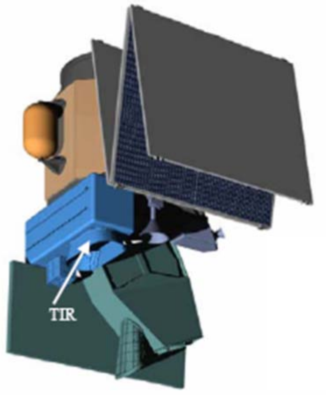

HyspIRI

TIR Science Questions

Presented by: Anupma Prakash

Contributors:

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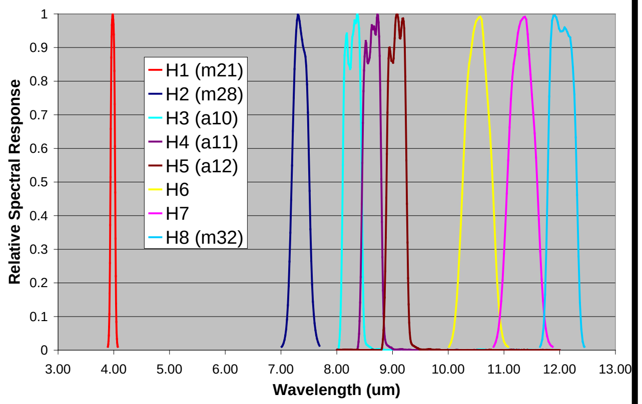
TIR Measurements

Spectral	
Bands (8) µm	3.98 µm, 7.35 µm, 8.28 µm, 8.63 µm, 9.07 µm, 10.53 µm, 11.33 µm, 12.05
Bandwidth	0.084 µm, 0.32 µm, 0.34 µm, 0.35 µm, 0.36 µm, 0.54 µm, 0.54 µm, 0.52 µm
Accuracy	<0.01 µm
Radiometric	
Range	Bands 2-8= 200K – 400K; Band 1= 1400K
Resolution	< 0.05 K, Linear Quantization to 14 bits
Accuracy	< 0.5 K 3-sigma at 250K
Precision (NEdT)	< 0.2K
Linearity	>99% characterized to 0.1 %
Spatial	
IFOV	60 m
MTF	>0.65 at FNy
Scan Type	Push-Whisk
Swath Width	600 km (±25.5° at 623 km altitude)
Cross-Track Samples	10,000
Swath Length	15.4 km (+/- 0.7-degrees at 623km altitude)
Down-Track Samples	256
Band-to-Band Co-registraion	0.2 pixels (12 m)
Pointing Knowledge	1.5 arcsec (0.1 pixels)



TIR Measurements

Temporal	
Orbit Crossing	11 am sun synchronous descending
Global Land Repeat	5 days at equator
OnOrbit Calibration	
Lunar View	1 per month {radiometric}
Blackbody Views	1 per scan {radiometric}
Deep Space Views	1 per scan {radiometric}
Surface Cal Experiments	2 (d/n) every 5 days {radiometric}
Spectral Surface Cal Experiments	1 per year
Data Collection	
Time Coverage	Day and Night
Land Coverage	Land surface above sea level
Water Coverage	Coastal zone -50 m and shallower
Open Ocean	Averaged to 1km spatial sampling
Compression	2:1 lossless

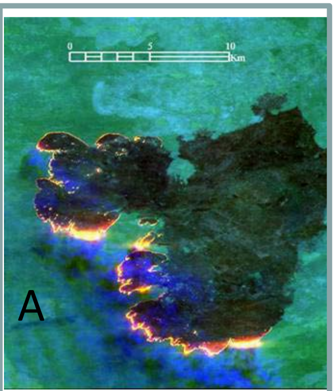
HyspIRI thermal measurements provide critical information on land surface temperature, which is a fundamental climate variable

HyspIRI measurements will:

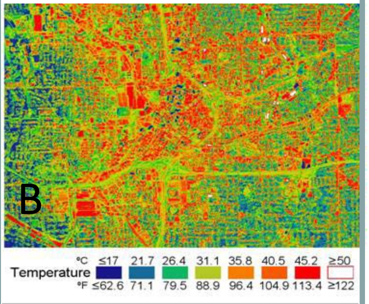
- produce fundamental climate temperature variables
- essential societal information on thermal phenomena

Critical thermal information provided by HyspIRI includes:

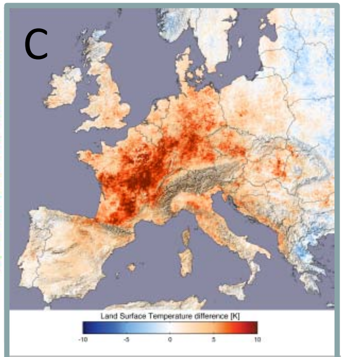
- The burning temperatures of fires
- The temperatures of cities
- Thermal stress and evapotranspiration of natural vegetation and croplands
- The temperature and evaporative rates of small inland water bodies



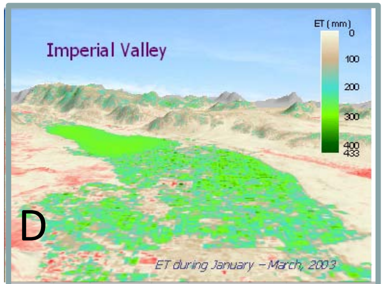
The narrow fire front, determines the temperature and carbon emission rate of fires



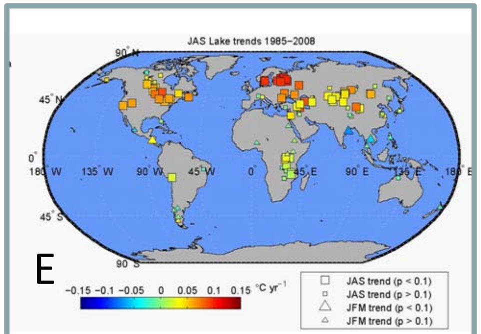
Heat island effect of cities: High resolution thermal image of downtown Atlanta,



2003 European heatwave compared to 2000, 2001, 2002, 2004 (IPCC 2007c)



Managing water resources: evapotranspiration in the Imperial Valley, California



Increase in summer temperatures of large inland water bodies show warming in the northern latitudes

HyspIRI multispectral thermal measurements provide < 5 day daytime and nighttime mapping of land surface temperature, a fundamental climate variable, at high resolutions (60 m).

