International Meteor Organization

# 2003 Meteor Shower Calendar

*compiled by Alastair McBeath*[1]

## 1. Introduction

Welcome to the 2003 International Meteor Organization (*IMO*) Meteor Shower Calendar. The year sees two of the "big three" major showers—the Perseids and Geminids—lost to bright moonlight, but the third, the Quadrantids, are well-placed, along with the $\alpha$-Centaurids, $\eta$-Aquarids, and Southern $\delta$-Aquarids. Minor or uncertain sources like the $\delta$-Leonids, June Boötids, $\alpha$-Aurigids, $\alpha$-Monocerotids, Coma Berenicids and Ursids also enjoy often moonless skies, amongst others. What the Leonids may do in 2003 needs checking as well. 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 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 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 18), 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 20) 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

For the major showers, the year begins with a superb northern-hemisphere Quadrantid return, and the southern-hemisphere $\alpha$-Centaurids in early February are also Moon-free at their best. The minor streams enjoy mixed fortunes. The $\delta$-Cancrids are lost to full Moon (peak January 17; full Moon January 18!), though their possibly earlier maximum on January 11 ($\lambda_\odot = 291°$) has the gibbous Moon setting between local midnight and $1^h$ and would be worth checking. By contrast, the $\delta$-Leonids are mostly moonless. 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 minor showers have been suggested in recent years, is partly Moon-free, but effectively only between last and first quarter Moon, January 25 to February 9, not ideal, especially for most of the January 20–27 period. Mid-March brings a badly moonlit spell for checking on the southern-hemisphere $\gamma$-Normids, whose details are most uncertain. A maximum may occur on either March 14 or 17 from recent results, with ZHRs virtually undetectable more than a day or two away from the peak. Daylight radio shower peaks are theoretically due from the Capricornids/Sagittarids around February 1, $20^h$ UT, and the $\chi$-Capricornids on February 13, $21^h$ UT. Recent radio results suggest the Cap/Sgr maximum may variably fall up to 2 or 3 days later than this however, while activity near the expected $\chi$-Capricornid peak has tended to be slight and perhaps a day or so later in 1999–2001. Both showers have radiants $< 10°$–$15°$ west of the Sun at maximum, so cannot be regarded as visual targets even from the southern hemisphere.

*Quadrantids*

Active: January 1–5; Maximum: January 4, $0^h$ UT ($\lambda_\odot = 283\overset{\circ}{.}16$);
ZHR = 120 (can vary 60–200);
Radiant: $\alpha = 230°$, $\delta = +49°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 41$ km/s; $r = 2.1$ at maximum, but variable;
TFC: $\alpha = 242°$, $\delta = +75°$ and $\alpha = 198°$, $\delta = +40°$ ($\beta > 40°$ N).
PFC: before $0^h$ local time $\alpha = 150°$, $\delta = +70°$;
after $0^h$ local time $\alpha = 180°$, $\delta = +40°$ and $\alpha = 240°$, $\delta = +70°$ ($\beta > 40°$ N).

An excellent return of the Quadrantids for northern observers starts the year perfectly, with an expected peak around midnight UT on January 3-4. The waxing crescent Moon is less than 28 hours old then, so produces no problems at all. For many northern locations the shower's radiant is circumpolar, in northern Boötes (see Fig. 1), but it attains a useful elevation only after local midnight, rising higher in the sky towards morning twilight. Consequently Europe eastwards to the Near East, and North Africa, are the most favored places to catch the shower's best this year. An interesting challenge is to try spotting the occasional long-pathed shower member from the southern hemisphere around dawn, but sensible Quadrantid watching cannot be carried out from such places.

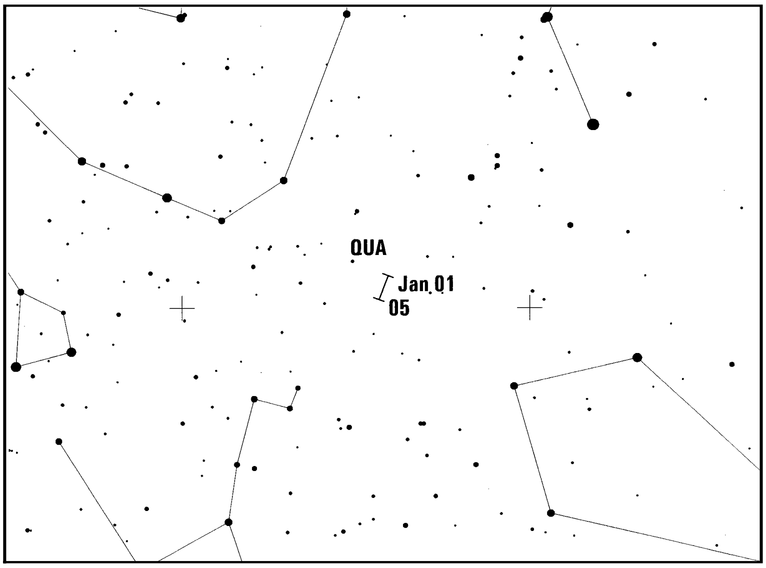


Figure 1 – Radiant position of the Quadrantids.

The maximum time given above is based on the best-observed return of the shower ever analyzed, in *IMO* 1992 data, confirmed by radio results in 1996, 1997, 1999 and 2001. The peak itself is normally short-lived, and can be easily missed in just a few hours of poor northern-winter weather, which may be why the ZHR level apparently fluctuates from year to year, but some genuine variability is probably present too. For instance, visual ZHRs in 1998 persisted for over two hours at their best. An added level of complexity comes from the fact that mass-sorting of particles across the meteoroid stream may make fainter objects (radio and telescopic meteors) reach maximum up to 14 hours before the brighter (visual and photographic) ones, so observers should be alert throughout the shower. Oddly, 2000 and 2001 saw primarily radio maxima following the main visual one by some 9–12 hours. Visual confirmation of any repeat near this time in 2003 would fall for sites in the Far Eastern eastwards to North Pacific regions.

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

*$\alpha$-Centaurids*

Active: January 28–February 21; Maximum: February 8, $10^{\rm h}20^{\rm m}$ UT ($\lambda_\odot = 319.^\circ2$);
ZHR = variable, usually $\sim 6$, but may reach 25+;
Radiant: $\alpha = 210°$, $\delta = -59°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 56$ km/s; $r = 2.0$.

The $\alpha$-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 $-4$). 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 $\alpha$-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, good news this year with the Moon a waxing crescent just before first quarter, setting by $23^{\mathrm{h}}$ local time on February 8 for most typical southern hemisphere sites.

