SYNERGIES BETWEEN VISIBLE/NEAR-INFRARED IMAGING SPECTROMETRY AND THE THERMAL INFRARED IN AN URBAN ENVIRONMENT: AN EVALUATION OF THE HYPERSPECTRAL INFRARED IMAGER (HYSPIRI) MISSION

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A majority of the human population lives in urban areas and as such, the quality of urban environments is becoming increasingly important to the human population. Furthermore, these areas are major sources of environmental contaminants and sinks of energy and materials. Remote sensing provides an improved understanding of urban areas and their impacts by mapping urban extent, urban composition (vegetation and impervious cover fractions), and urban radiation balance through measures of albedo, emissivity and land surface temperature (LST). Recently, the National Research Council (NRC) completed an assessment of remote sensing needs for the next decade (NRC, 2007), proposing several missions suitable for urban studies, including a visible, near-infrared and shortwave infrared (VSWIR) imaging spectrometer and a multispectral thermal infrared (TIR) instrument called the Hyperspectral Infrared Imagery (HyspIRI).

In this talk, we introduce the HyspIRI mission, focusing on potential synergies between VSWIR and TIR data in an urban area. We evaluate potential synergies using an Airborne Visible/Infrared Imaging Spectrometer (AVIRIS) and MODIS-ASTER (MASTER) image pair acquired over Santa Barbara, United States. AVIRIS data were analyzed at their native spatial resolutions (7.5m VSWIR and 15m TIR), and aggregated 60 m spatial resolution similar to HyspIRI. Surface reflectance was calculated using ACORN (http://www.imspec.com/) and a ground reflectance target to remove atmospheric and sensor artifacts (Clark et al., 2002). MASTER data were processed to generate estimates of spectral emissivity and LST using Modtran radiative transfer code (Berk et al., 2005) and the ASTER Temperature Emissivity Separation algorithm (Gillespie et al., 1998). A spectral library of common urban materials, including urban vegetation, roofs and roads was assembled from combined AVIRIS and field-measured reflectance spectra. LST and emissivity were also retrieved from MASTER and reflectance/emissivity spectra for a subset of urban materials were retrieved from co-located MASTER and AVIRIS pixels. Fractions of Impervious, Soil, Green Vegetation (GV) and Non-photosynthetic Vegetation (NPV), were estimated using Multiple Endmember Spectral Mixture Analysis (MESMA: Roberts et al., 1998) applied to AVIRIS

data at 7.5, 15 and 60 m spatial scales. Surface energy parameters, including albedo, vegetation cover fraction, broadband emissivity and LST were also determined for urban and natural land-cover classes in the region. Fractions were validated using 1m digital photography.

Biotic surfaces, including various urban tree species, live and senesced grasses were spectrally distinct in the VSWIR, but typically spectrally similar to black bodies in the SWIR, with only senesced grasslands showing lower emissivity in the TIR. (Figure 1). By contrast, abiotic materials including roads, roofs and soils were spectrally distinct in the VSWIR and TIR, suggesting potential synergies in discriminating non-biotic materials in urban environments.

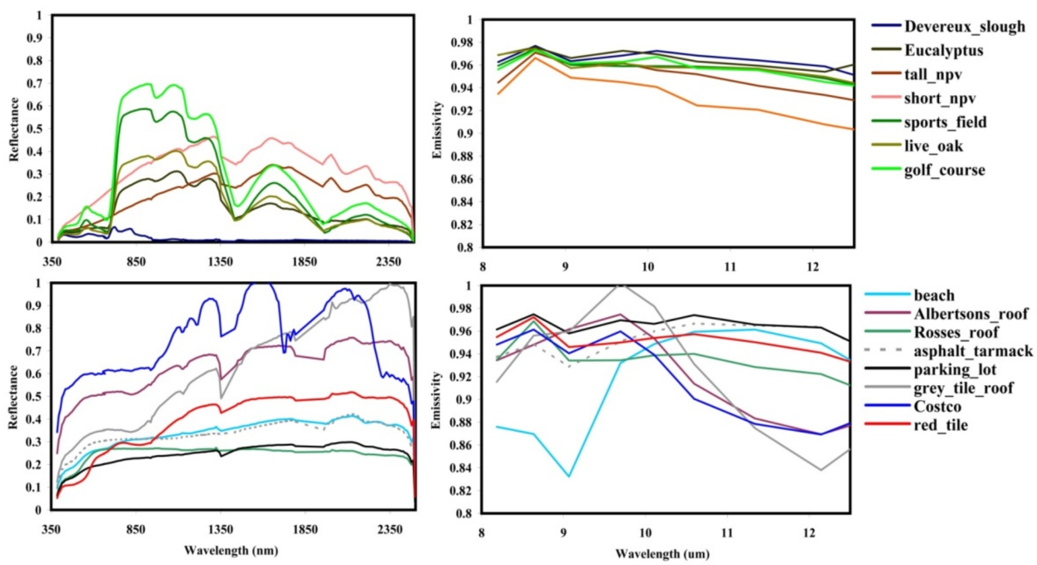

Figure 1) Showing VSWIR (left) and TIR (right) spectra of select biotic (top) and abiotic (bottom) materials derived from collocated pixels from AVIRIS and MASTER.

