

OPERA ArcGIS Pro Toolbox

Version 1.1

**Dinuke Munasinghe, Matthew Bonnema, Renato Prata de Moraes Frasson,
Alexander L. Handwerger, Steven Chan, David Bekaert**

Jet Propulsion Laboratory, California Institute of Technology

The research was carried out at the Jet Propulsion Laboratory, California Institute of Technology, under a contract with the National Aeronautics and Space Administration (80NM0018D0004).

© 2024 California Institute of Technology. Government sponsorship acknowledged.



Document Change Log

Revision	Cover Date	Sections Changed	Reason
V 1.0	12 April 2024	All Sections	First version of Document
V 1.1	27 May 2024	All Sections	Added Updated Version of OPERA Granule Downloader to the Toolbox

1.0 Introduction

1.1 Document Purpose

This document details the functionality of the OPERA ArcGIS Toolbox-Version1.1 (OPERA: Observational Products for End-users from Remote-sensing Analysis) developed to download the OPERA Level-3 Dynamic Surface Water Extent from Harmonized Landsat Sentinel-2 (DSWx-HLS) product, OPERA Level-3 Surface Disturbance Alert from Harmonized Landsat Sentinel-2 (DIST-ALERT) product, and OPERA Level-2 Radiometric Terrain Corrected SAR backscatter product from Sentinel-1 (RTC-S1). The toolbox also allows for the mosaicking of DSWx-HLS granules based on priority Land use/Land cover categories. For details of the OPERA project please refer to the [Product Specification Document](#).

1.2 Document Organization

Section 2 lists the prerequisites needed to use the toolbox.

Section 3 provides a detailed description of the geoprocessing tools in the toolbox.

Section 4 provides an illustrated walk-thorough of the tools' functionality.

Section 5 provides possible tool failure scenarios and troubleshooting support.

Section 6 provides details on acknowledgements and contact information for feedback on tools.

Appendix A provides an understanding of the minimum bounding geometry used in selection of granules.

Appendix B explains the DSWx-HLS class prioritization process used to mosaic OPERA granules.

2.0 Prerequisites:

2.1 Earth Data Credentials

[NASA Earth Data](#) hosts NASA's Earth Science data collections. Therefore, an Earth Data account is required to access OPERA granules archived on PO.DAAC (Physical Oceanography Distributed Active Archive Center), LP DAAC (Land Processes Distributed Active Archive Center) and ASF DAAC (Alaska Satellite Facility Distributed Active Archive Center). An account can be created at <https://urs.earthdata.nasa.gov/>.

2.1 Software/License Requirements

This is an ArcGIS Pro toolbox developed for ArcGIS Pro software to download and manipulate OPERA products. The ArcGIS Spatial Extension must be activated to run the tools.

3.0 The OPERA ArcGIS Pro Toolbox

3.1 Toolbox Overview

The toolbox contains three geoprocessing tools.

- (a) OPERA Granule Downloader
- (b) OPERA Granule Filter
- (c) OPERA Raster Mosaic

These tools:

- (a) Download OPERA DSWx-HLS granules from PO.DAAC.
Download OPERA DIST-ALERT granules from LP DAAC.
Download OPERA RTC-S1 granules from ASF DAAC.
- (b) Filter OPERA DSWx-HLS granules from the downloaded stack in (a) or from a previously downloaded stack based on a user-provided date range and Area of Interest (AOI). Optional functionality copies subsets of granules into a separate folder based on filter parameters.
- (c) Composite and mosaic OPERA DSWx-HLS granules based on user-provided land cover priorities (The mosaic operator will choose the prioritized land cover class in areas where granules overlap).

Detailed descriptions of the tools are provided in section 3.2 *Geoprocessing Tools in the Toolbox* and functionalities are demonstrated by way of image-walkthrough in section 4.0 *Tool Functionality*.

The toolbox contains:

- Toolbox Documentation (Documentation_OPERA ArcGISProToolbox_V1.1.pdf)
- The OPERA ArcGIS Pro Toolbox
- a folder with the Global MGRS (Military Grid Reference System) shapefile (mgrs_region.shp): This grid is used to query OPERA DSWx-HLS granules on PO.DAAC based on the user-provided AOI.
- a color ramp file (colorramp.clr): This is used to preserve original OPERA DSW-HLS color ramp information during geoprocessing.

NOTE: The MGRS grid shapefile and the colorramp.clr file are required to successfully run the tools. Please refrain from deleting/changing folder paths relative to its current location.

3.2 Geoprocessing Tools in the Toolbox

3.2.1 OPERA Granule Downloader

Tool Description:

This tool is used to download OPERA DSWx-HLS, OPERA DIST-ALERT-HLS, and OPERA RTC-S1 granules from PO.DAAC, LP DAAC and ASF DAAC based on a user-provided date range and AOI.

