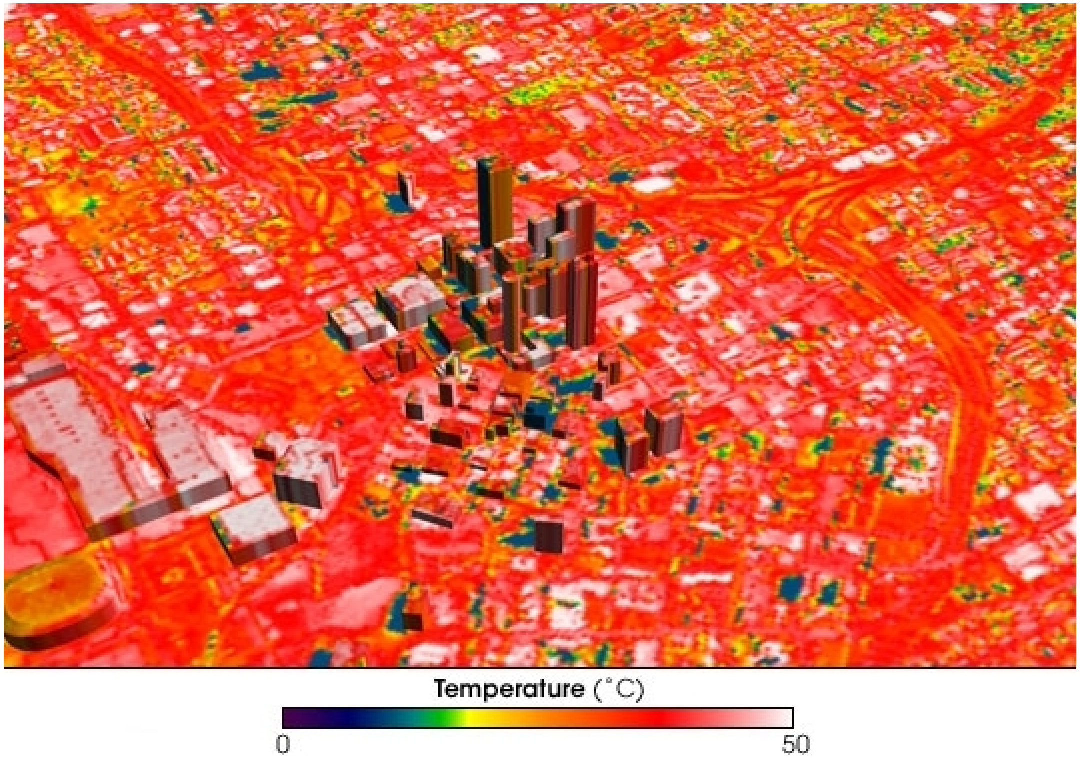

CQ6: Human Health and Urbanization

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2nd HyspIRI Science Workshop
Pasadena, CA (11-13 Aug 2009)

CQ6: Overarching Science Question

How do patterns of human environmental and infectious diseases respond to leading environmental changes, particularly to urban growth and change and the associated impacts of urbanization?

CQ6: Sub Questions

- **Caveat on Resolution:**
  - the use of space-based observations at the 60m spatial and weekly temporal scales to address urban human health and security concerns is not adequate alone
  - the data are most useful when merged with other data sources
    - public-health statistics
    - vector-based GIS databases
    - risk assessment, management and response information
    - higher resolution datasets
  - the merging of these datasets with HyspIRI would be beneficial with further with the proposed improvements in spaceborne technologies and the derived science/applications that come from those improvements

CQ6: Sub Questions

1. **How do land surface characteristics such as vegetation state, soil moisture, temperature and composition affect vector-borne and zoonotic diseases?**

   DS alignment: 156,158,160,183-184,198

2. **What is the impact to the local/regional scale land-atmosphere energy balance characteristics of measureable changes in the reflectance/emissivity of urban surfaces around the world?**

   DS alignment: 167-168

CQ6: Sub Questions

3. **How does the distribution of urban and peri-urban impervious surfaces affect hydrologic processes and biogeochemical fluxes; and what is the ecosystem response (e.g., heat stress, drought, etc.)?**

   DS alignment: 167-168,198, 203

4. **How do changes in urban hydrologic processes (e.g., heat, biogeochemical fluxes in coastal waters, pollution, etc.) impact human health and economic well-being; and how are these mitigated through environmental management strategies?**

   DS alignment: 146, 167, 196, 204, 208

CQ6: Sub Questions

5. How does air pollution (e.g., particulate matter, ozone, etc.) interact with the urban land cover fabric and impact respiratory and cardiovascular diseases?

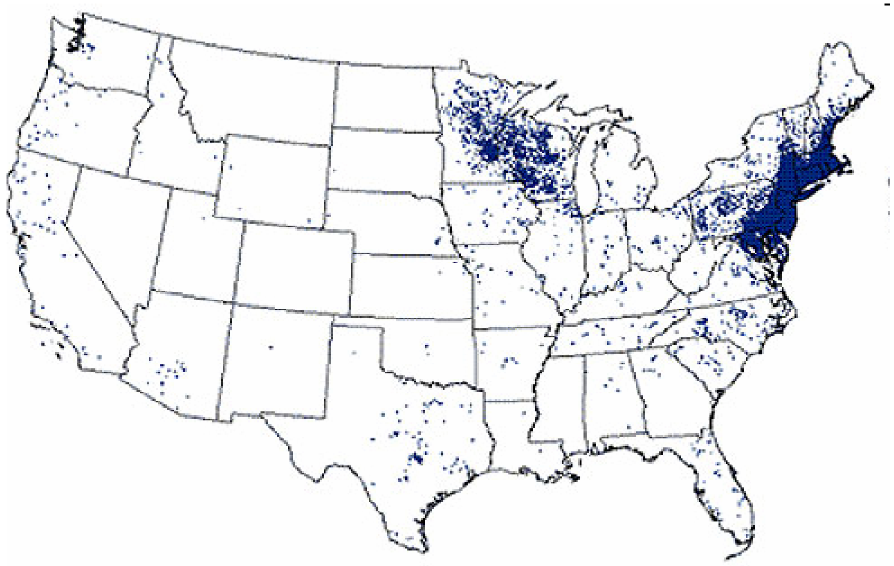
   DS alignment: 158, 177

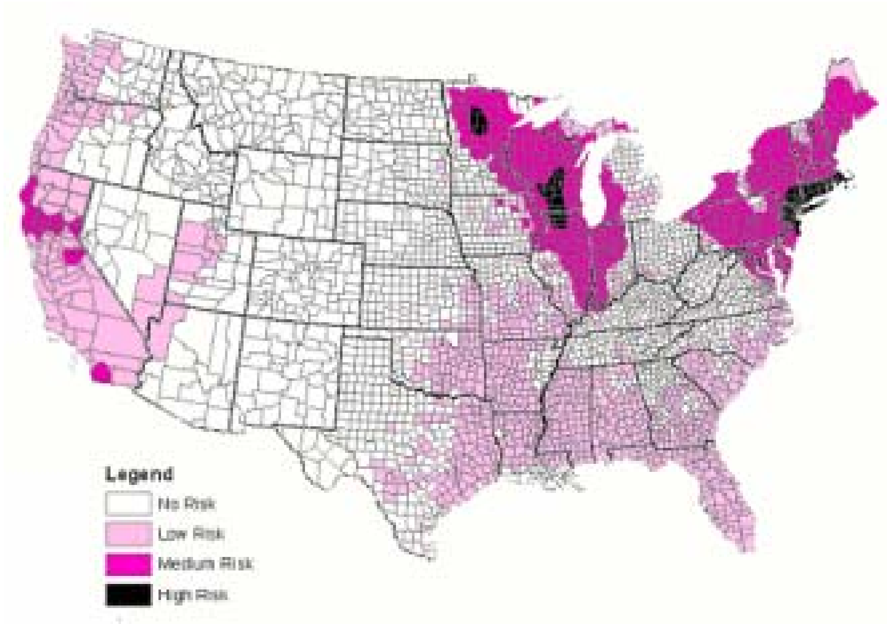
6. How can we monitor/characterize the dispersion, transport, and chemical evolution of hazardous plumes generated by industrial effluents and accidents?

