Climate Change and Examples of Combined HyspIRI VSWIR/TIR Advanced Level Products for Urban Ecosystems Analysis

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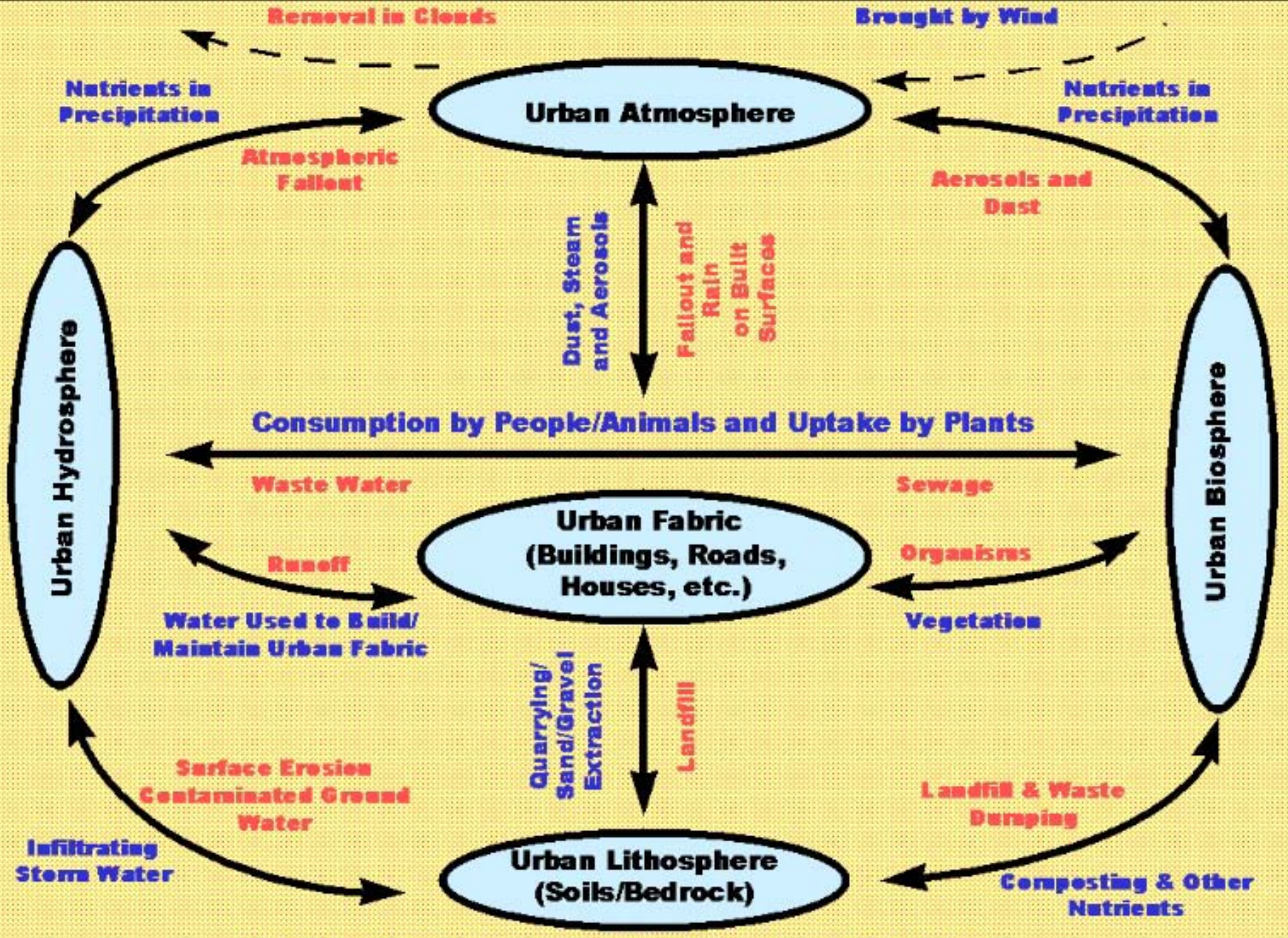
- **The 21st century is the first urban century in the history of humankind**
- **Current projections are suggest that 60-80% of the world population will live in urban settlements by the end of this century**
- **Across the globe, more than 411 cities have more than one million inhabitants**
- **In the 1970's the United Nations defined cities of 10 milliion or more residents as "megacities"**
- **In 1975 there were five megacities around the world**
- **Today there are 19+, and by 2015 the number of megacities is expected to grow to 23**



URBAN ECOSYSTEM CYCLES

(Revised from Douglas, 1983, P. 68)

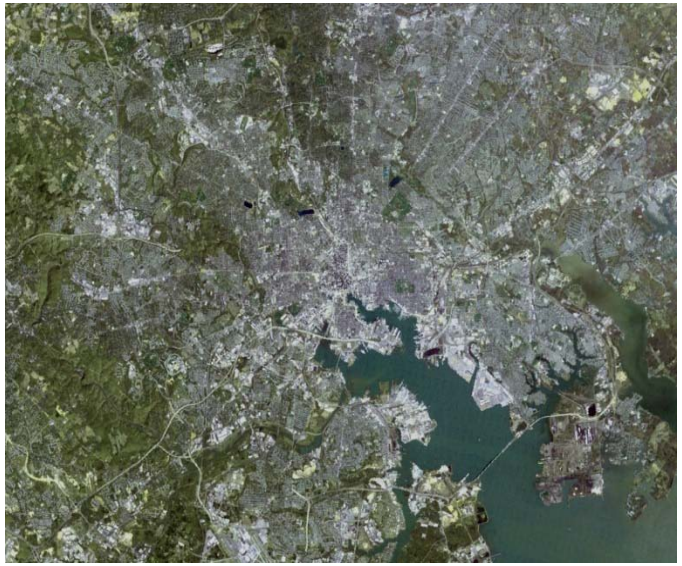
- **Because urbanization is growing so rapidly around the world, the total urban ecosystem is changing dramatically**

