Combining surface Reflectance and Emissivity for the Assessment of Ecosystem Diversity and Urban Boundaries, at Varying Spectral and Spatial Scales

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Problem: With the increase in the population density and the ever expanding conversion of land from rural to urban, the urban heat island (UHI) effect has become a problem of critical importance. Land cover type and land surface temperature (LST) in urban and rural areas display significant differences, such as higher LST and lower moisture content, with increasing urbanization.

The combination of high spectral resolution optical and thermal infrared imagery of the proposed HyspIRI mission will provide a powerful capability for more precise land cover type discrimination and ecosystem monitoring than is now possible using current satellite systems. This includes better mapping of cover types, aquatic and terrestrial ecosystem identification, vegetation/soil nutrient and moisture content determinations and assessment of ecosystems function and health.

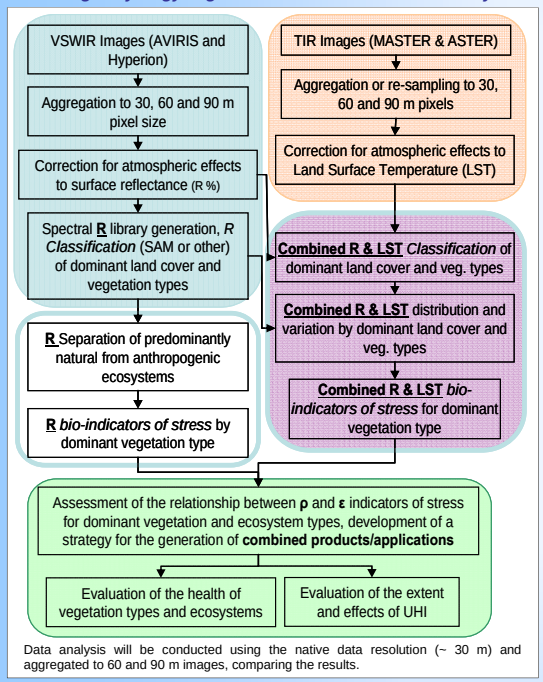
Goal: This investigation explores an approach, which uses VSWIR and TIR measurements together, to assess the differences in natural and anthropogenic ecosystem composition and their vegetation bio-physical parameters, to elucidate how urbanization impacts the environment. We would contribute toward improving the current capabilities for vegetation assessments by seeking common spectral trends associated with vegetation function, induced by natural and anthropogenic factors underplaying the effects of urbanization and UHI.

Science questions: We attempt to answer the following questions:

- How do natural and anthropogenic ecosystem compositions compare with regard to land cover types, diversity, function, and spectral properties?
- How do environmental characteristics associated with natural factors and effects of urban pressure and UHI, affect vegetation composition and function, and ecosystem health?
- How do species, functional type, and biodiversity composition within ecosystems respond spectrally to anthropogenic and non-anthropogenic stressors?
- How do natural ecosystems respond to impinging environmental changes, particularly to urban growth and land cover change and the associated impacts of urbanization?

Methods

Strategy for assessment of vegetation type and function, using in synergy vegetation reflectance and emissivity



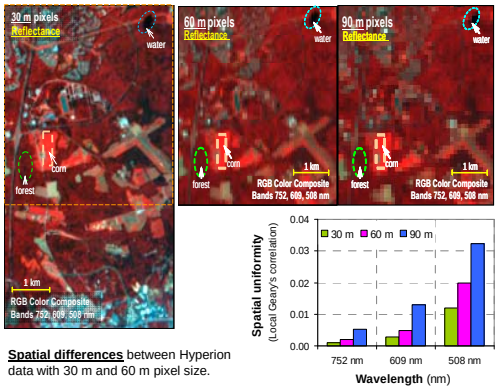
Data analysis will be conducted using the native data resolution (~ 30 m) and aggregated to 60 and 90 m images, comparing the results.

Calibration of TIR and VISWIR data: Lake Tahoe is a high-altitude, large-sized lake on the California-Nevada border near Reno, Nevada. The lake has a very low chlorophyll content, but of greater relevance for this work is the presence of multiple buoy systems that are used for the purpose of radiometric calibration of TIR imagers. The Ivanpah Playa test site is approximately 3 km by 7 km in size with excellent spatial uniformity, hence its use for the vicarious calibration of reflective bands.

