International Meteor Organization
2000 Meteor Shower Calendar

compiled by Alastair McBeath and Rainer Arlt[1]

Introduction

Welcome to the 2000 International Meteor Organization (*IMO*) Meteor Shower Calendar. The year promises many Moon-free major showers (except the Lyrids, Perseids, Orionids and Geminids), and the Leonids may produce high to storm rates in November. Of especial interest is the chance to see what the June Bootids produce in late June after their unexpected outburst in 1998. 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 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, visual/video 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.

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

[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 data analyses produced since. Layout by André Knöfel.

the advantages, and disadvantages, of both photographic and telescopic observing, 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 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 of the Virginids, active from late January to mid-April. Both major showers, the northern-hemisphere Quadrantids and the southern-hemisphere α-Centaurids are excellently-placed with regard to the Moon this year. The minor δ-Cancrids are lost in the near-full Moon glare in January, but the weak δ-Leonids in late February and the γ-Normids in mid-March fare better. Daylight radio peaks are theoretically due from the Capricornids/Sagittarids around 02^h UT on February 2, and the χ-Capricornids on February 14, around 03^h UT. Recent radio results suggest the Cap/Sgr peak may fall 2–3 days later than this however, while no significant enhancement in radio rates was found near the expected χ-Capricornid peak between 1994–1999. As both showers have radiants $< 10°$–$15°$ west of the Sun at maximum, they cannot be regarded as visual targets even from the southern hemisphere.

Quadrantids

Active: January 1-5; Maximum: January 4, 05^h UT ($\lambda_\odot = 283.16°$);
ZHR = 120 (can vary $\sim$ 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 00^h local time $\alpha = 150°$, $\delta = +70°$;
after 00^h local time $\alpha = 180°$, $\delta = +40°$ and $\alpha = 240°$, $\delta = +70°$ ($\beta > 40°$ N).

The year opens with a superb return of the Quadrantids for northern hemisphere observers, as the Moon is just two days before new on January 4. Since the shower's radiant is in northern Bootes, it is circumpolar for many northern locations, but it attains a useful elevation only after local midnight or so, and gets higher towards morning twilight. 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 locations.

The maximum time given above is based on the best-observed return of the shower ever analyzed, from *IMO* 1992 data, confirmed by radio results in 1996, 1997 and 1999. A repeat of this time in 2000 would favor sites from Europe to the east coast of North America. The peak itself is normally short-lived, and can be easily missed in just a few hours of poor winter weather in the north, 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!

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 normally seen away from 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.

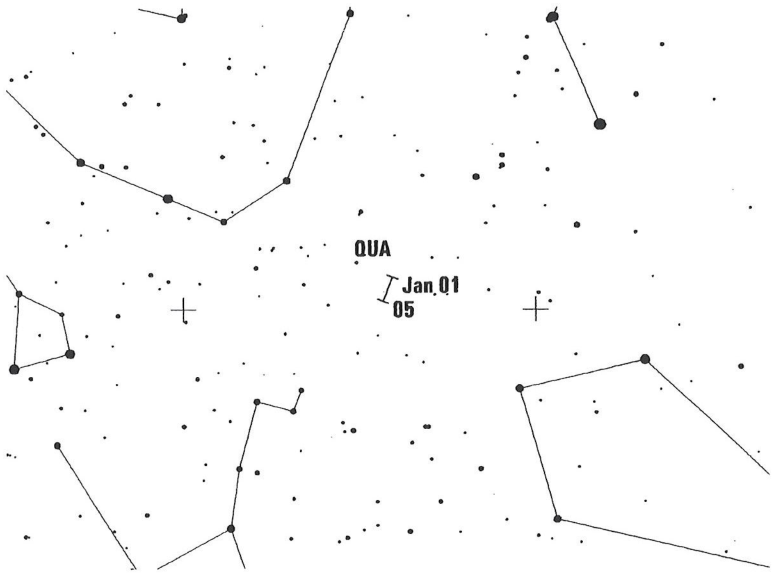

Figure 1: Radiant position and drift of the Quadrantids.

α-Centaurids

Active: January 28-February 21; Maximum: February 8, 16^h UT ($\lambda_\odot = 319.2°$);
ZHR = variable, usually ~ 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 α-Centaurids are one of the main southern hemisphere high points in the opening months of the year, producing many very bright, even fireball-class, objects (meteors of at least magnitude −3). Their peak ZHR is normally around 5–10, but in 1974 and again in 1980, bursts of only a few hours' duration yielded activity closer to 20–30. As we have no means of telling when another such event might happen, photographic, video and visual observers are urged to be alert, especially this year, as the Moon is new just three days before their maximum. Thanks to their brilliance, even a normal α-Centaurid return is worth looking out for, and almost one-third leave fine persistent trains after them. The radiant is nearly circumpolar for much of the sub-equatorial inhabited Earth, and is at a useful elevation from late evening onwards.

