Hyperion Applications and Validation for Fire Hazard Assessment in Santa Barbara, California

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Wildfires are one of the most serious economic and life-threatening catastrophes that occur today in Southern California. The annual cost of these disasters averages $163 million in structural losses alone; the cost of other fire-related damage, such as soil erosion and mud slides, following a fire may be even higher. The danger of such fires occurring where wild and urban areas meet is increasing.

This investigation focused on evaluating the potential of EO-1's Hyperion imaging spectrometer for fire danger assessment. Critical parameters included surface reflectance, canopy moisture, species composition, and fuel state.

Originally, the intent was to conduct the investigation over the Santa Monica Mountains. However, the lack of clear sky data sets forced the investigators to relocate to the backup location in the Santa Ynez Mountains, north of Santa Barbara (Figure 1). Cool winters with precipitation and warm summers with drought conditions characterize the area. The investigation was carried out using data acquired in June 2001.

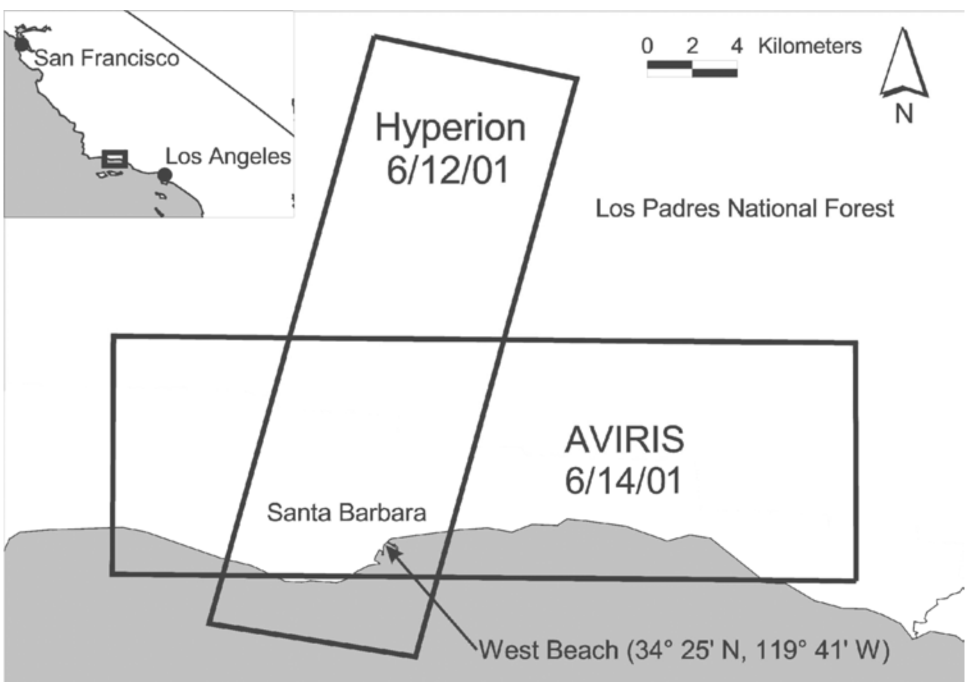


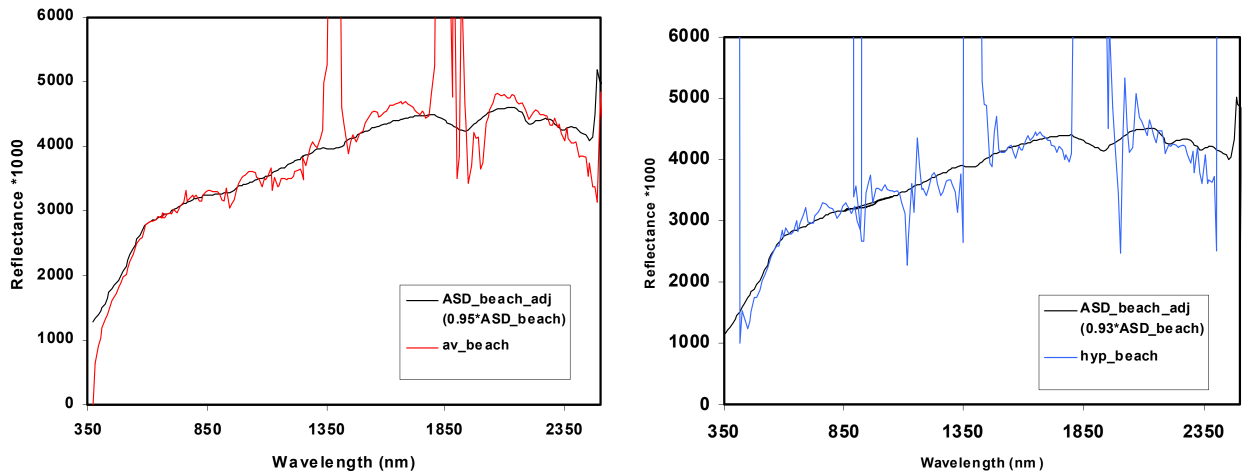
Figure 1. Study site.

