International Meteor Organization

2018 Meteor Shower Calendar

edited by Jürgen Rendtel [1]

1 Introduction

Welcome to the twenty-eighth International Meteor Organization (IMO) Meteor Shower Calendar. The main intention is to draw the attention of observers to regularly returning meteor showers as well as to provide information about events which may be possible according to model calculations. This includes both the possibility of extra meteor activity in terms of additional peaks and/or enhanced rates but also the observational evidence of no rate or density enhancement. Both may help to improve our knowledge about the numerous effects and interactions between meteoroid parent objects and the streams. Further, the Calendar hopefully continues to be a useful tool to plan your meteor observing activities.

Nowadays, video meteor networks are operational throughout the year which are less affected by moonlit skies than visual observers. So we refer to the moonlight conditions first of all for the visual observer. The moonlight circumstances for observations of the three strongest annual shower peaks bring an almost full Moon for the Quadrantids, an almost new Moon for the Perseids and a waxing crescent for the Geminids. Conditions for the maxima of the Lyrids (first quarter Moon), the Orionids (shortly before full Moon), and the Leonids (after first quarter) leave only little periods free of moonlight. The η-Aquariids are moonlit (waning gibbous), while the Southern δ-Aquariids and the Ursids reach their maxima close to the full Moon. The Draconids occur at new Moon.

Some interesting events are announced for 2018, although no spectacular outburst is predicted. Since there is always a possibility of completely unexpected events, ideally meteor observing should be performed throughout the year. While often there are many observers active during periods of high or medium activity, one should keep in mind that new events may happen at other times too. Continuous monitoring is possible with automated video systems and by radio/radar systems, but is also worthwhile for visual observers during moon-free nights. This way we can improve the data for established sources, including their outer ranges. Combining data obtained with different techniques may increase the reliability of derived quantities and is helpful for calibrating purposes. Since regular visual observations may be impractical for many people, however, one of the aims of the Shower Calendar is to highlight times when a particular effort might be most usefully employed. It indicates as well specific projects which need good coverage and attention.

[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. Particular thanks are due to David Asher, Peter Jenniskens, Hutch Kinsman, Esko Lyytinen, Mikhail Maslov, Regina Rudawska, Mikiya Sato and Jérémie Vaubaillon for new information and comments in respect of events in 2018 (see also the *References* in section 8). Koen Miskotte summarized information for the SDA and CAP activity in late July. Last but not least thanks to David Asher, Alastair McBeath, Robert Lunsford and Sirko Molau for carefully checking the contents.

The heart of the Calendar is the Working List of Visual Meteor Showers (Table 5) 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! To allow for better correlation with other meteor shower data sources, we give the complete shower designation including the codes taken from IAU's Meteor Data Center listings.

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 Bootids and the October Draconids. From stream modelling calculations we know that one meteoroid stream may cause several meteor showers, and that a stream may be related to more than one parent object.

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 – although attempts with optical observations can be useful too. Some of the showers are listed in Table 7, the Working List of Daytime Meteor Showers.

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 and 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.

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

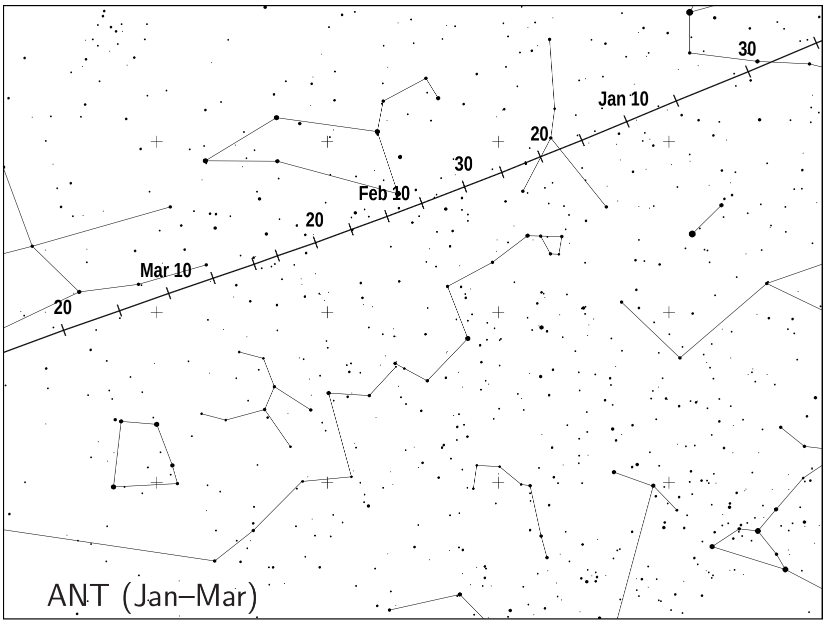
2 Antihelion Source

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 why, because 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 streams as coming from the ANT alone. Apart from this, we have been able to retain the July-August α-Capricornids, and particularly the Southern δ-Aquariids 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 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

The year starts with the **Quadrantid (010 QUA)** peak for the northern hemisphere observers on January 3 just after full Moon. The peak time based on the previous returns should be close to 22^{h} UT.

Favourable conditions will allow monitoring the **γ Ursae Minorids (404 GUM)** as well as late parts of the long-lasting **December Leonis Minorids (032 DLM)** which can be traced until early February. The southern hemisphere's **α-Centaurids (102 ACE)** in February and the possible minor **γ-Normids (118 GNO)** of March can be well observed.



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, although IMO analyses of visual data have suggested there may be an ill-defined minor peak with ZHRs ≈ 2 to 3 around $\lambda_{\odot} \approx 286°$–$293°$ (2018 January 6 to 13). ZHRs could be ≈ 3 for most of March with a slight increase derived from video flux data around $\lambda_{\odot} \approx 355°$ (2018 March 17).

Weak meteor activity may occur on March 20, at $22^{h}21^{m}$ UT associated with the minor planet $2016BA_{14}$, as forecast by Regina Rudawska. The radiant of these very slow meteors ($V_{\infty} = 17$ km/s) should be at $\alpha = 90°$, $\delta = -50°$ so will be visible from southern latitudes only. Observations are needed to confirm activity, and hence the association.

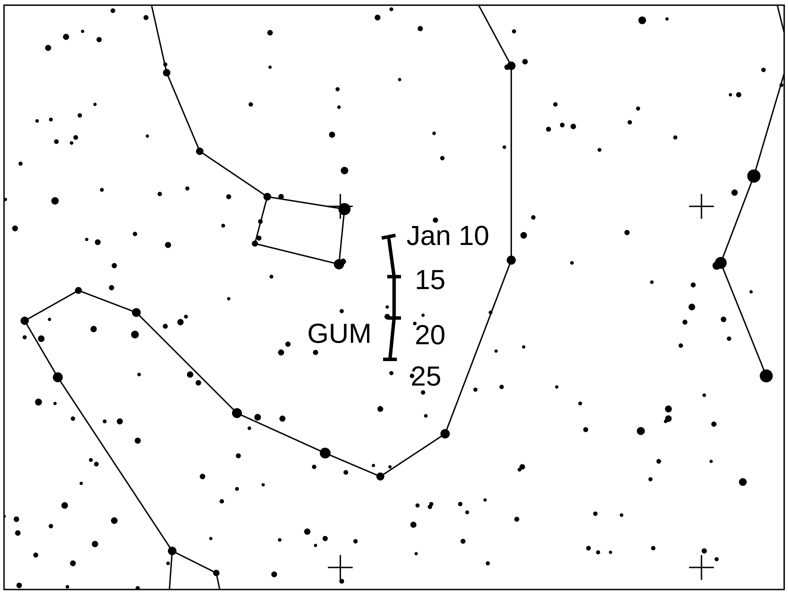
The list of possible events of Peter Jenniskens from 2006 includes a possible encounter with the 1-revolution trail of comet C/1907 G1 on March 31 at $11^{h}47^{m}$ UT ($\lambda_{\odot} = 10\overset{\circ}{.}463$ with an uncertainty of ± 1 hour at least). The radiant is far south at $\alpha = 309°$, $\delta = -60°$. Unfortunately this occurs at full Moon, but nevertheless it is worth to check whether and when there is any activity detectable as it may help us to improve our understanding of stream evolution.

On 2015 January 10 at $02^{h}50^{m}$ UT, radar and video data showed a short outburst of the **κ-Cancrids (793 KCA**; radiant at $\alpha = 138°$, $\delta = +9°$) at $\lambda_{\odot} = 289\overset{\circ}{.}315$. Activity was also found in the 2016 video data (Molau et al., 2017). Although there are no visual data available yet, observers are encouraged to check especially the period around 2018 January 09, 21^{h} UT for possible activity. The radiant of the Antihelion source centre is at $\alpha = 122°$, $\delta = +19°$, i.e. roughly 20° southeast, and the KCA meteors ($V_{\infty} = 47$ km/s) are faster than the ANT ($V_{\infty} = 30$ km/s).

Expected approximate timings for the **daytime shower maxima** this quarter are:
Capricornids/Sagittariids (115 DCS) – February 1, 16^{h} UT and χ-Capricornids (114 DXC) – February 13, 17^{h} UT. Recent radio results have implied the DCS maximum may fall variably sometime between February 1–4 however, while activity near the expected DXC 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.

