Hyperion image processing

Prepared for:	Binal Benjamin Christian MS University of Baroda
Prepared by:	Mary Martin and Lucie Plourde University of New Hampshire
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This document is divided into 2 main sections. The first is a description of the image processing steps, the second includes comments/observations about the image data. All input/output/intermediate files are listed in section I. A number of these are intermediate file transformations required for the different steps, and may not be of much interest. They are recorded and described for future reference in the event that any additional processing is required for this dataset. All files will be archived, and will be available if needed. Original jpg images used in this document will also be available for your use.

Critical output data files will be placed on the ftp site for download (highlighted in yellow). Image files have been converted to ERDAS IMAGINE format and compressed (see file list in section I.9) I have viewed all of the IMAGINE output files to verify that they look the same as they do in ENVI, and I have calculated the statistics on each image file, so they should open up in IMAGINE, and be capable of displaying spectral profiles. Also note that the hdr files which will be included with each image file are in ascii format, and contain lines, rows, bands, band wavelengths, etc.

I. Data Processing

1. Original data files – image data files and supporting files were transferred to UNH via ftp as a single zip file (md5sum checksums shown [1])

39b7dd9129e8d32f3a00739040376898	EO1H1480452006093110PX.hdr
85f5391cdc82252a89d541903326c6fc	EO1H1480452006093110PX.L1R
8f66998e320ee9a4584b18c3227116f6	EO1H1480452006093110PX.MET
986221ad1e8fa7d46e92508b2c21d66f	EO1H1480452006093110PX_PF1_01.fgdc
1d2f54d7ce8fadc50df3f504e44b39bb	README.txt

1 Checksums are generated using md5sum protocol. This 20 character alpha-numeric string uniquely identifies each file so that any future reprocessing or file transfers can be checked to insure that the exact files are used.

2. Subset image to 196 bands and rows 801-2500

196 band subset contains original band numbers: 8-57,79-224
1-7, 58-76, 225-242 are uncalibrated bands, with all values set to zero.
77-78 overlap with bands 56-57; 56-57 are less noisy, so these are retained.
NOTE: In addition, as a result of co-aligning the VNIR and SWIR, there is often a "fill" value
of -32767 in the first line of the SWIR. This value should be removed before any image processing steps, either by masking it, or removing the first line of the image. This was not an issue with this data processing, since we used a subset of the original image which did not include the first line, but should be noted in the event that you do additional work from the original Hyperion data cube.

Output files:

8a4ad8d50de4cb2be10fc9248a34bd46	india_hyp_196b_sub.bip
1e84856115abd514507859cf5cebe5eb	india_hyp_196b_sub.bip.hdr

3. Create image mask. A mask was provided, but for some reason, the imagine file didn't match up with the begin/end lines that we had specified. When I subset to the lines in step one, I see a greater extent than in that mask file, so I recreated a mask from the line 801-2500 subset. The rules for the mask were: *Band 148(of 242), where all values <= 400 equal water.*

Mask file:

325edbd7164eabb5b4168eb21f962cab	india_subset_mask
141de797e447ec6acd91623e1abc3253	india_subset_mask.hdr

4. Apply mask.

Output image:

a36e343f6deba508ae6ed873c7860c3d	india_hyp_196b_subset_masked.bip
96063a17b971d4c59838904f1097bccf	india_hyp_196b_subset_masked.bip.hdr

5. Prepare ACORN input files:

83e782d2317023295577d76d20d7b67c	fwhm.txt	Bandwidth file
47404c5b52c3707f2983cb94354eebb1	hyperion_gain.txt	Gain file
2e94102e1f20538dcf079d347f7c3a8f	hyperion_off.txt	Offset file

