International Meteor Organization

2008 Meteor Shower Calendar

compiled by Alastair McBeath[1]

1 Introduction

Welcome to the 2008 International Meteor Organization (IMO) Meteor Shower Calendar. The meteor year ahead starts well for the stronger showers, with moonless maxima for the Quadrantids, α-Centaurids, η-Aquarids and δ-Aquarids, but things go somewhat awry in August with the Perseids peaking near full Moon, while the Orionids in October, the Leonids in November and the Geminids in December are even worse-placed. However, the Draconid epoch should still be partly observable, while the late October to early November spell, which may bring another 'swarm' enhancement from the Taurids, is Moon-free, as too is the Ursid peak towards year's end. There are minor showers to be monitored as well, and ideally, meteor observing should be carried out throughout the year to check on all the established sources, and for any new ones. We appreciate this is impractical for most people, so the Shower Calendar has been helping to highlight times when a particular effort might most usefully be employed since 1991.

The heart of the Calendar is the Working List of Visual Meteor Showers, Table 5, which as many of you will appreciate, completed its most recent thorough overhaul by IMO analysts in 2006, to help it remain the single most accurate listing available anywhere today for naked-eye meteor observing. Of course, for all its accuracy, it is a *Working* List, so is continually subject to further checks and corrections, based on the best data we have. Consequently, more changes have been made this time, to amend some minor inconsistencies in the 2007 version. Please be sure to use the information here when preparing for your observing in 2008, as even some of the stronger showers like the Perseids and Leonids have had minor adjustments made to their radiant locations. The most major change this time has been the removal of the minor δ-Leonids, as their radiant now lies within the new Antihelion Source's radiant area.

Apart from these visually-observable showers, there are many others weakly active throughout the year which only still-imaging, video, radar or telescopic observations can separate from the omnipresent background sporadics, possibly including some of those recently removed from the visual showers' list. There is also a set of showers with radiants too near the Sun to be observed by the various optical methods, which can be detected only by forward-scatter radio or radar observations. Some of these showers are given in Table 7, the Working List of Daytime Radio Meteor Streams. The IMO's aims are to encourage, collect, analyze, and publish combined meteor data obtained from sites all over the globe, to help better our understanding of the meteor activity detectable from the Earth's surface. Thus, we encourage these more specialist forms of observing too, so all meteor workers, wherever you are and whatever methods you use to record

[1]Based on information in *IMO Monograph No. 2: Handbook for Visual Meteor Observers*, edited by Jürgen Rendtel, Rainer Arlt and Alastair McBeath, IMO, 1995, as amended by the commentaries in *WGN* 34:3 (June 2006), pp. 71–84, with subsequent corrections, plus additional material extracted from reliable data analyses produced since. Particular thanks are due to Jeff Brower, David Entwistle, Roberto Gorelli and Jérémie Vaubaillon for valuable discussions in respect of several potential events in 2008.

meteors, should follow the standard IMO observing guidelines when compiling your information, and submit those data promptly to the appropriate Commission for analysis (contact details are at the end of the Calendar). Thanks to the efforts of the many IMO observers worldwide since 1988 that have done this, we have been able to achieve as much as we have to date, including keeping the shower listings vibrant. This is not a matter for complacency however, since it is solely by the continued support of many people across the planet that our steps towards constructing a better and more complete picture of the near-Earth meteoroid flux can proceed.

Although timing predictions are included below on all the more active night-time and daytime shower maxima, as reliably as possible, it is essential to understand that in many cases, such maxima are not known more precisely than to the nearest 1° of solar longitude (even less accurately for the daytime radio showers, which have received little regular attention until quite recently). In addition, variations in individual showers from year to year mean past returns are only a guide as to when even major shower peaks can be expected. The information given here may be updated after the Calendar is published, so be sure to watch for alerts on the Internet (including on IMO-News) and in WGN, the IMO's bimonthly journal. Some showers are known to show particle mass-sorting within their meteoroid streams, so the radar, radio, still-imaging, telescopic, video and visual meteor maxima may occur at different times from one another, and not necessarily just in those showers. The majority of data available are for visual shower maxima, so this must be borne in mind when employing other observing techniques.

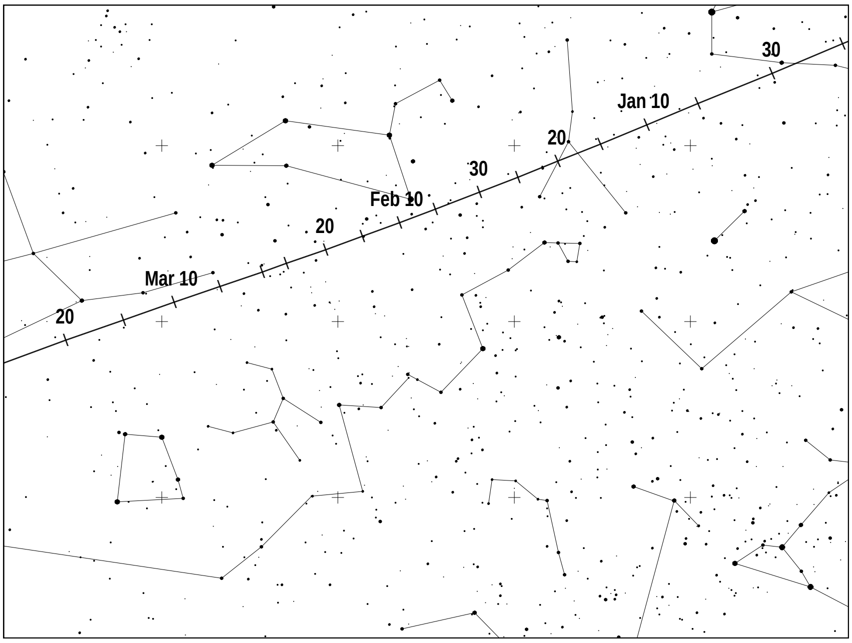
However and whenever you are able to observe, we wish you all a most successful year's work and very much look forward to receiving your data. Clear skies!

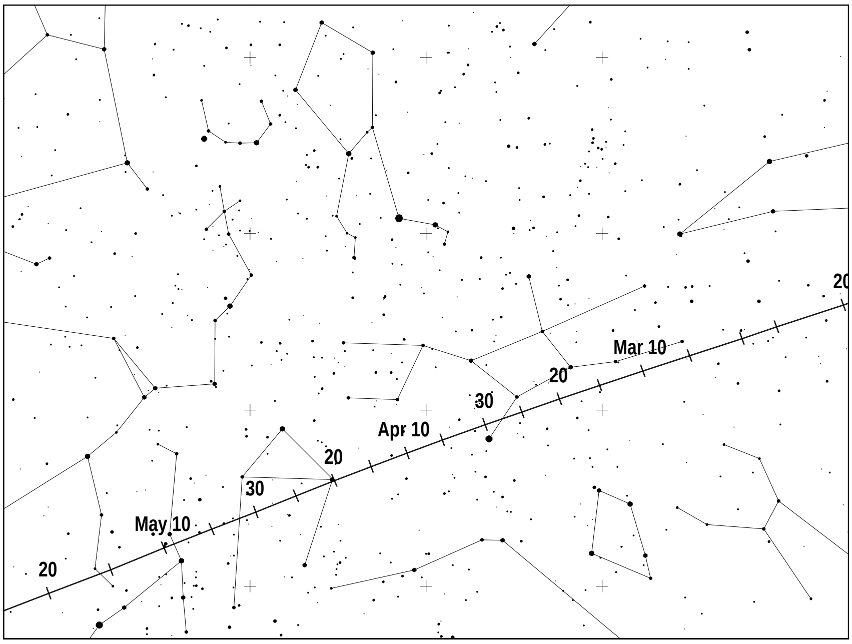
2 Antihelion Source

The biggest change in the 2006 upgrade of the Visual Working List was the removal of most of those minor near-ecliptic sources that previously seemed to 'chase' one another around the sky throughout the year, such as the Virginids of February-March, and many of the July-August Aquarid showers. They were replaced with a large, diffuse radiant area, whose size is taken to be roughly $\alpha = 30°$ by $\delta = 15°$, centred around 12° east of the solar opposition point on the ecliptic. Such a location names it as the 'Antihelion Source', abbreviated as 'ANT'. This has been done as it seems to give a better description of the actual observed activity than the cluster of previous, often supposedly variable, very minor sources in this part of the sky. At present, we think the July-August α-Capricornids (CAP), and particularly the δ-Aquarids (SDA), should remain discretely observable visually from the ANT, so they have been retained in the Working List, but time and plenty of observations will tell, as ever! Later in the year, the strength of the twin Taurid showers (STA and NTA) means the ANT should be considered inactive while the Taurids are underway, from late September to late November. To assist observers, a set of charts showing the location for the ANT and any other nearby shower radiants is included here, to compliment the numerical positions of Table 6, while comments on the ANT's location and likely activity are given in the quarterly summary notes.

3 January to March

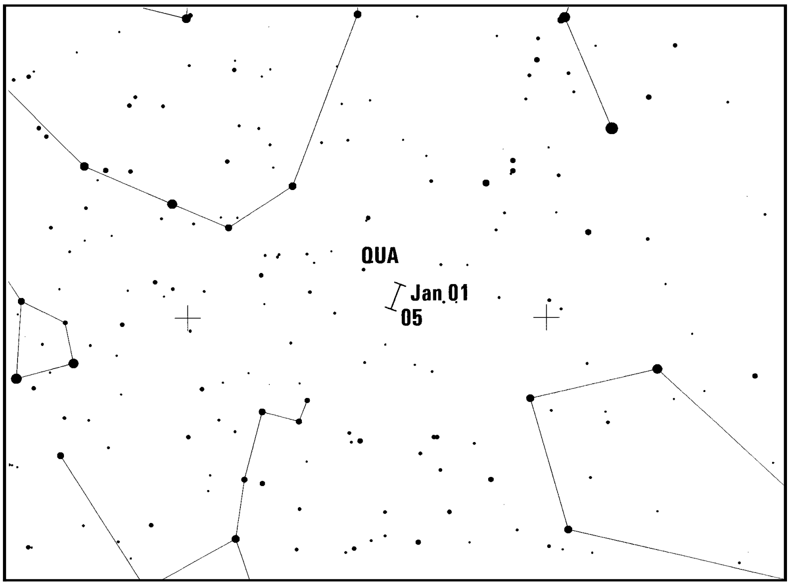
A waning crescent Moon favours the northern-hemisphere Quadrantids in early January, while the new Moon is still better for the probable southern-hemisphere α-Centaurid peak in February. Mid-March brings a reasonable to very good minor γ-Normid return too, for similarly southern places. The Antihelion Source's radiant centre starts January in south-east Gemini, and crosses Cancer during much of the month, before passing into southern Leo for most of February. It then slips through southern Virgo during March. Likely ANT ZHRs will be < 2, though IMO analyses suggest there may be an ill-defined minor peak with ZHRs ~ 2 to 3 around $\lambda_\odot \sim 286°$–$293°$ (January 7 to 14 in 2008, well-timed for the new and waxing crescent Moon, if so), and ZHRs could be ~ 3 for most of March. The late January to early February spell, during which several new, swift-meteor, minor showers, radiating from the Coma-Leo-Virgo area have been suggested in some recent years, unfortunately has a full Moon for the potential core period, January 20–27. Theoretical approximate timings (rounded to the nearest hour) for the daytime radio shower maxima this quarter are: Capricornids/Sagittarids – February 2, 03^h UT; and χ-Capricornids – February 14, 04^h UT. Recent radio results suggest the Cap/Sgr maximum may variably fall sometime between February 1–4 however, while activity near the expected χ-Capricornid peak has tended to be slight and up to a day late. Both showers have radiants $< 10°$–$15°$ west of the Sun at maximum, so cannot be regarded as visual targets even from the southern hemisphere.





Quadrantids (QUA)

Active: January 1–5; Maximum: January 4, $06^{h}40^{m}$ UT ($\lambda_{\odot} = 283\overset{\circ}{.}16$);
ZHR = 120 (can vary $\sim$ 60–200);
Radiant: $\alpha = 230°$, $\delta = +49°$; Radiant drift: see Table 6;
$V_{\infty} = 41$ km/s; $r = 2.1$ at maximum, but variable;
TFC: $\alpha = 242°$, $\delta = +75°$ and $\alpha = 198°$, $\delta = +40°$ ($\beta > 40°$ N).
IFC: before 0^{h} local time $\alpha = 150°$, $\delta = +70°$; after 0^{h} local time $\alpha = 180°$, $\delta = +40°$ and $\alpha = 240°$, $\delta = +70°$ ($\beta > 40°$ N).



