Environmental Change Detection from SAR Images in ArcGIS

Adapted from coursework developed by *Franz J Meyer, Ph.D.*, Alaska Satellite Facility

In this document you will find

A) Background

Due to their 24/7 observation capabilities, SAR data are relevant for a broad range of applications in environmental monitoring and emergency response. However, identifying changes in images with complex content is difficult, as the image content often masks the signatures of change. A simple and highly effective change detection approach is the so- called *log-ratio scaling method*. It is based on a differential analysis of repeated images and has shown to be effective in background suppression and change features enhancement.

B) Materials List

- Windows PC
- Two RTC images
  Options to obtain images:
    - Download and unzip sample images Image 1 and Image 2
    - Download and unzip RTC ALOS PALSAR images using Vertex
    - Process RTC images using Sentinel data
- ArcMap (ArcMap 10.4 was used in the recipe)

Note: To identify *RTC images* suitable for change detection, ensure images are from the *same season*. This is important for change detection operations as it avoids seasonal changes and focuses on true environmental changes in a change detection analysis.

C) Steps

Step 1: Load Data

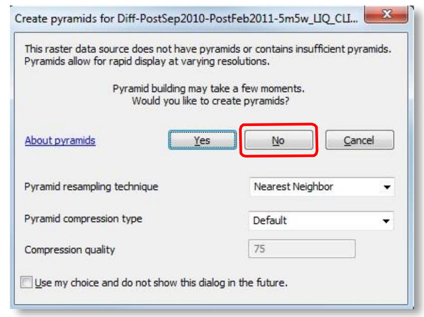
a. Open ArcMap

b. Ensure that the *Spatial Analyst Extension* is enabled by navigating to **Customize > Extensions** and select **Spatial Analyst**

c. Import the two RTC images into the Data Frame using **Add Data** function

i. In the top menu, navigate to **File > Add Data** and click on **Add Data**

ii. Select the **HH** polarization

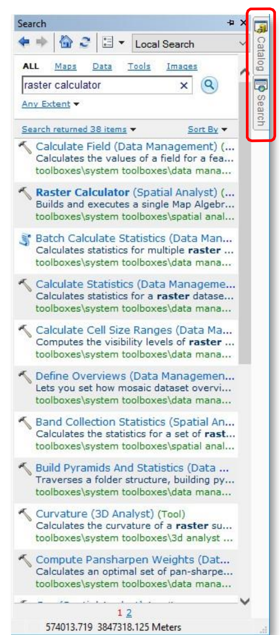


Note: Do not create Pyramids when prompted

Step 2: Calculate the Log-Ratio Image

a. Open the **Raster Calculator**

b. Type "Raster Calculator" in the search box and click on the **Raster Calculator** link in the results



Note: If the Search window is not visible, go to *Windows > Search* or *Ctrl + F*

c. Calculate log-ratio image in the *Raster Calculator* using the following expression (Fig. 1), double-click on filename to add expression:

Log10("newer image"/"older image")

Note: The newer image has the larger orbit number; e.g., 24566 is newer than 18527.

i. Select the output directory of your choosing

Note: If saving to folder, extension required (e.g., log-ratio_layer.tif)

