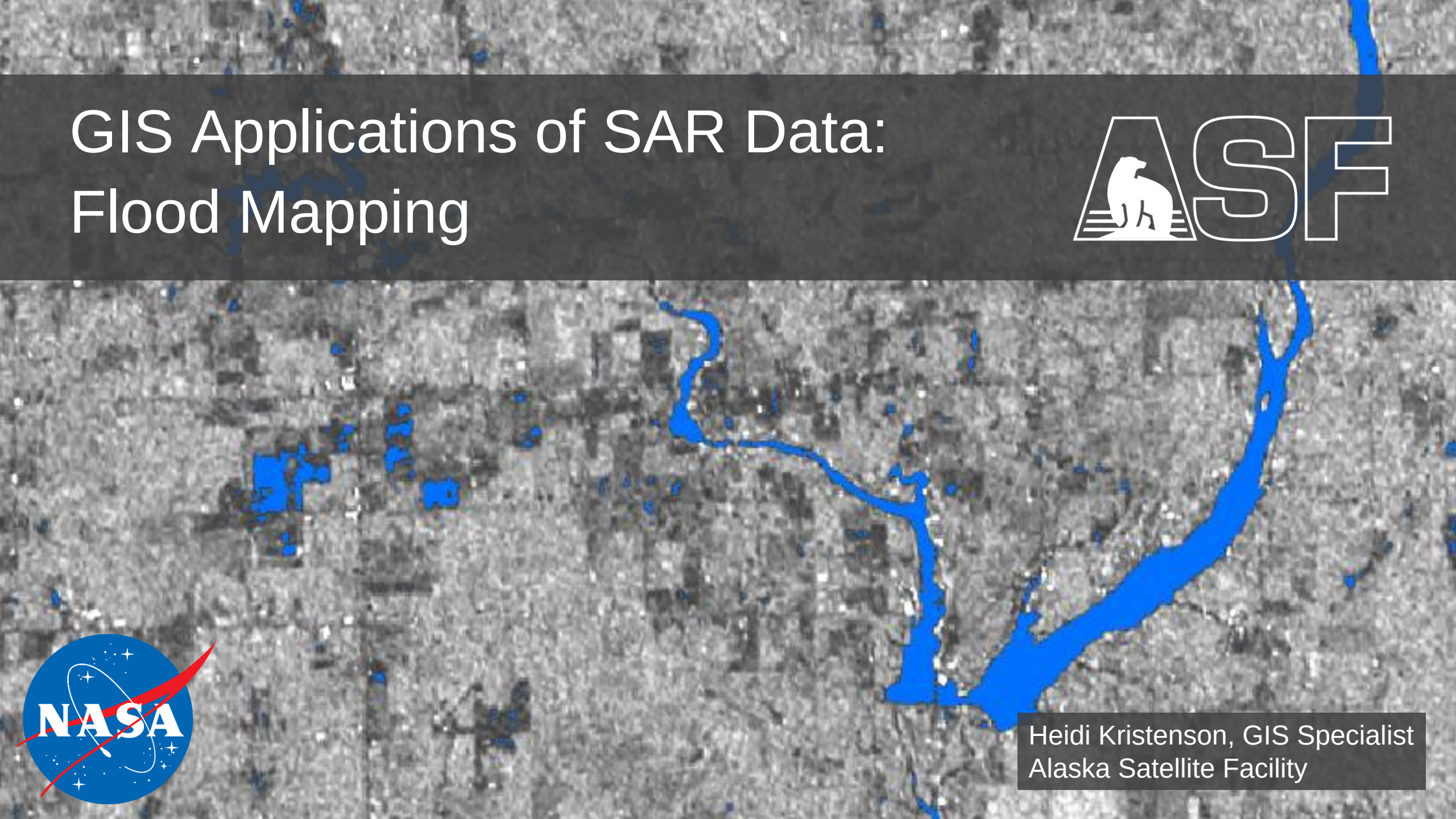
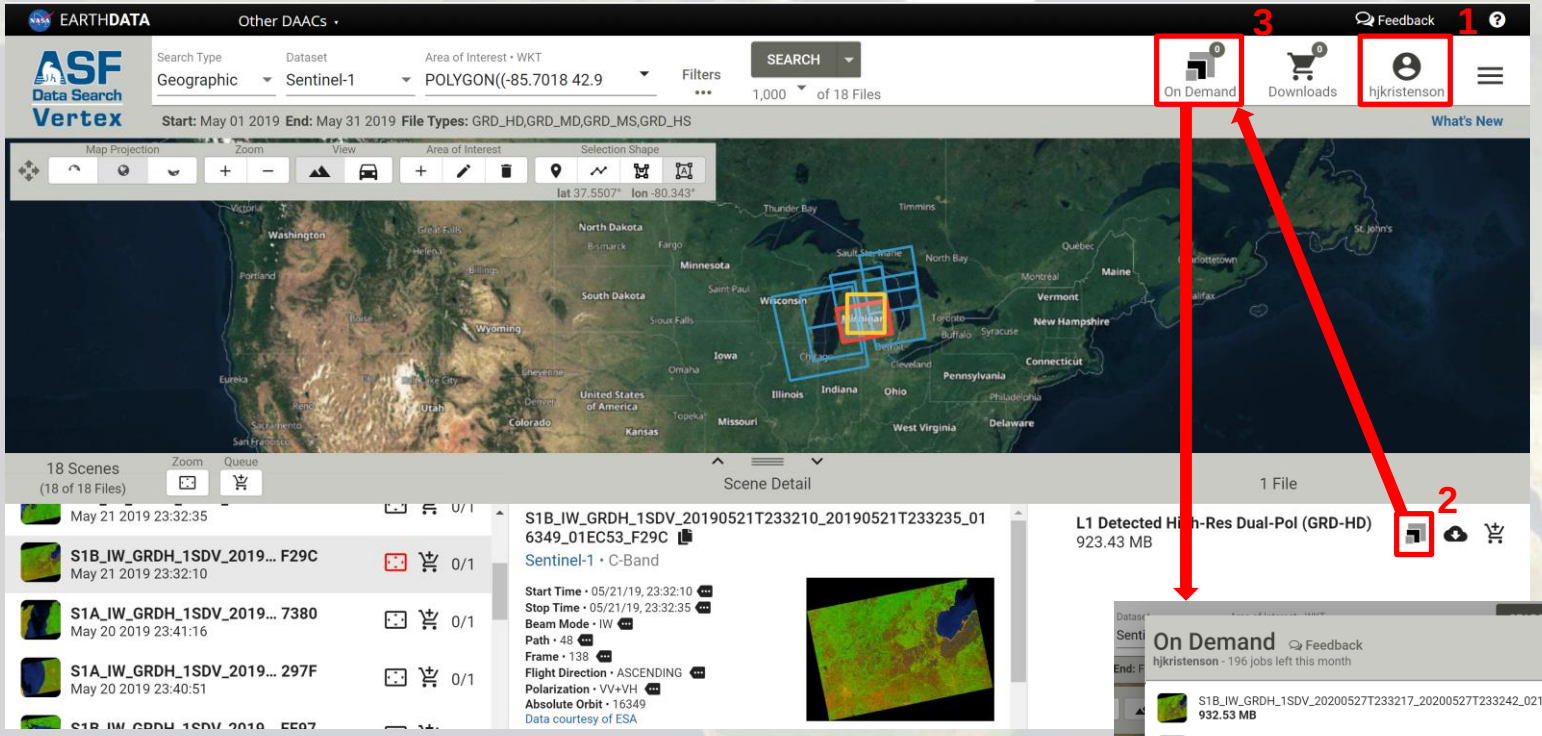
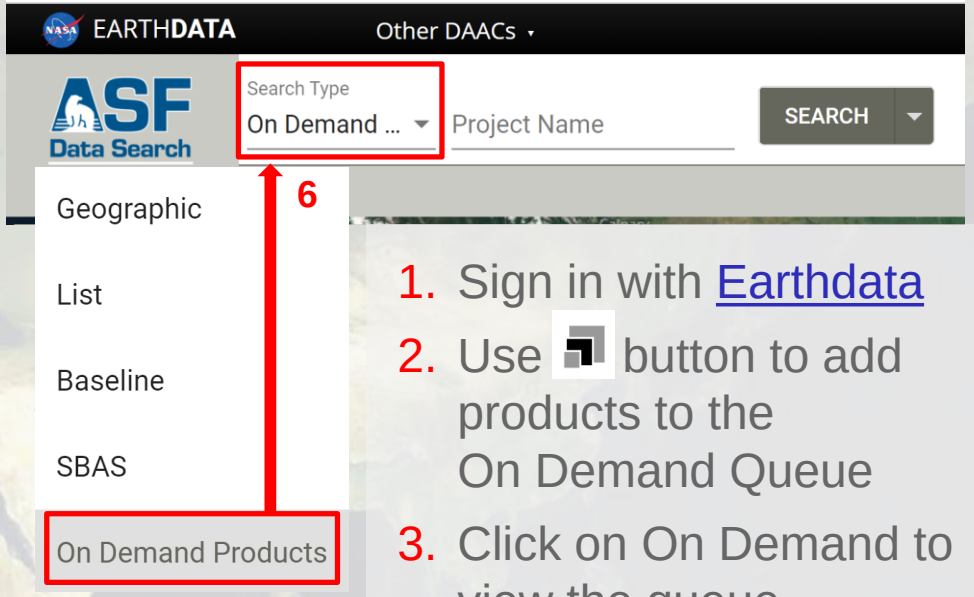
GIS Applications of SAR Data: Flood Mapping

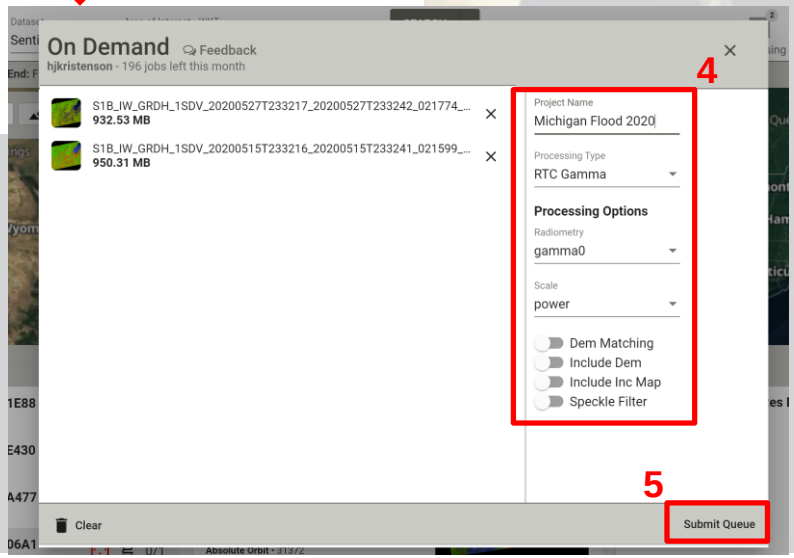


Heidi Kristenson, GIS Specialist
Alaska Satellite Facility

On-Demand RTC Products from Vertex







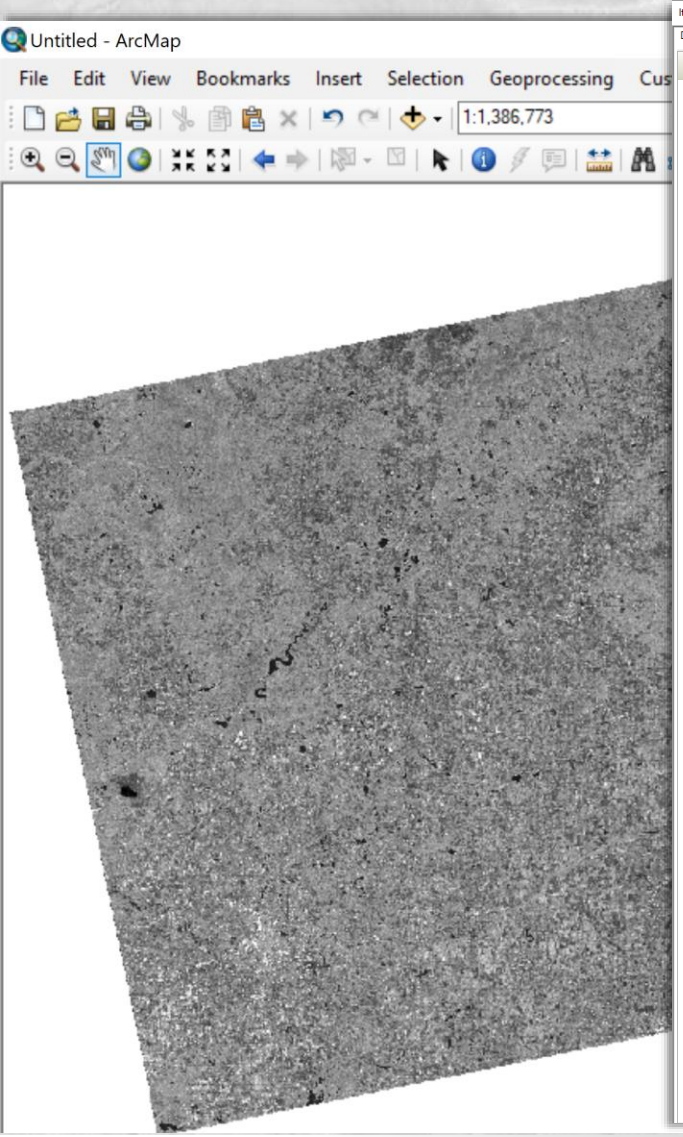
1. Sign in with Earthdata
2. Use button to add products to the On Demand Queue
3. Click on On Demand to view the queue
4. Enter a Project Name and adjust processing options (if desired)
5. Click the Submit Queue button
6. Select On Demand Products Search Type to view products

