ECOSTRESS - Pathway for Use of HyspIRI Thermal Data

- Urban Climatology
- Aquatic Ecosystems
- Public Health
- DEVELOP Projects
- Water Resources

Jeffrey Luvall MSFC
Christine Lee and Simon Hook JPL
ECOSTRESS Science Team Meeting, May 2017

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

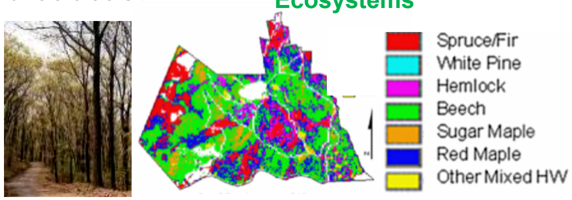
Volcanoes: Eruptions, emissions, regional and *global* impact

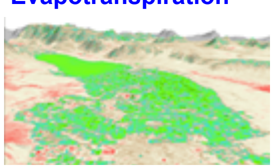
Geology and resources: *Global* distributions of surface mineral resources and improved understanding of geology and related hazards

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

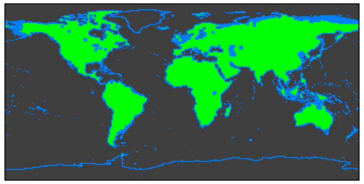
Imaging Spectrometer (VSWIR)

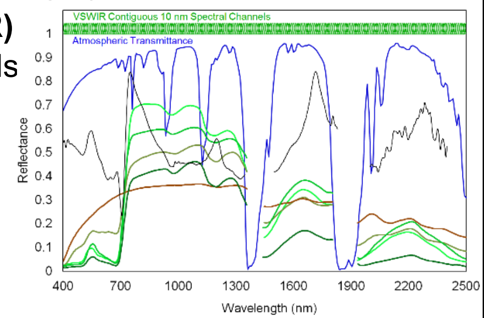
- 380 to 2500nm in ≤10nm bands
- 30 m spatial sampling*
- 19 days revisit*
- Global land and shallow water

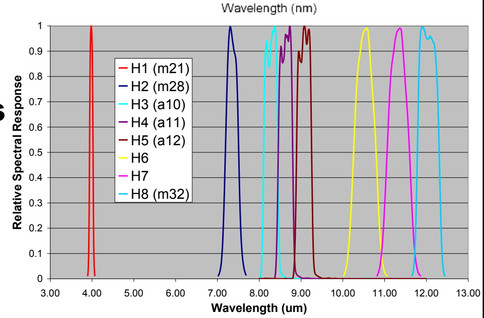
Thermal Infrared (TIR):

- 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**

International Journal of Low-Carbon Technologies Advance Access published September 5, 2013

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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[2]*The NOAA-CREST Center and Department of Mechanical Engineering, The City College of New York, New York, NY, USA;* [3]*Global Hydrology and Climate Center, NASA Marshall Space Flight Center, Huntsville, AL, USA*

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

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Department of Meteorology and Climate, San Jose State University, San Jose, California

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

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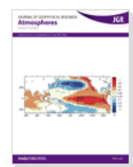

View issue TOC
Volume 120, Issue 18
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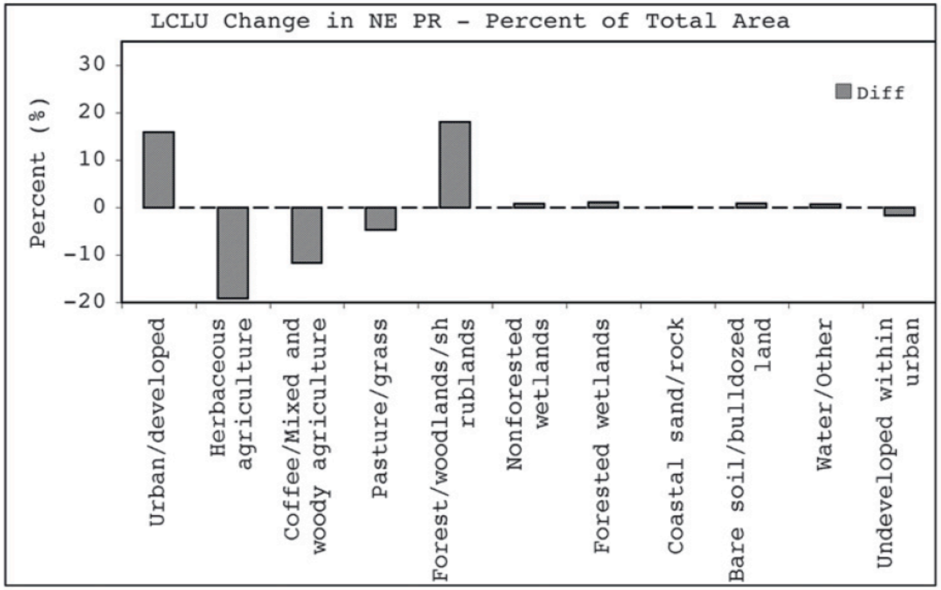
Research Article

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

Funding Information



Northeastern Puerto Rico

Description	class	1951	2000	Diff
Background/water	0			
Urban/developed	30	1.92	17.81	15.89
Herbaceous agriculture	8	19.19	0.09	-19.10
Coffee/Mixed and woody agriculture	12	12.38	0.76	-11.62
Pasture/grass	27	33.73	28.99	-4.74
Forest/woodlands/shrublands	3	9.37	27.43	18.06
Nonforested wetlands	16	0.00	0.76	0.76
Forested wetlands	19	0.00	1.08	1.08
Coastal sand/rock	26	0.00	0.14	0.14
Bare soil/bulldozed land	29	0.00	0.91	0.91
Water/Other	1	0.23	0.93	0.70
Undeveloped within urban	7	1.71	0.00	-1.71

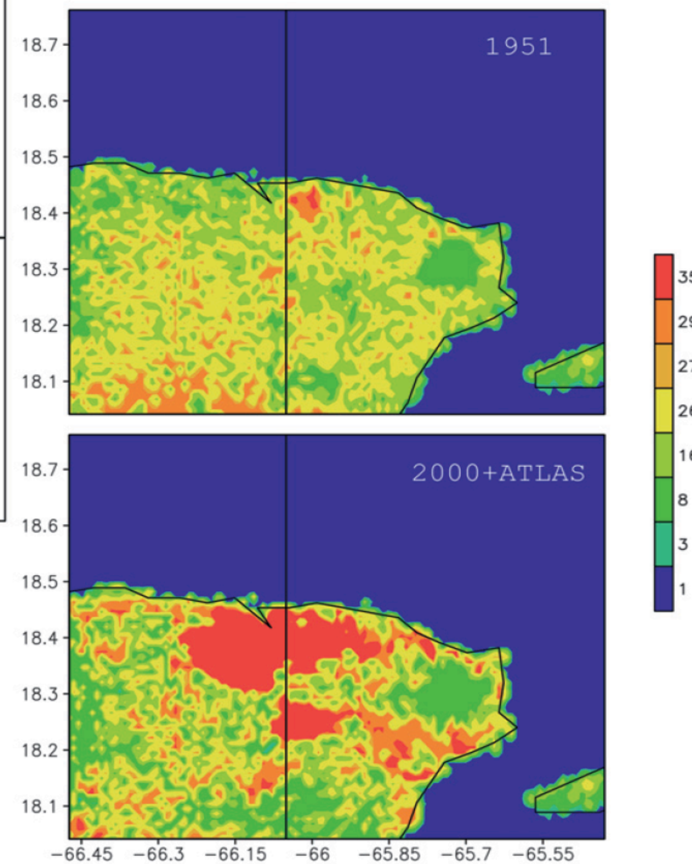


FIG. 3. (right) Map showing the LCLU specifications in northeastern Puerto Rico for (top) 1951 and (bottom) 2000; 2000 information is complemented with remote sensing data obtained from the ATLAS sensor. The thick solid vertical line represents the location of the north–south vertical cross section in Figs. 8 and 9. (left) (top) Histogram of historical LCLU changes in percent of total area covered from 1951 to 2000 and (bottom) description of the most relevant vegetation and land classes with percent change and conversion rates.