*$\delta$-Leonids*

Active: February 15–March 10; Maximum: February 25 ($\lambda_\odot = 336°$); ZHR = 2;
Radiant: $\alpha = 168°$, $\delta = +16°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 23$ km/s; $r = 3.0$;
TFC: $\alpha = 140°$, $\delta = +37°$ and $\alpha = 151°$, $\delta = +22°$ ($\beta > 10°$ N);
$\alpha = 140°$, $\delta = -10°$ and $\alpha = 160°$, $\delta = 00°$ ($\beta < 10°$ N).

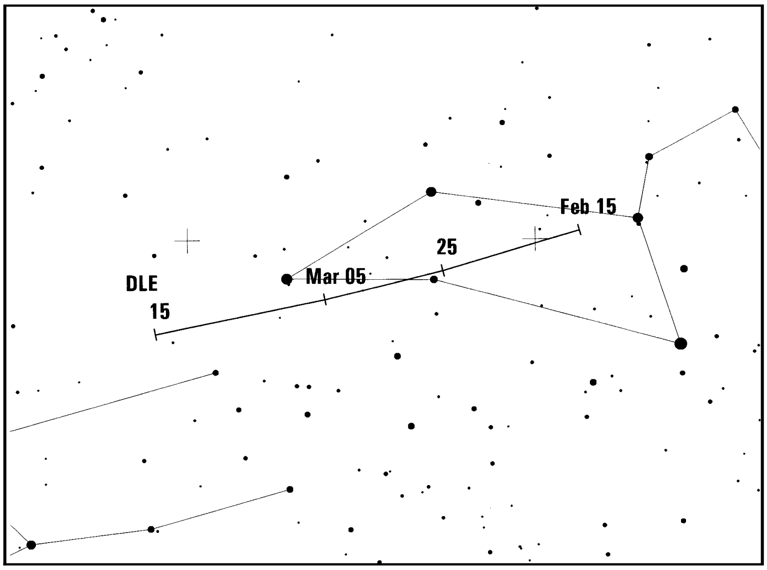


Figure 2 – Radiant position of the $\delta$-Leonids.

This minor shower is probably part of the early Virginid activity. Rates are normally low, and its meteors are predominantly faint, so it is a prime candidate for telescopic investigation. Visual observers must make very accurate plots of the meteors to distinguish them from the nearby Virginids and the sporadics. Northern hemisphere sites have an advantage for covering this shower, though southern hemisphere watchers should not ignore it, as they are better-placed to note many of the other Virginid radiants. The waning crescent Moon rises between about $3^{\mathrm{h}}$–$5^{\mathrm{h}}$ local time for typical northern sites, but around midnight for the mid-southern hemisphere, though it should not be too great a distraction. The $\delta$-Leonid radiant is well on view for most of the night near its peak.

## 3. April to June

Meteor activity picks up towards the April-May boundary, with shower peaks from the partly-moonlit Lyrids and $\pi$-Puppids. In early May, the $\eta$-Aquarids are perfectly moonless. Later in May and throughout June, most of the meteor action switches to the daytime 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, $20^{\rm h}$; $\delta$-Piscids—April 24, $20^{\rm h}$; $\varepsilon$-Arietids—May 9, $19^{\rm h}$; May Arietids—May 16, $20^{\rm h}$; $o$-Cetids—May 20, $19^{\rm h}$; Arietids—June 7, $22^{\rm h}$; $\zeta$-Perseids—June 9, $22^{\rm h}$; $\beta$-Taurids—June 2, $21^{\rm h}$. Signs of most of these peaks were found in radio data from 1994–2001, though some are difficult to define because of their proximity to other sources, while the Arietid and $\zeta$-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 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, with their probable peaks in May–June. Checking for any possible June Lyrids will be impractical this year as their potential peak on June 16 (see the *2002 Meteor Shower Calendar* for more details) is too close to full Moon on June 14. June's new Moon makes June Boötid hunting much easier.

*Lyrids*

Active: April 16–25; Maximum: April 22, $22^{\rm h}00^{\rm m}$ UT ($\lambda_\odot = 32\overset{\circ}{.}32$, but may vary—see text);
ZHR = 18 (can be variable, up to 90); Radiant: $\alpha = 271°$, $\delta = +34°$;
Radiant drift: see Table 6 (page 19); $V_\infty = 49$ km/s; $r = 2.1$;
TFC: $\alpha = 262°$, $\delta = +16°$ and $\alpha = 282°$, $\delta = +19°$ ($\beta > 10°$ S).

Audrius Dubietis and Rainer Arlt published a detailed investigation of the Lyrids in *IMO* results from 1988–2000 in 2001, the most detailed examination of the shower in modern times. Several fresh features were found, the most important of which was to redefine the maximum time as variable from year to year between $\lambda_\odot = 32\overset{\circ}{.}0$–$32\overset{\circ}{.}45$ (equivalent to 2003 April 22, $14^{\rm h}10^{\rm m}$ UT to April 23, $01^{\rm h}15^{\rm m}$ UT), with an ideal time of $\lambda_\odot = 32\overset{\circ}{.}32$. Although the mean peak ZHR was 18 over the thirteen years, actual peak ZHRs varied dependent on when the maximum time occurred. A peak at the ideal time produced the highest ZHRs, $\sim 23$, while the further the peak happened from this ideal, the more the ZHRs were reduced, to as low as $\sim 14$. (The last very high maximum occurred outside the examined interval, in 1982 over the USA, when a short-lived ZHR of 90 was recorded.) While generally thought of as having a short, quite sharp, maximum, this latest work revealed the shower's peak length was variable too. This was measured by how long ZHRs were above half the maximum value, the Full-Width-Half-Maximum (FWHM) time. It varied from 14.8 h in 1993 to 61.7 h in 2000, with a mean value of 32.1 h. Best rates are normally achieved for just a few hours however. One other aspect found, confirming data from earlier in the 20th century was that occasionally, as their highest rates occurred, the Lyrids produced a short-lived increase of fainter meteors. Overall, the unpredictability of the shower in any given year always makes the Lyrids worth watching, since we cannot say when the next unusual return may occur.

The shower is best viewed from the northern hemisphere, but it is visible from many sites north and south of the equator, and is suitable for all forms of observation. As the shower's radiant rises during the night, watches can be usefully carried out from about $22^{\rm h}30^{\rm m}$ local time onwards. The waning gibbous Moon rises between $2^{\rm h}$–$3^{\rm h}$ local time for mid-northern sites on April 22-23, giving several hours of darker skies for observers before this. The earlier moonrise south of the equator is much less favorable. The ideal maximum time, if it recurs, would be best-seen from sites in central Asia westwards to eastern Europe, but other maximum times are perfectly possible, as noted above.

*π-Puppids*

Active: April 15–28; Maximum: April 24, $3^h$ UT ($\lambda_\odot = 33.^\circ 5$);
ZHR = periodic, up to around 40;
Radiant: $\alpha = 110^\circ$, $\delta = -45^\circ$; Radiant drift: see Table 6 (page 19); $V_\infty = 18$ km/s; $r = 2.0$;
TFC: $\alpha = 135^\circ$, $\delta = -55^\circ$ and $\alpha = 105^\circ$, $\delta = -25^\circ$ ($\beta < 20^\circ$ N).

