Status of the CAMS-BeNeLux network

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The CAMS-BeNeLux network currently contributes about 10% of all heliocentric orbit data to the global CAMS project. In June 2015 the network has expanded to 45 cameras installed at 14 sites, which all together yielded over 23.000 accurate meteor orbits since the first couple of cameras started in March 2012. Some results of the past 12 months are highlighted such as the κ-Cygnids of 2014, the possible occurrence of a dust filament of the Leonids, the Quadrantids of 2015, the Lyrids of 2015 as well as some minor showers which were discovered in recent years.

1 Introduction

CAMS or *Cameras for All Sky Meteor Surveillance*[1] is a professional project financed by NASA, introduced by Peter Jenniskens and Pete Gural and most successfully operated since October 2010 (Jenniskens et al., 2011). The purpose of the project is to validate the IAU Working List of Meteor Showers[2]. Using small field of view optics covering the complete sky as a mosaic, and this from three different observing sites, a total of over 250000 heliocentric orbits have been accumulated through spring 2015.

CAMS was first introduced at the IMC by Pete Gural in Armagh in September 2010 (Gural, 2011). The technique used for processing images was similar to the technique used by the Croatian Meteor Network which was described in WGN (Gural and Segon, 2009). The selection of a best suitable video camera and optics for CAMS was done using a meteor simulation tool MeteorSIM which has been presented at the 2001 IMC in Cerkno, Slovenia (Gural, 2002). The Watec WAT-902H2 Ultimate combined with a 12-mm f 1.2 Pentax lens were chosen. Meanwhile cheaper cameras have been successfully tested and documented (Samuels et al., 2014).

Pete Gural built a single CAMS solution which was introduced in June 2011 and successfully applied in September 2011. The system was first introduced to Dutch amateur meteor observers at the occasion of the 2011 Draconids followed by a successful series of observations during the nights 21–28 October 2011 for the Orionids (Johannink, 2013). The start of the CAMS-BeNeLux network has been presented in 2013 at the IMC in Poznan, Poland (Roggemans et al., 2014). The achievements until mid-2014 were summarized at the IMC in Giron, France (Bettonvil et al., 2014).

2 Evolution of the CAMS-BNL network

When professional astronomers decide to create a meteor camera network sometimes years will pass before first light mainly due to the bureaucracy involved with funding and the procedures in general at research institutes. Thanks to the efforts of Pete Gural, Single CAMS came to Europe as a ready to use concept but still it took 6 months for the CAMS-BNL Network to get started and about two years to reach a good efficiency.

The Low Lands at the North Sea suffer a rather unstable mild sea climate which isn’t favorable at all for any astronomical observations. However, the number of nights that allowed obtaining heliocentric orbits for each month is impressive (blue bars in *Figure 1*). The number of participants in the network remained more or less stable during the last year (black line in *Figure 1*), but the average number of cameras running on clear nights (red line in *Figure 1*) and the maximum of cameras operated in a single night per month (green line in *Figure 1*) increased steadily. The unstable weather conditions with very variable cloud cover seriously reduces the chances to capture meteor events simultaneously by different stations. At this point the motivation and perseverance of the network participants to operate the cameras as frequently as possible makes the difference.

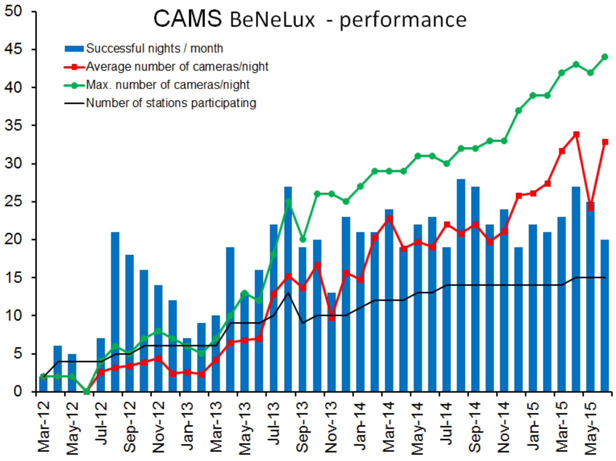

Figure 1 – The performance of the CAMS- BNL network.

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[1] http://cams.seti.org/

[2] http://www.astro.amu.edu.pl/~jopek/MDC2007/index.php

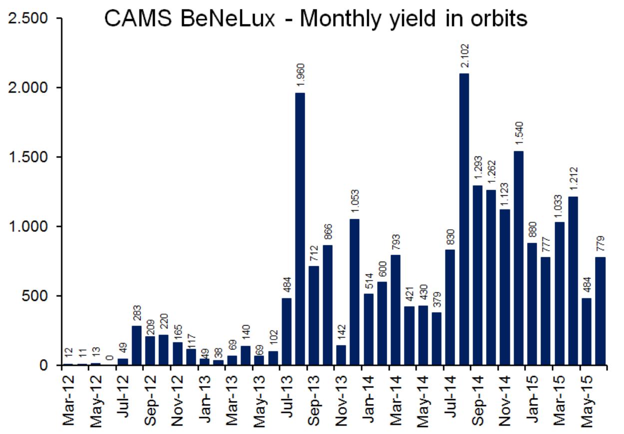


Figure 2 – Monthly distribution of the heliocentric orbits obtained by the CAMS- BNL network.

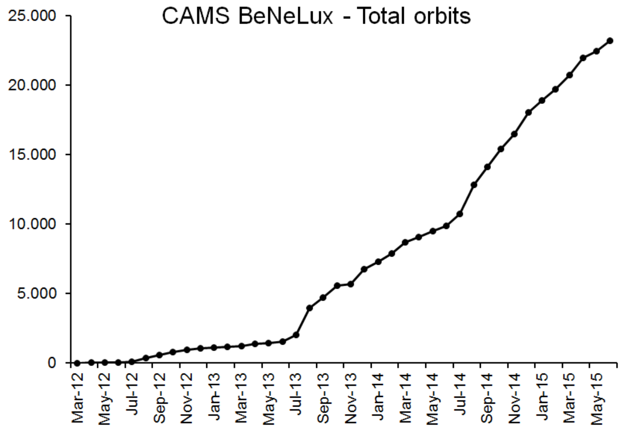
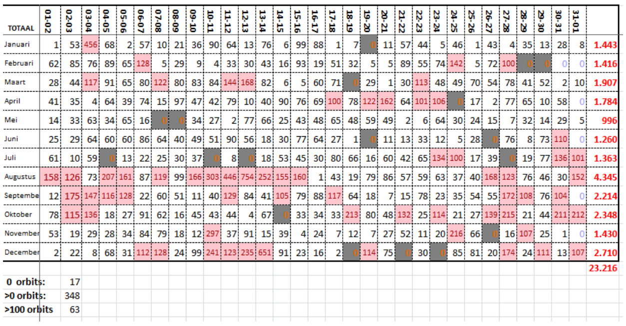


Figure 3 – The evolution of the total number of heliocentric orbits accumulated by the CAMS- BNL network.