Granules used for Demo:

S1B_IW_GRDH_1SDV_20200515T233216_20200515T233241_021599_02900D_FD9E

S1B_IW_GRDH_1SDV_20200527T233217_20200527T233242_021774_02953A_2D69

RTC-GAMMA Product



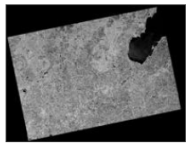
Item Description - S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV

Description Preview

Print Edit Validate Export Import

S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV.t

Raster Dataset



Tags

Alaska Satellite Facility, ASF, Synthetic Aperture Radar, SAR, Radiometric Terrain Correction, RTC, Sentinel

Summary

This file is a Radiometric Terrain Corrected (RTC) granule of GRD SAR data from the Sentinel-1 mission, processed using GAMM
Cell values indicate VV gamma-0 amplitude, and pixel spacing is 30 m.

Description

This Radiometric Terrain Corrected (RTC) product is derived from a Ground Range Detected (GRD) granule of Synthetic Apertur
from the Copernicus Sentinel-1 mission (European Space Agency), processed by ASF DAAC HyP3 2020 using the hyp3_rtc_gam
version 2.3.2 running GAMMA release 20191203. It is provided in WGS 84 / UTM zone 16N coordinates and is corrected for terr
Digital Elevation Model (DEM). The DEM used to generate this product is NED13 at 1/3 arc seconds (about 10 meters) resolutio

Processing Date/Time: 2020-10-07T02:51:35+00:00

In the filename, VV c
refer to https://sent

The name of the gra
S1B_IW_GRDH_1SDV
convention, refer to

The side-looking geo
radiometric variations
values directly relatin
provides geolocation
classification, and de

Cell values indicate V
dark when first displa
the layer symbology to Stretched - Standard Deviations (choose a number (n) that works best for your particular dataset; the
default of n: 2.5 will improve the display, but other values may give a better visualization).

This product was processed using 6 look(s). Multi-looking is the process of coherently averaging together pixels of an image.
effect of multi-looking is to reduce the noise level, thus reducing speckle, at the cost of decreased resolution. Multi-looking is
10-m products.

No speckle filter has been applied to this image. The default is to not apply a speckle filter, but the user can choose to apply
ordering the RTC imagery. When the filtering option is selected, an Enhanced Lee filter is applied during RTC processing to rem
while preserving edges. When applied, the filter is set to a dampening factor of 1, with a box size of 7x7 pixels and 180 looks.

You may wish to explore the filtering options available in ArcGIS rather than ordering imagery with a filter already applied. The
options for different speckle filter functions to be applied on the fly (including the filter settings listed above) using the Image
window. To learn more about speckle filtering options, refer to http://desktop.arcgis.com/en/arcmap/latest/manage-data/rast
images/speckle-function.htm, and to learn how apply a function (such as a speckle filter) to a raster, refer to
http://desktop.arcgis.com/en/arcmap/latest/manage-data/raster-and-images/editing-functions-on-a-raster-dataset.htm.

For areas where there is not a publicly-available digital elevation model (i.e. sea ice), geocoded products without terrain corre
available from http://hyp3.asf.alaska.edu.

The Sentinel-1A satellite was launched April 3, 2014, and the Sentinel-1B satellite was launched April 25, 2016. The satellites
12-day repeat cycle. More information about the mission is available at https://earth.esa.int/web/guest/missions/esa-operati
missions/sentinel-1.

Additional information about Sentinel-1 data, imagery, tools and applications is available at https://asf.alaska.edu/data-sets/s
sets/sentinel-1.

Credits

ASF DAAC HyP3 2020 using the hyp3_rtc_gamma plugin version 2.3.2 running GAMMA release 20191203. Contains modified Co
Sentinel data 2020, processed by ESA.

Use limitations

There are no restrictions on the use of this data, but it must be cited as listed in the credits.

S1B_IW_20200515T233216_DVP_RTC30_G_ga

File Edit Format View Help

```
ASF RTC Data Package (GAMMA)
============================

This folder contains radiometric terrain corrected (R
hyp3_rtc_gamma plugin version 2.3.2 running GAMMA rel

Processing Date/Time: 2020-10-07T02:51:35+00:00

The folder and each of its contents all share the sam
```

```
S1x_yy_aaaaaaaaTbbbbbb_ppo_RTCzz_G_defk1m_ssss
x:      Sentinel-1 Mission (A or B)
yy:     Beam Mode
aaaaaaaa:  Start Date of Acquisition (YYYYMMDD)
bbbbbb:    Start Time of Acquisition (HHMMSS)
pp:     Polarization
o:      Orbit Type: Precise (P), Restituted (R),
zz:     Terrain Correction Resolution
d:      Gamma-0 (g) or Sigma-0 (s) Output
e:      Power (p) or Amplitude (a) Output
f:      Unmasked (u) or Water Masked (w)
k:      Not Filtered (n) or Filtered (f)
l:      Entire Area (e) or Clipped Area (c)
m:      Dead Reckoning (d) or DEM Matching (m)
ssss:   Product ID
```

```
The source granule used to generate the products contained in this folder is:
S1B_IW_GRDH_1SDV_20200515T233216_20200515T233241_021599_02900D_FD9E
```

```
* HyP3 processing environment, DOI: [10.5281/zenodo.3962581](https://doi.org/10.5281/zenodo.3962581)
* HyP3 RTC GAMMA plugin, DOI: [10.5281/zenodo.3962936](https://doi.org/10.5281/zenodo.3962936)

For information on GAMMA SAR software, please see: https://gamma-rs.ch/

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# Product Contents #

The side-looking geometry of SAR imagery leads to geometric and radiometric distortions, causing foreshortening, layover, shadowing, and radiometric
variations due to terrain slope. Radiometric terrain correction converts unprocessed SAR data into geocoded TIFF images with values directly relating to
physical properties, alleviating the  inherent SAR distortions. The process improves backscatter estimates and provides geolocation information, so images
can be used as input for applications such as the monitoring of deforestation, land-cover classification, and delineation of wet snow-covered areas.

The files generated in this process include:

1. Radiometric Terrain Corrected GeoTIFF data files for each polarization available
2. Browse images (PNG and KMZ format) in grayscale and color (when dual-pol is available)
3. A copy of the DEM used to correct the data (included in standard products; you can choose to omit this layer when custom ordering imagery)
4. An incidence angle map (included in standard products; you can choose to omit this layer when custom ordering imagery)
5. A layover-shadow mask
6. An ArcGIS xml metadata file for each raster layer, displayed in the Item Description (ArcGIS Desktop) or Metadata (ArcGIS Pro)
7. An xml file in ISO 19115-2 format, describing all of the products
8. A shapefile indicating the data and raster extents
9. Log file

See below for detailed descriptions of each of the products.

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## 1. Radiometric Terrain Corrected data files
```

S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD

File Home Share View

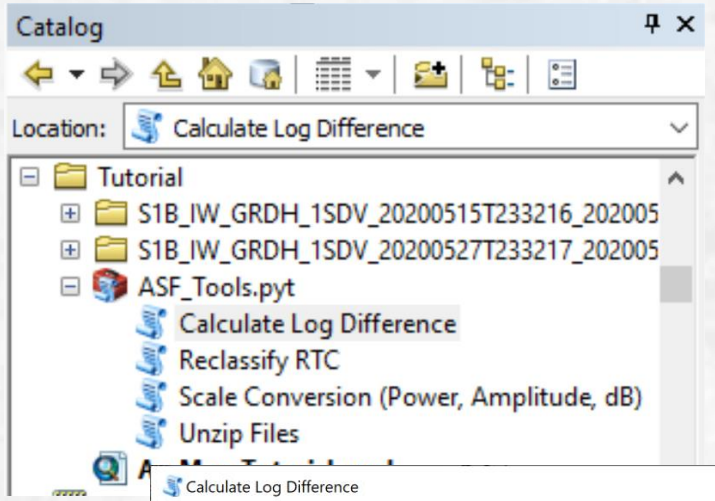
Michigan > S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD

Name	Date modified	Type	Size
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.kmz	10/15/2020 2:47 PM	KMZ	1,576 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.log	10/15/2020 2:47 PM	Text Document	130 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.png	10/15/2020 2:47 PM	PNG File	1,739 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.png.aux.xml	10/15/2020 2:47 PM	XML Document	1 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.png.xml	10/15/2020 2:47 PM	XML Document	18 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD.README.md.txt	10/15/2020 2:47 PM	Text Document	14 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_ls_map.tif	10/15/2020 2:47 PM	TIF File	128 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_ls_map.tif.xml	10/15/2020 2:47 PM	XML Document	15 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_rgb.kmz	10/15/2020 2:47 PM	KMZ	3,253 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_rgb.png	10/15/2020 2:47 PM	PNG File	4,339 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_rgb.png.aux.xml	10/15/2020 2:47 PM	XML Document	1 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_rgb.png.xml	10/15/2020 2:47 PM	XML Document	18 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_shape.dbf	10/15/2020 2:47 PM	DBF File	1 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_shape.prj	10/15/2020 2:47 PM	PRJ File	1 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_shape.shp	10/15/2020 2:47 PM	SHP File	230 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_shape.shx	10/15/2020 2:47 PM	SHX File	1 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VH.tif	10/15/2020 2:47 PM	TIF File	160,412 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VH.tif.xml	10/15/2020 2:47 PM	XML Document	24 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV.tif	10/15/2020 2:47 PM	TIF File	160,028 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV.tif.xml	10/15/2020 2:47 PM	XML Document	24 KB

