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Fireball over N-W Italy – 30 October 2016

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A –13 fireball has been observed in Northern Italy at 17h34m41s UT on 30 October 2016 The fireball was registered by video cameras of the Italian Meteor Group at 5 different stations. The trajectory above the Ligurian Sea could be calculated as well as the orbit in the Solar System.

1 Introduction

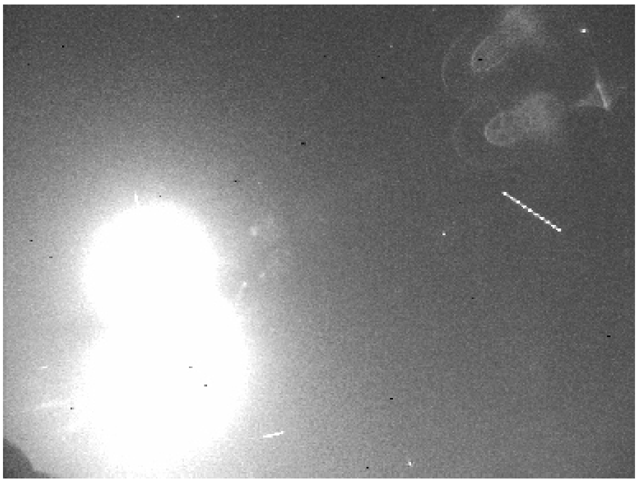
This fireball appeared at $17^{h}34^{m}41^{s}$ UT on 30 October 2016 above the Ligurian Sea.

At that time in central and northern Italy the nautical twilight was already finished, the Sun was at –17° below the horizon in the north-east and at –14° in the north-west. Due to the evening hour and to the brightness of the meteor, there have been many visual witnesses, most of them occasional.

The fireball was reported also visually by many people from France and Switzerland through the IMO fireball platform.

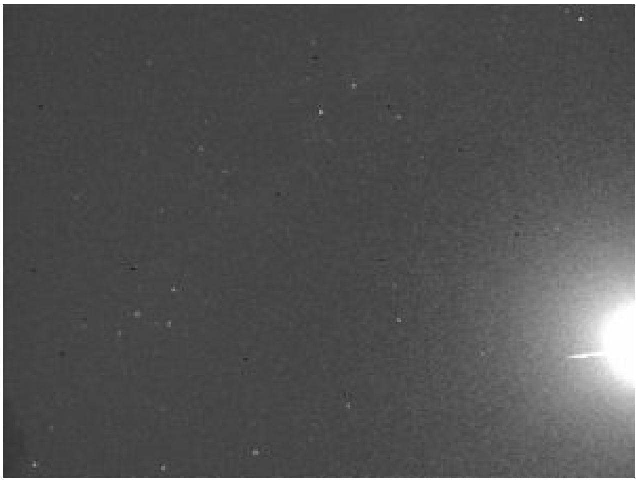
2 The observational results

All IMG-UAIsm[1] video cameras were operating, being already active as soon as the Sun reaches –8° below the horizon.



Five of the IMG video cams captured the fireball completely or partially: BILBO (*Figure 1*) and STG38 (*Figure 2*) from north-west, NOA38 (*Figure 3*), MET38 (*Figure 4*) and ROVER (*Figure 5*) from north-east Italy:

- BILBO cam, 44.55°N 9.04°E (obs: Stefano Crivello)
- STG38 cam, 44 .55°N 9.04°E (obs: Stefano Crivello)
- NOA38 cam, 45.56°N 12.11°E (obs: Enrico Stomeo)
- MET38 cam, 45.41°N 12.37°E (obs: Maurizio Eltri)
- ROVER cam, 45.86°N 11.00°E (obs: Fabio Moschini)



Even a photographic image (*Figure 6*) has been received from central Italy, from Lago Trasimeno (PG), 43.14°N 12.16°E (obs: Milena Pieri).

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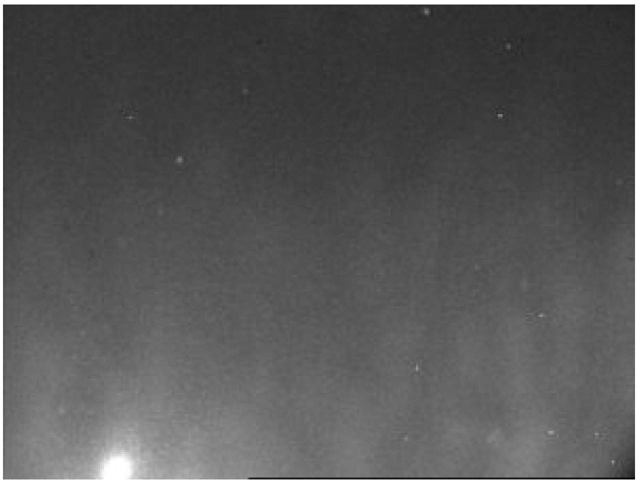
[1] Italian Meteor Group – UAI-Meteor Section: http://meteore.uai.it

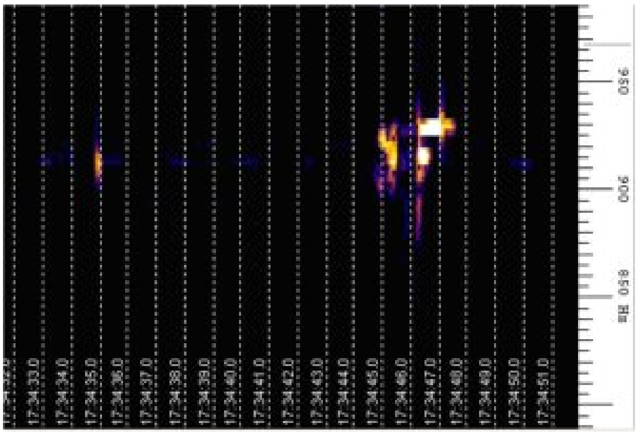


Three useful observations were selected from the Italian visual reports, including information about the fireball appearance:

- Report from Casole d'Elsa 43.31°N 11.14°E (obs: M.Cabibbo)
- Report from Verona 45.47°N 11.02°E (obs: M.Viviani)
- Report from Pontedera 43.66°N 10.65°E (obs: C.Casola)

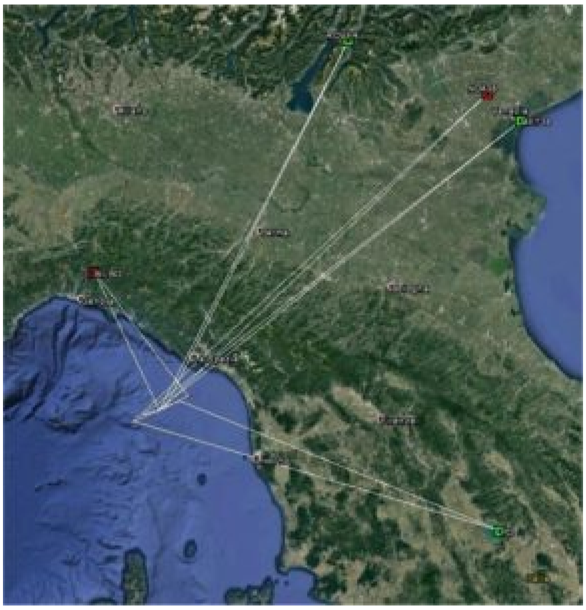
Most of the observations from France and Switzerland were not very useful, because these were too inaccurate or affected by errors due to the large distance.

The fireball was also recorded by the radio station located in Venice Planetarium (45.416°N 12.376°E). *Figure 7* shows graphically the persistence of the radio signal transmitted on the frequency 143.05 mHz from the Graves radar. The pulses were mirrored landwards by the atmospheric layers, ionized by the meteoroid.



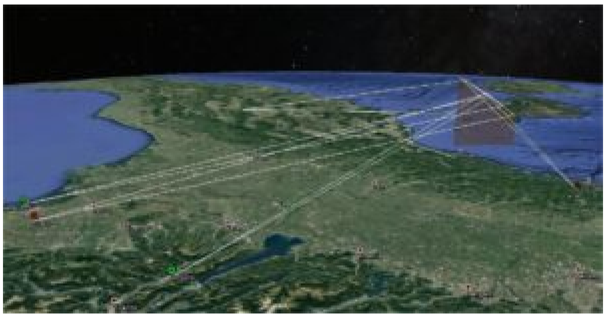
3 The triangulation results

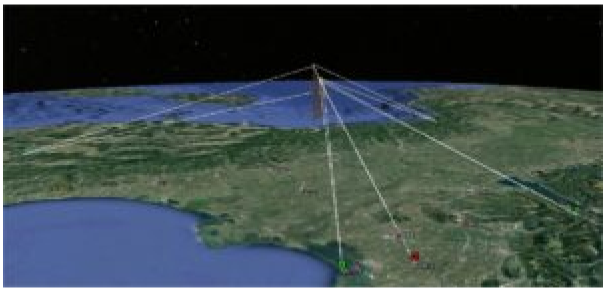
The map in *Figure 8* shows the projection on the ground of the atmospheric path of the fireball above the Ligurian Sea and the visual directions from the individual stations.

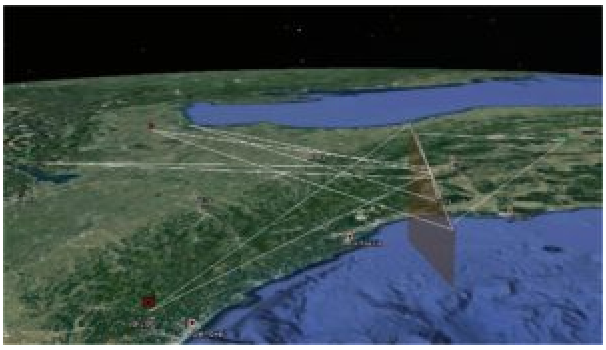


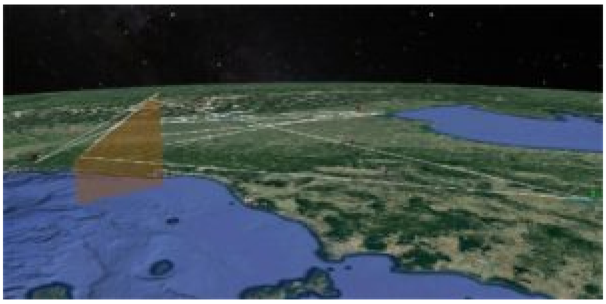
Calculations were performed with the IMG team software. Only the triangulations with high convergence angles and with low speed differences have been selected.

In the images below (*Figures 9-10-11-12*) the geometries of the atmospheric path of the fireball as seen from the north, east, west and south are indicated.









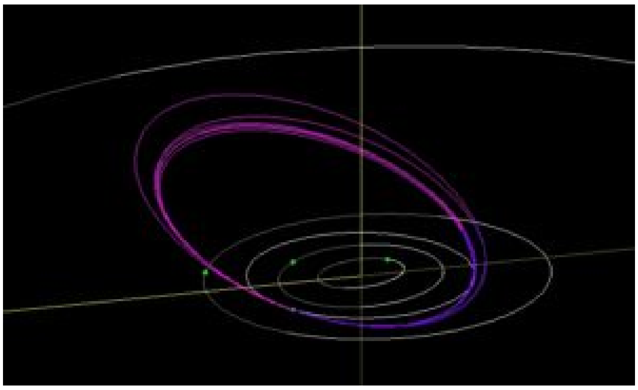
The best circumstances occurred for the BILBO and STG38 cams, which were closer and with the direction almost perpendicular to the plane of the meteor.

Combining the photographic data available, it appears that the meteoroid began to be visible in the atmosphere at an elevation of 92.3 km and ended at about 38 km height, after a sequence of explosions and spectacular flares, clearly visible in the video captured by BILBO[2].

The entire atmospheric path was situated above the Ligurian Sea from 43.91°N 9.90°E to 43.79°N 9.43°E, just south-west of the city of La Spezia.

The most likely values, which describe the atmospheric trajectory and the heliocentric orbit of the meteoroid are summarized below:

- Observed radiant (eq.2000):
  RA 9.0° DECL +44.9° (Andromeda)
- Geocentric radiant (eq.2000):
  RA 14.0° DECL +43.9°
- V_{obs}: 18.8 km/s V_g: 15.1 km/s V_h: 34.8 km/s
- $a = 1.54$ AU
- $q = 0.778$ AU
- $e = 0.494$
- $\omega = 249.8°$
- $\Omega = 217.5°$
- $i = 15.3°$



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[2] http://meteore.uai.it/b2016/20161030_173441_bilbo.mpg

Two slow meteors with spectra

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On January 2, 2017 two peculiar meteors (M20170102_001216 and M20170102_015202) were observed by several stations in Switzerland. Both had a long duration, slow velocity, similar brightness and a very similar radiant. As they appeared in a time interval of 100 minutes, a satellite was suspected as a possible origin of these two observations. A closer inspection however showed that this interpretation was incorrect. The two objects were slow meteors.
Spectra were taken from both objects, which were nearly identical. Together this points to a common origin of the two meteors.

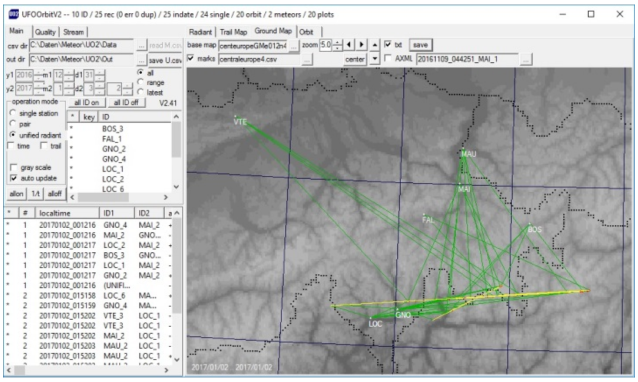
1 Equipment

A detailed list of the stations with their coordinates and equipment is given on our website[3].

2 Flight path, velocity

Four stations in Switzerland observed the first meteor; seven stations in Switzerland and Liechtenstein observed the second meteor. A map of the meteor stations of the Swiss network can be seen here[4].