Comarazamy, Daniel E, Jorge E Gonz‡lez, Jeffrey C Luvall, Douglas L Rickman, and Robert D Bornstein. 2013. “Climate Impacts of Land-Cover and Land-Use Changes in Tropical Islands Under Conditions of Global Climate Change.”Journal of Climate 26 (5): 1535–50. doi:10.1175/JCLI-D-12-00087.

World Urban Database

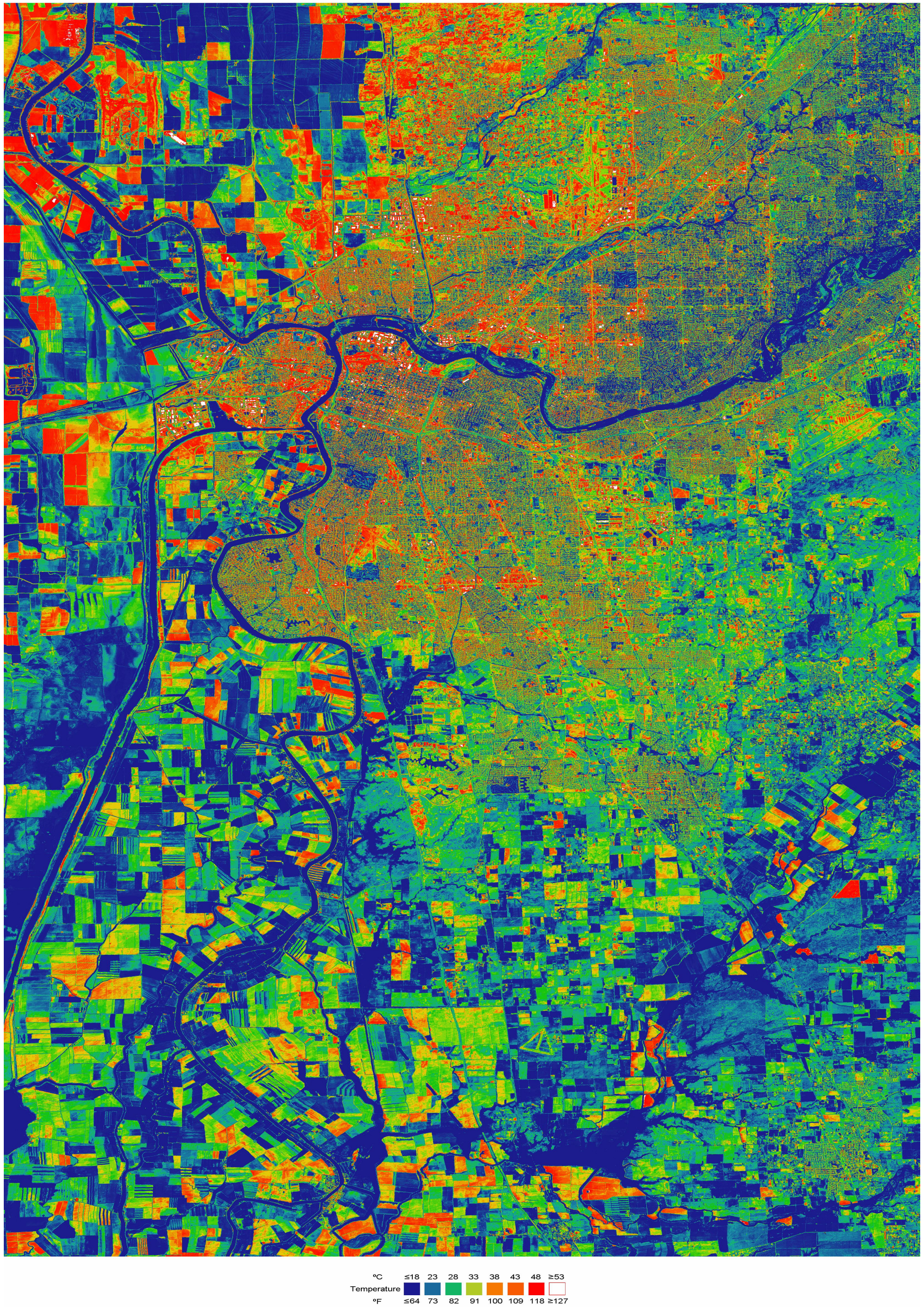
Home | Cities | Local Climate Zones | Outreach | Want to get involved? | Resources | HUMINEX 2.0

The World Urban Database and Access Portal Tools (WUDAPT) is an initiative to collect data on the form and function of cities around the world.

