Association of Lunar & Planetary Observers Meteors Section Observing Guide

Thanks for your interest in the ALPO Meteors Section! Our mission is to spread the word that observing meteors is a rewarding and scientifically useful endeavor. No instruments are necessary, just a good pair of eyes to catch swift streaks of light in the night skies. The instructions provided here will put you on the right path to becoming a successful meteor observer. Successful in this sense is to make the best use of your time spent out in the field by obtaining good quality data and sharing that data with others. Since I wish to address a wide audience, there is much material presented here, some of which you may never use. Don't get overwhelmed, just use what you need. Recording data can be as easy or as complicated as you wish. Everyone has their own level of interest. Some of you will wish just to record the bare minimum while others will want to record specific details of each meteor. The bottom line is that you have taken the step to record data and simply not sit back and watch the show. Many professional astronomers have begun their astronomical pursuits by viewing meteors and then adding more challenging fields of astronomy as their skills developed. Meteor observing is a great way to learn the night sky and to recognize the constellations that lie above. You will often see sights that elude those peering though telescopes with their small fields of view. Most observers concentrate on observing during the major annual showers. This means that there are other times of the year in which you may be the only person in the world out under the night sky concentrating on meteoric activity. Should an unexpected outburst occur, you may be the only witness available to share this observation!

Most of us observe alone out under the night sky. It is often difficult to get others to come out and view unless there is a major shower underway. Even though you may be alone, you should know that there are others wishing their clouds would part while still more anticipate receiving your observations to analyze the latest meteor activity. So you see, you are not really alone, but a valuable member of an observing team spread across the USA and beyond. Communication is the key to any team's success, and we hope you will stay in contact with us and your fellow observers as meteor showers wax and wane through the upcoming years.

When to Observe for Meteor Activity?

Meteors are shy and usually appear when most folks are asleep. Unfortunately, the evening hours are the worst time to view meteor activity. When you view the early evening sky, you are looking toward that portion of space from which the Earth is receding. Therefore, any meteor striking the atmosphere will have to catch up to the Earth. An analogy of this situation is that

during the evening hours you are looking out of the rear window of a vehicle driving in the rain. Most of the raindrops will strike the front windshield rather than the rear window. The rates slowly climb throughout the night. At midnight, you still see only perhaps only 25% of the activity seen during the last dark hour before dawn. Rates begin to increase dramatically after 2am and the skies are most active between then and the break of dawn.

Does this mean that evening observations are useless? Absolutely not! All observations are valuable. We are only trying to warn you that during most of the year, you will see very little activity during the evening hours. During the summer months in the northern hemisphere, evening observations can be entertaining as this is when sporadic (random) rates are near their highest. Some of the summer meteor showers also contribute to better evening rates.

There is also an annual cycle to sporadic meteor activity. In the northern hemisphere sporadic meteors peak between July and December and reach a nadir during the spring months. In the southern hemisphere just the opposite is true with peak rates occurring from January through June and a minimum from August through October. From a dark, rural location, during peak sporadic rates, one can expect to see approximately 15 sporadic meteors during the last hour before the start of morning twilight. The rate near the sporadic minimum during this same time of the night can be as low as only 5 per hour.

The cycles mentioned above do not include annual meteor showers. The strongest rates of the year can be observed during the peaks of the major annual showers when their radiant, the area of the sky where shower meteors appear to shoot from, is positioned highest above the horizon in a dark sky. The very best rates of the year, ignoring moonlight conditions, may be seen between 1 and 2 am local standard time (LST) on December 14th when the Geminid radiant lies nearly overhead for observers located in mid-northern latitudes. At this time rates as high as 100 per hour may be seen from observing sites located far from city lights. Other key dates when meteor activity is exceptional are Jan 3 (Quadrantids), August 12, 13 (Perseids), and December 14 (Geminids). These are the nights that provide the most activity and make up for those nights when observers suffer from low rates.

There are 9 major annual showers where the zenith hourly rate exceeds 10 per hour at maximum. These showers are listed on the next page. Note that the exact night of maximum activity may change slightly year to year. Visit the ALPO Meteors Sections online to see the latest data.

Shower (IMO Code) IAU#	Activity Period	Maximum		Radiant Position			Radiant Drift		Velocity km/s	30 Deg Elev.	Best Seen
		Date	S. L.	°	R.A.	Dec.	R.A.	Dec.			
Quadrantids (QUA) 010	Jan 01-Jan 10	Jan 04	283.16°	229.6°	15:18	+49.5°	0.59°	-0.08°	42.2	0200	0500
Lyrids (LYR) 006	Apr 16-Apr 25	Apr 22	032.32°	272.2°	18:08	+32.9°	0.57	-0.43°	48.4	0000	0500
Eta Aquariids (ETA) 031	Apr 28-May 21	May 06	046.8°	338.9°	22:36	-00.6°	0.67°	+0.32°	66.9	0500	0400
Delta Aquariids (SDA) 005	Jul 21-Aug 23	Jul 30	126.9°	340.4°	22:42	-16.4°	0.86°	+0.28°	42.0	0100	0300
Perseids (PER) 007	Jul 13-Aug 26	Aug 13	140.0°	048.1°	3:12	+57.6°	1.44°	+0.25°	60.5	0000	0400
Orionids (ORI) 008	Oct 04-Nov 14	Oct 22	208.9°	96.1°	6:24	+15.5°	0.78°	0.0°	67.3	0000	0400
Leonids (LEO) 013	Nov 05-Nov 30	Nov 18	236.1°	154.2°	10:16	+21.6°	0.61°	-0.3°	70.6	0200	0500
Geminids (GEM) 004	Dec 04-Dec 16	Dec 14	261.5°	113.3°	7:33	+32.2°	0.96°	-0.17°	35.0	2100	0100
Ursids (URS) 015	Dec 17-Dec 23	Dec 22	270.7°	217.6°	14:30	+74.8°	1.60°	-0.13°	32.6	0100	0500

The Major Annual Meteor Showers

Beginning meteor observers are encouraged to start by viewing these showers first. They offer the most activity and will quickly aid in the task of meteor classification. During the maximum dates of these showers, it will quickly become evident that most of the activity is coming from a particular portion of the sky, called the radiant. In no way though will **all** the activity be from this radiant. There are always sporadic meteors visible plus perhaps some activity from minor showers that happen to be active at the same time. Like the annual sporadic activity, all of these showers are best seen after midnight. Some are not visible until after midnight, when their radiant clears the horizon. Even when the radiant clears the horizon, you are only able to see a very small portion of the total activity from the shower. It is best to wait until the radiant has achieved an elevation of at least 30 degrees to begin observing these showers. Note that this time is listed in the table above as "30 Deg Elev.". These times are intended for observers located at 40 degrees north latitude but are still close for observers from 30-50 N. Times listed for showers from March through October are listed in daylight saving time. The radiant position is for the night of maximum activity. The radiant drift is the change in position per night. These positions must be adjusted by the figures under radiant drift for each night away from maximum.

