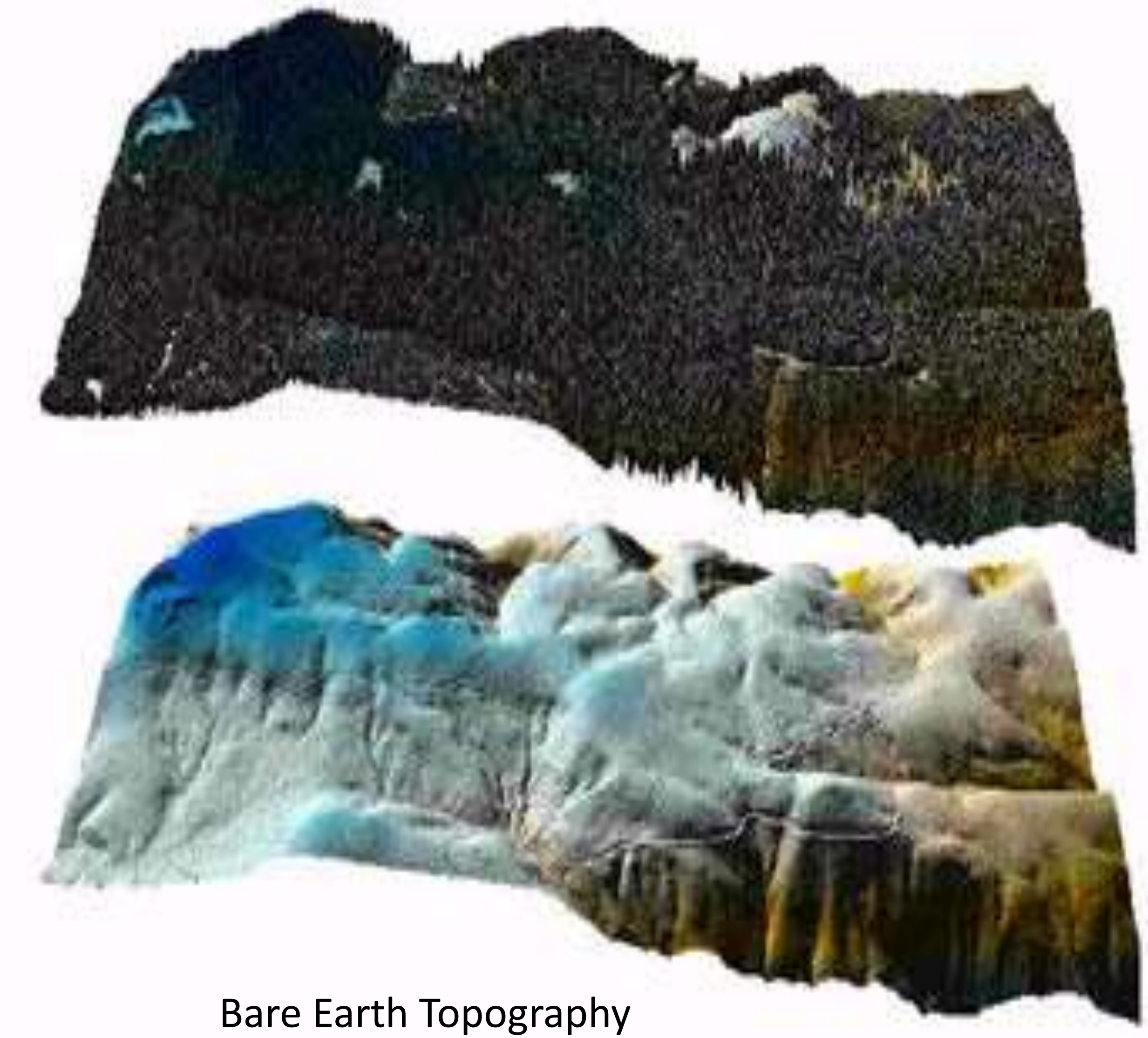
Session 3 (1 hr): Prof. Susan L. Ustin

Title: Remote sensing using active RaDAR and LiDAR for hydrologic properties and processes

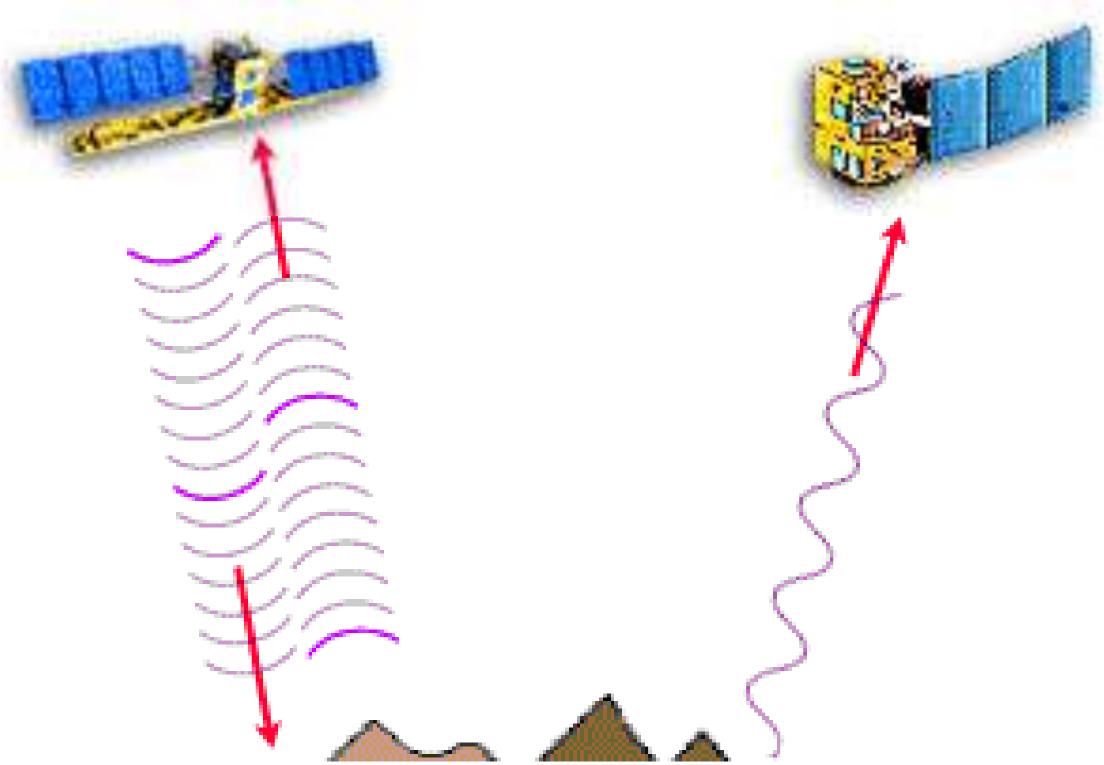
Canopy Height and Tree Cover



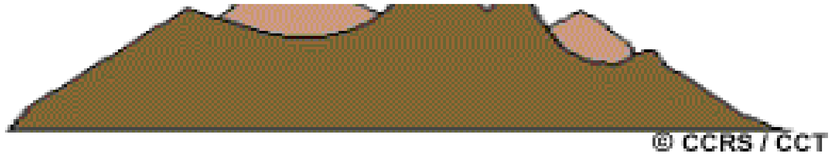
Bare Earth Topography

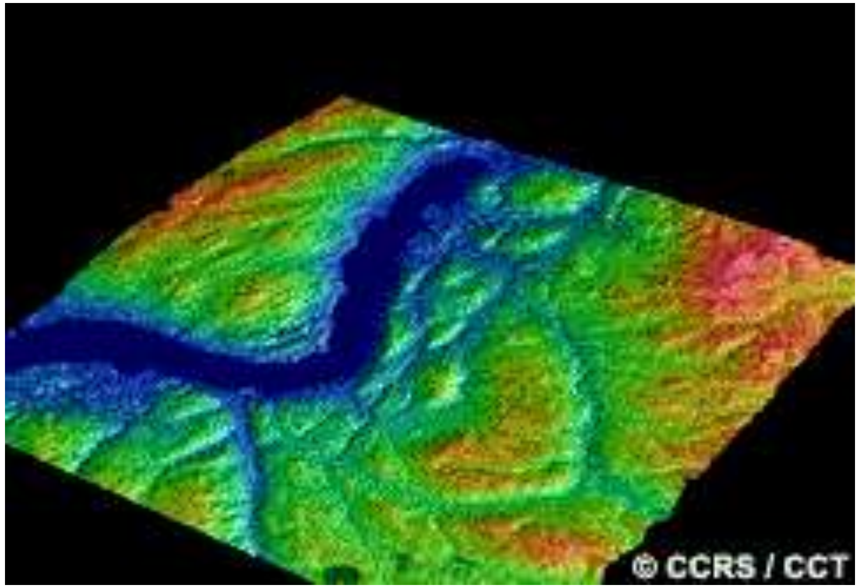
Contact me at:
slustin@ucdavis.edu

LiDAR and RaDAR Principles



Active vs. Passive Remote Sensing





Airborne Lidar measured over forested mountain landscape

Real Forest landscape

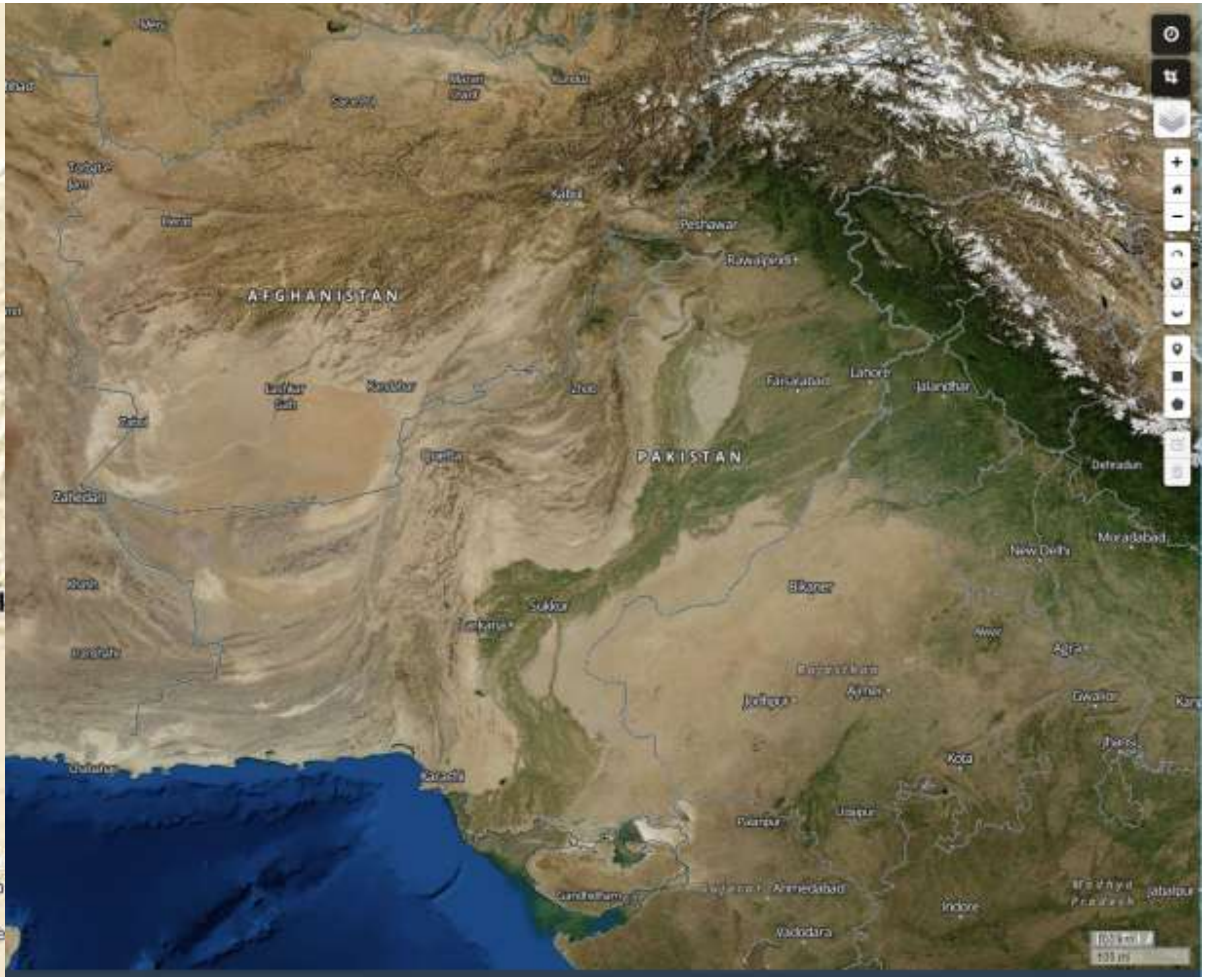
LiDAR simulated forest

Qinghua Gao, UCM and Maggi Kelly, UCB

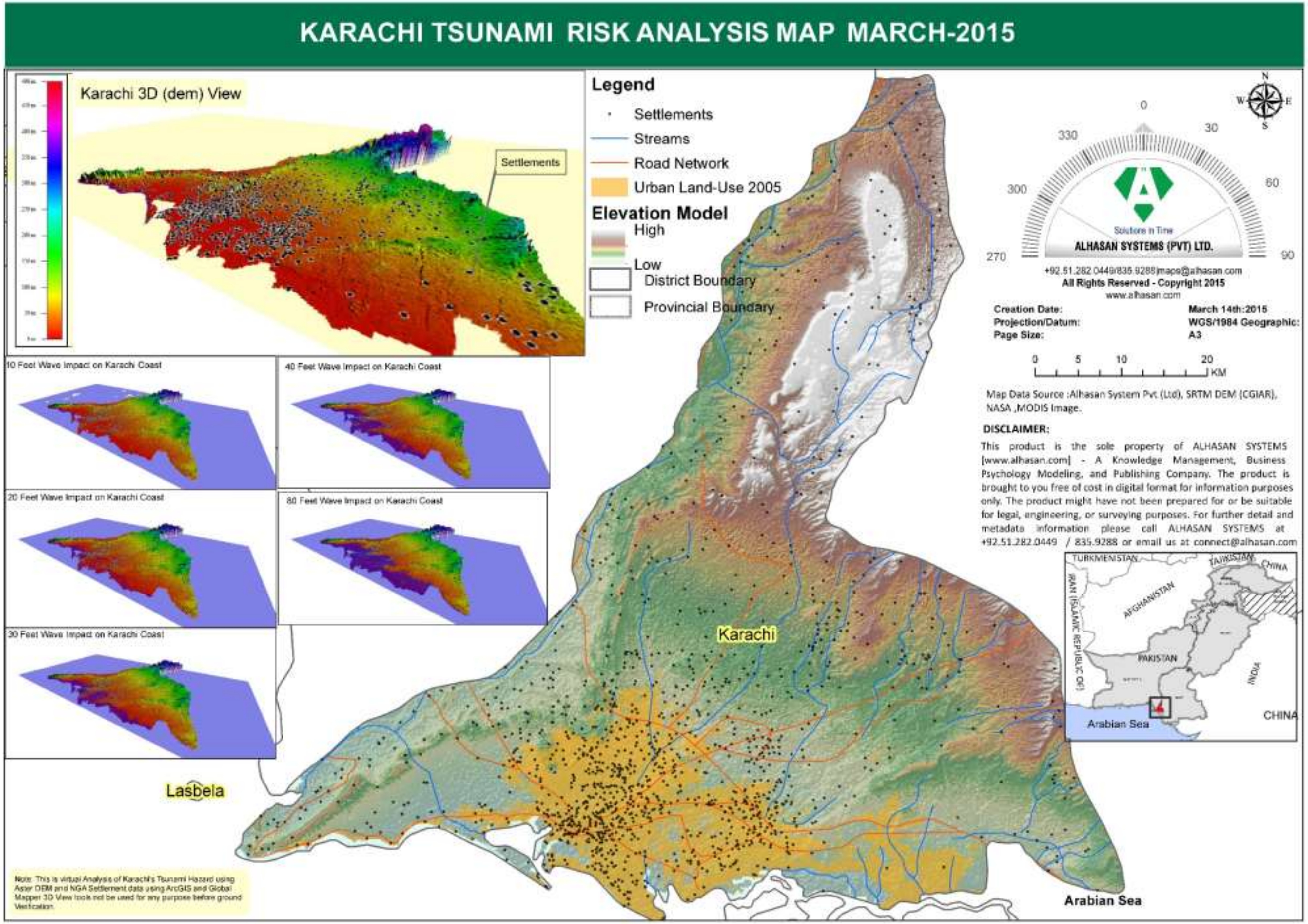
Main Application for Lidar and RaDAR is Creating Maps of Surface Topography

90m SRTM DEM Data

ASTER version 3 DEM (at 30m) with Landsat overlayed



Example of using ASTER, a 14 band imager from JAXA, located on the NASA Terra platform.



