The global radio η-Aquariids 2013

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Most of the years, the η-Aquariids are not very conspicuous for (radio) observers in the Northern Hemisphere. In 2013, a strong return was observed, confirming a last minute prediction of old dust trails that approached the Earth.

1 Potential increased activity

On May 4, 2013, Mikiya Sato posted on the `meteorobs` mailing list a message entitled "Dust Trail of Eta Aquariids in 2013"[1]. The highlights of his message were as follows:

> *"I found out that the old dust trails of Eta Aquariids (ETA) will approach the earth in 2013.*
>
> *Date (UT) May 06 05:45 to May 06 21:19*
>
> *The peak may be continuous or broader because distribution of the old dust has spread.*
>
> *I expect that they are about 2 times of the usual activity at the maximum because this case is similar to Orionids from 2006 to 2010.*
>
> *Detection of the increase is not easy since observation condition of ETA is not so good in the Northern Hemisphere."*

Radio observations of course overcome the twilight problem of the Northern Hemisphere.

2 The η-Aquariids observing conditions

The η Aquariids radiant is located at $\alpha = 336°$ and $\delta = -02°$. Hence it rises almost in the east, sets in the west, and is about half a day above the horizon every 24 hours, anywhere on the world.

For an observer in Brussels (representative for Western Europe), the radiant culminates at an elevation of 37° around 7^{h} UT (Figure 1). The low elevation is a drawback, but, on the other hand, the geometry is rather simple in comparison to a stream with a circumpolar radiant.

The high velocity of 66 km/s results in higher and less efficient radio reflections.

For these reasons, the η-Aquariids remain largely unnoticed in radio observations, as found in the Visual RMOB Archives[2].

[1] http://lists.meteorobs.org/pipermail/meteorobs/2013-May/016074.html.

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

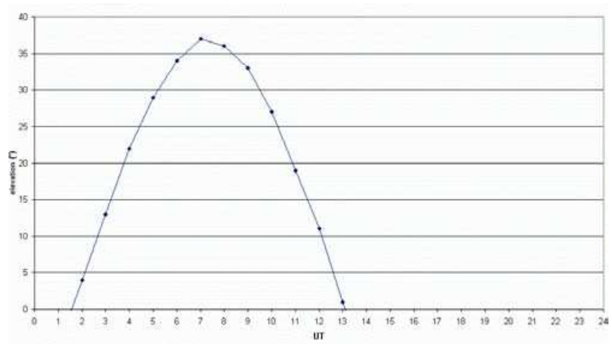


Figure 1 – Radiant elevation of the η-Aquariids versus time for Brussels ($\lambda = 5°$ E, $\varphi = 51°$ N).

3 Global hourly radio counts of the η-Aquarids 2013

"Radio Meteor Observatories On Line"[3] was described extensively by Steyaert (2013).

Of the many submissions, we selected two representative ones:

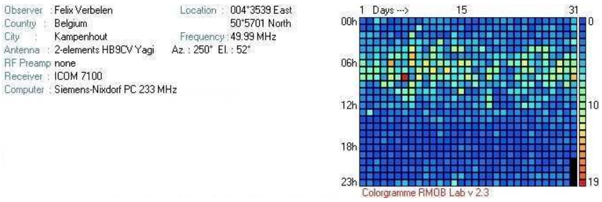
1. Felix Verbelen manually counting reflections of a low-power dedicated beacon (50 MHz) in Western Europe; and
2. Mikhal Svoiski counting reflections from a tens of kW TV transmitter (67.24 MHz) in central North America with an automated script.

Figure 2, (b), and Figure 3, (a), show their hourly counts of May 2013, with the visibility period of the η-Aquariids removed. Clearly there is little stream activity.

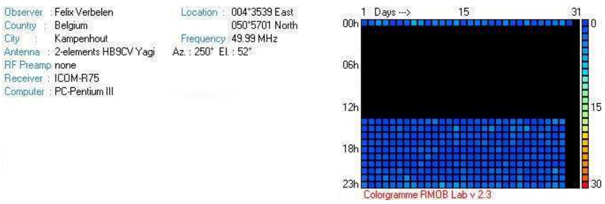
The picture changes dramatically when adding the η-Aquariids visibility period, cf. Figure 2, (c), and Figure 3, (b). From May 2 to 10, activity is seen with a daily maximum around 7^{h} local time and an absolute maximum on May 6. In the period 2005–2013, only Verbelen in 2009 observed significant activity on May 6, cf. Figure 2, (a).

