When the Sky Falls…
NASA's Response to bright bolide events over continental USA

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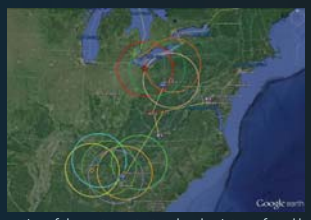
Introduction

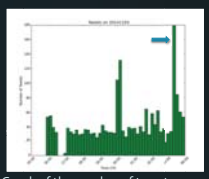
Being the only U.S. Government entity charged with monitoring the meteor environment, the Meteoroid Environment Office (MEO) has deployed a network of allsky and wide field meteor cameras, along with the appropriate software tools to quickly analyze data from these systems. However, the coverage of this network is still quite limited, forcing the incorporation of data from other cameras posted to the internet in analyzing many of the fireballs reported by the public and media. Information on these bright events often needs to be reported to NASA Headquarters by noon the following day; thus a procedure has been developed that determines the analysis process for a given fireball event based on the types and amount of data available. The differences between these analysis processes are shown by looking at four meteor events that the MEO responded to, all of which were large enough to produce meteorites.

November 3, 2014 - West Virginia

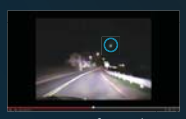
- Event occurred November 3, 2014 23:23 UTC or 18:23 EST.
- Event was just south of the MEO's north-east allsky network and just north of the MEO's south-east allsky network.
- 1,185 eye-witness reports on the American Meteor Society's website.
- Time of event found by mining tweets on Twitter containing 'meteor' or 'fireball'.
- Web search of event surfaced:
  - -Two dashcam videos: one from a police car in Benwood, WV and the other from a car sitting in traffic in Atlanta, GA.
  - -Video from a public webcam (EarthCam) located on the Washington Monument in DC.
  - -Video from a private allsky camera located in Elk Creek, VA.
- Locations of all videos/images were found and the azimuth of the start and/or end point of the meteor was mapped.
- Despite the event not being seen in any MEO cameras, the time it occurred, where it occurred, and the direction it was moving were all delivered quickly to Headquarters.



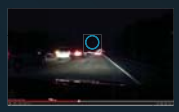
Location of the meteor, start and end points, as found by using videos and images of the event found on the web. A trajectory found by the American Meteor Society using eye-witness reports is plotted, which matched our results. MEO allsky camera locations and (conservative) approximate reach is also shown.



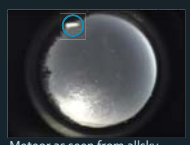
Graph of the number of tweets on Twitter containing 'meteor' or 'fireball', used to determine the time this event occurred.



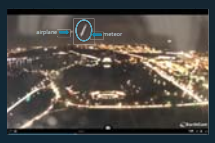
Meteor as seen from police car dashcam in Benwood, WV. Video found on youtube.com and geolocated.



Meteor as seen from dashcam in Atlanta, GA. Video found on youtube.com and geolocated.



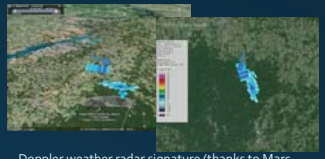
Meteor as seen from allsky camera run by Robert Wilkie in Elk Creek, VA.



Meteor as seen from publically accessed webcam located on the Washington Monument in DC.

October 30, 2012 - Addison Meteorite Fall

- Event occurred October 30, 2012 ~24:35 UTC (~17:35 CDT).
- Daytime fireball over Alabama.
- 56 eye-witness reports to American Meteor Society, from Arkansas to Florida, many reporting sonic booms.
- Doppler weather radar detected pieces of debris in the atmosphere.

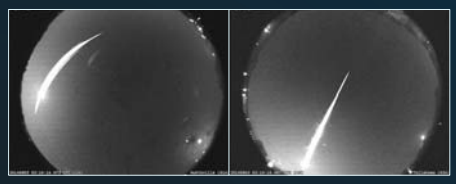


Doppler weather radar signature (thanks to Marc Fries for help in obtaining the radar signature) at time of the event. As it was a clear sky and no rain, this signature was from meteoritic debris, confirming the location and time of the meteor as well as existence of meteorites.

Two meteorites were found under the Doppler signature. This particle is 60 grams and was found by search team Stephen Beck, Tommy Brown, and Jerry Hinkle.

August 2, 2014 - Alabama

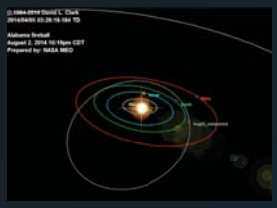
- Event occurred August 3,2014 3:29 UTC (August 2, 2014 22:29 CDT).
- Ideal event – seen in 4 of the Meteoroid Environment Office's allsky cameras.
- 122 eye-witness reports on the American Meteor Society's website
- Trajectory and lightcurve manually found using METAL (METeor AnaLzer), custom software created by the University of Western Ontario's Meteor Physics Group.
- Dark flight calculations incorporate winds at the time to find approximate location of meteorites.
- Apparent magnitude of -11.5, equating to an object tens of kg in mass.



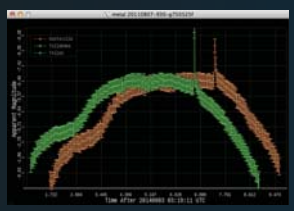
Event as seen in the MEO's Huntsville and Tullahoma allsky cameras.

Trajectory of the meteor (yellow) with respect to the four allsky cameras (blue). The meteor was first seen at a height of 92 km over Tennessee, moving 25 km/s and was last seen over eastern Alabama at a height of 28 km height moving 6 km/s. Its deceleration and low ending height indicates high probability of dropping meteorites.

Dark flight calculations. Using the final position and velocity of the meteor, along with incorporating winds at the time, a map is created to show where particles of various sizes may have landed on the ground.



Orbit visualization of meteoroid. Visualization tool was funded by the MEO, and created by Dr. David Clark of the University of Western Ontario.

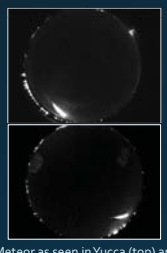


Lightcurve of meteor from Huntsville and Tullahoma cameras – the two cameras with the clearest view of the event. The flattening of the light curve as it brightens is clear evidence that the light from the meteor saturated the cameras. Thus a saturation correction was necessary which resulted in a peak apparent magnitude of approximately -11.5.

November 6, 2013 - California

- Event occurred November 7, 2013 3:49:29 UTC. (November 6, 19:49 PST)
- 219 eye-witness reports on the American Meteor Society's website
- Seen in four Sandia allsky cameras (skysentinel.nmsu.edu/allsky)
- Video converted and calibrated to be able to be used by MEO software
- Trajectory and lightcurve manually found using METAL (METeor AnaLyzer).
- Apparent magnitude of approximately -13, equates to an object ~ 500 kg.

Trajectory of event (yellow) and four Sandia allsky cameras which detected it (blue). Meteor was originally moving ~ 22.5 km/s and showed significant deceleration, but was hard to quantify since the event was seen low on the horizon from all cameras.



Meteor as seen in Yucca (top) and Parker (bottom), part of the Sandia allsky camera network run by NMSU. Both cameras were located over 160 km from the meteor.

The authors would like to thank The Meteor Physics Group at the University of Western Ontario for their aid in developing METAL and the orbit visualization tool, and the American Meteor Society for providing the bulk of the eye-witness reports.