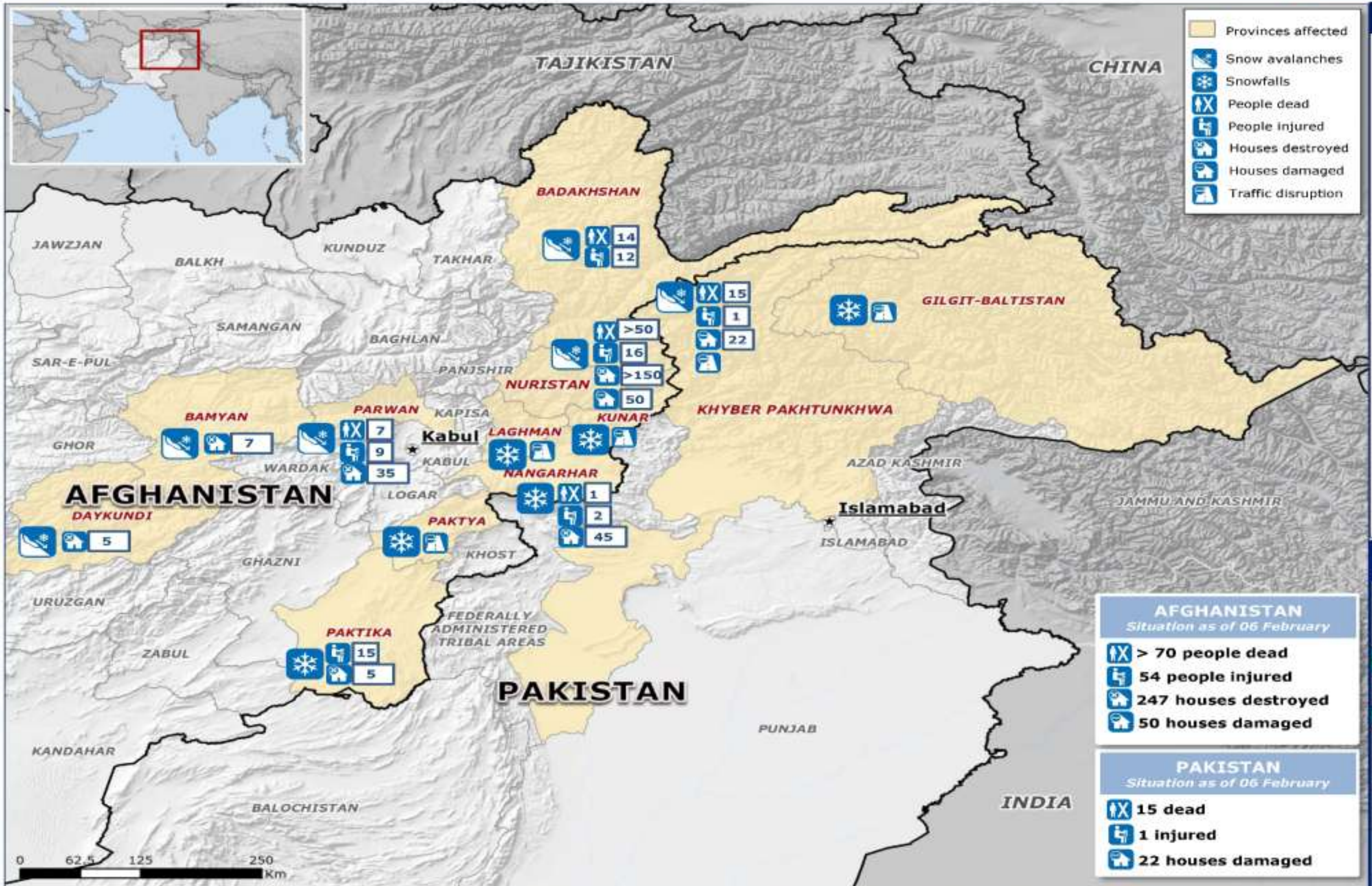
DEM to create a Tsunami Hazard Map for Karachi

Application for Global Sea Level Rise?

Emergency Response Coordination Centre (ERCC) – ECHO Daily Map | 06/02/2017

Afghanistan and Pakistan – Snow avalanches

European Commission | Humanitarian Aid and Civil Protection

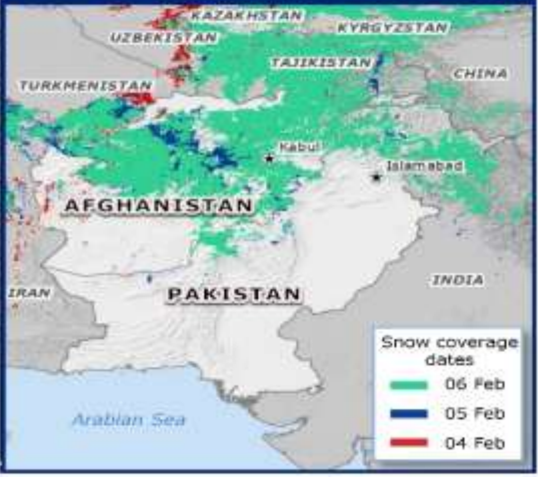


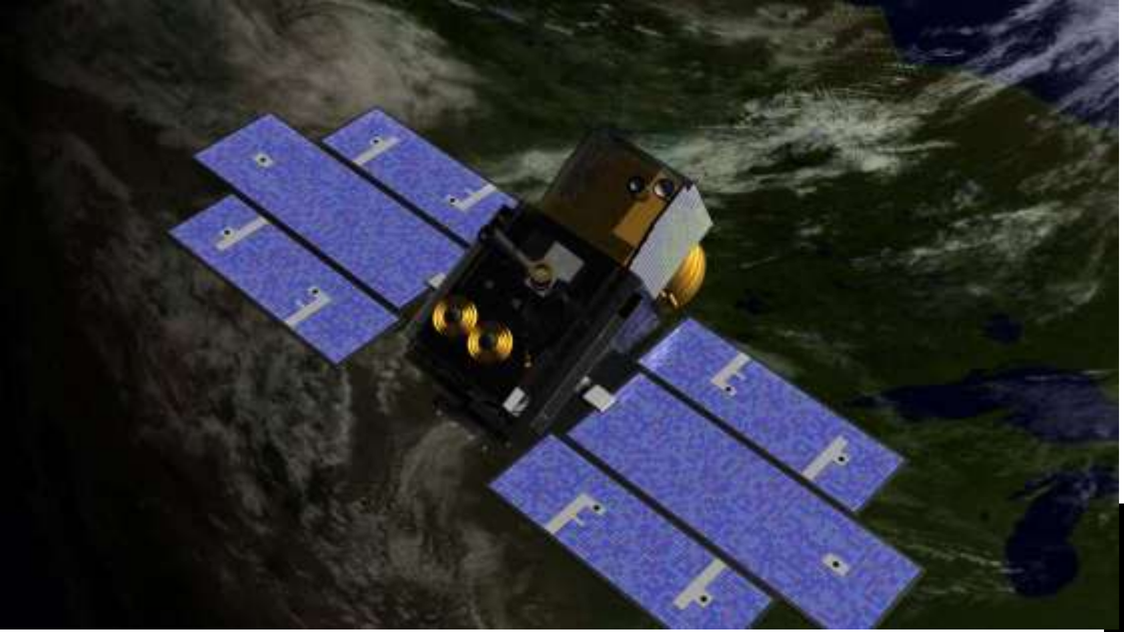
SITUATION

- Severe weather, including heavy rain and snowfalls, has been affecting the central and north-eastern provinces of Afghanistan and the northern provinces of Pakistan, causing casualties and damages.
- As of 6 February, national authorities reported at least 85 people dead, of which 70 in Afghanistan and 15 in Pakistan, over 245 houses destroyed in Afghanistan and at least 72 houses damaged throughout the affected areas. Traffic disruptions have also been reported.
- Over the next 72 h, cloudy to overcast conditions are to prevail over the areas affected by snow avalanches, with light to locally medium intensity precipitation phenomena (mainly snowfalls).

Sources: DG ECHO, UN OCHA, Government of Pakistan, Meteocentre, ECMWF, Media

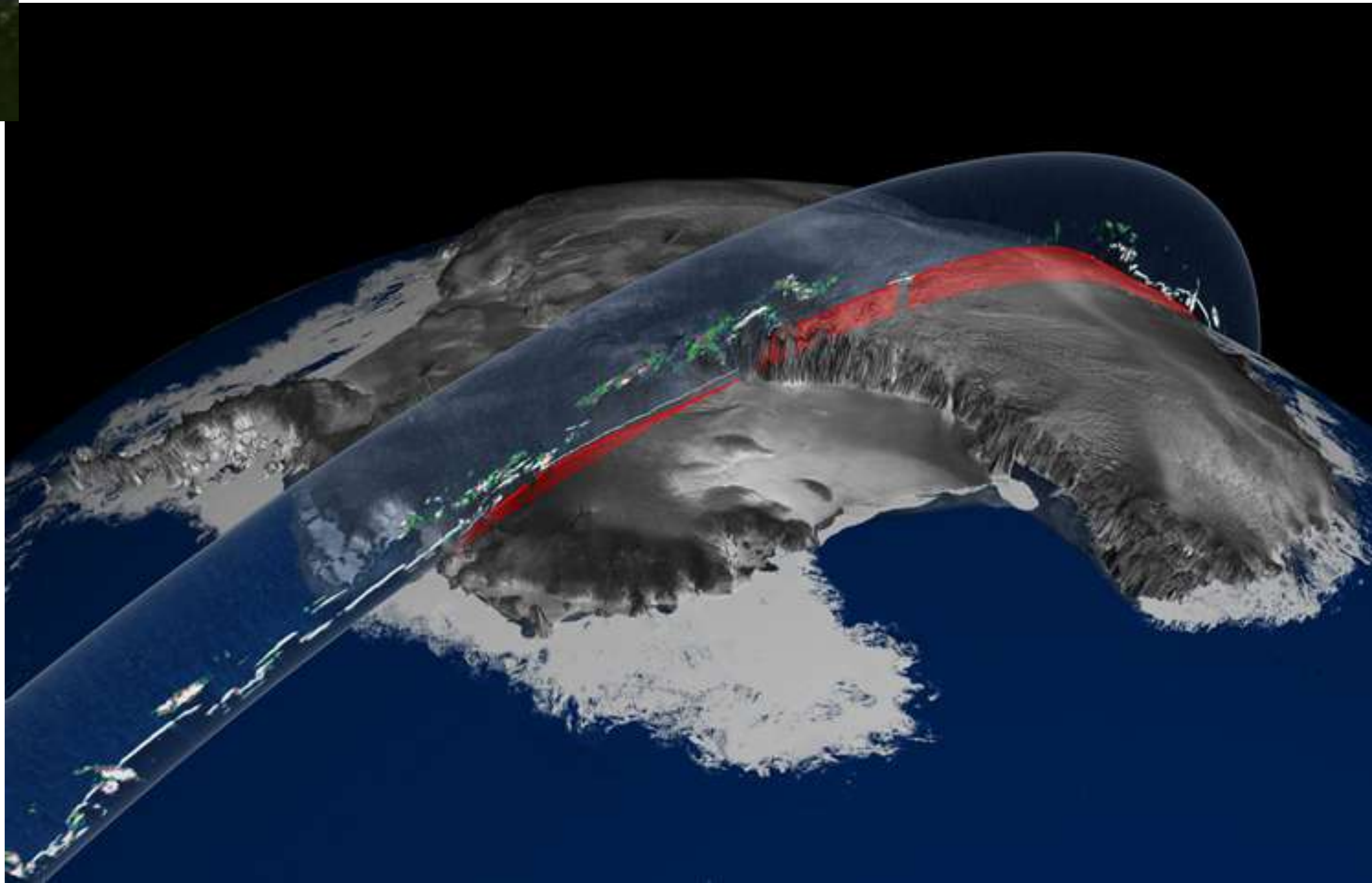
SNOW COVERAGE (04-06 Feb, MODIS)





Ice, Cloud and Land Elevation Satellite (ICESat)

- IceSat 2 Scheduled for launch in 2017



Measures:

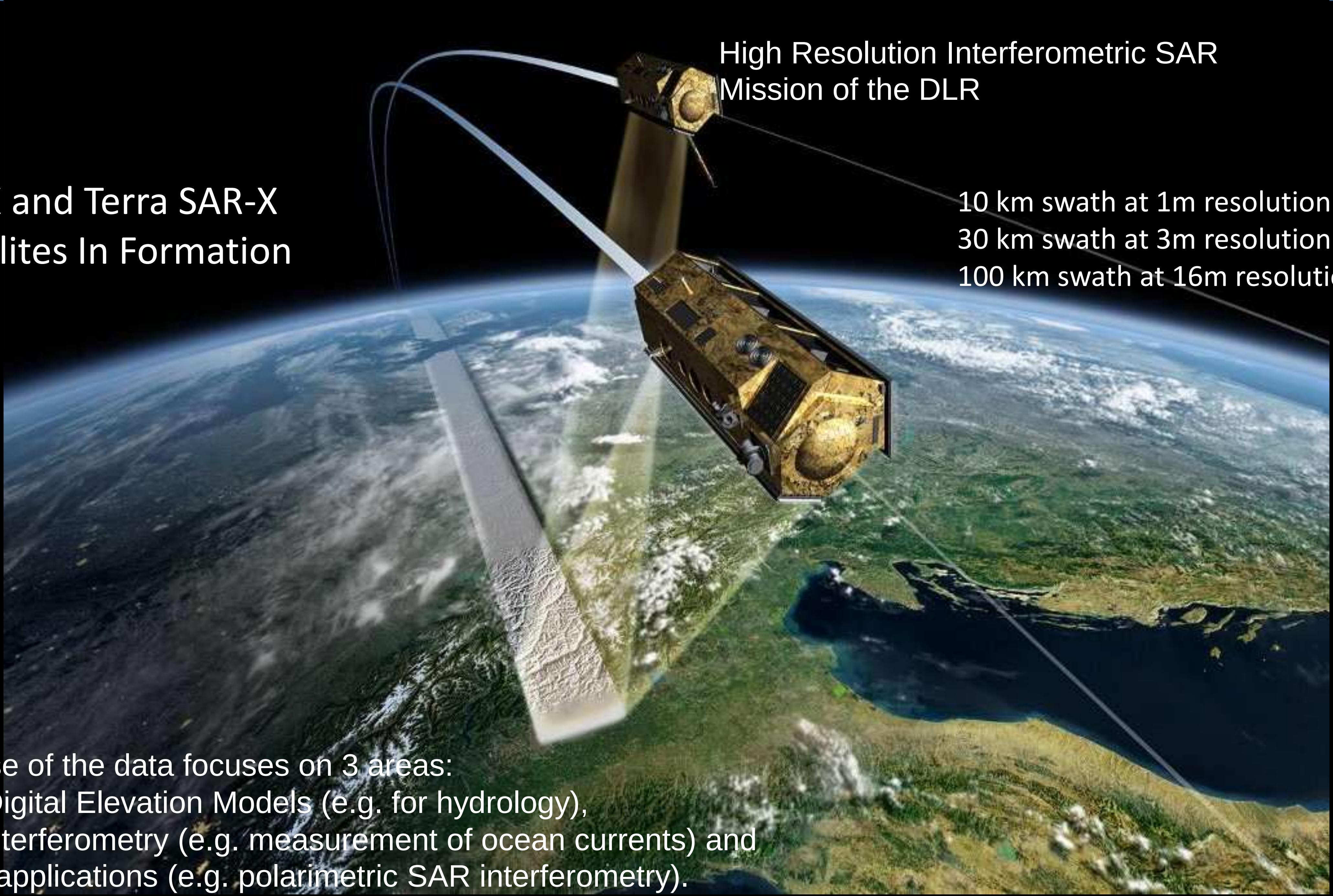
1. ice sheet mass balance, cloud and aerosol heights

2. land surface topography and vegetation characteristics

High Resolution Interferometric SAR Mission of the DLR

TanDEM-X and Terra SAR-X Twin Satellites In Formation

10 km swath at 1m resolution or
30 km swath at 3m resolution or
100 km swath at 16m resolution