TIR Overarching Science Questions

- **TQ1. Volcanoes/Earthquakes (MA,FF)**
  - How can we help predict and mitigate earthquake and volcanic hazards through detection of transient thermal phenomena?
- **TQ2. Wildfires (LG,DR)**
  - What is the impact of global biomass burning on the terrestrial biosphere and atmosphere, and how is this impact changing over time?
- **TQ3. Water Use and Availability, (MA,RA)**
  - How is consumptive use of global freshwater supplies responding to changes in climate and demand, and what are the implications for sustainable management of water resources?
- **TQ4. Urbanization/Human Health, (DQ,GG)**
  - 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?
- **TQ5. Earth surface composition and change, (AP,JC)**
  - What is the composition and temperature of the exposed surface of the Earth? How do these factors change over time and affect land use and habitability?

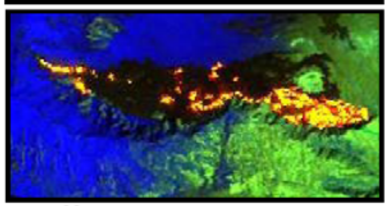
TQ1: Volcanoes and Earthquakes (MA,FF)

- Do volcanoes signal impending eruptions through changes in surface temperature or gas emission rates and are such changes unique to specific types of eruptions? [DS 227]
- What do changes in the rate of lava effusion tell us about the maximum lengths that lava flows can attain, and the likely duration of lava flow-forming eruptions? [DS 226]
- What are the characteristic dispersal patterns and residence times for volcanic ash clouds and how long do such clouds remain a threat to aviation? [DS 224]
- What do the transient thermal anomalies that may precede earthquakes tell us about changes in the geophysical properties of the crust? [DS 227, 229]
- Can the energy released by the periodic recharge of magma chambers be used to predict future eruptions? [DS 227]

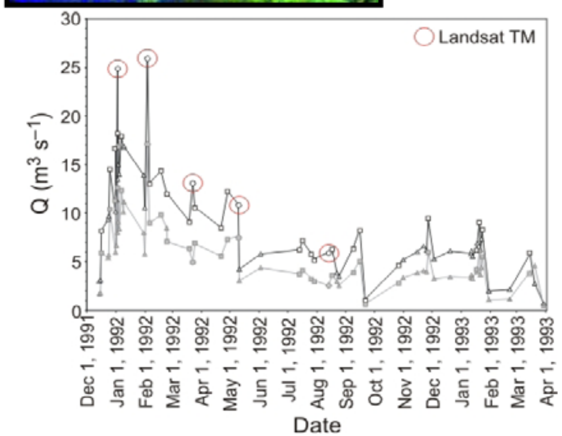
TQ1: Volcanoes and Earthquakes

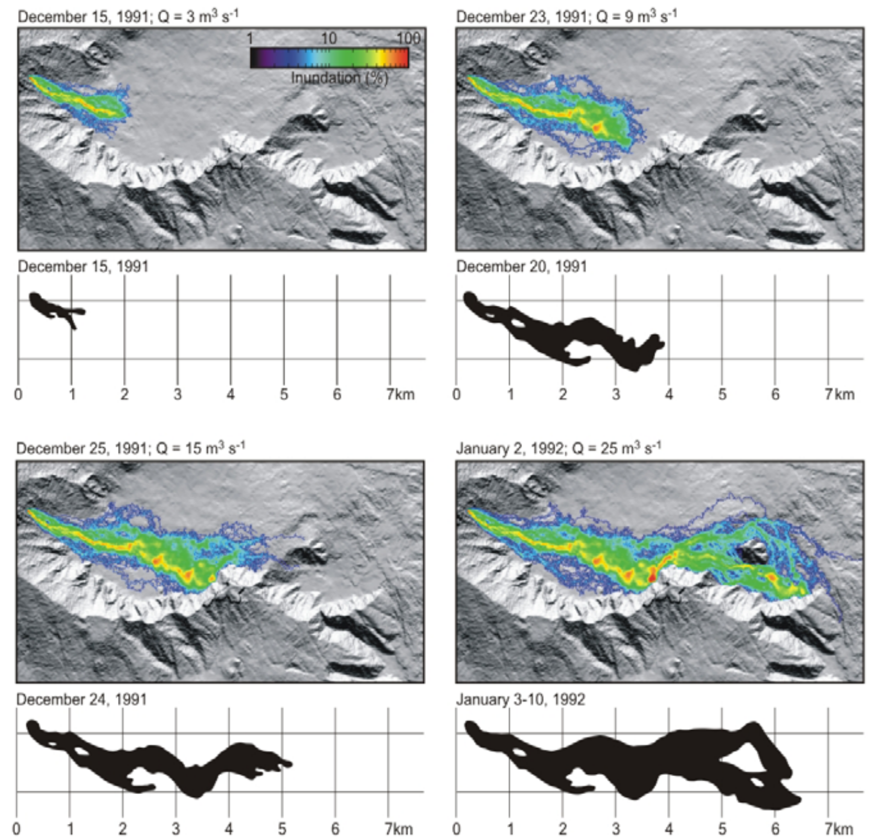
What do changes in the rate of lava effusion tell us about the maximum lengths that lava flows can attain, and the likely duration of lava flow-forming eruptions? [DS 226]

