

Finding Grazing Occultation “Sweet Spots” using Kaguya Profiles

2013 August 24, Barcelona, Spain

32nd European Symposium on Occultation
Projects

David W. Dunham, IOTA

Grazing Occultation Geometry

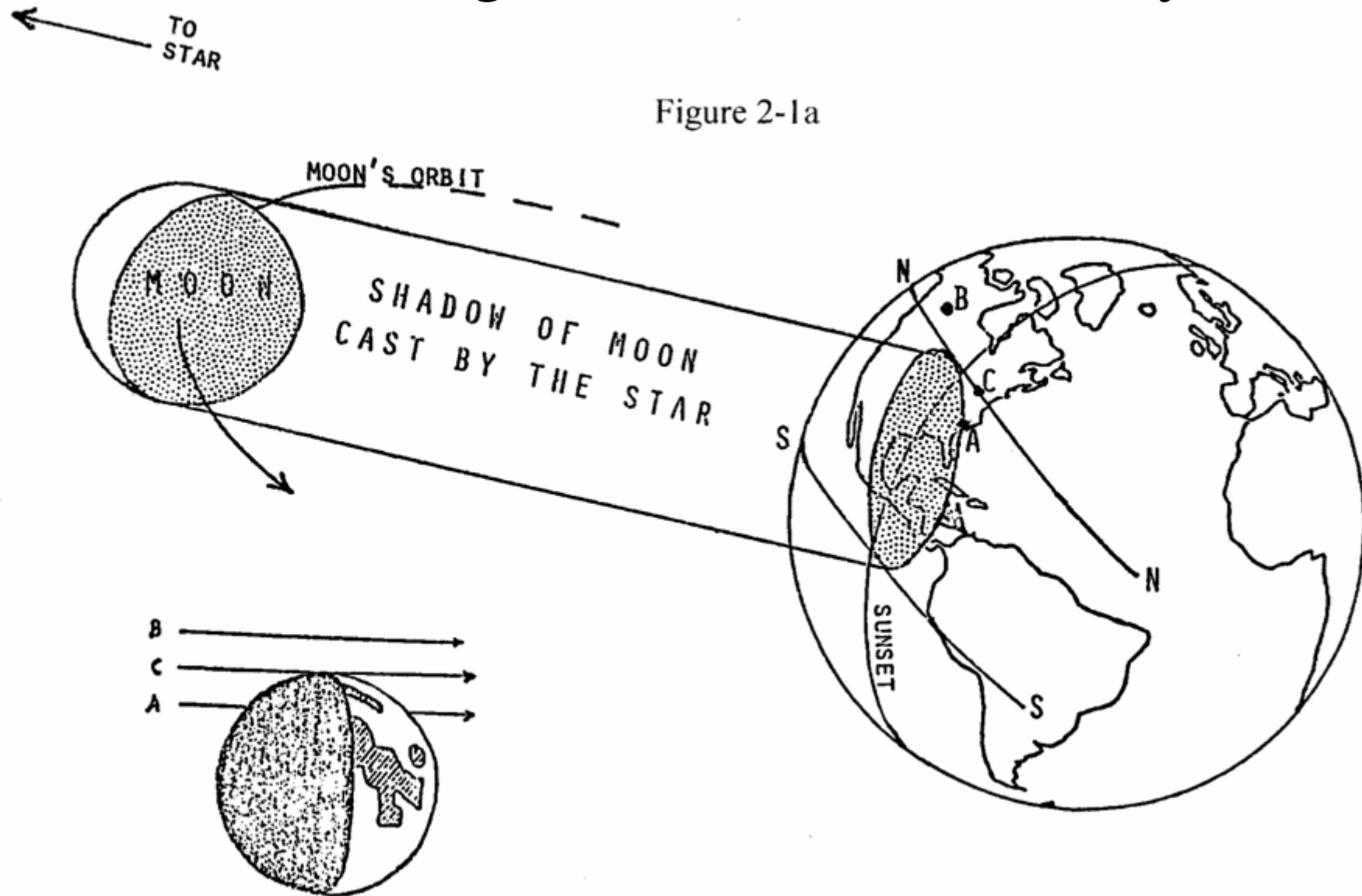
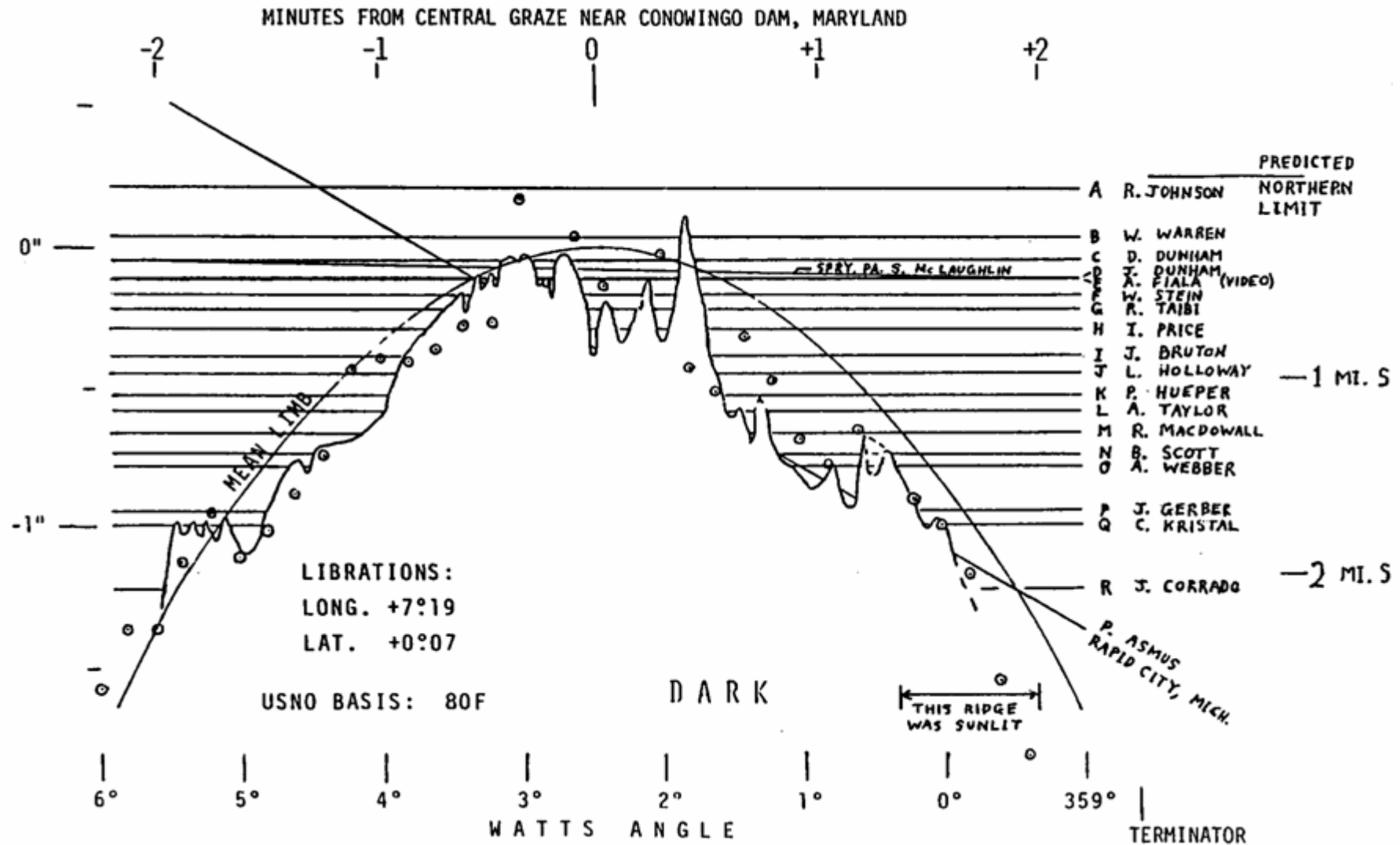


Figure 2-1a

Figure 2-1b

Lunar Profile from Graze of delta Cancri – 1981 May 9-10

Alan Fiala, USNO, obtained the first video recording of multiple events during this graze, with 7 D's and 7 R's



