Start values for four meteor showers as determined from TWEET's data

I-Ching Yang[1], Kai-Shiang Lai[2], Chun-Nan Lin[3], Loren Cheewei Chang[4] and Kun-Lin Hsieh[5]

[1] **Department of Applied Science, National Taitung University, Taitung, Taiwan**
icyang@nttu.edu.tw

[2] **Department of Physics, National Kaohsiung Normal University, Kaohsiung, Taiwan**
harry7929@gmail.com

[3] **Department of Logistics Management, Shu-Te University, Kaohsiung, Taiwan**
cnlin@mis.ccu.edu.tw

[4] **Graduate Institute of Space Science, National Central University, Taoyuan, Taiwan**
loren@jupiter.ss.ncu.edu.tw

[5] **Department of Information Science and Management System, National Taitung University, Taitung, Taiwan**
klhsieh2644@gmail.com

Based on 202 meteor shower trajectories acquired by TWEET in 2013, of which 91 were Perseids, 40 were Southern Delta Aquariids, 34 were Orionids and 37 were Southern Taurids, we determined the beginning height distributions and average geocentric velocity for these four meteor showers. Using p-value of t-test, we would divide the 4 meteor showers into two groups: (a) Perseids and Orionids, and (b) Southern Delta Aquariids and Southern Taurids. The average beginning height and average geocentric velocity in group (a) is greater than in group (b).

1 Introduction

The trajectories of meteors are determined by the high-speed relative motion between meteoroid and the Earth's atmosphere. The atmosphere of our planet can be used as a detector of the small particles originating from these meteoroid bodies. Helpfully, the process of meteoroid ablation also can provide some information about atmospheric composition and structure. For this reason, we study atmospheric trajectories and the beginning height of the meteors.

Figure – 1 The location in Taiwan of the seven sites.

2 Observing sites

The research team, named as "Taiwan elegant meteor and TLE network" (TWEET), with participants from different research institutions, has several sites from which to observe meteor event. In 2012, our team had the following seven sites (*Figure 1*): Taitung Campus of National Taitung University (label S1) in Taitung County, Yanchao Campus of National Kaohsiung Normal University (label S2) in Kaohsiung City, Lulin Observatory of National Central University (label S3) in Yushan National Park, National Central University (label S4) in Taoyuan City, Jin-Cheng Junior High School (label S5) in Kinmen County, Highland Experimental Farm of National Taiwan University (label S6) in Nantou County, and Shoufeng Campus of National Dong Hwa University (label S7) in Hualien County.

3 The observations

We chose four meteor showers in 2012: Perseids, Southern δ Aquariids, Orionids and Southern Taurids. The parent bodies from these four meteor showers are listed in *Table 1*. All meteors of these four meteor showers recorded by CCD are shown in *Figure 2*. We analyzed the trajectories of all meteors, and determined the beginning height, geocentric velocity and absolute magnitude of each meteor. Histograms for the four meteor showers are presented in *Figure 3* (beginning height), *Figure 5* (geocentric velocity) and *Figure 7* (absolute magnitude).

Table 1 – The parent bodies of four meteor showers.

meteor shower	group (a)		group (b)	
	Perseids	Orionids	Southern δ Aquariids	Southern Taurids
parent body	109P Swift-Tuttle	1P Halley	96P Machholz 1	2P Encke
orbital period (yr)	133.28	75.3	5.2322	3.2984

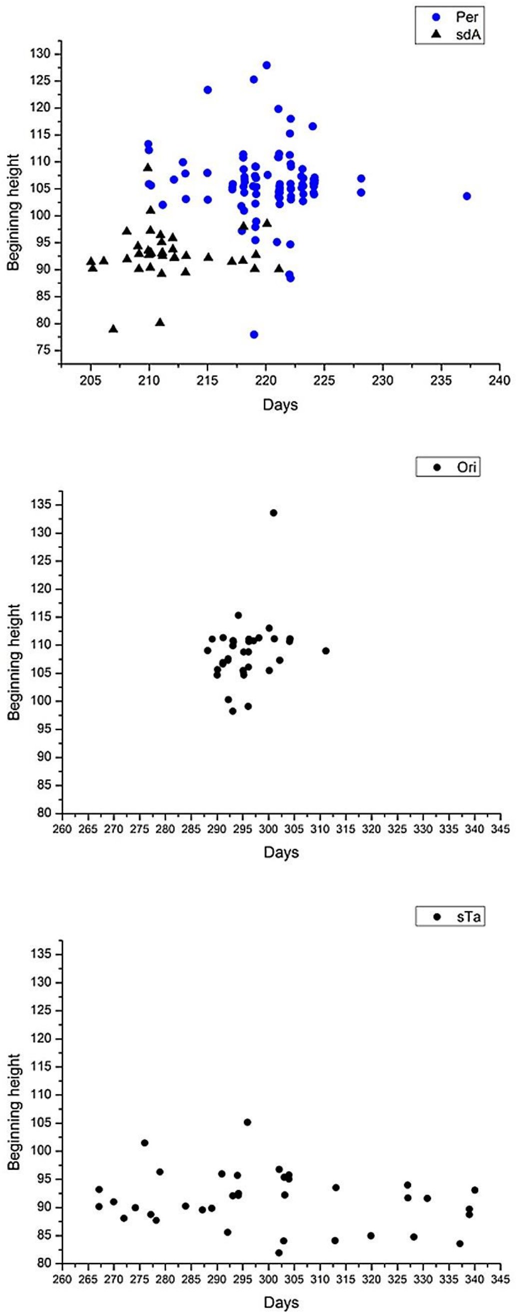

Figure 2 – Beginning heights for all meteors from the four meteor showers recorded by CCD.