ii. Click **OK** to calculate the log-ratio image

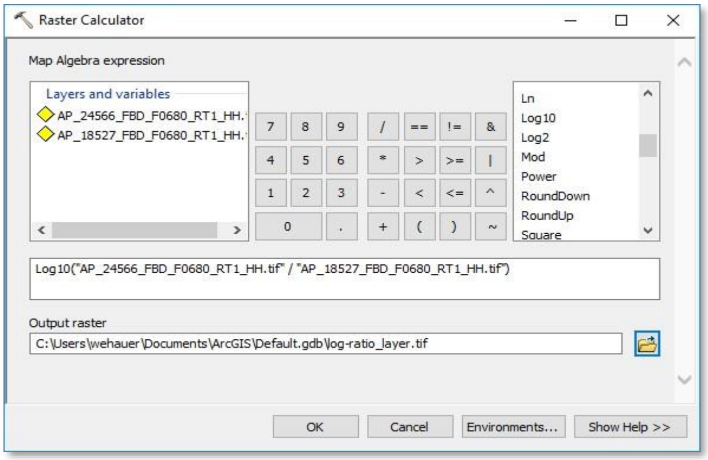
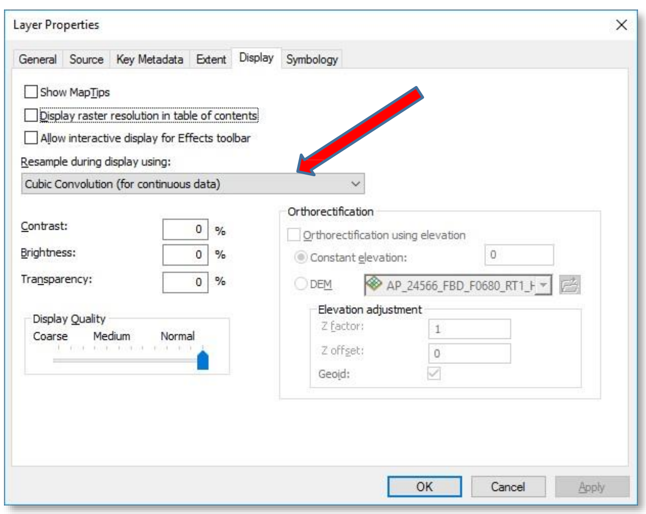


Figure 1: Raster Calculator dialog

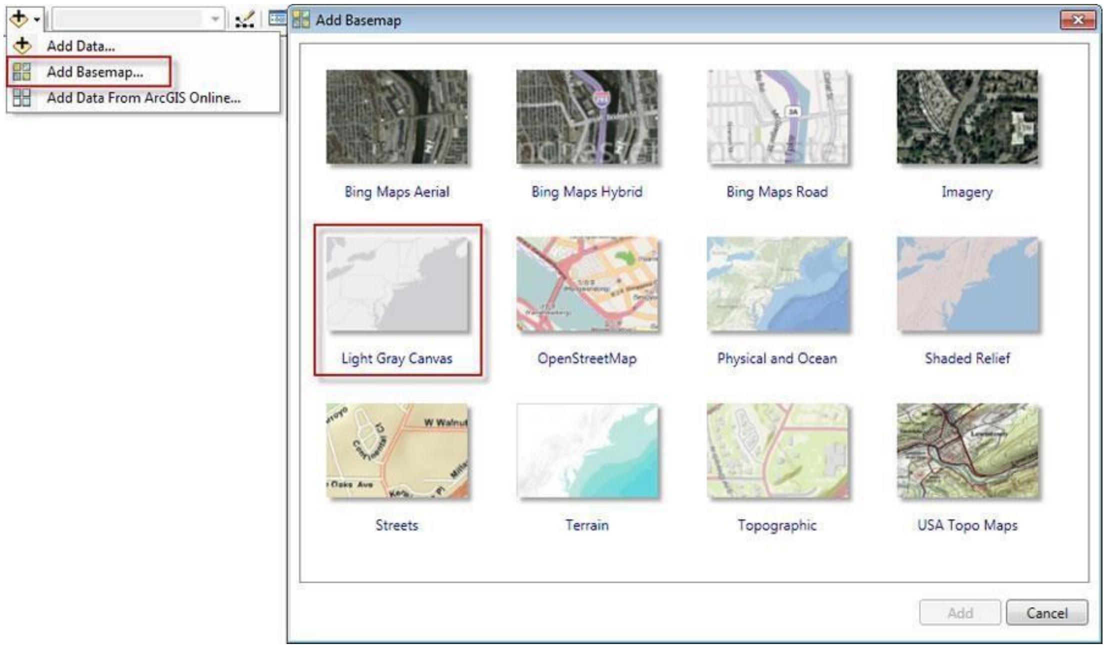
Step 3: Optional - To improve visualization, apply a change to the image properties

a. Right-click on one of the images in the *Layers Panel* and select **Properties**
b. Click on the **Display** tab
c. Under *Resample during display using:* select ***Cubic Convolution***
d. Click **OK**



