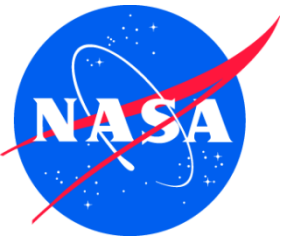




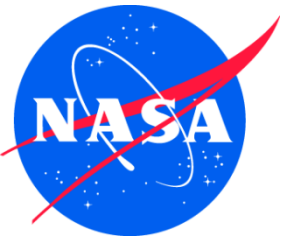
Examples of Level Products Possible from Existing Assets

Dale A. Quattrochi
NASA
Earth Science Office
Marshall Space Flight Center
Huntsville, AL
256-961-7887
dale.quattrochi@nasa.gov



Back to the Fundamentals: HyspIRI Science Questions

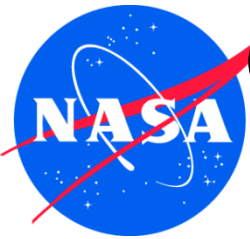
CQ6 Overarching Question: *How do patterns of human environmental and infectious diseases respond to leading environmental changes, particularly to urban growth and change and the associated impacts of urbanization?*



CQ6. Human Health and Urbanization Sub-questions

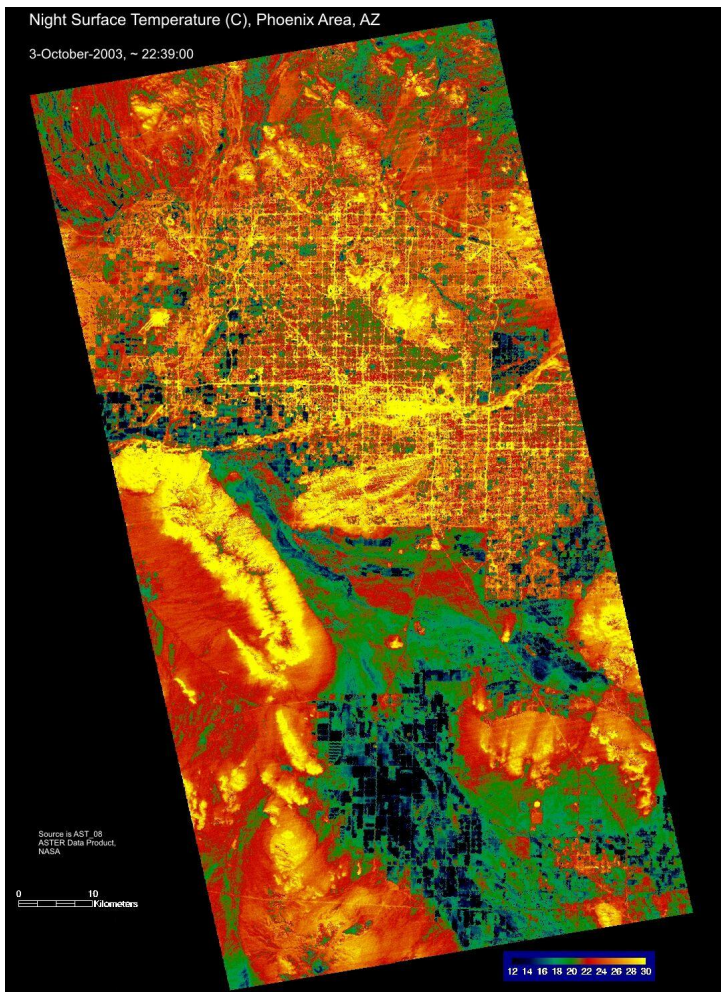


- How do land surface characteristics such as vegetation state, soil moisture, temperature, and land cover composition affect heat stress and drought, and vector-borne and zoonotic diseases?**
- What changes can be observed and measured in the emissivities of urban surfaces and how do emissivities change for different cities around the world as they impact the urban heat island and associated land-atmosphere energy balance characteristics?**

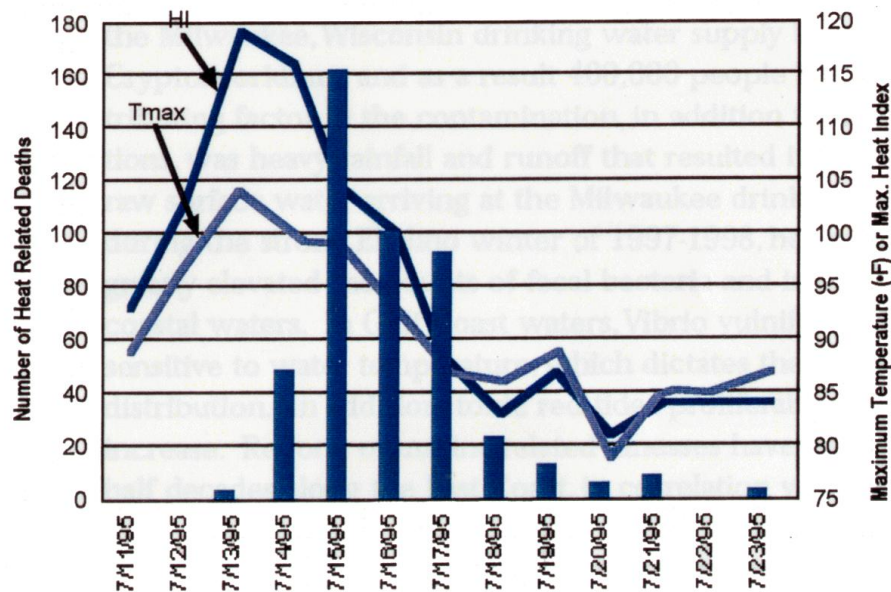


CQ6. HypsIRI Science Questions

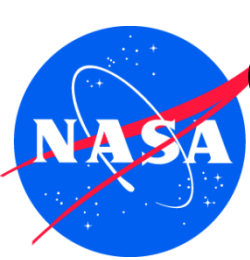
Human Health and Heat Island



Heat Related Deaths - Chicago
Maximum Temperature and Heat Index



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.

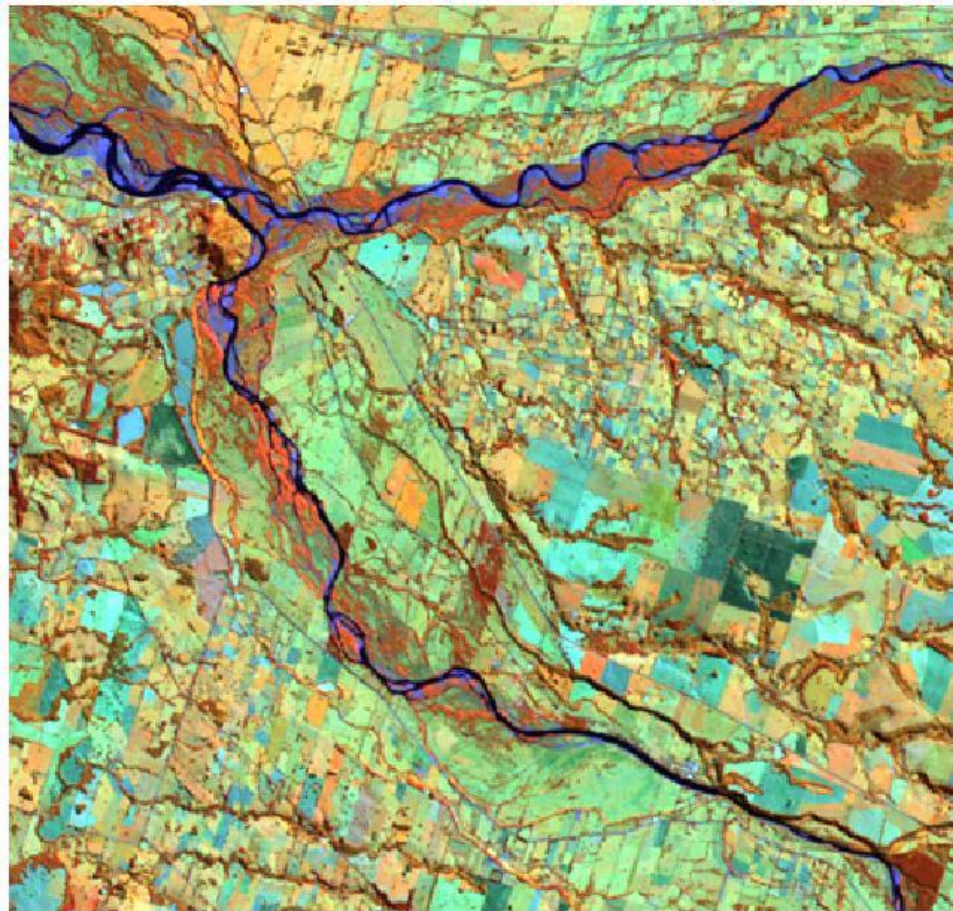


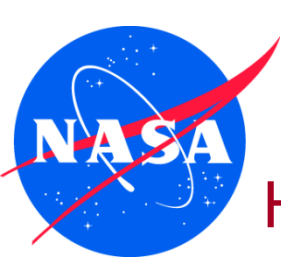
CQ6. HypsIRI Science Questions

Heat Stress & Drought



Chile 31 March 2001 Color Composite bands 3,5,4 (2.5% Saturation)

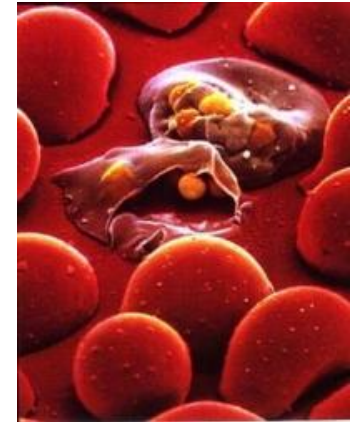
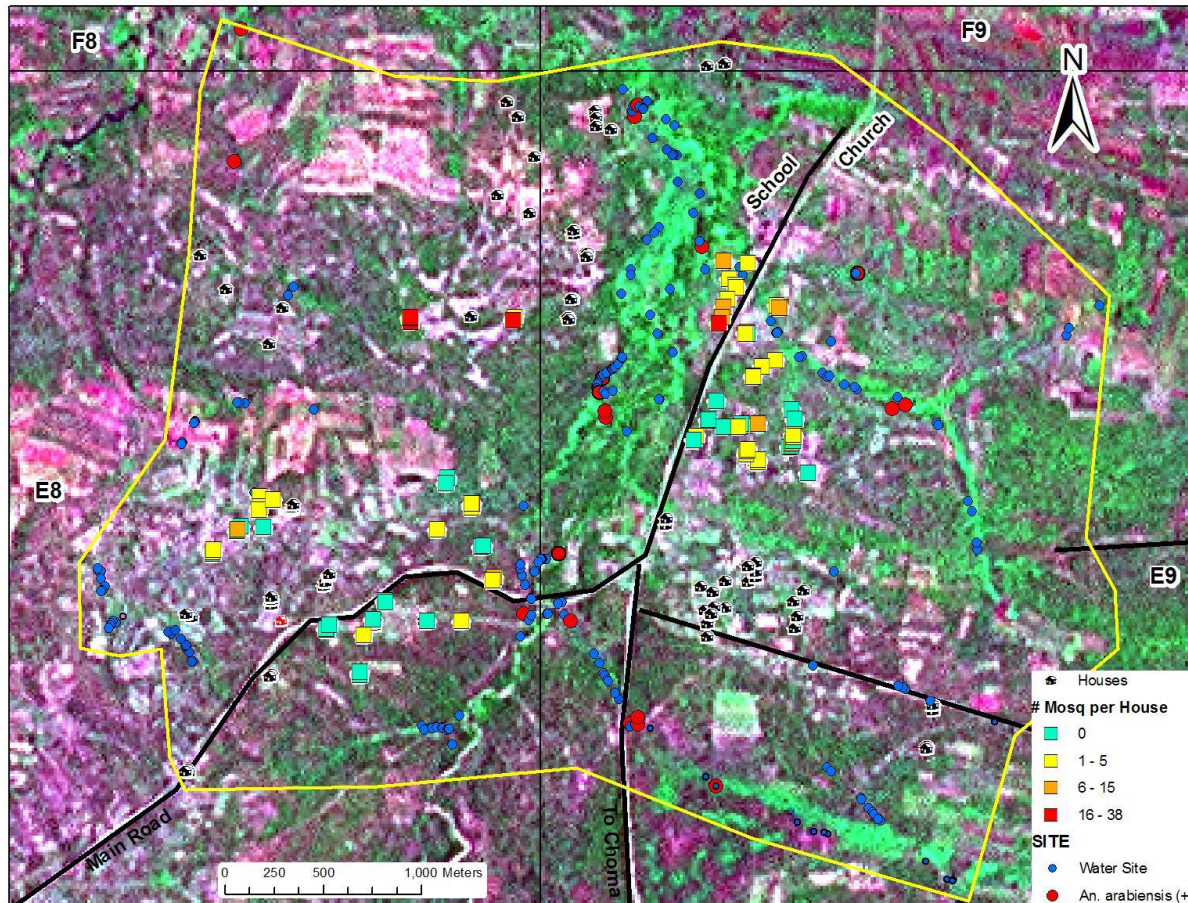




CQ6. HypsIRI Science Questions

Vector-borne Diseases (Malaria)