γ-Ursae Minorids (404 GUM)

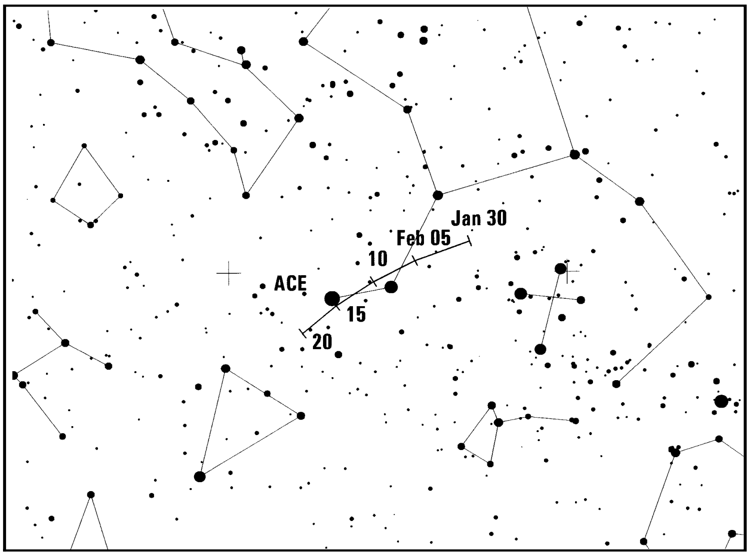
Active: January 10–22; Maximum: around January 18 ($\lambda_{\odot} = 298°$); ZHR ≈ 3; Radiant: $\alpha = 228°$, $\delta = 67°$; Radiant drift: see Table 6; $V_{\infty} = 31$ km/s; $r = 3.0$.



Little is yet known about this minor shower which has been detected in video and visual data recently. 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 need further confirmation. New Moon on January 17 provides excellent conditions for all observational efforts.

α-Centaurids (102 ACE)

Active: January 31–February 20; Maximum: February 8, 07^h 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; $V_\infty = 58$ km/s; $r = 2.0$.



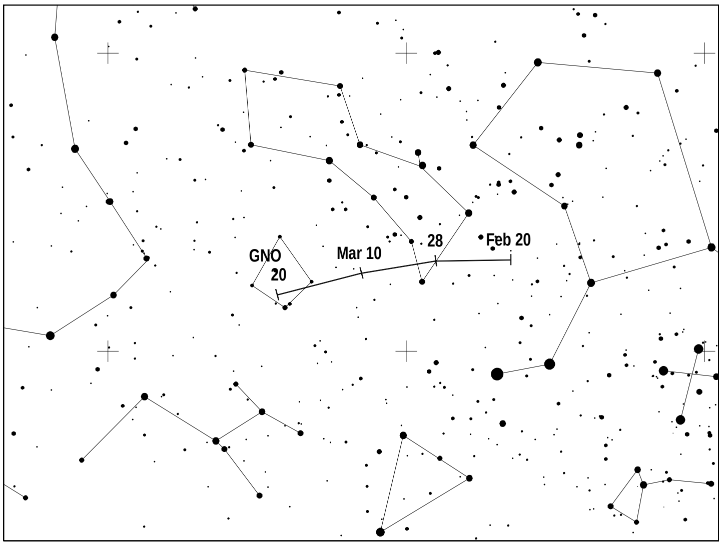
The α-Centaurids are one of the main southern summer high points, from past records supposedly producing bright, even fireball-class, objects. The average peak ZHR between 1988–2007 was merely 6 though (WB, p. 18), albeit coverage has frequently been extremely patchy. Despite this, in 1974 and 1980, bursts of only a few hours' duration apparently yielded ZHRs closer to 20–30. Significant activity was reported on 2015 February 14 (airborne observation) although there was no confirmation of an outburst predicted for 2015 February 8. Hence further data is needed to obtain information about the structure and extension of the stream. Based on video data, the given activity period is slightly shortened compared to the previous editions. 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 just after last quarter Moon, so is favourable for dark-sky coverage increasingly later in the night.

γ-Normids (118 GNO)

Active: February 25–March 28; Maximum: March 14 ($\lambda_\odot = 354°$); ZHR = 6; Radiant: $\alpha = 239°$, $\delta = -50°$, Radiant drift: see Table 6; $V_\infty = 56$ km/s; $r = 2.4$.

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). Results since 1999 have suggested the possibility of a short-lived peak alternatively between $\lambda_\odot \approx 347°–357°$, equivalent to 2018

March 8–18. Recent video and visual plotting information confirmed activity from that region, but a new analysis of video data obtained only from locations south of the equator has indicated that the activity occurs preferentially around March 25 ($\lambda_\odot = 4°$) instead, from a radiant at $\alpha = 246°$, $\delta = -51°$. 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). Moonlight circumstances are very favourable for any of the potential peak timings this year, with an early-setting waxing Moon, new on March 17.



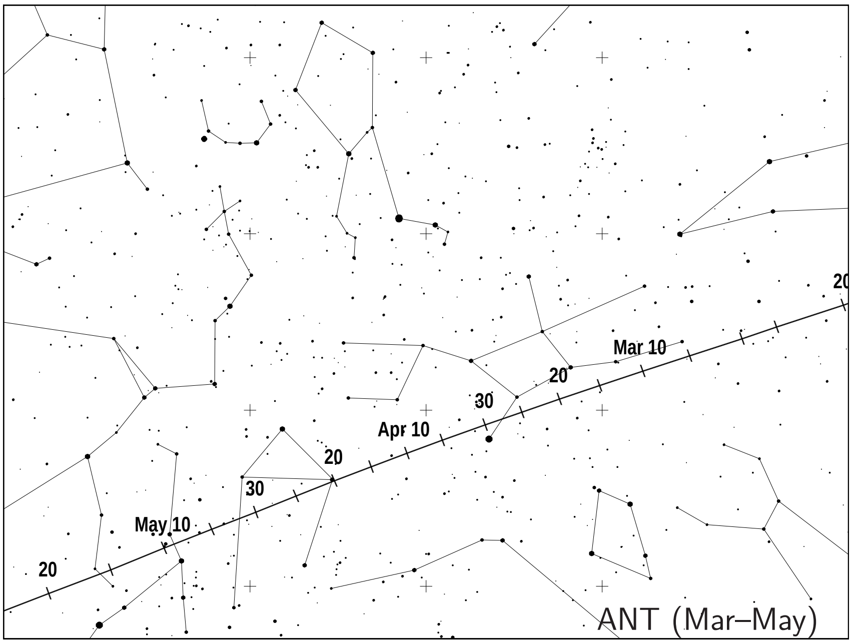
4 April to June

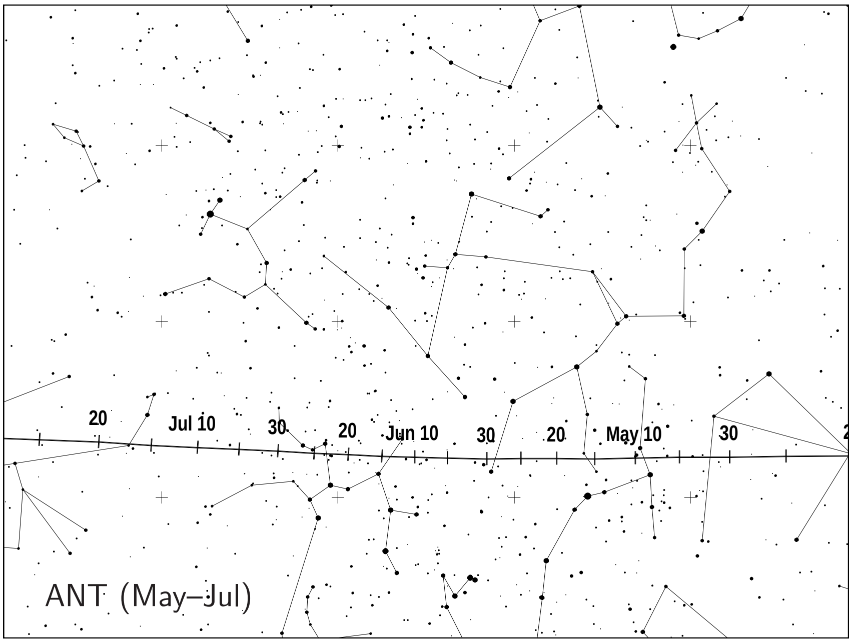
Meteor activity increases towards the April-May boundary, particularly caused by optically unobservable showers. The **Lyrid (006 LYR)** maximum has little moolight interference, but the **π-Puppids (137 PPU)** are less fortunate with the visibility of the waxing gibbous Moon coinciding with when their radiant is suitable above the horizon during the evening for southern latitude observers. The known peak position of the PPU is reached near 0^h UT on April 24.