Mount Etna, Sicily
ATSR, 3 January 1992



Mount Etna, Sicily
Landsat TM, 22 March 1992

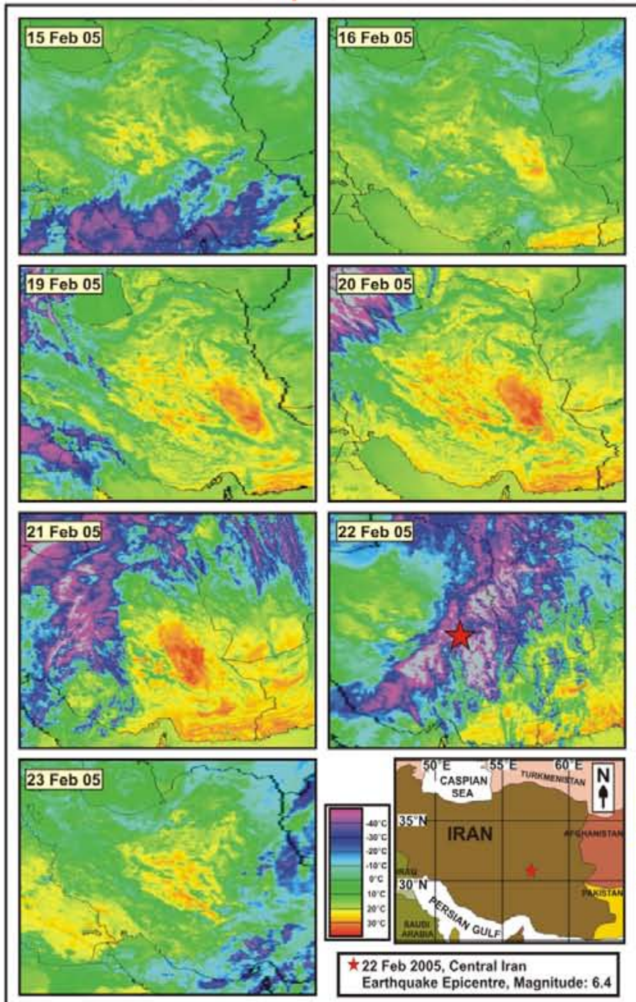




1. The length a lava flow can attain is governed by the effusion rate
2. The thermally active flow area as a function of time is proportional to the effusion rate
3. HyspIRI will allow us to determine the effusion rate twice in each 5 day period

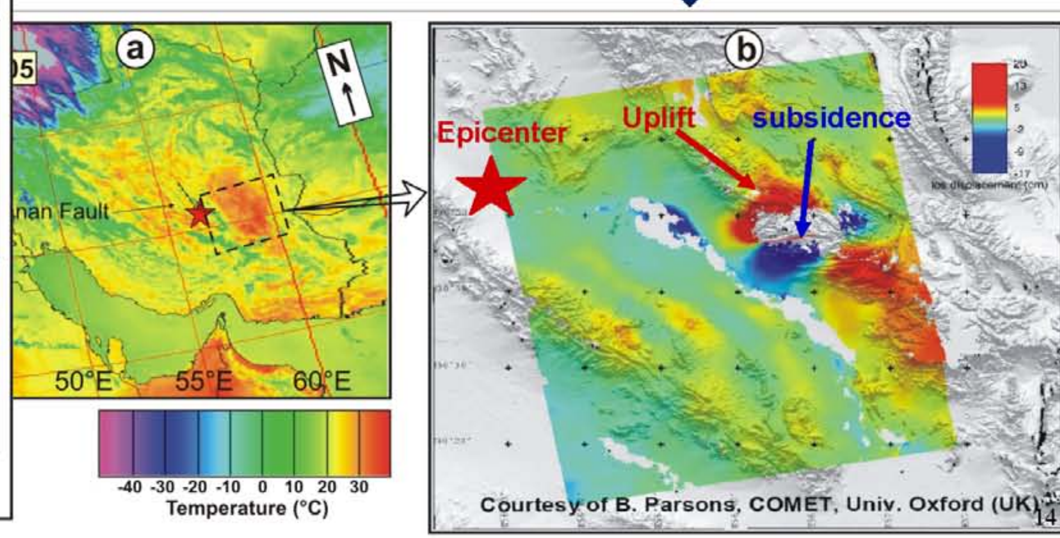
TQ1: Volcanoes and Earthquakes

What do the transient thermal infrared anomalies that may precede earthquakes tell us about changes in the geophysical properties of the crust



M=6.4 earthquake
in Iran 22 Feb. 2005
Good viewing conditions

IR Emission comes from region of maximum uplift/subsidence

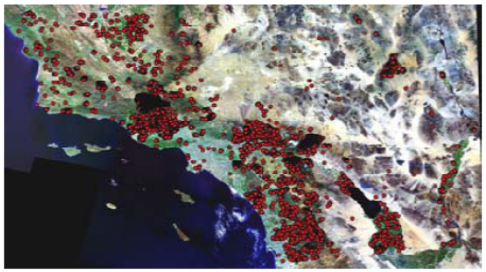


TQ2: Wildfires (LG)

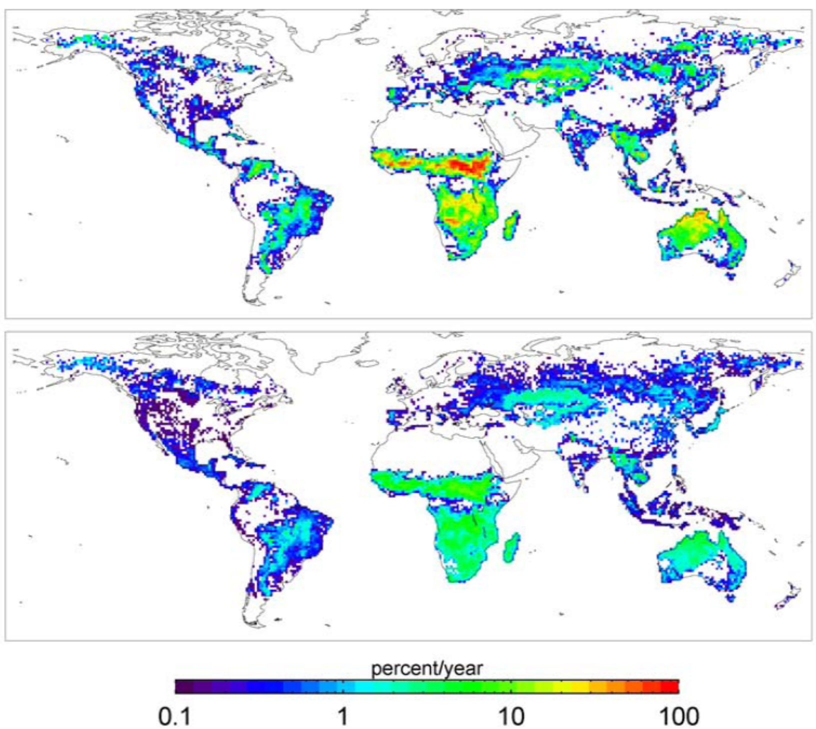
- How are global fire regimes changing in response to, and driven by, changing climate, vegetation, and land use practices? [DS 198]
- Is regional and local scale fire frequency changing? [DS 196]
- What is the role of fire in global biogeochemical cycling, particularly trace gas emissions? [DS 195]
- Are there regional feedbacks between fire and climate change?

