standard deviation. For example, in the case of radiants, the bottom number refers to the spread of radiants in terms of standard deviation. Each column RA_G, Dec_G and V_G showing mean measurements for the individual meteors is followed by an Ea column showing the analytical error incorporated into the measurement.

For example, in the case of Geminids (IAU #004: GEM), (right ascension, declination) of the radiant are ($111^{\circ}\!.7$, $32^{\circ}\!.8$), and the errors are ($0^{\circ}\!.2$, $0^{\circ}\!.1$). The spread of data, shown in the next row, are ($1^{\circ}\!.0$, $0^{\circ}\!.5$). In this case, the spread of radiant data is five times the measurement and analytical error in our observations and this clearly represents the spread of the radiants themselves. Such a trend can similarly be seen in major showers (e.g., Perseids, Quadrantids and Geminids).

With the major showers, the accuracy of observation is very high. This is because the imaging direction was decided after determining the radiant positions of the major showers, taking into account the arrangement of the two observation points, to allow a range of imaging aligned orthogonal to the radiants. The radiant directions of the other showers were random, and thus the accuracy of determining the individual radiants was lower. The overall accuracy of determining the 3 770 radiants (average error) was approximately $0\overset{\circ}{.}6$ (standard deviation).

Even among the major showers, the Leonids (IAU #013: LEO) shows a different trend. The mean accuracy of the determination of radiants in terms of (right ascension, declination) is ($0\overset{\circ}{.}3$, $0\overset{\circ}{.}1$), and the spread of the data is ($0\overset{\circ}{.}3$, $0\overset{\circ}{.}1$). The fact that the error and the spread were the same suggests that the spread of the data was actually smaller than this but could not be detected due to the error. The Leonids was seen as a meteor storm in 2001, and its degree of concentration was high (Shigeno et al., 2003).

5.3 Detection results of the unknown meteor showers in Table 2

For the data in Table 2, the accuracy of observation is the same as described above of non-major showers. In this case, there are no problems in accuracy because the unknown meteor showers have fewer numbers of meteors and therefore we include longer observational periods and use wider radiants.

In all of the showers detected, the mean was determined from multiple-year, multiple-day observations. In actually determining the mean, we used a maximum range of ± 6 days for the observation day, and a maximum of $\pm 6^\circ$ for the radiant. Given the larger number of observational results used (in order to obtain the same quality of meteor data), we consider these ranges to be appropriate.

6 Discussion

1. As shown in the distribution of radiants (Figure 4), the radiants of the IAU list are distributed across the whole sky throughout the year. The radiants we observed, on the other hand, were confined to just one area. As shown above in the identification of known meteor showers, only 22 such showers were matched. This result agrees with the report of SonotaCo, which used the results from 2007 to 2008 to cross-check with the IAU list (SonotaCo, 2009). In SonotaCo's report, there are 25 known meteor showers and 13 unknown meteor showers, which is close to the results of this report. It seems, therefore, that there may be many sudden showers and showers that are uneven in their yearly arrival time on the IAU list.

2. The unknown meteor shower reported by SonotaCo as IAU #342: BPI (August Beta-Piscids) is already registered on the IAU list; we identified it as a known meteor shower. Of the 13 unknown meteor showers reported by SonotaCo, this was the only one corresponding to our observational results.

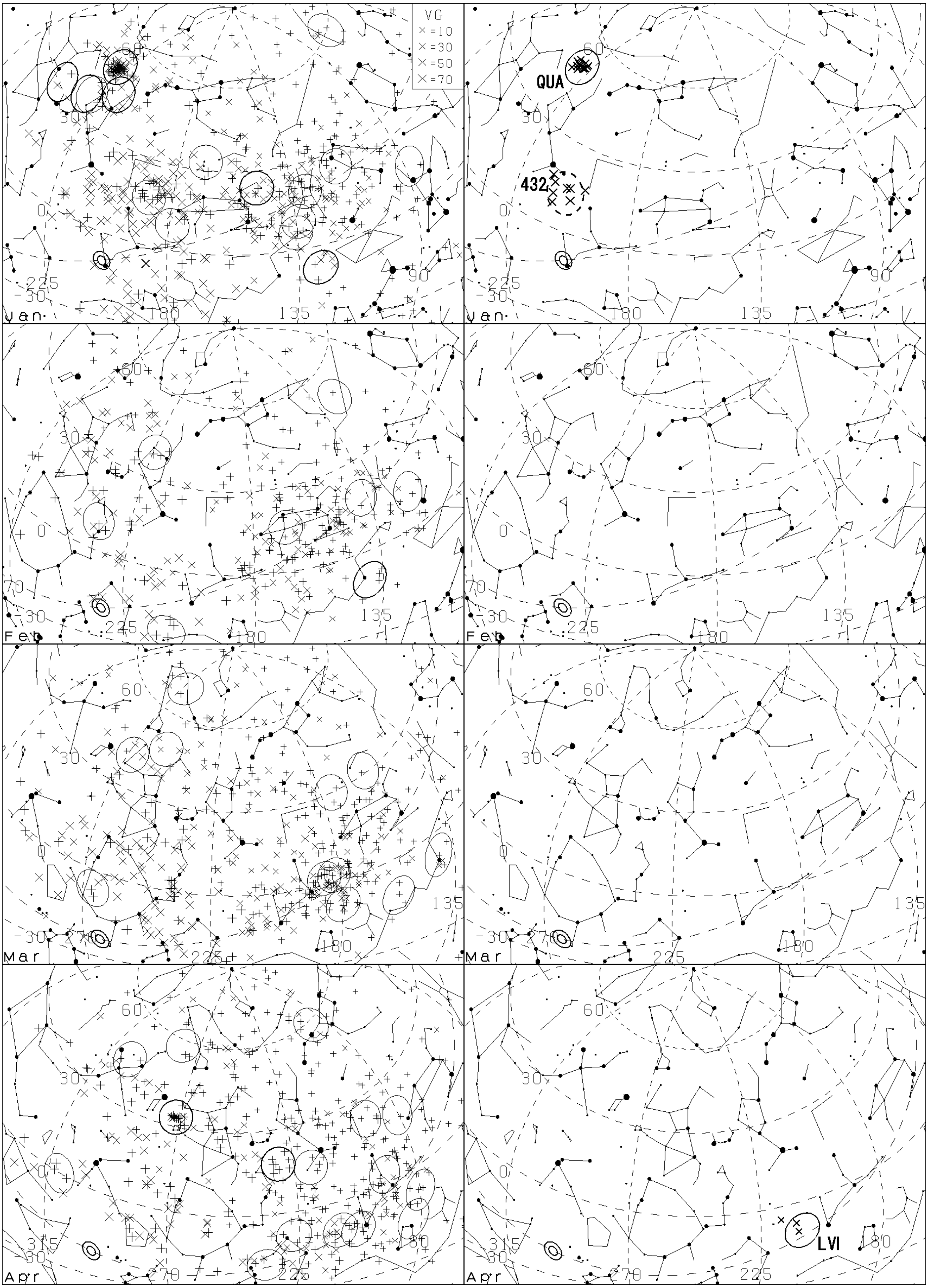
3. There are many fast meteors close to the apex in the northern hemisphere in winter (November to January). This is thought to be due to the following: a) Because the nights are long and the apex is in the northern hemisphere, the horizontal altitude nearby gets higher early in the morning, making them easier to observe. b) There were many fast but faint meteors among those near the apex, and the II targeted meteors as faint as magnitude 8.

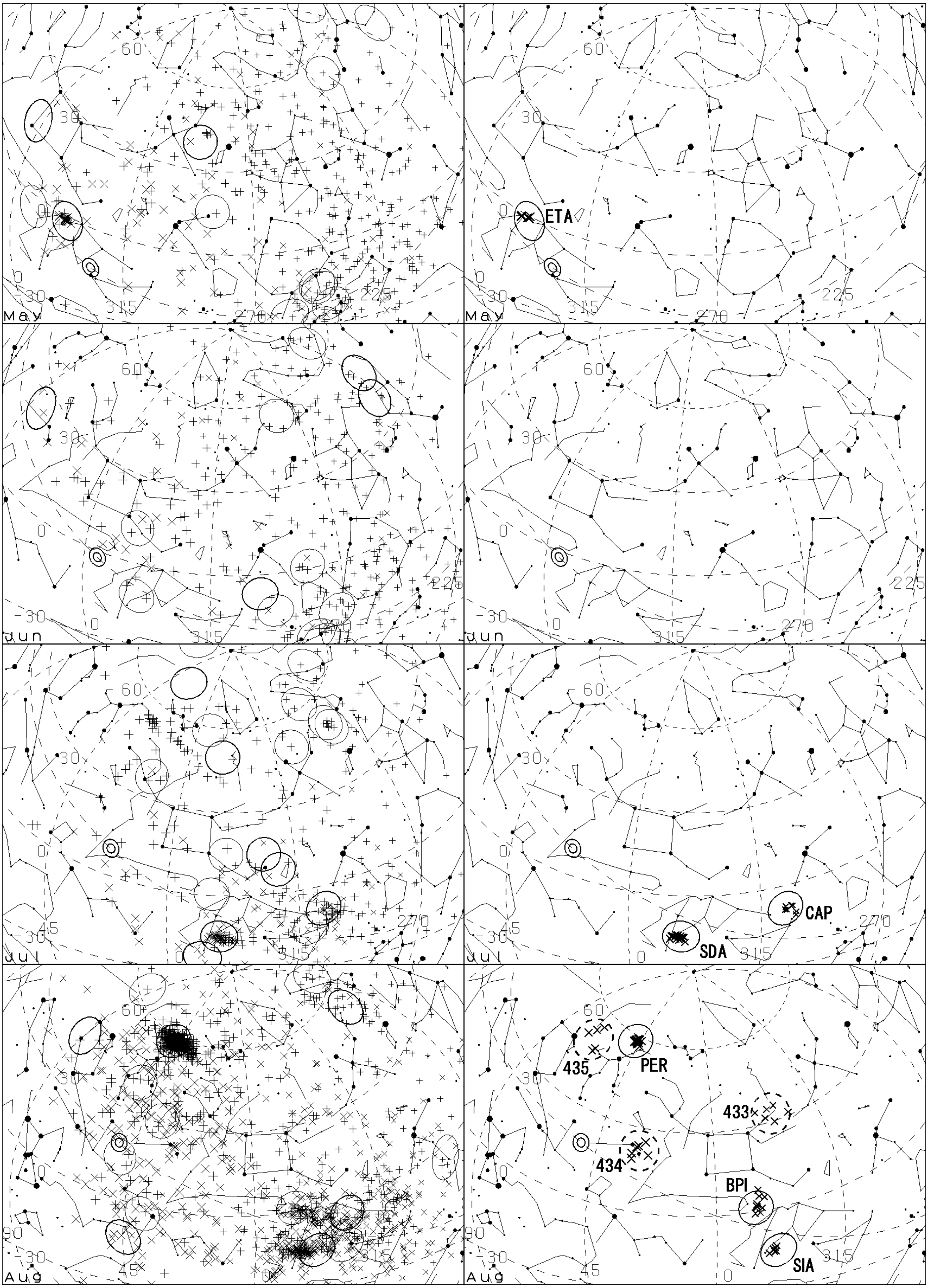
4. There is a possibility that the activity of faint meteors was detected for other unknown meteor showers. Indeed, we have used the II to perceive faint Piscids in the past. In visual observation carried out concurrently, it was not possible to see these at all (Shigeno & Shioi, 2002).

5. Comparing to the M&P data, it is clear that our method of observation of showers with faint mean luminosity detects a greater number of meteors (Tables 1 and 2). There are cases in the M&P data in which showers were identified from only one meteor observation, which suggests the showers with even fainter distributions will be detected in the future. However, there was no good match to with any of the IAU data of radiants detected via radio meteor observation (which is thought to have perceived faint meteor showers).

6. This study was based on the current IAU meteor shower list of June 2009. However, the number of meteor showers that have been detected and registered continues to grow. For example, 12 new showers have been added by Molau & Rendtel (2009). Meanwhile, Koseki (2009) has presented the following problems regarding the break-down of meteor showers and the increase in number of small meteor showers. a) The activity of meteor showers changes yearly, and, with the exception of the large meteor showers, they are not necessarily observed every year. b) Photographic and

Figure 4 – (following pages) – The month by month radiant distributions are shown. The left figure indicate radiants we observed, the radiants from the M&P data, and the radiants from the IAU list. The right figure represent meteor showers identified using our observations. The known and unknown meteor showers are included.
×: Radiants found in this study.
+: Radiants of M&P data.
⊚: Apex (position on the 15th of each month).
— The solid-lined ellipses (radius 6°) represent the radiants of known meteor showers. The 295 showers on the current IAU list of June 2009, Established 65 meteor showers are bold-lined.
— The dotted-lined ellipses (radius 7°) represent the radiants of unknown meteor showers detected in this study. (Due to the circumferential stretch produced by projecting a star chart onto a plane, which is proportional to the distance from the center, these appear as non-circular ellipses but represent circles with correct radii).