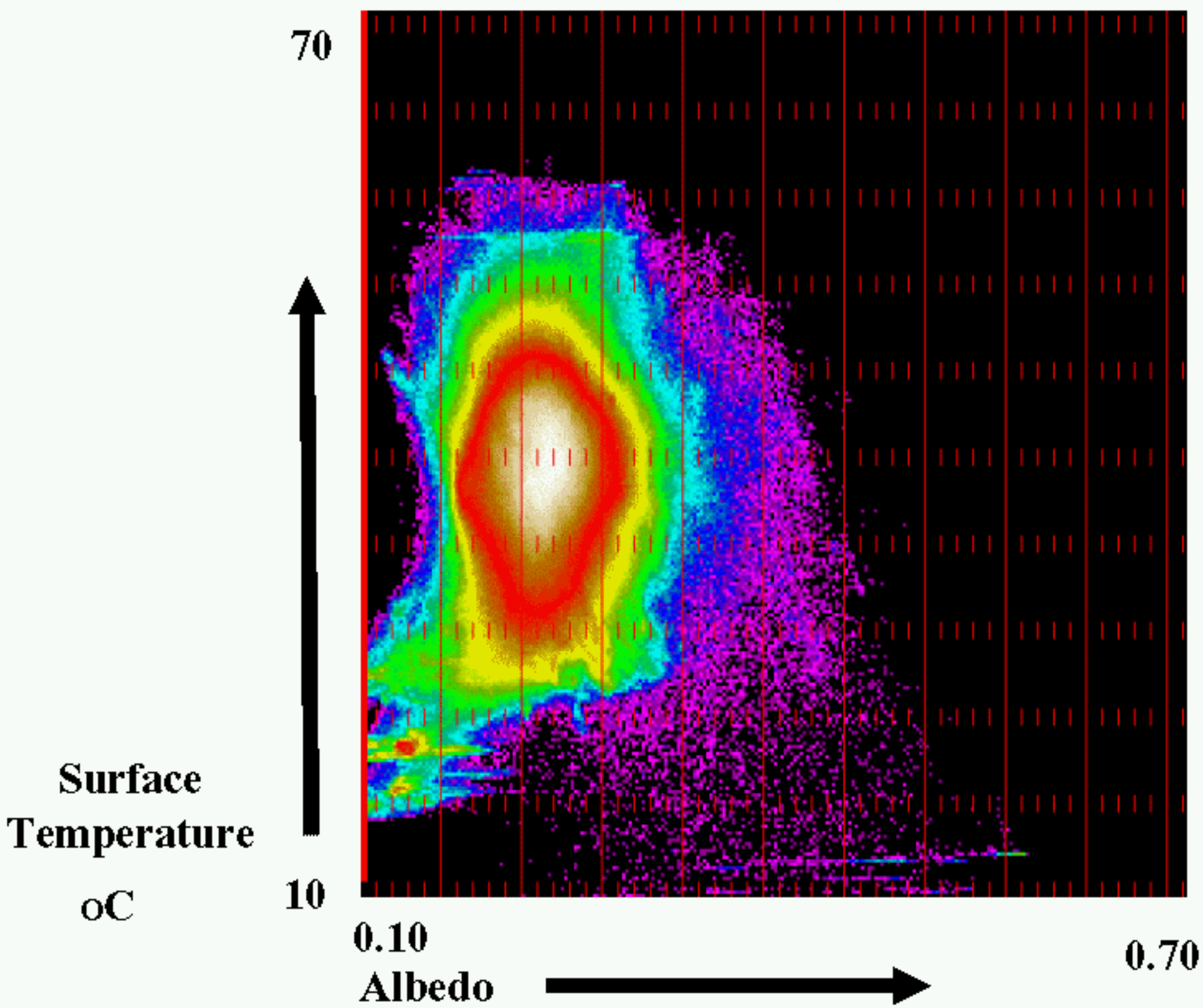
VIEW THE VIDEO

http://www.wudapt.org

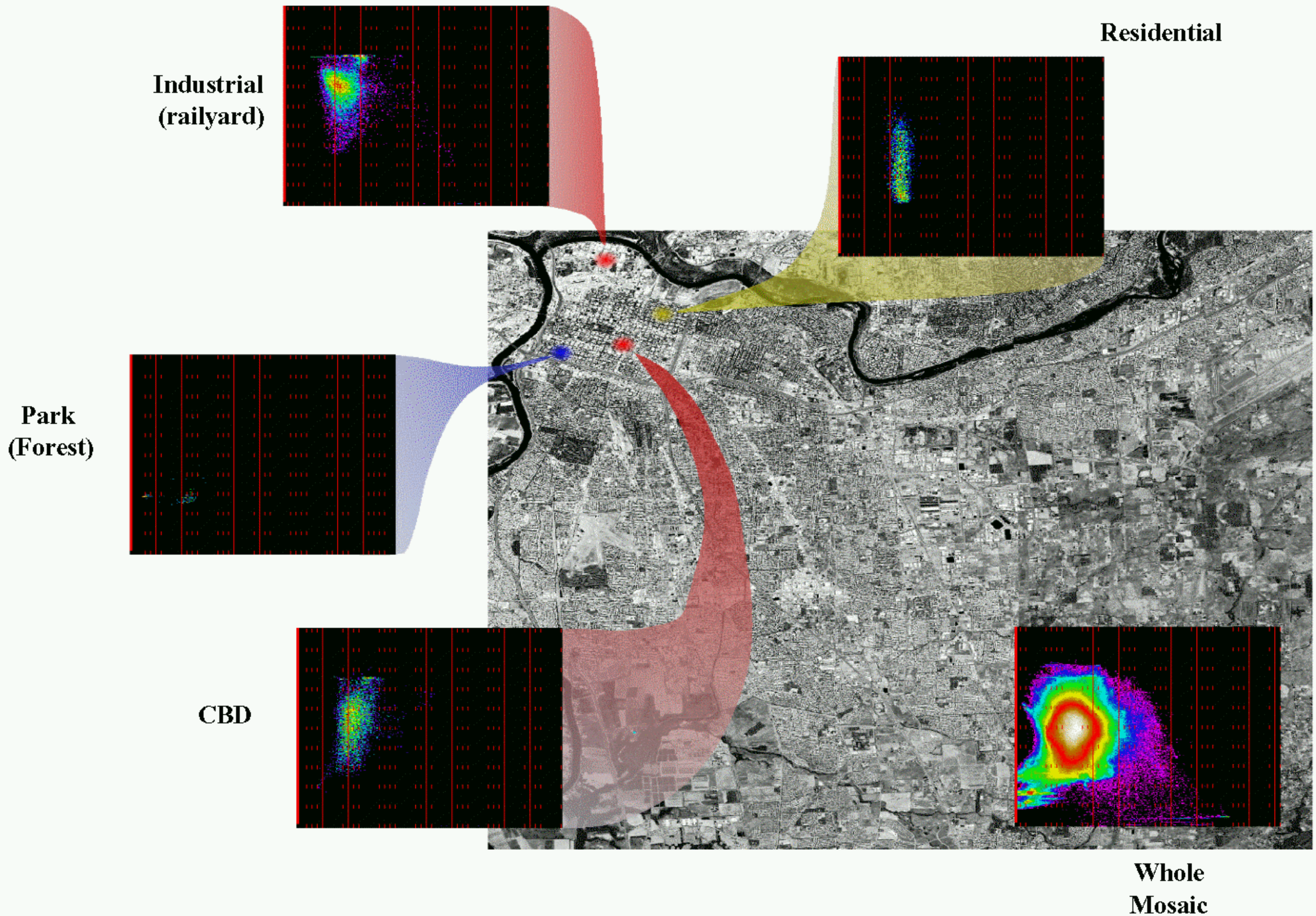
Sacramento, CA - Temperature - 29Jun1998



