International Meteor Organization

2005 Meteor Shower Calendar

compiled by Alastair McBeath[1]

1. Introduction

Welcome to the 2005 International Meteor Organization (*IMO*) Meteor Shower Calendar. The year's most moonless major shower maxima are the η-Aquarids in early May, and the Perseids in mid-August. Lesser sources, including the α-Centaurids, the July–August Aquarid-Capricornid showers, the α- and δ-Aurigids, and the various minor early-December showers, are reasonably free from moonlight too. Unfortunately, this leaves the other two of the "big three" major shower peaks – the Quadrantids and Geminids – badly moonlit. Of the sources worth checking-up on, the possible June Lyrid and June Boötid epochs will be partly moonlit, and thus difficult, but the Taurids in October–November are Moon-free, in a potential Taurid Complex meteoroid 'swarm' return year. There are also the badly moonlit α-Monocerotids, a decade on from their most recent outburst. Do not forget that monitoring of meteor activity should ideally be carried on throughout the rest of the year, however! We appreciate that this is not practical for many observers, and 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, please note 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, telescopic, video, visual and photographic 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 22), 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 photographic, radar, telescopic, or video 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 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 24) for analysis.

[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 additional material extracted from reliable data analyses produced since.

Visual and photographic 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 as in the last few years, and are starting to bear considerable fruit. These have the advantages, and disadvantages, of both photographic and telescopic observing, plus some of their own, but are increasing in importance. Radio receivers can be utilized at all times, 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 photographic and video 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

Last quarter Moon spoils the northern-hemisphere Quadrantids, as it will be well above the horizon after midnight, just like the Quadrantid radiant (maximum is due around $12^{h}20^{m}$ UT on January 3), but the southern-hemisphere α-Centaurids are superbly-placed for new Moon. The minor δ-Cancrids are reasonably moonless, but not so the δ-Leonids, whose February 24 peak coincides with full Moon! The diffuse ecliptical stream complex of the Virginids gets underway by late January, running through to mid April, probably producing several low and poorly observed maxima in March or early April. 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 recent years), is severely moonlit, especially for most of the, perhaps core, January 20–27 period. Mid-March brings more helpful dark skies to check for southern-hemisphere γ-Normid rates. Theoretical approximate timings for the daytime radio shower maxima this quarter are: Capricornids/Sagittarids – February 1, 8^{h} UT; χ-Capricornids – February 13, 9^{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.

δ-Cancrids

Active: January 1–24; Maximum: January 17 ($\lambda_{\odot} = 297°$); ZHR = 4;
Radiant: $\alpha = 130°$, $\delta = +20°$; Radiant drift: see Table 6 (page 23);
$v_{\infty} = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 115°$, $\delta = +24°$ and $\alpha = 140°$, $\delta = +35°$ ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = -03°$ and $\alpha = 140°$, $\delta = -03°$ ($\beta < 40°$ N).

This minor stream of predominantly faint meteors 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 α by 10° in δ about the radiant point given above. This type of large, loose radiant area is similar to the Virginids, and the δ-Cancrids are probably an early part of the Virginid activity. Recent observations have suggested the peak may occur close to $\lambda_{\odot} = 291°$ (2005 January 11), though ZHRs do not rise above $\sim$ 3–4 even then. New Moon on January 10 to first quarter on January 17 (moonset even then is around, or soon after, local midnight), means both potential peak times will be nicely moonless, so watches throughout this period to see what occurs 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.

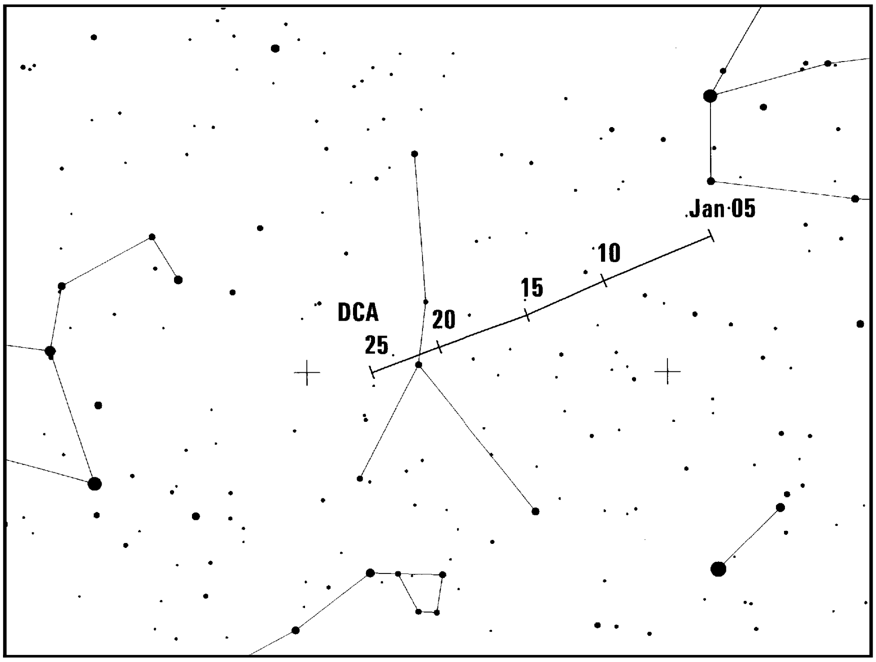

Figure 1 – Radiant position of the δ-Cancrids.

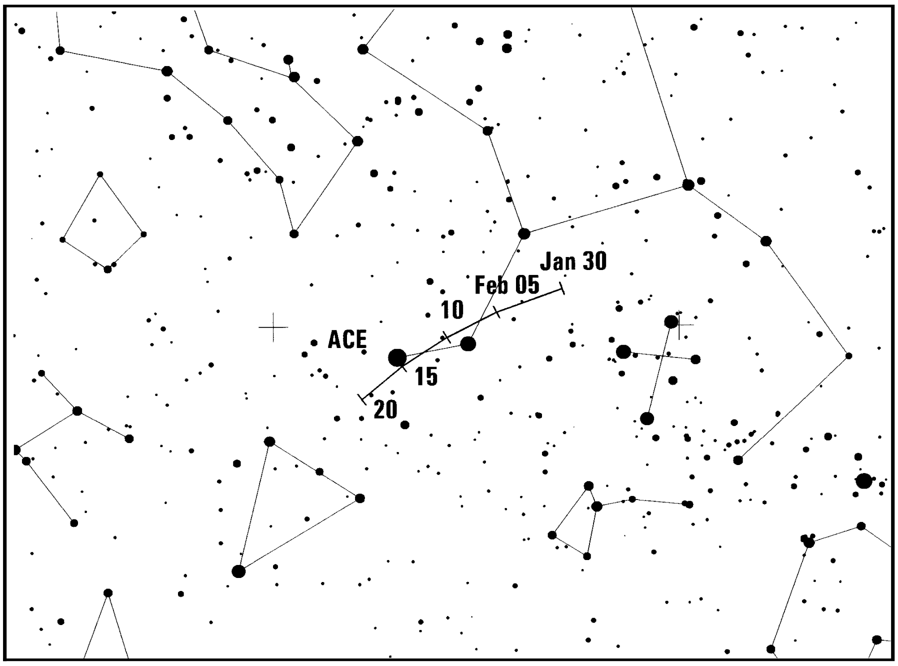

Figure 2 – Radiant position of the α-Centaurids.

α-Centaurids

Active: January 28–February 21; Maximum: February 7, $22^{\mathrm{h}}45^{\mathrm{m}}$ UT ($\lambda_{\odot} = 319.^{\circ}2$);
ZHR = variable, usually ~ 6, but may reach 25+;
Radiant: $\alpha = 210°$, $\delta = -59°$; Radiant drift: see Table 6 (page 23);
$v_{\infty} = 56$ km/s; $r = 2.0$.

The α-Centaurids are one of the main southern hemisphere high points in the opening months of the year, producing many very bright, even fireball-class, objects (meteors of at least magnitude -3). Their peak ZHR is normally around 5–10, but in 1974, and again in 1980, bursts of only a few hours' duration yielded activity closer to 20–30. As we have no means of telling when another such event might happen, photographic, video and visual observers are urged to be alert. Thanks to their brilliance, even a normal α-Centaurid return is worth looking out for, with almost one-third of shower meteors leaving persistent trains. The radiant is nearly circumpolar for much of the sub-equatorial inhabited Earth, and is at a useful elevation from late evening onwards. Lunar news is excellent this year, with new Moon on February 8 creating perfect observing conditions.

