ENVI Tutorial: Basic SAR Processing and Analysis

Basic SAR Processing and Analysis

This tutorial is designed to give you a working knowledge of ENVI's basic tools for processing single-band synthetic aperture radar (SAR) data such as RADARSAT, ERS-1, and JERS-1.

Files Used in this Tutorial

ENVI Resource DVD: `Data\rsat_sub`

File	Description
`lea_01.001`	RADARSAT leader file
`bonnrsat.img (.hdr)`	RADARSAT image subset
`rsi_f1.img (.hdr)`	Frost filter result
`dslice.dsr`	Density slice file
`rsi_f2.img (.hdr)`	Laplacian filter result
`rsi_f3.img (.hdr)`	Laplacian filter result with 90% add-back
`rsi_fus.img (.hdr)`	Simulated fused TM and RADARSAT
`rsi_map.jpg`	RADARSAT map composition example

Background

Use the **Radar** menu in ENVI to access standard and advanced tools for analysis of detected radar images and advanced SAR systems such as NASA/Jet Propulsion Laboratory's (JPL's) fully polarimetric AIRSAR and SIR-C systems. ENVI can process ERS-1, JERS-1, RADARSAT, SIR-C, X-SAR, and AIRSAR data and any other detected SAR dataset. In addition, ENVI is designed to handle radar data distributed in the CEOS format.

Most standard ENVI processing functions are inherently radar-capable, including all display capabilities, stretching, color manipulations, classification, registration, filters, geometric rectification, and so on. Additional specialized tools are provided for analyzing polarimetric radar data. A typical processing flow may include reviewing the CEOS header, reading the CEOS data, displaying and contrast stretching, removing speckle using an adaptive filter, density slicing, edge enhancement, data fusion, and map composition.

Single-Band SAR Processing

This section describes a typical single-band SAR processing scenario from data input through processing and analysis, to publication-quality or map output. You will use a subsetted RADARSAT 1 Path Image, Fine Beam 2, from December 17, 1995, Bonn, Germany.

Read and Display RADARSAT CEOS Data

ENVI provides the tools to read generic CEOS data tapes and RADARSAT data from both tape and CD-ROM. To read data from tape, select File > Tape Utilities > Read Known Tape Formats > RADARSAT CEOS. To read original RADARSAT data from disk or CD, select Radar > Open/Prepare Radar File > RADARSAT. For this tutorial, a RADARSAT image subset has already been extracted.

1. From the ENVI main menu bar, select **File > Open Image File**. A file selection dialog appears.
2. Navigate to `Data\rsat_sub` and select `bonnrsat.img`. Click **Open**.
3. In the Available Bands List, select the **Gray Scale** radio button and click **Load Band**. The following figure shows the subsetted RADARSAT image of Bonn, Germany, with a 2% linear stretch applied. This dataset was acquired during the RADARSAT commissioning phase and should not be used for scientific analysis or interpretation. Data are copyright, RADARSAT, 1995.

Review CEOS Header

Many SAR datasets are distributed in CEOS format. ENVI provides generic tools to read CEOS headers and display CEOS header information on the screen. ENVI also has tools specifically designed to read RADARSAT CEOS headers, which contain additional information.

1. From the ENVI main menu bar, select **Radar > Open/Prepare Radar File > View RADARSAT Header**. A file selection dialog appears.
2. Select the RADARSAT leader file `lea_01.001`. A CEOS Header Report dialog appears.
3. Browse the information in the CEOS Header Report, then close the dialog when you are finished.

Apply Square-Root Contrast Stretch

Radar data typically cover a large range of data values. As seen above, default linear stretches do not perform a very good job of enhancing the contrast in most radar images. ENVI's square-root stretch spreads out radar data over a given range of gray scales better than other types of stretches, resulting in an improved display of radar images.

1. From the Display group menu bar, select **Enhance > [Image] Square Root**. The stretch is applied based on the statistics of the data in the Image window. The following figure shows a square-root stretch of the Bonn RADARSAT image. Compare to the linear contrast stretch above.

2. In the Available Bands List, click **Display #1** and select **New Display**. Click **Load Band** again to display the image with the default 2% linear stretch.
3. From a Display group menu bar, select **Tools > Link > Link Displays**. Click **OK** to link the square-root image with the 2% linear stretch image. Click in an Image window to toggle between the two images.

Remove Speckle Using Adaptive Filters

Adaptive filters remove radar speckle from images without seriously affecting the spatial characteristics of the data. The Frost-filtered image shown below is a considerable improvement over the unfiltered data. The Frost filter, an exponentially damped, circularly symmetric filter that uses local statistics, is used to reduce speckle while preserving edges in the data. The pixel being filtered is replaced with a value calculated based on the distance from the filter center, the damping factor, and the local variance.

