The Global Radio Camelopardalids 2014

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The on-line hourly radio counts are analyzed for the presence of the predicted May 24 Camelopardalids. Selection criteria are developed and an averaging method is proposed. Meteor activity is indeed detected during the predicted period. The method works for short duration outbursts and almost stationary radiants.

1 Introduction

Several authors (Ye and Wiegert, 2014) alerted about a possible meteor activity associated with Comet 209P/LINEAR. Dust trails would intersect with the Earth path on May 24, 2014, centered around 7^h UT, with radiant position $\alpha = 122^\circ$, $\delta = +79^\circ$.

Thanks to its high declination, the radiant has a small daily movement. This means that the Observability Function is not varying a lot during the timeframe under study, and that the whole day is covered by observers in the Northern hemisphere. The meteors are very slow (20 km/s with zenith attraction), like the Draconids which got an outburst in 2011 (Steyaert, 2012).

2 The observations

The initial screen (Figure 1) of Radio Meteor Observatories On-Line (RMOB) includes now the name of the observers for easy positioning[1]. During May 2014, 45 submissions were made, most of them counting automatically.

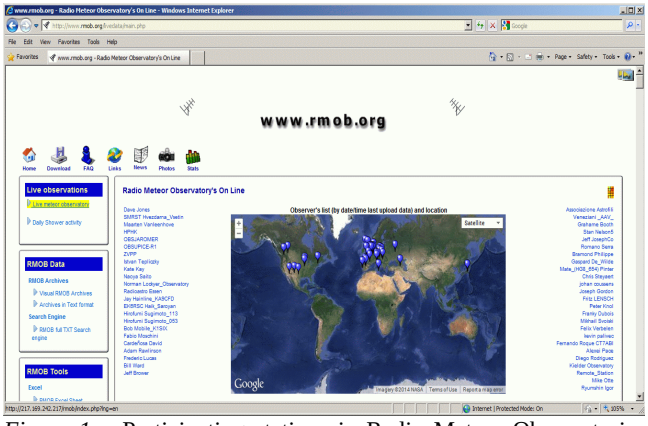

Figure 1 – Participating stations in Radio Meteor Observatories On-line.

A typical monthly graph (Figure 2) shows the daily pattern with a maximum in the morning hours local time, and a minimum in the evening, with superimposed stream activity, like the η Aquariids around May 8.

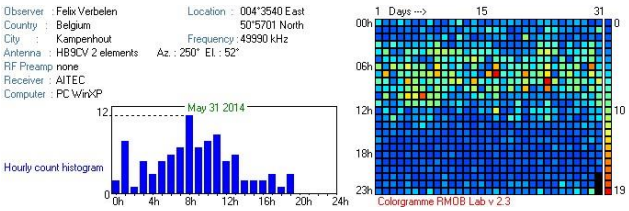

Figure 2 – Typical daily radio count pattern.

3 The selection technique

Unfortunately not all observations can be used. A first category comprises observations:

- having erratic counts / system setup or sensitivity change during the month,
- not observed on May 24.

Ten submissions are removed applying this criterion.

In a second pass, also removed are observations:

- having no data adjacent to May 24,
- not using UT.

Another 15 observations are removed applying this criterion. Please note that having increased counts in the predicted CAMs activity period was *not* a selection criterion. Eventually we are left with 11 observations in Europe, 6 in North America, and 3 in Japan. Six of the European observations are using the GRAVES transmitter.

4 The GRAVES observations

GRAVES stands for ***G**rand **R**éseau **A**dapté à la **Ve**ille **S**patiale*, a space debris tracking radar, capable of detecting objects of size 10 cm in low orbit (Federation of American Scientists, 2013)[2]. The transmitter is located near Dijon. Its EIRP (Equivalent Isotropically Radiated Power) is several

[1] http://www.rmob.org/livedata/main.php

[2] http://fas.org/spp/military/program/track/graves.pdf
"A GRAVES Sourcebook"

megawatts at 143.050 MHz, and it applies beam switching. Due to its enormous radiated power, the signal can be observed up to more than 1000 km from the transmitter.

Figure 3 – The GRAVES transmitter and the six retained observing stations for May 2014.

5 An averaging technique

Multiple observations can be combined in several ways. We are trying out the geometric mean of m counts $n_1, n_2, \ldots, n_m$ defined as:

$$(n_1\, n_2\, \cdots\, n_m)^{\frac{1}{m}}$$

The geometric mean smooths out the higher values, which is the more conservative approach to avoid spurious values.

If one or more of the counts equal zero, the geometric mean is zero too. This is a convenient way to deal with missing counts, which are represented by a zero count. Hence the geometric mean is always based on the total number m of observations.

We try this technique with just two observations, those labeled *_AAV__052014* and *TERRIER_052014*. In the resulting graph (Figure 4) the η Aquariids early May, as well as activity on May 24 is clearly seen.

