Johnson Space Center's Leonids optical observations

James F. Pawlowski, NASA Johnson Space Center, Houston, TX

Abstract. The 1998 Leonids Meteor Shower was videoed by NASA Johnson Space Center (JSC) personnel at Houston, Texas, and Cloudcroft, New Mexico. The videos were screened and the Leonids Meteors in the videos were analyzed. The outcome of this effort was tables of counts per hour over the viewing period and a comparison to the Leonids Meteors Mass Distribution model (Matney 1998) used for risk assessment calculations associated with space shuttle missions. The comparison exhibited a difference between the observed data and the model.

1.0 Introduction

The effort by the Johnson Space Center (JSC) to video the Leonids Meteor Shower of November 1998 was performed at two locations: Houston, Texas, and Cloudcroft, Mew Mexico. Two low-light level video cameras were operated on the JSC site in Houston, and one low-light level video camera was operated at the JSC Observatory in Cloudcroft.

Table 1 exhibits the characteristics of the three cameras. All the video was recorded on hi - 8 recorders.

The viewing period for the 1998 Leonids extended from midnight until dawn. This was 0600 to 1200 UT in Houston, and 0700 to 1300 UT in Cloudcroft.

2.0 Preparation

The cameras at Houston were pointed at the Leonids echo line (right angle to the radiant) from 0600 until 1100 UT. This was done to match the pointing angles of a co-located VHF radar. The pointing angles were updated every half hour on the half hour to follow the changes in the radiant's

direction. This caused the Leonids meteors to vertically traverse the video screen from top to bottom, which made them easy to recognize (Fig. 1).

Between 1100 and 1200 UT, however, the cameras were pointed vertically (azimuth 90°, elevation 90°). Again, this procedure followed the pointing timeline of the VHF radar, whose data we were attempting to complement.

The camera at Cloudcroft, New Mexico, was pointed vertically throughout the viewing period, 0700 to 1300 UT, so the Leonids traversed from the bottom to the top of the video image with the angle changing as the radiant changed.

The Houston cameras were installed on a modified telescope mount, which could manually be set to a desired azimuth and elevation. A simple initialization procedure was followed to ensure the cameras were pointed accurately. The mount was leveled, the cameras were pointed at Polaris (the North Star), then the azimuth was set to zero. Three different azimuth and elevation settings were entered, and a certain star was expected to be in view at each setting.

This procedure gave us confidence that our cameras were pointed accurately enough to generate a star field in our Video Data Analysis System Lab (VDAS), which would match the star background of a particular meteor image. Pointing accuracy was not a concern at Cloudcroft since the camera was mounted on a tripod, pointed vertically, and left in that position during the entire viewing period.

3.0 Observations

Skies were overcast in the Houston area on the early morning of November 16, 1998, so no video was recorded. Clear skies prevailed on November 17 and 18, 1998, so video was recorded from midnight, 0600 UT, until dawn, 1200 UT, on both days.

At Cloudcroft, video was recorded from midnight, 0700 UT, until dawn, 1300 UT, on November 16 and 17, 1998, and from 1000 UT until 1300 UT on November 18, 1998.

4.0 Results

Leonids Meteors were identified during video screening from the direction of the Leonids radiant. The radiant directions at Houston and Cloudcroft appear in Table 2, in half-hour intervals. Tables 3 and 4 display the Leonids and sporadic meteor counts at both locations.

Masses of 80 meteors were estimated by the procedure presented in Appendix A. The resulting mass distribution was then compared to the Leonids Meteor Mass Distribution model. This model was derived by Dr. Mark Matney, of the Lockheed Martin Company, and is being used along with an orbital debris model to calculate the risk assessment associated with each shuttle mission.

5.0 Conclusion

The extent to which the observed data and the theoretical model compare is exhibited in Fig. 2. The data shows the large meteoroids observed were more numerous relative to the small meteoroids than was expected by the model. The model computes the expected mass distribution near the densest portion of the Leonids stream. Due to the Earth's geometry during the 1998 Leonids Shower, instruments at Houston and Cloudcroft were unable to observe the densest portion of the stream. This discrepancy probably indicates variations in the mass distribution across the Leonids stream. When the data from all worldwide observations is integrated, the structure of these variations should become more apparent and then we will be able to determine whether a modification of the mass distribution assumptions of the NASA model and others is warranted.

References

MATNEY M., (1998) Leonid Meteors and Storm Hazard. Leonids Threat Assessment Meeting, Johnson Space Center, Houston, Texas, July 1, 1998.

SARMA T. AND JONES J., (1985) Double Station Observations of 454 TV Meteors. Bulletin of the Astronomical Institute of Czechoslovakia, Vol. 36.

Appendix A

Analysis of the data recorded on hi-8 tapes was performed in the VDAS where frame grabbing hardware digitizes a video frame which contains the particular meteor. The operator chooses the frame in which the meteor has peak brightness. The resulting image is stored in computer memory.

