ENVI

ENVI Tutorials: Atmospherically Correcting Multispectral Data Using the FLAASH Module

ITT

ITT Visual Information Solutions
4990 Pearl East Circle
Boulder CO, 80301
303.786.9900
www.ittvis.com

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Overview of This Tutorial

This tutorial provides an introduction to using the ENVI FLAASH Module to atmospherically correct a multispectral image. You will display the radiance image, prepare the data for use in FLAASH, apply an atmospheric correction, and examine the results.

In order to run this tutorial, you must have ENVI installed on your computer.

Files Used in This Tutorial
CD-ROM: Tutorial Data CD #1
Path: `envidata\flaash\multispectral\input_files` (radiance image, scale factors file, and template file)
`envidata\flaash\multispectral\flaash_results` (sample reflectance image)

The image used in this exercise was collected by the Landsat 7 ETM+ sensor on April 3, 1997. It is a standard L1G product. It is a spatial subset of a full Landsat TM scene for path 44 row 34. The image covers a portion of the Jasper Ridge Biological Preserve, located in the eastern foothills of the Santa Cruz Mountains at the base of the San Francisco Peninsula, nine kilometers west of the main Stanford University campus in San Mateo County, CA. The Landsat image was provided courtesy of the USGS EROS Data Center. The full scene is available at http://glovis.usgs.gov. This image contains approximately the same area as the AVIRIS image used for the FLAASH hyperspectral tutorial, however the pixel size, image orientation, and collection dates are different.

File	Description
LandsatTM7_Subset_JasperR_B10.FST	FLAASH input images (Landsat 7 ETM+ fast format Level 1G data product)
LandsatTM7_Subset_JasperR_B20.FST	
LandsatTM7_Subset_JasperR_B30.FST	
LandsatTM7_Subset_JasperR_B40.FST	
LandsatTM7_Subset_JasperR_B50.FST	
LandsatTM7_Subset_JasperR_B70.FST	
LandsatTM7_Subset_JasperR_HRF.FST	
JasperRidgeTM_template.txt	FLAASH template file
JasperRidgeTM_flaash_refl.img	FLAASH reflectance result

Note
The FLAASH Module requires an additional license in your installation; contact your ENVI sales representative to obtain a license. If you are not licensed for the FLAASH Module, the tool will be disabled.

Opening the Raw Landsat Image in ENVI

This exercise will demonstrate how to use FLAASH to produce an apparent surface reflectance image.

1. From the ENVI main menu bar, select **File → Open External File → Landsat → Fast**.
2. Navigate to the `envidata\flaash\multispectral\input_files` directory, select the **LandsatTM_JasperRidge_HRF.FST** header file from the list, and click **Open**. The Available Bands List is displayed.
3. From the Available Bands List, right-click on the **LandsatTM_JasperRidge_HRF.FST** file and select **Load True Color**. The image is loaded into the display.

   You may recognize several features in the scene, including a long lake oriented NW-SE in the middle of the image, various types of vegetation on the left hand side of the image, and urban areas on the right-hand side.

   This image is a standard Landsat 7 L1G data product, except that it has been spatially subsetted to a small area around Jasper Ridge. The data type is byte (8 bits per pixel) and the image contains uncalibrated digital numbers (or DN).

4. From the Display group menu bar, select **Enhance [Image] Gaussian** to enhance the display.

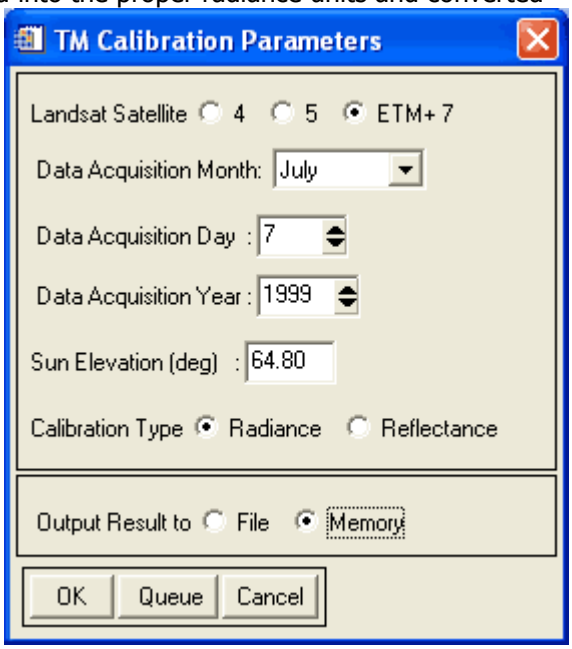
Preparing the Image for Use in FLAASH

Before the TM image can be corrected using FLAASH, it must be calibrated into the proper radiance units and converted into a BIP or BIL interleave.

