e-Zine for meteor observers

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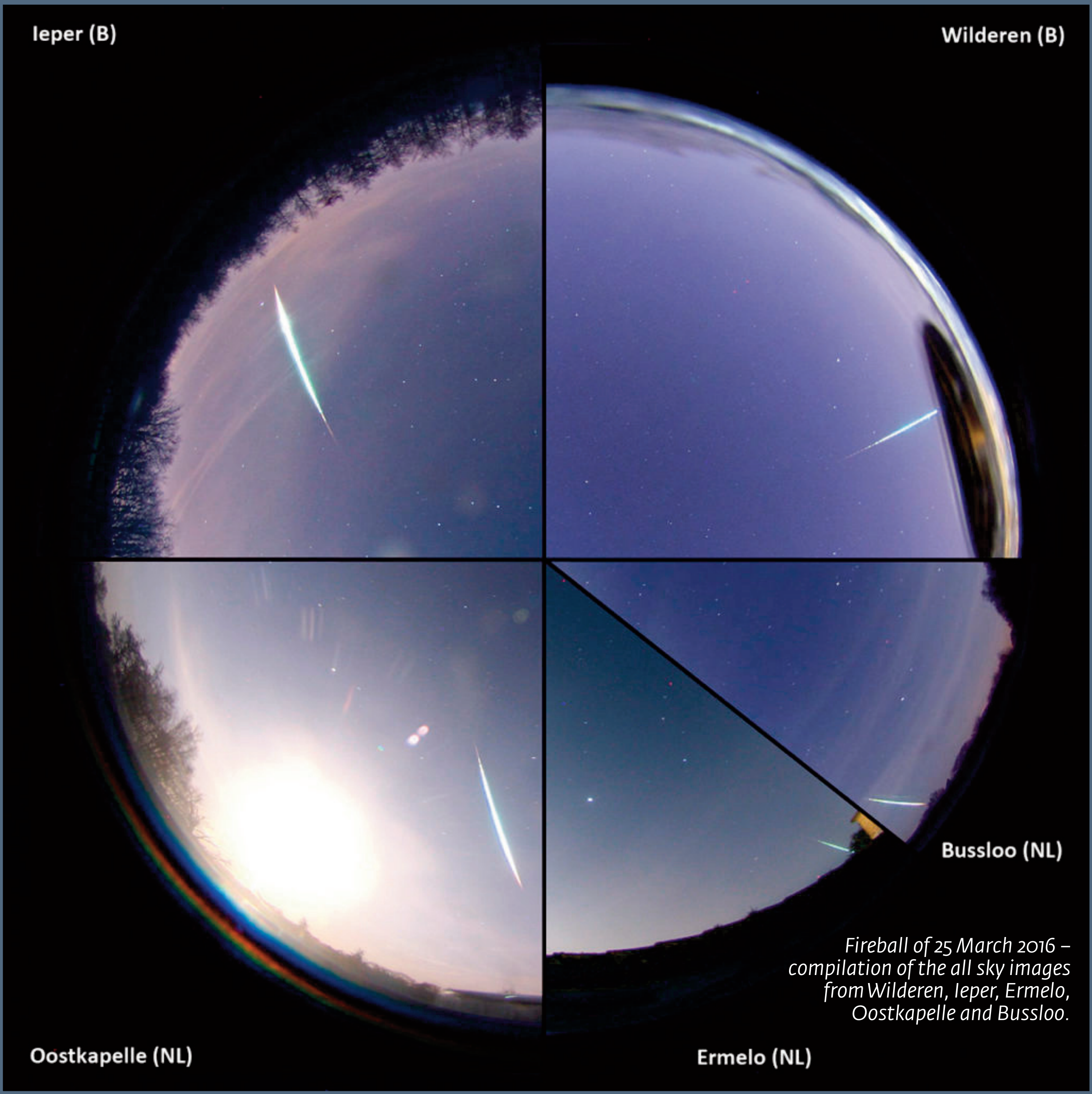

Fireball of 25 March 2016 – compilation of the all sky images from Wilderen, Ieper, Ermelo, Oostkapelle and Bussloo.

- **Perseids 2015, a global analysis**
- RAMBo: Meteor radar network
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Front cover picture: Compilation of the all sky images from Wilderen, Ieper, Ermelo, Oostkapelle and Bussloo.

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Obituary: Peter Bus (1951-2016)

Koen Miskotte

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It was a sad day and a great shock when the editors of eRadiant heard about the sudden death of their colleague editor, the Dutch comet and meteor observer Peter Bus. Peter passed away on June 25, 2016. Peter was an important member of the editorial board and was very interested in meteor work aside from his great passion for comets. At the start of his career, Peter used to do visual observations from the J. C. Kapteyn Observatory near Roden, the Netherlands, Together with other famous Dutch amateur astronomers such as Reinder Bouma, Georg Comello and Henk Feijth (†1997). Peter started with systematic forward scatter radio observations in the 1990s. He wrote many articles about his radio observations in eRadiant. Further he took care of observing calls for comets brighter than magnitude +8. The last few years this had all become a bit less due to his deteriorating health.

Peter Bus († July 2016).

The author could participate a few times together with Peter in the famous Leonid expeditions of the Dutch Meteor Society in 1998 (Sino Dutch Leonid expedition), 2002 (Portugal), 2003 (Portugal) and 2006 (Spain). I keep very pleasant memories of the long discussions about observing work for meteors and comets. The qualities of Peter as an observer were outstanding. I recall two important memories I keep about Peter. With the Leonids 2002 we were observing together with Jaap van 't Leven and Olga van Mil in Moncarapacho in South Portugal. The weather was rather unstable with rapidly changing skies, with cumulus and cirrus clouds, mixed with moonlight, mist and lightening. I just watched for fun as the circumstances were too variable. However, Peter was observing standing, during short intervals. Once he had transferred his data into ZHRs, his ZHR values fitted very well with these of the IMO. That was a very instructive experience for me with my 23 years of experience as observer at that time. In 2006 Peter observed the Leonids with a binocular and this data has been used in an article of Peter Jenniskens (2008).

The sudden decease of Peter Bus is a great loss for the editorial board of eRadiant. We will miss his input very much. Rest in peace Peter Bus.

Reference

Jenniskens P., de Kleer K., Vaubaillon J., Trigo-Rodríguez J. M., Madiedo J. M., Haas R., ter Kuile C. R., Miskotte K., Vandeputte M., Johannink C., Bus P., van't Leven J., Jobse K., and Koop M. (2008). "Leonids 2006 observations of the tail of trails: Where is the comet fluff?". *Icarus*, **196**, 171–183.

Visual observing reports

Paul Jones

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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. Past two months, since end of May the weather deteriorated, June was for about all actively reporting meteor workers the worst month since long. Apparently the Earth atmosphere got perturbed over most of Europe and America; hence rather few reports were submitted for June and July.

1 Reports by Paul Jones

2016 June 30–July 1

I was finally able to get back out under the stars this morning for my first substantive meteor watch since the tail end of the eta Aquariids back in mid-May. I ventured down to the Matanzas Inlet site once again and had pitch black skies and a sky full of stars and summer Milky Way. What an awesome morning!! There was a lot going on up there, too!

I logged two hours (2-4 a.m. EDT) and had a total of 32 meteors during the session. Some clouds came in around the edges of the sky and tried to crash my party, but dissipated before becoming a major issue. I was watching for several radiants listed on Bob Lunsford's excellent weekly reports and saw one or two from almost all of them.

Observed for radiants:

- June Bootids (JBO)
- f Ophiuchids (FOP)
- Anthelions (ANT)
- sigma Capricornids (SCA)
- pi Piscids (PPS)
- c Andromedids (CAN)

Here is the data:

June 30/July 1, 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).

0200 – 0300 EDT (0600 – 0700 UT)

T_{eff} 1.0 hour, No breaks, LM: 6.9, 10% cloud interference, Facing: West.

- ANT: +2, +3 (2)
- 1 FOP: +3
- 11 SPO: +1, +2 (2), +3(2), +4(4), +5, +6
- 15 total meteors

0300 – 0400 EDT (0700 – 0800 UT)

T_{eff} 1.0 hour, No breaks, LM: 6.9 , 15% cloud interference, Facing: East.

- PPS: +2, +3
- CAN: +1, +2
- 1 ANT: +4
- 12 SPO: 0, +1, +2(2), +3(4), +4, +5(2), +6
- 17 total meteors

9 of the 32 meteors left trains, yellow and gold colors were noted in a couple of them.

I decided to face west the first hour mainly to watch for any FOPs and JBOs, as those radiants had moved well west of the meridian. Also, I had a line of thunderstorms out over the ocean popping bright lightning every few minutes! The ANTs were quite noticeable and I was pleasantly surprised to catch the FOP – a long, slow mover going east in Capricorn that had a good radiant line up and the right speed. No JBOs showed up though, of course.

The "sea storms" subsided somewhat by the second hour so I turned to face east and it didn't take long for me to start seeing CAN and PPS candidates! I had about a half dozen meteors during the watch come the general area of each one of these two radiants – all being of swift velocity! Being conservative and very picky about characteristics and exact path of the meteors however, I factored out all but two from each radiant as SPOs. Still, a surprisingly good showing from them!

The brightest meteor of the watch was a lovely yellow zero magnitude, low in the SE. It lined up well with the PPS radiant, but was obviously of a medium speed and way too slow to actually be a PPS. One of the CAN meteors was a lovely golden bronze color and each of the four CAN/PPS candidates left glowing trains.

While I was there, a guy pulled up in the parking lot next to me. He was going to fish in the inlet, I wished him good luck. He came back later having caught two gigantic flounders! Seeing them made my mouth water, I think I'll have me some fried flounder for dinner tonight for sure… ;o). It seems that Matanzas Inlet is great for catching way more than just meteors… ;o).

2016 July 8–9 – Amazing session indeed

I had a very pleasant and productive two hour meteor watch from Butler Beach, Florida this morning that included 41 meteors all told, a majestic -4 alpha Capricornid fireball and my very first Perseid of 2016! All of that with dark, clear skies, no mosquitoes whatsoever, a gentle breeze and the soft sounds of the waves hitting the beach next to me! All that's pretty tough to beat…;o).

I decided to eschew my trusty Matanzas Inlet site for a while due to its becoming a bit overcrowded with summertime carloads of beachgoers pulling into the parking lot I use at all hours of the morning. Just too many distractions there now. I plan to return to it later on in the year after the summer masses go home…;o)!

Butler Beach is located about three miles south of St. Augustine Beach and although not quite as dark a sky as the Matanzas Inlet site, it is more than good enough to use as my good results attested to – and zero distractions! The LM was around 6.5 and perfect unobstructed horizons in all directions – a great trade off!

Here's my results:

Observed for radiants:

- CAP – alpha Capricornids
- SCA – sigma Capricornids
- JPE – July Pegasids
- PPS – pi Piscids
- CAN – C Andromedids
- ANT – Anthelions
- PER – Perseids

July 8/9. 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, clear, Facing: east.

0200 – 0300 EDT (0600 – 0700 UT), T_{eff}: 1.0 hour, No breaks.

- 2 CAP: -4, 0
- 2 SCA: +2, +4
- 1 ANT: +4
- 2 JPE: +3 (2)
- 15 SPO: 0, +1, +2(2), +3(5). +4(4). +5(2)
- 22 total meteors

7 of the 22 meteors left trains, the -4 CAP fireball was vivid yellow with orange sparks, and the zero mag CAP as also bright yellow.

0300 – 0400 EDT (0700 – 0800 UT), T_{eff}: 1.0 hour, No Breaks

- 3 JPE: +1, +3(2)
- 1 CAN: +3
- 1 PPS: +2
- 1 PER: +2
- 1 SCA: +4
- 12 SPO: +1 (2), +2, +3(3). +4(3), +5(3)
- 19 total meteors

4 of the 19 meteors left trains, one long, slow SPO was orange/yellow in color.

The first hour rocked the house! I was barely ten minutes into the watch when the CAP fireball blazed slowly across eastern Cygnus, heading north almost dead overhead, covering over 30 degrees of sky, arcing and sparking all the way and finished in the marvelous -4 terminal burst!! It left a puffy, glowing, smoky train behind that matched the bursts it had along its path: truly a meteor to remember! I have a feeling this radiant has many more like that one left in it!

About twenty minutes later, the second CAP flashed briefly SW of the radiant with a short trained path. LOVE those alpha CAPS!!!!

The second hour was more mundane in activity level with no more CAP fireworks showing up, but the JPEs and the SCAs continued showing up pretty well. The PER showed off the un-migrated radiant position of this famous shower, as the meteor actually came from Cassiopeia! About in the middle of the hour, I had a long, slow +2 SPO that tracked NE low in the northern sky that sorta seemed to line up generally with the June Bootid radiant area, but I figured it was long past that radiant's window of activity so I put it down as a SPO. I still wondered about it, though…;o).

The high pressure sitting over us is well entrenched, so I should be back out in the morning again to see these what else all these radiants have up their collective sleeve! Hope everyone has a chance to get out, there is a lot going on up there and much, much more to come!!

2016 July 9–10 – Kinda hazy skies… ;o(

I managed a three-hour meteor marathon session this morning from the Butler Beach, Florida site. Unfortunately, the skies were a bit cirrus hazy throughout and transparency was down, so my meteor counts were down also.

Still, I managed to catch a respectable total of 49 meteors in the 3 hours with a sampling of most of the active radiants showing up. Only one +1 CAP was seen, but the PERs really kicked in the last hour with 4 of them showing up!

Here's the data:

Observed for radiants:

- CAP – alpha Capricornids
- SCA –_ sigma Capricornids
- JPE – July Pegasids
- PPS – pi Piscids
- CAN – C Andromedids
- ANT – Anthelions
- PER – Perseids

July 9/10. 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.2, 10% cirrus haze, Facing: east.

0200 – 0300 EDT (0600 – 0700 UT), T_{eff}: 1.0 hour, No breaks.

- 1 SCA: +3
- 1 ANT: +21
- 1 JPE: +3
- 10 SPO: +1, +2, +3(3). +4(3). +5(2)
- 13 total meteors

4 of the 13 meteors left trains, the -SCA was yellow.

0300 – 0400 EDT (0700 – 0800 UT), T_{eff}: 1.0 hour, No Breaks.

- 1 JPE: +4
- 1 CAN: +2
- 1 CAP: +1
- 12 SPO: +1 (2), +2(2), +3(4). +4(3), +5
- 15 total meteors

4 of the 15 meteors left trains, orange tints were noticed in a couple of the brighter SPOs

0400 – 0500 EDT (0800 – 0900 UT), T_{eff}: 1.0 hour, No Breaks.

- 2 JPE: +3, +4
- 1 SCA: +1
- 4 PER: +2(2), +3(2)
- 14 SPO: -1, +1 (2), +2(3), +3(3). +4(4), +5
- 21 total meteors

8 of the 21 meteors left trains, yellow/orange tints were noticed in a couple of the brighter PERs and bright yellow in the -1 SPO.

Overall, the JPEs and the ANTs were fairly quiet this morning, although most of the JPEs I saw were quite faint, so some may have been missed in the hazy skies. The SCAs continued to impress me with a couple of nice meteors from that radiant. The highlight of course, was seeing 4 PERs in that last hour, what a treat! It's amazing to me to think that this shower can produce that type of activity a full month before the maximum! Can't wait for Aug 12th and 13th!! Numerous satellites were seen throughout the watch, going in every direction. I must have seen about as many of them as I did meteors!

I'll try a couple more pre-dawn watches later this week before the Moon takes over things, I'm keen to watch the PER build up toward the maximum.

2016 July 10–11

Well, the "call of the wild" was just too much for me to resist this morning, as I awoke at 0200 EDT and looked out to see perfectly clear, sharp and star-filled skies. So, I journeyed the mere seven miles over to my trusty new Butler Beach observing site for two more hours of prime, pre-dawn seaside meteor observing. It was totally awesome indeed!

I put in two hours observing from 0300 – 0500 EDT and saw a total of 46 meteors under the top notch sky conditions. The JPEs showed up real well, as did the SCAs and the CANs. The PERs contributed five meteors to the last hour just before dawn. The number of observed artificial satellites was once again through the roof!

Here's my data:

Observed for radiants:

- CAP – alpha Capricornids
- SCA – sigma Capricornids
- JPE – July Pegasids
- PPS – pi Piscids
- CAN – C Andromedids
- ANT – Anthelions
- PER – Perseids

July 10/11 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, clear, Facing: east.

0200 – 0300 EDT (0600 – 0700 UT), T_{eff}: 1.0 hour, No breaks.

- 2 CAN: +2, +4
- 1 CAP: +2
- 1 SCA: +3
- 1 PER: +4
- 2 JPE: +1, 3
- 14 SPO: +1, +2(2), +3(4). +4(4). +5(3)
- 21 total meteors

6 of the 21 meteors left trains, the CAP and the SCAs were golden yellow.

0300 – 0400 EDT (0700 – 0800 UT), Teff: 1.0 hour, No Breaks.

- 5 PER: +2(2), +3(2), +4
- 3 JPE: 0, +2, +3
- 2 CAN: +2, +3
- 2 SCA: +2, +4
- 13 SPO: -1, +1, +2, +3(4). +4(3), +5(3)
- 25 total meteors

9 of the 25 meteors left trains, the -1 SPO was orange/yellow in color with a train that lasted about three seconds. The zero mag JPE also left a nice train behind it.

All of the various radiant sources produced well for me this morning with the exception of the ANTs. This radiant has been strangely quiet the last few mornings, maybe because the radiant is well over in the SW sky by the time I get out to observe. All the other radiants have more than made up for it, though!

The zodiacal light was very evident this morning during the second hour, like an inverted ice cream cone stretching out all the way over into Aquarius! It was amazing to see the sharp, flat angle the ecliptic path makes with respect to the eastern horizon this time of year. The summer Milky Way was stunning as well this morning as I had two broad columns of light stretching across the sky above me – amazing! I never seem to tire of taking in Nature's awesome celestial spectacles!

2016 July 13–14

Another clear post-midnight here in North Florida enticed me once again into getting out for a productive two hour, pre-dawn Butler Beach meteor watch. With the "plethora" of active radiants going on this time of year, there is no shortage of sources to monitor, And, once again, most of them produced at least some activity for me in another busy session.

I was tracking nine separate radiants in all during the watch (from 3:00 a.m. to 5:00 a.m) , plus sporadics and once again broke twenty an hour both hours for a total of 43 meteors in a remarkably consistent session with my previous ones.

Here's the data:

Observed for radiants:

- CAP – alpha Capricornids
- SCA_ sigma Capricornids
- JPE – July Pegasids
- PPS – pi Piscids
- CAN – c Andromedids
- ANT – Anthelions
- PER – Perseids
- PSA – psi Cassiopeids
- SDA – South delta Aquariids

July 13/14 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, clear, Facing: east.

0300 – 0400 EDT (0700 – 0800 UT), T_{eff}: 1.0 hour, No breaks.

- 2 CAN: +2, +4
- 2 PPS: +1, +3
- 1 CAP: +2
- 1 SCA: +3
- 2 PER: +2, +3
- 2 JPE: 0,+ 3
- 2 PSA: +3(2)
- 10 SPO: 0. +1, +2(2), +3(2). +4(3). +5
- 22 total meteors

8 of the 22 meteors left trains, the zero mag JPE was blue-white with a 5 second train, one PER showed yellow.

0400 – 0500 EDT (0800 – 0900 UT), T_{eff}: 1.0 hour, No Breaks.

- 3 PER: +2(2), +3
- 1 JPE: +4
- 1 PSA: +2
- 1 SCA: +3
- 1 PPS: +2
- 1 SDA: +2
- 12 SPO: +1, +2, +3(4). +4(3), +5(3)
- 20 total meteors

7 of the 20 meteors left trains, one PER and two SPOs were yellow in color.

Once again my first hour was the more productive, with lots of bright and distinctive meteors crisscrossing the sky in all directions. The best meteor of the watch was the zero magnitude JPE that burst through twenty degrees of sky going WSW from Aquarius to Capricorn, leaving a five second long train hanging on on the sky. A pretty one indeed! A few minutes later, the +2 CAP slowly crossed fifteen degrees of sky shooting right back at the JPE radiant. Several other radiants contributed some nice meteors to this pleasant first hour.

The second hour seemed a lot slower in activity level, although the numbers weren't very different. Perhaps it was because the meteors were not as bright, showy or distinctive in the second hour. It was nice indeed though to see my first South delta Aquariid meteor of the year, hopefully, many more will follow it! The PERs also seemed a bit sluggish this morning, although I saw at least one going in all four directions from the radiant: one north of it, one south of it, one east of it and two west of it!

The zodiacal light was once again very clear and distinctively seen this morning tracing out a low angle with respect to the horizon stretching all the way to Aquarius. M31 the Andromeda Galaxy stood out very clearly to the naked eye and I even thought I glimpsed a hint of M33 in Triangulum with the naked eye!

I'll try it again in the morning. With moonset occurring around 3:00 a.m., I figure I can get in one more two-hour, pre-dawn watch tomorrow before the almost full moon takes over the morning sky for a while.

2016 July 14–15 – Double wow!

Well, for seemingly the umpteenth time in a row, I awoke to perfect post-midnight skies this morning. The run of high pressure we've been having here in North Florida lately has been amazing to say the least. I only hope it can keep it up for a while longer…;o).

Once again, I ventured over to Butler Beach to catch the pre-dawn meteor action and was not at all disappointed! Upon arrival, however, I discovered that even Butler Beach is not totally free from outside distractions. There was a shrimp boat just offshore, slowly trawling back and forth for shrimp with all its onboard lights blazing. It looked for all the world like a small floating city out there, just past the breakers! I had to position my knee to block out its lights – sort of like an eclipse or an occultation…;o). Finally, it moved off and took its lights with it.

Then just as the shrimp boat "city of lights" lumbered off, a thunderstorm on the southern horizon fired up and began to shoot bright flashes of lightning all over the sky every couple of minutes. That went of for about twenty more minutes, so the start of my watch was not memorable by any means.

I persevered though and when everything finally settled down around me, the meteors began to kick in big time! I had almost 50 of my 55 meteors seen during the 90 minutes from 3:30 a.m. to 5:00 a.m. That's better than 1 every two minutes for over an hour and a half!! Shoot, even some major meteor showers at maximum can't even do that!

Here's the data:

Observed for radiants:

- CAP – alpha Capricornids
- SCA – sigma Capricornids
- JPE – July Pegasids
- PPS – pi Piscids
- CAN – C Andromedids
- ANT – Anthelions
- PER – Perseids
- PSA: psi Cassiopeids
- SDA: South delta Aquariids

July 14/15 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, clear, Facing: east

0300 – 0400 EDT (0700 – 0800 UT), T_{eff}: 1.0 hour, No breaks.

- 2 PER: +1, +4
- 2 PPS: +2(2)
- 1 PSA: +3
- 1 CAP: +1
- 1 SCA: +3
- 1 SDA: +3
- 2 JPE: +3, +4
- 1 ANT: +4
- 10 SPO: +1, +2, +3(5). +4(2), +5
- 22 total meteors

6 of the 22 meteors left trains, the CAP and the SCA were golden yellow.

0400 – 0500 EDT (0800 – 0900 UT), T_{eff}: 1.0 hour, No Breaks.

- 6 PER: 0, +1, +2 +3(2), +5
- 4 JPE: 0, +2, +3(2)
- 2 PPS: +1, +4
- 2 SDA: +2, +3
- 1 CAP: +2
- 1 PSA: +4
- 1 ANT: +3
- 16 SPO: +1(2), +2(2), +3(5). +4(4), +5(3)
- 33 total meteors

10 of the 33 meteors left trains, the 0 magnitude JPE and the +1 PPS were both blue-white in color and left glowing trains behind them. The brighter PERs were yellow in color.

I really did have a hard time keeping track of the data for a while there this morning. They came in bunches at some points and all over the sky from horizon to horizon. I barely had time to evaluate a meteor for a radiant line up quite often before I'd see one or even two more right after it. Usually, it is a major shower max when this happens, like the PER or GEM max and you know they are mostly all from the same radiant.

Not so this morning though, I would see one I'd have to evaluate for one radiant or another, then see another one that may have come from a different radiant or even none of them! My ID calls were backing up two or three meteors deep a few times there. Never have I had that happen before that I can remember. The whole sky got into the act as well. I was picking most of the PERs off the NW and N horizons. It was like meteor anarchy up there…;o)!

I plan to squeeze this opportunity right to the max in the morning as moonset is around 0345 EDT. That gives me another 90 minutes of dark sky action once again! I'll let you know it goes.

2016 July 24–25 – pre-midnight, kinda slow…

I got out on Butler Beach last night to beat the moonrise and check out how the meteor rates were in the early evening timeframe. Predictably, they were somewhat slow, but I still managed 17 total meteors in two hours from 10:00 p.m. to midnight under pretty nice skies.

When I got there a bit before 10:00 p..m., there was a pretty stiff south wind kicking up and scattering the bone dry beach sand around pretty much everywhere in true sandblasting style…;o). I noticed a few folks walking around the beach with flashlights, probably looking for sea turtles trying to nest.

I was thinking also that maybe I should have been counting airplanes, because they were coming at a major shower maximum rate…;o). I pretty much had no less than six or seven of them in the sky all at once for pretty much the entire two hours! A few artificial satellites weaved in and out around the airplanes as well…;o).

Here's the (meteor) results:

Observed for radiants:

- CAP – alpha Capricornids
- JPE – July Pegasids

- ANT – Anthelions
- PER – Perseids
- SDA – South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

July 24/25 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, 20% cloud interference, Facing: east.

2200 – 2300 EDT (0200 – 0300 UT), T_{eff}: 1.0 hour, No breaks.