Step 4: Optional - Add a base layer to be able to compare image features to known landmarks

e. Navigate to **File > Add Data** and click **Add Basemap**
f. Select a base map, such as *Imagery* or *Imagery with Labels*



D) Example Image

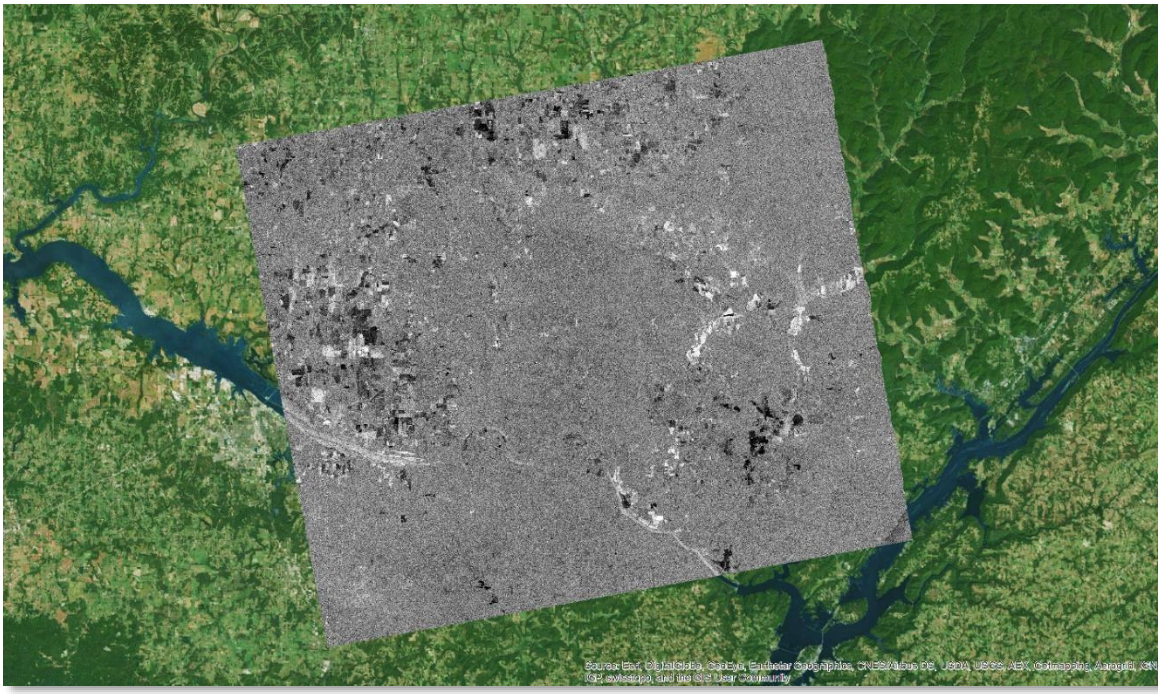


Figure 2: Log-ratio image with the ArcMap Imagery basemap
Credit: ASF DAAC 2017; Includes Material © JAXA/METI 2009, 2010.

The resulting log-ratio image over Huntsville, Alabama was created from a pair of images acquired on 7/17/2009 and 9/04/2010, approximately one year apart. As the data are seasonally coordinated, differences between the images should largely be due to environmental changes between the image acquisition times, such as urban development, changes in river flow, or differences in agricultural activity.

