International Meteor Organization

2013 Meteor Shower Calendar

compiled by Alastair McBeath [1]

1 Introduction

Welcome to the twenty-third International Meteor Organization (IMO) Meteor Shower Calendar, for 2013. Of the three strongest annual showers, only the Perseids enjoy moonless skies near their predicted peak this year, together with various less-active sources at different times. The Quadrantids and Geminids are at their respective best too close to full Moon. However, the three stronger southern hemisphere showers – α-Centaurids, η-Aquariids and Southern δ-Aquariids – are favourably-placed for dark-sky observing near their maxima, along with an all-but unknown possible shower in June, the γ-Delphinids, which might produce some activity for the first time since 1930. Ideally of course, meteor observing should be carried on throughout the year to check on all the established sources, and for any new ones. Such routine monitoring is possible now with automated video systems, but we appreciate not everyone is able to employ these, and that observing in other ways regularly is impractical for most people, so the Shower Calendar has been helping to highlight times when a particular effort might be most usefully employed since 1991.

The heart of the Calendar is the Working List of Visual Meteor Showers, Table 5, which has undergone a thorough revision in the last few years to help it to remain the single most accurate listing available anywhere today for naked-eye meteor observing. Of course, for all its accuracy, it is a **Working** List, so is continually subject to further checks and corrections, based on the best data we had at the time the Calendar was written, thus it is always as well to check the information here fully, taking account of any later changes noted in the IMO's journal *WGN* or on the IMO website, before going out to observe (and please tell us if you find any anomalies!).

This is an especially dynamic time for minor shower studies, with video results detecting many showers too weak to be observed visually, as well as sometimes revealing fresh aspects of those already known, and even of the low-activity phases of some of the major showers well away from their maxima. Video has established itself as a valuable tool in meteor studies in recent years, and professional radar meteor examinations have been producing excellent new results too, but we should not forget the other instrumental techniques available to amateur observers. Telescopic observations can also separate minor shower activity from the omnipresent background sporadics, and detect showers whose meteors are too faint even for current video systems. Still-imaging enables a whole range of studies to be carried out on the brighter meteors particularly, and multi-station observing with still or video cameras can allow orbital data to be established, essential

[1] Based on information in the *Handbook for Meteor Observers*, edited by Jürgen Rendtel and Rainer Arlt, IMO, 2008 (referred to as 'HMO' in the Calendar), and "A Comprehensive List of Meteor Showers Obtained from 10 Years of Observations with the IMO Video Meteor Network" by Sirko Molau and Jürgen Rendtel (*WGN* **37:4**, 2009, pp. 98–121; referred to as 'VID' in the Calendar), as amended by subsequent discussions and additional material extracted from reliable data analyses produced since. Particular thanks are due to Jürgen Rendtel for new information and comments in respect of events in 2013.

for meteoroid-stream examinations. Showers with radiants too near the Sun for observing by the various optical methods can be detected by forward-scatter radio or radar observations. Some of these showers are given in Table 7, the Working List of Daytime Radio Meteor Streams. Automated radio and radar work also allows 24-hour coverage of meteor activity.

The IMO's aims are to encourage, collect, analyze, and publish combined meteor data obtained from sites all over the globe, to help better our understanding of the meteor activity detectable from the Earth's surface. Thus, we encourage these more specialist forms of observing alongside visual work. Consequently, for best effects, all meteor workers, wherever you are and whatever methods you use to record meteors, should follow the standard IMO observing guidelines when compiling your information, and submit those data promptly to the appropriate Commission for analysis (contact details are at the end of the Calendar). Thanks to the efforts of the many IMO observers worldwide since 1988 that have done this, we have been able to achieve as much as we have to date, including keeping the shower listings vibrant. This is not a matter for complacency however, since it is solely by the continued support of many people across the planet that our attempts to construct a better and more complete picture of the near-Earth meteoroid flux can proceed.

Although timing predictions are included below on all the more active night-time and daytime shower maxima, as reliably as possible, it is essential to understand that in many cases, such maxima are not known more precisely than to the nearest 1° of solar longitude (even less accurately for the daytime radio showers, which have received little regular attention until quite recently). In addition, variations in individual showers from year to year mean past returns are only a guide as to when even major shower peaks can be expected. As noted already, the information given here may be updated and added-to after the Calendar has been published. Some showers are known to show particle mass-sorting within their meteoroid streams, so the radar, radio, still-imaging, telescopic, video and visual meteor maxima may occur at different times from one another, and not necessarily just in those showers. The majority of data available are for visual shower maxima, so this must be borne in mind when employing other observing techniques.

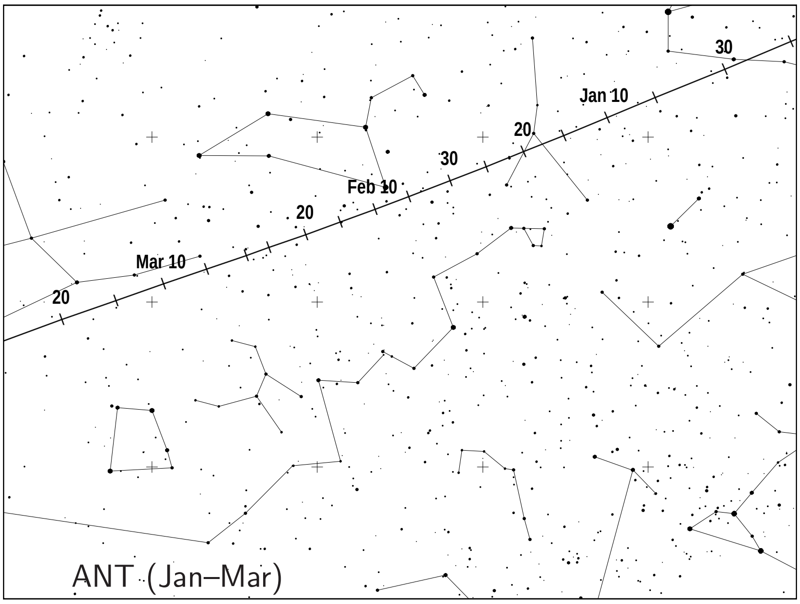
However and whenever you are able to observe, we wish you all a most successful year's work and very much look forward to receiving your data. Clear skies!

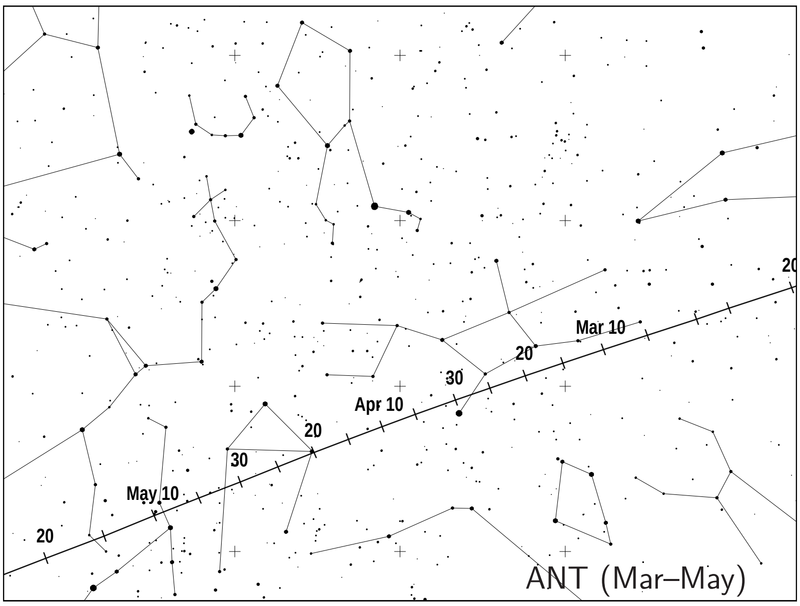
2 Antihelion Source

The Antihelion Source (ANT) is a large, roughly oval area around $\alpha = 30°$ by $\delta = 15°$ in size, centred about 12° east of the solar opposition point on the ecliptic, hence its name. It is not a true shower at all, but is rather a region of sky in which a number of variably, if weakly, active minor showers have their radiants. Until 2006, attempts were made to define specific showers within this complex, but this often proved very difficult for visual observers to achieve. IMO video results from the last decade have shown why, because even instrumentally, it was impossible to define distinct radiants for many of the showers here! Thus we believe currently it is best for observers simply to identify meteors from these streams as coming from the ANT alone. At present, we think the July-August α-Capricornids (CAP), and particularly the Southern δ-Aquariids (SDA), should remain discretely-observable visually from the ANT, so they have been retained on the Working List, but time and plenty of observations will tell, as ever. Later in the year, the strength of the Taurid showers (STA and NTA) means the ANT should be considered inactive while the Taurids are underway, from early September to early December. To assist observers, a set of charts showing the location for the ANT and any other nearby shower radiants is included here, to complement the numerical positions of Table 6, while comments on the ANT's location and likely activity are given in the quarterly summary notes.

3 January to March

Unfortunately, the northern-hemisphere's **Quadrantid** maximum, due around $13^{\mathrm{h}}30^{\mathrm{m}}$ UT on January 3, has a waning gibbous Moon which will create severe problems during the second half of the night, when the shower's radiant is properly observable. However, the southern-hemisphere's α-Centaurid and minor γ-Normid returns are much more favourable. The **ANT's** radiant centre starts January in south-east Gemini, and crosses Cancer during much of the month, before passing into southern Leo for most of February. It then glides through southern Virgo during March. Probable ANT ZHRs will be < 2, though IMO analyses have suggested there may be an ill-defined minor peak with ZHRs ~ 2 to 3 around $\lambda_{\odot} \sim 286°–293°$ (January 6 to 13 in 2013; well-timed for new Moon, if so), and ZHRs could be ~ 3 for most of March.

