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 meteors and occasional outbursts. Normal activity displays Zenithal Hourly Rates (ZHRs) 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 Meteor Environment Office predicted the timing, strengths and duration of the outburst for spacecraft risk using the MPE Meteoroid Model (M3M) [1]. A double peak was predicted, with an outburst displaying a ZHR of 210 ± 50 at 00:30 UTC Aug 12 (139.5° Solar Longitude), and a traditional peak - 12 hours later with rates significantly 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.

Notable Perseid Outbursts:
- 2009: Triple outburst of ZHR ~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 Swift-Tuttle.
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IMO Video and Visual Observations

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 0.0001-0.1 gms. These observations are used to calculate fluxes to +6.5 magnitude and ZHRs with a population index of 2.2.
- All visual observations from the 2016 Perseid campaign are shown in Figure 10.
- 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 Stoker Molari. See [8] for full IMO video and visual results.

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 (-4 magnitude).
- Meteors of this brightness correspond to cm-sized meteors, 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.
- Rates were heightened in 2016 over 2015.
- Figure 10: Distribution of visual reporters 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 Perseids radiant (6°7).
- It was made to conduct continuous meteor observations and meteor shower studies in 2016 for the Perseid outburst.
- System has a limiting mass of 10+10 grams.
- In 2015 and 2016, MAARSY detected enough Perseids 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 - 1.8 during the peak of the outburst indicating the outburst may have been rich in bright particles, not the low-mass particles that MAARSY detects (Figure 11).
- Additionally, Figure 12 indicates that the most significant new component of particles for the 2016 outburst is in a more massive range.

Conclusions

- NASA’s Meteoroid Environment Office predicted a Perseid Outburst in 2016 with a peak ZHR of 210, 12 hours prior to the traditional peak, and a traditional peak still
- Aerosol-clouds covered the lunar surface during the Perseid peak.
- The outburst was clearly seen in IMO Video & Visual results, as well as NASA All Sky Fireball Network data. The peak of the outburst was seen to have a ZHR 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 grams.
- This indicates the outburst was detected primarily in larger particles over smaller particles.
- NASA’s MEO correctly predicted the timing and approximate strength.
- The forecast over-predicts the flux from Perseids approaching and leaving the peak, particularly in large sizes as seen in Figures 6 and 7.