Automated counts are quite challenging at peak times of streams. Figure 4 shows Svoiski's most busy spectrograms during the η-Aquariids. The vertical lines are

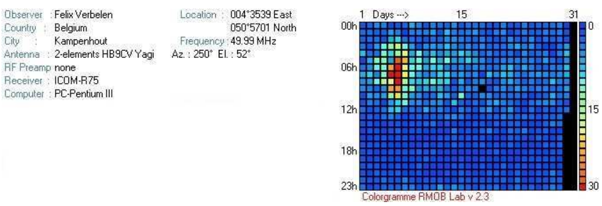
[3] http://www.rmob.org/livedata/main.php.



(a) May 2009

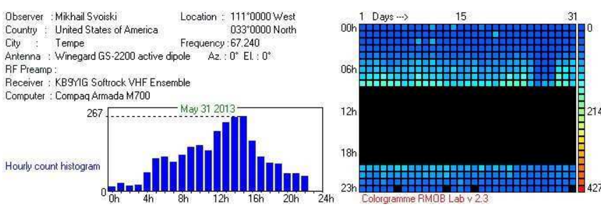


(b) May 2013, excluding ETA visibility period

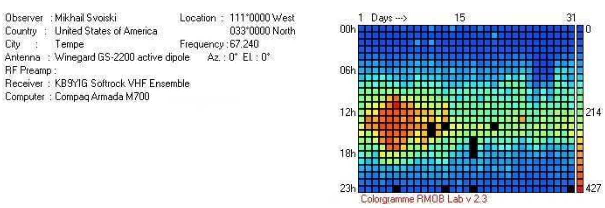


(c) May 2013, including ETA visibility period

Figure 2 – Observations by Felix Verbelen



(a) May 2013, excluding ETA visibility period



(b) May 2013, including ETA visibility period

Figure 3 – Observations by Micha Svoiski.

underdense meteors. The bifurcated or "epsilon" shaped long lasting reflections typically belong to stream meteors. For a full account of the features in the spectrograms, see Steyaert (2012, paragraph 2, "Detailed Observations").

4 Low number statistics

Meteors are normally arriving at random, which means that their number in a given interval follows the Poisson distribution. Hence, any measures based on meteor counts (be it the counts themselves, or, e.g., total reflection duration for that number of counts) will exhibit a spread from the "true" value.

(a)

(b)

Figure 4 – Crowded 5 minute intervals around the time of the apparent local maximum of the η-Aquariids recorded by Svoiski.

Figure 5, (a), is the hypothetical situation if the meteor activity could be measured precisely (like, e.g., a temperature) and the daily pattern would remain the same during the whole month. Figure 5 (b), (c), and (d), show simulations of Poisson for the daily pattern of Figure 4 (a) scaled for maximum 80, 40, and 21 counts. Not unexpectedly, deviations to both higher and lower counts emerge, and are relatively larger when the maximum counts are smaller. This raises the question if artificial stream-alike features can arise when using low counts. Verbelen's low May 2013 counts, cf. Figure 5, (e), are sufficiently convincing that the activity in early May is well above the noise threshold.

Verbelen counts only reflections of minimum duration 2 seconds. He could have higher counts including shorter reflections; however the additional meteors would be mainly sporadics. This would not help in improving the detection of streams. Svoiski's higher counts do include more sporadics, but he observes relatively more stream meteors thanks to a receiving antenna with a broader beam in combination with a stronger transmitter.

