International Meteor Organization

2024 Meteor Shower Calendar

edited by Jürgen Rendtel [1]

1 Introduction

This is the thirty-fourth edition of the International Meteor Organization (IMO) Meteor Shower Calendar. Its main goal is to draw the attention of observers to both regularly returning meteor showers and to events which may be possible according to model calculations. The publication date in the middle of the preceding year was chosen to have the information spread early enough for inclusion into other compilations.

Observers may find additional peaks and/or enhanced rates but also the observational evidence of no rate or density enhancement at predicted moments. Rate and timing data may help to improve our knowledge about meteoroid streams. We hope the Calendar continues to be a useful tool to plan your meteor observing activities.

Video meteor camera networks are collecting data throughout the year. Nevertheless, visual observations comprise an important data sample for many showers, and the well established analysing procedures allow us to derive reliable flux density data. Because visual observers are more affected by moonlit skies than video cameras, we consider the moonlight circumstances when describing the visibility of meteor showers. For the three strongest annual shower peaks in 2024 we find the Quadrantid peak coinciding with the Last Quarter, the Perseid peak near the First Quarter and the Geminid maximum just before Full Moon. In 2024 we find only the maximum periods of the η-Aquariids, the Aurigids and the September ε-Perseids undisturbed. The conditions for the maxima of other well-known showers are less favourable: April Lyrids (about two days before Full Moon), Southern δ-Aquariids (shortly after the Last Quarter), October Draconids (First Quarter) and the Orionids and Leonids roughly two–three days after Full Moon. The Ursid maximum suffers from a waning Moon.

The heart of the Calendar is the Working List of Visual Meteor Showers (Table 5, page 26) which is continuously updated so that it is the single most accurate listing available anywhere today for visual meteor observing. Nevertheless, it is a **Working** List which is subject to further modifications, based on the best data we had at the time the Calendar was written. Observers should always check for later changes noted in the IMO's journal *WGN* or on the IMO website. Vice versa, we are always interested to receive information whenever you find any anomalies!

[1] Based on information in the *Meteor Observers Workbook 2014*, edited by Jürgen Rendtel (referred to as 'WB' 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 (referred to as 'VID' in the Calendar), as amended by subsequent discussions and additional material extracted from data analyses produced since. I particularly thank Mikhail Maslov, Mikiya Sato and Jérémie Vaubaillon for new information and comments in respect of events in 2024 (see also the *References* in section 8). Masahiro Koseki added important data about several showers which led to necessary updates. Hiroshi Ogawa provided useful information concerning daytime showers detectable by radio forward scatter observations. Koen Miskotte provided information of the SDA and CAP activity in late July. Last but not least thanks to Tim Cooper, Robert Lunsford, Mikhail Maslov, Alastair McBeath, Chris Steyaert and Cis Verbeeck for carefully checking the contents.

In the Calendar we refer to the shower designation as listed by the IAU's Meteor Data Center, which has 122 "established showers" (2023 May 11).

Interesting encounters are listed in Table 6a (page 28). Since there is always a possibility of completely unexpected events, ideally meteor observing should be performed throughout the year. This way we can improve the data for established meteoroid streams covering their entire activity periods. Combining data obtained with different techniques improve the reliability of derived quantities and is helpful for calibrating purposes.

Video meteor observations allow us to detect weak sources. An increasing number of confirmed radiants provides us with more possibilities to establish relations between meteoroid streams and their parent objects. Some of the sources may produce only single events but no annual recurring showers, such as, for example, the June Boötids or the τ-Herculids.

Observing techniques which allow the collection of useful shower data include visual, video and still-imaging along with radar and radio forward scatter methods. Visual and video data allow rate and flux density calculations as well as determination of the particle size distribution in terms of the population index r or the mass index s. Multi-station camera setups provide us with orbital data, essential for meteoroid-stream investigations. Showers with radiants too near the Sun for observing by the various optical methods can be detected by forward-scatter radio or back-scatter radar observations. The list of daytime showers (Table 7) has been updated referring to IAU-established showers including comments on their detectability provided by Hiroshi Ogawa.

The IMO's aims are to encourage, collect, analyze, and publish combined meteor data obtained from sites all over the globe, to improve our understanding of the meteor activity detectable from the Earth's surface. For best effects, it is recommended that all observers should follow the standard IMO observing guidelines when compiling information, and submit those data promptly to the appropriate Commission for analysis (contact details are at the end of the Calendar). Many analyses try to combine data obtained by more than one method, extending the ranges and coverage but also to calibrate results from different techniques. 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.

Timing predictions are included below on all the more active night-time and daytime shower maxima as reliably as possible. However, it is essential to understand that in many cases, such maxima are not known more precisely than to the nearest degree of solar longitude. 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, 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.

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, whose input is possible via the online form on the IMO's website `www.imo.net`. Clear skies!

2 Antihelion Source

The Antihelion Source (ANT) is a large, roughly oval area of about 30° in right ascension and 15° in declination, centred about 12° east of the solar opposition point on the ecliptic, hence its name. It is not a true shower at all (hence it has no IAU shower number), 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 have shown that even instrumentally, it was impossible to define distinct and constantly observable radiants for many of the showers here! Thus we recommend observers simply to identify meteors from these showers as coming from the ANT alone. Apart from this, we have been able to retain the α-Capricornids and particularly the Southern δ-Aquariids in July to August as apparently distinguishable showers separate from the ANT. Later in the year, the Taurid showers dominate the activity from the Antihelion region meaning the ANT should be considered inactive while the Taurids are underway, from late September into 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

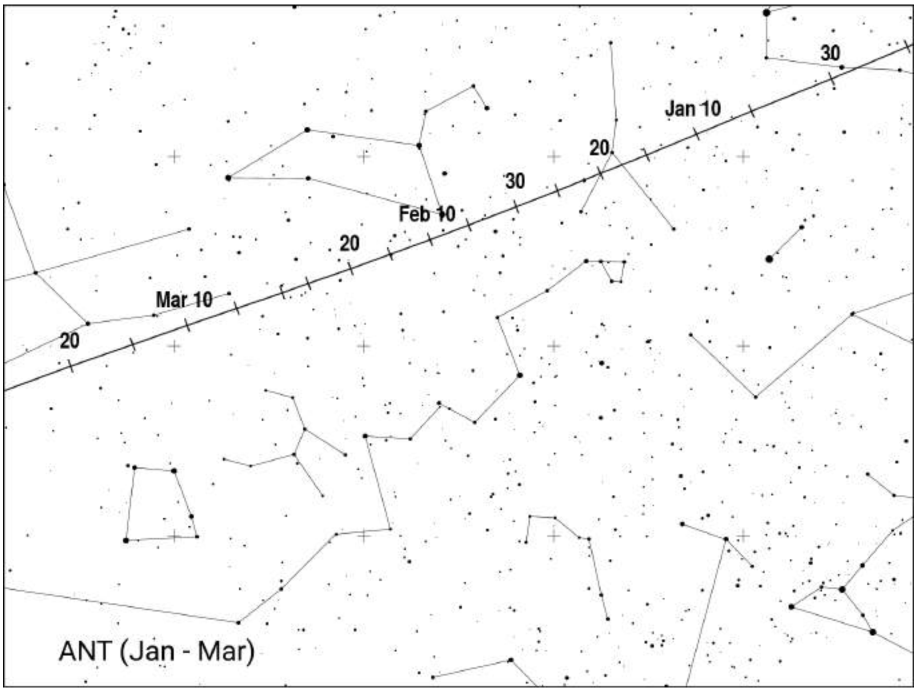
The year starts with the **Quadrantid (010 QUA)** peak for the northern hemisphere observers on January 4 close to 09^h UT – when the favourable post-midnight period is illuminated by the last quarter Moon.

There are a few sources with radiants close to the Sun so that optical observations are not possible; activity can be detected by radio/radar methods only. The 1834 trail of **comet 72P/Denning-Fujikawa** is expected to come close to the Earth on 2024 January 7, at 20:38 UT (calculations of Mikhail Maslov). The radiant ($\alpha = 292°$, $\delta = -21.°4$; about 8° south of β Cap) is very close to the Sun's position. The trail is quite rarified and the activity may be low to moderate, but worth checking.

On 2015 January 10 at 02^h50^m UT, radar and video data showed an outburst of the **κ-Cancrids (793 KCA**; radiant at $\alpha = 138°$, $\delta = +9°$) at $\lambda_\odot = 289.°315$. Activity from this source was also found in the 2016 video data (Molau et al., 2016a) and data of the SonotaCo network find the shower annually over the past decade around January 10. There are also hints that the KCA event of 2015 may have been an enhancement of the o-Leonids (515 OLE). Both are in the working list of the IAU MDC and require more data. The outburst position of 2015 is reached on 2024 January 10 near 10^h UT. The radiant of the Antihelion source centre is located at $\alpha = 122°$, $\delta = +19°$, which is roughly 20° northeast of the KCA radiant; KCA meteors ($V_\infty = 47$ km/s) are faster than those from the ANT ($V_\infty = 30$ km/s).

The **Comae Berenicids (020 COM)** can be traced until early February. Around January 19 we find weak activity of the **γ-Ursae Minorids (404 GUM)**. The **α-Centaurids (102 ACE)** reach their maximum around February 9 and perhaps later – see the ACE description below.

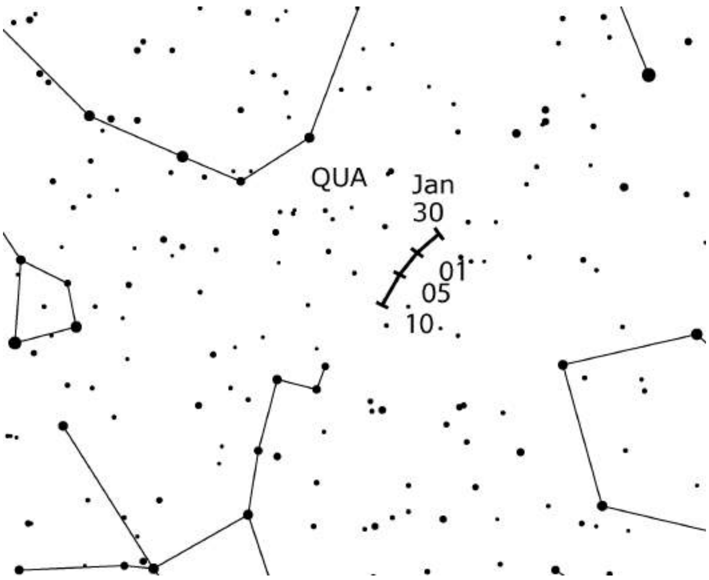
The **ANT's** radiant centre is in south-east Gemini in early January, and crosses Cancer during much of the month, before passing into southern Leo for most of February. It then shifts through southern Virgo during March – see the chart shown here.



Probable ZHRs will be of the order of 2 to 3 during most of the time. Video meteor flux density data indicate a slight increase in March around $\lambda_\odot \approx 355°$ (corresponding to 2024 March 15).

Quadrantids (010 QUA)

Active: December 28–January 12; Maximum: January 4, 09^h00^m UT ($\lambda_\odot = 283\overset{\circ}{.}15$),
ZHR = 80 (can vary $\approx 60 - 200$);
Radiant: $\alpha = 230°$, $\delta = +49°$; Radiant drift: see Table 6;
$V_\infty = 41$ km/s; $r = 2.1$ at maximum, 2.5 elsewhere.