Sacramento
Skattergram of Albedo vs Temperature



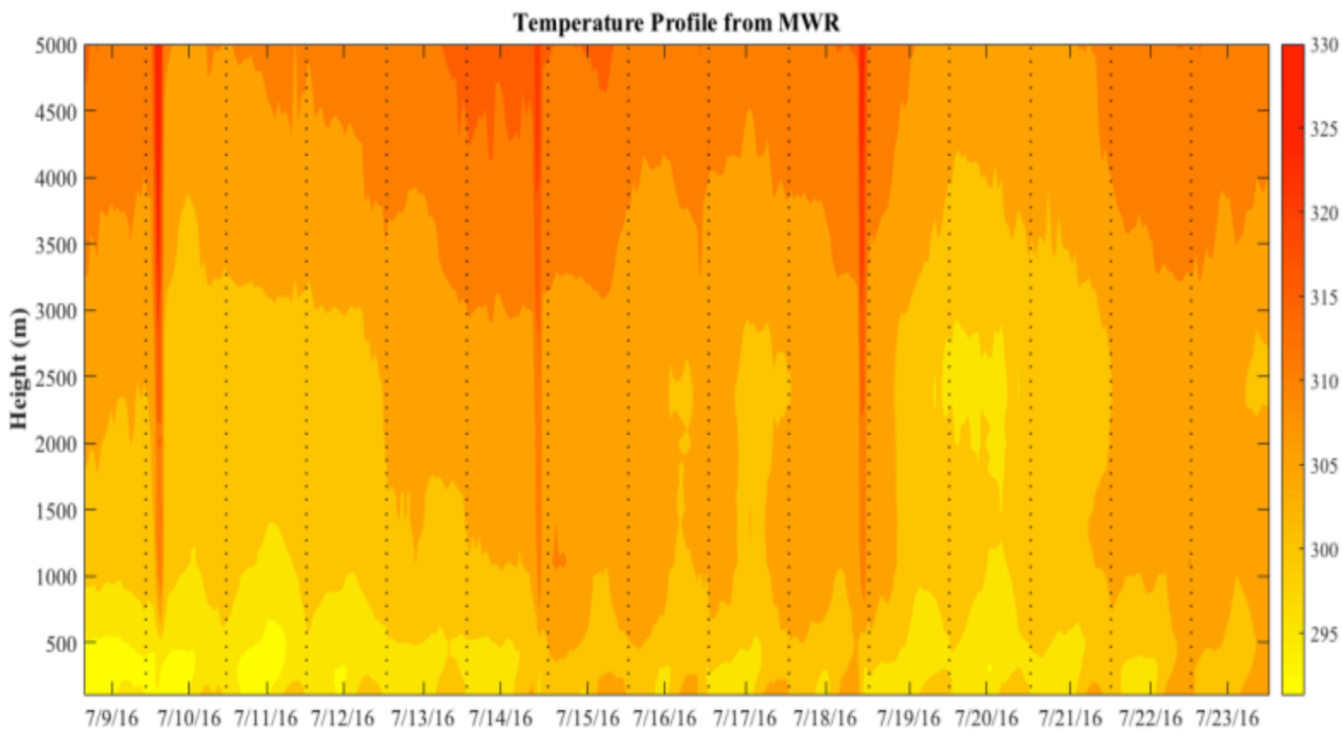
Sacramento Skattergrams
Albedo vs Temperature



Summer Field Studies to Improve Our Understanding of Extreme Heat Events in Dense Urban Environments

NYC Boundary-layer Observations:

The thermal conditions of the atmosphere above the City was continuously monitored using a microwave radiometer located at CCNY campus (operated by NOAA-CREST@CCNY). Fig below virtual potential temperature contours from ground to 5km beginning July 9 to July 23. During July 15th to 18th, when the 2-m air temperature were around 90°F during the midday and afternoon periods, high temperatures are visible in the lower portion of the boundary layer. This is also visible on July 22nd and 23rd as the heat wave sets in. During non-heatwave days, the temperature in the PBL is at least 10K cooler.



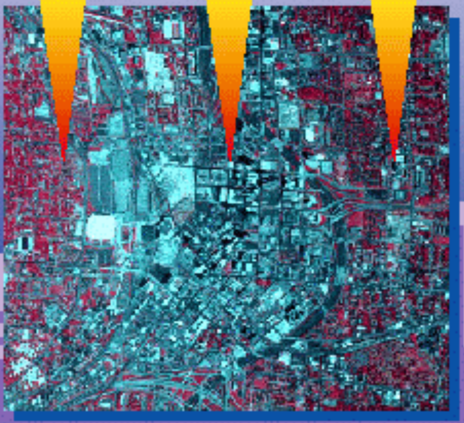
Jorge Gonzalez
gonzalez@me.ccny.cuny.edu

http://cuerg.ccny.cuny.edu/nyc-summer-campaign/

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.

Vicarious calibration and visible derivative spectroscopy to estimate the composition of the 2015 CyanoHAB in Sandusky Bay, Lake Erie

Dr. J.D. Ortiz (Kent State Univ), Stephen Schiller (SDSU), Jeffrey Luvall (NASA MSFC), John Lekki (NASA Glenn), and George Bullerjhan (BGSU)

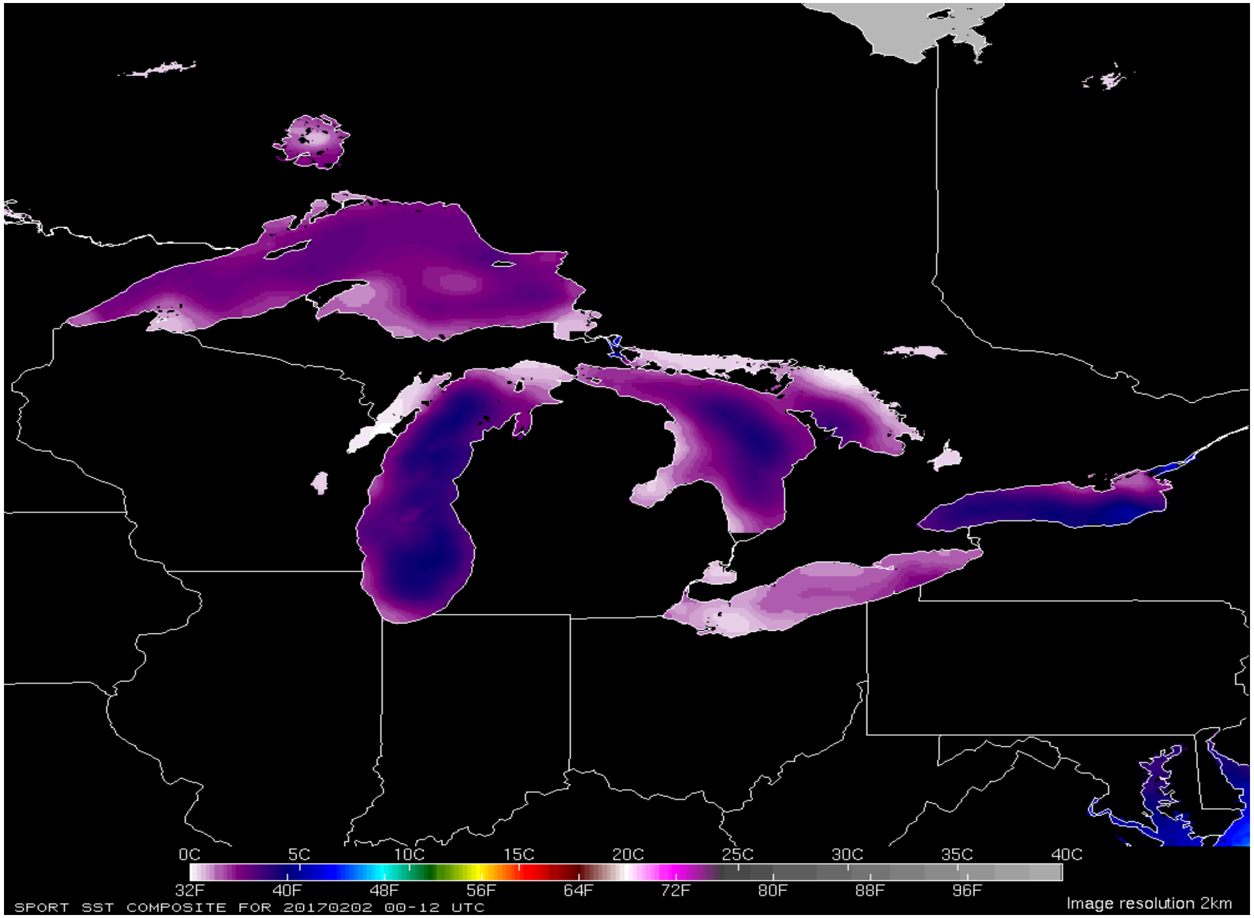
CyanoHAB on Lake Erie
September 3, 2011

(AGU Blogopshere)

Ortiz et al., (HyspIRI 2015)