- **The urban ecosystem is extremely complex and consists of a number of intertwined and interacting systems**

- **Because of their complexity, the processes and flows into and out of the urban ecosystem are best studied as separate entities**

- **Remote sensing in conjunction with ancillary or *in situ* data can be used to observe, monitor, measure, and model many of the components that comprise urban ecosystems cycles**

- **In particular, remote sensing can be used to observe, quantify and model changes in land surface characteristics within the city (e.g., land covers, NDVI, surface thermal radiance)**



Landsat

ASTER

MODIS

- The satellites that have been principally used to date, to provide data on urban ecosystems, however, have limited capabilities

- Some general limitations are:

- MODIS – 250m-1km spatial resolution
- ASTER – 90m spatial resolution in TIR; data acquisition must be tasked
- Landsat – Non-hyperspectral; revisit time not optimal, especially for TIR data collection over urban areas
- EO-1 – very small swath width

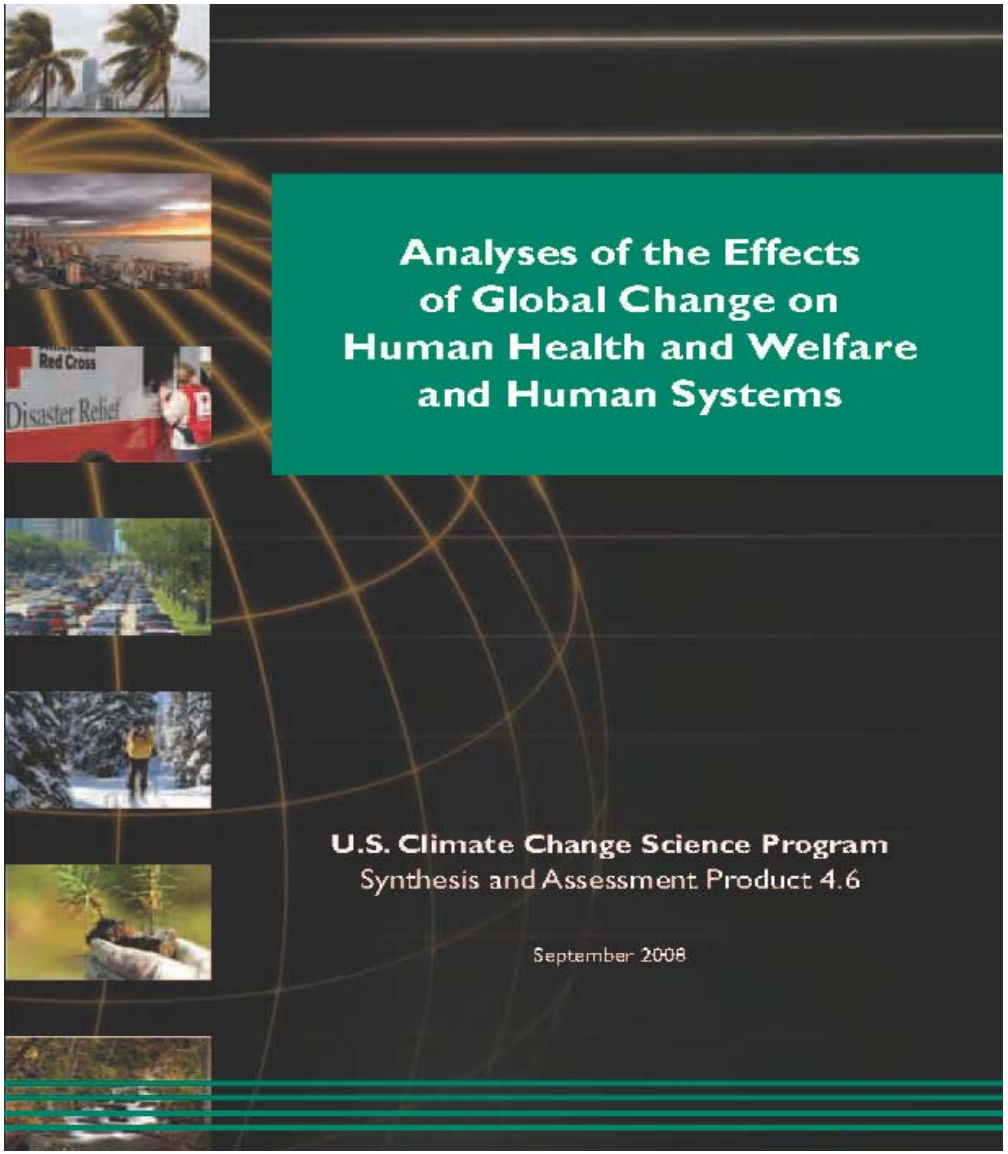
- None of these sensors is “truly” hyperspectral in the same ‘vain’ as AVIRIS for example

- HyspIRI's spectral, spatial and orbit characteristics will make HyspIRI very attractive for producing advanced image/data products that can provide more precise and accurate data on various aspects of the urban ecosystem for use in analysis and modeling by scientists and decision makers

Decadal Survey – Chapter 6 – Human Health and Security

(Concerns about the use of Landsat and ASTER and their deficiencies in regard to measuring the urban heat island effect as a cycle within the urban ecosystem)

"They allow surface vegetation and temperature to be mapped down to the scale of cities, towns, and agricultural fields and forest patches (i.e., 1km), revealing important relationships between heat and land use. Unfortunately, these satellite/sensor systems have poor return times, typically 18 days or more, limiting their usefulness for monitoring"..."Heat stress (on biophysical systems and humans) may begin to climb within just a few days after the start of extreme conditions"


Red Cross
Disaster Relief
Analyses of the Effects of Global Change on Human Health and Welfare and Human Systems
U.S. Climate Change Science Program
Synthesis and Assessment Product 4.6
September 2008

Climate Change Impacts on Urban Ecosystems

(From U.S. Climate Change Science Program, Synthesis and Assessment Product 4.6 - “Analysis of the Effects of Global Change on Human Health and Welfare and Human Systems”)

