## International Meteor Organization

# 2007 Meteor Shower Calendar

*compiled by Alastair McBeath*[1]

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## 1 Introduction

Welcome to the 2007 International Meteor Organization (IMO) Meteor Shower Calendar. The year looks set to be one of two unequal parts, with chiefly poorly-placed shower peaks through to the end of July, then a lot of virtually moonless shower maxima till mid December. The major Perseids and Geminids come off especially well, along with the possible Draconid epoch and Orionid maximum in October, the Taurids and Leonids in November, and most of the cluster of minor showers in early December. Of the stronger showers, the main lunar casualties are the Quadrantids, $\eta$-Aquarids, Southern $\delta$-Aquarids and Ursids. While monitoring meteor activity should ideally be carried on throughout the year, we appreciate that this is not practical for many people, so this Calendar was first devised back in 1991 as a means of helping observers deal with reality by highlighting times when a particular effort might most usefully be employed. Although we include timing predictions for all the more active night-time and daytime shower maxima, based on the best available data, it is essential to realise 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 only recently begun to receive regular attention again). In addition, variations in individual showers from year to year mean past returns are at best only a guide as to when even major shower peaks can be expected, plus as some showers are known to show particle mass-sorting within their meteoroid streams, the radio, still-imaging, telescopic, video and visual meteor maxima may occur at different times from one another, and not necessarily just in these showers. The majority of data available are for visual shower maxima, so this must be borne in mind when employing other observing techniques.

The heart of the Calendar is the Working List of Visual Meteor Showers (see Table 5 on page 26), thanks to regular updating from analyses using the IMO's Visual Meteor Database, the single most accurate listing available anywhere today for naked-eye meteor observing. Even this can never be a complete list of all meteor showers, since there are many showers which cannot be properly detected visually, and some which only imaging, radar or telescopic observations can separate from the background sporadic meteors, present throughout the year.

The IMO's aims are to encourage, collect, analyze, and publish combined meteor data obtained from sites all over the globe in order to further our understanding of the meteor activity detectable from the Earth's surface. Results from only a few localized places can never provide such total comprehension, and it is thanks to the efforts of the many IMO observers worldwide since 1988 that we have been able to achieve as much as we have to date. This is not a matter for complacency, however, since it is solely by the continued support of many people across the whole world that our steps towards constructing a better and more complete picture of the

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[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, and the new Shower List published in WGN 34:3 in 2006.

near-Earth meteoroid flux can proceed. This means that all meteor workers, wherever they are and whatever methods they use to record meteors, should follow the standard IMO observing guidelines when compiling their information, and submit their data promptly to the appropriate Commission (see page 28) for analysis.

Visual and still-imaging techniques remain popular for nightly meteor coverage (weather permitting), although both suffer considerably from the presence of moonlight. Telescopic observations are much less popular, but they allow the fine detail of shower radiant structures to be derived, and they permit very low activity showers to be accurately detected. Video methods continue to be dynamically applied, and are increasingly bearing considerable fruit. These have the advantages, and disadvantages, of both still-imaging and telescopic observing, plus some of their own, but are increasing in importance. Radio receivers can be utilized at all times (suitable transmitters permitting!), regardless of clouds, moonlight, or daylight, and provide the only way in which 24-hour meteor observing can be accomplished for most latitudes. Together, these methods cover virtually the entire range of meteoroid sizes, from the very largest fireball-producing events (using all-sky imaging patrols or visual observations) through to tiny dust grains producing extremely faint telescopic or radio meteors.

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 January to March

Full Moon wrecks the northern-hemisphere Quadrantids in early January (maximum due around $0^h30^m$ UT on January 4), while the waning gibbous Moon does much the same in the southern hemisphere for the probable $\alpha$-Centaurid peak, expected near $11^h$ UT on February 8. The minor, late February's $\delta$-Leonids should just escape the waxing Moon. The interesting 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), falls well for the new and waxing Moon, giving dark skies for most of the, perhaps core, January 20–27 period. Mid-March brings a rather poor minor $\gamma$-Normid return, perhaps with a peak around either March 14 or 17 (it has not been properly observed for many years, and even its current existence has been doubted in some quarters), which has a waning Moon. March 17 has the better conditions, the Moon then only two days from new, for anyone wishing to check on this possible source. Theoretical approximate timings for the daytime radio shower maxima this quarter are: Capricornids/Sagittarids – February 1, $20^h$ UT; and $\chi$-Capricornids – February 13, $22^h$ UT. Recent radio results suggest the Cap/Sgr maximum may variably fall sometime between February 1–4 however, while activity near the expected $\chi$-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.

*Antihelion Source (ANT)*

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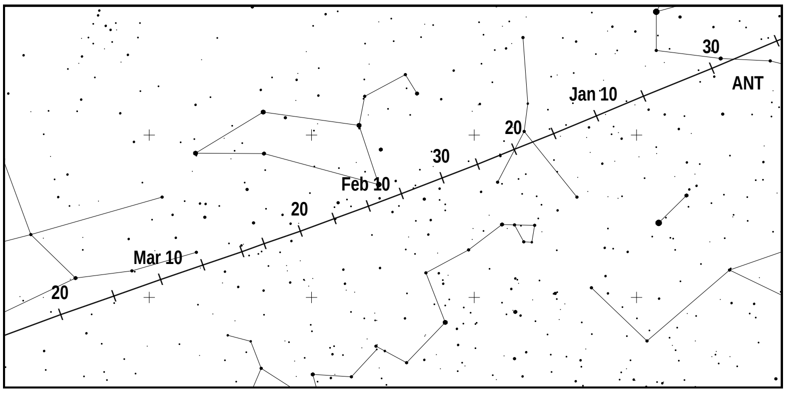
|---|
| Active: January 1–December 31, interrupted by NTA/STA; Maximum: none; ZHR = 3; |
| Radiant drift: see Table 6 (page 27); |
| $V_\infty = 30$ km/s; $r \approx 3$; |

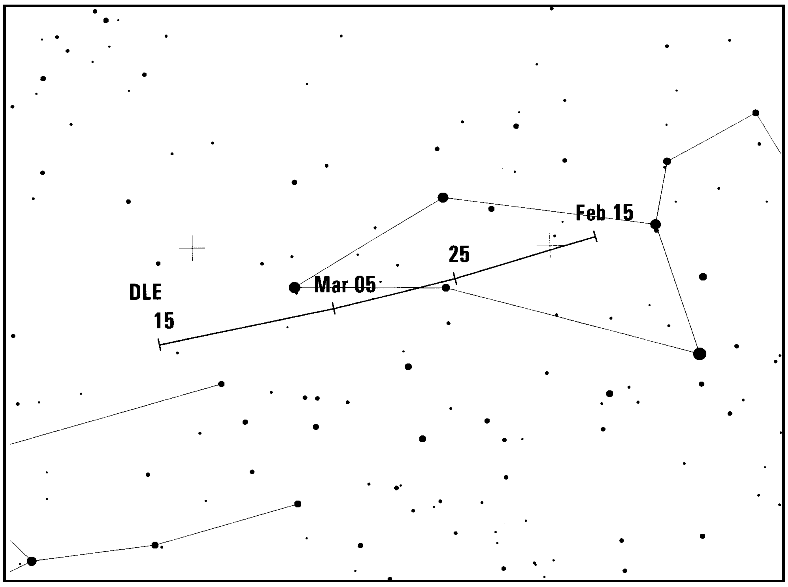
The revised Working List of Visual Meteor Showers as included in this Calendar does not list individual periods for various ecliptical showers, but combines them into a year-round source with a radiant drift as given in Table 6.




The Antihelion Source in January produces predominantly faint meteors and is well-suited to telescopic observations, with a large, complex, diffuse radiant that probably consists of several sub-centres. Visual observers should assume a minimum radiant size of roughly 20° in $\alpha$ by 10° in $\delta$ about the radiant point given in the above graph. Observations submitted to the IMO over the last decade have suggested an activity maximum may occur close to $\lambda = 297°$ (2007 January 17), though ZHRs do not rise above $\sim$ 3–4 even then. New Moon on January 19 makes the possible peak nicely moonless, and watches throughout this period to see what takes place should definitely be attempted. The long northern winter nights are ideal for making observations, while the radiant is above the horizon almost all night in either hemisphere.

*δ-Leonids (DLE)*

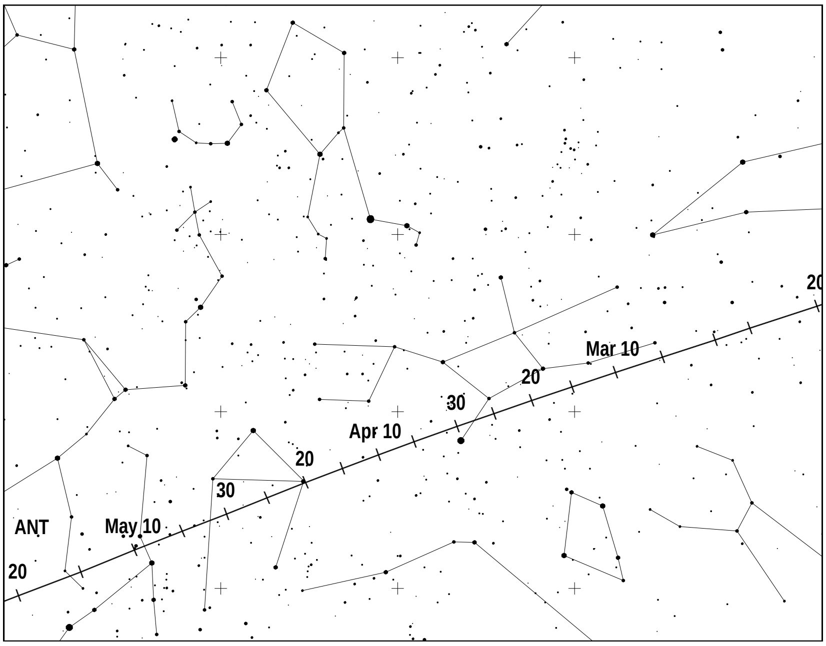
Active: February 15–March 10; Maximum: February 25 ($\lambda = 336°$); ZHR = 2;
Radiant: $\alpha = 168°$, $\delta = +16°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 23$ km/s; $r = 3.0$;
TFC: $\alpha = 140°$, $\delta = +37°$ and $\alpha = 151°$, $\delta = +22°$ ($\beta > 10°$ N);
$\alpha = 140°$, $\delta = -10°$ and $\alpha = 160°$, $\delta = 00°$ ($\beta < 10°$ N).