Heterogeneous Transmission with Landscape



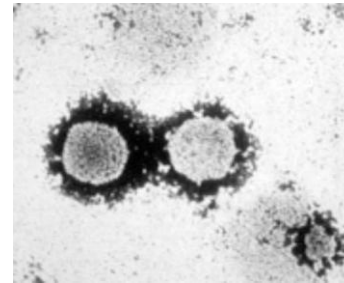
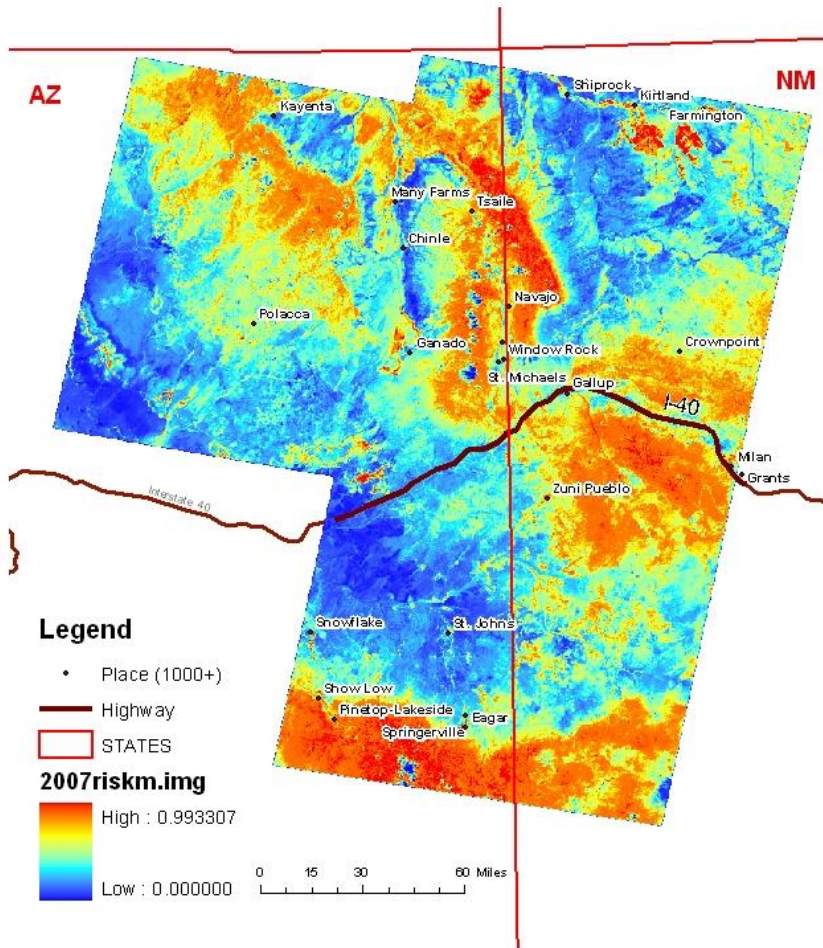


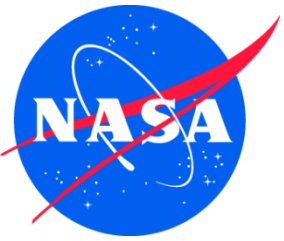
CQ6. HyspIRI Science Questions

Zoonotic Diseases



Hantavirus Pulmonary Syndrome Riskmap
Southwestern, USA 2007

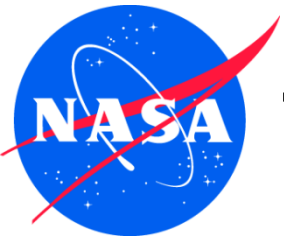




Back to the Fundamentals: HyspIRI Science Questions



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

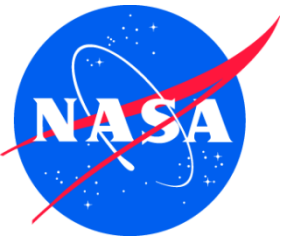


TQ4. Human Health and Urbanization

Sub-questions



- How do changes in land cover and land use, in particular urbanization, affect surface energy balance characteristics that impact human welfare?
- 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 factors affecting heat stress on humans be better resolved and measured?
- How can the characteristics associated with environmentally related health effects, 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?



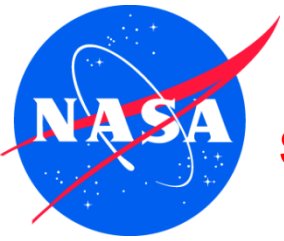
TQ4 HypsIRI Science Questions



Science Issue: How do changes in land cover and land use affect surface energy balance and the sustainability and productivity of natural and human ecosystems?

Approach

- Use HypsIRI high spatial resolution, multispectral, and multitemporal TIR data to track energy balance and energy flux characteristics for changing land covers/land uses through time to provide synoptic views of impacts on surface energy fluxes, emissivity and temperature
- Use HypsIRI 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



TQ4 HypsIRI Science Questions



Science Issue: How do changes in land cover and land use affect surface energy balance and the sustainability and productivity of natural and human ecosystems?

Potential Level 3 Products

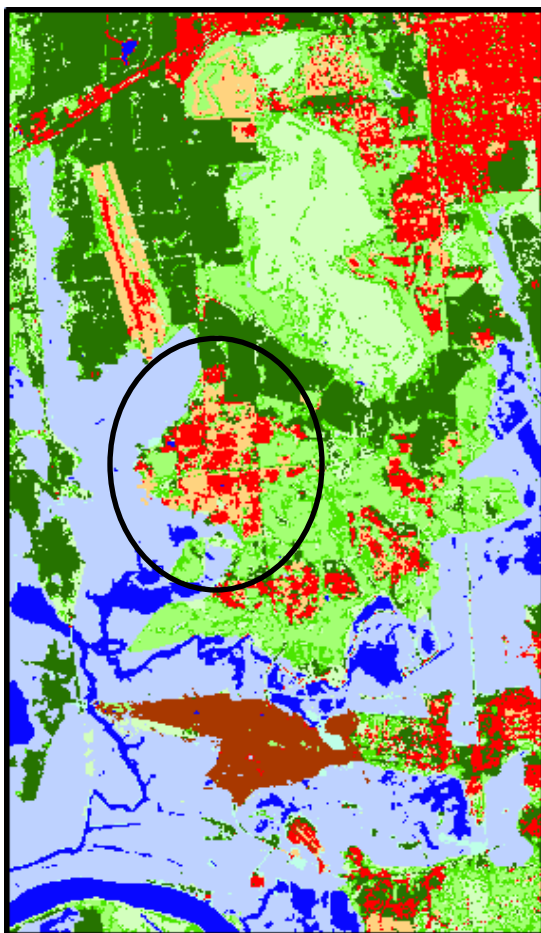
- **Multispectral thermal IR land cover maps at a high spatial resolution (60m) on a weekly basis for long-term validation of surface energy responses and changes in emissivity**
- **Integration of HypsIRI TIR data with spatial modeling to assess changes in land cover/land use through time and subsequent changes in thermal energy responses**



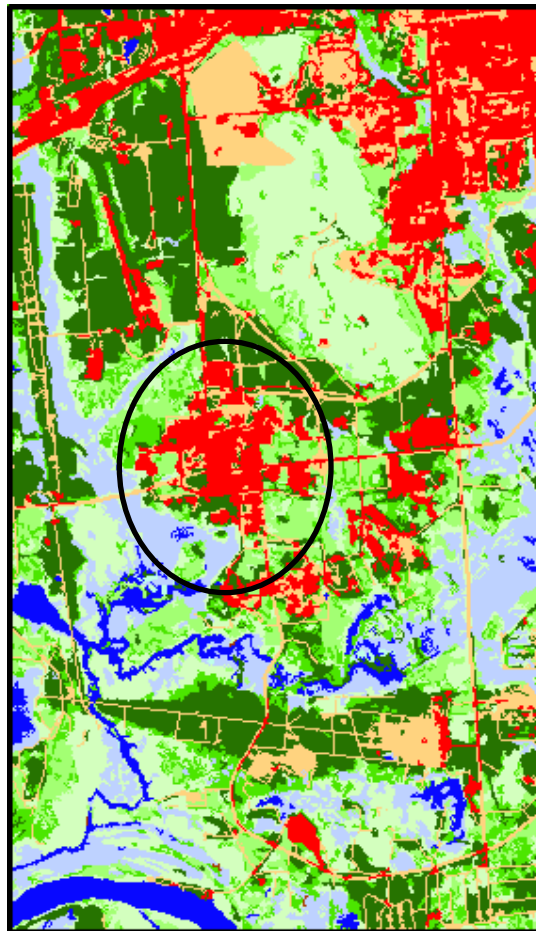
Land Use Change around MSFC



Dramatic increase in urban-residential land use category from 1992-2001

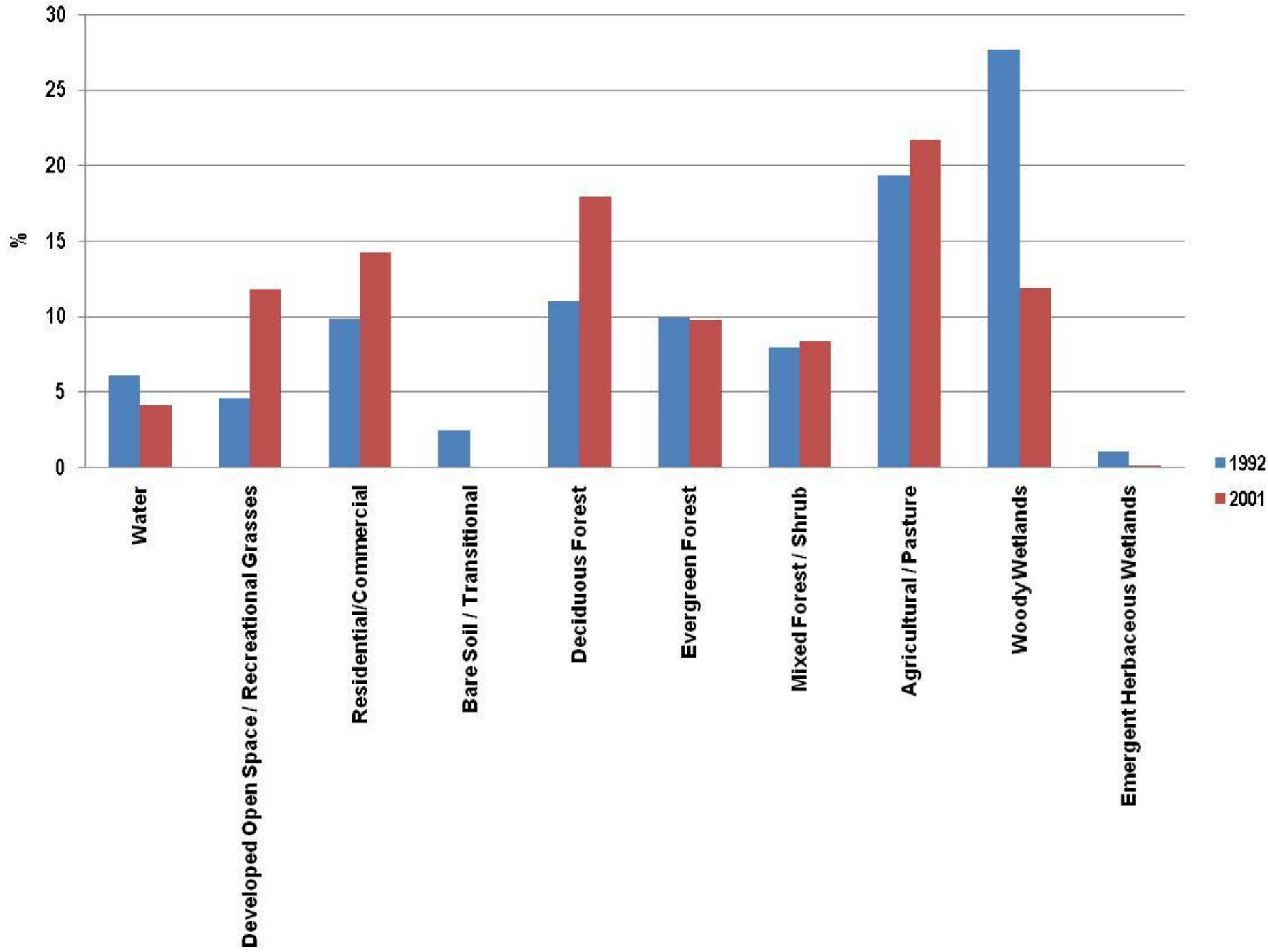


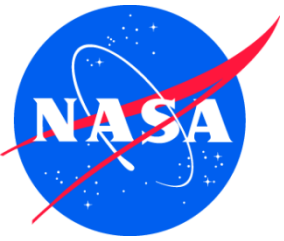
1992



2001

- Water
- Developed Open Space/Recreational Grasses
- Residential/Commercial
- Bare Soil / Transitional
- Deciduous Forest
- Evergreen Forest
- Mixed Forest / Shrub
- Agricultural / Pasture
- Woody Wetlands
- Emergent Herbaceous Wetlands



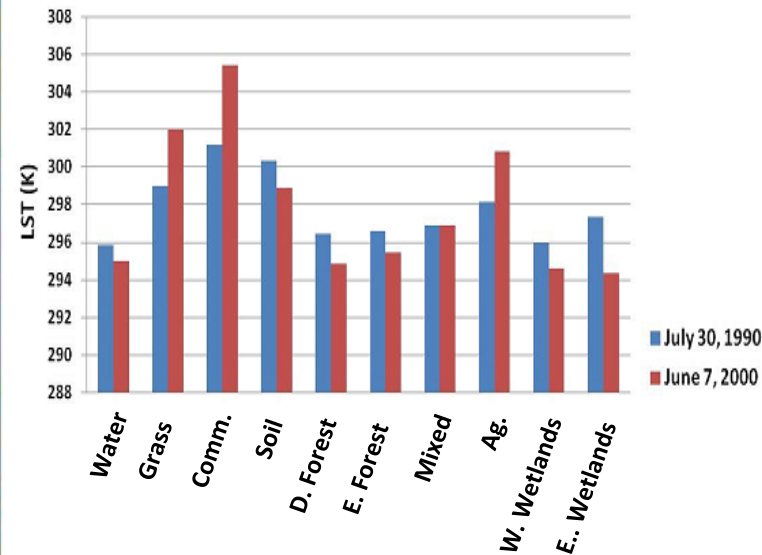


Land Use Change Drives Thermal Change

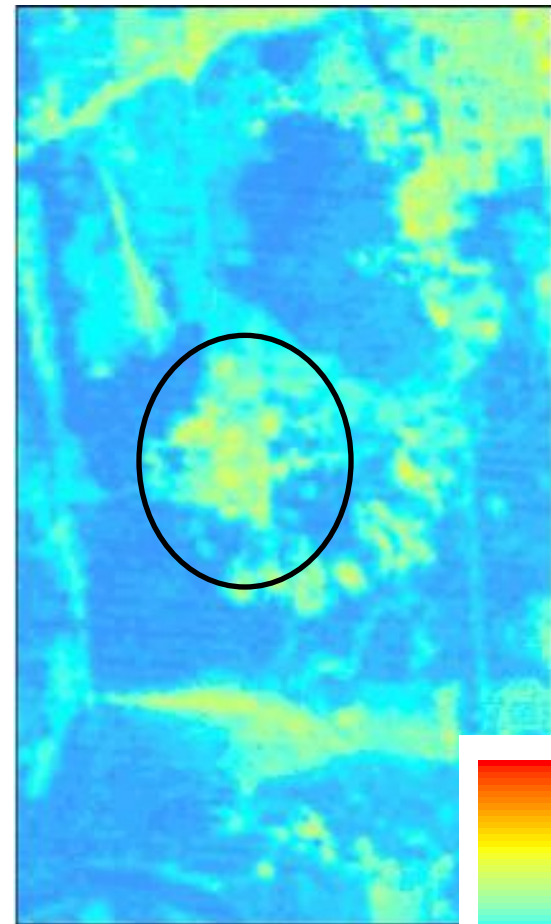


Conversion of forest, shrub, and agricultural land to MSFC infrastructure substantially changes surface thermal signatures