A waning gibbous moon (full on April 30, last quarter on May 8) will badly affect optical observations of the **η-Aquariids (031 ETA)** this year, with their peak due on May 6. Nevertheless, it is recommended to record the activity: research initiated by an investigation of ETA observations back in the Maya period by Hutch Kinsman shows a slight enhancement on May 3 centred at 19^h11^m UT ($\lambda_\odot = 43.^\circ042$) due to a Jovian 1:8 resonance of the 164 BC trail of the parent comet 1P/Halley. The particles would be small. Further, there are three solutions for May 5 due to a 1:8 Jovian resonance of the comet's AD 218 trail. The first occurs at 05^h49^m UT ($\lambda_\odot = 44.^\circ441$), the second occurs at 07^h34^m UT ($\lambda_\odot = 44.^\circ511$) and the third at 07^h35^m UT ($\lambda_\odot = 44.^\circ512$) All of these particles would be small. Perhaps the combination of the latter two enhancements would have the best chance of being seen under good circumstances and the direct moonlight shielded.

Moonlight also affects the **η-Lyrids (145 ELY)** with an expected peak on May 9 or slightly later. The **June Bootids (170 JBO)** produced unexpected activity in 1998 and 2004. This year, their likely peak periods around June 23 (outburst and annual video data) or June 27 (outburst only) are unhelpfully moonlit, with full Moon on June 28. At least, there are currently no known predictions for rate enhancements based on model calculations in-force for 2018.

According to analyses of visual and video IMO data, the **ANT** should produce ZHRs between 2 and 4 with insignificant variations. There may be a rather slow increase towards end-May followed by a decrease into July. 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.





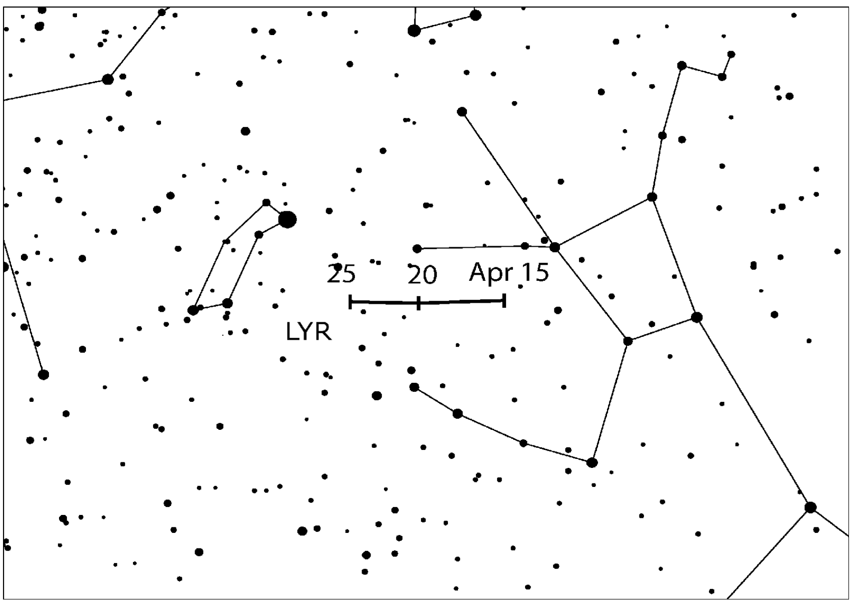
Daytime showers: In the second half of May and throughout June, most of the annual meteor action switches to the daylight sky, with several shower peaks expected during this time. For radio observers, the expected UT peak times for these showers are as follows:
April Piscids (144 APS) – April 22, 22^h;
ε-Arietids (154 DEA) – May 9, 15^h;
May Arietids (294 DMA) – May 16, 16^h;
o-Cetids (293 DCE) – May 20, 15^h;
Arietids (171 ARI) – June 7, 16^h (more details see page 9);
ζ-Perseids (172 ZPE) – June 9, 18^h;
β-Taurids (173 BTA) – June 28, 17^h.

Signs of most were found in radio data from 1994–2008, though some are difficult to define individually because of their proximity to other radiants. The maxima of the Arietids and ζ-Perseids tend to blend into one another, producing a strong radio signature for several days in early to mid June. The shower maxima dates are not well established and may occur up to a day later than indicated above. There seems to be a modest recurring peak around April 24 as well, perhaps due to combined rates from the first two showers listed here, and possibly the δ-Piscids, which we previously listed for many years as having a peak on April 24, although the IAU seems not to recognise this currently as a genuine shower. Similarly, there are problems in identifying the o-Cetids in the IAU stream lists, despite the fact this (possibly periodic) source was detected by radar more strongly that the η-Aquariids of early May when it was first observed in 1950–51. The current number and abbreviation given here for it is actually for the IAU source called the "Daytime ω-Cetid Complex", because that seems a closer match to the o-Cetids as defined by earlier reports.

Lyrids (006 LYR)

Active: April 14–30; Maximum: April 22, $18^{\rm h}$ UT ($\lambda_\odot = 32\overset{\circ}{.}32$, but may vary – see text);
ZHR = 18 (can be variable, up to 90);
Radiant: $\alpha = 271°$, $\delta = +34°$; Radiant drift: see Table 6;
$V_\infty = 49$ km/s; $r = 2.1$

The $\lambda_\odot = 32\overset{\circ}{.}32$ timing given above is the maximum position found in *IMO* results from 1988–2000. However, the maximum time was variable from year to year between $\lambda_\odot = 32\overset{\circ}{.}0$–$32\overset{\circ}{.}45$ (equivalent to 2018 April 22, $10^{\rm h}$ to April 22, $21^{\rm h}$ UT). Activity was variable too. A peak at the ideal time produced the highest ZHRs, ≈ 23, while the further the peak happened from this, the lower the ZHRs were, down to ≈ 14. (The last very high maximum was in 1982, when a short-lived ZHR of 90 was recorded.) The mean peak ZHR was 18 over the thirteen years examined. Further, the shower's peak length varied: using the Full-Width-Half-Maximum time (the period ZHRs were above half the peak level), a variation between 14.8 to 61.7 hours was detected (mean 32.1 hours). The best rates are normally achieved for just a few hours even so. The analysis also confirmed that occasionally, as their highest rates occurred, the Lyrids produced a brief increase in fainter meteors.



For 2018 there are no predictions for any activity increase from theoretical modelling. Lyrid meteors are best viewed from the northern hemisphere, but are visible from many sites north and south of the equator. As the radiant rises during the night, watches can be carried out usefully after about $22^{h}30^{m}$ local time from mid-northern sites, but only well after midnight from the mid-southern hemisphere. Moon's first quarter on April 22 leaves just the morning hours undisturbed. Based on video data, we give a slightly extended activity period for the Lyrids. There were several reports particularly from the end of April including recognizeable numbers of shower meteors.

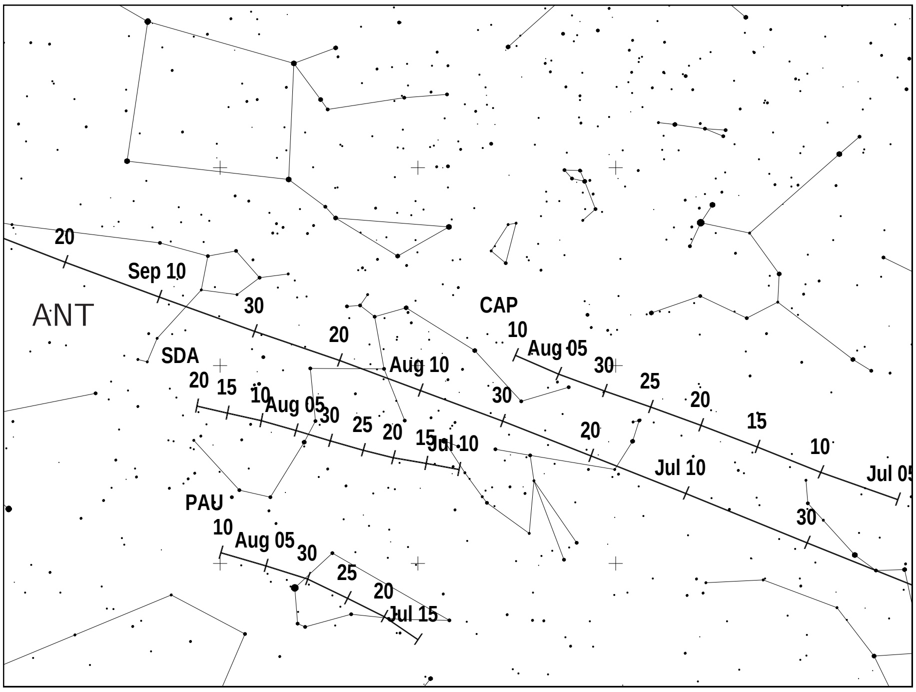
Daytime Arietids (171 ARI)

Active: May 14–June 24 (uncertain); Maximum: June 07 ($\lambda_{\odot} = 76.^{\circ}6$);
ZHR ≈ 30(?);
Radiant: $\alpha = 44^{\circ}$, $\delta = +24^{\circ}$; Radiant drift: see Table 6;
$V_{\infty} = 38$ km/s; $r = 2.8$.

