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Shower records
Perseids
Video meteors

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Front cover photo

A probable meteorite-dropping fireball captured in flight on 2009 October 13 at 16^h57^m UT from Groningen, The Netherlands. The author used a Canon EOS 450D camera equipped with Tamron 18–200 mm lens operating at 200-mm f/6.3, set at 1/200 s exposure and ISO 800. Photo courtesy: Robert Mikaelyan.

Writing for WGN This Journal welcomes papers submitted for publication. All papers are reviewed for scientific content, and edited for English and style. Instructions for authors can be found in WGN **31:4**, 124–128, and at `http://www.imo.net/articles/writingforwgn.pdf` .

Cover design Rainer Arlt

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Editorial — Meteoric fun

Javor Kac

Great months for meteor enthusiasts are behind us. First, the moonless interval gave space to Southern δ-Aquariids and α-Capricornids to display their full potential in late July. Next, the Perseids had a great display despite moonlit nights. As many as three separate maxima were noticed by the observers, topping at around ZHR 200. Unfortunately, none of the maxima could be seen well by the European observers, so I have largely missed them. Following in September, the 2009 IMC was held in Poreč, Croatia. There, observers from across the world gathered for a four-day event full of lectures, informal discussions and having fun. It was great to meet old friends and to get to know new ones. Recently, the Orionids put on a great show for the fourth year in a row. A wide maximum with ZHR about 40 could be observed for at least four consecutive days.

Although these past months have been exciting, the meteoric fun is not over yet – two major showers, the Leonids and the Geminids are still scheduled this year. I hope we will be reading about all these meteor events in the future issues of WGN.

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Erratum: Back Cover of WGN 37:4

The WGN Editorial Team

In the August issue of WGN, Journal of the International Meteor Organization, we published an article on the meteor showers detected by the IMO Video Meteor Network (Molau & Rendtel, 2009). It announced a colour version of Figures 18 and 19 on the back cover. We regret that due to an error in printing, the back cover was reproduced in grayscale. As colours are essential to comprehend the figures, we are republishing them in this issue. We sincerely apologize to the readers.

References

Molau S. and Rendtel J. (2009). "A comprehensive list of meteor showers obtained from 10 years of observations with the IMO Video Meteor Network". *WGN*, **37:4**, 98–121.

IMO bibcode WGN-375-erratum NASA-ADS bibcode 2009JIMO...37..133E

From the Treasurer — IMO Membership/WGN Subscription Renewal for 2010

Marc Gyssens

We invite all our members/subscribers to renew for 2010. The fees are as tabulated below. We are happy that we can offer WGN at the same cost as last year, at least in euros. In view of the unfavorable evolution of the dollar/euro conversation rate, and since all our expenses are in euros, we were forced to revise the renewal fees in dollars, unfortunately.

IMO Membership/WGN Subscription 2010				
Surface mail delivery:		€26		US$ 39
Airmail delivery (outside Europe only):		€49		US$ 73
Supporting membership:	add	€26	add	US$ 39

It is possible to renew for two years by paying double the amount.

General payment instructions can be found on the IMO's website, `http://www.imo.net`. Members and subscribers who have not yet renewed will find enclosed a leaflet with payment instructions that apply to their geographical region. Please follow these instructions! Choosing the most appropriate payment method results in low or even no additional costs for you as well as the IMO. The IMO strives to keeping these costs low in order to control the price of the journal!

When you renew, give a few minutes of thought to becoming a **supporting member**. Every year, the IMO helps active meteor workers to attend the annual International Meteor Conference, who would otherwise not have been able to come. Our ability to provide this help depends primarily on the gifts we receive from supporting members! Particularly in 2010, we wish to make an extra effort in this respect. With the IMC in Northern Ireland, flying will be the only option for many prospective participants, which may affect transportation costs adversely. With your help, the IMO intends to offer twice as much support as in an average year!

Another way to help meteor workers with limited funds is to offer them a gift subscription.

We already thank all our members that will renew for their continued trust in our Organization!

One final request: every year, a lot of members renew late. As a consequence, back issues that already appeared have to be sent out to these members. Please support our volunteers in their bimonthly effort to have WGN shipped to you by renewing promptly! Thank you for your understanding and cooperation!

IMO bibcode WGN-375-gyssens-renewals NASA-ADS bibcode 2009JIMO...37..133G

IMC 2010 in Armagh

David Asher
on behalf of the Local Organizing Committee

After another very successful International Meteor Conference (IMC), in Poreč, Croatia, the next IMC will take place in Armagh, Northern Ireland, from 2010 September 16th (Thursday evening) to 19th (Sunday lunchtime). It will be organized by the Armagh Observatory, a modern astronomical research institute having a rich heritage and a longstanding association with meteor science. Most participants will be accommodated in the Armagh City Youth Hostel; there is also bed & breakfast and hotel accommodation in Armagh. The registration fee, probably similar to this year at 150 EUR, and other details will appear on the IMO website in time for registration to open early in 2010. The local organizing committee is Apostolos Christou (chairman), David Asher, Geert Barentsen and Miruna Popescu.

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Call for Future IMCs

Jürgen Rendtel and Marc Gyssens

Since this year, the IMO Council sends out calls for organizing future IMCs. In this way, the Council wants to avoid the situation that no spontaneous proposals is offered, with as a possible undesirable consequence that we might have a year without IMC. To give interested parties full opportunity to prepare themselves, we have decided to publish the call for the next IMC already now. It will be repeated in the February issue of WGN.

Hence, this is a formal call for organizing the 2011 IMC, which is supposed to take place around the third week of September, from Thursday evening (arrival of the participants) to Sunday lunchtime (departure of the participants).

Proposals are due 2010 June 1, and should be sent to the President, `president@imo.net`, preferably in PDF-format.

The IMO Council will decide on the proposal to be accepted in 2010 September, at the IMC in Armagh, Northern Ireland. The Council may take advantage of the intermediate time to ask for clarifications or additional information from the candidates.

From past experience, we know it is often difficult to choose between several proposals. If multiple proposals merit the opportunity to host an IMC, the Council will contact such candidates to ask them to retain their candidacy for the next year. If in the next round the Council must decide between equally worthy proposals, priority will be given to the older one.

There are no forms to solicit for the 2011 IMC, but your proposal should at least contain the following elements:

1. **Who are you?** Who is going to be the local organizers? Which local, regional, or national astronomical organization(s) is/are backing you up? What is your experience with meteor work? Have you been involved in past IMCs, as passive/active participant or as co-organizer? Do you or the organization(s) to which you belong have experience in organizing events that can be compared to an IMC?

2. **Why do you want to do it?** What is your motivation for wanting to organize an IMC?

3. **Where do you want to do it?** At what location do you want to organize an IMC? Why is this a good location? Can it easily be reached by plane, public transportation, and/or car? How many hours is it by public transport from the nearest major international airport? Provide a few pictures of the location, or, a weblink to such pictures.

4. **At what venue are you going to hold the IMC?** Preferably, lectures and accommodation should be under the same roof, but there is no real objection to the lecture room being at a separate location within easy walking distance from the accommodation. Describe the accommodation at your disposal. Preferably, add an offer from the hotel and/or the institution providing additional accommodation to prove that the venue you propose is indeed available and that the price is within the limits of your budget (see below). Provide also a few pictures of the accommodation, or, a weblink to such pictures.

5. **What will it cost?** Draft a preliminary budget for the IMC proposed. Mention all sources of income, in particularly sponsors or subsidies. Take into account that the price per participant should not exceed 150 EUR by much. Of this amount, 10 EUR must be reserved for producing and mailing the (post-)proceedings to the participants. With respect to the expenditures, take into account that the participants must be offered full board from Thursday evening, dinner, up to Sunday, lunch, inclusive. Of course, lecture room facilities should be accounted for, as well as a coffee break in the morning and in the afternoon. Finally, it is also customary to have a half-day excursion, usually on Saturday afternoon.

   Note that, although the IMC provides the service of collecting the registration fees for you, the IMC will in principle *not* cover any negative balance that you might incur, so, please, draft your budget responsibly!

6. **Can it also be done in a later year?** We can only have one IMC every year. It is therefore important for us to know if you can also make this offer in a subsequent year. If there are reasons why the application cannot be postponed, please describe these reasons clearly! It is imperative that you answer the questions honestly. Of course, we understand that you are keen to organize next year's IMC, otherwise you would not have applied, but having a clear picture of the real time constraints of all the candidates is a serious help for the Council to make the best decision possible!

Of course, you may add to your application any information or considerations which you think may influence your candidacy favorably. In general, however, help the Council in seeing the wood for the trees! While it is important that your application is complete and addresses all the issues mentioned above, please do so *concisely*! Avoid beating about the bush with meaningless phrases and be as factual as possible!

If you are interested in applying for the local organization of the 2011 IMC, please email the President as soon as possible that you intend to apply by the due date of 2010 June 1. Even though such a declaration of intent is not a formal commitment, it is an indication for the Council as to how many applications may be expected: based on this information, the Council may actively solicit additional candidacies.

We hope to receive many candidacies!

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Letter — Matters arising from "The Leonid meteor shower and the history of the Semites"

Alastair McBeath [1]

Aspects of a paper by Suleyman (2009) in this journal, relating to theoretically-strong Leonid activity in 569 AD and 1226 BC possibly having been recorded in the Quran and Bible respectively, are discussed. Little reason is found to suppose either textual source referred to such astronomical events.

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1 Introduction

The commentary on Sura 105 of the Quran and parts of Exodus Chapter 9 from the Bible by Suleyman (2009), which suggested both related to theoretically-strong Leonid activity in 569 AD and 1226 BC respectively, was interesting, but failed to address a number of important points concerning both sources. These omissions were

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significant, because they greatly reduced the possibility that either text related to astronomical events at all, let alone the specific preferred ones. While I have not attempted here a comprehensive review of all pertinent materials, primarily because they have little relevance to meteors, I have highlighted some of the problems. I have also deliberately chosen English translations of the texts which are different to those in Suleyman, to further demonstrate the importance of not relying simply on a single variant translation which may appear to favour one or another theory.

2 Sura 105 of the Quran

The interpretation of parts of the Quran, even in the original medieval Arabic, is fraught with difficulties, such that it is often easier to appreciate whole passages complete, than to analyse individual lines or words for specific meanings. When translated into another language, which may not include comparable concepts, the difficulties become magnified.

Lines 3–5 of the Quran's Sura 105 that Suleyman (2009, pp. 85–86) indicated as most important, were cited there in English as:

"And send down upon them birds in flocks,
Casting against them stones of baked clay,
So He rendered them like straw eaten up?".

[Note that in all instances in this section, 'He' means the god Allah.] However, a leading English-language translation (Farid, 2006, p. 1307) gave this alternative:

"And He sent against them swarms of birds,
Which ate their dead bodies, striking them against stones of clay.
And *thus* made them like broken straw, eaten up."

The italicised words have been added to this translation to explain better the text's meaning, in the editor's opinion, though they do not appear in the original Arabic.

The term 'swarms', not 'flocks' of birds has been used in the second case, since the Arabic term 'abābīl' in line 3 has been suggested as having the meaning of separate groups, in this case of birds, following one another, or coming together from different places (loc. cit., footnote 3437). Birds simply flocking to feed upon dead bodies is of course a perfectly reasonable explanation of the lines, but appears to require a degree of reinterpretation to achieve, from the English translation of the Arabic text alone.

One further version of the translated lines is worth citing, to help show just what different interpretations can be placed on the same Arabic text. From Ali (2001, p. 552):

"And sent hordes of chargers flying against them,
(While) you were pelting them with stones of porphyritic lava,
And turned them into pastured fields of corn?".

Thus now we have horsemen metaphorically flying into a swift attack, not birds really flying, while other troops hurled rocks at the enemy. Ali's notes (loc. cit.) explained why this translated wording had been preferred.

That the attempted military attack upon Mecca in 570 AD by Abraha Ashram, generally believed the subject of Sura 105, was prevented by a virulent illness including skin sores, is known from other texts, as Suleyman noted (see also p.1306 of Farīd, 2006). The illness is thought modernly to have been smallpox, which is probably reasonable, albeit another well-known English translation (Rodwell, 1909, p. 36, footnote 1), still current despite its date, indicated that "the Arabic word for small-pox also means 'small stones', " suggesting this, and not the 'eaten-up straw' of Sura 105's fifth line that Suleyman mentioned, could be interpreted as referring to this illness.

Suleyman's proposal (2009, p. 86) that 'baked clay' might be taken as meaning the material was burning, and thus somehow meteoric, is incorrect. Baked clay is and was a well-known substance, used across the Near East for millennia, found mentioned in texts back to the third millennium BC and in far-earlier archaeological contexts. It is a lightly-fired form of clay, in other words, clay which has been heated in a fire either deliberately or accidentally, then allowed to cool before use. This makes the material much harder and more resistant to damage, like a stone. It was, for example, ideal for making ammunition for use with a sling – small rounded objects a few centimetres across in size.

Indeed, another alternative explanation of the lines could be that the army attacking Mecca was itself attacked by a missile-armed force of defenders, using baked-clay slingshots, and arrows. The latter could be inferred from the 'bird flocks' line preceding the 'clay stones' one. Birds could scarcely have flocked to feed upon the army before its members were killed, but the use of terms such as 'feather' and 'wing' can also mean 'arrow' in Near Eastern texts, because of the feather-flights needed to stabilize an arrow in the air. Such word-substitution can be found in texts back to at least the early second millennium BC in the Near East (e.g. the myth 'Anzu' – cf. Dalley, 1989, especially pp. 215–216). Sura 105 might then have begun as a tale intended to euphemize prohibited weapon use so close to Mecca by a defending army, assuming it did refer to events in 570 AD, and assuming a more straightforward military response, as interpreted by Ali, was not intended by the original text.

3 Exodus Chapter 9 of the Bible

Two main proposed dates for the events in Exodus already exist, based on historical and archaeological evidence, as well as information in the Bible, following examination and discussion over many years by scholars in those fields. These dates are around 1450–1440 BC and 1260–1250 BC, making the unnamed pharaoh either Thutmose III (circa 1479–1425 BC) or Rameses II (circa 1279–1213 BC). Egyptian chronology for the period is not firmly-fixed however, and alternative dates for these rulers may be found elsewhere in the literature, for example 1290–1224 BC for Rameses II. The reasoning behind these two alternatives is quite involved, but needs to be thoroughly understood by anyone seriously attempting to challenge either dating. See for instance (Dennis & Grudem, 2008, p. 33) for a summary of the main points. Other dates have been suggested from time to time too, but these two are widely accepted as more probable, with modern opinion generally tending to favour the $\sim$ 1255 BC date.

Merenptah (circa 1213–1203 BC) is considered an unlikely candidate as the pharaoh, Exodus 2 : 23 notwithstanding, because of the existence of a stela from early in his reign (probably before his fifth year as pharaoh). This stela recorded a victory over a number of rebellious vassals in what is modernly Israel, anciently Canaan, including the people of Israel. This is the earliest historical mention of Israel in a non-biblical source. Biblically, 'Israel' was the name of the people living in the Goshen region of Egypt, on the southeastern side of the Nile delta in Exodus (see Genesis 32 : 28–29 & 46 : 1–7 on this definition). These were the people who left Egypt in Exodus, and then spent forty years travelling through the desert to reach Canaan, according to the Bible. Even if, as is often supposed, this value of forty years was just a rounded figure, material in the books of Exodus, Numbers and Deuteronomy gave a clear indication that the time between the departure from Egypt and the arrival in Canaan was a generation, implying a minimum of, say, $\sim$ 20–30 years. Merenptah's reign was so short, and his reference to the people of Israel in the Canaan area so early in his reign, these events cannot be fitted-in to the time available if he were also the pharaoh at the time of Exodus. For historical references on all these pharaohs, see for example (Shaw, 2000), while the footnote to Genesis 32 : 28 on p. 108 of (Dennis & Grudem, 2008) included a translation of the 'Israel' passage from Merenptah's stela.

Concerning the nature of the very severe hail in Exodus 9, what is widely regarded as the most nearly-literal English translation of the Bible presently available (op. cit.) gives the following passages. Note that in this translation, the deity name 'Yahweh' is always given as 'the LORD'.

Exodus 9 : 23–24: "Then Moses stretched out his staff toward heaven, and the LORD sent thunder and hail, and fire ran down to the earth. And the LORD rained hail upon the land of Egypt. There was hail and fire flashing continually in the midst of the hail, very heavy hail, such as had never been in all the land of Egypt since it became a nation."

Exodus 9 : 33: "So Moses went out of the city from Pharaoh and stretched out his hands to the LORD, and the thunder and the hail ceased, and the rain no longer poured upon the earth."

This seems to graphically describe simply an unusually severe hailstorm, with rain and thunder, so it would be natural for translators trying to help people better understand the sense of the original, to prefer the term 'lightning' for the more poetic 'fire running down to the earth' and 'fire flashing continually in the midst of the hail'. These are exactly the conditions found in severe, and sometimes not so severe, hailstorms modernly, after all, so the omission of lightning from the description would be more remarkable than its inclusion. The sense that the hail was within exceptional, but not impossible, natural parameters was maintained by the statement that no hail fell in Goshen. So just as in a very severe thunderstorm with hail today, one place might be deluged and suffer serious damage, yet another a few kilometres along the road might have had a dry day.

There is nothing in the Biblical text to support Suleyman's assertion (2009, p. 89) that the hailstorm lasted almost two days. Moses was instructed by the god Yahweh to rise early one morning (that is, some time after sunrise) and warn the pharaoh what would happen next day, at about the same time, if the Israelites were not freed (Exodus 9 : 13–19). On the following morning, as instructed, Moses called down the hailstorm, was summoned by the pharaoh as soon as its severity was apparent, and stopped the storm (Exodus 9 : 22–33). No statement of the amount of time involved was given in this second section, but the passages ran quickly from one to the next, suggesting immediacy, thus were probably indicative of no more than a few hours, beginning with the early to mid morning start of the storm.

It is difficult too to see how this text could be reinterpreted to somehow include a view of otherwise unrecorded strong Leonid activity, which would have been visible only under clear night skies after midnight, while the hailstorm occurred during the morning daylight hours, from what could only have been at least a virtually-overcast sky.

4 Conclusion

Earlier literary works suspected of containing possible references to specific, past, real or theoretical meteoric activity, must be examined very carefully, and in conjunction with any historical or archaeological materials that may be relevant. It is insufficient to make assumptions based on just one translation of a text alone. It can be difficult for those well-versed in meteor studies to appreciate the amount of information that may be available in such disciplines in which an investigator is far less expert, and it is in these cases that especial care must be taken.

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Emergent property

Howard V. Hendrix[1]

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The astronomer, separating the "signal" of shower-associated meteors from the "noise" of sporadic meteor background, does not ask whether the mind conjures constellations out of the stars, or the stars conjure constellations out of the mind. Her fleeting scratches of light, caught by motion-triggered video cameras, make stars constellated by imagination seem solid and enduring as the pillars of eternity.

She knows the old Arabic tale: shooting stars are stones thrown by angels at afreets eavesdropping on the secret counsels of heaven. Were all meteor-shower astronomers enormous skulking demons stoned on shooting stars and heavenly secrets in previous lives or alternate universes? She wonders. Perhaps it is to appease our inner demons that we spend our time searching out creatures from the Id. Draconids. Hydrids. Cygnids. Leonids. Taurids. Ursids. Et ceterids.

Her colleagues have used that last joke against her, but when she's done subtracting from the daily background of sporadics all known meteors associated with named showers, she thinks she'll name what's left – the "shower" of all meteors which are not part of named showers – "Ephemerids," just to annoy them with the logic of it.

They consider her an irritant, but it is sand makes oyster grow pearl, stone makes air grow meteor, noise makes message grow signal – and not too much to imagine meaningful dreams and nightmares might flash from anywhere in the sky, anytime.

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Ongoing meteor work

Meteor Shower Records: A Reference Table of Observations from Previous Centuries

Masahiro Koseki [1]

Meteor history shows the complex nature of meteor showers. The author presents the Comae Berenicids as an example of the difficulties in defining meteor showers for visibility using different observational techniques. It is not useful to give a fixed or coded name to a 'meteor shower' because it may not be real and could lead observers to fictitious results.

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1 Introduction

We see a meteor but it will never be observable again. We may observe a meteor shower by chance. Will we observe it again?

A meteoroid itself produces a meteoric phenomenon in the Earth's atmosphere only once but a group of meteoroids shows us a possible recurrent meteor shower. Can we observe it every year? Sometimes yes, but not always.

A parent body releases meteoroids and they gradually disperse. We meet them at different stages of their evolution and see different activity profiles. Lovell (1954) divided them into two groups, which are, permanent showers and periodic ones. We may divide them into major and minor ones based on other aspects. Major showers show us fine displays every year but minor ones appear not as a high-activity shower but a low-activity drip (Jenniskens, 1988; Roggemans, 1989). A minor stream may display an outburst unexpectedly but another brings a photographic record a year or even longer period. It is very difficult to identify one meteor shower/event with others.