It should also be noted that during the date of maximum activity for the showers above, that this is some of the best opportunity to witness a fireball (a meteor with a maximum brightness in excess of magnitude -4, the average magnitude of the planet Venus). These meteors are often colorful and leave a persistent train lasted many seconds after the meteor has vanished.

The next section offer tips on viewing each of the individual major annual showers.

Quadrantids (QUA)

The **Quadrantids** are active from New Year's Day through January 10th. Very little activity will be seen away from the night of maximum activity, usually January 4th. Even on the night of maximum activity most of the meteors will be seen only during a 6 hour window centered on the peak. For all practical purposes, these meteors are invisible prior to midnight. The radiant reaches 30 degrees elevation near 0200 and is best placed 3 hours later when it lies high in the northeastern sky. With only a 3 hour window, this shower is difficult to observe in all its glory. It has the potential to produce in excess of 100 meteors per hour if you are located in the right place at the right time. Unfortunately, early January usually offers poor weather prospects for most observers. In 30 years of observing I have only caught one Quadrantid maximum, when visual hourly rates reached 104. The equivalent zenith hourly rates (ZHR) was even higher! Weather played a role in most of the misses. The best quadrant to face for this shower is north to east. When moonlight does not interfere, you can count on 25 Quadrantids per hour between 0200 and 0500 local standard time (LST). Your average Quadrantid meteor is of medium velocity with a low percentage of trains. This shower produces fireballs on occasion. The brightest I have witnessed being magnitude -10.

Lyrids (LYR)

The **Lyrids** are active from April 16 through the 25th. Maximum activity occurs on the 22nd or 23rd, when most of the activity is seen. Good rates are usually seen on both these nights with little seen at other times. The Lyrid radiant reaches 30 degrees altitude near midnight local daylight saving time. Therefore, you have a nice stretch of 5 hours to view this shower before morning twilight begins. This shower can be entertaining as I have seen hourly rates as high as 25. Most of the time though, hourly rates are only 10-15 under dark, moonless skies. These meteors are usually dim so observing under the best possible conditions is highly recommended. Moonlight wreaks havoc on this shower, often reducing hourly rates to less than 5, even at maximum activity. The best quadrant to face for this shower is again north to east. The average Lyrid meteor is of medium velocity with a low percentage of trains. Fireballs are possible but rare due to the low number of Lyrids seen. My brightest Lyrid fireball was magnitude -8 with an impressive train lasting one minute.

Eta Aquariids (ETA)

This shower is the most difficult of the major showers to observe. The reason for this is the fact that the radiant lies only 45 degrees west of the sun. The radiant does not rise until near 0300 DST for most of us, allowing only 2 hours of observing before the start of morning twilight. The

situation is even worse the further north one is located. This shower is invisible north of 60 degrees north latitude as radiant rise and the start of morning twilight occur simultaneously. Unlike the previous two showers, the Eta Aquariids possess a plateau-like maximum centered on May 6th. Good rates may be seen any time from May 4th through the 8th. On the morning of May 6th, an observer watching from a dark location with no moon at 40 degrees N latitude will see 5-10 Eta Aquariids during the last dark hour before dawn. The rates will increase until one reaches the southern tropical latitudes where hourly rates as high as 30-40 may be seen. These rates makes this shower the second strongest of the year as seen from the southern hemisphere, surpassed only by the Geminids.

The Eta Aquariids are impressive meteors. They are swift and all of the brighter members leave persistent trains. The shape and velocity of these meteors makes them appear as "heavenly spears". It has been my experience that this shower is deficient in fireballs. There are many bright ones but they rarely exceed magnitude -2.

To view this display, face toward the eastern half of the sky just as the radiant is rising. Face half way up with the bottom of your field of view just reaching the horizon. These meteors will shoot upwards, often appearing in the upper regions of your field of view and shooting into the western sky. Most of them though will stay closer to the horizon, shooting far to the north or south. If viewing the Eta Aquariids between May 6th and May 15th, be on the lookout for slightly slower meteors coming from Lyra. These would be members of a minor shower known as the Eta Lyrids.

Delta Aquariids (SDA)

The Delta Aquariids, also known as the Southern Delta Aquariids, are active from July 21 to August 23. Maximum occurs on July 30, when up to 20 meteors per hour can be seen, depending on your latitude. This shower is active during one of the most active periods for meteors. There are several minor showers active simultaneously plus (in the northern hemisphere) the sporadic rates are near their annual peak. The radiant for this shower is located in the southern portions of the constellation of Aquarius. It is not well seen from the northern hemisphere. Still, an observer situated at 40N latitude can see approximately 10 Delta Aquariid meteors near maximum activity when the radiant lies on or near the meridian. From 40N latitude observations may begin near 0100 LDT. Peak activity should occur two hours later when the radiant is positioned on the meridian. At 42 km/per, these meteors will be of medium velocity. The SDA's are not known for producing bright meteors so it is important to view from the darkest site possible. The best region for viewing this activity would be from the southern tropics, when the radiant passes directly overhead. Be careful not to confuse these meteors with the nearby Alpha Capricornids, which are usually slower and brighter. Another nearby

radiant would be the Antihelion, which is centered in northern Aquarius at this time and also produces meteors of slower velocity. Good rates from the SDA's may be seen from July 28 to the 31st. Rates fall rapidly in August but a trickle of activity is still produce all the way through the 23rd of August.

Perseids (PER)

The Perseids are the most popular annual meteor shower due to the fact that they peak during the warm summer nights in the northern hemisphere. They are active from July 13 through August 26, with a distinct peak on either August 12 or 13. The Perseids seen in July actually radiate from the constellations of Andromeda and then Cassiopeia. The radiant actually enters the boundaries of Perseus only a few days before maximum activity. The radiant only spends a few days with the boundaries of Perseus before crossing into the dim constellation of Camelopardalis. Hourly rates seen in July rarely exceed 5. Rates remain low until August 10, when a surge of activity commences. At maximum activity, one can often count up to 60 Perseids per hour if viewing from a dark sky site. The night after maximum also offers good rates but thereafter, rates fall precipitously.

From mid-northern latitudes the Perseid radiant remains in the sky the entire night. During the early evening hours though, the radiant lies very low in the north and only a trickle of activity can be seen during these hours. The Perseids seen during the evening are often remarkable as the often just skim the upper portions of the atmosphere. This allows them to last much longer than normal, often shooting over great lengths of the sky. As the radiant gains in altitude the Perseid meteor will become shorter in both duration and length.