Effects on Urban Metabolism:

- Climate change will impact a host of inputs, transformations, and outputs such as heat, and energy and many other inputs and outputs from the urban ecosystem

- An example is the Urban Heat Island (UHI) effect that is expected to greatly increase over cities as a function of urban growth and increased solar radiation and warmer surface temperatures

IN EFFECT, CLIMATE CHANGE WILL BASICALLY IMPACT THE ENTIRE URBAN ECOSYSTEM

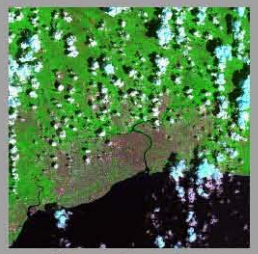
Inter-Urban Variability

1999 - 2001 Landsat ETM+

30 x 30 km

Small, 2002

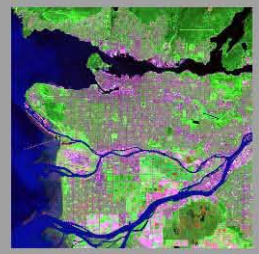

Shanghai


Santo Domingo

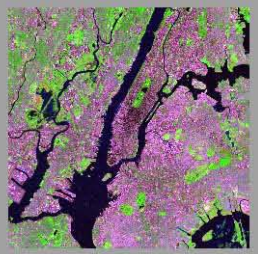

St. Petersburg


Taipei


Tianjin

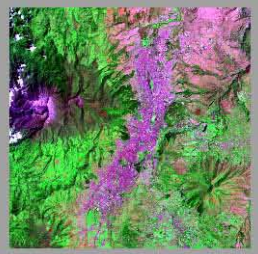

Vancouver

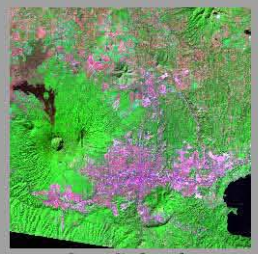

Vienna


New York


Port au Prince

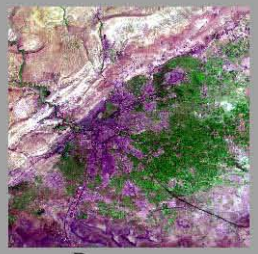

Pyongyang


Quito


San Salvador

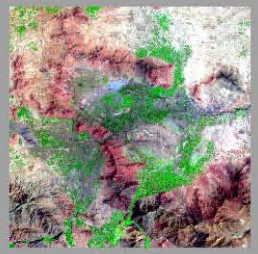

Sao Paulo

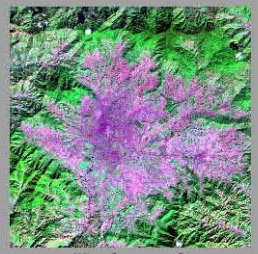

San Francisco

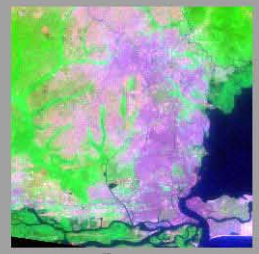

Damascus


Guangzhou

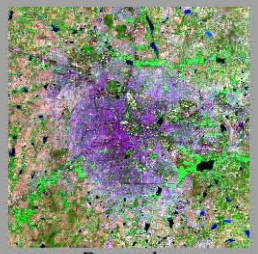

Hanoi


Kabul


Kathmandu


Lagos


Miami

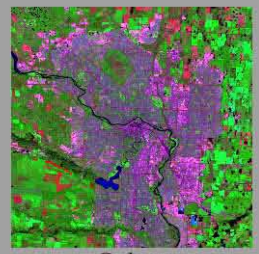

Bangalore


Beirut


Budapest


Cairo


Calcutta


Calgary


Chicago

Reflectance Spectra

Manmade materials

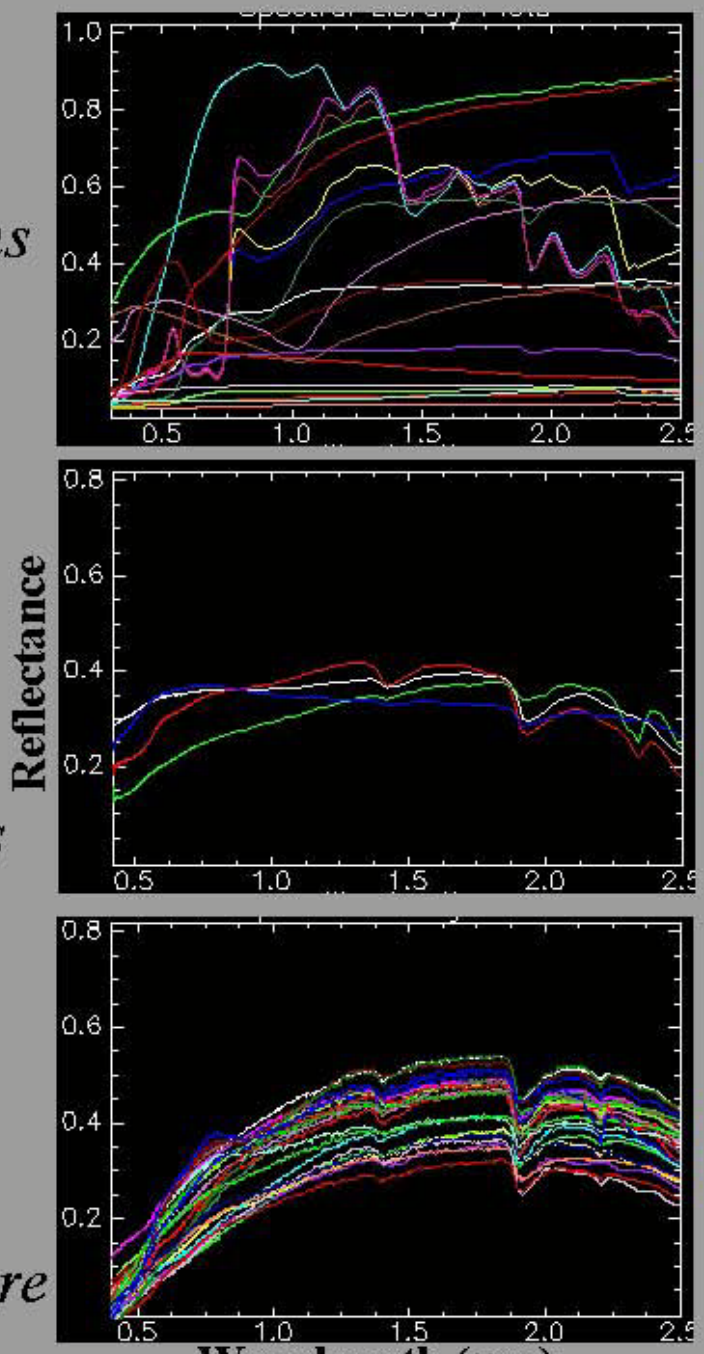
Diverse w/ characteristic absorbtions
Highly variable albedo
Rarely areally extensive