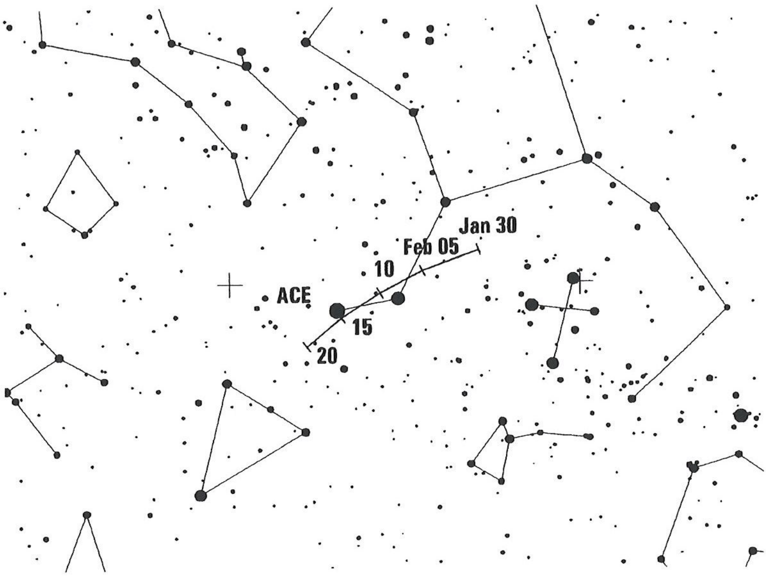

Figure 2: Radiant position and drift of the α-Centaurids.

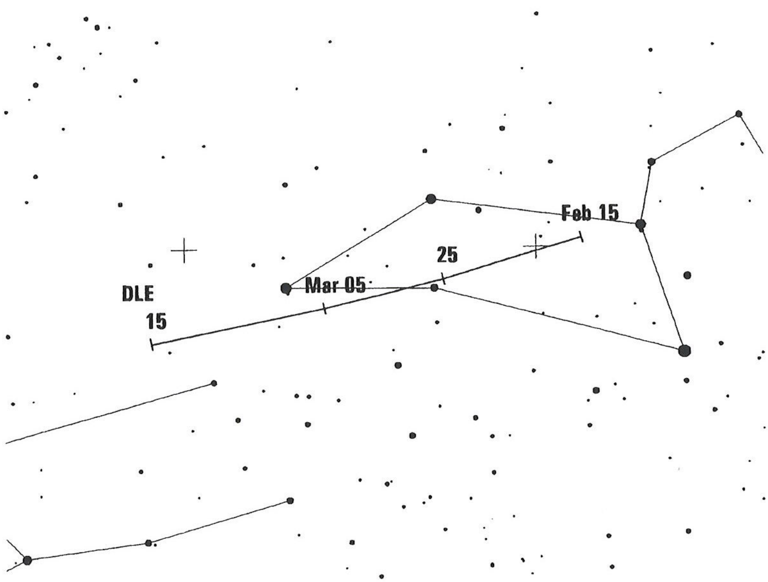

Figure 3: Radiant position and drift of the δ-Leonids.

δ-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).

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 a distinct advantage for covering this stream, especially this year as the waning gibbous Moon will rise around or after midnight at the peak for sites north of 35° N latitude. Southern hemisphere watchers should not ignore the stream, as they are better-placed to note many of the other Virginid radiants, but with moonrise as early as 22^h30^m at 35° S latitude on February 25, conditions are not ideal. At least the δ-Leonid radiant in mid-Leo is well on view for most of the night near the peak.

γ-Normids

Active: February 25-March 22; Maximum: March 13 ($\lambda_\odot = 353°$); ZHR = 8;
Radiant: $\alpha = 249°$, $\delta = -51°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 56$ km/s; r = 2.4;
TFC: $\alpha = 225°$, $\delta = -26°$ and $\alpha = 215°$, $\delta = -45°$ ($\beta < 10°$ S).

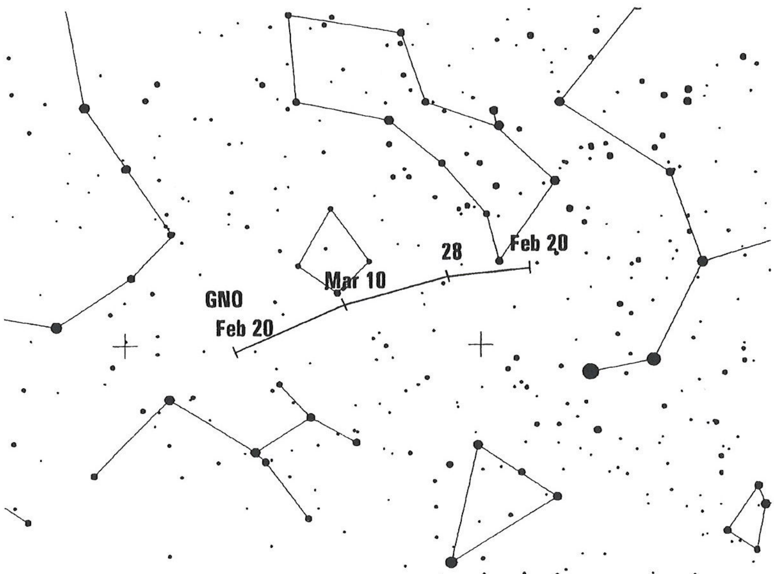

Figure 4: Radiant position and drift of the γ-Normids.

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. First quarter Moon on March 13 is thus excellent news, as it will set before midnight. All forms of observation can be carried out for the shower, though 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 (maximum expected between April 21, 22^h UT to April 22, 05^h UT), π-Puppids (peak around April 23, 09^h UT) and η-Aquarids. Both former sources suffer from bright waning gibbous 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 past 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, 02^h; δ-Piscids — April 24, 01^h; ε-Arietids — May 9, 00^h; May Arietids — May 16, 01^h; o-Cetids — May 20, 00^h; Arietids - June 7, 03^h; ζ-Perseids — June 9, 03^h; β-Taurids — June 28, 02^h. Some signs of most of these peaks were found in data from 1994-1998, except the April Piscids and May Arietids. The ecliptical complexes continue with some late Virginids and the best from the minor Sagittarids in May–June. Visual observers hoping to see any possible June Lyrid peak this year on June 15 will be severely hampered by full Moon.