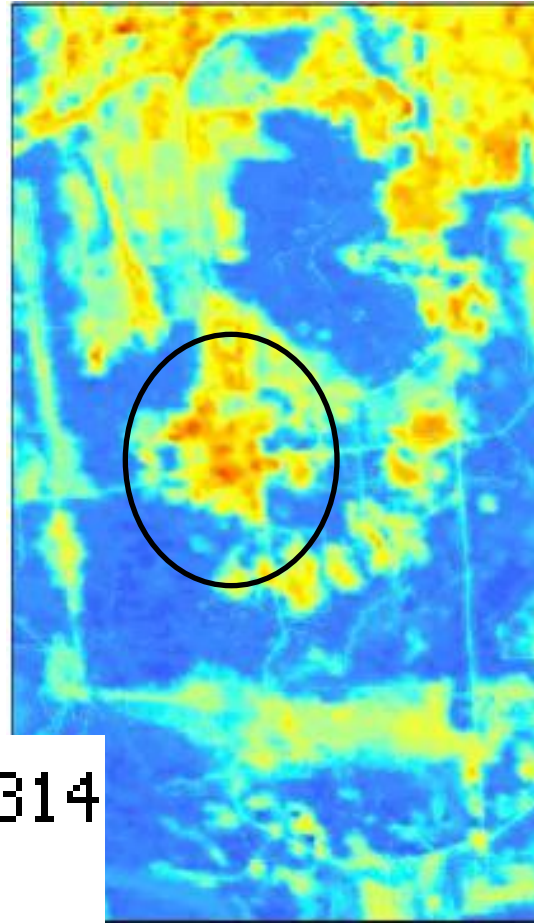
Spatial Mean Landsat-derived LST Per LCLU Class



Need to determine impact on local temperatures

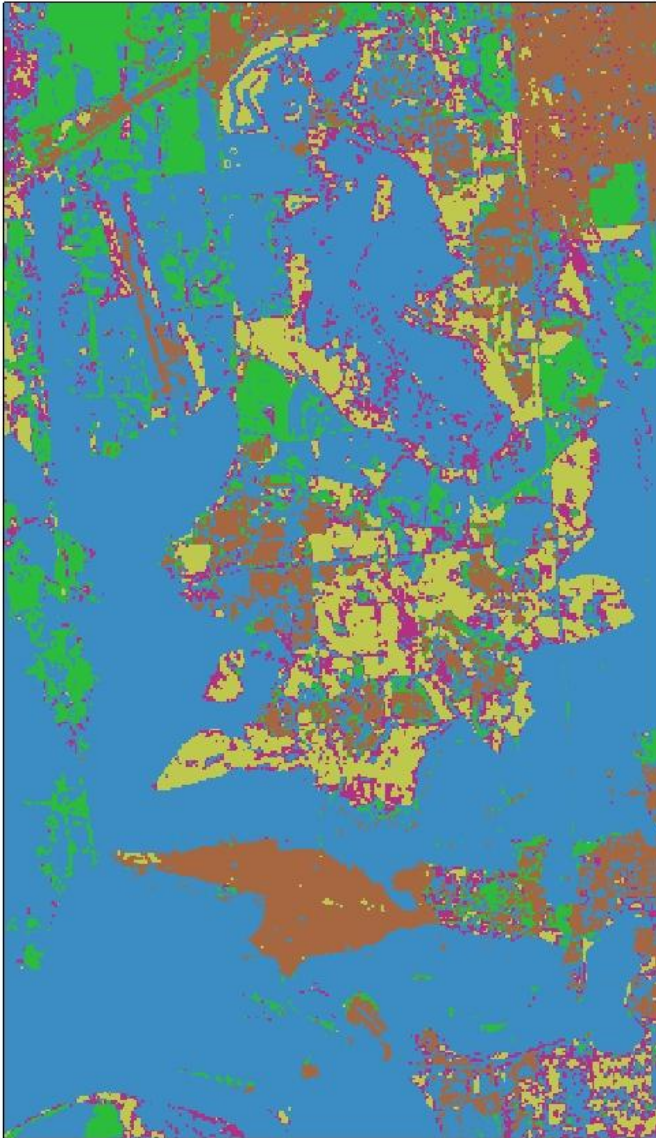


1992



2001

Emissivity 1992

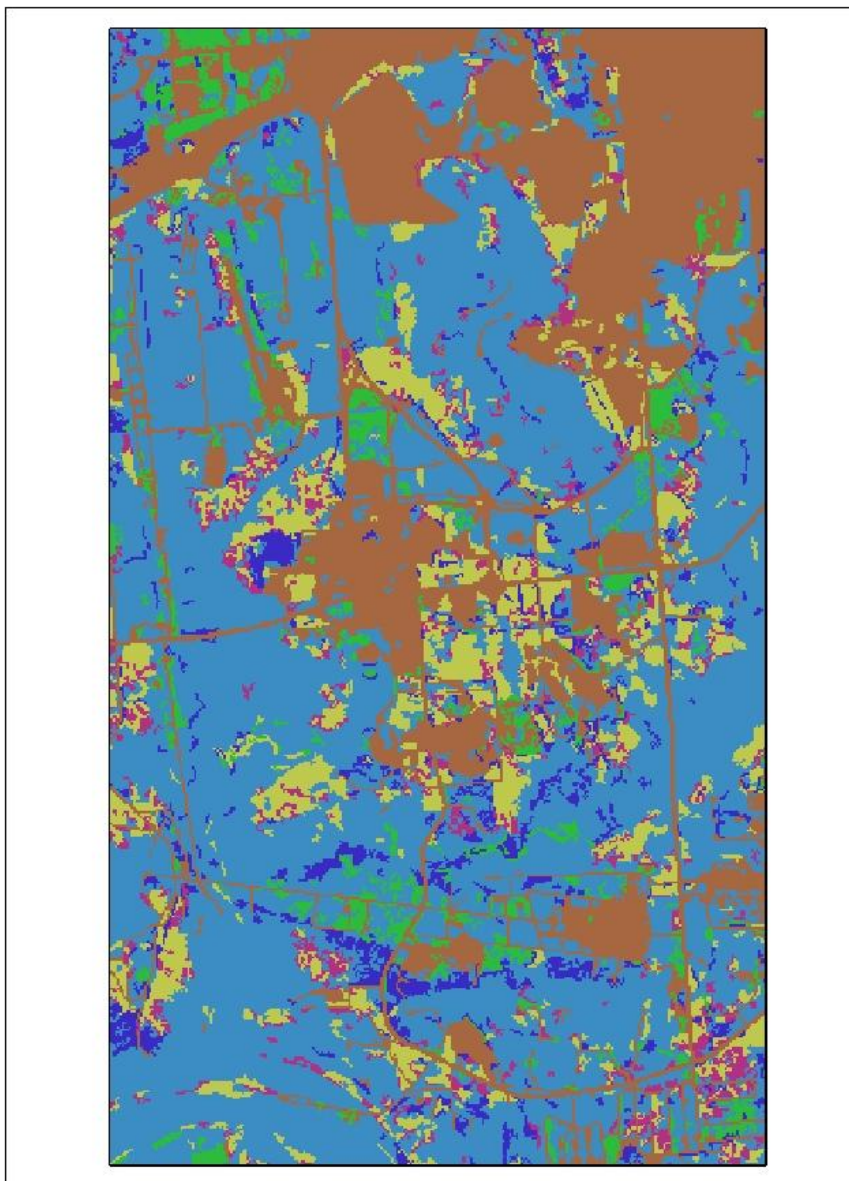


Emissivity

- 0.969 (Used for Bare Soil; and Developed Pixels)
- 0.974 (Used for Shrub Pixels)
- 0.980 (Used for Crops Pixels)
- 0.989 (Used for Deciduous Forests (assuming they're mostly Broadleaf); Wetlands, and Water Pixels)
- 0.9895 (Used for Mixed Forests Pixels)
- 0.990 (Used for Evergreen Pixels (assuming they're mostly Needle))

Based on a look-up table in Snyder et al. 1998 and given that our analysis is for a period when the vegetation is green.

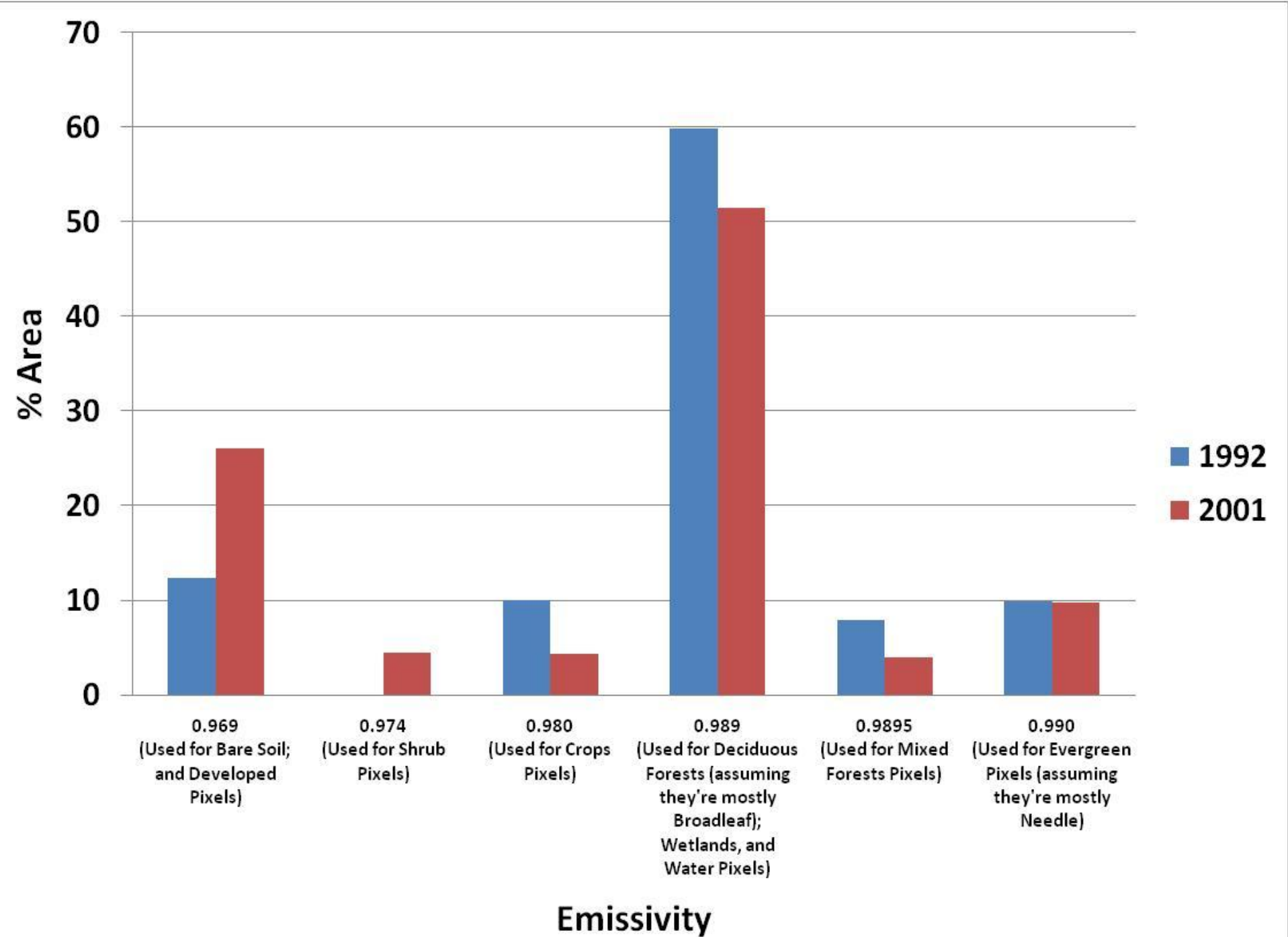
Emissivity 2001

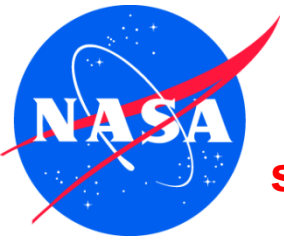


Emissivity

- 0.969 (Used for Bare Soil; and Developed Pixels)
- 0.974 (Used for Shrub Pixels)
- 0.980 (Used for Crops Pixels)
- 0.989 (Used for Deciduous Forests (assuming they're mostly Broadleaf); Wetlands, and Water Pixels)
- 0.9895 (Used for Mixed Forests Pixels)
- 0.990 (Used for Evergreen Pixels (assuming they're mostly Needle))

Based on a look-up table in Snyder et al. 1998 and given that our analysis is for a period when the vegetation is green.





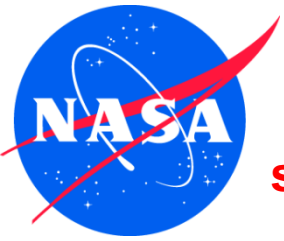
TQ4 HypsIRI Science Questions



Science Issue: What are the dynamics, magnitude, and spatial form of the UHI? How can it best be characterized?

