Hot Science Cool Talks

UT Environmental Science Institute

22

I Spy…Seeing Our Environment in a New Light: The Technology of Remote Sensing

Dr. Kelley Crews-Meyer

January 24, 2003

I Spy… Seeing Our Environment in a New Light:

The Technology of Remote Sensing

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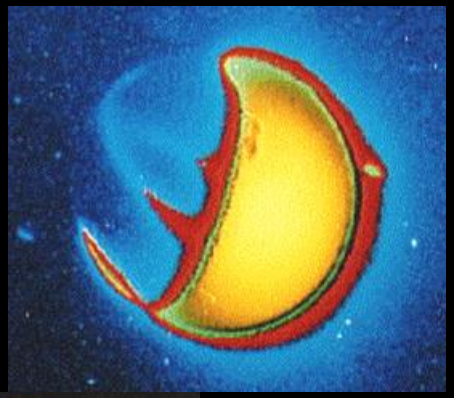
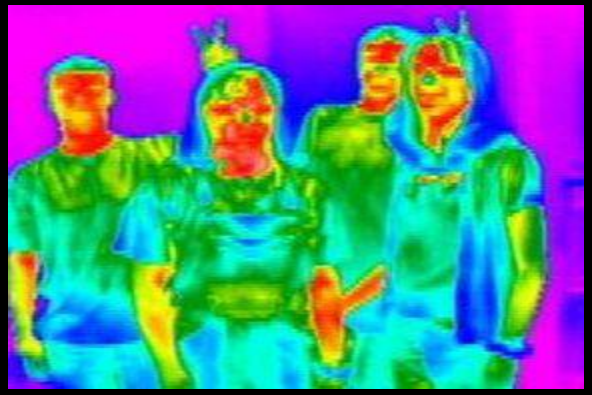
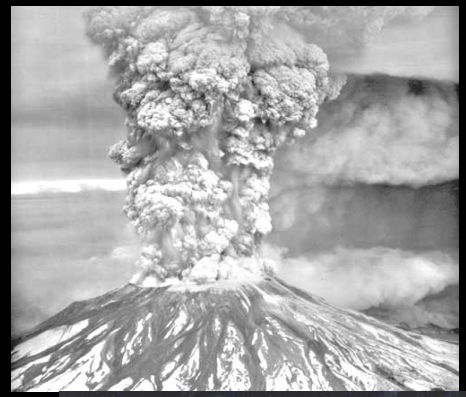
Department of Geography
University of Texas

Pictures are worth a thousand words…






The Earth from Space

Apollo 17 Crew, NASA

Credit: Apollo 17 Crew, NASA

Darrell K. Royal Texas Memorial Stadium

University of Texas

Daytona 500 Racetrack

February 1995, NAPP (USGS EDC)

Great Lakes, September 1987

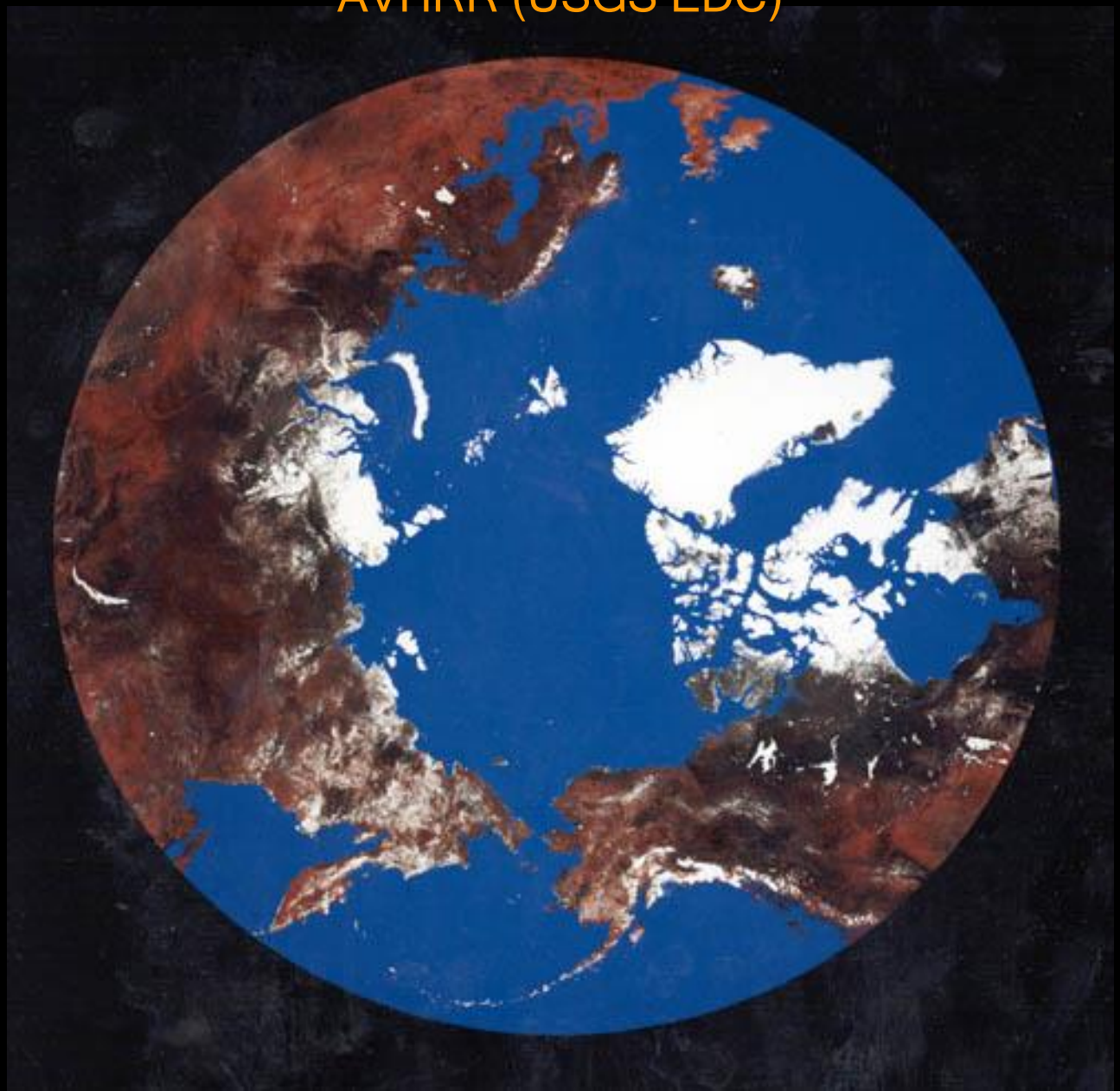
AVHRR (USGS EDC)

Mt. St. Helens, May 1980

Aircraft photo (USGS EDC)

The North Pole, June 1992

AVHRR (USGS EDC)



The Earth at Night, DMSP mosaic

(NASA, Astronomy Picture of the Day)

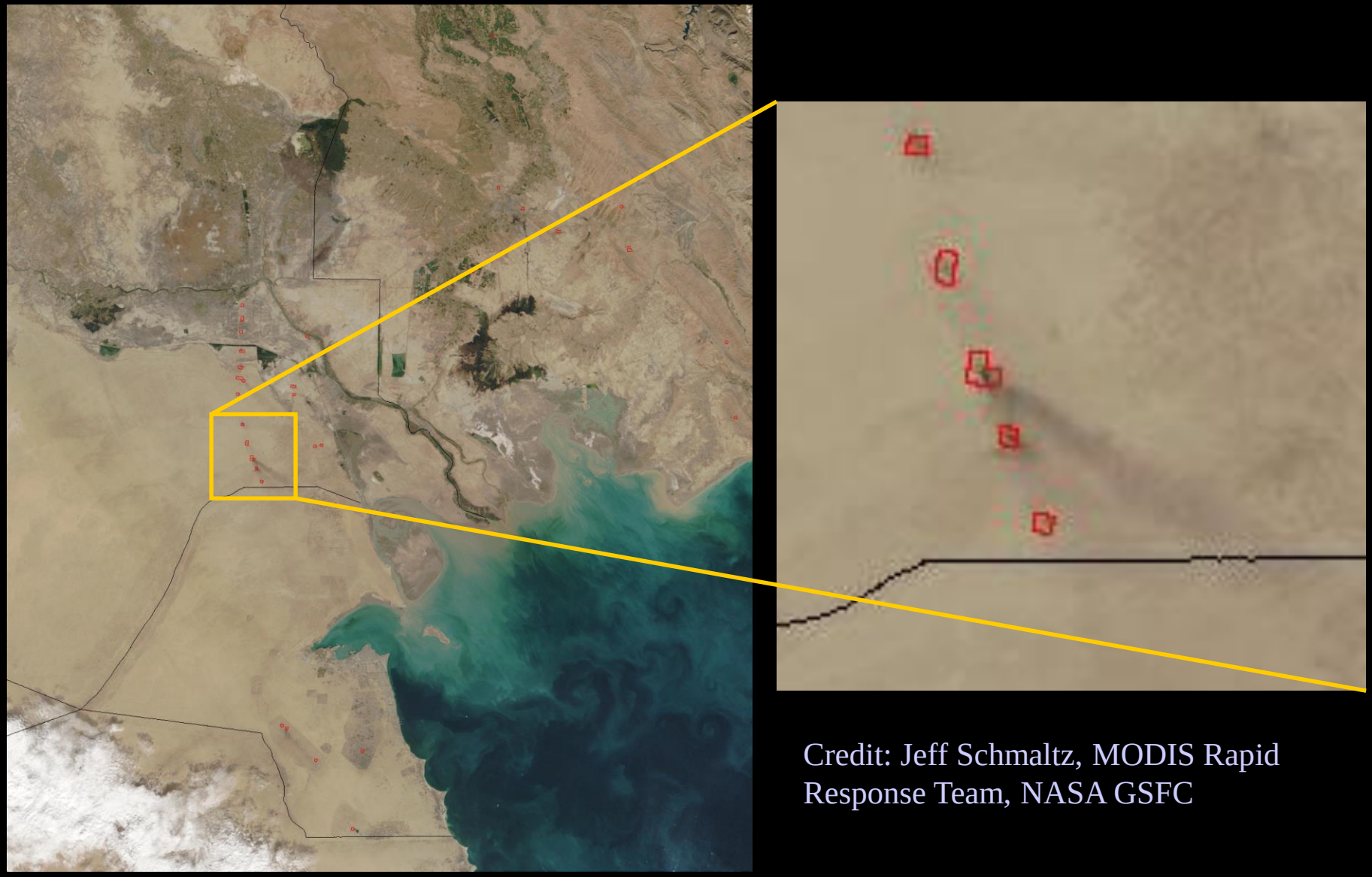
Credit: C. Mayhew & R. Simmon (NASA/GSFC),
NOAA/ NGDC, DMSP Digital Archive

Kuwait Oil Fires, April 1991

Shuttle (USGS EDC)

Middle East Oil Fires, November 4, 2002

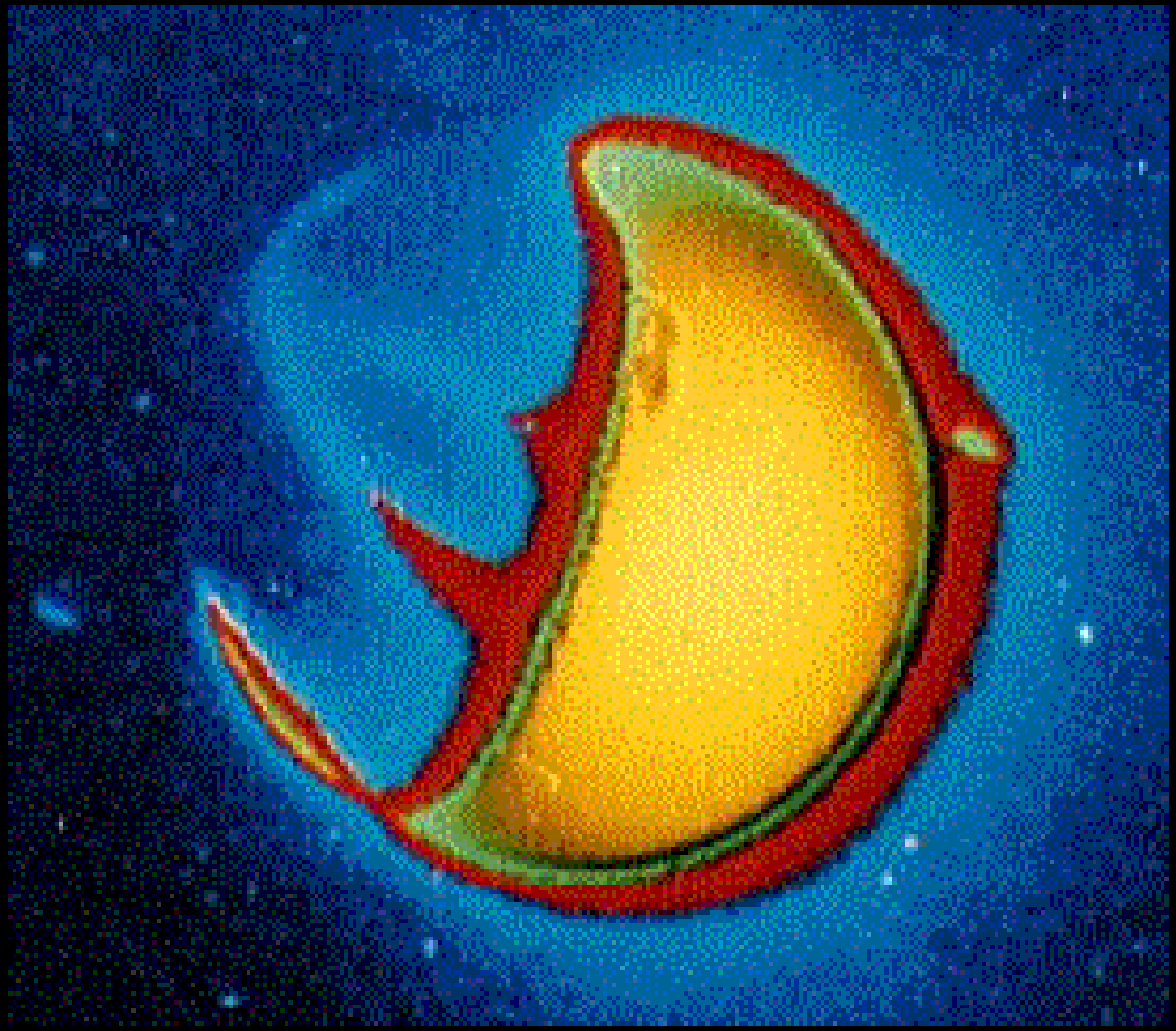
MODIS, NASA EOS



Credit: Jeff Schmaltz, MODIS Rapid Response Team, NASA GSFC

Far UV Earth from Moon (Apollo 16 crew),

(NASA, Astronomy Picture of the Day)



Credit: G. Carruthers (NRL) et al., Far UV Camera, Apollo 16, NASA

Thermal (Far Infrared) People

(NASA Remote Sensing Tutorial)

