Tutorial - Using Occult for (Total) Lunar Occultation prediction, reporting and analysis.

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Introduction

There are many reasons to observe lunar occultations, and may include; a simple desire to observe stars disappear or reappear at the lunar limb as the Moon orbits the Earth, to have your observations added to the archive of lunar occultation observations – that dates from 1623, to observe double stars during lunar occultation, and perhaps to test the accuracy of your equipment and technique. Considering the latter case, it's much better to work the Gremlins out of your gear and techniques by observing lunar occultations, than to try and perhaps mess up a likely asteroid occultation.

Occult provides the means to create a list of predictions unique for your site and telescope for a night of observation, or a list of predictions for any time period desired. It also offers the means to create an observation report and will give immediate indication of the accuracy of your observations.

This document does not however include methods to extract event times from recordings.

Updating Occult

This tutorial does not cover the installation of Occult, however the task of keeping Occult up to date is essential for accurate predictions and analysis, so I'll briefly mention it here.

Occult requires access to the internet to download various information from a host of different sites, and most of the required downloads can be found on the one form.

Click on the "Maintenance" tab, then Click on the "General downloads" button.

Shown here is the top of the form.
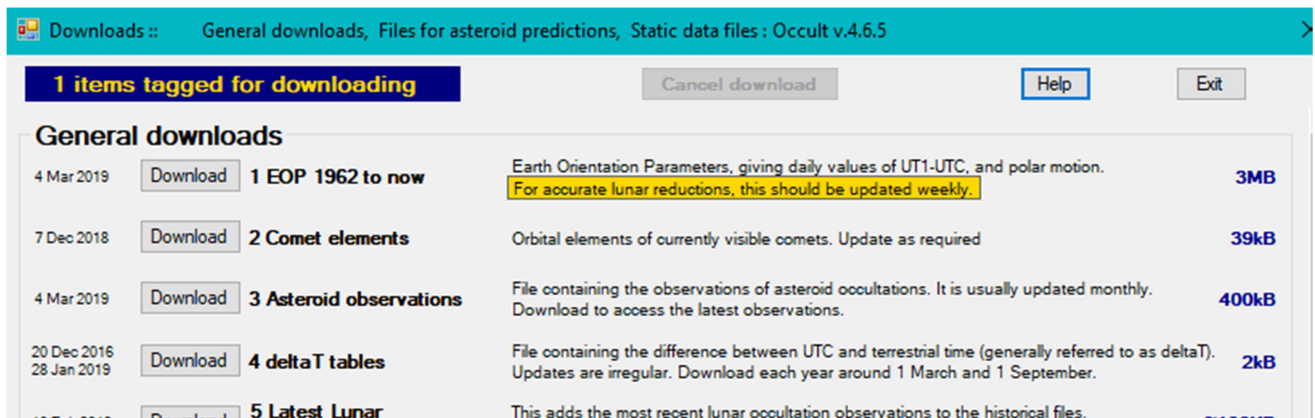
All items are numbered from 1 to 42.

On the left is the date of the last download, then the download button, the item#, the title of the download, a description, and finally the download size.

From time to time, you will see a **>>** symbol next to one or more items. This means the file needs updating so it's best to do so straight away.