530754e0902bca5e070f61015ba2bccd india_acorn_parameters1.in Run parameters

6. Run ACORN, generating the following files (output file descriptions can be found in the ACORN manual):

e39431a1c40d5b219925a9684c298e1c	india_acorn_parameters1.in.eco
f78fdba745947022773bf843ce725431	india_hyp_196b_subset_masked_refl1.bip
c7203c641d881f7817146373a33fe178	india_hyp_196b_subset_masked_refl1.bip.diag1
937af817439a9fb9c4ad9d0e3ff9b1f2	india_hyp_196b_subset_masked_refl1.bip.diag2
938f7eb97b22072621a81b525a1bb6c3	india_hyp_196b_subset_masked_refl1.bip.hdr
ad4554327094e5985a87c582c5a7df29	india_hyp_196b_subset_masked_refl1.bip.sta
ccb72ab09e39546c4103193a4967d9cf	india_hyp_196b_subset_masked_refl1.bip_wtrl
3290687ffa434b29588dd7f430099049	india_hyp_196b_subset_masked_refl1.bip_wtrl.hdr
8124d39c6903be00d0b7da37000ab129	india_hyp_196b_subset_masked_refl1.bip_wtrv
1584fd8777758fc2cdcb092f9f53fcb8	india_hyp_196b_subset_masked_refl1.bip_wtrv.hdr

7. **Run destreak** on reflectance image (Datt et al. 2003)

Convert ACORN bip file to bsq for destreak input
Input files (bsq format required for destreak input, so these do not really differ in content from the output files in section 6:

90d55dafd89845b2809374e41e742afa	india_hyp_196b_subset_masked_refl1.bsq
246cbe0f90a4f198578933b9dcb63af6	india_hyp_196b_subset_masked_refl1.bsq.hdr

Command:

```
/net/home/ja/mem/proj/destreak/src/destreak  -L 1700 -C 256 -B 196 -i
india_hyp_196b_subset_masked_refl1.bsq -o
india_hyp_196b_subset_masked_refl1_destreak.bsq
```

Output files:

f3ac0c046eeee184cad95e835936ccfe	india_hyp_196b_subset_masked_refl1_destreak.bsq
246cbe0f90a4f198578933b9dcb63af6	india_hyp_196b_subset_masked_refl1_destreak.bsq.hdr

This output file (exported as india_hyp_196b_subset_masked_refl1_destreak.img) is the final output, and the file that we typically use for our data analysis.

8. Run MNF transform on VNIR bands of original, reflectance, and destreaked images to verify that processing has removed striping and cross-track gradients in column values.

Output from reflectance image mnf:

e25acbd8f63720a06c93c07ce40d743f	mnfimg_vnir_refl
9409f6687ee0fe93a3720488fedadea9	mnfimg_vnir_refl.hdr
a8eb08b5b5918d384966913ba63e90e5	mnfnoise_refl_vnir.sta
c89a0d8d553972f78b4912547bb8ec00	mnfstats_vnir_refl.sta

Output from destreaked reflectance mnf:

299f7835aaa9f153b04c65eb865d63d8	mnfimg_vnir_refl_destr
94bcbaed95b0f41bdf28139059dc4ffc	mnfimg_vnir_refl_destr.hdr
7e686ea39b099b90f62d89b6d62947f1	mnfnoise_vnir_refl_destr.sta
186411610b08ea6586a3c4ef547da73f	mnfstats_vnir_refl_destr.sta

9. zipped IMAGINE export files:

d58a4eb328af0cc32a7ac646071d96a9	india_hyp_196b_sub.img.zip
09412c3db660c70c9973e44a00275eef	india_hyp_196b_subset_masked_refl1_destreak.img.zip
24264b4c2047434f2086a22d8f86e00c	india_hyp_196b_subset_masked_refl1.img.zip
64cb9e8dd23a401db1340954f96088c3	india_hyp_196b_subset_masked_refl1_wtrv.img.zip
deb111d77c310156ed5ab4372cb7ad30	india_subset_mask.img.zip

II. Observations and comments

Illustration 1 shows band 1 of the MNF transform for VNIR bands (see Goodenough et al. 2003 and citations therein for description of MNF transform). This routine is similar to principal components, and reduces the data dimensionality in a manner that separates noise into the higher order bands. The first band typically emphasizes column-to-column issues such as a brightness gradient due to view angle, and/or variation due to cross-track smile. In this dataset, the ACORN processing accounted for the cross-track smile (by using mode 1.5pb), but there is still a strong cross-track gradient in the output reflectance image. The destreak processing, which normalized each column in the image removes this effect, and the MNF output in Ill 1 demonstrates this with the before and after MNF band 1.

The destreaking routine also removes the column striping artifact in Hyperion data. This can be seen in the before/after images in Ill 2, which show the Hyperion band at 426nm.