This is a young stream produced by Comet 26P/Grigg-Skjellerup, and shower activity has only been detected from it since 1972. Notable short-lived shower maxima of around 40 meteors per hour took place in 1977 and 1982, both years when the parent comet was at perihelion, but before 1982, little activity had been seen at other times. In 1983, a ZHR of about 13 was reported, perhaps suggesting that material has begun to spread further along the comet's orbit, as theory predicts. Comet Grigg-Skjellerup reached perihelion last in October 2002, so this will be an interesting year to check for whatever happens.

The shower is best-seen from the southern hemisphere, with useful observations mainly possible before local midnight, as the radiant is very low to setting after $1^h$ local time. The last quarter Moon will be rising around $23^h$–$0^h$ local time from such locations on April 23-24, which should work out reasonably well for watchers. Well-placed sites are likely to be across Central and South America, if the maximum time proves correct. So far, visual and radio data have been collected on the shower, but the slow, bright nature of the meteors makes them ideal photographic subjects too. No telescopic or video data have been reported in any detail as yet.

*η-Aquarids*

Active: April 19–May 28; Maximum: May 6, $11^h30^m$ UT ($\lambda_\odot = 45.^\circ 5$);
ZHR = 60 (occasionally variable);
Radiant: $\alpha = 338^\circ$, $\delta = -01^\circ$, Radiant drift: see Table 6 (page 19);
$V_\infty = 66$ km/s; $r = 2.7$;
TFC: $\alpha = 319^\circ$, $\delta = +10^\circ$ and $\alpha = 321^\circ$, $\delta = -23^\circ$ ($\beta < 20^\circ$ S).

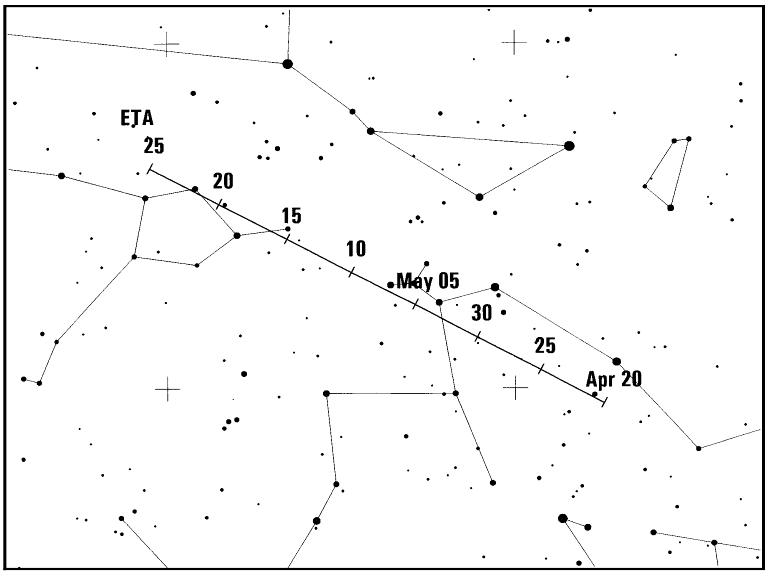


Figure 3 – Radiant position of the η-Aquarids.

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, $\eta$-Aquarid meteors tend to have very long paths, which can mean observers underestimate the apparent speeds of the meteors, so extra care is needed when making such angular speed reports.

A relatively broad maximum, sometimes with a variable number of submaxima, usually occurs in early May. ZHRs are generally above 30 between about May 3–10, based on *IMO* observations during 1988–1997, analyzed by Tim Cooper, and confirmed by visual and radio observations since. The waxing crescent Moon on May 6 will have set long before radiant-rise, so conditions are ideal in 2003. All forms of observing can be used to study the $\eta$-Aquarids, with radio work allowing activity to be followed even from many northern latitude sites throughout the daylight morning hours. The radiant culminates at about $8^{\rm h}$ local time.

*June Boötids*

Active: June 26–July 2; Maximum: June 27, $19^{\rm h}30^{\rm m}$ UT ($\lambda_\odot = 95.^\circ7$);
ZHR = variable, 0–100+;
Radiant: $\alpha = 224°$, $\delta = +47°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 18$ km/s; $r = 2.2$;
TFC: $\alpha = 156°$, $\delta = +64°$ and $\alpha = 289°$, $\delta = +67°$ ($\beta = 25°$–$60°$ N).

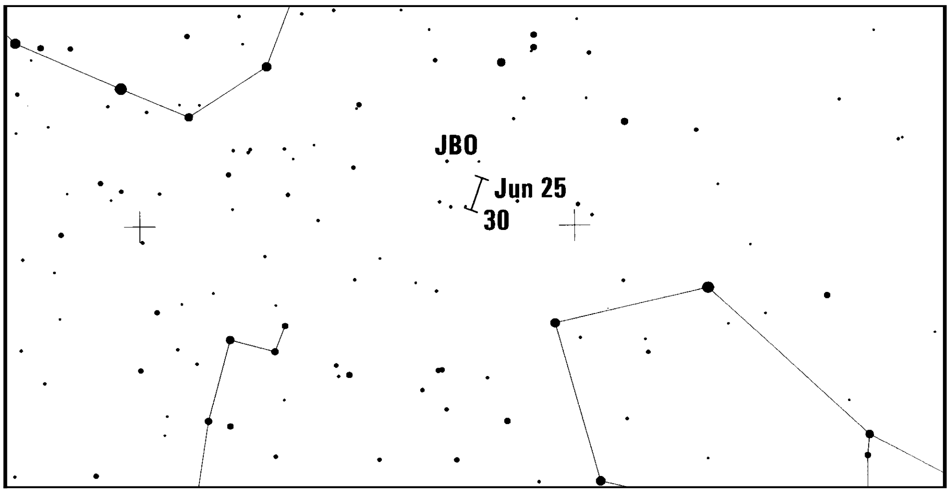


Figure 4 – Radiant position of the June Boötids.

Following the wholly unexpected strong return of this shower in 1998, when ZHRs of 50–100+ were visible for more than half a day, we reintroduced this source to the Working List of Visual Meteor Showers, and encourage all observers to routinely monitor the expected activity period in case of future outbursts. Prior to 1998, only three returns of the shower had been detected, in 1916, possibly in 1921 and 1927, and with no significant reports between 1928–1997, it seemed probable the stream no longer encountered Earth. The dynamics of the stream are poorly understood. The shower's parent comet 7P/Pons-Winnecke was at perihelion in January 1996 and again in May 2002. Its orbit currently lies around 0.24 astronomical units outside the Earth's at its closest approach, and the 1998 outburst is thought to be caused by old material in mean-motion resonance with Jupiter. Recent modelling by Asher and Emel'yanenko indicate possibly heightened rates for 2003 (June 27, $19^h$ UT). The radiant is at a useful elevation for most of the short summer night in the northern hemisphere (only), and the waning crescent Moon, less than two days from new on June 27-28, will present no problems for watching.