The radiant is located only about 30° west of the Sun, but despite that, a few optical observations have been repeatedly reported from it in the past. However, its low radiant elevation by the time morning twilight is too bright means the number of shower meteors recorded by individual video or visual observers is always low. Consequently, an ongoing IMO project to pool data on the shower using all techniques was initiated in 2014, to combine results from many independent observing intervals, even those periods which contain few, or even no ARI meteors. The currently available video data do not show a clear profile but a recognizable activity level over a week or so. Hence all contributions for this project will be most welcome! Since both the correction factor for radiant elevation and the observing conditions change rapidly in the approach to morning twilight in early June, it is recommended that visual observers break their watches into short intervals (of the order of about 15 minutes), determining the limiting magnitude frequently for each interval. Observers at latitudes south of about 30°N are better placed because of the significantly poorer twilight conditions further north in June.

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 that ZHRs for most of the month should be ≈ 2 to 3. The large ANT radiant area overlaps that of the minor **α-Capricornids (001 CAP)** in July-August, but the lower apparent velocity of the CAP allows observers to separate the two. The **Southern δ-Aquariids (005 SDA)** are strong enough, and the **Piscis Austrinids (183 PAU)** have a radiant distant enough from the ANT area, that both should be more easily separable from the ANT, particularly from the southern hemisphere. Full Moon on Jul 27 will badly affect the period of highest rates from these southern radiants which are due on July 27 (PAU) and July 30 (CAP, SDA), respectively.



New Moon on August 11 provides optimal conditions for observations of the **Perseids (007 PER)** before and around the peak. This also holds for the first part of the minor **κ-Cygnids (012 KCG)**. Later, conditions are poor to check the **Aurigid (206 AUR)** peak on September 1, as last quarter Moon is not until September 3. There are no predictions for known activity enhancements in 2018 from this source. A week or so later, and the better activity of the **September ε-Perseids (208 SPE)** is much more favourable for any possible peculiarities this time.

On 2016 July 28 at $00^{\mathrm{h}}07^{\mathrm{m}}$ UT a remarkable outburst (ZHR probably of the order of 100) of the **July γ-Draconids (184 GDR)** was detected by radar and video observations (Molau et al., 2017). The same position is reached again on 2018 July 28 near $12^{\mathrm{h}}30^{\mathrm{m}}$ UT, well worth a check whether something is observable around this time – despite the lunar circumstances. The radiant is at $\alpha = 280°$, $\delta = +51°$, and the meteors have medium speed ($V_\infty = 27$ km/s).

In 2015, several video data sets showed low rates had persisted essentially throughout September, identified as originating with the **χ-Cygnids (757 CCY)**. A weak maximum was found on September 14/15 (ZHRs about 2 or 3). The shower was also suspected in previous years, but at a lower activity level, hence further observations would be useful. First quarter moon on September 16 provides good conditions for optical observations to improve our knowledge of this minor source. The radiant of these very slow meteors ($V_\infty = 19$ km/s) is at $\alpha = 300°$, $\delta = +31°$. For convenience, we have included the radiant drift in Table 6.

Calculations by Jérémie Vaubaillon hint at a possible activity on **September 20**, 13^h24^m UT, from a radiant at $\alpha = 327°$, $\delta = +77°$ (i.e. in northwestern Cepheus, about halfway between γ and κ Cephei). The meteors are associated with the minor planet 2009 SG_{18} and should enter the Earth's atmosphere at 34 km/s. This is an occasion where data is needed to confirm the link and the activity at all.

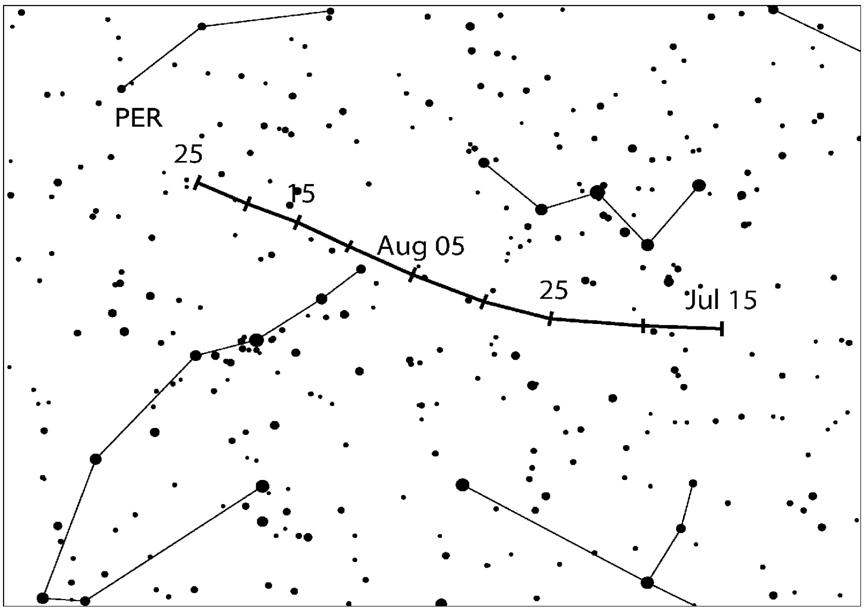
Visual and imaging observers are encouraged to catch some **Daytime Sextantids (221 DSX)** in the pre-dawn of late September to early October. Most parameters of the shower are yet uncertain. The full Moon on September 25 adds little to the problem with poor limiting magnitude due to the twilight as the radiant is roughly 30° west of the Sun. As with the Arietids, both the radiant elevation correction and the observing conditions change rapidly as morning twilight approaches. Hence visual observers should report their data in short intervals, no longer than about 15–20 minutes.

Remember that the **Southern Taurids (002 STA)** begin around September 10, effectively taking over the near-ecliptic activity from the ANT through to December.

For **daylight radio observers**, the high activity of May-June has waned, but there remain the γ-Leonids (203 GLE; peak due near August 25, 17^h UT, albeit not found in recent radio results), and the Sextantids (221 DSX; see above).

Perseids (007 PER)

Active: July 17–August 24; Maximum: August 12, 20^h to 13, 08^h UT (node at $\lambda_\odot = 140.^\circ0$–$140.^\circ1$), but see text; ZHR = 110;
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 2018 August 12, 20^h to August 13, 08^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 with additional peaks due to passages through separated dust trails. Such peaks are not to be expected for the 2018 return. Instead, a possible encounter with a Perseid filament is announced for August 12 around 20^h UT ($\lambda_\odot \approx 139.^\circ79$) by Peter

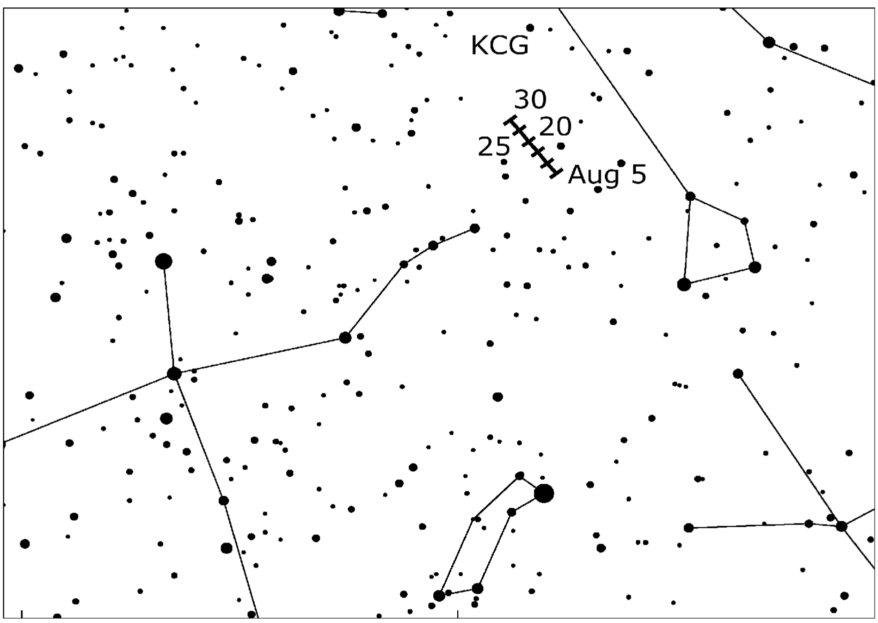
Jenniskens. The filament is thought to be an accumulation of meteoroids in a mean-motion resonance. Observations are needed to see what is detectable around this position which is right at the start of the given peak period. An additional potential enhancement due to a very old dust trail on August 13 at 01^h37^m UT, found in computations by Jérémie Vaubaillon, may give only negligible rates anyway, thus could easily pass unnoticed within the normal main maximum period. Visual observers should break their reports into short intervals (no longer than 15 minutes for both rate and magnitude data) for the entire period, this way allowing to search for signatures of the trail and filament, respectively.

New Moon on August 11 provides perfect conditions for all optical observations. Sites at mid-northern 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. Regrettably, the shower cannot be properly viewed from most of the southern hemisphere.

κ-Cygnids (012 KCG)

Active: August 3–25; Maximum: August 18 ($\lambda_\odot = 145°$); ZHR = 3;
Radiant: $\alpha = 286°$, $\delta = +59°$; Radiant drift: see Table 6;
$V_\infty = 25$ km/s; $r = 3.0$.

