

The Conundrum of Impacts of Climate Change on Urbanization: Prospects for Using HypsIRI Data Products for Regional to Global Societal Impacts Analysis

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Impacts of Climate Change on Urbanization

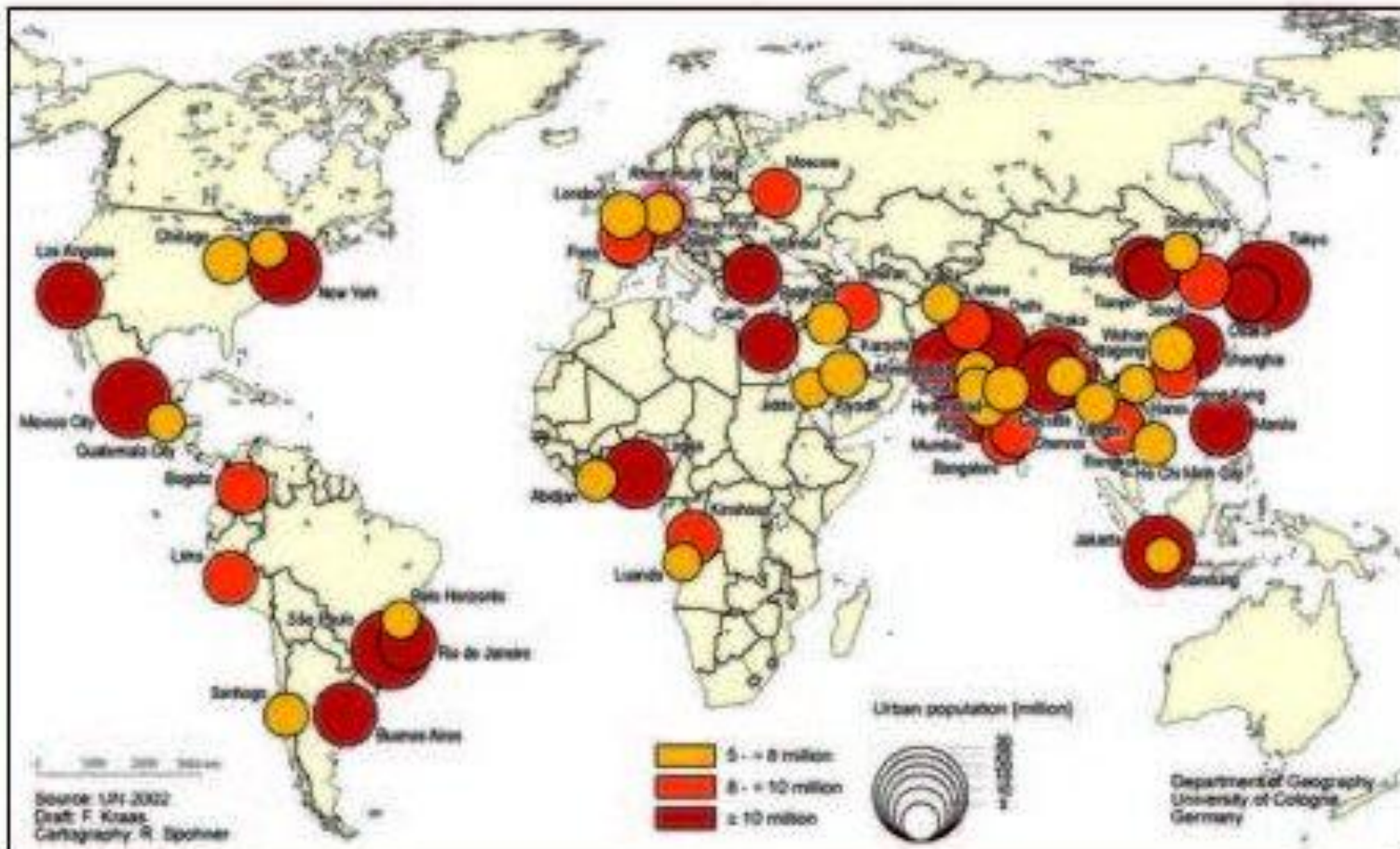
THE CONUNDRUM:

- The 21st century is the first “urban century”
- In 2000, approximately 3 billion people (40% of global population) resided in urban areas
- The United Nations estimates that by 2025, 60% of the world’s population will live in cities
- As a consequence, the number of “megacities” – those cities with populations of 10 million or more – will increase to 100 by 2025



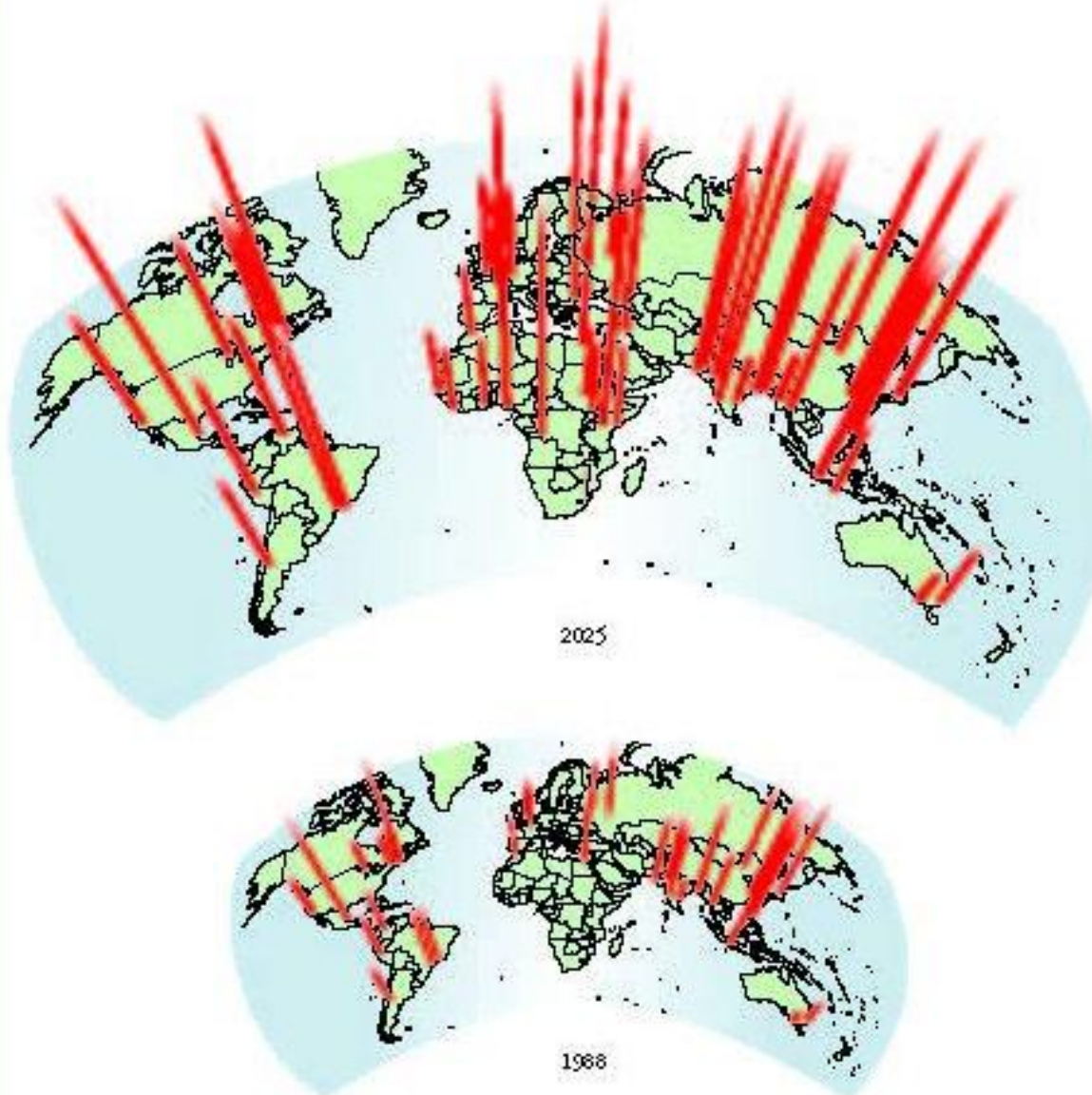
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Map of Megacities worldwide in the year 2015.



