International Meteor Organization
1999 Meteor Shower Calendar

compiled by Alastair McBeath[1]

Introduction

Welcome to the 1999 *International Meteor Organization (IMO)* Meteor Shower Calendar. The year promises to be another interesting one, with many major showers free from moonlight interference (except the Quadrantids, η-Aquarids, Southern δ-Aquarids and Orionids). The Leonids may possibly produce high to very high activity in November, while in August, the millennium's last total solar eclipse ensures perfect conditions for the Perseids. Do not forget that monitoring of meteor activity should ideally be carried on throughout the rest of the year too, however! We appreciate that this is not practical for many observers, and this Calendar was devised as a means of helping observers deal with reality by highlighting times when a particular effort may most usefully be employed. Although we include to-the-hour 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 received little attention in recent years). 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, 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 page 14), 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 16) for analysis.

Visual and photographic techniques remain popular for nightly meteor coverage (weather permitting), although both suffer considerably from the presence of moonlight. Telescopic observations are 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 have been dynamically applied in the last few years, and are starting to bear considerable fruit. These have the advantages,

[1] based on data in *IMO Monograph No.2: Handbook for Visual Meteor Observers*, edited by Jürgen Rendtel, Rainer Arlt and Alastair McBeath, IMO, 1995; with additional contributions from Rainer Arlt and Marc de Lignie. Layout by André Knöfel.

and disadvantages, of both photographic and telescopic observing, but are already 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 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!

January to March

The year's first quarter brings several low activity showers, including the diffuse ecliptical stream complex, the Virginids, active from late January to mid–April. Of the two major showers, the northern-hemisphere Quadrantids (visual peak around January 3, 23^h UT) are lost to bright moonlight. The southern–hemisphere α-Centaurids (maximum expected circa February 8, 10^h UT) are somewhat better-placed, but the last quarter Moon rises around local midnight on February 8, a nuisance as the shower is most observable only after late evening. However, the minor δ-Cancrids benefit from new Moon in January, as do the γ-Normids in March. Daylight radio peaks are due from the Capricornids/Sagittarids around 20^h UT on February 1, and the χ-Capricornids on February 13, probably around 21^h UT. Neither radio shower has been well-observed in recent times, and as both have radiants under 10°–15° west of the Sun at maximum, they 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 3 (page 15); Size: $\alpha = 20° \times \delta = 10°$;
$V_\infty = 28$ 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).

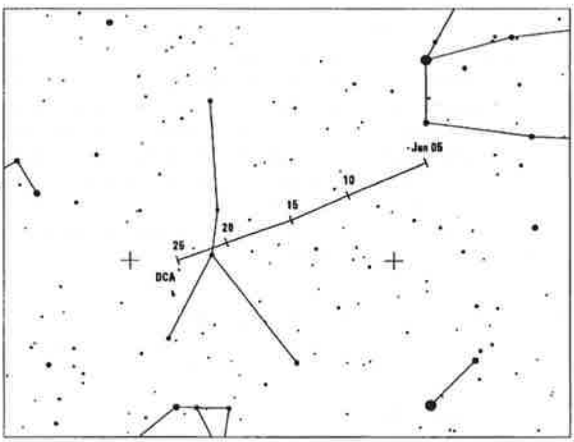

Figure 1: Radiant position and drift of the δ-Cancrids.

This minor stream is well-suited to telescopic observations, with its large, complex radiant area, that probably consists of several sub-centers. Many of its meteors are faint. It is probably an early part of the Virginid activity. Recent observations show the δ-Cancrid ZHR is unlikely to rise much above 3–4, and the visual maximum may fall around $\lambda_\odot = 291°$ (1999 January 11). January's new Moon on January 17 provides an excellent opportunity for checking what happens this year. The long winter nights in the northern hemisphere provide a further incentive, though the radiant is above the horizon almost all night, whether your site is north or south of the equator. Even on January 11, the first half of the night is Moon–free for all observers.

γ–Normids

Active: February 25–March 22; Maximum: March 14 ($\lambda_\odot = 353°$); ZHR = 8;
Radiant: $\alpha = 249°$, $\delta = -51°$; Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 56$ km/s; $r = 2.4$;
TFC: $\alpha = 225°$, $\delta = -26°$ and $\alpha = 215°$, $\delta = -45°$ ($\beta < 15°$ S);

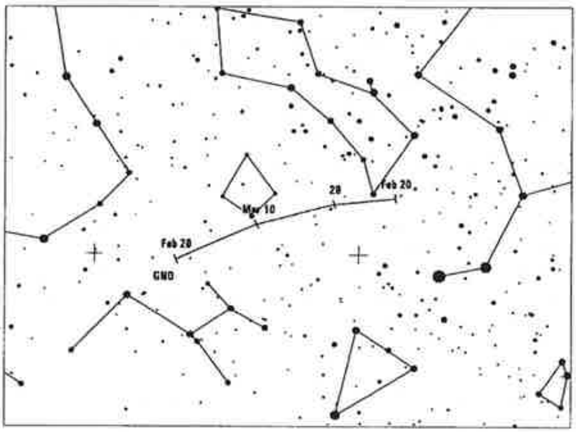

Figure 2: Radiant position and drift of the γ-Normids.

