"HYDROHASARDS" PostGraduate Study Program

Remote Sensing Lab Exercises

LAB 2: Band Math – Map Composition

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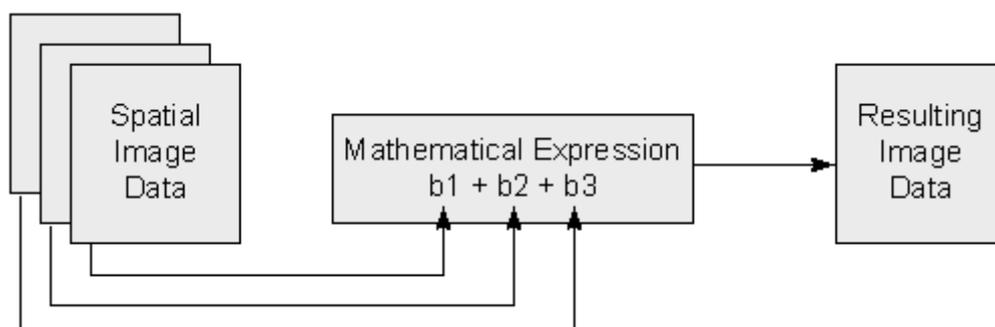
Band Math

Band Math Basics

ENVI's Band Math function can be used to call a custom processing function you have written. The Band Math interface is used to define the bands or files used as input, call your function, and write the result to a file or memory. Band Math accesses data spatially by mapping the variables to bands or files. Spatial data that are too large to read entirely into memory are automatically accessed using ENVI's data tiling.

A Band Math function is written using variables named b1 (or B1), b2, etc. The function is called by entering its name and variables in the Band Math expression text box. The variables are assigned to bands or files using the Band Math dialog.

The following figure depicts the band math processing for the addition of three bands. Each band in the expression is mapped to an input image band, summed together and output as the resulting image data. Any one or more of the expression's variables can be mapped to a file instead of mapping each variable to a single band. The resulting output is a new image file. For example, in the expression b1 + b2 + b3, if b1 is mapped to a file and b2 and b3 are mapped to a single band then the resulting image file contains the bands of the b1 file summed with b2 and b3.

Figure 2-1: Band Math Processes - Addition of Three Bands

Entering Mathematical Expressions

1. From the ENVI main menu bar, select **Basic Tools- Band Math**. The Band Math dialog appears.

2. In the Band Math dialog, enter the desired mathematical description, including variable names, into the **Enter an expression** field. Use variables in place of band names or filenames (the variables will be assigned in the next step). Variable names must begin with the character "b" or "B" followed by up to 5 numeric characters. For example, to calculate the average of three bands, use the following equation:

(float(b1)+float(b2)+float(b3))/3.0

Three variables are used in this expression: B1, B2, and B3.
The Band Math dialog also contains the following functionality:
Previous Band Math Expressions —This list shows previously applied mathematical expressions. To apply an expression to a new set of bands, select it from the list and enter it into the **Enter an expression** field. Click **OK**.

Save— Save mathematical expressions to a file. The Save Expressions to a File dialog appears. Enter an output filename with an **.exp** extension. Click **OK**. You can save expressions to a file without having to first run them through the Band Math function.
Restore— Restore previously saved mathematical expressions. The Enter Expressions Filename dialog appears. Select a filename and click **OK**.
Clear— Clear all expressions from the **Previous Band Math Expressions** list.
Delete— Delete a single expression from the **Previous Band Math Expressions** list**.**
Add to List— To add an individual expression to the **Previous Band Math Expressions** list, enter it in the **Enter an expression** field and click **Add to List**.

3. After entering a mathematical expression in the **Enter an expression** field, click **OK**
The Variables to Bands Pairings dialog appears.

Assigning Values to Variables

Use the Variables to Bands Pairings dialog to assign bands from a list of input bands to variable names you entered in the **Enter an expression** field of the Band Math dialog.
Using the example mathematical expression
(float(b1) + float(b2) + float(b3))/3.0,
1. In the **Variables used in expression** field, select the variable **B1 - [undefined]**.
2. Select the band in the **Available Bands List**. When the first band is selected, only those bands with the same spatial dimensions are shown in the band list.
3. Continue to assign a value to B2, B3, and so forth in the same manner.