   DS alignment: 160-161, 170-178

CQ6.1: Disease Transmission

- **Direct linkage between climate and many disease vectors (e.g., mosquitoes, ticks, rodents)**
  - heterogeneous transmission with landscape/climate/urbanization

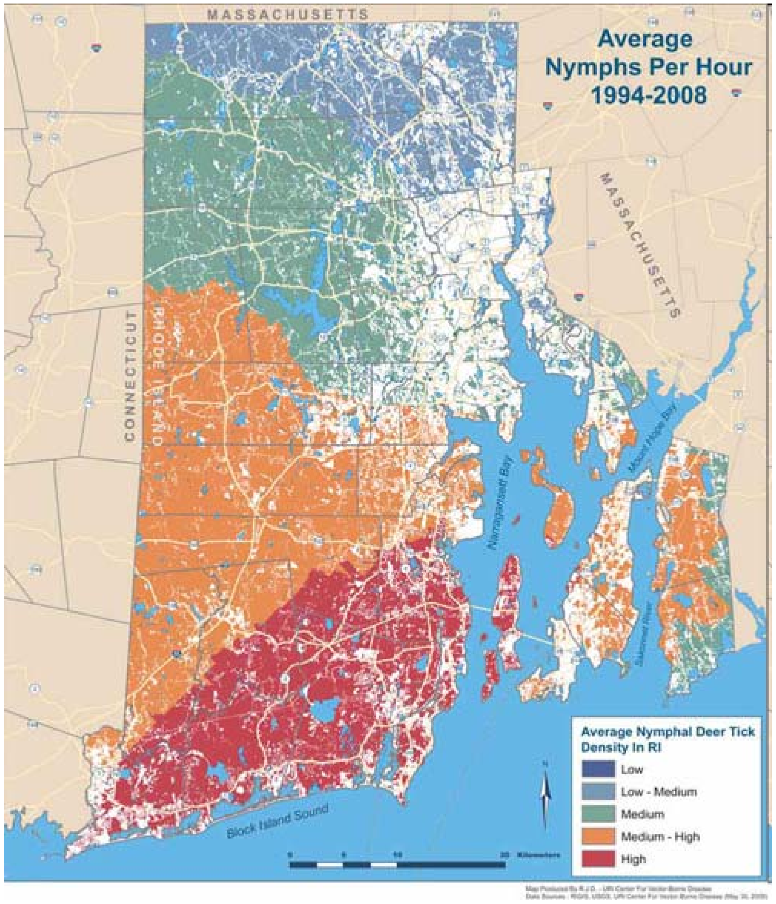




Lyme Disease -- United States, 2004
source: CDC

CQ6.1: Disease Transmission

- **Direct linkage between climate and many disease vectors (e.g., mosquitoes, ticks, rodents)**



  - example: the wet, cool summer of 2009 in the NE United States
    - deer tick populations are up as much as 4100% in locations in Rhode Island
    - transmit Lyme disease, babesiosis an anaplasmosis

Map produced by RJD URI Center for Vector-Borne Disease / Data sources RIGIS, USGS, URI Center for Vector-Borne Disease, May 30, 2009

CQ6.1: Disease Transmission

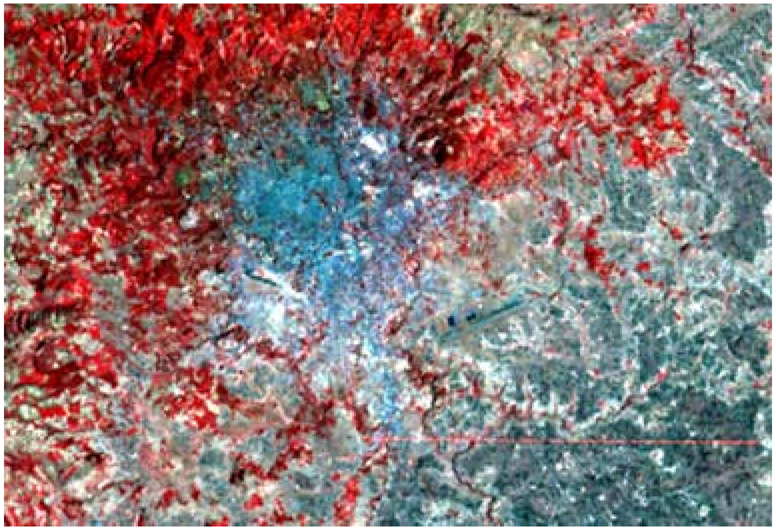
- **HyspIRI Targeted Application**
  - assessment of land cover characteristics or vegetation state that promote the propagation of vector or animal disease carriers
    - linkage to CDC or WHO in order to target suspected urban areas
    - VSWIR ~monthly vegetation species and ground cover maps
    - TIR for ~weekly updates on the heat, soil moisture, distribution of standing water

- **HyspIRI Mapping Application**
  - use VSWIR data to characterize global urbanization and impacts on the environment, such as forest degradation
  - VSWIR + TIR data to evaluate landscape state particularly surrounding urban areas

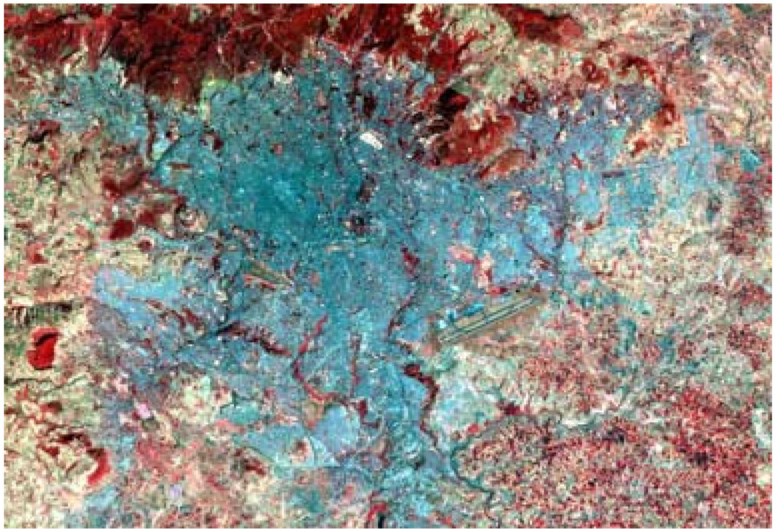
CQ6.2: Local Energy Balance

- **Measureable changes in the reflectance/emissivity of urban surfaces**
  - easy to emphasize on dramatic urbanization over the decadal time scale
  - however, the focus needs to be on using ASTER/Landsat to establish a baseline for future change as well as the reflectance/emissivity properties
    - including seasonality variations
  - understand what changes are measureable in the 2-3 year timeframe at 60m/pixel

Addis Ababa in 1973 (Landsat MSS)



Addis Ababa in 2007 (ASTER)