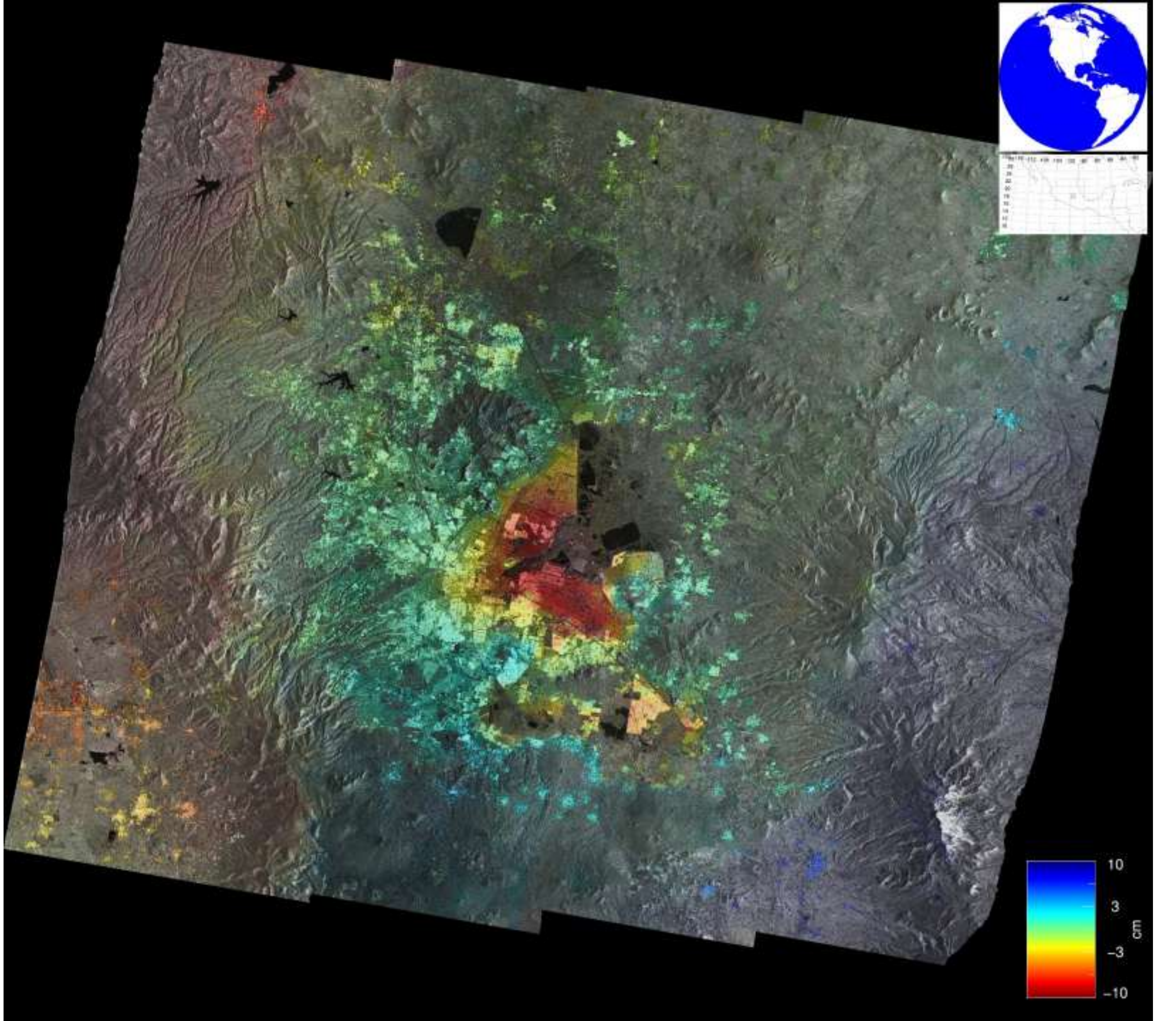


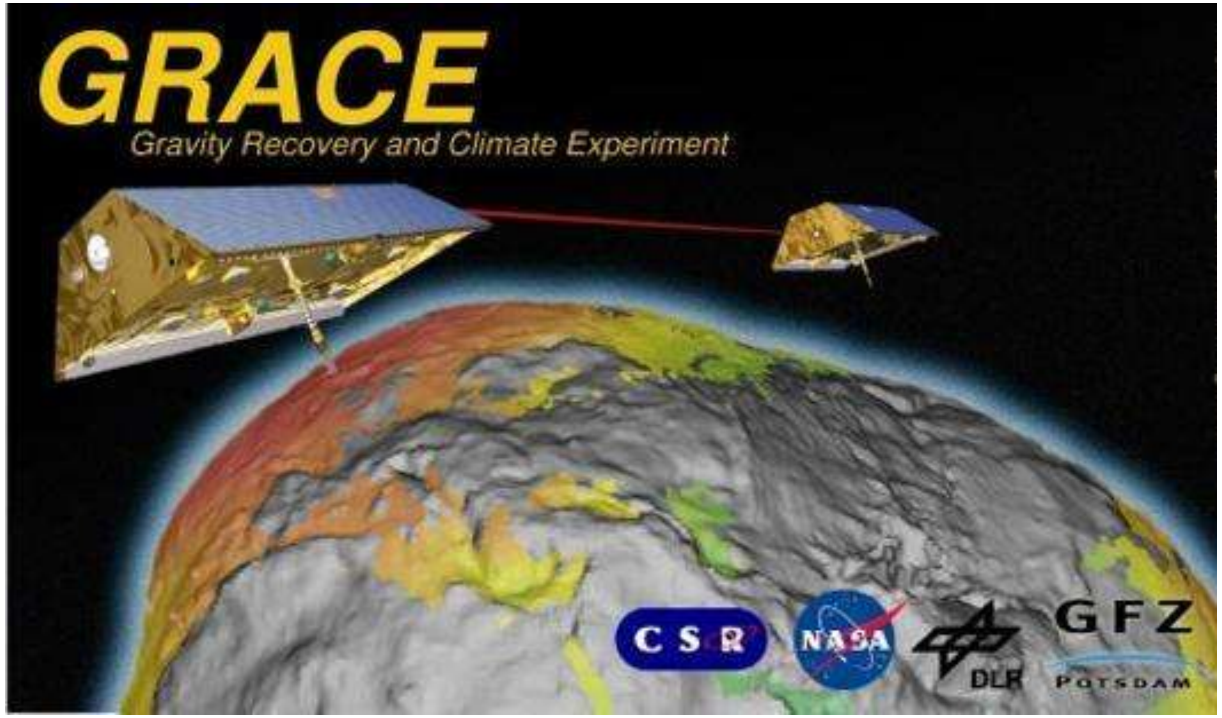
The scientific use of the data focuses on 3 areas:
a) high quality Digital Elevation Models (e.g. for hydrology),
b) along-track interferometry (e.g. measurement of ocean currents) and
c) new bi-static applications (e.g. polarimetric SAR interferometry).

Changes in ground height of Mexico City over a 4 month period, 20 Sept. 2009 to 30 Jan. 2010, as measured by TanDEM-X.

Changes here are primarily due to groundwater extraction.

The TanDEM-X system is designed to build the “WorldDEM” to a vertical accuracy of 2m (relative) and 4m (absolute), with a horizontal raster of approximately 12x12 square meters. This meets **HRTE-3** (High Resolution Terrain Elevation, level-3) also called DTED 3.





The Gravity Recovery and Climate Experiment Follow-on (GRACE-FO) mission is a partnership between NASA and the German Research Centre for Geosciences (GFZ).

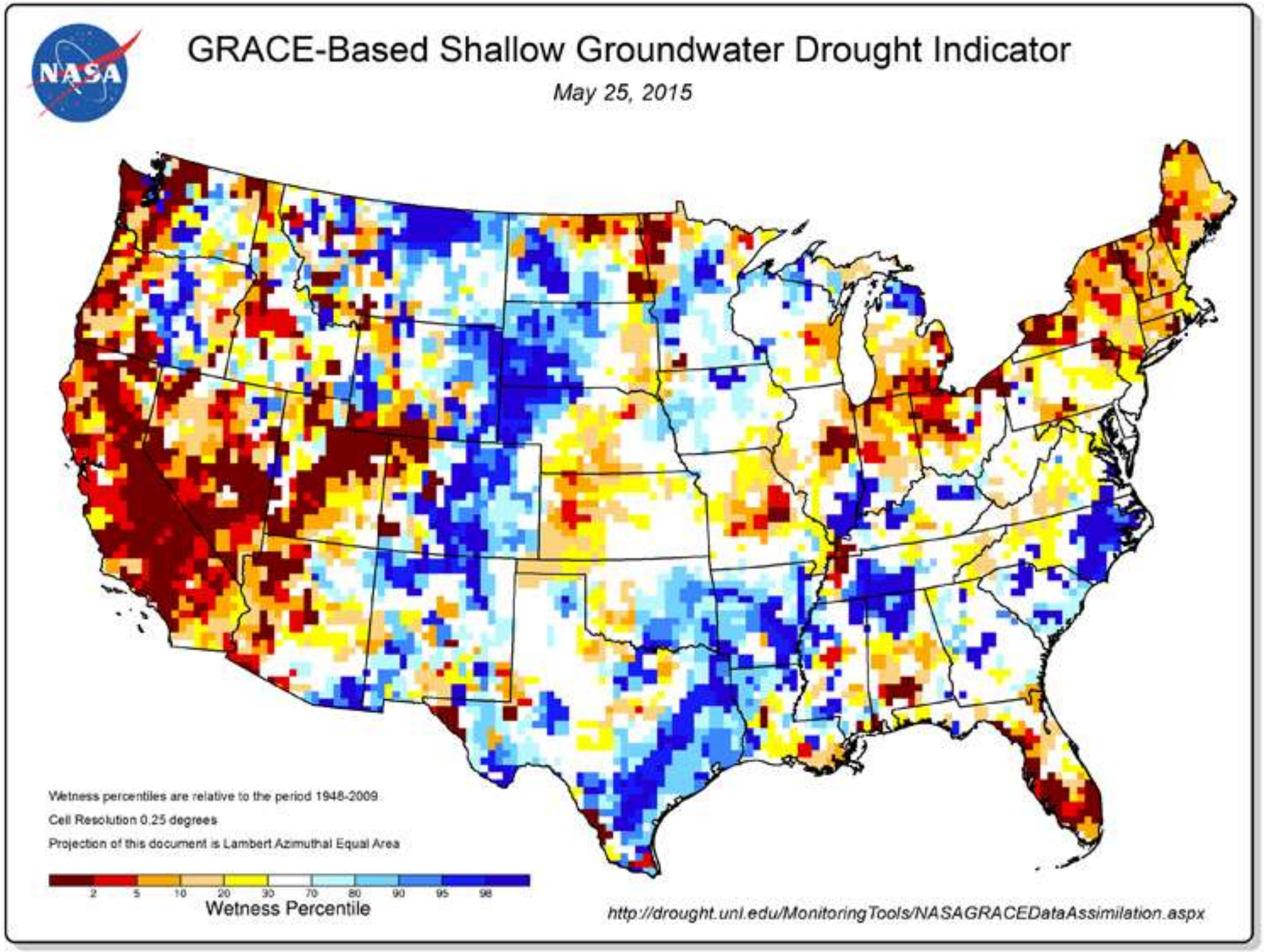
GRACE-FO will follow the GRACE mission, which was launched March 17, 2002. Expected launch in 2017

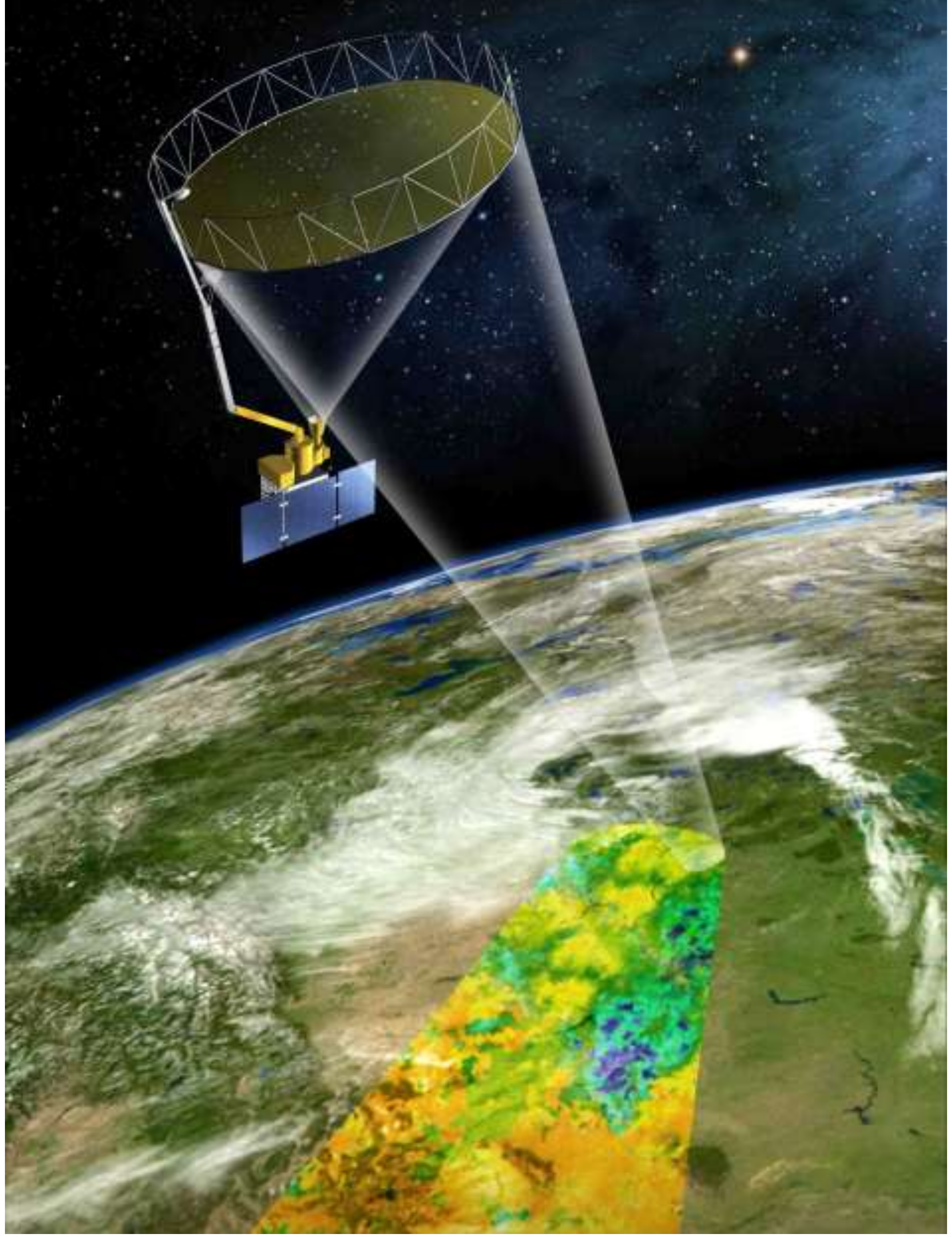
Scientific Instrument(s)

- Microwave K-band ranging instrument
- Accelerometers
- Global Positioning System receivers

The GRACE missions measure variations in gravity over Earth's surface, producing a new map of the gravity field every 30 days. Thus, GRACE shows how the planet's gravity differs not only from one location to another, but also from one period of time to another.

Changes in groundwater cause this measurement to change.


NASA
GRACE-Based Shallow Groundwater Drought Indicator
May 25, 2015
Wetness percentiles are relative to the period 1948-2009
Cell Resolution 0.25 degrees
Projection of this document is Lambert Azimuthal Equal Area
2 5 10 20 30 70 80 90 95 98
Wetness Percentile
http://drought.unl.edu/MonitoringTools/NASAGRACEDataAssimilation.aspx



SMAP Mission: Soil Moisture Active Passive

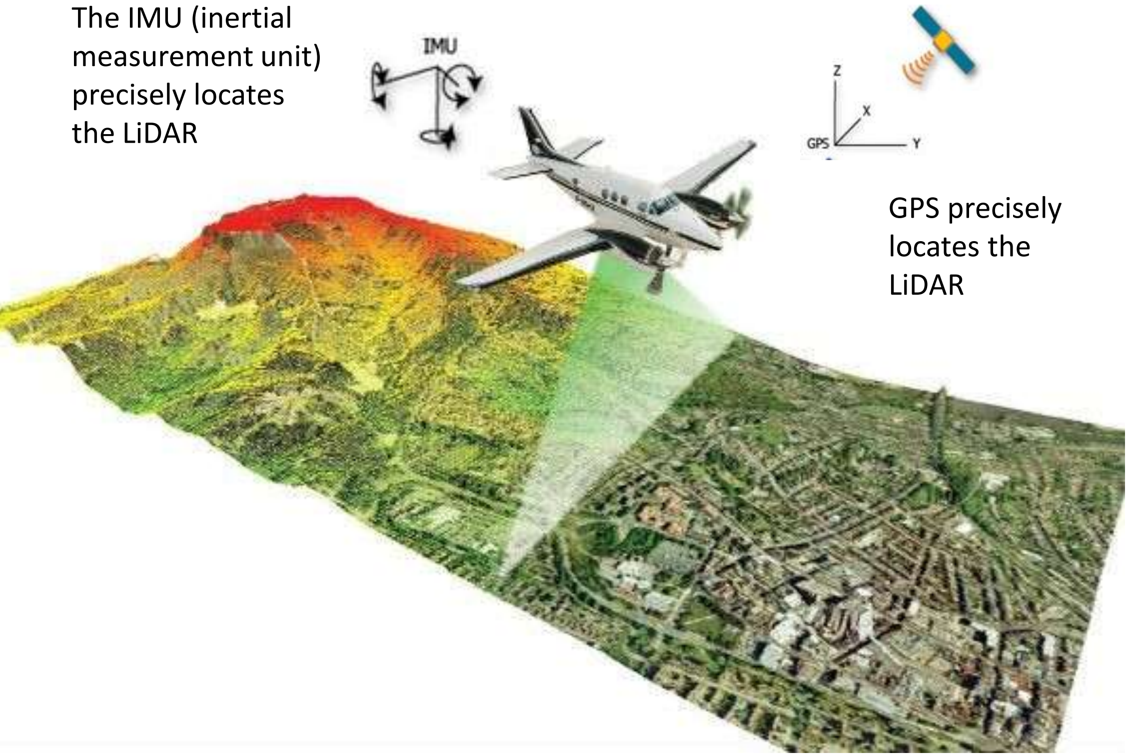
Launched: Jan. 31, 2015

- provide global measurements of soil moisture and its freeze/thaw state.
- enhance understanding of processes that link the water, energy and carbon cycles.
- extend the capabilities of weather and climate prediction models.
- quantify net carbon flux in boreal landscapes
- improved flood prediction and drought monitoring capabilities

SMAP included a radiometer and a synthetic aperture radar (SAR) operating at L-band (1.20-1.41 GHz), with VV, HH, HV, at 1-3 km resolution; SAR failed soon after.

