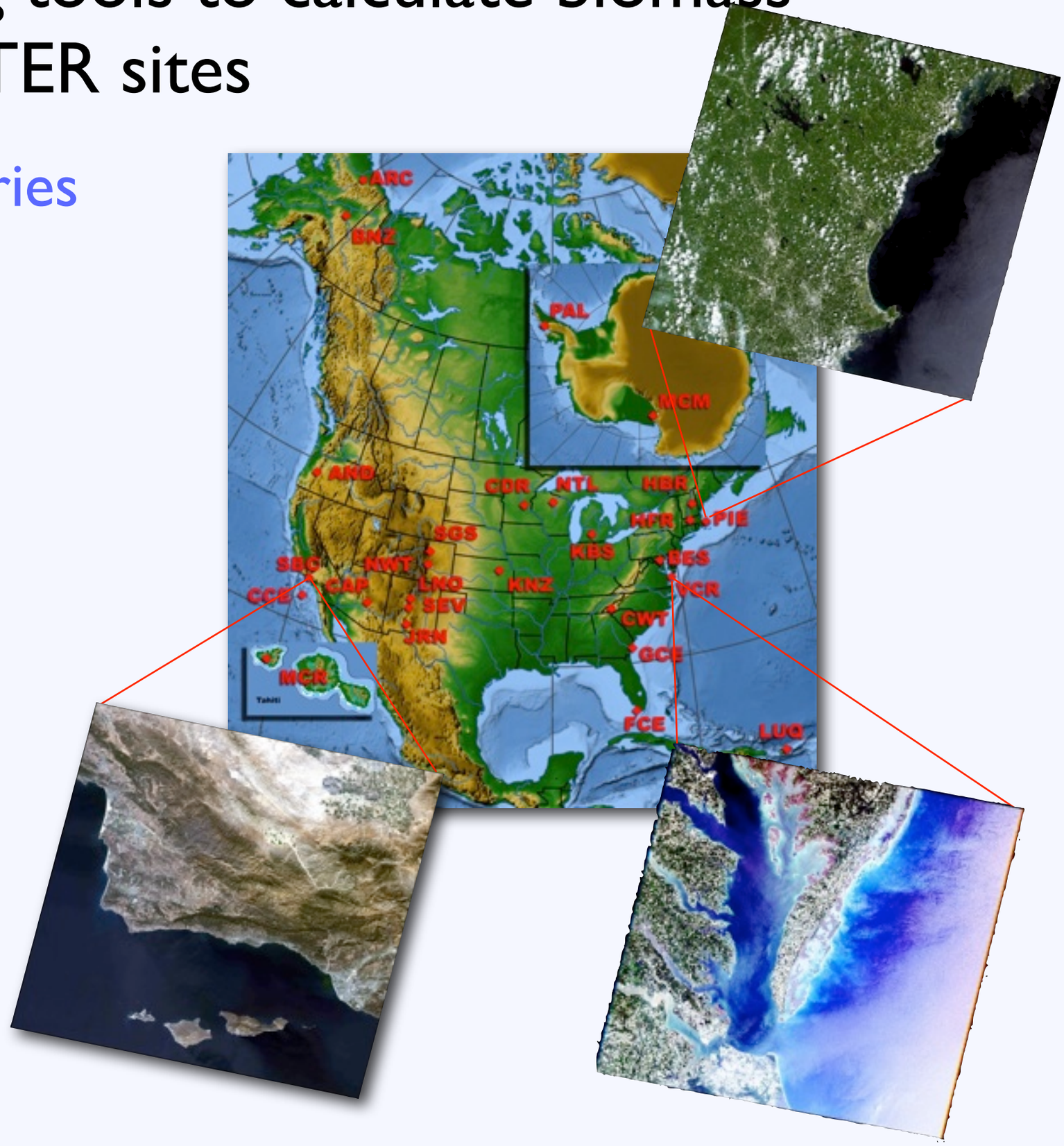
Using remote sensing tools to calculate biomass consistently across LTER sites

Utilizing Landsat time series



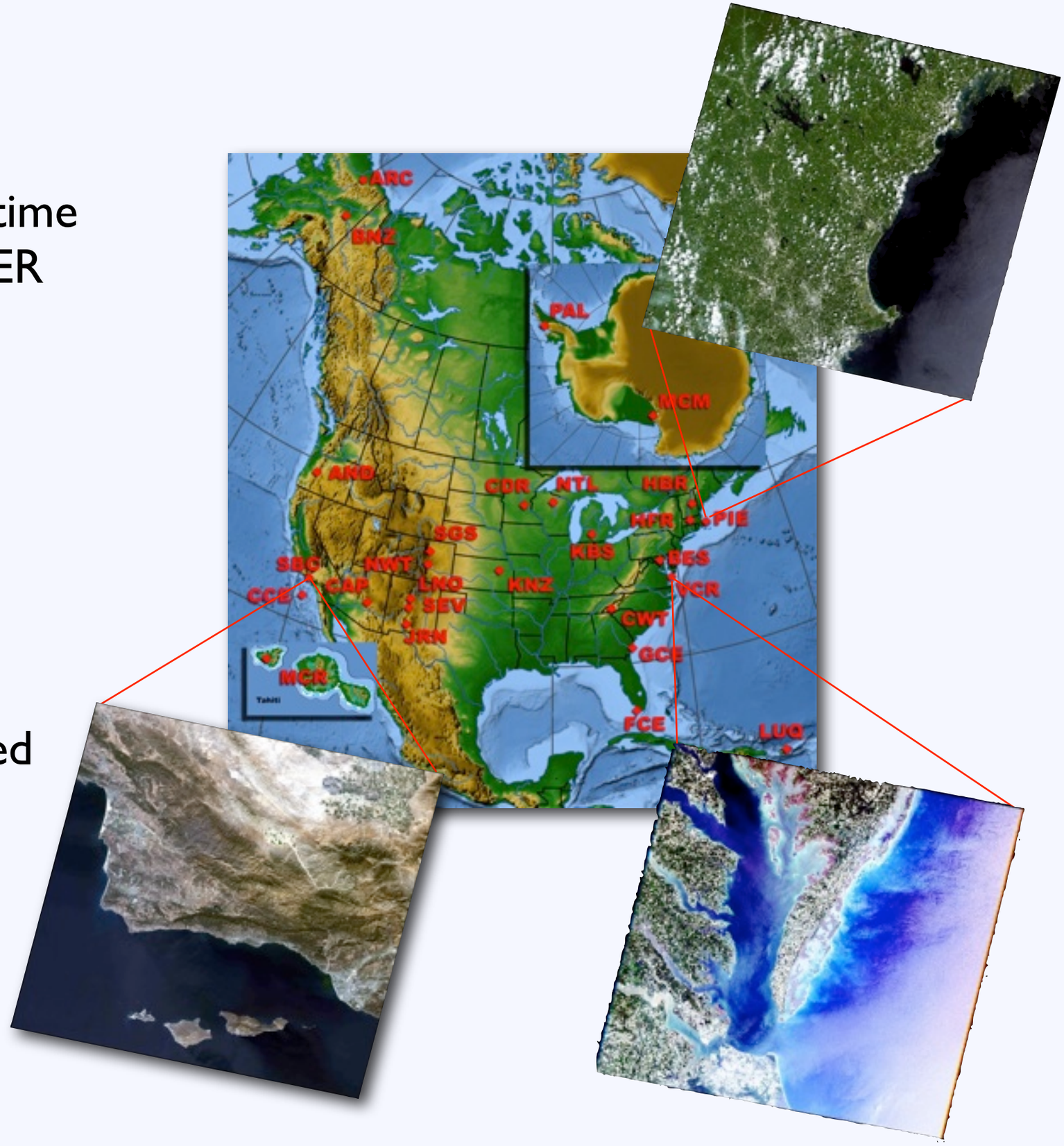
Kyle Cavanaugh
SBC, LNO

Tom Bell
SBC

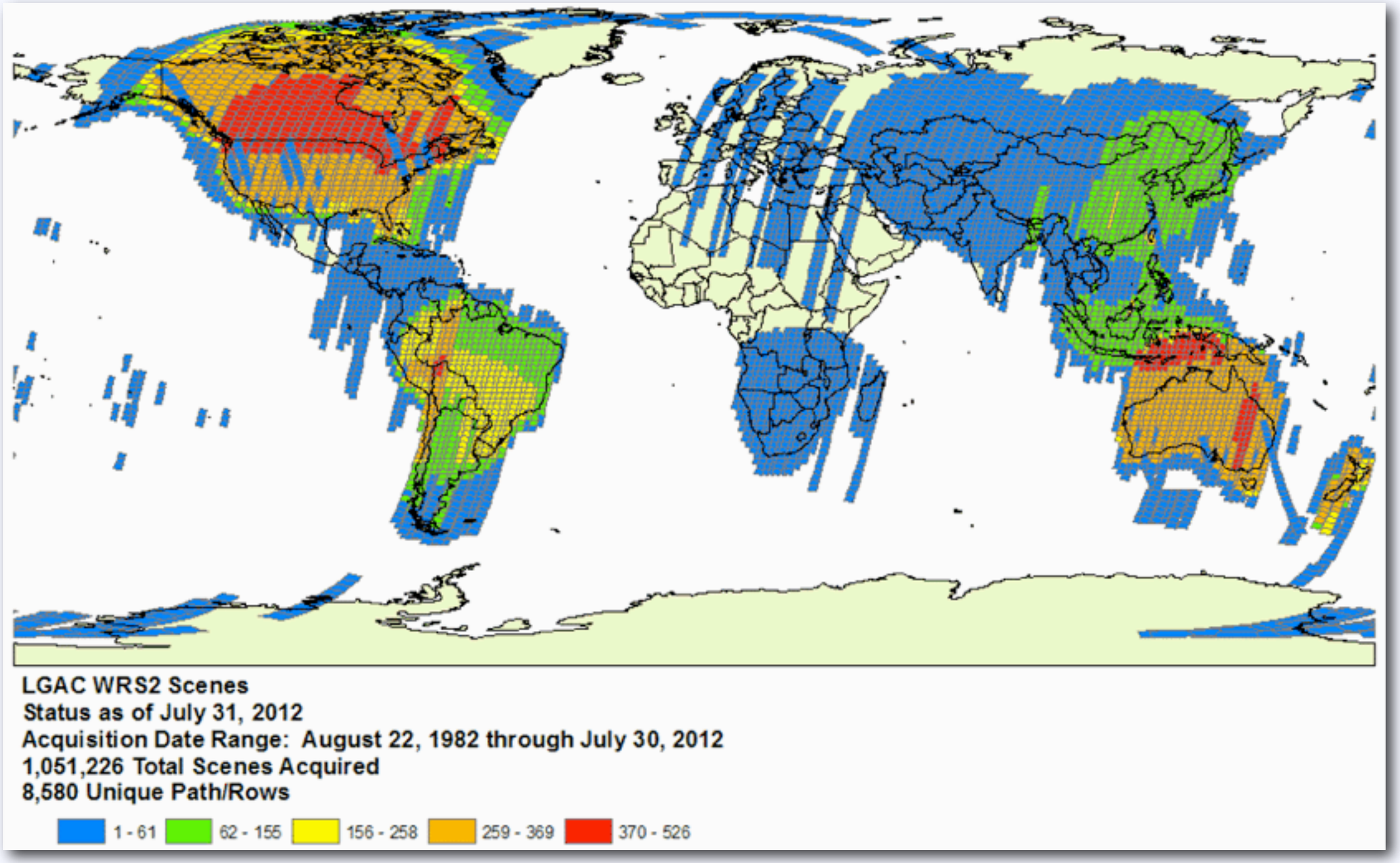
LTER All Scientists Meeting
September 11, 2012

LTER and Landsat

- Landsat satellite program started around the same time as funding for the first LTER sites
- Landsat 5 TM: 1984-2011
  - 30 m resolution
  - nearly global coverage
  - 16 day repeat time
- Individual sites have utilized Landsat
- Lack of cross-site studies utilizing Landsat