η-Aquarids

Active: April 19-May 28; Maximum: May 5, 17^h UT ($\lambda_\odot = 45.5°$);
ZHR = 60 (occasionally variable);
Radiant: $\alpha = 338°$, $\delta = -01°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 66$ km/s; r = 2.7;
TFC: $\alpha = 319°$, $\delta = +10°$ and $\alpha = 321°$, $\delta = -23°$ ($\beta < 20°$ S).

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

A relatively broad maximum, sometimes with a variable number of submaxima, usually occurs in early May. ZHRs are generally above 30 for almost a week centred on the main peak, based on *IMO* observations between 1988–1997. With new Moon on May 4, the shower is perfectly-placed for watchers in 2000. All forms of observing can be used to study the η-Aquarids, with radio work allowing activity to be followed even from mid-northern latitude sites throughout the daylight morning hours. The radiant culminates at about 08^h local time.

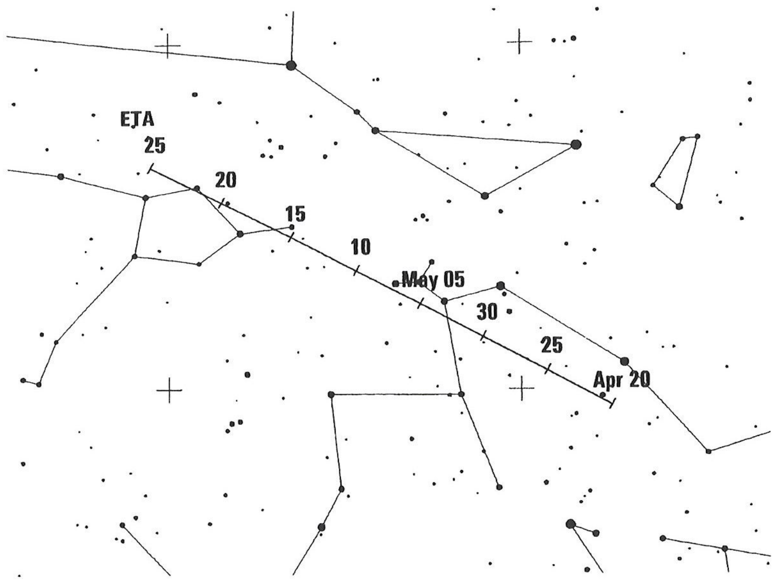

Figure 5: Radiant position and drift of the η-Aquarids.

June Bootids

Active: June 26–Jul 02; Maximum: June 27, 01^h UT ($\lambda_\odot = 95.7°$); ZHR = variable, 0–100+;
Radiant: $\alpha = 224°$, $\delta = +48°$, 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).

Following the wholly unexpected strong return of this shower in 1998, we are delighted to reintroduce the June Bootids to the Working List of visual meteor showers this year, and to encourage all observers to routinely monitor the expected activity period in case of future outbursts. Prior to 1998, only four definite returns of the shower had been detected, in 1916, 1921 and 1927. With no significant visual reports between 1928–1997, we were justified in assuming the stream no longer encountered the Earth, and accordingly removed the shower from the Working List in 1996. The dynamics of the stream are not well understood. The shower's parent comet 7P/Pons-Winnecke was last at perihelion in January 1996, and its orbit currently lies around 0.24 astronomical units outside the Earth's orbit at its closest approach, so we have no way at present to predict likely future activity. In 1998, high Bootid rates (ZHRs 50–100+) were visible for more than half a day, beginning shortly before the time indicated above, again quite contrary to the short-lived nature of other known shower outbursts. The radiant is at a useful elevation for most of the short summer night in the northern hemisphere (only), and the waning crescent Moon, just four days from new, will present no real problems.

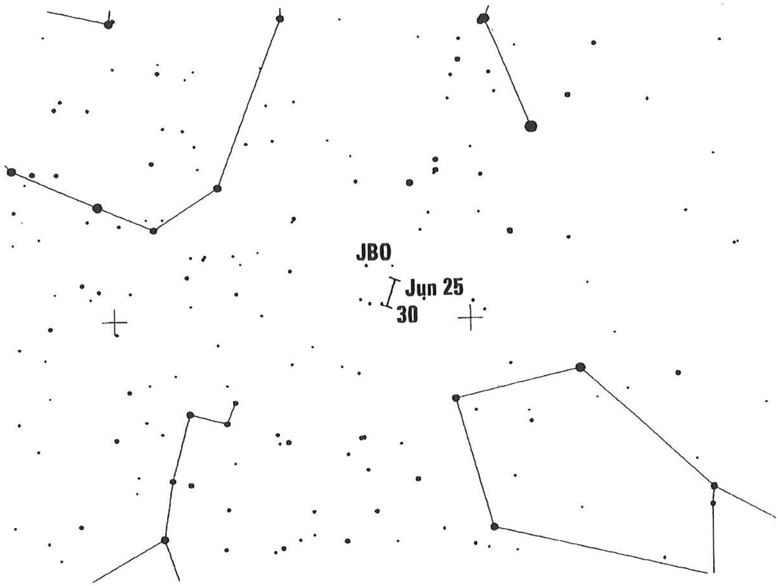

Figure 6: Radiant position and drift of the June Bootids.