3. April to June

Meteor activity picks up towards the April-May boundary, with shower peaks from the hopelessly moonlit Lyrids (between 2^h30^m and 13^h30^m UT on April 22, probably stronger the nearer the peak falls to 10^h30^m UT) and π-Puppids (around 15^h30^m UT on April 23). In early May, the η-Aquarids are rather better-placed to the nearly-new Moon. 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 a few meteors from the o-Cetids and Arietids have been reported 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, 9^h; δ-Piscids – April 24, 9^h; ε-Arietids – May 9, 7^h; May Arietids – May 16, 8^h; o-Cetids – May 20, 7^h; Arietids – June 7, 10^h; ζ-Perseids – June 9, 10^h; β-Taurids – June 28, 9^h. Signs of most of these peaks were found in radio data from 1994–2002, though some are difficult to define because of their proximity to other sources, while the Arietid and ζ-Perseid maxima tend to blend into one another, producing a strong radio signature for several days in early June. There are indications these two shower maxima now each occur up to a day later than indicated here too. The visual ecliptical complexes continue with some late Virginids up to mid April, after which come the minor Sagittarids, and their probable peaks in May–June. For northern observers, checking for any June Lyrids will be hampered by the waxing gibbous Moon near their possible maximum on June 16, while the waning gibbous Moon makes June Boötid hunting equally difficult near their prospective peak on June 27 (potentially within six hours of 8^h UT, if anything manifests at all). Further general details on both showers were in the 2004 *Meteor Shower Calendar*.

η-Aquarids

Active: April 19–May 28; Maximum: May 5, 24^h UT ($\lambda_\odot = 45.^\circ5$);
ZHR = 60 (periodically variable, $\sim$ 40–85);
Radiant: $\alpha = 338^\circ$, $\delta = -01^\circ$; Radiant drift: see Table 6 (page 23);
$v_\infty = 66$ km/s; $r = 2.4$;
TFC: $\alpha = 319^\circ$, $\delta = +10^\circ$ and $\alpha = 321^\circ$, $\delta = -23^\circ$ ($\beta < 20^\circ$ S).

This is a fine, rich stream associated with Comet 1P/Halley, like the Orionids of October, but it is 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-Aquarid meteors 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. Visual ZHRs should thus be around 50–60 in 2005, according to this idea. Whatever the case, the slim waning crescent Moon on May 5–6 (new on May 8) will be only a minor distraction late in the night for southern hemisphere viewers then. 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.

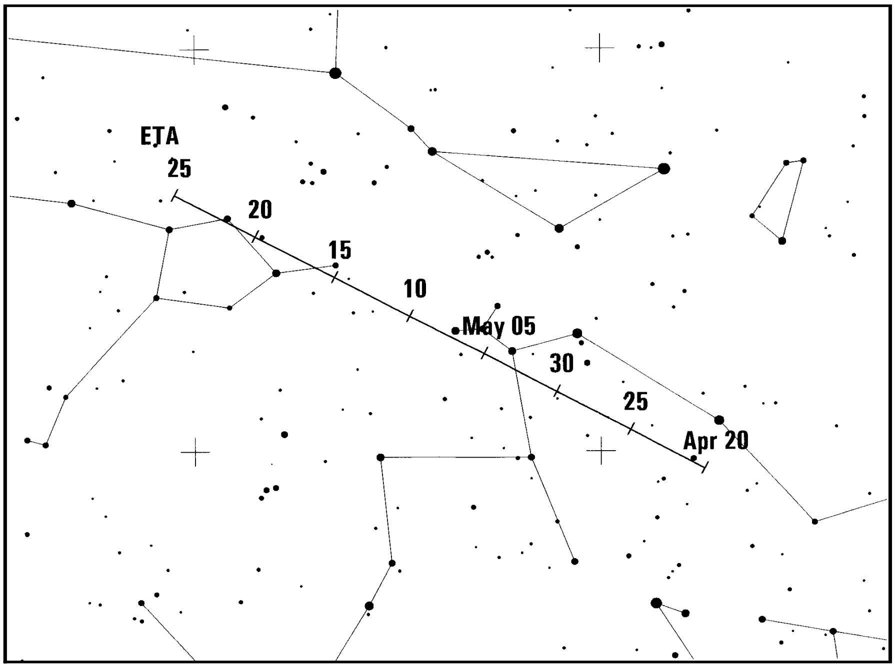

Figure 3 – Radiant position of the η-Aquarids.

4. July to September

July's new Moon brings dark skies for the minor Pegasids and July Phoenicids, along with the near-ecliptic low activity Sagittarids, which end in mid-July. The various Aquarid and α-Capricornid sources continue the near-ecliptic shower complex theme from then until August, after which come the Piscids throughout September (with their badly moonlit probable maximum around September 19). The two late-July better peaks, from the Southern δ-Aquarids and the α-Capricornids, have a waning Moon, but should still survive to view for southern observers especially, along with the minor Piscis Austrinids. Early August's new Moon is good news for the minor Southern ι-Aquarid and Northern δ-Aquarid maxima, and for the major Perseids. Conditions deteriorate after that, but only for the low-activity κ-Cygnid, and the very weak Northern ι-Aquarid peaks, on August 17 and perhaps August 19 respectively. Note the Northern ι-Aquarid maximum is poorly resolved. It may fall between $\lambda_{\odot} = 148°–151°$, August 21–24, according to *IMO* 1988–95 results, or around $\lambda_{\odot} = 147°$, August 19, based on earlier data. Then both the α- and δ-Aurigid maxima in early September are splendidly Moon-free. For daylight radio observers, the interest of May–June has waned, but there remain the visually impossible γ-Leonids (peak towards August 25, 9^{h} UT, albeit not found in recent radio results), and a tricky visual shower, the Sextantids. Their maximum is expected on September 27, 9^{h} UT, but may possibly occur a day earlier. In 1999 a strong return was detected at $\lambda_{\odot} \sim 186°$, equivalent to 2005 September 29, while in 2002, the September 27 peak was not found, but one around September 29–30 was! There is currently some debate over whether several minor maxima in early October may also be due to this radio shower. The waning crescent Moon adds only slightly to the 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 anyway.

Pegasids

Active: July 7–13; Maximum: July 9 ($\lambda_\odot = 107\overset{\circ}{.}5$); ZHR = 3;
Radiant: $\alpha = 340°$, $\delta = +15°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 70$ km/s; $r = 3.0$;
TFC: $\alpha = 320°$, $\delta = +10°$ and $\alpha = 332°$, $\delta = +33°$ ($\beta > 40°$ N);
$\alpha = 357°$, $\delta = +02°$ ($\beta < 40°$ N).

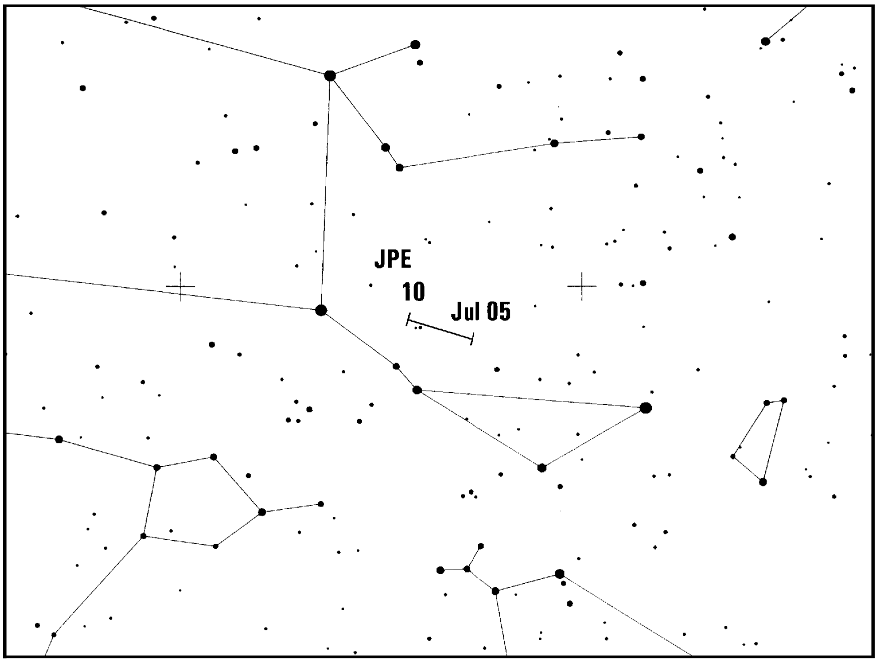

Figure 4 – Radiant position of the Pegasids.

Monitoring this short-lived minor shower is never easy, as a few cloudy nights mean its loss for visual observers. The shower is best-seen in the second half of the night. Consequently, the waxing crescent Moon, setting by the mid to late evening hours on July 9–10, provides near-perfect conditions for observers north and south of the equator this year. The maximum ZHR is generally low, and swift, faint meteors can be expected, favouring telescopic observing.

July Phoenicids

Active: July 10–16; Maximum: July 13 ($\lambda_\odot = 111°$); ZHR = variable 3–10;
Radiant: $\alpha = 032°$, $\delta = -48°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 47$ km/s; $r = 3.0$;
TFC: $\alpha = 041°$, $\delta = -39°$ and $\alpha = 066°$, $\delta = -62°$ ($\beta < 10°$ N).