- 1 CAP: +4
- 1 ANT: +3
- 5 SPO: +3(2). +4(2), +5
- 7 total meteors

2 of the 7 meteors (the CAP and the ANT) left trains. No meteor colors were seen.

2300 – 0000 EDT (0300 – 0400 UT), T_{eff}: 1.0 hour, No Breaks, 20% cloud interference.

- 2 SDA: +2, +3
- 1 CAP: 0
- 1 ANT: +3
- 6 SPO: +3(3). +4(2), +5
- 10 total meteors

3 of the 10 meteors left trains, the 0 magnitude CAP and both the SDAs left glowing trains behind them. No meteor colors were seen.

A few low, fast cumulus clouds began to come in off the south winds, getting more frequent in the second hour. And then the moon rose over the ocean a bit before midnight. The CAP in the second hour was long and lovely, with a couple of bursts along its almost 30 degree path and left a nice, puffy train behind it. A classic CAP! Both the SDAs were quite pretty also. The waning gibbous moon rising over the ocean painted deep golden yellow was a very pretty sight as well!

Looking ahead, the rest of the week looks good in the weather department here in North Florida as the Bermuda High is still quite dominant. I think I'll start my watches later in the night though, as there just isn't much going on that first full dark hour of the night. A later rising moon each night will help in that regard as well.

2016 July 25–26 – Cloud problems

Seems like our Bermuda High "line of defense" may be breaking down a bit here in North Florida as I tried to put in 90 minutes observing from Butler Beach last night before moonrise, but clouds interfered badly…:o(. Somehow, I still managed to come away with fairly good numbers though, as the sky was crystal clear through gaps in the ragged, cottony, altocumulus cloud banks passing through.

Here's what I had (just one hour observing possible):

Observed for radiants:

- CAP – alpha Capricornids
- JPE – July Pegasids
- ANT – Anthelions
- PER – Perseids
- SDA – South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

July 25/26 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.5, 35% cloud interference, Facing: east.

2300 – 0000 EDT (0300 – 0400 UT), T_{eff}: 1.0 hour, No breaks.

- 3 ANT: +3, +4(2)
- 1 CAP: +4
- 1 SDA: +3
- 1 GDR: +1
- 6 SPO: +3(2). +4(2), +5(2)
- 12 total meteors

3 of the 12 meteors (the GDR, an ANT and the SDA) left trains. No meteor colors were seen.

I sort of felt like I was impersonating a CAMS unit for a while there last night: that is, trying to pick off meteors from around the edges of the clouds! And I actually did in a couple of cases. The SDA was seen out over the ocean through just such a gap. About twenty minutes of the hour were like this – and I thought several times about leaving, but persisted.

Finally, the clouds worked through my area and soon came my reward for perseverance: a beauty of a +1 GDR tracking south from the tail of Aquila dropping down into Sagittarius. It was long and slow and looked just like an "anti-CAP", similar speed and characteristics, just going in the opposite direction…;o). It tracked back right to the radiant near the Head of Draco (about 5 degrees east of Eltanin, delta Draconis). Positive ID on that puppy, for sure…;o)!

Soon after, the clouds began to return and with moonrise imminent, I decided to pack it up. I was pleased though, I had gotten my prize – the GDR. Now, it's back to finger-crossing for clear skies in the nights ahead. Will advise…

2016 July 27–28 – Tale of two sessions

Our ongoing nighttime cloud pattern issues continue in earnest here locally as I was chased around between two observing sites last night/this morning trying to get away from the pesky, persistent cirrus cloud invasion.

Somehow through it all, I managed two good hours of meteor data and even met up with fellow ACACer Jeff Corder down at Matanzas Inlet for a near all-night marathon!

I started in at Butler Beach just before midnight and managed a cloud challenged hour observing there, before packing it up and travelling the ten or so miles down to Matanzas Inlet in search of clearer skies for a second hour crossing moonrise. The difference in my results from the two sites is as dramatic as night and day! To wit:

Here's my data:

- CAP – alpha Capricornids
- JPE – July Pegasids
- ANT – Anthelions
- PER – Perseids
- SDA: South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

Session One:
July 27/28 2016, observer: Paul Jones, Location: Butler Beach, Florida (about three miles south of St. Augustine, Beach, Florida), Lat: 29.79 N, Long: 81.26 W., LM: 6.2, 25% cloud interference, Facing: east.

0000 – 0100 EDT (0400 – 0500 UT), T_{eff}: 1.0 hour, No breaks.

- 2 ANT: +3, +4
- 1 PAU: +3
- 1 CAP: +4
- 2 SDA: +3(2)
- 1 GDR: +2
- 5 SPO: +3(2). +4, +5(2)
- 12 total meteors

2 of the 12 meteors (the GDR, and a SDA) left trains. No meteor colors were seen.

Session Two:
July 27/28, 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).

0137 – 0237 EDT (0537 – 0637 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, except for some very slight haze near the horizons.

- 15 SDA: 0, +1(2) +2(3), +3(5), +4(3), +5
- 6 PER: 0(2), +1(2). +2, +3
- 4 CAP: -2, 0, +2, +4
- 7 SPO: +2, +3, +4(3), +5(2)
- 32 total meteors

14 of the 32 meteors left trains (all the PERs did and most of the brighter SDAs and CAPs did as well), a couple of the PERs were bluish and a couple were yellowish, as were the two bright CAPs. One PER train hung on the sky for over four seconds.

As you can see from the data, I saw almost three times the number of meteors in the hour at Matanzas Inlet than I did in the hour from Butler Beach! Aside from slightly fewer clouds, the much darker Limiting Magnitude at Matanzas was the main reason. It was an amazing verification that darker skies make a world of difference, and only ten miles apart!

The SDAs were popping everywhere down at Matanzas, I had two about five seconds apart at the start of the hour and a case of two simultaneous SDAs later on! The zero mag SDA was a gorgeous vivid yellow with a nice train.

I saw the 0 mag CAP and then the -2 CAP along the SW horizon about five minutes apart. Both were bright yellow and left nice trains. The PERs really picked up nicely, shooting swift darts out in all directions and almost every one I saw was bright and left a train. LOVE those PERs, we are in for one great show from them next month!!!

A little after 3:00 a.m., Jeff showed up and we enjoyed a nice long visit yakking about every topic in amateur astronomy and meteorology we could think of while Jeff worked on is very interesting telescopic asterism- naming project. The clouds began to take over again after 4:00 a.m., so I bade Jeff adieu out of exhaustion, but we will be out there again tonight for sure!

July 28/29 2016 observations from North Florida – a memorable all-nighter indeed!

The night had been shrouded in overcast up until after 1:00 a.m. EDT, but my gamble to travel down to trusty Matanzas Inlet anyway, paid off once again for sure. Our weather pattern this summer has been remarkable and consistent – crystal clear blue sky days, cloudy, overcast evenings and finally clearing away nicely after midnight . Virtually no rain has fallen either.

Here's my data from the two hour counting session:

Here's my data:

- CAP – alpha Capricornids
- JPE – July Pegasids
- ANT – Anthelions
- PER – Perseids
- SDA – South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

Session One:
July 28/29 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).LM: 6.9, clear, Facing: east.

0115 – 0215 EDT (0515 – 0615 UT), T_{eff}: 1.0 hour, No breaks.

- 13 SDA: +1, +2(2), +3(4), +4(4), +5
- 1 ANT: +3
- 1 PAU: +3
- 1 PER: +4
- 1 GDR: +2
- 7 SPO: +2, +3(2). +4(2), +5(2)
- 24 total meteors

6 of the 24 meteors (4 of the SDAs and the GDR) left trains. Yellow was noted in couple of the brighter SDAs.

Session Two:
July 28/29, 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).

0215 – 0315 EDT (0615 – 0715 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, except for some very slight haze near the horizons.

- 17 SDA: -1, 0, +1(2) +2(3), +3(4), +4(4), +5(2)
- 5 PER: 0, +1, +3(2), +4
- 2 CAP: +2, +4
- 2 GDR: +1, +3
- 9 SPO: -5, +2(2), +3(2), +4(2), +5(2)
- 35 total meteors

13 of the 35 meteors (6 of the SDAs, the -5 SPO, 3 PERs, 2 other SPOs and a GDR) left trains. Yellow was noted in couple of the brighter SDAs and PERs and the -5 fireball was a vivid turquoise in color.

Overall it was an eclectic night to say the least! I helped a group of flounder fishermen from Lake City, Florida find assistance when they locked their keys in their truck and were stranded in the parking lot next to me for three hours! I think I may have converted them to meteor watchers as well with all the ones they saw while awaiting help to come. They were a cool bunch of guys who handled their misfortune very well indeed!

My fellow ACAC observing partner Jeff Corder joined me again and we watched a beautiful bright limb occultation of Aldebaran by the 24% sunlit waning crescent moon – that was an unexpected treat to say the least.

Combined with the 3 nice GDRs, all the SDAs, PERs and the –5 SPO fireball skimming along the NW horizon, this was a session that was quite unusual to say the least. It's amazing to me to see and experience how much goes in the wee hours of the morning when most folks are sound asleep!!

July 29/30 2016 observations from North Florida – SDAs go bonkers!

Once again, our nightly pattern repeated itself as it was overcast with thick cirrus haze until after 1:00 a.m. when again it began to break up nicely. One can almost set one's time by it here lately! By 1:25, I was ready to rock and roll one more time for three hours from trusty Matanzas Inlet.

In contrast to yesterday, however, I had no human company at all in the parking lot with me this morning. I did have fellow ACAC founding member Brenda Branchett in contact via cell phone by voice and text however as she observed from Deltona, Florida, about 75 miles to my southwest. We had fun comparing notes on mutually seen meteors. Her data follows mine. And it was a busy session yet again!

Here's what I had:

- CAP – alpha Capricornids
- JPE – July Pegasids
- ANT – Anthelions
- PER – Perseids
- SDA: South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

Session One:
July 28/29 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).LM: 6.9, clear, Facing: east.

0125 – 0225 EDT (0525 – 0625 UT), Teff: 1.0 hour, No breaks.

- 13 SDA: 0, +1(2), +2(2), +3(4), +4(3), +5
- 4 PER: +3(2), +4(2)
- 3 CAP: +1, +2, +3
- 1 GDR: +2
- 10 SPO: +2, +3(3). +4(4), +5(2)
- 31 total meteors

9 of the 31 meteors (5 of the SDAs, 2 APs and the GDR) left trains. Yellow was noted in couple of the brighter SDAs and CAPs.

Session Two:
July 28/29, 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).

0225 – 0325 EDT (0625 – 0725 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, except for some very slight haze near the horizons

- 14 SDA: 0, +1(3) +2(2), +3(2), +4(4), +5(2)
- 6 PER: +2, +3(3), +4, +5
- 3 CAP: 0. +1, +3
- 1 GDR: +3
- 1 ANT: +2
- 12 SPO: +1, +2, +3(3), +4(4), +5(3)

- 37 total meteors

12 of the 37 meteors (6 of the SDAs, 2 PERs, 2 CAPs and 2 SPO) left trains. Yellow was noted in couple of the brighter SDAs CAPs and PERs.

Session Three:

July 28/29, 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).

0325 – 0425 EDT (0725 – 0825 UT) T_{eff}: 1.0 hour, No breaks, LM: 6.9, Clear, except for some very slight haze near the horizons.

- 23 SDA: 0, +1(2) +2(4), +3(7), +4(6), +5(3)
- 8 PER: +1, +2, +3(3), +4, +5
- 3 CAP: +1, +2, +3
- 12 SPO: +1(2), +2(3), +3(2), +4(4), +5
- 46 total meteors

13 of the 46 meteors (6 of the SDAs, 3 PERs, 2 CAPs and 2 SPO) left trains. Yellow was noted in couple of the brighter SDAs, CAPs and PERs.

It was interesting to note the change in characteristics of the SDAs during the watch. In the first two hours, the radiant was east of the meridian and the meteors were somewhat brighter and their path lengths longer. In the third hour, however, the radiant was west of the meridian and the path lengths noticeably shortened and the meteors got fainter, yet became more numerous. I've noticed this effect with the Orionids of October as well.

The PERs were numerous once again, but seemed quite a bit fainter than the ones I had yesterday morning. In fact. most of all the meteors were fainter this morning, it helped to have that last hour mostly moon-free also!

My fellow ACACer Brenda Branchett put in two hours of her own down in Deltona this morning and battled cirrus haze and light pollution, but saw a respectable 34 total meteors with 18 SDAs between 0330 and 0530 this morning. Her Limiting Magnitude was only about 4.5, once again showing the difference sky condition has on observed meteor rates.

Here's her data:

Observer: Brenda Branchett, Location: Deltona Florida (75 miles SW of St. Augustine, Florida)Sky Conditions: 4-4.5 magnitude, hazy.

60-70 percent of the sky visible.

3:30-4:30

- Delta Aquarid – 10
- Perseids – 6
- Alpha Caps – 2
- Sporadic – 2
- Total – 20
- 4:30-5:30
- Delta Aquaird- 8
- Perseids – 4
- Sporadics -2
- Total – 14

3 Satellites also graced her skies.

Most meteors were 1st or 2nd magnitude. She had a few 3rd also.

We had fun comparing notes and impressions of meters we each saw and helped each other stay awake through the watch…;o). Brenda and I have co-observed many times and our results are usually very similar to each other under the same skies. It is only the magnificent Matanzas Inlet skies and wide horizons that allow me to see so many meteors!

I plan to be back out again in the morning… Hope other folks can get out some, too!

July 30/31 2016 meteor observations from North Florida – and the beat goes on…

It's kind of hard to believe with all the clear nights we've had lately, but last night might have been the best of them all for most of the night! The ACAC's monthly star party was a smash hit earlier in the evening as members and guests enjoyed telescopic views of Saturn, Mars, Jupiter, the famous double star Albireo and several Messier objects.

In between, we caught several lovely CAPs, including a gorgeous -2 orange beauty that broke up and flared several times on its path! Wow! Then we went over to Butler Beach and observed for another hour or so seeing many more meteors of all types and enjoying each other's company and the gentle sounds of the surf and the sea breezes.

We finally adjourned the star party a bit after 1:00 a.m. and I continued on by cruising down to Matanzas Inlet for yet more meteor watching under spectacular clear and pitch black skies. The stars looked like hundreds of glittering diamonds strewn across an inky, jet black background when I got down there! It was breathtaking! The likes of which I have never seen better from anywhere on Earth.

I could easily see with the naked eye, dozens of etched and mottled dark dust lanes in the Milky Way superimposed across partially resolved star clouds, giving an almost 3D type effect visually. It was like that all along the length of it, from horizon to horizon! I was speechless! Such is the clarity potential of the full-fledged, maximum strength Bermuda High and enough distance away from man-made light pollution!

Needless to say, meteors were jumping out all over the sky and just ten minutes after I started, a bright yellow, -5 SDA fireball dropped into the southern horizon no more than three degrees up. About ten minutes later, a bright blue, -2 PER streaked across Lyra, passing almost right over Vega, leaving behind a five second train etched on the sky! I was on major league sensory pumped up overload by then!

Here are my results:

- CAP – alpha Capricornids
- JPE – July Pegasids
- ANT – Anthelions
- PER – Perseids
- SDA: South delta Aquariids
- PAU – Piscids Austrinids
- GDR – July gamma Draconids
- BPE – beta Perseids

Session One:
July 30/31 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).LM: 7.0, clear, Facing: west.

0150 – 0250 EDT (0550 – 0650 UT), T_{eff}: 1.0 hour, No breaks.

- 18 SDA: -5, 0, +1(2), +2(3), +3(5), +4(3), +5(2), +6
- 4 PER: -2, +1, +2, +3
- 3 CAP: +1, +2, +3
- 2 ANT: +4, +5
- 14 SPO: +2, +3(3). +4(5), +5(3), +6(2)
- 41 total meteors

14 of the 41 meteors (8 of the SDAs, 3 of the PERs, 1 CAP and 2 SPOs) left trains. Yellow was noted in couple of the brighter SDAs and CAPs and blue in the -2 PER..

Session Two:
July 30/31, 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).

0250 – 0350 EDT (0650 – 0750 UT) T_{eff}: 1.0 hour, No breaks, LM: 7.0, Clear, except for some slight haze near the end of the hour.

- 15 SDA: -3, 0, +1(2) +2(3), +3(3), +4(3), +5(2)
- 7 PER: 0, +2(2), +3(3), +4,
- 2 CAP: 0. +2
- 1 GDR: +2
- 1 ANT: +3
- 11 SPO: +1, +2, +3(2), +4(4), +5(3)
- 37 total meteors

13 of the 37 meteors (6 of the SDAs, 3 PERs, 1 CAP and 3 SPO) left trains. Yellow was noted in couple of the brighter SDAs CAPs and PERs.

Seventy-eight meteors in just two hours! Toward the end of the second hour, haze and bright flashes of lightning from a pop up thunderstorm to the west, quickly degraded the pristine skies. It just goes to show how fast conditions can change around here! All that interference and my growing tiredness convinced me reluctantly that it was time to pack it up.

But not before I had a busy second hour that featured another bright yellow SDA, this one a -3 dropping into the SW horizon – again, not more than 3 degrees above the horizon. I had another nice GDR ad several lovely PERs as well. Also, we all had seen a lovely +1 GDR casually earlier in the evening during the star party.

It’s back to work (and reality) for me tomorrow, but I do plan to hit a couple of pre-dawns this week to monitor the PER build up. More to follow…

Perseids 2015, a global analysis

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An interesting Perseids return occurred in 2015, leading up to the 2016 appearance of the stream when a significantly increased activity is expected due to the presence of multiple dust trails from e.g. 1076 and 1862. On 13 August 2015 increased activity has been observed over North America coinciding with the traditional Perseid maximum (ZHR 120 – 140 instead of 100). Another short peak was observed from Europe around 21^h UT. It is possible that this was just the end of the increased activity over Asia around 18^h39^m UT which had been predicted by Jérémie Vaubaillon or otherwise, an earlier than expected appearance of the filament which was predicted for 12 August 2015 around 23^h UT (Jenniskens, 2006). Unfortunately this could be confirmed neither by radio, nor by CAMS observations.

1 Introduction

In May and June 2015 I made a global analysis of the 2015 Lyrids (Miskotte, 2015). I used the data which had been submitted by many observers to the IMO. This was the first time that I made an analyses based on data not provided by Dutch Meteor Society observers. The result was rather satisfactory and I decided to repeat this work with the Perseid data for this year. I was aware that this would be a much bigger job to do than in the case of the Lyrids.

However, there will never be any real global analyses in the sense of a continuous 24/24 and 7/7 monitoring of the Perseids. There are always interruptions in the dataset, about 4 hours due to the Atlantic Ocean between Europe and America and another 8–10 hours due to the Pacific Ocean between America and Asia. Looking at the activity profile "on-the-fly" on the IMO website, we can see that this graph is based on 40000 reported Perseids[1]. After the appearance of eRadiant 2015-3 I started to collect the data. The results are presented in this article.

2 The observational data

The data has been collected observer by observer selecting and sorting the data in function of the limiting magnitude. This data can be consulted via a webpage, sorted on the date[2]. A hyperlink on the name of the observer allows accessing the observing report. Observations made with a limiting magnitude of less than +5.9 were ignored. These reports could be easily copied and pasted into an Excel spreadsheet and saved with the date and IMO code as filename. For instance the observations of Michel Vandeputte of 11-12 August were saved as 2015_08_11_12_VANMC. This way all the data could be stored in a chronologic way.

In the next step, the hourly rate data from these observations were copied into the spreadsheet for the ZHR computation. The magnitude distributions were stored separately with the average limiting magnitude in order to calculate the population index r. In total the data for about 27000 Perseids was copied into the ZHR spreadsheet, or 65% of the total number of the reported Perseids. The remaining 13000 Perseids were ignored due to too poor limiting magnitudes.

3 Determining the C_p

To obtain a reliable ZHR value we need some information about each individual observer as the number of meteors seen depends on the perception of each individual. This value is known as the perception coefficient C_p. This is a value which qualifies the alertness of the observer. To obtain these perception coefficients we compare the observed sporadic hourly rate for August, observed between 22^h and 2^h local time with the assumed sporadic hourly rate of 10 with a limiting magnitude of +6.5, valid for the standard observer. The observed hourly rates are corrected relative to the +6.5 limiting magnitude reference.

To obtain a reliable estimate of the coefficient C_p for an observer at least 15 observing periods should be used. Unfortunately many observers didn't provide so many different observing periods. For all observers with at least 3 different observing periods, the sporadic hourly rate data was stored in the C_p spreadsheet in order to add past or future observational data for these observers in order to obtain a reliable C_p coefficient for them. This data can be used in future analyses with data from these observers. A new C_p determination will be done after 5 to 10 years for each observer as this may vary over a long period of time. From my own experience I know that my C_p coefficient was 1.4 in the 1980s, but remained constant at 1.2 in later years. In southern France this parameter is about 1.3 in my case.

This, together with the determination of the population index *r* and the *ZHR* calculation resulted in the conclusion that according to me we can distinguish four groups of observers:

Beginning observers

Sub group 1: Observers with both moderate magnitude estimates and moderate hourly counts, due to a lack of

[1] http://www.imo.net/live/perseids2015/
[2] http://vmo.imo.net/imozhr/obsview/perseids2015.php

Table 1 – The list of observers whose Perseid observations have been used in this analyses together with their perception coefficient C_p. (*) identifies the calculated C_p values while all other were assumed to be 1.0. (†) indicates that the calculated C_p value was replaced by 1.0 as the application of the calculated value resulted in systematic too high or too low ZHRs.

Name	IMO code	C_p	Year(s)	Intervals	Country
Marina Arnaut	ARNMA	0.8*	2015	23	Serbia
Atieh Sadat Afzali	ATIAF	1.0	2015	1	Iran
Ioan Alexandru Babiuc	BABIO	1.0	2015	4	Romania
Orlando Benítez Sánchez	BENOR	1.1*	2015	15	Spain
Felix Bettonvil	BETFE	1.0	2015	7	Croatia
Martina Birosikova	BIRMA	1.0	2014/2015	11	Slovakia
Maja Bjelanovic	BJEMA	0.6*	2015	12	Serbia
Ilija Bogdanovic	BOGIL	0.7*	2015	17	Serbia
Ljubomir Brankovic	BRALJ	1.0*	2015	36	Serbia
Andreas Buchmann	BUCAN	1.1*	2015	4	Switzerland
Ivana Burmazovic	BURIV	0.9*	2015	13	Serbia
David Buzgo	BUZDA	1.7*	2015	21	Serbia
Matej Ciganj	CIGMA	1.0	2015	2	Croatia
Ilie Cosovanu	COSIL	1.0	2015	2	Romania
Martin Dana	DANMA	4.4†	2015	5	Slovakia
Anja Djajic	DJAAN	1.0	2015	3	Serbia
Audrius Dubietis	DUBAU	1.3*	2014/2015	15	Lithuania
Jaroslaw Dygos	DYGJA	0.6*	2015	11	Poland
Reza Ensandoost	ENSRE	1.0	2015	1	Iran
Frank Enzlein	ENZFR	0.8*	2015	8	Germany
Branislav Faktor	FAKBR	1.0	2015	2	Slovakia
Martin Fuchs	FUCMA	1.6†	2015	4	Czech Republic
Fujie Tang	FUJTA	1.0	2015	2	China
Gang Li	GANLI	1.0	2015	3	China
Kalina Georgieva	GEOKA	1.0	2015	1	Bulgaria
George Gliba	GLIGE	0.7*	2015	6	U.S.
Mitja Govedi	GOVMI	1.0*	2015	14	Slovakia
Ljubica Grasic	GRALJ	1.0	2015	8	Serbia
Shy Halatzi	HALSH	1.5*	2015	9	Israel
Amir Hasanzadeh	HASAM	1.0	2015	4	Iran
Robin Hegenbarth	HEGRO	1.0	2015	3	Germany
Hojatola Hekmat'zade	HEKHO	1.0	2015	4	Iran
Davood Hemmati	HEMDA	1.0	2015	1	Iran
Carl Hergenrother	HERCA	1.2*	2015	5	U.S.
Lukas Hreha	HRELU	1.0	2015	2	Slovakia
Milos Igrutinovic	IGRMI	1.0	2015	2	Serbia
Stefan Jackovic	JACST	1.0*	2015	18	Slovakia
Jovana Jankov	JANJO	1.9*	2014/2015	20	Serbia
Jixia Li	JIXLI	2.5*	2015	8	China
Paul Jones	JONPA	1.0	2015	7	U.S.
Jovana Kabic	KABJO	1.0	2015	3	Serbia
Javor Kac	KACJA	0.8*	2014	15	Slovakia
Javor Kac	KACJA	1.0*	2015	36	U.S.
Alzbeta Kadlecova	KADAL	1.4*	2015	9	Czech Republic
Georgiena Kaleva	KALGE	2.6*	2015	7	Bulgaria