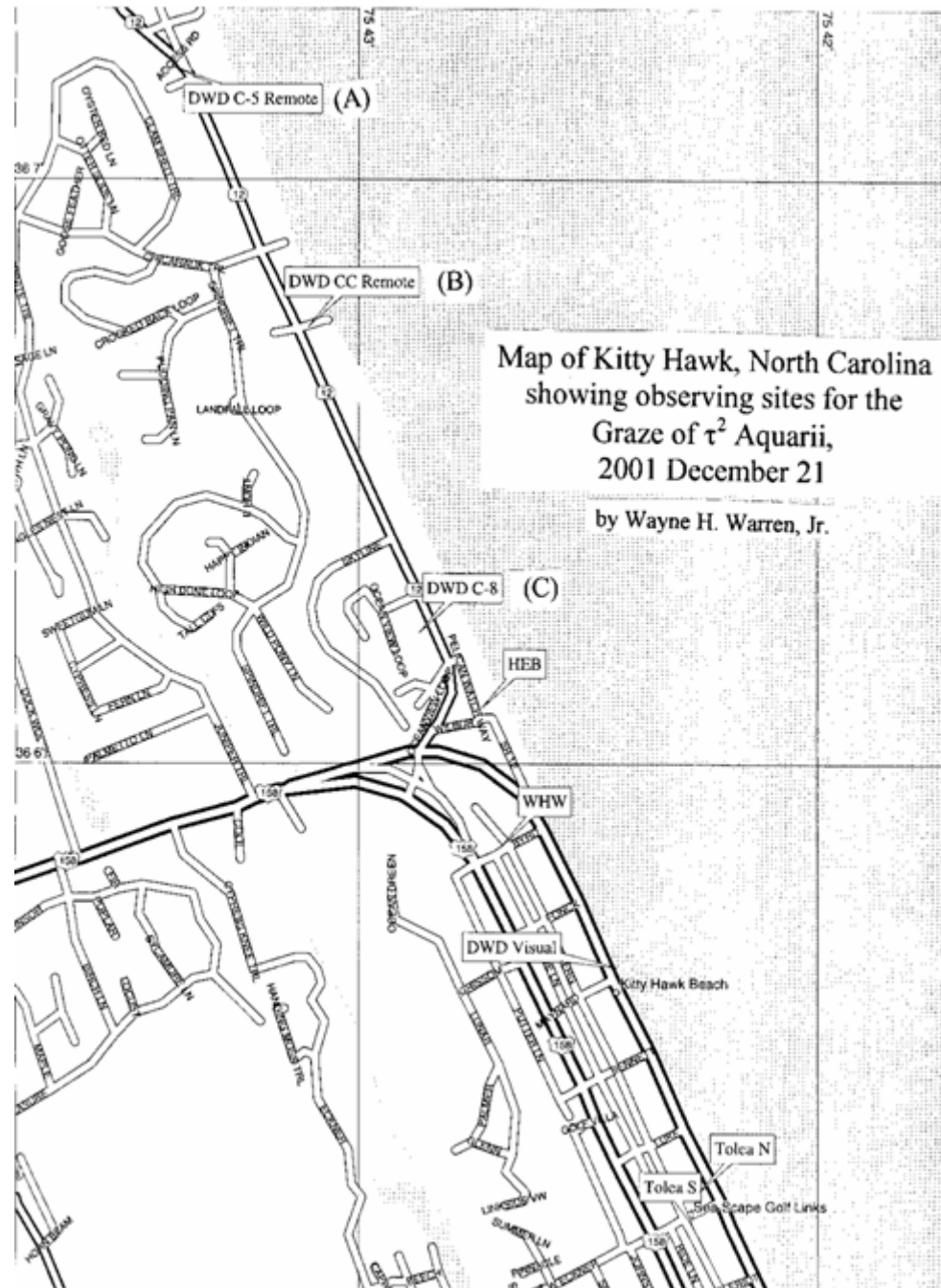
Circled dots are Watts' predicted limb corrections

The First Multiple Stations were Deployed for Grazing Occultations

- In the 1990's, I often thought, the equipment is doing all the work, maybe I should be somewhere else making another observation.
- For a graze of omicron Leonis the morning of 1998 November 12, I set up a 5-in. clock-driven SCT at Delta, Pennsylvania, near York
- I left a student there after showing him how to make adjustments to keep the star in the field of view, and set up another telescope about 0.5 km away to record the event
- When I came back, he was excited to see the multiple occultations of the star. “Did you make any adjustments?” “No”. “At least, you were there to protect the equipment”.
- “Actually, it was the other way around. Whenever a car drove by, I hid behind the telescope box.”

2001 Dec. 21 Grazing Occultation of 4.0-mag. τ^2 Aqr

- Moon 32%+, Cusp Angle 12S
- Observed from 8 stations at Kitty Hawk, North Carolina, by only 4 observers. Kitty Hawk has many summer homes, unoccupied on a December weekday, so we had many safe places to set up telescopes 1 to 2 hours before the graze.
- 4 of the video stations were unattended
- Also observed from 6 stations in Georgia



Map of Kitty Hawk, North Carolina
showing observing sites for the
Graze of τ^2 Aquarii,
2001 December 21

by Wayne H. Warren, Jr.


My Telescopes for Remote Observation



Station “B”, Sony Digital Camcorder



No Telescope, just an undriven good camcorder! I set the Moon just outside the field, above and left, 8 min. before the graze. This station had 5 D's and 5 R's, more than any other; although it had less than 1000th the aperture of the 1m telescope on Hokkaido, it was more successful!



**Multi-Station Occultation
Observing with Galileo Sized
Optical Systems**

Scott Degenhardt, IOTA

**Galileo's Legacy 2009
Waianae, Hawaii**

Mighty Mini



Can record occultations of stars to mag. 9.5, even mag. 10.0 under good conditions. These are fine for asteroidal occultations, but how about lunar grazes? Glare from the Moon and their low power cause problems

Mighty Midi – Orion 80mm short tube



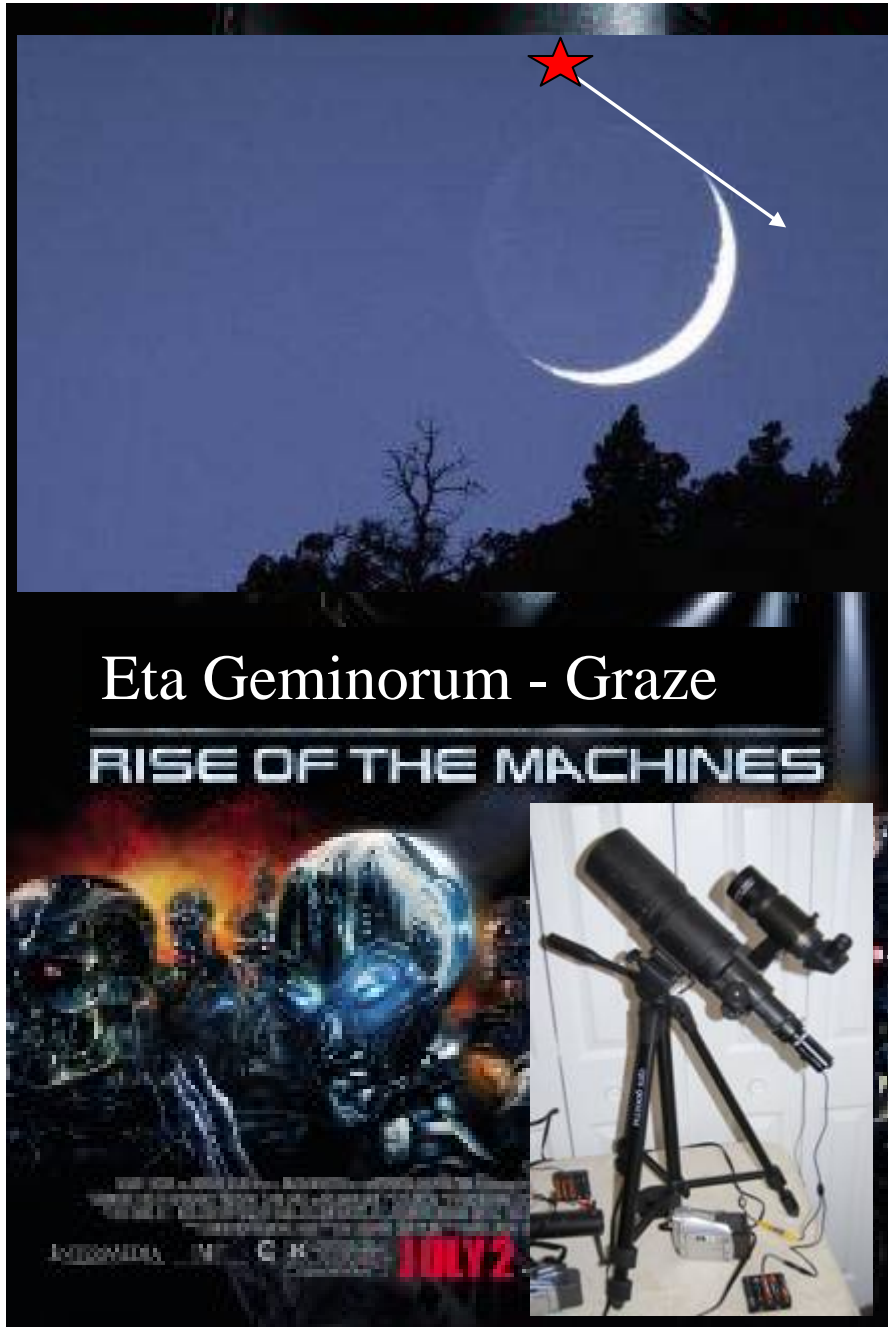
Can record occultations of stars to mag. 11.0, even mag. 11.3 under good conditions; these work better for grazes

