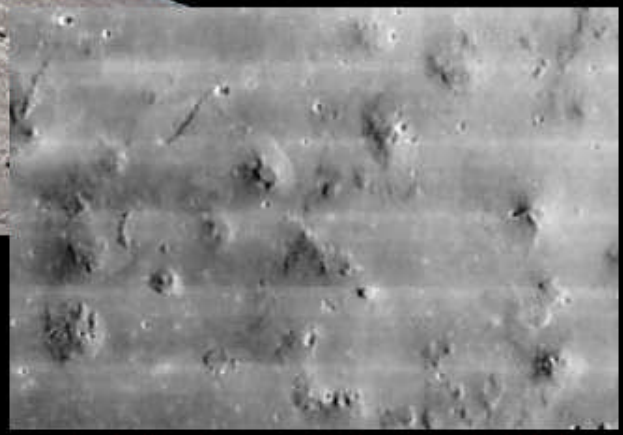
Simple Shape-from-shading (SfS) with Carlotto's method and MS-Excel
Part 3: Convert source images to text data and import

Katima, Alaska

Mons Rumker - Apollo 15 AS15-97-13252

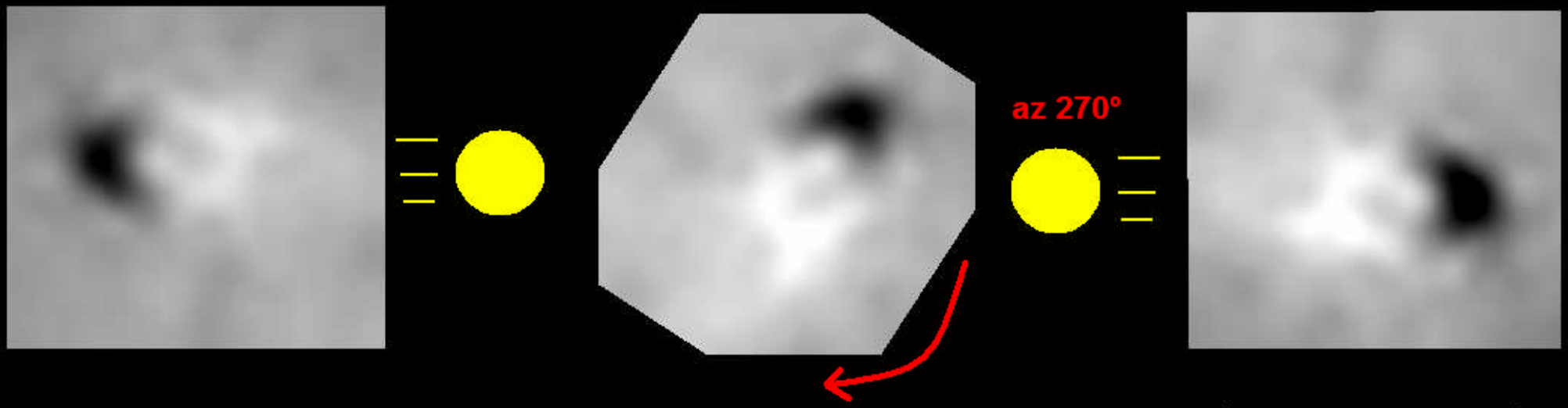


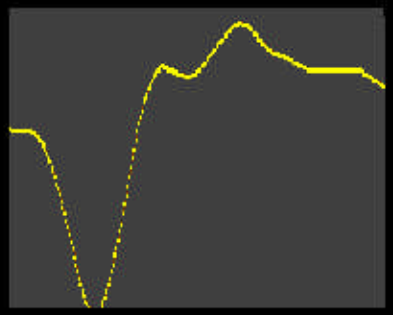
Marius Hills - Lunar Orbiter IV - IV-15-H2

K. Fisher fisherka@csolutions.net Org. 3/2007

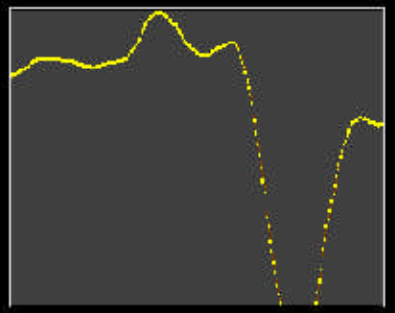
In Part 1, we discussed how Carlotto's method simplifies computation by rotating all lunar features images so the apparent azimuth of the Sun is 270°.

fits -> Astronomical Image Processing for Windows (AIP4WIN) -> fits





In this part, you will learn the steps to convert the image pixel values into a text data file and how to import that text data into the spreadsheet DEMCarlottoMethod.xls.



Converting and importing lunar feature images

Image Processing Checklist

Item	Software	Software type	Task type	Task
1	AIP4WIN	Image processing	Pre-process image - rectify	Convert color source fits to color jpg
2	LTVT	Lunar observing	Pre-process image - rectify	Two-point register and rectify image
3	LTVT	Lunar observing	Pre-process image - rectify	Export rectified color jpg to file
4	AIP4WIN	Image processing	Pre-process image - make greyscale levels	Convert color source jpg to 8-bit or
5	AIP4WIN	Image processing	Pre-process image - rotate and crop to rectangular	Rotate the image so the apparent s
6	AIP4WIN	Image processing	Pre-process image - rotate and crop to rectangular	Crop the image
7	AIP4WIN	Image processing	Pre-process image - rotate and crop to rectangular	Resave the image as an 8 bit or 16-
8	FV Tool	Digitize pixel values	Convert image to csv text data	Export the greyscale image to an N
9	Microsoft Excel	General spreadsheet	Convert csv text data to Excel worksheet	Import the csv data as an Excel wor
10	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Import NxM matrix to DEM spreadsheet	Copy/move the NxM matrix in the E worksheet in DEMCarlottoMethod.x
11	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Store info on image	Update worksheet StorelPM_Info wo
12	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Generate DEM - enter data	Generate the DEM using DEMCarlo
13	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Generate DEM - enter data	Copy the stored image pixel data to worksheet ImagePixelValueMap
14	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Generate DEM - enter data	Update the image characteristics to WorkflowMenu
15	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Generate DEM - enter data	Identify/name the working image pix
16	DEMCarlottoMethod.xls	Purpose-built spreadsheet	Generate DEM - housekeeping	Delete any preexisting DEM or Grac

ImageProcessingChecklist | WorkflowMenu | ImagePixelValueMap | VerticalDEMSlices-ScratchSht | Calculators

You will be covering the first eleven steps in the image processing checklist. The checklist is embedded inside DEMCarlottoMethod.xls and is included separately in the reference materials.

Converting and importing images

This section uses a variety of software and freeware to convert your lunar image into text data. Recommended software discussed on the project website and used in this presentation are:

1) An astronomical image processing package - AIP4WIN or the package of your choosing.

2) Mosher and Bondo's Lunar Terminator Visualization Toolkit (LTVT) for image rectification (freeware).

3) NASA HEARSAC's FV Tools (freeware).

Converting and importing images

If you do not have a lunar dome image to work with a sample image of Cauchy Omega is available at the project website, provided courtesy of Paolo Lazzorotti.

Convert and import images
Learning goals for Part 3

1) Proper rotation of a feature image to an apparent solar azimuth of 270°.

2) Rectification of an image to offset the effect of foreshortening.

3) Conversion of your fits or jpg image to 8-bit greyscale.

4) Conversion of your greyscale rotated image to text data.

5) Importing and storing your image's text data into DEMCarlottoMethod.xls.

Convert and import images

Process overview

Convert color source fits to color jpg

Two-point register and rectify image in LTVT

Export rectified color jpg to file

Gather ephemeris data

Convert color source jpg to 8-bit or 16-bit greyscale fits

Rotate the image so the apparent solar azimuth is 270°

Crop the image

Convert and import images
Process overview - continued

Export the greyscale image to an NxM csv matrix

Import the csv data as an Excel worksheet

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

Update worksheet StoreIPM_Info worksheet with image characteristics.

Convert and import image

Convert color source fits to color jpg

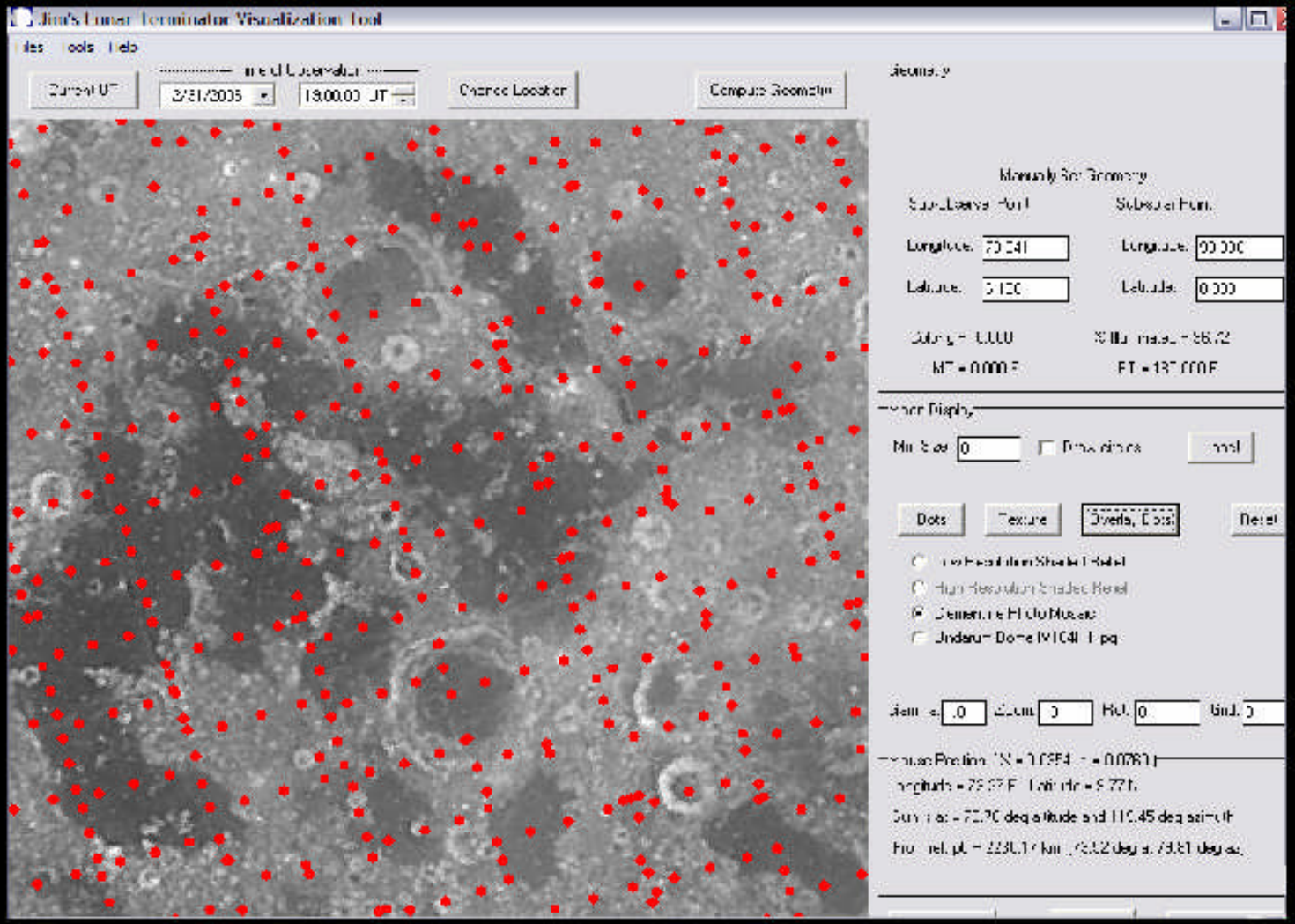
For the first step of the process - rectification of the image to reduce the impact of foreshortening - Mosher and Bondo's LTVT will be used.

LTVT imports jpg or bmp images, but not FITS. Use your astronomical imaging processing software to convert your greyscale or color fits to *.jpg.

Convert and import image
Two-point register and rectify image in LTVT

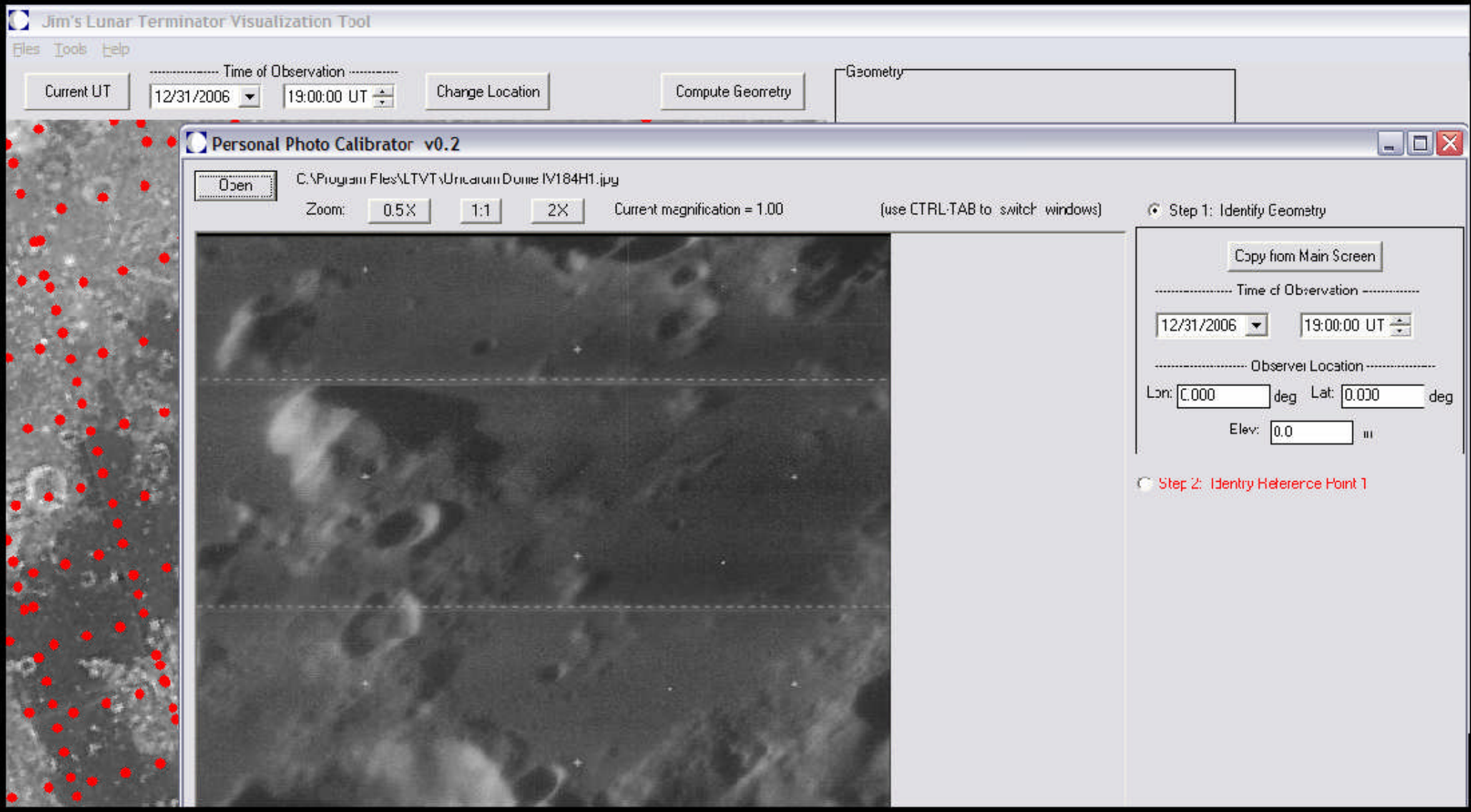
Mosher and Bondo's Lunar Terminator Visualization Tool (LTVT) uses two-point registration to rectify an image. Here, we will briefly overview the process.