CQ6.2: Local Energy Balance

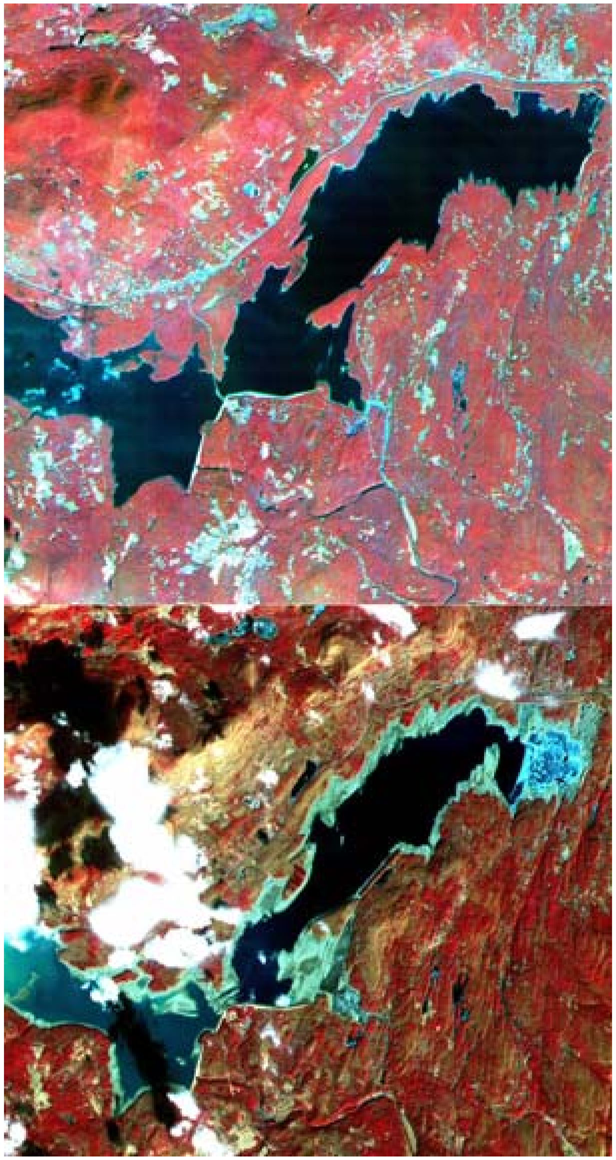
Astana, Kazakhstan

March 20, 2001

September 5, 2003

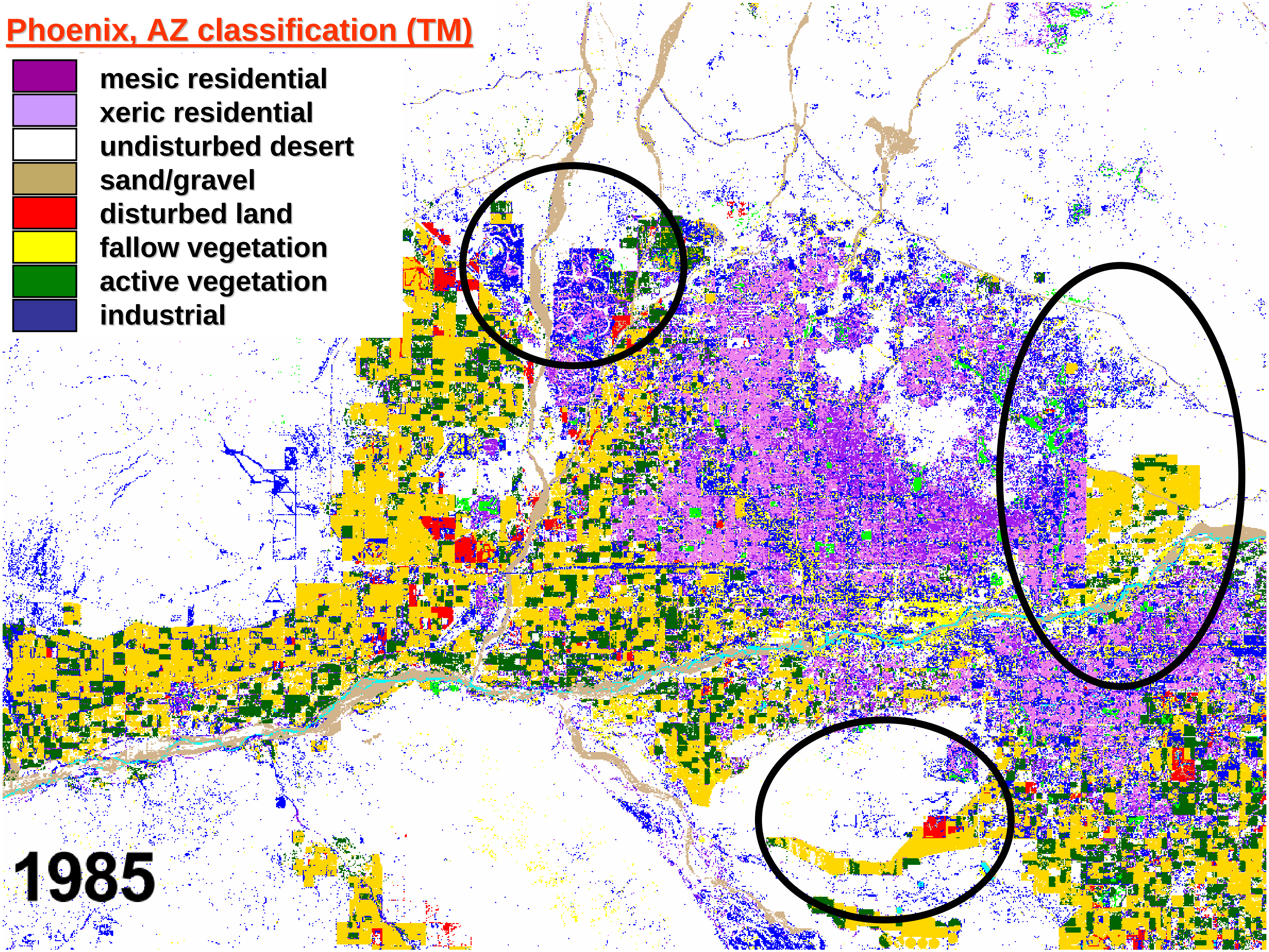
CQ6.3: Impervious Surfaces

- **How does the distribution of urban and peri-urban impervious surfaces affect hydrologic processes and biogeochemical fluxes?**
  - broad topic that encompasses water runoff, pollution inputs to local water sources, urbanization, and climate *(e.g., flooding and drought conditions)*
  - VSWIR/TIR measurements:
    - vegetation state/condition
    - quantification of biogeochemical fluxes in or near urban areas
    - observation of lakes, rivers, wetlands, marshlands, and coastal estuaries impacted by urbanization