γ-Normid meteors are similar to the sporadics in appearance, and for most of their activity period, their ZHR is virtually undetectable above this background rate. The peak itself is normally quite sharp, with ZHRs of 3+ noted for only a day or two to either side of the maximum. Activity may vary somewhat at times, with occasional broader, or less obvious, maxima having been reported in the past. Post–midnight watching yields best results, when the radiant is rising to a reasonable elevation from southern hemisphere sites. The waning crescent Moon on March 14 rises around or after 02^h local time south of the equator, and should cause only minor problems. All forms of observation can be carried out for the shower, although most northern observers will see nothing from it.

April to June

Meteor activity picks up towards the April-May boundary, with showers like the Lyrids, π-Puppids (maximum due around April 24, 02^h UT) and η-Aquarids (peak between May 5, 10^h UT to May 6, 11^h UT), with both these latter sources suffering from moonlight this year. During May and

June, most of the activity is in the daytime sky, with six shower peaks 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 previous years, sensible activity calculations cannot be carried out from such observations. For radio observers, the expected UT maxima for these showers are as follows: April Piscids — April 20, 19^h UT; δ-Piscids — April 24, 19^h UT; ε-Arietids — May 9, 18^h UT; May Arietids — May 16, 19^h UT; o-Cetids — May 20, 17^h UT; Arietids — June 7, 21^h UT; ζ-Perseids — June 9, 20^h UT; β-Taurids — June 28, 20^h UT. The ecliptical complexes continue with some late Virginids and the best from the minor Sagittarids in May–June. Visual observers should also be alert for any possible June Lyrids this year.

Lyrids

Active: April 16–25; Maximum: April 22, 16^h UT ($\lambda_\odot = 32\overset{\circ}{.}1$);
ZHR: 15 (can be variable, up to 90);
Radiant: $\alpha = 271°$, $\delta = +34°$; Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 49$ km/s; $r = 2.9$;
TFC: $\alpha = 262°$, $\delta = +16°$ and $\alpha = 282°$, $\delta = +19°$ ($\beta > 10°$ S).

The Lyrids are best viewed from the northern hemisphere, but they are observable from many sites north and south of the equator, and are suitable for all forms of observation. Maximum rates are generally attained for only an hour or two at best, although in 1996, mean peak ZHRs of 15–20 persisted for around 8–12 hours. The ZHR can be rather erratic at times, a variability also seen in 1996, when rates ranged between 10–30 from hour to hour during the peak. The last high maximum occurred in 1982 over the USA, when a very short-lived ZHR of 90 was recorded. This unpredictability always makes the Lyrids a shower to watch, since we cannot say when the next unusual return may occur.

As the shower's radiant rises during the night, watches can be usefully carried out from about 22^h30^m local time onwards. This year, the first quarter Moon sets around 01^h–02^h local time north of the equator, so will cause only slight problems in the early post-midnight period. The predicted maximum should favour sites in Eastern Russia and Asia if correct, but variations in the stream could mean this is not the case in actuality.

June Lyrids

Active: June 11–21; Maximum: June 16 ($\lambda_\odot = 85°$); ZHR: variable, 0–5;
Radiant: $\alpha = 278°$, $\delta = +35°$;
Radiant drift: June 10 $\alpha = 273°$, $\delta = +35°$,
June 15 $\alpha = 277°$, $\delta = +35°$,
June 20 $\alpha = 281°$, $\delta = +35°$;
Radius: 5°; $V_\infty = 31$ km/s; $r = 3.0$;

This shower 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, however, and because the shower's probable maximum benefits from a waxing crescent Moon this year, we urge all observers who can to cover this possible stream. The radiant is a few degrees south of the bright star Vega (α Lyrae), so will be well on–view throughout the short northern summer nights, but there are discrepancies in its position in the literature. All potential June Lyrids should be carefully plotted, paying especial attention to the meteors' apparent velocity. Confirmation or denial of activity from this source in 1999 would be very useful.

July to September

Minor shower activity continues apace from near–ecliptic sources throughout this quarter, first from the Sagittarids, then the Aquarid and Capricornid showers, and finally the Piscids into September. The two strongest sources, the Southern δ-Aquarids (peak on July 28, 12^h UT) and the α-Capricornids (maximum July 30), are lost to July's full Moon, along with the less–active Piscis Austrinids and the Southern ι-Aquarids. However, the Pegasids and Phoenicids in July, the Perseids in August and the δ-Aurigids in September do much better. The Northern δ-Aquarid (around August 9) and κ-Cygnid (August 18) maxima should be good too, but the α-Aurigids (peak due around September 1, 12^h UT) are another lunar casualty, together with the most likely Piscid peak, on September 20. For daylight radio observations, the interest of May–June has waned, but there remain the visually–inaccessible γ-Leonids (peak circa August 25, 21^h UT), and a tricky visual shower, the Sextantids (maximum expected September 27, 20^h UT). The latter has particular problems from the almost full Moon, and rises less than an hour before dawn in either hemisphere anyway.

