The Best Lunar Grazing Occultations in North America during 2023

The map below shows the paths of lunar grazing occultations for the 22 brighter stars and planets visible from much of North America in 2023. The events are limited to stars of magnitude 5.5 or brighter that will graze the limb of the Moon when it is at a favorable elongation from the Sun and at least as high above the horizon in degrees as the star's magnitude (e.g., a third-magnitude star is included only if its altitude is at least 3°). Some stars fainter than mag. 5.5 are included, to provide a good geographical distribution of paths. The map is a "false" projection, since the latitude and longitude scales are both linear. This makes it much easier for measuring coordinates or plotting locations with known coordinates than is possible with any other type of projection. The longitude scale is compressed by a factor of cos 50°. The maps are not detailed enough for locating oneself in the 2- or 3-km-wide zone where multiple disappearances of the star may occur. To obtain detailed predictions of any graze for plotting on larger-scale maps of your region, write to IOTA at PO Box 20313, Fountain Hills, AZ 85268-0313 or better, send an email to **business@occultations.org.** For some grazes, IOTA overlays the predicted limit line on the very detailed maps and imagery of maps.google.com, but further corrections are needed based on the predicted lunar profile and the observer's height above sea level. A Web .htm file to do this is generated by IOTA's Occult4 program available free at **http://www.lunar-occultations.com/iota/occult4.htm** . The height above sea level in the area where the graze will occur, needs to be specified when generating the .htm file.

The 2023 month and day of month, and the star or planet's name or number are given along each track on the map. Conditions are represented by three different types of lines:
solid line = dark limb, night; dashed line = bright limb, night; and dotted line, dark or bright limb, day.

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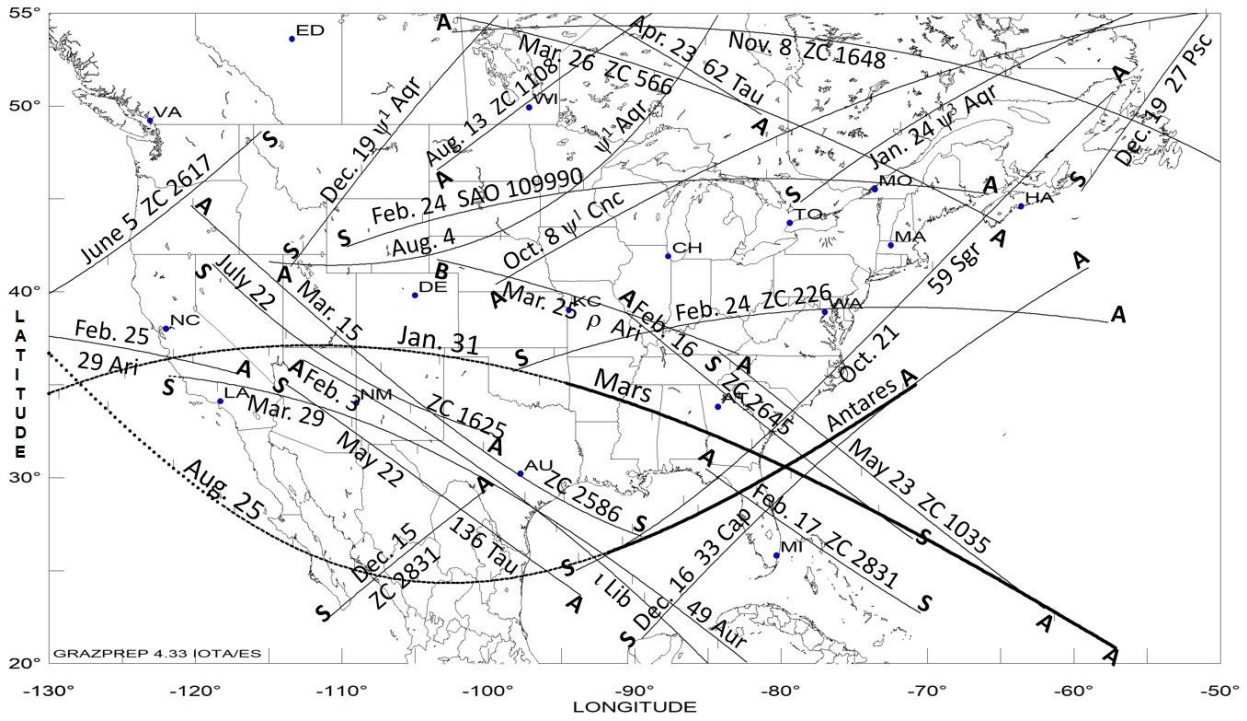

