Assessing the Impact of Urbanization Using Remote Sensing On A Global Scale, Past Present And Future Directions

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Global Urbanization- A Sense of Scale

• 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
Surface Radiation Budget

\[ Q^* = (K_{in} + K_{out}) + (L_{in} + L_{out}) \]

\[ Q^* = \text{Net Radiation} \]

\[ K_{in} = \text{Incoming Solar} \]

\[ K_{out} = \text{Reflected Solar} \]

\[ L_{in} = \text{Incoming Longwave} \]

\[ L_{out} = \text{Emitted Longwave} \]
Surface Energy Budget

\[ Q^* = H + LE + G \]

- \( H = \) Sensible Heat Flux
- \( LE = \) Latent Heat Flux
- \( G = \) Storage (maybe + or - )
European heat wave caused 35,000 deaths 2003

Over 15,000 likely dead in Russian 2010 heat wave; Asian monsoon floods kill hundreds more

Heat wave death toll in NYC rises to 8 NYDN 7/23/13

UK Heat wave death toll: Up to 760 killed and total may double as temperatures above 30° c continue 7/18/13

Chicago July 1995 more than 700 died
Quantification and mitigation of long-term impacts of urbanization and climate change in the tropical coastal city of San Juan, Puerto Rico

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Climate Impacts of Land-Cover and Land-Use Changes in Tropical Islands under Conditions of Global Climate Change

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Combined impacts of land cover changes and large-scale forcing on Southern California summer daily maximum temperatures

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Funding Information
Urban Remote Sensing and Air Quality Models

Volatile Organic Compounds + Nitrogen Oxides + Sunlight → Ozone

- Air pollution remains a National issue.
- Temperature increases the ozone levels.
- Urban heat island has major effect on temperature and height of mixing layer.
- Measurement program is defining land use patterns and relationship to heat production.
- Remote sensing data are being used to improve air quality modeling.
NASA's Project Objectives

- To use high spatial resolution thermal infrared and visible data obtained from aircraft to measure, map, and model the surface energy budget characteristics of surfaces typical of the urban landscape for three US cities.
- Provide these data to EPA for evaluation of the overall "fabric" of the cities in relation to the urban heat island and air quality modeling.
- Transfer NASA technology and research to the public.

NASA's Project Atlanta
~ 1996 - 2001

EPA/NASA Urban Heat Island Pilot Project
~ 1997 - 2000

NASA EPSCoR San Juan, Puerto Rico UHI
2004

Urban Heat Island Mitigation Strategies

- Albedo Modification
  - Lighter colored roofs and pavements
  - New materials/coatings
- Plant trees and increase green space
  - Shade buildings, rooftops, parking lots and roads
  - Cool the air through transpiration
- Rooftop gardens
  - Keep roofs cool by shading and/or transpiration
  - Storm water reduction
Baton Rouge
Scatter Plots of Albedo vs Temperature
Baton Rouge Scatter Plots
Albedo vs Temperature

Industrial (refinery)

Bayou (Forest)

CBD

Residential

Whole Mosaic
Epidemiologic Triangle of Disease (Vector-borne Diseases)

A multi-factorial relationship between hosts, agents, vectors and environment.
Water stress is quantified by the Evaporative Stress Index, which relies on evapotranspiration measurements. When stomata close, CO2 uptake and evapotranspiration are halted and plants risk starvation, overheating and death.

**Science Objectives**

- Identify **critical thresholds of water use and water stress** in key climate-sensitive biomes
- Detect the timing, location, and predictive factors leading to plant **water uptake decline** and/or cessation over the **diurnal cycle**
- Measure **agricultural water consumptive use** over the contiguous United States (CONUS) at spatiotemporal scales applicable to improve drought estimation accuracy

**ECOSTRESS** will provide critical insight into **plant-water dynamics** and how **ecosystems change with climate** via **high spatiotemporal** resolution thermal infrared radiometer measurements of evapotranspiration from the **International Space Station** (ISS).
**Mission Concept Status**

**Level 1 Measurement Requirements:** Vetted by community and stable

**Payload:** VSWIR Imaging Spectrometer, TIR Multi-spectral Radiometer, and **Intelligent Payload Module (IPM)**

**Full Mission original option:** Mature

**Separate Small Mission option:** Pegasus-based solutions identified and studied

*SLI Support: HyspIRI VSWIR evolving to 30m at 185km swath

**ECOSTRESS TIR:** Selected EVI for ISS

**VSWIR Dyson Option:** Technology/Science ISS Demonstration

**Summary:** The HyspIRI mission measurement requirements and baseline instruments approach are mature and stable with good heritage, low risk and modest cost. Now exploring a range of instrument and data options to save cost, per guidance letter.

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**HyspIRI Objectives and Approach**

**Key Science and Science Applications**

**Climate:** Ecosystem biochemistry, condition & feedback; spectral albedo; carbon/dust on snow/ice; biomass burning; evapotranspiration

**Ecosystems:** Global biodiversity, plant functional types, physiological condition, and biochemistry including agricultural lands

**Fires:** Fuel status; fire frequency, severity, emissions, and patterns of recovery globally

**Coral reef and coastal habitats:** Global composition and status

**Volcanoes:** Eruptions, emissions, regional and global impact

**Geology and resources:** Global distributions of surface mineral resources and improved understanding of geology and related hazards

**Applications:** Disasters, EcoForecasting, Water, Health/AQ

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**Mission Urgency**

The HyspIRI science and applications objectives are critical today and uniquely addressed by the combined imaging spectroscopy, thermal infrared measurements, and IPM direct broadcast.

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**Measurement**

**Imaging Spectrometer (VSWIR)**
- 380 to 2500nm in ≤10nm bands
- 60 m spatial sampling*
- 19 days revisit*
- Global land and shallow water

**Thermal Infrared (TIR):**
- 8 bands between 4-12 µm
- 60 m spatial sampling
- 5 days revisit; day/night
- Global land and shallow water

**IPM-Low Latency data subsets**
HyspIRI 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?

- Human Health - heat mortality, vector borne diseases
- Heat and Air Quality
- Urban Heat Island (UHI)
- Land Cover/Land Use change
- Regional climate impacts
References


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