Begin by overlaying ULCN 2005 control points over a high resolution Clementine image (provided as part of the LTVT distribution).



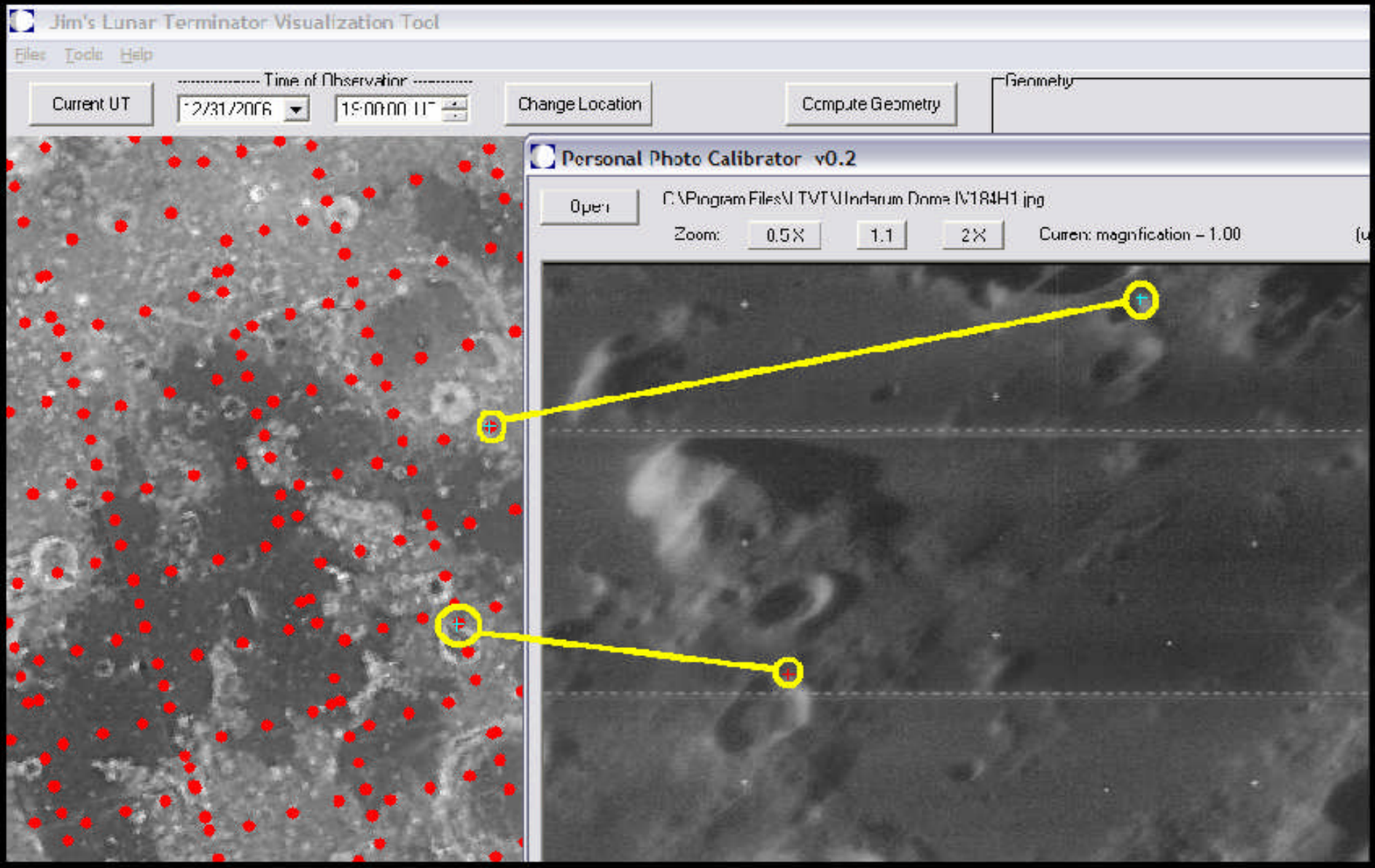
Convert and import image
Two-point register and rectify image in LTVT

The registration or calibration process is begun by opening your user image in a second window.



Convert and import image
Two-point register and rectify image in LTVT

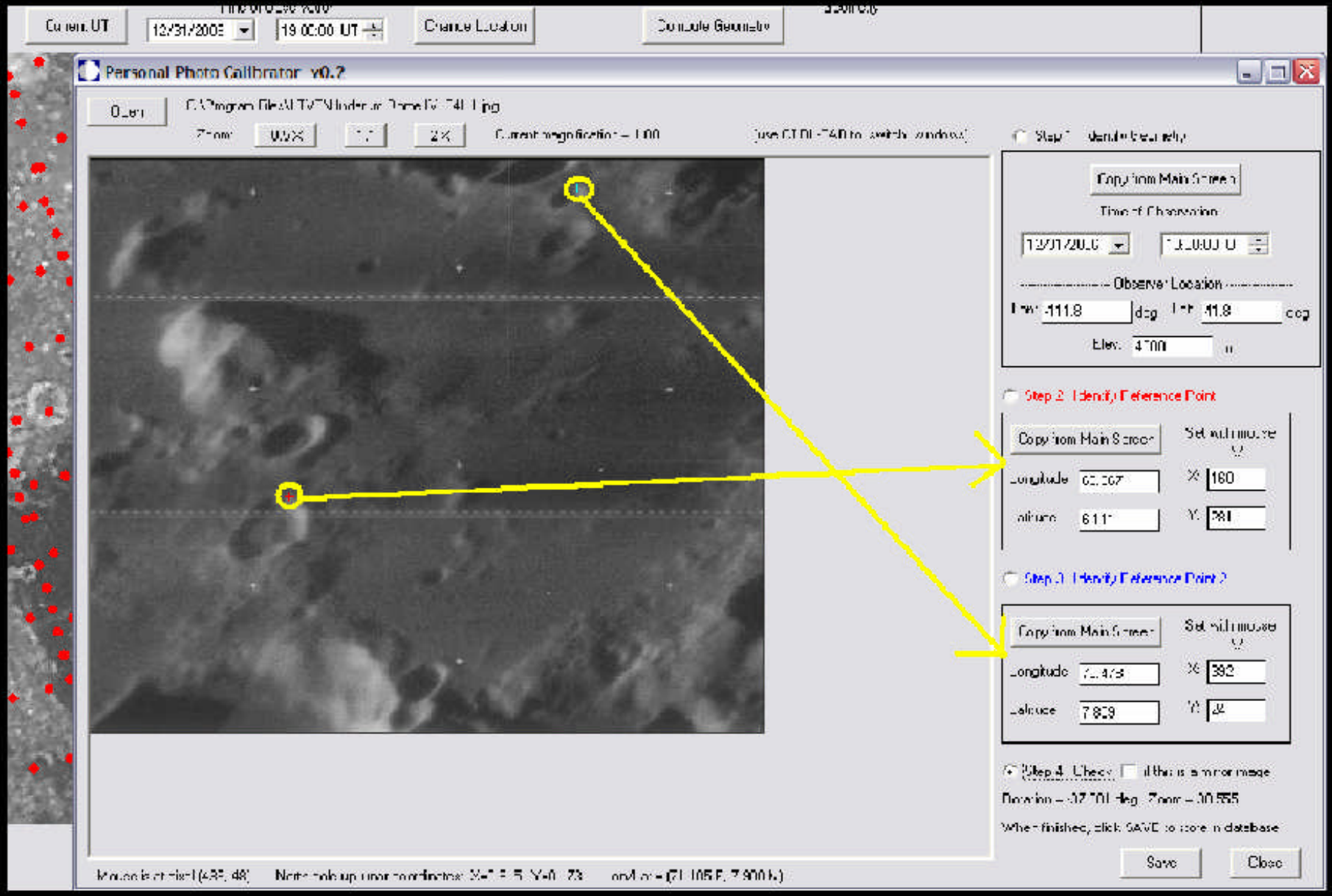
An association is built between two points on each image. This provides a transformation function for the rotation and scaling of the user's image.



See Berry and Burnell's HAIP for the mathematics of two point rotation.

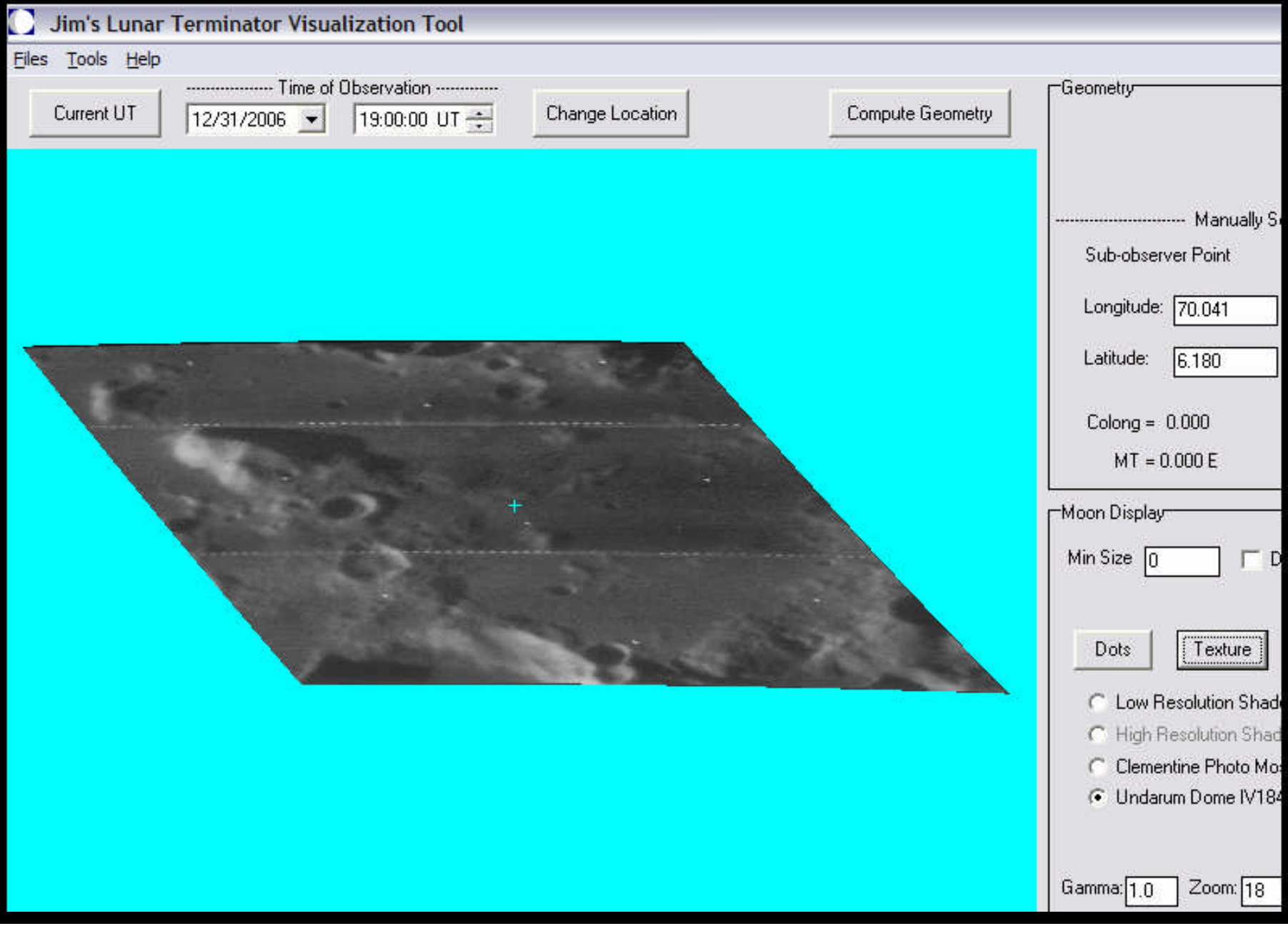
Convert and import image
Two-point register and rectify image in LTVT

Establishing the association includes pairing pixels on the user's image with estimated lunar coordinates.



Convert and import image
Two-point register and rectify image in LTVT

With this positional information, LTVT performs two-point rotation to rectify the image.