Concrete

Areally extensive
Few characteristic absorbtions
Compositionally similar to some soils

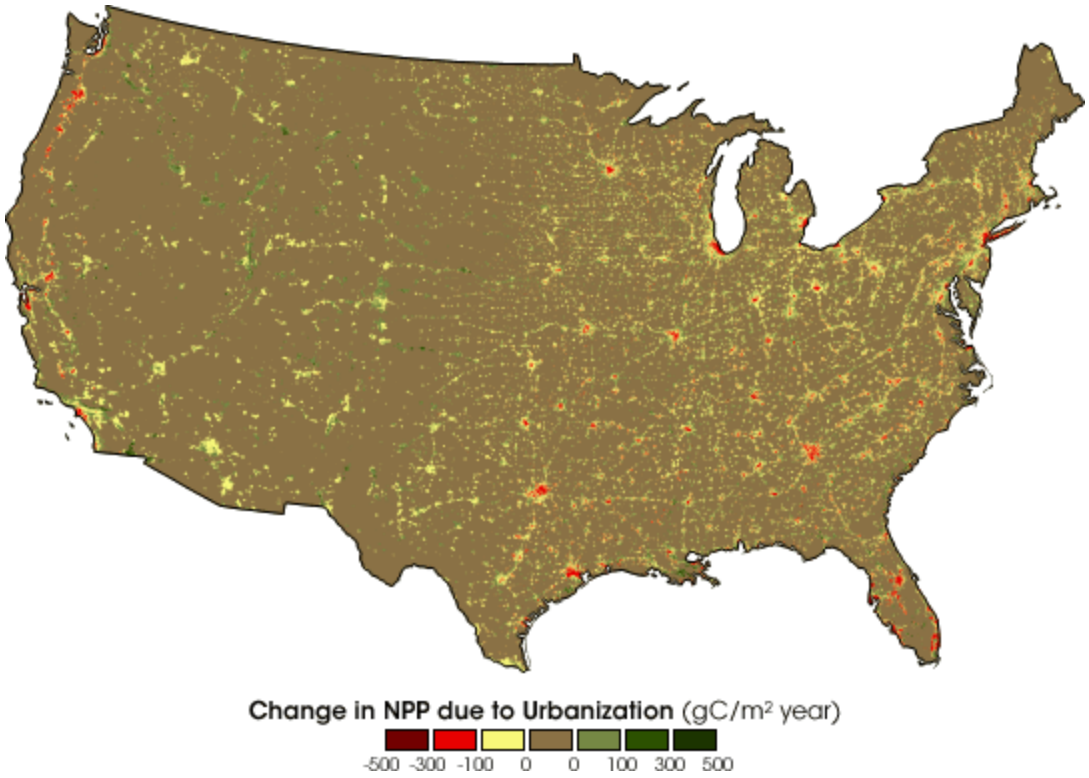
Soils

Subtle absorbtions
Similar shape w/ variable albedo
Albedo strongly dependent on moisture



Small, 2002

U.S. Urbanization



- Total Impervious Surface Area of Continental U.S. is 112,610 km^2 (Slightly smaller than the state of Ohio)

Source: *EOS*, June 2004

The V-I-S Model

Proposed by Ridd (1995)