Map Composition

You can use ENVI's QuickMap utility to generate a basic map template and add more information using ENVI's annotation capabilities.

1. From the ENVI main menu bar, select **File > Open Image File**. A file selection dialog appears.
2. Navigate to the given folder «ys_tmsub» and select ysratio.img. Click **Open**. The 5/7, 3/1, and 3/4
ratio bands are automatically loaded into the R, G, and B fields of the Available Bands List, respectively.
3. Click **Load RGB**. Once the image appears in a display group, complete the following steps to build a QuickMap template and to add individual map components.

Build the QuickMap Template
1. From the Display group menu bar, select **File > QuickMap > New QuickMap**. The QuickMap Default Layout dialog appears. This dialog allows you modify the output page size, page orientation, and map scale.
2. For this exercise, accept the default values but change the **Map Scale** to **200000**. Click **OK**. A QuickMap Image Selection dialog appears.
3. Use the full image for this exercise. Click and drag the lower-right corner of the red box downward so that the whole image is selected. Click **OK**. The QuickMap Parameters dialog appears.
4. Click inside the **Main Title** field and type **Yellowstone National Park Image-Map**.
5. Right-click inside the **Lower Left Text** field and select **Load Projection Info** to load the image map projection information from the ENVI header.
6. For this exercise, you should leave the **Scale Bars**, **Grid Lines**, and **North Arrow** check boxes selected.
7. Click the **Declination Diagram** check box to select it.
8. Click **Save Template** at the bottom of the dialog. A Save QuickMap Template to File dialog appears.
9. In the **Enter Output Filename** field, enter ysratio.qm. Click **OK** to save the QuickMap results as a QuickMap template file. You can recall this template later and use it with any image of the same pixel size by displaying the desired image and selecting **File > QuickMap > from Previous Template** from the Display group menu bar.
10. Click **Apply** in the QuickMap Parameter dialog to display the QuickMap results in a display group. If desired, you can modify the settings in the QuickMap Parameters dialog and click **Apply** to change the displayed QuickMap.
11. Review the QuickMap results and observe the map grids, scale bars, north arrow, and positioning of the default text.

Map Elements
ENVI offers many options for customizing your map composition. Options include virtual borders, text annotation, grid lines, contour lines, plot insets, vector overlays, and classification overlays. You can use the display group (Image window, Scroll window, or Zoom window) to perform additional, custom map composition. (If you are working in the Scroll window, you may want to enlarge it by dragging one of the corners to resize the display.) The following sections describe the different elements and provide general

unstructions.

Adding Virtual Borders
Default display groups contain only the image, with no surrounding blank space. Map composition typically requires some map objects to reside outside the image. ENVI provides a virtual border capability that allows annotation in the image borders without creating a new image. You can add virtual borders to an image in several ways, which are described in the following sections. When you generate a QuickMap, ENVI automatically adds a virtual border to all sides of the image to accommodate the QuickMap grid, and it displays a default grid.
1. To change the default border, select **Overlay > Grid Lines** from the Display group menu bar associated with the QuickMap. A Grid Line Parameters dialog appears.
2. From the Grid Line Parameters dialog menu bar, select **Options > Set Display Borders**. Display Borders dialog appears.
3. Enter values as shown in the following figure.
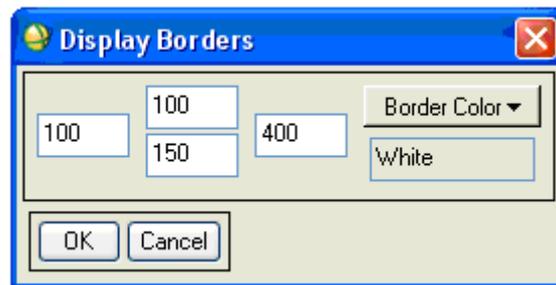
4. Click **OK**. The new virtual border characteristics are immediately applied to the image. If you select **File > Save Setup** from the Grid Line Parameters dialog menu bar, the border information will be saved with the grid and will be restored when you restore the grid parameters file later.