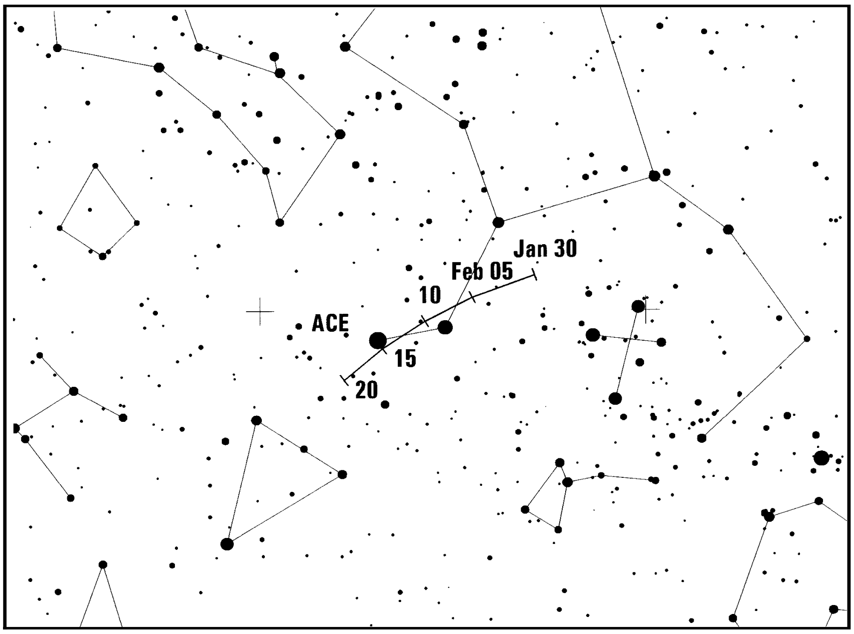




By contrast, the late January to early February spell, during which several, swift-meteor, **minor showers radiating from the Coma-Leo-Virgo area** have been proposed in some recent years, has an unhelpful waxing gibbous to full Moon for its potential core period, January 20–27. Theoretical timings (rounded to the nearest hour) for the **daytime radio shower maxima** this quarter are: Capricornids/Sagittarids – February 1, $09^{\rm h}$ UT and χ-Capricornids – February 13, $10^{\rm h}$ UT. Recent radio results have implied the Cap/Sgr maximum may fall variably sometime between February 1–4 however, while activity near the expected χ-Capricornid peak has tended to be slight and up to a day late. Both showers have radiants $< 10°$–$15°$ west of the Sun at maximum, so cannot be regarded as visual targets even from the southern hemisphere.

α–Centaurids (ACE)

Active: January 28–February 21; Maximum: February 8, $00^{\rm h}00^{\rm m}$ UT ($\lambda_\odot = 319\overset{\circ}{.}2$);
ZHR = variable, usually ~ 6, but may reach 25+;
Radiant: $\alpha = 210°$, $\delta = -59°$; Radiant drift: see Table 6;
$V_\infty = 56$ km/s; $r = 2.0$.



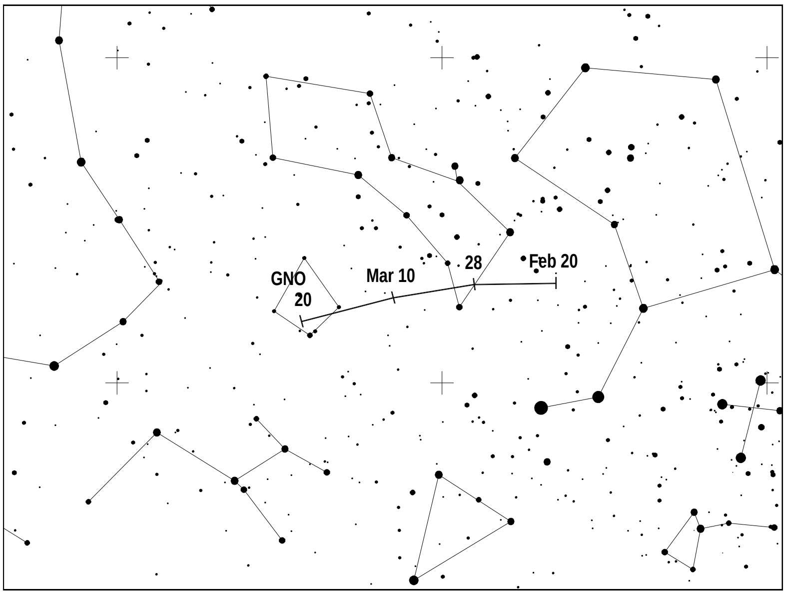
In theory, the α-Centaurids are one of the main southern summer high points, from past records supposedly producing many very bright, even fireball-class, objects (meteors of at least magnitude -3), commonly with fine persistent trains. However, the average peak ZHR between 1988–2007 was merely 6 (HMO, p. 130), albeit coverage has frequently been extremely patchy. Despite this, in 1974 and 1980, bursts of only a few hours' duration apparently yielded ZHRs closer to 20–30.

As with many southern hemisphere sources, we have more questions than answers at present, nor do we have any means of telling when, or if, another stronger event might happen. Consequently, imaging and visual observers are urged to be alert at every opportunity. The radiant is nearly circumpolar for much of the sub-equatorial inhabited Earth, and is at a useful elevation from late evening onwards. With new Moon on February 10, conditions could scarcely be more favourable for examining whatever the shower provides this time.

γ–Normids (GNO)

Active: February 25–March 22; Maximum: March 14 ($\lambda_\odot = 354°$); ZHR = 6;
Radiant: $\alpha = 239°$, $\delta = -50°$, Radiant drift: see Table 6;
$V_\infty = 56$ km/s; $r = 2.4$;
TFC: $\alpha = 225°$, $\delta = -26°$ and $\alpha = 215°$, $\delta = -45°$ ($\beta < 15°$ S).

For most of their activity, γ–Normid ZHRs seem to be virtually undetectable above the background sporadic rate. The maximum itself has been reported as quite sharp, and an analysis of IMO data from 1988–2007 showed an average peak ZHR of ~ 6 at $\lambda_\odot = 354°$, with ZHRs < 3 on all other dates during the shower (HMO, pp. 131–132).



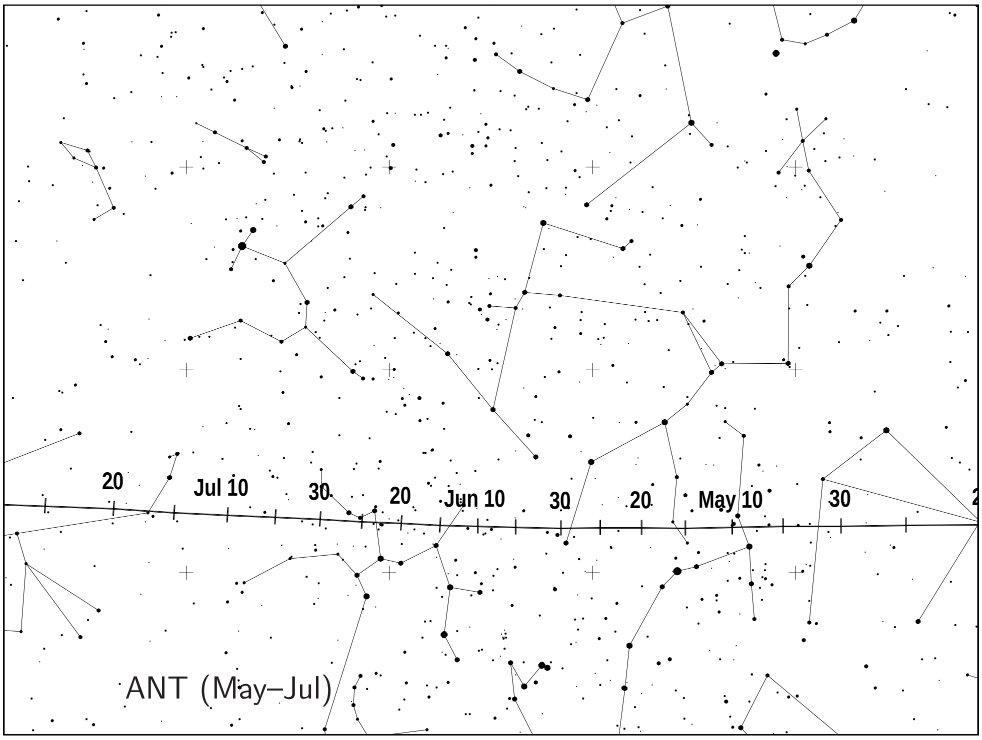
Limited data means this is uncertain, and activity may vary somewhat at times, with occasional broader, or less obvious, maxima having been noted in the past. Results since 1999 have suggested the possibility of a short-lived peak alternatively between $\lambda_\odot \sim 347°$–$357°$, equivalent to 2013 March 7–17, while video and visual plotting information from the same period agreed on the above radiant position, though this was different to that suggested earlier for the shower. Post-midnight watching yields better results, when the radiant is rising to a reasonable elevation from southern hemisphere sites (the radiant does not rise for many northern ones). The shower badly needs more regular attention, and March's new Moon period is ideally-placed to cover the above potential maximum timings. All observing techniques can be employed.

4 April to June

Meteor activity picks up towards the April-May boundary, although full Moon falls too near the Lyrid and π-Puppid maxima in late April for them to be properly observed visually. For non-visual observations the **Lyrid** peak should fall on April 22 sometime between roughly 04^h–15^h UT, with marginally higher ZHRs likely the closer the maximum happens to $\sim 11^h30^m$ UT. The **π-Puppid** peak is due near 17^h UT on April 23. Luckily, the η-Aquariids in early May enjoy a nearly-new Moon, along with the minor η-Lyrids.

Daytime showers: Later in May and throughout June, most of the meteor action switches to the daylight sky, with six shower peaks expected during this time. Although occasional meteors from the o-Cetids and Arietids have been claimed as seen from tropical and southern hemisphere sites visually in past years, ZHRs cannot be sensibly calculated from such observations. For radio observers, the theoretical UT peak times for these showers are as follows: April Piscids – April 20, 10^h; δ-Piscids – April 24, 10^h; ϵ-Arietids – May 9, 09^h; May Arietids – May 16, 10^h; o-Cetids – May 20, 08^h; Arietids – June 7, 12^h; ζ-Perseids – June 9, 11^h; β-Taurids – June 28, 10^h. Signs of most were found in radio data from 1994–2007, though some are difficult to define individually because of their proximity to other radiants. There seems to be a modest recurring peak around April 24, perhaps due to combined rates from the first three showers listed here, for instance, while the Arietid and ζ-Perseid maxima tend to blend into one another, producing a strong radio signature for several days in early to mid June. There are indications these two June shower maxima now each occur up to a day later than indicated above.