Sentinel 1's C-band radar is not the only radar in space — or even the closest substitute for the L-band radar — but it is the only one that trails SMAP closely enough to gather timely radar images of the swath of Earth that SMAP covers -

LiDAR instruments can be:

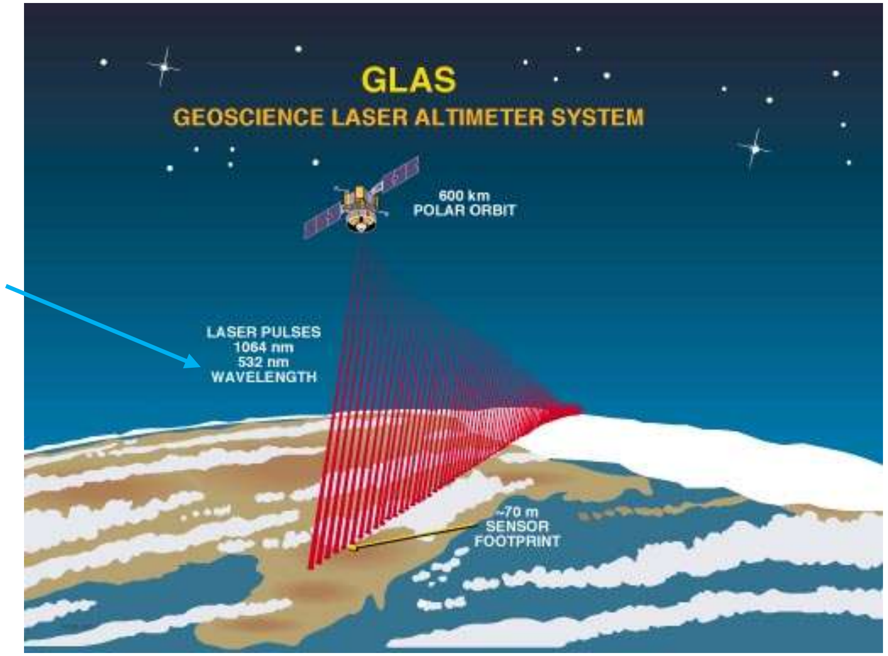


Mobile (Field Based)

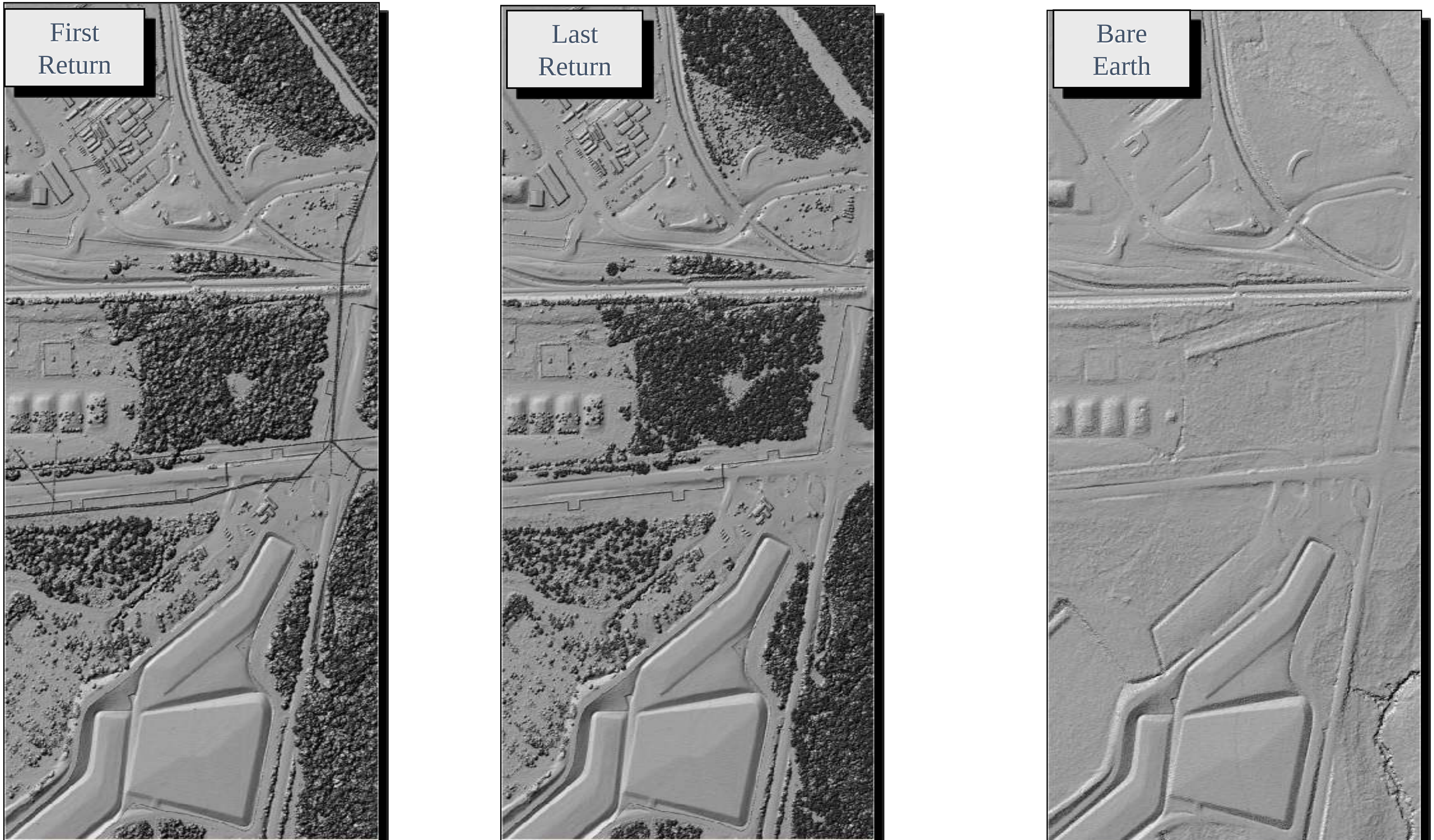
Mobile LiDAR

Note: 2 wavelengths

Satellite LiDAR

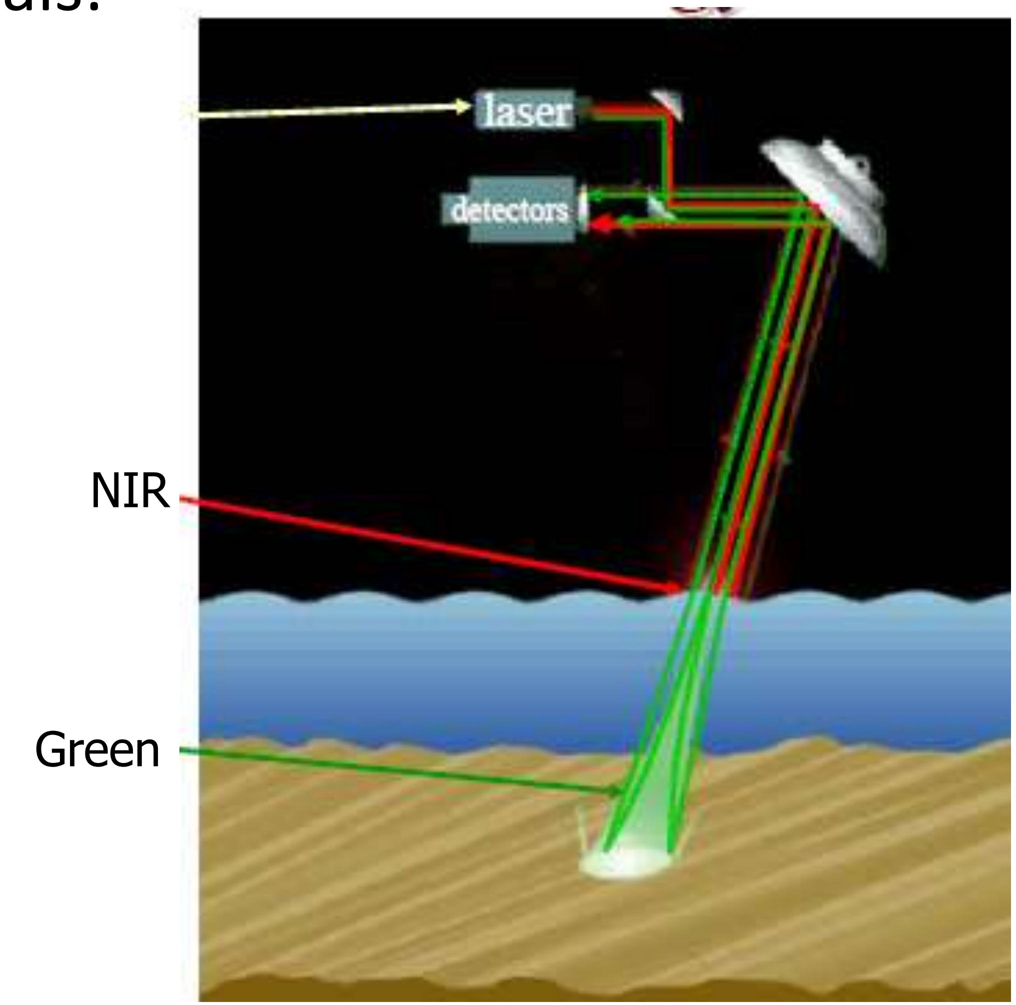


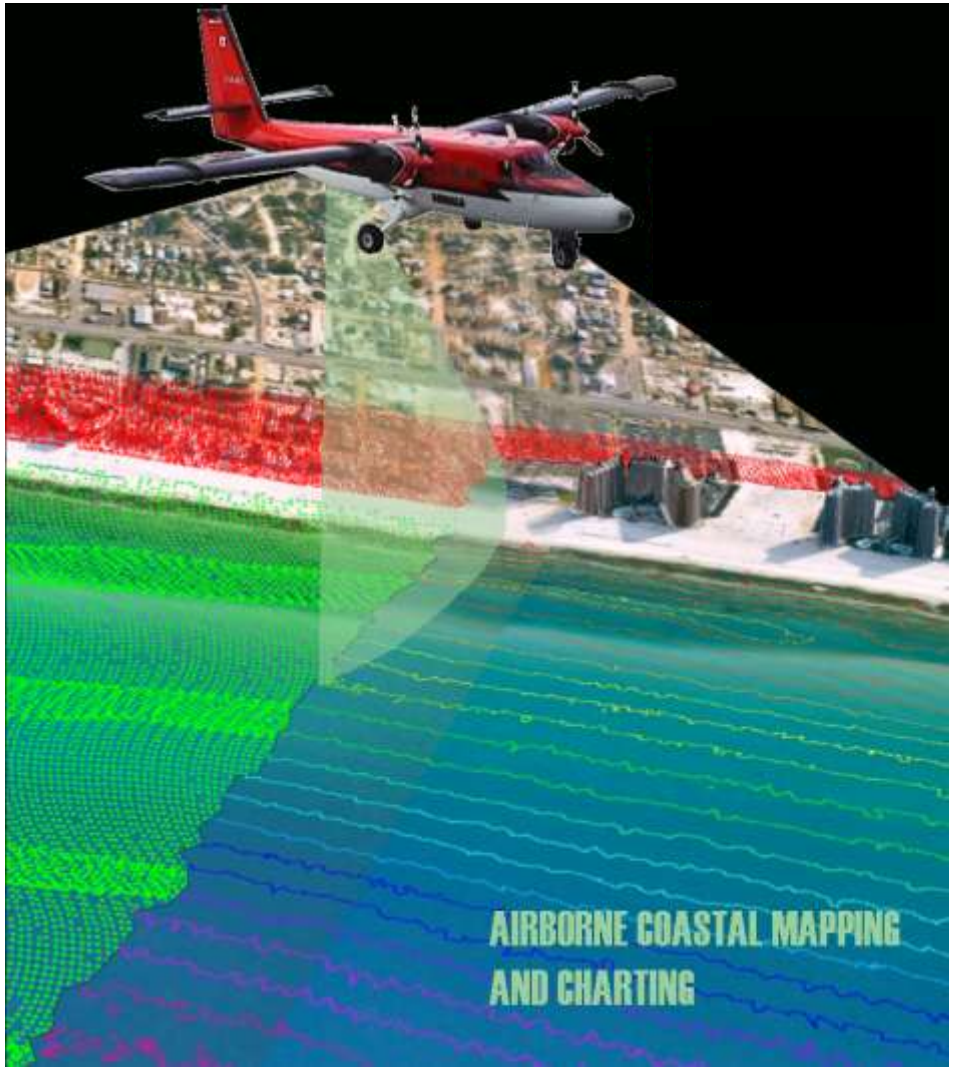
Airborne LiDAR Data: Bare Earth Model



Bathymetry Measurements

- Wavelengths (nm) used in USACE Shoals:
  - 532
  - 1047
  - 1540

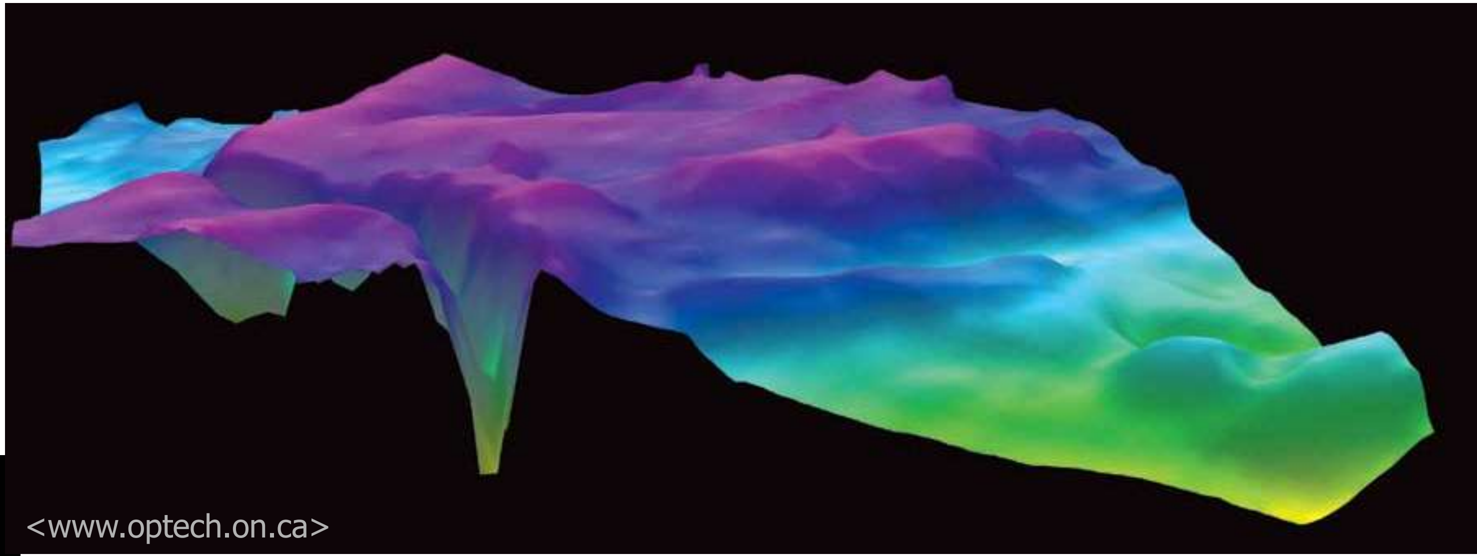




Naval Research Laboratory

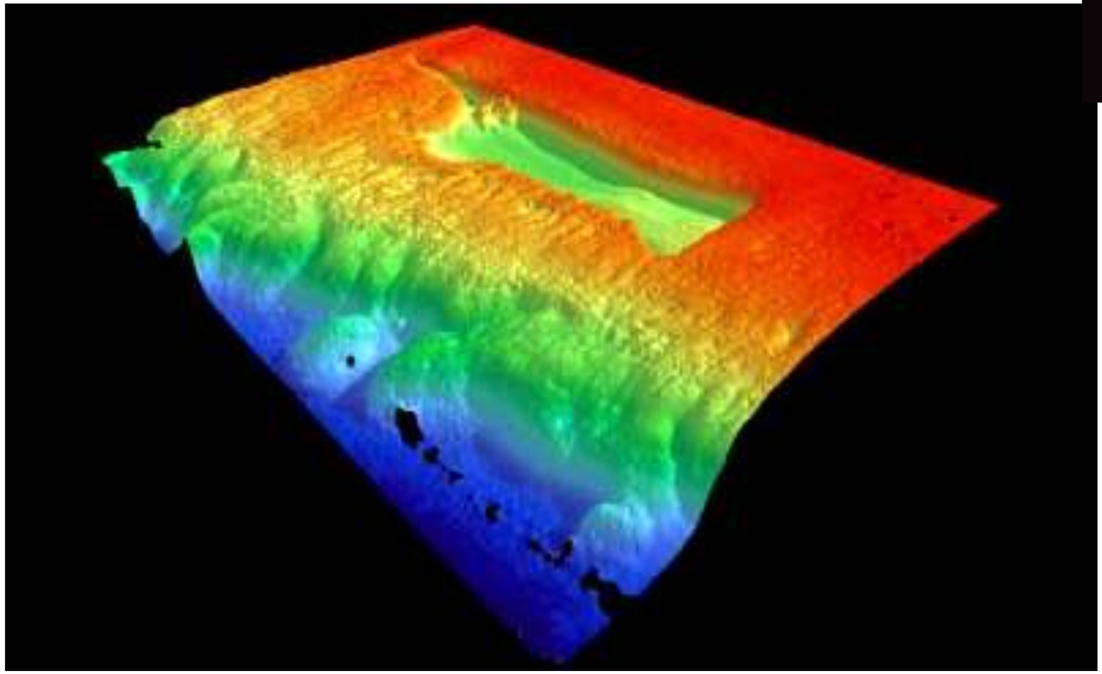
D.Philpot, Cornell University, 2003
U.S. Army Corps of Engineers <shoals.sam.usace.army.mil>