In addition, the correlation analysis was also used to verify the relationship among four meteor showers in this study. The Pearson-Moment correlation coefficient is a popular method to measure the degree of correlation of two variables in an analysis. The correlation analysis results for beginning height, displayed in *Figure 4*, indicate a clear similarity between Perseids and Orionids. The correlation coefficient of 0.634 was found to be statistically significant at 0.05. In addition, the Southern δ Aquariids and Southern Taurids are seen to be positively correlated with one another. The correlation coefficient of 0.754 was found to be statistically significant at 0.05. The correlation analysis results for geocentric velocity are displayed in *Figure 6*. The Perseids and Orionids are seen to be positively correlated with one another. The correlation coefficient of 0.555 was found to be statistically significant at 0.05. *Figure 8* shows the correlation analysis results of the absolute magnitude. All of these four meteor showers are seen to be positively correlated and the correction coefficients were found to be statistically significant.

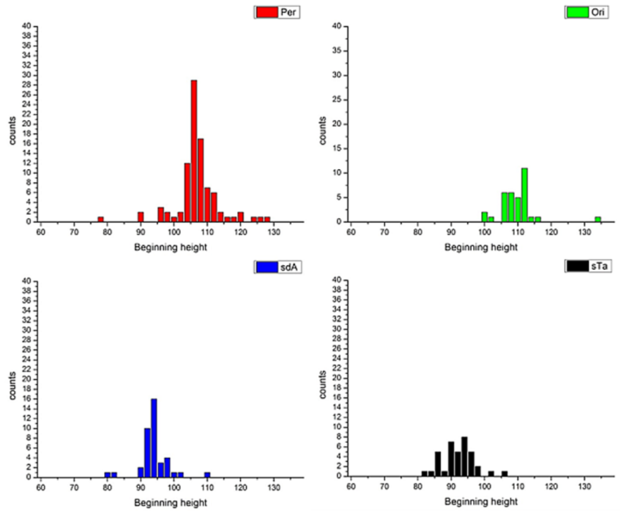

Figure 3 – Histograms showing beginning heights for the four meteor showers.

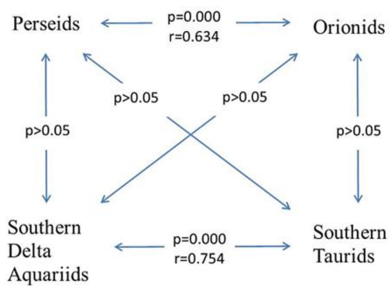

Figure 4 – The correlation analysis results for the beginning height.

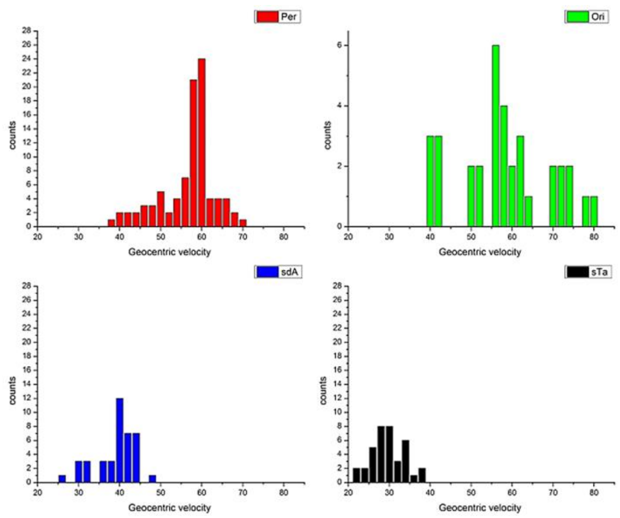

Figure 5 – Histograms showing geocentric velocities for the four meteor showers.

Overall, we group together the Perseids and Orionids, because the results show a clear similarity between them. The Southern δ Aquariids and Southern Taurids are also grouped together, although there is little similarity between them in the geocentric velocity. As is seen in *Table 1*, the Perseids and Orionids could be members of a group (a), whose parent bodies have a relatively long-period. In contrast, the Southern δ Aquariids and Southern Taurids would belong to group (b), whose parent bodies have relatively short-period.

