Observational Results

The 1993 Perseids and the Meteoroid Dust Cloud

Casper ter Kuile, Marco Langbroek, and Jacob Kuiper

An overview is given of observations of the Perseids 1993 in the Provence by members of the *Dutch Meteor Society (DMS)*. We present preliminary results of visual and photographic observations. A likely observation of the Perseid meteoroid cloud in space is discussed.

1. Introduction

In 1992, a very successful "crash" campaign was organized by members of the *Dutch Meteor Society (DMS)* to a region near Basel/Mulhouse in order to observe a possible Perseid outburst [1]. Indeed, observers Marco Langbroek, Peter Jenniskens, Carl Johannink, Romke Schievink, and Casper ter Kuile did observe the last 20 minutes of an outburst, albeit in deep twilight.

The excitement of that event led us to organize a more extended expedition in August 1993 [2]. In order to escape the usually unpredictable weather conditions in the Netherlands, a multi-station network was set up in the Provence in the South of France, the nearest place with good prospects for clear weather. The aim of our expedition was to obtain a good activity profile from visual and radio observations and high-precision orbital elements of multi-station photographed meteors associated with the outburst.

This article will summarize the preparations and results of our campaign [3,4]. As a special topic, we present a detailed description of the Perseid meteoroid cloud which has actually been observed by two independent observing groups who were located at a great distance from each other.

2. Preparations

A series of newsletters informed our members of progress in the organization [2]. On Saturday, June 12, 1993, *DMS* organized a preparatory meeting at Harderwijk, the Netherlands, which was attended by 25 meteor observers. Special guests were the Belgian *VVS Meteor Section* representative Peter Aneca and the *IMO* representative Paul Roggemans. We evaluated the logistic problems associated with an expedition, the meteorological aspects of the chosen site, and the necessary changes to the observing techniques in case of high meteor rates.

Figure 1 – Group photograph at the meeting in Harderwijk.