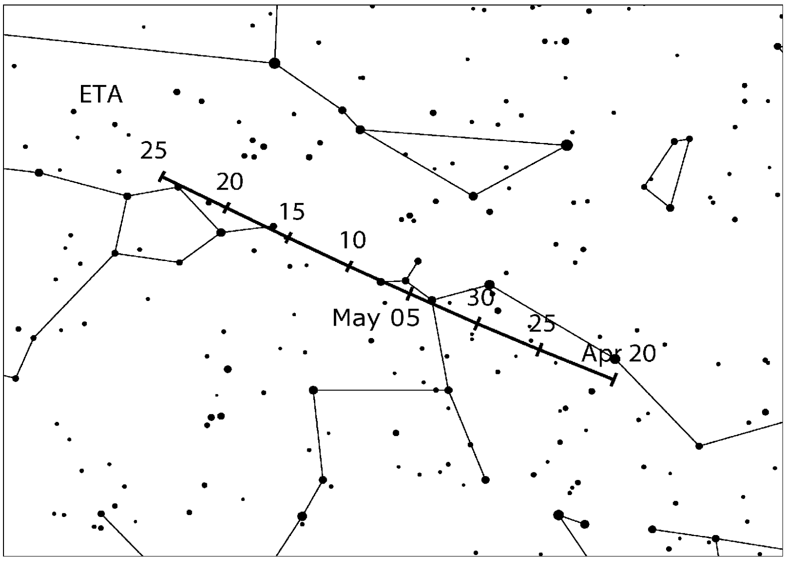
The **ANT** should be relatively strong, with ZHRs of 3 to 4 through till mid April, and again around late April to early May, late May to early June, and late June to early July. At other times, its ZHR seems to be below $\sim$ 2 to 3. The radiant area drifts from south-east Virgo through Libra in April, then across the northern part of Scorpius to southern Ophiuchus in May, and on into Sagittarius for much of June. For northern observers, circumstances for checking on any potential June Lyrids are reasonably favourable this year, although possible **June Boötid** hunting near the expected minor annual June 23 peak reported by VID and the occasional stronger outburst return date of June 27 are both marred by June's full to waning gibbous Moon.



Possible γ–Delphinid return: According to information in Peter Jenniskens' book "Meteor Showers & Their Parent Comets" (Cambridge University Press, 2006), on 1930 June 11, three American Meteor Society observers at the same site in Maryland, USA, apparently saw a short-lived meteor outburst from an otherwise unknown source, the γ-Delphinids, with a radiant estimated as near $\alpha = 312°$, $\delta = +17°$. The meteors were apparently quite fast-moving (a geocentric velocity of $\sim$ 57 km/s has been suggested). Activity was seen from the proposed shower during only a thirty-minute interval, 02^h15^m–02^h45^m UT, albeit there was a full Moon in the sky throughout. It seems no confirmation of this report was made elsewhere, while the suggested radiant was very low at the claimed time, all of which difficulties create doubts about exactly what the three observers may have witnessed. However, Peter Jenniskens' has proposed that a fresh return of this possible shower may happen in 2013, on June 11 at or around 08^h28^m UT. As the Moon will be just a slim waxing crescent on this date, observing conditions are ideal for seeing whether any activity occurs or not. No ZHR estimate had been proposed for the event when this Calendar was prepared, nor any indication of the likely particle sizes/meteor brightnesses that might be involved, but anything that does take place should be recorded either by video or very careful visual plotting, to enable further details about the source to be established. If anything happens as predicted from this radiant area, it would be best-seen from sites across North America.

η-Aquariids (ETA)

Active: April 19–May 28; Maximum: May 6, 01^{h} UT ($\lambda_{\odot} = 45.^{\circ}5$);
ZHR = 55 (periodically variable, $\sim$ 40–85);
Radiant: $\alpha = 338^{\circ}$, $\delta = -1^{\circ}$; Radiant drift: see Table 6;
$V_{\infty} = 66$ km/s; $r = 2.4$;
TFC: $\alpha = 319^{\circ}$, $\delta = +10^{\circ}$ and $\alpha = 321^{\circ}$, $\delta = -23^{\circ}$ ($\beta < 20^{\circ}$ S).

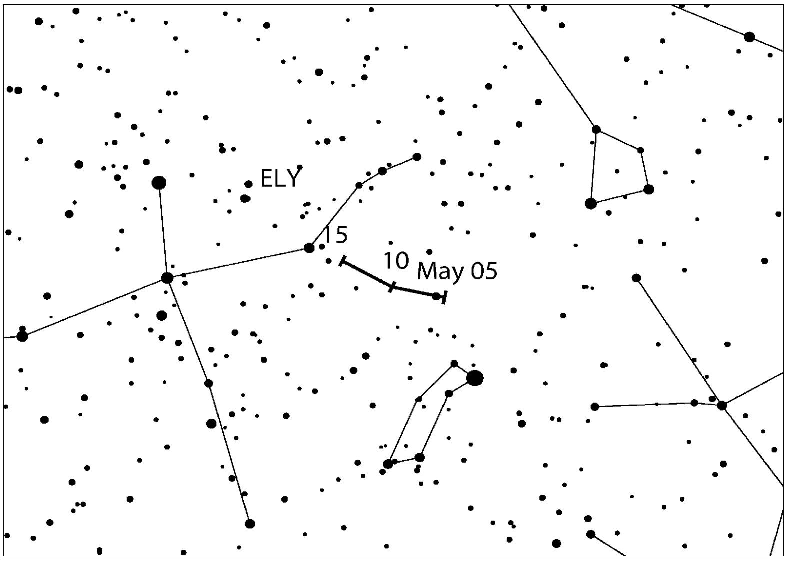


A fine, rich stream associated with Comet 1P/Halley, like the Orionids of October, but one visible for only a few hours before dawn, essentially from tropical and southern hemisphere sites. Some useful results have come even from places around 40° N latitude in recent years however, and occasional meteors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

A relatively broad maximum, sometimes with a variable number of submaxima, usually occurs in early May. IMO analyses in recent years, based on data collected between 1984–2001, have shown that ZHRs are generally above 30 between about May 3–10, and that the peak rates appear to be variable on a roughly 12-year timescale. Assuming this Jupiter-influenced cycle is borne-out, the next trough is due around 2014–2016, so ZHRs should be relatively modest in 2013, according to this idea. Activity around the most recent ZHR peak period in circa 2008 and 2009 seemed to have been $\sim$ 85 and 65 respectively, with ZHRs up to $\sim$ 65 recorded again in 2011. There appeared to have been no additional influence following the protracted, sometimes stronger than expected, Orionid returns from October 2006–2009 inclusive in the η-Aquariids in those years, as far as the available results allowed. New Moon on May 10 creates near-perfect viewing conditions for whatever the shower provides this year, with no more than a slender waning crescent Moon by the maximum date. All forms of observing can be used to study it, with radio work allowing activity to be followed even from many northern latitude sites throughout the daylight morning hours. The radiant culminates at about 08^{h} local time.

η-Lyrids (ELY)

Active: May 3–14; Maximum: May 8 ($\lambda_\odot = 48°$); ZHR = 3;
Radiant: $\alpha = 287°$, $\delta = +44°$; Radiant drift: see Table 6;
$V_\infty = 43$ km/s; $r = 3.0$;
TFC: $\alpha = 325°$, $\delta = +40°$ or $\alpha = 285°$, $\delta = +15°$, and $\alpha = 260°$, $\delta = +30°$ ($\beta > 10°$ S).



This recent introduction to the Visual Working List is associated with Comet C/1983 H1 IRAS-Araki-Alcock, though it appears to be only a weak shower. Most of the recent observational data on it has come from purely video results, which have suggested the maximum might fall at $\lambda_\odot = 50°$ instead (if so, on 2013 May 10). There is little evidence to suggest it has been definitely observed visually as yet, but the discussion on p. 137 of HMO had more information.

Video work, diligent telescopic, or perhaps equally careful visual, plotting will be needed to separate any potential η-Lyrids from the sporadics. The general radiant area is usefully on-view all night from the northern hemisphere (primarily), while May's new Moon gives ideal observing circumstances.

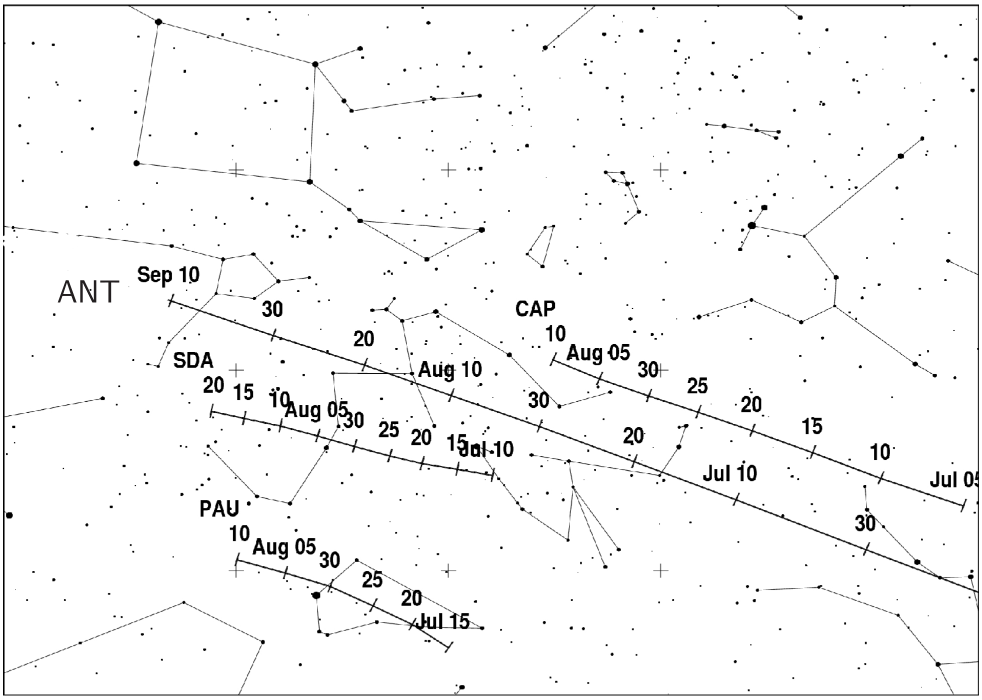
June Lyrids (JLY)

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

This possible source does not feature in the current IMO Working List, as apart from some activity seen from northern hemisphere sites in a few years during the 1960s (first seen 1966) and 1970s, evidence for its existence has been virtually zero since. In 1996, several observers independently reported some June Lyrids, though no definite activity has been found subsequently. The probable maximum date in 2013 has a first quarter Moon that will set around midnight, yielding dark skies after this for all observers who wish to check for it. The radiant may lie a few degrees south of the bright star Vega (α Lyrae), so would be well on-view throughout the short northern summer nights, but there are discrepancies in its position in the literature. All suspected visual June Lyrids should be carefully plotted, paying especial attention to the meteors' apparent velocities. Confirmation or denial of activity from this source by imaging techniques would be very useful too.

