G R A Z P R E P ver. 5.0

Introduction

'GRAZPREP' originally was designed as a tool to easily access the grazing occultation prediction data supplied each year to interested observers worldwide by IOTA/ES. The software assists in finding and listing individually favorable occultation events and in figuring out the best observing site in advance or even under way by graphically showing the expected apparent stellar path through the lunar limb terrain. Through the use of the high-resolution lunar topographic data supplied by NASA's Lunar Orbiter Laser Altimeter (LOLA) on board of the Lunar Reconnaissance Orbiter (LRO), recalculated to allow GRAZPREP a quick display of the profile in all position angles and any libration combination, the approximate number and times of dis- and reappearances can be predicted for any earthbound site coordinates and elevation.

The main idea of the program is to easily visualize the complete list of all grazing occultation events in an area plus the complete line data for any selected event and (simultaneously on the same screen) both the geographic circumstances on Earth and the enlarged topographic situation at the lunar limb including a fairly realistic display of the sunlit lunar portion as well as the approximate sky brightness due to the sun's altitude. Thus a judgment about the entire graze circumstances is easily possible at a few glances and a selection of the best events quick and easy. Using Google Earth the optimum site location can be found as GRAZPREP plots the outline of the lunar profile on the Earth's surface in the area of the selected observing longitude at the mean local elevation.

Besides that the software assists in creating individual station prediction files with any center and radius, that way filtering out the most suitable events according to a variety of personal preferences. Also other observers can be supported that way with individual occultation predictions.

Besides predictions of grazing occultation events GRAZPREP also allows the easy prediction of total lunar occultations by the moon for any night and place. Additionally a planetarium function optimized for the interest of occultation observers can be used to visualize all stellar and planetary occultation events at the lunar limb as well as stellar occultations of the 8 major planets.

GRAZPREP presently utilizes the stellar position data of the Gaia-catalog 's 2nd release (DR2) where available.

1. Installation

GRAZPREP was successfully tested under Windows 10 and Windows 11. Enough RAM must be available (4 GB recommended). GRAZPREP is a fully native software thus completely independent of any .NET-environment.

The necessary installation file is available under www.grazprep.com in a zipped format. Clicking on the unzipped EXE-file starts the installation process. The required password is 'IOTA/ES'. Do NOT use any Windows/Program Files-directory for the installation but choose another self created directory! Some 1,6 GB of hard disk space is necessary, plus some space for the prediction data files.

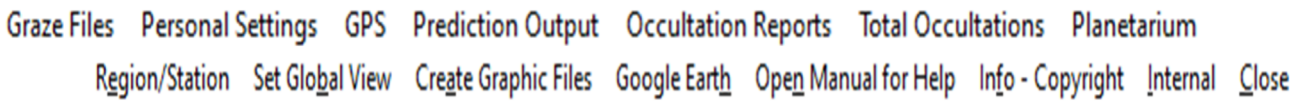
In case there is a need for a prediction output for a group of observers an additional individual binary (*.OBS) or ASCII-stationfile (*.TXT) is needed in order to enable the program to generate an observer

scan along with the prediction output. This observer station file is not important though for all other functions.

Furthermore the original graze prediction data consisting of two files with suffix '.GG0' and '.GG1' is necessary. This data is supplied by IOTA/ES on a yearly basis via www.GRAZPREP.COM. Note that BOTH files ('.GG0' and '.GG1') must be put and present in the same directory. Sometimes also a *.GG2-file is offered which provides data of crossing graze events (see below under 14).

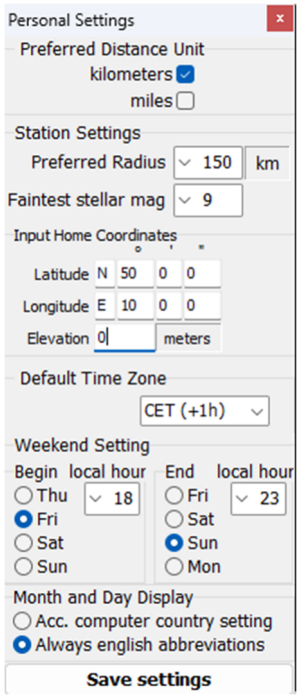
2. Starting the program

The program starts by double clicking on the installed GRAZPREP icon. If all files were copied correctly into the directory the program will start showing the main menu:



If necessary files are missing in the program's directory or do not have the correct length a window will appear giving all information to be able to correct or complete the files.

3. Personal settings



Starting GRAZPREP for the very first time a window will open on the first mouse move for entering a few necessary personal settings. Here the preferred distance unit, preferred travel radius and faintest stellar magnitude as a default setting as well as the home coordinates and time zone and an individual definition of a weekend must be entered (serves as a default for a later limiting prediction selection filter for weekend events). Enter the weekend times according to the preferred time zone. The time zones for Iran and India are at the bottom of the drop-down-list.

Also choose the display of the name of days and months either according to the computer language setting or as English abbreviations. These entries can be changed anytime later using 'Adjust personal settings' in the main menu.

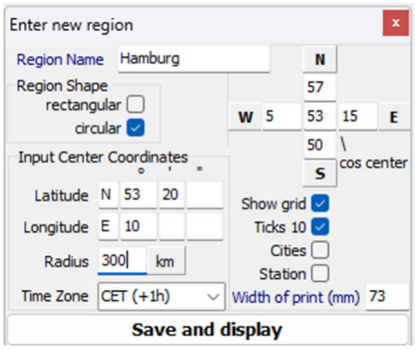
4. Types of graze files

Concerning the graze data files it is necessary to distinguish between two types:

1. **Unfiltered region graze data**, e.g. in the way supplied by IOTA/ES and normally covering a 'square' region limited by longitudes and latitudes, and covering all events in that region normally for one full year. These files are referred to as 'Main graze file'.

2. **Subset data file(s)** to be produced by the user of GRAZPREP, having geographic outlines defined individually. These outlines can be both square (limited by longitudes and latitudes) or round (with center coordinates and a radius). Note that areas with square outlines are referred to as '**regions**', whereas areas with round outlines are called '**stations**'.

5. Setting up a new region / station



Click on '**Region/Station**' in the main menu and select 'Add region / station'. In the following window a region or station name and the shape of the region must be selected. When selecting '**rectangular**' only the longitude/latitude cross on the right is shown for entering the full degree limits in all directions. Use the minus sign for longitudes west of Greenwich. Finally a double click on the center field enters the median of the limiting latitudes as the center latitude. Any other preferred center must be entered manually. Note that any direct entry in the longitude/latitude cross assumes that a square region is created. At any false or impossible entry the field that has to be corrected turns red. The 'Save'-Button will not be activated until all entries make sense.

When selecting a **circular** shape only entries in the 'Input Center Coordinates'-boxes (lower left) are allowed as the longitude/latitude cross is filled in automatically. The change from eastern to western or from northern to southern hemisphere or vice versa works with a click on the hemisphere fields. No minus signs are allowed here. If minutes and seconds of arc are zero these fields may stay empty. Also the correct time zone is detected from the longitude but can be changed using the drop down box. Then additional items to be displayed of the map can be selected or deselected: '**Show Grid**' shows longitudes/latitudes in a 1-degree-interval, **'Ticks 10**' shows the time ticks along the graze path every full 10 minutes (otherwise every 20 minutes), '**Cities**' includes city entries (not very many available!) and '**Station**' shows the (round!) station outline if a circular area was selected. Neglect the 'Width of print' field!

Then save the entries. The region or station will be added to the existing set.

6. Opening a graze file

By opening '**Graze Files**' in the main menu select 'Open Graze Prediction File' and 'Open New Region File'. In the open dialog (filtering '*.GG0') the region data file or any other subset file can be found and selected in the correct subdirectory.

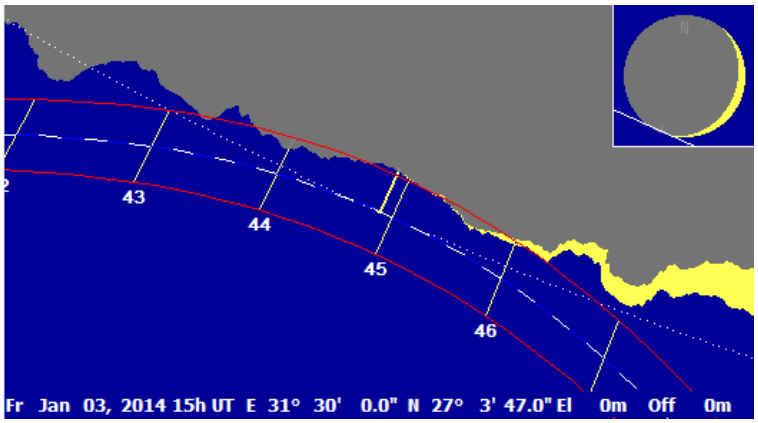
Any selected file prompts with the first event in the file at its westernmost graze path coordinate included in the data. In case the opened file covers events of the current year the event list is automatically set to the first occultation following the current date and time. Earlier events can be found by scrolling up.

On opening a file two tables appear:

1. The left one chronologically gives all the graze events in that file. The displayed event is always shown as a red row, usually on top of the table. Double click on any row to select the any other graze event.
2. The right table shows the full list of limit line data of the event selected in the left table with a spacing of 10 arc minutes of longitude starting with the westernmost coordinate.

Furthermore two figures appear:

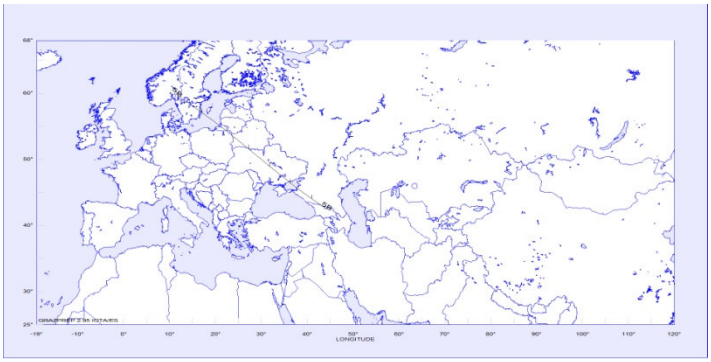
1. The left figure on the screen, besides a little inset showing the moon's illumination phase, shows the profile situation and the apparent stellar path of the presently selected graze event at the presently selected line coordinates. The stellar path is the curved white and blue dashed line, the color changing every 10 seconds of time. As a default the lunar limb profile is stretched by a factor of 6.