SST Composite from 00Z to 12Z - Great Lakes Regional

Select an image: February 02, 2017 — 06:00 UTC



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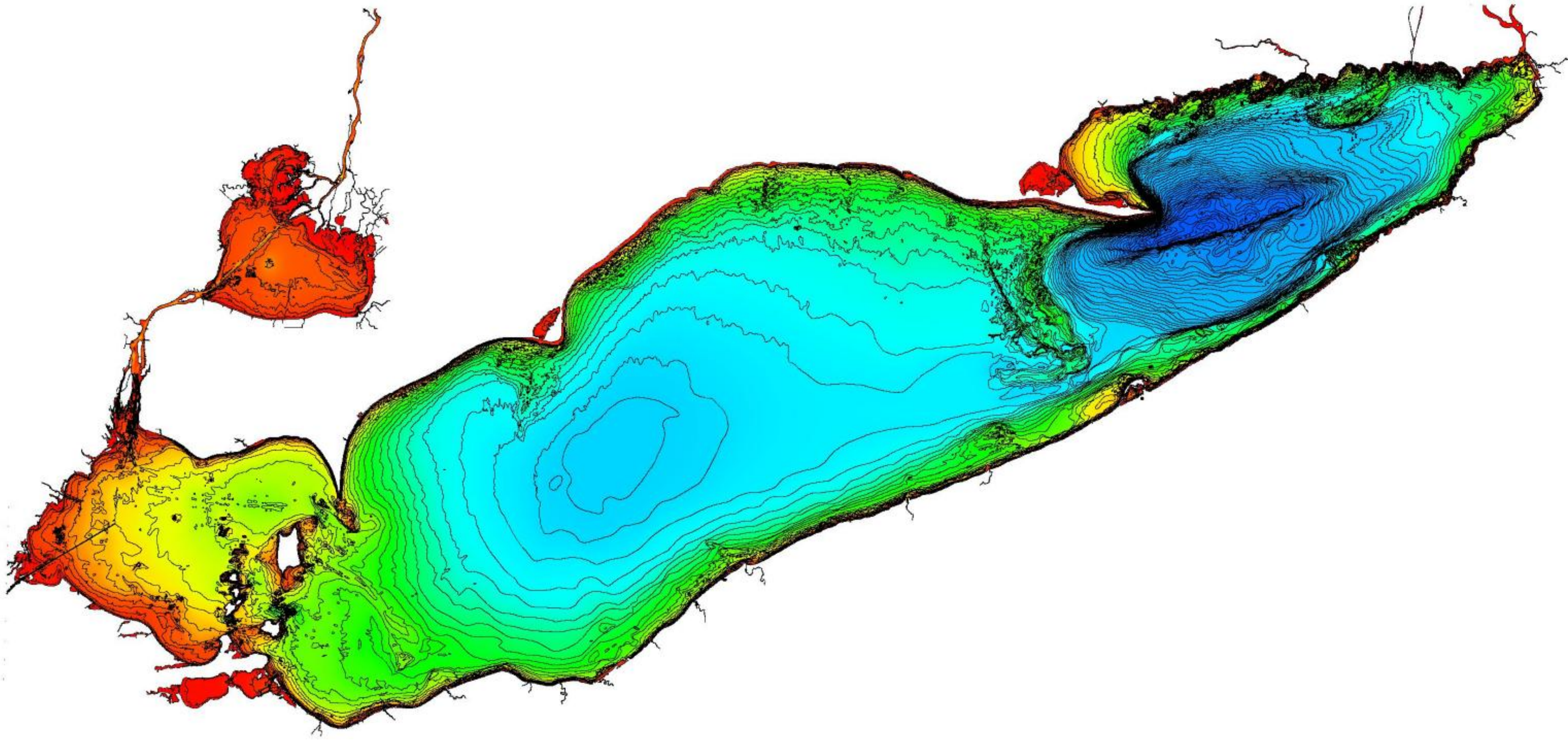
Lake Erie Bathymetry



NOAA

A Ecological Thermodynamic Paradigm

☀ θΔ ics 🌎

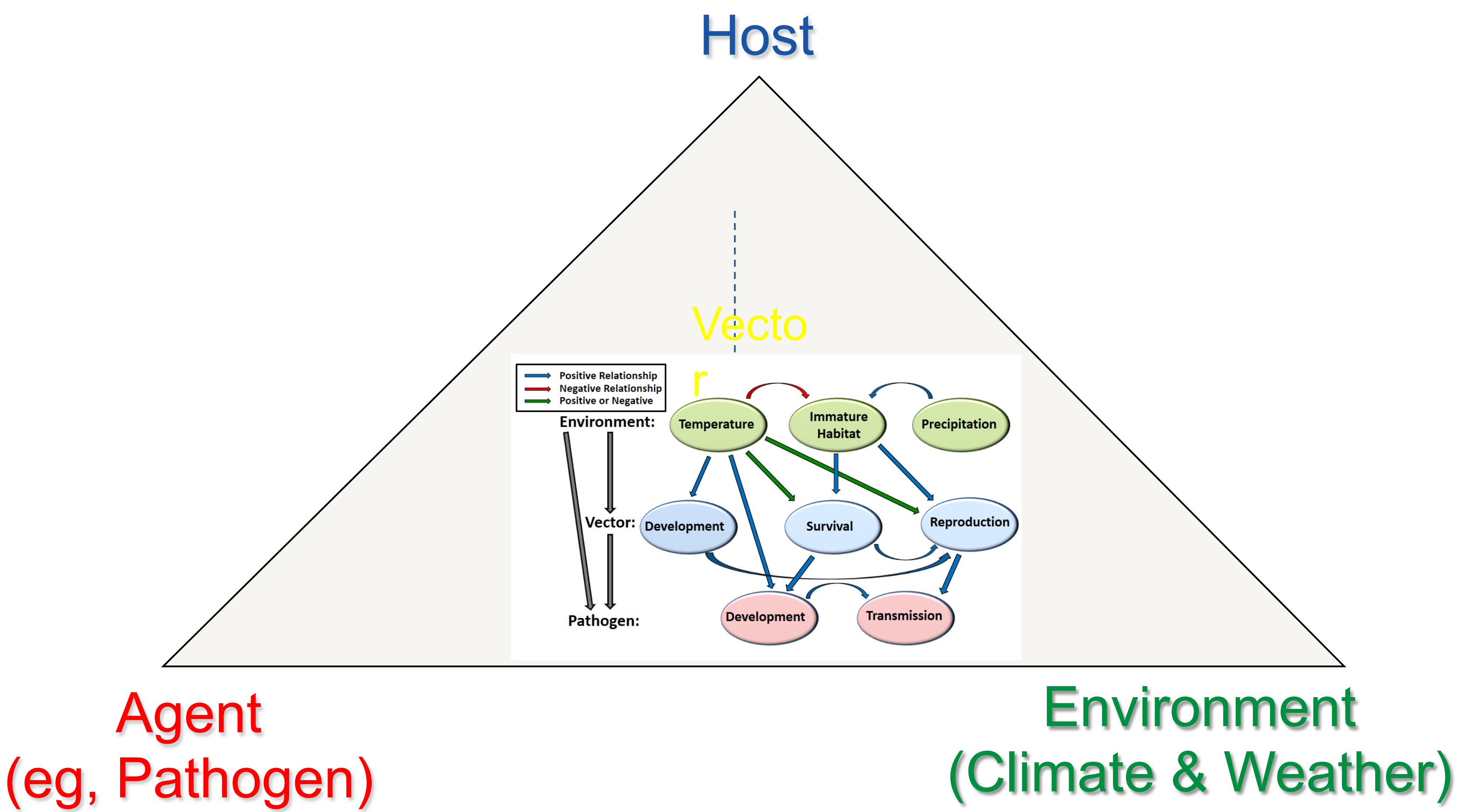
The epidemiological equations (processes) can be adapted and modified to *explicitly incorporate environmental factors and interfaces*

Remote sensing can be used to measure or evaluate or estimate *both environment (state functions) and interface (process functions).* The products of remote sensing must be expressed in a way they *can be integrated directly into the epidemiological equations.* The desired logical structures must be consistent with thermodynamic and with probabilistic frameworks.