Pegasids

Active: July 7–13; Maximum: July 10 ($\lambda_\odot = 107\overset{\circ}{.}5$); ZHR = 3;
Radiant: $\alpha = 340°$, $\delta = +15°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 70$ 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).

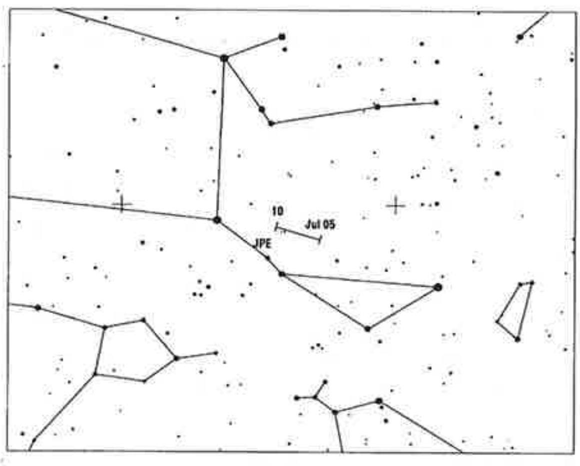

Figure 3: Radiant position and drift of the Pegasids.

Monitoring this short-lived minor shower is not easy, as a few cloudy nights mean its loss for visual observers, but with the Moon nearly new for its peak this year, everyone – particularly those in the northern hemisphere – should attempt to cover it. The shower is best-seen in the second half of the night, and the Moon will be only a slight distraction near dawn. The maximum ZHR is generally low, and swift, faint meteors can be expected. Telescopic observing would be especially useful.

July Phoenicids

Active: July 10–16; Maximum: July 13 ($\lambda_\odot = 111°$); ZHR = variable 3–10, usually < 4;
Radiant: $\alpha = 032°$, $\delta = -48°$, Radiant drift: see Table 3 (page 15); Radius: 7°;
$V_\infty = 47$ km/s; $r = 3.0$;
TFC: $\alpha = 041°$, $\delta = -39°$ and $\alpha = 066°$, $\delta = -62°$ ($\beta < 10°$ N).

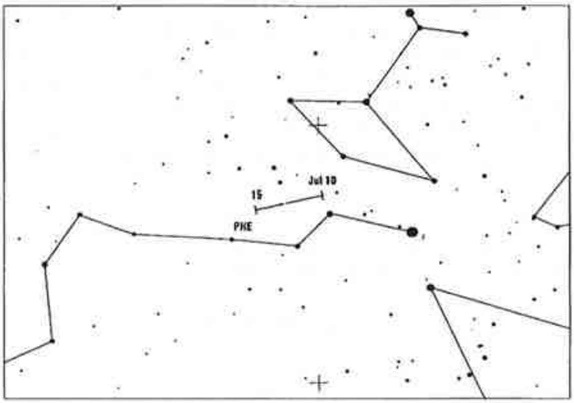

Figure 4: Radiant position and drift of the July Phoenicids.

This minor shower can be seen from the southern hemisphere, from where it only attains a reasonable elevation above the horizon after midnight. This is an ideal year to watch it, since new Moon falls perfectly for its expected peak. Activity can be quite variable visually, and indeed observations show it is a richer radio meteor source (possibly also telescopically too, but more results are needed). The peak has not been well-observed for some considerable time, though 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!

Perseids

Active: July 17–August 24; Maxima: August 12, 23^h UT ($\lambda_\odot = 139°.81$),
August 13, 05^h UT ($\lambda_\odot = 140°.03$) and August 13, 13^h UT ($\lambda_\odot = 140°.35$);
ZHR: primary peak = variable, recently $\sim$ 120–160, secondary and tertiary peaks = 100;
Radiant: $\alpha = 46°$, $\delta = +58°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 59$ km/s; $r = 2.6$;
TFC: $\alpha = 019°$, $\delta = +38°$ and $\alpha = 348°$, $\delta = +74°$ before 02^h local time;
$\alpha = 043°$, $\delta = +38°$ and $\alpha = 073°$, $\delta = +66°$ after 02^h local time ($\beta > 20°$ N);
PFC: $\alpha = 300°$, $\delta = +40°$, $\alpha = 000°$, $\delta = +20°$ or $\alpha = 240°$, $\delta = +70°$ ($\beta > 20°$ N).

