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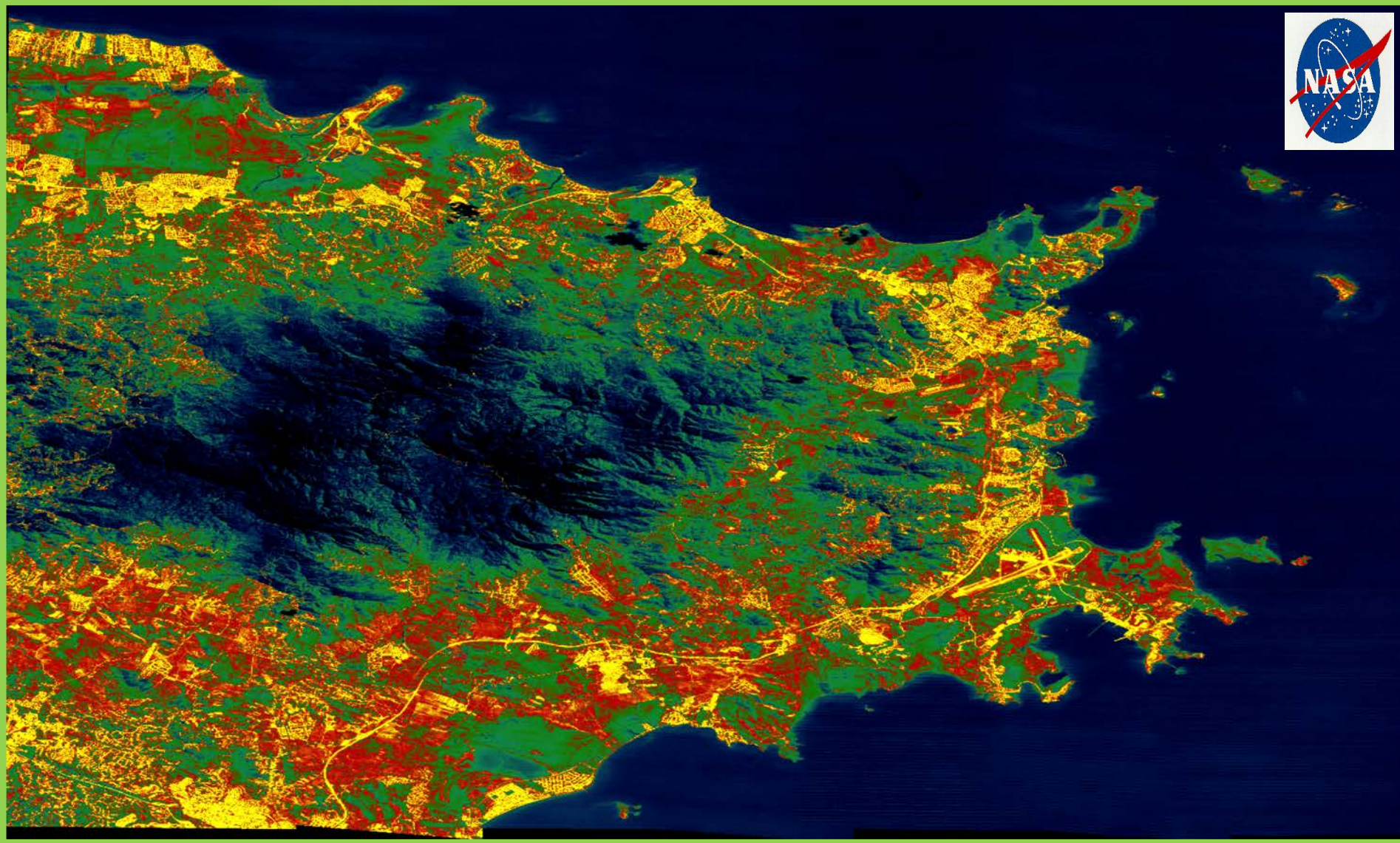
Assessing the Impact of Urbanization Using Remote Sensing On A Global Scale, Past Present And Future Directions



Jeffrey C. Luvall and Glynn Hulley
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JPL

θΔics

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^* = Net Radiation

K_{in} = Incoming Solar

K_{out} = Reflected Solar

L_{in} = Incoming Longwave

L_{out} = 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^{o} c continue 7/18/13
- Chicago July 1995 more than 700 died


ATLANTA 25

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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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(Manuscript received 7 February 2012, in final form 6 September 2012)

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Research Article

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

Pedro Sequera ✉, Jorge E. González, Kyle McDonald, Robert Bornstein, Daniel Comarazamy