The monthly totals of orbits (*Figure 2*) were significantly higher past 12 months compared to the previous year. *Figure 3* illustrates the growth of the orbits database obtained in the BeNeLux. The BeNeLux delivers approximately 10% of the global CAMS data. The initial aim of the CAMS project was to obtain at least 100 accurate orbits for each solar longitude in two years of time. The Cams project got far beyond that initial target and continues to accumulate data. The CAMS-BNL network is likely to achieve the initial global target on its own, although it will take a few years more to achieve this goal. *Figure 4* is a screenshot from the day-by-day tally and shows a rapidly growing number of days with more than hundred orbits. The poor climate of the BeNeLux is why few nights didn't allow any single observation over 4 years of video capturing.



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	1	53	456	68	2	57	10	21	36	90	64	13	76	6	99	88	1	7	0	11	57	44	5	46	1	43	4	35	13	28	8	1.443
Februari	62	85	76	89	65	128	5	29	9	4	33	30	43	16	93	19	51	32	5	5	89	55	74	142	5	72	100	0	0	0	0	1.416
Maart	28	44	117	91	65	80	122	80	83	84	144	168	82	6	5	60	71	0	29	1	30	113	48	49	70	54	78	41	52	2	10	1.907
April	41	35	4	64	39	74	15	97	47	42	79	10	40	90	76	69	100	78	122	162	64	101	106	0	17	2	77	65	10	58	0	1.784
Mei	14	33	63	34	65	16	0	0	34	27	2	77	66	25	43	48	65	48	59	49	2	6	64	30	24	15	7	32	14	29	5	996
Juni	25	29	64	60	60	86	64	40	49	51	90	56	18	30	77	64	27	1	0	11	13	33	12	5	28	0	76	8	73	110	0	1.260
Juli	61	10	59	0	13	22	25	30	37	0	8	0	18	53	45	30	80	66	16	60	42	65	134	100	17	39	0	19	77	136	101	1.363
Augustus	158	126	73	207	161	87	119	99	166	303	446	754	252	155	160	1	43	19	79	86	57	59	63	37	40	168	123	76	46	30	152	4.345
Septembe	12	175	147	116	128	22	60	51	11	40	129	84	41	105	79	88	117	64	18	7	15	78	23	35	54	55	172	108	76	104	0	2.214
Oktober	78	115	136	18	27	91	62	16	45	43	44	4	67	0	33	34	33	213	80	48	132	25	114	21	27	139	215	21	44	211	212	2.348
November	53	19	29	28	34	84	79	18	12	297	37	91	15	39	4	24	7	12	7	27	52	11	20	216	66	0	16	107	25	1	0	1.430
December	2	22	8	68	31	112	128	24	99	241	123	235	651	91	23	16	2	0	114	75	0	30	0	85	81	20	174	24	111	13	107	2.710
																																23.216
0 orbits:		17																														
>0 orbits:		348																														
>100 orbits		63																														

Figure 4 – Total number of orbits per calendar date (~1° in Solar Longitude) accumulated 2012–2015.

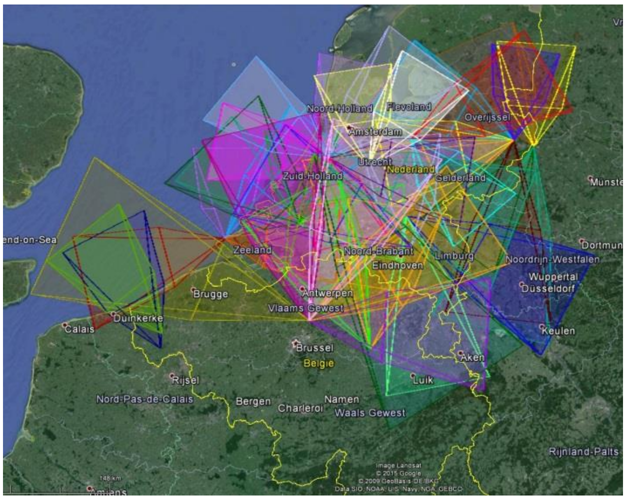


Figure 5 – Projected camera fields at 90km height for 43 cameras as in July 2015.

Compared to one year ago two extra regions of the atmosphere were added to the surveillance scheme. Still more cameras will be needed to cover the atmosphere above Belgium. With Single CAMS the optimization of the overlap between the fields of view of the cameras is crucial to increase the chances for simultaneous captures. Moreover each zone in the atmosphere requires coverage from 3 or more different stations in order to deal with the very variable weather circumstances that characterize the Low Lands.

3 CAMS Highlights June 2014 – July 2015

The 2014 Kappa Cygnid radiant area in close up

A selection of 250 meteors was made with a radiant position within the range $\alpha \approx$ [220° to 310°] and $\delta \approx$ [+39° to +74°], the geocentric velocity $V_g \approx$ [12 to 34 km/s], with as inclination $i \approx$ [16° to 46°] and as argument of perihelion $\omega \approx$ [150° – 216°] for the period $\lambda_\odot$ [115°–158°]. These criteria were chosen on bases of the known information available on the κ-Cygnids and related showers. For a single station visual observer each of these meteors, regardless where these would be spotted at the sky, would fulfil the criteria available for visual observers to identify a meteor as a κ-Cygnid. With the

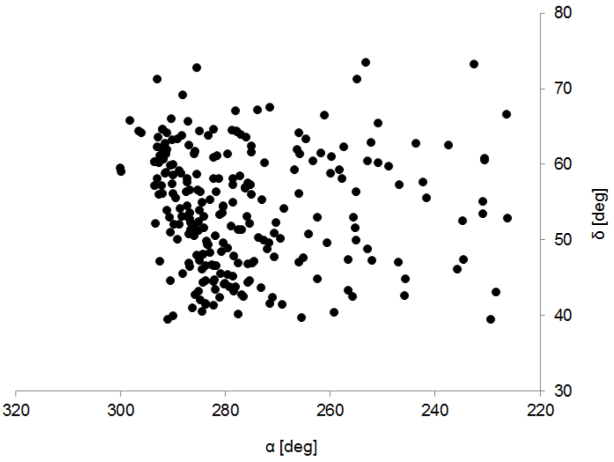


Figure 6 – 250 radiant positions from CAMS-BNL according to a first pre selection of orbits.

orbits available we can verify the shower association with previously obtained orbits. All 250 radiants have been plotted in *Figure 6* which shows a very large scatter.

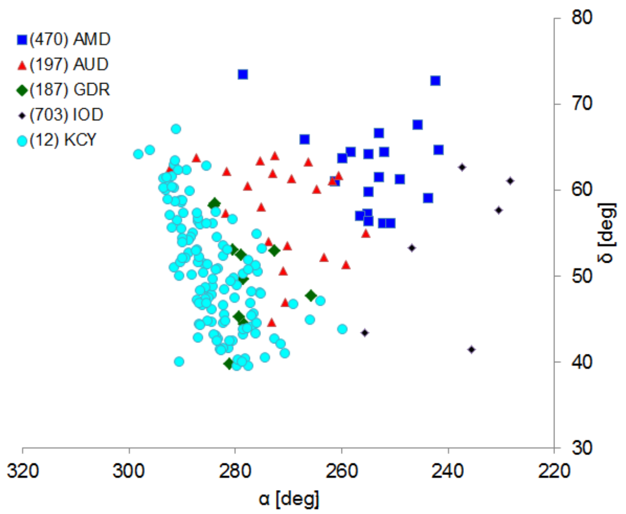


Figure 7 – 189 radiant positions with a D-criterion < 0.105 and the associated sources according to the best D_{SH}-value.