We now have a large collection of meteor records spanning a more than a century. But meteor observations are continually developing from solely visual to photographic, radar and video techniques, each with different properties. Radar observations can detect a daytime shower but optical methods cannot contribute any data. Radar techniques can observe fainter meteor than photographic and video but suffers from selection effects. Visual observations have a longer baseline of records than the others but lacks orbital data.

It is very important to examine meteor records by every technique considering their properties and to compile a reference table of meteor showers. The author has worked out the series of meteor activity research and is going to review them.

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2 Visual observations

2.1 Properties of visual observations: short reviews on visual radiant studies

The historical sequence of meteor radiant conception could be summarized as follows (Jenniskens, 1988; Roggemans, 1989):

1. A meteor shower comes from a stationary radiant.
2. Major meteor showers are accompanied by minor radiants.
3. An older shower has a broader radiant than younger ones.

In the nineteenth century, meteor showers were not well known. Leonids, Perseids, Orionids, Geminids and Andromedids had been detected because of their outbursts or superior activities. Interest goes to investigate their nature and, therefore, observations concentrated into their activity period. Adding to this, another observational bias arose because Denning collected European observations at high northern latitudes. But, it is clear that Denning's catalogue is very important for meteor researchers, because meteor activities are not stable in the long term. His collection contains the most extensive meteor data of the nineteenth century.

2.1.1 Denning

Denning (1899) collected early observations of radiants and compiled a list of showers. Meteor observers in those days determined a radiant from several nights or even weeks or more, because they had not known that meteor radiants shift eastward in general. Not only meteor charts but ordinary star charts were rare in those days and meteor paths were recorded from many days on the same sheet. Meteor activity was thought to continue throughout the year in the same area and Denning himself accumulated radiants at the same position throughout the year except for the Perseids. As a result, his "radiants" are composed of several showers. Denning's radiant groups should be broken down one by one and we must search for meteor showers using individual observations separately.

1. It is necessary to select radiants detected from less than 5 nights. If we apply Olivier's rules (1925) strictly, we might miss important records from the nineteenth century.
2. The middle date of the observation can be used for such records.

3. All records lack decimal date resolution and it might be faultless to place the date at zero hours, that is, observations were carried out at midnight in Europe.
4. Some radiants do not have a year of observation and we must assume they were recorded in 1875 in such cases.

But, we can disregard the errors resulted from above treatments, because the precession is small enough for this research since observational errors are much greater.

2.1.2 Hoffmeister

Hoffmeister investigated "ecliptic meteor showers" and reached the modern concept of meteor origin that they do not come from interstellar space such as dark nebulae but are members of our solar system. He himself recorded innumerable meteor paths and treated them statistically. He published a list of their convergences (Hoffmeister, 1948) but did not call them "radiants". He estimated the probability of fictitious radiating points and applied his original method to detect radiant points. He calculated the density of prolonged meteor paths on the meteor chart and some researchers with computerized program now use this procedure. His estimate shows that more than half of ordinary observed radiant might be by chance and demands that visual data should be treated statistically.

He deduced most reliable meteor activities by four steps and he listed three phases of his working list. For this work, the author uses his initial convergence list. In spite of his careful investigation, there are many differences between his last stage and this search. It means visual results should be considered as probable estimates and this discrepancy is very natural. It is worthy to note his list includes observations from both the northern and southern hemispheres and is based mainly on his own observations, which could be used for homogeneous quality.

2.1.3 AMS

Olivier was a very enthusiastic meteor investigator and organized the American Meteor Society (AMS). He and Millman led visual meteor observations during the first quarter of the twentieth century. His instructions for observers (1925) have been spread world wide and used as the standard. But, it is unfortunate for Japanese meteor researchers that they cannot access all AMS radiant data. AMS' results were often published in the monograph of Leander McCormick Observatory, the Flower Observatory Reprints, or elsewhere and the author could not access more than half of these results. I may add the worst story in this connection that my input data of AMS' radiant volatized from my floppy disk and output of my search remains only.

AMS' observations cover the period of Hoffmeister's observations and afterwards, which is the same period as the Nippon Meteor Society's (NMS) observations. It is, therefore, possible to compare these two series directly and to check their propensities.

2.1.4 NMS

The Nippon Meteor Society was founded in 1968 but sprung from the meteor section of Oriental Astronomical Association (OAA). The meteor section had started in 1926 and recorded radiants since 1928. The radiant data used here was published in two parts: Komaki (1964) and by the author himself (Koseki, 1971).

Komaki had been a member of AMS also and the basic techniques are nearly identical in both AMS and NMS. Especially, "the sections dealing with radiants" are the same but their interests differ of course as well as positions on the Earth.

2.2 Data management

There are many problems with the use of visual observations.

1. Only trained observers can yield radiant positions accurate enough for examination.
2. There were not enough gnomonic charts for meteor observations in the 19th century.
3. Many meteor paths make chance convergence frequently.
4. It is impossible to confirm meteor activity from a few meteors when sporadic base level would be high.
5. Meteor counts without recording meteor paths is useless for determining meteor radiants and insufficient for even counting meteor numbers of minor showers.

Though there might be many spurious radiants in visual observations, there remains many probable meteor activities that are not confirmed by other observational techniques. Minor meteor showers change their activity year by year as well as major ones. It is noticeable that visual observations are carried out more often than modern techniques and, therefore, the former can detect variable meteor activity that the latter could not.

It should be stressed that we can identify one record with another by their radiant position and date only. Visual data does not give meteor velocity but does provide spatial information.

We examine four typical lists of visual meteor radiants in order to reduce fictitious radiants by comparing each of the lists. The ecliptic coordinates are useful for comparing radiant positions by the following steps.

1. Radiant coordinates (R.A., Dec.) are converted to ecliptic coordinates (λ, β).
2. Sun's longitude at the time of observation ($\lambda_\odot$) is subtracted from the longitude of the radiant ($\lambda - \lambda_\odot$).
3. Radiant positions ($\lambda - \lambda_\odot$, β) are plotted on Hammer's projection in 15° bins of $\lambda_\odot$ (see Figure 1 for an example).

We can reduce the influence of radiant drift by these steps and compare the observations of longer time intervals. A meteor shower might be active in an area where more than 5 radiants are concentrated and were observed within 5° in Sun's longitude of each other. The visual radiant area might span about 10° in radius following the example of the major showers, though its radius comes from the limitations of visual observations and not from the spatial distribution of meteoroids. We should not set the exact limitation of radiant areas a priori though it may lead to subjective view. We will investigate and compensate for this prejudice by comparing visual observations with each other later.

3 Modern techniques

3.1 Properties of modern techniques

3.1.1 Photographic observations

This gives the most reliable results but cannot detect faint meteors. Only the Super Schmidt cameras could register as meteors as faint as 4th magnitude and smaller cameras yielded data for meteors brighter than 1st magnitude. We have thousands of photographic meteor orbits and most were obtained by the Super Schmidts. This means photographic data gives meteor activities during the 1950's and mostly in the brighter meteor range. Basically, photographic technique is applied during the period of dark nights because the Moon light hinders the observations. It is necessary to observe over a period of 3 years to cover the whole meteor activity since minor showers change their activity year by year.

The author had checked published orbital data and found some mistakes and they had been corrected in the IAU Meteor Data Center (MDC). Meteor data were compiled each 80 column a meteor omitting their original meteor number. Though the MDC might provide much more data, the author used his own data storage inputted from original papers. There are more than 4000 orbits by a total of 25 sources (Table 6) but they are mainly from the 1950's (Table 7).

3.1.2 Radar observations

They can detect fainter meteors than other techniques and yield the greatest volume of meteor data. But, observation systems vary greatly and the results should be treated very carefully. Also, radar systems are often operated for an interval of a few days and not all year round in general. Radar results are often different from visual ones, that is, the former catches the apex source and the latter, mainly, the antihelion source.

3.1.3 Video observations

This includes two different techniques: Image Intensifier and high sensitive CCD. The former can catch meteors as faint as radar can and the latter was developed for a fireball watch in Japan. The former can give more precise results than the latter but is more expensive also. The latter technique is becoming popular with amateurs but, unfortunately, the results have only been partially published. Thousands of video orbits are buried throughout the World Wide Web and the investigation on minor streams will be rewritten when they are available to every one.

3.2 Data management

3.2.1 Koseki's work

The author (Koseki, 1986) compiled the reference list of meteor streams from 10 orbital catalogues by using the cluster analysis (the centroid method) with D-criterion (Southworth & Hawkins, 1963) as a measure of the similarity between orbits. It is necessary to note that the "meteor showers" of Table 5 are alike only in orbital elements of two or more observations and they are not always real but sometimes fictitious. There are some showers referred by only one observation, it is because twin showers are shown separately.

3.2.2 Jenniskens' list

Jenniskens (2006) published an extensive meteor shower list in which many minor showers are studied and combined (or divided) into proper ones. Jenniskens gave major or interesting streams low numbers but we cannot call them "established". The author examines the above visual and modern results comparing with his showers in the following sections.

4 Discussions

4.1 Comparison between observations

4.1.1 Visual observations

The author has done research on the above four visual observation data groups (Tables 1-4) and the summaries of the results are shown in Table 8.

It is clear that there exist biases from restricted conditions and from conceived ideas (see Section 2.1). Meteorological and geological constraints hindered observers from observing some meteor streams. Hoffmeister could detect the southern most radiants that could not be recorded by others. Some major shower seemed to have sub-radiants, which are regarded as fictitious.

Because Hoffmeister listed the concentrations of extrapolated meteor paths and did not directly call them meteor radiants, his convergence points are naturally more dispersed than others. Visual records of meteor paths are not accurate enough to distinguish meteor radiants located 10-20 degrees apart. Prolonged paths of many shower meteors and of occasional sporadic meteors cross near the shower radiant and assumed ideas of accompanied radiants lead them to "confirm" it. The main goal of the observations by the AMS and NMS aimed to determine precise positions of meteor radiants and they naturally concentrate their attention towards a narrower region than Hoffmeister did. Olivier denied the idea of stationary radiant but suggested so-called accompanied radiants, for example, Orionids and its subradiants. His ideas influenced the AMS' and NMS' observations. The comparison between Hoffmeister's results and other three observational series suggests that so-called accompanied radiants might be fictitious.

4.1.2 Differences between observations

The author compares his streams of Nos. 1-34 with older visual observations (Tables 1-4) and with the reference list of orbital data (Table 5). It is very easy to find evidence of all major streams in all observations

Table 1 – Radiant concentrations from Denning's (Koseki, 1979a). Nos. will be referred as D- hereafter.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Obs.
1	17	255	+53	217	+74	14
2	24	213	+55	152	+60	10
3	25	178	+38	137	+34	5
4	26	232	+22	197	+40	9
5	27	195	+4	165	+10	6
6	30	270	+34	240	+57	53
7	30	301	+18	278	+38	5
8	30	224	+1	191	+17	8
9	32	289	+50	280	+70	8
10	36	294	+8	261	+29	9
11	62	270	+60	197	+81	5
12	102	290	+38	199	+59	8
13	106	308	+23	212	+40	7
14	108	342	+34	251	+37	6
15	109	280	+62	185	+83	5
16	110	313	+47	230	+60	7
17	112	339	+80	316	+66	6
18	117	246	+56	94	+74	7
19	120	270	+24	151	+47	6
20	122	344	+69	277	+63	9
21	124	336	+39	233	+44	12
22	124	325	11	200	+3	9
23	125	330	+2	208	+13	5
24	125	285	+47	174	+69	6
25	125	21	+68	289	+53	5
26	126	271	+37	145	+60	10
27	126	311	+33	199	+48	8
28	127	339	12	209	−3	6
29	128	304	9	177	+10	14
30	129	340	29	202	−19	5
31	129	338	+27	222	+34	8
32	131	297	+70	265	+80	7
33	131	269	+48	137	+71	16
34	133	304	+43	192	+60	8
35	133	313	+48	209	+61	12
36	134	63	+17	297	+28	17
37	134	18	+56	268	+44	20
38	134	42	+56	283	+38	112
39	135	251	+38	104	+59	6
40	136	264	+66	27	+86	12
41	136	305	+10	174	+28	13
42	136	67	+68	302	+46	14
43	136	4	+52	254	+45	20
44	136	41	+21	269	+5	9
45	136	16	+41	256	+31	12
46	137	38	+41	272	+25	35
47	137	342	+52	236	+53	10
48	138	285	+60	184	+80	9
49	138	173	+77	339	+63	9
50	138	306	+26	178	+44	11
51	139	9	+75	282	+60	10
52	141	4	+37	239	+32	13
53	141	29	+35	258	+22	7
54	142	331	+85	303	+67	8
55	142	347	+44	228	+44	9
56	143	342	4	199	+3	7
57	144	54	+70	288	+49	5
58	144	331	+9	193	+20	8
59	144	295	+52	179	+71	5
60	144	18	+32	245	+22	7
61	144	326	+67	244	+68	27
62	148	355	+13	213	+13	10
63	163	78	+21	276	−2	7
64	170	63	+59	263	+37	7
65	175	76	+43	264	+21	15
66	181	74	+11	253	−12	5
67	183	103	+73	272	+51	11
68	188	69	+48	246	+27	15
69	195	27	+39	204	+26	11
70	203	57	+19	216	−1	8
71	205	122	+55	267	+34	8
72	206	92	+16	247	−8	59
73	206	111	+28	263	+6	8
74	207	75	+26	229	+3	6
75	213	50	+5	197	−13	10
76	217	24	+12	170	+1	9
77	224	54	+20	192	+2	100
78	226	96	+42	229	+19	6
79	231	74	+32	205	+10	7
80	229	128	+70	240	+49	11
81	232	157	+44	270	+32	6
82	232	42	+63	189	+46	19
83	232	121	+37	243	+16	6
84	232	150	+24	272	+11	79
85	234	49	+9	175	−9	5
86	240	30	+39	162	+25	75
87	240	196	+49	294	+49	9
88	254	350	+65	141	+61	7
89	254	202	+73	240	+67	8
90	256	142	+29	240	+13	6
91	258	108	+33	207	+10	54
92	259	102	+55	199	+32	7
93	259	144	+43	232	+27	16
94	263	115	+18	211	−3	8
95	280	140	+47	207	+30	5
96	282	231	+51	278	+65	28
97	302	204	+57	222	+58	10
98	307	225	+31	264	+46	11
99	330	163	+12	190	+5	5
100	344	243	+10	255	+31	5

Table 2 – Radiant concentrations from Hoffmeister's (Koseki, 1978). Nos. will be referred as H- hereafter.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Obs.
1	0	187	−25	196	−21	26
2	1	190	+33	172	+34	20
3	2	184	+1	182	+3	46
4	7	171	+19	158	+14	23
5	11	219	+9	203	+22	30
6	12	255	−28	244	−6	9
7	14	230	+49	186	+63	16
8	17	246	+60	181	+77	15
9	19	226	+35	189	+49	26
10	21	297	+37	291	+56	15
11	22	232	−25	213	−6	8
12	25	210	+39	164	+47	11
13	26	198	+28	158	+32	16
14	26	215	−18	193	−5	54
15	28	209	+3	178	+14	16
16	31	270	+39	238	+61	50
17	40	340	+54	335	+55	7
18	50	333	−5	284	+6	32
19	55	225	+38	150	+52	7
20	62	230	−23	172	−4	28
21	64	249	+39	172	+59	20
22	67	258	−24	192	−2	90
23	70	230	+15	152	+32	16
24	72	280	+44	213	+65	37
25	75	268	+3	194	+26	15
26	77	232	−8	155	+10	11
27	78	263	+22	183	+44	22
28	80	267	−36	187	−13	25
29	80	313	+20	241	+36	19
30	81	331	−50	232	−36	8
31	81	255	−26	175	−4	9
32	82	291	−49	204	−27	7
33	84	345	+11	267	+16	27
34	90	299	−16	209	+4	21
35	95	249	−34	158	−13	9
36	96	218	+52	86	+60	11
37	97	198	−19	107	−10	9
38	101	289	−23	187	−1	26
39	102	317	+15	223	+30	10
40	110	310	+24	211	+41	11
41	111	25	−18	265	−26	8
42	111	336	+47	252	+51	11
43	113	301	+39	204	+57	11
44	114	28	+17	278	+5	15
45	115	352	+8	241	+11	16
46	120	299	−37	174	−17	19
47	120	353	−27	223	−22	16
48	122	289	−16	166	+6	17
49	123	5	+35	256	+30	22
50	124	327	+19	212	+30	16
51	126	338	−24	205	−14	50
52	128	341	+35	231	+39	13
53	129	312	+4	187	+20	26
54	129	335	+6	210	+16	18
55	129	299	+24	178	+44	12
56	131	342	+51	241	+52	14
57	131	5	+55	263	+47	10
58	132	315	−13	182	+4	50
59	133	338	−7	204	+2	45
60	134	303	+52	199	+67	11
61	135	44	+55	284	+37	221
62	136	101	+65	321	+42	11
63	137	38	−16	252	−29	11
64	138	338	+14	207	+21	10
65	140	40	+37	269	+20	17
66	142	33	+25	258	+11	9
67	142	7	+30	237	+24	8
68	143	51	−26	256	−43	17
69	145	330	+50	215	+56	23
70	145	348	+62	244	+59	17
71	149	57	+12	268	−8	16
72	149	19	+39	244	+29	28
73	150	194	+70	350	+65	12
74	151	297	+62	191	+76	70
75	151	341	−22	184	−13	26
76	151	3	−30	198	−29	15
77	153	357	+48	228	+44	26
78	153	34	+47	256	+31	26
79	154	85	+40	292	+17	21
80	157	4	−9	203	−10	12
81	158	66	+59	277	+38	38
82	158	351	+8	197	+11	35
83	158	322	+13	171	+26	9
84	162	349	+28	200	+30	11
85	162	67	+34	268	+12	34
86	164	10	+38	222	+31	16
87	166	15	+21	216	+14	28
88	166	38	+31	240	+15	24
89	167	71	+1	263	−21	15
90	169	61	+23	255	+3	11
91	169	343	+42	196	+45	25
92	169	359	+5	192	+5	41
93	170	58	+46	257	+26	26
94	170	340	−21	164	−12	21
95	172	99	+54	284	+31	15
96	178	45	+60	245	+42	37
97	184	333	+39	170	+46	16
98	185	16	+27	200	+19	17
99	187	19	−15	184	−21	37
100	193	75	+44	246	+21	31
101	193	56	+30	228	+10	24
102	193	36	+45	216	+29	31
103	195	11	+15	181	+10	33
104	199	314	+65	176	+71	13
105	199	22	+39	197	+27	14
106	204	91	+18	247	−5	100
107	217	3	+39	162	+35	75
108	218	46	−5	185	−21	16
109	218	31	+3	172	−9	7
110	220	53	+19	196	+1	345
111	231	39	+12	170	−3	14
112	232	32	+34	170	+20	13

Table 2 – Radiant concentrations from Hoffmeister's (Koseki, 1978). Nos. will be referred as H- hereafter. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Obs.
113	233	153	+24	273	+12	41
114	238	127	+24	245	+5	24
115	239	97	+48	216	+25	14
116	250	125	−26	246	−44	20
117	253	109	+11	216	−11	18
118	255	83	+4	188	19	22
119	258	100	−44	210	−66	14
120	260	163	+43	247	+33	10
121	260	114	+31	211	+9	80
122	263	64	+39	167	+17	13
123	266	142	52	270	−61	15
124	275	183	+54	239	+49	8
125	283	154	−27	245	−35	8
126	285	152	+51	209	+37	8
127	287	234	+55	271	+69	11
128	300	126	+20	185	+2	73
129	306	140	+37	185	+21	13
130	323	213	+24	238	+35	15
131	336	184	+29	195	+28	14
132	339	243	−21	267	0	7
133	340	155	+18	170	+8	21
134	343	191	−3	209	+1	13
135	349	230	+54	203	+67	9
136	351	259	+35	262	+57	10
137	352	252	+60	215	+79	8
138	356	222	+28	212	+42	19

(list) except for the η-Aquariids and the Leonids, because the η-Aquariids are a difficult shower for observers in Northern Europe and the Leonids fluctuated greatly. We can call the following major streams as real: Quadrantids, Lyrids, η-Aquariids, Orionids, Leonids and Geminids. Of course, we can add some so-called ecliptic streams, such as the Taurid and δ-Aquariids antihelion source streams. But, it is a well known fact that they are so complicated streams that many visual observers find difficulty in separating their Northern and Southern branches. The author tries to study the δ-Aquariids period for example, while the remaining ecliptic streams of Jenniskens' list would be left for future consideration: η-Virginids, χ-Orionids, Taurids, Andromedids, α-Virginids, Arietids, κ-Serpentids, δ-Leonids, Piscids. There remain the Giacobinids, Ursids and others. They are classified as two different types: periodic or occasional, and typical minor ones. Giacobinids and Ursids are the ones of the former and December Comae Berenicids are representative of the latter. In the following sections, the author will study meteor streams representing these three categories.