Using the Display Preferences
You can also change virtual borders and other display settings using the Display Preferences dialog.
1. From the Display group menu bar associated with the QuickMap, select **File > Preferences**. Display Parameters dialog appears with a Display Border section similar to the above figure.
2. Enter the desired values and select the desired color for the border.
3. Click **OK**. The new borders are immediately applied to the image.

Using the Annotation Function
You can also control virtual borders in the Annotation dialog.
1. From the Display group menu bar associated with the QuickMap, select **Overlay > Annotation**. An Annotation dialog appears.
2. From the Annotation dialog menu bar, select **Options > Set Display Borders**. A Display Borders dialog appears.

3. Enter the desired border characteristics and click **OK**. The new virtual border characteristics are immediately applied to the image. If you save an annotation to a file, the border information is also saved and restored when you restore the annotation file later.

Adding Grid Lines

ENVI supports simultaneous pixel, map coordinate, and geographic (latitude/longitude) grids. To add or modify image grids, follow these steps:

1. From the Display group menu bar associated with the QuickMap, select **Overlay > Grid Lines**. A Grid Line Parameters dialog appears and a default grid is displayed with default grid spacings.

2. In the **Grid Spacing** field, enter **4000**.

3. To change line and label characteristics for the grid, select **Options > Edit Map Grid Attributes**
or **Edit Geographic Grid Attributes** from the Grid Line Parameters dialog menu bar.
Alternatively, you can access grid line parameters by clicking **Additional Properties** in the QuickMap Parameters dialog.

4. Click **OK** to apply the selected attributes.

5. In the Grid Line Parameters dialog, click **Apply** to post the new grid to the displayed image.

6. To save grid parameters for later use, select **File > Save Setup** from the Grid Parameters dialog menu bar and select an output file. This saves a template of the grid parameters, which you can recall later and use with another map composition (select **File > Restore Setup** from the Grid Parameters dialog menu bar).

Working with Annotation
ENVI's annotation utility provides a way to insert and position map objects in an ENVI display group for map composition. Several classes of map objects are available.

1. From the Display group menu bar associated with the QuickMap, select **Overlay > Annotation**. An Annotation dialog appears.

2. From the Annotation dialog menu bar, select **Object** and choose the desired annotation object.

3. In the Annotation dialog, select the Image, Scroll, or Zoom radio button to indicate where the annotation will appear.

4. Drag the object to a preferred location, then right-click to lock it in place.

5. To reselect and modify an existing annotation object, select **Object > Selection/Edit** from the Annotation dialog menu bar. Then select the object by drawing a box around it. You can move the selected object by clicking the associated handle and dragging the object to a new location. You can delete or duplicate an object by choosing the appropriate option from the selected menu. **Right-click to relock the annotation in place**.

6. Remember to select the **Off** radio button in the Annotation dialog before attempting non-annotation mouse functions in the display group.

7. **Keep the Annotation dialog open for the following exercises**.

Text and Symbol Annotation
ENVI currently has a wide variety of text fonts and different standard symbol sets. In addition, ENVI can use TrueType fonts installed on your system. This provides access to a wide range of different text fonts and symbols. You can interactively scale and rotate these fonts and symbols, and you can set different colors and thickness. ENVI provides some useful symbols (including special north arrows) as a custom TrueType font. To modify the font characteristics, click Font and select ENVI Symbols in the Annotation dialog. Following are some examples of ENVI Symbols:

Text:
1. Select **Object > Text** from the Annotation dialog menu bar.
2. Click **Font** and select a font.

3. Select the font size, color, and orientation using the appropriate buttons and fields in the Annotation dialog. For information on adding additional fonts, see "Using Other TrueType Fonts with ENVI" in ENVI Help. TrueType fonts provide more flexibility. Select one of the TrueType fonts available on your system by clicking **Font**, selecting a **True Type** option, and selecting the desired font.