With UFO Orbit the trajectories were calculated (see *Figure 1*).



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*		GNO_2
*		GNO_4
*		LOC_1
*		LOC_2
*		LOC_6

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*	1	20170102_001216	MAI_2	GNO...	-
*	1	20170102_001217	LOC_2	MAI_2	+
*	1	20170102_001217	BOS_3	GNO...	-
*	1	20170102_001217	LOC_1	MAI_2	-
*	1	20170102_001217	GNO_2	MAI_2	+
*	1	20170102_001216	(UNIFI...		-
*	2	20170102_015158	LOC_6	MA...	+
*	2	20170102_015159	GNO_4	MA...	-
*	2	20170102_015202	VTE_3	LOC_1	-
*	2	20170102_015202	VTE_3	LOC_1	-
*	2	20170102_015202	MAI_2	LOC_1	-
*	2	20170102_015203	MAU_2	LOC_1	-
*	2	20170102_015203	MAU_2	LOC_1	+

Figure 1 – The flight path of the two meteors as observed by the stations of the FMA in Switzerland and Liechtenstein.

The velocity v_0 was calculated as 12.8 to 13.9 km/sec for the first object, the second object had a v_0 of 13.0 to 14.3 km/sec. This is considerably higher than the escape velocity from the Earth, therefore a satellite orbiting the Earth can be definitely excluded.

Further analysis of the radiant and velocities showed a very similar orbit for the two meteoroids. The difference in flight direction is explained by the rotation of the Earth in 100 minutes, the fact that it was observed in almost the same location must be a pure coincidence.

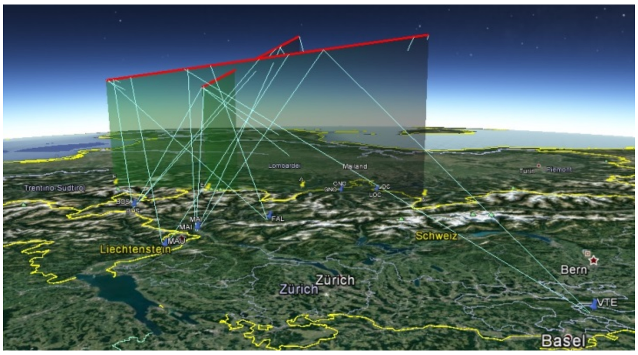
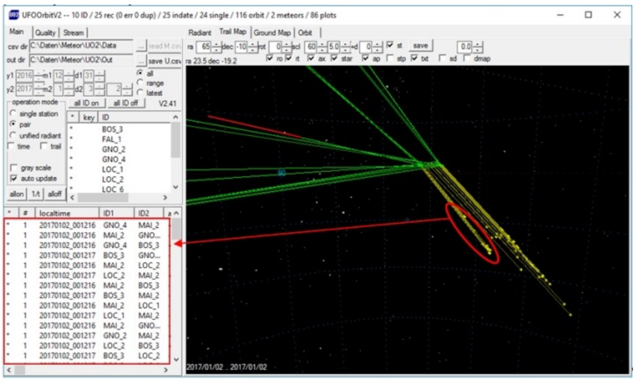


Figure 2 – 3D view of the meteor paths in Google Earth.

The different stations combined pairwise gave slightly different radiants, as shown in the following plot (the red circle and rectangle indicate the first meteor). The difference is probably caused by measurement errors.



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*		LOC_1
*		LOC_2
*		LOC_6

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*	1	20170102_001217	BOS_3	LOC_2

Figure 3 – Radiants of the two meteors. Green: observed great circle trajectories, yellow: correction to radiant for zenith attraction, due to the slow velocity and large zenith distance this correction is very large and variable for the scatter in velocity.

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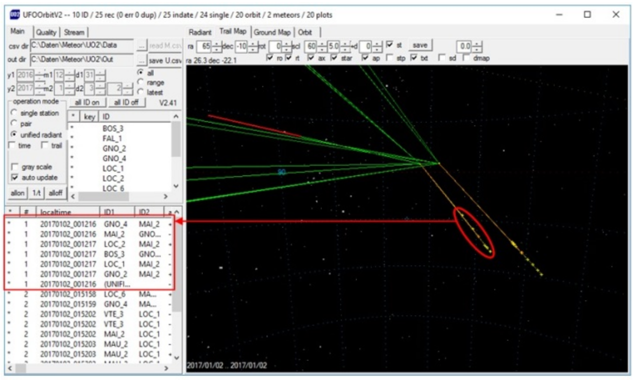
[3] http://www.meteorastronomie.ch/stationen.html

[4] http://www.meteorastronomie.ch/images/Karte_Beobachtungsstationen.jpg



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☑ ro ☑ rt ☑ ax ☑ star ☑ ap ☐ stp ☑ txt ☐ sd ☐ dmap
ra 26.3 dec -22.1
operation mode ○ single station ○ pair ◉ unified radiant
☐ time ☐ trail
☐ gray scale ☑ auto update

*	key	ID
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*		FAL_1
*		GNO_2
*		GNO_4
*		LOC_1
*		LOC_2
*		LOC_6

*	#	localtime	ID1	ID2
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*	1	20170102_001216	MAI_2	GNO...
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*	1	20170102_001217	LOC_1	MAI_2
*	1	20170102_001217	GNO_2	MAI_2
*	1	20170102_001216	(UNIFI...	
*	2	20170102_015158	LOC_6	MA...
*	2	20170102_015159	GNO_4	MA...
*	2	20170102_015202	VTE_3	LOC_1
*	2	20170102_015202	VTE_3	LOC_1
*	2	20170102_015202	MAI_2	LOC_1
*	2	20170102_015203	MAU_2	LOC_1
*	2	20170102_015203	MAU_2	LOC_1

Figure 4 – Unified radiant calculated for the two meteors. Again, the left points are from the first meteor, the right points from the second meteor, with the spread caused by the different velocities as observed from the different stations.

The orbit calculation for these two objects shows two ellipses with an inclination of 6 degrees to the ecliptic, nearly osculating to the Earth orbit. The measurement data of all the stations have been analyzed in detail by *Beat Booz*, giving independent results from UFO Orbit for the orbital elements.

Table 1 – Orbital elements

	20170102_001216	20170102_015158	Difference
a	2.0641	2.0659	0.0018
q	0.9649	0.9782	0.0133
e	0.5325	0.5265	0.06
P	2.965	2.969	0.004
i	6.603	6.346	0.257
ω	18.9176	10.0484	8.8682
Ω	101.558	101.627	0.069

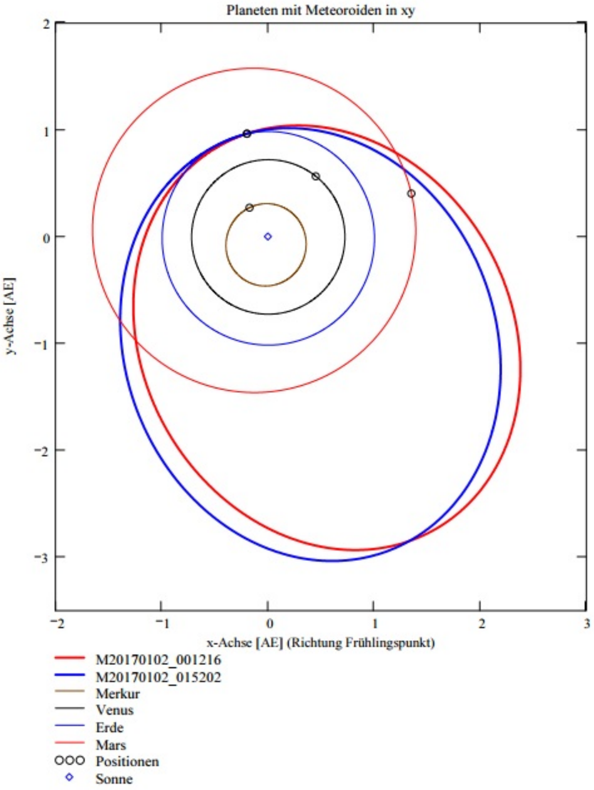

Figure 5 – Orbits of the two meteors.

Details of the calculation can be consulted online[5].

5 Spectrum, M20170102_001216_MAI_2P

Peak image, the flight direction is almost exactly parallel to the dispersion direction, zero order recorded for 3.6 sec, first order Na-line overlapping in the peak image.

Figure 6 – Spectrum (peak image extracted from video) of M20170102_001216_MAI_2, –1.3m.

6 Spectrum, M20170102_015202_MAI_2

Again, the meteor flight direction is almost parallel to the dispersion direction, zero order (left, recorded over 5.4 sec) and first order (Na-line, right) are separated. The meteor was visible for 8 sec in zero or first order.

Figure 7 – Spectrum (peak image extracted from video) of M20170102_015202_MAI_2, –1.8m.

The spectrum was extracted from the video as described in (Dubs and Maeda, 2016)[6], where the details of the extraction are described (separation of video into fields, background subtraction, linearization, registering and

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[5] http://www.meteorastronomie.ch/intranet/pdfarchiv/691483321922M20170102_015202_PLOT.PDF

[6] http://www.meteorastronomie.ch/images/20160605_Calibration_of_Meteor_Spectra_Dubs_IMC2016.pdf

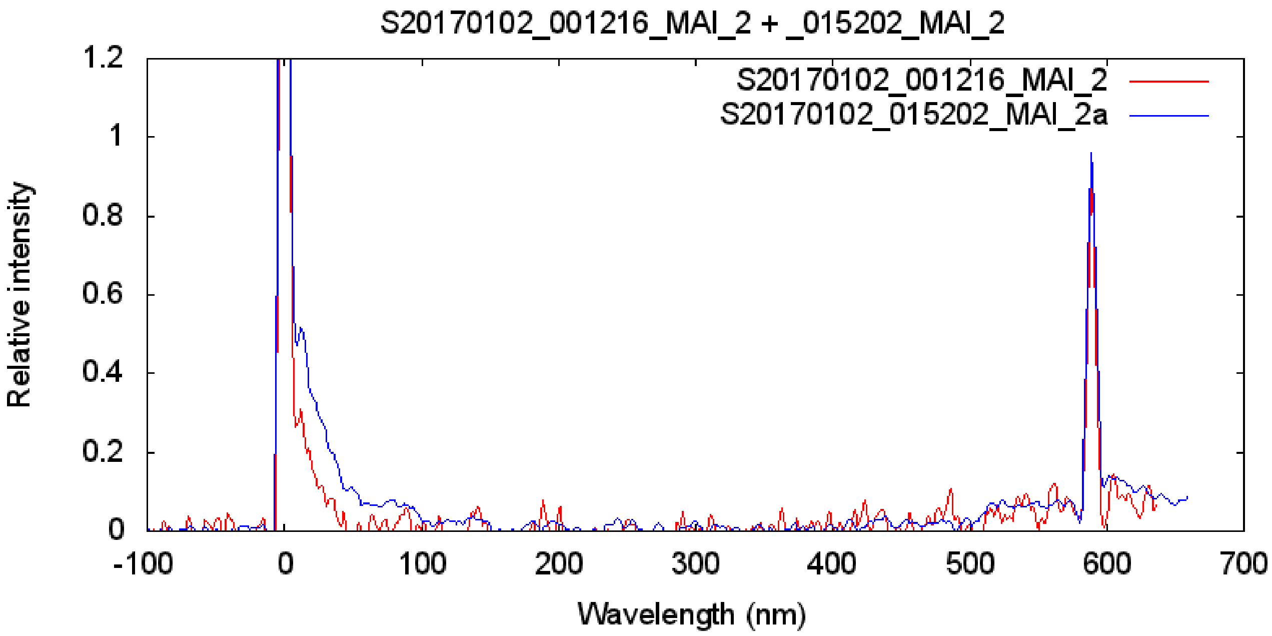

Figure 8 – Full spectrum including zero order of the two meteors. The meteor train shows as asymmetric zero order peak (Meteor moving to the left). Only prominent line: Na I (589 nm), used for calibration, plus weak continuum and train of Na-line. Both meteors showed a nearly identical spectrum.

stacking, wavelength calibration). Additional information on the calibration method can be found in (Dubs and Schlatter, 2015).

As the meteor entered from the right, at first only the zero order was visible (see movie[7])

Extracted spectrum from separated video fields, 185 fields added (3.7 sec). Red: first meteor; blue: second meteor, 100 min later (see *Figure 8*).

The meteor train to the right of the zero order peak, with possible fragment (*Figure 9*).

Figure 9 – M20170102_015202_MAI_2.jpg, 170 fields added after background subtraction, linearization and registration.

7 Spectrum M20170102_015202_GNO_6

A spectrum with similar equipment (Watec 902 H2 ultimate, f = 8mm, F/1.0, grating 600 L/mm) was recorded by *Stefano Sposetti*.

The spectrum was mirrored and then analyzed with the same procedure as the spectra from MAI. Both spectra show an asymmetric line shape for the zero order and the Na-line caused by the meteor train.

Figure 10 – Spectrum recorded at Gnosca. Meteor moving to the left, first order at other side of zero order compared to MAI_2, therefore the meteor train pointing in the other direction with respect to the spectrum. 50 fields added.

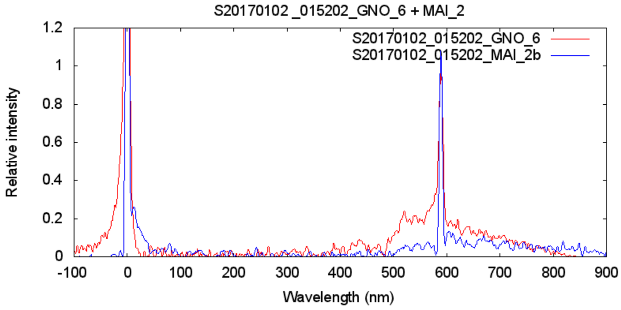

Figure 11 – Red: spectrum from GNO_6, meteor train at left of zero order and Na-line, fall off at high wavelength caused by the movement of the meteor out of image. Blue: spectrum from MAI for comparison.

