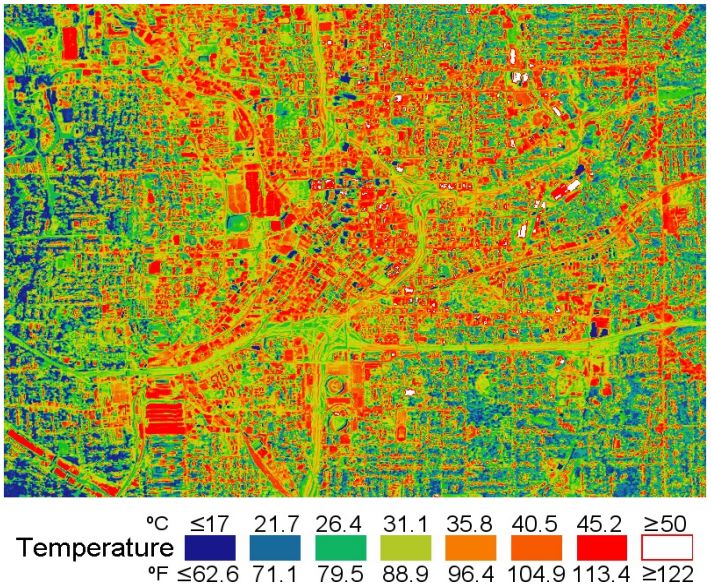
TQ4. Human Health and Urbanization

How does urbanization affect the local, regional, and global environment? Can we characterize this effect to help mitigate its impact and welfare?

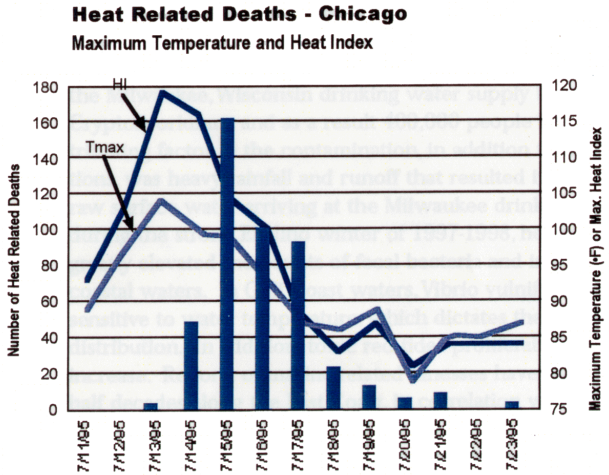
TQ4: Sub-Questions

- **How do changes in land cover and land use affect surface energy balance and the sustainability and productivity of natural and human ecosystems?**
- **What are the dynamics, magnitude, and spatial form of the urban heat island effect (UHI), how does it change from city to city, what are its temporal, diurnal, and nocturnal characteristics, and what are the regional impacts of the UHI on biophysical, climatic, and environmental processes?**
- **How can the characteristics associated with environmentally related health effects, such as factors influencing heat stress on humans and surface temperatures that affect vector-borne and animal-borne diseases, be better resolved and measured?**
- **How do horizontal and temporal scales of variation in heat flux and mixing relate to human health, human ecosystems, and urbanization?**

TQ4: How does urbanization affect the local, regional, and global environment? Can we characterize this effect to help mitigate its impact and welfare?



Daytime thermal image of Atlanta, GA



This graph tracks maximum temperature, heat index, and heat-related deaths in Chicago each day from July 11 to 23, 1995. The gray line shows maximum daily temperature, the blue line shows the heat index, and the bars indicate number of deaths for the day.

