

Practical Session - Working with airborne imaging spectrometer data ENVI

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1. Introduction

This practical session provides an introduction to working with airborne imaging spectrometer (hyperspectral) data using ENVI. By the end of this practical you will be able to:

1. Open and view airborne hyperspectral data in ENVI
2. Perform an empirical line correction to convert to surface reflectance

2. Airborne Data

For this practical data from the Specim ASIAFenix instrument collected by the NERC Airborne Research Facility (NERC-ARF¹) will be used. These data were flown over the Barrax site in Spain on 17th June 2015 as part of the ATSC summer school². The line used for the practical is shown in Figure 1.

The Fenix instrument covers visible and near infrared (VNIR) to short wave infrared (SWIR) portion of the spectrum, wavelengths (380 – 2500 nm) over a maximum of 622 bands.

For this practical a subset of line 5 will be used. This line was flown at an altitude of 1400 m from south east to north west at 10:50 (GMT). The VNIR bands were spectrally binned, providing a total of 448 bands, before masking and 439 after masking.

These data have been pre-processed by the NERC-ARF Data Analysis Node (NERC-ARF-DAN³) using the following steps:

1. Radiometric Calibration
2. Masking out of bad pixels, including dropping completely masked out bands (at the VNIR/SWIR overlap).
3. GPS and Inertial Measurement Unit (IMU) processing and synchronisation
4. Mapping of data
5. Subsetting to area around targets (to reduce processing time in practical session)

¹ <https://www.bas.ac.uk/nerc-arf>

² <https://www.nceo.ac.uk/training/atsc-training/>

³ <https://nerc-arf-dan.pml.ac.uk/>

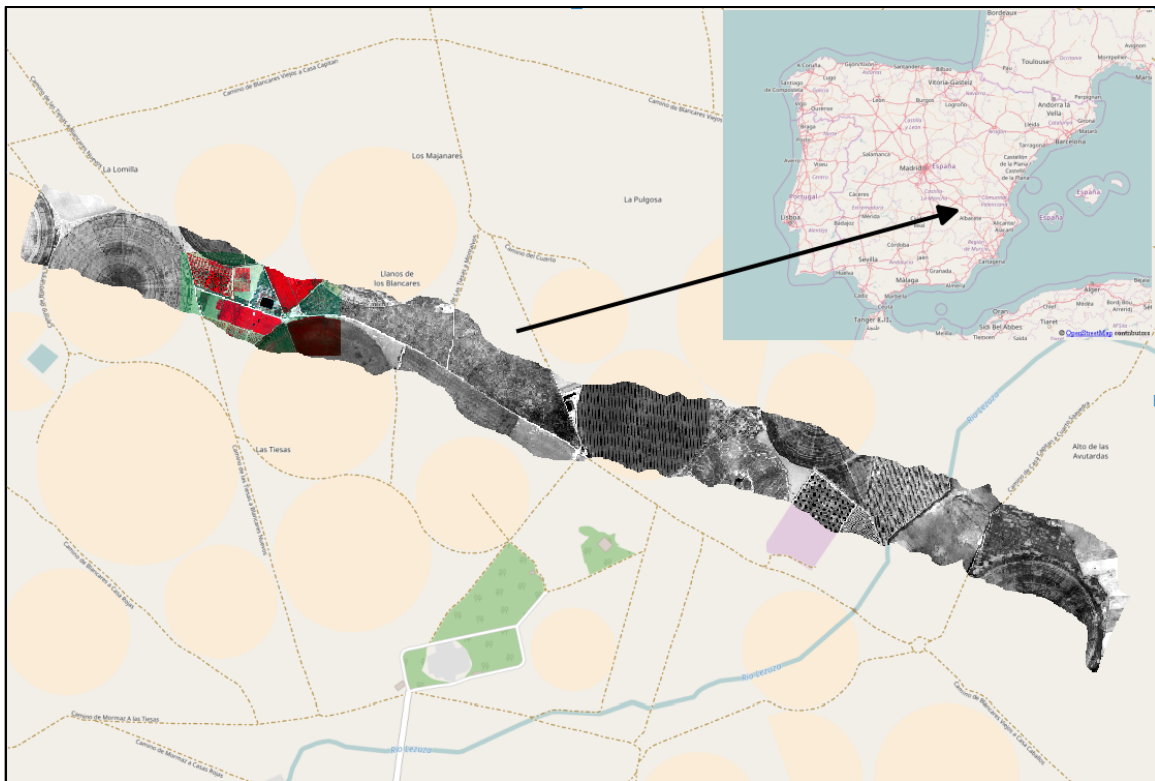


Figure 1: Hyperspectral line used for practical session over Barrax site in Spain. Subset used for practical is shown in colour.

