A new Working List of meteor showers

Rainer Arlt[1] *and Jürgen Rendtel*[2]

After the last revision of the working list of visual meteor showers in 1995, an updated version is proposed to be used starting in 2007. The list is meant to provide a collection of showers which are both visually observable and scientifically interesting for meteor astronomy. Major changes are the introduction of an all-year Antihelion Source comprising a number of ecliptical meteor showers. Showers new to the list are the η-Lyrids in May, and the October Leo Minorids. The former δ-Aurigids have been recognized as two individual sources, the September Perseids and the actual δ-Aurigids. A full listing of radiant motions in 5-day steps is also given.

1 Which showers are relevant?

The main goal of a working list of meteor showers is to collect observing records of showers which are supposed to deliver enough data for meaningful studies of meteoroid streams in the solar system. As a first prerequisite, a shower in the list should provide a minimum of activity and should be distinguishable from the general ("background") activity. Otherwise, the data collected over decades will not be enough to yield insight in dynamics of particles in the inner solar system. In the same respect, it seems worthwhile to emphasize meteor showers which originate from known comets or present asteroids, because those are the ones most likely offering information about minor bodies in general. If no parent is known, it should at least be possible to associate it with a set of orbits in space. There is a huge difference in reliability between a shower which is only known by virtue of a radiant in the two-dimensional sky, and a meteoroid stream which manifests its existence by a set of orbits in the three-dimensional solar system.

The working list of meteor showers is not meant as a list of potential showers in a search for radiants. It is obvious that millions of comets have entered the inner solar system during its existence. They have left behind the same number of meteoroid streams which will disperse gradually. It is thus natural that we will observe very many meteor showers in different stages of age. We are not seeking a "complete" list of meteor showers which does not exist as there is no sharp boundary between meteor showers and sporadic meteors.

The updated Working List of Meteor Showers is given at the end of this Paper in the Conclusions. There is also a full list of radiant positions in 5-day steps for all the showers of the Working List. The following Section will deal with the major changes in the shower list, ordered by the time of the year.

2 Shower list amendments

2.1 Antihelion source

There has been little evidence for individual meteor showers forming a sequence of radiants positioned a few degrees east of the antihelion direction. The exception is the Taurids showing very concentrated northern and southern radiants during October and November. The embedded Comet 2P/Encke and resonance effects with Jupiter make the Taurids an interesting source on their own which requires the separation from the ecliptical background activity which is essentially sporadic (Triglav-Čekada & Arlt, 2005; Triglav et al. 2006, this issue).

A smooth radiant drift over the rest of the year is proposed to account for the general activity from about 15° east of the antihelion point. The 'shower' will be called 'Antihelion Source' and abbreviated by ANT.

The Antihelion Source will thus replace a number of meteor showers which have hitherto represented the ecliptical background activity from the region near the antihelion point. The δ-Cancrids, Virginids, Sagittarids, Northern and Southern ι-Aquarids, Piscids, and χ-Orionids will be omitted from the new Working List.

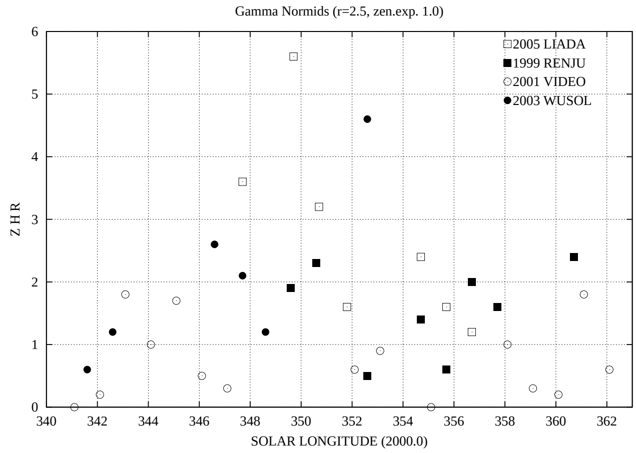

Figure 1: Activity of the γ-Normids derived from visual data (Trigo-Rodríguez et al., 2005; and Rendtel – visual data 1999; Wusk – visual data 2003) and video data (relative rate (GNO/SPO)×10 from March 2001; sso1 camera).