1. From the ENVI main menu bar, select **Radar > Adaptive Filters > Frost**. A Frost Filter Input File dialog appears.
2. Select `bonnrsat.img` and click **OK**. A Frost Filter Parameters dialog appears.
3. Use the default Filter Size (3x3) and Damping Factor (1.0). Enter an output filename and click **OK**.
4. In the Available Bands List, select the new Frost-filtered image and click **Load Band**. Or, load the pre-generated file `rsi_f1.img` to a new display group and apply a square-root stretch.

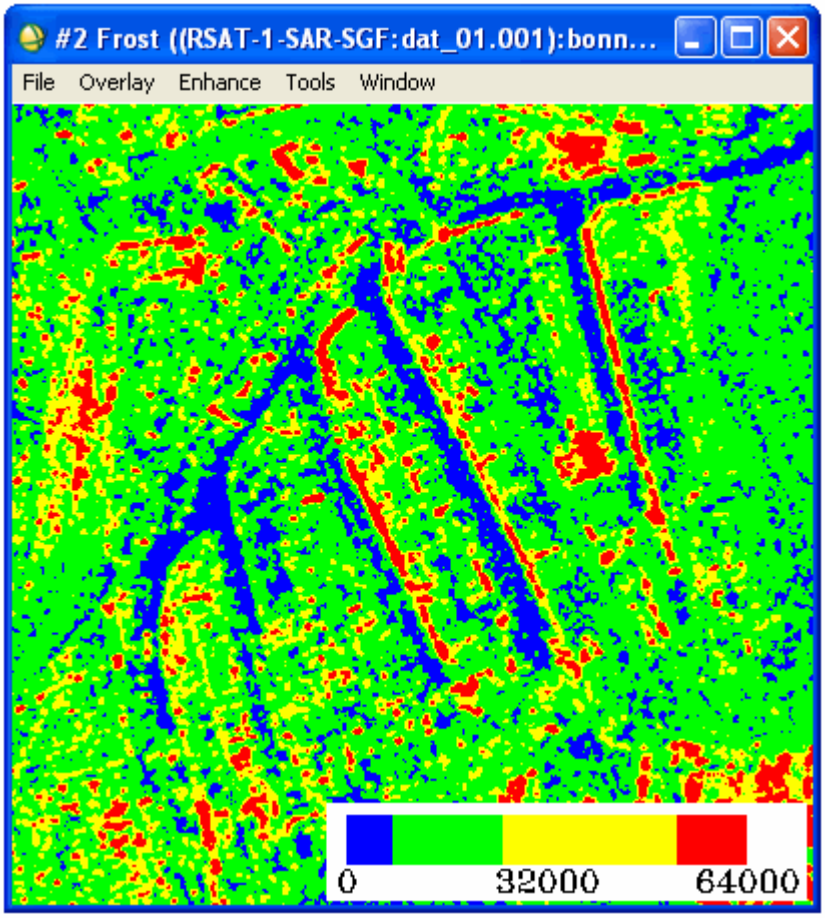
5. From a Display group menu bar, select **Tools > Link > Link Displays**. Click **OK** to link the Frost-filtered image with the 2% linear stretch image. Click in an Image window to toggle between the two images.

Density Slice

Density slicing visually enhances radar differences based on image brightness. The density-sliced image below has four levels, with higher radar backscatter in the warmer colors.

1. From the Display group menu bar associated with the Frost-filtered image, select **Tools > Color Mapping > Density Slice**. A Density Slice Band Choice dialog appears.
2. Select the name of your Frost-filtered image and click **OK**. A Density Slice dialog appears.
3. From the Density Slice dialog menu bar, select **File > Restore Ranges**. A file selection dialog appears.
4. Select `dslice.dsr` and click **Open**.
5. Click **Apply** in the Density Slice dialog. Use image-linking and dynamic overlays to compare the density-sliced image to the gray scale images.