GV and NPV Fractions were highly correlated with validation data at all spatial scales, producing a near 1:1 relationship but with a <10% overestimate of GV using MESMA applied to AVIRIS. Impervious fractions were also accurately mapped, but were typically underestimated due to spectral confusion between several roof types and soils, an error that may be reduced by combining VSWIR and TIR reflectance data in the same mixing model and taking advantage of increased spectral contrast between soils, asphalt and some roof types in the TIR. Comparison of fractions across scales showed high correlation between GV and NPV at 7.5 and 60m resolution, suggesting that HyspIRI will provide accurate measures of these two measures in urban areas. An inverse relationship was observed between GV fractions and LST with each 10% increase in GV fraction equal to a 1.6K decrease in LST (Figure 2).

Considerable scatter around this relationship, emphasizes the complex relationship between vegetation cover and LST, in which a closed canopy or open field can show significant variability in LST depending upon stress or moisture status. Equivalent water thickness also proved to be inversely correlated with LST, but surface albedo proved to be poorly correlated with LST. Residential and commercial areas showed a general pattern of increasing LST with increasing impervious fraction and decreasing GV fraction (Figure 3). The results demonstrate some of the potential of HyspIRI data for urban studies and provide an insight of what will be possible globally using HyspIRI.

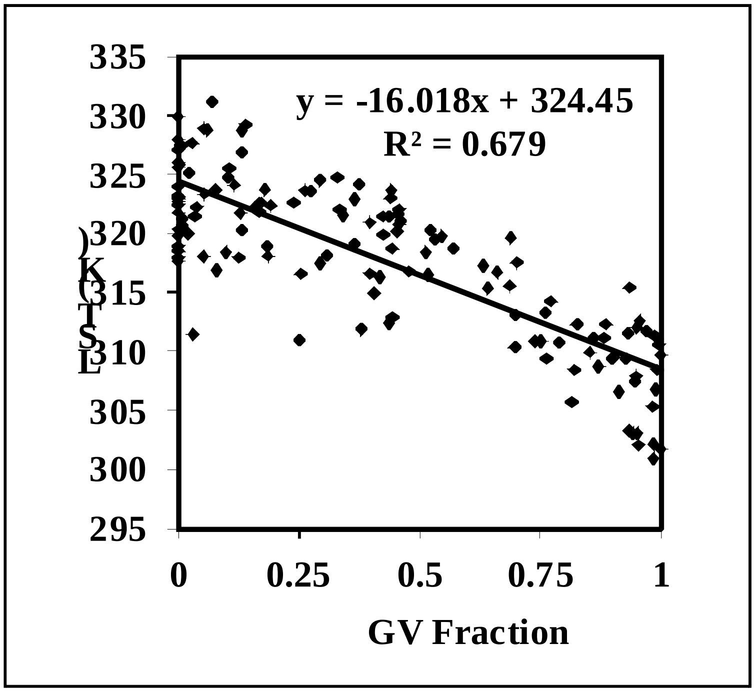

Figure 2) Showing scatter plot between LST (y) and the GV Fraction (x)

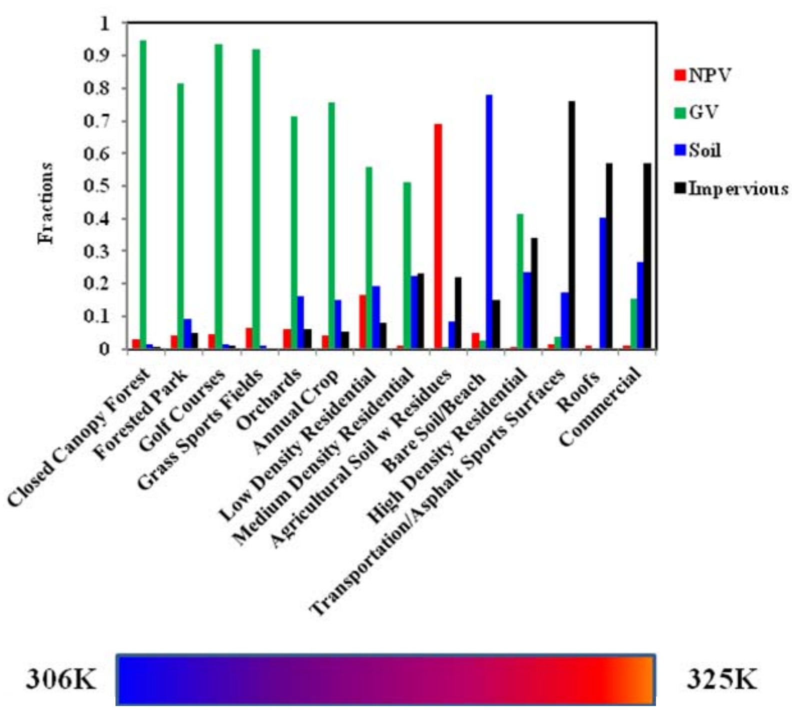

Figure 3) Showing changes in GV, NPV and soil fractions and LST as a function of land-cover class.

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