

## Don't Forget the Grazers!

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Remember your favorite meteor? Mine is a Leonid seen from Australia during the last “storm” in November 2001. I can still see it approaching rapidly like a dark-tipped missile low on the horizon. We ducked as it passed 60 miles overhead and kept going, seemingly forever<sup>1,2</sup>. Despite the thousands of more typical meteors we saw that night, two of those “Earth-grazing” events spoiled me – until last August’s Perseids.

Since 2001, I have dutifully followed the standard rules of wisdom and watched meteor showers in pre-dawn hours as Earth moves headfirst into the approaching meteoritic particles. Usually I see a fleeting streak every few minutes at best. So I decided to sleep in for last summer’s Perseids: Been there, done that. But Nature got my attention much earlier!

At 10 pm on August 12, on the shore of Lake Superior in northern Minnesota, we were roasting marshmallows over a campfire. A nearby hill blocked our view of the northern half of the sky. The skies were brightened by the nearby lights of Two Harbors and Duluth. Nevertheless, out the corner of my non-dark-adapted eye a meteor streaked overhead and continued moving. I had time to show my family. I knew the Perseid shower would be at its maximum and best viewed after midnight. Unexpectedly, this meteor occurred well before midnight and started from the north. So I dismissed it, but in the next twenty minutes we saw twenty more of these Earth-grazers. We could not avoid seeing them! In hindsight, this experience is more remarkable because the measured zenithal hourly rate<sup>3</sup> had peaked 16 hours earlier, so we were only witnessing ~35% of the maximum rate. (Had we waited until the customary time of 3 am, the rate would have been another ~20% less.) In addition, our location was angled to the incoming direction, reducing our exposure by another 50%.

Earth-grazers (also known as “skippers”) are memorable and easy to observe. They are the usual tiny pieces of comet debris moving at high speeds (~30-70 km/sec), but their trajectories pass at low angles through Earth’s thin, upper atmosphere (~60 miles overhead) where they can survive in the low density and leave long trails from an observer’s perspective. They last long enough to turn your head, show your friends, and together watch as the trail continues. They may appear to move slowly but that aspect is probably the result of their relatively long duration and their motion downrange along your line-of-sight. Observing Earth-gazers goes against much of the standard lore.

In the days before a meteor shower, astronomers and the media routinely advise prospective observers as follows: “Observe after midnight – when the Earth is moving into the meteor stream.” “Pre-dawn hours are best.” “Go to dark skies.” “Dark adapt your eyes.” “Do not look directly at the radiant.” “Pick half of the sky and pair up with a friend or two, watching in opposite directions to increase your meteor-spotting chances.” “Don’t blink.”

Although well intended and correct, these guidelines do not consider Earth-grazers and would have discouraged my experience last summer. From northern Minnesota the radiant of the Perseid shower is circumpolar. Around 10 pm (4 UT) Perseus lingered low, ~29 deg above the horizon towards the north-east. The incoming particles were moving nearly parallel to the horizon. This timing provided an excellent opportunity to see Earth-grazers as they skimmed the Earth’s atmosphere. There was no need to observe after midnight because the radiant had already risen and the relative velocity was already maximized; in fact, you are less likely to see Earth-grazers when the radiant is high. Farther south near Tucson, Arizona, when the radiant was ~11 deg above the horizon, the MMT Observatory’s all-sky camera<sup>4</sup> recorded one visibly-bright Earth-grazer on both August 12 and 13 (Figure 1). On the same

nights, NASA's All Sky Fireball Network<sup>5</sup> recorded nine Perseid fireballs at angles of 14-20 degrees above the horizon.

Although you may see only one or two Earth-grazers, each one is a memorable event. To maximize your chances, add the following tips to the general advice. Begin observing before the radiant rises, ~20 minutes prior when the radiant is ~5 degrees below the horizon. If possible have a clear view to the horizon towards the radiant, perhaps from an elevated location. Simply lie down, look up and let the natural field-of-view of your eye (~60 degrees to either side) take over. Due to atmospheric extinction, you are most likely to see grazers that start within 45 degrees of the zenith when they are ~150 km away<sup>6</sup> as you look through a longer range of the atmosphere. However, brighter ones can appear much lower, like my favorite Leonid, perhaps as low as 5-7 degrees above the horizon. You will be able to follow them for at least 5-10 seconds, a seeming eternity compared to typical meteors. As they move downrange, they will become fainter, and the trails will seem shorter. Although dark skies and dark adapted eyes are helpful, they aren't as vital because your eye is more sensitive to moving objects, and these meteors last a long time. Therefore, you should be able to follow them even lower than 45 degrees, giving plenty of opportunity to discover, turn your head, verify, discuss with friends, and enjoy. Although you may only see one or two events, they're worth it, and you can get more sleep or decide to stay awake to watch the more typical show! An excellent opportunity<sup>7</sup> occurs right during twilight of May 23, when scientists have predicted a possible new, intense meteor shower from Comet 209P/LINEAR in the constellation of Camelopardis.

