

The status of the NASA All Sky Fireball Network

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Established by the NASA Meteoroid Environment Office, the NASA All Sky Fireball Network consists of 6 meteor video cameras in the southern United States, with plans to expand to 15 cameras by 2013. As of mid-2011, the network had detected 1796 multi-station meteors, including meteors from 44 different meteor showers. The current status of the NASA All Sky Fireball Network is described, alongside preliminary results.

1 Introduction

The NASA Meteoroid Environment Office (MEO), located at the Marshall Space Flight Center in Huntsville, Alabama, USA, is the NASA organization responsible for meteoroid environments as they pertain to spacecraft engineering and operations. Understanding the meteoroid environment can help spacecraft designers to better protect critical components on spacecraft or avoid critical operations such as extravehicular activities during periods of higher flux such as meteor showers.

In mid-2008, the MEO established the NASA All Sky Fireball Network, a network of meteor cameras in the southern United States. The objectives of this video network are to

1. establish the speed distribution of centimeter-sized meteoroids;
2. determine which sporadic sources produce large particles;
3. determine (low precision) orbits for bright meteors;
4. attempt to discover the size at which showers begin to dominate the meteoroid flux;
5. monitor the activity of major meteor showers; and
6. assist in the location of meteorite falls.

2 Instrumentation and software

In order to achieve the above objectives with the limited resources available to the MEO, it was necessary that the network function almost fully autonomously, with very little required from humans in the areas of upkeep or analysis. With this in mind, the camera design and the ASGAR (All Sky and Guided Automatic Real-time Detection) meteor detection software were adopted from the University of Western Ontario's Southern Ontario Meteor Network (SOMN), as NASA has a cooperative agreement with Western's Meteor Physics Group.

Table 1 – NASA All Sky Fireball Network station location, establishment date, and cluster assignment.

Location	Date established	Cluster
Huntsville, AL	June 2008	A
Chickamauga, GA	October 2008	A
Tullahoma, TN	January 2011	A
Cartersville, GA	March 2011	A
Las Cruces, NM	September 2011	B
Mayhill, NM	September 2011	B

To date, 15 cameras have been built with the goal of deploying 15 stations in the United States, distributed in two or more clusters with overlapping fields of view, operational some time in 2013. Currently, the network has 6 cameras operating in Alabama, Georgia, Tennessee, and New Mexico, with plans to expand into North Carolina in 2012. The locations of these stations are shown in Figure 1. Network expansion has been slow, largely due to NASA bureaucracy, which requires a contractual agreement (Space Act) with each site hosting a camera system. Naturally, this greatly increases the amount of time to bring a site online (Table 1).

Each station consists of a computer and a black and white, all sky, low light level video camera—a Wattec 902H2 Ultimate equipped with a 3.4 mm $f/1.4$ fish-eye lens running at 30 fps. The weatherproof camera housing consists of a 5 inch diameter PVC pipe and a clear acrylic dome. Figure 2 shows a picture of a typical camera. Thermal control is accomplished with micro-fans and heaters, while a timer switch turns off all power to the camera between 6 am and 6 pm local time. The system is run by a 12V 2A off-the-shelf power “brick”. Cabling integrates power and video coaxial cable, and feeds into a Linux machine running the ASGAR software. GPS receivers are used for time keeping and an Uninterruptible Power Supply (UPS) provides emergency power to the system. This design is robust but inexpensive.

The ASGAR software is discussed in detail by Weryk et al. (2008) and Brown et al. (2010). Installed at each