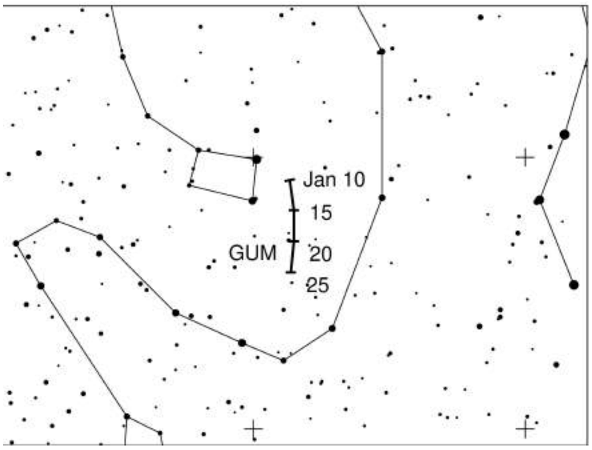
In 2022 and 2023, the highest visual QUA rates were in the lower range of the values given above at the same position as usual. Video meteor data of 2020–2022 indicated a peak time a few hours ahead of the reference time (2023 peak at $283\overset{\circ}{.}15$ again). In the same years, the radio forward scatter data show a maximum which is wider than the usually quoted 4 hours. Modelling the stream is difficult – the more regular QUA peak ZHR and timing are helpful to check the current model parameters. Therefore, all activity data are welcome despite the last quarter Moon in Virgo at the time of the maximum in 2024. Shielding the direct view to the Moon is essential.

It is well known that the activity extends until about January 12 and even a few days after the actual peak, bright fireballs have been observed. The late part of the activity can be followed without moonlight interference.

γ-Ursae Minorids (404 GUM)

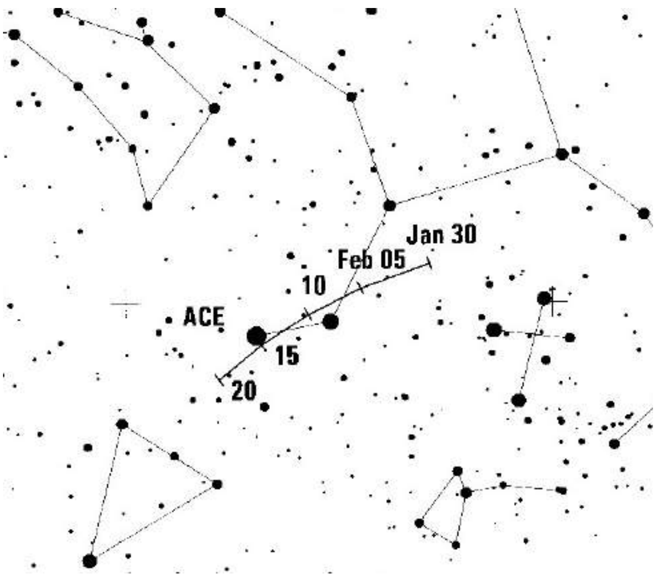
Active: January 10–22; Maximum: around January 19 ($\lambda_\odot = 298°$); ZHR ≈ 3;
Radiant: $\alpha = 228°$, $\delta = 67°$; Radiant drift: see Table 6; $V_\infty = 31$ km/s; $r = 3.0$.

Little is yet known about this minor shower which is found in both video and visual data. It was included in our working list from 2017 onwards and has been observed annually. Considering the velocity, meteors from this far northern radiant should be similar to the Ursids in their appearance. All data about the activity period and shower parameters should be treated as tentative and require further confirmation. The first quarter Moon on January 18 allows observations of the early activity and around the given maximum.



α-Centaurids (102 ACE)

Active: January 31–February 20; Maximum: February 9($\lambda_\odot = 319.°4$);
ZHR = variable, usually ≈ 6;
Radiant: $\alpha = 211°$, $\delta = -58°$; Radiant drift: see Table 6; $V_\infty = 58$ km/s; $r = 2.0$.



The α-Centaurids are mainly known from their appearances in 1974 and 1980 when bursts of only a few hours' duration apparently yielded ZHRs close to 20–30. The average peak ZHR between 1988–2007 was merely 6 though (WB, p. 18), albeit coverage has frequently been extremely patchy. Significant activity was reported on 2015 February 14 (airborne observation) although there was no confirmation of an outburst predicted for 2015 February 8. An outburst during 2021 February 13–15 associated with the γ-Crucids (1047 GCR) might have been a return of the ACE; therefore observers should continue checking for ACE activity at least until February 15 also in 2024.

Further data is needed to obtain information about the stream which is not clearly detectable recently by visual and video observations. The shower's radiant is nearly circumpolar for much of the sub-equatorial inhabited Earth, and is at a useful elevation from late evening onwards. This year the maximum period falls close to new Moon.

4 April to June

In this period the visually accessible meteor rates increase significantly, although much of the total meteor activity in late April into May remains unobservable for optical methods as it is caused by daytime showers with their radiants located less than about 30° distant from the Sun.

The **Lyrids (006 LYR**, also called April-Lyrids) reach their maximum – expected on April 22, 07^{h}UT – only three days before Full Moon. Strong moonlight interference hampers also the **π-Puppid (137 PPU)** maximum on April 23. For both shower returns there are no specific predictions available.

Observations of the maximum of the strong **η-Aquariids (031 ETA)** can be observed essentially under moon-free conditions. This also holds for the minor **η-Lyrids (145 ELY)** with activity around May 10. The **June Boötids (170 JBO)** reach their maximum between June 23 and 28 – this time near Full Moon, and with no peculiarities to be expected.

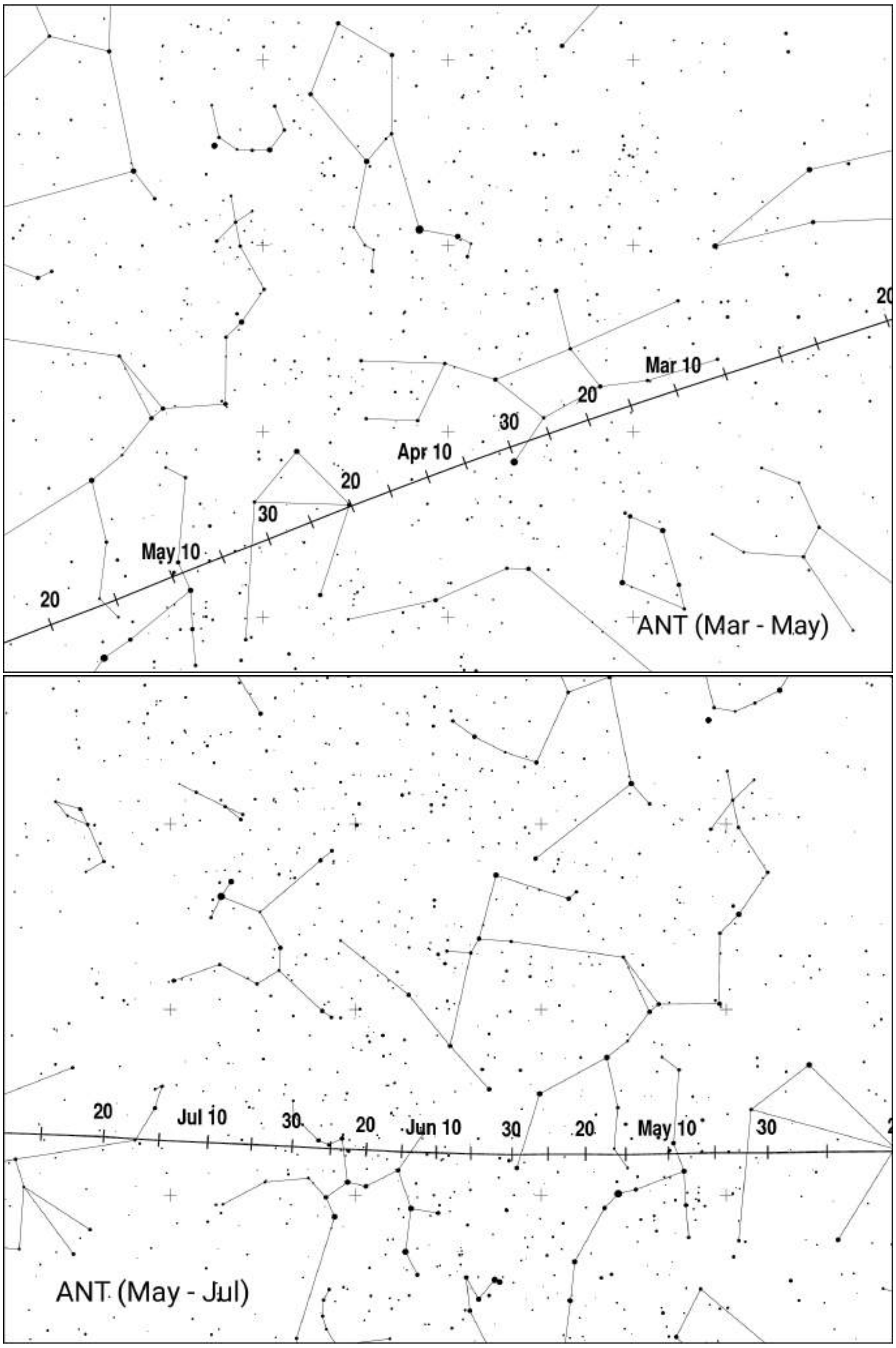
The **Camelopardalids (451 CAM)** of comet 209P/LINEAR showed a ZHR of about 15 on 2014 May 24. In 2024, there will be another close encounter to several trails. However, the minimum distances to older trails (released in the 18th and 19th centuries) are not favourable for considerable activity (both in calculations of Maslov and Vaubaillon). The closest approaches of the old trails happen between May 23, 04^{h}UT and 11^{h} UT. Maslov finds an approach to the 1929 trail at the end of the given interval ($10^{h}46^{m}$ UT) and to the 1934 trail later on May 23 at $17^{h}56^{m}$UT. New calculations by Jéremie Vaubaillon (2023) reveal that there are also approaches to very recent trails (1979, 1984). These are closest to the Earth on 2024 May 23, $17^{h}55^{m}$ UT ($\lambda_{\odot} = 62.^{\circ}747$). So the timing of the possible 1934 as well as the 1979/84 trails is identical. Again, the rate which may be expected is unknown, but it is worth monitoring possible activity. Radiant: $\alpha = 123^{\circ}, \delta = +80^{\circ}$, in an “apparently empty region” (about 10° from Polaris towards o UMa); $V_{\infty} = 16$ km/s. An additional limiting factor for optical observations is the Full Moon. Its position near α Sco is roughly opposite to the radiant so that some shielding of direct moonlight should be possible.

According to analyses of visual and video IMO data, the **ANT** should produce ZHRs between 2 and 4 with insignificant variations. 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 (charts see on the facing page).

Daytime showers: In the second half of May and throughout June, most of the meteor action switches to sources with their radiants in the daylight sky (see also Table 7 at page 28). Here we give the data of the IAU MDC and recent findings (Ogawa, 2022; 2023) and some brief comments.