   Since the mean lunar limb is always shown spherical (white dots) the stellar path appears curved as long as the lunar profile is shown stretched. The red lines parallel to the stellar path give a range along the graze path at the observing site. This range is +/- 3000 m in the default setting (after selecting an event in the left table) in a direction perpendicular to the limit line on Earth. The color of the sky gives an approximate impression of the sky brightness according to the altitude of the sun. The top line resp. bottom line gives the date, the hour, and the geographical position.

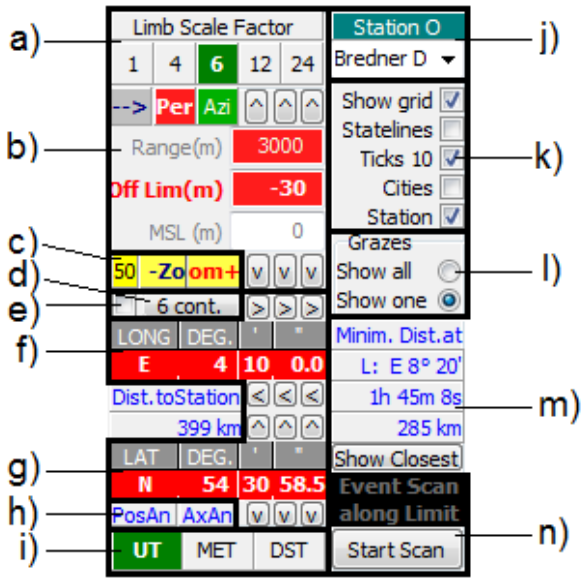
   The image of the lunar limb can be moved and centered in any desired direction by grabbing it with the left mouse button. The mouse wheel enables zooming in and out.

2. On the right there is a map displaying that part of the world map that is covered by the graze file data. In case a graze data file is opened covering a region not yet included in the region/station data this region/station will automatically be added to the existing list. The path of the presently selected graze will be shown on the map. The present line coordinate is marked by a red vertical bar. Watch this red bar move along the graze path on double clicking on different line coordinates in the right table.



7. Adjusting the graphic display

Between the two figures there is a tool box that allows a number of changes to the profile plot and map displays.



a) This field allows changes of the stretching of the lunar limb terrain heights by double clicking on the multiplier. The default setting is 6 times for grazing occultations of stars and 1 (no stretching) for grazing occultations of planets. The planets are shown with their true diameter, true shape and current illumination phase. Saturn is shown with its rings. The planets are hidden when stretching is applied to the profile.

b) With field b) it is possible to the set the red range lines and to virtually change to any desired distance observing position away from the predicted graze limit position for a certain distance in meters and perpendicular to the mean limb. These meter changes can be made by directly typing in the entry fields. Alternatively the three little arrow buttons above and below the entry fields can be used to change the meters by tens, hundreds, or thousands.

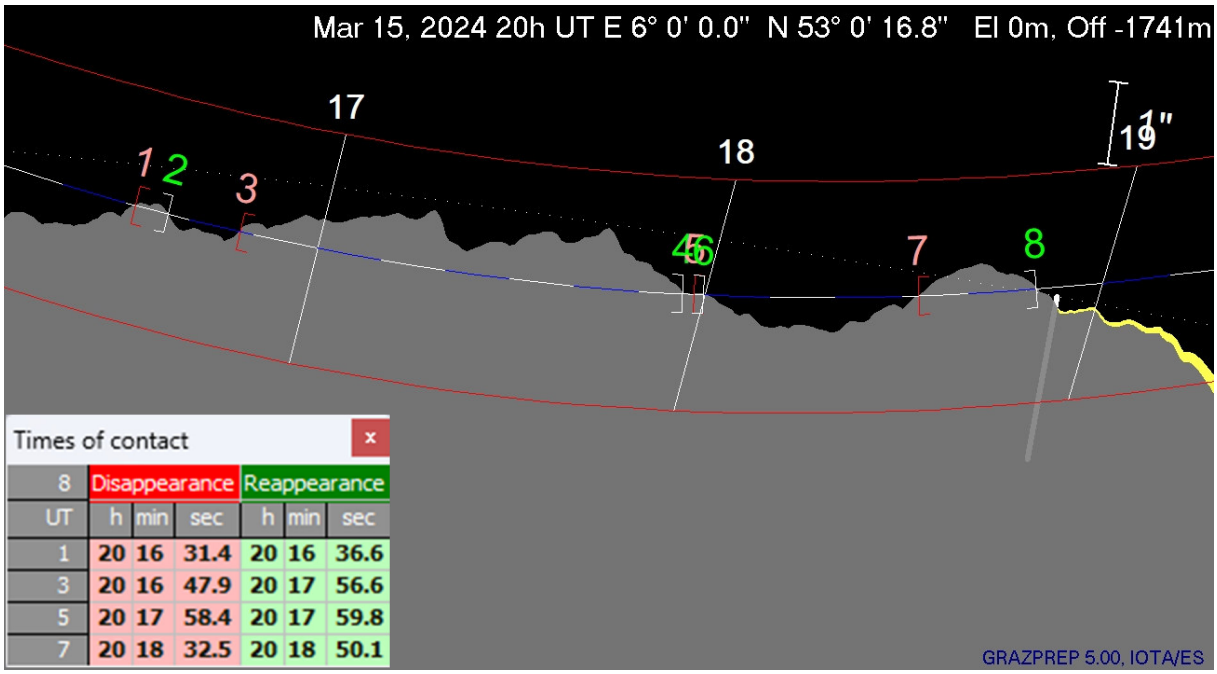
Per The red button labeled 'Per' indicates that any entry of meters in the 'Off Lim' field is applied in a perpendicular direction to the mean limb. It is also the default choice when a graze event is selected in the left table giving a red background in the entry field.
An entry in the Off Lim-field results in a change of the longitude and latitude values in the red rows below (f and g) showing the coordinates of the chosen graze path position. Positive Off Lim entries always increase the latitude, whereas negative offsets decrease the latitude. The selected row in the graze path table becomes yellow indicating that the displayed situation at the lunar limb does not match the predicted coordinate for the mean lunar limb. Accordingly also the profile situation changes: any large enough entry directly leads to a displacement of the apparent stellar path along the lunar limb. Double clicking on the yellow row sets everything back to the predicted coordinate.

Any direct change of the geographic coordinates (see under f and g) of course also changes the offset value which generally gives the perpendicular distance to the predicted limb.

Azi When the button labeled 'Azi' is activated only the meter offsets entered in the 'MSL' field have any effect resulting in a change of longitude and latitude in the direction towards the lunar limb. Thus the necessary displacement to correct for the elevation dependent changing line of sight is indicated to stay on or close to the limit line. Note that theses entries have become obsolete due to the possibility to plot the lunar profile on the Earth's surface as described in chapter 14.

c) Use the zoom buttons to zoom in fixed increments to change the lunar limb image. More comfortably the mouse wheel enables zooming in and out. The picture can be moved to any desired direction by grabbing it with the left mouse button.

d) Whenever the star is occulted by the lunar limb terrain the number of dis- and reappearances (contacts) is given in this field. Clicking on this button opens (or closes) a small window showing all calculated contact times.
Simultaneously the contact positions are marked in the profile plot referring to the numbering in the time list.



Times of contact

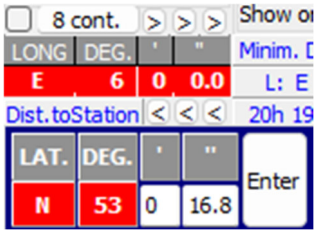
8	Disappearance			Reappearance		
UT	h	min	sec	h	min	sec
1	20	16	31.4	20	16	36.6
3	20	16	47.9	20	17	56.6
5	20	17	58.4	20	17	59.8
7	20	18	32.5	20	18	50.1

Double clicking on each of the displayed contact times opens the planetarium to show the 'real' limb situation and explore more details of the graze event (see under chapter 22.) Double clicking on the field showing the time zone lets you save the contact time table as a PDF-file.

e) When this field is checked the terminator is shown with an artificially reduced height. This allows a better judging of the true lunar surface at the cusps being sometimes overlayed by stretched terminator details.

f) and

g) It is also possible to study different apparent stellar paths by directly changing the longitude and latitude in 2 different ways:



The arrow buttons above and below the entry fields can be used to change minutes, seconds and 1/10 seconds of arc step by step in any desired direction.
Alternatively, by clicking on the red coordinate lines an edit field opens to type in the minutes and seconds of arc directly. When the coordinates are changed this way the resulting displacement from the predicted limit will be given in the Off Lim-field above in meters. For larger displacements in longitude first select a different longitude in the right table.

h) Select and deselect the display of a position angle scale or axis angle scale in the lunar limb plot.

i) The 3 time zone buttons allow to give all time related values according to different time zones. The left button is always 'UT' and is the default setting. Double clicking the button next to it gives the times of the home time zone entered in the 'Personal Settings'-window (see under 3) and can be adjusted anytime. The button 'DST' displays Daylight Saving Time, which is always the selected home time zone +1 hour.

j) The Region/Station dropdown box lists all regions and stations that were entered by the user or automatically added when opening graze prediction files of another region. The presently selected region or station is given in the field. The user defined regions and stations can always be changed or deleted by using the '**Region/Station**' menu or the popup menu received on right mouse click on the active dropdown box entry.

   The first two entries though are always present and cannot be changed or deleted:

   - On selecting 'Event' an area of the map will be displayed that covers the complete outline of the selected graze path.
   - 'World' always shows the world map centering the Greenwich meridian.

k) Some map features can be set: Add or take away longitude/latitude lines, stateliness, province borders and lakes, tick marks, cities (only for a few countries) and the present station outline. These settings only influence the present display and do not affect the region/station settings themselves.

l) To see the selected graze path clearly on the map usually the choice of **one** shown graze is active. To make all grazes in the opened graze file visible simultaneously the upper button must be clicked. This only works when there are no more than 500 events in one graze file. See under 8. for breaking up large graze files to smaller ones.

m) When a station file (round with a center coordinate!) was created every event included within the station radius has one coordinate with the least distance to the station center. Click on the 'Show closest'-button to move to that specific path coordinate. The entries above this button give information about the longitude, time and distance of the graze's closest approach to the station center. The entries on the left (between f) and g) give the distance to the station's center from the presently selected path coordinate.

n) The 'Start Scan'-button allows moving along the graze path until it is clicked another time or the end of the graze path is reached. The profile plot changes simultaneously according to the local circumstances. In some cases this helps to find the best observing site (darkest sky background, greatest distance from the bright limb etc.). Note that this scan does not show changing situations at just ONE observing site but the changing profile and illumination circumstances for all increasing longitudes along the predicted path. This button is not active during 'Global View' (see chapter 17.)