For observers south of the equator, the Perseids are not visible before midnight. The radiant rises in the northeast during the morning hours and stays low in the north as the night progresses. From the equator, the radiant culminates near dawn with an elevation of 33 degrees high. Of course, you cannot watch at dawn so equatorial observers will have to do with a radiant perhaps 25 degrees high during the last dark hour before dawn. This will allow decent rates but far below those seen from the mid-northern hemisphere. The situation gets even worse for the most populous areas of the southern hemisphere near latitude 25S. Their longer night will allow the Perseid radiant to be seen at culmination, it will lie only 8 degrees over the northern horizon. All they will get to see of the Perseids is a few "earthgrazing" Perseids occurring just before dawn.

From mid-northern latitudes, the Perseid radiant reaches a usable altitude near midnight. This is when serious observations should begin. The radiant will climb higher into the northeastern sky during the entire morning, culminating just after sunrise. Therefore, the best time to view Perseid activity would be during the last dark hour before the start of morning twilight. This

time varies by location but usually falls near 0400-0500 LDT. The Perseids strike the atmosphere at a speed of 61 km/sec. This means that a majority of Perseid meteors will appear swift with brighter members leaving persistent trains. The only exceptions will be Perseid meteors seen near the radiant (which will be foreshortened) and those seen near the horizon. In both cases the meteors will appear shorter in length compared to your average Perseid.

Perseid meteors can be seen in all areas of the sky. Even if the radiant is not within your field of view, Perseid activity will soon become evident. Although the brightness and length may vary, all Perseid meteors will be parallel to one another and will enter your field of view from one direction. All other meteors moving in other directions will be sporadic or belong to one of the many minor showers active at this time.

This shower is one of the few that should be viewed no matter the lunar phase. Even when the moon is full, the Perseids will produce more activity than can be seen on 300 other nights of the year. So like in 2011, don't let the full moon deter you away from viewing this spectacle.

Orionids (ORI)

The Orionids are active from October 4 through November 14. There is a plateau-like maximum centered on October 22. From October 19 through the 24th, good Orionid rates may be seen from dark sky sites. During the 1970's and 1980's, your average Orionid maximum produced 25 shower members per hour. During the 1990's and 2000's, the Orionids have been stronger, producing 40 per hour and often matching the strength of the Perseids. Twice recently, there have been minor outbursts of Orionid fireballs that occurred several nights before the predicted maximum.

The Orionid radiant lies near the "club" of Orion in the northern portion of the constellation. In mid-October, the radiant rises during the late evening hours and reaches an altitude of 30 degrees near midnight LDT. It is best placed near 0400 LDT when it lies on the meridian and is highest above the horizon. With the radiant lying near the celestial equator, this shower is seen equally well from either hemisphere. Conditions are slightly better in the northern hemisphere where the nights are a bit longer this time of year.

The Orionids are very fast meteors and the brightest members often leave persistent trains. It is advisable to face in a direction so that the radiant lies near the edge of your field of view. This would make it easier to separate the Orionids, the Epsilon Geminids, and the Leonis Minorids, all which are swift meteors.

Leonids (LEO)

The Leonids are best known for meteor storms produced in intervals of approximately 33 years. The last storm occurred in 2002, and unfortunately none are forecasted until 2099. The years near 2033 and 2066 should produce significant activity, but below storm levels (>1000/hr). It was once thought that the displays between storms were uneventful but now we are discovering trails of debris that could produce enhanced activity in nearly any year. Therefore, it is difficult to state exactly the strength of each Leonid return from one year to the next. Probably the safest thing to state is that enhancements are usually short-lived and visible over a small portion of the earth. Therefore, a rate of 10-15 Leonids per hour is all that one should expect to see at maximum activity.

The first Leonids are seen near November 5 and rates will remain very low until the 17th. The maximum can occur on either the 17th, 18th or 19th, so these are the key dates on which to watch. The Leonid radiant does not achieve 30 degrees altitude until near 0200 LST. It is best seen during the last dark hour before dawn. Unfortunately, the radiant reaches its highest point after sunrise. The Leonids are the fastest of the major annual showers with shower members striking the earth at nearly a head-on position. Therefore, they are very swift and produce a high percentage of persistent trains.

The Leonids are best seen with the radiant lying near the edge of your field of view. I would advise facing toward the south so that you can see any possible activity coming from Taurus (Northern Taurids), Orion (November Orionids), and Monoceros (Alpha Monocerotids).

Geminids (GEM)

Ask an experienced meteor observer what their favorite shower is and they will most likely mention the Geminids. Year in and year out, the Geminids are the most consistently strongest shower of the year. It is not uncommon to read reports of hourly rates in excess of 100 for this shower. Another reason that this shower is favored is that it actually produces good rates during the evening hours, a rarity for most displays. This is another shower that should be watched no matter the phase of the moon. During displays peaking with a full moon in the sky, I have seen up to 25 meteors per hour, which is better than many of the major annual showers seen under perfect conditions. Even urban dwellers can enjoy the Geminids as 20-30 Geminids per hour can be seen from urban areas near maximum when the radiant lies high overhead. Of course, this is a small fraction of what is actually visible to rural observers under dark skies.

The Geminids are active from December 4 through December 16 with a sharp maximum on the 14th. The activity curve is not symmetrical as the climb toward maximum is slower than the fall from maximum. The rates are strong on both the 13th and 14th. As seen from the mid-northern

latitudes the radiant reaches 30 degrees altitude near 2100 or 9:00pm local standard time. Actually, activity can be seen as soon as it becomes dark but early evening rates are low. Activity increases as the night progresses reaching a peak between 0100 and 0200 LST when the radiant lies nearly overhead. Near this time Geminid meteors fall gracefully in all directions. Therefore, you can view in any direction, hopefully toward the darkest/least obstructed horizon. To also keep tabs of the several minor radiants also active at this time, it is suggested to view toward the dim constellation of Cancer. Looking there you can also monitor activity from the Antihelion source, the Monocerotids, the Sigma Hydrids, the Coma Berenicids and the December Leonis Minorids.

The Geminids possess a medium velocity and therefore produce very few persistent trains. They often produce fireballs that are vividly colored. The combination of slower velocity and many bright meteors makes this shower the most photogenic of all the major showers.

Ursids (URS)

The Ursids are the most difficult of the major annual showers to observe. This display peaks just before Christmas, when observers often lack the time to observe due to other commitments. The weather is also often inclement during this time of year. It is also the weakest of the major shower with rates often struggling to reach 10 per hour. I have seen hourly rates up to 25 per hour but the normal is closer to 10. This shower is active from December 17 through the 23rd, with maximum occurring either on the 22nd or 23rd. With a radiant lying close to the bowl of the Little Dipper, the Ursids are the most northerly of all the major showers. This means that shower members are not visible from the southern hemisphere. From mid-northern latitudes, the Ursids are visible all night long. Unfortunately the radiant lies beneath the Polaris until 0200 LST. Rates will be lower until after midnight. After then the radiant will have achieved sufficient altitude to provide decent rates.