The κ-Cygnids showed enhanced activity in 2014 and 2007. Apart from these events, the general ZHR level seems to increase in the recent years, from an apparent dip in the period 1990–2005. However, the currently-available data do not confirm a periodic activity variation in the visual activity range, and for 2018 there are no available predictions suggesting further peculiarities may occur. VID suggested a number of discrepancies to the currently-accepted parameters listed above, including that the peak might happen closer to August 14, and that activity might be present only from August 6–19 overall. The shower is best-observed from northern hemisphere sites, from where the radiant is easily available all night. The radiant has been found to be rather complex with several sub-centres around the predicted position extending towards the constellations of Draco and Lyra. Due to their low velocity, visual shower association may be possible tying individual meteors to these sub-radiants. Consequently observers should be aware that the shower may not behave as it is "supposed to"!

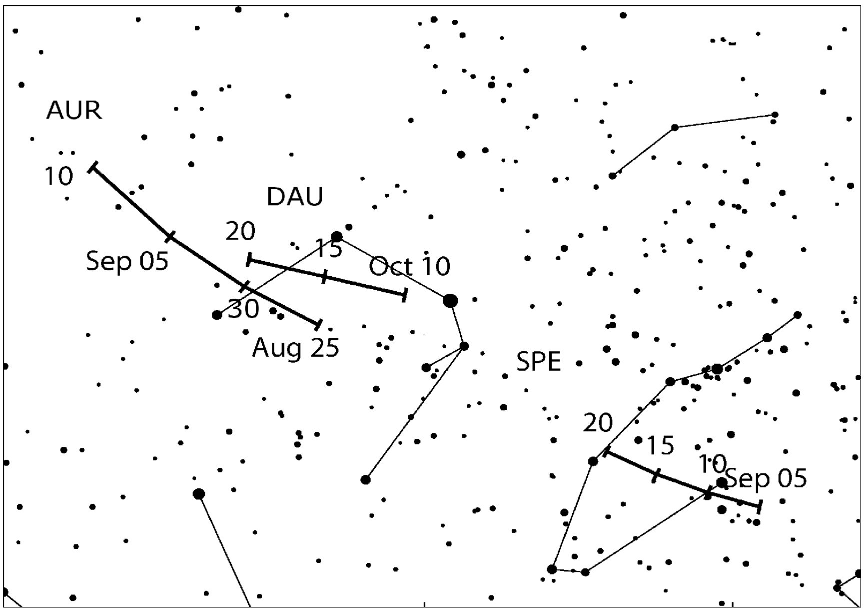


September ε-Perseids (208 SPE)

Active: September 5–21; Maximum: September 9, 16^h UT ($\lambda_\odot = 166.^\circ 7$), and possibly September 9, 19^h UT ($\lambda_\odot = 166.^\circ 8$) – see text; ZHR = 5; Radiant: $\alpha = 48^\circ$, $\delta = +40^\circ$; Radiant drift: see Table 6; $V_\infty = 64$ km/s; $r = 3.0$.

New Moon on September 9 provides excellent observing conditions for 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. This shower produced outbursts of swift, bright meteors 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. Esko Lyytinen's modelling has suggested the next really impressive SPE return may not be before 2040.

Assuming a long period cometary orbit (roughly 1000 year period) and based on the timing of the two recent events (with the 2013 considering closest to the potential parent orbit), Mikiya Sato's calculations hint at a possible outburst on 2018 September 09, 19^h12^m UT ($\lambda_\odot = 166.^\circ 801$) which – although difficult to estimate – may be comparable to the above mentioned events.



6 October to December

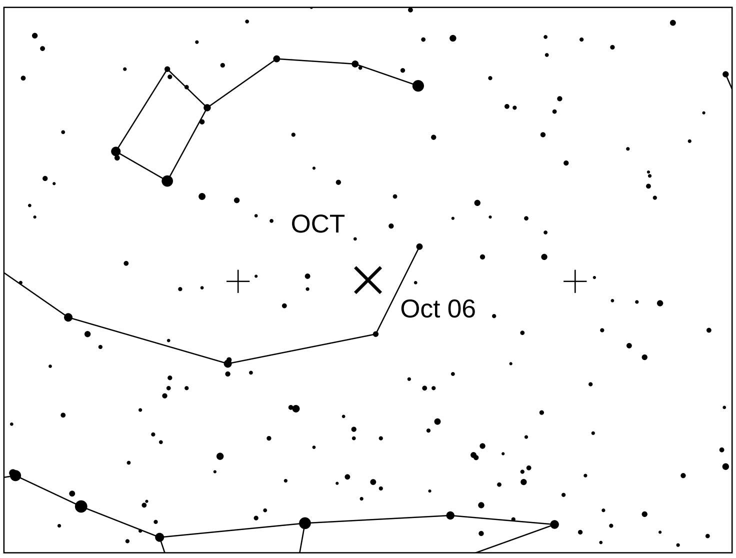
During the last quarter of the year many of the more significant showers are observable under good lunar conditions, as detailed below. The less well-placed shower peaks include those of the **Leonis Minorids (022 LMI)** on October 24, the **November Orionids (250 NOO)** on November 28, the **Phoenicids (254 PHO)** on December 2, the weak **Comae Berenicids (020 COM)** on December 16 and the **December Leonis Minorids (032 DLM)** on December 20. 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.

The "lost" comet 3D/Biela should theoretically reach perihelion at the end of 2018. A weak return of the Andromedids, which now appear as **December φ-Cassiopeids (446 DPC)**, is possible in early December according to work of Paul Wiegert and colleagues back in 2012. A return of this source in 2008 (the ZHR-equivalent was estimated at ≈ 30) was detected in CMOR radar data. The radiant should be at $\alpha = 18°$, $\delta = +56°$, and meteors are extremely slow ($V_\infty = 16$ km/s).

The **α-Monocerotids (246 AMO)** on November 21 and the **Ursids (015 URS)** on December 22 are also badly affected by moonlight, but both would benefit from monitoring in 2018. The **AMO** may show a peak at November 22 around 00^h50^m UT from modelling by Mikiya Sato using a 1-revolution trail of a long-periodic object, which suggested possible activity in all years between 2016 and 2019. In 2016, the radio data indicated a probable AMO peak. The prediction for 2018 hints at a lower rate than in 2016. The 2017 event is still to come as this Calendar was being written, which may give further clues for events in 2018. Despite the unfavourable moonlight conditions, the expected maximum interval should be carefully checked for any unusual activity. On December 22 around $19^h - 20^h$ UT, according to Peter Jenniskens, the Earth may encounter an **URS filament** of meteoroids in a mean-motion resonance. Any unusual activity recorded around this time, despite the bright Moon, needs reporting to try to confirm this.

October Camelopardalids (281 OCT)

Active: October 5–6; Maximum: October 6, 03^h30^m ($\lambda_\odot = 192.°58$); ZHR = 5(?)
Radiant: $\alpha = 164°$, $\delta = 79°$; Radiant drift: negligible;
$V_\infty = 47$ km/s; $r = 2.5$ (uncertain).



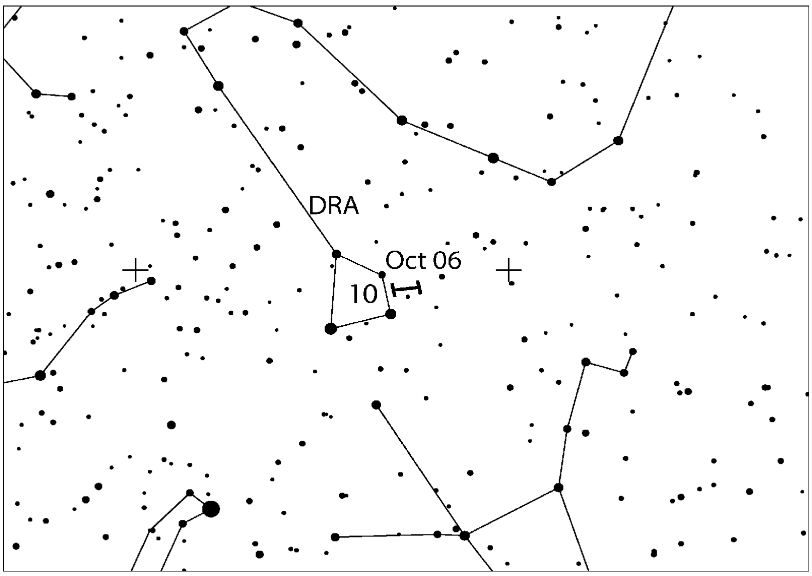
Short-lived video outbursts were first recorded in 2005 and 2006 on October 5/6 (near $\lambda_\odot 193°$) from this north-circumpolar radiant. The shower has been detected annually (Molau et al., 2017) and produced a peak at $\lambda_\odot = 192\overset{\circ}{.}58$ repeatedly with an estimated ZHR of about 5. Enhanced activity was found last on 2016 October 5 at the predicted position at 14^h45^m UT in radio forward scatter data and video camera data from Finland.