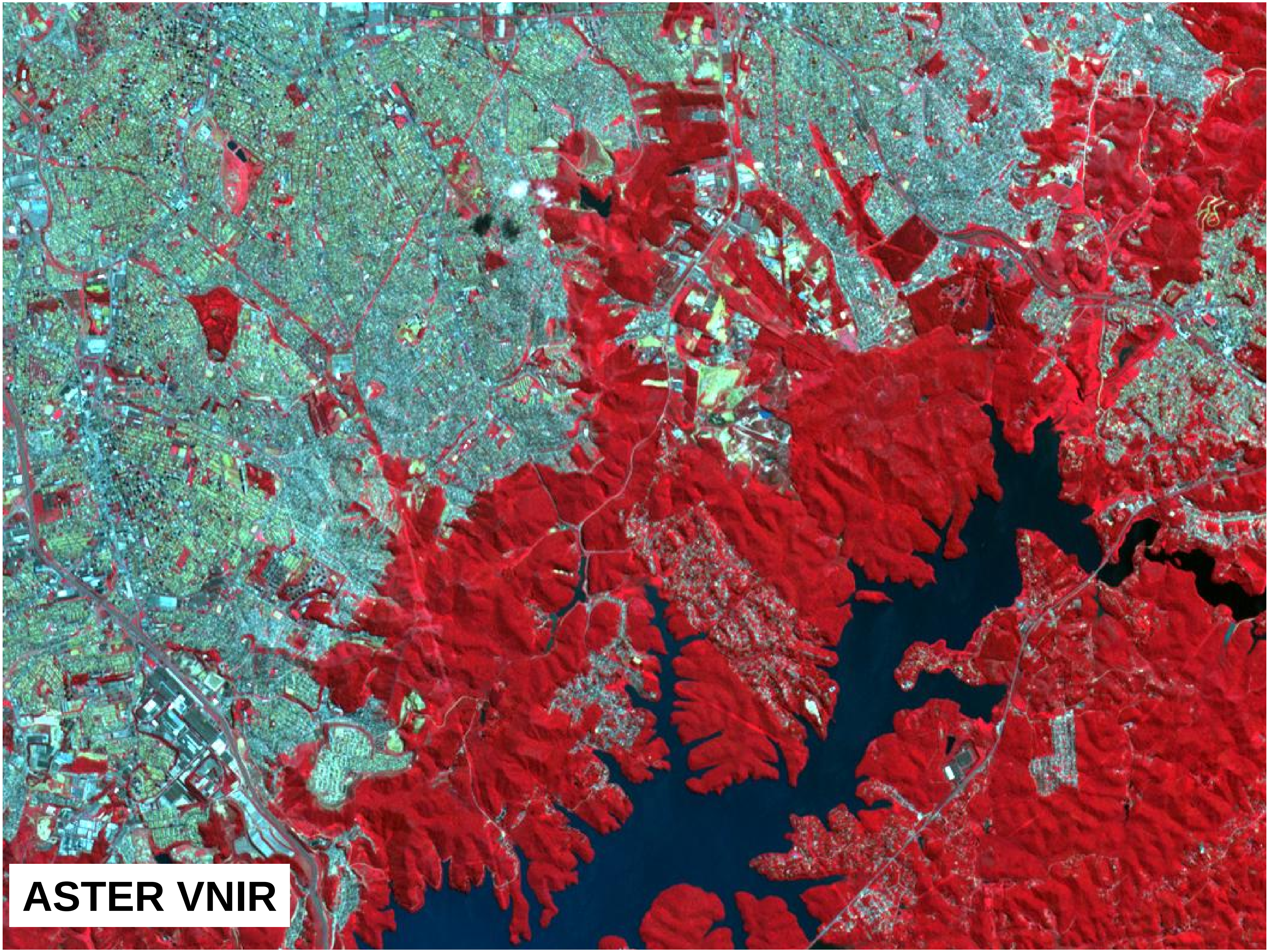


Drought monitoring in NY's Ashokan Reservoir using ASTER. Top: 9/18/2000. Bottom: 2/3/2002

Phoenix, AZ classification (TM)

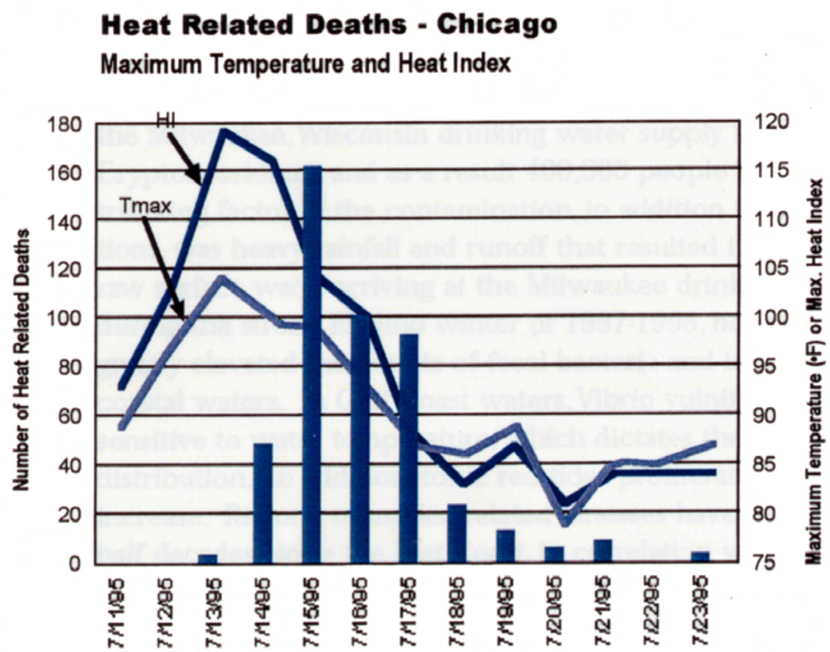



Landsat ETM+ VIS (São Paulo, Brazil)


ASTER VNIR

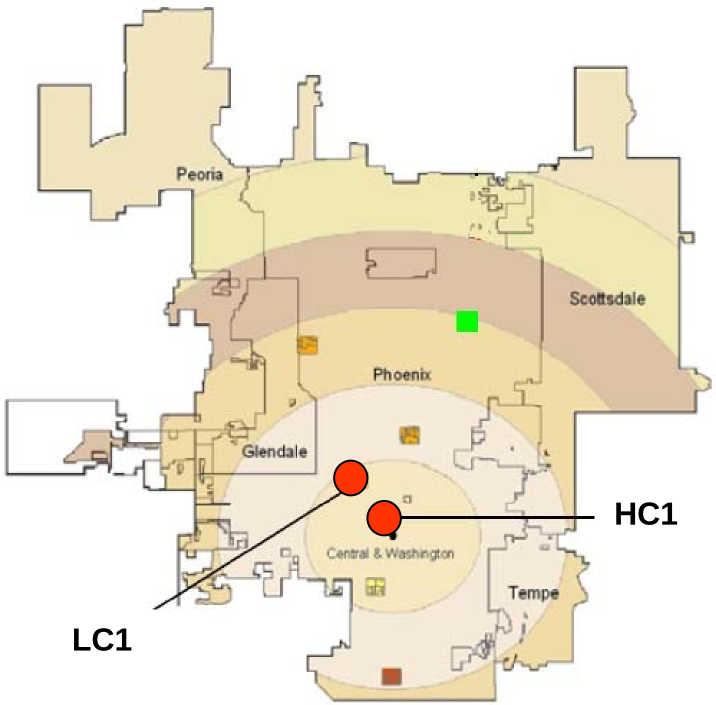
CQ6.4: Human Health

- **How do changes in urban processes (e.g., heat, biogeochemical fluxes in coastal waters, pollution, etc.) impact human health?**
  - UHI is fairly well-known and understood on a macro-scale for many cities
    - addressed in the TQ4
  - can we better understand urban microclimates using HyspIRI data?
    - also links with GIS data on populations, poverty, and health at the neighborhood scale
      - *studies using Landsat and ASTER in Phoenix, AZ (Harlan et al., 2008 and 2006)*



This graph tracks maximum temperature, heat index, and heat-related deaths in Chicago each day from July 11 to 23, 1995. The gray line shows maximum daily temperature, the blue line shows the heat index, and the bars indicate number of deaths for the day.