Adding *SVAKOV-R4_052014* (Figure 5) makes the May 24 activity even standing out better. If on the other hand the observations would be uncorrelated or random, the signals would cancel each other out.

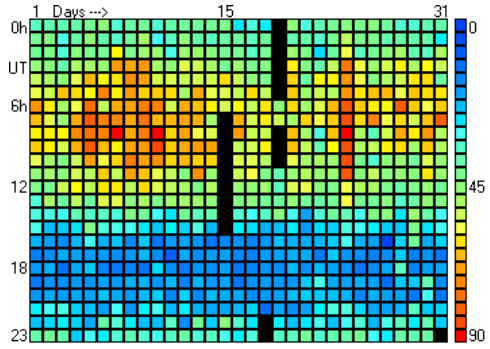

Figure 4 – Combining two.

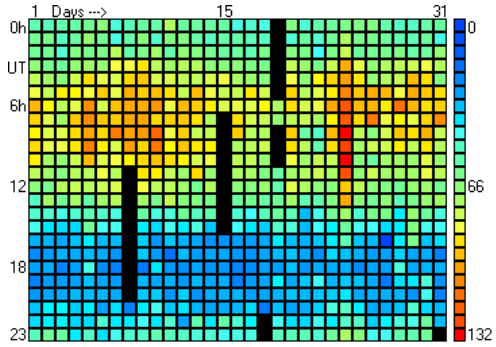

Figure 5 – Combining three.

Adding the three remaining observations, *Jones_052014 ZVPP_052014* and *Observatory_Vyskov_052014*, yields Figure 6.

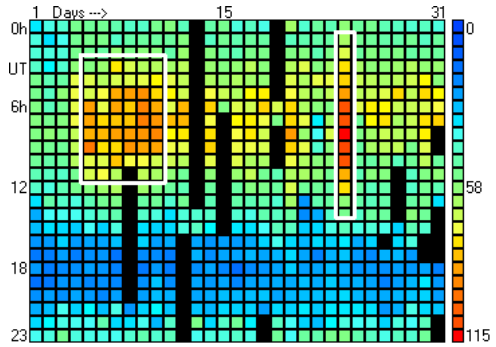

Figure 6 – The GRAVES transmitter and the six retained observing stations for May 2014.

The combined result of these heterogeneous observations exceeds the expectations. There is an extended activity period on May 24, from 1^h UT to 13^h UT. There is a shallow maximum from 7^h to 9^h UT, in line with the 209P/LINEAR stream forecasts. Figure 7 is the periodogram of the May 23-25 geometric means.

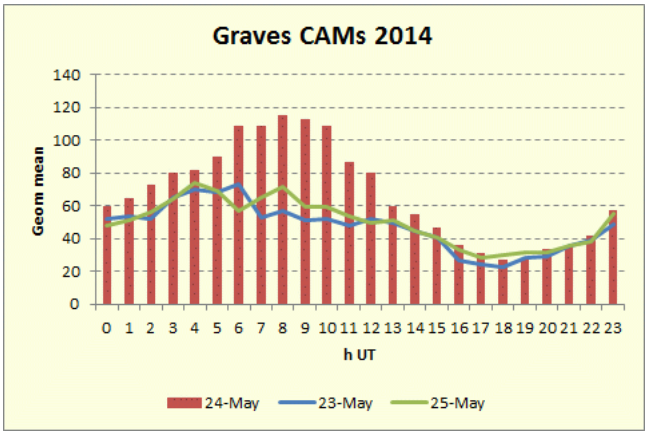

Figure 7 – Showing the excess averaged counts during May 24, 0^h to 14^h UT interval.

On Figure 6 the CAMs activity of May 24 is higher than that of the η Aquariids. However the Observability Function of the η Aquariids is varying strongly during the day and is very different for the various observers. Hence the averaging technique reduces the signature of this

stream. No conclusions about absolute strength of a stream can be made.

Assuming that the CAMs activity would have happened 10 hours later, the combined GRAVES observations would have looked like Figure 8. As the CAMs are superimposed on the lower activity in the local afternoon/evening, the total counts would be lower too. However, the signature would even be clearer.

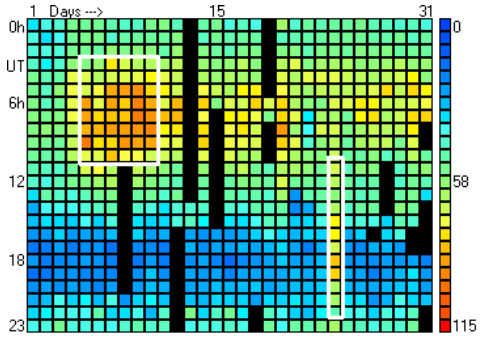

Figure 8 – Simulation of the CAMs activity would have happened 10 hours later.