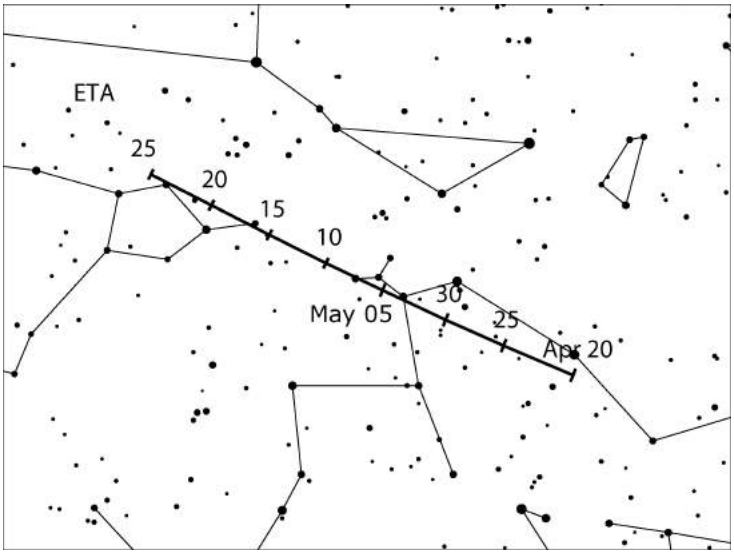
Shower	Maximum $\lambda_{\odot}$ (Date)	
	IAU MDC	Ogawa
April Piscids (144 APS)	$26.^{\circ}0$ (Apr 15)	$32.^{\circ}6$ (Apr 22)
N. ω-Cetids (152 NOC)	$47.^{\circ}8$ (May 08)	$52.^{\circ}0$ (May 12)
S. ω-Cetids (153 OCE)	$48.^{\circ}6$ (May 09)	$48.^{\circ}8$ (May 09)
S. May Arietids (156 SMA)	$52.^{\circ}7$ (May 13)	
Arietids (171 ARI)	$76.^{\circ}7$ (Jun 07)	$77.^{\circ}8$ (Jun 08)
ζ-Perseids (172 ZPE)	$78.^{\circ}6$ (Jun 09)	$83.^{\circ}5$ (Jun 15)
β-Taurids (173 BTA)	$96.^{\circ}7$ (Jun 28)	

For the **April Piscids (144 APS)**, Ogawa (2022) finds an activity which seems to be of similar strength to the radio Ursids + of December in the period $\lambda_{\odot} = 30.^{\circ}5 - 34.^{\circ}5$ and a maximum at $\lambda_\odot = 32.^\circ6$. This differs significantly from the values in the IAU MDC database: maximum at $\lambda_\odot = 26^\circ$ (April 15) or even earlier. This early date is before the start date found by Ogawa (2022) and requires observations. Later in May there are three showers: 152 NOC, 153 OCE, 156 SMA, with radiants relatively close to one another and overlapping activity periods. Therefore it is probably not possible to separate the activity of these showers in radio forward scatter observations. We may perhaps identify a broad activity profile around $\lambda_\odot = 50^\circ$ (2024 May 10/11). The **Arietids (171 ARI)** is the strongest of the daytime showers, but again we find an overlap, now with the **ζ-Perseids (172 ZPE)** between 73°and 88°. The actual duration of the shower(s) is not well known.



η-Aquariids (031 ETA)

Active: April 19–May 28; Maximum: May 5, 21^h UT ($\lambda_\odot = 45\overset{\circ}{.}5$); ZHR = 50 (var., 40–85);
Radiant: $\alpha = 338°$, $\delta = -1°$; Radiant drift: see Table 6; $V_\infty = 66$ km/s; $r = 2.4$.



This stream is associated with Comet 1P/Halley, like the Orionids of October. Shower meteors are only visible in the hours before dawn essentially from tropical and southern hemisphere sites. The shower is one of the best for southern observers. Useful results may be obtained from places up to about 40° N latitude. The radiant culminates near 8^h local time. In most years, a substantial amount of optical ETA-data is collected worldwide. However, due to the relatively short observing window between radiant rise and morning twilight for each site, it remains difficult to obtain a continuous profile.
This year there is no moonlight interference around the maximum period (New Moon on May 8). IMO analyses of visual data collected since 1984 have shown that ZHRs are generally above 30 in the period May 3–10. An often claimed variability of the peak rates associated with Jupiter's orbital period close to 12 years has not been confirmed in a recent study (Egal et al., 2020) using optical and radar data. However, there might be enhanced activity (Egal, 2020) related to the 1:6 mean motion resonance in 2023 and 2024 – hence observers should try to monitor the activity of the near-peak period which extends from May 4 to 6. Apart from a (likely) maximum near $\lambda_\odot \approx 43°$, the preliminary data of the moonlit 2023 return do not show peculiarities of the rate. Recent peak ZHRs were:

2008	2009	2017	2018	2019	2020	2021	2022	2023
≈ 85	≈ 70	75	60	50	50	45	42	40 (preliminary)

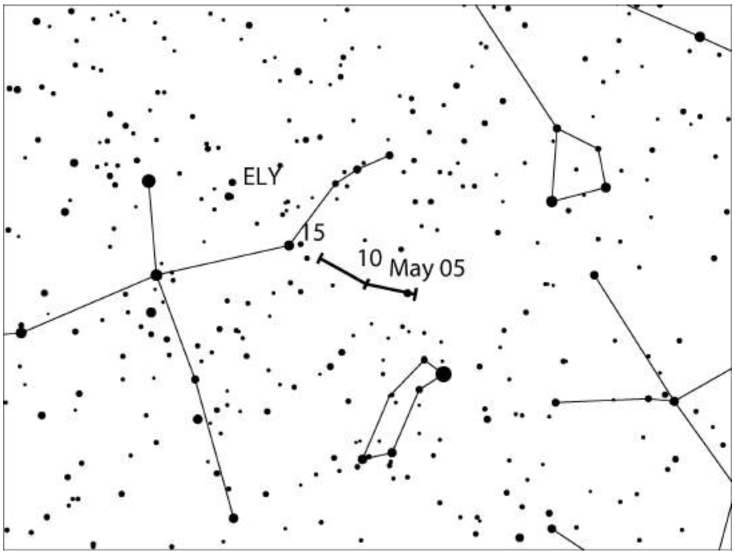
Mikhail Maslov's calculations reveal that in 2024 the Earth comes close to meteoroids ejected from the comet in −985. Meteoroids of the trail had ejection velocities of ≥ 10 m/s. Observers might see some activity increase on May 3 between 05^h and 08^h UT. The ejection velocity range suggests that the trail is composed of comparatively large particles so that there might be a larger portion of bright meteors.

η-Lyrids (145 ELY)

Active: May 5–14; Maximum: May 10 ($\lambda_\odot = 50°$); ZHR = 3;
Radiant: $\alpha = 291°$, $\delta = +43°$; Radiant drift: see Table 6; $V_\infty = 43$ km/s; $r = 3.0$.

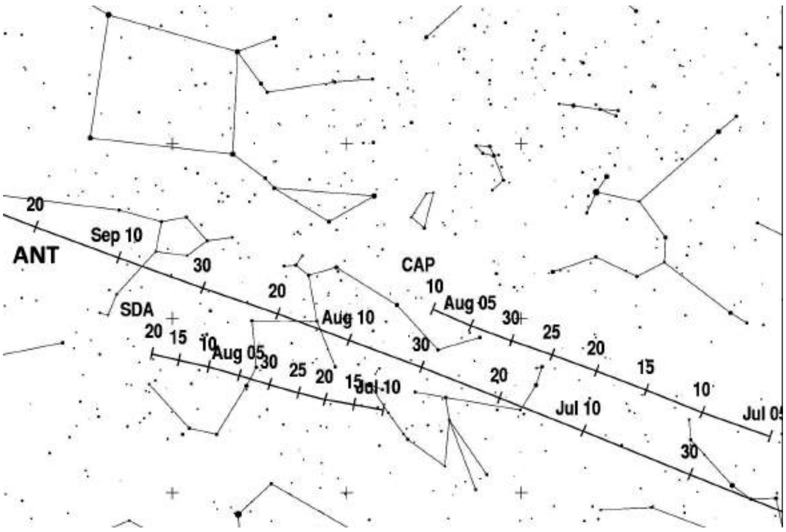
This weak shower is associated with Comet C/1983 H1 IRAS-Araki-Alcock. Most of the observational data on the shower has come from video results which define the radiant and the maximum position reliably. (Note that both have been updated from the previous calendars.)

Visual data obtained between 2007 and 2021 yield an average peak ZHR of 3–4 between $\lambda_{\odot} = 49°$ and $50°$. Care needs to be taken to separate any potential η-Lyrids from the sporadics. The radiant area is usefully on-view all night from the northern hemisphere (primarily). New Moon on May 8 offers good circumstances to observe meteors of the shower essentially throughout the entire activity period.



5 July to September

The **ANT** is the chief focus for visual attention in the first half of July, as its radiant area moves steadily through eastern Sagittarius, then across northern Capricornus into southwest Aquarius (see chart below). ZHRs for most of the month should be ≈ 2 to 3. From around September 20, the **Southern Taurids (002 STA)** effectively take over the near-ecliptic activity from the ANT through to December (see chart on page 17).



For some days around July 10, low activity may be observed from the **July Pegasids (175 JPE)**. After mid-July the large ANT radiant area overlaps that of the minor **α-Capricornids (001 CAP)** into August, but the lower apparent velocity of the CAP allows observers to separate the two. The stronger and faster **Southern δ-Aquariids (005 SDA)** should be distinguishable from the ANT as well. The highest rates of CAP and SDA are due on July 30/31, shortly after the last quarter Moon.

On 2016 July 28 at $00^{h}07^{m}$ UT ($\lambda_{\odot} = 125\overset{\circ}{.}132$) the **July γ-Draconids (184 GDR)** produced an outburst detected by radar and video observations (Molau et al., 2016b). The same position is reached again on 2024 July 28 near 01^{h} UT – worth checking although there was no extra activity observed in 2017 – 2022. SonotaCo net observations indicate that the GDR is an annual shower with a sharp but variable maximum from year to year (Koseki, 2020). The radiant is at $\alpha = 280°$, $\delta = +51°$, and the meteors have low speed ($V_{\infty} = 27$ km/s).

The **η-Eridanids (191 ERI)** are mainly visible in the first half of August before the Full Moon on August 19. The **Perseid (007 PER)** maximum occurs near the first quarter Moon, leaving the second half of the night undisturbed.

Conditions are worse for the maximum period of the **κ-Cygnids (012 KCG)** around August 17 (two days before Full Moon). Research by Koseki (2014) has shown a complex KCG-radiant structure extending into Draco and Lyra. The isolated radiant area position and the low velocity of the meteoroids should be used to associate KCG meteors to the complex.

Circumstances are optimal for observations of the **Aurigid (206 AUR)** maximum in the night August 31 – September 1. The **September ε-Perseids (208 SPE)** reach their maximum on September 9/10.