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Megacities and population growth, 1988 - 2025



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Key Question Regarding Urbanization and the Impacts of Climate Change on Urbanization

- *How does urbanization affect the local, regional, and global environment and how will climate change impact the overall effects that urban areas have on the environment?*
- *What changes can be observed and measured in the albedo and emissivity of urban surfaces for different cities around the world?*
- *How will these factors impact urban heat island dynamics under climate change scenarios at the local, regional, and even global scales?*



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TQ4. Urbanization/Human Health

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



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TQ4. Urbanization/Human Health (Cont'd)

- 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?
- What changes can be observed and measured in 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?



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The U.S.
Climate Change Science Program
Vision for the Program
and Highlights
of the Scientific Strategic Plan



A Report by the Climate Change Science Program and
the Subcommittee on Global Change Research



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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



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CLIMATE CHANGE VULNERABILITIES AND IMPACTS IN HUMAN SETTLEMENTS

Determinants of Vulnerabilities/Impacts

In many cases, it has been difficult to project impacts of climate change

Climate change forecasts currently are not specific enough for decision-making at the human settlement/urban level

- **More often, attention is paid to vulnerabilities to climate change**
- **At the current state of knowledge, vulnerabilities to possible impacts are easier to project than actual impacts**



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Potentials for Adaptation to Climate Change in Human Settlements

Where climate change might present risks of adverse impacts for settlements and their populations, there are two basic alternatives to respond to such concerns:

1. **Mitigation strategies** (e.g., by taking actions to reduce their greenhouse gas emissions and by showing leadership in encouraging others to support such actions)
2. **Adaptation strategies** (e.g., finding ways either to reduce sensitivity to projected changes or to increase the settlement's coping capacities)
3. **Combining both mitigation and adaptation strategies**



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THE CHALLENGE:

- **What will be the role that HypsIRI will play in addressing the vexing questions related to climate impacts on urban areas?**
- **What kinds of HypsIRI data products will be needed at local, regional and global scales to address these questions?**
- **How can HypsIRI data be used to help develop risk assessment plans and mitigation and adaptation strategies for climate change impacts that can be used by decision makers, policy makers, and the general public?**



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National Climate Assessment

U.S. Global Change Research Program

Climate Change Impacts and Responses:
Societal Indicators for the National Climate Assessment

Workshop Discussion Paper



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Societal Indicators of Climate Change: Climate Vulnerability, Risk Reduction, and Adaptation

Although there are many, HysplRI data products can target several indicators to identify and monitor climate change impacts on urban areas, help assess the vulnerability/risk of urban areas to climate change, and assist in developing adaptation measures as related to:

- Human health, heat mortality and morbidity vectors (e.g., heat events)
- Heat and air quality
- Urban Heat Island (UHI)
- Land Cover/Land Use change



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Critical to Societal Indicators and Climate Change Impacts and Responses are:

- **We must have measurable and reliable data**
- **These data must be verifiable and validated**





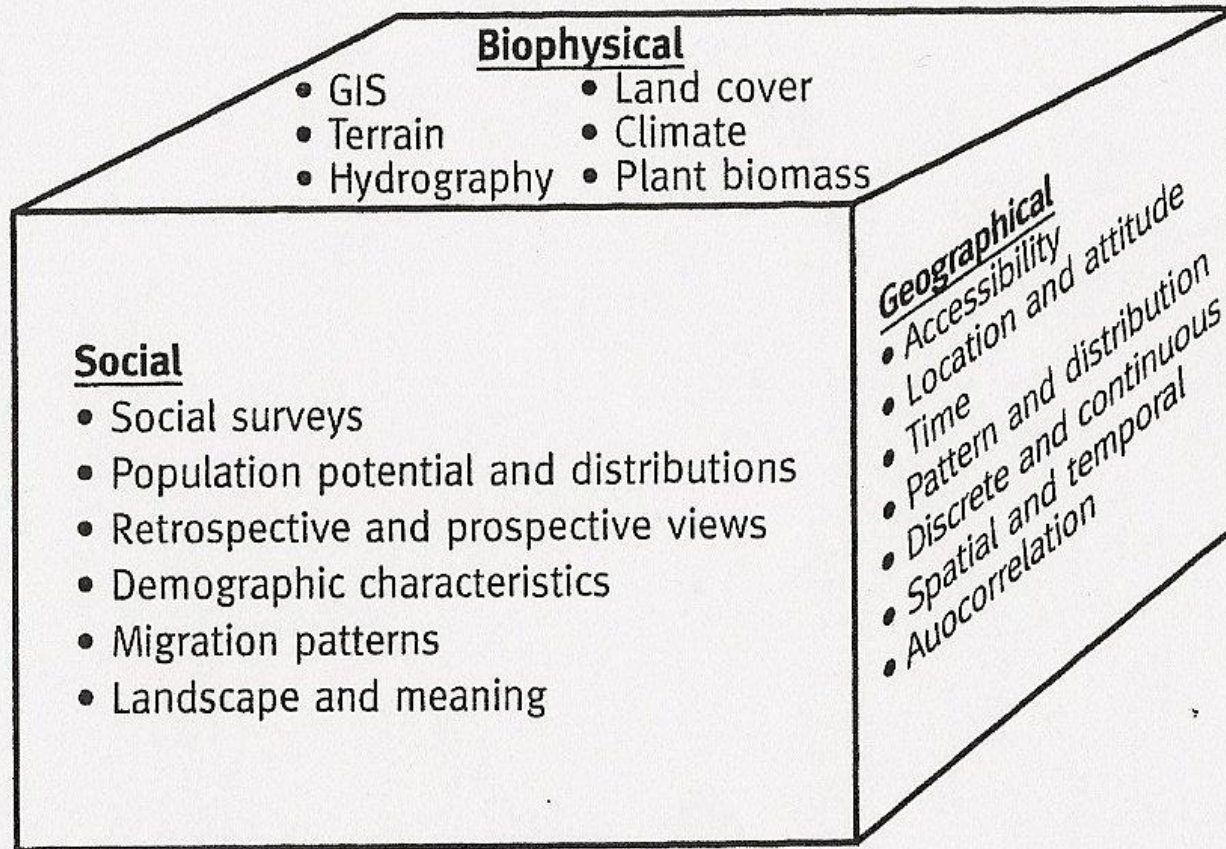
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Societal Indicators of Climate Change: Climate Vulnerability, Risk Reduction, and Adaptation – Spatial and Temporal Scaling