Name	IMO code	C_p	Year(s)	Intervals	Country
Václav Kala?	KALVA	1.4*	2015	5	Czech Republic
Jozef Karlik	KARJO	1.0	2015	8	Slovakia
Jakub Kazimir	KAZJA	1.0	2015	2	Slovakia
Matus Kepic	KEPMA	1.0	2015	2	Slovakia
Zdenek Komarek	KOMZD	0.5*	2015	12	Slovakia
Dusanka Kovacevic	KOVDU	1.0	2015	4	Serbia
Roman Kovalyk	KOVRO	1.0	2015	1	Italy
Jiří Kubánek	KUBJI	1.0	2015	2	Czech Republic
Peter van Leuteren	LEUPE	1.0	2008	20	The Netherlands
Anna Levina	LEVAN	0.7*	2014/2015	11	Israel
Robert Lunsford	LUNRO	1.0*	2015	16	U.S.
Boris Majic	MAJBO	1.6*	2015	13	Serbia
Milica Maletic	MALMI	1.0*	2015	25	Serbia
Ivana Marjanovic	MARIV	0.9*	2015	10	Serbia
Pierre Martin	MARPI	1.0*	2007	?	Canada
Mikhail Maslov	MASMI	1.0	2015	3	Russia
naimeh masoumi	MASNA	1.0	2015	2	Iran
Istvan Matis	MATIS	1.0	2015	8	Romania
Alastair McBeath	MCBAL	1.0	2015	4	England
Bruce McCurdy	MCCBR	1.0	2015	6	Canada
Saeed Mehdizad	MEHSA	1.0	2015	2	Iran
Fabrizio Melandri	MELFA	1.0	2015	6	Italy
Frederic Merlin	MERFR	1.0	2015	9	France
Roman Mihalov	MIHRO	1.0	2015	2	Slovakia
Koen Miskotte	MISKO	1.3*	2015	62	France
Koen Miskotte	MISKO	1.2*	1995	?	The Netherlands
Sirko Molau	MOLSI	0.6*	2015	14	Germany
Alexsandr Morozov	MORAL	1.0	2015	1	Russia
Konstantin Morozov	MORKO	1.0	2015	2	Belorussia
Yulia Moralyiska	MORYU	1.0	2015	2	Bulgaria
Maryam Mostafavi Alhosseini	MOSMA	1.0	2015	2	Iran
Maciek Myszkiewicz	MYSMA	1.0	2015	11	Poland
Sven Näther	NÄTSV	1.0	2015	2	Germany
Sasa Nedeljkovic	NEDSA	1.0	2015	3	Serbia
Jos Nijland	NIJJO	1.6	2015	4	The Netherlands
Adam Nikic	NIKAD	1.0	2015	12	Serbia
Mohammad Nilforoushan	NILMO	1.0	2015	5	Iran
Vladimir Obradovic	OBRVL	1.1*	2015	12	Serbia
Liliya Pachalova	PACLI	1.0	2015	2	Bulgaria
Parya Abouhamzeh	PARAB	1.0	2015	2	Iran
Igor Parnahaj	PARIG	1.0	2015	2	Slovakia
Debora Pavela	PAVDE	1.0	2015	12	Serbia
Dunja Pavlovic	PAVDU	1.3*	2015	27	Serbia
Adam Pazderka	PAZAD	1.0	2015	3	Czech Republic
Ludovit Popik	POPLU	1.1*	2015	7	Slovakia
poriya momen	PORMO	1.0	2015	1	Iran
Sasha Prokofyev	PROSA	1.0	2015	1	Cyprus
Antonija Radulovic	RADAN	0.9*	2015	16	Serbia

Name	IMO code	C_p	Year(s)	Intervals	Country
Ella Ratz	RATEL	1.0	2015	2	Israel
Ina Rendtel	RENIN	0.9*	2015	20	Scotland
Boris Rosko	ROSBO	1.0	2015	2	Slovakia
Terrence Ross	ROSTE	0.9	2014	24	U.S.
Terrence Ross	ROSTE	0.9*	2015	39	U.S.
Katerina Ruseva	RUSKA	1.0	2015	1	Bulgaria
Mirco Saner	SANMI	1.0	2015	10	Switzerland
Branislav Savic	SAVBR	1.1	2014	11	Serbia
Branislav Savic	SAVBR	1.1*	2015	45	Serbia
Alex Scholten	SCHAL	0.7*	2015	9	Czech Republic
Matej Schwartz	SCHMA	1.0	2015	2	Slovakia
Stefan Schmeizer	SCHST	0.7	2014	10	Romania
Stefan Schmeissner	SCHST	0.6	2014/2015	5	Romania
Ivan Sergey	SERIV	1.0	2015	2	Belorussia
Shi Wei	SHIWE	1.1*	2015	6	China
Shlomi Eini	SHLEI	1.0	2015	3	Israel
Vesna Slavkovic	SLAVE	1.1*	2015	7	Serbia
Danica Spasic	SPADA	1.0*	2015	15	Serbia
Jelena Spegar	SPEJE	1.2*	2015	24	Serbia
Ivan Stankovits	STAIV	1.5†	2015	33	Serbia
Anton Stipek	STIAN	1.0	2015	1	Croatia
Wesley Stone	STOWE	1.1*	2015	8	U.S.
Matej Sustr	SUSMA	1.0	2015	1	Slovakia
Miroslav Tirpak	TIRMI	1.0	2015	2	Slovakia
Snezana Todorovic	TODSN	0.8*	2014/2015	29	Serbia
Oliver Toskovic	TOSOL	1.0	2015	4	Serbia
Michel Vandeputte	VANMC	1.3	2003	?	Belgium
Michel Vandeputte	VANMC	1.3*	2015	62	France
Bozhena Varbanova	VARBO	1.8*	2015	5	Bulgaria
Valentin Velkov	VELVA	1.0	2015	7	Bulgaria
Kristina Veljkovic	VERKR	0.5†	2015	28	U.S.
Frank Waechter	WAEFR	0.3	2015	8	Germany
Sabine Waechter	WAESA	0.6	2015	10	Germany
Weiqiao Chen	WEICH	1.0	2015	2	China
Oliver Wusk	WUSOL	0.8*	2015	22	Germany
Xicheng Tian	XICTI	1.0	2015	4	China
Yasuhiro Tonomura	YSTO	1.0	2015	2	China
Miroslav Zivanovic	ZIVMI	1.3*	2015	12	Serbia

experience, fatigue or lack of concentration. This results in a large fluctuation in their *ZHR*-values, extreme *r*-values, extreme limiting magnitudes (too low or too high) and sometimes very deviant C_p values.

Subgroup 2: Observers with moderate magnitude estimates but with reliable hourly counts and a good concentration. These are suitable for both C_p and *ZHR* calculations.

Experienced observers

Subgroup 1: Observers who record significant numbers of major shower meteors, but taking also the minor meteor showers into account too. Taking into account more radiants for the shower classification, smaller numbers of meteors remain as sporadics, resulting in a too low C_p value and hence too high *ZHR*s. In general this group has very good magnitude distributions and counts for the major shower. This is good to calculate the *ZHR*, less favorable for the C_p. An obvious solution is to add the minor shower counts with the sporadics in order to have

C_p values compatible with those for other observers. For a number of observers this was effectively applied and the resulting *ZHR*s were more in line with the average for all observers active at the same time.

Subgroup 2: Observers who distinguish only the major shower meteors and sporadics. This results in reliable C_p values and the *ZHR*s from this data compare very well. The data from these observers is most suitable for the calculation of the population index *r*, the perception coefficient C_p and the *ZHR*s.

Finally I obtained a long list of observers (*Table 1*), with their IMO code, their C_p value, the number of periods used to obtain the C_p value, the year and the country. In the ZHR spreadsheet only C_p values were applied if this perception coefficient was obtained from at least 15 observing periods. For observers with less than 15 periods available, a $C_p = 1.0$ has been assumed as best estimate, unless the number of periods could be extended with data from 2014. Classifying the observers within the four groups described above, led to the following conclusion: "*Use only the most relevant data of observers for the calculation of the population index r and the ZHRs.*"

This means that for some observers in some cases only the counts have been selected for ZHR calculations and in some other cases only the magnitude distributions to calculate the population index.

4 Calculating the population index *r*

The population index could be quickly obtained by copy and paste of data from the spreadsheet with magnitude distributions into the spreadsheet for the population index r calculation. Only magnitude distributions obtained with a limiting magnitude of +5.9 or better have been used for this purpose. The selected magnitude distributions are copied into a spreadsheet designed by Carl Johannink where all the magnitude distributions are converted automatically to the standard conditions with a limiting magnitude of +6.5.

One problem occurred with the selection of the magnitude distributions to be used or to be rejected. Some observers report excessive many bright meteors while others report nothing brighter than +1. This kind of issues with the observing data results in deviant *r*-values. In a discussion with Carl Johannink we reached a consensus how to deal with this kind of problems: The difference between the average limiting magnitude and the average magnitude of the observed Perseids should not be larger than 4.5 magnitude.

For instance we had an observer for the night of 12–13 August with an average limiting magnitude of 6.82, reporting a significant number of Perseids with an average magnitude of +0.64. With a difference of 6.18 magnitudes this is definitely an outlier which is not suitable for the determination of the population index *r*. This approach worked out very well although some tolerance must be observed as the Perseids display some more bright meteors during the maximum. Rejected observations were considered case by case if these could be used for the calculation of the *r*-value, taking into account the degree of experience of the observer as well as the average magnitude of the Perseids.

5 Calculating the *ZHR*

*ZHR*s are calculated in the DMS according to the method of Peter Jenniskens (Jenniskens, 1994; Miskotte and Johannink, 2005a; 2005b):

$$ZHR = \frac{n \cdot F \cdot r^{6.5-LM}}{(\sin h)^{\gamma} \cdot C_p \cdot T_{eff}}$$

where $\gamma = 1.4$ for the radiant elevation correction. When all data was entered into the ZHR spreadsheet, the calculated C_p's were added as well as the computed results for the population index *r*. While entering the data, the following aspects were carefully checked:

- The *effective observing time* T_{eff}: for the nights 10–11, 11–12, 12–13 and 13–14 August only half hour counts have been used. Some observers reported shorter intervals and these have been combined where possible. Intervals of at least 0.40 hour and maximal 0.60 hour were used. E.g. an observing session as short as 0.35 hour in a night was ignored. For all other nights counts per hour have been used (0.75 until 1.5 hour).
- Only observations obtained under a limiting magnitude *LM* of +5.90 or better have been used.
- Observations with the radiant elevation *h* less than 25° were ignored.
- Observations with an obstruction coefficient *F* larger than 1.1 were ignored.

At a next step the ZHR for each observer was considered using the Auto filter of Excel. The cause for extreme outliers was verified. In most cases this is just due to too high or too low limiting magnitudes, but in some cases the erroneous input of the geographical coordinates for the observing site resulted in deviant results. This happened for a single case. Real outliers were deleted.

6 The results: population index r

The results of the population index calculations are listed in *Table 2*. A total of 11819 Perseids have been used to compute the population index, the number of Perseids used per night or per period is listed in *Table 2*.

I have chosen to use the magnitude classes from –1 up to +5 to derive the *r*-values as most of the data was available for this magnitude range and moreover results were about the same as for a magnitude range of –2 up to +5.

Table 2 – Computed r values for the Perseids 2015. The values in the column $r_{[-1;+5]}$ have been used for the ZHR calculation.

Date		Until	λ⊙	$r_{[-2;+5]}$	n_{Per}	$r_{[-1;+5]}$	n_{Per}
2015	8 August	23 UT	135.864	2.00	229	1.96	224
2015	10 August	0 UT	136.863	2.36	184	2.39	181
2015	10 August	10 UT	137.263	2.30	154	2.27	152
2015	11 August	0 UT	137.822	2.14	677	2.20	662
2015	11 August	10 UT	138.222		x	2.12	234
2015	12 August	00 UT	138.782	2.33	1172	2.44	1148
2015	12 August	7 UT	139.042		x	2.25	116
2015	12 August	9 UT	139.162	2.11	217	2.13	213
2015	12 August	17 UT	139.462	2.32	175	2.11	174
2015	12 August	19 UT	139.542		x		x
2015	12 August	21 UT	139.622	2.21	835	2.30	814
2015	12 August	23 UT	139.702	2.17	654	2.31	635
2015	13 August	1 UT	139.782	2.25	1738	2.29	1704
2015	13 August	3 UT	139.862	2.35	539	2.49	529
2015	13 August	5 UT	139.942	2.06	222	1.94	219
2015	13 August	7 UT	140.022	2.03	439	2.05	428
2015	13 August	9 UT	140.102	2.01	712	2.07	693
2015	13 August	11 UT	140.182	2.03	499	2.02	489
2015	13 August	21 UT	140.582	2.34	835	2.42	814
2015	13 August	23 UT	140.662	2.40	654	2.42	635
2015	14 August	1 UT	140.742	2.70	467	2.70	463
2015	14 August	3 UT	140.822	1.84	167	1.95	160
2015	14 August	6 UT	140.942	1.88	120	2.12	113
2015	14 August	10 UT	141.103	2.07	73	1.97	72
2015	14-August	23 UT	141.623	2.06	312	2.11	305
2015	15-August	23 UT	142.584	2.25	212	2.29	208
2015	16-August	23,5 UT	143.565	2.07	111	2.10	109
2015	17-August	23 UT	144.504		x	2.79	111
2015	19-August	0 UT	145.509		x	2.53	92
2015	20-August	0 UT	146.471	2.41	70	2.37	69
2015	21-August	0 UT	147.434		x	x	x
2015	22-August	0 UT	148.397	2.12	56	2.35	54

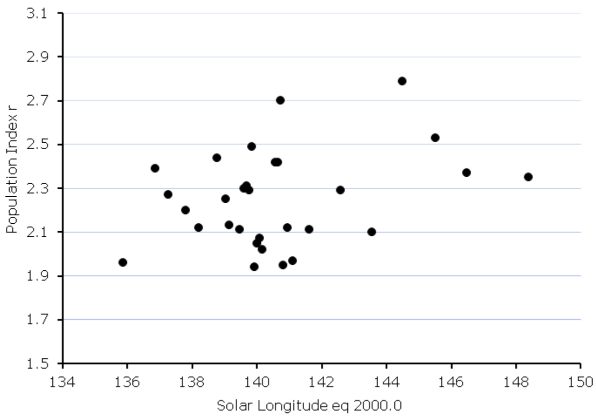

Figure 1 – Population index r for the Perseids 2015 obtained from the magnitude range [–1:+5] for the period 134°–150° in solar longitude.

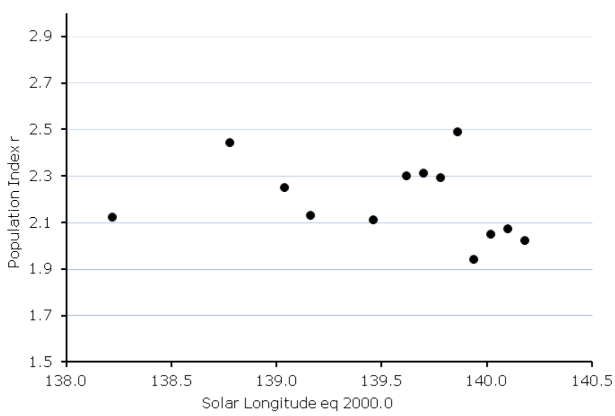

Figure 2 – Close up at the r-values during the Perseid maximum. The solar longitude correspondents to the time range 12 Aug. 10^h UT to 13 Aug. 11^h UT.

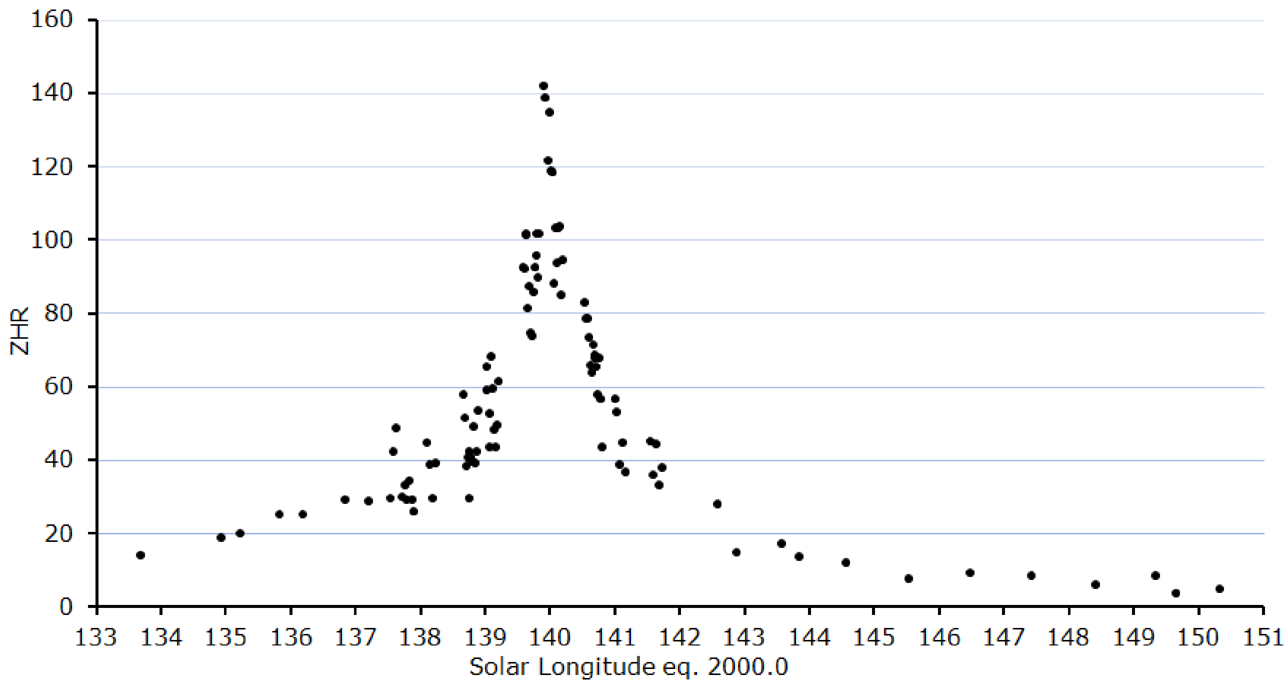

Figure 3 – The ZHR profile for the Perseids during the time interval of 6–24 August 2015.

It is striking that the *r*-value is above the average value before the maximum, but the difference decreases towards the maximum. During the night of 12–13 August over Europe the *r*-value shows a lot of scatter. The *r*-value was rather low, at about 2.00 (dots near $\lambda_{\odot} = 140°$), during the traditional maximum above the Eastern part of America. American meteor observers from this region reported indeed an impressive Perseid display. After the maximum the *r*-values increase again. *Figure 2* is a close up at the Perseid maximum. The decrease at $\lambda_{\odot} = 139.9°$ has probably to do with the increased activity over America.

7 The results: the ZHR profile

When all the data was sorted and filtered in the *ZHR* spreadsheet, 14875 Perseids and 7249 sporadics were still taken into account. The data of the sporadic meteors has been used for the calculation of the perception coefficient C_p. Only 37% of the data reported to the IMO could be used. Most of the rejected data did not fit our selection criteria due to too low limiting magnitudes. 991 time intervals could be used for *ZHR* calculations and the result is displayed in *Figure 3*.

The peak value of the ZHR is remarkable high for a traditional Perseid maximum. These *ZHR*s are mainly based on data from two very experienced observers from the eastern part of North America. We'll take a look at the Perseid maximum in detail. The profile shows how the Perseid *ZHR* increases from a *ZHR* of 10 at 6 August and decreases to a ZHR less than 5 around 24 August. After this date it becomes difficult to identify the rare Perseids among the sporadic activity.

11–12 August: Europe and North America

There is only one Asian observer who reported data with a limiting magnitude better than +5.9. The *ZHR*s vary strongly between 20 and 75 with an average of 50, but this data has not be included in this analyses as it is based on too few intervals.

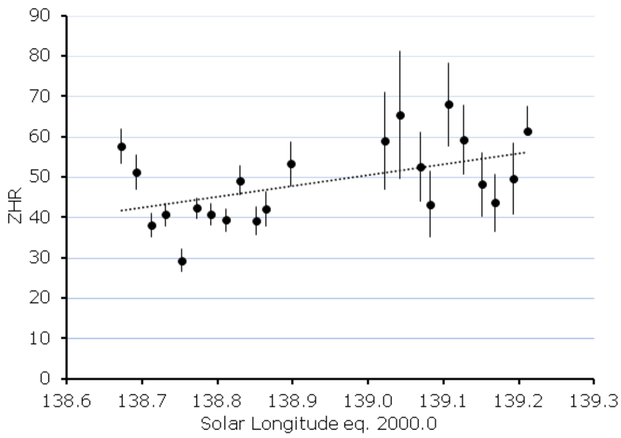

Figure 4 – The ZHR for the interval 11 August 21^h UT – 12 August 11^h UT. The dotted line is the linear regression fit through these points.

Something that strikes immediately are the larger error bars in *Figure 4* above the American continent, ($139.0° < \lambda_{\odot} < 139.2°$). This is due to the smaller numbers of observers and therefore smaller numbers of data. About 15 visual observers were active in America, but only 4 managed to deliver useable data. This is a pity as it was mainly due to the too poor limiting magnitude that these observers have no data included. Luckily these observers were all very experienced. Europe counts many more visual observers but this group includes beginning observers and casual observers who only watch some shower maximum activity. All this data is always screened on quality and any outliers are rejected.

Looking at the variation of the activity profile shown in *Figure 4*, we see that Europe starts with *ZHR*s of 50 – 60 followed by a decrease to 40 and again increasing to about 50 at the end of the night. When American observers get started the *ZHR* is at a level of 60 but the activity shows quite some scatter as if there were three sub-peaks of about 60 – 70. There is some increasing trend visible too.

The population index *r* was about 2.44 for Europe (relatively more fainter meteors), while for America this was a bit lower, decreasing from 2.25 to 2.16.

12–13 August: Asia, Europe and North-America

Again the same situation repeats itself with the data from Asia as for 11 August. There is quite some good observational data available submitted by about 15 observers. Only 3 were selected with a limiting magnitude of +5.9 or better. It is a pity as this way it is not possible to monitor the activity profile continuously. The Asian observers reported counts with *ZHR*s between 85–110 with a single outlier of 50. *Figure 5* shows the result for observations reported from Asia, Europe and North America for the time interval $139.4° < \lambda_{\odot} < 140.2°$, corresponding with 12 August 16^h UT and 13 August 12^h UT.

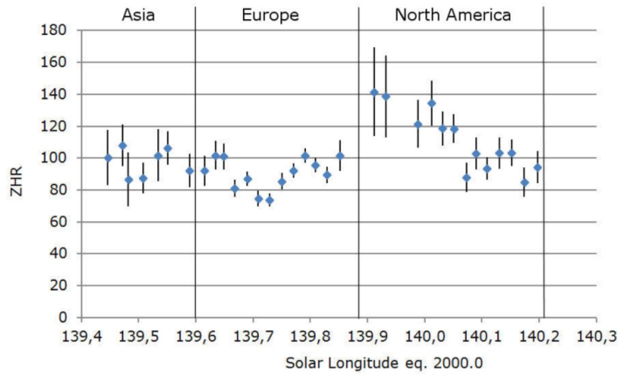

Figure 5 – The *ZHR* profile 12–13 August from 16^h until 12^h UT. The *ZHR*s for Asia are based on data from only 3 observers.

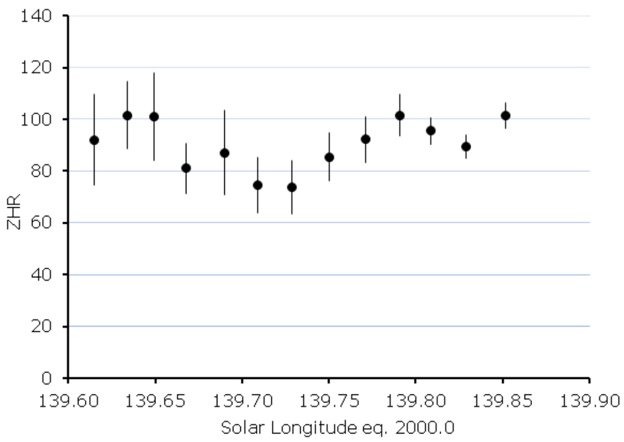

Figure 6 – The *ZHR* profile for 12–13 August for Europe alone. No linear regression has been applied because of the likely sub maximum at the beginning of the night.

12–13 August: A short peak in activity over Europe?

As described in the observing report of Michel Vandeputte (Vandeputte and Miskotte, 2016), the observers in the French Provence had the impression that at the start quite a bit bright Perseids were observed followed by a dip in the activity. Other observers shared this impression, e.g. Felix Bettonvil who observed in Croatia. A quick calculation for the data of MISKO and VANMC, both in the Provence, shows that the data by MISKO has a small peak combined with a lower *r*-value. No trace of any increased *ZHR* in the data of VANM, but also here we find a lower *r*-value. Unfortunately, the data of both observers could not be used because of the radiant elevation which was significant less than 25° during these observations.

Analyzing all available data with a radiant elevation higher than 25° also shows this peak. Also the CAMS data indicates that there was something going on at $21^h – 22^h$ UT, but nothing conclusive can be derived from this data when checking the orbital data (Johannink, 2016). Radio observations by Peter Bus do not show any peak (Bus, 2016).

Last but not least we take a look at the number of Perseids recorded with the All-sky camera of Koen Miskotte, a Canon 6D with a Canon EF 8-15 mm F 4.0 "L" zoom fish eye lens, installed at Revest du Bion. The camera was set at 8 mm (circular fish eye exposures of the entire sky), F 4.5, ISO 3200 and an exposure time of 29 seconds. These settings easily allow capturing Perseids of magnitude 0. The quality of the night sky remained unchanged during this period of time. The results are listed in *Table 3.*

Only the radiant elevation has been corrected to calculate the photographic ZHR. Also the apparent angular velocity would require some correction as meteors close to their radiant have a slower angular velocity and are easier to be captured.

