Environmental Change Detection from SAR Images in QGIS

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 masks signatures of change. A simple and highly effective change detection approach is the so-called *log-ratio scaling method*. Based on a differential analysis of repeated images it has been shown to be effective in background suppression and change features enhancement.

B) Materials List

- Windows, Mac, or Linux PC
- Two RTC images
  Options to obtain images:
  1. Download and unzip Sample 1 and Sample 2,
  2. Download and unzip RTC ALOS PALSAR images using Vertex
  3. Process RTC images using Sentinel data
- QGIS (version 2.18.12 was used in this 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 QGIS
b. Import two RTC images into QGIS

i. Click on the **Add Raster**  icon to open your image

ii. Browse to the directory of your RTC images

iii. Select the polarization of your choosing (e.g., HH)

iv. Select multiple images by holding the Ctrl or Shift button on your keyboard and clicking **OK**

Step 2: Calculate the Log-Ratio Image

a. Open the **Raster Calculator**

i. In the top menu navigate to **Raster > Raster Calculator**
ii. Construct the following expression (Figure 1):

log10 ("newer image"/ "older image")

Note: The newer image has larger orbit number; e.g., 24566 is newer than 18527.
Double-click on file name to add to the expression

iii. Set the *Output Layer* to a filename and directory of your choice (e.g., "log-ratio_layer.tif")
iv. Click **OK** to calculate the log-ratio image
a) With the *Add result to project checkbox*, the result layer will automatically be added to the legend area and can be visualized

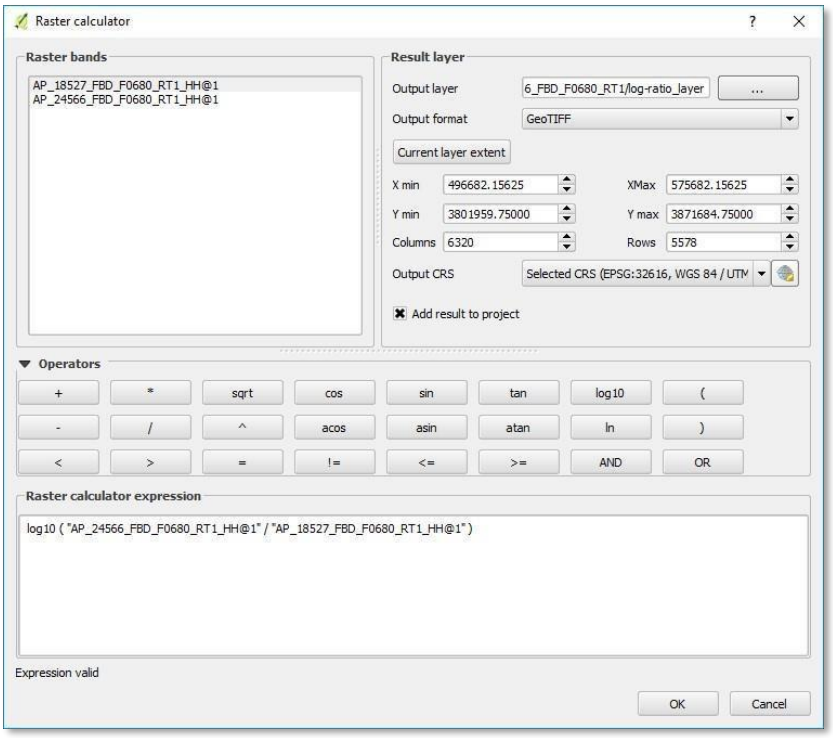

Figure 1: Raster Calculator dialog

b. To improve visualization at all spatial scales, apply a few changes to the image properties

    a. Right-click on the image in the *Layers Panel* and select **Properties**
    b. In the *Layer Properties* window click on **Style** (Figure 2)
    c. Change the resampling method for *Zoomed: in* to **Cubic**, and *Zoomed: out* to **Average**
    d. Click **OK**