8 Spectrum M20170102_015202_VTE_8

The third station in Switzerland equipped for spectroscopic observation which became recently active also captured the spectrum, at higher resolution, without zero order. A Sony alpha 7S II (ILCE-7SM2), equipped with a Canon 24mm, F/1.4 lens and a 600L/mm grating was used. Again the flight direction was almost parallel to the dispersion direction. The prominent Na-line also showed the train to the right of the line. The zero order was outside the image (to the left). In addition to the Na-line several Mg- and Fe-lines can be identified.

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[7] http://www.meteorastronomie.ch/intranet/videoarchiv/1221483321922M20170102_015202_MAI_2.MP4

Figure 12 – Spectrum (106 images linearized, registered and added) from VTE_8.

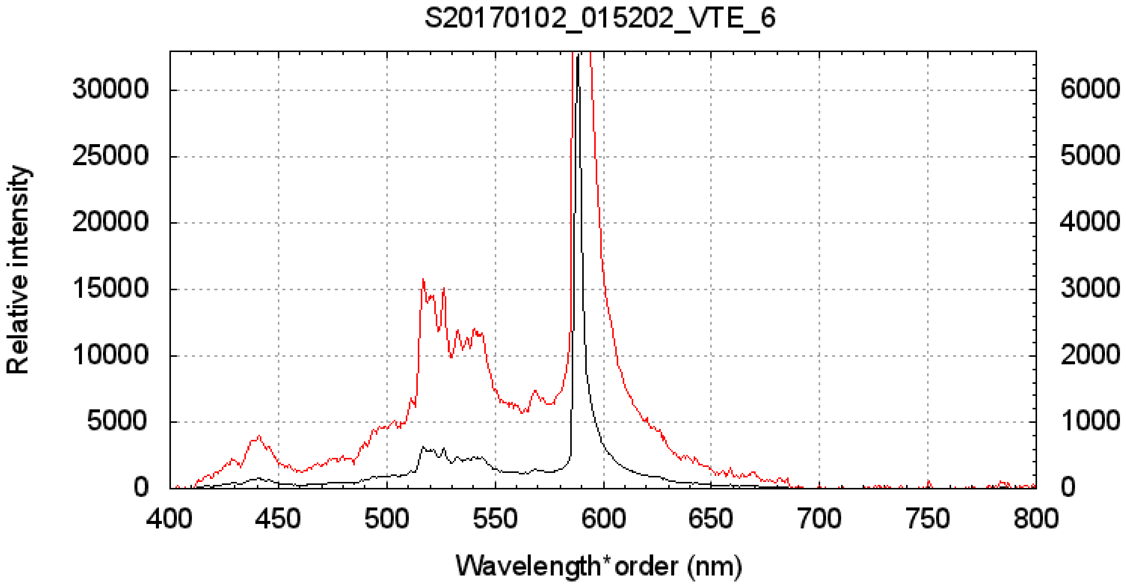

Figure 13 – Wavelength calibrated spectrum with expanded scale (red) to show the weaker metallic lines.

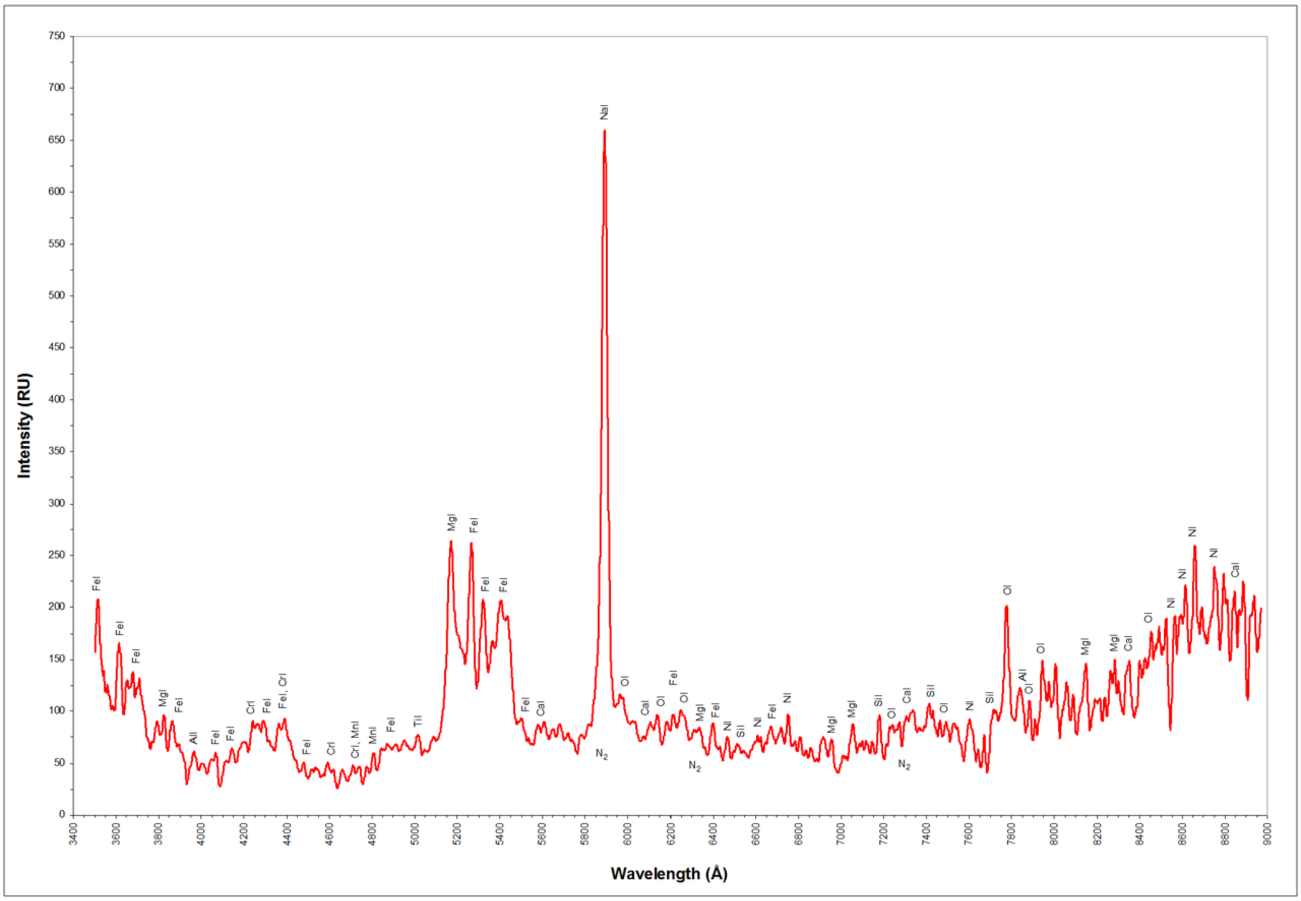

Figure 14 – For comparison the spectrum of M20160326_222332 recorded by Jakub Koukal.

There seems to be some difference in dispersion in comparison with the spectrum by J. Koukal (2016), (particularly at longer wavelengths). Notice also that our spectra have not been corrected for instrument response.

9 Conclusion

The Swiss meteor network of the FMA (Fachgruppe Meteorastronomie) is fully operational with stations operating video meteor cameras, All-Sky cameras, spectroscopic video cameras, (with radio, infrasound and seismic equipment in addition, which did not record the events presented here). That all three stations equipped with spectrometers recorded one of the two meteors is a happy coincidence, as the view angle of the three cameras is limited and the weather not always good on both sides of the Alps at the same time.

The similarity of the spectra and the orbits of the two meteors point to a common origin of the two meteors, which probably are fragments of a larger body which broke apart some short time ago (possible causes are thermal stress when approaching the Sun or collision with another meteoroid). The orbit does not coincide with a known meteor stream which could explain the common origin.

The spectra recorded by the three stations are very similar; the main characteristic is the dominance of the Na-line at 589 nm. This can be explained by the low velocity and the resulting low temperature of the ablation process (Borovicka et al., 2008). The differences in the relative intensity of the continuum or unresolved background of other metallic lines compared to the Na-line are in part caused by the different resolution of the spectra. In addition spectra have been recorded from different portions of the flight path, which may explain the remaining differences. The unfortunate coincidence of flight direction and spectrum dispersion and the prominent meteor train reduced the resolution of the spectra. The spectra were recorded at the detection limit, requiring the addition of all the frames in order to get a reasonable S/N. This may have reduced the resolution somewhat.

Acknowledgment

The following members of the FMA contributed additional data for the calculation of the meteor flight path:

- *Jose de Queiroz*, Falera (FAL)
- *Jochen Richert*, Bos-cha (BOS)
- *Hansjörg Nipp*, Mauren, FL (MAU)
- *Jonas Schenker* presented and collected the data on our website and stimulated us to publish the results.

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Fireball over Belgium 2017 January 3, 2h10m UT

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A bright slow moving fireball was observed by numerous casual witnesses, photographed by all-sky stations and captured at three CAMS stations. The trajectory and orbit could be determined. With an ending point at ~27 km height above Antwerp, Belgium, this bolide is considered as a possible meteorite dropping event. The dark flight and strewn field has been calculated and field searches have been organized.

1 Introduction

The night of 2–3 January 2017 was partially clear and allowed visual observers to watch for the Quadrantids while the CAMS network could capture many meteors. At 2^h10^m UT a –10 slow moving fireball appeared above the Benelux visible for 7 seconds. Few hours later messages started to appear on the Benelux meteor mailing list (Yahoo group Meteoren NV).

2 The observational data

Klaas Jobse: “last night a very nice slow bright fireball was captured in the South-East, duration on the video all-sky was 7 seconds”.

Michel Vandeputte: “It doesn’t often happen that I get out of the roof with a fireball occurrence, but this time at 02^h10^m UT, I did reasonable well ;-). Check your cameras! Moving from west to east along an extreme long track. I estimate about 8 seconds duration with multiple fragmentations along the trajectory, very colorful, magnitude –10 beyond doubt… A peculiar detail, 4 minutes later (2^h14^m UT) I heard a strong dull bang in the background… e.g. firework bang. Could this be a sonic boom so long after the appearance?”

Franky Dubois: “Worthwhile to get out of the roof! The most beautiful from my career: see *Figure 1*.

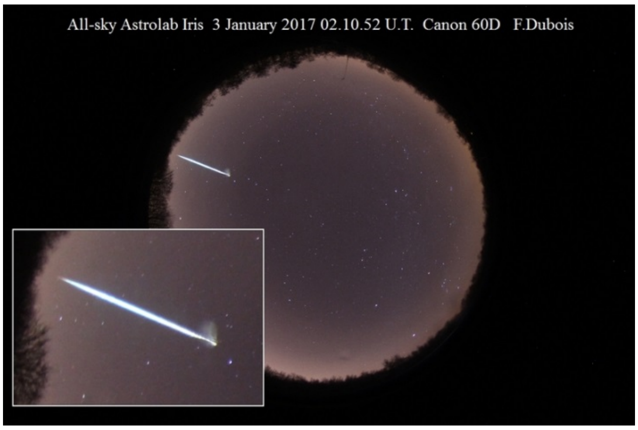

Figure 1 – Submitted by Franky Dubois – Astrolab Iris, Verbrandemolenstraat 5, Zillebeke, Belgium. The camera is a Canon 60d, the lens is 8mm fisheye (Canon). The exposures are 45 sec iso 800.

Checking out the CAMS registrations of this night, *Paul Roggemans* got the end of the fireball on CAMS 389 at Mechelen (BE), displaying a remarkable splitting of the fireball trail after its final last flare (see *Figure 2*). Luc Gobin captured the start of the fireball with multiple flares on CAMS 390 and 391 also at Mechelen (BE) (*Figure 3 and 4*).

Figure 2 – The picture from CAMS 389 with the final last flare and a remarkable split of the luminous trail.

Figure 3 – CAMS 390 with the start of the fireball and first flares captured at Mechelen by Luc Gobin.

Figure 4 – CAMS 391with the start of the fireball and first flares captured at Mechelen by Luc Gobin.

3 Preliminary analyses

Meanwhile both CAMS and the All-sky data allowed some preliminary analyses.

Figure 5 – All sky registration in Oostkapelle (NL), by Klaas Jobse.

Carl Johannink could derive the exact time of the appearance at $02^h10^m49^s$ UT. CAMS allowed a trajectory and orbit calculation between CAMS 339 (Klaas Jobse, Oostkapelle, NL) and CAMS 390 and 391 (Luc Gobin, Mechelen BE). The data of CAMS 389 with the final part of the fireball was not taken into account by the CAMS coincidence software. The reason why is not yet clear, but the CAMS project is designed for fainter meteors and has often problems to obtain accurate positions from overexposed flares. The fireball trajectory started at 89 km above Roeselare in Belgium and the last position from CAMS (339–390/391) was at a height 51 km about 15 km east of Gent (BE). The radiant was situated ~3° south of γ Ori. The geocentric velocity was 11.3 km/s. The orbital elements:

- $q = 0.876$ AU
- $e = 0.513$
- $i = 6.3°$
- $\omega = 47.3°$

Marco Langbroek analysed the all sky pictures from Ieper (BE) and from Oostkapelle (NL). The begin height from the all-sky pictures was 80.9 km and the end height 30.1 km above Ekeren near Antwerp. Since no velocity information is available from the all-sky data, nothing can be said about the deceleration, mass or possible dropping of any remnants. The path is plotted in Figures 6 and 7.

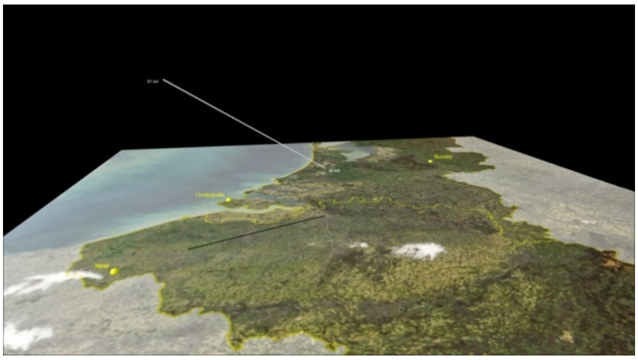

Figure 6 – The fireball trajectory, preliminary result obtained by Marco Langbroek from the all-sky registrations.