Science Issue:

•Urban areas are considerably warmer than their rural counterparts and this phenomenon is known as the urban heat island (UHI) effect. Although it is known to exist globally, we do not know how it changes based on urban landscape morphology or in different climatic regimes around the world. HyspIRI data can provide significant improvement in measuring and evaluating the UHI and associated impacts on human health and

Tools:

•Satellite observations for measurement of surface temperature, energy balance, energy fluxes, emissivity with global coverage

•Integration of satellite data with physical and quantitative models to better characterize UHI effects on humans

Approach:

•Use HyspIRI high spatial resolution, multi-temporal and multispectral thermal IR data to observe and measure the UHI for cities around the world in differing climatic regions

•Use HyspIRI data in conjunction with *in* situ and modeled data to track and assess the impacts of the UHI on human well-being, such as heat stress

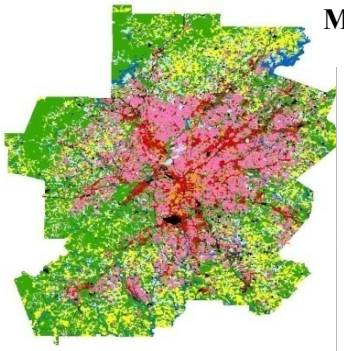
Results:

Changes in the growth of urban areas and the corresponding dynamics of the UHI can be observed and tracked with HyspIRI data on a regular basis and at a high spatial resolution on a global scale. HyspIRI multispectral thermal data can provide multi-temporal measurements of urban surface temperature fluxes, albedo, and emissivity for calculation of global urban surface energy balance characteristics. HyspIRI data in conjunction with *in situ* and other data can be used to evaluate the impacts of the UHI on human well-being and welfare.

TQ4a: How do changes in land cover and land use affect surface energy balance and the sustainability and productivity of natural and human ecosystems? (DS 160-161, 166-167, 198)

1999

Projected land use change for the Atlanta Metropolitan area – 1999-2030



2030

- **Low Density Residential**
- **Med. Density Residential**
- **High Density Residential**
- **Commercial/Services**
- **Institutional**
- **TCU**
- **Industrial/Commercial**
- **Water**
- **Crops/Pasture**
- **Row Crops**
- **Deciduous Forest**
- **Evergreen Forest**
- **Mixed Forest**
- **Woody Wetlands**
- **Quarries/Mines/Gravel Pits**
- **Transitional**

Satellite and aircraft data were used in conjunction with a spatial growth model to project land use/land cover change for the Atlanta metropolitan area from 1999 to 2030. Inputs to the model are current land use and current and projected population, employment, and road networks.

Science Issue:

•Changes in land cover and land use have profound affects on the environment and on surface energy balances. HyspIRI data can provide significant improvement in measuring and evaluating these changes and their subsequent impacts on the sustainability and productivity of natural and human ecosystems be measured.

Tools:

•Satellite observations for measurement of surface temperature, energy balance, energy fluxes, emissivity with global coverage

•Integration of satellite data with physical and quantitative models to characterize affects that land cover/land use changes have on natural and human ecosystems

•*In situ* surface temperature measurements to validate satellite and modeled data

Approach:

•Use HyspIRI high spatial resolution, multi-temporal and multispectral thermal IR data to track energy balance and energy flux characteristics for changing land covers/land uses through time to provide synoptic view of impacts on surface energy fluxes, emissivity, and temperature