Defining Remote Sensing

- Remote: not in contact with, away from
- Sensing: the act of observation
- “Remote Sensing is a technology for sampling electromagnetic radiation to acquire and interpret non-immediate *geospatial data* from which to extract information about features, objects, and classes on the Earth's land surface, oceans, and atmosphere….” (NASA)

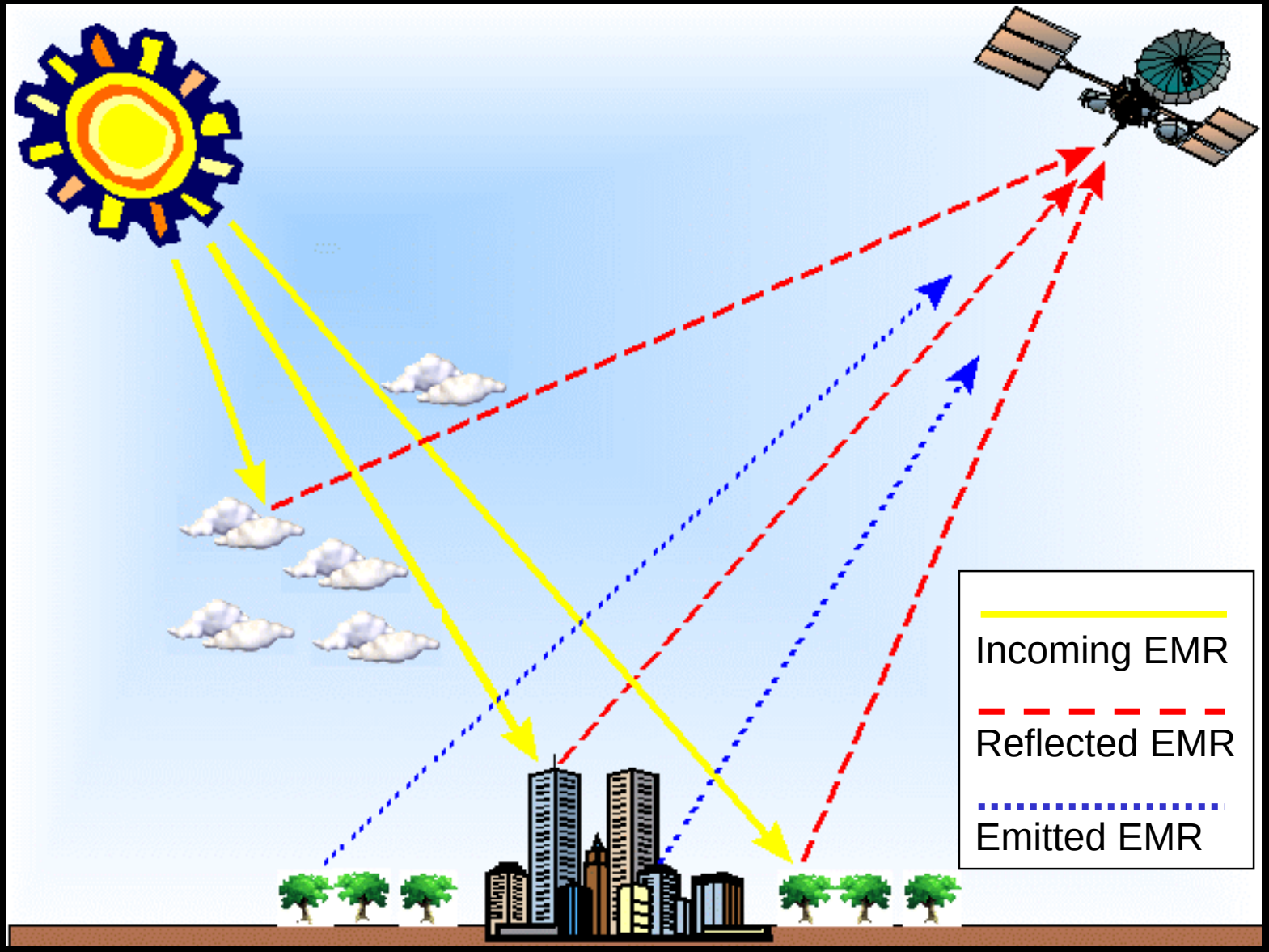
WHAT???

A more workable definition

- From a satellite or airplane, we figure out what an object is by the way it reflects “light”

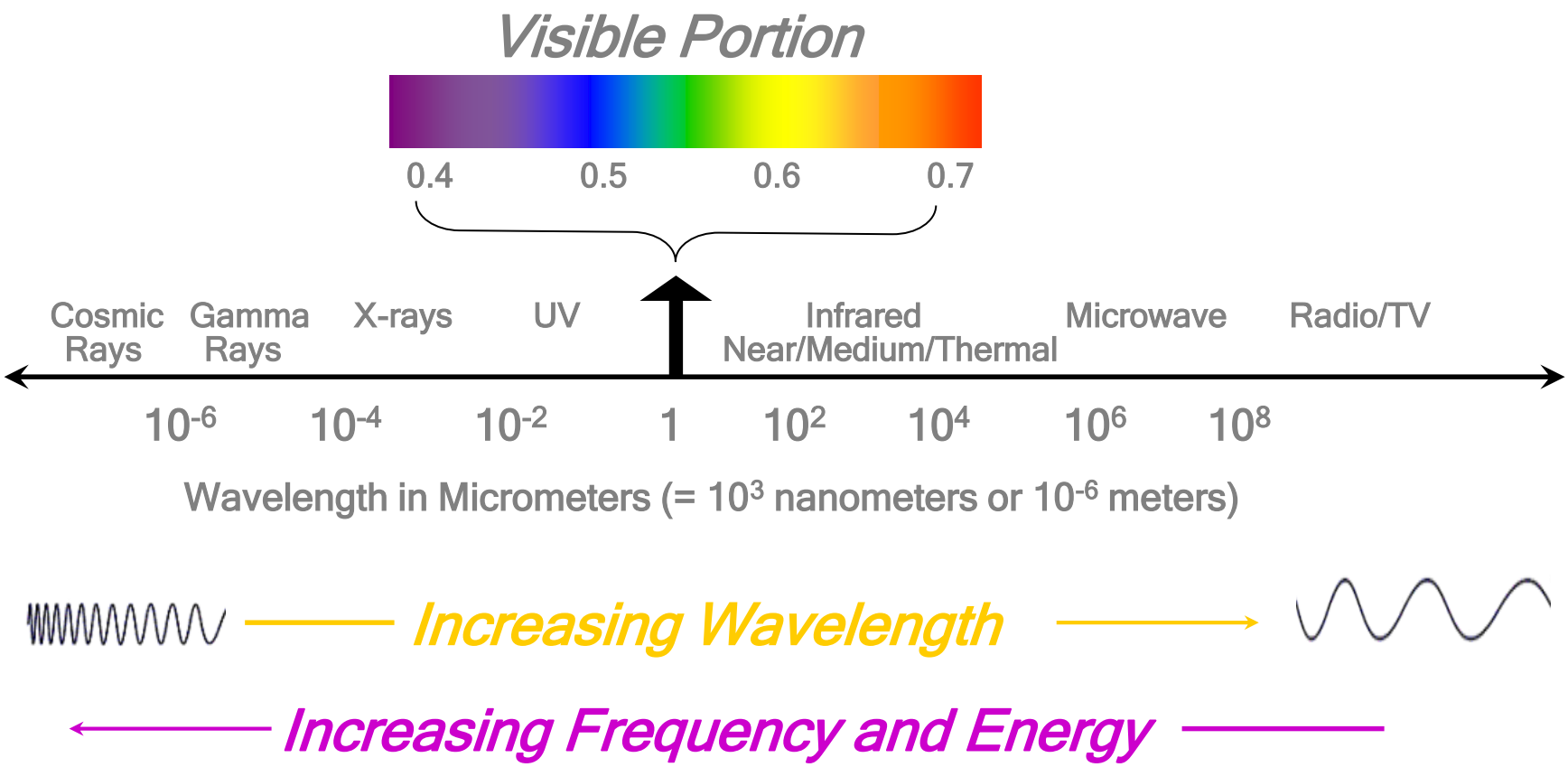
- Remember “I SPY”
  - I is for ***Image*** (not a “picture”)
  - S is ***Signatures*** – a unique identifier
  - P is for ***Perspective*** – the bird’s eye view
  - Y is for ***You*** – computers need people

Passive (Optical) Sensor Technology



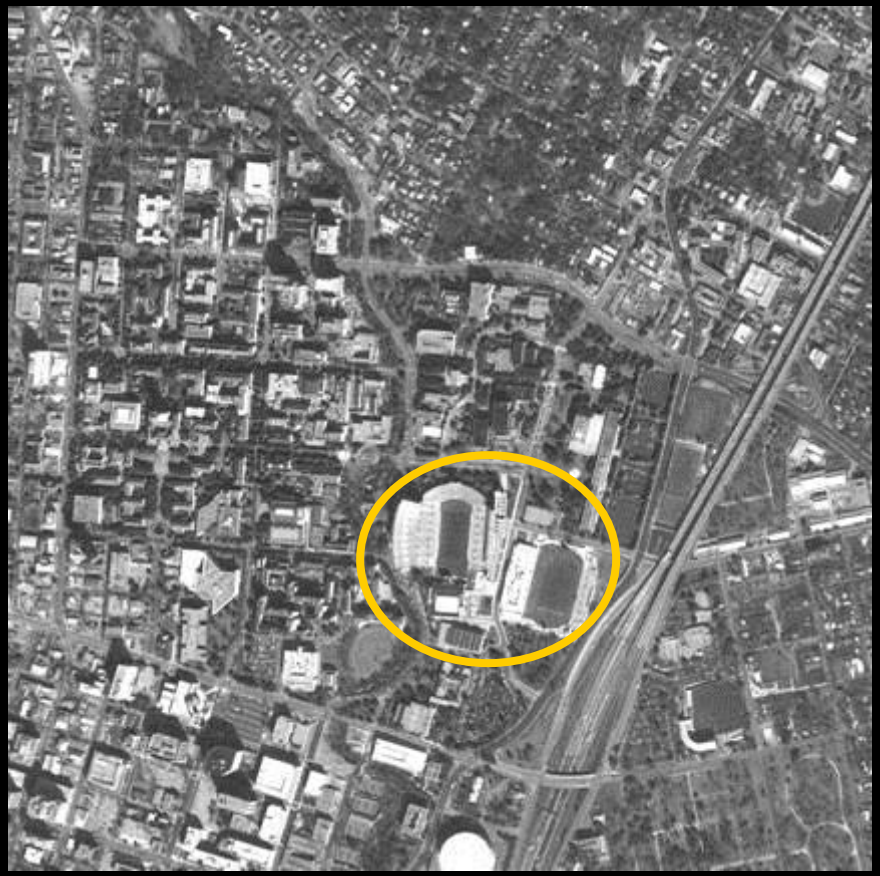
Source: Remote Sensing Core Curriculum, Volume 3 (Jensen)

Electromagnetic or EM Spectrum

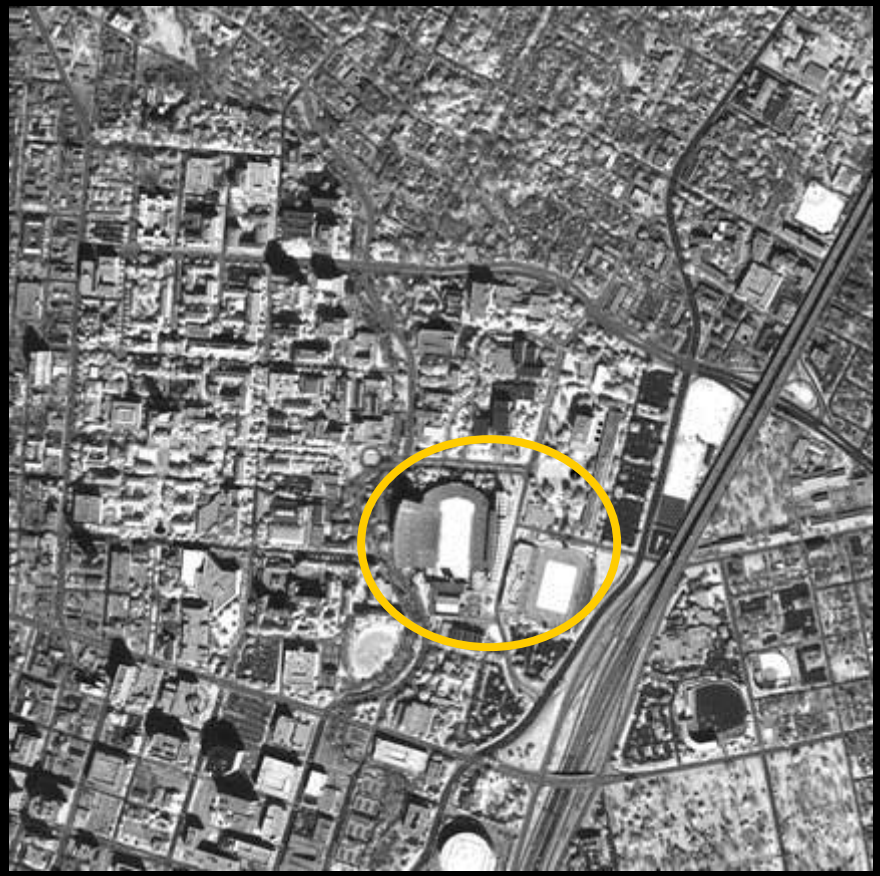


1 band = 1 B&W photo

Differences in Bands

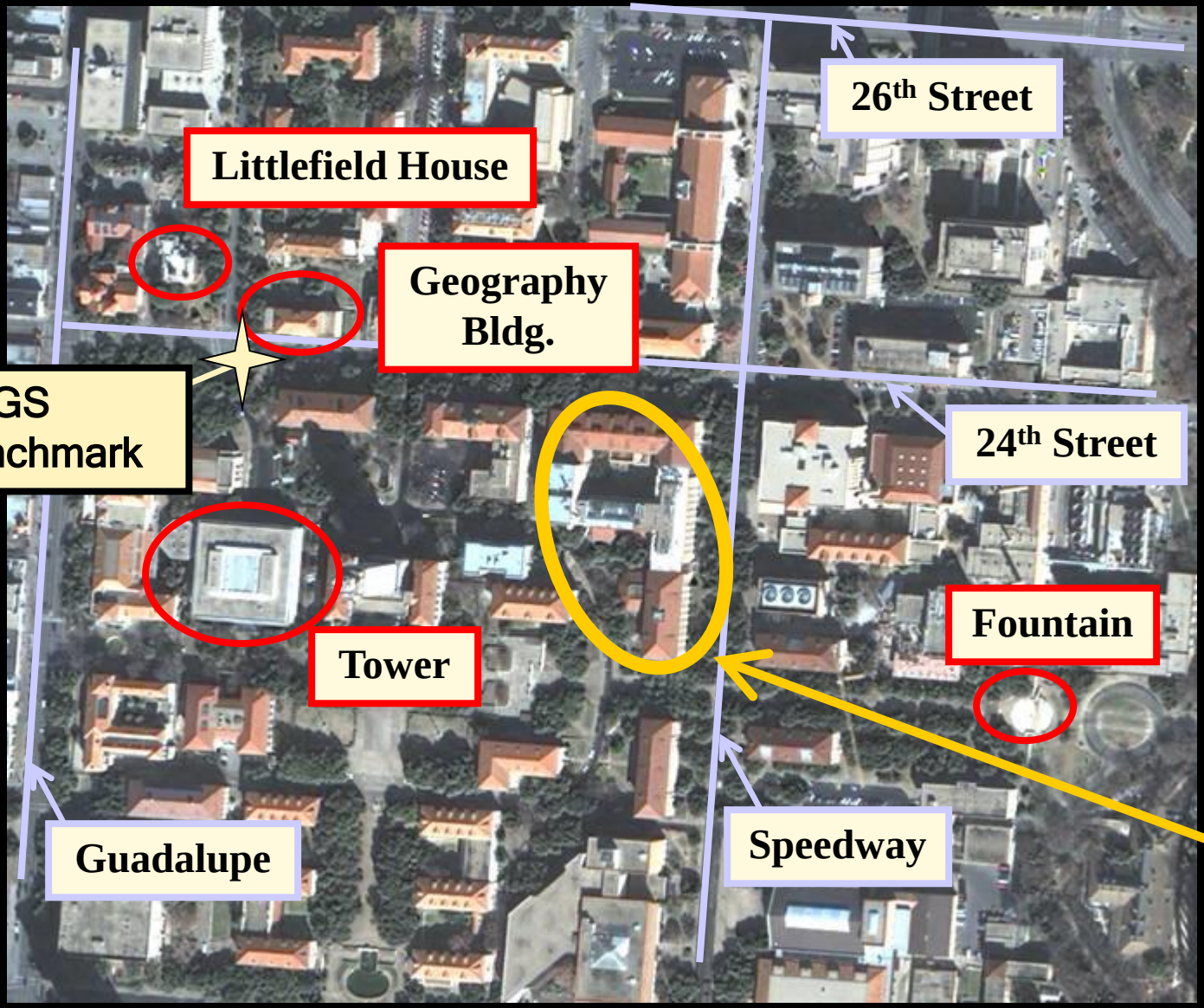


QuickBird, 0.7m
Visible (Blue)