2.2 γ-Normids

Only little information is available for this southern shower. An analysis of 2005 data (Trigo-Rodríguez et al., 2005) shows a maximum close to $\lambda_\odot = 350°$, i.e. about three days before the previously assumed time. Rates seem to vary slightly from one year to the next with peak ZHRs reported between 2 and 6 with a probable median ZHR of 2–3. Recent rate data is shown in Figure 1.

Positional video data is not yet sufficient for final conclusions. The result obtained from two cameras of the video network is shown in Figure 2. Interestingly, this position also fits the radiant position derived from two data sets of visual plotting observations. Further,

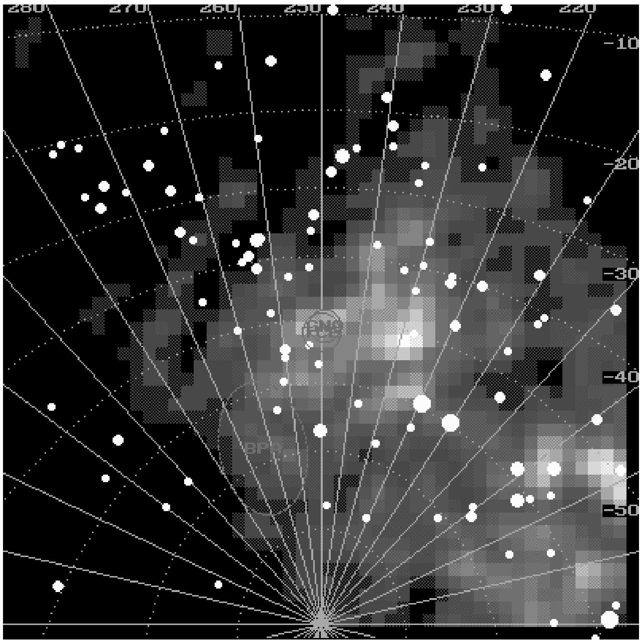

Figure 2: Radiant area of the γ-Normids as derived from 1264 video meteor positions obtained between 2001 March 01 and 20 (swat and sso1 cameras). There is no distinct radiant at the listed position. A weak concentration can be found somewhat west near 230–240°, −50°.

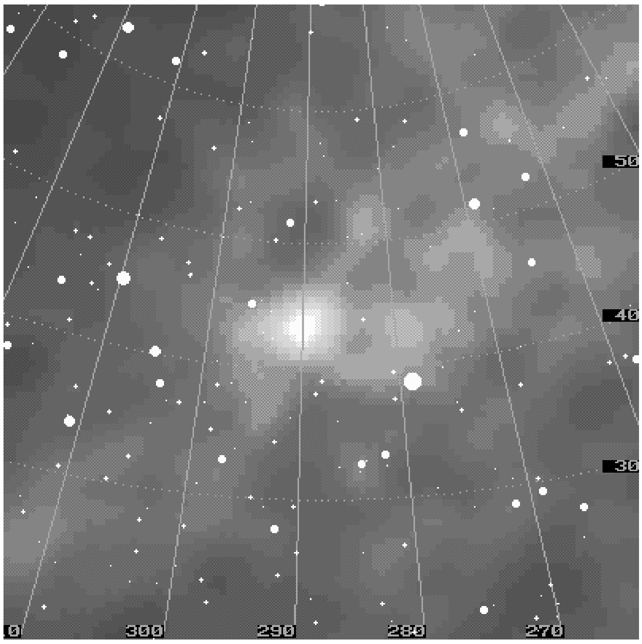

Figure 3: Radiant plot with 684 video meteors of May 6-13 around the possible radiant of the η-Lyrids.

the orbital databases do not supply support for this minor shower which makes it the weakest candidate in the shower list. However, we leave it in our Working List with the urgent request for detailed observations. The radiant position is fitted with the location derived from the recent video and visual data.

2.3 η-Aquarids

The only thing which was updated is the radiant motion. Video data of the IMO video network up to 2005 were used to determine the radiant positions in 5-day steps. The results are very close to the old list values, and changes were $\leq 2°$.

2.4 η-Lyrids

This shower is often referred to as the meteors from IRAS-Araki-Alcock which is a comet that passed perihelion in May 1983. We are following the usual shower naming which refers to constellations and use the abbreviation `ELY`.