CQ6.4: Human Health



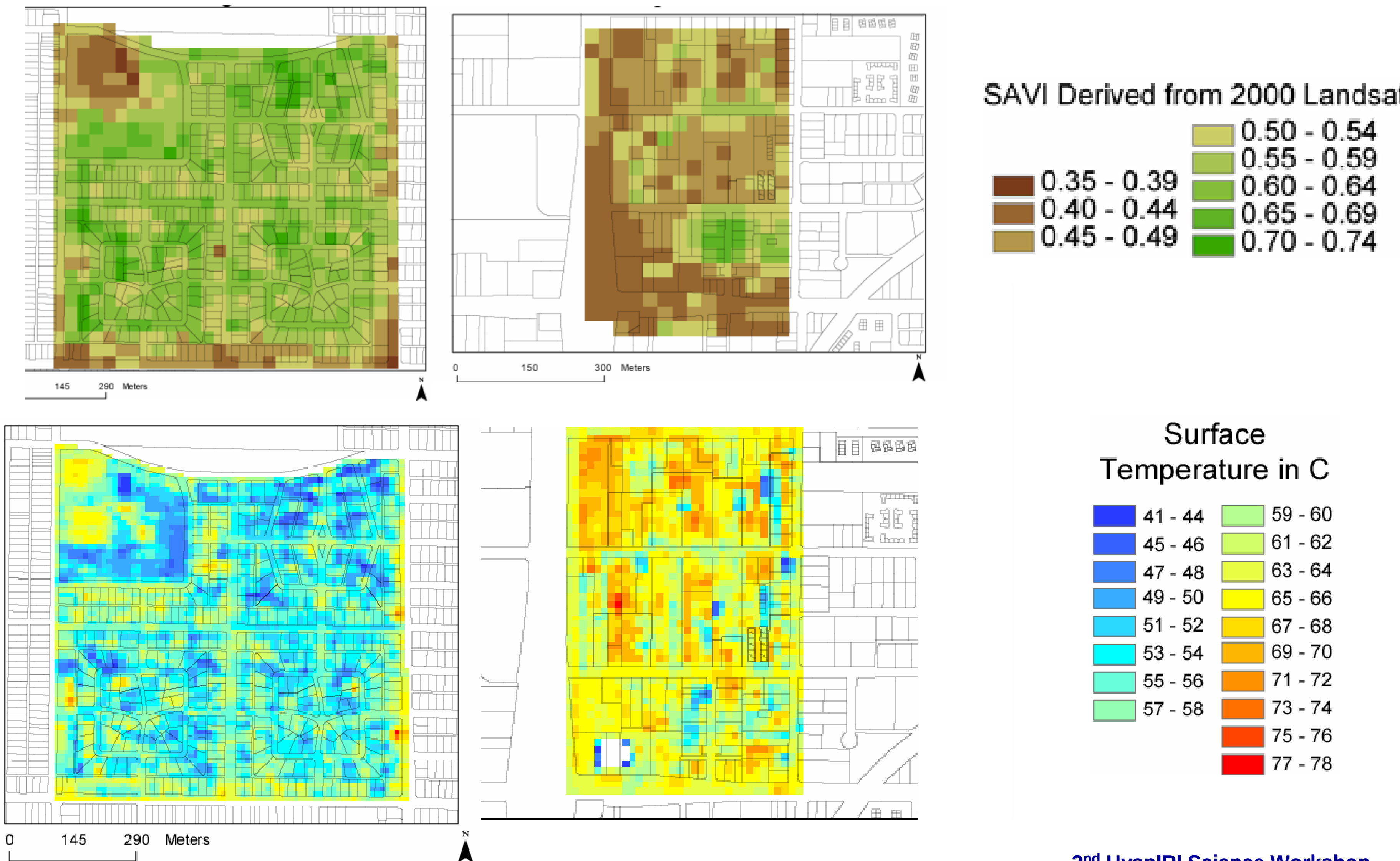
HC1

LC1

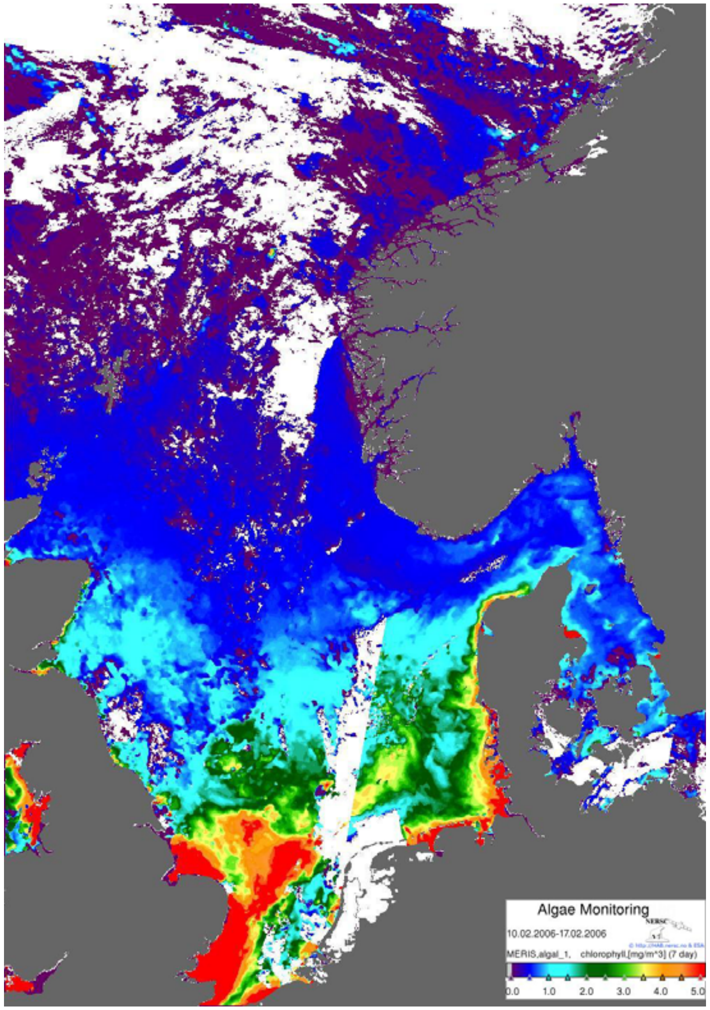
Locations of Survey Neighborhoods in Phoenix

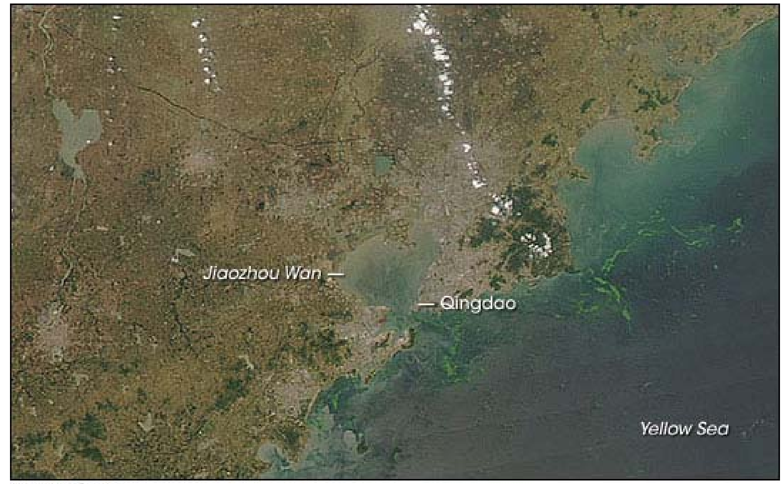
	Social Capital	Population	% Hispanic	Median HH Income	%Home Owners	%Edu College+	Mean Age
HC1	**3.5**	**981**	**23**	**77,404**	**74**	**42**	**38**
LC1	**2.4**	**2,024**	**77**	**25,785**	**6**	**1**	**23**

CQ6.4: Human Health



CQ6.4: Human Health





Natural Color

False Color (Shortwave, Near-Infrared, and Red)

Algal Blooms in near shore regions – North Sea (left) and China (right)

CQ6.5: Air Pollution

- **How does air pollution (e.g., particulate matter, ozone, etc.) interact with the urban land cover fabric?**
  - these can be persistent urban pollution conditions or one time events due to climate conditions, fire, other natural/anthropogenic event
  - can have moderate to severe impacts on pulmonary and cardiovascular diseases
    - example: massive decline of the Aral Sea
      - since the 1960s, overexploitation for irrigation
      - resulted in 80% volume loss
      - increase in dust/asthma in the region

MISR false-color nadir image of San Diego, CA (2003)

CQ6.5: Air Pollution

- **Fine particulate air pollution (PM2.5) globally**
  - causes 3% of mortality from cardiopulmonary disease, 5% of mortality from cancer of the trachea/lung, and 1% of mortality from acute respiratory infections in children under 5 yr, worldwide.
  - 0.8 million (1.2%) premature deaths
  - 6.4 million (0.5%) years of life lost

TABLE 1. Excess Deaths from Selected Environmental Factors

Environmental risks	Global estimate	Asian estimate (S, SE Asia + W Pacific)	Asia as a percent of global
Unsafe water	1,730,000	730,000	42%
Urban outdoor air	799,000	487,000	65%
Indoor air	1,619,000	1,025,000	63%
Lead	234,000	88,000	37%