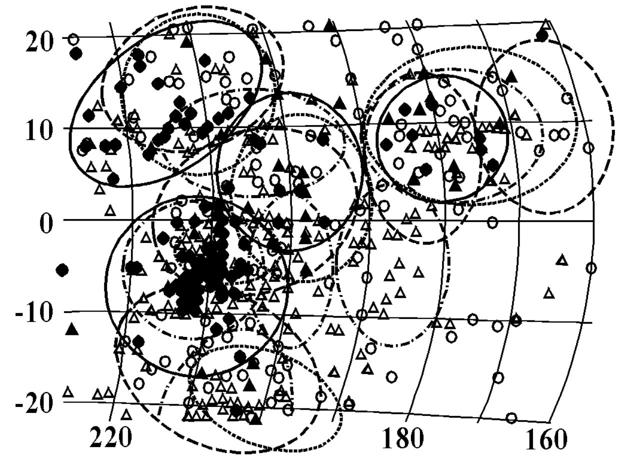

Figure 1 – Visual radiant distribution around antihelion area during $\lambda_\odot$=120–135.

4.2 Problems on the definition of a meteor stream

4.2.1 Ecliptic showers

Meteor activities in the antihelion region are difficult to define as a definite shower by visual observations and are sometimes combined as a single shower. The Virginids and Taurids clearly consist of several streams. Visual radiants should be classified with probabilities to several showers like individual meteors and we cannot divide such meteor complex into smaller parts only by these radiant observations.

Many meteors radiate from Aquarius in the summer. The ι-Aquariids are covered with the Capricornids, Southern and Northern δ-Aquariids. Figure 1 shows individual radiants from the four visual observation series and their concentration areas.

Explanations for Figure 1, 2a-d, 5-7, 10a-d, 11, 12 and 14: Plotted individual radiants on $\lambda - \lambda_\odot$ and β chart.

- Denning's radiants: solid triangles encircled by dotted line
- Hoffmeister's radiants: open circles encircled by broken line
- AMS' radiants: open triangles encircled by long and short dashed line
- NMS' radiants: solid circles encircled by solid line

The Southern δ-Aquariids display a clear concentration in the lower left and Capricornids are shown separately in the upper right. Northern δ-Aquariids are located to the upper left and the ι-Aquariids might be recognizable between them. Figures 2a-d show the differences between each of the four visual series and Jenniskens' radiant positions, which are abbreviated SD for the Southern δ-Aquariids, ND for the Northern δ-Aquariids, CA for the Capricornids, SI for the Southern ι-Aquariids and PA for the Piscis Australids. The Southern δ-Aquariids and Capricornids are in good agreement with each other, though Hoffmeister's radiant distribution is curious. The Northern δ-Aquariids of Jenniskens seems to be located slightly east of the visual observations. Jenniskens' ι-Aquariids are too close to the Southern δ-Aquariids and have only one possible identical radiant area with the AMS (A-59). Though it may be active now, we cannot count the ι-Aquariids separately from the surrounding strong meteor activity by visual observations. Ecliptic streams are very complex and their membership might be classified with probabilities; for example a single meteor is

Table 3 – Radiant concentrations from the AMS (Koseki, 1980). Nos. will be referred as A- hereafter.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Obs.
1	3	113	+32	106	+11	7
2	7	194	+3	185	+9	9
3	7	159	+4	152	−5	13
4	8	195	+23	177	+27	13
5	11	212	+38	181	+46	6
6	15	154	+25	132	+14	12
7	20	185	+38	147	+36	5
8	21	289	−30	266	−8	10
9	22	251	−49	235	−26	5
10	27	268	−8	241	+15	5
11	27	236	−21	211	−1	10
12	32	289	+11	261	+32	5
13	34	278	+35	248	+58	61
14	36	284	−30	246	−8	8
15	41	217	+21	165	+34	12
16	42	255	+27	207	+49	25
17	46	232	−19	189	+0	8
18	46	336	−1	291	+9	108
19	48	302	−14	253	+6	5
20	48	326	−17	274	−3	11
21	48	327	−35	269	−20	6
22	50	276	−29	226	−5	15
23	50	309	+14	266	+32	10
24	60	240	+29	170	+48	9
25	60	268	−12	208	+11	10
26	60	253	+55	167	+75	6
27	60	286	+8	228	+30	6
28	70	234	−17	166	+2	11
29	81	265	−19	184	+4	11
30	83	233	+28	138	+45	10
31	93	309	+20	225	+37	11
32	94	290	+34	206	+55	6
33	95	268	+54	170	+77	9
34	96	299	−13	203	+7	15
35	97	325	−15	226	−1	12
36	97	351	+25	265	+26	6
37	97	272	+21	175	+44	27
38	98	293	+3	197	+25	8
39	99	224	+55	83	+65	16
40	101	286	−19	183	+3	16
41	104	317	+34	229	+47	11
42	106	307	+47	227	+62	10
43	107	352	−8	242	−4	5
44	109	338	+17	238	+24	9
45	109	335	−32	216	−20	11
46	111	304	+20	200	+39	5
47	114	337	+49	253	+52	10
48	114	330	+9	221	+20	6
49	120	273	+41	156	+64	14
50	123	0	+31	251	+28	7
51	123	11	+42	266	+34	16
52	124	275	−2	151	+21	6
53	125	347	+2	224	+7	21
54	126	304	−11	178	+8	35
55	126	342	−15	211	−6	142
56	127	293	+30	175	+51	9
57	128	333	−3	206	+8	24
58	128	33	−9	260	−21	13
59	128	331	−14	200	−4	35
60	129	302	+59	220	+73	6
61	129	343	−29	204	−20	40
62	130	329	−34	190	−20	15
63	130	67	−38	285	−59	6
64	130	4	−19	225	−19	17
65	132	321	−19	186	−4	35
66	132	350	+29	232	+30	20
67	133	328	+29	210	+39	25
68	134	23	+18	254	+8	12
69	134	6	+15	237	+11	17
70	135	54	0	277	−19	6
71	135	333	+43	222	+49	10
72	135	336	+12	207	+21	17
73	136	304	+47	193	+64	15
74	137	42	+56	281	+38	265
75	138	38	+34	268	+18	22
76	138	334	+60	242	+62	17
77	139	314	+15	183	+31	33
78	139	11	+51	255	+42	26
79	142	279	+56	149	+78	10
80	153	335	+2	185	+11	20
81	158	14	−12	210	−16	6
82	160	31	+31	240	+17	9
83	161	34	+66	259	+49	9
84	164	356	+21	201	+20	15
85	167	321	+4	157	+18	7
86	168	30	+52	240	+37	8
87	169	29	+25	227	+12	20
88	170	74	+11	263	−11	10
89	171	60	+40	255	+19	15
90	173	352	+20	189	+22	7
91	177	360	+52	209	+46	16
92	181	343	+18	171	+23	7
93	201	20	+13	182	+5	10
94	206	90	+15	244	−8	242
95	208	94	+47	245	+24	6
96	217	55	+15	200	−3	137
97	220	19	+27	168	+18	22
98	232	150	+23	272	+10	72
99	233	147	+53	256	+37	7
100	235	99	+11	224	−12	6
101	236	105	+61	223	+39	5
102	237	76	+46	203	+23	6
103	261	111	+31	208	+9	50
104	262	149	+16	243	+3	10
105	275	187	+22	262	+22	6
106	277	163	+30	236	+22	10
107	282	219	+51	264	+60	13
108	296	99	+21	162	+0	24
109	317	203	−40	260	−29	6
110	345	156	+18	166	+7	9
111	346	152	−7	171	−17	6
112	346	239	+7	249	+27	5

Table 4 – Radiant concentrations from the NMS (Koseki, 1979b). Nos. will be referred as N- hereafter.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Obs.
1	1	187	+23	176	+23	5
2	7	200	−4	192	+4	25
3	11	242	+21	224	+41	6
4	25	232	+27	196	+45	17
5	32	276	+37	247	+60	49
6	40	294	+12	258	+33	5
7	45	337	−1	293	+8	54
8	48	164	+15	112	+8	6
9	55	207	+30	138	+38	12
10	60	252	+1	190	+23	−6
11	68	239	+22	163	+41	9
12	69	274	+38	207	+61	11
13	81	253	+35	164	+56	24
14	85	219	+27	121	+39	16
15	91	259	+57	142	+76	21
16	93	217	+54	86	+61	9
17	106	334	+35	247	+41	7
18	115	302	+68	277	+77	13
19	125	292	+27	175	+47	9
20	126	307	−9	181	+10	13
21	126	341	−14	211	−6	82
22	127	284	+6	159	+28	8
23	128	340	+4	215	+12	29
24	133	3	+23	239	+19	23
25	135	334	+59	241	+61	8
26	137	43	+55	281	+36	242
27	137	338	−3	202	+5	26
28	137	282	+43	153	+65	8
29	137	13	+58	263	+47	48
30	139	53	+36	281	+17	19
31	140	355	+21	223	+21	12
32	140	21	+44	256	+33	12
33	141	324	+34	201	+45	5
34	143	322	+47	206	+57	11
35	144	280	+56	153	+77	8
36	169	20	+21	218	+12	9
37	172	350	+30	193	+31	17
38	173	62	+39	255	+18	6
39	176	86	+39	270	+16	10
40	177	26	+44	225	+31	5
41	179	44	+51	239	+33	8
42	181	326	+52	178	+59	7
43	185	68	+37	247	+15	5
44	185	85	+30	261	+7	6
45	195	265	+53	62	+76	8
46	198	357	+51	186	+47	8
47	203	79	+39	238	+16	5
48	207	93	+15	246	−8	291
49	210	111	+27	259	+5	15
50	213	71	+20	220	−2	18
51	214	67	+7	212	−14	15
52	218	13	+33	167	+26	58
53	219	125	+9	266	−10	16
54	219	50	+17	193	0	202
55	222	34	+27	179	+12	14
56	230	148	+11	276	−2	8
57	232	142	+48	256	+31	7
58	233	167	+11	291	+5	8
59	233	80	+27	209	+4	7
60	233	152	+22	272	+10	157
61	235	109	+5	235	−17	5
62	236	157	+37	268	+26	12
63	240	126	+50	236	+30	8
64	240	129	+7	250	−11	18
65	241	132	+21	251	+4	29
66	248	119	+24	229	+4	20
67	251	160	+42	253	+31	8
68	258	108	+9	210	−13	18
69	259	131	+4	233	−14	9
70	260	113	+32	210	+10	133
71	260	88	+9	187	−15	8
72	262	164	+22	255	+14	21
73	263	148	+34	235	+20	9
74	267	110	+27	201	+5	19
75	267	173	+38	249	+31	9
76	270	230	+77	209	+74	8
77	277	85	+7	168	−16	9
78	281	204	+52	251	+56	18
79	283	230	+53	273	+66	66
80	283	195	+35	254	+38	5
81	283	214	+33	274	+43	5
82	288	181	+25	242	+23	23
83	299	154	+16	211	+5	5
84	304	174	+19	223	+16	9
85	307	218	+14	263	+27	6
86	316	221	+45	239	+56	14
87	316	200	−5	244	+4	5
88	319	149	+35	180	+22	10
89	320	233	+29	260	+46	5
90	324	153	+13	186	+1	10
91	340	139	−1	163	−16	5
92	358	217	+10	211	+23	7
93	359	268	+37	267	+60	18
94	360	174	+6	172	+3	19

Table 5 – Compiled shower list from 10 orbit catalogues. Nos. will be referred as R- hereafter.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	References
1	2	210	−10	210	+2	LE 120,T3 27
2	2	155	+25	146	+14	LE 109,T1 36,T2 177,T3 21
3	2	202	+6	201	+3	LE 118,T2 181,S2 14
4	6	175	+24	159	+20	T1 38,T1 39,T3 22,S3 31
5	7	43	+56	52	+38	T2 184,S2 17,S3 49
6	8	173	−3	166	−5	T1 30S,T2 187a
7	9	289	+70	27	+82	S2 19,S3 39
8	10	192	−1	182	+4	T1 47,S2 13
9	11	308	+65	−4	+75	S2 18,S3 40
10	13	202	−9	190	+1	LE 116,T3 42,S3 46
11	18	19	+21	−7	+12	S2 21
12	20	214	+1	192	+13	T1 53,S2 20,S3 44
13	20	210	−10	191	+2	T1 48,L1 83
14	22	225	−13	204	+4	LE 140,S3 42
15	22	202	+50	150	+53	T3 41
16	22	208	+22	175	+31	LE 115,LE 138,T2 190a,T3 57b
17	24	189	+9	161	+12	LE 137,T1 41
18	24	215	+35	172	+45	T1 51,L1 203
19	26	171	+54	119	+45	T1 37,T2 188,T3 54,S3 53,L1 160
20	26	185	−5	16	−3	K1 33,T2 187b
21	28	237	−19	211	+1	K1 9,S3 52
22	29	196	+11	161	+16	T1 40,T1 44,T3 39,T3 55,T3 57a,S3 51
23	29	7	+4	339	+1	K1 19,NI 61.4.2
24	29	195	−6	166	+1	T1 42,T1 45,T1 59,L1 8
25	30	272	+33	243	+56	K1 32.LE 149,S1 10,L1 217
26	30	22	+10	354	+1	K1 35
27	33	235	−19	204	+1	T1 69,T3 45,L1 81,S2 22
28	34	216	+17	173	+30	T1 62,T2 191,L1 191
29	38	16	+13	342	+6	K1 25,K1 39
30	38	59	+22	24	+1	S3 55
31	41	224	−7	183	+9	T1 64N, L1 144
32	42	241	+50	172	+68	T1 70,L1 188
33	43	237	+74	88	+77	T1 63
34	43	212	−12	171	+1	T1 61N,T1 61S,T2 196N,T2 196S,S2 29
35	43	188	+36	127	+35	LE 136,T2 195b,L1 152
36	45	248	−18	204	+4	T1 71N,L1 123
37	46	2	+16	168	+13	K1 55,LE 163,S3 57
38	47	28	+9	342	−2	K1 31,K1 41,LE 188
39	47	291	+29	253	+50	K1 37,LE 169
40	47	338	−1	292	+7	S2 28
41	48	338	−1	293	+7	K1 65,LE 177
42	48	236	−10	188	+10	T3 59
43	49	296	+22	254	+42	K1 38,LE 168
44	49	231	−4	180	+14	T2 197,T2 199,T3 66
45	52	16	+18	329	+11	K1 47,K1 49,LE 164,LE 180,S3 58
46	53	160	+70	72	+55	T3 53,S2 33
47	53	250	−24	199	−2	S2 30,S3 62,L1 59
48	54	310	+11	261	+29	K1 59,LE 208
49	56	295	+23	246	+43	K1 51,LE 204
50	56	223	+37	147	+50	LE 194,LE 195
51	56	23	+22	333	+12	K1 61,K1 71,LE 184
52	57	53	+22	359	+2	LE 192,LE 193,S3 59,NI 61.5.5
53	57	332	+22	286	+31	K1 63,LE 218

Table 5 – Compiled shower list from 10 orbit catalogues. Nos. will be referred as R- hereafter. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda-\lambda_\odot$	β	References
54	57	291	+26	241	+47	K1 50,LE 202
55	58	283	+16	229	+38	K1 52,K1 72,LE 201,S3 64
56	58	335	+15	285	+24	K1 64,LE 219
57	59	350	−4	291	+0	NI 61.5.12
58	59	324	+22	276	+34	K1 56,LE 216
59	60	22	+14	326	+4	LE 182,LE 183,NI 61.5.13
60	64	43	+20	342	+3	LE 189,LE 241,S3 61,NI 61.5.1
61	64	229	+66	101	+74	T2 206,S3 67
62	64	258	−18	194	+5	T1 86,S2 32,S2 36,S3 63,NI 61.5.10
63	67	211	+80	47	+71	T2 204,S3 65
64	69	220	−27	157	−11	T1 77b,T3 65
65	70	239	−7	168	+13	T1 79N,T2 208
66	72	55	+23	347	+3	K1 40,K1 42,LE 191,LE 244,LE 245,S2 38,S3 74,N1 61.5.2
67	74	230	+39	136	+55	T1 76,T1 78,T1 80,T1 90,L1 168
68	74	262	−27	189	−4	T2 214,L1 98
69	75	249	−11	173	+11	T1 83,T1 94N,S2 34,S3 69,L1 119
70	76	211	−4	135	+9	T2 205,T3 77
71	77	49	+17	334	−1	LE 240
72	77	42	+24	329	+7	K1 48,LE 236,LE 239,S2 39,S3 71
73	78	64	+13	347	−8	K1 80,LE 247
74	78	79	+28	3	+5	LE 253
75	78	18	+56	325	+43	LE 231A,LE 231B
76	78	53	+6	334	−12	K1 79,LE 242
77	79	74	+21	356	−1	K1 77,LE 250,LE 252,NI 61.6.5
78	81	179	+58	67	+50	T1 75,T2 218
79	82	295	−6	213	+15	LE 254,S3 79,NI 61.6.4
80	85	46	+26	326	+8	NI 61.6.1,NI 61.6.2
81	85	268	−25	183	−2	S3 76,NI 61.6.9
82	86	278	−20	191	+3	NI 61.6.6
83	89	275	−13	186	+10	T1 96,L1 146
84	92	283	−25	190	−2	T1 98,S2 40,S3 82,S3 90,NI 61.6.10
85	92	77	+23	347	0	LE 249,S2 43,S3 102
86	94	279	−3	185	+21	S2 42,S3 85
87	95	246	+69	59	+81	T1 91,S2 44
88	95	268	−15	173	+9	T1 95,L1 73
89	95	93	+31	357	+8	S3 86
90	96	278	−3	182	+21	T1 97,L1 174
91	102	94	+28	352	+4	S3 101
92	110	260	+33	145	+56	T1 101,T2 219
93	114	7	+65	290	+54	K1 86,LE 279,S3 112
94	115	329	+9	219	+20	K1 94,LE 317
95	117	337	+14	227	+22	LE 319,T2 228
96	118	28	+31	279	+19	LE 293,T3 88
97	118	114	+15	355	−7	LE 308
98	121	10	+29	260	+22	K1 84,LE 333
99	123	324	−10	200	+4	K1 91,NI 61.7.11
100	123	39	+8	277	−7	LE 297,LE 358
101	123	319	15	194	+1	LE 311,S2 46,S3 103,S3 135
102	124	12	+40	265	+32	K1 96,LE 334
103	125	335	+2	212	+11	LE 377,S3 120
104	126	340	−8	213	+0	K1 93
105	126	116	+25	347	+4	LE 365
106	128	336	−4	209	+5	K1 89,LE 376

Table 5 – Compiled shower list from 10 orbit catalogues. Nos. will be referred as R- hereafter. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	References
107	128	343	−17	210	−9	K1 95,LE 379B,LE 474B,S1 3,S3 121,L1 196,NI 61.7.1
108	128	122	+22	351	+2	S3 130
109	128	37	+10	270	−4	LE 294,LE 418C
110	130	32	+57	282	+41	K1 109,LE 350
111	130	274	+10	145	+33	LE 444,T3 90
112	130	199	+56	32	+56	S3 116,S3 155
113	131	40	+1	267	−14	K1 101,LE 354
114	132	14	+15	247	+8	K1 119,LE 330
115	132	39	+37	276	+20	K1 121,LE 352
116	132	39	+28	273	+12	LE 351,LE 413A
117	133	49	+20	279	+2	LE 360,LE 424
118	134	258	+46	113	+68	LE 368,LE 440
119	134	344	−11	207	−4	LE 379A,L1 110
120	134	147	+72	342	+53	LE 433,S3 132
121	135	36	+11	262	−3	K1 132,LE 349,LE 409
122	135	260	+31	120	+54	T1 109,L1 167
123	136	269	−15	133	+8	T1 111,T1 114,L1 45
124	136	43	+35	275	+18	K1 102,K1 117,LE 415
125	136	279	+42	149	+65	LE 442,T1 115,L1 204
126	136	28	+47	268	+33	K1 110,LE 401
127	136	319	−2	184	+13	LE 454,L1 122
128	136	335	−9	198	+1	S2 47
129	138	44	+58	282	+39	K1 115,LE 417,S3 143,L1 221
130	138	7	+11	232	+7	LE 385,LE 389
131	139	326	+74	267	+71	S2 48,S3 139
132	139	142	−4	−7	−18	LE 431
133	139	310	+69	247	+75	LE 449,LE 451
134	139	10	+69	272	+56	LE 388,S3 141
135	139	345	+69	261	+63	LE 462,S3 145
136	140	229	+44	64	+58	LE 438,LE 439
137	140	298	+10	162	+30	T1 117,T1 118
138	140	320	−9	180	+6	LE 453,S2 49,S3 136
139	140	342	−8	200	+0	LE 461
140	141	347	+2	208	+7	LE 466,LE 468,S1 4,S3 153,L1 171,NI 61.8.6
141	142	343	−9	199	−1	LE 463,NI 61.8.3
142	142	272	+59	136	+82	LE 441,LE 445,T1 112,S3 147,L1 207
143	143	355	−10	208	−7	LE 474A,NI 61.8.1
144	143	294	+54	181	+73	LE 447,T1 116
145	150	154	+21	359	+9	S3 158,NI 61.8.4
146	153	350	+0	198	+4	S2 50,S2 52,S3 137,S3 159,L1 78,NI 61.8.2
147	154	17	+76	268	+59	S3 160,S3 161
148	160	64	+23	266	+2	K1 139,LE 418A
149	166	168	+4	2	−1	S3 169
150	169	248	+64	18	+80	S2 54,S3 185
151	172	302	+13	135	+32	LE 504,T1 128a
152	175	338	−5	163	+5	T1 130,S2 53,L1 20
153	176	25	+16	213	+5	LE 481,LE 482,S3 192
154	178	65	+15	248	−6	K1 136,LE 489
155	178	65	+29	250	+7	K1 145,LE 488
156	178	344	+8	170	+13	LE 506,S2 55,S3 191
157	178	58	+25	243	+5	K1 143,LE 484
158	178	10	+6	193	+1	S3 188,NI 61.9.5
159	179	159	+16	336	+6	LE 503,NI 61.9.4