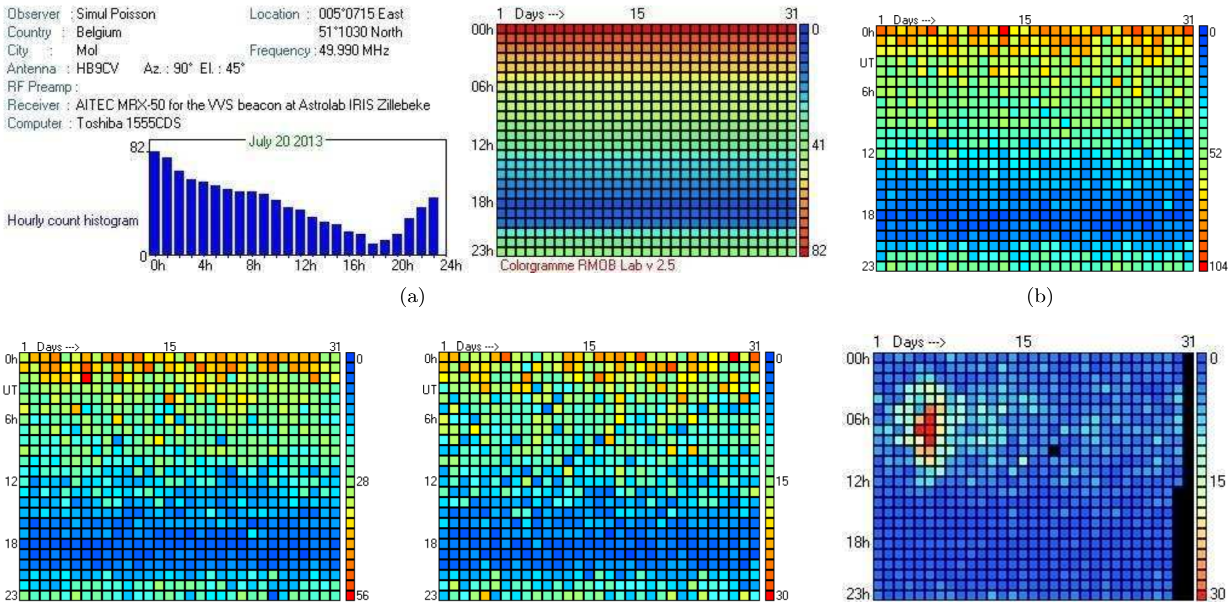


Figure 5 – Hypothetical exact measurements (a) versus patterns emerging from random events with maximum counts of respectively 82 (b), 41 (c) , 20 (d), and Verbelen's May 2013 counts (e).

5 Repeatability of radio meteor counts

Figure 6 shows Verbelen's daily totals of manual counts during eight years (April 2005–June 2013).

The largest streams that can be recognized during the year are the Perseids (end July–mid August), Geminids (December 7–17), and the Quadrantids (very narrow on January 3 or 4). Also seen are the daytime Arietids and Taurids during the whole of June. The Lyrids (April 22), Orionids (October 20), and Ursids (December 23) are not as strong, but detected every year. The Leonids (November 17) are absent as their activity was rather low, and their high speed is less favorable. The very short Draconid outbursts (October 9) of 2011 and 2012 are seen. The η–Aquariids of 2013 activity, the subject of this paper, show up nicely.

The period starting after the Quadrantids and ending before the Lyrids has almost no streams, and the sporadic activity is the lowest of the year. The daily counts on the same days do vary year by year. Firstly, the effect of the low number counts described above plays a role, and secondly there can be some real variations. All in all, these manual counts have a sufficient degree of repeatability.

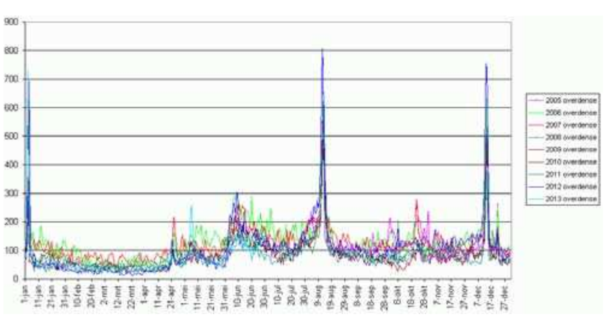


Figure 6 – Eight years of dayly counts by Felix Verbelen.