This minor shower can be seen from the southern hemisphere, from where its radiant attains a reasonable elevation above the horizon after midnight. This is a useful year to watch it, since the waxing Moon sets between local midnight and 1h for typical southerly sites on July 13. Visual activity can be quite variable, and indeed it appears to be a richer radio meteor source (possibly also telescopically; more results are needed). The peak has not been well-observed for some considerable time. Recent years have brought maximum ZHRs of under 4, when the winter weather has allowed any coverage at all. More data would be very welcome!

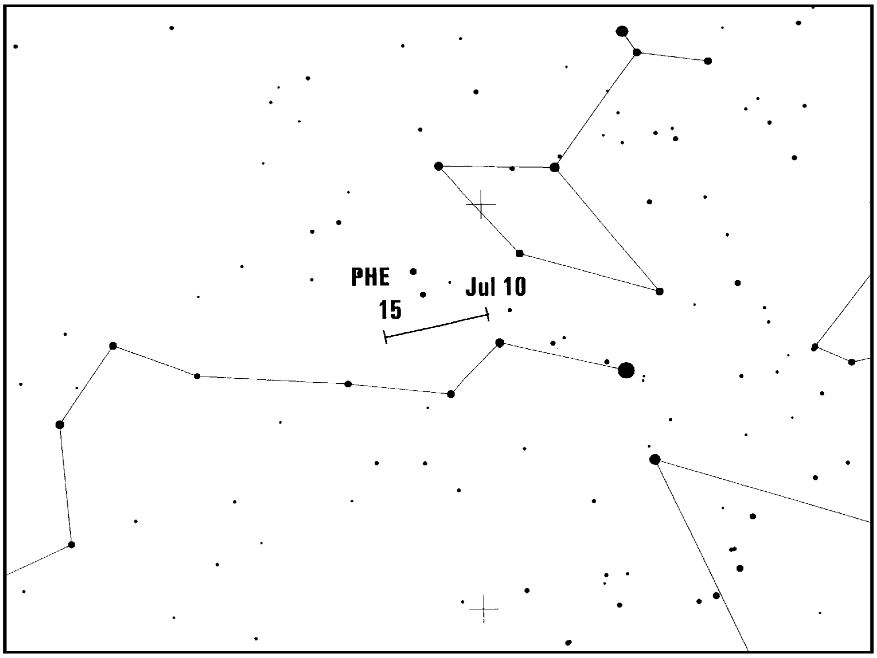

Figure 5 – Radiant position of the July Phoenicids.

Piscis Austrinids and Aquarid/Capricornid Complex

Piscis Austrinids

Active: July 15–August 10; Maximum: July 28 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 35$ 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).

Southern δ-Aquarids

Active: July 12–August 19; Maximum: July 28 ($\lambda_\odot = 125°$); 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 α ($\beta < 40°$N).

α-Capricornids

Active: July 3–August 15; Maximum: July 30 ($\lambda_\odot = 127°$); 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 α ($\beta < 40°$N);
PFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N), $\alpha = 320°$, $\delta = -05°$ (β from 0° to 45° N),
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$).

Southern ι-Aquarids

Active: July 25–August 15; Maximum: August 4 ($\lambda_\odot = 132°$); ZHR = 2;
Radiant: $\alpha = 334°$, $\delta = -15°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 34$ km/s; $r = 2.9$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$N).

Northern δ-Aquarids

Active: July 15–August 25; Maximum: August 8 ($\lambda_\odot = 136°$); ZHR = 4;
Radiant: $\alpha = 335°$, $\delta = -05°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 42$ km/s; $r = 3.4$;
TFC: $\alpha = 255°$ to $000°$, $\delta = 00°$ to $+15°$, choose pairs separated by about 30° in α ($\beta < 30°$N).

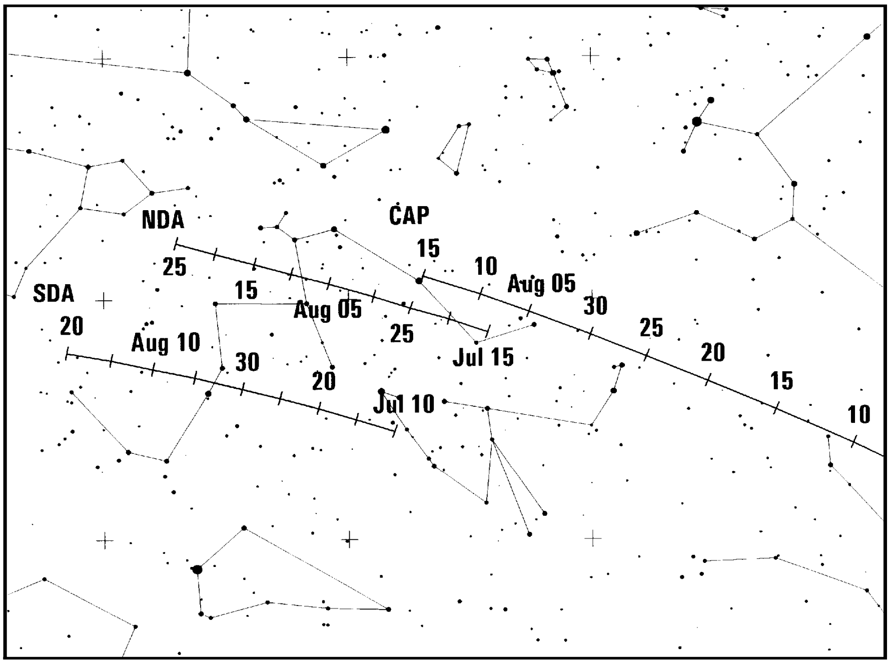

Figure 6 – Radiant position of the Capricornids, Northern and Southern δ-Aquarids.

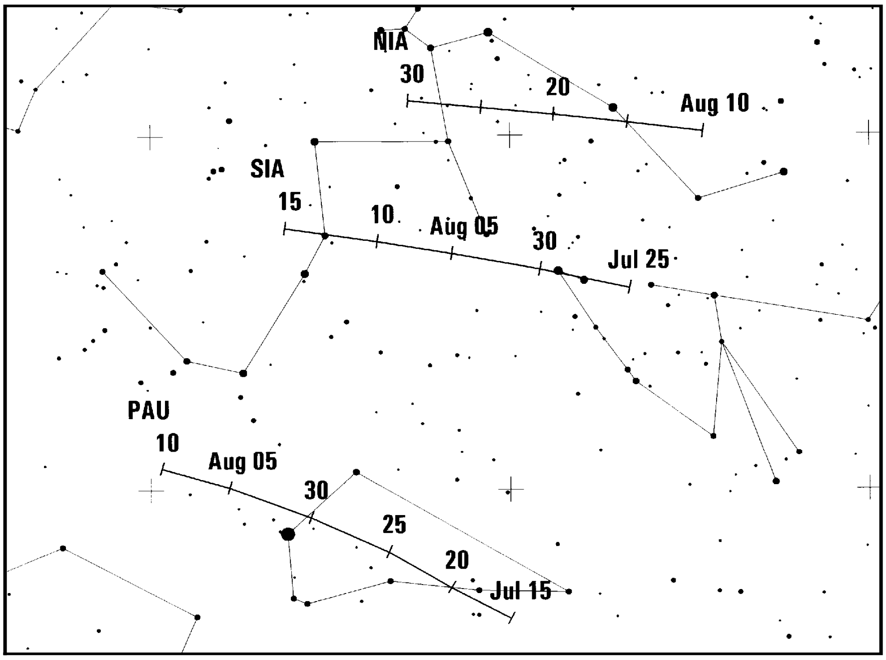

Figure 7 – Radiant position of the Northern and Southern ι-Aquarids and the Piscis Austrinids.

The Aquarids and Piscis Austrinids are all streams rich in faint meteors, making them well-suited to telescopic work, although enough brighter members exist to make visual and photographic observations worth the effort too, primarily from more southerly sites. Radio work can be used to pick up the Southern δ-Aquarids especially, as the most active of these showers. The α-Capricornids are noted for their bright – sometimes fireball-class – events, 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 α-Capricornid ZHRs to ~ 10 was noted in 1995 by European *IMO* observers, although the Southern δ-Aquarids were the only one of these streams previously suspected of occasional variability.

Such a concentration of radiants in a small area of sky means that familiarity with where all the radiants are is essential for accurate shower association. Visual watchers in particular should plot any potential stream members seen in this region of sky rather than trying to make shower associations in the field. The only exception is when the Southern δ-Aquarids are near their peak, as from southern hemisphere sites in particular, rates may become too high for accurate plotting.