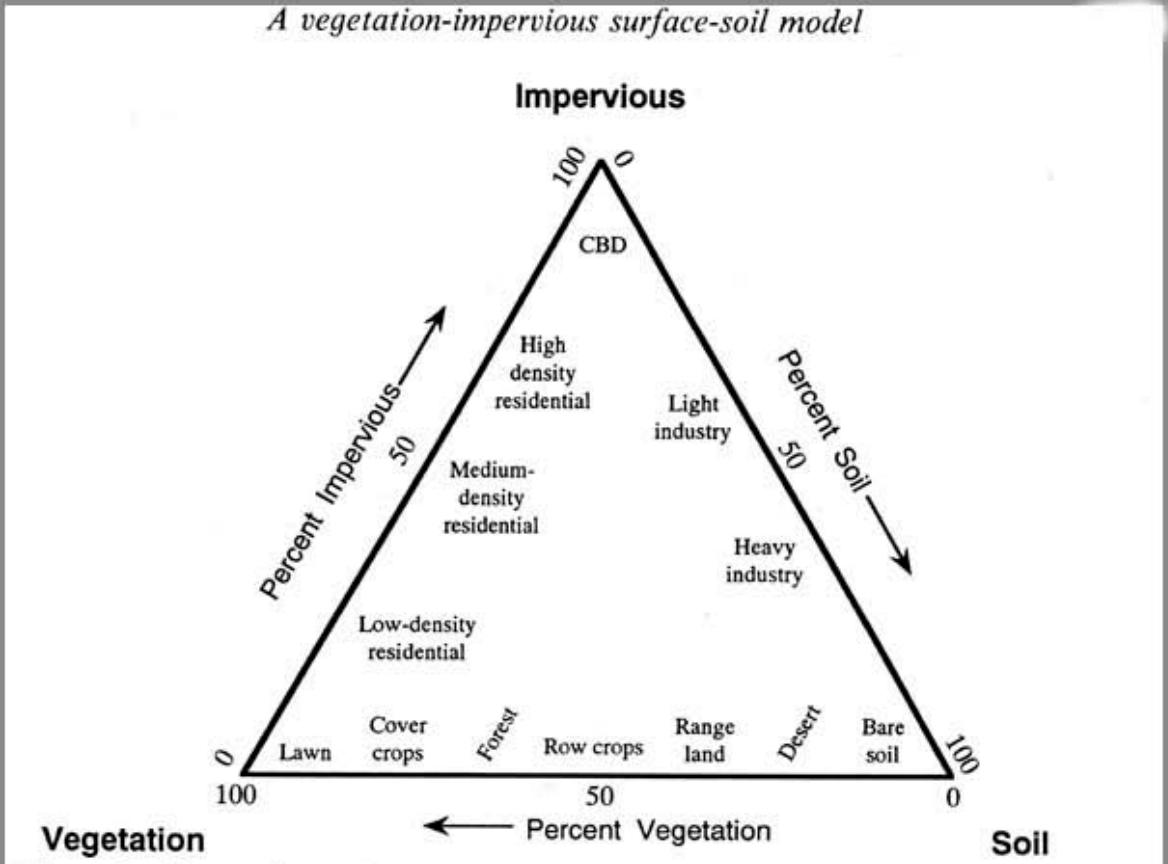


Figure 6. Some urban and near-urban features placed in the ternary V-I-S model.

Small, 2002

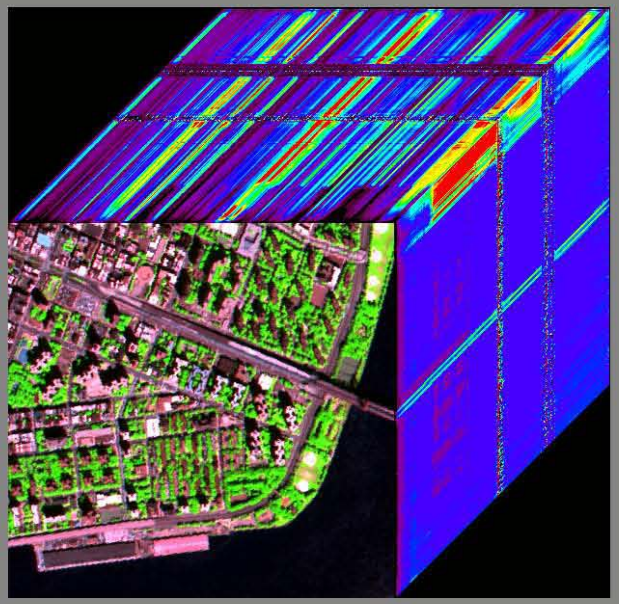
- Using the VIS model for classification of optical imagery is problematic because **Impervious surfaces and Soils often have indistinguishable reflectances**.
- A variety of approaches (*Unsupervised, Maximum Likelihood, Decision Tree, Expert System classifications, Spectral Mixture Analysis*) result in wide range of accuracies (44% to 94%).
- Highest accuracies are associated with moderate sized settlements in densely vegetated areas.

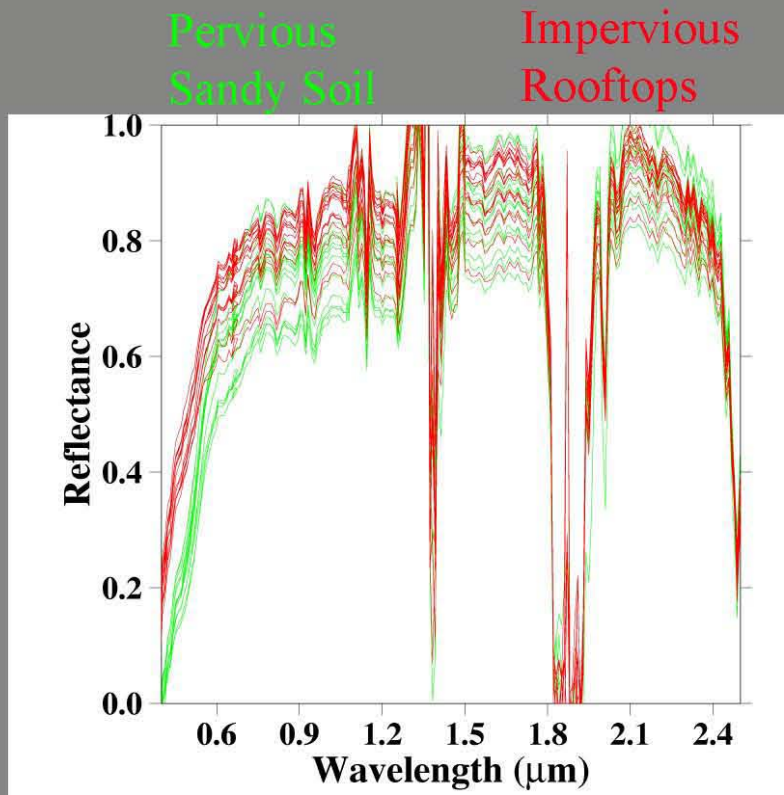
Spectral Resolution

Many pervious and impervious surfaces are compositionally similar and therefore have similar spectral properties.

Even with high spatial and spectral resolution, considerable spectral ambiguity still exists.