QuickBird, 0.7m
Near Infrared

I is for *Image* (not a "picture")



The RGB compositing process

Infrared band (4)

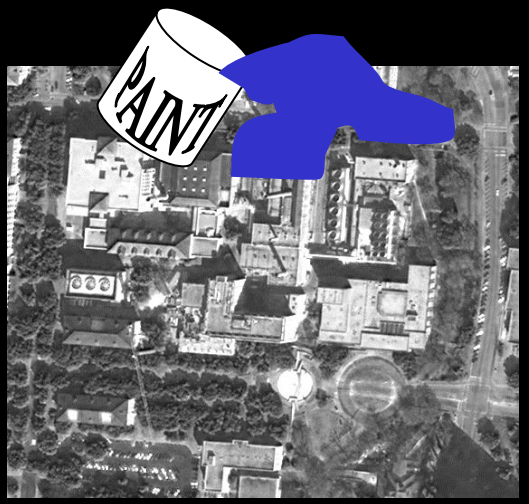
↓

Red color gun

Red band (3)

↓

Green color gun

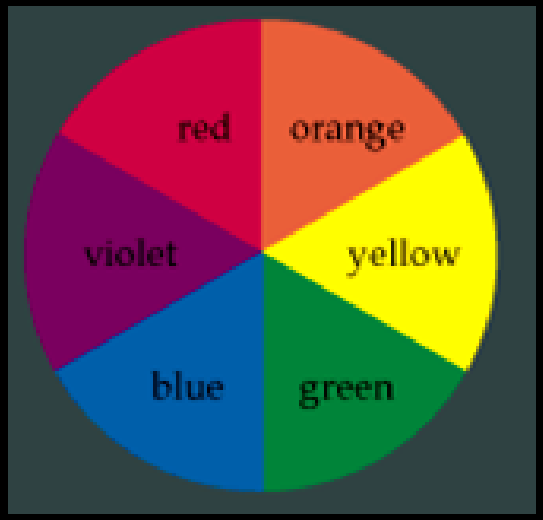


Green band (2)

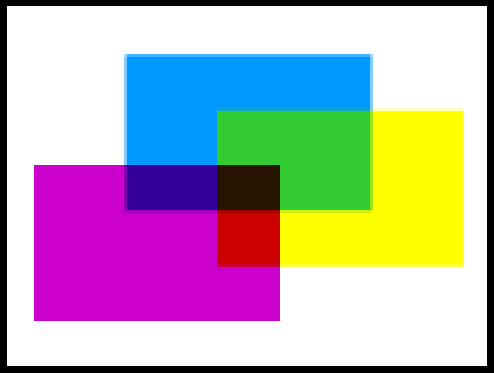
↓

Blue color gun

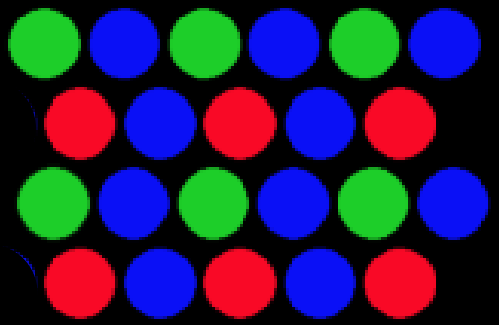
Color Theory and Image Processing



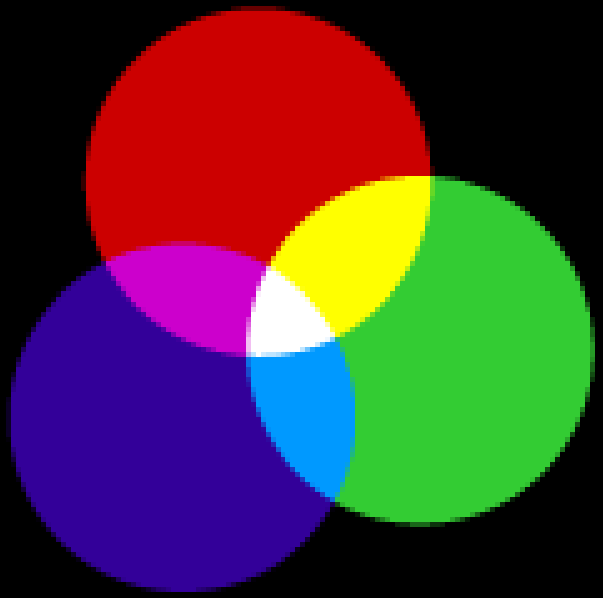
Traditional Color Practice



Subtractive Color Theory



TV / Computer Screens



Additive Color Theory

3 for the price of 1…

432 Composite

Color Infrared (no camouflage!)

321 Composite

True Color

Different Spatial Resolutions*

1-2m

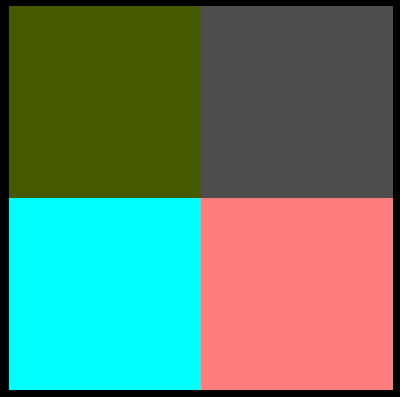
QuickBird, IKONOS

30m

Landsat TM, ETM

79m

Landsat MSS

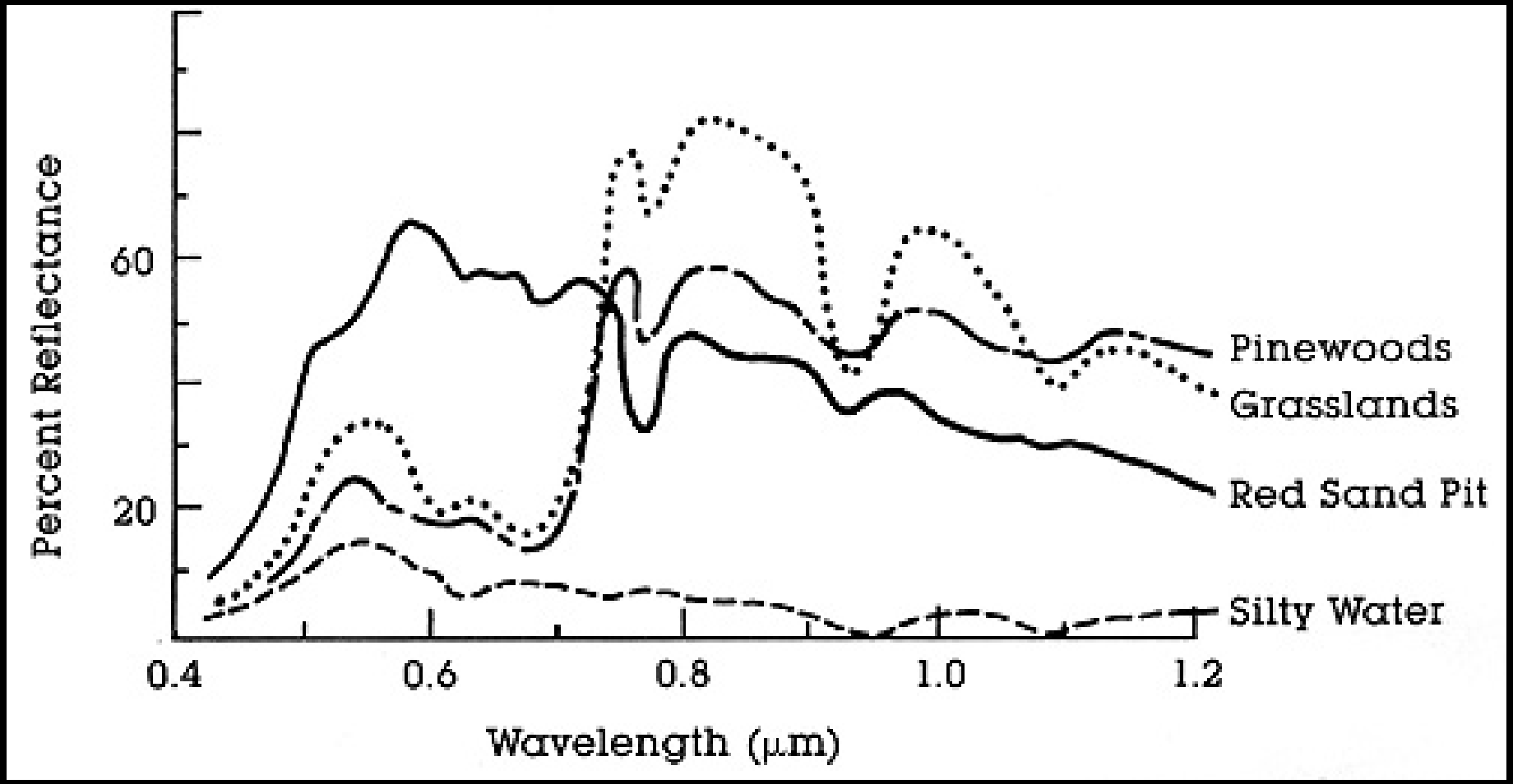


1.1km

AVHRR

*Simulated

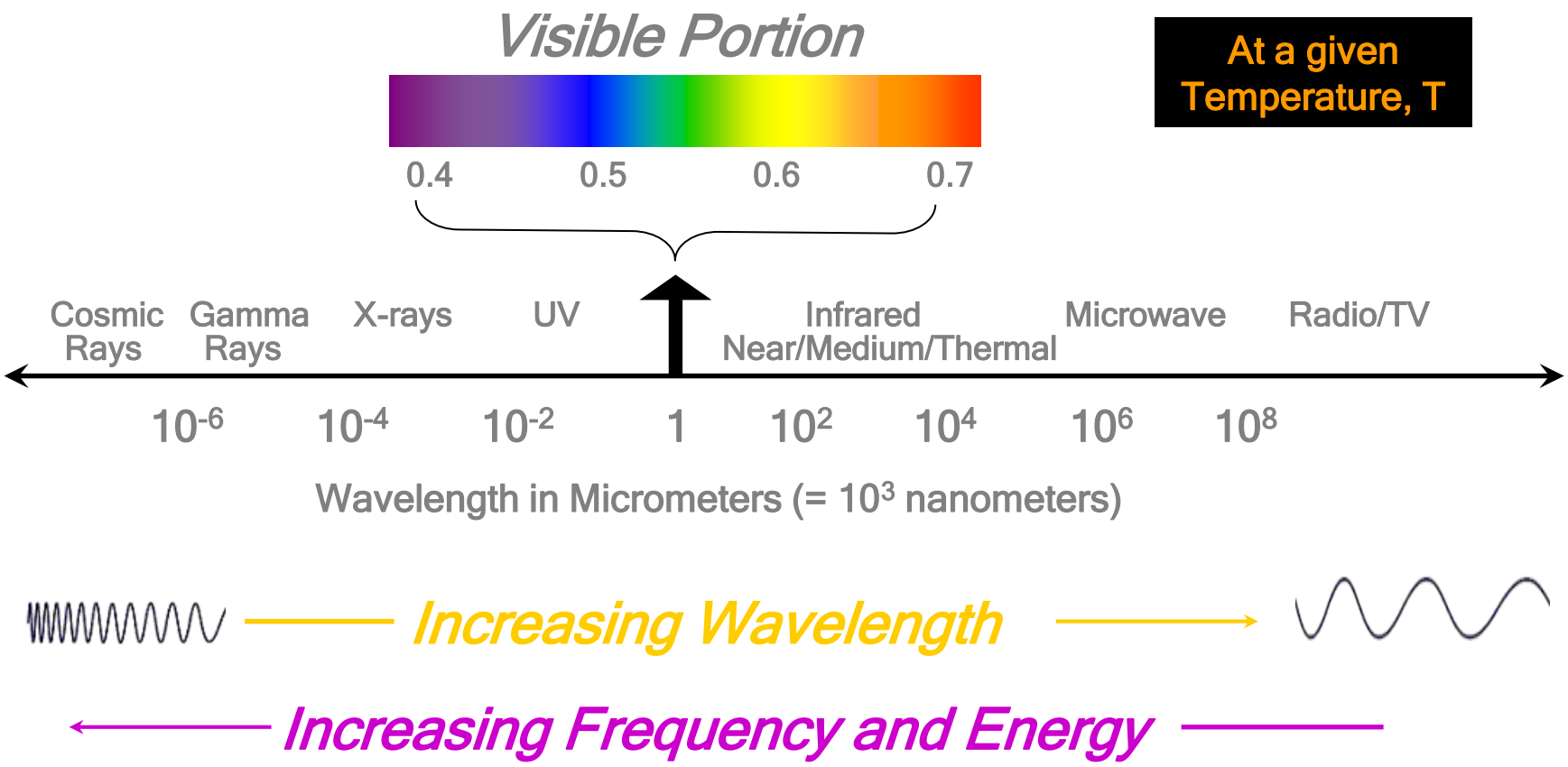
S is *Signatures* – a unique identifier…