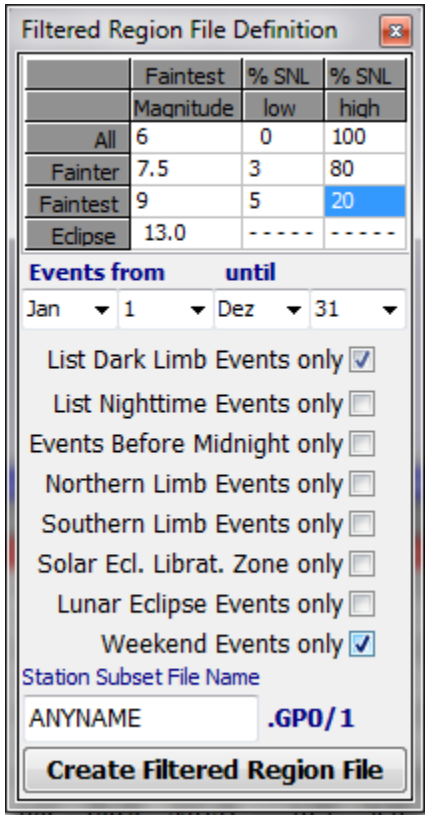
   A double click on the profile or on the map display opens another window to show the picture larger, also making it possible to save it as a BMP- or a JPG-file.

8. Creating subset files - Selecting individual graze events

Until so far only the unfiltered region graze data supplied by IOTA/ES with probably several hundred or more graze events was opened by the software. The data set in the region/station drop down box contains the Event-region (automatically outlined according to the limit line of each event), the World-region and the region belonging to the presently open data set.
Through the individual definition of additional regions or stations it is possible to create subsets of the large data set according to the needs of the user. There are three ways to do this:

a. Create a **rectangular region** smaller than the presently opened one as described under 5 or open it from the drop down box if it exists already (don't be surprised if there is no graze path within the new region and the graze path listing and the profile plot stay empty). Then under '**Graze Files**' click on '**Create Unfiltered Region Subset File**'. The program quickly selects all grazes inside the smaller region without any further selection criteria and asks for a file name to save this subset data (always two files: *.GG0 and *.GG1!). The new files will be opened directly.

b. After having created or reselected a **rectangular region**, click '**Create Filtered Region File**' under '**Graze Files**'.
A window opens that allows a variety of filtering entries:
   - limiting minimum magnitudes for different illumination phases of the moon
   - date boundaries
   - selection of events according to their type and times.



After entering a new file name a new data set will be created with all the events in the rectangular region meeting the conditions set before. The new file will be opened directly.

If no distinction of magnitude limits is to be applied to the subset files (common magnitude limit over all events) the 'Fainter' and/or 'Faintest' rows can be left empty. Otherwise it is necessary that the magnitude entries increase in each row, the low percentages of the sunlit part of the moon also increase downwards or stay equal, and the high percentages decrease downwards (or may stay equal, if the low percentages increase).

At any false or impossible entry the field that has to be corrected turns red. The 'Create'-Button will not be activated until all entries make sense. If only lunar eclipse events want to be selected the limiting magnitudes for all other events are set to '-5.0' and the 'Eclipse'-magnitude to the desired limit with no other entries.

c. If the creation of a **circular station** is intended this either has to be set up first (see chapter 5) regarding to be <u>within</u> the boundaries of the presently selected rectangular region or opened from the drop down box if it exists already. Then under '**Graze Files**' click on '**Create Station Subset File**'. If that option is not active it must be checked whether really a circular station was opened (under '**Region/Station**' and '**View/modify region/station**').

Then the same filtering options as under b. are offered. After entering a new file name a new data set will be created with all the events in the circular station meeting the conditions set before. The new file will be opened directly.

Note that only this (circular!) **station file** type allows information about the distance of each selected graze coordinate and the use of the 'Show closest'-button (see under7.m). Any further output of prediction material also only works with station file types (see under 12).

Actually it is possible to create a station subset file also from another pre filtered station subset. In that case a warning will appear if new filters are applied for events that are not included in the parent file. To avoid this it is always recommended to produce subset files out of unfiltered region files! That way any number of subset files can be created, each with different filter settings.

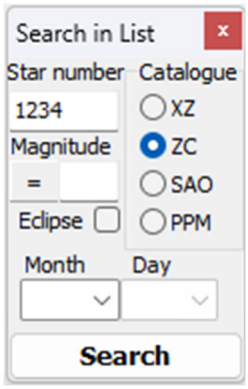
9. Displaying data of grazed star

When the mouse arrow is moved over the headline column named 'Occulted body' (stellar occultations only) a data field appears showing all details of the occulted star like all catalogue numbers, its coordinates and magnitudes as well as double and variable star data.

Data of Grazed Star

Bayer/Flamsteed-Name	10 Virginis															SAO-Number:	119245	
XZ-Number:	18116			ZC-Number:	1749											PPM-Number:	158569	
Spect.	K3	Tycho-Number:														HIP-Number:	59285	
UCAC 2	31171245			Gaia ID												3699664732622451840		
JD 2018.0182	RA	12	h	10	m	36.3537	s	DE	+	1	°	47	'	50.069	"	Ded.Error		
JD 2000.0000	RA	12	h	9	m	41.3103	s	DE	+	1	°	53	'	52.395	"	0.000"		
Visual Mag.:	5.95			Photogr.Mag.:	7.07									Posit.Source:		Gaia	Variable	
No double star														Magn.Source:		Hipparcos	No	

10. Searching events



Under '**Graze Files**' or in the popup menu that opens on right mouse click in the table of events there is the option '**Search in List**'. The list of events is scanned according to the options entered (star, magnitude, eclipse grazes only and/or date). Double clicking the field left to the magnitude entry field changes its function between '>=' (magnitudes equal or brighter than entry), '<' (magnitudes fainter than entry), and '=' (magnitude equals entry). Pressing the Search-button results in another table with the matching events. Click on one of these events to display it. A message will appear when no event was found.

11. Modifying the event list

It is often useful to delete unfavorable events like those being entirely over water or having unfavorable circumstances. The event to be deleted must first be selected by a double click on the list of events. Then on right mouse button '**Modify Event List**' in the popup menu must be clicked, followed by '**Delete Event**'. The event entry is grayed then and the profile plot as well as the limit line in the map disappears. The remaining events can be saved in a new subset file under '**Graze Files**' and '**Save Subset File**', followed by an opening of this new file.

As long as the file with deleted events is not saved it is possible to undelete any deleted event using the same procedure described above.

Several more options are offered under '**Modify Event List**'. The complete event list can be scanned starting with a selected event. Then for each event it can be decided to fully or partly delete it or not. Also the end labels can be set and unset. The new selection with all selected details can be saved in a new file. Thus a personal observing file with the most interesting events can be created.

12. Prediction Output

This option in the main menu is only available when a (circular!) station file is opened. It gives the opportunity to produce output data very similar to the former GRAZEREG output to be saved or printed. In this data all stellar information is included as well.

- When only a graze overview is needed choose the option **'List/Print Graze Event Overview'**.
- For a detailed output of single (or all) events choose **'List / Print Graze Details'**. Before a preview of the data is shown it can be indicated, whether the output is supposed to include the overview data, an observer scan and/or a profile plot and whether just one or all events in the files are to be included. (Note that in the latter case a sometimes huge printing job is started; printing to a PDF-file is therefore recommended.)
  When the observer scan is to be included an open dialog asks for the observer station file (*.OBS) that suits the outlines of the selected station. If no observer station file is selected or present the output will be done without the observer scan.
  The profile plot always shows the situation at the path coordinates closest to the station and always with the red range lines at +/- 3000 m in the direction perpendicular to the graze path at that position. The profile plot will only be printed but never appear in the preview.
  It is possible that in the plot (as well as in the profile displayed on the screen) the apparent stellar path not always touches precisely the mean lunar limb at the Axis Angle of closest contact. This is due to the algorithm used to calculate the limit line. The profile plot as it is displayed is recalculated 'on the spot' and therefore gives the true situation, so the observing position can be adjusted, if necessary.
  Before the final printing it is possible to choose a printer from the list of installed printers with the standard printer as default.
- 'Print Limb Situation' initiates a direct print of the presently displayed lunar limb situation to the printer defined as standard.

There is one output column not familiar to all observers of grazing occultations. It is titled 'ELx OFF LIMIT' and gives a coefficient similar to TANZ. While TANZ is the correction multiplier for the observing site elevation towards the lunar azimuth, ELxOFF LIMIT works the same way but perpendicular to the graze path heading. Thus multiplying the observing site elevation with the ELxOFF LIMIT-coefficient directly gives the perpendicular offset to the graze's limit line, so with it it's easier to decide whether that distance has to be corrected or not.

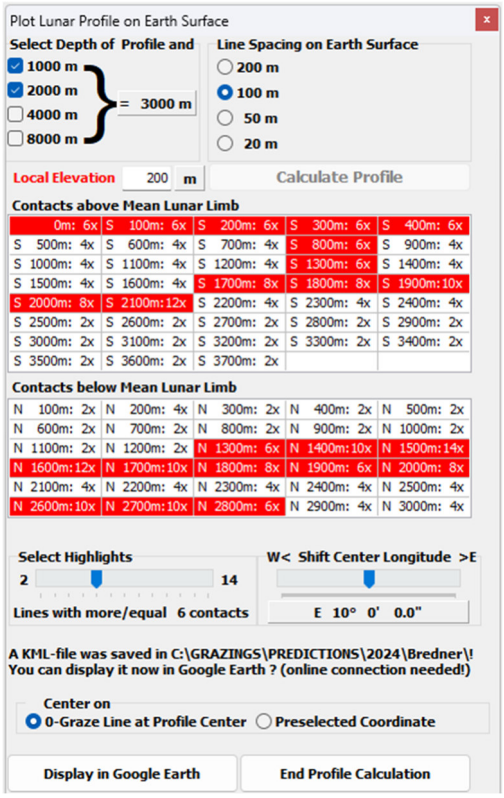
Note that theses entries have become obsolete due to the new possibility to plot the lunar profile on the Earth's surface as described in the following chapter 14 on the following page.