VG
×=10
×=30
×=50
×=70
QUA
432
LVI
Jan
Feb
Mar
Apr
60
30
0
-30
225
180
135
90
70
270
315


May
ETA
May
Jun
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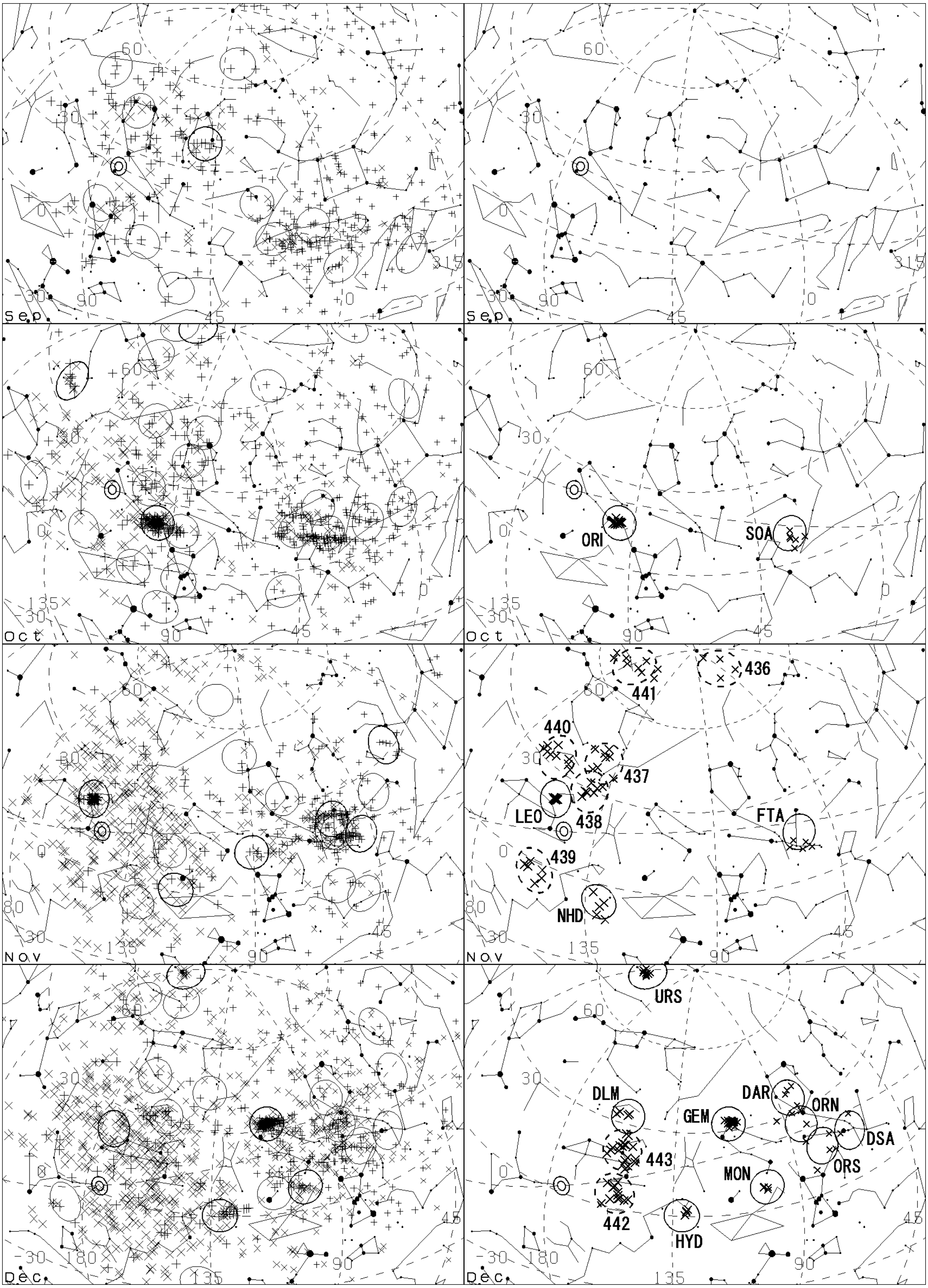
Jul
SDA
CAP
Jul
Aug
435
PER
433
434
BPI
SIA
Aug


Sep
Oct
ORI
SOA
Nov
441
436
440
437
LEO
438
FTA
439
NHD
Dec
URS
DLM
GEM
DAR
ORN
DSA
443
ORS
MON
442
HYD

radio observations do not always agree regarding faint meteors. c) In the classification of small meteor showers, there are a number of different schools of thought, which raises the possibility that observers may be overinterpreting their results. Caution is therefore required.

Consequently, Koseki (2009) has stated that fixed names for meteor showers should be reserved for only the larger meteors showers. The IAU list fulfills an important role in this kind of discussion, and we think that the results of comparison with our data do support this idea.

7 Conclusion

From 1992 through 2009, we carried out sustained double-station video observation using an II, taking care to ensure that observations were distributed evenly throughout the year. From a total of 3 770 observed simultaneous meteors, high-accuracy radiant analysis was performed, from which we succeeded in creating a detailed radiant map for each of the regions in Japan (north latitude 35°) at which observation was possible. This dataset is useful for evaluating past radiant data, in particular the IAU list for radiants north of declination −45°. Through comparison with the 295 showers on the current IAU list of June 2009, we identified the 22 known meteor showers shown in Table 1 and newly reported a further 12 unknown ones in Table 2. Compared to the M&P data of about 50 years previous, the benefit of our II observation of meteors as faint as magnitude 8 was verified for showers with high (faint) mean magnitudes.

Appendix. Distribution of double-station video meteor footage

We converted all 160 Hi8 tapes used for double-station observation from 1995 to 2005 to DV files. This came to approximately 6 TB, which is not a very manageable size. Accordingly, we made files of only the meteors of magnitude 6 and brighter, discarding the others. In the files, observations are generally around 3 seconds per meteor, but meteors with persistent trains take up to 120 seconds. We ended up with a total of 579 meteors, including those recorded direct to DV format at the observation points after 2005, coming to 15.6 GB of data. This dataset can be recorded to DVD-R and distributed to individuals who desire it. For further details please refer to the following link: `http://meten.net/meteor`. The DV format can be played on almost any application for viewing video files, such as Media Player or Quick Time. The file size is large, but image quality is better than MPEG. Image size is 640 × 480 pixels, and the frame rate is 29.97 fps.

All meteors have been opened to the public and are accessible at `http://www.imo.net/files/data/msswg/`.

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Table 1 – Results of identification of known meteor showers.
All measurements are with respect to Equinox J2000. Those with year indicated under DATE are cases in which the mean has been determined using observational data from the day with the greatest number of meteors. Those with no year indicated are cases in which an average date has been determined from the observation of multiple years and days. $\lambda_\odot$: solar longitude; RA_G and Dec_G: corrected radiants; V_G: geocentric velocity; a, e, q, ω and Ω, i: orbital elements; H_b and H_e: beginning and end height; Amag: absolute magnitude; clc: number of meteors used to determine mean; MSS: number of meteors thought to be of the same shower in our observation data; M&P: number of meteors thought to be of the same shower in M&P data.
Regarding errors: For each meteor shower, the top row indicates the mean values and the bottom row represents the spread of data in terms of standard deviation (Note: these are not the measurement and analytical errors for the individual meteors). Each column RA_G, Dec_G and V_G showing mean measurements for the individual meteors is followed by an Ea column showing the analytical error incorporated into the measurement. IAU number, code and shower name for the known meteor showers identified are as follows:

IAU code	Shower Name	IAU code	Shower Name	IAU code	Shower Name	IAU code	Shower Name
001 CAP	alpha Capricornids	003 SIA	South. iota Aquariids	004 GEM	Geminids	005 SDA	South. delta Aquariids
007 PER	Perseids	008 ORI	Orionids	010 QUA	Quadrantids	013 LEO	Leonids
015 URS	Ursids	016 HYD	sigma Hydrids	019 MON	Dec. Monocerotids	028 SOA	South. Oct. delta Arietids
031 ETA	eta Aquariids	032 DLM	Dec. Leonis Minorids	049 LVI	lambda Virginids	245 NHD	Nov. Hydrids
256 ORN	North. chi Orionids	257 ORS	South. chi Orionids	258 DAR	Dec. alpha Aurigids	286 FTA	omega Taurids
288 DSA	South. Dec. delta Arietids	342 BPI	Aug. Beta Piscids				

IAU	DATE (UT)	$\lambda_\odot$	RA_G	Ea	Dec_G	Ea	V_G	Ea	a	e	q	ω	Ω	i	H_b	H_e	Amag	clc	MSS	M&P
001	19980731.62	128.23	305.0	0.3	−8.7	0.8	20.8	1.1	2.32	0.728	0.632	264.0	128.2	7.1	98.4	87.1	5.0	7	26	20
CAP	± 0.02	±0.02	±1.6	—	±1.3	—	±0.8	—	—	±0.022	±0.026	±3.2	±0.0	±0.9	±3.4	±2.6	±0.6			
003	19980801.65	129.21	340.7	0.2	−15.6	0.5	38.2	1.2	2.07	0.952	0.100	148.1	309.2	20.7	101.0	83.5	3.9	6	24	6
SIA	±0.04	±0.04	±1.0	—	±0.8	—	±1.1	—	—	±0.009	±0.005	±0.9	±0.0	±2.7	±0.9	±2.6	±2.3			
004	19991212.70	260.22	111.7	0.2	+32.8	0.1	33.4	1.1	1.27	0.883	0.149	324.1	260.2	22.8	101.6	85.8	4.7	50	242	147
GEM	±0.06	±0.06	±1.0	—	±0.5	—	±1.1	—	—	±0.012	±0.007	±0.9	±0.1	±1.3	±1.7	±3.2	±1.6			
005	19980801.65	129.22	343.3	0.5	−15.8	0.7	38.6	1.1	1.82	0.953	0.085	151.3	309.2	26.7	99.8	85.9	3.5	16	34	13
SDA	±0.03	±0.03	±1.4	—	±0.6	—	±1.6	—	—	±0.012	±0.007	±1.6	±0.0	±2.4	±2.3	±4.2	±1.5			
007	19970812.66	140.00	47.3	0.6	+58.1	0.3	58.8	1.0	10.9	0.913	0.950	150.5	140.0	112.6	119.3	99.0	1.7	20	142	330
PER	±0.06	±0.06	±1.2	—	±0.6	—	±1.0	—	—	±0.071	±0.009	±2.5	±0.0	±1.3	±7.3	±2.6	±1.9			
008	19961021.76	208.68	95.9	0.8	+15.8	1.1	66.2	2.0	8.47	0.932	0.574	83.1	28.7	164.1	115.8	99.0	2.2	16	37	46
ORI	±0.06	±0.06	±1.0	—	±0.5	—	±1.4	—	—	±0.071	±0.028	±4.7	±0.1	±1.0	±1.5	±5.0	±0.9			
010	19970103.67	283.38	230.1	0.9	+49.7	0.4	41.1	0.9	2.95	0.668	0.979	172.0	283.4	71.5	105.8	96.3	2.4	16	33	22
QUA	±0.04	±0.04	±2.1	—	±1.2	—	±0.9	—	—	±0.037	±0.004	±3.8	±0.1	±1.4	±2.9	—	±1.7			
013	20011118.78	236.48	154.3	0.3	+21.5	0.1	70.6	1.1	9.57	0.897	0.986	174.4	236.5	162.5	125.8	92.3	0.9	35	141	23
LEO	±0.03	±0.03	±0.3	—	±0.1	—	±0.8	—	—	±0.061	±0.001	±1.2	±0.0	±0.2	±17.0	±4.3	±3.0			
015	20061222.75	270.66	219.2	2.3	+75.1	0.2	32.4	1.0	4.19	0.776	0.939	206.3	270.7	52.3	105.7	97.1	4.6	10	10	3
URS	±0.04	±0.04	±3.7	—	±0.7	—	±1.2	—	—	±0.054	±0.006	±1.7	±0.0	±1.4	±2.1	±1.1	±0.6			
016	1215.25	262.85	130.4	0.3	+1.5	0.4	57.7	1.0	9.76	0.978	0.217	125.3	82.9	126.8	116.4	94.7	3.2	4	6	5
HYD	±0.83	±0.74	±0.4	—	±0.8	—	±0.5	—	—	±0.007	±0.007	±0.9	±0.7	±1.5	—	±1.4	±1.3			

Table 1 – Results of identification of known meteor showers — continued from previous page.

IAU	DATE (UT)	$\lambda_\odot$	RA_G	Ea	Dec_G	Ea	V_G	Ea	a	e	q	ω	Ω	i	H_b	H_e	Amag	clc	MSS	M&P
019	1212.95	260.51	102.1	0.2	+7.8	0.4	40.1	1.1	7.29	0.973	0.199	128.3	80.3	33.8	103.2	88.8	5.1	4	11	8
MON	±0.59	±0.66	±0.9	—	±0.5	—	±1.6	—	—	±0.020	±0.004	±0.9	±0.5	±1.7	±3.6	±4.9	±1.1			
028	19931011.67	198.44	32.9	1.4	+9.0	4.9	27.0	1.1	1.66	0.805	0.323	121.2	18.4	5.0	103.6	90.7	3.6	6	6	33
SOA	±0.03	±0.03	±1.4	—	±1.6	—	±1.7	—	—	±0.041	±0.032	±3.7	±0.0	±1.7	±4.0	±3.4	±1.3			
031	19950506.72	45.79	338.1	0.6	−0.8	0.3	66.0	1.9	21.7	0.972	0.599	100.1	45.8	162.9	114.4	99-	1.9	5	19	2
ETA	±0.02	±0.02	±1.4	—	±0.5	—	±0.6	—	—	±0.026	±0.024	±2.8	±0.0	±1.2	—	—	±1.7			
032	1214.08	261.90	158.0	0.4	+33.0	0.3	61.9	1.8	4.80	0.878	0.587	262.3	261.8	133.3	113.9	100.0	4.2	4	7	5
DLM	±0.51	±0.59	±2.7	—	±0.5	—	±1.3	—	—	±0.081	±0.027	±3.0	±0.5	±1.0	±1.3	±2.4	±0.3			
049	20070414.68	24.24	215.7	0.3	−6.8	1.3	26.5	0.9	1.50	0.723	0.414	293.7	24.3	7.0	102.8	93.4	5.2	3	3	6
LVI	±0.10	±0.10	±3.7	—	±3.2	—	±4.7	—	—	±0.060	±0.026	±4.1	±0.1	±4.2	±3.5	±3.6	±0.3			
245	1118.68	235.91	130.0	0.5	−7.1	1.0	64.5	2.5	7.26	0.877	0.895	36.8	55.8	134.5	113.1	95.7	3.8	5	6	0
NHD	±0.35	±0.26	±1.9	—	±3.5	—	±1.9	—	—	±0.113	±0.027	±6.2	±0.3	±5.8	±6.2	±5.3	±1.3			
256	1212.25	259.96	86.5	0.2	+29.3	0.1	22.9	1.1	1.76	0.723	0.487	282.0	259.9	4.9	100.2	90.5	6.1	5	19	23
ORN	±0.51	±0.25	±5.5	—	±2.1	—	±1.4	—	—	±0.036	±0.064	±9.0	±0.2	±1.8	±2.1	±1.3	±0.8			
257	20011211.65	259.65	80.8	0.3	+14.1	0.3	20.4	1.0	1.97	0.706	0.579	89.5	79.6	6.2	97.2	87.6	6.2	4	29	14
ORS	±0.05	±0.05	±4.6	—	±5.0	—	±3.0	—	—	±0.063	±0.090	±10.1	±0.0	±3.4	±5.4	±2.6	±0.2			
258	1212.87	260.65	83.8	0.4	+35.1	0.2	19.9	0.8	1.60	0.652	0.559	275.4	260.7	8.1	95.3	82.4	6.5	5	24	6
DAR	±1.39	±1.31	±2.0	—	±4.0	—	±2.8	—	—	±0.071	±0.067	±6.2	±1.3	±2.6	±5.9	±9.3	±0.4			
286	1123.06	240.72	58.7	0.3	+11.7	0.3	19.4	0.8	1.86	0.661	0.630	84.6	60.5	5.2	98.5	86.6	4.8	5	10	6
FTA	±4.09	±4.22	±2.9	—	±1.3	—	±1.4	—	—	±0.035	±0.056	±7.0	±4.3	±0.3	±6.0	±2.3	±1.9			
288	1212.16	260.19	72.9	0.5	+16.0	0.3	16.0	0.9	1.80	0.601	0.719	73.6	80.0	3.0	92.0	84.1	6.0	5	16	12
DSA	±0.91	±1.07	±4.4	—	±3.1	—	±1.9	—	—	±0.055	±0.046	±6.6	±1.0	±2.4	±5.2	±4.0	±1.0			
342	0811.90	139.51	345.0	0.6	+4.5	1.6	36.1	1.2	1.38	0.907	0.129	326.7	139.4	24.8	100.2	84.2	3.4	9	16	11
BPI	±0.39	±0.35	±0.7	—	±3.0	—	±3.0	—	—	±0.031	±0.016	±0.9	±0.2	±4.2	±3.4	±2.8	±1.4			