In the ACORN correction process, a water vapor image is generated. This calculation is made from band depth ratios at water absorption features in the original *radiance* data. This pixel-by-pixel water vapor value is used in the radiance to reflectance transformation in ACORN. Ill 3 shows the image and histogram for water vapor output. You can recognize topographic features in the image since there is less water vapor in the atmospheric column above areas at high elevation. This pixel-by-pixel atmospheric correction is unique to this type of correction model (also used in HATCH, FLAASH, ATREM models).

The standard atmosphere parameters that are included in ACORN (mid-lat temperate used here), may be derived from only US data. We are looking into this now, and I will pass along anything that I learn about this. It might be something to look at more closely, to determine if there is any reason that the atmospheric parameters would differ between +/- longitude.

The most striking observation about the resulting reflectance image is that there appears to be a very weak or non-existent vegetation signal throughout most of the image. This may be due to the type of vegetation cover – we typically work in forests with closed canopy cover and an LAI of 3 or greater, so we are accustomed to seeing a strong vegetation signal in most of our pixels. The images shown in Ill 4-6 are displayed with bands 1649, 854, 447nm as RGB. This sequence of images shows original radiance data, and final reflectance data for varying levels of vegetaion. The bright green areas are those with the strongest vegetation signal, however, the mountains south of the waterbody show up darker green in this display combination and seem to have a much weaker vegetations signal. Once you register this image and can locate your study sites, you will have a better idea of the type of reflectance signature you will be working with.

We hope that this final reflectance image is useful to you. As we mentioned earlier, there are alternative methods to accomplish this correction, and you may want to investigate some of those to determine which type of processing will meet the needs of your project. Please keep in touch, and let us know how your project is progressing.