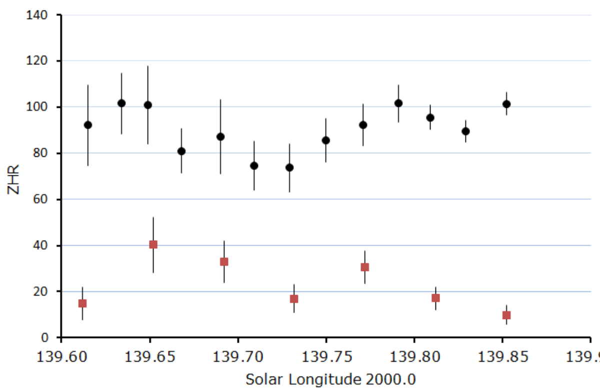

Figure 7 – Combined *ZHR* profiles for visual data (black dots) and photographic data (red suares).

Also the photographic *ZHR* profile shows a slight increased activity at the start. The photographic *ZHR* profile looks remarkably similar in shape as the visual one, except at the end of the night. Where the visual *ZHR*

Table 3 – The number of photographed Perseids with the All sky camera at Revest du Bion, france during the night 12–13 August 2015. Camera: Canon 6D, Optics: Canon EF 8–15 mm F 4.0.

Period UT	–6	–5	–4	–3	–2	–1	0	Total	Photo ZHR
20:15-21:15					2			2	15 ± 7
21:15-22:15			1	2	3	1	4	11	40 ± 12
22:15-23:15	1			2	3	2	4	12	33 ± 9
23:15-00:15		1	1		2	3	2	9	17 ± 6
00:15-01:15				3	1	5	8	17	31 ± 7
01:15-02:15			1	2	1	4	5	13	17 ± 5
02:15-03:15					2	2	6	10	10 ± 4
20:15-03:15	1	1	3	9	14	17	29	74	

increases, the photographic *ZHR* decreases and this can have two explanations. First of all by the fact that the visual population index *r* increased from 2.3 to 2.5 at the end of the night, hence a decrease in bright meteors that could be photographed, secondly there were more cirrus clouds at the sky towards the morning which may have reduced the chances to capture meteors photographically. *Figure 7* shows the combined visual and photographic *ZHR* profiles.

Jérémie Vaubaillon made some theoretical modelling for meteoroids released from the parent body of the Perseids, 109P/Swift-Tuttle, indicating a possible increased activity expected on 12 August 2015 around 18^h39^m UT with duration of a few hours (McBeath, 2014). This time is just a bit earlier than the observed increased activity.

The observing window around 18^h39^m UT coincides with the Asian data (*Figure 5*), which also suggest slightly higher ZHRs than what can be expected at that solar longitude. However this is data from no more than three observers for who no perception coefficient C_p could be calculated and about who nothing is known regarding the level of experience. Another possible explanation is that the filament which was expected on 12 August 2015 around 23^h UT has occurred sooner than expected (Jenniskens, 2006).

12–13 August: increased activity over North America!

The traditional maximum was expected on 13 August 2015 from 6^h30^m and 9^h00^m UT (McBeath, 2014). However the reports by observers at the eastern part of North America describe a fantastic meteor display starting as soon as it got dark. You may read the reports from two veteran meteor observers, Pierre Martin and George Gliba (Martin and Gliba, 2016). The *ZHR* calculations give *ZHR* values in the range of 120 – 140, decreasing to 80 – 90 at the end of the night. A traditional Perseid maximum has a typical *ZHR* around 100, hence the observed activity appears to be above the expected level. When it got dark over the western part of North America the activity was already less.

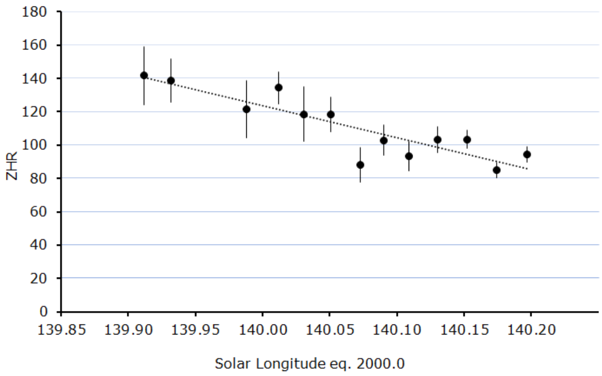

Figure 8 – The *ZHR* profile for Northern America. A linear regression fit has been added as a dotted line to indicate the trend. According to IMO the maximum was expected during the interval of 140.0° < $\lambda_\odot$ < 140.1°.

13–14 August: Europe and North America

A normal level of Perseid activity was recorded over Europe during this night. The *ZHR* decreased from about 80 to about 50 at the end of the night. This trend continued as seen from North America with *ZHR*s decreasing from about 55 to 35.

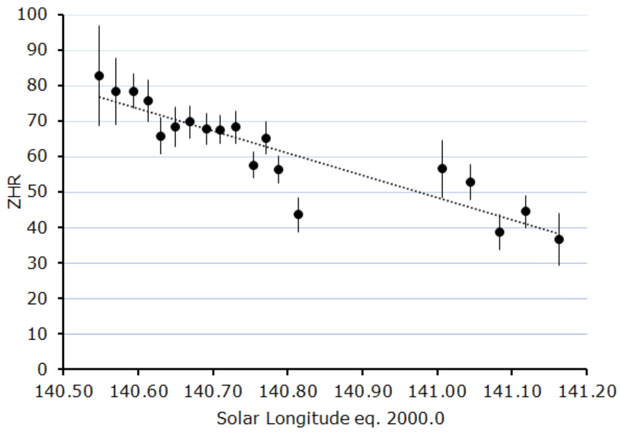

Figure 9 – *ZHR* profile for the interval 13 August 20^h UT until 14 August 12^h UT. A linear regression fit is added to indicate the trend.

8 Recommendation

It would be very helpful if meteor observers in North America and Asia could travel to dark sky locations for observing as too many do suffer from too poor limiting magnitudes. Further there is a structural shortage in visual observers in these regions; hence any initiative to encourage amateurs to report more visual meteor observations would be very welcome.

9 Conclusion

2015 produced a most interesting Perseid return, most promising in view of the 2016 display during which significant increased activity is expected due to the presence of multiple dust trails such as these of 1076 and 1862. An increased activity has been observed above North America around the traditional Perseid maximum (*ZHR* 120 – 140 instead of the expected 100). There are also strong indications for a short peak observed from Europe around 21^h UT, possibly connected with the end of the increased activity above Asia around 18^h39^m UT, predicted by Jérémie Vaubaillon, or related to the earlier occurrence of the filament expected on 12 August at 23^h UT (Jenniskens, 2006). Unfortunately no confirmations could be found in either radio data or in CAMS data.

Acknowledgment

The author wishes to thank all observers very much for their efforts! Without them no analyses like this would be possible. Thanks also to Carl Johannink for the helpful spreadsheets and the useful discussions. Thanks to Paul Roggemans, Michel Vandeputte, Jaap van 't Leven and Peter Bus for their critical reading of this article.

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Geminids 2015 analysis

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The 2015 Geminids have been successfully observed and an analysis has been made, based on all available data. The maximum activity occurred beyond the European observing window and could not be taken into account due to a lack of data from the Far East. The rising slope of the activity profile before the predicted time of maximum activity displayed less strong activity compared to a number of previously well observed Geminid returns. The 2015 Geminid observations are not conclusive about the question whether or not the maximum activity of the Geminid meteor shower is on the wane.

1 Introduction

The Geminids are the most active meteor shower of the 'Big Three'. During a complete clear night 13–14 December any active and experienced observer may count more than 1000 meteors in a single night! The shower displays also a nice brightness profile. Before and during the maximum the fainter meteors are prominent, immediately followed by a significant increase in the average brightness. This results almost always in a number of fireballs. A nice and probably rather extreme example of this occurred in 2007 (Vandeputte, 2008). At this occasion about 18 different Geminid meteors were seen with magnitudes between –3 and –8 in just five hours of time while observing in Portugal!

The author has published a detailed article in 2010 about the Geminids (Miskotte et al., 2010; Miskotte et al., 2011). The purpose of this article was to check if we could detect any variation in the maximum activity over the years. From this analysis it occurred that the maximal Geminid ZHR varied between 80 and 100 in the 1980s. The 1990s produced ZHRs between 100 and 140. The first decade since 2000 produced also maximal ZHRs up to 140, although 2009 produced somehow lower ZHRs like in 2001. The first next opportunity to collect data for comparison with the past was 2012 as in that year we watched the same solar longitude interval as in 2006 and 1996. Unfortunately this attempt failed completely. We got another chance in 2015 although the maximum would take place during daylight hours. Asia was the place to be for the maximum. Unfortunately the weather was very unstable in Europe and only Central and Eastern Europe offered good chances for longer periods with clear sky between 13 and 15 December.

2 The available data

Sadly the data that was usual available via the IMO website with the ZHR-activity-on-the-fly wasn't immediately available. Begin of March 2016 I received some hyperlinks from Rainer Arlt to access the available IMO data. Little bit later the ZHR-graphs-on-the-fly appeared again on the IMO website.

The data from each observer was checked and a selection was made. Data with limiting magnitudes of less than +5.9 or with a cloud cover percentage above 10% (*F = 1.10*) were rejected. If these rejected reports included useable observing intervals of at least 0.45 hour with less than 10% cloud cover and a limiting magnitude better than +5.9, then these intervals were still selected for our dataset. Beyond the data obtained from the IMO website, the author also contacted a number of visual observers who did not report to IMO, to ask them to provide their observational data. This resulted in a significant number of extra Geminid data.

In total we collected data for 9724 Geminids and 1820 sporadic meteors. *Table 1* lists the names of the visual observers whose data has been used in this analysis. For each observer the perception coefficient is given, which was known for most of the observers what saved some time for this analysis.

As soon as all data were entered into the *ZHR* spreadsheet, the typical global distribution of the observers worldwide became visible. A lot of data from Europe (20 observers), again somewhat less observers from America (6 observers) and only one single observer from the Far East, Australia, New Zealand and China. There are about 10 to 15 observers active in China but unfortunately they appear to work in light polluted cities as most observers report limiting magnitudes of +4 to +5 which is too low to make any reliable analyses. The data from Australia and New Zealand did not qualify because of the too low radiant elevation.

The population index *r* has been derived as described by Miskotte (2016) according to the criteria to use only the most relevant data for the calculation of the population index r and the *ZHR*. To select the data for the calculation of the *r*-values the difference between the average limiting magnitude and the average magnitude of the Geminids had to be less than 4.5. For data after the time of maximum activity ($\lambda_\odot$ 262.2°) this was set to less than 5.0 because of the significant increase in brightness of the Geminids. 5944 Geminids fulfilled the criteria and the interesting result has been listed in *Table 2*.

Table 1 – List of all observers whose data has been used in this analysis. A complete list of observers who reported Geminid data can be found on the IMO website.

Name	IMO code	C_p	Year	Intervals	Country
Marina Arnaut	ARNMA	0.8	2015	23	Serbia
Jure Atanackov	ATAJU	2.0	2015	~	Slovakia
Pierre Bader	BADPI	1.0	2015	~	Germany
Orlando Benítez Sánchez	BENOR	1.1	2015	15	Spain
Felix Bettonvil	BETFE	1.0	2007	10	France
Ilija Bogdanovic	BOGIL	0.7	2015	17	Serbia
Ljubomir, Brankovic	BRALJ	1.0	2015	36	Serbia
Andreas Buchmann	BUCAN	1.1	2015	4	Switzerland
David Buzgo	BUZDA	1.7	2015	21	Serbia
Sietse Dijkstra	DIJSI	1.0	2013	?	Germany
Milica Dodevski	DODMI	1.0	2015	~	Serbia
John Drummond	DRUJO	1.0	2015	~	New Zeeland
Christoph Gerber	GERCH	1.0	2015	~	Germany
Ljubica Grasic	GRALJ	1.0	2015	8	Serbia
Robin Hegenbarth	HEGRO	1.0	2015	3	Germany
Carl Hergenrother	HERCA	1.2	2015	5	U.S.
Carl Johannink	JOHCA	1.2	1995	30+	Germany
Paul Jones	JONPA	1.0	2015	7	U.S.
Javor Kac	KACJA	1.0	2015	36	U.S.
Ralf Koschack	KOSRA	1.0	2015	5	Germany
Anna Levina	LEVAN	0.7	2014-15	11	Israel
Mike Linnolt	LINMI	1.0	2015	~	U.S.
Caslav Lukic	LUKCA	1.0	2015	~	Serbia
Milica, Maletic	MALMI	1.0	2015	25	Serbia
Adam Marsh	MARAD	1.0	2015	~	Australia
Pierre Martin	MARPI	1.0	2007	30+	Canada
Koen Miskotte	MISKO	1.2	1995	30+	Netherlands
Sirko Molau	MOLSI	0.6	2015	14	Germany
Pedro Pérez	PERPE	1.0	2015	~	Spain
Nastasija Petkovic	PETNA	1.0	2015	~	Serbia
Antonija, Radulovic	RADAN	0.9	2015	16	Serbia
Ina Rendtel	RENIN	0.9	2015	20	Germany
Jurgen Rendtel	RENJU	1.0	2007	30+	Germany
Miguel Rodriguez-Alarcon	RODMI	1.0	2015	~	Spain
Terrence Ross	ROSTE	0.9	2014	24	U.S.
Terrence Ross	ROSTE	1.0	2015	39	U.S.
Mirco Saner	SANMI	1.0	2015	10	Switzerland
Branislav Savic	SAVBR	1.1	2014	11	Serbia
Branislav Savic	SAVBR	1.1	2015	45	Serbia
Stefan Schmeizer	SCHST	0.7	2014	10	Romania
Tunc Tezel	TETZU	1.0	2015	~	Turkey
Snezana, Todorovic	TODSN	0.8	2014-15	29	Serbia
Oliver Wusk	WUSOL	0.8	2015	22	Germany
Hu Yandong	YANHU	1.0	2015	~	China

There is a very obvious decrease to be seen from 14 December 1^h00^m UT.

Table 2 – Population index r for the Geminids 2015 obtained for the magnitude intervals [–2;+5] and [–1;+5].

Date Dec. 2015	Until UT	Continent	λ⊙ eq. 2000.0	r[–2;5]	r[–1;5]
10-12	4.50	EUR/US	257.56	~	3.22
11-12	5.50	EUR/US	258.66	~	2.82
11-12	22.83	EUR	259.38	~	2.74
12-12	8.50	US	259.76	2.60	2.70
13-12	0.00	EUR	260.42	2.12	2.09
13-12	19.50	EUR	261.24	2.95	2.90
13-12	22.50	EUR	261.37	2.40	2.37
14-12	1.50	EUR	261.50	2.67	2.66
14-12	4.50	EUR	261.63	2.07	2.18
14-12	7.50	US	261.76	2.14	2.06
14-12	19.50	EUR	262.26	1.78	1.78
14-12	22.50	EUR	262.39	1.32	1.30
15-12	01.50	EUR	262.52	1.70	1.73
15-12	04.50	EUR	262.65	1.61	1.58

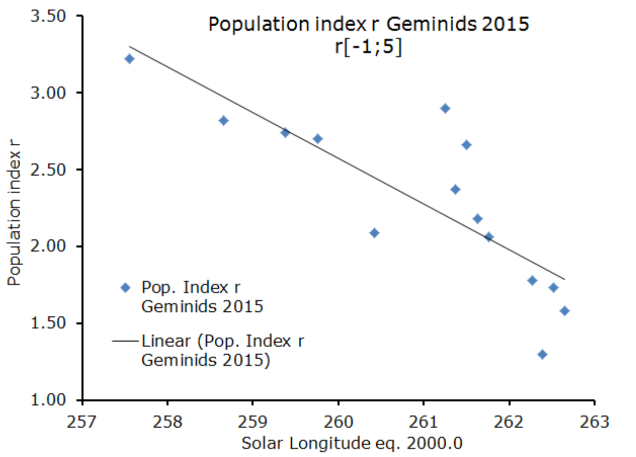

Figure 1 – Population index *r* for the 2015 Geminids based on 5944 Geminids.

3 The results of the ZHR calculations

The ZHRs are calculated according to the method of Peter Jenniskens (Jenniskens, 1994; Miskotte and Johannink, 2005a; 2005b):

$$ZHR = \frac{n \cdot F \cdot r^{6.5-LM}}{(\sin h)^{\gamma} \cdot C_p \cdot T_{eff}}$$

The value γ has been set to 1.0 for the radiant elevation correction. After that all the data had been entered in the *ZHR* spreadsheet, the values for C_p and the obtained *r*-values were added. During the input procedure the following aspects were carefully checked:

- Effective observing time: for the nights 12–13, 13–14 and 14–15 December only half hour intervals were used. However, some observers do report shorter intervals and these have been summed where possible. Time bins of minimal 0.4 and maximal 0.6 hour have been used. For instance an observing session of 0.35 hour has not been used. For the other nights the usual hourly counts were used (0.75 to 1.5 hour).
- Only observations done with a limiting magnitude of +5.9 or better were used.
- Observations with the radiant elevation less than 30 degrees were not used.
- Observations done with some obstruction, mostly due to clouds, larger than $F = 1.10$ were not used.

At the next step the *ZHR* for each observer was considered using the auto filter in Excel. For some extreme outliers the possible causes were checked. This may be due to a too low or too high estimated limiting magnitude, but in some cases this might be due to erroneous input of the geographical coordinates. Finally 8758 Geminids were selected out of the 9724 that were available for the *ZHR* profile. By the way, the total number of Geminids reported on the IMO website was 11595. The percentage of usable observations is a much better score than for the 2015 Perseids. A possible explanation is that the Geminids were more observed by experienced 'die-hard' observers, while during the summer more casual observers are involved. The resulting ZHR graph is shown in *Figure 2*.

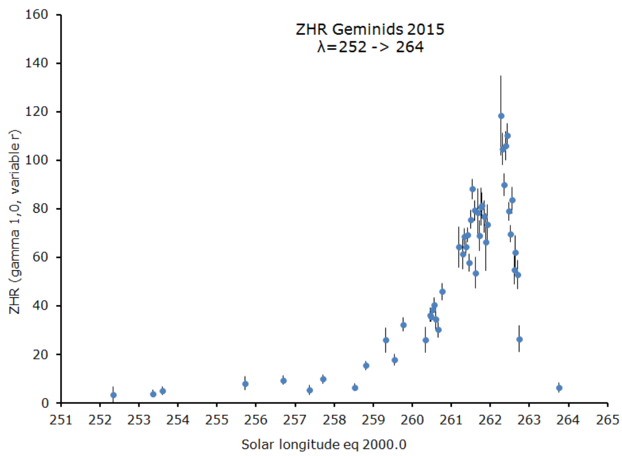

Figure 2 – The complete ZHR graph for the 2015 Geminids based on 8758 Geminids and the calculated *r*-values in *Table 1*, The zenith attraction γ was set as 1.0.

In *Figure 3* we zoom in on the period 12–13 until 14–15 December 2015. The gaps in the curve are due to the lack of data from the Pacific Ocean and Asia. It can be very well seen how the activity profile shows an increase in activity during the night of 12–13 December, which continues to increase the next night, although with some ups and downs. It could be that there is some peak around λ⊙ 261.6°. The ZHR varied this night between 60 and 80.

The night of 14–15 December shows a rapid decrease in activity, from a ZHR = 120 at the start of the night (over Europe) to a ZHR = 20 around λ⊙ 262.8°. The decrease in

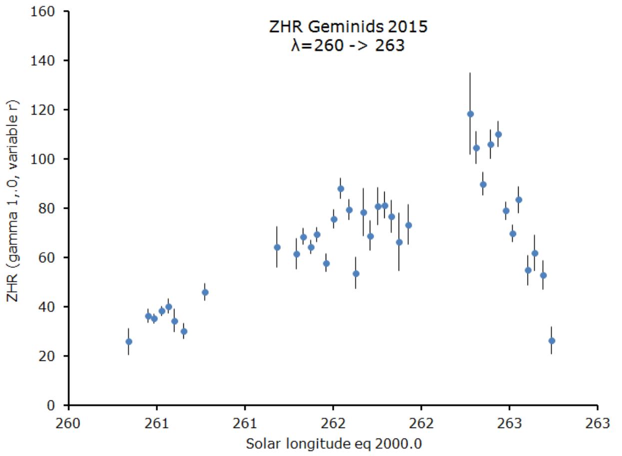

Figure 3 – The Geminid activity for the nights 12–13, 13–14 and 14–15 December 2015.

activity is much steeper than the increasing slope before the maximum, this skew activity profile is a phenomenon that has been observed for many years now. On the observing field the observers noticed very well how fast the activity decreases during the night. In most cases this goes together with many brighter Geminids. *ZHR* calculations for 14 December 2015 at 20^h00^m UT suggest that the *ZHR* was still slightly higher. Unfortunately these were calculations with lower radiant elevation which were disregarded for the final result. The maximum occurred a few hours earlier.

4 Comparing with other Geminid years

I would like to compare the Geminid activity with previous successful years, just like in (Miskotte et al., 2010; Miskotte et al., 2011). Let's compare the conclusion made from the 2010 analysis. For the 1980s we found maximum *ZHR*-values in the range 80–100. In the 1990s this increased from about 100 to 140 and also after the year 2000 maximum ZHRs were found around 120–140. For the year 2009 we found a slightly lower peak value than in 2001. These were two years during which the peak could be observed. The question rose whether or not the maximum rates of the Geminids were declining.

The year 2015 fits in the series 1983–1991–1999–2007. Luckily the Geminid observations for the years 1983, 1991 and 2007 were successful. The analysis from 2010 (Miskotte et al., 2010) had been done with fixed *r*-values. Until λ⊙ 262.2, *r* = 2.50 was assumed and after this solar longitude r = 2.30 was assumed. This has been done again in order to calculate in the same way like we did in 2010. There is, unfortunately, one important difference with the calculations that we made in 2010. In 2010 the ZHR data was based on Dutch Meteor Society data only, but since less DMS observers were active in 2015 we are now depending from IMO data. This complicates the comparison between good Geminid years.

During the night 13–14 December 2015, Carl Johannink, Sietse Dijkstra and the author observed the Geminids from the Black Forest (Miskotte, 2015). Once arrived at the observing field the observers noticed that the activity was rather disappointing. The first ZHR calculations confirm this. Also the observations by Jürgen Rendtel yield low ZHR values of 40–50 to 65 at the end of the night. Hence the series 1983–1991–2007 is ideal to verify whether the 2016 activity was at a higher, or the same, or at a lower level compared to previous years. Unfortunately no observations of the maximum, which occurred over the Far East, became available. For reason of completeness we include the 2015 Geminid ZHR curve (*Figure 4*) like given in *Figure 2*, but based on the fixed *r*-value like described above.

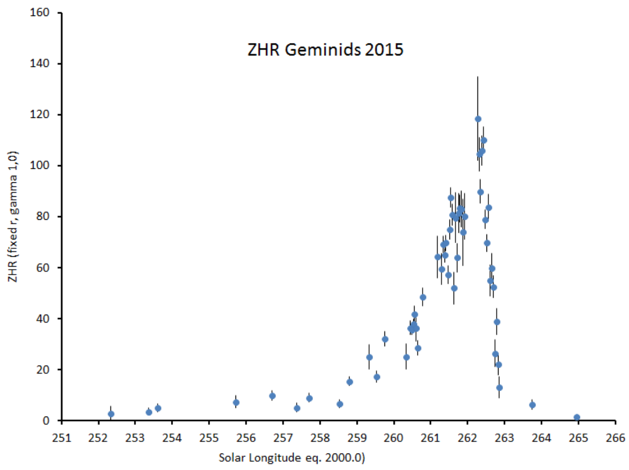

Figure 4 – The complete ZHR graph for the 2015 Geminids based on 8758 Geminids and a fixed r-value of 2.5 before λ⊙ 262.2 and *r* = 2.30 after this λ⊙

The years 2007–2015

Good observations were obtained during both years for the nights 12–13, 13–14 and 14–15 December. The comparison of both datasets is displayed in *Figure 5*. It is obvious that the 2015 activity profile is well in step with that of 2007 for the nights 12–13 and 14–15 December. The level of the activity remains well below that of 2007 during the night of 13–14 December, but towards the end of the night the *ZHR* values for 2007 and 2015 seem to

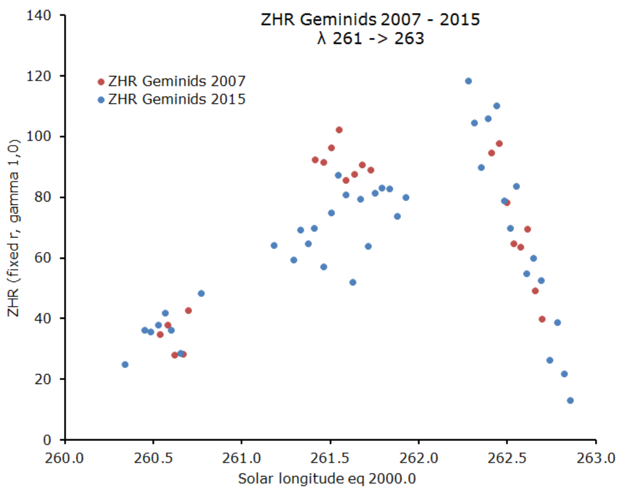

Figure 5 – The ZHR curves for the Geminids 2007 and 2015. It is nice to see the coincidence of the ZHR values for the night 14–15 December (Europe and North America). These ZHR curves are based on 5767 Geminids from 2007 and 8560 Geminids from 2015.

converge towards each other. For clarity; we consider a slightly disappointing activity level at the rising shoulder of the Geminid *ZHR* curve towards the Geminid maximum. Unfortunately there is no data available for the real Geminid maximum around λ⊙ 262.2°.

I checked if the *ZHR* values obtained by MISKO, JOHCA and DIJSI drag the *ZHR* curve to lower values, but that is not the case. Also fatigue seems to be ruled out as other observers report comparable *ZHR* values, sometimes a bit higher and sometimes a bit lower as well.