Calibrating the TM Image into Radiance

FLAASH requires that the input image be calibrated into radiance in units of [µm/(cm^2*sr*nm)]. This can be accomplished in two simple steps using standard ENVI utilities.

1. From the ENVI main menu bar, select **Basic Tools → Preprocessing → Calibration Utilities → Landsat TM**. The TM Calibration Input File dialog appears.
2. Select the **LandsatTM_JasperRidge_hrf.fst** file and click **OK**. The TM Calibration Parameters dialog appears.
3. Click the **Radiance** Calibration Type radio button.
4. Click the **Memory** radio button, and click **OK**. The new bands are loaded into the Available Bands List.



Adjusting the Radiance Units

ENVI's TM/ETM+ calibration utility outputs data with radiance units of [W/(m^2*sr*µm)]. However, FLAASH requires radiance in units of [µW/(cm^2*sr*nm)]. These two units differ by a factor of 10, so an additional step is required to convert the units. This exercise uses Band Math to divide the radiance units by 10.

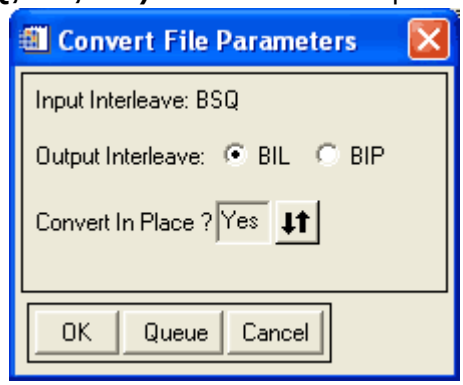
1. From the ENVI main menu bar, select **Basic Tools → Band Math**.
2. In the **Enter an expression** field, type the expression:
   ```
   b1 / 10.0
   ```
3. Click **OK**. The Variables to Bands Pairings dialog appears.
4. Click **Map Variable to Input File**. The Band Math Input File dialog appears.
5. Select the **Memory** file result and click **OK**.
6. In the **Enter Output Filename** field, type **JasperRidgeTM_radiance.img** and click **OK**. The new bands are loaded into the Available Bands List.

Converting the Interleave

The Band Math result from the previous step has a BSQ interleave, but FLAASH requires the input radiance image to be in either BIL or BIP interleave.

1. From the ENVI main menu bar, select **Basic Tools → Convert Data (BSQ, BIL, BIP)**. The Convert File Input File dialog appears.
2. Select the **JasperRidgeTM_radiance.img** file and click **OK**. The Convert File Parameters dialog appears.
3. Click the **BIL** Output Interleave radio button.
4. Toggle the Convert in Place option to **Yes**, click **OK** to start processing, and answer **Yes** to the warning message.