Figure 7 – The fireball trajectory, preliminary result obtained by Marco Langbroek from the all-sky registrations.

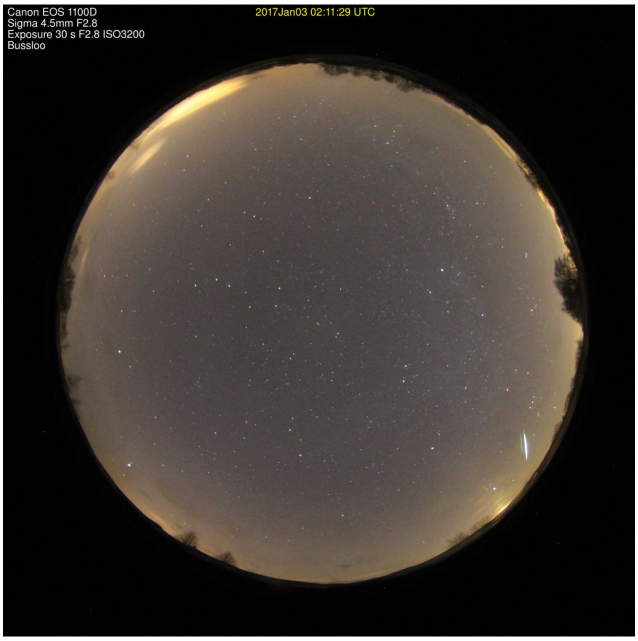

Figure 8 – All sky registration in Bussloo (NL), by Jaap van 't Leven.

A more detailed analyses from the combined data of CAMS and the All-sky stations will be made in order to fine-tune the results on this event.

4 More results

Marco Langbroek calculated the velocity profile from the CAMS data (*Figure 9*), but CAMS data was not taken into account for the trajectory and radiant. Some ending heights:

- Oostkapelle 30.6 km (all-sky)
- Ieper 28.9 km (all-sky)
- Bussloo 27.8 km (all-sky)
- Mechelen 27.0 km (CAMS), at this height the velocity was 2.9 km/s.

Observed values:

- $\mathrm{RA}_{\mathrm{obs}}$: 86.3 ± 0.1°
- $\mathrm{Dec}_{\mathrm{obs}}$: +12.1 ± 0.1°
- $\mathrm{V}_{\mathrm{inf}}$: 16.68 ± 0.1 km/s

Geocentric values:

- $\mathrm{RA}_{\mathrm{geo}}$: 79.6°
- $\mathrm{Dec}_{\mathrm{geo}}$: +3.6°
- $\mathrm{V}_{\mathrm{geo}}$: 11.33 km/s

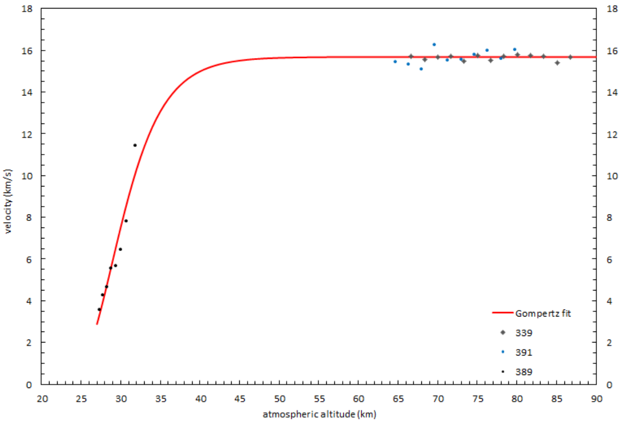

Figure 9 – Velocity profile calculated by Marco Langbroek for CAMS 339, 389 and 391.

Orbit:

- q = 0.8742 AU
- a = 1.7826 AU
- e = 0.5096
- i = 6.241°
- ω = 47.839°
- Ω = 10206572°
- Π = 150.50°
- Q = 2.69 AU
- P = 2.38 year

From the deceleration Marco calculated a terminal mass between 0.2 and 0.5 kg, a stone of 4 to 7 cm diameter. However, the CAMS measurements are based on only one of the two visible fragments. Therefore we may assume that more fragments of this size (0.2–0.5 kg) were dropped and that a total mass of 0.5–1 kg is more likely.

Damir Šegon offered to go manually through the CAMS 389 data and could distinguish a third and a fourth fragment. *Pete Gural* calculated the CAMS data for the manually measured positions and *Peter Jenniskens* could recalculate the strewn field based on the trajectories of the 4 fragments (see *Figure 10*).

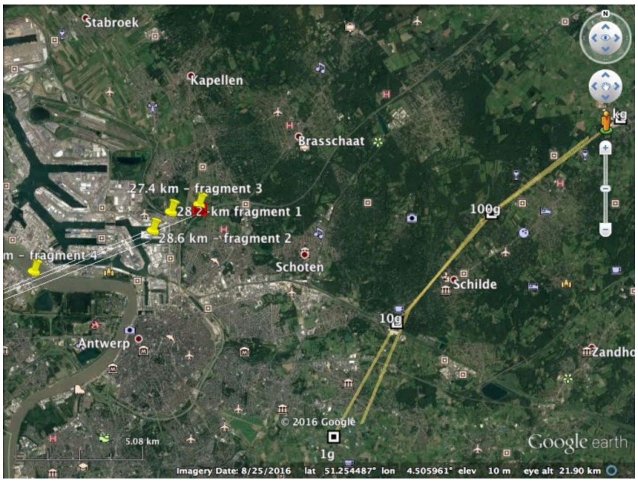

Figure 10 – Strewn field calculated by Peter Jenniskens based on the measurements provided by Damir Šegon and Pete Gural.

5 Field searches

Since 29 January 2017 *Jean-Marie Biets* has organized a number of field searches. The first search with about 10 volunteers was unsuccessful while the next attempts had too few volunteers.

Although a large part of the strew field consists of farm land, some parts are residential areas with private gardens and inaccessible domains. Without help from local habitants via newspapers or authorities a successful recovery of any meteorites is almost impossible. To search farm land many more volunteers are necessary than what a small group of amateur astronomers can do.

Fireball captured on video by EXOSS Stations at Espirito Santo's Brazilian state

Marcelo De Cicco

`decicco10@gmail.com`

A fireball occurred on 2017 January 9, 12h41m UT and was registered by the Exoss network.

1 Introduction

New Year has only begun and we have good news! We got a fireball video with many eyewitnesses. It occurred on 2017, January 9th at 12^h41^m UT. This event was recorded by two Exoss project stations at different cities, Colatina and Vitória (ES – Capital), by the Exoss associates Luciana Fontes and Willian Eugênio.

2 Some results

As the bolide images were captured double station, the parallax calculation could be applied and the resulting trajectory data offered more accurate results than the bolido.exoss.org report tool.

Figure 1 – Exoss station on Espirito Santo state recorded a meteor fragmentation above Minas Gerais state Skies.

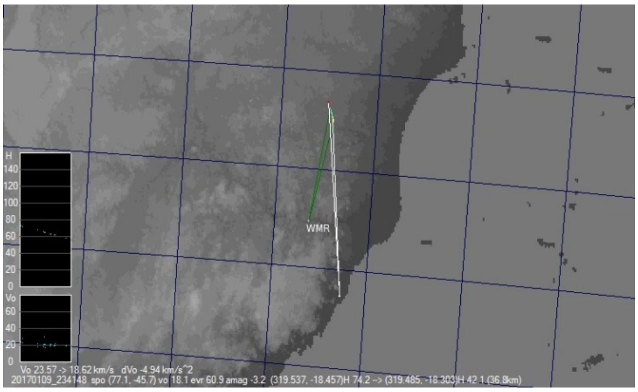

Figure 2 – The trajectory.

First, the radiant had been calculated as Epsilon Columbids (98 – ECO, IAU-code). After a more accurate recalculation, using quality criteria, the bolide was classified as a sporadic. The following features were determined:

- Mean observed velocity: 18 Km/s;
- Deceleration : -4.92 km/sec;
- Trajectory duration : 2,3 sec (the trajectory was not completely included);
- Trajectory length: 48,2 Km.

The event presented an unusual peculiarity with multiple fragmentations eye witnessed by observers. Unfortunately, the Exoss cameras did not registered it, because the final trajectory was not recorded.

Figure 3 – A 3D view of the fireball trajectory.

Long grazing and slow fireball over Portugal

Carlos Saraiva and Rui Gonçalves

Carlos.saraiva@netcabo.pt

A grazing fireball was captured by cameras of the Portuguese Meteor Network on 2017 January 20, 0h32m UT.

1 Introduction

A long and fast trail grazing meteor with an absolute magnitude estimated of –2, was captured on 20 January under clear sky condition by three PMN (Portuguese Meteor Network) systems; TEMPLAR5 (*Figure 1*), TEMPLAR2 (*Figure 2*) and TEMPLAR4 (*Figure 3*).

2 Some results

The meteor started in the East (Templar5 at 00:03:32-35), crossed from left to right through Templar2's entire field at south (00:03:34-37) and ended at southwest at Templar4's field (00:03:37). Rui Gonçalves has calculated the trajectory, but unfortunately the meteor had traveled through PMN gaps, and only his systems caught this event. Systems from southern Spain were under clouds. The baseline between Templar5 and Templar2 and 4 is only 9 km which is too short.

Nevertheless, the trajectory seems correct (with interception plane's angle of 1.8°) and 0.0° horizontal angle. UFOrbiter gives roughly the same result. The meteor was detected from 106.6 km to 113.0 km with an initial velocity of about 66.0 km/s. The velocity remains almost constant with small increase (?!). The estimated photometric mass is very small (about 1 g).

At start, the altitude is decreasing (for just 0.32 s) then the altitude increases until the meteor vanished after a flight of about 300 km in the course of 4,6 s. The light curve value also decreases as the meteor interacts less and lesser with the thin upper Earth atmosphere.

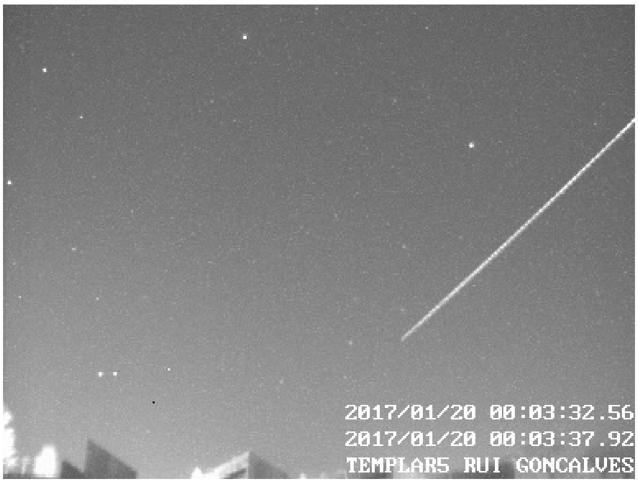

Figure 1 – TEMPLAR5 summed image (IPT-Tomar).

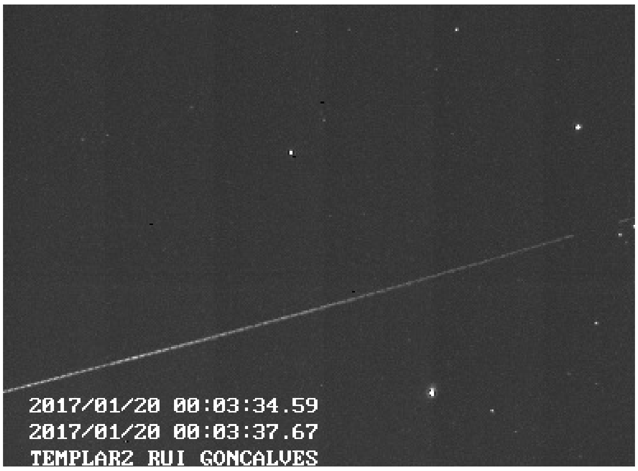

Figure 2 – TEMPLAR2 summed image (Linhaceira-Tomar).

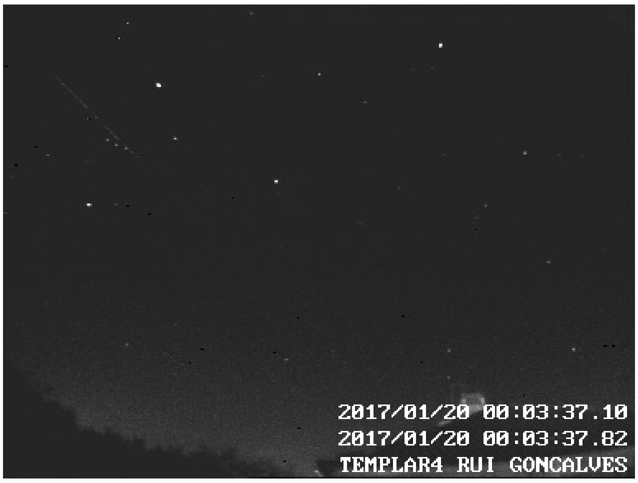

Figure 3 – TEMPLAR4 summed image (Linhaceira-Tomar).

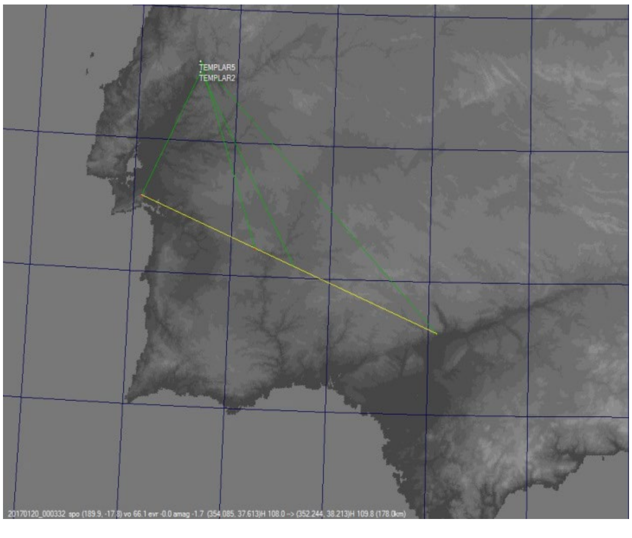

Figure 4 – Ground projection from UFOrbit software.