## 4. July to September

The minor Pegasid shower should just survive July's waxing gibbous Moon, but the usually minor (ZHRs 3–10) July Phoenicids are lost to full Moon on July 13. Other minor shower activity continues from various near-ecliptic sources throughout the quarter, first from the Sagittarids till mid July, then from the Aquarids and Capricornids, and finally the Piscids into September. The two strongest sources are timed excellently for new Moon in late July, the Southern $\delta$-Aquarids and the $\alpha$-Capricornids, along with the minor Piscis Austrinids, and the Southern $\iota$-Aquarids in early August. The Northern $\delta$-Aquarid maximum on August 9 loses out to the waxing Moon, and the full Moon wrecks this year's Perseids (main maximum on August 13, $4^h40^m$ UT, possibly with two other maxima on August 13, at $\sim 2^h40^m$ UT and $14^h40^m$ UT respectively). As the Moon wanes, it next knocks out the minor $\kappa$-Cygnid peak on August 18, but the very weak Northern $\iota$-Aquarid maximum may still be glimpsed. Early September's waxing crescent Moon favors the $\alpha$-Aurigid peak, but not the $\delta$-Aurigids (peak on September 9; full Moon September 10...). For daylight radio observers, the interest of May–June has waned, but there remain the visually-impossible $\gamma$-Leonids (peak circa August 25, $21^h$ UT, though not found in recent radio results), and a tricky visual shower, the Sextantids (maximum expected on September 27, $21^h$ UT, but possibly occurring a day earlier. In 1999 a strong return was detected at $\lambda_\odot \sim 186°$, equivalent to 2003 September 29). New Moon gives no extra problems for visual observers hoping to catch some Sextantids in late September, though the radiant rises less than an hour before dawn in either hemisphere.

*Pegasids*

Active: July 7–13; Maximum: July 10 ($\lambda_\odot = 107.°5$); ZHR = 3;
Radiant: $\alpha = 340°$, $\delta = +15°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 70$ 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).

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, which with a waxing gibbous Moon on July 10, will allow most observers from mid-northern latitudes southwards a 1 h+ window of darker skies between moonset and dawn twilight starting (local moonset is around $0^h30^m$–$1^h30^m$ at mid-northern latitudes, or between $3^h$–$4^h$ for typical southern hemisphere sites). The maximum ZHR is generally low, and swift, faint meteors can be expected, favoring telescopic observing.

## 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 19);
$V_\infty = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to $000°$, $\delta = 00°$ to $+15°$,
choose pairs separated by about 30° in $\alpha$ ($\beta < 30°$ N).

*Southern $\delta$-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 19);
$V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to +15°,
choose pairs separated by about 30° in $\alpha$ ($\beta < 40°$ N).

*$\alpha$-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 19);
$V_\infty = 23$ km/s; $r = 2.5$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to +15°,
choose pairs separated by about 30° in $\alpha$ ($\beta < 40°$ N);
PFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N),
$\alpha = 320°$, $\delta = -05°$ ($\beta 0°$ to 45° N),
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$).

*Southern $\iota$-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 19);
$V_\infty = 34$ km/s; $r = 2.9$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to +15°,
choose pairs separated by about 30° in $\alpha$ ($\beta < 30°$ N).

*Northern $\iota$-Aquarids*

Active: August 11–31; Maximum: August 20 ($\lambda_\odot = 147°$); ZHR = 3;
Radiant: $\alpha = 327°$, $\delta = -06°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 31$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to 000°, $\delta = 00°$ to +15°,
choose pairs of fields separated by about 30° in $\alpha$ ($\beta < 30°$ N).

The Aquarids and Piscis Austrinids are all showers 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 $\delta$-Aquarids especially, as the most active of these showers. The $\alpha$-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 $\alpha$-Capricornid ZHRs to $\sim 10$ was noted in 1995 by European *IMO* observers, although the Southern $\delta$-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 shower members seen in this region of sky rather than trying to make shower associations in the field. The only exception is when the Southern $\delta$-Aquarids are near their peak, as from southern hemisphere sites in particular, rates may become too high for accurate plotting.

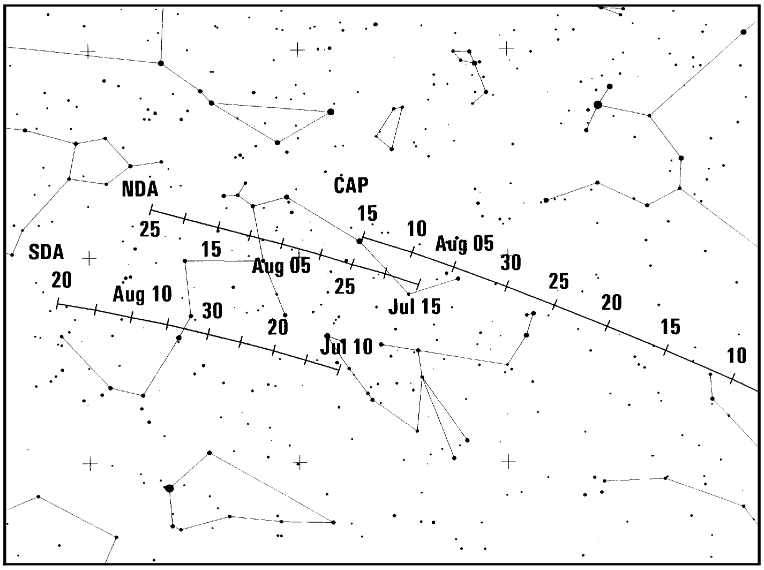


Figure 5 – Radiant position of the $\delta$-Aquarids and $\alpha$-Capricornids.

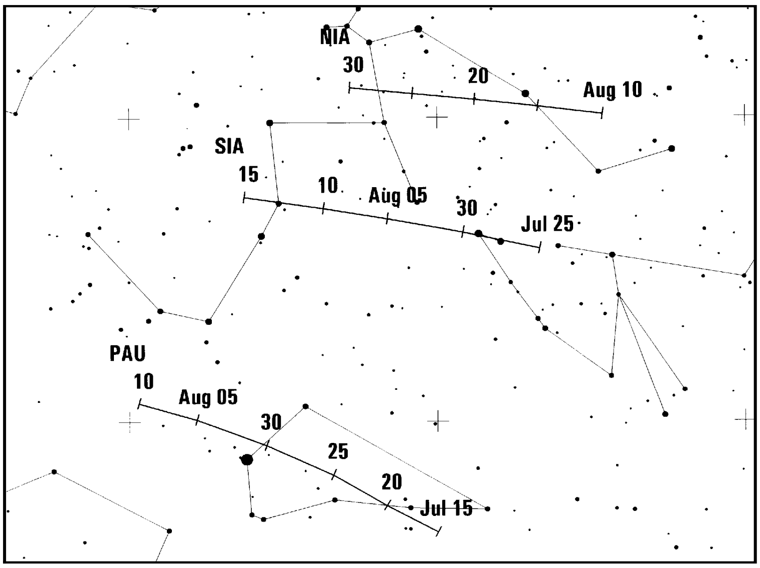


Figure 6 – Radiant position of the $\iota$-Aquarids and Piscis Austrinids.