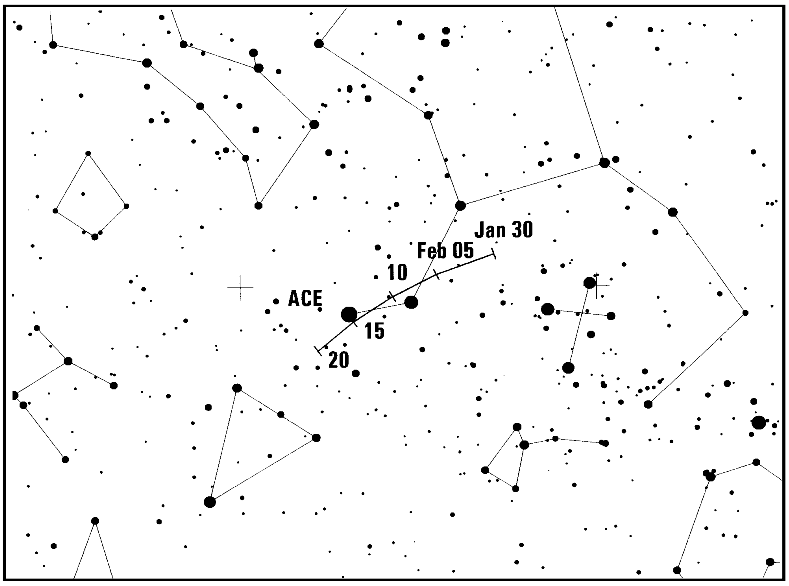
A virtually moonless maximum of the Quadrantids opens the northern meteor watchers' year very well, with a waning crescent Moon, four days from new, which rises only around or after 04^{h} at mid northern latitudes, so it will be little nuisance. From many northern locations, the shower's radiant is circumpolar, in northern Boötes, but it attains a useful elevation only after local midnight, rising higher in the sky towards morning twilight. Consequently, eastern North American longitudes east to those of extreme western Europe and North Africa will be the most favoured places to catch the shower's best, if the peak keeps to time. An interesting challenge is to try spotting the occasional long-pathed shower member from the southern hemisphere around dawn, but sensible Quadrantid watching cannot be carried out from such places.

The maximum timing given above is based on the best-observed return of the shower ever analysed, from IMO 1992 data, confirmed by radio results in most years since 1996. The peak itself is normally short-lived, and can be easily missed in just a few hours of poor northern-winter weather, which may be why the ZHR level apparently fluctuates from year to year, but some genuine variability is probably present too. For instance, visual ZHRs in 1998 persisted for over two hours at their best. An added level of complexity comes from the fact that mass-sorting of particles across the meteoroid stream may make fainter objects (radio and telescopic meteors) reach maximum up to 14 hours before the brighter (visual and photographic) ones, so observers should be alert throughout the shower. A few, but apparently not all, years since 2000 seem to have produced a, primarily radio, maximum following the main visual one by some 9–12 hours. Visual confirmation of any repeat near this time in 2008 would fall ideally for sites from East Asia east to sites around the eastern North Pacific Ocean.

Past observations have suggested the QUA radiant is diffuse away from the maximum, contracting notably during the peak itself, although this may be a result of the very low activity outside the hours near maximum. Still-imaging and video observations from January 1–5 would be particularly welcomed by those investigating this topic, using the IFCs and TFCs given above, along with telescopic and visual plotting results.

α-Centaurids (ACE)

Active: January 28–February 21; Maximum: February 8, 17^{h} UT ($\lambda_{\odot} = 319.^{\circ}2$);
ZHR = variable, usually ~ 5, but may reach 25+;
Radiant: $\alpha = 211°$, $\delta = -59°$; Radiant drift: see Table 6;
$V_{\infty} = 56$ km/s; $r = 2.0$.

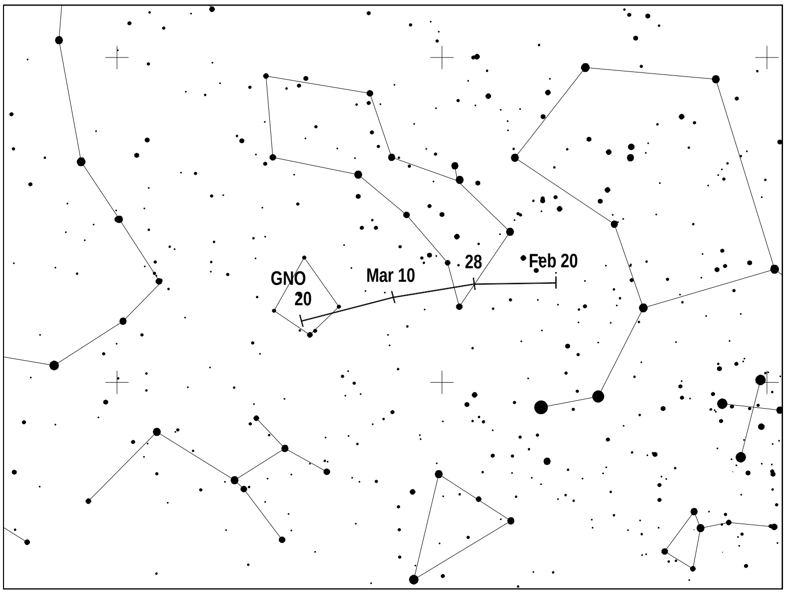


In theory, the α-Centaurids are one of the main southern summer high points, from past records supposedly producing many very bright, even fireball-class, objects (meteors of at least magnitude −3), commonly with fine persistent trains. However, peak ZHRs recently have been found as 5 or less in the few sketchy reports available, though in 1974 and 1980, bursts of only a few hours' duration apparently yielded activity closer to 20–30. As with many southern hemisphere sources, we have more questions than answers at present, nor do we have any means of telling when, or if, another stronger event might happen. Thus imaging and visual observers are urged to be alert at every opportunity. The radiant is nearly circumpolar for much of the sub-equatorial inhabited Earth, and is at a useful elevation from late evening onwards. New Moon falls almost perfectly for the predicted peak, an ideal chance for anyone favoured by clearer skies.

γ-Normids (GNO)

Active: February 25–March 22; Maximum: March 13 ($\lambda_{\odot} = 353°$); ZHR = 4;
Radiant: $\alpha = 239°$, $\delta = -50°$, Radiant drift: see Table 6;
$V_{\infty} = 56$ km/s; $r = 2.4$;
TFC: $\alpha = 225°$, $\delta = -26°$ and $\alpha = 215°$, $\delta = -45°$ ($\beta < 15°$ S).

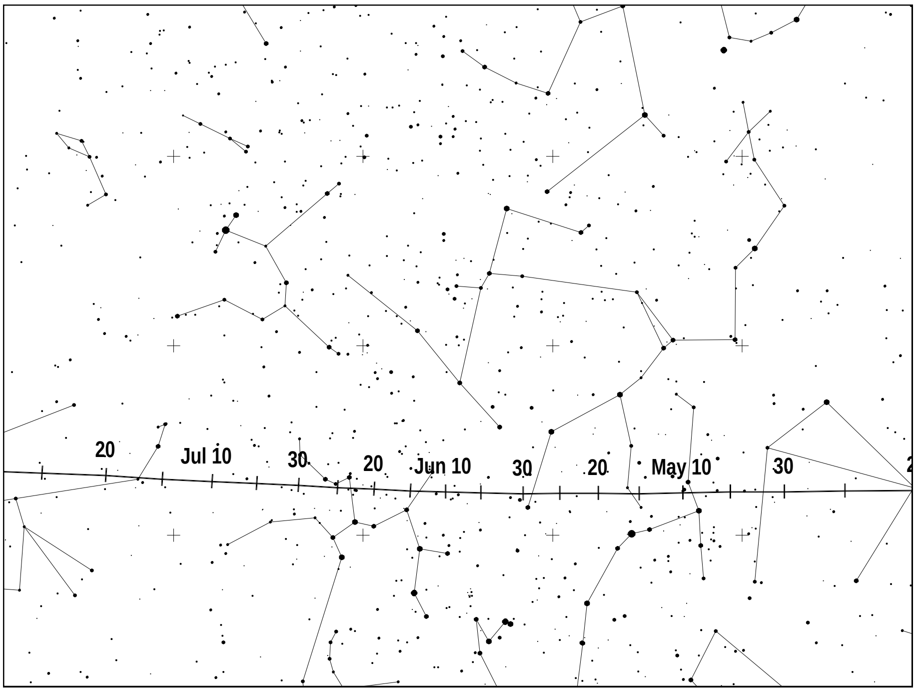
γ-Normid meteors seem to be similar to the sporadics in appearance, and for most of their activity period, their ZHR is virtually undetectable above this background rate. The peak itself has been reported as quite sharp, with ZHRs of 3 to 4 often noted for only a day or two to either side of the maximum. Activity may vary somewhat at times, with occasional broader, or less obvious, maxima having been noted in the past. Limited data since 1999 have suggested the possibility of a maximum at some, albeit short-lived, stage between $\lambda_\odot \sim 350°$–$357°$, equivalent to 2008 March 10–17, while video information from the same period found the earlier radiant position to be no longer applicable. The details given here are now to be preferred. Post-midnight watching yields best results, when the radiant is rising to a reasonable elevation from southern hemisphere sites (the radiant does not rise for many northern ones). The shower badly needs more regular observation, and March's waxing Moon, at first quarter on March 14, means 2008 would be an excellent year to start. All observing techniques can be employed.



4 April to June

Meteor activity picks up towards the April-May boundary, with badly moonlit shower peaks in late April from the Lyrids (between 21^h UT on April 21 to 08^h UT on April 22, with probably better rates the closer the peak falls to $\sim 05^h$ UT on April 22) and π-Puppids (but see below), then the perfectly moonless η-Aquarids in early May, followed a few days later by a new Working List minor shower, the η-Lyrids. Later in May and throughout June, most of the meteor action switches to the day sky, with six shower maxima expected during this time. Although occasional meteors from the o-Cetids and Arietids have been claimed as seen from tropical and southern hemisphere sites visually in past years, ZHRs cannot be sensibly calculated from such observations. For radio observers, the theoretical UT peaks for these showers are as follows: April Piscids – April 20, 03^h; δ-Piscids – April 24, 03^h; ε-Arietids – May 9, 02^h; May Arietids – May 16, 03^h; o-Cetids – May 20, 01^h; Arietids – June 7, 05^h; ζ-Perseids – June 9, 04^h; β-Taurids – June 28, 04^h. Signs of most of these were found in radio data from 1994–2007, though some are difficult to define individually because of their proximity to other radiants. There seems to be a modest recurring peak around April 24, perhaps due to combined rates from the first three showers listed here, for instance, while the Arietid and ζ-Perseid maxima tend to blend into one another, producing a strong radio signature for several days in early to mid June. There are indications these two June shower maxima now each occur up to a day later than indicated above. The Antihelion Source should be relatively strong, with ZHRs of 3 to 4 found in recent investigations through till mid April, and again around late April to early May, late May to early June, and late June to early July. At other times, the ZHR seems to be below ~ 2 to 3.

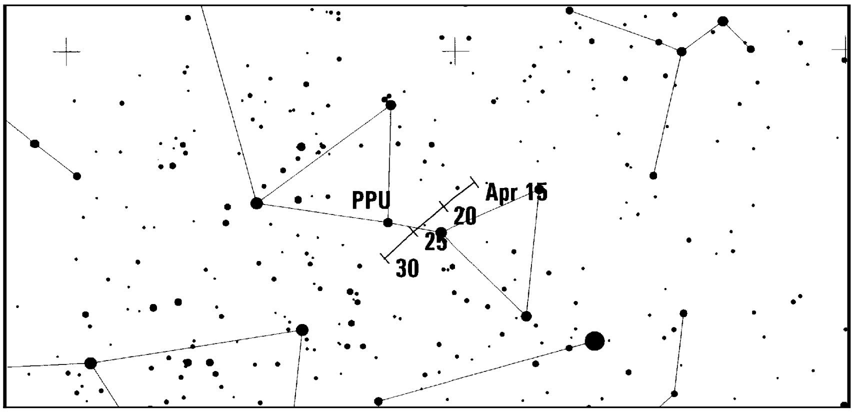
The radiant area drifts from south-east Virgo through Libra in April, then across the northern part of Scorpius to southern Ophiuchus in May, and on into Sagittarius for much of June. For northern observers, circumstances for checking on any potential June Lyrids (not currently on the Working List, but possibly producing some weak activity, if at all, around June 15) are very unfavourable this year, with a waxing gibbous Moon visible virtually all night then for most mid latitude sites. Conditions are much better for possible June Boötid hunting.



