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

Petya K. E. Campbell*, **, Alexandra Anderson-Frey☺ and Kurtis J. Thome**

** Joint Center for Earth Systems Technology (JCET), University of Maryland Baltimore County; ** NASA Goddard Space Flight Center ☺Atmospheric Science, McGill University, Montreal, QC, Canada*

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 species, functional type, and biodiversity composition within ecosystems respond spectrally to anthropogenic and non-anthropogenic stressors?**
- **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?**

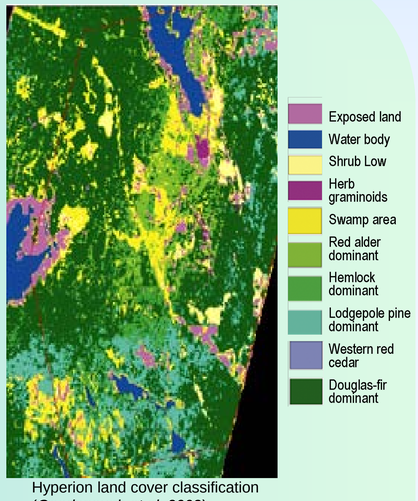
Methods

Study Sites

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 shrubland, herbaceous perennial wetlands, and annual grasslands.

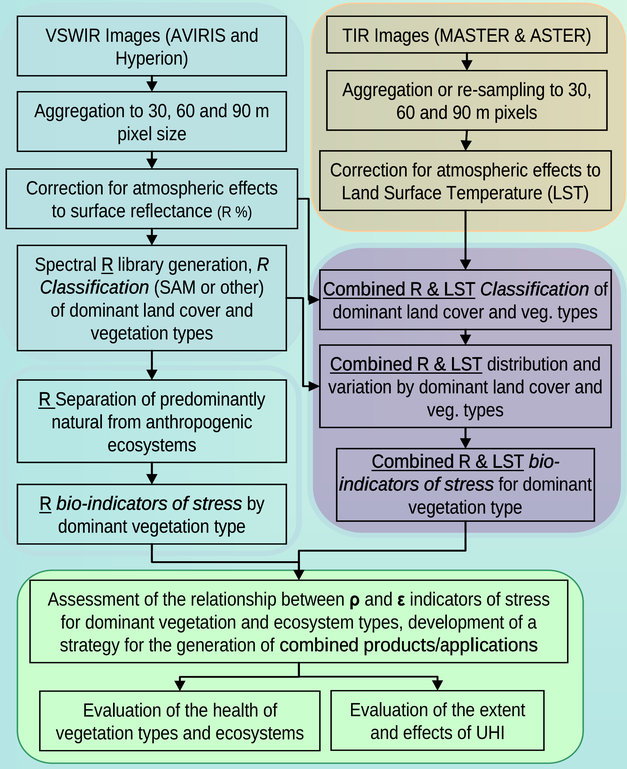


Hyperion land cover classification (*Goodenough et al. 2003*)

Data Characteristics and Sources

Parameters	HyspIRI VSWIR	AVIRIS	MASTER
Spectral range	0.38 - 2.5 µm	0.4 - 2.5 µm	0.4 - 13 µm, 50 bands
Band width	10 nm	10 nm	0.05 µm (0.45-2.39 µm)
Number of bands	~ 220	224	0.15 µm (3.15-5.27 µm)
Spectral Coverage	contiguous	contiguous	0.4-0.8 µm (7.75-12.87 µm)
Spatial resolution	60 m	20 m	50 m
Swath width / FOV	145 km	11 km	85.92°

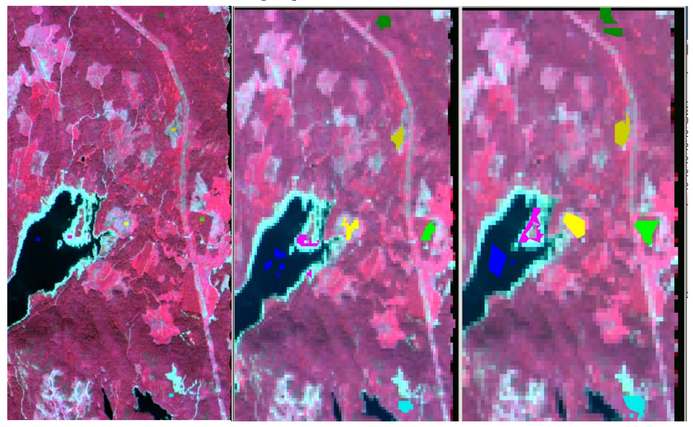
Strategy for assessment of vegetation type and function, using in synergy vegetation reflectance and emissivity



Data analysis are conducted using the native data resolution and aggregated to 60 and 90 m images, comparing the results for the same locations.

