Characterizing the 2016 Perseid Meteor Shower Outburst

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Introduction & Predictions

The Perseid meteor shower has been observed for millennia and is known for its visually spectacular meteor and occasional outbursts. Normal activity displays Zentral Hussel Hours (ZHLs) of ~100. The Perseids were expected to outburst in 2016, primarily due to particles released during the 1862 and 1479 revolutions of parent Comet Swift-Tuttle. NASA’s Meteoroid Environment Office predicted the timing, strength and duration of the outburst for spacecraft risk using the MSEC/Meteoroid Stream Model. A double peak was predicted, with an outburst displaying a ZHL of 210 ± 50 at 03:00 UTC Aug 12 (139.5° Solar Longitude), and a traditional peak - 12 hours later with rates still heightened from the outburst [2]. Video, visual, and radar observations taken worldwide by various entities were used to characterize the shower and compare to predictions.

Past Notable Perseid Outbursts:
• 1993: ZHL ~200 (delayed STS-51 Launch).
• 2003: ZHL of 230.0.
• 2004: ZHL of 187.
• 2009: Triple outburst of ZHL ~180–220 prior, during, and past traditional peak. See predictions and results below in Figure 3.

Why does this happen?
• Jupiter perturbs the trail of debris left by Comet 109P/Swift-Tuttle.

All Sky Camera Network Results

• NASA’s All Sky Fireball Network consists of 15 cameras, placed in 4 groups around continental USA to detect meteors brighter than the planet Venus (Z ∼ magnitude 4.3).
• Meteor rates of this brightness correspond to cm-sized meteoroids, weighing ~1 gram.
• During 2016, clouds were over most of the networks approaching the peak of the Perseids, but cleared off soon after dark on the peak night.
• Being in North America and constrained by daylight, these cameras missed the outburst, however, during, and past the predicted activity (dark) is contrasted with the average activity of 2015 (light), which were all non-outburst years.

Figure 1: Distribution of visual meteor sightings around the world. (IMO)

MAARSY Results

• Middle Atmosphere Alomar Radar System (MAARSY) is an HPLA radar employing an active phased array antenna suitable to monitor the Perseid radiant (6,7).
• It was modified to conduct continuous meteor observations and meteor shower studies in 2016 for the Perseid outburst.
• System has a limiting mass of 10+10-10 grams.
• In 2015 and 2016, MAARSY detected enough Perseid meteors to produce an activity curve with 3 hour bins.
• Activity is comparable from 2015 to 2016, no notable outburst in this small size range.
• The population index is low – ~3.8 during, and past the peak indicating the outburst may have been in bright particles, not the low mass-particles that MAARSY detects (Figure 11). Additionally, Figure 4 indicates that the most significant new component of particles for the 2016 outburst is in a more massive range.

Figure 2: Periods are known to be rich in bright meteors, such as the one seen August 13, 2011 by amateur Ross Goss from the ISS.

Figure 4: Particle mass prediction 2016 (left) and 2015 (right) for comparisons to a non outburst population index of 1.8, with an average magnitude of 6.5 magnitude and ZHRs using a population index of 2.2.

Figure 5: 2015-2016 meteor stream Model results for 2016 Perseids. The 2016 peak activity (left) corresponds to a ZHL of ~210 ± 50. Solar Longitude, and the second peak at the minima at ~140.0, with a ZHL of 125, will slightly heightened because of the outburst.

Figure 6: 2016 Perseid rate as seen in NASA’s All Sky Fireball Network. Shown here is a normalized activity. Raw numbers were scaled by the Perseid radiant altitude and observed activity, and how much additional clear-camera data aided in zero. 2015 is shown for comparison. The peak activity was observed by NASA’s All Sky Fireball Network from 277 to 278 in 2015, however when taking into account the camera that was only –1, only a small gain from prior numbers to a meaningful activity 2016 showed on the right.

Figure 7: Predictive results and of the 2015 Perseid in comparison with the 2016 Perseid activity. The visual observations were processed with a population index of 1.8, with 100% data. The relative activity is ~6:5 and the visual observation display shows that rates were most enhanced between 22:15 and 23:45 UTC August 12/13.

Figure 8: IMO video results of peak Perseid activity. Activity from visual and radar stations combined with 2015 activity (dark), which were seen on non-outburst years. Between 129° and 148°, both beyond the 1862 and 1479 land, the rates were clearly much lower than average. Solar longitude 119° to 148° was daylight in Europe in 2016, where most video cameras are located.

Most of North America was in daylight during the outburst peak, thus the International Meteor Organization (IMO) video observations and visual observations were heavily relied upon to characterize the outburst peak.
• The IMO video network had more than 70 cameras in operation in August 2016 with 12,000 effective observing hours and 96,000 detected meteors.
• Detects meteors between 0.0001-1.0 grams. These observations are used to calculate fluxes to +6.5 magnitude and ZHRS using a population index of 2.2.
• Visual observable outburst from the 2016 Perseid campaign (See Figure 9).
• The IMO visual observations resulted in ZHRS, converted to fluxes +6.5 magnitude using a population index of 2.0 [3].
• Results were provided by Siero Molau. See [8] for full IMO video and visual results.

Figure 9: IMO video results of peak Perseid activity. Activity from visual and radar stations combined with 2015 activity (dark), which were seen on non-outburst years. Between 129° and 148°, both beyond the 1862 and 1479 land, the rates were clearly much lower than average. Solar longitude 119° to 148° was daylight in Europe in 2016, where most video cameras are located.

Figure 10: Distribution of visual meteorites around the world. (IMO)

Figure 11: (top) shows the population index profile of the Perseids and sporadic meteors between August 7 and 17 (139° SL). The horizontal lines show the distribution of particle sizes in the meteoroid stream. The Perseid population index increases around 2.3, with an average index that is 0.5 from the sporadic index. Figure 12 is the same as Figure 11, but is scaled to the outburst peak. The smallest peak index is from 22:00-00:00 which has a population index of 1.9. [Data from 16/08/2016]

Figure 12: MAARSY detection activity as seen in MAARSY in 2016 and 2015. Corrected activity sizes cease activity and rates by radar altitude as well observation time. Error bars are due to number statistics. As time scale size increases, most errors are obtained from the peak. The activity is also seen to be a small spike in 2015, though this is likely due to the increased observed rate.

Figure 13: MAARSY observation time in 2016 and 2015. Figure 14 shows how many years of observation time occurred in 30 3-hour bins.

Conclusions

• NASA's Meteoroid Environment Office predicted a Perseid Outburst in 2016 with a peak ZHL of 210, 12 hours prior to the traditional peak, and a traditional peak still
• Accepted and monitored activity
• The outburst was clearly seen in IMO Video & Visual reports, as well as NASA All Sky Fireball Network data.
• The peak of the outburst was seen to have a ZHL of 280 according to IMO video observations, and 205 as seen in visual observations.
• The outburst was not seen in MAARSY, which has a limiting mass of 10+10-10 grams.
• This indicates the outburst was detected primarily in bright meteors, not the low mass particles that MAARSY detects.
• NASA’s MEO correctly predicted the timing and approximate strength.
• The forecast over the peak Perseid activity (2015) matched with 2016 activity (light), which were seen on non-outburst years. Between 129° and 148°, both beyond the 1862 and 1479 land, the rates were clearly much lower than average. Solar longitude 119° to 148° was daylight in Europe in 2016, where most video cameras are located.

References