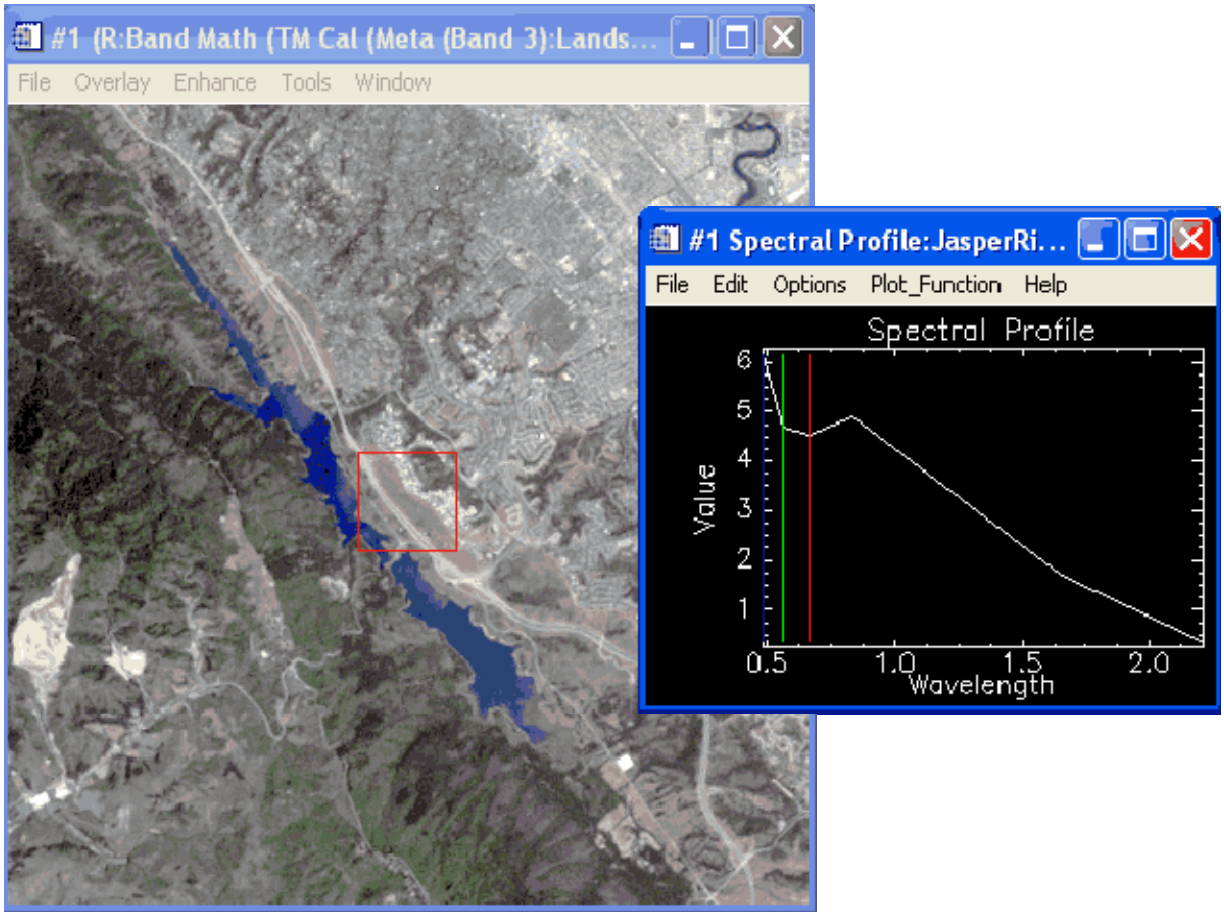
   For relatively small files such as this, it is faster to perform the interleave



conversion In Place. For larger images, such as a full Landsat TM scene, it will be considerably faster to write the new interleave file to disk.

Atmospherically Correcting the TM Image Using FLAASH

1. From the Available Bands List, right-click on the **JasperRidgeTM_radiance.img** file and select **Load True Color to <current>**.
2. From the Display group menu bar, select **Enhance → [Image] Gaussian** to enhance the display.
3. Right-click in the Image window and select **Z Profile (Spectrum)** to display the Spectral Profile.
4. Click and drag in the bottom middle part of the image, over the vegetated areas, and note the shape of the radiance curves. The most prominent atmospheric feature in these spectra is the consistent upward trend in the blue and green bands. This is likely caused by atmospheric aerosol scattering, or what is often referred to as 'skylight'. An accurate atmospheric correction should compensate for the skylight to produce spectra that more truly depict surface reflectance.