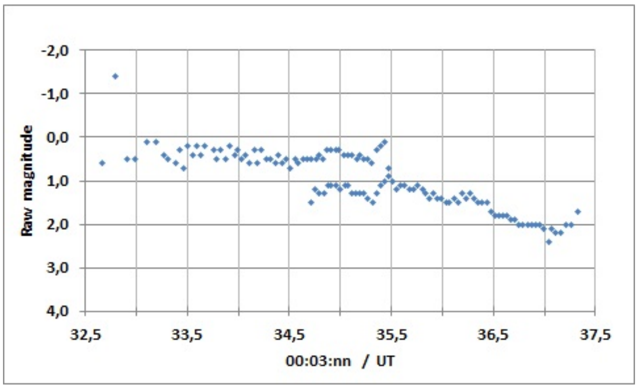

Figure 5 – Magnitude raw data from Templar5, 2 and 4.

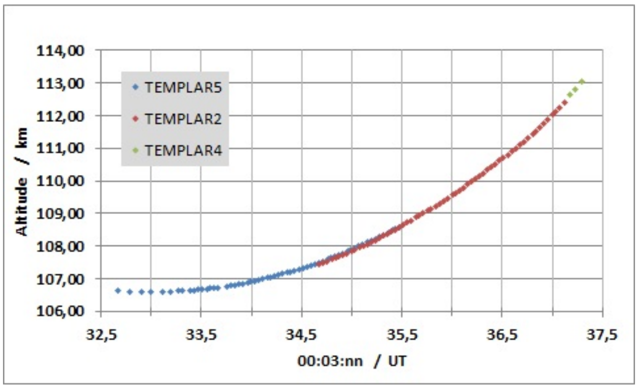

Figure 7 – Altitude versus time.

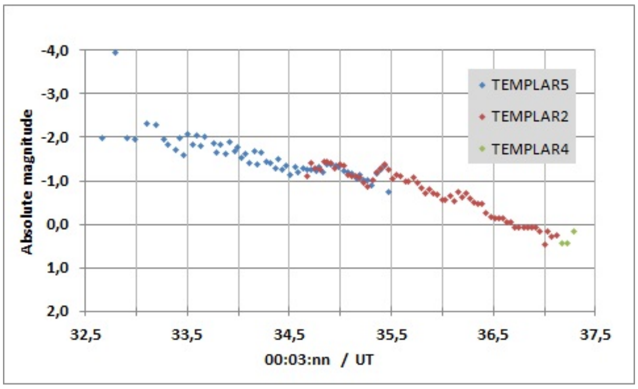

Figure 6 – Absolute Magnitude data (instrumentally corrected) from Templar5, 2 and 4.

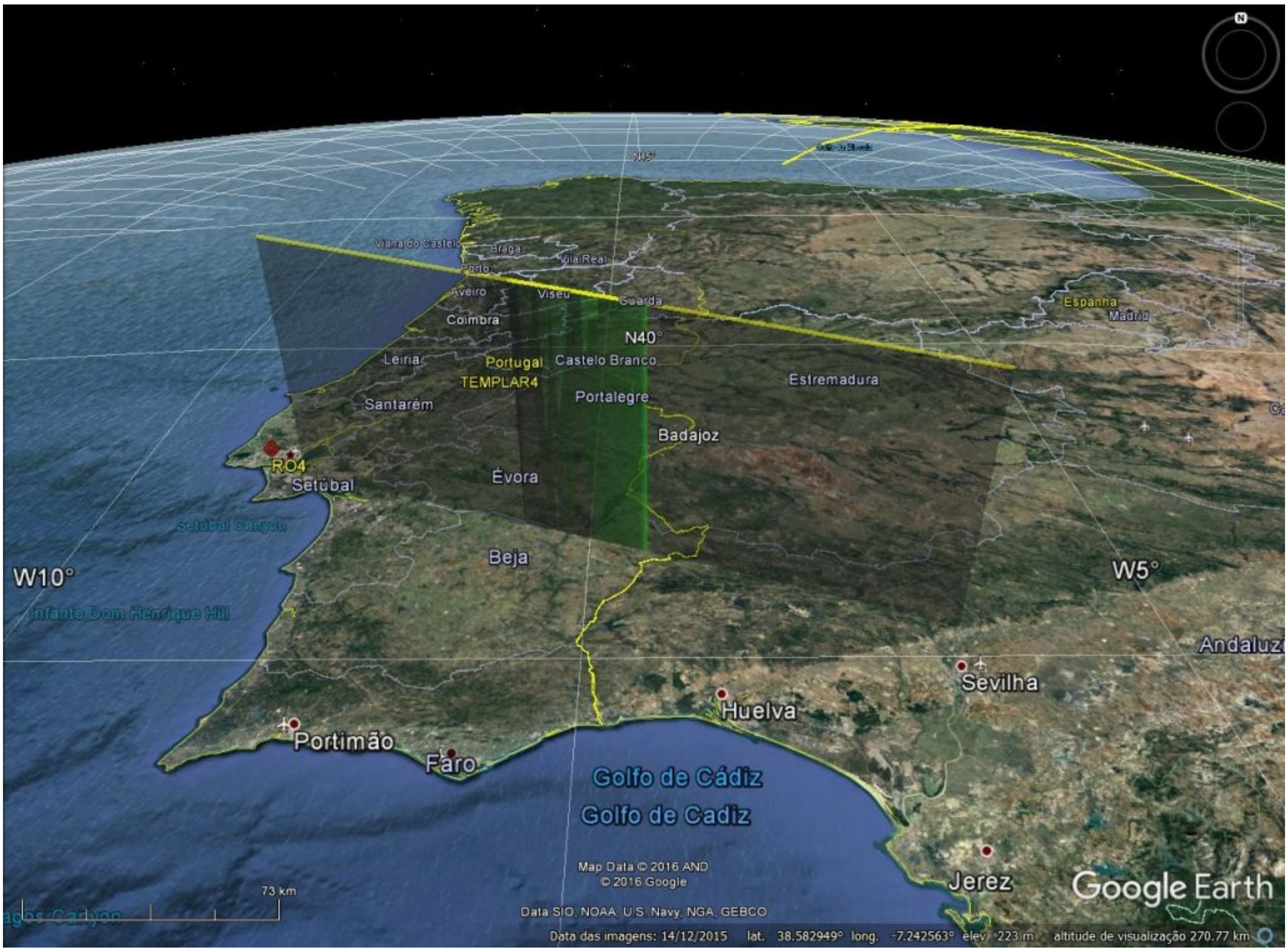

Figure 8 – Fireball atmospheric trajectory over southern Spain and Portugal.

Another fireball captured by Portuguese meteor network cameras

Carlos Saraiva and Rui Gonçalves

`Carlos.saraiva@netcabo.pt`

A fireball occurred over Portugal on 2017 January 22 and its trajectory could be calculated.

1 Introduction

Another fireball crossed the sky in the night 21–22 February over Portugal. It was registered by TEMPLAR4 and RO2 systems from Portuguese Meteor Network (*Figures 1 and 2*).

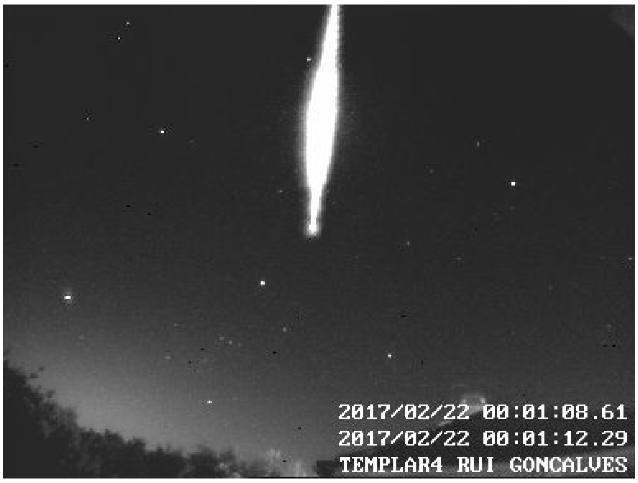

Figure 1 – The fireball captured by Templar4.

Figure 2 – The fireball captured by RO2.

We were able to compose two MPEG videos from individual BMP frames from each camera (videos 1 and 2).

- http://meteornews.org/wp-content/uploads/2017/02/T4.mp4
- http://meteornews.org/wp-content/uploads/2017/02/SPO20170221.mp4

2 Some results

Rui Gonçalves calculated its initial velocity as being 58400 m/s, beginning at 117,1 km high and ending at 76,4 km (*Figures 3 and 4*).

With a negligible mass its magnitude was estimated to be –2,7 according to Sirko Molau's MetRec software, but we think its true magnitude was underestimated.

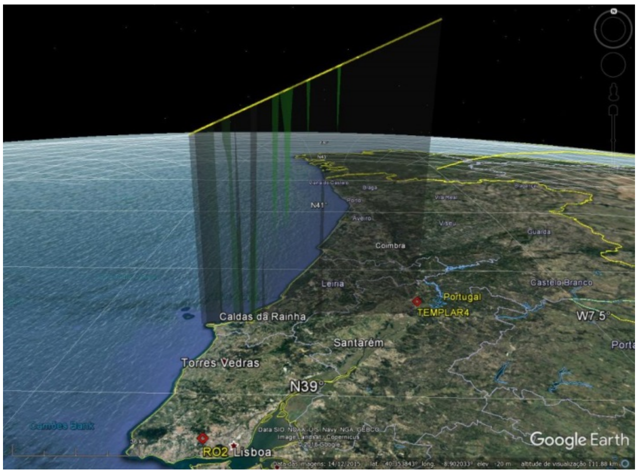

Figure 3 – A 3D reconstruction of the fireball trajectory.

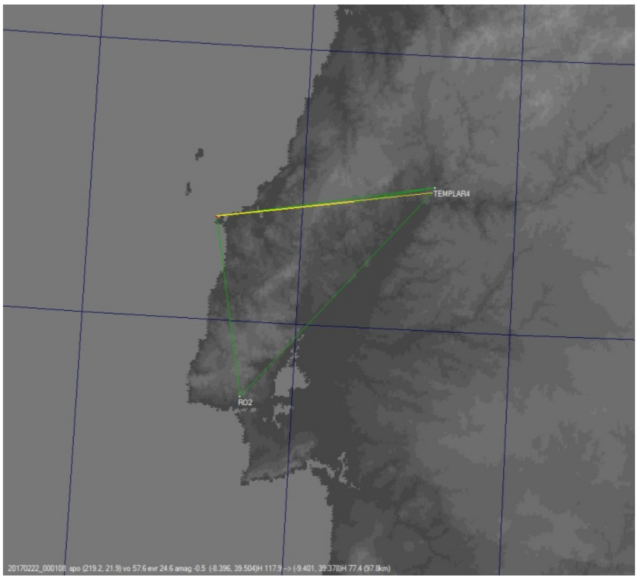

Figure 4 – The path of the fireball projected on the Earth surface.

Fireball events

Compiled by Paul Roggemans

paul.roggemans@gmail.com

An overview is presented of exceptional fireball events which got covered in Meteor News during the period January – February 2016.

1 Quadrantid Fireball over Denmark, 2017 January 3, 20h17m00s UT

A bright Quadrantid fireball has been photographed by several cameras of the Danish Meteor Network.

Figure 1 –

Figure 2 – Camera from Hobro, Denmark.

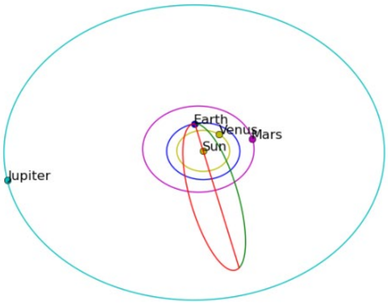

Figure 3 – The orbit of the meteoroid that caused this fireball.

The fireball started at 106 km height and ended at 69 km, with a velocity of 42 km/s, from a radiant at R.A. 230.2° and decl. 49.2°. The orbit fits well with the Quadrantid Meteor Shower.

For more details, please check out online[8].

2 Fireball over Denmark, 2017 January 20

A bright slow moving fireball was captured above Denmark at $06^h12^m50^s$ UT. It started at 78 km and ended at 50 km elevation with an entrance angle of 14°. The velocity was 19 km/s and the radiant was sporadic with R.A. at 132.3° and decl. +5.1°.

Figure 4 – The photo was registered at Hobro, Denmark.

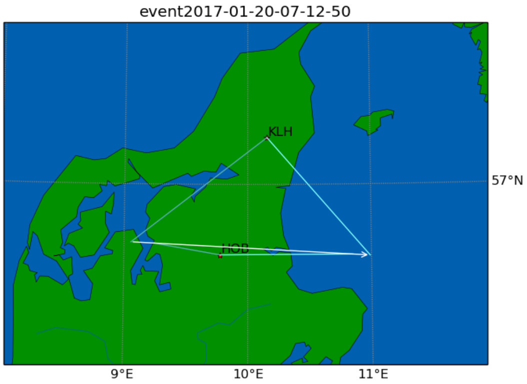

Figure 5 – The fireball path projected on the map.

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[8] http://stjerneskud.info/fb/event2017-01-03-21-17-00/

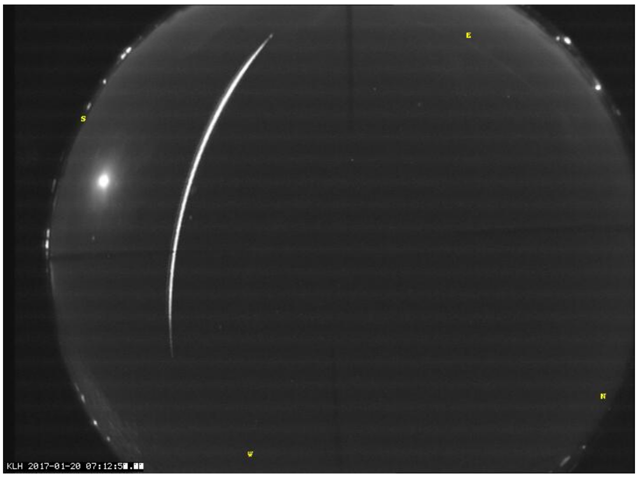

Figure 6 – The fireball registered at Klokkerholm, Denmark.