NASA

Epidemiologic Triangle of Disease (Vector-borne Diseases)

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



Morin 2014

Surface Energy Budget

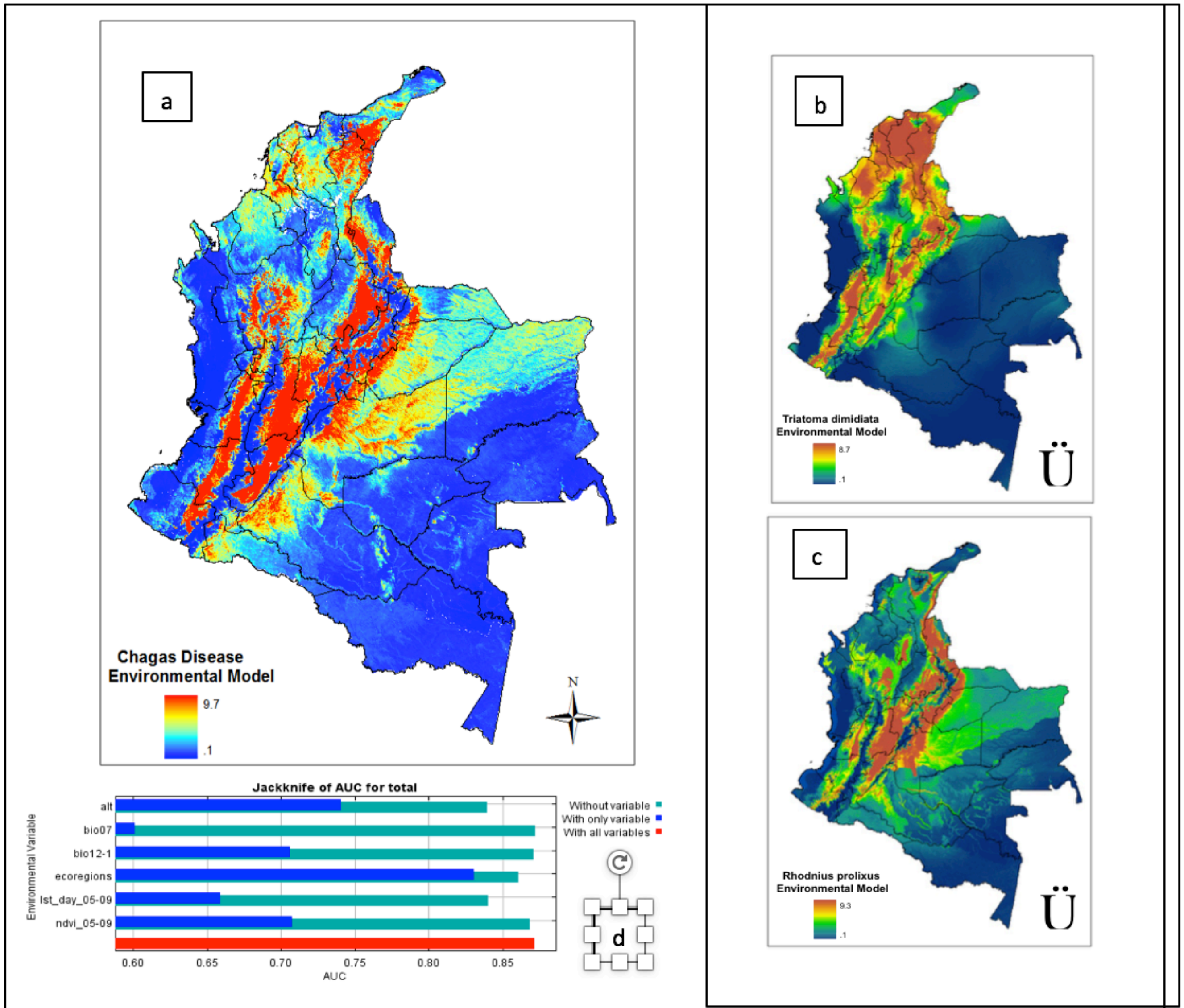
$$Q^* = H + LE + G$$

H = Sensible Heat Flux

LE = Latent Heat Flux

G = Storage (maybe + or -)

Maxent generated risk surfaces for Colombia generated from national scale datasets on Chagas disease



Malone 2005

Table 7. Descriptive statistics of dengue cases, environmental and socio-demographic characteristics compared across GND with incidence rate (IR) above and below the median IR

	Overall	High IR[%]	Low IR[%]	P-value
Characteristics of dengue cases				
Number of Cases (n)	5379	3096	2283	
Number of Dengue cases by years				**0.0342**
Year 2005	436	245 (7.9)	191 (8.4)	
year 2006	300	156 (5.0)	135 (5.9)	
Year 2007	261	167 (5.4)	102 (4.5)	
Year 2008	314	195 (6.3)	116 (5.1)	
Year 2009	812	479 (15.5)	322 (14.1)	
Year 2010	1269	700 (22.6)	578 (25.3)	
Year 2011	1987	1154 (37.3)	839 (36.8)	
Age (mean, SD)	13.7	14.9 (14.3)	12.1 (12.8)	
Age range (in years)	0.1-89	0.1 -89	0.1 -81	
Age Categories (n, %)				**<0.0001**
0-5	1688 (31.4)	884 (28.6)	804 (35.2)	
5.1 - 9	1222 (22.7)	687 (22.2)	535 (23.4)	
9.1 to 19	1168 (21.7)	643 (20.8)	525 (23.0)	
>19	1302 (24.2)	882 (28.5)	419 (18.4)	
Sex				0.6017
Males	2897 (53.9)	1658 (46.5)	1239 (45.7)	
Females	2482 (46.1)	1438 (53.6)	1044 (54.3)	
Environmental Characteristics				
Buildings (mean, SD)	0.47 (0.07)	0.48	0.45	0.1548
Vegetation	0.22 (0.09)	0.21 (0.09)	0.22(0.08)	0.7117
Roads	0.08 (0.04)	0.12 (0.07)	0.13 (0.05)	0.7304
Shadow	0.13 (0.06)	0.08 (0.04)	0.07 (0.04)	0.4616
Green Space	0.04 (0.04)	0.04 (0.05)	0.04 (0.03)	0.9504
Household Characteristics				
Brick Walls	0.4 (0.1)	0.64 (0.12)	0.54 (0.14)	**0.001**
Cement Walls	0.6 (0.1)	0.31 (0.13)	0.40 (0.13)	**0.0169**
Other wall materials	0.1 (0.1)	0.05 (0.07)	0.06 (0.7)	0.5195
Tile Roofs	0.4 (0.2)	0.36 (0.13)	0.36 (0.13)	**0.0244**
Asbestos Roof	0.5 (0.1)	0.52 (0.13)	0.55 (0.09)	0.3901
Other wall materials	0.1 (0.1)	0.04 (0.06)	0.08 (0.08)	0.0294
Population Characteristics				
Population density (per 1000 sq meters)	20 (12.7)	18 (13)	24 (11)	0.06
Housing density	4.2 (2.5)	347 (258)	494 (223)	**0.0277**