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 (whose most likely peak on September 19 will suffer from the bright waning Moon) into September. The two strongest sources, the Southern δ-Aquarids and the α-Capricornids, are free from moonlight this year, along with the less-active Piscis Austrinids, Southern ι-Aquarids and Northern δ-Aquarids. Something of the Pegasids should still be seen in early July as well, but the July Phoenicids (peak July 13), Perseids (maxima expected near 05^h and 10^h UT on August 12; if the tertiary peak — seen so far only in 1997 — repeats in 2000, that should fall around 19^h UT on August 12), κ-Cygnids (maximum August 17) and Northern ι-Aquarids (peak August 19) all lose their best rates to bright moonlight. The α-Aurigids are much more favourable, and even the δ-Aurigids in early September are not too unfavourable. For daylight radio observers, the interest of May–June has waned, but there remain the visually-inaccessible γ-Leonids (peak circa August 25, 03^h UT, though not found in recent radio results), and a tricky visual shower, the Sextantids (maximum expected September 27, 03^h UT, but possibly occurring a day earlier). The latter prediction is perfectly timed for new Moon, though the radiant rises less than an hour before dawn in either hemisphere.

Pegasids

Active: July 7-13; Maximum: July 9 ($\lambda_\odot = 107.5°$); 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, good news as the waxing gibbous Moon will set soon after midnight for the more favorable northern hemisphere sites, to 00^h30^m at 35° S latitude. The maximum ZHR is generally low, and swift, faint meteors can be expected. Telescopic observing would be especially useful.

Piscis Austrinids and Aquarid/Capricornid Complex

Piscis Austrinids

Active: July 15-August 10; Maximum: July 27 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 35$ km/s; r = 3.2;
TFC: $\alpha = 255°$–$000°$, $\delta = 00°$–$+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Southern δ-Aquarids

Active: July 12-August 19; Maximum: July 27, 18^h UT ($\lambda_\odot = 125°$); ZHR = 20;
Radiant: $\alpha = 339°$, $\delta = -16°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 41$ km/s; r = 3.2;
TFC: $\alpha = 255°$–$000°$, $\delta = 00°$–$+15°$, choose pairs separated by about 30° in α ($\beta < 40°$ N).

α-Capricornids

Active: July 3-August 15; Maximum: July 29 ($\lambda_\odot = 127°$); ZHR = 4;
Radiant: $\alpha = 307°$, $\delta = -10°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 23$ km/s; r = 2.5;
TFC: $\alpha = 255°$–$000°$, $\delta = 00°$–$+15°$, choose pairs separated by about 30° in α ($\beta < 40°$ N);
PFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 40°$ N), $\alpha = 320°$, $\delta = -05°$ ($\beta = 0°$–$45°$ N),
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$).

Southern ι-Aquarids

Active: July 25-August 15; Maximum: August 4 ($\lambda_\odot = 132°$); ZHR = 2;
Radiant: $\alpha = 334°$, $\delta = -15°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 34$ km/s; r = 2.9;
TFC: $\alpha = 255°$–$000°$, $\delta = 00°$–$+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

Northern δ-Aquarids

Active: July 15-August 25; Maximum: August 8 ($\lambda_\odot = 136°$); ZHR = 4;
Radiant: $\alpha = 335°$, $\delta = -05°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 42$ km/s; r = 3.4;
TFC: $\alpha = 255°$–$000°$, $\delta = 00°$–$+15°$, choose pairs separated by about 30° in α ($\beta < 30°$ N).

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

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

In 2000 the Piscis Austrinid, Southern δ-Aquarid, α-Capricornid and Northern ι-Aquarid maxima benefit from new Moon on July 31, while the Northern δ-Aquarid peak has only a few problems from the waxing gibbous Moon, which will set between 23^h and 01^h30^m local time in either hemisphere. All these radiants are above the horizon for much of the night.

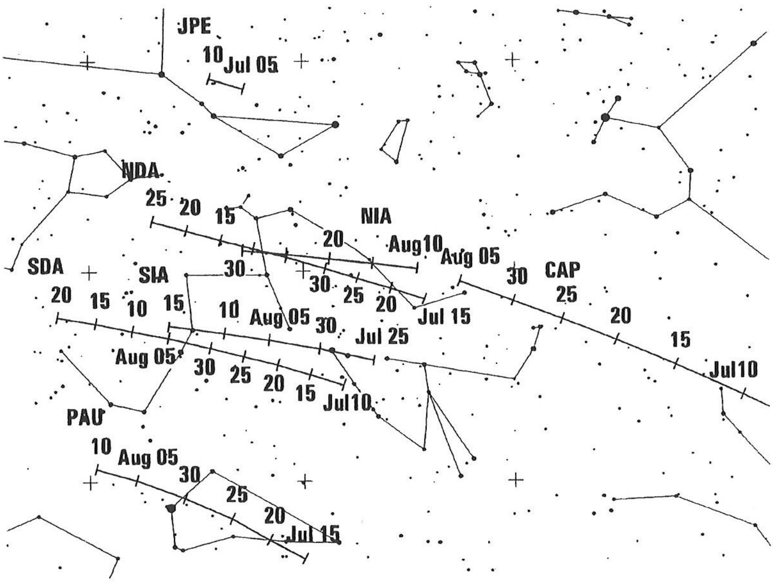

Figure 7: Radiant position and drift of the Piscis Austrinids and Aquarid/Capricornid Complex.

α- and δ-Aurigids

α-Aurigids

Active: August 25-September 5; Maximum: August 31, 18^h UT ($\lambda_\odot = 158.6°$); ZHR = 10;
Radiant: $\alpha = 084°$, $\delta = +42°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 66$ km/s; r = 2.5;
TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$ ($\beta > 10°$ S).