Table 2 – Results of detecting unknown meteor showers.
Data items and details are the same as Table 1. The shower numbers assigned by IAU, CODE and ShowerName for the previously unknown meteor showers detected are defined here as follows:

IAU code	Shower Name	IAU code	Shower Name	IAU code	Shower Name	IAU code	Shower Name
432 NBO	nu Bootids	433 ETP	eta Pegasids	434 BAR	beta Arietids	435 MPR	mu Perseids
436 GCP	gamma Cepheids	437 NLY	Nov. Lyncids	438 MLE	mu Leonids	439 ASX	alpha Sextantids
440 NLM	Nov. Leonis Minorids	441 NLD	Nov. lambda Draconids	442 RLE	rho Leonids	443 DCL	Dec. Leonids

IAU	DATE (UT)	$\lambda_\odot$	RA_G	Ea	Dec_G	Ea	V_G	Ea	a	e	q	ω	Ω	i	H_b	H_e	Amag	clc	MSS	M&P
432	0119.74	299.18	206.0	0.8	+12.6	0.3	62.8	2.5	2.75	0.691	0.850	221.7	299.8	140.5	111.3	97.6	3.9	8	13	1
NBO	±4.39	±4.29	±4.1	—	±2.7	—	±2.5	—	—	±0.166	±0.086	±24.6	±4.4	±4.9	±1.8	±5.2	±1.1			
433	0808.16	135.40	334.6	0.4	+32.7	0.4	34.5	0.9	1.46	0.685	0.460	293.1	134.8	55.1	101.7	88.1	5.0	6	7	3
ETP	±2.82	±2.93	±5.2	—	±2.0	—	±7.9	—	—	±0.147	±0.067	±17.2	±3.2	±10.9	±2.6	±8.3	±1.4			
434	0808.16	135.38	28.8	0.4	+21.9	0.9	65.5	2.8	3.25	0.728	0.882	226.2	135.0	161.1	111.4	101.5	4.2	6	12	1
BAR	±2.20	±2.34	±2.6	—	±2.7	—	±2.2	—	—	±0.135	±0.072	±14.8	±2.1	±5.8	±4.1	±4.7	±0.8			
435	0812.10	139.64	70.4	0.9	+50.0	0.3	54.2	2.6	1.91	0.691	0.592	88.4	139.5	121.3	108.1	99.0	4.1	5	5	2
MPR	±0.56	±0.54	±4.6	—	±2.6	—	±3.8	—	—	±0.042	±0.099	±15.8	±0.4	±7.2	±3.2	±6.2	±0.5			
436	1117.32	234.99	47.6	10.	+79.5	0.8	33.8	1.5	6.12	0.864	0.830	228.9	235.6	51.6	105.1	98.0	4.5	4	4	1
GCP	±1.36	±1.31	±15.4	—	±5.0	—	±1.4	—	—	±0.058	±0.048	±7.9	±1.2	±3.3	±0.6	±2.2	±0.8			
437	1120.35	237.92	141.8	0.8	+40.0	0.4	60.6	2.0	2.57	0.709	0.748	246.1	237.9	132.5	110.8	98.0	4.2	8	15	1
NLY	±3.68	±3.81	±5.6	—	±3.4	—	±3.7	—	—	±0.144	±0.101	±18.7	±3.8	±9.1	±4.2	±4.9	±0.9			
438	1118.09	235.70	142.4	0.5	+29.3	0.2	66.0	2.9	3.31	0.740	0.860	225.2	235.8	153.6	109.7	97.9	3.5	7	31	0
MLE	±0.60	±0.74	±2.5	—	±2.6	—	±2.2	—	—	±0.119	±0.067	±13.6	±0.7	±4.2	±3.5	±4.5	±1.0			
439	1119.71	237.37	154.6	0.5	−3.4	0.5	68.8	2.4	16.9	0.947	0.898	325.3	56.6	155.6	116.6	99.7	3.2	6	17	2
ASX	±3.60	±3.60	±3.1	—	±2.0	—	±2.3	—	—	±0.191	±0.055	±11.8	±3.4	±4.1	±10.3	±1.6	±2.0			
440	1120.28	237.99	162.2	1.6	+33.0	0.2	65.2	1.8	3.83	0.750	0.959	171.0	237.4	138.9	111.8	100.4	3.4	9	29	1
NLM	±3.25	±3.29	±6.4	—	±1.4	—	±1.6	—	—	±0.119	±0.033	±20.6	±2.7	±4.5	±6.3	±4.2	±1.8			
441	1118.52	236.07	177.3	7.2	+70.4	0.6	41.7	1.4	2.57	0.630	0.953	200.8	236.0	74.8	104.3	87.5	3.9	9	17	2
NLD	±0.64	±0.75	±12.1	—	±3.6	—	±2.6	—	—	±0.156	±0.034	±13.5	±0.7	±3.8	±9.7	±4.9	±1.9			
442	1214.31	262.18	155.6	0.5	+5.2	0.8	65.6	3.0	3.00	0.771	0.686	72.8	82.2	170.8	112.3	96.0	4.4	12	23	0
RLE	±1.04	±1.02	±2.1	—	±2.7	—	±2.3	—	—	±0.117	±0.078	±13.2	±1.0	±4.8	±4.8	±4.8	±0.7			
443	1214.42	262.19	155.3	0.4	+20.8	0.3	64.1	2.0	3.27	0.835	0.539	270.1	262.3	159.0	109.0	94.9	4.0	19	24	2
DCL	±3.20	±3.21	±3.0	—	±3.4	—	±2.2	—	—	±0.102	±0.082	±11.3	±3.3	±8.1	±6.6	±5.5	±1.5			

Confirmation of the July Gamma Draconids (GDR, IAU #184)

David Holman and Peter Jenniskens [1]

During routine low-light level video observations with CAMS (Cameras for All-sky Meteor Surveillance) made in the month of July 2011, we detected the July Gamma Draconids (GDR), a meteor stream discovered by P. Babadzhanov in 1963, and observed by the SonotaCo Network in 2007–2008. The stream is included in the IAU Working List of Meteor Showers as shower #184, awaiting verification. We detected this shower beginning on July 24, through its peak on July 28, and to the shower's end on August 1. Our mean orbital elements are $q = 0.978 \pm 0.001$ AU, $1/a = 0.022 \pm 0.005$ AU^{-1}, $i = 40\overset{\circ}{.}24 \pm 0\overset{\circ}{.}20$, $\omega = 202\overset{\circ}{.}31 \pm 0\overset{\circ}{.}22$, and $\Omega = 124\overset{\circ}{.}66 \pm 0\overset{\circ}{.}37$ ($N = 25$). The GDR meteors move in an intermediate long-period comet orbit with orbital period between 270 and 600 years. The parent body remains undiscovered.

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1 Introduction

The IAU Working List of Meteor Showers contains more than 300 unconfirmed minor showers that need verification. A new network of low-light level video cameras has been established in Northern California with the goal to confirm these showers existence. Each verified minor shower can be used to identify a parent body among the recent Near Earth Object discoveries and trace its origins and three dimensional dust distribution back in time (Jenniskens et al., 2011).

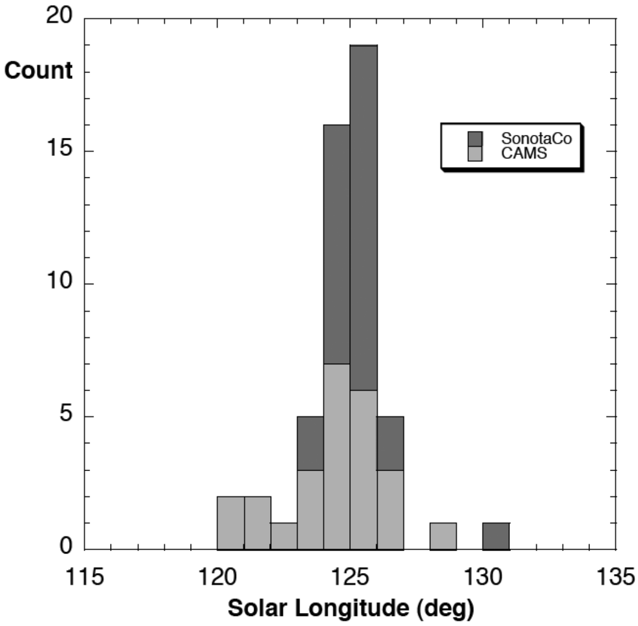

Figure 1 – Activity curve of July Gamma Draconids from SonotaCo and CAMS data.

Here, we report on observations made during the month of 2011 July, which confirm the July Gamma Draconids shower. This shower was first recognized by Pulat Babadzhanov (Babadzhanov, 1963), based on only three photographed meteors with anomalous radiant, speed, and orbital elements. Based on the provided B1950 coordinates, it was included in the working list of Jenniskens (2006) with geocentric radiant (J2000) of $\alpha = 278\overset{\circ}{.}8$, $\delta = +48\overset{\circ}{.}8$, and $V_g = 25.1$ km/s. It was also noticed by the SonotaCo meteor video survey of 2007–2008 made in Japan (SonotaCo, 2009), initially designated as IAU #344 (JUG), before it was recognized to be the same shower as #184. Shower #344 was subsequently dropped from the IAU Working List.

Based on 22 orbits from the solar longitude period $\lambda_\odot = 121\overset{\circ}{.}8$–$125\overset{\circ}{.}3$, SonotaCo put the radiant on July 28 at $\alpha_p = 280\overset{\circ}{.}1$ (drifting by $+1\overset{\circ}{.}17$/day), $\delta_p = +51\overset{\circ}{.}1$ (drifting by $+1\overset{\circ}{.}45$/day), and speed $V_g = 27.4$ km/s using a 4° diameter circle for shower association. The 2007–2009 database contains 27 meteors associated with this shower (labeled "J5_jug"), shown in Figure 1. This shower is noticeably absent from the Canadian Meteor Orbit Radar (CMOR) observations made from 2001 to 2008 (Brown et al., 2009). The shower was also not (yet) detected in single-station video observations in the IMO Video Meteor Network, part of which overlapped the SonotaCo observing time interval (Molau and Rendtel, 2009).

2 CAMS: Cameras for All-sky Meteor Surveillance

CAMS is a three-station 60-camera meteor surveillance using Watec Wat902 H2 cameras equipped with 12-mm focal length lenses. During July 2011, the CAMS network stations were located at Fremont Peak Observatory, at Lick Observatory, and at a low altitude site near Lodi, California. The CAMS methods have been described in detail in previous works (Jenniskens et al., 2011; Jenniskens and Gural, 2011), and more information about the CAMS network can be found on the web-site, `http://cams.seti.org`.

3 Confirmation of the July Gamma Draconids

On a graph of the July 2011 results plotted in right ascension and declination (Figure 2), one shower stood out immediately at high ca. +50° declination. Checking against the IAU Working List of Meteor Showers, the radiant location, duration and peak solar longitudes, and geocentric velocity corresponded to the July Gamma Draconids (GDR, IAU #184), awaiting confirmation.

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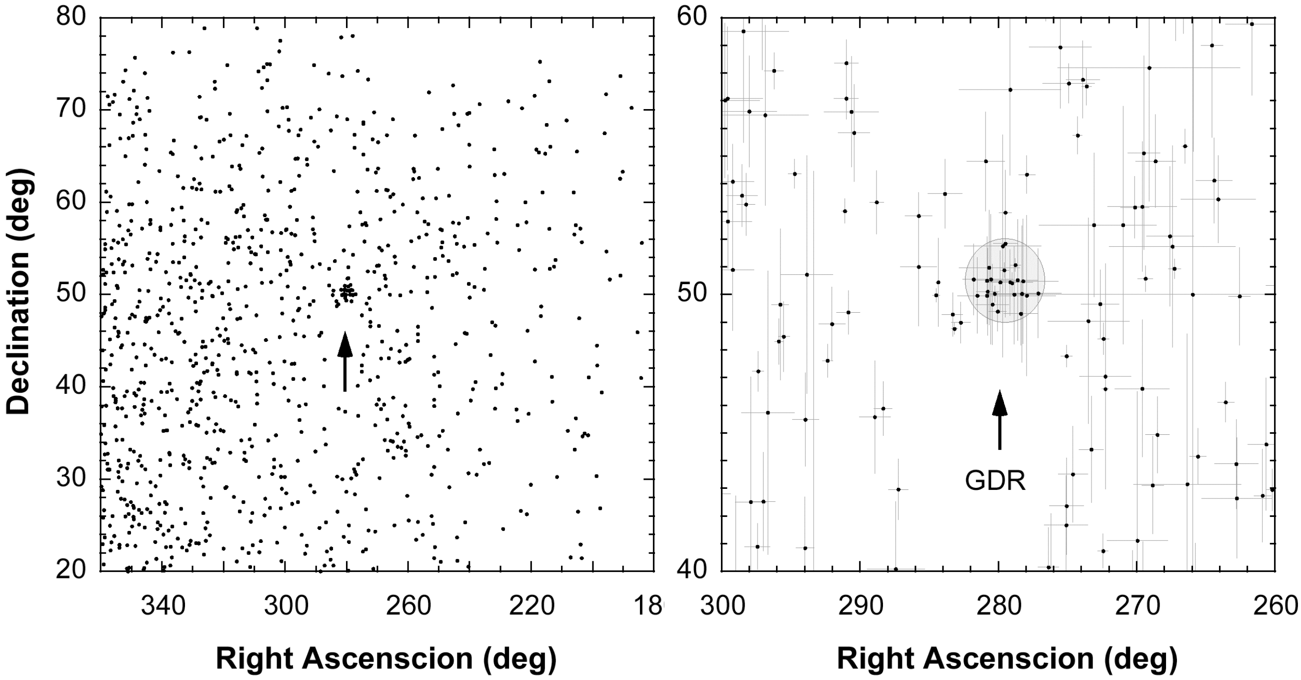

Figure 2 – The cluster of GDR orbits stands out clearly against the sporadic background of orbits recorded during July 2011 (*left*). A close-up of the GDR cluster is shown (*right*).