4. Type your text in the empty field in the Annotation dialog.

5. Drag the text object to a preferred location in the image and right-click to lock it in place.

Symbols:

1. Select **Object > Symbol** from the Annotation dialog menu bar.

2. Select the desired symbol from the table of symbols that appears in the Annotation dialog.

3. Drag the text object to a preferred location in the image and right-click to lock it in place.

Polygon and Shape Annotation

You can draw rectangles, squares, ellipses, circles, and free-form polygons in an image. These can be an outline only, or filled with a solid color or a pattern. Placement is interactive, with easy rotation and scaling.

1. Select **Object > Rectangle**, **Ellipse**, or **Polygon** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. Drag the shapes to a preferred location in the image and right-click to lock them in place. For polygons, use the left mouse button to define polygon vertices and the right mouse button to close the polygon.

Line and Arrow Annotation

You can draw polylines (lines) and arrows in an image. You have full control over the color, thickness and line type, and the fill and head characteristics for arrows.

Arrows:

1. Select **Object > Arrow** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. To draw an arrow, click and hold the left mouse button and drag the cursor in the image to define the length and orientation of the arrow. Release the left mouse button to complete the arrow. You can move it by dragging the red diamond handle. Right-click to lock the arrow in place.

Lines:

1. Select **Object > Polyline** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. To draw a free-form line, click and hold the left mouse button as you are drawing. To draw a straight line, click repeatedly (without holding the left mouse button) to define the vertices. Rightclick to complete the line. You can move it by dragging the red diamond handle. Right-click again to lock the line in place.

Scale Bar Annotation

ENVI automatically generates map scales based on the pixel size of the image in the map composition. Units include feet, miles, meters, or kilometers.

You can configure the number of major and minor divisions, and the font and character size.

1. Select **Object > Scale Bar** from the Annotation dialog menu bar.

2. Enter object parameters as desired in the Annotation dialog.

3. Click once in the image to show the scale bar. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the scale bar in place.

Declination Diagrams

ENVI generates declination diagrams based on your preferences. You can specify the size of the diagram and enter azimuths for true north, grid north, and magnetic north in decimal degrees.

1. Select **Object > Declination** from the Annotation dialog menu bar.
2. Enter object parameters as desired in the Annotation dialog.
3. Click once in the image to show the declination diagram. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the diagram.

Map Key Annotation

Map keys are automatically generated for classification images and vector layers, but you can manually add them for all other images. Following is an example of a map key:

1. Select **Object > Map Key** from the Annotation dialog menu bar.
2. Click **Edit Map Key Items** to add, delete, or modify individual map key items.
3. Click once in the image to show the map key. Move it to a preferred location by dragging the red diamond handle. Right-click to lock the map key in place.
4. If you want a border and title for the map key, you must add these separately as polygon and text annotations, respectively:

Overlaying Contour Lines

You can contour Z values of images and overlay the contour lines as vectors on an image background. Digital elevation models (DEMs) work best. Add contours to a map composition as follows:

1. From the Display group menu bar associated with the map composition, select **Overlay > Contour Lines**. A Contour Band Choice dialog appears.
2. Select the desired image to contour and click **OK**. A Contour Plot dialog appears.
3. To use the default contour values, click **Apply**. Otherwise, you can add new contour levels, edit contours, and change colors and line types using the Contour Plot dialog.

Incorporating Regions of Interest

You can incorporate Regions of interest (ROIs) into ENVI map compositions. Display an ROI in a map composition as follows:

1. From the Display group menu bar associated with the map composition, select **Overlay > Region of Interest**. An ROI Tool dialog appears, listing any existing ROIs having the same dimensions as the displayed image. These ROIs appear in the image.
2. Add or modify ROIs as desired.

Customize the Map Layout

This section uses several map elements described in the previous sections to demonstrate some of ENVI's custom map composition capabilities.

The QuickMap you created earlier will be used in the following exercises. If you already closed ysratio.img, redisplay it as follows.

1. From the ENVI main menu bar, select **File > Open Image File**. A file selection dialog appears.
2. Navigate to Data\ys_tmsub and select ysratio.img. Click **Open**. The 5/7, 3/1, and 3/4 ratio bands are automatically loaded into the R, G, and B fields of the Available Bands List.
3. Click **Load RGB**.

