The rate profile of the eta Aquarid meteor stream

T P Cooper
PO Box 14740, Bredell, 1623

Abstract: A short history of South African observations is given. Activity curves for the eta Aquarids are presented for the period 1986 to 1995, indicating that no effects of the 1986 passage of comet Halley have been detected. The importance of observation of the eta Aquarids and prospects for future years are discussed.

1. Introduction

The earth passes through the debris stream left behind by comet Halley twice each year. In May it encounters the stream on its inward journey around the sun, resulting in visibility of the eta Aquarid meteor shower, and in October it encounters the stream on its outward passage into space, when we see the Orionid meteor shower. The observation of these two showers enables us to study conditions and changes in the dust matrix of this well-known comet.

The Orionids are well observed each year, principally by northern hemisphere observers, favoured by longer October nights and the northerly declination of the radiant at +16°.

In contrast, the eta Aquarids have been somewhat neglected. This is a pity, since the radiant rises to a respectable altitude before dawn for southern hemisphere observers, rates are generally reliable for several days and the meteors are impressive to watch.

The purpose of my paper is to show the behaviour of the eta Aquarids over the past decade, and to convince further observers of the need to collect observational data on this shower in future years.

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2. A short history of eta Aquarid observation from South Africa

First records of the eta Aquarids date back to 74 B.C. (Roggemans 1989:116), but it was not until the late nineteenth century that serious records were kept. South Africa played a significant role in the observational history of the shower. The first modern-day observation was made by Tupman in South Africa in 1870. Hoffmeister observed the eta Aquarids during his sojourn here, and this country was very active during the nineteen fifties and sixties. Thackeray (1973) recorded observations and plotted meteor paths in 1973. Thereafter, there were few observations until the return of comet Halley in 1986, when a request was made by the International Halley Watch to observe this shower. In recent years, South Africans have again been active in observing this shower.

3. The Importance of the eta Aquarids

With the passage of comet Halley around the sun in early 1986, it was firstly important to determine if there would be any change in the rate profile of the shower. The rate profile, or activity curve, shows the meteor rate as a function of the position of the earth in its orbit. Thus by determining the meteor rate over a wide range of solar longitude enables us to determine the mass density of meteors over the width of the dust stream.

The recent outburst peak in the Perseid activity curve due to the return of comet Swift-Tuttle is by now well known. The Leonids have started to show signs of increased activity, some five years before the return of comet Tempel-Tuttle. More importantly, the Orionids, the other shower associated with comet Halley, showed an outburst peak in their 1993 activity curve, seven years after passage of the parent comet

(Rendtel & Betlem 1993, Jenniskens 1995). It is thus important that we monitor the eta Aquarids carefully to determine whether a similar peak shows up, to detect any changes in the Halley dust matrix, and contribute to the understanding of the evolution of the dust stream.

4. Listed shower details

According to the IMO (McBeath 1995), the eta Aquarids are detectable from April 19 to May 28 each year. These dates correspond roughly to solar longitudes ($\lambda_\odot$) 29 to 66. The date of maximum is quoted as May 3. Various other sources have given date of maximum between May 3 and May 6, corresponding to solar longitudes approximately 42.5-45.5.

The activity curve shows a broad maximum, and on several occasions has shown two maxima, with the second maximum occurring about May 8 ($\lambda_\odot$=47.5). Orbital studies of radio meteors indicate that the eta Aquarids consist of two sub-streams, the eta Aquarids 'proper', and the Halleyids (Wood 1995). Since the two streams radiate from closely situated radiants and their maxima are separated by only 4-5 days, the two streams appear either as one broad maximum or two closely spaced maxima.

The eta Aquarids are fast meteors (66 km s^{-1}) with a high proportion of yellow coloured meteors. The brighter meteors often leave persistent trains. Very bright eta Aquarids tend to leave spectacular green trains. This paper will draw some comparisons to these listed details.

5. Reduction of observations 1986-1995

The activity curves presented in this paper are based entirely on observations made by southern hemisphere observers. Observations made from the northern hemisphere, where the altitude of the radiant does not climb to significant altitudes above the horizon, will be published elsewhere to compare the activity profiles with southern hemisphere observations. To ensure some consistency in the calculated rates, I used data made by a selected number of observers who have observed the shower over many years in the last decade. These included 10 from South America, 10 from Australasia, and 4 from southern Africa. The latter were Tim Cooper, Nico Kriek, Harry Mitchell and Colin Henshaw.