In 2005, the early-rising last quarter to waning crescent Moon creates especial problems for northern observers hoping to cover the late July maxima, although southern hemisphere watchers enjoy a significantly later moonrise for the July 28 and 30 peaks. The very weak Southern ι-Aquarids are ideally-located near new Moon, and the Northern δ-Aquarids are very favourable too, leaving only the Northern ι-Aquarids to fend off full Moon at their ill-defined maximum. All these radiants are above the horizon for much of the night.

Perseids

Active: July 17–August 24;
Maximum: August 12, 17^{h}–$19^{\mathrm{h}}30^{\mathrm{m}}$ UT ($\lambda_{\odot} = 140.^{\circ}0$–$140.^{\circ}1$), but see text; ZHR = 100;
Radiant: $\alpha = 046^{\circ}$, $\delta = +58^{\circ}$; Radiant drift: see Table 6 (page 23);
$v_{\infty} = 59$ km/s; $r = 2.6$;
TFC: $\alpha = 019^{\circ}$, $\delta = +38^{\circ}$ and $\alpha = 348^{\circ}$, $\delta = +74^{\circ}$ before 2^{h} local time;
$\alpha = 043^{\circ}$, $\delta = +38^{\circ}$ and $\alpha = 073^{\circ}$, $\delta = +66^{\circ}$ after 2^{h} local time ($\beta > 20^{\circ}$ N);
PFC: $\alpha = 300^{\circ}$, $\delta = +40^{\circ}$, $\alpha = 000^{\circ}$, $\delta = +20^{\circ}$ or $\alpha = 240^{\circ}$, $\delta = +70^{\circ}$ ($\beta > 20^{\circ}$ 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 $\sim$ 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.

An average annual shift of $+0.^{\circ}05$ in $\lambda_{\odot}$ had been deduced from 1991–99 data, and allowing for this could give a possible primary peak time around $18^{\mathrm{h}}30^{\mathrm{m}}$ UT on August 12 ($\lambda_{\odot} = 140.^{\circ}06$), if so within the most probable maximum time, that of the "traditional" peak always previously found, given above. Another feature, seen only in *IMO* data from 1997–99, was a tertiary peak at $\lambda_{\odot} = 140.^{\circ}4$, the repeat time for which would be 3^{h} UT on August 13. Some researchers commented several years ago that 2004–06 might see a return of the primary peak. No specific predictions for 2005 had been issued before this Shower Calendar was prepared, but any prepared subsequently should feature in the *IMO*'s journal *WGN* or on the *IMO-News* e-mailing list, and observers need to be alert to this possibility.

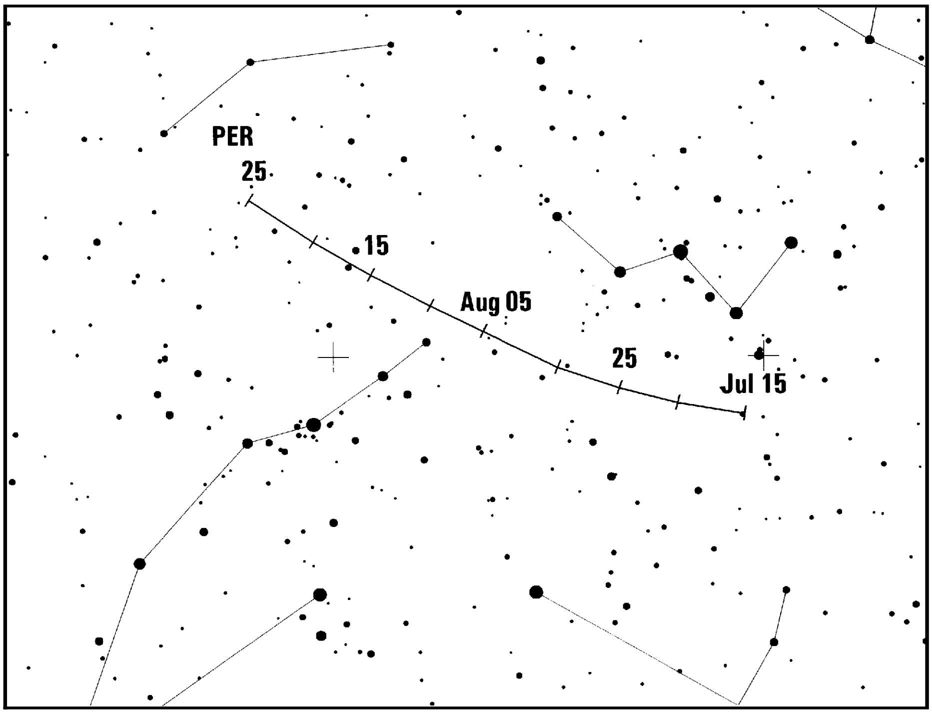

Figure 8 – Radiant position of the Perseids.

Whatever happens, and whenever the peak or peaks fall around August 12, the waxing crescent Moon, just before first quarter, will set for mid-northern latitudes about the time the radiant is becoming sensibly observable, between 22^{h}–23^{h} local time. The radiant gains altitude throughout the night for these more favourable locations. The August 12 maxima timings would be best-viewed from a zone running from the Near East to east Asia, including Japan, although the later the peak occurs, the less favourable places east in this region would be. The August 13 timing would be visible from the extreme west of both Europe and North Africa westwards to the eastern seaboard of North America and northern South America, over the North Atlantic Ocean.

Visual and photographic 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.

α- and δ-Aurigids

α-Aurigids

Active: August 25–September 8; Maximum: September 1, 0^{h} UT ($\lambda_{\odot} = 158.^{\circ}6$); ZHR = 7;
Radiant: $\alpha = 84^{\circ}$, $\delta = +42^{\circ}$; Radiant drift: see Table 6 (page 23);
$v_{\infty} = 66$ km/s; $r = 2.6$;
TFC: $\alpha = 052^{\circ}$, $\delta = +60^{\circ}$; $\alpha = 043^{\circ}$, $\delta = +39^{\circ}$ and $\alpha = 023^{\circ}$, $\delta = +41^{\circ}$ ($\beta > 10^{\circ}$ S).

δ-Aurigids

Active: September 5–October 10; Maximum: September 9 ($\lambda_\odot = 166.°7$); ZHR = 5; Radiant: $\alpha = 060°$, $\delta = +47°$; Radiant drift: see Table 6 (page 23); $v_\infty = 64$ km/s; $r = 2.9$; TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$ ($\beta > 10°$ S).

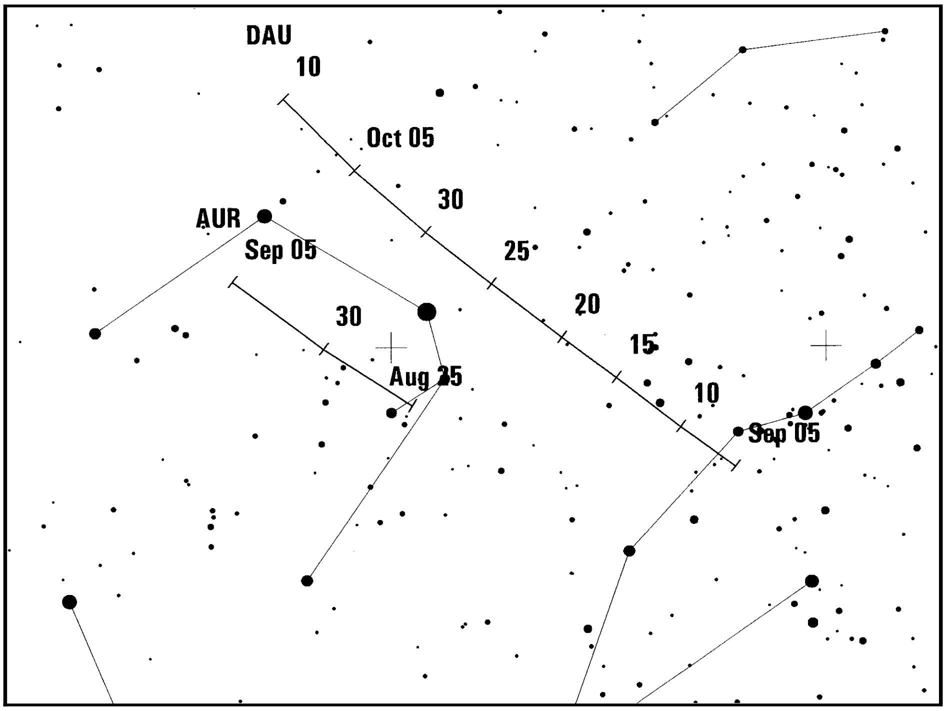

Figure 9 – Radiant position of the α- and δ-Aurigids.

Both these essentially northern hemisphere showers are excellently placed to catch the best dark skies near September's new Moon this year, so every opportunity should be taken to secure more observations on them. They appear to be part of a series of poorly observed showers 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 Aurigid sources have recently been investigated by analysts Audrius Dubietis and Rainer Arlt, using *IMO*-standard data since 1986, and their known parameters updated accordingly.