TQ2a: How are global fire regimes (fire location, type, frequency, and intensity) changing in response to changing climate and land use practices? [DS 198]

MODIS active fire detections 2000-2006 for Southern California



2001-2004 mean annual burned area derived from Terra MODIS active fire observations (top) and accompanying one-sigma uncertainties (bottom), expressed as fraction of grid cell that burns each year. From Giglio et al. (2005), *Atmos. Chem. Phys. Discuss.*, 5, 11091-11141



- Science issue
  Fire regimes vary considerably on a regional and global scale. Mapping fire location, type, frequency, and intensity at different times can contribute to an understanding of how they are affected by a changing climate and land use patterns.

- Tools
  Requires long-term regional or global data sets of thermal infrared imagery (low and normal gain channels at 4 and 11 µm). HyspIRI TIR data has a significantly improved capability of mapping flaming and smoldering fires. HyspIRIs greatly expanded spatial and temporal coverage can provide large sample sizes. Requires further pre-fire and post-fire thematic maps of climate variables and land use.

- Approach
  The HyspIRI thermal infrared data will provide large samples of detailed fire characteristics that are useful for statistical modeling of fires and their behavior. The database of fire detections can be analyzed in conjunction with thematic data sets of climate and land use.

Fire Regimes and Climate

GEOPHYSICAL RESEARCH LETTERS, VOL. 33, L09703, doi:10.1029/2006GL025677, 2006

Recent changes in the fire regime across the North American boreal region—Spatial and temporal patterns of burning across Canada and Alaska

Eric S. Kasischke[1] and Merritt R. Turetsky[2]

Received 16 January 2005; accepted 29 March 2006; published 3 May 2006.

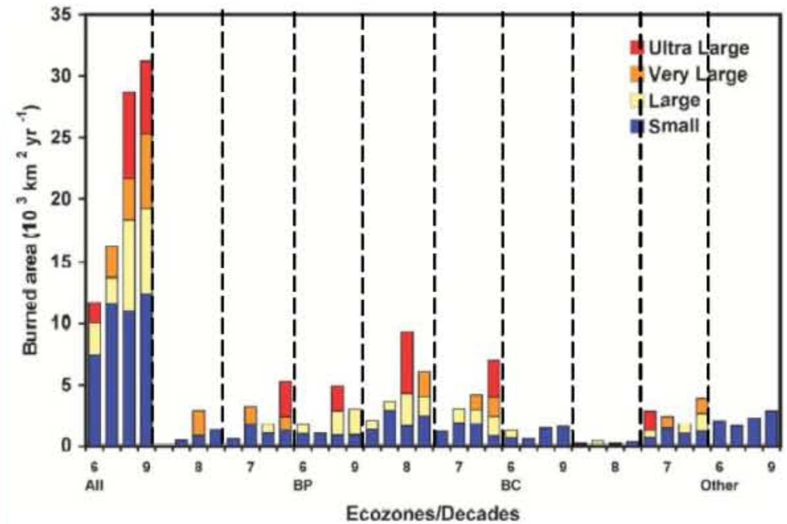
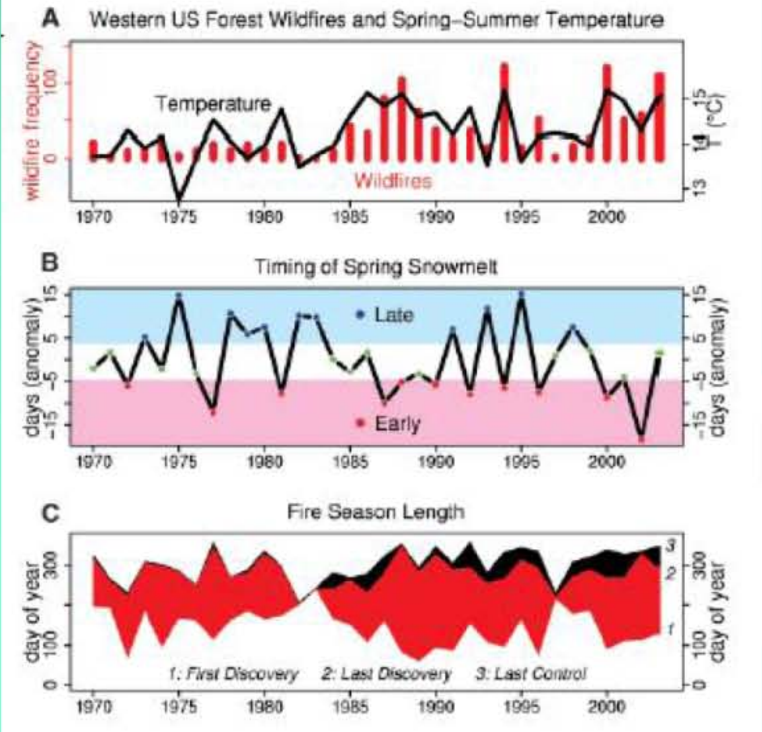


Figure 1. Decadal patterns in burned area across the NABR and in individual ecozones (on the x-axis, 6 = 1960s, 7 = 1970s, etc.; see Table 2 for the key to the ecozones).