Thicker lines are drawn for first-magnitude stars and planets. Many tracks begin and/or end with the letter A, B, or S: A denotes that the Moon is at a low altitude, B that the bright limb interferes, and S that sunlight or twilight interferes. The tick marks along the tracks indicate multiples of 10 min of every hour. For

example, if the time for the west end of the track is 3:16.2, the tick marks proceeding eastward correspond to 3:20, 3:30, etc. Time always increases from west to east along the path. *The time ticks are on the side of the limit with an occultation,* that is north of southern limits and south of northern limits. The locations for the North American standard stations for lunar total occultation predictions given on pages 162-171 of the 2023 *Handbook* are indicated by asterisks on the graze map. 248 grazes are shown on six maps and tables, similar to what we published in the Handbook for previous years, at track on the map.

Table of the best lunar grazing occultations in North America during 2023

Date	Object Name	ZC/SAO	d	m	%sl	L	W.U.T. h	W.U.T. m	Lo.	La.
Jan. 24	ψ^3 Aqr	ZC 3428	A	5.0	13+	S	22	12.6	-78	45
Jan. 31	Mars			-0.3	74+	N	4	38.8	-130	35
Feb. 13	ι Librae	ZC 2172	Z	4.5	54-	S	8	32.0	-112	36
Feb. 16		ZC 2645		6.2	21-	S	10	56.5	-90	39
Feb. 17		ZC 2831		6.0	12-	S	10	58.5	-85	30
Feb. 24		ZC 226	Y	6.5	17+	S	0	35.7	-98	36
Feb. 24		SAO 109990		7.0	18+	S	1	13.2	-109	42
Feb. 25	29 Arietis	ZC 374	V	6.0	29+	S	5	44.4	-130	38
Mar. 15		ZC 2586	K	6.0	46-	S	11	20.7	-120	45
Mar. 25	ρ Arietis	ZC 433		5.6	13+	N	2	32.4	-122	44
Mar. 26		ZC 566		6.0	21+	N	2	41.1	-102	55
Mar. 29	49 Aur	ZC 1008		5.3	49+	N	2	32.7	-122	35
Apr. 23	62 Tauri	ZC 652	Y	6.3	10+	N	3	11.9	-92	55
May 22	136 Tauri	ZC 890	V	4.6	6+	N	2	35.4	-114	35
May 23		ZC 1035	X	6.7	11+	N	0	59.0	-84	37
Jun. 5		ZC 2617	K	4.5	98-	N	11	34.5	-130	40
Jul. 22		ZC 1625	Y	5.8	16+	N	3	30.7	-118	41
Aug. 4	ψ^1 Aqr	ZC 3419	A	4.2	91-	N	4	56.4	-115	42
Aug. 13		ZC 1108	V	7.0	8-	N	9	22.5	-103	47
Aug. 25	Antares	ZC 2366	O	1.1	57+	S	1	52.5	-130	37
Oct. 8	υ^1 Cancri	ZC 1274	K	5.7	34-	N	7	2.7	-99	40
Oct. 21	59 Sgr	ZC 2912		4.5	48+	S	23	42.5	-94	25
Nov. 8		ZC 1648		6.9	23-	S	9	9.1	-102	54
Dec. 15		ZC 2831		6.0	5+	S	0	51.1	-110	23
Dec. 16	33 Cap	ZC 3130		5.4	19+	S	23	24.5	-89	21
Dec. 19	ψ^1 Aqr	ZC 3419	A	4.2	40+	S	0	7.8	-113	41
Dec. 19	27 Psc	ZC 3526	A	4.9	50+	S	20	18.1	-59	45

The columns of the table above are explained below:

Date …….. The 2023 date
Object name …. Planet name, or star's proper name, Bayer Greek letter or Flamsteed number
ZC/SAO …… The star's ZC or Smithsonian Astrophysical Observatory (SAO) catalogue number
d …… Double star code (if the star is double or triple) – see below
m …….. The star's visual magnitude
%sl …… the percent of the Moon sunlit (+ for waxing, - for waning, E for lunar eclipse*)
L …… whether the track is a northern (N) or southern (S) limit
W.U.T. ……. the Universal Time at the west end of the track
Lo., La. ……. the longitude and latitude of the west end of the track

*In this case, the number is the % of the Moon's disk that is NOT in the umbral shadow (none in 2023)

Occulted stars known to be double

In the table below gives data for double stars for which graze predictions are given, either on the map and table above, or on the maps and tables of the 248 grazes portrayed elsewhere on this Web page. The information is from DSFILE, a comprehensive file of zodiacal double-star data compiled by Don Stockbauer, Henk Bulder, Mitsuru Sôma, David Herald, and David Dunham; most of the data for the ZC stars are in the Sato ZC catalogue. The successive columns give the ZC number of the star, the 2023 graze date, the double star code (d), the magnitudes of the brighter (A) and fainter (B) components, the separation in arcseconds, and the position angle (PA) of B from A measured eastward from north. If the star is triple, the third component's magnitude is given under C, and its separation and PA from A are given in the last columns.

The parameters are given for the epoch of the occultation, computed from orbital elements when available or from extrapolations from a long series of observations. If there is little change in the available observations, the last-observed separation and PA are used. Most components fainter than magnitude 12.0 are not listed, and some very close doubles whose parameters are not known, generally with separations less than 0.2", are also not listed. The latter include spectroscopic binaries (code U, or sometimes V) and visual occultation doubles (most codes K and X, and many Vs).

The codes have the following meanings:

A .....Visual double listed by Aitken and/or Burnham (ADS, BDS)
C .....Visual double listed by Innes, Couteau, or other visual observers
D .....primary of wide pair; secondary has separate catalogue entry
H .....triple, with close occultation pair and third visual component; prediction uses a mean position (J,U,orV & M)
K .....U or V, but duplicity doubtful, only reported "gradual" from a past visual occultation observation
L.....close triple star (only two stars often listed because inner pair is often spectroscopic; J or U, & V; all V; or all J)
M .....mean position (centre of light) of a close pair is used by the ZC and/or XZ catalogue
O.....orbital elements available and used to calculate the separation and PA
U.....Double, separation 0.05" or less, usually a 2-line spectroscopic binary
V .....Close double discovered by occultation or by interferometry
Y .....triple, K or X (visual A component) and A or C (C component)
Z .....triple, O (A/B components) and V (C component) (O and A or C, or V or X or L)

Many close pairs have rapid orbital motion such that the current separation and/or PA is unknown, and they are then not listed in the table below.

ZC#	2023 Date	d	A	B	Sep. ″	PA °	C	Sep. ″	PA °	Notes
55	Jul. 9		M	6.5	8.9	0.4	267			
226	**Feb. 24**		**Y**	**7.2**	**7.2**	**0.1**	**90**	**10.7**	**4.2**	**74**
416	Aug. 8		M	5.5	8.4	3.2	120			
442	Jul. 12		M	6.8	9.8	2.2	50			
485	Sep. 5		M	7.0	10.8	0.6	338			Was also occulted on April 21
486	Sep. 5		H	5.4	7.9	0.2	38	8.2	0.8	227
487	Sep. 5		M	5.3	8.5	0.5	289			
594	Jul. 13		A	6.9	7.8	7.3	128	9.3	58.0	241
598	Oct. 3		T	6.4	6.4	0.1	214	12.2	25.5	257
652	**Apr. 23**		**Y**	**7.2**	**7.2**	**0.1**	**90**	**8.8**	**28.9**	**290**
844	July 15		M	6.6	6.6	1.1	134			Was also occulted on March 28
885	Oct. 5		Y	5.9	7.2	0.01	270	12.0	15.0	232
909	Sep. 8		T	6.2	8.2	0.03	194	12.4	350.3	242 Was also occulted on March 1
1026	Oct. 6		C	6.5	11.7	30.7	46	10.4	55.9	57
1093	Nov. 3		Z	7.2	7.2	0.7	296	12.3	15.6	94
1093	Apr. 26		Z	7.2	7.2	0.7	297	12.3	15.6	94
1181	Oct. 7		M	7.0	10.1	0.4	208			
1211	Dec. 1		C	6.2	11.0	45.5	23			
1263	Mar. 31		D	7.1	7.6	5.8	49			
1363	Apr. 1		M	5.7	6.2	0.3	62			
1596	Oct. 11		A	7.0	12.0	1.5	95			
1625	**Jul. 22**		**Y**	**6.7**	**6.7**	**0.1**	**90**	**11.4**	**21.5**	**238**
1772	Nov. 9		O	4.6	5.9	0.1	102			