The Perseids have become the single most exciting and dynamic meteor shower in recent times, with outbursts producing EZHRs of 400+ in 1991 and 1992, decreasing to around 300 in 1993, 220 in 1994 and $\sim$ 120–160 since, at the shower's primary maximum. Allowing for an average annual shift of $\sim +0.05°$ in $\lambda_\odot$ since 1991, this peak is expected to fall around 23^h UT on August 12. Other timing variations cannot be ruled-out, however. A new feature in 1997 was a tertiary peak, of strength comparable to the traditional (currently secondary) maximum, but a few hours after it. The timing for this third peak is based on just this one return, but there are no guarantees it will recur in 1999. Even now, as the Perseids' parent comet, 109P/Swift-Tuttle, returns to the outer Solar System after its 1992 perihelion passage, the shower can still spring surprises! The August new Moon provides the perfect opening for all watchers, certainly. As the radiant rises throughout the night for the northern hemisphere, near and post-midnight watching is most valuable. If the maxima appear as predicted the places to be should be Europe; Eastern North America; Far Eastern Siberia, Alaska and the Northern Pacific Ocean, respectively.

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. Radio data would naturally enable early confirmation, or detection, of perhaps otherwise unobserved maxima if the timings 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.

δ–Aurigids

Active: September 5–October 10; Maximum: September 9 ($\lambda_\odot = 166°$); ZHR = 6;
Radiant: $\alpha = 60°$, $\delta = +47°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$($\beta > 10°$ S).

An essentially northern hemisphere shower, badly in need of more observations. The δ-Aurigids are actually part of a series of showers with radiants in Aries, Perseus, Cassiopeia and Auriga, active from late August into October. They typically produce low rates of generally faint meteors, and have yet to be well-seen in more than an occasional year. Circumstances are perfect for their peak in 1999, with new Moon on September 9. Telescopic data to examine all the radiants in this region of sky – and possibly observe the telescopic β-Cassiopeids simultaneously – would be especially useful, but photographs, video records and visual plotting would be welcomed too. The δ-Aurigid radiant is at a useful elevation from roughly 23^h–00^h onwards, so protracted watching is distinctly possible.

October to December

Ecliptical minor shower activity reaches what might be regarded as a peak in early to mid November, with the Taurid streams in action. Before then is a moonless Draconid epoch, together with badly Moon-affected ε-Geminid and Orionid maxima, all in October. The Orionids' central peak is likely around 20^h UT on October 21 for radio observers. The Leonids in November may still be capable of producing high to storm activity this year, but the α-Monocerotids (November 22, 01^h UT) are lost to the Moon. December's new Moon is excellent news for covering the χ-Orionids, Phoenicids, Puppid-Velids, Monocerotids and σ-Hydrids, along with the Geminids. The downside is losing the Coma Berenicids and Ursids (peak due circa December 22, 23^h UT) to full Moon.

Draconids

Active: October 6–10; Maximum: October 9, 03^h UT ($\lambda_\odot = 195.4°$);
ZHR = periodic, up to storm levels;
Radiant: $\alpha = 262°$, $\delta = +54°$; Radiant drift: negligible; Radius: 5°;
$V_\infty = 20$ km/s; $r = 2.6$;
TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ N).

New Moon perfectly favours any Draconids that appear this year. Unfortunately for potential observers, although this periodic shower has produced spectacular, brief, meteor storms twice already this century, in 1933 and 1946, and lower rates in several other years (ZHRs ~ 20–200+), so far, detectable activity has only been seen in years when the stream's parent comet, 21P/Giacobini-

Zinner, has returned to perihelion. It did this last in 1998 November. The peak time above is based on the Earth's closest approach to the comet orbit's node, but activity might be seen before or considerably after this too. The radiant is circumpolar from many locations, but is higher in the pre-midnight and near-dawn hours on October 8–10. The shower is only properly observable from the northern hemisphere.

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 3 (page 15); size: $\alpha = 20° \times \delta = 10°$;
$V_\infty = 27$ 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 3 (page 15); size: $\alpha = 20° \times \delta = 10°$;
$V_\infty = 29$ km/s; $r = 2.3$;
TFC: as Southern Taurids.

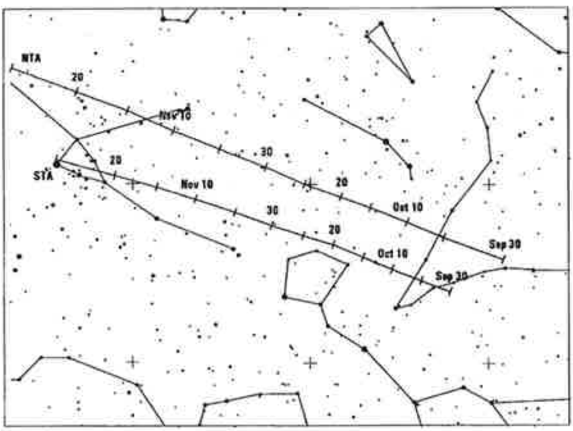

Figure 5: Radiant position and drift of the Northern and Southern Taurids.