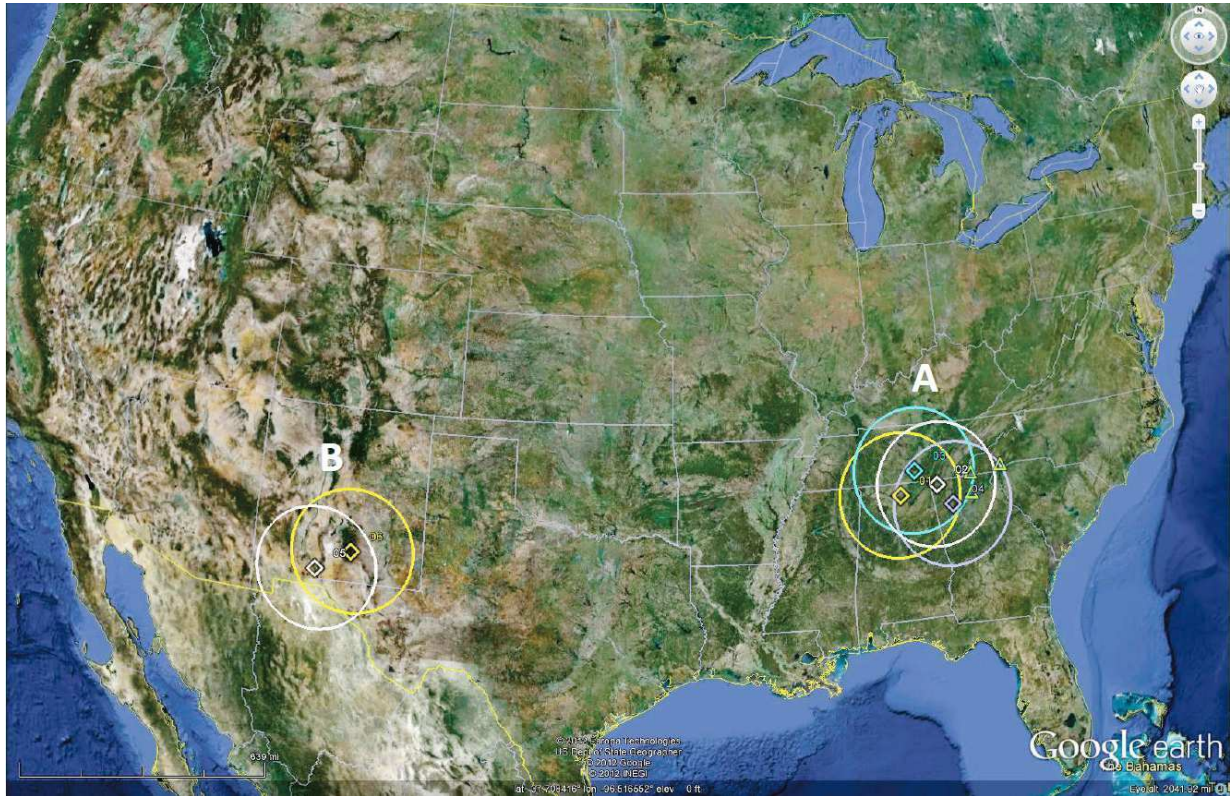


Figure 1 – Location of the 6 stations of the NASA All Sky Fireball Network. Circles indicate approximate sky coverage. The 2012 expansion locations are shown as triangles. Letters A and B indicate cluster assignment.



Figure 2 – NASA All Sky Fireball Network meteor camera, pictured here undergoing testing and calibration before deployment.

station, ASgard detects and records events throughout the night. Each station then sends its data to a central server, where ASgard correlates the events from each camera in the network based on the time of the observation. (Fast, reliable internet is therefore a requirement for each station.) For each multi-station event, ASgard runs MILIG (Borovička, 1990) to compute the atmospheric trajectory and MORB (Ce-

plecha, 1987) to calculate the heliocentric orbit. The central server, where data storage of each event and automated analysis occurs, also automatically generates a web page (<http://fireballs.ndc.nasa.gov>) each morning containing the particulars of events from the previous night (Figures 3 and 4). It also e-mails the interested parties with a detection summary each day.

Calibration plates are created approximately every two weeks using stacked 40 second images produced by ASgard every 30 minutes. Stacking the images lets a user identify more stars, and in turn, match them to those in the star catalog. This process allows for the transformation from the pixel coordinates of the camera to celestial coordinates (azimuth and elevation), performed using a least squares fit to determine plate parameters as outlined in Ceplecha (1987).

3 Preliminary results

As of mid-2011, 1796 multi-station meteors had been detected. This count includes meteors from 44 different meteor showers (as listed in the IAU Meteor Data Center), the most active of which have been the Perseids (Figure 5). A radiant map of all meteors, color-coded by speed, highlights the shower radiants in Figure 6. Removing the shower meteors, Figure 7 shows the radiant distribution of the sporadics, again color-coded by speed. There is some shower contamination here that has yet to be removed at this early stage of analysis. The majority of the events are double-station as the network operated only two cameras until early 2011.