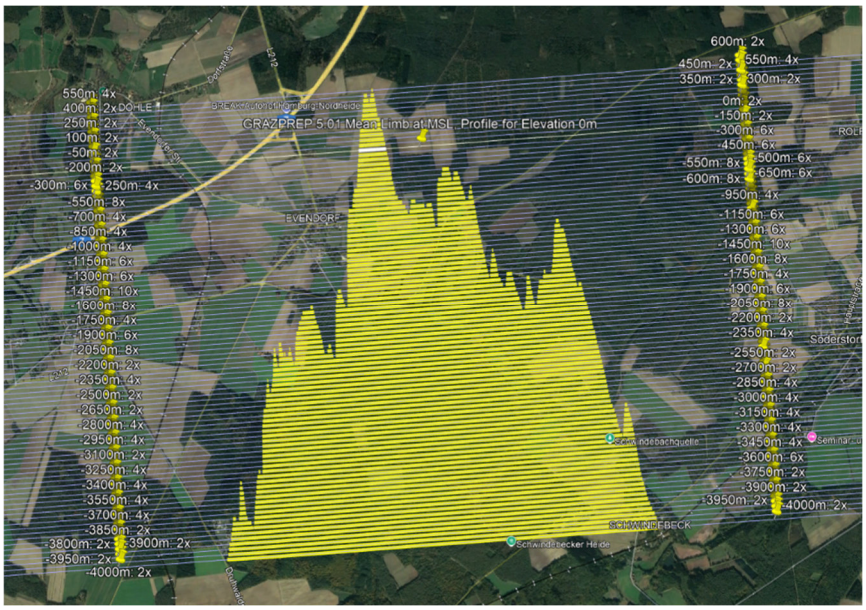
13. Creating user defined observer station files

If there is a need to supply groups of observers in different regions/stations in the world (formerly known as 'Super Standard Stations') with graze prediction output including the observer scan ASCII-observer files in the presently adopted column format can be changed to the binary format processed by GRAZPREP using the option '**Convert ASCII-Stationfile**' under '**Graze Files**'. The ASCII input file should have the suffix *.TXT. It has to be made sure that the column format is correct and each line is terminated by a Carriage Return command (chr(13)).

14. Plotting the Lunar Terrain on the Earth's Surface

After a preselection of a probable longitude to observe a grazing occultation the lunar profile as it projects on the Earth's surface in that region can be calculated. Under '**Google Earth**' in the main menu choose '**Plot Lunar Profile on Earth'.** A window opens to set the desired depth of the profile (below the mean lunar limb), the desired line spacing (resolution) of the projected profile and the mean elevation of the selected region. On 'Calculate Profile' first all contacts above the mean lunar limb, if there are any, and then the contacts down to the selected lunar depth are calculated. A right mouse click on each grid entry shows the times and axis angles of the calculated contacts. The left trackbar selects the number of lines to be displayed in Google Earth: all calculated lines or just those with a desired minimum number of contact events. With a left mouse click single grid entries can be selected and deselected.
The right trackbar allows to move the projected profile for +/- 5 minutes of arc in longitude along the graze path.





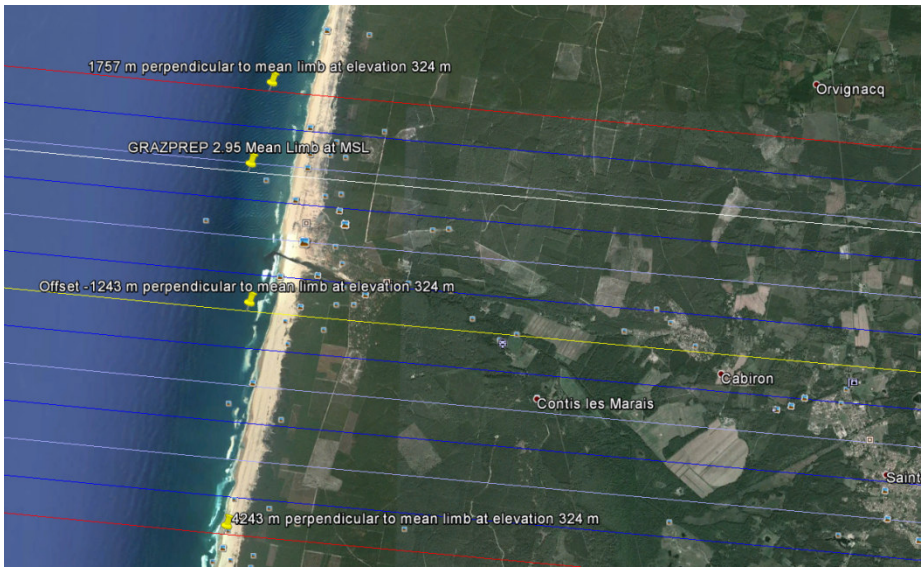
The plot shows the true heights of the lunar limb as they project on the Earth's surface at a mean elevation of the selected area. The predicted number of contacts at each offset line is given at the edges. When zooming in the terrain underneath the lines becomes visible making a selection of the best observing station easy and any more calculation obsolete.

15. Plotting Limit Lines in Google Earth

For this option, as well as for the previous chapter, Google Earth must be installed on the PC and there must be an online internet connection. Under '**Google Earth**' in the main menu choose '**Plot Graze Limit Line with Distance Lines'** and select the spacing of distance lines (200, 500, or 1000m or none) which show parallel to the limit line at the chosen location. A KML-file of that line data is produced (being saved automatically) which can be shown in Google Earth directly or at any later time (in the latter case by double clicking the KML-file from the Windows Explorer or similar).

For any selected event and any chosen preferred offset from the mean limit resp. any elevation the lines displayed in Google Earth have the following color:

- The limit line of the mean lunar limb at mean sea level is white.
- The limit line crossing the preferred favorable location is yellow. All other lines run symmetrically in distance to this yellow line.
- The distance lines change in color from light to dark blue.
- The presently chosen range limits are shown red.



This option has become more or less obsolete due to the possibility to plot the lunar profile on the Earth's surface as described in the previous chapter 14.

16. Plotting crossing limit lines

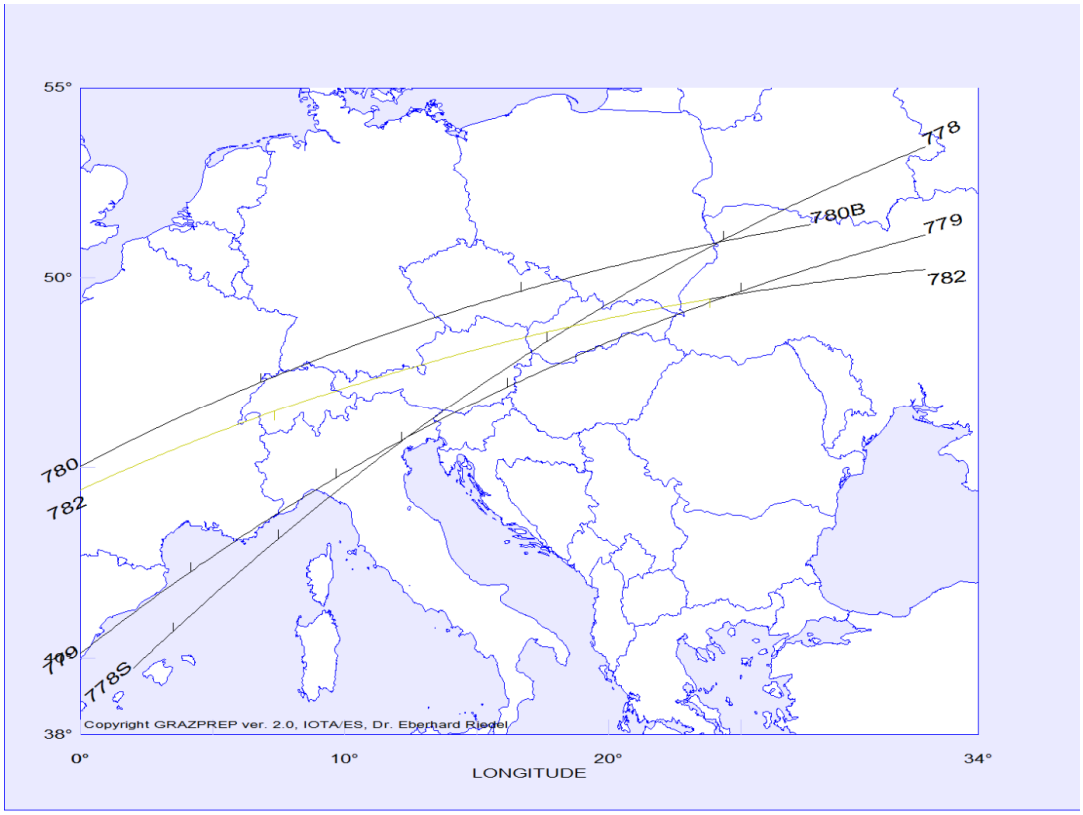
On request to the author data of crossing limit lines for a specified region and time can be provided. This data is kept in a *.GG2-file having the same prefix as the GG0/GG1-main data files. Two events happening within 6 hours at one geographical location are regarded as crossing grazing occultations. Any further crossing events for the same graze in some other geographical location are possible and are also shown by the program.