δ-Aurigids

Active: September 5-October 10; Maximum: September 8 ($\lambda_\odot = 166°$); ZHR = 6;
Radiant: $\alpha = 060°$, $\delta = +47°$, Radiant drift: see Table 6 (page 19);
$V_\infty = 64$ km/s; r = 3.0;
TFC: $\alpha = 052°$, $\delta = +60°$; $\alpha = 043°$, $\delta = +39°$ and $\alpha = 023°$, $\delta = +41°$ ($\beta > 10°$ S).

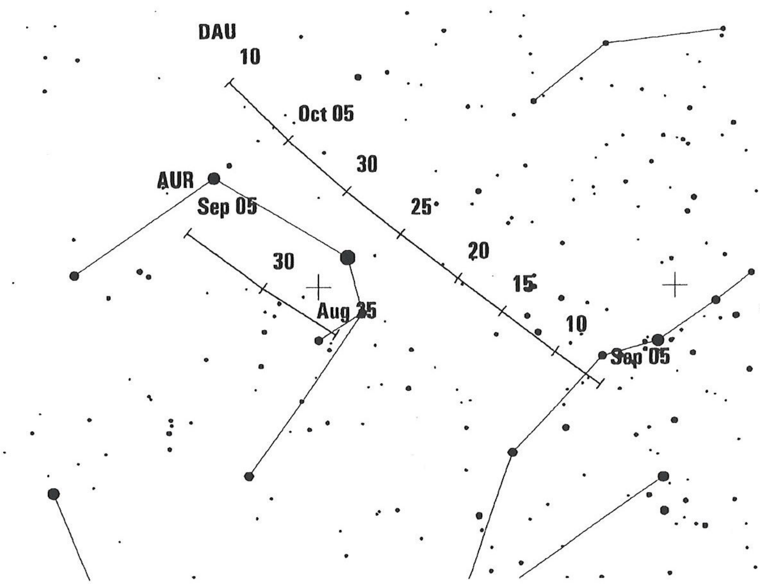

Figure 8: Radiant position and drift of the α-Aurigids and δ-Aurigids.

These 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. The δ-Aurigids typically produce low rates of generally faint meteors, and have yet to be well-seen in more than an occasional year. Both radiants reach a useful elevation only after 23^h–00^h local time, meaning lunar circumstances are near perfect for the α-Aurigid peak in 2000, with new Moon on August 29, while the δ-Aurigids enjoy dark skies after moonset (between 00^h–01^h local time north of 20° N latitude). 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.

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. Unfortunately, both Northern and Southern Taurid maxima suffer from bright moonlight this year, but the interesting late October to early November period which sometimes produces more Taurid fireballs is excellently Moon-free. Taurid activity in late October 1998 reached levels comparable to the usual maximum rates, and checking what happens this year would be valuable, though nothing unusual has been predicted. Before then is a partly moonless Draconid epoch, together with badly Moon-affected ε-Geminid and Orionid maxima, all in October. The main Orionid peak is likely around 02^h–03^h UT on October 21 for radio observers. Some predictions suggest a Leonid storm may occur in November, but moonlight will be a problem. However, the α-Monocerotid peak is nearly Moon-free, together with the χ-Orionids in December. Shower maxima lost to moonlight in December include those of the Phoenicids (December 6 around 02^h UT), early December's best from the Puppid-Velids, the Monocerotids (December 8), σ-Hydrids (December 11), Geminids (December 13, 17^h UT to December 14, 02^h UT) and Coma Berenicids (December 19). The Ursids at least survive this lunar-light onslaught.

Draconids

Active: October 6-10; Maximum: October 8, 01^h30^m UT ($\lambda_\odot = 195\overset{\circ}{.}075$)
or around October 8, 09^h UT ($\lambda_\odot = 195.4°$);
ZHR = periodic, up to storm levels;
Radiant: $\alpha = 262°$, $\delta = +54°$, Radiant drift: negligible;
$V_\infty = 20$ km/s; r = 2.6;
TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ N).

Unfortunately for potential Draconid 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 $\sim$ 20–500+), 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, and in 1998 October, a short-lived Draconid outburst yielding ZHRs of $\sim$ 700 was seen from Far Eastern sites, as well as being recorded by radio. This occurred at $\lambda_\odot = 195\overset{\circ}{.}075$, but a later time towards $\lambda_\odot = 195\overset{\circ}{.}4$ may be more generally applicable, based on the Earth's closest approach to the comet orbit's node. Activity in 2000 is unlikely, and conditions are far from ideal with a waxing gibbous Moon, but checking is important. The radiant is circumpolar from many northern hemisphere locations, but is higher in the pre-midnight and near-dawn hours on October 8–10. With moonset only after local midnight, a repeat of the 1998 peak time would favour sites in central to eastern North America, while the later time would be better for European to West Asian observers. Note that Draconid meteors are exceptionally slow-moving, a characteristic which helps separate genuine shower meteors from sporadics accidentally lining up with the radiant.

Leonids

Active: November 14-21; Maximum: November 17, 08^h UT ($\lambda_\odot = 235\overset{\circ}{.}27$);
ZHR = 100+ ($\sim$ 150? in 1997, $\sim$ 340 in 1998), but may reach storm level in 2000;
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 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 $\alpha = 160°$, $\delta = -10°$ ($\beta < 0°$ N).

The Leonids' parent comet, 55P/Tempel-Tuttle, reached perihelion last in 1998 February, but recent stream evolution studies suggest high to storm-level Leonid activity may still occur in 2000 or even until 2002. 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! Young material from the most recent, i.e. the 1965 and 1932 perihelion passages of the comet, is likely to cause enhanced activity near closest approach to the comet's node on November 17, 08^h UT ($\lambda_\odot = 235^\circ\!.27$), as also indicated by the stream model developed by Peter Brown, but the model finds an older trail from 1733 suggesting a peak as late as November 18, 08^h UT. This finding is supported by the studies of David Asher and Robert McNaught yielding November 18, 03^h45^m for the 1733 trail and another possible peak at 07^h50^m for the 1866 trail. A repeat of the spectacular and extended fireball outburst seen in 1998 is regrettably unlikely this year.