Each observer reported meteor counts, start and end times of watches, and limiting magnitudes for each watch. The most simple way of depicting activity is to plot hourly counts against time:

$$\text{Rate} = N/T \qquad (1)$$

where

N	=	number of meteors observed
T	=	observation time in hours

However, this does not take into account different atmospheric conditions of observers, differing elevations of the radiant and other variables. Therefore, Zenithal Hourly Rates (ZHR) were calculated for each watch according to the formula:

$$ZHR = N.r^{(6.5-LM)}/Teff.c_p.\sin(h) \qquad (2)$$

where

r	=	population index of shower
LM	=	limiting magnitude of watch
c_p	=	perception coefficient of observer
h	=	mean radiant altitude in degrees
Teff	=	Effective observing time

The population index for the eta Aquarids was taken as 2.3. The value of c_p, normally ranging from 0.4-2.5, and calculated from the number of observed sporadic meteors against the predicted number, was taken as 1.0. This was due to the fact that observers were not consistent in differentiating sporadic meteors from other showers active at the same time, principally the May Capricornids. Thus to avoid inaccurate corrections the factor was omitted. All watch times were corrected for cloud cover, to give effective time Teff. Finally, all observations for $h < 10°$ were rejected.

This treatment resulted in ZHR values, which were plotted against solar longitude for the time of observation to give activity curves as shown in Figure 1. ZHR values were averaged for each 0.1 degree of solar longitude, and error bars were determined according to the formula:

$$\Delta ZHR = ZHR / \sqrt{N} \qquad (3)$$

6. Results

Activity curves based on visual observations for individual years are shown in Figure 1. In Figure 2, I have combined annual data to give a composite activity curve. The mean ZHR in 0.5° bins is plotted against solar longitude. While this does not represent an activity curve for any specific year, it is probably a good indication of what can be expected in an average year. The profile is essentially the same for the two periods and the following can be noted:

1. Low activity is present at $\lambda_\odot$=30
2. Activity increases slowly to about $\lambda_\odot$=40, exceeding ZHR=10 at about $\lambda_\odot$=37.5
3. Activity then increases to a broad maximum at about $\lambda_\odot$=45.5. The slope of the main increase is about 8 meteors/hour/degree
4. The maximum may persist to about $\lambda_\odot$=48 followed by a rapid decrease
5. The mean curves show no evidence of two distinct maximum peaks. Indeed as will be discussed below, rates may fluctuate widely even within 1° of solar longitude.
6. The rate of decrease after maximum is similar to the increase before maximum, with a slope of about 7.5 meteors/hour/degree.
7. The ZHR at maximum has a mean value of 60-70
8. The outburst peak of 1993 is clearly seen.
9. Observations are required later than $\lambda_\odot$=53 to determine the latest visible date of the shower.

Returning to the yearly curves. There were no observations in 1987 or 1991. In 1988 we see that low activity is already present at $\lambda_\odot$=30, as is the case in 1990, and 1993. In fact, the earliest eta Aquarid activity present from all the data was 1993 April 19 at $\lambda_\odot$=29.6. The 1988 curve shows typical behaviour with a slow increase in rate to about $\lambda_\odot$=40, followed

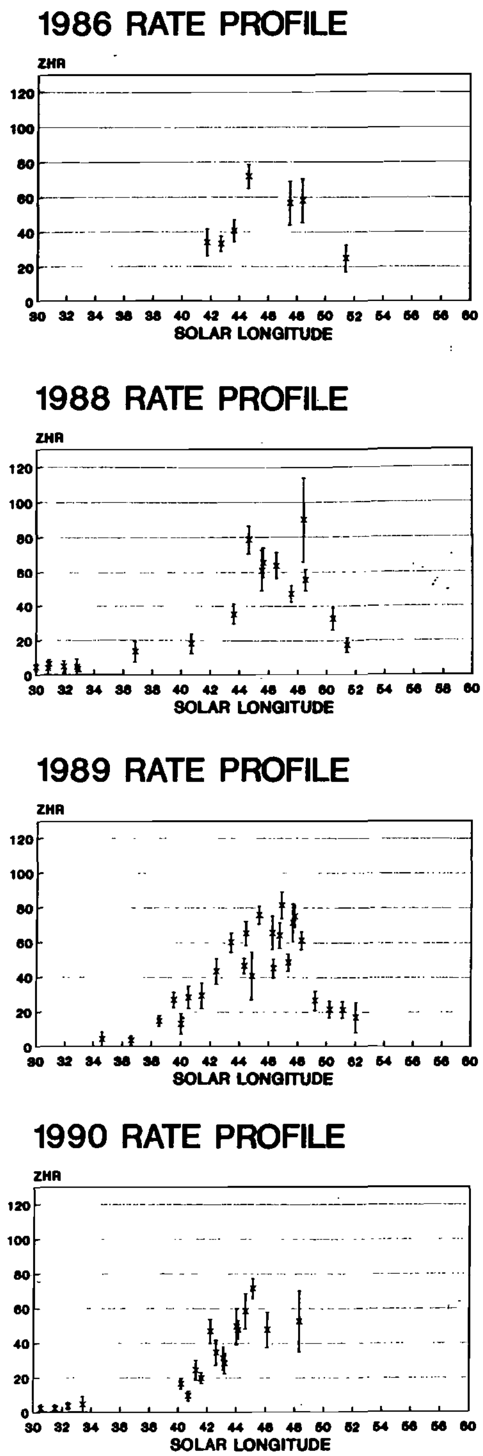
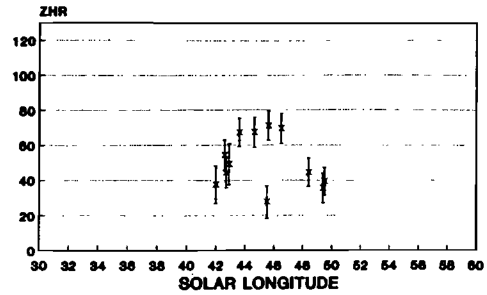
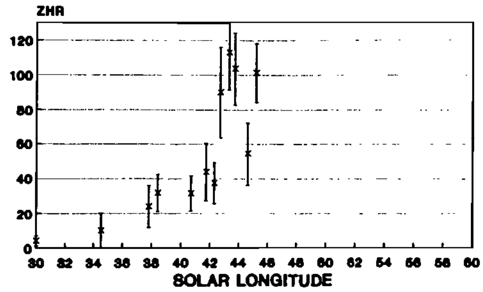