…and very similar to your own signatures

Source: NASA Remote Sensing Tutorial

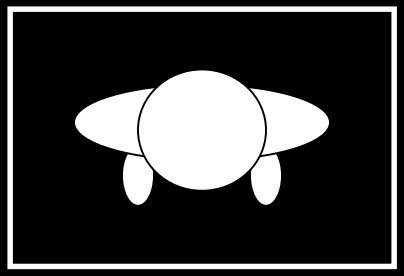
Electromagnetic or EM Spectrum



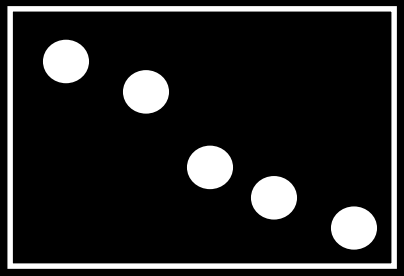
P is for *Perspective* – the bird's eye view

- Perfectly plumb to the point at which you look
- Also known as nadir or vertical (as opposed to off vertical or oblique)
- The nadir perspective comes more naturally at more macro scales (think road maps)
- The nadir perspective also tends to come more naturally to people who walk their landscape rather than drive
- Linking the oblique perspective (as you see objects at eye level) with the nadir perspective is key to interp

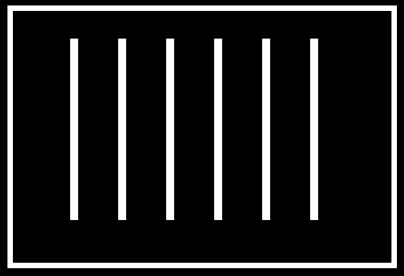
Test your ‘interp’ skills…



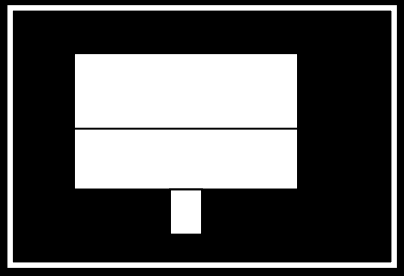
(a) A person whose head is in the center, shoulders on each side, and feet sticking out the front or bottom



(b) Depending upon where you are, central pivot irrigation, crop circles, or pater noster (glacial) lakes



(c) Again, they could be agriculture rows, highway lanes, etc.



(d) A house with the roofline evident and a sidewalk or driveway

How important is it to know…

- *Where* your image is located?
- That landscape?
- The culture?
- The scale?

- In the absence of fieldwork, other products can help (e.g., written descriptions or ground photos) but there is no substitute for local knowledge

Y is for *You* – computers need people

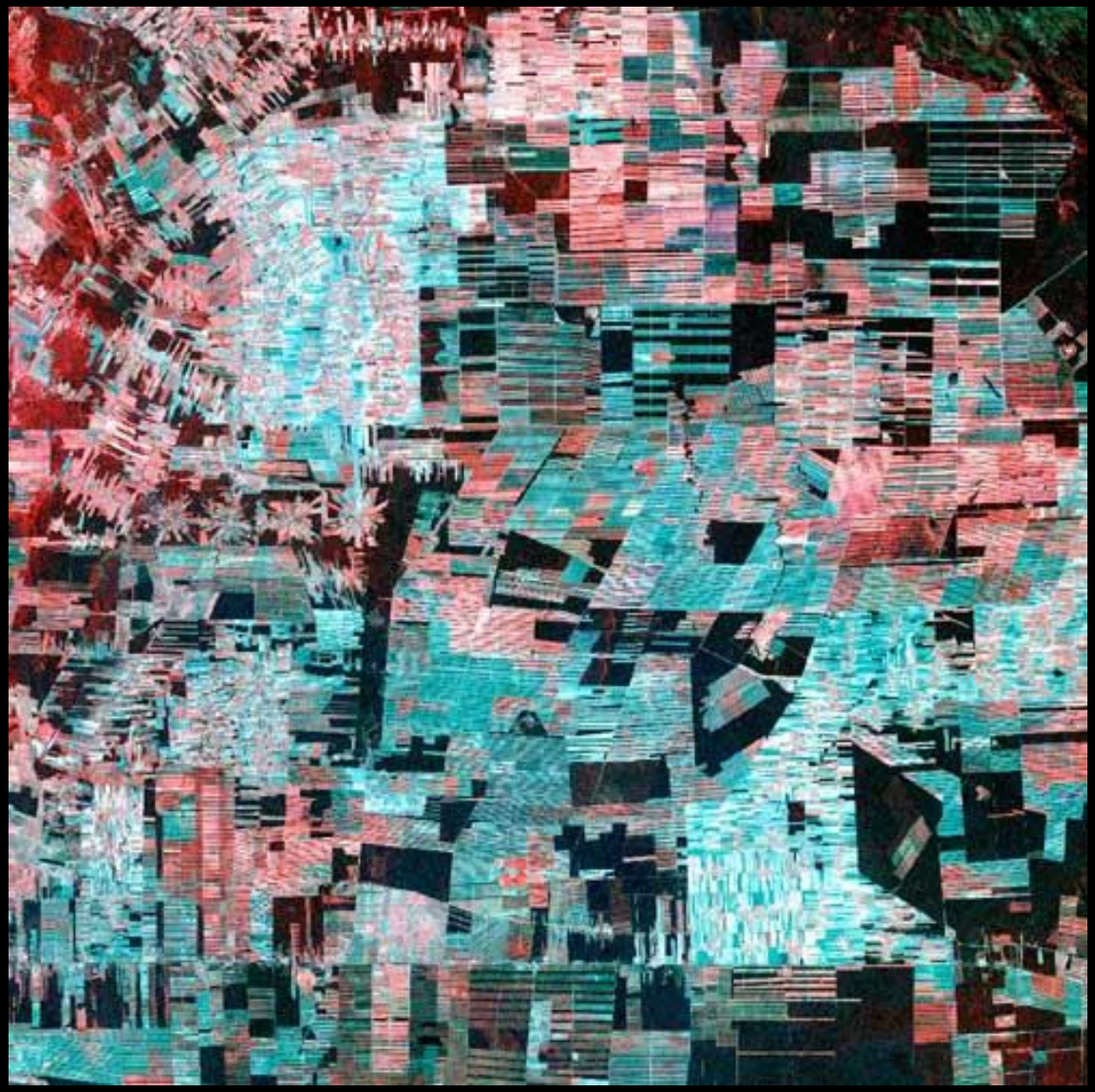
- Everyday skills
- Color, shape, size
- Texture, Pattern
- Proximity, Relationship
- Logical Consistency
- There is no completely automated process that is *generalizable*

You know you're an analyst if...

- ...on airplanes you spend most of your time figuring out where you are and what the shapes on the ground are
- ...you like to solve puzzles, and enjoy problem-solving
- ...you tend to look for and find patterns, whether in numbers or graphics
- ...you could draw your neighborhood -nadir perspective-- without thinking
- ...you pay attention to how things change over time

Deforestation in the Bolivian Rainforest

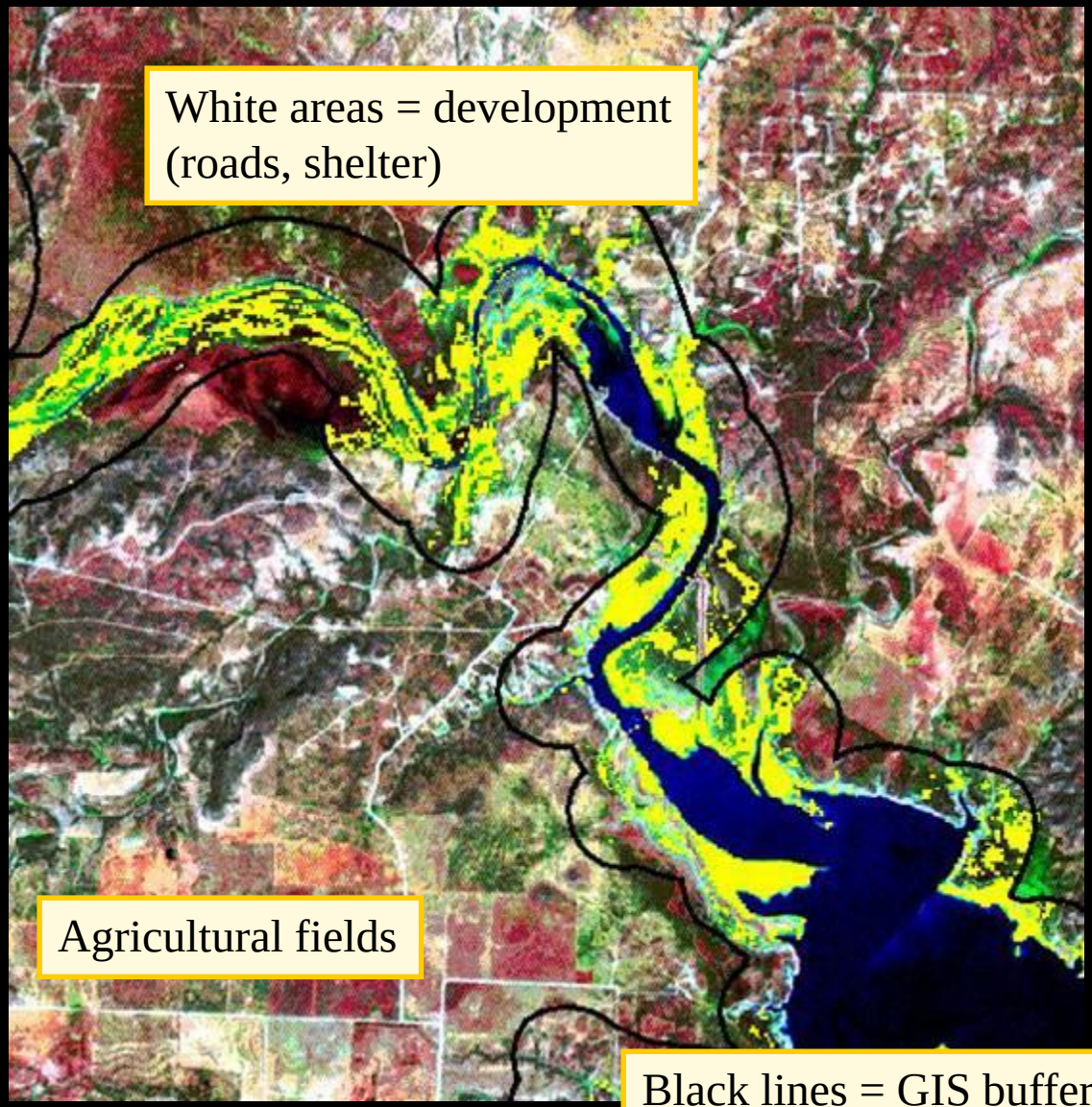
May 2000, Landsat 7 ETM (USGS EDC)



- NOTE:
- Geometric shapes
- Regular pattern
- Size versus density
- Pasture and agriculture

Salt Cedar in Coke County, Texas

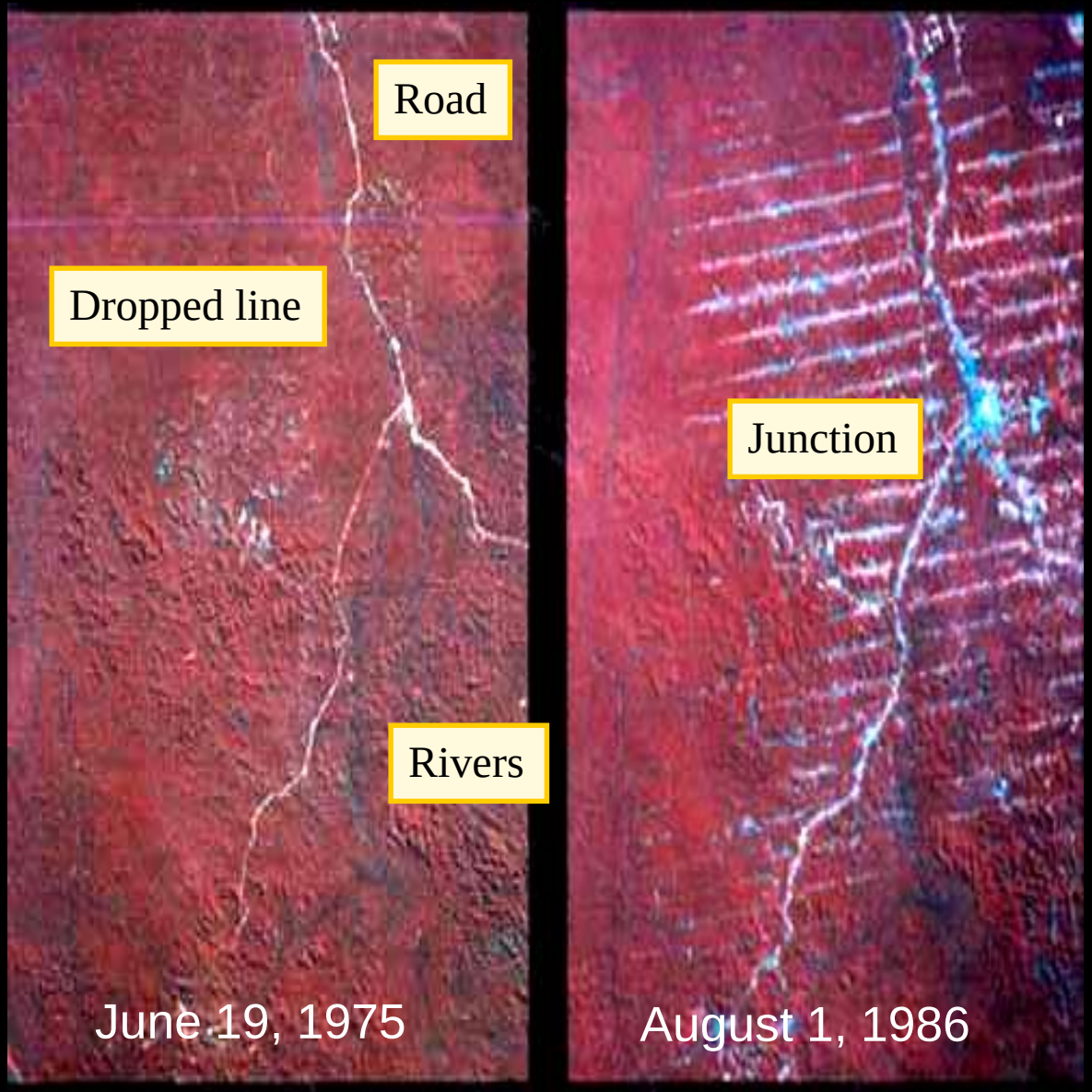
November 3, 1999, Landsat 7 (UT CSR Synergy)



- NOTE:
- Salt cedar in yellow
- Riparian corridor
- Water dependence
- Worse up-channel