In a next step each of these 250 meteors were matched with the reference orbit of the κ-Cygnids (12 KCG) and its related minor streams such as 179 AUD, 470 AMD, 703 IOD and 184 GDR using the D-criterion (Drummond, 1981). Since several meteors fulfilled the D-criterion for different sources, each meteor was related to a single source based on the best D-criterion of all possible associations. Only 189 meteors associated with a $D_{SH} < 0.105$ were selected. The result (*Figure 7*) is still a rather scattered radiant populated mainly by κ-Cygnid (12 KCG) meteors as well as associated minor shower members: August Draconids (197 AUD), August μ Draconids (470 AMD), ι-Draconids (703 IOD) and July γ-Draconids (184 GDR). The results are listed in *Table 1*. If we would ignore the minor subradiants and just use all orbits with DSH < 0.105 for the κ-Cygnid (12 KCG), we would have a dataset of 171 κ-Cygnids with slightly different averages list in italics. It makes no sense to apply the same for the minor subradiants as the number of κ-Cygnid is too abundant that all averaged values tend to converge towards the mean κ-Cygnid position and orbit, except for the γ-Draconids (184 GDR) which are distinct from the other sources.

Of course the scatter is partly caused by the long time lapse of about 45° in solar longitude. It would be useful to split the dataset into bins of about 5° or less in solar longitude each to reduce the scatter by radiant drift. However, splitting up the sample in more bins would reduce the statistical significance due to too small numbers of meteors.

Based on the 131 κ-Cygnid with $D_{SH} < 0.105$, a radiant drift could be calculated as $\Delta\alpha/\Delta\lambda_\odot = +0.51°$ and $\Delta\delta/\Delta\lambda_\odot = +0.59°$. This is much more than the radiant drift used in the IMO Meteor Shower Calendars but in good agreement with Koseki (2014) with $\Delta\alpha/\Delta\lambda_\odot = +0.60°$ and $\Delta\delta/\Delta\lambda_\odot = +0.62°$ as average for the interval $120° < \lambda_\odot < 150°$. However, the radiant drift is not linear.

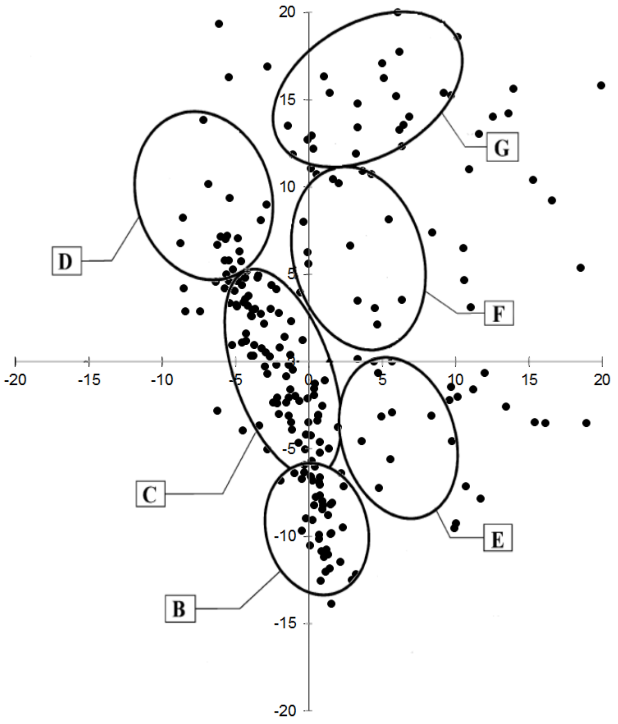


Figure 8 – 250 radiant positions from CAMS BeNeLux according to the first pre-selection of orbits, plotted in azimuthal equidistant projection in ecliptic coordinates centered at $(\lambda-\lambda_\odot, \beta) = (160°, +75°)$. The line $\lambda-\lambda_\odot = 160°$ runs along the y-axis. The ecliptic pole is at (x,y) = (0,15). The 2014 CAMS-BNL radiants are plotted relative to the groups previously described by Koseki (2014).

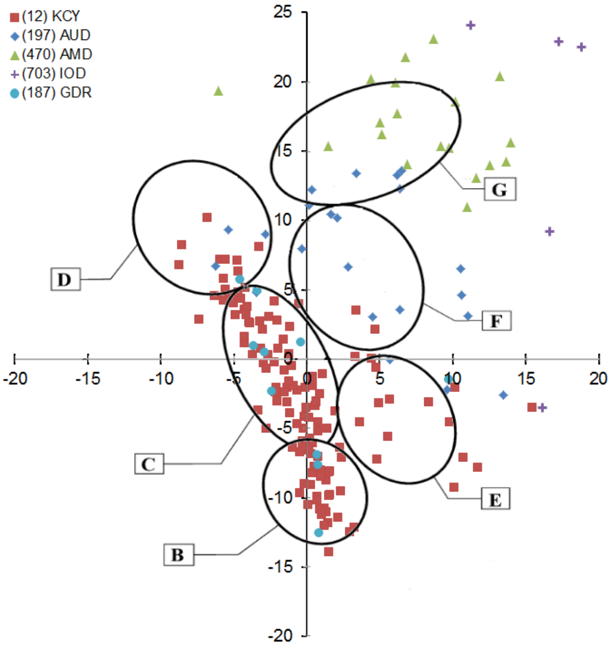


Figure 9 – 189 radiant positions for 2014 with a $D_{SH} < 0.105$ and the associated sources according to the best D_{SH}-value, plotted in ecliptic coordinates relative to the groups previously described by Koseki (2014).

Masahiro Koseki (2014) published an elaborated study of the κ-Cygnids and draw attention to a 7 year periodicity with enhanced activity previously observed in 1950, 1957, 1993 and 2007. A call was issued for observations in 2014 to check if any enhanced κ-Cygnid activity would occur. Koseki used 7 tentative groups based on past observations to describe the rather complex structure

Table 1 – Comparing orbits from different sources for the Cygnid-Draconid-Complex. The CAMS-BNL dated, marked in bold, are compared with global CAMS-data, DMS data and sources described by Koseki (2014). The κ-Cygnids for CAMS-BNL (*) marked in italics are all κ-Cygnids, including the 40 orbits which result in a slightly better D_{SH} value for one of the minor streams.