Figure 1 (right) Activity curves (rate profiles) for the eta Aquarids, based on visual observation from the southern hermisphere. The graphs show meteor rate as a function of the position of the earth in its orbit.

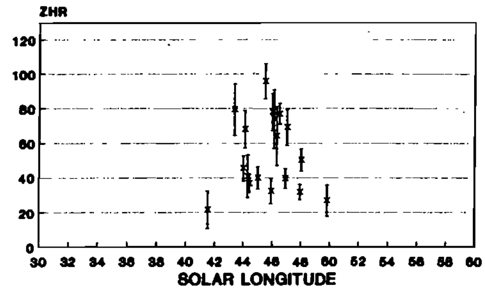
1992 RATE PROFILE



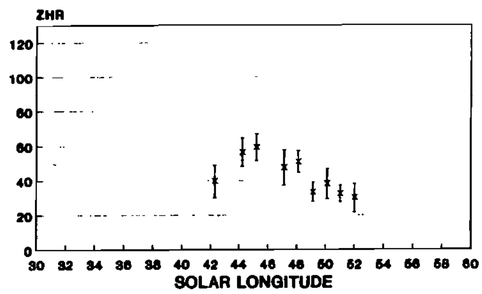
1993 RATE PROFILE



1994 RATE PROFILE



1995 RATE PROFILE



by a more rapid increase to maximum at about $\lambda_{\odot}$=44-45. There is a second peak at about $\lambda_{\odot}$=48.5. The same increase behaviour is evident in 1989, 1990 and 1993. Data in other years is missing on the rise due to moonlight interference. It can further be seen from the individual curves that the ZHR at maximum is generally in the region of 60-80 meteors/hour. The ZHR in 1993 however reached 110 for a brief period as observed from both New Zealand and South Africa. A similar outburst occurred in 1980 from Australia (Roggemans 1989:117). Observations should be secured in future years to see if this peak recurs.

Finally, I studied the data for signs of a second later maximum. Only the 1988 and 1994 profiles, and possibly 1993 show signs of a double peak, but the data is inconclusive. The search is hampered by the rather sparse data, and the fact that observed rates can fluctuate significantly within one night. As evidence consider both the 1989 and 1994 curves. In 1989 rates fluctuated from 66 at $\lambda_{\odot}$=46.2, 45 at 46.3, 64 at 46.7, 81 at 46.8 and 43 at 47.3. In 1994 rates fluctuated from 96 at $\lambda_{\odot}$=45.5, 33 at 45.9, 78 at 46.0, 77 at 46.5, and 40 at 46.9. With such variations based on so few observers, it is difficult to see any distinct maximum over normal nightly variations. The fact is clear, detailed observations are required from more observers, and while the findings of earlier researchers is not questioned, no conclusions regarding a second maximum could be drawn from the presented data.

7. Properties of observed meteors

Based exclusively on southern African observations over the last three years, we found the mean magnitude of 293 meteors to be 2.36. About 54% were yellow. The total number of meteors leaving trains was 32%, rising to over 75% for meteors of magnitude 1 or brighter. The colour of trains left by brighter meteors is often green. The brightest eta Aquarids recorded were magnitude -2.