First published: 21 September 2015 Full publication history

DOI: 10.1002/2015JD023536 View/save citation

Cited by: 0 articles Check for new citations

Am score 6

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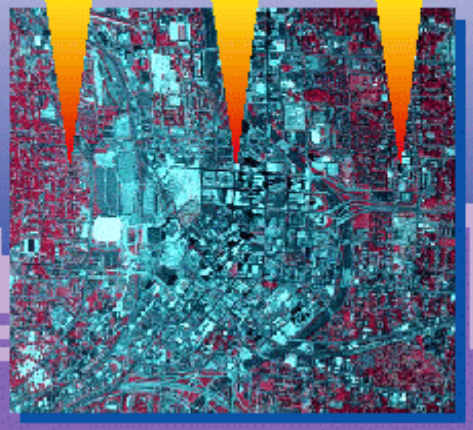
Mission to Planet Earth
National Aeronautics and Space Administration

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.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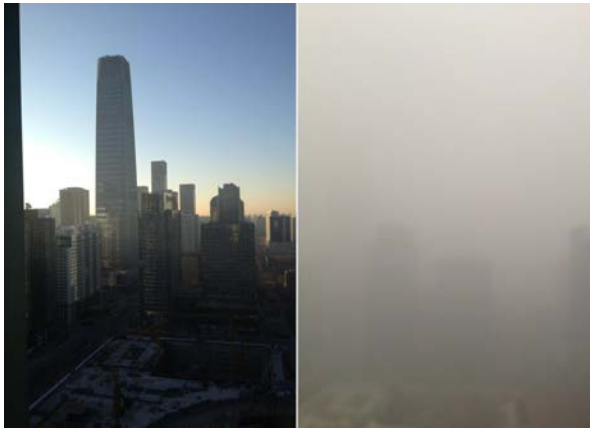


NASA's Project Objectives

- 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

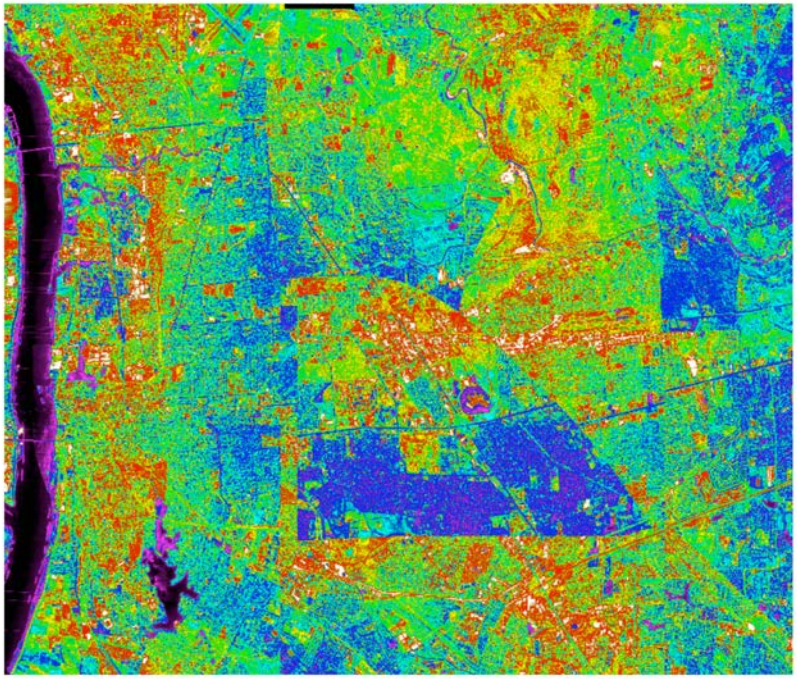
NASA EPSCoR San Juan, Puerto Rico UHI
2004