5 July to September

The **ANT** is the chief focus for visual attention during most of July, as its radiant area moves steadily through eastern Sagittarius, then across northern Capricornus into southwest Aquarius. Results suggest the Source may not be especially recognisable after the first few days however, as ZHRs for most of the month seem < 2, and for a time in mid-month even < 1! Activity appears to improve somewhat, with ZHRs ~ 2 to 3, by late July and through the first half of August. The large ANT radiant area overlaps that of the minor α-Capricornids (CAP) in July-August, but the Southern δ-Aquariids (SDA) are strong enough, and the Piscis Austrinids (PAU) have a radiant probably distant enough from the ANT area, that both should be separable from it, particularly from the southern hemisphere.



August's waxing gibbous Moon will prevent useful observations of the probable **κ-Cygnid** peak on the 17th, although VID suggested the maximum might happen closer to August 13, from a more southerly radiant around $\alpha = 186°$, $\delta = +51°$, which would be much more favourable if so. **ANT** ZHRs will likely have dropped back below 2 again by late August, rising once more to ~ 2–3 by early September, as the radiant tracks on through Aquarius and into western Pisces. Remember, the Southern Taurids begin around September 10, effectively taking over the near-ecliptic activity from the ANT through to December.

For **daylight radio observers**, the interest of May-June has waned, but there remain the visually-impossible γ-Leonids (peak due near August 25, 11^{h} UT, albeit not found in recent radio results), and a tricky visual shower, the Sextantids. Their maximum is expected on September 27, around 11^{h} UT, but possibly it may occur a day earlier. In 1999 a strong return was detected at $\lambda_\odot \sim 186°$, equivalent to 2013 September 29, while in 2002, the September 27 peak was not found, but one around September 29–30 was! It seems plausible several minor maxima in early October may also be due to this radio shower. September's last quarter Moon will rise in time to cause some further hindrance for visual observers hoping to catch some Sextantids in the pre-dawn of late September, though radiant-rise is less than an hour before sunrise in either hemisphere.

Piscis Austrinids (PAU)

Active: July 15–August 10; Maximum: July 28 ($\lambda_\odot = 125°$); ZHR = 5;
Radiant: $\alpha = 341°$, $\delta = -30°$; Radiant drift: see Table 6;
$V_\infty = 35$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to $0°$, $\delta = 0°$ to $+15°$, choose pairs separated by about $30°$ in α ($\beta < 30°$ N).

Very little information has been collected on the PAU in recent decades, so the details on the shower are not well-confirmed, and it seems possible the ZHR may be a little optimistic. However, that impression could be due simply to the large amount of northern hemisphere summer data, and the almost complete lack of southern hemisphere winter results, on it. The shower seems to be rich in faint meteors, rather like the nearby ANT and SDA, so telescopic and video work is advisable to try to establish more about it. Waning gibbous moonrise allows particularly southern hemisphere observers to cover much of the first half of the predicted maximum night, as the PAU radiant, like those of the SDA/ANT/CAP, is available virtually all night, especially from mid-southern latitudes.

Southern δ-Aquariids (SDA)

Active: July 12–August 23; Maximum: July 30 ($\lambda_\odot = 127°$); ZHR = 16;
Radiant: $\alpha = 340°$, $\delta = -16°$; Radiant drift: see Table 6;
$V_\infty = 41$ km/s; $r = 3.2$;
TFC: $\alpha = 255°$ to $0°$, $\delta = 0°$ to $+15°$, choose pairs separated by about $30°$ in α ($\beta < 40°$ N).

Like the PAU and ANT, SDA meteors are often faint, thus are suitable targets for telescopic observing, although enough brighter members exist to make visual and imaging observations worth the effort too, primarily from more southerly sites. Radio work can pick up the SDA as well, and indeed the shower has sometimes given a surprisingly strong radio signature. Careful visual plotting is advised, to help with accurate shower association. The SDA enjoys a longer dark-sky spell before last quarter moonrise for its likely peak than the PAU, albeit the maximum may not be quite so sharp as the single date here might imply, with perhaps similar ZHRs from July 28–30. Its rates have been suspected of some variability at times too, though not in more recent investigations.

α-Capricornids (CAP)

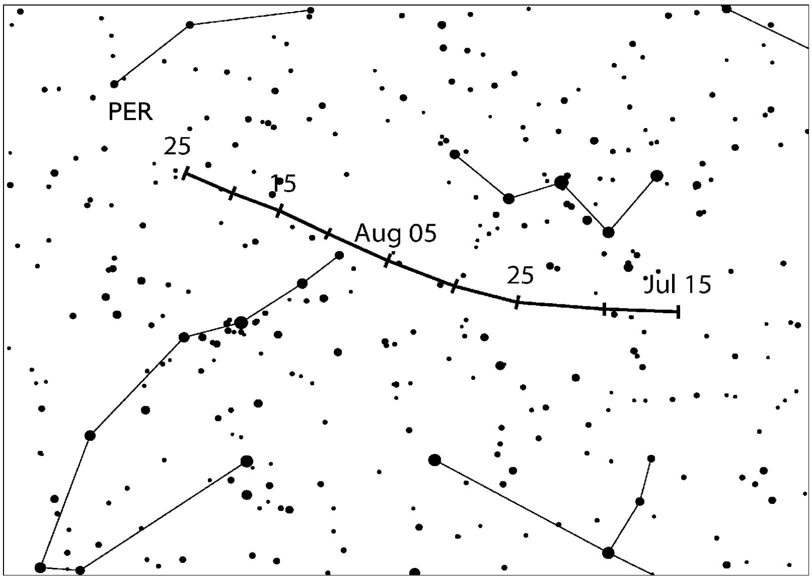
Active: July 3–August 15; Maximum: July 30 ($\lambda_\odot = 127°$); ZHR = 5;
Radiant: $\alpha = 307°$, $\delta = -10°$; Radiant drift: see Table 6;
$V_\infty = 23$ km/s; $r = 2.5$;
TFC: $\alpha = 255°$ to $0°$, $\delta = 0°$ to $+15°$, choose pairs separated by about $30°$ in α ($\beta < 40°$ N);
IFC: $\alpha = 300°$, $\delta = +10°$ ($\beta > 45°$ N), $\alpha = 320°$, $\delta = -5°$ (β $0°$ to $45°$ N),
$\alpha = 300°$, $\delta = -25°$ ($\beta < 0°$).

The CAP and SDA radiants were both definitely detected visually in former years, standing out against those much weaker ones supposed active in Capricornus-Aquarius then. Whether the CAP can still be detected as visually separate from the ANT radiant area is unclear, as its radiant now partly overlaps that of the large ANT region. Observers failed to find a clear maximum for the shower in 2009 for example. However, their bright, at times fireball-class brilliance, combined with their low apparent velocities, might make them distinctive enough to be detected still by means other than video. A minor enhancement of CAP ZHRs to ~ 10 was noted in 1995 by European IMO observers. Recent results suggest the maximum may continue into July 31, with similar lunar conditions to the 30th.

Perseids (PER)

Active: July 17–August 24; Maximum: August 12, 18^h15^m to 20^h45^m UT (node at $\lambda_\odot = 140^\circ\!.0$–$140^\circ\!.1$), but see text; ZHR = 100;
Radiant: $\alpha = 48^\circ$, $\delta = +58^\circ$; Radiant drift: see Table 6;
$V_\infty = 59$ km/s; $r = 2.2$;
TFC: $\alpha = 19^\circ$, $\delta = +38^\circ$ and $\alpha = 348^\circ$, $\delta = +74^\circ$ before 2^h local time;
$\alpha = 43^\circ$, $\delta = +38^\circ$ and $\alpha = 73^\circ$, $\delta = +66^\circ$ after 2^h local time ($\beta > 20^\circ$ N);
IFC: $\alpha = 300^\circ$, $\delta = +40^\circ$, $\alpha = 0^\circ$, $\delta = +20^\circ$ or $\alpha = 240^\circ$, $\delta = +70^\circ$ ($\beta > 20^\circ$ N).

The Perseids produced strong activity from an unexpected primary maximum throughout the 1990s, associated with the perihelion passage of their parent comet, 109P/Swift-Tuttle, in 1992. The comet's orbital period is about 130 years. Further enhanced activity ahead of the usual maximum was last seen in 2004. Recent IMO observations (see HMO p. 145) found the timing of the mean or 'traditional' broad maximum varied between $\lambda_\odot \sim 139^\circ\!.8$ to $140^\circ\!.3$, equivalent to 2013 August 12, 13^h15^m to August 13, 01^h45^m UT. No additional peaks are anticipated this year, but this does not guarantee what **will** occur!



The Moon is a waxing crescent approaching first quarter on August 14 for the maximum, so will set early enough to create no problems for mid-northern observers. Sites at such latitudes are more favourable for Perseid observing, as from here, the shower's radiant can be usefully observed from 22^h–23^h local time onwards, gaining altitude throughout the night. The near-nodal part of the 'traditional' maximum interval would be best-viewed from extreme eastern Europe eastwards across much of Asia, assuming it happens as expected. All forms of observing can be carried out on the shower, though unfortunately, it cannot be usefully observed from most of the southern hemisphere.