In 2003 new Moon on July 29 favors all the July–August maxima from these sources except the Northern $\delta$-Aquarids. In late August, the Northern $\iota$-Aquarids showed an ill-defined maximum between $\lambda_{\odot} = 148° – 151°$ in 1988–1995 results, which could mean the highest rates (even so, very weak) happen several days after the suspected peak time given here. The early-rising last quarter Moon on August 20 for northern hemisphere sites makes more southerly sites favored this year, but moonlight conditions will improve even a few days later in the month. All these radiants are above the horizon for much of the night.

*α-Aurigids*

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|---|
| Active: August 25–September 8; Maximum: September 1, $12^h$ UT ($\lambda_\odot = 158.^\circ6$); ZHR = 7;<br>Radiant: $\alpha = 84^\circ$, $\delta = +42^\circ$, Radiant drift: see Table 6 (page 19);<br>$V_\infty = 66$ km/s; $r = 2.6$;<br>TFC: $\alpha = 052^\circ$, $\delta = +60^\circ$; $\alpha = 043^\circ$, $\delta = +39^\circ$ and $\alpha = 023^\circ$, $\delta = +41^\circ$ ($\beta > 10^\circ$ S). |

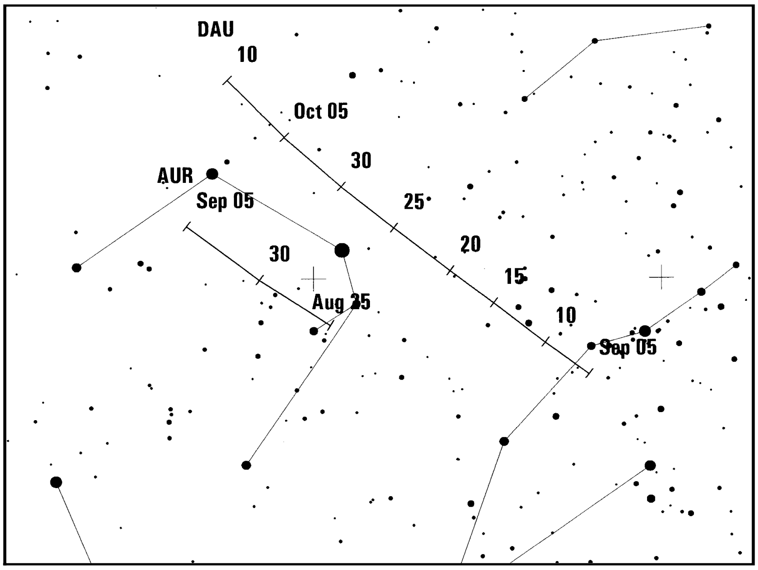


Figure 7 – Radiant position of the α-Aurigids and δ-Aurigids.

This shower and its less-favorable nearby source, the δ-Aurigids, are both essentially northern hemisphere showers, badly in need of more observations. They are 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. Of the known showers, 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. Audrius Dubietis and Rainer Arlt published a detailed investigation of *IMO* data between 1986–2000 on this shower in 2002, following which a few minor amendments have been made to the shower parameters given above and used in the Working List of Visual Meteor Showers below. The very tiny number of reports on the 1986 and 1994 outbursts (just three observers in total!) meant almost no useful details could be derived on these regrettably, reinforcing the need for more observers to be active in a favorable year such as 2003. The radiant reaches a useful elevation after $23^h$–$00^h$ local time, so lunar circumstances are ideal, with a waxing crescent Moon setting by mid-evening. 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.

*Piscids*

| |
|---|
| Active: September 1–30; Maximum: September 20 ($\lambda_\odot = 177^\circ$); ZHR = 3;<br>Radiant: $\alpha = 005^\circ$, $\delta = -01^\circ$; Radiant drift: see Table 6 (page 19);<br>$V_\infty = 26$ km/s; $r = 3.0$;<br>TFC: $\alpha = 340^\circ$ to $020^\circ$, $\delta = -15^\circ$ to $+15^\circ$,<br>choose pairs of fields separated by about $30^\circ$ in $\alpha$ ($\beta$ any). |

Audrius Dubietis carried out an examination of *IMO* data on the Piscids (earlier known as the Southern Piscids; no other Piscid radiant has been clearly defined as visually active for many years) between 1985–1999 in early 2001, which essentially confirmed the current details on the shower are correct, including that this is another poorly-studied minor shower! Its radiant near the maximum is very close to the March equinox point in the sky, and consequently, it can be observed equally well from either hemisphere throughout the night near the September equinox. This year, the waning crescent Moon gives at least the first half of the night with dark skies for observers (longer in the southern hemisphere). Telescopic and video methods can be usefully employed to study the Piscids, along with methodical visual plotting.

## 5. October to December

October's full Moon spoils any chance to hunt for potential Draconid activity this year. Possible peak timings span across October 8, $20^{\rm h}$ UT ($\lambda_\odot = 197\overset{\circ}{.}075$, the equivalent 1998 outburst time), October 9, $4^{\rm h}$ UT (nodal crossing time, $\lambda_\odot = 195\overset{\circ}{.}4$), to October 9, $9^{\rm h}30^{\rm m}$–$12^{\rm h}40^{\rm m}$ UT (the equivalent 1999 minor outburst time, $\lambda_\odot = 195\overset{\circ}{.}63$–$195\overset{\circ}{.}76$). The very weak $\varepsilon$-Geminids are lost to waning moonlight at their maximum on October 18 this year, but moonlight circmstances will have improved somewhat for the main Orionid peak. Early to mid November sees the minor, extended, Taurid maximum lost to full Moon too, with the Southern and Northern branches expected to produce their stronger rates around November 5 and 12 respectively. The late October to early November spell, which sometimes seems to produce more or brighter Taurids, is mostly free from moonlight this year however. David Asher has suggested such enhanced activity may be due to a denser "swarm" of larger Taurid particles within the stream, and two recent such events in 1995 and 1998 provide some support for this. Though the next October-November "swarm" return is not predicted until 2005, this would be a good year to check for any additional unusual activity. Later in November, the Leonids are not especially well-placed regarding the waning Moon, and although no storm is expected this time, observations are still vital. This is a marvellous year for covering the $\alpha$-Monocerotids at least. In the first half of December, only the $\chi$-Orionid maximum is sufficiently Moon-free for useful observing. Other peaks are due as follows: Phoenicids - December 6, $20^{\rm h}30^{\rm m}$ UT; Puppid Velids—around December 7; Monocerotids—December 9; $\sigma$-Hydrids—December 12; Geminids—December 14, $11^{\rm h}40^{\rm m} \pm 2.5\,{\rm h}$. Luckily, the Coma Berenicids and Ursids end the visual observer's year on a high note, as both enjoy dark skies.