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

Albedo - May 11, 1998

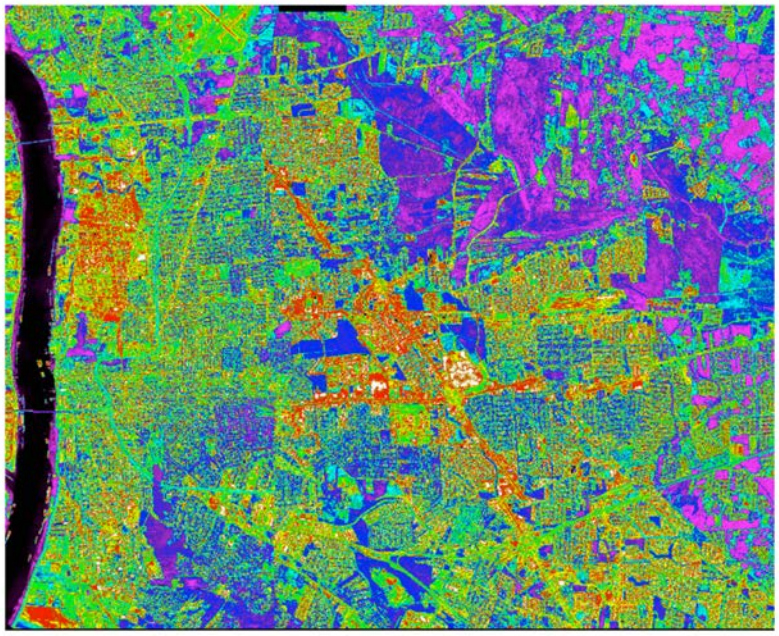


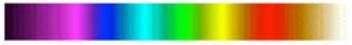
0.07 0.11 0.19 0.23 0.26 0.30 0.35 0.50

Albedo

Baton Rouge

Temperature - May 11, 1998

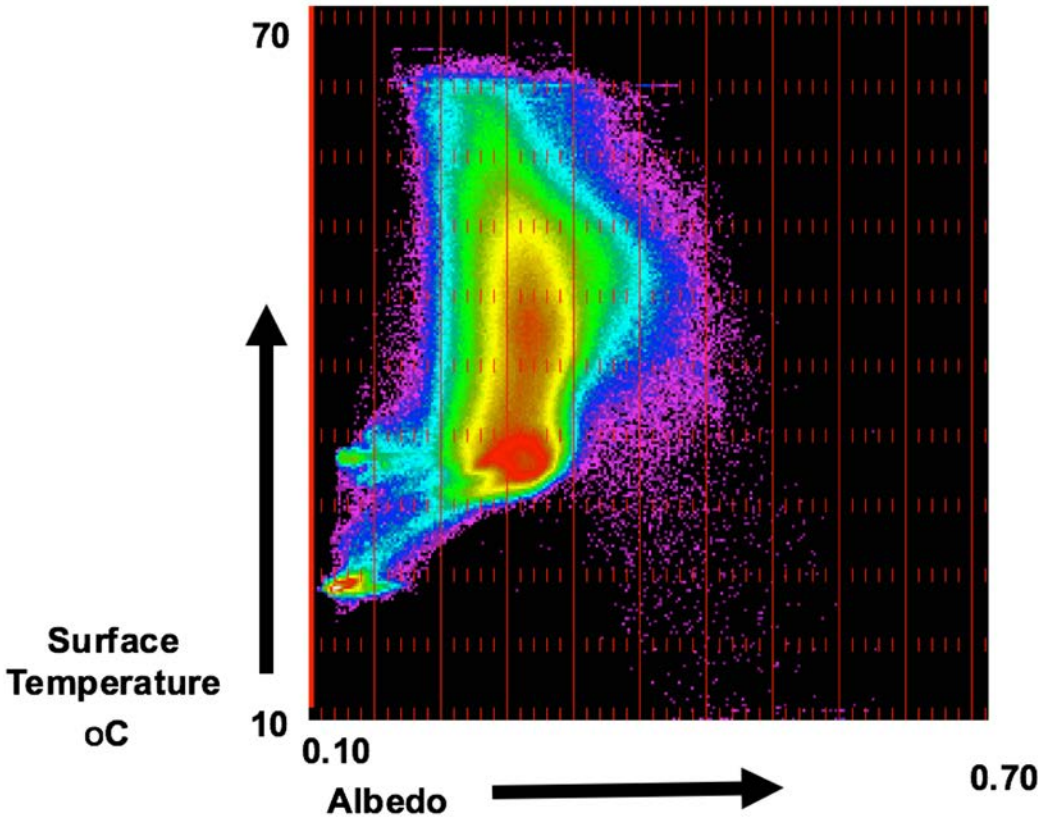




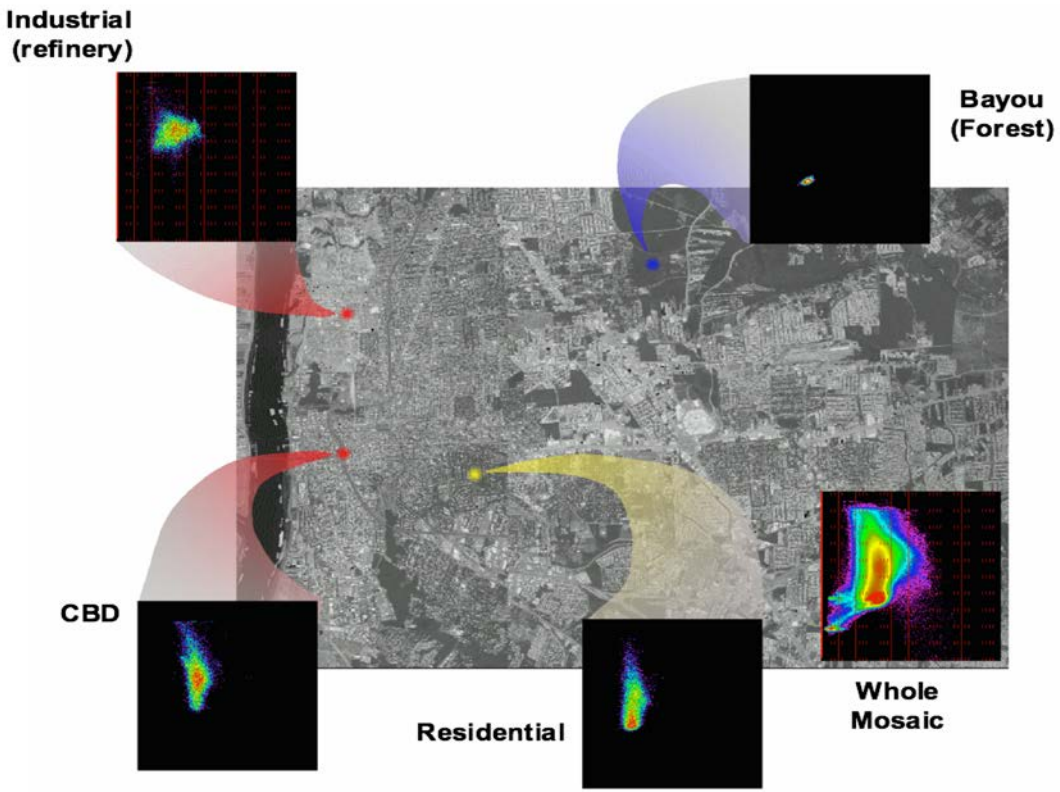
21 30 33 38 41 48 52 63

Temperature oC

Baton Rouge
Scatter Plots of Albedo vs Temperature



Baton Rouge Scatter Plots
Albedo vs Temperature

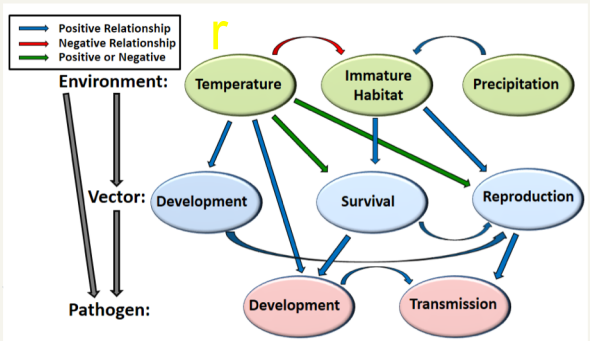


Epidemiologic Triangle of Disease (Vector-borne Diseases)

A multi-factorial relationship between hosts, agents, vectors and

Host

Vecto



Agent
(eg, Pathogen)

Environment
(Climate & Weather)