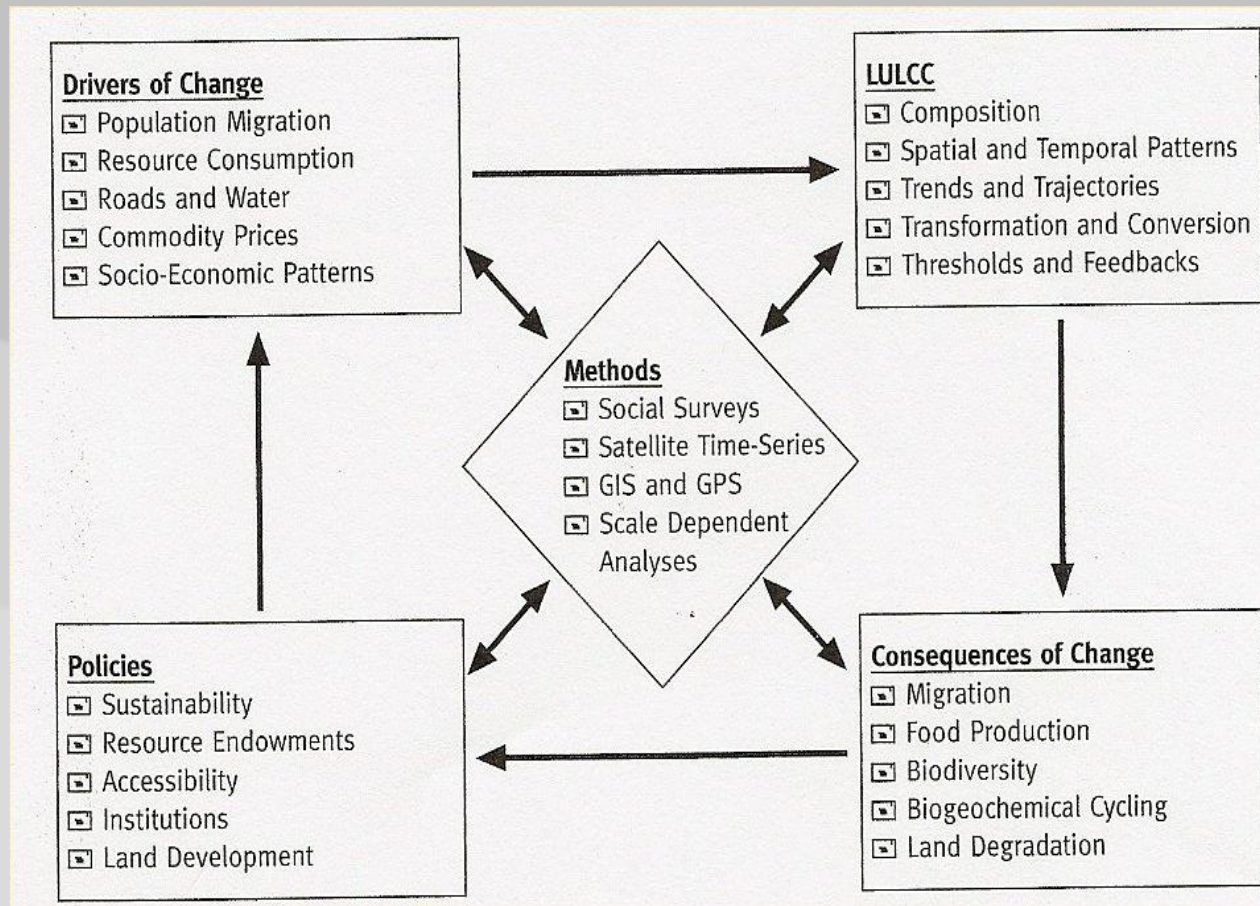
An ideal approach is to develop “nested” indicators so that the same indicator approach can be used at local, regional, and national scales to allow for comparisons across different geographical regions and for the targeted identification of vulnerable locations.



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Human health, heat mortality, morbidity vectors:

- HyspIRI Data Products:
 - Surface temperature across the urban landscape (local, regional, national scales)

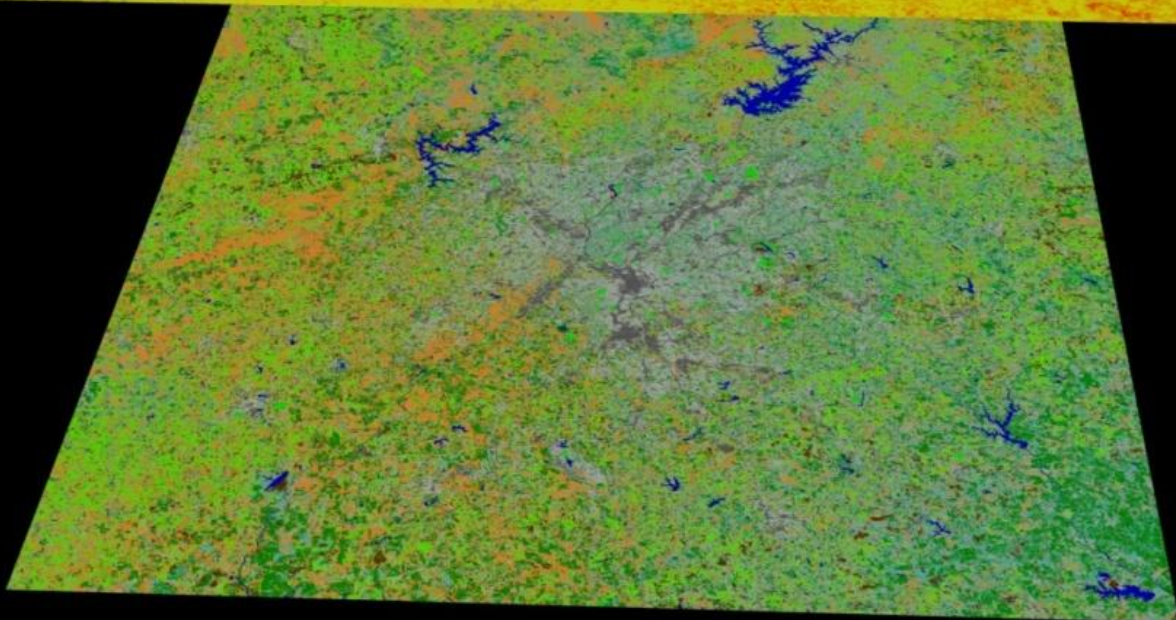
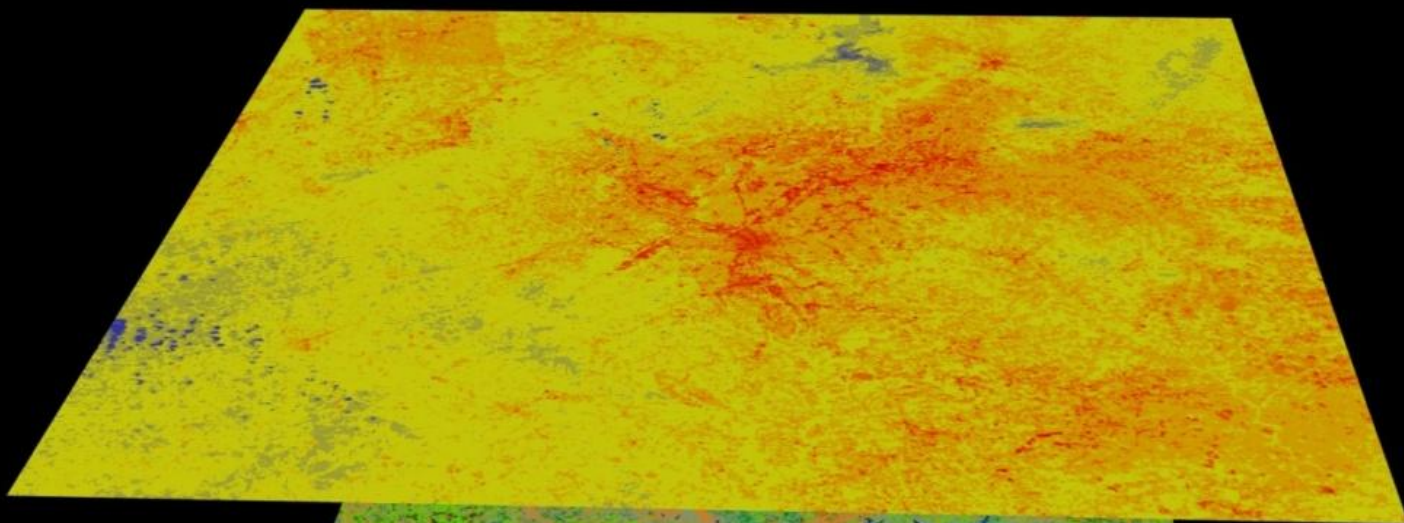
60m Multispectral TIR data/day & night acquisition