I use visual finder scope and \$60 Quantaray tripod while scotty uses a mighty mini video as the finder and MX-350 tripod (not as sturdy as the Quantaray)

Scotty's Maxi Mount



- Solid as a rock
- All sky accessible
- Air portable @ < 12 lbs.
- (<20 including scope)
- 2 axis slow motion control
- Stealthy black for multi-station deployment
- Stands only 24" tall
- Costs ~\$100



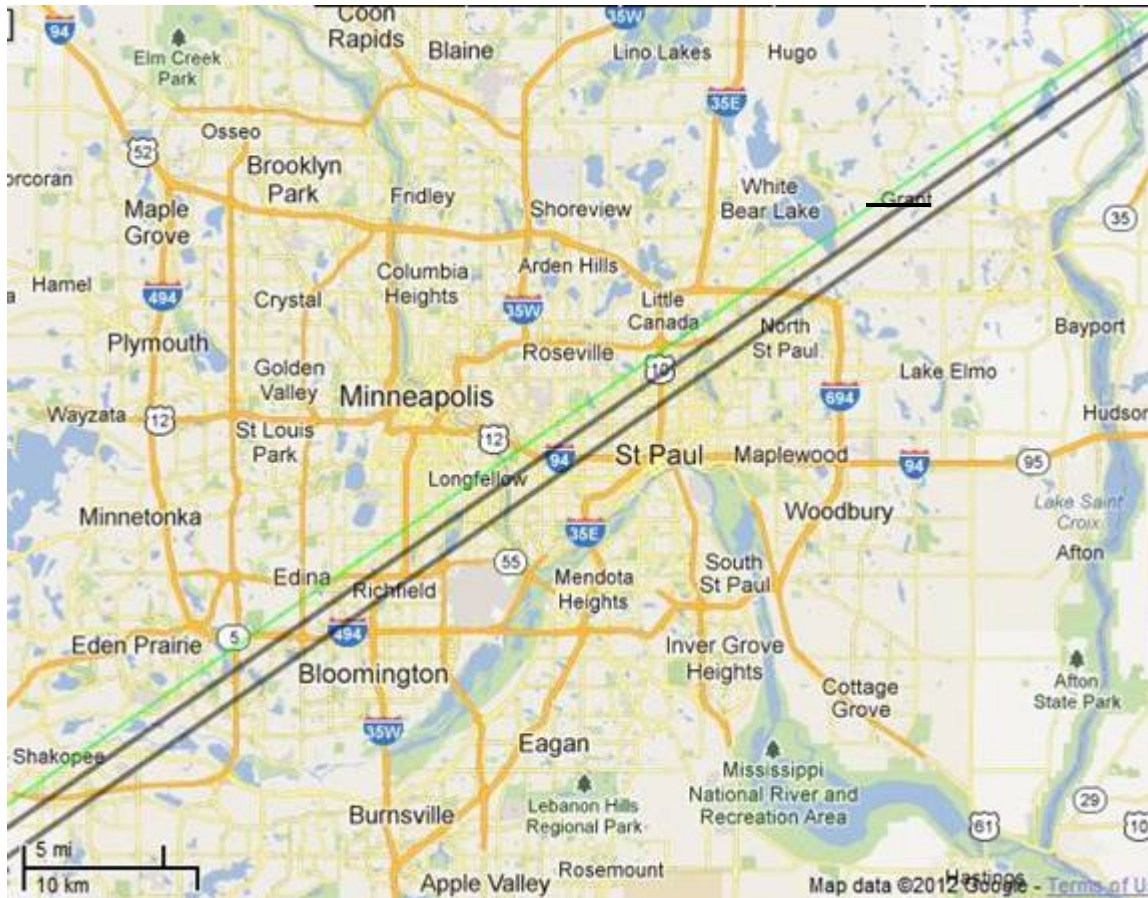
Grazing
Occultation of
3.5-mag. eta
Geminorum in
Arizona,
2011 April 10,
my first success
with remote
stations (a
humiliating
defeat, it was
machines, 3;
humans, 0)
Moon 36%+
Cusp Angle 15N

Stations on N. 387th Ave.



(Map center is at (WGS84 datum) Lat = 33.520538, Lon = -112.884222, which is 0.335 Km from path center.)

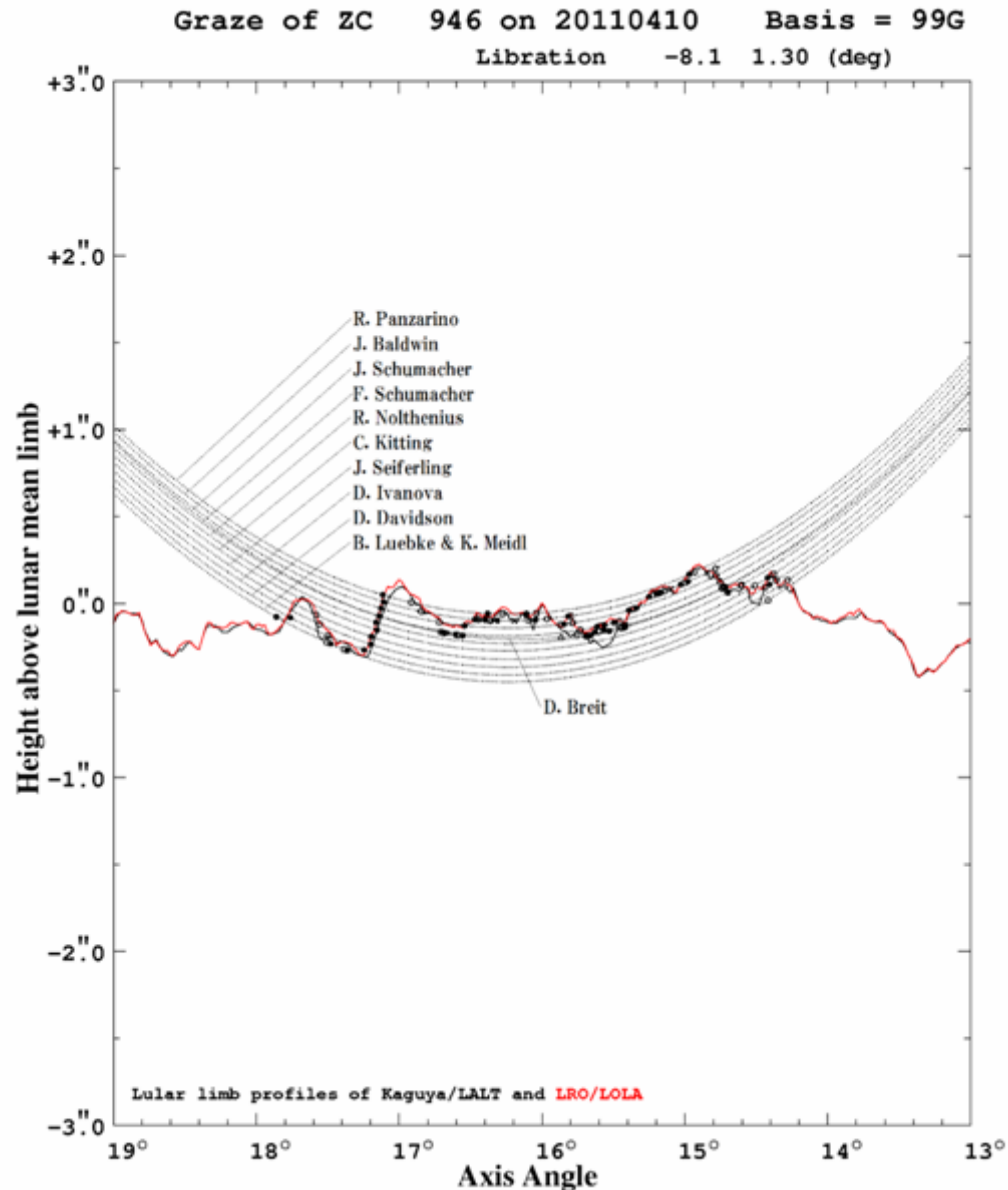
Graze of 4.9-mag. ω^2 Tauri (ZC 628) over Minneapolis, Minn. on 2012 Aug. 11, Moon 35%-, CA 2N



Station 4's single R indicates a south shift of about 200m; we can still determine corrections to stellar proper motions from graze observations

I attended an astrodynamics conference in Minneapolis, Minnesota Aug. 12-16. I went there early because I noticed that this graze occurred 2 days before; I made plans to observe it from near Grant. With the small cusp angle, I thought that there would be too much glare to record with midi systems, but I took 2 of them, to try, and 2 4-inch SCT's for attended stations that Joan and I ran. But like in Arizona, the machines triumphed; it was machines, 2, humans, 0. Station 3 recorded 6 D's and 6 R's; I'll play the video.

Comparison of Kaguya & LRO profiles



Here is a recent reduction of observations of the 2011 April 10th eta Geminorum graze by Dr. Mitsuru Sôma at the Japanese National Observatory. The profiles are close, but LRO's, with more orbits and points than Kaguya, is more accurate near Axis Angles 14.3 and 15.4.