Morin 2014

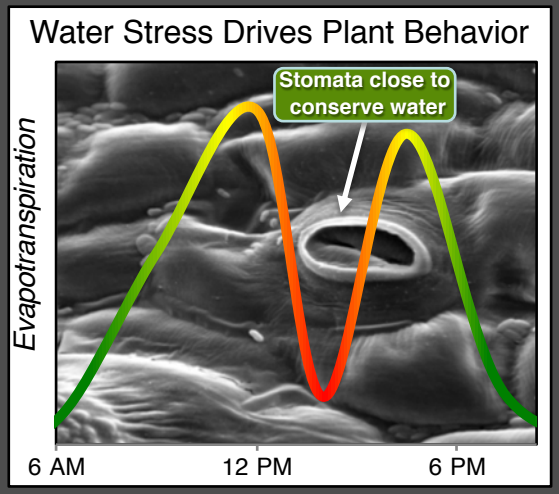
ECOSTRESS

ECOsystem Spaceborne Thermal Radiometer Experiment on Space Station

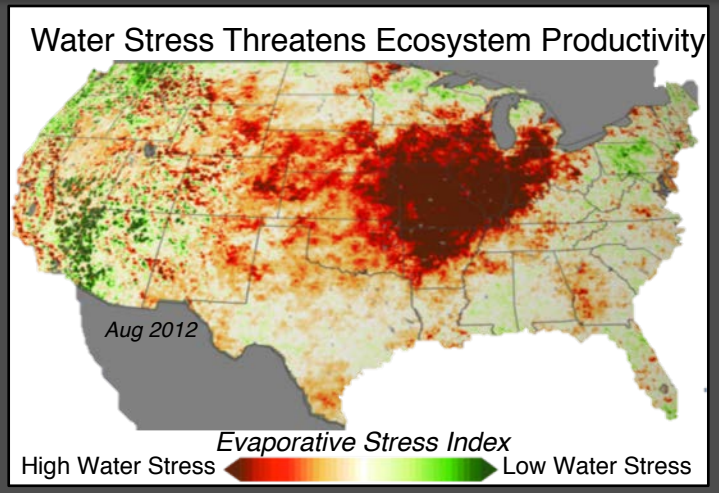
Dr. Simon J. Hook, JPL, Principal Investigator

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



When stomata close, CO_2 uptake and evapotranspiration are halted and plants risk starvation, overheating and death.



Water stress is quantified by the Evaporative Stress Index, which relies on evapotranspiration measurements.

*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).*

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

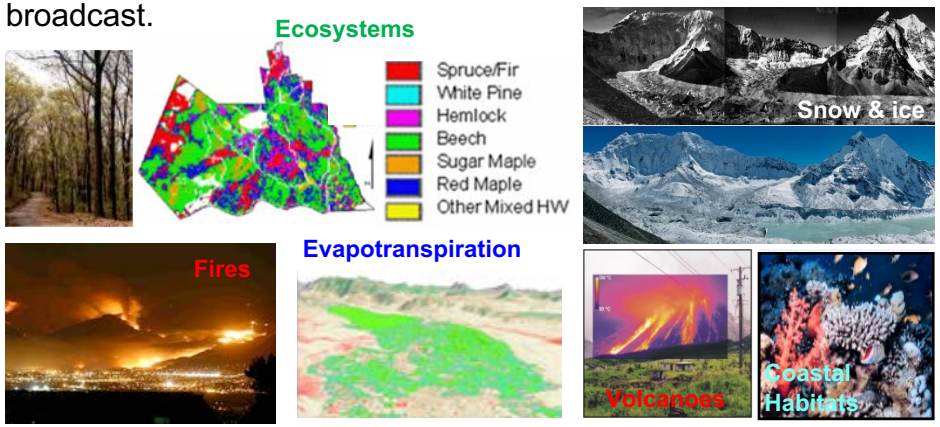
Volcanoes: Eruptions, emissions, regional and *global* impact

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

Applications: Disasters, EcoForecasting, Water, Health/AQ

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.

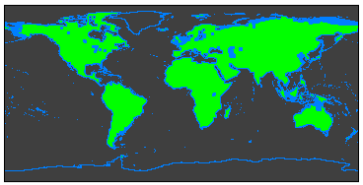


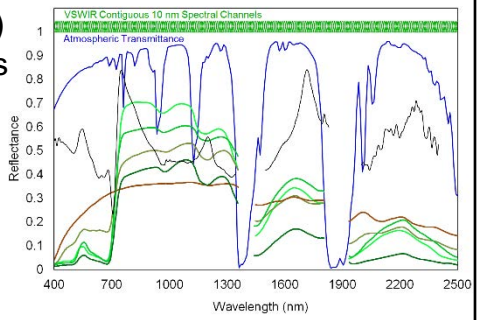
Measurement

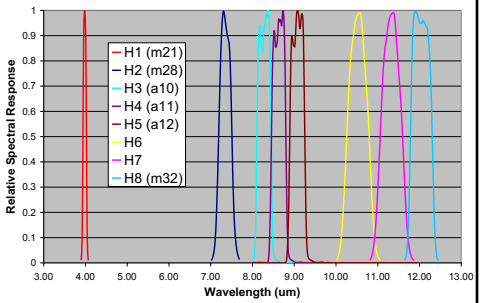
Imaging Spectrometer (VSWIR)
- 380 to 2500nm in ≤10nm bands
- 60 m spatial sampling*
- 19 days revisit*
- Global land and shallow water

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







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.

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

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