Assuming a long-period parent, and using the 2005 outburst as reference point, we might see similar activity on 2018 October 06, 02^h16^m UT ($\lambda_\odot = 192\overset{\circ}{.}529$). Both the recurrent maximum given in the box and the calculated position are favourable for observers at European longitudes and occur close to new Moon.

Draconids (009 DRA)

Active: October 6–10; Maximum: October 9, 00^h10^m UT ($\lambda_\odot = 195\overset{\circ}{.}4$), but see text;
ZHR = 10+;
Radiant: $\alpha = 263°$, $\delta = +56°$; Radiant drift: negligible;
$V_\infty = 21$ km/s; $r = 2.6$.

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 ≈ 20–500+). Most detected showers were in years close to when the stream's parent comet, 21P/Giacobini-Zinner, returned to perihelion. The next perihelion will be on 2018 September 10. Recent outbursts happened in 2011 October (ZHR ≈ 300) under bright moonlight then, and wholly unexpectedly on 2012 October 8 (chiefly very faint meteors, detected primarily by the Canadian CMOR meteor radar system). Outlying maximum times from the recent past have spanned from $\lambda_\odot = 195\overset{\circ}{.}036$ (in 2011), equivalent to 2018 October 08, 15^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 ≈ 10–20), equating to 2018 October 09, 08^h50^m UT.



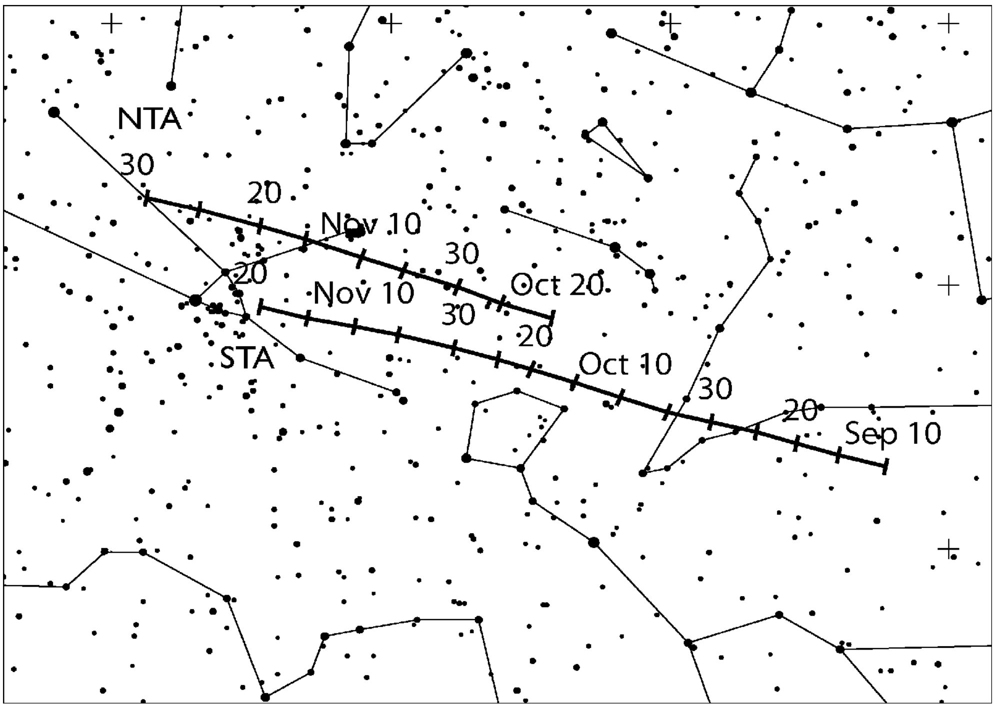
Mikiya Sato has found an approach of the Earth to the comet's 1953 dust trail. This trail was slightly disturbed when it approached the Earth in 1985. As a consequence, the dust should be spread somewhat, but could still produce recognizeable rates. By comparison to the 2011 return of the 1900 dust trail, a ZHR in the range 20–50 may be expected on October 9, 00^h14^m UT ($\lambda_\odot = 195\overset{\circ}{.}406$). Modelling the Draconids using recent ephemeries from JPL, Jérémie Vaubaillon noted a possible maximum on October 8 at 23^h31^m UT instead ($\lambda_\odot = 195\overset{\circ}{.}374$), with a ZHR of about 15. Mikhail Maslov's modelling found several dust trails, but none of them close enough to cause high rates in 2018. The closest was the 1953 trail which has been rarified due to previous Earth encounters. Even so, he suggests a ZHR of 10–15 may occur on October 8, 23^h34^m UT.

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 (002 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; $r = 2.3$.

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, about $20° \times 10°$, $\alpha \times \delta$, 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 visual 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 a nearly new 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 clear of the horizon.



δ-Aurigids (224 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; $r = 3.0$.

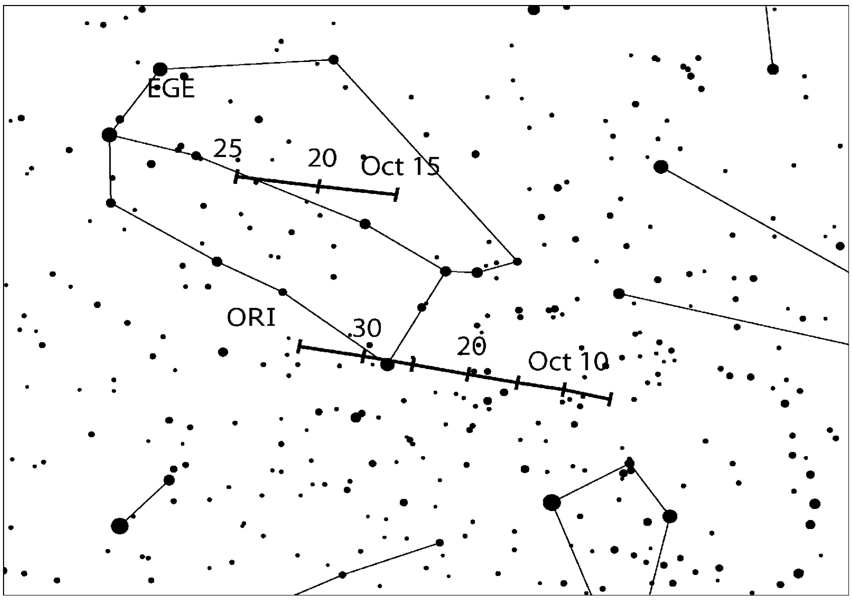
The weakest of the three known persistent near-Auriga-Perseus showers of late August to October, visual observers seem to have struggled to properly identify this minor source previously, and its current parameters are based on a detailed review of IMO video data since the late 1990s. This year the entire activity can be monitored. The radiant area is visible chiefly from the northern hemisphere (see chart on page 13), from where it can be properly observed after local midnight.

During the period from late September until mid-October, other sources from this northern region have been found active. The overall picture is not yet clear. Probably the Earth encounters a number of slightly different streams of variable number density over years. Several reports clearly state meteors e.g. of the September Lyncids (081 SLY) which are very similar in appearance and apparently 'connect' the activity periods of the SPE and DAU. Hence observers should try to apply plotting method to test association with radiants in the respective area in the sky.

ε-Geminids (023 EGE)

Active: October 14–27; Maximum: October 18 ($\lambda_\odot = 205°$); ZHR = 3; Radiant: $\alpha = 102°$, $\delta = +27°$; Radiant drift: see Table 6; $V_\infty = 70$ km/s; $r = 3.0$.

A weak minor shower with characteristics and activity nearly coincident with the Orionids, so great care must be taken to separate the two sources, preferably by video or telescopic work, or perhaps visual plotting. The waxing crescent Moon on October 18/19 will set before the radiant becomes usefully observable from either hemisphere. Northern observers have a radiant elevation advantage, with observing practical there from about midnight onwards. There is some uncertainty about the shower's parameters, with both visual and video data indicating the peak may be up to four or five days later than suggested above.



Orionids (008 ORI)

Active: October 2–November 7; Maximum: October 21 ($\lambda_\odot = 208°$); ZHR = 20+; Radiant: $\alpha = 95°$, $\delta = +16°$; Radiant drift: see Table 6; $V_\infty = 66$ km/s; $r = 2.5$.

October's waxing gibbous Moon sets after local midnight across much of the inhabited Earth for the peak night of October 21/22 this year. The shower's radiant is at a useful elevation from local midnight or so in either hemisphere, somewhat before in the north. Each return from 2006 to 2009 produced unexpectedly strong ZHRs of around 40–70 on two or three consecutive dates. An earlier IMO analysis of the shower, using data from 1984–2001, found both the peak ZHR and r parameters varied somewhat from year to year, with the highest mean ZHR ranging from $\approx$ 14–31 during the examined interval. In addition, a suspected 12-year periodicity in stronger returns found earlier in the 20th century appeared to have been partly confirmed. That suggested the lower activity phase of the cycle should fall between 2014–2016, so Orionid ZHRs may now slowly increase again (about 20–25 in 2018). The Orionids often provide several lesser maxima, helping activity sometimes remain roughly constant for several consecutive nights centred on the main peak. In 1993 and 1998, a submaximum about as strong as the normal peak was detected on October 17/18 from Europe, for instance. Particularly the pre-maximum period is well suited to check for possible peculiarities.