Regards,
Mary and Lucie

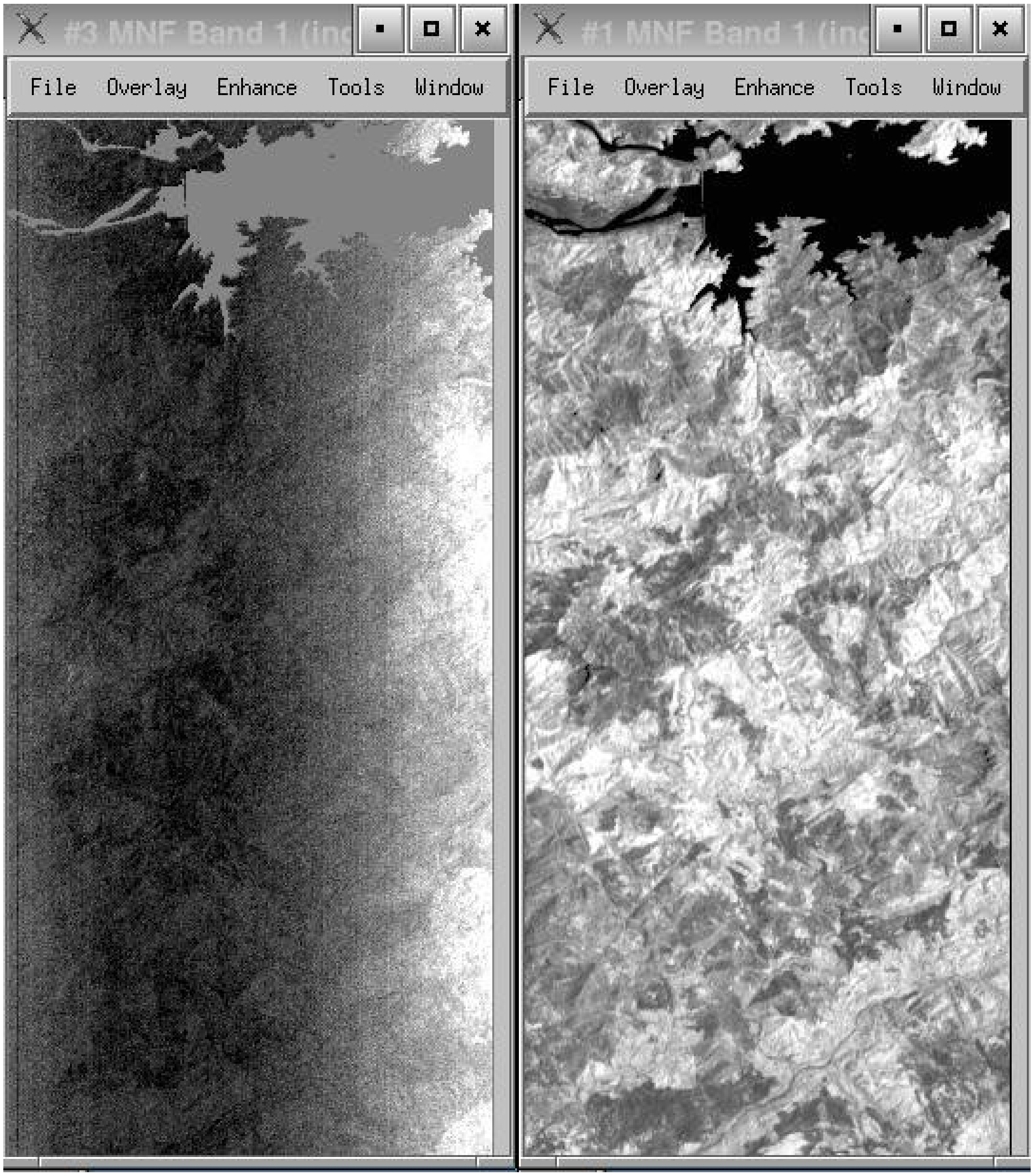

Illustration 1: MNF transform of VNIR bands. MNF band 1 for reflectance on left and MNF band 1 for destreaked reflectance on right.