3. Introduction to ENVI

ENVI (Environment for Visualising Images) is a commercial software package for visualisation and analysis of remote sensing data. It has a number of features and algorithms targeted to hyperspectral data. There are two interfaces for ENVI, the new interface and ENVI 'classic', for this practical session ENVI classic mode will be used.

1. Open ENVI by selecting "ENVI Classic" from the start menu.
2. Load the hyperspectral data into ENVI using "File" → "Open Image file" from the main menu and selecting "f168053b_utm_wgs84N30_sub.bil", you may need to navigate to the directory the practical data are stored first.
3. In the "Available Bands List" window right click on "f168053b_utm_wgs84N30_sub.bil" and select "Load True Colour". This will open 3 windows as shown in Figure 2:
 - **Scroll** – Shows an overview of the image
 - **Image** – Shows a subset and includes the image specific menu bar
 - **Zoom** – Shows a zoomed in subset, the zoom can be adjusted using the – and + icons in the lower left corner.
4. Within the Image window menu select "Tools" → "Profiles" → "Z Profile (Spectrum)" to bring up the spectral profile window.
5. With the spectral profile window open select different pixels to view the profile, try looking at the spectra of the targets. As the image hasn't been atmospherically corrected the profile

shows at-sensor radiance in units of $nWcm^{-2}sr^{-1}nm^{-1}$. The red, green and blue lines show the wavelengths of the bands currently displayed.

6. After you have finished exploring the image you can close the Spectral Profile window but keep the other windows open.