The α-Aurigids are the more active, with short unexpected bursts having given EZHRs of ~ 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 δ-Aurigids probably represent a combination of two separate, but possibly related, minor sources, the September Perseids and δ-Aurigids, whose activities and radiants effectively overlap one another. The showers are probably not resolvable by visual watchers, who are advised to apply the parameters listed above, although these primarily derive from the "September Perseid" phase. The "δ-Aurigid" phase seems to give a weak maximum around $\lambda_\odot = 181°$ (2005 September 23–24; ZHR ~ 3, $r = 2.5$).

Radiants for both main showers reach useful elevations after 23^h–0^h local time, thus the new to waxing crescent Moon creates ideal lunar circumstances, setting at worst by early to mid-evening around September 9. Conditions will be much less favourable for the possible September 23–24 peak however, with a waning gibbous Moon. 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 photographs, video records and visual plotting would be welcomed too.

5. October to December

Potential Draconid hunting should be practical this year in early October. Unfortunately, things are less helpful for the very weak ϵ-Geminids (maximum due on October 18) and the major Orionids (main peak expected on October 21), which are both lost to waning gibbous moonlight. As the Moon rolls on, Taurid-watching from late October to almost mid-November is chiefly Moon-free. Later, the Leonids must endure full Moon near their probable maximum, towards $14^{\mathrm{h}}30^{\mathrm{m}}$ UT on November 17. Although the α-Monocerotid peak is also badly moonlit, the shower is highlighted here on the tenth anniversary of its latest outburst. The early December mostly minor shower maxima are acceptably free from moonlight through to the σ-Hydrids, but this means both the major Geminids (maximum within 2 h 20 m of $4^{\mathrm{h}}30^{\mathrm{m}}$ UT on December 14) and the minor Coma Berenicids (peak around December 19) are both swamped by full moonlight. Something of the Ursids at least should still be seen without the Moon.

Draconids

Active: October 6–10; Maximum: October 8, 16^{h} UT ($\lambda_{\odot} = 195\overset{\circ}{.}4$, 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).

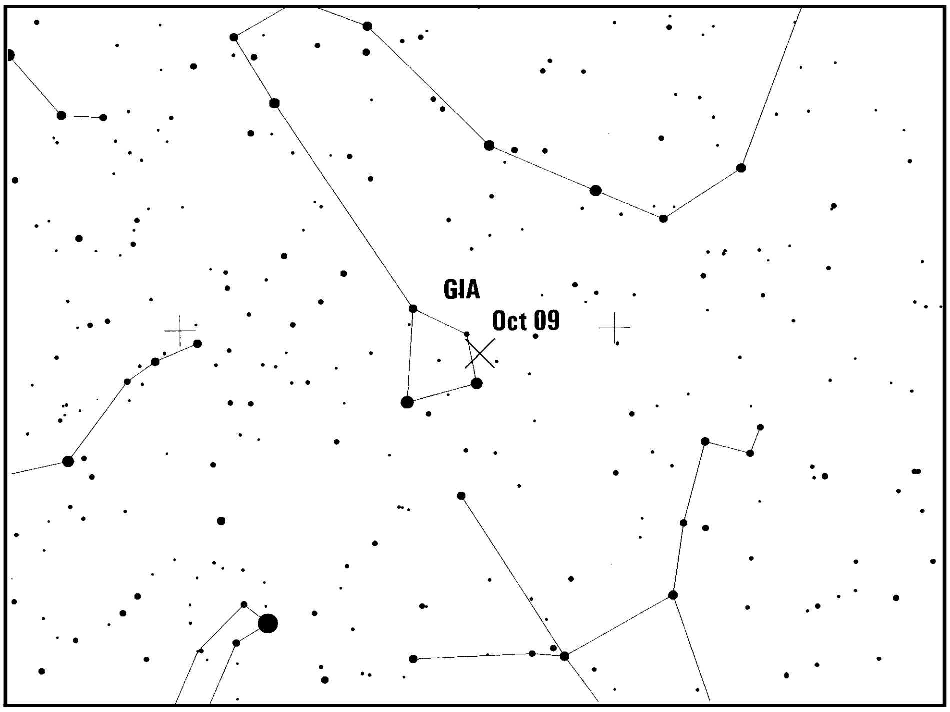

Figure 10 –Radiant position of the Draconids.

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 recently in 1998 (when EZHRs briefly reached 700). Most detected showers were in years when the stream's parent comet, 21P/Giacobini-Zinner, returned to perihelion, as it did in 1998 November. The comet returns to perihelion again in July this year, but whether it will have any effect on the Draconids we see in 2005 is not clear. Earlier theoretical discussions suggested an outburst was unlikely, but theory is not always the perfect guide to reality! The 1998 outburst happened at $\lambda_\odot = 195\overset{\circ}{.}075$, equivalent to 2005 October 8, 8^h15^m UT, although the nodal crossing time used above may be more generally applicable. In 1999 an unexpected minor visual-radio outburst (ZHRs $\sim$ 10–20) occurred over the Far East between $\lambda_\odot = 195\overset{\circ}{.}63$–$195\overset{\circ}{.}76$. A repeat at this time would fall between 2005 October 8, 21^h40^m to October 9, 0^h50^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. The waxing crescent Moon sets by mid-evening on October 8 and 9 at such places, so much of the night will be available for dark-sky observing, 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.

Taurids

Southern Taurids

Active: October 1–November 25; Maximum: November 5 ($\lambda_\odot = 223°$); ZHR = 5;
Radiant: $\alpha = 052°$, $\delta = +13°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 27$ 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

Active: October 1–November 25; Maximum: November 12 ($\lambda_\odot = 230°$); ZHR = 5;
Radiant: $\alpha = 058°$, $\delta = +22°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 29$ 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, photography or video work, since they are large and diffuse. They are currently being studied using *IMO* data by Mihaela Triglav. The brightness and relative slowness of many shower meteors makes them ideal targets for photography, 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 streams produces an apparently plateau-like maximum for about ten days in early November, and the showers have a reputation for producing some excellently bright fireballs at times, although seemingly not in every year.

David Asher has 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 and 1998 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. This year brings the next potential October-November "swarm" return. Thus, observing what happens with the Taurids between last quarter Moon in October through to the Northern Taurid maximum in November is most important, especially as early November's new Moon makes almost the whole of this spell very favourable.

The near-ecliptic radiants for both shower branches mean all meteoricists can observe the streams. 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.

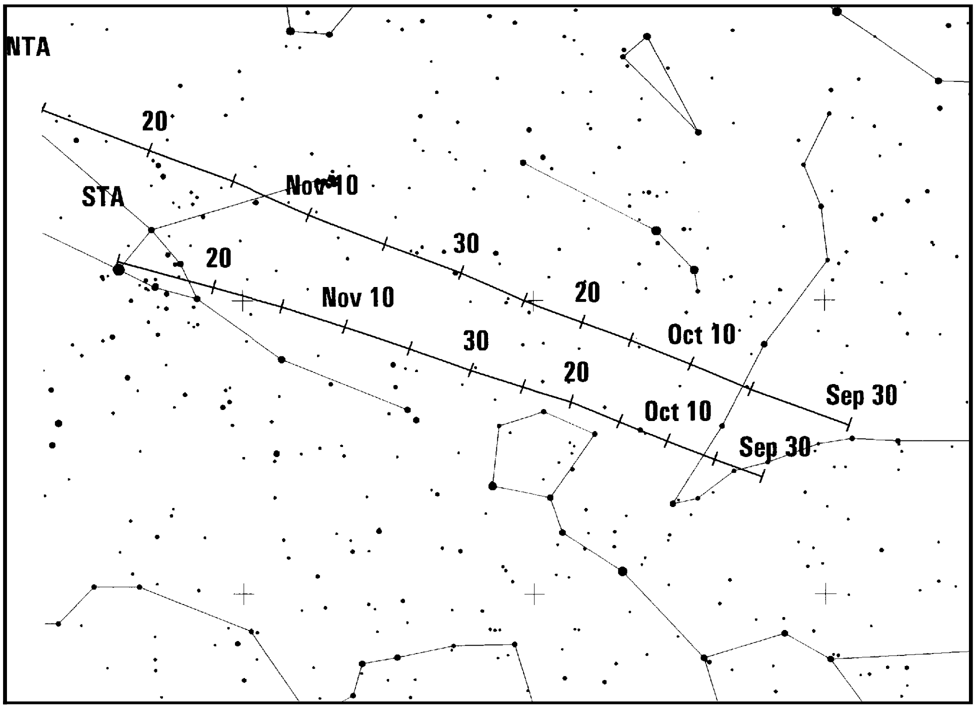

Figure 11 –Radiant position of the Northern and Southern Taurids.