Comet C/1983 H1 IRAS-Araki-Alcock is a well studied object, and meteor activity from that parent has been significant though not very high. A comprehensive set of video meteors shows the radiant very clearly (Figure 3). Since nearly all the video meteors are in the visual range of brightnesses, the radiant is also a good representation of what visual observations would obtain, less accurately though.

Ohtsuka (1991) reported about five orbits in the IAU orbital database which were associated with the Comet. These orbits give a radiant position of about $\alpha = 289°$, $\delta = +43.^\circ2$ centered around a solar longitude of $\lambda_\odot = 49.^\circ6$. The closest approach to the orbit of C/1983 H1 is $\lambda_\odot = 48.^\circ4$ with a theoretical radiant position of $\alpha = 288.^\circ0$, $\delta = 44.^\circ0$ and a geocentric velocity of $v_g = 43.8$ km/s. Bearing in mind that the difference in reference dates for the observational and the theoretical estimates are about one day, they agree very well. The radiant position from video data in Figure 3 refers to $\lambda_\odot = 49.^\circ0$.

In the new Shower List, we adopt an activity period of May 3–12 as was done by Kronk (1988). There are several methods of how to compute the possible evolution of meteoroid particles to approach Earth, without actually following the motion of individual particles. The methods compiled by Neslušan et al. (1998) yield a time of probable maximum activity at $\lambda_\odot = 48.^\circ4$ or roughly May 9. The encounter velocity of the particles including the gravity of the Earth is 44 km/s. A daily modetion of the radiant of 1° per day is assumed for the ephemeris given in Table 2.

The η-Lyrids may be an interesting source as both orbital elements and parent are available. The shower should not be mixed with the τ-Herculids theoretically generated from the disintegrated Comet 73P/Schwassmann-Wachmann 3, but not exhibiting significant meteor numbers hitherto.

2.5 June Lyrids

First observations of this shower have been reported in the 1960s. Later the shower was dropped off the working lists because its evidence was very low. A comprehensive review of observations collected between 1985 and 1997 by Kidger (2000) shows a low but significant activity around $\lambda_\odot = 86°$ with ZHRs of the order of 3. Hindley (1970) suggested a link of the stream with Comet C/1915 C1 (Mellish) which is not very evident because of the comet's near-parabolic orbit and its per-

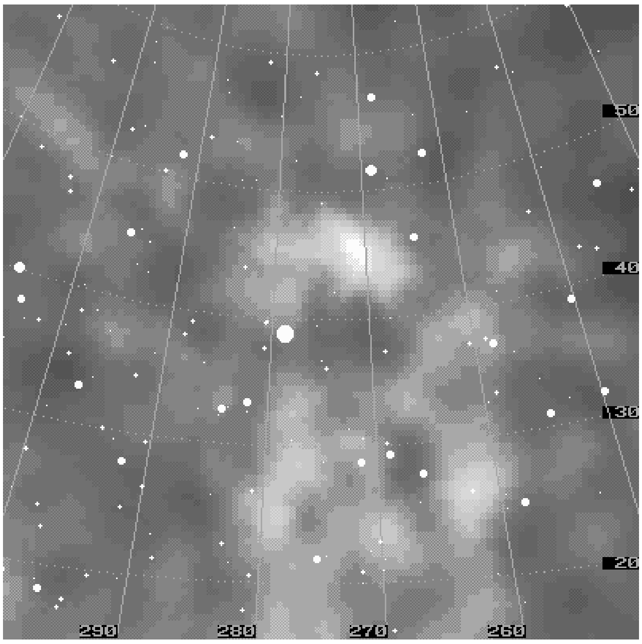

Figure 4: Radiant plot with 679 video meteors around the possible radiants of the June Lyrids and ξ-Draconids.

ihelion outside the Earth's orbit. Orbits of stream meteoroids are missing except for a single case (Sekanina, 1979) which may be a coincidence. The radiant distribution around the area of the June Lyrid radiant is shown in Figure 4. There is a slightly enhanced radiant density at the position of the June Lyrid radiant as listed in the pre-1995 shower lists. The strongest radiant areas distributed over an area of 30° diameter, north, south, and southwest of the expected place.

This shower – or one which has its radiant nearby – may be an interesting source to be followed also in future observations, but the poor knowledge of physical parameters does not yet allow us to include the shower in the Working List.