The primary objective of this investigation was achieved by directly comparing Hyperion and Airborne Visible Infrared Imaging Spectrometer (AVIRIS) data. AVIRIS data was acquired on June 14, 2001, while Hyperion data was acquired on June 12. Six land-cover classes were mapped: soil, grassland, chamise, Ceanothus, manzanita, and oak.

Production of four important fuel categories was compared: fuel type, fuel load (live green and woody biomass), fuel condition (the proportion of live vs. dead canopy elements), and fuel moisture. Both data sets were processed to retrieve surface reflectance with ACORN using a ground reflectance target to improve reflectance retrievals. To assess fuel moisture, several algorithms were tested including the Water Index of Penuelas et al, the NDWI (Normalized Difference Water Index) of Gao, liquid water fits, and a modified NDWI. Fuel condition was mapped using spectral mixture analysis (SMA), with the same reference endmembers applied to both. System performance was compared using more than 80 reference polygons located in the field that covered a range of natural vegetation in the area.

Significant findings included:

1. Hyperion proved to have good radiometric calibration and radiometric stability, providing high quality reflectance after use of a post-launch correction (Figure 2). Hyperion produces spectra that are noisier at specific bands due to a lower signal-to-noise ratio, especially in the short-wave infrared (SWIR) region.



AVIRIS Beach Calibration Target **Hyperion Beach Calibration Target**

Figure 2. Hyperion and AVIRIS reflectance retrieval.

2. Hyperion could map canopy moisture well, but only using indices that excluded the 980-nm water band. Of the indices compared, the NDWI and modified NDWI proved to be the most effective. Figure 3 compares the liquid water fit between Hyperion and AVIRIS using the NDWI. Figure 4 compares the two using the modified NDWI.

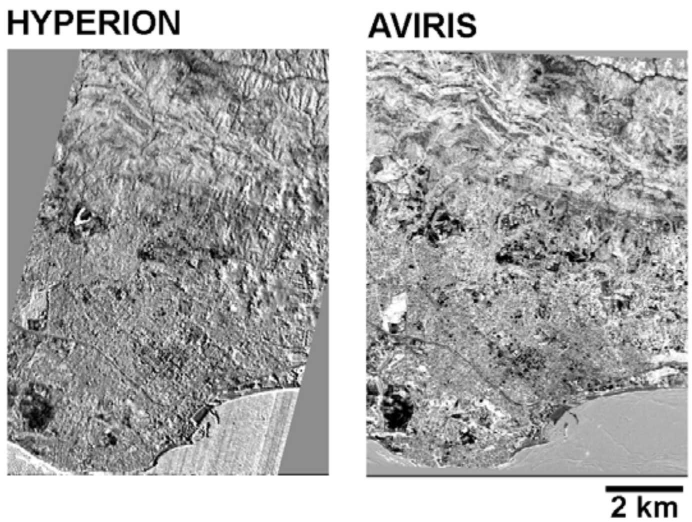


Figure 3. Comparison of fuel moisture estimated using the NDWI. Light areas have high fuel moisture and low wildfire danger.

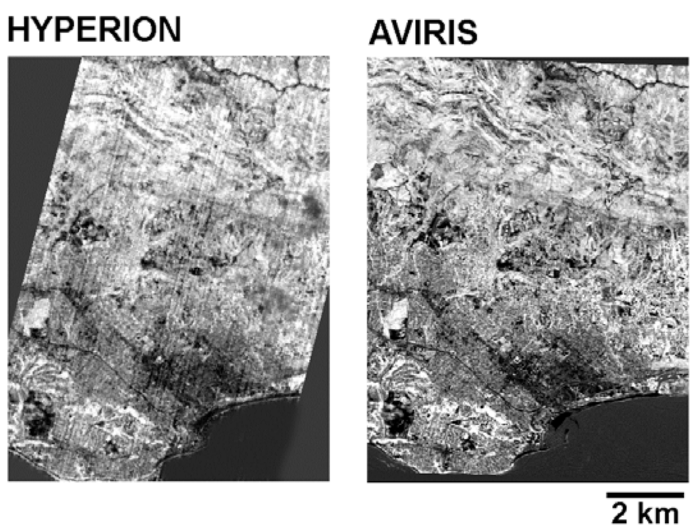


Figure 4. Measures of fuel moisture estimated using the modified NDWI. Light areas have high fuel moisture and low fire danger.