Tool Parameters:

Parameter	Parameter Description	Parameter Function/Notes
Start Date ^R	Start Date for granule search	All OPERA granules from start date until end date are queried. Start date is included in the query. The end date is NOT included in the query. Currently only the 'date' option in the radio buttons is supported. 'Date and Time' and 'Time' are not supported.
End Date ^R	End Date for granule search	
Area of Interest ^R	The Geographical Region for granule search.	This can either be a (a) point(s), line(s) or polygon(s) shapefile, or (b) interactively drawn point(s), line(s) or polygon(s) on the ArcGIS Pro Map Frame. Images are queried based on a minimum bounding box principle using the point(s), line(s) or polygon(s) provided. Please see Appendix A for the details on the creation of the minimum bounding box.
Output Location ^R	Folder where the granules will be downloaded into.	A new folder can be created using the browse icon or the dialog box for the Output Location. The browse icon allows the user to set the location to an already existing folder, or to create a new folder. A folder name given in the parameter dialog box will create a folder in the current map geodatabase.
Visualize downloaded granules in contents pane ^O	Enables the automatic visualization of downloaded granules in the contents pane with metadata enhancement.	Automatic visualization of granules in the contents pane allows easy ingestion of granules into the "OPERA Raster Mosaic". Users can pick and choose granules (i.e., exclude high cloud cover granules, exclude granules that are marginally intersecting the AOI) during the creation of the mosaic. The automatically visualized granules are metadata enhanced. For OPERA DSWx-HLS;

		<p>class labels are added in place of underlying integer values for ease of interpretation. DSWx-HLS integer values and corresponding class labels</p> <p>0: Not Water 1: Open Surface Water 2: Partial Surface Water 252: HLS Snow/Ice 253: HLS Cloud/Cloud Cover</p> <p>For OPERA DIST-ALERT; 0: No disturbance 1: First <50% 2: Provisional <50% 3: Confirmed <50% 4: First ≥50% 5: Provisional ≥50% 6: Confirmed ≥50% 7: Confirmed <50% finished 8: Confirmed ≥50% finished</p> <p>For OPERA RTC-S1; Granules are stretched between 0.0 and 0.2 for better contrast.</p> <p>NOTE: The metadata enhancement only occurs for visualization purposes. The original OPERA color ramp and labels of these granules are preserved within the downloaded granules.</p>
Username ^R	NASA Earth data login credentials	<p>The Username and Password are the user's Earth Data login credentials which are used to access OEPRG granules on PO.DAAC, LP DAAC and ASF DAAC.</p> <p><i>An Earth Data account is required to access OPERA granules. Please see 2.0 Prerequisites section for URL to create an Earth Data account.</i></p>
Password ^R	NASA Earth data login credentials	

^RRequired parameter. ^OOptional Parameter

Additional Notes:

If attempted downloads contain no granules within the given AOI and date range, the tool will run to completion and issue the message “No OPERA tiles within given date range and or/AOI. Please Try Again with different date range and/or AOI” (See 5.0 Troubleshooting for more details).

3.2.2 OPERA Granule Filter

Tool Description:

This tool filters OPERA DSWx-HLS granules from an already existing stack based on a user-provided date range and AOI, and (optionally) copies and subsets existing granules in separate folders.

Tool Parameters:

Parameter	Parameter Description	Parameter Function/Notes
Location of OPERA granules ^R	Folder where current OPERA granules exist	This is a folder. Geodatabases are not supported in this version of the tool.
Area of Interest ^R	The Geographical Region for granule search.	As with the OPERA Granule Downloader (3.3.2), This can either be a (a) point(s), line(s) or polygon(s) shapefile, or (b) interactively drawn point(s), line(s) or polygon(s) on the ArcGIS Pro Map Frame. Images are queried based on a minimum bounding box principle using the point(s), line(s) or polygon(s) provided. Please see Appendix A for the details on the creation of the minimum bounding box.
Start Date ^R	Start Date of granule search	All OPERA granules from start date until end date are queried. Start date AND end date are included in the query.
End Date ^R	End Date of granule search	
Visualize in Contents Pane ^O	Enables the automatic visualization of downloaded granules in the contents pane with metadata enhancement.	Same as 3.3.1 OPERA Granule Downloader.
Make Copy of Granules into Folder ^O	Makes a copy of granules that meet the search criteria into a user-defined folder.	The original granules remain intact. Copies are placed in the designated folder.

^RRequired parameter. ^OOptional Parameter

Additional Notes:

After a successful run, the number of filtered granules from the stack is displayed in tool messages that can be accessed via 'view details' at the end of tool run. If there are no OPERA

granules within the given date range and/or AOI, the tool will run to completion without creating output. In that case, “No OPERA tiles within given date range and or/AOI. Please Try Again with different date range and/or AOI” is displayed in tool messages (see 5.0 Troubleshooting for details).

3.2.3 OPERA Raster Mosaic

Tool Description:

This tool mosaics OPERA DSWx-HLS granules based on user-provided land cover priorities (The mosaic operator will choose the prioritized land cover class in areas where granules overlap. Please see Annexure B for details on land cover prioritization).