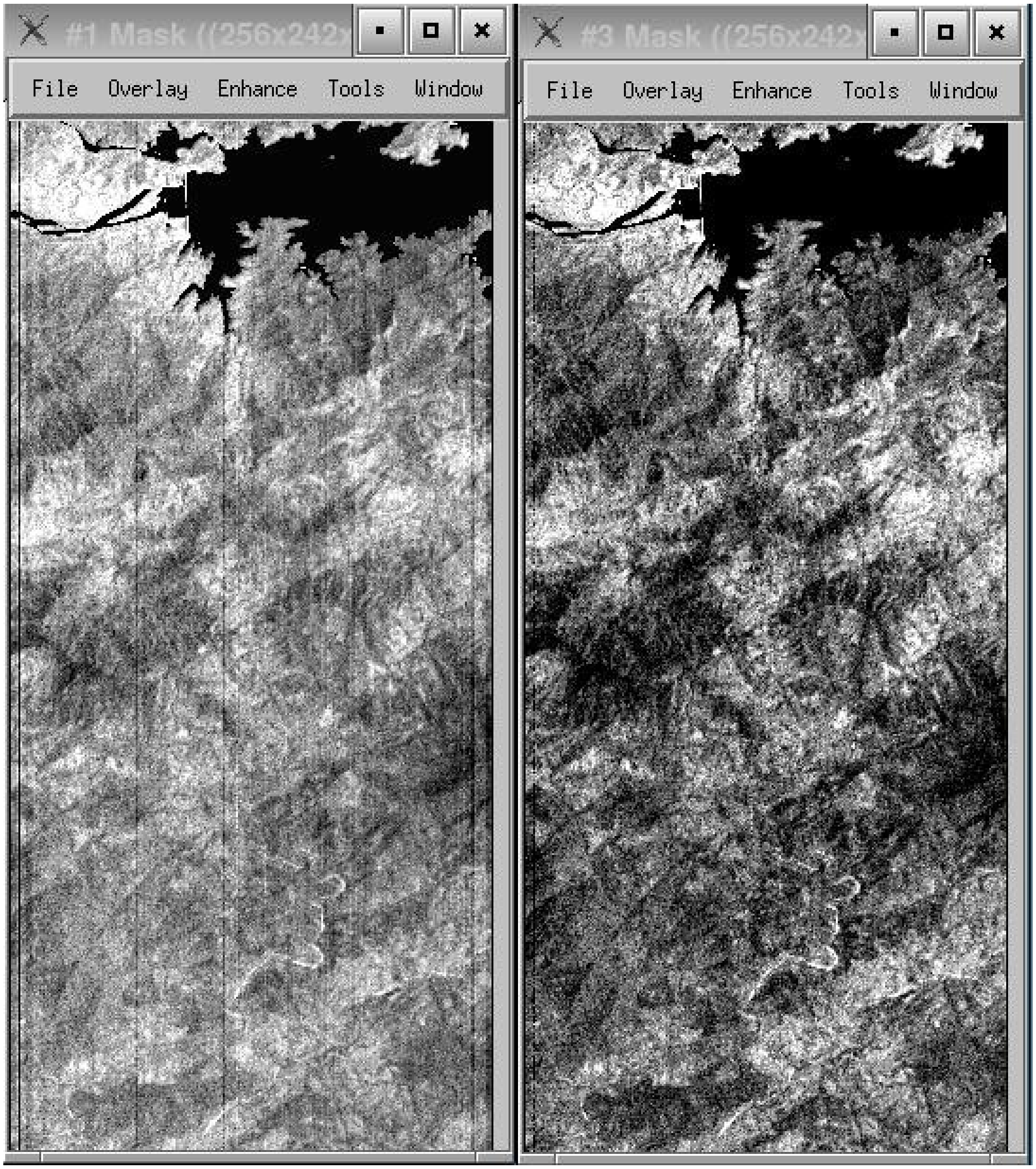

Illustration 2: Hyperion band at 426nm, reflectance on left, destreaked reflectance for 426nm on right. Image demonstrates the removal of the column striping artifact in Hyperion imagery.