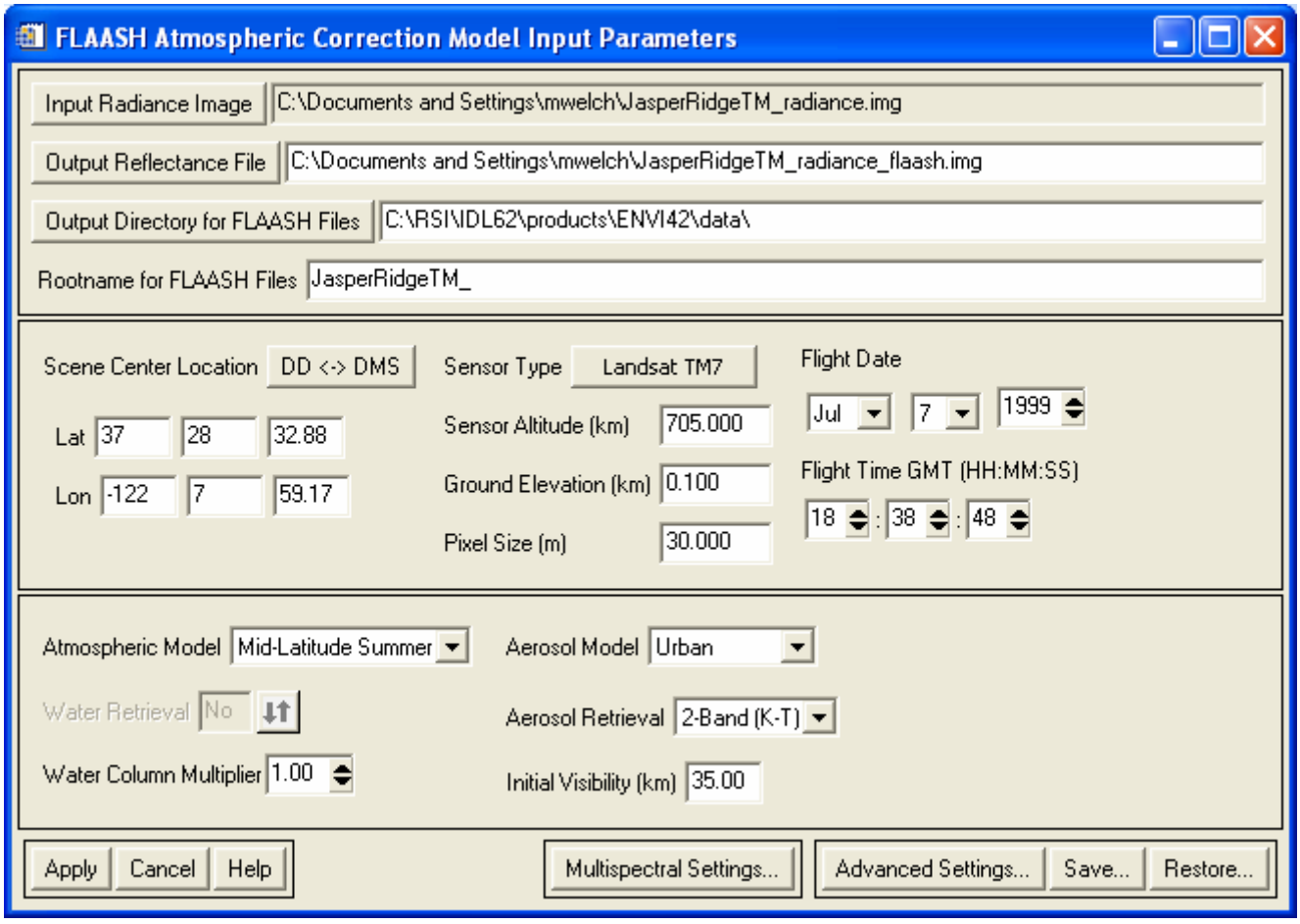


5. From the ENVI main menu bar, select **Spectral → FLAASH**.
6. Click the **Input Radiance Image** button, select the **JasperRidgeTM_radiance.img** file, and click **OK**. The Radiance Scale Factors dialog appears.
7. Select the **Use single scale factor for all bands** radio button. Since the input image units have already been correctly scaled (see the exercise "Adjusting the Radiance Units"), the Single Scale Factor default value of 1 is acceptable. If the units had not already been scaled, you would enter a single scale factor of 10. Click **OK**.
8. In the Output Reflectance File field, type a name for the FLAASH-corrected output reflectance file. To navigate to the desired output directory before defining the output file name, click the **Output Reflectance File** button (see image on following page).