Approach

- Use HypsIRI high spatial resolution, multispectral, and multitemporal TIR data to observe and measure the UHI for cities around the world in differing climatic regimes
- Use HypsIRI 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



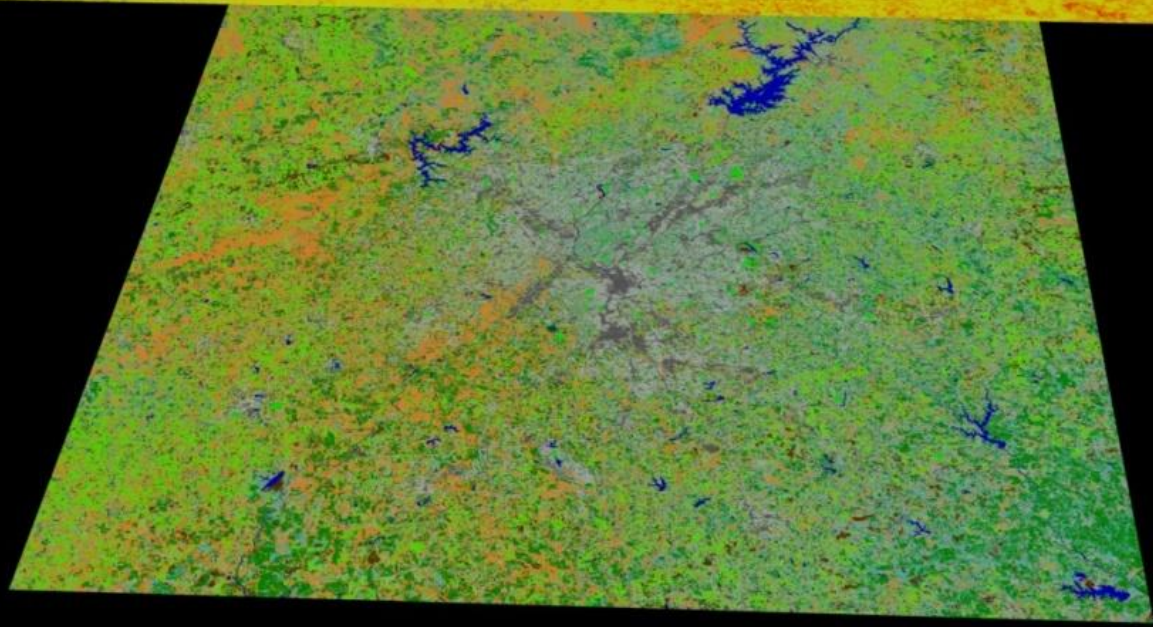
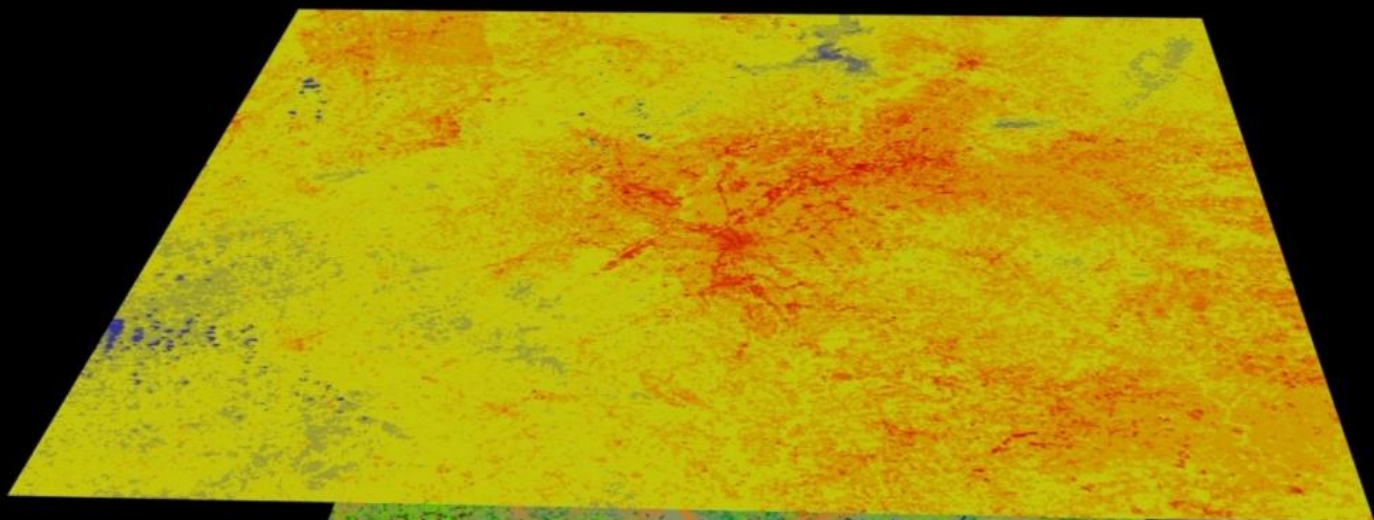
TQ4 HypsIRI Science Questions

Science Issue: What are the dynamics, magnitude, and spatial form of the UHI? How can it best be characterized?



Potential Level 3 Products

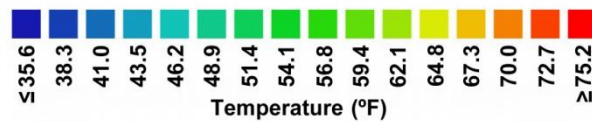
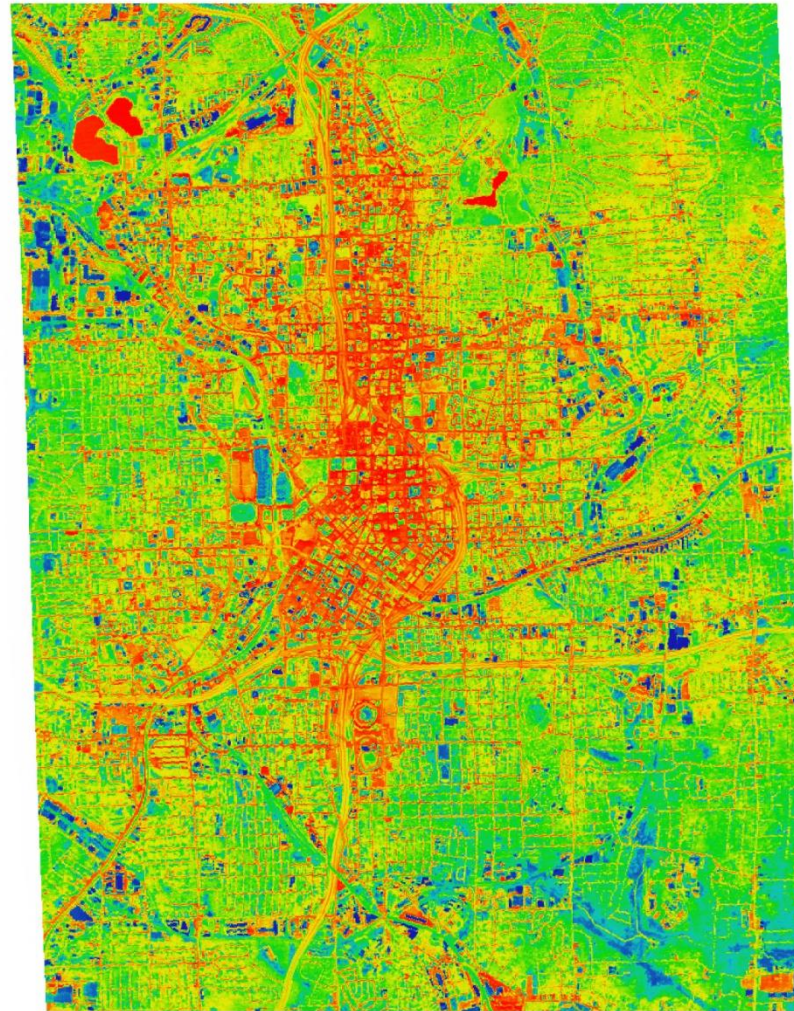
- **Maps of UHI development, extent and dynamics for various cities around the world using HypsIRI high spatial resolution (60m) data**
- **Multitemporal (weekly, seasonal) maps of UHI dynamics**
- **Day/Night maps of UHI dynamics**



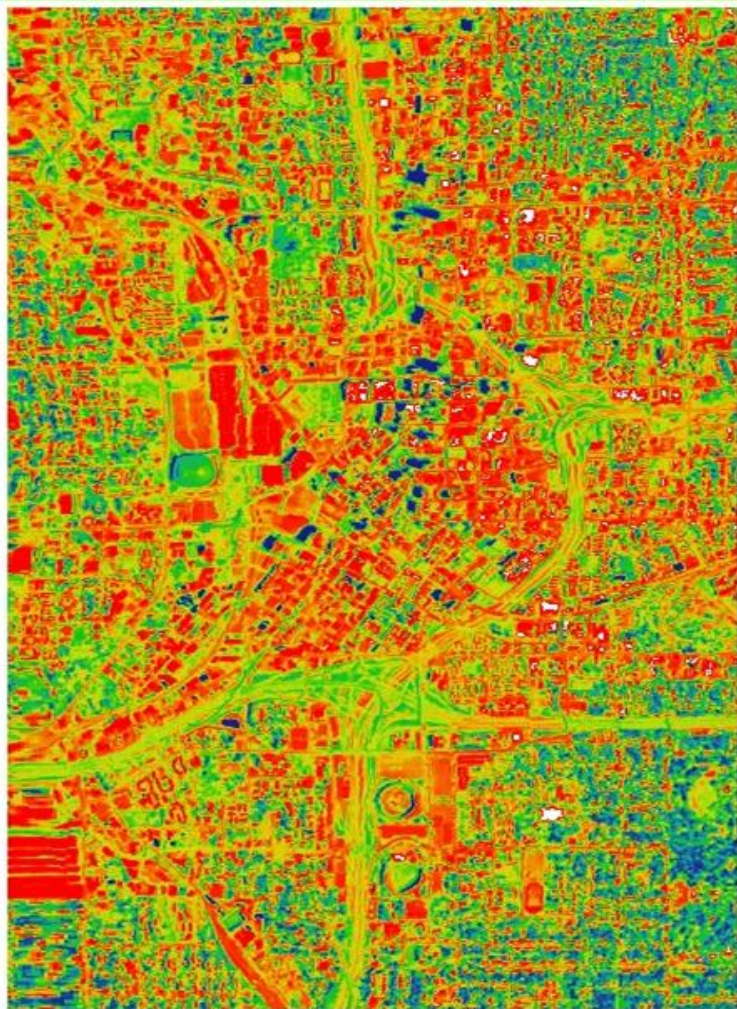
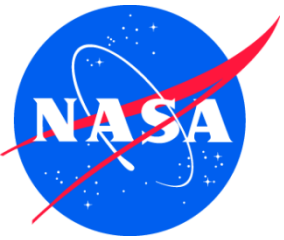




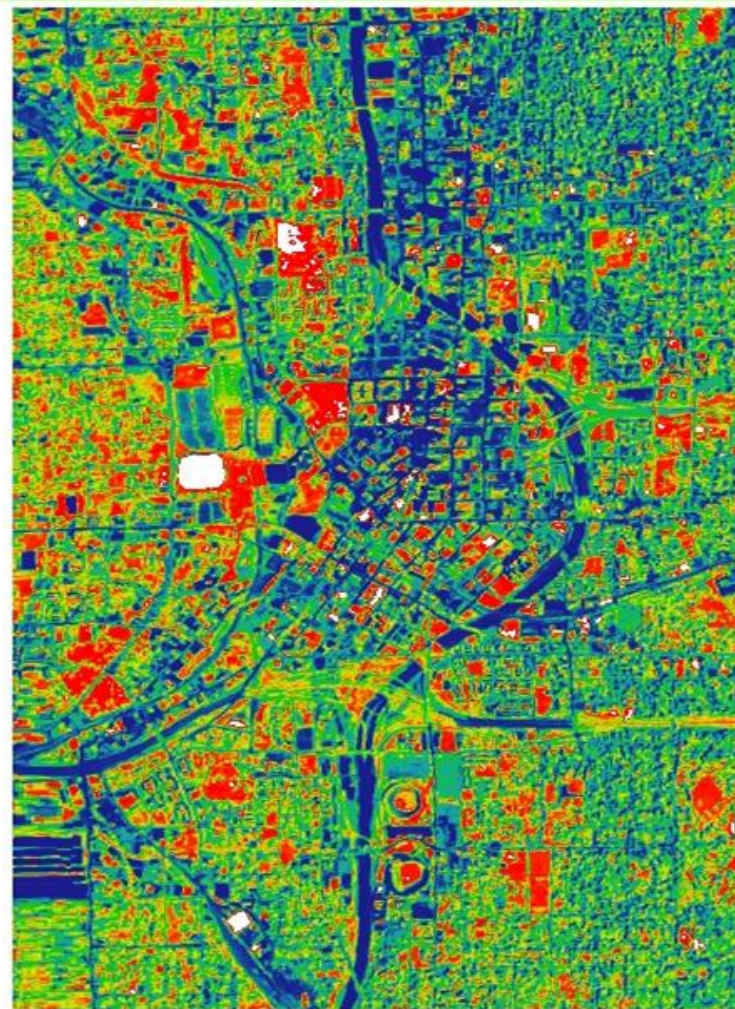
Atlanta Central Business District Night Data – May 1997