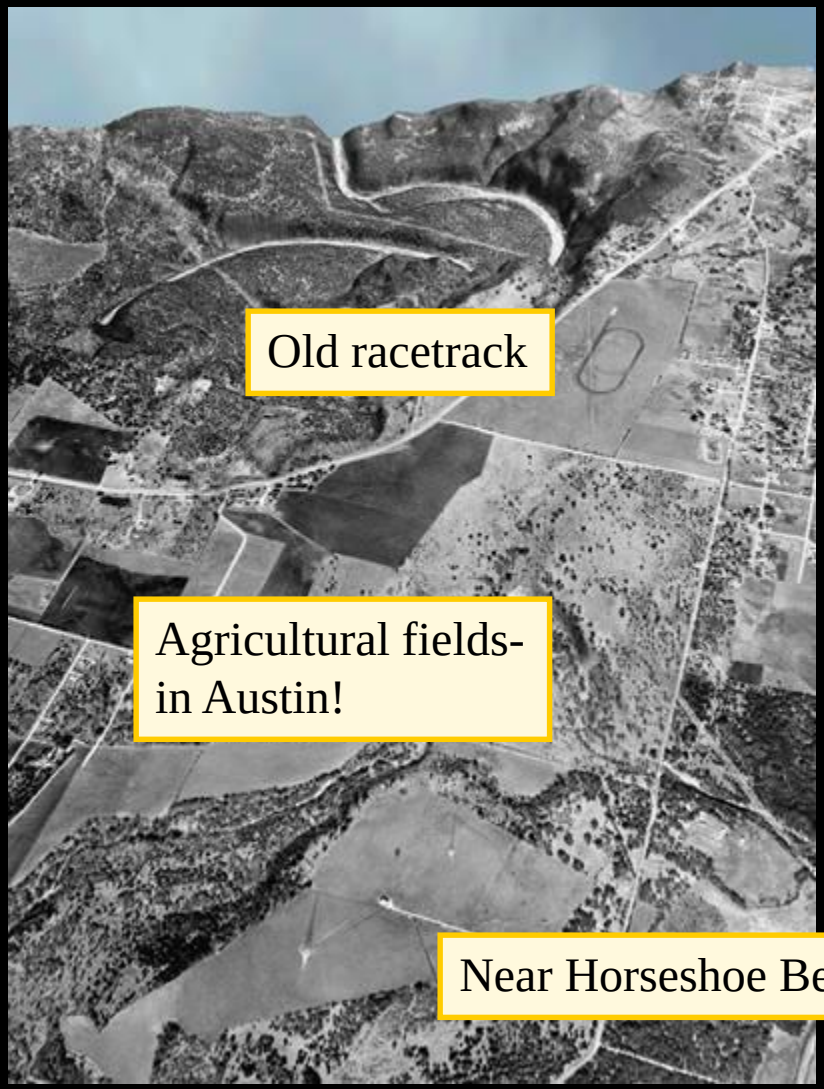
Change in Brasilian Rainforests

Landsat MSS (USGS EDC)

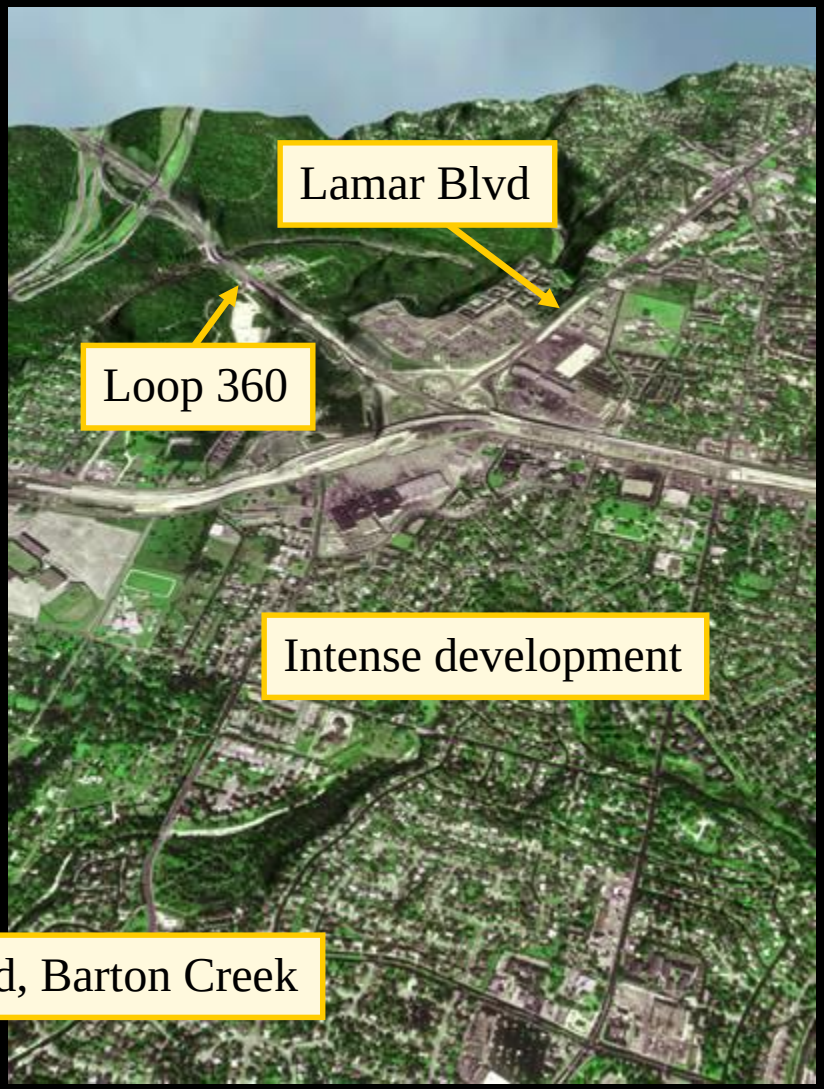


- NOTE:
- Linear pattern in removal
- Proximity to roads
- Enlarging of junction
- Inter-annual (seasons?)

Austin, 1951 and 1995



TOBIN photography
(TNRIS)

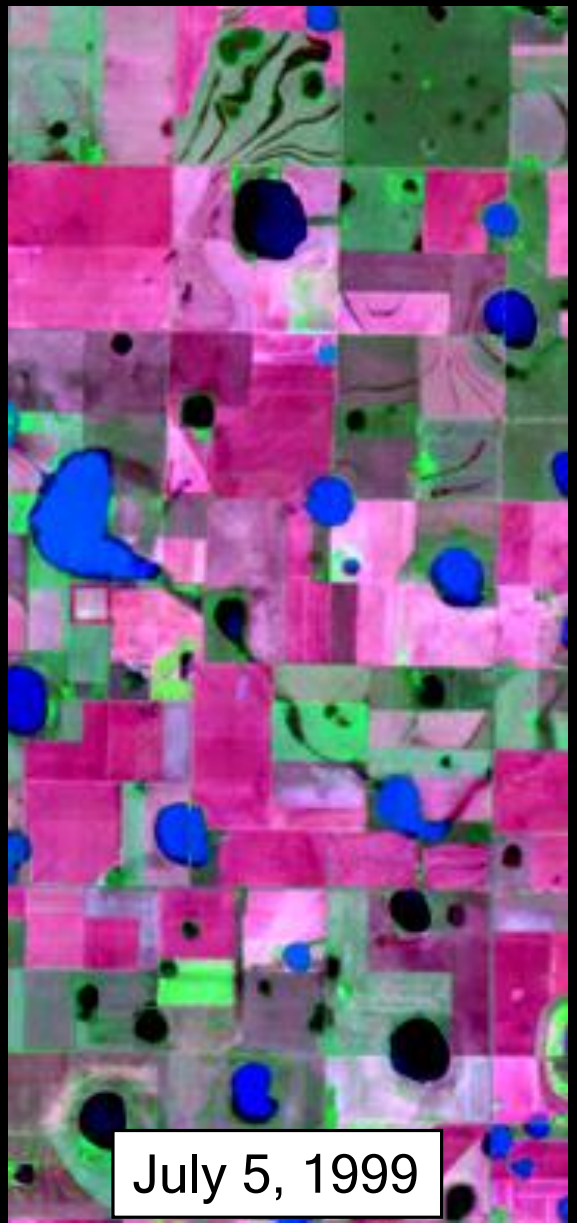


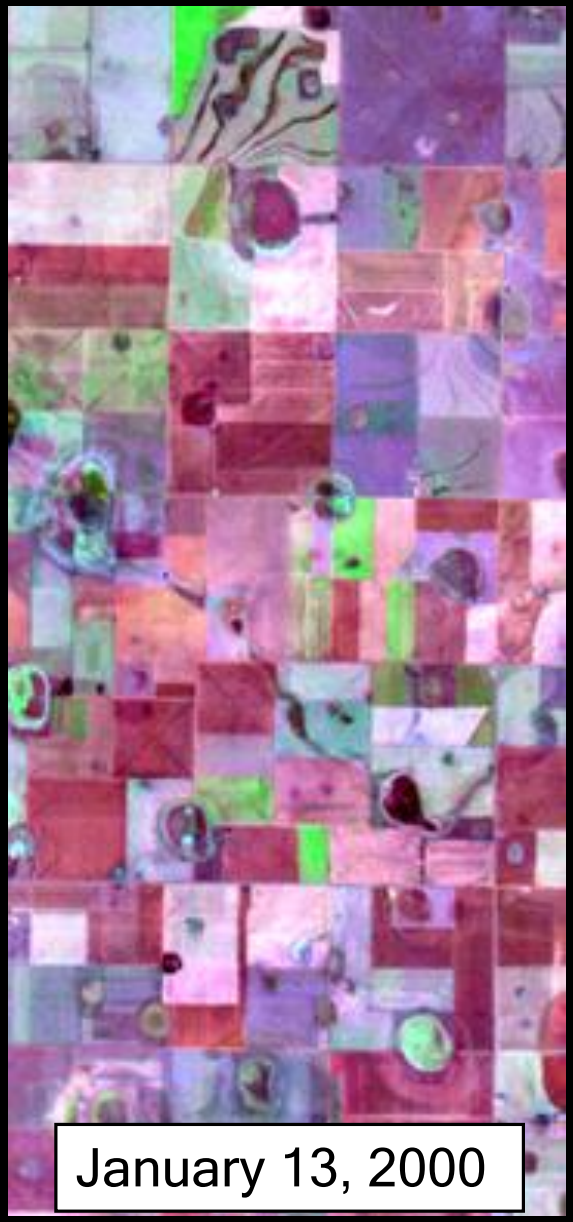
DOQQ (TNRIS)