Tool Parameters:

Parameter	Parameter Description	Parameter Function/Notes
Input Rasters ^R	The OPERA granules to be mosaicked.	These granules can be either (a) dragged and dropped from the contents pane, (b) selected from the drop-down buttons in the tool dialog box (if granules exist in the contents pane), or (c) bulk-selected by browsing to the folder containing the granules.
Land Cover Priority ^R	Prioritizes land cover classes in areas of overlap.	Annexure B explains the use of such a prioritization and how the prioritization is performed.
Convert HLS Snow/Ice to Open Surface Water ^O	Converts HLS labeled snow/ice pixels into open water pixels.	There exists a known error in the Harmonized Landsat Sentinel-2 (HLS) Imagery Mask Layer (the primary image input of the OPERA DSWx product) where sediment-laden or white (i.e. turbulent) Surface Water may be misclassified as Snow/Ice. Therefore, the user is given the option to convert HLS Snow/ice to Open Surface water if study date ranges and AOI suggest that is appropriate (e.g., if no snow/ice is expected)
Output Mosaic dataset ^R	The name and extension of the output mosaic raster to be created.	The extension is required, but currently the tool only supports .tif .
Spatial Reference of Mosaic Dataset ^R		Spatial reference can be defined either by using the drop-down tool or setting in using the 'globe' icon.

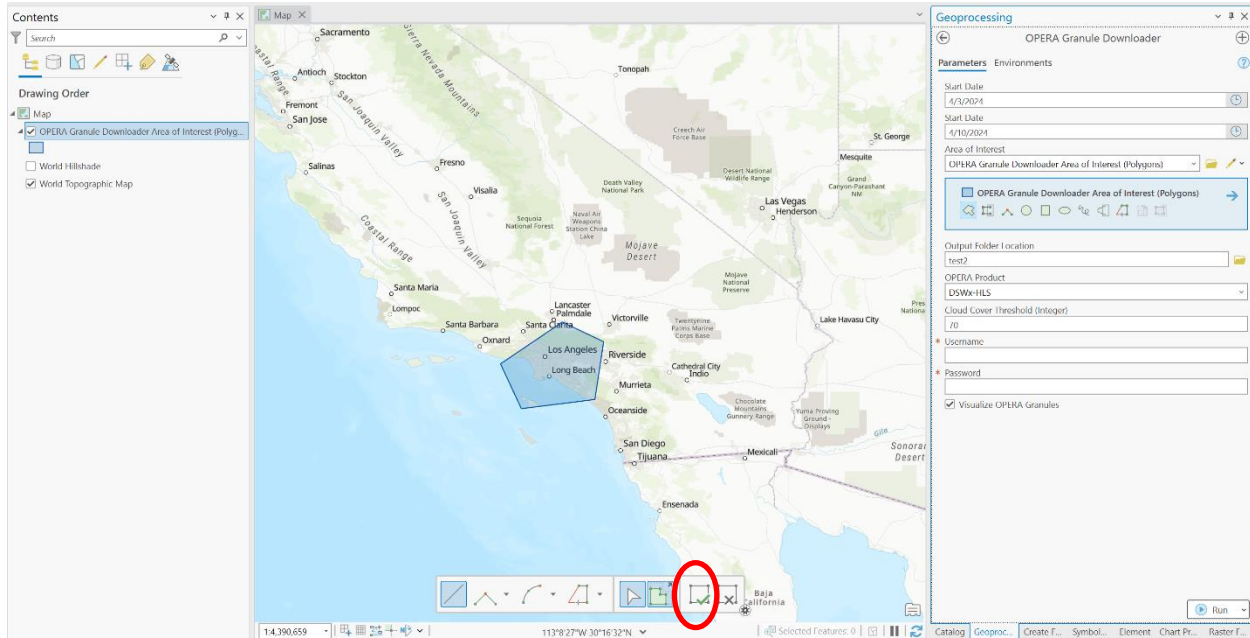
		If mosaicking large geographical regions across UTM zones, we recommend “WGS 84” if a Geographic Coordinate System is preferred, or “WGS 84 Web Mercator” if projected coordinates are preferred.
--	--	---

