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

Dave Gault and Dave Herald

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.

🖳 Downloads :: General downloads, Files for aster	oid predictions, Static data files : Occult v.4.6.5	>
1 items tagged for downloading	Cancel download Help	Exit
General downloads		
4 Mar 2019 Download 1 EOP 1962 to now	Earth Orientation Parameters, giving daily values of UT1-UTC, and polar motion. For accurate lunar reductions, this should be updated weekly.	ЗМВ
7 Dec 2018 Download 2 Comet elements	Orbital elements of currently visible comets. Update as required	39kB
4 Mar 2019 Download 3 Asteroid observations	File containing the observations of asteroid occultations. It is usually updated monthly. Download to access the latest observations.	400kB
20 Dec 2016 28 Jan 2019 Download 4 delta T tables	File containing the difference between UTC and terrestrial time (generally referred to as del Updates are irregular. Download each year around 1 March and 1 September.	^{taT).} 2kB
10 Eab 2019 Download 5 Latest Lunar	This adds the most recent lunar occultation observations to the historical files.	~100KP

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.

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Telescope aperture (cm) 10	
Correction to limiting magnitude 0.0 (for lunar occultation	n predictions)
ravel distance for lunar grazes (km)	
Include in Occult maps	
Include in Google maps	
Accept	

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...

... Occult Site file - continued

🔛 Site Editor : Occult v.4.6.5		– 🗆 X
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Accept	Cancel	

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 <u>Edit site details</u> 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.





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 Time P Star Sp Mag Mag % Elon Sun Moon CA PA VA AA Libration A в RV Cct durn R.A. (Appnt) Dec Mdist SV day m d h m No D S r V ill Alt Alt Az 0 0 o o L B m/om/o"/s o sec h m 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 nonmirrored (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 <u>be systematic</u> 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

🛃 Observations editor : TutorialR	Report			-		×
File 🔵 Submit report	Double star report Light curve report 🍣 GoogleEarth LiMovie 🜒 Help					
Display in Old format View :	○ Report Edit ● Header ○ Sites & Names ○ Events	Reduce a	& Plot	LRO-	LOLA	
	Name of nearby city, town or landmark, plus country Limit of 50 characters : 2 Place name Sydney, N.S.W., Australia	25 remaining	Insert default view in	Set as default ToolTip		
	Email address davegault@bigpond.com					
	Representative Dave Gault					
	This box is for any special messages or comments you think the person processing this report needs Messages should be kept as short as possible. They will not be archived with the observations.	s to know.	~			

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

💀 Observations editor : 201901Gau	ult.txt		– 🗆 X
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Sites / Telescopes	ision (surveyed) 38.9	Telescope Aperture 30.0 cm Focal length 150.0 cm Optics Cassegrain or Schmidt v Mounting Atazimuth v Drive Clock Driven v	Names of Observers Name for Observers 25 characters D. Gault 17 Initial + Family name. eg 'J. Smith' Observer's Email address (optional, not archived) davegault@bigpond.com Sort / move Names by Number by Full Name Move name:
Add as new site Replace selected Add de as new TA CAD 30 150 +1503	ected Delete ault selected fault ReNumber	Sort / move Sites by Number by Longitude Move site: up down by Latitude	by Name initial down Add as new name Set selected as default Replace selected Add default as new name OA D. Gault davegault@bigpond.com

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 "<u>Set</u> <u>selected as default</u>" button. To use the default, simply click "<u>Add default as new site</u>" 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