Stream	λ_{Θ}	α	δ	V_g	q	e	i	ω	Ω	N	Source
184 GDR	125.3	280.1	+51.1	27.4	0.978	0.947	40.2	202.3	125.3	22	SonotaCo (2009)
184 GDR	125.3	279.6	+50.4	27.5	0.978	0.972	40.2	202.3	124.7	25	CAMS (2015)
184 GDR	**125.9**	**278.3**	**+50.1**	**26.2**	**0.980**	**0.929**	**38.4**	**201.2**	**125.9**	**10**	**CAMS-BNL**
Group A	125.9	280.2	+51.2	27.3	0.980	0.948	40.2	201.7	125.9	45	Koseki (2014, Tab.9)
703 IOD	**135.79**	**239.0**	**+53.2**	**17.3**	**1.005**	**0.662**	**25.3**	**174..0**	**135.8**	**6**	**CAMS-BNL**
α-Lyrids	136.9	278.7	+44.8	20.2	0.971	0.723	29.3	204.7	136.9	21	Photo (Koseki, 2014)
MK74	137.2	281.0	+44.6	20.7	0.968	0.728	30.1	206.4	137.2	12	Koseki (1982, 2009)
Group E	139.9	275.5	+44.7	18.1	0.983	0.645	26.5	201.5	139.9	80	Koseki (2014, Tab.9)
12 KCG	140.7	285.0	+50.1	21.9	-	-	-	-	-	213	SonotaCo (2009)
12 KCG	**140.8**	**283.9**	**+50.5**	**22.0**	**0.977**	**0.694**	**33.6**	**203.5**	**140.8**	**131**	**CAMS-BNL**
12 KCG	141	276.9	+53.6	21.4	0.995	0.688	32.6	197.4	141	32	DMS-1993
197 AUD	**141.3**	**271.6**	**+57.7**	**20.8**	**1.006**	**0.626-**	**33.1**	**189.6**	**141.3**	**22**	**CAMS-BNL**
Group B	141.8	286.8	+45.5	21.3	0.958	0.712	31.2	209.1	141.8	92	Koseki (2014, Tab.9)
12 KCG	***141.9***	***279.1***	***+52.5***	***21.7***	***0.984***	***0.681***	***33.3***	***198.7***	***141.9***	***171***	***CAMS-BNL (*)***
Group C	141.9	286.8	+53.1	23.2	0.977	0.706	36.0	203.6	141.9	95	Koseki (2014, Tab.9)
197 AUD	143	271.8	+58.8	21.1	1.008	0.640	33.5	188.9	142.8	28	CAMS (2015)
Group F	143.9	274.1	+57.3	21.0	1.003	0.634	33.3	191.6	143.9	89	Koseki (2014, Tab.9)
MK83	148.5	290.8	+55.8	25.0	0.978	0.758	38.8	202.5	148.5	6	Koseki (1982, 2009)
470 AMD	149	254.4	+62.5	21.3	1.009	0.648	33.8	175.5	149.5	53	CAMS (2015)
Group D	149.2	290.1	+63.6	27.2	0.993	0.720	44.0	195.4	149.2	29	Koseki (2014, Tab.9)
Group G	149.7	260.6	+63.0	21.8	1.010	0.643	34.8	178.2	149.7	77	Koseki (2014, Tab.9)
470 AMD	**149.8**	**254.2**	**+62.6**	**21.1**	**1.008**	**0.638**	**33.4**	**174.3**	**149.8**	**20**	**CAMS-BNL**
ζ-Draconids (P)	149.9	269.0	+61.7	22.0	1.008	0.659	35.0	184.3	149.0	18	Photo (Koseki, 2014)
ζ-Draconids (V)	151.3	255.1	+62.4	21.3	1.006	0.641	33.8	174.5	151.3	108	Video (Koseki, 2014)
MK84	152.4	267.1	+60.6	21.6	1.009	0.659	34.3	183.5	152.4	11	Koseki (1982, 2009)
703 IOD	157	232.3	+53.3	17.8	0.990	0.664	26.1	161.5	157.2	12	CAMS (2015)

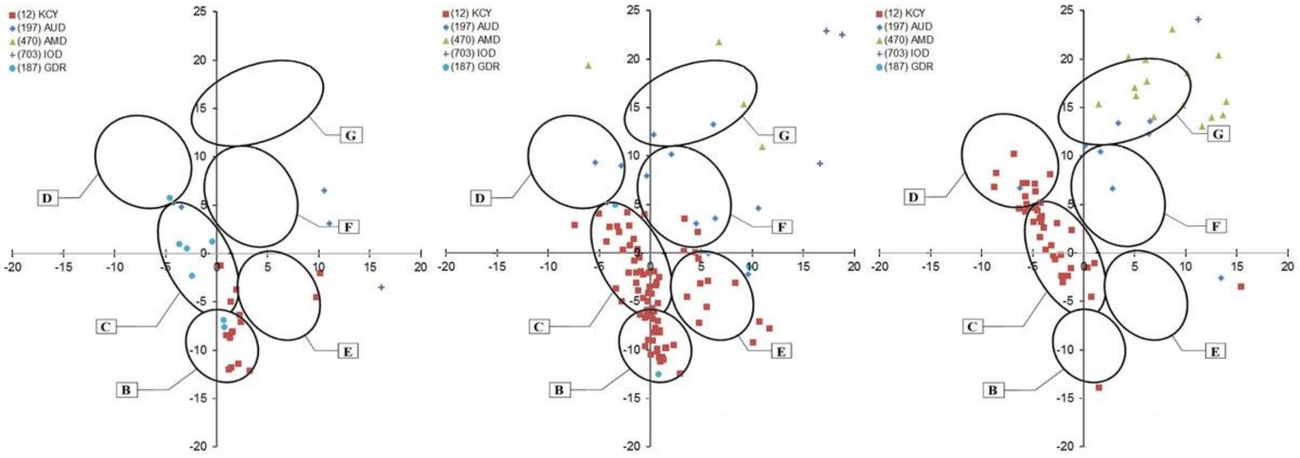


Figure 10 – 189 radiant positions for 2014 with a $D_{SH} < 0.105$ and the associated sources according to the best D_{SH}-value, plotted in ecliptic coordinates relative to the groups previously described by Koseki (2014) splitted in three periods of time: at left $\lambda_{\Theta} < 130°$, in the middle $130° < \lambda_{\Theta} < 145°$ and at right $\lambda_{\Theta} > 145°$.

of the κ-Cygnid radiant in detail. Having 189 orbits sampled by the CAMS-BNL network in 2014, we wonder if we noticed anything of some enhanced κ-Cygnid and also how the new data of 2014 would fit with the groups defined by Koseki in his analyses.

The surprisingly large number of κ-Cygnid orbits sampled by CAMS-BNL in 2014 already suggests that the shower was more abundant than previous year, although such statement is subjective as the rapid expansion of the CAMS-BNL may explain this impression too. As we don’t have past time series yet to compare meteor stream activity year after year from our own CAMS-BNL network, we make an attempt to compare our data with the previously published analyses by Koseki (2014) who provided us with the original tools to plot our data in a perfectly comparable way. All 250 radiant positions were transferred from equatorial coordinates into ecliptic coordinates and plotted using the groups introduced by Koseki. The result is shown in *Figure 8*.