π–Puppids (PPU)

Active: April 15–28; Maximum: April 23, 10^{h} UT ($\lambda_{\odot} = 33\overset{\circ}{.}5$ – but see below);
ZHR = periodic, up to around 40;
Radiant: $\alpha = 110°$, $\delta = -45°$; Radiant drift: see Table 6;
$V_{\infty} = 18$ km/s; $r = 2.0$;
TFC: $\alpha = 135°$, $\delta = -55°$ and $\alpha = 105°$, $\delta = -25°$ ($\beta < 20°$ N).

Despite the very poor lunar circumstances for observing this shower in 2008, we urge all who can to do so, because this is a young stream produced by Comet 26P/Grigg-Skjellerup, and the comet is at perihelion on 2008 March 23, just a month before the Earth passes nearest to the stream orbit. Activity has only been detected from this source since 1972, with notable, short-lived, shower maxima of around 40 meteors per hour found in 1977 and 1982, both years when the parent comet was at perihelion. Before 1982, little activity had been seen at other times, but in 1983, a ZHR of ~ 13 was reported, perhaps suggesting material has begun to spread further along the comet's orbit, as theory predicts. Comet Grigg-Skjellerup's perihelion in 2002 November produced nothing meteorically significant the following April, but this time's closer approach may yield something more interesting. There are no guarantees of course, but even registering a negative return this year would be valuable information, and regular monitoring of the shower epoch generally is vital, as past coverage has commonly been patchy, so other short-lived maxima could have been missed. Apart from the timing suggested above, Jérémie Vaubaillon has found three stream trails may pass close enough to the Earth to produce some activity, though these seem likely to consist of small particles only, perhaps producing meteors too faint for visual observation. The three trails were laid down in 1937, 1942 and 1947, and should be encountered between $\sim 22^{h}50^{m}$–$23^{h}20^{m}$ UT on April 22. The ZHR from each component may be ~ 10, ~ 4 and ~ 10 respectively, albeit possibly only for radio observers, unless we are fortunate.



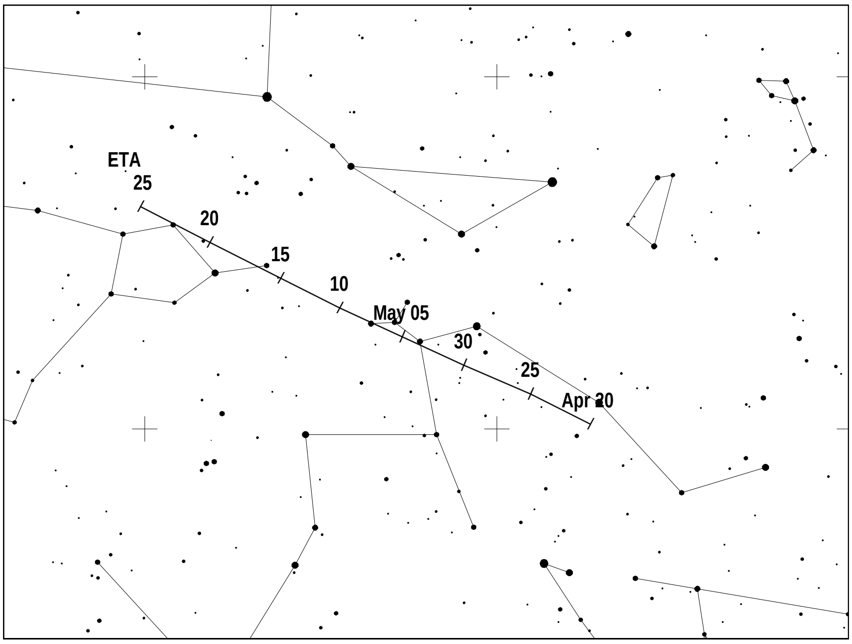
The π-Puppids are best-seen from the southern hemisphere, with useful observations mainly practical there before midnight, as the radiant is very low to setting after 01^{h} local time. Even on April 23, the waning gibbous Moon will rise about as astronomical twilight is ending from mid-southern latitudes, thus the dark-sky observing window is virtually nil. Covering whatever happens is important however, so visual watchers must just make the best of things, and face away from the Moon, and not too close to the radiant, if clear skies manifest. Sites best-placed to catch the predicted maxima timings, if they prove accurate, should be from east Brazil east to Africa on April 22, and across the southern Pacific Ocean, including the eastern one-third of Australia and all of New Zealand on April 23. So far, visual and radio data have been collected on the shower, but the slow, sometimes bright nature of the meteors makes them ideal subjects for imaging too. No telescopic or video data have been reported in any detail as yet.

η-Aquarids (ETA)

Active: April 19–May 28; Maximum: May 5, 18^{h} UT ($\lambda_{\odot} = 45\overset{\circ}{.}5$);
ZHR = 70+ (periodically variable, $\sim$ 40–85);
Radiant: $\alpha = 338°$, $\delta = -01°$; Radiant drift: see Table 6;
$V_{\infty} = 66$ km/s; $r = 2.4$;
TFC: $\alpha = 319°$, $\delta = +10°$ and $\alpha = 321°$, $\delta = -23°$ ($\beta < 20°$ S).

A fine, rich stream associated with Comet 1P/Halley, like the Orionids of October, but one visible for only a few hours before dawn, essentially from tropical and southern hemisphere sites. Some useful results have come even from sites around 40° N latitude in recent years however, and occasional meteors have been reported from further north, but the shower would benefit from increased observer activity generally. The fast and often bright meteors make the wait for radiant-rise worthwhile, and many events leave glowing persistent trains after them. While the radiant is still low, η-Aquarids tend to have very long paths, which can mean observers underestimate the angular speeds of the meteors, so extra care is needed when making such reports.

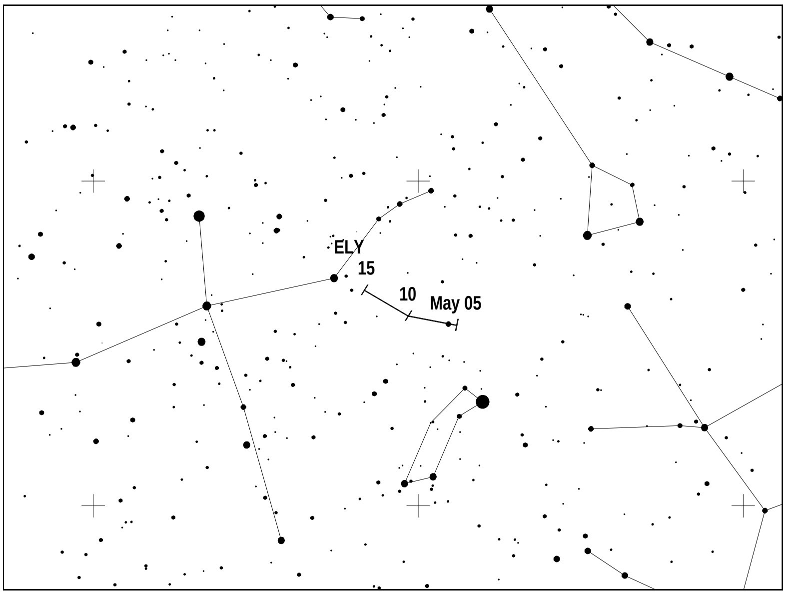
A relatively broad maximum, sometimes with a variable number of submaxima, usually occurs in early May. Fresh IMO analyses in recent years, based on data collected between 1984–2001, have shown that ZHRs are generally above 30 between about May 3–10, and that the peak rates appear to be variable on a roughly 12-year timescale. The next highest rates should fall towards 2008–2010, if this Jupiter-influenced cycle is borne-out, thus ZHRs should be around 70 or more in 2008, according to this idea. The unexpectedly strong Orionid return of 2006 October adds a degree of extra uncertainty over what may be possible from this shower too, and new Moon on May 5 makes this a perfect year for checking. A more recent analysis of IMO video results has led to a slight amendment in the radiant drift, though the radiant at maximum is unchanged. All forms of observing can be used to study the shower, with radio work allowing activity to be followed even from many northern latitude sites throughout the daylight morning hours. The radiant culminates at about 8^{h} local time.



η-Lyrids (ELY)

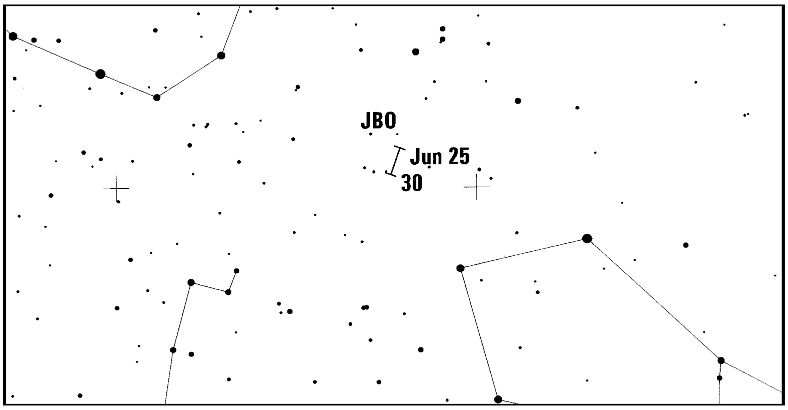
Active: May 3–12; Maximum: May 8, 18^{h} UT ($\lambda_{\odot} = 48\overset{\circ}{.}4$); ZHR = 3;
Radiant: $\alpha = 287°$, $\delta = +44°$; Radiant drift: see Table 6;
$V_{\infty} = 44$ km/s; $r = 3.0$;
TFC: $\alpha = 325°$, $\delta = +40°$ or $\alpha = 285°$, $\delta = +15°$, and $\alpha = 260°$, $\delta = +30°$ ($\beta > 10°$ S).

This new introduction to the Working List is associated with Comet C/1983 H1 IRAS-Araki-Alcock, though it appears to be only a weak meteoric source. Most of the observational data on it so far has been based on imaging results. The radiant position is likely to be somewhere near the point given above at the presumed maximum, but may be some degrees from it. Recent IMO video results found a radiant centred near $\alpha = 290°$, $\delta = +42°$, for example, so other than video work careful visual or telescopic plotting will be needed to separate any potential η-Lyrids from the sporadics. The radiant drift remains unmeasured, but was supposed to be 1° parallel to the ecliptic. The proposed radiant area is usefully on-view all night from the northern hemisphere (primarily), and the thin waxing crescent Moon will be setting by midnight for mid-northern latitudes on May 8, so will not be a significant problem for checking on any possible activity.



June Boötids (JBO)

Active: June 22–July 2; Maximum: June 27, 02^h30^m UT ($\lambda_\odot = 95\overset{\circ}{.}7$);
ZHR = variable, 0–100+;
Radiant: $\alpha = 224°$, $\delta = +48°$; Radiant drift: see Table 6;
$V_\infty = 18$ km/s; $r = 2.2$;
TFC: $\alpha = 156°$, $\delta = +64°$ and $\alpha = 289°$, $\delta = +67°$ ($\beta = 25°$–$60°$ N).



This source was reinstated on the Working List after its unexpected return of 1998, when ZHRs of 50–100+ were visible for more than half a day. Another outburst of similar length, but with ZHRs of ~ 20–50 was observed on 2004 June 23, a date before definite activity had previously been recorded from this shower. Consequently, in the latest upgrade of the List, the shower's start date has been altered to try to ensure future activity so early is caught, and we encourage all observers to routinely monitor throughout the expected activity period, in case of fresh outbursts. Prior to 1998, only three more probable returns had been detected, in 1916, 1921 and 1927, and with no significant reports between 1928 and 1997, it seemed likely these meteoroids no longer encountered Earth. The dynamics of the stream were poorly understood, although recent theoretical modelling has improved our comprehension. The shower's parent Comet 7P/Pons-Winnecke has an orbit that now lies around 0.24 astronomical units outside the Earth's at its closest approach. It was last at perihelion in 2002, and is next due on September 26 this year. Clearly, the 1998 and 2004 returns resulted from material shed by the comet in the past, which now lies on slightly different orbits to the comet itself. Dust trails laid down at various perihelion returns during the 19th century seem to have been responsible for the last two main outbursts. There were no predictions in force for possible activity in 2008 at the time of writing, but conditions for checking are quite favourable from the mid-northern latitudes where the radiant is best-seen. Last quarter Moon, though rising by midnight on June 26/27 from such locations, should be only a small problem after it appears, though the prolonged – in some places continuous – twilight means the summer nights are short anyway. The radiant is usefully accessible virtually all night, and all observing techniques can be employed.

