The 2017 Meteor Shower Activity Forecast for Earth Orbit

Issued December 16, 2016

Althea Moorhead
Meteoroid Environment Office
Marshall Space Flight Center
(256) 544-7352
althea.moorhead@nasa.gov

Bill Cooke
Meteoroid Environment Office
Marshall Space Flight Center
(256) 544-9136
william.j.cooke@nasa.gov

Danielle Moser
Jacobs, ESSSA Group
Marshall Space Flight Center
(256) 544-2423
danielle.e.moser@nasa.gov

Overview

Most meteor showers will display typical activity levels in 2017. Perseid activity is expected to be higher than normal but less than in 2016; rates may reach 80% of the peak ZHR in 2016. Despite this enhancement, the Perseids rank 4^{th} in flux for 0.04-cm-equivalent meteoroids: the Geminids (GEM), Daytime Arietids (ARI), and Southern delta Aquariids (SDA) all produce higher fluxes.

Aside from heightened Perseid activity, the 2017 forecast includes a number of changes. In 2016, the Meteoroid Environment Office used 14 years of shower flux data to revisit the activity profiles of meteor showers included in the annual forecast. Both the list of showers and the shape of certain major showers have been revised. The names and three-letter shower codes were updated to match those in the International Astronomical Union (IAU) Meteor Data Center, and a number of defunct or insignificant showers were removed. The most significant of these changes are the increased durations of the Daytime Arietid (ARI) and Geminid (GEM) meteor showers.

This document is designed to supplement spacecraft risk assessments that incorporate an annual averaged meteor shower flux (as is the case with all NASA meteor 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 Perseids (PER), 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. As an example, the Arietids contribute a flux of about 5×10^{-6} meteoroids m^{-2} hr^{-1} in the 0.04-cm-equivalent range, but only 1×10^{-8} 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 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

The Canadian Meteor Orbit Radar (CMOR) has provided the Meteoroid Environment Office (MEO) with daily meteor flux measurements for over 14 years. These radar observations now cover a longer time span than the ten years of visual observations previously used to characterize forecasted meteor showers. CMOR is also able to detect smaller particles than visual observers, allowing us to probe deeper into the threat regime and characterize their activity at the sizes included in the meteor shower forecast.

We have now derived shower profiles from the radar flux data and incorporated these into the 2017 forecast. Twelve showers in total have updated profiles: the April Lyrids (LYR), eta Aquariids (ETA), Daytime zeta Perseids (ZPE), Daytime Arietids (ARI), Southern delta Aquariids (SDA), Capricornids (CAP), Daytime Sextantids (DSX), Leo Minorids (LMI), Orionids (ORI), Geminids (GEM), Ursids (URS), and Quadrantids (QUA). In some cases, the change is significant. For instance, the Geminids and Arietids both show substantially broader activity profiles in radar than in visual observations. The Arietids also peak later than previously thought (see Fig. 1).

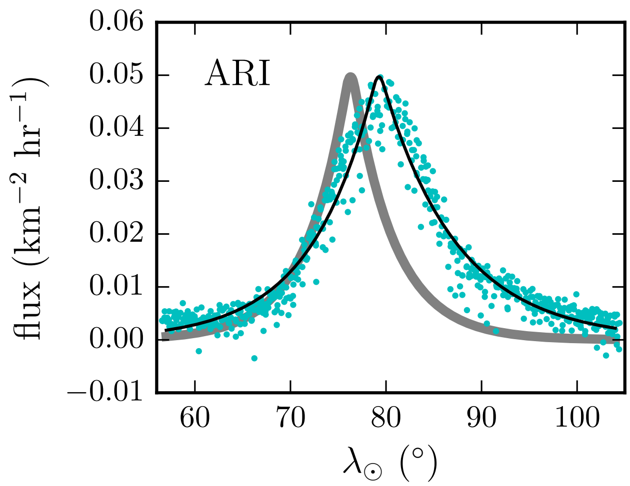

Figure 1. Daily meteoroid flux as measured by CMOR for the Daytime Arietid (ARI) meteor shower (cyan points). Time is measured in terms of solar longitude, which reflects the portion of its orbit around the Sun that the Earth has completed at a given time. Our fit to the data appears as a thin black line. The shape of the Arietid shower used in previous forecasts appears as a thick gray line. The data reveal that the Arietids have a longer duration and peak at a later date than previously thought, and these characteristics have been included in the 2017 forecast.

