e-Zine for meteor observers meteornews.org

MeteorNews

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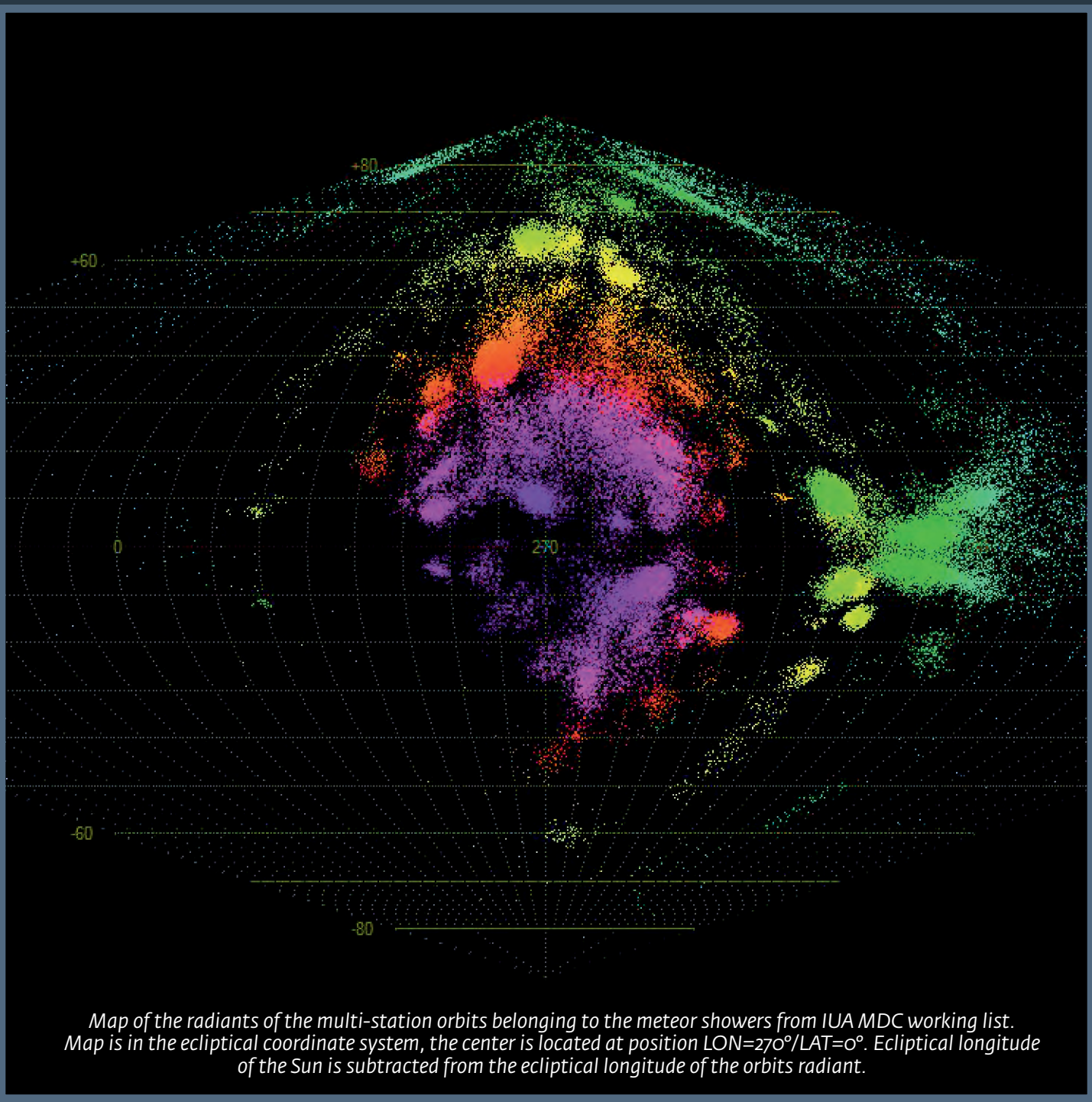

Map of the radiants of the multi-station orbits belonging to the meteor showers from IUA MDC working list. Map is in the ecliptical coordinate system, the center is located at position LON=270°/LAT=0°. Ecliptical longitude of the Sun is subtracted from the ecliptical longitude of the orbits radiant.

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Editorial

A new initiative requires some explanation; hence exceptionally this new journal starts with an editorial.

At the beginning of 2016 the undersigned editors discussed the possibilities to improve exchange of news, data and information between active meteor workers. The need to share information has always existed and for many years the most popular way was to produce a journal. The appearance of the internet in the mid 90-ies suddenly offered plenty of advantages to share information, but not all of these advantages have been ever used in an optimal way. Past 20-years we have seen a multitude of initiatives by meteor workers to share their news via new media such as mailing groups, forums, Facebook, Twitter, etc. All these media work fast and are free of charge, but there is actually nobody who can keep track of all these interesting postings. It has become a jungle of information.

Most of the traditional amateur meteor journals have disappeared and this may explain why amateurs search for alternatives online. The amateur community is eager to read as soon as possible about the observing experiences of colleagues worldwide and for this specific purpose the more academic professional journals are of little or no use. The publication procedures introduce delays of months, sometimes more than one year and that is not what most amateurs want.

The fastest publication tool turned out to be a dedicated website which allows instant publication by a team of editors. The best solution for archiving information turned out to be an e-zine with a selection of the contents of the website available as PDF. In just a few weeks http://meteornews.org became reality and after two months a first issue of the e-zine could be compiled.

We hope that you will like our initiative. As for any new initiative some people may have doubts. It is up to us to prove that this is a realistic project. 2016 is a year to test, to try out, to improve and to fine tune. So far the feedback is very positive and most encouraging.

We work as a team of individuals, independently from any society, institute or observatory. Hereby we invite you to join our team to help us improve communication and exchange of information between the active meteor workers.

May 2016

Richard Kacerek, Jakub Koukal, Koen Miskotte, Roman Piffl and Paul Roggemans

Why to start with eMeteorNews?

Paul Roggemans

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Amateur meteor workers have always been interested to exchange information and experience. In the past this was only possible via personal contacts by letter or by specialized journals. With internet a much faster medium became available and plenty of websites, mailing lists, Facebook groups, etc., have been created in order to communicate about meteors. Today there is a wealth of meteor data circulating on internet, but the information is very scattered and not directly available to everyone. The authors have been considering how to organize an easy access to the many different meteor related publications. The best solution for the current needs of amateur meteor observers proved to be a dedicated website combined with a PDF journal, both being free available without any subscription fee or registration requirement. The authors decided to start with this project and in March 2016 the website meteornews.org has been created. A first issue of eMeteorNews has been prepared in May 2016. The year 2016 will be a test period for this project. The mission statement of this project is: "*Minimizing overhead and editorial constraints to assure a swift exchange of information dedicated to all fields of active amateur meteor work*."

1 Introduction

Amateur meteor work is booming since video meteor observing became easily accessible for a large number of amateurs. However it is very difficult to follow all the developments as there are too many different sources to check. Some journals impose time-consuming editing procedures and require a semiprofessional level. Most amateurs don't have the time for that and therefore seek alternatives in social media such as Facebook and Twitter, various online Newsgroups and blogs. So far internet and social media in particular prove to be a jungle of information and it became impossible to keep track of all interesting news. The traditional media like specialized journals, serve mainly as reference source for ongoing research. These journals are not suitable for amateurs who just wish some 'easy reading' information about the meteor community. Something is missing and the question is if and how amateurs can improve the situation.

2 Aims and mission statement

It is obvious that there is a gap between the swift publication online and the advanced paper publications. Could a new meteor platform fill the gap in the market? eRadiant as online journal in PDF is still very popular among Dutch speaking amateurs. Would it be useful to set up something similar for the international community of amateur meteor observers? Discussions with several leading amateur meteor workers in recent months proved very positive. The idea was suggested to consider a new online publication with as name eMeteorNews which is straightforward for what it stands for. The first idea was to produce an online journal as PDF, inspired by eRadiant. But another brilliant idea is to set up a dedicated website to publish meteor news as soon as possible when it becomes available. The main purpose is to share meteor news, quickly and easy, with a minimum of editing constraints. Combining the advantages of a Meteor News website with these of a PDF journal, we can 'eat from two bags of food' and have something as fast as social media, combined with a PDF journal for archiving and reference purposes. Some of the advantages would be:

- Free of charge as the production would require zero costs;
- No membership required being independent from any society;
- Fast publication on the website;
- Flexibility in volume and periodicity;
- Archiving as PDF for storage with the ADS Abstract service;
- Ease of use with no editing constraints to submit content;
- Printable as PDF format allows local printing;
- Searchable content on both the website and in the PDF archive;
- Full color publication on the website and in the PDF;
- Boost outreach in this field being unlimited free available;

With eMeteorNews we hope to bring the essential information together in a single source. The new eMeteorNews should be complementary and not compete with any existing publications. There is no restriction to the type of content. It should remain dedicated to the active amateur meteor workers for quick and efficient dissemination of meteor news without any bureaucratic overhead.

The mission statement of this project: "*Minimizing overhead and editorial constraints to assure a swift exchange of information dedicated to all fields of active amateur meteor work*."

3 Practical aspects

Who will take care of this? Several people volunteered to become MN-editor. Meteor workers interested to join the editorial board are welcome to join the current editorial board (April 2016):

- Salvador Aguirre (Mexico)
- Karl Antier (France)
- François Colas (France)
- Paul Jones (USA)
- Richard Kacerek (U.K.)
- Jakub Koukal (Czech Republic)
- Bob Lunsford (USA)
- Esko Lyytinen (Finland)
- Jose Maria Madiedo (Spain)
- Koen Miskotte (Netherlands)
- Roman Piffl (Slovakia)
- Paul Roggemans (Belgium)
- Your name here?

When? Discussions about this project started begin of 2016. The response to the idea was very positive. Several people offered to help and are interested to participate. Since we start from scratch, we'll work out a prototype as experiment and use the rest of 2016 as a test period. We hope to collect news on the website meteornews.org and to compile a few online issues in PDF format. If the test period proves successful we'll register an ISSN number and start archiving with ADS abstract service.

What to publish? We welcome input from all meteor workers: reports on visual observations, reports from camera networks, reports on radio observations, fireball and particular meteor sightings, anything related to meteor work. The content should focus on practical aspects, the style should be informal easy reading text.

4 How to submit content?

Send your text and pictures by mail to one of the MeteorNews.org editors. Short announcements can be published easily in WordPress without any layout requirements. To keep MeteorNews.org easy reading, submit the following as text without bothering about editing aspects:

- A short title (mandatory);
- Name of author(s) (mandatory);
- Contact address(es) of the author (optional);
- Abstract (optional but recommended for articles);
- Body text (mandatory);
- Pictures (optional, but if pictures are submitted a caption is mandatory);
- References (optional).

If you have a relative long and elaborated contribution it may be worth the effort to prepare this as a Word document. In such case we recommend to use the Word template which can be downloaded from meteornews.org. Save this dotx file on your computer. In Word you find under 'File' – 'Options' – 'Add ins', here at the bottom you see 'Manage' select 'Templates' & click 'Go' in the tab 'Templates browse to select the eMeteorNews dotx file. Make sure to mark 'Automatically update document styles'.

5 Publication policy

As soon as some content is received by an editor, it will be published as soon as possible on the MeteorNews.org website.

Every now and then a selection of articles collected on the website will be assembled as a journal in PDF which will be reported and archived with the ADS abstract service (from 2017 onwards). All papers published in MeteorNews.org and its PDF journal eMeteorNews will be archived for consultation and reference purposes.

Obituary: Teodor Pintér (1947-2016)

Paul Roggemans

The Slovak Facebook page 'Slovenská ústredná hvezdáreň' announced the sad news that Teodor Pintér, former General Director of the Slovak Central Observatory in Hurbanovo, has deceased.

Figure 1 – During the IMC in Mistelbach, Austria, end of August 2015, Teodor Pinter in discussion with Tibor Hegedus (credit Axel Haas).

Figure 2 – Teodor Pinter at Pic du Midi during the IMC 7 – 10 June 2007, Barèges – France (credit Galina Ryabova).

Teodor Pintér died on March 31st, 2016 at the age of nearly 69 years. He was born on May 21st, 1947 in Galanta. Teodor Pinter studied a follow-up study of astronomy (after high school) from 1967 to 1969 in Valasske Mezirici (Czech Republic) and later from 1973 to 1979 he studied geodesy and cartography at the Slovak Technical University in Bratislava (Slovakia). Teodor Pintér worked in the Central Observatory in Hurbanovo since 1967. From 1991 to 2013 he was a director of the Slovak Central Observatory in Hurbanovo. He dealt with research of the photosphere, chromosphere and corona of the Sun. He participated in 13 expeditions aimed at observing a total solar eclipse. In recent times he was interested in SID monitor and he started to prepare SDR and video meteor observations at home. He worked in SCO in Hurbanovo to his last day. On 22nd March 2016 he guided his last group of students at the observatory.

Meteor workers know Teodor Pinter as a regular participant at the International Meteor Conferences. He participated for a first time at the IMC in Cerkno, Slovenia in 2001. Later he also participated at the IMC's of 2003, 2004, 2007, 2011, 2012, 2013 and last year 2015 for his 8th IMC in Mistelbach, Austria. Although that meteors were not his first field of interest, he enjoyed the good contacts with the amateur community. Whenever he arrived at an IMC he came with some presents for many of his IMC friends, a beer, some sweet and always with his friendship and a smile. We have, all of us, lost a great friend.

Acknowledgment

The author thanks Peter Dolinsky of the Slovak Central Observatory in Hurbanovo for the information in this obituary.

Visual observing reports

Compiled by Paul Roggemans

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In this overview we summarize reports published by visual observers shortly after the field work has been done and first impressions and memories of the real meteor observing experiences are fresh in mind. March-April being silent months meteor wise and the weather circumstances in 2016 having been rather unfavorable almost no visual observing efforts have been reported. Long term visual observer, Koen Miskotte could observe in this rather poorly known period and reported his data in MeteorNews.org. The Eta Aquariids 2016 provided a surprising nice display well covered by fellow visual observer Paul Jones in Florida.

1 Report on the first months of 2016 by Koen Miskotte

I present an overview of my observing activities during the first three months of 2016. Unfortunately the first active meteor shower of the year, the Quadrantids, was lost due to the clouds.

Figure 1 – combined image of the bright meteor of Februari 28, 2016 at 21:24:44 UT.

The first night of 2016 that allowed observations was 8/9 January, observing at the flat roof of my dormer. Thanks to the clear sky conditions (LM 6.3) 37 meteors were counted. Highlights of this night were a blue magnitude +1 sporadic (SPO) meteor with multiple flares and a 3 seconds persistent train. Further a magnitude +3 Earth grazer was seen having a long track from Cepheus into Ursa Major. The meteor had a glitter tail of one degree. The best meteor however was a magnitude -3 December Leo Minorid (DLM) moving from Bootes to Corona Borealis at 02:08:45 UT. This meteor was also captured with my all sky camera.