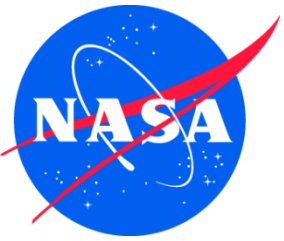
Source: NASA / EPA



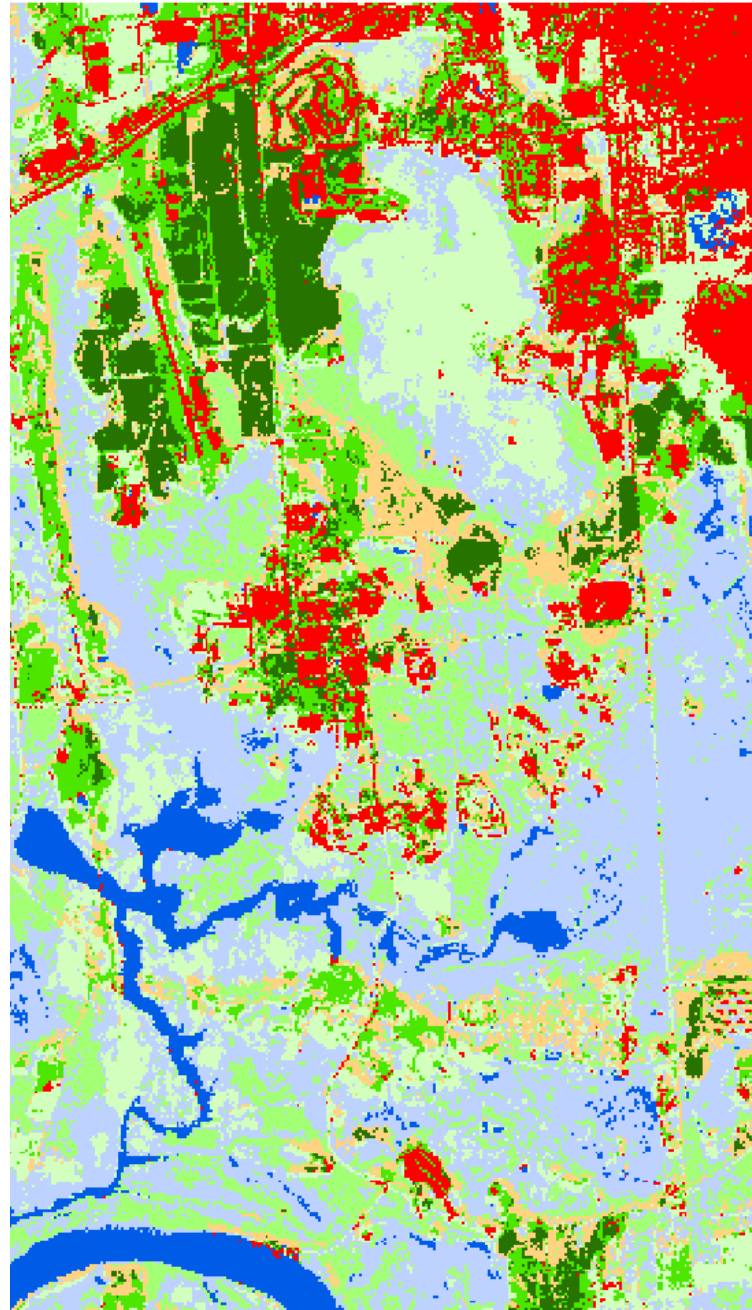
Temperature



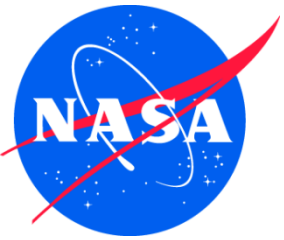
Albedo



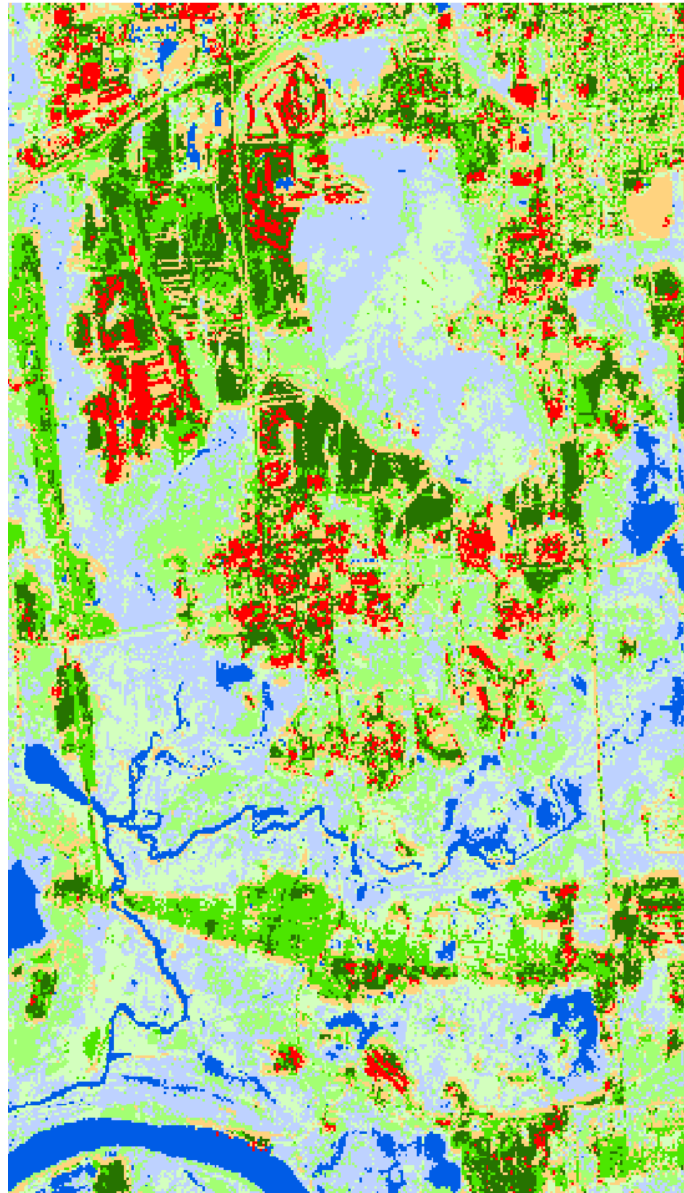
ASTER LULC (APR 6, 2001)



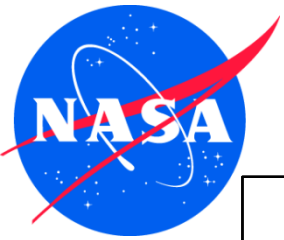
- Water
- Developed Open Spc./Rec. Gr.
- Residential/Commercial
- Deciduous Forest
- Evergreen Forest
- Mixed Forest / Shrub
- Agricultural / Pasture
- Woody Wetlands



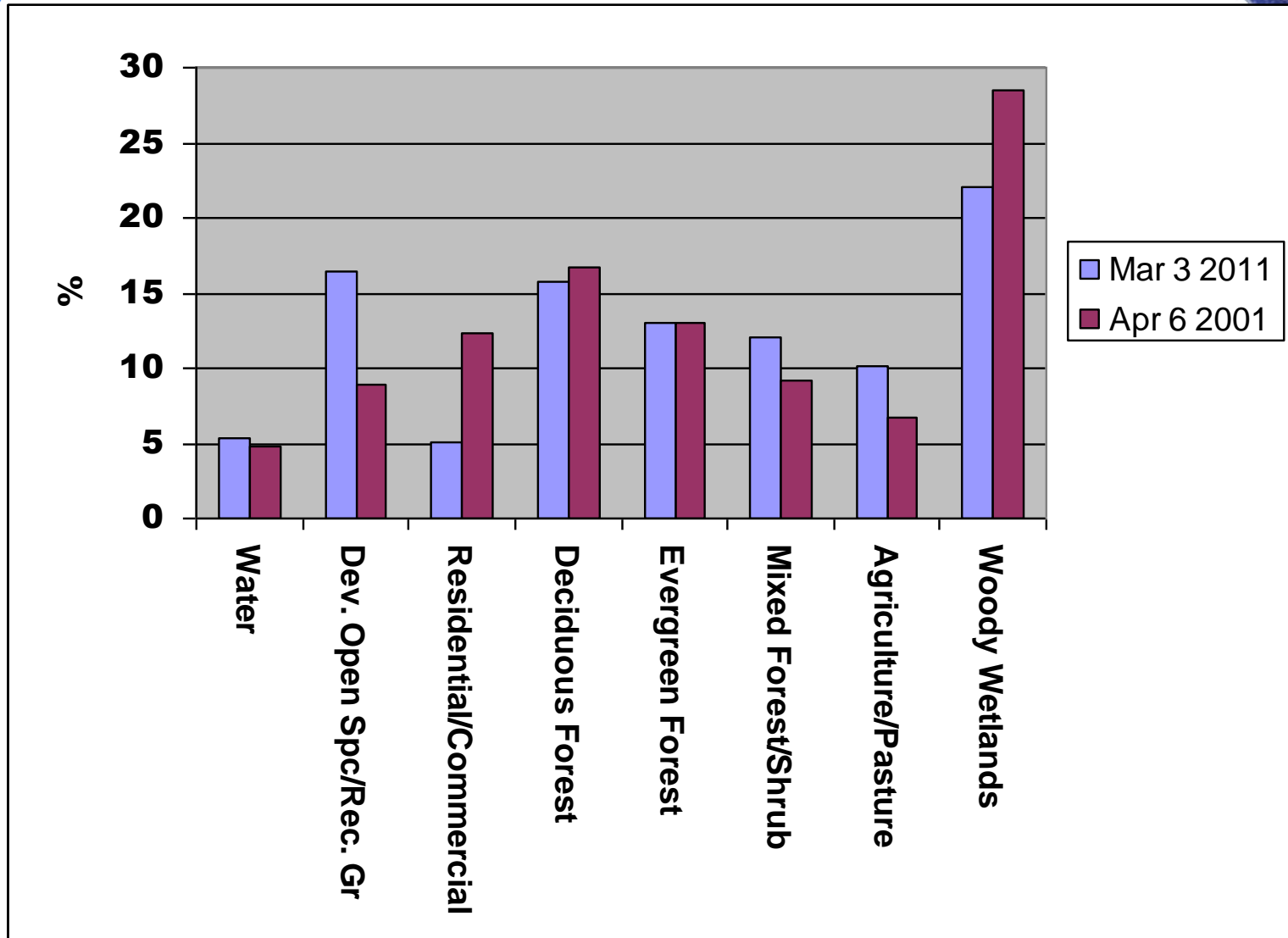
ASTER LULC (MAR 1, 2011)

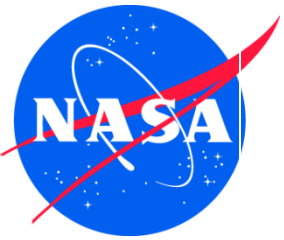


- Water
- Developed Open Spc./Rec. Gr.
- Residential/Commercial
- Deciduous Forest
- Evergreen Forest
- Mixed Forest / Shrub
- Agricultural / Pasture
- Woody Wetlands

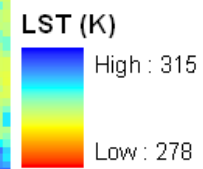
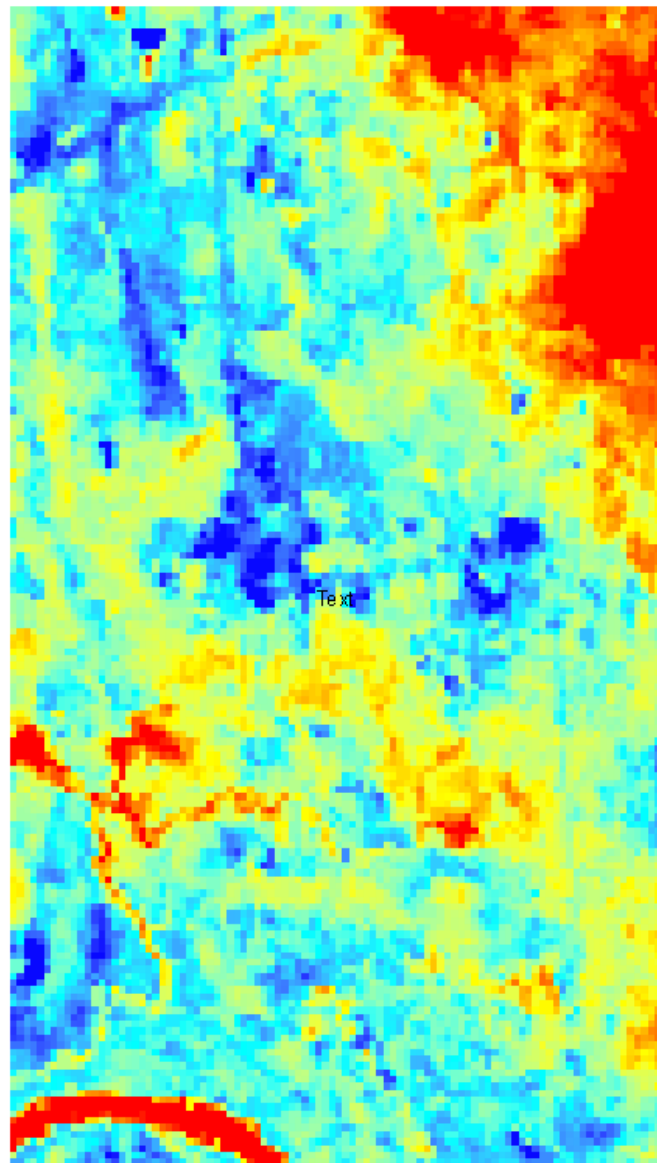


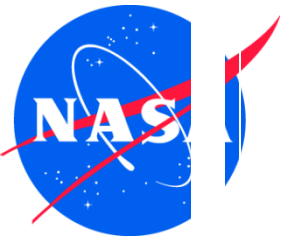
Land Cover and Climate Change Impacts



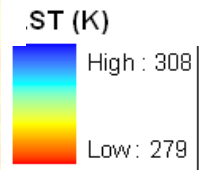
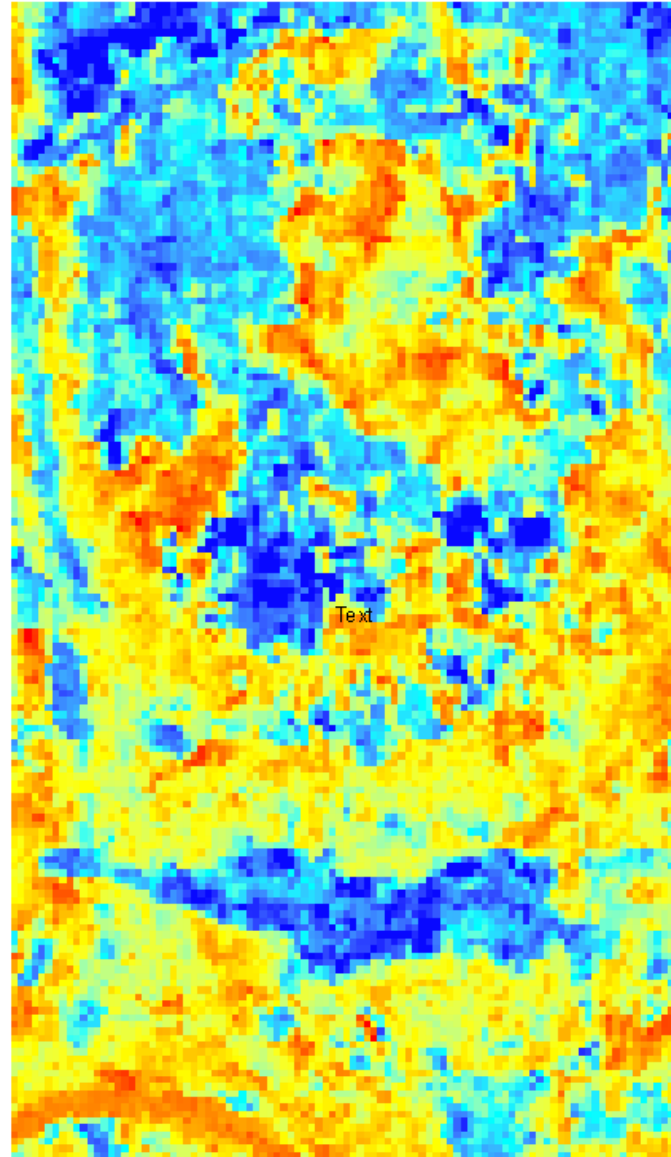