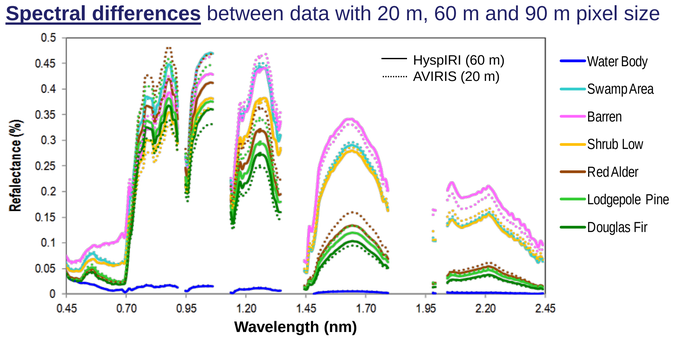
Preliminary Findings

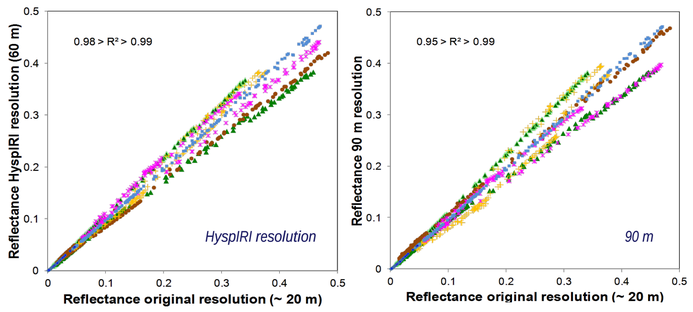
HyspIRI VSWIR



AVIRIS images (20 m pixels) was re-sampled to 60 m and 90 m and calibrated to reflectance

Spectral differences between data with 20 m, 60 m and 90 m pixel size

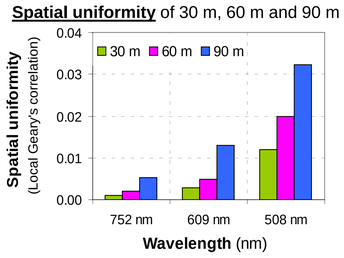




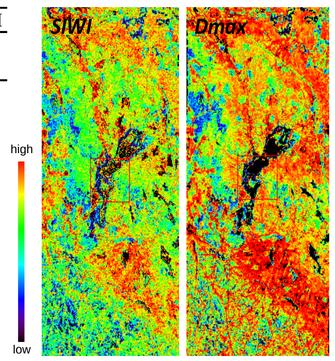
The spectral properties of the major species and land cover types did not significantly differ, comparing the original resolution to the 60 m and the 90 m images

Pixel size	Vegetation Indices: V1	PRI	REIP	Dmax	NDWI	NDVI
30 m	1.81	-0.14	721	0.749	0.14	0.81
60 m	1.88	-0.15	721	0.748	0.15	0.82

Spatial uniformity of 30 m, 60 m and 90 m data

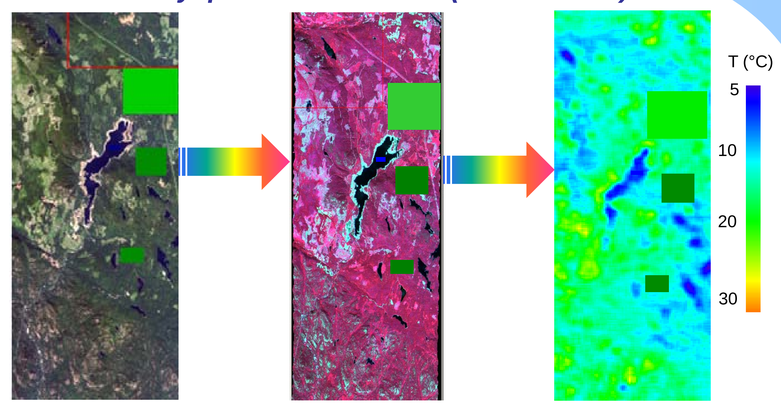


Indicators of plant function (60 m)



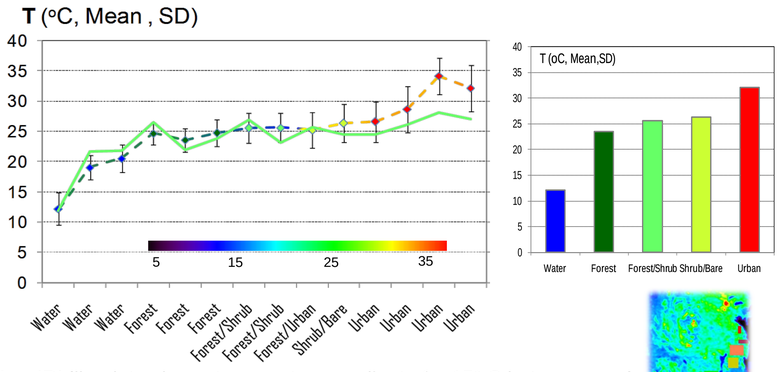
While there were significant differences in the spatial variability between the original 20 m and the aggregated to 60 and 90 m data, the spectral properties of the major land cover types did not significantly differ.

HyspIRI VISWIR & TIR (60m R& LST)

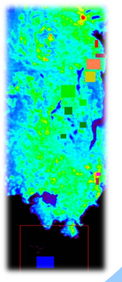


MASTER imagery from the Ivanpah test site show three-band color mixes of the reflective bands (A, vegetation in bright green) and the TIR (B). The dominant feature in both images is the dry lake bed with a golf course in the lower left, highway runway diagonally through the image, and a shopping center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

T (°C, Mean , SD)



HyspIRI-like data shows temperature gradient of ~ 15º C between rural and urban areas in British Columbia.



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.

Future Work and Anticipated Results

The data simulation and processing have already made one important contribution - they have laid the groundwork for the tools and methodologies necessary for use with the actual HyspIRI data.

Now that HyspIRI-like data have been generated, the next step is to examine the data in more depth and compare findings between the two study sites – British Columbia, Canada and Jasper ridge, California, in order to improve our understanding of the satellite's capabilities. By examining the HyspIRI-like spectra over different land surfaces, for instance, we will test VSWIR/TIR bio-indicators of ecosystem health. In addition, this HyspIRI-like data will be classified using known landcover types, creating a spectral database of ecosystem and vegetation types that can be used for identification purposes once the satellite becomes operational.

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.

Petya.Campbell@nasa.gov