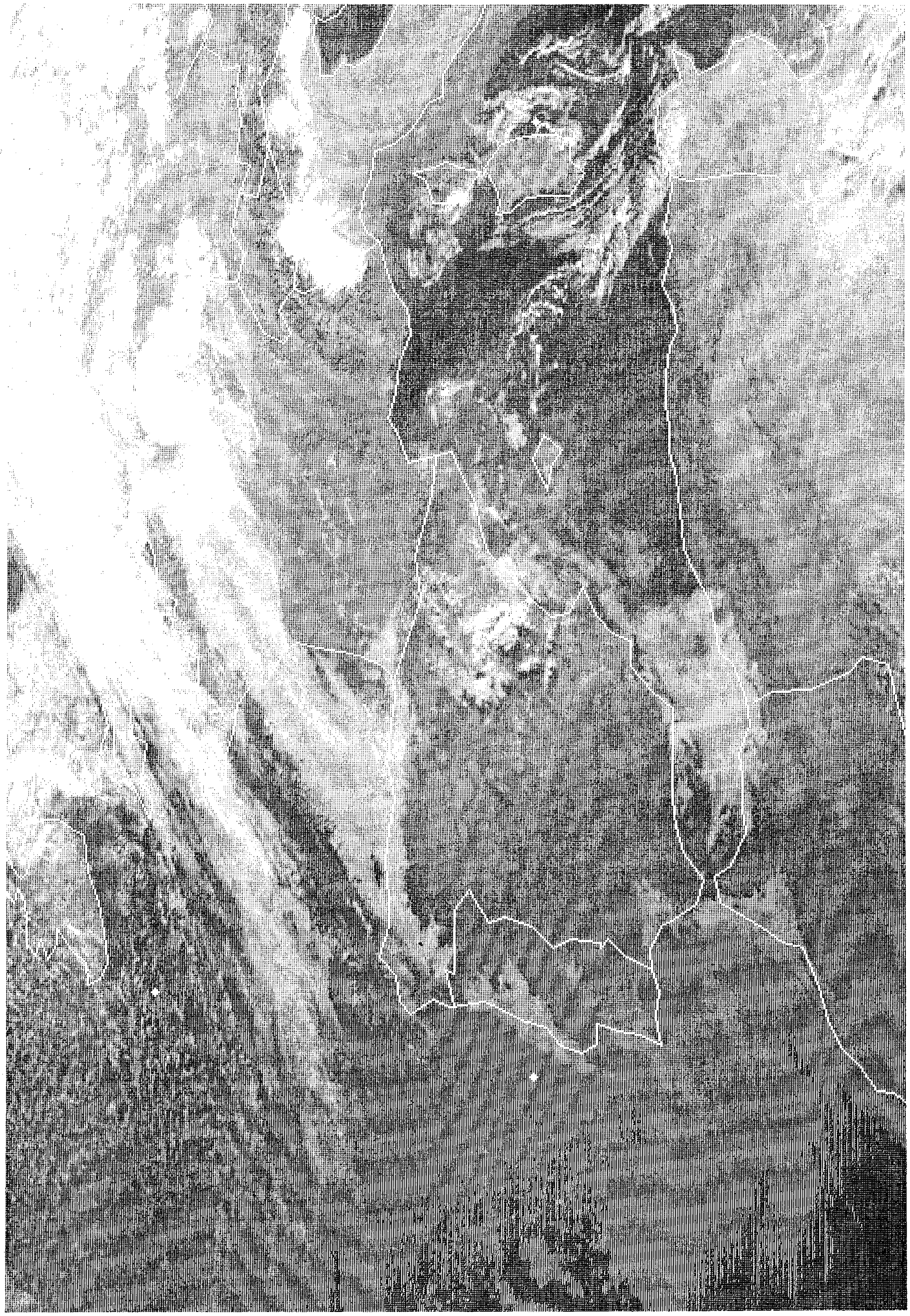

Figure 2 – Meteosat-4, August 12, 1993, 6^h30^m UTC, Visible. © ESA/EUMETSAT/KNMI.

Most visual observers were going to work with tape-recorders, which are often equipped with "time-indexed recording." During the quiet part of the night, we were to record each meteor's brightness, shower classification, distance from center of vision (DCV), angular velocity, and sky location. As activity rose, information was to be restricted to brightness, if possible DCV, and a note on classification in case the meteor was a non-Perseid. One of us, Marco Langbroek, who preferred to use pencil and paper for recording, decided to only count during five-minute intervals with the aid of his Casio watch equipped with an audio-signal countdown mode; this meant no magnitude information was obtained.

In order to modify our photographic techniques to suit high meteor rates, new equipment was built that allowed for short exposure times and a minimum of dead-time between exposures [5]. Short exposure times greatly ease the correct identification of meteors on negatives. An exposure time of 10 minutes was decided upon as a good balance between available film length and short exposure time. A fully automatic camera battery was needed. Therefore, we used Canon AV-1 cameras equipped with winders which are controlled by a Canon T-70 with a command back 70. The command back is programmed with a timing accuracy of 1 second. For very high rates, reprogramming of the exposure times was possible. The accuracy of the calculated orbital elements highly depends on the accuracy of the time measurements and the frequency of the rotating shutters. Precise timing was acquired by means of a DCF time signal from Frankfurt. Much effort was spent in constructing high-accuracy neatly balanced quartz-controlled rotating shutters. All these efforts enabled us to achieve accuracies of 0.05 km/s or better in meteoroid speed determinations.

Two new automatic camera batteries were built by Koen Miskotte and Casper ter Kuile for the station at Rognes, France. Jaap van 't Leven constructed a similar system for Tourves, and Romke Schievink and Jerôme de Jong van Lier constructed a system for Lardiers. In addition, Robert Haas completed an automated 6×6 all-sky camera for Rognes. Klaas Jobse prepared video image intensifier (IPCS) systems that were set up in Puimichel, Lardiers, and Tourves.

On August 10, 1993, a second meeting was organized by the *IMO* at Puimichel. An important topic to be discussed during this meeting was the weather prediction provided by Jacob Kuiper. The weather forecast was very favorable, and indeed the Meteosat-4 picture in the early morning of August 12 showed an almost cloudless Southern France (Figure 2).