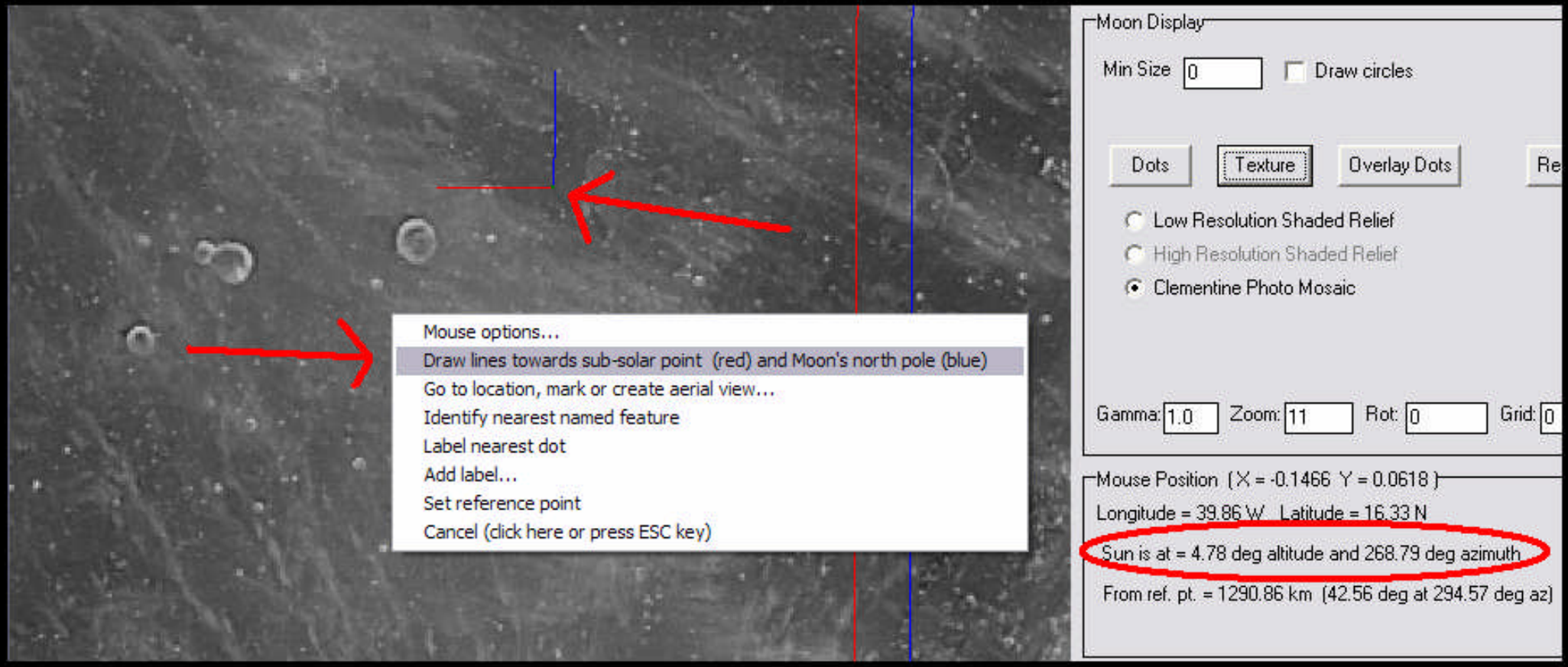


Convert and import image
Two-point register and rectify image in LTVT

Once rectified, the jpg image can be exported and saved as a jpg.

Convert and import image
Collect ephemeris data

LTVT also include ephemeris information, based on high accuracy ephemeris files downloaded from JPL. The information window provides information on the solar alitiude and azimuth at the current cursor position. Right-clicking provides an option to plot the relative direction of the Sun and lunar north pole.



Convert and import image
Collect ephemeris data

The training directory contains a checklist of image and ephemeris data to be gathered. This data is used later in the SfS process.

What was the feature imaged:
- Lunar lat and long.

Where it was taken from:
- Earth lat and long., city name

When it was taken:
- UTC Date and Time.

Image data:
- Resolution pixels/meter of the uncropped image.
- Gamma.
- Number of pixel rows in the cropped image.
- Number of pixel columns in the cropped image.

Ephemeris data:
- Solar altitude and az on Moon when image was taken.
- observer's sub-Earth lunar latitude and longitude.

Catalogue data:
- Feature coordinates
- Related UCLN control points near the feature.
- Feature surface composition. (False ratio Clementine image)

Partial list of data to be gathered.

Convert and import image
Collect ephemeris data

There are many sources for ephemeris data. Traditionally, Jamieson's Lunar Tool Kit 1997 has been used. Other options include LTVT and the USNO's Multi-Year Interactive Computer Almanac.

Moon

Apparent Topocentric Positions
Local Zenith and True North

Dubai
Location: E 55°17'00.0", N25°13'00.0", 0m
(Longitude referred to Greenwich meridian)

Moon

Topocentric Physical Ephemeris: Rotation Parameters

Dubai
Location: E 55°17'00.0", N25°13'00.0", 0m
(Longitude referred to Greenwich meridian)

Date	Time (UT1) h m s	Selenographic Coordinates Earth Lat. °	Earth Long. °	Sun Lat. °	Sun Long. °	Position Angles Axis °	Bright Limb °	Distance to Object km
2007 Mar 11	03:41:02.0	7.547	-6.705	0.11	275.33	9.310	100.80	394757.580
2007 Mar 11	04:41:02.0	7.517	-6.913	0.11	274.82	9.177	100.62	395432.899
2007 Mar 11	05:41:02.0	7.462	-7.083	0.11	274.31	9.028	100.41	396324.609
2007 Mar 11	06:41:02.0	7.387	-7.207	0.12	273.81	8.858	100.17	397363.436
2007 Mar 11	07:41:02.0	7.298	-7.278	0.12	273.30	8.667	99.91	398471.261

The MICA quickly reports an observer's selenographic subEarth latitude and longitude for anywhere on the globe. Lunar distance is used to reduce the image's scale.

Convert and import image
Collect ephemeris data

E) Find your image scale						
1) Find the tilt factor at the feature						
Parameter	Value	Units				
Lunar longitude of object	60.0	deg				
Lunar latitude of object	30.0	deg				
Tilt factor	2.31	scalar				
2) Find the pixel scale of your lunar astrophotograph, adjusting for tilt factor						
	Name	Pixels fro	Altas size	Tilt factor	Pixels per km	
Object1	C. One	100	50.0	2.31	0.87	
Object2	C. Two	50	30.0	2.31	0.72	
Object3	C. Three	200	80.0	2.31	1.08	
Pixel/km conversion factor		0.89	scalar (average)			
Standard deviation		0.18				

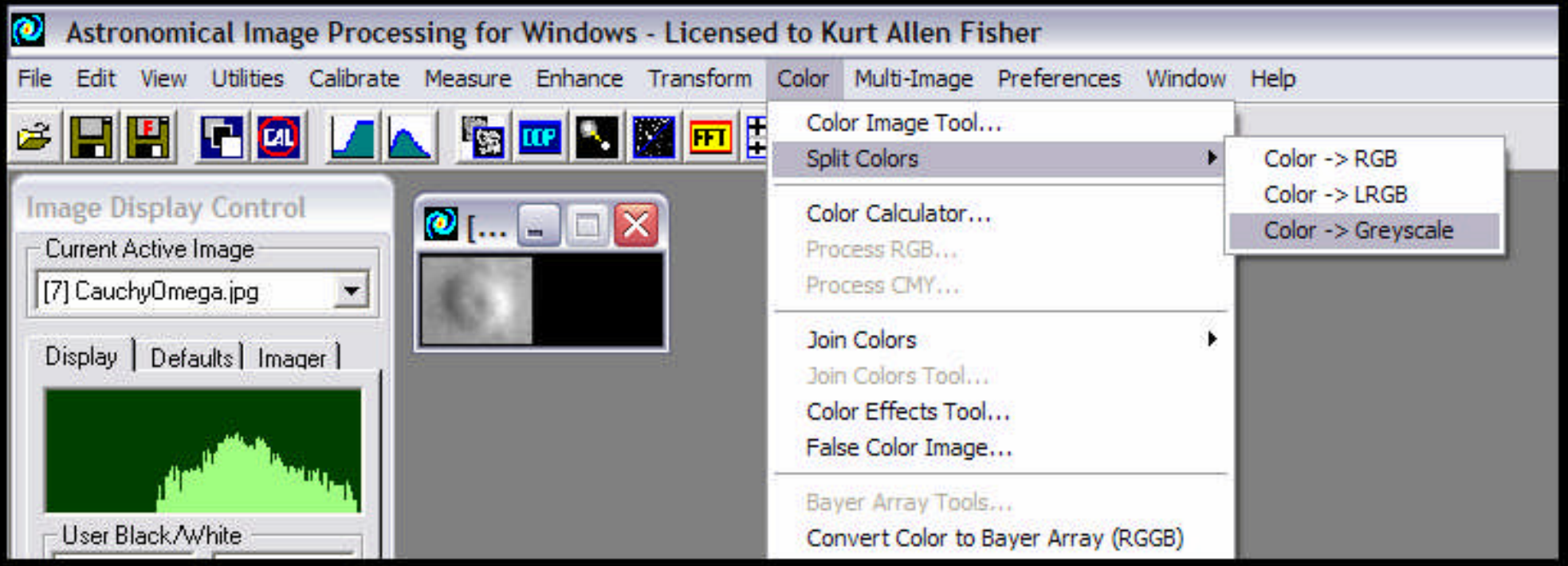
Calculators | StoreImage_InfoLog | StoreIPM_CauchyOmega_Evans2

The Calculators tab in DEMCarlottoMethod.xls has convienence utility calculators that can aid in some reductions, but an authoritative source like Jamieson's Lunar Tools are a better option.

Convert and import image

Convert color source jpg to 8-bit or 16-bit greyscale fits

Most astronomical processing image packages have features to convert a fits or jpg image into an 8-bit greyscale image. The process shown here uses AIP4WIN.

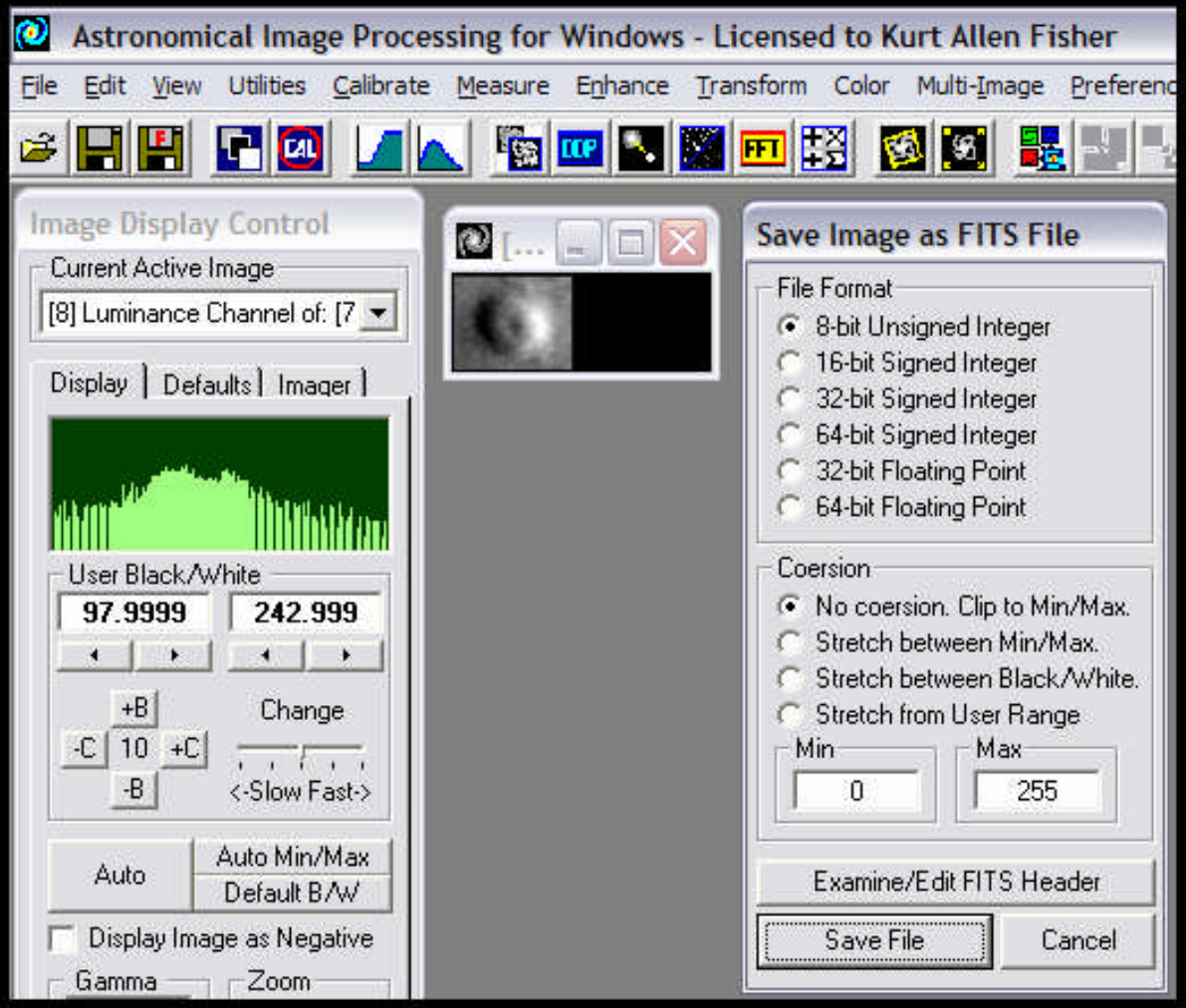


Converting a color jpg to greyscale in AIP4WIN.

Convert and import image

Convert color source jpg to 8-bit or 16-bit greyscale fits

Saving a color fits or jpg as an 8-bit greyscale using AIP4WIN.

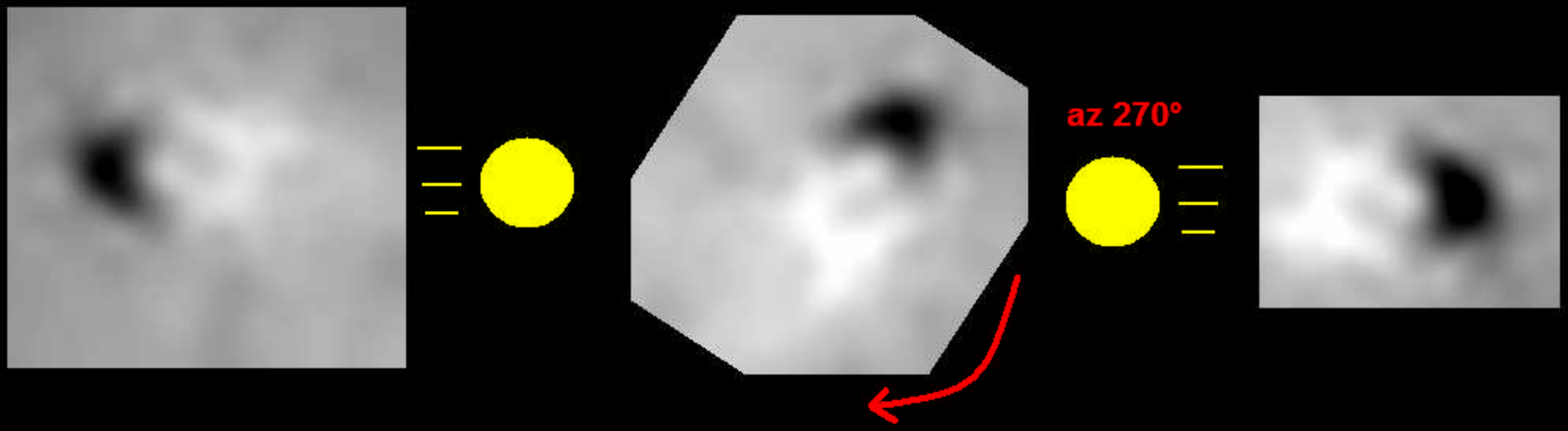


There is no advantage to a 16-bit as opposed to an 8-bit image for a 1000 meter high dome. If the image horizontal resolution is 300 meters, the extra brightness levels in a 16-bit image will not resolve in the DEM.