2.6 June Bootids

The activity period is an issue with this shower, since the maximum on June 27 follows the beginning of the period, June 26, very closely. Dust trail predictions have delivered peak dates as early as June 22. That case may have been exceptional, nevertheless, we propose to extend the activity period of the June Bootids to June 22 to July 2. Even if this activity period is overestimated, a pollution by sporadic meteors is not very likely because of the high elongation of the radiant from the apex and the peculiar velocity of the shower.

2.7 July Pegasids

The activity of this shower has been very low to nonexistent over the last two decades at least. We propose to omit the shower from the Working List, because it will not deliver any meaningful results on a long term.

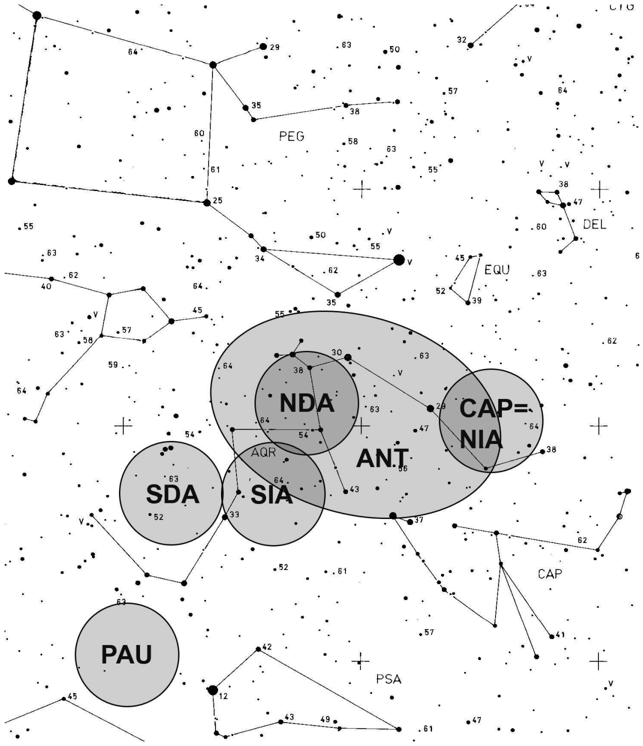

Figure 5: Radiant positions of the Aquarid showers and the main location and area of the anthelion background activity. The radiant position of the traditional showers are taken from the 2006 Meteor Shower Calendar (McBeath 2005).

2.8 July Phoenicids

Lack of data, orbital information, and parent object give little prominence to this shower, and we propose to omit it from the Working List.

2.9 Northern δ-Aquarids

It has been hard to detect this shower apart from the general ecliptical activity in July and August as an individual source. Based on the shower associations in the records of the Visual Meteor Database, a rate profile of the Northern δ-Aquarids was computed. The two-sided exponential fit yielded a maximum ZHR of 2.6 (Dubietis & Arlt, 2004). An isolated radiant would be suitable for visual observations at this level of activity, but the close vicinity of the antihelion background component makes the discrimination of Northern δ-Aquarids very unreliable. Similar findings were published by Arlt et al. (1992) within the Aquarid project. Figure 5 shows that the radiant of NDA as it was listed in the old Working List actually lies within the average radiant area of the antihelion source.

2.10 Capricornids

Despite the radiant overlap with the Antihelion Source, we leave the shower in the Working List, because of the interesting connection with a comet or perhaps asteroids, the good knowledge of orbits, and the prominence in activity curves of the ecliptical activity in July–August. Observers should make a careful distinction between the Capricornids and the Antihelion Source from

July 3 to August 15.

2.11 Perseids

There is not much really to be changed for the Perseids. The only thing we adapted is the radiant motion which was studied by Arlt (2003). The positions of August 10 and later are taken from that paper, while earlier position have been recomputed with a larger set of video meteors and longer, overlapping intervals in order to produce a smooth ephemeris of the radiant. The positions were also compared with the photographic results based by Svoreň and Kaňuchová (2005) based on the most recent version of the IAU orbital database. We found fairly good agreement, especially on the fact the radiant does not lie below $\delta = +40$ or even below $\delta = +30$ in July and early July, respectively. Radiant positions in the central part of Andromeda have often been reported from visual data, but cannot be deduced from video and photographic data.