These two streams forms a 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. 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 shower has a reputation for producing some superbly bright fireballs at times, although seemingly not in every year. In 1995, an impressive crop of brilliant Taurids occurred between late October and mid-November, for instance. New Moon on November 8 means the entire Taurid peak should be treated to dark skies in 1999.

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.

Leonids

Active: November 14–21; Maximum: November 17, 23^h UT ($\lambda_\odot = 235.^\circ16$);
ZHR = 100+ (45 in 1996, ~ 150? in 1997), but may reach storm level in 1999;
Radiant: $\alpha = 153°$, $\delta = +22°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 71$ km/s; $r = 2.9$;
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);
PFC: $\alpha = 120°$, $\delta = +40°$ before 00^h local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before 04^h local time and
$\alpha = 160°$, $\delta = 00°$ after 04^h local time ($\beta > 00°$ N);
$\alpha = 120°$, $\delta = +10°$ before 00^h local time and $\alpha = 160°$, $\delta = -10°$ ($\beta < 00°$ N).

The perihelion passage of the Leonids' parent comet, 55P/Tempel-Tuttle, in 1998 February means high to storm-level Leonid activity may occur in 1999. There are, of course, no guarantees that this will happen, but all observers must realise that even discovering the absence of any unusual Leonid activity would still be very valuable information – albeit not all that interesting to witness! Recent visual *IMO* International Leonid Watch and radio observations suggest a peak timing around $\lambda_\odot = 235.^\circ16$ is most likely, but another plausible time is when the Earth passes the node of the comet's orbit, at $\lambda_\odot = 235.^\circ25$ (1999 November 18, 01^h UT).

The radiant rises only around local midnight (or indeed afterwards south of the equator), by which time the waxing gibbous Moon will be setting. Either suggested peak timing would favour locations in Europe, North Africa, the Near and Middle East plus European Russia. Even a minor variation in the peak's occurrence could mean places east or west of this zone may see something of the shower's best too, however. Look out for further updates in the *IMO*'s journal *WGN* after the 1998 return. All observing methods should be utilised to the full, especially photography and video if a storm manifests.

χ-Orionids

Active: November 26–December 15; Maximum: December 2 ($\lambda_\odot = 250°$); ZHR = 3;
Radiant: $\alpha = 082°$, $\delta = +23°$, Radiant drift: see Table 3 (page 15); Radius: 8°;
$V_\infty = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 083°$, $\delta = +09°$ and $\alpha = 080°$, $\delta = +24° (\beta > 30°$ S).

A weak visual stream, but moderately active telescopically. Some brighter meteors have been photographed 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. 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. The waning crescent Moon should give few problems, as the radiant is well on display in both hemispheres throughout the night.

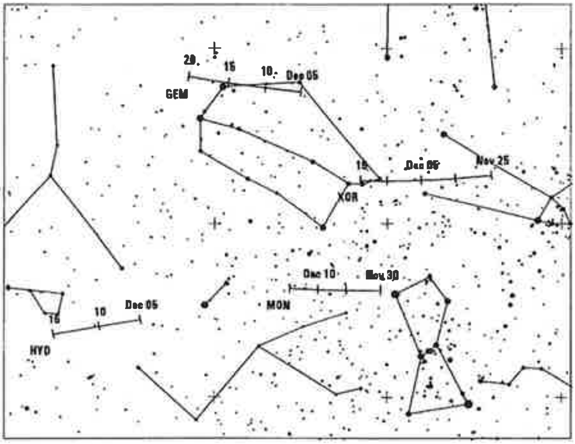

Figure 6: Radiant position and drift of the χ-Orionids, Monocerotids, σ-Hydrids, and Geminids.

Phoenicids

Active: November 28–December 9; Maximum: December 6, 20^{h} UT ($\lambda_{\odot} = 254^{\circ}\!.25$);
ZHR = variable, usually 3 or less, may reach 100;
Radiant: $\alpha = 018^{\circ}$, $\delta = -53^{\circ}$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_{\infty} = 18$ km/s; $r = 2.8$;
TFC: $\alpha = 040^{\circ}$, $\delta = -39^{\circ}$ and $\alpha = 065^{\circ}$, $\delta = -62^{\circ}$ ($\beta < 10^{\circ}$ N).

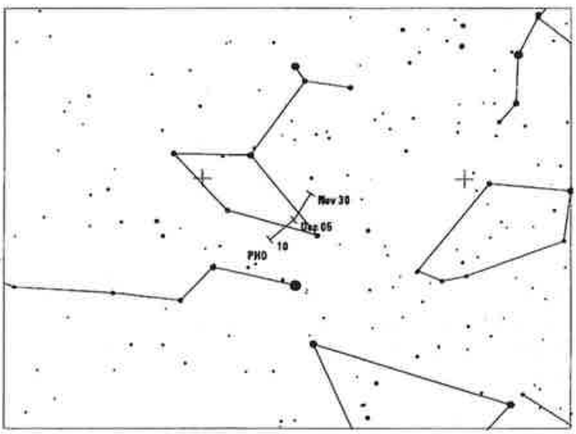

Figure 7: Radiant position and drift of the Phoenicids.