*Orionids*

Active: October 2–November 7; Maximum: October 21, $21^{\rm h}$ UT ($\lambda_\odot = 208°$); ZHR = 20;
Radiant: $\alpha = 095°$, $\delta = +16°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 66$ km/s; $r = 2.9$;
TFC: $\alpha = 100°$, $\delta = +39°$ and $\alpha = 075°$, $\delta = +24°$ ($\beta > 40°$ N); or
$\alpha = 080°$, $\delta = +01°$ and $\alpha = 117°$, $\delta = +01°$ ($\beta < 40°$ N).

October's waning crescent Moon partly favors the Orionids near their best. They are noted for having several maxima other than the main one above, with activity sometimes remaining almost constant for several consecutive nights centered on this peak. In 1993 and 1998, a submaximum as strong as the normal peak was detected on October 17-18 from Europe, for instance. All observers should be aware of these possibilities, though covering October 17-18 in dark skies will not be possible in 2003. Several subradiants have been reported in the past, but recent video work suggests the radiant is far less complex; photographic, telescopic and video work to confirm this would be useful, as visual observers have clearly had problems with this shower's radiant determination before. With a radiant near the celestial equator, the shower can be seen from most of the globe, and observations are possible from midnight onwards in both hemispheres, perhaps a little before in the north.

*Leonids*

Active: November 14–21; Maximum: November 18, $2^h30^m$ UT ($\lambda_\odot = 235.^\circ27$); ZHR = 100+?;
Radiant: $\alpha = 153°$, $\delta = +22°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 71$ 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 $0^h$ local time ($\beta > 40°$ N);
$\alpha = 120°$, $\delta = +20°$ before $4^h$ local time and
$\alpha = 160°$, $\delta = 00°$ after $4^h$ local time ($\beta > 00°$ N);
$\alpha = 120°$, $\delta = +10°$ before $0^h$ local time and
$\alpha = 160°$, $\delta = -10°$ ($\beta < 00°$ N).

Following the series of strongly enhanced to storm level returns of the Leonids since 1998, associated with the 1998 perihelion passage of the shower's parent comet 55P/Tempel-Tuttle, 2003 may well see falling rates as the shower begins its decline to more "normal" levels of activity. Certainly, no very strongly enhanced activity is predicted, although as meteor enthusiasts know well, surprises can occur from even the best-known showers on occasion! Observers should be alert to covering whatever the shower produces, as following the post-storm phases after this best-ever observed series of storm returns is as vital to our understanding of the stream as seeing the storms themselves.

The Leonid radiant rises usefully only around local midnight (or indeed afterwards south of the equator), not good news, as the last quarter Moon in Leo rises around the same time this year on November 17-18. Observers should persevere however, facing away from the Moon where possible. If the peak occurs at the nodal crossing time (above), it will favor sites across Europe, Africa and the Near East especially, but other peak times cannot be excluded, and observers should be watching for as much of November 16-17 to 19-20 as conditions will allow, in case something unexpected happens. All observing techniques can be usefully employed.

*$\alpha$-Monocerotids*

Active: November 15–25; Maximum: November 22, $2^h45^m$ UT ($\lambda_\odot = 239.^\circ32$);
ZHR = variable, usually $\sim 5$, but may produce outbursts to $\sim 400+$;
Radiant: $\alpha = 117°$, $\delta = +01°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 65$ 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 $\alpha$-Monocerotids gave their most recent brief outburst in 1995 (the top EZHR, $\sim 420$, lasted just five minutes; the entire outburst 30 minutes). Many observers across Europe witnessed it, and we have been able to completely update the known shower parameters as a result. Whether this indicates the proposed ten-year periodicity in such returns is real or not, only the future will tell (two more years to go!), so all observers should continue to monitor this source closely. New Moon on November 23 makes this an ideal year for detailed scrutiny. The radiant is well on view from either hemisphere after about $23^h$ local time, so the expected peak falls especially well for sites across the Near East, Africa and all of Europe.

*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 19);
$V_\infty = 28$ km/s; $r = 3.0$;
TFC: $\alpha = 083°$, $\delta = +09°$ and $\alpha = 080°$, $\delta = +24°$ ($\beta > 30°$ S).

A weak visual stream, but 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 with the waxing gibbous Moon setting between $0^h30^m$–$1^h30^m$ local time in either hemisphere on December 2, the second half of the night should be fully employed to cover the stream.

*Coma Berenicids*

Active: December 12–January 23; Maximum: December 20 ($\lambda_\odot = 268°$); ZHR = 5;
Radiant: $\alpha = 175°$, $\delta = +25°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 65$ km/s; $r = 3.0$;
TFC: $\alpha = 180°$, $\delta = +50°$ and $\alpha = 165°$, $\delta = +20°$ before $3^h$ local time,
$\alpha = 195°$, $\delta = +10°$ and $\alpha = 200°$, $\delta = +45°$ after $3^h$ local time ($\beta > 20°$ N).

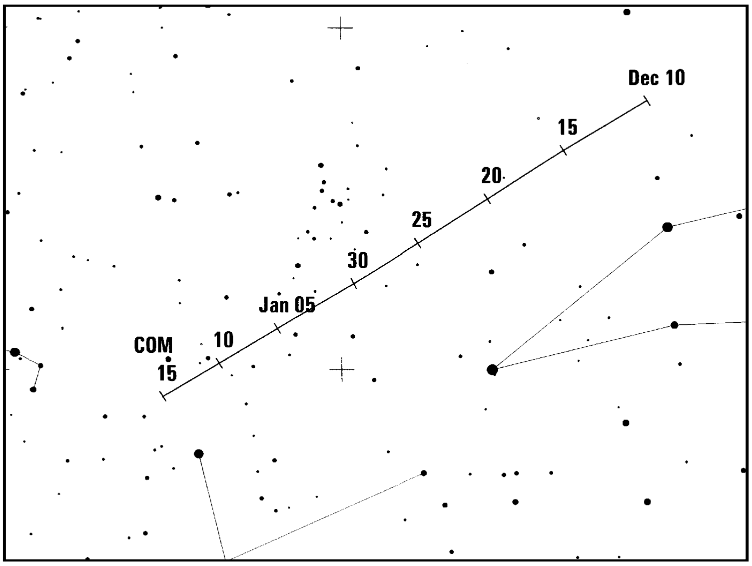


Figure 8 – Radiant position of the Coma Berenicids.