The MEO also used CMOR fluxes – in conjunction with published meteor shower studies – to review the list of forecasted showers. We found that many minor showers produced no flux measurable by CMOR or the southern hemisphere meteor radar SAAMER. After considering the body of published work on each such shower, we identified a number of minor showers to remove from the current forecast. Showers may be re-added in the future if they are shown to contribute significantly to the meteoroid flux. Table 2 provides a brief summary of the changes made to the forecast based on the reviews of available data and literature.

Figure 1 gives the expected visual meteor rates (ZHR) for ground observers during calendar year 2017. The visual rate is dominated by the Geminids in mid-December and the Perseids in mid-August, with strong showings from Quadrantids in early January, the eta Aquarids in May, and the Arietids in June. 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.

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.

Figure 2 also indicates that there are, depending on the threat size considered, approximately 5 showers that produce the highest fluxes. The basic characteristics of these showers, including radiant position, are listed in Table 1.

Table 1. The five most active meteor showers of 2017 (in terms of flux).

Shower	Radiant		Speed	Date of Maximum (UTC)
	RA (deg)	Dec (deg)	(km s^{-1})	
Quadrantids	230	+49	41	2017-01-03 23:55
Daytime Arietids	44	+24	39	2017-06-10 15:59
Southern delta Aquariids	340	-16	41	2017-07-28 01:03
Perseids	48	+58	59	2017-08-12 20:02
Geminids	112	+33	35	2017-12-14 07:01

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 2017 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. 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 2017. Column 2 provides the current 3-letter code for each shower while Column 3 provides the code used in previous forecasts. Column 4 indicates which showers have had their activity profiles updated. Removed showers appear in gray; although they are not included in the 2017 forecast, Column 5 lists their approximate dates. Finally, Column 6 provides the cumulative shower ZHR at each shower's peak date and time. These cumulative ZHRs often include substantial contributions from adjacent showers.