2.12 September Perseids and δ-Aurigids

These two shower designations have been combined in the shower code `DAU` in the old Working List, because a smooth radiant drift was found indicating that it could actually be one shower being active for more than a month. However, a recent activity analysis by Dubietis & Arlt (2002) shows clearly separated activity maxima, and it was concluded that the continuation of the radiant drift of one shower by the other is accidental.

The analysis showed the minimum between the two maxima near September 17. We propose an activity period of September 05–17 for the September Perseids (`SPE`) and a period of September 18–October 10 for the δ-Aurigids (`DAU`). In the stream search by Welch (2001), the September Perseids at position 21 in the ranking of the most prominent 'orbit clusters' (note that the shower is called δ-Aurigids there but definitely refers to SPE).

2.13 Leo Minorids

The first mention of this shower dates back to McCrosky & Posen (1959) who found just two meteors with very similar orbits in their photographic survey. More recent compilations of photographic and video data by the Dutch Meteor Society confirmed this confined meteoroid stream (de Lignie & Betlem 1999). Visual activity of the shower is weak; Jenniskens (1994) estimated the maximum ZHR to be 2 from a two-sided exponential fit. According to his graph, we propose to set the activity period to October 19–27, but the maximum is hard to fix. We therefore propose to use the solar longitude of 211° as it was listed in the very first IMO Working List, or approximately October 24. The average of ascending nodes of the photographic orbits given by de Lignie & Betlem (1999) is near $\lambda_\odot = 209°$ though, matching the peak time of the two-sided exponential fit by Jenniskens (1994). Their results for the geocentric velocity of the meteoroids was 61.9 km/s converting to an entry velocity of 63 km/s. The average radiant position for a solar longitude of 210° is $\alpha = 160.^\circ 2$, $\delta = 36.^\circ 8$. Recently, Borovička (2001) reported about a spectrum of a Leo Minorid. The stream is also detected by the new search method by Welch (2001).

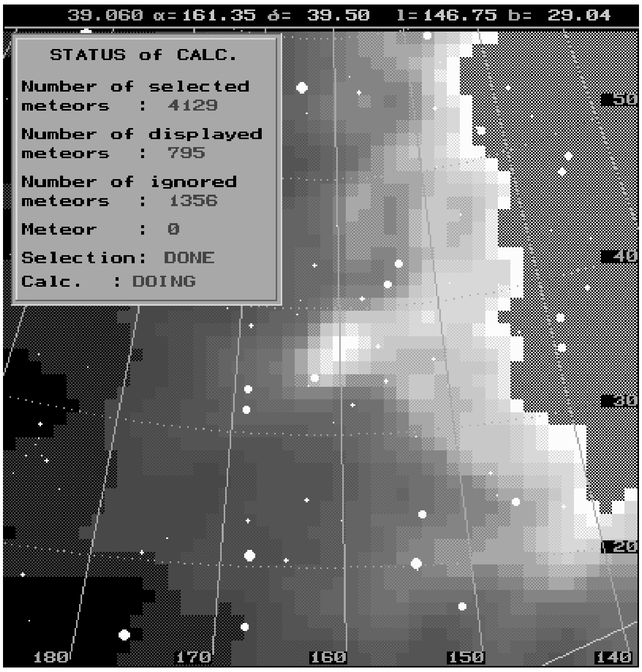

Figure 6: Radiant plot from 795 video meteors showing the radiant of the Leo Minorids. The huge area of radiants of various sources, such as the Orionids, ε-Geminids and ecliptical background meteors had to be suppressed to make the `LMI` radiant visible.

The data from the IMO video network also exhibit a weak but well confined radiant area very close to the photographic position of the Leo Minorid radiant (Figure 6). If the radiant were closer to the radiant of ε-Geminids and Orionids, it is probably hardly detectable in such a radiant plot. However, the well separated position and the clear evidence in orbital data makes the shower an interesting target for future observations. The IMO code will be `LMI`.

2.14 Taurids

As was discussed already in Section 2.1, the Taurids are a very prominent part of ecliptical activity which will for sure provide new insights in the dynamics of meteoroid streams of short-period comets. According to the study by Triglav-Čekada & Arlt (2005), we propose the activity period of the Northern and Southern Taurids to be September 25 to November 25. This is the period in which a consistent radiant drift was found for both branches.