Landsat imagery has been available for free since 2009



Landsat data has been used for a wide variety of ecological purposes

Land cover change

Urban expansion

Crop production

Deforestation/reforestation

Monitoring glacial changes

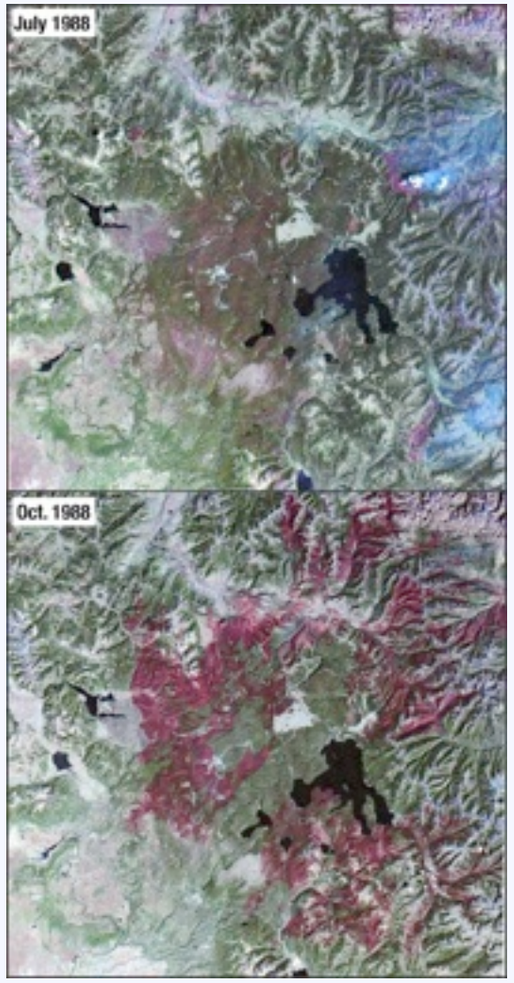
Coral reef health

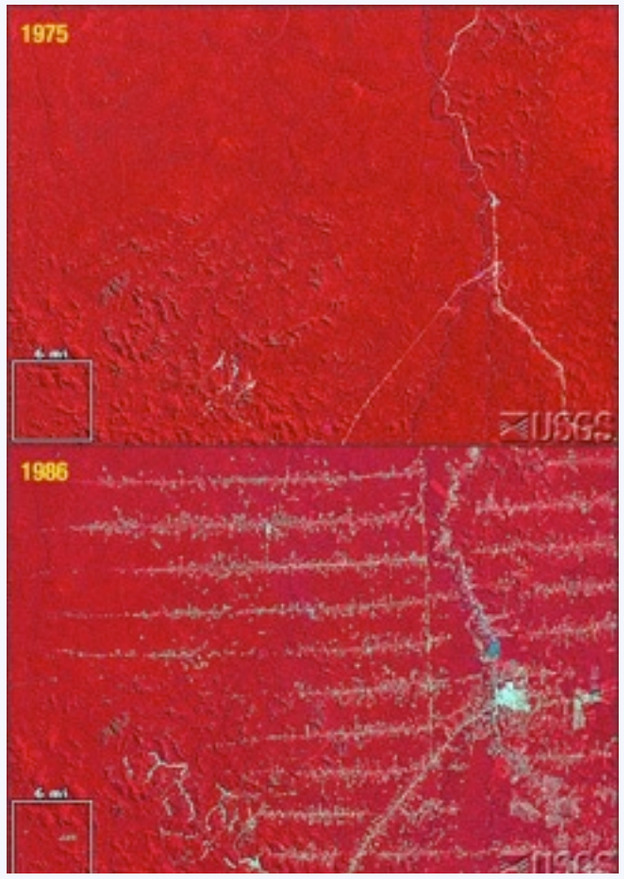
Shoreline mapping

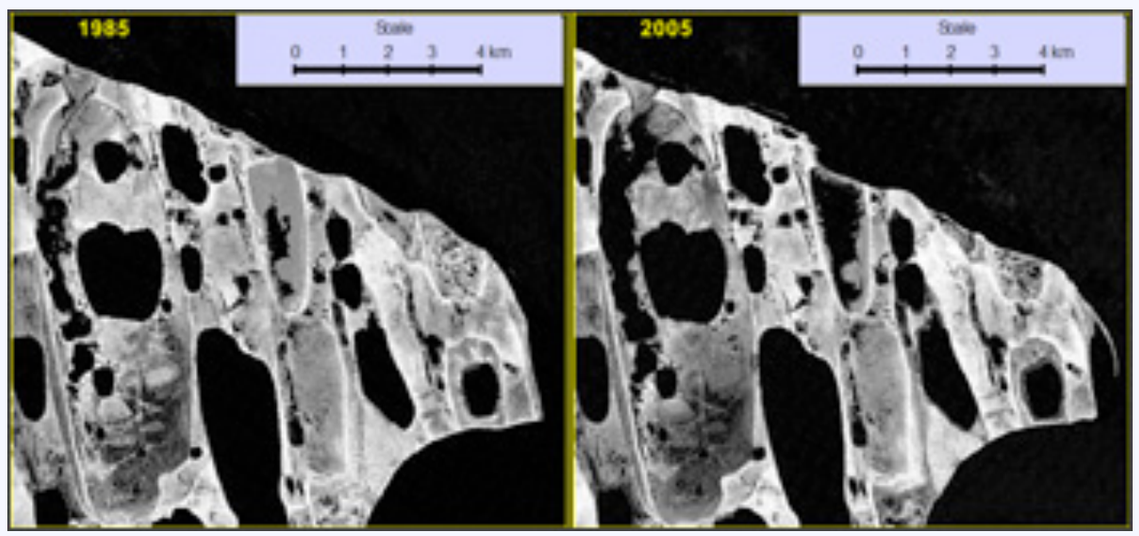
Monitoring forest fires

Tracking vegetative biomass dynamics

and much more...







Landsat data has been used for a wide variety of ecological purposes

Land cover change

Urban expansion

Crop production

Deforestation/reforestation

Monitoring glacial changes

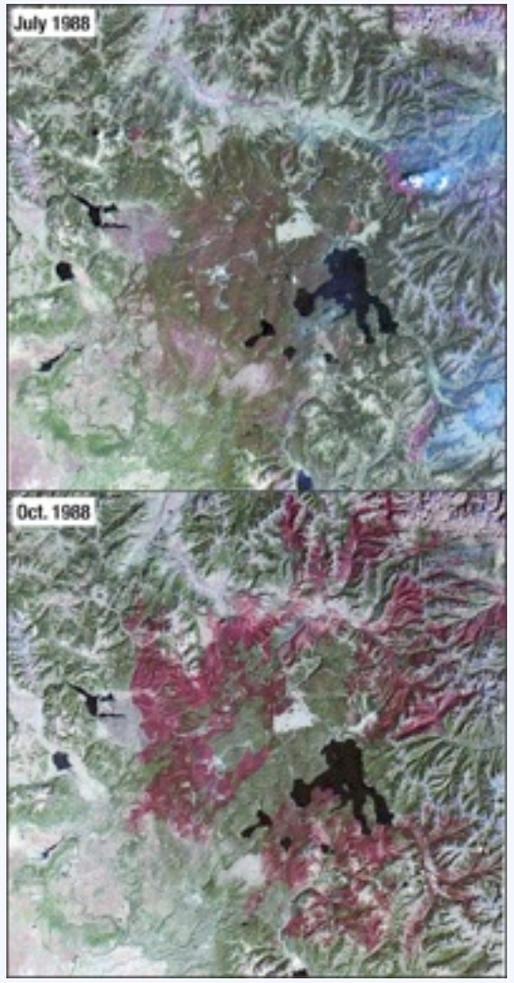
Coral reef health

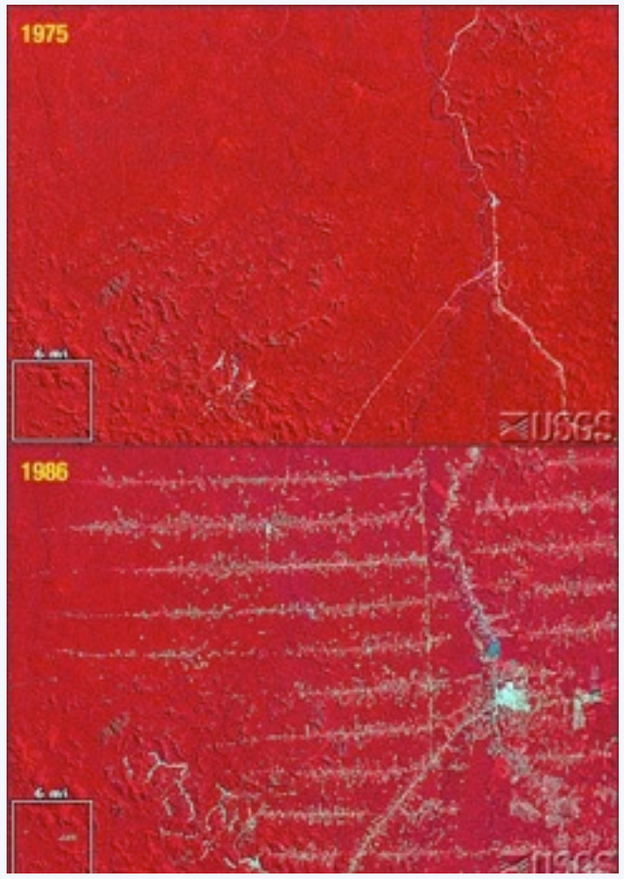
Shoreline mapping

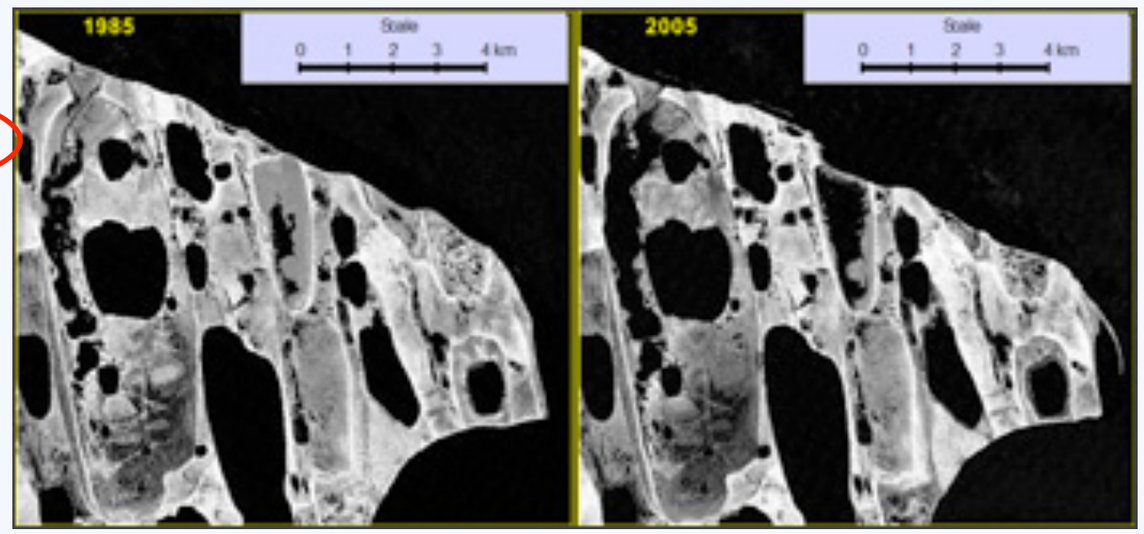
Monitoring forest fires

Tracking vegetative biomass dynamics

and much more...







Advantages and limitations for using Landsat to perform cross-site biomass comparisons

Advantages

- Unmatched historic record
- Spatial coverage
- Temporal coverage
- Free

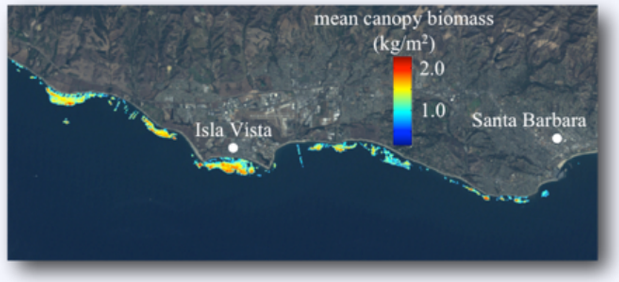
Limitations

- Data saturation at high biomass levels
- relatively insensitive to vegetation height
- lack of freely available higher-level data products

How can we better leverage Landsat for cross-site studies?

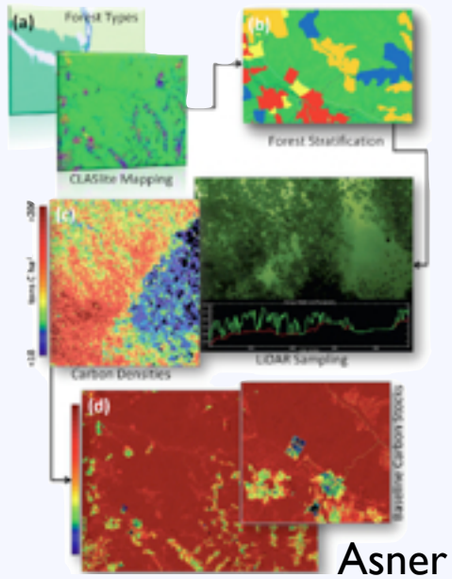
Estimating biomass with Landsat: case study

giant kelp forests (SBC)



Cavanaugh et al. (2011)

Integrating LiDAR and Landsat

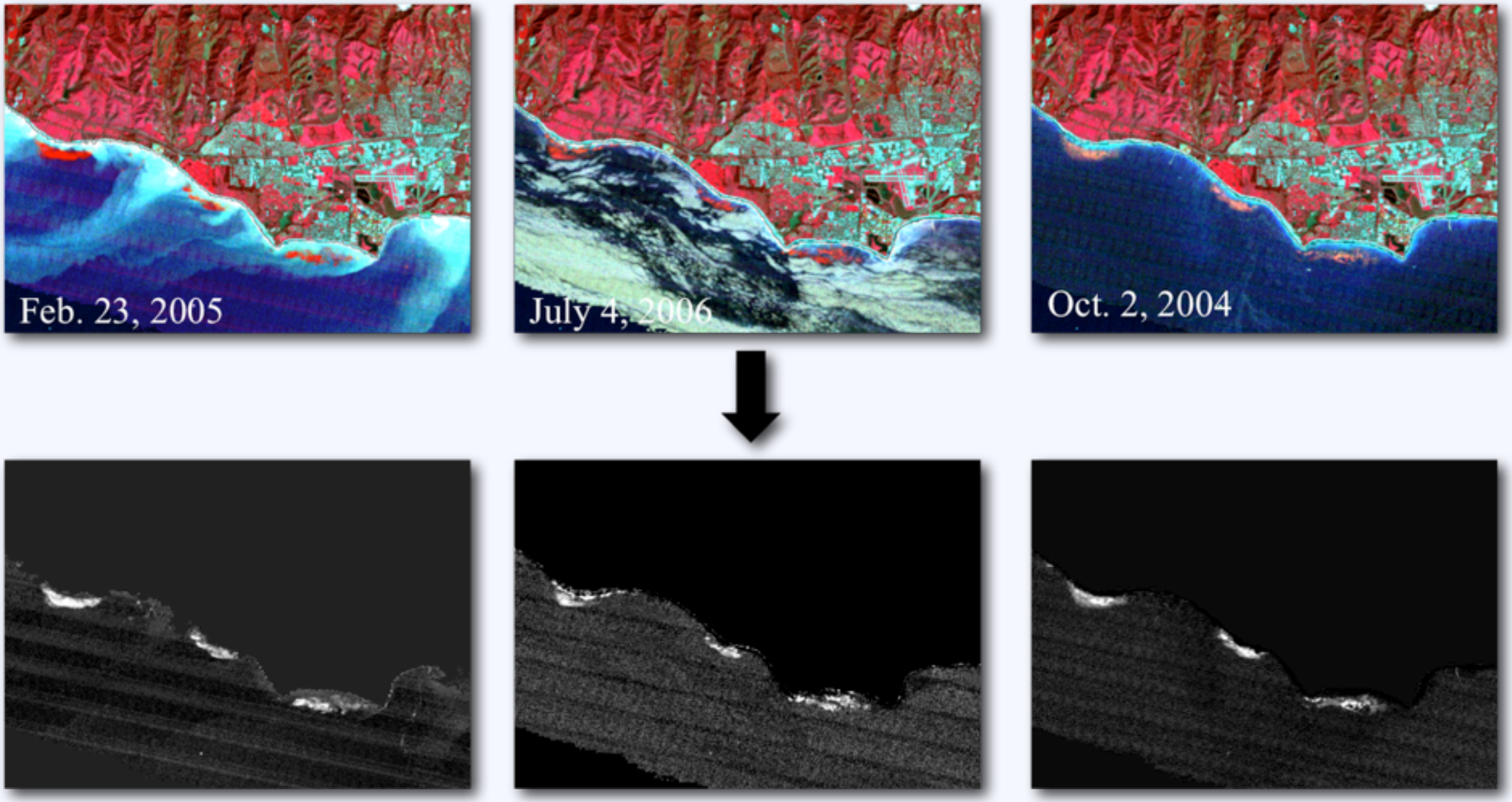


Asner (2009)