The Ursids enter the atmosphere with medium velocity. Most shower members are faint so persistent trains will be rare. The moon and urban lighting will severely compromise this display.

Shower (IMO Code) IAU#	*Activity*	*Maximum*		*Radiant Position*			*Radiant Drift*		*Velocity*	*30 Deg*	*Best*
	Period	Date	S. L.	°	R.A.	Dec.	R.A.	Dec.	km/s	Elev.	Seen
Anthelion Source (ANT)	Dec 11-Sep 06	-	-		-	-			30	2200	0100
Alpha Centaurids (ACE) 102	Jan 28-Feb 21	Feb 08	319.2°	210°	14:00	-59°	1.2°	-0.3°	56.0	0000*	0400
Pi Puppids (PPU) 137	Apr 15-Apr 28	Apr 23	033.5°	110°	7:20	-45°	0.5°	-0.1°	18	2000*	2000
Eta Lyrids (ELY) 145	May 03-May 14	May 08	048°	287°	19:08	+44°	0.2°	-0.0°	44	0000	0400
June Bootids (JBO) 170	Jun 22-Jul 02	Jun 27	095.7°	224°	14:56	+48°	0.4°	-0.2°	18	2100	2100
Alpha Capricornids (CAP) 001	Jul 03-Aug 15	Jul 30	127°	307°	20:28	-10.2°	0.57°	+0.27°	23	2300	0100
Piscis Austrinids (PAU) 138	Jul 15-Aug 10	Jul 28	125°	341°	22:44	-30°	0.9°	+0.3°	35	0300	0300
Kappa Cygnids (KCG) 012	Aug 03-Aug 25	Aug 18	145°	285.9°	19:04	+51°	0.6°	+0.7°	22.7	2100	2100
Aurigids (AUR) 206	Aug 29-Sep 04	Sep 01	158.6°	90.7°	6:02	+39.3°	1.5°	-0.4°	66.7	0300	0500
Epsilon Perseids (SPE) 208	Sep 05-Sep 21	Sep 10	167°	047.2°	3:12	+40.5°	0.7°	0.0°	66.4	2300	0500
Draconids (GIA) 009	Oct 06-Oct 10	Oct 09	196.0°	262°	17:28	+56.0°	0.0°	0.0°	19.0	2000	2000
Southern Taurids (STA) 002	Sep 07-Nov 19	Oct 10	197°	31.7°	2:06	+08.7°	0.85°	+0.18°	28.9	2200	0200
Leonis Minorids (LMI) 022	Oct 16-Oct 27	Oct 23	210°	160.8°	10:43	+36.4°	1.1°	-0.2°	59.8	0400	0500
Northern Taurids (NTA) 017	Oct 19-Dec 10	Nov 13	231°	059.7°	3:58	+22.7°	0.84°	+0.15°	28.5	2000	0000
November Orionids (NOO) 250	Nov 12-Dec 06	Nov 30	248°	91.9°	6:04	+15.2°	0.73°	-0.03°	44.1	2100	0100
Sigma Hydrids (HYD) 016	Nov 26-Dec 20	Dec 06	254°	123.9°	8:12	+2.8°	0.80°	-0.20°	60.8	0000	0400
Dec Phoenicids (PHO) 254	Nov 28-Dec 09	Dec 06	254.3°	018°	1:12	-53°	0.8°	-0.1°	18	2100*	2100
Puppid/Velids (PUP) 301	Dec 01-Dec 15	Dec 07	255°	123°	8:12	-45°	0.6°	0.0°	40	2200*	0300
Monocerotids (MON) 019	Dec 07-Dec 19	Dec 08	256°	099.2°	6:37	+08.1°	0.66°	-0.15°	40.9	2200	0100
Dec.Leonis Minorids (DLM) 32	Dec 06-Jan 18	Dec 21	269°	161.5°	10:46	+30.5°	0.86°	-0.43°	64.0	0000	0400
Coma Berenicids (COM) 20	Dec 24-Jan 03	Dec 31	280°	185.7°	12:22	+11.7°	1.3°	-0.7°	69.7	0000	0400

The Annual Minor Showers

The major showers are active on 164 of the 365 nights a year. Perhaps two dozen of these nights offer truly significant activity. What about the other 201 nights per year? Well, the list on the pervious page will fill the void. These are minor showers that have peak ZHR's between 3 and 10. Nearly all of them produce activity on an annual basis. I have included temporary showers that appear occasionally such as the **Pi Puppids**, **June Bootids**, **Draconids**, and the **Phoenicids**. These showers are usually apparent when at maximum activity. Away from maximum their rates are often less than 1 per hour and it becomes difficult to pick them out from the sporadic activity. Remember to wait until these radiants have achieved an elevation of 30 degrees before attempting to watch for them. Those with an asterisk will not achieve this elevation as seen from mid-northern latitudes. The times listed for these showers are for 25 degrees south latitude.

Notice that the **Anthelion** radiant is active nearly year-round. In contrast to most of the other showers, this one is produced by debris associated with minor planets and short period comets, especially comet **2P/Encke**. During the year the Anthelion radiant follows the ecliptic at a point 12 degrees east of the opposition point of the sun (hence Anti-Helion). These meteors are visible all night long, usually peaking between 0100 and 0200 local time. Rates are usually 2-3 per hour with little variance. This radiant is very large compared to most. It encompasses 30 degrees in right ascension (celestial longitude and 15 degrees in Declination (celestial latitude). Therefore this area can cover several constellations. It is difficult to exclude some sporadic activity due to the large radiant size.

Details on these minor showers are available in my new book called "***Meteors and How to Observe Them***" available from many book sources such as **Amazon .com**

Where to Observe

You have seen it mentioned throughout the text "from dark sky sites". To see any shower in all its glory, it is necessary to watch from a dark location far from city lights. Urban observing is possible, but the activity seen is usually less than 25% of the total meteors available. Most of the meteors seen by visual observers lie in the magnitude range from +2 to +4. There are a great many more faint meteors produced compared to bright ones. Since most meteors are seen toward the edge of your field of view, many of the fainter ones will go unnoticed. Sky glow, caused by outdoor lights, will also obscure fainter meteors, making them more difficult to detect.

We encourage observers to view from the darkest site possible. Local astronomy groups usually have areas set aside in rural locations where meteor and telescopic viewing may be safely

conducted. Urban observations are acceptable but large corrections are necessary to convert such data into useable form. The smaller the corrections, the more reliable the data. All data is converted to a standard limiting magnitude of +6.5. If your limiting magnitude is +5.0, then your results will be converted to +6.5 using formulas that artificially increase the number of meteors. This (and other factors) is how the resulting zenith hourly rate is achieved.