Convert and import image

Rotate the image so the apparent solar azimuth is 270°

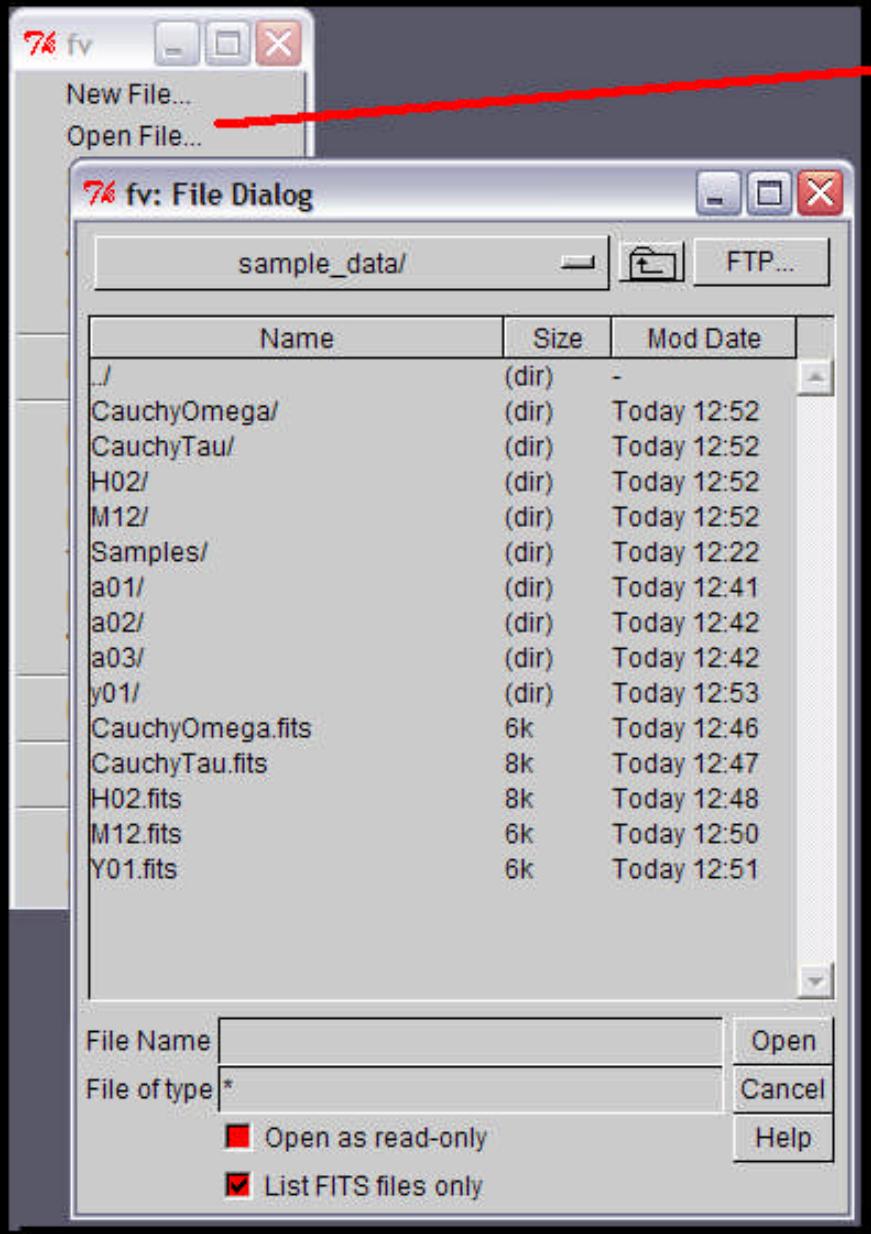
Crop the image



Convert and import image

Export the greyscale image to an NxM csv matrix

The working example shown here will use HEARSAC's FV Tools to digitize the image's pixel brightnesses.

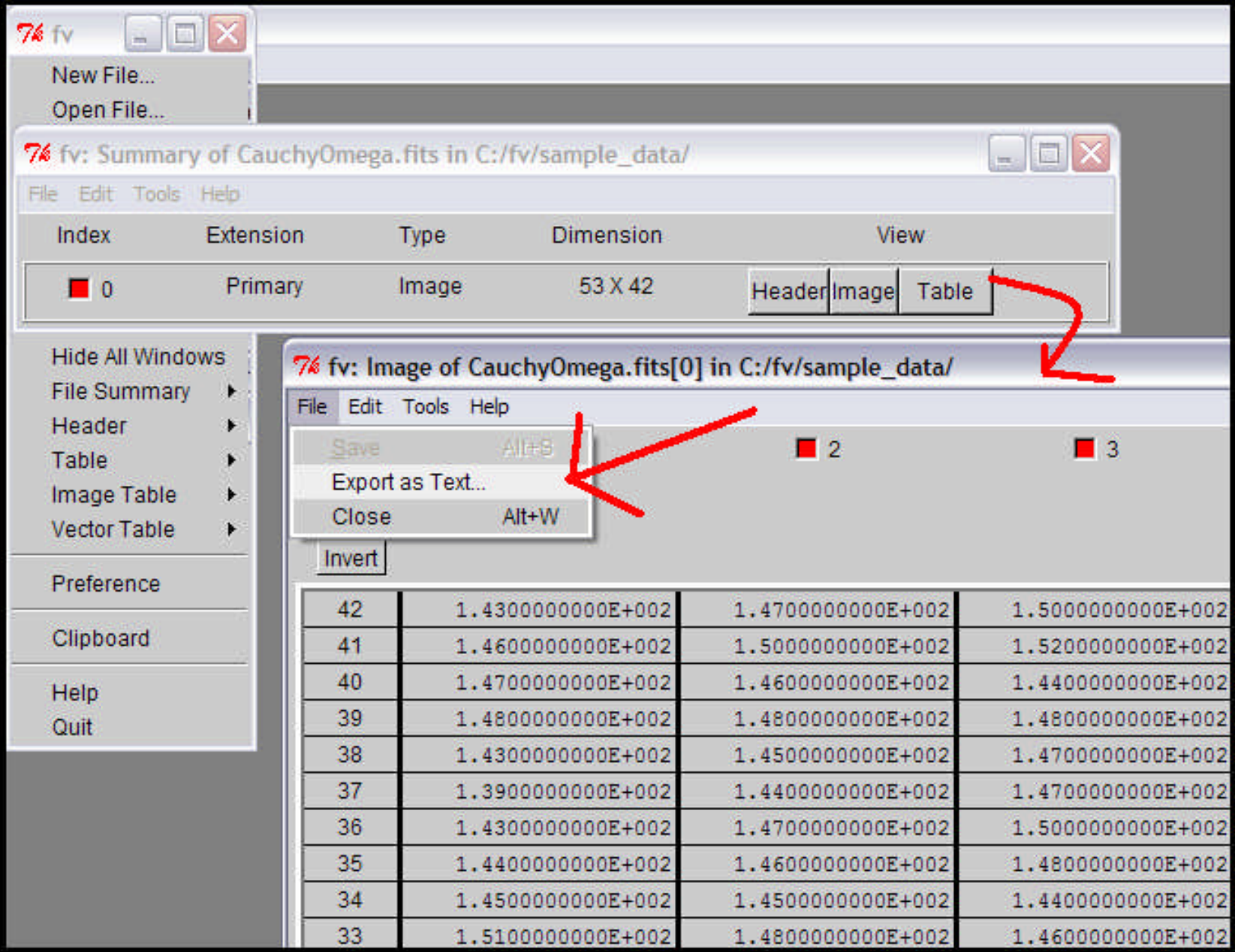


Open the image with the FV Tools "File Open" Menu.

Convert and import image

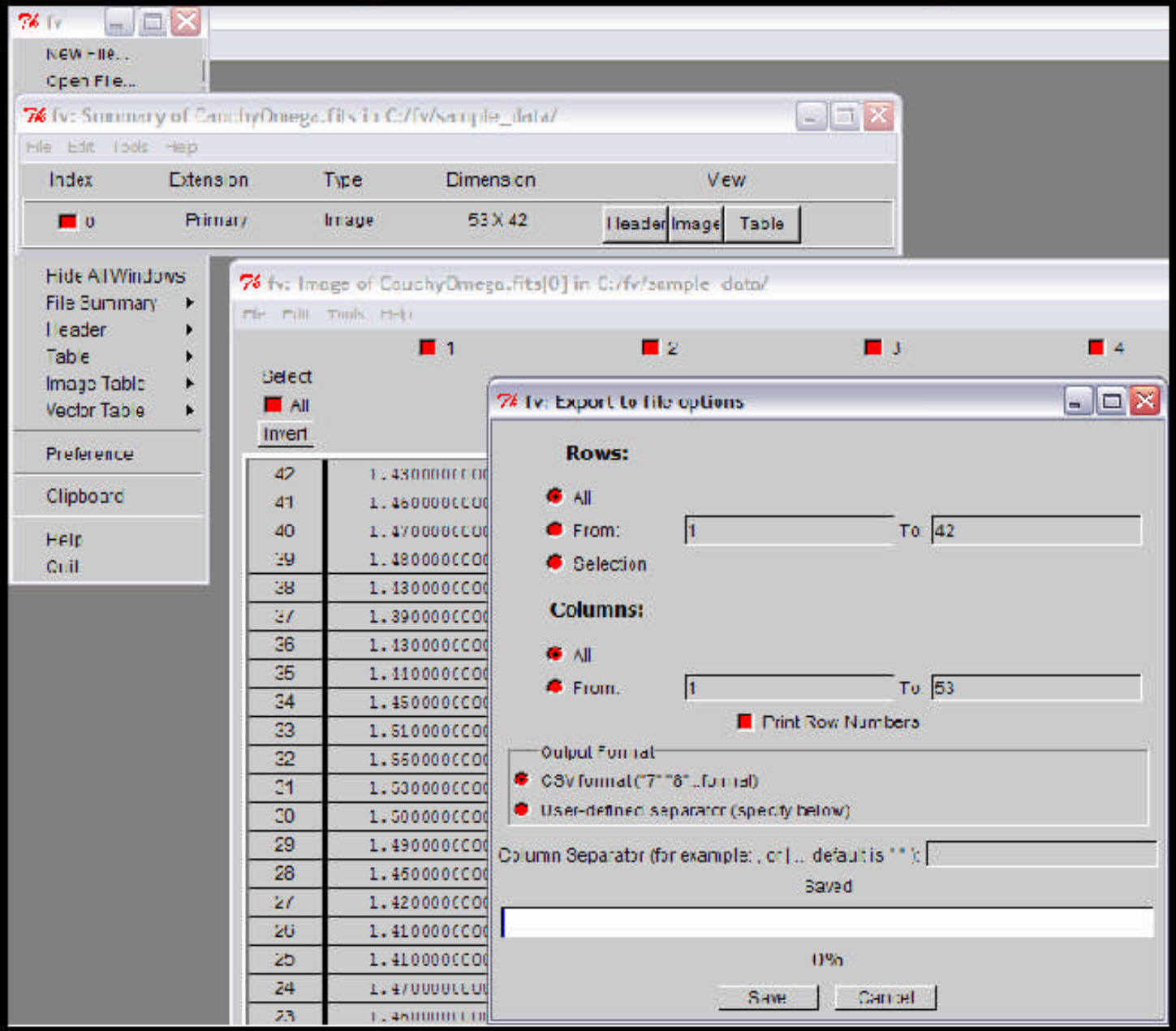
Export the greyscale image to an NxM csv matrix

Once the image is open, use the "Table" option to convert the image's pixel brightnesses to text data.



Convert and import image
Export the greyscale image to an NxM csv matrix

The "Export to Text" option initiates conversion to a csv text file.
You can select a range of pixel rows and columns to export.



Convert and import image

Import the csv data as an Excel worksheet

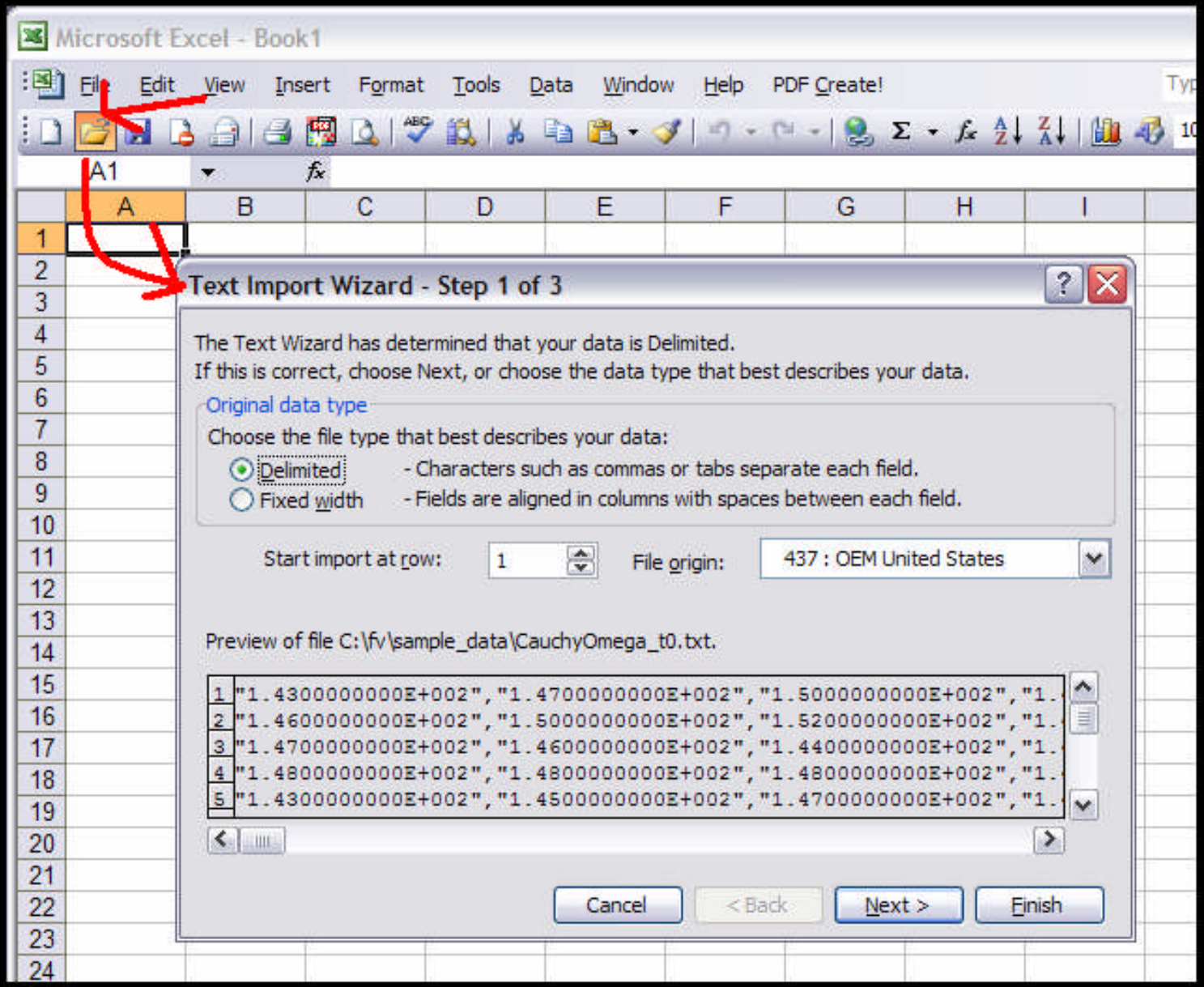
HEARSAC FV Tools has now created a csv file that contains the rows and columns of pixels digitized as brightness integers between 0 and 255.