The items required for lunar occultations are #1, 4, 5, 12, 14, 15, 16, 17, 26, 27, 28, 31, 33, 34 or 35, 40 or 41.
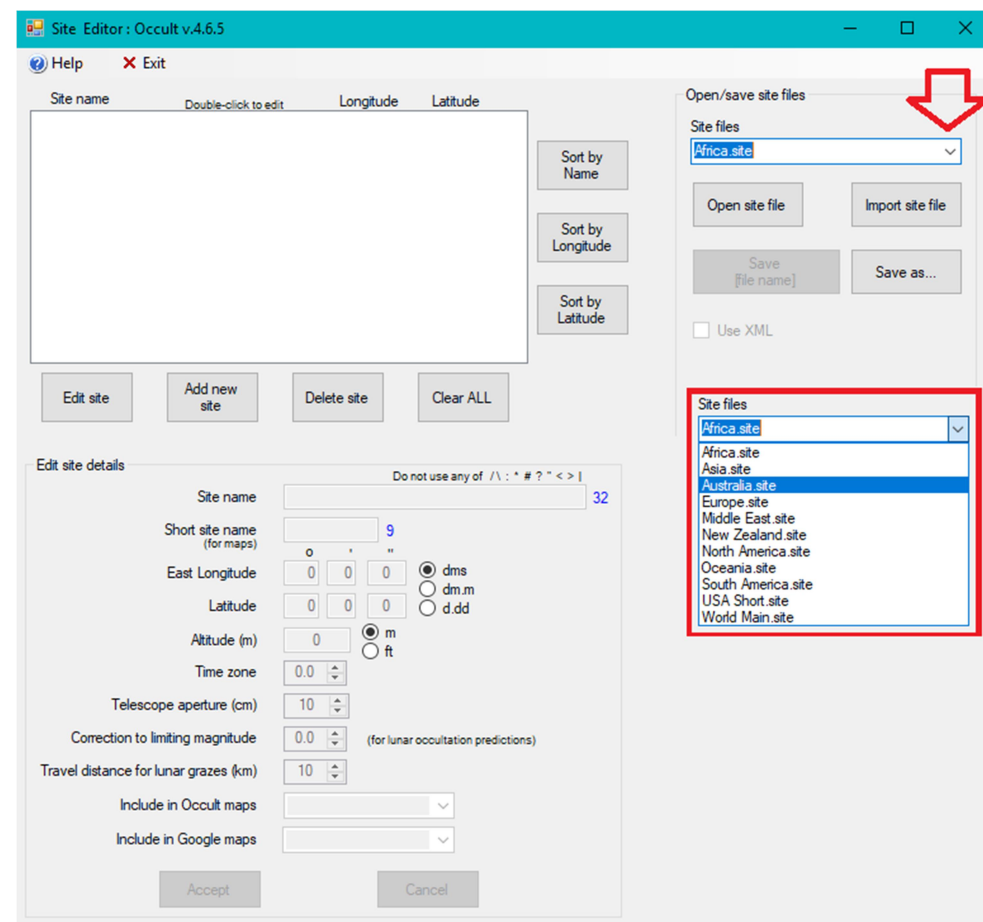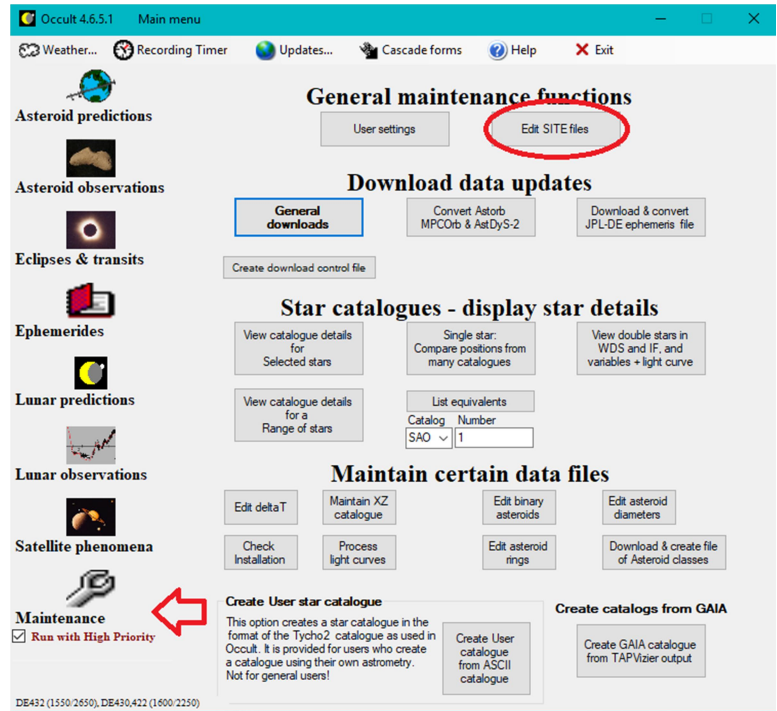
Occult Site File

Occult needs to know your geographic location and basic information about your telescope, contained in a site file.

You can either choose to:-
- Modify an existing site file by adding an entry for your site
- Create a new site file completely with one site details or multiple site details – as many as you wish.
-

I'll choose to describe the first option.