Near Horseshoe Bend, Barton Creek

Texas High Plains Drought

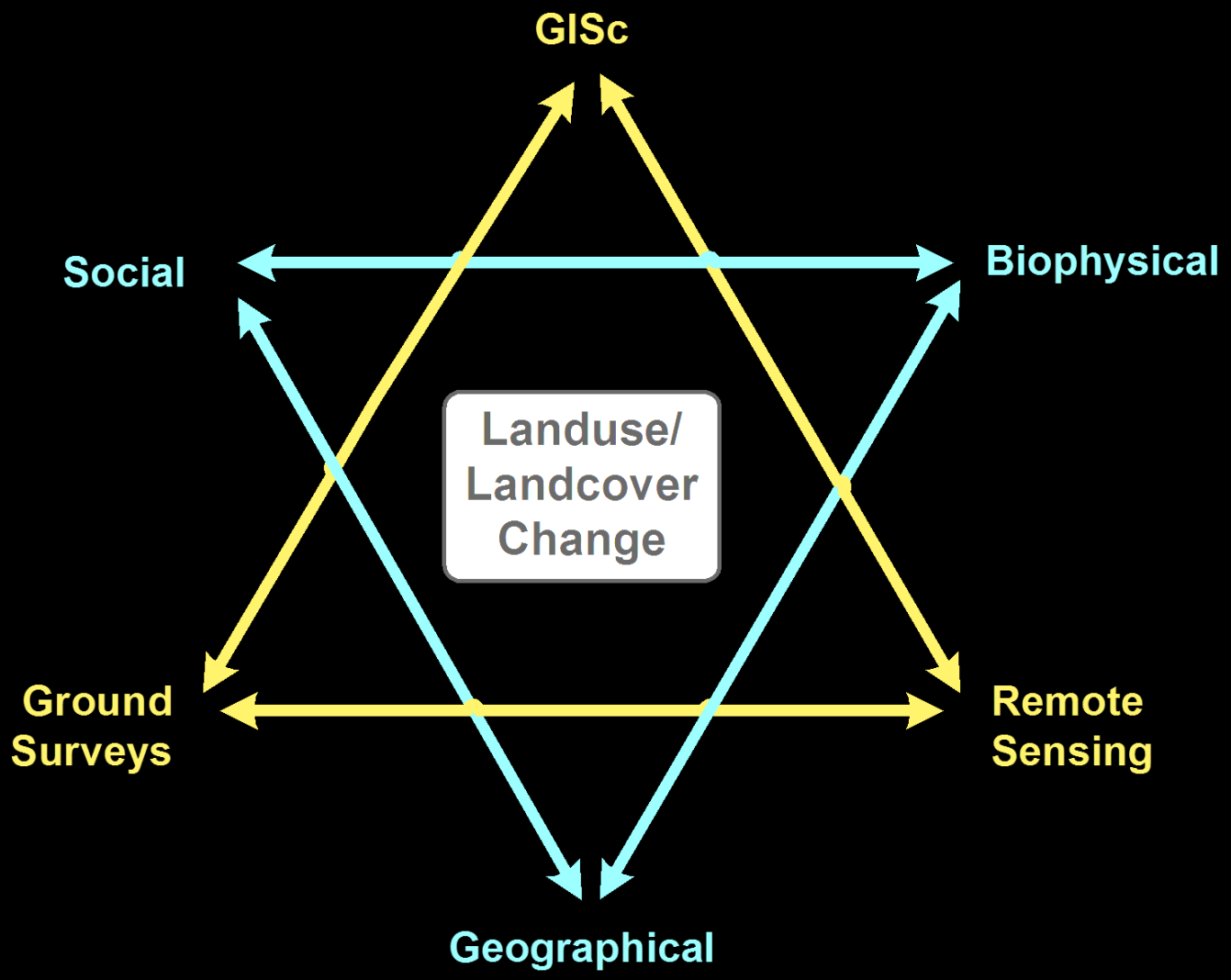
Landsat 7 ETM, UT CSR Synerg



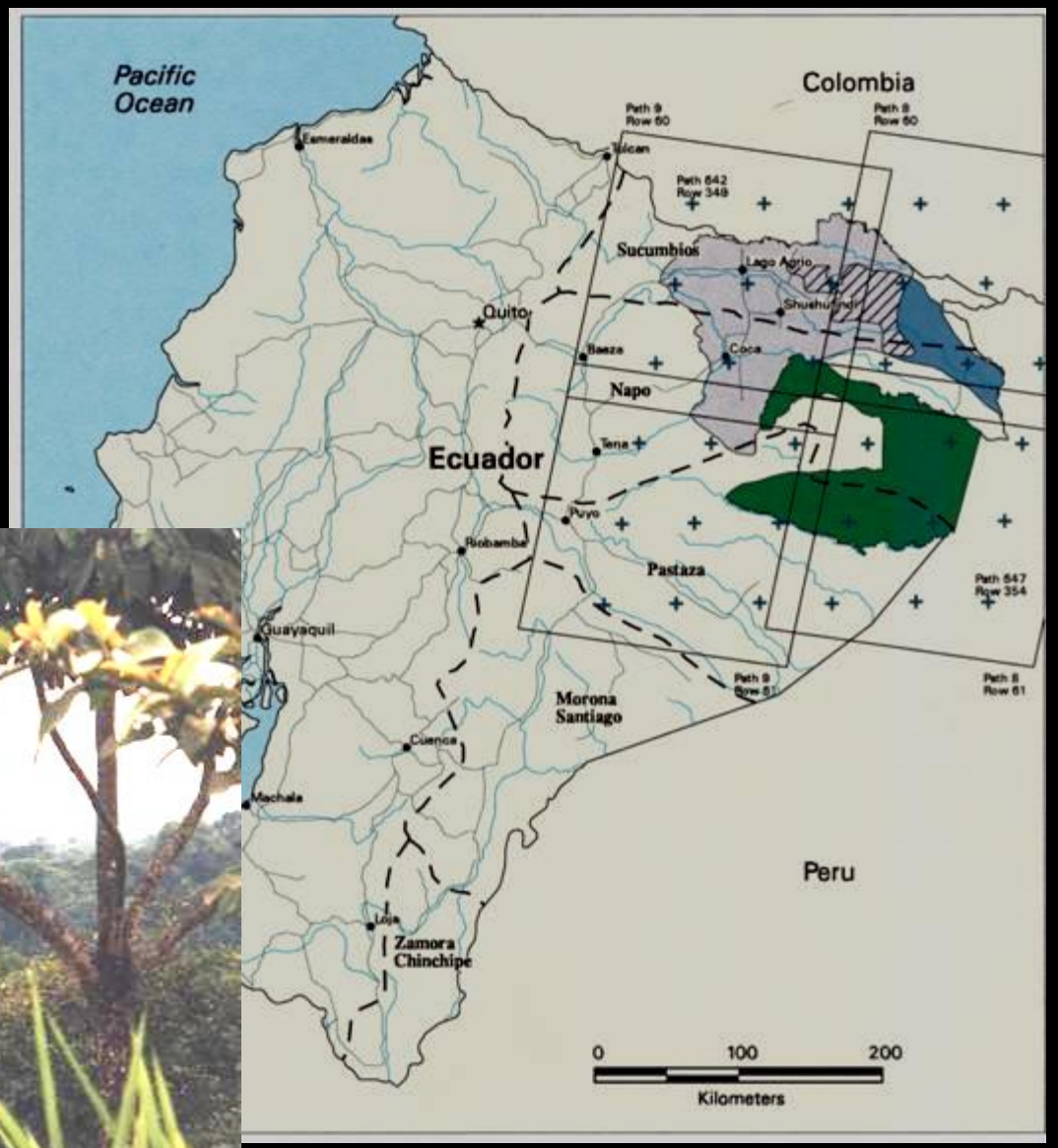


- NOTE:
- Change in ponds
- Agricultural areas
- Importance of seasons
- Near Lubbock, north to Amarillo
- 741 composite

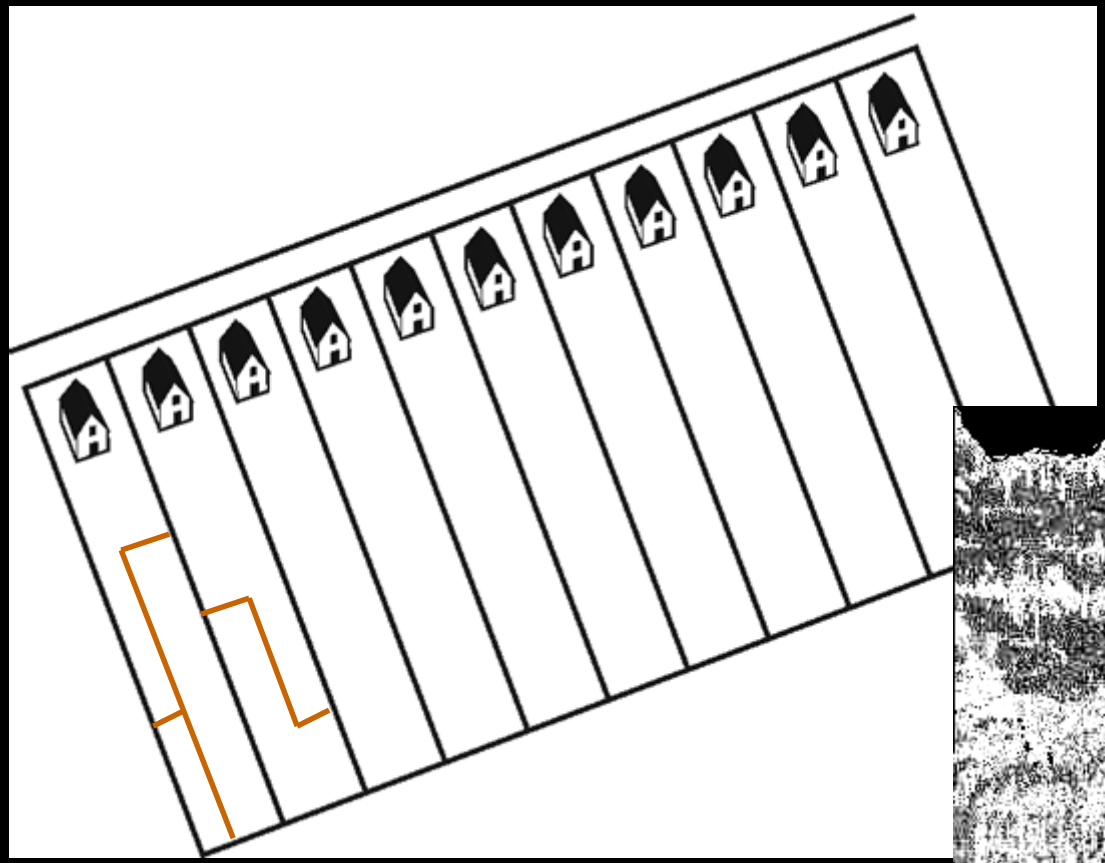
Environmental Vulnerability Analysis

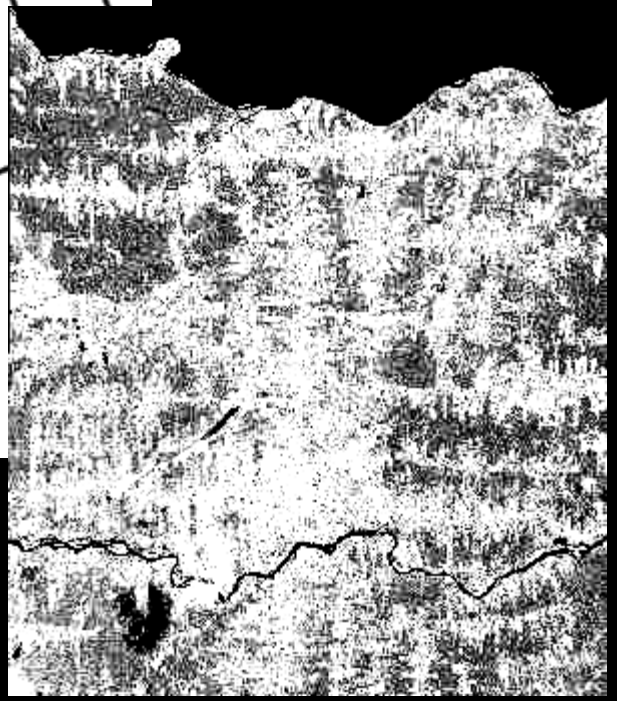


Landuse / Landcover Change (LULC) in the Oriente of the northeastern Ecuadorian Amazon



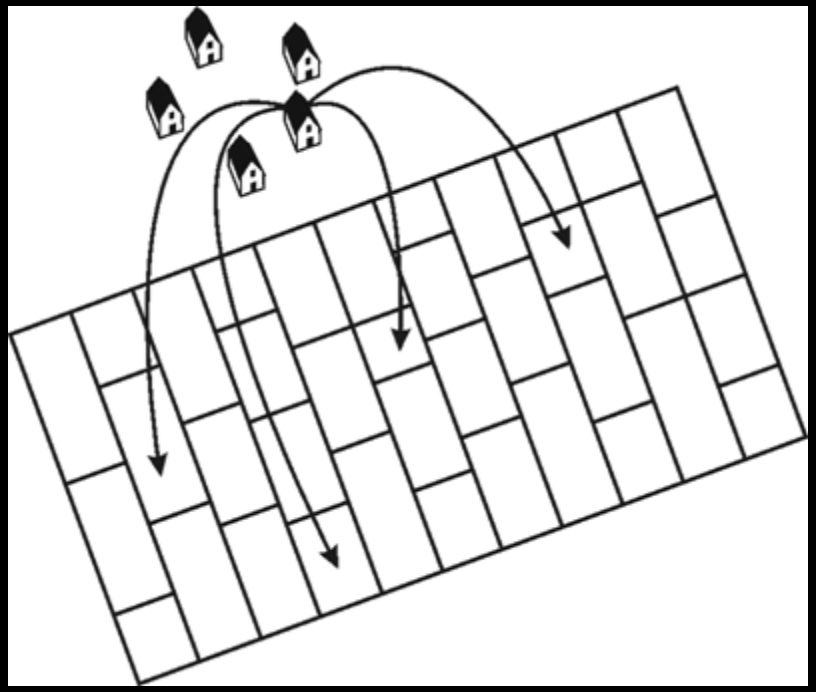
Settlement Patterns in the Oriente





LULC in Nang Rong District, Isaan Region, Northeast Thailand

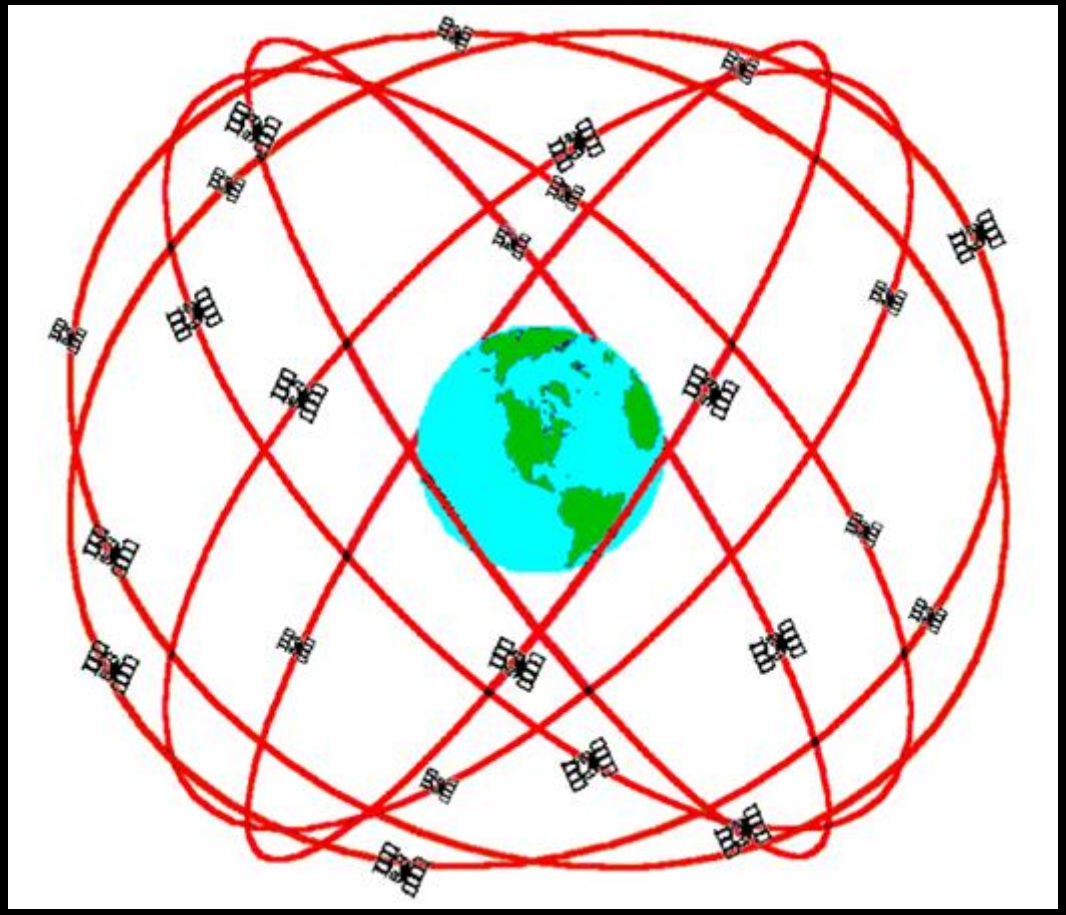
Northeast Thai Settlement Pattern



Thai nuclear village settlement pattern is characterized by a spatial disconnect between people and the land they manage

Global Positioning Systems (GPS)

- Fully operational in 1994
- > 20 satellites, 98% operational
- Not as available during times of conflict
- 6 Orbital Planes
- 20,200 km orbit
- ~ 12 hour orbital period
- Each visible for ~ 5 hours



Source: Remote Sensing Core Curriculum

Human-Environment Interactions & Analysis

WHO, WHAT

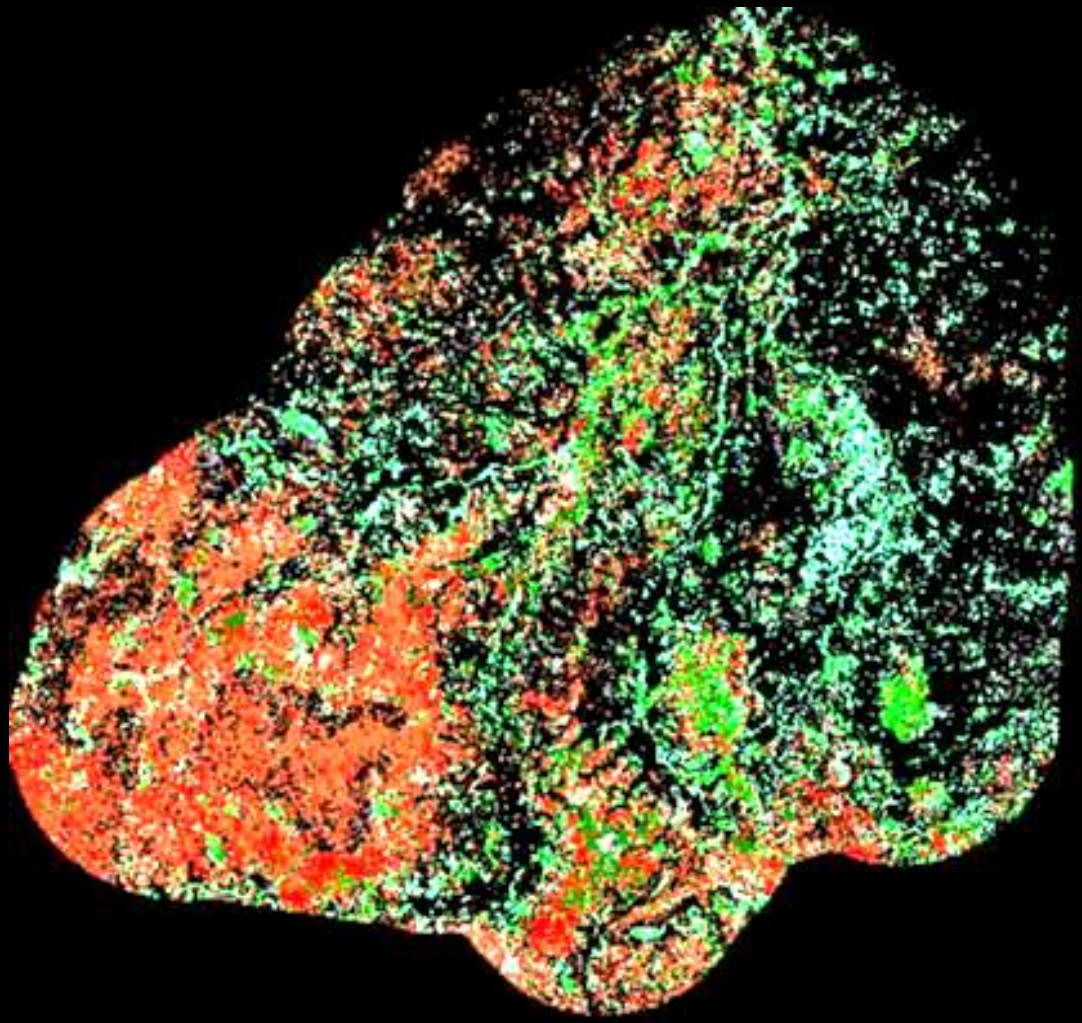
- Population potential created via survey data
- Access to surface water
- Accessibility to transportation infrastructure (roads, rivers)
- Digital elevation model (DEM)
- Soil moisture potential
- Landcover/Landuse (LCLU) Change, Vegetation Indices