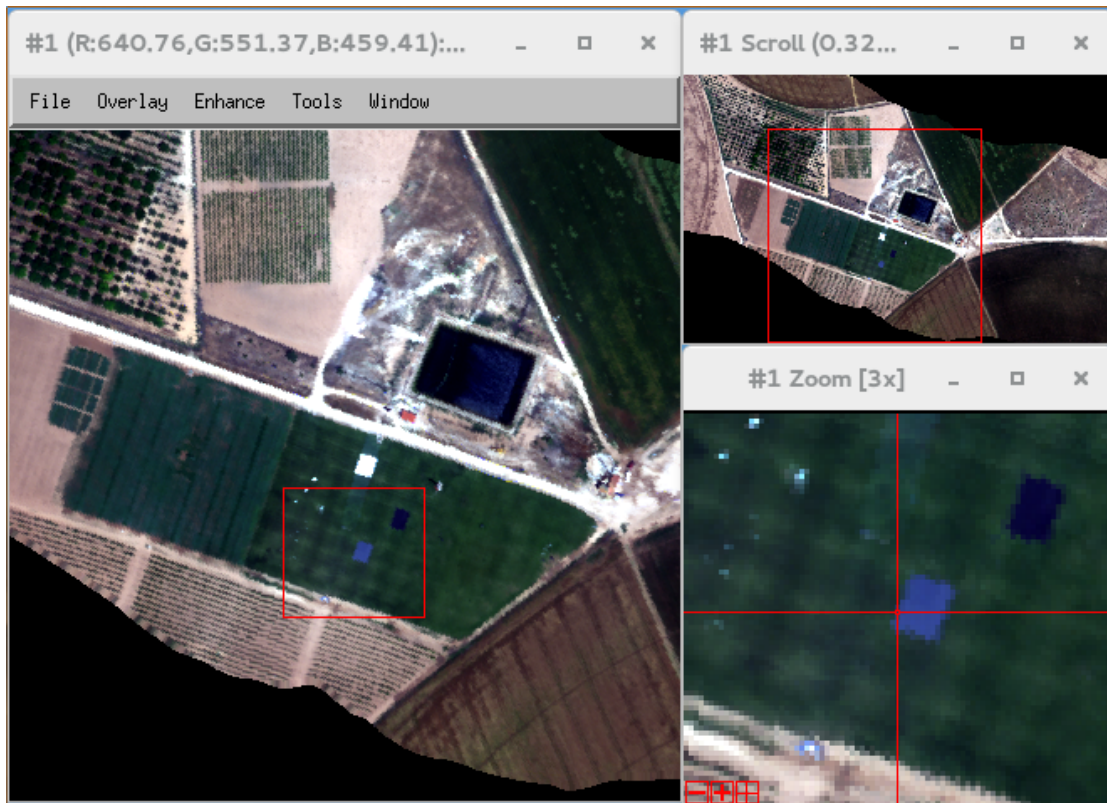


Figure 2: Image display windows in ENVI

4. Empirical Line Correction

1. With the image Window still open from the previous section select “Tools” → “Region of Interest” → “ROI tool” from the image menu.
2. The ROI tool is used to identify the pixels for each target.
 - a) From the ROI window select “Window:” “Zoom”, so only pixels clicked in the Zoom window are recorded.
 - b) Select “ROI_Type” → “Point”, this allows you to select individual pixels rather than drawing polygons, which is better for small features.
 - c) Select “Region #1” in the ROI list and rename to “White” by double clicking on the name, press “Enter” once you have renamed.
 - d) In the zoom window select pixels from the centre of the white target by clicking on them as shown in Figure 3. It is important to select pixels towards the centre to avoid mixed pixels towards the edge of the target where the spectra will be a mixture of the target and the surface it has been laid out on. If you make a mistake you can remove a pixel using the middle mouse button (press on the scroll wheel).

- e) After a ROI has been defined for the white target, select “New Region” from the ROI window and repeat for the black and grey targets.



Figure 3: Selecting pixels for White target using ROI tool.

3. Once an ROI has been defined for each target save these using “File” → “Save ROIs” from the ROI window. Use “Select All Items” and use the “Choose” button to navigate the directory you are working in. The recommended name for the ROI file is “f168053b_utm_wgs84N30_sub_targets.roi”
4. You can view the variation in spectra within each of the targets by clicking selecting an ROI and clicking the “Stats” button. By default it will show the mean (white) +/- 1 standard deviation (green) and min/max (red), you can change using “Select Plot”.
5. After the ROIs have been identified the empirical line calibration can be performed.
 - a) Select “Spectral” → “Pre-processing” → “Calibration Utilities” → “Empirical Line” → “Compute Factors and Calibrate” from the main menu.
 - b) Select “f168053b_utm_wgs84N30_sub.bil” as the input file.
 - c) For “Data Spectra” select “Import Spectra” then ‘Import’ → “from ROI/EVG from input file”. Select all items (White, Grey and Black), click “OK” followed by “Select All” and “Apply” to load into the Empirical Line dialogue, the import window can then be closed.
 - d) For “Field Spectra” Select “Import Spectra” then “Import” → “from Spectral Library”. Use the “Open” dialogue to open a spectral library file. Navigate to the practical directory and select “panels_avg_all_envi.sli”. This has been generated using the average field spectra from each target. Select all items (White, Grey and Black) and click OK, then “Select All” and “Apply” to load into the Empirical Line dialogue, the import window can then be closed.
 - e) Select “White” in the “Data Spectra” box and “White” in the “Field Spectra” box and click “Enter Pair” to identify them as a matching image spectra and field spectra pair. Repeat for the other two targets then click “OK”.
 - f) In the output file window select “Chose” to navigate to the practical data directory

and use “f168053b_utm_wgs84N30_sub_elc.bil” as the output file name, use the same procedure and select “f168053b_utm_wgs84N30_sub_elc_cff.cff” for the Calibration Filename. The calibration file contains the results of the regression between the image and field spectra and can be used to apply the empirical line correction to lines which don’t contain targets. Click OK to start running.

6. Once the Empirical Line Correction has finished a new file (f168053b_utm_wgs84N30_sub_elc.bil) will appear in the Available Bands List window. Right click on this and select “Load True Colour to <new>”.

7. Within the Image window menu for the new file select “Tools” → “Profiles” → “Z Profile (Spectrum)” to bring up the spectral profile window and use this to view the spectra. The values are reflectance and go from 0 – 1, as shown in Figure 4. There are likely to be noisy regions of the spectrum where reflectance is recorded as being negative, these can be removed as part of post processing if required.