3. Multi-station network

Late in 1992, members of the *DMS* wanting to participate in the project formed four observing groups. Each group hired a house from the "France Gîte" organization. These gîtes were chosen to be located about 50 to 70 kilometers apart in order to have optimum geometrical conditions for multistation photography and video observations (see Figure 3).

Marc de Lignie, Klaas Jobse, and Michiel van Vliet settled near Puimichel, where both visual, photographic, and video observations were carried out. A second group, including Jaap van 't Leven, Peter van der Heiden, Frank Kooiman, and Cor Meulmeester, settled between Tourves and Brignole. They observed visually, photographically, by video, and by radio. Carl Johannink, Andre Kluitenberg, Romke Schievink, Jerôme de Jong van Lier, and Ralf Mulder of the *"Werkgroep voor Sterrenkunde"* of Denekamp and some French observers settled in Lardiers. The Lardiers team observed visually, photographically and by video. *DMS* members Marco Langbroek, Koen Miskotte, Robert Haas, and Casper ter Kuile chose Rognes as their observing station. The members of the Rognes team observed visually using time-index recorders, with the exception of Marco Langbroek who used a five-minute count system. In total, 24 fully automated cameras were used for photographic observations.

Several other groups of meteor observers were active in the Provence during the Perseid campaign. In Puimichel, *IMO* members Paul Roggemans, Peter Brown, Martin Beech and Yasuo Yabu, and 35 young observers of the *Dutch Astronomical Association (NVWS)* were present. Puimichel served as an organizational center, and observers could obtain the latest weather information provided by Jacob Kuiper of the *Royal Dutch Meteorological Institute (KNMI).*

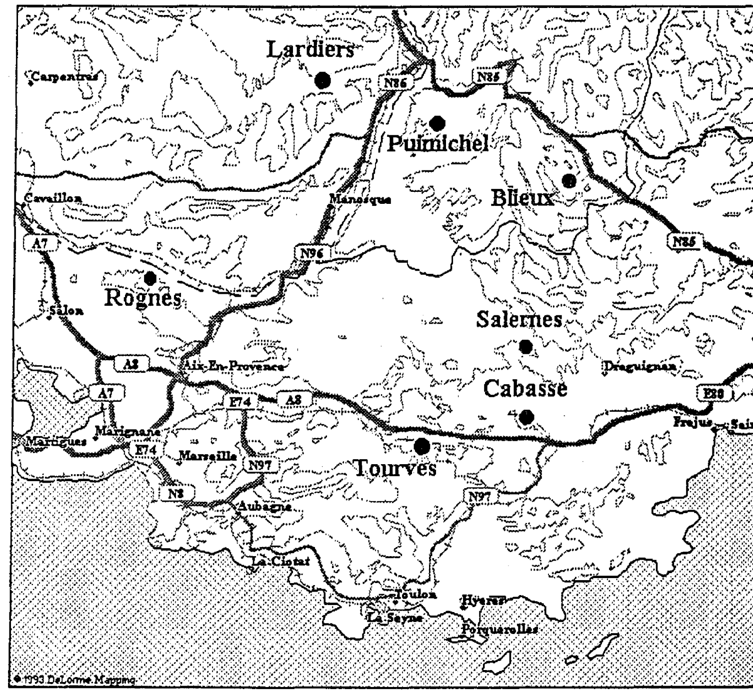

Figure 3 – The observing sites in the Provence.

Near Blieux (Castellane), a group of the Belgian *VVS*, lead by Peter Aneca watched for Perseids [6]. Some 30 observers of the *International Astronomical Youth Camp*, among them Erwin van Ballegoy, observed the Perseids near Coucouron (Ardeche). Joe Rao observed from a cruise ship in the Mediterranean Sea [7]. Two observing groups from the *NVWS Meteor Section*, including Felix Bettonvil, Urijan Poerink, Ben Apeldoorn, Niek de Kort, Siem van Leverink, and Serge ter Hall [8], settled in Salernes and Cabasse, about 18 km apart.