Table 1 – Orbital elements of July gamma Draconids ($D_{SH} < 0.1$).

Date	α	δ	V_g	q	e	i	ω	Ω	D	D_{SH}
2011-07-24	279°.69	+51°.76	28.37	0.981	0.981	41°.97	201°.50	120°.93	0.037	0.099
2011-07-24	280°.45	+49°.65	27.79	0.972	0.956	40°.92	204°.37	120°.97	0.028	0.060
2011-07-25	281°.79	+50°.55	28.68	0.973	0.986	42°.28	203°.83	121°.90	0.044	0.060
2011-07-25	280°.06	+49°.36	28.16	0.972	0.999	40°.96	204°.00	121°.91	0.030	0.050
2011-07-26	281°.53	+49°.97	27.65	0.972	0.941	40°.87	204°.42	122°.92	0.040	0.045
2011-07-27	279°.50	+51°.84	27.79	0.983	0.971	41°.03	200°.97	123°.79	0.022	0.048
2011-07-27	279°.88	+50°.45	28.58	0.977	1.035	41°.40	202°.29	123°.85	0.027	0.034
2011-07-27	280°.82	+49°.97	28.07	0.974	0.990	40°.98	203°.55	123°.86	0.024	0.027
2011-07-28	280°.83	+50°.52	28.03	0.976	0.988	41°.02	202°.87	124°.68	–	–
2011-07-28	277°.94	+49°.96	27.59	0.980	1.020	39°.74	201°.54	124°.72	–	–
2011-07-28	277°.13	+50°.05	26.62	0.982	0.968	38°.66	201°.21	124°.74	–	–
2011-07-28	280°.78	+50°.12	28.12	0.975	1.001	40°.95	203°.17	124°.75	–	–
2011-07-28	278°.39	+49°.31	27.14	0.977	0.991	39°.17	202°.55	124°.82	–	–
2011-07-28	280°.29	+50°.03	27.81	0.975	0.992	40°.48	202°.99	124°.87	–	–
2011-07-28	278°.87	+50°.00	26.61	0.978	0.940	38°.99	202°.43	124°.91	–	–
2011-07-29	279°.03	+50°.42	27.17	0.980	0.974	39°.63	201°.80	125°.65	0.005	0.012
2011-07-29	278°.31	+50°.03	26.69	0.980	0.961	38°.87	201°.80	125°.66	0.023	0.025
2011-07-29	280°.53	+50°.56	26.67	0.977	0.915	39°.50	202°.90	125°.68	0.061	0.066
2011-07-29	278°.22	+50°.49	26.97	0.981	0.975	39°.27	201°.22	125°.73	0.011	0.016
2011-07-29	278°.78	+51°.07	27.13	0.982	0.968	39°.73	201°.03	125°.79	0.009	0.016
2011-07-29	279°.17	+50°.44	27.42	0.979	0.990	39°.88	201°.74	125°.86	0.014	0.020
2011-07-30	278°.63	+50°.53	26.95	0.981	0.973	39°.24	201°.28	126°.63	0.012	0.027
2011-07-30	280°.67	+50°.98	27.75	0.979	0.985	40°.61	202°.01	126°.66	0.016	0.037
2011-07-30	279°.57	+50°.89	27.72	0.980	1.040	40°.31	201°.34	126°.69	0.010	0.028
2011-08-01	279°.58	+51°.21	27.02	0.982	0.967	39°.54	200°.92	128°.45	0.011	0.056
Average	279°.62	+50°.41	27.54	0.978	0.972	40°.24	202°.31	124°.66	0.024	0.040
±	0°.23	0°.13	0.12	0.001	0.005	0°.20	0°.22	0°.37	–	–
σ	1°.17	0°.63	0.62	0.003	0.025	0°.99	1°.10	1°.84	0.015	0.023

Our data show good agreement with the mean radiant position and speed and the shower duration reported by SonotaCo (2009). Our mean radiant position is at $\alpha = 279\fdg62 \pm 0\fdg23$ and $\delta = 50\fdg41 \pm 0\fdg13$, which fits well inside of the radiant distribution circle presented in the above reference. Twenty-four radiant points fit inside a circle sized 3° (encircled gray area in Figure 2). All have entry speeds of $V_g = 27.54 \pm 0.62$ km/s. One more possible GDR was identified in data from August 1 after inspecting the August 1–7 period using the D-criterion against the mean orbital elements derived from the July data. This brings the total to 25 shower candidates in the period July 24 through August 1 (Table 1).

Figure 3 shows those 25 radiant coordinates plotted against solar longitude. The solid lines show the drift rates given by SonotaCo (2009). The dashed line is a least-squares fit to our data, showing a much lower declination drift, and a negative right ascension drift, contrary to what has been reported by SonotaCo. Using the slopes of the regression lines, we measure these drift rates to be $-0\fdg24$/day in right ascension, and $+0\fdg07$/day in declination. However, the correlation coefficients for these regression lines are very low at $R = 0.37$ in right ascension and $R = 0.20$ in declination.

There is also a drift in speed, at -0.20 km/s per degree of solar longitude, with a more significant regression coefficient of $R = 0.60$. In fact, the 27 meteors identified as July Gamma Draconids in the most recent SonotaCo database have a radiant drift of $-0\fdg20$/day in right ascension and $+0\fdg28$/day in declination, in good agreement. Three have slightly higher velocity. Combined data, minus the higher velocity candidates ($N = 49$), have a radiant drift of $-0\fdg23$/day in right ascension and $+0\fdg14$/day in declination, and a drift in speed of -0.18 km/s per day.

The duration of the shower given by SonotaCo is $7\fdg0$ in solar longitude, ranging from $\lambda_\odot = 121\fdg8$ to $\lambda_\odot = 128\fdg8$, with a mid-point at $\lambda_\odot = 125\fdg3$, which is also the value given for the peak. Our data show a duration of $7\fdg52$ degrees in solar longitude, starting at $\lambda_\odot = 120\fdg93$ and ending at $\lambda_\odot = 128\fdg45$, with the midpoint between our two best nights occurring at $\lambda_\odot = 125\fdg3$, in good agreement. SonotaCo reports a geocentric velocity of 27.4 km/s, with an allowable error of ±3.0 km/s for their shower associations. Our results show a mean geocentric velocity of 27.54 ± 0.12 km/s for our GDR candidates, in good agreement. Here, the error is that of mean value, not the standard deviation of individual orbits. Both are listed in Table 1.

4 Orbital elements

The GDR candidates also stand out when graphed in terms of their orbital elements, inclination and longitude of perihelion (Figure 4). Note that the distribution of the GDR orbits, while dispersed, does not appear to be Gaussian in either Figures 2, *right*, and 4, *right*.

The GDR meteor candidates have mean heliocentric velocities of 41.57 km/s that are very close to the parabolic limit of 42.13 km/s, and four candidates have eccentricities just above 1 and negative values for $1/a$ due to inaccuracies in the calculation of their semi-major axes (Table 1). We used the orbital elements from our best night, July 28, as a comparison to check the validity of all other GDR candidate orbital elements. The D-criteria procedure is described in detail by Jenniskens and Gural (2011) and Jenniskens (2008). Here, two different types of D-criteria were examined: D and D_{SH}. The mean eccentricity of the other candidates is substituted for the four candidates with $e > 1.0$. These D-criterion test values are shown in Table 1. All of the resulting D_{SH} values are below the often adopted cut-off level of $D_{SH} \leq 0.15$ (see the above-mentioned references), and the similarly low values for D indicate that these orbits are related, so these meteors are verified as GDR shower members.

The magnitude range of the GDR meteors is +0.2 to +4.0, with a mean absolute magnitude (at 100 km distance) of $M_v = +2.3$. The magnitude distribution index averages $\chi = 1.8 \pm 0.3$ for three magnitude intervals. The light curve F-values range from 0.19 to 0.91, with a mean value of $F = 0.61$. Nineteen GDR meteors have F-values above 0.5, and six have lower values, from 0.19 to 0.48, suggesting most peak late during entry, typical for somewhat more cohesive materials. The GDR meteors tend to have a beginning height from the middle to the top range of other observed meteors with similar entry speeds (93–104 km), with one GDR at the lowest end of the range (86 km). These penetration depths are consistent with a cometary origin.

5 Discussion

The Earth intercepts the GDR steam at its descending node, just before the stream reaches perihelion (Figure 5, perihelion position marked "GDR"). Locations and distribution of ascending node points are shown in Figure 6. Most tend to pass just behind the orbit of Uranus. These ascending nodes scatter around $r_\Omega = 19.7$ AU, somewhat beyond the orbit of Uranus at 19.1 AU. The clustering of orbits behind the orbit of Uranus might suggest that this comet was captured by Uranus in a previous orbit.

The GDR orbit semi-major axes, a, ranges from 11.5 to 771.7 AU ($N = 21$), not including the four orbits with longer (> 1000 AU) but unspecified values of a. The aphelion distances are larger than 22 AU and the orbital periods longer than 39 years. The mean value of $1/a$ is $+0.019 \pm 0.005$ AU, corresponding to $a = 53 \pm 20$ AU. Such an orbit would have an orbital period of about 380 years, at the border of intermediate long-period comets ($P > 200$ years) and the shorter Halley-type comet orbits, both originating from the Oort cloud.

The observed radiant and velocity drift translate into a significant daily drift of the longitude of perihelion of $+0\fdg56$ per degree of solar longitude ($N = 49$, $R = 0.80$), and a decreasing inclination of $-0\fdg31$ per degree of solar longitude ($R = 0.66$). Such variations are expected only if the comet or meteoroid orbits had significant precession over time.

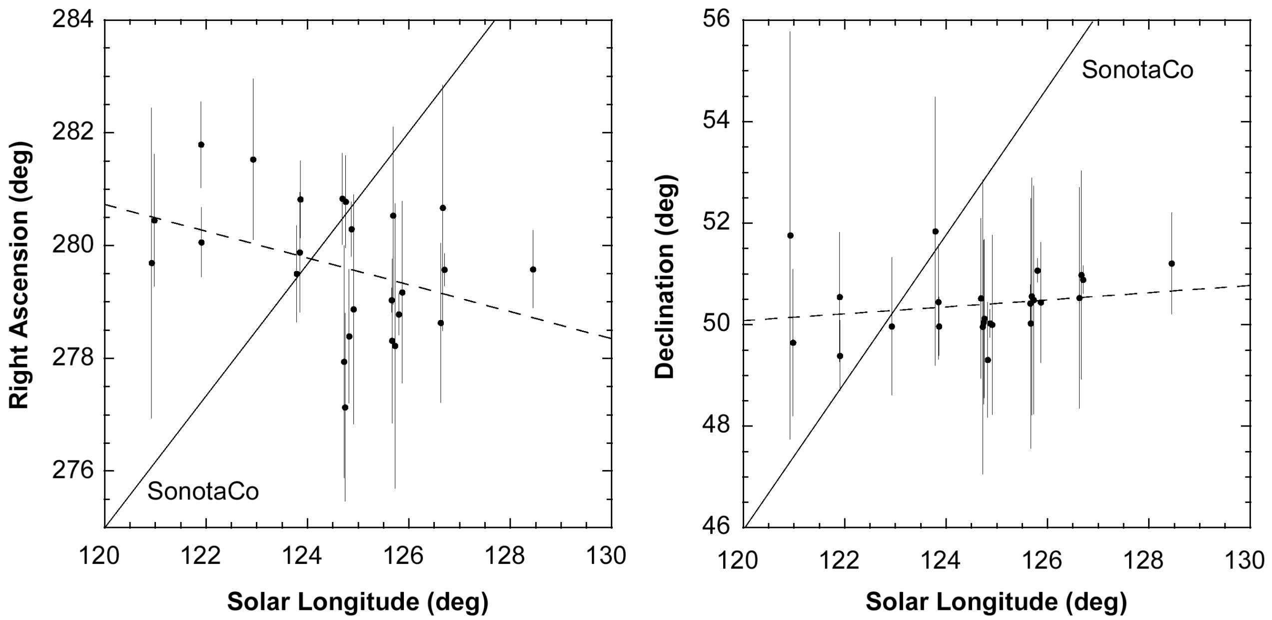

Figure 3 – Radiant drift is shown for right ascension and declination for the GDR meteors. The solid lines show the rates of drift reported by SonotaCo (2009). The dashed lines are fitted regression lines to our data that show the rates of GDR drift observed in July 2011.

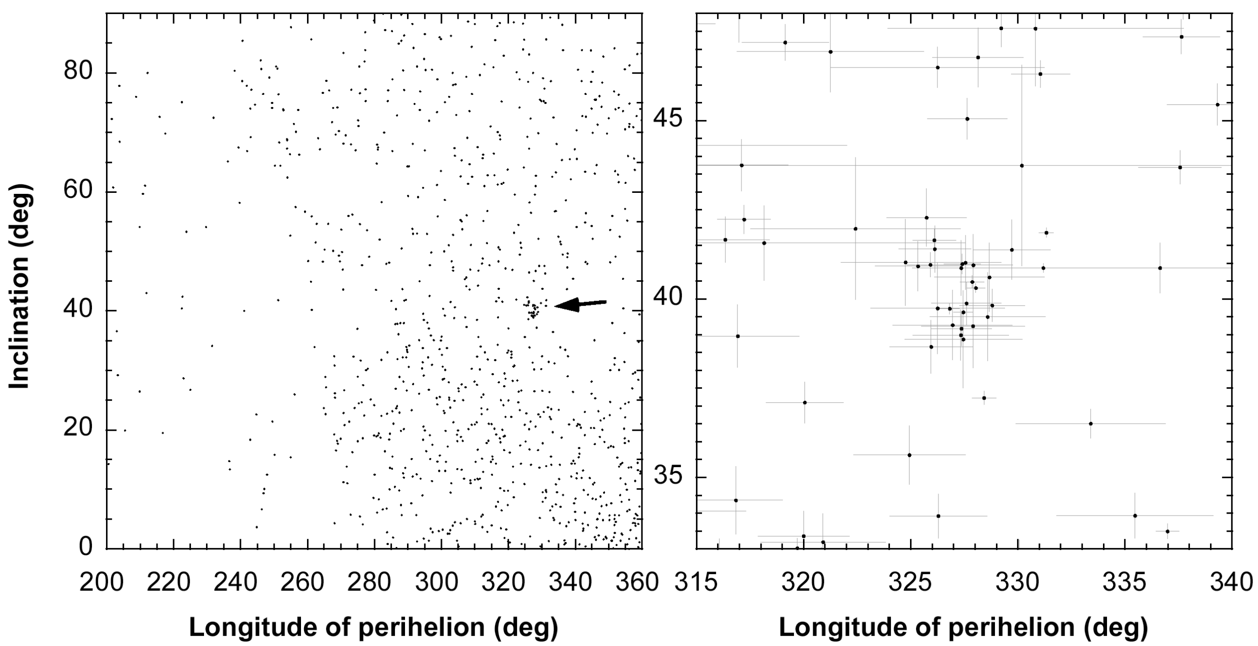

Figure 4 – GDR candidates shown by inclination versus longitude of perihelion.