In order to make a comparison between the datasets of 2007 and 2015 for the night of 13–14 December with the same observers for both years I plotted the *ZHR* values in *Figure 6*. The result is rather striking.

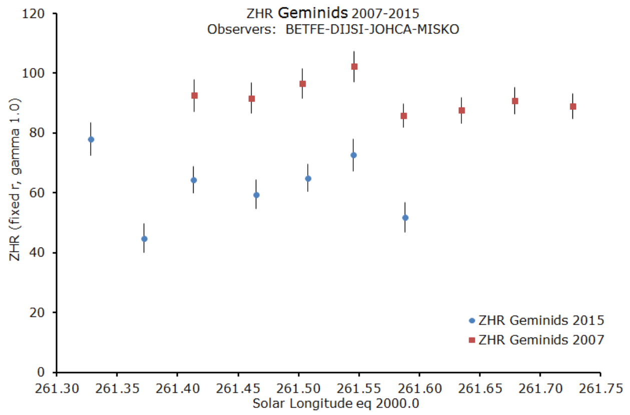

Figure 6 – Comparing ZHR-values based on data of observers BETFE, DIJSI, JOHCA and MISKO. It is notable that the ZHR-values display a similar course, although that the activity level in 2015 was ~30% lower than in 2007. These ZHR curves are based on 3128 Geminids for 2007 and 1141 Geminids for 2015.

Altogether the size of the dataset is too small to draw the conclusion as if the Geminid activity is on the wane. The lack of data about the maximum activity does not allow any solid conclusions, only the rising shoulder of the activity profile in the night of 13–14 December 2015 from Europe indicates a weaker level in the activity compared to 2007.

2016 compares well with the year 1991. In that year we also had rather disappointing ZHR values for the night 13–14 December compared to 1983 while the night 14–15 December had a comparable activity level as in 1983. At the occasion I suggested the eruption of the volcano Pinatubo at the Philippines as a possible explanation. Due to the presence of a huge amount of dust particles in our atmosphere, the fainter Geminids would have been less visible because of the stronger extinction at lower elevations at the sky, while that influence would have been less in the night of 14–15 December because of the occurrence of more brighter Geminids due to the mass sorting effect known in the Geminid stream.

The years 1991–2015

As the activity level during the night 13–14 December 1991 was considerable lower than in 1983, we have also compared 1991 with 2015. Only the nights 13–14 and 14–15 December could be compared as 12–13 December 1991 remained overcast in the Netherlands.

Are there any agreements? The result is displayed in *Figure 7*. Again the rather scattered activity distribution during the night 13–14 December is striking (between λ⊙ 261.5° and 261.8°), while the ZHR values at the decreasing shoulder of the profile for the night 14–15 December are more closely to each other. The activity in 1991 between λ⊙ 261.5° to 261.8° (13–14 December 1991) was a little bit lower than in 2015.

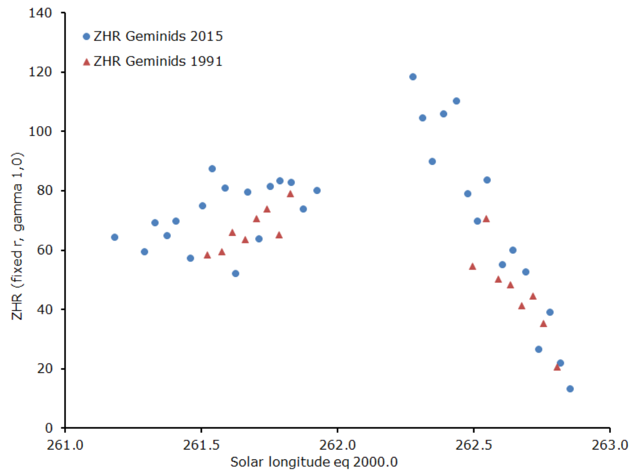

Figure 7 – The ZHR curves for the Geminids 1991–2015. The ZHR values were calculated for 4207 Geminids in 1991 and 7149 Geminids in 2015.

The years 1983–2015

Finally a comparison has been made with 1983, see *Figure 8*. It is obvious that the activity in 2015 was slightly lower than in 1983 but the differences can be neglected. Not mentioning the young observers of that time who are being compared with the old ones of today, 32 years later. Luckily the recent calculated C_p values solve this problem to a large extend.

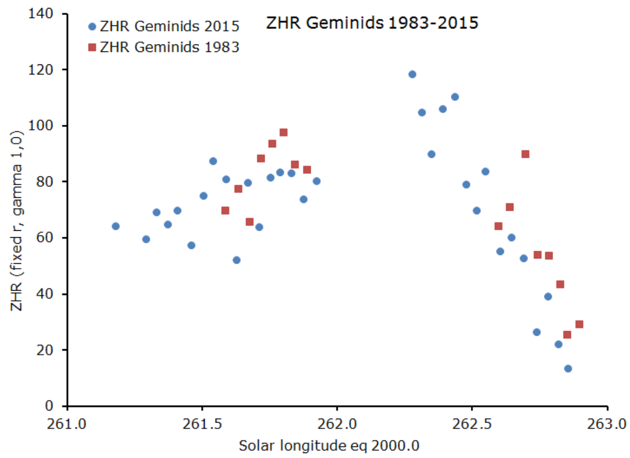

Figure 8 – The ZHR curves of the Geminids 1983 and 2015 based on respectively 1659 and 7149 Geminids.

5 Conclusions and challenges

The Geminids displayed a nice activity over Europe in the night of 14–15 December 2015. During the night 13–14 December 2015 the ZHR as obtained from Europe appears to be somewhat less than the same period in $\lambda_\odot$ in 2007. Unfortunately there is no good data of the maximum around $\lambda_\odot$ 262.2°. Based on the available observations from 2015 we cannot provide solid proof that the Geminid activity is on the wane. It isn't clear what could be the cause for the lower ZHR in the ascending branch of the activity profile. Also the rather scattered appearance of the activity curve towards the maximum is rather confusing. The appearance of multiple sub maxima could be an explanation or a lower increase may be due to a later occurrence of the Geminid maximum.

We are missing good observations for the 2015 maximum. Therefore it is important that the maximum should be well observed in 2017, in that year it is best visible from Europe. That year fits well in the series 1985 (well observed), 1993 (not observed), 2001 (well observed) and 2009 (well observed). In 2009 the activity was slightly less than in 2001, hence 2017 offers a good opportunity to verify if the lower ZHR-values recorded in 2009 were just a fluctuation or a more structural begin of the wane of the Geminid activity.

In 2017 we have the closest approach of the Geminid parent body to the Earth orbit during the Geminid maximum. 3200 Phaeton will get as close as 0.088 AU from the Earth. From research done in 2010 (Miskotte et al., 2010; Miskotte et al., 2011) there could be a possibility to see more bright Geminids. However the indications for this are rather weak and may also be due to statistical fluctuations. The way to find the truth is to go into the field and to observe the impressive Geminid display.

Acknowledgment

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Fireball events

Compiled by Karl Antier

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

1 Fireball over Finland on 11 May 2016 at 21:03 UT

See separate article page 34 in this issue.

2 New England Fireball 17 May 2016

American Meteor Society received nearly 700 public reports about a very large meteor spotted over North East US on 17 May 2016 at 12:50 AM.

The fireball was seen primarily from Maine but witnesses from Vermont, New Hampshire, New Jersey, Massachusetts, New York, Rhode Island, Pennsylvania, Connecticut, Ontario (Canada) and Québec (Canada) also reported the event.

Figure 1 – Fireball over North East US on 17 May 2016 at 12:50 AM.

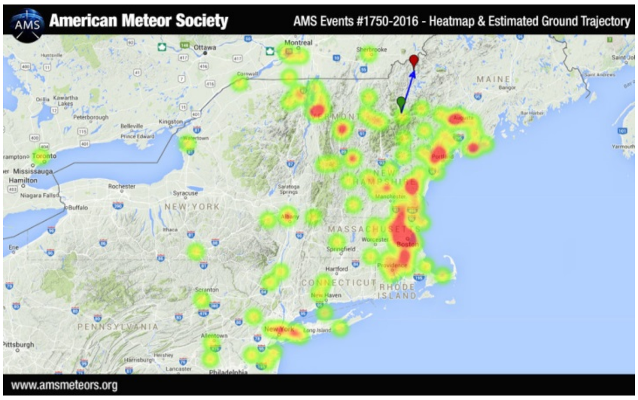

Figure 2 – AMS Event #1750-2016 – Heatmap and Estimated Ground Trajectory.

Read more about this fireball at [AMS website](). (Reported by *Richard Kacerek*).

3 Arizona fireball, June 2nd, 2016, 10h57 UT

A huge fireball shooting North to South over Arizona was widely observed and filmed on June 2nd, 2016, 10h57 UT, from Northern Utah to Western Texas and Southern California. More than 200 reports were sent to the IMO/AMS via the application form, leading to an automatic trajectory analysis that show the meteor started being observed above Kohls Ranch/Bear Flat, and followed a North-South trajectory in direction of the Salt River.

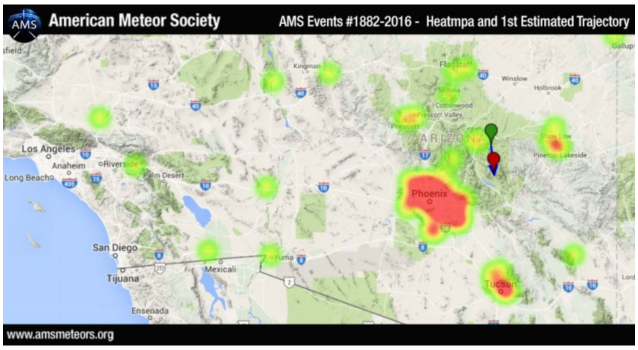

Figure 3 – Credit: IMO/AMS.

The fireball and the huge persistent train was photographed and filmed, showing a very bright meteor that lasted more than 5 seconds, lighting up the sky several times before disappearing. The bright persistent train survived several minutes, and twisted due to high altitude winds.

This fireball, according to Bill Cooke (NASA's Meteoroid Environment Office), is the brightest ever recorded by the NASA's All Sky Fireball Network. From first analysis, the small asteroid dimensions should range around 3 m diameter, and its maximal brightness peaks saturates all detectors, but its magnitude must have been close to -15.

UPDATE (29/06/2016) : meteorites have been recovered from this fireball. For more information, please have a look [here]()!

4 Fireball 22 May 2016 from Italy over Adriatic sea

See separate article page 35 in this issue.

5 Amazing June Lyrid fireball recorded over Spain

The fireball shown in the following video was captured over the South of Spain just one minute after the start of summer, on 20 June 2016 at 00:35 UT (21 June at 22:35 local time).

See video online.

The event was recorded by eight cameras deployed at four meteor-observing stations operating in the framework of the SMART Project. The analysis of its radiant and orbit revealed that it was produced by a meteoroid belonging to the June Lyrid stream. (Reported by *Jose Maria Madiedo*).

6 Missouri-Illinois border fireball, June 6th, 2016, 16h40 UT

It was caught by a video camera in Wentzville, North-West of O'Fallon, Missouri, by Tom Stolze. This video must be a good guess on what has been observed by many witnesses, as most of them lies along the Mississippi river, South-East from the path of the meteor.

See video online.

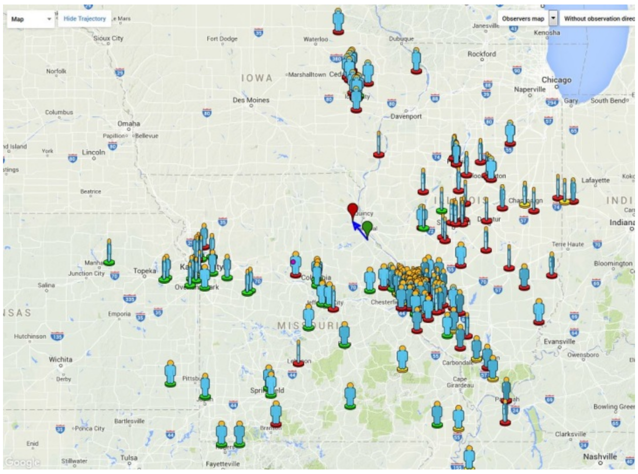

Figure 4 – Map of the people who reported the June 6th, 2016 fireball. Credit: IMO/AMS.

7 USA-Canada border crossing fireball, June 15th, 2016, 01h29 UT

On June 15th, 2016, on both sides of the USA-Canada border, more than 150 persons reported having observed a very bright fireball. After report analysis, the object was discovered to have a South-East to North-West trajectory, crossing the border vertical of Brookville, North-East of Lake Ontario. Observed from Montreal to Washington City, and from Cleveland to Boston, it eventually fragmented in more than 5 visible pieces, before disappearing.

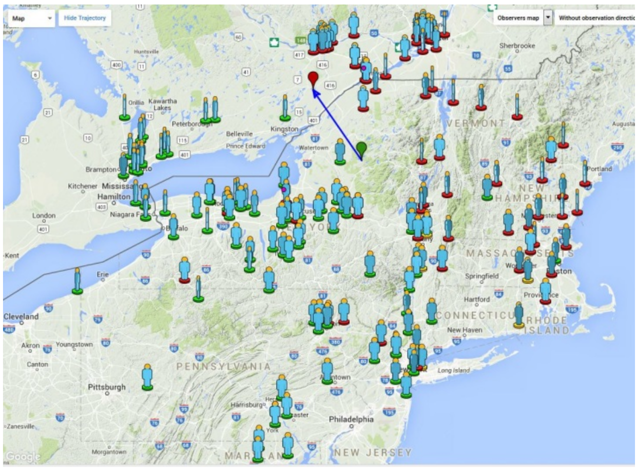

Figure 5 – Map of witnesses of the June 16th, 2016 fireball, which crossed the USA – Canada border at 01h29 UT. Credit: IMO/AMS.

8 June 22nd, 01h14 UT recorded by the FRIPON network

A bright fireball was largely recorded by the new FRIPON network, as it was recorded by 18 video stations (out of more than 60 dispatched all over the French territory), and 2 radio receptors (Orsay and Orléans, that are currently the only ones installed).

The fireball appeared on June 22nd, 2016, at 01h14 UT. It was recorded on 2 radio receptors located in Orsay and Orléans. And it was also visually observed by people who reported it on the IMO/AMS fireball report platform.

Calculations performed with FRIPON team software indicates that the meteor luminous path started between Chambéry and Grenoble, over the Alps, travelled north-West in N285 azimuth, passing few kilometers South to the vertical of Lyon, to disappear between Roanne and Montbrison.

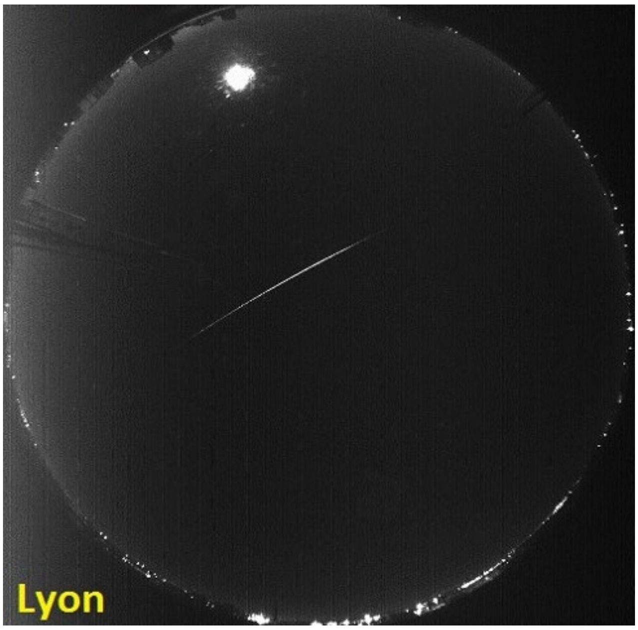

Figure 6 – The FRIPON camera at Lyon: June 22nd, 01h14 UT.

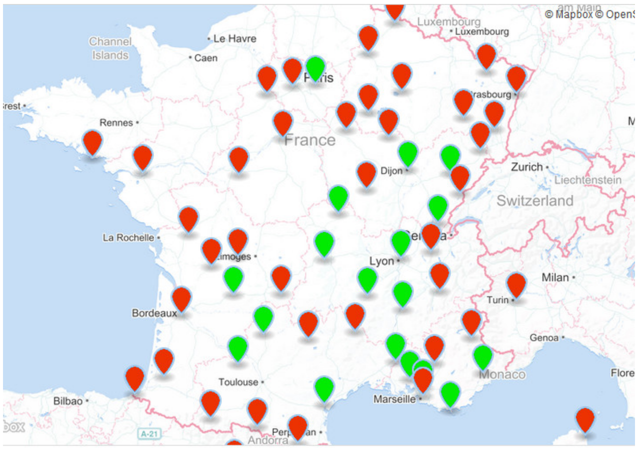

Figure 7 – Map of the video stations (in green) that recorded the June 22nd, 01h 14 UT fireball over South-Eastern France. Credit: FRIPON.

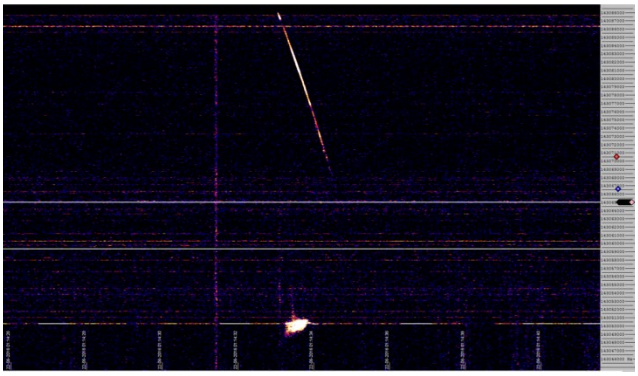

Figure 8 – Radio echo from the June 22nd, 2016, 01h1 UT fireball, as recorded on Orsay radio receptor. Credit: FRIPON.

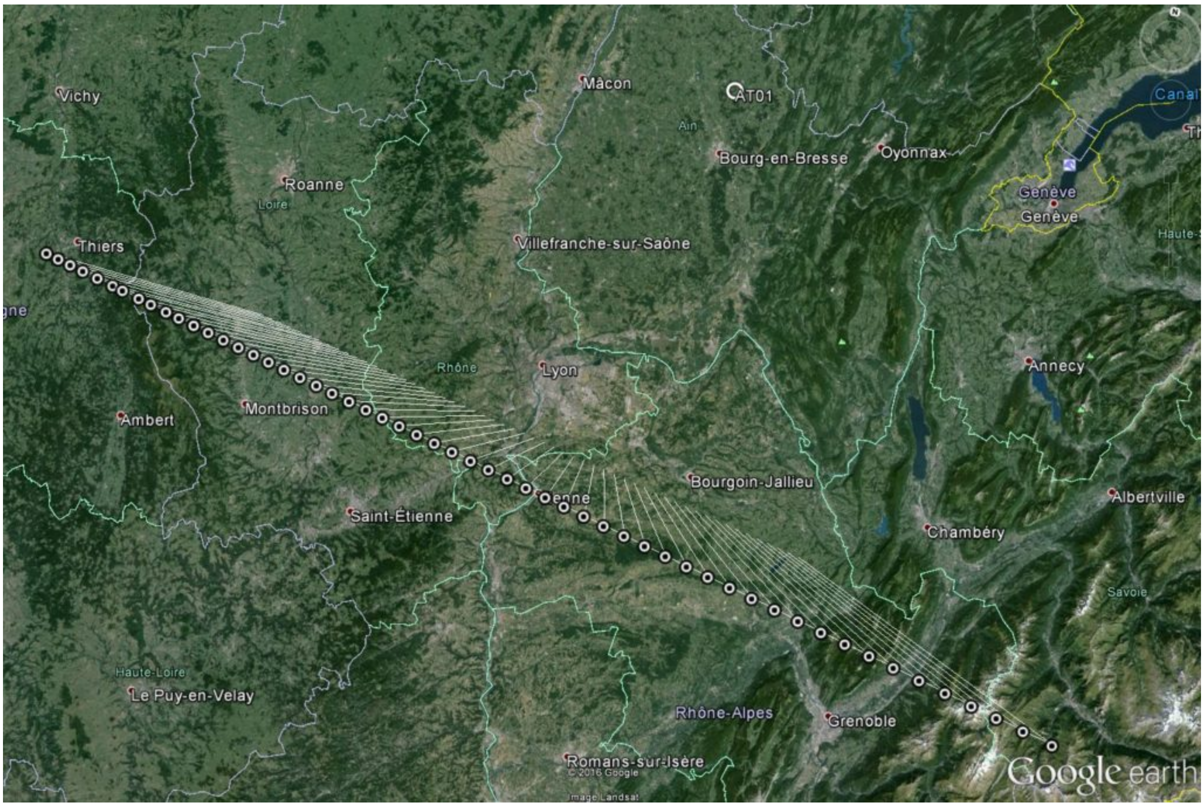

Figure 9 – Meteoroid trajectory of the June 22nd, 2016, 01^{h}14^{m} UT fireball calculated by FRIPON team from the 18 video records made by the network. Credit: FRIPON.

9 Alpha Capricornid fireballs in July

Several alpha-Capricornid fireballs have been recorded over Spain in the framework of the SMART Project during the end of July. On July 27, a mag. -10 event was observed over the South of Spain at 2:24:57 UT. A video of this meteor can be found on Youtube: https://youtu.be/IGZiL2gcXVY.

Besides, two additional alpha-Capricornids were observed on the night of 29 July 2016 at 0:45 and 2:08 UT, respectively. The first event had a magnitude of -12 and the second one was even brighter (mag. -13). This Youtube video shows both fireballs: https://youtu.be/jFgIsM-0F5g.

Figure 10 shows a sum-pixel image of the mag. -13 alpha-Capricornid observed on July 29, which exhibited several flares along its atmospheric trajectory (the bright object on the left is the Moon). (reported by Jose Maria Madiedo).

Figure 10 – Mag. -13 α-Capricornid recorded on 29 July 2016.

The bright fireball of 26 March 2016 over Belgium and the Netherlands: some early results

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This short contribution gives preliminary analytical results (trajectory, radiant and orbit) for a slow brilliant magnitude –12 fireball that appeared over the Dutch-Belgian border on 25 March 2016, 23:00:45 UT. This fireball was widely observed by many casual observers in Belgium, the Netherlands, France and Germany. It was photographically captured by three Dutch and two Belgian all-sky stations, allowing triangulation of the fireball trajectory. Trajectory, radiant and orbit were determined using *TRAJECT 2.5-beta and METORB 9.0*. The entry angle was steep (66° with the horizon). With an end height of only 18.8 km and clear deceleration in the speed over the trajectory, this was almost certainly a meteorite dropper. The potential dropping zone is in the province of Oost Vlaanderen in Belgium just 6 km short of the Dutch border. The geocentric radiant of the fireball was determined at RA 199°.08, Dec +31°.26 (V_{geo} 9.33 km/s). The orbit is a short period Apollo (orbital period only 1.18 year), with eccentricity 0.2482, inclination 10°.32, perihelion at 0.841 AU and aphelion at 1.40 AU, i.e. completely within the orbit of Mars.

1 Introduction

On 25 March 2016 at 23:00:45 UT, five photographic stations in the Dutch and Belgian All Sky network captured a brilliant slow sporadic fireball, a potential meteorite dropper, over the Belgian-Dutch border area (*Figure 1*). This contribution gives some preliminary results on the orbit and atmospheric trajectory of this fireball based on the photographic images.

The atmospheric trajectory and speed were calculated using TRAJECT 2.5-beta, an Excel implementation of Ceplecha's plane-fitting method (Ceplecha, 1987) created by the author. The orbit was calculated using the *TRAJECT* output as input in *METORB 9.0* (Langbroek, 2004).

2 Photographic data and visual reports

This fireball was widely observed and reported by casual observers in the Netherlands, Belgium, Germany and France. It was also captured by three Dutch all sky stations of the Dutch Meteor Society (DMS) and two Belgian all-sky stations of the Belgian Association for Astronomy (VVS). It concerned the stations Ieper and Wilderen in Belgium (operated by Franky Dubois and Jean-Marie Biets); and stations Oostkapelle, Ermelo and Bussloo in the Netherlands (operated by Klaas Jobse, Koen Miskotte and Jaap van 't Leven) . The very slow mag -12 fireball had a duration of more than 3 seconds.

3 Trajectory and speed

Trajectory results from *TRAJECT 2.5-beta* place the fireball over the Dutch-Belgian border area, over the northernmost part of the Belgian province of Oost Vlaanderen. The fireball moved from the E-SE to W-NW (coming from azimuth 124°) with a steep entry angle (66° with the horizontal), starting at an atmospheric altitude of more than 75 km near 3°.89 E, 51°.09 N and ending at an atmospheric altitude of only 18.8 km near 3°.2 E, 51°.6 N over Belgium, only 6 km short of the Dutch border (note: more accurate coordinates are available but are withheld at the moment).

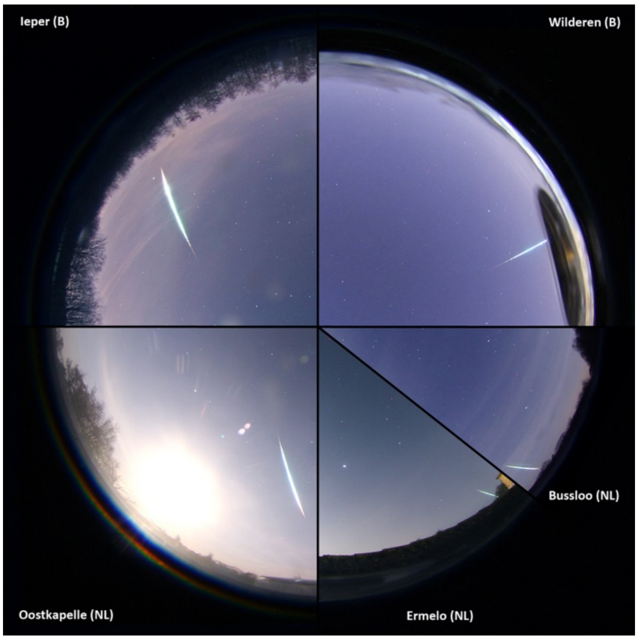

Figure 1 – Compilation of the all sky images from Wilderen, Ieper, Ermelo, Oostkapelle and Bussloo.

