EO-1 Hyperion Hyperspectral Aggregation and Comparison With EO-1 Advanced land Imager and Landsat 7 ETM+

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This investigation compared the performance of the EO-1 Hyperion imaging spectrometer with the Advanced Land Imager (ALI) and the Landsat 7 Enhanced Thematic Mapper Plus (ETM+) sensor using an aggregation method that combined portions of the Hyperion 10 nm bands to emulate the broader multispectral response of ALI and ETM+. This capability placed radiometric measurements from different spectral bands onto a common base, thus allowing direct radiometric comparisons. The comparison was facilitated by the sensor platforms providing virtually coincident collects of the same target area.

The aggregation methodology, which was applied to each temporal frame, combined Hyperion's narrow hyperspectral bands so that they synthesized the ALI and ETM+ broader multispectral bands. The general process was to calculate a weighted sum of the Hyperion bands that covered each ALI or Landsat band. The weights used in the sum were derived by comparing the spectral response of the hyperspectral bands with the multispectral band. Mathematically, the process involved convolving the Hyperion gaussian spectral response with the broad band spectral response and normalizing carefully to ensure consistent units between instruments.

Based on the equations used to create the normalized weight (Equations 1 and 2), a text file was created for each ALI and ETM+ band. This text file was used in a third equation (Equation 3) to aggregate the calibrated Hyperion data for each temporal frame. The result was a Hyperion data set aggregated to an ALI data set and a Hyperion data set aggregated to an ETM+ data set spanning the spatial extent of the Hyperion scene.

1. $$W_{xzb} = \sum_{k=z-15nm}^{K=z+15nm} G_{xzk} \times F_{kb}$$

2. $$P_{xzb} = \frac{W_{xzb}}{fwhm * \sum_{z} W_{xzb}}$$

3. $$HB_{xb} = \sum_{z} P_{xzb} \times H_{xz}$$

x: field of view location
z: Hyperion spectral band
k: spectral range bounding the Hyperion band
b: Landsat or ALI band
F: Landsat or ALI spectral response
G: Hyperion gaussian spectral response
W: unnormalized spectral weight for each Hyperion pixel
P: normalized spectral weight for each Hyperion pixel
H: Radiance value for each Hyperion pixel
HB: Aggregated Radiance for a Landsat or ALI band

The initial portion of the investigation that established the radiometric cross- comparison used two desert sites: one at Railroad Valley in Nevada, and the second at Lake Frome, a dry salt lake in South Australia (Figure 1). Uniform regions were selected that spanned the field-of-view and which exhibited different intensity levels and spectral characteristics.

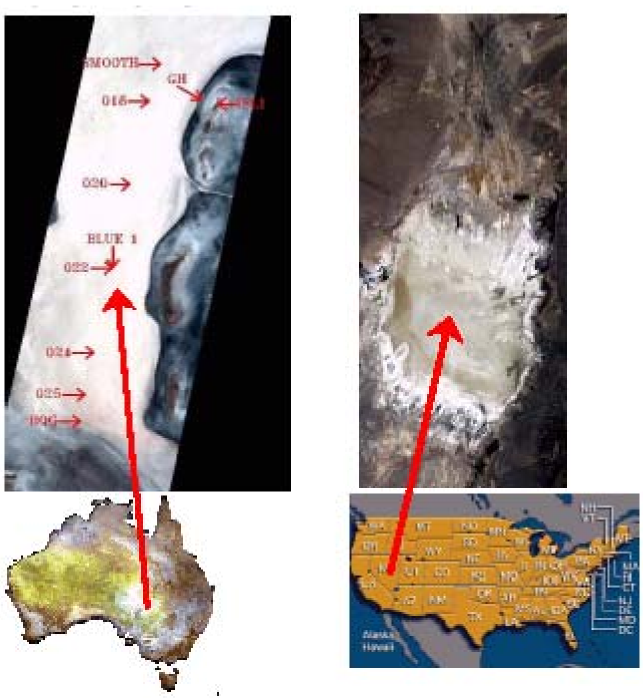

Figure 1. Desert Sites Used for Cross Calibration

Lake Frome **Railroad Valley**

The Railroad Valley site was used for the first Hyperion-ALI cross comparison. A set of ground points common to both the Hyperion and ALI scene was identified and used to derive an approximate Hyperion to ALI spatial transformation. A uniform region in the center of the scene of 30 x 30 pixels was identified and the average Hyperion aggregated to ALI data was compared with the corresponding average ALI data. An identical process was used to compare regions that encompassed a range of spectral intensities and spectral signatures. The comparisons turned out to be independent of field-of-view location and spectral signature, important in confirming the aggregation and comparison process.