Excellent NEdT (0.2 K)

5-day repeat cycle

600 km swath width





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Heat and air quality:

- HyspIRI Data Products:
 - Urban surface heating through time for input into air quality models (regional, national scale)

60m Multispectral TIR data

Excellent NEdT (0.2 K)

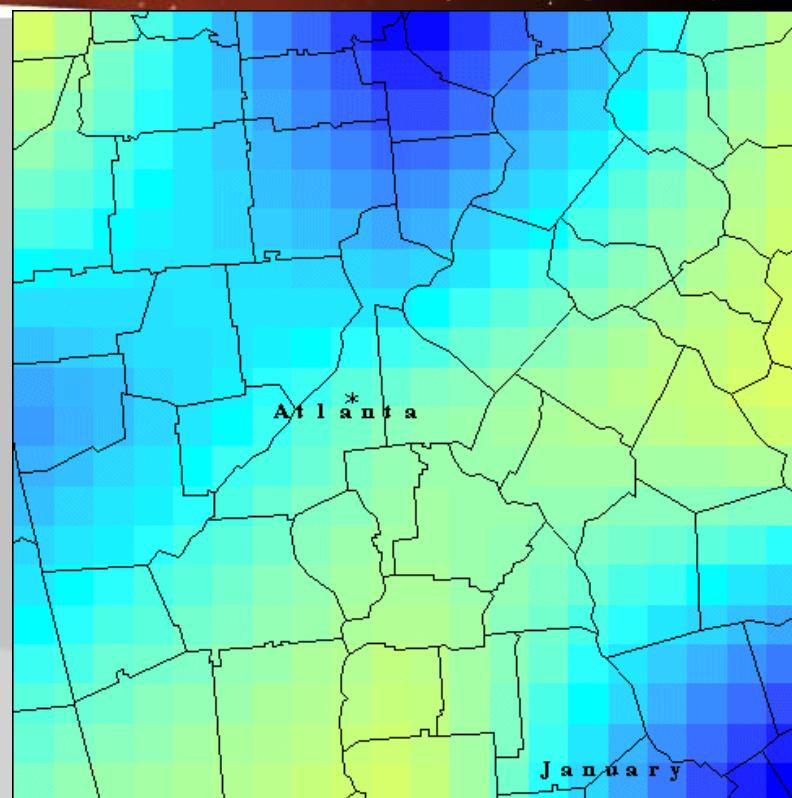
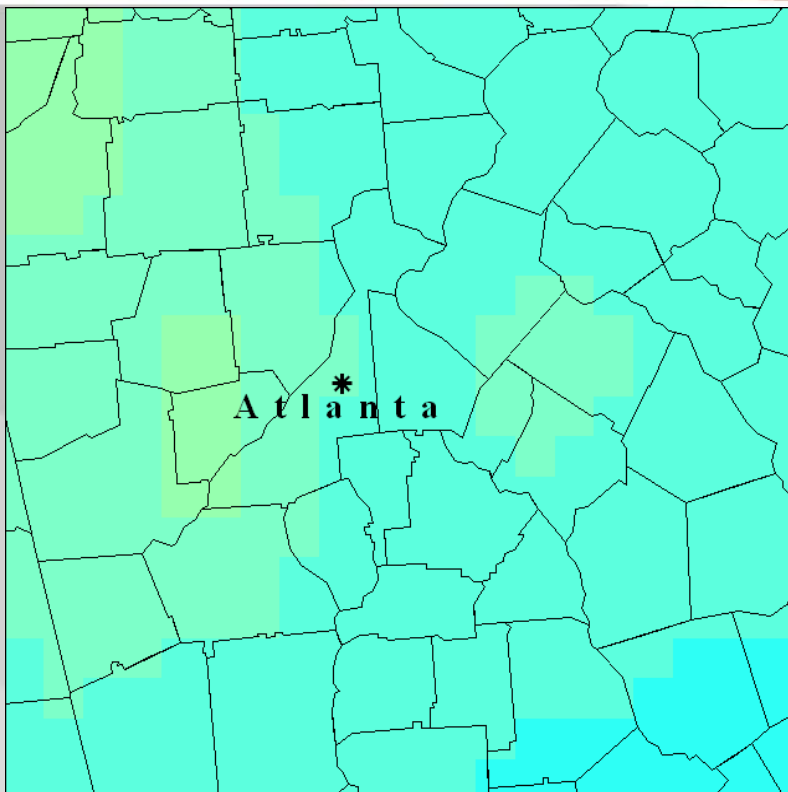
5-day repeat cycle/day & night acquisition

600 km swath width

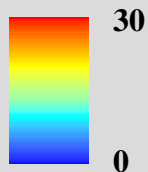


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Year 2002

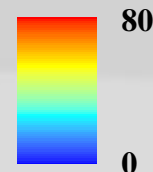


Monthly Mean PM_{2.5} (ug/m³)



January

Monthly Asthma Visits Rate (Per 10,000)



Year 2002



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Urban Heat Island (UHI):

- HyspIRI Data Products:

- Urban land cover change, surface energy fluxes through time, albedo (local to regional scales)