Near Shore Bathymetry



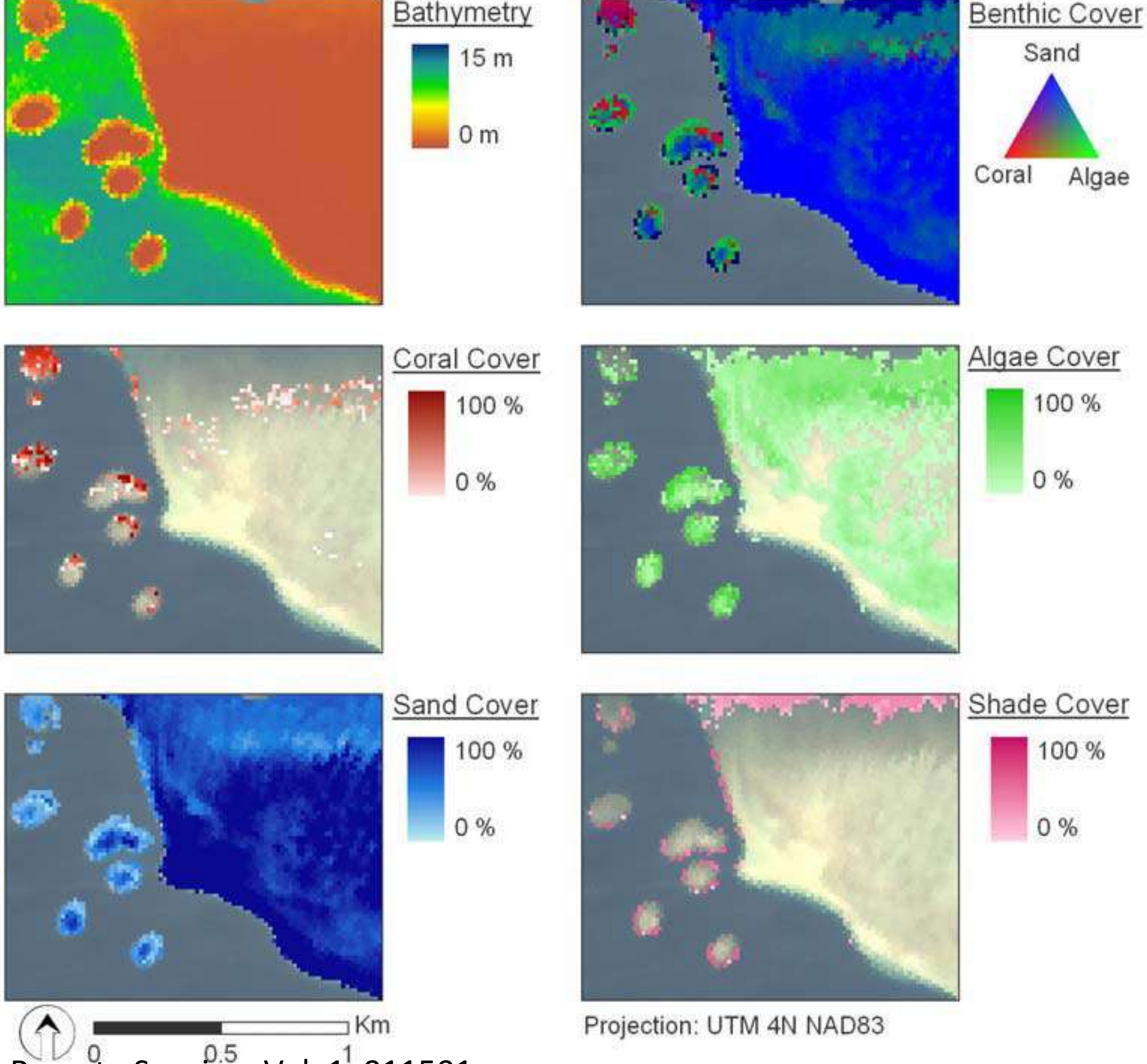
Molokai, Hawaii

Looe Key, Florida



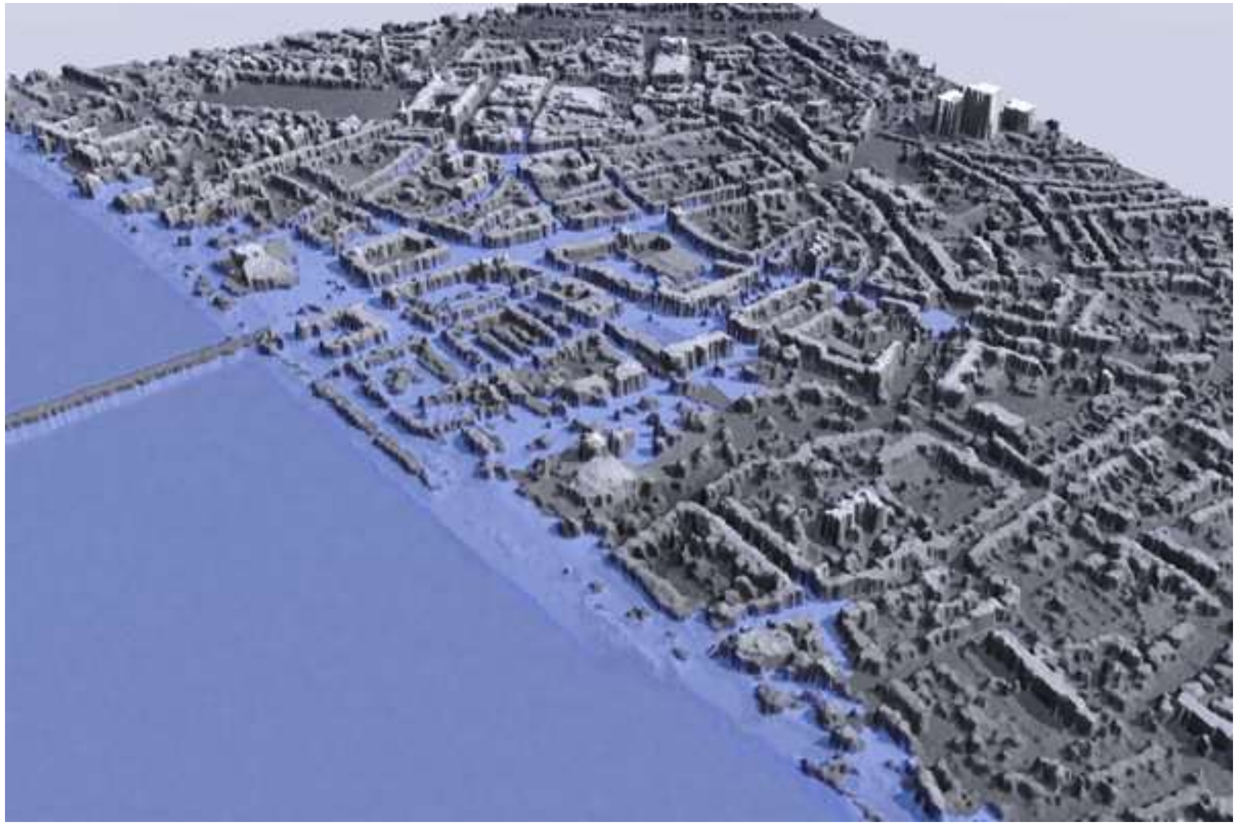
James Goodman <coralreefs.wr.usgs.gov>

Bathymetry (SHOALS) for a region with small corals of the coast of Kanehoe Bay, HI and classification of materials in area.

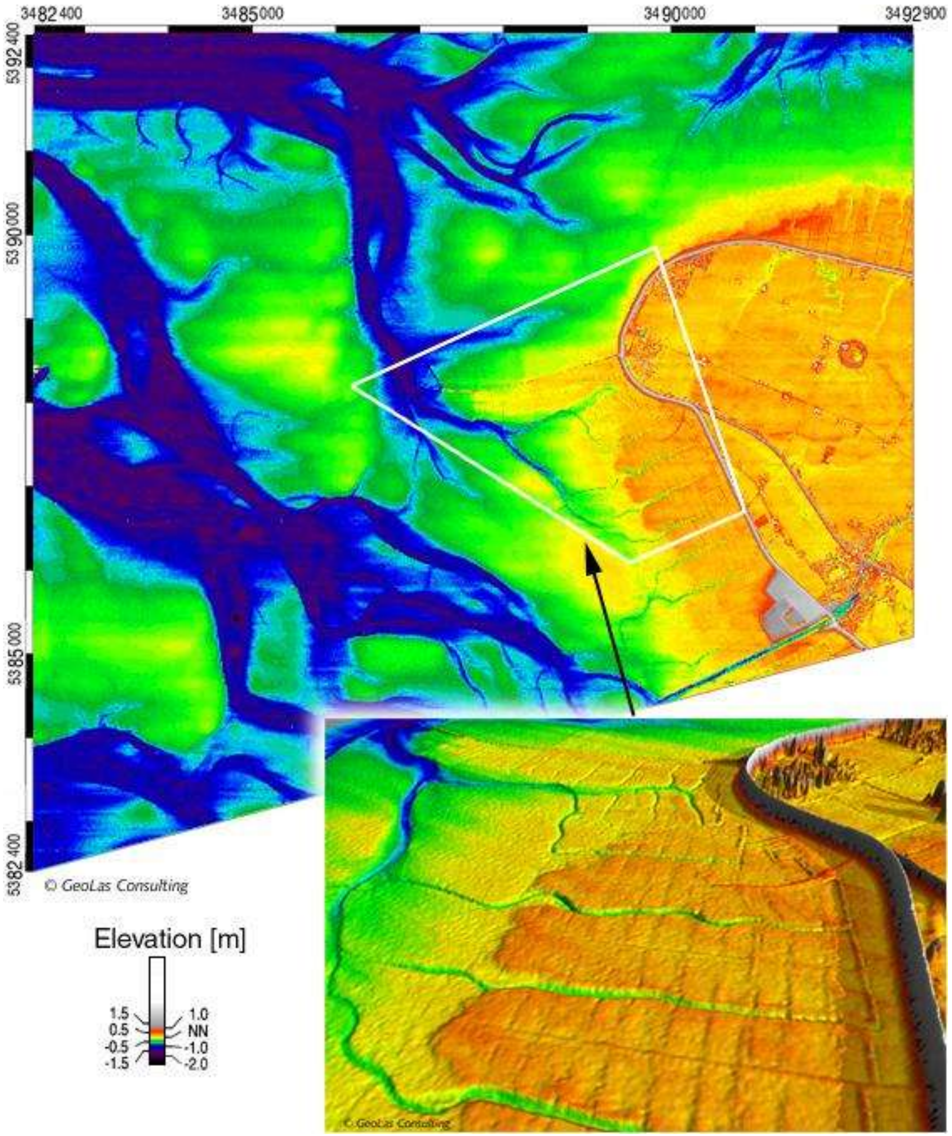


Goodman and Ustin 2007 Journal of Applied Remote Sensing, Vol. 1, 011501

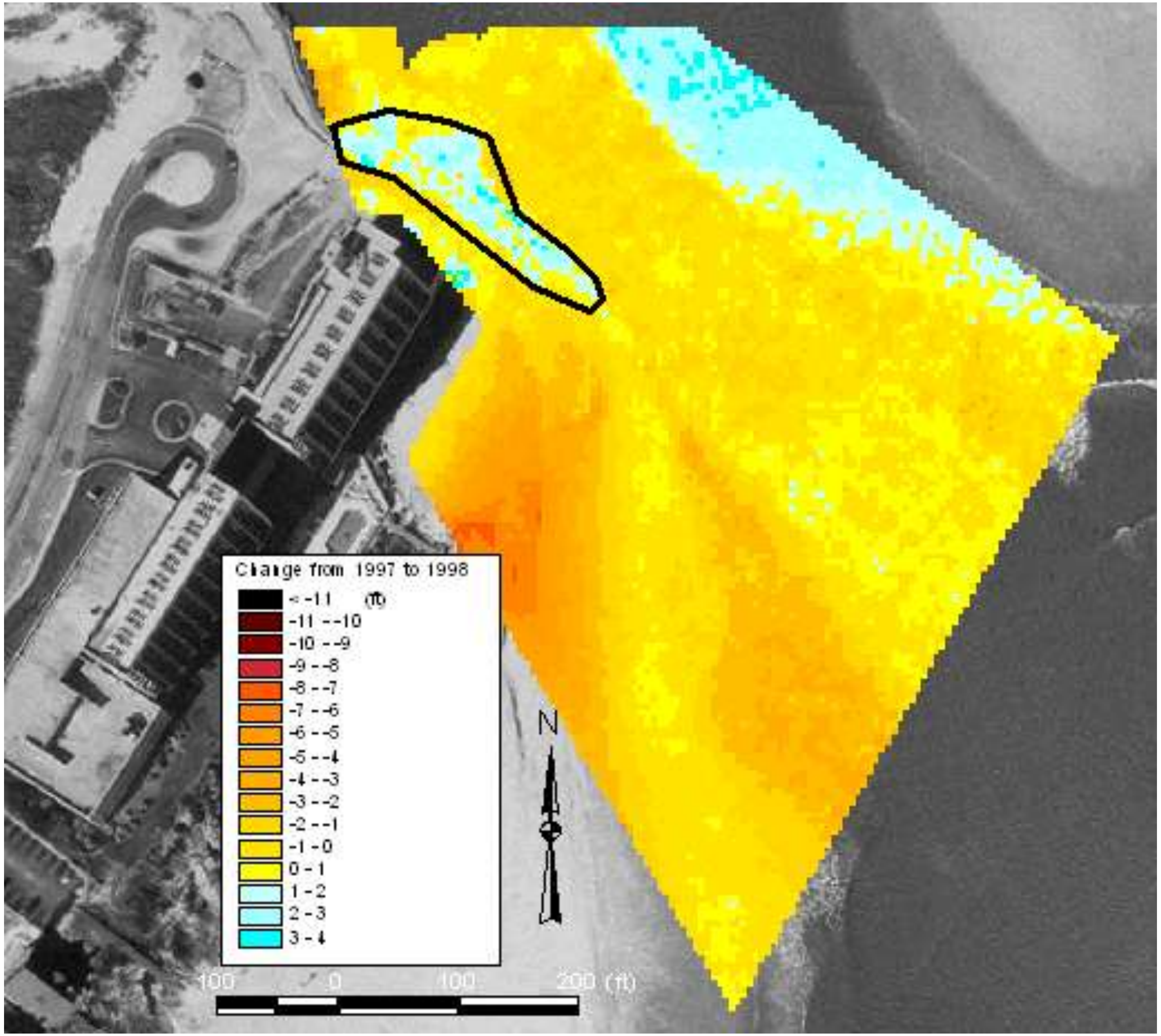
Floods: Water penetration into surrounding uplands