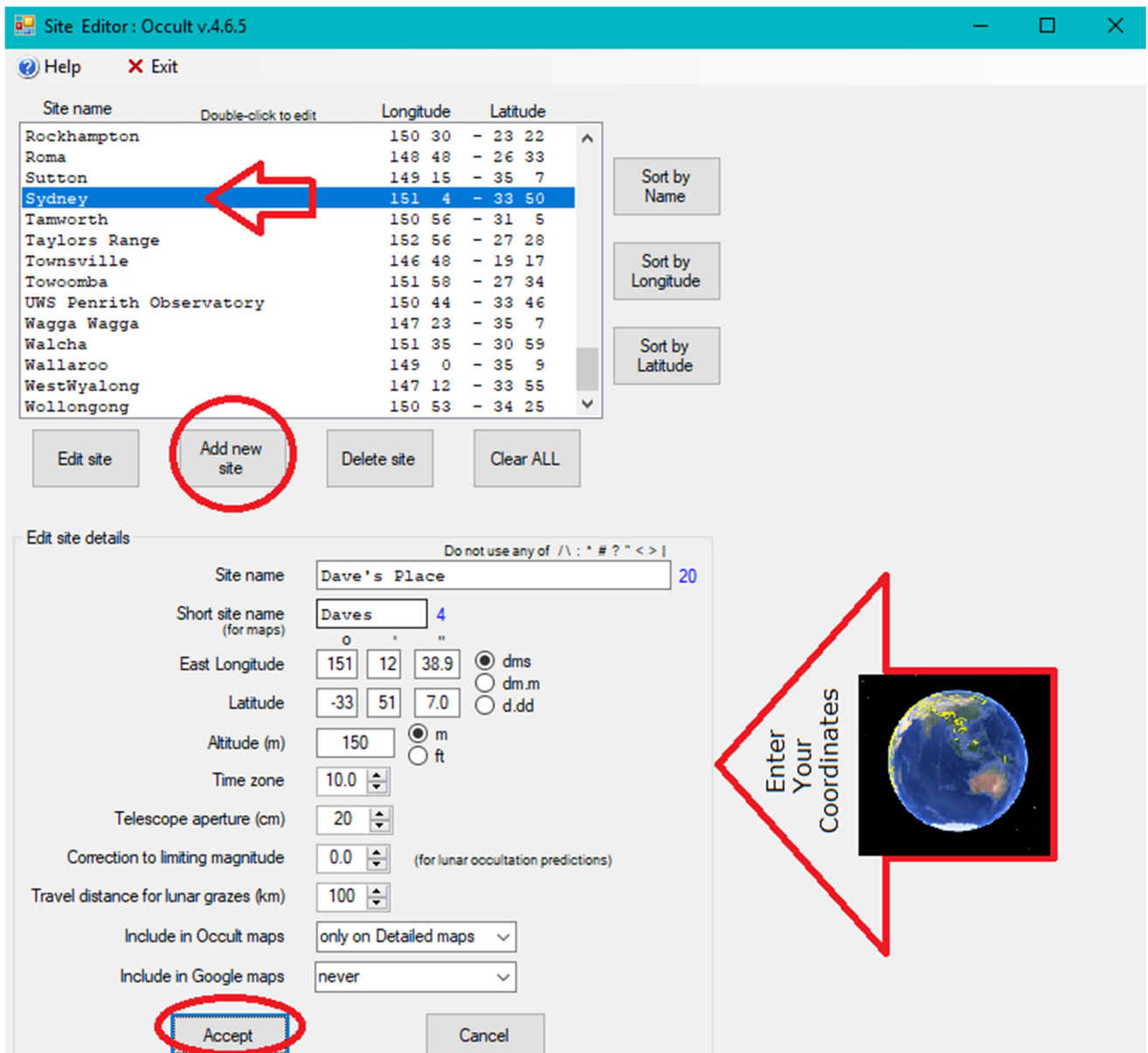Click on the "Maintenance" tab, then Click on the "Edit SITE files" button.

Click in the little check and a list of site files will appear.

Click on an appropriate file. I live in Australia so that is appropriate for me. Your mileage will vary.

Then click the "Open site file" button.

Continued…

Search for a nearby town or city. You may be tempted to be satisfied choosing (in my case) Sydney, but we need to input your exact site coordinates (latitude, longitude and Altitude).

The Datum required is WGS 84 for latitude and longitude, and Mean Sea Level (MSL) for altitude. Luckily most GPS receivers have this set as default as does Google Earth.

1) Once you have found you nearby town, click on it.
2) Click "Add new site" button. This will insert the selected town coordinates into the Edit site details area of the form – as a template.
3) Type over what's there with your details
    a. West longitude is negative
    b. South latitude is negative
4) Click accept.
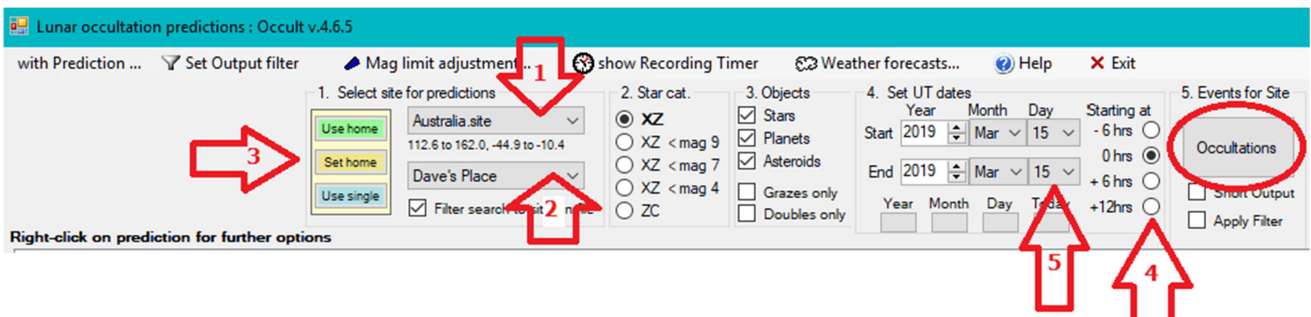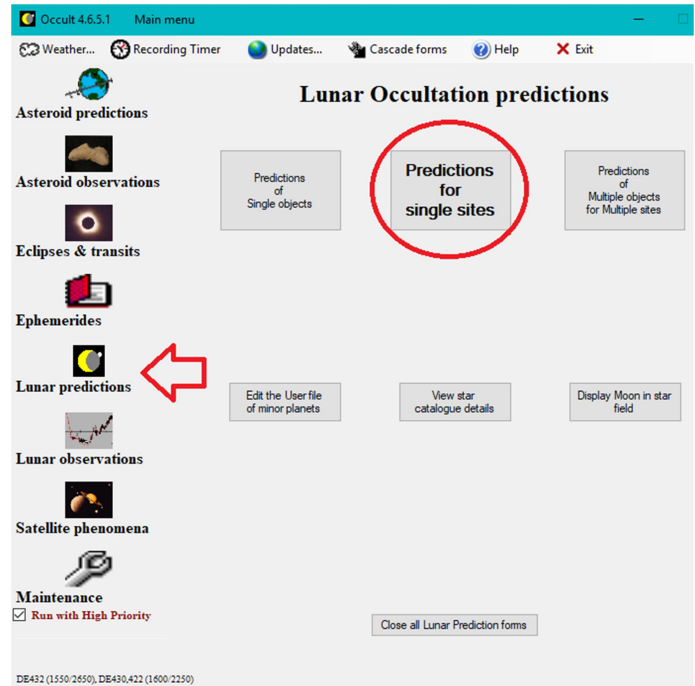5) Click Save "SiteFileName" button