Aurigids (AUR)

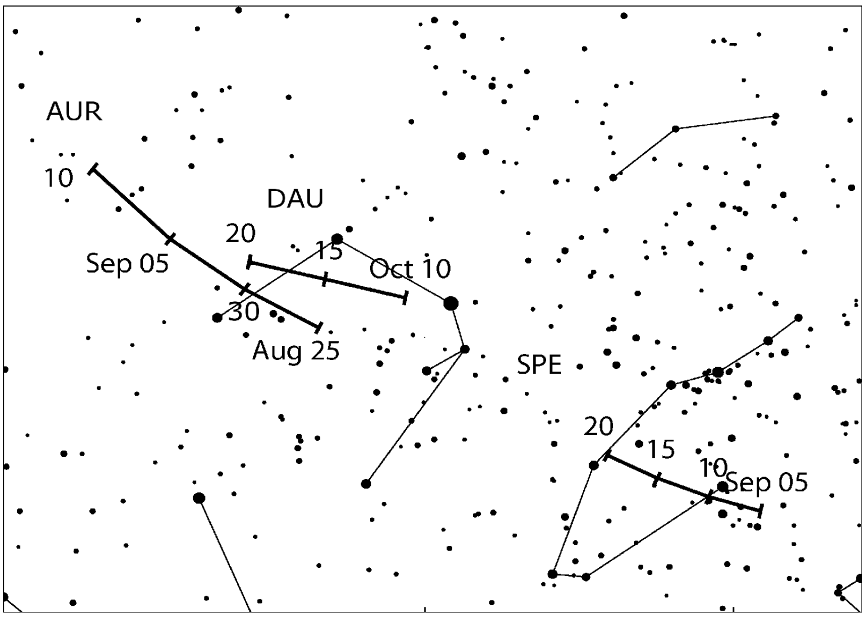
Active: August 28–September 5; Maximum: September 1, 02^h UT ($\lambda_\odot = 158^\circ\!.6$); ZHR = 6;
Radiant: $\alpha = 91^\circ$, $\delta = +39^\circ$; Radiant drift: see Table 6;
$V_\infty = 66$ km/s; $r = 2.5$;
TFC: $\alpha = 52^\circ$, $\delta = +60^\circ$; $\alpha = 043^\circ$, $\delta = +39^\circ$ and $\alpha = 23^\circ$, $\delta = +41^\circ$ ($\beta > 10^\circ$ S).

This northern-hemisphere shower, formerly known as the α-Aurigids, has produced short, unexpected, outbursts at times, with EZHRs of $\sim$ 30–40 recorded in 1935, 1986 and 1994, although it has not been monitored regularly until very recently, so other events may have been missed. Only three watchers in total covered the 1986 and 1994 outbursts, for instance! While badly moonlit, the first predicted outburst happened roughly as expected in 2007, producing short-lived EZHRs of ~ 130 for western North America, with many bright meteors. Radio data suggested there was a 'tail' to that event where more faint meteors continued for maybe an hour after the strongest peak, but visual observers could not confirm this, probably due to the moonlit sky. The Aurigid radiant reaches a useful elevation only after $\sim 01^{\mathrm{h}}$ local time, and although no predictions for unusual activity have been made for 2013, the nearly-new Moon provides ideal skies for whatever may happen. With the SPE and the DAU, the Aurigids are suspected of being (perhaps simply the more active) part of a series of poorly-observed sources with radiants around Aries, Perseus, Cassiopeia and Auriga during the northern early autumn. The telescopic shower of the β-Cassiopeids is suspected of being active too during September, for example, and there may be others awaiting discovery or confirmation.

September ε-Perseids (SPE)

Active: September 5–21; Maximum: September 9, 10^{h} UT ($\lambda_{\odot} = 166\overset{\circ}{.}7$), but see text;
ZHR = 5;
Radiant: $\alpha = 48°$, $\delta = +40°$; Radiant drift: see Table 6;
$V_{\infty} = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 30°$, $\delta = +55°$; $\alpha = 28°$, $\delta = +35°$ and $\alpha = 25°$, $\delta = +40°$ ($\beta > 10°$ S).

September's waxing crescent Moon provides perfect observing circumstances for this primarily northern-hemisphere shower's maximum too. The radiant area is well on-view all night from about 22^{h}–23^{h} local time for mid-northern locations. Though previously little-known, this radiant was apparently that responsible for producing an unexpected outburst of swift, bright meteors on 2008 September 9, between roughly $\lambda_{\odot} = 166\overset{\circ}{.}894$–$166\overset{\circ}{.}921$. The repeat time for that outburst interval converted to 2013 would be September 9, between $14^{\mathrm{h}}50^{\mathrm{m}}$–$15^{\mathrm{h}}30^{\mathrm{m}}$ UT, but nothing unusual is predicted to occur this time.



6 October to December

A disappointing quarter ends the year, with all the stronger annual showers troubled by bright moonlight for their maxima. However, some of the less-active sources are not so affected, while the strongest of all, the Geminids in December, can produce a pleasing display even when moonlight intervenes.

October 5/6 meteors: Short-lived video outbursts were recorded in 2005 and 2006 by European observers, with activity from a north-circumpolar radiant near the 'tail' of Draco, around $\alpha \sim 165°$, $\delta \sim +78°$, on October 5/6. The meteors showed an atmospheric velocity of $\sim$ 45–50 km/s. The 2005 event (only) was recorded very weakly by radio, but no visual results confirmed either occurrence, and no recurrence was reported in 2007, 2008 or 2011. Weak video rates were claimed detected near the 2009 and 2010 repeat times, but again, no other method confirmed these, and the shower was not found by the full ten-year VID analysis. The active interval suggested by video data lies between $\lambda_\odot \sim 192\overset{\circ}{.}5$–$192\overset{\circ}{.}8$, equivalent to 2013 October 5, 18^h50^m to October 6, 02^h10^m UT, almost coincident with new Moon. If the active interval remains the same, it should be best-observed from Europe eastwards across Asia. Given the heavy concentration of visual and video observers in Europe and Japan from this region, this should provide our best opportunity to confirm whether the shower can be detected by visual means as well as by video, if skies are clear.

In the second half of October, the full to waning gibbous Moon will spoil three shower maxima, from the minor **ε–Geminids** due on October 18, the major **Orionids** around October 21 (their ZHRs, like those of their twin η-Aquariids should be falling towards their next rates-trough circa 2015, so could be $\sim$ 20 at best this time) and the minor **Leonis Minorids** on October 24. The waning Moon is particularly problematic for these sources as they are all observable only after midnight, just like the Moon.

November's near-full Moon period largely wipes out another three shower maxima, from the minor **Northern Taurids** on or about November 12, the major Leonids on November 17 and the usually-minor **α–Monocerotids** on November 21, around 16^h15^m UT. Two maximum timings have been suggested for the **Leonids** in 2013, one by Mikhail Maslov in *WGN* **35:1** (2007, p. 8) for $\sim 10^h$ UT (ZHR $\sim$ 15–20), the other at the nodal-crossing time close to 16^h UT (ZHR perhaps 15?), both on November 17.

December's long northern winter nights help reduce the shower maximum lunar casualty-count to just two minor sources, the **Comae Berenicids** around December 16 and the **December Leonis Minorids** on December 19. However, many of the remainder are reduced to just a few darker-sky hours after sunset or before dawn for useful observations.

The **ANT** starts the quarter effectively inactive in favour of the Taurids, resuming only around December 10, as the Northern Taurids fade away, from a radiant centre that tracks across southern Gemini during later December, likely producing ZHRs < 2, although some of this apparent inactivity may be due to the strength of the Geminids close-by to the north during part of December, plus the minor Monocerotids a little way to its south simultaneously.

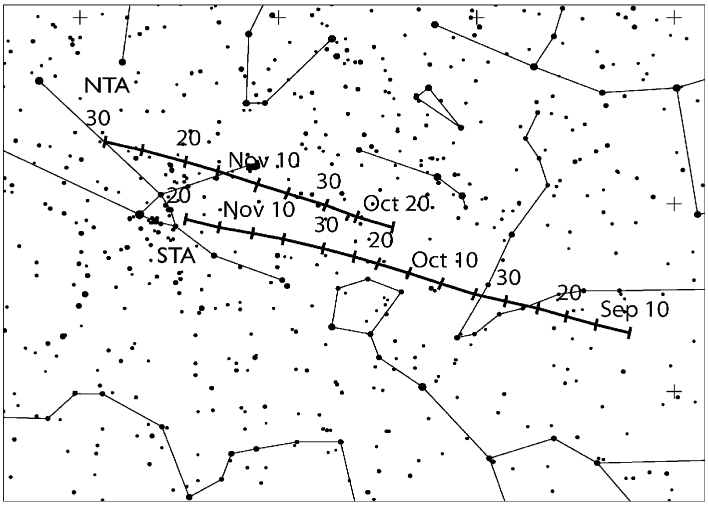
Draconids (DRA)

Active: October 6–10; Maximum: October 8, 17^h30^m UT ($\lambda_\odot = 195\overset{\circ}{.}4$), but see text;
ZHR = periodic, up to storm levels;
Radiant: $\alpha = 262°$, $\delta = +54°$; Radiant drift: negligible;
$V_\infty = 20$ km/s; $r = 2.6$;
TFC: $\alpha = 290°$, $\delta = +65°$ and $\alpha = 288°$, $\delta = +39°$ ($\beta > 30°$ N).

The Draconids are primarily a periodic shower which produced spectacular, brief, meteor storms twice last century, in 1933 and 1946, and lower rates in several other years (ZHRs $\sim$ 20–500+). Most detected showers were in years close to when the stream's parent comet, 21P/Giacobini-Zinner, returned to perihelion, as it did in 2012 February, producing EZHRs of $\sim$ 300 in 2011 October despite bright moonlight then. The comet's orbital period is currently about 6.6 years. Outlying maximum times from the recent past have spanned from $\lambda_\odot = 195\overset{\circ}{.}036$ (in 2011), equivalent to 2013 October 8, 08^h30^m UT, through the nodal passage time above, to the end of a minor outburst in 1999 at $\lambda_\odot 195\overset{\circ}{.}76$ (not a perihelion-return year, but ZHRs reached $\sim$ 10–20), equating to 2013 October 9, 02^h10^m UT. No predictions of unusual activity are in-force this October. However, observers should be alert just in case, especially as October's new Moon makes this a very favourable year. The Draconid radiant is north-circumpolar, at its highest during the first half of the night, and Draconid meteors are exceptionally slow-moving.