In the following step, you will importing this csv file into a temporary Excel spreadsheet. In a later final step, this temporary Excel worksheet will be copied into DEMCarlottoMethod.xls.

Convert and import image

Import the csv data as an Excel worksheet

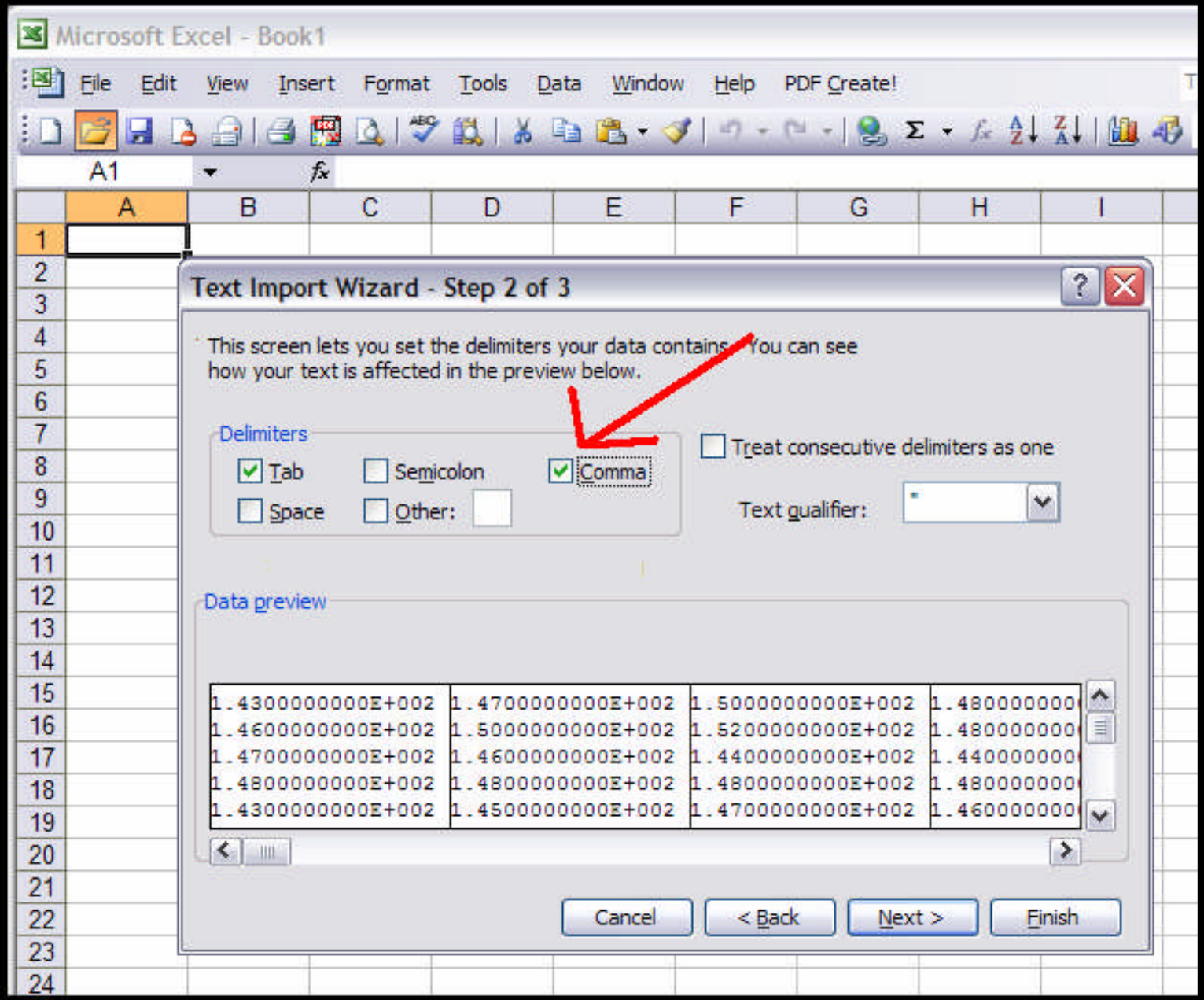
Use Excel's "File | Open" option to open your csv text file. Opening the csv file start's Excel's text import wizard.



Convert and import image

Import the csv data as an Excel worksheet

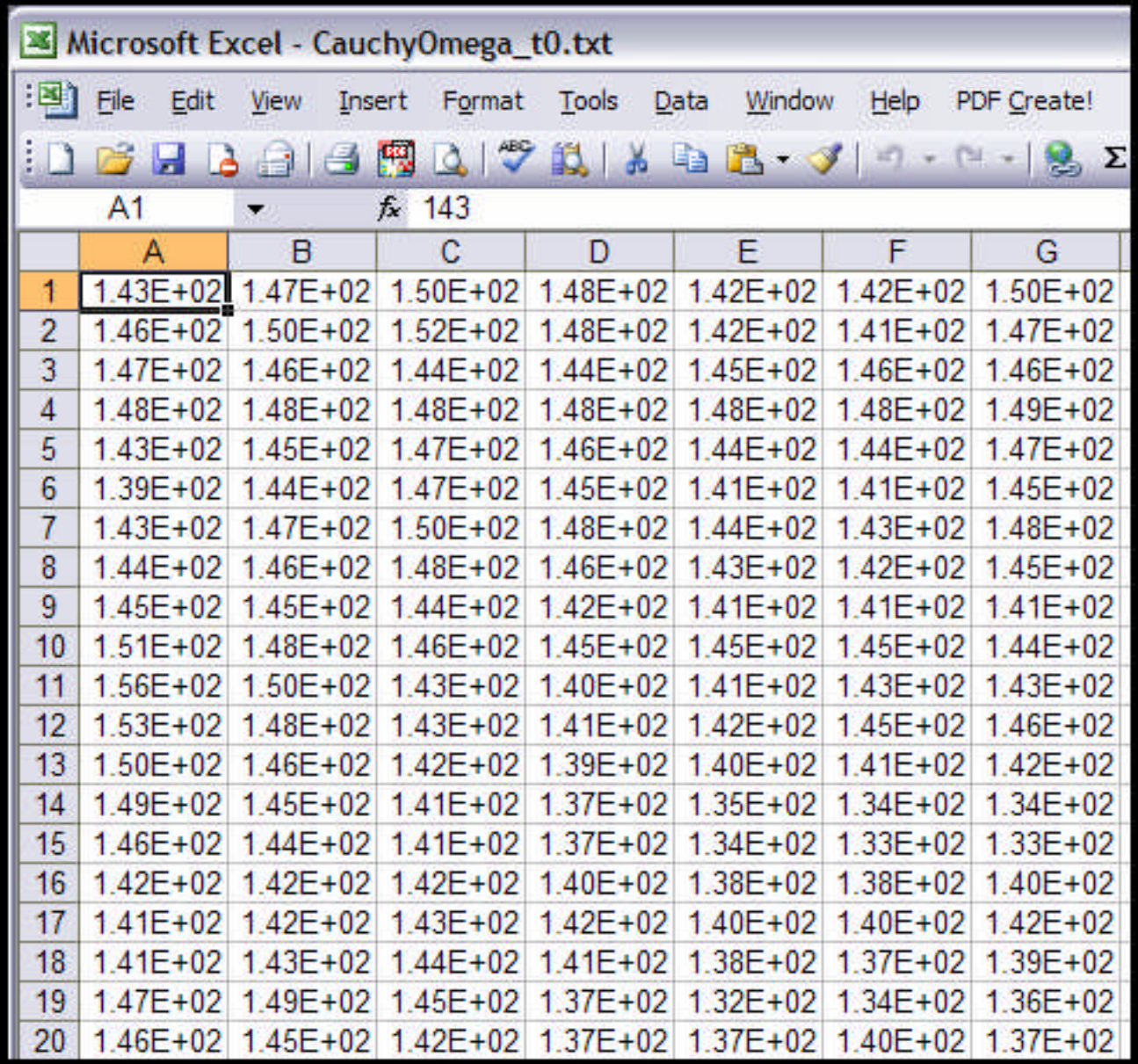
Set the option to separate fields using a comma character.



Convert and import image

Import the csv data as an Excel worksheet

The import wizard will import the text in scientific notation.

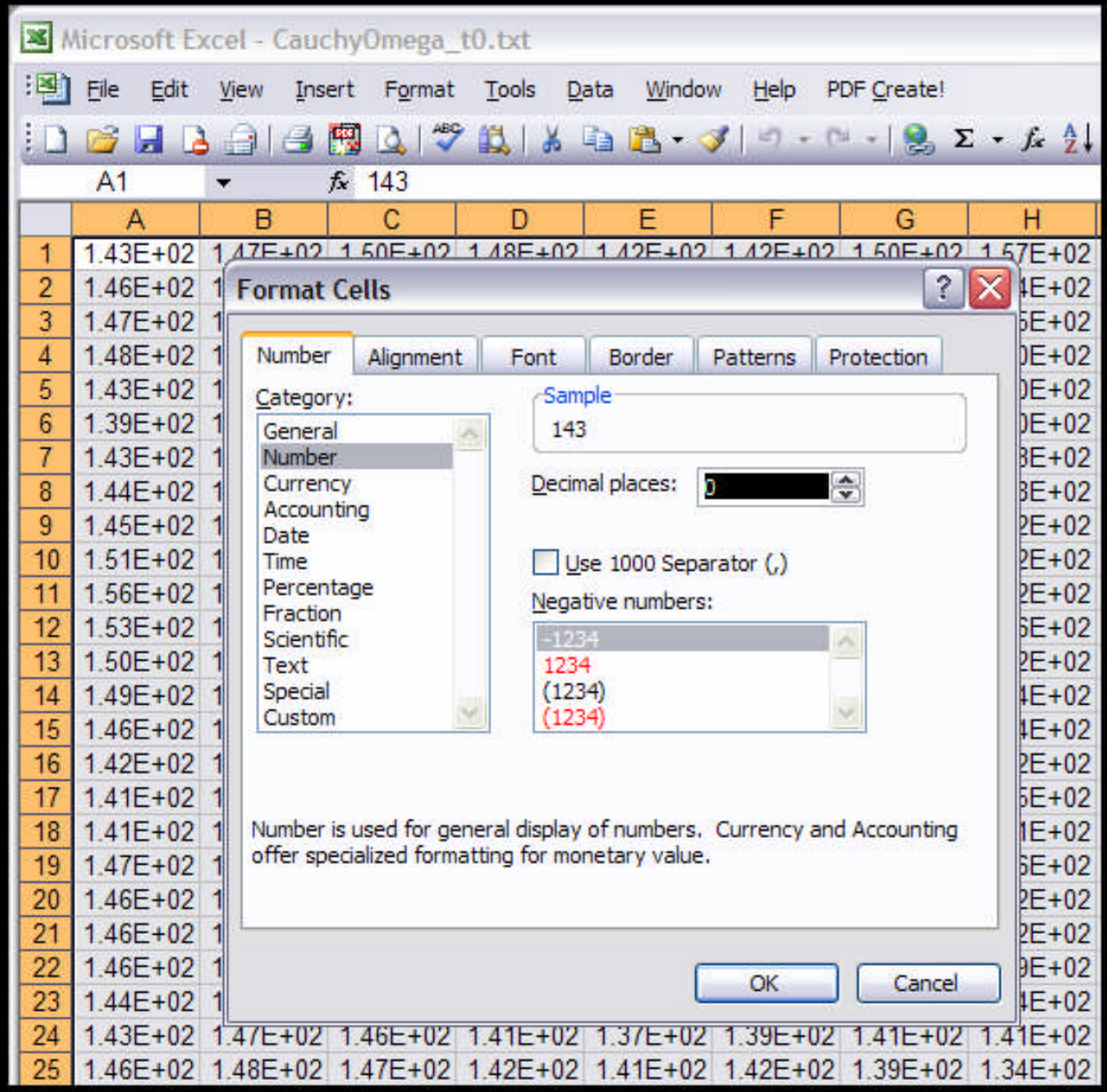


	A	B	C	D	E	F	G
1	1.43E+02	1.47E+02	1.50E+02	1.48E+02	1.42E+02	1.42E+02	1.50E+02
2	1.46E+02	1.50E+02	1.52E+02	1.48E+02	1.42E+02	1.41E+02	1.47E+02
3	1.47E+02	1.46E+02	1.44E+02	1.44E+02	1.45E+02	1.46E+02	1.46E+02
4	1.48E+02	1.48E+02	1.48E+02	1.48E+02	1.48E+02	1.48E+02	1.49E+02
5	1.43E+02	1.45E+02	1.47E+02	1.46E+02	1.44E+02	1.44E+02	1.47E+02
6	1.39E+02	1.44E+02	1.47E+02	1.45E+02	1.41E+02	1.41E+02	1.45E+02
7	1.43E+02	1.47E+02	1.50E+02	1.48E+02	1.44E+02	1.43E+02	1.48E+02
8	1.44E+02	1.46E+02	1.48E+02	1.46E+02	1.43E+02	1.42E+02	1.45E+02
9	1.45E+02	1.45E+02	1.44E+02	1.42E+02	1.41E+02	1.41E+02	1.41E+02
10	1.51E+02	1.48E+02	1.46E+02	1.45E+02	1.45E+02	1.45E+02	1.44E+02
11	1.56E+02	1.50E+02	1.43E+02	1.40E+02	1.41E+02	1.43E+02	1.43E+02
12	1.53E+02	1.48E+02	1.43E+02	1.41E+02	1.42E+02	1.45E+02	1.46E+02
13	1.50E+02	1.46E+02	1.42E+02	1.39E+02	1.40E+02	1.41E+02	1.42E+02
14	1.49E+02	1.45E+02	1.41E+02	1.37E+02	1.35E+02	1.34E+02	1.34E+02
15	1.46E+02	1.44E+02	1.41E+02	1.37E+02	1.34E+02	1.33E+02	1.33E+02
16	1.42E+02	1.42E+02	1.42E+02	1.40E+02	1.38E+02	1.38E+02	1.40E+02
17	1.41E+02	1.42E+02	1.43E+02	1.42E+02	1.40E+02	1.40E+02	1.42E+02
18	1.41E+02	1.43E+02	1.44E+02	1.41E+02	1.38E+02	1.37E+02	1.39E+02
19	1.47E+02	1.49E+02	1.45E+02	1.37E+02	1.32E+02	1.34E+02	1.36E+02
20	1.46E+02	1.45E+02	1.42E+02	1.37E+02	1.37E+02	1.40E+02	1.37E+02