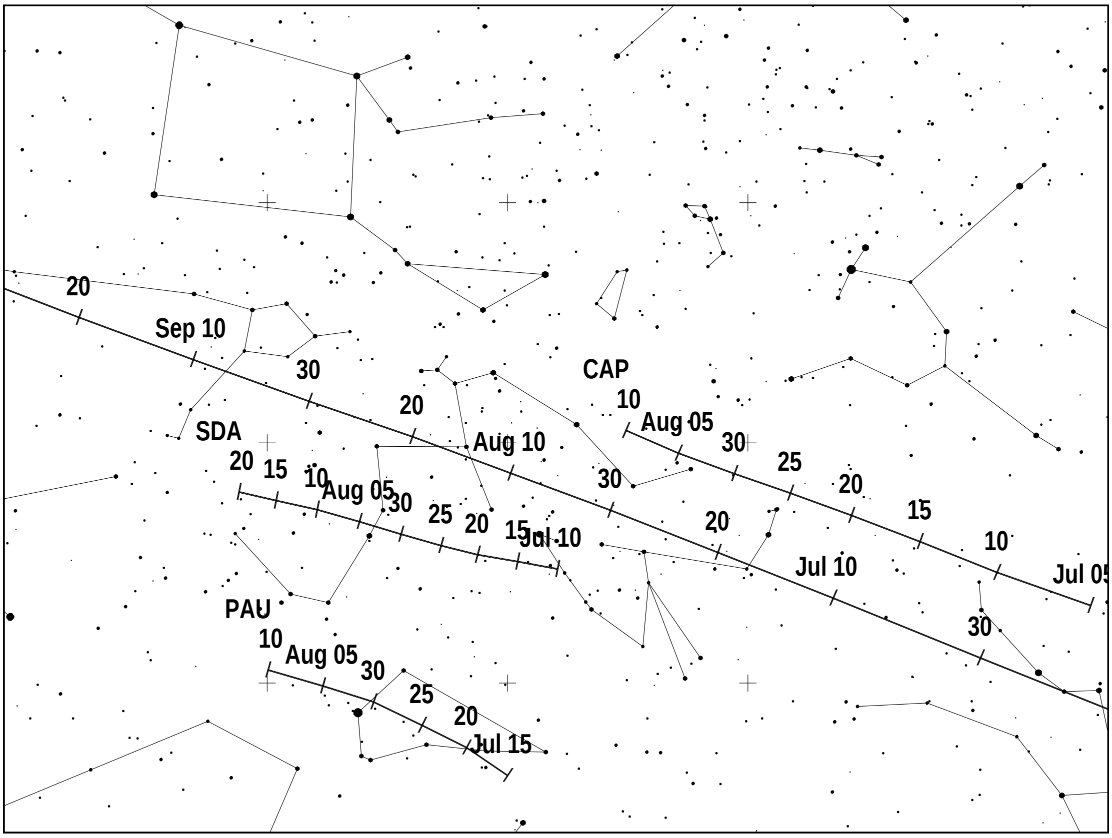
5 July to September

With the former minor showers of the Pegasids and July Phoenicids having proven undetectable in the latest full IMO analyses, and so deleted from the Working List, this leaves just the Antihelion Source active and more or less visually identifiable for most of July, while its radiant area moves steadily through eastern Sagittarius and across northern Capricornus into south-west Aquarius. Results suggest the Source may not be especially recognisable after the first few days however, as ZHRs for most of the month seem < 2. Activity appears to improve somewhat, with ZHRs ~ 2 to 3, by late July and through the first half of August. This level of ZHRs may make it more practical to still identify the moonless α-Capricornid maximum, despite that radiant's overlap with the Antihelion Source's.

The Southern δ-Aquarids are strong enough, and the Piscis Austrinids have a radiant probably distant enough from the ANT area, that both should still be separable from it, particularly from the southern hemisphere. By the best from the major, and partly moonlit, Perseids, ANT ZHRs will likely have dropped back below 2 again, as the radiant tracks on through Aquarius, and into western Pisces by the α-Aurigid maximum on the August-September boundary. Only the κ-Cygnid peak is completely lost this August, as their peak is just the day after full Moon, on August 17.

Both the newly-renamed September Perseids (formerly the δ-Aurigids) and what we now term the δ-Aurigids proper, separated into two showers, even though they follow one another directly on exactly the same radiant drift track, have maxima that should be recordable in September, skies permitting. For most of September, ANT rates can still be detected from the radiant in Pisces, albeit probably no better than 2–3, but remember that from September 25, Antihelion meteors are no longer to be recorded as such, as both Taurid showers take over the near-ecliptic shower baton until late November.

For daylight radio observers, the interest of May-June has waned, but there remain the visually-impossible γ-Leonids (peak towards August 25, 04^{h} UT, albeit not found in recent radio results), and a tricky visual shower, the Sextantids. Their maximum is expected on September 27, around 04^{h} UT, but may possibly occur a day earlier. In 1999 a strong return was detected at $\lambda_{\odot} \sim 186°$, equivalent to 2008 September 28, while in 2002, the September 27 peak was not found, but one around September 29–30 was! It seems plausible that several minor maxima in early October may also be due to this radio shower. New Moon creates no additional difficulties for visual observers hoping to catch some Sextantids in late September, though radiant-rise is less than an hour before dawn in either hemisphere.



Piscis Austrinids (PAU)

Active: July 15–August 10; Maximum: July 27 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 6;
$V_\infty = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to $000°$, $\delta = 00°$ to $+15°$,
choose pairs separated by about 30° in α ($\beta < 30°$ N).

Very little information has been collected on the Piscis Austrinids in recent decades, so the details on the shower are not well-confirmed, and it seems possible the ZHR may be a little optimistic. However, that impression may simply be due to the large amount of northern hemisphere summer data, and the almost complete lack of southern hemisphere winter results, on it. The stream seems to be rich in faint meteors, rather like the nearby ANT and SDA, so telescopic work is advisable to try to establish more about it. Along with all the late July shower peaks this year, the PAU benefits from a nearly-new Moon.

Southern δ-Aquarids (SDA)

Active: July 12–August 19; Maximum: July 27 ($\lambda_\odot = 125°$); ZHR = 20;
Radiant: $\alpha = 339°$, $\delta = -16°$; Radiant drift: see Table 6;
$V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to $000°$, $\delta = 00°$ to $+15°$,
choose pairs separated by about 30° in α ($\beta < 40°$ N).

One of the biggest changes brought about in the revamp of the Working List was the removal of the former streams of the Northern δ-Aquarids, and the Northern and Southern ι-Aquarids, all of which proved separately unidentifiable in a series of recent IMO and non-IMO analyses. This greatly simplifies matters for visual observers especially, who often struggled because of the confusion of minor radiants thought present in the Aquarius-Capricornus region during July-August. Like the PAU and ANT, the SDA meteors are often faint, thus are suitable targets for telescopic observing, although enough brighter members exist to make visual and imaging observations worth the effort too, primarily from more southerly sites. Radio work can pick up the SDA as well, and indeed the shower has sometimes given a surprisingly strong radio signature. Careful visual plotting is advised, to help with accurate shower association. The SDA/PAU/ANT/CAP radiants are well above the horizon for much of the night. The moonless maximum may not be quite so sharp as the single date suggested here might imply, perhaps lasting with similar activity from July 27–29. Its rates have been suspected of some variability at times too, though not in the more recent investigations.

α-Capricornids (CAP)

Active: July 3–August 15; Maximum: July 29 ($\lambda_\odot = 127°$); ZHR = 4;
Radiant: $\alpha = 307°$, $\delta = -10°$; Radiant drift: see Table 6;
$V_\infty = 23$ km/s; $r = 2.5$;
TFC: $\alpha = 255°$ to $000°$, $\delta = 00°$ to $+15°$,
choose pairs separated by about 30° in α ($\beta < 40°$ N);
IFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N), $\alpha = 320°$, $\delta = -05°$ (β 0° to 45° N),
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$).

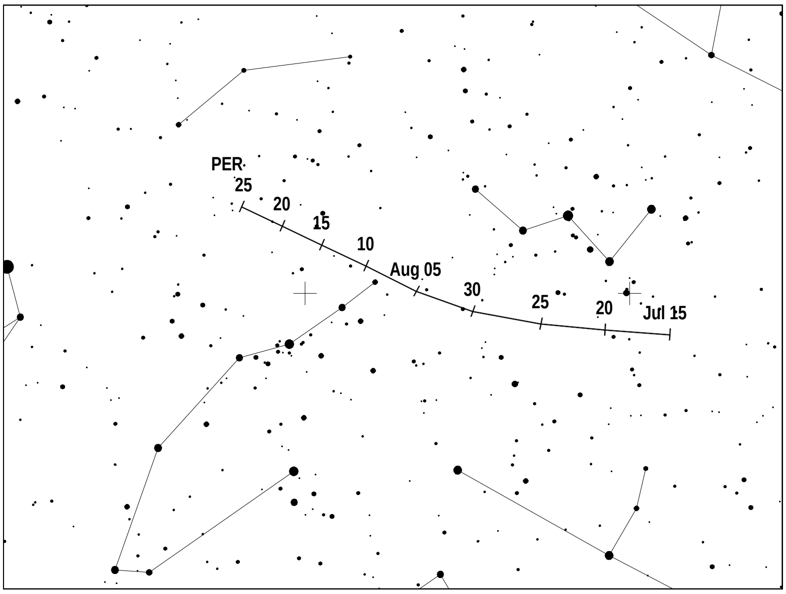
The α-Capricornids and SDA were both definitely detected visually in former years, standing out against the much weaker other radiants supposed active in Capricornus-Aquarius then. Whether the CAP can still be detected separately from the new ANT radiant area remains to be discovered, as its radiant now partly overlaps that of the large ANT oval region. In their favour, CAP meteors are noted for being bright, at times even of fireball-class, which, combined with their low apparent velocity, can make some of these objects among the most impressive and attractive an observer could wish for. A minor enhancement of CAP ZHRs to ~ 10 was noted in 1995 by European IMO observers. More recent results suggest the maximum may continue for an extra day, so perhaps from July 29–30 this year.

Perseids (PER)

Active: July 17–August 24; Maximum: August 12, 11^h30^m–14^h00^m UT ($\lambda_\odot = 140.^\circ0$–$140.^\circ1$),
but see text; ZHR = 100;
Radiant: $\alpha = 49°$, $\delta = +58°$; Radiant drift: see Table 6;
$V_\infty = 59$ km/s; $r = 2.6$;
TFC: $\alpha = 019°$, $\delta = +38°$ and $\alpha = 348°$, $\delta = +74°$ before 2^h local time;
$\alpha = 043°$, $\delta = +38°$ and $\alpha = 073°$, $\delta = +66°$ after 2^h local time ($\beta > 20°$ N);
IFC: $\alpha = 300°$, $\delta = +40°$, $\alpha = 000°$, $\delta = +20°$ or
$\alpha = 240°$, $\delta = +70°$ ($\beta > 20°$ N).

The Perseids were one of the most exciting and dynamic meteor showers during the 1990s, with outbursts at a new primary maximum producing EZHRs of 400+ in 1991 and 1992. Rates from this peak decreased to ~ 100–120 by the late 1990s, and in 2000, it first failed to appear. This was not unexpected, as the outbursts and the primary maximum (which was not noticed before 1988), were associated with the perihelion passage of the Perseids' parent comet 109P/Swift-Tuttle in 1992. The comet's orbital period is about 130 years, so it is now receding back into the outer Solar System, and theory predicts that such outburst rates should dwindle as the comet to Earth distance increases. However, additional predictions suggested 2004–2006 might bring a return of enhanced rates ahead of the usual maximum, and in 2004 a short, strong peak happened close to that anticipated pre-peak time, though activity seemed to be roughly normal in 2005, and the 2006 return was badly moonlit and poorly-observed.