http://www.geolas.com/

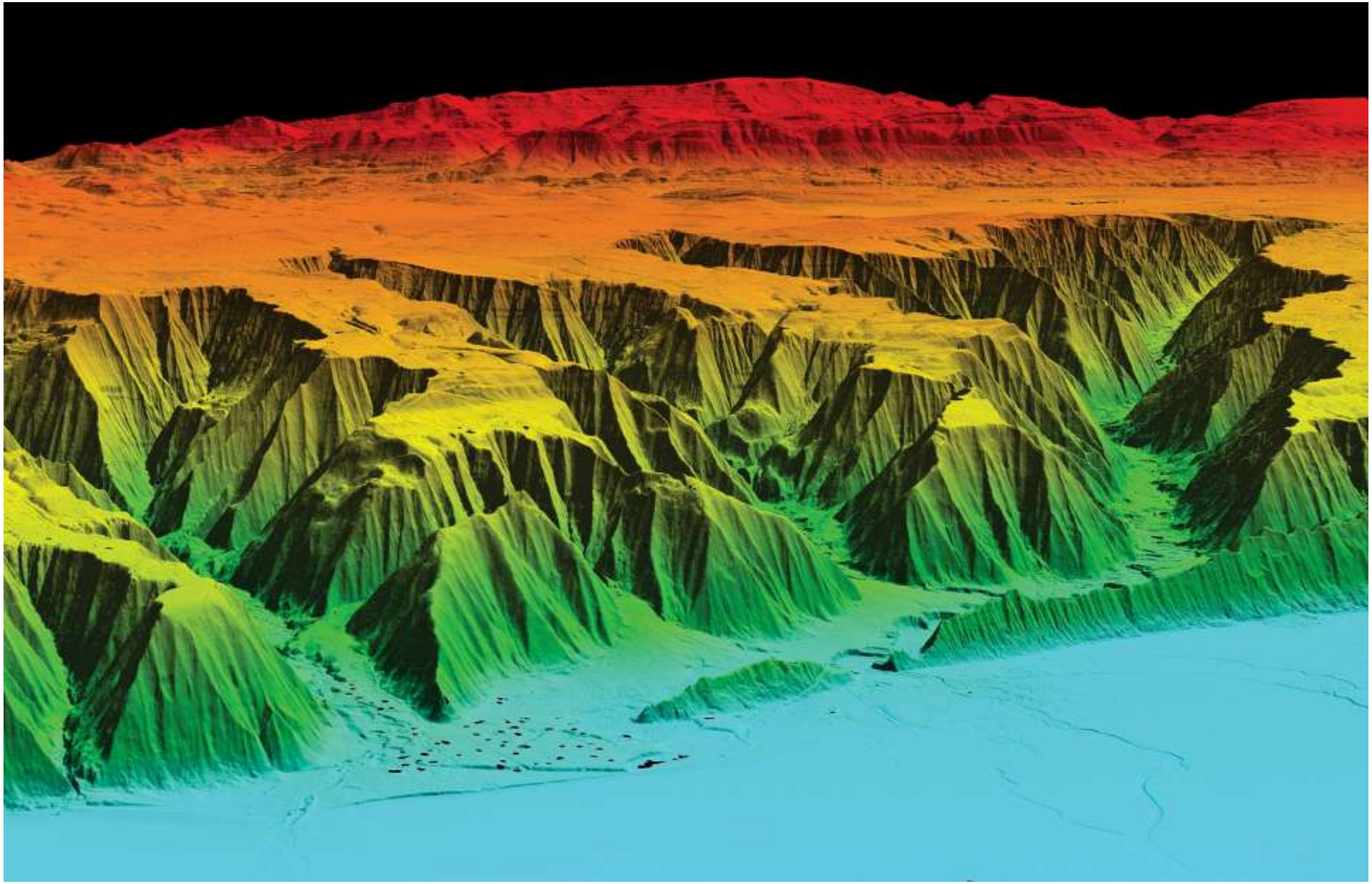


Coastal erosion



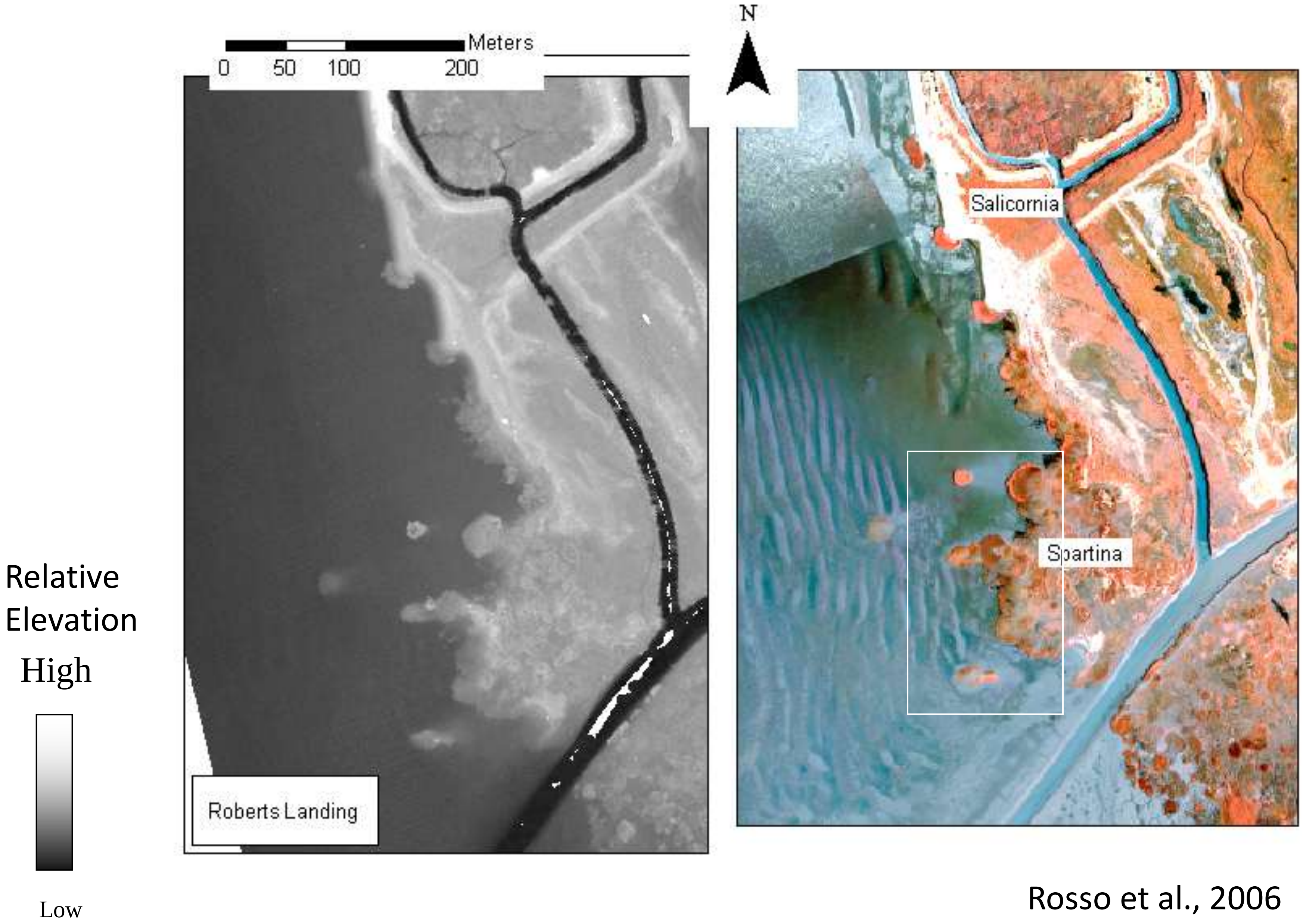
Mapping change in coastal elevation between 1997 and 1998 for coastal area of North Carolina (North Wrightsville Beach), on the southeast coast of the USA.

http://www.csc.noaa.gov/products/nchaz/htm/lidtopo.htm#lidar



Southern Kenai Peninsula, Alaska from LiDAR

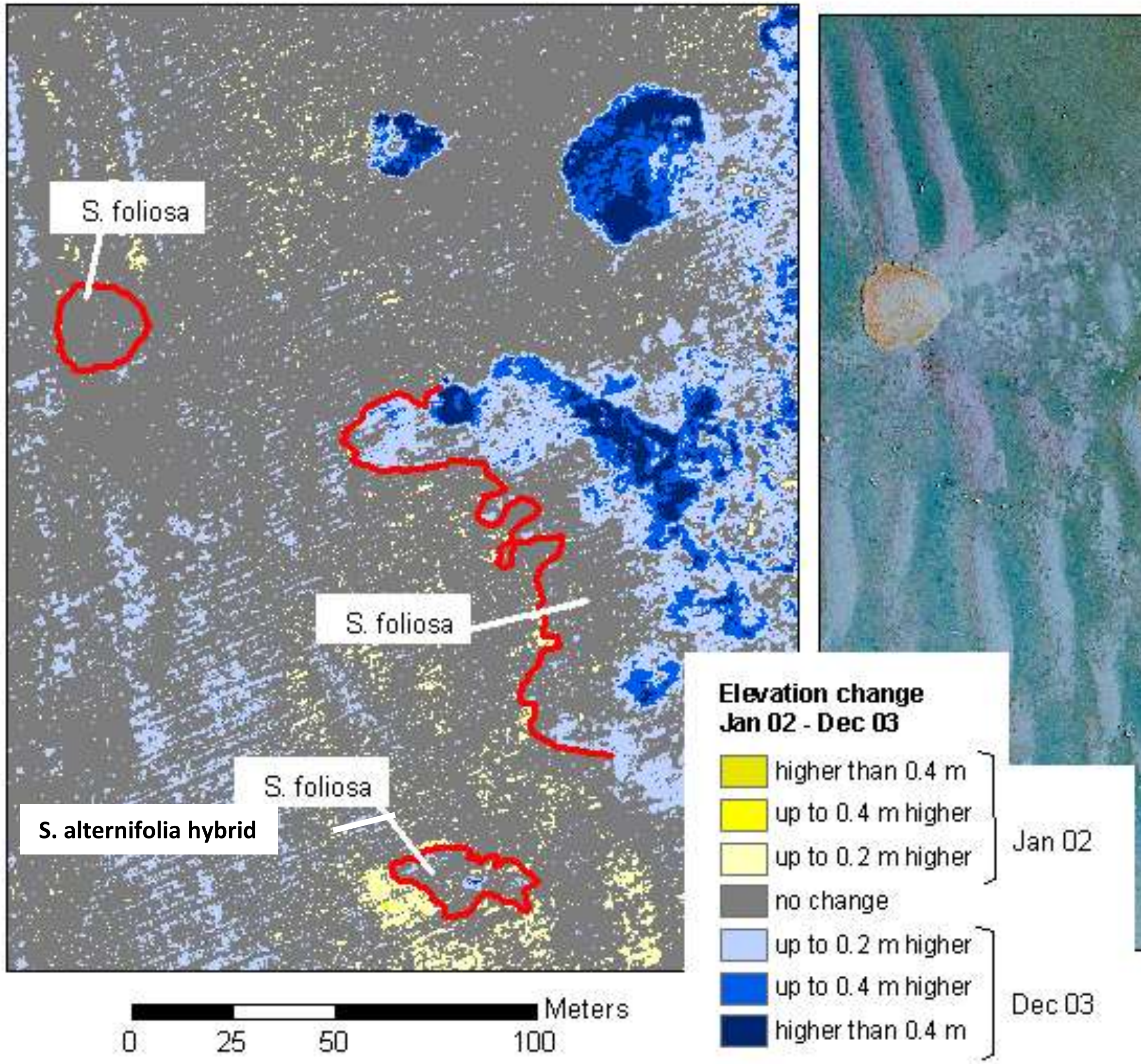
Expansion of Extent of Salt Marsh from Deposition