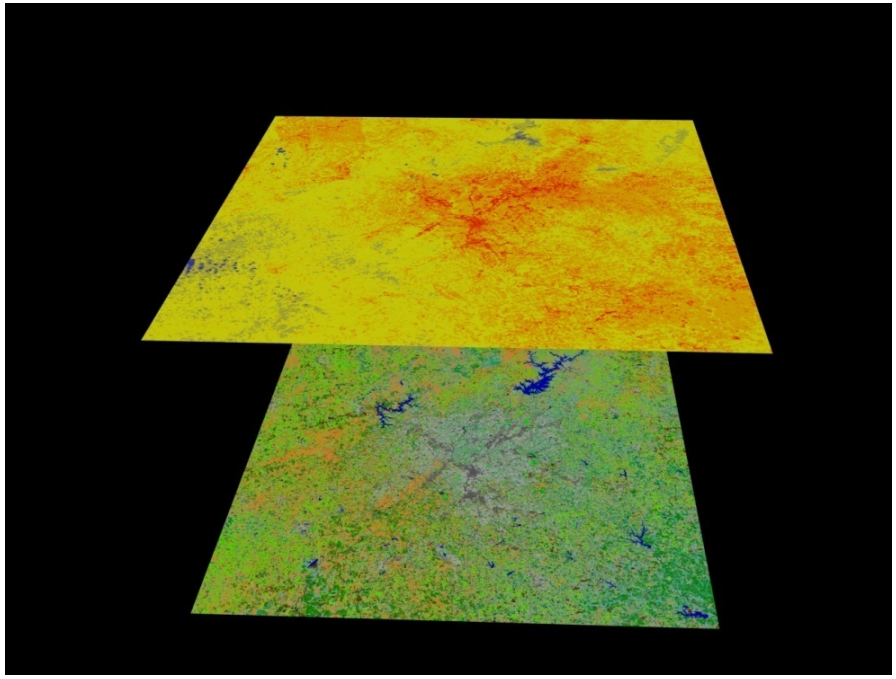
•Use HyspIRI data in conjunction with spatial growth models to project land cover/land use changes in the future to assess impacts on natural and human ecosystems.

Results:

Changes in land covers/land uses can be observed and tracked with HyspIRI data on a regular basis and at a high spatial resolution on a global scale. HyspIRI multispectral thermal data can provide multi-temporal measurements of surface temperature and emissivity for calculation of surface energy balance characteristics. Using HyspIRI data in conjunction with *in situ* and other data, models can be developed to assess the impact of land cover/land use changes on the sustainability and productivity of natural and human ecosystems.

TQ4b: What are the dynamics, magnitude, and spatial form of the urban heat island effect (UHI), how does it change from city to city, what are its temporal, diurnal, and nocturnal characteristics, and what are the regional impacts of the UHI on biophysical, climatic, and environmental processes? (DS 158, 166-168)

Landsat ETM+ images of the Atlanta, Georgia metropolitan area and elevated surface temperatures related to urbanization



The Atlanta urbanized area is shown in gray on the bottom image. The top image shows increased surface temperatures for the corresponding urbanized area as derived from the Landsat thermal band

Science Issue:

•The UHI is a well-known effect, but there are inadequate measurements of its diurnal, temporal, and nocturnal characteristics as they vary from city to city around the globe. HyspIRI measurements can be used to collect more in-depth data on the UHI and help assess what its impacts are on biophysical, climatic, and environmental processes for urban areas around the world.

Tools:

•Satellite observations for measurement of urban surface temperature spatial extent for different sizes of cities and in different geographic and climatic domains around the globe

•Daytime and nighttime satellite thermal measurement of urban surface to assess fluxes attributable to the UHI

•Seasonal observations of urban surface temperatures to evaluate impacts on variations in the UHI

•Integration of urban surface temperatures derived from to generate global UHI models for cities around the globe

Approach:

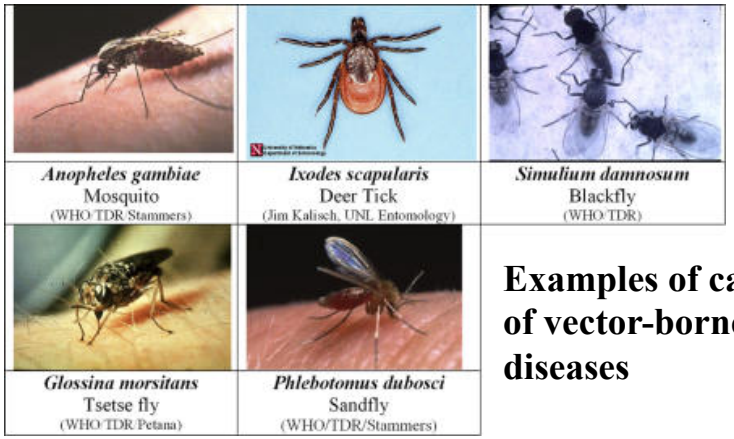
•Use HyspIRI TIR data to evaluate the size, form, and dynamics of the UHI for cities around the world to better understand how the UHI varies in different climatic zones and geographic locales globally