The second night (17/18 January), was a long session from Goevenbeekse Heide (a heath about 1 km south of my home) with nearly five hours effective. A total of 47 meteors were counted, including 8 ANT and 3 DLM. The Anti Helion source showed some fine meteors, including a magnitude +1 and a magnitude 0. Temperatures went down to -8.4 C.February 15/16 I could again observe from the Groevenbeekse Heide. A four-hour session produced 42 meteors which is a pretty good score in February. This was also thanks to the top conditions (according to Dutch standards) because the limiting magnitude got up to 6.4 with a dark sky background. 5 Anti Helions were seen, many faint meteors in the class +3 to +5, the brightest was a +1 SPO. Temperature again dropped to -8.0 C.

Another memorable night was 28/29 February. As the Moon rose at 23:30 UT I decided to started early. That was at 21:22 UT and already at 22:24:44 UT I saw the most beautiful meteor of this session. A yellow -2 SPO with a big wake moved very slowly from Gemini through Cancer to Leo. The meteor was captured with both my all sky camera and CAMS camera (351).

Also during the night 12/13 March, a beautiful meteor was seen, an orange magnitude 0 with a short wake. It moved slowly from the Big Dipper to Serpens and lasted three seconds. This meteor was captured with my CAMS 351 camera. In total I could observe for 32 hours, resulting in 263 visual meteors. See table 1 for the results.

All Sky camera EN-98

Table 1 – Overview observing activities of Koen Miskotte

Date	Location	Period UT		T.eff	Lm	ANT	DLM	QUA	SPO	TOT	Remarks
08/09-1-2016	52.2 n, 5.4 e	0:05	3:05	3	6,28	3	2	3	29	37	@home, Ermelo, -3 DLM
17/18-1-2016	52.2 n, 5.4 e	1:15	6:10	4,92	6,38	8	3	~	36	47	@Groevenbeekse Heide
18/19-1-2016	52.2 n, 5.4 e	2:00	4:05	2,08	6,28	1	3	~	14	18	@home, Ermelo
12/13-2-2016	52.2 n, 5.4 e	0:30	2:45	2,25	6,27	2	~	~	13	15	@home, Ermelo
15/16-2-2016	52.2 n, 5.4 e	1:26	5:30	4,05	6,39	5	~	~	37	42	@Groevenbeekse Heide
16/17-2-2016	52.2 n, 5.4 e	2:23	5:31	3,12	6,32	2	~	~	23	25	@Groevenbeekse Heide
27/28-2-2016	52.2 n, 5.4 e	20:50	22:52	2,03	6,17	1	~	~	6	7	@home, Ermelo
28/29-2-2016	52.2 n, 5.4 e	21:22	23:46	2,4	6,35	4	~	~	11	15	@home, Ermelo
04/05-3-2016	52.2 n, 5.4 e	1:48	2:52	1,07	6,3	0	~	~	6	6	@home, Ermelo
12/13-3-2016	52.2 n, 5.4 e	1:22	4:25	3,05	6,26	4	~	~	21	25	@Groevenbeekse Heide
13/14-3-2016	52.2 n, 5.4 e	2:15	4:25	2,17	6,17	1	~	~	13	14	@home, Ermelo
15/16-3-2016	52.2 n, 5.4 e	1:12	3:15	2,02	6,29	1	~	~	11	12	@home, Ermelo
12 sessions				32,16		32	8	3	220	263	

issue), which was photographed trough the branches of the trees in the west. A second very bright fireball was photographed on March 25, 2016 at 23:00 UT, it appeared over Belgium and has been captured by several all sky cameras in the Benelux.

2 2016 Eta Aquariid reports from Florida (USA) by Paul Jones

2016 May 3–4

Here is a detailed report on my one hour ETA session from up on the "meteor roof" of my home in St. Augustine, Florida USA this morning.

May 3/4, 2016, Observer: Paul Jones, Location 5 miles southwest of St. Augustine, Florida, USA, Lat: 29 degrees 89 minutes North, Long: 81 degrees 30 minutes West.

0410 – 0510 EDT (0810 – 0910 UT) T_{eff}: 1.0 hour, No breaks LM: 6.0, Clear, Facing: South:

- 8 ETA: 0, +2, +3(3), +4(2). +5(1)
- 1 ELY: +4
- 1 ANT: -1
- 7 SPO: +1, +2, +3(3), +4(1), +5(1)
- 17 total meteors

5 of the 8 ETAs left visible trains (strangely though, the zero mag ETA did not).

I had two ETAs in quick succession about 15 seconds apart no more than three minutes into the watch, then it took about 20 minutes for me to see another. As usual, most of the ETAs I saw were long-pathed and left nice trains. They looked like quick, glowing darts being thrown up into the sky from someone standing on the southeastern horizon. I love the ETAs for this visual effect that only they seem to be able to produce in quite this way.

The one η-Lyrid (ELY) was faint and short going south near the bottom of Lyra, it will be interesting to see how this little shower evolves over the course of the next few mornings and this minor radiant is an added bonus to ETA watches in early May.

The top meteor of the morning was by far the ANT! It started in Ophiuchus and slowly paced its way northeastward going all the way over to the NE edge of Cygnus. It glittered and sparked all along its path and left a thin train behind it. It alternately glowed gold, silvery white, yellow and orange during the almost five seconds I had it in sight. Not 30 seconds after that beauty finally ended, a nice +2 ETA popped going northwestward right over part of the track the ANT had just taken.

I must have seen about a dozen artificial satellites during the watch as well, going in just about every direction except east to west….;o).

It looks like we have a frontal system coming through our area today or early tomorrow that should sweep out the skies behind it and give us a few cool and clear nights for the maximum period. Hopefully, I can report for several more mornings.

2016 May 4–5

My Cinco de Mayo celebration started early in the pre-dawn this morning as I managed to get out on the "meteor roof" in St. Augustine, Florida again for 1.5 hours and the ETAs responded very well indeed. There was a noticeable uptick in their rates this morning and they might have approached 20 an hour from my location had twilight not

interfered. All told, I had 23 ETAs and 17 others for 40 total meteors during the session. Here's my data:

May 4/5, 2016 Observer: Paul Jones, Location: 5 miles southwest of St. Augustine, Florida, Lat: 29.89 N, Long: 81.30 W, Elevation: 35 feet.

0400 – 0500 EDT (0800 – 0900 UT) T_{eff}: 1.0 hour, No Breaks, LM: 6.3, Clear, Facing: South:

- 14 ETA: 0, +1(2), +2(4), +3(4), +4(2), +5
- 1 GAQ: +3 (gamma Aquilid)
- 9 SPO: +1, +2, +3(3), +4(2), +5(2)
- 24 total meteors

0500 – 0530 EDT (0900 – 0930 UT) T_{eff}: .5 hour, No Breaks, LM: 6.3, Clear, Facing: South:

- 9 ETA: +1(2), +2(3),+3, +4(2), +5
- ELY: +3(2)
- SPO: +2, +3, +4(2), +5
- 16 total meteors

17 of the 23 ETAs left visible trains, predominate colors were yellow and orange tints.

Once again, the watch got off to a fast start as less than five minutes into it, I saw two perfectly simultaneous meteors – one little sporadic and one majestic +2 ETA hit at exactly the same instant not too far apart from each other on the sky. Love it when that happens…;o).

Besides that cool coincidence, ETA activity was pretty much evenly spread out through the watch, with just one spurt of 5 ETAs all hitting within about ten minutes of each other midway through the first hour. A majority of the ETAs left long trains along their paths, even some of the fainter ones, with an average meteor path length of easily 20 to 30 degrees in many cases.

The increase in ETA rates seemed very gradual and was no doubt caused solely by the radiant getting higher in the sky and not by any ramp up within the stream. After not seeing any ELYs in the first hour, two within a few minutes of each other happened in the second period.

I was aided this morning by the cool, clear, crisp air that flowed in quickly after the front passage. The timing was perfect as it had been pouring rain last night at 10:00 p.m. Local Time! The temperature for the watch was about 55 degrees Fahrenheit or 12.77 degrees Celsius. That's mighty chilly for Florida on a May morning, but I was not complaining! The good weather should continue for us for at least a couple more morning, so I'll be back out tomorrow.

2016 May 5–6

Fellow Ancient City Astronomy Club (St. Augustine, Florida) member Jeffrey Corder and I met down at Matanzas Inlet, Florida, about 18 miles south of St. Augustine this morning for an amazing and very memorable 3 ½ hour session of combined deep sky observing and meteor watching. It was some of the best all-around amateur astronomy I have done in quite a long while, maybe ever!

We set up just after 2:00 a.m. EDT under full 360 degree skies that were spectacularly clear, crisp and dark to say the least. Our intention was to go to dawn's early light and we had no problem whatsoever meeting that goal! Jeffrey set up his photomultiplier-enhanced Celestron 8 scope and I got out my Celestron 16 x 70 binoculars and the subsequent views we had through both instruments while we waited for the η-Aquariid radiant to rise simply were to die for.

Jeffrey started us out at Polaris and cautioned me that looking at the star through his scope might tend to impact my night vision and he was right! His self-made, photomultiplier set-up enhances the scope's capability by some three full magnitudes, effectively making it roughly the equivalent of a 24 inch telescope!!! The views we had were the amazing proof to the pudding. We toured several well-known Messier objects with each one looking like the pictures from huge observatory scopes. I was dumbfounded. Every globular cluster we looked at was resolved to the core! M13 was mind-blowing… I also glimpsed the North American nebula near Deneb in Cygnus with my 16 x 70s and the star clouds in the Sagittarius area were magnificent.

I signed on for meteors at 3:00 a.m. EDT, while Jeffrey went on a deep sky hunt for super faint deep sky objects, we each had plenty to keep us busy!! I saw my first ETA at 3:18 a.m. and ended up with 7 total ETAs for the first hour with the radiant still very low in the SE. Here is my meteor data from this morning:

May 5/6, 2016 Observer: Paul Jones, Location: North Bank of Matanzas Inlet, Florida, Lat: 29.75N, Long: 81.24W (approximately 18 miles south of St. Augustine, Florida).

0300 – 0400 EDT (0700 – 0800 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.8, Clear, except for some very slight haze near the southern horizon:

- 7 ETA: -1, 0, +2, +3(2), +4, +5,
- 1 ANT: +2
- 1 ELY: +3
- 11 SPO: +1, +3(3), +4(3), +5(3), +6
- 20 total meteors

0400 – 0500 EDT (0800 – 0900 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.8, Clear, except for some very slight haze near the southern horizon:

- 16 ETA: -1, 0, +1, +2(4), +3(4), +4(3), +5(2)
- 1 GAQ: +3
- 1 ANT: +3
- 12 SPO: +1, +2(3), +3(5), +4, +5, +6
- 30 total meteors

0500 – 0530 EDT (0900 – 0930 UT) T_{eff}: .5 hour, No breaks, LM: 6.2 (twilight), Clear

- 11 ETA: -2, -1, +1, +2, +3(3), +4(2), +5(2)
- 5 SPO: +1(2), +3, +4, +6
- 16 total meteors

22 of the 34 ETAs left trains, a couple lasting several seconds on the sky, same colors as before.

It was quite a mixed bag of ETAs this morning as bright ones would be intermingled with fainter ones with no real pattern to establish. Occasionally, there would be short bursts of ETAs or two in quick succession, but for the most part, they were pretty evenly spread out. One thing I did notice in particular about this morning's ETAs was that on average their individual path lengths on the sky were shorter than the two previous mornings. There really were less 30 to 40 degree long tracks, but the meteors themselves were somewhat brighter.

Both Jeffrey and I were not very happy to see dawn come! We wanted to keep going! We knew it was a rare and crystal morning we were having and did not want to see it end… I'm pretty sure that had I been able to put in a third full dark hour, I would have had close to 25 ETAs. One thing we both noticed was the large number of artificial satellites that were visible. At one point in the second hour, there was a group of four of them all traveling near one another going west to east all within about 20 degrees on the sky of each other. Neither Jeffrey nor I had ever seen anything like that before!

I would like to thank Jeffrey for his "home run" suggestion of the Matanzas Inlet observing site and for showing me so many unforgettable views of deep sky objects I had seen before, but never like I did this morning!! I'll be back out at it in the morning as the sky today is so blue, it hurts…;o).

2016 May 6–7

I journeyed back down to the Matanzas Inlet, Florida site for another two hour ETA session this morning and found the skies were even better (if that's possible) than they were the previous morning for Jeffrey and me! There were a couple of thunderstorms on the eastern horizon far off shore riding the Gulf Stream, but their lightning flashes were only a minor distraction.

I decided to start my session this time at the half hour mark, so I could back my second hour up to coincide with onset of morning twilight in an attempt to finally crack the 20 ETA in an hour "magic number". Turns out, I came close but fell just short of it once again, but I was hardly complaining! Here's my data:

May 6/7, 2016 Observer: Paul Jones, Location: North Bank of Matanzas Inlet, Florida, Lat: 29.75N, Log: 81.24W (approximately 18 miles south of St. Augustine, Florida).

0330 – 0430 EDT (0730 – 0830 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9 Clear, except for some distant lightning near the eastern horizon

- 10 ETA: +1(2), +2, +3(2), +4(2), +5(2), +6
- ANT: +2, +3
- ELY: +2, +4
- 13 SPO: +3(5), +4(4), +5(3), +6
- 27 total meteors

0430 – 0530 EDT (0830 – 0930 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.3 (twilight), Clear, except for some distant lightning near the southern horizon

- 17 ETA: -1, 0, +1, +2(4), +3(5), +4(3), +5(2)
- ELY: +2, +3
- 1 GAQ: +4
- 1 ANT: +3
- 11 SPO: +1, +2(2), +3(3), +4(3), +5, +6
- 32 total meteors
- 17 of the 27 ETAs left trains

The first hour produced two majestic ETA earthgrazers, both +1, tracking across no less than 90 degrees of sky leaving spreading trains behind them. Each was the kind of meteor you can just sit back and enjoy the show to the fullest! They alone made the watch worthwhile. There was a nice burst of sporadic meteors also, that got me up to a respectable count of 13 SPO for the hour.

The second hour, the ETAs noticeably shortened in their average path length and became a bit more numerous, but couldn't quite make it that 20 magic number mark. I couldn't blame twilight interference for it this time, either...;o). There were a couple of nice bright ones though.

I noticed that Bob Lunsford mentioned in his weekly column that the ETAs were strangely devoid of fireballs and I totally concur with him on that. I don't recall ever seeing an ETA fireball in all my years of observing them, despite having the good looks at the shower that a lower latitude allows. They seem remarkably consistent in their brightness both from hour to hour and from year to year - amazing.

The last hour was neatly topped off by a way cool pass of the International Space Station! It made its usual SW to NE sojourn across virtually the entire sky briefly reaching almost -3 in magnitude! I was tempted to wave at the astronauts as they went over...;o). Other than that, the artificial satellite population slacked off this morning from what it had been the last couple.