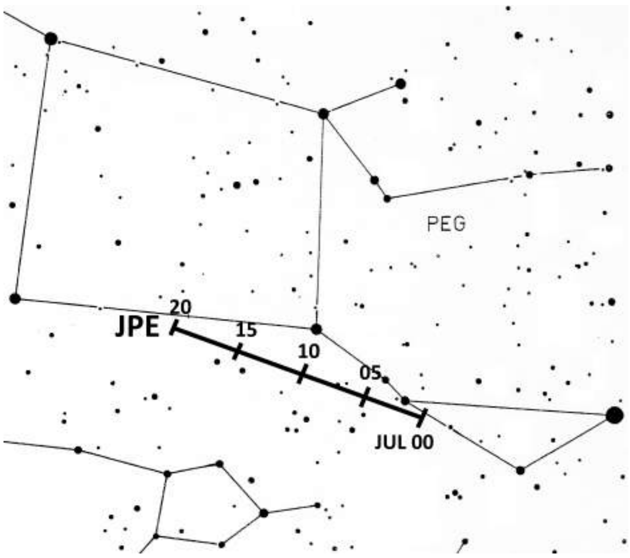
For **radio observers**, the high daytime activity of May–June has waned (see the remarks given for Table 7 on page 27). We may detect the **κ-Leonids (212 KLE)** at $\lambda_\odot = 183°$ (September 25) as another established daytime shower. Further, there is the **Daytime Sextantid (221 DSX)** maximum at $\lambda_\odot = 188°$ on October 1. A few single meteors of this shower may also be detected by optical methods.

July Pegasids (175 JPE)

Active: July 1–20, Maximum: July 10, $\lambda_\odot = 108°$; ZHR = 3;
Radiant: $\alpha = 347°$, $\delta = 11°$; Radiant drift: see Table 6; $V_\infty = 63$ km/s; $r = 3.0$.

Meteors of this essentially northern shower have been observed repeatedly, and the shower was also included in the 1995 edition of the IMO's Meteor Observer Handbook. Recent video meteor data (VID as well as Koseki, 2021) suggest an activity period which may extend well over the end given here, perhaps to end-July or into early August. Here we emphasize the period around the given maximum for the visual observer.

The rates remain low all the time, but occasionally bright shower meteors have been recorded visually, photographically and by video cameras. All studies quoted in the IAU MDC database agree on the maximum date.



The radiant is above the horizon all night for observers at mid-northern latitudes, with conditions best after local midnight. Meteors of this shower appear fast. New Moon on July 5 provides favourable circumstances for visual and video meteor observations.

Southern δ-Aquariids (005 SDA)

Active: July 12–August 23; Maximum: July 31 ($\lambda_\odot = 128°$); ZHR = 25;
Radiant: $\alpha = 340°$, $\delta = -16°$; Radiant drift: see Table 6; $V_\infty = 41$ km/s; $r = 2.5$ (see text).

The shower is one of the most active annual sources in the southern hemisphere. The ZHR of the SDA is around 25 for about two days; the ZHR exceeds 20 between $\lambda_\odot = 124°$ and 129°. During the maximum there are numerous bright SDA meteors visible, causing $r \approx 2.5$ around the maximum and $r \approx 3.1$ away from the peak period. Outbursts with a ZHR of about 40 were reported by Australian observers on 1977 July 28/29 and from Crete on 2003 July 28/29 – both before the maximum date found in recent years (e.g., Koseki, 2021) and given here. The activity level and variations of the shower need to be monitored. Last quarter Moon on July 28 leaves the descending branch of the activity profile less disturbed.

The radiant is shown in the chart on page 9. At mid-northern latitudes only a small portion of the shower meteors is visible, but conditions significantly improve towards southern latitudes.

α-Capricornids (001 CAP)

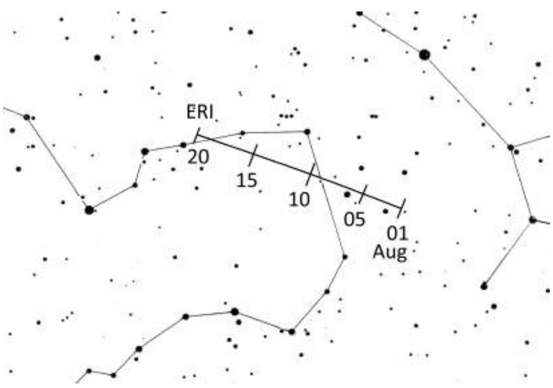
Active: July 3–August 15; Maximum: July 31 ($\lambda_\odot = 128°$); ZHR = 5;
Radiant: $\alpha = 307°$, $\delta = -10°$; Radiant drift: see Table 6; $V_\infty = 23$ km/s; $r = 2.5$.

The CAP and SDA radiants were both definitely detected visually in all years, standing out against those much weaker ones supposed active in Capricornus-Aquarius then. Although the radiant of the CAP (see chart on page 9) partly overlaps that of the large ANT region, the low CAP velocity should allow to distinguish between the two sources. Frequently, bright and at times fireball-class shower meteors are seen. Minor rate enhancements have been reported at a few occasions in the past, although the highest observed ZHR of ≈ 10 dates back to 1995. Recent results suggest the maximum date of July 30/31.

η-Eridanids (191 ERI)

Active: July 31–August 19; Maximum: August 08, $\lambda_\odot = 135°$; ZHR = 3;
Radiant: $\alpha = 41°$, $\delta = -11°$; Radiant drift: see Table 6; $V_\infty = 64$ km/s; $r = 3.0$.

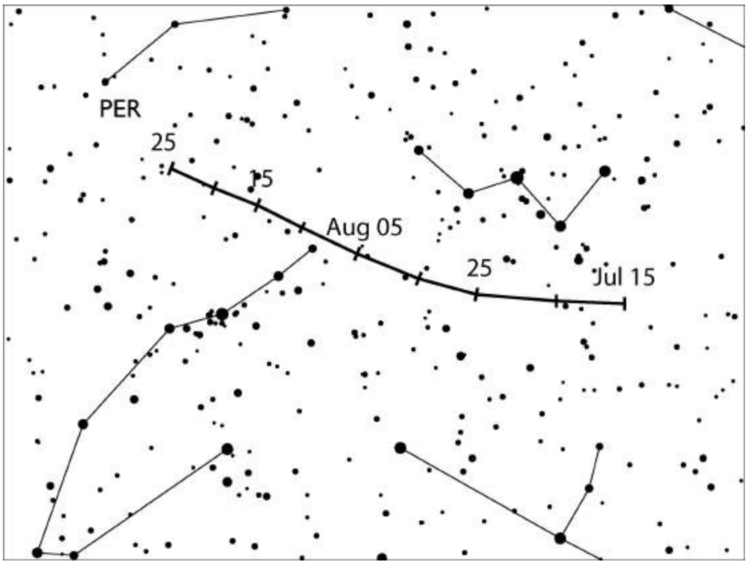
The η-Eridanids (191 ERI) included in our working list recently may be associated with comet C/1852 K1 (Chacornac). The activity period given here has been adapted from Koseki (2021; pp. 140–141). The expected maximum period occurs under Moon-free conditions. It seems that the activity continues long after its maximum which needs observational data. However, this will be difficult after about August 15 due to increasing moonlight interference. The radiant of these fast meteors in the northwestern part of Eridanus is best observed after midnight, preferably from southern locations.



Perseids (007 PER)

Active: July 17–August 24; Maximum: August 12, 13^h to 16^h UT (node at $\lambda_\odot = 140.^\circ0 - 140.^\circ1$), but see text; ZHR = 100;
Radiant: $\alpha = 48°$, $\delta = +58°$; Radiant drift: see Table 6; $V_\infty = 59$ km/s; $r = 2.2$.

IMO observations (see WB pp. 32–36) found the timing of the mean or 'traditional' broad maximum varied between $\lambda_\odot \approx 139.^\circ8$ to $140.^\circ3$, equivalent to 2024 August 12, $09^h - 21^h$ UT. The orbital period of the parent comet 109P/Swift-Tuttle is about 130 years. The Perseids produced strong activity from a primary maximum throughout the 1990s. Enhanced activity was last observed in 2016 due to passages through separated dust trails.



A filament crossing occurred on 2018 August 12 around 20^h UT ($\lambda_\odot \approx 139.^\circ79$) at the predicted position. (A filament is thought to be an accumulation of meteoroids in a mean-motion resonance.)

High activity well after the main peak has been reported during some recent returns. On 2021 August 14, shortly after 08^hUT ($\lambda_\odot \approx 141.^\circ48$), a sharp increase of the ZHR – more than 100 above the basic level – was observed by different techniques. This was about 1.5 days after the nodal maximum and about 0.7 days after the lesser late maxima in 2018 and 2020. Nothing similar has been observed during the 2022 return.

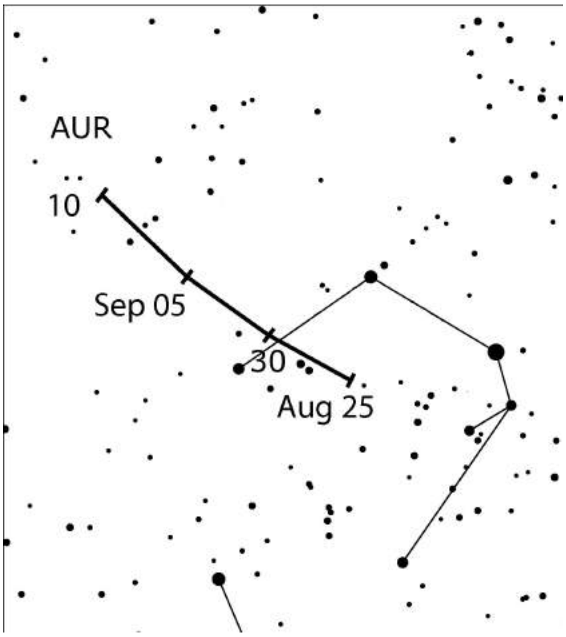
A weak filament is expected to be crossed on 2024 August 12, around 09^h UT near $\lambda_\odot = 139.^\circ81$ (Table 5d in Jenniskens, 2006). The given ZHR level is about one tenth of the well observed 2018 filament.

Jéremie Vaubaillon noted that there are encounters with five very old trails (four of them more than 1,300 years old) mainly on August 12 between 04^h and 11^h UT. Monitoring activity during this period is of interest because such observations are scarce.

First quarter Moon on August 12 provides reasonably good conditions for visual observations as the period with the high radiant elevation remains undisturbed. Seen the extra events after the nodal peak during the past returns it is recommended to include the nights around the main maximum in the observing program to record peculiarities. Mid-northern latitude sites are best for Perseid observing, as from here, the radiant has reached a reasonable elevation from 22^h–23^h local time onwards. Regrettably, the shower cannot be properly viewed from most of the southern hemisphere and from latitudes north of about 60°N.

Aurigids (206 AUR)

Active: August 28–September 5; Maximum: August 31, 11^{h} UT ($\lambda_\odot = 158^\circ\!.178$) – see text; ZHR = 10; Radiant: $\alpha = 91^\circ$, $\delta = +39^\circ$; Radiant drift: see Table 6; $V_\infty = 66$ km/s; $r = 2.5$.



This northern-hemisphere shower has produced outbursts with peak ZHRs of ≈ 30–50 recorded in 1935, 1986, 1994 and 2019. Observations of the first *predicted* outburst in 2007 confirmed the calculated values widely. This outburst was characterised by many bright meteors. The peak ZHR of ≈ 130 lasted only for about 20 minutes. Slightly enhanced rates were also observed in 2021. According to calculations of Sato (2023) the assumed one-revolution dust trail was last in the vicinity of the Earth on 2022 September 01 at 01^{h} UT ($\lambda_\odot = 158^\circ\!.289$, but not close enough for detectable extra activity. Subsequently, the orbital plane shifts a bit so that the node is crossed on 2024 August 31, shortly before 11^{h} UT ($\lambda_\odot = 158^\circ\!.178$). In the case of distant trails, activity may occur – if at all – up to an hour off the given time. The Aurigid radiant reaches a useful elevation only after $\approx 01^{\mathrm{h}}$ local time – this year with no moonlight interference.