The picture becomes very clear when we consider the shower associations with a $D_{SH} < 0.105$ as plotted in *Figure 9*. The group C is the most abundant activity of the κ-Cygnids just like it appears in the pictures of the 2007 κ-Cygnids event recorded by SonotaCo and described by Koseki (2014).

In an attempt to simplify the overall picture of the radiant plot we split the 45° in solar longitude into three periods, $\lambda_{\odot} < 130°$, $130° < \lambda_{\odot} < 145°$ and $\lambda_{\odot} > 145°$. The result is plotted in *Figure 10*. The GDR (184) radiants appear in the early activity interval. The main κ-Cygnids event occurred in the middle but unstable weather conditions do not allow reconstructing an activity profile of orbits per night. In the last 15° of solar longitude under consideration we see the AMD (470) appear while group B and E became inactive.

In *Table 1* we compare some minor stream. Although the average CAMS-BNL γ-Draconids radiant position matches very well with the values for Group A as published by Koseki (2014), our 10 GDR radiant positions appear spread over the area of Groups B and C. Group A is a small area in the center of Group C but has not been plotted in the figures in this article. We cannot confirm the strong concentration of GDR radiants in such a small region, but 10 GDR orbits is statistical not yet significant. Our August Draconid (197-AUD) radiants appear in or close to the region of Group F and also the averaged radiant position and orbital elements compare well with those for Group F. The August μ-Draconids (470-AMD) populate in or near the G Group region and the averaged radiant position and orbital elements compare very well with those of the video ζ-Draconids and Group G. Finally our few ι-Draconids (703-IOD) don't seem to fit anywhere.

The Perseids and other showers 2014

Although Full Moon occurred on 10 August, 890 Perseid orbits were recorded in 2014, 101 in July and 789 in August. The CAMS hardware and software has very little problems with light pollution, either from streetlights or from moonlight, as long as the sky is reasonable clear, meteors can be captured and orbits obtained. The CAMS project is meant to resolve the many minor streams from the sporadic background, therefore major streams like the Perseids are not a priority. The large numbers of orbits gathered for these streams will be analyzed in a separate paper.

Of course many orbits were registered for the α-Capricornids, δ-Aquariids South, Orionids, Taurids and several minor shower radiants. The large number of orbits obtained for these meteor showers will allow a detailed analyzes for which we prefer to accumulate still more data in order to cover the activity period for their entire range of solar longitudes.

Any trace of the 1567 Leonids dust trail?

Vaubaillon et al. (2005) listed a possible enhanced Leonid activity, expected around 2014 November 21, 8^h25^m, later corrected to 9^h17^m UT. The IMO Meteor Shower Calendar 2014[3] encouraged observers to try to observe this possible event. Although the predicted time was too late for the CAMS-BNL network on 20–21 November and much too early for 21–22 November to record any short lived event at the predicted time, we were curious if anything of this 1567 dust trail got captured by our cameras. Both nights were partially clear. The 21 cameras operated on November 20–21 resulted in 24 orbits, 5 of which were Leonids, November 21–22 had 31 of all 33 operational cameras capturing, good for 36 orbits of which only 2 were Leonids.

Since both nights suffered under very variable weather conditions, the chances to capture meteors simultaneously were much reduced. The main, nodal maximum of the 2014 Leonids was predicted for November 17, 16^h UT, but both nights, November 16–17 and 17–18 had only 6 and 9 cameras active, yielding 2 and 7 orbits of which only one was a Leonid. The uncooperative weather doesn't allow any conclusions in this particular case, but CAMS may help to identify shower meteors associated with similar enhanced activity in the future. The 5 Leonid orbits obtained few hours before the predicted time of the enhanced activity may be related to the 1567 dust trail.

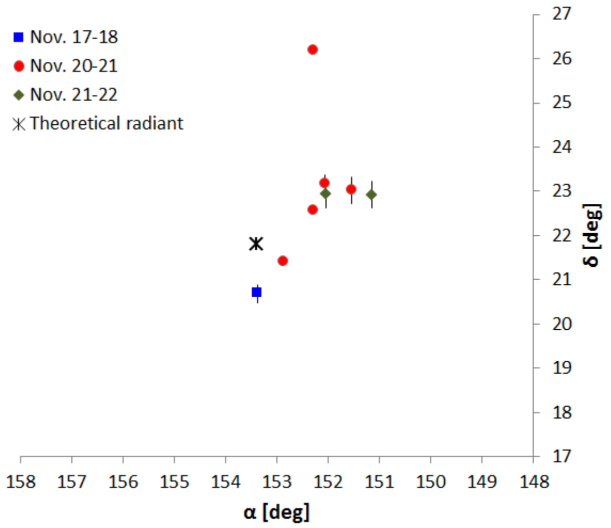


Figure 11 – Radiant positions 2014 Leonids computed from the CAMS data and corrected for the radiant drift.

The Geminids 2014

The Geminid activity period suffers often from totally clouded skies in the Low Lands without any chance to make astronomical observations. However CAMS-BNL was exceptionally lucky in 2014 with as many as 9 partially clear nights during the Geminid activity, including the night of maximum activity 13–14 December when all 37 operational cameras could participate. The nights 9–10 and 11–12 did not allow any observing while 12–13 allowed only 3 stations to record some (7) orbits. In total 528 orbits were identified as Geminid orbits.

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[3] http://www.imo.net/calendar/2014

Quadrantids 2015

A total of 38 cameras took advantage of the clear night of 3–4 January 2015 and 270 orbits were obtained for this single night, 157 of these were identified as Quadrantids, 143 of high quality. The circumstances weren't perfect as clouds interfered and reduced the number of simultaneous coincidences. With the maximum predicted for 2015 January 4, at 2^h UT, we split the dataset in an interval before 0h UT (radiant very low), a period of 4 hours centered around the predicted time of the maximum and a last interval for the Quadrantids captured after 4^h UT. The first interval had only 10 QUA orbits, the second had 51 QUA orbits and the last interval had 82 QUA orbits. Only two Quadrantids were recorded on 4–5 January although the CAMS-BNL network had all of its 39 cameras operated that night. Only four more Quadrantids were captured on later nights.

Figure 12 displays a rather compact radiant, about 6° x 4° slightly elongated in Right Ascension. With 285 radiants plotted (149 for 2015 and 136 for 2014) *Figure 12* contains much more data than Figure 20.9 published by Jenniskens (2006), but the compactness of the radiant and the elongation in Right Ascension are similar. In literature we often read that the Quadrantid radiant is rather diffused and contracts into a compact radiant during the shower maximum. The few Quadrantids we have from nights after 3–4 January 2015 don't indicate any diffuse radiant. We didn't bother to correct for the radiant drift but if we would do, the post maximum Quadrantids move even closer into the compact radiant region.