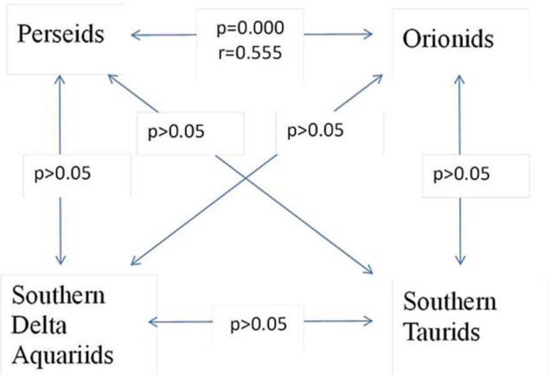

Figure 6 – The correlation analysis results for the geocentric velocity.

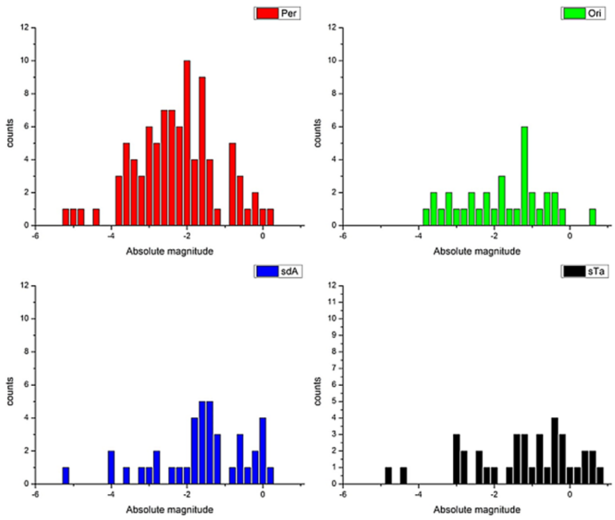

Figure 7 – Histogram showing absolute magnitudes for the four meteor showers.

For these four meteor showers, a regression model relating beginning height H_b to a linear function of the geocentric velocity v_g is shown in *Figure 9*, and its coefficient of determination R^2 is 0.525.

Finally, the light energy I produced from the process of meteoroid ablation which was given by Whipple (1943) is

$$I = -\frac{1}{2}\frac{dm}{dt}\tau_p v^2 , \qquad (1)$$

where τ_p is the luminosity efficiency. If the mechanism of meteoroid ablation is the same for every meteor, we can suggest that

$$I_{(A)} = I_{(B)} . \qquad (2)$$

Then we have

$$\frac{v_{(A)}^2}{v_{(B)}^2} = \frac{\frac{dm_{(B)}}{dt}\tau_{p(B)}}{\frac{dm_{(A)}}{dt}\tau_{p(A)}} . \qquad (3)$$

Since $\frac{dm}{dt}\tau_p$ will be a function of ρ_{air}, and ρ_{air} also will be a function of H_b, this implies that the beginning height of the meteors should be a function of their geocentric velocity.

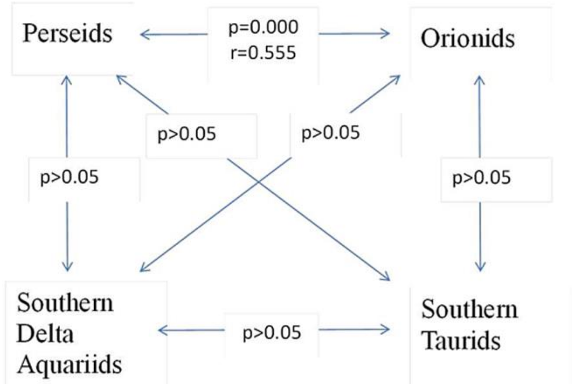

Figure 8 – The correlation analysis results for the absolute magnitude.

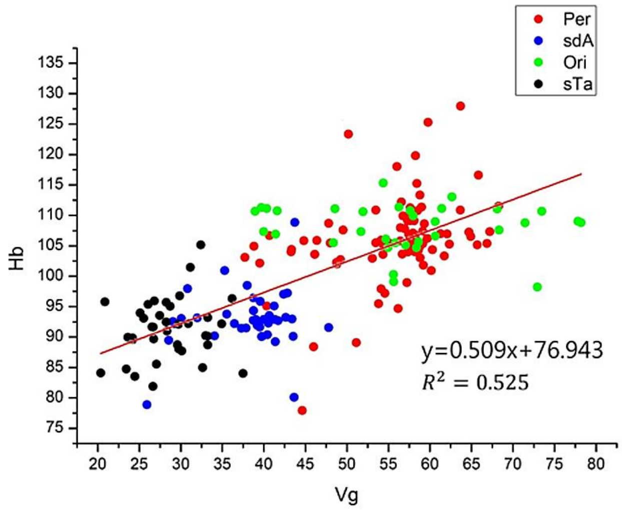

Figure 9 – Plot showing beginning heights and geocentric velocities for the four meteor showers.

Acknowledgments

I.-C. Yang and Loren C. Chang would like to thank Ministry of Science and Technology (Taiwan) for financial support. We also thank C.-C. Tsao and B.-X. Wu for collecting the images of meteors.

Reference

Whipple F. L. (1943). "Meteors and the Earth's upper atmosphere". *Reviews of Modern Physics*, **15**, 246–264.