9. In the Output Directory for FLAASH Files field, type the full path of the directory where you want to have all other FLAASH output files written. You may also click the **Output Directory for FLAASH Files** button to navigate to the desired directory (see image below).
10. In the Rootname for FLAASH Files field, type the name you want to use as a prefix for the FLAASH Output Files. In the next step, ENVI will automatically add an underscore character to the rootname that you enter.

    If Water Retrieval is selected, the FLAASH output files will consist of the column water vapor image, the cloud classification map, the journal file, and (optionally) the template file. All of these files are written into the FLAASH output directory and use the rootname as a prefix to their individual standard filenames.
11. Click the **Restore** button.
12. Navigate to the `envidata\flaash\multispectral\input_files` directory, select the **JasperRidgeTM_template.txt** file, and click **Open**. This file provides the FLAASH model parameters for the Jasper Ridge image. Review the scene collection details and model parameters for the Jasper Ridge TM image see image below).

    In this example, the Water Retrieval toggle is set to No because the Landsat TM sensor does not have bands in he water absorption regions that can be used to compute the atmospheric water vapor. As is common for multispectral sensors, a fixed water amount based on a typical atmosphere must be used instead.



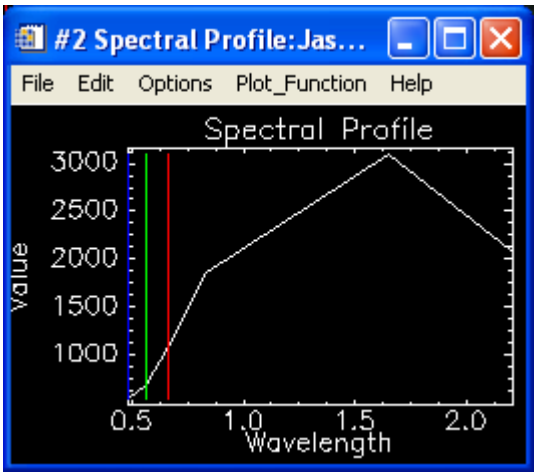
13. Click the **Multispectral Settings** button to explore the multispectral settings variable. The Multispectral Settings dialog is used to select a filter function file and define the bands which are used for various FLAASH processing steps. The water retrieval bands are left undefined because water retrieval is not possible with Landsat TM data. However, the Landsat TM sensor does contain bands that can be used to estimate the aerosol concentration.
14. Click the **Kaufman-Tanre Aerosol Retrieval** tab to see which bands were selected.
15. Click **Cancel** to dismiss this dialog and return to the previous dialog.

16. Click the **Advanced Settings** button to explore the available advanced settings options. The parameters in the Advanced Settings dialog allow you to adjust additional controls for the FLAASH model. The default setting for Automatically Save Template File is **Yes** and Output Diagnostic Files is **No**. While you may find it excessive to save a template file for each FLAASH run, this file is often the only way to determine the model parameters that were used to atmospherically correct an image after the run is complete, and access to it can be quite important. The ability to output diagnostic files is offered solely as an aid for ENVI Technical Support engineers to help diagnose problems.
17. Click **Cancel** to dismiss this dialog and return to the previous dialog.
18. In the FLAASH Atmospheric Model Input Parameters dialog, click **Apply** to begin the FLAASH processing. You may cancel the processing at any point, but be aware that there are some FLAASH processing steps that can't be interrupted, so the response to the **Cancel** button may not be immediate.

Viewing the Corrected Image

When FLAASH processing completes, the output reflectance image will be entered into the Available Bands List. You should also find the journal file and the template file in the FLAASH output directory.

1. Click **Cancel** on the FLAASH Atmospheric Correction Model Input Parameters dialog to dismiss the dialog.
2. Examine then close the FLAASH Atmospheric Correction Results dialog.
3. From the Available Bands List right-click on the **JasperRidgeTM_radiance_flaash.img** file and select **Load True Color to <New>**. The image is loaded into a new display.
4. Right-click in the new Image window and select **Z Profile (Spectrum)** to display the Spectral Profile.
5. Click and drag around the image and note the shape of the radiance curves. The vegetation reflectance curves now display a more characteristic shape, with a peak in the green, a chlorophyll absorption in the red, and a sharp red edge leading to higher near infrared reflectance.



Verifying the Model Results

The results you produce with the sample Jasper Ridge files should be identical to the data found in the `envidata\flaash\multispectral\flaash_results` directory.