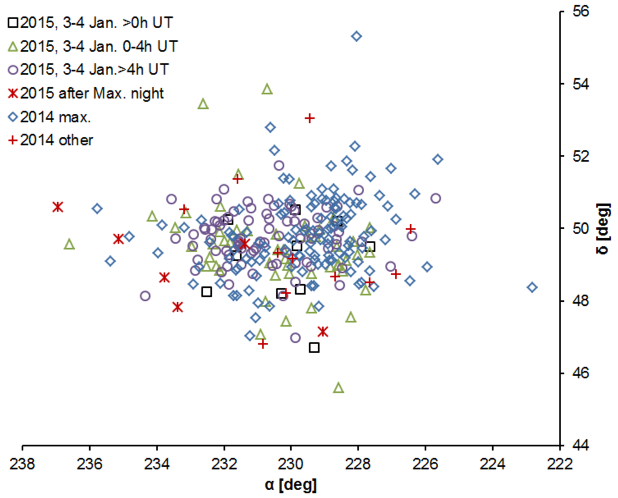

Figure 12 – Radiant positions for the 2015 and 2014 Quadrantids computed from the CAMS-BNL network.

Since we also have good data from 2014 January 3–4 we added these radiant positions into *Figure 12*. Also in 2014 on January 3–4 the entire CAMS-BNL network was operational at that time with 27 cameras and accumulated 186 orbits of which 125 were good quality Quadrantid orbits. 2–3 January was also entirely clear and 4–5 January was a partial clear night. In 2014 the maximum was expected on January 3, at 20^h UT when the radiant was very low in the sky. Also for 2014 the Quadrantid radiant shows to be a compact region and also in 2014 the Quadrantids captured before and after the maximum night give no indication for a diffuse radiant. The information about a diffuse Quadrantid radiant with a very compact radiant nucleus during the peak hours appeared systematically in the IMO Shower Calendar as well as in the older Handbooks without references. Checking up literature brought us back to Prentice (1940) who mentions "*It is well known that the radiant of the quadrantid shower is exceedingly complex and apparently covers a wide area at least 20° in diameter, with center about 230° +50°*", without reference. We did not succeed in tracing the source for the observed diffuse nature of this radiant.

Although the number of Quadrantid orbits outside the observing window of the shower maximum is too small to draw formal conclusions, at least we can say that from the orbits we obtained there is no indication for a diffuse Quadrantid radiant outside the activity period. This information might be better left out of the shower description unless some proves can be found to sustain it.

The average radiant position for the Quadrantid maximum nights confirms the position listed by IMO ($\alpha = 230°$ and $\delta = +49°$):

- $\alpha = 229.6° \pm 1.9°$ and $\delta = +49.8° \pm 1.2°$ (2014)
- $\alpha = 230.6° \pm 1.7°$ and $\delta = +49.6° \pm 1.0°$ (2015)

Oh, so boring month of February

After the Quadrantids at the beginning of January the best part of the year meteor-wise ends, a period that started mid-July with the α-Capricornids, δ-Aquariids and Perseids. When one major stream fades away another one starts in this period, combined with a rich activity of many minor meteor streams. The often poor weather, cold winter nights and absence of major showers explain why this period of the year has never been popular among visual observers. Is there really nothing to be seen?

February tends to be a dry month with a good number of clear nights in the Low Lands. This was also the case in February 2015 with 21 nights that allowed capturing double station meteors, just like in 2014 but with up to 39 operational cameras in 2015 against 30 in 2014. As many as 777 orbits were obtained in February 2015 and 10 minor showers from the IAU Working list of Meteor showers could be identified.

427 FED (February η-Draconids): On the night of 3–4 February 2011, CAMS in California registered 6 orbits with a radiant close to η-Draconids. Jenniskens (Jenniskens and Gural, 2011) concluded that this could be a young meteor shower related to an unknown long periodic comet. The orbits occurred only in a single night, 3–4 February and nothing of it was found of it in the SonotaCo database of 2007 – 2009. Since then the shower was added to the IAU list among the established showers. In the early evening of 4 February 2015 some stations of CAMS-BNL captured two meteors with almost identical orbits as found in 2011. Applying the

D-criterion of Drummond proves the relationship between the orbits with $D_{SH} < 0.02$.

Table 2 – comparing the orbital elements for the FED (427) with the orbits obtained by the CAMS-BNL stations 331, 342 and 364.

	California	BNL-1	BNL-2
YYYYMMDD	2011.02.04	2015.02.04	2015.02.04
Time (UT)		$18^h15^m55.86$	$18^h21^m09.30$
H_b (km)	103.6±1.4	108.4	101.6
H_e (km)	95.7±1.5	89.9	90.8
α (°)	239.92±0.50	239.92±0.11	240.92±0.34
δ (°)	+62.49±0.22	+62.31±0.23	+62.36±0.44
V_g (km/s)	35.58±0.34	35.18±0.11	35.06±0.17
q (AU)	0.971±0.0001	0.97083±0.00027	0.97238±0.00061
1/a (AU^{-1})	-0.004±0.025	0.0293±0.0119	0.0299±0.0212
e	>1	0.9715±0.0115	0.9709±0.0206
i (°)	55.2±0.34	54.916±0.163	54.725±0.295
ω (°)	194.09±0.35	194.260±0.106	193.501±0.291
Ω (°)	315.07±0.10	315.3951±0.0003	315.3988±0.0004
Π (°)	149.2	149.655±0.106	148.900±0.292

The main CAMS installations in California did not register any meteor related to the FED (427) in that same period although the observing conditions were perfect. In the next years we should carefully monitor the sky for more meteors from this meteor stream around 4 February.

February γ-Lyrids? An outburst was reported by radio observers on 2015 February 5 between 10^h and 11^h UT. First another outburst of the February η-Draconids was assumed, but this was quickly reconsidered. The Canadian Meteor Orbit Radar (CMOR) at Tavistock, Ontario produces every day orbits from 4000 to 5000 meteors. The 24 hour radar image of February 5 shows a clear concentration at α = 285° and δ = +35° or some 45° east and 30° south from the position of the η-Draconid radiant. This position is close to the star γ Lyrae. A Belgian radio observer (Lucas Pellens) indicated that the radiant responsible for this activity had to be close to the local zenith and indeed Lyra was at the zenith for this radio observer. The Full Moon may explain why no visual observations were reported about this event.

CAMS-BNL had up to 38 cameras capturing in the nights before and after this event, for instance 4–5 February yielded 41 orbits, 5–6 February, 56 orbits and 6–7 February 116 orbits. However not any orbit matches with the positions found by CMOR which means that either the activity was too short lived or the meteors were too faint to be captured by CAMS-BNL.

429 ACB (α-Coronae Borealids): John Greaves (2012) found some activity from a radiant near α-Coronae Borealis end of January, begin of February, from the SonotaCo database in the period 2007 to 2009. In the 2015 CAMS-BNL data we find 4 candidate orbits begin February and 2 candidates end of January for these fast (V_g ~58 km/s) meteors. The D-criterion confirms that 4 of these meteors definitely belong to this minor shower.

506 FEV (February ε-Virginids): Steakley and Jenniskens (2013) detected this minor shower from CAMS in California and SonotaCo in Japan based on 22 candidate orbits. The radiant position is α = 201.7°, δ = +10.4° with a geocentric velocity V_g = 63 km/s. In the 2015 dataset of CAMS-BNL we find three candidate orbits for this stream with a D-criterion between 0.03 and 0.05.