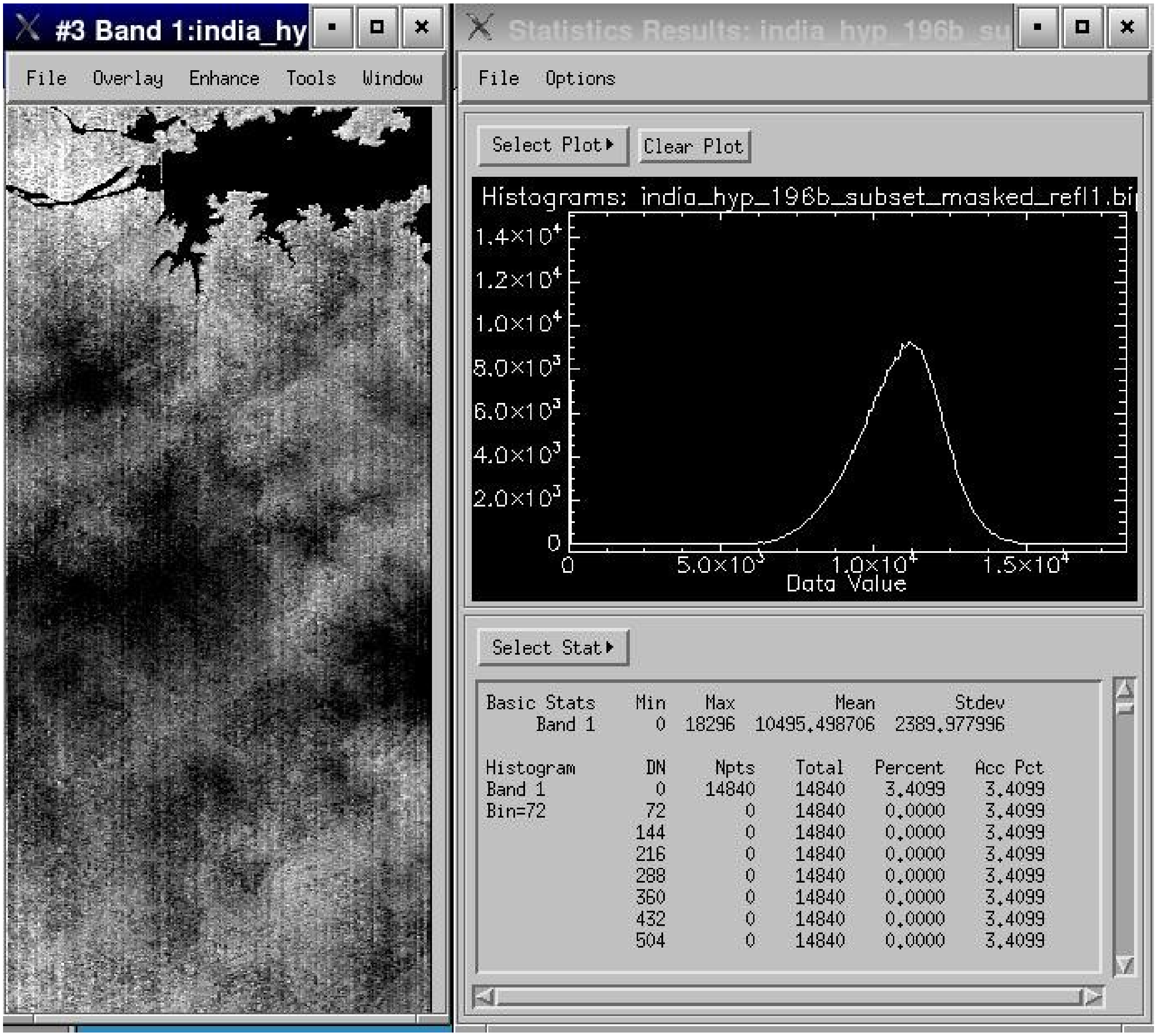

Illustration 3: Water vapor image and histogram. Precipitable water vapor in microns.

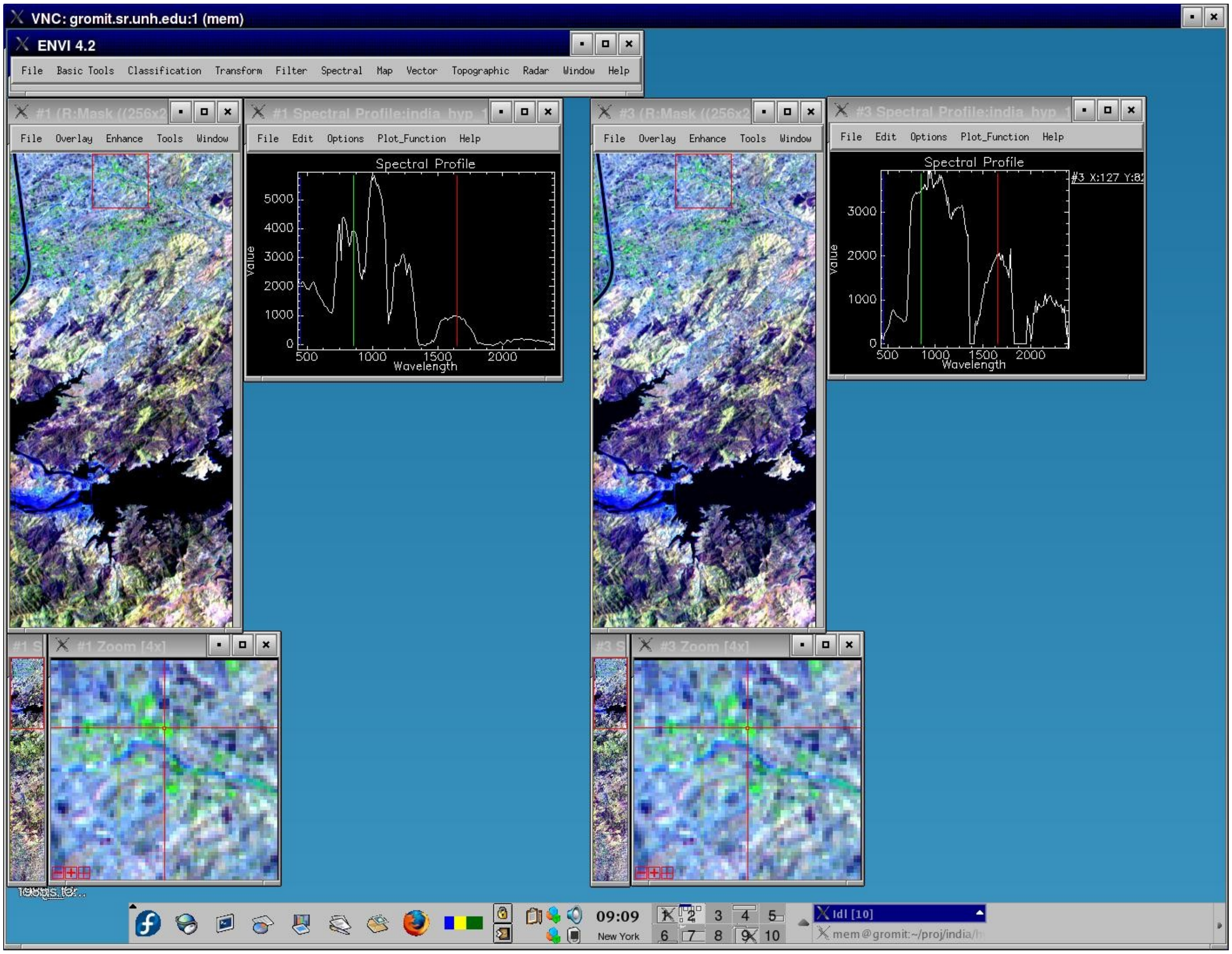

Illustration 4: ENVI screenshot of original radiance (left) and ACORN reflectance (right). This is an example of a pixel with a strong vegetation signal (green peak in the visible bands). The image layout for each section is as follows: upper left=normal view, upper right=spectra, lower left=full scene, lower right=zoom window. The extracted pixel is located at the cross-hair in the zoom window, normal view window image location is indicated by red box in full scene window, zoom window image location is indicated by red box in normal-view window.