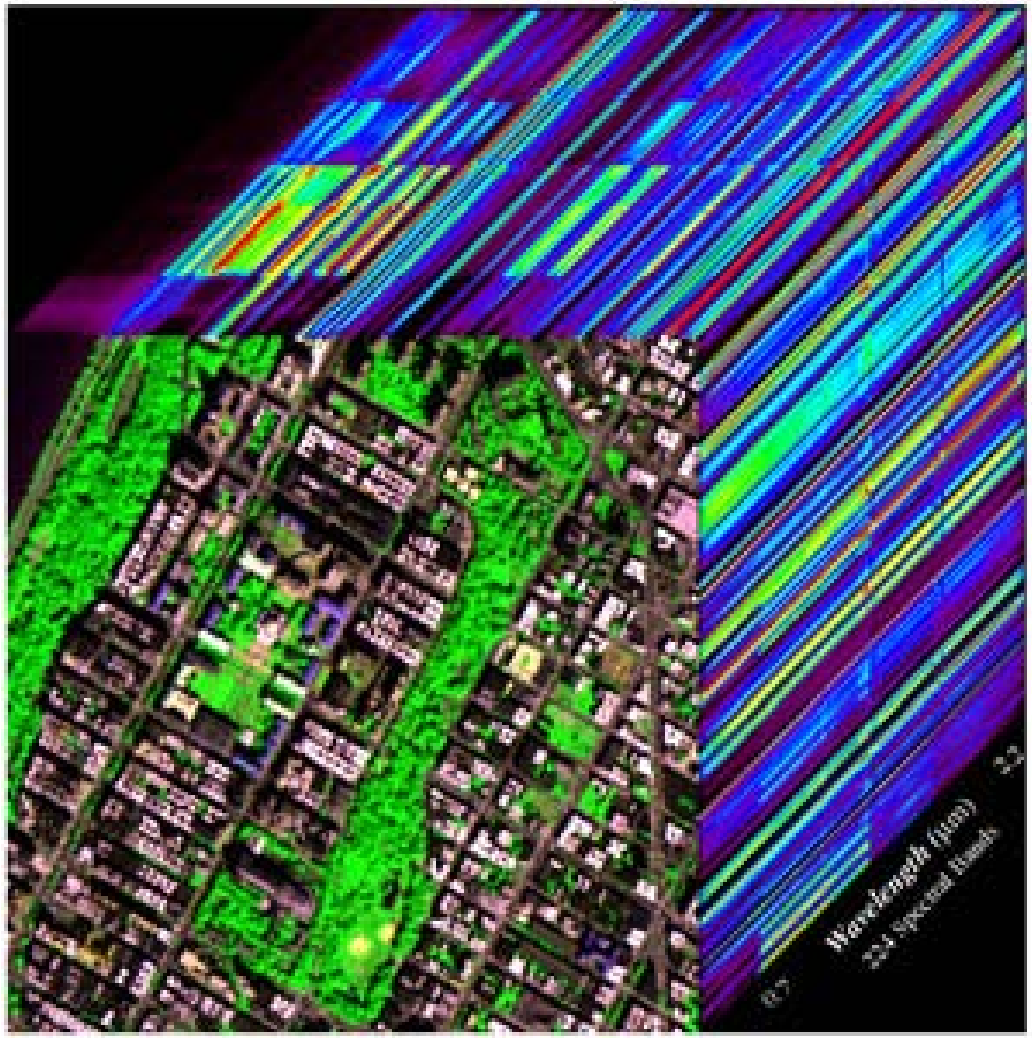
AVIRIS NYC 9/16/2001 4m

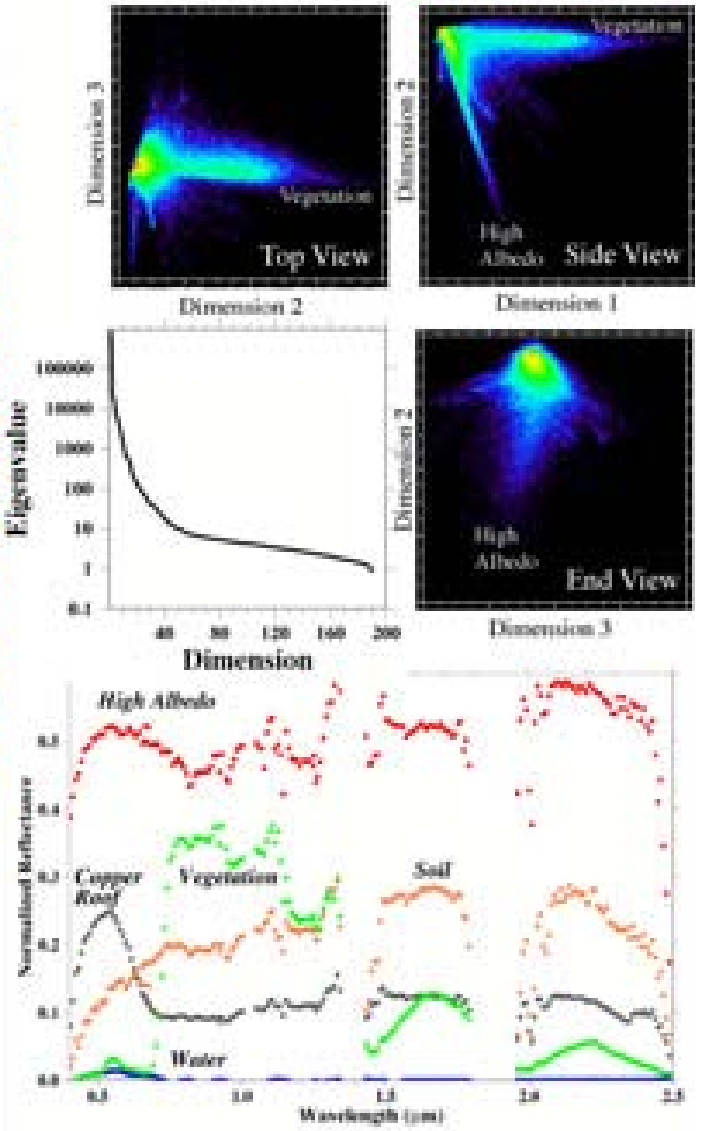




Small, 2002

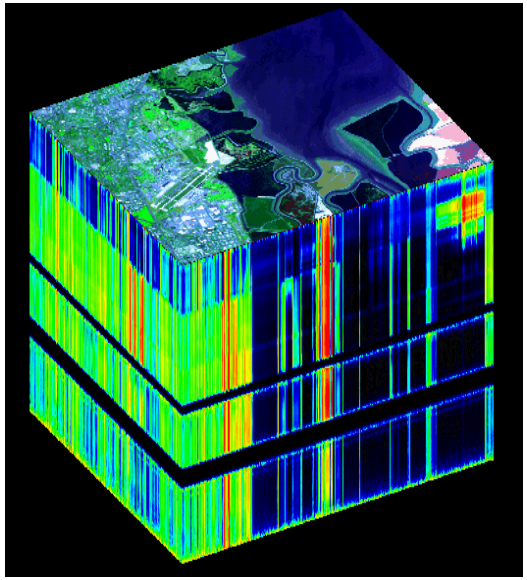
AVIRIS 4 meter Manhattan 16 September, 2001





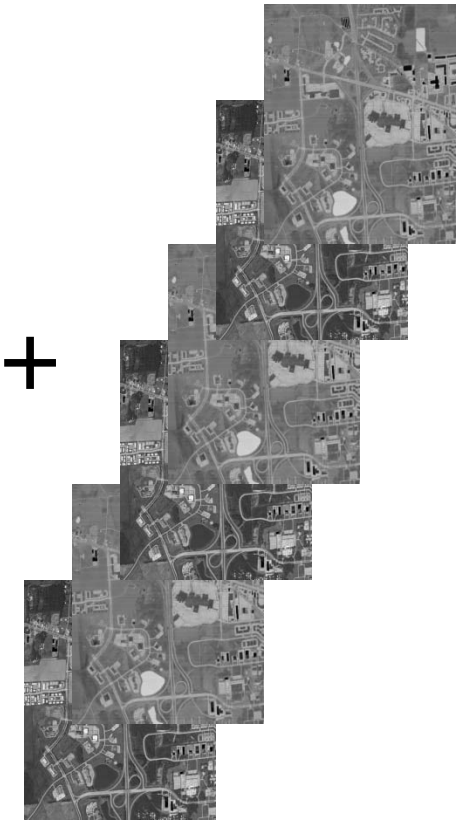
Small, 2002

HyspIRI Combined Composite Data Set Advanced Product for Urban Ecosystems Analysis



HyspIRI Hyperspectral VSWIR Level II Product
(NDVI, fPAR, surface reflectance characteristics)

+



HyspIRI TIR multispectral Level II product (8 TIR Bands)
(surface temperature, radiance, [day/night], emissivity)