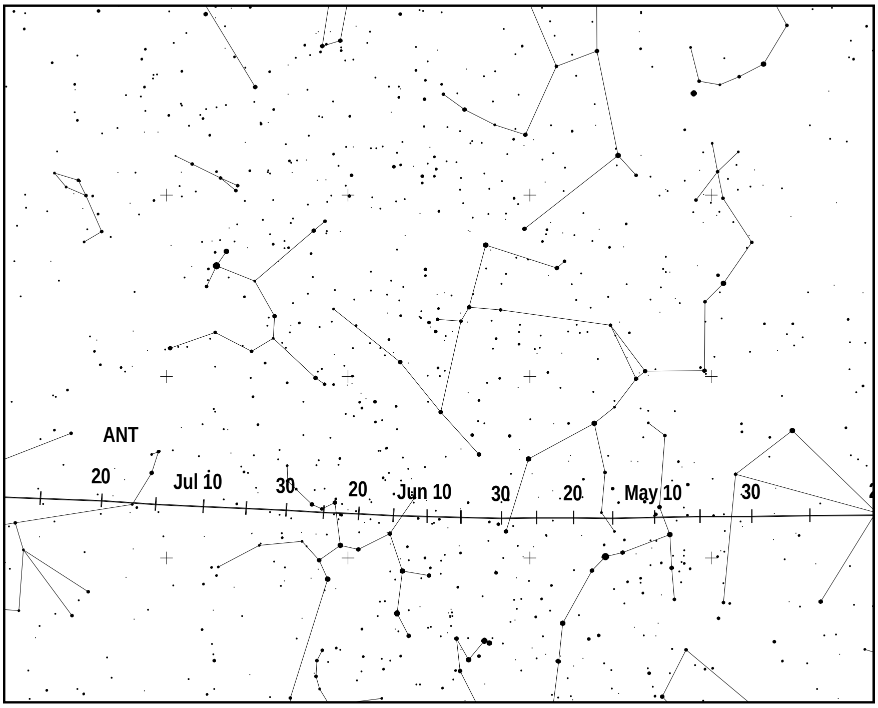



This minor shower has a radiant very close to the Antihelion radiant, but has been found well separated in position and is probably linked with Asteroid (4450) Pan. These facts make the δ-Leonids an interesting source for meteor astronomy. Rates are normally low, and its meteors are predominantly faint, so it is a prime candidate for telescopic investigation. Visual observers must make very accurate plots of the meteors to distinguish them from the nearby Antihelion meteors and the sporadics. Northern hemisphere sites have an advantage for covering this shower, though southern hemisphere watchers should not ignore it, as they are better-placed to note many of the possible Antihelion sub-radiants. On the peak night, the waxing gibbous Moon sets far enough from dawn north of the equator to allow a couple of hours' dark-sky watching at least, though the mid-southern hemisphere has a distinct advantage, with moonset around local midnight. The $\delta$-Leonid radiant is well on view for most of the night then.

## 3 April to June

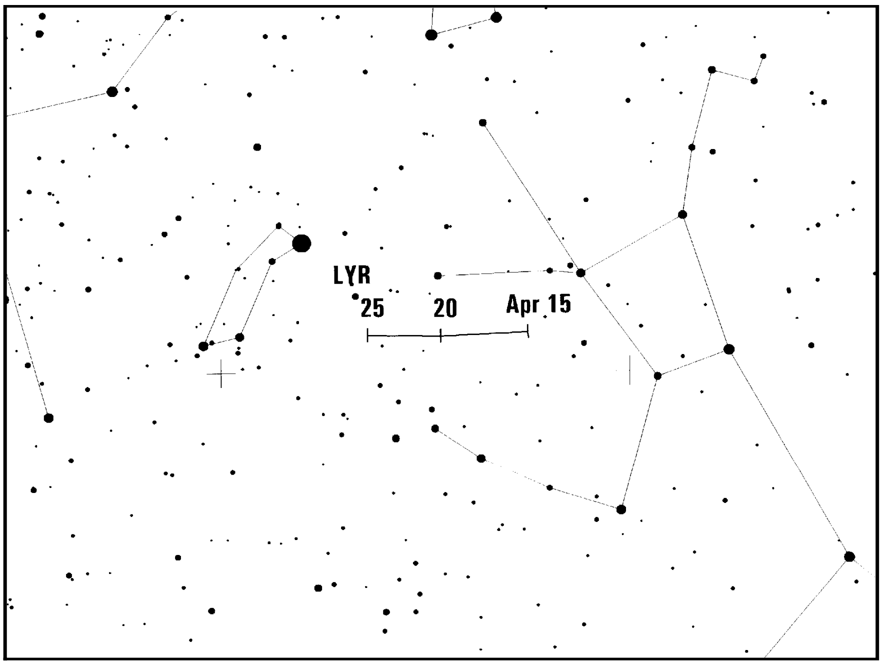
Meteor activity picks up towards the April-May boundary, with shower peaks from the Lyrids and $\pi$-Puppids in late April, then the badly moonlit $\eta$-Aquarids in early May (peak due at about $12^{\mathrm{h}}$ UT on May 6), and the $\eta$-Lyrids – a shower new to the Working List – with a peak on May 9, $12^{\mathrm{h}}$. 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, $21^{\mathrm{h}}$; $\delta$-Piscids – April 24, $21^{\mathrm{h}}$; $\varepsilon$-Arietids – May 9, $20^{\mathrm{h}}$; May Arietids – May 16, $21^{\mathrm{h}}$; $o$-Cetids – May 20, $19^{\mathrm{h}}$; Arietids – June 7, $23^{\mathrm{h}}$; $\zeta$-Perseids – June 9, $22^{\mathrm{h}}$; $\beta$-Taurids – June 28, $21^{\mathrm{h}}$. Signs of most of these were found in radio data from 1994–2005, though some are difficult to define individually because of their proximity to other radiants, while the Arietid and $\zeta$-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 shower maxima now each occur up to a day later than indicated here too. The visual Antihelion Source continues with positions in Libra up to the end of April, in Scorpius and Ophiuchus in May, and in Sagittarius in June. The motion of the center of the radiant complex is given in the following two Figures. For northern observers, circumstances for checking on any potential June Lyrids are very favourable this year, albeit not so positive for possible June Boötid hunting.






*Lyrids (LYR)*

Active: April 16–25; Maximum: April 22, $22^{h}30^{m}$ UT ($\lambda = 32\overset{\circ}{.}32$, but may vary – see text);
ZHR = 18 (can be variable, up to 90);
Radiant: $\alpha = 271°$, $\delta = +34°$; Radiant drift: see Table 6 (page 27);
$V_{\infty} = 49$ km/s; $r = 2.1$;
TFC: $\alpha = 262°$, $\delta = +16°$ and $\alpha = 282°$, $\delta = +19°$ ($\beta > 10°$ S).




The $\lambda = 32\overset{\circ}{.}32$ timing given above was the "ideal" maximum time found in the most detailed examination of the Lyrids in modern times, published in 2001 by Audrius Dubietis and Rainer

Arlt, drawing on IMO results from 1988–2000. However, the maximum time was found to be variable from year to year between $\lambda = 32.^\circ 0$–$32.^\circ 45$ (equivalent to 2007 April 22, $14^h45^m$ to April 23, $1^h45^m$ UT). Activity was discovered to be variable too. A peak at the ideal time produced the highest ZHRs, $\sim 23$, while the further the peak happened from this, the lower the ZHRs were, down to $\sim 14$. (The last very high maximum occurred outside the examined interval, in 1982 over the USA, when a short-lived ZHR of 90 was recorded.) The mean peak ZHR was 18 over the thirteen years examined. While generally thought of as having a short, quite sharp, maximum, this latest work revealed the shower's peak length was inconstant too. Using the interval that ZHRs were above half the maximum amount, the Full-Width-Half-Maximum time, a variation of from 15 hours (in 1993) to 62 hours (in 2000) was detected, with a mean value of 32 hours. The very best rates are normally achieved for just a few hours however. One other aspect of the analysis confirmed data from earlier in the 20th century, that occasionally, as their highest rates occurred, the Lyrids produced a short-lived increase of fainter meteors. Overall, the unpredictability of the shower in any given year always makes the Lyrids worth watching, since we cannot say when the next unusual return may take place.

Lyrids are best viewed from the northern hemisphere, but they are visible from many sites north and south of the equator, and the shower is suitable for all forms of observation. As its radiant rises during the night, watches can be usefully carried out from about $22^h30^m$ local time onwards from mid-northern sites, but only from well after midnight from the mid-southern hemisphere. The waxing Moon, at first quarter on April 24, sets between roughly local midnight and 1 a.m. for mid-northern sites on April 22, giving several hours of darker skies for observers between moonset and the start of morning twilight (sites further north have a progressively shorter useful observing interval). For the mid-southern hemisphere, the Moon sets much earlier in mid evening, so dark skies will prevail while the radiant is above the horizon. If the ideal maximum time recurs, it should be best-seen from sites in Europe and most of (particularly North) Africa eastwards to central Asia, but other maximum times are perfectly possible, as noted above.