LTER Landsat database

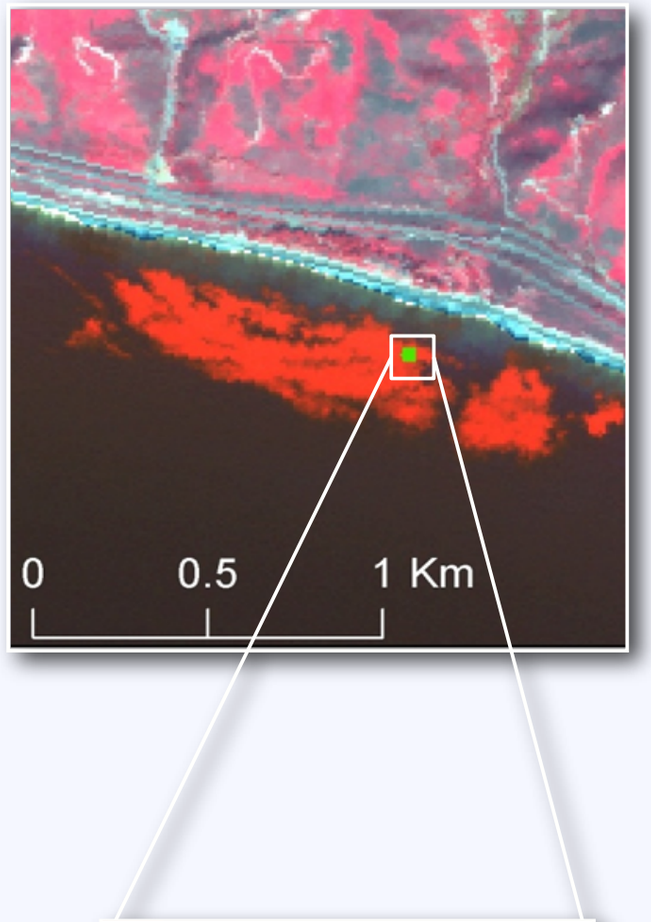
1. Estimating biomass with Landsat: a kelp forest case study from SBC

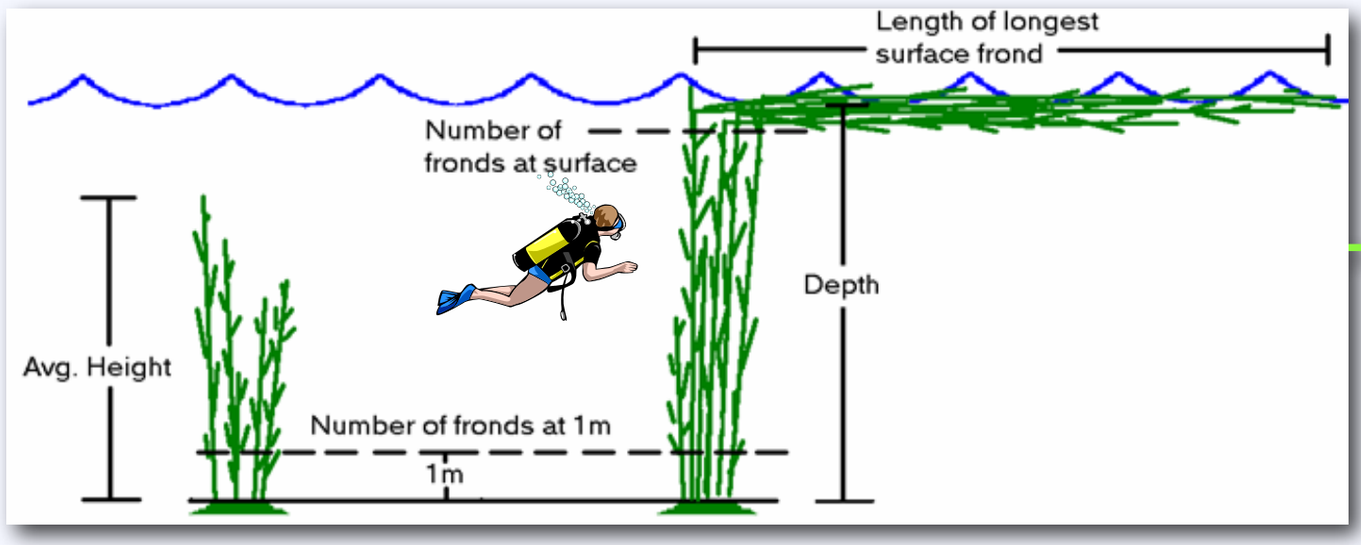
Spectral unmixing used to estimate the percent of each pixel covered by kelp canopy

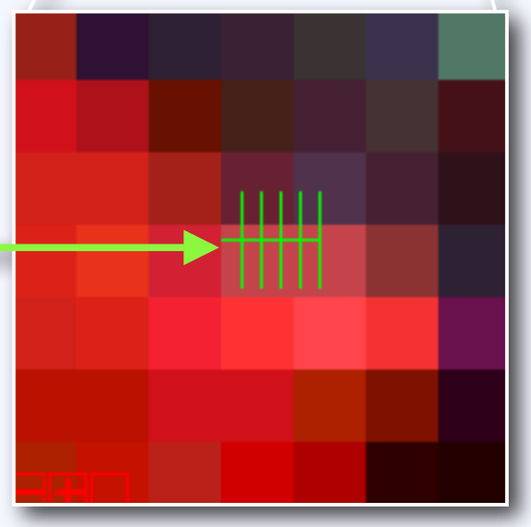


SBC-LTER diver surveys used to transform Landsat kelp fractions into canopy biomass

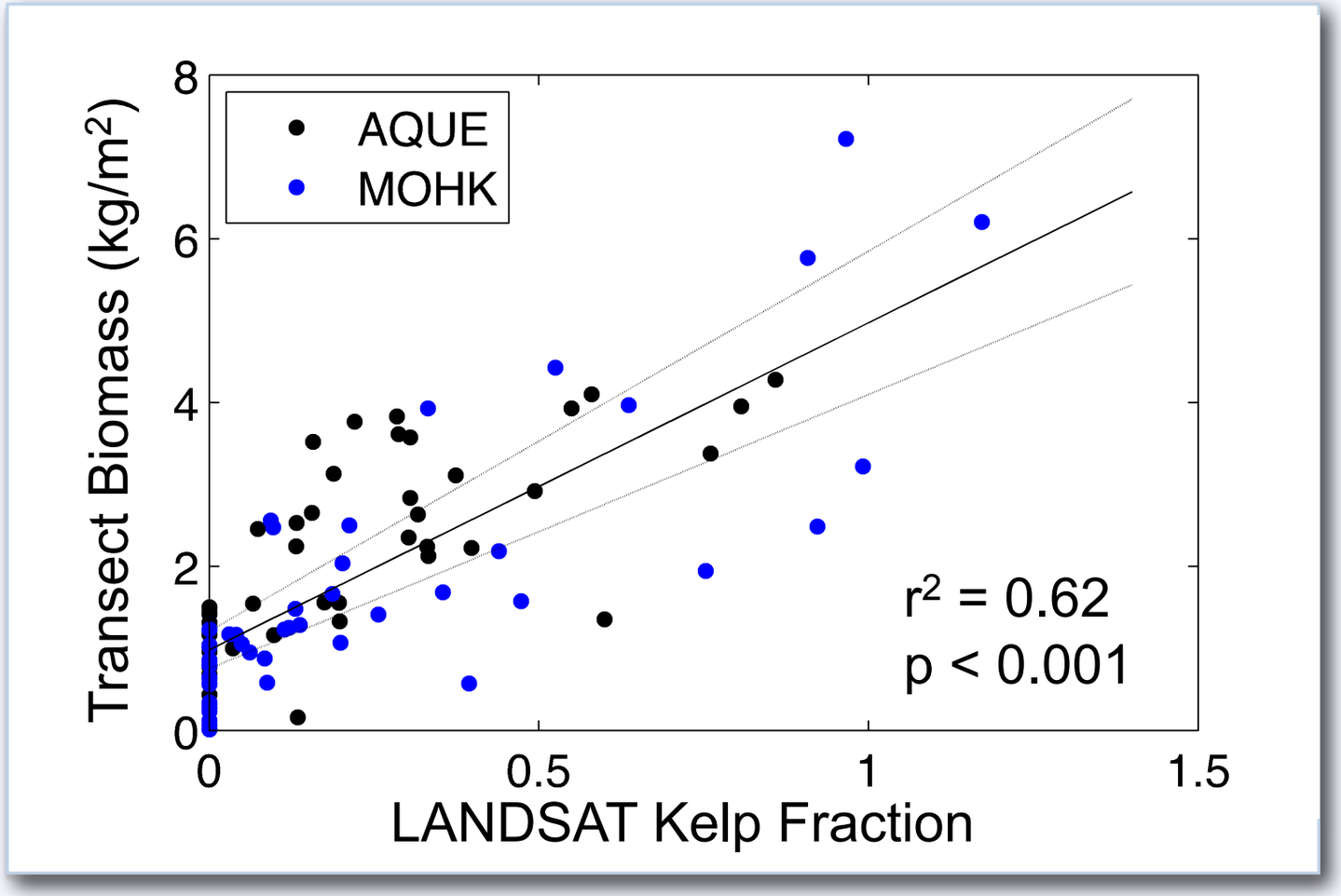
- Monthly non-destructive allometric biomass surveys from 2002-present
- Compared Landsat image to diver survey closest in time





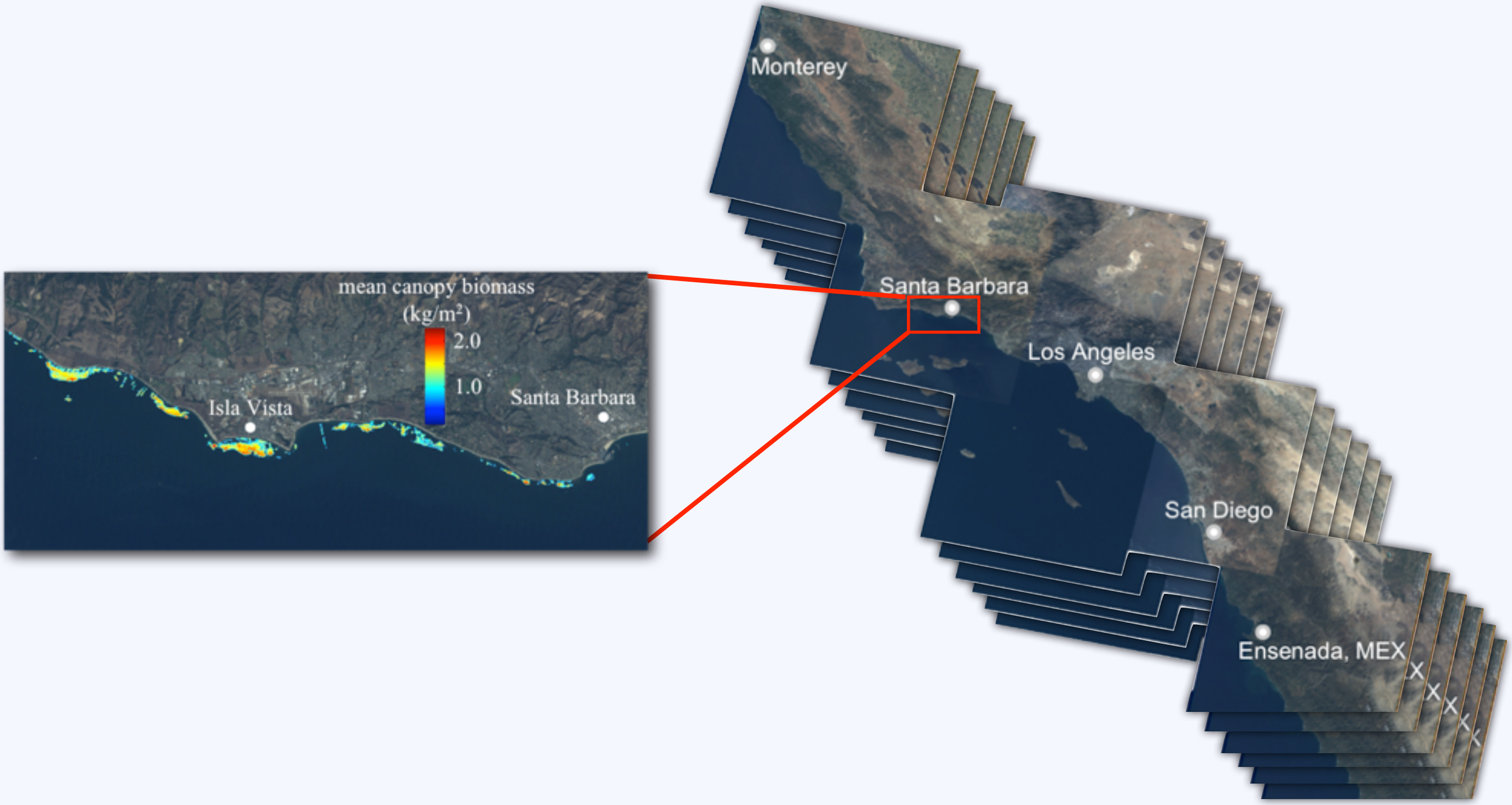


Strong relationship between kelp fraction and diver measured canopy biomass



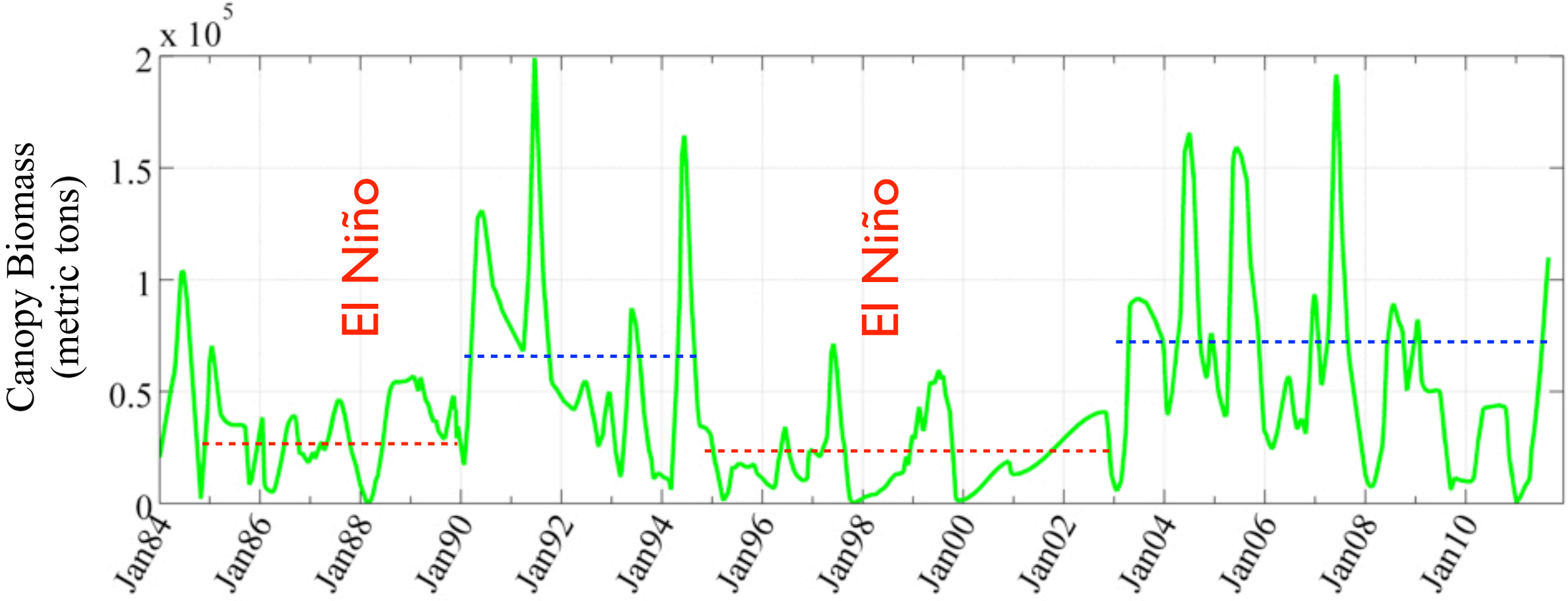
Cavanaugh et al. (2011)