^RRequired parameter. ^OOptional Parameter

4.0 Tool Functionality Demonstration

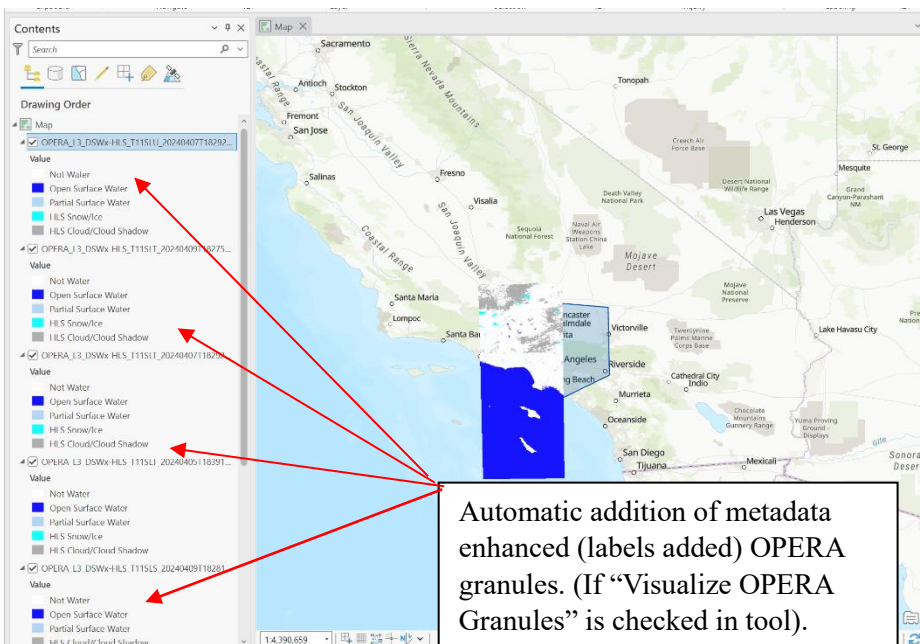
4.1. OPERA Granule Downloader

Setting up the tool



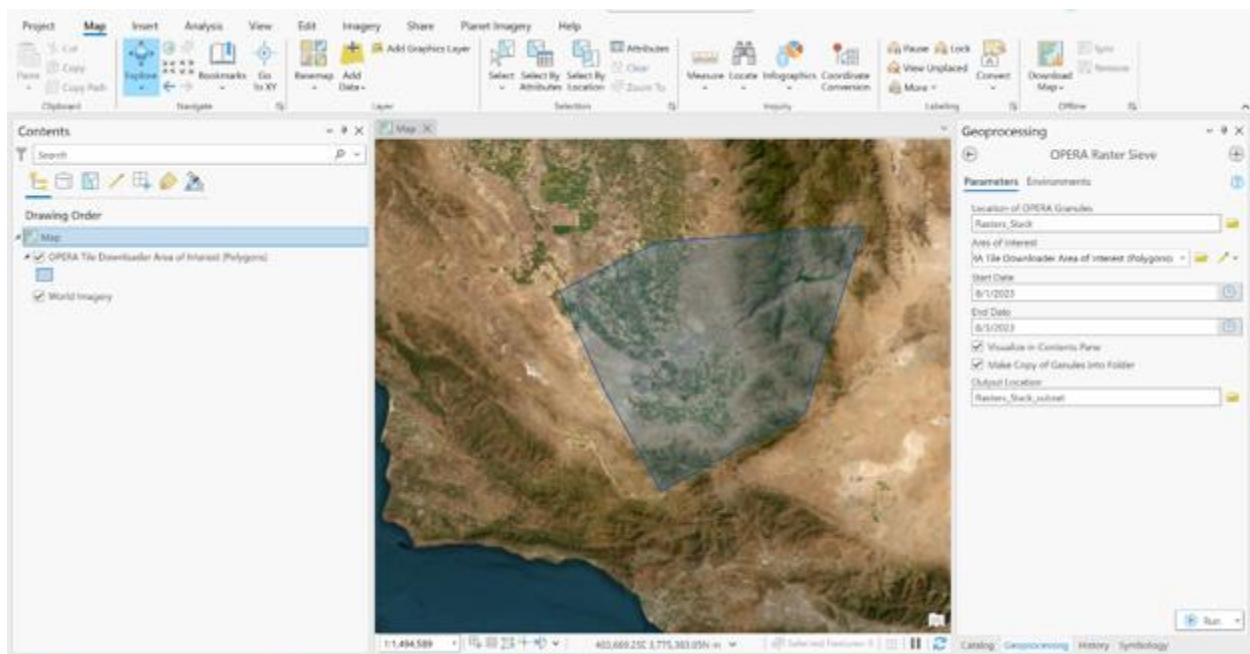
Make sure to apply uncommitted geometry sketches by clicking on the check mark (circled in red) after drawing the AOI.