New long period comets tend to have intermittent compact debris streams lasting just a few hours. Hence, the ca. 8-day duration of this shower also indicates that the detected GDR meteors belong to an older stream with multiple returns to the inner solar system.

Notice that the shower was not detected by CMOR (Brown et al., 2009). In that sense, the GDR are different from the recently confirmed ARC shower (Phillips et al., 2011), which was discovered by CMOR and had video activity levels similar to the GDR. The relatively low magnitude distribution index for the GDR may be responsible, the CMOR radar being sensitive for fainter meteors of magnitude +6 to +8.

6 Conclusions

We confirm the existence of the July Gamma Draconids shower, previously detected in a photographic survey by Babadzhanov (1963) and in a video survey by the SonotaCo Network in 2007–2009. We confirm the time of the shower peak (July 28) and the activity period (July 24–August 1), but find a different radiant drift than reported before.

While there is no known parent body at the present time, the GDR stream of meteoroids likely originated from an intermediate long-period comet, with a small possibility that the source was in a Halley-type orbit.

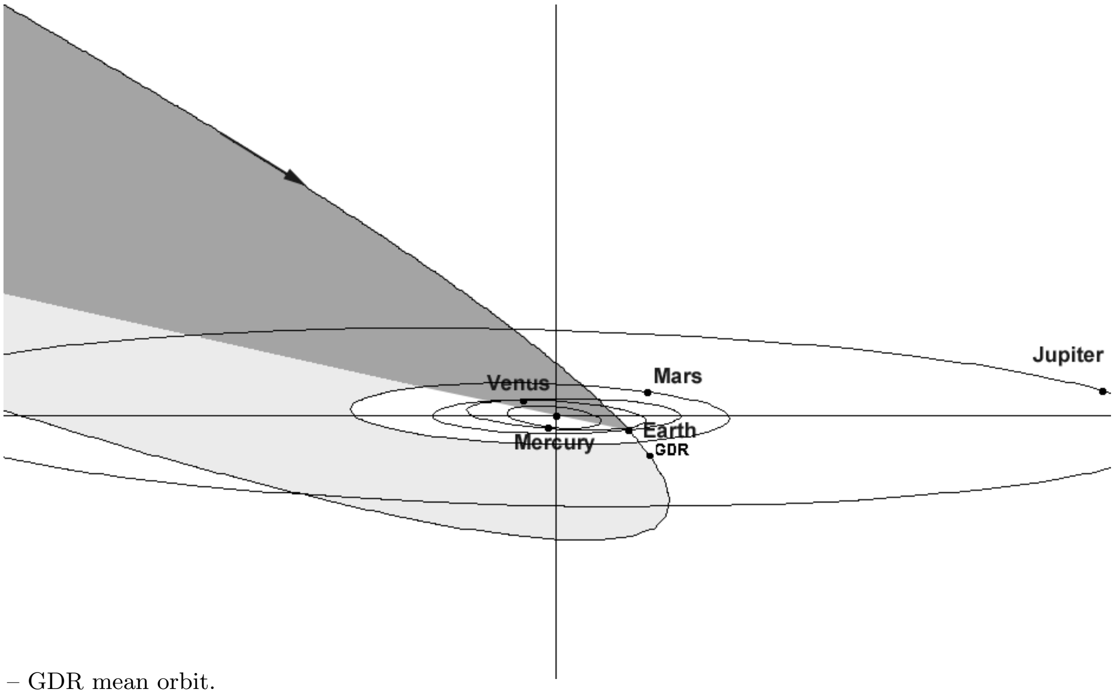

Figure 5 – GDR mean orbit.

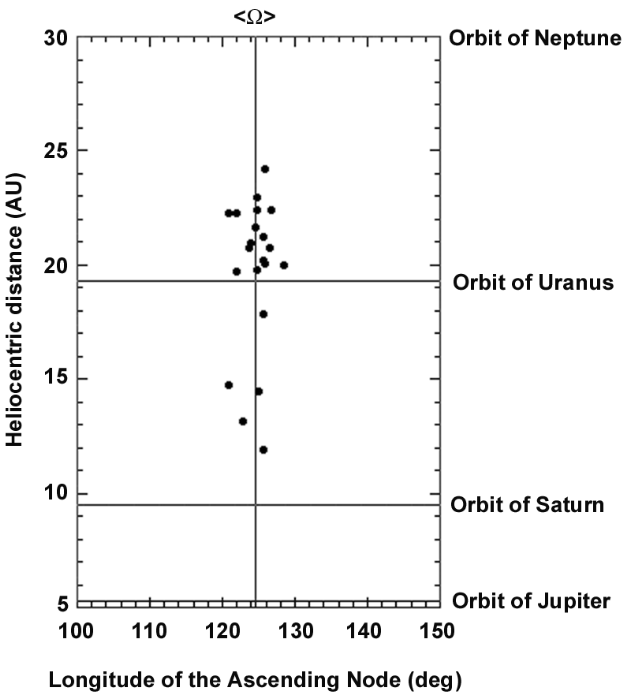

Figure 6 – The heliocentric distances to each orbits ascending node are shown. A clustering just beyond the orbit of Uranus is evident.

Acknowledgements

We thank Peter Gural for developing the software algorithms used in this investigation.

We also thank the Fremont Peak Observatory Association and the Lick Observatory staff for their assistance in maintaining two of the CAMS stations, specifically FPOA director Rick Morales and board member Mark Levine. And, finally, we also thank Tom and Carmela Hoffman of Heritage Oaks Winery in Lodi, California for graciously hosting the third CAMS station. CAMS is supported by the NASA Planetary Astronomy program.

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Preliminary results

Results of the IMO Video Meteor Network — October 2011

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October 2011 was a record month for the 66 cameras of the IMO Video Meteor Network. About 59 000 meteors were recorded in more than 10 000 hours of effective observing time. The outburst of the Draconids was observed, peaking on 2011 October 8 at 20^h10^m UT with a flux density of about 110 meteoroids per 1 000 km^2 per hour and FWHM 80 minutes. High-resolution flux density profile of the Draconids is presented. The Orionids peaked on October 23/24 with a flux density of about 25 meteoroids per 1 000 km^2 per hour. Flux density profile covering full activity interval is presented. Activity profiles of the October Ursae Majorids, ε-Geminids and Leo Minorids are also presented.

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1 Introduction

From the view point of a meteor observer, October was without doubt the highlight of this year. The splendid observing weather of the previous month continued with only some short breaks. Thanks to the increasing length of observing nights in the northern hemisphere and high meteor shower activity due to the Draconids, Orionids and Taurids as well as a further growth of the camera network, we beat all records once more. A total of 66 video cameras were active in October, 42 of which managed to obtain twenty and more observing nights (Table 1 and Figure 1). With a few exceptions, all cameras collected at least one hundred hours of observing time, and many more than two hundred. Thus, for the first time we obtained more than ten thousand hours of effective observing time in just one month, which is a plus of 15% compared to September 2011 (Molau et al., 2011b). In this time, we recorded about 59 000 meteors, which is an increase of 10% over August 2011 (Molau et al., 2011a).

We welcomed Grahame Kelaher and David Judge from Perth as new observers in our camera network. They started the West-Australian camera network with the two cameras Wamcam1 and Wamcam2. Stefano Crivello put into operation his third Mintron camera Bilbo, with its 3.8 mm Computar lens. In Germany, Wolfgang Hinz resumed operation. After the camera Akm2 broke in June, he now operates the camera Acr from Astroclub Radebeul. It is a camera of the "first hour" – the image intensifier comes from a group purchase that was the basis for the first series of video meteor cameras in Germany in 1995. The 35 mm $f/2.0$ photographic lens did a good job for Avis many years ago. Acr has a limiting magnitude well beyond seventh magnitude.

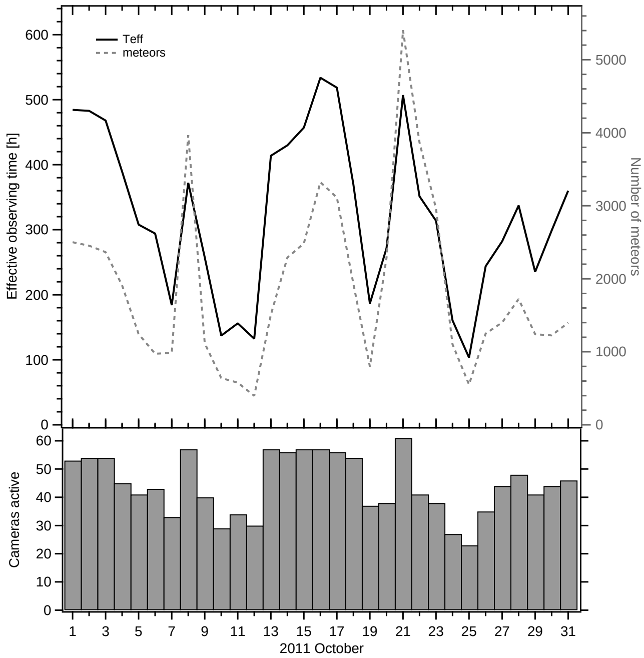

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2011 October.

2 Draconids

Of the meteor showers in October, the first highlight was the Draconids. Several renowned meteor researchers had predicted an outburst at about 20^h UT on October 8 (Maslov, 2011; Vaubaillon et al., 2011). The observers disagreed only on the strength of the outburst – the predictions reached from a noticeable, but hardly spectacular peak ZHR of 50, up to half a meteor storm with zenithal hourly rates up to 600. The time of maximum was well placed for European observers, if we forget for a moment the almost full Moon.

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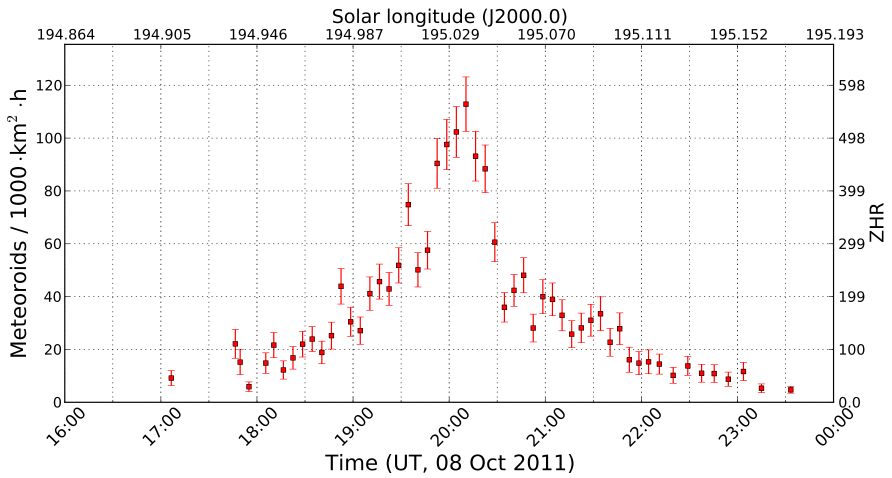

Figure 2 – High resolution flux density profile of the Draconids on 2011 October 8, derived from data of the IMO Video Meteor Network.

For the Draconids, we started a special experiment in the IMO Video Network. For the first time, the observing data were to be automated and transferred in real-time to the central Virtual Meteor Observatory (VMO) server. There the data were analysed such that the Draconid activity could be followed live via the Internet. Shortly after the 2011 International Meteor Conference, both the recognition software MetRec and the online flux tool were adapted and in early October first data were uploaded for testing in real-time. The whole experiment was planned and installed at the last minute and, although there were many variables which could have ruined the effort, still everything went well in the end.

Before the Draconids, more than twenty observers had agreed to join the experiment. The nice weather, which yielded perfect observing conditions until early October, ended just in time for the Draconids. Thus, most observers had to fight with poor weather conditions. In the end there were four cameras in Germany, Slovenia and Portugal (Klemoi, Orion1, Orion2, Templar3) whose data from mainly clear skies were uploaded online. Thanks to these cameras, observers with clouded skies or daylight could follow the activity in real-time. At `http://www.imonet.org/draconids/` you will find a time-lapse sequence that shows how the flux density graph has developed in the course of the night. A time-lapse movie of the recordings by Avis2 with almost 200 Draconids can be found there as well.

Of course, the data set grew significantly in the following days, when all the other observers uploaded the data of 57 video cameras, enabling a more thorough analysis of the outburst. Figure 2 shows the high resolution flux density profile for eight hours around the peak. Thanks to the high meteor number, intervals of only five minute length could be used. The peak occurred at $20^{h}10^{m}$ UT ($\lambda_{\odot} = 195\overset{\circ}{.}036$) with an (equivalent) flux density of about 110 meteoroids per 1 000 km^2 per hour.

To determine the full width at half maximum (FWHM) of the outburst, a third order polynomial was fitted to the ascending and descending branch of the activity profile (Figure 3). The FWHM was determined to be 80 minutes ($19^{h}20^{m} - 20^{h}40^{m}$ UT). Figure 3 shows also visual data from the IMO quick look analysis (International Meteor Organization, 2011). They yield a peak at $20^{h}12^{m}$ UT with identical FWHM. Peak visual eZHR was about 300. The eZHR calculated from the video flux densities was nearly twice as high, matching the counts we made in the last meteor shower analyses.

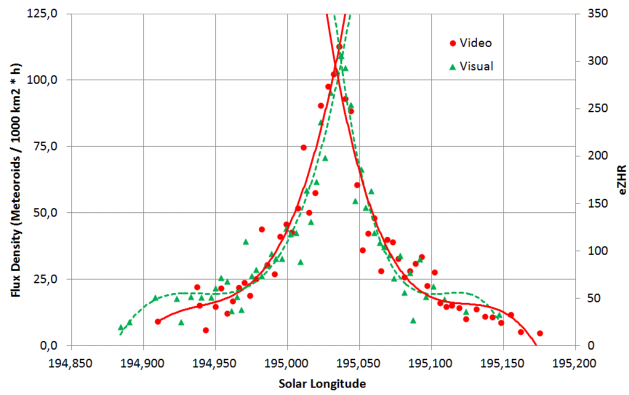

Figure 3 – Comparison of video (dots) and visual (triangles) observations of the Draconid outburst. The lines show a third order polynomial fit to the ascending and descending activity branches, respectively.