Dynamics of kelp forests in the Santa Barbara Channel from 1984-2011



Dynamics of kelp forests in the Santa Barbara Channel from 1984-2011

- Regional mean: 42,000 metric tons of giant kelp canopy
- low in winter, high in summer/fall
- annual cycle superimposed on 11-13 year cycle
- no clear long-term trend

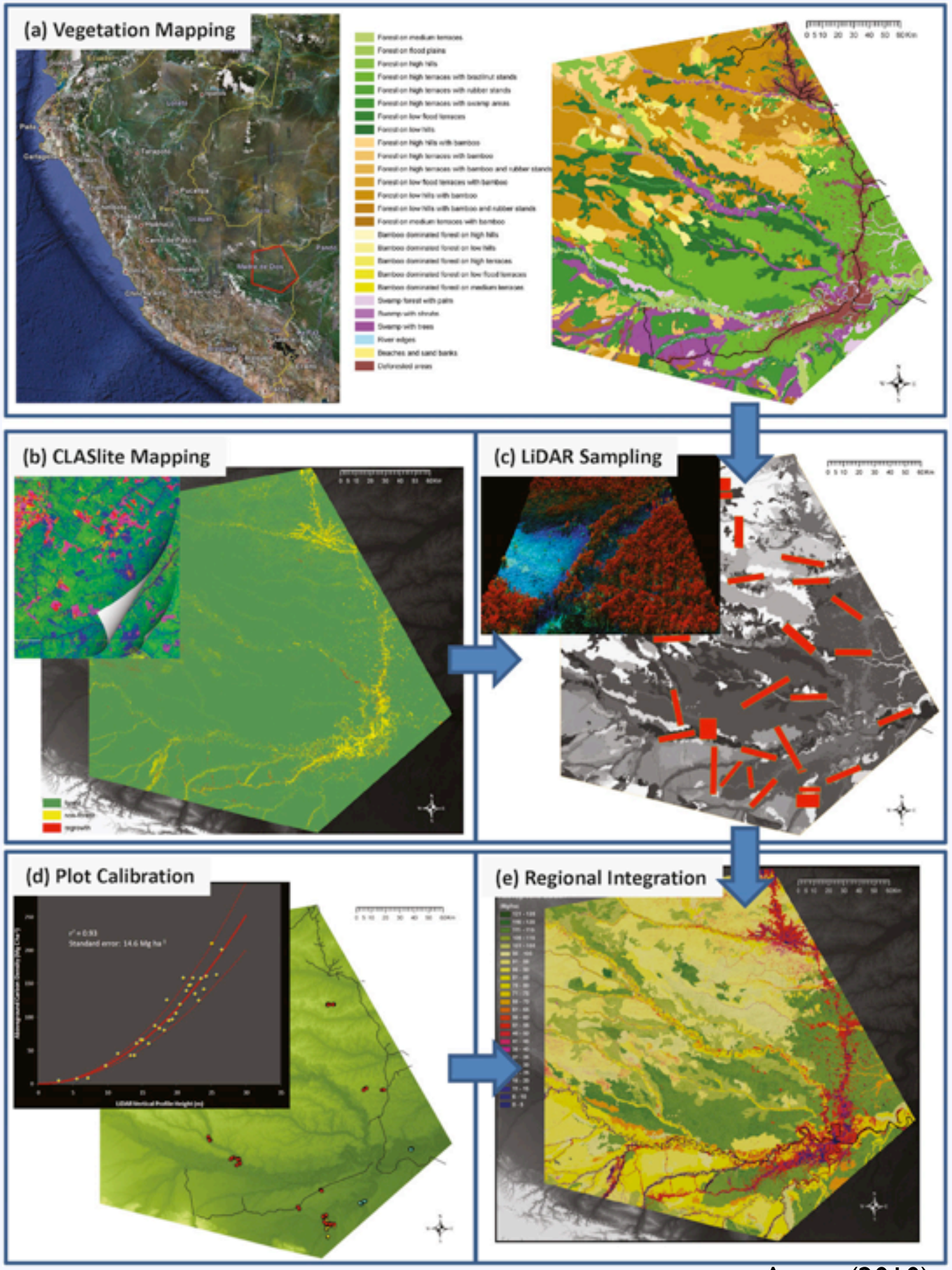


This data allows us to expand the scale of our LTER site research

- regional variability in biomass and NPP dynamics
- regional variability in the drivers of NPP
- regional variability in kelp forest food web structure
- range limit dynamics

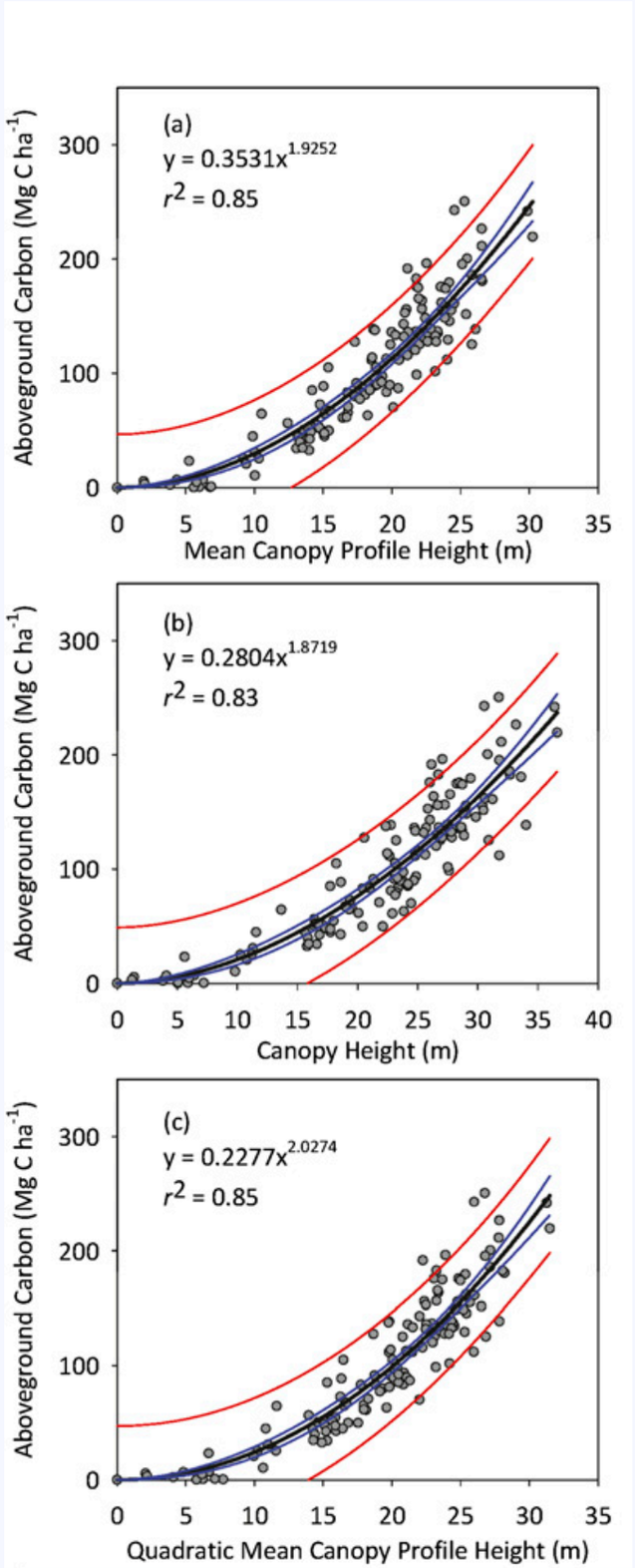
2. Integrating LiDAR and Landsat

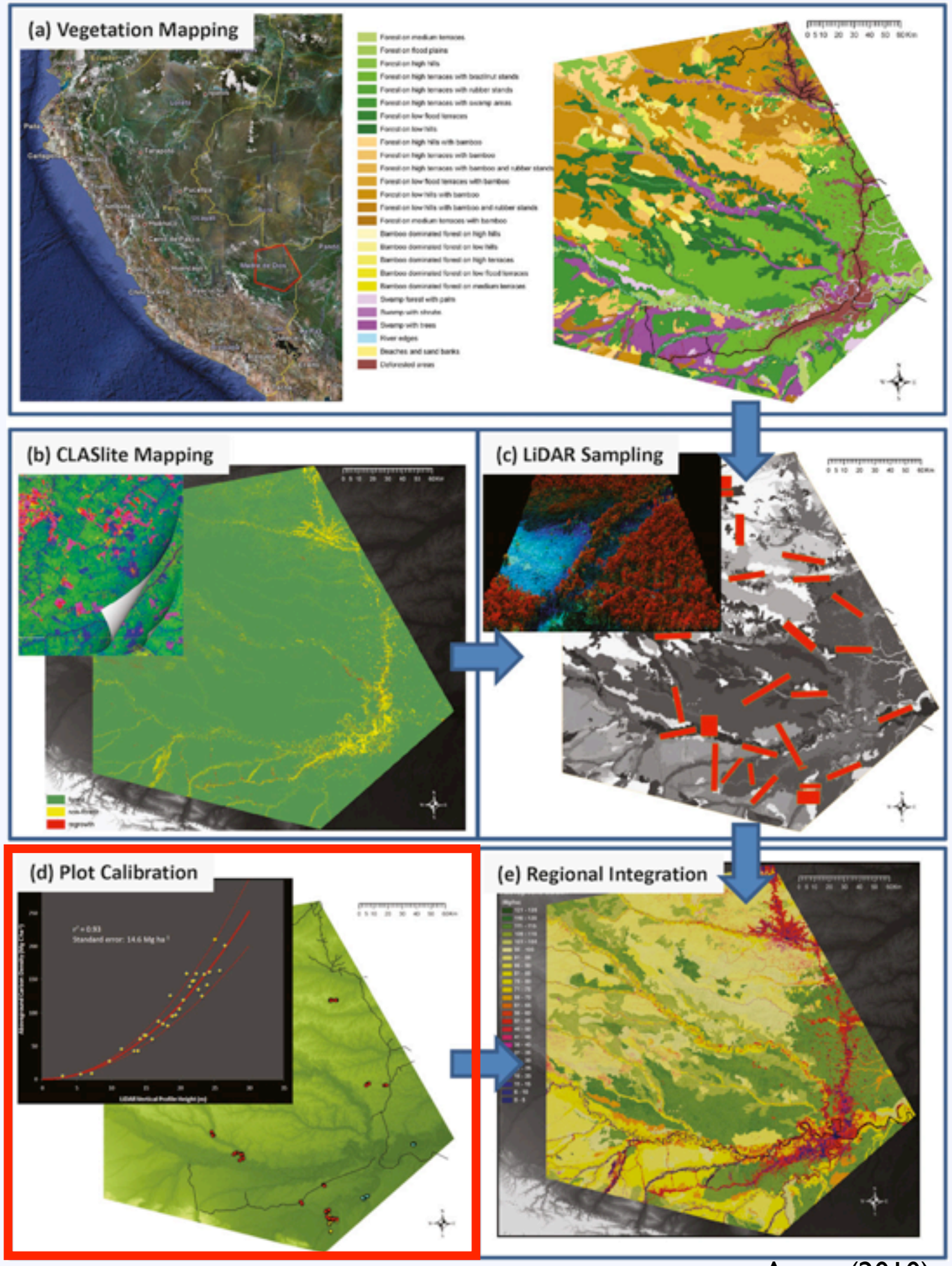
- Landsat does forest cover well, but is insensitive to vegetation height
- LiDAR can accurately estimate forest biomass but has limited spatial and temporal coverage
- Integrating the two could yield repeated high resolution and cost effective maps of forest biomass



Asner (2010)