Shower	ID	Old ID	Updated profile?	Max time (UTC)	Max ZHR
Quadrantids	QUA	Qua	Yes	2017-01-03 23:55	120
~~gamma Velids~~		~~gVe~~		~~2017-01-05~~	
~~delta Cancrids~~		~~dCa~~		~~2017-01-17~~	
~~alpha Carinids~~		~~aCa~~		~~2017-01-30~~	
~~alpha Centaurids~~		~~aCe~~		~~2017-02-08~~	
~~omicron Centaurids~~		~~oCe~~		~~2017-02-11~~	
~~delta Leonids~~		~~dLe~~		~~2017-02-24~~	
gamma Normids	GNO	gNo	No	2017-03-12 22:26	8
~~delta Pavonids~~		~~dPa~~		~~2017-03-31~~	
April Lyrids	LYR	Lyr	Yes	2017-04-23 08:40	19
~~mu Virginids~~		~~mVi~~		~~2017-04-29~~	
eta Aquariids	ETA	eAq	Yes	2017-05-06 14:07	49
~~alpha Scorpiids~~		~~Sco~~		~~2017-05-16~~	
~~omega Scorpiids~~		~~oSc~~		~~2017-06-02~~	
Daytime zeta Perseids	ZPE	zPe	Yes	2017-06-02 23:20	41
Daytime Arietids	ARI	Ari	Yes	2017-06-10 15:59	74
Southern mu Sagittariids	SSG	Sag	No	2017-06-19 20:38	31
beta Taurids	BTA	BTa	No	2017-06-28 10:52	23
~~tau Cetids~~		~~Cet~~		~~2017-06-26~~	
~~tau Aquariids~~		~~tAq~~		~~2017-06-29~~	
July Phoenicids	PHE	uPh	No	2017-07-12 22:18	11
~~omicron Cygnids~~		~~oCy~~		~~2017-07-18~~	
Piscis Austrinids	PAU	PAu	No	2017-07-26 18:10	34
Southern delta Aquariids	SDA	dAZ	Yes	2017-07-28 01:03	42
Capricornids	CAP	Cap	Yes	2017-07-28 14:51	40
~~iota Aquariids South~~		~~iAZ~~		~~2017-08-03~~	
~~delta Aquariids North~~		~~dAN~~		~~2017-08-08~~	
Perseids	PER	Per	No	2017-08-12 20:02	148
kappa Cygnids	KCG	kCy	No	2017-08-17 23:41	18
~~iota Aquarids North~~		~~iAN~~		~~2017-08-20~~	
~~gamma Doradids~~		~~gDo~~		~~2017-08-28~~	
Aurigids		Aur		2017-09-01 02:00	11
September epsilon Perseids		SPE		2017-09-09 10:35	6
~~kappa Aquariids~~		~~kAq~~		~~2017-09-19~~	
~~Piscids~~		~~Pis~~		~~2017-09-20~~	
Daytime Sextantids	DSX	Sex	Yes	2017-10-02 16:46	7
Draconids	DRA	Dra	No	2017-10-08 18:51	5
~~epsilon Geminids~~		~~Eps~~		~~2017-10-18~~	
Leo Minorids	LMI	LMi	Yes	2017-10-19 14:07	16
Orionids	ORI	Ori	Yes	2017-10-22 15:28	29
Southern Taurids	STA	TaZ	No	2017-11-05 11:31	12
Northern Taurids	NTA	TaN	No	2017-11-12 10:49	13
~~zeta Puppids~~		~~zPu~~		~~2017-11-13~~	
Leonids	LEO	Leo	No	2017-11-17 16:22	27
~~alpha Monocerotids~~		~~aMo~~		~~2017-11-21~~	
~~chi Orionids~~		~~cOr~~		~~2017-12-02~~	
~~Phoenicids~~		~~Pho~~		~~2017-12-06~~	
Puppids/Velids	PUV	PuV	No	2017-12-07 04:16	23
December Monocerotids	MON	Mon	No	2017-12-09 03:32	34
sigma Hydrids	HYD	sHy	No	2017-12-12 02:23	65
Geminids	GEM	Gem	Yes	2017-12-14 07:01	126
~~Comae Berenicids~~		~~CBe~~		~~2017-12-19~~	
Ursids	URS	Urs	Yes	2017-12-22 20:48	15

