The 2018 Meteor Shower Activity Forecast for Earth Orbit

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Overview

A number of meteor showers – the Ursids, Perseids, Leonids, eta Aquariids, Orionids, Draconids, and Andromedids – are predicted to exhibit increased rates in 2018. However, no major storms are predicted, and none of these enhanced showers outranks the typical activity of the Arietids, Southern delta Aquariids, and Geminids at small particle sizes.

The MSFC stream model[1] predicts higher than usual activity for the Ursid meteor shower in December 2018. While we expect an increase in activity, rates will fall short of the shower's historical outbursts in 1945 and 1986 when the zenithal hourly rate (ZHR) exceeded 100. Instead, the expected rate for 2018 is around 70.

The Perseids, Leonids, eta Aquariids, and Orionids are expected to show mild enhancements over their baseline activity level in 2018. In the case of the Perseids, we may see an additional peak in activity a few hours before the traditional peak, but we do not expect activity levels as high as those seen in 2016 and 2017. The eta Aquariids and Orionids, which belong to a single meteoroid stream generated by comet 1P/Halley, are thought to have a 12-year activity cycle and are currently increasing in activity from year to year.

Finally, we may see minor outbursts of the Draconids and Andromedids in 2018. Both showers have been difficult to model and have produced unexpected outbursts in recent years (the Draconids in 2012 and the Andromedids in 2011 and 2013). The Andromedids may produce two peaks, both of which are listed in Table 2.

This document is designed to supplement spacecraft risk assessments that incorporate an annual averaged meteor shower flux (as is the case with all NASA meteoroid models). Results are presented relative to this baseline and are weighted to a constant kinetic energy. Two showers – the Daytime Arietids (ARI) and the Geminids (GEM) – attain flux levels approaching that of the baseline meteoroid environment for 0.1-cm-equivalent meteoroids. This size is the threshold for structural damage. These two showers, along with the Quadrantids (QUA) and Ursids (URS), exceed the baseline flux for 0.3-cm-equivalent particles, which is near the limit for pressure vessel penetration. Please note, however, that meteor shower fluxes drop dramatically with increasing particle size. For example, the Arietids contribute a flux of about 2×10^{-6} meteoroids m^{-2} hr^{-1} in the 0.04-cm-equivalent range, but only 4×10^{-9} meteoroids m^{-2} hr^{-1} for the 0.3-cm-equivalent and larger size regime. Thus, a PNP risk assessment should use the flux and flux

[1] https://doi.org/10.1007/978-0-387-78419-9_40

enhancements corresponding to the smallest particle capable of penetrating a component, because the flux at this size will be the dominant contributor to the risk.

Details

For the 2017 annual forecast, we revised the list of forecasted showers and improved the activity profiles for a dozen major showers. We have retained those activity profiles in the present forecast, and have now also modified the population index of the Ursid meteor shower. Based on the distribution of Ursid radar echoes measured by the Canadian Meteor Orbit Radar, we now believe this shower to have a significantly shallower population index of 2.1, rather than the value of 3.0 used previously. This lower value is consistent with that reported by Moreno-Ibáñez et al. (2017).[2] The significance of this change is that the Ursids are skewed more strongly toward large particles than most showers. Thus, despite the forecasted increase in activity in 2018, the flux enhancement at small particle sizes due to the Ursids is modest.

We have also revised our forecasting algorithm and made a number of improvements in advance of this year's forecast. These improvements are discussed at length in Moorhead et al. (2017),[3] but one of the most important changes is that we now specifically and consistently report shower fluxes on a plate *facing the shower radiant*. This assumes the least favorable geometry possible in terms of risk, and thus gives a "worst-case scenario" for flux enhancement. However, the average contribution a shower makes to the flux on a *randomly tumbling* plate will be ¼ as large. Thus, in order to obtain the average background flux, we subtract ¼ the directional shower flux. As a result, the integral of the enhancement factor curve in Figure 3 is no longer zero.

Figure 1 gives the expected visual meteor rates (ZHR) for ground observers during calendar year 2018. The visual rate is dominated by the Quadrantids in early January, the Geminids in mid-December, and the Perseids in mid-August. The Daytime Arietids technically have a significant ZHR, but since they occur at dawn they are difficult to observe visually. Although meteor astronomers record and predict showers in terms of visual rates, ZHR does not directly correspond to meteoroid flux. The conversion from ZHR to flux must take into account the biases of the typical human observer, the speeds of the shower meteors, and the mass distributions of meteoroids belonging to these showers. The result is a flux profile that looks significantly different from the ZHR profile, and high flux does not necessarily correspond to a visually spectacular meteor shower.