The orbit was of an asteroid type with:

- q= 0.545 AU
- e = 0.467
- i = 6.8°
- ω = 113.6°
- Ω = 120.2

The video can be from both camera stations can be viewed from:

- http://stjerneskud.info/fb/event2017-01-20-07-12-50/klh.avi
- http://stjerneskud.info/fb/event2017-01-20-07-12-50/hob.avi

3 Fireball with meteorite fall WI, USA

Galactic Analytics reports on a major fireball event on 2017 February 6, at 7h25m UT, seen and filmed from various locations in Indiana, Illinois, Michican, Wisconsin and Ohio. A meteorite felt near Sheboygan, WI, and was registered by radar. For meteorite hunters: bring your swimming gear as it felt into Lake Michigan!

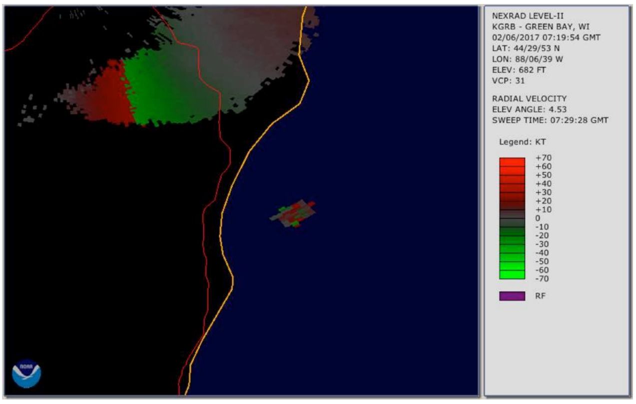

Figure 7 – Weather radar captured the position of the meteorite dropping.

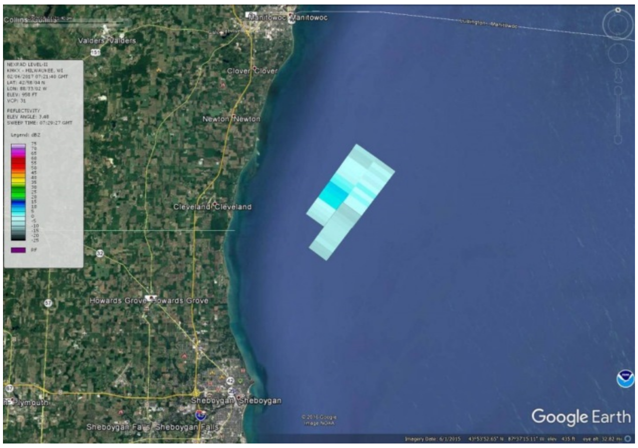

Figure 8 – First two scans from Milwaukee Doppler radar.

- https://youtu.be/LHubXCtdEbo
- https://youtu.be/-AozuKJZK_4

New tool to visualize meteor streams for CAMS

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An online app has been made available to render meteor streams visible in 3D. The tool can be used on the CAMS website.

1 Introduction

Peter Jenniskens announced an impressive tool on the website of CAMS (http://cams.seti.org/) to visualize meteor streams in 3D. The tool has been designed by the software engineer Ian Webster for the visualization of CAMS data. You can display all showers that were identified in the March 2013 release, including the sporadic background! You can drag the point of view with your cursor to change the perspective, select different showers or zoom-in and out. Below are the Quadrantids, currently active for northern hemisphere observers.

Perfect tool to demonstrate meteor showers to the public. Have fun!

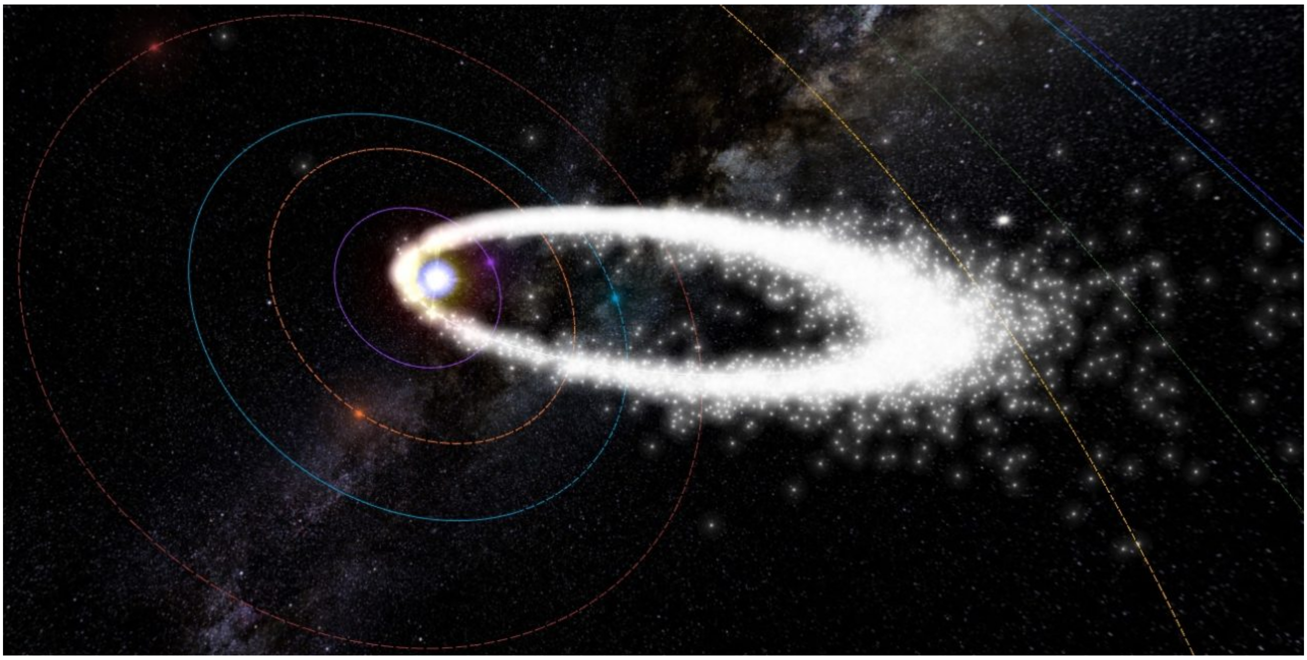

Figure 1 –

Radio meteor observations in the world: Monthly Report for December 2016

Hiroshi Ogawa

h-ogawa@amro-net.jp

This report was provided by The International Project for Radio Meteor Observation and covers the December 2016 radio observations.

1 Geminids 2016

One of the major meteor showers, the Geminids occurred in this month. There was no unusual acitivty during this year. The peak was estimated at around 21:30(UT) on 13th Dec. with a peak level A_{max} = 4.0. This activity profile was the same as it was in 2013[9] and 2015[10].

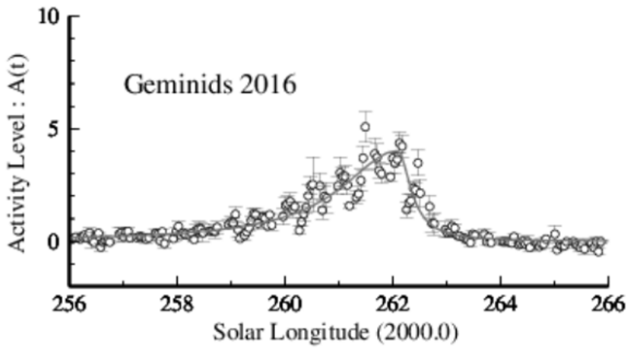

Figure 1 – Using 30 observing stations in 12 countries.

You can see the detailed information on the page "Result for the Geminids 2016[11]".

In addition, Mr.Hirofumi Sugimoto converted from the Activity Level index to the visual ZHR[12].

2 Ursids 2016

At the end of December, the Ursids showed a high activity around 10:30(UT) on the 22nd Dec. (Solar Longitude: 270°.78). The structure has A_{max} = 1.0 with FWHM = –2.0/+4.0 hours. Although a strong Ursid activity was also observed in 2014[13], the activity in 2016 was weaker than in 2014.

You can see the more detailed information on the page "Result of Ursids 2016[14]". In addition, Mr.Hirofumi Sugimoto converted from the Activity Level index to the visual ZHR[15].

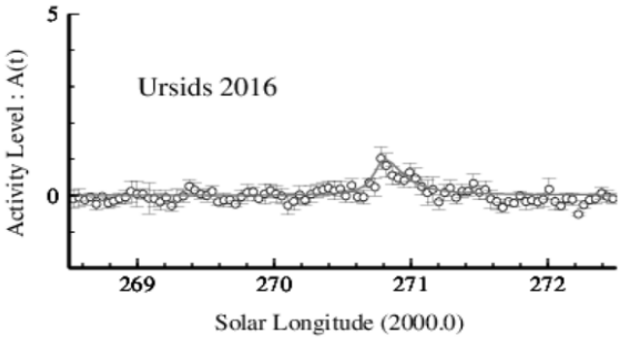

Figure 2 – Using 22 observing stations in 10 countries.

3 The possible enhanced activity on 2–3 December

On 2–3 December 2016, a possible enhanced activity was predicted by J. Vaubaillon. The suspected radiant was the 66-Draconids with $\alpha = 310°$ and $\delta = +64°$. Although worldwide data were calculated, there was no unusual activity.

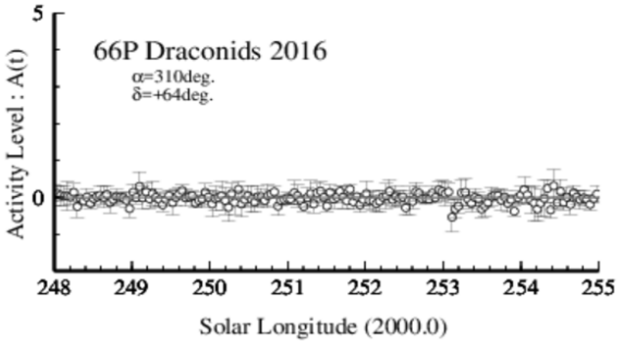

Figure 3 – Using 17 observing stations in eight countries.

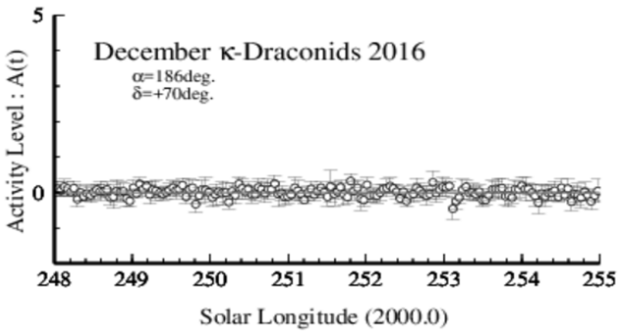

Figure 4 – Using 17 observing stations in eight countries.

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[9] http://www.amro-net.jp/meteor-results/12_gem/2013gem.html
[10] http://www.amro-net.jp/meteor-results/12_gem/2015gem.html
[11] http://www.amro-net.jp/meteor-results/12_gem/2016gem.html
[12] http://www5f.biglobe.ne.jp/~hro/Flash/2016/GEM/index.html
[13] http://www.amro-net.jp/meteor-results/12_urs/2014urs.html
[14] http://www.amro-net.jp/meteor-results/12_urs/2016urs.html
[15] http://www5f.biglobe.ne.jp/~hro/Flash/2016/URS/index.html

In addition, the CAMS-Network recorded some activity from the December κ Draconids with α = 186° and δ = +70°(Johannink and Breukers, 2016). On the other hand, however, worldwide radio meteor observations did not register this activity. In the case of the Activity Level index, it is only possible to detect some meteor activity when the ZHR is more than 20–30 (depending on the geocentric velocity).

Mr.Hirofumi Sugimoto converted the activity level index into the visual ZHR, and there was a possible very weak December κ Draconids activity. This result showed a Zenithal Hourly Rate of around 20.

Beside these topics, the following graph in *Figure 5* displays the monitored result (using ONLY Japanese stations) in December 2016.

A distinct Geminid activity was observed between 10th and 15th of December. The Ursids were not clear in Japan. This is because of a low radiant elevation. There was no unusual activity except for the Geminids period.

Acknowledgment

- Radio Meteor Observing Bulletin (RMOB)
- Radio Meteor Observation in Japan (RMOJ)
- All radio meteor observers

References

Johannink C. and Breukers M. (2016). “Stabbing the Dragon with some enhanced activity”. *eMeteorNews*, **1**, 141.

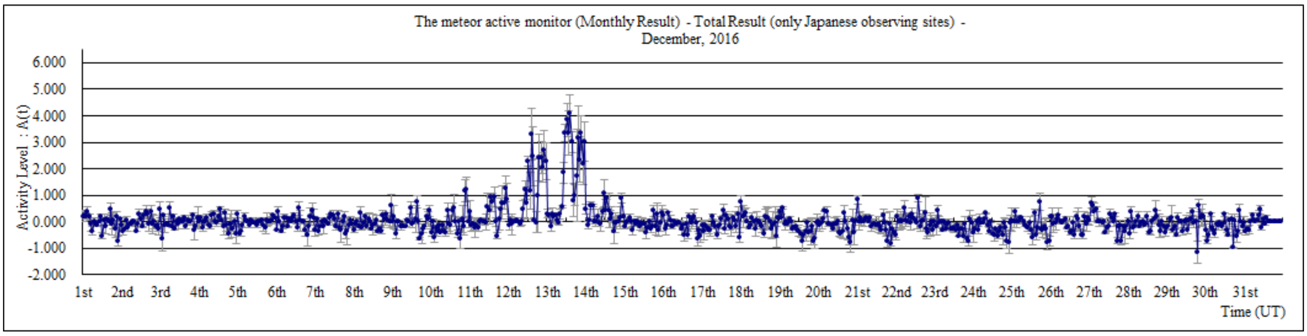

Figure 5 – Monitored result for December (only Japan).