During tool Run



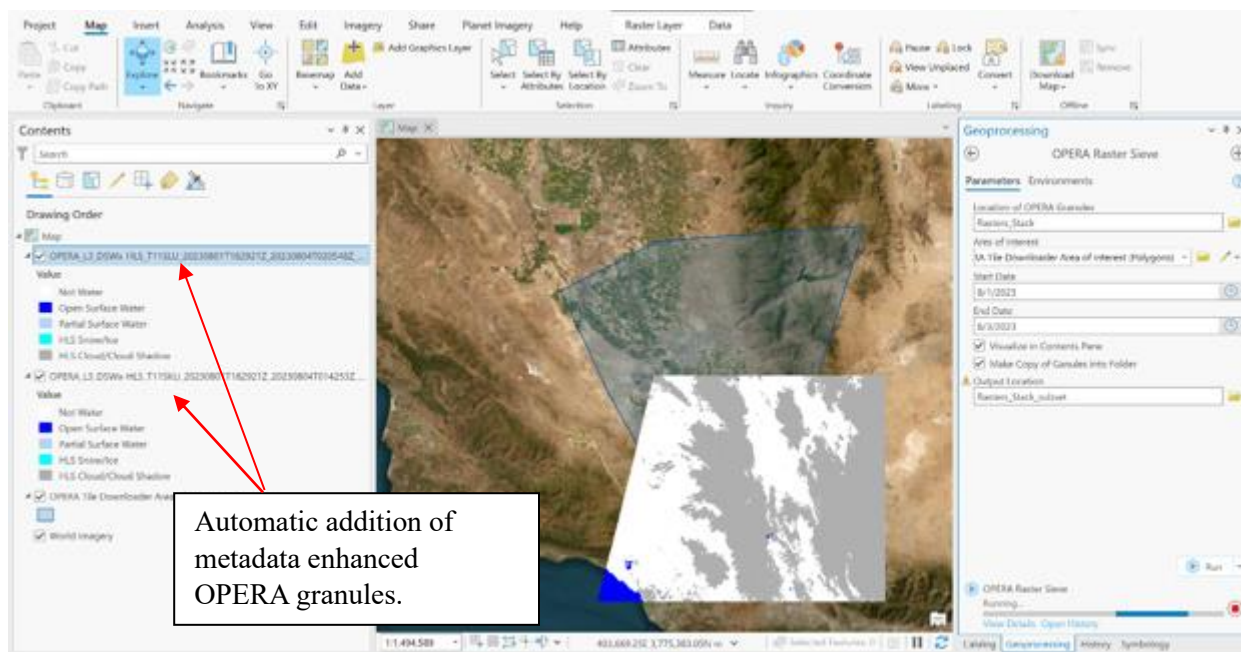
4.2 OPERA Granule Filter

Setting up the tool



NOTE: Tool run Illustrated using an interactively drawn “Polygon”. Interactive point(s), lines(s) and point(s), line(s) and polygon(s) shapefiles are also supported.