An average annual shift of $+0\overset{\circ}{.}05$ in the $\lambda_{\odot}$ of the 'old' primary peak had been deduced from 1991–99 data, and allowing for this could give a possible recurrence time around $16^{\rm h}40^{\rm m}$ UT on August 12 ($\lambda_{\odot} = 140\overset{\circ}{.}21$), if so a few hours after the most probable maximum, that of the 'traditional' peak always previously found, given above. The timing of a tertiary peak, not seen in IMO data since 1999, would be around $\lambda_{\odot} = 140\overset{\circ}{.}4$, $21^{\rm h}30^{\rm m}$ UT on August 12. While recent observations imply only the 'traditional' peak is liable to recur in 2008, observers should be aware of these additional timings as possibilities, and plan their efforts accordingly, just in case!



The waxing gibbous Moon will be setting between local midnight and $01^{\rm h}30^{\rm m}$ on August 12/13 for the mid-northern latitudes best-placed to follow the shower (moonset is progressively earlier for places further north), leaving some dark skies to cover whatever happens. For these same locations, the Perseid radiant is viably observable from $22^{\rm h}$–$23^{\rm h}$ local time onwards, gaining altitude throughout the night, so circumstances overall are quite favourable. The 'traditional' maximum timing would be best-viewed from places in and around the northern Pacific Ocean, including the extreme west of North America west as far as extreme eastern Japan and China, assuming it happens as expected.

All forms of observing can be usefully carried out on the shower. For example, video data has been used in the latest IMO analyses to clarify and refine the radiant position for the shower – and to confirm that the occasional visual suspicions the radiant may be multiple are almost certainly only illusory. The only negative aspect to the shower is the impossibility of covering it from the bulk of the southern hemisphere.

Aurigid-Perseid Showers

α-Aurigids (AUR)

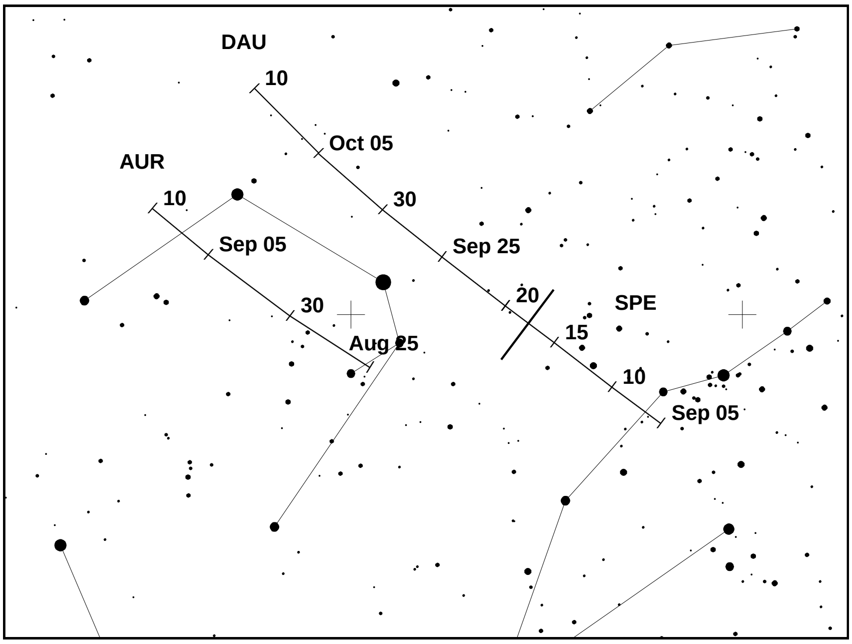
Active: August 25–September 8; Maximum: August 31, 19^h UT ($\lambda_\odot = 158.°6$); ZHR = 7;
Radiant: $\alpha = 84°$, $\delta = +42°$; Radiant drift: see Table 6;
$V_\infty = 66$ km/s; $r = 2.6$;
TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$ ($\beta > 10°$ S).

September Perseids (SPE)

Active: September 5–17; Maximum: September 9, 03^h UT ($\lambda_\odot = 166.°7$); ZHR = 5;
Radiant: $\alpha = 60°$, $\delta = +47°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 2.9$;
TFC: As AUR.

δ-Aurigids (DAU)

Active: September 18–October 10; Maximum: September 28 ($\lambda_\odot = 186°$), but see text; ZHR = 3;
Radiant: $\alpha = 82°$, $\delta = +49°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 2.9$;
TFC: As AUR.



These essentially northern hemisphere showers appear to be part of a series of poorly-observed sources with radiants in Aries, Perseus, Cassiopeia and Auriga, active from late August into October. British and Italian observers independently reported a possible new radiant in Aries during late August 1997 for example. IMO investigations using using data collected since 1986 have suggested there are at least three distinct showers which repeat annually, of which the α-Aurigids is the marginally stronger. The other two are the September Perseids and δ-Aurigids.

The α-Aurigids have produced short, unexpected, outbursts at times, with EZHRs of $\sim$ 30–40 recorded in 1935, 1986 and 1994, although they have not been monitored regularly until very recently, so other events may have been missed. Only three watchers in total covered the 1986 and 1994 outbursts, for instance! The badly moonlit 2007 event, for which another, perhaps still stronger, outburst had been predicted, was still to come when this text was prepared, which, whether anything unusual occurred or not, may have implications for future returns. All three Aurigid-Perseid radiants reach useful elevations after 23^h–00^h local time, and this year conditions are perfect for the α-Aurigid peak, with new Moon preceding it by just one day.

The September Perseids were formerly called the 'δ-Aurigids' on the IMO Working List of Visual Showers, with that earlier shower now separated into two. The final decision on the relevance of the separation has to be based on multiple-station imaging. The date of the split between the two has been set to coincide with the lowest ZHRs from either, and the showers should be treated as distinct in your observations at present. The September 9 maximum is favoured by a waxing gibbous Moon, which sets at about the time the radiant can first be properly observed, between 23^h–00^h, from mid-northern locations.

As the less active phase of the new September Perseids, the δ-Aurigids seem to give a weak and very ill-defined maximum between roughly $\lambda_\odot = 181°–191°$ (2008 September 23 to October 3). September 28 is about the middle of this peak interval, which almost coincides with new Moon this year, though the earlier part of this maximum spell will still have some problems from the last quarter Moon, because the radiant and the Moon will be nicely risen only after local midnight.

Telescopic data to examine all the radiants in this region of sky – and possibly observe the telescopic β–Cassiopeids simultaneously – would be especially valuable, but still-imaging, video records and visual plotting would be welcomed too.

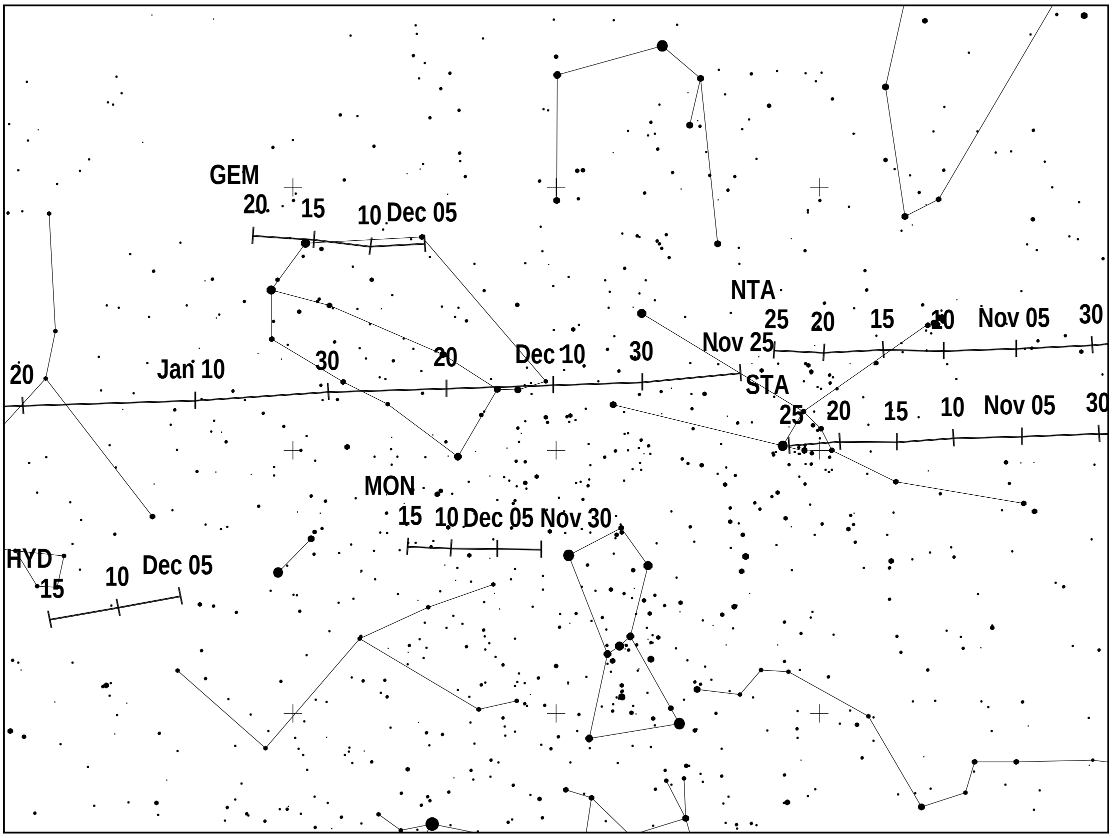
6 October to December

A weak final quarter to the year sees the best from the most active showers lost to the bright Moon, though there are still some positive aspects to it. While the latter stages of the minor δ-Aurigid peak may carry over into the opening days of October, the Antihelion Source's activity does not. Indeed, the ANT is to be considered in abeyance in favour of the Taurids from late September until late November, when the Antihelion radiant centre returns to activity in eastern Taurus. During December, it tracks across southern Gemini, and although analyses indicate its likely ZHRs are < 2 for most of this time, some of this apparent inactivity may be due to the strength of the Geminids very close-by to the north during part of December, plus also the minor Monocerotids a little way to its south simultaneously.

October 5/6 meteors: In 2005 and 2006, European video observers recorded short-lived outbursts from a north-circumpolar radiant near the 'tail' of Draco, around the Dra-Cam border, on October 5/6. The 2005 event (only) was recorded very weakly by radio, but no visual results confirmed either occurrence. Any 2007 event was still to come when this was written, but 2008 brings a good chance to check for it again. The 2005–06 events happened between $\lambda_\odot \sim 192\overset{\circ}{.}55$–$192\overset{\circ}{.}64$, equivalent to 2008 October 5, 13^h15^m–15^h30^m UT. The radiant was found around $\alpha \sim 165°$, $\delta \sim +78°$, the meteors with an atmospheric velocity of $\sim$ 45–50 km/s. If the active interval keeps to the same time, it would be best-observed from central Asia east to the extreme west of North America, and has only a waxing crescent Moon as accompaniment.

The potential Draconid epoch in early October survives the Moon, but the minor ε-Geminids (peak due on October 18) and the major Orionids (maximum expected on October 20/21) have a waning gibbous to last quarter Moon, visible when their radiants are, so will likely struggle to be usefully seen. However, following the unexpectedly strong Orionid activity in 2006, when ZHRs were around 50–60 at best, with many bright meteors, and the fact the shower may be nearing the peak of its theoretical 12-year cycle (like its twin, the η-Aquarids of April-May), observing may still be worthwhile, in case such better rates should manifest again this year. The new very weak possible shower of the Leo Minorids has fewer moonlight problems in late October, while October's new Moon also assists viewing the possible Taurid 'swarm' return interval in late October to early November.

Leonids: The Leonids may produce just a normal maximum close to their 'traditional' nodal time in 2008, on November 17, around 09^{h} UT, though the bright waning Moon will be a severe problem if so. However, Mikhail Maslov proposed that the shower may show a peak with ZHRs ~ 130 at $00^{h}22^{m}$ UT on November 17 in *WGN* 35:1 (2006, p. 7), with meteors brighter than average. Many of his other model calculations for the Leonids in the period 2001–2006 showed considerable differences to what was actually observed – including suggesting the two storm peaks of 2002 would fall on November 18, not November 19 – so while this is an interesting possibility for 2008, its accuracy is unknown and unproven. Jérémie Vaubaillon finds instead two potential stream encounters, centred on November 17 at $01^{h}32^{m}$ UT (1466 trail; ZHR most uncertain – perhaps ~ 50, but maybe ~ 25–100) and November 18 at $21^{h}38^{m}$ UT (1932 trail; ZHR possibly ~ 20 at best?). Checking on all these times (or any others that may be suggested subsequently) will be difficult due to the Moon, but valuable.