Convert and import image

Import the csv data as an Excel worksheet

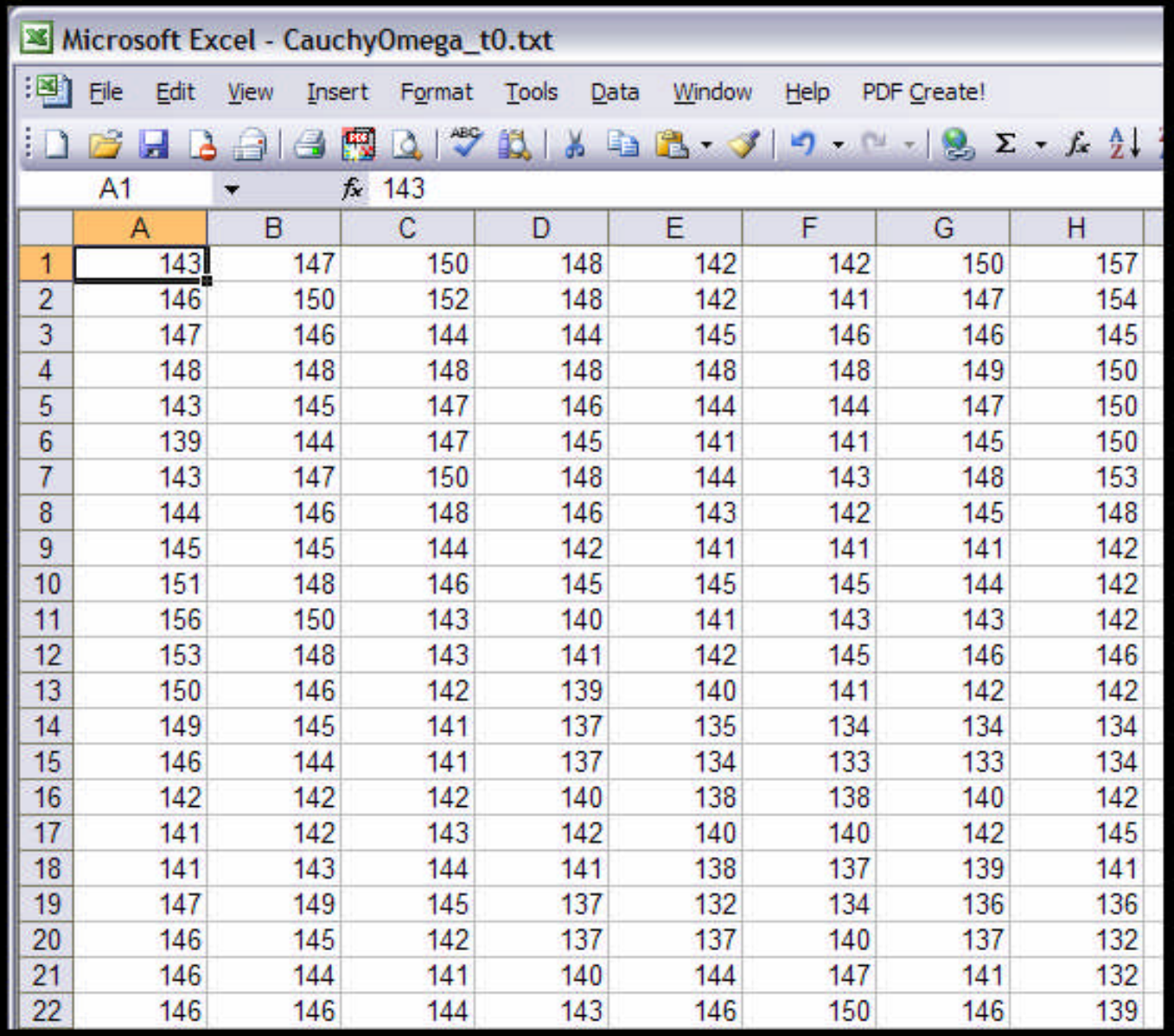
Select all the cells and reformat them as integers.



Convert and import image

Import the csv data as an Excel worksheet

After reformatting, the image pixel value map is not ready for copying into DEMCarlottoMethod.xls.

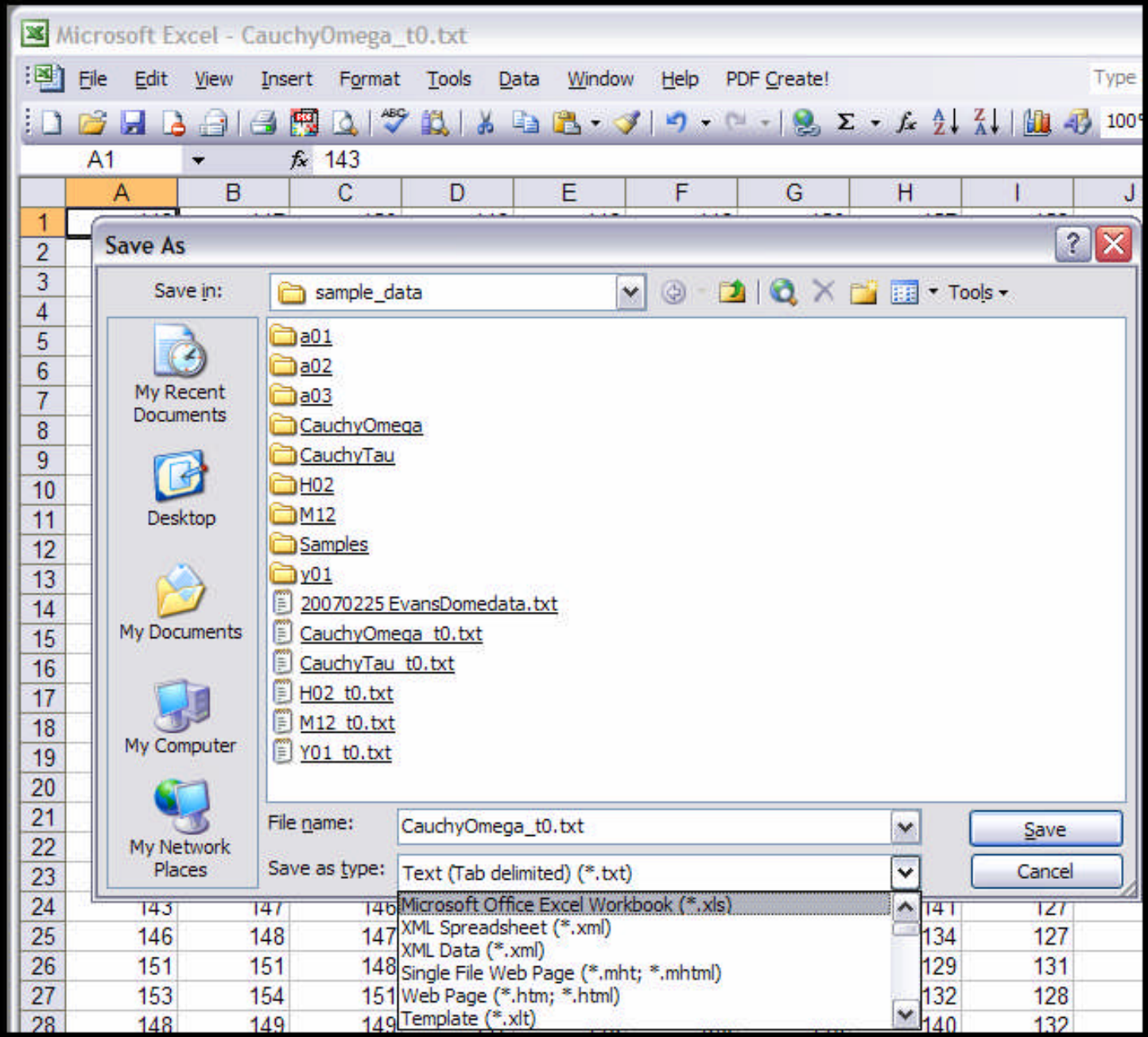


	A	B	C	D	E	F	G	H
1	143	147	150	148	142	142	150	157
2	146	150	152	148	142	141	147	154
3	147	146	144	144	145	146	146	145
4	148	148	148	148	148	148	149	150
5	143	145	147	146	144	144	147	150
6	139	144	147	145	141	141	145	150
7	143	147	150	148	144	143	148	153
8	144	146	148	146	143	142	145	148
9	145	145	144	142	141	141	141	142
10	151	148	146	145	145	145	144	142
11	156	150	143	140	141	143	143	142
12	153	148	143	141	142	145	146	146
13	150	146	142	139	140	141	142	142
14	149	145	141	137	135	134	134	134
15	146	144	141	137	134	133	133	134
16	142	142	142	140	138	138	140	142
17	141	142	143	142	140	140	142	145
18	141	143	144	141	138	137	139	141
19	147	149	145	137	132	134	136	136
20	146	145	142	137	137	140	137	132
21	146	144	141	140	144	147	141	132
22	146	146	144	143	146	150	146	139

Convert and import image

Import the csv data as an Excel worksheet

Finally, save your text file from Excel as an Excel spreadsheet.



Convert and import image

Working files created to this point.