During tool Run

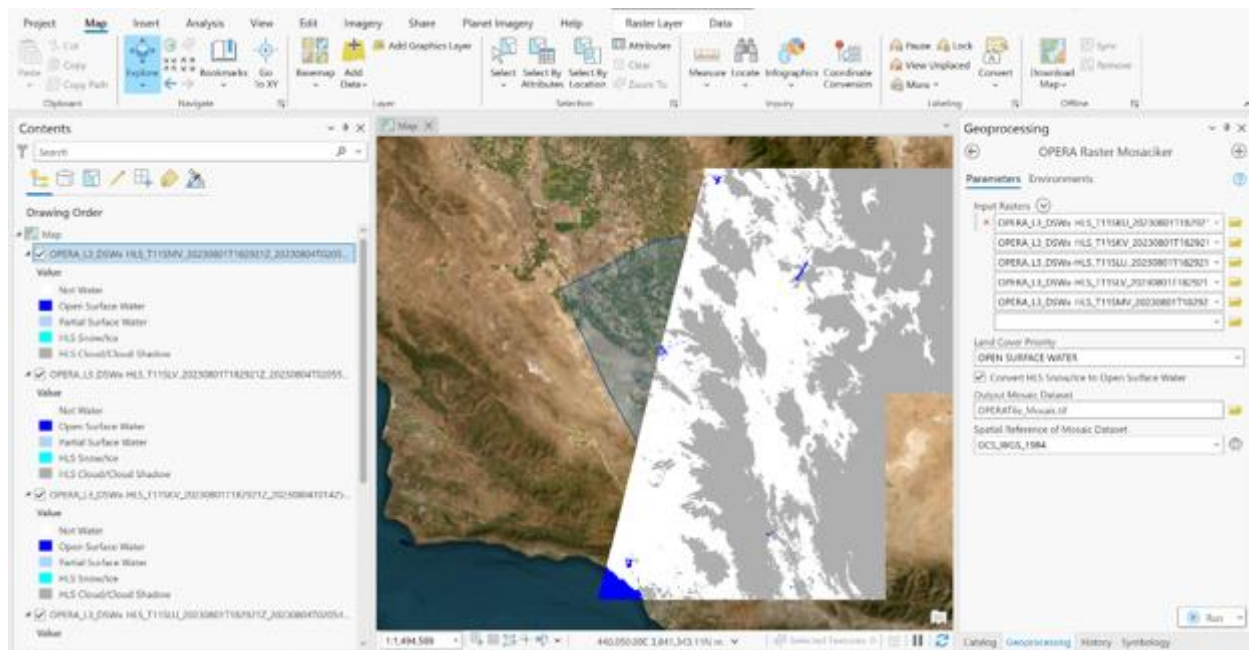


End of Successful Tool Run

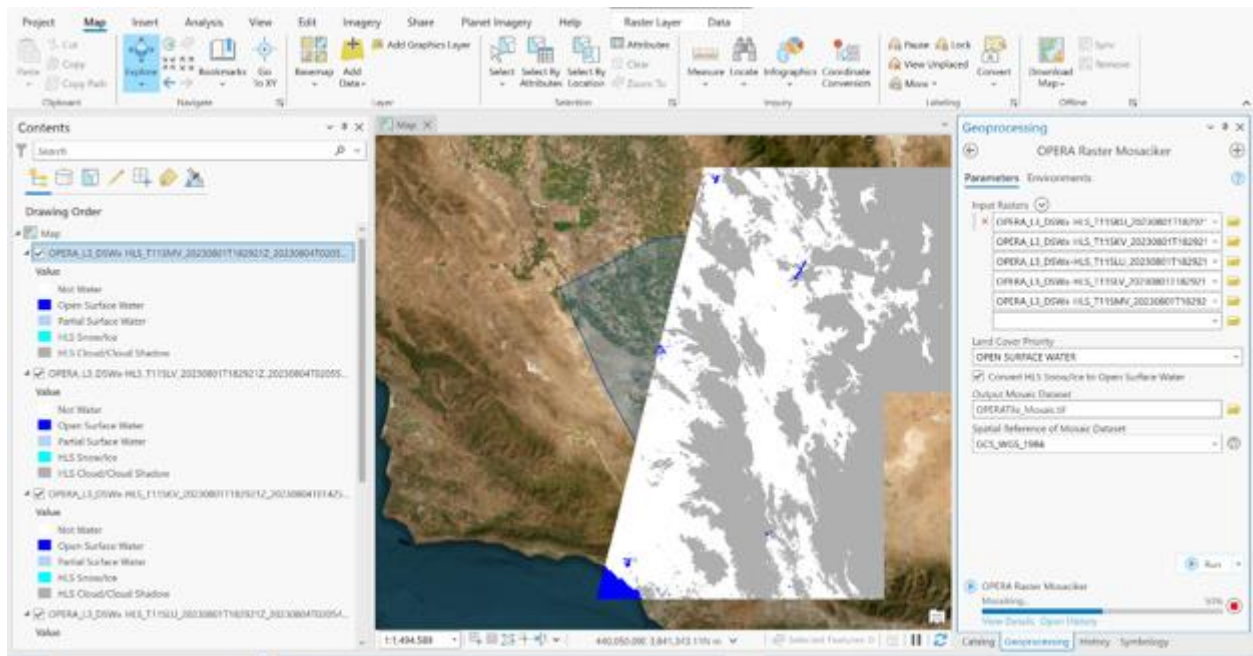


4.3 OPERA Raster Mosaic

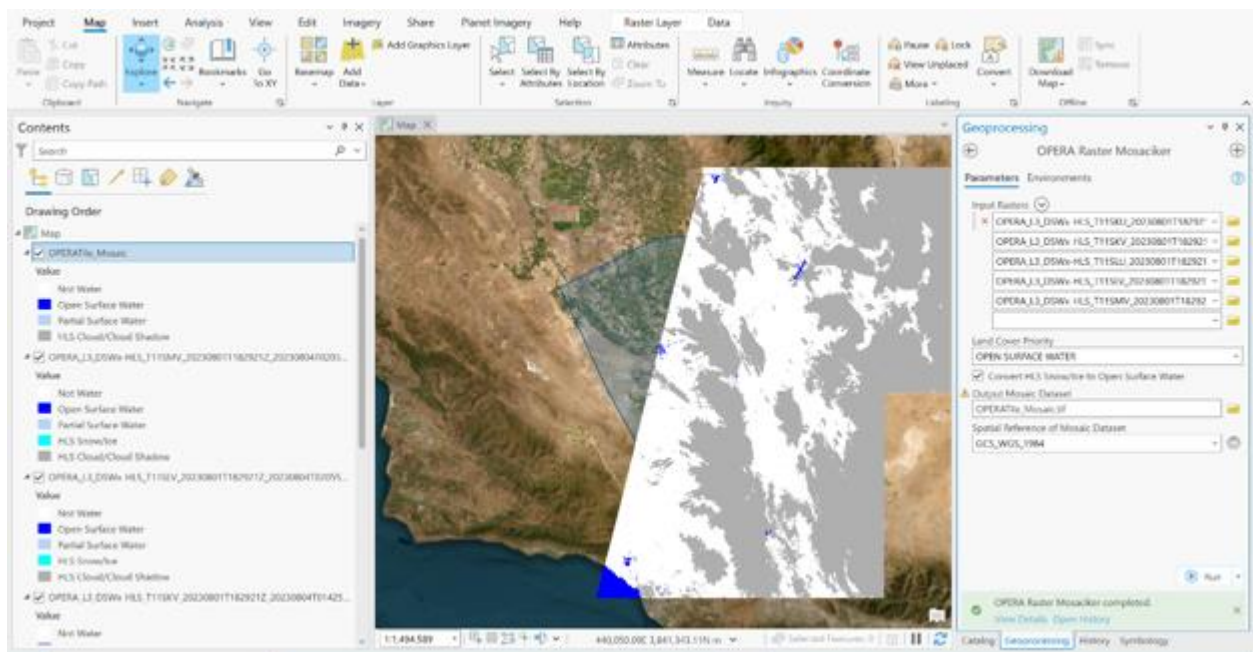
Setting up the tool



During tool Run



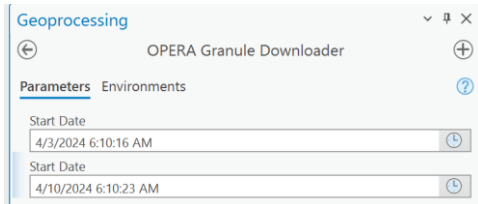
End of Successful Tool Run



5.0 Troubleshooting

5.1 OPERA Granule Downloader

Case 1: Date and time selected.



Geoprocessing OPERA Granule Downloader

Parameters Environments

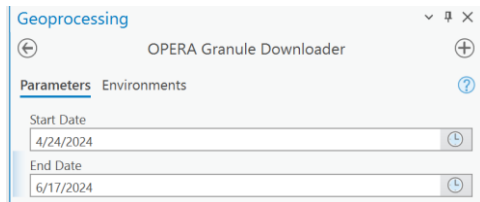
Start Date
4/3/2024 6:10:16 AM

Start Date
4/10/2024 6:10:23 AM



```
raise ValueError("unconverted data remains: %s" %  
ValueError: unconverted data remains: 9:51:09 AM  
Failed script OPERA Tile Downloader...  
❗ Failed to execute (OPERATileDownload).
```

Case 2: Dates not properly set. End date earlier than Start Date.



Geoprocessing OPERA Granule Downloader

Parameters Environments

Start Date
4/24/2024

End Date
6/17/2024



```
KeyError: 'feed'  
Failed script OPERA Tile Downloader...  
❗ Failed to execute (OPERATileDownload).
```

Case 3: Incorrect Username and/or Password

```
Start Time: Saturday, September 23, 2023 28:07:35 AM  
-119.73907409181308, 34.72180473660908, -118.11121828520048, 35.89566843142396  
  
Status Code:  
200  
  
URLS of Downloaded OPERA Tiles:  
['https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115W_20230801T182921Z_20230804T020547Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115V_20230801T182921Z_20230804T020552Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115K_20230801T182921Z_20230804T014254Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115J_20230801T182921Z_20230804T020548Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115I_20230801T182921Z_20230804T020548Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115L_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115U_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115G_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif', 'https://archive.podaac.earthdata.nasa.gov/podaac-ops-cumulus-protected/OPERA_L3_DSX-HLS_PROVISIONAL_V1/OPERA_L3_DSX-HLS_T115H_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif']  