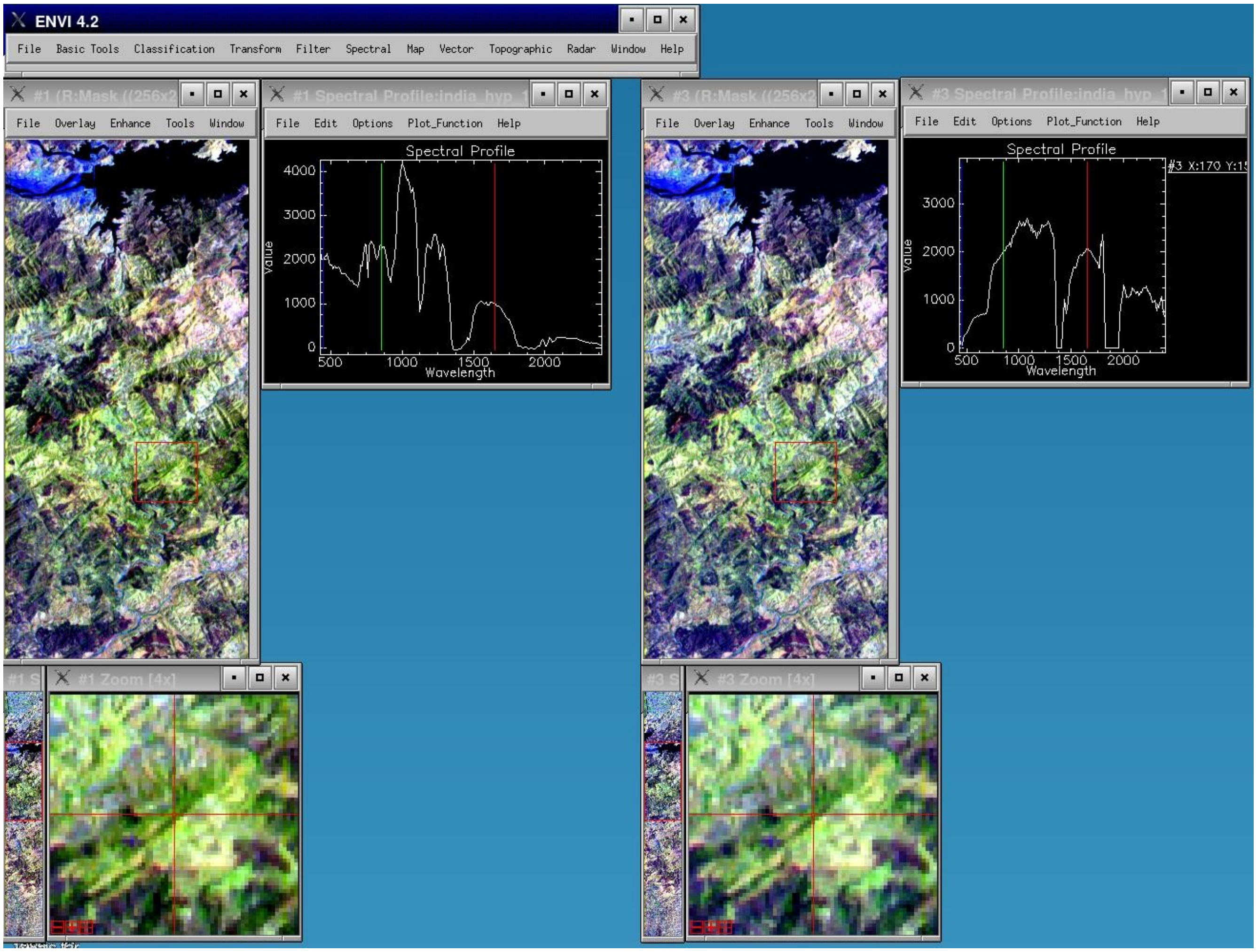

Illustration 5: ENVI screenshot of original radiance (left) and ACORN reflectance (right). This is an example of a pixel with a weak vegetation signal.