Radio meteor observations in the world: Monthly Report for January 2017

Hiroshi Ogawa

h-ogawa@amro-net.jp

This report gives a summary of the radio observations of the Quadrantids 2017. The activity was comparable to previous years.

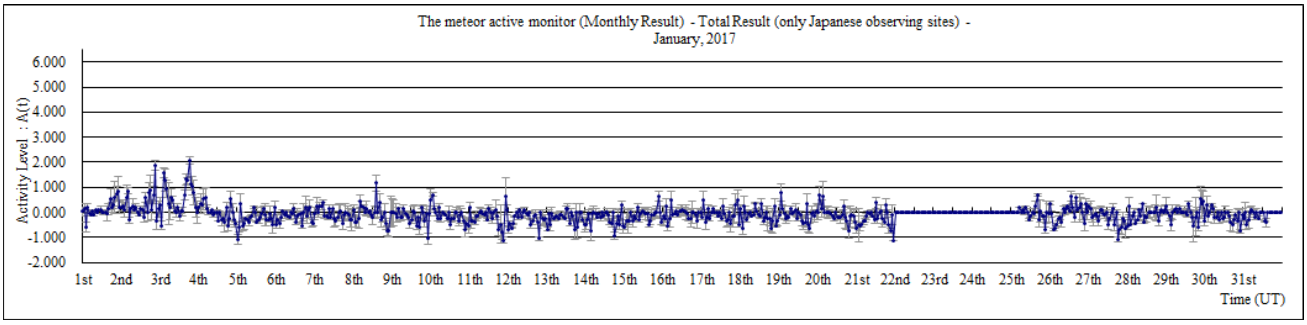

Figure 1 – Monitored result for January (only Japan).

1 Quadrantids 2017

The Quadrantids 2017 by worldwide radio meteor observers showed a similar activity as usual in previous years, although it was weaker than in 2016.

As a result of the International Project for Radio Meteor Observation, the Quadrantid peak time was around 15:30(UT) on January 3rd (solar longitude 282°.2). Its FWHM was –9.0hours / +5.0hours. The activity Level was around $A_{max} = 4.0$. This is the same activity level as usual. Besides of these data, the Quadrantids 2017 displayed an ascending branch of FWHM that was longer than the descending branch.

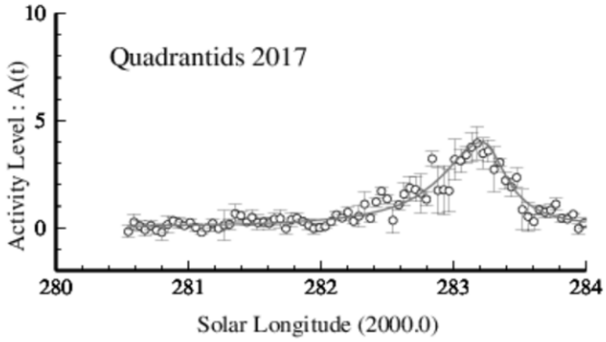

Figure 2 – Using 26 observing stations in 11 countries.

More detailed results are provided online[16].

This project also provides past observed results since 2001[17].

In addition, Mr.Hirofumi Sugimoto converts from the Activity Level index to the Zenithal Hourly Rate . This result is provided online[18].

Beside this, the graph in *Figure 1* displays the monitored result (using ONLY Japanese stations) in January 2017.

A distinct Quadrantid activity was observed between 1st and 5th of January. There was no unusual activity except for the Quadrantids period. The transmitting station was under machine failure between 22nd and 25th of January.

Acknowledgment

- Radio Meteor Observing Bulletin (RMOB)
- Radio Meteor Observation in Japan (RMOJ)
- All radio meteor observers

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[16] http://www.amro-net.jp/meteor-results/01_qua/2017qua.html

[17] http://www.amro-net.jp/meteor-results/01_qua/qua-total-graph.html

[18] http://www5f.biglobe.ne.jp/~hro/Flash/2017/QUA/index.html

CAMS BeNeLux overview 2016

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The CAMS network expanded with 8 stations and 12 new cameras, while 2 stations with 2 cameras each were temporary discontinued. The number of operational cameras increased from 49 to 57 and a larger portion of the atmosphere could be monitored. 309 of the 366 nights allowed successful collection of orbits. In total 25187 orbits were obtained in 2016.

1 Introduction

Started in March 2012 with two stations and two cameras, CAMS Benelux counted 21 stations with 57 cameras by end of 2016. The number of orbits collected has increased year after year, thanks to the growing number of operational cameras and stations, combined with improved software and a smooth reduction pipeline. CAMS Benelux is based on 100% volunteers work and is financed by its participants. All results from CAMS Benelux are transferred to the global CAMS project, coordinated by *Peter Jenniskens*.

2 2016 Statistics

The first few months of 2016 offered a normal weather pattern for our climate without any exceptional months in neither good, nor bad sense. From mid-May until about mid-July the weather was mostly uncooperative with lots of rain and cloudy nights. June 2016 was the worst month of June ever in weather statistics, not only bad for CAMS but also agriculture was severely hit by the extreme bad weather. Altogether it is most remarkable that CAMS managed to collect a nice number of orbits in such exceptional bad weather period.

Table 1 – Year statistics of CAMS BeNeLux.

Year	Nights/ month	Total orbits	Aver. Cam.	Max Cam.	Posts	Nights
2012	10,1	1.079	2,6	8	6	101
2013	16,5	5.684	9,5	26	13	198
2014	22,4	11.288	20,6	37	14	269
2015	24,5	17.259	29,1	49	15	294
2016	25,8	25.187	40,3	57	21	309
	-	60.497	-	-		1.171

The situation improved somehow in July and the exceptional poor period was followed by exceptional favorable months of August and September with record numbers of orbits collected. Although that the night 11-12 August with a predicted activity outburst was ruined by clouds at most stations, the traditional night of the Perseid maximum had all over the network clear sky, good for a record number of 830 orbits recorded in a single night. All 30 September nights allowed to successfully collect orbits with some series of transparent nights at most stations.

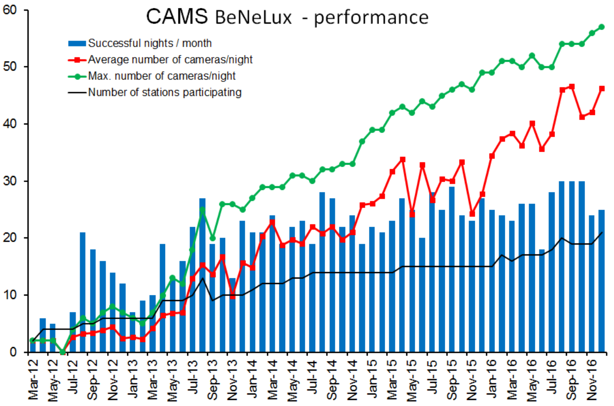


Figure 1 – Evolution of the performance of the CAMS network: blue bars are the number of nights with successfully collected orbits, the black line displays the number of operational stations active in the month, de red line is the average number of operational cameras effectively active in the month and the green line gives the maximum number of available operational cameras during the month.

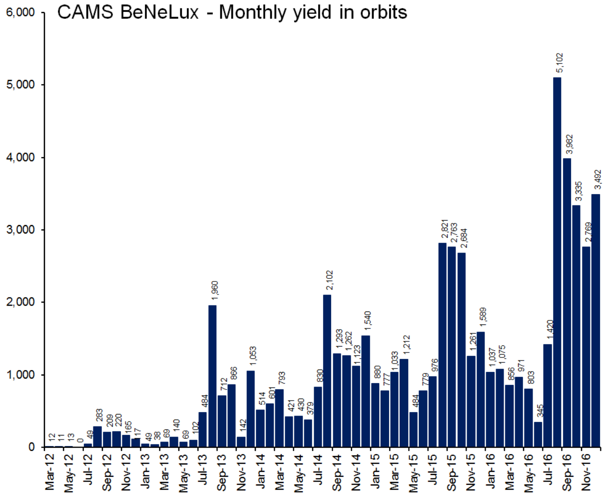


Figure 2 – The monthly yield in number of orbits.

October 2016 had the usual return to the less favorable autumn weather circumstances with mainly partial clear nights. Only one night during the Orionid activity offered favorable weather circumstances, we'll have to hope for a better chance to register the Orionids in one of the next years. November and December came with the typical poor autumn weather, except for several unusual transparent nights in the last week of November as well as in the first week of December. Both the Geminids and the Ursids maxima remained hidden behind clouds for most of the cameras.

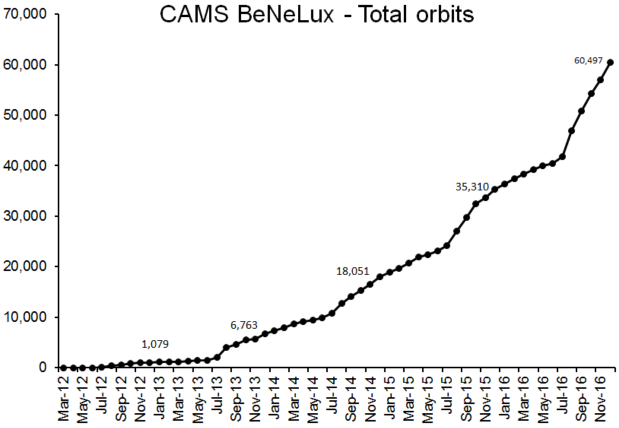


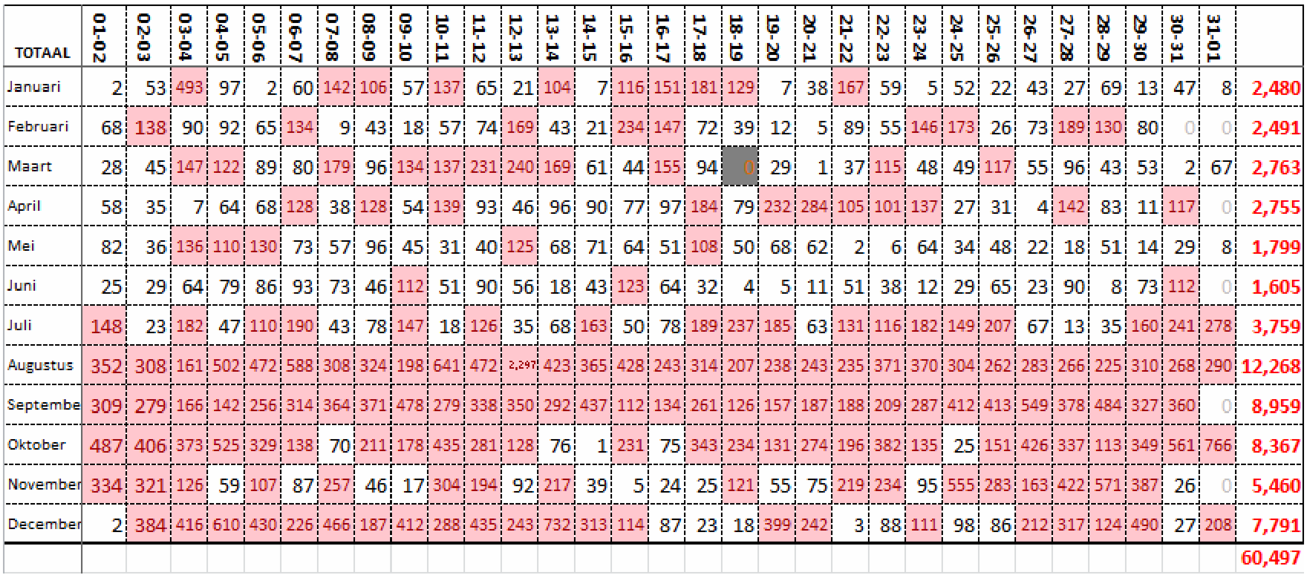
Figure 3 – The growth rate in number of orbits collected.

Figure 1 and *Table 1* display the growth of the network very well. While the number of useable nights still increased from 294 in 2015 to 309 in 2016, mainly thanks to the more generalized use of *auto-CAMS* and the expansion of the network with the increase in the number of operational stations and cameras. Thanks to *auto-CAMS* a larger portion of the available hardware could be operated on almost permanent bases.

That the capacity of the CAMS network increased significantly in 2016 appears very well from *Figure 2* with record numbers of orbits recorded in the last 6 months of 2016. This growth in orbits collected is also very well visible in the accumulated number of orbits displayed in *Figure 3*.

The CAMS project has its main focus on the poorly known meteor activity throughout the year, the major shower maxima are not a priority for CAMS. Therefore we keep track of a day by day tally to see how many orbits we collect for each calendar date which correspondents to about 1° in solar longitude (see *Figure 4*). With hundreds of orbits per solar longitude it makes sense to look for associations between the orbits to reveal weak shower activity.

In about 5 years of work one single night must have been always cloudy and remains without orbits: 18–19 March. For as many as 193 nights 100 or more orbits were collected, 84 nights with 250 or more orbits, 12 with 500 or more orbits. Best night is 12–13 August with as many as 2297 orbits for a single night. May and June prove they are the most challenging months to obtain orbits, due to frequent bad weather combined with short nights.