Since Earth-grazers are more likely seen when the radiant lies near, or even below, the horizon, any shower whose radiant rises during the night comes into play, even showers normally considered as southern hemisphere events. So, one might add the Puppis-Velids, Phoenicids, Centaurids, and Puppids to the list<sup>8</sup> of possibilities. Similarly, circumpolar radiants that linger along the horizon at night are excellent options such as the Quadrantids and Ursids. Even though this year's Perseids will occur during a nearly 17-day-old Moon, I'll be watching for Earth-grazers again!

#### **TABLE 1.**

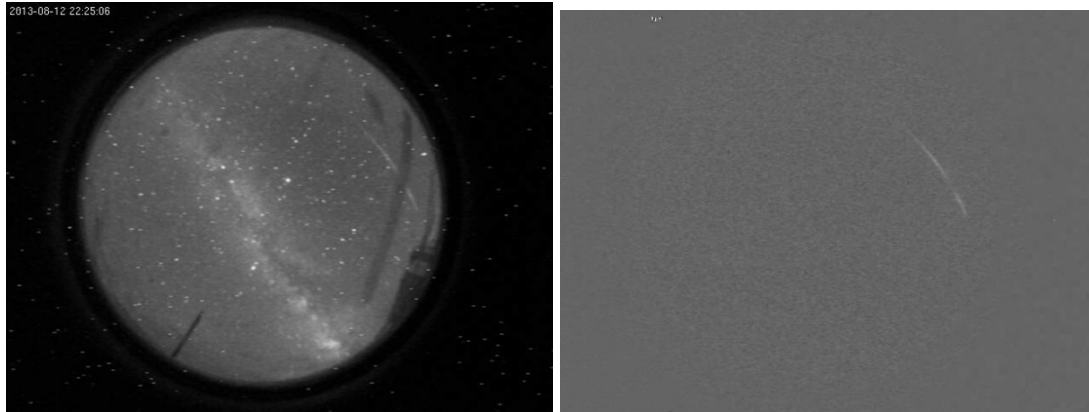
List of the best showers showing possibilities for Earth-grazers, such as the table below.

#### **REFERENCES FOR THIS ARTICLE**

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3. Perseids 2013: Visual Data Quick Look, International Meteor Organization, <http://www.imo.net/live/perseids2013/>
4. The MMT Observatory's all sky camera Web site: <http://skycam.mmt.org/>
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7. The Next New Meteor Shower, Sky & Telescope, Bochanski, J., Nov. 12, 2013, <http://www.skyandtelescope.com/observing/highlights/The-Next-New-Meteor-Shower-231466791.html>

8. 2014 Meteor Shower List, American Meteor Society, <http://www.amsmeteors.org/2013/12/2014-meteor-shower-list/>



**Figure 1.** A Perseid Earth-grazer seen from an all sky camera at the MMT Observatory on Mt. Hopkins, Arizona at UT 0525 August 13, nearly the same time as the author observed from northern Minnesota. The meteor crosses a dark defect in the camera system about 30 degrees above the horizon towards the west. On the right, only the meteor is shown streaking ~40 degrees across the sky during the 8.5 second exposure.

### 2014 Major Meteor Showers (Class I)

Shower	Activity Period	Maximum		Radiant		Velocity km/s	r	Max. ZHR	Time	Moon
		Date	S. L.	R.A.	Dec.					
Quadrantids (QUA)	Jan 01-Jan 10	Jan 03	283.16°	15:18	+49.5°	42.2	2.1	120	0500	02
Lyrids (LYR)	Apr 18-Apr 25	Apr 22	032.32°	18:08	+32.9°	48.4	2.1	18	0400	21
Eta Aquarids (ETA)	Apr 29-May 20	May 07	046.8°	22:36	-00.6°	67.5	2.4	60	0400	07
Delta Aquarids (SDA)	Jul 21-Aug 23	Jul 30	126.9°	22:42	-16.4°	42.0	3.2	20	0300	03
Perseids (PER)	Jul 13-Aug 26	Aug 13	140.0°	03:12	+57.6°	60.5	2.6	100	0400	17
Orionids (ORI)	Aug 25-Nov 19	Oct 22	208.9°	06:24	+15.5°	67.1	2.5	20	0500	28
Leonids (LEO)	Nov 06-Nov 30	Nov 18	236.1°	10:16	+21.6°	70.6	2.5	15	0500	25
Geminids (GEM)	Dec 04-Dec 16	Dec 13	261°5	07:33	+32.2°	35.0	2.6	120	0100	20
Ursids (URS)	Dec 17-Dec 24	Dec 22	270°7	14:30	+74.8°	32.6	3.0	10	0500	01

Information and Table Template Courtesy the International Meteor Organization.