Southern Taurids (STA)

Active: September 10–November 20; Maximum: October 10 ($\lambda_\odot = 197°$); ZHR = 5;
Radiant: $\alpha = 32°$, $\delta = +09°$; Radiant drift: see Table 6;
$V_\infty = 27$ km/s; $r = 2.3$;
TFC: Choose fields on the ecliptic and $\sim$ 10° E or W of the radiant ($\beta > 40°$ S).



This stream, with its Northern counterpart, forms part of the complex associated with Comet 2P/Encke. Defining its radiant is best achieved by video, telescopic or careful visual plotting, since it is large and diffuse. For shower association, assume the radiant to be an oval area, $\sim 20° \times 10°$, $\alpha \times \delta$, centred on the radiant position for any given date. The Taurid activity overall dominates the Antihelion Source area's during the northern autumn, so much so that the ANT is considered inactive while either branch of the Taurids is present. The brightness and relative slowness of many Taurid meteors makes them ideal targets for still-imaging, while these factors coupled with low, steady, Taurid rates makes them excellent subjects for newcomers to practice their plotting techniques on. Although long thought to combine with the Northern Taurids to produce an apparently plateau-like maximum in the first decade of November, VID and recent visual plotting work have indicated the Southern branch probably reaches its peak about a month before the Northern one, this year with just a waxing crescent Moon. Its near-ecliptic radiant means all meteoricists can observe the STA, albeit northern hemisphere observers are somewhat better-placed, as here suitable radiant zenith distances persist for much of the night. Even in the southern hemisphere however, 3–5 hours' watching around local midnight is possible with Taurus well above the horizon.

δ-Aurigids (DAU)

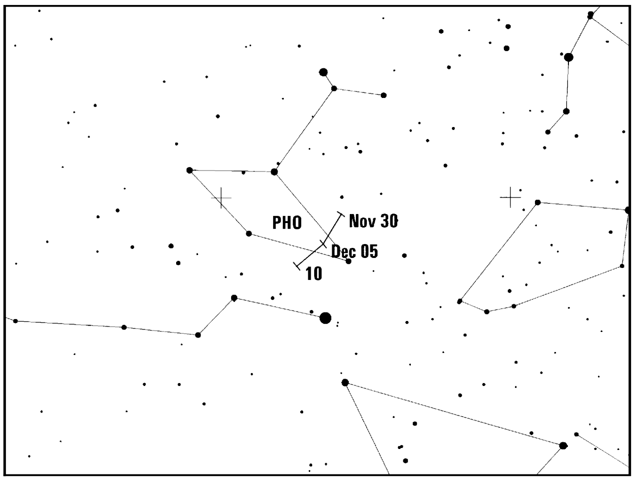
Active: October 10–18; Maximum: October 11 ($\lambda_\odot = 198°$); ZHR = 2;
Radiant: $\alpha = 84°$, $\delta = +44°$; Radiant drift: see Table 6;
$V_\infty = 64$ km/s; $r = 3.0$;
TFC: $\alpha = 80°$, $\delta = +55°$; $\alpha = 80°$, $\delta = +30°$ and $\alpha = 60°$, $\delta = +40°$ ($\beta > 10°$ S).

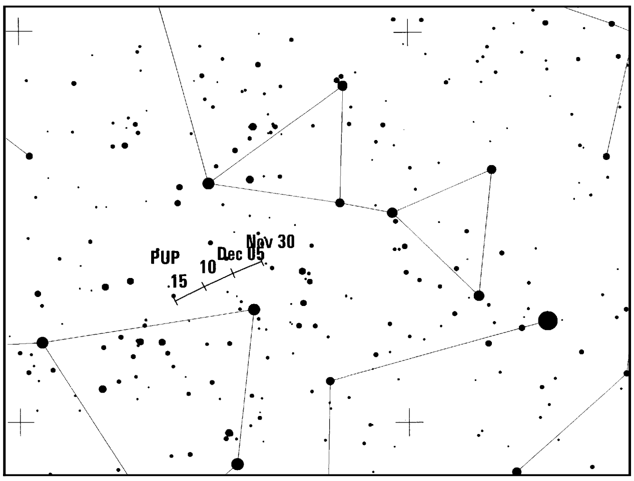
The weakest of the three known near-Auriga-Perseus showers of late August to October, visual observers seem to have struggled to properly identify this minor source previously, and its current parameters are based on a detailed review of IMO video data since the late 1990s. If correct, the peak will have little trouble from the first quarter Moon, which will have set before the radiant area, visible chiefly from the northern hemisphere, can be properly observed after local midnight.

Phoenicids (PHO)

Active: November 28–December 9; Maximum: December 6, 10^h00^m UT ($\lambda_\odot = 254\overset{\circ}{.}25$);
ZHR = variable, usually none, but may reach 100;
Radiant: $\alpha = 18°$, $\delta = -53°$; Radiant drift: see Table 6;
$V_\infty = 18$ km/s; $r = 2.8$;
TFC: $\alpha = 40°$, $\delta = -39°$ and $\alpha = 65°$, $\delta = -62°$ ($\beta < 10°$ N).

Only one impressive Phoenicid return has been reported so far, that of its discovery in 1956, when the EZHR was probably ~ 100, possibly with several peaks spread over a few hours. Three other potential, if uncertain, bursts of lower activity have been claimed. Reliable IMO data has shown recent activity to have been virtually nonexistent, while a predicted possible return in 2011 seemed not to have produced anything unusual. This may be a periodic shower however, and more observations of it are needed by all methods. From the southern hemisphere (only), the Phoenicid radiant culminates at dusk, remaining well on view for most of the night. The waxing crescent Moon presents no difficulties for observers on December 6. Phoenicids are extremely slow meteors.





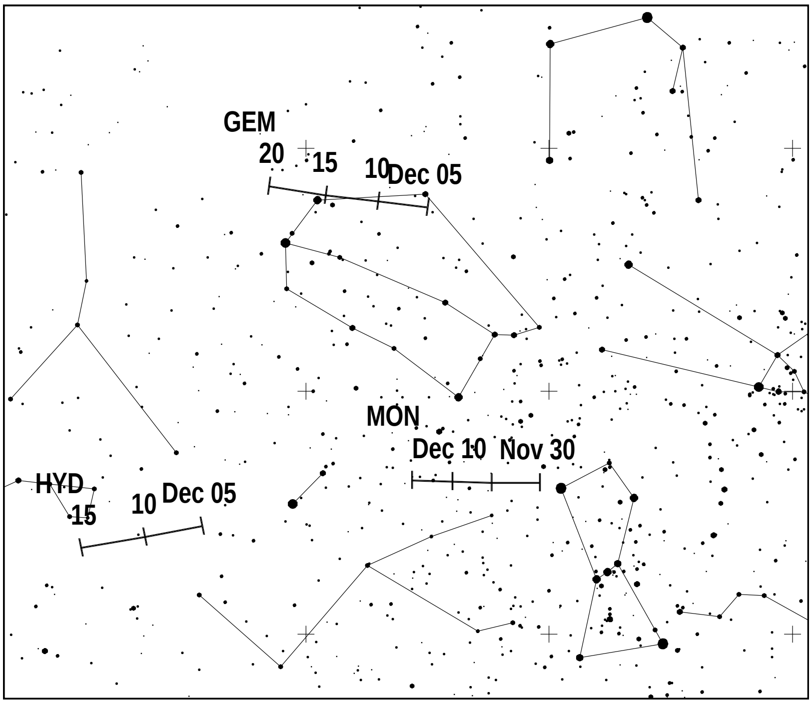
Puppid-Velids (PUP)

Active: December 1–15; Maximum: December ~ 7($\lambda_\odot \sim 255°$); ZHR ~ 10;
Radiant: $\alpha = 123°$, $\delta = -45°$; Radiant drift: see Table 6;
$V_\infty = 40$ km/s; $r = 2.9$;
TFC: $\alpha = 90°$ to $150°$, $\delta = -20°$ to $-60°$; choose pairs of fields separated by about 30° in α, moving eastwards as the shower progresses ($\beta < 10°$ N).

This is a complex system of poorly-studied showers, visible chiefly to those south of the equator. Up to ten sub-streams have been proposed, with radiants so tightly clustered, visual observing cannot readily separate them. Imaging or telescopic work would thus be sensible, or very careful visual plotting. The activity is poorly-established, though the higher rates seem to occur in early to mid December, with a waxing crescent to gibbous Moon this year. Some PUP activity may be visible from late October to late January, however. Most PUP meteors are quite faint, but occasional bright fireballs, notably around the suggested maximum, have been reported previously. The radiant area is on-view all night, highest towards dawn.

Monocerotids (MON)

Active: November 27–December 17; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 2;
Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6;
$V_\infty = 42$ km/s; $r = 3.0$;
TFC: $\alpha = 088°$, $\delta = +20°$ and $\alpha = 135°$, $\delta = +48°$ ($\beta > 40°$ N);
or $\alpha = 120°$, $\delta = -03°$ and $\alpha = 084°$, $\delta = +10°$ ($\beta < 40°$ N).



This very minor shower's details, including its radiant position, are rather uncertain. Telescopic results have suggested a later maximum, around $\lambda_\odot \sim 264°$ (December 16), from a radiant at $\alpha = 117°$, $\delta = +20°$, for instance. December's waxing moonset leaves some dark-sky observing time for checking on the shower after moonset near December 9 particularly, as the radiant area is available virtually all night for much of the globe, culminating at about 1^h30^m local time.