2172	**Feb. 13**	**Z**	**5.0**	**6.2**	**0.1**	**85**	**9.2**	**57.8**	**111**	
2349	Aug. 24	L	3.3	5.3	.0005		5.2	0.4	258	
2366	**Aug. 25**	**O**	**1.2**	**5.5**	**2.3**	**274**				
2586	**Mar. 15**	**K**	**6.3**	**7.3**	**0.3**	**276**				
2617	**Jun. 5**	**K**	**5.1**	**5.9**	**0.3**	**12**				
3178	Nov. 20	U	6.9	7.0	0.001					
3356	Jul. 7	V	6.4	6.9	0.1	109				
3419	**Aug. 4**	**A**	**4.5**	**8.5**	**49.6**	**312**				**Will also be occulted Dec. 19**
3428	Jan. 24	A	5.2	11.2	1.8					
3526	**Dec. 19**	**A**	**5.1**	**10.4**	**1.3**	**313**				

The lines in the double star table in bold type are for grazes shown on the map on the first page of this document.

Names of occulted stars

The stars that are occulted by the Moon are stars that lie along the zodiac; hence they are known by their number in the Zodiacal Catalogue (ZC) compiled by James Robertson and published in the *Astronomical Papers Prepared for the Use of the American Ephemeris and Nautical Almanac, Vol. 10,* Part 2 (U.S. Government Printing Office, Washington, 1940). Robertson's ZC has been out of print for many years. In 1986, Isao Sato, a member of the Lunar Occultation Observers Group in Japan, republished the ZC. This new edition is based on the epoch J2000 and includes much new data, particularly on double stars. Since stars are not usually recognized by their ZC numbers, the Bayer designations or Flamsteed numbers of the stars occulted during 2023 are given in the table below. The ZC and larger XZ (now version XZ80Q) catalogues, updated in 2018 by D. Herald using Gaia data, are available through IOTA's website.

ZC	Name	ZC	Name	ZC	Name
55	10 Cet	1026	25 Gem	2270	V1040 Sco
153	73 Psc	1088	47 Gem	2349	σ Sco (Al Niyat)
167	80 Psc	1119	59 Gem	2366	α Sco (Antares)
180	ζ PscA	1149	υ Gem	2371	22 Sco
184	88 Psc	1169	76 Gem	2505	43 Oph
272	54 (Cet)/Ari	1206	ω Cnc	2554	X Sgr
374	29 Ari	1211	4 Cnc	2631	V4045 Sgr
415	40 Ari	1233	ψ Cnc	2910	ω Sgr
416	π Ari	1251	λ Cnc	2912	59 Sgr (Terebellum)
429	44 Ari	1263	24 Cnc	2914	60 Sgr
432	45 Ari	1270	28 Cnc	3130	33 Cap
433	ρ Ari	1274	υ^1 Cnc	3141	35 Cap
442	50 Ari	1279	υ^2 Cnc	3158	37 Cap
455	53 Ari	1363	ξ Cnc	3160	38 Cap
465	δ Ari (Botein)	1365	79 Cnc	3164	ε Cap
486	τ Ari	1484	η Leo	3175	κ Cap
487	63 Ari	1504	37 Leo	3304	56 Aqr
492	65 Ari	1749	10 Vir	3356	74 Aqr
582	32 Tau	1772	η Vir (Zaniah)	3358	75 Aqr
584	33 Tau	1891	θ Vir (Apami-Atsa)	3419	ψ^1 Aqr
598	36 Tau	1945	76 Vir	3425	ψ^2 Aqr
652	62 Tau	2021	ER Vir	3428	ψ^3 Aqr
890	136 Tau	2120	10 Lib	3526	27 Psc
1008	49 Aur	2172	ι Lib	3535	29 Psc
1022	54 Aur				

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