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; $r = 2.3$.

Some details on this branch of the Taurid streams were given with the Southern Taurids above. Other aspects are the same too, such as 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. 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. Whatever the case, new Moon on November 11 should allow plenty of coverage. (For the radiant drift graph see page 16.)

Leonids (013 LEO)

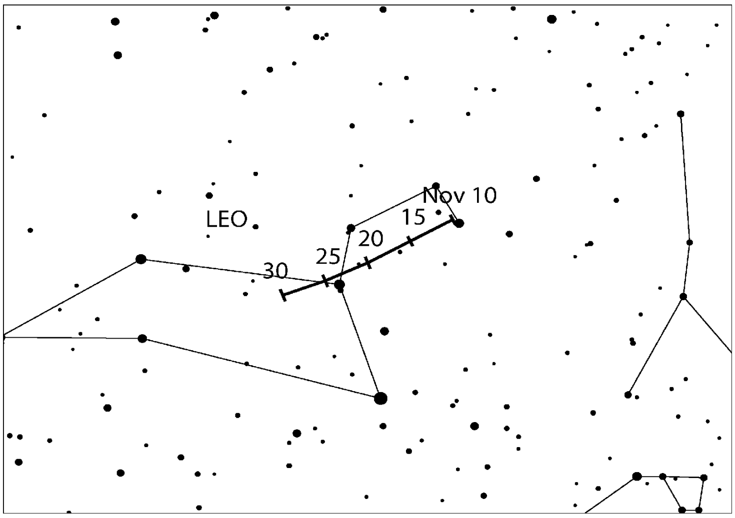
Active: November 6–30; Maximum: November 17, 22^h30^m UT (nodal crossing at $\lambda_\odot = 235.^\circ27$), but see text; ZHR $\approx 10 - 20$ Radiant: $\alpha = 152°$, $\delta = +22°$; Radiant drift: see Table 6; $V_\infty = 71$ km/s; $r = 2.5$.

The latest perihelion passage of the Leonids' parent comet, 55P/Tempel-Tuttle, in 1998 was two decades ago now. From an increased knowledge of the dust ejection mechanisms and trail evolution since then, variable activity has been both modelled and observed in several years more recently. The main (nodal) Leonid maximum should be reached three days after first quarter Moon in 2018. Since the shower's radiant is usefully observable only by local midnight or so north of the equator, afterwards for places further south, the morning hours remain undisturbed by moonlight for all observers.

Jérémie Vaubaillon's calculations have yielded four trails the Earth should approach this year, although none of them closely enough to cause high rates. The first encounter happens on November 18, 23^h27^m UT and may be one of the more promising trails. Weaker activity may occur on November 19, 23^h59^m UT (1069 trail) and November 21, 00^h54^m UT. A late encounter, with better prospects for recognizeable activity, although just after full Moon is reached on November 25, 23^h26^m UT (1567 trail).

Mikiya Sato reported two dust trails should pass close to the Earth, on November 19, 22^h20^m UT (1069 trail) and November 20, 07^h04^m UT (1433 trail) for their respective peak times. However, both trails have been perturbed a lot and should be quite thin, so the rate increase may be less than 10 and thus difficult to detect separately from the general shower rate.

Mikhail Maslov adds some additional, probably bright, Leonids may occur on November 20, 09^h30^m UT, from the 1466 trail. However, this is expected to be a minor effect and could be difficult to detect.



Puppid-Velids (301 PUP)

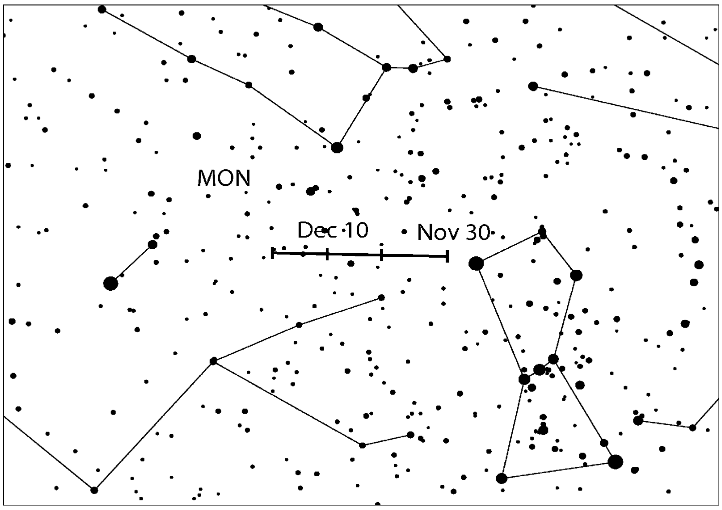
Active: December 1–15; Maximum: December ≈ 7 ($\lambda_\odot \approx 255°$); ZHR ≈ 10;
Radiant: $\alpha = 123°$, $\delta = -45°$; Radiant drift: see Table 6;
$V_\infty = 40$ km/s; $r = 2.9$.

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 (301 PUP representing an "average" position), with radiants so tightly clustered, visual observing cannot readily separate them. Video data would thus be helpful, 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 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 (019 MON)

Active: November 27–December 17; Maximum: December 9 ($\lambda_\odot = 257°$); ZHR = 3;
Radiant: $\alpha = 100°$, $\delta = +08°$; Radiant drift: see Table 6;
$V_\infty = 42$ km/s; $r = 3.0$.

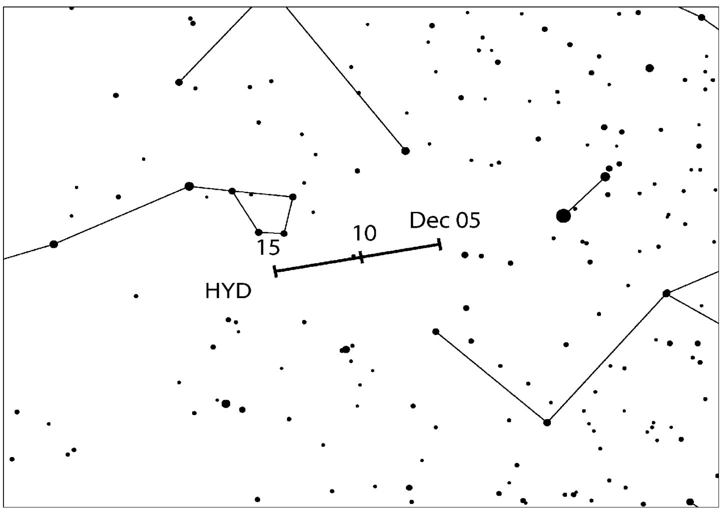
This very minor shower's details need further improvement by observational data. Visual data give a maximum of ZHR 2–3 at $\lambda_\odot \approx 257°$. Video data (2011–2016) show a peak at $\lambda_\odot \approx 262\overset{\circ}{.}0$ (i.e. December 14) with a ZHR of the order of 8 coinciding with the Geminid peak. Care needs to be taken to clearly distinguish MON from GEM. Visual observers should choose their field of view such, that the radiants do not line up. (Field centres near Taurus in the evening or near Leo in the morning are possible choices.) December's new Moon period creates perfect conditions for either potential maximum timing, as the radiant area is available virtually all night for much of the globe, culminating at about $01^{h}30^{m}$ local time.



σ-Hydrids (016 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; $r = 3.0$.

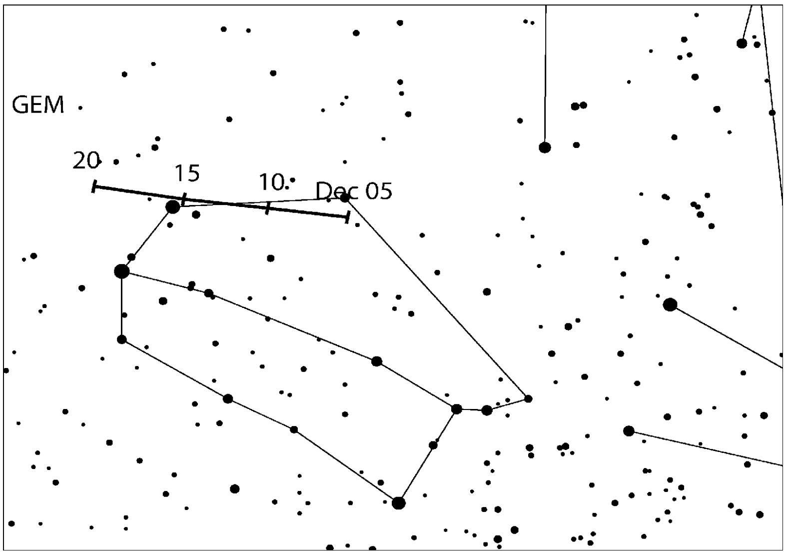
Although first detected in the 1960s by photography, σ-Hydrids are typically swift and faint, and rates are generally close to the visual-detection threshold, although some bright meteors are repeatedly seen. The radiant rises in the late evening hours, to be best viewed after local midnight from either hemisphere. This is a splendid year for them, thanks to new Moon on December 11. Recent IMO visual data (WB p. 65) 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. 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).