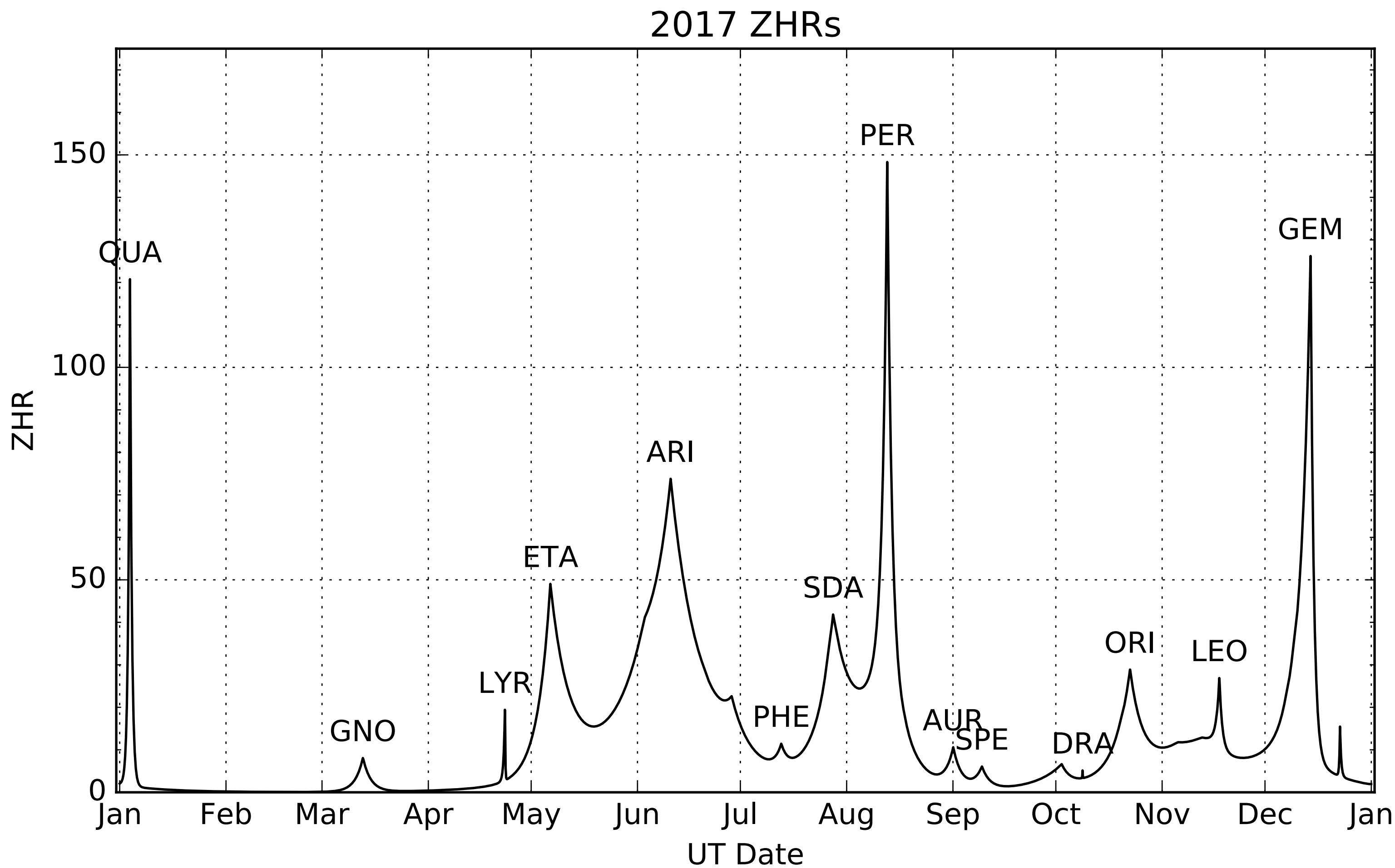

Figure 2. Meteor shower visual rates (zenithal hourly rate, or ZHR) over the course of 2017. Note how showers overlap; a large, broad shower such as the Daytime Arietids (ARI) can boost the cumulative shower flux at the peak of an adjacent shower (Column 6 of Table 2).