*π-Puppids (PPU)*

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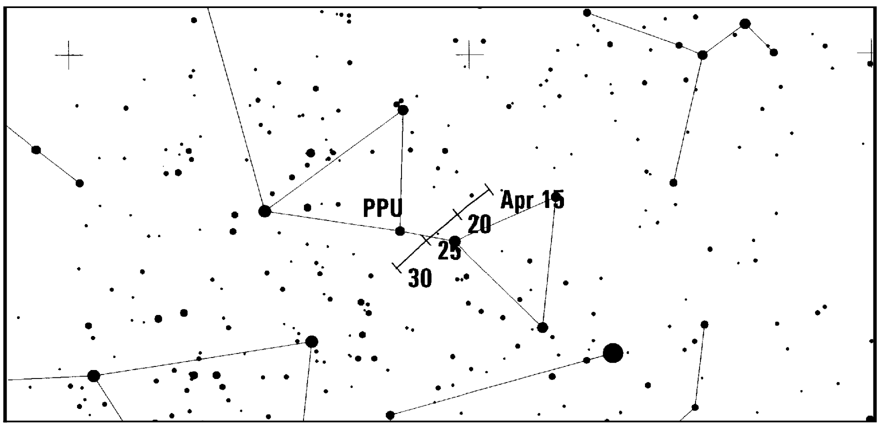
| Active: April 15–28; Maximum: April 24, $3^h40^m$ UT ($\lambda = 33.^\circ 5$); |
| ZHR = periodic, up to around 40; |
| Radiant: $\alpha = 110^\circ$, $\delta = -45^\circ$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 18$ km/s; $r = 2.0$; |
| TFC: $\alpha = 135^\circ$, $\delta = -55^\circ$ and $\alpha = 105^\circ$, $\delta = -25^\circ$ ($\beta < 20^\circ$ N). |



This is a young stream produced by Comet 26P/Grigg-Skjellerup, and shower activity has only been detected from it since 1972. Notable short-lived shower maxima of around 40 meteors per hour took place in 1977 and 1982, both years when the parent comet was at perihelion, but before 1982, little activity had been seen at other times. In 1983, a ZHR of about 13 was reported, perhaps suggesting that material has begun to spread further along the comet's orbit, as theory predicts. Comet Grigg-Skjellerup reached perihelion last in 2002 November, but nothing significant was detected from this source in 2003 April. The comet's next perihelion passage is in 2008 March, which may make that year's $\pi$-Puppids potentially more interesting. Activity this year may be unlikely, but regular monitoring of the shower epoch in future is vital, as coverage has commonly been patchy, and short-lived maxima could have been missed in the past.

The $\pi$-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 $1^{\rm h}$ local time. On April 24, first quarter Moon sets around local midnight from such locations in 2007, leaving a short viewing window under dark skies. Well-placed sites combining darker skies with the radiant's visibility are likely to be in South America, if the maximum time proves correct. So far, visual and radio data have been collected on the shower, but the slow, 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.

*June Lyrids (JLY)*

Active: June 11–21; Maximum: June 16 ($\lambda = 85°$); ZHR = variable, 0–5;
Radiant: June 10 : $\alpha = 273°$, $\delta = +35°$;
June 15 : $\alpha = 277°$, $\delta = +35°$;
June 20 : $\alpha = 281°$, $\delta = +35°$;
$V_\infty = 31$ km/s; $r = 3.0$.

This possible source does not feature in the current IMO Working List of Visual Meteor Showers, as apart from some activity seen from northern hemisphere sites in a few years during the 1960s (first seen 1966) and 1970s, evidence for its existence has been virtually zero since. In 1996, several observers independently reported some June Lyrids, though no definite activity has been found subsequently. The probable maximum date in 2007 has a virtually new Moon, yielding perfect viewing conditions for all observers who wish to check for this potential shower. The radiant may well lie a few degrees south of the bright star Vega ($\alpha$ Lyrae), so would be well on-view throughout the short northern summer nights, but there are discrepancies in its position in the literature. All suspected June Lyrids should be carefully plotted, paying especial attention to the meteors' apparent velocities. Confirmation or denial of activity from this source by imaging techniques would be very useful too.

*June Boötids (JBO)*

Active: June 22–July 2; Maximum: June 27, $20^{\rm h}00^{\rm m}$ UT ($\lambda = 95.°7$);
ZHR = variable, 0–100+;
Radiant: $\alpha = 224°$, $\delta = +48°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 18$ 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 of Visual Meteor Showers after its unexpected return in 1998, when ZHRs of 50–100+ were visible for more than half a day. A further outburst of similar length, but with ZHRs of $\sim$ 20–50 was observed on 2004 June 23, a date before definite activity had previously been recorded from this shower. We encourage all observers to routinely monitor the expected activity period, in case of future outbursts. Prior to 1998, only two definite returns had been detected, in 1916 and 1927, and with no significant reports between 1928–1997, it seemed probable 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 in late 2008. Consequently, the 1998 and 2004 returns resulted from material shed by the comet in the past, and 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 2007 at the time of writing, but the approach of June's second full Moon on the 30th will create problems for observations of the 1998 repeat time anyway (given above). Moonset between $1^h$–$2^h$ local time will allow a short – in some areas very short! – darker-sky interlude for those mid-northern places where all-night twilight does not occur in June, as from here, the radiant is at a useful elevation for most of the short summer nights. All observing techniques can be employed.

# 4 July to September

The Antihelion low activity source is complemented by various radiants in the Cap/Aqr region until mid-August. Full Moon ruins all the late-July peaks from these, including the Piscis Austrinids (due on July 28), Southern $\delta$-Aquarids (around July 28–30) and $\alpha$-Capricornids (circa July 30–31). The best of the major Perseids comes with a new Moon, whose subsequent waning crescent favours the minor $\kappa$-Cygnid peak. In early September, the $\alpha$-Aurigid maximum (due near $12^h30^m$ UT on September 1) is lost to the waning gibbous Moon, but the minor September Perseid peak is far more visible. For daylight radio observers, the interest of May-June has waned, but there remain the visually-impossible $\gamma$-Leonids (peak towards August 25, $21^h$ UT, albeit not found in recent radio results), and a tricky visual shower, the Sextantids. Their maximum is expected on September 27, $22^h$ UT, but may possibly occur a day earlier. In 1999 a strong return was detected at $\lambda \sim 186°$, equivalent to 2007 September 29, 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. Full Moon creates additional difficulties for visual observers hoping to catch some Sextantids in late September, tricky enough with radiant-rise less than an hour before dawn in either hemisphere.

**Aquarids and Capricornids**

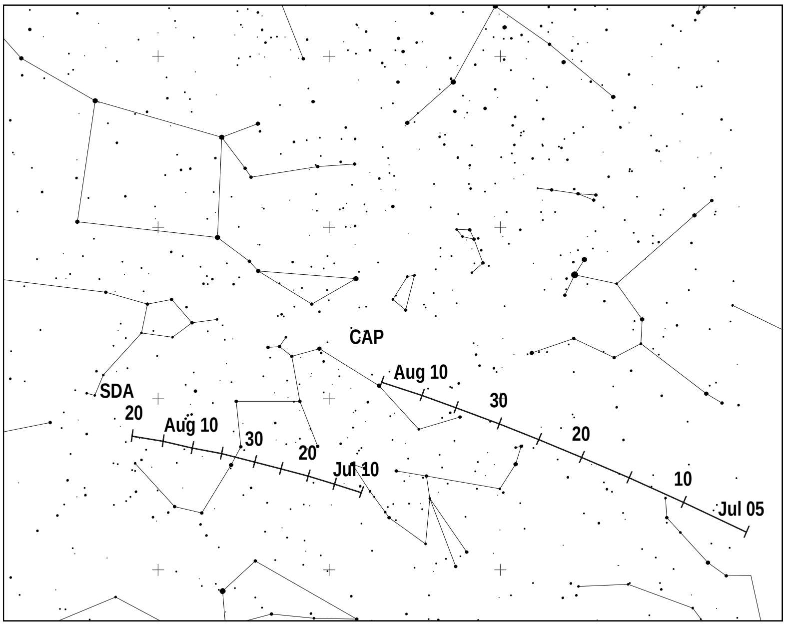
*Southern $\delta$-Aquarids (SDA)*

Active: July 12–August 19; Maximum: July 28 ($\lambda = 125°$); ZHR = 20;
Radiant: $\alpha = 339°$, $\delta = -16°$; Radiant drift: see Table 6 (page 23);
$V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to $+15°$,
choose pairs separated by about 30° in $\alpha$ ($\beta < 40°$ N).

*α-Capricornids (CAP)*

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

Fresh investigations of the near-ecliptic Aquarid and α-Capricornid (CAP) streams using IMO and other visual and video data have been published in recent years. These have generally confirmed the known details for the stronger Southern δ-Aquarid (SDA) and CAP maxima, but the SIA and NIA did not appear at all clearly, unsurprising given their borderline-visible ZHRs. The greatest oddity was the NDA, for which no distinct maximum could be traced, and whose ZHRs were never better than ∼ 3. A recent investigation of the ecliptical radiants showed that what was regarded as the NDA radiant is in fact entirely within the radiant area of the Antihelion Source (radiant motion on page 13). The showers SIA, NIA, and NDA are no longer included in the new Working List for 2007.




Excepting the moonlit CAP, the Antihelion Source and SDA are rich in faint meteors, making them well-suited to telescopic work, although enough brighter members exist to make visual and imaging observations worth the effort too, primarily from more southerly sites. Radio work can be used to pick up the SDA especially, as the most active source, and indeed the shower can sometimes give a surprisingly strong radio signature. Such a concentration of radiants in a small area of sky makes for problems in accurate shower association. Visual watchers in particular should plot all potential shower members, rather than trying to make shower associations in the field. All SDA, CAP and ANT radiants are above the horizon for much of the night, with the fewest moonlight problems in the period of about August 8–24.

*Perseids (PER)*

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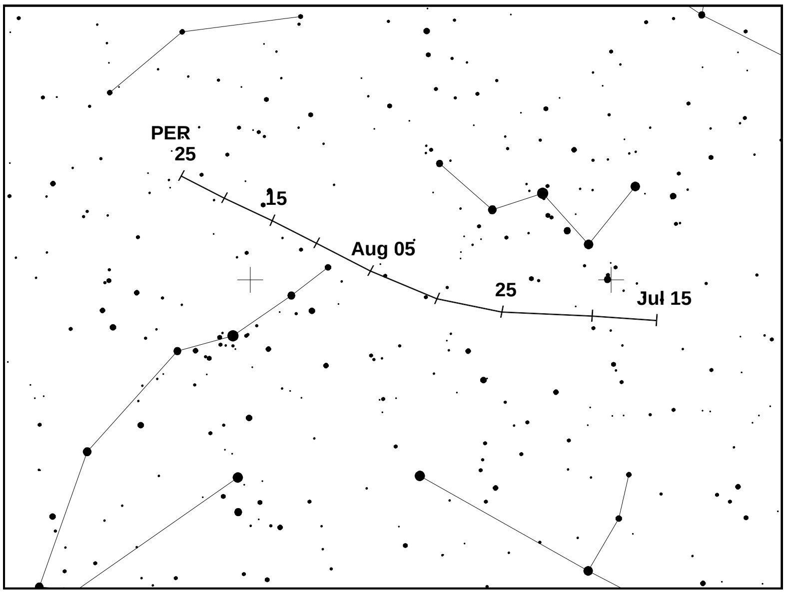
| Active: July 17–August 24; Maximum: August 13, $5^h$–$7^h30^m$ UT ($\lambda = 140.^\circ0$–$140.^\circ1$), but see text; ZHR = 100; |
| Radiant: $\alpha = 046°$, $\delta = +58°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 59$ km/s; $r = 2.6$; |
| TFC: $\alpha = 019°$, $\delta = +38°$ and $\alpha = 348°$, $\delta = +74°$ 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). |