Later in November, the α-Monocerotids should peak far enough after last quarter Moon to mostly survive the moonlight. Into December, and the Phoenicids have a bright Moon to contend with for their possible maximum, due at about 03^{h} UT on December 6, with a similar problem for what may be the better activity during early December for the Puppids-Velids. The minor Monocerotids just survive the waxing Moon, but the σ-Hydrid (December 11) and Geminid (December 13, $23^{\rm h} \pm 2^{\rm h}\!.3$) maxima are both too near full Moon for detailed visual observations. The Geminids' strength does mean they would be worth looking out for if skies are clear though, but more out of casual interest than scientific investigation. The year does at least end better, with largely moonless returns of the Ursids and Coma Berenicids.

Draconids (GIA)

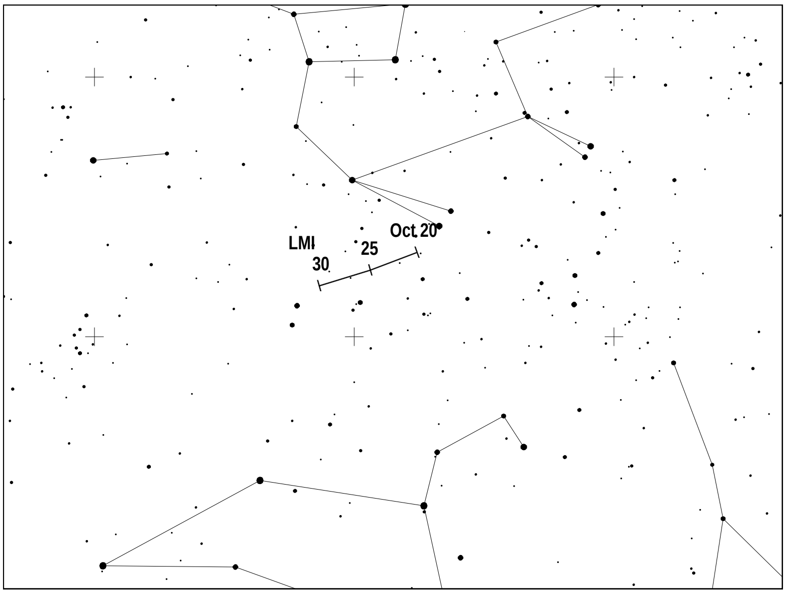
Active: October 6–10; Maximum: October 8, $10^{\rm h}30^{\rm m}$ UT ($\lambda_\odot = 195\,^\circ\!\!.4$, but see below);
ZHR = periodic, up to storm levels;
Radiant: $\alpha = 262^\circ$, $\delta = +54^\circ$; Radiant drift: negligible;
$V_\infty = 20$ km/s; $r = 2.6$;
TFC: $\alpha = 290^\circ$, $\delta = +65^\circ$ and $\alpha = 288^\circ$, $\delta = +39^\circ$ ($\beta > 30^\circ$ N).

The Draconids are primarily a periodic shower which produced spectacular, brief, meteor storms twice last century, in 1933 and 1946, and lower rates in several other years (ZHRs $\sim$ 20–500+). Most detected showers were in years when the stream's parent comet, 21P/Giacobini-Zinner, returned to perihelion, as it did last in 2005 July. Its orbital period is currently about 6.6 years. In 2005 October, a largely unexpected outburst happened near the comet's nodal crossing time, around $\lambda_\odot = 195\,^\circ\!\!.40$–$195\,^\circ\!\!.44$, probably due to material shed in 1946. Visual ZHRs were $\sim$ 35, though radar detections suggested a much higher estimated rate, closer to $\sim$ 150. The peak was found in radio results too, but it did not record especially strongly that way. Outlying maximum times from the recent past have spanned from $\lambda_\odot = 195\,^\circ\!\!.075$ (in 1998; EZHRs $\sim$ 700), equivalent to 2008 October 8, $02^{\rm h}40^{\rm m}$ UT, through the nodal passage time above, to $\lambda_\odot = 195\,^\circ\!\!.63$–$195\,^\circ\!\!.76$ (a minor outburst in 1999, not a perihelion-return year; ZHRs $\sim$ 10–20), equating to 2008 October 8, $16^{\rm h}$–$19^{\rm h}30^{\rm m}$ UT. The radiant is circumpolar from many northern hemisphere locations, but is higher in the pre-midnight and near-dawn hours of early October. For such sites, the waxing gibbous Moon rises between $\sim 21^{\rm h}$–$23^{\rm h}$ local solar time on October 7/8 and between $\sim 23^{\rm h}$–$00^{\rm h}$ on October 8/9, meaning the first part of the night is available for dark-sky checking, whatever the shower may yield – even if that is nothing detectable. Draconid meteors are exceptionally slow-moving, a characteristic which helps separate genuine shower meteors from sporadics accidentally lining up with the radiant.

Leo Minorids (LMI)

Active: October 19–27; Maximum: October 24 ($\lambda_\odot = 211^\circ$); ZHR = 2;
Radiant: $\alpha = 162^\circ$, $\delta = +37^\circ$; Radiant drift: See Table 6;
$V_\infty = 62$ km/s; $r = 3.0$;
TFC: $\alpha = 190^\circ$, $\delta = +58^\circ$ and $\alpha = 135^\circ$, $\delta = +30^\circ$ ($\beta > 40^\circ$ N).

The second new addition to the Working List during the current revision, this is a weak minor shower, and its peak ZHR appears to be on or below the visual threshold. Low rates may be a result of neglecting the shower during the vast majority of late-October observations though. Imaging results have found signs of a radiant near the proposed position, but there is almost no reliable visual information on when the shower is most probably active, nor when its peak is. The details above are simply a best-guess. The radiant area can be seen only from the northern hemisphere, and rises around midnight. The proposed maximum date sees the waning crescent Moon rising between 01^h–02^h at mid-northern latitudes, but this should not be too great a problem even so. Telescopic or imaging observations are advised.



Taurids

Southern Taurids (STA)

Active: September 25–November 25; Maximum: November 5 ($\lambda_\odot = 223°$); ZHR = 5;
Radiant: $\alpha = 52°$, $\delta = +15°$; Radiant drift: see Table 6;
$V_\infty = 27$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\sim 10°$ E or W of the radiants ($\beta > 40°$ S).

Northern Taurids (NTA)

Active: September 25–November 25; Maximum: November 12 ($\lambda_\odot = 230°$); ZHR = 5;
Radiant: $\alpha = 58°$, $\delta = +22°$; Radiant drift: see Table 6;
$V_\infty = 29$ km/s; $r = 2.3$;
TFC: as Southern Taurids.

These two streams form part of the complex associated with Comet 2P/Encke. Defining their radiants is best achieved by careful visual or telescopic plotting, or imaging recordings, since they are large and diffuse. Each radiant should be considered an oval area of $\sim 20° \times 10°$, $\alpha \times \delta$, centred on the radiant position for that date, for shower association. Their activity very clearly dominates the Antihelion Source area's during the northern autumn, so much so that the ANT is considered inactive while they are present.

The brightness and relative slowness of many shower meteors makes them ideal targets for still-imaging, while these factors coupled with low, steady, combined Taurid rates makes them excellent subjects for newcomers to practice their plotting techniques on. The activity of both showers produces an apparently plateau-like maximum for about ten days in early November, and they have a reputation for producing some excellently bright fireballs at times, although seemingly not in every year.

Studies by David Asher have indicated that increased Taurid fireball rates may result from a 'swarm' of larger particles within the Taurid stream complex, and he suggested such 'swarm' returns might happen in 1995, 1998 and 2005 most recently. In 1995, an impressive crop of bright Taurids occurred between late October to mid November, while in 1998, Taurid ZHRs reached levels comparable to the usual maximum rates in late October, together with an increased flux of brighter Taurids generally. The 2005 event was the most impressive and best-observed yet, with a lot of, occasionally very brilliant, fireballs, and enhanced combined ZHRs of $\sim$ 10–15, that persisted from about October 29 to November 10. Another 'swarm' return is predicted for 2008, while late October into early November has a new to first quarter Moon, so all observers should be alert to cover whatever happens (but do remember that nothing is ever guaranteed in meteor astronomy!).

The Southern Taurid maximum will have relatively little lunar interference, but the Northern peak falls just a day before full Moon, so will likely be missed this time. The near-ecliptic radiants for both shower branches mean all meteoricists can observe these streams, albeit northern hemisphere observers are somewhat better-placed, as here suitable radiant zenith distances persist for much of the night. Even in the southern hemisphere, a good 3–5 hours' watching around local midnight is possible with Taurus well above the horizon, however.

α-Monocerotids (AMO)

Active: November 15–25; Maximum: November 21, $09^{\mathrm{h}}25^{\mathrm{m}}$ UT ($\lambda_{\odot} = 239\overset{\circ}{.}32$);
ZHR = variable, usually $\sim$ 5, but may produce outbursts to $\sim$ 400+;
Radiant: $\alpha = 118°$, $\delta = +01°$; Radiant drift: see Table 6;
$V_{\infty} = 65$ km/s; $r = 2.4$;
TFC: $\alpha = 115°$, $\delta = +23°$ and $\alpha = 129°$, $\delta = +20°$ ($\beta > 20°$ N);
or $\alpha = 110°$, $\delta = -27°$ and $\alpha = 098°$, $\delta = +06°$ ($\beta < 20°$ N).

A late-year shower capable of producing surprises, the α-Monocerotids gave their most recent brief outburst in 1995 (the top EZHR, $\sim$ 420, lasted just five minutes; the entire outburst 30 minutes). Many observers across Europe witnessed it, and we were able to completely update the known shower parameters as a result. However, the proposed ten-year periodicity in such returns passed unconfirmed when nothing unusual took place during the moonlit shower of 2005. Due to this, all observers need to monitor this source closely in every year, to try to spot the next outburst. The brevity of all past outbursts means breaks under clear skies should be kept to an absolute minimum near the predicted peak. Although the Moon is a waning crescent on November 21, it will rise between 00^{h} and 01^{h} across the globe then, which will make it something of a nuisance, as the AMO radiant is well on view from either hemisphere only after about 23^{h} local time. If correct, the peak timing would fall well for sites across North and Central America.

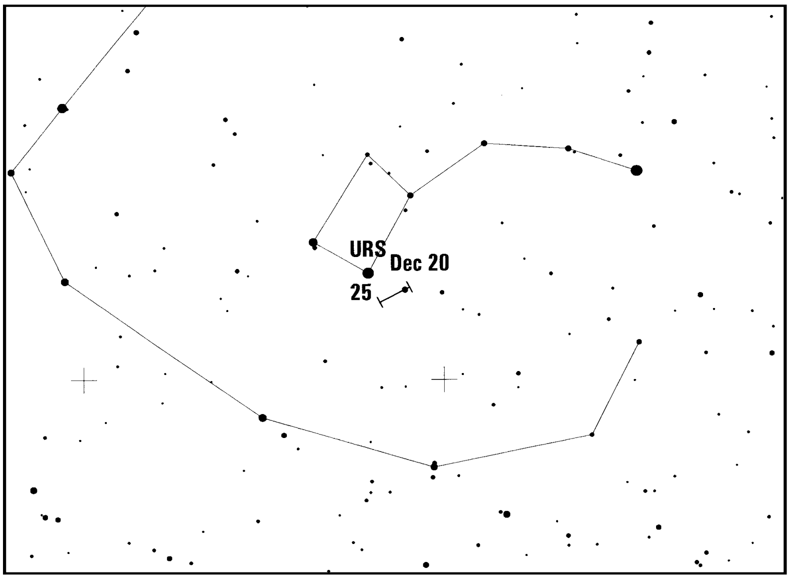
Monocerotids (MON)

Active: November 27–December 17; Maximum: December 8 ($\lambda_{\odot} = 257°$); ZHR = 2;
Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6;
$V_{\infty} = 42$ km/s; $r = 3.0$;
TFC: $\alpha = 088°$, $\delta = +20°$ and $\alpha = 135°$, $\delta = +48°$ ($\beta > 40°$ N);
or $\alpha = 120°$, $\delta = -03°$ and $\alpha = 084°$, $\delta = +10°$ ($\beta < 40°$ N).