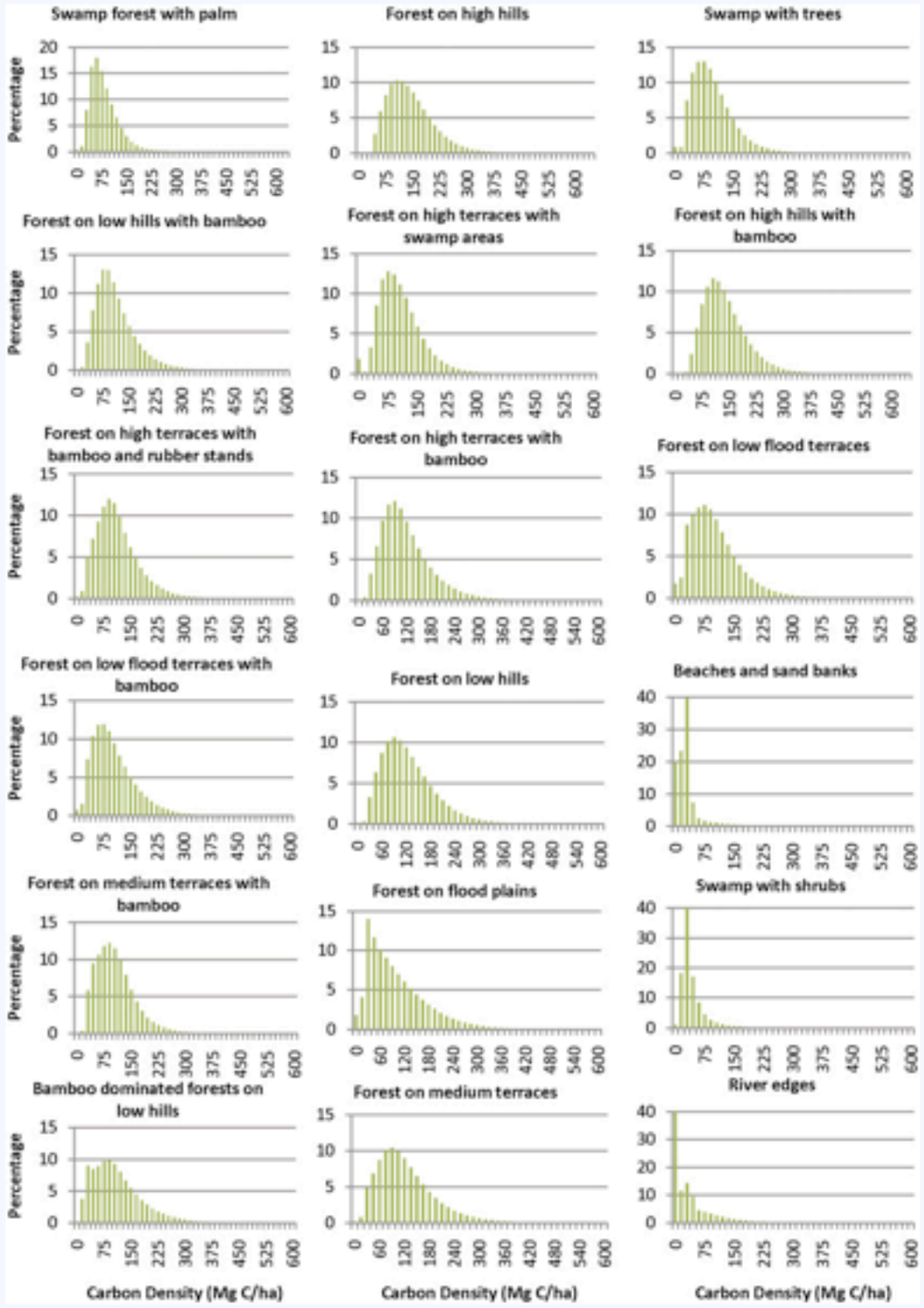
A. Calibrate LiDAR w/ field measurements

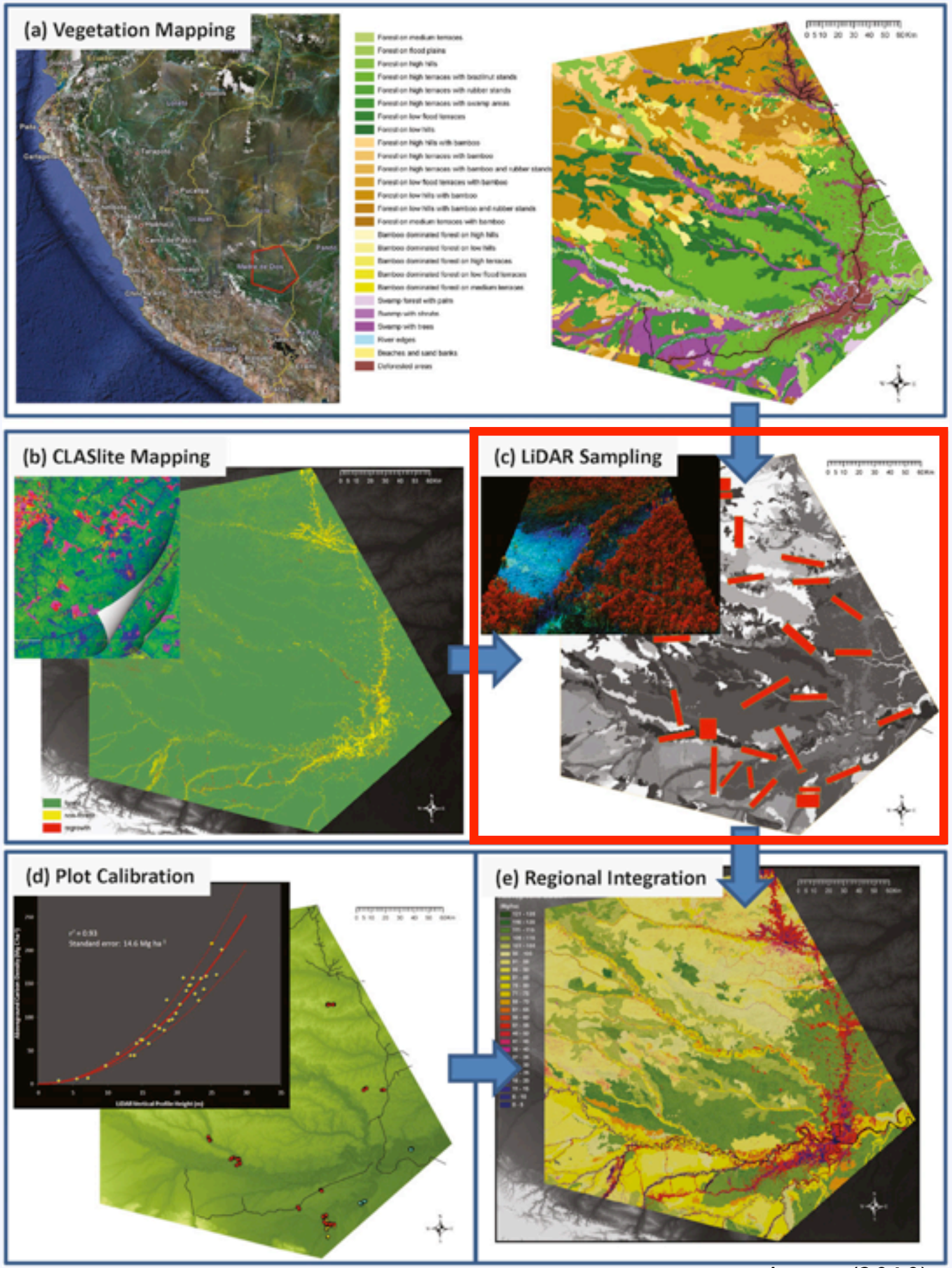




Asner (2010)

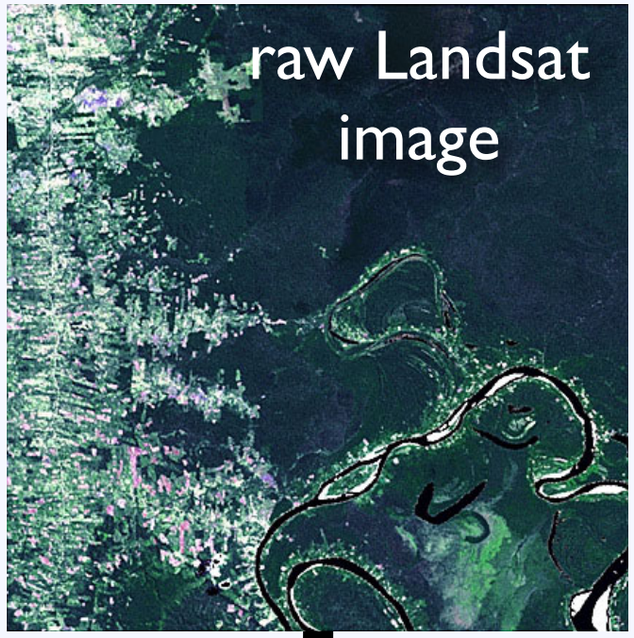
B. Sample each vegetation type w/ LiDAR

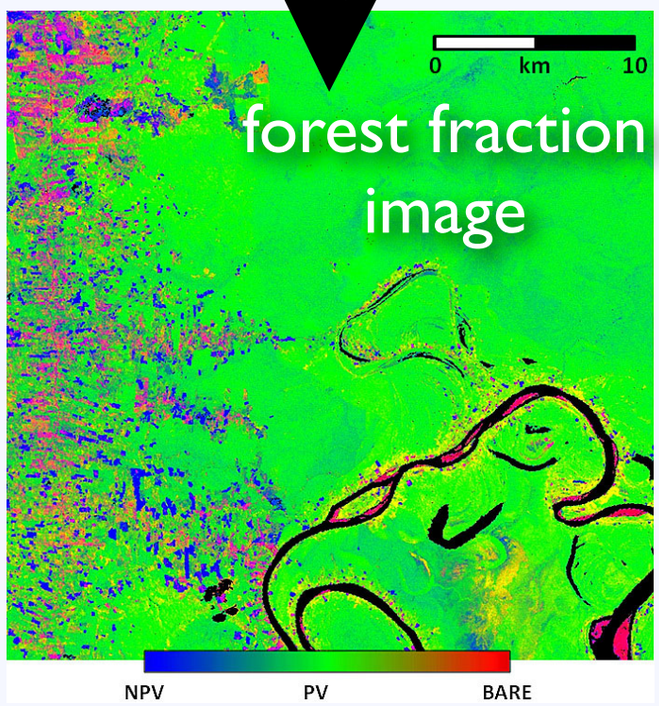


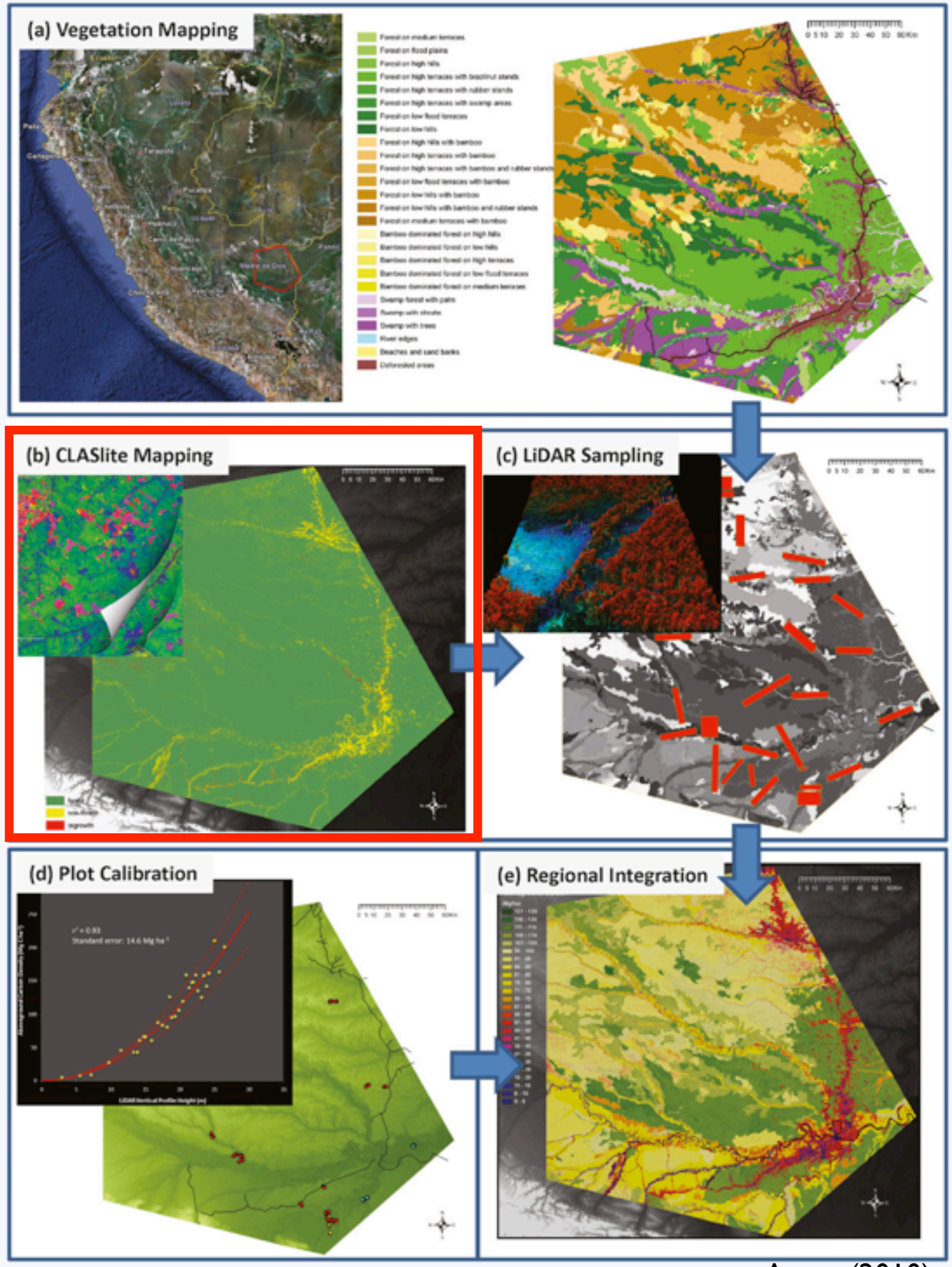


Asner (2010)