Any event with one or more crossing events will be shown in the event list as a yellow marked line

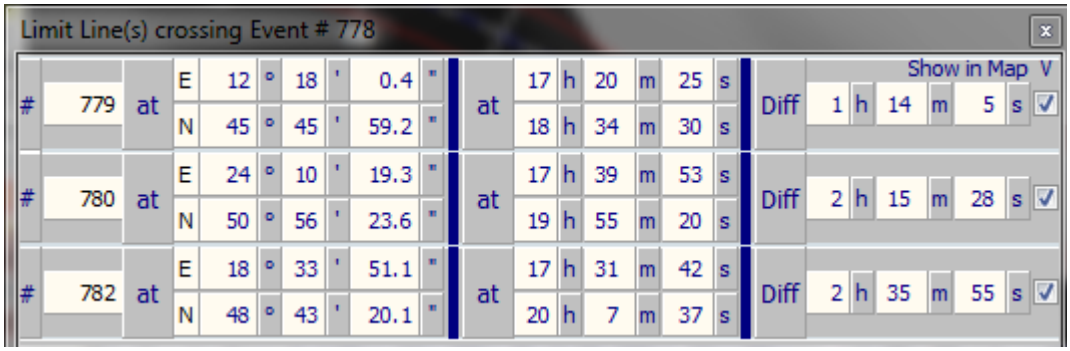
771	Tu	Dec	18	S	63 kappa Aqr (Situla)	5.0	ZC 3320	146210	K2	35+	156.7	34.5	5.2	-11.7	-39.8		
772	Tu	Dec	18	S		9.1	X 30865	146218	K0	35+	156.6	50.9	10.1	-12.1	-53.5		A
773	Tu	Dec	18	S		8.0	X 30870	146222	K0	35+	156.5	42.6	6.9	-27.8	-62.7		A
774	Tu	Dec	18	S	207 B. Aqr	6.4	ZC 3326	146239	F6	35+	156.5	35.9	6.8	-32.7	-60.1		B
775	Tu	Dec	18	S		7.2	X 30908	146252	A0	35+	156.5	25.3	7.0	-42.2	-58.5		B
776	We	Dec	19	S		8.8	X 53259	181599	G	44+	156.4	18.9	17.7	-4.9	-8.1	S	
777	We	Dec	19	S	22 B. Psc	6.3	ZC 3444	128156	K2	45+	156.3	53.1	32.5	-2.3	-34.6	S	
778	**We**	**Dec**	**19**	**S**		**9.1**	**X 31545**	**128158**	**G5**	**45+**	**156.4**	**50.2**	**28.8**	**-5.3**	**-36.3**	**S**	
779	**We**	**Dec**	**19**	**S**		**8.9**	**X 31564**	**128175**	**G0**	**45+**	**156.3**	**55.4**	**22.6**	**-5.1**	**-46.7**	**S**	
780	**We**	**Dec**	**19**	**S**		**9.2**	**X 31592**	**128193**	**K0**	**45+**	**156.4**	**55.2**	**16.6**	**-8.9**	**-52.6**		**B**
781	We	Dec	19	S		8.8	X 31615	128204	K0	46+	156.3	22.9	18.6	-61.8	-66.1		B
782	**We**	**Dec**	**19**	**N**	**8 kappa Psc**	**5.0**	**ZC 3453**	**128186**	**A0**	**45+**	**336.4**	**39.7**	**12.4**	**-33.5**	**-57.2**	**B**	
783	We	Dec	19	S		8.8	X 31628	128207	K0	46+	156.4	49.4	17.8	-29.8	-60.6		B
784	We	Dec	19	N	9 Psc	6.3	ZC 3455	128188	G7	45+	336.4	17.2	10.6	-43.9	-47.8	B	

(or as the currently selected event marked red with yellow letters). To see the crossing event(s) first select the event (double click) and then open the Popup menu with the right mouse button and click on '**Show Crossing Event'**.

All crossing limit lines are shown in the map display.



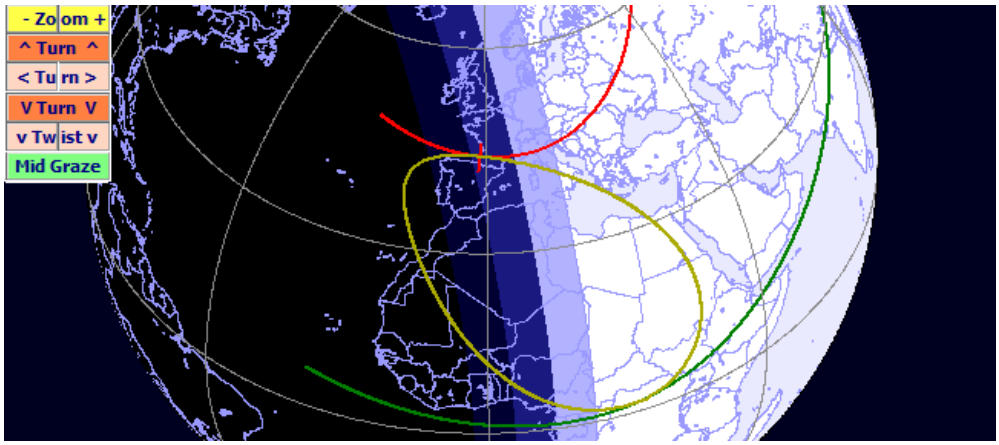
Also another window opens (see below) giving all details of the crossing event(s). The check buttons below on the right allow to show or to hide the corresponding limit line in the map above.



At this moment it is possible to directly switch back and forth between the different events by double clicking them on the graze event table. Crossing events are marked pink. By then also changing the offset to the limit lines to different test values it is possible to find the best single location from where the most dis- and reappearances of the stars can be expected on both events. Move the window above to uncover the profile plot. On switching between the different events the offset values do not change.

17. Plotting the lunar shadow with 'Global View'

In addition to the geographic map in Mercator projection a global view in central projection can be displayed by clicking on 'Set Global View' in the main menu. The perspective first centers on the location and time of the currently selected event. Not only this current event limit line is shown but, if occurring, also the corresponding limit line, both to their full geometric extent regardless of any visibility restrictions. A northern limit line is always red, a southern one always green. The current observing position is indicated by a tick mark.



The Earth is shown according to its illumination at the selected moment. The twilight zones (the sun is 6, 12, or 18 degrees below the horizon) are included. The changing lunar shadow and the Earth's rotation can be observed by double clicking on different line coordinates in the right table.

A small control panel in the upper left of the picture allows the Earth to be zoomed in and out (also with the mouse wheel) and turned and twisted in all directions. An enlarged picture of the Earth can be moved around by grabbing it with the left mouse button. When 'Mid Graze' is pressed the line of sight on the Earth always centers on the central graze coordinates.

Note that as long as the Global view is displayed some adjustment functions left of the picture are inoperative. To retrieve these and get back to the Mercator projection press the same button in the main menu now reading 'Set Map View'.

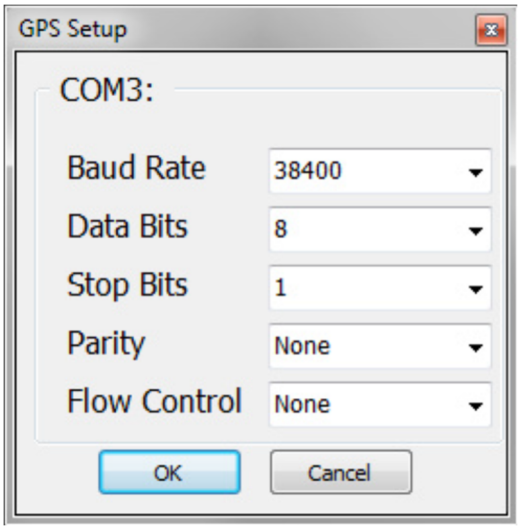
A double click on the map display again opens another window to show the picture larger, also making it possible to save it as a BMP- or a JPG-file.

18. GPS 'navigation' through the lunar profile

In order to use this feature a USB-GPS dongle or similar GPS-device must be attached to the PC and must have been installed properly. GRAZPREP expects the common NMEA 0183 format which most GPS devices produce or can be set to.

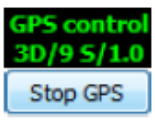
This feature assumes that a notebook or similar is running GRAZPREP when the observing site is being approached. The purpose of this tool is to let the GPS-device do a constant input of the geographic position to GRAZPREP including the elevation above the WGS-ellipsoid and its correction for the local geoid height. Thus it is possible to move around in the planned observing area and directly see the expected apparent stellar path at the lunar limb from each spot, not having to change the coordinates manually.

This tool may be useful in all cases where local maps or the Google Earth coverage are not precise enough to choose a definite observing site in advance. For those observers who want to chase for very close contacts of the star to specific lunar features this tool will save much calculation time to find the best site in the country.



Starting the GPS-function works in three steps:

1. Select the graze event to be observed from the list of events in the left table and also the longitude closest to the area where the observation is planned in the right table.
2. Choose 'Connect to USB GPS-device' under 'GPS'. The GPS-setup window (below) appears allowing to set all necessary serial parameters (refer to the information along with the GPS-device). GRAZPREP automatically finds the COM-Port of the receiver. Confirm the parameters with 'OK'. A message appears if no device was found.
3. If a GPS-receiver was detected the 'Start Scan'- button (see under 6. l) changes its function to 'Start GPS'. This button must be pressed to start the readout from the device and let GPS take over the control. After the GPS-fix was found the panel above the button gives information about the position quality and the number of satellites received. In the example shown here there is a 3- dimensional reception with 9 satellites received and a horizontal delution value of 1.0 (the smaller the better).



Any time after the 'Start GPS'-button was pressed the data coming in from the receiver can be displayed when moving the mouse into the black information panel above the button. In a window then appearing to the right the contents of the stream can be checked in case it takes longer to find a fix. This window also gives information when a wrong setting of the serial parameters leads to no incoming data.

With the GPS-stream running the measured geographic position including the corrected geoid height are constantly displayed in the adjustment box (see under 7.) and the profile display shows the apparent stellar path along the lunar limb from each location. This way it is possible to choose the most promising observing site even with little time while driving around.

While GPS is running a large panel is displayed constantly informing about the present distance perpendicular to the limit line, the heading to the limit line and the remaining time to mid event in hours and minutes.

Make sure to stop the data stream ('Stop GPS'-button) or disconnect the GPS-device (again under '**GPS**') before terminating GRAZPREP.