Load the QuickMap Template

Once the image is displayed, follow these steps to load the previously saved QuickMap template and to add individual map components:

1. From the Display group menu bar, select **File > QuickMap > from Previous Template**. The Enter QuickMapTemplate Filename dialog appears.

2. Navigate to your output directory, select ysratio.qm, and click **Open**. A QuickMap Parameters dialog appears.

3. Click **Apply** to generate the QuickMap image. The Load To: Current Display button is selected by default, so the QuickMap parameters are applied to the display group from which you started QuickMap.

4. Restore saved grid parameters by selecting **Overlay > Grid Lines** from the Display group menu bar associated with the QuickMap. A Grid Line Parameters dialog appears.

5. From the Grid Line Parameters dialog menu bar, select **File > Restore Setup**. A file selection dialog appears.

6. Navigate to Data\ys_tmsub and select the saved grid parameters file ysratio.grd. Click **Open**, followed by **Apply**.

7. Modify some of the grid line parameters and click Apply to show your changes on the image. Be sure to save any changes by selecting **File > Save Setup** from the Grid Line Parameters dialog menu bar.

8. Restore saved ENVI annotation by selecting **Overlay > Annotation** from the Display group menu bar associated with the QuickMap. The Annotation dialog appears.

9. Select **File > Restore Annotation** from the Annotation dialog menu bar.

10. Navigate to Data\ys_tmsub and select the saved annotation file ysratio.ann. Click **Open**

11. In the Annotation dialog, click the **Image** radio button, select **Object > Selection/Edit** from the menu bar, and click and drag a box around the annotation objects in the QuickMap image window. A red diamond handle appears for the selected objects.

12. Click and drag the handles to move the annotation objects. Modify some parameters for the selected objects. Right-click the objects to lock them in place. Be sure to save any changes by selecting **File > Save Annotation** from the Annotation dialog menu bar. See ENVI Help for further details.

Save the Results
You can save a map composition for future modification as a display group, or with the map composition "burned in" to an image.

Saving for Future Modification
This is the most flexible option.

1. From the Display group menu bar associated with the map composition, select **File > Save as Display Group**.

2. Enter an output filename and click **OK**.

3. To restore this map composition, select **File > Restore Display Group** from the ENVI main menu bar.

Saving as a "Burned-in" Image
1. From the Display group menu bar associated with the map composition, select **File > Save Image As > Postscript File**. An ENVI QuickMap Print Option dialog appears.

Select **Standard Printing** and click **OK** to output a Postscript file. An Output Display to Postscript File dialog appears. Change the page size and scaling parameters as desired. This option provides additional control, but it may produce a map that does not fit well with the originally selected QuickMap scale.

Select **Output QuickMap to Postscript**, select an output filename, and click **OK** to output Postscript file with the specified QuickMap page size and scaling. If your additional annotation enlarged the image so it will not fit in the specified page size, ENVI asks if you

want to output to multiple pages. If so, click **Yes**, and ENVI automatically creates multiple Postscript files.

Saving as an Image File

You can save your map composition as an image file. Output formats include ENVI (binary) image, BMP, HDF, JPEG, PICT, PNG, SRF, TIFF/GeoTIFF, and XWD, as well as common image processing system formats such as ERDAS (.lan), ERMAPPER, PCI, and ArcView Raster.

1. From the Display group menu bar associated with the map composition, select **File > Save Image As > Image File**.
2. Set the resolution, output file type, and other parameters as described in ENVI Help; enter an output filename; and click **OK**.

Printing

You can also select direct printing of the ENVI map composition, in which case, the map composition will be printed directly to your printer using system software drivers.

1. From the Display group menu bar associated with the map composition, select **File > Print**. An ENVI QuickMap Print Preferences dialog appears.
2. Select **Standard Printing** or **Output QuickMap to Printer** as described above.
3. Choose your printer, then click **OK**.

In all of the output options listed above, graphics and map composition objects are burned into the image on output.