How to Observe

First and foremost, one must be comfortable while observing. A patio lawn chair is ideal. Pillows and sleeping bags (if it is cold) also help. One must be suitably rested or you will soon fall asleep. While all of us inevitably fall asleep at one time or another, please note these "breaks" on your observing sheet rather than letting these periods go without any activity. It is advised that you memorize the location of each radiant active on a particular night. These positions may be obtained from the ALPO web site at: https://alpo-astronomy.org/Meteor Look for the meteor activity outlook for this particular week. Once out under the stars, aim your chair so that one radiant is off to the side of your field of view or your FOV lies between two or more radiants. Tilt your chair so that the horizon lies at the bottom of your FOV. Do not look straight up as this is the area of the sky that produces the least activity. The center of your FOV should lie near the halfway point between the horizon and the zenith above.

While it is convenient and more helpful for analysis, there is no need to start precisely on the hour. Whenever you do start though, please watch for at least 60 minutes unless a break is absolutely necessary. Shorter times are acceptable, but it becomes a real chore to enter many observing periods when just a few will do. I know that the International Meteor Organization requires data of major showers in 10 minute periods, but currently I do not have the time to analyze data in such small increments. For the AMS, 1 hour increments will do just fine.

Since most of the observations take place during the morning hours, it is advisable to stop at the start of nautical twilight, when the sun lies 12 degrees below the horizon. Beyond this time the sky becomes too bright for serious observations. If activity is predicted for the evening hours then the time to start would be at the end of nautical twilight.

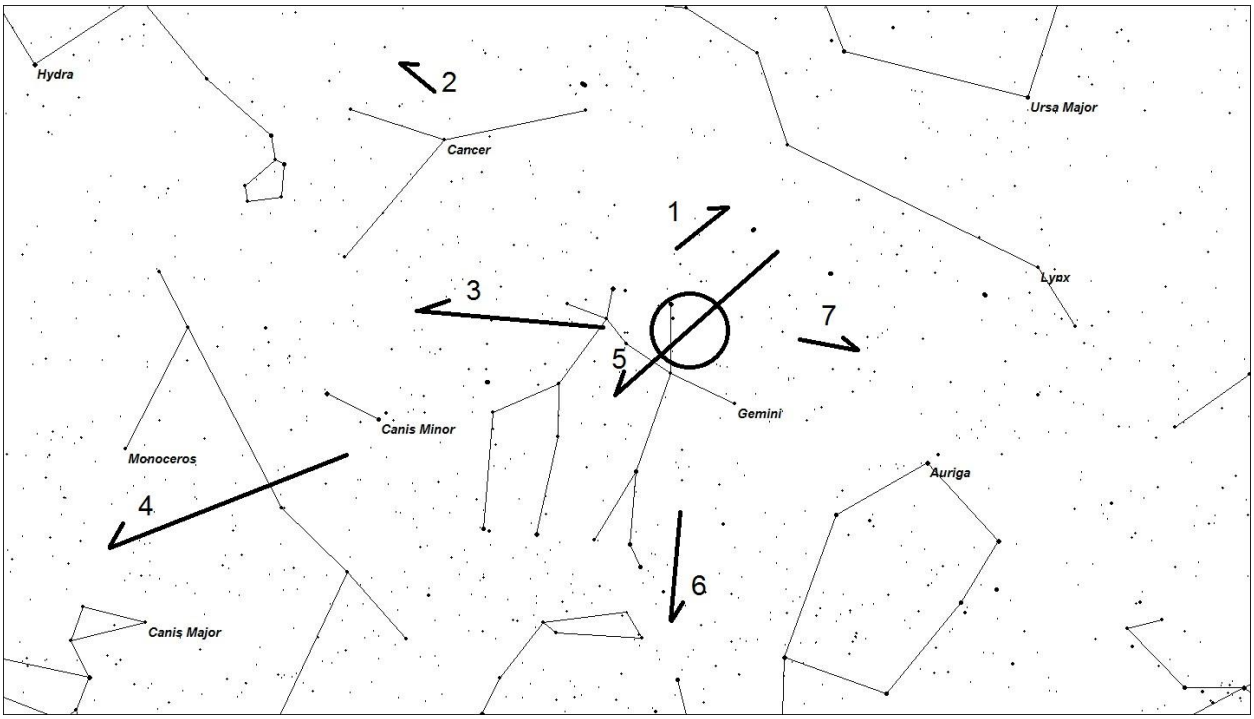
If you are alone then a radio or media player helps pass the time. If you are unsure of your surroundings then it would be advisable to listen to "nature" and to keep close to your vehicle should you hear something alarming. A snack and drink is also advisable to have along as a hungry observer loses their concentration. Warm drinks can be a help on frigid nights. The use of stimulates such as caffeine tables to stay awake is not suggested. If you are that tired a quick one hour nap would be more beneficial.

While actually observing, you will want to project the path of any meteor seen against the stellar background to see if it intersects any active radiant. While you can do this mentally, it is easier to use a dark (which is easier to see against the sky) cord such as a shoestring. As soon as possible, place the cord against the path of the meteor with one end near the ending point of the meteor. It helps if the meteor has a persistent train as this gives you a bit more time for that perfect lineup. Once your cord is lined up then follow the path backward to see if it intersects any active radiant. If it passes close to the radiant (within 5 degrees) then most likely it is a shower member.

Some observers print observing forms and fill them out in the field as each meteor occurs. This is fine except that time is wasted looking at the form instead of the sky. This time needs to be subtracted from your actual observing time. Rather than do this I would suggest using a recording device that you can use while keeping your eyes on the sky. This way no time is lost while recording data. You can record all your data on paper once the session has ended. Other items that come in handy are flashlights, spare batteries, charts, extra pencils, and a mobile phone.

What to Record

It is absolutely necessary to record the beginning time, ending time, and any the length of any breaks taken during your watch. Better yet is to provide an hourly breakdown of the activity you record. The time of each meteor is not necessary, but helpful. Shower association is also necessary. All the meteors seen during a watch can be sporadic, but in no way can all the meteors seen belong to one shower, no matter how strong it is. Besides path, several other parameters can help one be certain of shower association. Path length is also important. A short meteor can be seen at any distance from the radiant but a long meteor cannot occur near the radiant. In general, a meteor must be twice the distance of its length from a radiant to be considered a member of that shower. On the chart on the following page, meteor #3 lines up with the Geminid radiant but it is too long to be a Geminid meteor. #2 is short but still lines up with the Geminid radiant (circle). Therefore, it is most likely a Geminid meteor. Meteor #3 lies up well with the radiant but at this position, close to the radiant, it is too long to be a Geminid. Meteor #4 is long but far enough from the radiant to belong to the Geminid shower. Lastly, meteor #7 occurs close to the radiant but is short enough to also belong to the Geminids.