Table 5 – Compiled shower list from 10 orbit catalogues. Nos. will be referred as R- hereafter. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	References
160	180	17	+4	197	−3	LE 477,NI 61.9.1,NI 61.9.6
161	183	186	+6	0	+8	NI 61.9.7
162	190	10	+6	181	+2	L1 92
163	192	186	−9	357	−6	S3 233,NI 61.9.8
164	193	266	+78	261	+79	S1 6,S3 217
165	195	27	+11	194	−1	K1 149,S2 58,S3 232,L1 31
166	201	18	+6	177	−2	LE 514,S3 211
167	201	294	+53	121	+72	LE 560,S2 61
168	202	271	+44	71	+67	LE 557,L1 202
169	204	45	+22	205	+5	K1 147,LE 524
170	205	33	+18	192	+4	K1 179
171	206	49	+16	205	−3	K1 162,LE 526
172	206	121	+15	274	−5	K1 170,LE 549
173	207	7	+2	160	−1	LE 509,LE 511,T1 131
174	207	23	−15	169	−23	T1 132,T1 133,L1 126
175	209	95	+16	246	−8	K1 165,LE 539,S1 7,L1 228,S3 234,NI 61.10.2
176	209	122	+20	271	+1	K1 151,LE 550,LE 593
177	209	105	+26	254	+3	LE 544,L1 231
178	210	260	+55	32	+78	LE 556,S3 249
179	210	42	+15	194	−2	K1 160,LE 520,LE 521,S3 250,L1 61,NI 61.10.1
180	211	13	+20	169	+13	LE 510,LE 512
181	211	38	−2	184	−16	LE 518,NI 61.10.6
182	213	61	+22	211	+2	LE 531,NI 61.10.7
183	223	342	+22	130	+27	LE 564,T1 144,L1 105
184	235	111	+9	236	−13	LE 658,T1 143S
185	237	197	+64	273	+61	LE 627,LE 695
186	237	211	+58	292	+62	LE 628,LE 698
187	237	28	+33	161	+20	LE 565,LE 630,LE 631,LE 632,L1 129
188	238	88	+31	210	+8	LE 573,LE 653,LE 655,T1 142a
189	238	166	+26	280	+18	LE 613,LE 685
190	238	162	+12	281	+4	LE 608,LE 683
191	238	78	+22	201	−1	LE 569,LE 649
192	238	152	+28	266	+15	LE 597,LE 678
193	239	56	+19	179	−1	LE 567,LE 639,LE 641
194	240	64	+19	185	−2	LE 568,LE 642,LE 643,LE 704,S1 2,NI 61.11.1
195	241	77	+11	196	−12	LE 645,LE 647
196	241	133	+20	248	+3	LE 665
197	242	45	+7	162	−9	LE 633,LE 635
198	247	49	+31	168	+13	LE 566,LE 634,LE 636,LE 702,T1 146
199	249	92	+15	203	−8	LE 571,LE 651,LE 710,S2 67,S3 266,NI 60.12.9,NI 61.12.2
200	251	58	+7	166	−13	LE 637,T1 145S
201	254	85	+22	191	−1	S2 70,S3 265
202	255	291	+73	157	+80	LE 808,S2 68
203	256	247	−25	353	−3	NI 60.12.5,NI 61.12.3
204	257	141	−54	279	−63	NI 60.12.8,NI 61.12.6
205	258	95	+22	197	−1	K1 188,LE 709,S2 69,S3 269
206	258	139	+31	234	+15	LE 724,T1 151N
207	259	84	+21	185	−3	K1 186,LE 707,LE 708,T1 148,S3 270,L1 76,L1 109
208	259	103	+9	204	−14	LE 711,T1 150,NI 61.12.7
209	259	79	+13	180	−10	LE 705,NI 60.12.2
210	259	267	+52	3	+75	LE 803,LE 805
211	259	273	+58	18	+80	LE 804,LE 806
212	260	161	+18	256	+9	K1 194,LE 737

Table 5 – Compiled shower list from 10 orbit catalogues. Nos. will be referred as R- hereafter. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	References
213	260	162	+29	252	+20	K1 193,LE 736
214	260	110	+32	207	+9	K1 187,K1 189,LE 714,S1 1,S3 272,L1 186,NI 60.12.1,NI 61.1
215	260	104	+19	203	−4	K1 192,LE 712
216	261	53	+24	155	+4	T1 145Q,L1 42
217	261	128	+2	229	−17	T1 151S,L1 223
218	266	41	+73	162	+53	S2 71,S3 271
219	282	101	+7	179	−16	LE 2
220	283	230	+49	279	+63	LE 46,S1 5,L1 216
221	283	111	+24	187	+2	LE 4
222	283	283	+72	122	+83	LE 57,S2 2
223	286	128	−9	208	−27	LE 6,T1 10
224	286	81	+49	157	+25	S2 72,S3 2
225	287	109	+32	179	+9	S2 3
226	288	104	+20	175	−3	LE 1,LE 3,T3 2,S3 7
227	295	284	−19	348	+4	S3 9
228	296	126	+20	188	+1	T1 8,T1 9,S2 4,S3 11,L1 28
229	297	117	+9	181	−12	T2 158,NI 61.1.2
230	298	113	+31	172	+9	T1 6,L1 90
231	300	126	+31	181	+11	T2 160,S3 12,L1 137
232	301	98	+33	156	+10	T1 5,T3 1
233	309	299	−14	349	+7	S3 16
234	310	145	+17	192	+2	T1 17,S3 13
235	314	324	−11	9	+3	S3 21
236	322	140	+9	177	−7	LE 60,S3 22
237	324	143	+34	171	+18	LE 61,T2 166b
238	324	314	−24	346	−6	S2 9
239	326	158	+28	182	+17	LE 64,T1 20,T1 21
240	327	158	+8	189	−2	LE 65,T2 167
241	328	130	+10	162	−9	LE 59,T2 166a,T2 175,L1 102
242	328	235	+6	263	+25	T1 26,T3 17
243	333	173	+4	199	+0	LE 69,T1 22,T1 33,L1 62
244	334	157	+10	181	+0	LE 63A,LE 63B,S3 27
245	335	155	+17	176	+6	LE 62,T1 18,T2 178b,S2 10,L1 21
246	343	172	+13	185	+9	LE 67,T1 29,T1 31,S2 11
247	346	124	+12	137	−8	T1 16,T2 173
248	352	184	+3	170	+2	LE 112,T1 32,S2 12,L1 52
249	353	156	+8	162	−1	LE 108,T2 176,T2 178a
250	353	187	−1	156	−2	K1 3,S3 29,NI 61.3.3
251	354	***	**	***	**	T1 35,T3 13,T3 60,S3 25,S3 26,S3 43
252	355	170	+15	170	+10	LE 110,T1 27a,T1 28
253	355	172	+3	177	0	K1 1
254	357	178	−4	183	−5	K1 2,LE 111,S2 15,S3 32
255	360	197	−4	197	+3	S2 16,S3 35

References in Table 5:

K1 = Kashcheev B. L., Lebedinets V. N., and Lagutin M. F. (1967). "Meteor phenomena in the Earth's atmosphere". Moscow, Nauka, 260 pp. (in Russian)

LE = Lebedinets V. N., Korpusov V. N., and Sosnova A. K. (1972). "Trudy inst. eksper. meteorologii". Issue 1(34)

T1 = Terenteva, A. K. (1966). "Issledovanie meteorov". **1**, 62–132.

T2 = Terenteva, A. K. (1967a). *Astron. Tsirk.*, **415**, 1–7.

T3 = Terenteva, A. K. (1967b). *Astron. Tsirk.*, **423**, 1–7.

S1 = Sekanina, Z. (1970). *Icarus*, **13**, 475–493.

S2 = Sekanina, Z. (1973). *Icarus*, **18**, 253–284.

S3 = Sekanina, Z. (1976). *Icarus*, **27**, 265–321.

L1 = Lindblad, B. A. (1971). *Smiths. Contr. Astrophys.*, **12**, 14–24.

NI = Nilsson, C. S. (1964). *Aust. J. Phys.*, **17**, 205–256.

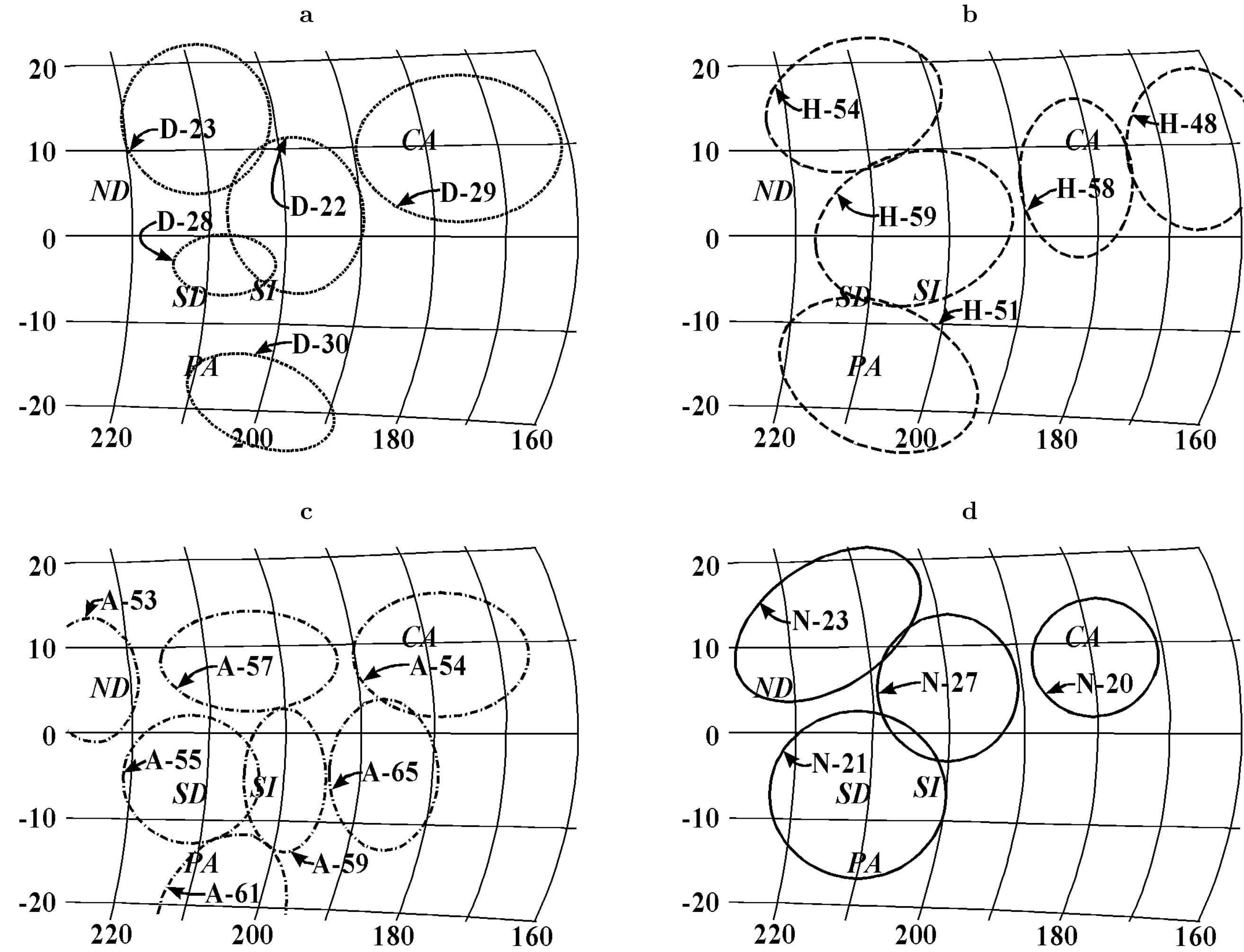

Figure 2 – Radiant concentration areas in Figure 1 according to Denning (a), Hoffmeister (b), AMS (c) and NMS (d). Jenniskens' radiants are abbreviated as follows; Southern δ-Aquariids=SD, Northern δ-Aquariids=ND, Southern ι-Aquariids=SI, Capricornids=CA and Piscis Australids=PA.

classified as 40% Southern δ-Aquariids and 60% Southern ι-Aquariids. Even the three stronger showers may consist of smaller parts; their activities peak at their first maximum around late July but seem to continue till late August with a possible secondary peak.

The "κ-Cygnids" are another difficult shower though not exactly an ecliptic stream. It is located at high ecliptic latitude but its orbit is similar to a typical ecliptic one. The nature of the "κ-Cygnids" is also like the Capricornids, that is, they have a longer activity duration and dispersed radiant area. Figure 3 shows the photographic radiant distribution around $\lambda_\odot$ =110–160, $\lambda - \lambda_\odot$=155 and β=75. There is no clear concentration and the distribution seems much wider than for the Capricornids. Figure 4 gives velocity data for meteors within 15° of the center of Figure 3. Some may consider these meteors components of one shower and others may divide them into two or three showers. The "κ-Cygnids" are not active enough for visual observations to give any distinct conclusions because of their scarcity and the chance for fictional radiant determinations.

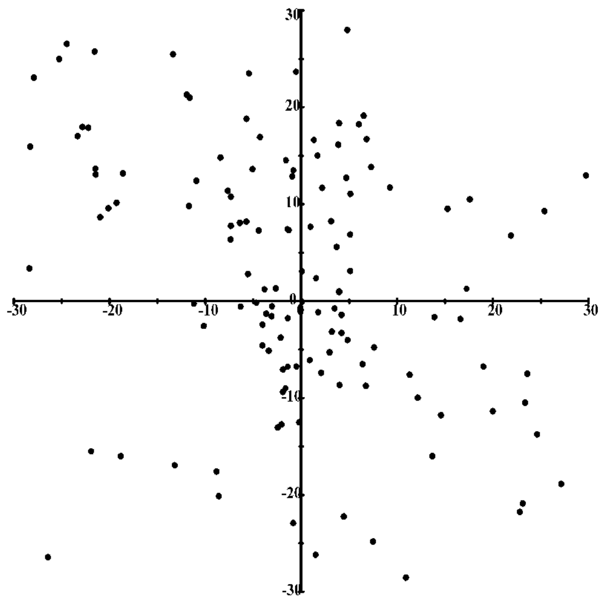

Figure 3 – Photographic radiant distribution around κ-Cygnids area during $\lambda_\odot$=110–160.

The δ-Cancrids have not been detected except in Hoffmeister's observations (Figure 5). Jenniskens' δ-Cancrids are shown in Figure 5 by an asterisk (*) and plus sign (+) for the Northern and Southern branches, respectively. Visual observations suggest they are antihelion activities and they show neither clear concentration nor an activity peak. This means the δ-Cancrids

Table 6 – Data sources of photographic orbits (Koseki, 1986).

H1 – McCrosky R. E. and Posen A. (1961), *Smithsonian Contr. Astrophysics*, **4**, 15–84.
H2 – Hawkins G. S. and Southworth R. B. (1961), *Smithsonian Contr. Astrophysics*, **4**, 85–95.
H3 – Jacchia L. G. and Whipple F. L. (1961), *Smithsonian Contr. Astrophysics*, **4**, 97–129.
H4 – Posen A. and McCrosky R. E. (1967), *NASA Contr. Rep.* CR-862.
H5 – Whipple F. L. (1954), *Astron. J.*, **59**, 201–217.
H6 – McCrosky R. E., et al. (1976), *Center for Astrophysics Preprint Series* **665**.
D1 – Katasev L. A. (1957), "Photographical methods of meteor astronomy", Gos. izd-vo tech.-teor. lit-ry, Moscow, 1957, 180 pp. (table 12 on pages 138-156).
D2 – Babadzhanov P. B. and Kramer E. N. (1963), "Ionosfera i meteory", **12**, Moscow, Izd-vo AN SSSR, 143 pp. (pages 102-124).
D3 – Babadzhanov P. B., Suslova N. N. and Karaselnikova S. A. (1966), *Bull. instit. astrofiz.*, **41-42**, 3–11.
D4 – Babadzhanov P. B., et al. (1968), *Bull. instit. astrofiz.*, **49**, 3–12.
D5 – Babadzhanov P. B. and Getman T. I. (1970), *Bull. instit. astrofiz.*, **53**, 3–6
D6 – Babadzhanov P. B., et al. (1982), *Bull. instit. astrofiz.*, **73**, 22–30.
D7 – Babadzhanov P. B. and Getman T. I. (1985), *Bull. instit. astrofiz.*, **76**, 28–31.
O1 – Babadzhanov P. B. and Kramer E. N. (1963), "Ionosfera i meteory", **12**. Moscow, Izd-vo AN SSSR, 143 pp. (pages 125–131).
O2 – Kramer E. N. and Markina A. K. (1966), *Problemy kosmicheskoj fiziki*, **1**, Kiev, Visha shkola, (pages 21–32).
O3 – Kramer E. N. and Markina A. K. (1980), *Problemy kosmicheskoj fiziki*, **15**, Kiev, Visha shkola, (pages 53–63).
O4 – Kramer E. N. and Markina A. K. (1976), *Problemy kosmicheskoj fiziki*, **11**, Kiev, Visha shkola, (pages 51–56).
K0 – Benyukh V. V., Kruchinenko V. G. and Sherbaum L. M. (1980), *Astrometriya i astrofizika*, **41**, 68–81.
K1 – Sandakova E. V. and Sherbaum L. M. (1966), *Problemy kosmicheskoj fiziki*, **1**, Kiev, Visha shkola, (pages 3–20).
K2 – Kruchinenko V. G., et al. (1969), *Vestnik Kiev. Univ., ser. astron.*, **11** 59–90.
K3 – Tryashin S. S., at al. (1970), *Vestnik Kiev. Univ., ser. astron.*, **12**, 64–67.
C1 – Ceplecha Z. (1957), *Bull. astron. Inst. Czech.*, **8**, 51–61.
C2 – Ceplecha Z. (1959), *Bull. astron. Inst. Czech.*, **10**, 133–135.
C3 – Ceplecha Z. (1958), *Bull. astron. Inst. Czech.*, **9**, 225–234.
C4 – Ceplecha Z., et al. (1964), *Bull. astron. Inst. Czech.*, **15**, 144–155.

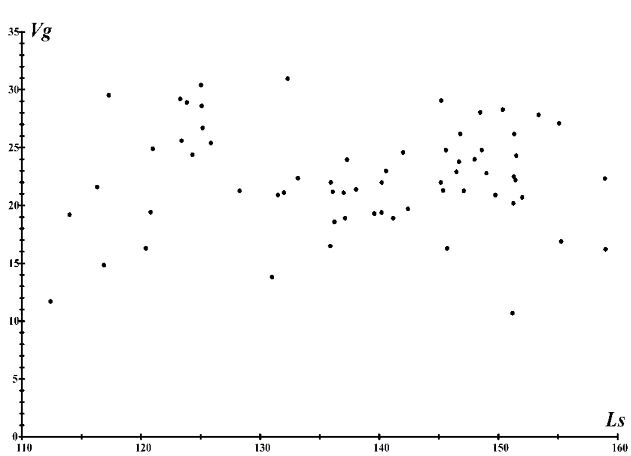

Figure 4 – Geocentric velocity distribution of Figure 3 meteors within thirteen degrees from the center of $\lambda - \lambda_{\odot}$=155 and β=75.

