Atmospheric Correction of Hyperion Data and Techniques for Dynamic Scene Correction
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Hyperspectral data, such as that acquired from the EO-1 Hyperion, requires atmospheric correction for the conversion of radiance to reflectance in order to correct for path radiance, precipitable water vapor, and other trace gases. This investigation examined the capability of various models to correct for atmospheric effects associated with the acquisition of hyperspectral data.

The investigation focused on three atmospheric models: ATREM (Atmosphere REMoval), HATCH (High Accuracy ATmospheric Correction for Hyperspectral data), and ACORN™ atmospheric correction software. It also compared the performance of these models with simulated radiances using MODTRAN 4, another atmospheric model, and with actual data from NASA's AVIRIS and Hyperion for which simultaneous ground reflectances were acquired. Each of the models focused on the 0.4-2.5 µm wavelength region.

The HATCH model was developed to convert sensor radiance to reflectance on a pixel-by-pixel basis and to overcome some of the shortcomings of ATREM, which overestimated atmospheric water vapor content in vegetated areas and also exhibited other inconsistencies, in particular because it was difficult to obtain proper correction in the 0.9-1.2 µm region. HATCH reflectance retrievals are insensitive to liquid water content in vegetation cover if the 940 nm band is used for retrieval. When the 1140 nm band was used, as was necessary with Hyperion, HATCH also overestimated water vapor if vegetation is present.

A version of HATCH called HATCH 2-d was created for use with Hyperion measurements. HATCH 2-d makes column-by-column atmospheric correction to compensate for shifts in wavelength calibration associated with "smile." Atmospheric corrections on a column-by-column basis are justified because water vapor images and MNF (Maximum Noise Fraction) images display increased accuracy when correction is applied on that basis rather than by choosing a center wavelength as required for ACORN and ATREM. Results using HATCH with Hyperion and ACORN with AVIRIS were compared, and although Hyperion data became more accurate, the effect of its lower signal-to-noise ratio (SNR) masked HATCH's true advantage over ACORN.

Both HATCH and HATCH-2d used a unique "smoothness criterion" to determine the water vapor amount. This algorithm adjusted the spectral calibration and the instrument PSF (point spread function) to match the model based on the minimum overshoot at the water band edges. The end result was a much smoother reflectance spectrum with fewer amplitude overshoots at the water vapor band edges than obtained using ATREM
(Figure 1).