60 Hyperspectral VSWIR data with good revisit time

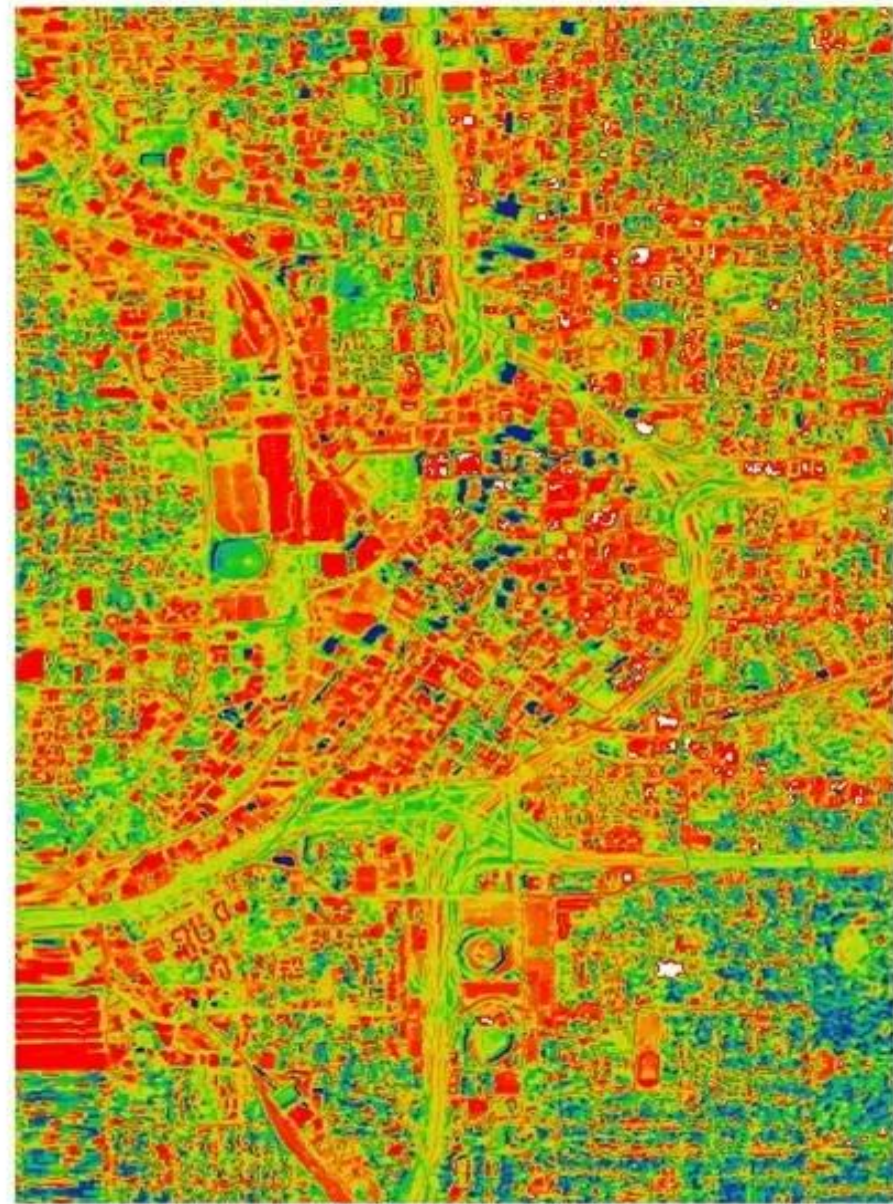
60m Multispectral TIR data

Excellent NEdT (0.2 K)

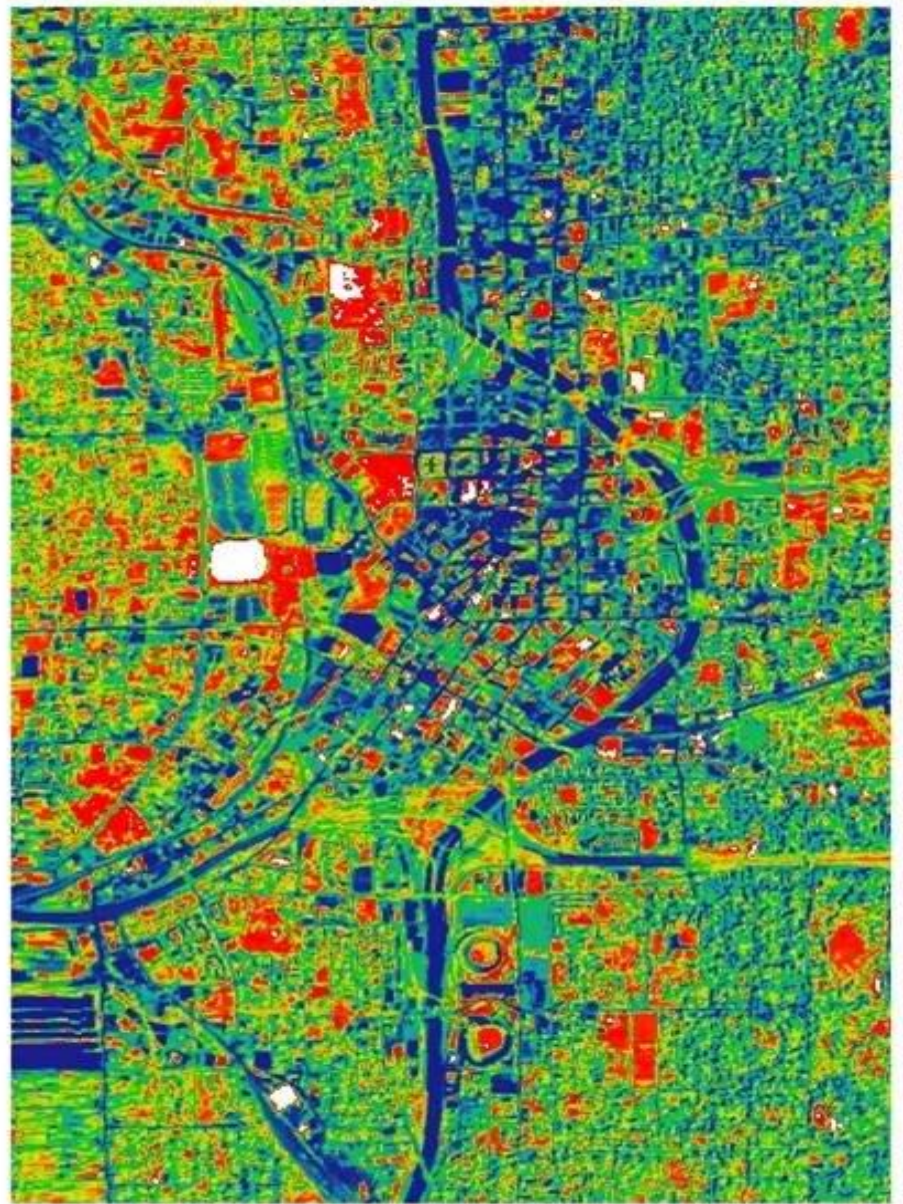
5-day repeat cycle/day & night acquisition

600 km swath width





Temperature



Albedo

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Land Cover/Land Use change:

- HyspIRI Data Products:

- Urban land cover change (local, regional, ~national scales)