Table 7 – Number of photographic orbits included in the above list

Year	Number of orbits
-1939	20
1940-1949	53
1950	74
1951	24
1952	870
1953	1122
1954	579
1955	22
1956	157
1957	236
1958	276
1959	126
1960-1969	778
1970-1979	114
Total	4451

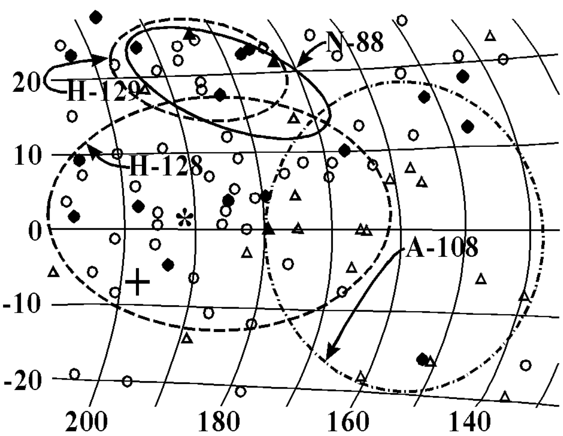

Figure 5 – Visual radiant distribution around antihelion area during $\lambda_{\odot}$=285–315; δ-Cancrids.

are so spread out that we can only detect it visually by chance.

If one wants to observe minor showers, it is strongly recommended to plot meteor paths on meteor charts. It is necessary to classify a meteor as a meteor shower member by the charts and not by their impression on the sky, which will disappear easily. Following Olivier's basis, we can only recognize meteor shower activity on the charts when more than four meteors originate from a compact area during a single night.

4.2.2 Periodic/Occasional streams

Both the α-Aurigids (Figure 6) and α-Monocerotids (Figure 7) do not have radiants that coincide within these four series. Hoffmeister's H-79 seems to be identical with the α-Aurigids in position but H-79 contains a longer period of observations which begin at $\lambda_{\odot}$ =137 and end at $\lambda_{\odot}$ =176. NMS' N-61 also seems to be near the α-Monocerotids but N-61 has only five radiants which are spread over more than ten days.

The Giacobinids (Draconids) are a typical example of the periodic nature that is so obvious that we observe outbursts every 13 years though favorable area of

Table 8 – Reference table for above mentioned shower list.

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Denning	Hoffmeister	AMS	NMS	Ref-List	Jenniskens	Shower
1	3	191	26	175	28		2	4	1			
2	5	218	10	207	23		5		92			
3	9	251	58	204	77	1	8,137					
4	18	211	39	172	47		12	5		18		
5	23	230	28	194	45	4		9		4		
6	32	274	36	243	59	6	16	13	5	25	6	Lyrids
7	34	208	25	162	33		13	15		28	141	
8	36	223	19	191	3		14	17				
9	36	292	10	260	31	10		12	6			
10	47	335	−2	289	8		18	18	7	40	31	η-Aquariids
11	68	247	34	169	54		21	24	13			
12	84	226	28	130	42			30	14			
13	93	299	15	206	6		34	34			168	
14	93	264	56	156	77			33	15			
15	96	220	54	85	62		36	39	16		170	
16	98	290	36	203	57	12		32				
17	103	309	22	216	39	13	40	31				
18	103	294	37	203	57	12	43	32				
19	108	310	47	229	61	16		42			177	
20	123	314	69	273	73	20,32			18			
21	123	8	39	261	32		49	51		102		
22	125	179	−23	224	−21		57	64				
23	127	335	4	211	14	23	54		23	103	26	Northern δ-Aquariids
24	128	308	−11	180	8	29	58	54	20	127	1	Capricornids
25	128	340	−12	209	−3	28	59	55	21	107	5	Southern δ-Aquariids
26	128	340	−27	204	−18	30	51	61			186	
27	129	275	44	149	67	33		49	28	125	178	
28	130	298	27	177	47	50	55	56	19			
29	131	334	−6	203	5	22	59	57	27	106		ι-Aquariids
30	134	5	19	238	15			69	24	114		
31	136	43	56	282	37	38	61	74	26	129	7	Perseids
32	137	337	13	207	21		64	72				
33	138	38	38	270	22	46		75		124	191	
34	138	19	43	256	32	45			32	126		
35	139	325	47	213	56	35	69	71	34	142	12	

Table 8 – Reference table for above mentioned shower list. *(continued)*

No.	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Denning	Hoffmeister	AMS	NMS	Ref-List	Jenniskens	Shower
36	141	336	62	243	63	61	70	76	25	135		
37	143	280	56	151	78			79	35			
38	148	352	46	228	44	55	77					
39	158	9	−11	207	−13		80	81				
40	163	35	31	240	16		88	82				
41	168	18	21	217	13		87		36			
42	168	352	25	196	26		84	84,90	37			
43	172	64	42	258	21	65	93	89	38			
44	175	40	54	241	37		96	86	41			
45	189	71	43	246	21	68	100		43		81	
46	197	25	39	201	27	69	105					
47	206	92	16	246	−7	72	106	94	48	175	8	Orionids
48	208	111	28	261	6	73			49	177	23	
49	208	64	20	218	−2	70			50			
50	210	42	15	195	1	77	92,110	96	54	179	2	Taurids
51	214	9	30	166	25	86	97,107,112,122	85,92,97	52	183	18	Andromedids
52	232	77	30	207	7	79			59	188	247	
53	233	145	51	256	34			99	57			
54	233	151	23	272	11	84	113	98	60		13	Leonids
55	234	157	41	269	29	81			62			
56	237	127	27	246	8	83	114		65			
57	256	109	10	213	−12		117		68	208	19	
58	258	86	7	188	−17		118		71			
59	259	145	35	236	20	90,93			73	206	32	
60	260	112	32	209	10	91	121	103	70	214	4	Geminids
61	264	168	41	248	32		120		75			
62	283	146	49	208	34	95	126					
63	284	229	53	272	65	96	127	107	79	220	10	Quadrantids
64	313	145	36	183	22		129		88			
65	314	229	30	262	46	98			89			
66	327	158	13	188	3	99			90	244		
67	345	241	9	252	29	100		112				
68	348	162	14	169	6		133	110	94	252	125	
69	355	264	36	265	59		136		93			
70	357	185	3	187	5	99	3	2	2	248	11	

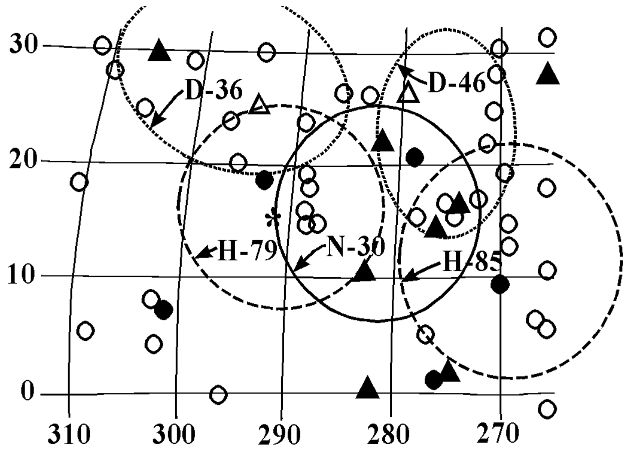

Figure 6 – Visual radiant distribution around α-Aurigids area during $\lambda_\odot$=150–165.

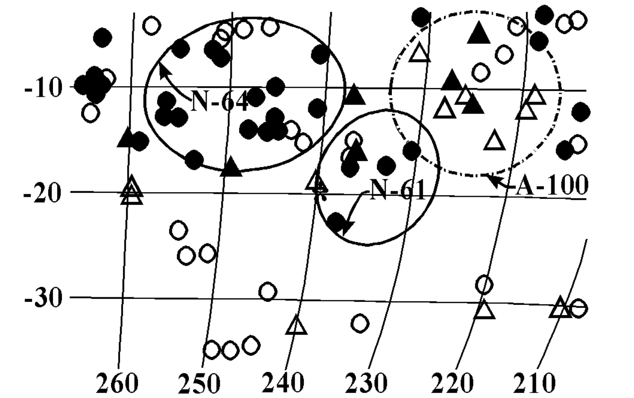

Figure 7 – Visual radiant distribution around α-Monocerotids area during $\lambda_\odot$=225–255.

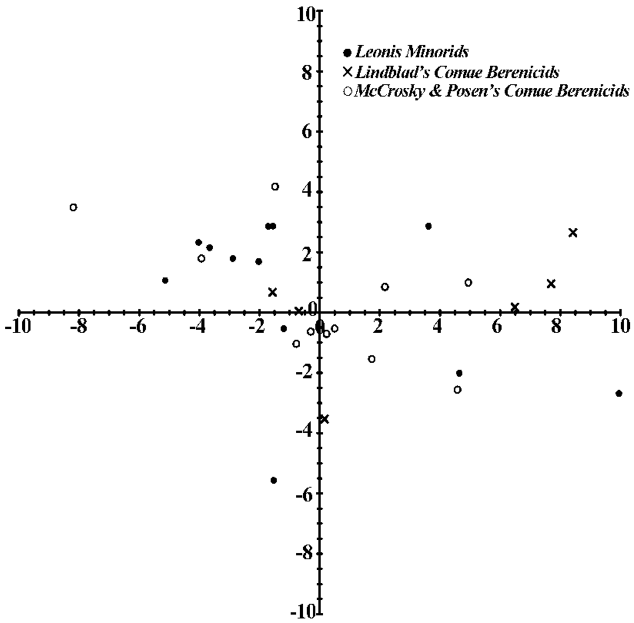

Figure 8 – Photographic radiant distribution around "Coma Berenicids" during $\lambda_\odot$=250–310.

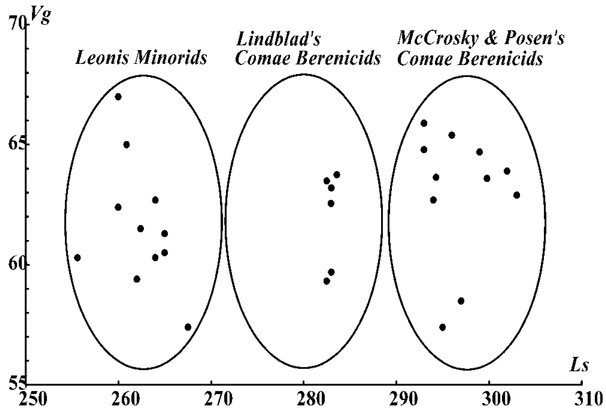

Figure 9 – Geocentric velocity distribution of Figure 8 meteors within ten degrees from the center of $\lambda - \lambda_\odot$=240 and β=20.

observation is restricted. Giacobinids radiants are recognized only in NMS' data and the Giacobinids have few orbital measurements even with modern observations. Ursids are also not found in photographic and radar observations as well as by visual groups except for the NMS.

We should not expect to observe these occasional streams every year because they do not give enough meteors, especially for visual observers.

4.2.3 Typical minor streams

At first, the author would like to explain how the study of minor streams is difficult with the example of the Comae Berenicids complex.

The December Leonis Minorids, December Comae Berenicids and January Comae Berenicids are a curious set. McCrosky and Posen (1959) found a minor meteor shower during mid-January in Harvard photographs and named it the Coma Berenicids and Lindblad (1971) recognized a similar meteor orbit set which radiated from the same constellation in early January from a precise reduction of the meteor list. Later, Cook et al. (1973) noticed weak meteor activity in December and Cook (1973) considered the above three as one in his working list. There are three "Coma Berenicids" (Table 9 and Figure 9) and each observer and researcher labels meteor activity in this area as the "Coma Berenicids".

The IMO Handbook (Rendtel et al., 1995) lists the "Coma Berenicids" based on Cook's working list and created its profile using the VMDB during the time of "Coma Berenicid" activity. ZHRs seem to have two maxima, one of which reaches ZHR=3-4 (not ZHR=5) at $\lambda_\odot$ =268, and the authors of the Handbook wrote, "The profile calculated from the VMDB data (Fig.2) indicates a permanent rate right above the detection limits. The shower needs more attention during its entire activity period."

Kronk (1988) extended the duration of the "Coma Berenicids" to a start date of December 8 on the basis of one photographic meteor and filled in the blanks with visual observations. There does not seem to be enough observations to discriminate the "Coma Berenicids" from the sporadic background and to confirm bridging the three showers into one because there are many visual radiants in this area (see later).

Jenniskens (2006) listed the December Leonis Minorids (No.1 of Table 9) and two Comae Berenicids, one of which coincides with the first detected one (No.3

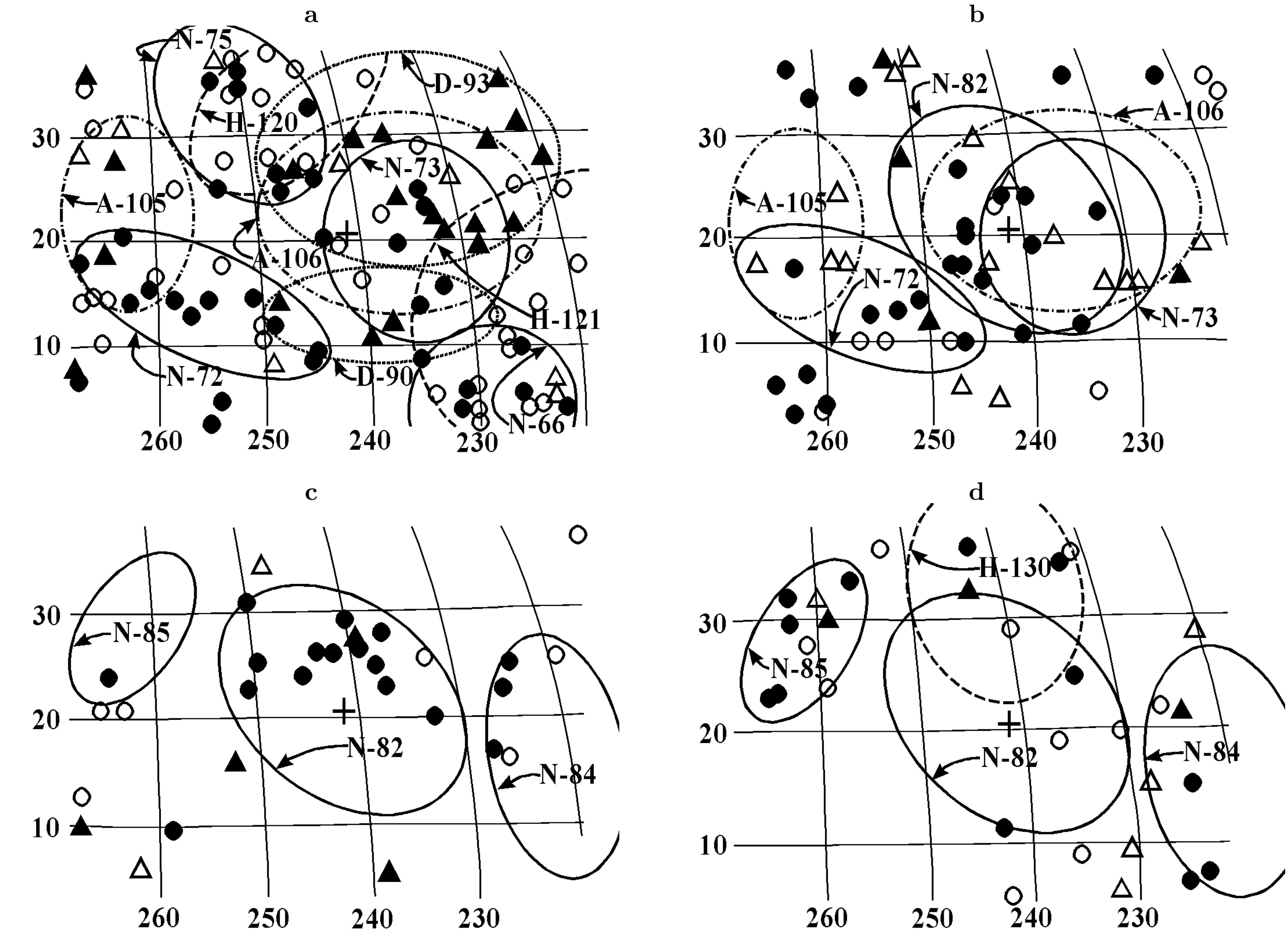

Figure 10 – Visual radiant distribution around December and January Comae Berenicids area during $\lambda_{\odot}$=255–270 (a), $\lambda_{\odot}$=270–285 (b), $\lambda_{\odot}$=285–300 (c), $\lambda_{\odot}$=300–315 (d).

Table 9 – Chaos in "Coma Berenicids"

No.	R.A.	Dec.	Vg (km/s)	Name	Duration	Source
1	156°.1	34°.6	63.7	Leo Minorids	12-17 Dec.	Cook et al. (1973)
2	176°	24°	65	Coma Berenicids	3-4 Jan.	Lindblad (1971)
3	187°	18°	65.7	Coma Berenicids	13-23 Jan.	McCrosky and Posen (1959)
4	175°	25°	65	Coma Berenicids	12 Dec.-23 Jan.	Cook (1973)

of Table 9) and is named the "January Comae Berenicids" by him. He calls another the "December Comae Berenicids" but this creates confusion. The latter consists of two parts (Nos. 1 and 2 of Table 9) and its activity data comes from the IMO Handbook, which treated the three as one. It is proper to study all three of them individually and the "December Comae Berenicids" should be left under reconsideration.

Visual radiant distributions are shown in Figure 10a-d and these three showers are shown with the same plus sign symbol (+) because they are located very near each other in $(\lambda-\lambda_{\odot}, \beta)$ coordinates. Photographic meteors, which are candidates of Nos. 1-3 of Table 9, concentrate as if they are one (Figure 8).

The December Leonis Minorids are defined from a small number of photographic meteors. Radio meteors suggest their existence though there seems to be too few to distinguish them from the sporadic background. Visual meteor radiants are so numerous in that area (Figure 10a) that one could point any meteor activity.

The two Comae Berenicids of January could be abbreviated below as A-Comds for No.2 of Table 9 and B-Comds for No.3 of Table 9. A-Comds is almost buried in the apex source radiants, which might also include fictitious ones resulting from Quadrantids meteor trails. NMS' N-82 is coincides well with them both but these radiants are derived from the knowledge of B-Comds and the observers intended to determine the radiant position. But, it is interesting to note that NMS' observations seem to shift A-Comds forward in time, that is, early January though B-Comds might be active during middle and late January. B-Comds do not have certain visual observations without NMS's after middle January. Circumstances of B-Comds are similar to the σ-Hydrids and they seem to be of heavy fluctuations.

Visual observations (Figure 10a-d) suggest that meteor activities decline from December to January and these three meteor showers are just above the back-

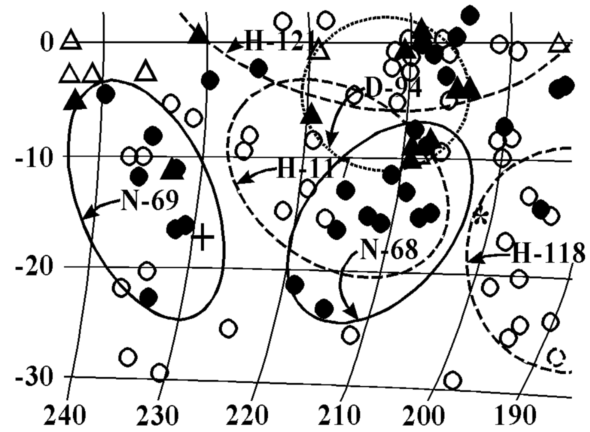

Figure 11 – Visual radiant distribution around December Monocerotids and σ-Hydrids area during $\lambda_\odot$=255–270.

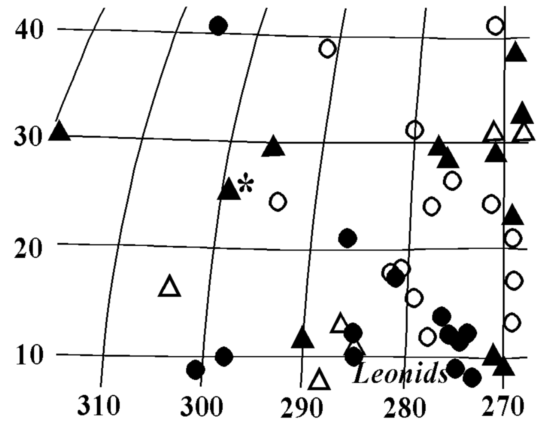

Figure 12 – Visual radiant distribution around Leonis Minorids area during $\lambda_\odot$=195–225.

ground meteor activity. It is very difficult to conclude whether the three meteor showers might be bridged. Candidates for these three showers from photographic meteors are distributed separately through time because of interruptions in the Harvard survey. We may treat them individually and try to test the hypotheses. They might be active periodically or provide only small portion to background meteor activity. There are possibly many other meteor activities like these and weaker showers which are more difficult to identify/define. It is recommended to plot meteor paths in case of observations, which aim to judge minor meteor activity against sporadic background.