2.15 Leonids

Stream modelling of the Leonids led to various activity peaks which occurred outside the activity period of the shower in the previous Working List. Observers not being aware of the predictions will fail to associate the meteors seen with the Leonids on such occasions. Also automated video systems will ignore possible activity. We propose to extend the activity period to November 10–23. The Leonid radiant is sufficiently isolated

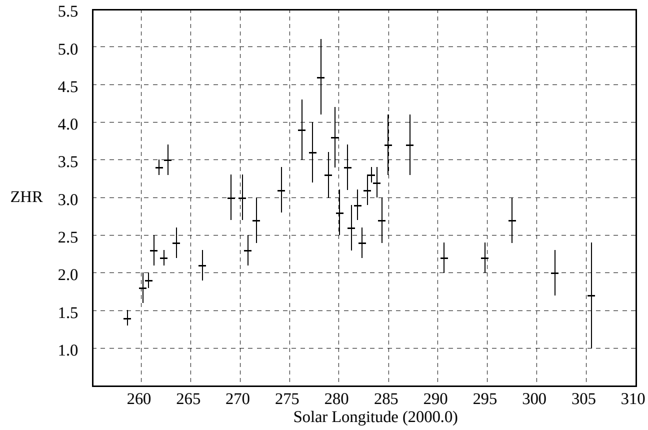

Figure 7: Average activity profile of the Coma Berenicids derived from 5700 visual observations of 1986–2005.

from other sources. Their very high speed make the Leonids well distinguishable from the sporadic meteors. A severe contamination from sporadic meteors at the far ends of the activity period does not seem harmful. On the other hand, we may obtain information about possible activity caused by meteoroids on orbits far from the main stream.

2.16 December Phoenicids

Lack of data, orbital information, and parent object gave little prominence to this shower, and the original proposal was to omit it from the Working List. Recent observations of the planet-crossing minor planet 2003 WY_{25} indicate a cometary nature of the object and support its identification with the lost comet D/1819 W1 (Blanpain) (Jewitt, 2006). Perhaps the comet split and the breakup accounts for the 1956 activity (Jenniskens & Lyytinen, 2005). Although there are still open questions, we suggest to leave the shower in our Working List. Otherwise there is a chance to miss data if we were omitting the entry now.

2.17 Coma Berenicids

This shower with an assumed activity period for about 1.5 months has not been associated successfully with a parent object. An activity profile of the shower was constructed using 5700 observations of the Visual Meteor Database. The result is shown in Figure 7 and indicates that there is indeed significant activity over the entire proposed activity period. Since the radiant position of the Coma Berenicids is also quite isolated, we propose to keep the long activity period of the shower as was in the previous Working List.

3 More showers?

In an attempt to add potentially interesting meteor showers to the list which were not included in the old version, we evaluated the showers of other compilations. The radiant list given by Jenniskens (1994), contains five showers which were not listed in the previous IMO list, have known orbital parameters, and do not belong to the ecliptical source near the antihelion point. These are the γ-Velids, α-Hydrusids, δ-Pavonids, κ-Aquarids, and Leo Minorids. We were unable to detect the first three in a radiant search with video meteors, but the amount of data from the southern hemisphere is inferior to the one from the northern hemisphere. The κ-Aquarids deliver a very weak radiant signal, and may be an interesting target for future updates of the Working List.

The new stream search method by Welch (2001) delivered 29 most prominent 'orbit clusters'. It is interesting to note that there is only a single stream among these 29 which has not yet been in the old Working List; this is the Leo Minorids which we have now included.

4 Conclusions

The new Working List of Meteor Showers is given in Table 1. We remind the reader that the list contains visually observable and scientifically interesting showers. The radiant motion of each of these showers is given in 5-day steps in Table 2. Some of the ephemerides are based on recent research, others are taken from the previous version of the Working List; we refer to the above sections for corresponding notes.

Acknowledgements

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Table 1: New Working List of Meteor Showers to be adopted starting in 2007. The solar longitude $\lambda_\odot$ refers to equinox J2000.0. The date of maximum has to be computed for each individual year. The dates given here are only approximate and may vary by ±1 day. The entry-velocity V_∞ is the geocentric encounter velocity plus acceleration by the gravity of the Earth. Th radiant positions can be taken from Table 2. Radiants for the time of maximum are not given, because of the risk of being used for the entire activity period by less involved observers. The same holds for the population index which varies during the activity periods of each shower. Meteor showers typically exhibit a population index of $r = 2.0$ to 2.5 during their maximum. Values in this range should be used for tentative analyses; otherwise r must be determined as a function of time before any activity computation of a meteor shower.