Many Dutch observers stayed home and had to face bad weather conditions. Jacob Kuiper, however, tried to escape by traveling to the Vosges Mountains, specifically the Pointe d'Honneck near Colmar in Northern France. He was joined by a group of observers, including Michiel Severin, Edward Hamers, Mark Neits, and Jan Tromp [9]. In addition, a small multi-station project was set up by Peter Jenniskens and Mike Wilson in Los Banos and Livermore in California.

4. Results

Fortunately, August 11-12, 1993, was a fine, clear night with very good conditions, slightly affected by moonlight late in the night. The sky was monitored from the moment of sunset. The first set of bright Perseids appeared around 22^h30^m UT. Everybody thought this was the beginning of the so hoped-for Perseid outburst, but rates declined again, and at 0^h45^m UT the observers at Rognes were in despair about what was going on above. To our surprise—and satisfaction—hourly rates suddenly rose again after 1^h15^m UT. Maximal hourly rates were reached at about 3^h00^m UT shortly before twilight started interfering.

Visual observations were conducted with sky limiting magnitudes reaching +6.9 in the early part of the night, falling to +6.3 after moonrise. From the start of serious observations around 19^h45^m UT until 22^h30^m UT, Perseid activity was normal with a ZHR around 60 and an r-value of 2.5. After 22^h30^m UT, the r-value suddenly dropped to about 1.9, and activity rose to a peak ZHR of about 140 around 0^h15^m UT. This first phase of enhanced activity was followed by a quick decline in activity to almost normal ZHR-values of 70 around 0^h45^m UT. Most notably, the observed r-value fell to almost normal during this period. After this decline, which left observers quite disappointed, activity dramatically rose again after 1^h15^m UT. The r-value again dropped to 1.7–2.1. Around 2^h45^m UT the ZHR value reached about 300. After this time, corrected rates become uncertain because of interfering twilight [10]. Around 3^h15^m UT, most observers registered 25 or more Perseids per five-minute interval. The observations in the Provence ended around 3^h40^m UT. In Los Banos, meteor rates were found to be back to normal by 8^h00^m UT.

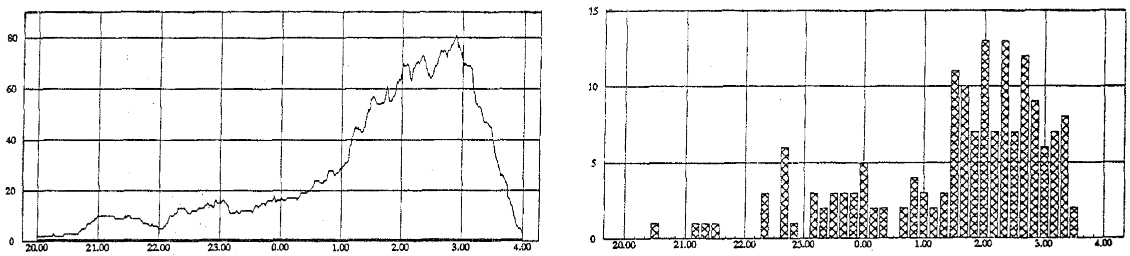

Figure 4 – Hourly rates of bright visual meteors *(left)* and photographed meteors *(right)* during the night of August 11-12. All times are in UT.

Figure 4 *(left)* shows the rate of visually recorded meteors of magnitude 0 and brighter. For these meteors, we recorded time, location, magnitude, and, if relevant, trails and colors. The graph is calculated by means of a 1-hour moving average with increments of 1 minute. Interestingly, the graph does not indicate a peak around 22^h30^m UT nor does it show a clear dip around 0^h45^m UT. Marco Langbroek has suggested that the visually observed decrease in hourly rates around 0^h45^m UT might have been due to a decline in the number of meteors between magnitudes 0 and +2. Such a scenario would explain the difference between visual and photographic results as shown in Figure 4 *(right)*, and still account for the observed r-value differences. Evaluation of the visual results must confirm or reject this hypothesis.

All photographic equipment worked perfectly: 300 meteors had been photographed in Rognes, about 200 of which were obtained on the night of August 11-12, most of these between 1^h30^m and 3^h30^m UT. We expect the total number of multi-station photographed meteors to be near 200, most of them recorded from three or even four stations. Between 1^h30^m and 3^h30^m UT, the negatives show 1, 2, or 3 meteors which are easy to match with the visible observations.