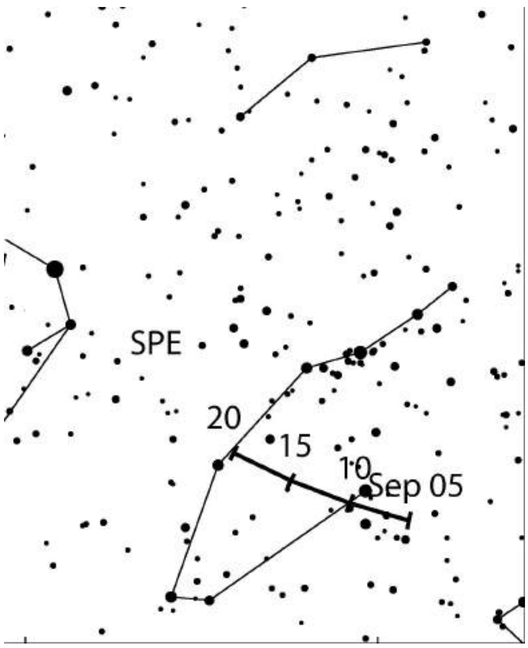
September ε-Perseids (208 SPE)

Active: September 5–21; Maximum: September 9, 06^{h} UT ($\lambda_\odot = 166^\circ\!.7$), ZHR = 5+; Radiant: $\alpha = 48^\circ$, $\delta = +40^\circ$; Radiant drift: see Table 6; $V_\infty = 64$ km/s; $r = 3.0$.

This shower produced high rates on 2008 September 9, between roughly $\lambda_\odot = 166^\circ\!.894$–$166^\circ\!.921$, and another bright-meteor event with a very sharp peak at $\lambda_\odot = 167^\circ\!.188$ in 2013 but no later unambiguous increase subsequently.

According to Esko Lyytinen's modelling the next impressive SPE return may not be before 2040, but since we do not yet know more about the position and extension of the assumed 1-revolution dust trail of the unknown parent object, monitoring of the activity is of great importance.

The Moon reaches its first quarter on September 11 so that the second half of the night remains unaffected around the maximum of this primarily northern-hemisphere shower. The radiant area is well on-view all night from about 22^{h}–23^{h} local time for mid-northern locations.



6 October to December

The **Orionids (008 ORI**; maximum October 21) and the **Leonids (013 LEO**; maximum November 17) reach their maxima shortly after the Full Moon. The situation is no better for the **Geminids (004 GEM)**. The broad maximum with an expected ZHR level of about 150 at $\lambda_\odot = 262\overset{\circ}{.}2$ (= December 14, $01^{\rm h}$ UT) occurs just before Full Moon, strongly reducing the visible number of shower meteors. At locations south of about 30° N the Moon sets well before dawn, leaving an hour or so with dark sky and reasonable radiant elevation. Observations of the **Ursids (015 URS)** are less affected by the Moon.

Although we do not give details for these showers, we advise to observe the **Leonids**. Maslov (2007) points out that the "normal" maximum will be relatively strong (ZHR 15–20 on 2024 November 17, $04^{\rm h}$ UT). Calculations of Vaubaillon (2023) show that the Earth encounters the very old trail of the parent comet 55P/Tempel-Tuttle on November 14 at $16^{\rm h}37^{\rm m}$UT. It is not clear what to expect because the trail is far from the comet. Unfortunately, this encounter – about 3 days before the nodal passage – happens just before the Full Moon. Sato (2023) finds an encounter with the 1733 trail on 2024 November 19/20 at $\lambda_\odot = 237\overset{\circ}{.}805$ and $237\overset{\circ}{.}848$, that it $23^{\rm h}53^{\rm m}$ and $00^{\rm h}54^{\rm m}$ UT, respectively. Since the minimum distance is relatively large (about -0.002 au) and the required ejection velocity is high, the rates will be low. Nevertheless, all data is welcome to verify and possibly to adjust model parameters.

The two **Taurid** branches reach their highest rates around November 05 (Southern Taurids, 002 STA) and November 12 (Northern Taurids, 017 NTA), respectively, with little or no moonlight interference. The **ANT** activity resumes only around December 10, as the Northern Taurids fade away. The radiant centre tracks from Taurus across southern Gemini during later December. The typical ZHR level is about 2.

Several minor showers are active in the last quarter of the year. The maximum of the **October Camelopardalids (281 OCT)** occurs on October 5 under good circumstances. The **October Draconids (009 DRA)** reach their maximum on October 8 with evening moonlight. The moonlight disturbances increase for the very weak **δ-Aurigids (224 DAU**, maximum October 11) and particularly for the **ε-Geminids (023 EGE**, maximum October 18). The later **Leonis Minorids (022 LMI)** see less moonlight interference. The **α-Monocerotids (246 AMO)** – with no peculiar activity expected in 2024 – have a waning gibbous Moon in the sky (maximum date November 21). The **November Orionids (250 NOO)** can be nicely traced.

In the past years, there were several activity signs from the **Andromedids (018 AND)** – 2021 November 28, 2018 December 02 – and possibly also 2023 December 02 (still to come). There is nothing predicted for the 2024 return, but observers might want to check for slow AND meteors. Recent analyses indicate that weak AND activity is observable annually.

Conditions are optimal for the early December southern showers – **Phoenicids (254 PHO**) and the complex **Puppid-Velids (301 PUP)**. More than a week later, the **Monocerotids (019 MON**, maximum December 09) and the **σ-Hydrids (016 HYD**, maximum December 09) have Moon-free skies only in the (favourable) second half of the nights.

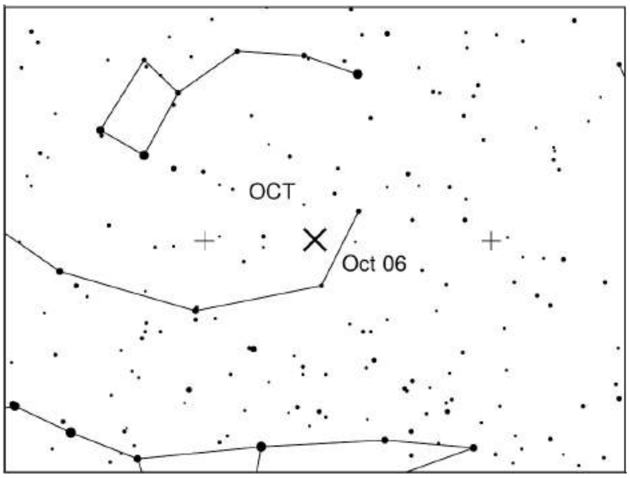
The tentative maximum of the weak and long-lasting **Comae Berenicids (020 COM)** around December 16 occurs close to the Full Moon. There are several showers with similar radiants and also orbital elements to the COM and previously listed **December Leonis Minorids (032 DLM)**. An activity period of over 70 degrees appears too long for a meteor shower having such a high inclination orbit. Due to the complex situation (especially for the visual observer – see Rendtel, 2023) we suggest to summarise all meteors from the (extended) COM/DLM-region under "COM" for the entire activity period.

At the end of the year, the first **Quadrantids (010 QUA)** can be seen.

October Camelopardalids (281 OCT)

Active: October 5–6; Maximum: October 5, 16^h ($\lambda_\odot = 192{.}^\circ58$); ZHR = 5(?)
Radiant: $\alpha = 164°$, $\delta = 79°$; Radiant drift: negligible; $V_\infty = 47$ km/s; $r = 2.5$ (uncertain).

Activity from this north-circumpolar radiant was recorded annually since 2005 (Molau et al., 2017) with a peak at $\lambda_\odot = 192{.}^\circ58$. Well recognisable rates were observed on 2018 October 6, 00^h30^mUT $\pm 1.3^h$ ($192{.}^\circ45 \pm 0{.}^\circ05$; ZHR ≈ 5). Enhanced activity was also found in 2016 and 2018.

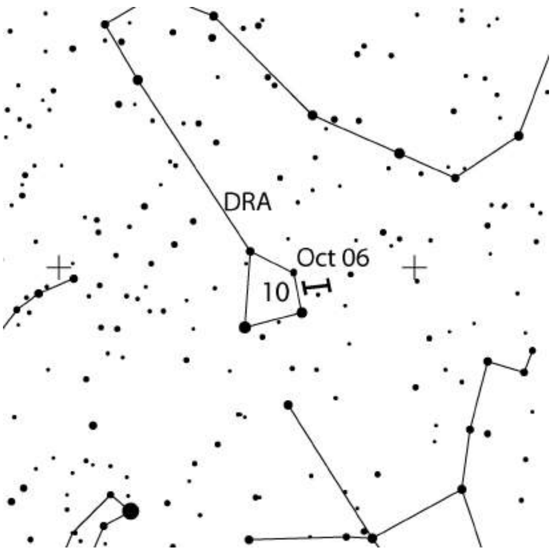


Assuming a long-period parent, and using the 2005 outburst as reference point, Esko Lyytinen's calculations indicated that we might see activity near $\lambda_\odot = 192{.}^\circ529$ in 2018 and 2019. In both years, some activity was recorded with a slightly higher rate in 2018. Surprises are possible because the stream is either a long-period case with an atypically wide 1-revolution trail *or* we have still to encounter the densest part of the trail. However, for 2024 no activity prediction has been issued.

Draconids (009 DRA)

Active: October 6–10; Maximum: October 8, 13^h UT ($\lambda_\odot = 195{.}^\circ4$); ZHR = 5 (?);
Radiant: $\alpha = 263°$, $\delta = +56°$; Radiant drift: negligible; $V_\infty = 21$ km/s; $r = 2.6$.

The Draconids (also called October Draconids) are known as a periodic shower which produced spectacular meteor storms in 1933 and 1946, and lower rates in several other years (ZHRs $\approx$ 20–500+). Recent outbursts happened in 2011 (ZHR $\approx$ 300; predicted) and in 2012 (unexpected). The 2018 return yielded a ZHR of about 150 lasting for about 4 hours, much higher than the predicted values.

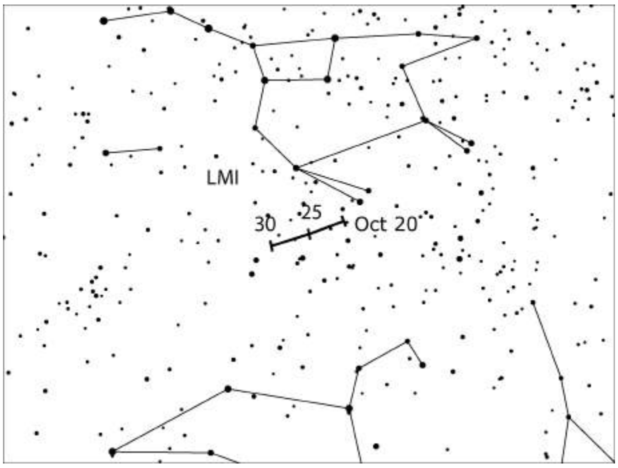


For the 2024 return there are two dust trails (ejected in 1852 and 1859, respectively) listed in Table 6d of Jenniskens (2006). The closest approaches occur on October 8 at 06^h36^m and 06^h53^m UT. The same trails are also found by Vaubaillon to come close to the Earth. The calculated timing differs only very little (06^h23^m and 06^h31^m UT, respectively). Since the trails are quite old, no values for any possible activity is given.