α-Monocerotids

Active: November 15–25; Maximum: November 21, 15^h00^m UT ($\lambda_\odot = 239°32$);
ZHR = variable, usually ~ 5, but may produce outbursts to $\sim 400+$;
Radiant: $\alpha = 117°$, $\delta = +01°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 65$ 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, ~ 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. Whether this indicates the proposed ten-year periodicity – with heightened rates in 1925, 1935, 1985 and 1995 – is real or not, only this year (or other future decadal returns) may tell, so all observers should continue to monitor this source closely.

The waning gibbous Moon on November 21 is very bad news however, as it will rise between mid to late evening across much of the world, ruining any chance of dark skies for watchers, because the radiant is well on view from either hemisphere only after about 23^{h} local time. The expected peak time falls especially well for sites around and in the western Pacific Ocean, including eastern China, far eastern Russia, Japan, Oceania, and Alaska in North America. With the Moon so problematic, visual observing will be extremely difficult, but highly important, along with all other techniques, especially radio, which should readily detect any strong outburst from this source.

χ-Orionids

Active: November 26–December 15; Maximum: December 2 ($\lambda_{\odot} = 250°$); ZHR = 3;
Radiant: $\alpha = 082°$, $\delta = +23°$; Radiant drift: see Table 6 (page 23);
$v_{\infty} = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 083°$, $\delta = +09°$ and $\alpha = 080°$, $\delta = +24°$ ($\beta > 30°$ S).

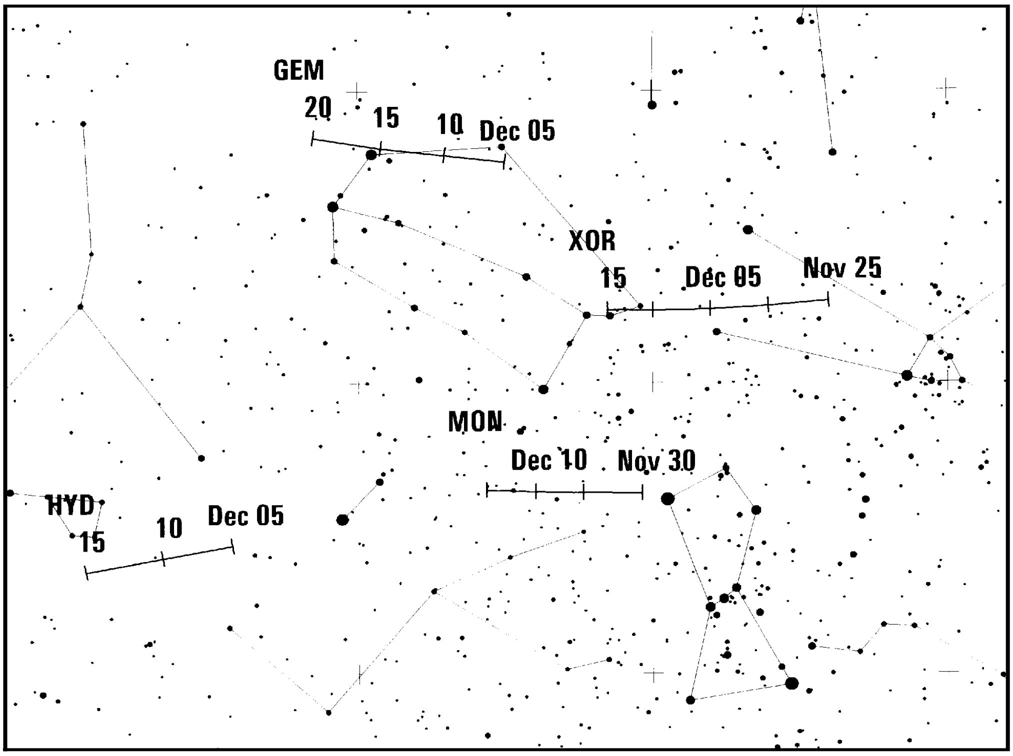

Figure 12 –Radiant position of the Geminids, χ-Orionids, Monocerotids, and σ-Hydrids.

A weak visual stream, but one moderately active telescopically. 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 χ-Orionids may be a continuation of the ecliptic complex after the Taurids cease to be active in late November.

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, and new Moon on December 1 makes this a perfect year for watching it.

Phoenicids

Active: November 28–December 9; Maximum: December 6, $8^{h}45^{m}$ UT ($\lambda_\odot = 254\overset{\circ}{.}25$);
ZHR = variable, usually 3 or less, may reach 100;
Radiant: $\alpha = 018°$, $\delta = -53°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 18$ km/s; $r = 2.8$;
TFC: $\alpha = 040°$, $\delta = -39°$ and $\alpha = 065°$, $\delta = -62°$ ($\beta < 10°$ 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 be 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 quite good, with a waxing crescent Moon setting half an hour either side of local midnight in most mid-southern locations on December 6, while the radiant culminates at dusk, remaining well on view for most of the night.

Puppid-Velids

Active: December 1–15; Maximum: December ~ 7 ($\lambda_\odot \sim 255°$); ZHR ~ 10;
Radiant: $\alpha = 123°$, $\delta = -45°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 40$ km/s; $r = 2.9$;
TFC: $\alpha = 090°$ to $150\circ$, $\delta = -20°$ to $-60°$; choose pairs of fields separated by about 30° in α, moving eastwards as the shower progresses ($\beta < 10°$ N).

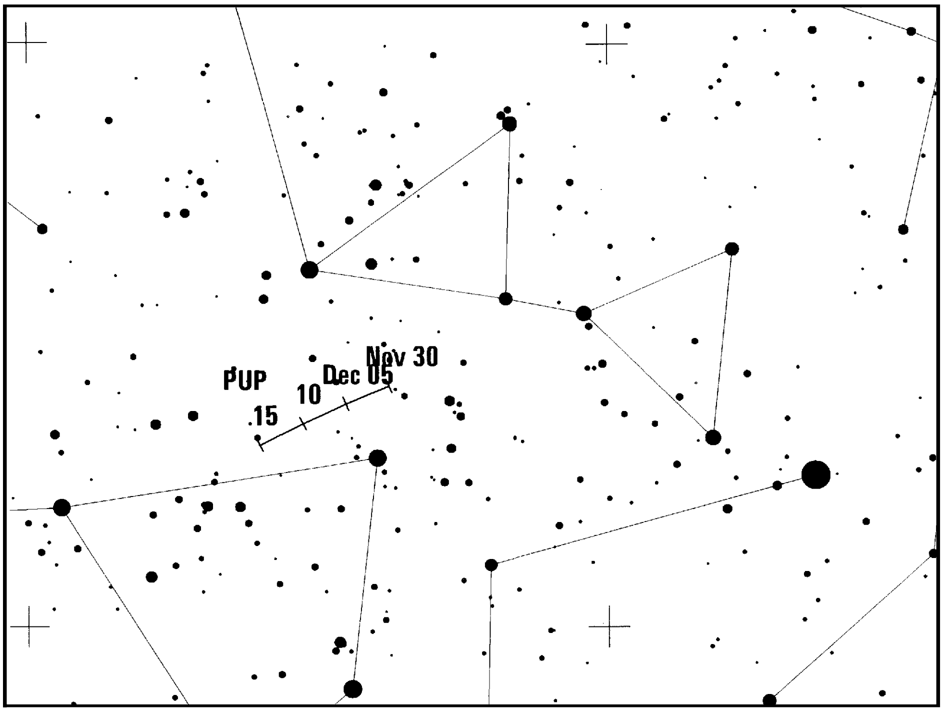

Figure 13 –Radiant position of the Puppid-Velids.

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. Photographic, video 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 a waxing Moon this year. Some of these showers may be visible from late October to late January. 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, so the better radiant elevations will happen after moonset.

Monocerotids

Active: November 27–December 17; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 3;
Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 42$ 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 suggest a later maximum, around December 15–16($\lambda_\odot \sim 264°$) from a radiant at $\alpha = 117°$, $\delta = +20°$. This is quite a good year for making observations, as the waxing gibbous Moon sets between local midnight and 1h across the world on December 9, while the radiant is on-show virtually all night, culminating about $1^{\mathrm{h}}30^{\mathrm{m}}$ local time.

σ-Hydrids

Active: December 3–15; Maximum: December 12 ($\lambda_\odot = 260°$); ZHR = 2;
Radiant: $\alpha = 127°$, $\delta = +02°$; Radiant drift: see Table 6 (page 23);
$v_\infty = 58$ 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, σ-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 (α 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. Although the Moon is only three days before full for their predicted peak, there remains a short dark-sky observing window after moonset and before dawn, particularly north of the equator, for observers to take advantage of. Recent data indicates the maximum may happen up to six days earlier than this theoretical maximum, which would be very much more favourable for Moon-free watching. The shower would benefit from visual plotting, telescopic or video work to pin it down more accurately.