Note:

If the site details you have just created is a site you'll use frequently, then the next section will describe how to set site as default "set home" and "use home".
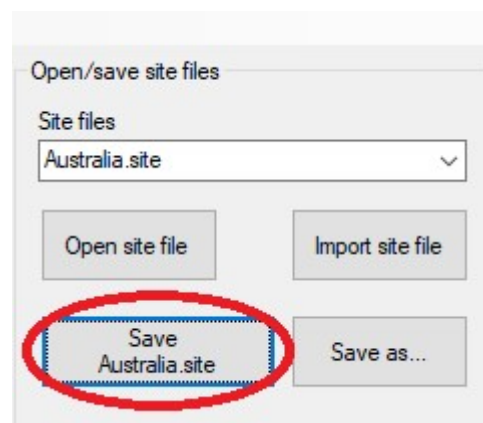
Lunar Predictions – for single (your) sites

Click the Lunar predictions tab
Click the Predictions for single sites button.

Start Hour	Regions/countries
-6	North and South America, including all of Canada, USA (except for Alaska and Hawaii), Mexico, Argentina, Brazil
0	Oceania (including Hawaii), Alaska, New Zealand, eastern states of Australia
6	Asia (including Japan), Western Australia, India, Iran
12	Europe, Africa, Middle East

Setup the Lunar occultation Prediction form:-
1) Choose the site file you just edited.
2) Choose the site you just created.
3) If this is a site you use frequently, you can set this as a default home site by clicking "Set home"
4) Select an appropriate "Starting at" button for your region of the globe.
Note:- Occult will remember this setting for the next session.
5) By default Occult will display the current UTC day date. Adjust as required.
6) Stand back, and click Occultations Button.

Occult will generate predictions unique for your site. Shown here is the form header.

```
Occultation prediction for Dave's Place
E. Longitude  151 12 38.9,  Latitude -33 51  7.0,  Alt.  150m;  Telescope dia 20cm;  dMag 0.0

      day Time        P   Star Sp  Mag  Mag    % Elon Sun Moon  CA  PA  VA  AA Libration   A   B   RV   Cct durn  R.A. (Appnt)   Dec    Mdist   SV
  y   m  d  h  m   s       No  D   v    r V  ill      Alt Alt Az   o   o   o   o  L    B   m/o m/o  "/s    o  sec  h   m   s    o   m  s   Mm    m/s
```

The first time you list predictions, check the site coordinates are correct. Occult will then list event circumstances for every star viewable using your telescope.
- Event times are listed heirarchically by ZC, SAO or XZ identifiers.
- You can adjust the list by selecting different buttons under the Star cat. group, or by adjusting the Mag. limit from the menu bar, or by using the Set output filter on the menu bar.

You can print the list as-is, but before you do that, I'll show you what I do for a night's observing. Cont…

I think it is important to take out to the telescope a one page printout, that can be used to find the stars on the lunar limb, in the order that the events will occur. You can use this form for notes, and for any calculations required to determine event times. Here is what I do;
- R-click on the first event listed a menu will appear.
- Choose menu item – Moon map.
  - Choose the orientation that suits. I like South UP (because I live in Australia) and non-mirrored (because I don't use a star diagonal). Your preference may be different.
- R-click on the map and choose an appropriate number of stars to display.
- Using the "with Map" menu, choose Copy…
- And paste this into a horizontal formatted Word (or similar) Document
- Go back to the predicted list and using the "with Prediction" menu, choose Copy all…
- And paste into the document. You may have to choose a small font to fit everything across the page.

This is taken to the telescope. Here's what a typical observing run form looks like after LiMovie analysis.

This is what I do, and all my observations going back nearly 20 years are in ring binders for easy reference. The message here is not necessarily to copy what I do, best is to suit yourself but be systematic is the recomendation.

This neatly side steps the actual analysis of the video, which is outside this tutorial anyway.