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Year Month Day Today 2019 🗣 4 🜩 25 🜩	ZC 0 SAO 0	Method of Timing & recording (use the left box, or both) Video (time insert) + frame an:	Station (site) A: 40.0cm at 1413 3939436 - 3433 XXXXX
Hour Min. Second 14 (\$) (\$) (\$) (\$2.45 Camera	XZ 46234	Time source GPS (using 1PPS output, NOT screen display) V	Observer A: 0. Bserver V
Event type Disappear Reappear Blink Plash Miss Started Stopped Other	Unidentified star For unidentified stars only GSC format: RRRRNNNN or Solar System	PE PE application (PE is NOT camera corrections) PE not relevant to the method of timing [eg Video] Accuracy Remarkable circumstances 0.01 No remarkable circumstances Stability Transparency Curation	
Graze event Limb Dark limb O Bright limb O Umbra	Planet V Moon V Asteroid #	Double stars Under that the even occurred Double stars WDS [] No double star effects seen or noted	Limb-corrected residual Residual P.A. Mag. 0.01 [232.99] 9.9
Arrange events ReNumber Sort by Number by Date by Date	by TEL Delete by OBS selected	Comments [not archived]	Add as Replace new event selected
1 2019 415104346.19 S 99016 DD 2 2019 416101919.39 S 99482 DD 3 2019 416121329.59 R 1622 DD 4 2019 417 82826.97 R 1739 DD 5 2019 417 82826.97 R 1739 DD 6 2019 417101246.36 S119222 DD 7 2019 417142032.31 R 1755 DD 8 2019 423133254.08 X 42680 RD 9 2019 424183733.27 S187161 RD 10 2019 425144932.45 X 46234 RD	EG G0.01 14. EG G0.01 15. EG G0.01 14. EG G0.01 17. EG G0.01 15. EG G0.02 14. EG G0.02 14. EG G0.02 14. EG G0.02 14. EG G0.01 15. EG G0.01 13.	11 AA	

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 '<u>Camera</u>' 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.

Reap	pear			
	D	ouble-cli	ck to select	a star
Star	No.	Mag	P.A.	Res.
X4623	4	9.9	233.1	0.2 *
X1686	28	11.3	290.4	-20.5
X2356	37	12.1	329.3	-24.6
X2356	42	11.6	204.3	28.5
1				
Match a	a GSC	numbe	r	
GSC nu	mber			Match to
Coordina	ates (.	12000)		
coordina				

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.
- 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

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Display in old format	View :	○ Report	Edit :	⊖ Header	○ Sites & Names	Events	Reduce & Plot	LRO-	LOLA	

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.

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02 A 0. 1	Server	S 99482	2019 4	6 10	19 19.39	DD	G 1	+7	-0.02	-0.41	127.95	-0.58	-5.94	104.07	104.03	-1.75	1.067	
03 A 0. 1	Bserver	R 1622	2019 4	6 12	13 29.59	DD	G 1	+16	-0.07	2.37	178.39	-0.82	-5.86	154.47	154.43	-5.39	1.068	
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05 A 0.1	Server	S 119216	2019 4	.7 9	39 4.95	DD	G 1	+15	-0.03	0.40	97.33	1.21	-6.80	73.20	73.33	3.38	1.065	
6 A 0. 1	server	S 119222	2019 4	7 10	12 46.36	DD	G 1	+2	0.00	-0.25	84.24	1.16	-6.78	60.12	60.28	4.64	1.067	
07 A 0. 1	Bserver	R 1755	2019 4	7 14	20 32.31	DD	G 1	-3	0.02	0.73	183.82	0.67	-6.54	159.78	159.61	-5.65	1.068	
08 A 0. 1	Bserver	X 42690	2019 4	3 13	32 54.08	RD	G 1	+7	0.01	-0.41	296.33	6.68	-3.22	295.92	295.94	-4.34	0.998	
09 A O. I	Bserver	S 187161	2019 4	4 18	37 33.27	RD	G 1	+3	0.01	0.57	255.96	5.28	-1.38	261.90	261.86	-5.16	0.989	
10 A O. 1	Bserver	X 46234	2019 4	15 14	49 32.45	RD	G 1	+6	0.02	-0.20	232.99	5.21	-0.24	243.51	243.42	-4.51	0.973	
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r - G if th	e event is d	during a graze	bright in	ω, υ	- In unor	La UI	Iunai ec	TTDRE										
r - Method	of timing ar	nd recording. N	fain types	are:														
G = vie	leo with time	insertion, V	= video w	th ot	her time	link	ing											
C	ual using a	stopwatch, T =	visual u	sing a	tape rec	orde	r, E = ey	e/ear										
5 - VI:		-		_	-		_											
e - Certain	nty. 1 = cert	ain, 2 = may h	e spuriou	, 3 =	most li	cely	spurious											

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.