I must say that I am falling in love this observing site. It is so soothing to hear the constant sound of the breaking surf in the distance and to hear the frequent calls of aquatic birds as they pass by fishing in the inlet behind me. The occasional puttering of a small fishing boat is heard as Matanzas Inlet is well known and a popular haunt of local

human fishermen also. Back at it in the morning if the weather holds...

2016 May 7–8

I didn't quite know what to expect from the ETAs this morning as I have never watched them this late in their maximum plateau before. What I saw from them though totally blew me away! For the third night in a row, I made the 18 minute drive from my house down to the dark, clear 360 degree skies at Matanzas Inlet and ended up considering it one of the best drives I've made in a long time…;o). Some lost sleep was a small, insignificant price to pay for what I was about to see.

I signed on at 0315 EDT and saw my first ETA at 0325 – a nice +2 with a train. After about a long twenty minute lull that had me a bit worried, the veritable ETA floodgate opened and from that point on until dawn, they proceeded to just about knock me out of my chaise lounge!!

Here's my data:

May 7/8, 2016 Observer: Paul Jones, Location: North Bank of Matanzas Inlet, Florida, Lat: 29.75N, Long: 81.24W (approximately 18 miles south of St. Augustine, Florida).

0315 – 0415 EDT (0715 – 0815 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, Facing: East:

- 9 ETA: -3, -2, 0, +2, +3(2), +4(2), +5
- ELY: +1, 3(2)
- 1 GAQ: +2
- 10 SPO: +1, +3(2), +4(4), +5(2), +6
- 23 total meteors

0415 – 0515 EDT (0815 – 0915 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.3 (twilight), Clear, Facing: East:

- 24 ETA: 0, +1(3), +2(5), +3(7), +4(5), +5(2). +6
- 5 ELY +1, +2, +3(2), +4
- 14 SPO: 0, +1, +2(2), +3(5), +4(2), +5(2), +6
- 43 total meteors

22 of the 33 ETAs left visible trains, predominate colors were yellow and orange with reddish tints.

The second ETA of the first hour this morning was the one that really opened up the "deluge". It was a stunning -2 almost point meteor going north almost on top of the radiant about ten degrees above the eastern horizon! It was no more than two or three degrees in path length. About five minutes later, the reddish -3 ETA streaked also northward, about fifteen degrees long, leaving a long lasting and flaring train that hung on the sky for about eight seconds! WOW, was I ever pumped then! A few more "normal" ETAs rounded out the first hour and from there, I didn't know what the second hour might bring…

The ETA activity then proceeded into high gear, big time and they were flashing and popping all over the sky from horizon to horizon for the rest of the hour! At one point, I had four ETAs all hit within about twenty seconds of each other and about a minute later, a fifth one rounded out the amazing mini-burst. No other minus magnitude ETAs were seen during this second hour, but I did see another one: a -2, flash through twilight in the northern sky from my car on the drive home.

In addition to the ETAs, the ELYs flashed up with some nice activity as well. And the sporadic rate was busy under the once again spectacular clear and dark skies of the Matanzas Inlet site. I hardly had a chance whatsoever to get fatigued or drowsy during the watch with all that activity going on! Oh, and there was also another occurrence of two simultaneous meteors during that second hour: one a sporadic, the other an ETA, perfectly coincided one another about twenty degrees apart and going in the same direction.

I am pleased to see our Canadian and European comrades confirming the amazing ETA activity this year as well. Seems the Force is with all of us this time around! Keep up the great work, Koen and Pierre! The ETAs show no sign of slacking off at all yet, so I plan to give it yet another go in the morning as the sky here in North Florida continues to be a wonderfully dark shade of blue…;o). When the "getting" is this good, you just got to go with, man…;o). And, a Mercury Transit on top of it all?? Does it get any better than this…;o)??

2016 May 8–9

It's turning into quite a run of clear nights for me to observe the ETAs and I'm loving every minute of it. I got in two more hours of prime pre-dawn viewing this morning from the Matanzas Inlet site and after yet another slow start, they ended up kicking in pretty good indeed once again. In addition, the ELYs and the ANTs. chimed in very well themselves this morning! It was a busy session once again. Here's the data:

May 8/9, 2016 Observer: Paul Jones, Location: North Bank of Matanzas Inlet, Florida, Lat: 29.75N, Log: 81.24W (approximately 18 miles south of St. Augustine, Florida).

0315 – 0415 EDT (0715 – 0815 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, Facing: East

- 5 ETA: +2, +3(2), +4, +5
- ELY: +1, 3
- ANT: +2, +4
- 10 SPO: +1, +2, +3(4), +4(3), +5
- 19 total meteors

0415 – 0515 EDT (0815 – 0915 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.3 (twilight), Clear, Facing: East

- 17 ETA: +1(2), +2(3), +3(5), +4(4), +5(3)
- 6 ELY: +2, +3(3), +4, +5
- 5 ANT: +2(2), +3, +4(2)
- 12 SPO: +2(2), +3(4), +4(3), +5(2), +6
- 40 total meteors

15 of the 22 ETAs left visible trains, predominate colors were yellow and orange with reddish tints.

The first meteor of the watch was a nice +1 "eta" - but not an ETA, it was an ELY, splitting the distance between Vega and Altair and shooting straight at Altair in a perfect radiant line up. Once again, this minor radiant showed up well this morning and really kicks in the last hour before dawn, it seems.

The ETAs got off to a very slow start once again and I thought they might be really finally ramping down, but as usual they surprised me by kicking in very nicely in that last hour. Right at the end of the second hour, I even spotted one tracking due east from the radiant. They were fainter this morning on the average than they were yesterday, but the high train percentage kept going and there were some lovely long, speedy meteors with glowing trains hung on the sky behind them - rocking awesome!

Yet another pleasant surprise was the return of the ANT radiant which had been strangely quiet the last two mornings. They returned in fine form this morning though, with some nice long and slow meteors tracking eastward to counterpoint the blazing fast streaks of the ETAs usually going west. And then in the middle of them, I had the ELYs and SPOs going too for a true, full-sky, holistic visual experience...;o).

I actually saw a few hazy clouds around the edges of the sky while out this morning, the first I'd seen in days. I imagine that means that the glorious high pressure dome is weakening and my pristine skies are endangered species, but I plan to give it another go in the morning to monitor the ETA ramp down. Plus, the predicted max of the ELYs is in the morning as well, we'll see what they can do. too.

2016 May 14–15

After several nights of clouds, I finally was able to return to the Matanzas Inlet site for a two hour, follow-up look at the ETAs this morning and darned if they aren't still producing! In fact, I had a respectable overall total of 38 meteors in the two hour session with 8 ETAs under a glittering, star-filled, pre-dawn sky. I also caught 3 good candidates for the May β-Capricornid (MBC) radiant.

Here are the results:

May 14/15, 2016 Observer: Paul Jones, Location: North Bank of Matanzas Inlet, Florida, Lat: 29.75N, Log: 81.24W (approximately 18 miles south of St. Augustine, Florida).

0315 – 0415 EDT (0715 – 0815 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, Facing: East

- ETA: 0, +1, +3
- 1 MBC_ +2
- 12 SPO: -1, +1, +2, +3(3), +4(3), +5(2), +6
- 16 total meteors

0415 – 0515 EDT (0815 – 0915 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.5 (twilight), Clear, Facing: East

- ETA: +2(2), +3(2), +4,
- MBC: +2, +4
- 15 SPO: 0, +1(2), +2(2), +3(5), +4(2), +5, +6(2)
- 22 total meteors

7 0f the 8 ETAs left visible trains, predominate colors were yellow and orange with reddish tints.

I had barely logged on and settled back to observe when a lovely +1 SPO shot south out of eastern Hercules. It looked almost like a late η-Lyrid (ELY) but didn't line up well enough with the migrated radiant that shower would have had this morning, but it was nice anyway! That meteor set the tone for many more bright and colorful meteors zipping in all directions from horizon to horizon throughout the entire watch!

About five minutes after that first meteor, I saw my first MBC candidate, a nice, bluish-white, +2 that shot straight north in eastern Cygnus. It tracked back perfectly to the projected radiant and although it resembled an ETA, it was way too far west to be one also it was distinctly bluish, which is a color I have yet to see any ETA exhibit. Of course, most veteran meteor observers will admit that observed color in meteors is very subjective and rarely do any two folks agree on it

Two of the ETAs in the first hour hit within about 3 minutes of each other and both were spectacular – earthgrazers both over 30 degrees in path length with long, spreading trains – awesome!! Not long after, another ETA shot westward so fast that all I saw was the train it left behind sitting on the sky for several seconds!

The second hour was busy also as the activity picked up all around the sky and several more nice ETAs were spotted. Two more candidates for the MBC radiant were seen also, both showing exactly the same characteristics of the first one. My seeing them left little doubt in my mind that all three were actually members of this recently discovered radiant. The artificial satellite "parade" continued in earnest also this morning with around 20 to 25 of them spotted altogether! I must say, they do add additional interest to these pre-dawn meteor watches!

Weather permitting there is a brief dark window after moonset in the morning, so I'll be back at it once again for one more look before closing the chapter on the 2016 ETAs. It has indeed been a remarkable ride for them this year!

3 The η Aquariids 2016 from Ermelo, Netherlands by Koen Miskotte

Introduction

Every year the first week of May is a special period for meteor observers in Belgium and the Netherlands. Early May the meteor shower the η-Aquariids (ETA) reaches its

maximum. From the Benelux, the meteor shower is difficult to observe. As the ETA radiant rises above the horizon around 3:15 local time, at the same time begins the astronomical twilight. To 4:00 pm local time, you can observe well, after that, dusk is getting on quickly. Some observers continue until 5:00 pm local time, as only stars of +2 or brighter are visible. ETA observations from the Benelux cannot be used for normal activity profiles that we use for other meteor showers. After all, the radiant level remains far below the required 30 degrees altitude between 3:15 and 5:00 pm local time.

For visual meteor observers in the Benelux it is a sport to see an η-Aquariid before the sky gets too bright. Marco Langbroek wrote in 1995 an article about this (Langbroek, 1995). Indeed there are one, two and very occasionally three ETA's to be seen, but often also nothing! Exception was 2013 when the ETA's had increased activity (Johannink, 2013). The author then counted 12 ETAs including some fine earth grazers. The period of May 3 to 7 is the most important, because the meteor shower reaches a maximum ZHR in this period of time which is variable between 40–80.

Early May 2016 we had a nice weather period in the Benelux so that I was able to observe a lot. In addition to the ETA's there were also other sources of meteor activity: the η-Lyrids (ELY) and the Antihelions (ANT). Below are the reports.

The observing reports

The first clear night was April 30th / May 1st. The hunt was opened on the ETAs! A few clouds were expected, so I observed from the meteor roof of my house. Limiting magnitude around 6.3 with a nice dark sky background. I observed between 23:30 and 02:30 UT and in those three hours observing time I only saw 17 meteors of which 1 Anti Helion. No ELY and ETA's.

The following night of May 1/2, was entirely clear. Monday is my day off so I decided to observe from the Groevenbeekse Heide, a heath near my house. I observed between 23:15 and 02:40 UT. In that period there was some problems with haze formation in the beginning of the session, but later the situation improved greatly. Also the cirrus which was constantly present low in the west stayed out of my field of view until 02:30 UT. This session from 3,40 hours yielded 27 meteors from which 1 ELY, 1 ANT and yes 1 ETA. The first one of this year. This +4 ETA appeared on 01:46 UT and put a relatively long trail down from Cepheus to Ursa Minor. During the observing session two bright meteors were observed, at 00:03 UT, a fast white sporadic (SPO) meteor was seen with a 2 second persistent train. And somewhat later a 0 SPO was seen. This night was a cold one, with temperatures that dropped to -2 degree C at ground level.

The third night which could be observed was May 3/4. A shorter session from the meteor roof because today I had to go to work. I could observe between 23:55 and 02:24 UT with a result of 17 meteors at 2,48 hours of effective observation time. Amongst them were 2 ELY 1 ETA (2nd of this year) and no ANT's. The ETA appeared at a time when I no longer expecting to see an ETA, a few minutes before the end of this session. Also this night temperatures got just below freezing.

The night May 4/5 was also entirely clear, because it was Ascension Day and I did not have to work. That meant I could observe from the Groevenbeekse Heide. When I started up the all sky camera and the CAMS camera's it still did not look so very beautiful: there were quite a bit of cirrus clouds. I hoped it would get dissolving like previous night. And indeed, that happened. Some cirrus clouds remained very low at the sky, in western and eastern directions. When I started the session the lm was somewhat disappointing: 6,3 despite the fairly dark sky background. Some patches of very thin cirrus were visible, similar to the weaker parts of the galaxy. I could observe between 23:55 and 02:46 UT. During effectively 2,85 hours I observed 25 meteors. The first hour 23:55-01:00 UT was quiet with 8 meteors (including one ANT + 3). The second hour (01:00-02:00 UT) was fine with quite a few meteors and bright ones too! At 01:04 and 01:20 UT two fast +1 sporadic meteors were seen. Highlight, however, was a very beautiful magnitude 0 or -1 Anti Helion which had a long path from the northern parts of Ophiuchus, by Hercules, Draco and extinguished in Cepheus. The yellow meteor exhibited a varying brightness and showed a short wake. These are still the pearls for which I lie in the field. In addition, this hour I observed two ETA's (+3, +5) observed at 1:35 and 1:51 UT, respectively.

The last period ran from 02:00 to 02:46 UT and yielded only 3 sporadic meteors through the twilight on.

The nights 5/6 and 6/7 May in were clear but with a lot of cirrus clouds. Thus, these were not observed visually. The night of May 7/8 was okay again, beautifully clear sky in which the lm rose to 6.4. Again I observed from the Groevenbeekse Heide and watching meteors between 23:30 and 02:40 UT. During this session I counted 26 meteors among which 5 ELY, 1 ANT and 2 ETA's. Again some beautiful meteors were observed; at 02:52 UT a +2 ELY and at 00:25 UT a +1 ELY which both appeared in Cygnus. The best meteor was a very nice magnitude 0 ETA earth grazer. This meteor started just east of the star eta Cygnus and moved along the "head" of Draco, Lyra, Hercules, Bootes and extinguished in Canes Venatici. WOW! This is what I wanted to see. A second ETA was seen a few minutes before the end of the session. This one was also captured with my CAMS 351 camera (*Figure 1*).

The night of May, 8/9 was very clear. All day beautiful blue skies almost Provencal. And it stayed that clear at night, so I decided to start a little earlier. I could observe meteors between 22:37 and 02:32 UT. Just before 01:00 UT I took a short power nap to be fully fit for the eta Aquariids period.

Figure 1 – Eta Aquariid captured with CAMS 351 camera on May 8, 2016. It was also seen visually by the author.

Unfortunately, this night was in respect of the meteors a bit disappointing. Despite a very bright sky, I saw effective per hour less meteors. No bright meteors, the brightest were two SPO +2. In total, I saw in 3,83 hours effective 27 meteors including 4 ELY, 1 ETA (+4) and 1 ANT. Fortunately, the stunning view of the starry sky was quite a saving grace. The Milky Way was visible from Cassiopeia into the southern part of Ophiuchus and slightly right below that part the particularly attractive trio Saturn, Mars and Antares were visible in the constellation Scorpius!