C. Calculate the fraction of each pixel covered by forest using Landsat imagery

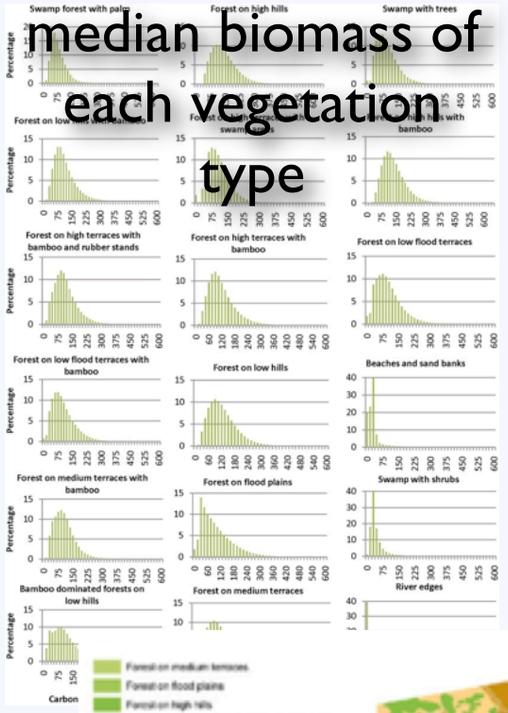


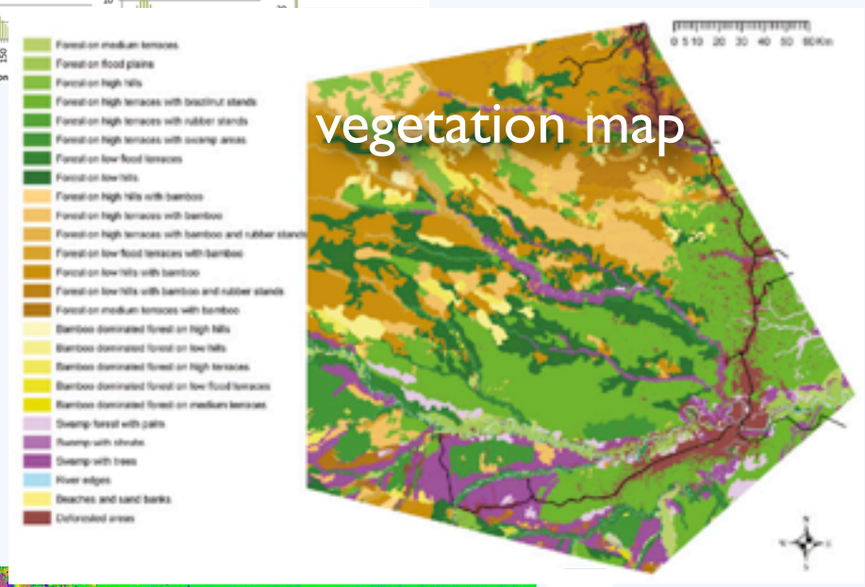


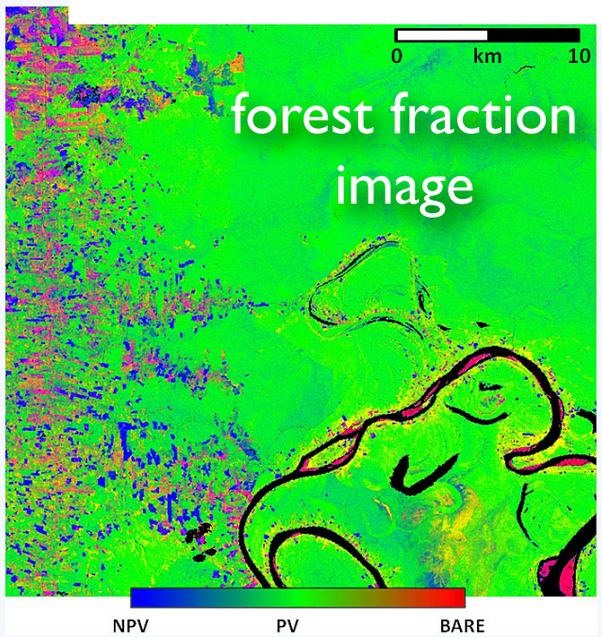


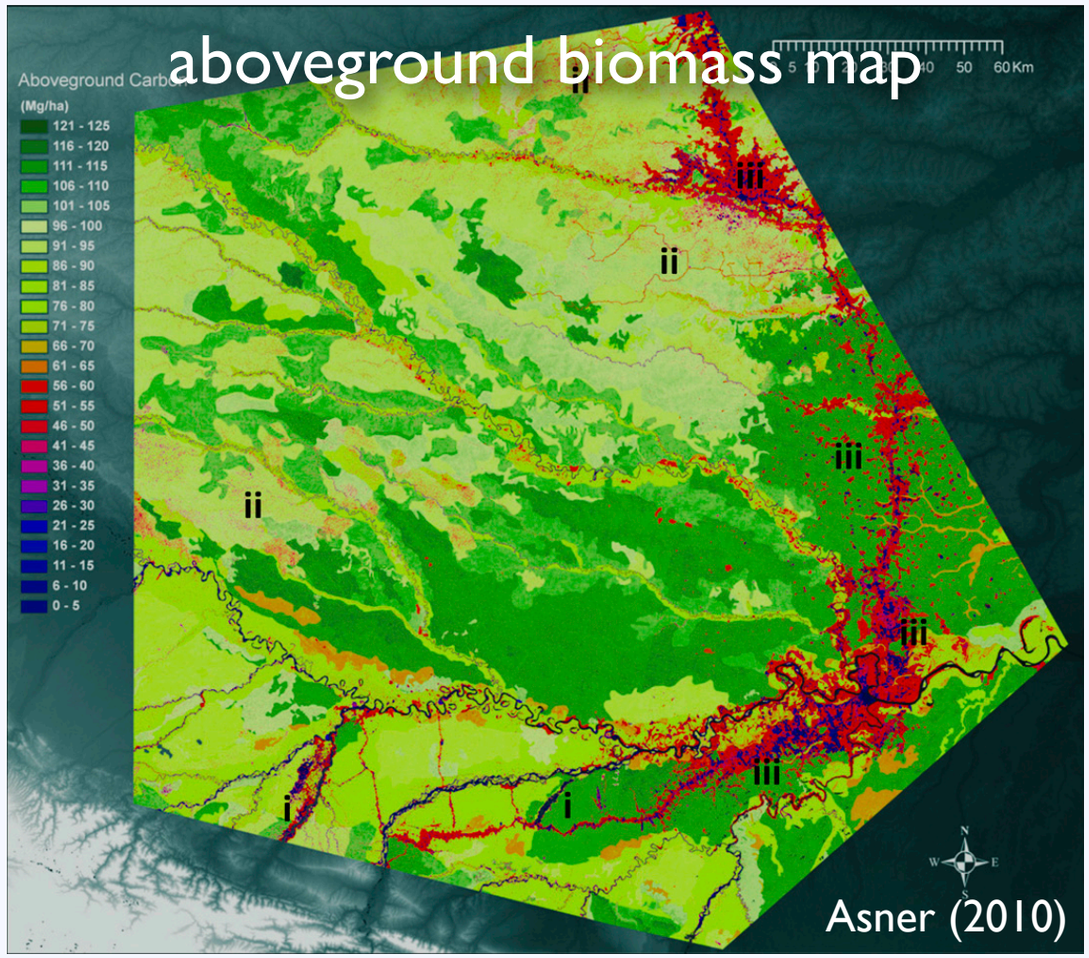
Asner (2010)

D. Assign each pixel a biomass value based on the median biomass of its vegetation type and weight biomass by fraction of pixel covered by forest

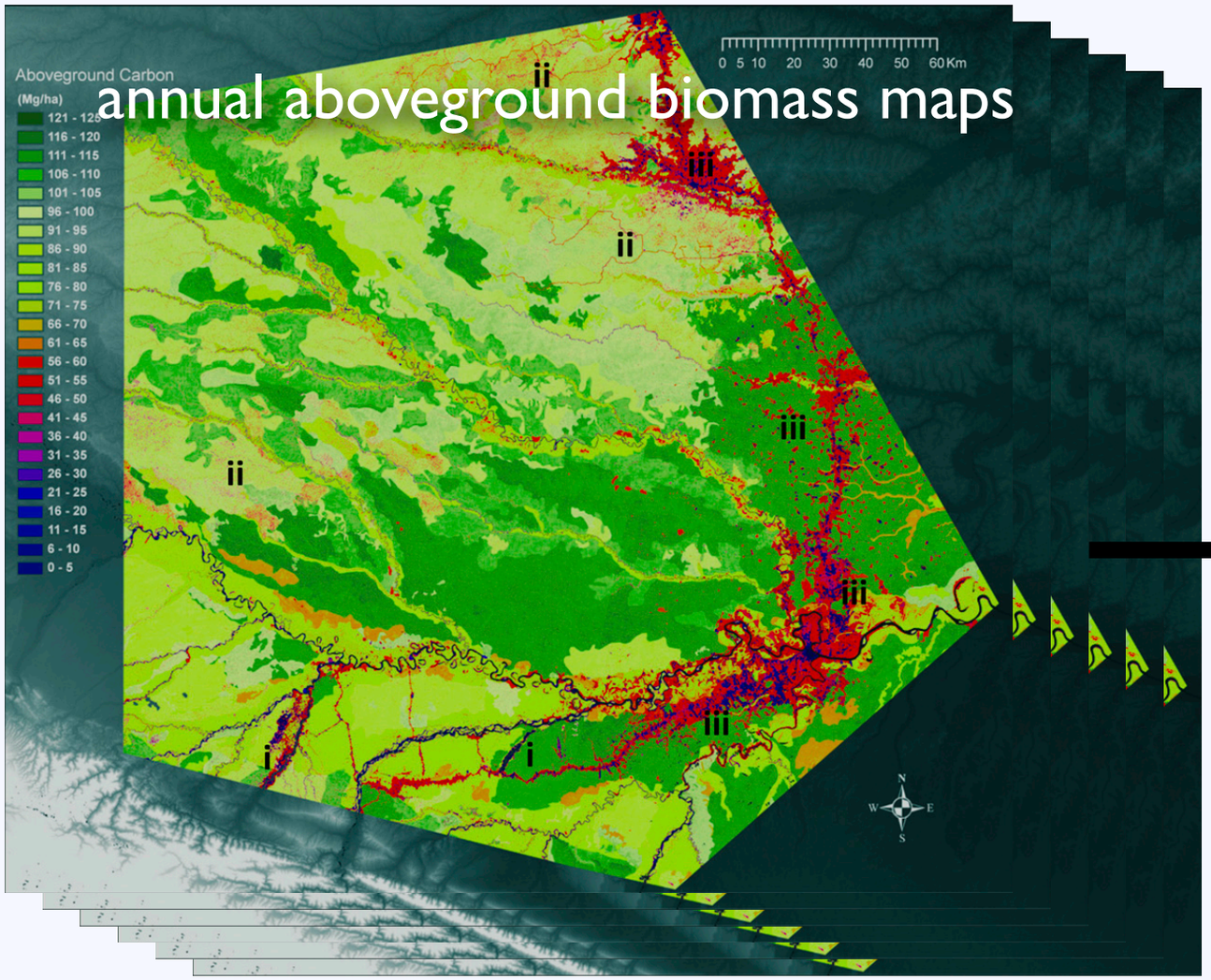


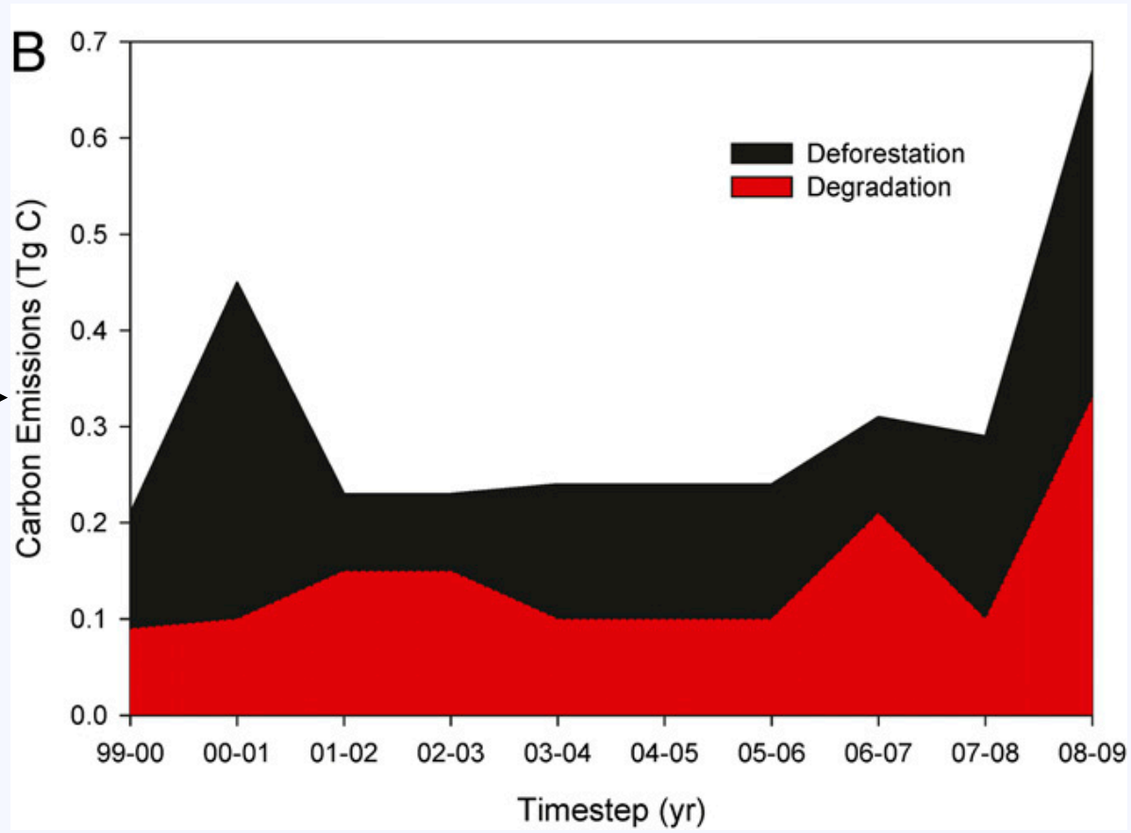






Landsat can be used to create time series of forest biomass dynamics based on changes in forest coverage of each pixel