Two stations (Ermelo and Wilderen) were equipped with rotating shutters and provide speed data. The reconstructed initial atmospheric speed was low, only 14.58 km/s. Deceleration is visible over the part of the trajectory for which we have speed information: unfortunately both stations equipped with rotating shutters missed the end of the fireball due to horizon obstruction. The terminal speed can therefore only be extrapolated from the observed deceleration in the early part of the trajectory, but must have been below 10 km/s. Given the very low atmospheric end height (~19 km) derived from the data of the stations that did capture the fireball in its entirety, this was almost certainly a meteorite dropping event. Field recovery efforts are conducted at the moment of writing.

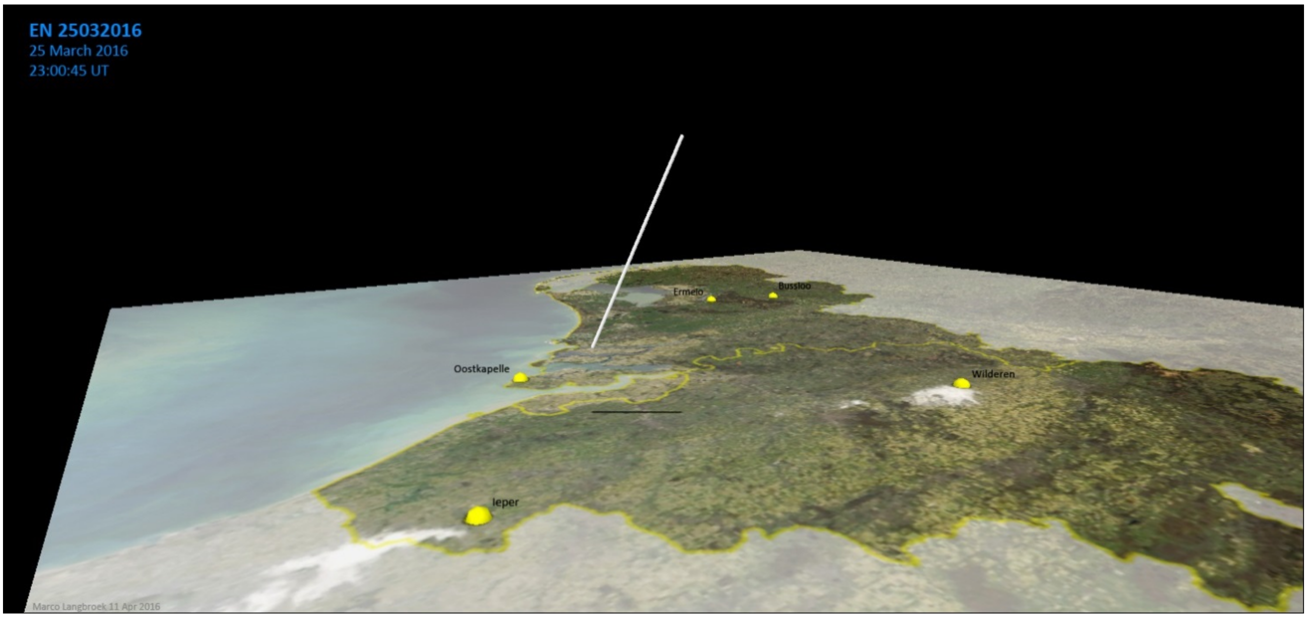

Figure 2 – 3D reconstruction of the fireball trajectory (graphic made with QGIS).

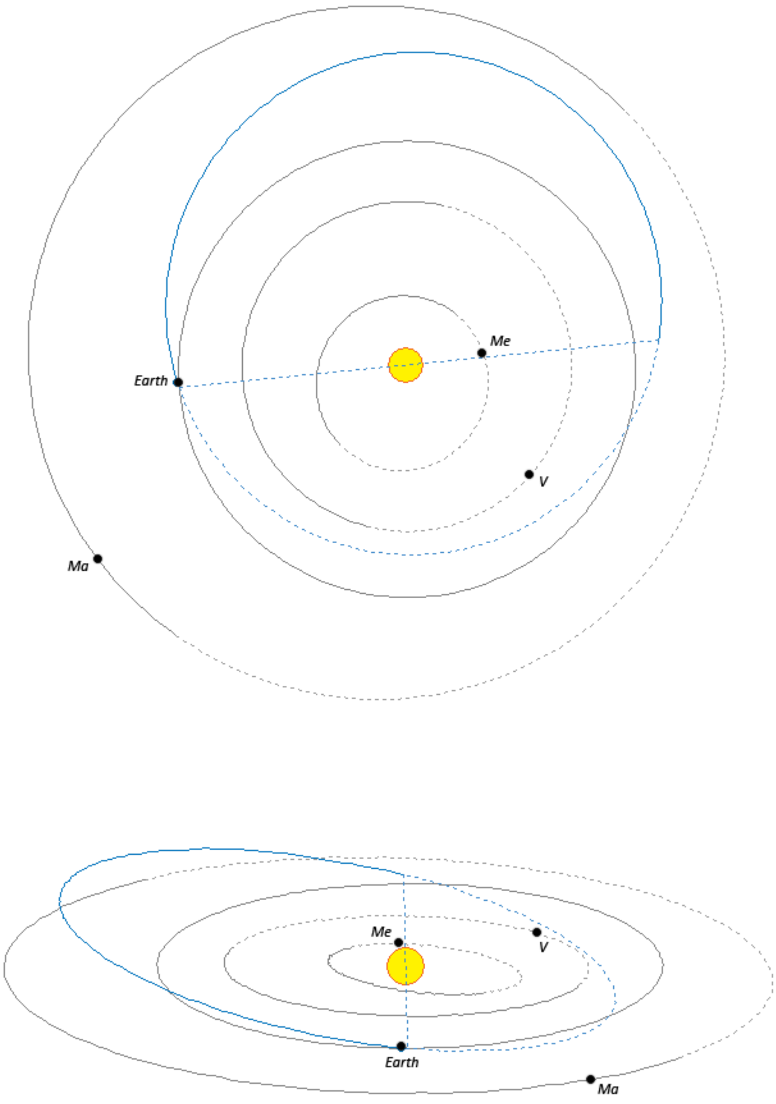

Figure 3 – Orbit of the fireball.

4 Radiant and orbit

The preliminary analysis of the photographic data results in the radiant and orbit data presented in *Tables 1 and 2*.

Table 1 – preliminary radiant data (2000.0), fireball 26 March 2016 23:00:45 UT.

	Observed	Geocentric
RA	196°.64	199°.08
DEC	+35°.01	+31°.26
V	14.58 km/s	9.33 km/s

Table 2 – preliminary orbit (J2000), fireball 26 March 2016 23:00:45 UT.

q	0.841 AU
Q	1.4 AU
a	1.119 AU
e	0.2482
inc	10°.32
ω	257°.752
Ω	5°.5026
π	263°.25
Period	1.18 Year

The radiant of the fireball is located not too far from that of the Glanerbrug, Pribram and Neuschwanstein meteorites (three historic early April falls). The geocentric speed of the 25 March 2016 fireball (9.33 km/s) was however much slower than for those meteorite falls, and as a result the orbit is quite different. A dynamic link is therefore unlikely.

The fireball orbit is a low inclined, asteroidal, Apollo type orbit and interesting because it is completely within the orbit of Mars with an aphelion at 1.40 AU and an orbital periodicity of less than 1.2 years.

5 Infrasound detection

Jelle Assink and Laslö Evers (Royal Dutch Meteorological Institute KNMI) communicated that infrasound has been captured from this fireball by three Dutch infrasound stations.

Acknowledgments

I thank Jean-Marie Biets, Franky Dubois, Klaas Jobse, Koen Miskotte and Jaap van ’t Leven for making imagery of the fireball available for analysis. Jelle Assink and Laslö Evers (KNMI) communicated preliminary infrasound results. I am much obliged to Felix Bettonvil (NL) and Rob Matson (USA) for discussions and verification of initial results. Field recovery efforts in Belgium are currently organized by Jean-Marie Biets.

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Fireball over Finland on 11 May 2016 at 21:03 UT

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Some preliminary results are presented on a bright fireball photographed by 8 cameras of the Finnish Fireball Network.

1 Introduction

This fireball over Middle Finland close to local DST midnight resulted in more than a hundred visual reports to our Taivaanvahti, and this was captured on about 8 cameras.

2 Preliminary results

The entry track is derived by means of mainly two quite nearby (to the fireball) and mutually favorably situated cameras of Mikkeli and Joutsa. The Mikkeli image by Aki Taavitsainen and Jani Lauanne is seen in this, see *Figure 1*.

It is difficult to measure the brightness of the flash but this may be around –15, possibly more bright as seen from Mikkeli.

The fireball arrived from azimuth direction of 192 with the slope of 29 degrees.

The entry velocity was 16.8 km/s. The beginning of luminous flight was at the height of 87 km and the terminal height at 29 km at the velocity of 4.2 km/s.

The bright flash was at the height of 44 or 45 km. Then the dynamic pressure was only about 4 kp/cm^2.

Assuming that a constant ablation coefficient during the flight would give 0.031 s^2/km^2, which is quite big and more or less which is the result of fragmentations.

The entry mass was derived around 10 kg and the main fragment in the end, something like 150 or 200 g. Considering the brightness and relatively modest velocity this is quite small, but consistent to the big ablation coefficient. In total there may be several more smaller fragments of this. These mass-values are valid for a normal chondrite density assumption. If the density were smaller, then these values would get bigger. The main fragment might be around half a kg.

The solar system orbit is in between 0.90 and 3.93 au. And the special thing in this is the very small inclination of the orbit. This was derived as 0.02 degrees. Actually the uncertainty is bigger than this value, so it is not even known on which side of the Sun the ascending node is. Longitude of perihelion is 275.1 degrees.

Another image of this fireball can be found at http://www.taivaanvahti.fi/observations/show/.

Figure 1 – 11 May 2016 at 21:03 UT –15 Fireball.

Fireball 22 May 2016 from Italy over Adriatic sea

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A bright fireball was captured by cameras of the Italian Meteor and TLE Network as well two cameras of the Croatian Meteor Network. The atmospheric trajectory and preliminary orbit data are presented.

1 Introduction

On May 22, a fireball was captured by IMTN video stations (Italian Meteor and TLE Network) Ferrara, Tortoreto (TE) and Chianti (SI), respectively operated by Ferruccio Zanotti, Diego Valeri and Roberto Manganelli.

The Fireball from Ferrara Station went through a stretch of sky about 30 degrees above the horizon about 25°, an apparent maximum magnitude of about –7 with duration of 2.72s and expressed an interesting flare. Visual testimonies bring a green color.

Also captured from Croatian Meteor Network station Duino (close to Trieste), Italy, camera operator Mark Sylvester and from Pula (Croatia).

Figure 1 – The Fireball from Ferrara Station.

Figure 2 – The Fireball from Tortoreto Station.

Figure 3 – The Fireball from Chianti Station.

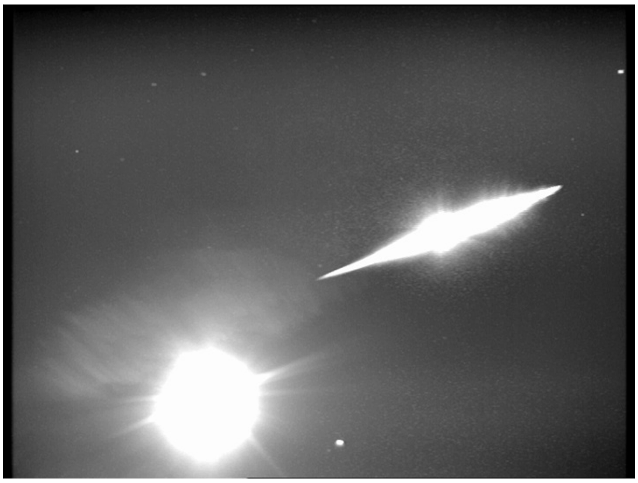

Figure 4 – from Croatian Meteor Network station Duino (close to Trieste), Italy, camera operater Mark Sylvester.

Figure 5 – From Croatian Meteor Network station Pula.

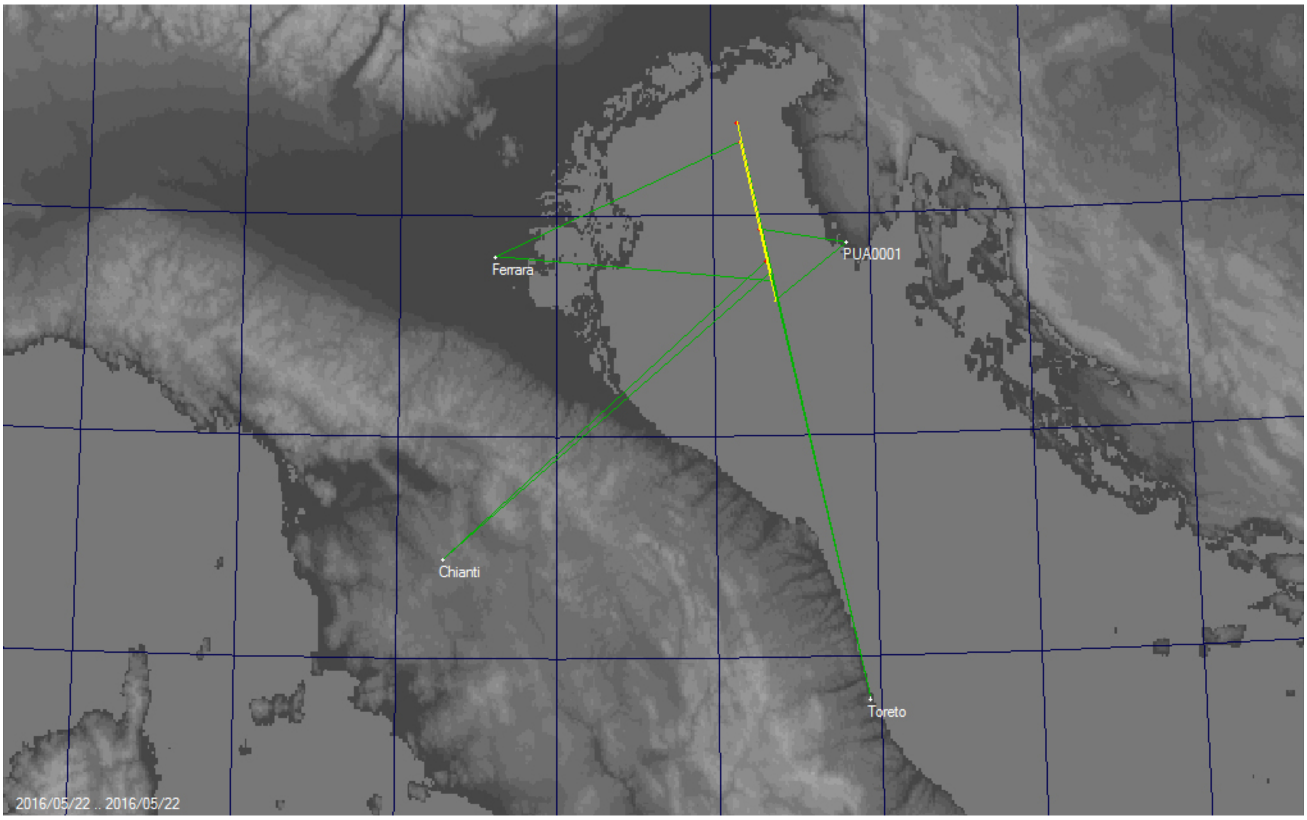

Figure 6 – The atmospheric trajectory.

2 Trajectory

- Preliminary trajectory (ITA.FIR v.8)
- Height above sea level of start point = 103.01 km
- Height above sea level of end point = 51.02 km
- Mean inclination above Earth surface = 29.95°
- Mean Azimut (N -> E) = 167.97°
- Mean geocentric velocity = 34.7 km/s
- SPORADIC meteor

3 Preliminary Orbital Elements (2000)

- Semi-major axis = 1.995 UA
- Eccentricity = 0.883
- Inclination = 11.81°
- Longitude of the ascending node = 62.07°
- Argument of the perihelion = 309.78°
- Perihelion distance = 0.234 UA
- Aphelion distance = 3.755 UA

Official launching of FRIPON

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Tuesday May 31st, 2016 marks the official launch of FRIPON, a unique interconnected network to search for meteorites. Eventually comprising 100 cameras spread out all over France, FRIPON introduces a night and day 360° watch of the sky. Born from the joint scientific expertise of Observatoire de Paris, of Muséum national d'Histoire naturelle, of Université Paris-Sud, of Université Aix-Marseille and of CNRS, this network aims to detect meteorite falls, measure their trajectories and estimate their strewnfields so that field search campaigns can be organized.

1 Introduction

The explosion on February 15, 2013 of a large meteorite above the Russian town of Chelyabinsk was a real shock, which triggered public authorities and public opinion worldwide into realizing that such an event could happen again anywhere and at any time.

Most of the fireballs and smaller meteors usually disintegrate totally upon entering the terrestrial atmosphere, transformed into dust before they even reach the ground. However, it sometimes happens that a larger incoming chunk of extraterrestrial material will produce a meteorite that falls on Earth. The number of meteorites falling in France yearly is estimated as around ten, but no more than one every ten years is actually observed. Surprisingly, the rate of observed meteorite falls was five times higher in the 19th century. Several reasons may be found for this, but one thing is clear: most of the meteorites falling in France are lost forever!

Figure 1 – FRIPON camera installed on the roof of the Observatoire de Paris. © François Colas / Observatoire de Paris / IMCCE.

Based on this observation, scientists François Colas (Senior scientist at Observatoire de Paris and CNRS), Brigitte Zanda (Associate Professor at Muséum national d'Histoire naturelle) and Sylvain Bouley (Associate Professor at Université Paris Sud), have been making use of their complementary expertise since 2013 to work towards the setting up of FRIPON[3], an acronym for "Fireball Recovery Interplanetary Observation Network".

Funded at the level of 550000 euros by Agence nationale de Recherche (ANR – National Research Agency), this project aims to deploy a large-scale detector (eventually 100 cameras and 25 radio receivers) over the whole French territory. Data from weather radars and seismographs will also be used to characterize the events detected by the network.

Figure 2 – Location of the 60 cameras in operation by the end of May 2016, the completion of the network being planned for the end of 2016. Notice the camera installed at the Torino Observatory, first in the upcoming Italian network. © FRIPON.

2 The principle

On average, three to nine cameras are set up per region, at a distance of 50 to 100 kilometers from one another. Roofs of observatories, universities, natural history and other museums and scientific outreach associations, the camera locations are varied and the program has close to 150 participants so far.

[3] www.fripon.org.

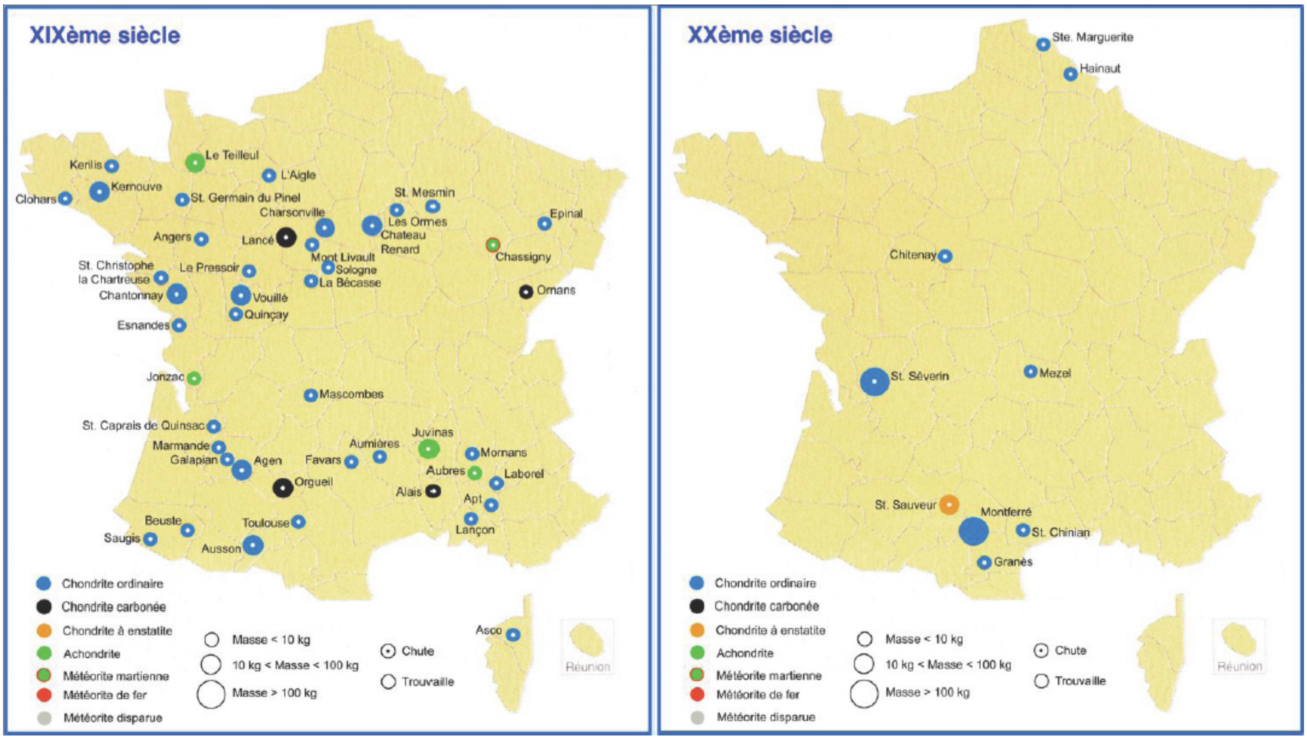

Figure 3 – A comparison of meteorite falls observed in France in the 19th and the 20th century. © MNHN.

Easy to install and to use, the cameras are equipped with a fisheye lens enabling a 360° view of the sky on a single image. They are connected to computers running software that was developed specifically to analyze images and detect luminous events. When a detection takes place, a signal is sent to the mainframe located in Université Paris-Sud, which collects data in real-time from the whole network. The entire computing chain is now functional, making it possible to launch a field search campaign within about a day.

With over 60 cameras now in working order in France, FRIPON is operational. Its extension abroad has already started. Real time images can be obtained from the www.fripon.org website. "*This setup allows us to detect incoming objects in real time and from several angles, making it possible to compute their trajectories in 3D, estimate their speed and determine their potential fall location with a precision of the order of a few hundred meters*" says François Colas, the Principal investigator of the FRIPON project at Observatoire de Paris, within the Institut de mécanique céleste et de calcul des éphémérides.

3 Objectives

This monitoring above the French national territory comes with multiple aims: one is to determine the intensity and the origin of the extraterrestrial matter flux, and another to eventually collect fallen meteorites, in both cases in order to better understand the Solar System.

Collecting such raw material direct from space may bring invaluable information about the composition of the Solar System in its primitive state, and about planets and their evolution, including the Earth. "*Our planet is made of the same material as some of these meteorites, but it was transformed through geological processes. Having evolved little since the formation of the Solar System, the meteorites that are currently falling hold clues to the nature of the primitive Earth.*" emphasizes Brigitte Zanda, meteoriticist at the Muséum national d'Histoire naturelle.

"*Upon penetrating the Earth's atmosphere, the object disintegrates into debris. The spatial distribution of these chunks over the strewn field usually defines a search area of more than 20 square km.*" points out Sylvain Bouley, planetologist at Paris-Sud university.

In practice, the FRIPON working organization will be taken over in the field by the Vigie-Ciel network, run by the Muséum national d'Histoire naturelle and to be launched in 2017. This citizen science program will make it possible to set up field search parties both quickly and efficiently, with the help of volunteers who will have previously been trained in the framework of Vigie-Ciel.

RAMBo: the “Radar Astrofilo Meteorico Bolognese”

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Radio meteors are usually investigated by professional radars. Amateur astronomers cannot have transmitters, so usually they can only listen to sounds generated by a radio tuned to a TV or military transmitter. Until recently, this kind of observation has not produced good data. The experience of “RAMBo” (Radar Astrofilo Meteorico Bolognese) shows which data can be extracted from an amateur meteor scatter observatory and the results which can be achieved.

1 Introduction

RAMBo is a homemade, low cost project born in Bologna (Italy). Its goal is the observation and the automatic recording of meteor activity.

Like other European observatories, also RAMBo uses a military radar transmitter that is continuously on air in VHF at great power: it is located in Graves, near Dijon, in France. It is built for satellites and for aircraft position control.

The RAMBo receiving set up is composed of a Yagi directive antenna (10 elements) pointed in azimuth in the direction of the transmitter (300°), and in declination about 25 degrees above the horizon. Its polarization is vertical.

Given the characteristics of the antenna (high directivity), the area of the sky that is investigated consists of a twenty per thirty square degrees area, above the Alps, roughly vertically on the Matterhorn.

The receiver is a Yaesu 897 tuned in SSB (Single Side Band) about 1000 Hz below the Graves carrier.