The radiant rises only around local midnight (or indeed afterwards south of the equator), so the waning gibbous Moon will be a considerable nuisance for all observers. The two $\sim 08^h$ UT peak timings would favor locations across North America, while the 03^h45^m possible peak would be best-seen from Europe and North Africa. Even minor variations from these timings would mean places east or west of these zones may see something of the shower's best too. Look out for further updates in the *IMO*'s journal *WGN* after the 1999 return. All observing methods should be utilised, especially photography and video if a storm manifests.

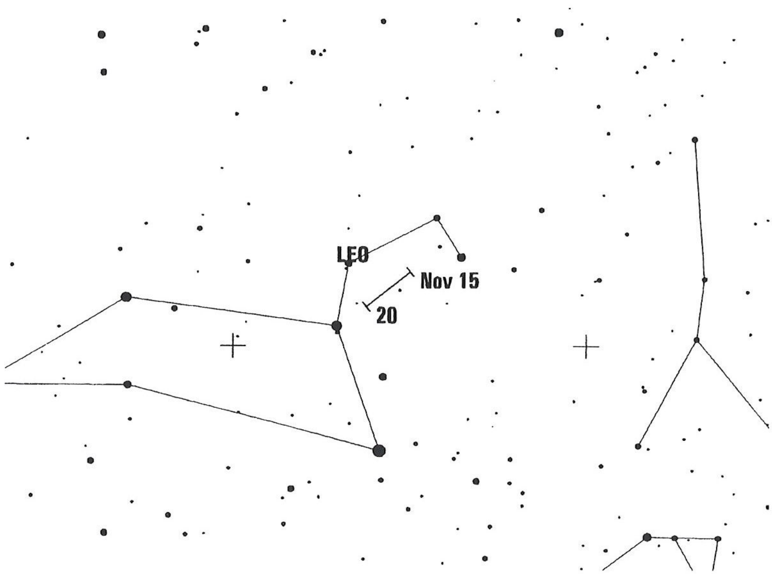

Figure 9: Radiant position and drift of the Leonids.

α-Monocerotids

Active: November 15-25; Maximum: November 21, 08^h UT ($\lambda_\odot = 239.32°$); ZHR = variable, usually 5, but may produce outbursts to 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).

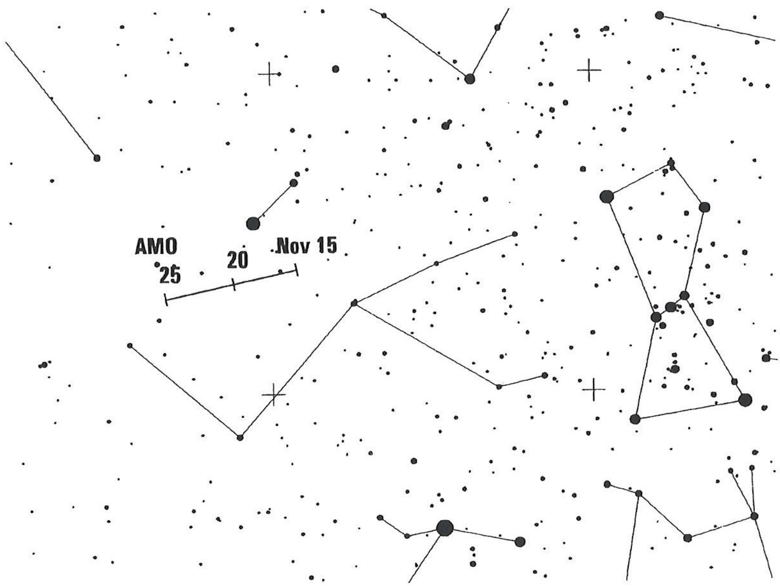

Figure 10: Radiant position and drift of the α-Monocerotids.

Another late-year shower capable of producing surprises, the α-Monocerotids gave their most recent brief outburst in 1995 (the top EZHR, $\sim$ 420, lasted just five minutes; the entire outburst 30 minutes). Many observers across Europe witnessed it, and we 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, however, so all observers should continue to monitor this source closely. We are currently at the mid-point of any decade-long cycle. The waning crescent Moon on November 21 makes this a good year for such scrutiny, with the radiant well on view in both hemispheres after about 23^h local time or so. The expected peak time falls especially well for North America.

χ-Orionids

Active: November 26-December 15; Maximum: December 1 ($\lambda_\odot = 250°$); ZHR = 3; Radiant: $\alpha = 082°$, $\delta = +23°$, Radiant drift: see Table 6 (page 19); $V_\infty = 28$ km/s; r = 3.0; TFC: $\alpha = 083°$, $\delta = +9°$ and $\alpha = 080°$, $\delta = +24°$ ($\beta > 30°$ S).