In a summary, I can say that this year's ETA hunt was very successful. For 6 nights I counted 7 ETA's. Outside of the special year 2013 (13 ETA's in two nights) a record! The all sky camera captured three bright meteors in this period and also both CAMS cameras were successful and captured a dozen ETA's.

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Langbroek M. (1995). "The Tale of Two Mad Meteor hunters". *WGN, Journal of the International Meteor Organization*, **23**, 251–253.

Johannink C., Jobse K., Breukers M., Neels P., Langbroek M., Haas R., Miskotte K., Biets J.M. (2013). "Eta Aquariiden uitbarsting waargenomen met CAMS". *eRadiant*, 35–37.

Miskotte K. (2013). "Meteoren, kometen en vuurbollen in het voorjaar van 2013". *eRadiant*, 47–55.

Figure 2 – This bright meteor (magnitude -2) was captured with CAMS 352 camera on May 5, 2016 at 23:53:02 UT. Unfortunately this meteor was not recorded simultaneously.

Fireball events March – April 2016

Compiled by Paul Roggemans

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An overview is presented of exceptional fireball events which got covered in Meteor News during the period March-April 2016.

1 Fireball 2016 March 6 over Florida

A bright (estimated magnitude around -9) slow moving fireball was largely observed on 2016 March 6, at 01h01m UT, by more than 100 witnesses all over Florida and Southern Georgia. Travelling from South to North along the Eastern coast of Florida, it lasted nearly 10 seconds before fragmenting in around ten fragments, and disappearing. The fireball was recorded low on the Western horizon by Andy Howell and his SkySentinel video camera located at Newberry Star Park.

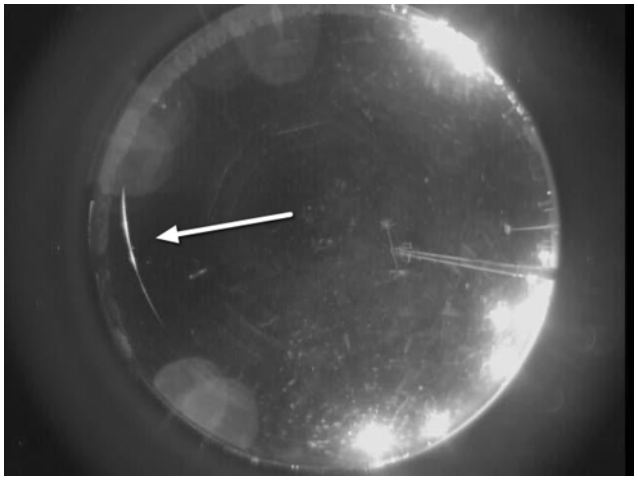

Figure 1 – The SkySentinel video camera located at Newberry Star Park recorded the fireball low on the Western horizon (photo: Andy Howell).

2 Fireball 2016 March 6 over Austrian-German border

An exceptional fireball appeared on 2016 March 6 at 21h36m51s UT above Austria and ended 5.5 seconds later above the German- Austrian border. A detailed article can be read in the article "New meteorite fall observed in detail by Czech fireball cameras".

A search for meteorites took place on March 12 and was successful. A sample was identified as an ordinary chondrite (LL6). At the moment the meteorite is called Stubenberg (not yet official).

Figure 2– fireball of March 6 obtained by the automatic digital all-sky fireball camera at the station of the Czech Hydrometeorological Institute in Kocelovice (photo: ASÚ AV ČR).

3 2016 March 17, St. Patrick's Day fireball over United Kingdom

On Saturday 17th March 2016 UK public woke up to bit of a shock. 8 UKMON stations (Church Crookham, Clanfield, Wilcot, Norman Lockyer, Natural History Museum and even Scotch Street station in Northern Ireland) at 3:16AM captured a -14 mag fireball over South of England. More about this event in a separate article in this issue.

4 Fireball 2016 March 20, over Granada, Spain

A nice presentation of a slow bolide has been put online on YouTube[1]. This fireball has been recorded on 20 March 2016 at 22h36m UT over Granada, Spain. The video shown displays all details, a great piece of work to document this event!

5 Fireball 2016 March 25 over Belgium

A bright fireball was recorded by Klaas Jobse in Oostkappele, Netherlands, and by Jean-Marie Biets in Wilderen, Belgium, on 25 March 2016 at 23h00m45s UT. This fireball was also captured by 3 FRIPON stations at Lille, Arras and Cappelle la Grande in the North of France. At this moment 70 reports have been registered with the Fireball report form. Klaas Jobse has a short video of the event online.

[1] http://lunarmeteoritehunters.blogspot.be/2016/03/granada-fireball-meteor-20mar2016-w.html?spref=fb

Figure 3 – Fireball 25 March 2016 at 23h00m45s UT captured at Wilderen, Belgium (EN92) by Jean-Marie Biets. The fireball moved slow and took 3 seconds before disappearing at the edge of the shutter device.

6 Fireball 2016 March 29 over Florida

Flying South of Miami, a -10 fireball was spotted on 2016 March 29, around 10h37m UT by nearly 150 witnesses that reported it. Its trajectory was roughly East to West, and it remained visible for nearly 5 seconds before suffering successive fragmentations and vanishing.

7 Fireball 2016 March 31 over Spain

José María Madiedo reports on Facebook about a spectacular fireball recorded on 31 March at Castile-La Mancha, Spain. This amazing fireball turned the night into day for a fraction of a second. It was observed on 31 March 2016 at 2h36m UT. The event was produced by the impact of a cometary fragment with the atmosphere at a velocity of about 90.000 km/h. Watch the video on youtube[2].

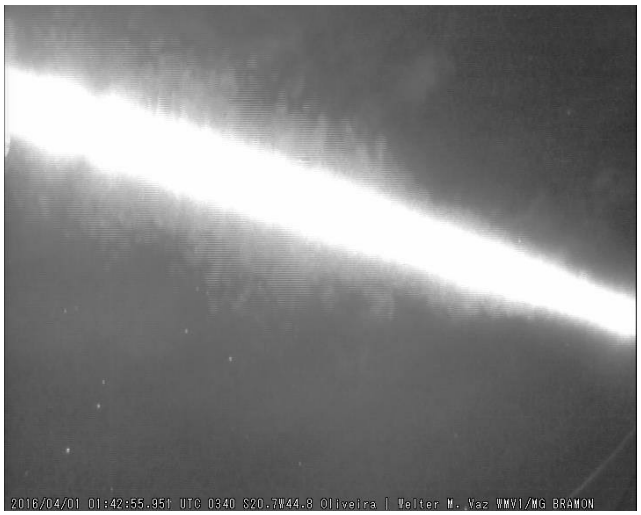

Figure 4 – April 1, 2016 at 01:42:55 UT very bright fireball flashed over Brazil.

8 Fireball 2016 April 1 over Brazil

On April 1, 2016 at 01:42:55 UT very bright fireball flashed over Brazil. Magnitude of that fireball was over -12 and it lasted more than 11 seconds. This fireball was captured by 5 cameras of BRAMON – Brazilian Meteor Observation Network.

9 Fireball 2016 April 13 over Russia

Nikita Kulanov reports about a fireball over Russia, brighter than the Full Moon captured by the URSA network in Finland as well as from Russia and Sweden. A little before dusk, the sky lit up and lightened the landscape in blue light for a moment: a spectacular fireball appeared! Esko Lyytinen calculated that the fireball entered into the atmosphere at about 90 km at a speed of 20,6 km/s at a very steep angle of 80°. The initial mass should have been in the order of 5 to 50kg and any fragments that dropped to the Earth surface probably felt into the water of a lake. The brightest flash occurred at 27.6 km and the body was destroyed at an elevation of 22.7 km. The event was also recorded from Sweden, as far as about 700 km. The origin was sporadic.

Figure 5 – Fireball of 13 April 2016 at 00h29m22s UT over Russia.

10 Fireball 2016 April 16 over Illinois

A very bright green fireball flying over central Illinois was reported by nearly 600 people located South of the Great Lakes, from Southern Ontario until Northern Alabama and Oklahoma. The long lasting object appeared on 2016 March 16, at 03h16m UT, and was travelling along a WSW to ENE (azimuth ~295°) trajectory, ending in a final flash leading to fragmentation. It was also recorded on video from Sullivan (IL) by Clint Parrish and Brad Emel.

11 Fireball 2016 April 27 over California

More than 250 people reported a bright fireball West of California coast on 2016 April 27, around 04h37m UT. It travelled 60 km offshore San Diego, from West to East, on a very steep trajectory and was visible during nearly 5 seconds before going on a dark flight above the Pacific Ocean. Just the time for it to be recorded by a travelling car[3].

[2] https://www.youtube.com/watch?v=NER_hBvVWTI

[3] https://www.youtube.com/watch?v=saSNs5O7Mjg

St. Patrick's Day fireball over United Kingdom

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On Saturday 17th March 2016 UK public woke up to bit of a shock. 8 UKMON stations (Church Crookham, Clanfield, Wilcot, Norman Lockyer, Natural History Museum and even Scotch Street station in Northern Ireland) at 3:16AM captured -14 mag fireball over South of England.

1 Introduction

The International Meteor Organization (IMO) received over 45 public reports so far about a fireball spotted also by French and Belgian networks. The public described the event as a very bright fireball (bolide) with a green tint, since then UKMON team named this event as St. Patrick's Day Fireball.

The UKMON network has been in operation for 4 years with 23 operational cameras and this was the brightest meteor recorded up to date. Videos from their cameras have been promptly posted on the UKMON website and Twitter.

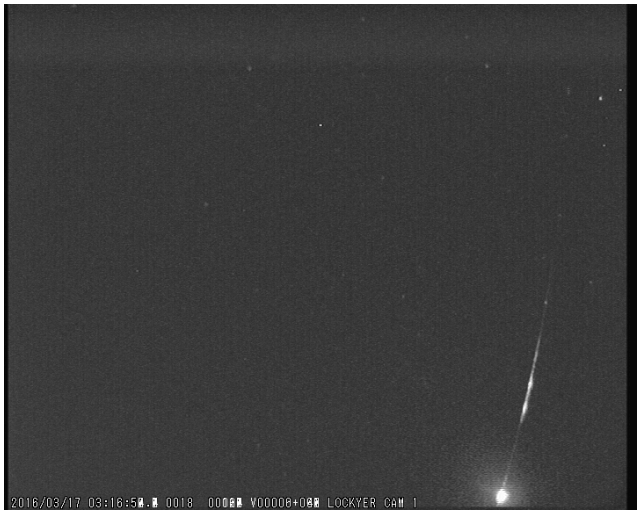

Figure 1 – Corrected image from Norman Lockyer station.

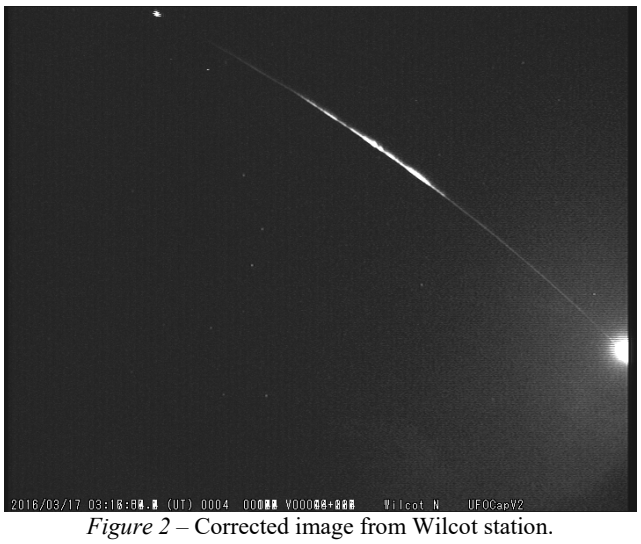

Figure 2 – Corrected image from Wilcot station.

The preliminary results

A great deal of work has been performed by the EDMOND team and Jakub Koukal in particular, calculating the orbit, atmospheric path and deceleration fit from fully saturated cameras. Manually corrected images showing the meteor trail are displayed in *Figures 1, 2 and 3.* The team quickly calculated the ground map and orbit (*Figure 4*).

Figure 3 – Corrected image from Clanfield station.

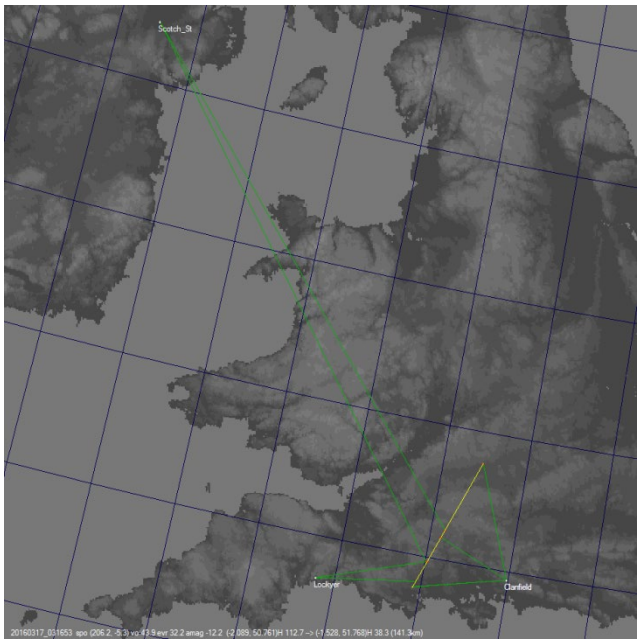

Figure 4 – St. Patrick's Day fireball ground map.