However I use IOTA-VTI time stamped analogue video, mostly analysed using LiMovie for lunar events. For the events listed, I used a Watec 910BD camera, which has a Instrument Delay (ID) which must be subtracted from the video time-stamp. Occult will list the recommended ID to apply for your camera and VTI and this will be discussed in the next section.
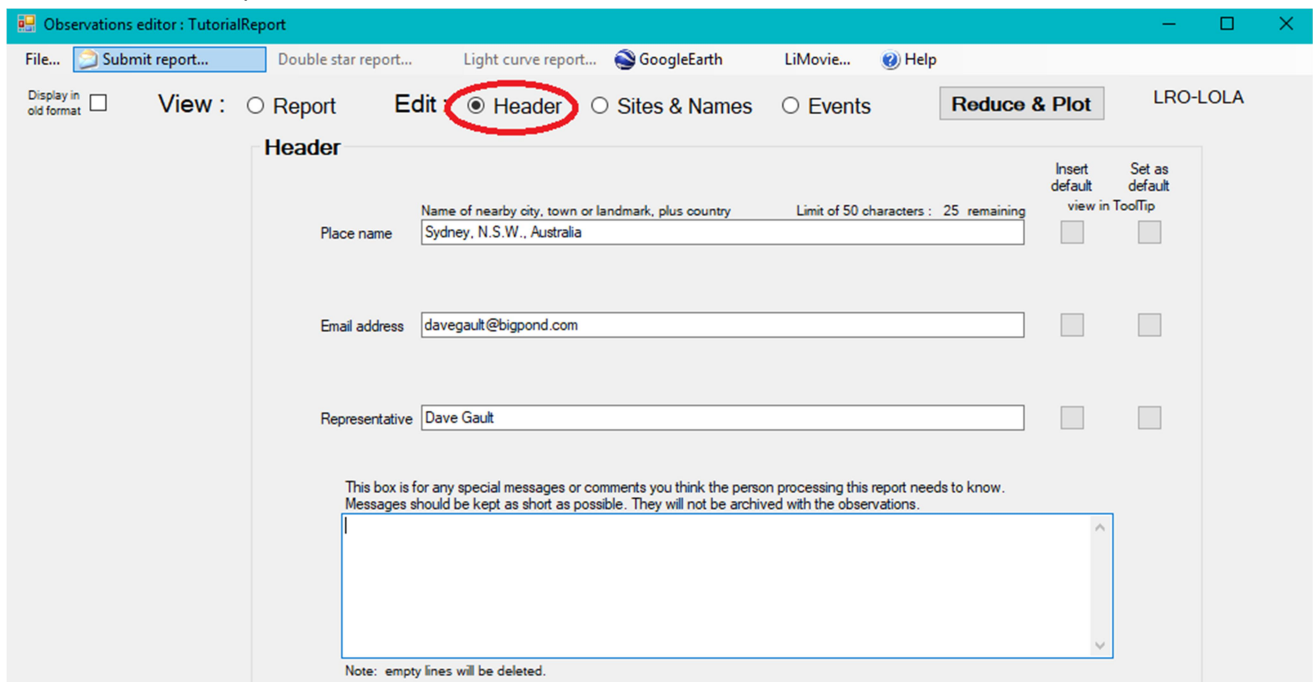
Lunar Observations – Creating an observation report.

Once you have your event timings, the next task is to create an observation report.

Click the Lunar Observations tab
Click the Add/Edit/Plot observed Lunar Observations button.
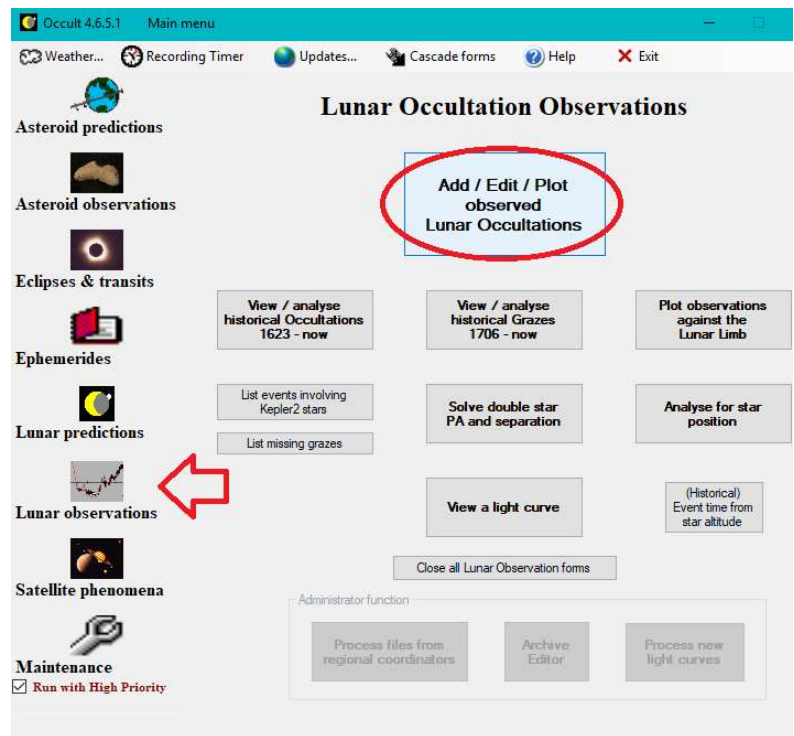
LunarObservatin Report - Header