60 Hyperspectral VSWIR data: 19-day revisit time @ equator

3-days cross-track pointing

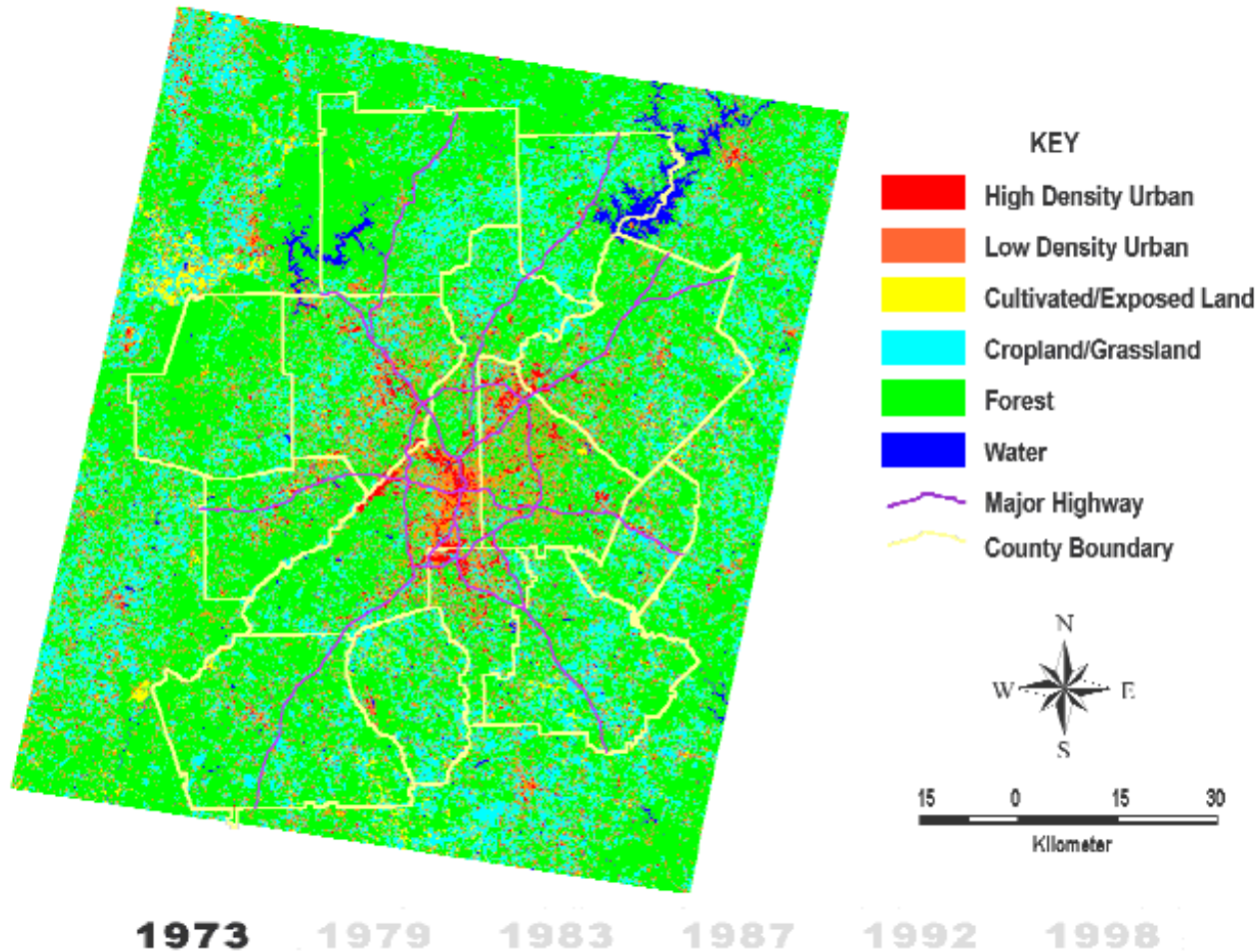
60m Multispectral TIR data @ 5-day revisit time

600 km swath width



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Changes in Land Use/Cover, Atlanta: 1973-1998



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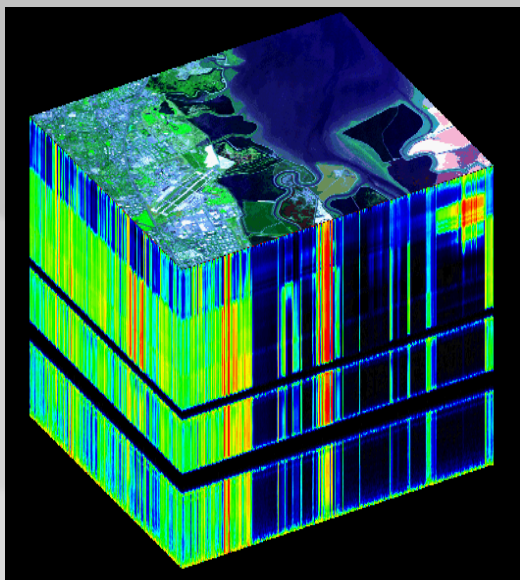
Summary

Utility of HypsIRI Data Products to the National Climate Assessment and for the World:

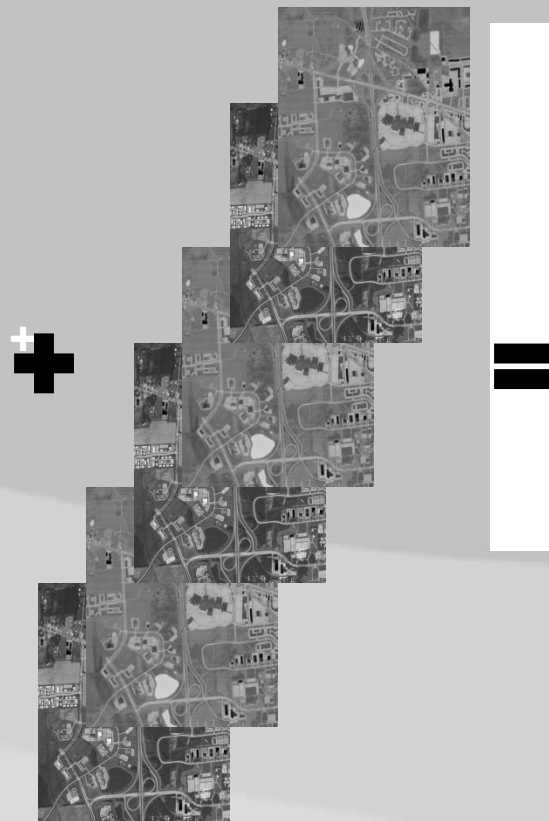
- Measurable and reliable data
- Data will be verified and validated
- Data collected can be applied to local, regional, national – and global scales
- Data will fill significant gap for identifying climate indicators (physical/ecological/social) using remote sensing that can be integrated and assimilated with other non-remotely sensed data on societal conditions to better evaluate climate change impacts on urban areas, assess the vulnerability/risk of urban areas to climate change, and assist in developing adaptation measures



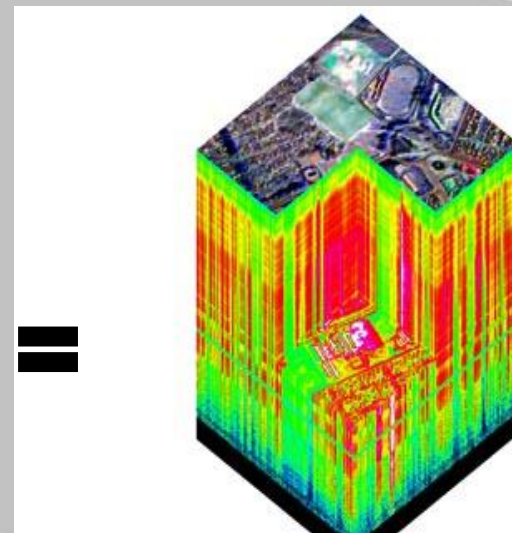
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**HypsIRI
Hyperspectral
VSWIR Level II
Product**
(NDVI, fPAR,
surface
reflectance
characteristics)



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

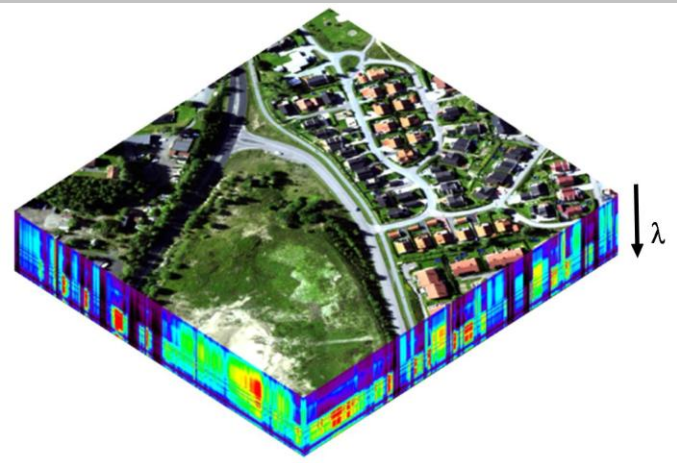


**HypsIRI VSWIR/TIR
composite data set**
(quantitative integrative
measurement of urban
surface reflectances,
temperatures, and
emissivity across the urban
ecosystem)