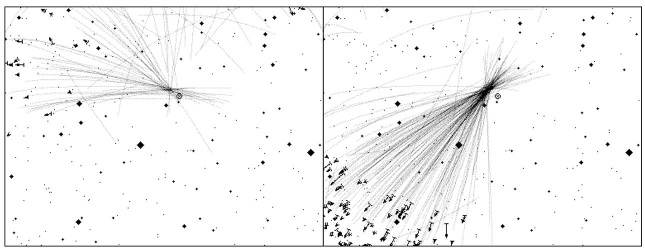

Figure 4 – Two radiant plots of the Draconids on 2011 October 8 (left Hermine, right Templar2).

As expected, most cameras with clear skies obtained nice radiant plots, two of which are shown in Figure 4. It's obvious that the apparent radiant deviates from the expected position given in the IMO meteor shower calendar ($\alpha = 262°$ / $\delta = 54°$, $v_\infty = 20$ km/s) (McBeath, 2010).

The explanation was soon found: Due to the low velocity of the meteor shower, the radiant position is noticeably shifted by zenith attraction. Right after the outburst, Marco Langbroek communicated a preliminary mean geocentric radiant from 28 multi-station Draconids of a American/German/Dutch observing campaign of $\alpha = 262.^\circ 8 \pm 0.^\circ 7$ / $\delta = +55.^\circ 5 \pm 1.^\circ 1$ and $v_{\text{geo}} = 20.98 \pm 0.95$ km/s (Langbroek, 2011). For comparison we calculated the mean radiant position of all 2 425 single-station Draconids, recorded by IMO Video Network cameras in 2011 October 8/9. We applied the same method as in previous meteor shower analyses (i.e. including the effect of zenith attraction), but with a higher resolution of $0.^\circ 1$ in α/δ and 0.1 km/s. Our result ($\alpha = 262.^\circ 2$ / $\delta = +56.^\circ 2 \pm 1.^\circ 3$ and $v_\infty = 20.7 \pm 0.6$ km/s) agreed within the error bars with the results communicated by M. Langbroek. There is a little problem, however: the different velocity bases (v_{geo} and v_∞)! If we transform the velocity given by M. Langbroek, we get a value of $v_\infty = 23.8$ km/s, which differs significantly from the values obtained by us and given in the Meteor Shower Calendar. Thus, further clarification is needed here.

3 Orionids

The second highlight of October were the Orionids. In the final third of the month, the lunar phase was much more favourable. Only in the morning hours was light from the waning Moon slightly disturbing. Figure 5 shows the flux density profile over the full activity interval from end of September until early November, based on 14 200 Orionids (with 27 700 sporadic meteors in parallel). The graph shows the well-known symmetric profile, which only near the maximum looks like a "tilted plateau". Some video observers thought the maximum would be observed on October 20 or 21, so they were surprised by the further growth of rates in subsequent nights, which peaked on October 23/24.

Similar to the Perseids (Molau et al., 2011a), the detailed view of the peak looked somewhat chaotic, with strong activity fluctuations in the course of each night. That is no surprise considering that the Orionid radiant also gains significant altitude at European observing sites in the course of the night. A possible zenith exponent would have a strong impact. Contrary to the Perseids, the Orionids do not show a sharp peak, but have an almost constantly high activity over several nights, so the effect of the zenith exponent can be better analysed. For this reason, we re-calculated the flux density for all cameras with zenith exponents between 1.0 and 2.0 in steps of 0.1, just as we did for the Perseids (Molau et al., 2011a). The result is partly given in Figure 6. From subjective judgement, we suspect a zenith exponent between 1.5 and 1.6 yields the lowest scatter of the data points, which agrees well with the findings for the Perseids ($\gamma = 1.6$).

In parallel we checked whether the formula used in MetRec for radiant altitude correction (after Kresak, 1954) yields an extra offset to the pure cosine for altitudes below 10 degrees, and whether this has an influence on the activity profile. It turned out, however, that the differences with and without the correction term were only marginal. At peak time, the Orionds presented a flux density of about 25 meteoroids per 1 000 km^2 per hour – about the same peak flux density as their counterpart in May (η-Aquariids) and more than half of the Perseid activity in 2011. The ZHR obtained from the flux densities is three to four times higher than the visual peak ZHR of about 30. For this effect we do not have an explanation, particularly given the size and quality of the data sets used.

4 Other showers

The October Camelopardalids, which could be observed in previous years only for a few hours near their peak at $\lambda_\odot = 192.^\circ 6$, fell into the European daytime hours this year and could not be observed. The October Ursae Majorids, which were discovered a few years ago as well, showed the expected smooth maximum on October 16. Their flux density profile (Figure 7) is based on 550 shower members.

The ε-Geminids, which are sometimes hard to discern from the Orionids because of their similarity, showed a flat activity profile without significant structure in their full activity interval (Figure 8, based on almost 1 200 shower members).

Last but not least, the Leo Minorids presented (based on 220 shower meteors) a distinct activity profile with a flux density of up to 8 meteoroids per 1 000 km^2 per hour, which curiously broke down significantly just at the expected peak time (Figure 9).

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Table 1 – Observers contributing to 2011 October data of the IMO Video Meteor Network. Eff.CA designates the effective collection area and Tot.CA the total collection area.

Code	Name	Place	Camera	FOV [°2]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	13	64.7	14.1	91
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	26	184.9	182.4	1354
			Hulud2 (0.75/6)	4860	3.9	1103	25	163.7	101.2	682
			Hulud3 (0.75/6)	4661	3.9	1052	24	146.6	103.5	484
BREMA	Breukers	Hengelo/NL	Mbb3(0.75/6)	2399	4.2	699	12	108.2	39.7	639
			Mbb4(0.8/8)	1470	5.1	1208	16	138.2	75.8	586
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	26	203.5	86.2	1110
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	26	188.9	235.5	1185
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	21	141.5	170.5	728
			Bmh2 (1.5/4.5)*	4243	3.0	371	17	120.0	250.4	805
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	21	196.0	—	1619
			C3P8 (0.8/3.8)	5455	4.2	1586	26	251.5	312.0	1493
			Stg38 (0.8/3.8)	5614	4.4	2007	25	219.7	343.6	1874
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	17	100.6	19.8	395
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	24	203.3	168.7	1346
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	25	246.4	323.0	1480
			Templar2 (0.8/6)	2080	5.0	1508	25	248.3	207.4	1292
			Templar3 (0.8/8)	1438	4.3	571	28	245.0	137.1	1077
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	20	168.2	314.7	907
HERCA	Hergenrother	Tucson/US	Salsa3 (1.2/4)*	2198	4.6	894	25	212.1	—	918
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	16	131.1	—	1716
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	26	154.2	—	758
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	16	144.3	—	583
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	26	200.4	—	789
		Sopron/HU	Husop (0.8/6)	2031	3.8	460	23	129.4	—	1563
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	20	153.7	108.4	649
JUDDA	Judge	Perth/AU	Wamcam2 (0.95/2.8)	4742	—	—	16	91.7	—	237
KACJA	Kac	Kostanjevec/SI	Metka (0.8/8)*	1372	4.0	361	10	94.6	42.8	345
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	20	149.3	123.1	728
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	19	132.0	—	1053
			Rezika (0.8/6)	2270	4.4	840	17	105.3	176.1	1164
			Stefka (0.8/3.8)	5471	2.8	379	18	129.8	70.2	768
KELGR	Kelaher	Secret Harbour/AU	Wamcam1 (0.8/3.8)	5607	—	—	15	113.4	—	122
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	17	97.8	220.5	528
KOSDE	Koschny	Noordwijkerhout/NL	Icc7 (0.85/25)	714	5.9	1464	19	110.9	190.0	753
			Lic4 (1.4/50)*	2027	6.0	4509	22	141.7	279.0	985

Table 1 – Observers contributing to 2011 October 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]	Tot.CA [10^3km^{2}h]	Meteors
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	16	71.4	—	258
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	22	141.9	40.3	324
			Pav36 (1.2/4)*	5732	2.2	227	25	162.0	—	545
			Pav43 (0.95/3.75)*	2544	2.7	176	21	163.9	43.6	320
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	1	1.4	—	7
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	19	160.4	589.8	3349
			Mincam1 (0.8/8)	1477	4.9	1084	24	173.7	220.7	963
		Ketzür/DE	Remo1 (0.8/3.8)	5600	3.0	486	24	161.2	—	643
			Remo2 (0.8/3.8)	5613	4.0	1186	27	160.5	97.1	470
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	22	175.0	106.9	584
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	28	163.3	—	961
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	25	166.8	—	1959
ROETO	Roeland	Oostmalle/BE	Kempen (0.95/8)	1593	4.2	524	21	126.2	—	273
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	13	101.7	—	507
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	16	122.1	81.6	593
			Ro2 (0.75/6)	2381	3.8	459	25	186.0	—	696
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	27	221.6	272.9	1132
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	24	147.4	—	592
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	588	—	—	20	93.8	—	383
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	24	211.4	342.0	2112
			Noa38 (0.8/3.8)	5609	4.2	1911	25	213.8	325.9	1655
			Sco38 (0.8/3.8)	5598	4.8	3306	25	198.8	—	2293
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	15	109.7	83.1	466
			Mincam3 (0.8/12)	728	5.7	975	24	169.0	—	878
			Mincam5 (0.8/6)	2349	5.0	1896	24	183.9	190.7	1420
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	25	178.8	153.8	1036
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	21	145.0	—	544
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	18	94.0	99.0	547
ZELZO	Zelko	Budapest/HU	Huvcse02 (0.95/5)	1606	3.8	390	15	98.4	47.4	344
			Huvcse03 (1.0/4.5)	2224	4.4	933	15	106.1	70.3	330
						Overall	31	10 040.1	—	58 990

* active field of view smaller than video frame

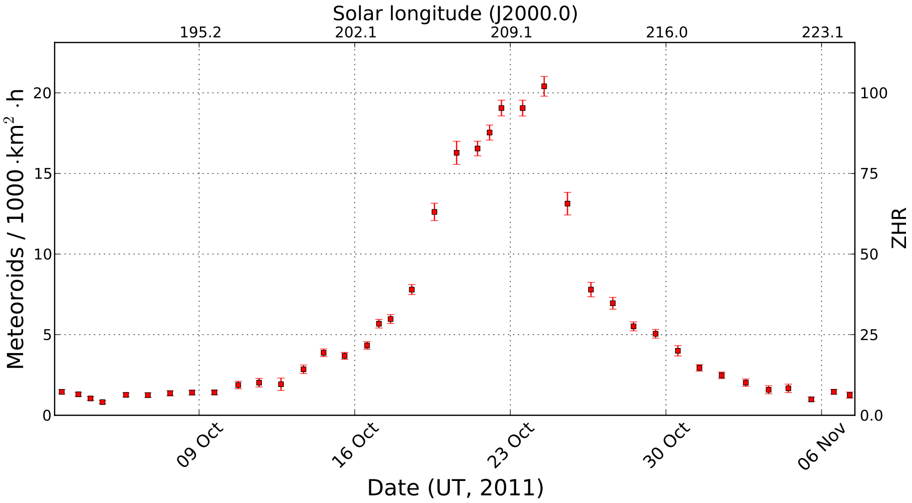

Figure 5 – Flux density profile of the Orionids over the full activity interval in 2011, derived from data of the IMO Video Meteor Network.

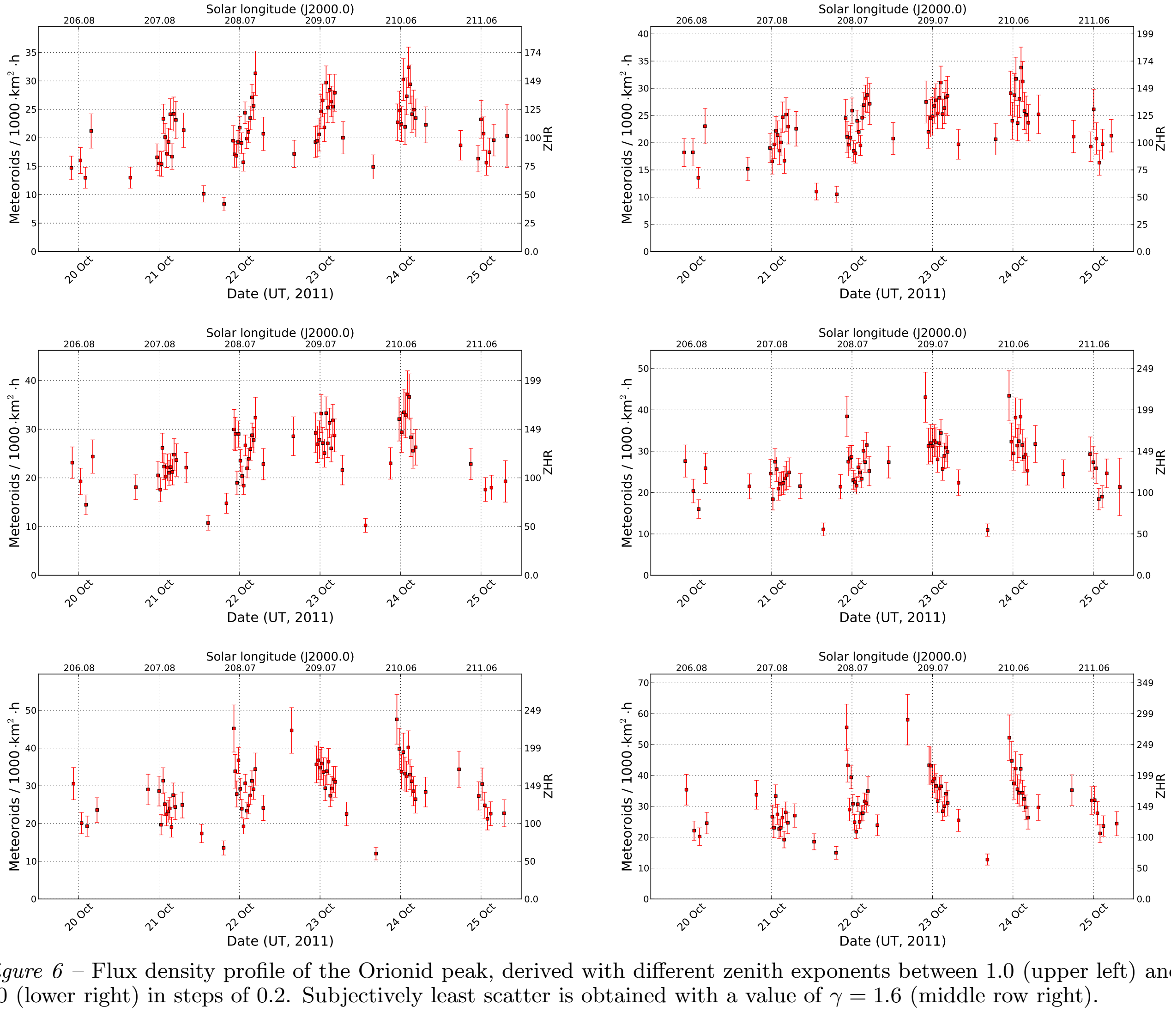

Figure 6 – Flux density profile of the Orionid peak, derived with different zenith exponents between 1.0 (upper left) and 2.0 (lower right) in steps of 0.2. Subjectively least scatter is obtained with a value of $\gamma = 1.6$ (middle row right).