WHERE, WHEN, WHY, HOW

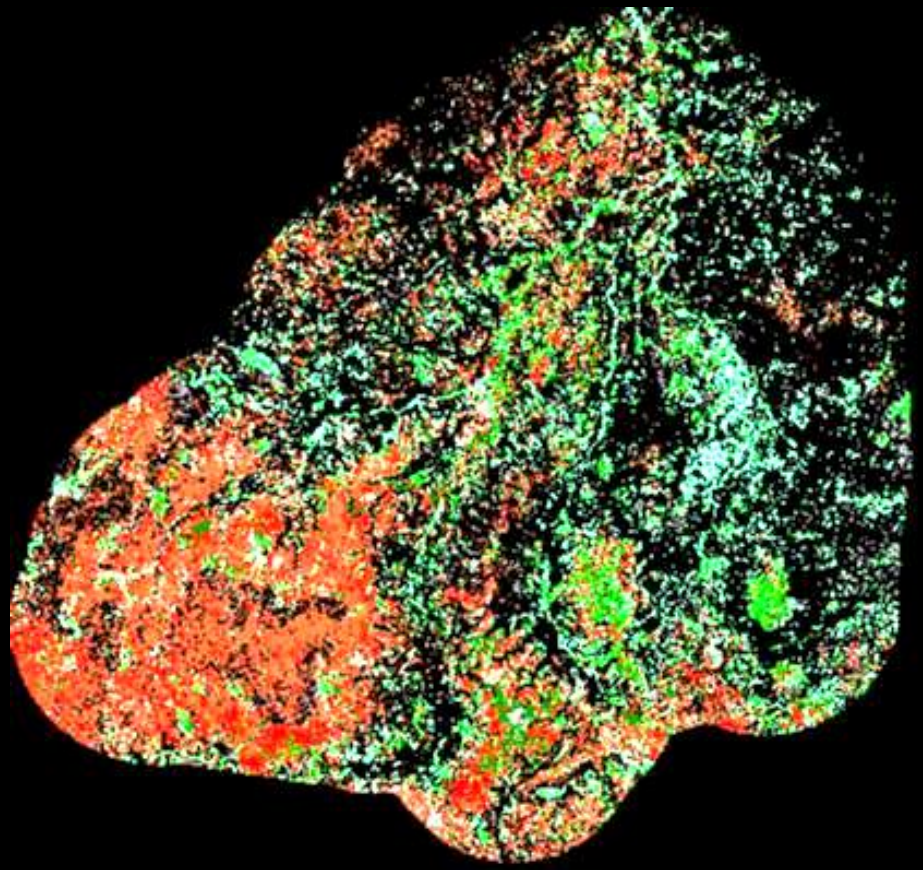
- Change Detection
- Overlay analysis, Lagged correlations
- Statistical correlations, Regression analysis
- Spatial autocorrelation
- Pattern Metrics

Change Detection in Thai Forests, 1972 to 1999

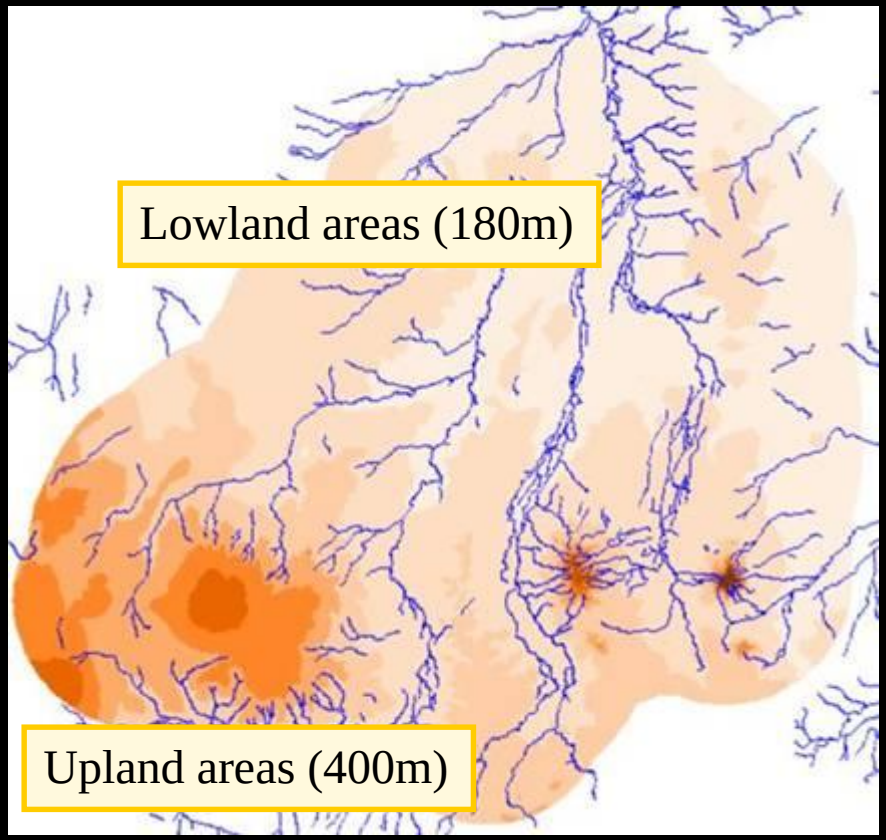
Early Deforestation
Late Deforestation
Stable Forest
Early Reclamation
Late Reclamation



Visual and Overlay Analysis

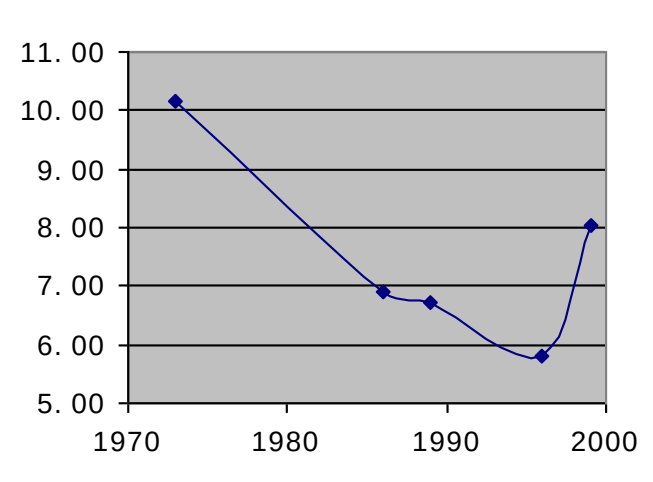


Early Deforestation
Late Deforestation
Stable Forest
Early Reclamation
Late Reclamation

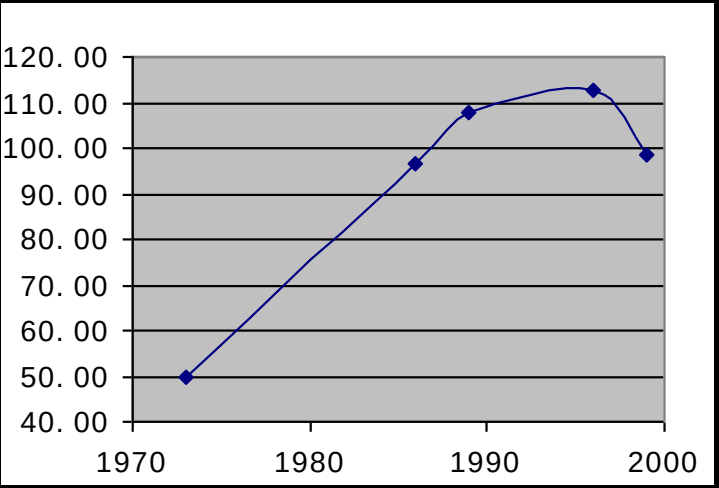


Digital elevation model (DEM) with higher elevations in darker tones and rivers shown in blue.