Geminids (004 GEM)

Active: December 4–17; Maximum: December 14, 12^h30^m UT ($\lambda_\odot = 262.°2$); ZHR = 120;
Radiant: $\alpha = 112°$, $\delta = +33°$; Radiant drift: see Table 6;
$V_\infty = 35$ km/s; $r = 2.6$.

Probably the best and most reliable of the major annual showers presently observable reaches its broad maximum on December 14 centred at 12^h30^m UT. 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^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 (WB, p. 66) all having occurred within $\lambda_\odot = 261.°5$ to $262.°4$, 2018 December 13, 20^h to December 14, 17^h UT. Usually, near-peak Geminid rates persist for almost a day, so much of the world has the chance to enjoy something of the shower's best. Mass-sorting within the stream means fainter meteors should be most abundant almost a day ahead of the visual maximum. The 2018 return happens one day before the Moon reaches first quarter, leaving about half of the night with dark skies.

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.

	$V_\infty = 25$ 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

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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 implies a larger fraction of brighter meteors than average, while r above 3.0 is richer in fainter meteors 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_∞: 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 2018.

New Moon	First Quarter	Full Moon	Last Quarter
		January 2	January 8
January 17	January 24	January 31	February 7
February 15	February 23	March 2	March 9
March 17	March 24	March 31	April 8
April 16	April 22	April 30	May 8
May 15	May 22	May 29	June 6
June 13	June 20	June 28	July 6
July 13	July 19	July 27	August 4
August 11	August 18	August 26	September 3
September 9	September 16	September 25	October 2
October 9	October 16	October 24	October 31
November 7	November 15	November 23	November 30
December 7	December 15	December 22	December 29

Table 5. Working List of Visual Meteor Showers. Details in this Table were correct according to the best information available in June 2017, with maximum dates accurate only for 2018. 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 which 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	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 (010 QUA)	Dec 28–Jan 12	Jan 03	283°.15	230°	+49°	41	2.1	110
γ-Ursae Minorids (404 GUM)	Jan 10–Jan 22	Jan 18	298°	228°	+67°	31	3.0	3
α-Centaurids (102 ACE)	Jan 31–Feb 20	Feb 08	319°.2	210°	−59°	58	2.0	6
γ-Normids (118 GNO)	Feb 25–Mar 28	Mar 14	354°	239°	−50°	56	2.4	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 06	45°.5	338°	−01°	66	2.4	50
η-Lyrids (145 ELY)	May 03–May 14	May 09	48°.0	287°	+44°	43	3.0	3
Dayt. Arietids (171 ARI)	May 14–Jun 24	Jun 07	76°.6	44°	+24°	38	2.8	30
June Bootids (170 JBO)	Jun 22–Jul 02	Jun 27	95°.7	224°	+48°	18	2.2	Var
Piscis Austr. (183 PAU)	Jul 15–Aug 10	Jul 28	125°	341°	−30°	35	3.2	5
S. δ-Aquariids (005 SDA)	Jul 12–Aug 23	Jul 30	127°	340°	−16°	41	2.5	25
α-Capricornids (001 CAP)	Jul 03–Aug 15	Jul 30	127°	307°	−10°	23	2.5	5
Perseids (007 PER)	Jul 17–Aug 24	Aug 12	140°.0	48°	+58°	59	2.2	110
κ-Cygnids (012 KCG)	Aug 03–Aug 25	Aug 18	145°	286°	+59°	25	3.0	3
Aurigids (206 AUR)	Aug 28–Sep 05	Sep 01	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	5
Dayt. Sextantids (221 DSX)	Sep 09–Oct 09	Sep 27	184°.3	152°	+00°	32	2.5	5
Oct. Camelopard. (281 OCT)	Oct 05–Oct 06	Oct 06	192°.58	164°	+79°	47	2.5	5
Draconids (009 DRA)	Oct 06–Oct 10	Oct 09	195°.4	262°	+54°	20	2.6	10
S. Taurids (002 STA)	Sep 10–Nov 20	Oct 10	197°	32°	+09°	27	2.3	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
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	15
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 02	250°.0	18°	−53°	18	2.8	Var
Puppid-Velids (301 PUP)	Dec 01–Dec 15	(Dec 07)	(255°)	123°	−45°	40	2.9	10
Monocerotids (019 MON)	Dec 05–Dec 20	Dec 09	257°	100°	+08°	41	3.0	2
σ-Hydrids (016 HYD)	Dec 03–Dec 15	Dec 12	260°	127°	+02°	58	3.0	3
Geminids (004 GEM)	Dec 04–Dec 17	Dec 14	262°.2	112°	+33°	35	2.6	120
Comae Berenic. (020 COM)	Dec 12–Dec 23	Dec 16	264°	175°	+18°	65	3.0	3
Dec. L. Minorids (032 DLM)	Dec 05–Feb 04	Dec 20	268°	161°	+30°	64	3.0	5
Ursids (015 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°			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°	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°	250°	−49°										
Mar 30	202°	−9°	255°	−49°										
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°	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°	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									
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		CCY		289°	+60°		
Sep 5	355°	−1°	STA		96°	+39°	43°	+40°	293°	+29°				
Sep 10	0°	+1°	12°	+3°	102°	+39°	48°	+40°	297°	+30°				
Sep 15			15°	+4°			53°	+40°	301°	+31°				
Sep 20			18°	+5°	DSX		59°	+41°	305°	+32°				
Sep 25			21°	+6°	150°	0°			309°	+33°				
Sep 30			25°	+7°	155°	0°	ORI				OCT			
Oct 5			28°	+8°			85°	+14°	DAU		164°	+79°	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	NOO		56°	+15°	56°	+22°			147°	+24°			AMO	
Nov 15	81°	+16°	60°	+16°	61°	+23°			150°	+23°			112°	+2°
Nov 20	84°	+16°	64°	+16°	65°	+24°			153°	+21°			116°	+1°
Nov 25	88°	+16°			70°	+24°	PHO		156°	+20°	PUP		120°	0°
Nov 30	92°	+16°	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°	98°	+9°
Dec 10	90°	+23°	108°	+33°	153°	+35°	22°	−53°	126°	+2°	125°	−45°	101°	+8°
Dec 15	96°	+23°	113°	+33°	157°	+33°	174°	+19°	130°	+1°	128°	−45°	105°	+7°
Dec 20	101°	+23°	118°	+32°	161°	+31°	177°	+18°	HYD		217°	+76°	108°	+7°
Dec 25	106°	+22°	QUA		166°	+28°	180°	+16°			217°	+74°	MON	
Dec 30	111°	+21°	226°	+50°	170°	+26°	COM				URS			
	ANT				DLM									

Table 7. Working List of Daytime Radio Meteor Showers. According to the naming rules, the shower names should all have 'Daytime' added (it is omitted in this Table). An asterisk ('*') in the 'Max date' column indicates that source may have additional peak times, as noted in the text above. See also the details given for the Arietids (171 ARI) and the Sextantids (221 DSX) in the text part of the Calendar. Rates are expected to be low (L), medium (M) or high (H). An asterisk in the 'Rate' column shows the suggested rate may not recur in all years. (Thanks to Jean-Louis Rault and Cis Verbeeck for comments on the Table.)

Shower	Activity	Max Date	$\lambda_\odot$ 2000	Radiant α	Radiant δ	Rate
Capricornids/Sagittariids (115 DCS)	Jan 13–Feb 04	Feb 01*	312°5	299°	−15°	M*
χ-Capricornids (114 DXC)	Jan 29–Feb 28	Feb 13*	324°7	315°	−24°	L*
April Piscids (144 APS)	Apr 20–Apr 26	Apr 22	32°5	9°	+11°	L
ε-Arietids (154 DEA)	Apr 24–May 27	May 09	48°7	44°	+21°	L
May Arietids (294 DMA)	May 04–Jun 06	May 16	55°5	37°	+18°	L
o-Cetids (293 DCE)	May 05–Jun 02	May 20	59°3	28°	−04°	M*
Arietids (171 ARI)	May 14–Jun 24	Jun 07	76°6	42°	+25°	H
ζ-Perseids (172 ZPE)	May 20–Jul 05	Jun 09*	78°6	62°	+23°	H
β-Taurids (173 BTA)	Jun 05–Jul 17	Jun 28	96°7	86°	+19°	M
γ-Leonids (203 GLE)	Aug 14–Sep 12	Aug 25	152°2	155°	+20°	L*
Daytime Sextantids (221 DSX)	Sep 09–Oct 09	Sep 27*	184°3	152°	0°	M*

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

The IMO has Commssions for various fields, about which you may enquire with the respective director:

Photographic Commission: William Ward, School of Engineering, Rankine Building, Oakfield Avenue, Glasgow G12 8LT, Scotland, U.K.; e-mail: William.Ward@glasgow.ac.uk

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

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

Visual Commission: Rainer Arlt, Leibniz-Institut f. Astrophysik, An der Sternwarte 16, D-14482 Potsdam, Germany; e-mail: rarlt@aip.de

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