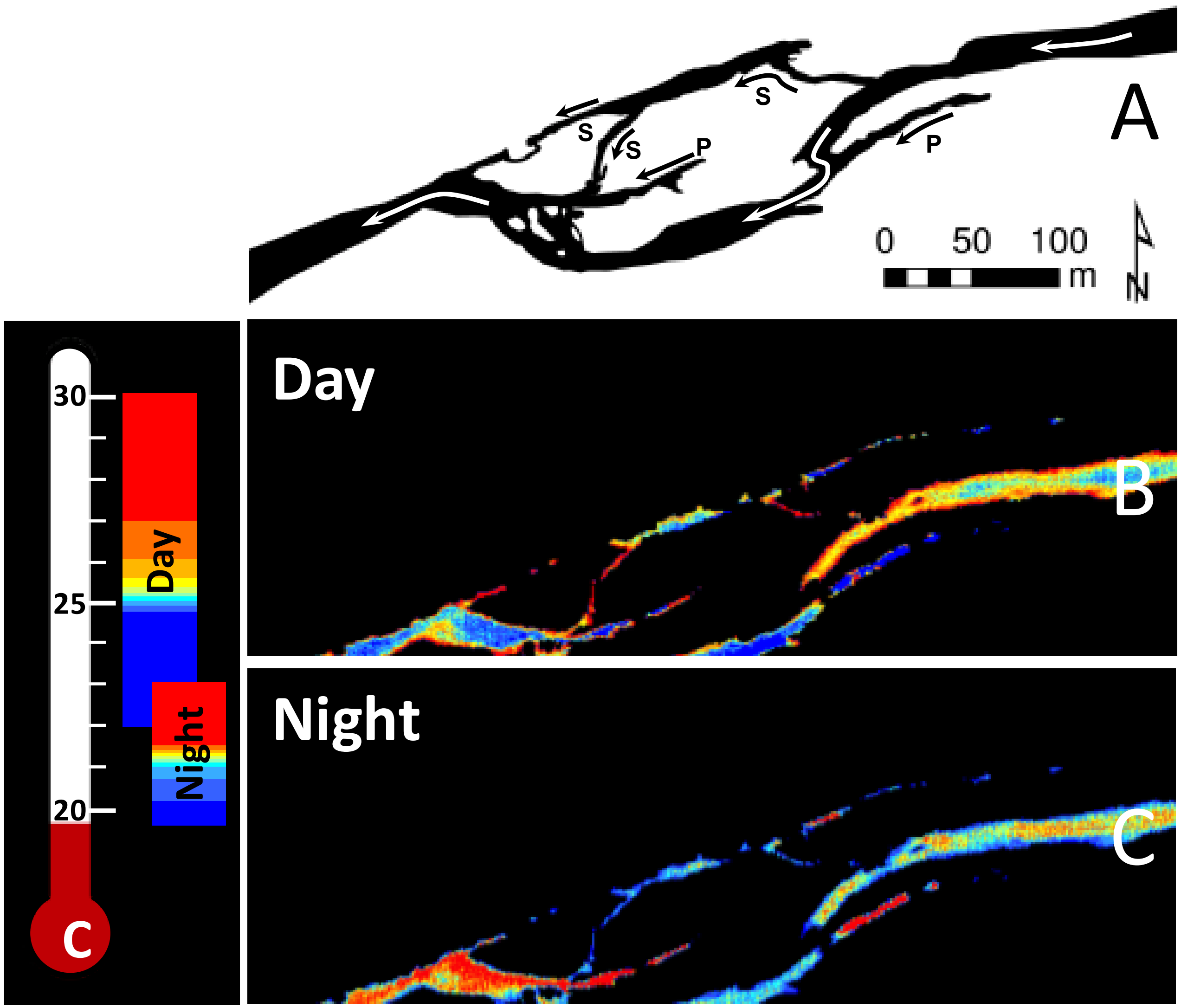
Meghan Tipre 2014 PhD, UAB

NASA DEVELOP National Program 2017 Summer Project

Mobile County Health Department and Marshall Space Flight Center

Coastal Alabama Oceans

Using NASA Earth Observations to Detect Water Quality in Coastal Alabama in Order to Enhance Marine Wildlife Management



Confederated Tribes of the Umatilla Indian Reservation (CTUIR)

Thermal remote sensing data to better understand habitats for Pacific Salmon

Scott O'Daniel (CTUIR)

Geostatistics and Spatial Correlation of Metered Irrigation Data in the Apalachicola-Chattahoochee-Flint River Basin, southwestern Georgia

Lynn J. Torak, Hydrologist
Jaime A. Painter, Geographer
U.S. Geological Survey
Georgia Water Science Center
Norcross, Georgia
http://ga.water.usgs.gov/

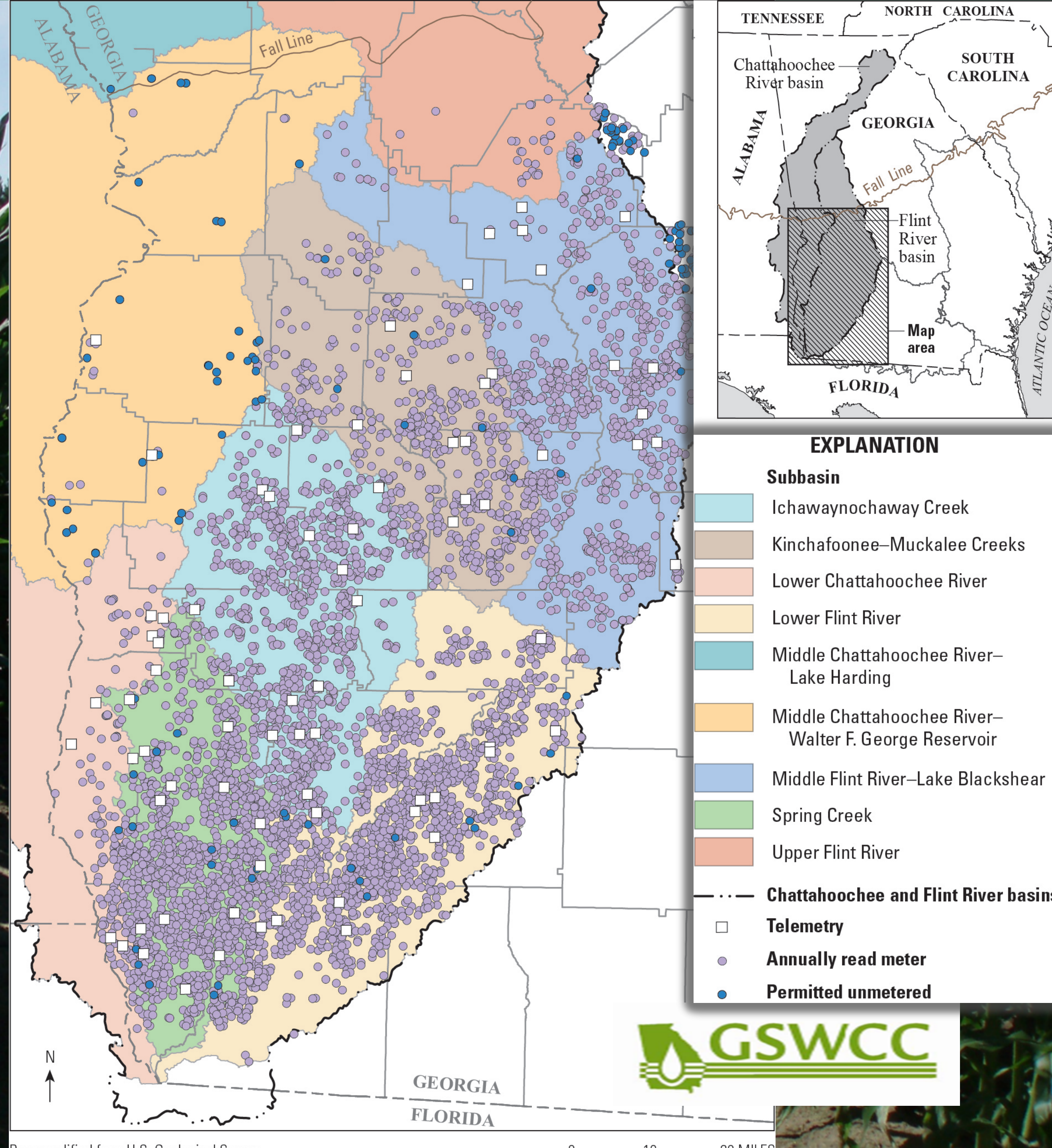
NASA-MSFC, NSSTC
Presentation
March 19, 2014