Data Availability: These sites were selected for their diverse vegetation cover, proximity to urban centers and because the available AVIRIS and MASTER data are also contemporary (± 2 weeks) with existing EO-1 Hyperion and ASTER imagery. Field surveys, vegetation maps and meteorological data (historic and current) will be available for the project through collaborations with universities and science teams located within the study areas.

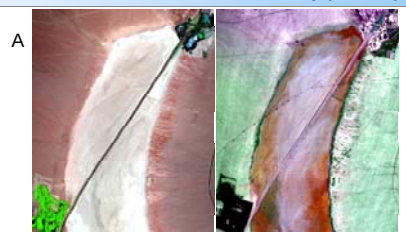
Preliminary Findings

VSWIR Hyperion reflectance data (30 m pixels) and the re-sampled to 60 and 90 m subset

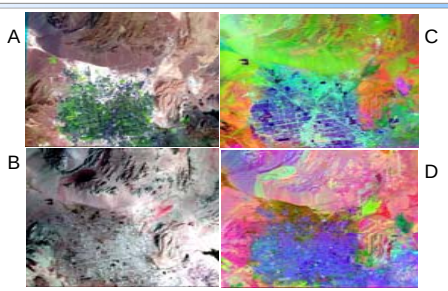


Spatial differences between Hyperion data with 30 m and 60 m pixel size.

MASTER and ASTER Emissivity (R& LST)



MASTER imagery from the Ivanpah test site show three-band color mixes of the reflective bands (A, vegetation in bright green) and the TIR (B). The dominant feature in both images is the dry lake bed with a golf course in the lower left, highway runway diagonally through the image, and a shopping center and casinos in the upper right.



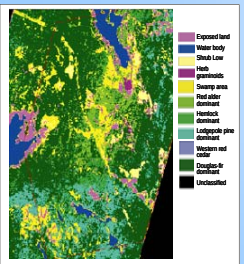
ASTER imagery of Las Vegas area: A. VSWIR is aggregated to 90 m (vegetation in green) and B. TIR bands, C. PCA of reflective bands and D. VSWIR & TIR .

Principal components analysis (PCA) of the MASTER data gave effectively identical results indicating the dominance of the reflective bands in the imagery. It remains to be seen whether the emissive bands alter the classification of the data sets. In both cases the separation between the "desert" and the "lakes" at the golf resort are readily discerned but with differing principal components. TIR data are shown in the lower left. Principal components analysis of the ASTER R & LST data reveals striking differences, with the reflective bands showing roadways as a more significant component than the emissive bands.

Spectral VSWIR parameters: indicators of stress and albedo for major cover types

Pixel	Vegetation Indices:						Albedo		
size	V1	PRI	REIP	Dmax	NDWI	NDVI	water	corn	forest
30 m	1.81	-0.14	721	0.749	0.14	0.81	0.03	0.20	0.14
60 m	1.88	-0.15	721	0.748	0.15	0.82	0.04	0.20	0.13

Study Sites and Data Collections

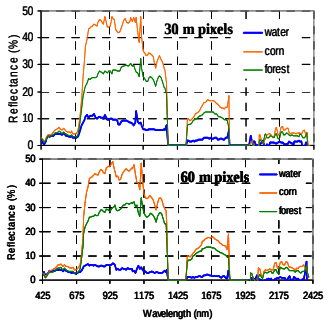


Hyperion land cover classification of the Greater Victoria Watershed (GVWD) test site on Vancouver Island (September 10 2001, Goodenough et al. 2003).

The study includes two independent locations with different regional climates and ecosystem types, and also sites for TIR and VSWIR data calibration.

Vancouver Island, Canada/Hoquiam, WA: includes portions of unique natural ecosystems such as the Olympic National Park, WA and the Great Victoria Watershed (GVWD) test site on Vancouver Island, BC and rural, sub-urban and urban environment associated with the city of Victoria, BC.

Jasper Ridge Biological Preserve, CA (JRBP): provides Mediterranean-type climate, with five major vegetation types: evergreen forest, deciduous forest, chaparral shrublands, herbaceous perennial wetlands, and annual grasslands.



While there were significant differences in the spatial variability between the original 30 m and the aggregated to 60 and 90 m data, the spectral properties of the major land cover types did not significantly differ.

Spectral differences between high spectral resolution data with 30 m and 60 m pixel size.

Anticipated Outcome and Implications

By fusion of spectroscopy and thermal remote sensing, this study will assess the potential of HyspIRI-like data for delineating land covers and vegetation types, discriminating natural versus urban ecosystems, and assessing ecosystems diversity and health.

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