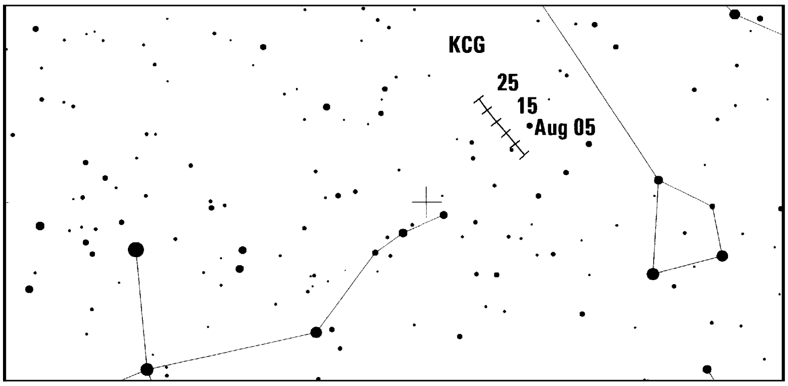

The Perseids were one of the most exciting and dynamic meteor showers during the 1990s, with outbursts at a new primary maximum producing EZHRs of 400+ in 1991 and 1992. Rates from this peak decreased to ∼ 100–120 by the late 1990s, and in 2000, it first failed to appear. This was not unexpected, as 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, some 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. After that, activity seemed to be roughly normal in 2005, and the moonlit 2006 return was still to come when this text was prepared, but nothing untoward was predicted for 2007 in any case. An average annual shift of $+0.^\circ05$ in the $\lambda$ of the "old" primary peak had been deduced from 1991–99 data, and allowing for this could give a possible recurrence time around $9^h$ UT on August 13($\lambda = 140.^\circ16$), if so a little after the most probable maximum, that of the "traditional" peak always previously found, which is given above. Another feature, seen only in IMO data from 1997–99, was a tertiary peak at $\lambda = 140.^\circ4$, the repeat time for which would be $15^h$ UT on August 13. Observers should be aware that these predictions may not be an absolute guide to the best from the Perseids, and plan their efforts accordingly, so as not to miss out, just in case!

Whatever happens, and whenever the peak or peaks fall around August 13, new Moon on August 12 creates perfect observing circumstances this year. For mid-northern latitudes, the radiant is sensibly observable from $22^h$–$23^h$ local time onwards, gaining altitude throughout the night. The UT morning-hour maxima suggested here would be best-viewed from across North America and northern South America, while the possible $\sim 15^{\text{h}}$ UT peak would fall best for Far Eastern Asia.

Visual and still-imaging observers should need little encouragement to cover this stream, but telescopic and video watching near the main peak would be valuable in confirming or clarifying the possibly multiple nature of the Perseid radiant, something not detectable visually. Recent video results have shown a very simple, single radiant structure certainly. Radio data would naturally enable early confirmation, or detection, of perhaps otherwise unobserved maxima, assuming more than one takes place, if the timings or weather conditions prove unsuitable for land-based sites. The only negative aspect to the shower is the impossibility of covering it from the bulk of the southern hemisphere.

*$\kappa$-Cygnids (KCG)*

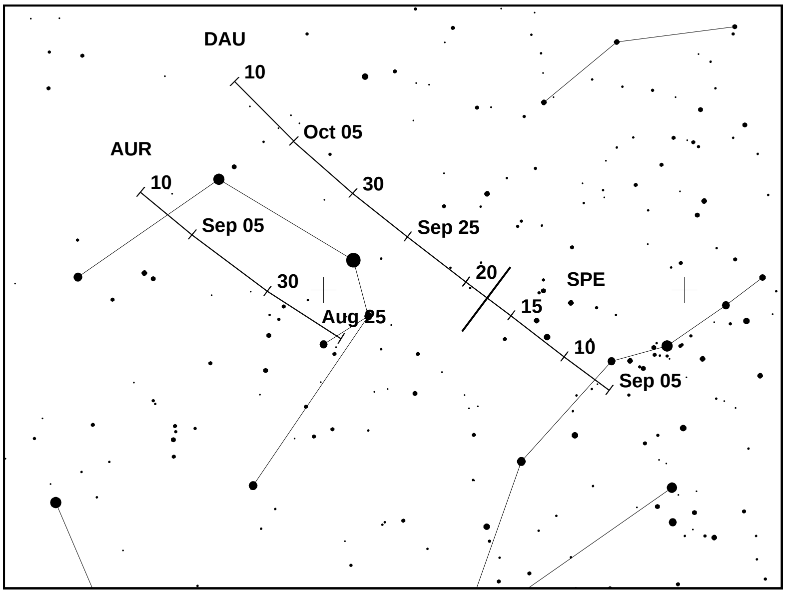
Active: August 3–25; Maximum: August 18 ($\lambda = 145°$); ZHR = 3;
Radiant: $\alpha = 286°$, $\delta = +59°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 25$ km/s; $r = 3.0$;
IFC: $\alpha = 330°$, $\delta = +60°$ and $\alpha = 300°$, $\delta = +30°$ ($\beta > 20°$ N).




The early-setting waxing crescent Moon poses no problems for covering the expected $\kappa$-Cygnid peak this year by northern hemisphere observers (the locations from which the shower is chiefly accessible). Its $r$-value suggests telescopic and video observers may benefit from its presence, but visual and still-imaging workers should note that occasional slow fireballs from this source have been reported too. Its almost stationary radiant results from its close proximity to the ecliptic north pole in Draco. There has been some suggestion of a variation in its activity at times, perhaps coupled with a periodicity in fireball sightings, but more data are needed on a shower that is often ignored in favour of the major Perseids during August.

*September Perseids (SPE)*

Active: September 5–September 17; Maximum: September 9 ($\lambda = 166.^\circ7$); ZHR = 5;
Radiant: $\alpha = 060°$, $\delta = +47°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 64$ km/s; $r = 2.9$;
TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$ ($\beta > 10°$ S).




This essentially northern hemisphere shower appears 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. Both this shower and the similarly located $\delta$-Aurigids have recently been investigated by analysts Audrius Dubietis and Rainer Arlt, using IMO-standard data since 1986, and their parameters updated accordingly.

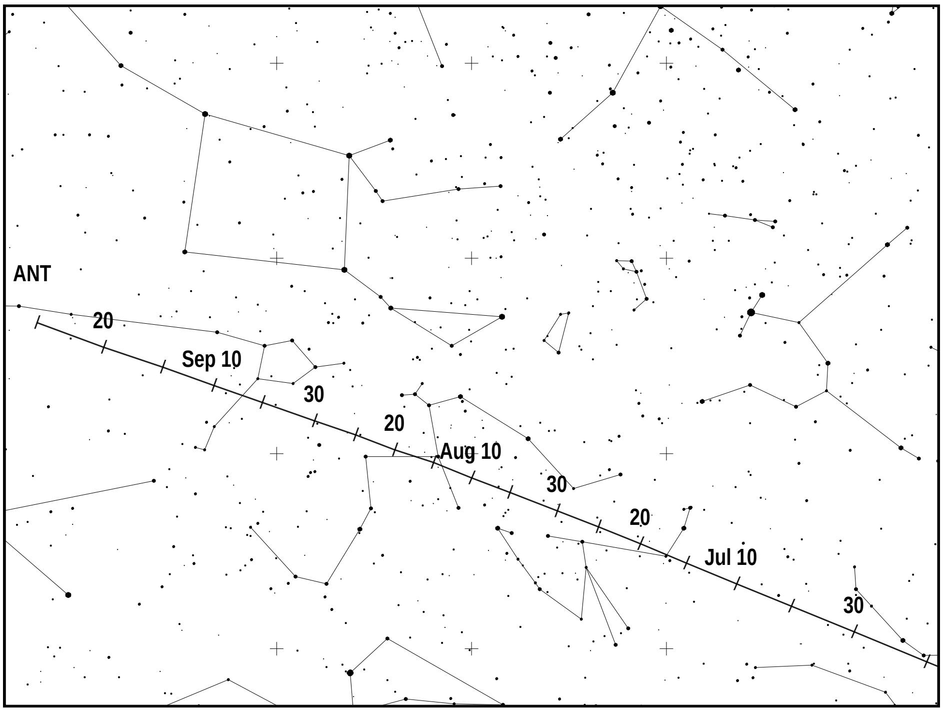
Of the two known Aurigid sources, the $\alpha$-Aurigids (AUR) are the more active, with short unexpected bursts having given EZHRs of $\sim$ 30–40 in 1935, 1986 and 1994, although they have not been monitored regularly until very recently, so other outbursts may have been missed. Only three watchers in total covered the 1986 and 1994 outbursts, for instance!

The September Perseids and $\delta$-Aurigids, whose activities and radiants effectively overlap one another, were combined into one source in the Working List up to 2006. Since the activity curves show evidence for two individual showers, we have split them into the September Perseids and $\delta$-Aurigids in the Working List for 2007. Near September 17, activities of both showers are actually interfering, but it is not recommended to distinguish the showers as their individual radiants are not resolvable. The $\delta$-Aurigid phase seems to give a weak maximum around $\lambda = 181°$ (2007 September 24; ZHR $\sim$ 3, $r = 2.5$), but its peak time is poorly defined and may occur as late as $\lambda = 191°$ (2007 October 4).

Radiants in and near Auriga reach useful elevations after $23^{\rm h}$–$0^{\rm h}$ local time for early autumn northern watchers. Consequently, the September Perseid peak on September 9 is favoured over the main $\alpha$-Aurigid one, as the Moon is almost new for it. Telescopic data to check for other radiants in this region of sky – and possibly observe the telescopic $\beta$-Cassiopeids simultaneously – would be especially valuable, but imaging records and visual plotting would be welcomed, as always.