The December Monocerotids are near the Geminids in position and in activity period. It was suspected as a southern branch of the Geminids by some researchers but photographic orbits revealed that their origins differ from each other. The December Monocerotids and σ-Hydrids are observed during the period of Geminids and many radiants are near to both. Figure 11 shows the situation for the December Monocerotids, σ-Hydrids and Geminids which is out of this figure but the outskirt of its radiant distribution is labeled as H-121. December Monocerotids (*) and σ-Hydrids(+) are not in the concentration of radiants but several degrees away. Visual observations and showers in the reference table (Table 5) have two concentrations near the December Monocerotids, that is, $\lambda_\odot$ =208, $\beta = -9$ and $\lambda_\odot$ =208, β=0. Observations of σ-Hydrids are based on Harvard photographic meteors which are measured mainly by graphical reduction. This may be the reason for the difference with mere radiants in visual observations. This shower is suspected to be an occasional one, which was active in the middle of the 1950s when visual data was scarce. NMS's N-69 might be a possible candidate but does not seem to greatly exceed the mean radiant distribution level.

The Leonis Minorids are well represented in photographic observations but scarcely recognized in visual observations (Figure 12). Former Soviet small cameras caught three Leonis Minorids out of seven. It might be suggested that this shower consists mainly of bright meteors and is not an example of the outburst type.

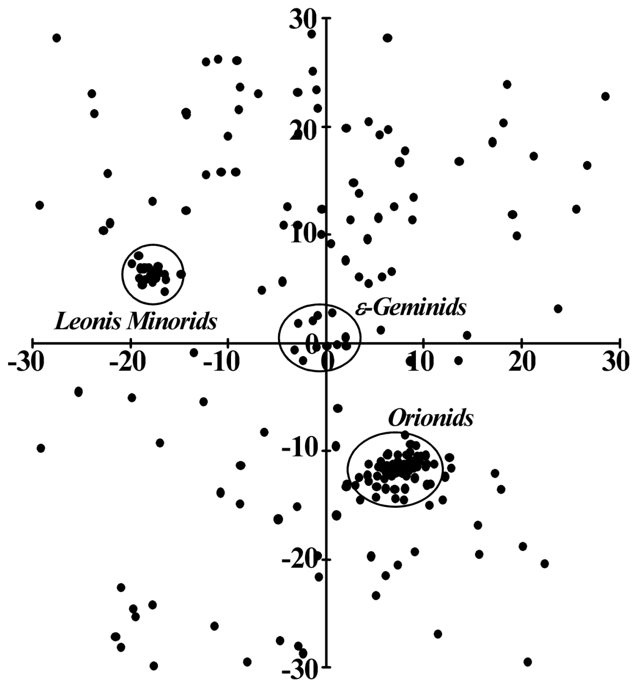

Figure 13 – Photographic radiant distribution around ε-Geminids area during $\lambda_\odot$=180–250.

ε-Geminids are similar to the December Monocerotids which are very near the Geminids and Taurids (Figure 13). ε-Geminids are so close to the Orionids in position and activity period that it was a suspected sub-radiant of the latter. Unlike the December Monocerotids, the ε-Geminids are somewhat distinct from the sporadic background because there is no other major shower in this area. Visual observers paid attention to the ε-Geminids as sub-radiant of Orionids and detected it well though slightly to the east. Photographic records might suggest that meteor activity in this area continues over a much longer period from September 27 to November 12 but visual observations has not confirmed this.

The μ-Pegasids is very unique with regards to its activity period. Photographic data had been recorded over the course of only two hours, of course, from the same day on the same year. Though its orbital characteristics show it to be of an ecliptic origin and suggest its radiant area might be as large as the Capricornids

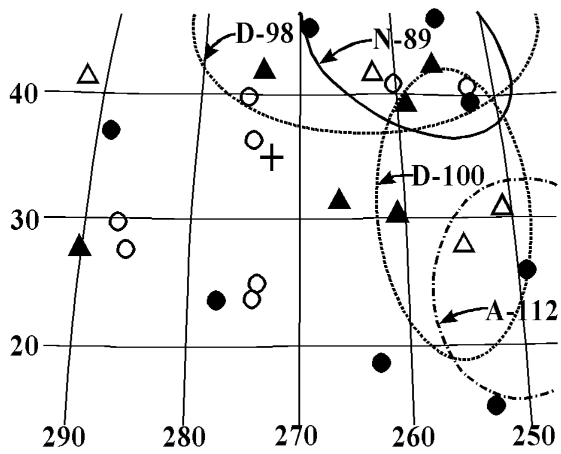

Figure 14 – Visual radiant distribution around δ-Serpentids area during $\lambda_\odot$=315–345.

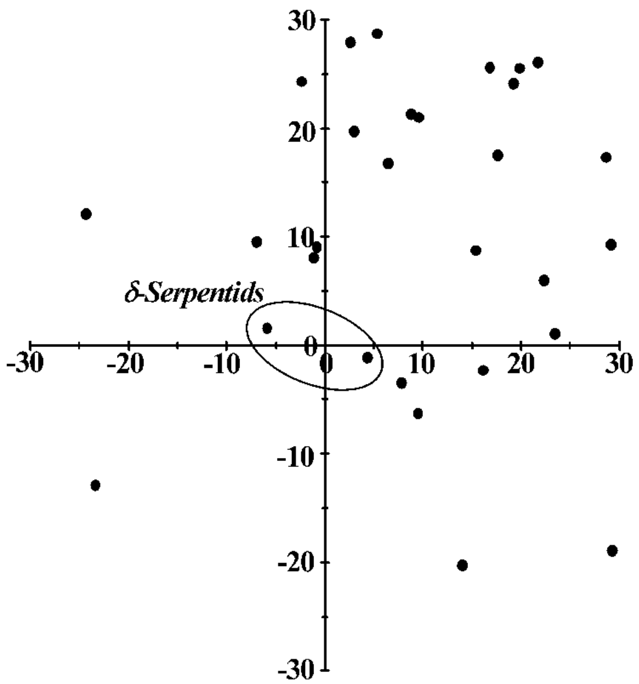

Figure 15 – Photographic radiant distribution around δ-Serpentids area during $\lambda_\odot$=180–250.

since its photographic radiants are well concentrated. Last column in Table 10 gives the distance of each radiant from $\lambda - \lambda_\odot$=122 and β=29. But, no other indications of this shower have not been recorded in visual and radio observations, not to mention photographs.

The δ-Serpentids could not be confirmed in either photographic or visual observations. Figure 14 shows the distribution of visual radiants around $\lambda_\odot$ =315–345 and it is clear that there is no definite meteor activity in this area. Figure 15 presents the photographic radiant distribution around $\lambda_\odot$ =315–345 and encircled two points are meteors that Jenniskens listed in his table. Jenniskens quoted H3-6429 and H3-6546 but the former seems to be a misprint of H3-6433. Both photographic and visual radiants are located to the northwest of the δ-Serpentids radiant and visual radiants suggest minor meteor showers might be active in that area (Nos.65 & 67 in Table 8). It is not good to confirm any meteor activity center at his proposal.

Thus we have been strongly influenced by the photographic observations of the 1950s and by Cook's "working list". We may not be able to recognize the weak meteor activities listed as Nos. 1-34 in Jenniskens' table. It derives from a low level of activity and biased data based mainly on 1950's photographic observations. Meteor activity is changing every year and shows very different characteristics depending on which observation technique is used. Photographs might record a few bright meteors but visual observers might miss them as sporadics. We must be careful with the kind of technique we use for recording the meteor showers.

"We know in part" is especially true for modern techniques, because they have been carried over a short period and not over a continuum of years. We should be cautious in the classification of meteor activity, because meteor activity is not the same as comets and asteroids, which can be reaffirmed in following years. Meteor activity, especially for minor ones, might not be recurrent and not be certified by later observations like comets.

Meteor history shows that one thinks certain activity exists in the sky when he/she said some meteor shower might be active on that night. These conceived ideas led him/her to find fictitious meteor radiants/activity. It is not proper to create a fixed meteor showers list. Cook's "working list" has influenced meteor observations and researchers so intensively that we find many so-called "established showers". Proper shower names are only proper for major showers. It is recommended that meteor activity detected on multiple occasions be called by a preliminary name as is the case with comets. For example, meteor activity detected during the first half-month of January 2008 in the constellation of Coma Berenices might be designated as the Comae Berenicids (2008X1). It is not necessary to mention the name of such meteor events with the first report of observations with the designation being given by International Astronomical Union (IAU). Future studies could identify it with other observations and the IAU would give the established name by similar steps of comets and asteroids, though identifying meteor shower is more difficult. A comet and an asteroid is a single object and can be re-observed via their ephemerides, but a meteor shower consists of many particles and the identification could be stated in a statistical form. The author's focus here is not in the nomenclature of meteor showers but the long-term variation of them. The discussion for the proper designation system of a meteor shower should be done elsewhere.

5 Conclusions

This research shows the complex nature of meteor activity and the difficulties in defining a meteor shower.

1. The major meteor showers are not detected by every observation technique. Geological location, meteorological condition, characteristics of the observations, occasions of observations and so on, affect the results though they are of the most famous showers.

Table 10 – Photographic μ-Pegasids

Code	Year	Month	Day	$\lambda_\odot$	R.A.	Dec.	$\lambda - \lambda_\odot$	β	Vg	d
H2-5375	1952	11	12.1935	229.7	339.85	22.433	121.1	28.5	9.5	0.94
H2-5373	1952	11	12.1903	229.7	342.167	22.083	123.1	27.2	11.1	2.02
H1-5367	1952	11	12.18	230	341	21	121.2	26.7	10.5	2.38
H1-5369	1952	11	12.19	230	338	24	119.8	30.6	13.9	2.49
H2-5396	1952	11	12.2639	229.8	342.967	21.866	123.7	26.7	11.2	2.71
H3-5370	1952	11	12.18	229.7	334.833	21.433	115.8	29.5	11.2	5.43

2. Meteor streams are not stable in nature and vary over time. There are surely many minor shower activities but it is very difficult to confirm them on other occasion. We need patient work to identify them as the same stream because there are so many of them and they are not stable.
3. Though there are many proposed streams, they are suggested from somewhat biased data. It is noteworthy to note that we have been influenced strongly by 1950's photographic observations. Photo meteors are likely bright and many of them are of an antihelion origin. On the other hand, radio meteors are mostly faint and originate from the apex origin. We know of many antihelion streams from photographs and also apex streams from radio observations. There are not enough showers in common between the two methods.

It is inappropriate to give a definite name to weak meteor activity because history tells us that the established list might lead observers to fictitious results. Visual observations are suitable for monitoring the major showers such as the Quadrantids, Lyrids, η-Aquariids, Southern δ-Aquariids, Orionids, Leonids and Geminids. As a result, they could be considered established showers and have definite designations. Weak meteor activity is an open world for new observational techniques and should be observed precisely and investigated their evolution in orbit. Until the time comes, we should refer to them by preliminary names.

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Preliminary results

The 2004 Perseid meteor shower – Polish Fireball Network double station preliminary results

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The results of the Perseid 2004 observing campaign are presented. A short description of the equipment and reduction methods is given. The predicted 1-revolution Perseid peak on August 11/12 was confirmed by video and visual observations, and moreover another peak of activity was detected the same night around 1^{h} UT. In total 87 meteoroid trajectories and orbits were calculated and the resulting mean orbital elements of the Perseid stream are presented.

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1 Introduction

The Polish Fireball Network (PFN) was founded in February 2004, a few months before the Perseid shower maximum described in this article. Initially it consisted of CCTV cameras which were used during the Leonid 2002 campaign and some photographic devices with rotating shutters. During the first half of the year these cameras were relocated to new fireball stations and new viewing directions suitable for double station work were calculated. In the middle of 2004 fireball stations in Ostrowik, Złotokłos, Poznań, Cracow and Nowy Dwór Mazowiecki were ready to observe.

According to predictions given by Lyytinen and Van Flandern (2004) and Vaubaillon (2004), enormous Perseid activity was expected in 2004. Due to the close encounter with the 1-revolution trail from Comet 109P/Swift-Tuttle's 1862 return, a narrow, short lived peak was expected on 2004 August 11 at $20^{\mathrm{h}}54^{\mathrm{m}}$ UT. Vaubaillon (2004) pointed out that this peak would consist mostly of small particles and might be observed by radio equipment rather than by video or photographic techniques.

We decided to organize a special astronomical camp in Ostrowik Observatory (40 km SE of Warsaw) during this maximum. A video fireball station in Telatyn (about 250 km SE of Warsaw) was temporarily created too. On 2004 August 10 two photographic and six video fireball stations as well as more than 10 visual observers were ready to begin.

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NASA-ADS bibcode 2009JIMO...37..161Z

2 The Perseids 2004 observing campaign and data reduction

The weather over Poland in the middle of August was rather good. One night before maximum we had excellent visibility, reaching visual LM = +6.8 mag in Ostrowik Observatory when the camp was held. This value was only slightly less good during the next two nights. The whole video system worked continuously during three consecutive nights – 10/11, 11/12 and 12/13 of August 2004. Video fireball stations were equipped with Tayama and Mintron CCTV cameras; 8 and 4 mm lenses were used, enabling the cameras to detect +3.0 and +2.0 magnitude meteors respectively (Figure 1). The typical distance between video stations was 200–250 km (with the exception of the Ostrowik-Złotokłos baseline which is only 50 km long). The whole fireball network registered 364 meteors on August 10/11, 1209 meteors on August 11/12 and 402 meteors on August 12/13.

First results coming from our visual observers confirmed a strong and narrow peak on August 11 around $20^{\mathrm{h}}55^{\mathrm{m}}$ UT. It was created mostly by faint meteors, with $r \geq 2.5$ and ZHR at least 200. Surprisingly, another wide peak was observed before sunrise with a presence of bright meteors which were easy to catch by video and even photographic systems. High Perseid activity was also observed in the evening of August 12 (it probably came from the annual maximum which occurred during daylight). These maxima were also clearly visible in the IMO visual analysis (Rendtel, 2008). With almost two thousand meteors registered we had a chance to confirm it by video methods.

All video records were reduced by MetRec software (Molau, 1999). Taking coordinates from MetRec's DBF files, we created planes between every fireball station and meteor points observed by this station. Intersecting these planes using IMOgena software resulted in a list of more than 300 double events. Reduction routines used by IMOgena software are described in detail by Żołądek et al. (2006). Calculations were made for every double event using IMOgena Planes and IMOgena Orbit and then data selection was applied. We rejected all events with plane intersection

Figure 1 – Perseid meteors registered by 4 mm (left) and 8 mm CCTV cameras (right).

angle less than 10°, with uncertainty in radiant coordinates greater than 5° or with large geocentric velocity uncertainty. Some meteors required additional image reduction using AstroRecord 3.0 software (De Lignie, 1997). During reduction we found some differences between results obtained by the 8 mm and 4 mm video systems. Astrometric reduction for the 8 mm was quite simple, images with good quality and without significant off-axis aberrations being easy to measure. However, the 4 mm lenses caused some trouble. We found that the coordinate grid created from all stars visible on the image was not sufficient to obtain the precision required for orbital calculations, even in the case of using 3rd or 5th degree plate constants. Thus local coordinate systems were created from stars closely surrounding each meteor on the image and that provided us with the best results. Every meteor has its own local coordinate system free of image edge distortion influences. This method is of course more time demanding than the traditional one.

During image reduction we found that the 8 mm systems have much better precision and meteor limiting magnitude than 4 mm. This caused some differences in the mean parameters calculated by these systems. For example, the mean trajectory beginning height calculated from 8 mm cameras was a bit higher due to better meteor limiting magnitude (meteors being detectable earlier and higher than with 4 mm systems). Statistical analysis of some parameters (e.g., beginning heights, trajectory lengths or photometric masses) should be done separately for datasets coming from the two camera systems.

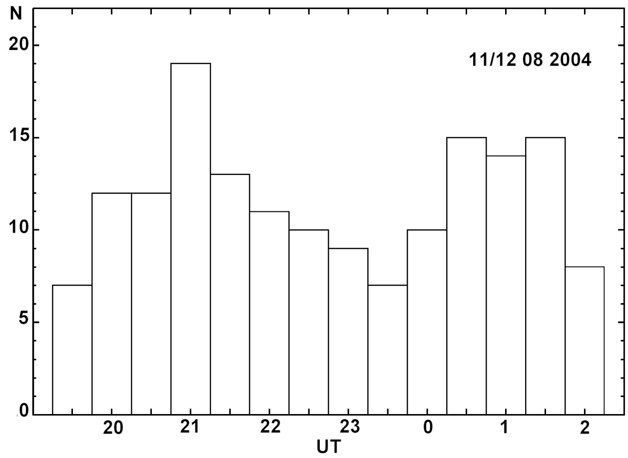

Figure 2 – Perseid counts in 30-minute periods from two 8 mm CCTV cameras.

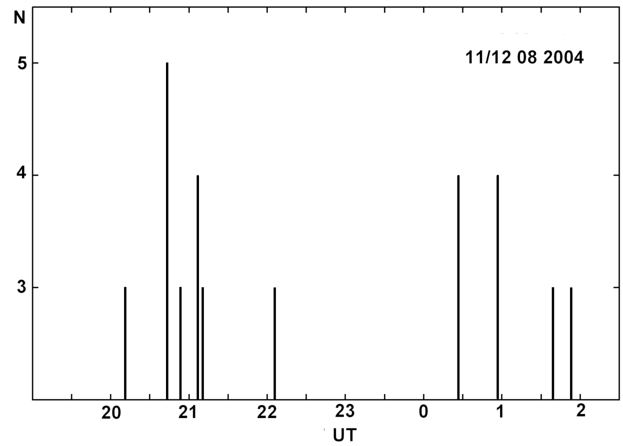

Figure 3 – Occurrence of Perseids – time groupings in one minute periods observed by two 8 mm CCTV cameras (only groups larger than 2 meteors are shown).

3 Preliminary analysis

The PFN video system recorded 1975 video meteors during three consecutive nights. Meteor counts on the 8 mm CCTV cameras clearly show a strong, narrow maximum on August 11/12 around 21^{h} UT (see Figure 2). Exact time determination for such a narrow peak is not easy because we observed strong time grouping, typical for the Perseid stream. For example our 8 mm camera in Ostrowik observed five Perseids during one minute at $20^{\mathrm{h}}43^{\mathrm{m}}$ UT (see Figure 3) and then did not observe any meteors during the next 3 minutes.

Another increase in the Perseid activity is visible during the second half of the night. The second, slightly diffuse peak observed around 1^{h} UT is rather wide and consists of brighter meteors than the first peak observed around 21^{h} UT.

For double station events the geocentric velocity distribution was calculated. It is shown in Figure 4. The vast majority of calculated events has velocities

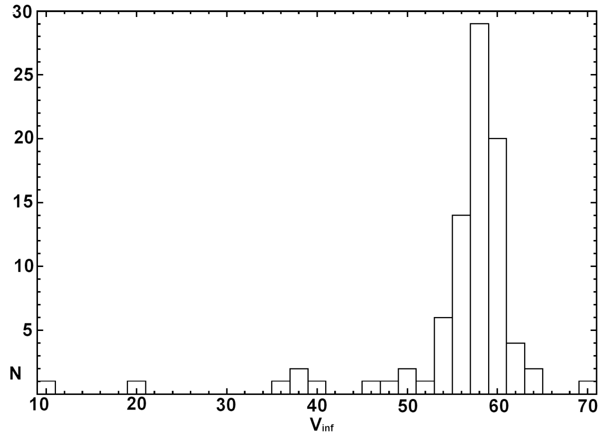

Figure 4 – Geocentric velocity distribution for all 87 calculated events.

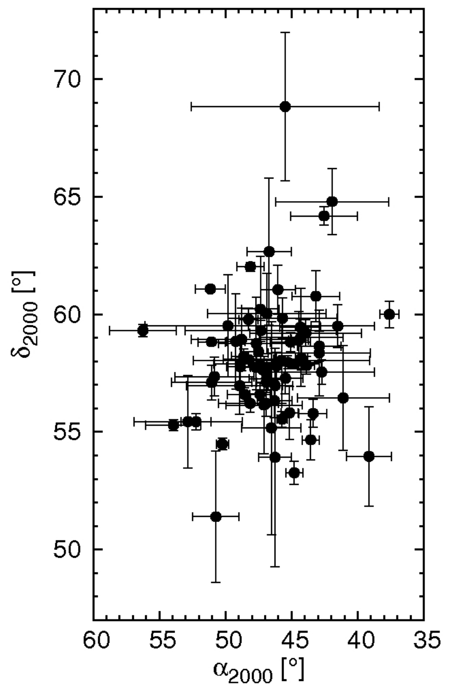

Figure 5 – Individual radiants from double station calculations.

typical for the Perseid stream with mean value 57.86 ± 2.33 km/s. A trace of some Aquarid complex meteors can also be noticed around 40 km/s.