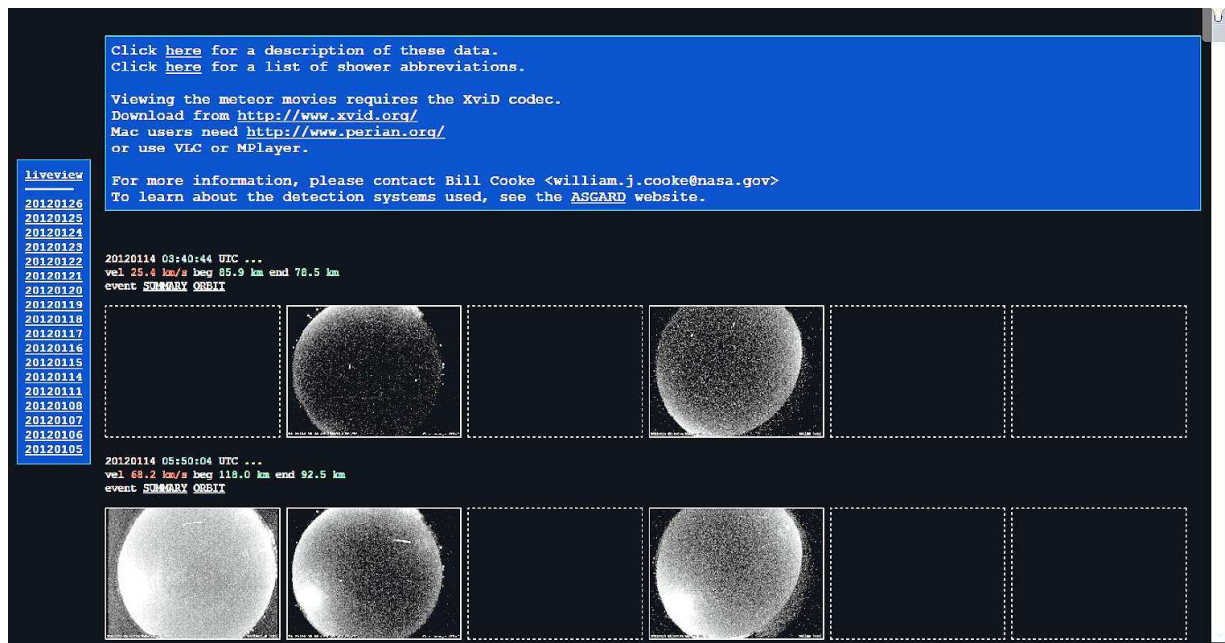


Figure 3 – The webpage generated by ASPGARD each morning. The site contains videos and images of events seen the previous night, alongside speed, height, shower identification, and orbital information.

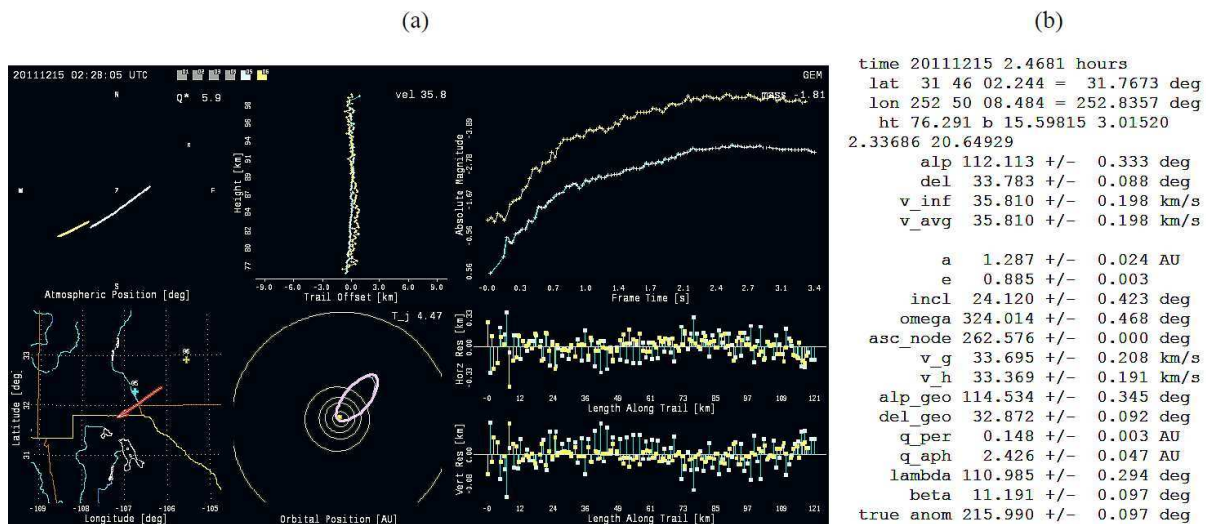


Figure 4 – Other data products generated by ASPGARD and placed online include (a) a summary graphic for each multi-station meteor as well as (b) orbital information. From left to right, the six sections of the summary graphic show: the location of the meteor in the camera's field of view, the height of the event as a function of trail offset, the light curve, the geographic location of the meteor overlaid on a map of the United States, the meteor's orbit, and errors in the trajectory determination.