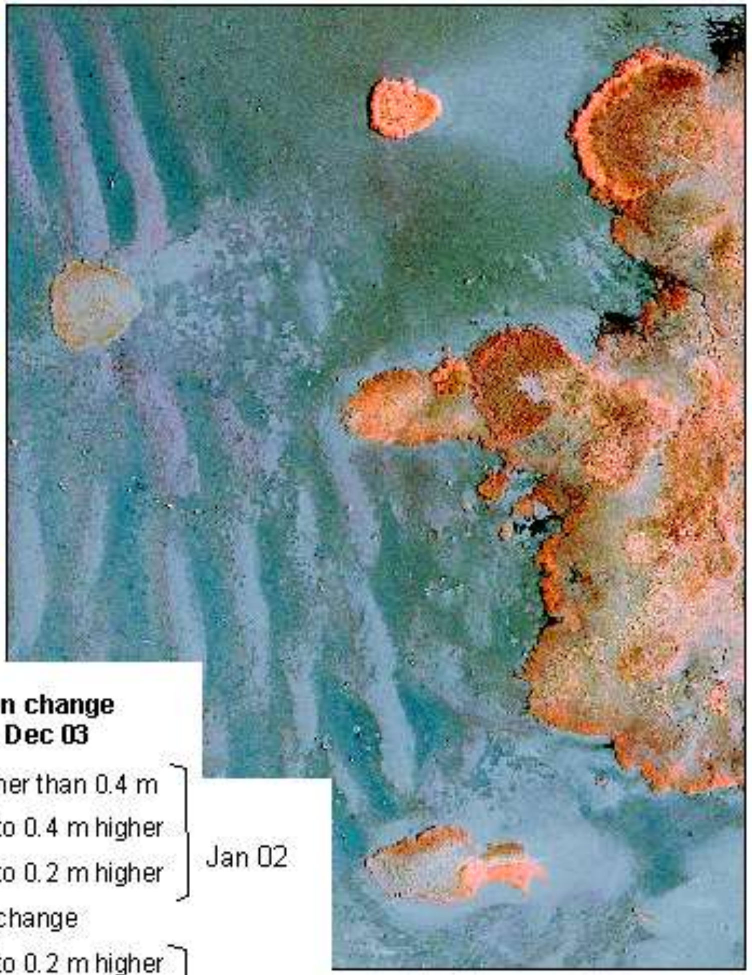


Rosso et al., 2006

Change Detection

LiDAR Height Difference: January 2002 and December 2003

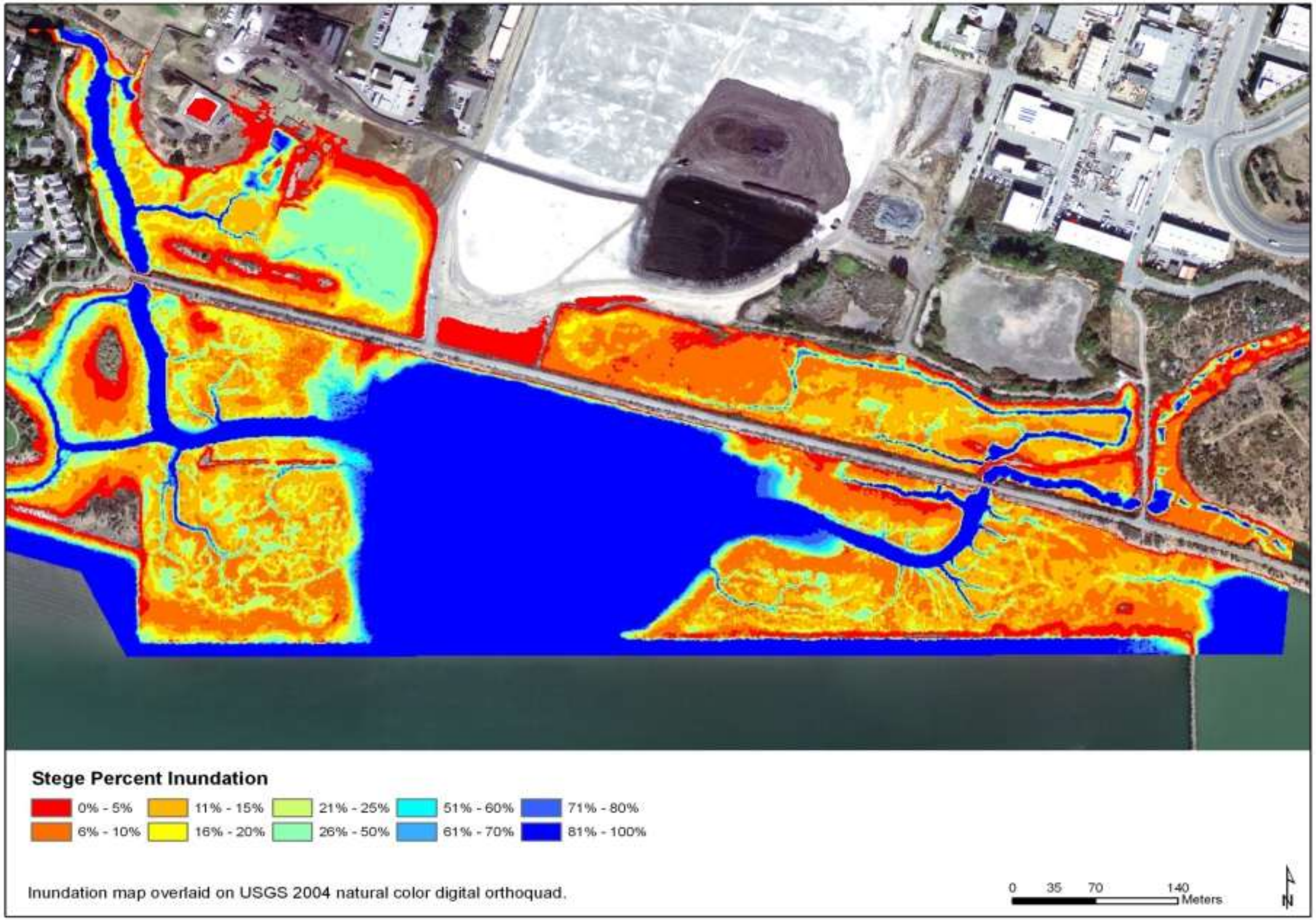




Roberts Landing marsh , San Francisco Bay

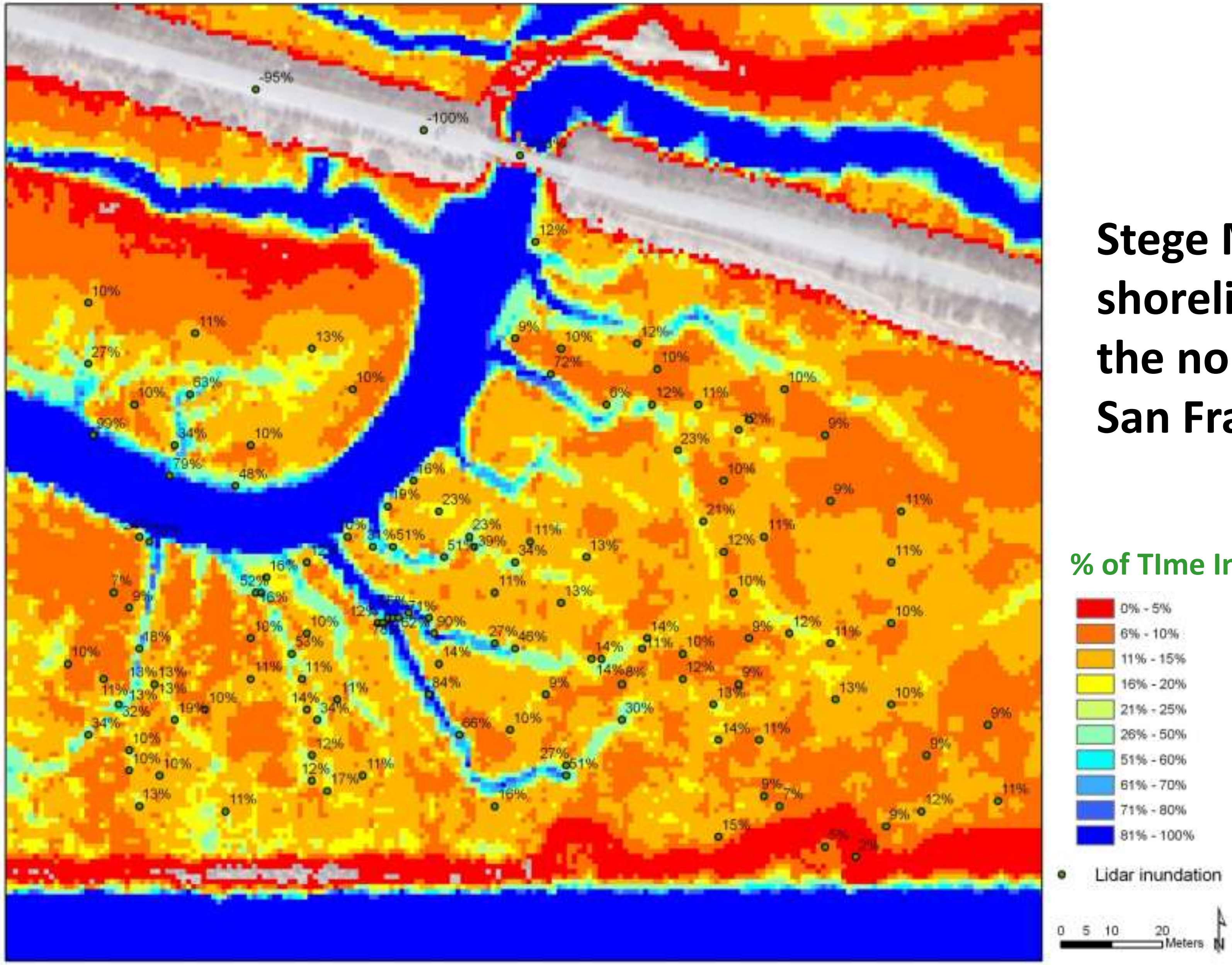
Rosso et al., International Journal Remote Sensing 2006

LiDAR Marsh Height: Estimate % Time Inundated



Inundation map overlaid on USGS 2004 natural color digital orthoquad.

Micro-topography Controls Length of Inundation Period & Marsh Species Distribution



Stege Marsh along the shoreline of San Pablo Bay, the northern extension of San Francisco Bay

Sacramento – San Joaquin Delta

- Tidal estuary
- ~2500 km^2 area
- 1770 km waterways
- Aging earthen levees (built ~80-110 yrs ago)
- Subsidence (~7.6 cm/yr)
- ~2/3 of the population of California gets its drinking water from the delta

Levees:

- Protect farmland from inundation and erosion,
- Prevent saltwater intrusion into the freshwater rivers
- Control the rise of floodwaters during the rainy season

Levee's At Risk:

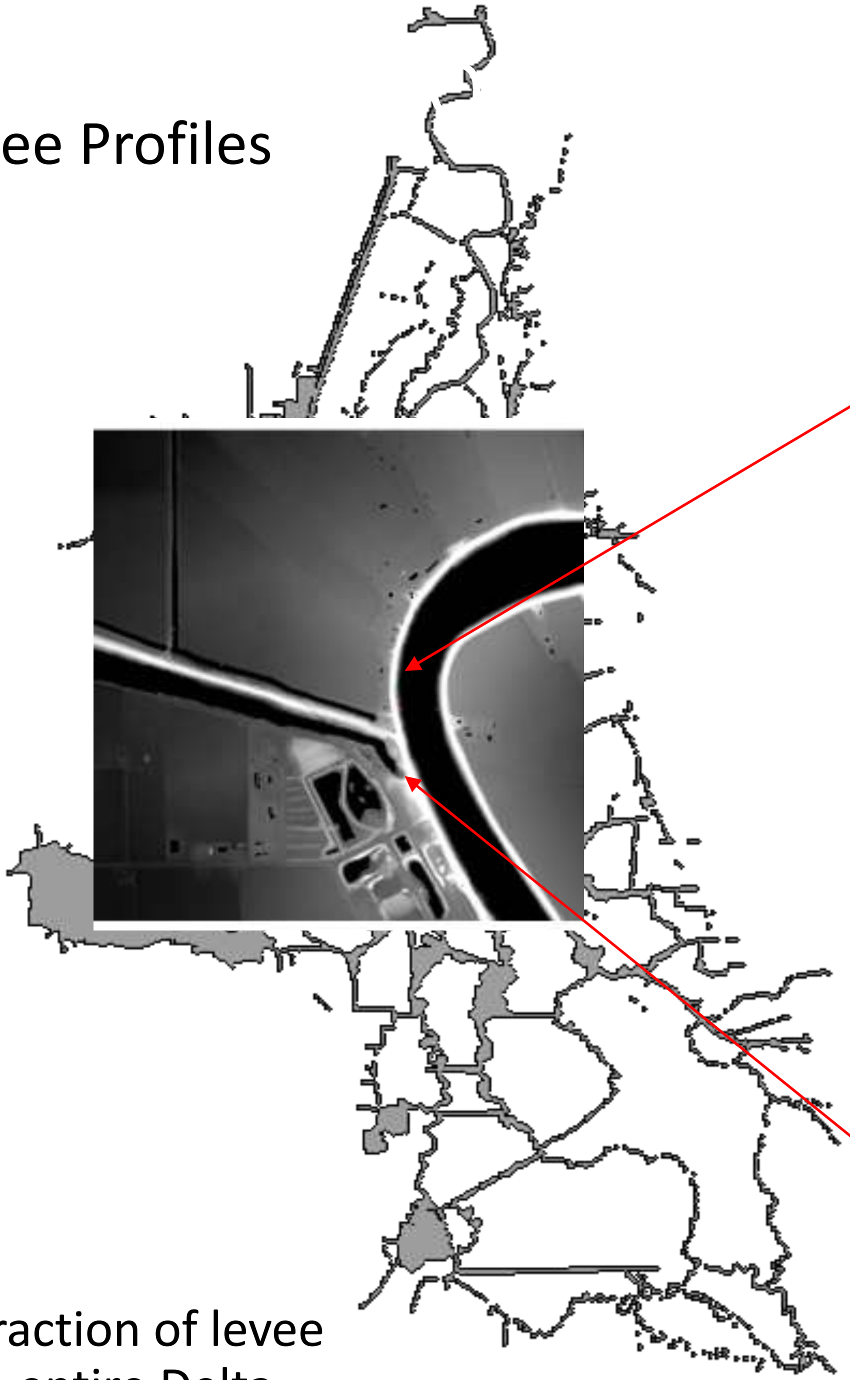
Poorly maintained
Climate change
Changing inflow
Sea level rise
Earthquakes

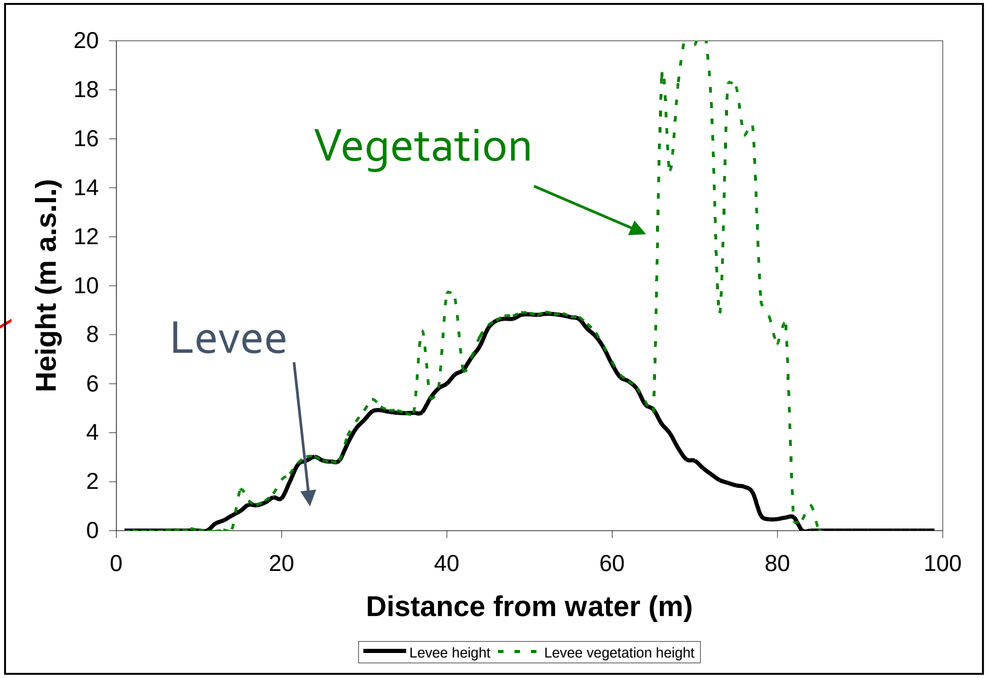
California's Sacramento-San Joaquin Delta is likely a next levee catastrophe, given its concentration of levees, people, and multiple potential failure mechanisms (e.g. earthquakes, rapid snowmelt, winter storms, and poor maintenance.

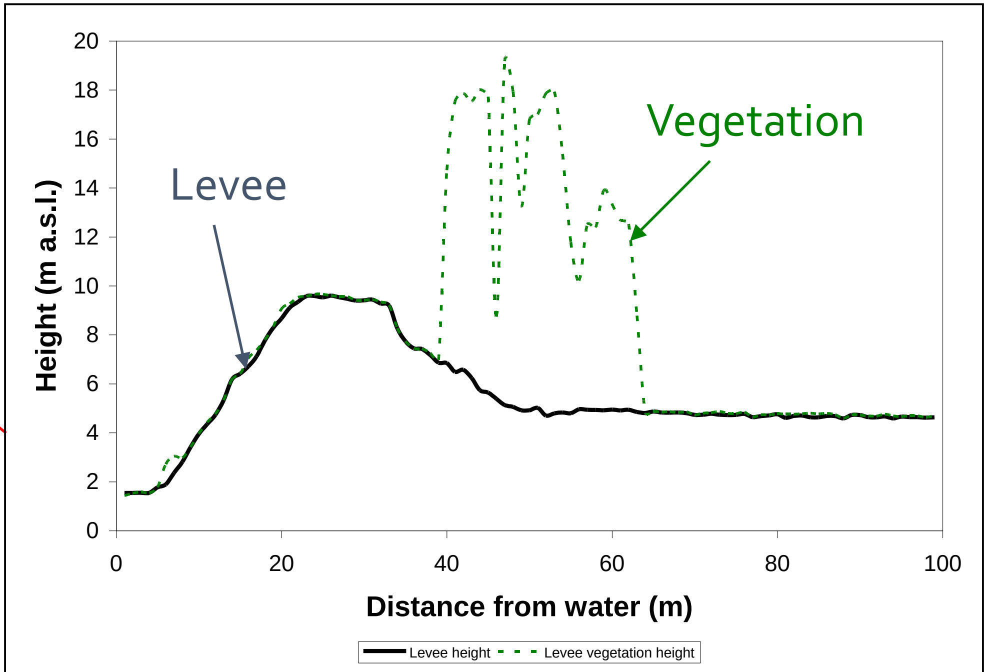
Flynn, S. 2007. The edge of disaster, Random House, New York.