6 Modeling the stream activity

A method to model a single stream in the presence of the sporadic background was developed by Steyaert et al. (2006), Figure 7.

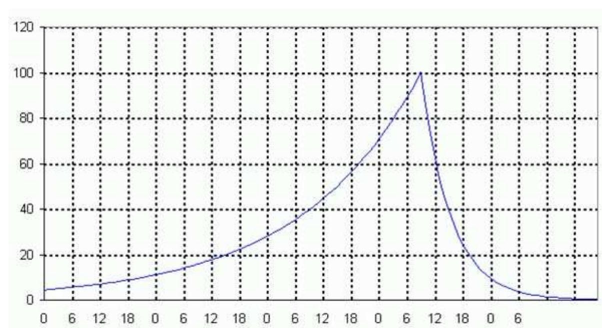


Figure 7 – General asymmetric activity versus time stream model.

The observed activity O is written as the sum of sporadic background S and the stream profile Z times the Observability Function OF:

$$\begin{aligned} O(t) &= S(T) + Z(T)\mathrm{OF}(T); \\ T &= \frac{t - t_0}{D}, \end{aligned}$$

with t_0 an arbitrary starting point and D the length of the day. We assume a double asymmetric exponential function for the stream:

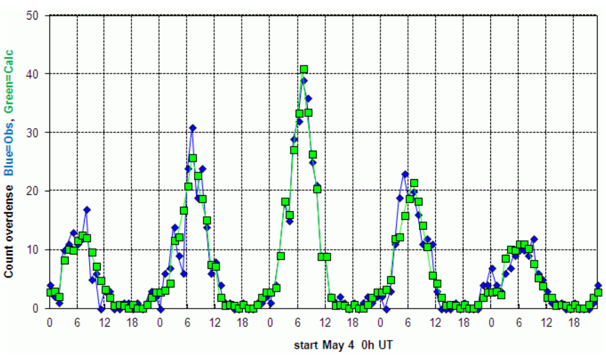
$$Z(t) = e^{-(t-t_M)/a},$$

for $t \leq t_M$, the time of the maximum, with constant rising time a, and

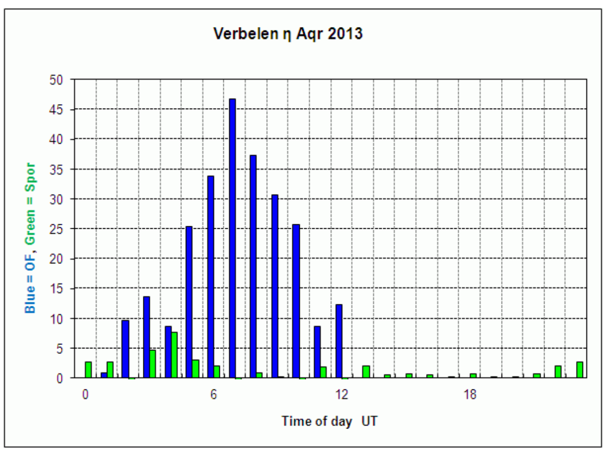
$$Z(t) = e^{-(t_M - t)/b},$$

for $t \geq t_M$, with constant decay time b.

Figure 8, (a), shows the resulting fit to Verbelen's 2013 η-Aquariids. The match is not and cannot be perfect because of the random nature of the counts, and potential limitations of the model. Figure 8, (b), shows the indirectly determined OF for the stream, as well as the calculated sporadics background. The OF is forced to zero when the η-Aquariids radiant is below the horizon.



(a)



(b)

Figure 8 – Model fit to Verbelen's 2013 η Aquariids (a) and numerically determined sporadics and Observability Function (b).

For the east-west geometry of the receiver-transmitter and the relatively low culmination height, the OF has a single maximum around the culmination time of the radiant. This was to be expected from Figure 2, (c).