6 Other observations

The only other reported multiple observations of the same transmitter are by *De_Wilde_052014*, *Dubois_052014*, *Steyaert_052014*, *Verbelen_052014* of the VVS beacon (49.99 MHz, 50 W output power). There is activity detected on May 24, but so there is e.g. on May 30. The probable reason for the less efficient detection is the relatively low counts of Verbelen.

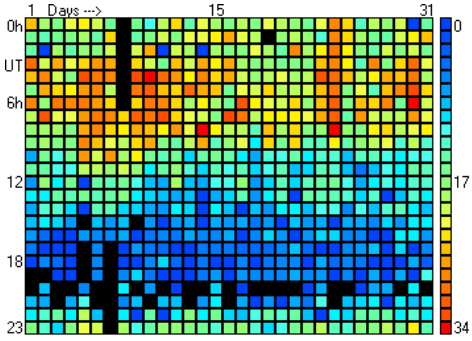

Figure 9 – VVS beacon four observations.

Single Japanese observations do not show well increased activity, although the timing (during the low of the daily cycle) was favorable. Antenna geometry and the low counts might be the reason.

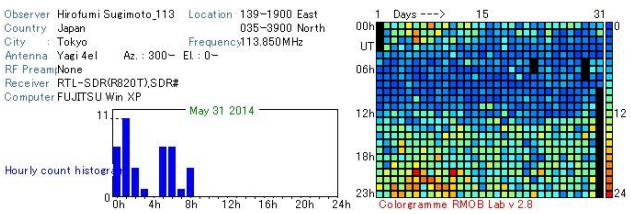

Figure 10 – Representative Japanese observation.

An observer located 550 km to the southwest of the 250 W ouput power BRAMS beacon (49.97 MHz) did record activity, but only around the maximum.

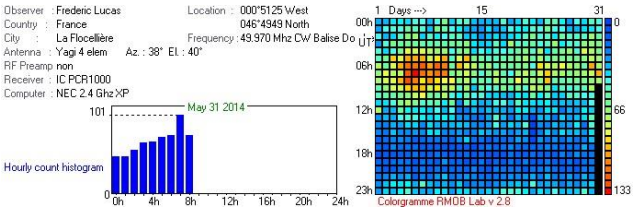

Figure 12 – BRAMS beacon observation.

The author used the Draconids 2011 (Steyaert, 2013) and η Aquariids 2012 (Steyaert, 2014) observations of Michael Svoiski. This time, hardly any activity can be noted. Unfavorable geometry (which doesn't change a lot) must be the cause, although it was not investigated in detail.

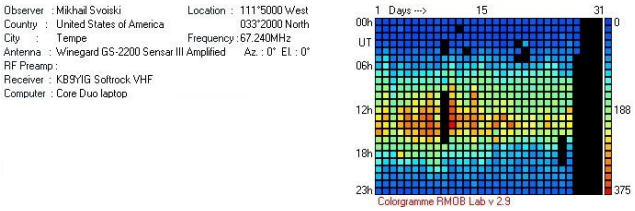

Figure 12 – Michael Svoiski – United States.

Conditions were apparently more favorable for Jeff Brower in Canada.

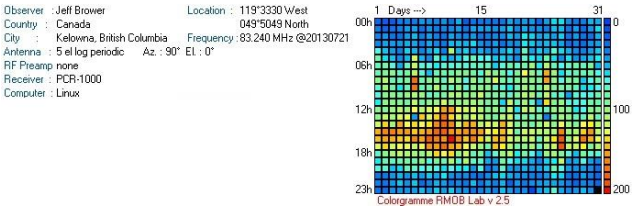

Figure 13 – Jeff Brower - Canada.

7 Detailed observations and spatial correlation

We looked in detail at the spectrograms and found out that many overdense meteors, characterized by the 'ε' shaped reflections appeared in the period May 24, 08^h15^m – 08^h40^m, whilst there are mainly underdense reflections outside that interval. This is both the case for European and North American observers (Figures 14 and 15).

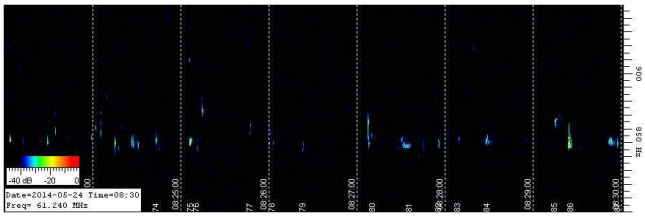

Figure 14 – Seven minute activity period Brower Canada.