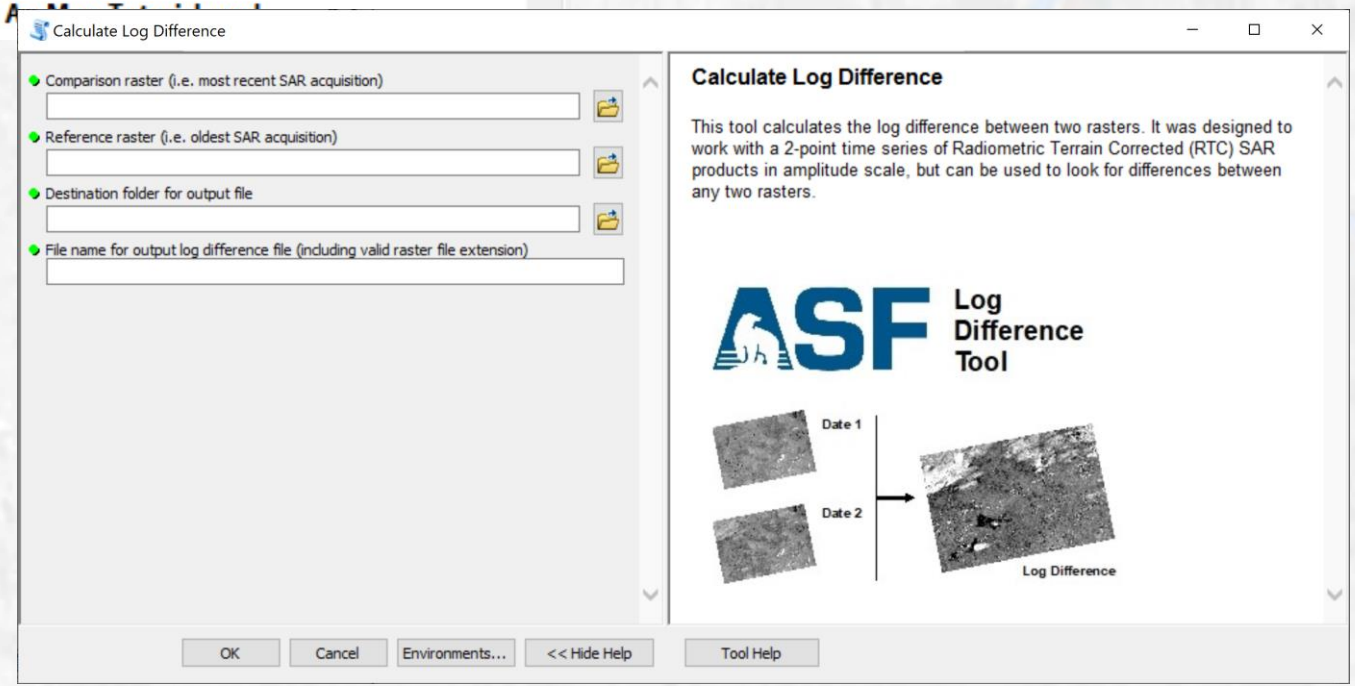
20 items

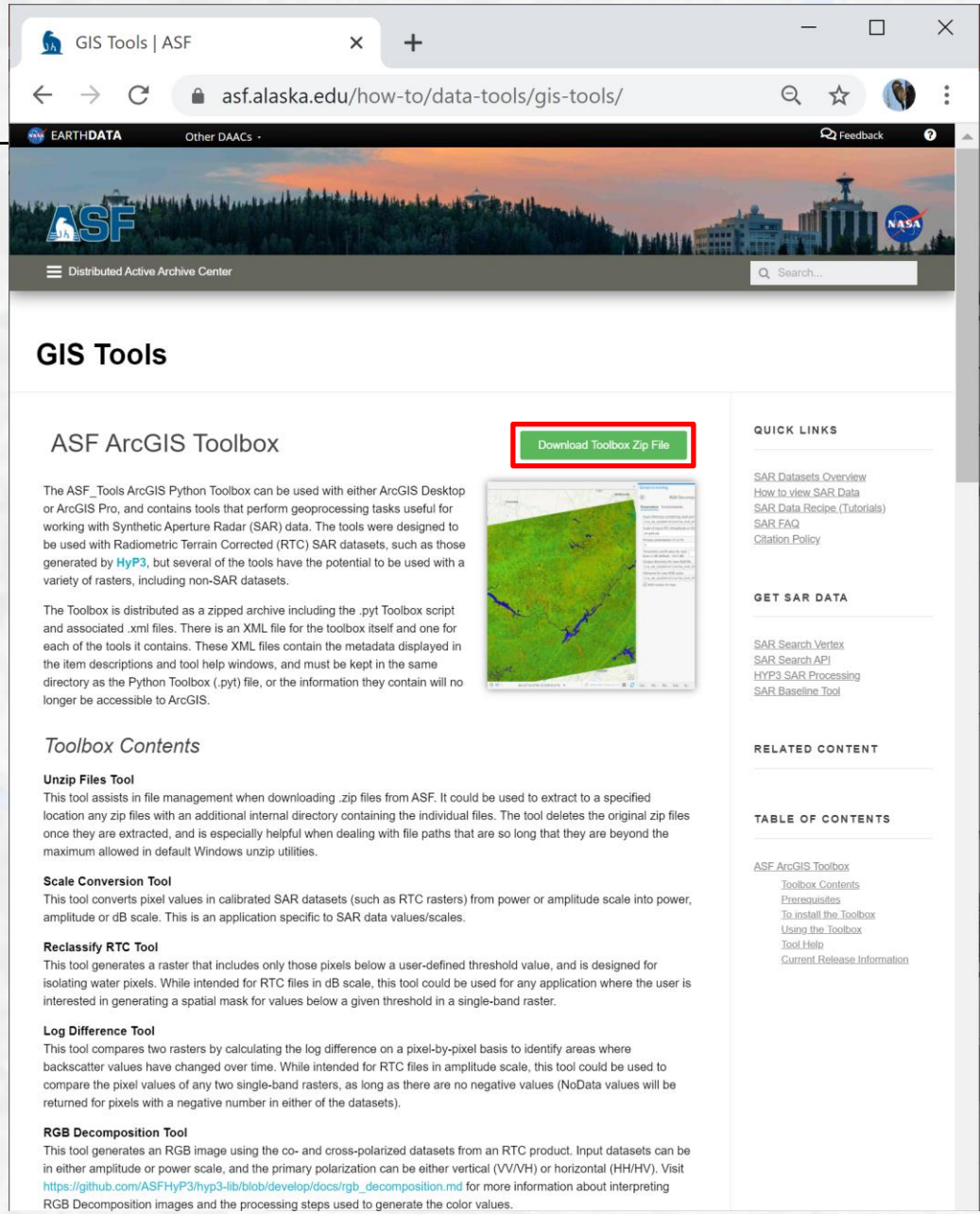
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VH.tif	10/15/2020 2:47 PM	TIF File	160,412 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VH.tif.xml	10/15/2020 2:47 PM	XML Document	24 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV.tif	10/15/2020 2:47 PM	TIF File	160,028 KB
S1B_IW_20200515T233216_DVP_RTC30_G_gauned_51FD_VV.tif.xml	10/15/2020 2:47 PM	XML Document	24 KB

ASF Custom Toolbox for ArcGIS



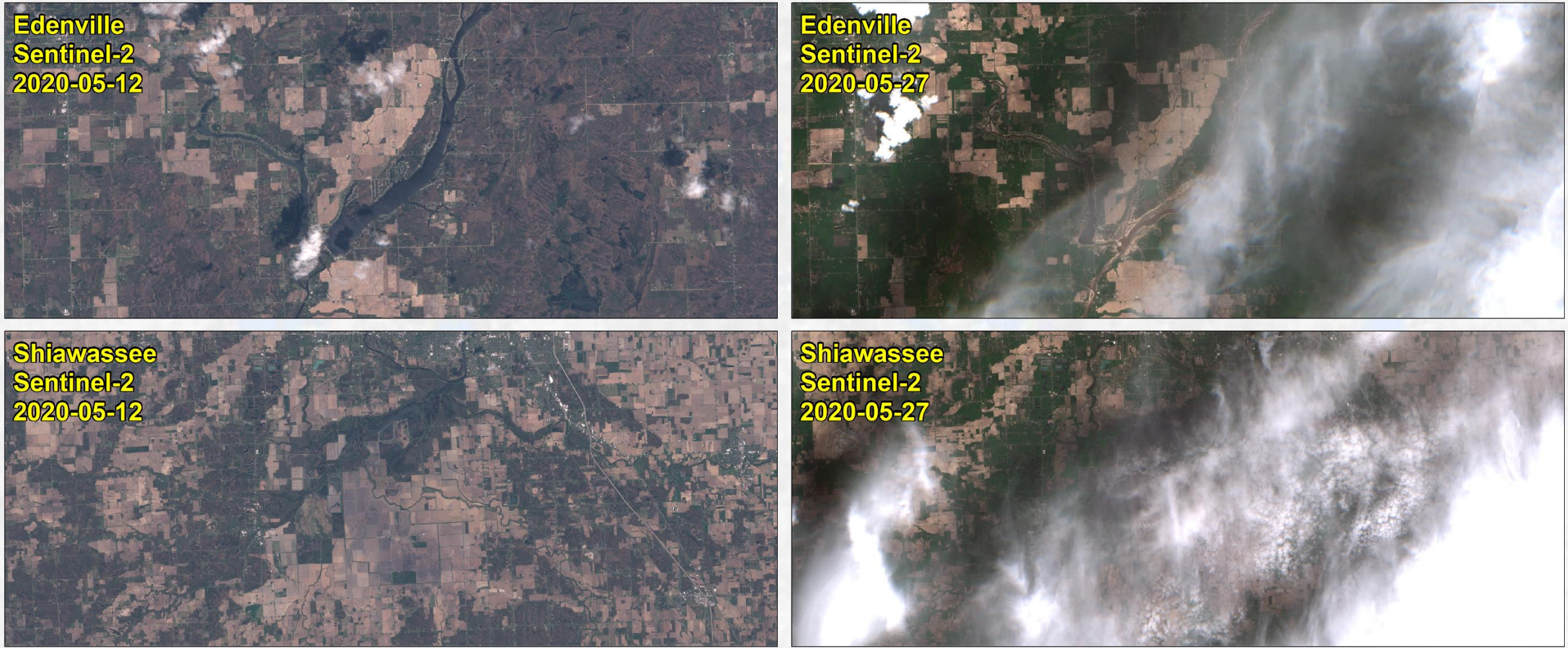
- For ArcMap or ArcGIS Pro
- Designed for use with HyP3 RTC products
  - some tools can be used with other datasets, even non-SAR data





Case Study: Midlands County, Michigan, USA

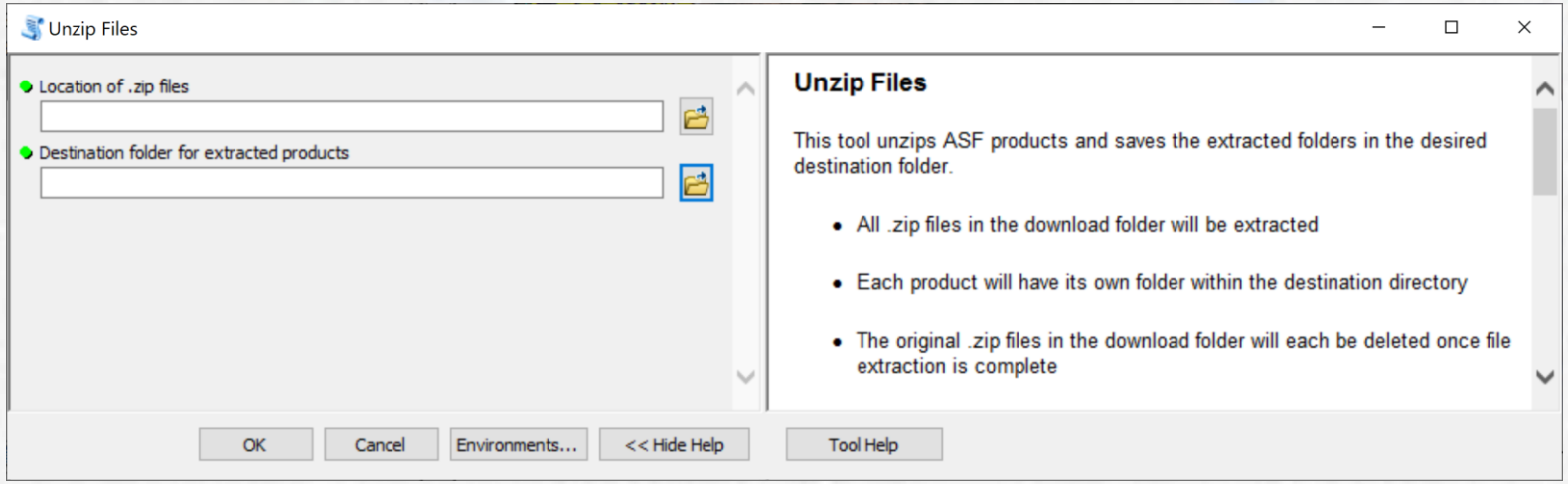
- Heavy rainfall resulted in dam failure and flooding, May 2020



Unzip RTC Products

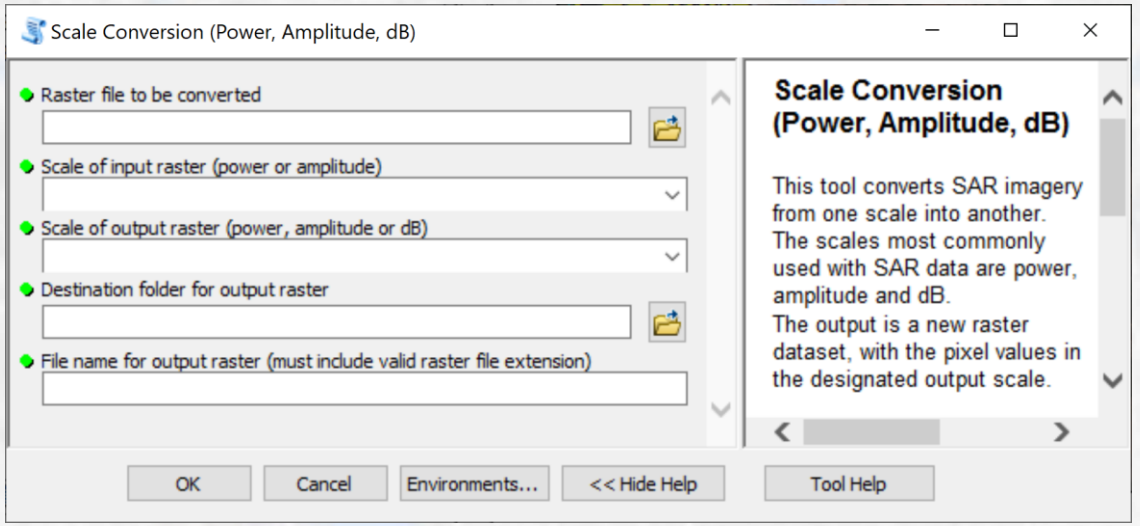
This tool will:

- Unzip any .zip archives in a selected directory
- Save the extracted data in the desired directory
  - can be the same directory that houses the zip archives or a different one
- Delete the zip files

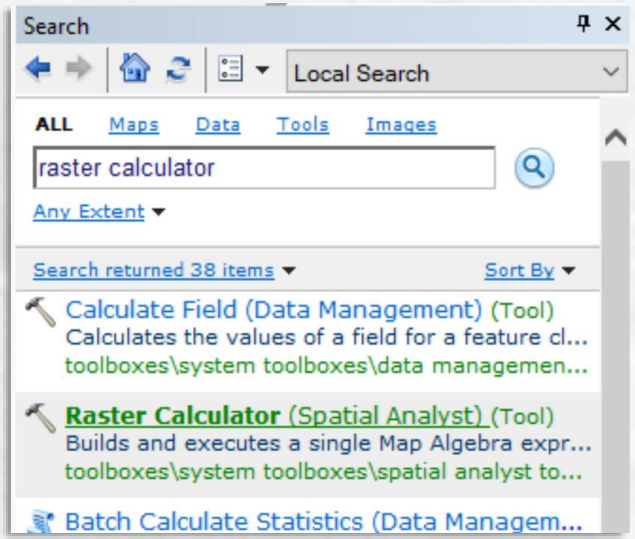


Convert RTC Products to a Different Scale

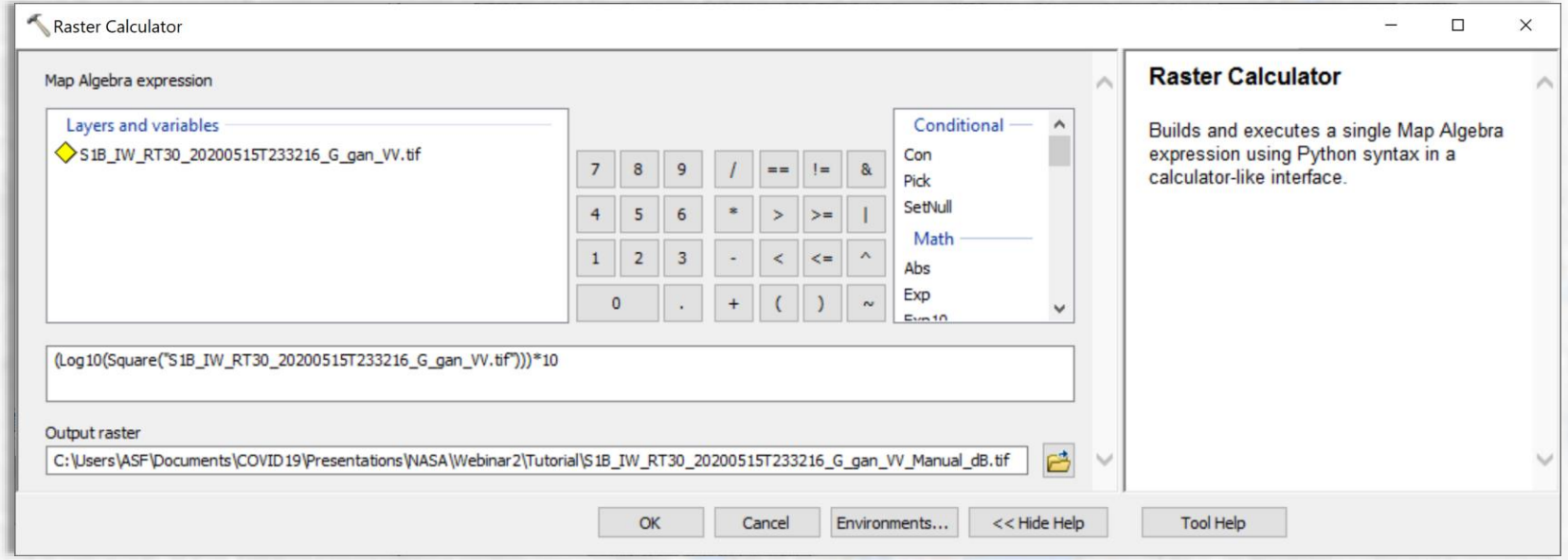
- RTC outputs are commonly in power scale
  - Often visualizes poorly
  - Good for numeric analysis
- Amplitude scale (square root of power)
  - Generally good visualization
  - Good for most numeric analysis
- dB scale (10 x log10 of power)
  - Good for differentiating among very dark pixels
  - Not suitable for all numeric analyses



ArcMap Manual Option: Raster Calculator



- Search for Raster Calculator or find the tool in the Spatial Analyst toolbox



- You must add rasters to the ArcMap project to make them available in the Layers and Variables list
- Enter the formula in the expression field
- Select the destination directory and enter an output raster name, including the .tif extension

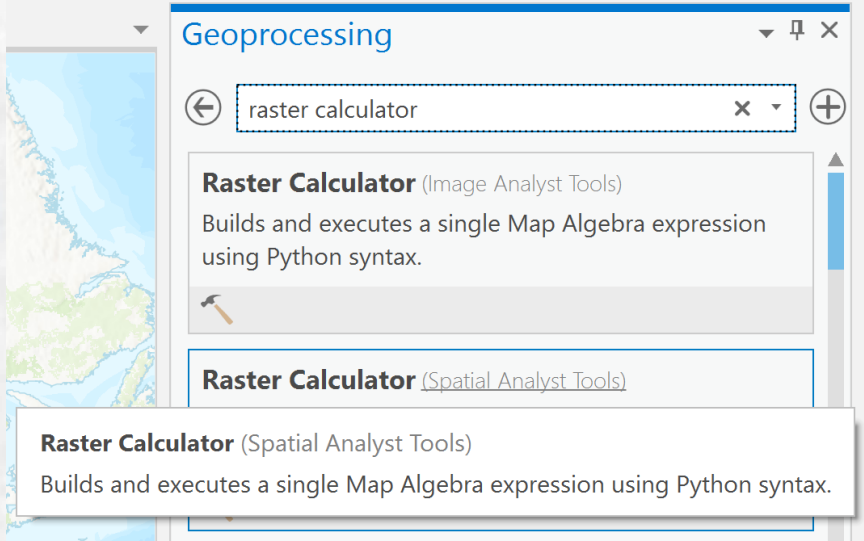
*To convert power (instead of amplitude) to dB, remove the square function from the equation

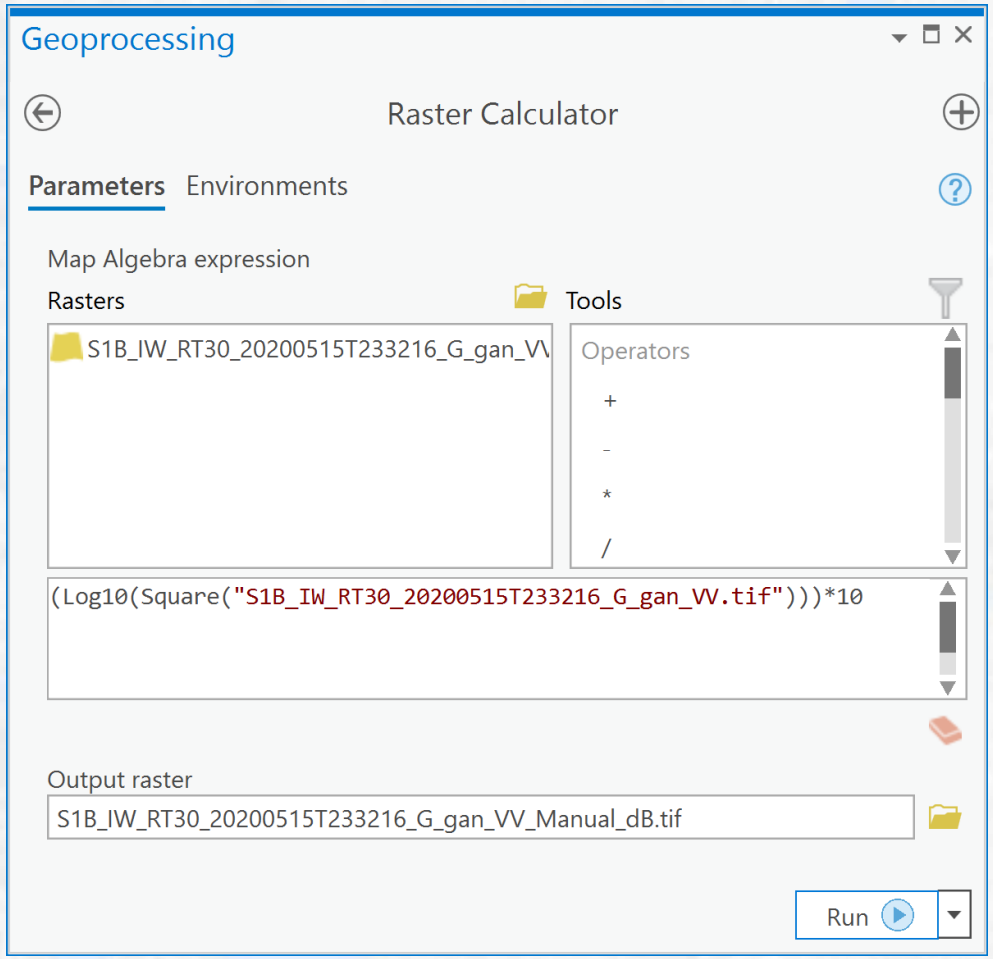
(Log10(Square("S1B_IW_RT30_20200515T233216_G_gan_VV.tif")))*10

ArcGIS Pro Manual Option: Raster Calculator

- Search for Raster Calculator (Spatial Analyst) in the Geoprocessing pane

- The dialog is similar to ArcMap
- The raster must be in the map to appear in the list of rasters
- Enter the expression and set the output raster directory and name, including the .tif extension