Examples of meteors during the Geminid maximum

1. Sporadic meteor as it completely misses the Geminid radiant (Circle)
2. Geminid meteor, short and lines up with the radiant
3. Sporadic meteor, lines up with radiant but is too long to be a Geminid
4. Geminid meteor, long but far enough from the radiant to be a Geminid
5. Sporadic meteor, crosses over Geminid radiant. Actual radiant lies in U. Major or beyond
6. Geminid meteor, medium length and lines up well with radiant
7. Geminid meteor, close to radiant but short enough to be a Geminid meteor

One can also use the speed of a meteor to determine its association. Points to remember as to speed: fast meteors cannot appear close to their radiant. Meteors are foreshortened near the radiant therefore they will appear slower here than they do when further away. The speed of a meteor will peak when it lies 90 degrees from the radiant. Slower meteors can appear close to the radiant and close to the horizon. Finally, a shower with a slow entry velocity (<30km/sec) cannot produce a swift meteor. Swift showers can produce both fast and slow meteors, depending on their position. While this sounds complicated, you should remember that these are general terms over the entire sky. The shower meteors you see within your field of view will all be of similar velocity.

Using the Visual Meteor Form

While you may observe in groups, it is absolutely necessary that each and every observer keep track of their own data. Only record what you actually see. Do not record what someone else saw. If two or more observers viewed the same meteor, it must be recorded on all their forms. As for faint meteors you suspect that occur near the edge of your field, it is probably best not to include them. As you gain experience you will learn to trust your intuition as to what is real or not.

The form is laid out in a logical order (at least to this observer). Those using recording devices are encouraged to record data in the order of the columns, in a left to right manner, so that you do not have to jump around on the page as you listen to your data. The form is available in two versions, easy and advanced. We will accept either form or another you have created yourself. All we ask is that all the data be presented in a clear and concise manner.

The **basic form** is meant for beginners who may not have a full grasp of all the parameters listed on the advanced form. As for the basic form, the columns are fairly self-explanatory. The most difficult aspect of any session will be determining an accurate estimate of your limiting magnitude of your field of view. This is important as it gives us an indication of your observing conditions. The old method of determining limiting magnitude was to find the faintest star you could see and then find that star on a chart and then look up its magnitude. This was difficult as you were constantly looking at the sky and then the chart, trying to find the star. A better method is to use star counting areas provided by the International Meteor Organization at: http://www.imo.net/visual/major/observation/lm

This method involves counting the number of stars within a certain small area of the sky. You need to memorize these areas in advance or take the charts out in the field with you. Once you have used this method several times, it becomes quite easy to recall these areas. Once you know the area simply count the number of stars you see (including the corner stars) and note this number on your form or on your recording device. After the session you can look up this number and find the corresponding limiting magnitude. This method has the advantage is that you never need to take your eyes off the sky unless you need to look up the recording areas. It also saves you from using a flashlight which affects your dark adaptation. These “star counts” should involve at least two areas in or near your field of view. The more areas you count, the better the estimate will be. Since conditions also change during the night, it is advised to recount at least once an hour. While this may seem like a chore, you should not strain to see stars. Just a simple sweep of the area will suffice. It should take no longer than 30 seconds. If you strain to see the faintest stars you will artificially increase your limiting magnitude, reducing the accuracy of your data. There is no contest to try and see the best limiting magnitude. We just want a true indication of your observing conditions.

While the date may seem easy, it can get confusing as there are two types of time in use. We encourage observers to convert their data to “Universal Time” or GMT. For observers in North America, the use of UT almost always eliminates the need for a double date on your form as

0000 UT usually occurs before it becomes totally dark in most areas of North America. This also eliminates the need for us to convert your time as UT is used everywhere else in the scientific community. Use the chart below to convert your local times (both standard and daylight saving) to Universal Time.

UT	AST/EDT	EST/CDT	CST/MDT	MST/PDT	PST/ADT	AST	AHST
00:00	8:00pm	7:00pm	6:00pm	5:00pm	4:00pm	3:00pm	2:00pm
01:00	9:00pm	8:00pm	7:00pm	6:00pm	5:00pm	4:00pm	3:00pm
02:00	10:00pm	9:00pm	8:00pm	7:00pm	6:00pm	5:00pm	4:00pm
03:00	11:00pm	10:00pm	9:00pm	8:00pm	7:00pm	6:00pm	5:00pm
04:00	12:00am	11:00pm	10:00pm	9:00pm	8:00pm	7:00pm	6:00pm
05:00	1:00am	12:00am	11:00pm	10:00pm	9:00pm	8:00pm	7:00pm
06:00	2:00am	1:00am	12:00am	11:00pm	10:00pm	9:00pm	8:00pm
07:00	3:00am	2:00am	1:00am	12:00am	11:00pm	10:00pm	9:00pm
08:00	4:00am	3:00am	2:00am	1:00am	12:00am	11:00pm	10:00pm
09:00	5:00am	4:00am	3:00am	2:00am	1:00am	12:00am	11:00pm
10:00	6:00am	5:00am	4:00am	3:00am	2:00am	1:00am	12:00am
11:00	7:00am	6:00am	5:00am	4:00am	3:00am	2:00am	1:00am
12:00	8:00am	7:00am	6:00am	5:00am	4:00am	3:00am	2:00am
13:00	9:00am	8:00am	7:00am	6:00am	5:00am	4:00am	3:00am

Converting Universal Time to USA Time Zones

If you insist on using local time then only supply a double date when you actually observe before and after midnight.

Longitude and latitude are not mandatory but helpful. Please list the elevation in meters. To convert feet into meters, multiply the number of feet by 0.3048. The remainder of the top portion is fairly clear. Several entries are available should the percentage of cloudiness or obstructions change or if you change the direction you are facing.

As for the individual information on each meteor, please use whole magnitudes for brightness. As for “Type” of meteor, use the 3 digit abbreviations listed with the tables in this kit. Use “SPO” for random meteors. You may also use a 1-5 scale for speed or Fast, Medium, or Slow.

Trains are the persistent streaks that occur with swift meteors after they have disappeared. On the basic form a simply yes will suffice. Leave it blank for no train. Accuracy may be listed as Good, Fair, or Poor. A good accuracy indicates the meteor occurred near the center of your field of view and was well seen. Fair is half-way out to the edge of your field of view. Poor is a meteor seen near the edge of your field of view and not well seen.