With multiple stations and LRO data, there are still new things that can be done with grazing occultations!

Mother's Day Grazing Occultation of ZC 846

Finksburg, MD, 2013 May 13 UT

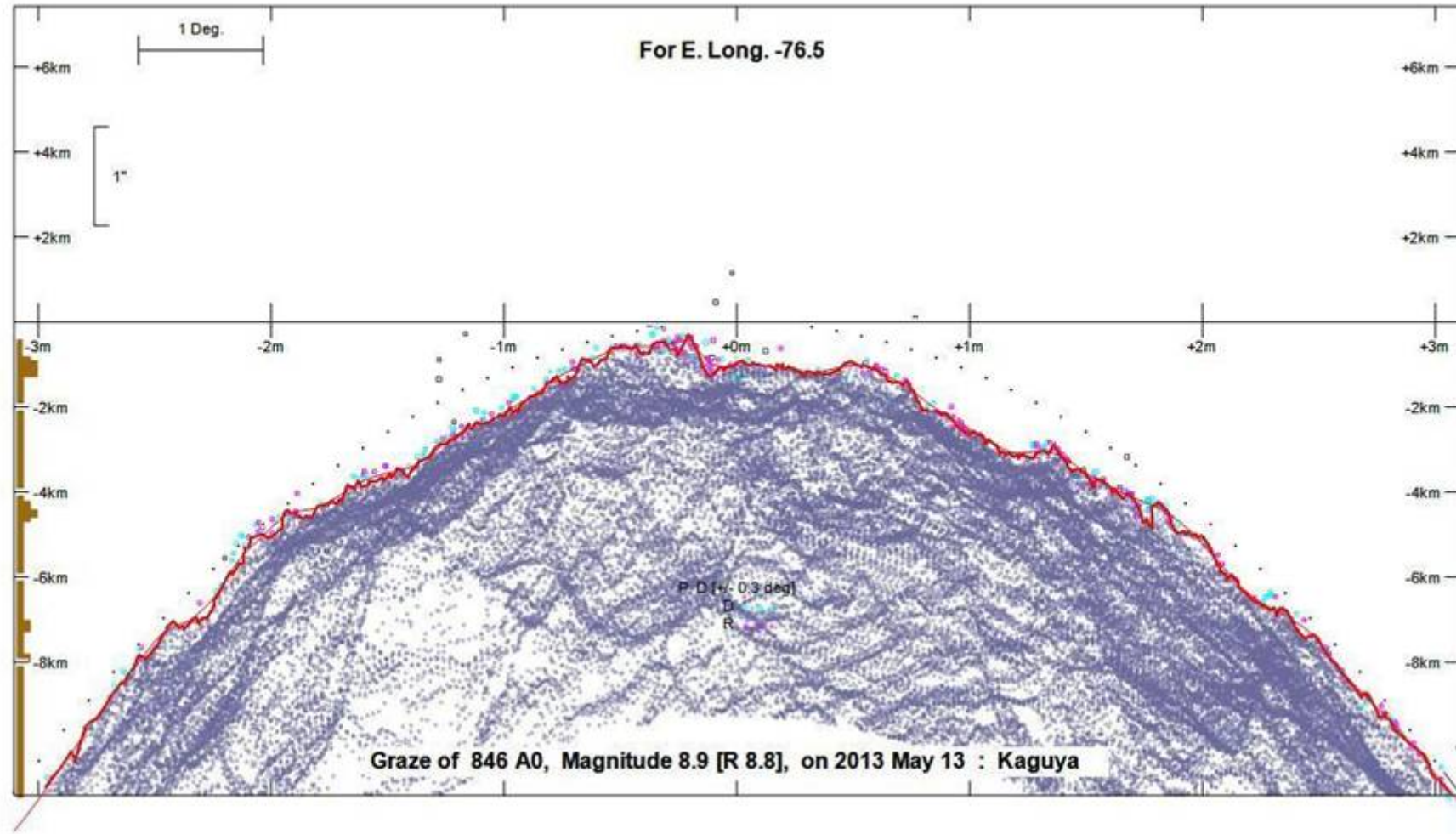
May 12 at 8:56pm EDT, the 8.9-mag. Star grazed
6° from the north cusp of 8% sunlit waxing Moon
17° above w. horizon, Sun

alt. -8°; Total occultations of stars in Taurus
Milky Way field observed for an hour after the
graze until the Moon set in trees