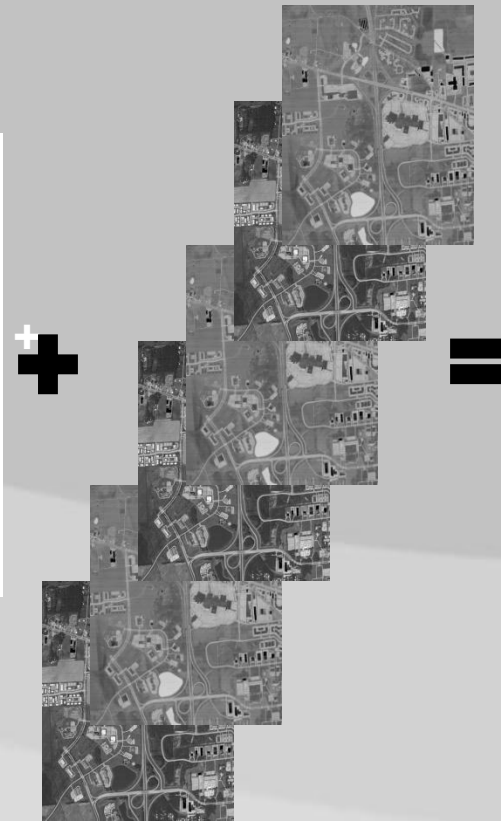


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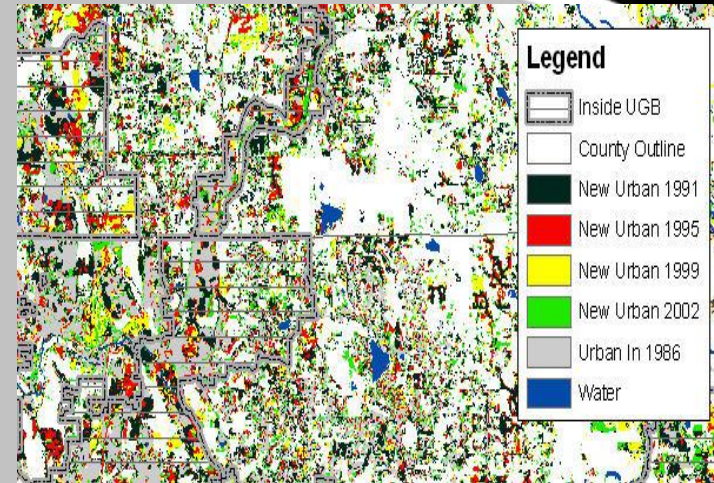
Through Time



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

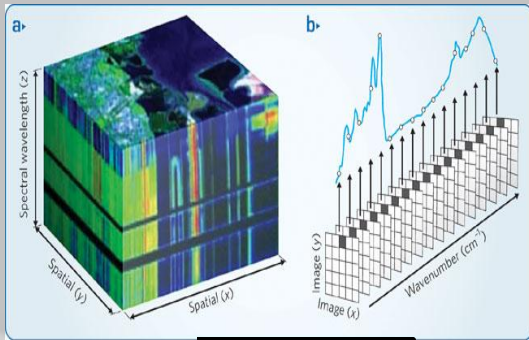


**HyspIRI TIR multispectral
Level II product (8 TIR
Bands)**
(surface temperature, radiance,
[day/night], emissivity)

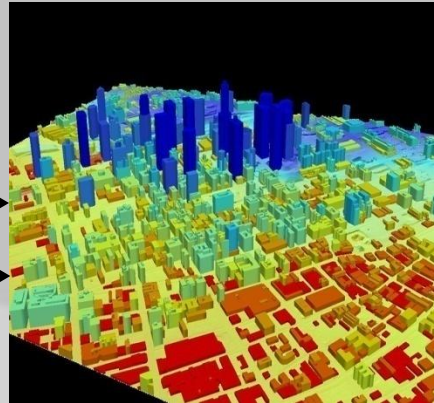


**HyspIRI VSWIR/TIR
composite land cover
change data set**
(quantitative integrative
measurement of urban
surface reflectances,
temperatures, and
emissivity across the urban
ecosystem as they change
through time)

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



Lidar Data



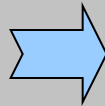
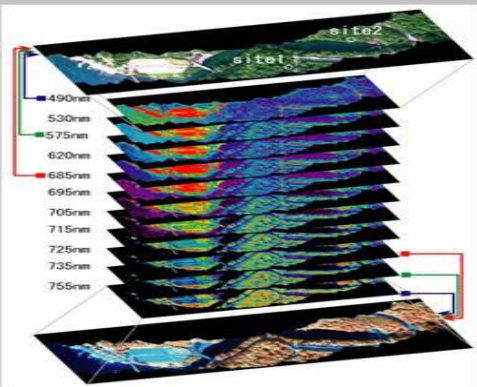
HyspIRI VSWIR/TIR and Lidar composite data set

(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)

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

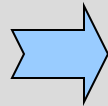


**Digital Topographic Data
(DEM)**

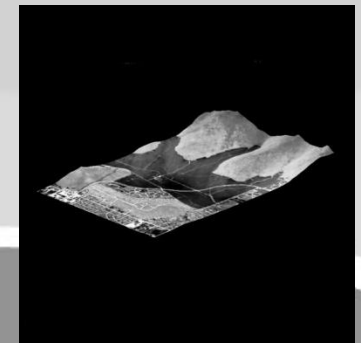
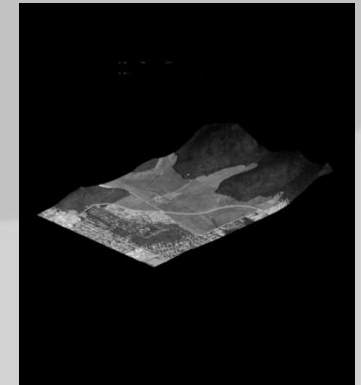
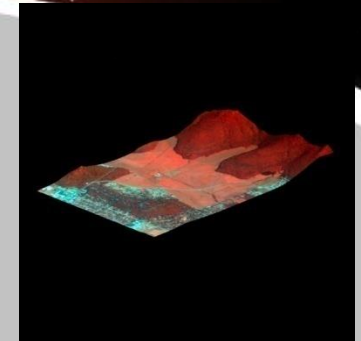
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**HyspIRI VSWIR/TIR and DEM
composite data set
(hyperspctral/day/night TIR digital
elevation model data sets))**