Only one impressive Phoenicid return has so far been reported, that of its discovery in 1956, when the ZHR was ~ 100. 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. Radio workers may find difficulties, as radar echoes from the 1956 event were only 30 per hour, perhaps because these low-velocity meteors produce too little radio-reflecting ionization. Observing conditions this year are excellent for all southern hemisphere watchers, with new Moon on December 7. The radiant is well on view for most of the night, but culminates at dusk.

Puppid-Velids

Active: December 1-15; Maximum: December ~ 7 ($\lambda_\odot \sim 255°$); ZHR ~ 10;
Radiant: $\alpha = 123°$, $\delta = -45°$, Radiant drift: see Table 3 (page 15); Radius: 10°;
$V_\infty = 40$ km/s; $r = 2.9$;
TFC: $\alpha = 090°$ to 150°, $\delta = -20°$ to $-60°$; choose pairs of fields separated by about 30° in α, 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. 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, perfect for the new Moon period this year. Some of these showers may visible from late October to late January. Most shower 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.

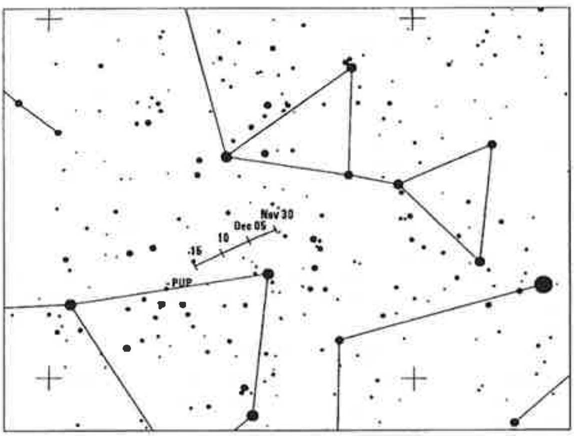

Figure 8: Radiant position and drift of the Puppid-Velids.

Monocerotids

Active: November 27–December 17; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 3;
Radiant: $\alpha = 100°$, $\delta = +08°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 42$ 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 visual rates can be expected from this source, making accurate visual plotting, telescopic or video work essential, particularly because the meteors are normally faint. The shower details, even including the radiant position, are rather uncertain. Recent *IMO* data shows only weak signs of a maximum as indicated above. Telescopic data suggests a later maximum, around December 16 ($\lambda_\odot \sim 264°$) from a radiant at $\alpha = 117°$, $\delta = +20°$. This is a very good year for all meteor workers to make observations to help resolve these points, as the Moon is not a problem. The radiant is on-show nearly all night, culminating around 01^h local time.

σ-Hydrids

Active: December 3–15; Maximum: December 12 ($\lambda_\odot = 260°$); ZHR = 2;
Radiant: $\alpha = 127°$, $\delta = +02^h$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 58$ 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. This means the waxing crescent Moon will have set long before σ-Hydrid watching can begin at their peak in 1999. Recent data indicates the peak may occur up to six days earlier than suggested above, and would benefit from visual plotting, telescopic or video work to pin it down more accurately.

Geminids

Active: December 7–17; Maximum: December 14, 11^h UT ($\lambda_\odot = 262.°0$); ZHR = 120;
Radiant: $\alpha = 112°$, $\delta = +33°$, Radiant drift: see Table 3 (page 15); Radius: 5°;
$V_\infty = 35$ 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).
PFC: $\alpha = 150°$, $\delta = +20°$ and $\alpha = 060°$, $\delta = +40°$ ($\beta > 20°$ N);
$\alpha = 135°$, $\delta = -05°$ and $\alpha = 080°$, $\delta =$ 00° ($\beta < 20°$ N).

One of the finest annual showers presently observable. The waxing crescent Moon will have set by about 22^h–23^h local time at their peak, so much of the second half of the night at least will be available for observing them. Well north of the equator, their radiant rises around sunset, and is at a usable elevation from the local evening hours onwards. In the southern hemisphere, the radiant appears only around local midnight or so. Even here, this is a splendid stream of often bright, medium-speed meteors, a rewarding sight for all watchers. The peak has shown slight signs of variability in its maximum rates and the actual peak timing, so the best activity may occur a little before or, more likely, after, the suggested time above, perhaps up to 15^h-16^h UT. This means North American to Far Eastern sites are most likely to see the best from the 1999 Geminids. Some mass-sorting within the stream means the fainter telescopic meteors should be most abundant almost 1° of solar longitude ahead of the visual maximum, with telescopic results indicating these meteors radiate from an elongated region, perhaps with three sub-centers. Further results on this topic would be useful, but all methods can be employed to observe the shower.