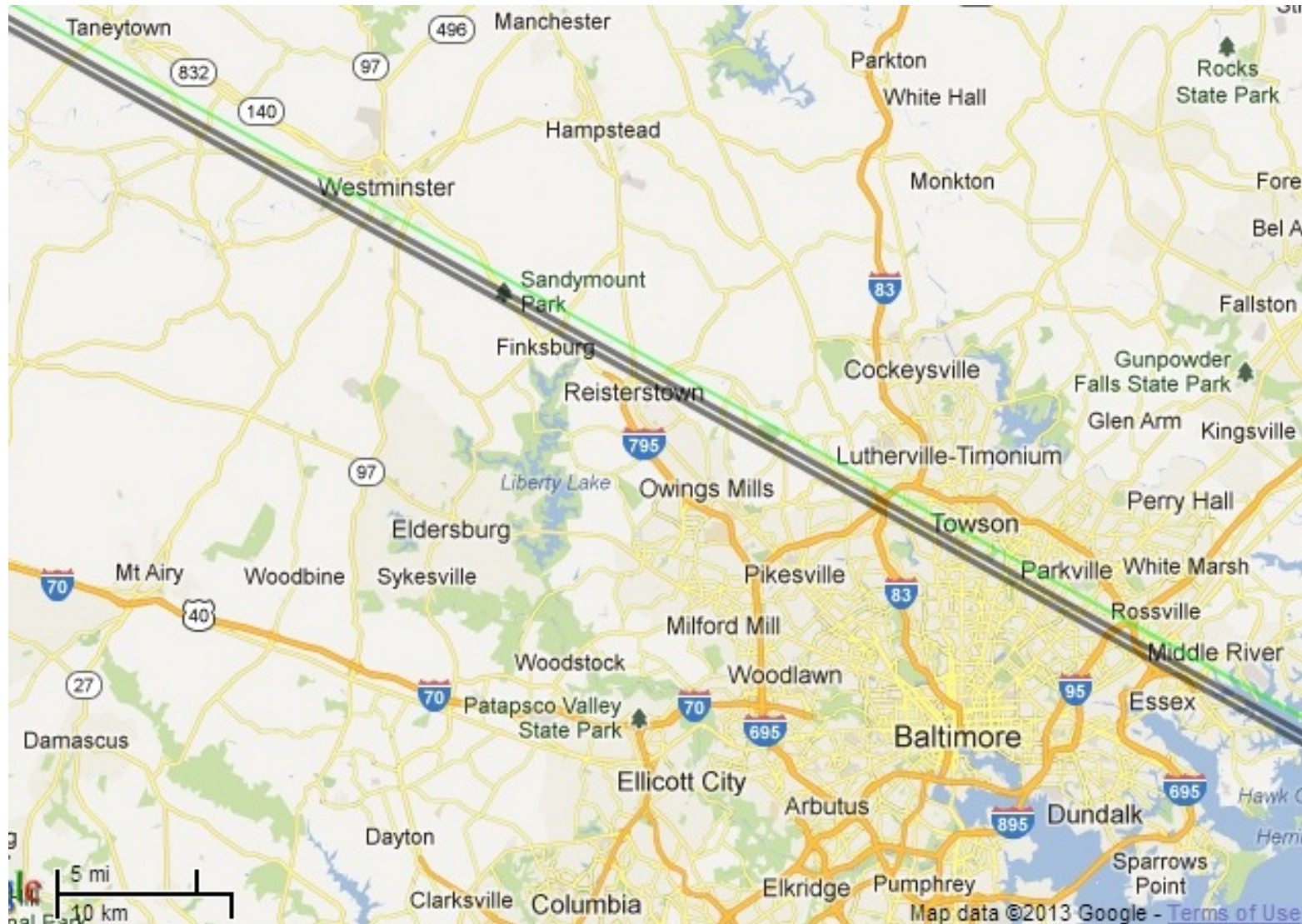
David W. Dunham

Kaguya profile for the Graze

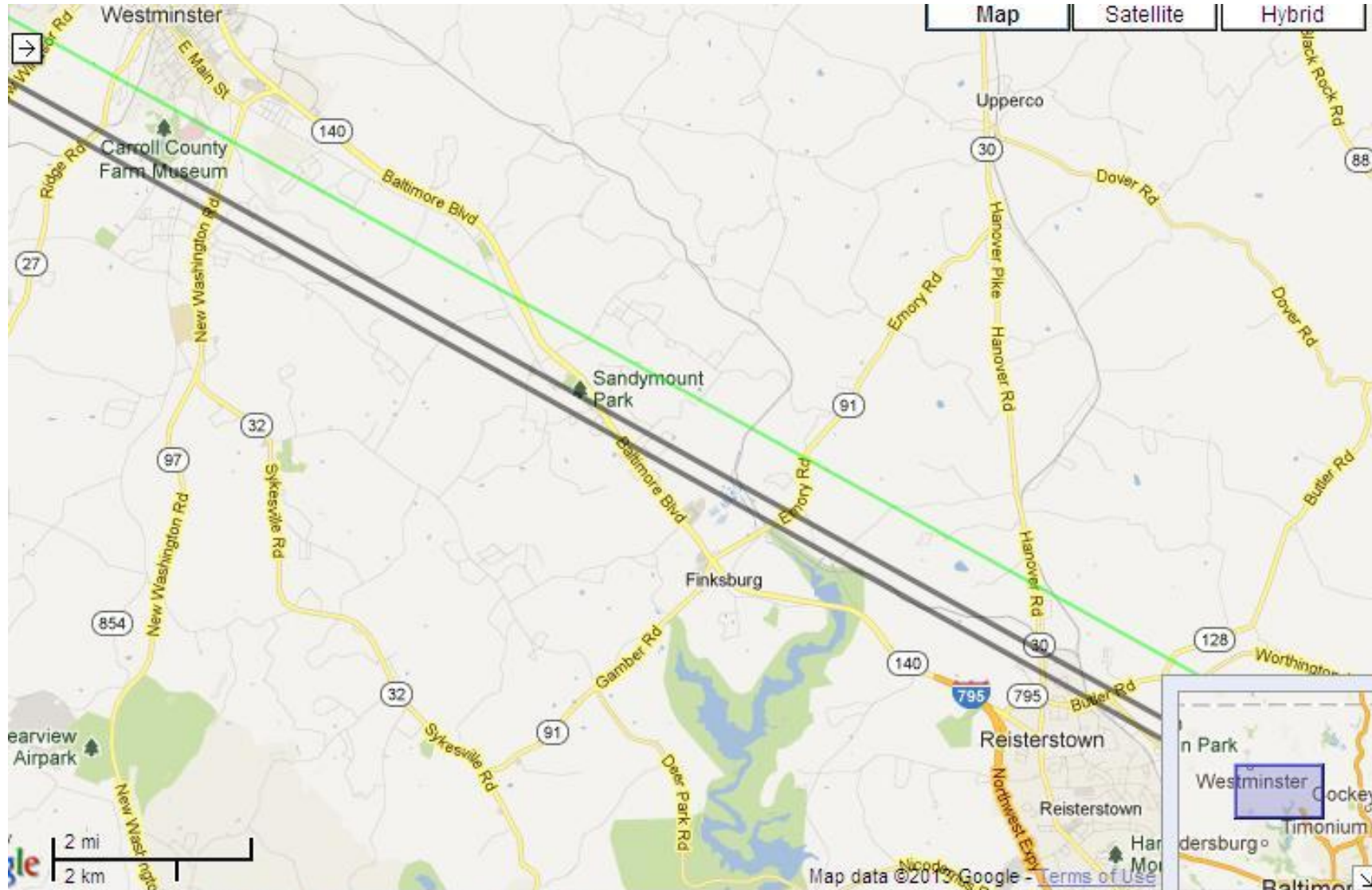
Occult 4.1.0.4



The graze path, overview



Westminster to Reisterstown



(Map center is at (WGS84 datum) Lat = 39.513576. Lon = -76.902924. which is 0.937 Km from path center.)

Detailed view



(Map center is at (WGS84 datum) Lat = 39.515298, Lon = -76.911164, which is 1.111 Km from path center.)

All gates to Gerstell Academy locked, I observed near central "140". Show videos.

Results of the 2013 May 13 Graze

- Although I thought that I was in the center of the narrow multiple events zone, I only had 1 D and 1 R, and no events (star continuously visible) during the time that the star was passing through (actually over) the “sweet spot” zone
- But I used $h = 50\text{m}$, my home value, assuming that Maryland is flat; my home and Finksburg are about the same distance from Chesapeake Bay
- But Finksburg is on the other (west) side of the “Fall Line”; it’s $h = 200\text{m}$, and that shifted the zone 150m farther south
- I learned more about the topography of my home State, Maryland, than about the Moon
- Mitsuru Soma’s analysis of the timings indicated an additional shift from the prediction due likely to error in the star’s proper motion accumulated since the 1991 Hipparcos epoch.