8-bit rectified greyscale conversion fits-jpg

Original color fits image

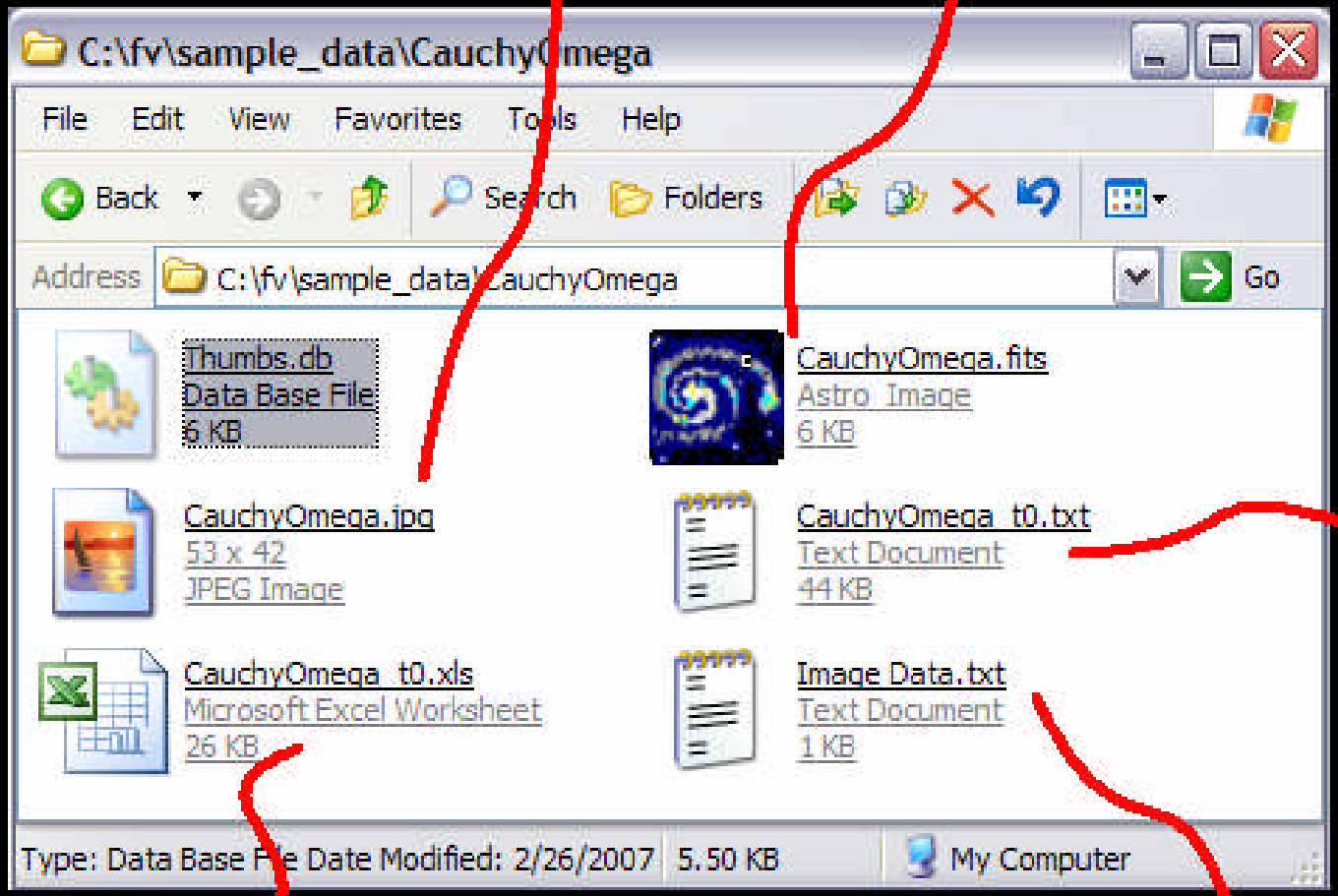


Image converted to csv data

csv data saved as an Excel worksheet

Notes on image characteristics and ephemeris data

Convert and import image

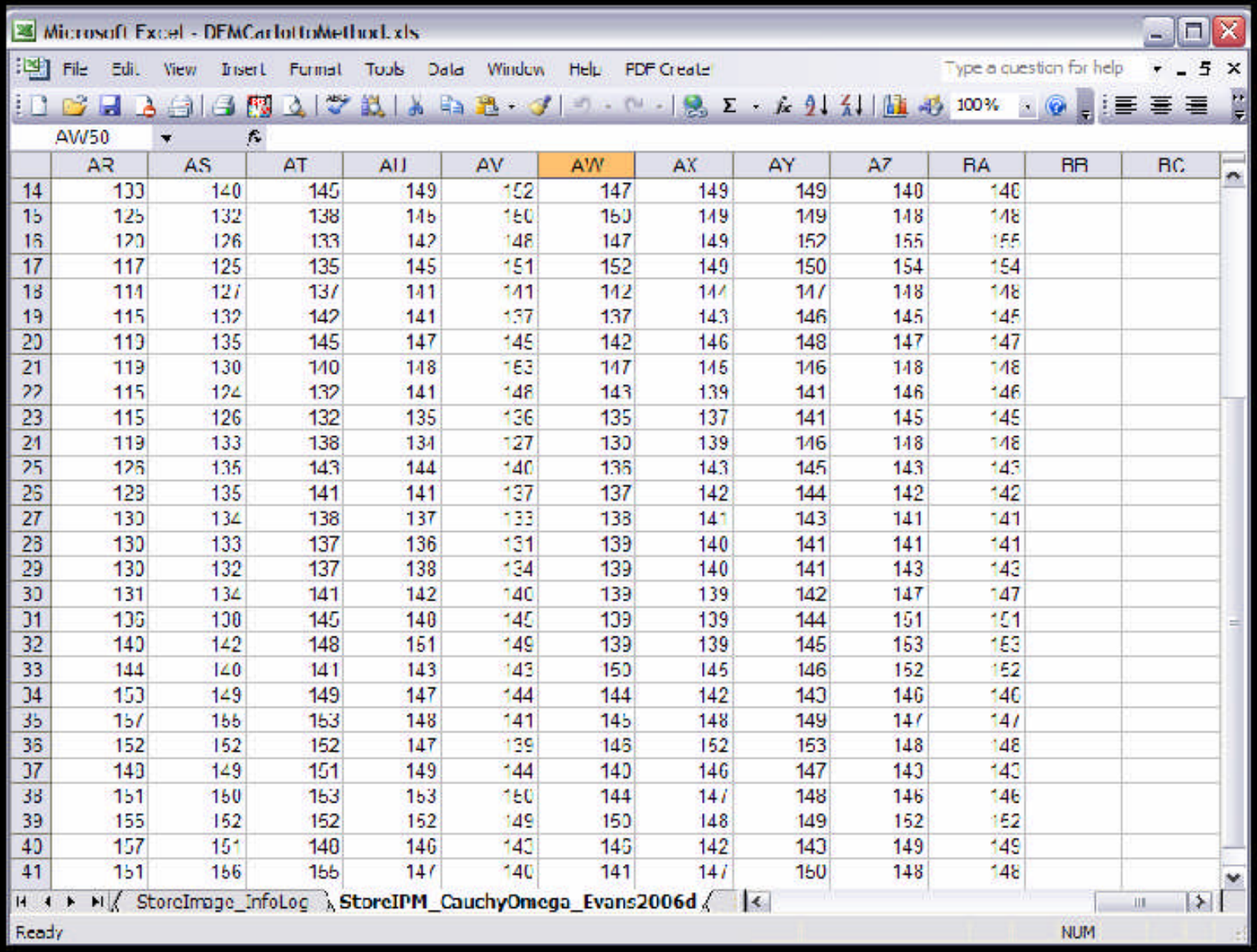
Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

The next step in the process involves moving the image pixel value map in the temporary Excel worksheet into DEMCarlottoMethod.xls.

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

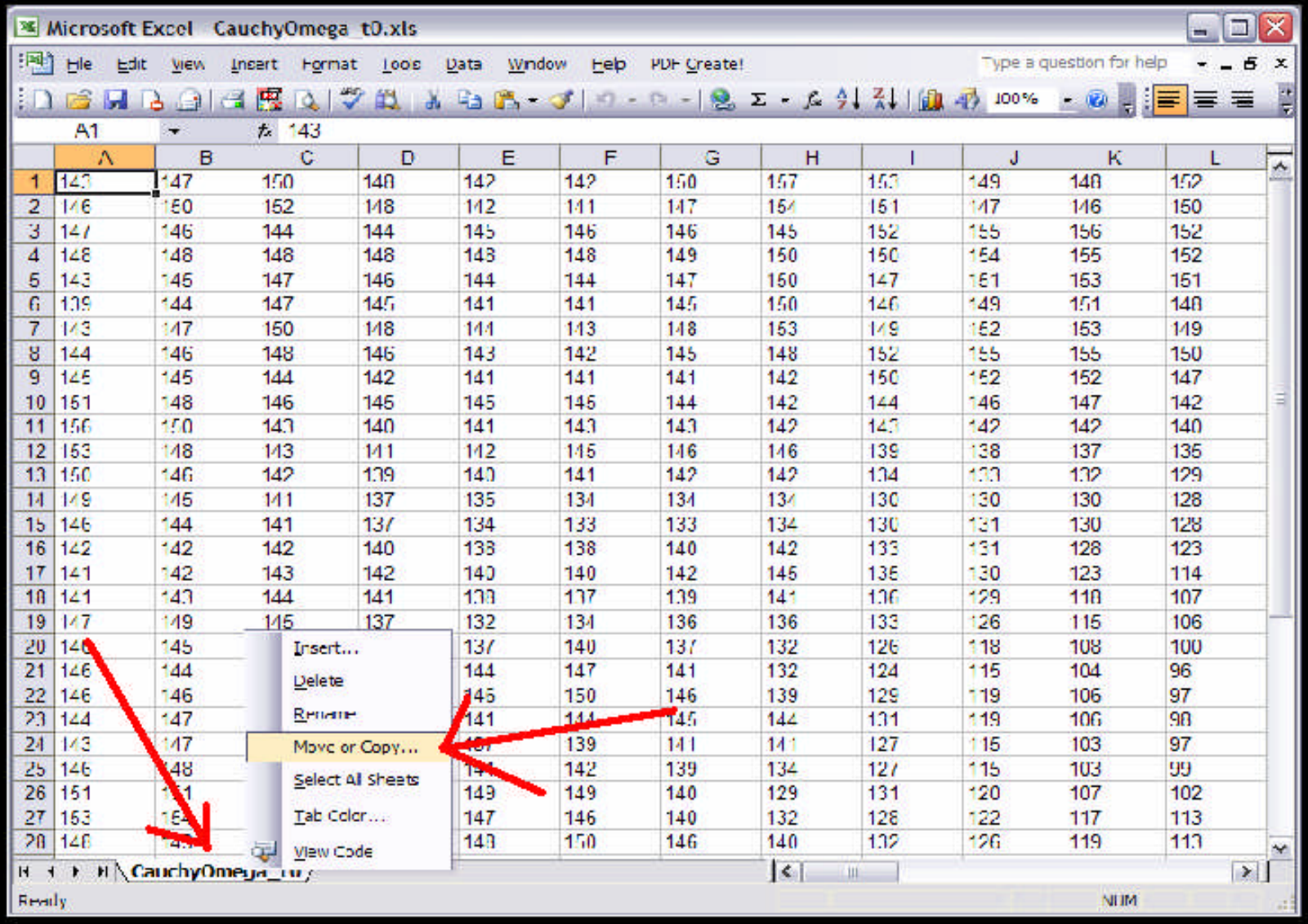
Open DEMCarlottoMethod.xls



Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

Open the temporary spreadsheet that contains your image pixel value map.

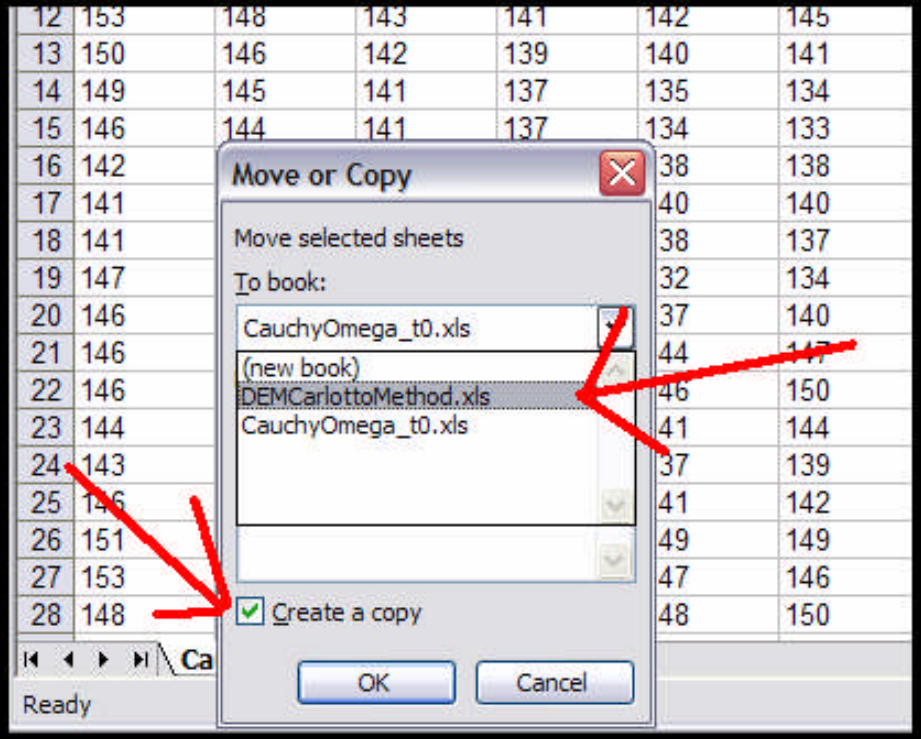


Then right-click on the worksheet tab to begin the move-copy process.

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

In the move dialogue box, set the target "to book" to DEMCarlottoMethod.xls.

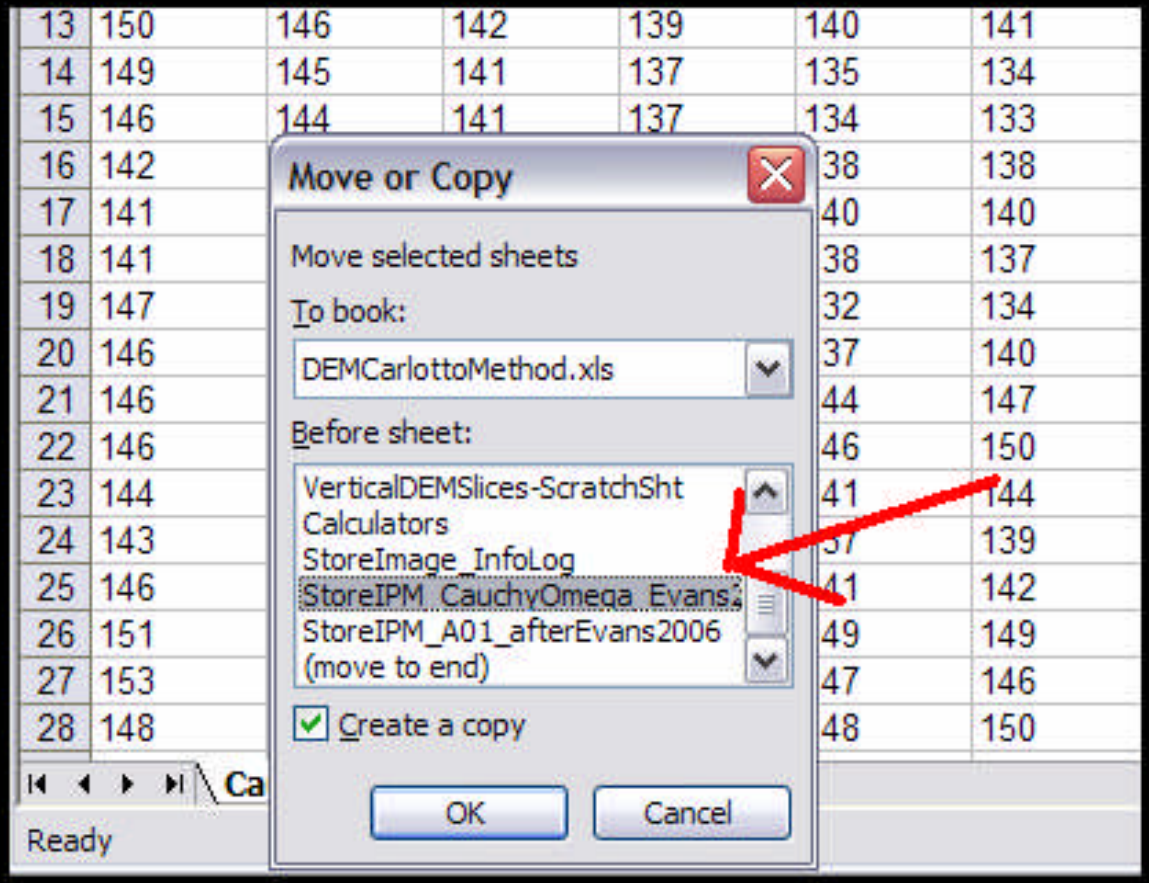


Check the "Create a copy" option button.

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

Again responding to the move/copy worksheet dialogue, set the position inside DEMCarlottoMethod.xls where you want to copy your new image pixel value map.