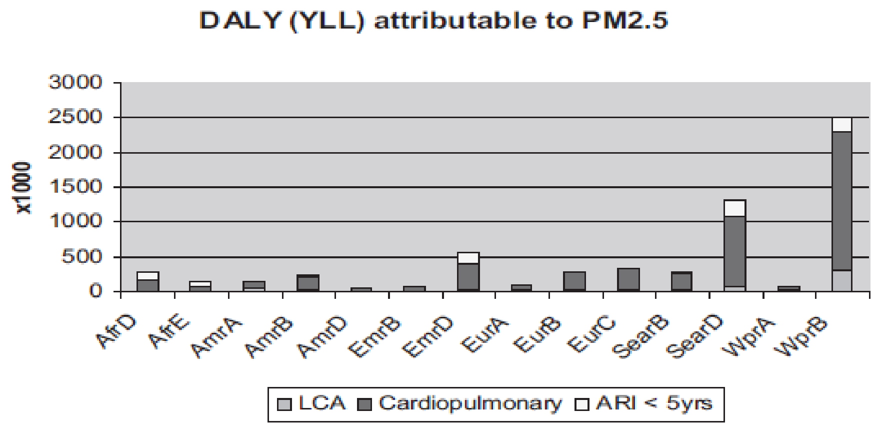
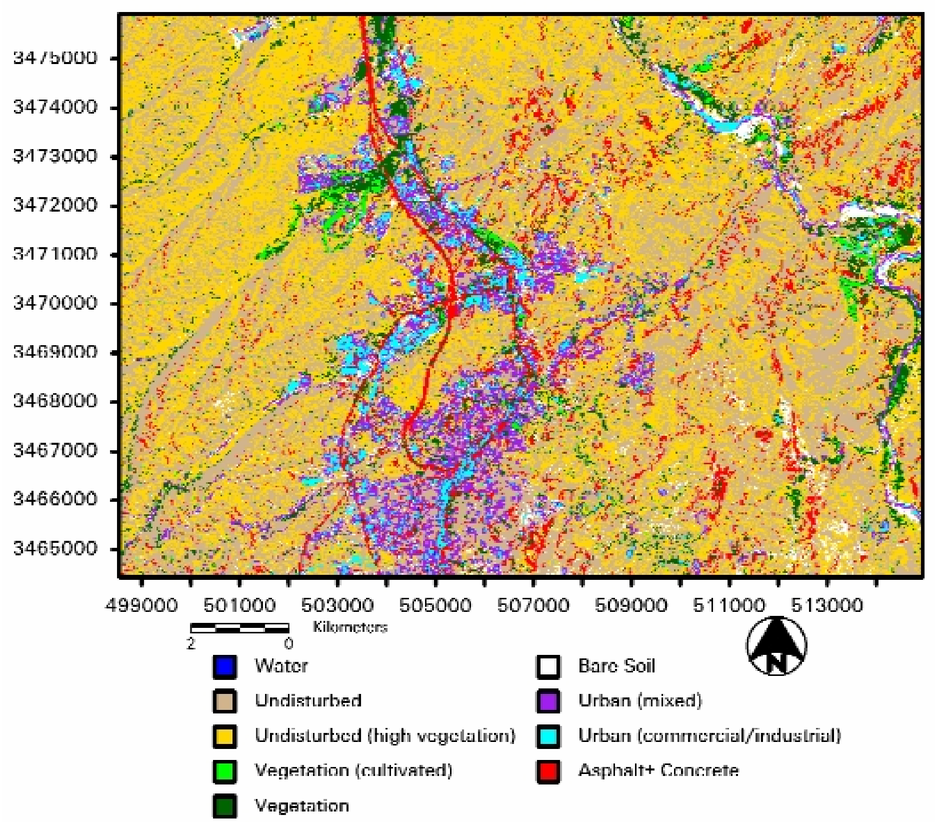
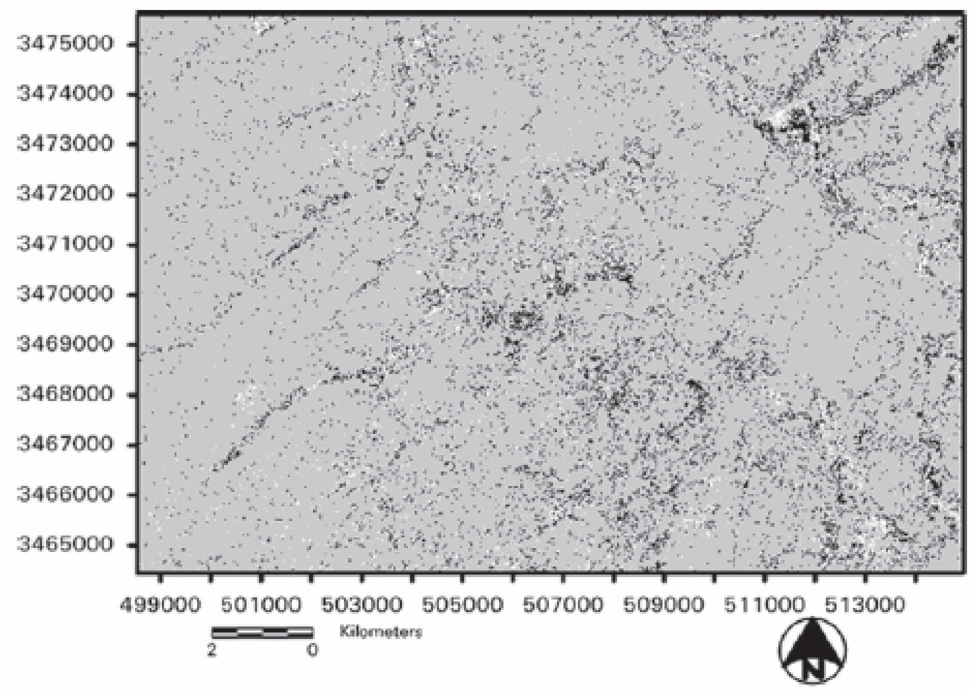


FIGURE 3. Years of life lost attributable to urban air pollution by region.

Cohen AJ, et al 2005

CQ6.5: Air Pollution





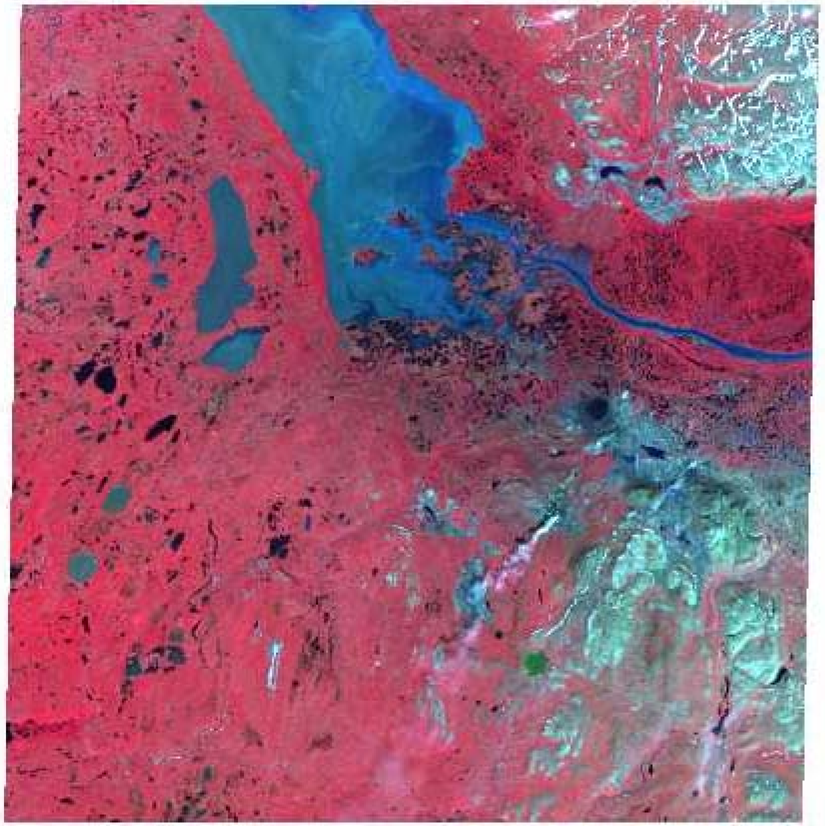
– can use image-based classifications of land cover and digital topography to map dust generating locations within an urban environment. Stefanov et al. (2003) used Landsat TM data of Nogales, AZ to map suspected dust generating pixels (right)