Failed to download: OPERA_L3_DSX-HLS_T115W_20230801T182921Z_20230804T020547Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115V_20230801T182921Z_20230804T020552Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115K_20230801T182921Z_20230804T014254Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115J_20230801T182921Z_20230804T020548Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115I_20230801T182921Z_20230804T020548Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115L_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115U_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif  
Failed to download: OPERA_L3_DSX-HLS_T115G_20230801T182921Z_20230804T014253Z_S2A_30_v1.0_B01_WTR.tif  
  
Number of Downloaded OPERA Tiles:  
0
```


Case 4: No imagery within search area/date range

```
Status Code:
200

URLS of Downloaded OPERA Tiles
[]

No OPERA Rasters within given date range and/or AOI.
Please Try Again with different date range and/or AOI.

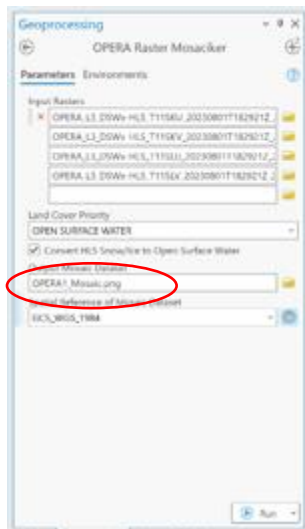
Number of Downloaded OPERA Tiles:
0
```

5.2 OPERA Granule Filter

Case 1, 2, 3 and 4 in section 4.1 is applicable to this tool as well.

5.3 OPERA Raster Mosaic

Currently only .tif output raster formats are supported.



RuntimeError: **ERROR 010093:** Output raster format UNKNOWN is unsupported.
Failed script OPERA Raster Mosaiciker...
Failed to execute (OPERA Raster Mosaiciker).
Failed at Saturday, September 23, 2023 2:04:53 PM (Elapsed Time: 34.65 seconds)

6.0 Feedback and Citation

We are eager to hear your feedback! Please let us know of any technical difficulties that you might encounter via our [github page](#).

We would also appreciate it if users of this toolbox considered acknowledging our work in the following manner.