The **advanced form** provides us with more details of each meteor. Duration is included in the advanced form to help determine velocity. An accuracy of no better than .2 second is expected so measurements can be given in .2 second increments. .2 is a fast streak, .4 is a slower streak, at .6 the meteoroid can be suspected, at .8 the meteoroid is definitely visible, and at 1.0 second, you actually have time to turn and follow the meteor. Most short meteors (<5 degrees in length) have a duration of .4 second, .2 is much less common. Many longer meteors are .6 of a second. Less than 10% of your meteors will have a duration exceeding .6 of a second. Most meteor durations are grossly inflated by beginners so if you find yourself with many meteors lasting in excess of .6 second, you will need to recalibrate your estimates.

Like duration, the length of a meteor is usually overestimated. Most meteors are less than 5 degrees long. Just for reference, a degree is 1/90 of the length from the horizon to the zenith (straight up). The moon has a diameter of one half degree so most meteors have a length of less than 10 lunar diameters. The velocity column is filled in after the session is complete. Velocity is stated in degrees per second so to obtain this figure, divide the length by the duration. This figure is used to help solidify shower association as a certain velocity is expected from a shower, depending on the distance from the radiant. Should this figure be too high or too low, then the meteor is most likely a sporadic or a member of another shower. Most meteors have a velocity of 5-15 degrees per second. If many of your results exceed this figure then either your length is too long or duration too short.

DCV is Distance from Center of View and should be expressed in increments of 10 degrees. This replaces the accuracy column in the advance form. Radiant Distance again helps determine shower association as does altitude. Both estimates may be listed in increments of 10 degrees.

If you happen to plot meteors on gnomic charts, then this box should be checked for each meteor plotted so that a reduction in the actual observing time can be added from the hourly or total figure. Only the basic form is provided as the advanced form will not fit. Both forms can be obtained from the ALPO web site at: https://alpo-astronomy.org/Meteor

VISUAL METEOR OBSERVING FORM

DATE: _____ (year) _____ (month)_____ (day) Begin _____ h_____ m End _____ h_____ m (____)

LOCATION: Long.=_____ W. Lat.=_____N. Elevation =_____m

OBSERVER:_____PLACE:_____

LIMITING MAGNITUDE: _____@____:____ _____@____:____ _____@____:____ _____@_____:_____

___@____:____ ___@____:____ _____@____:____ _____@___:___ _____@____:___ _____@____:____

PERCENT CLOUDY: ___%@___:___ ___%@___:___ ___%@___:___ ___%@___:___ ___%@____:____

DIRECTION FACING & ALTITUDE : ____@____:____ ____@___:__ ____@___:___ ____@____:____

BREAKS:_____

COMMENTS:_____

NO.	TIME	MAG.	COLOR	TYPE	SPEED	TRAIN	ACCURACY	REMARKS
1								
2								
3								
4								
5								
6								
7								
8								
9								
10								
11								
12								
13								
14								
15								
16								
17								
18								
19								
20								

NO.	TIME	MAG.	COLOR	TYPE	SPEED	TRAIN	ACCURACY	REMARKS

SAMPLE VISUAL METEOR OBSERVING FORM

DATE: 2011 (year) 08 (month) 13 (day) Begin 11 h 00 m End 12 h 00 m (UT)

LOCATION: Long.=116 32 32 W. Lat.=32 50 50 N. Elevation =1000m

OBSERVER: ROBERT LUNSFORD PLACE: MT. LAGUNA, CA

LIMITING MAGNITUDE: +5.25 @ 11:00 +5.00 @ 12:00 _____@____:____

PERCENT CLOUDY: 0% @11 : 00 0%@ 12 : 00 ___%@___:___ ___%@___:___ _

DIRECTION FACING & ALTITUDE : N50 @11 : 00 N50 @ 12 :00 ____@___:___

BREAKS : NONE

COMMENTS: FULL MOON LOW IN SW SKY (OUT OF FIELD OF VIEW)

NO.	TIME	MAG.	COLOR	TYPE	SPEED	TRAIN	ACCURACY	REMARKS
1	1101	2		PER	FAST		GOOD	
2	1103	3		"	FAST		POOR	
3		2		"	FAST		GOOD	
4	1105	1	YELLOW	"	FAST	YES	GOOD	2 SEC TRAIN
5	1106	2		SPO	MED		POOR	
6	1108	3		PER	FAST		GOOD	
7	1109	2		"	FAST	YES	FAIR	
8	1111	-5	BLUE	"	MED	YES	GOOD	FIREBALL!!!
9	1112	1		"	FAST	YES	GOOD	
10	1115	0	YELLOW	KCG	SLOW		FAIR	FRAGMENTED
11	1118	2		PER	FAST	YES	GOOD	
12	1122	3		"	FAST		GOOD	
13	1125	4		"	MED		POOR	
14	1129	3		"	FAST		GOOD	
15	1133	3		"	FAST		GOOD	
16	1140	2		"	FAST	YES	GOOD	
17	1141	1	ORANGE	SPO	SLOW		FAIR	
18	1145	2		PER	FAST	YES	GOOD	
19	1149	3		"	FAST		POOR	
20	1155	2		"	FAST		FAIR	

General Activity throughout the Year

January – The **Quadrantids** are active early in the month and provide a sharp peak on the 3rd or 4th. The Anthelion radiant traverses the dim constellation of Cancer and provides 1-2 meteors per hour throughout the month. The early morning sporadic rates are good the first half of the month but fall somewhat during the second half. For the southern hemisphere, diffuse activity occurs from Carina, eastward through Centaurus. Rates are low, but fairly continuous throughout the month. Sporadic rates climb steadily toward a broad peak centered in February.

February – In the northern hemisphere meteor activity continues a slow decline. Only the Anthelion radiant, which traverses the constellation of Leo this month, provides any shower activity. These rates are only 1-2 per hour at best. Sporadic activity continues to fall from slowly. On the bright side, February signifies the start of evening fireball season, which continues through April. From the southern hemisphere, several diffuse radiants are active in the Centaurus region. The strongest of these, the Alpha Centaurids, peaks on February 8th. As the month progresses, activity diminishes as the radiants move eastward into Lupus. Southern sporadic rates are at their annual maximum this month.

March – This is one of the quietest months for the northern hemisphere. Only the Anthelion radiant produces 2-3 meteors per hour as it moves eastward through western Virgo this month. Evening fireball sightings are probably the highlight of the month. Sporadic rates are now only near 5 per hour and this rate continues through June. From the southern hemisphere, this is the last month for diffuse activity in Centaurus-Lupus region. Sporadic rates fall slightly but are still in double digits and will continue these rates through June.

April – This is the last month of notable evening fireballs for the northern hemisphere. The **Lyrids** are active during the last half of the month, increasing morning activity. They peak on the 22nd. The Anthelion radiant now passes south of the celestial equator through eastern Virgo and Libra. Rates still average 2-3 per hour. Sporadic rates continue at a low level. From the southern hemisphere, only a small fraction of the **Lyrid** activity may be seen as the radiant does not rise very high in their sky. Members of the **Eta Aquariids** may be seen during the last few days of the month. Sporadic rates continue near 10 per hour during the late morning hours.