Sound analysis and data recording are both made with Arduino, the well-known low cost microprocessor of the “Internet of Things” (IoT) through a program written by us.

- For every meteor echo we record:
- Progressive event number;
- Hourly number;
- Date and time (UT);
- Echo length (milliseconds);
- Echo amplitude (millivolts);
- A number proportional to the rise time.

For each echo RAMBo realizes a data string CSV type (common delimited values) containing the six above listed informations. Every night at 18 U.T. Arduino sends the file via the web to a cloud site, so that it can be analyzed at home.

After three years of trials and improving we arrived at the sixth version. Now the results are good and reliable. Who need to know more about us, can visit our website: www.ramboms.com where you can find the project history, see our data, and get to know our amateur team.

2 Reports from RAMBo

Normal activity for 23-30/5/2016:

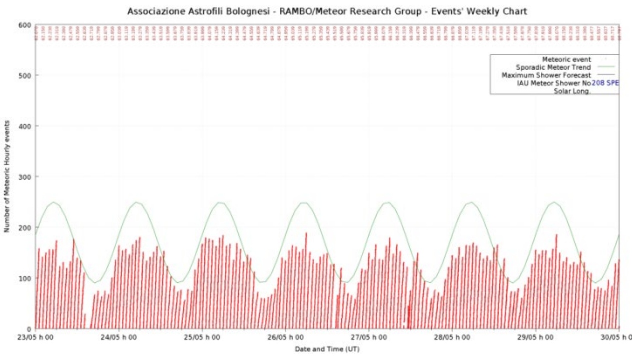

Figure 1 – “Rambo” hourly rate (HR) for 23-30/5/2016.

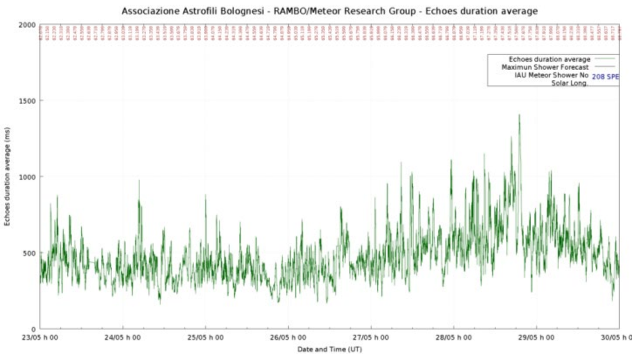

Figure 2 – “Rambo” average echo duration for 23-30/5/2016.

Activity for 30/5–6/6/2016:

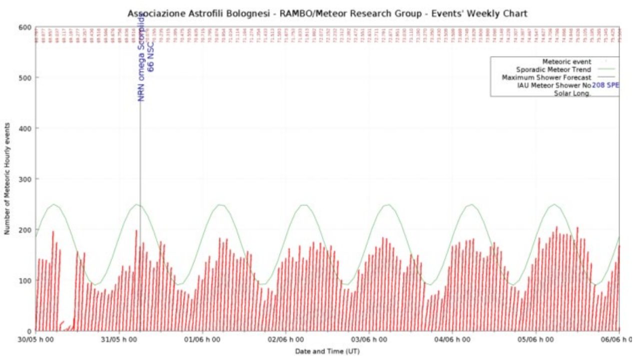

Figure 3 – “Rambo” hourly rate (HR) for 30/5–6/6/2016.

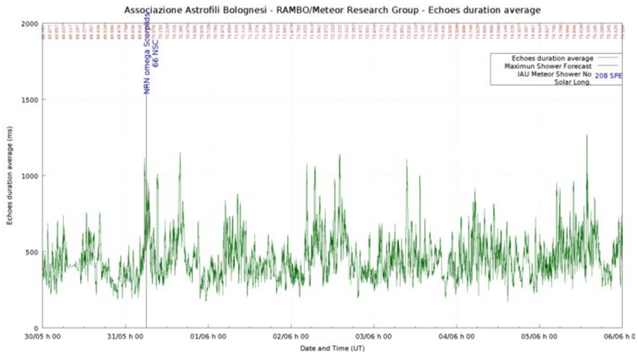

Figure 4 – "Rambo" average echo duration for 30/5–6/6/2016.

Comparing the hourly rate profile with the mass activity in the echoes duration average profile, it is possible to see a faint evidence of the Omega Scorpionids activity, just at the awaited time.

Normal activity for 7-13 June 2016:

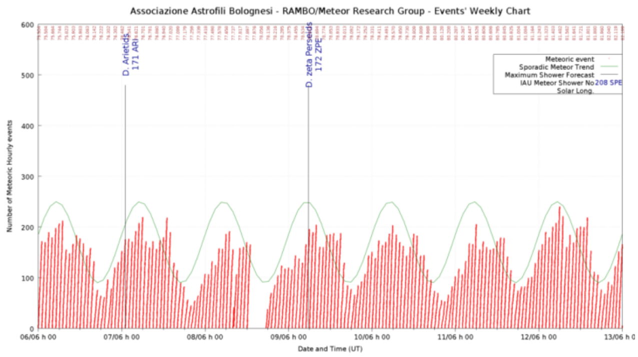

Figure 5 – "Rambo" hourly rate (HR) for 7–13/6/2016.

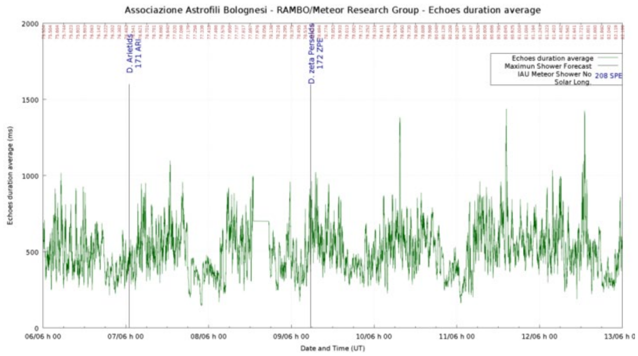

Figure 6 – "Rambo" average echo duration for 7–13/6/2016.

EDMOND database 2016 from January to March

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The first quarter of 2016 suffered from poor weather conditions over Europe. A summary is given for the data reported so far by a number of participating networks. Results with the trajectory plots and the radiant distributions for both wide angle cameras and narrow field cameras are presented.

1 Introduction

The weather in the first quarter of the year 2016 in Europe was not favorable. Nowadays (May 26, 2016) data from the following networks are in the EDMOND database (Kornoš et al., 2014a):

- CEMeNt (Central European Meteor Network, cross-border network of Czech and Slovak amateur observers);
- FMA (Fachgruppe Meteorastronomie, Switzerland);
- HMN (Hungarian Meteor Network or Magyar Hullócsillagok Egyesulet, Hungary);
- NEMETODE (Network for Meteor Triangulation and Orbit Determination, United Kingdom);
- UKMON (UK Meteor Observation Network, United Kingdom).

The presented results are thus partial and they do not include results of all national networks from the first third of the year 2016.

2 Results (wide-angle cameras)

During the first quarter of 2016 all 99 working stations (of the networks listed above) together registered 25536 individual meteors. It was possible to calculate trajectories in the atmosphere and the meteoroid's orbits in the Solar system for 4479 paired meteors. A ground map (projection of the meteor atmospheric trajectory on the ground) for these paired meteors is shown on *Figure 1* and a map of the radiants of these paired meteors is shown on *Figure 2*. Most meteors were sporadic meteors (3208 orbits), others belonging to known showers – QUA (Quadrantids, 214 orbits), COM (Dec. Comae Berenicids, 71 orbits), ECV (η-Corvids, 27), TBO (12 Bootids, 27), LBO (λ-Bootids, 26), FPL (February π-Leonids, 24), JLL (January λ-Leonids, 23), XUM (χ-Ursae Majorids, 21), NBO (ν-Bootids, 20), PVI (January π-Virginids, 20) and other meteor showers with one or more orbits from IAU MDC working list (Jopek et al., 2014).

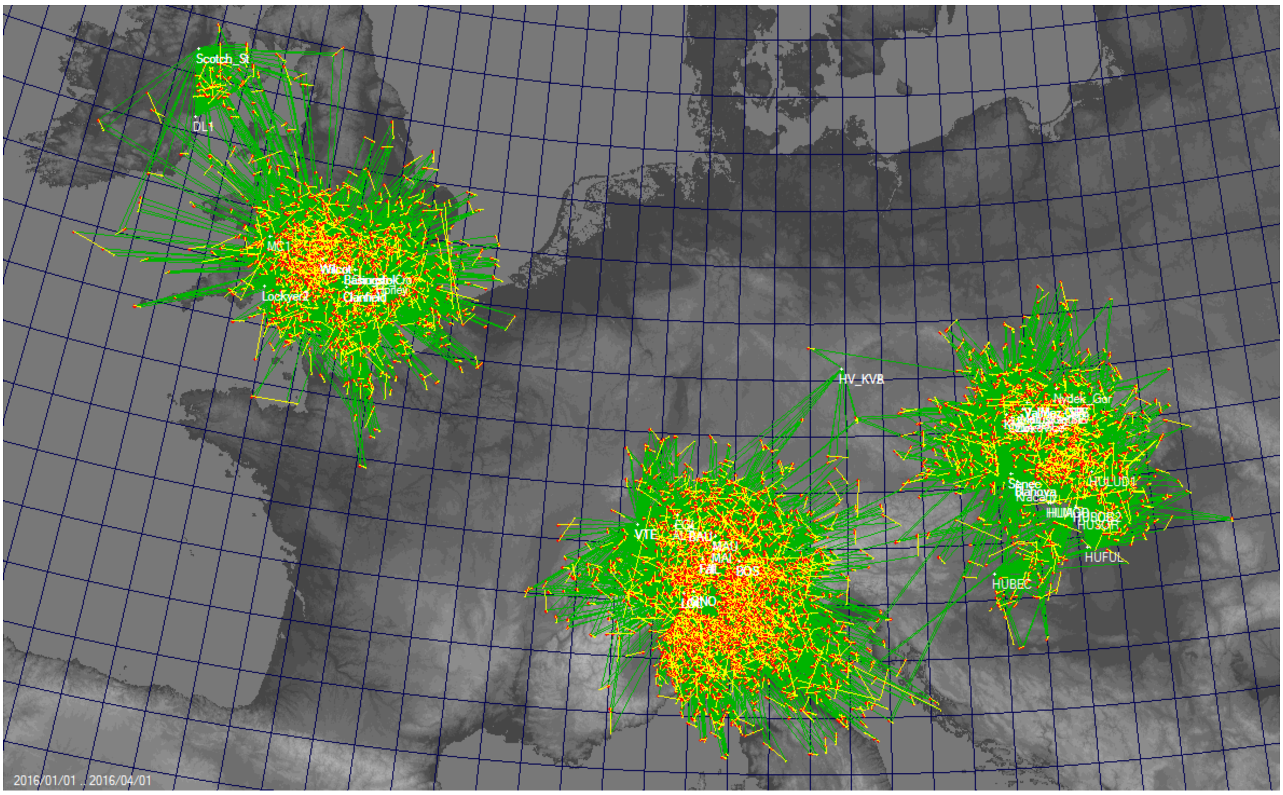

Figure 1 – Ground map (projection of the atmospheric trajectory of the meteors on the ground) of the multi-station meteor orbits.

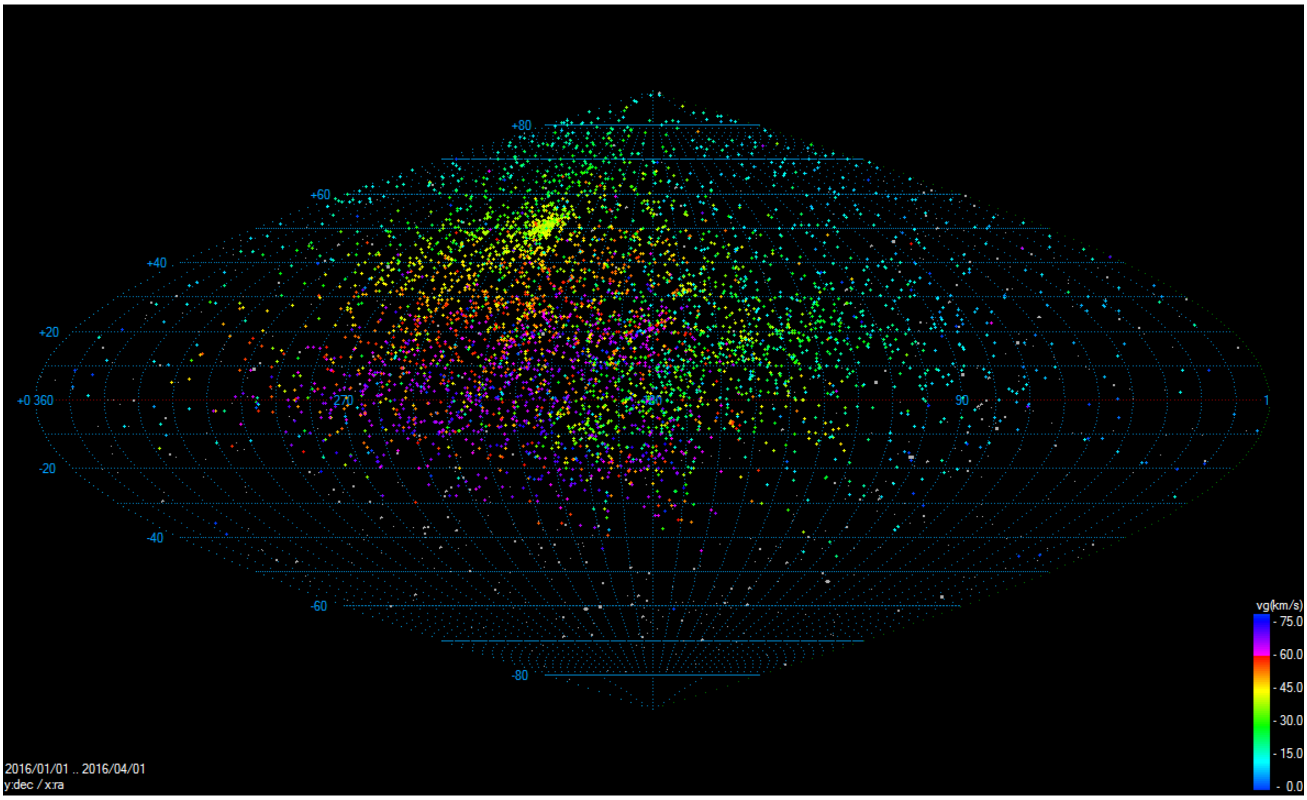

Figure 2 – Map of the radiants of the multi-station orbits. The map is in the equatorial coordinate system, the center is located at position RA=180°/DEC=0°.

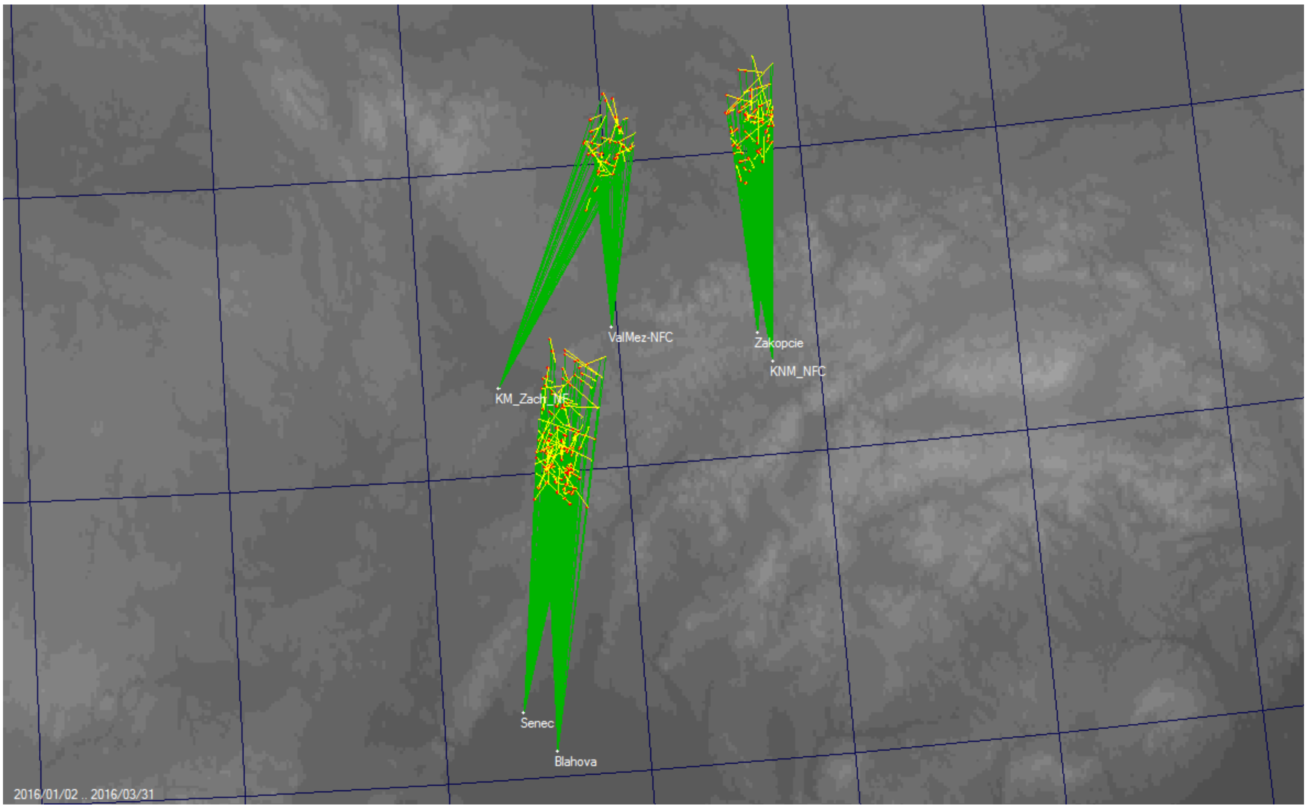

Figure 3 – Ground map (projection of the meteor atmospheric trajectory on the ground) of the two-station meteor orbits.

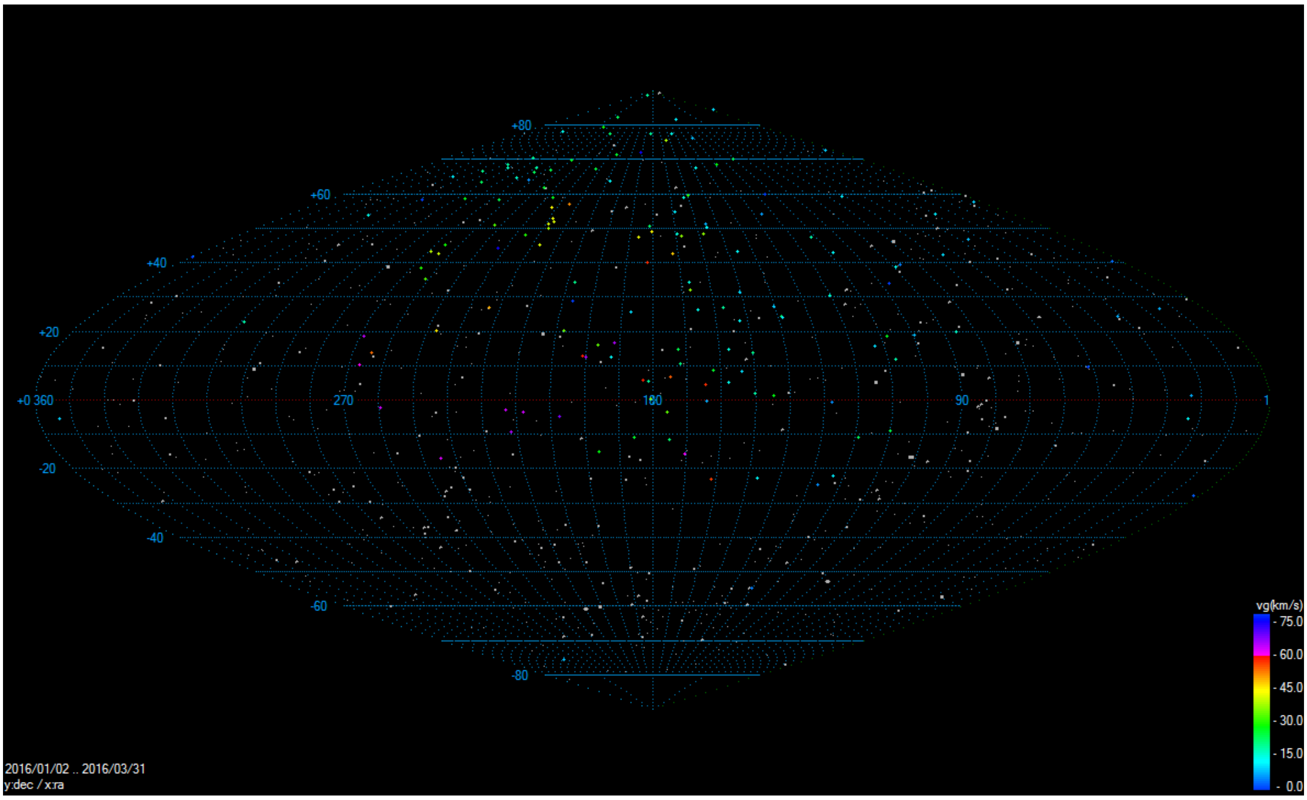

Figure 4 – Map of the radiants of the two-station orbits. The map is in the equatorial coordinate system, the center is located at position RA=180°/DEC=0°.

3 Results (narrow field cameras)

During the first quarter of 2016 all 6 working stations together registered 766 individual meteors. For 152 paired meteors it was possible to calculate very accurate trajectories in the atmosphere and the meteoroid's orbits in the Solar system. A ground map (projection of the meteor atmospheric trajectory on the ground) for these paired meteors is shown on *Figure 3* and a map of the radiants of these paired meteors is shown on *Figure 4*. Most were sporadic meteors (126 orbits), with others belonging to known showers – QUA (Quadrantids, 3 orbits), PVI (January π-Virginids, 2 orbits), NBO (ν-Bootids, 2), FHE (f Herculids, 2) and other meteor showers with one orbit from IAU MDC working list (Jopek et al., 2014).

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Recording and comparison of the lightning spectrum

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Three cameras equipped with a spectroscopic system are currently operating at the Valasske Mezirici Observatory. The main goal of these cameras is to capture the spectra of meteors and thus to identify the chemical composition of meteoroids and also emission lines of elements contained in the Earth's atmosphere. However, during the occurrence of storm activity the objective of the observations may change and spectrographs can record the spectra of electrostatic discharges – lightning. This was the case during a thunderstorm in the evening on June 19, 2016.

1 Introduction

The first camera for observing the spectra of meteors was installed at the Valasske Mezirici Observatory during the summer of 2014. It is located on the building of a professional workplace and the FOV of this camera is directed northwards (VM_N), the camera is equipped with a CCD sensor Sony Super HAD II 960 H (ICX 663 AKA) with the resolution of 720 × 576 px. In autumn 2015 two other spectral cameras were put into operation, equipped with a more advanced camera QHY5L-IIM with a higher resolution of the CMOS sensor (1280 × 960 px) and therefore with a higher spectral resolution (see *Figure 1*). The FOV of these cameras is directed to the southwest (VM_SW) and to the northwest (VM_NW).

Figure 1 – The camera QHY5L-IIM.

The northern camera (VM_N) was put into operation on July 25, 2014. This is a CCTV camera VE 6047 with the diffraction grating with a density of 500 lines/mm, which is equipped with fast Tokina lens (F/0.98) with a variable focus (3–8 mm). An effective field of view of 60 × 48° is for the focus adjustment of the lens is, the resolution of the meteors spectrum first order is 32.8 Å/px. All the necessary equipment was purchased through funding of the SMPH (Society for interplanetary matter). Spectrographs VM_NW (northwest camera) and VM_SW (southwest camera) were put into operation in October 2015 (*Figure 2*). These cameras are of the type of QHY5L-IIM with a CMOS sensor Aptina MT9M034, which are equipped with fast megapixel Tamron lens (F/1.0) with a variable focus (3–8 mm) and equipped with a diffraction gratings with a density of 1000 lines/mm. An effective field of view of 80 × 60° degrees is for the focus adjustment of the lens is (VM_SW camera) and 89 × 67º (VM_NW camera), the resolution of the meteors spectrum first order is 9.7 Å/px (VM_SW) and 10.8 Å/px (VM_NW).

Figure 2 – Stacked image of the bolide spectrum 20151119_034504, belonging to the Leonids meteor shower. Recording and analysis of the meteors spectra is the primary target of the spectrographs installed at the Valasske Mezirici Observatory. *Author: Valasske Mezirici Observatory.*

2 Spectrum of the lightning

The recent storm has offered an interesting possibility of spectral registering of a very interesting phenomenon of storms, the lightning (*Figures 2 and 3*). At that moment the spectroscopic observations at the Valasske Mezirici Observatory switched from celestial phenomena to equally interesting phenomena on Earth. This phenomenon offered us an interesting comparison. Under laboratory conditions we are trying, in cooperation with colleagues from the J. Heyrovsky Institute of Physical Chemistry in Prague, to imitate the spectra glowing from the plasma of meteors by means of various attempts, particularly the shelling of meteorites using the lasers, creating laser sparks in the air or electrical discharges. This way astronomers could not regret that it is raining, nature has prepared another comparative experiment and allows the record of the lightning on spectrographic camera.