σ-Hydrids (HYD)

Active: December 3–15; Maximum: December 12($\lambda_\odot = 260°$); ZHR = 3;
Radiant: $\alpha = 127°$, $\delta = +02°$; Radiant drift: see Table 6;
$V_\infty = 58$ km/s; $r = 3.0$;
TFC: $\alpha = 95°$, $\delta = 0°$ and $\alpha = 160°$, $\delta = 0°$ (all sites, after midnight only).

Although first detected in the 1960s by photography, σ-Hydrids are typically swift and faint, and rates are generally close to the visual-detection threshold. The radiant rises in the late evening hours, to be best viewed after local midnight from either hemisphere. This is a moderate year for them, with waxing gibbous moonset leaving a short observing window before dawn on December 12. Recent IMO visual data (HMO p. 170) have indicated the maximum might happen nearer $\lambda_\odot \sim 262°$ (December 14), while VID implied a peak closer to $\lambda_\odot \sim 254°$ (December 6), and that HYD activity might persist till December 24.

Geminids (GEM)

Active: December 4–17; Maximum: December 14, $05^{\rm h}45^{\rm m}$ UT ($\lambda_\odot = 262.^\circ 2$); ZHR = 120;
Radiant: $\alpha = 112^\circ$, $\delta = +33^\circ$; Radiant drift: see Table 6;
$V_\infty = 35$ km/s; $r = 2.6$;
TFC: $\alpha = 087^\circ$, $\delta = +20^\circ$ and $\alpha = 135^\circ$, $\delta = +49^\circ$ before $23^{\rm h}$ local time,
$\alpha = 87^\circ$, $\delta = +20^\circ$ and $\alpha = 129^\circ$, $\delta = +20^\circ$ after $23^{\rm h}$ local time ($\beta > 40^\circ$ N);
$\alpha = 120^\circ$, $\delta = -3^\circ$ and $\alpha = 84^\circ$, $\delta = +10^\circ$ ($\beta < 40^\circ$ N).
IFC: $\alpha = 150^\circ$, $\delta = +20^\circ$ and $\alpha = 60^\circ$, $\delta = +40^\circ$ ($\beta > 20^\circ$ N);
$\alpha = 135^\circ$, $\delta = -5^\circ$ and $\alpha = 80^\circ$, $\delta = 0^\circ$ ($\beta < 20^\circ$ N).

One of the finest, and probably the most reliable, of the major annual showers presently observable. Well north of the equator, the radiant rises about sunset, reaching a usable elevation from the local evening hours onwards. In the southern hemisphere, the radiant appears only around local midnight or so. It culminates near $02^{\rm h}$. Even from more southerly sites, this is a splendid stream of often bright, medium-speed meteors, a rewarding event for all observers, whatever method they employ. The peak has shown slight signs of variability in its rates and timing in recent years, with the more reliably-reported maxima during the past two decades (HMO, p. 171) all having occurred within $\lambda_\odot = 261.^\circ 5$ to $262.^\circ 4$, 2013 December 13, $13^{\rm h}$ to December 14, $10^{\rm h}$ UT. Near-peak rates usually persist for almost a day, so much of the world has the chance to enjoy something of the Geminids' best. Some mass-sorting within the stream means fainter telescopic meteors should be most abundant almost a day ahead of the visual maximum, with telescopic results indicating such meteors radiate from an elongated region, perhaps with three sub-centres. Further results on this topic would be useful. The shower's peak this year has a waxing gibbous Moon to contend with, and while casual sky-watchers should still be able to see enough of the brighter Geminids to entertain them in the moonlight, dedicated meteor observers must make the best of the brief dark-sky spell between moonset and dawn on the maximum night.

Ursids (URS)

Active: December 17–26; Maximum: December 22, $14^{\rm h}$ UT ($\lambda_\odot = 270.^\circ 7$);
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217^\circ$, $\delta = +76^\circ$; Radiant drift: see Table 6;
$V_\infty = 33$ km/s; $r = 3.0$;
TFC: $\alpha = 348^\circ$, $\delta = +75^\circ$ and $\alpha = 131^\circ$, $\delta = +66^\circ$ ($\beta > 40^\circ$ N);
$\alpha = 63^\circ$, $\delta = +84^\circ$ and $\alpha = 156^\circ$, $\delta = +64^\circ$ ($\beta 30^\circ$ to 40° N).

A very poorly-observed northern hemisphere shower, but one which has produced at least two major outbursts in the past 70 years, in 1945 and 1986. Several lesser rate enhancements have been reported as well, most recently from 2006–2008 inclusive which were probably influenced by the relative proximity of the shower's parent comet, 8P/Tuttle, at perihelion in January 2008. Other events could have been easily missed. No predictions for unusual activity are in-force for 2013. The Ursid radiant is circumpolar from most northern sites (thus fails to rise for most southern ones), though it culminates after daybreak, and is highest in the sky later in the night. The waning gibbous Moon for the maximum will rise around $21^{\rm h}30^{\rm m}$ from mid northern sites, so this return is favourable for full coverage only during the evening hours.

7 Radiant sizes and meteor plotting for visual observers

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 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°

Note that this radiant diameter criterion applies to all shower radiants *except* those of the Southern and Northern Taurids, and the Antihelion Source, all of which have notably larger radiant areas. The optimum $\alpha \times \delta$ size to be assumed for each radiant of the two Taurid showers is instead $20° \times 10°$, while that for the Antihelion Source is still larger, at $30° \times 15°$.

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 geocentric velocities (V_∞). All velocities are in °/s.

$h \backslash D$	$V_\infty = 25$ km/s					$V_\infty = 40$ km/s					$V_\infty = 60$ km/ s				
	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°	10°	20°	40°	60°	90°
10°	0.4	0.9	1.6	2.2	2.5	0.7	1.4	2.6	3.5	4.0	0.9	1.8	3.7	4.6	5.3
20°	0.9	1.7	3.2	4.3	4.9	1.4	2.7	5.0	6.8	7.9	1.8	3.5	6.7	9.0	10
40°	1.6	3.2	5.9	8.0	9.3	2.6	5.0	9.5	13	15	3.7	6.7	13	17	20
60°	2.2	4.3	8.0	11	13	3.5	6.8	13	17	20	4.6	9.0	17	23	26
90°	2.5	4.9	9.3	13	14	4.0	7.9	15	20	23	5.3	10	20	26	30

8 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 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 IFC: Suggested telescopic and still-imaging (including photographic) field centres 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 IFC depends on the observer's location and the elevation of the radiant. Note that the TFCs are also useful centres to use for video camera fields as well.

Table 4. Lunar phases for 2013.

New Moon	First Quarter	Full Moon	Last Quarter
			January 5
January 11	January 18	January 27	February 3
February 10	February 17	February 25	March 04
March 11	March 19	March 27	April 3
April 10	April 18	April 25	May 2
May 10	May 18	May 25	May 31
June 8	June 16	June 23	June 30
July 8	July 16	July 22	July 29
August 6	August 14	August 21	August 28
September 5	September 12	September 19	September 27
October 5	October 11	October 18	October 26
November 3	November 10	November 17	November 25
December 3	December 9	December 17	December 25

Table 5. Working List of Visual Meteor Showers. Details in this Table were correct according to the best information available in May 2012, with maximum dates accurate only for 2013. Except for the Antihelion Source, all other showers are listed in order of their maximum solar longitude. An asterisk ('*') in the 'Shower' column indicates that source may have additional peak times, as noted in the text above. The parenthesized maximum date for the Puppids-Velids indicates a reference date for the radiant only, not necessarily a true maximum. Some showers have ZHRs that vary from year to year. The most recent reliable figure is given here, except for possibly periodic showers. These are either are noted as 'Var' = variable, where there is considerable uncertainty over the likely maximum rates, or with an asterisk to indicate the value is that suggested from theoretical considerations for the current year. For more information, contact the IMO's Visual Commission.

Shower	Activity	Maximum Date	$\lambda_\odot$	Radiant α	δ	V_∞ km/s	r	ZHR
Antihelion Source (ANT)	Dec 10–Sep 10 –	March–April, late May, late June		see Table 6		30	3.0	4
Quadrantids (QUA)	Dec 28–Jan 12	Jan 03	283°.16	230°	+49°	41	2.1	120
α-Centaurids (ACE)	Jan 28–Feb 21	Feb 08	319°.2	210°	−59°	56	2.0	6
γ-Normids (GNO)	Feb 25–Mar 22	Mar 14	354°	239°	−50°	56	2.4	6
Lyrids (LYR)	Apr 16–Apr 25	Apr 22	32°.32	271°	+34°	49	2.1	18
π-Puppids (PPU)	Apr 15–Apr 28	Apr 23	33°.5	110°	−45°	18	2.0	Var
η-Aquariids (ETA)	Apr 19–May 28	May 06	45°.5	338°	−01°	66	2.4	55*
η-Lyrids (ELY)	May 03–May 14	May 08	48°.0	287°	+44°	43	3.0	3
June Bootids (JBO)	Jun 22–Jul 02	Jun 27	95°.7	224°	+48°	18	2.2	Var
Piscis Austrinids (PAU)	Jul 15–Aug 10	Jul 28	125°	341°	−30°	35	3.2	5
South. δ-Aquariids (SDA)	Jul 12–Aug 23	Jul 30	127°	340°	−16°	41	3.2	16
α-Capricornids (CAP)	Jul 03–Aug 15	Jul 30	127°	307°	−10°	23	2.5	5
Perseids (PER)	Jul 17–Aug 24	Aug 12	140°.0	48°	+58°	59	2.2	100
κ-Cygnids (KCG)	Aug 03–Aug 25	Aug 17	145°	286°	+59°	25	3.0	3
Aurigids (AUR)	Aug 28–Sep 05	Sep 01	158°.6	91°	+39°	66	2.5	6
Sept. ε-Perseids (SPE)	Sep 05–Sep 21	Sep 09	166°.7	48°	+40°	64	3.0	5
Draconids (DRA)	Oct 06–Oct 10	Oct 08	195°.4	262°	+54°	20	2.6	Var
Southern Taurids (STA)*	Sep 10–Nov 20	Oct 10	197°	32°	+09°	27	2.3	5
δ-Aurigids (DAU)	Oct 10–Oct 18	Oct 11	198°	84°	+44°	64	3.0	2
ε-Geminids (EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	3
Orionids (ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.5	20*
Leonis Minorids (LMI)	Oct 19–Oct 27	Oct 24	211°	162°	+37°	62	3.0	2
Northern Taurids (NTA)*	Oct 20–Dec 10	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (LEO)*	Nov 06–Nov 30	Nov 17	235°.27	152°	+22°	71	2.5	15*
α-Monocerotids (AMO)	Nov 15–Nov 25	Nov 21	239°.32	117°	+01°	65	2.4	Var
Phoenicids (PHO)	Nov 28–Dec 09	Dec 06	254°.25	18°	−53°	18	2.8	Var
Puppid/Velids (PUP)	Dec 01–Dec 15	(Dec 07)	(255°)	123°	−45°	40	2.9	10
Monocerotids (MON)	Nov 27–Dec 17	Dec 09	257°	100°	+08°	42	3.0	2
σ-Hydrids (HYD)	Dec 03–Dec 15	Dec 12	260°	127°	+02°	58	3.0	3
Geminids (GEM)	Dec 04–Dec 17	Dec 14	262°.2	112°	+33°	35	2.6	120
Comae Berenicids (COM)	Dec 12–Dec 23	Dec 16	264°	175°	+18°	65	3.0	3
Dec. Leonis Minorids (DLM)	Dec 05–Feb 04	Dec 19	268°	161°	+30°	64	3.0	5
Ursids (URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	3.0	10

Table 6 (next page). Radiant positions during the year in α and δ.