Ursids

Active: December 17–26; Maximum: December 22, 13^{h} UT ($\lambda_{\odot} = 270.^{\circ}7$); ZHR = 10 (occasionally variable up to 50); Radiant: $\alpha = 217^{\circ}$, $\delta = +76^{\circ}$; Radiant drift: see Table 6 (page 23); $v_{\infty} = 33$ km/s; $r = 3.0$; TFC: $\alpha = 348^{\circ}$, $\delta = +75^{\circ}$ and $\alpha = 131^{\circ}$, $\delta = +66^{\circ}$ ($\beta > 40^{\circ}$ N); $\alpha = 063^{\circ}$, $\delta = +84^{\circ}$ and $\alpha = 156^{\circ}$, $\delta = +64^{\circ}$ (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 60 years, in 1945 and 1986. Several other rate enhancements, recently in 1988, 1994 and 2000, 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 $\lambda_{\odot} = 270.^{\circ}8$, for instance, which might suggest a slightly later maximum time in 2005 of December 22, $15^{h}20^{m}$ UT, while the 2000 enhancement was seen surprisingly strongly (EZHR $\sim$ 90) by video at $\lambda_{\odot} = 270.^{\circ}78$ (equivalent to 2005 December 22, 15^{h} UT), although the visual enhancement was much less, ZHR $\sim$ 30. 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 gibbous Moon will rise around 23^{h} local time on December 22, so conditions will not be perfect for seeing whatever happens this time. The expected peaks favour northerly sites between central Asia eastwards across the Pacific Ocean to western North America.

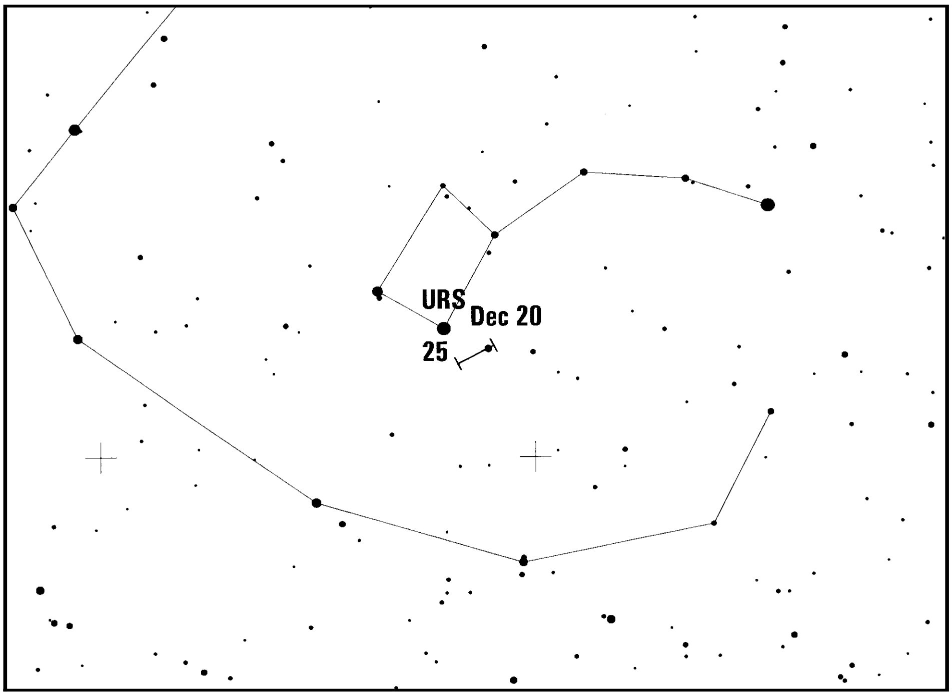

Figure 14 –Radiant position of the Ursids.

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.

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

D	Diameter	D	Diameter
15°	14°	50°	20°
30°	17°	70°	23°

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.

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. Figure 15 is a graphical representation of for two radiant distances of the meteor.

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 atmospheric entry velocities (v_∞). All angular 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

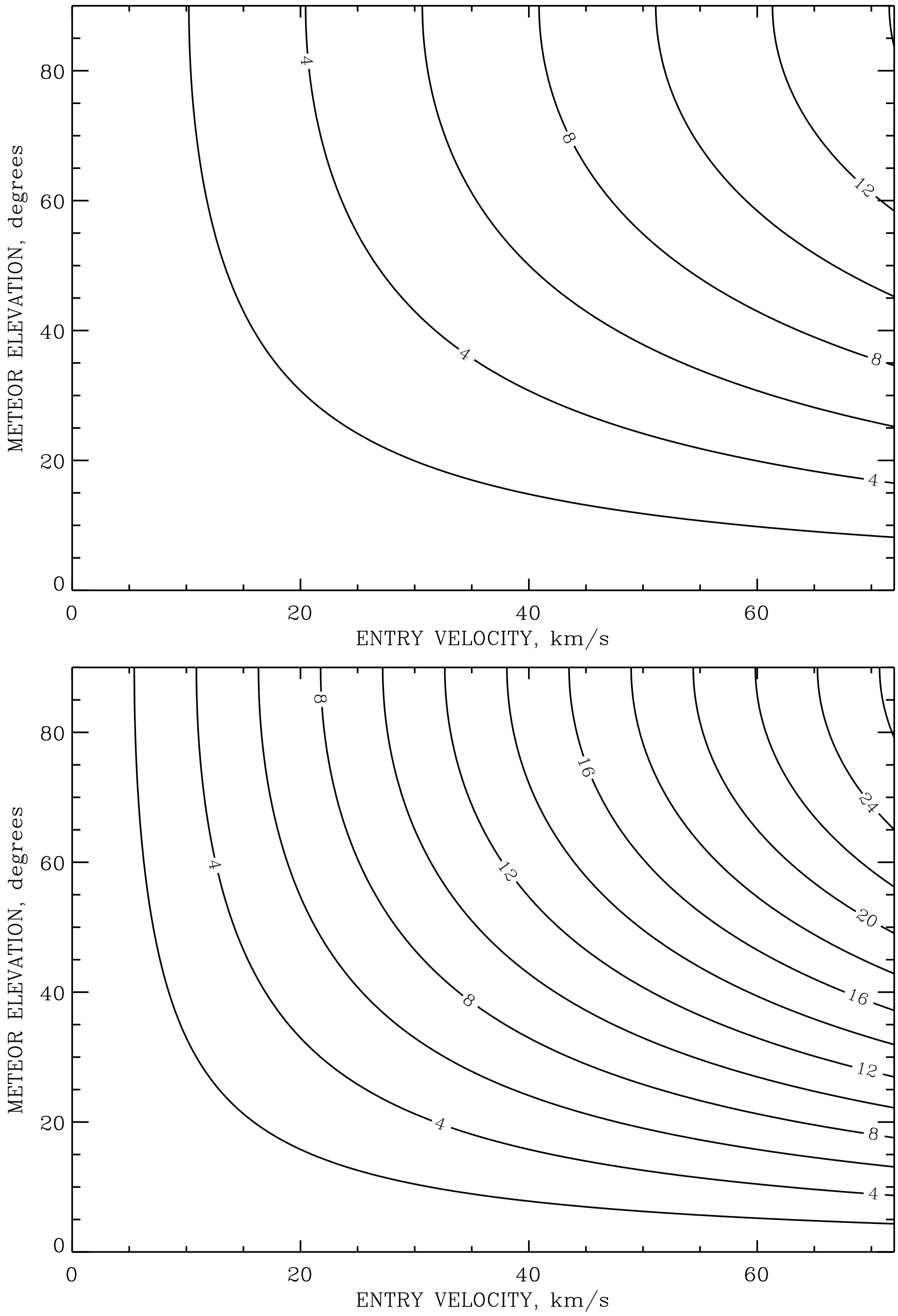

Figure 15 –Graphical representation of Table 3. The upper plot is valid for a meteor distance from the radiant of 20°, the lower for 40°. The contours give the resulting angular velocity in °/s.

7. Abbreviations and tables for observers

- 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 (page 23) 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 J2000.0.
- v_∞: Atmospheric or meteoric entry 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, an equivalent ZHR (EZHR) is used measuring the activity as if it would have lasted for an hour.
- TFC and PFC: Suggested telescopic and small-camera photographic field centers 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 PFC depends on the observer's location and the elevation of the radiant. Note that the TFCs are also useful centers to use for video camera fields as well.

Table 4 – Lunar phases for 2005.

New Moon	First Quarter	Full Moon	Last Quarter
			January 3
January 10	January 17	January 25	February 2
February 8	February 16	February 24	March 3
March 10	March 17	March 25	April 2
April 8	April 16	April 24	May 1
May 8	May 16	May 23	May 30
June 6	June 15	June 22	June 28
July 6	July 14	July 21	July 28
August 5	August 13	August 19	August 26
September 3	September 11	September 18	September 25
October 3	October 10	October 17	October 25
November 2	November 9	November 16	November 23
December 1	December 8	December 15	December 23
December 31			

Table 5 – Working list of visual meteor showers. Details in this Table were correct according to the best information available in May 2005. 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. An asterisk ("*") in the "$\lambda_\odot$" column indicates the shower may have other or additional peak times, noted in the text.