Only low rates are likely from this very minor source, making accurate visual plotting, telescopic or video work essential, particularly because the meteors are normally faint. The shower's details, even including its radiant position, are rather uncertain. Recent IMO data showed only weak signs of a maximum as indicated above. Telescopic results have suggested a later maximum, around $\lambda_{\odot} \sim 264°$, 2008 December 15, from a radiant at $\alpha = 117°$, $\delta = +20°$. The waxing Moon sets between 01^{h} and $02^{h}30^{m}$ on December 8, reasonable news as the radiant area is on-show virtually all night, culminating about $1^{h}30^{m}$ local time. A December 15 peak would be very unfavourable however, as too near full Moon.

Ursids (URS)

Active: December 17–26; Maximum: December 22, $07^{h}30^{m}$ UT ($\lambda_{\odot} = 270\overset{\circ}{.}7$);
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 6;
$V_{\infty} = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348°$, $\delta = +75°$ and $\alpha = 131°$, $\delta = +66°$ ($\beta > 40°$ N);
$\alpha = 063°$, $\delta = +84°$ and $\alpha = 156°$, $\delta = +64°$ (β 30° to 40° N).



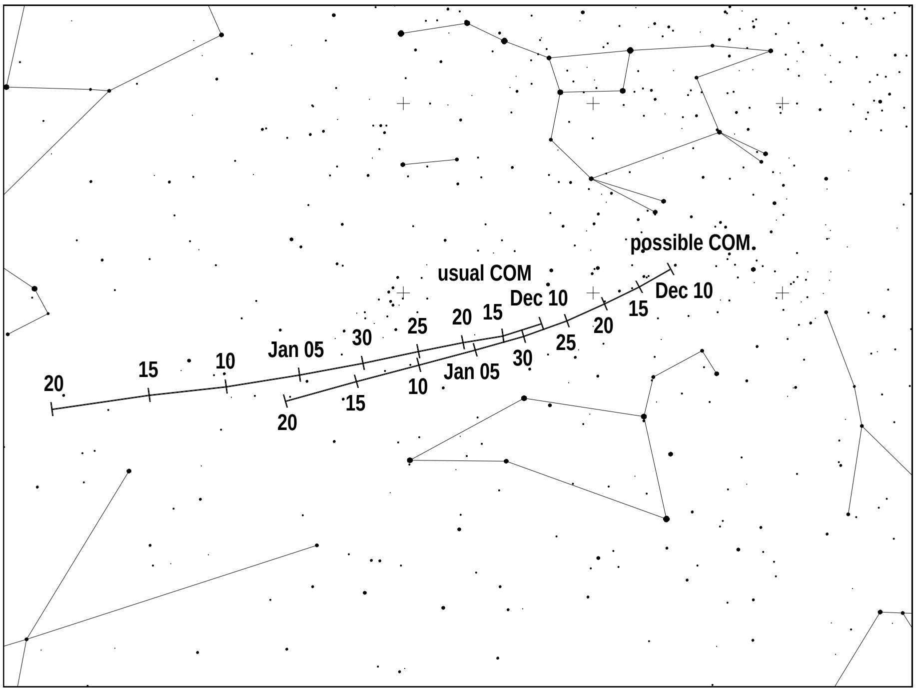
A very poorly-observed northern hemisphere shower, but one which has produced at least two major outbursts in the past 70 years, in 1945 and 1986. Several other rate enhancements, recently in 1988, 1994, 2000 and 2006 (when ZHRs were around 30 for two hours or more), have been reported too. Other similar events could easily have been missed due to poor weather or too few observers active. All forms of observation can be used for the shower, since many of its meteors are faint, but with so little work carried out on the stream, it is impossible to be precise in making statements about it. The radio maximum in 1996 occurred around $\lambda_{\odot} = 270\overset{\circ}{.}8$, for instance, which might suggest a slightly later maximum time in 2008 of December 22, $\sim 10^{h}$ UT, while the 2000 enhancement was seen surprisingly strongly (EZHR ~ 90) by video at $\lambda_{\odot} = 270\overset{\circ}{.}78$ (equivalent to 2008 December 22, $09^{h}30^{m}$ UT), although the visual enhancement then was much less, ZHR ~ 30. Whether the relative proximity of the shower's parent comet, 8P/Tuttle, at perihelion on January 26 this year, will have any influence on the shower this December, is unclear, though no such direct linkage has been apparent previously. The Ursid radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The waning crescent Moon should cause few difficulties for observing the maximum on this occasion, and if any recur as suggested, the peak timings should favour northerly sites between North America westwards across the Pacific Ocean to east Asia, including Japan and China.

Coma Berenicids (COM)

Active: December 12–January 23; Maximum: December 29 ($\lambda_{\odot} = 278°$); ZHR = 5;
Radiant: $\alpha = 185°$, $\delta = +21°$; Radiant drift: see Table 6;
$V_\infty = 65$ km/s; $r = 3.0$;
TFC: $\alpha = 180°$, $\delta = +50°$ and $\alpha = 165°$, $\delta = +20°$ before $3^{\rm h}$ local time,
$\alpha = 195°$, $\delta = +10°$ and $\alpha = 200°$, $\delta = +45°$ after $3^{\rm h}$ local time ($\beta > 20°$ N).

One of the significant bonuses of the new Working List upgrade has been to define a rather better visual activity profile for the Coma Berenicids than had been possible previously. The shower was confirmed as quite weak, but apparently long-lasting, though coverage after the Quadrantid epoch in January still left many gaps, a period which needs more observations. The maximum was found to be about ten days later in December than previously thought too, hence the amended parameters above.

The radiant ephemeris of the shower is severely questioned after the scrutinization of single-station video data showing a clear radiant drift with an offset of about 15° to the Working List positions. The result is given as 'possible COM' in the figure below. We recommend to use the old positions in 2008, while meteors from the 'possible COM' position should be noted separately.



In 2006, Spanish video observers reported an unexpected COM outburst on December 24/25, with EZHRs suggested as perhaps ~ 60, but this was not apparent in any of the radio observations then, nor in another detailed set of video observations made in Italy at the same time, so it remains uncertain. Since the possible outburst came from the 'old' COM position, the new ephemeris from video data may actually indicate a separate source rather than an erroneous COM drift.

There is much we still do not know about this shower, and as it is almost unobservable from the southern hemisphere, northern watchers must brave the winter cold to improve matters. The radiant is at a useful elevation from local midnight onwards, and new Moon near the probable peak makes this a particularly good year to make observations.

7 Radiant sizes and meteor plotting for visual observers

by Rainer Arlt

If you are not observing during a major-shower maximum, it is essential to associate meteors with their radiants correctly, since the total number of meteors will be small for each source. Meteor plotting allows shower association by more objective criteria after your observation than the simple imaginary back-prolongation of paths under the sky. With meteors plotted on gnomonic maps, you can trace them back to their radiants by extending their straight line paths. If a radiant lies on another chart, you should find common stars on an adjacent chart to extend this back-prolongation correctly.

How large a radiant should be assumed for shower association? The real physical radiant size is very small, but visual plotting errors cause many true shower meteors to miss this real radiant area. Thus we have to assume a larger effective radiant to allow for these errors. Unfortunately, as we enlarge the radiant, so more and more sporadic meteors will appear to line up accidentally with this region. Hence we have to apply an optimum radiant diameter to compensate for the plotting errors loss, but which will not then be swamped by sporadic meteor pollution. Table 1 gives this optimum diameter as a function of the distance of the meteor from the radiant.

Table 1. Optimum radiant diameters to be assumed for shower association of minor-shower meteors as a function of the radiant distance D of the meteor.

D	optimum diameter
15°	14°
30°	17°
50°	20°
70°	23°

Note that this radiant diameter criterion applies to all shower radiants **except** those of the Southern and Northern Taurids, and the Antihelion Source, all of which have notably larger radiant areas. The optimum $\alpha \times \delta$ size to be assumed for each radiant of the two Taurid showers is instead 20° × 10°, while that for the Antihelion Source is still larger, at 30° × 15°.

Path-direction is not the only criterion for shower association. The angular velocity of the meteor should match the expected speed of the given shower meteors according to their geocentric velocities. Angular velocity estimates should be made in degrees per second (°/s). To do this, make the meteors you see move for one second in your imagination at the speed you saw them. The path length of this imaginary meteor is the angular velocity in °/s. Note that typical speeds are in the range 3°/s to 25°/s. Typical errors for such estimates are given in Table 2.

Table 2. Error limits for the angular velocity

angular velocity [°/s]	5	10	15	20	30
permitted error [°/s]	3	5	6	7	8

If you find a meteor in your plots which passes the radiant within the diameter given by Table 1, check its angular velocity. Table 3 gives the angular speeds for a few geocentric velocities, which can then be looked up in Table 5 for each shower.

Table 3. Angular velocities as a function of the radiant distance of the meteor (D) and the elevation of the meteor above the horizon (h) for three different geocentric velocities (V_∞). All velocities are in °/s.

$h\backslash D$	$V_\infty = 25$ km/s					$V_\infty = 40$ km/s					$V_\infty = 60$ km/s				
	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°
10°	0.4	0.9	1.6	2.2	2.5	0.7	1.4	2.6	3.5	4.0	0.9	1.8	3.7	4.6	5.3
20°	0.9	1.7	3.2	4.3	4.9	1.4	2.7	5.0	6.8	7.9	1.8	3.5	6.7	9.0	10
40°	1.6	3.2	5.9	8.0	9.3	2.6	5.0	9.5	13	15	3.7	6.7	13	17	20
60°	2.2	4.3	8.0	11	13	3.5	6.8	13	17	20	4.6	9.0	17	23	26
90°	2.5	4.9	9.3	13	14	4.0	7.9	15	20	23	5.3	10	20	26	30

8 Abbreviations

- α, δ: Coordinates for a shower's radiant position, usually at maximum. α is right ascension, δ is declination. Radiants drift across the sky each day due to the Earth's own orbital motion around the Sun, and this must be allowed for using the details in Table 6 for nights away from the listed shower maxima.
- r: The population index, a term computed from each shower's meteor magnitude distribution. $r = 2.0$–2.5 is brighter than average, while r above 3.0 is fainter than average.
- $\lambda_\odot$: Solar longitude, a precise measure of the Earth's position on its orbit which is not dependent on the vagaries of the calendar. All $\lambda_\odot$ are given for the equinox 2000.0.
- V_∞: Atmospheric or apparent meteoric velocity, given in km/s. Velocities range from about 11 km/s (very slow) to 72 km/s (very fast). 40 km/s is roughly medium speed.
- ZHR: Zenithal Hourly Rate, a calculated maximum number of meteors an ideal observer would see in perfectly clear skies with the shower radiant overhead. This figure is given in terms of meteors per hour. Where meteor activity persisted at a high level for less than an hour, or where observing circumstances were very poor, an estimated ZHR (EZHR) is used, which is less accurate than the normal ZHR.
- TFC and IFC: Suggested telescopic and still-imaging (including photographic) field centres respectively. β is the observer's latitude ('$<$' means 'south of' and '$>$' means 'north of'). *Pairs* of telescopic fields must be observed, alternating about every half hour, so that the positions of radiants can be defined. The exact choice of TFC or IFC depends on the observer's location and the elevation of the radiant. Note that the TFCs are also useful centres to use for video camera fields as well.

Table 4. Lunar phases for 2008.

New Moon	First Quarter	Full Moon	Last Quarter
January 8	January 15	January 22	January 30
February 7	February 14	February 21	February 29
March 7	March 14	March 21	March 29
April 6	April 12	April 20	April 28
May 5	May 12	May 20	May 28
June 3	June 10	June 18	June 26
July 3	July 10	July 18	July 25
August 1	August 8	August 16	August 23
August 30	September 7	September 15	September 22
September 29	October 7	October 14	October 21
October 28	November 6	November 13	November 19
November 27	December 5	December 12	December 19
December 27			

Table 5. Working List of Visual Meteor Showers. Details in this Table were correct according to the best information available in May 2007, with maximum dates accurate only for 2008. Except for the two Antihelion Source line, all other showers are listed in order of their maximum solar longitude. An asterisk ('*') in the 'Shower' column indicates that source may have additional peak times, as noted in the text above. The parenthesized maximum date for the Puppids-Velids indicates a reference date for the radiant only, not necessarily a true maximum. Some showers have ZHRs that vary from year to year. The most recent reliable figure is given here, except for possibly periodic showers. These are either noted as 'Var' = variable, where there is considerable uncertainty over the likely maximum rates, or with an asterisk to indicate the value is that suggested from theoretical considerations for the current year. For more information, contact the IMO's Visual Commission.