Enter the following information
- Place name - the name of the closest town or city. You can enter something like Daves Observatory, so long as you also include a nearby town or city, and Country. This will be archived.
- Email address – this is for correspondence with your Regional Collector, and is not archived.
- Representitive – the name of the person responsible for this observation report. In the case of a graze observation report, then this will be the graze leader. It is used for correspondence purposes only, and is not archived.

You can set and retrieve default information.
At this point you should save the file by giving it a name, eg. 201901_YourName.txt – that is the observation report for events observed in January 2019.

LunarObservatin Report – Sites & Names

Enter the following information

- your observation site coordinates
- your telescope details – note:- in centimeters (cm)

Make sure you click - **Add as new site**

- your name in the format:- G. Fnnnnn where G is your Given name and Fnnnnn is your Family name. This will be archived.
- your email address, it may be the same as that in the header, or it may be different. This will not be archived.

Make sure you click – **Add as new name**

Use the File menu and save the file.

A graze observation may have many site coordintates listed as well as well as observer names and their email addresses.

If you make most of your observations from the same site, once you have all the details correct, click the "**Set selected as default**" button. To use the default, simply click "**Add default as new site**" button.

For observer names, you can use the "**Set selected as default**" and "**Add default as new name**" buttons.

Additionally an observer can list their favourite sites that they observe from frequently, and save the file a template – just make sure to use the correct site with each particular observation.

LunarObservatin Report – Events
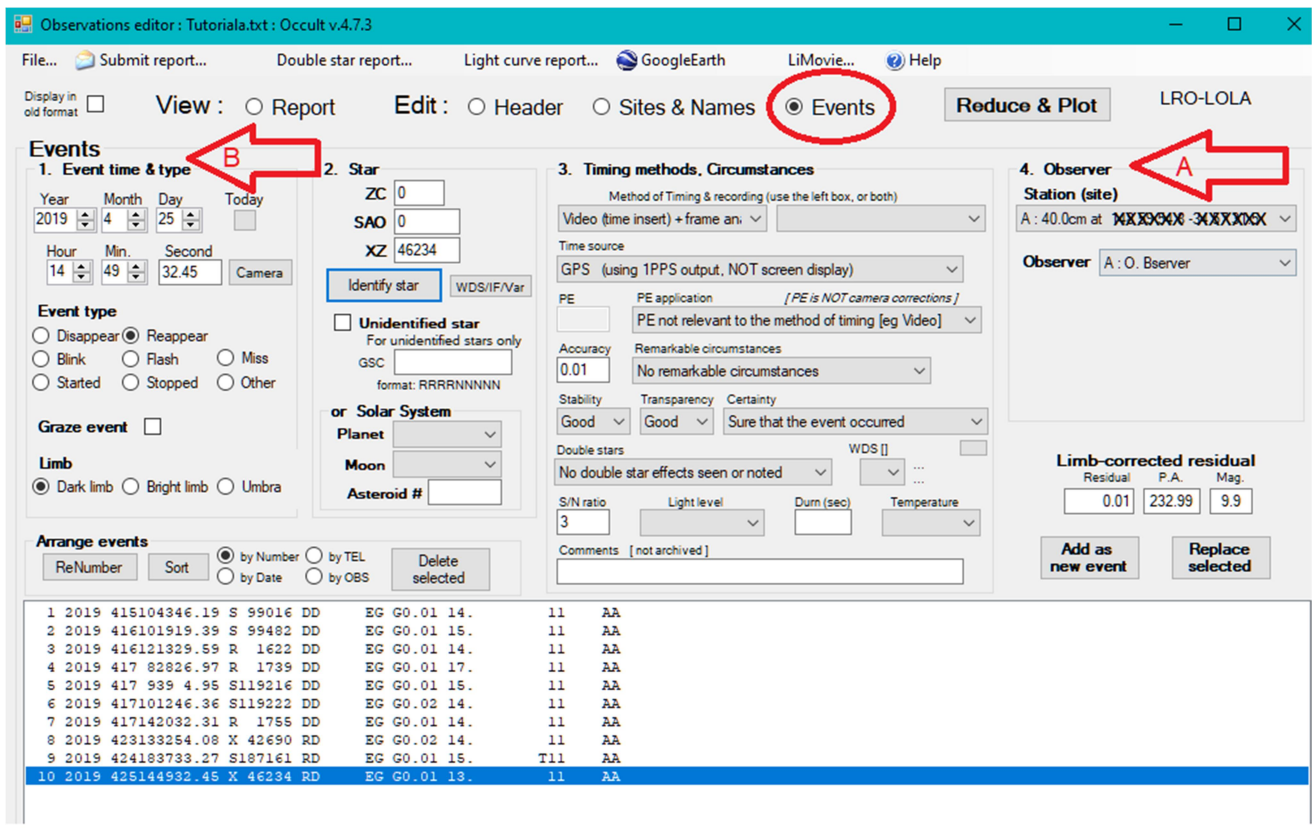
Shown here is a typical observation report. Note:

- Events 1-7 are disappearance events.
- Events 8-10 are reappearance events.
- All are dark limb events and all are observed at the same site by the same observer.