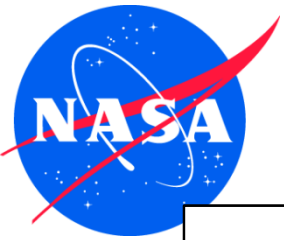
ASTER LST (K) (APR 6, 2001)





ASTER LST (K) (MAR 1, 201 I)

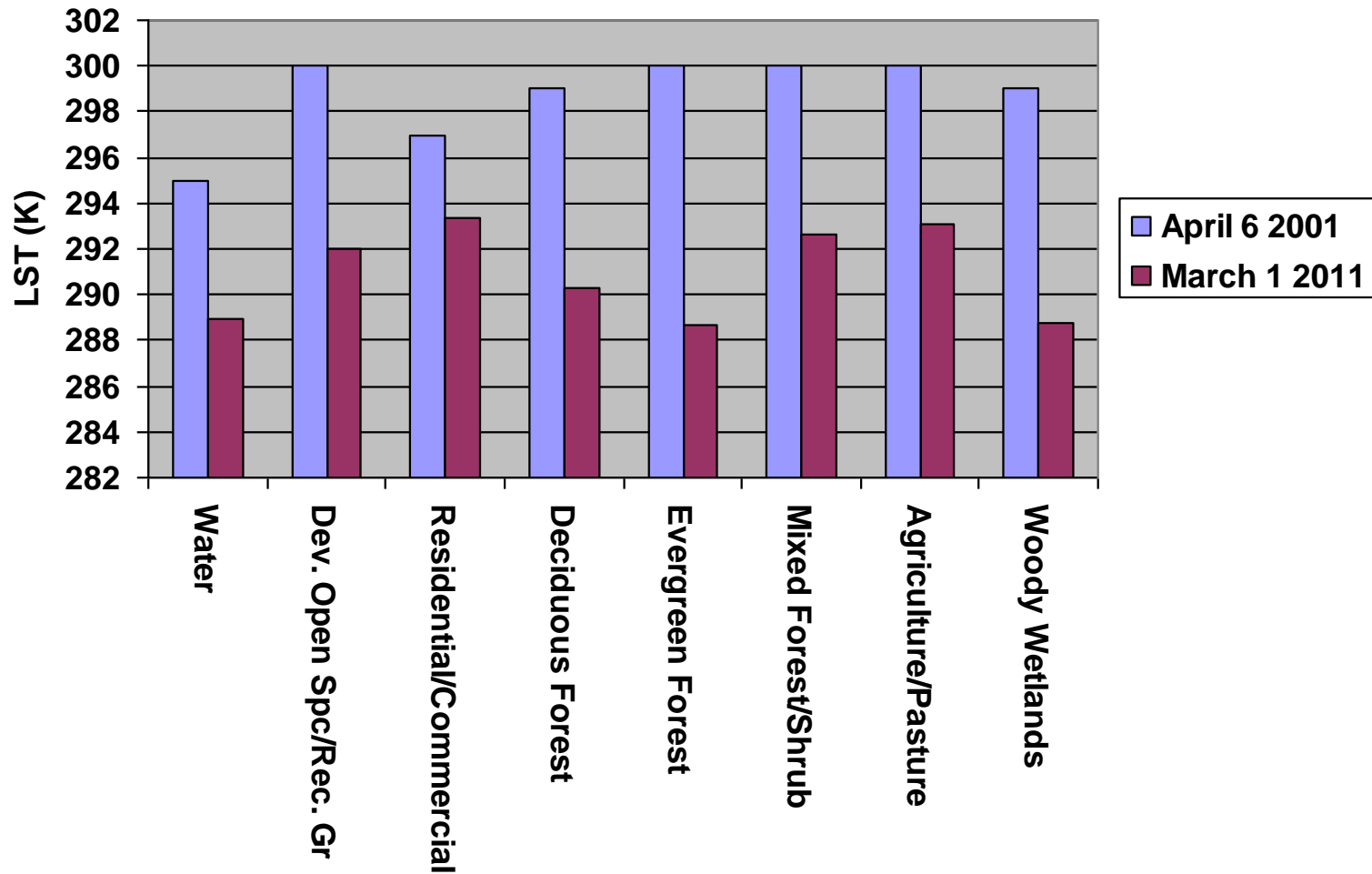


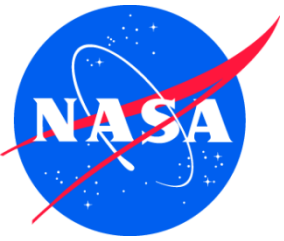


Land Cover and Climate Change Impacts



Spatial Mean ASTER-derived LST per LCLU Class





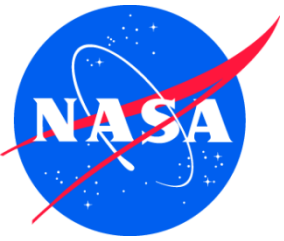
TQ4 HyspIRI Science Questions



Science Issue: How can factors affecting heat stress on humans be better resolved and measured?

Approach

- **Collect HyspIRI data in conjunction with times of high heat events (i.e., know when these events will most likely occur) over urban areas**
- **Obtain heat morbidity and mortality data from public health sources for heat events**
- **Evaluate relationships between high surface temperatures and morbidity/mortality data to derive quantitative assessments of heat stress indicators (e.g., where geographically morbidity/mortality occurred)**
- **Develop heat stress risk maps for cities around the world for use by public health officials**



TQ4 HypsIRI Science Questions



Science Issue: How can factors affecting heat stress on humans be better resolved and measured?

Potential Level 3 Products

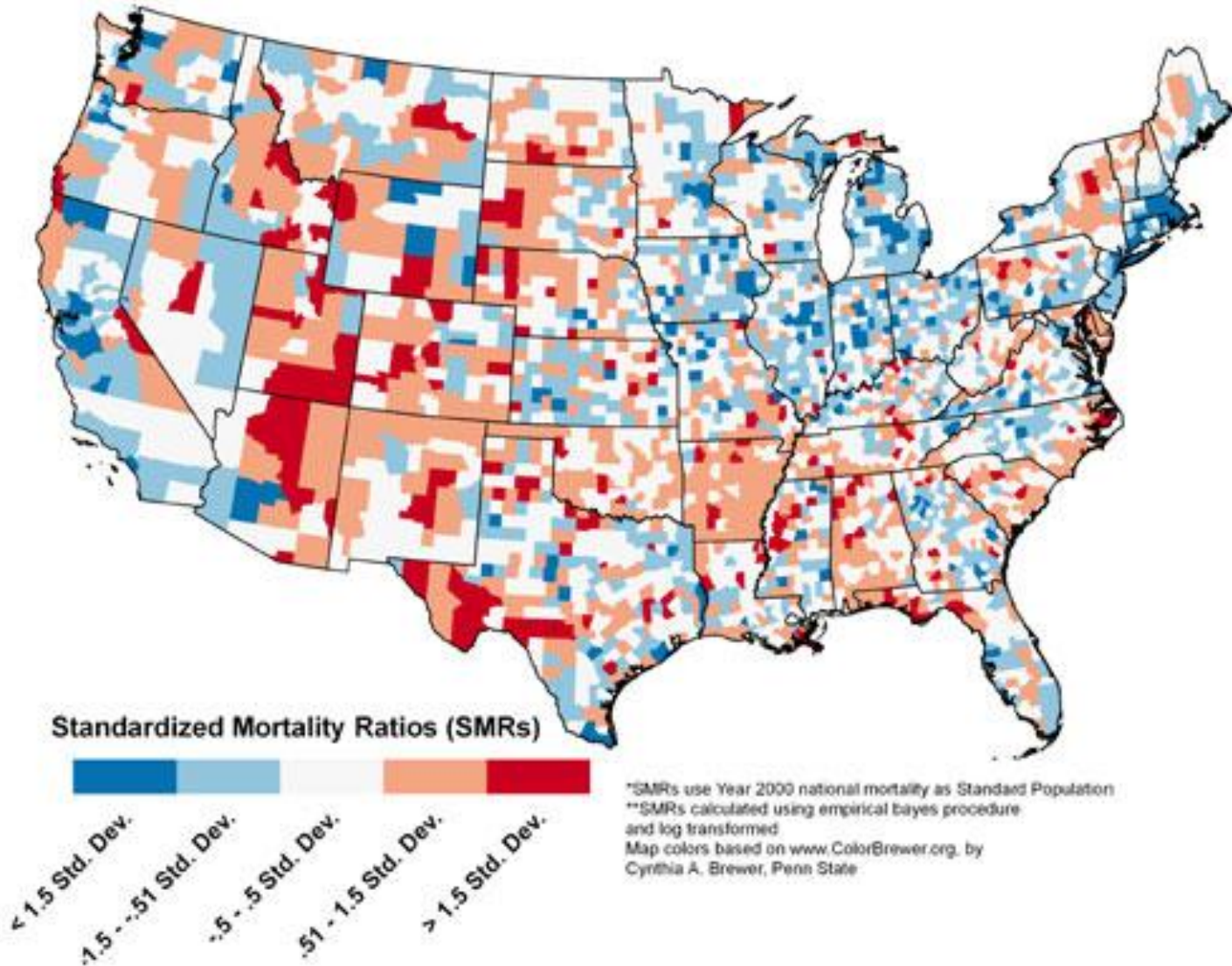
- **Heat stress maps as derived from HypsIRI thermal IR data for cities known to have morbidity/mortality cases during times of excess heat events**
- **HypsIRI modeled data to develop risk assessment maps for people who are at high health risk from heat-related events**

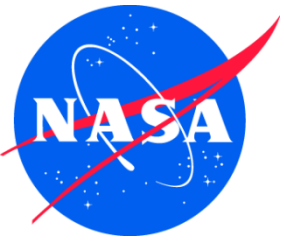


TQ4 HypsIRI Science Questions



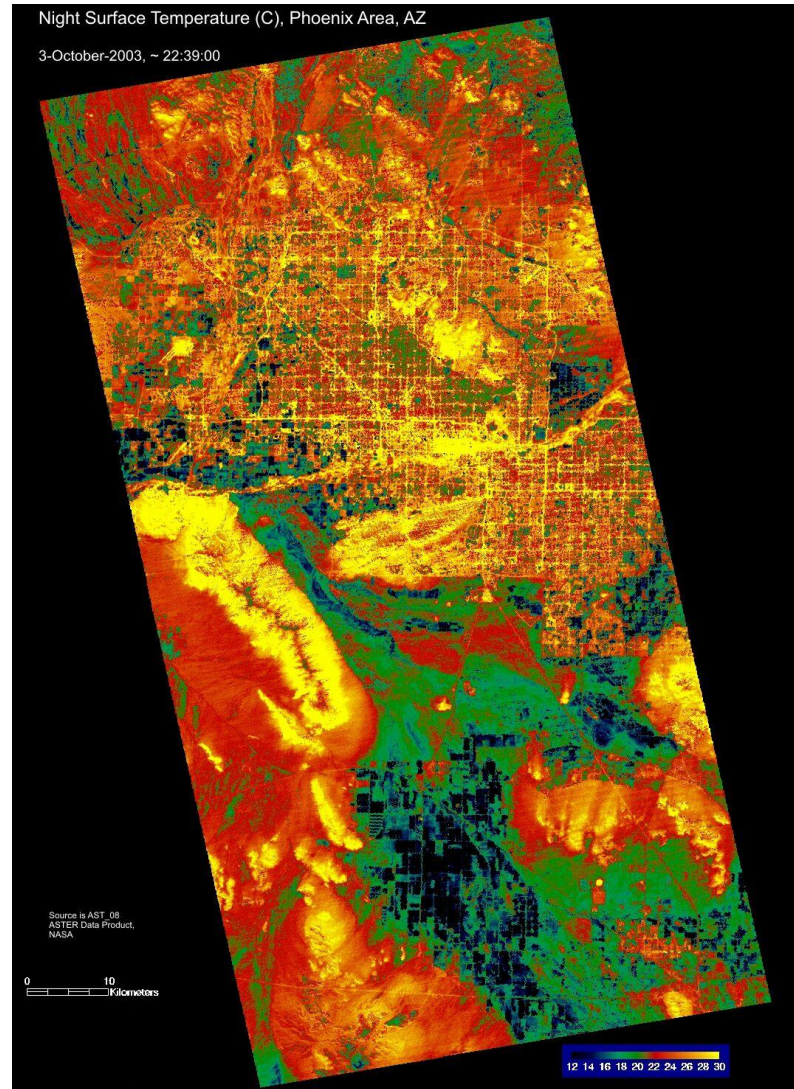
Science Issue: How can factors affecting heat stress on humans be better resolved and measured?

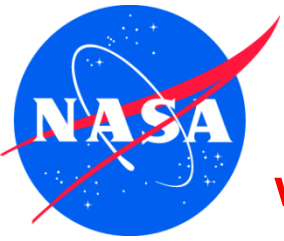




TQ4 HypsIRI Science Questions

Science Issue: How can factors affecting heat stress on humans be better resolved and measured?