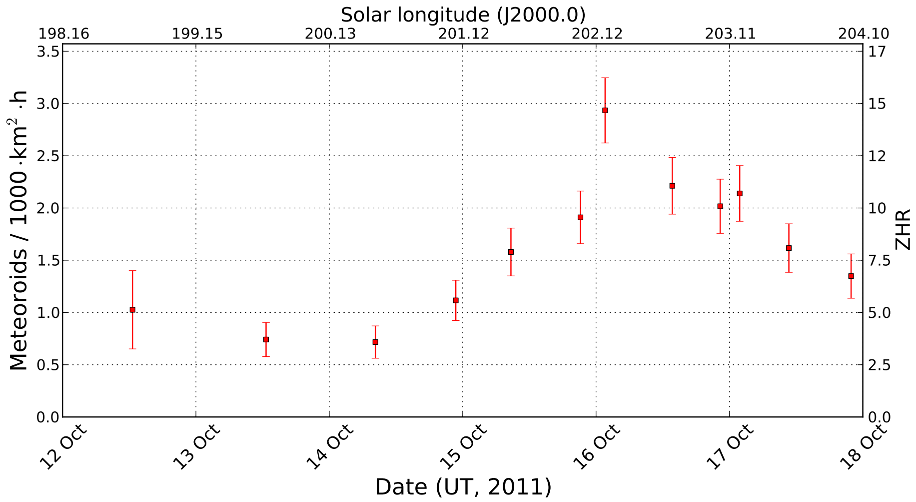

Figure 7 – Flux density profile of the October Ursae Majorids in 2011 October.

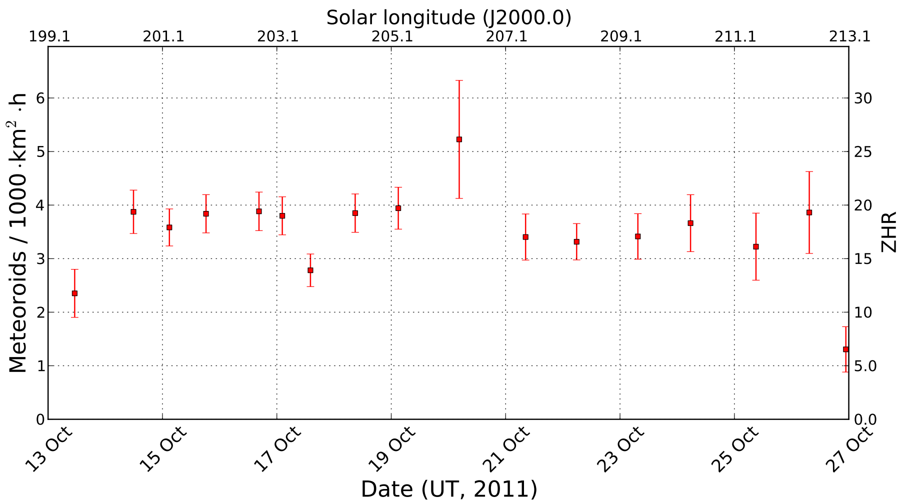

Figure 8 – Flux density profile of the ε-Geminids in 2011 October.

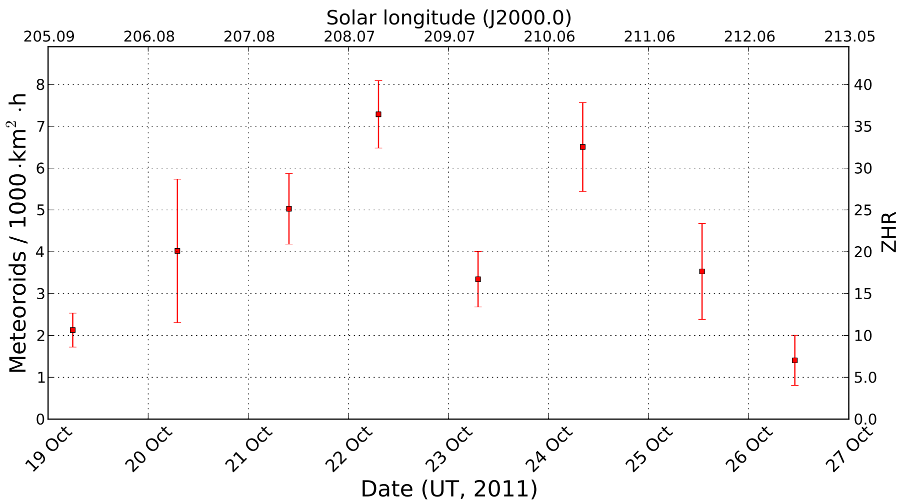

Figure 9 – Flux density profile of the Leo Minorids in 2011 October.

Results of the IMO Video Meteor Network — November 2011

Sirko Molau[1], *Javor Kac*[2], *Erno Berko*[3], *Stefano Crivello*[4], *Enrico Stomeo*[5], *Antal Igaz*[6] *and Geert Barentsen*[7]

In November 2011, 64 cameras contributed their data, covering over 8 000 hours of effective observing time and recording almost 34 000 meteors. Between September 25 and November 25, 7 000 Northern Taurids and 6 900 Southern Taurids were recorded by the Network. The flux density profiles for both branches of the Taurids, covering the entire activity period, are presented. The Leonids reached their maximum on 2011 November 18/19 and their activity profile is presented, based on 1 800 meteors. The α-Monocerotids were mostly lost in the sporadic background. Only on November 22 was their activity above the background. The one millionth meteor of the Network was recorded, and some thoughts about the prospects of the Network are given.

Received 2012 January 19

1 Introduction

The pleasant observing conditions continued in November at least at some observing sites. Even though the month, which is renowned for mediocre weather, could not quite compare with the preceding ones, there were very good observing conditions in particular in Germany and Italy. In fact, if not one or the other observer had to fight with fog in some night, the result would have even been better.

A third of those 64 active video systems obtained twenty and more observing nights. The effective observing time sums to over 8 000 hours during which almost 34 000 meteors were recorded (Table 1 and Figure 1). That is more than twice as many as last year (Molau et al., 2011).

New observers did not join our network in November, but Carlos Saraiva from Portugal brought a third camera dubbed Sofia into operation. It is a Watec camera with a 12 mm $f/0.8$ Panasonic lens.

2 Taurids

November marks the end of the Taurid activity period – a good point in time to review the activity profile of that shower in 2011. Figure 2 shows the flux density profile for the Northern (upper left) and Southern (upper right) Taurids between September 25 and November 25, based on 7 000 and 6 900 recorded shower meteors, respectively.

The southern branch shows from the beginning of the activity interval until the Orionids a continuous growth in flux density from 0.3 to 0.9 meteoroids per 1 000 km^2 per hour. On October 25 the activity level drops suddenly, and then it remains at an almost constant level of 0.4 to 0.5. The long-term profile of 2009 also shows such a drop after the maximum, but four days earlier at a solar longitude of 207°(Molau & Rendtel, 2009).

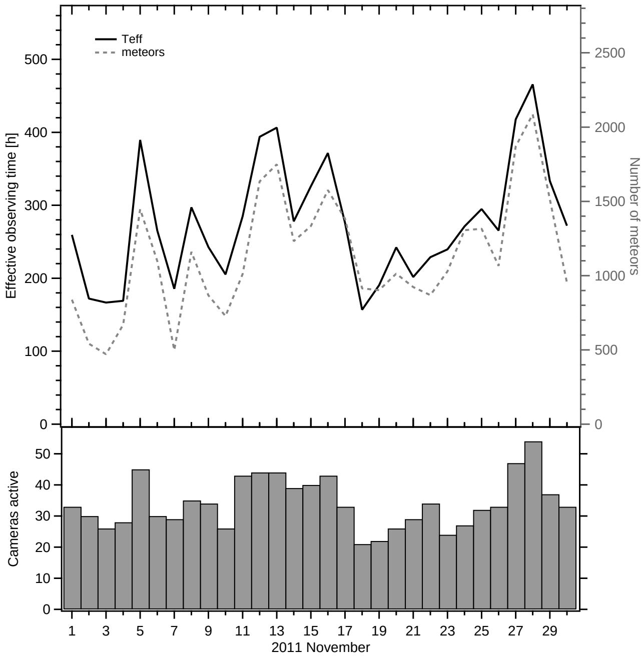

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2011 November.

The northern branch shows an increase until the Orionids as well, but at a lower level from 0.4 to 0.6 meteoroids per 1 000 km^2 per hour. Again on October 25, a drop back to 0.4 can be seen, and not before November 3 does the flux density rise significantly again. It then remains at a level of 0.8 meteoroids per 1 000 km^2 per hour until November 14 and decreases towards the end of the activity interval. The long-term profile of 2009, however, showed a largely symmetric profile with maximum on November 14 ($\lambda_\odot = 231°$) (Molau & Rendtel, 2009).

To check whether external factors (number of cameras, moon, weather) have an impact on the result, the sporadic profile of the same time interval is presented in the lower part of Figure 2 for comparison. It shows

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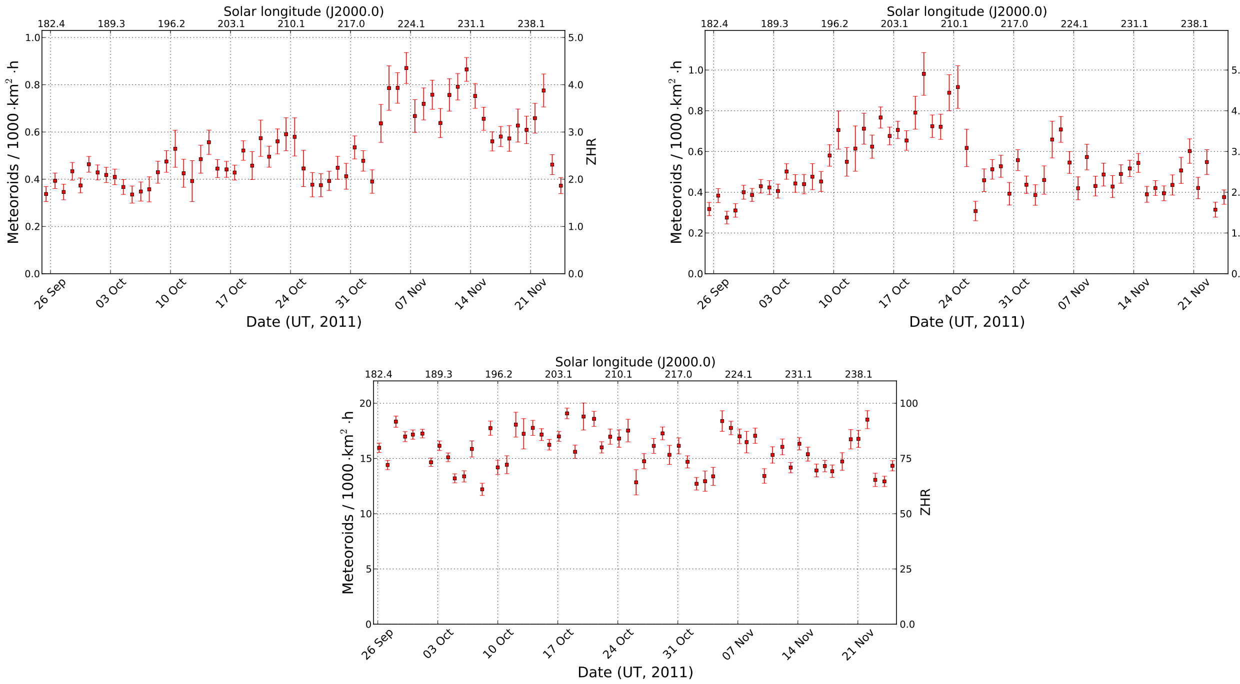

Figure 2 – Flux density profile of the Northern (upper left) and Southern Taurids (upper right) from observations of the IMO Video Meteor Network. Note the slightly different scale of the y-axis in the upper two graphs. For comparison, the flux density of sporadic meteors is given in the bottom graph.

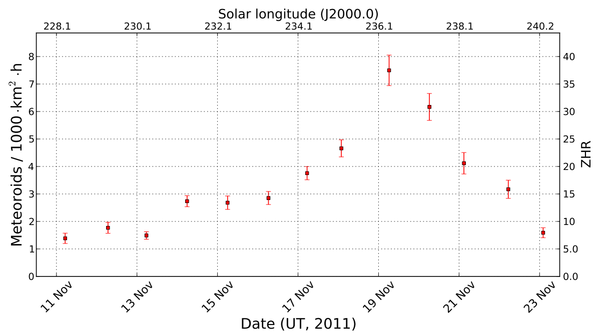

Figure 3 – Flux density profile of the 2011 Leonids.

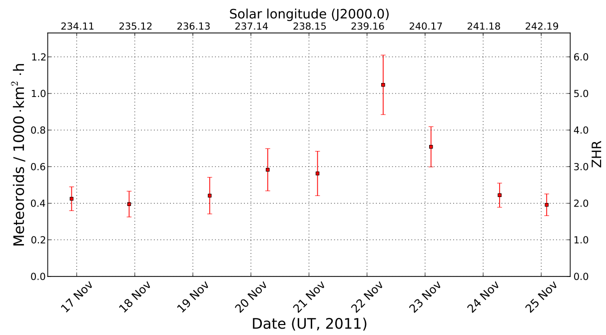

Figure 4 – Flux density profile of the α-Monocerotids in 2011.

a flat profile of roughly 15 meteoroids per 1 000 km^2 per hour, and some short-term fluctuations. There is indeed a small drop in flux density on October 26 from 17 to 14 meteoroids per 1 000 km^2 per hour. The drop in Taurid activity cannot be fully explained this way, but at least it was magnified by external observing conditions that left the same trace in the sporadic profile. Also striking is the small dip between November 14 and 21, which can be found in all three profiles.

3 Leonids

There were no predictions for unusual Leonid rates in 2011. The activity profile (Figure 3) is based on 1 800 shower meteors and shows an increase of flux density up to 8 meteoroids per 1 000 km^2 per hour in the maximum night of November 18/19.

4 α-Monocerotids

A few days later, the α-Monocerotids remained almost invisible again. Only in the morning of November 22 they stood out from the sporadic background with a flux density of 1.0 meteoroids per 1 000 km^2 per hour (Figure 4). Overall 340 meteors were assigned to that radiant in the given activity interval.