U.S. Department of the Interior
U.S. Geological Survey

Stat Region 1 Middle and Lower Chattahoochee-Flint River basin 2009

- 81 Telemetry sites
  - 46 GW
  - 35 SW
- 4,357 Annually reported sites
  - 3,609 GW
  - 748 SW

USGS



GSWCC

HyspIRI Application TM

Application Question	Application Concept	Application Measurement Goals	Applied Sciences Category	Potential Host Agency	Mission Data Product	Projected Mission Performance	ARL	Ancillary Measurements
How do we schedule water releases & determine [...] for irrigation use?	The major pathway of water transport in the hydrologic cycle is evapotranspiration(ET). ET is difficult to measure directly for large areas and determination of ET relies on a combination of models and surface parameterizations. Accurate determination of surface temperatures is critical in model parameterizations.	Spatial variability of landscape elements necessaite fine spacial resolution measurements ~ 60m. Repeat measurements of approximately 5 days are required to constrain ET models.	Water Management Agriculture	Western Governors Association 1600 Broadway Suite 1700 Denver, CO 80202 303 623-9378 Sebal North America 1772 Picasso [...] Suite E Davis, Califor[...] Phone: (530) [...]	Surface temperature	Measure surface temperature within 0.5 K , 60 m resolution [...]	9	SEBAL, other ET models, agricultural crop indentification/management info, stream flow, ppt [...]
[...] productivity of the intercoastal waters & barrier islands, e.g. Monitoring Gulf Mexico - spawning cycles, migration, land-use, productivity.	Characterize the physical, chemical, and biological status of coastal and estuarine environments and ecosystems.	[...] fine spacial resolution measurements ~ 60m. Repeat measurements of approximately 5 days are required for enviromental measurements. 19 days for hyperspectral vegetation mapping/physological status.	Ecological Forcasting	[...] national Seashore Maththew Johnson, matthew_w_johnson@nps.gov (228) 230 4139.	Hyperspectral radiance measurements & surface temperatures	[...] within 0.5 K , 60 m resolution and 5 day repeat cycle. Provide hyperspectral radiance measurements at 60 m resolution on a 19 day repeat cycle.	6	Ecosystem structural & functional measurments, hydrolab water chemistry measurements,
How does surface water temperature affect manatee migration	Characterize patterns and trends in fine spacial scale river, estuarine, and near coastal water temperatures.	30-60m spatial resolution, 3-5 day thermal measurements (0.5K). At least 1 nightime measurement within the 3-5 dya window.	Ecological Forcasting	Dauphin Island Sea Lab Ruth Carmichael rcarmichael@disl.org. (251) 861 7555	Surface temperature	Measure surface temperature within 0.5 K , 60 m resolution and 5 day repeat cycle	6	Bouy temperatures
What are the abiotic environmental factors are important in determining the distribution of disease-causing vectors and their life-cycles?	Research!America's global health program advocates for funding and policies that spur research to develop vitally important global health technologies.	Spatial variability of landscape elements necessaite fine spacial resolution measurements ~ 60m. Repeat measurements of approximately 5 days are required for enviromental measurements. 19 days for hyperspectral vegetation mapping/physological status	Public Health	Alexandra FrankAlexandra Frank Senior Program Manager, Global Health R&D Advocacy Research!America 703-739-2577 (main) 571-482-2707 (direct)	Hyperspectral radiance measurements & surface temperatures	Measure surface temperature within 0.5 K , 60 m resolution and 5 day repeat cycle. Provide hyperspectral radiance measurements at 60 m resolution on a 19 day repeat cycle.	6	Assimilations driven by observational data LDAS and satellite-derived meteorological forcing data, parameter datasets, and assimilation observations, including:Precipitation from TRMM, and GPM Land Cover Type from HyspIRI Soil Moisture from AMSR-E (where applicable), SMAP and HyspIRI. Terrestrial Water Storage from GRACE and GRACE II. Surface temperature, Vegetation Fraction/ Leaf Area Index, and canopy physiology from HyspIRI. Topography from SRTM. Epidemiological surveys of targed diseases. Vector population sampling & testing for disease organism.

Full abstracts of these and other presentations are located at *www.agu.org/meetings/fm06/fm06-sessions/fm06_A33G.html*, …*A34C.html*, and …*A43A.html*.

Thermal Remote Sensing Data for Earth Science Research: The Critical Need for Continued Data Collection and Development of Future Thermal Satellite Sensors

Co-convenors: *Dale A. Quattrochi; Jeffrey C. Luvall [NASA Marshall Space Flight Center (MSFC)]; Simon J. Hook [Jet Propulsion Laboratory]; Martha Anderson [U.S. Department of Agriculture-Agricultural Research Service (USDA-ARS) Hydrology and Remote Sensing Laboratory]*

Summary: There is a rich and long history of thermal infrared (TIR) remote sensing data for multidisciplinary Earth science research. The continuity of TIR data collection, however, is now in jeopardy given there are no planned future Earth observing TIR remote sensing satellite systems with moderately high spatial resolutions to replace those currently in orbit

- **Richard Allen** [University of Idaho] *The Need for High-Resolution Thermal Imaging in Water Resource Management* who talked about the importance of TIR data for measuring factors related to evapotranspiration and water resource management and water budget modeling.
- **Todd Steissberg** [University of California, Davis] *High-Spatial Resolution Thermal Infrared Satellite Images for Lake Studies* who discussed how TIR satellite images can be used to study transport processes in lakes.
- **Gregory Vaughan** [JPL] *Spaceborne Thermal Infrared Measurements of Volcanic Thermal Features* who described how TIR measurements of high-temperature volcanic features improve our understanding of volcanic processes and our ability to identify renewed volcanic activity, forecast eruptions, and assess hazards.

A number of other oral presentations were also given during the session.