The parent comet 21P/Giacobini-Zinner will reach its next perihelion on 2025 March 25. The waxing moon illuminates the hours before local midnight when the radiant is high in the sky. The radiant is north-circumpolar for latitudes north of about 45°N. Draconid meteors are exceptionally slow-moving.

Leonis Minorids (022 LMI)

Active: October 19–27; Maximum: October 24 ($\lambda_\odot = 211°$); ZHR = 2;
Radiant: $\alpha = 162°$, $\delta = +37°$; Radiant drift: see Table 6; $V_\infty = 62$ km/s; $r = 3.0$.



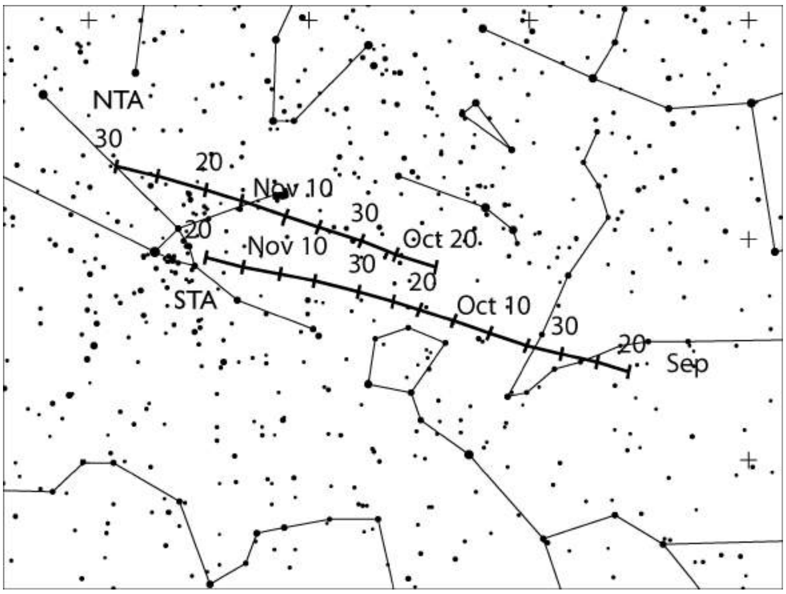
This shower was first found in photographic orbital data and comet C/1739 K1 (Zanotti) is suggested as parent object. The activity was established from video data and over the past years, and a reasonable sample of visual data has been collected as well.

Visual data from 2017–2021 yield a maximum ZHR of the order of 5 around October 24 or perhaps slightly earlier. The radiant area can be seen solely from the northern hemisphere, where it rises around midnight. The given maximum date is close to the last quarter Moon so that the later part of the activity can be monitored better.

Southern Taurids (002 STA)

Active: September 20–November 20; Maximum: November 05 ($\lambda_\odot = 223°$); ZHR = 5–10;
Radiant: $\alpha = 52°$, $\delta = +15°$; Radiant drift: see Table 6; $V_\infty = 27$ km/s; $r = 2.3$.

This stream, with its Northern counterpart, forms part of the complex associated with Comet 2P/Encke. Observers find a superposition of activities. For shower association, assume the radiant to be an oval area, about 20° in α by 10° in δ, centred on the radiant position for any given date. Its near-ecliptic radiant makes the shower a target for observers at all latitudes, albeit those in the northern hemisphere are somewhat better-placed, as here suitable radiant zenith distances persist for much of the night.



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 visual plotting techniques. The main maximum (ZHR 5–10) of the STA is found around November 05, but there is an early maximum (ZHR near 5) around October 13 – a date which often was listed as actual STA maximum.

Northern Taurids (017 NTA)

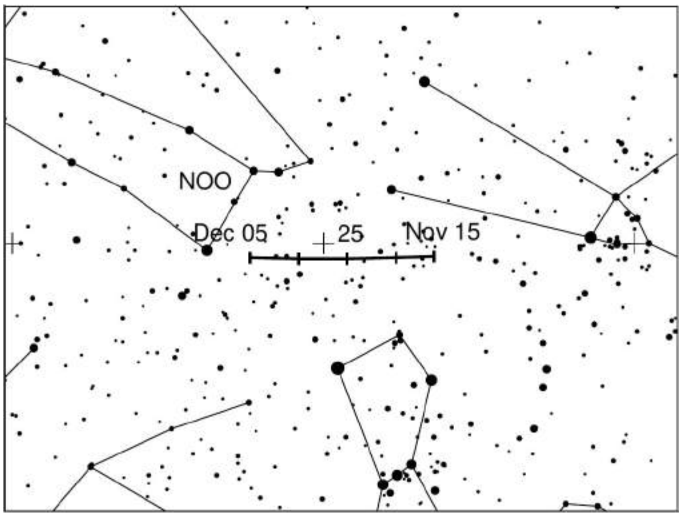
Active: October 20–December 10; Maximum: November 12 ($\lambda_\odot = 230°$); ZHR = 5;
Radiant: $\alpha = 58°$, $\delta = +22°$; Radiant drift: see Table 6; $V_\infty = 29$ km/s; $r = 2.3$.

The large, oval radiant region to be used for shower association, the shower's excellent visibility overnight, and its dominance over the ANT during September to December are essentially the same as discussed in the STA section above. As previous results had suggested seemingly plateau-like maximum rates persisted for roughly ten days in early to mid November, the NTA peak may not be so sharp as its single maximum date might imply. The first quarter Moon on November 9 allows undisturbed optical observations especially in the period between the dates given as maxima of the two Taurid branches.

November Orionids (250 NOO)

Active: November 14–December 6; Maximum: November 28 ($\lambda_\odot = 246°$); ZHR = 3;
Radiant: $\alpha = 91°$, $\delta = +16°$; Radiant drift: see Table 6; $V_\infty = 41$ km/s; $r = 3.0$

Detailed analysis of video data revealed that there are two consecutive, very similar showers whose activity intervals partially overlap each other: the November Orionids (250 NOO), followed by the Monocerotids (019 MON). In the last days of November the NOO shower is the strongest source in the sky.

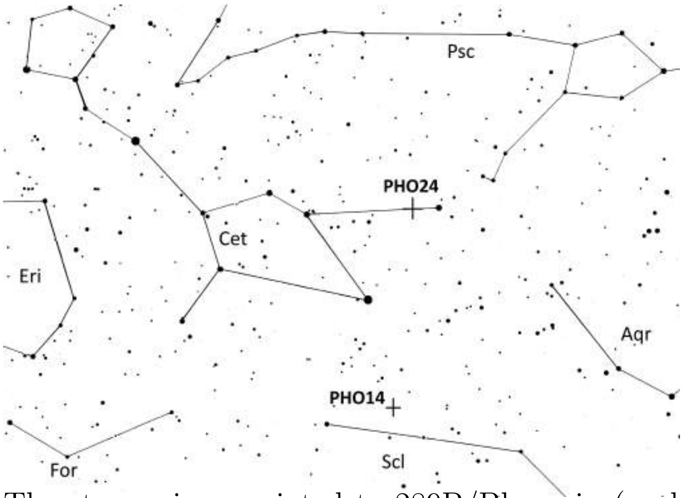


The radiant is located in northern Orion, about 8° north of α Ori. This location is close to the Northern Taurids, but far enough east to distinguish meteors from the two sources. Additionally, the faster velocity of the November Orionids should help distinguish these meteors from the slower Taurids.

The radiant culminates near 2^h local time, but is above the horizon for most of the night. New Moon on December 1 provides good conditions for optical observations.

Phoenicids (254 PHO)

Active: November 14–17(?) and(?) around December 1 (see text); ZHR = unknown;
Radiant: $\alpha = 8°$, $\delta = -27°$ (further details in the text); $V_\infty = 15$ km/s; $r = 2.8$ (?).



Only one impressive Phoenicid return has been reported, that of its discovery in 1956, when the ZHR probably reached ≈ 100 from $\alpha = 16°, \delta = -45°$, possibly with several peaks spread over a few hours. Recent significant activity was observed on 2014 December 1 which occurred at the time predicted by Sato and Watanabe (2010). From this paper we also take the radiant position (labelled in our chart as "PHO14") which is about 7° southwest of the star β Cet – far north of the radiant found in 1956.

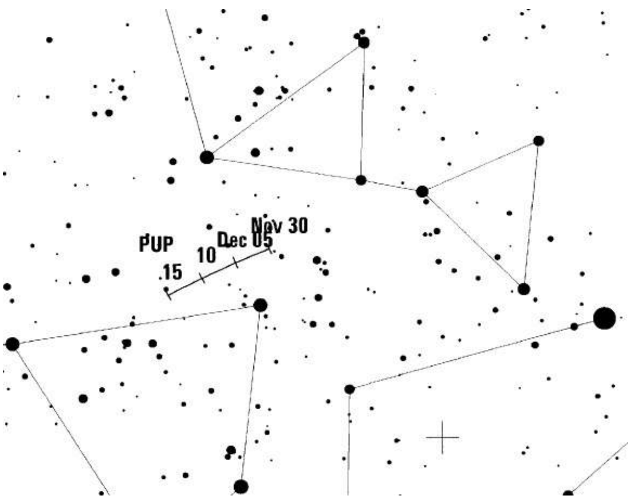
The stream is associated to 289P/Blanpain (probably = 2003 WY25). The orbit of the comet is subject to Jupiter perturbations. For 2024, Sato (2023) calculated three approaches to dust trails released in 1861 and 1866. The parameters indicate only very low rates and rather faint meteors, but nevertheless we want to draw your attention to the possible encounters. Note also the activity dates and the radiant labelled "PHO24" in the chart near ι Cet for the possible 2024 events which are much different from the tabulated values:

Trail	Date	Time (UT)	Radiant (α, δ)	
1866	Nov 14	07^h37^m	7°	−8°
1861	Nov 15	22^h07^m	7°	−9°
1861	Nov 17	13^h36^m	7°	−10°

The designation Phoenicids is kept here as the historical name of the shower (similar to the τ-Herculids in 2022). Phoenicids are extremely (!) slow meteors. Any kind of observation, including "negative" reports, may help to verify the model parameters.

Puppid-Velids (301 PUP)

Active: December 1–15(?); Maximum: December ≈ 4 ($\lambda_\odot \approx 252°$); ZHR ≈ 10;
Radiant: $\alpha = 130°$, $\delta = -44°$; Radiant drift: see Table 6; $V_\infty = 44$ km/s; $r = 2.9$.



This is a complex system of poorly-studied showers, visible chiefly from locations south of the equator. Several sub-streams have been proposed. The designation 301 PUP represents an "average" position which is close to the 746 EVE (e-Velids). The radiants summarised here as PUP are so tightly clustered, visual observing cannot readily separate them. The activity is not well established, though slightly higher rates seem to occur in early to mid December and perhaps around December 20 again (then being close to a radiant which is given as 784 KVE (κ-Velids) in the IAU database. All this has "working" status and needs further investigation. The Moon reaches its first quarter on December 8. Thus, especially the early part of the complex activity can be well observed. The radiant area is on-view all night from tropical and southern locations, highest towards dawn. Occasional bright fireballs, notably around the suggested maximum, have been reported.