Shower	Activity	Maximum		Radiant		V_∞	r	ZHR
		Date	$\lambda_\odot$	α	δ	km/s		
Quadrantids (QUA)	Jan 01–Jan 05	Jan 03	283°16	230°	+49°	41	2.1	120
δ-Cancrids (DCA)	Jan 01–Jan 24	Jan 17	297°	130°	+20°	28	3.0	4
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 07	319°2	210°	−59°	56	2.0	6
δ-Leonids (DLE)	Feb 15–Mar 10	Feb 24	336°	168°	+16°	23	3.0	2
γ-Normids (GNO)	Feb 25–Mar 22	Mar 13	353°	249°	−51°	56	2.4	8
Virginids (VIR)	Jan 25–Apr 15	(Mar 24)	(4°)	195°	−04°	30	3.0	5
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32°32	271°	+34°	49	2.1	18
π-Puppids (PPU)	Apr 15–Apr 28	Apr 24	33°5	110°	−45°	18	2.0	var
η-Aquarids (ETA)	Apr 19–May 28	May 05	45°5	338°	−01°	66	2.4	60
Sagittarids (SAG)	Apr 15–Jul 15	(May 19)	(59°)	247°	−22°	30	2.5	5
June Bootids (JBO)	Jun 26–Jul 02	Jun 27	95°7	224°	+48°	18	2.2	var
Pegasids (JPE)	Jul 07–Jul 13	Jul 09	107°5	340°	+15°	70	3.0	3
Jul Phoenicids (PHE)	Jul 10–Jul 16	Jul 13	111°	32°	−48°	47	3.0	var
Piscis Austrinids (PAU)	Jul 15–Aug 10	Jul 28	125°	341°	−16°	35	3.2	5
South. δ-Aquarids (SDA)	Jul 12–Aug 19	Jul 28	125°	339°	−30°	41	3.2	20
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 30	127°	307°	−10°	23	2.5	4
South. ι-Aquarids (SIA)	Jul 25–Aug 15	Aug 04	132°	334°	−15°	34	2.9	2
North. δ-Aquarids (NDA)	Jul 15–Aug 25	Aug 08	136°	335°	−05°	42	3.4	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
North. ι-Aquarids (NIA)	Aug 11–Aug 31	Aug 19	147°	327°	−06°	31	3.2	3
α-Aurigids (AUR)	Aug 25–Sep 08	Sep 01	158°6	84°	+42°	66	2.6	10
δ-Aurigids (DAU)*	Sep 05–Oct 10	Sep 09	166°7	60°	+47°	64	2.9	5
Piscids (SPI)	Sep 01–Sep 30	Sep 19	177°	5°	−01°	26	3.0	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	23
Southern Taurids (STA)	Oct 01–Nov 25	Nov 05	223°	52°	+13°	27	2.3	5
Northern Taurids (NTA)	Oct 01–Nov 25	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (LEO)	Nov 14–Nov 21	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
χ-Orionids (XOR)	Nov 26–Dec 15	Dec 02	250°	82°	+23°	28	3.0	3
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	3
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 12	260°	127°	+02°	58	3.0	2
Geminids (GEM)	Dec 07–Dec 17	Dec 14	262°2	112°	+33°	35	2.6	120
Coma Berenicids (COM)	Dec 12–Jan 23	Dec 19	268°	175°	+25°	65	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°7	217°	+76°	33	3.0	10

Table 6 – Radiant drift positions during the year in α and δ.

	COM	**DCA**	**QUA**					
Jan 0	186 +20	112 +22	228 +50					
Jan 5	190 +18	116 +22	231 +49					
Jan 10	194 +17	121 +21						
Jan 20	202 +13	130 +19		**ACE**	**VIR**			
Jan 30				200 -57	157 +16	**DLE**		
Feb 10				214 -60	165 +10	155 +20	**GNO**	
Feb 20				225 -63	172 +6	164 +18	225 -53	
Feb 28					178 +3	171 +15	234 -52	
Mar 10					186 0	180 +12	245 -51	
Mar 20					192 -3		256 -50	
Mar 30					198 -5			
Apr 10	**SAG**	**LYR**	**PPU**		203 -7			
Apr 15	224 -17	263 +34	106 -44	**ETA**	205 -8			
Apr 20	227 -18	269 +34	109 -45	323 -7				
Apr 25	230 -19	274 +34	111 -45	328 -5				
Apr 30	233 -19			332 -4				
May 5	236 -20			337 -2				
May 10	240 -21			341 0				
May 20	247 -22			350 +5				
May 30	256 -23							
Jun 10	265 -23							
Jun 15	270 -23							
Jun 20	275 -23	**JBO**						
Jun 25	280 -23	223 +48						
Jun 30	284 -23	225 +47	**CAP**			**JPE**		
Jul 5	289 -22		285 -16	**SDA**		338 +14		
Jul 10	293 -22	**PHE**	289 -15	325 -19	**NDA**	341 +15	**PER**	**PAU**
Jul 15	298 -21	032 -48	294 -14	329 -19	316 -10		012 +51	330 -34
Jul 20			299 -12	333 -18	319 -9	**SIA**	018 +52	334 -33
Jul 25			303 -11	337 -17	323 -9	322 -17	023 +54	338 -31
Jul 30	**KCG**		308 -10	340 -16	327 -8	328 -16	029 +55	343 -29
Aug 5	283 +58	**NIA**	313 -8	345 -14	332 -6	334 -15	037 +57	348 -27
Aug 10	284 +58	317 -7	318 -6	349 -13	335 -5	339 -14	043 +58	352 -26
Aug 15	285 +59	322 -7		352 -12	339 -4	345 -13	050 +59	
Aug 20	286 +59	327 -6	**AUR**	356 -11	343 -3		057 +59	
Aug 25	288 +60	332 -5	076 +42		347 -2		065 +60	
Aug 30	289 +60	337 -5	082 +42	**DAU**	**SPI**			
Sep 5			088 +42	055 +46	352 -4			
Sep 10			092 +42	060 +47	356 -3			
Sep 15				066 +48	000 -2			
Sep 20				071 +48	005 -1			
Sep 25	**NTA**	**STA**		077 +49	010 0			
Sep 30	021 +11	023 +5	**ORI**	083 +49	015 +1			
Oct 5	025 +12	027 +7	085 +14	089 +49		**GIA**		
Oct 10	029 +14	031 +8	088 +15	095 +49	**EGE**	262 +54		
Oct 15	034 +16	035 +9	091 +15		099 +27			
Oct 20	038 +17	039 +11	094 +16		104 +27			
Oct 25	043 +18	043 +12	098 +16		109 +27			
Oct 30	047 +20	047 +13	101 +16					
Nov 5	053 +21	052 +14	105 +17					
Nov 10	058 +22	056 +15		**LEO**	**AMO**			
Nov 15	062 +23	060 +16		150 +23	112 +2			
Nov 20	067 +24	064 +16	**XOR**	153 +21	116 +1			
Nov 25	072 +24	069 +17	075 +23		120 0	**MON**	**PUP**	**PHO**
Nov 30			080 +23	**HYD**		091 +8	120 -45	014 -52
Dec 5	**COM**	**GEM**	085 +23	122 +3		096 +8	122 -45	018 -53
Dec 10	169 +27	108 +33	090 +23	126 +2		100 +8	125 -45	022 -53
Dec 15	173 +26	113 +33	094 +23	130 +1	**URS**	104 +8	128 -45	
Dec 20	177 +24	118 +32			217 +75			

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	$\lambda_\odot$	Radiant		Best Observed		Rate
		Date	2000.0	α	δ	50° N	35° S	
Cap/Sagittarids	Jan 13–Feb 04	Feb 01	312°5	299°	−15°	11^h–14^h	09^h–14^h	medium
χ-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
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

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, Habichtstr. 1, D-15526 Reichenwalde, Germany.
e-mail: `fidac@imo.net`

Photographic Commission:
Marc de Lignie, Prins Hendrikplein 42, NL-2264 SN Leidschendam, The Netherlands.
e-mail: `m.c.delignie@xs4all.nl`

Radio Commission:
Temporarily vacant. e-mail: `radio@imo.net`

Telescopic Commission:
Malcolm Currie, 25 Collett Way, Grove, Wantage, Oxfordshire, OX12 0NT, UK.
e-mail: `tele@imo.net`

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: `http://www.imo.net`

For further details on **IMO membership**, please write to: Ina Rendtel, *IMO* Treasurer, Mehlbeerenweg 5, D-14469 Potsdam, Germany. e-mail: `IRendtel@t-online.de`

Please try to enclose return postage when writing to any *IMO* officials, either in the form of stamps (same country only) or as an International Reply Coupon (I.R.C.—available from main postal outlets). Thank you!