*Antihelion Source (ANT) in September*

| |
|---|
| Active: until September 25 when NTA/STA take over; Maximum: none; ZHR = 3; |
| Radiant drift: see Table 6 (page 27); |
| $V_\infty = 30$ km/s; $r \approx 3$; |



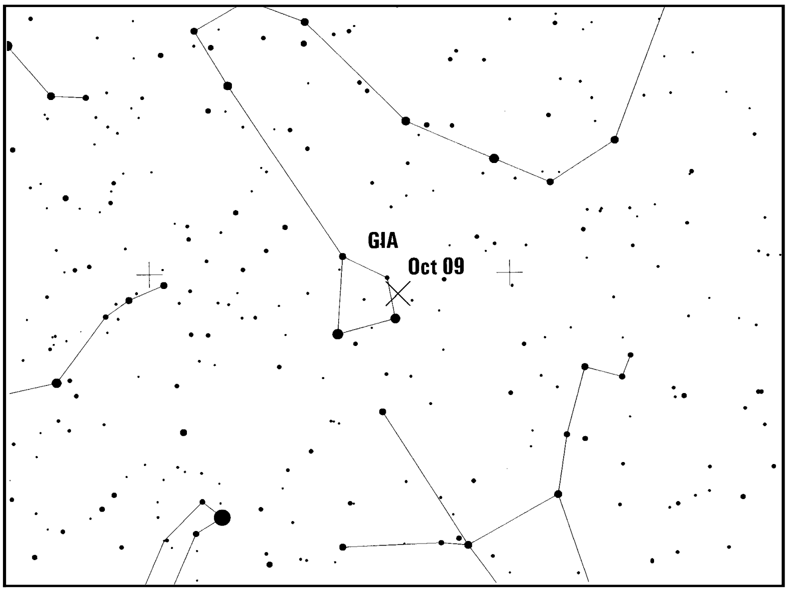

Audrius Dubietis carried out an examination of IMO data on the Piscids (now comprised by the definition of the Antihelion Source) between 1985–1999 in early 2001, which essentially confirmed the current details on it are correct, including that this is another poorly observed part of the ecliptic-complex activity! Its radiant during the September spell is very close to the March equinox point in the sky, and consequently, it can be observed equally well from either hemisphere throughout the night near the September equinox. This year, September's waxing gibbous Moon allows about half the night for observing, with moonset between the late evening (for mid-northern latitudes) to early morning hours (for mid-southern ones). Telescopic and video techniques can be employed to study the Antihelion Source, along with methodical visual plotting.

# 5 October to December

A very promising final quarter to the year beckons, with only the northern-sky Ursids in December really too close to full Moon to allow useful watching. The Ursid parent comet, 8P/Tuttle, reaches perihelion next in January 2008, though past returns have not shown any directly-linked shower activity, and no predictions of enhanced rates had been made for 2007 when this text was prepared. The normal Ursid peak is due between $1^h$–$3^h30^m$ UT on December 22. The Leo Minorids are a shower recently added to the Working List with a maximum on October 24/25 when the Moon sets after $5^h$ local time in the northern hemisphere.

*Draconids (GIA)*

| |
|---|
| Active: October 6–10; Maximum: October 9, $4^h30^m$ UT ($\lambda = 195\overset{\circ}{.}4$, but see below); |
| ZHR = periodic, up to storm levels; |
| Radiant: $\alpha = 262°$, $\delta = +54°$; Radiant drift: negligible; |
| $V_\infty = 20$ km/s; $r = 2.6$; |
| TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ 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 ~ 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.

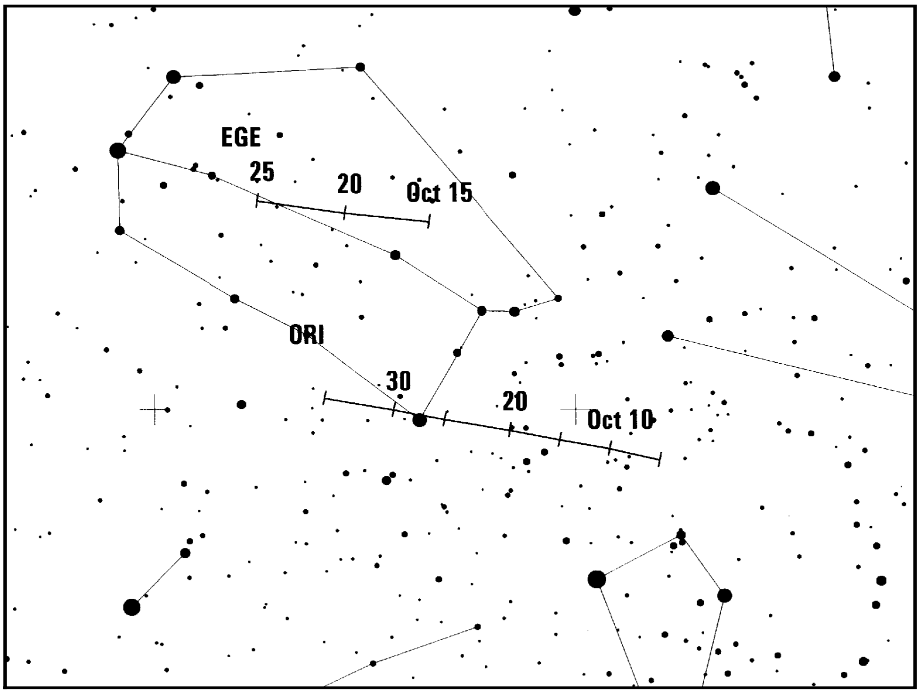
In 2005 October, a largely unexpected outburst happened near the comet's nodal crossing time, around $\lambda = 195.^\circ 40$–$195.^\circ 44$, probably due to material shed in 1946. Visual ZHRs were ~ 35, though radar detections suggested a much higher estimated rate, closer to ~ 150. The peak was found in radio results too, but it did not record especially strongly that way either. Outlying maximum times from the recent past have spanned from $\lambda = 195.^\circ 075$ (in 1998; EZHRs ~ 700), equivalent to 2007 October 8, $20^h30^m$ UT, through the nodal passage time above, to $\lambda 195.^\circ 63$–$195.^\circ 76$ (a minor outburst in 1999, not a perihelion-return year; ZHRs ~ 10–20), equating to 2007 October 9, $10^h$–$13^h$ UT.

The radiant is circumpolar from many northern hemisphere locations, but is higher in the pre-midnight and near-dawn hours of early October. New Moon on October 11 makes for an almost perfect observing opportunity, 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.

*ε-Geminids (EGE)*

| |
|---|
| Active: October 14–27; Maximum: October 18 ($\lambda = 205^\circ$); ZHR = 2; |
| Radiant: $\alpha = 102^\circ$, $\delta = +27^\circ$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 70$ km/s; $r = 3.0$; |
| TFC: $\alpha = 090^\circ$, $\delta = +20^\circ$ and $\alpha = 125^\circ$, $\delta = +20^\circ$ ($\beta > 20^\circ$ S). |

A weak minor shower with characteristics and activity nearly coincident with the Orionids, so great care must be taken to separate the two sources by instrumental techniques – especially video or telescopic work – or visual plotting. The waxing Moon will set well before midnight (north of the equator) to about midnight (south of it), giving a fine chance to obtain more data on this shower from either hemisphere. Northern observers have a radiant elevation advantage, permitting useful access from about midnight onwards.




*Orionids (ORI)*

| |
|---|
| Active: October 2–November 7; Maximum: October 21 ($\lambda = 208°$); ZHR = 25; |
| Radiant: $\alpha = 95°$, $\delta = +16°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 66$ km/s; $r = 2.5$; |
| TFC: $\alpha = 100°$, $\delta = +39°$ and $\alpha = 75°$, $\delta = +24°$ ($\beta > 40°$ N); or |
| $\alpha = 80°$, $\delta = +01°$ and $\alpha = 117°$, $\delta = +01°$ ($\beta < 40°$ N). |

The Orionid radiant, a little north of the celestial equator, is at a useful elevation by around local midnight in either hemisphere, somewhat before in the north, so most of the world can enjoy the shower. The waxing gibbous Moon will set by around $0^h30^m$–$2^h30^m$ for all observers this year, so leaving darker skies for much of the radiant's best-visible time. Audrius Dubietis' recent analysis of IMO data from 1984–2001 showed some minor changes to past expectations, with the peak ZHR and $r$ values varying somewhat from year to year. Maximum mean ZHRs ranged from $\sim$ 14–31 during the examined interval, with partial confirmation of a suspected 12-year periodicity in higher returns found earlier in the 20th century. This may mean stronger returns in 2008–10, and perhaps best ZHRs of around 25 this year. The Orionids were always noted for having several lesser maxima other than the main one above, helping activity sometimes to remain roughly constant for several consecutive nights centred on this peak. In 1993 and 1998, a submaximum about as strong as the normal peak was detected on October 17–18 from Europe, for instance. All observers should be aware of these possibilities, as observing circumstances are particularly favourable for covering the Orionids on both October 17 and 18 under dark skies in 2007. Several visual subradiants were reported in the past, but recent video work suggests the radiant is far less complex; more imaging and telescopic work to confirm this would be useful, as visual observers have clearly had problems with the shower's radiant determination before.