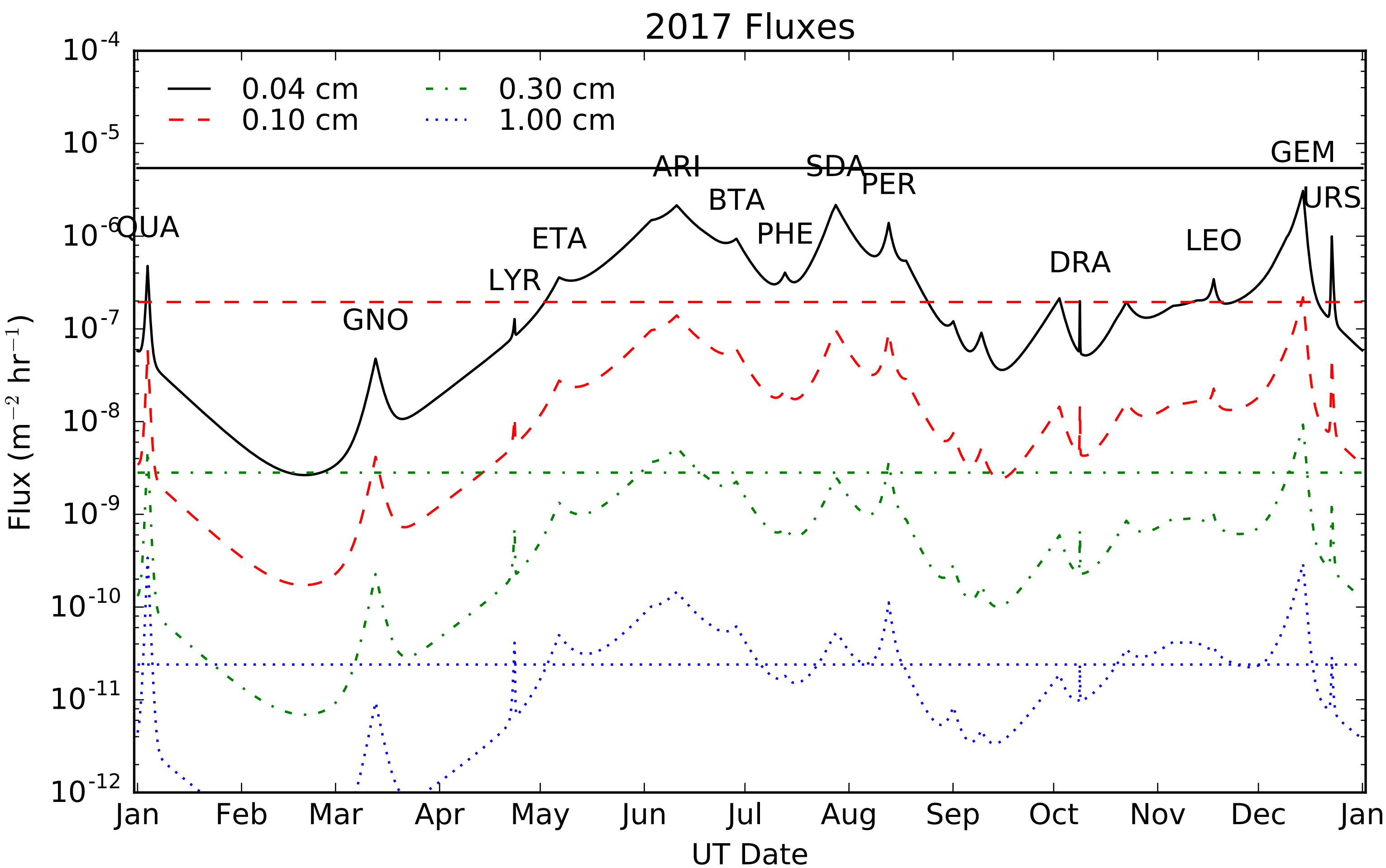

Figure 3. Meteor shower flux (variable lines) and total meteoroid flux (horizontal lines) over the course of 2017. Fluxes have been weighted to a constant limiting kinetic energy. Fluxes are quoted for four particle kinetic energies; these kinetic energies correspond to particles with diameters of 0.04 cm, 0.1 cm, 0.3 cm, and 1 cm, assuming a density of 1 g/cc and a speed of 20 km/s. Some showers, such as the Quadrantids (QUA) are more heavily weighted toward large particles and thus play a more significant role for 1-cm-equivalent particles than for 0.04-cm-equivalent particles.