The mean Perseid radiant resulting from double station results was observed at $\alpha = 47\overset{\circ}{.}36 \pm 3\overset{\circ}{.}22$, $\delta = 57\overset{\circ}{.}76 \pm 2\overset{\circ}{.}31$. Individual radiants for all calculated events are presented in Figure 5. Mean orbital elements calculated from all non-hyperbolic orbits are shown in Table 1.

4 Conclusion

This article describes the results of the first serious PFN observing campaign. It was a test for our camera system and for our IMOGENA software. Our results clearly confirmed the activity peak caused by the 1-revolution trail; however, another peak was observed on August 12 around 1^{h} UT. Trajectory parameters and orbital elements were calculated for 87 individual double station

Table 1 – Mean orbital elements for the Perseid stream calculated from PFN video data. The semi-major axis a is very sensitive to the velocity and therefore the mean perihelion distance q is more reliable than a.

Parameter	Value	Uncertainty (1 std dev)
a	3.68 [AU]	
$1/a$	0.271 [1/AU]	0.056
e	0.88 [deg]	0.17
i	111.8 [deg]	3.7
q	0.942 [AU]	0.032
Ω	139.60 [deg]	0.50
ω	148.2 [deg]	8.9

results. We found that the mean trajectory beginning height calculated from 8 mm cameras was a bit higher due to better meteor limiting magnitude than on 4 mm systems.

These data will be reexamined again in the future with our new RECOSTAR software for meteor astrometry which was presented at IMC 2008.

Acknowledgments

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Results of the IMO Video Meteor Network — July 2009

Sirko Molau [1] *and Javor Kac* [2]

July 2009 was an outstanding month for the IMO Video Meteor Network observers. The 34 Network cameras were operated on all 31 nights. More than 13 000 meteors were recorded in more than 2 700 hours effective observing time. The 2009 July results are presented with a focus on the Southern δ-Aquariid and α-Capricornid maxima.

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1 Introduction

July 2009 was an outstanding month that raised the bar of the camera network still a bit higher. Let's start with our new observer Istvan Tepliczky, who is the second Hungarian supporting the video network. His camera Humob has not yet found a fixed observing site and was therefore operated at different locations in July. Including Istvan, we had 20 observers operating a total of 34 cameras in July.

Next, the weather should be mentioned, which was unusually good. In particular, our observers in southern Europe rarely suffered from clouded nights and, thus, a total of 16 cameras obtained 20 or more observing nights. In the last week of July, there was fine weather at almost every observing site with close to 30 cameras active each night. Even though July is the month with the second shortest nights in the northern hemisphere, we managed to obtain more than 2 700 hours of effective observing time. That is not only the best July result to date by far, but the second best monthly result in the full history of the video network! Whereas the meteor counts remained low in the first few days of July, there was a significant increase once the Moon disappeared in the middle of the month. Just as you get in mid-January the impression that meteor counts are cut in half from one day to the next, it felt as if they were doubling after mid-July. Beside the Moon, the slowly raising Perseid activity and the maximum of the Southern δ-Aquariids were to blame for this effect. On July 29, we recorded again more than 1 000 meteors in a single night, and by the end of July more than 13 000 meteors in total were obtained by the observers (Table 1 and Figure 8).

Once more, there were also outstanding events in the previous month. Enrico Stomeo managed to record two blazing fireballs of visually estimated as −11 mag (recorded by Min38 and Noa38) and −20 mag (recorded by Min38, Noa38 and Sco38) within two nights (Figure 1). Such meteors are far too bright for our cameras which are tuned for sensitivity, which is why they are hard to analyse. Still, at least a few points along their trajectory could be measured in both cases.

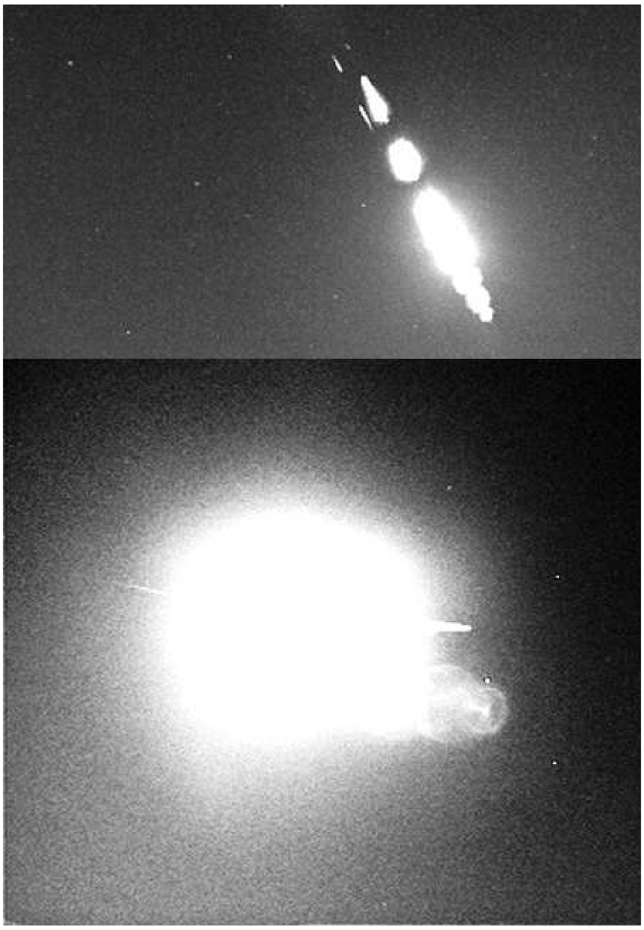

Figure 1 – Two bright fireballs recorded by Enrico Stomeo. On top an Antihelion meteor from 2009 July 17, $00^{h}46^{m}$ UT, and on bottom a Southern δ-Aquariid from 2009 July 19, $01^{h}59^{m}$ UT.

2 Southern δ-Aquariids

The Southern δ-Aquariids are the dominating shower of the month. In our video database, they can be tracked from July 21 until well into September (Molau & Rendtel, 2009). However, the last radiant positions are quite uncertain, which is why we defined the end date as August 23 (Figure 2).

The long-term analysis of all data until 2008 shows a plateau of almost constant activity at maximum between July 27 and 31 reaching a video rate (comparable to the visual ZHR) of about 18. The highest value occurs on July 30 (solar longitude 127°), thereafter the activity drops clearly but can be detected at a low level for a long time (Figure 3, bars). For the analysis of the 2009 data, the number of Southern δ-Aquariids (1325

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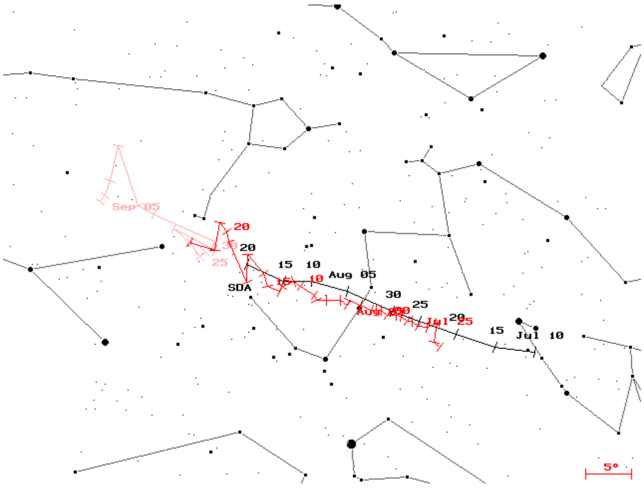

Figure 2 – Radiant position of the Southern δ-Aquariids from data of the IMO Video Meteor Database.

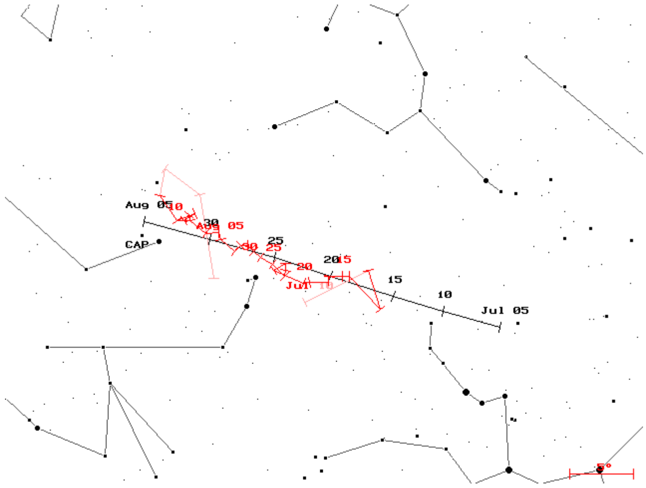

Figure 5 – Radiant position of the α-Capricornids from data of the IMO Video Meteor Database.

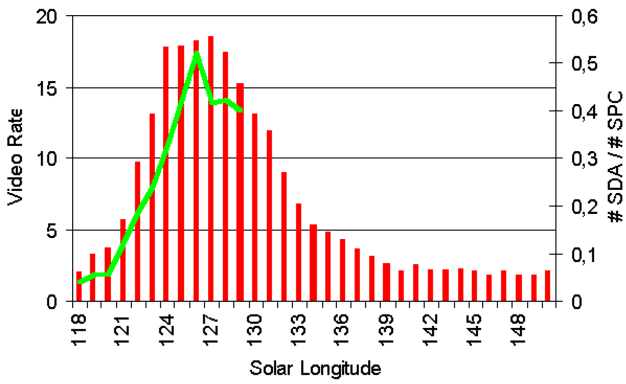

Figure 3 – Long-term activity profile of the Southern δ-Aquariids (bars). The line represents the ratio between Southern δ-Aquariids (SDA) and sporadics (SPO) in 2009 July.

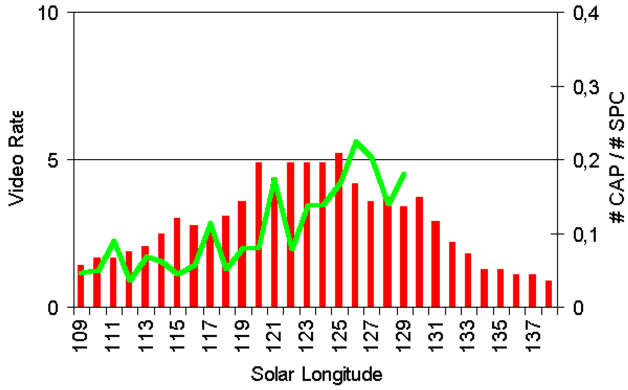

Figure 6 – Long-term activity profile of the α-Capricornids (bars). The line shows the ratio between α-Capricornids (CAP) and sporadics (SPO) in 2009 July.

in total) was divided by the number of sporadics (4564 in total) to get an estimate of the shower activity for each night (Figure 3, line). Both graphs match well, but highest Southern δ-Aquariids activity in this year occurred already on the night of July 28/29.

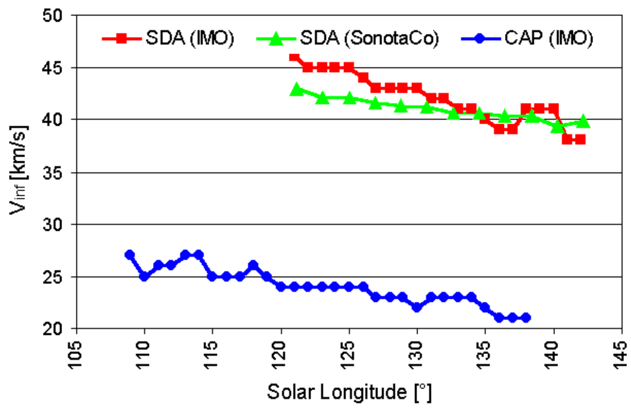

Figure 4 – Meteor shower velocity v_{inf} of the Southern δ-Aquariids and the α-Capricornids over solar longitude.

During the latest analysis of the Southern δ-Aquariids we noted that the velocity of this shower was not constant but decreased slowly. This effect was observed already during earlier analyses of the long-lasting meteor showers, but was thought be due to systematic errors of our analysis method. This time we asked the network coordinator of the Japanese SonotaCo network, and it turned out that SonotaCo observed the same trend towards lower velocities in his Southern δ-Aquariids orbits obtained from double station data (Figure 4). Even though the decrease is smaller than in the IMO data, the tendency is unequivocal. The same consensus was obtained for three other showers that we compared. So now we believe that this effect, for which we have first ideas but no consistent explanation yet, is real.

3 α-Capricornids

By the end of July, the α-Capricornids reach their activity maximum as well, but their peak video rate of 5 is significantly lower. Also this shower has a plateau of almost constant maximum activity between July 23 and 28, with the largest value at the end of the period (so-

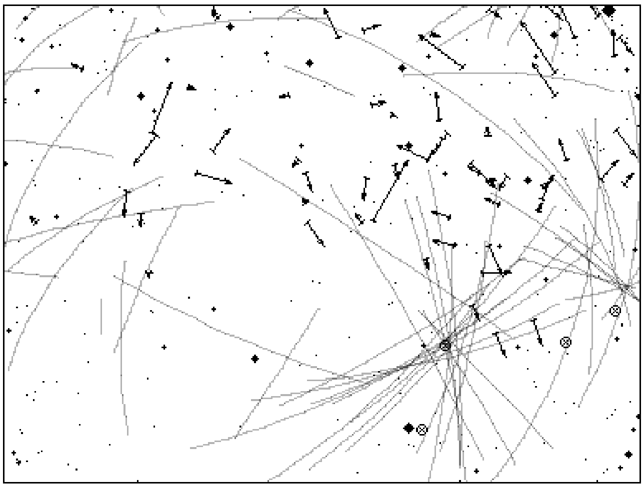

Figure 7 – The radiant plot of Min38 from July 28/29 shows the Southern δ-Aquariids radiant left and the α-Capricornids radiant right.

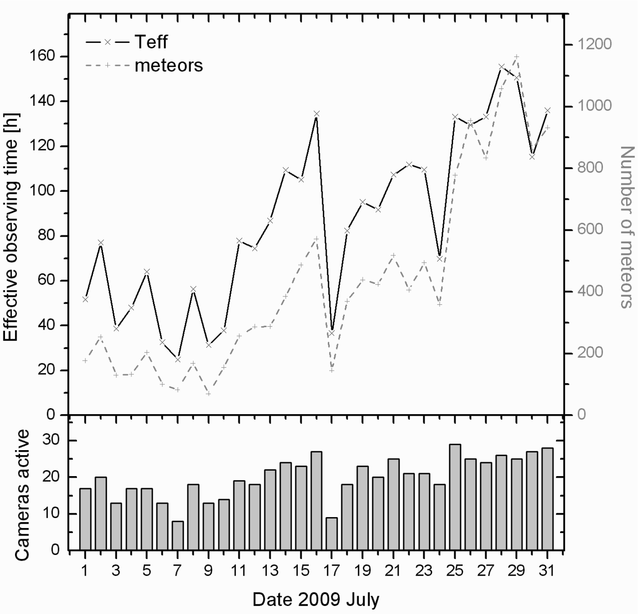

Figure 8 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2009 July.

lar longitude 125°). The radiant position is well defined between July 11 and August 11 (Figure 5).

The ratio between α-Capricornids (900 in total) and sporadics (8420 in total) confirms the late maximum on July 29 (Figure 6). Hence, there were two active southern showers in these nights, which is well reflected in the radiant plots of some cameras. Figure 7 shows a section from the corresponding plot of Min38 on July 28/29.

Last but not least it should be mentioned that we observed a decreasing velocity for the α-Capricornids as well. With −0.18 km/s per degree solar longitude, the value was slightly smaller than for the Southern δ-Aquariids (Figure 4).

Figure 9 – This −4th magnitude Perseid was captured on 2009 July 25 at $03^h50^m05^s$ UT by Rui Goncalves using Templar2 camera from Tomar, Portugal.

Figure 10 – Almost a twin, the −3rd magnitude Perseid was captured on 2009 July 26 at $03^h35^m50^s$ UT by Rui Goncalves using Templar2 camera from Tomar, Portugal.

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Table 1 – Observers contributing to July 2009 data of the IMO Video Meteor Network.

Code	Name	Place	Camera	FOV	LM	Nights	Time (h)	Meteors
BRIBE	Brinkmann	Herne	HERMINE (0.8/6)	⊘ 55°	3 mag	23	69.6	309
CASFL	Castellani	Monte Baldo	BMH1 (0.8/6)	⊘ 55°	3 mag	8	36.4	136
			BMH2 (0.8/6)	⊘ 55°	3 mag	9	47.8	218
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	⊘ 80°	3 mag	27	138.9	750
			STG38 (0.8/3.8)	⊘ 80°	3 mag	10	54.4	224
ELTMA	Eltri	Venezia	MET38 (0.8/3.8)	⊘ 80°	3 mag	17	93.5	349
GONRU	Goncalves	Tomar	TEMPLAR1 (0.8/6)	⊘ 55°	3 mag	28	181.0	1075
			TEMPLAR2 (0.8/6)	⊘ 55°	3 mag	28	155.7	585
GOVMI	Govedič	Središče ob Dravi	ORION2 (0.8/8)	⊘ 42°	4 mag	28	139.7	946
HERCA	Hergenrother	Tucson	SALSA (1.2/4)	⊘ 80°	3 mag	23	75.1	148
			SALSA2 (1.2/4)	⊘ 80°	3 mag	23	86.7	225
HINWO	Hinz	Brannenburg	AKM2 (0.85/25)	⊘ 32°	6 mag	16	66.5	365
IGAAN	Igaz	Hódmező-vásárhely	HUHOD (0.8/3.8)	⊘ 80°	3 mag	12	85.2	434
JOBKL	Jobse	Oostkapelle	BETSY2 (1.2/85)	⊘ 25°	7 mag	13	55.8	335
KACJA	Kac	Kostanjevec	METKA (0.8/8)	⊘ 42°	4 mag	18	84.9	185
		Ljubljana	ORION1 (0.8/8)	⊘ 42°	4 mag	27	112.2	310
		Kamnik	REZIKA (0.8/6)	⊘ 55°	3 mag	11	42.1	265
			STEFKA (0.8/3.8)	⊘ 80°	3 mag	7	25.7	63
KOSDE	Koschny	Noord-wijkerhout	TEC1 (1.4/12)	⊘ 30°	4 mag	17	40.2	95
LUNRO	Lunsford	Chula Vista	BOCAM (1.4/50)	⊘ 60°	6 mag	25	118.5	641
MOLSI	Molau	Seysdorf	AVIS2 (1.4/50)	⊘ 60°	6 mag	20	67.6	1032
			MINCAM1 (0.8/6)	⊘ 60°	3 mag	26	96.9	405
		Ketzür	REMO1 (0.8/3.8)	⊘ 80°	3 mag	23	80.8	302
			REMO2 (0.8/3.8)	⊘ 80°	3 mag	26	90.3	445
OCHPA	Ochner	Albiano	ALBIANO (1.2/4.5)	⊘ 68°	3 mag	17	74.1	171
SLAST	Slavec	Ljubljana	KAYAK1 (1.8/28)	⊘ 50°	4 mag	18	43.9	86
STOEN	Stomeo	Scorze	MIN38 (0.8/3.8)	⊘ 80°	3 mag	27	139.8	1047
			NOA38 (0.8/3.8)	⊘ 80°	3 mag	26	125.6	545
			SCO38 (0.8/3.8)	⊘ 80°	3 mag	27	142.9	896
STORO	Stork	Ondřejov	OND1 (1.4/50)	⊘ 55°	6 mag	2	9.4	232
STRJO	Strunk	Herford	MINCAM2 (0.8/6)	⊘ 55°	3 mag	14	37.5	115
			MINCAM3 (0.8/8)	⊘ 42°	4 mag	8	20.1	71
			MINCAM5 (0.8/6)	⊘ 55°	3 mag	12	35.0	185
TEPIS	Tepliczky	Budapest	HUMOB (0.8/3.8)	⊘ 80°	3 mag	6	33.6	295
					Overall	31	2 707.4	13 485

Results of the IMO Video Meteor Network — August 2009

Sirko Molau [1] *and Javor Kac* [2]

August 2009 was again a record-breaking month for the IMO Video Meteor Network. 23 observers operating 38 video cameras covered all 31 nights with almost 4 200 hours effective observing time and more than 28 500 meteors. The triple Perseid peak that was recorded by the visual observers was not observed well by the IMO Video Meteor Network cameras as it occurred outside the European observing window where most of our cameras are located.

Received 2009 October 9

1 Introduction

Even if we run the risk of writing the same thing every month, we have to begin this new report with the following summary: The previous month was again record-breaking. In August 2009 we beat all previous records of the IMO Video Meteor Network at once.

