Correlative Analysis of EO-1, Landsat 7, and Terra Data of the Department of Energy ARM CART Sites: An Investigation of Instrument Performance and Atmospheric Correction

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The primary goals of this investigation were to: (1) develop an improved atmospheric correction algorithm; (2) investigate the information content of the EO-1 measurements with respect to atmospheric NO_2, O_3, water vapor, aerosols, and cloud; and (3) to evaluate the effects of spatial and spectral resolution on both atmospheric correction and the retrieval of atmospheric properties. The investigation centered on scenes from the Department of Energy ARM (Atmospheric Radiation Measurement) CART (Cloud and Radiation Testbeds) sites. Ground-based data were used to provide constraints on the aerosols, retrieving water vapor amounts from Hyperion, and comparing the retrieved Hyperion water vapor data with ground-based measurements. In addition, investigators compared ground-based measurements of aerosol properties with the aerosol properties inferred from satellite data.

Along with the increased use of remote sensing instrumentation to simultaneously acquire imagery as well as the spectra of each pixel in the image has come the need for fast and accurate atmospheric correction methods. Water vapor and aerosols are the primary sources of uncertainty in the atmosphere, and it is necessary to develop accurate calculations that correct for these constituents. Such calculations need to be fast, accurate, and simple so that atmospheric corrections of hyperspectral data (such as from Hyperion) can be performed both while airborne and at ground stations that receive hyperspectral data from aircraft.

To achieve this objective, investigators have successfully developed and used an improved atmospheric correction algorithm to correct several hyperspectral images acquired from Hyperion. The correction, applied to retrieved water amounts, is shown in the following pair of figures (Figure 1). The figure on the left shows a retrieved water vapor image for the Southern Great Plains ARM CART site: mean water vapor column is 0.763 precipitable cm with a standard deviation of 0.072 cm. The figure on the right shows a false color image of the same scene. As can be seen, the algorithm has some problems over dark surfaces; nonetheless, the retrieved column agrees well with the ground-based measurements that showed the water vapor column increasing from 0.5 to 0.9 precipitable cm with time and a value of 0.6 cm at the time of the satellite overpass. Results indicated that the potential exists to perform atmospheric correction using this algorithm in near real time.

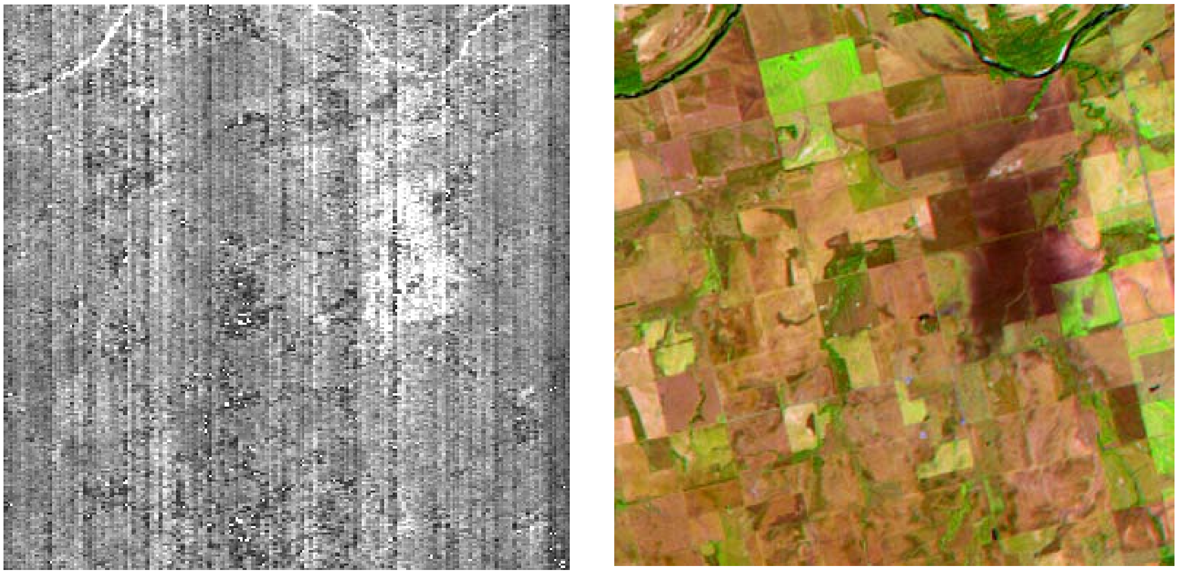

Figure 1. This pair of figures compares a water vapor image (left) with a false color image (right) for the Southern Great Plains site. The mean water vapor column is 0.763 cm with a standard deviation of 0.072 cm. While there is an obvious problem over dark surfaces (e.g., water), the agreement with ground-based water retrievals is acceptable. Unresolved calibration issues produce striping in water vapor retrieval.

Related to the second objective, to evaluate the information content of the EO-1 measurements with respect to atmospheric NO_2, O_3, water vapor, aerosols, and cloud, investigators found that measurements successfully indicated the degree to which atmospheric NO_2, O_3, water vapor, aerosols, and cloud were present.

The third objective focused on an evaluation of the effects of spatial and spectral resolution on both atmospheric correction and the retrieval of information about atmospheric properties. It was found that increased spectral resolution allowed the acquisition of additional information on the distribution of absorbers in the atmosphere. This additional information might be useful when correcting for atmospheric constituents. Increased spatial resolution may be important in particular situations, such as in resolving individual cloud and clear elements in a broken cloud field. However, coarser spatial resolution data would contain the mixture from cloudy and clear sub-pixel elements. Higher spatial resolution was also found to be of less importance for atmospheric correction if the aerosol or water vapor in the atmosphere varied slowly over large spatial scales. In such situations, coarser resolution data would be acceptable.

Research was also conducted using EO-1 data for the Southern Great Plains, Oklahoma, and Coleambally Irrigation Area, New South Wales, Australia. Comparisons of pre-launch laboratory data for the spectral "smile" on the visible and near infrared (VNIR) detector using the oxygen A-band with Hyperion data indicated that a change occurred in the VNIR detector following launch that was represented by a spectral offset and a change in the shape of the spectral "smile".

Conclusions:

Investigators concluded that atmospheric corrections of Hyperion hyperspectral measurements can be made using algorithms that allow for near real time corrections. Further, measurements successfully indicated the degree to which particular atmospheric constituents were present. Finally, data that made use of the increased spatial and spectral resolution available with Hyperion were determined to be useful in particular situations but unnecessary in others.