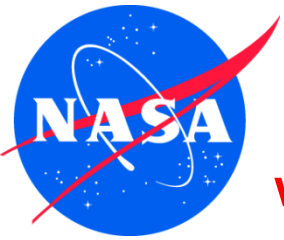
TQ4 HypsIRI Science Questions



Science Issue: How can characteristics associated with environmentally-related health effects that affect vector-borne and animal-borne diseases be better measured and resolved?

Approach

- Evaluate land cover, surface temperature and surface wetness conditions using HypsIRI thermal IR data where conditions are favorable for initiation of vector- and animal-borne diseases globally
- Use high spatial/multitemporal HypsIRI TIR data as inputs to disease models to produce risk maps for vector- and animal-borne disease outbreak and expansion globally
- Provide rapid tracking of vector- and animal-borne disease events globally



TQ4 HypsIRI Science Questions



Science Issue: How can characteristics associated with environmentally-related health effects that affect vector-borne and animal-borne diseases be better measured and resolved?

Potential Level 3 Products

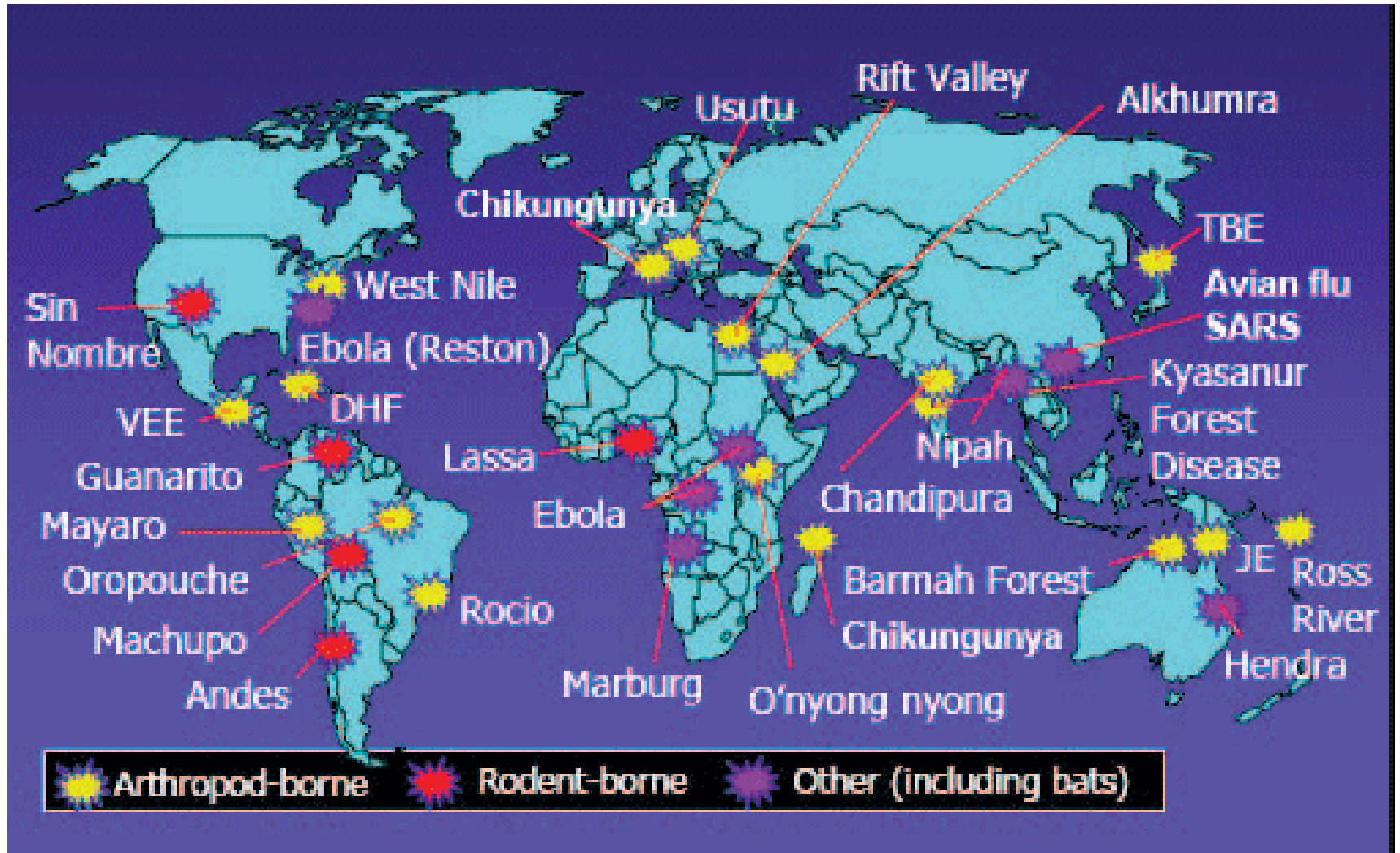
- Use HypsIRI TIR data to obtain observations and measurements of surface temperature and surface wetness as indicators of regions for possible disease transmission
- Use high spatial/temporal resolution, multispectral thermal HypsIRI data as inputs to disease models to produce risk maps for vector- and animal-borne disease persistence and expansion globally

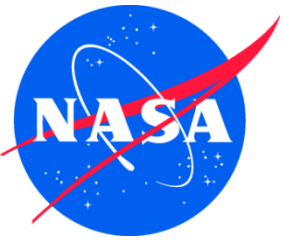


TQ4 HyspIRI Science Questions



Science Issue: How can characteristics associated with environmentally-related health effects that affect vector-borne and animal-borne diseases be better measured and resolved?

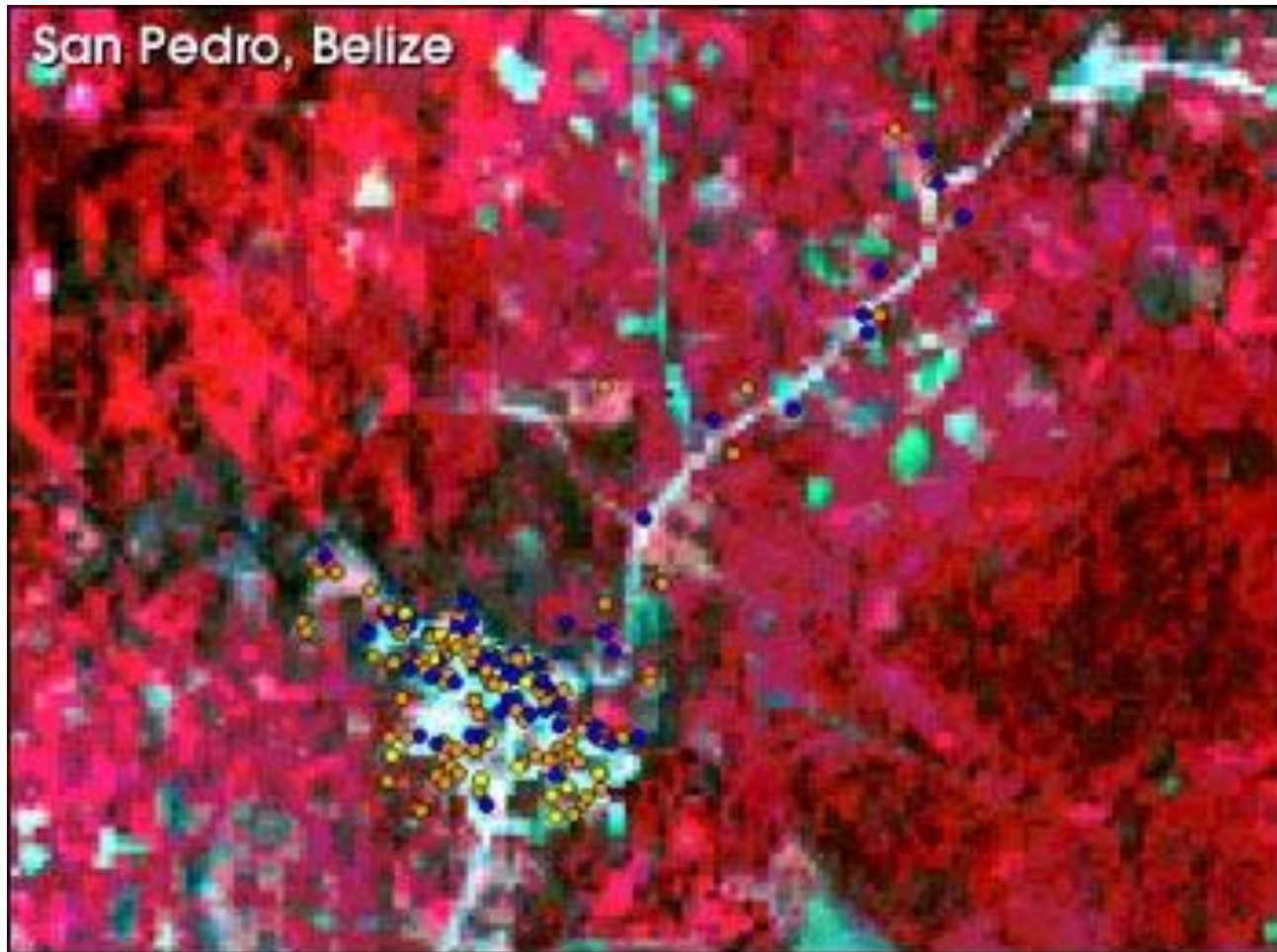




TQ4 HypsIRI Science Questions

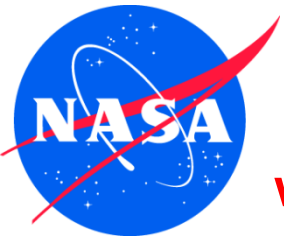


Science Issue: How can characteristics associated with environmentally-related health effects that affect vector-borne and animal-borne diseases be better measured and resolved? human ecosystems and urbanization?



0 0.5 1 1.5 2 kilometers



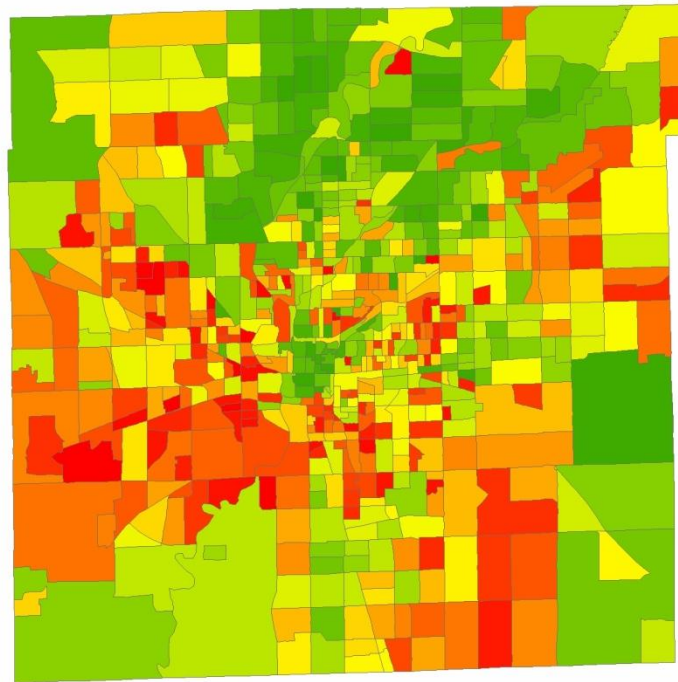


TQ4 HyspIRI Science Questions



Science Issue: How can characteristics associated with environmentally-related health effects that affect vector-borne and animal-borne diseases be better measured and resolved?