2013 June 2nd Grazing Occultation of λ Piscium = ZC 3494

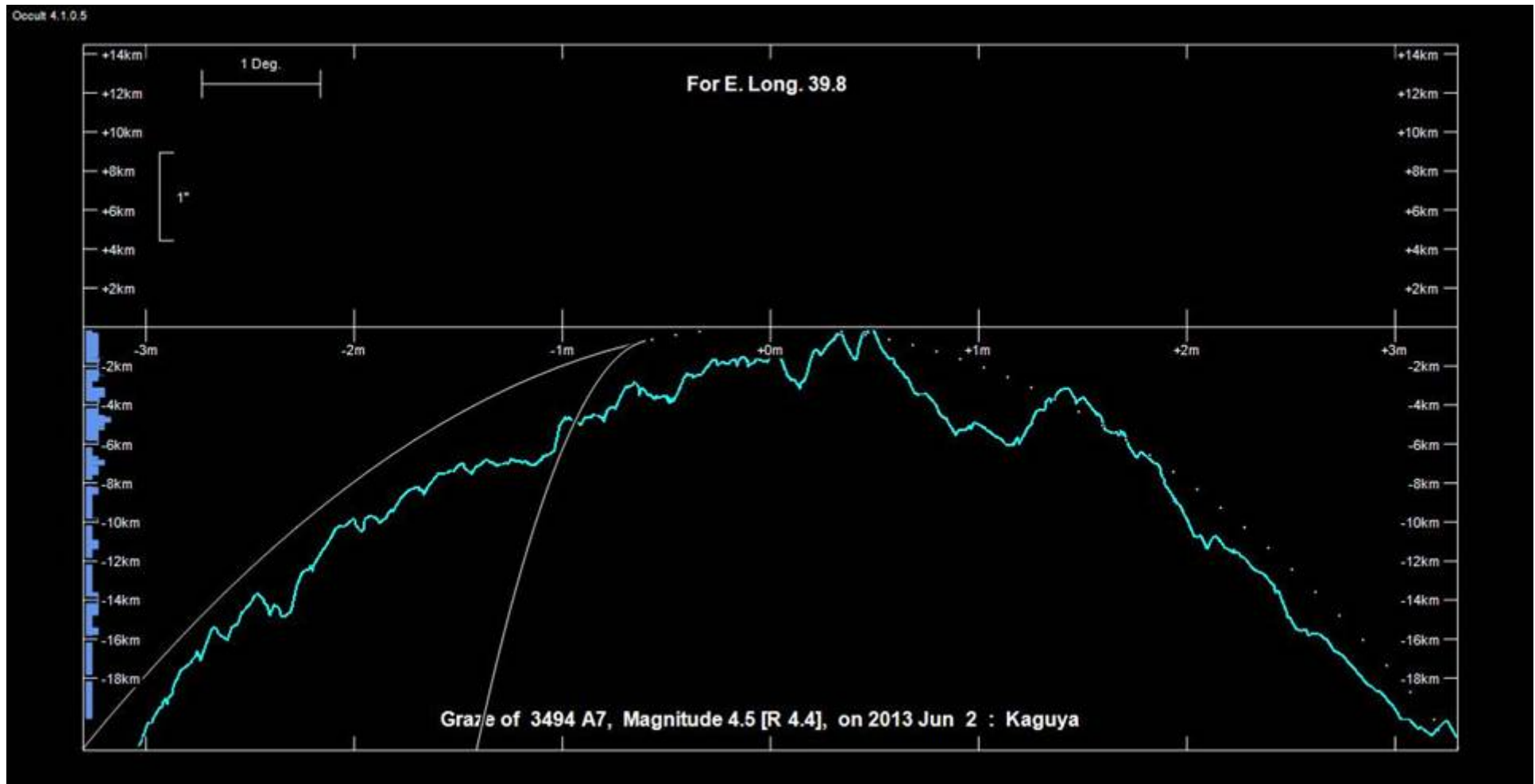
Near Mozhayskoye,

about 50 km s.e. of Voronezh, s.w. Russia

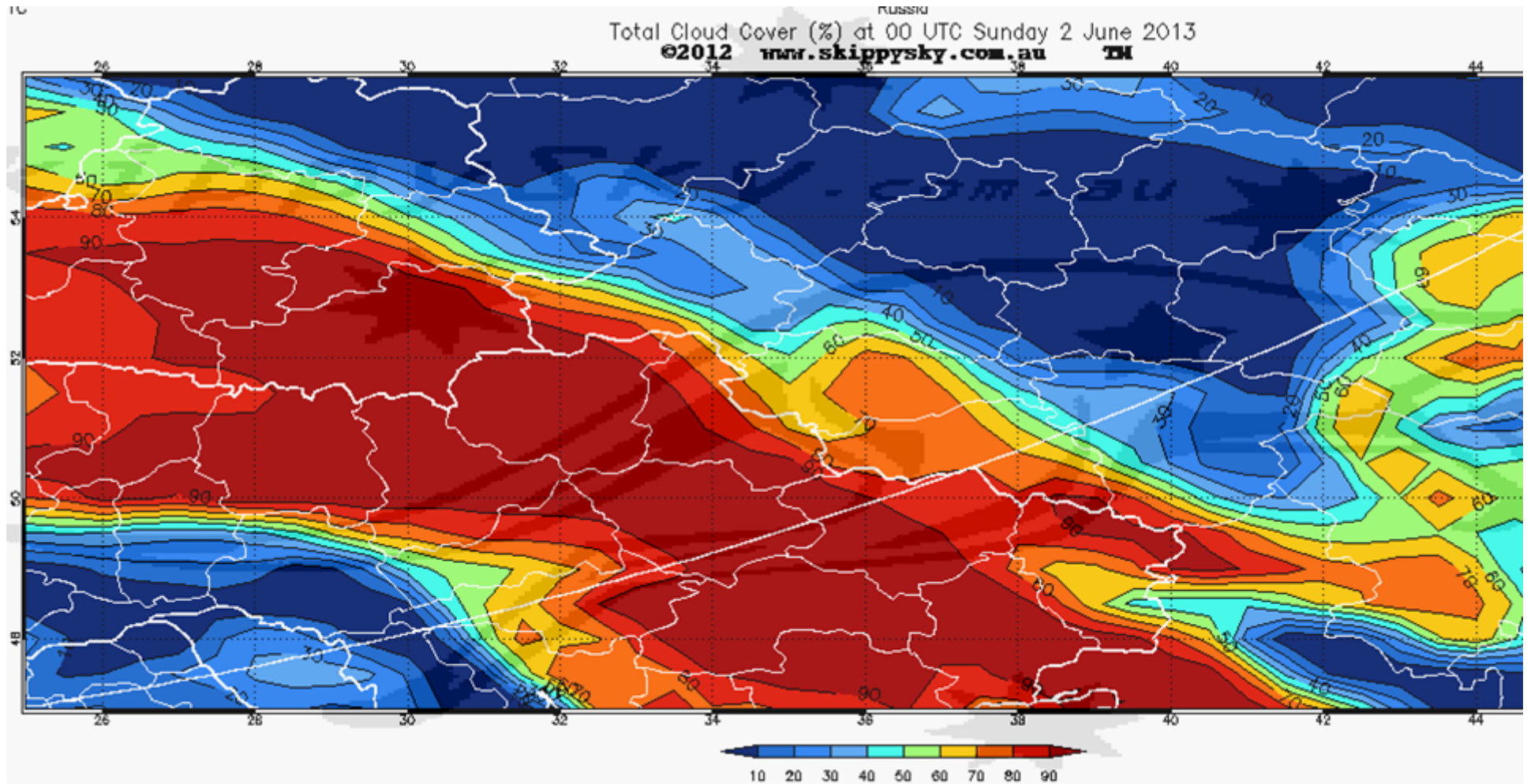
At 4:13am Moscow time, the 4.5-mag. star grazed 1° from
the north cusp of 37% sunlit waxing Moon 19° above e.
horizon, Sun alt. -7°

