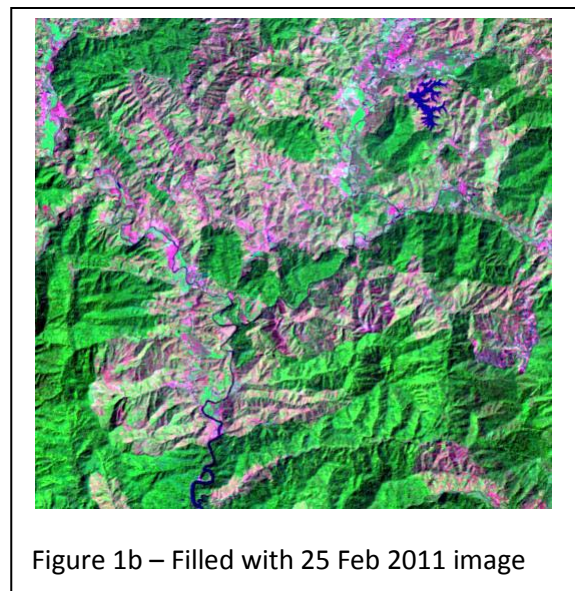
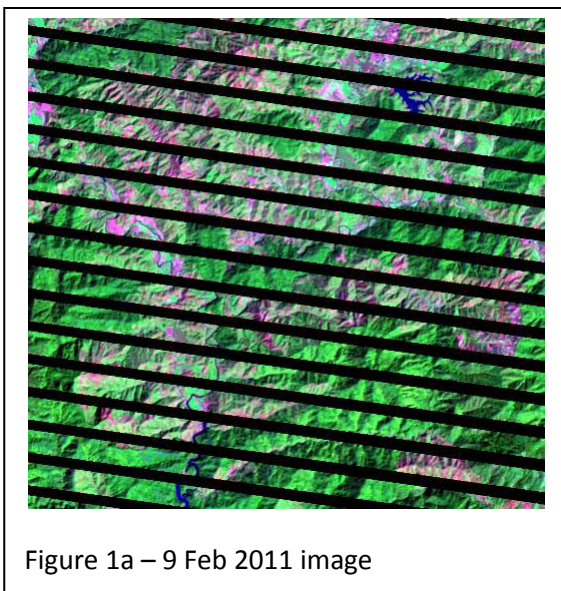


Filling Gaps in Landsat ETM Images

On 31 May 2003 the Landsat 7 Enhanced Thematic Mapper (ETM) sensor had a failure of the Scan Line Corrector (SLC). Since that time all Landsat ETM images have had wedge-shaped gaps on both sides of each scene, resulting in approximately 22% data loss. These images are available for free download from the USGS [GloVis](#) website and are found in the **L7 SLC-off** collection.

Scaramuzza, *et al* (2004) developed a technique which can be used to fill gaps in one scene with data from another Landsat scene. A linear transform is applied to the “filling” image to adjust it based on the standard deviation and mean values of each band, of each scene. More information about this technique can be found in the USGS article "[SLC Gap-Filled Products, Phase One Methodology](#)".

This document describes how to apply this gap filling technique using an add-on module in the ENVI software. Guidelines are provided for the selection of images that may produce a quality gap-filled Landsat ETM image. Below you can see an example of this gap-filling technique as applied to a pair of Landsat ETM images from Path 130 Row 45 acquired on 9 and 25 February 2011.



1. Image Selection

Your first step is to find appropriate images that can be used to produce a quality result. Care must be taken when evaluating images for this technique. At a minimum, these images must be accurately co-registered. Images obtained from the USGS GloVis site in the “GeoTIFF plus Metadata” format have all been terrain corrected so this will not be an issue when using these images. If you obtain images from other sources you will need to co-register these images before proceeding.

Optimal results will be obtained if both images are free of clouds and shadows, or snow and ice. Generally you should try to find images that have been acquired as close in time as possible. Landsat ETM repeats coverage of

an area every 16 days. For some studies you may be able to use images approximately one year apart. This would eliminate any scene variation due to sun angle and distance.

Pay attention to local landscape changes such as plant phenology and harvesting practices. For example, you should not combine images acquired before and after leaf-out in areas with deciduous forests. Also consider major events that may change the landscape, such as tsunamis or hurricanes. You should not use images from before *and* after a major change event to produce a meaningful gap-filled image.

2. Preparation

In some cases you may want to perform pre-processing functions such as atmospheric correction or conversion of digital numbers to top-of-atmosphere reflectance on these images. Because these are scene-specific operations they cannot be applied correctly to a blended multi-date image. Any pre-processing functions such as these must be done *before* using this image gap-fill routine.

Finally, you need to evaluate which image will be the master scene to be filled, and which will be used to fill in the gaps. This is a subjective decision based on your review of the selected scenes. Take the time to view the scenes using different band combinations, perhaps even linking the two scenes.

3. Image Gap Filling

Use the ENVI software program to open the two Landsat ETM images you have selected above. Now from the ENVI main menu bar, select **Basic Tools → Preprocessing → Data-Specific Utilities → Landsat TM → Landsat Gapfill**. This will open the *Select input file(s) and processing type* dialog, Figure 2. You should only use the option **Two band gap-fill (Local histogram matching)**, the other options do not perform as well. Next, click on the *Choose* button to navigate to a folder and enter an output filename.

Click *OK* to open the *Select input files* dialog box, Figure 3. Make sure you select the appropriate image data type; *30m multispectral*, *60m thermal*, or *15m pan*. Select your master image as the image to be gap filled then select the second image; you will use this to fill gaps in the first image. Click *OK* and wait for this to complete. This process could take up to 30 minutes.

4. Restore Data Type

The gap-filling technique produces an output image with a 4-byte floating point data type. If you are working with TOA Reflectance values, then your work is complete. However if you are working with the original digital numbers, you should convert these data back to integers. This will reduce the file size by 75% and make all subsequent processing faster.

From the ENVI main menu bar, select **Basic Tools → Band Math** and enter the expression: **byte(round(b1))** Click *OK* and select the button *Match Variable to Input File* to convert the entire dataset at once. Save this as a new file and delete the gap-filled image created in Section 3 above.

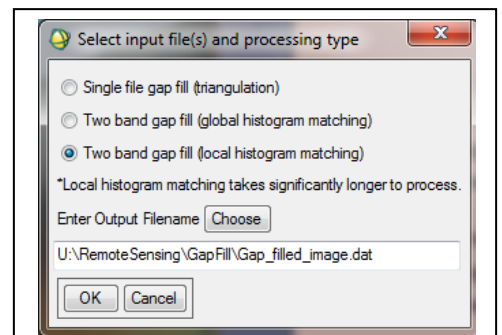


Figure 2

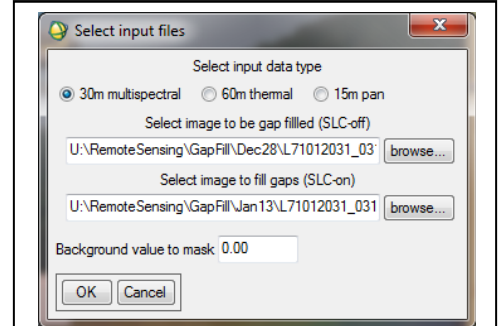


Figure 3