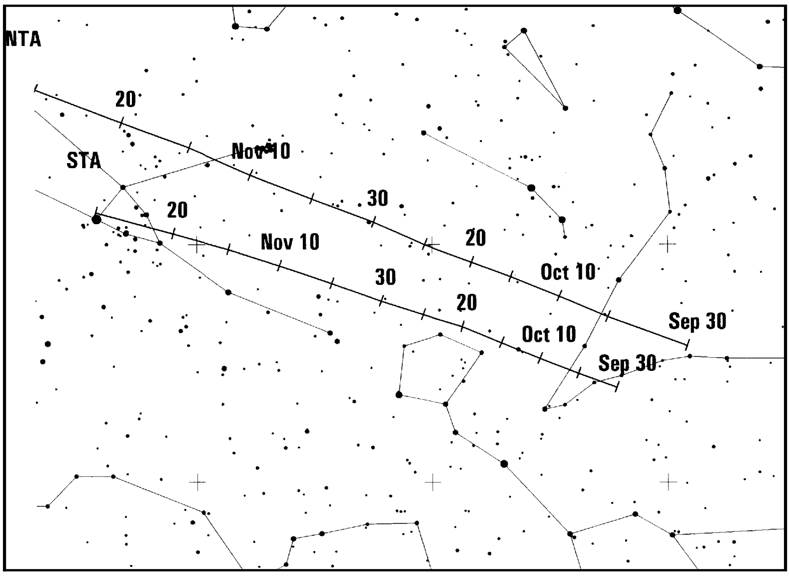
**Taurids**

*Southern Taurids (STA)*

| |
|---|
| Active: September 25–November 25; Maximum: November 5 ($\lambda = 223°$); ZHR = 5; |
| Radiant: $\alpha = 052°$, $\delta = +13°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 27$ 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 ($\lambda = 230°$); ZHR = 5; |
| Radiant: $\alpha = 058°$, $\delta = +22°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 29$ km/s; $r = 2.3$; |
| TFC: as Southern Taurids. |

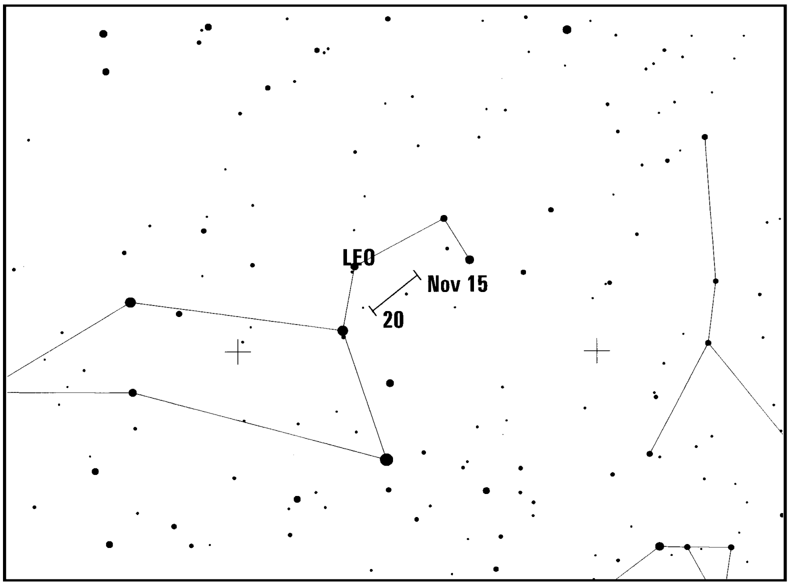



These two streams form part of the complex associated with Comet 2P/Encke. Defining their radiants is best achieved by careful visual or telescopic plotting, or imaging recordings, since they are large and diffuse. They have recently been studied using IMO data by Mihaela Triglav. The Taurid radiants coincide very closely with the diffuse Antihelion Source; it is actually not possible to distinguish them. The Antihelion Source – although active all year round – should not be reported during the activity period of the Taurids.

The brightness and relative slowness of many Taurid meteors makes them ideal targets for still-imaging, while these factors coupled with low, steady, combined Taurid rates makes them excellent targets 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. Late October into early November has a full to last quarter Moon in 2007, but this will clear away nicely to allow dark skies for the usual maximum spell in November. Luckily, the next potential October-November "swarm" return is not anticipated till 2008, though coverage to ensure unexpected events are not happening in other years remains valuable. The near-ecliptic radiants for both shower branches mean all meteoricists can observe these showers. Northern hemisphere observers are somewhat better-placed, as here suitable radiant zenith distances persist for much of the late autumnal nights. Even in the southern hemisphere, a good 3–5 hours' watching around local midnight is possible with Taurus well above the horizon, however.

*Leonids (LEO)*

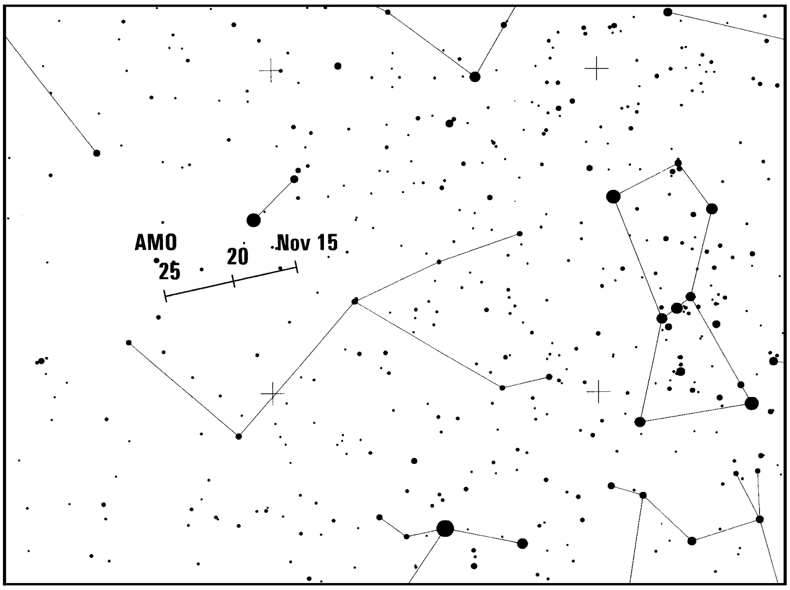
Active: November 10–23; Maximum: November 18, $2^h50^m$ UT ($\lambda = 235\overset{\circ}{.}27$), but see below; ZHR = 15+?;
Radiant: $\alpha = 153°$, $\delta = +22°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 71$ km/s; $r = 2.5$;
TFC: $\alpha = 140°$, $\delta = +35°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta > 35°$ N); or
$\alpha = 156°$, $\delta = -03°$ and $\alpha = 129°$, $\delta = +06°$ ($\beta < 35°$ N).
IFC: $\alpha = 120°$, $\delta = +40°$ before $0^h$ local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before $4^h$ local time and
$\alpha = 160°$, $\delta = 00°$ after $4^h$ local time ($\beta > 00°$ N);
$\alpha = 120°$, $\delta = +10°$ before $0^h$ local time and $\alpha = 160°$, $\delta = -10°$ ($\beta < 00°$ N).




As the events in 2003–2005 demonstrated, when enhanced ZHRs of $\sim$ 20–40 were found, the ending of the strong to storm Leonid returns between 1998–2002, associated with the 1998 perihelion passage of parent comet 55P/Tempel-Tuttle, have not meant an end to interest in this fascinating shower. The possibly enhanced 2006 return was still to come when this text was prepared, but there were no other predictions for potentially increased rates in force after then until 2009. Consequently, it is possible that only the usual nodal crossing peak may happen in 2007. If so, it may see a fall back to the more typical peak ZHR levels seen away from the near-perihelion returns. Nothing is certain about this year's shower however, so please be alert, and look out for any updates or fresh predictions! The Leonid radiant rises usefully only around local midnight (or indeed afterwards south of the equator), roughly the same time that the waxing gibbous Moon will be setting on November 18, so darker skies will be available for covering whatever happens. The maximum timing above would favour sites in Europe, Africa and the Near East. All observing techniques can be used.

*α-Monocerotids (AMO)*

Active: November 15–25; Maximum: November 22, $3^h10^m$ UT ($\lambda = 239\overset{\circ}{.}32$);
ZHR = variable, usually $\sim 5$, but may produce outbursts to $\sim 400+$;
Radiant: $\alpha = 117°$, $\delta = +01°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 65$ 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).

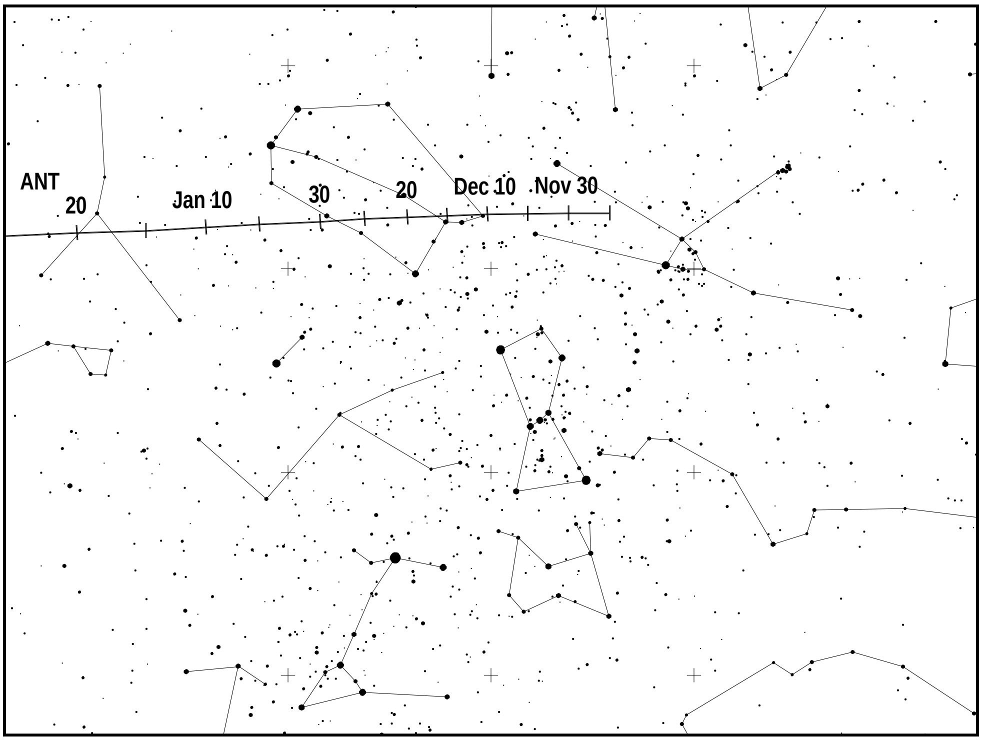



Another late-year shower capable of producing surprises, the α-Monocerotids gave their most recent brief outburst in 1995 (the top EZHR, $\sim 420$, lasted just five minutes; the entire outburst 30 minutes). Many observers across Europe witnessed it, and we were able to completely update the known shower 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.

Despite the waxing gibbous Moon being only two days from full on November 22, because the radiant is well on view from either hemisphere only after about $23^h$ local time, there will be a short dark-sky observing window between moonset and dawn twilight for northern observers then particularly. If correct, the peak timing would fall well for sites in Europe, North Africa and the Near East.