David W. Dunham
and Vladimir Belousov

Lunar Profile for the Graze



SkippySky Weather Forecast

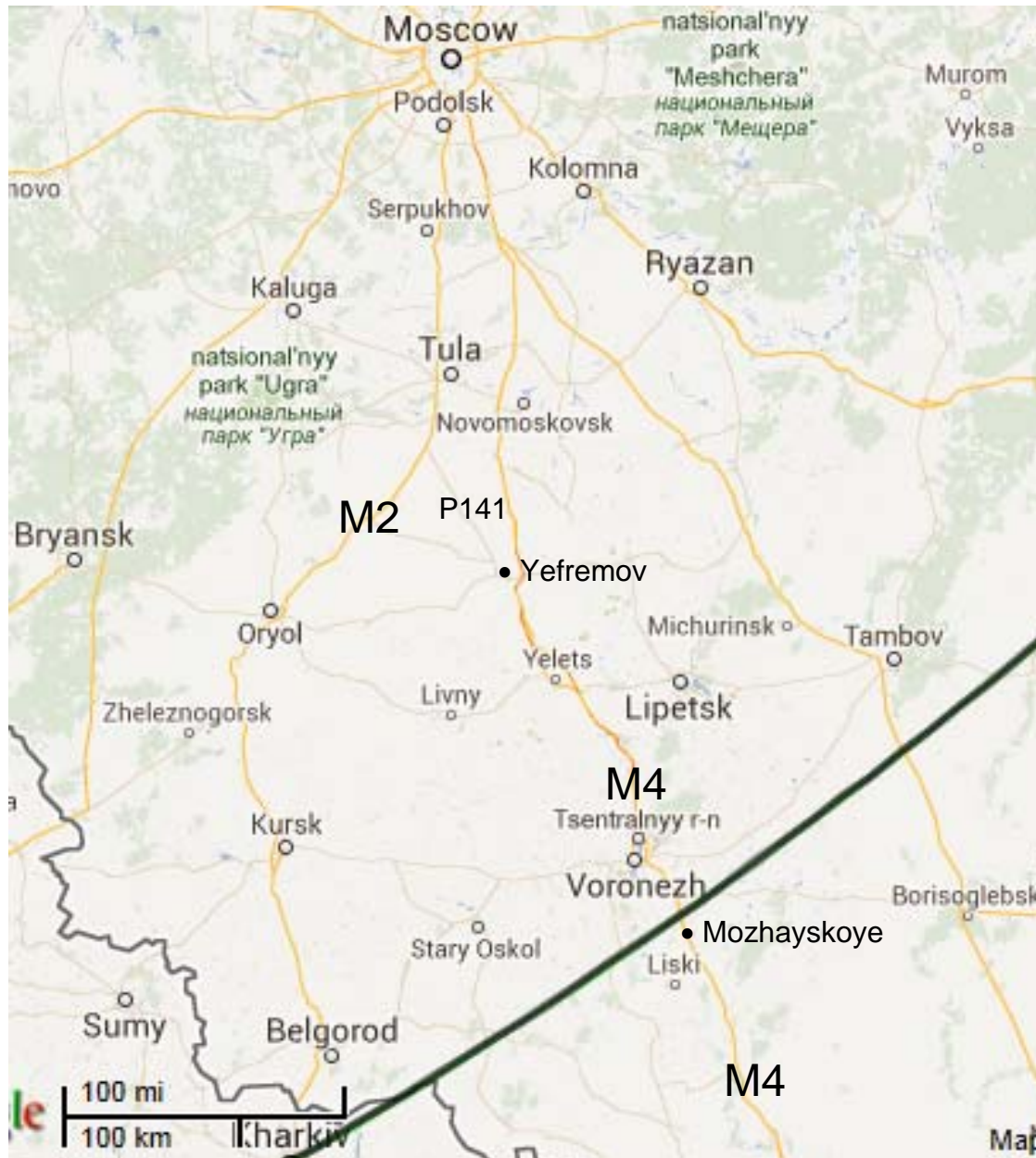


Apartment to Park Kultury Metro

Pugovishnikov per., 8; Podbezd 2, apart. 18



Map, Moscow to Mozhayskoye

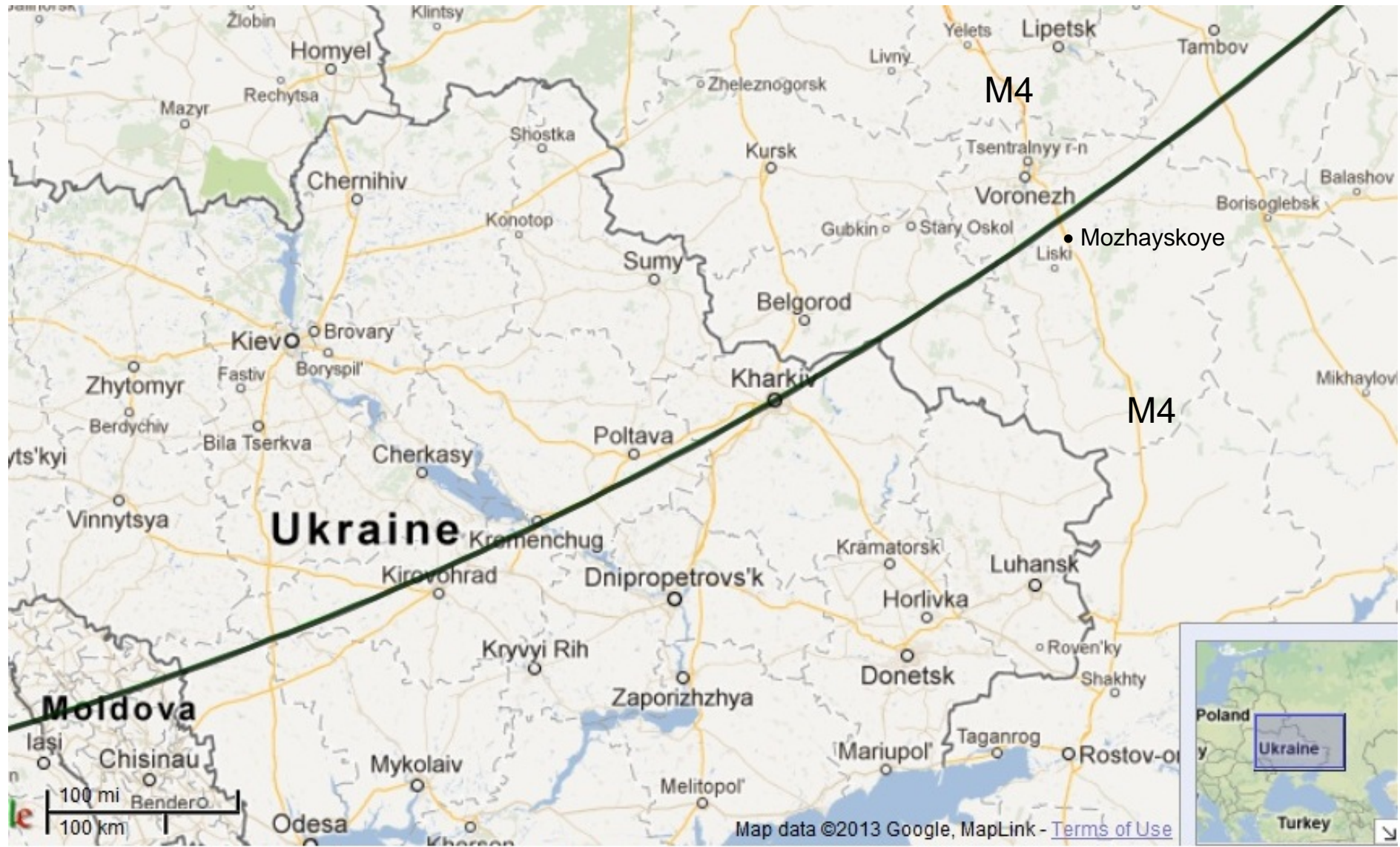


From Kurskaya Station in Moscow, I rode in a train to Tula, Where Vladimir met me. He drove us south on the M2 highway about 30km to the 2-lane P141 highway that we drove on for 100 km to join the M4 highway (Interstate quality) just southeast of Yefremov. Then we drove south on M4 through Voronezh to the graze site near the exit to Mozhayskoye, a distance of a little more than 400 km from Tula.

Leaving Tula



2013 June 2 Graze Path



(Map center is at (WGS84 datum) Lat = 50.134664, Lon = 34.870605, which is 60.096 Km from path center.)

Trees along P141 highway



Open spaces along P141 hwy



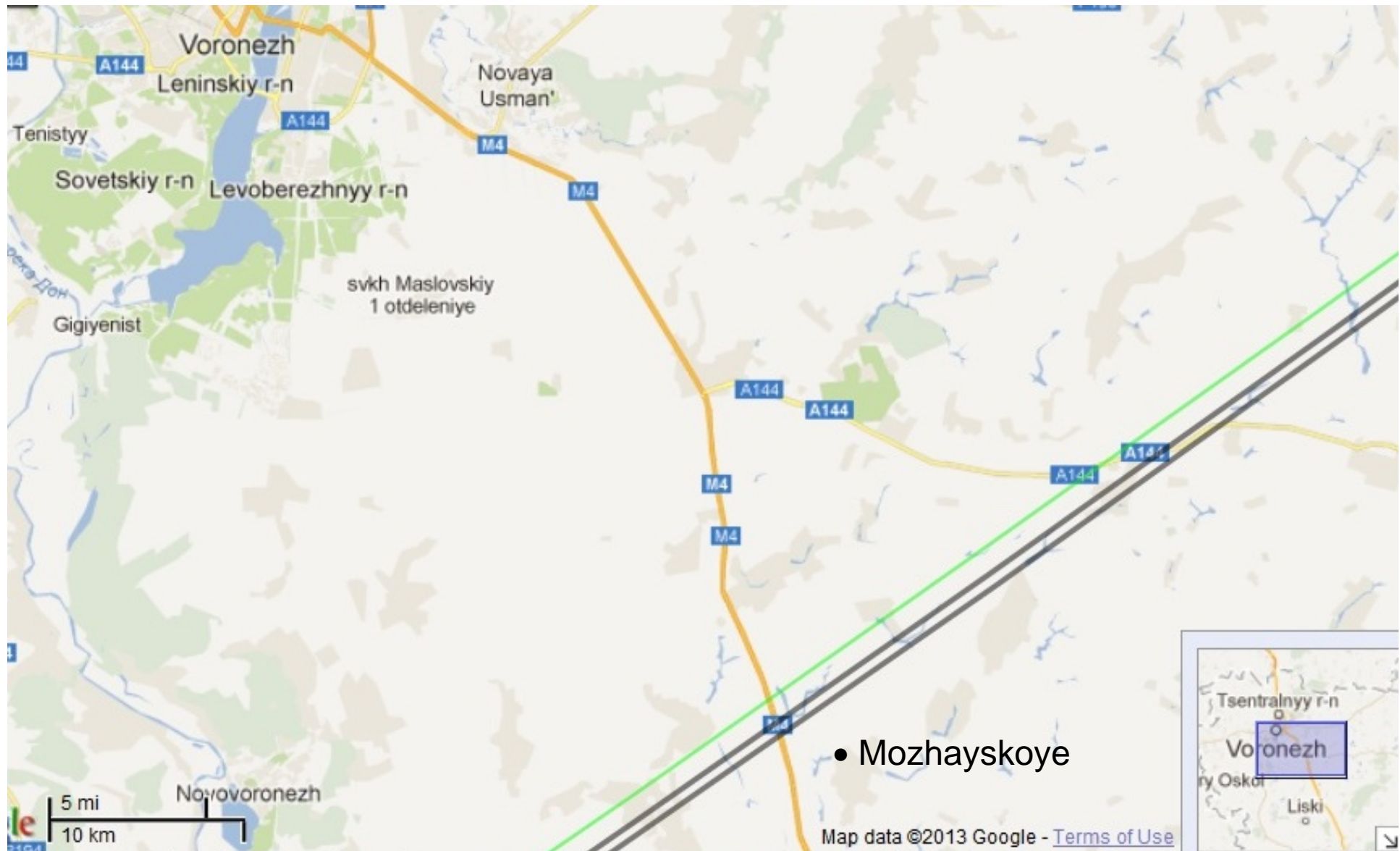
Church at Yefremov



Thunderstorm from M4 highway



2013 June 2 Graze Path



• Mozhayskoye

(Map center is at (WGS84 datum) Lat = 51.497629, Lon = 39.516448, which is 16.155 Km from path center.)

Google Map Graze Zone Detail



(Map center is at (WGS84 datum) Lat = 51.336188, Lon = 39.604339, which is 2.031 Km from path center.)

Northern midi about 60m north



Moon after the graze



After the graze



After the graze



Results of the 2013 June 2nd Graze

- We were able to make GPS measurements and navigate on a dirt road around a large farm field near the M4 highway exit, to within 12m of the desired target point.
- I ran two pre-pointed 80mm midi's about 75 m north and south of Vladimir's position.
- Vladimir used a relatively high power with his long focal-length refractor to manually follow the star.
- In spite of the telescope motion causing the star to move across the field, Vladimir's recording showed 3 D's and 3 R's well (the star's blue color contrasted nicely with the yellowish-white of the Moon), with only one occultation in the "sweet spot"; apparently again the path shifted a little to the south.
- Glare from thin clouds gave a poor view of the event with the wide-angle midi's. Graze events are faintly visible, but will be quite difficult for measuring timings. Even the southern station was apparently north of the "sweet spot" zone.