Doubling of Annual Burned Area and increase in frequency of large fire events



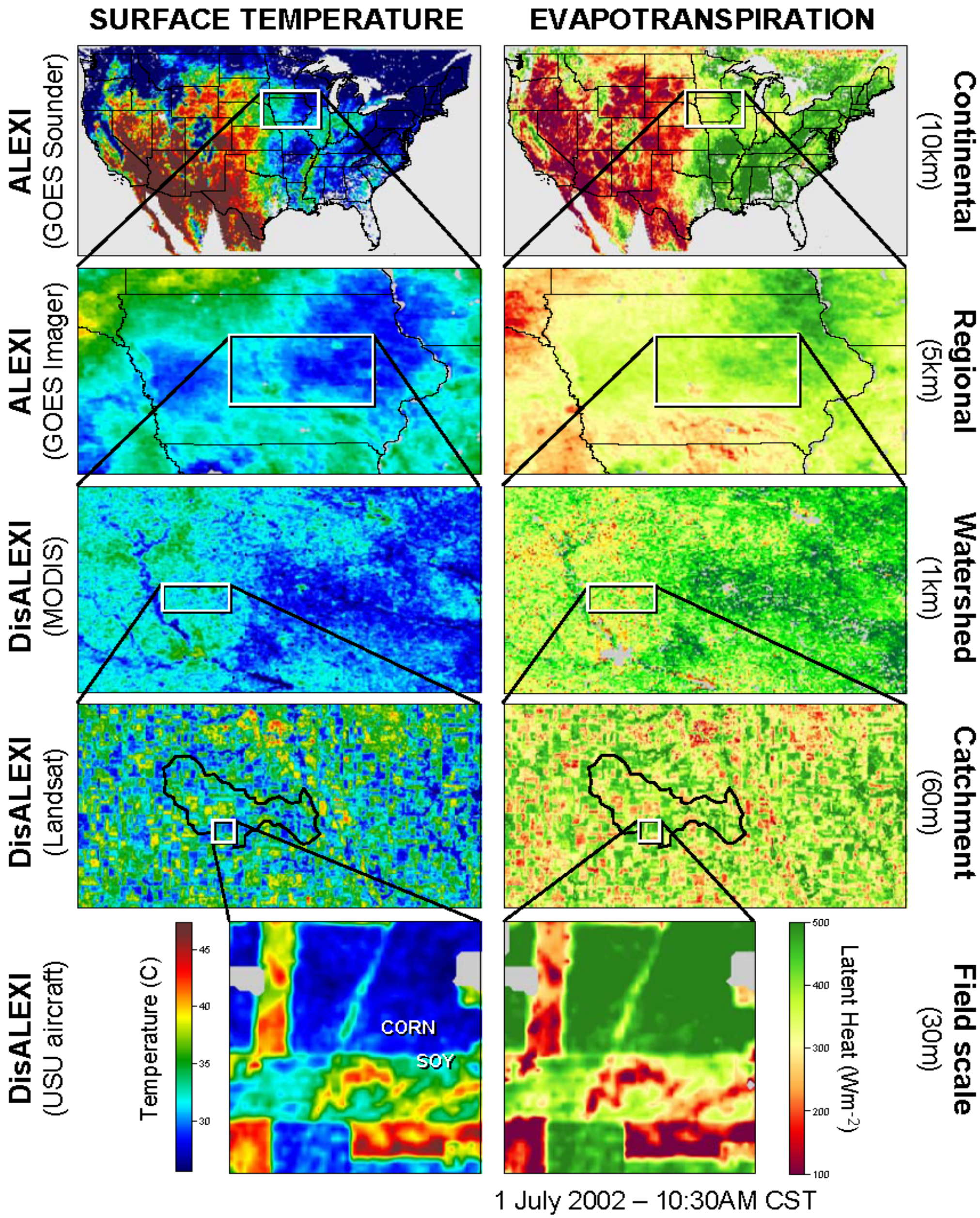
18 AUGUST 2006 VOL 313 SCIENCE www.sciencemag.org

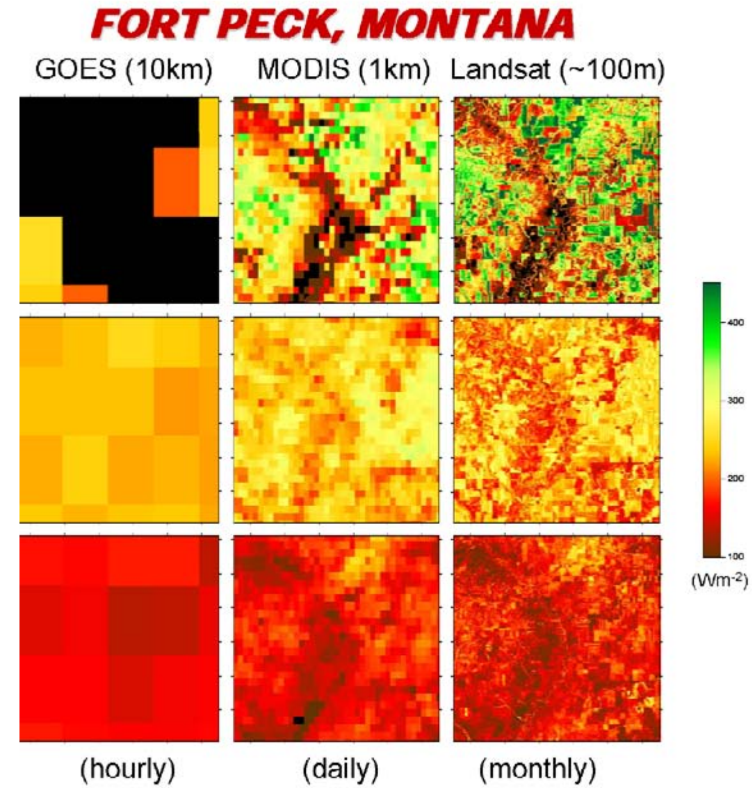
Warming and Earlier Spring Increase Western U.S. Forest Wildfire Activity