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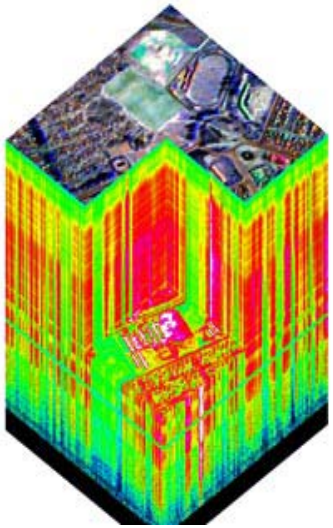
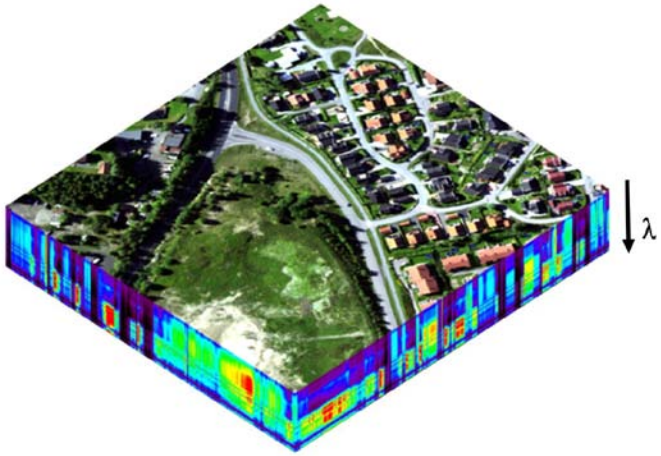


HyspIRI VSWIR/TIR composite data set
(quantitative integrative measurement of urban surface reflectances, temperatures, and emissivity across the urban ecosystem)

HyspIRI Combined Composite Land Use Change Advanced Product for Urban Ecosystems Analysis

Through Time



HyspIRI Hyperspectral VSWIR Level II Product
(NDVI, fPAR, surface reflectance characteristics)

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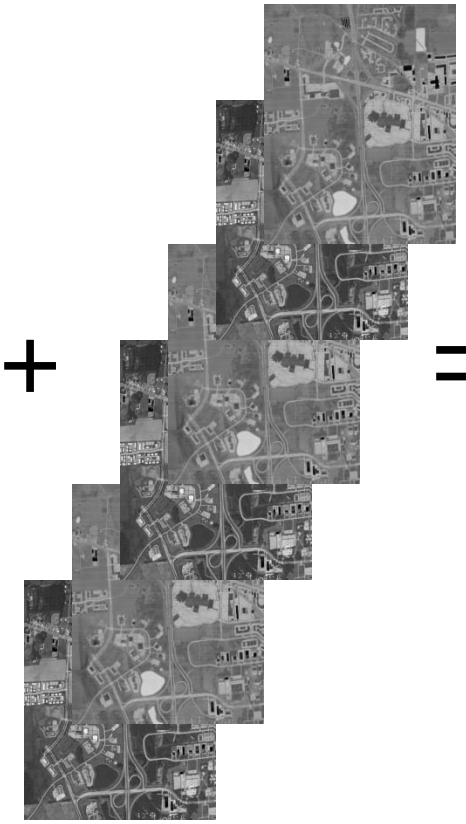