8. Keep all the windows open for the next section.

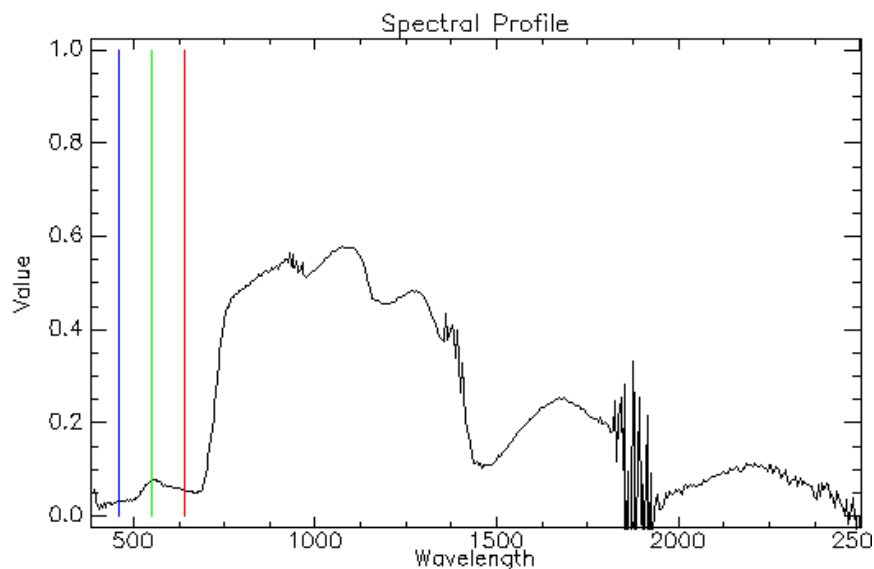


Figure 4: Image spectra of grass after empirical line correction.

5. Exploring Image Spectra

1. Within the spectral profile window select “Edit” → “Plot Parameters” and change the range of the Y-Axis from 0 to 1 to prevent the range from moving.

2. Still in the spectral profile window drag the red line to ~ 800 nm, right click on the plot and select “Load New RGB combination” to change the bands displayed. Notice in this combination how vegetation (which has a high NIR reflectance) appears as bright red. Try different combinations and notice how at different band reduce or emphasise the contrast between certain features.

3. To export the data from the plot you can select “File” → “Save Plot As” → “ASCII..” from the plot window. This will create a text file which can be opened in other programs, for example Excel.

4. As you move the plot tool around the image you will notice the spectra varies for similar

covers, to demonstrate this select “Options” → “Collect Spectra” and move the cursor around the grass which the targets are located on, the plot will keep a spectra for each point so you can see the spread of values. Untick “Options” → “Collect Spectra” and move the cursor to clear the plot.

5. To zoom in on a specific area of the spectra you can use the middle mouse button (scroll wheel).

6. Further exercises

This practical has provided a brief introduction to airborne imaging spectrometer data, including how to calibrate to surface reflectance using targets so each pixel is comparable with measurements made from a field spectrometer. There is a lot more analysis which can be carried out on these data, in particular when combined with field measurements, a lot of which will be specific to your application and the research questions you wish to answer.

If you have ideas of what you would like to achieve using airborne data but aren’t quite sure of how to go about it feel free to discuss with NERC-ARF and FSF. Outside the workshop you can contact the NERC-ARF help desk on nerc-arf-processing@pml.ac.uk

Some further exercises to try in ENVI during this practical are:

1. Spectrally resample the image to match a satellite sensor. Within ENVI use “Spectral” → “Spectral Resampling” and in the “Spectral Resampling Parameters” window select a Pre-Defined Filter Function (e.g., Landsat TM7). Compare the spectra from that of the original data. The resampled image with a reduced number of bands is easier to view in a GIS program (e.g, ArcMap)
2. Calculate vegetation indices such as the Normalised Difference vegetation Index (NDVI⁴). Within ENVI this can be done using: “Spectral” → “Vegetation Analysis” → “Vegetation Index Calculator”
3. Using the ROI tool, define regions for areas you are interested in (e.g., grass, water) and extract statistics for each one, using a similar procedure as used for the targets.

⁴ <https://earthobservatory.nasa.gov/Features/MeasuringVegetation/>