Figure 5 – Perseid photographed by the Rognes team on August 13, $2^h13^m17^s$ UT.

Similarly successful were the video observations. A bright κ-Cygnid fireball was captured by Romke Schievink at Lardiers (August 11-12, $0^h34^m53^s$ UT) and photographically recorded at other stations. During the same night, some confusion as to viewing direction caused many meteors not to be filmed from multiple stations. The problem was corrected the subsequent night, and many multi-station results of annual Perseids were obtained.

5. The Perseid cloud

A highly interesting observation was obtained from the Provence and the Vosges Mountains. Two observing teams at totally different locations observed a diffuse cloud before the peak of the outburst. This cloud may have been caused by sunlight scattered by the dust along the trail of P/Swift-Tuttle. In view of its potential importance, we describe the observations in as much detail as possible. We also try to demonstrate that the cloud could not have as its source any phenomena in the Earth's atmosphere.

In [11,12], Joe Rao indicated the possibility of visually observing the Perseid meteoroid dust cloud. Subsequently, Michiel van Vliet made some computations to find out whether the dust cloud could become visible to the naked eye [2]. His conclusions were quite pessimistic, but nevertheless we watched for the possible occurrence of the phenomenon during the maximum night. Rao had calculated the position of the cloud to be 10° south of Algol. At the time of observation, we were unaware that Duncan Steel had shown the calculated position by Rao to be wrong [13]. The predicted location according to Steel was at the true radiant, which is near Polaris ($\alpha = 33.^\circ5$, $\delta = +84.^\circ7$, eq. 2000.0). Kessler and Zook recommended monitoring the arc between the true and apparent radiant. They also observed that any glow from a dust cloud which would collide with the Earth would become visible at the apparent radiant! [13]

At Rognes, around 0^h39^m UT, observer Robert Haas was the first to notice some kind of cloud near Algol. All of us could clearly see something resembling a streak of cirrus cloud, but surely it was not cirrus! As recorded by Marco Langbroek around 0^h45^m UT and confirmed by all observers [2], it roughly extended from $\alpha = 64°$ and $\delta = +43°$ to $\alpha = 40°$ and $\delta = +36°$ and was centered at $\alpha = 52°$ and $\delta = +40°$ (Figure 6). Although there is some uncertainty as to the extremities of the cloud, its dimensions were at least 2° by 5°. This position was recorded by Marco Langbroek around 0^h45^m UT and confirmed by all observers [2].

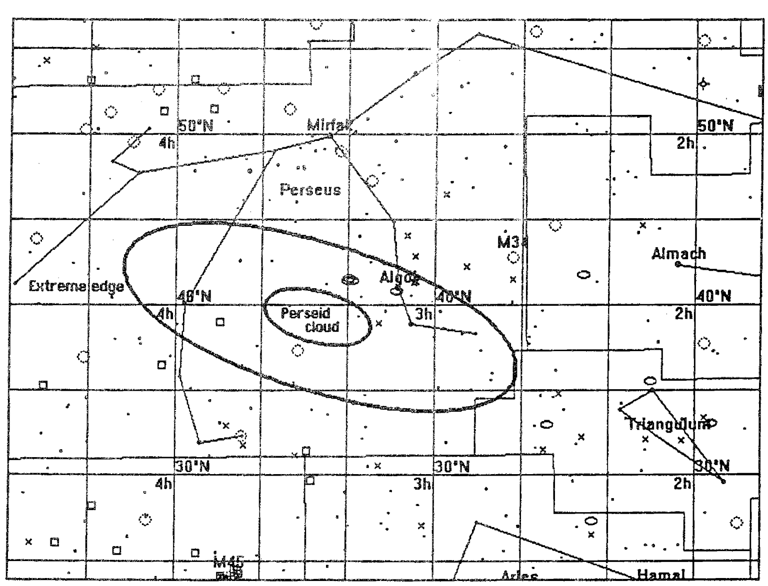

Figure 6 – Position of the cloud observed from Rognes

The cloud was transparent and had a silvery glow resembling that of noctilucent clouds or weak aurorae. The cloud remained stationary with respect to the background stars, unlike the real cirrus which appeared later that night. During the observation, the cloud broadened and became fainter: with an initial magnitude of about +4.5, its brightness at first was comparable to that of the Milky Way in Perseus. The cloud was observed for some 10–15 minutes. About half an hour after the cloud disappeared, Perseid rates began to increase rapidly.