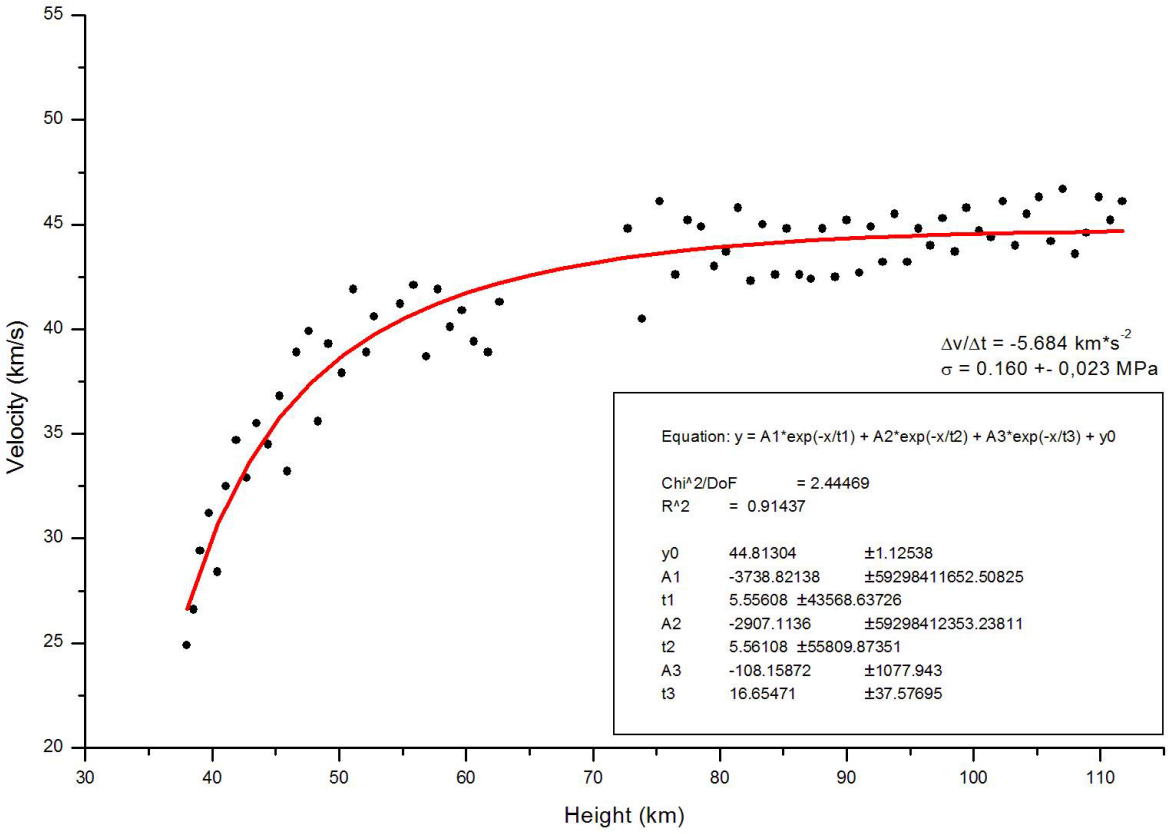

Figure 5 – St. Patrick's Day fireball deceleration fit. From the graph we can confirm nothing could have survived because of high terminal velocity at 26.6 km/s at 38.8 km.

Table 1 – The initial mass calculation data prepared by Jakub Koukal.

Station	Geographic coordinates		Distance	Elevation	Extinction	Magnitude		Initial mass	
	Latitude	Longitude	*km*	°	-	Relative	Absolute	*kg*	+-
Clanfiled	50,938801	-1,019700	98,678	42,213	0,595	-12,4	-13,4	53,9	12,2
Church Crookham	51,261501	-0,848000	91,809	46,232	0,692	-13,1	-14,1	110,4	29,5
Lockyer	50,687801	-3,219600	148,454	26,526	0,895	-12,7	-14,7	203,9	74,3
NHM London	51,496715	-0,176367	not calculated, bolide outside of FOV						
Scotch Street	54,438801	-6,512300	468,100	8,143	2,824	-6,2	-12,4	19,4	4,3
Wilcot	51,352100	-1,801700	67,027	81,554	0,404	-13,1	-13,4	53,9	18,4
Unified orbit							**-13,6**	**66,1**	**16,4**

Bright bolide on February 21 over the Opole voivodship by the eyes of the CEMENT

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Due to the inclement weather over the Czech Republic in February, and thus the lack of fireballs typical for this time of the year, we consider a very bright meteor that was seen February 21, 2016 at 22:18:15 UT (23:18:15 CET). The beginning of the projection of the atmospheric path of the bolide was located inside the territory of the Czech Republic, the bulk of the path, however, took place over the Opole voivodship in Poland.

1 Meteor activity in February and March

There are no significant meteor showers active at this time of the year and the overall activity of the meteor showers is very low, also the sporadic background is at a minimum of its activity during the year. February and March also belong to the months with the worst of the weather in the Czech Republic and therefore the activity of visual observers is very small. Hence, this period belongs to the least known periods throughout the calendar year. In this period most active meteor showers are belonging to the Antihelion source. Activity of the Virginid-Leonids complex prevails in the months of January, February and March, which is then transferred into the Scorpio-Sagittarids complex in April. The common characteristic of the meteors belonging to the Antihelion source is the relatively low geocentric velocity. Most of the meteors from this source have a speed between 20–30 km/s.

2 Evening fireball in the sky with the Full Moon

Despite the relatively unfavorable weather conditions mainly over the territory of Moravia and Silesia, the phenomenon was observed visually by many people in the Czech Republic. The overview report of the ASÚ AVČR[4] contains 8 sighting reports (at the date of February 25, 2016) from the general public about the bolide observations. There is only 1 report (from northern Austria) in the fireball reporting form named Fireball report[5] on the IMO (International Meteor Organization) pages. The circumstances of this event were described in great detail in an article[6] by RNDr. Pavel Spurný, CSc. (ASÚ AVČR Ondřejov, 24.2.2016) which was published on the website of the Astronomical Institute of the AVČR. These results are from the observation of very accurate bolide cameras that are part of the European fireball network (EN)[7].

Figure 1 – The summary image of the bolide 20160221_221815, station Otrokovice N. (Author: *Michal Čechmánek*).

The amateur network CEMENT (Central European Meteor Network) captured this phenomenon, despite adverse weather conditions, on three cameras; two were located in central Moravia (Kroměříž, Otrokovice) and one in the south of Slovakia (Kračany). The cameras failed to capture the end of the event, due to the low elevation of the end of the visible part of the atmospheric path of the fireball. At the station Kračany the fireball was visible through a continuous cloud layer (*Figure 3*). At the station Otrokovice the phenomenon was mainly in the area of the crumbling low clouds (*Figure 1*). At the station Kroměříž only part of the path was recorded through an almost continuous layer of low clouds (*Figure 2*), especially around the fragmentation of the body. Since the fragmentation of the body is usually associated with abrupt brightening of the bolide, it was not possible to use data obtained from the Kromeriz station to calculate the atmospheric path of the fireball. Due to the unfavorable weather no spectrum of this bolide has been recorded by the spectrographs at Valašské Meziříčí observatory.

[4] http://meteor.asu.cas.cz/db/report/
[5] http://fireballs.imo.net/imo_view/event/2016/705
[6] http://www.asu.cas.cz/articles/1030/19/jasny-bolid-nad-slezskem-v-nedeli-21-unora-2016-pozde-vecer
[7] https://en.wikipedia.org/wiki/European_Fireball_Network

Figure 2 – The summary image of the bolide 20160221_221815, station Kroměříž ENE. (Author: *Jakub Koukal*).

Figure 3 – The summary image of the bolide 20160221_221815, station Kráčany N. (Author: *UMa Astronomy*).

The recordings from the stations Kračany and Otrokovice were used to calculate the atmospheric path of the bolide and the orbit of the meteoroid in the Solar system. The projection of the beginning of the atmospheric path was located at the coordinates N49,966° E18,121° near the village of Borova (CZ), the height of the bolide at this time was 89.3 kilometers above the Earth's surface. The end of the projection of the atmospheric path was located at the coordinates N50,366° E18,097° near the village of Poborszów (PL), the height of the bolide at this time was 51.7 kilometers above the Earth's surface. The bolide was not captured along the entire length, from the station Otrokovice N the phenomenon lasted for 2.82 s. The bolide reached an absolute brightness of -7.1m, which is not the maximum absolute brightness of the bolide throughout the flight due to the lack of the end of the atmospheric path. The 2D projection of the bolide trajectory in the atmosphere is shown in *Figure 4*.

It was a slow meteor, its geocentric velocity before entering the Earth's gravitational field was only 19,7 km/s, including the effect of the deceleration. The orbital elements of the meteoroid´s orbit were as follows: a = 2,06 AU (semi-major axis), q = 0,681 AU (perihelion distance), e = 0,670 (eccentricity), i = 10,2° (inclination), ω = 77,0° (argument of the perihelion), Ω = 152,5° (longitude of the ascending node). The bolide was a sporadic meteor with the observed radiant at RA = 144,2°, DEC = -4,4°. The projection of the meteoroid orbit in the Solar system is shown in *Figure 5*.

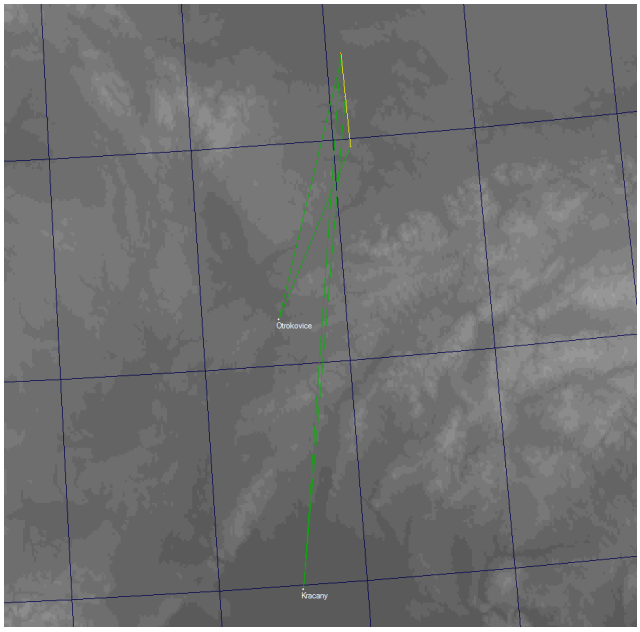

Figure 4 – The 2D projection of the bolide 20160221_221815 trajectory on the Earth surface. (Author: *Jakub Koukal*).

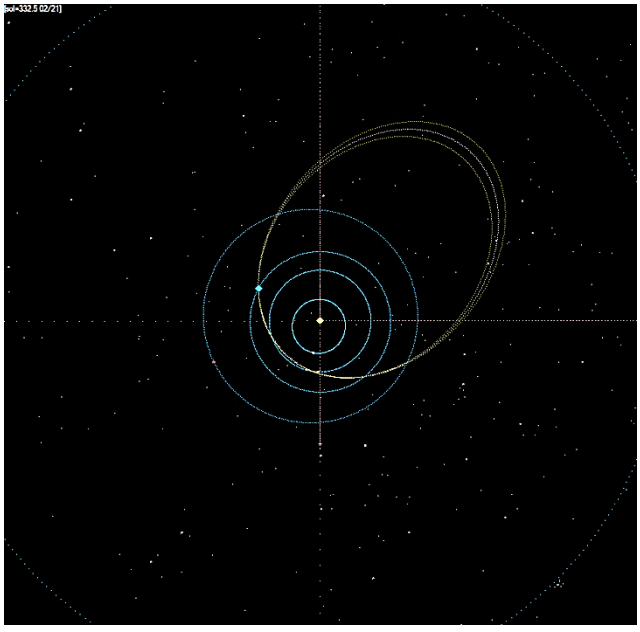

Figure 5 – The projection of the meteoroid orbit in the Solar system including the effect of the deceleration on the geocentric velocity v_g. (Author: *Jakub Koukal*).

3 Comparison of the results of the European Fireball Network (EN) and CEMENT

The atmospheric path of this bright bolide was calculated independently from two different sources (EN and CEMENT), it is thus possible to perform a mutual comparison of the orbital elements. The projection of the atmospheric path of the bolide calculated on the basis of

data from CEMENT has a twist of 0,1° to the atmospheric path derived from EN. The atmospheric path from CEMENT is entirely shifted eastward against of the path from the EN cameras, at the beginning of the path it is about 250 m, at the end it is about 310 m. The orbital elements and parameters of the atmospheric path from EN cameras are taken from the article, as well as the position of the projected beginning and end point of the atmospheric path of the bolide.

Table 1 – Comparison of the orbital elements and parameters of the atmospheric path of the bolide 20160221_221815 detected by the European fireball Network cameras and by the CEMENT cameras. Remark: (*) the data cannot be compared because not the whole atmospheric path of the bolide was captured by the CEMENT cameras.

	European fireball Network	CEMENT
Semi-major axis **a** (AU)	1.68	2.06
Perihelion distance **q** (AU)	0.699	0.681
Inclination **i** (°)	9.0	10.2
Eccentricity **e** (-)	0.585	0.670
Geocentric velocity $\mathbf{v_g}$ (km/s)	20.6	19.5
Beginning height $\mathbf{H_B}$ (km)	89.1	89.3
Terminal height $\mathbf{H_E}$ (km)	32.4	51.7*
Absolute brightness **amag** (^{m})	-10.4	-7.1*

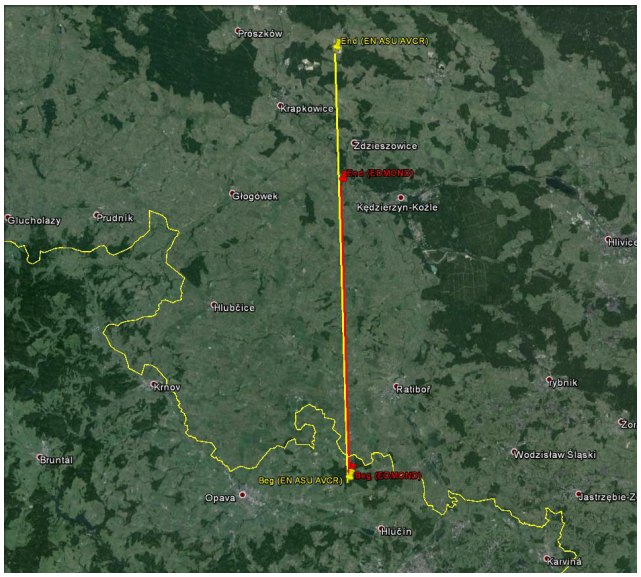

Figure 6 – The overall view of the projection of the atmospheric path of the bolide 20160221_221815 calculated within EN and CEMENT.

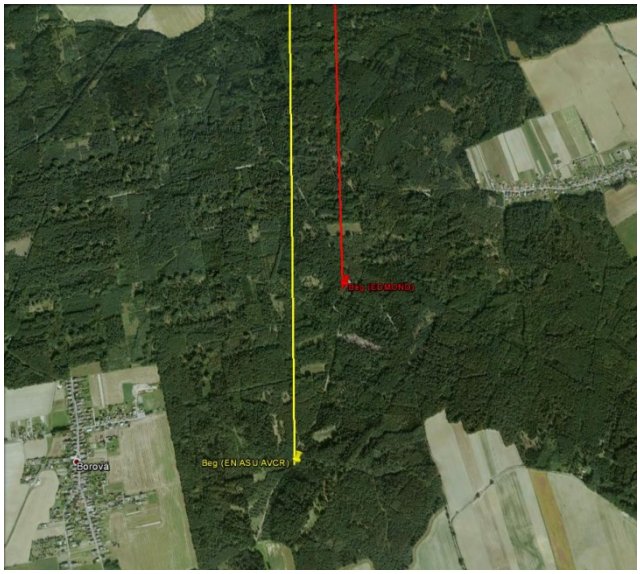

Figure 7 – The projection of the beginning of the bolide 20160221_221815 atmospheric path calculated within EN and CEMENT.

Figure 8 – The detail of the end of the projection of the bolide 20160221_221815 atmospheric path calculated within EN and CEMENT.