A) Despite the layout of the form, it's best to set (or ensure it is correctly set) section 4) Observer Site and Name codes, created or edited on the previous Sites & Names form.

B) To enter an event, move to section 1) Event time and type, and tab through the following steps:-

   a. enter the date. If the UTC date is still current, click the 'Today' button.
   b. Enter the time of the event with Camera and VTI Instrument Delay (ID) already subtracted.
      i. Click the '**Camera**' button and Occult will display a form that lists the ID for various popular cameras and VTI devices.
   c. Click on the Radio Button to select Event Type. Disappearance or Reappearance.
      i. Blink, Flash, Miss, Started, Stopped and Other are for Graze reports.
      ii. … as is the Graze event check-box.
   d. Click on the Limb type Radio Button. Generally, Bright limb events arevery difficult to observe and event times tend to be unreliable.

   Section 2) Star
   e. Enter the star identifier #. To prevent miss-typing errors, simply click on the '<u>Identify Star</u>' button. If the date, time and event type (disappear or reappear) are correct, Occult will list candidate stars, in order of the computed residual. Most commonly the first star in the list is the relevant star, however if there are several stars with small residuals, you need to ensure to select the correct one.
   Double click on the appropriate star ID.
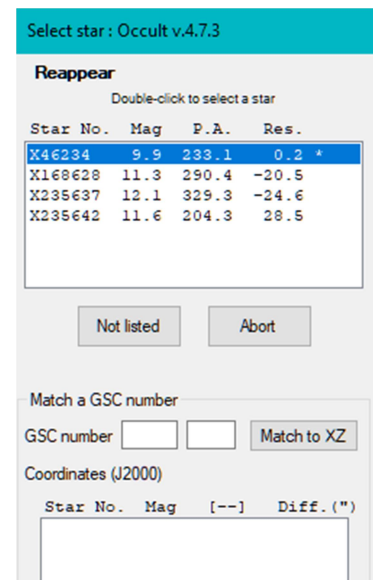
Section 3) Timing Methods and Circumstances.

f. Tab through to and use the menu pull-downs to <u>enter information</u> that best describes your timing equipment and event circumstances.

g. When you are done, click '<u>Add as new event</u>' button, to list the event data below. This will Auto-save the report.

h. Any line can be edited by clicking on the line, correcting the information and then click the '<u>Replace selected</u>' button, however the report is not be saved at this time. It will be saved if you add another new event or if you use the File-Save menu item.

C) Note the Limb-corrected residual value. This will usually fall within the range +/- 0.10". Occasionally the Residual can be a little larger, usually caused by poor star positions, or associated with components of double stars. Values greater than 0.2" usually indicates; there is an error in the date or time, or in the star number; or if the star is a double star, that the reduction has not been corrected for the component; or the occultation was missed - usually as a result of the observing conditions. More discussion on this later…

D) Double Star events.

a. A double star observed during lunar occultation will produce a stepped light curve.

b. Times for each component can be obtained.

c. A separate entry is then created listing the time for each component,

d. Circumstances fields 'Double Stars' and 'WDS' are used to describe each component.