TOTAAL	01-02	02-03	03-04	04-05	05-06	06-07	07-08	08-09	09-10	10-11	11-12	12-13	13-14	14-15	15-16	16-17	17-18	18-19	19-20	20-21	21-22	22-23	23-24	24-25	25-26	26-27	27-28	28-29	29-30	30-31	31-01	
Januari	2	53	493	97	2	60	142	106	57	137	65	21	104	7	116	151	181	129	7	38	167	59	5	52	22	43	27	69	13	47	8	2,480
Februari	68	138	90	92	65	134	9	43	18	57	74	169	43	21	234	147	72	39	12	5	89	55	146	173	26	73	189	130	80	0	0	2,491
Maart	28	45	147	122	89	80	179	96	134	137	231	240	169	61	44	155	94	0	29	1	37	115	48	49	117	55	96	43	53	2	67	2,763
April	58	35	7	64	68	128	38	128	54	139	93	46	96	90	77	97	184	79	232	284	105	101	137	27	31	4	142	83	11	117	0	2,755
Mei	82	36	136	110	130	73	57	96	45	31	40	125	68	71	64	51	108	50	68	62	2	6	64	34	48	22	18	51	14	29	8	1,799
Juni	25	29	64	79	86	93	73	46	112	51	90	56	18	43	123	64	32	4	5	11	51	38	12	29	65	23	90	8	73	112	0	1,605
Juli	148	23	182	47	110	190	43	78	147	18	126	35	68	163	50	78	189	237	185	63	131	116	182	149	207	67	13	35	160	241	278	3,759
Augustus	352	308	161	502	472	588	308	324	198	641	472	2,297	423	365	428	243	314	207	238	243	235	371	370	304	262	283	266	225	310	268	290	12,268
Septembe	309	279	166	142	256	314	364	371	478	279	338	350	292	437	112	134	261	126	157	187	188	209	287	412	413	549	378	484	327	360	0	8,959
Oktober	487	406	373	525	329	138	70	211	178	435	281	128	76	1	231	75	343	234	131	274	196	382	135	25	151	426	337	113	349	561	766	8,367
November	334	321	126	59	107	87	257	46	17	304	194	92	217	39	5	24	25	121	55	75	219	234	95	555	283	163	422	571	387	26	0	5,460
December	2	384	416	610	430	226	466	187	412	288	435	243	732	313	114	87	23	18	399	242	3	88	111	98	86	212	317	124	490	27	208	7,791
																																60,497

Figure 4 – Total number of orbits per calendar date accumulated for the years 2012–2016.

3 Evolution of the hardware

January 2016 started with 49 operational cameras at 15 stations and got a first expansion with a new camera, 393, at Uccles (Belgium) and another one, 394, at Dourbes (Belgium), far south near the French border. Especially the location in Dourbes proves to be a strategic position in order to complete the coverage of the atmosphere above Belgium. The only drawback at Dourbes is that no camera operator is available on site as the station is remote controlled from Brussels. Any intervention on site requires at least a half day to go to Dourbes to do some maintenance and to return. This situation explains why a technical problem with the 394 took about a month to be solved when also the second camera at Dourbes, the 395, got started on 1st of April. The three new cameras are owned by BISO and managed by *Hervé Lamy* and *Stijn Calders*. The purpose is to investigate the correlation between meteor trajectories obtained by video and the radio echo data obtained by the BRAMS project.

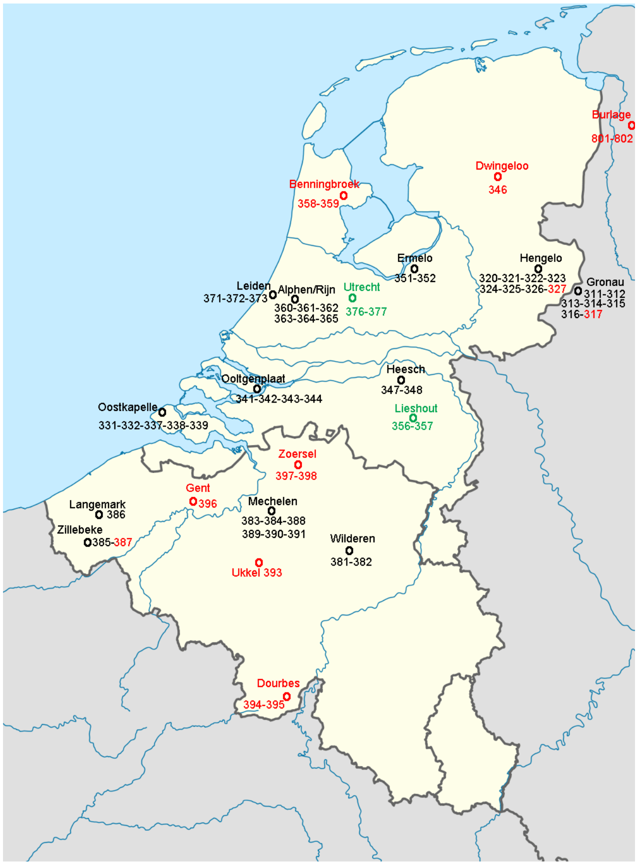


Figure 5 – Operational stations during 2016. Cameras and stations added in 2016 are marked in red, cameras and stations that were discontinued in 2016 are marked in green.

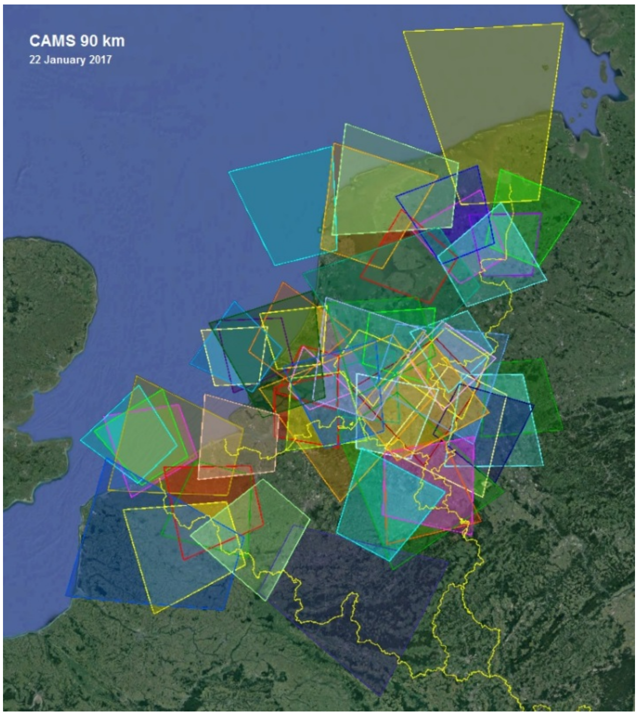


Figure 6 – Camerafields intersected at 90 km elevation, situation as on 22 January 2017.

From 13 March onwards the 356 and 357 were deactivated at Lieshout (the Netherlands) by *Paul Lindsay* due to lack of time. The new 327 registered its first successful night on 20-21 April in Hengelo, the Netherlands, operated by *Martin Breukers* and the 396 was switched on by *Tim Polfliet* on 27-28 April in Gent (Belgium). CAMS 358 and 359 were successfully started in July by *Jos Nijland* in Benningbroek (the Netherlands). CAMS 387 is another remote station at Ypres (Belgium) and was started on 5 August by *Steve Rau*. CAMS 346 was restarted mid-August at Dwingeloo (the Netherlands) by *Cees Bassa*.

Carl Johannink added CAMS 317 to his CAMS station on 26 September as a first step to provide coverage of the thus far unexplored atmosphere above the Northern parts of the Netherlands. CAMS 376 and 377 were switched off for several months by *Felix Bettonvil* in Utrecht (the Netherlands) due to technical problems.

Bart Dessoy turned his new CAMS 397 and 398 on in Zoersel (Belgium) on 21 November and on 12 December *Robert Haas* started a semi-remote station at Burlage (Germany) with CAMS 801 and 802 for coverage of the most northern part of the Netherlands.

All stations are plotted in *Figure 5* and the corresponding camera fields are plotted as intersected at an elevation of 90 km in *Figure 6*.

4 Evolution of the software

The CAMS *CaptureAndDetect* software for single CAMS was developed to be used by amateurs to provide extra coverage with single cameras to the all-sky coverage of the three professional stations with 20 cameras each in California, USA. When some amateurs had two or four cameras on a single PC, *CaptureTwoandDetect* and *CaptureFourandDetect* had been developed, but except for two cameras this version did not work for the European version. Since the USB data capacity determines the bottle neck for the number of dongles (*EzCap* frame grabbers) that can be connected on a single PC, the idea was that for more than two cameras the *SensoRay* card is to be recommended. With amateurs running 4 or 6 Watecs on a single PC with dongles, *Pete Gural* decided to adapt the CAMS software with a version called *CaptureDonglesAndDetect* that allows combining up to 8 cameras connected with dongles on a single PC, assuming that the USB connection can handle this.

The newly developed software was tested by the author end of August and in September 2015. The final version was successfully implemented in *autoCAMS* in March 2016. The new capture and detect software is more CPU efficient and has an optimized cloud mitigation included. Using the new version the problem with dropped frames disappeared on most PCs while the number of false detections got reduced to 10% of previous scores.

Besides the new CAMS software which has been stored and distributed in a well-organized way via *Steve Rau*, Steve also optimized the *autoCAMS* processes and assisted several CAMS operators to implement *autoCAMS* in order to cover all nights. The installation of *autoCAMS* definitely accounts to a large extend for the significant increase in the number of nights with orbits as well as the total number of orbits obtained in 2016.

Another important improvement was the newest version of the *Binviewer,* developed by *Denis Vida,* as confirmation tool. Detection points are marked with colors which make it much easier to recognize faint meteors and thus confirm these and get more chances for double station meteors. Several members of the CAMS team now use the *Binviewer* to do the confirmation.

5 Highlights of 2016

As far as the major meteor showers were concerned, only the Eta-Aquariids begin of May and the Perseids in August were favored with clear skies. The Perseid maximum on 12-13 August had clear sky and with 830 orbits this night broke all records in the CAMS history. All other major showers suffered poor weather circumstances with partial clear skies or totally over casted skies.

Some minor shower activity caught the attention of the network coordinators. At several occasions our hard working network coordinators, *Martin Breukers* and *Carl Johannink*, managed to surprise the entire team with enthusiastic reports. The smooth teamwork and rapid data delivery within the network in some cases meant that the CAMS BeNeLux network was the first to share results on some unusual events. The γ-Draconids (GDR-184) displayed an outburst on 27–28 July which was covered by only few stations due to poor weather (Roggemans, 2016). A distinct activity of the September ε Perseids (SPE-208) could be recorded in September with 77 orbits (Johannink, 2016a). Exceptional good weather allowed to collect orbits from different minor showers in September, (Johannink, 2016b). Activity from the predicted October Camelopardalids (OCT-281) was confirmed by the network with 4 orbits (Johannink, 2016c).

On the outlook for some predicted possible activity of the 66 Draconids (SDD-541), nothing was recorded for this shower but instead unexpected enhanced activity was recorded from the December kappa Draconids (DKD-336) in the night of 2-3 December (Johannink and Breukers, 2016).

The unpredictable nature of meteor showers guarantees that the CAMS project remains an exciting hobby for amateurs. One never knows which surprise may turn up from the registrations made during the night. Also 2016 confirmed that CAMS brings such surprises every now and then and this at great satisfaction of the entire team.

6 Annual CAMS day

Every year the participants of the CAMS project have a meeting to discuss technical issues, results and to organize the aiming points of the cameras. With the annual IMC being organized in the Netherlands with the presence of the global CAMS coordinator, Peter Jenniskens, the CAMS software developer Pete Gural and the developer of the BIN viewer, Denis Vida, the CAMS meeting was organized at the site of the IMC immediately after the end of the IMC. Since the majority of the CAMS team did not participate in the IMC, CAMS operators could pick up a glimpse of the IMC and meet some people from abroad.

Although that the last two IMC sessions took place Sunday morning, a number CAMS people skipped these to enjoy an informal meeting with arriving fellows on a terrace right in front of the IMC host. Lunch time offered some extra time for informal chat.

The CAMS day had three eminent guest speakers in 2016 with *Pete Gural, Peter Jenniskens* and *Denis Vida*. For the first time ever all participants could ask questions and discuss technical aspects with the CAMS software developer as well as with the global CAMS coordinator. *Denis Vida* presented a demo of the functions offered by the *Binviewer.*

Figure 7 – 5 June 2016, CAMS-day at Egmond with from left to right: Denis Vida (Croatia, developer Binviewer), Adriana en Paul Roggemans, Martin Breukers, Pete Gural (developer CAMS software), Robert Haas, Piet Neels, Stijn Calders, Marc Neijts, Tim Polfliet, Peter Jenniskens (global CAMS coordinator), Hans Betlem, Jean-Marie Biets, Klaas Jobse, Carl Johannink, Jos Nijland, Felix Bettonvil and Erwin van Ballegoij.

7 Future options

Comparing 5 years statistics of the CAMS Benelux network (see *Figure 8*); it is obvious that with over 300 nights we reached the limit of number of nights that may allow successful video meteor work in our climate.

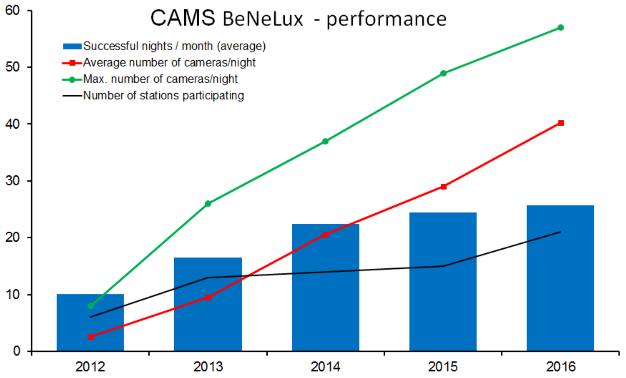


Figure 8 – The evolution of the CAMS network like in Figure 1, but on annual bases.

There is still room for improvement:

- Increase the number of stations using Auto-CAMS to improve coverage during partial clear nights;
- Increase the density of the network with extra cameras at existing stations as well as with new stations;
- Try to set-up remote controlled stations where nobody is interested in CAMS, and, or try to encourage amateurs in neighboring countries to connect to the CAMS BeNeLux network.
- The green and the black line in *Figure 8* can increase further while the red line can converge towards the green line by using AutoCAMS at more stations.

8 Conclusion

By end of 2016 the BeNeLux CAMS network has achieved an operational status capable to collect many orbits on any single night. On annual bases CAMS BeNeLux is now doing better than the famous Japanese Sonotaco network which started in 2007. With its current configuration, clear sky is all that the network needs to score large numbers of orbits.

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