19. Total and Grazing Occultation Reports (IOTA 2008 Report Format)

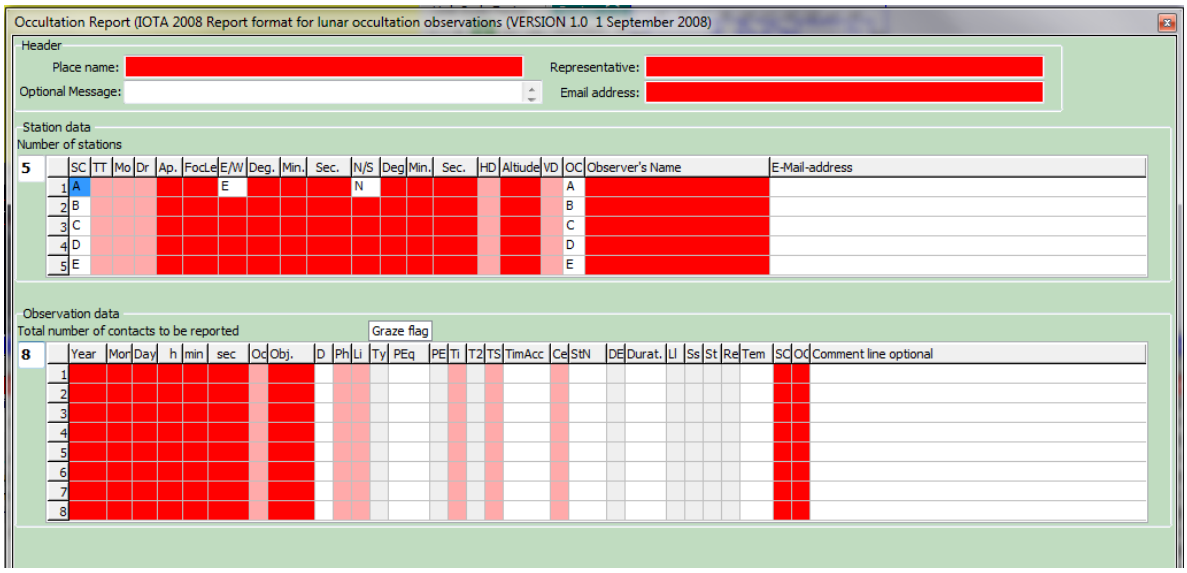
Successful observations of occultations must be reported to be evaluated and thus serve a scientific purpose. For this the IOTA has developed a specific text file format that can be read out by the persons collecting and processing the data. GRAZPREP assists in creating such report files for further use in the reduction process. As the amount of needed information is big and the number of details is confusing an entry mask with many explaining hints is offered that eventually leads to a complete and valid report file.

The entry mask (see picture on next page) can be reached from the Main Menu under '**Occultation Reports**'. Clicking on '**Create Occultation Report**' and '**Create New Report**' opens a window with three entry large fields:

- Header (general information about the person submitting the report)
- Station data (the report can include observations made by one or several observers and from different stations; one observer can run two or even more stations)
- Observation data (there is space for any number of single contact observations for each included observer/telescope, every line giving one contact).

The required number of entry rows can be selected in the upper left corner of each entry box. The required input of each column is shown by a hint flashing when the cursor enters that column. All entry fields shown red definitely require an input and turn white when a correct entry is made. All dark red fields require manual typing in of values or text whereas all light red fields only allow an entry taken from a selection window that opens when clicking on the field. All white fields do not necessarily require an entry. A double click on an empty field in a column with an existing entry further above copies its contents in all in between rows. This speeds up the entering of repeated values.

Finally a completed report can be recognized when all entry fields are white.

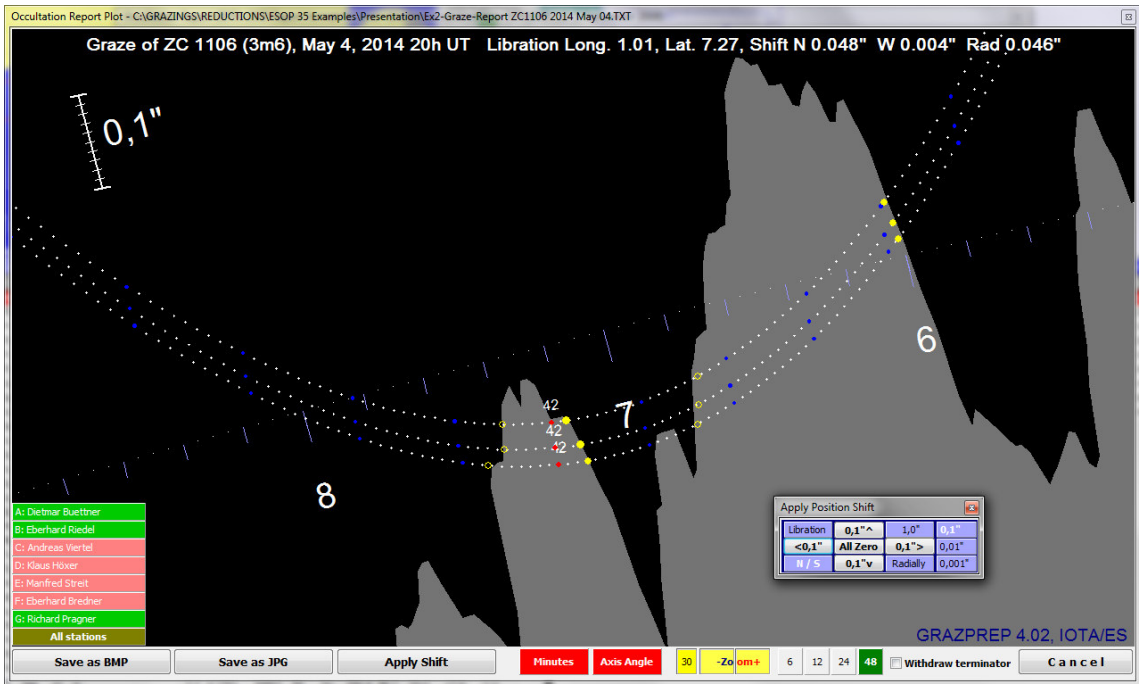


A report can be saved at any time of the entry, also before being complete. An incomplete file is always saved with the prefix 'INC-' to the chosen file name. Such a file is of course not valid for reduction purposes. Any report file can be reopened using '**Open Occultation Report**' under '**Graze Reports**' through an open dialog.

Clicking on '**Create Occultation Report**' and '**Use presently selected event**' automatically fills the first line of the station data with the station location data and the first 2 lines of the observation data with the date of the event and the star number. To use this simplification GRAZPREP has to be set to the event to be reported and to the location of one observer.

20. Graphic reductions of occultation timings

When an occultation report was opened (see previous chapter) clicking on the '**Show timings on lunar limb'**-button under the report entry mask opens a window showing the reported event graphically with all the entered occultation times. For each station the predicted stellar path from that location is given as a curved dotted white line with a spacing of 1 second of time between each dot. Blue dots along the line give full 10 seconds and red dots show full minutes. The actually observed times are shown as yellow circles (empty for dis-, and solid for reappearances, flashes and blinks accordingly with a cross within the dot.) Larger circles depict a Start (green), End (red) or Other (yellow) phenomenon. O-C-values can thus be easily estimated graphically. The plot can also be modified concerning the stretching of the lunar heights as well as moved in all directions and zoomed in and out using the tools below the plot or the mouse. Overlapping numbers can be avoided by selecting and deselecting the minutes and/or axis angle display (see buttons below the plot).



The participating observers are shown on the lower left. To better distinguish between different observations for stations shown closely together it is possible to select and deselect stations by clicking on the station button.

By hitting the ‘Apply Shift’-button another window opens that allows changes of the position of the apparent stellar paths relative to the lunar surface. The ‘Radial’ or the ‘N/S’-buttons must be active for that. Adjustments due to a wrong stellar position can be made in three different increments either in north/south and east/west direction or applied radially with respect to the center of the moon. The applied shifts are given in the headline/bottom line of the plot for all directions. Note that the radial shifts have a larger extent than the north/south/east/west-shifts due to the stretching of the profile heights. The scale shown in the plot giving 1” or fractions of it refers ONLY the radial extent of the lunar plot. Also note that the seconds of time represent a lunar motion of some 0,5” each second and thus a smaller scale in north/south/east/west-direction.

When using the ‘Libration’-button on the Shift window it is possible to change the libration in longitude and latitude. This enables a check of the neighboring profile features.

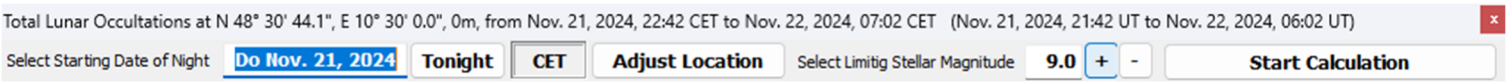
21. Calculation of Total Occultations by the Moon

Total occultations of stars by the moon can be calculated for any desired location and time within the years 2010 to 2030. This option is partly related, but practically fully independent of the data files for grazing occultations which are not needed for these calculations.

On choosing ‘Total Occultations’ in the main menu it is possible to preselect

- the preset home location (see chapter 3) to calculate the local occultations for the current night (taking into account the computer's system time information with or without Daylight Saving Time) or
- the location and time of the currently selected graze event to find out about all total occultations alongside a planned grazing occultation observation that night.

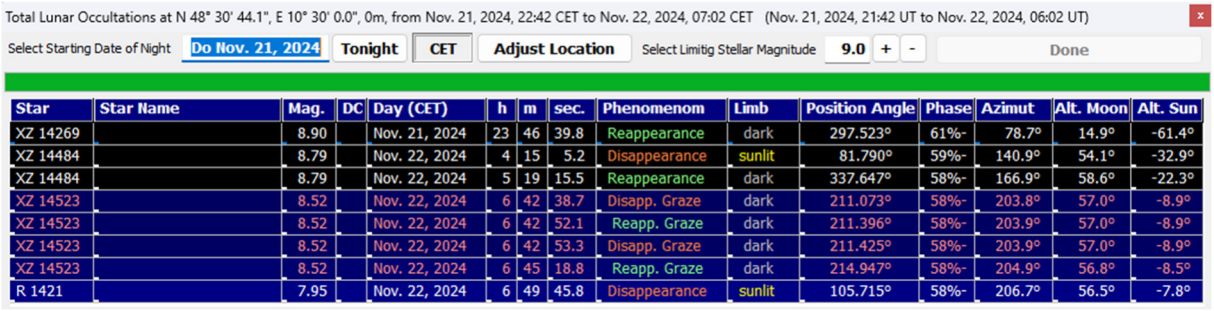
On selecting one of the options a window opens (see below) already stating in its header the time span of the selected night in which the occultations will be calculated. The considered time limits require a lunar altitude of at least 5° above and a solar altitude of at most 6° below the horizon as well as any star to the chosen magnitude limit that is in the field of the lunar motion.



In this window it is still allowed to change both the date and the location, any adjustment resulting in a quick recalculation of the considered time span. To adjust the time click into the time display, then e.g. using the right and left arrow keys to change the days forward and backward and the up and down arrow keys to change the months forward or backward. For larger time adjustments double click the time display to open the calendar function and pick the date from there.

To change the location coordinates by pressing the 'Adjust Location'-button a window similar to the home address window opens where all changes can be made. Press 'Enter' to save the coordinates or 'Cancel' to discard the changes. To adjust the limiting stellar magnitude use the small +/- - buttons next to the magnitude display to increase or decrease the magnitude by 0,5 mag.