The same exercise occurred using data collected later in the year at Railroad Valley and also at Coleambally, another site in Australia, using data that had been collected earlier in the year. The results indicated that the relationship between aggregated Hyperion and ALI data remained stable within a scene and over an extended period of time.

The same method was employed to compare Hyperion aggregated to ETM+ and ETM+ data sets from Railroad Valley and Lake Frome. The results again indicated that the relationship between the aggregated Hyperion and ETM+ were stable within a scene and over an extended period of time. The cross-comparison was later used, in conjunction with other science validation team results, to help justify an update to the Hyperion calibration file.

The next step after confirming the aggregation process, and determining the radiometric cross calibration, was to create synthesized ALI and ETM+ data sets from the Hyperion bands. The synthesized data set was the Hyperion aggregated data set with adjustments made to account for the cross calibration results. A site in Coleambally in which precise Hyperion-ETM+ registration was available was used. This allowed direct quantitative comparisons. Figure 2 shows a red-green-blue color combination based on ETM+ bands 4, 3, and 2. Figure 3 shows the quantitative comparison. There was excellent agreement between the Landsat red, green, and blue bands and the Hyperion synthesis of the ETM+ red, green, and blue bands.

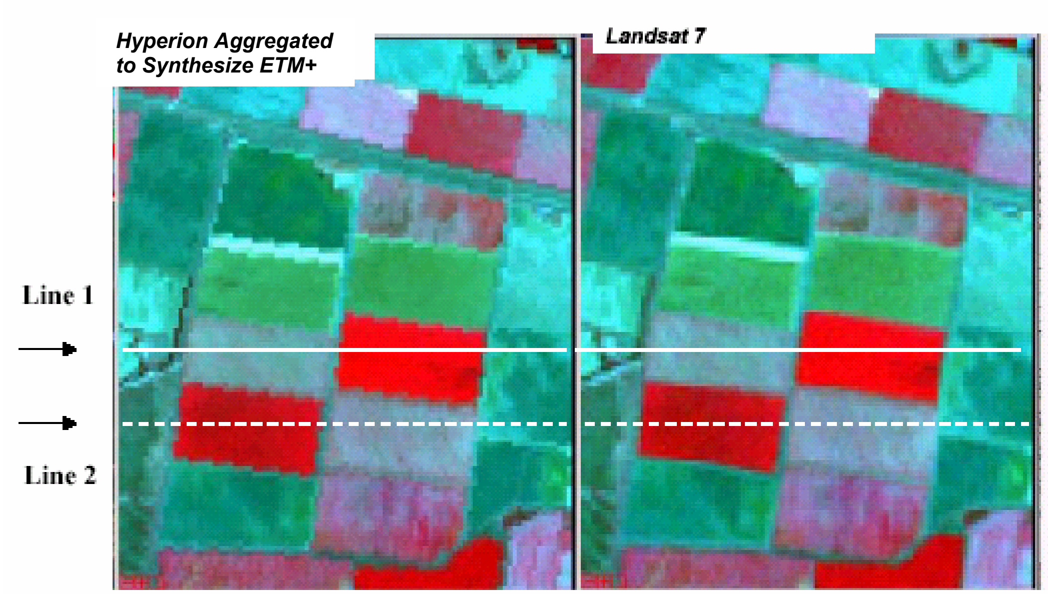

Figure 2. Hyperion - ETM+ comparison of color composite.