Abbreviations

- α, δ: Coordinates for a shower's radiant position, usually at maximum. α is right ascension, δ is declination. Radiants drift across the sky each day due to the Earth's own orbital motion around the Sun, and this must be allowed for using the details in Table 3 (page 15) 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 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 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 centres to use for video camera fields as well.

Table 1: Lunar phases for 1999.

New Moon	First Quarter	Full Moon	Last Quarter
		January 02	January 09
January 17	January 24	January 31	February 08
February 16	February 23	March 02	March 10
March 17	March 24	March 31	April 09
April 16	April 22	April 30	May 08
May 15	May 22	May 30	June 07
June 13	June 20	June 28	July 06
July 13	July 20	July 28	August 04
August 11	August 19	August 26	September 02
September 09	September 17	September 25	October 02
October 09	October 17	October 24	October 31
November 08	November 16	November 23	November 29
December 07	December 16	December 22	December 29

Table 2: Working list of visual meteor showers. Details in this Table were correct according to the best information available in June 1998. 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 Period	Maximum		Radiant		V_∞	r	ZHR	*IMO*
		Date	$\lambda_\odot$	α	δ	km/s			Code
Quadrantids	Jan 01–Jan 05	Jan 03	283°.16	230°	+49°	41	2.1	120	QUA
δ-Cancrids	Jan 01–Jan 24	Jan 17	297°	130°	+20°	28	3.0	4	DCA
α-Centaurids	Jan 28–Feb 21	Feb 08	319°.2	210°	−59°	56	2.0	6	ACE
δ-Leonids	Feb 15–Mar 10	Feb 25	336°	168°	+16°	23	3.0	2	DLE
γ-Normids	Feb 25–Mar 22	Mar 14	353°	249°	−51°	56	2.4	8	GNO
Virginids	Jan 25–Apr 15	(Mar 25)	(004°)	195°	−04°	30	3.0	5	VIR
Lyrids	Apr 16–Apr 25	Apr 22	032°.1	271°	+34°	49	2.9	15	LYR
π-Puppids	Apr 15–Apr 28	Apr 24	033°.5	110°	−45°	18	2.0	var.	PPU
η-Aquarids	Apr 19–May 28	May 06	045°.5	338°	−01°	66	2.7	60	ETA
Sagittarids	Apr 15–Jul 15	(May 20)	(059°)	247°	−22°	30	2.5	5	SAG
Pegasids	Jul 07–Jul 13	Jul 10	107°.5	340°	+15°	70	3.0	3	JPE
July Phoenicids	Jul 10–Jul 16	Jul 13	111°	32°	−48°	47	3.0	var.	PHE
Piscis Austrinids	Jul 15–Aug 10	Jul 28	125°	341°	−30°	35	3.2	5	PAU
Southern δ-Aquarids	Jul 12–Aug 19	Jul 28	125°	339°	−16°	41	3.2	20	SDA
α-Capricornids	Jul 03–Aug 15	Jul 30	127°	307°	−10°	23	2.5	4	CAP
Southern ι-Aquarids	Jul 25–Aug 15	Aug 04	132°	334°	−15°	34	2.9	2	SIA
Northern δ-Aquarids	Jul 15–Aug 25	Aug 09	136°	335°	−05°	42	3.4	4	NDA
Perseids	Jul 17–Aug 24	Aug 12	139°.81	46°	+58°	59	2.6	140	PER
κ-Cygnids	Aug 03–Aug 25	Aug 18	145°	286°	+59°	25	3.0	3	KCG
Northern ι-Aquarids	Aug 11–Aug 31	Aug 20	147°	327°	−06°	31	3.2	3	NIA
α-Aurigids	Aug 25–Sep 05	Sep 01	158°.6	84°	+42°	66	2.5	10	AUR
δ-Aurigids	Sep 05–Oct 10	Sep 09	166°	60°	+47°	64	3.0	6	DAU
Piscids	Sep 01–Sep 30	Sep 20	177°	5°	−01°	26	3.0	3	SPI
Draconids	Oct 06–Oct 10	Oct 09	195°.4	262°	+54°	20	2.6	var.	GIA
ε-Geminids	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	2	EGE
Orionids	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.9	20	ORI
Southern Taurids	Oct 01–Nov 25	Nov 05	223°	52°	+13°	27	2.3	5	STA
Northern Taurids	Oct 01–Nov 25	Nov 12	230°	58°	+22°	29	2.3	5	NTA
Leonids	Nov 14–Nov 21	Nov 17	235°.16	153°	+22°	71	2.5	100+	LEO
α-Monocerotids	Nov 15–Nov 25	Nov 22	239°.32	117°	+01°	65	2.4	var.	AMO
χ-Orionids	Nov 26–Dec 15	Dec 02	250°	82°	+23°	28	3.0	3	XOR
Phoenicids	Nov 28–Dec 09	Dec 06	254°.25	18°	−53°	18	2.8	var.	PHO
Puppid-Velids	Dec 01–Dec 15	(Dec 07)	(255°)	123°	−45°	40	2.9	10	PUP
Monocerotids	Nov 27–Dec 17	Dec 09	257°	100°	+08°	42	3.0	3	MON
σ-Hydrids	Dec 03–Dec 15	Dec 12	260°	127°	+02°	58	3.0	2	HYD
Geminids	Dec 07–Dec 17	Dec 14	262°.0	112°	+33°	35	2.6	120	GEM
Coma Berenicids	Dec 12–Jan 23	Dec 20	268°	175°	+25°	65	3.0	5	COM
Ursids	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	3.0	10	URS

Table 3: Radiant positions during the year in α and δ.