6. When you are finished, close the Density Slice dialog.



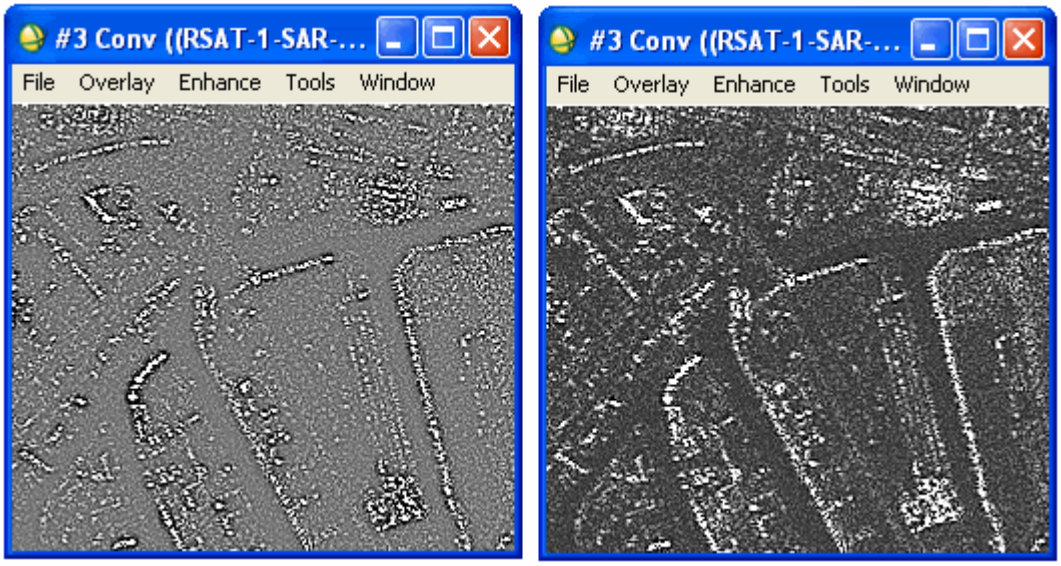
Edge Enhancement

A Laplacian filter is a convolution filter that enhances edges in SAR and other data types. A 5 x 5 filter has the following kernel:

0	0	-1	0	0
0	-1	-2	-1	0
-1	-2	16	-2	-1
0	-1	-2	-1	0
0	0	-1	0	0

1. From the ENVI main menu bar, select **Filter > Convolutions and Morphology**.
2. From the Convolutions and Morphology Tool dialog menu bar, select **Convolutions > Laplacian**.
3. Set the **Kernel Size** field to **5**.
4. Click **Quick Apply**. An input band selection dialog appears.
5. Select `bonnrsat.img` and click **OK**. Or, view the pre-generated file `rsi_f2.dat`. Applying the kernel in this manner strongly enhances the edges while losing most of the radiometric information in the image.

6. Repeat Steps 1-4, but set the **Image Add Back** field to **90**.
7. Click **Quick Apply**. Or, view the pre-generated file `rsi_f3.dat`. The following figure shows Laplacian filter results (left) and 90% Add Back results (right):



8. Use image linking and dynamic overlays to compare these results with the original gray scale images.
9. When you are finished, close the Convolutions and Morphology Tool dialog.
10. From the ENVI main menu bar, select **File > Exit**.

Data Fusion

SAR data complement other types of data by providing spatial information that other data do not contain. Conversely, SAR data do not have the composition expressed in multispectral, optical data. Therefore, a combined SAR/optical data analysis is usually required.

You can use an intensity-hue-saturation (IHS) transform to combine a multispectral, color-composite image with a monochromatic SAR-sharpening band. ENVI provides a simple tool to conduct data merging using IHS.

See the *Landsat TM and SAR Data Fusion* tutorial for more information, and view the pre-generated, fused TM/SAR file `rsi_fus.img`.