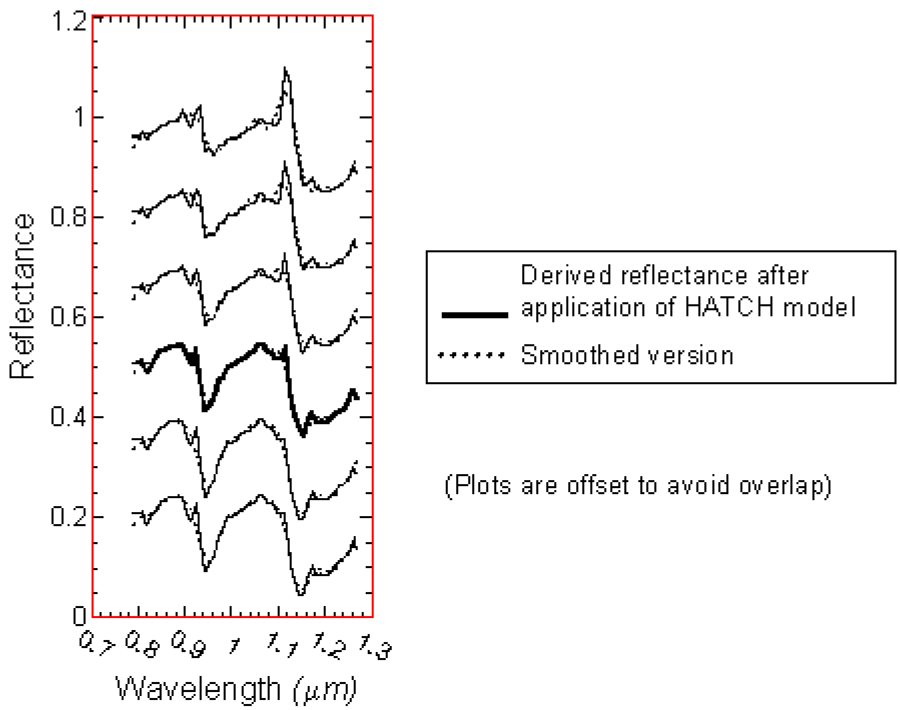
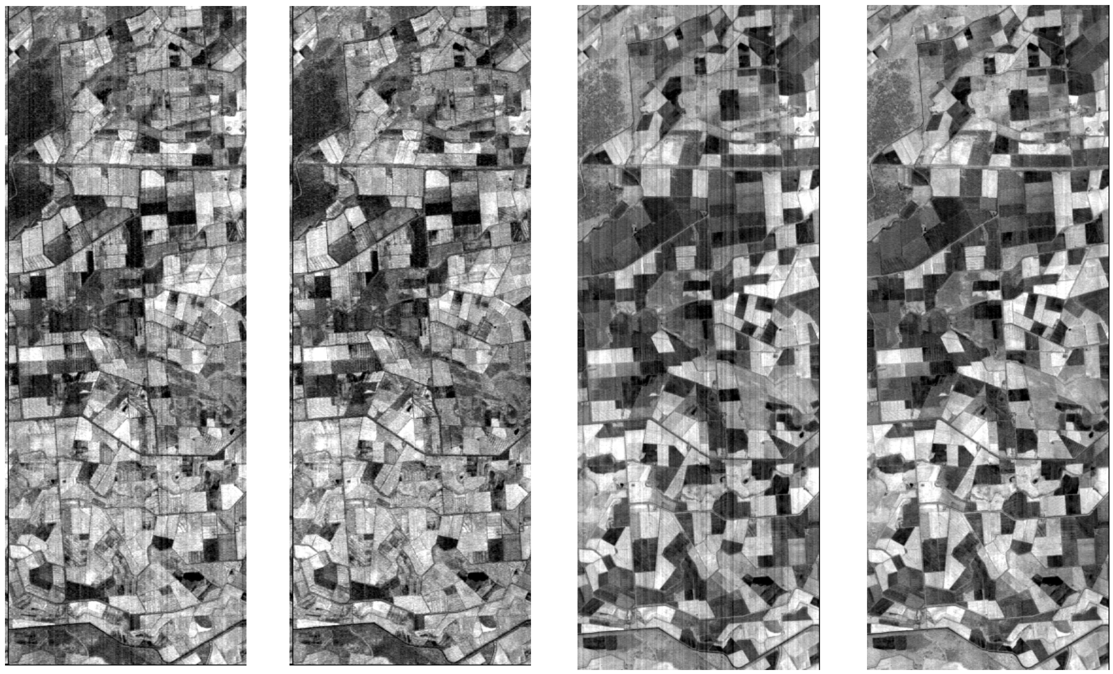


Figure 1. "Smoothness Test" for Water Vapor Retrieval.

Data acquired from 2-D detector arrays with low SNR, such as Hyperion, display column-column striping artifacts. These are a manifestation of the wide range of sensitivities and noise characteristics of individual detectors and the fact that as many as 2% of individual detectors are not operational. Striping also is due to the presence of bad pixels and the lack of precision in detector-to-detector calibration. These striping artifacts must be removed before Hyperion data can be analyzed. A technique to remove the striping was developed and applied to both radiance and reflectance images. The quality of the correction was then determined by inspecting higher order MNF images for striping artifacts. Figure 2 shows selected reflectance bands both before and after destriping. The increase in perceived quality is significant, but it is not yet known what effect the corrections will have on the absolute radiometric integrity of the data.



Band 80 before destriping. | **Band 80 after destriping.** | **Band 120 before destriping.** | **Band 120 after destriping.**

Figure 2. Radiances Showing Effects of Destriping, Coleambally, New South Wales

HATCH 2-d was applied to Hyperion radiance images from three locations and compared to simultaneously acquired field spectrometer reflectance of bare soil and stubble-covered areas. In the first location in Salar de Arizaro, Argentina, the HATCH 2-d algorithm overestimated the water vapor content. At Brush, Colorado, the coincidence between the HATCH-retrieved reflectance and the field measurements was excellent except in the 900-1000 nm region. At the third site in Coleambally, NSW, Australia, there was good coincidence between field reflectance spectra and the HATCH-2d retrieved reflectance except in the 900-1200 nm region.

Conclusions

HATCH 2-d was used to retrieve reflectance from Hyperion data. The model compensated for "smile" in the Hyperion spectrometer by making column-by-column corrections. The compensation for "smile," coupled with model differences in HATCH 2-d, resulted in somewhat smoother-looking retrieved reflectance spectrum when HATCH was used than when other models were applied. However, no model yielded perfect results. There were still errors in the 0.9-1.4 µm water vapor band regions. These errors were found in all models and may have been the result of errors in HITRAN, the line strength database used for all atmospheric correction algorithms. The effects were also magnified by Hyperion's poor instrument SNR in this region.