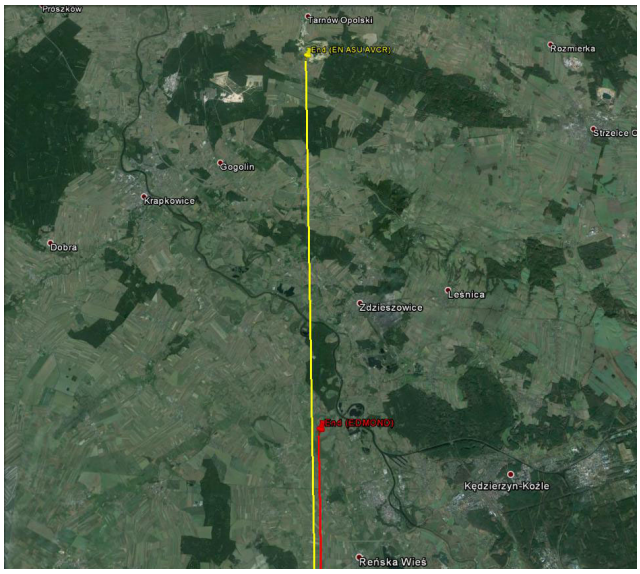

Figure 9 – The end of the projection of the bolide 20160221_221815 atmospheric path calculated within EN and CEMENT.

Results of the EDMOND and SonotaCo united databases

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The first results of the united databases analysis, in which we studied the identification of the meteor showers from the IAU MDC working list, are presented. Using the D-criterion of orbits similarity method we identified 548 meteor showers from a total of 757 meteor showers in the list. The united largest database EDMOND (European video MeteOr Network Database) and SonotaCo contains 412 414 multi-station orbits of meteors.

1 Introduction

The European viDeo Meteor Observation Network (EDMONd) and the European video MeteOr Network Database (EDMOND) has been established only recently (Kornoš et al., 2014a,b). The network originates from spontaneous cooperation between observers in several parts of Europe. The EDMONd Network has been enlarged in recent years and at present consists of observers from the following national networks (in alphabetical order): BOAM (Base des Observateurs Amateurs de Metéores, France); BosNet (Bosnia); CEMeNt (Central European Meteor Network, cross-border network of Czech and Slovak amateur observers); CMN (Croatian Meteor Network or Hrvatska Meteorska Mreza, Croatia); FMA (Fachgruppe Meteorastronomie, Switzerland); HMN (Hungarian Meteor Network or Magyar Hullócsillagok Egyesulet, Hungary); IMO VMN (IMO Video Meteor Network); MeteorsUA (Ukraine); IMTN (Italian amateur observers in Italian Meteor and TLE Network, Italy); NEMETODE (Network for Meteor Triangulation and Orbit Determination, United Kingdom); PFN (Polish Fireball Network or Pracownia Komet i Meteorów, PkiM, Poland); Stjerneskud (Danish all-sky fireball cameras network, Denmark); SVMN (Slovak Video Meteor Network, Slovakia); and UKMON (UK Meteor Observation Network, United Kingdom). The latest established network (January 2014) is on the southern hemisphere – BRAMON (BRAzilian MeteOr Network). It´s an independent network of the EDMOND database, its task is to map the activity of meteor showers in the southern hemisphere.

Nowadays, due to the international cooperation, meteor activity is monitored over almost entire Europe. Consequently, in recent years, multi-national networks of video meteor observers have contributed many new data. As a result, the latest version of EDMOND database (v5.0, January 2015) contains 3 275 335 single meteors and 221 639 orbits collected from 2001 to 2015. Data from 2015 are incomplete, observations of IMO VMN from 2015 are not yet included.

The SonotaCo network (SonotaCo, 2009) has been working since 2004 in Japan, the catalog of multi-station orbits was established since 2007. Nowadays, it contains 190 775 orbits collected from 2007 to 2014.

2 Methodology

The main part of the orbit calculations from two or more stations is realized with the UFO Orbit software (Sonotaco, 2009). Data reduction is implemented in two steps. The first step is used in calculation of the orbits in UFO Orbit software. Only the combinations of the identical single-station meteors with a time difference $\Delta t < 5$ sec are used and all meteors with duration dur < 0.1 sec are excluded. The qualitative multi-station trajectory criteria have to be met as follows: a maximum speed difference $\Delta v < 7$ km/s between the observations from two stations is accepted; empirically calculated multi-station trajectory quality parameter in the range of QA > 0.15; the height of the beginning and of the end of the atmospheric trajectory H1 < 200 km and H2 > 15 km respectively. In this first step the unrealistic and low accurate trajectories are excluded.

In the second step the specific reduction criteria are applied to already calculated orbits. The angle of the observed trajectory has to be $Q_o > 1°$, the convergence angle $Q_c > 10°$, the difference between two poles of the ground trajectory $\Delta GP < 0.5°$ and the difference between the unified velocity and the velocity from one of the stations $\Delta v12\% < 7.07\%$ (Kornoš et al., 2013b).

Assigning of the derived meteor trajectories to the mean meteor stream orbit is based on the D-criterion of orbits similarity, which compares orbital elements of the meteors (i.e. e, q, i, ω and Ω). In the case of assigning potential members of the meteor showers from the IAU MDC working list (Jopek et al., 2014) the Southworth-Hawkins criterion D_{SH} (Southworth and Hawkins, 1963) was used. The value limit of the criterion was set $D_{SH} < 0.1$ for meteor showers from the IAU MDC working list.

3 Results

The total number of assigned orbits to the meteor showers from the IAU MDC working list was 153 990 (with $D_{SH} < 0.1$). At least one orbit has been assigned to 548 meteor showers from a total of 757 in the list. 178 meteor showers have more than 100 orbits, 29 meteor showers have more than 500 orbits and finally 18 major meteor showers have more than 1000 orbits.

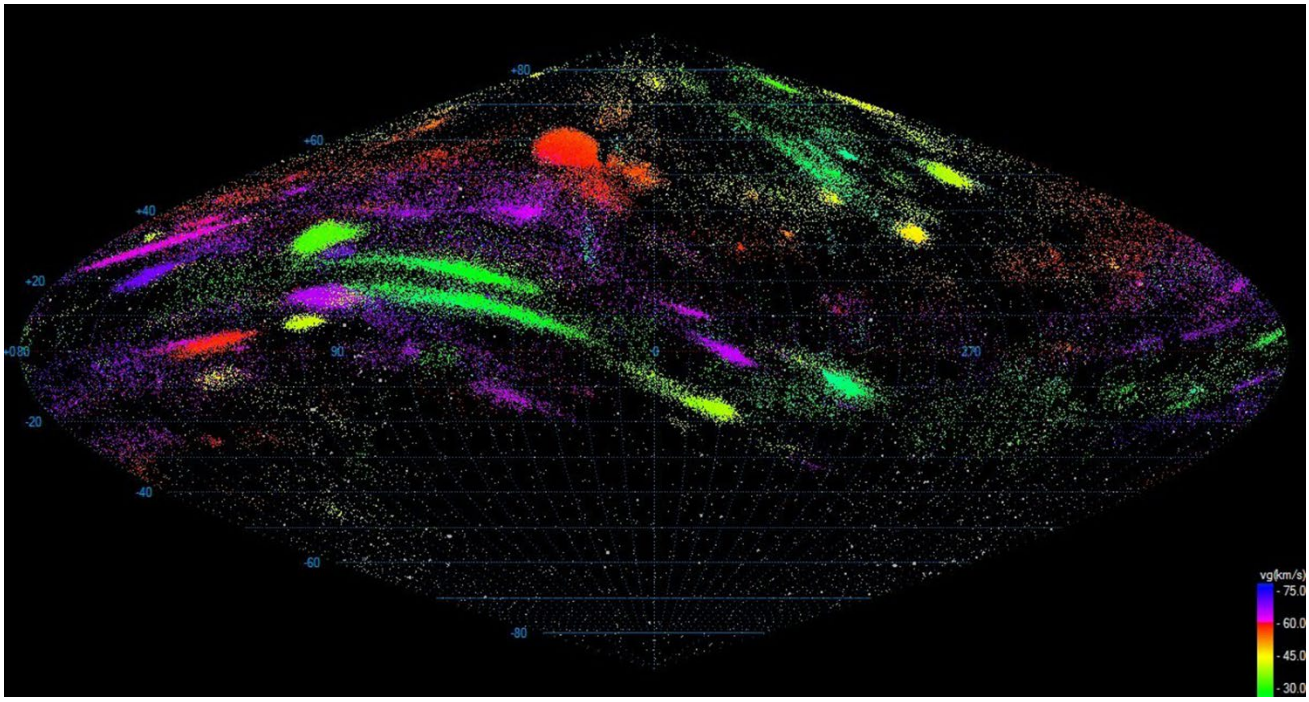

Figure 1 – Map of the radiants of the multi-station orbits belonging to the meteor showers from the IUA MDC working list. The map is in the equatorial coordinate system, the center is located at position RA=0°/DEC=0°.

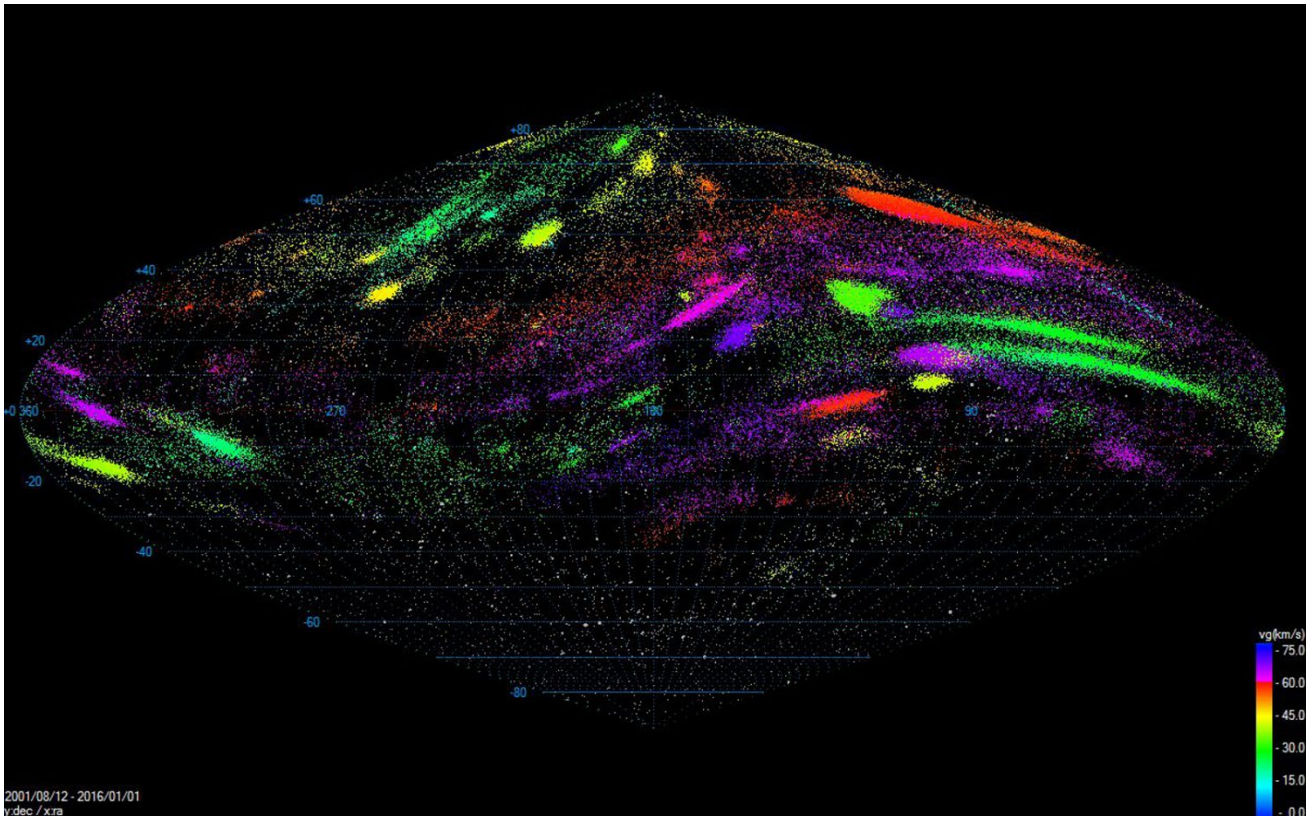

Figure 2 – Map of the radiants of the multi-station orbits belonging to the meteor showers from the IUA MDC working list. The map is in the equatorial coordinate system, the center is located at position RA=180°/DEC=0°.

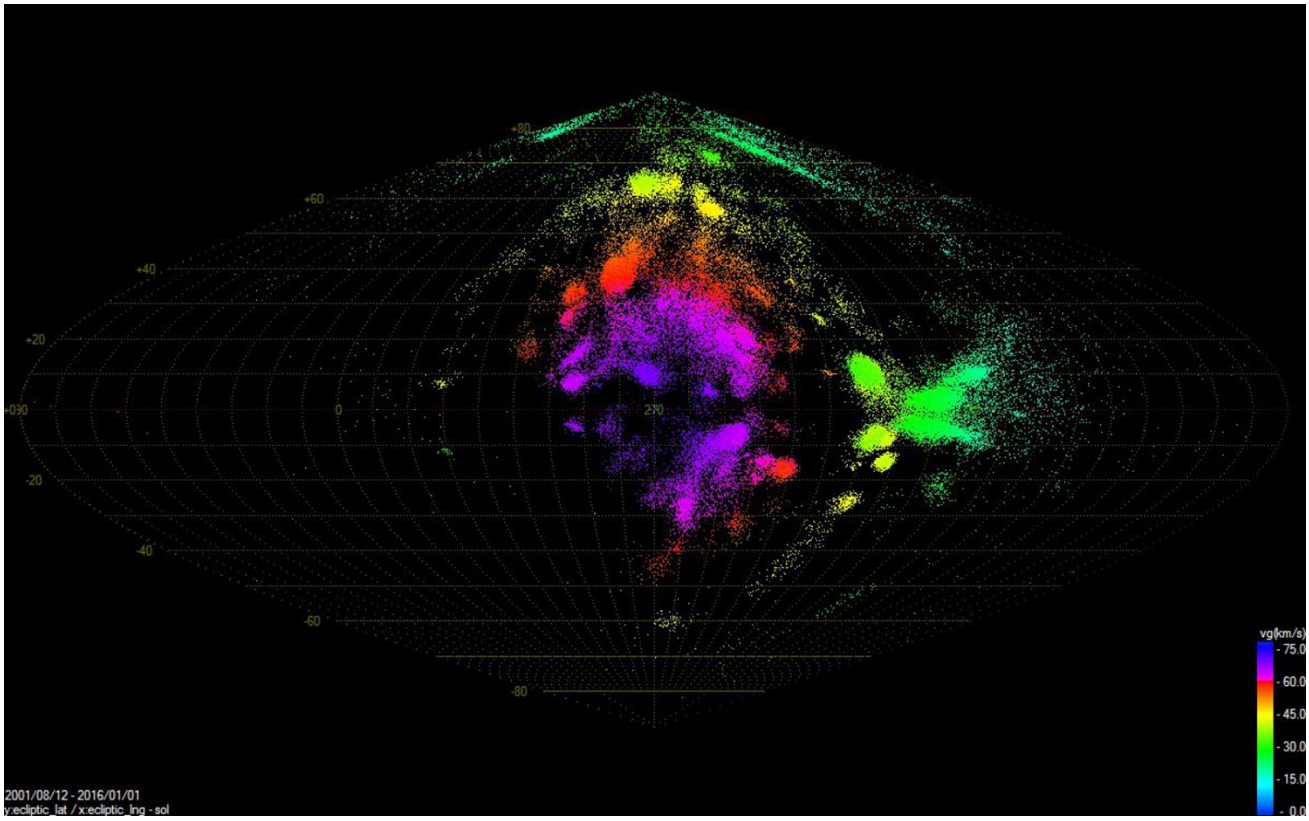

Figure 3 – Map of the radiants of the multi-station orbits belonging to the meteor showers from the IUA MDC working list. Map is in the ecliptical coordinate system, the center is located at position LON=270°/LAT=0°. The ecliptical longitude of the Sun is subtracted from the ecliptical longitude of the orbit radiants.