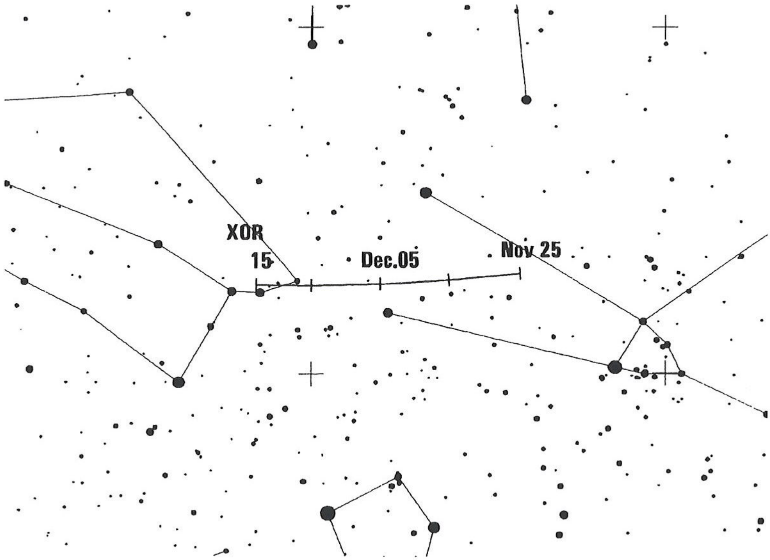

Figure 11: Radiant position and drift of the χ-Orionids.

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 waxing crescent Moon should give few problems, as the radiant is well on display in both hemispheres throughout the night.

Ursids

Active: December 17-26; Maximum: December 22, 06^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 $\alpha = 156°$, $\delta = +64°$ ($\beta = 30°$–$40°$ N).

A very poorly-observed northern hemisphere shower, but one which has produced at least two major outbursts in the past half-century or so, in 1945 and 1986. Several other rate enhancements, recently in 1988 and 1994, 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 1998 of December 22, 08^h30^m UT. The Ursid radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The nearly-new Moon will give dark skies for observations almost all night on December 22.

Radiant sizes and meteor plotting

If you are not observing during a major-shower maximum, it is much more essential to associate meteors with their radiants correctly, since the total numbers will be small. Meteor plotting allows the a shower association by more objective criteria than the prolongation of paths under the sky. As you plotted the meteors on gnomonic maps, you can trace the radiant by straight lines. If the radiant lies on another chart, you should find common stars on an adjacent chart to extend the backward prolongation there.

How large should the radiant be assumed for shower association? The physical radiant size is very small; visual plotting errors cause many true shower meteors to pass the radiant outside this area. We have to asume a larger radiant. The opposite behavior is caused by sporadic meteors — more and more sporadics line up accidentally upon enlarging the radiant. Hence, we have to apply an optimum radiant diameter compensating the loss due to plotting errors, and the sporadic meteor pollution. Table 1 gives the optimum diameter as a function of the distance of the meteor from the radiant.

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

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

The direction of the path is not the only criterion for shower association. The angular velocity of the meteor should match the expected speed of the shower meteors according to the geocentric velocity of the meteoroids. Angular velocity estimates should be made in degrees per second (°/s). In your imagination you make the meteors move for one second. 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 of 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

In you found a meteor which hits the radiant within the above diameter, check its angular velocity. Table 3 gives the angular speeds for a few geocentric velocities, which can be looked up in Table 5 for each shower.

Table 3: Angular velocities as a function of the radiant distance of the meteor and the elevation of the meteor for three different geocentric velocities. All velocities are in °/s. (The tables are symmetric in D and h.)

	$v_\infty = 25$ km/s					$v_\infty = 40$ km/s					$v_\infty = 60$ km/s				
$h \backslash D$	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

Abbreviations

α, δ: Coordinates for a shower's radiant position, usually at maximum. α is right ascension, δ is declination. Radiants drift across the sky each day due to the Earth's own orbital motion around the Sun, and this must be allowed for using the details in Table 6 (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_{∞}: 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 centers to use for video camera fields as well.

Table 4: Lunar phases for 2000.

New Moon	First Quarter	Full Moon	Last Quarter
January 06	January 14	January 21	January 28
February 05	February 12	February 19	February 27
March 06	March 13	March 20	March 28
April 04	April 11	April 18	April 26
May 04	May 10	May 18	May 26
June 02	June 09	June 16	June 25
July 01	July 08	July 16	July 24
July 31	August 07	August 15	August 22
August 29	September 05	September 13	September 21
September 27	October 05	October 13	October 20
October 27	November 04	November 11	November 18
November 25	December 04	December 11	December 18
December 25			