A very similar observation has been made by Jacob Kuiper at the Vosges Mountains near Colmar, Northern France, about 500 km north of Rognes [9]. As a meteorologist, Jacob has much experience with cloud types and he is quite convinced that the phenomenon he observed could not have been a cirrus cloud! Also, Jacob fully agrees with the description of the cloud as seen for Rognes, and he too saw it due east of Algol. Assuming that both observations refer to the same phenomenon, it must be concluded that the phenomenon occurred outside the Earth's atmosphere. Therefore, we are quite sure that we have observed the meteoroid dust cloud in space. To further substantiate this hypothesis, we examined the various atmospheric phenomena that might have caused such a cloud:

1. *Cirrus clouds.* In Colmar, Jacob Kuiper noticed that during 15–30 minutes the glow did not move with respect to the background stars. At that time, westerly winds were blowing with speeds of 60–100 km/h at a height of 7 to 10 km. During that period, a cirrus cloud would have traveled quite a distance in the sky. Later that night, we indeed saw some fast-moving cirrus clouds. Also, the glow was too transparent for a real cirrus cloud.
2. *Noctilucent clouds.* This type of "cloud" consists of meteoritic dust, covered with a very thin layer of water-ice. In the months June, July, and August, these clouds can occasionally be observed 1 to 1.5 hours after sunset or before sunrise north of 50° N. The glow, however, was seen well into the night, south of 50° N.
3. *Aurora.* Aurorae are generally observed at high northern or southern latitudes; when the activity of the sun is very high, they can also be witnessed at lower latitudes. Explaining the glow as an auroral phenomenon poses a parallax problem: a phenomenon at a height of about 100 km cannot be seen in the same direction from two positions 500 km apart. To be absolutely sure the glow could not have been aurora, Jacob Kuiper obtained information on the activity of the ionosphere that particular night from the Head of the Geophysics Department of the Royal Meteorological Institute in Belgium. The data supplied show neither extreme activity of the sun and nor a big disruption of the geo-magnetic field of the Earth; hence we may exclude an aurora as the cause of the cloud.

The parallax argument also excludes other explanations, such as reflection of big town lights on high clouds.

We would like to point out that the observed location of the dust cloud is definitely *not* the same as the (wrong) position indicated by Rao. People may have doubts about our observations, because "our" cloud appeared at another location than it theoretically should have been according to *IAUC 5840*. We would like to point out, however, that the position stated in *IAUC 5840* is given for *a strong concentration of material exactly such that it will collide with the Earth*, and the absence of a meteor storm strongly suggests that the concentration was *not* on an Earth-colliding course! (See also [14,15].) Also, "our" cloud, within the accuracy of the observation, *did* occur on the arc joining true radiant, apparent radiant and anti-radiant.

Assuming we did observe a Perseid dust cloud, a number of questions still remain: At what distance did the Earth and the meteoroid cloud pass each other? What are the dimensions of the dust cloud? Did we observe only a dense part of a filament or the main stream of the Perseid dust cloud? The outburst which happened about 3 hours later was probably caused by the passage of the Earth through a different dust filament. Hopefully, professional astronomers can cast some light on this complicated but very intriguing matter!

Interestingly, a possible photograph of the cloud was presented by Ben Apeldoorn (*NVWS Meteor Section*) after we brought our observation to his attention [8]. However, his photographs were made two to three hours after our sighting and the linear features on it are very different from the phenomenon we observed. In our opinion, these features may have been caused by internal reflections of moonlight in the complex lens system of his fish-eye lens. The only feature which seems not to have been caused by reflected moonlight, bears close resemblance to the isolated cirrus clouds we photographed at Rognes around the same time, and can be seen to be evidently moving across the sky on the series of photographs.