A star field is generated of stars which appear in the background of the meteor's image. The star field is then overlaid on the meteor image and is translated and rotated by the analyst until its stars overlap those in the meteor's image. A number of stars are chosen, usually 5, and their magnitudes are read and recorded. The intensities of the chosen stars, as well as the meteor, are read and recorded.

A graph of the magnitude of the stars verses $\log_{10}$ (intensity of the meteor) is generated. The $\log_{10}$ (intensity of the meteor) is introduced and its magnitude is read from the graph.

The following equation depicts the relation of magnitude to intensity.

$$M = -(5/2) \log_{10} I_M + B \qquad (1)$$

where

M = magnitude

I_M = intensity of a star at apparent magnitude M

B = constant

then

the meteor mass is then estimated by the formula (Sarma and Jones (1985)).

$$\log_{10} m = (9.88 - 7.17 \log_{10} (71.7 \text{ km/sec}) + 0.1 \log_{10} (\cos Z) - M) / 2.02 \qquad (2)$$

where

m = mass in grams

M = magnitude

Z = zenith angle = 90° - elevation angle of the Leonids radiant

Table 1. Camera characteristics.

Location	Focal Length	Aperture	Image Intensifier	Camera	Field of View	Cameras Sensitivity
JSC - Houston	135 mm	f.3.5	25mm Gen II MCP	Marshall	13 degrees	M = 7*
JSC - Houston	50 mm	f/0.95	25mm Gen II MCP	Cohu	15 degrees	M = 6
Cloudcroft	50 mm	f/1.4	25mm Gen II MCP	Sony	35 degrees	M = 7

* Environmental conditions in Houston degrade sensitivity.

Table 2. Radiant of Leonids Meteor Shower on November 16, 17, & 18, 1998.

		HOUSTON RADIANT (DEG)			CLOUDCROFT RADIANT (DEG)	
UT	CST	AZ	EL	MST	AZ	EL
6:00	0:00	67	6			
6:30	0:30	71	12			
7:00	1:00	74	18	0:00	69	8
7:00	1:30	77	24	0:30	73	14
8:00	2:00	80	31	1:00	77	20
8:30	2:30	83	37	1:30	81	26
9:00	3:00	87	44	2:00	84	32
9:30	3:30	90	50	2:30	88	38
10:00	4:00	94	57	3:00	92	45
10:30	4:30	99	63	3:30	97	51
11:00	5:00	106	69	4:00	102	57
11:30	5:30	118	75	4:30	110	63
12:00				5:00	118	69
12:30				5:30	138	74

Table 3. Leonids counts at JSC with 15 degree field-of-view camera.

Date 11/16/98

OVERCAST

Date 11/17/98

TIME (UT)	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200
# of Leonids	4	7	5	9	7	6
# of Sporadic	1	1	2	0	1	0

Date 11/18/98

TIME (UT)	0600-0700	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200
# of Leonids	0	7	4	4	3	8
# of Sporadic	3	2	1	1	0	1

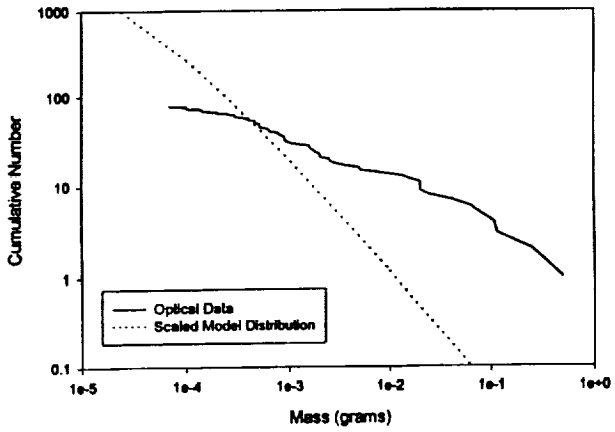

Fig. 2. Optical data vs. Leonid meteor mass distribution model.

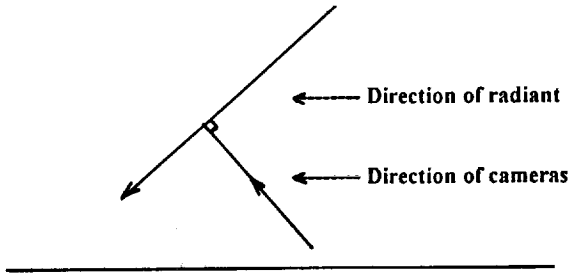

Fig. 1. Geometric relation of camera to Leonids radiant.

Table 4. Leonids counts at Cloudcroft with 35 degree field-of-view camera.

Date 11/16/98

TIME (UT)	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300
# of Leonids	3	2	4	6	12	5
# of Sporadic	6	4	3	10	9	7

Date 11/17/98

TIME (UT)	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300
# of Leonids	4	4	9	13	13	9
# of Sporadic	5	5	4	9	13	6

Date 11/18/98

TIME (UT)	0700-0800	0800-0900	0900-1000	1000-1100	1100-1200	1200-1300
# of Leonids	No Recording	No Recording	No Recording	12	10	3
# of Sporadic	No Recording	No Recording	No Recording	13	8	14