Shower	Activity	Maximum Date	Maximum $\lambda_\odot$	Radiant α	Radiant δ	V_∞ km/s	r	ZHR
Antihelion Source (ANT)	Nov 26–Sep 24	late May, late June		see Table 6		30	3.0	3
Quadrantids (QUA)	Jan 01–Jan 05	Jan 04	283°.16	230°	+49°	41	2.1	120
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 08	319°.2	211°	−59°	56	2.0	5
δ-Leonids (DLE)	Feb 15–Mar 10	Feb 25	336°	168°	+16°	23	3.0	2
γ-Normids (GNO)	Feb 25–Mar 22	Mar 13	353°	239°	−50°	56	2.4	4
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32°.32	271°	+34°	49	2.1	18
π-Puppids (PPU)	Apr 15–Apr 28	Apr 23	33°.5	110°	−45°	18	2.0	Var
η-Aquarids (ETA)	Apr 19–May 28	May 05	45°.5	338°	−01°	66	2.4	70+*
η-Lyrids (ELY)	May 03–May 12	May 08	48°.4	287°	+44°	44	3.0	3
June Bootids (JBO)	Jun 22–Jul 02	Jun 27	95°.7	224°	+48°	18	2.2	Var
Piscis Austrinids (PAU)	Jul 15–Aug 10	Jul 27	125°	341°	−30°	35	3.2	5
South. δ-Aquarids (SDA)	Jul 12–Aug 19	Jul 27	125°	339°	−16°	41	3.2	20
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 29	127°	307°	−10°	23	2.5	4
Perseids (PER)*	Jul 17–Aug 24	Aug 12	140°.0	46°	+58°	59	2.6	100
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 17	145°	286°	+59°	25	3.0	3
α-Aurigids (AUR)	Aug 25–Sep 08	Aug 31	158°.6	84°	+42°	66	2.6	7
September Perseids (SPE)	Sep 05–Sep 17	Sep 09	166°.7	60°	+47°	64	2.9	5
δ-Aurigids (DAU)	Sep 18–Oct 10	Oct 03	191°	88°	+49°	64	2.9	3
Draconids (GIA)	Oct 06–Oct 10	Oct 08	195°.4	262°	+54°	20	2.6	Var
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	2
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.5	30*
Leo Minorids (LMI)	Oct 19–Oct 27	Oct 24	211°	162°	+37°	62	3.0	2
Southern Taurids (STA)	Sep 25–Nov 25	Nov 05	223°	52°	+15°	27	2.3	5
Northern Taurids (NTA)	Sep 25–Nov 25	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (LEO)	Nov 10–Nov 23	Nov 17	235°.27	153°	+22°	71	2.5	20+*
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 21	239°.32	117°	+01°	65	2.4	Var
Dec Phoenicids (PHO)	Nov 28–Dec 09	Dec 06	254°.25	18°	−53°	18	2.8	Var
Puppid/Velids (PUP)	Dec 01–Dec 15	(Dec 06)	(255°)	123°	−45°	40	2.9	10
Monocerotids (MON)	Nov 27–Dec 17	Dec 08	257°	100°	+08°	42	3.0	2
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 11	260°	127°	+02°	58	3.0	3
Geminids (GEM)	Dec 07–Dec 17	Dec 13	262°.2	112°	+33°	35	2.6	120
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 20	268°	177°	+25°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	3.0	10

Table 6 (next page). Radiant positions during the year in α and δ.

Date		ANT		QUA		COM									
Dec	31	112°	+21°	228°	+50°	186°	+20°								
Jan	5	117°	+20°	231°	+49°	190°	+18°								
Jan	10	122°	+19°			194°	+17°								
Jan	15	127°	+17°			198°	+15°								
Jan	20	132°	+16°			202°	+13°								
Jan	25	138°	+15°					**ACE**							
Jan	30	143°	+13°					200°	−57°						
Feb	5	149°	+11°					208°	−59°						
Feb	10	154°	+9°					214°	−60°	**DLE**					
Feb	15	159°	+7°					220°	−62°	159°	+19°				
Feb	20	164°	+5°	**GNO**				225°	−63°	164°	+18°				
Feb	28	172°	+2°	225°	-51°					171°	+15°				
Mar	5	177°	0°	230°	-50°					176°	+13°				
Mar	10	182°	−2°	235°	-50°					180°	+12°				
Mar	15	187°	−4°	240°	-50°										
Mar	20	192°	−6°	245°	-49°										
Mar	25	197°	−7°												
Mar	30	202°	−9°												
Apr	5	208°	−11°												
Apr	10	213°	−13°	**LYR**		**PPU**									
Apr	15	218°	−15°	263°	+34°	106°	−44°	**ETA**							
Apr	20	222°	−16°	269°	+34°	109°	−45°	323°	−7°						
Apr	25	227°	−18°	274°	+34°	111°	−45°	328°	−5°						
Apr	30	232°	−19°					332°	−3°	**ELY**					
May	05	237°	−20°					337°	−1°	283°	+44°				
May	10	242°	−21°					341°	+1°	288°	+44°				
May	15	247°	−22°					345°	+3°	293°	+45°				
May	20	252°	−22°					349°	+5°						
May	25	256°	−23°												
May	30	262°	−23°												
Jun	5	267°	−23°												
Jun	10	272°	−23°												
Jun	15	276°	−23°												
Jun	20	281°	−23°	**JBO**											
Jun	25	286°	−22°	223°	+48°										
Jun	30	291°	−21°	225°	+47°	**CAP**									
Jul	5	296°	−20°			285°	−16°	**SDA**							
Jul	10	300°	−19°	**PER**		289°	−15°	325°	−19°	**PAU**					
Jul	15	305°	−18°	6°	+50°	294°	−14°	329°	−19°	330°	−34				
Jul	20	310°	−17°	11°	+52°	299°	−12°	333°	−18°	334°	−33				
Jul	25	315°	−15°	22°	+53°	303°	−11°	337°	−17°	338°	−31				
Jul	30	319°	−14°	29°	+54°	308°	−10°	340°	−16°	343°	−29	**KCG**			
Aug	5	325°	−12°	37°	+56°	313°	−8°	345°	−14°	348°	−27	283°	+58°		
Aug	10	330°	−10°	45°	+57°	318°	−6°	349°	−13°	352°	−26	284°	+58°		
Aug	15	335°	−8°	51°	+58°			352°	−12°			285°	+59°		
Aug	20	340°	−7°	57°	+58°	**AUR**		356°	−11°			286°	+59°		
Aug	25	344°	−5°	63°	+58°	76°	+42°					288°	+60°		
Aug	30	349°	−3°			82°	+42°	**SPE**				289°	+60°		
Sep	5	355°	−1°			88°	+42°	55°	+46°						
Sep	10	0°	+1°			92°	+42°	60°	+47°						
Sep	15	5°	+3°					66°	+48°	**DAU**					
Sep	20	10°	+5°	**NTA**		**STA**		71°	+48°	71°	+48°				
Sep	25	14°	+7°	19°	+11°	21°	+6°			77°	+49°				
Sep	30			22°	+12°	25°	+7°	**ORI**		83°	+49°				
Oct	5			26°	+14°	28°	+8°	85°	+14°	89°	+49°			**GIA**	
Oct	10	**EGE**		30°	+15°	32°	+9°	88°	+15°	92°	+42°			262°	+54°
Oct	15	99°	+27°	34°	+16°	36°	+11°	91°	+15°			**LMI**			
Oct	20	104°	+27°	38°	+18°	40°	+12°	94°	+16°			158°	+39°		
Oct	25	109°	+27°	43°	+19°	43°	+13°	98°	+16°			163°	+37°		
Oct	30			47°	+20°	47°	+14°	101°	+16°			168°	+35°		
Nov	5			52°	+21°	52°	+15°	105°	+17°	**LEO**					
Nov	10			56°	+22°	56°	+15°			147°	+24°			**AMO**	
Nov	15			61°	+23°	60°	+16°			150°	+23°			112°	+2°
Nov	20	**ANT**		65°	+24°	64°	+16°			153°	+21°			116°	+1°
Nov	25	75°	+23°	70°	+24°	72°	+17°	**MON**		**PHO**		**PUP**		120°	0°
Nov	30	80°	+23°	**GEM**				91°	+8°	14°	−52°	120°	−45°	**HYD**	
Dec	5	85°	+23°	103°	+33°	**COM**		96°	+8°	18°	−53°	122°	−45°	122°	+3°
Dec	10	90°	+23°	108°	+33°	169°	+27°	100°	+8°	22°	−53°	125°	−45°	126°	+2°
Dec	15	96°	+23°	113°	+33°	173°	+26°	104°	+8°	**URS**		128°	−45°	130°	+1°
Dec	20	101°	+23°	118°	+32°	177°	+24°			217°	+76°				
Dec	25	106°	+22°			181°	+23°			217°	+74°				
Dec	30	111°	+21°			185°	+21°								

Table 7. Working List of Daytime Radio Meteor Streams. An asterisk ('*') in the 'Max date' column indicates that source may have additional peak times, as noted in the text above. The 'Best Observed' columns give the approximate local mean times between which a four-element antenna at an elevation of 45° receiving a signal from a 30 kW transmitter 1000 km away should record at least 85% of any suitably positioned radio-reflecting meteor trails for the appropriate latitudes. Note that this is often heavily dependent on the compass direction in which the antenna is pointing, however, and applies only to dates near the shower's maximum. An asterisk in the 'Rate' column shows the suggested rate may not recur in all years.

Shower	Activity	Max Date	$\lambda_\odot$ 2000	Radiant α	Radiant δ	Best observed 50° N	Best observed 35° S	Rate
Cap/Sagittarids	Jan 13–Feb 04	Feb 02*	312.°5	299°	−15°	11^h–14^h	09^h–14^h	Medium*
χ-Capricornids	Jan 29–Feb 28	Feb 14*	324.°7	315°	−24°	10^h–13^h	08^h–15^h	Low*
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30.°3	7°	+07°	07^h–14^h	08^h–13^h	Low
δ-Piscids	Apr 24–Apr 24	Apr 24	34.°2	11°	+12°	07^h–14^h	08^h–13^h	Low
ε-Arietids	Apr 24–May 27	May 09	48.°7	44°	+21°	08^h–15^h	10^h–14^h	Low
Arietids (May)	May 04–Jun 06	May 16	55.°5	37°	+18°	08^h–15^h	09^h–13^h	Low
o-Cetids	May 05–Jun 02	May 20	59.°3	28°	−04°	07^h–13^h	07^h–13^h	Medium*
Arietids	May 22–Jul 02	Jun 07*	76.°7	44°	+24°	06^h–14^h	08^h–12^h	High
ζ-Perseids	May 20–Jul 05	Jun 09*	78.°6	62°	+23°	07^h–15^h	09^h–13^h	High
β-Taurids	Jun 05–Jul 17	Jun 28	96.°7	86°	+19°	08^h–15^h	09^h–13^h	Medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152.°2	155°	+20°	08^h–16^h	10^h–14^h	Low*
Sextantids	Sep 09–Oct 09	Sep 27*	184.°3	152°	00°	06^h–12^h	06^h–13^h	Medium*

9 Useful addresses

For more information on observing techniques, and when submitting results, please contact the appropriate IMO Commission Director:

Fireball Data Center (FIDAC): André Knöfel, Am Observatorium 2, D-15848 Lindenberg, Germany; e-mail: `aknoefel@minorplanets.de`

Photographic Commission: Vacant. Questions can be sent to e-mail: `photo@imo.net`

Radio Commission: Vacant. Questions can be sent to e-mail: `radio@imo.net`

Telescopic Commission: Malcolm Currie, 25 Collett Way, Grove, Wantage, Oxfordshire, OX12 0NT, UK; e-mail: `mjc@star.rl.ac.uk`

Video Commission Sirko Molau, Abenstalstraße 13b, D-84072 Seysdorf, Germany; e-mail: `sirko@molau.de`

Visual Commission: Rainer Arlt, Friedenstraße 5, D-14109 Potsdam, Germany; e-mail: `rarlt@aip.de`

or contact IMO's Homepage on the World-Wide-Web at: `http://www.imo.net`

For further details on **IMO membership**, please write to: Robert Lunsford, IMO Secretary-General, 1828 Cobblecreek Street, Chula Vista, CA 91913-3917, USA; `lunro.imo.usa@cox.net`

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