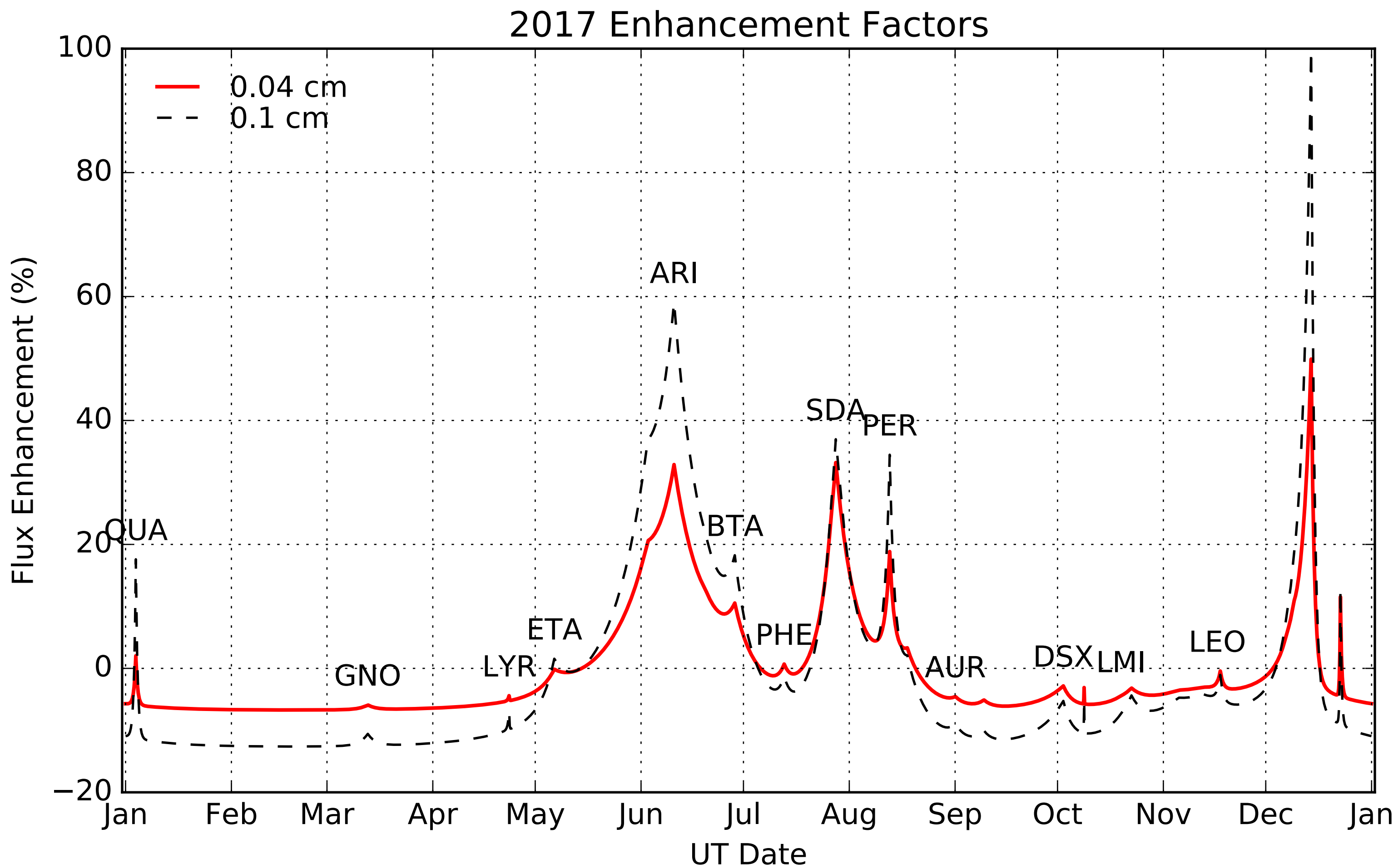

Figure 4. Meteor shower flux enhancement (or diminishment) relative to the average annual meteoroid flux. These factors can be used in conjunction with a meteoroid model such as MEM to compute the flux at a particular point in the year.