*Antihelion Source (ANT) in December*

| |
|---|
| Active: taking over from NTA/STA on November 26; ZHR = 3; |
| Radiant drift: see Table 6 (page 27); |
| $V_\infty = 30$ km/s; $r \approx 3$; |

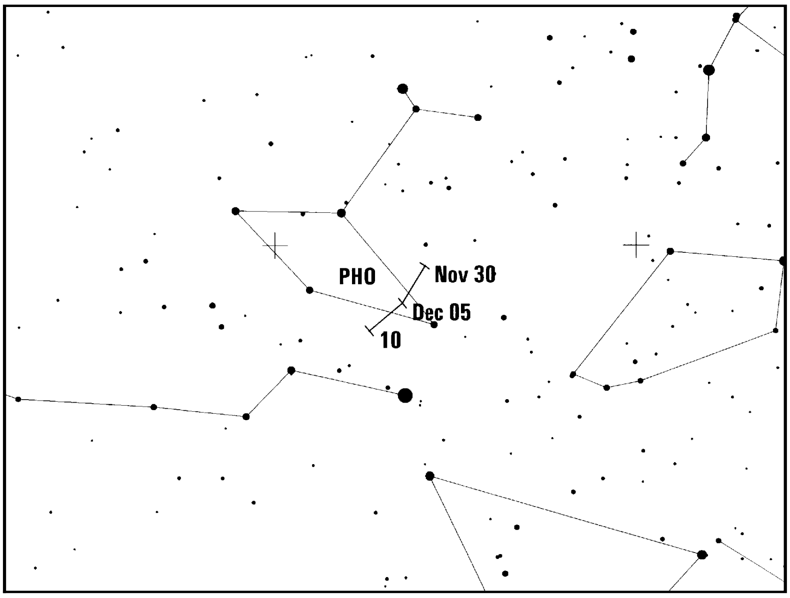



A weak part of the ecliptical meteor activity. Some brighter meteors have been photographed from it too. The shower has at least a double radiant, but the southern branch has been rarely detected. The radiant used here is a combined one, suitable for visual work, although telescopic or video observations should be better able to determine the exact radiant structure. It is well on display in both hemispheres throughout the night, but pre-midnight observing is recommended this year, as the last-quarter Moon will rise at around local midnight across the globe.

*Phoenicids (PHO)*

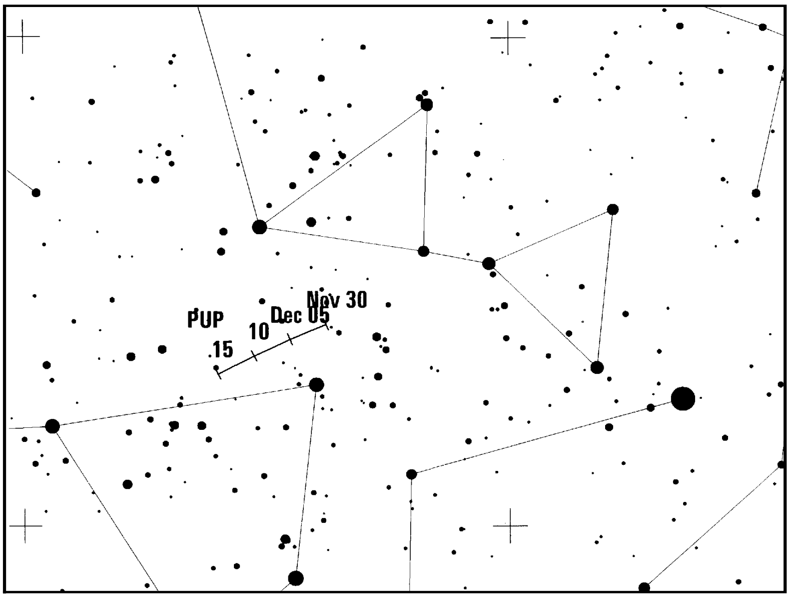
| |
|---|
| Active: November 28–December 9; Maximum: December 6, $21^{\rm h}00^{\rm m}$ UT ($\lambda = 254.^\circ25$); |
| ZHR = variable, usually 3 or less, may reach 100; |
| Radiant: $\alpha = 18^\circ$, $\delta = -53^\circ$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 18$ km/s; $r = 2.8$; |
| TFC: $\alpha = 40^\circ$, $\delta = -39^\circ$ and $\alpha = 065^\circ$, $\delta = -62^\circ$ ($\beta < 10^\circ$ N). |

Only one impressive Phoenicid return has so far been reported, that of its discovery in 1956, when the EZHR was probably $\sim 100$, possibly with several peaks spread over a few hours. Three other potential bursts of lower activity have been reported, but never by more than one observer, under uncertain circumstances. Reliable IMO data shows recent activity to have been virtually nonexistent. This may be a periodic shower however, and more observations of it are needed by all methods. Lunar circumstances for southern hemisphere watchers are pretty well perfect in 2007, thanks to new Moon on December 9. The Phoenicid radiant culminates at dusk, remaining well on view for most of the night.




*Puppid-Velids (PUP)*

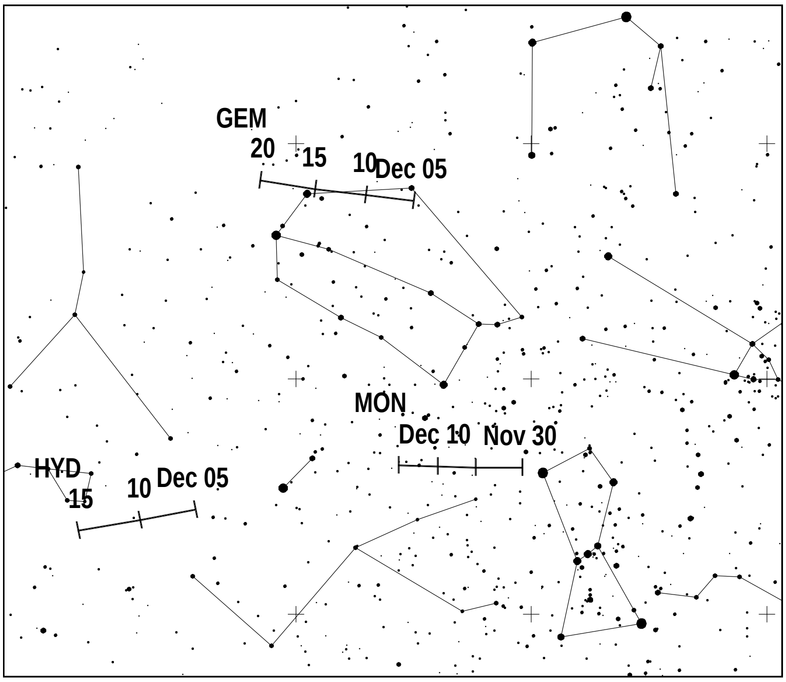
Active: December 1–15; Maximum: December $\sim 7$ ($\lambda \sim 255°$); ZHR $\sim 10$;
Radiant: $\alpha = 123°$, $\delta = -45°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 40$ km/s; $r = 2.9$;
TFC: $\alpha = 090°$ to $150°$, $\delta = -20°$ to $-60°$;
choose pairs of fields separated by about 30° in $\alpha$, moving eastwards as the shower progresses ($\beta < 10°$ N).




This is a very complex system of poorly studied showers, visible chiefly to those south of the equator. Up to ten sub-streams have been identified, with radiants so tightly clustered, visual observing cannot readily separate them. Imaging or telescopic work would thus be sensible, or very careful visual plotting. The activity is so badly known, we can only be reasonably sure that the highest rates occur in early to mid December, coincident with the dark of the Moon this year. Some of these showers may be visible from late October to late January, however. Most Puppid-Velid meteors are quite faint, but occasional bright fireballs, notably around the suggested maximum here, have been reported previously. The radiant area is on-view all night, but is highest towards dawn.

*Monocerotids (MON)*

| |
|---|
| Active: November 27–December 17; Maximum: December 9 ($\lambda = 257°$); ZHR = 3; |
| Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 42$ 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 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 December 16 ($\lambda \sim 264°$) from a radiant at $\alpha = 117°$, $\delta = +20°$. This is an ideal year for making observations, with the December 9 peak falling precisely at new Moon. The radiant area is on-show virtually all night, culminating about $1^h30^m$ local time.

*σ-Hydrids (HYD)*

| |
|---|
| Active: December 3–15; Maximum: December 12 ($\lambda = 260°$); ZHR = 2; |
| Radiant: $\alpha = 127°$, $\delta = +02°$; Radiant drift: see Table 6 (page 27); |
| $V_\infty = 58$ km/s; $r = 3.0$; |
| TFC: $\alpha = 095°$, $\delta = 00°$ and $\alpha = 160°$, $\delta = 00°$ (all sites, after midnight only). |

Although first detected in the 1960s by photography, $\sigma$-Hydrids are typically swift and faint, and rates are generally very low, close to the visual detection threshold. Since their radiant, a little over 10° east of the star Procyon ($\alpha$ Canis Minoris), is near the equator, all observers can cover this shower. The radiant rises in the late evening hours, but is best viewed after local midnight, so this is a perfect year for them, with an early-setting waxing crescent Moon. Recent data indicates the maximum may happen up to six days earlier than this theoretical timing, which would be almost as favourable for Moon-free watching. The shower would benefit from visual plotting, telescopic or video work to pin it down more accurately.

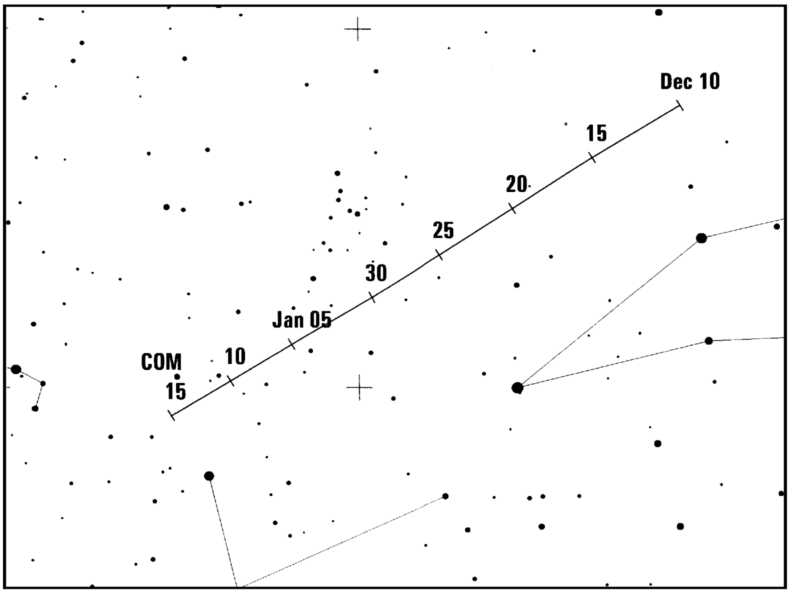
*Geminids (GEM)*

Active: December 7–17; Maximum: December 14, $16^{h}45^{m}$ UT ($\lambda = 262.°2$) $\pm$ 2.3h;
ZHR = 120;
Radiant: $\alpha = 112°$, $\delta = +33°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 35$ km/s; $r = 2.6$;
TFC: $\alpha = 087°$, $\delta = +20°$ and $\alpha = 135°$, $\delta = +49°$ before $23^{h}$ local time,
$\alpha = 087°$, $\delta = +20°$ and $\alpha = 129°$, $\delta = +20°$ after $23^{h}$ local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = -03°$ and $\alpha = 084°$, $\delta = +10°$ ($\beta < 40°$ N).
IFC: $\alpha = 150°$, $\delta = +20°$ and $\alpha = 060°$, $\delta = +40°$ ($\beta > 20°$ N);
$\alpha = 135°$, $\delta = -05°$ and $\alpha = 080°$, $\delta = 00°$ ($\beta < 20°$ N).