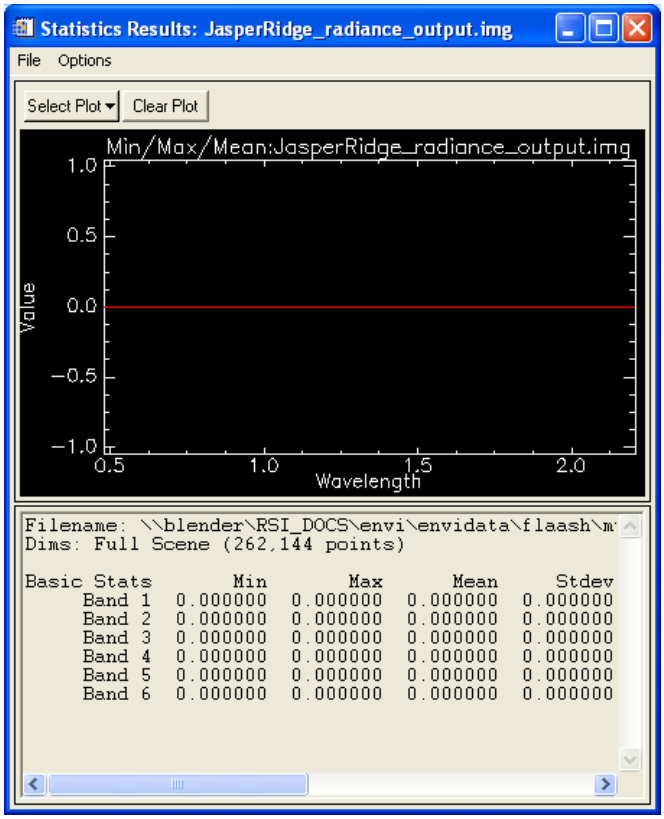
Comparing Images

1. From the ENVI main menu bar, select **File → Open Image File**.
2. Navigate to the `envidata\flaash\multispectral\flaash_results` directory, select the **JasperRidgeTM_flaash_refl.img file** and click **Open**. The Available Bands List is displayed.
3. From the Available Bands List right-click on the **JasperRidgeTM_flaash_refl.img** file and select **Load True Color to <New>**. The image is loaded into a new display.
4. From the Display group menu bar, select **Tools → Link → Link Displays**. You can also right-click in the image and select **Link Displays**.
5. Toggle the **Dynamic Overlay** option **Off** and click **OK** in the Link Displays dialog to establish the link.
6. Double-click in one of the Image windows to display the Cursor Location/Value window.
7. Move your mouse cursor around in one of the images and note the data values in the Cursor Location/Value window. You should see that the data values are identical for corresponding bands in both images.

Computing a Difference Image Using Band Math

For a more quantitative verification of the reflectance results, you will compute a difference image using Band Math.

1. From the ENVI main menu bar, select **Basic Tools → Band Math**. The Band Math dialog appears.
2. In the Enter an Expression field, type the following expression:
   `float(b1) - b2`
   then click **OK**. The Variables to Bands Pairings dialog appears.
3. Click on **B1** to select it then click **Map Variable to Input File**. The Band Math Input File dialog appears.
4. Select the **JasperRidgeTM_flaash_refl.img** file and click **OK**.
5. Click on **B2** to select it then click **Map Variable to Input File**. The Band Math Input File dialog appears.
6. Select the **JasperRidgeTM_radiance_flaash.img** file and click **OK**.
7. In the Enter Output Filename field, type or choose a file name for the output result and click **OK**. Note that the file size for this difference image will be twice as large as the FLAASH reflectance image file, so be sure you have sufficient disk space for this Band Math result.
8. Every value in the difference image should be zero. To ensure that the results are identical, select **Basic Tools → Statistics → Compute Statistics** from the ENVI main menu bar to calculate the basic statistics for the difference image.



9. Note the Max and Min columns in the statistics report window.
10. Due to differences in computer machine precision, your FLAASH reflectance image result may differ from those in the verification directory by approximately 1-5 DNs, or 0.0001 to 0.0005 reflectance units.

Ending the ENVI Session

You can quit your ENVI session by selecting **File → Exit** from the ENVI main menu.