After pressing 'Start Calculation' allow some time for the complete run or interrupt the calculation with the same button. A list like the following will appear. The background color of each row gives a



Star	Star Name	Mag.	DC	Day (CET)	h	m	sec.	Phenomenom	Limb	Position Angle	Phase	Azimut	Alt. Moon	Alt. Sun
XZ 14269		8.90		Nov. 21, 2024	23	46	39.8	Reappearance	dark	297.523°	61%-	78.7°	14.9°	-61.4°
XZ 14484		8.79		Nov. 22, 2024	4	15	5.2	Disappearance	sunlit	81.790°	59%-	140.9°	54.1°	-32.9°
XZ 14484		8.79		Nov. 22, 2024	5	19	15.5	Reappearance	dark	337.647°	58%-	166.9°	58.6°	-22.3°
XZ 14523		8.52		Nov. 22, 2024	6	42	38.7	Disapp. Graze	dark	211.073°	58%-	203.8°	57.0°	-8.9°
XZ 14523		8.52		Nov. 22, 2024	6	42	52.1	Reapp. Graze	dark	211.396°	58%-	203.9°	57.0°	-8.9°
XZ 14523		8.52		Nov. 22, 2024	6	42	53.3	Disapp. Graze	dark	211.425°	58%-	203.9°	57.0°	-8.9°
XZ 14523		8.52		Nov. 22, 2024	6	45	18.8	Reapp. Graze	dark	214.947°	58%-	204.9°	56.8°	-8.5°
R 1421		7.95		Nov. 22, 2024	6	49	45.8	Disappearance	sunlit	105.715°	58%-	206.7°	56.5°	-7.8°

hint concerning the sky brightness during dusk and dawn.

If a star disappears and reappears more than once or within less than 5 minutes a graze situation will be stated and highlighted with red letters and numbers. When stars are approached by the lunar limb to less than 10 seconds of arc and not occulted these events are added at the bottom of the list stating 'Graze Nearby'.

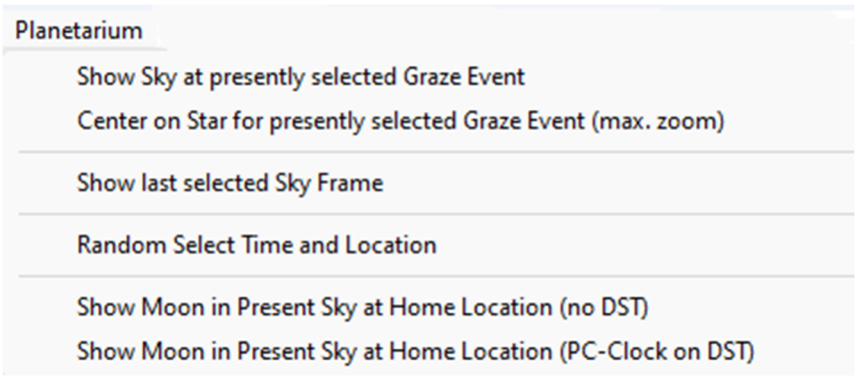
Double clicking on each row opens the planetarium to show the situation at the lunar limb and for possible further investigations (see next chapter 22.). The number of displayed stars will be automatically adjusted to the above chosen magnitude limit.

A right click finally opens a printer dialog to print out the complete list of events.

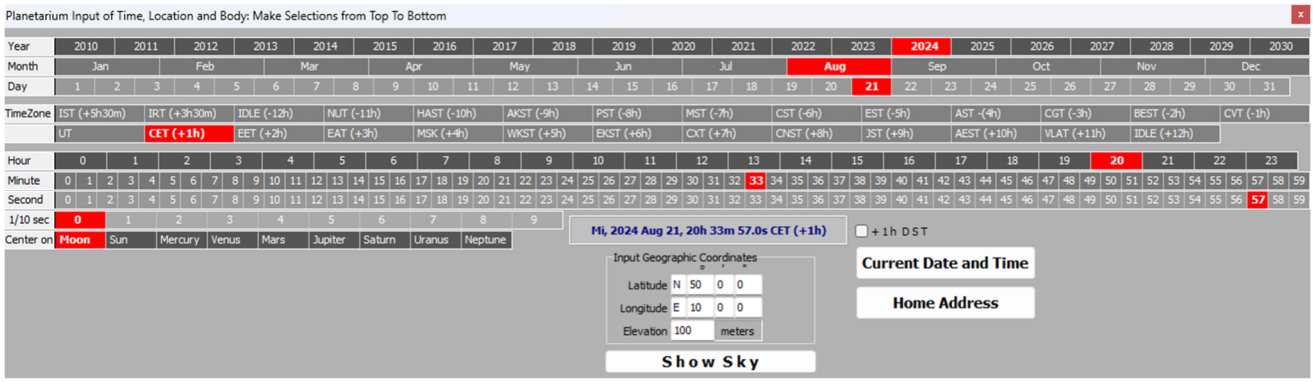
22. Planetarium

The Planetarium function is as well fully independent of the data files for grazing occultations and represents a program within a program, but it closely relates to that occultation data making it possible to thoroughly study specific graphic aspects of different kinds of occultations at a very high resolution of the lunar limb.

If not opened by clicking on total- and grazing occultation contact times (refer to chapters 7 and 21) the planetarium can be reached via the main menu in the following ways:



a. The sky is shown with the moon and the stars around, centering on the presently grazed star.
b. The sky is centered on the presently grazed star at highest zoom level.
c. When the planetarium is used the last display of the sky is saved on closing the planetarium window. With this option it is possible to retrieve this last view for continuous work.
d. With this option any location, time and target body can be selected for display. The following mask will open:

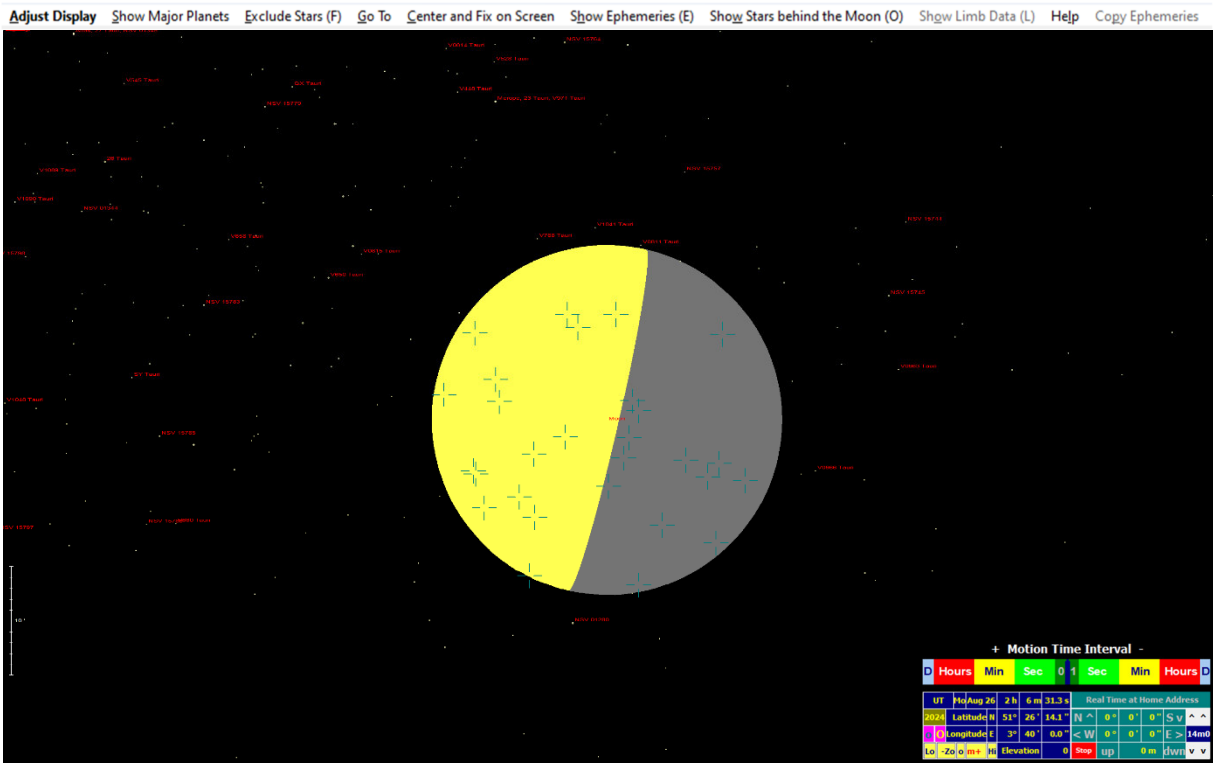


Here it is possible to select the desired year, month, day, time zone, hour, minute, second and 1/10 of a second as well as the body to be centered by simply clicking on the grid positions from top to bottom. The default entries are the computer's system time and the home address.

The button 'Current Date and Time" resets the time values according to the computer's system time. The button 'Home Address' does this accordingly to reset the home address.

On clicking 'Show Sky' the planetarium shows the selected view.

e. If the current position of the moon in the sky at the home address is supposed to be displayed chose this option when the PC-clock is set without Daylight Saving Time.
f. If the current position of the moon in the sky at the home address is supposed to be displayed chose this option when the PC-clock is set on Daylight Saving Time.



When the planetarium screen opens there are many ways and commands to set, change and adjust the display. These commands can partly be given directly from the keyboard, from the planetarium's main menu, with the mouse and from the control panel at lower right.

Note that most stars (except the brightest ones) are displayed as single dots with their magnitude differences somewhat indicated by different colors. This is supposed to create the most realistic impression of an artificial sky especially picturing the best imitation of the sudden moments of lunar occultations. Most other existing planetarium software use filled circles of differing sizes for stars thus neglecting any realistic display.

The dot display of stars in GRAZPREP sometimes makes it difficult though to see the stars well enough on the screen (especially on dusty screens!). Any labelling (see below under keyboard commands) and also a tool to increase the size of stars (see below under control panel) makes them better visible when that should be necessary.

