The 2016 Perseids

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The Perseid meteor shower is a prolific annual shower, known to outburst.

At least 2 spacecraft have suffered anomalies potentially caused by meteoroid impacts during Perseid outbursts.

The Perseids may outburst again in 2016. Observing geometry favors Russia/Europe and North America.

Goal: Describe preliminary predictions, encourage discussion and observation planning.
Perseid background info

**Parent comet:** 109P/Swift-Tuttle  
**Peak:** Max. around Aug 11-13  
**Activity range:** Jul 17 – Aug 24  
**Speed:** 59 km/s  
**Radiant:** $\alpha = 48^\circ$, $\delta = +58^\circ$ at peak  
**Typical ZHR:** 100/hr  
**Features:** Not known to storm, but can produce enhanced activity (100s meteors/hr)  
**Prediction history:** Forecasts less accurate than those for Leonids

Perseid fireball recorded Aug 12, 2012
Perseid History

Official discovery of annual shower 1835

Comet Swift-Tuttle discovered 1862

Schiaparelli links PER to Swift-Tuttle 1864

Denning derives daily radiant motion 1898

Outburst 1920

Outburst 1931

Outburst 1945

Outburst, 120/hr 1950

Mass sorting studies 1954

Persistent train studies 1950

Outburst, ZHR 120-350 1991

Outburst, ZHR 90-220 1992

Swift-Tuttle at perihelion 1992

Schiaparelli links PER to Swift-Tuttle 1864

Outburst, ZHR 250 1994

Outburst, ZHR 160 1995

Outburst, ZHR 187 2004

Outburst, ZHR 224 2009

Outburst? 2016

1835

1836 Max rates 30-50/hr

1839 Max rate 160/hr

1841 Annual rate reports begin

1855 Max rates 19-51/hr

1858 Max rates 37-88/hr

1861 Rates jump to 78-102/hr

1863 Rates high, 109-215/hr

1865 "Normal" rates return

1900 Declining rates, 30/hr

1913

1939

1965

1991

2016

Max rates 19-51/hr

1950 Max rates 40-60/hr 1950s-1960s

1955 Max rate 80+/hr

1955 Rates 65/hr 1966-1975

1959 Dbl noticed peak 1955

1966 Rates 65/hr 1966-1975

1976 Dbl noticed peak 1976-1983

1985 Return to normal rates


1989

1996

Dbl noticed peak 1988-1989

1996 Dbl noticed peak 1996

1999

Today

Max rates 19-51/hr

Max rates 80+/hr

"Normal" rates return

Max rate 160/hr

Max rate 40-60/hr 1950s-1960s

Info. from Kronk (2014), Kronk (n.d.), and the IMO
Spacecraft affected by Perseids

**Olympus**
ESA communication satellite
Struck by a Perseid near the time of the shower peak in August 1993
Sent tumbling, fuel exhausted, end of mission
Caswell et al. (1995)

**Landsat-5**
NASA/USGS imaging satellite
Struck by a Perseid near the time of the shower peak in August 2009
Sent tumbling, stabilized, returned to normal operations
Cooke (2009)
MSFC Meteoroid Stream Model

What
Model of particle ejection and subsequent meteoroid stream evolution from comets.

Why
To provide accurate meteor shower forecasts to spacecraft operators for hazard mitigation and mission planning purposes.

Who
International Space Station and science spacecraft.
2016 Perseid model results: MSFC preliminary

Particles ($\beta = 10^{-2} - 10^{-5}$) ejected hourly proportional to $r^{-6}$ while Swift-Tuttle is inside 2.5 AU.
2016 Perseid model results: MSFC preliminary

2016 Perseids

- Scatter plot: Earth-Particle Distance vs. Solar Longitude
- Histogram: Number of particles vs. Earth-Particle Distance
- Scatter plot: Particle mass vs. Solar Longitude
- Histogram: Number of particles vs. Log10 particle mass
2016 Perseid model results: MSFC preliminary

Predicted ZHR

Date

ZHR

220
200
180
160
140
120
100
80
60
40
20

08/09/16 08/10/16 08/11/16 08/12/16 08/13/16 08/14/16 08/15/16
### 2016 Perseid model results - Summary -