One of the finest, and probably the most reliable, of the major annual showers presently observable. This year, the waxing crescent Moon will set by mid-evening across the globe on December 14 (the actual moonset timing is progressively later the further south you are), giving mostly dark skies for all observers, especially those in the northern hemisphere. The Geminid radiant culminates around $2^{h}$ local time, but well north of the equator it rises around sunset, and is at a usable elevation from the local evening hours onwards, while in the southern hemisphere, the radiant appears only around local midnight or so. Even from more southerly sites, this is a splendid stream of often bright, medium-speed meteors, a rewarding sight for all watchers, whatever method they employ. The peak has shown slight signs of variability in its rates and timing in recent years, with the more reliably-observed maxima during the past two decades all having occurred within 2h20m of the time given above. The main predicted timing, coupled with moonset, favours places from central Asia eastwards across the Pacific Ocean to Alaska. An earlier or later timing would extend this best-visible zone some way eastwards or westwards respectively. Some mass-sorting within the stream means the fainter telescopic meteors should be most abundant almost 1° of solar longitude (about one day) ahead of the visual maximum, with telescopic results indicating such meteors radiate from an elongated region, perhaps with three sub-centres. Further results on this topic would be useful.

*Coma Berenicids (COM)*

Active: December 12–January 23; Maximum: December 20 ($\lambda = 268°$); ZHR = 5;
Radiant: $\alpha = 175°$, $\delta = +25°$; Radiant drift: see Table 6 (page 27);
$V_\infty = 65$ km/s; $r = 3.0$;
TFC: $\alpha = 180°$, $\delta = +50°$ and $\alpha = 165°$, $\delta = +20°$ before $3^{h}$ local time,
$\alpha = 195°$, $\delta = +10°$ and $\alpha = 200°$, $\delta = +45°$ after $3^{h}$ local time ($\beta > 20°$ N).




A weak minor shower that is usually observed only during the Geminid and Quadrantid epochs, but which needs more coverage at other times too, especially to better-define its maximum. The shower is almost unobservable from the southern hemisphere, so northern watchers must brave the winter cold to improve our knowledge of it. The radiant is at a useful elevation from local midnight onwards, and despite the peak's proximity to full Moon, several hours of dark-sky watching will still remain possible at mid-northern latitudes after moonset.

# 6 Radiant sizes and meteor plotting

*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.

The 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.

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 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° |

Table 2. Error limits for the angular velocity.

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

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 ($V_\infty$). 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 |

# 7 Abbreviations

- $\alpha$, $\delta$: Coordinates for a shower's radiant position, usually at maximum. $\alpha$ is right ascension, $\delta$ 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 (page [add page number]) 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.
- $\lambda$: Solar longitude, a precise measure of the Earth's position on its orbit which is not dependent on the vagaries of the calendar. All $\lambda$ are given for the equinox 2000.0.
- $V_\infty$: 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. $\beta$ 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 2007.

| New Moon | First Quarter | Full Moon | Last Quarter |
|---|---|---|---|
| | | January 3 | January 11 |
| January 19 | January 25 | February 2 | February 10 |
| February 17 | February 24 | March 3 | March 12 |
| March 19 | March 25 | April 2 | April 10 |
| April 17 | April 24 | May 2 | May 10 |
| May 16 | May 23 | June 1 | June 8 |
| June 15 | June 22 | June 30 | July 7 |
| July 14 | July 22 | July 30 | August 5 |
| August 12 | August 20 | August 28 | September 4 |
| September 11 | September 19 | September 26 | October 3 |
| October 11 | October 19 | October 26 | November 1 |
| November 9 | November 17 | November 24 | December 1 |
| December 9 | December 17 | December 24 | December 31 |

Table 5. Working list of visual meteor showers. Details in this Table were correct according to the best information available in June 2006. Contact the IMO's Visual Commission for more information. Maximum dates in parentheses indicate reference dates for the radiant, not true maxima. Some showers have ZHRs that vary from year to year. The most recent reliable figure is given here, except for possibly periodic showers that are noted as "var." = variable.

| Shower | Activity | Maximum | | Radiant | | $V_\infty$ | $r$ | ZHR |
|---|---|---|---|---|---|---|---|---|
| | | Date | $\lambda$ | $\alpha$ | $\delta$ | km/s | | |
| Antihelion Source (ANT) | Jan 01–Dec 31 | interrupted for NTA/STA | | see Table 6 | | 30 | 3.0 | 3 |
| Quadrantids (QUA) | Jan 01–Jan 05 | Jan 04 | 283.°16 | 230° | +49° | 41 | 2.1 | 120 |
| $\alpha$-Centaurids (ACE) | Jan 28–Feb 21 | Feb 08 | 319.°2 | 211° | −59° | 56 | 2.0 | 5 |
| $\delta$-Leonids (DLE) | Feb 15–Mar 10 | Feb 25 | 336° | 168° | +16° | 23 | 3.0 | 2 |
| $\gamma$-Normids (GNO) | Feb 25–Mar 22 | Mar 14 | 353° | 239° | −50° | 56 | 2.4 | 4 |
| Lyrids (LYR) | Apr 16–Apr 25 | Apr 22 | 32.°32 | 271° | +34° | 49 | 2.1 | 18 |
| $\pi$-Puppids (PPU) | Apr 15–Apr 28 | Apr 24 | 33.°5 | 110° | −45° | 18 | 2.0 | var |
| $\eta$-Aquarids (ETA) | Apr 19–May 28 | May 06 | 45.°5 | 338° | −01° | 66 | 2.4 | 60 |
| $\eta$-Lyrids (ELY) | May 03–May 12 | May 09 | 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 28 | 125° | 341° | −30° | 35 | 3.2 | 5 |
| South. $\delta$-Aquarids (SDA) | Jul 12–Aug 19 | Jul 28 | 125° | 339° | −16° | 41 | 3.2 | 20 |
| $\alpha$-Capricornids (CAP) | Jul 03–Aug 15 | Jul 30 | 127° | 307° | −10° | 23 | 2.5 | 4 |
| Perseids (PER)* | Jul 17–Aug 24 | Aug 13 | 140.°0 | 46° | +58° | 59 | 2.6 | 100 |
| $\kappa$-Cygnids (KCG) | Aug 03–Aug 25 | Aug 18 | 145° | 286° | +59° | 25 | 3.0 | 3 |
| $\alpha$-Aurigids (AUR) | Aug 25–Sep 08 | Sep 01 | 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 |
| $\delta$-Aurigids (DAU) | Sep 18–Oct 10 | Oct 04 | 191° | 88° | +49° | 64 | 2.9 | 2 |
| Draconids (GIA) | Oct 06–Oct 10 | Oct 09 | 195.°4 | 262° | +54° | 20 | 2.6 | var |
| $\varepsilon$-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 | 23 |
| Leo Minorids (LMI) | Oct 19–Oct 27 | Oct 24 | 211° | 162° | +37° | 62 | 3.0 | 2 |
| Southern Taurids (STA) | Oct 01–Nov 25 | Nov 05 | 223° | 52° | +15° | 27 | 2.3 | 5 |
| Northern Taurids (NTA) | Oct 01–Nov 25 | Nov 12 | 230° | 58° | +22° | 29 | 2.3 | 5 |
| Leonids (LEO) | Nov 10–Nov 23 | Nov 18 | 235.°27 | 153° | +22° | 71 | 2.5 | 15+ |
| $\alpha$-Monocerotids (AMO) | Nov 15–Nov 25 | Nov 22 | 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 07) | (255°) | 123° | −45° | 40 | 2.9 | 10 |
| Monocerotids (MON) | Nov 27–Dec 17 | Dec 09 | 257° | 100° | +08° | 42 | 3.0 | 2 |
| $\sigma$-Hydrids (HYD) | Dec 03–Dec 15 | Dec 12 | 260° | 127° | +02° | 58 | 3.0 | 3 |
| Geminids (GEM) | Dec 07–Dec 17 | Dec 14 | 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 23 | 270.°7 | 217° | +76° | 33 | 3.0 | 10 |

Table 6 (next page). Radiant positions during the year in $\alpha$ and $\delta$.

| 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° | 0° | 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. 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.

| Shower | Activity | Max Date | $\lambda$ 2000 | Radiant $\alpha$ | Radiant $\delta$ | Best observed 50° N | Best observed 35° S | Rate |
|---|---|---|---|---|---|---|---|---|
| Cap/Sagittarids | Jan 13–Feb 04 | Feb 01 | 312°5 | 299° | −15° | $11^h$–$14^h$ | $09^h$–$14^h$ | medium |
| $\chi$-Capricornids | Jan 29–Feb 28 | Feb 13 | 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 |
| $\delta$-Piscids | Apr 24–Apr 24 | Apr 24 | 34°2 | 11° | +12° | $07^h$–$14^h$ | $08^h$–$13^h$ | low |
| $\varepsilon$-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 |
| $\zeta$-Perseids | May 20–Jul 05 | Jun 09 | 78°6 | 62° | +23° | $07^h$–$15^h$ | $09^h$–$13^h$ | high |
| $\beta$-Taurids | Jun 05–Jul 17 | Jun 28 | 96°7 | 86° | +19° | $08^h$–$15^h$ | $09^h$–$13^h$ | medium |
| $\gamma$-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 |

# 8 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:**
Temporarily vacant. e-mail: photo@imo.net

**Radio Commission:**
Members of a mailing list forum will answer questions directed to 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. email: 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. e-mail: lunro.imo.usa@cox.net

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