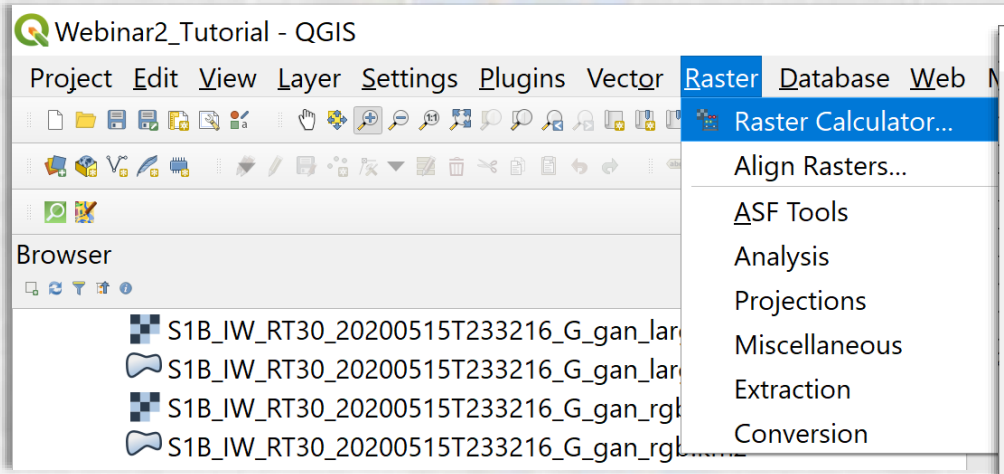


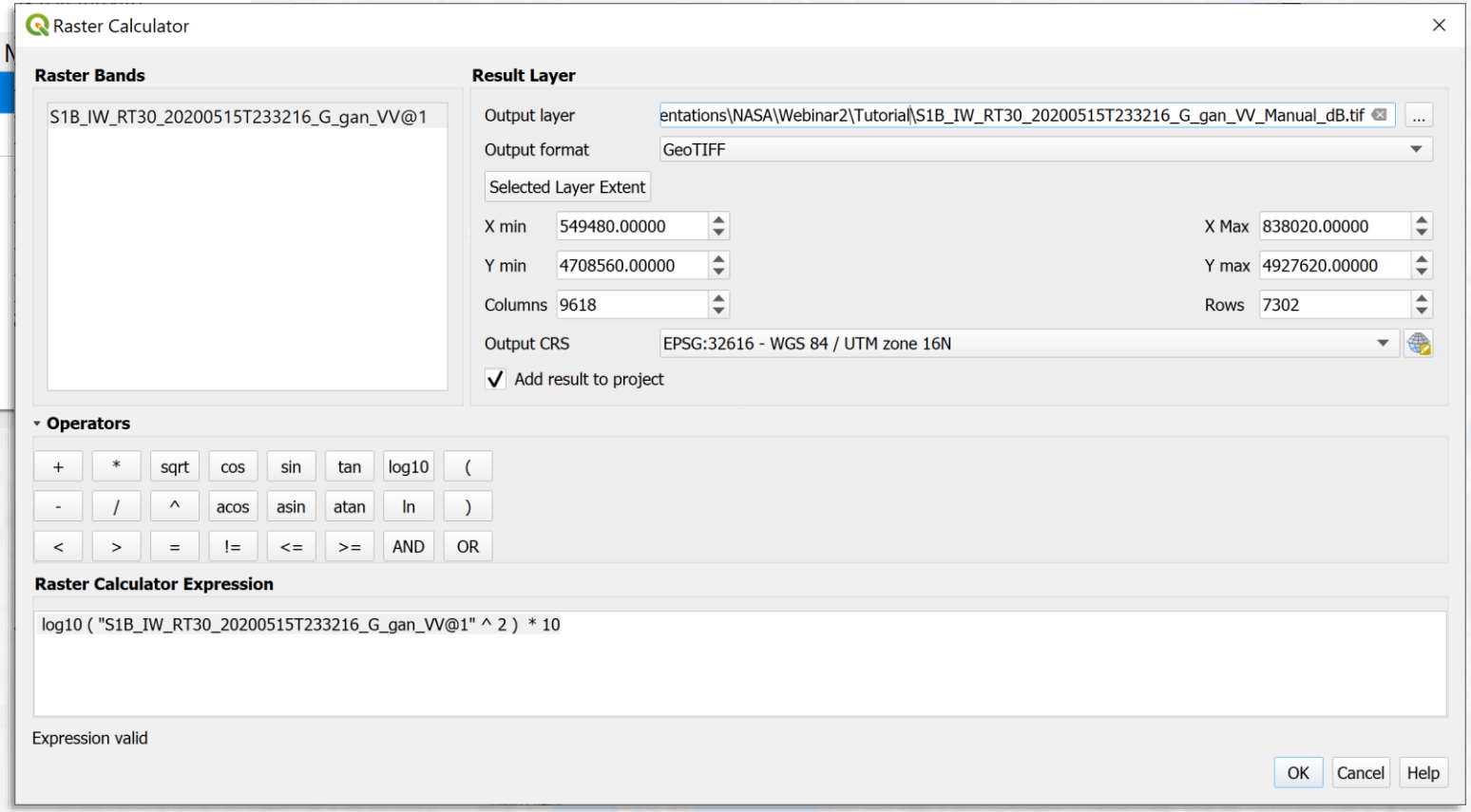


(Log10(Square("S1B_IW_RT30_20200515T233216_G_gan_VV.tif")))*10

QGIS Manual Option: Raster Calculator

- Select Raster Calculator from Raster menu



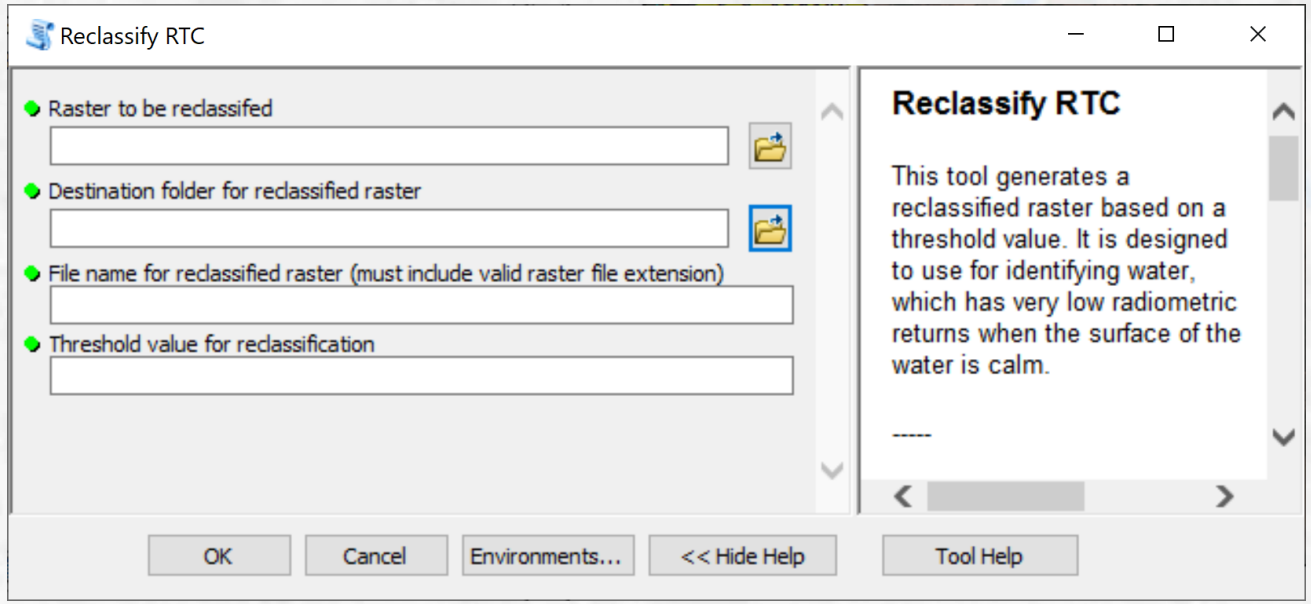


- The interface is similar to ArcGIS, but there are differences in expression syntax
- The raster must be added to the QGIS project to appear in the Raster Bands list. The band is indicated, even for single-band rasters.
- Enter the expression and set the output layer directory and name, output as GeoTIFF

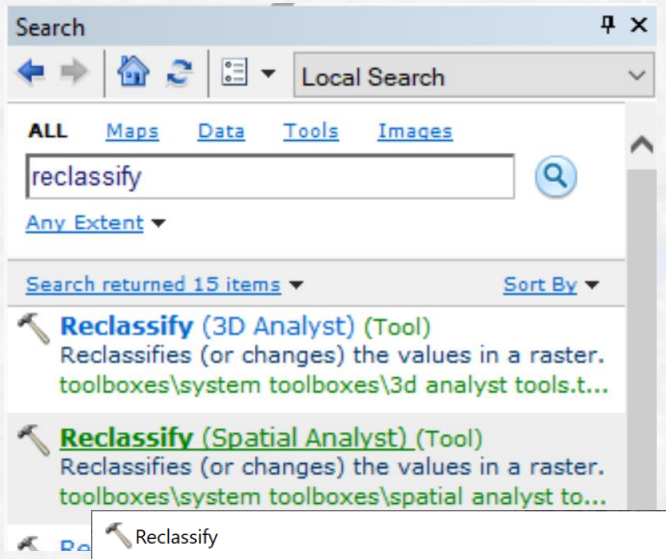
```
log10 ( "S1B_IW_RT30_20200515T233216_G_gan_VV@1" ^ 2 ) * 10
```

Reclassify RTC – Water Masking

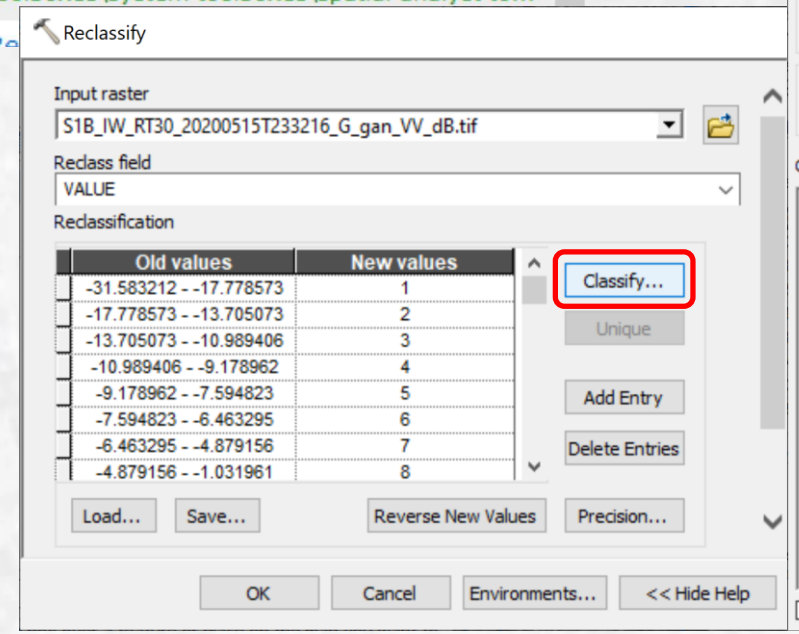
- Set dB threshold to reflect water extent
- Export a mask where pixels with values below the threshold are set to a value of 1 and all other pixels are set to NoData