Shower	Code	Activity period –	$\lambda_\odot$ of maximum J2000.0	Approx. date of maximum	V_∞ km/s	ZHR
Anthelion source	ANT	Jan 01–Dec 31	–	–	30	(3)
		ANT not observable during NTA/STA				
Quadrantids	QUA	Jan 01–Jan 05	283°.16	Jan 03	41	120
α-Centaurids	ACE	Jan 28–Feb 21	319°.2	Feb 07	56	5
δ-Leonids	DLE	Feb 15–Mar 10	336°	Feb 24	23	2
γ-Normids	GNO	Feb 25–Mar 22	353°	Mar 13	56	4
Lyrids	LYR	Apr 16–Apr 25	32°.32	Apr 22	49	18
π-Puppids	PPU	Apr 15–Apr 28	33°.5	Apr 24	18	var
η-Aquarids	ETA	Apr 19–May 28	45°.5	May 05	66	60
η-Lyrids	ELY	May 03–May 12	48°.4	May 09	44	3
June Bootids	JBO	Jun 22–Jul 02	95°.7	Jun 27	18	var
Piscis Austrinids	PAU	Jul 15–Aug 10	125°	Jul 28	35	5
Southern δ-Aquarids	SDA	Jul 12–Aug 19	125°	Jul 28	41	20
α-Capricornids	CAP	Jul 03–Aug 15	127°	Jul 30	23	4
Perseids	PER	Jul 17–Aug 24	140°.0	Aug 12	59	100
κ-Cygnids	KCY	Aug 03–Aug 25	145°	Aug 17	25	3
α-Aurigids	AUR	Aug 25–Sep 08	158°.6	Sep 01	66	7
September Perseids	SPE	Sep 05–Sep 17	166°.7	Sep 09	64	5
δ-Aurigids	DAU	Sep 18–Oct 10	191°	Oct 04	64	2
Draconids	GIA	Oct 06–Oct 10	195°.4	Oct 08	20	var
ε-Geminids	EGE	Oct 14–Oct 27	205°	Oct 18	70	2
Orionids	ORI	Oct 02–Nov 07	208°	Oct 21	66	23
Leo Minorids	LMI	Oct 19–Oct 27	211°	Oct 24	62	2
Southern Taurids	STA	Sep 25–Nov 25	223°	Nov 05	27	5
Northern Taurids	NTA	Sep 25–Nov 25	230°	Nov 12	29	5
Leonids	LEO	Nov 10–Nov 23	235°.27	Nov 17	71	var
α-Monocerotids	AMO	Nov 15–Nov 25	239°.32	Nov 21	65	var
December Phoenicids	PHO	Nov 28–Dec 09	254°.25	Dec 06	18	var
Puppid/Velids	PUP	Dec 01–Dec 15	(255)	Dec 07	40	10
Monocerotids	MON	Nov 27–Dec 17	257°	Dec 09	42	2
σ-Hydrids	HYD	Dec 03–Dec 15	260°	Dec 12	58	3
Geminids	GEM	Dec 07–Dec 17	262°.2	Dec 14	35	120
Coma Berenicids	COM	Dec 12–Jan 23	268°	Dec 19	65	5
Ursids	URS	Dec 17–Dec 26	270°.7	Dec 22	33	10

Table 2: Radiant drifts of the showers in the new Working List in Table 1. Positions refer to eq. J2000.0.