7 Location of the maximum

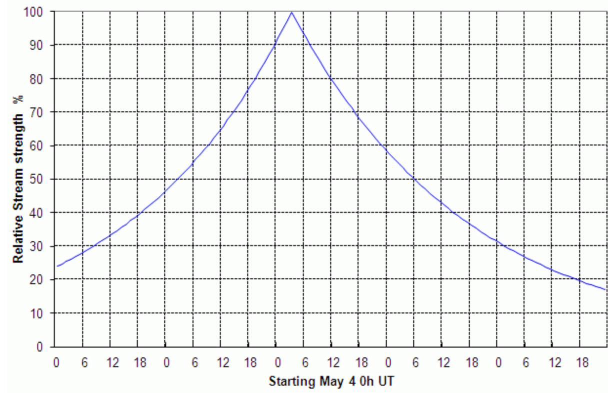
The values of the model parameters are, for Verbelen,

$$t_M = \text{May 6, } 3^{\mathrm{h}}.4 \pm 4^{\mathrm{h}} \text{ UT}, a = 36^{\mathrm{h}} \pm 7^{\mathrm{h}},\ b = 39^{\mathrm{h}} \pm 9^{\mathrm{h}},$$

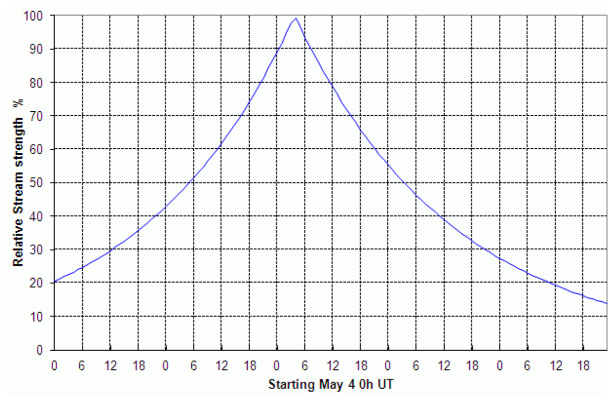
and, for Svoiski,

$$t_M = \text{May 6, } 4^{\mathrm{h}}.0 \pm 2^{\mathrm{h}}.5 \text{ UT}, a = 33^{\mathrm{h}} \pm 8^{\mathrm{h}},\ b = 34^{\mathrm{h}} \pm 10^{\mathrm{h}},$$

yielding very similar calculated stream profiles (Figure 9). The standard deviations to the parameters were found by means of Monte Carlo simulations.



(a) Verbelen



(b) Svoiski

Figure 9 – Calculated η-Aquariid stream profiles.

Considering the rather large spread on the time constants a and b, it is safe to say that the activity profile is symmetric. If there is no upfront indication that the activity is strongly asymmetric, the model could be simplified for one time constant a, additionally reducing the computational effort.

It should be noted that, for both observers, the observed maximum (May 6, 7^{h} UT for Verbelen, and 11^{h} UT for Svoiski) does not correspond to the time of the maximum. In the formula for $O(t)$, the OF outweighs the stream strength Z at culmination time.

8 Visual comparison

Sufficient visual observers were able to contribute to the ZHR curve of the IMO which is shown in Figure 10 and Table 1.[4]

The radio maximum of May 6, 4^{h} UT found here is compatible with the visual ZHR maximum of May 6, $2^{\mathrm{h}}.75$ UT. Due to daylight conditions, the next visual observations are only of May 6, 15^{h} and 18^{h} UT. With respect to the visual observations, Mikiya Sato wrote a

[4] http://www.imo.net/live/eta-aquariids2013/.

Table 1 – IMO visual ZHR values of the 2013 η-Aquariids.