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





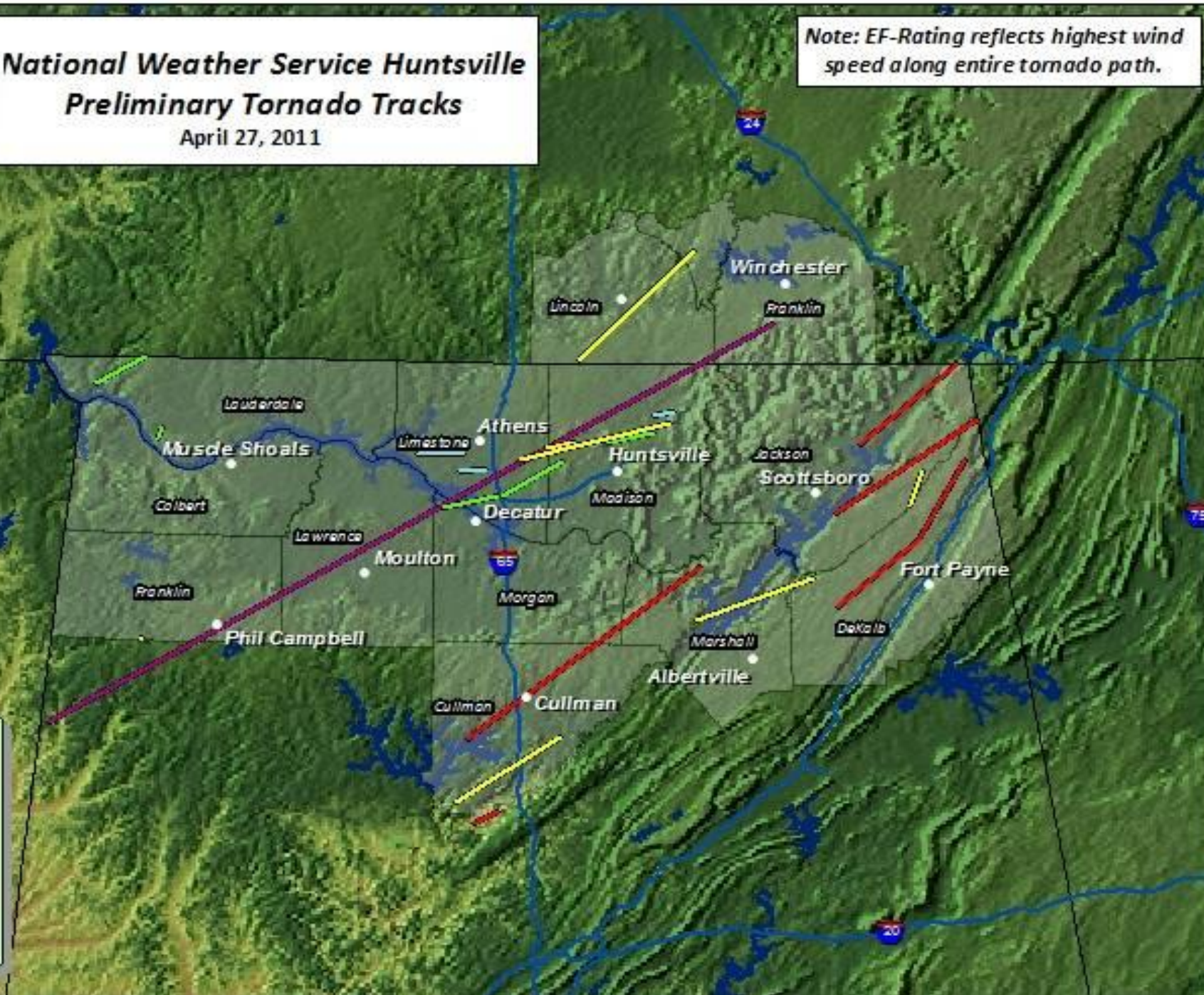


National Weather Service Huntsville Preliminary Tornado Tracks

April 27, 2011

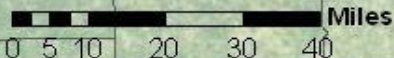
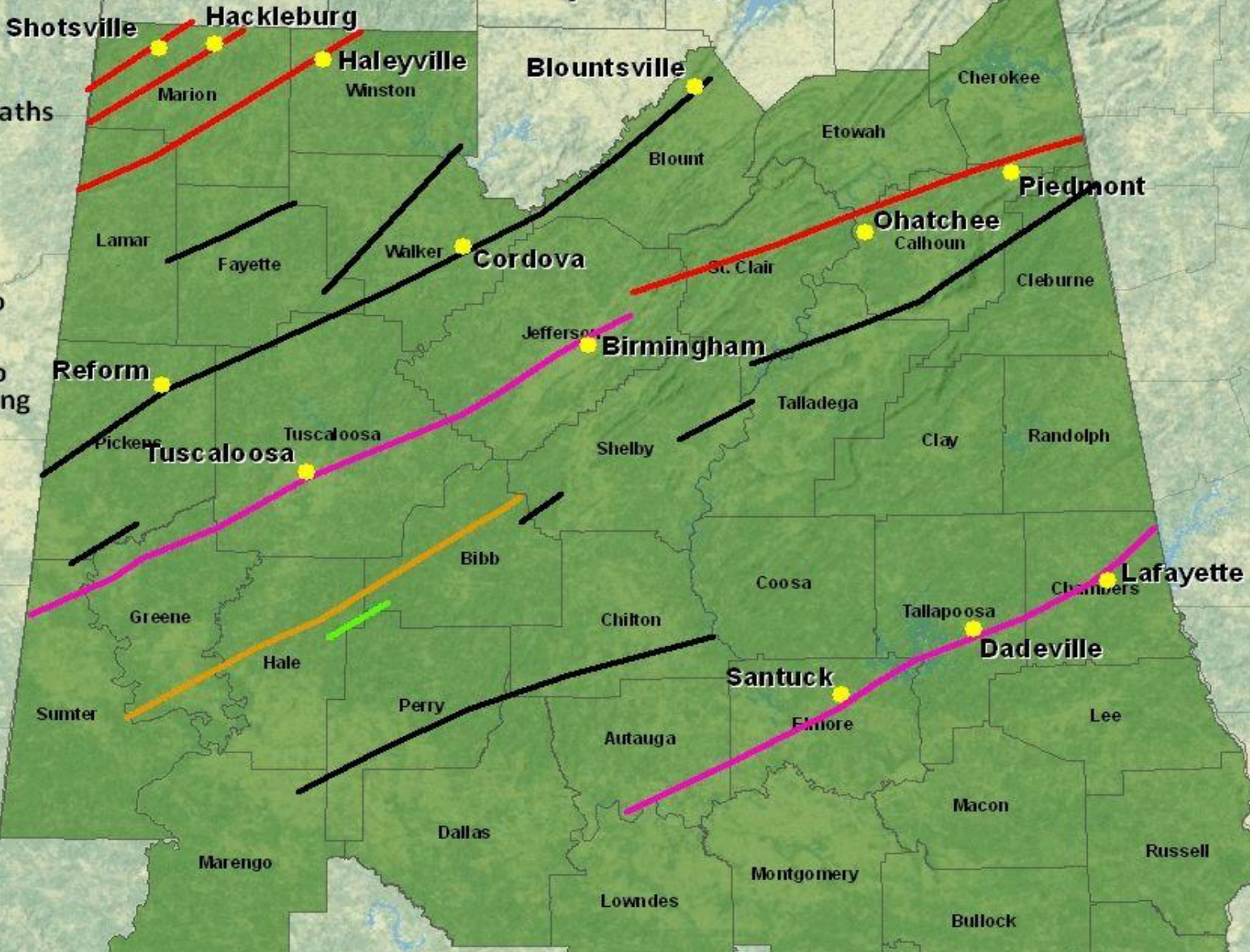
Note: EF-Rating reflects highest wind speed along entire tornado path.

- EF Rating**
- EF0
 - EF1
 - EF2
 - EF3
 - EF4
 - EF5



Supercell Track Information Tornado Outbreak - April 27, 2011

- Non Verified Paths
- EF-1 Tornado (Confirmed)
- EF-3 Tornado (Confirmed)
- EF-3 + Tornado (Confirmed)
- EF-3 + Tornado Surveys Ongoing



[Click for more information](#)

Tornado track ASTER data

(MSFC SPoRT Lab)



tornado track—

Pleasant Grove

Concord

Hueytown

I-20

1 km

Tornado track ASTER data

(MSFC SPoRT Lab)