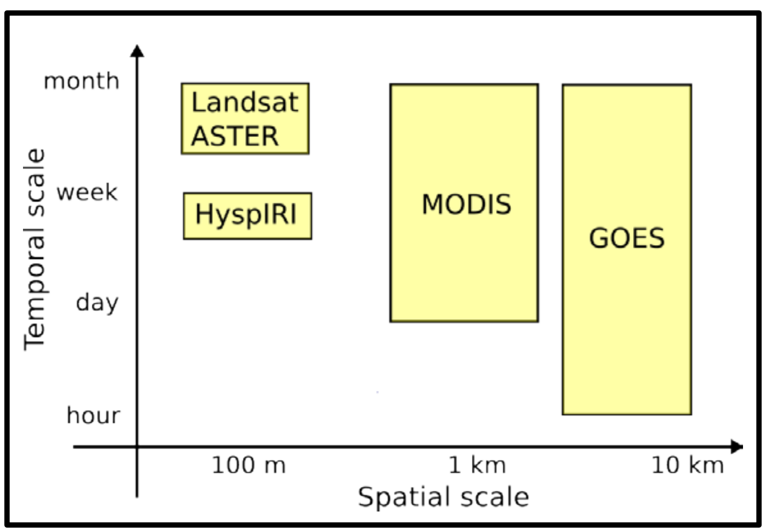
A. L. Westerling,[1,2*] H. G. Hidalgo,[1] D. R. Cayan,[1,3] T. W. Swetnam[4]

TQ3: Water Use and Availability (MA,RA)

- How is climate variability (and ENSO) impacting the evaporative component of the global water cycle over natural and managed landscapes? [DS 166, 196, 203, 257, 368]
- What are relationships between spatial and temporal variation in evapotranspiration and land-use/land-cover and freshwater resource management? [DS 196, 203, 368]
- Can we improve early detection, mitigation, and impact assessment of droughts at local to regional scales anywhere on the globe? [DS 166, 196, 203, 368]; How does the partitioning of Precipitation into ET, surface runoff and ground-water recharge change during drought?
- What areas of Earth have water consumption by irrigated agriculture that is out of balance with sustainable water availability? [DS 196, 368]
- Can we increase food production in water-scarce agricultural regions while improving or sustaining quality and quantity of water for ecosystem function and other human uses? [DS 196, 368]


SURFACE TEMPERATURE
EVAPOTRANSPIRATION
ALEXI (GOES Sounder)
Continental (10km)
ALEXI (GOES Imager)
Regional (5km)
DisALEXI (MODIS)
Watershed (1km)
DisALEXI (Landsat)
Catchment (60m)
DisALEXI (USU aircraft)
Field scale (30m)
Temperature (C)
45
40
35
30
CORN
SOY
Latent Heat (Wm-2)
500
400
300
200
100
1 July 2002 – 10:30AM CST


FORT PECK, MONTANA
GOES (10km)
MODIS (1km)
Landsat (~100m)
400
300
200
100
(Wm-2)
(hourly)
(daily)
(monthly)

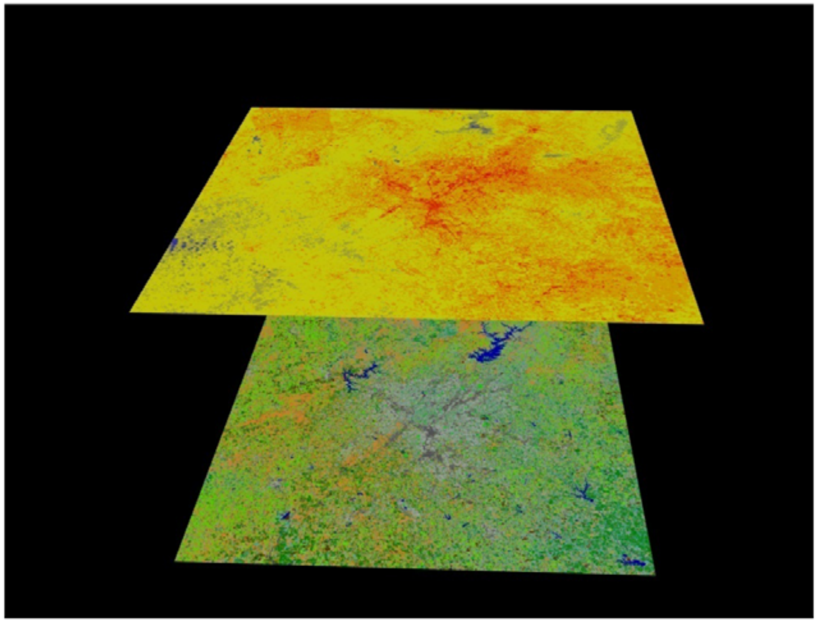

Temporal scale
month
week
day
hour
Landsat
ASTER
HyspIRI
MODIS
GOES
100 m
1 km
10 km
Spatial scale

TQ4: Human Health and Urbanization (DQ,GG)

- How do changes in local and regional land cover and land use, in particular urbanization affect surface energy balance characteristics that impact human welfare [DS: 160-161, 166-167, 196, 198]
- 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? [DS: 158, 166-168]
- How can the factors influencing heat stress on humans be better resolved and measured. [DS: 156, 158, 160, 183-184]
- How can the characteristics associated with environmentally related health effects, that affect vector-borne and animal-borne diseases, be better resolved and measured? [DS: 156, 158, 160, 183-184]
- How do horizontal and temporal scales of variation in heat flux and mixing relate to human health, human ecosystems, and urbanization? [DS: 156, 160-161, 166-167, 179,184]

TQ4b: 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? (DS 158, 166-168)

Landsat ETM+ images of the Atlanta, Georgia metropolitan area and elevated surface temperatures related to urbanization



The Atlanta urbanized area is shown in gray on the bottom image. The top image shows increased surface temperatures for the corresponding urbanized area as derived from the Landsat thermal band

Science Issue:

•The UHI is a well-known effect, but there are inadequate measurements of its diurnal, temporal, and nocturnal characteristics as they vary from city to city around the globe. HyspIRI measurements can be used to collect more in-depth data on the UHI and help assess what its impacts are on biophysical, climatic, and environmental processes for urban areas around the world.