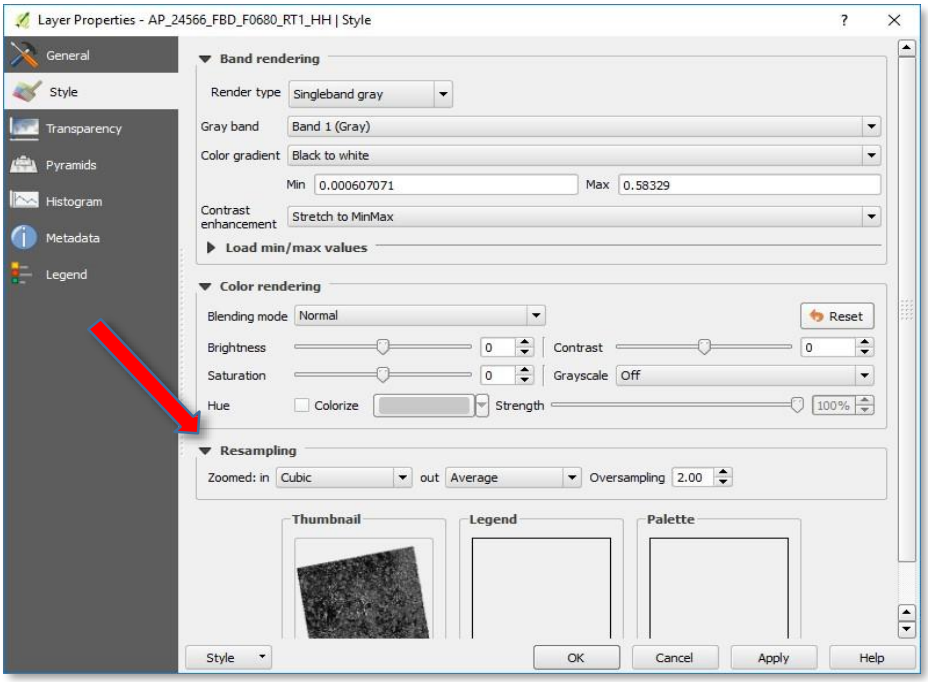

Figure 2: Layer Properties > Style Properties dialog

Step 3: Optional - Add a base layer to compare image features to known landmarks

a. Load the **OpenLayers Plugin** into your QGIS system via the **Plugins/Manage** and **Install Plugins**… Item in the menu bar at the top of the QGIS interface

b. Open a base layer by using the top menu, **Web > OpenLayers plugin**

Note: The base layer used in Figure 1 can be found in *Web > OpenLayers plugin > Google Maps > Google Hybrid*

c. In the *Layers Panel* in the lower left corner, drag and drop the base layer so that it is below the log-ratio layer.

D) Resulting Image and Analysis

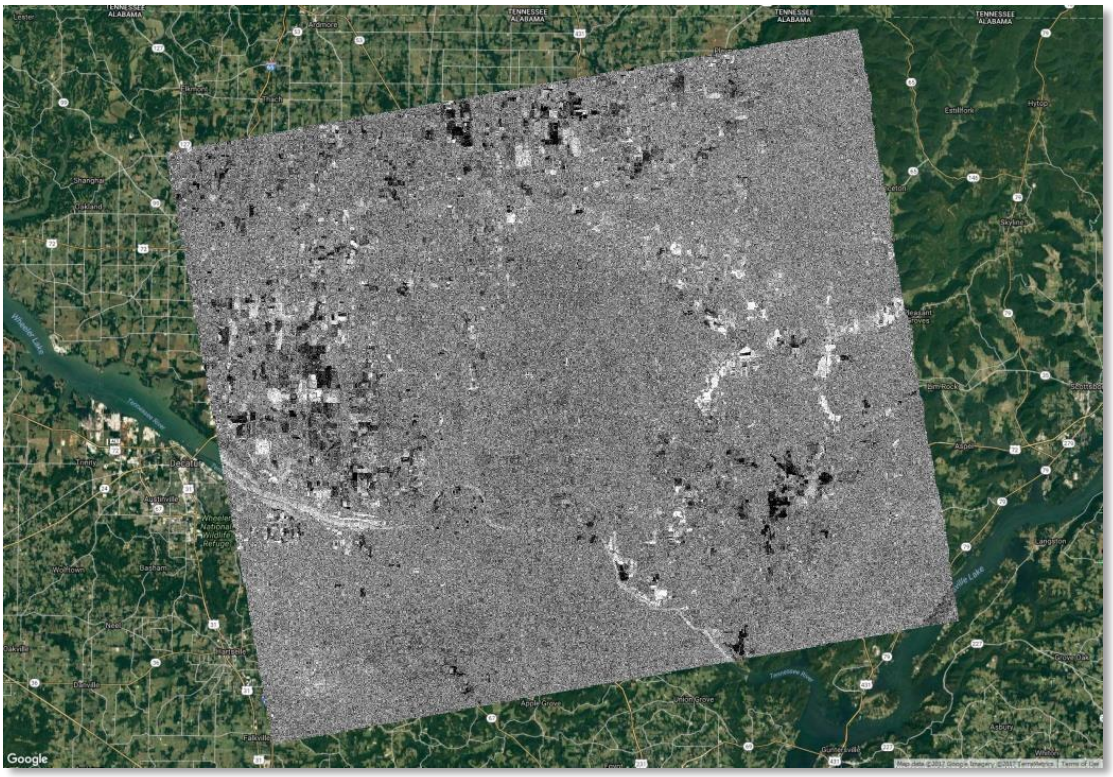

Figure 3: Log-ratio image with OpenLayers Google Maps hybrid base map
Credit: ASF DAAC 2017; Includes Material © JAXA/METI 2009, 2010.

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 4: 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 4). 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.

F) 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. "TwoStage 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. 874887, 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): 287291.