CQ6.6: Hazardous Plumes

- **How can we monitor/characterize the dispersion, transport, and chemical evolution of hazardous plumes?**
  - several candidate urban sites that could be used to better understand the effects of hazardous plumes and their effect on local populations
    - example: Norilsk, Russia (entirely contaminated)
    - has an extremely high level of air pollution from the mining
      - particulates, sulfur dioxide, heavy metals (nickel, copper, lead), hydrogen sulfide, and phenols

CQ6.6: Hazardous Plumes

- **How can we monitor/characterize the dispersion, transport, and chemical evolution of hazardous plumes?**
  - plumes can be detected on most ASTER and Landsat images of Norilsk
  - vegetation stress/death easily seen
  - better quantification of the land surface pollution and constituents of hazardous plumes
  - ideal link with other atmospheric chemistry instruments and ground based monitoring



ASTER (2001)

Possible L3 Products

- **Apparent Thermal Inertia Product**
  - rely on well-calibrated VSWIR albedo and TIR day/night temperature (soil moisture, vegetation distribution, urban mat'l)
- **Urban Land Cover Classification Product**
  - input from the VSWIR and TIR
  - used to derive land use and change

Possible L3 Products

- **Urban Primary Productivity Product**
  - vegetation mapping/modeling (VSWIR)
  - temperature/wetness (TIR)

- **Urban Health Product**
  - atmospheric chemistry/aerosols,
  - integrated product with GIS vector layers generated from public heath, CDC, WHO, and/or federal/state/local emergency management agencies

- **Others?**

Validation Approach

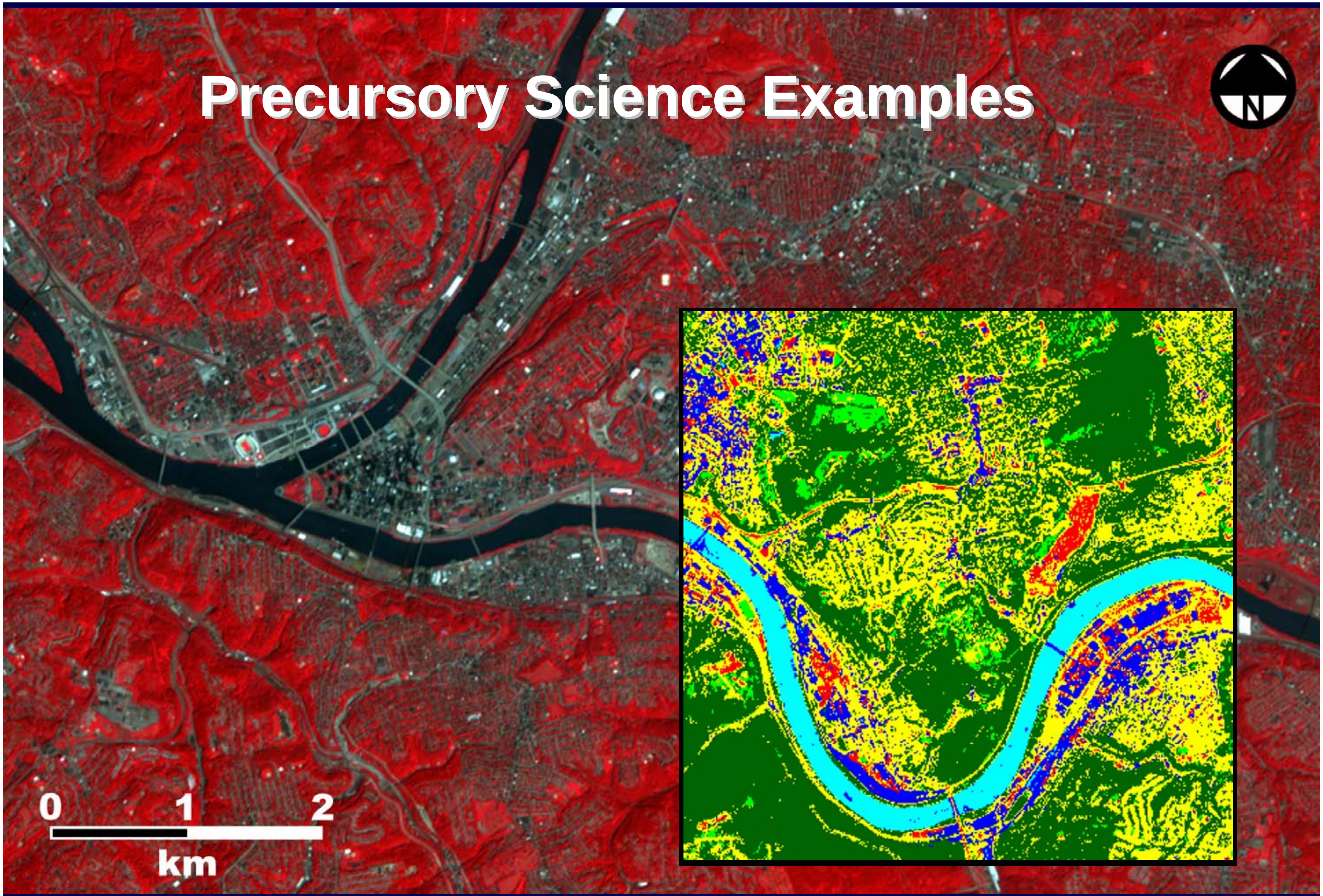
- **Develop a Validation VSWIR/TIR Protocol now**
  - using well-studied urban targets with high to moderate resolution data
- **Establish an Urban Cal/Val Network**
  - similar in ways to **AERONET** (AErosol RObotic NETwork)
    - which provides continuous observations of spectral aerosol optical depth (AOD), precipitable water, and inversion aerosol products in diverse aerosol regimes
- **Choose a Subset of Urban Targets**
  - perform ground and airborne-based thermal/spectral measurements during the first year of HyspIRI

Precursory Science

- **Mining the existing urban archive**
  - "100 Cities Project" at Arizona State University (http://hundredcities.asu.edu/)
    - large archive of ASTER data applied to the problems of urbanization, the environment, and sustainability
    - establish better linkages between NASA-based thematic data and government-based vector data
    - seasonality effects
    - new image processing tool development
      - super-resolution approach allows quantitative 15m TIR to be extracted from ASTER 90m data