First, we welcome a new observer in the video network. Hans Schremmer is operating the "standard setup" (Mintron camera, Computar 0.8/3.8 mm lens) in Niederkruechten, Germany, close to the Dutch border. With 26 nights, his first result was indeed respectable. Further, Detlef Koschny has started to operate another image-intensified camera, Lic1. He selected the same Philips XX-1332 intensifier tube as other observers, and he demonstrated its abilities in the Perseid maximum nights.

Overall, 23 observers operated 38 video cameras in August 2009. Contrary to previous years, the weather was largely cooperative in central Europe. Most observers obtained long sequences of observing nights, and on some nights more than thirty cameras were in operation. The excellent weather was also reflected in the fact that 22 of the cameras recorded meteors in twenty or more nights. Stefano Crivello was on top of the list – he did not miss a single night with his camera C3P8.

In general, the Italian observers were remarkably strong. Over the previous few months it had already become clear that their cameras are exceptionally sensitive and record more meteors than other cameras with identical setup. In August 2009 the difference was in particular obvious. For the first time, the three most successful cameras that recorded most meteors were not image-intensified! Maybe the circumstances were a bit unusual, because the Perseids suffered strongly from the waning Moon that affected intensified cameras much more strongly than wide-angle non-intensified cameras. Still, the result was remarkable.

With respect to effective observing time, October 2008 (2 761 h), July 2009 (2 710 h) and January 2009 (2 559 h) were on top of the list. August 2009 surpassed those previous marks by more than 50% with almost 4 200 hours of effective observing time. To date, we never recorded more meteors than in October 2008 (17 000), August 2007 (15 100) and August 2008 (14 400). August 2009 provided more than 28 500 meteors, which is an increase of two thirds (Table 1 and Figure 1)!

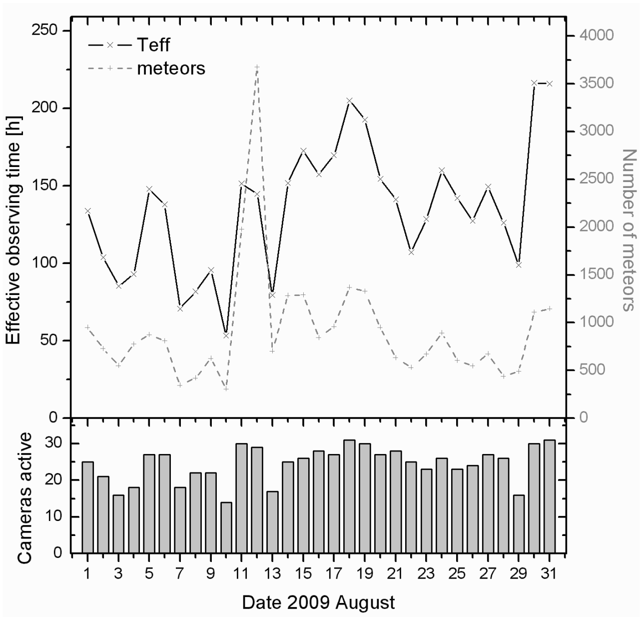

Figure 1 – Monthly summary for the effective observing time (solid black line), number of meteors (dashed gray line) and number of cameras active (bars) in 2009 August.

During the analysis of the observations it became clear that the current method of manually collecting and checking the data set cannot cope with such an amount of data. By early 2010 latest, we will start to use the Virtual Meteor Observatory (VMO) for data collection (Koschny et al., 2007; Koschny et al., 2008; Koschny et al., 2009), which has a number of consistency checks built in. Then the first author can focus on new observers with less experience and will do only random checks of the other observations.

2 Perseids

The detailed analysis of the August 2009 data was focused on the Perseids again. As in previous years, several maxima were predicted from dust trail analyses (Vaubaillon, 2009). The IMO QuickLook analysis of visual data (International Meteor Organization, 2009) confirmed three maxima (August 12 at 8^h15^m UT and 18^h15^m UT; August 13 at 6^h30^m UT). The analysis of our video data was particularly demanding for two reasons. On the one hand, the waning Moon disturbed

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IMO bibcode WGN-375-molau-vidaug
NASA-ADS bibcode 2009JIMO...37..168M

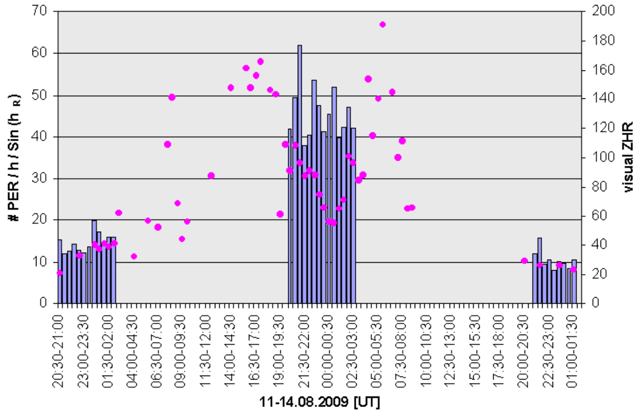

Figure 2 – Comparison of the Perseid activity graph obtained from video data (bars) with the preliminary ZHR from the IMO QuickLook analysis (dots).

observations in the second half of night, significantly reducing the meteor counts. On the other hand, there were only few sites with continuously clear skies. Often, clouds patches drifted through the field of view, rendering the data of these cameras useless for an activity analysis. The results presented here (Figure 2) are based on Perseid counts in 30-minute intervals, which were corrected for the radiant altitude and averaged over all cameras enjoying longer spells of clear skies. For comparison, the visual ZHR taken from the QuickLook analysis of the IMO is given as well. From this it is clear that all three maxima occurred outside the European observing window. The increase in rates on August 11/12 is noticeable, as are the decreasing rates in the evening of August 12 after the 18^h15^m UT peak. The following increase in the morning hours of August 13 is not visible, though, probably because the Moon reduced the limiting magnitude. By the following night, the show was already over.

Finally, we would like to present the picture of an unusual double Perseid recorded by Sirko's camera MINCAM1 on August 8 at 01^h33^m UT. In the past, we previously recorded double meteors flying in parallel, but this time they appeared directly one after the other (Figure 3). The corresponding video sequence shows that the relative distance between the two objects increased by 70% in the 0.8 s they were both visible. If the meteors are interpolated back linearly, their trails overlap roughly 0.8 s before the first meteor entered the field of view. Hence, these were probably not two meteoroids that burned up independently in the atmosphere, but one larger meteoroid. It broke apart when entering the atmosphere, and each fragment experienced a different deceleration.

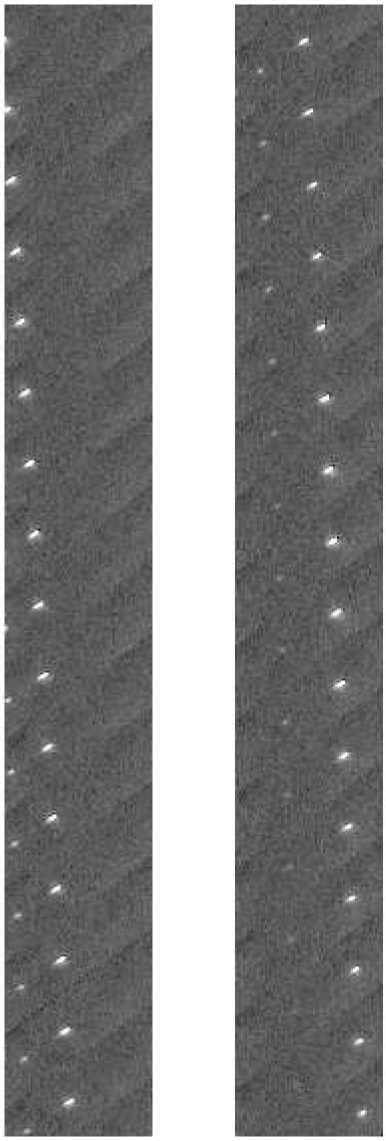

Figure 3 – Sequence of a double Perseid, recorded by MINCAM1 on 2009 August 8 at 01^h31^m UT.

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Table 1 – Observers contributing to August 2009 data of the IMO Video Meteor Network.

Code	Name	Place	Camera	FOV	LM	Nights	Time (h)	Meteors
BENOR	Benitez-S.	Las Palmas	TIMES5 (0.95/50)	⊘ 10°	3 mag	12	25.7	72
BRIBE	Brinkmann	Herne	HERMINE (0.8/6)	⊘ 55°	3 mag	28	156.8	911
CASFL	Castellani	Monte Baldo	BMH1 (0.8/6)	⊘ 55°	3 mag	16	94.4	414
			BMH2 (0.8/6)	⊘ 55°	3 mag	18	92.6	387
CRIST	Crivello	Valbrevenna	C3P8 (0.8/3.8)	⊘ 80°	3 mag	31	209.3	1862
			STG38 (0.8/3.8)	⊘ 80°	3 mag	14	104.2	364
ELTMA	Eltri	Venezia	MET38 (0.8/3.8)	⊘ 80°	3 mag	26	170.7	1035
GONRU	Goncalves	Tomar	TEMPLAR1 (0.8/6)	⊘ 55°	3 mag	27	197.1	1368
			TEMPLAR2 (0.8/6)	⊘ 55°	3 mag	25	171.5	781
GOVMI	Govedič	Središče ob Dravi	ORION2 (0.8/8)	⊘ 42°	4 mag	24	154.0	891
HERCA	Hergenrother	Tucson	SALSA (1.2/4)	⊘ 80°	3 mag	9	32.6	74
			SALSA2 (1.2/4)	⊘ 80°	3 mag	8	36.4	91
HINWO	Hinz	Brannenburg	AKM2 (0.85/25)	⊘ 32°	6 mag	20	118.2	668
IGAAN	Igaz	Hódmező-vásárhely	HUHOD (0.8/3.8)	⊘ 80°	3 mag	19	122.4	708
JOBKL	Jobse	Oostkapelle	BETSY2 (1.2/85)	⊘ 25°	7 mag	24	139.8	1599
KACJA	Kac	Kostanjevec	METKA (0.8/8)	⊘ 42°	4 mag	23	127.5	432
		Ljubljana	ORION1 (0.8/8)	⊘ 42°	4 mag	27	154.0	645
		Kamnik	REZIKA (0.8/6)	⊘ 55°	3 mag	13	55.9	541
			STEFKA (0.8/3.8)	⊘ 80°	3 mag	15	55.4	287
KOSDE	Koschny	Noord-wijkerhout	LIC1 (1.4/50)	⊘ 60°	6 mag	2	6.9	596
			TEC1 (1.4/12)	⊘ 30°	4 mag	10	39.7	133
LUNRO	Lunsford	Chula Vista	BOCAM (1.4/50)	⊘ 60°	6 mag	20	107.3	870
MOLSI	Molau	Seysdorf	AVIS2 (1.4/50)	⊘ 60°	6 mag	19	84.9	1640
			MINCAM1 (0.8/6)	⊘ 60°	3 mag	29	142.9	935
		Ketzür	REMO1 (0.8/3.8)	⊘ 80°	3 mag	19	101.5	543
			REMO2 (0.8/3.8)	⊘ 80°	3 mag	21	105.8	916
OCHPA	Ochner	Albiano	ALBIANO (1.2/4.5)	⊘ 68°	3 mag	28	148.6	647
SCHHA	Schremmer	Niederkrüchten	DORAEMON (0.8/3.8)	⊘ 80°	3 mag	26	138.1	616
SLAST	Slavec	Ljubljana	KAYAK1 (1.8/28)	⊘ 50°	4 mag	14	49.0	92
STOEN	Stomeo	Scorze	MIN38 (0.8/3.8)	⊘ 80°	3 mag	27	182.5	1953
			NOA38 (0.8/3.8)	⊘ 80°	3 mag	27	170.3	1252
			SCO38 (0.8/3.8)	⊘ 80°	3 mag	27	175.6	1899
STORO	Stork	Ondřejov	OND1 (1.4/50)	⊘ 55°	6 mag	3	21.2	625
STRJO	Strunk	Herford	MINCAM2 (0.8/6)	⊘ 55°	3 mag	28	121.8	543
			MINCAM3 (0.8/8)	⊘ 42°	4 mag	23	108.2	504
			MINCAM5 (0.8/6)	⊘ 55°	3 mag	25	131.9	857
TEPIS	Tepliczky	Budapest	HUMOB (0.8/3.8)	⊘ 80°	3 mag	9	54.2	323
YRJIL	Yrjölä	Kuusankoski	FINEXCAM (0.8/6)	⊘ 55°	3 mag	23	86.8	503
					Overall	31	4 195.7	28 577

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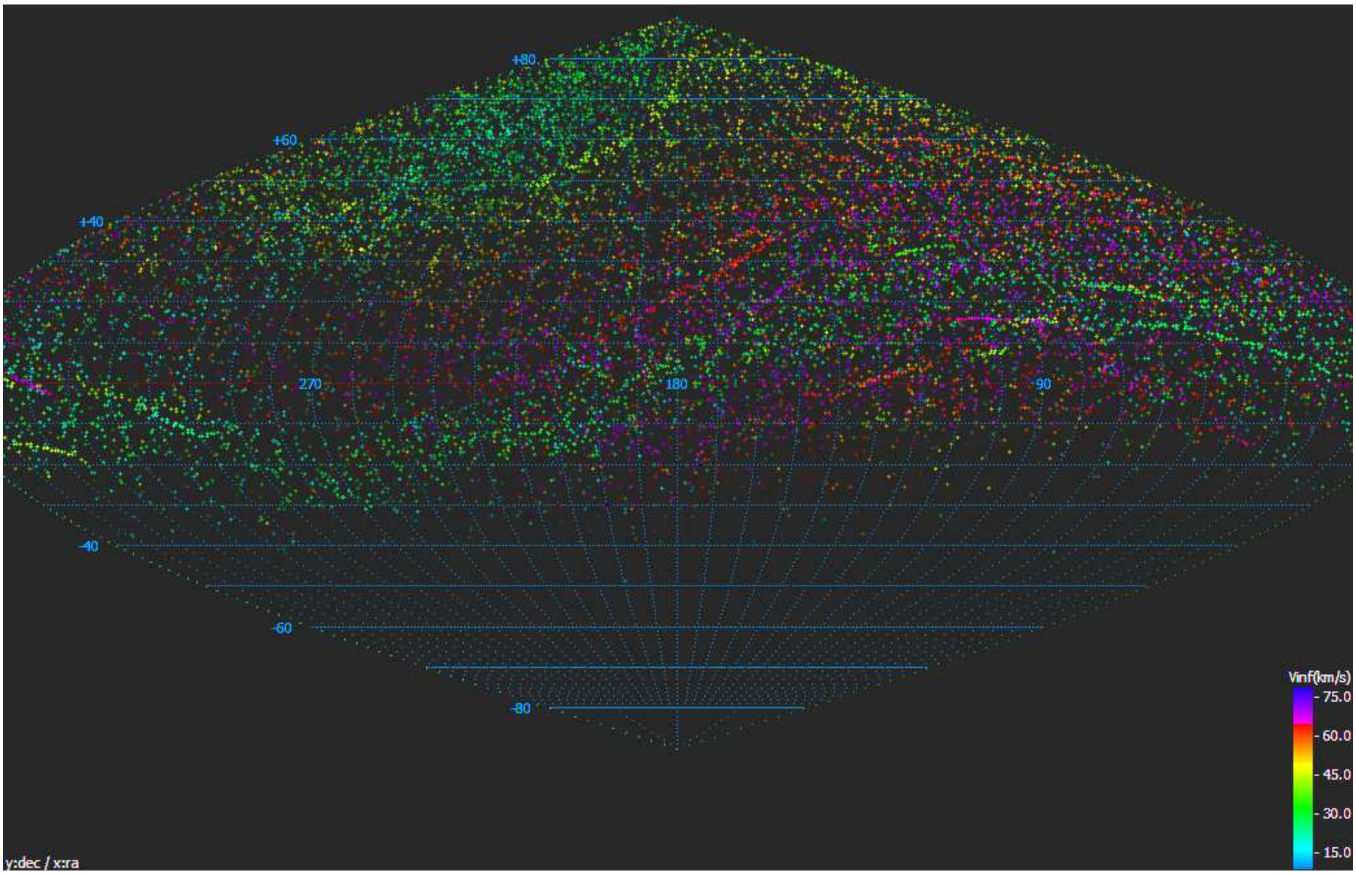
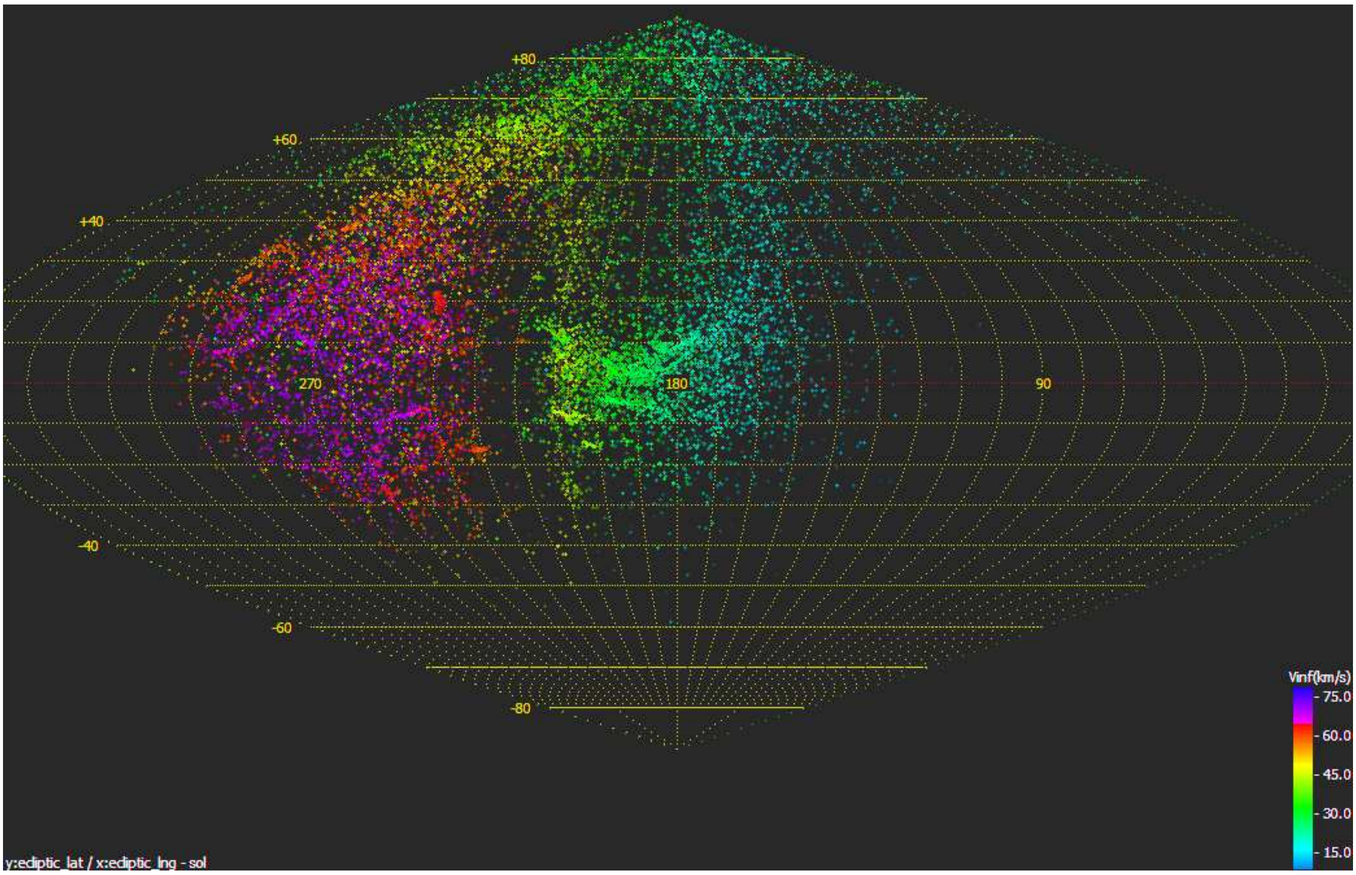
Radiant plots of the IMO Video Meteor Network



Distribution of radiants detected in the IMO Video Meteor Database over right ascension and declination in a sinusoidal projection. The brightness of each spot represents the number of meteors that contributed to the radiant, and the meteor shower velocity is coded in the color.



Distribution of radiants detected in the IMO Video Meteor Database in Sun-centered ecliptical coordinates with the ecliptical radiant longitude minus the solar longitude as x-axis, and the ecliptical latitude as y-axis. For more information and full analysis of the IMO Video Meteor Network data, see the paper by Molau and Rendtel on page 98.