Tools:

•Satellite observations for measurement of urban surface temperature spatial extent for different sizes of cities and in different geographic and climatic domains around the globe

•Daytime and nighttime satellite thermal measurement of urban surface to assess fluxes attributable to the UHI

•Seasonal observations of urban surface temperatures to evaluate impacts on variations in the UHI

•Integration of urban surface temperatures derived from to generate global UHI models for cities around the globe

Approach:

•Use HyspIRI TIR data to evaluate the size, form, and dynamics of the UHI for cities around the world to better understand how the UHI varies in different climatic zones and geographic locales globally

•Use high spatial/temporal resolution, multispectral thermal HyspIRI data to measure and model the effects of the UHI on global biophysical, climatic, and environmental processes

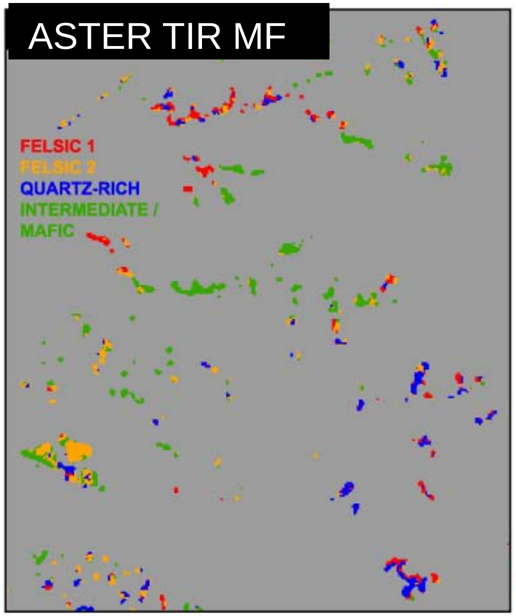
Results:

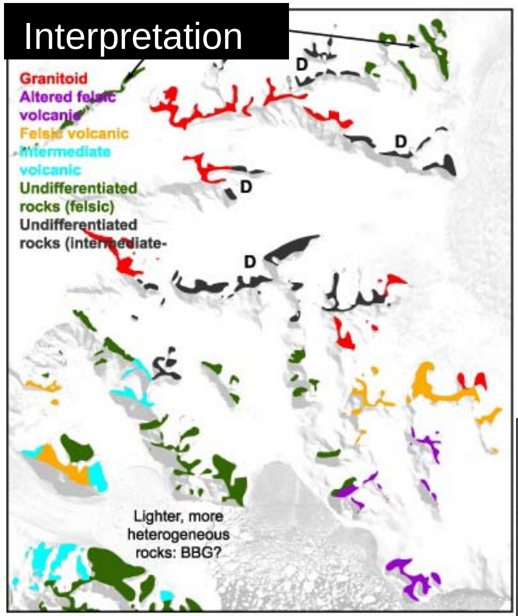
The UHI has been attributed to excess deaths during heat waves on days with higher-than-average temperatures. Current satellite systems do not have adequate revisit times or multiple thermal spectral bands to provide the information to model UHI dynamics and its impact on humans and adjacent environments. HyspIRI will have a return time, spectral characteristics and nighttime viewing to greatly enhance our knowledge of UHI thermal characteristics around the world.

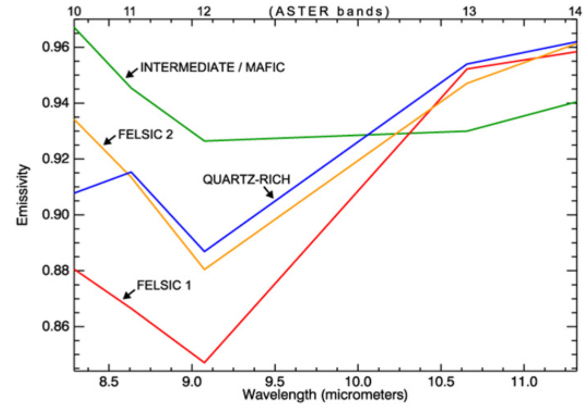
TQ5: Earth Surface Composition and Change (AP,LM)

- What is the spectrally observable mineralogy of the Earth's surface and how does this relate to geochemical and surficial processes? [DS 114]
- What is the nature and extent of man-made disturbance of the Earth's surface associated with exploitation of non-renewable resources (oil & gas, mining)? How do these vary over time? [DS 227]
- How do surface temperature anomalies (hot spots) relate to deeper thermal sources, such as buried lava tubes, underground coal fires and engineering structures? How do changes in the surface temperatures relate to changing nature of the deep seated hot source? [DS 243]
- What is the spatial distribution pattern of surface temperatures and emissivities of various land surfaces and how do these influence the Earth's heat budget?
- What are the water surface temperature distributions in coastal, ocean, and inland water bodies. How do they change, and how do they influence aquatic ecosystems? [DS 378]

TQ5a: What is the spectrally observable mineralogy of the Earth's surface and how does this relate to geochemical and surficial processes? (DS 114)