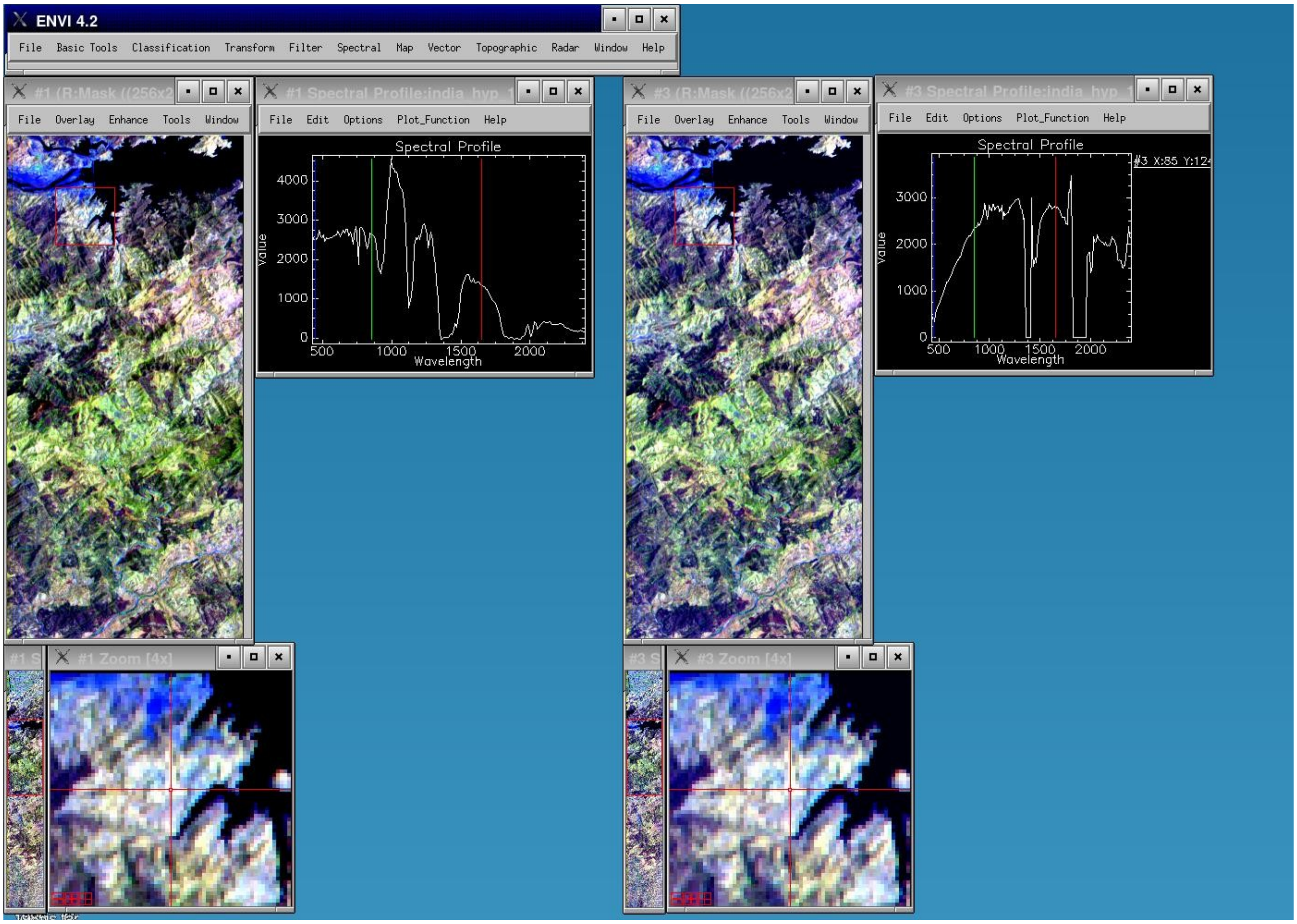

Illustration 6: ENVI screenshot of original radiance (left) and ACORN reflectance (right). This is an example of a pixel with no vegetation signal.