The **keyboard commands** are:

+ / -: Zoom in and out
N: Show and hide names
X: Show and hide XZ-numbers
Z: Show and hide ZC-numbers

S: Show and hide SAO-numbers
H: Show and hide HIP-numbers
G: Show and hide Gaia-IDs
M: Show and hide stellar and planetary magnitudes
D: Show and hide double star codes
P: Show and hide position angles on the lunar limb (minimum zoom level necessary)
A: Show and hide axis angles on the lunar limb (minimum zoom level necessary)
Esc: Delete all labels
F: Exclude resp. include the display of stars (speeding up animated motions)
E: Show and hide a box in the lower left of the screen giving position data of the sun, the moon and the 8 major planets

	Right Ascension			Declination			Ecl. Longitude			Ecl. Latitude			Radius	Azimut	Altit.	Lib/Mag.
Body	h	m	sec	°	'	"	°	'	"	°	'	"	' "	°	°	
Sun	10	21	4.7157	+	10	16	42.415	153	20	35.135	-	0	0	6.588	15 49.6	37.1	-21.34	L 6.55
Moon	3	47	2.4693	+	23	32	9.345	59	33	47.527	+	3	22	4.247	16 7.1	110.0	44.80	B- 4.70
Mercury	9	33	20.0201	+	11	26	48.555	141	55	22.761	-	2	54	26.694	4.8	47.8	-15.26	2.57
Venus	11	46	17.8814	+	2	47	8.780	175	45	0.967	+	1	11	41.493	5.4	16.5	-34.56	-3.32
Mars	5	33	53.3282	+	23	6	9.357	83	59	51.640	-	0	12	0.588	3.2	87.5	28.10	0.77
Jupiter	5	9	23.4132	+	22	13	41.470	78	18	2.861	-	0	41	53.203	18.9	93.0	31.28	-2.25
Saturn	23	15	37.8875	-	7	7	40.620	347	1	0.085	-	2	10	21.966	9.5	204.2	28.66	0.84
Uranus	3	40	4.5241	+	19	17	4.384	57	14	18.316	-	0	15	51.146	1.8	115.4	42.46	5.72
Neptune	23	59	10.0775	-	1	31	37.750	359	12	5.778	-	1	19	6.175	1.2	192.9	36.31	7.85
2024	Mo Aug 26		UT	2h		6m	31.3 s	delta-t event/calc			69.54s / 69.49s			Sid.Tim	0 h	40 m	28.8 s	

O: Show resp. hide stars presently occulted by the moon. Occulted stars are always shown with an empty cross. When 'O' is selected the occulted star is shown within the cross.
L: Show and hide limb data (minimum zoom level necessary). This option gives the lunar height values and axis angles at the present libration dependent profile situation.
All Arrow keys: Shift the display for a fixed distance in any direction
Enter (<CR>) or Space bar: Stops an animation.

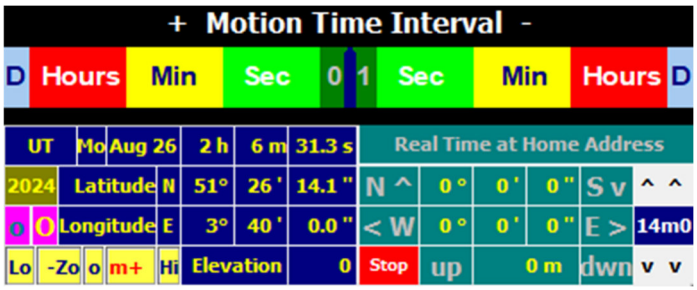
The Commands from the **Main Menu** are:
From the main menu all keyboard commands (except the zoom and shift functions) can also be given. From the main menu it is also possible to center and fix the moon, the sun, a major planet or the Earth's shadow (only at times close to lunar eclipses) on the screen. This is useful during animations (see below) not to lose the moving moon, sun or planet off the screen. The default setting though is a fixed right ascension and declination.

The **mouse** accomplishes the following when applied to the sky image:

- Left mouse click: Centers the screen to the selected spot in the sky.
- Right mouse click: Displays right ascension, declination, azimuth and altitude of the selected spot in the sky. When a coordinate close to the lunar surface is selected, also the distance to the lunar center in degrees, the distance to the mean lunar limb in seconds of arc, the position and the axis angle are displayed.
- Moving mouse while holding right mouse button: Shifts the screen accordingly.
- Double Clicking on any star: Stellar data is shown (table as in chapter 9, minimum zoom level necessary)

Note that the option 'Horizontal System' under '**Adjust Display**' in the planetarium main menu is not implemented yet. The horizon as it projects in the equatorial system is shown with the azimuth values, taking into account the refraction by generally lifting the horizon by 0,6°. All altitude numbers are geometrical though. Any display of the sky below the horizon has a gray background, whereas displays above the horizon gives a sky color related to the sun's altitude at the present geographical location.

The **control panel** in the lower right offers the following:



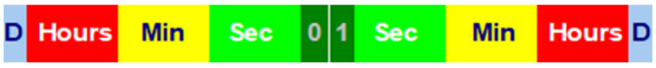
The time and the geographic location of the presently shown sky are shown in the blue panels on the left side. Clicking on the small yellow panels on the bottom left allows a faster in and out zooming where the panel marked 'o' always gives a medium zoom value, whereas the panels marked 'Lo' resp. 'Hi' let the display jump to the lowest and the highest possible zoom.

The pink panels marked 'O' and 'O' on the left side allow an increase and decrease of the displayed diameters of stars to make them better visible.

With the gray panels on the lower right it is possible to change the geographic location in longitude, latitude or elevation at a chosen rate. First enter the desired rate by clicking on the fields with the zeros: one click adds 1, a double click adds 10 (degrees, minutes or seconds of arc). In case of the elevation field one click adds 10, a double click adds 100 meters to the elevation. A right mouse click changes the entry back to zero. The sky display is only affected by these chosen offsets when one of the buttons 'N ^', 'S v', '< W', 'E >', 'up' or 'dwn' is clicked. These buttons only become active (yellow letters!) with a chosen offset value. A single click results in a single step motion in the chosen direction whereas a double click starts an animation as a continuous location change. This animation stops after the mouse leaves the clicked field or by pressing 'Enter' or the space bar on the keyboard.

The light gray panels on the lower right allow an adjustment of the number of stars being displayed. Clicking on the left arrows decreases resp. increases the magnitude limit by 1, the right arrows decrease or increase the magnitude limit by 0.1. At a certain low zoom level the limiting magnitude is reduced automatically to 8.0, being increased again automatically when higher zoom levels are chosen.

The animation in time is accomplished with the **motion time panel** on top of the control

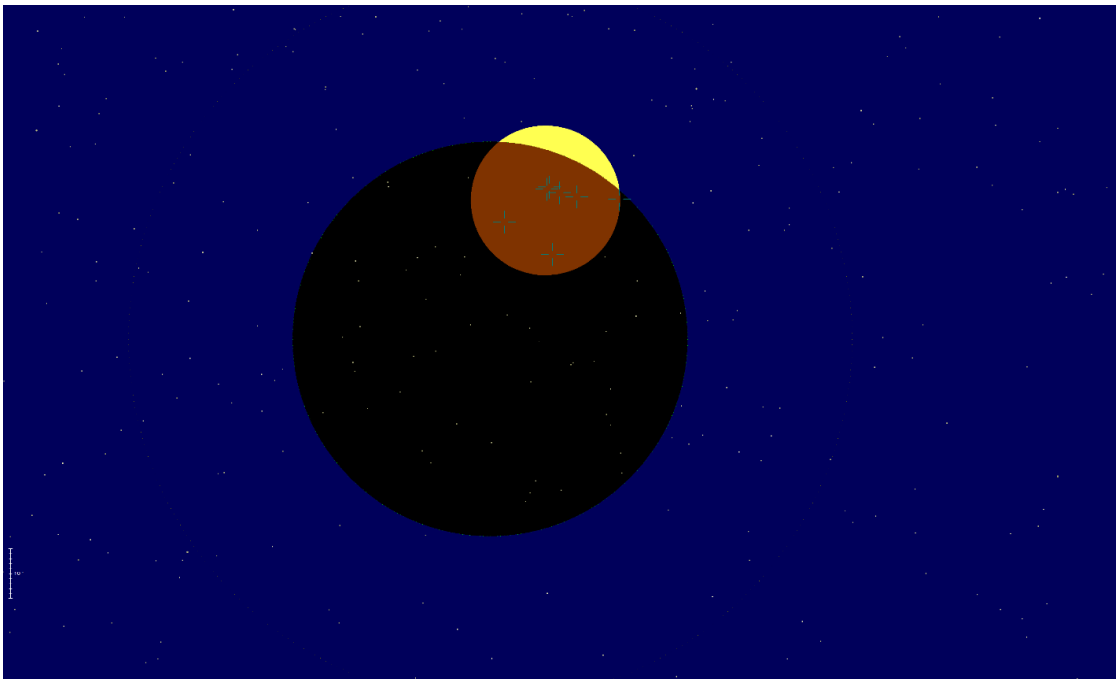


panel giving the different time intervals in different colors. To start a forward motion in time the left panels must be used and the right panels respectively for a backward motion. When moving the mouse over these panels the time interval shows depending on the selected position within each panel. In the Sec and Min parts there is an interval choice of 1, 2, 5, 10 or 30 (seconds or minutes). The hours can be chosen by 1, 2, 5, 10 or 12, the days by 1 and 7. The center panels allow an interval of only 0.1 second both backward and forward.

When the cursor has found the correct time interval a single left mouse click results in a sky display for the new time. A double click starts an animation with a continuous change of time due to the selected interval. To keep this animation running the mouse must not leave the motion time panel. During animation any sliding of the mouse on the motion time panel changes the speed of the animation or can reverse the direction. The animation stops immediately by moving the mouse out of the motion time panel or by pressing 'Enter' or the space bar.

Two buttons on the bottom of the sky image allow to save the image as a BMP- or JPG- file.

Finally the button ‘Real Time at Home Address’ becomes active (only!) when the planetarium was entered from the main menu choosing the present time and the home address (options e. and f., see on top of this chapter). Clicking this button shows the centered and continuously moving body in the sky (mainly useful for the moon) in real time with a new picture about every second. This run can always be interrupted by pressing ‘Enter’.



Thus the planetarium feature offers a wide variety of possibilities to display occultations of all kinds (excluding asteroids), among them predictions and evaluations of Baily’s Beads events during solar eclipses and the situation of total and grazing occultations, also during lunar eclipses (see above).

23. Outlook / Restrictions, Acknowledgements

The author is grateful for any correction hint or advice for additional features. Note that despite of a lot of testing and debugging, the software may fail under certain circumstances. If anyone encounters problems when running the program please report these.

Future plans include the revision of the stellar data especially concerning updated double star information as available through Gaia, the improvement of reductions of observations calculated from the LOLA-data for the true libration and an extension of highly precise ephemeris data for future decades.

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