Date	ANT		QUA		DLM									
Jan 0	112°	+21°	228°	+50°	172°	+25°								
Jan 5	117°	+20°	231°	+49°	176°	+23°								
Jan 10	122°	+19°	234°	+48°	180°	+21°								
Jan 15	127°	+17°			185°	+19°								
Jan 20	132°	+16°			189°	+17°								
Jan 25	138°	+15°			193°	+15°	**ACE**							
Jan 30	143°	+13°			198°	+12°	200°	−57°						
Feb 5	149°	+11°			203°	+10°	208°	−59°						
Feb 10	154°	+9°					214°	−60°						
Feb 15	159°	+7°					220°	−62°						
Feb 20	164°	+5°	**GNO**				225°	−63°						
Feb 28	172°	+2°	225°	-51°										
Mar 5	177°	0°	230°	-50°										
Mar 10	182°	−2°	235°	-50°										
Mar 15	187°	−4°	240°	-50°										
Mar 20	192°	−6°	245°	-49°										
Mar 25	197°	−7°												
Mar 30	202°	−9°												
Apr 5	208°	−11°												
Apr 10	213°	−13°	**LYR**		**PPU**									
Apr 15	218°	−15°	263°	+34°	106°	−44°	**ETA**							
Apr 20	222°	−16°	269°	+34°	109°	−45°	323°	−7°						
Apr 25	227°	−18°	274°	+34°	111°	−45°	328°	−5°						
Apr 30	232°	−19°					332°	−3°	**ELY**					
May 05	237°	−20°					337°	−1°	283°	+44°				
May 10	242°	−21°					341°	+1°	288°	+44°				
May 15	247°	−22°					345°	+3°	293°	+45°				
May 20	252°	−22°					349°	+5°						
May 25	256°	−23°					353°	+7°						
May 30	262°	−23°												
Jun 5	267°	−23°												
Jun 10	272°	−23°												
Jun 15	276°	−23°												
Jun 20	281°	−23°	**JBO**											
Jun 25	286°	−22°	223°	+48°										
Jun 30	291°	−21°	225°	+47°	**CAP**									
Jul 5	296°	−20°			285°	−16°	**SDA**							
Jul 10	300°	−19°	**PER**		289°	−15°	325°	−19°	**PAU**					
Jul 15	305°	−18°	6°	+50°	294°	−14°	329°	−19°	330°	−34				
Jul 20	310°	−17°	11°	+52°	299°	−12°	333°	−18°	334°	−33				
Jul 25	315°	−15°	22°	+53°	303°	−11°	337°	−17°	338°	−31				
Jul 30	319°	−14°	29°	+54°	307°	−10°	340°	−16°	343°	−29	**KCG**			
Aug 5	325°	−12°	37°	+56°	313°	−8°	345°	−14°	348°	−27	283°	+58°		
Aug 10	330°	−10°	45°	+57°	318°	−6°	349°	−13°	352°	−26	284°	+58°		
Aug 15	335°	−8°	51°	+58°			352°	−12°			285°	+59°		
Aug 20	340°	−7°	57°	+58°	**AUR**		356°	−11°			286°	+59°		
Aug 25	344°	−5°	63°	+58°	85°	+40°					288°	+60°		
Aug 30	349°	−3°			90°	+39°	**SPE**				289°	+60°		
Sep 5	355°	−1°	**STA**		96°	+39°	43°	+40°						
Sep 10	0°	+1°	12°	+3°	102°	+39°	48°	+40°						
Sep 15			15°	+4°			53°	+40°						
Sep 20			18°	+5°			59°	+41°						
Sep 25			21°	+6°										
Sep 30			25°	+7°			**ORI**							
Oct 5			28°	+8°			85°	+14°	**DAU**				**DRA**	
Oct 10	**EGE**		32°	+9°			88°	+15°	82°	+45°			262°	+54°
Oct 15	99°	+27°	36°	+11°	**NTA**		91°	+15°	87°	+43°	**LMI**			
Oct 20	104°	+27°	40°	+12°	38°	+18°	94°	+16°	92°	+41°	158°	+39°		
Oct 25	109°	+27°	43°	+13°	43°	+19°	98°	+16°			163°	+37°		
Oct 30			47°	+14°	47°	+20°	101°	+16°			168°	+35°		
Nov 5			52°	+15°	52°	+21°	105°	+17°	**LEO**					
Nov 10			56°	+15°	56°	+22°			147°	+24°			**AMO**	
Nov 15			60°	+16°	61°	+23°			150°	+23°			112°	+2°
Nov 20			64°	+16°	65°	+24°			153°	+21°			116°	+1°
Nov 25					70°	+24°	**PHO**		156°	+20°	**PUP**		120°	0°
Nov 30	**ANT**		**GEM**		74°	+24°	14°	−52°	159°	+19°	120°	−45°	91°	+8°
Dec 5	85°	+23°	103°	+33°	149°	+37°	18°	−53°	122°	+3°	122°	−45°	96°	+8°
Dec 10	90°	+23°	108°	+33°	153°	+35°	22°	−53°	126°	+2°	125°	−45°	100°	+8°
Dec 15	96°	+23°	113°	+33°	157°	+33°	174°	+19°	130°	+1°	128°	−45°	104°	+8°
Dec 20	101°	+23°	118°	+32°	161°	+31°	177°	+18°	**HYD**		217°	+76°	**MON**	
Dec 25	106°	+22°	**QUA**		166°	+28°	180°	+16°			217°	+74°		
Dec 30	111°	+21°	226°	+50°	170°	+26°	**COM**				**URS**			
					DLM									

Table 7. Working List of Daytime Radio Meteor Streams. An asterisk (‘*’) in the ‘Max date’ column indicates that source may have additional peak times, as noted in the text above. 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. An asterisk in the ‘Rate’ column shows the suggested rate may not recur in all years.

Shower	Activity	Max Date	$\lambda_\odot$ 2000	Radiant α	Radiant δ	Best observed 50° N	Best observed 35° S	Rate
Cap/Sagittariids	Jan 13–Feb 04	Feb 01*	312°5	299°	−15°	11^h–14^h	09^h–14^h	Medium*
χ-Capricornids	Jan 29–Feb 28	Feb 13*	324°7	315°	−24°	10^h–13^h	08^h–15^h	Low*
Piscids (Apr)	Apr 08–Apr 29	Apr 20	30°3	7°	+07°	07^h–14^h	08^h–13^h	Low
δ-Piscids	Apr 24–Apr 24	Apr 24	34°2	11°	+12°	07^h–14^h	08^h–13^h	Low
ε-Arietids	Apr 24–May 27	May 09	48°7	44°	+21°	08^h–15^h	10^h–14^h	Low
Arietids (May)	May 04–Jun 06	May 16	55°5	37°	+18°	08^h–15^h	09^h–13^h	Low
o-Cetids	May 05–Jun 02	May 20	59°3	28°	−04°	07^h–13^h	07^h–13^h	Medium*
Arietids	May 22–Jul 02	Jun 07*	76°7	44°	+24°	06^h–14^h	08^h–12^h	High
ζ-Perseids	May 20–Jul 05	Jun 09*	78°6	62°	+23°	07^h–15^h	09^h–13^h	High
β-Taurids	Jun 05–Jul 17	Jun 28	96°7	86°	+19°	08^h–15^h	09^h–13^h	Medium
γ-Leonids	Aug 14–Sep 12	Aug 25	152°2	155°	+20°	08^h–16^h	10^h–14^h	Low*
Sextantids	Sep 09–Oct 09	Sep 27*	184°3	152°	00°	06^h–12^h	06^h–13^h	Medium*

9 Useful addresses

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

Fireball Data Center (FIDAC): André Knöfel, Am Observatorium 2, D-15848 Lindenberg, Germany; e-mail: aknoefel@minorplanets.de

Photographic Commission: Vacant. Questions can be sent to e-mail: photo@imo.net

Radio Commission: Jean-Louis Rault, Société Astronomique de France, 16 Rue de la Valleé, 91360 Epinay sur Orge, France; e-mail: f6agr@orange.fr

Telescopic Commission: Malcolm Currie, 25 Collett Way, Grove, Wantage, Oxfordshire, OX12 0NT, UK; e-mail: mjc@star.rl.ac.uk

Video Commission Sirko Molau, Abenstalstraße 13b, D-84072 Seysdorf, Germany; e-mail: sirko@molau.de

Visual Commission: Rainer Arlt, Bahnstraße 11, D-14974 Ludwigsfelde, Germany; e-mail: rarlt@aip.de

or visit the IMO's Homepage on the World-Wide-Web at: http://www.imo.net

For further details on **IMO membership**, please write to: Robert Lunsford, IMO Secretary-General, 1828 Cobblecreek Street, Chula Vista, CA 91913-3917, USA; lunro.imo.usa@cox.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!