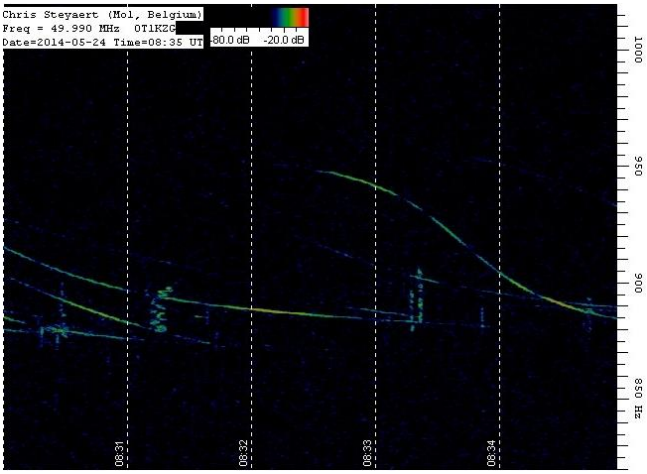

Figure 15 – Five minute activity period at Steyaert, Belgium.

The distance between the two observers orthogonal to the direction in which the meteoroids move is approx. 8000 km (Figure 16). The difference along the travelling direction is much smaller. A difference of 1000 km corresponds to approx. 1 minute in arrival time. This is small compared to the dimension of the stream, which confirms that the longer lasting reflections take place at almost the same time.

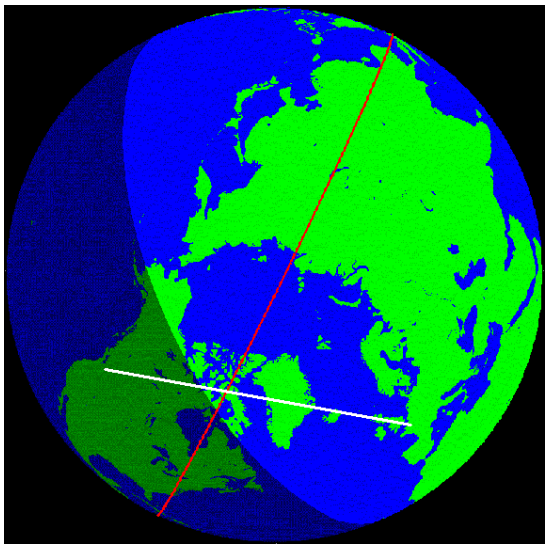

Figure 16 – Encounter geometry according to (Maslov, 2014)[3].

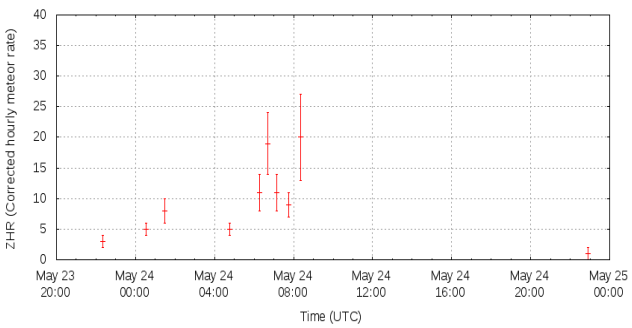

Figure 17 – Visual observations collected by IMO.

The visual observations collected by IMO[4] (Figure 17) situation on July 9, 2014 stop around 8^h UT, perhaps due to daylight or other adverse visual conditions. Maybe the maximum of brighter meteors wasn't seen by anybody.

8 Analysis opportunity

Readers interested in making their own analysis of the CAMs 2014 or of any other stream can find the basic data in the Visual RMOB Archives[5] [6]. The number of monthly submissions and their quality is steadily increasing since the start in 2000.

9 Conclusion

The CAMs were detected beyond doubt in most radio forward scatter observations. Most successful were the observations of the GRAVES transmitter. Not only was it observed from many places, also its strong power favored the registration of smaller particles during the long interval of May 24, 1^h – 13^h UT. A maximum of larger particles occurred on May 24, 8^h – 9^h UT.

Acknowledgment

The author wishes to thank the `rmob.org` contributors, Pierre Terrier for his hosting and continuous improvements of `rmob.org`, and Jeff Brower for his detailed observations. We learned about the 209P/LINEAR promise at the IMC 2013 meeting. The (meteorobs) mailing list kept the world in real time informed about the progress of the 209P/LINEAR stream.

References

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Ye Q., and Wiegert P. A. (2014). "Will Comet 209P/LINEAR Generate the Next Meteor Storm?". *Mon. Not. R. Astron. Soc.*, **437**, 3283–3287.

[3] http://feraj.narod.ru/Radiants/Predictions/209p-ids2014eng.html "209P-ids 2014: prediction of activity"

[4] http://www.imo.net/live/cameleopardalids2014/

[5] http://www.rmob.org/articles.php?lng=en&pg=28

[6] http://rmob.org/visual/2014/