e. In addition, a Double Star Report should be created and sent to the Double Star coordinator, (currently Brian Loader) however the creation of this report is outside the scope of this tutorial and should probably be a tutorial in it's own right.
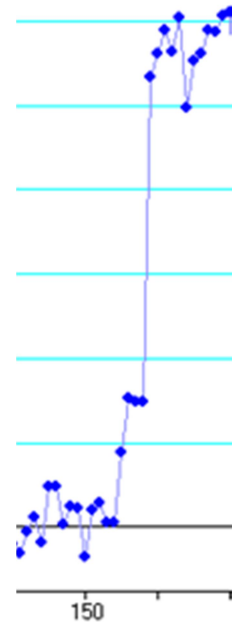
Reduce and Plot
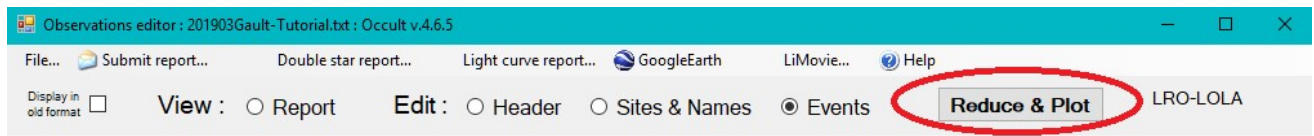
Click the Reduce and Plot button at the top of the Observations Editor. Occult will process your observations and produce a List of occultation residuals form.
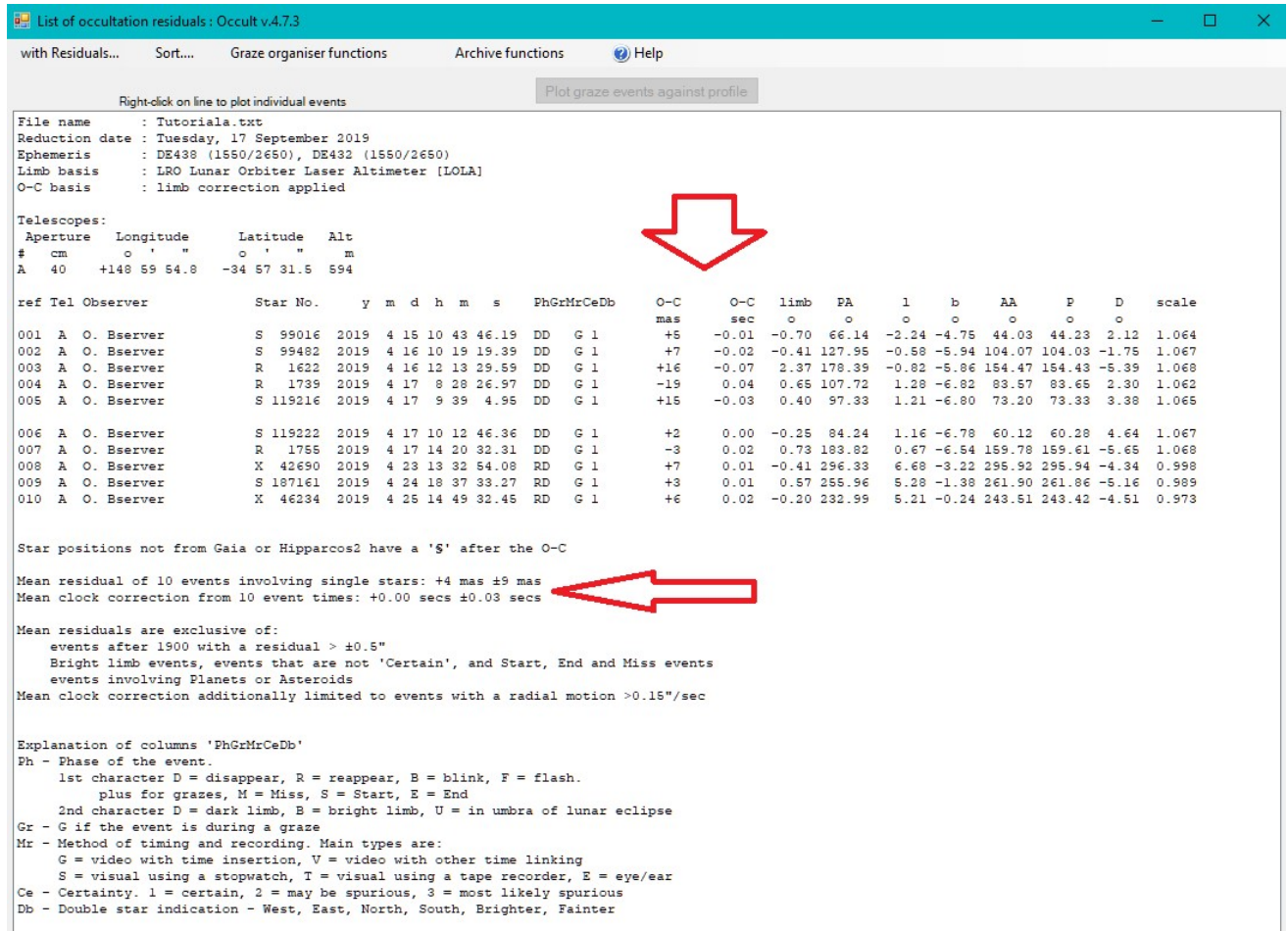
Take note of the O-C columns.

- O-C mas, is the observation residual in milli-arc-seconds.
- O-C sec, is the equivalent time error.

Don't use an individual residual value as a means to judge the quality of the observation. There are many factors that can influence an individual result. e.g. components of double stars can have large residuals.

Take note of the statement:- Mean residual of events involving single stars.

Provided you have a good sample size (at least 10 observations), this will give you a good idea of your general accuracy. For an instrumental observer (e.g. using GPS+1pps Time Inserted NTSC or PAL video) you should expect a mean residual of <~10mas, and an uncertainty of <~30 mas. However these residuals do not give you a good idea of timing accuracy.

The line giving the 'Mean clock correction' provides the information about time accuracy. It provides a mean value and an uncertainty value. Typically, the mean value for an instrumental observer should be less than 0.02secs, and the uncertainty less than 0.04 secs.

Please refer to the **Journal for Occultation Astronomy** (JOA v20XX NoX) for a more complete discussion on how to interpret this information.

Observe more lunar occultations! – Wishing clear skies, DaveG and DaveH.