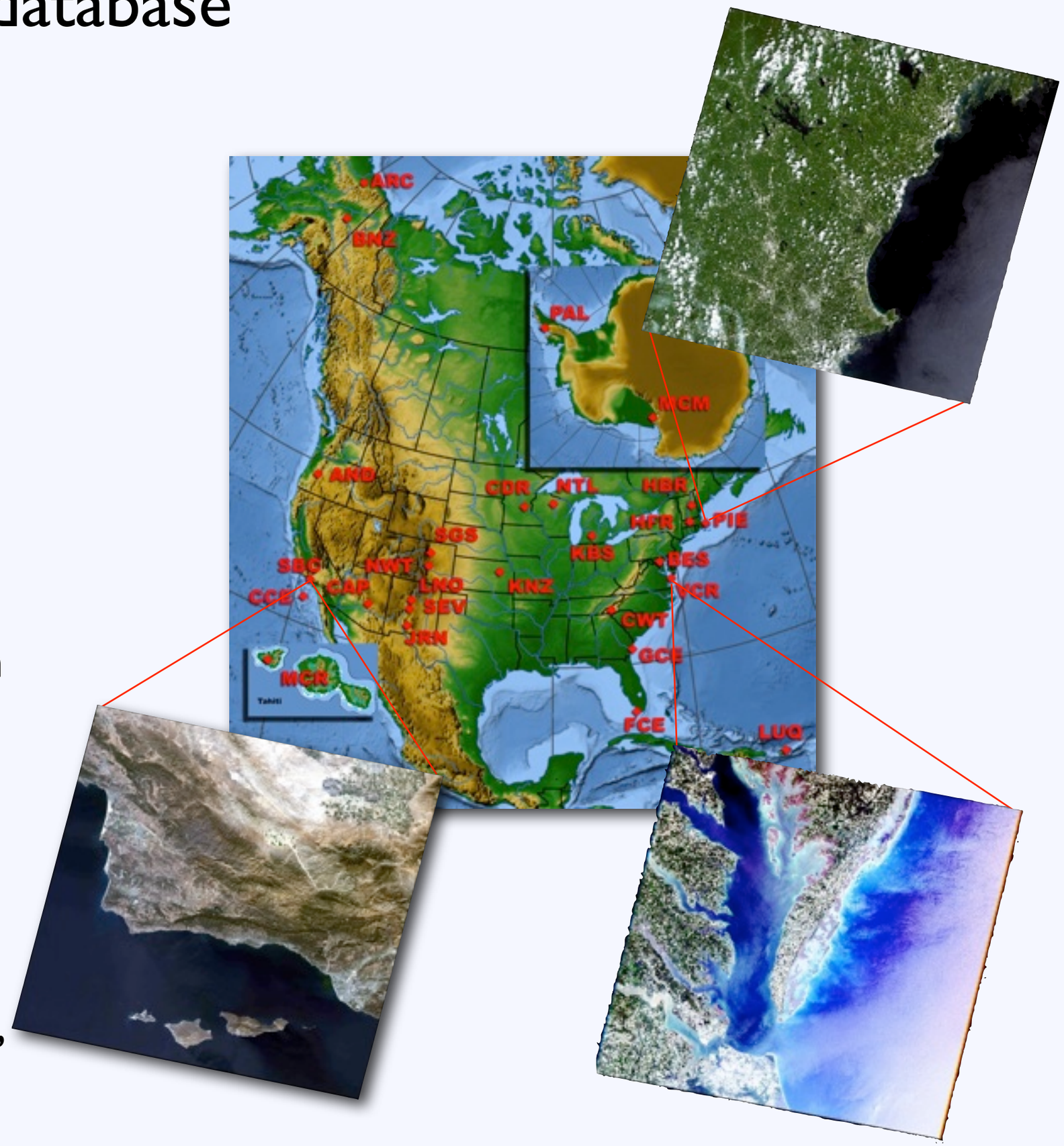




Asner (2010)

3. LTER Landsat database

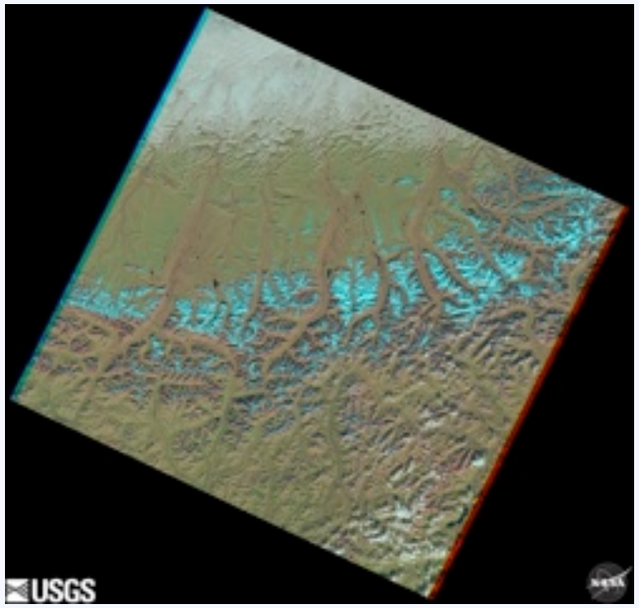
- LTER Network Office is creating a database of all acceptable (<50% cloud cover) Landsat 5 imagery for each site (1984-2011)
- each site: 40-1000 images
- Currently working on integrating database into LTER Network Information System
- Next steps: repository for Landsat analysis algorithms, protocols, higher level data products (e.g. atmospheric corrections, landcover data, biomass data, etc.)



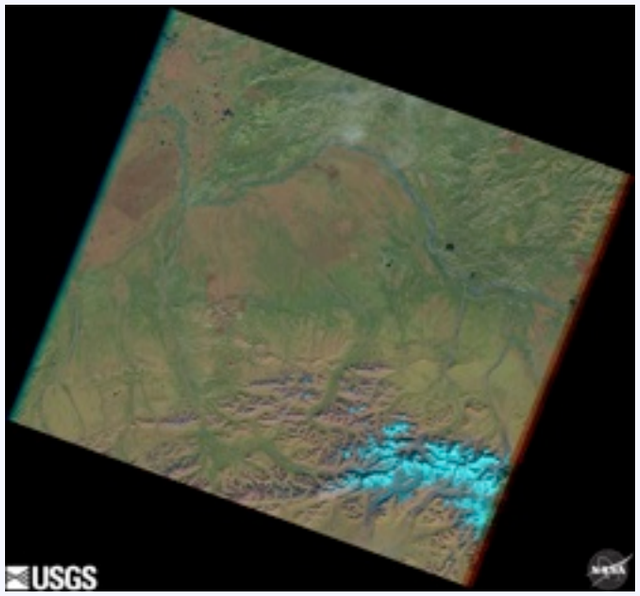
Arctic & Antarctic sites

- High latitude sites have very limited availability of Landsat imagery

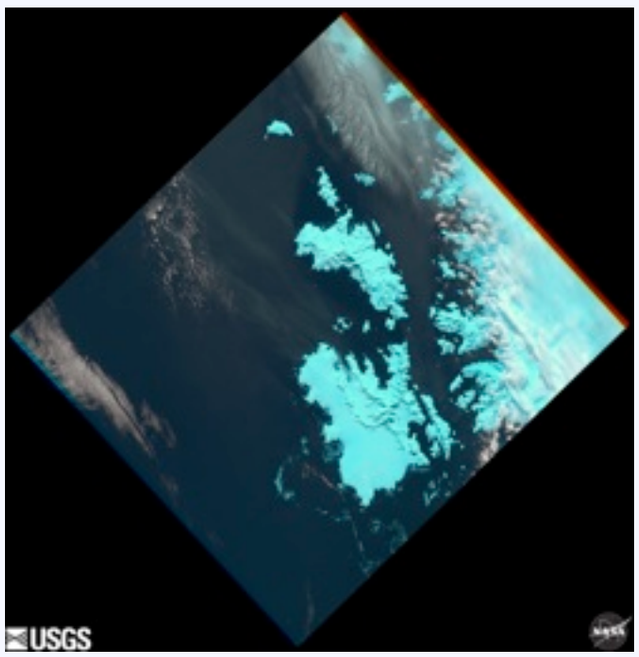
ARC



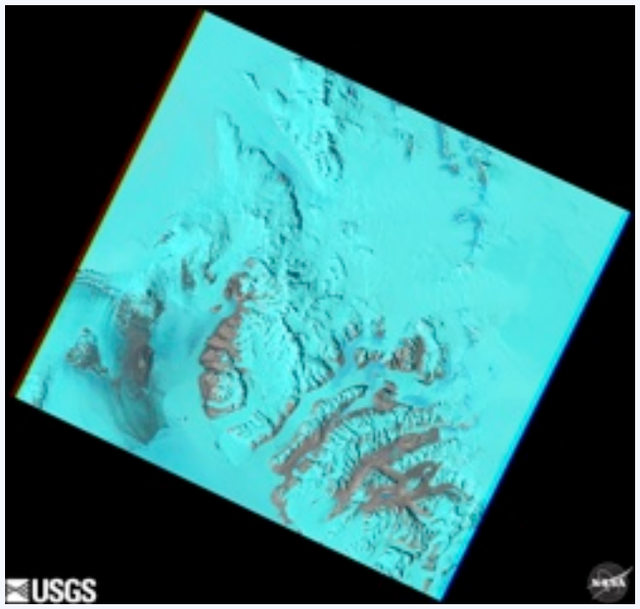
BNZ



PAL

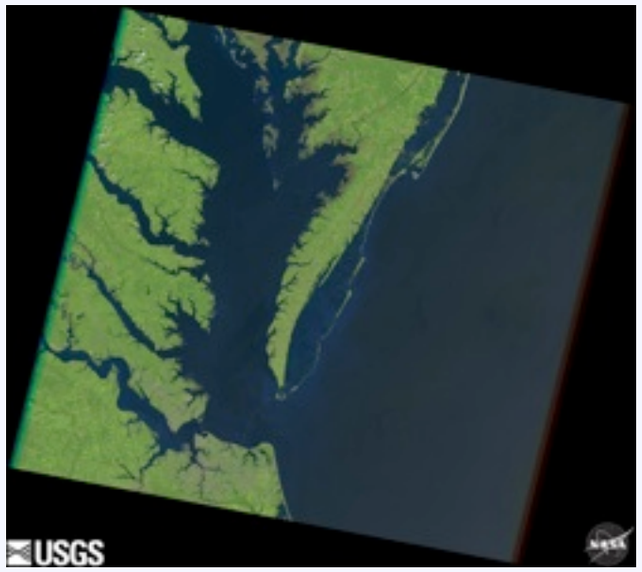


MCM

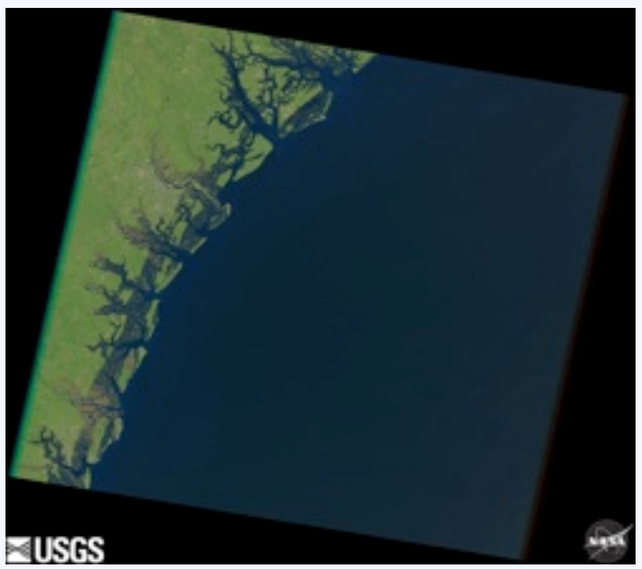


Coastal sites - Atlantic

VCR

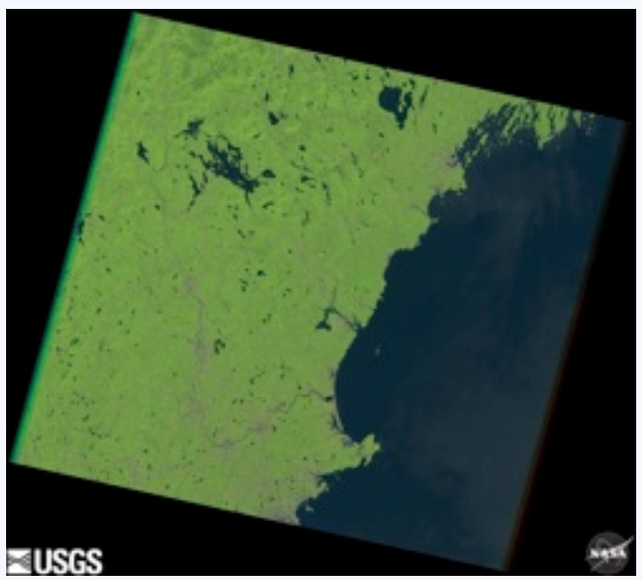


GCE



FCE

PIE



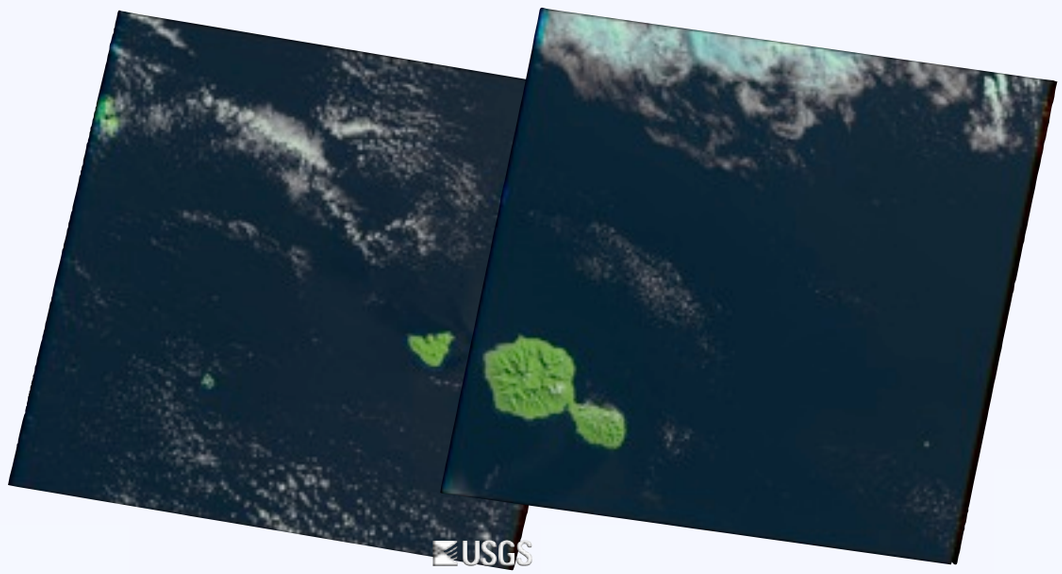
- Mangrove, salt marshes, seagrasses, coral reefs, kelp forests