May – Nights are now short in the northern hemisphere and there is little meteor activity to enhance the short nights. Feeble activity continues from the Anthelion radiant, which crosses the constellations of Scorpius and Ophiuchus this month. Late morning sporadic rates are now only 5 per hour and will remain virtually the same through June. From the southern hemisphere, the **Eta Aquariids** put on a fine show the first half of the month. Observers located in the north tropical regions can also view this activity. Rates peak near 30 per hour on the 7th,

making this one of the strongest displays visible from the southern hemisphere. Sporadic rates continue near 10 per hour.

June – This is another very quiet month for meteor observing, especially from the northern hemisphere. There are no major showers active plus the Anthelion radiant lies low in the south crossing the constellation of Sagittarius. Sporadic rates finally begin to rise during the last week of the month, though it is not really noticeable until July has arrived. From the southern hemisphere, there are several weak, diffuse radiants active in Ophiuchus and Sagittarius, which are usually included in the Antihelion count of 2-3 per hour. As winter arrives in the southern hemisphere, the sporadic rates remain high but will soon plummet as the season progresses.

July – Meteor activity in the northern hemisphere finally kicks into high gear in July. The first week is much like June, but right around the 20th, it's like someone turns on the faucet. There are many minor radiants in the Pegasus-Triangulum-Andromeda region that contribute to the higher activity. The Perseids, (now located in northern Andromeda) also become active around mid-month, contributing a few meteors per hour throughout the last half of July. The Anthelion radiant traverses Capricornus this month. These meteors are often difficult to separate from the **Alpha Capricornids** and the **Delta Aquariids**. The strongest shower of the month is the aforementioned **Delta Aquariids**, which peak on July 30th. These meteors are best seen from the tropical regions of the Earth where the radiant passes overhead. As many as 25 meteors per hour can been seen at maximum. Further away from the tropics, counts of 10-15 per hour are more common. While northern sporadic rates are increasing rapidly, the opposite is true in the southern hemisphere. Rates now average 8 per hour and fill fall to only 5 next month.

August – If the moon cooperates, the first half of August can be a meteor lover's paradise as seen from the northern hemisphere. Sporadic rates are now near 15 per hour plus there are many radiants scattered throughout the sky during this time. The major source of activity in the northern hemisphere is the **Perseids**, which peak near the 12th. These are spectacular meteors which brighter members often exhibiting vivid colors and persistent trains. Rates can reach 60 per hour at maximum, with decent rates during the entire second week of the month. Unfortunately, Perseid rates fall off rapidly after maximum. The second half of the month offers excellent sporadic activity, but many of the showers active during the first half of the month have now ceased activity. From the southern hemisphere, very little Perseid activity can be seen as the radiant passes very low in their northern sky just before dawn. Sporadic rates are also near their annual minimum and will remain low for the next 3 months.

September – Numerous minor radiants are active this month in Perseus, Auriga, Aries, and Taurus. Even the Southern Taurids, now located in eastern Pisces, come to life during the second week of the month. It is now impossible to differentiate the Southern Taurids from the

Anthelion radiant as the two overlap. This condition will continue through mid-December as these radiants pass through Pisces, Aries, and Taurus. Sporadic activity from the northern hemisphere still remains high but is often difficult to separate from the many radiants active this month. From the southern hemisphere the sporadic rates reach an annual low this month. Not much of the high declination activity can be seen from the southern hemisphere so the overall activity as seen from south of the equator this month is somewhat dull.

October – As seen from the northern hemisphere, this month is much like last except for the fact that a major display occurs during the third week of the month, the **Orionids**. This shower is active all month long and has a prolonged maximum centered on the 22nd. Maximum rates are usually 25 per hour for the Orionids but recently have been 40-60, often rivaling the much more popular Perseids. Sporadic rates continue to be good enhancing the overall activity for the month. The Orionids are equally well seen from the southern hemisphere and provide a majority of the activity seen from south of the equator this month.

November – The **Leonids** are the only major shower active this month, and they are quite variable usually providing good rates on only one night. The **Taurids** provide an average of 4 meteors per hour throughout the night. These meteors are visible from both hemispheres but slightly better seen from north of the equator due to the longer nights and higher declination. Sporadic activity continues to be good from the northern hemisphere. The skies are quiet as seen from the southern hemisphere with an average sporadic rate of only 5 per hour.

December – The year's strongest shower, the **Geminids** are very active the second week of the month, peaking on the 13th or 14th. These meteors can be seen from both hemispheres, but the north is favored due to the longer nights and higher radiant altitude. The **Ursids** are also active for a week near Christmas, but rates are good only on the night of maximum activity, usually December 21/22. After mid-month, activity decreases noticeably as the many showers of early December end and the sporadic rate begins to decline. This month is also a transition period for the southern hemisphere. Sporadic activity begins to increase plus diffuse activity begins in the Carina-Puppis-Vela region of the southern sky. This activity is strongest during the first half of the month but will continue off and on for the next 4 months as the center of activity slowly drifts eastward.

This visual observing guide will be updated with each passing year so that the shower information listed in the tables will remain current. It is also a work in progress and your input and comments about this material is greatly appreciated.

Suggested further reading:

Meteors and How to Observe Them by Robert Lunsford, Springer Publishing 2009. Intended for all levels of experience listing all the information necessary for successful meteor observing. Extensive coverage of major, minor, variable, and possible new showers is provided. Other observing techniques such as video, photographic, and radio observing is also covered. Observing tables to 2040 are also listed. History and math relating to meteorics, well covered in other books, is not provided in this book.

Meteors and Meteor Showers by Peter V. Bias 2005. Miracle Publishing Co. A good source of general information on major annual showers and all aspects of meteor observing including math and formulas related to meteoric phenomena. Also includes a good discussion of recent advances in the prediction of meteor outbursts.

IMO Handbook for Meteor Observers by Jürgen Rendtel and Rainer Arlt 2014. This is an updated version of the IMO's original handbook. It covers major and minor showers providing extensive formulas related to meteoric phenomena. It also provides good coverage of the history of major showers,

Meteor Showers and their Parent Comets by Peter Jenniskens. Cambridge University Press 2006. Expensive, but provides a wealth of information found nowhere else in print. Nearly 800 pages of information, charts, and illustrations. The final 200 pages consist of tables listing the IAU showers plus past and future circumstances of meteor outbursts.

Useful web sites for the meteor observer:

https://alpo-astronomy.org/Meteor

https://www.amsmeteors.org/

https://www.imo.net/