Activity from 2015 CA40? Marco Langbroek discovered a fast moving minor planet on 16 February. The about 45 meter sized object passed about 2.4 million kilometer outside the Earth orbit. Integrating the orbit of the object back in time indicated that the minor planet possibly crossed the Earth orbit some 3000 years ago. According to Marco Langbroek the object is too small to be a parent body itself, but it may be a remnant of a larger disrupted body. Therefore he asked to check the CAMS-BNL data for slow meteors in the nights 20–24 February from a large radiant area around α = 267°, δ = 68° and V_g = 8.1 km/s. The radiant for such slow velocity may be 30° in diameter. However no meteors were discovered to match the orbit of this object, neither from CAMS-BNL nor from the main CAMS in California. Although this is a negative result, as nothing has been detected or confirmed, this clearly proves the usefulness of CAMS to available to check out on events like this.

Lyrids 2015

An exceptional period with clear night allowed the CAMS-BNL network to function with up to 43 cameras during 27 nights, 11 of which were only partial clear. In total 1212 orbits were obtained this month. The Lyrid activity could be well monitored and 86 Lyrid orbits were identified with a D-criterion < 0.105.

Table 3 – Observing nights during the 2015 Lyrids activity. refers to the average for the Lyrid orbits obtained, CAMS is the number of cameras active. Further the total number of orbits and number of Lyrids orbits is listed for each night with the average radiant position obtained for this night.

Date	$\lambda_\odot$	CAMS	Orbits	Lyrids	α (°)	δ (°)
14–15	24.41	40	67	1	268.7	+30.7
15–16		38	35	0		
16–17		16	13	0		
17–18	27.38	41	89	1	262.6	+40.7
18–19	28.53	42	63	4	269.9	+38.0
19–20	29.41	42	88	10	271.3	+34.7
20–21	30.40	42	87	12	269.5	+34.9
21–22	31.42	41	58	10	270.5	+34.1
22–23	32.32	32	69	34	272.0	+33.3
23–24	33.33	43	69	14	273.9	+33.1

The IMO Shower Calendar for 2015 lists as activity period April 16–25 with a maximum at $\lambda_\odot$ = 32.32°, which is about 22-23 April at 0^h UT. The first Lyrid orbit was identified in the night of 14–15 April while the nights of 15–16 and 16–17 April suffered some interference from poor weather conditions (less cameras active and much less orbits obtained). Although the network had 41 of its 42 cameras running all night on 17–18 April only 1 Lyrid orbit was identified among 89 orbits. The nights 18–19 and 21–22–23–24 April had less favorable weather conditions while 24–25 April was completely lost due to bad weather. Although only 32 of the 42 cameras could be operated and weather wasn't very cooperative, as many as 34 Lyrid orbits were identified for this night. All details are listed in *Table 3*.

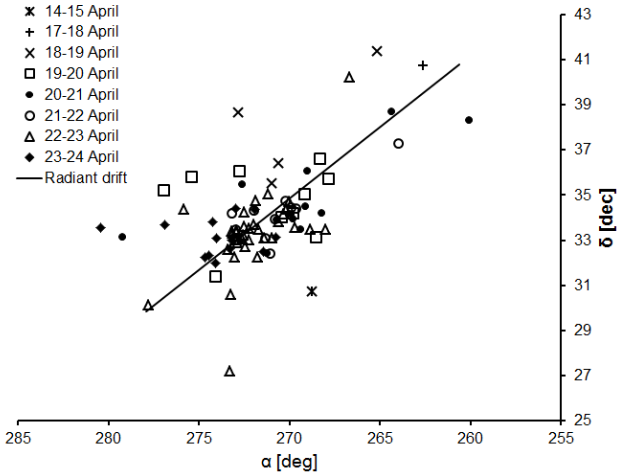

Figure 13 – Radiant positions for 86 Lyrids computed from the CAMS-BNL network in April 2015.

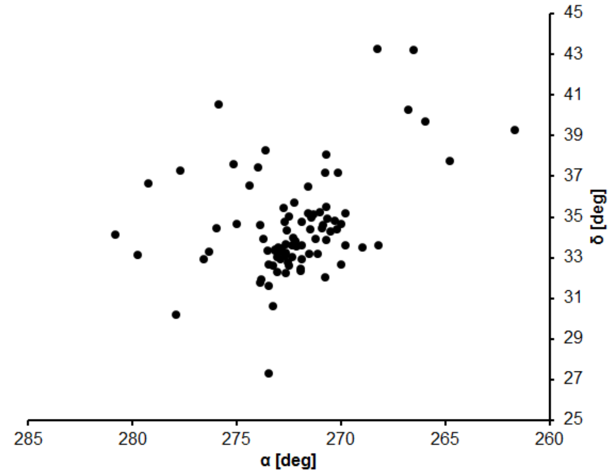

Figure 14 – Radiant positions for 86 Lyrids computed from the CAMS-BNL network in April 2015, corrected for radiant drift.

Figure 13 shows the plot of the radiant positions of all the individual Lyrids. Although there is a clearly visible concentration around the radiant position mentioned in the IMO Shower Calendar (α = 271° and δ = +34°), several individual radiant positions differ quite a bit from the concentration of radiant points. In this case there is no explanation such as plotting errors or large uncertainties on the position. The radiants from the orbits indicate that the Lyrids radiant is rather diffuse with a concentration at the position α = 271 ± 3 and δ = +34 ± 2 (°). The radiant drift was calculated as Δα = +0.78° and Δδ = -0.49°. When we plot all the radiant positions corrected for this radiant drift, the picture is still a clearly diffuse radiant area (*Figure 14*). Considering the orbital elements per night, it is obvious that the two earliest Lyrids were outliers. Especially the Lyrid orbits obtained during the maximum night are close to values found in literature (*Table 4*).

Table 4 – The orbital elements of the 2015 Lyrids per night and for the entire period by CAMS-BNL compared to the photographic results of DMS in 2010 and Brown et.al. (2010).

Date	$\lambda_\odot$	V_g	q	e	i	ω	Ω
14–15	24.41	50.8	0.921	1.097	85.8	212.53	24.40
17–18	27.38	40.1	0.929	0.905	65.8	212.60	27.37
18–19	28.53	43.6	0.948	0.915	73.5	207.92	28.52
19–20	29.41	46.3	0.935	0.963	78.6	210.49	29.40
20–21	30.40	45.1	0.921	0.934	76.3	213.91	30.39
21–22	31.42	45.7	0.918	0.940	77.4	214.85	31.41
22–23	32.32	46.6	0.918	0.952	79.3	214.67	32.31
23–24	33.33	47.0	0.925	0.945	80.4	213.22	33.32
All	31.44	46.2	0.923	0.948	78.4	213.50	31.44
DMS	32.4	46.6	0.921	-	79.6	214.3	31.8
Brown	32	46.6	0.915	0.916	80.0	215.71	32.0

372 PPS (φ Piscids)

This minor shower was identified by the CMOR system using radar data from 2001 to 2008 (Brown et al., 2010) and was also listed by SonotaCo, the IMO Video Meteor Network and confirmed by CAMS (Holman and Jenniskens, 2013), see *Table 5*. Checking the datasets of CAMS-BNL for the period 95°< $\lambda_\odot$ <101°, 13 orbits were found in 2014 identified as φ-Piscids (PPS-372), and as many as 37 orbits for 2015 for the period 95°< $\lambda_\odot$ <108. The dataset for 2015 isn't yet complete at the moment that this paper is written.