Showers typically contain proportionally more large particles than the sporadic background does; for this reason, showers are more significant at larger particle sizes. Figure 2 gives the flux profiles for four particle sizes; because damage is more closely related to kinetic energy than it is to particle size, we have computed the particle size for each shower that has the same kinetic energy as a 20 km/s particle with a diameter of 0.04, 0.1, 0.3, or 1.0 cm and a density of 1 g/cc. The average annual meteoroid flux for each of these diameters is also shown for comparison (dashed horizontal lines). Note that for small particle sizes, the shower flux is a small fraction of the average total flux.

[2] https://doi.org/10.1093/mnras/stx592
[3] https://ntrs.nasa.gov/search.jsp?R=20170004446

Figure 2 also indicates that there are, depending on the threat size considered, approximately five or six showers that produce the highest fluxes. The basic characteristics of these showers, including radiant position, are listed in Table 1.

Table 1. The six most active meteor showers of 2018 (in terms of flux).

Shower	**Radiant** RA (deg)	Dec (deg)	**Speed ($km\ s^{-1}$)**	**Date of Maximum (UTC)**
Quadrantids	230	+49	41	2018-01-04 06:05
Daytime Arietids	44	+24	39	2018-06-10 22:07
Southern delta Aquariids	340	-16	42	2018-07-28 07:12
Perseids	48	+58	61	2018-08-13 02:07
Geminids	112	+33	35	2018-12-14 13:09
Ursids	220	+75	33	2018-12-22 23:22

Because showers are included in the total flux in an average sense, it would be incorrect to add the shower flux to the annual average flux. In order to facilitate correct risk assessments, including BUMPER PNP calculations, we provide flux enhancement factors for all of 2018 in 1-hour intervals (Figure 3). The flux enhancement is positive during periods of shower activity when the risk is higher, and negative during periods of relative inactivity when the flux is below average. Due to the changes discussed above, however, positive enhancements exceed negative enhancements overall. The larger flux enhancement factors correspond to 0.1-cm-equivalent particles, which have lower absolute fluxes.

The Meteoroid Environment Office will update this forecast as necessary. Those with questions or special needs in the near future are encouraged to contact Bill Cooke (email: william.j.cooke@nasa.gov, phone: 256-544-9136) or Althea Moorhead (email: althea.moorhead@nasa.gov, phone: 256-544-7352).

Table 2. Meteor showers in 2018. Column 2 provides the 3-letter code for each shower, Column 3 lists the date and time of peak activity, and Column 4 provides the cumulative shower ZHR at the time of each shower's peak activity. These cumulative ZHRs often include substantial contributions from adjacent showers.

Shower	ID	Max time (UTC)	Max ZHR
Quadrantids	QUA	2018-01-04 06:05	120
gamma Normids	GNO	2018-03-13 04:37	8
April Lyrids	LYR	2018-04-23 14:45	19
eta Aquariids	ETA	2018-05-06 20:20	54
Daytime zeta Perseids	ZPE	2018-06-03 05:32	41
Daytime Arietids	ARI	2018-06-10 22:07	74
Southern mu Sagittariids	SSG	2018-06-20 02:39	31
beta Taurids	BTA	2018-06-28 17:01	23
July Phoenicids	PHE	2018-07-13 04:23	11
Piscis Austrinids	PAU	2018-07-27 00:18	33
Southern delta Aquariids	SDA	2018-07-28 07:12	40
Capricornids	CAP	2018-07-28 21:01	38
Perseids	PER	2018-08-13 02:07	106
kappa Cygnids	KCG	2018-08-18 05:44	14
Aurigids	AUR	2018-09-01 08:15	8
September epsilon Perseids	SPE	2018-09-09 16:44	6
Daytime Sextantids	DSX	2018-10-02 23:02	7
Draconids	DRA	2018-10-09 00:30	15
Leo Minorids	LMI	2018-10-19 20:18	18
Orionids	ORI	2018-10-22 21:42	32
Southern Taurids	STA	2018-11-05 17:45	14
Northern Taurids	NTA	2018-11-12 16:58	17
Leonids	LEO	2018-11-17 22:33	31
Andromedids (first peak)	AND	2018-11-23 15:53	15
Andromedids (second peak)	AND	2018-12-02 11:23	17
Puppids/Velids	PUV	2018-12-07 10:27	23
December Monocerotids	MON	2018-12-09 09:41	34
sigma Hydrids	HYD	2018-12-12 08:31	66
Geminids	GEM	2018-12-14 13:09	127
Ursids	URS	2018-12-22 23:22	68