Date		**ANT**		**QUA**		**COM**									
Dec	31	112°	+21°	228°	+50°	186°	+20°								
Jan	5	117°	+20°	231°	+49°	190°	+18°								
Jan	10	122°	+19°			194°	+17°								
Jan	15	127°	+17°			198°	+15°								
Jan	20	132°	+16°			202°	+13°								
Jan	25	138°	+15°					**ACE**							
Jan	30	143°	+13°					200°	−57°						
Feb	5	149°	+11°					208°	−59°						
Feb	10	154°	+9°					214°	−60°	**DLE**					
Feb	15	159°	+7°					220°	−62°	159°	+19°				
Feb	20	164°	+5°	**GNO**				225°	−63°	164°	+18°				
Feb	28	172°	+2°	225°	-51°					171°	+15°				
Mar	5	177°	0°	230°	-50°					176°	+13°				
Mar	10	182°	−2°	235°	-50°					180°	+12°				
Mar	15	187°	−4°	240°	-50°										
Mar	20	192°	−6°	245°	-49°										
Mar	25	197°	−7°												
Mar	30	202°	−9°												
Apr	5	208°	−11°												
Apr	10	213°	−13°	**LYR**		**PPU**									
Apr	15	218°	−15°	263°	+34°	106°	−44°	**ETA**							
Apr	20	222°	−16°	269°	+34°	109°	−45°	323°	−7°						
Apr	25	227°	−18°	274°	+34°	111°	−45°	328°	−5°						
Apr	30	232°	−19°					332°	−3°	**ELY**					
May	05	237°	−20°					337°	−1°	283°	+44°				
May	10	242°	−21°					341°	0°	288°	+44°				
May	15	247°	−22°					345°	+3°	293°	+45°				
May	20	252°	−22°					349°	+5°						
May	25	256°	−23°												
May	30	262°	−23°												
Jun	5	267°	−23°												
Jun	10	272°	−23°												
Jun	15	276°	−23°												
Jun	20	281°	−23°	**JBO**											
Jun	25	286°	−22°	223°	+48°										
Jun	30	291°	−21°	225°	+47°	**CAP**									
Jul	5	296°	−20°			285°	−16°	**SDA**							
Jul	10	300°	−19°	**PER**		289°	−15°	325°	−19°	**PAU**					
Jul	15	305°	−18°	6°	+50°	294°	−14°	329°	−19°	330°	−34				
Jul	20	310°	−17°	11°	+52°	299°	−12°	333°	−18°	334°	−33				
Jul	25	315°	−15°	22°	+53°	303°	−11°	337°	−17°	338°	−31				
Jul	30	319°	−14°	29°	+54°	308°	−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°	76°	+42°					288°	+60°		
Aug	30	349°	−3°			82°	+42°	**SPE**				289°	+60°		
Sep	5	355°	−1°			88°	+42°	55°	+46°						
Sep	10	0°	+1°			92°	+42°	60°	+47°						
Sep	15	5°	+3°					66°	+48°	**DAU**					
Sep	20	10°	+5°	**NTA**		**STA**		71°	+48°	71°	+48°				
Sep	25	14°	+7°	19°	+11°	21°	+6°			77°	+49°				
Sep	30			22°	+12°	25°	+7°	**ORI**		83°	+49°				
Oct	5			26°	+14°	28°	+8°	85°	+14°	89°	+49°			**GIA**	
Oct	10	**EGE**		30°	+15°	32°	+9°	88°	+15°	92°	+42°			262°	+54°
Oct	15	99°	+27°	34°	+16°	36°	+11°	91°	+15°			**LMI**			
Oct	20	104°	+27°	38°	+18°	40°	+12°	94°	+16°			158°	+39°		
Oct	25	109°	+27°	43°	+19°	43°	+13°	98°	+16°			163°	+37°		
Oct	30			47°	+20°	47°	+14°	101°	+16°			168°	+35°		
Nov	5			52°	+21°	52°	+15°	105°	+17°	**LEO**					
Nov	10			56°	+22°	56°	+15°			147°	+24°			**AMO**	
Nov	15			61°	+23°	60°	+16°			150°	+23°			112°	+2°
Nov	20	**ANT**		65°	+24°	64°	+16°			153°	+21°			116°	+1°
Nov	25	75°	+23°	70°	+24°	72°	+17°	**MON**		**PHO**		**PUP**		120°	0°
Nov	30	80°	+23°	**GEM**				91°	+8°	14°	−52°	120°	−45°	**HYD**	
Dec	5	85°	+23°	103°	+33°	**COM**		96°	+8°	18°	−53°	122°	−45°	122°	+3°
Dec	10	90°	+23°	108°	+33°	169°	+27°	100°	+8°	22°	−53°	125°	−45°	126°	+2°
Dec	15	96°	+23°	113°	+33°	173°	+26°	104°	+8°	**URS**		128°	−45°	130°	+1°
Dec	20	101°	+23°	118°	+32°	177°	+24°			217°	+76°				
Dec	25	106°	+22°			181°	+23°			217°	+74°				
Dec	30	111°	+21°			185°	+21°								

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