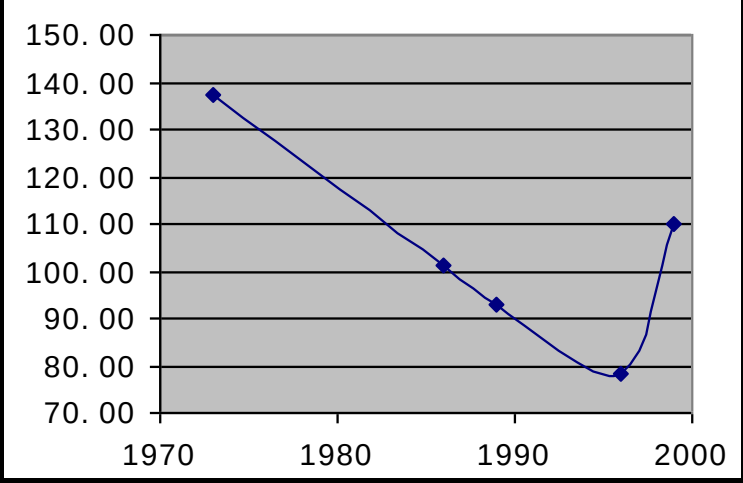
Pattern Metrics: Graphical Analysis



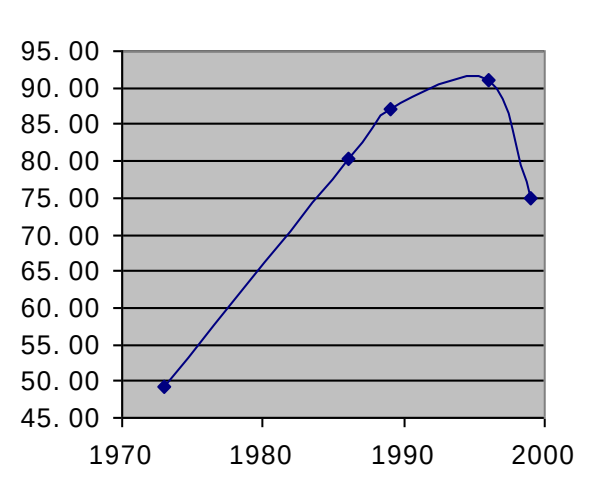
Patches



Borders

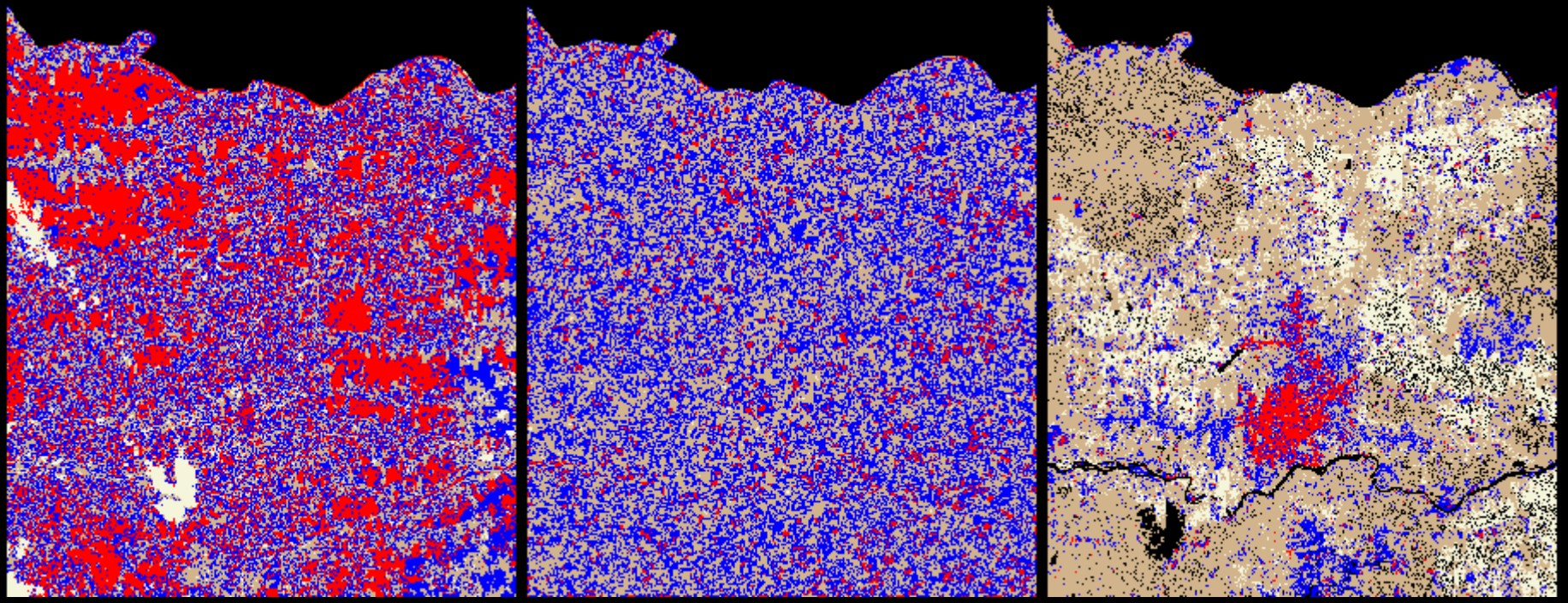


Closeness



Mixedness

Pattern Metrics - Mapping



LULC Stability

PPU

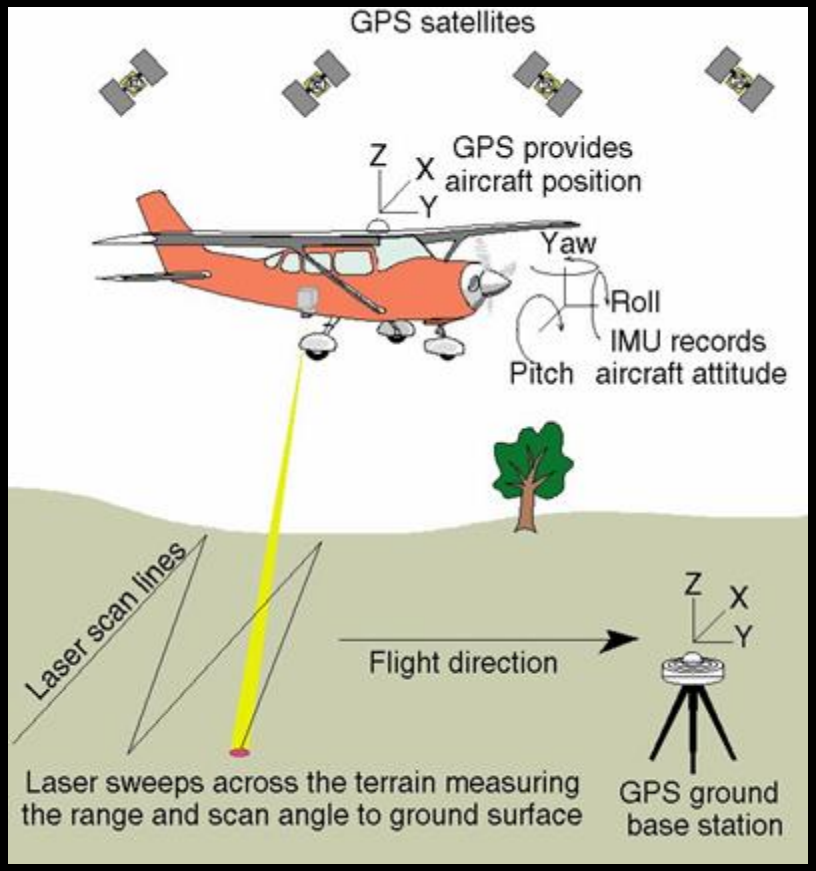
Fractal Dimension

PANEL TYPE	MORAN'S I	GEARY'S c
Landuse/landcover	0.7263	0.2714
PPU	0.5741	0.4229
Sj	0.6975	0.2630

Spatial Autocorrelation (30m)

Highly unstable
Unstable
Fairly stable
Little change

Active Sensor Applications: LIDAR

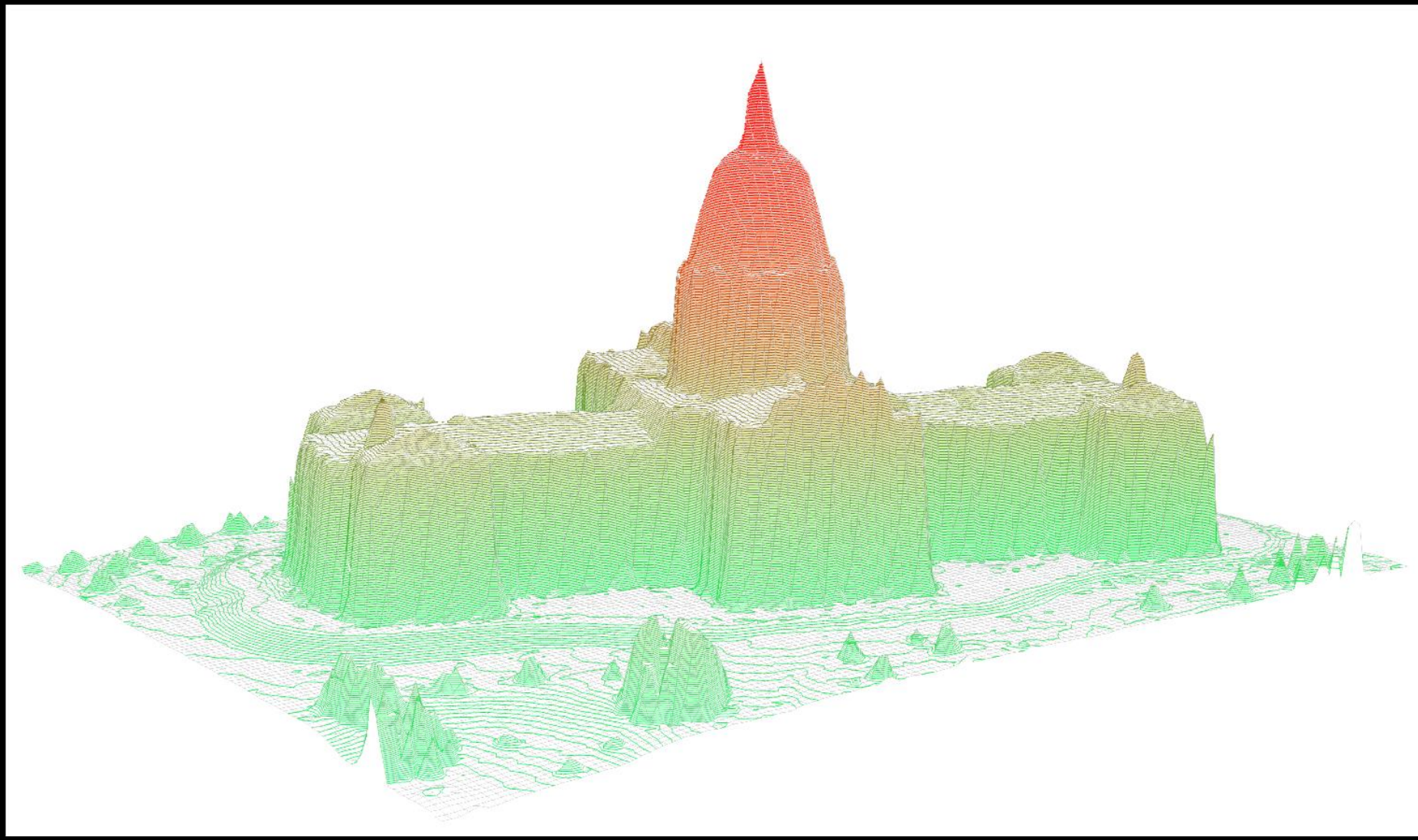


Graphics courtesy of UT Bureau of Economic Geology and UT Center for Space Research Training Materials

UT Memorial Stadium LIDAR-based Digital Elevation Model (DEM)

Source: UT Bureau of Economic Geology and UT Center for Space Research

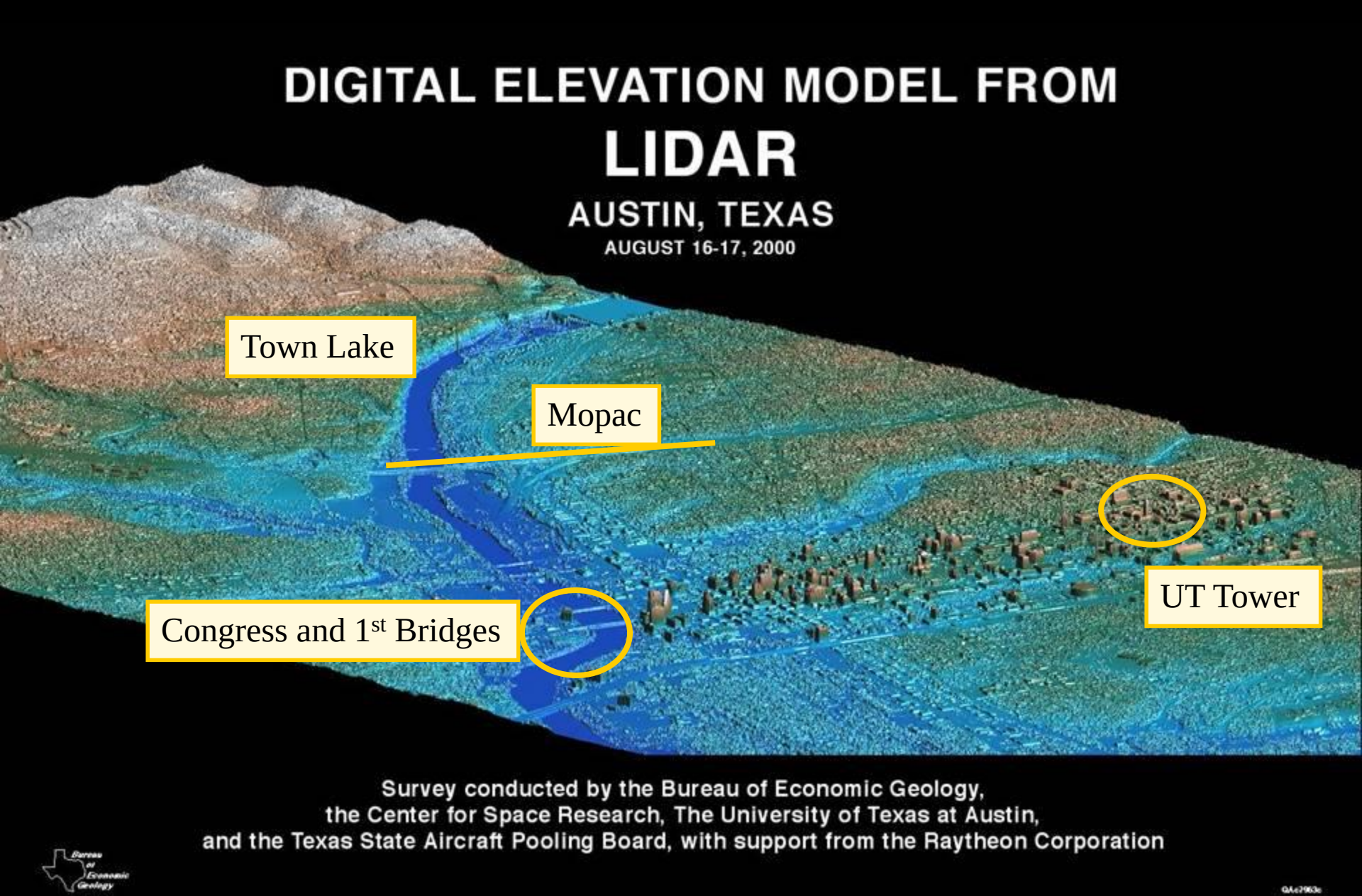
Texas State Capitol LIDAR Image



Source: UT Bureau of Economic Geology
and UT Center for Space Research

UT Area LIDAR Image

Source: UT Bureau of Economic Geology and UT Center for Space Research


DIGITAL ELEVATION MODEL FROM
LIDAR
AUSTIN, TEXAS
AUGUST 16-17, 2000
Town Lake
Mopac
UT Tower
Congress and 1st Bridges
Survey conducted by the Bureau of Economic Geology,
the Center for Space Research, The University of Texas at Austin,
and the Texas State Aircraft Pooling Board, with support from the Raytheon Corporation

Ground-based LIDAR, Pentagon

Post September 11, 2001 (NASA)

Texans & Remote Sensing

- First permanent air photo (taken and developed by Niepce) held in UT's LBJ Museum
- GRACE (Gravity Recovery and Climate Experiment) mission is the first in NASA history to be led by someone outside NASA: Dr. Byron Tapley, Director, Center for Space Research (CSR)
- Soon-to-be-home of receiving station for Landsat 7 ETM and other satellites (CSR) in addition to other receiving stations (e.g., AVHRR)

Links

- NASA RS Tutorial,
  http://rst.gsfc.nasa.gov/Front/tofc.html
- USGS EROS Data Center, http://edc.usgs.gov
- NASA's Astronomy Picture of the Day,
  http:antwrp.gsfc.nasa.gov/apod/archivepix.html
- Remote Sensing Core Curriculum,
  http://www.research.umbc.edu/~tbenja1/
- CSR, http://www.csr.utexas.edu (general),
  http://www.csr.utexas.edu/rs (applied), and
  http://synergy1.csr.utexas.edu/ (Texas-focused)
- TNRIS, http://www.tnris.org

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- Geographic Information Science Center, College of Liberal Arts
- Department of Geography
- Center for Space Research
- Bureau for Economic Geology
- TNRIS (Texas Natural Resources Information System)
- Environmental Science Institute

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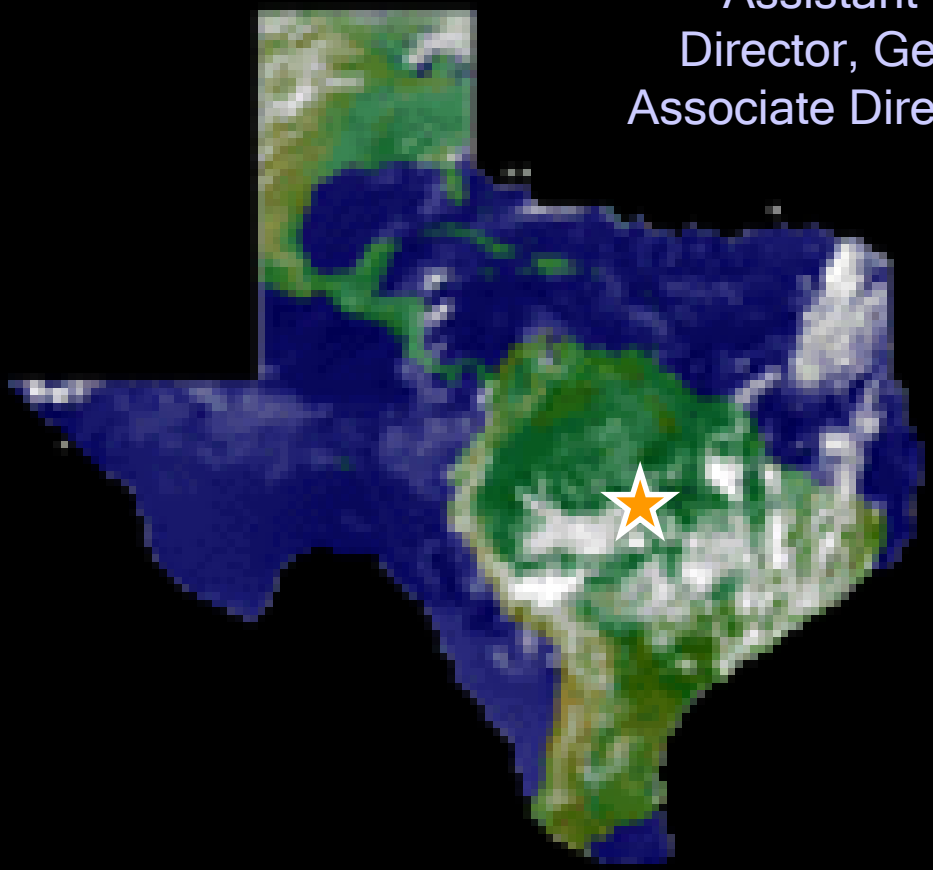

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Dr. Kelley A. Crews-Meyer received her Ph.D. from North Carolina in 2000. Her research interests include geographic information science, remote sensing, land use / land cover change, human-environment interactions, environmental policy, global tropics especially Thailand and Andean South America.