Monocerotids (019 MON)

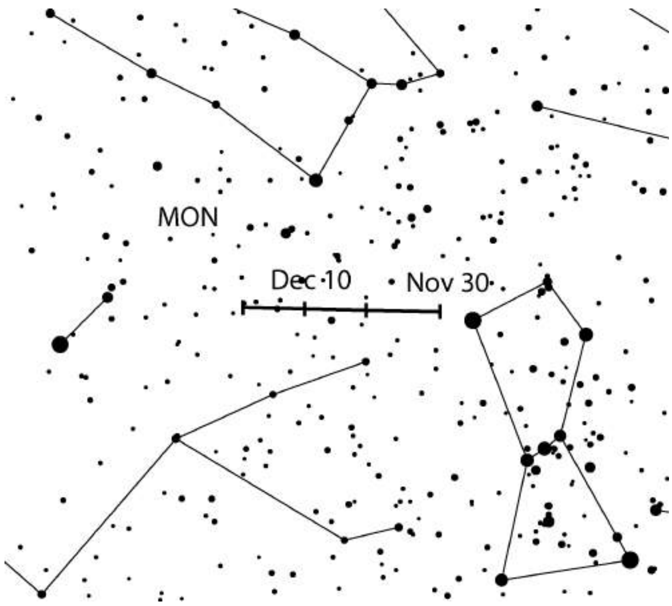
Active: November 27–December 20; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 3;
Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6; $V_\infty = 42$ km/s; $r = 3.0$.

This shower (also called December Monocerotids) is well known for a long time, but the amount of data is not sufficient to investigate details. In most years, visual data give a maximum ZHR = 3 at $\lambda_\odot \approx 257°$ while the general ZHR level is about 2. In a few years, we also find an apparent slight enhancement in the Geminid peak night – perhaps an effect of Geminids erroneously classified as MON.

Video data (2011–2022) show a peak of roughly $0.^\circ4$ width centred at $\lambda_\odot \approx 262°$ (i.e. December 14) with a ZHR of the order of 8 coinciding with the Geminid peak. A much weaker ZHR ≈ 3 appears near $\lambda_\odot = 255.^\circ5°$. This still needs to be clarified.

Care needs to be taken to clearly distinguish MON from GEM and NOO. Visual observers should choose their field of view such, that the radiants do not line up. (Field centres north of Taurus in the evening or near Leo in the morning are possible choices.)

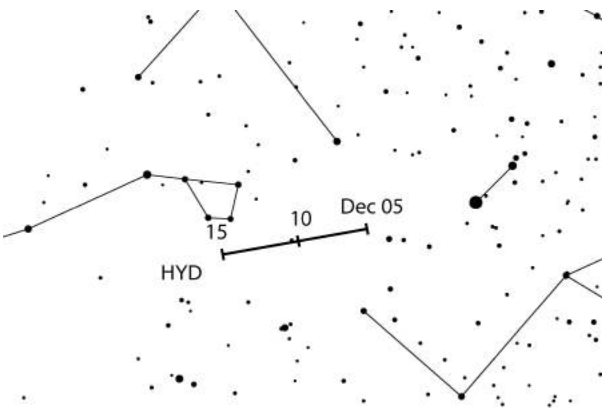
The radiant area is available virtually all night for much of the globe, culminating at about 01^h30^m local time.



σ-Hydrids (016 HYD)

Active: December 3–20; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 7;
Radiant: $\alpha = 125°$, $\delta = +02°$; Radiant drift: see Table 6; $V_\infty = 58$ km/s; $r = 3.0$.

The σ-Hydrids are often thought to be a very minor shower with rates close to the visual detection threshold for much of the activity period. However, some bright meteors are repeatedly seen and the maximum ZHR reliably reaches 5–8. A maximum occasionally found nearer $\lambda_\odot \approx 262°$ (December 14) is probably caused by mis-aligned Geminids as described for the MON.



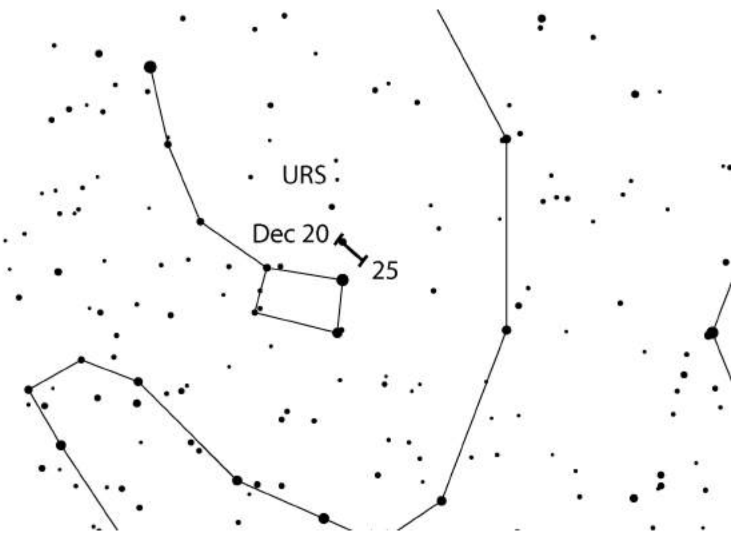
Visual IMO data from the period 2010–2021 show a maximum at $\lambda_\odot = 257° - 258°$ (December 9–10). Video data from 2010–2021 indicate a peak at $\lambda_\odot \approx 255\overset{\circ}{.}5$ (December 6), and that HYD activity might persist till December 24. A careful choice of the observing field is necessary to distinguish HYD from GEM and MON which are active at the same time (see notes in the MON section above). Since the HYD radiant rises in the late evening hours, it is best viewed after local midnight from either hemisphere.

Ursids (015 URS)

Active: December 17–26; Maximum: December 22, 10^h UT ($\lambda_\odot = 270\overset{\circ}{.}7$) and see text;
ZHR = 10 (occasionally variable up to 50);
Radiant: $\alpha = 217°$, $\delta = +76°$; Radiant drift: see Table 6; $V_\infty = 33$ km/s; $r = 2.8$.

This poorly-observed northern hemisphere shower has produced at least two major outbursts (in 1945 and 1986). Further events could have been missed due to weather conditions. The maximum is rather narrow and seems to fluctuate from year to year. Several lesser rate enhancements have been reported from 2006 to 2008, in 2011, 2014, 2015, 2017 and 2020 (visual and video data). The parent comet 8P/Tuttle has an orbital period of 13.6 years. It passed its perihelion last on 2021 August 27. In the past, many Ursid peaks occurred when the comet was close to its *aphelion,* indicating that predictions are difficult.

For the 2024 return, Jenniskens (2006, Table 5b) lists a **filament encounter on December 21,** 23^h49^m **UT** ($\lambda_\odot = 270\overset{\circ}{.}27$). The given ZHR of 21 is similar to the values indicated for the 2021–23 returns.



The Ursid radiant is circumpolar from most northern sites, so fails to rise for most southern ones. The radiant is highest in the sky towards the morning – the period which is affected by moonlight (last quarter Moon on 2024 December 22).

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. The optimum $\alpha \times \delta$ size to be assumed for the STA and NTA is instead $20° \times 10°$, while that for the ANT 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.

	$V_\infty = 25$ 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

8 References and Abbreviations

References:

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Abbreviations:

$\boldsymbol{\alpha}$, $\boldsymbol{\delta}$: Coordinates for a shower's radiant position, usually at maximum. $\boldsymbol{\alpha}$ 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.

$\boldsymbol{r}$: The population index, a term computed from each shower's meteor magnitude distribution. $r = 2.0 - 2.5$ implies a larger fraction of brighter meteors than average, while r above 3.0 is richer in fainter meteors than average.

$\boldsymbol{\lambda_\odot}$: 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.

$\boldsymbol{V_\infty}$: Pre-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 (reference limiting magnitude +6.5) with the shower radiant overhead. This figure is given in terms of meteors per hour.

9 Tables: lunar and shower data

Table 4. Lunar phases for 2024.

New Moon	First Quarter	Full Moon	Last Quarter
			January 4
January 11	January 18	January 25	February 2
February 9	February 16	February 24	March 3
March 10	March 17	March 25	April 2
April 8	April 15	April 24	May 1
May 8	May 15	May 23	May 30
June 6	June 14	June 22	June 28
July 5	July 13	July 21	July 28
August 4	August 12	August 19	August 26
September 3	September 11	September 18	September 24
October 2	October 10	October 17	October 24
November 1	November 9	November 15	November 23
December 1	December 8	December 15	December 22
December 30			

Table 5. Working List of Visual Meteor Showers. Details in this Table were correct according to the best information available in June 2023, with maximum dates accurate only for 2024. For the Phoenicids see details on page 19. The parenthesized maximum date for the Puppids-Velids indicates a reference date for the radiant only, not necessarily a true maximum. The given ZHR is based on recent oberved returns. Possibly periodic showers are noted as 'Var' = variable. For more information check the updates published e.g. in the IMO Journal *WGN*.

Shower	Activity	Maximum Date	$\lambda_\odot$	Radiant α	Radiant δ	V_∞ km/s	r	ZHR
Antihelion Source (ANT)	Dec 10–Sep 20 –	March–April, late May, late June		see Table 6		30	3.0	4
Quadrantids (010 QUA)	Dec 28–Jan 12	Jan 04	283°.15	230°	+49°	41	2.1	80
γ-Ursae Minorids (404 GUM)	Jan 10–Jan 22	Jan 19	298°	228°	+67°	31	3.0	3
α-Centaurids (102 ACE)	Jan 31–Feb 20	Feb 09	319°.4	211°	−58°	58	2.0	6
Lyrids (006 LYR)	Apr 14–Apr 30	Apr 22	32°.32	271°	+34°	49	2.1	18
π-Puppids (137 PPU)	Apr 15–Apr 28	Apr 23	33°.5	110°	−45°	18	2.0	Var
η-Aquariids (031 ETA)	Apr 19–May 28	May 05	45°.5	338°	−01°	66	2.4	50
η-Lyrids (145 ELY)	May 03–May 14	May 10	50°.0	291°	+43°	43	3.0	3
Dayt. Arietids (171 ARI)	May 14–Jun 24	Jun 07	76°.7	43°	+24°	38	2.8	30
June Bootids (170 JBO)	Jun 22–Jul 02	Jun 27	95°.7	224°	+48°	18	2.2	Var
July Pegasids (175 JPE)	Jul 04–Jul 14	Jul 10	108°.0	347°	+11°	63	3.0	3
July γ-Draconids (184 GDR)	Jul 25–Jul 31	Jul 28	125°.13	280°	+51°	27	3.0	5
S. δ-Aquariids (005 SDA)	Jul 12–Aug 23	Jul 31	128°	340°	−16°	41	2.5	25
α-Capricornids (001 CAP)	Jul 03–Aug 15	Jul 31	128°	307°	−10°	23	2.5	5
η-Eridanids (191 ERI)	Jul 31–Aug 19	Aug 08	135°	41°	−11°	64	3.0	3
Perseids (007 PER)	Jul 17–Aug 24	Aug 12	140°.0	48°	+58°	59	2.2	100
κ-Cygnids (012 KCG)	Aug 03–Aug 28	Aug 17	144°	286°	+59°	23	3.0	3
Aurigids (206 AUR)	Aug 28–Sep 05	Aug 31	158°.6	91°	+39°	66	2.5	6
Sep. ε-Perseids (208 SPE)	Sep 05–Sep 21	Sep 09	166°.7	48°	+40°	64	3.0	8
Dayt. Sextantids (221 DSX)	Sep 09–Oct 09	Sep 27	184°.3	156°	−02°	32	2.5	5
Oct. Camelopard. (281 OCT)	Oct 05–Oct 06	Oct 05	192°.58	164°	+79°	47	2.5	5
Draconids (009 DRA)	Oct 06–Oct 10	Oct 08	195°.4	262°	+54°	20	2.6	5
δ-Aurigids (224 DAU)	Oct 10–Oct 18	Oct 11	198°	84°	+44°	64	3.0	2
ε-Geminids (023 EGE)	Oct 14–Oct 27	Oct 18	205°	102°	+27°	70	3.0	3
Orionids (008 ORI)	Oct 02–Nov 07	Oct 21	208°	95°	+16°	66	2.5	20
Leonis Minorids (022 LMI)	Oct 19–Oct 27	Oct 24	211°	162°	+37°	62	3.0	2
S. Taurids (002 STA)	Sep 20–Nov 20	Nov 05	223°	52°	+15°	27	2.3	7
N. Taurids (017 NTA)	Oct 20–Dec 10	Nov 12	230°	58°	+22°	29	2.3	5
Leonids (013 LEO)	Nov 06–Nov 30	Nov 17	235°.27	152°	+22°	71	2.5	10
α-Monocerotids (246 AMO)	Nov 15–Nov 25	Nov 21	239°.32	117°	+01°	65	2.4	Var
Nov. Orionids (250 NOO)	Nov 13–Dec 06	Nov 28	246°	91°	+16°	44	3.0	3
Phoenicids (254 PHO)	(Nov 28)–(Dec 09)	(Dec 01)	249°.5	08°	−27°	15	2.8	Var
Puppid-Velids (301 PUP)	Dec 01–Dec 15	(Dec 07)	(255°)	123°	−45°	44	2.9	10
Monocerotids (019 MON)	Dec 05–Dec 20	Dec 09	257°	100°	+08°	41	3.0	3
σ-Hydrids (016 HYD)	Dec 03–Dec 20	Dec 09	257°	125°	+02°	58	3.0	7
Geminids (004 GEM)	Dec 04–Dec 20	Dec 14	262°.2	112°	+33°	35	2.6	150
Comae Berenicids (020 COM)	Dec 05–Feb 04	Dec 16	264°	158°	+30°	64	3.0	3
Ursids (015 URS)	Dec 17–Dec 26	Dec 22	270°.7	217°	+76°	33	2.8	10