Table 1 – The list of meteor showers from the IAU MDC working list with more than 500 multi-station. Remark: * meteor shower is member of the Taurids complex.

IAU MDC Number	Code	Meteor shower name	Num. of orbits	Av. D_{sh}	IAU MDC Number	Code	Meteor shower name	Num. of orbits	Av. D_{sh}
#007	PER	Perseids	36905	0.06	#250	NOO	Novemver Orionids	1117	0.08
#004	GEM	Geminids	28881	0.04	#226	ZTA	ζ-Taurids	1116	0.08
#008	ORI	Orionids	13098	0.06	#012	KCG	κ-Cygnids	857	0.05
#016	HYD	σ-Hydrids	3771	0.08	#718	XGM	χ-Geminids	713	0.09
#020	COM	Coma Berenicids	3554	0.08	#191	ERI	η-Eridanids	695	0.07
#013	LEO	Leonids	3409	0.06	#023	EGE	ε-Geminids	624	0.09
#005	SDA	Southern δ-Aquariids	3279	0.09	#641	DRG	December ρ-Geminids	614	0.08
#002	STA	Southern Taurids	3044	0.05	#625	LTA	λ-Taurids	581	0.04
#010	QUA	Quadrantids	2720	0.06	#627	MPI	μ-Piscids	557	0.06
#031	ETA	η-Aquariids	2697	0.05	#631	DAT	δ-Arietids	537	0.05
#017	NTA	Northern Taurids	2343	0.05	#505	AIC	August ι-Cetids	525	0.08
#006	LYR	April Lyrids	1916	0.04	#529	EHY	η-Hydrids	517	0.08
#208	SPE	September ε-Perseids	1506	0.06	#015	URS	Ursids	515	0.05
#001	CAP	α-Capricornids	1348	0.03	#334	DAD	December α-Draconids	513	0.09
#019	MON	December Monocerotids	1181	0.05					

References

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Kornoš L., Matlovič P., Rudawska R., Tóth J., Hajduková M. Jr., Koukal J., and Piffl R. (2014b). "Confirmation and characterization of IAU temporary meteor showers in EDMOND database". Proceedings of the Meteoroids 2013 Conference, Aug. 26-30, 2013, A.M. University, Poznań, Poland, eds. Jopek T.J., Rietmeijer F.J.M., Watanabe J., Williams I.P., pages 225–233.

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Using R to analyze your meteor data

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The UKMON team created series of scripts using analytical suite R to automatically process and summarize meteor data our network produces. Peter Campbell-Burns has extensive experience in data analysis which helped us to create this idea of semi-automated process. The old way of manipulating Excel documents was just taking too much time and R allows us to manage large data sets very easily.

1 Introduction

First we created some fairly basic scripts to test the idea, adding more maths into each script. A result is a full library of written scripts to save you time. And this is exactly our idea, to simplify process of creating reports and graphs within seconds. Once you have R and R Studio installed you can take data from all your stations and export via UFO Orbit. This data bundle is then fed into R and analyzed by your criteria. You can choose shower and year to filter your data further. With one script you can generate your full reports in just a few minutes. All reports can be exported in JPG or PDF formats.

2 Edmond's Perseid shower meteors

So let's have a look at all Edmond's Perseid shower meteors. First we can see how many actual matches the network gets:

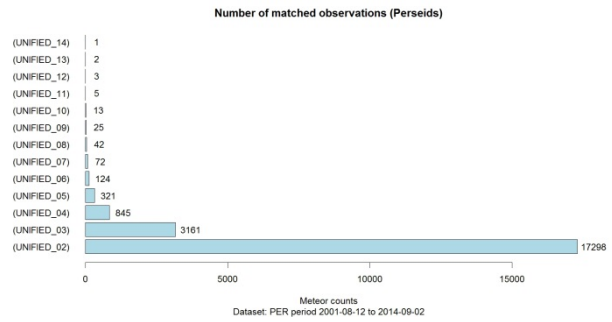

Figure 1 – Number of matched observations (Perseids).

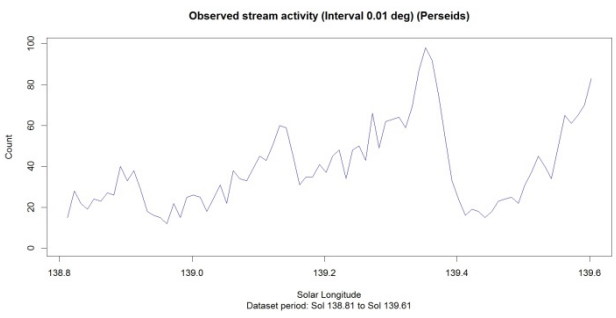

Figure 2 – Observed stream activity (Interval 0.01 deg) (Perseids).

Figure 1 shows the number of stations that matched meteors. Two-station captures are most common with 17.298 matches but Edmond has up to 14 cameras matching the same meteors, an impressive result right there.

Further on we can generate some more graphs and analyse stream activity (*Figures 2, 3 and 4*).

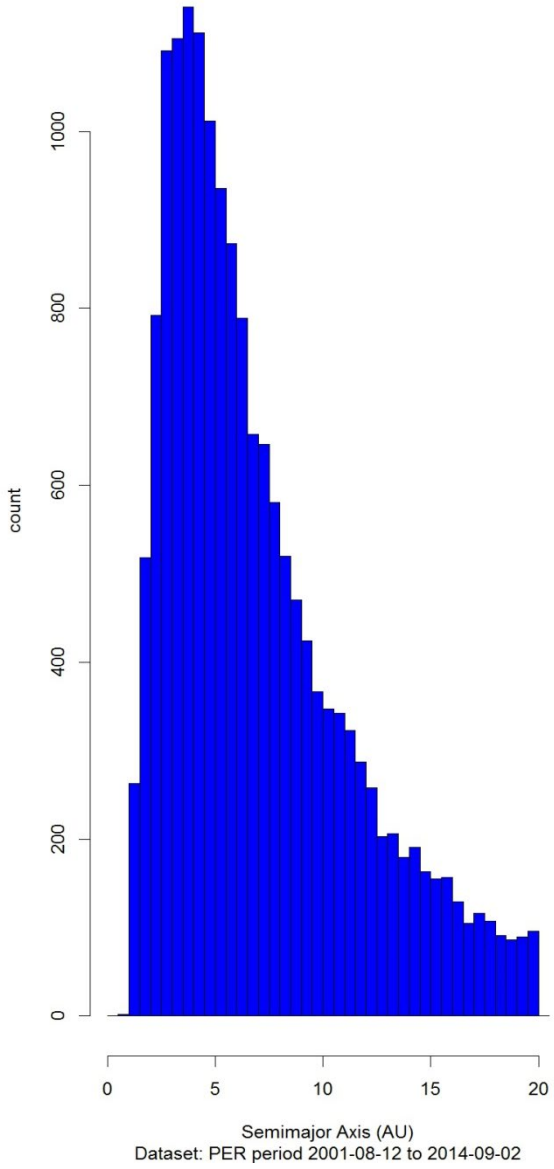

Figure 3 – Semimajor axis frequency distribution (Perseids).

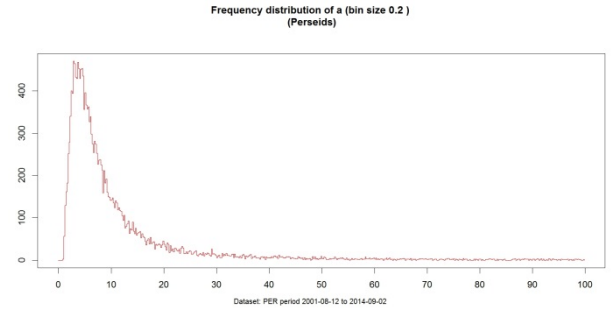

Figure 4 – Frequency distribution of a (bin size 0.2) (Perseids).

But we can do much more; let's have a look at these velocity plots (*Figures 5 and 6*).

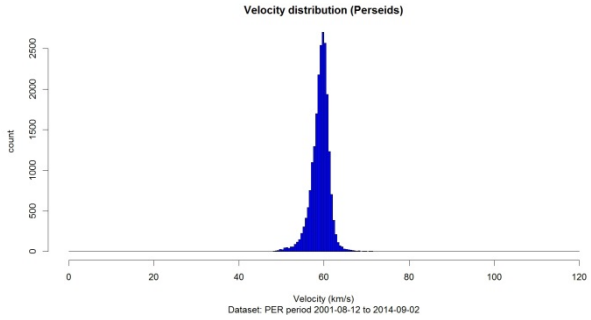

Figure 5 – Velocity distribution (Perseids).

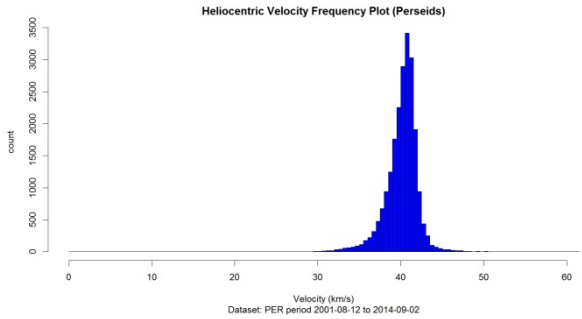

Figure 6 – Heliocentric Frequency Plot (Perseids).

And we are just getting warmed up so let's see what we can do with data that includes magnitudes (*Figures 7, 8 and 9*).

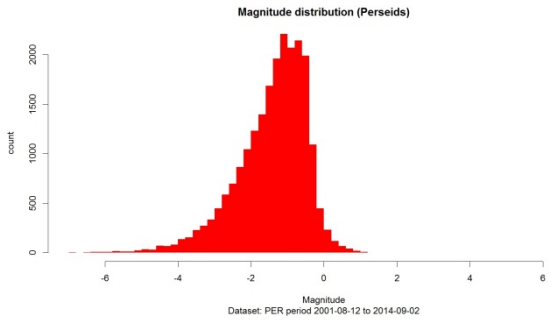

Figure 7 – Magnitude distribution (Perseids).

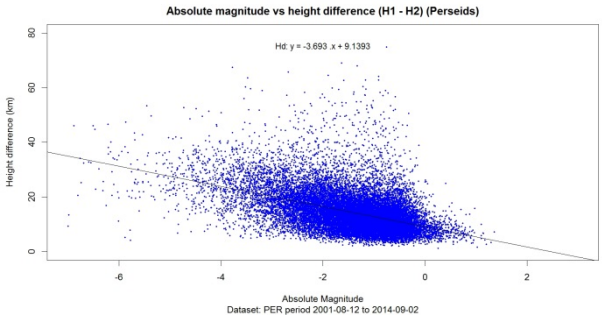

Figure 8 – Magnitude distribution (Perseids).

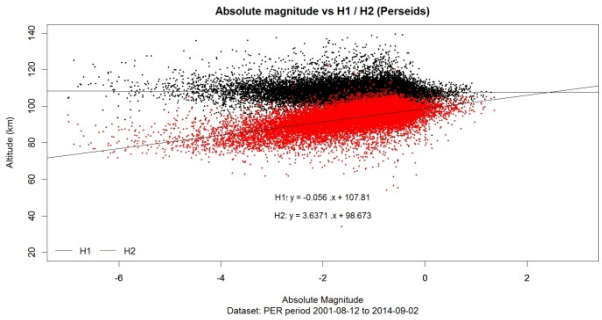

Figure 9 – Magnitude distribution (Perseids).

With R we don't have to stop here (*Figures 10, 11 and 12*).

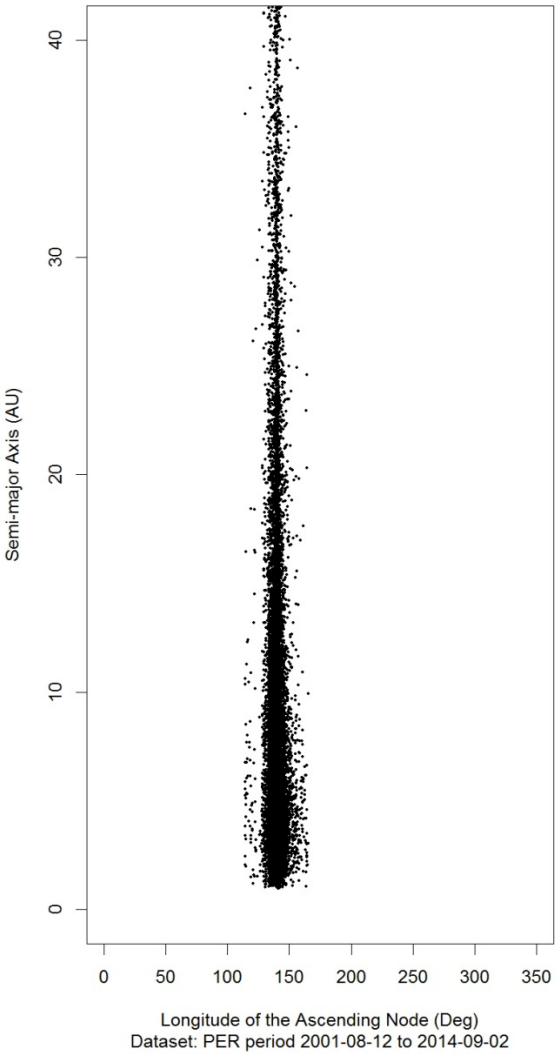

Figure 10 – Longitude of ascending node vs Semi-major axis (Perseids).