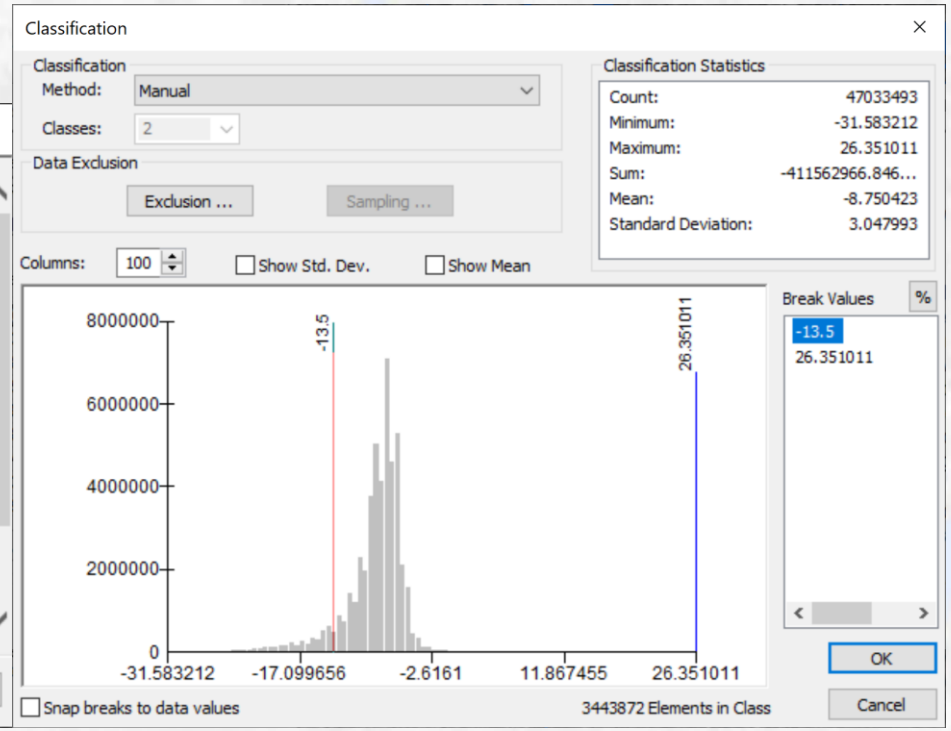


ArcMap Manual Option: Reclassify

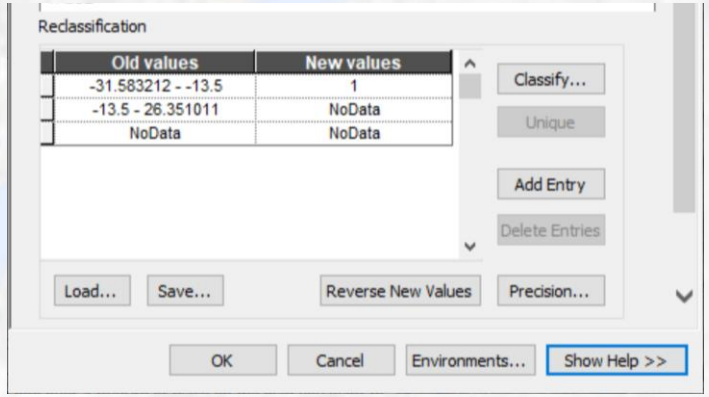


- Search for Reclassify or find the tool in the Spatial Analyst toolbox



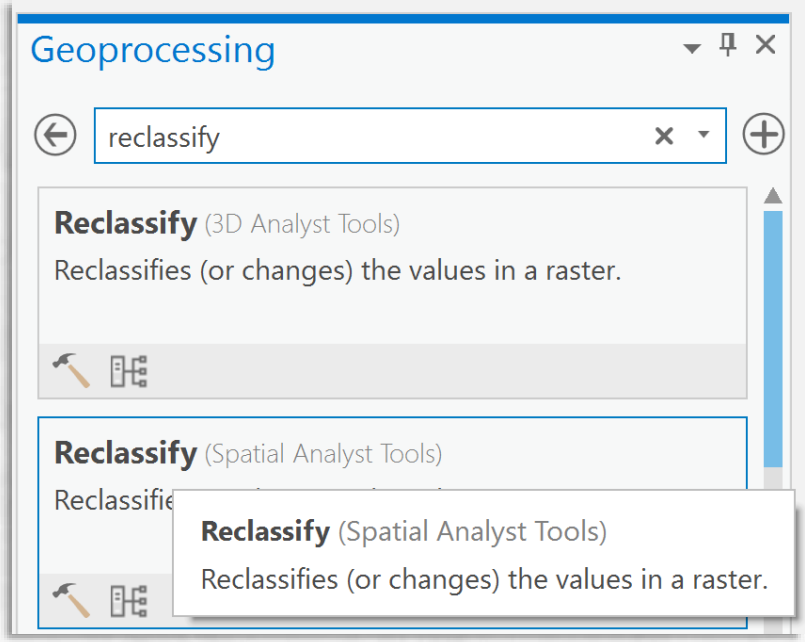


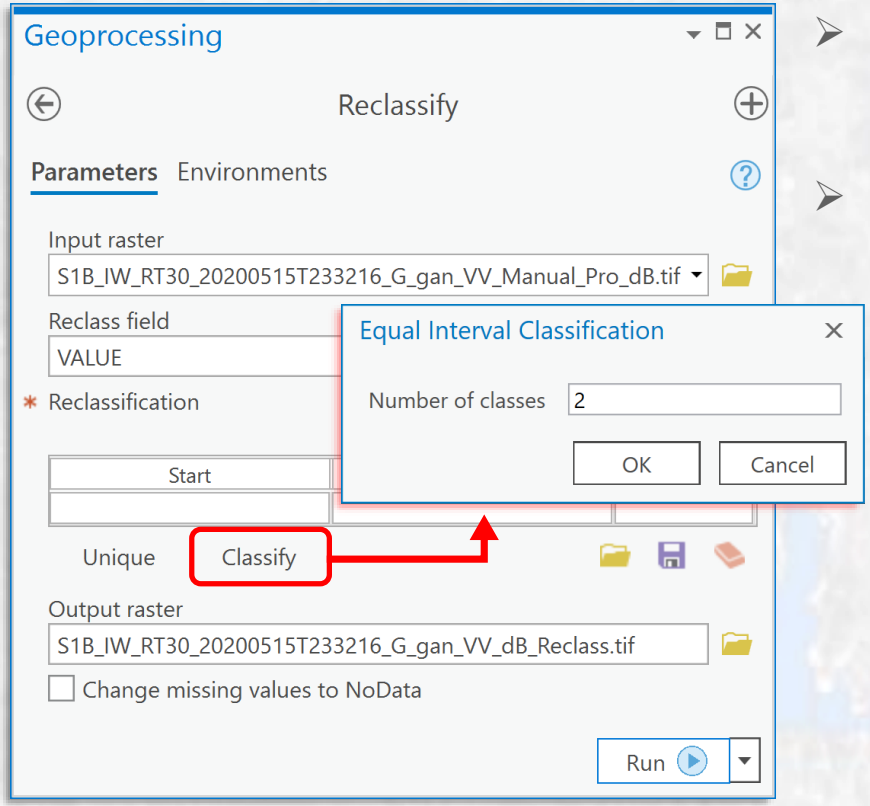
- Select the raster and click the Classify button
- Set the number of classes to 2
- Set the first break value to the desired value (-13.5 in this example)
- Click OK to return to first window
- Set the first range of values to be classified as 1, and the second range of values to be NoData (or 0, if desired)
- Click OK to run the reclassification



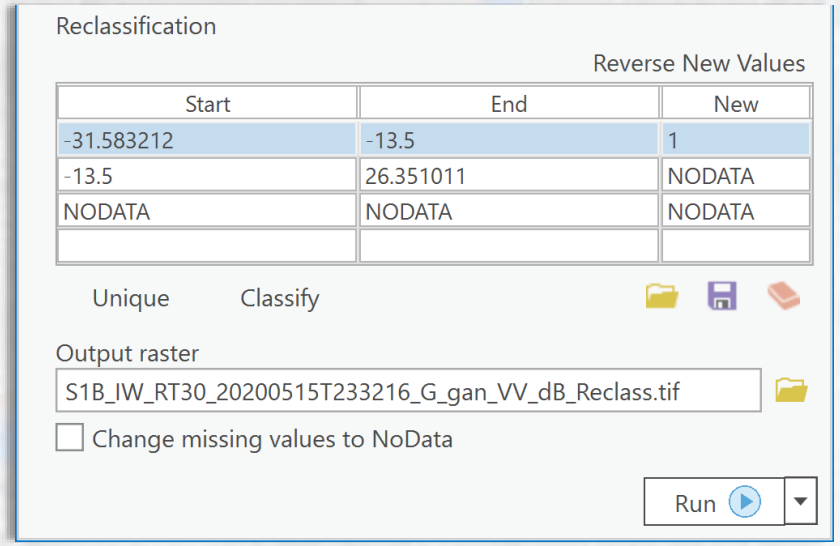
ArcGIS Pro Manual Option: Reclassify

- Search for Reclassify (Spatial Analyst) in the Geoprocessing pane



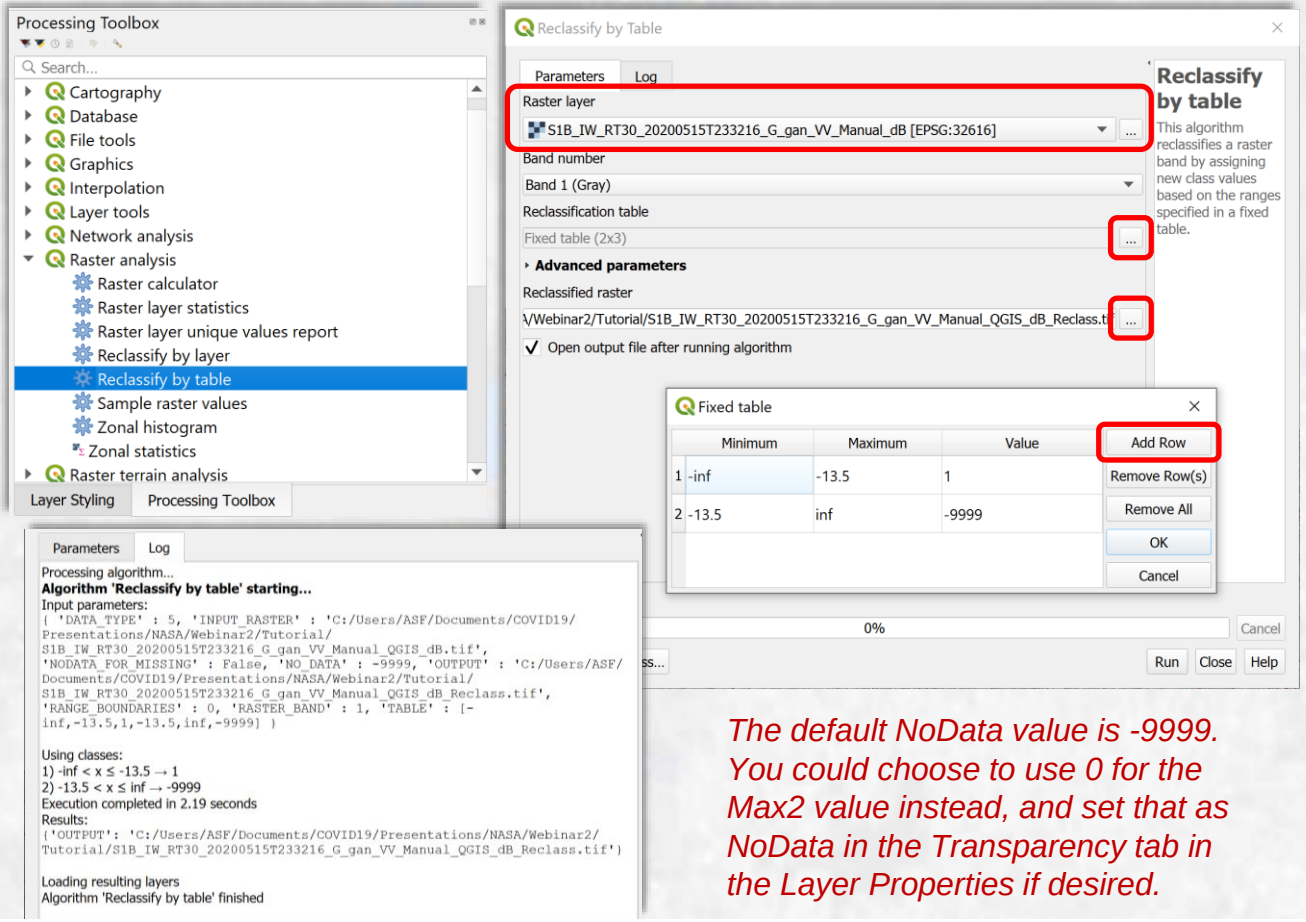


- Select the raster and click the Classify link
- Set the number of intervals to 2
- Set the first End value to the desired value (-13.5 in this example) and set the New value to 1
- Set the Start value for the second class to the End value of the first class, and enter NODATA (or 0, if desired) for the New value
- Click Run to process the data

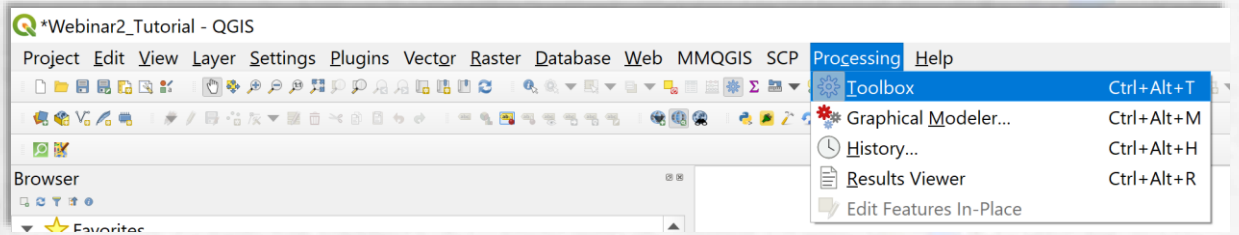


QGIS Manual Option: Reclassify by Table

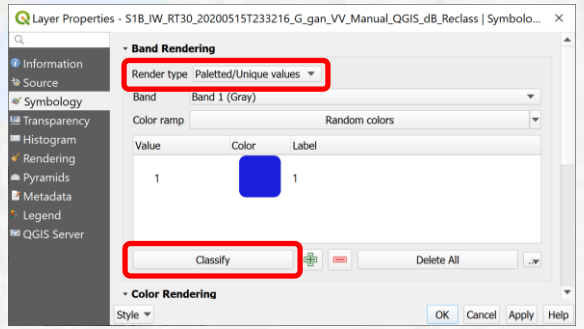
- Select Reclassify by Table from the Processing Toolbox



The default NoData value is -9999. You could choose to use 0 for the Max2 value instead, and set that as NoData in the Transparency tab in the Layer Properties if desired.