<table>
<thead>
<tr>
<th>Modeler</th>
<th>Rev</th>
<th>Date</th>
<th>Time (UT)</th>
<th>$\lambda_s$ (°)</th>
<th>ZHR</th>
<th>$r_d$-$r_E$ (AU)</th>
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</thead>
<tbody>
<tr>
<td>Maslov (web, undated)</td>
<td>1862</td>
<td>Aug 11</td>
<td>22:34</td>
<td>139.436</td>
<td>?</td>
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<tr>
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<td>Aug 11</td>
<td>23:23</td>
<td>-</td>
<td>160-180</td>
<td>-</td>
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<tr>
<td>Maslov (web, undated)</td>
<td>1479</td>
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<td>23:23</td>
<td>139.468</td>
<td>?</td>
<td>0.00008</td>
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<tr>
<td>Vaubaillon (Rao, 2012)</td>
<td>-</td>
<td>Aug 12</td>
<td>~00:00</td>
<td>-</td>
<td>“Unusually high activity”</td>
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<tr>
<td><strong>Main MSFC (June 2015)</strong></td>
<td></td>
<td><strong>Combined</strong> 15 revs</td>
<td>Aug 12</td>
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<td>139.515</td>
<td><strong>210 ± 50</strong></td>
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<td>Vaubaillon (Jenniskens, 2006)</td>
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<td>MSFC single rev (June 2015)</td>
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<td>Aug 12</td>
<td>13:03</td>
<td>140.016</td>
<td>Comprises secondary peak?</td>
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Increased activity lasts about half a day, from late-Aug 11 to mid-Aug 12.
Observing geometry

1862 trail
Observing geometry

Maslov peak
1479 trail
Observing geometry

MSFC peak
Observing geometry

Adjusted MSFC peak
Observing geometry
Observing geometry

Vaubaillon peak
1079 trail
Observing geometry
Observing geometry
Observing geometry
Observing geometry

Nodal peak
Lunar observing geometry

- Phase not good (62%) for lunar impact observing during the peak. (First Quarter on Aug 10.)
- Moonset around 12-1 am local time.

Perseids
Aug 12 at 00:00 UT

LunarScan output (Gural 2007)
General camera deployment considerations

- Predicted peak observable
  - Night time for optical cameras
- Radiant high in the sky
  - Higher radiant = better rates
  - Keep radiant alt. >15° for the max. amount of time
- Good weather
- Minimal light pollution
- Mobility
  - Don’t deploy cameras to islands, valleys, etc.
  - Choose area with well-connected road systems
- Choose camera pointing directions to max. collecting area

(a) Total night sky brightness acct. for alt., at zenith
(b) Naked eye star visibility (V mag)

http://isccp.giss.nasa.gov/

http://www.lightpollution.it/worldatlas/pages/fig1.htm
Spacecraft risk

Fluxes

- 0.04 cm
- 0.10 cm
- 0.30 cm
- 1.00 cm

SIA, NDA, PER, KCG, NIA, GDO
Summary

• The Perseids may outburst in 2016.
• Increased activity predicted late Aug 11 – Aug 12, lasting ~half a day.
  – Rates predicted between 160 – 580/hr.
  – Observing best from Russia & Europe, then North America.

• The outburst may represent a time of increased risk to spacecraft.
2016 Perseid model results: Vaubaillon


Approx. region covered by MSFC model
Other weather data: Night only

Completely Clear Sky
Frequency of Occurrence (%)

August (1971 - 1996) Night

Degrees of Freedom:

Total: 23186

Land Areas Only

Global Average (Land): 24.8 %

http://www.atmos.washington.edu/

File name = imco08cr1.txt, MGRP = 9078, TYPE = 2, PCODE = 2, SN = 8
Past NASA deployment 2014 May Camelopardalids

Deployed 2 cameras to northern Arizona

WEST SYSTEM
Past NASA deployment
2014 May Camelopardalids

Orion capture device

AC adapter
power cable
video cable

BNC-Phono adapter

Analog to SDI converter

Short BNC from Kiwi
Short BNC to Ronin
AC adapter

Ronin video display

Short BNC from Kiwi
Short BNC to Ronin
AC adapter

Orion capture device

Analog to SDI converter

Short BNC from Kiwi
Short BNC to Ronin
AC adapter

Ronin video display
<table>
<thead>
<tr>
<th>Year</th>
<th>Meteor Shower</th>
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<tbody>
<tr>
<td>2020</td>
<td>Ursids</td>
</tr>
<tr>
<td>2022</td>
<td>τ-Herculids</td>
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<tr>
<td>2027</td>
<td>Perseids</td>
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<tr>
<td>2028</td>
<td>Perseids</td>
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<tr>
<td>2034</td>
<td>Leonids</td>
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References