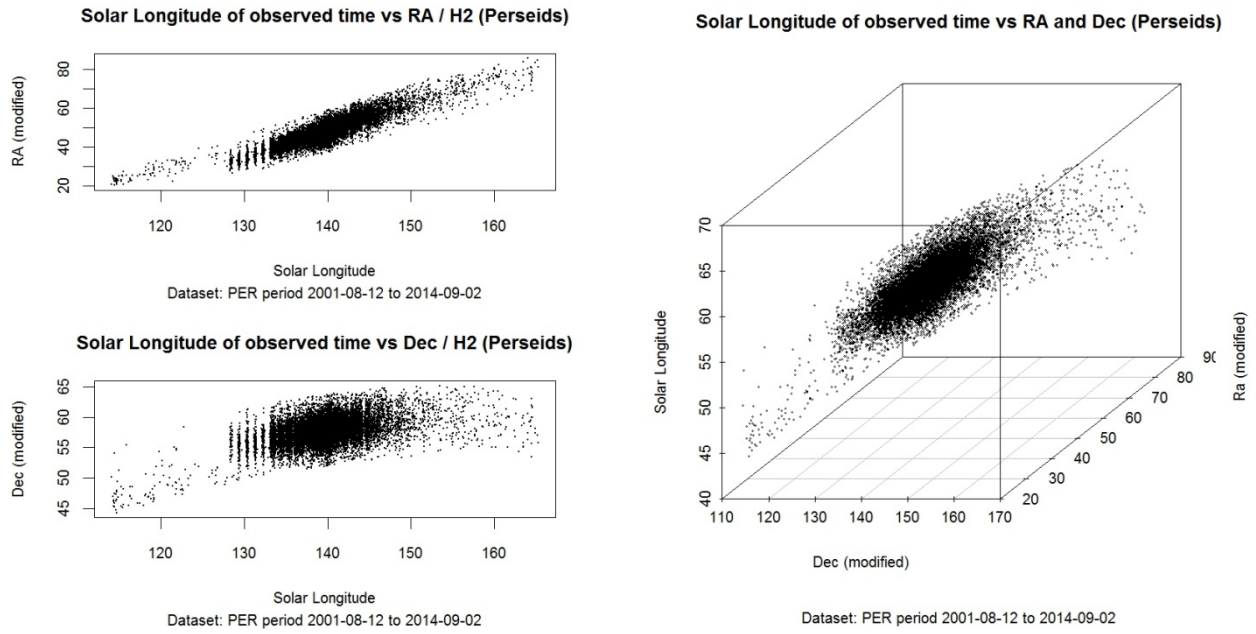

Figure 11 – Solar longitude of observed time vs RA/H2 (top left), Solar longitude of observed time vs Dec/H2 (bottom left), Solar longitude of observed time vs RA and Dec. (Perseids).

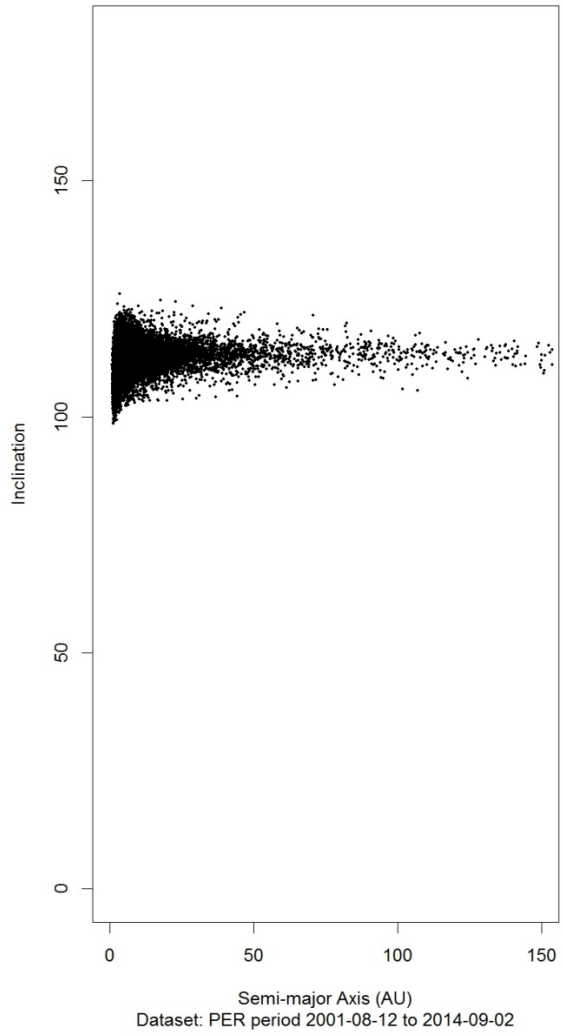

Figure 12 –Semi-major axis vs inclination (Perseids).

Yes there is a lot R can do. Especially considering the time it took to generate these reports. About 5 minutes. And this is the idea of our scripts; you can just add fresh data set and run the same script that will generate graphs for you.

If you would like to give it a go, you can download our full Suite for R[8].

[8] https://www.ukmeteornetwork.co.uk/rsuite/UKMON_R_SUITE.zip

A peculiar meteor recorded by CAMS@Benelux on 29 February 2016

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One of the first meteors captured on the new camera 394 installed in Dourbes, Belgium, proved to be simultaneously with two other stations: Mechelen, Belgium (camera 390-391) and Oostkapelle, the Netherlands (camera 339). This meteor displayed a remarkable end flare of about magnitude –4.

1 Introduction

The CAMS@Benelux network started with two Watec cameras at two stations in March 2012. Four years later the network has 52 cameras at 18 stations. The network has the capacity to collect about 20.000 orbits per year and contributes to the main CAMS project (Jenniskens et al., 2011). More about CAMS@Benelux can be read in Roggemans et al. (2015).

2 Some results

Two new cameras, 394 and 395, were installed in Dourbes, near the Belgian-French border to operate within the CAMS@Benelux network. A missing connector prevented the 395 to start capturing meteors, but the 394 was successfully started. Although the pointing of the camera still needs to be adjusted, one of the first captured meteors appeared to be peculiar with an end flare. With the camera being pointed 17° too much north in azimuth compared to the calculated position, this meteor was captured in the field covered by the CAMS 390-391 (Mechelen, Belgium) and CAMS 339 (Oostkapelle, Netherlands).

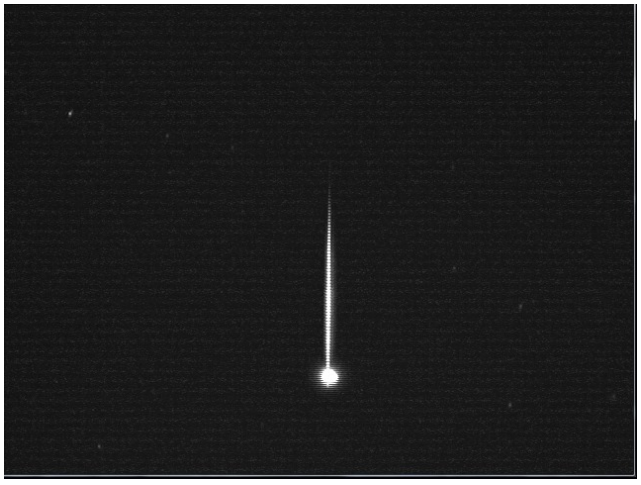

Figure 1 – The meteor of 2016-02-29 22:13:43.44 UT captured by CAMS 394 (Dourbes, Belgium).

Speaking about 'beginners luck', the new camera 394 captured this slow meteor nice in the center of the field of view. It is the kind of meteor trails we all hope to find each time that we confirm meteors and delete the false detections from our cameras. *Figures 1 & 2* shows the images taken in Dourbes and Mechelen. The CAMS network coordinator, Carl Johannink, found this meteor back on data from 4 camera's at 3 stations. The trajectory in height (km) and the light curve are plotted in *Figure 3 & 4*. For people not familiar with the CAMS program, it is important to know that within the CAMS network all 52 cameras are pointed at some calculated aiming points in order to optimize the overlap of the rather small FOV (30° × 22°).

Figure 2 – The meteor of 2016-02-29 22:13:43.44 UT captured by CAMS 391 (Mechelen, Belgium). (Photo : *Luc Gobin*).

Table 1 – Radiant and orbital elements computed by Carl Johannink for the meteor 2016-02-29 22:13:43.44 UT captured by CAMS 339 (Oostkapelle, the Netherlands), 390–391 (Mechelen, Belgium) and 394 (Dourbes, Belgium).

	CAMS Coincidence
Radiant R.A. (°)	149,0 ± 0,1
Declination (°)	+33,6 ± 0,8
V_g (km/s)	16,38 ± 0,16
Semi-major axis **a** (AU)	3,001
Perihelion distance **q** (AU)	0,83622 ± 0,00328
Inclination **i** (°)	8,786 ± 0,311
Eccentricity **e** (-)	0,7214 ± 0,0089
Argument of perihelion **ω** (°)	231,125 ± 0,594
Ascending node **Ω** (°)	340,5427 ± 0,0020

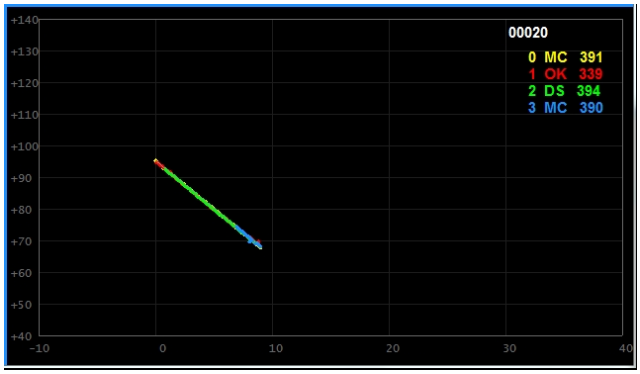

Figure 3 – The meteor of 2016-02-29 22:13:43.44 UT the height of the atmospheric trajectory.

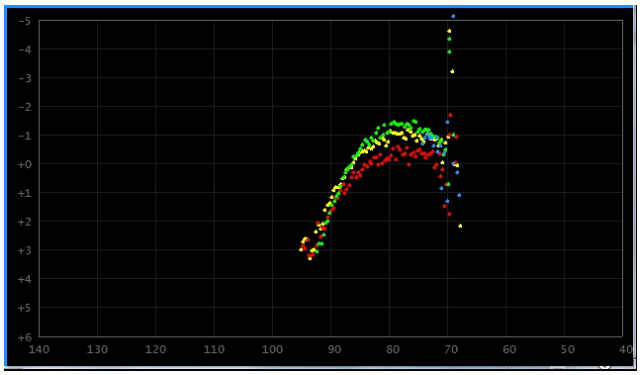

Figure 4 – The meteor of 2016-02-29 22:13:43.44 UT the light curves as registered by the different cameras.

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Roggemans P., Johannink C., and Breukers M. (2015). "Status of the CAMS-BeNeLux network". In Rault J.-L., and Roggemans P., editors, Proceedings of the International Meteor Conference, Mistelbach, Austria, 27–30 August 2015. IMO, pages 41–50.

AMOS in Chile

Juraj Tóth

Slovak astronomers from Comenius University continue in installation of their original AMOS meteor system, particularly in Atacama desert in Chile. AMOS (All-sky Meteor Orbit System) is observing almost entire sky by video and provides meteor trajectory and orbital data. Two AMOS cameras were installed in Space Observatory (San Pedro de Atacama) and in Paniri Caur Observatory in Chiu-Chiu. The distance of stations is 83.5 km and almost ideal for triangulation.

Figure 1 – AMOS in Chile.

Figure 2 – First fireball captured from San Pedro de Atacama.

AMOS is located in elevation of 2400 – 2500 m above the sea level, with dark skies and excellent observing conditions that allow the system to enhance its efficiency. Currently AMOS is located on four sites in Slovakia, two sites in Canary Islands and two in Chile. This configuration allows monitoring of both hemispheres and covers about 18 hours of the 24 hours of a day.

AMOS is patented and was awarded by a gold medal at INVENTO 2013 exhibit. The latest generation of AMOS was invented, developed and installed within grant project APVV-0517-12 by astronomers and engineers (Tóth, Kalmančok, Zigo, Kornoš, Világi, Šimon) of the Faculty of Mathematics, Physics and Informatics, Comenius University in Bratislava.

Figure 3 – The same fireball from Paniri Caur Observatory.

Figure 4 – Installation of AMOS in Chile (P. Zigo).

Figure 5 – Installed AMOS in Paniri Caur Observatory.

New Catalogue of Moroccan meteorites

Prof. Abderrahmane Ibhi has documented the meteorite collection of Ibn Zohr exhibited at the "Musée Universitaire de météorites" in his new "Catalogue de Météorites" (Catalogue of meteorites). This museum is the first with exposure over entire Africa and the Arab world. Each piece of the collection is precisely identified with its name, location, GPS coordinates, its classification, its weight and the number of fragments, including a detailed photograph prepared at the University Ibn Zohr.

This new catalogue is a scientific inventory of the meteorites found in Morocco and is of particular value to collectors, traders, students and Moroccan meteorite hunters. This publication will also inspire the reader to learn more about shooting stars and meteor astronomy in general. This work is written in French and it is dedicated to newbies as well as specialists.

Copies can be order from the author:

a.ibhi – at – uiz.ac.ma (replace – at – by @).

Est doublement docteur en pétrologie minéralogique de l'Université Pierre et Marie Curie (Paris VI) et de l'Université Ibn Zohr (Maroc). Depuis le début des années 2004, il étudie les météorites et il est responsable du Club d'Astronomie Ibn Zohr. En 2012, il a publié le premier livre sur les météorites du Maroc Les Mésosidérites du Maroc et la structure d'impact associée.

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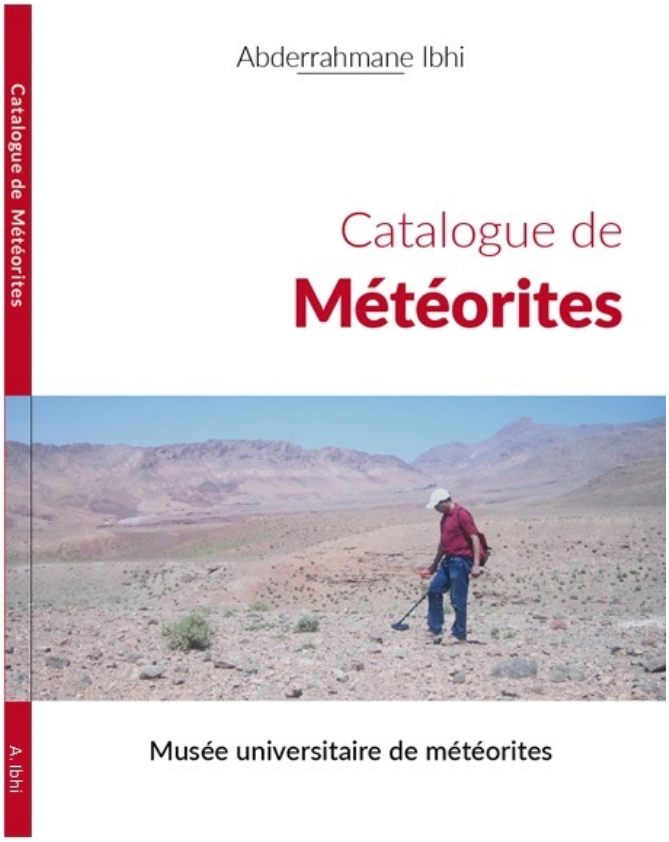

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