It can be seen that most of the original image content (city of Huntsville, hills and vegetation structures near town, etc.) was effectively suppressed from the image. In the log-ratio image, unchanged features have intermediate gray tones (gray value around zero) while change features are either bright white or dark black. Black features indicate areas where radar brightness decreased while in white areas, the brightness has increased.

E) Other Applications

Figure 3: Logging roads can be identified in these optical satellite data of an area around Altamira, Brazil.

Illegal Logging/Deforestation

Background:

The region near Altamira, Brazil is one of the most active logging regions of the Amazon rainforest. While some of the logging activities in this area are legitimate, illegal logging operations have flourished over the last decade. Existing logging roads can be clearly identified in optical satellite images such as those used by Bing Maps© (Figure 3).
However, frequent rain and cloud cover make change detection based on optical remote sensing data impractical.

Steps:

Select and download High-Res Terrain Corrected ALOS PALSAR repeated images over the logging areas near the Brazilian city of Altamira. Target similar seasons. Due to the evergreen vegetation in this tropical area, there is no preference for which season you choose. Use the Log-Ratio Scaling method as outlined in Section C.

Note**:** To use Sentinel-1 data, please use *high res GRD data*. You must first extract, project, and scale to byte before the data can be used in the GIS environment.

Further Reading

- Chatelain, F., Tourneret, J. Y., Inglada, J., and Ferrari, A., 2007, Bivariate Gamma Distributions for Image Registration and Change Detection: IEEE Transactions on Image Processing, v. 16, no. 7, p. 1796-1806.
- Cha, Miriam, Rhonda D. Phillips, Patrick J. Wolfe, and Christ D. Richmond. "Two-Stage Change Detection for Synthetic Aperture Radar." (2015).
- Dogan, Ozan, and Daniele Perissin. "Detection of Multitransition Abrupt Changes in Multitemporal SAR Images." Selected Topics in Applied Earth Observations and Remote Sensing, IEEE Journal of 7, no. 8 (2014): 3239-3247.
- F. Bovolo and L. Bruzzone, "A detail-preserving scale-driven approach to change detection in multitemporal SAR images," Geoscience and Remote Sensing, IEEE Transactions on, vol. 43, pp. 2963-2972, 2005.
- J. Inglada and G. Mercier, "A new statistical similarity measure for change detection in multitemporal SAR images and its extension to multiscale change analysis," Geoscience and Remote Sensing, IEEE Transactions on, vol. 45, pp. 1432-1445, 2007.
- L. Bruzzone and D. F. Prieto, "Automatic analysis of the difference image for unsupervised change detection," Geoscience and Remote Sensing, IEEE Transactions on, vol. 38, pp. 1171-1182, 2000.
- R. J. Dekker, "Speckle filtering in satellite SAR change detection imagery," International Journal of Remote Sensing, vol. 19, pp. 1133-1146, 1998.
- S. Huang, "Change mechanism analysis and integration change detection method on SAR images," The International Archives of the Photogrammetry, Remote Sensing and Spatial Information Sciences. Vol. XXXVII. Part B7, 2008.
- S.-H. Yun, E. J. Fielding, F. H. Webb, and M. Simons, "Damage proxy map from interferometric synthetic aperture radar coherence," ed: Google Patents, 2012.
- T. Celik, "A Bayesian approach to unsupervised multiscale change detection in synthetic aperture radar images," Signal processing, vol. 90, pp. 1471-1485, 2010.
- Y. Bazi, L. Bruzzone, and F. Melgani, "An unsupervised approach based on the generalized Gaussian model to automatic change detection in multitemporal SAR images," Geoscience and Remote Sensing, IEEE Transactions on, vol. 43, pp. 874-887, 2005.
- Xiong, Boli, Qi Chen, Yongmei Jiang, and Gangyao Kuang. "A threshold selection method using two SAR change detection measures based on the Markov random field model." IEEE Geoscience and Remote Sensing Letters, vol. 9, no. 2 (2012): 287-291.