This minor stream has been studied using the CAMS data as available in 2012. Meanwhile a lot of more CAMS orbits became available. Considering the latest two years CAMS-BNL data compares well with previously obtained results. Since CAMS-BNL is only a subset in the order of 10% of the global CAMS network. These preliminary results for recent years indicate what to expect from future analyses of the datasets as a whole.

507 UAN (υ Andromedids)

The Upsilon Andromedids were first noticed in 2012 from the analyses of CAMS data (Holman and Jenniskens, 2013). The first analyses allowed to identify 13 shower members and a new analyses based on 2010–2013 data included 28 orbits (Jenniskens et al., 2015).

A search through 2014 CAMS-BNL orbits for the period 95°< $\lambda_\odot$ <100 resulted in 17 orbits identified as υ Andromedids. In the period 95°< $\lambda_\odot$ <109 in 2015, another 20 orbits were found. Although these numbers of orbits allow considering this source as established, more data is required to document this minor meteor stream properly. It is obvious that because of the low activity level and the presence of other nearby radiants, only orbital data may help to identify shower members for this shower.

Table 5 – The orbital elements of the φ Piscids (PPS 372) and the υ Andromedids (UAN 507) according to different references.

(372) PPS φ Piscids

Year	$\lambda_{\odot}$	N	$\lambda_{\odot}$	α_{geo} (°)	$\Delta\alpha$	δ_{geo} (°)	$\Delta\delta$	V_{geo}	q	e	i (°)	ω (°)	Ω (°)
Brown 2010		1395	106	20.1	1.6	+24.1	0.4	62.9	0.856	0.590	152.6	125.2	106.0
PJ 2013		43	94	12.9		+22.0		67.1	0.883	0.898	152.6	136.7	97.7
SonotaCo				16.3		+23.4		66.6	0.882		152.2	136.2	101.6
VMN				15.3		+23.5		69.1					
CAMS 2014	95 - 101	13	100	18.9	0.77	+27.2	0.6	66.9	0.892	0.920	150.7	138.2	99.7
CAMS 2015	95 - 108	37	102	18.7	0.77	+26.9	0.3	66.1	0.891	0.882	148.5	137.6	101.9

(507) UAN υ Andromedids

Year	$\lambda_{\odot}$	N	$\lambda_{\odot}$	α_{geo} (°)	$\Delta\alpha$	δ_{geo} (°)	$\Delta\delta$	V_{geo}	q	e	i (°)	ω (°)	Ω (°)
PJ 2011		13	98	19.8	1.18	+42.5	0.35	58.8	0.688	0.968	116.4	110.3	98.0
PJ 2010/13		28	96	7.1	0.96	+40.3	0.39	59.3	0.849	0.910	117.8	130.0	101.0
CAMS 2014	95 - 100	17	99	16.7	1.74	+43.2	0.60	58.2	0.759	0.931	114.9	118.4	98.6
CAMS 2015	95 - 109	20	99	20.5	1.07	+43.6	0.53	57.6	0.691	0.947	113.4	109.9	102.8

The CAMS-BNL orbits identified for these minor showers compare well for 2015 and 2014. The φ Piscids seem to have their maximum later than $\lambda_{\odot}$ ~94° (Jenniskens (2015). With the current available data it looks too early to draw conclusions, but at least these two sources are very well present in the 2014 and 2015 datasets of CAMS-BNL. With these minor streams, new questions arise and future data should allow more conclusive results.

4 Conclusion

The period of July 2014 – June 2015 totals 13313 orbits against 8355 in the corresponding period one year earlier. It is obvious that with the current number of operational cameras, 30 at the beginning of this period and 45 at the end, a statistical significant dataset of orbits has been generated by the CAMS-BNL network, although this represents no more than 10% of the global CAMS dataset. This offers plenty of possibilities for amateur based analyses on the local CAMS-BNL data. The results discussed in this paper also show the capacities of CAMS as an independent meteor video capturing technique, next to SonotaCo with UFOCapture, the IMO VMN with MetRec, FRIPON with FreeTure, CMN with MTP Meteor Detector software and few other systems.

Since CAMS-BNL focuses on the meteor producing layer of the atmosphere above Belgium and the Netherlands, interested amateurs are invited to join the network to improve the coverage of the network area. Any amateurs living abroad within about 200 km from the border with Belgium or the Netherlands could connect to the existing network. French amateurs being able to point a camera in Northern direction, German amateurs willing to point westwards or amateurs in the South East of the U.K. aiming some camera in eastern direction would be most welcome to join the CAMS-BNL network.

Acknowledgment

The authors wish to thank all participants for their efforts and discipline to submit the CAMS data shortly after each observing night. We also emphasize that all the efforts of the CAMS-BNL team are done as volunteers and that all equipment is being financed privately by each participant without any kind of subsides. The current (June 2015) CAMS-BNL team:

Hans Betlem (Leiden, operating CAMS 371, 372 and 373), *Felix Bettonvil* (Utrecht, operating CAMS 376 and 377), *Jean-Marie Biets* (Wilderen, operating CAMS 381 and 382), *Martin Breukers* (Hengelo, assistant coordinator and operating CAMS 320, 321, 322, 323, 324, 325, 326), *Franky Dubois* (Langemark, operating CAMS 386), *Luc Gobin* (Mechelen, operating CAMS 390), *Robert Haas* (Alphen aan de Rijn, operating CAMS 360, 361, 362, 363, 364 and 365), *Klaas Jobse* (Oostkapelle, operating CAMS 331, 332, 337 and 338), *Carl Johannink* (Gronau, coordinator and operating CAMS 311, 312, 313, 314, 315 and 316), *Paul Lindsay* (Lieshout, operating CAMS 356 and 357), *Koen Miskotte* (Ermelo, operating CAMS 351 and 352), *Piet Neels* (Ooltgenplaat, operating CAMS 341, 342, 343 and 344), *Steve Rau* (Zillebeke, operating CAMS 385), *Paul Roggemans* (Mechelen, operating CAMS 383, 384, 388 and 389) and *Erwin Van Ballegoij* (Heesch, operating CAMS 347 and 348).

The authors also wish to thank *Masahiro Koseki* for his assistance with the presentation of the 2014 κ-Cygnids data according to the presentation of his analyses of the κ-Cygnids. Thanks to *Dr. Peter Jenniskens* for his efforts to involve amateurs in the CAMS project. Last but not least, thanks to *Pete Gural* for having created the CAMS software, for his continuous support and his creativity which makes our single CAMS network possible.

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