8. Conclusions and future prospects

The rate profile of the eta Aquarids has not shown any major change in character over the past decade since perihelion of the parent body, comet Halley. Activity begins around solar longitude 30. Observations did not permit determination of the end limit. A broad maximum occurs at about solar

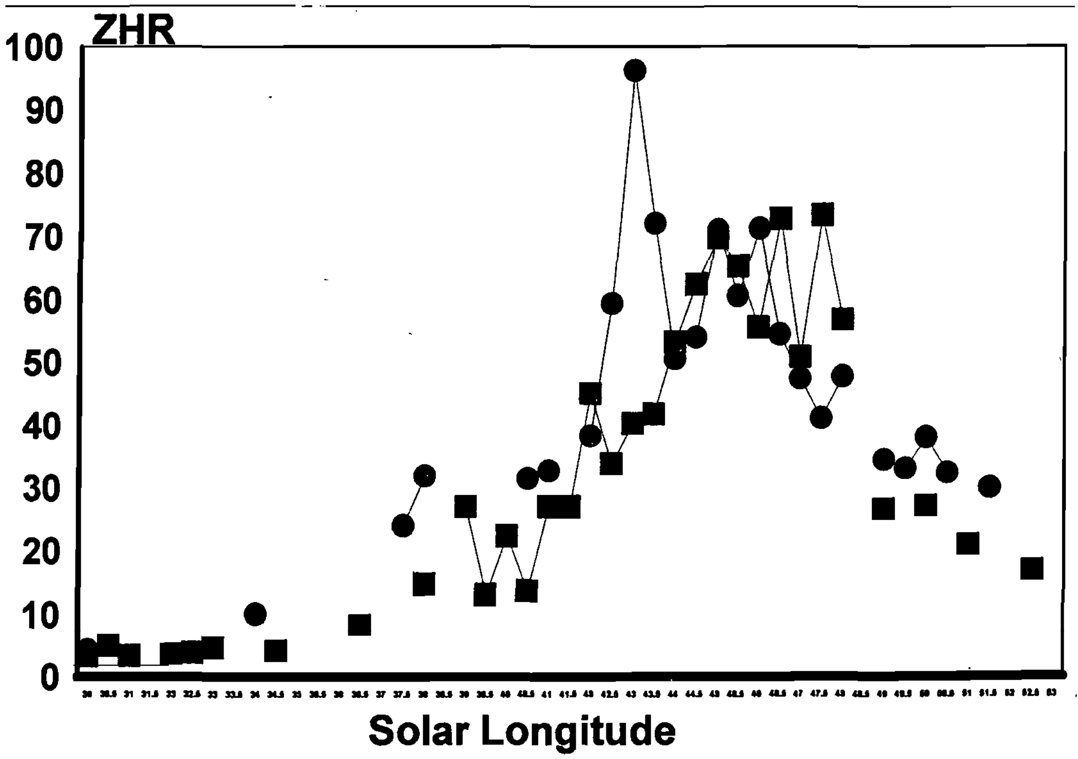


Figure 2. Combined rate profiles for the eta Aquarid shower. ■ represent observations between 1986 - 1990, and ● indicate observations for 1992 - 1995.

longitude 45.5 with zenithal hourly rates of 60-70. High variations in observed rates do not permit confirmation of a second maximum. A possible outburst occurred in 1993, as also happened in 1980.

The eta Aquarids require increased study in the next decade. We need to determine if a regular outburst peak occurs in complement to the Orionids, or if the 1980 and 1993 peaks are recurrent. More detailed observations are required to determine the nature of the maximum. Observing conditions in May 1996 are not favourable, with near full moon at shower maximum.

In the following two years conditions are favourable; in 1997 New moon occurs on May 6, and in 1998 the waxing moon only interferes from May 8 onwards. I invite ASSA members to join in the observation of the eta Aquarids and help in furthering our understanding of this important meteor shower.

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References

Jenniskens, P. (1995) Meteor Stream Activity, Paper II. Meteor Outbursts. *Astron. Astrophys. 295*, 206-235.

McBeath, A. (1995) *1995 Meteor Shower Calendar*, IMO_INF (2-95).

Rendtel, J. & Betlem, H. (1993) Orionid Meteor Activity on October 18, 1993. *WGN, 21(6)*, 264-268.

Roggemans, P. (1989) *Handbook for Visual Meteor Observations.* Sky Publishing.

Thackeray, F. (1973) Observations of the eta Aquarid meteor shower. *MNASSA*, *32*, 51-52.

Wood, J. (1995) Visual Observers' Notes: May-June 1995. *WGN, 23(2)*, 38.