	COM	**DCA**							
Jan 0	186° +20°	112° +22°	**QUA**						
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°								
Jun 25	280° −23°								
Jun 30	284° −23°		**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°	32° −48°	294° −14°	329° −19°	316° −10°		12° +51°	330° −34°	
Jul 20			299° −12°	333° −18°	319° −9°	**SIA**	18° +52°	334° −33°	
Jul 25			303° −11°	337° −17°	323° −9°	322° −17°	23° +54°	338° −31°	
Jul 30	**KCG**		308° −10°	340° −16°	327° −8°	328° −16°	29° +55°	343° −29°	
Aug 5	283° +58°	**NIA**	313° −8°	345° −14°	332° −6°	334° −15°	37° +57°	348° −27°	
Aug 10	284° +58°	317° −7°	318° −6°	349° −13°	335° −5°	339° −14°	43° +58°	352° −26°	
Aug 15	285° +59°	322° −7°		352° −12°	339° −4°	345° −13°	50° +59°		
Aug 20	286° +59°	327° −6°	**AUR**	356° −11°	343° −3°		57° +59°		
Aug 25	288° +60°	332° −5°	76° +42°		347° −2°		65° +60°		
Aug 30	289° +60°	337° −5°	82° +42°	**DAU**					
Sep 5			88° +42°	55° +46°	**SPI**				
Sep 10				60° +47°	357° −5°				
Sep 15				66° +48°	1° −3°				
Sep 20				71° +48°	5° −1°				
Sep 25	**NTA**	**STA**		77° +49°	9° 0°				
Sep 30	21° +11°	23° +5°	**ORI**	83° +49°	13° +2°				
Oct 5	25° +12°	27° +7°	85° +14°	89° +49°		**GIA**			
Oct 10	29° +14°	31° +8°	88° +15°	95° +49°		262° +54°			
Oct 15	34° +16°	35° +9°	91° +15°		**EGE**				
Oct 20	38° +17°	39° +11°	94° +16°		99° +27°				
Oct 25	43° +18°	43° +12°	98° +16°		104° +27°				
Oct 30	47° +20°	47° +13°	101° +16°		109° +27°				
Nov 5	53° +21°	52° +14°	105° +17°						
Nov 10	58° +22°	56° +15°		**LEO**	**AMO**				
Nov 15	62° +23°	60° +16°		150° +23°	112° +2°				
Nov 20	67° +24°	64° +16°	**XOR**	153° +21°	116° +1°				
Nov 25	72° +24°	69° +17°	75° +23°		120° 0°	**MON**	**PUP**	**PHO**	
Nov 30			80° +23°	**HYD**		91° +8°	120° −45°	14° −52°	
Dec 5	**COM**	**GEM**	85° +23°	122° +3°		96° +8°	122° −45°	18° −53°	
Dec 10	169° +27°	108° +33°	90° +23°	126° +2°		100° +8°	125° −45°	22° −53°	
Dec 15	173° +26°	113° +33°	94° +23°	130° +1°	**URS**	104° +8°	128° −45°		
Dec 20	177° +24°	118° +32°			217° +75°				

Table 4: 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	$\lambda_\odot$ 2000.0	Radiant α	Radiant δ	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
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	030°.3	7°	+7°	07^h-14^h	08^h-13^h	low
δ-Piscids	Apr 24-Apr 24	Apr 24	034°.2	11°	+12°	07^h-14^h	08^h-13^h	low
ϵ-Arietids	Apr 24-May 27	May 09	048°.7	44°	+21°	08^h-15^h	10^h-14^h	low
Arietids (May)	May 04-Jun 06	May 16	055°.5	37°	+18°	08^h-15^h	09^h-13^h	low
o-Cetids	May 05-Jun 02	May 20	059°.3	28°	−4°	07^h-13^h	07^h-13^h	medium
Arietids	May 22-Jul 02	Jun 07	076°.7	44°	+24°	06^h-14^h	08^h-12^h	high
ζ-Perseids	May 20-Jul 05	Jun 09	078°.6	62°	+23°	07^h-15^h	09^h-13^h	high
β-Taurids	Jun 05-Jul 17	Jun 28	096°.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°	0°	06^h-12^h	06^h-13^h	medium

Useful addresses

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

Fireball Data Center (FIDAC):
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e-mail: `fidac@imo.net`

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e-mail: `photo@imo.net`

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

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

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