Table 5: Working list of visual meteor showers. Details in this Table were correct according to the best information available in June 1999. 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* Code
		Date	$\lambda_\odot$	α	δ	km/s			
Quadrantids	Jan 01–Jan 05	Jan 04	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 13	353°	249°	−51°	56	2.4	8	GNO
Virginids	Jan 25–Apr 15	(Mar 24)	(4°)	195°	−04°	30	3.0	5	VIR
Lyrids	Apr 16–Apr 25	Apr 21	32°1	271°	+34°	49	2.9	15	LYR
π-Puppids	Apr 15–Apr 28	Apr 23	33°5	110°	−45°	18	2.0	var.	PPU
η-Aquarids	Apr 19–May 28	May 05	45°5	338°	−01°	66	2.7	60	ETA
Sagittarids	Apr 15–Jul 15	(May 19)	(59°)	247°	−22°	30	2.5	5	SAG
June Bootids	Jun 26–Jul 02	Jun 27	95°7	224°	+48°	18	2.2	var.	JBO
Pegasids	Jul 07–Jul 13	Jul 09	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 27	125°	341°	−30°	35	3.2	5	PAU
South. δ-Aquarids	Jul 12–Aug 19	Jul 27	125°	339°	−16°	41	3.2	20	SDA
α-Capricornids	Jul 03–Aug 15	Jul 29	127°	307°	−10°	25	2.5	4	CAP
South. ι-Aquarids	Jul 25–Aug 15	Aug 04	132°	334°	−15°	34	2.9	2	SIA
North. δ-Aquarids	Jul 15–Aug 25	Aug 08	136°	335°	−05°	42	3.4	4	NDA
Perseids	Jul 17–Aug 24	Aug 12	*139°8	46°	+58°	59	2.6	140	PER
κ-Cygnids	Aug 03–Aug 25	Aug 17	145°	286°	+59°	25	3.0	3	KCG
North. ι-Aquarids	Aug 11–Aug 31	Aug 19	147°	327°	−06°	31	3.2	3	NIA
α-Aurigids	Aug 25–Sep 05	Aug 31	158°6	84°	+42°	66	2.5	10	AUR
δ-Aurigids	Sep 05–Oct 10	Sep 08	166°	60°	+47°	64	3.0	6	DAU
Piscids	Sep 01–Sep 30	Sep 19	177°	5°	−01°	26	3.0	3	SPI
Draconids	Oct 06–Oct 10	Oct 08	*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°27	153°	+22°	71	2.5	100+	LEO
α-Monocerotids	Nov 15–Nov 25	Nov 21	239°32	117°	+01°	65	2.4	var.	AMO
χ-Orionids	Nov 26–Dec 15	Dec 01	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 06)	(255°)	123°	−45°	40	2.9	10	PUP
Dec Monocerotids	Nov 27–Dec 17	Dec 08	257°	100°	+08°	42	3.0	3	MON
σ-Hydrids	Dec 03–Dec 15	Dec 11	260°	127°	+02°	58	3.0	2	HYD
Geminids	Dec 07–Dec 17	Dec 13	*262°0	112°	+33°	35	2.6	120	GEM
Coma Berenicids	Dec 12–Jan 23	Dec 19	268°	175°	+25°	65	3.0	5	COM
Ursids	Dec 17–Dec 26	Dec 22	270°7	217°	+76°	33	3.0	10	URS

*) Showers may have other or additional peak times; see text.

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

	COM	**DCA**	**QUA**						
Jan 0	186° +20°	112° +22°	228° +50°						
Jan 5	190° +18°	116° +22°	231° +49°						
Jan 10	194° +17°	121° +21°							
Jan 20	202° +13°	130° +19°		**ACE**	**VIR**				
Jan 30				200° −57°	157° +16°	**DLE**			
Feb 10				214° −60°	165° +10°	155° +20°	**GNO**		
Feb 20				225° −63°	172° +6°	164° +18°	225° −53°		
Feb 28					178° +3°	171° +15°	234° −52°		
Mar 10					186° 0°	180° +12°	245° −51°		
Mar 20					192° −3°		256° −50°		
Mar 30					198° −5°				
Apr 10	**SAG**	**LYR**	**PPU**		203° −7°				
Apr 15	224° −17°	263° +34°	106° −44°	**ETA**	205° −8°				
Apr 20	227° −18°	269° +34°	109° −45°	323° −7°					
Apr 25	230° −19°	274° +34°	111° −45°	328° −5°					
Apr 30	233° −19°			332° −4°					
May 5	236° −20°			337° −2°					
May 10	240° −21°			341° 0°					
May 20	247° −22°			350° +5°					
May 30	256° −23°								
Jun 10	265° −23°								
Jun 15	270° −23°								
Jun 20	275° −23°	**JBO**							
Jun 25	280° −23°	223° +48°							
Jun 30	284° −23°	225° +47°	**CAP**			**JPE**			
Jul 5	289° −22°		285° −16°	**SDA**		338° +14°			
Jul 10	293° −22°	**PHE**	289° −15°	325° −19°	**NDA**	341° +15°	**PER**	**PAU**	
Jul 15	298° −21°	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 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 α	Radiant δ	Best Observed 50° N	Best Observed 35° S	Rate
Cap/Sagittarids	Jan 13–Feb 04	Feb 02	312°5	299°	−15°	11^h–14^h	09^h–14^h	medium
χ-Capricornids	Jan 29–Feb 28	Feb 14	324°7	315°	−24°	10^h–13^h	08^h–15^h	low
Piscids (April)	Apr 08–Apr 29	Apr 20	30°3	7°	+7°	07^h–14^h	08^h–13^h	low
δ-Piscids	Apr 24–Apr 24	Apr 24	34°2	11°	+12°	07^h–14^h	08^h–13^h	low
ε-Arietids	Apr 24–May 27	May 08	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 19	59°3	28°	−4°	07^h–13^h	07^h–13^h	medium
Arietids	May 22–Jul 02	Jun 07	76°7	44°	+24°	06^h–14^h	08^h–12^h	high
ζ-Perseids	May 20–Jul 05	Jun 09	78°6	62°	+23°	07^h–15^h	09^h–13^h	high
β-Taurids	Jun 05–Jul 17	Jun 28	96°7	86°	+19°	08^h–15^h	09^h–13^h	medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152°2	155°	+20°	08^h–16^h	10^h–14^h	low
Sextantids	Sep 09–Oct 09	Sep 27	184°3	152°	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):
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: `photo@imo.net`

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

Telescopic Commission:
Malcolm Currie, 660 N'Aohoku Place, Hilo, HI 96720, U.S.A.
e-mail: `tele@imo.net`

Video Commission:
Sirko Molau, Weidenweg 1, D–52074 Aachen, Germany.
e-mail: `video@imo.net`

Visual Commission:
Rainer Arlt, Friedenstraße 5, D–14109 Berlin, Germany.
e-mail: `visual@imo.net`

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

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e-mail: `treasurer@imo.net`

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