HyspIRI TIR multispectral Level II product (8 TIR Bands)
(surface temperature, radiance, [day/night], emissivity)

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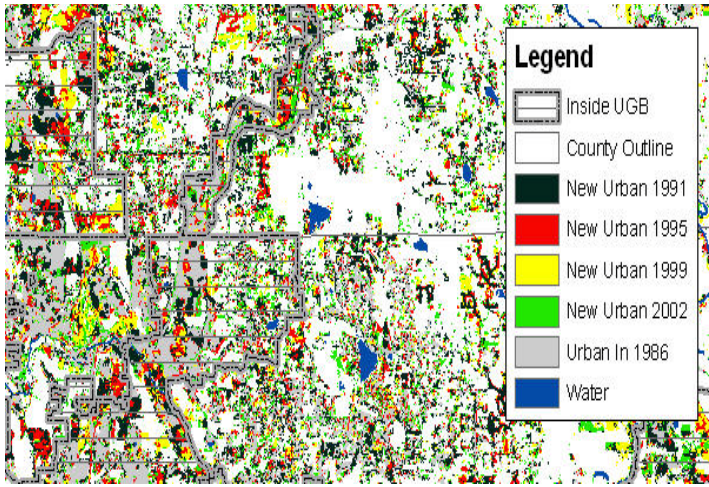
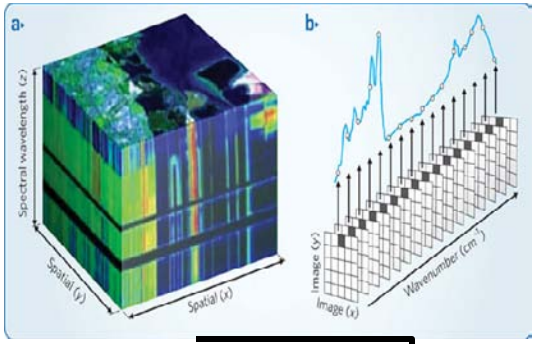
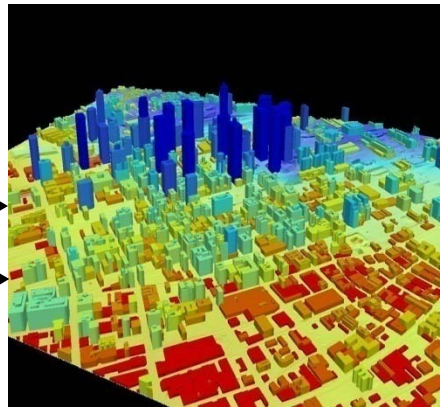


HyspIRI VSWIR/TIR composite land cover change data set
(quantitative integrative measurement of urban surface reflectances, temperatures, and emissivity across the urban ecosystem as they change through time)

HyspIRI Combined "Integrated" Advanced Product for Urban Ecosystems Analysis



HyspIRI Hyperspectral VSWIR Level II Product
(NDVI, fPAR, surface reflectance characteristics)



Lidar Data

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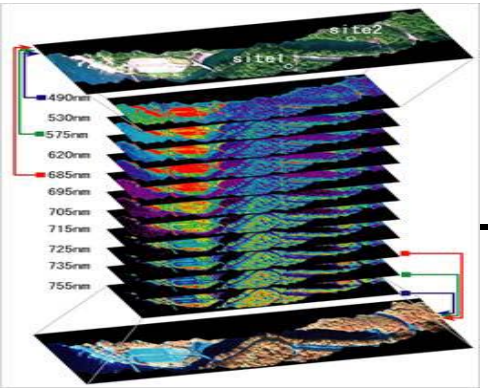
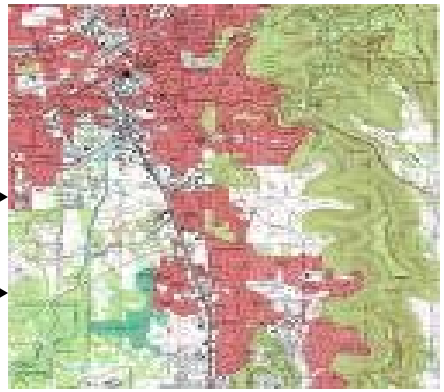
HyspIRI VSWIR/TIR and Lidar composite data set
(X, y, z surface reflectance/thermal interactions of urban ecosystem processes)

HyspIRI TIR multispectral Level II product (8 TIR Bands)
(surface temperature, radiance, [day/night], emissivity)

HyspIRI Combined “Integrated” Topographic Advanced Product for Urban Ecosystems Analysis



Hyperspectral VSWIR Level II Product (NDVI, fPAR, surface reflectance characteristics)



Digital Topographic Data (DEM)

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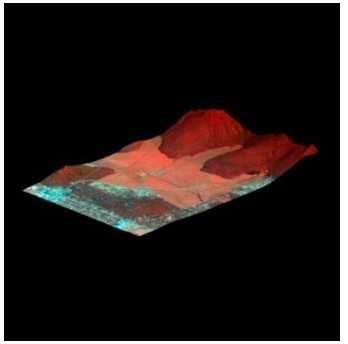

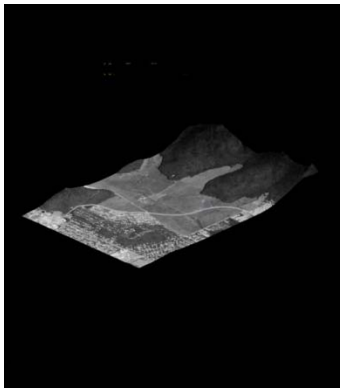

HyspIRI VSWIR/TIR and DEM composite data set

(hyperspctral/day/night TIR digital elevation model data sets))

HyspIRI TIR multispectral Level II product (8 TIR Bands) (surface temperature, radiance, [day/night], emissivity)