An interesting phenomenon, like a meteor or a powerful laser spark has created plasma and prepared this way a rich spectrum containing emissions of the hydrogen, nitrogen and oxygen lines. The figure below shows a comparison of the lightning spectrum with spectra obtained in the laboratory using a powerful Nd:YAG laser and a glow discharge. Nature has prepared for spectroscopic eyes a real harvest full of spectral lines. While in the laboratory laser spark reaches a temperature of around 10000 – 20000 real harvest full of spectral lines. While in the laboratory

Figure 3 – Snapshot of the spectrum of lightning 20160619_200130, this is the first picture (FR 15) of the lightning spectrum with an exposure time of 0.067 seconds. *Author: Valasske Mezirici Observatory.*

Figure 4 – Snapshot of the spectrum of lightning 20160619_200130, this is the second picture (FR 16) of the lightning spectrum with an exposure time of 0.067 seconds. *Author: Valasske Mezirici Observatory.*

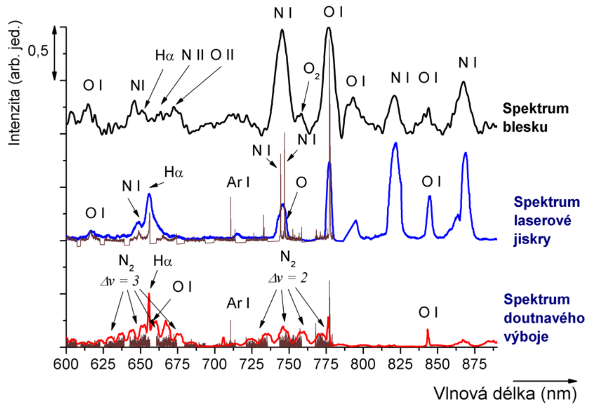

Figure 5 – Identification of the elements emission lines in the spectrum of the lightning 20160619_200130 (FR 15) – comparison of the spectrum of the lightning (black line) with a spectrum obtained in a laboratory of the J. Heyrovsky Institute of Physical Chemistry using a powerful Nd:YAG laser (blue line) and a glow discharge (red line). *Author: Martin Ferus*.

laser spark reaches a temperature of around 10000 – 20000 real harvest full of spectral lines. While in the laboratory laser spark reaches a temperature of around 10000 – 20000 K and the electric discharge generated by a voltage of 1500 V with an electric current of 1 A reaches a temperature of only up to 5000 K, lightning with a temperature up to 50000 K, with an electric current over 30000 A and with a voltage of hundreds of millions volts excite as electric discharge to the dazzling glow molecular nitrogen and oxygen (O2 and N2) and it breaks air and water vapor to atoms such as laser spark (HI, OI and NI) and also ripped electrons from hard ionisable nitrogen and oxygen, which shines in the spectrum in the form of lines of ions of N II and O II (*Figure 5*).

3 Conclusions

Recording of the lightning spectrum and its subsequent analysis seems to be a very useful tool for the main spectroscopic research, thus to analyze the spectra of meteors. The second level needed for subsequent analysis is a comparison of the spectra of lightning and TLE phenomena (Transient Luminous Events) captured using the spectrographs at the Valasske Mezirici Observatory with the results obtained in the laboratory of the J. Heyrovsky Institute of Physical Chemistry in Prague using powerful Nd:YAG laser and a glow discharge. This comparison of the results from a laboratory and real spectral measurements (meteors, lightning, TLE) allows more accurate identification of emission lines in the spectra taken by spectrographs at the Valasske Mezirici Observatory. The result of the analysis of the spectrum of lightning captured on June 19, 2016 ($20^h01^m30^s$ UT) is the identification of the hydrogen emission line in the spectrum of the previously analyzed bolide 20150812_232101, which belonged to Perseids meteor shower.

The analyzed spectrum of the lightning (*Figure 6*) type CC (there was a discharge between clouds) includes only the emissions of the elements contained in the Earth's atmosphere (Walker et al., 2014). Dominant in the analyzed spectrum are emission of OI-multiplet 1 (laboratory wavelength 7774 Å), OI-35 (7947 Å), OI-4 (8447 Å) and NI-3 (7442 Å), NI-2 (8223 Å), NI-8 (8629 Å), NI-1 (8683 Å). The identification of the emission lines of hydrogen H-alpha (6563 Å) or H-gamma (4341 Å) is very interesting as well as the emission lines of argon, for example Ar-1 (8115 Å) or emission lines of ionized elements, eg. OII-10 (4075 Å) or NII-31 (6610 Å).

Acknowledgment

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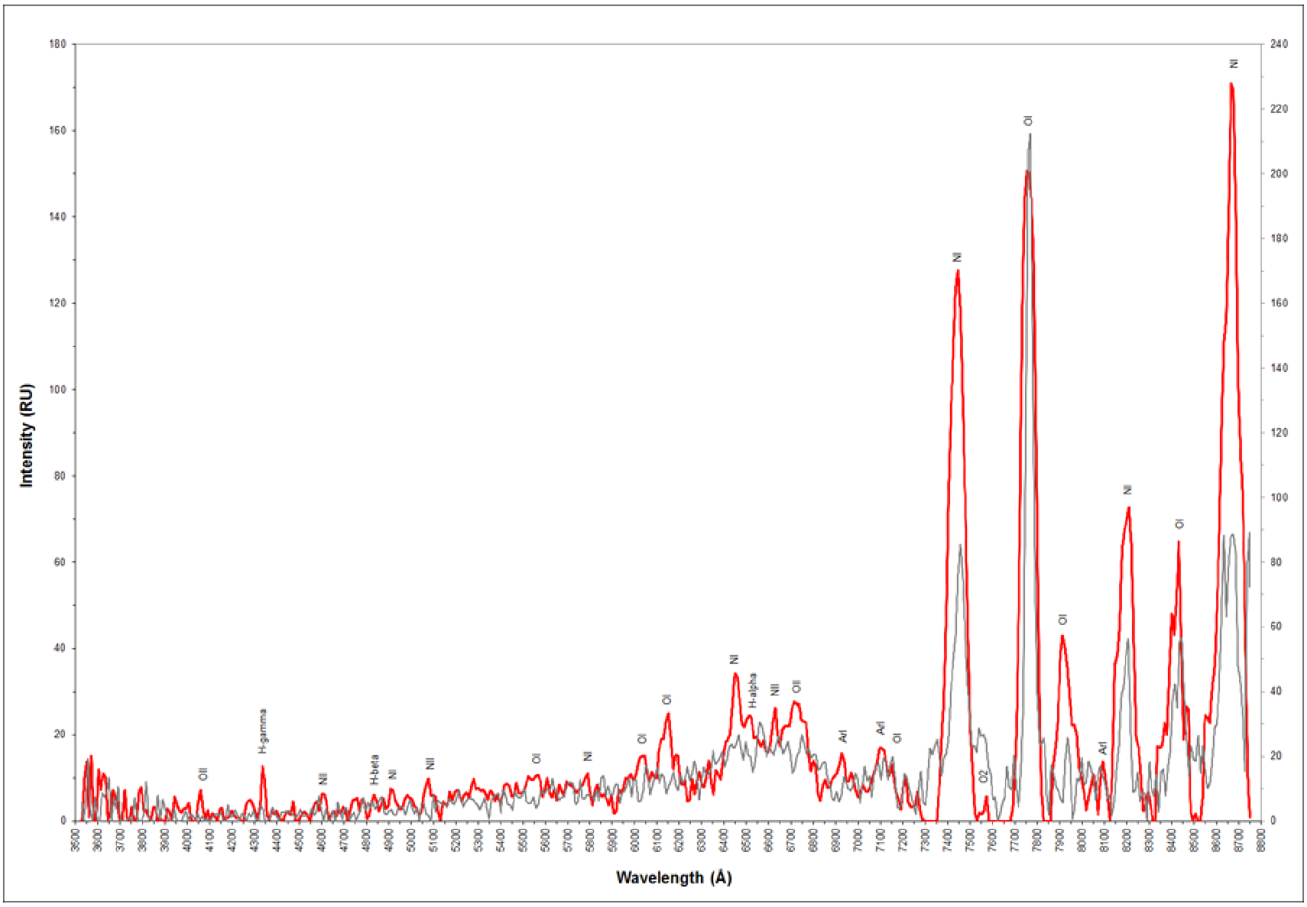

Figure 5 – Identification of the emission lines of the elements in the calibrated spectrum of the lightning 20160619_200130 – comparison of the intensity of elements emission lines in both captured images of the lightning spectrum (FR 15 – red line, FR 16 – gray line). *Author: Jakub Koukal.*

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IMC & CAMS meeting in Egmond, the Netherlands

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The 35th IMC broke a few records: the largest total number of participants, the largest number of presentations, both talks and posters and the thickest IMC Proceedings ever. After the IMC the Benelux CAMS group had its meeting in Egmond. A summary is presented of the highlights of this IMC and CAMS day.

1 Introduction

On Thursday the 2nd of June we had the first day of the 35th IMC at Egmond, the Netherlands. The first day is always very relaxed with plenty of time to chat with friends seeing each other again after one or more years.

The IMC host proved to be a very suitable accommodation for an IMC. About 160 participants gathered from 20 countries from all 5 continents. It is the first time that so many participants from all five continents were together at an IMC. The Local Organizing Committee had prepared everything very carefully and all arriving people were warmly welcomed by the LOC.

2 First day, Thursday 2 June 2016

The only official part of the IMC Thursday were the opening speeches. This took place in a very informal style. with Felix Bettonvil sketching the history of the Dutch Meteor Section (Werkgroep Meteoren). Felix referred to a publication of the late 1940's where meteor astronomy was described to be a domain where mainly amateurs could make useful contributions. Now so many years later, the situation changed and many professional scientists specialized into meteor astronomy. 1 on 3 of the IMC participants today is a professional scientist. After the official opening followed a happy hour with drinks for free at the occasion of the 70th anniversary of the Dutch Werkgroep Meteoren.

Figure 1 – Korado Korlevic (back), Tim Polfliet, Paul Roggemans and Pete Gural exchanging anecdotes. (Photo Adriana Roggemans).

3 Second day, Friday 3 June 2016

The second day of the conference had a day full of lectures, a poster session and optional parallel sessions from 9 am until as later as past 11 pm.

As many as 38 lectures were scheduled for this day. Beyond the lectures there was still time for informal contacts, but I did not like the program. Such heavy program was exhausting and limited somehow the socializing when people were too tired to stay for a chat and disappeared to relax.

The 2016 IMC program had all kinds of topics mixed without a real logic structure; hence if you were interested in some particular talks you were forced either to take a nap during those that were of no interest, or just to leave the conference room. I finally happened to be half of the lecture time outside to chat with people, unfortunately missing several talks I would otherwise have liked to hear.

Figure 2 – Eduard Bettonvil and the author at the poster about MeteorNews.org. (Photo Adriana Roggemans).

Figure 3 – During the coffee break, Eva Bujorova who had birthday during the IMC. (Photo Adriana Roggemans).

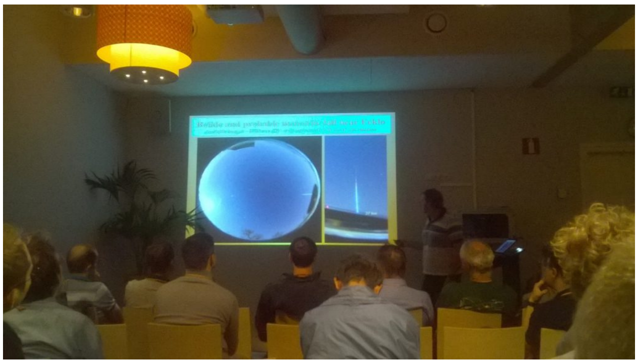

Figure 4 – Pavel Spurny during the late evening session about the meteorite dropping fireball over Belgium 25 March 2016 and the problems encountered to calculate the strewfield. (Photo Adriana Roggemans).

Another aspect of the 2016 IMC that I did not like was the limit of 12 minutes for each talk. When I had registered as participant I reserved 20 minutes for a talk, hence I prepared a compact talk to fit 20 minutes and spent a huge amount of time on calculations, checking literature and writing up conclusions. Just shortly before the IMC all talks were cut to 12 minutes what meant that most of my preparation work had been for nothing, impossible to present this in 12 minutes. If had known, I would not have prepared such talk. A happy few speakers got extra time to talk in evening sessions, but then most people were too tired and saturated to really pay much attention. There were many interesting topics, but except those extended in the evening, 12 minutes is too short for certain topics. Short talks are okay for short communications or very sketchy presentations, but not for all talks.

The IMC poster session for the first time took place outdoors as open air poster session which offered comfortable room for the large number of posters.

After dinner the participants got a late evening program, optional and rather few remained for informal socializing. The author skipped the very last late presentation as it was really too much to keep any longer attention. Moreover, time was almost up to enjoy some socializing.

4 Third day, Saturday 4 June 2016

A bit tired, we didn't bother anymore to be on time for the first talks. The 3rd day started with two sessions in the morning covering as many as 13 lectures.

At noon all participants got a lunch packet for the excursion. The 2016 IMC excursion brought us to the harbor of Den Helder where we all boarded on a large fishing boat to fish for shrimps. As it was a very sunny day the organizers had plenty of sun cream for anyone who had not foreseen these circumstances. While we could watch the fishing techniques for these shrimps, there was plenty of time for socializing. Once the first catch was taken on board, the fishes, crabs, etc. were separated from the shrimps, the shrimps were cooked and a little bit later everyone could eat the shrimps as fresh like nobody had eaten them before. The group photo of this IMC was made on the ship on while navigating on the Sea.

Figure 5 – Boarding the fishing boat for the IMC excursion. (Photo Adriana Roggemans).

We returned a bit sooner from the excursion than expected and everyone enjoyed the extra time for some more socializing. After dinner there were some more late evening options with more detailed presentations and a workshop. The official program ended with the announcement of the winners of the awards for the best poster and the best meteor photo.

Traditionally the last night of the IMC is the most entertaining, with guitar play and a lot of singing, the 2016 IMC continued this tradition. For some people this night was also time to say goodbye as some had to catch a plane next morning.

5 The Fourth and last day: Sunday 5 June

While the IMC continued with another rich program with still 11 more shortlectures and a summary overview, the author skipped the last day of this IMC as there was something more important and more useful for him as participant in the CAMS Benelux network: the annual CAMS day of the Benelux. Only few of all the CAMS operators had participated at the IMC, although the CAMS group represents many of the most active meteor workers of the hosting country and its neighbors, Belgium and Germany.

While most IMC participants enjoyed the last few hours of the IMC and some prepared to move on to the nearby Meteoroids conference, the CAMS participants started to arrive in Egmond.

Figure 6 – During the coffee break with Peter Jenniskens. (Photo Adriana Roggemans).

Figure 7 – Denis Vida during his talk. (Photo Adriana Roggemans).

6 The Benelux CAMS day in Egmond

The CAMS meeting had been scheduled after the IMC and in Egmond in order to be able to meet with CAMS experts Peter Jenniskens and Pete Gural from the USA and Denis Vida from Croatia. This created a unique opportunity to discuss technical matter with the people who are behind the CAMS project and the software.

Like usual the CAMS day was a highlight for many of the active video meteor workers in the Benelux.

7 The Proceedings of the 2016 IMC

Since nobody was interested to edit the 2016 IMC Proceedings, the IMC organizer Felix Bettonvil asked the author at some occasions, seen my past experience with 9 previous IMC Proceedings. Initially I declined because it became almost impossible to edit Proceedings in an efficient way, not being able to be in contact with authors, before the IMC. The author accepted to edit these Proceedings as late as 14 May, but on his strict condition to progress fast which was accepted by the IMC organizer. The Proceedings were ready on 17 July and shared from 24 July onwards.

Figure 8 – The cover design by the author which was officially acknowledged by the LOC on 15 June.

Outburst of July gamma Draconids

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The Gamma Draconids (GDR-184) displayed a noticeable activity this year in the night 27-28 July 2016. All observers and camera network operators were encouraged to check their records for this minor shower. The outburst has been confirmed by CMOR with an equivalent zenith hourly rate of 50/hour between 0 and 1 UT, July 28, 2016.

1 Introduction

Last few nights the weather was not favorable at all, but Benelux CAMS data registered a remarkable number of meteors from a minor shower γ-Draconids (GDR-184). Most of the CAMS stations were clouded out, the few that could function under partial clear sky had several meteors from this minor shower radiant.

The activity of this minor shower was first noticed by CAMS in July 2011 (Jenniskens and Holman, 2011). It wasn't new and was mentioned before by Babadzhanov (1963) and SonatoCo (2009). The activity appears typically between July 24 and 28 but can be detected until begin of August. With a radiant at α= 278°, δ = 49° and V_g = 25 km/s these meteors are real look-alikes of the later Kappa Cygnids. Also last year this stream popped up distinctly from the CAMS orbit data (*Figure 3*).

2 GDR activity 2016

On the mailing list MeteorObs several messages mentioned activity from the Omicron Draconids reported by visual observers. Also CMOR captured significant meteor activity from the GDR (184) radiant (see *Figure 2*).

From the CBET Telegram 2016, August 2 - Outburst of July gamma Draconids: While reducing the CAMS BeNeLux data of the partially cloudy night of July 27/28, including data from the new station by Jos Nijland, Martin Breukers noticed unusually strong activity from the July Gamma Draconids shower (IAU #184) between July 27 23^h56^m and July 28 00^h23^m UT. About half of all 126 single-station detected meteors, typically about +2 magnitude bright, radiated from this shower's radiant (see *Figure 1*), as did 5 out of 9 multi-station meteors. The median geocentric radiant position was R.A. = 279.88 +/ 0.12 deg., Decl. = +50.12 +/- 0.46 deg., with speed V_g = 27.31 +/- 0.09 km/s, corresponding to a Halley-type comet orbit with semi-major axis a = 27 +/- 4 AU, q = 0.977 +/- 0.002 AU, I = 39.9 +/- 0.2 deg., w = 202.7 +/- 0.5 deg., and node = 125.133 +/- 0.007 deg (J2000). The parent body is unknown. Confirmation comes from the Canadian Meteor Orbit Radar: Peter Brown reports that an outburst was detected centered on 0h UT with a Full-Width-at-Half-Maximum of about 2 hours and an equivalent zenith hourly rate of 50/hour between 0 and 1 UT, July 28.

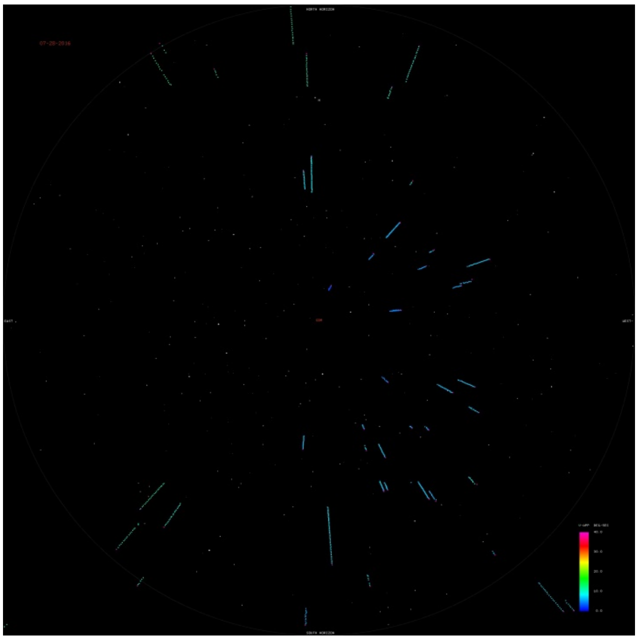

Figure 1 – CAMS BEnelux, all possible GDR meteor trails 27-28 July 2016 (Martin Breukers).

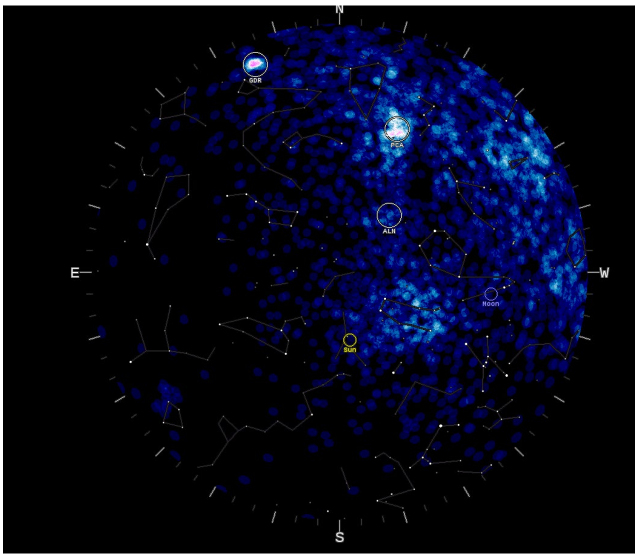

Figure 2 – The GDR (184) radiant pops out of the CMOR map 29 July ~20h UT.

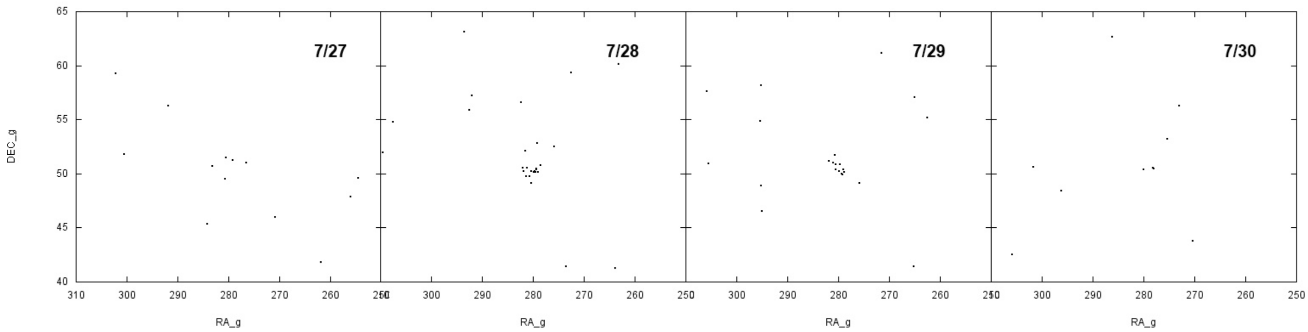

Figure 3 – GDR (184) radiants from CAMS in 2015 (P. Jenniskens).

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2016 Perseids: outreach video

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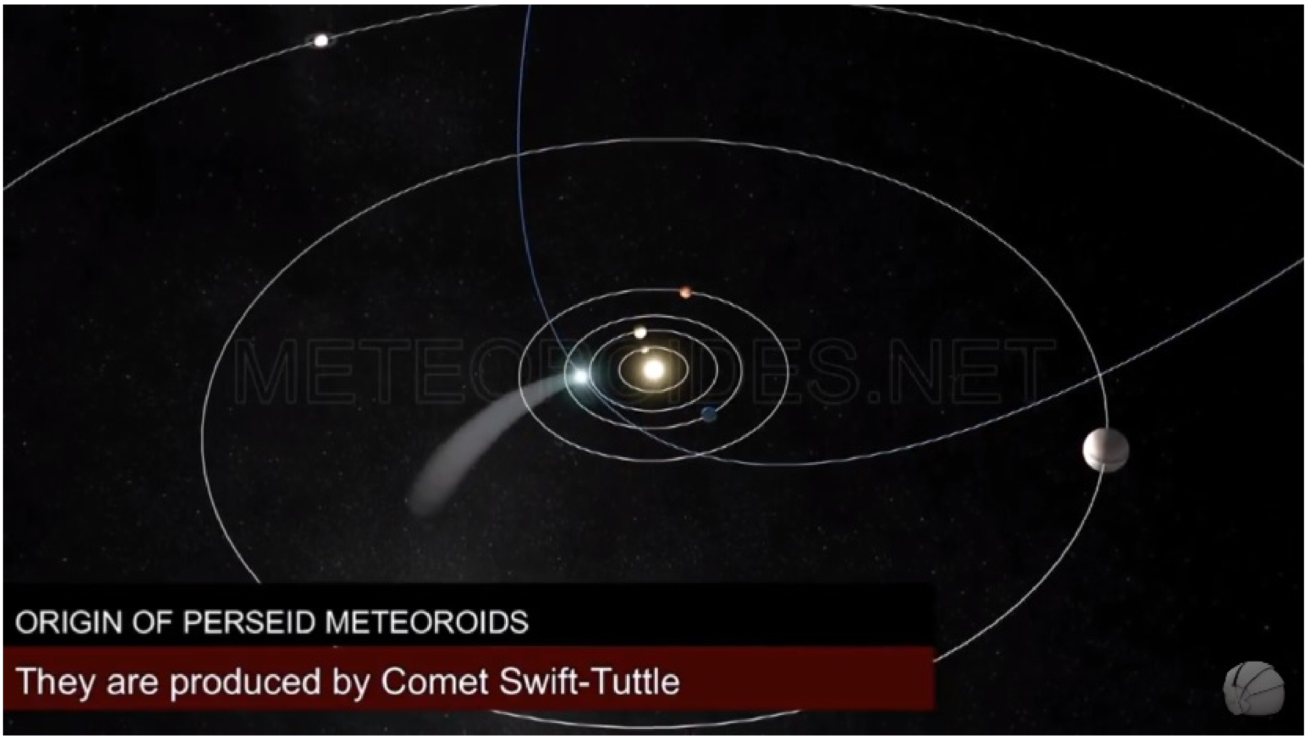
In order to promote the observation of the Perseids in August 2016 I have prepared an outreach video. The video contains computer animations and actual footage related to this meteor shower. It has been released by the University of Huelva and the Institute of Astrophysics of Andalusia in two versions: English and Spanish.

The link to the English version on Youtube is the following one: https://youtu.be/fG3WqQzWWAM

And you can view also the version in Spanish under this URL: https://youtu.be/cCyLiL3Cyto

Please share this video and help to promote meteor observing!



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