A weak minor shower that is usually observed only during the Geminid and Quadrantid epochs, but which needs more coverage at other times too, especially to better define its maximum. The shower is almost unobservable from the southern hemisphere, so northern watchers must brave the winter cold to improve our knowledge of it, especially this year as its expected peak benefits from a nearly-new Moon. The radiant is at a useful elevation from local midnight onwards.

*Ursids*

Active: December 17–26; Maximum: December 23, $1^h$ UT ($\lambda_\odot = 270.^\circ7$);
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 6 (page 19);
$V_\infty = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348°$, $\delta = +75°$ and $\alpha = 131°$, $\delta = +66°$ ($\beta > 40°$ N);
$\alpha = 063°$, $\delta = +84°$ and $\alpha = 156°$, $\delta = +64°$ ($\beta 30°$ to $40°$ N).

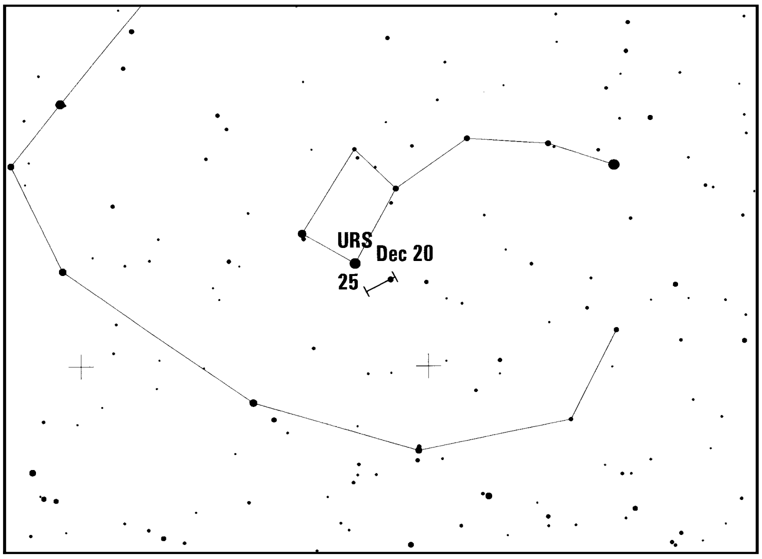


Figure 9 – Radiant position of the Ursids.

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 $\lambda_\odot = 270.^\circ8$, for instance, which might suggest a slightly later maximum time in 2003 of December 23, $3^h$ UT, while the 2000 enhancement was seen surprisingly strongly (EZHR $\sim 90$) by video at $\lambda_\odot = 270.^\circ78$ (equivalent to 2003 December 23, $2^h40^m$ UT), although the visual enhancement was much less, ZHR $\sim 30 \pm 5$. 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. New Moon makes this a perfect year for seeing whatever happens. The expected peak times favor northerly sites between western Asia westwards to eastern North America.

## 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.

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 ($v_\infty$). 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 |

## 7. Abbreviations and tables for observers

- $\alpha$, $\delta$: Coordinates for a shower's radiant position, usually at maximum. $\alpha$ is right ascension, $\delta$ is declination. Radiants drift across the sky each day due to the Earth's own orbital motion around the Sun, and this must be allowed for using the details in Table 6 (page 19) for nights away from the listed shower maxima.
- $r$: The population index, a term computed from each shower's meteor magnitude distribution. $r = 2.0$–$2.5$ is brighter than average, while $r$ above 3.0 is fainter than average.
- $\lambda_{\odot}$: Solar longitude, a precise measure of the Earth's position on its orbit which is not dependent on the vagaries of the calendar. All $\lambda_{\odot}$ are given for the equinox 2000.0.
- $V_{\infty}$: 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. $\beta$ is the observer's latitude ("<" means "south of" and ">" means "north of"). *Pairs* of telescopic fields must be observed, alternating about every half hour, so that the positions of radiants can be defined. The exact choice of TFC or 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 2003.

| New Moon | First Quarter | Full Moon | Last Quarter |
|---|---|---|---|
| January 2 | January 10 | January 18 | January 25 |
| February 1 | February 9 | February 16 | February 23 |
| March 3 | March 11 | March 18 | March 25 |
| April 1 | April 9 | April 16 | April 23 |
| May 1 | May 9 | May 16 | May 23 |
| May 31 | June 7 | June 14 | June 21 |
| June 29 | July 7 | July 13 | July 21 |
| July 29 | August 5 | August 12 | August 20 |
| August 27 | September 3 | September 10 | September 18 |
| September 26 | October 2 | October 10 | October 18 |
| October 25 | November 1 | November 9 | November 17 |
| November 23 | November 30 | December 8 | December 16 |
| December 23 | December 30 | | |

Table 5 – Working list of visual meteor showers. Details in this Table were correct according to the best information available in June 2002. 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 "Shower" column indicates the shower may have other or additional peak times, noted in the text.