5 One million meteors and counting

Finally, we want to celebrate a particular highlight in the IMO Video Meteor Network: Exactly 12 years and 8 months after the start of the camera network, we recorded our 1 000 000th meteor!

One million, that is a figure which can hardly be conceived. To illustrate that number: If a film was created from all those meteors without a break, it would run longer than three days. The meteors were recorded in 4 200 nights, i.e. we could observe in 90% of all nights since the start of the network in March 1999. The gaps were big in the beginning, but in the past four years we did not miss even a single night. The observing time over all cameras accumulates to more than 25 years till now. And let us not forget: It is a pure amateur astronomical project, based on the enthusiasm and thousands of spare time hours spent by dedicated amateurs to meteor observation without getting a single Euro of support. We think that is a merit we can be proud of.

Where are we heading? The detailed annual statistics for 2011 will be published next month. Already now it is clear, however, that not only the number of observers and video systems is further increasing, but that also the exponential growth in the number of observing hours and recorded meteor is continuing. Whereas it took us four years to collect the first 100 000 meteors, it was little more than two months for the last 100 000. That is a development which is exciting and scary at once. What do we have to prepare for? The quality control of the incoming observations has been shared among six persons in the past year, which have become a good team by now: Bernd Brinkmann and Sirko Molau from Germany, Stefano Crivello and Enrico Stomeo from Italy, and Erno Berko and Antal Igaz from Hungary. But in the mid term, even that team will not be able to cope with the further network growth alone. So do we need even more automation? Our experience is, that new observers typically master the software and processes after a month or two, so that their observations can be taken over easily into the video meteor database. On the other hand we see that even experienced observers are making mistakes from time to time. In addition, new functions like the flux density measurement introduced this year are a challenge for all observers. For this reason we believe that the manual quality check is still necessary for the time being.

And conceptually? The recording of a million meteors is not an end in itself – we want to gain scientific findings from these! In the past, the focus was on the recognition of meteor showers and their properties. The database has more than doubled since the last meteor shower analysis in 2009, and also the astrometric accuracy has improved. So a new edition of the analysis to even better determine the characteristics of major showers and to let minor showers stand out even stronger from the sporadic background, is almost mandatory. With the calculation of flux densities we opened a new window this year. The first results are promising, but we are still at the beginning. For sure the quality of the flux data will improve significantly in the future.

We would like to take the opportunity for an appeal to our professional astronomers: In the past few years, some researchers called for improvements in the meteor data quality. To answer specific scientific questions they calculated for example, how accurate a radiant position or meteoroid orbit would need to be known, and what accuracy with respect to position, velocity and timing of meteors is required for this. But is it not a good time to turn the tables? Why don't our professional colleagues check what further findings can be drawn from the available raw data or analysis results with the given quality? There are numerous examples in astronomy and astrophysics where big discoveries were not obtained by a strict plan that someone looked specifically for a certain predicted effect, developed the corresponding instruments, did the measurements and finally proved the effect. No, maybe the more interesting findings were obtained by a clever combination of existing data or by looking at them for a different perspective.

For illustration, we want to give two examples at the end, where a professional could pick up and continue the threads prepared by amateurs. On the one hand, we showed in 2009 (Molau & Rendtel, 2009) that the velocity v_∞ of certain meteor showers is systematically increasing or decreasing in their activity interval. To our knowledge, a conclusive explanation for this effect is still missing.

On the other hand, we created activity profiles of hitherto unknown quality for a number of meteor showers in the same 2009 analysis (Molau & Rendtel, 2009). Each shower has a characteristic profile, which it shows every year by and large. But what does it teach us about the parent body and the formation of the meteor shower? About 10 years ago, Rainer Arlt and colleagues did an interesting experiment trying to obtain a three-dimensional density profile of the Antihelion source in fall from Taurid video observations. Should we not be able to deduce information about the formation and evolution of meteor showers from the observed activity profiles at times where meteor outburst can be predicted accurately to a few minutes? We do not think that the data set is still the bottleneck.

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Molau S. and Rendtel J. (2009). “A Comprehensive List of Meteor Showers Obtained from 10 Years of Observations with the IMO Video Meteor Network”. *WGN, Journal of the IMO*, **37:4**, 98–121.

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Table 1 – Observers contributing to 2011 November data of the IMO Video Meteor Network. Eff.CA designates the effective collection area and Tot.CA the total collection area.

Code	Name	Place	Camera	FOV [$^{\circ 2}$]	Stellar LM [mag]	Eff.CA [km^2]	Nights	Time [h]	Tot.CA [10^3km^{2}h]	Meteors
BASLU	Bastiaens	Hove/BE	Urania1 (0.8/3.8)*	4545	2.5	237	1	4.2	0.8	2
BERER	Berko	Ludányhalászi/HU	Hulud1 (0.95/3)	2256	4.8	1540	18	150.8	141.3	680
			Hulud2 (0.75/6)	4860	3.9	1103	17	111.6	77.1	338
			Hulud3 (0.75/6)	4661	3.9	1052	17	99.9	76.5	245
BREMA	Breukers	Hengelo/NL	Mbb3(0.75/6)	2399	4.2	699	12	94.9	55.5	235
			Mbb4(0.8/8)	1470	5.1	1208	14	95.9	—	186
BRIBE	Brinkmann	Herne/DE	Hermine (0.8/6)	2374	4.2	678	23	219.4	92.4	694
		Bergisch Gladbach/DE	Klemoi (0.8/6)	2286	4.6	1080	23	210.8	246.3	765
CASFL	Castellani	Monte Baldo/IT	Bmh1 (0.8/6)	2350	5.0	1611	25	235.3	243.0	872
			Bmh2 (1.5/4.5)*	4243	3.0	371	22	208.6	522.5	1011
CRIST	Crivello	Valbrevenna/IT	Bilbo (0.8/3.8)	5458	4.2	1772	23	235.6	357.6	1247
			C3P8 (0.8/3.8)	5455	4.2	1586	23	225.0	225.5	875
			Stg38 (0.8/3.8)	5614	4.4	2007	20	197.2	387.2	1180
CSISZ	Csizmadia	Zalaegerszeg/HU	Huvcse01 (0.95/5)	2423	3.4	361	11	54.1	9.0	197
ELTMA	Eltri	Venezia/IT	Met38 (0.8/3.8)	5631	4.3	2151	14	144.9	190.6	666
GONRU	Goncalves	Tomar/PT	Templar1 (0.8/6)	2179	5.3	1842	14	116.3	202.4	526
			Templar2 (0.8/6)	2080	5.0	1508	17	138.6	172.4	547
			Templar3 (0.8/8)	1438	4.3	571	23	177.4	—	495
GOVMI	Govedič	Središče ob Dravi/SI	Orion2 (0.8/8)	1447	5.5	1841	13	116.0	218.2	321
HINWO	Hinz	Brannenburg/DE	Acr (2.0/35)*	557	7.4	4954	20	136.1	—	1115
IGAAN	Igaz	Baja/HU	Hubaj (0.8/3.8)	5552	2.8	403	17	66.6	27.0	389
		Debrecen/HU	Hudeb (0.8/3.8)	5522	3.2	620	21	177.7	99.9	549
		Hódmezővásárhely/HU	Huhod (0.8/3.8)	5502	3.4	764	19	147.5	64.6	413
		Sopron/HU	Husop (0.8/6)	2031	3.8	460	15	83.3	—	492
JONKA	Jonas	Budapest/HU	Husor (0.95/4)	2286	3.9	445	18	138.3	83.9	406
JUDDA	Judge	Perth/AU	Wamcam2 (0.95/2.8)	4742	—	—	1	8.7	—	15
KACJA	Kac	Kostanjevec/SI	Metka (0.8/8)*	1372	4.0	361	9	71.7	27.0	201
		Ljubljana/SI	Orion1 (0.8/8)	1402	3.8	331	7	46.3	34.7	142
		Kamnik/SI	Cvetka (0.8/3.8)	4914	4.3	1842	12	92.0	77.5	428
			Rezika (0.8/6)	2270	4.4	840	12	100.6	158.6	658
			Stefka (0.8/3.8)	5471	2.8	379	12	99.1	42.8	323
KELGR	Kelaher	Secret Harbour/AU	Wamcam1 (0.8/3.8)	5607	—	—	1	8.3	—	9
KERST	Kerr	Glenlee/AU	Gocam1 (0.8/3.8)	5189	4.6	2550	23	129.6	291.9	744
KLAGR	Kladnik	Tacen/SI	Tacka (0.8/12)	715	5.4	796	4	34.9	—	180
KOSDE	Koschny	Noordwijkerhout/NL	Lic4 (1.4/50)*	2027	6.0	4509	15	87.9	81.6	317

Table 1 – Observers contributing to 2011 November 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]	Tot.CA [10^3km^{2}h]	Meteors
LERAR	Leroy	Gretz/FR	Saphira (1.2/6)	3260	3.4	301	3	15.0	—	18
MACMA	Maciejewski	Chelm/PL	Pav35 (1.2/4)	4383	2.5	253	19	159.9	—	263
			Pav36 (1.2/4)*	5732	2.2	227	19	170.3	67.3	340
			Pav43 (0.95/3.75)*	2544	2.7	176	19	189.2	38.8	250
MARGR	Maravelias	Lofoupoli-Crete/GR	Loomecon (0.8/12)	738	6.3	2698	8	53.5	56.1	236
MOLSI	Molau	Seysdorf/DE	Avis2 (1.4/50)*	1776	6.1	3817	17	117.9	290.5	945
			Mincam1 (0.8/8)	1477	4.9	1084	18	129.7	96.8	353
		Ketzür/DE	Remo1 (0.8/8)	1467	6.0	3139	23	229.9	623.4	1358
			Remo2 (0.8/3.8)	5613	4.0	1186	22	216.9	183.0	468
MORJO	Morvai	Fülöpszállás/HU	Huful (1.4/5)	2522	3.5	532	17	139.4	59.4	330
OTTMI	Otte	Pearl City/US	Orie1 (1.4/5.7)	3837	3.8	460	14	80.2	—	374
PERZS	Perko	Becsehely/HU	Hubec (0.8/3.8)*	5498	2.9	460	14	109.9	56.6	849
ROTEC	Rothenberg	Berlin/DE	Armefa (0.8/6)	2366	4.5	911	17	149.7	—	367
SARAN	Saraiva	Carnaxide/PT	Ro1 (0.75/6)	2362	3.7	381	18	158.1	86.0	399
			Ro2 (0.75/6)	2381	3.8	459	1	8.4	2.4	34
			Sofia (0.75/6)	738	5.3	907	15	122.4	—	316
SCALE	Scarpa	Alberoni/IT	Leo (1.2/4.5)*	4152	4.5	2052	22	205.0	—	668
SCHHA	Schremmer	Niederkrüchten/DE	Doraemon (0.8/3.8)	4900	3.0	409	23	177.1	—	436
SLAST	Slavec	Ljubljana/SI	Kayak1 (1.8/28)	588	—	—	3	13.3	—	84
STOEN	Stomeo	Scorze/IT	Min38 (0.8/3.8)	5566	4.8	3270	24	257.7	448.6	1750
			Noa38 (0.8/3.8)	5609	4.2	1911	22	250.0	489.8	1413
			Sco38 (0.8/3.8)	5598	4.8	3306	23	219.0	—	2185
STRJO	Strunk	Herford/DE	Mincam2 (0.8/6)	2362	4.6	1152	21	129.4	128.6	471
			Mincam3 (0.8/12)	728	5.7	975	24	152.9	126.7	551
			Mincam5 (0.8/6)	2349	5.0	1896	22	155.7	129.6	691
TEPIS	Tepliczky	Budapest/HU	Humob (0.8/6)	2388	4.8	1607	12	117.5	149.2	471
TRIMI	Triglav	Velenje/SI	Sraka (0.8/6)*	2222	4.0	546	17	101.4	—	316
YRJIL	Yrjölä	Kuusankoski/FI	Finexcam (0.8/6)	2337	5.5	3574	13	79.2	—	411
ZELZO	Zelko	Budapest/HU	Huvcse03 (1.0/4.5)	2224	4.4	933	15	95.1	43.3	186
						Overall	30	8 269.4	—	33 996

* active field of view smaller than video frame

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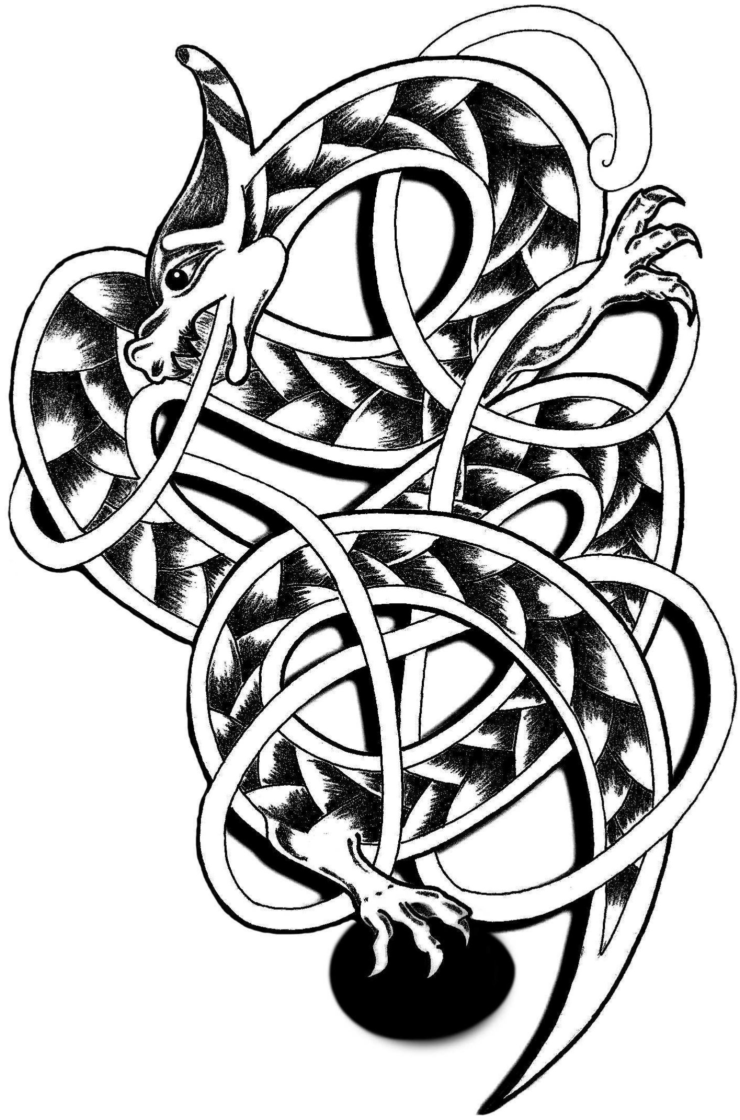

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