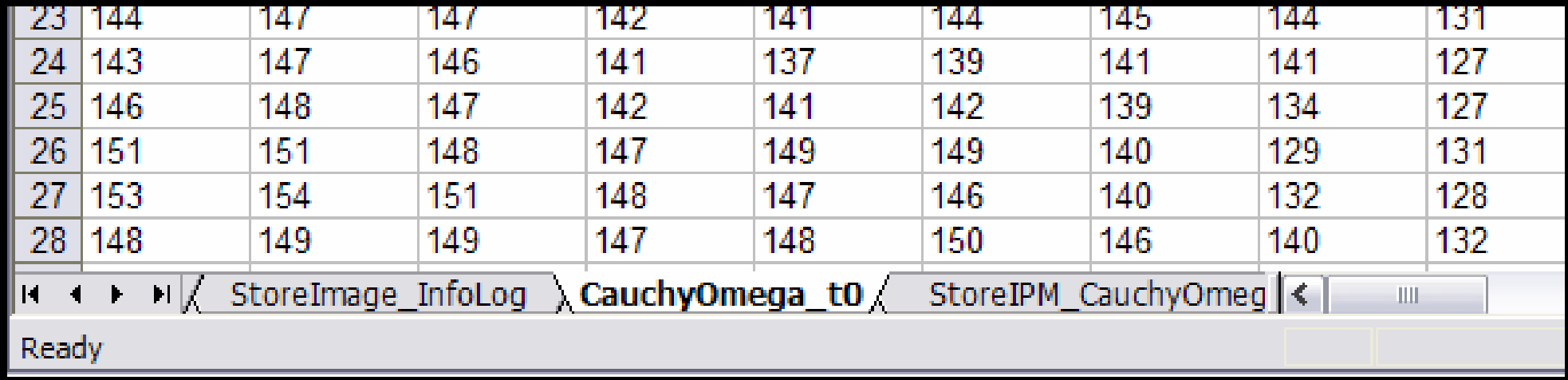


In the example, we will move the new image pixel map for storage after the StoreImage_InfoLog worksheet.

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

Executing the move/copy operation copies your new image data for storage in DEMCarlottoMethod.xls.

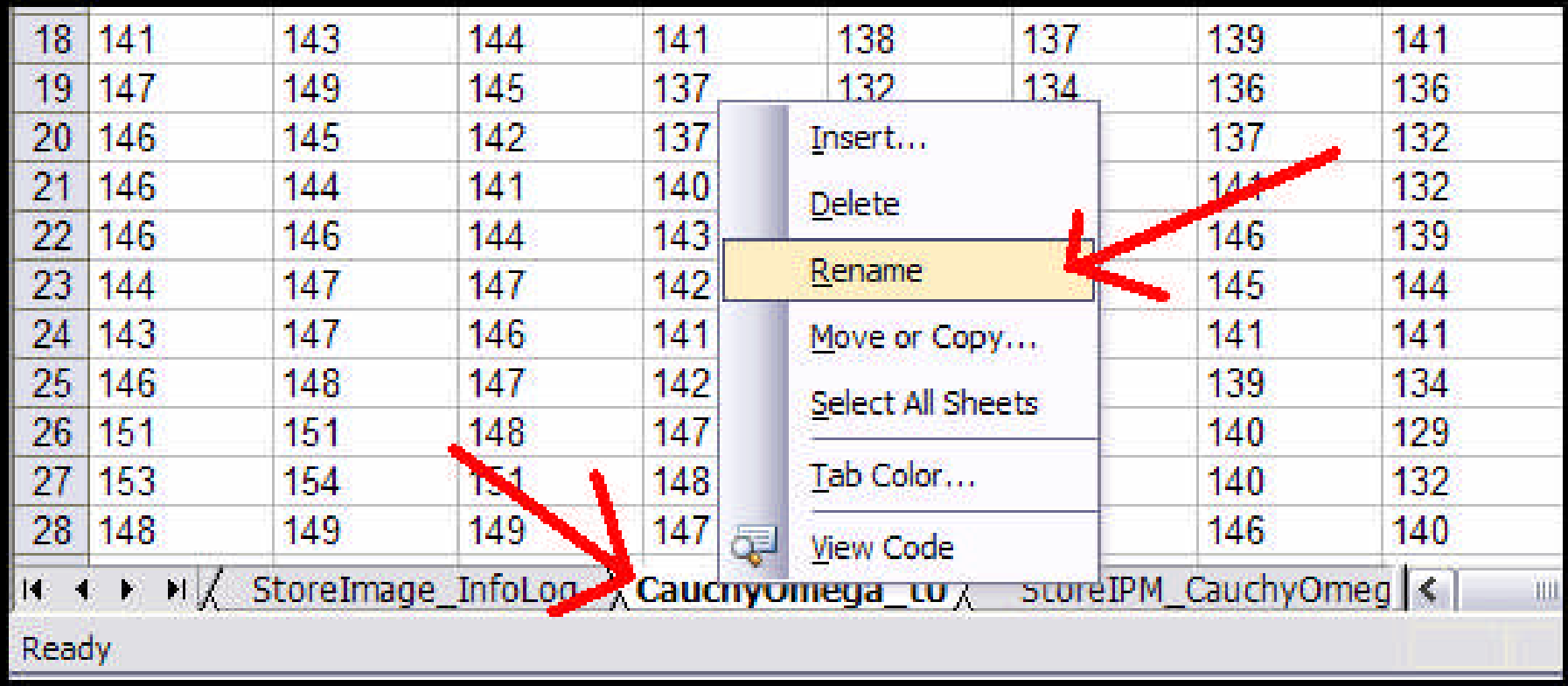


23	144	147	147	142	141	144	145	144	131
24	143	147	146	141	137	139	141	141	127
25	146	148	147	142	141	142	139	134	127
26	151	151	148	147	149	149	140	129	131
27	153	154	151	148	147	146	140	132	128
28	148	149	149	147	148	150	146	140	132

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

This worksheet inside DEMCarlottoMethod.xls is a permanent storage worksheet for the image's pixel values. To rename the worksheet something meaningful, right-click the worksheet's tab.



Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

A new name has been assigned to the stored data.

20	146	145	142	137	137	140	137	132	126
21	146	144	141	140	144	147	141	132	124
22	146	146	144	143	146	150	146	139	129
23	144	147	147	142	141	144	145	144	131
24	143	147	146	141	137	139	141	141	127
25	146	148	147	142	141	142	139	134	127
26	151	151	148	147	149	149	140	129	131
27	153	154	151	148	147	146	140	132	128
28	148	149	149	147	148	150	146	140	132

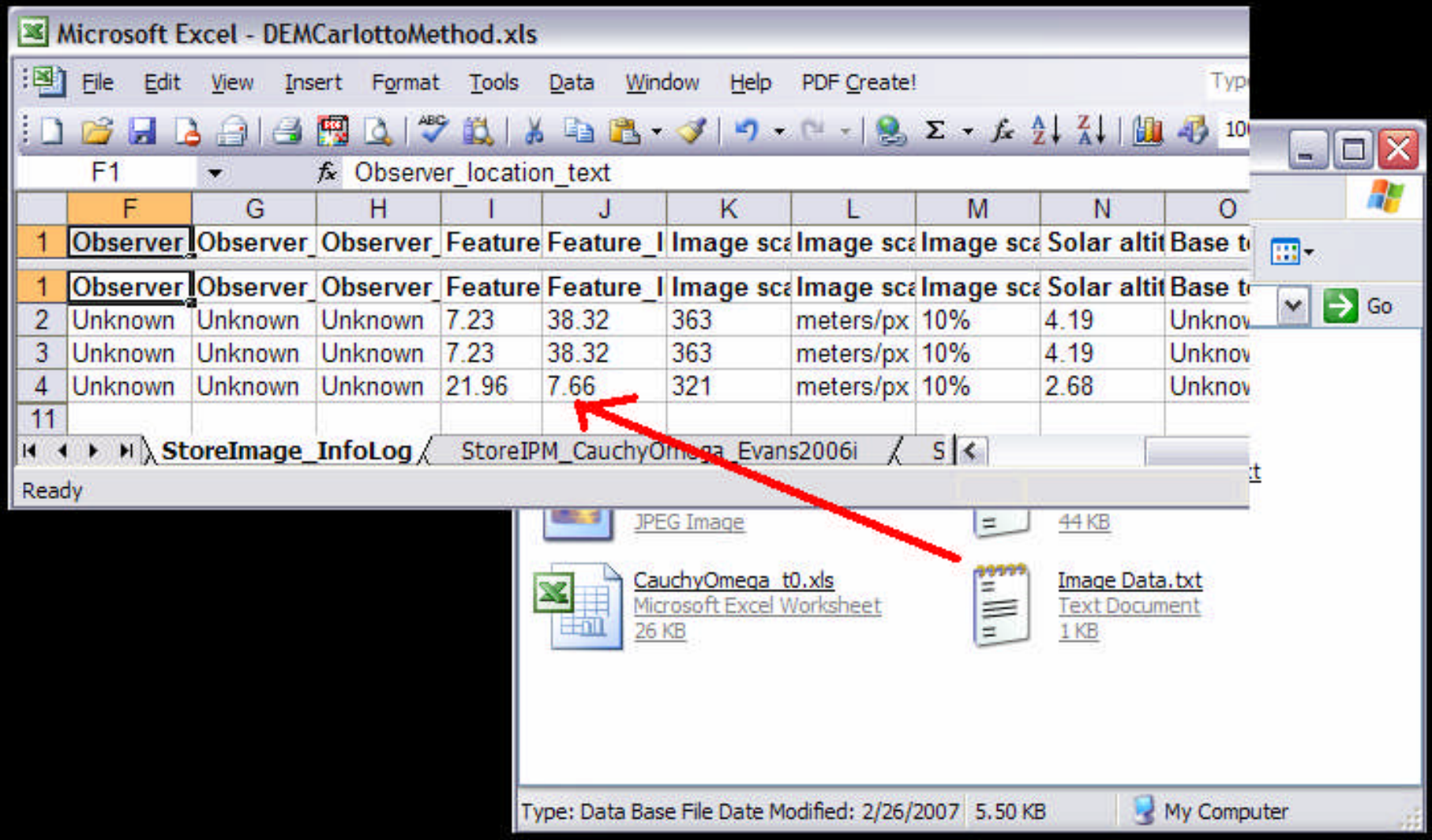
StoreImage_InfoLog | **StoreIPM_CauchyOmega_Evans2006i** | S

Ready

Convert and import image

Copy/move the NxM matrix in the Excel worksheet to a storage worksheet in DEMCarlottoMethod.xls

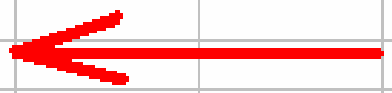
Finally, update the image's data to the image info log.



Convert and import image

Normally, the next step would be to proces the image data into a DEM by moving the new image pixel value map to the working image pixel map. That process was covered in the "Spreadsheet Parts" presentation beginning at Slide 40.

1	Shape from Shading Utility after Carlotto 1996 and Evans 2006				Version:	pre-al
2	for Microsoft Office for Windows (not compatible with MS Office for Mac)					
3						
4	A - Process image to digital elevation map					
5						
6	Step 1 - Paste source image's luminance pixel values into worksheet ImagePixelValueMap					
7	as an NxM matrix					
8						
9	Step 2 - Identify the range of the image pixel values to this spreadsheet					
10						
11		2a	Enter the upper left-hand pixel cell name:	$A$1	as absolute cell reference, e	
12		2b	Enter the lower right-hand pixel cell name:	$AJ$26	as absolute cell reference, e	
13		2c	Click button to identify and name the range:			
14		Name pixel range				
15			Current value:	ImagePixelValueMap!$A$1:$AJ$26		
16						
17		Clear Image Pixel Map				



Review of learning goals for Part 3

1) The image is rectified and then rotated so the apparent solar azimuth is 270°.

2) The rectified image is saved as an 8-bit greyscale fits.

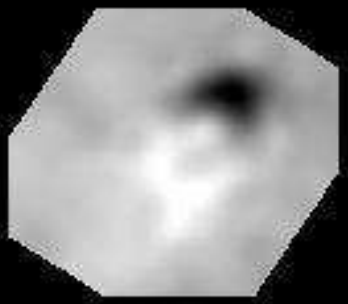
3) The greyscale fits is converted to csv text data using HEARSAC's FV Tools.

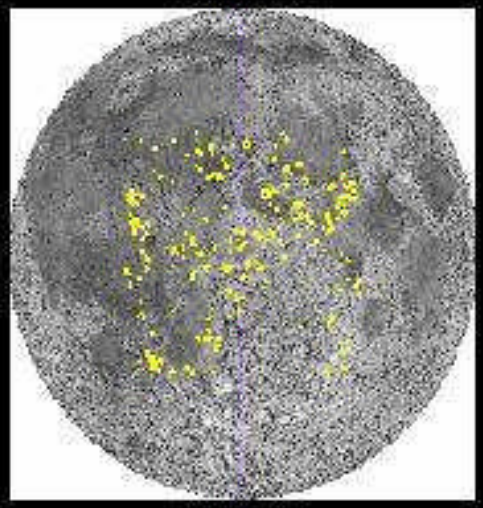
4) The csv text data is imported to a temporary working Excel worksheet and spreadsheet.

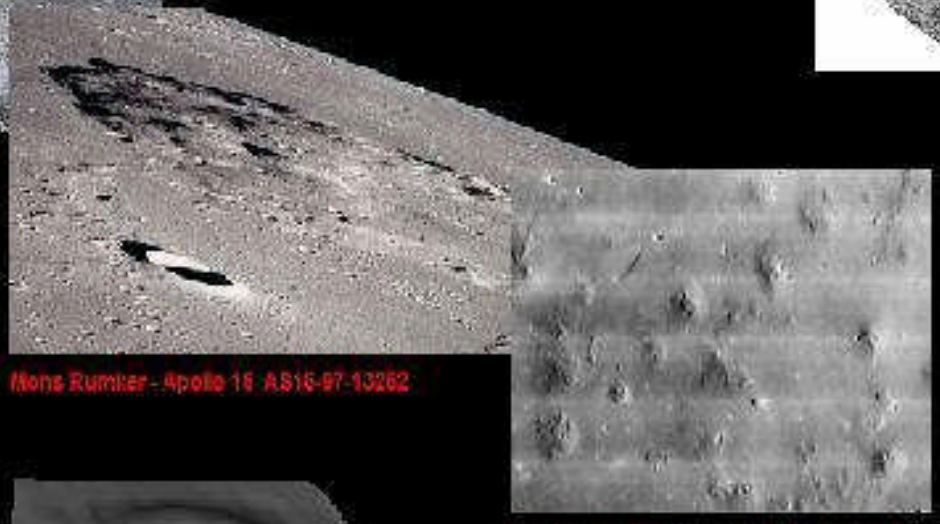
5) The temporary worksheet is imported for long-term storage into DEMCarlottoMethod.xls.

End of Part 3: Convert images and import

Katima, Alaska







Mons Rumker - Apollo 16 AS16-97-13262

Marius Hills - Lunar Orbiter IV - IV-164H2

3D floating point

z-plane fx