| Shower | Activity | Maximum | | Radiant | | $V_\infty$ | $r$ | ZHR |
|---|---|---|---|---|---|---|---|---|
| | | Date | $\lambda_\odot$ | $\alpha$ | $\delta$ | km/s | | |
| Quadrantids (QUA) | Jan 01–Jan 05 | Jan 04 | 283.°16 | 230° | +49° | 41 | 2.1 | 120 |
| $\delta$-Cancrids (DCA) | Jan 01–Jan 24 | Jan 17 | 297° | 130° | +20° | 28 | 3.0 | 4 |
| $\alpha$-Centaurids (ACE) | Jan 28–Feb 21 | Feb 08 | 319.°2 | 210° | −59° | 56 | 2.0 | 6 |
| $\delta$-Leonids (DLE) | Feb 15–Mar 10 | Feb 24 | 336° | 168° | +16° | 23 | 3.0 | 2 |
| $\gamma$-Normids (GNO) | Feb 25–Mar 22 | Mar 14 | 353° | 249° | −51° | 56 | 2.4 | 8 |
| Virginids (VIR) | Jan 25–Apr 15 | (Mar 25) | (4°) | 195° | −04° | 30 | 3.0 | 5 |
| Lyrids (LYR) | Apr 16–Apr 25 | Apr 22 | 32.°32 | 271° | +34° | 49 | 2.1 | 18 |
| $\pi$-Puppids (PPU) | Apr 15–Apr 28 | Apr 24 | 33.°5 | 110° | −45° | 18 | 2.0 | var |
| $\eta$-Aquarids (ETA)* | Apr 19–May 28 | May 06 | 45.°5 | 338° | −01° | 66 | 2.7 | 60 |
| Sagittarids (SAG) | Apr 15–Jul 15 | (May 20) | (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 10 | 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. $\delta$-Aquarids (SDA) | Jul 12–Aug 19 | Jul 28 | 125° | 339° | −30° | 41 | 3.2 | 20 |
| $\alpha$-Capricornids (CAP) | Jul 03–Aug 15 | Jul 30 | 127° | 307° | −10° | 23 | 2.5 | 4 |
| South. $\iota$-Aquarids (SIA) | Jul 25–Aug 15 | Aug 04 | 132° | 334° | −15° | 34 | 2.9 | 2 |
| North. $\delta$-Aquarids (NDA) | Jul 15–Aug 25 | Aug 09 | 136° | 335° | −05° | 42 | 3.4 | 4 |
| Perseids (PER)* | Jul 17–Aug 24 | Aug 13 | 140.°0 | 46° | +58° | 59 | 2.6 | 110 |
| $\kappa$-Cygnids (KCG) | Aug 03–Aug 25 | Aug 18 | 145° | 286° | +59° | 25 | 3.0 | 3 |
| North. $\iota$-Aquarids (NIA) | Aug 11–Aug 31 | Aug 20 | 147° | 327° | −06° | 31 | 3.2 | 3 |
| $\alpha$-Aurigids (AUR) | Aug 25–Sep 08 | Sep 01 | 158.°6 | 84° | +42° | 66 | 2.6 | 7 |
| $\delta$-Aurigids (DAU) | Sep 05–Oct 10 | Sep 09 | 166° | 60° | +47° | 64 | 3.0 | 6 |
| Piscids (SPI) | Sep 01–Sep 30 | Sep 20 | 177° | 5° | −01° | 26 | 3.0 | 3 |
| Draconids (GIA) | Oct 06–Oct 10 | Oct 09 | 195.°4 | 262° | +54° | 20 | 2.6 | var |
| $\varepsilon$-Geminids (EGE) | Oct 14–Oct 27 | Oct 18 | 205° | 102° | +27° | 70 | 3.0 | 2 |
| Orionids (ORI) | Oct 02–Nov 07 | Oct 21 | 208° | 95° | +16° | 66 | 2.9 | 20 |
| 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 18 | 235.°27 | 153° | +22° | 71 | 2.5 | 100+ |
| $\alpha$-Monocerotids (AMO) | Nov 15–Nov 25 | Nov 22 | 239.°32 | 117° | +01° | 65 | 2.4 | var |
| $\chi$-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° | 22 | 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 |
| $\sigma$-Hydrids (HYD) | Dec 03–Dec 15 | Dec 12 | 260° | 127° | +02° | 58 | 3.0 | 2 |
| Geminids (GEM) | Dec 07–Dec 17 | Dec 14 | 262.°0 | 112° | +33° | 35 | 2.6 | 120 |
| Coma Berenicids (COM) | Dec 12–Jan 23 | Dec 20 | 268° | 175° | +25° | 65 | 3.0 | 5 |
| Ursids (URS) | Dec 17–Dec 26 | Dec 23 | 270.°7 | 217° | +76° | 33 | 3.0 | 10 |

Table 6 – Radiant drift positions during the year in $\alpha$ and $\delta$.

| | | | | | | | | |
|---|---|---|---|---|---|---|---|---|
| | **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** | | | | |
| Sep 5 | | | 088 +42 | 055 +46 | **SPI** | | | |
| Sep 10 | | | | 060 +47 | 357 −5 | | | |
| Sep 15 | | | | 066 +48 | 001 −3 | | | |
| Sep 20 | | | | 071 +48 | 005 −1 | | | |
| Sep 25 | **NTA** | **STA** | | 077 +49 | 009 0 | | | |
| Sep 30 | 021 +11 | 023 +5 | **ORI** | 083 +49 | 013 +2 | | | |
| 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 Date | $\lambda_\odot$ 2000.0 | Radiant $\alpha$ | Radiant $\delta$ | Best Observed 50° N | Best Observed 35° S | Rate |
|---|---|---|---|---|---|---|---|---|
| Cap/Sagittarids | Jan 13–Feb 04 | Feb 01 | 312°5 | 299° | −15° | $11^h$–$14^h$ | $09^h$–$14^h$ | medium |
| $\chi$-Capricornids | Jan 29–Feb 28 | Feb 13 | 324°7 | 315° | −24° | $10^h$–$13^h$ | $08^h$–$15^h$ | low |
| Piscids (Apr) | Apr 08–Apr 29 | Apr 20 | 30°3 | 7° | +07° | $07^h$–$14^h$ | $08^h$–$13^h$ | low |
| $\delta$-Piscids | Apr 24–Apr 24 | Apr 24 | 34°2 | 11° | +12° | $07^h$–$14^h$ | $08^h$–$13^h$ | low |
| $\varepsilon$-Arietids | Apr 24–May 27 | May 09 | 48°7 | 44° | +21° | $08^h$–$15^h$ | $10^h$–$14^h$ | low |
| Arietids (May) | May 04–Jun 06 | May 16 | 55°5 | 37° | +18° | $08^h$–$15^h$ | $09^h$–$13^h$ | low |
| $o$-Cetids | May 05–Jun 02 | May 20 | 59°3 | 28° | −04° | $07^h$–$13^h$ | $07^h$–$13^h$ | medium |
| Arietids | May 22–Jul 02 | Jun 07 | 76°7 | 44° | +24° | $06^h$–$14^h$ | $08^h$–$12^h$ | high |
| $\zeta$-Perseids | May 20–Jul 05 | Jun 09 | 78°6 | 62° | +23° | $07^h$–$15^h$ | $09^h$–$13^h$ | high |
| $\beta$-Taurids | Jun 05–Jul 17 | Jun 28 | 96°7 | 86° | +19° | $08^h$–$15^h$ | $09^h$–$13^h$ | medium |
| $\gamma$-Leonids | Aug 14–Sep 12 | Aug 25 | 152°2 | 155° | +20° | $08^h$–$16^h$ | $10^h$–$14^h$ | low |
| Sextantids* | Sep 09–Oct 09 | Sep 27 | 184°3 | 152° | 00° | $06^h$–$12^h$ | $06^h$–$13^h$ | medium |

## 8. Useful addresses

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

**Fireball Data Center (FIDAC):**
André Knöfel, Saarbrücker Strasse 8, D-40476 Düsseldorf, 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, 660 N'Aohoku Place, Hilo, HI 96720, USA. e-mail: `tele@imo.net`

**Video Commission:**
Sirko Molau, Weidenweg 1, D-52074 Aachen, Germany. e-mail: `sirko@molau.de`

**Visual Commission:**
Rainer Arlt, Friedenstrasse 5, D-14109 Potsdam, Germany. email: `visual@imo.net`

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: `treasurer@imo.net`

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!