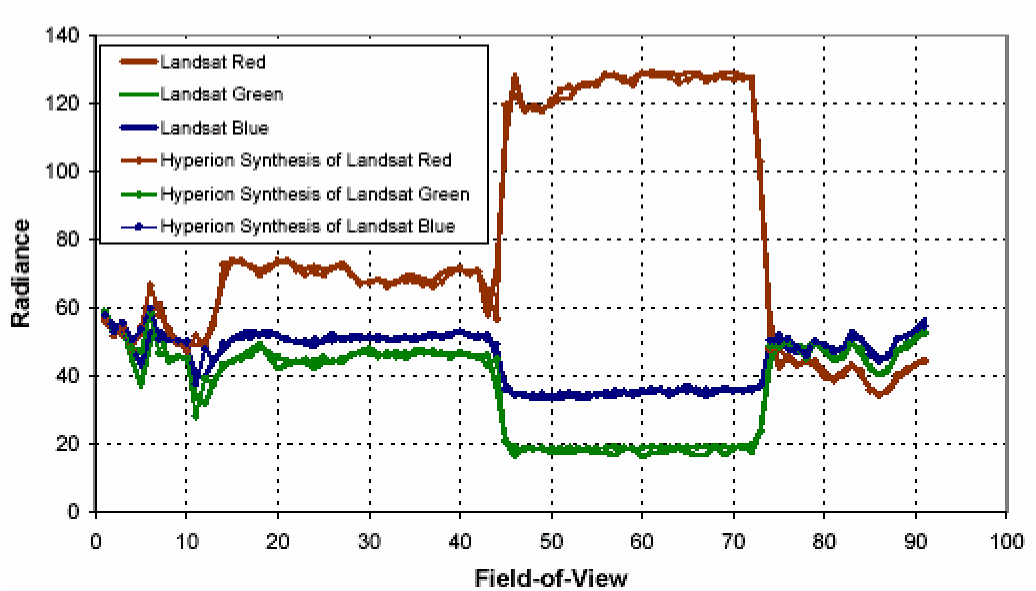

Figure 3. Hyperion – ETM+ comparison. Profile at Line 1.

A data collect at Cuprite in west central Nevada was used to compare Hyperion synthesized to ALI with ALI bands. A color band ratio image is presented in Figure 4. In this figure, the red, green and blue used in the RGB color model is defined as follows: the color seen as red is the ratio of band 5 to band 7, green is the ratio of band 3 to band 1, and blue is the ratio of band 4 to band 5. Qualitatively the Hyperion-synthesized to ALI image looks virtually identical to the ALI image. Figure 5 shows a line plot of a region within the Cuprite scene but not included in the previous figure. The plot exhibited excellent agreement between the ALI data and the Hyperion synthesis of the ALI data used. Although not included here, a plot of the data including the SWIR bands indicated higher fluctuation in the Hyperion synthesized data sets than the ALI data sets, possibly due to the lower SNR of Hyperion in the SWIR compared to ALI.

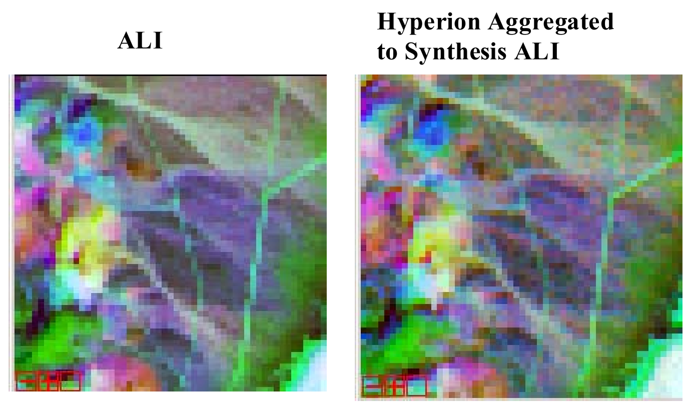

Figure 4. Color band ratios (Red: bands 5/7, Green: bands 3/1 and Blue: bands 4/5)

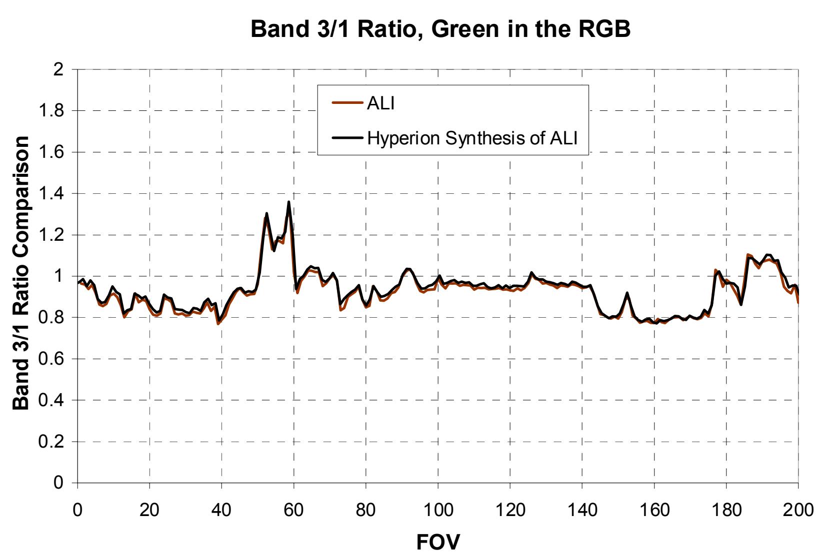

Figure 5. Hyperion – ALI Comparison

Conclusion:

Researchers developed and used an aggregation method to combine Hyperion 10-nm bands into emulated ETM+ and ALI broader multispectral bands. This capability allowed a radiometric cross calibration to be made between the Hyperion hyperspectral sensor and the ETM+ and ALI sensors. It also enabled Hyperion to synthesize ALI and ETM+ data. The technique of synthesizing broad band data from a hyperspectral sensor enables users to test the selection of broad bands for future missions by using various combinations of Hyperion bands.