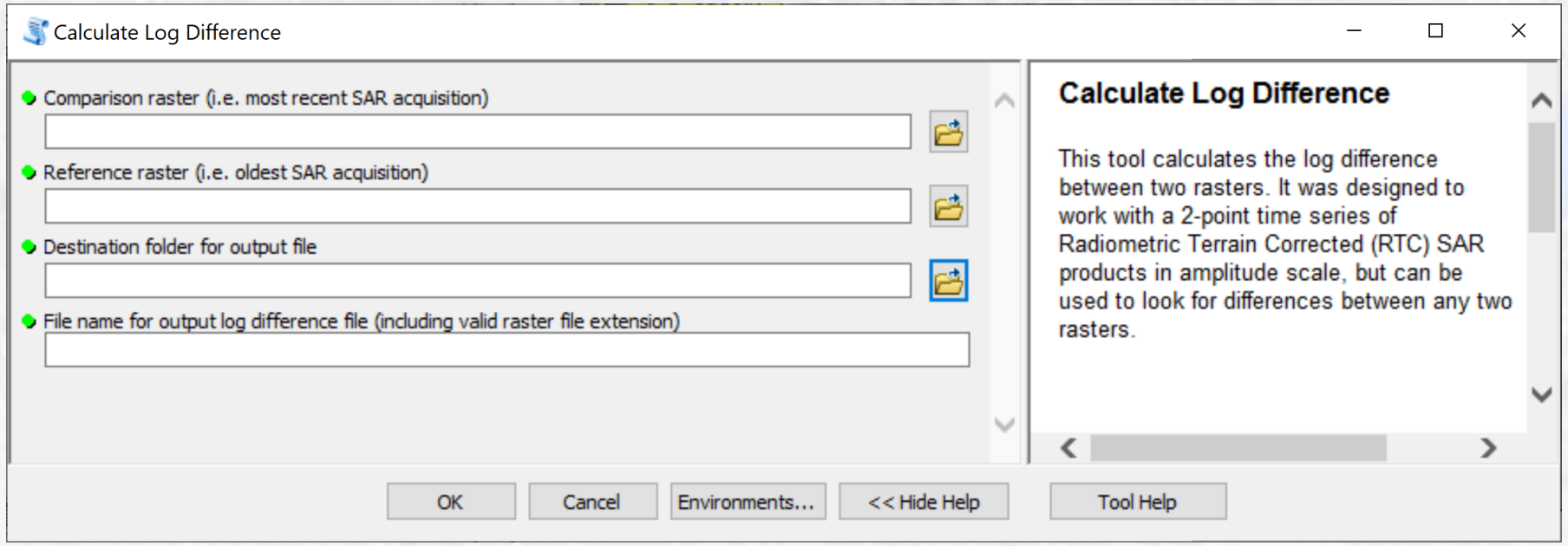
- If the Processing Toolbox is not open, select it from the Processing menu
- Select the raster to reclassify
- Click the ellipses next to the Reclassification Table field, and use the Add Row button to add two new rows.
- Populate the rows as shown, using -inf for Min1, inf for Max2, the break value for Max1 and Min2, and -9999 for NoData
- Click the ellipses next to the Reclassified Raster field, select Save to File, and select the filename and destination
- Click Run to process the data
- To visualize the data:
  - Select the Symbology tab in the Layer Properties window
  - Set the Render type to Paletted/Unique values
  - Click the Classify button



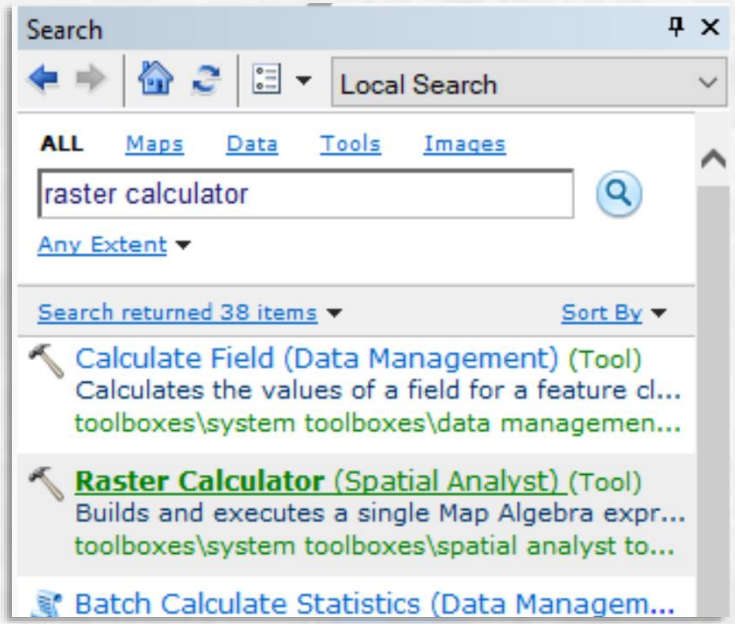
Log Difference

- Taking the log difference of two different rasters can identify areas of change
  - Designed for use with amplitude scale

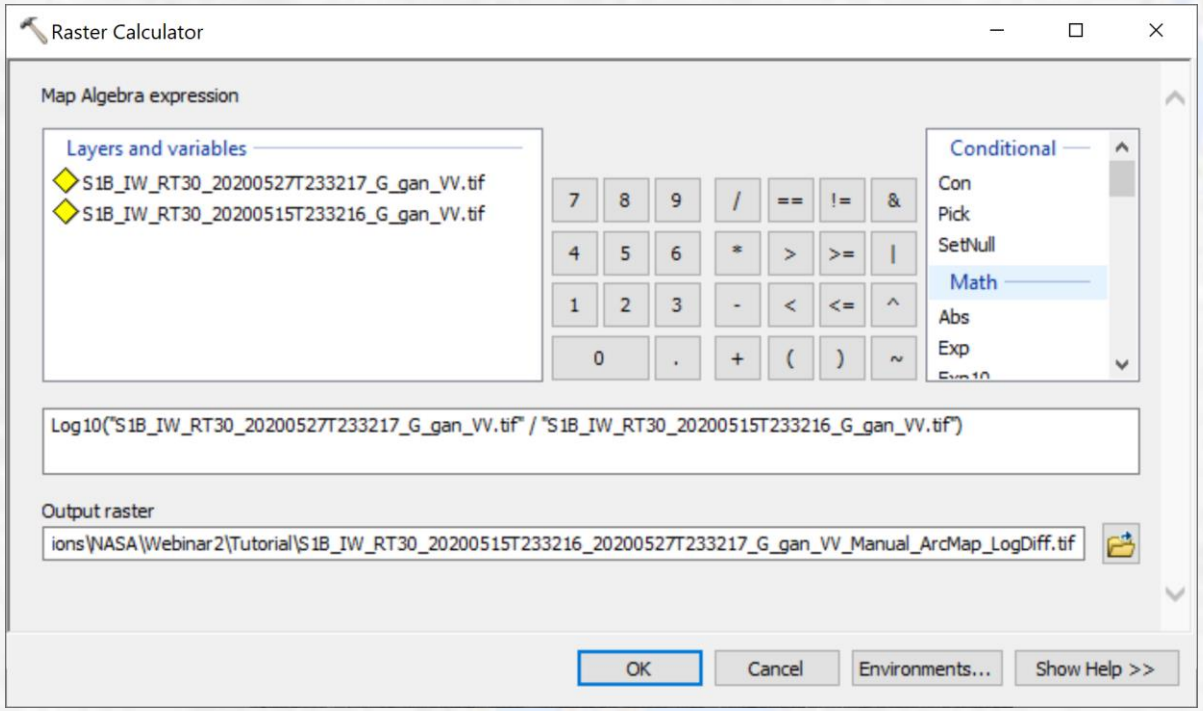
    Log10(RTC2/RTC1)



ArcMap Manual Option: Raster Calculator



- Same approach as for converting scale, but use the log difference formula

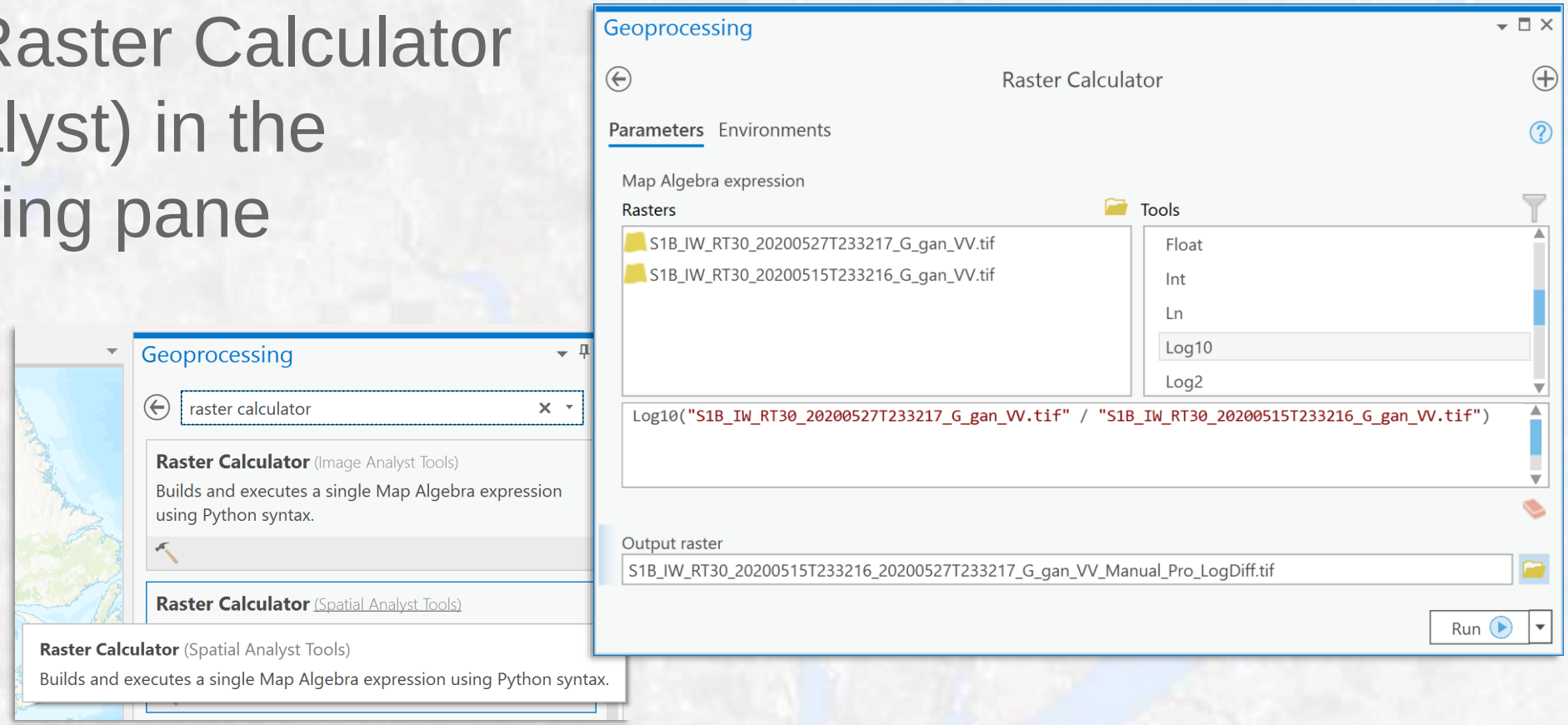


- To use the Log10 function, scroll down the list of expressions and double-click Log10
- Divide the newer image by the older image
- Enter the name and directory for the output raster, including the .tif extension

Log10("S1B_IW_RT30_20200527T233217_G_gan_VV.tif" / "S1B_IW_RT30_20200515T233216_G_gan_VV.tif")