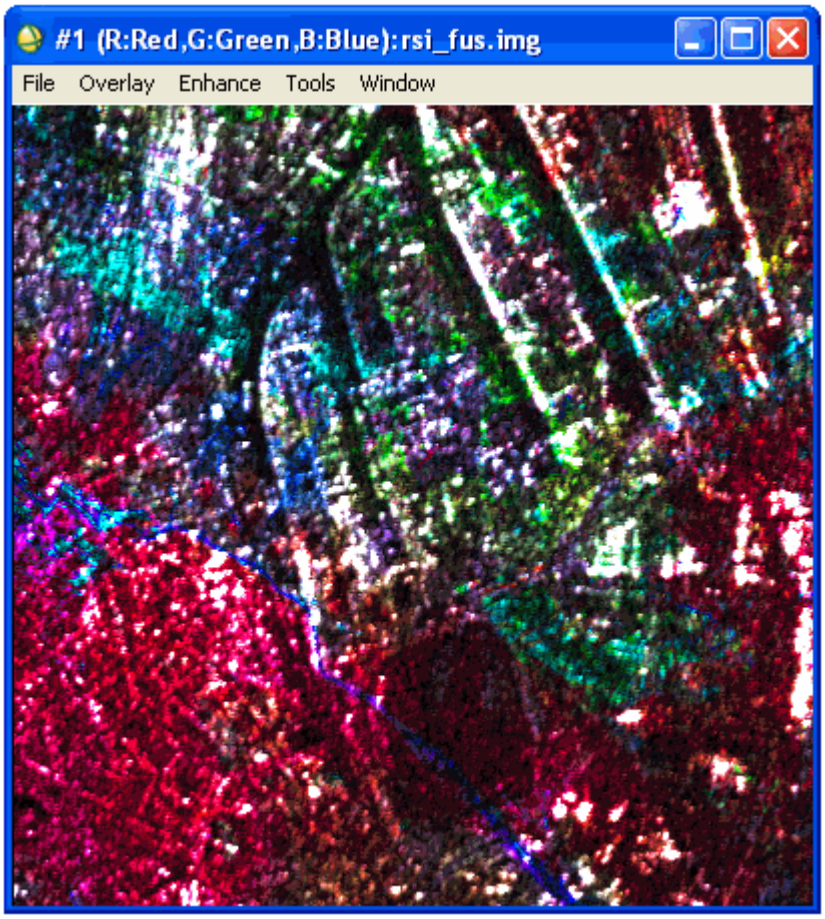
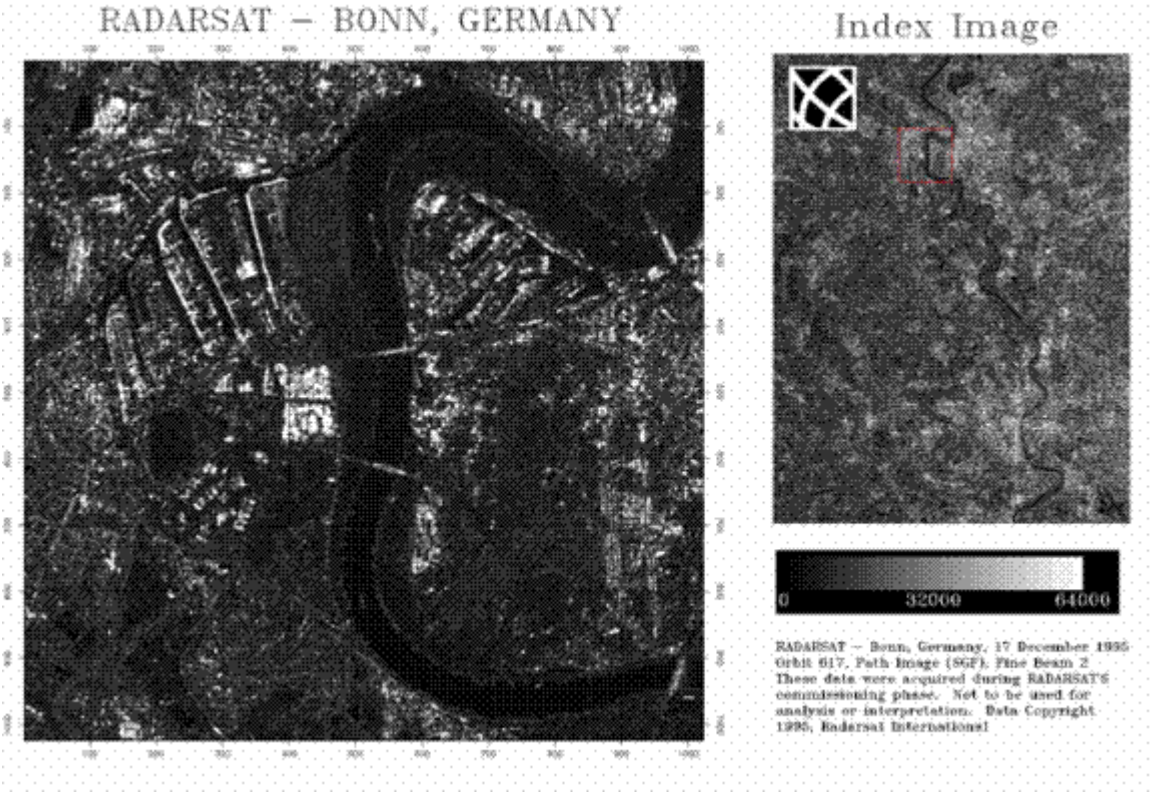


Image-Map Output

Output from ENVI image processing usually consists of a map-oriented, scaled image-map for presentation or visual analysis and interpretation. Radar data can be used in a map composition, just like any other dataset. See the *Image Georeferencing and Registration* and *Map Composition* tutorials for more information.


RADARSAT – BONN, GERMANY
Index Image
0
32000
64000
RADARSAT – Bonn, Germany, 17 December 1995
Orbit 617, Path Image (SGF), Fine Beam 2
These data were acquired during RADARSAT'S
commissioning phase. Not to be used for
analysis or interpretation. Data Copyright
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