Date and ime (UTC)	$\lambda_\odot$	Intervals	ETA	ZHR	Particle density
2013-04-20 07^{h}52^m	30.°215	2	0	6 ± 6	11×10^{-9} km^{-3}
2013-04-22 02^{h}10^m	31.°934	2	0	15 ± 15	27×10^{-9} km^{-3}
2013-05-01 01^{h}58^m	40.°680	1	1	14 ± 10	25×10^{-9} km^{-3}
2013-05-02 02^{h}11^m	41.°660	5	19	25 ± 6	46×10^{-9} km^{-3}
2013-05-03 23^{h}27^m	43.°489	10	40	35 ± 5	64×10^{-9} km^{-3}
2013-05-05 00^{h}15^m	44.°490	9	31	74 ± 13	135×10^{-9} km^{-3}
2013-05-05 01^{h}36^m	44.°545	6	43	72 ± 11	131×10^{-9} km^{-3}
2013-05-05 04^{h}16^m	44.°652	3	42	73 ± 11	133×10^{-9} km^{-3}
2013-05-05 21^{h}56^m	45.°366	6	31	101 ± 18	184×10^{-9} km^{-3}
2013-05-06 01^{h}05^m	45.°493	10	41	101 ± 16	184×10^{-9} km^{-3}
2013-05-06 02^{h}45^m	45.°560	6	67	135 ± 16	246×10^{-9} km^{-3}
2013-05-06 15^{h}06^m	46.°059	4	30	132 ± 24	240×10^{-9} km^{-3}
2013-05-06 18^{h}11^m	46.°183	3	32	121 ± 21	220×10^{-9} km^{-3}
2013-05-07 01^{h}06^m	46.°462	11	30	71 ± 13	129×10^{-9} km^{-3}
2013-05-07 02^{h}20^m	46.°512	8	68	96 ± 12	175×10^{-9} km^{-3}
2013-05-07 04^{h}29^m	46.°598	12	61	63 ± 8	115×10^{-9} km^{-3}
2013-05-07 08^{h}28^m	46.°759	4	30	88 ± 16	160×10^{-9} km^{-3}
2013-05-07 10^{h}19^m	46.°833	3	31	77 ± 14	140×10^{-9} km^{-3}
2013-05-08 01^{h}50^m	47.°459	5	36	63 ± 10	115×10^{-9} km^{-3}
2013-05-08 03^{h}48^m	47.°539	4	32	38 ± 7	69×10^{-9} km^{-3}
2013-05-08 16^{h}51^m	48.°065	5	31	30 ± 5	55×10^{-9} km^{-3}
2013-05-09 23^{h}45^m	49.°311	11	30	23 ± 4	42×10^{-9} km^{-3}

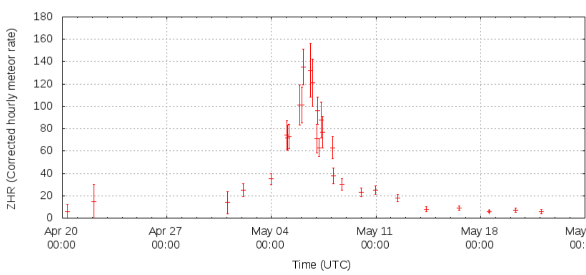


Figure 10 – Visual 2013 η-Aquariid ZHRs.

follow up post on the `meteorobs` mailing list, entitled "Eta Aquariids in Japan (May 6)"[5]:

> *"From IMO web, it seems that two peaks of ETA were observed. The first peak time was about 3h on May 6. Probably, this was formed by -910 trail.*
>
> *Similarly, the 2nd peak about 15h was caused by -1197 trail.*
>
> *However, these two peaks might be continuous.*
>
> *And, the outburst lasted about 2 days or more. This may mean that distribution of dust had spread because two or more kind of dust trails approached."*

We feel however that two peaks cannot be inferred from the visual observations, as there is no local minimum between the May 6, 3^h UT and May 6, 15^h–18^h UT values. We agree more with the statement about a broader (as indicated by the fairly large time constant a of approximately 35 hours) smooth activity profile.

[5] `http://lists.meteorobs.org/pipermail/meteorobs/2013-May/016122.html`.

Acknowledgments

The author wishes to thank Felix Verbelen for his record-long uninterrupted radio counts of the "VVS beacon" operated by Astrolab IRIS, Zillebeke, Belgium, during already eight years. Felix Verbelen and Micha Svoiski submitted their radio observations to the RMOB portal, created and maintained by Pierre Terrier. Several more observations are waiting to be analyzed. David Entwistle pointed the author in the right direction regarding the error margins calculation of the stream model. Without the on-line facilities provided by Lew Gramer (`meteorobs`) and the IMO (visual data quicklook), this study might not have been initiated.

References

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