2013 August 2nd Grazing Occultation of ZC 798

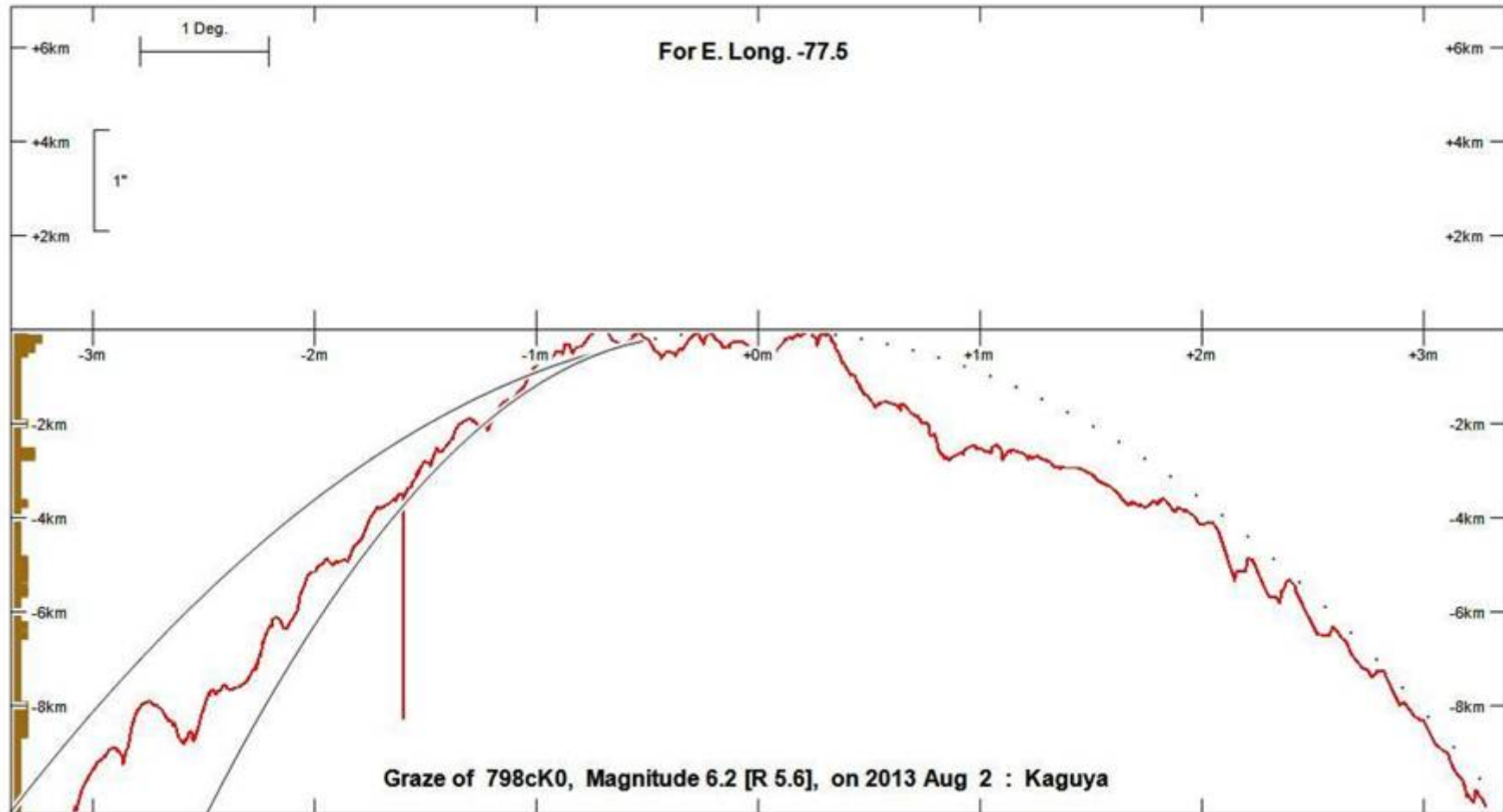
In the parking lot of Hanover High School,
Mechanicsville, Virginia, about
15 km n.e. of Richmond, Virginia

At 4:53am eastern time, the 6.2-mag. star grazed
1° from the north cusp of 17% sunlit waxing Moon
25° above e. horizon, Sun alt. -12°

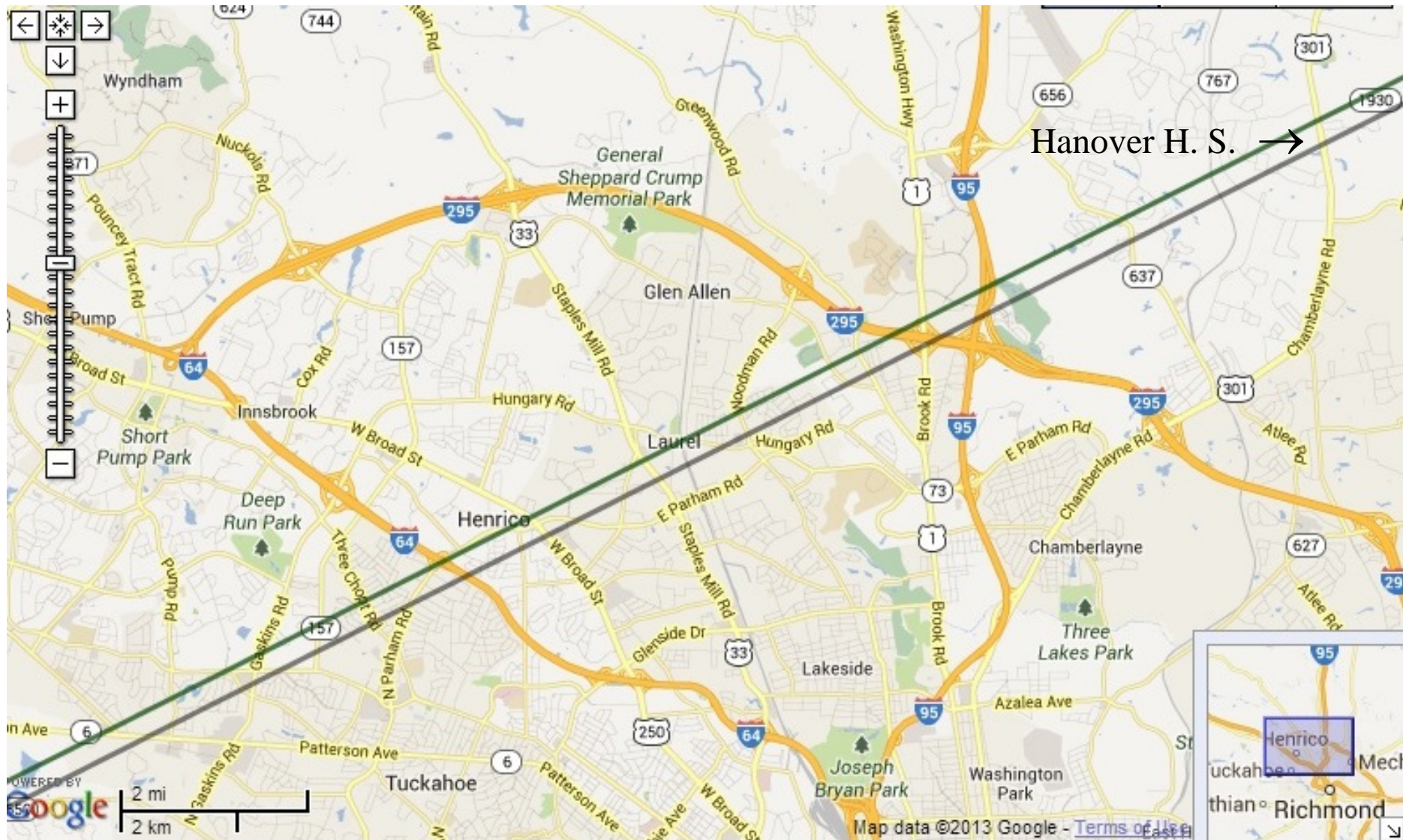
David W. Dunham
and Joan B. Dunham

Kaguya profile for ZC 798 graze on 2013 August 2

Occult 4.1.0.5



Graze path for ZC 798 graze on 2013 August 2



(Map center is at (WGS84 datum) Lat = 37.648762, Lon = -77.503396, which is 0.428 Km from path center.)

Stations for ZC 798 graze on 2013 August 2



Results of the 2013 August 2nd Graze

- The accurate prediction finally enabled us to hit the sweet spot, and clear skies allowed observation of the small cusp-angle graze, in spite of the small cusp angle.
- Station 1, the northernmost, a pre-pointed IOTA VTI time-inserted recording with a 120mm “maxi” (new mount design), recorded 6 D’s and 6 R’s of the star, and a faint flash.
- Station 2, Joan manually guided a 20cm SCT to obtain the best recording in the middle, with 8 D’s and 8 R’s.
- Station 3, the southernmost successful station, was a pre-pointed 80mm “midi” that recorded 5 D’s and 5 R’s, although the star is faint
- Station 4 (not shown in the previous figure) was an old wobbly-mount 120mm “maxi” at the southern edge of the multiple events zone, which David planned to guide to record the event, but he got the star on target a minute after the graze.

End; Grazing Occultation Videos

- If time permits (or later during the meeting, if possible), I will show some past graze videos
- I consider the best being one of Spica recorded in Japan on 1994 November 29; the Moon was only about 4% sunlit and the graze took place at the northern cusp, hitting a “sweet spot” only with Watts profile predictions
- Station 2, and maybe station 1, from 2013 August 2.
- Vladimir’s recording of the 2013 June 2nd graze
- Southern station with an 80mm midi from the 2011 April 10th graze of 3rd-mag. eta Geminorum (a large cusp-angle graze)
- My recording of the 1987 October 12th graze of 2nd-mag. El Nath (beta Tauri) on the dark side of a gibbous Moon at Genoa Airport near Houston; event occurred right after that year’s IOTA meeting