•Use high spatial/temporal resolution, multispectral thermal HyspIRI data to measure and model the effects of the UHI on global biophysical, climatic, and environmental processes

Results:

The UHI has been attributed to excess deaths during heat waves on days with higher-than-average temperatures. Current satellite systems do not have adequate revisit times or multiple thermal spectral bands to provide the information to model UHI dynamics and its impact on humans and adjacent environments. HyspIRI will have a return time, spectral characteristics and nighttime viewing to greatly enhance our knowledge of UHI thermal characteristics around the world.

TQ4c: How can characteristics associated with environmentally-related health effects, such as factors influencing heat stress on humans and surface temperatures that affect vector-borne and animal-borne diseases be better resolved and measured? (DS 156, 158, 160, 183-184)



Examples of carriers of vector-borne diseases

Science Issue:

•Space-based measurements of factors related to vector- and animal-borne diseases have been useful for risk management decision making by health professionals. More detailed satellite data such as that to be provided by HyspIRI, are needed to further develop better risk assessments and disease and health hazard risk maps.

Tools:

•Satellite observations for global measurement of surface temperature and surface water/wetness

•*In* situ observations and measurements of disease vectors and conditions for vector propagation and growth

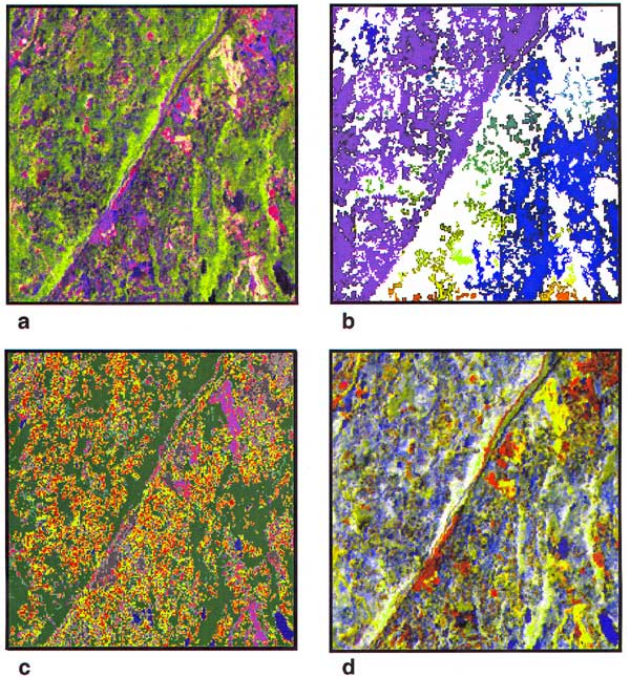
•Integration of disease vector models with satellite and *in* situ data

Approach:

•Evaluate land cover, surface temperature and surface wetness conditions that can sustain vector- and animal-borne diseases globally

•Use high spatial/temporal resolution, multispectral thermal HyspIRI as inputs to disease models to produce risk maps for vector- and animal-borne disease sustainability and expansion globally

Lyme disease and the use of remote sensing data



a) Raw Landsat TM image b) contiguous forest patches c) 12-class land cover map d) Composite image of three spectral indices [brightness in red, greenness in green, and wetness in blue]

Results:

In addressing human health concerns, space-based observations are most useful when used along with many other sources of data. Public health and risk management decision making has benefited from space-based technologies. HyspIRI multispectral thermal IR and frequent revisit times will afford, added benefits will include:

•Better prediction of occurrence of disease and disease outbreaks

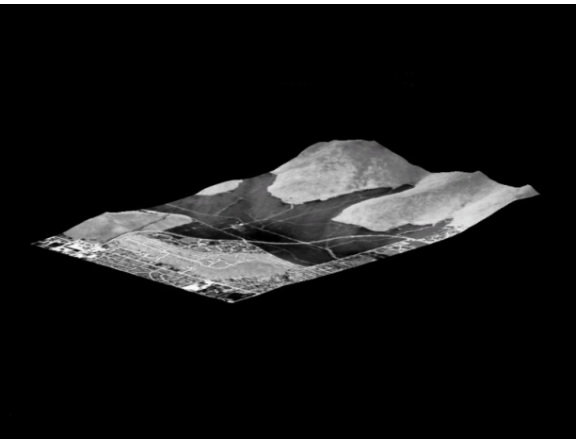
•Rapid detection and tracking of events

•Construction of disease risk maps

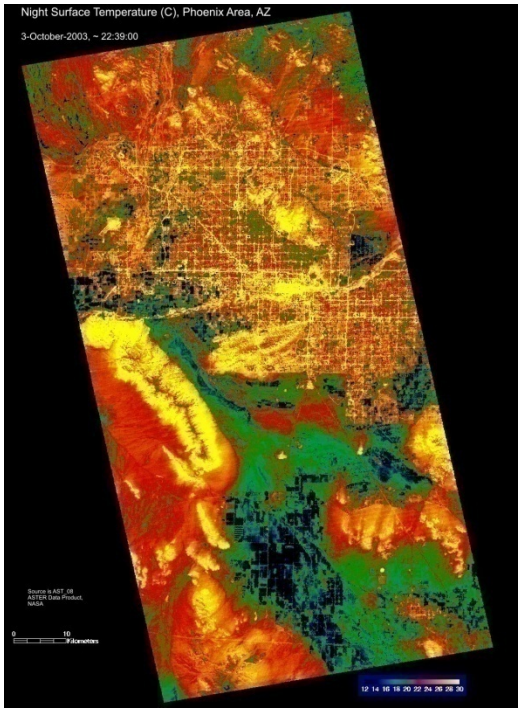
•Targeting interventions to reduce the vulnerability of humans to health risks

•Enhancing knowledge of human health-environment interactions

TQ4d: How do horizontal and temporal scales of variation in heat flux and mixing relate to human health, human ecosystems, and urbanization? (DS 156, 158, 160, 183-184)



Nighttime thermal IR image collected by aircraft over a portion of the Huntsville, Al metropolitan area. The TIR data have been overlain on top of digital elevation data to provide a 3D view of surface thermal responses.



Nighttime ASTER data showing surface temperature variability across the Phoenix, AZ metropolitan area.

Science Issue:

•Scale impacts the detection, observation, measurement and modeling of heat fluxes and energy balance across the earth. HyspIRI data will enable more precise quantitative assessment of how spatial and temporal scale impacts energy balance impacts on human health, human ecosystems, and urbanization.

Tools:

•Satellite observations for global measurement of surface temperature, energy balance, and energy fluxes at multi-temporal scales

•Spatial models of land surface characteristics across differing horizontal domains and for different biophysical and human environments

Approach:

•Evaluate surface temperature and energy fluxes for various land covers/ land uses across different temporal and horizontal scales as derived from HyspIRI data to assess how scale affects these parameters

•Use HyspIRI high spatial/temporal resolution, multispectral thermal data to quantify diurnal and nocturnal surface energy characteristics and establish baselines on scale impacts for land cover/land use surface energy fluxes globally

Results:

Effective incorporation of remote sensing data into public health and risk management practices requires measurements that are at spatial and temporal resolutions appropriate to the scale of the problems at hand. This often means that data are at more finely detailed spatial and temporal resolutions than current technology allows. HyspIRI with its multispectral thermal IR capabilities and high spatial and temporal thermal characteristics will provide data that will be of great assistance in furthering our knowledge of how scale affects surface energy balance characteristics and their impacts on human and natural ecosystems.