4 Summary

The NASA All Sky Fireball Network is operational and detecting decent numbers of meteors. The detections are expected to increase as the network grows from 6 to 15 cameras in the next 2 years. Video of all of the meteors, as well as trajectory and orbital information, is posted online every morning by ASPGARD at <http://fireballs.ndc.nasa.gov>.

Acknowledgements

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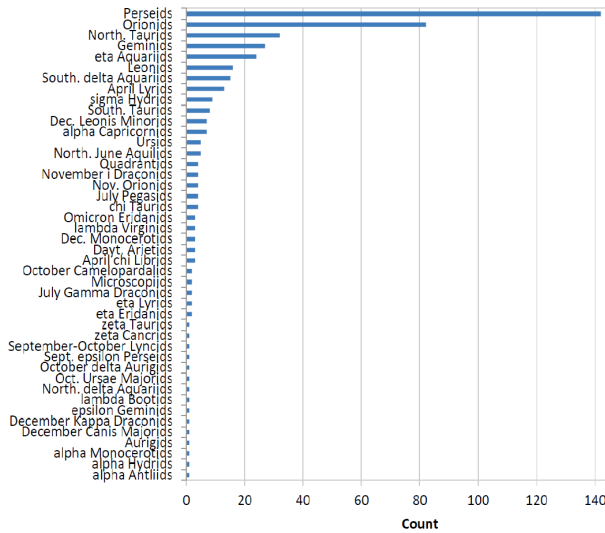


Figure 5 – Shower histogram. As of mid-2011, the Perseids and Orionids made up 31% and 18% of the shower meteors detected by the NASA All Sky Fireball Network, respectively.

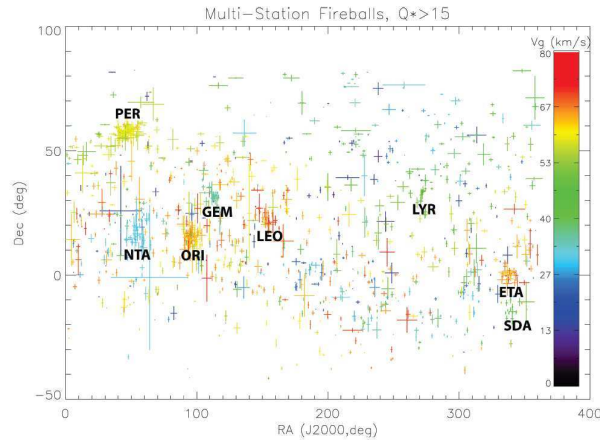


Figure 6 – Radiant map of meteors detected by the NASA All Sky Fireball Network, color-coded by geocentric speed. Only meteors with convergence angles greater than 15° are plotted.

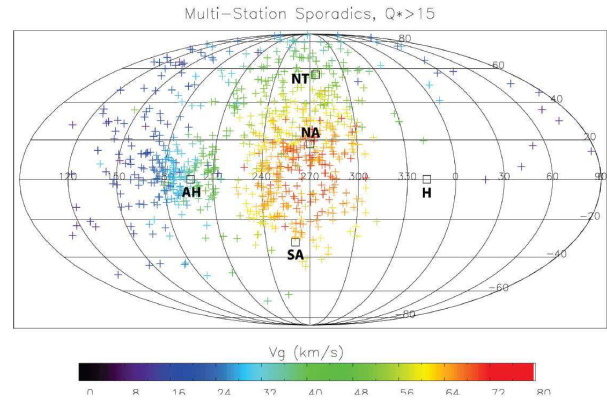


Figure 7 – Radiant distribution of sporadic meteors detected by the NASA All Sky Fireball Network, color-coded by geocentric speed. Only meteors with convergence angles greater than 15° are plotted. The sporadic sources are also given: H = Helion, AH = Anti-Helion, NA = North Apex, SA = South Apex, NT = North Toroidal. There may be some shower contamination in the data at this early analysis stage.

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