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

Date		ANT		QUA		COM									
Jan	0	112°	+21°	228°	+50°	172°	+25°								
Jan	5	117°	+20°	231°	+49°	176°	+23°			**GUM**					
Jan	10	122°	+19°	234°	+48°	180°	+21°			220°	+71°				
Jan	15	127°	+17°			185°	+19°			224°	+69°				
Jan	20	132°	+16°			189°	+17°			228°	+67°				
Jan	25	138°	+15°			193°	+15°	**ACE**		232°	+65°				
Jan	30	143°	+13°			198°	+12°	199°	−56°						
Feb	5	149°	+11°			203°	+10°	206°	−58°						
Feb	10	154°	+9°					213°	−59°						
Feb	15	159°	+7°					219°	−61°						
Feb	20	164°	+5°					224°	−62°						
Feb	28	172°	+2°												
Mar	5	177°	0°												
Mar	10	182°	−2°												
Mar	15	187°	−4°												
Mar	20	192°	−6°												
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°	279°	+34°			332°	−3°	**ELY**					
May	05	237°	−20°					337°	−1°	286°	+43°				
May	10	242°	−21°					341°	+1°	291°	+43°				
May	15	247°	−22°					345°	+3°	296°	+44°				
May	20	252°	−22°					349°	+5°						
May	25	256°	−23°					353°	+7°						
May	30	262°	−23°	**ARI**											
Jun	5	267°	−23°	42°	+24°										
Jun	10	272°	−23°	47°	+24°										
Jun	15	276°	−23°												
Jun	20	281°	−23°	**JBO**											
Jun	25	286°	−22°	223°	+48°										
Jun	30	291°	−21°	225°	+47°	**CAP**						**JPE**			
Jul	5	296°	−20°			285°	−16°	**SDA**				343°	+10°		
Jul	10	300°	−19°	**PER**		289°	−15°	325°	−19°			347°	+11°		
Jul	15	305°	−18°	6°	+50°	294°	−14°	329°	−19°			351°	+12°		
Jul	20	310°	−17°	11°	+52°	299°	−12°	333°	−18°			356°	+13°	**GDR**	
Jul	25	315°	−15°	22°	+53°	303°	−11°	337°	−17°					277°	+51°
Jul	30	319°	−14°	29°	+54°	307°	−10°	340°	−16°	**ERI**		**KCG**		282°	+51°
Aug	5	325°	−12°	37°	+56°	313°	−8°	345°	−14°	39°	−14°	281°	+45°		
Aug	10	330°	−10°	45°	+57°	318°	−6°	349°	−13°	44°	−12°	284°	+49°		
Aug	15	335°	−8°	51°	+58°			352°	−12°	48°	−10°	287°	+53°		
Aug	20	340°	−7°	57°	+58°	**AUR**		356°	−11°	52°	−9°	289°	+56°		
Aug	25	344°	−5°	63°	+58°	85°	+40°					291°	+59°		
Aug	30	349°	−3°			90°	+39°	**SPE**				293°	+62°		
Sep	5	355°	−1°			96°	+39°	43°	+40°						
Sep	10	0°	+1°			102°	+39°	48°	+40°						
Sep	15	5°	+2°	**STA**				53°	+40°						
Sep	20			18°	+5°	**DSX**		59°	+41°						
Sep	25			21°	+6°	147°	−2°								
Sep	30			25°	+7°	152°	−2°	**ORI**				**OCT**			
Oct	5			28°	+8°			85°	+14°	**DAU**		164°	+79°	**DRA**	
Oct	10			32°	+9°	**EGE**		88°	+15°	82°	+45°			262°	+54°
Oct	15	**NTA**		36°	+11°	99°	+27°	91°	+15°	87°	+43°	**LMI**			
Oct	20	38°	+18°	40°	+12°	104°	+27°	94°	+16°	92°	+41°	158°	+39°		
Oct	25	43°	+19°	43°	+13°	109°	+27°	98°	+16°			163°	+37°		
Oct	30	47°	+20°	47°	+14°			101°	+16°			168°	+35°		
Nov	5	52°	+21°	52°	+15°			105°	+17°	**LEO**					
Nov	10	56°	+22°	56°	+15°	**NOO**				147°	+24°			**AMO**	
Nov	15	61°	+23°	60°	+16°	81°	+16°			150°	+23°			112°	+2°
Nov	20	65°	+24°	64°	+16°	84°	+16°	**PHO**		153°	+21°			116°	+1°
Nov	25	70°	+24°			88°	+16°	4°	−26°	156°	+20°	**PUP**		120°	0°
Nov	30	74°	+24°	**GEM**		92°	+16°	7°	−27°	159°	+19°	130°	−44°	91°	+8°
Dec	5	85°	+23°	103°	+33°	149°	+37°	10°	−27°	122°	+3°	132°	−44°	98°	+9°
Dec	10	90°	+23°	108°	+33°	153°	+35°	13°	−28°	126°	+2°	135°	−44°	101°	+8°
Dec	15	96°	+23°	113°	+33°	157°	+33°			130°	+1°	138°	−44°	105°	+7°
Dec	20	101°	+23°	118°	+32°	161°	+31°			134°	0°	217°	+76°	108°	+7°
Dec	25	106°	+22°			166°	+28°			**HYD**		217°	+74°	**MON**	
Dec	30	111°	+21°	226°	+50°	170°	+26°					**URS**			
		ANT		**QUA**		**COM**									

Table 6a. Dates and radiant positions (in α and δ) for the sources of possible or additional activity described in the text.

Shower (or parent)	Activity Date	$\lambda_\odot$ 2000.0	Radiant α	Radiant δ	Details see page
72P/Denning-Fujikawa	Jan 07	286°.70	292°	−21°	3
κ-Cancrids (793 KCA)	Jan 10	289°.315	138°	+9°	3
Camelopardalids (451 CAM)	May 23	62°.75	123°	+80°	6
July γ-Draconids (184 GDR)	Jul 28	125°.132	280°	+51°	9
Perseids (007 PER)	Aug 12	139°.81	48°	+58°	12
October Draconids (009 DRA)	Oct 08	195°.134	263°	+56°	16
Leonids (013 LEO)	Nov 14	232°.461	152°	+22°	14
	Nov 20	237°.81-85	155°	+21°	14
Phoenicids (254 PHO)	Nov 14	232°.084	7°	−8°	19
	Nov 15	233°.698	7°	−9°	19
	Nov 17	235°.357	7°	−10°	19
Ursids (015 URS)	Dec 22	270°.14	218°	+76°	21

Table 7. Working List of Daytime Radio Meteor Showers. According to the naming rules, all shower names have the prefix 'Daytime' which is omitted in our Table. We only included showers which are listed as "established" in the IAU MDC database and are strong enough for forward scatter observations ($W_{\mathrm{Cmax}} > 500$ in Brown et al., 2010). For recent activity data compiled here see Ogawa (2022; 2023). See also the Table of northern summer daytime showers on page 6. In most cases, the start and end of the activity period are uncertain and the given values are tentative. For the 144 APS we refer to the values provided by Ogawa (2022) and described on page 6.

Shower	Activity	Max Date	$\lambda_\odot$ 2000.0	Radiant α	Radiant δ
April Piscids (144 APS)	Apr 20 – Apr 25	Apr 22	32°.6	5°	+5°
N. ω-Cetids (152 NOC)	May 01 – May 17	May 05	45°.5	9°	+17°
S. ω-Cetids (153 OCE)	May 01 – May 17	May 05	45°.5	20°	−6°
S. May Arietids (156 SMA)	May 01 – May 17	May 07	47°.1	28°	+8°
Arietids (171 ARI)	May 25 – Jun 20	Jun 07	77°.0	43°	+24°
ζ-Perseids (172 ZPE)	May 30 – Jun 20	Jun 09	78°.6	67°	+23°
β-Taurids (173 BTA)	Jun 15 – Jul 05	Jun 25	94°	82°	+20°
κ-Leonids (212 KLE)	Sep 20 – Sep 30	Sep 25	183°	162°	+15°
Sextantids (221 DSX)	Sep 15 – Oct 05	Oct 01	188°	156°	2°

10 Useful addresses

On the IMO's website http://www.imo.net you find online forms to submit visual reports and reports of fireball sightings. It is also possible to submit reports of visual observation sessions for other observers. You can also access all reports in the database, both of visual data and fireball reports.
Visual reports: http://www.imo.net → Observations → Add a visual observation session
Fireball reports: http://www.imo.net → Observations → Report a fireball

For more information on observing techniques, to see the latest results from well-observed major meteor showers and unusual shower outbursts, or when you wish to submit your results, please use the IMO's website, www.imo.net as your first stop. The web page also allows to access the data for own analyses. Questions can be mailed to the appropriate address (note the word "meteor" **must** feature in your message's "subject" line to pass the anti-spam filters):

For especially bright meteors: fireball@imo.net
For meteor still imaging: photo@imo.net
For forward-scatter radio observing: radio@imo.net
For meteor moving-imaging: video@imo.net
For visual observing: visual@imo.net

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Radio Commission: Christian Steyaert, Kruisven 66, B-2400 Mol, Belgium; e-mail: steyaert@vvs.be

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

Visual Commission: Jürgen Rendtel, Eschenweg 16, D-14476 Potsdam, Germany; e-mail: jrendtel@web.de

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