- **Develop a better and more complete urban spectral library**

Precursory Science Examples



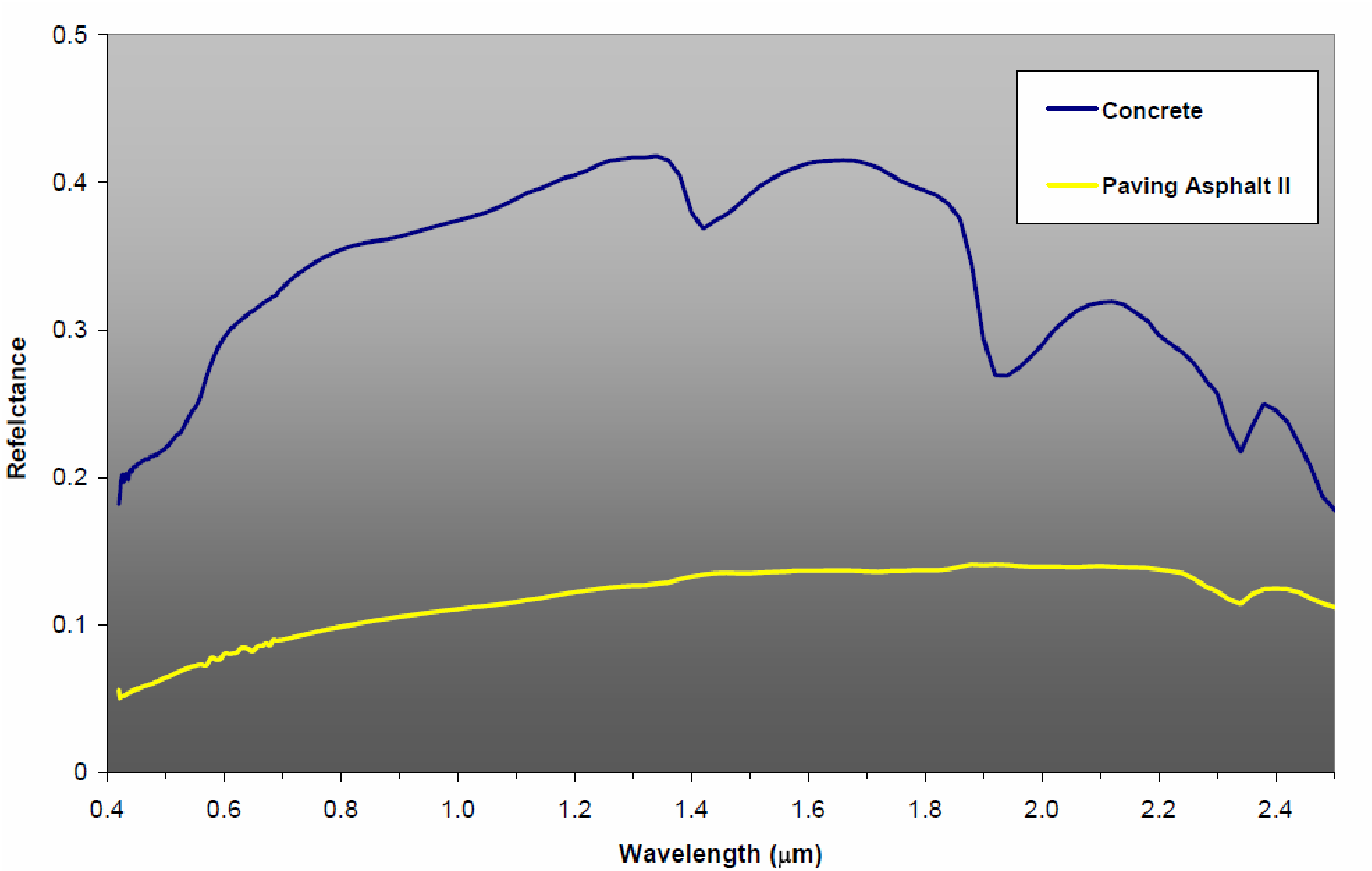
ASTER: Pittsburgh, PA

Land Cover Classification

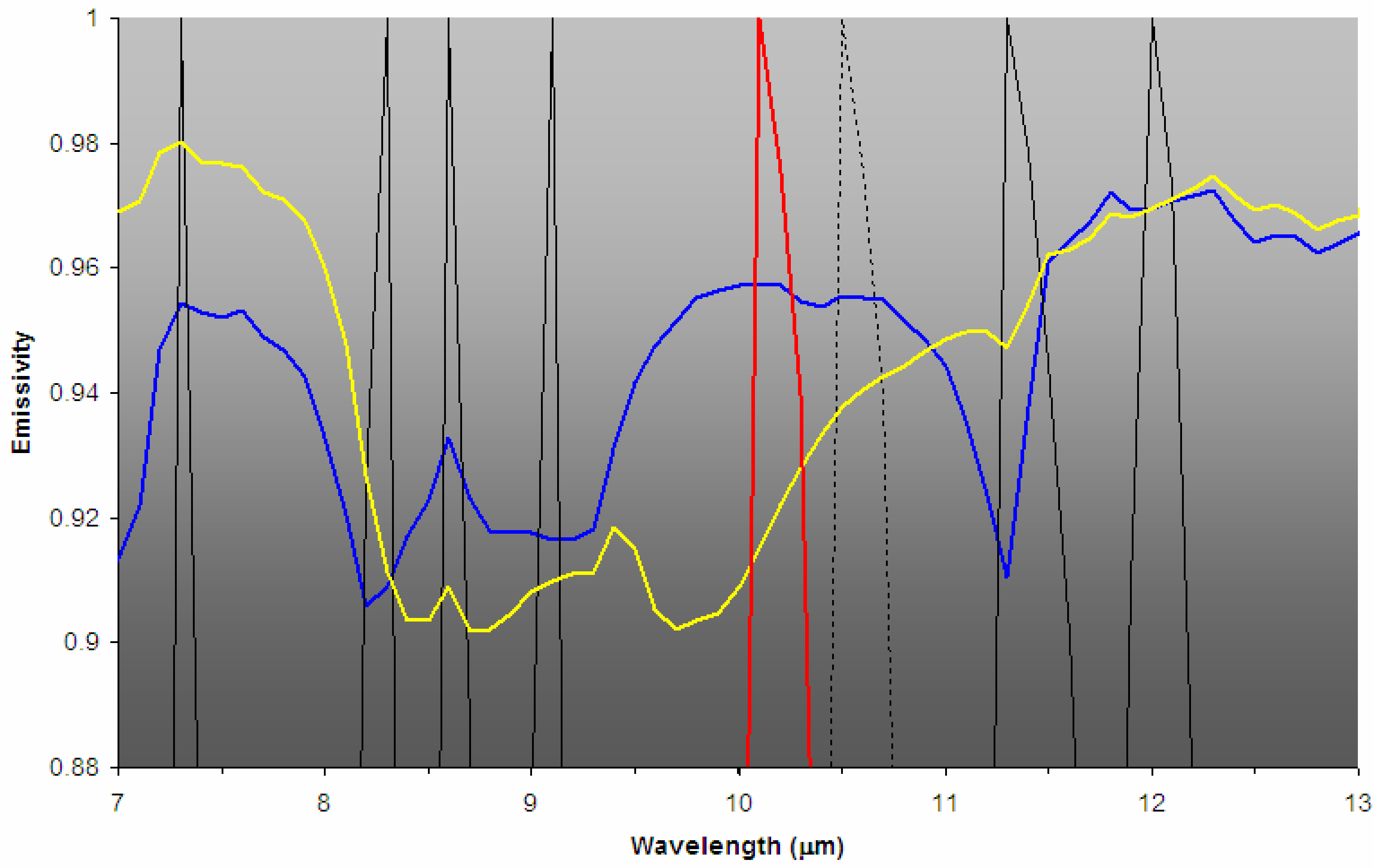
Precursory Science

- **Trade Space Analysis**
  - TIR band position and number
    - what are the most common urban surface materials, gases, and anthropogenic hazards?
    - what is the detection accuracy of these materials in the TIR with the notional TIR bands?
  - synergy between VSWIR and TIR for these materials
    - for the above materials, which can be detected/better detected in the VSWIR (and vice versa)?
  - synergy between HyspIRI and other DS instruments
    - soil moisture from thermal inertia (relation to SMAP data)
    - improvement in land cover/land use accuracy (DESDynI data)

Precursory Science Examples



Precursory Science Examples



Precursory Science Examples

- **Spectral vs. Spatial**
  - clear improvement with sub 5m/pixel urban data
  - increased accuracy in urban land cover model *(6 land cover classes):*
    - with multispectral SWIR
      - **69% → 73%**
    - with night TIR
      - **73% → 79%**
    - with multispectral TIR
      - **79% → 83%**
    - with longer wavelengths (multi-polar SAR)
      - **83% → 89%**

land cover classification of Phoenix, AZ

CQ6: Human Health and Urbanization