Coastal sites - Pacific

SBC

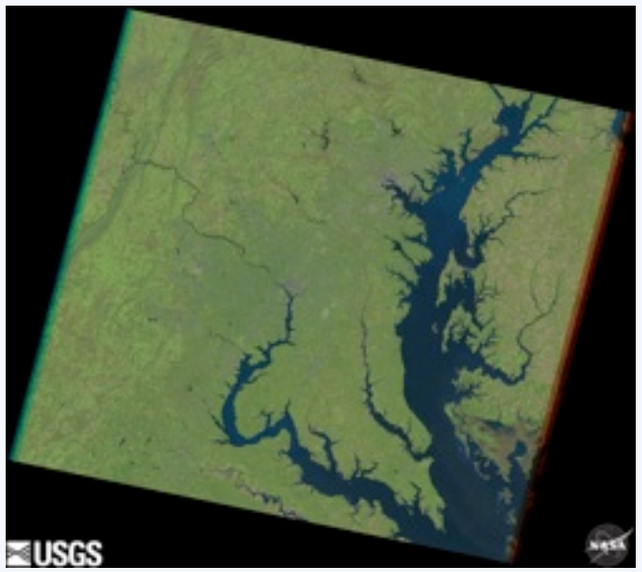
CCE

MCR



Urban sites

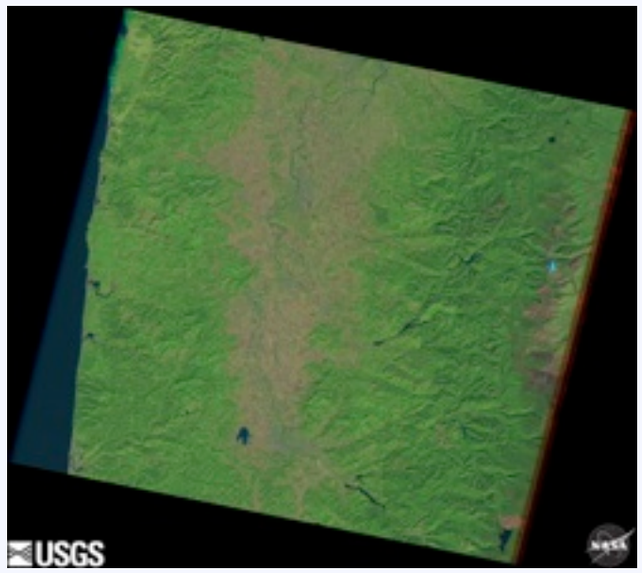
BES



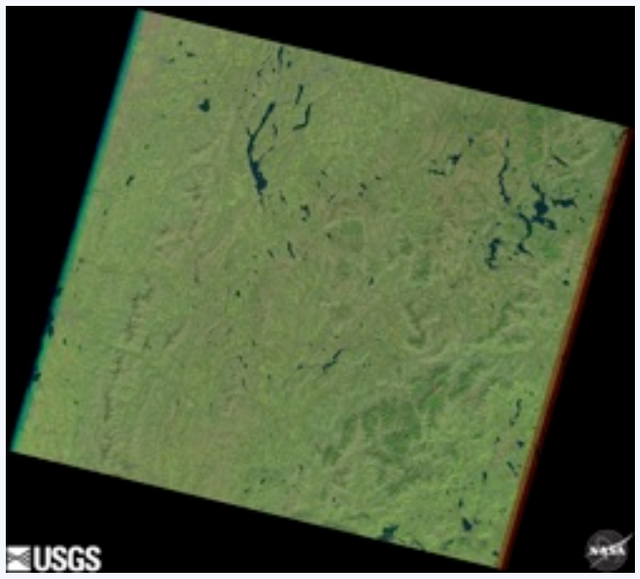
CAP

Forest sites

AND

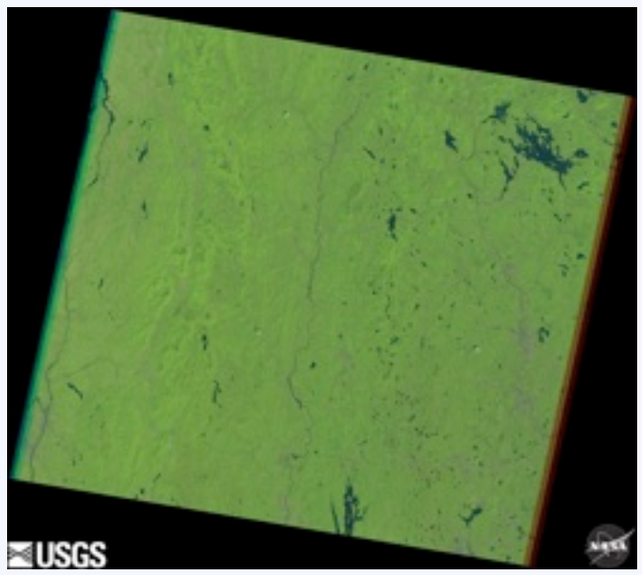


HBR



LUQ

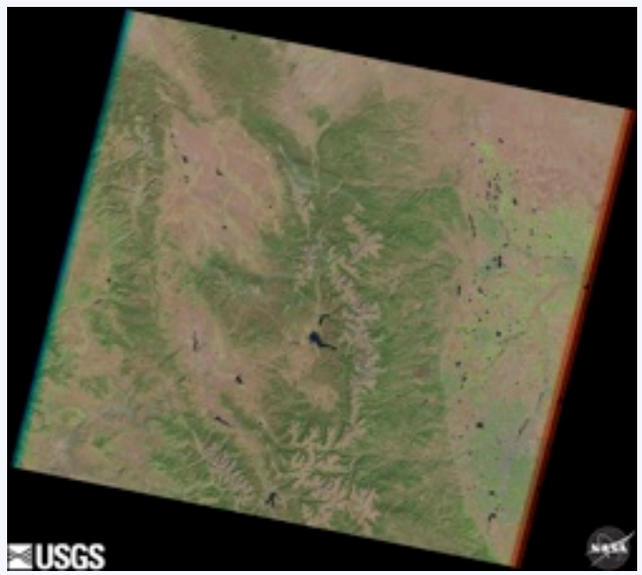
HFR



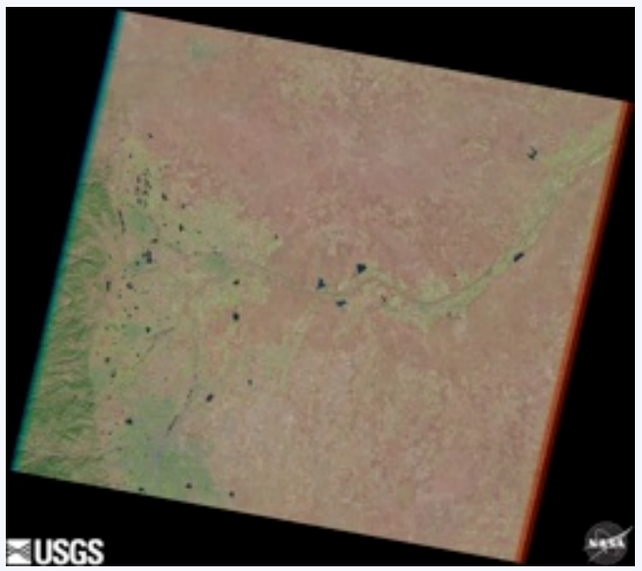
- May need to integrate LiDAR data to accurately estimate forest biomass changes

Grassland sites

NWT

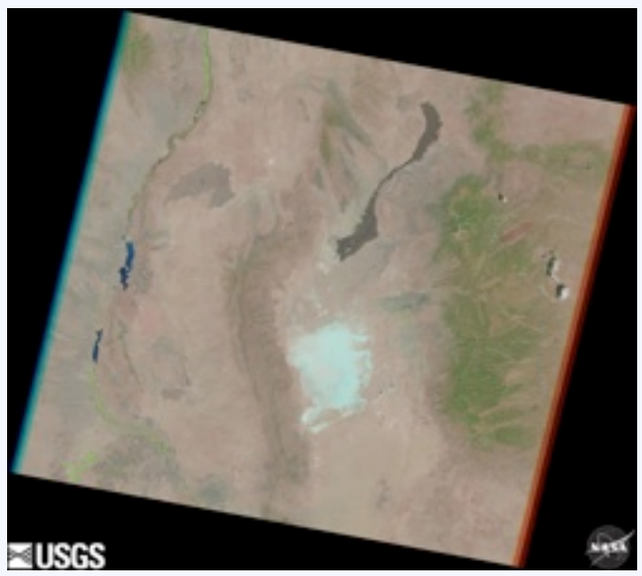


SGS



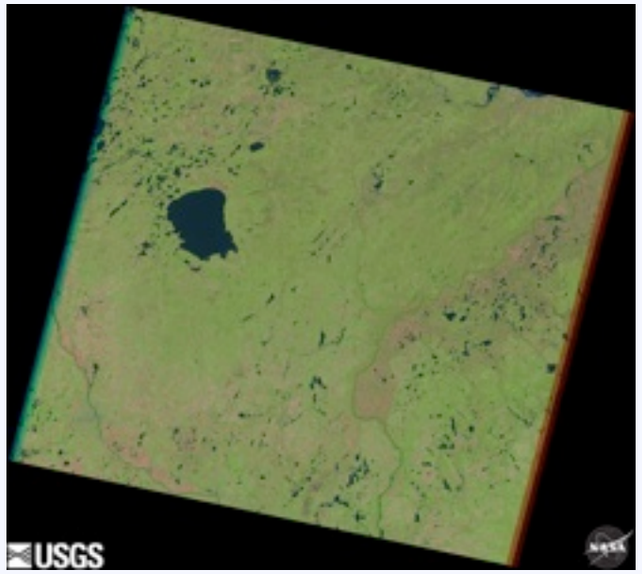
SEV

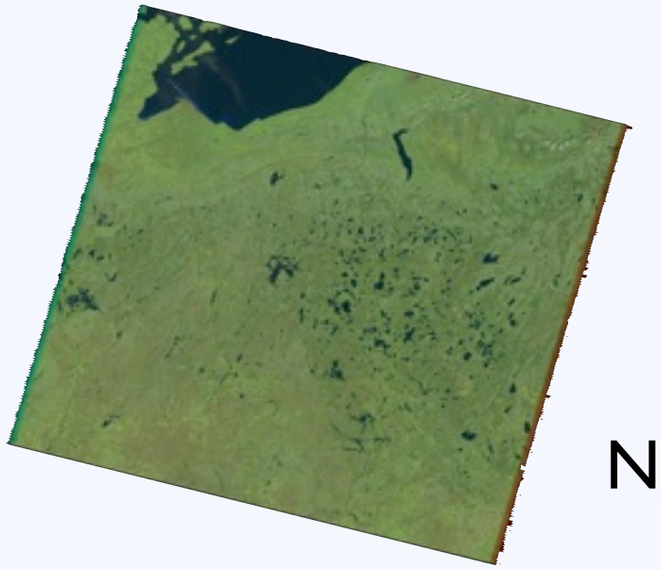
JRN



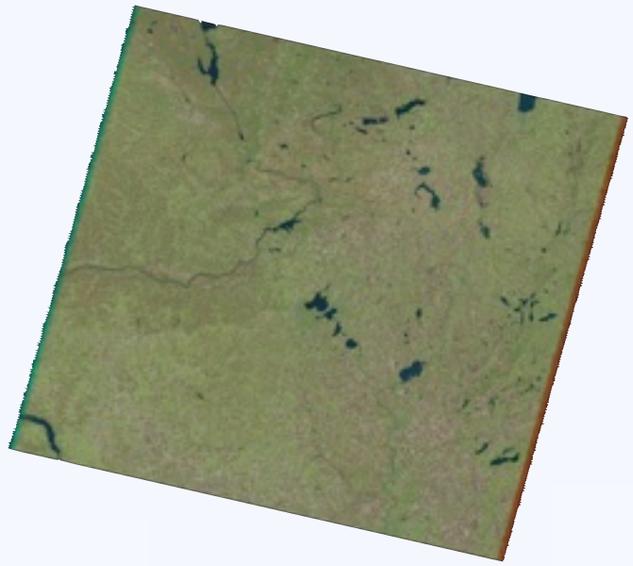
Mid-western sites

CDR

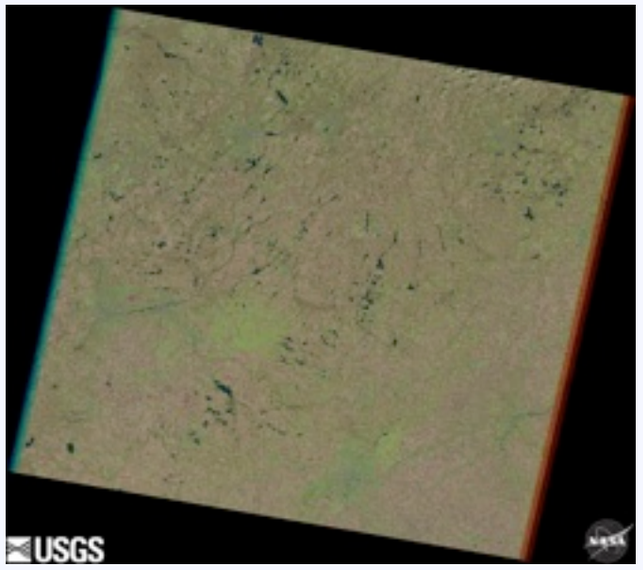




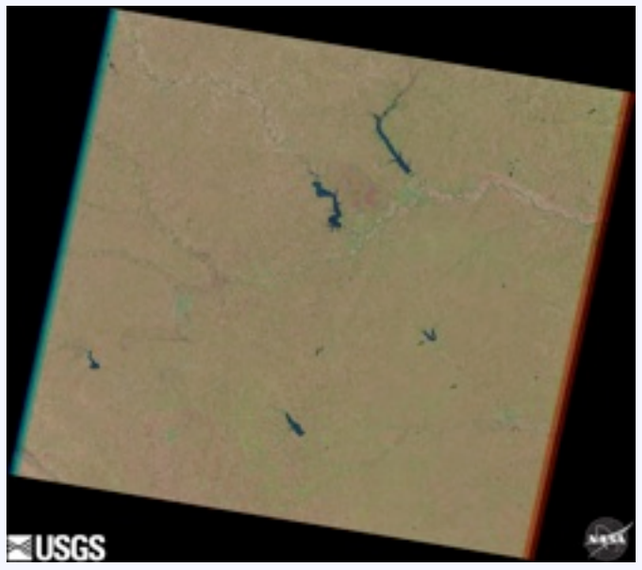
NTL



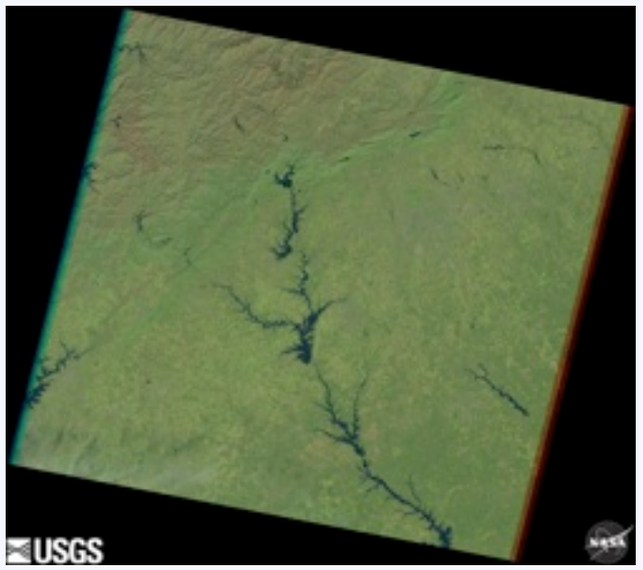
KBS



KNZ



CWT



Cross-site project issues

- Should cross-site projects focus on a specific ecosystem type (e.g. forest, wetland)? Sensor type (e.g. Landsat, LiDAR)? Something else (e.g. phenology, long-term trends, response to disturbance)?

- What are the standardized data products we need to produce? Can we leverage existing data products that have already been created by individual sites?