3. Fractions of non-photosynthetic vegetation (NPV), e.g., stems, wood, and litter; and soil, generated from Hyperion, showed very high correlation with AVIRIS estimates, producing nearly a 1:1 relationship (Figure 5). Differences in green vegetation were attributed to the higher solar zenith of Hyperion. It was concluded that Hyperion had the capability to map fuel condition well.

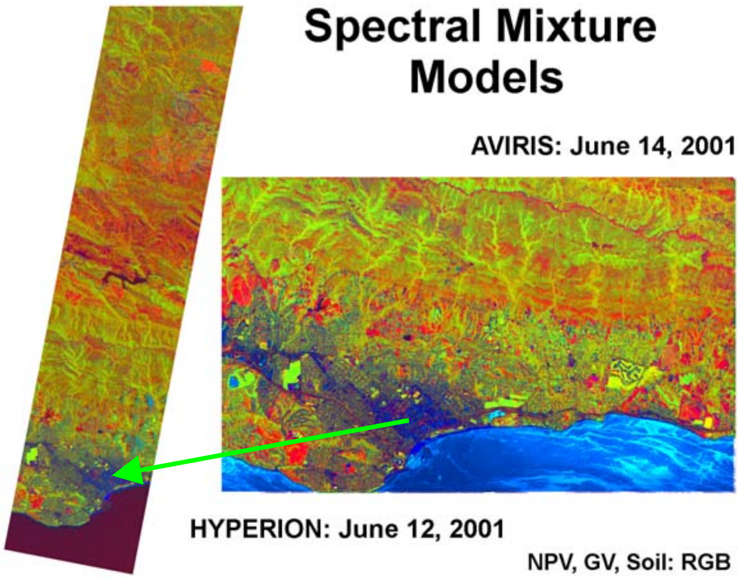


Figure 5. Fuel Condition. Hyperion provides comparable measures to AVIRIS over a larger geographic region.

4. Fuel type maps, generated from Hyperion proved to have significantly lower accuracies than maps generated from AVIRIS. However, several fuel classes of interest were mapped to very high accuracies, including senesced grass, soil, and chamise. The greatest errors were between live oak and Ceanothus (Figure 6).

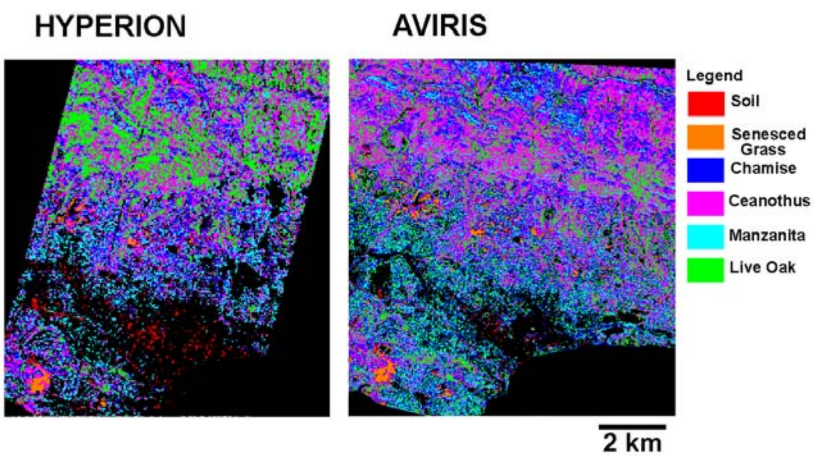


Figure 6. Vegetation type mapping.

Additional research is currently being carried out that focuses on a number of areas. One investigation centers on acquiring ground reflectance targets for reflectance retrieval and building a spectral library of all dominants. A second involves collection of field spectra and CCD images along a climatic gradient in Kohala (Hawaii) and evaluating AVIRIS/Hyperion capabilities for mapping live and senesced vegetation in pastures (fuels). A third focuses on analyzing a time series of data from the Santa Barbara area to evaluate seasonal changes in fuels. This is an extension of the research described in this summary, but covers data acquired over a season rather than only on a single date.