ArcGIS Pro Manual Option: Raster Calculator

- Search for Raster Calculator (Spatial Analyst) in the Geoprocessing pane

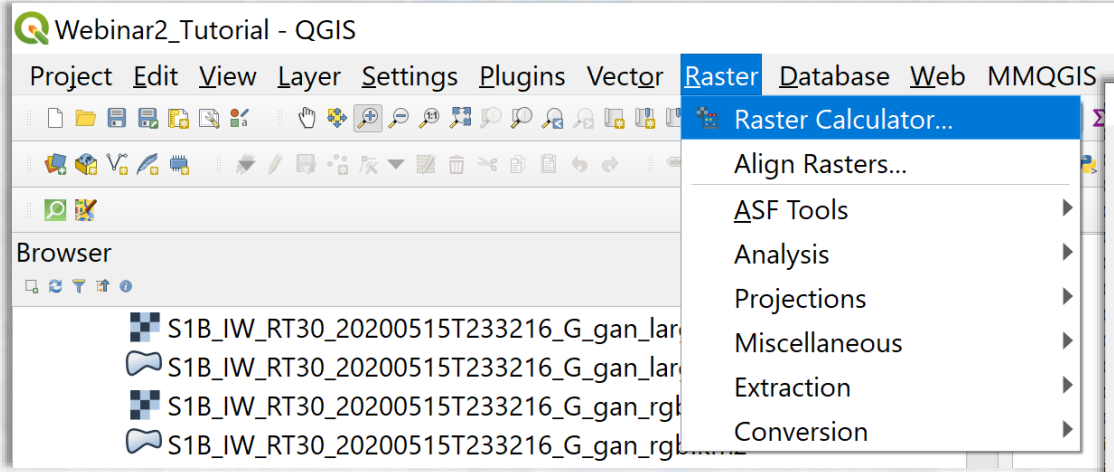


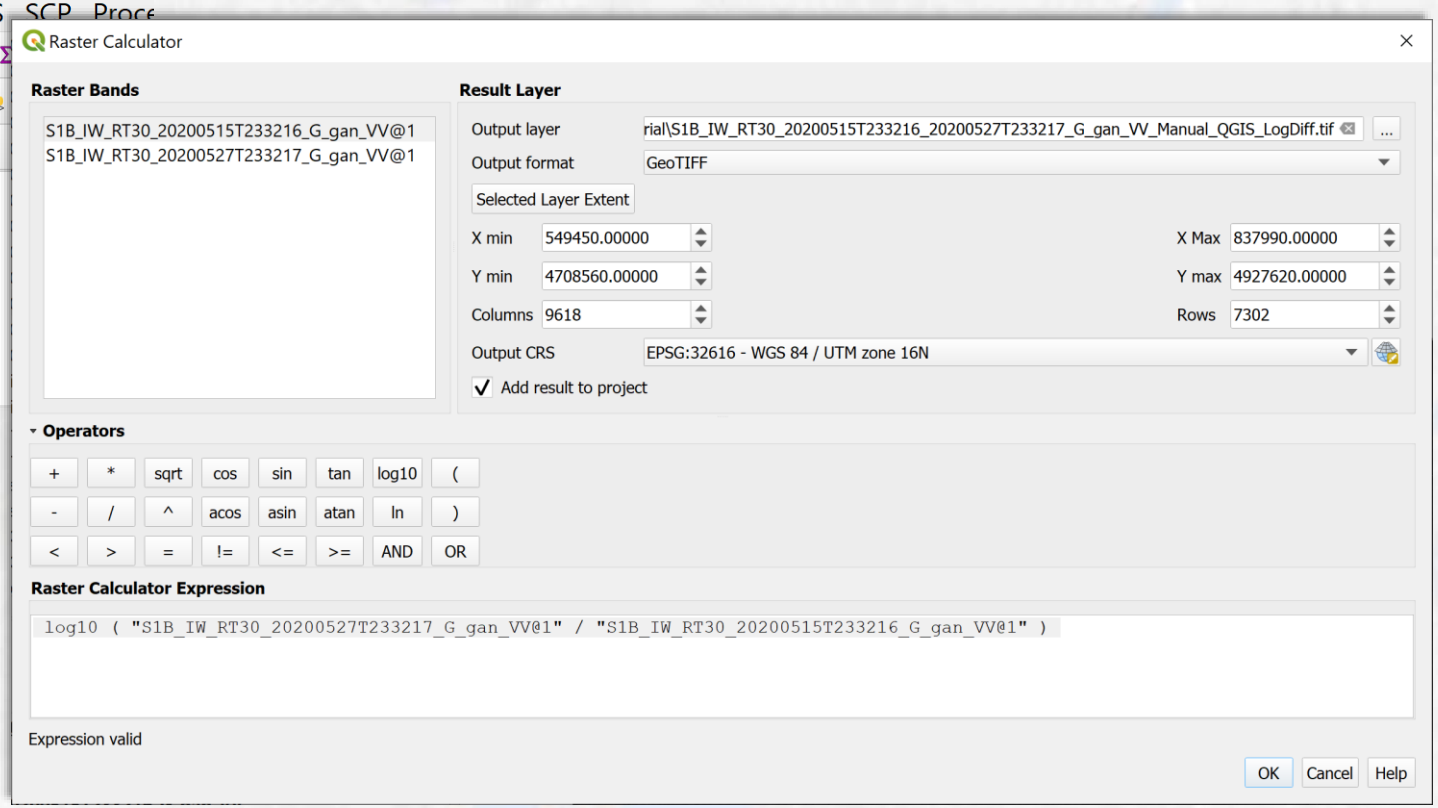
- The dialog is similar to ArcMap
- The rasters must be added to the map to appear in the list of rasters
- Enter the expression and set the output raster directory and name, including the .tif extension

```
Log10("S1B_IW_RT30_20200527T233217_G_gan_VV.tif" / "S1B_IW_RT30_20200515T233216_G_gan_VV.tif")
```

QGIS Manual Option: Raster Calculator

- Select Raster Calculator from Raster menu



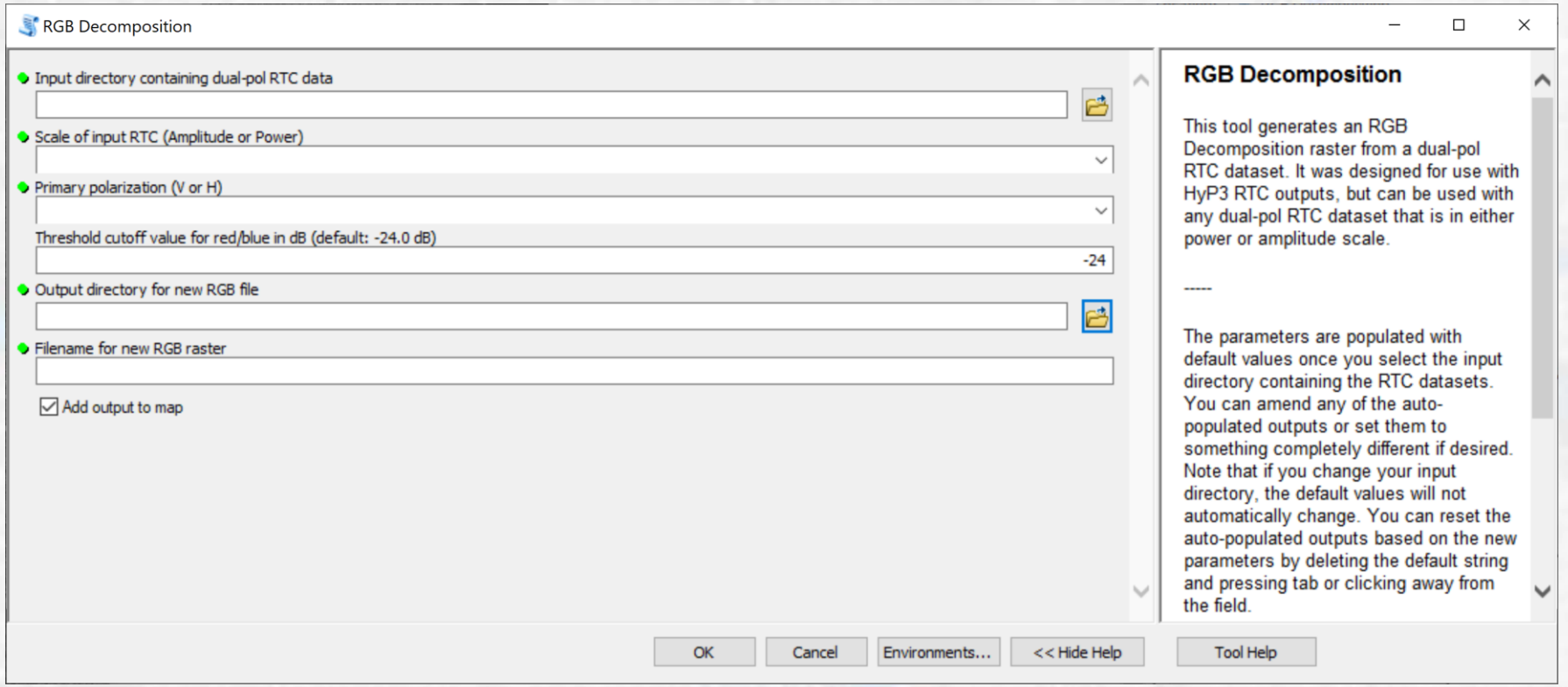


- The interface is similar to ArcGIS, but there are differences in expression syntax
- The rasters must be added to the QGIS project to appear in the Raster Bands list. The band is indicated, even for single-band rasters.
- Enter the expression and set the output layer directory and name, output as GeoTIFF

```
log10 ( "S1B_IW_RT30_20200527T233217_G_gan_VV@1" / "S1B_IW_RT30_20200515T233216_G_gan_VV@1" )
```

Complex Tools: RGB Decomposition

- Complex workflow, based on ASF's method of dual-pol RGB Decomposition: https://github.com/ASFHyP3/hyp3-lib/blob/master/docs/rgb_decomposition.md
- Recent addition to the Toolbox
- In general, water is blue, vegetation is green, urban areas more red
  - Dry and frozen areas can be misleadingly blue

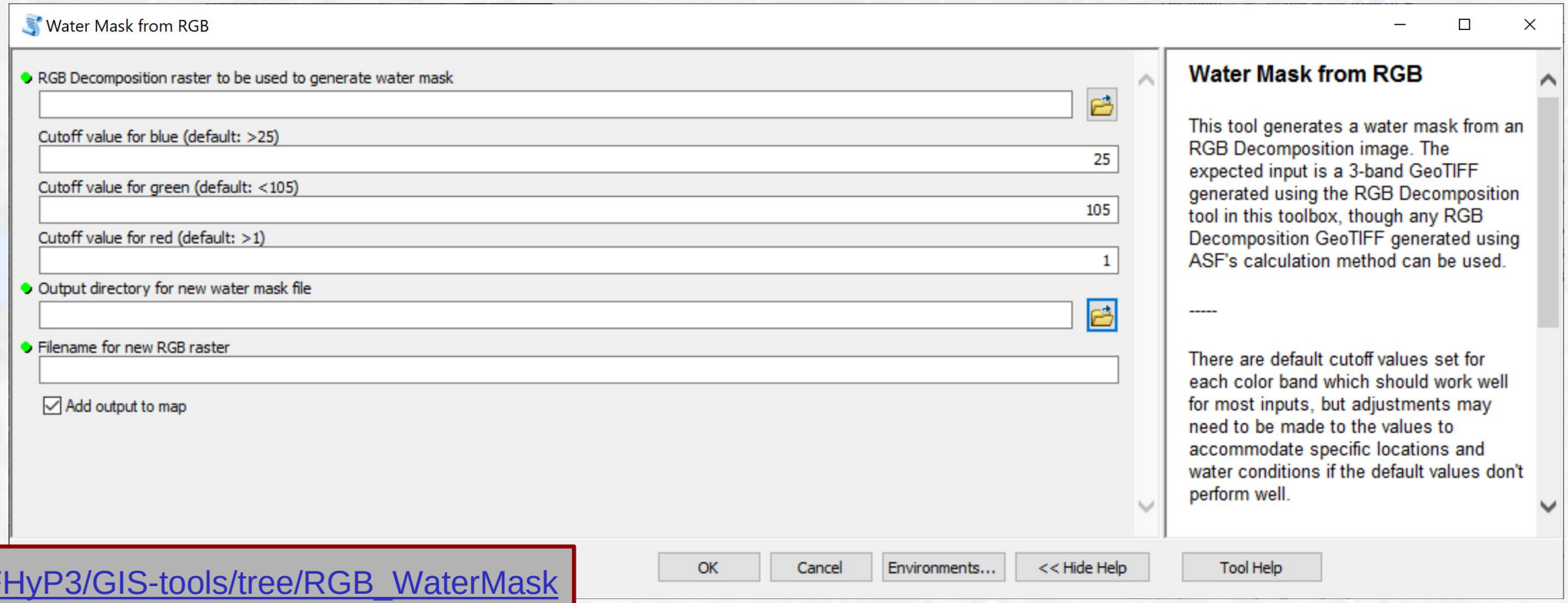


Complex Tools: Water Mask from RGB Decomposition

- Uses RGB Decomposition values to identify water
- Beta: Can be downloaded from GitHub if you'd like to try it out

This approach will be subject to the same color limitations as RGB Decomposition:

- Desert is often identified as water
- Frozen ground may be interpreted as water



https://github.com/ASFHyP3/GIS-tools/tree/RGB_WaterMask

Other resources

- Data Recipe for mapping water using ALOS PALSAR RTC: https://asf.alaska.edu/how-to/data-recipes/how-to-map-regional-inundation-with-spaceborne-l-band-sar-using-arcgis/

- More information about On-Demand Processing in Vertex: https://asfhyp3.github.io/using/vertex/

- Webinar recording including some of this content: https://earthdata.adobeconnect.com/p7heudoyqqey/

QUESTIONS?

https://www.asf.alaska.edu/

https://www.asf.alaska.edu/contact/

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Image: Hurricane Florence Color Decomposition, ASF DAAC 2018.
Contains modified Copernicus Sentinel data 2018, processed by ESA
Basemap: National Geographic