The observers at Rognes and Jacob Kuiper welcome any observation that could confirm our observations, in particular (professional) photographs and CCD registrations. We strongly call for observers to watch for the phenomenon during the 1994 Perseid return!

Acknowledgments

We would like to thank all observers who participated in the 1993 Perseid Campaign and shared this almost "religious" moment with us. We appreciate the logistic support supplied by Paul Roggemans during our stay in Southern France. We also thank Peter Aneca and Erwin van Ballegoy for their cooperation. We also had useful discussions before and after the campaign with Carl Johannink, Michiel van Vliet, Koen Miskotte, Robert Haas, Marc de Lignie, and Hans Betlem. Special thanks go to Peter Jenniskens who spent his precious time to read the manuscript and provide us with many useful suggestions to improve our paper.

Finally, Casper ter Kuile thanks Marco Langbroek for his radical editing of the first draft of this paper, and Marco Langbroek thanks Casper ter Kuile for having spent his Christmas holidays to correct his radical editing...

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Comments by the Editor-in-Chief

The observations described above are indeed quite remarkable and intriguing. As Editor-in-Chief, however, it is my duty to caution the reader against hasty conclusions. Therefore I found it appropriate to publish the following comment by Jürgen Rendtel. I also want to point out that the author's arguments stand or fall with the assumption that both observations indeed refer to the same phenomenon. Although they give some strong arguments to sustain this assumption, the possibility that the two observations are coincidental remains, and in that case many explanations are possible.

Comments by Jürgen Rendtel

In this paper, the authors describe a cloud-like phenomenon, observed from two locations at a substantial distance from each other. Several terrestrial explanations are investigated and are rightfully dismissed. Therefore, the authors conclude that they might have observed the glow of the Perseid meteoroid cloud. Although I cannot offer another explanation here, I would like to stress a few facts which should be kept in mind.

The observation took place when the Moon already was above the horizon. I know of other attempts from northern hemisphere observers to see the glow of the Perseids meteoroid cloud, but they found the moonlight too disturbing. Also, there are no indications for a comparable glow near the anti-radiant from the southern hemisphere (without interference from the Moon) after the phenomenon was seen here.

If we interpret the observation as the Perseid glow, which did not occur at the predicted position, we could assume that the Earth missed a dense particle cloud. However, the structure must have been very narrow spatially and perhaps of another mass distribution. The observed activity reached its peak more than 3 hours later, and the global analyses did not show a variation in the population index r during the ascending activity. Even at the moment that the highest rates occurred on the morning of August 12 (ZHR $\approx$ 350), the number density of particles with a mass of at least 1 mg was lower than that of an average Geminid maximum (see Table 1). Since glow observations of the regular Geminid maximum are not known, we should expect that a much denser particle cloud is necessary to cause such a phenomenon. For comparison, the figures for the Leonid storm are added.

Table 1 – Number densities of particles with a mass of at least 1 mg per 10^9 km^3 ($\rho_{1\ \mathrm{mg}}$) of the Perseids and the Geminids for different conditions. The last line gives the Perseid ZHR to be expected for a number density comparable to the Leonid storm. Note that all figures are rough estimates only.

Shower	r	ZHR	$\rho_{1\ \mathrm{mg}}$	Comment
Perseids	1.8	350	3	Observed 1993 peak at $\lambda_\odot = 139\overset{\circ}{.}535$
	2.5	350	5	Observed 1993 peak, with a higher r
	2.5	700	10	Twice the ZHR, with a higher r
	2.5	1400	20	Like a storm, with a higher r
Geminids	2.2	120	20	Average Geminid maximum
Leonids	2.5	240000	140	Leonid storm
Perseids	2.5	10000	130	Expected Perseid ZHR for a Leonid-storm-like number density

Even if we do not have an explanation of the observation at hand, the interpretation needs much care. I suggest that observers should prepare suitable photographic and LLLTV equipment for the 1994 Perseids to obtain reference data which can be used also for other occasions.