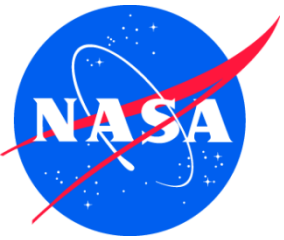
Risk areas of WNV in 2002



□ Census blockgroups

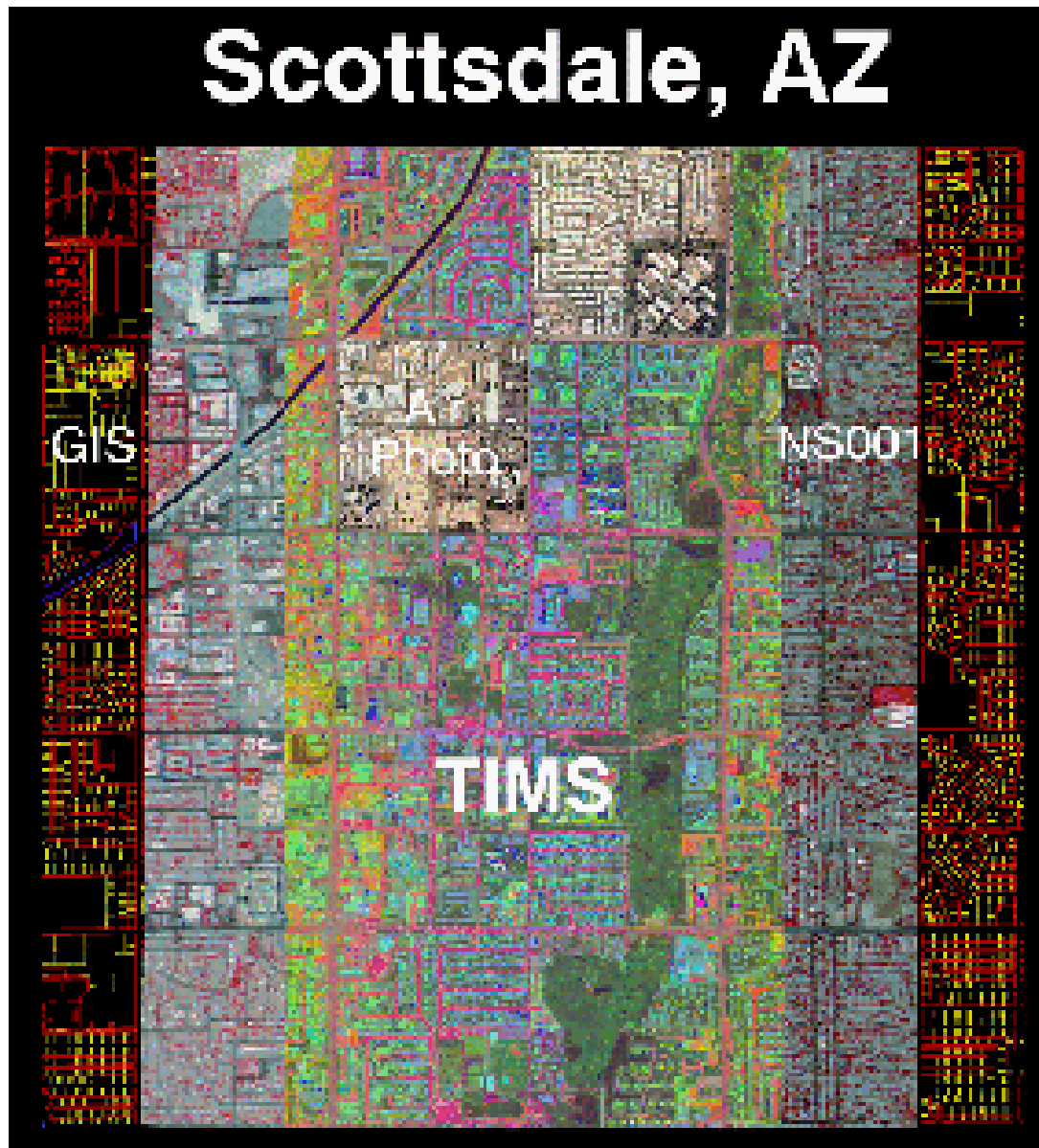
0 1.5 3 6 9 12
Kilometers

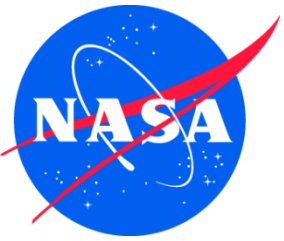




TQ4 HypsIRI Science Questions

Human Health and Urbanization Sub-questions





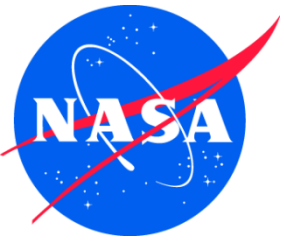
TQ4 HyspIRI Science Questions



Science Issue: How do horizontal and temporal scales of variation in heat flux and mixing relate to human health, human ecosystems and urbanization?

Approach

- **Satellite observations for global measurement of surface temperature, energy balance, and energy fluxes at multitemporal scales**
- **Spatial models of land surface characteristics across differing horizontal and vertical domains for different biophysical and human environments**



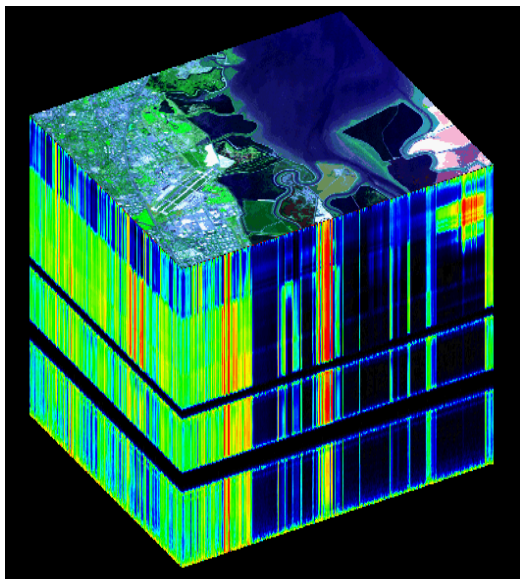
TQ4 HypsIRI Science Questions



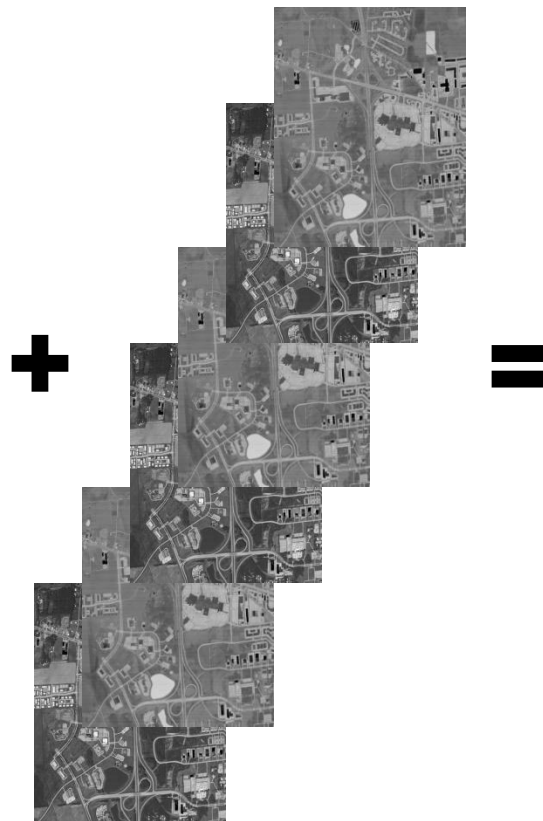
Science Issue: How do horizontal and temporal scales of variation in heat flux and mixing relate to human health, human ecosystems and urbanization?

Potential Level 3 Products

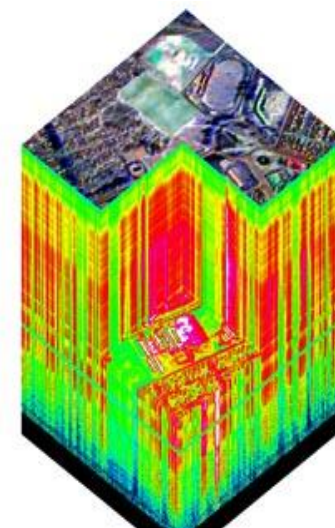
- **Maps of heat flux dynamics for various natural (e.g., forest, desert, mountain) and human (e.g., agriculture) derived from high spatial/multitemporal resolution HypsIRI data over multiple time periods**
- **Maps of emissivity for various land covers around the globe using HypsIRI thermal IR data**
- **Maps of vertical dynamics of heat flux derived from HypsIRI thermal IR data (i.e., overlain on 3-D topographic perspective)**



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



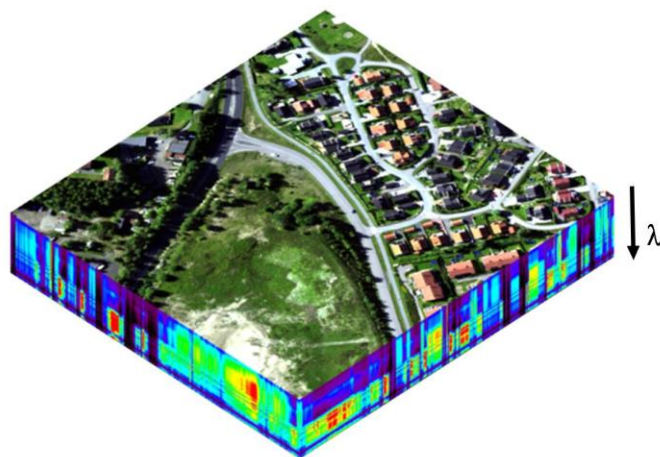
**HypsIRI TIR
multispectral Level II
product (8 TIR Bands)**
(surface temperature, radiance,
[day/night], emissivity)



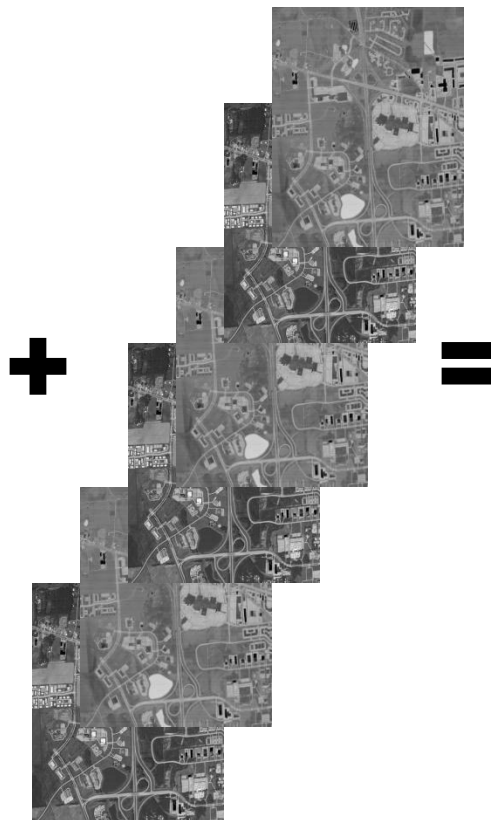
**HypsIRI VSWIR/TIR
composite data set**
(quantitative integrative
measurement of urban
surface reflectances,
temperatures, and
emissivity across the urban
ecosystem)



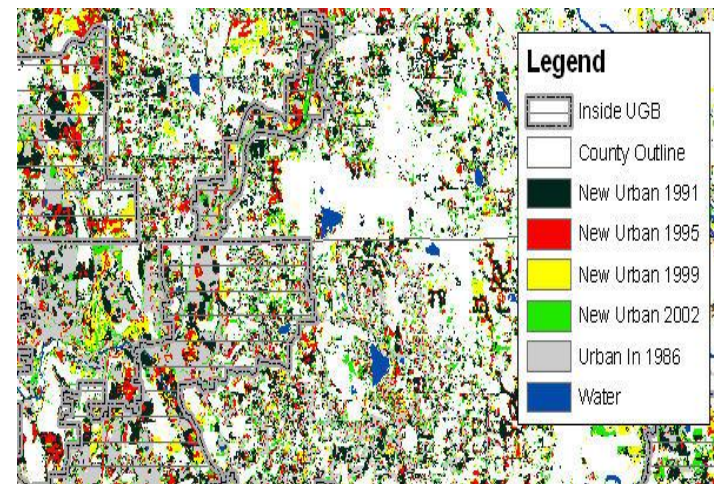
Through Time



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

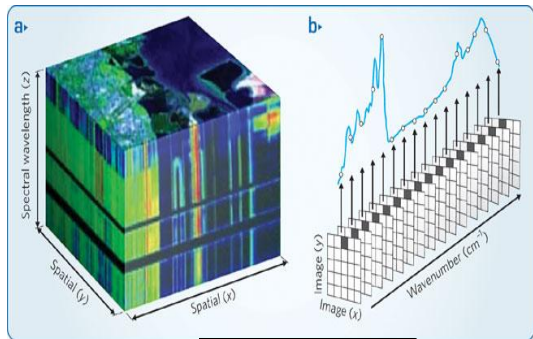


**HyspIRI TIR
multispectral Level II
product (8 TIR Bands)
(surface temperature, radiance,
[day/night], emissivity)**

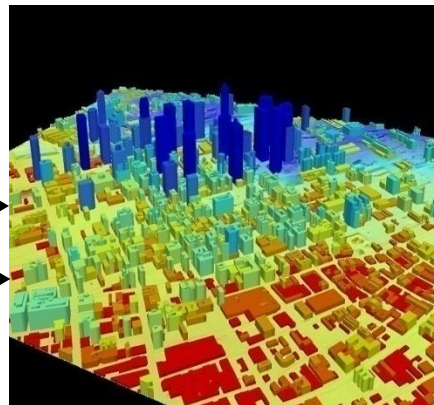


**HyspIRI VSWIR/TIR
composite land
cover change data
set**

**(quantitative integrative
measurement of urban
surface reflectances,
temperatures, and
emissivity across the urban
ecosystem as they change
through time)**



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



Lidar Data

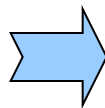
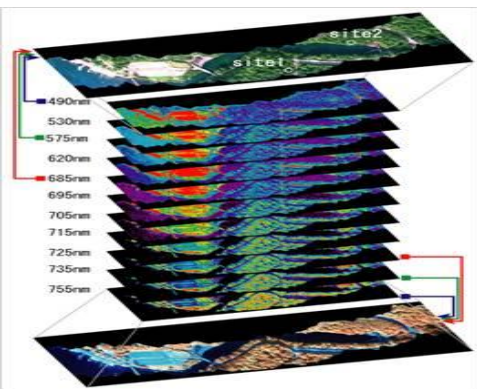
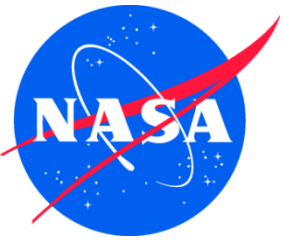


HyspIRI VSWIR/TIR and Lidarcomposite data set

(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)

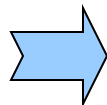
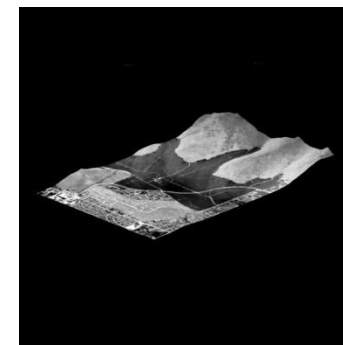
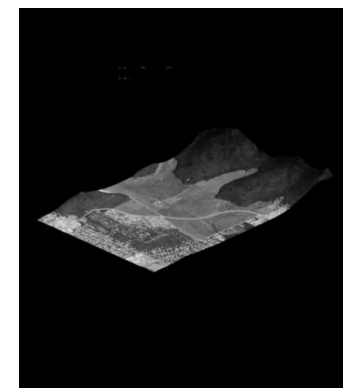
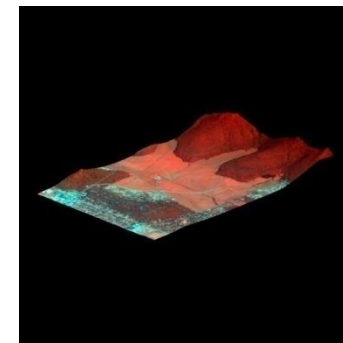


**Hyperspectral VSWIR Level II Product
(NDVI, fPAR, surface reflectance
characteristics)**



**Digital Topographic Data
(DEM)**

=



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

**HyspIRI VSWIR/TIR and DEM
composite data set
(hyperspctral/day/night TIR digital
elevation model data sets))**