Munasinghe, D., Bonnema, M., Frasson, R.P.M., Handwerger, A.L., Chan, S., Bekaert, D.
OPERA ArcGIS Pro Toolbox_V1(2023). Jet Propulsion Lab, California Institute of Technology,
CA, USA.

APPENDIX A: The Minimum Bounding Geometry of the AOI

The AOI is a required input for the “OPERA Granule Downloader” and OPERA Granule Filter”. This specifies the geographical regions for which the OPERA granule search should be carried out. There are two ways of inputting the AOI. This would be either as;

- (a) Point(s), line(s) or polygon(s) shapefile, or
- (b) Point(s), line(s) or polygon(s) drawn interactively on the ArcGIS Pro Map Frame.

Once an AOI is specified, the latitude and longitude of the minimum bounding box of the AOI provided by the user is used to identify intersecting OPERA granules. The main reason why a bounding box approach is used is to give users the opportunity to be able to download OPERA granules based on a much bounding box rather than the AOI itself. A bounding box allows for neighboring regions also to be captured providing the users an increased amount of information content about the AOI. (See comparison between AOI based approach and bounding box-based approach in Figure 1). The bounding box approach also allows shapes other than polygons to be used for image search. For example, an interactively drawn line or line shapefile may be used as an AOI to obtain OPERA granules intersecting the line. If the user chooses to do so, a clip operation can be subsequently performed using the OPERA file Mosaic tool to extract the exact region bounded by the edges of a user provided AOI.

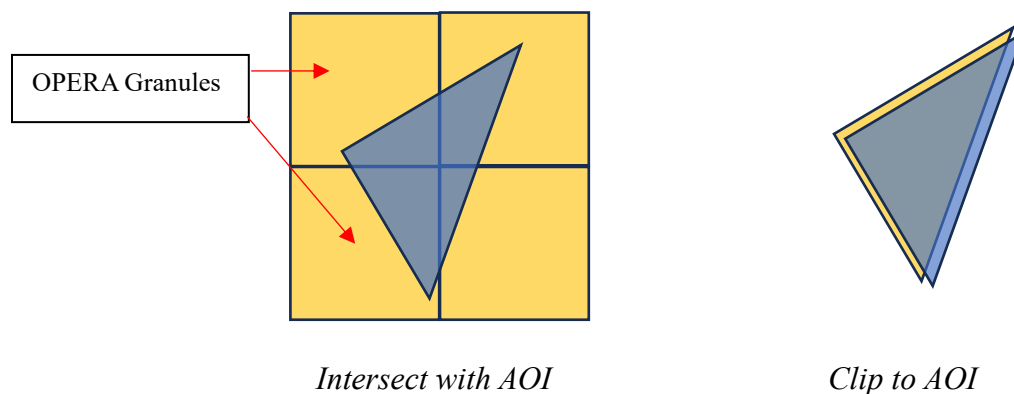


Figure 1: Comparison between intersect with bounding box of AOI and clip to AOI.

As mentioned before the AOI can be a point/multiple points, line/lines or polygon/polygons if drawn interactively, or a point/multiple points, line/multiple lines, polygon/multi-polygon shapefile. Different shapes of bounding boxes can be created in ArcGIS Pro. Please refer to ArcGIS Pro [documentation](#) for further details. Only a ‘rectangle by area’ type is activated in the OPERA Granule Downloader and OPERA Granule Filter tools.

APPENDIX B:

Land cover prioritization in the OPERA Raster Mosaic tool.

An OPERA granule is classified into a maximum of 5 land cover classes (i.e., 0: Not Water, 1: Open Surface Water, 2: Partial Surface Water, 252: HLS Snow/Ice, and 253: HLS Cloud/Cloud Shadow). During the creation of the mosaic, determination of land cover priority is required in overlapping granule areas. This determination is based on the user's end goal. For example, if the user needs a mosaicked raster that shows the maximum extent of open surface water area, the user would prioritize 'Open Surface Water'. When this prioritization is made, for a given pixel in the overlapping area of the stack of rasters used in the mosaicking process, the Open Surface Water Pixel is selected to be included in the mosaic. If no Open Surface Water pixels are found in the stack for that particular pixel, Partial Surface Water >> Not Water >> HLS Cloud/Cloud Shadow >> HLS Snow/Ice is picked in that order (See red rectangle in table 1 for the prioritization when "Open Surface Water" is selected). Table 1 also provides the ranking of prioritizations under each user-selected land cover class.

The order of prioritizations under each selection is given below.

Priority Rank	User Selection				
	Open Surface Water (OSW)	Partial Surface Water (PSW)	Not Water (NW)	HLS Snow/Ice (HLS-S/I)	HLC Cloud/Cloud Cover (HLS-C/CS)
1	OSW	PSW	NW	HLS-S/I	HLS-C/CS
2	PSW	OSW	OSW	OSW	OSW
3	NW	NW	PSW	PSW	PSW
4	HLS-C/CS	HLS-C/CS	HLS-C/CS	NW	NW
5	HLS-S/I	HLS-S/I	HLS-S/I	HLS-C/CS	HLS-S/I