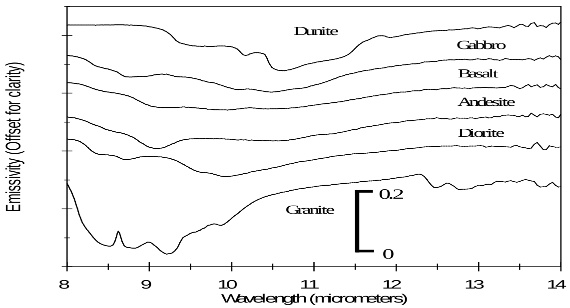


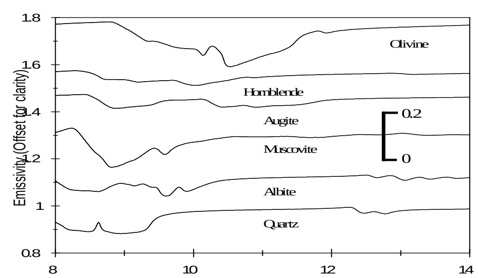


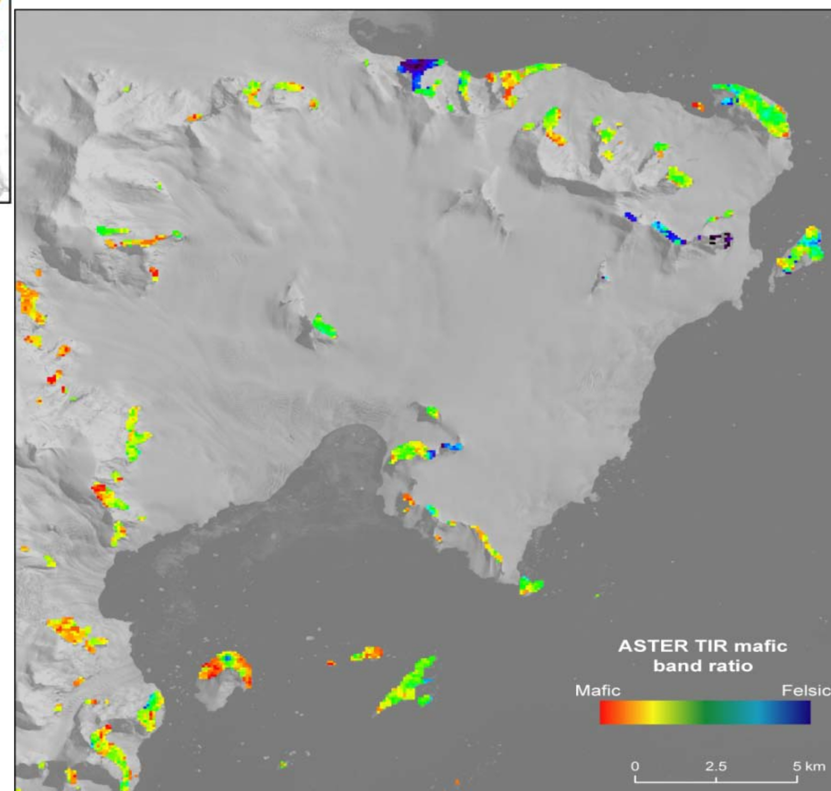


ASTER TIR image end-members

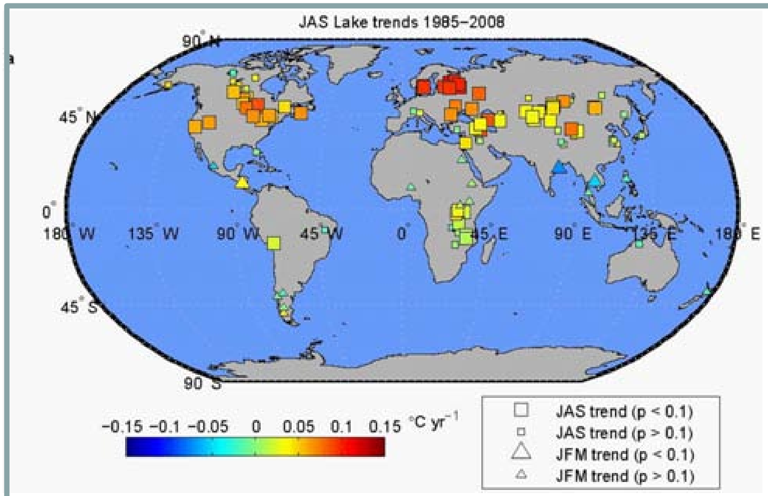
Haselwimmer et al., (2010)



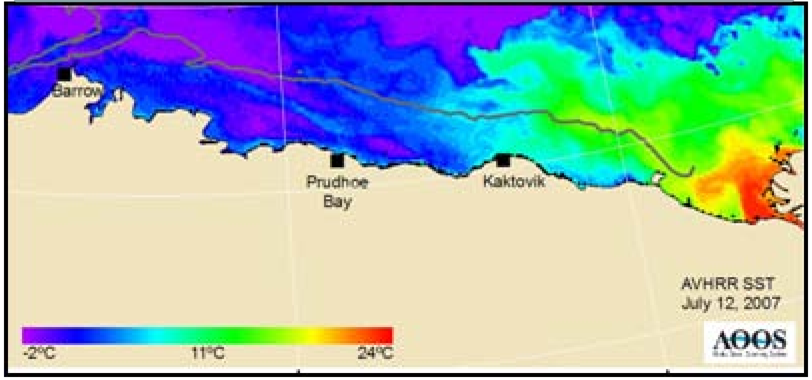




TQ5e: What are the water surface temperature distributions in coastal, ocean, and inland water bodies, how do they change, and how do they influence aquatic ecosystems? (DS 378)



Increase in summer temperatures of large inland water bodies show warming in the northern latitudes



Processed AVHRR TIR image of the coast of the Arctic Alaska coast. Outflow from the Mackenzie River influences temperatures in coastal waters, breakup of sea ice, and thermal habitats of a variety of flora and fauna. Okkonen et al, 2009 (submitted to JGR)

Science Issue:

- Aquatic habitats are subject of dynamic temperature regimes, eg. coastal water temperatures vary due to temperatures of the neighboring land surface, outflow from rivers, general ocean circulation patterns, and local wind conditions.
- Flora and fauna in aquatic environments are sensitive to the water temperatures.
- They dynamics of the water temperatures and the controlling processes are not well understood.

Tools:

- HyspIRI TIR data with NEΔT < 0.2 K and weekly temporal repeat.
- Ancillary data such as high-resolution hydrography and acoustic Doppler current profiler measured currents, bathymetric information, when possible.

Approach:

- Derive water surface temperature images from HyspIRI TIR bands using established temperature estimation algorithm.
- Relate spatial temperature distribution pattern to local conditions (wind, riverine outflow, etc.)
- Relate surface temperature to bulk water temperature where ancillary data is available.

Fore more details…..

- http://hyspiri.jpl.nasa.gov/science
- http://hyspiri.jpl.nasa.gov/documents/2008-workshop/presentations
- http://hyspiri.jpl.nasa.gov/documents/2009-workshop/2009-workshop-agenda-and-presentations