Microtopography & Levee Stability

Levee Profiles



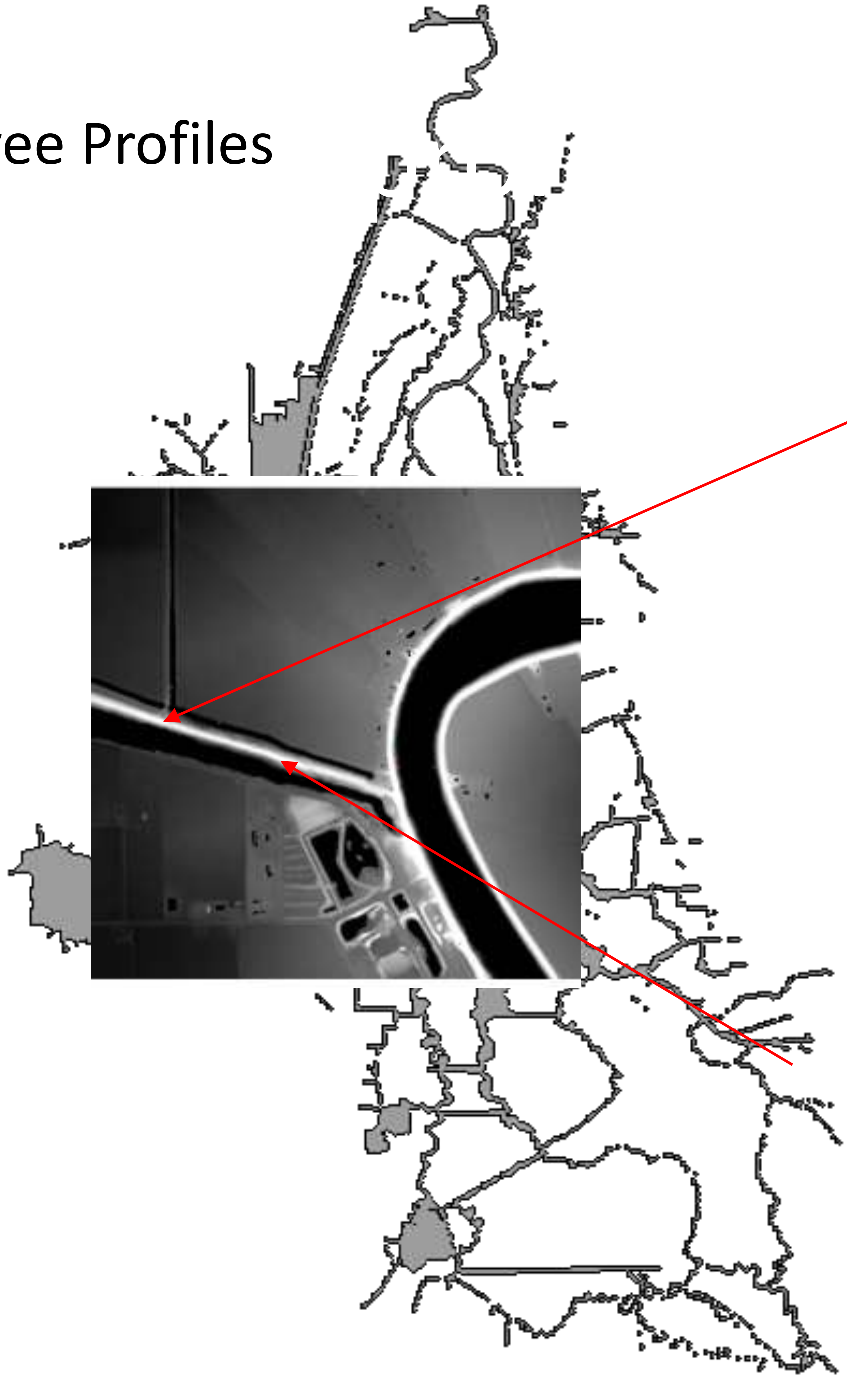


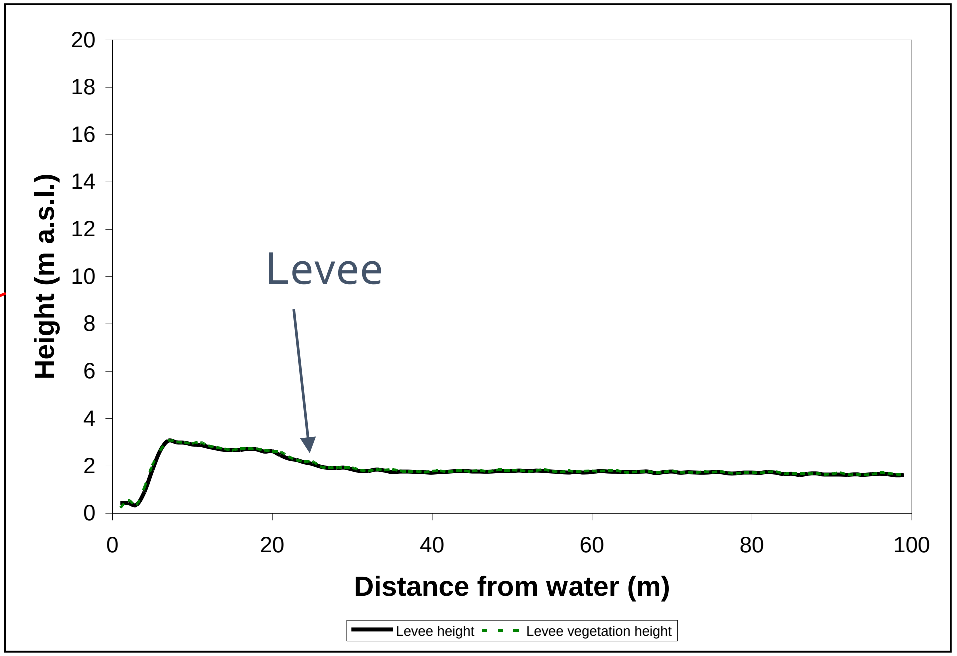


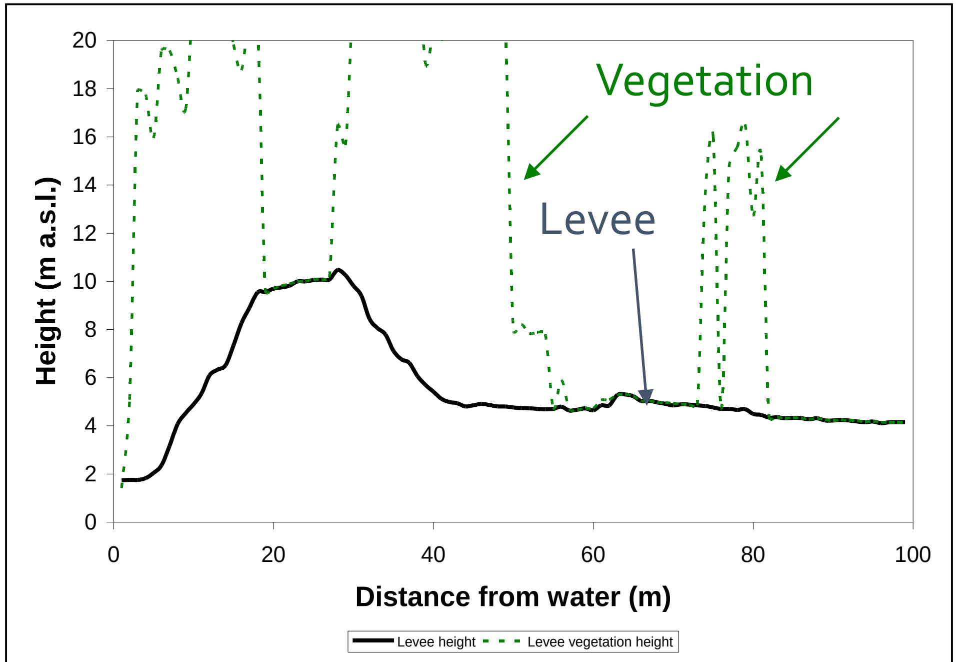
Automatic extraction of levee profiles for the entire Delta

Microtopography & Levee Stability

Levee Profiles







Evaluate Levee Stability for Pocket Neighborhood of Sacramento

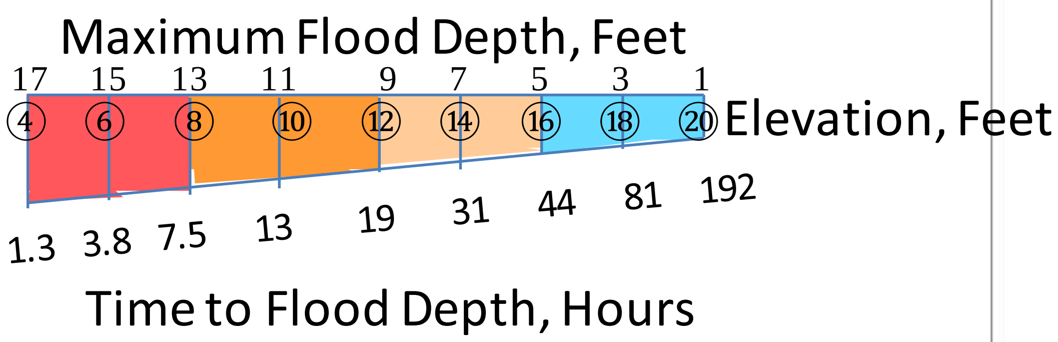
Sacramento Metropolitan Area

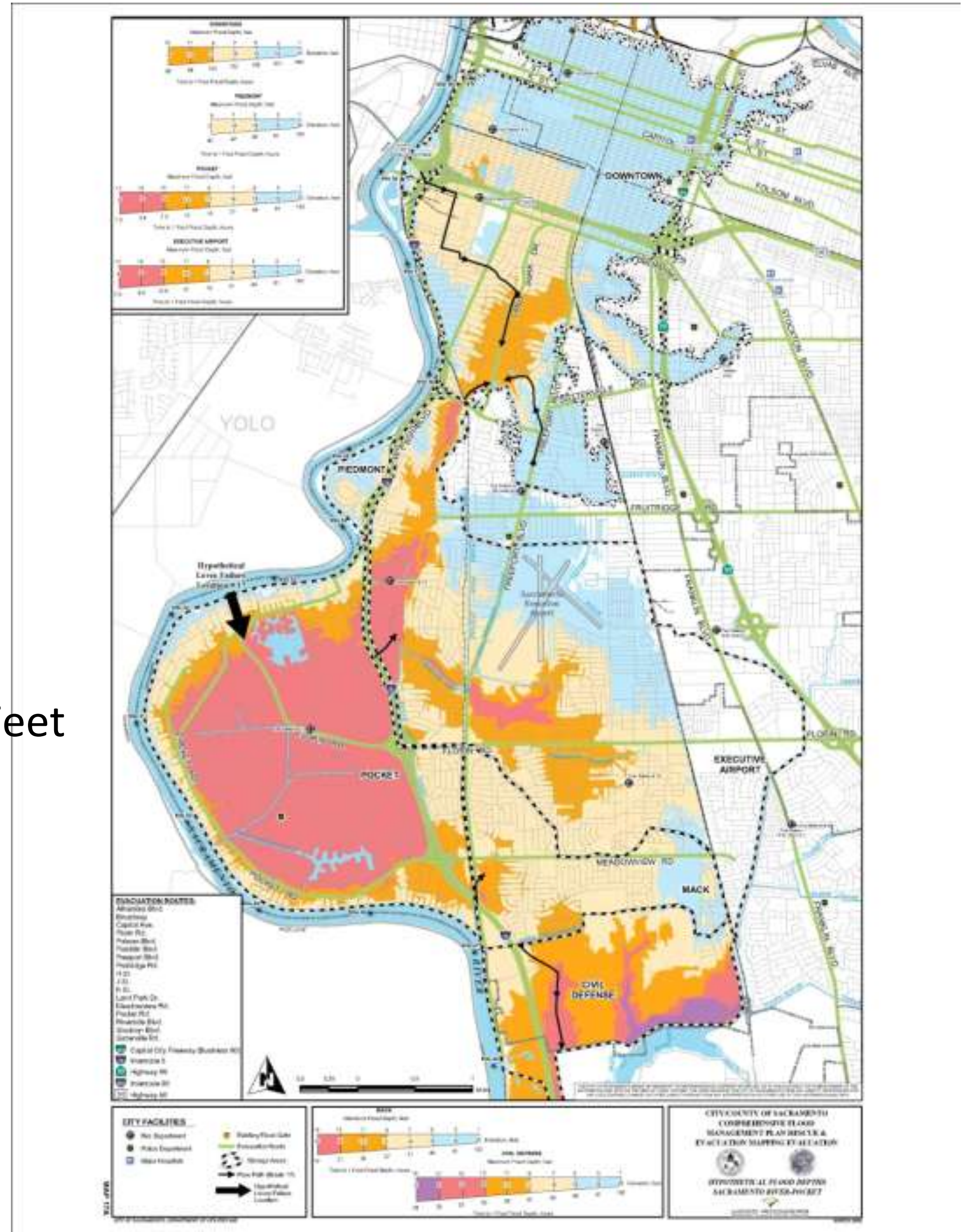
Pocket Area

Quantify levee geometrics and its relation to vegetation occurrence and distribution over a 16 km reach of the Sacramento River using high resolution airborne LiDAR and Hyperspectral Imagery.

Why is Stability of the Levees in the Pocket Area Important?

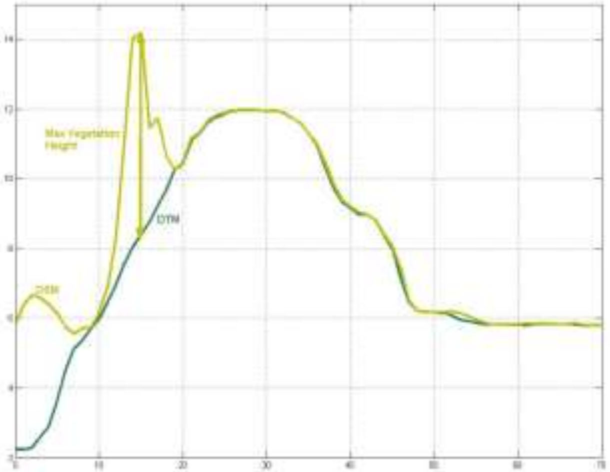
Pocket Area, Sacramento





Methodology: Characterisation of levees against design standards using LiDAR data

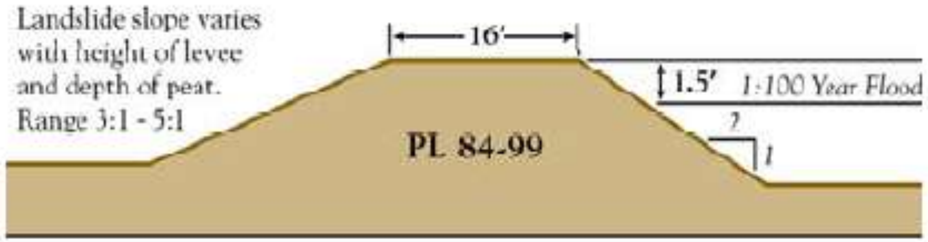
Profiles of the Terrain and the Canopy for 118 cross sections



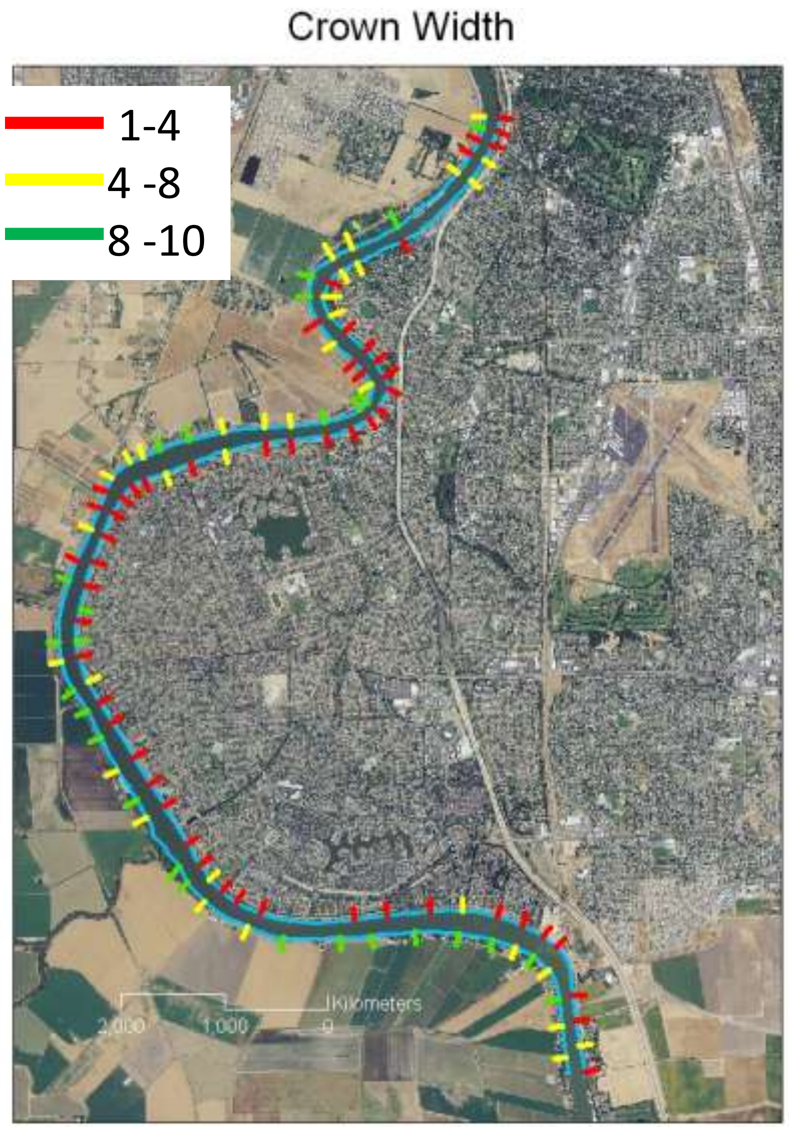
100m

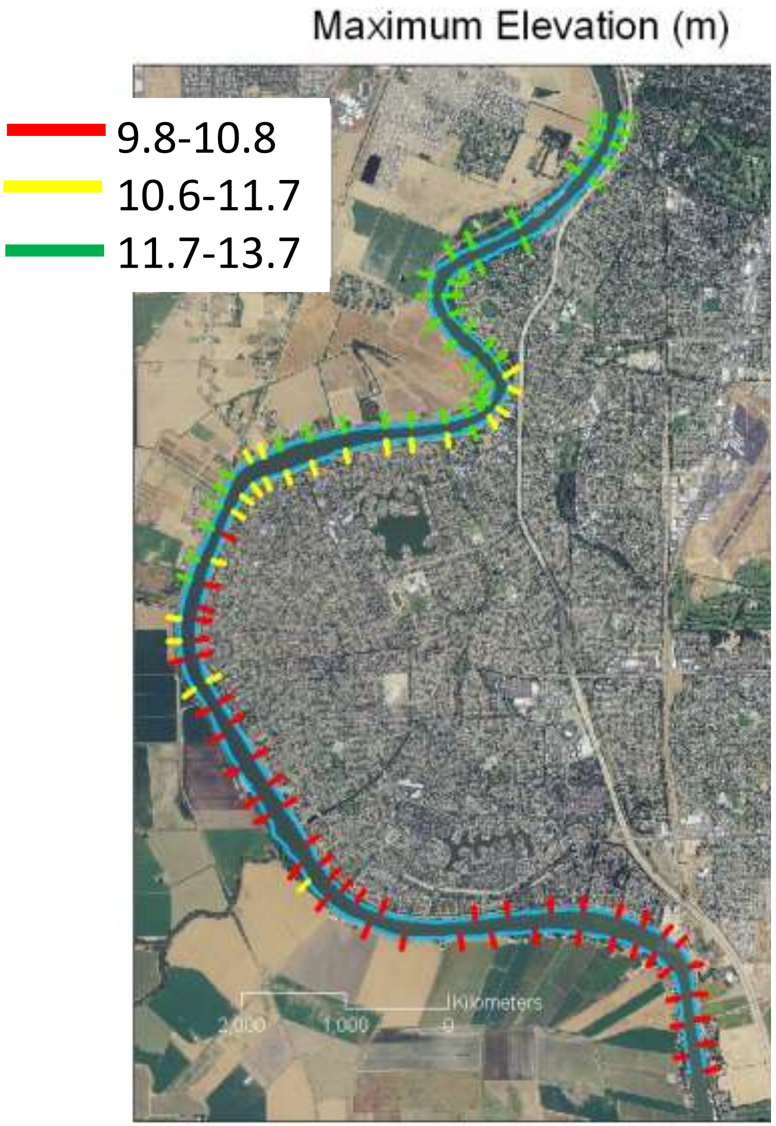
Delta Levee standards: crown width and slope

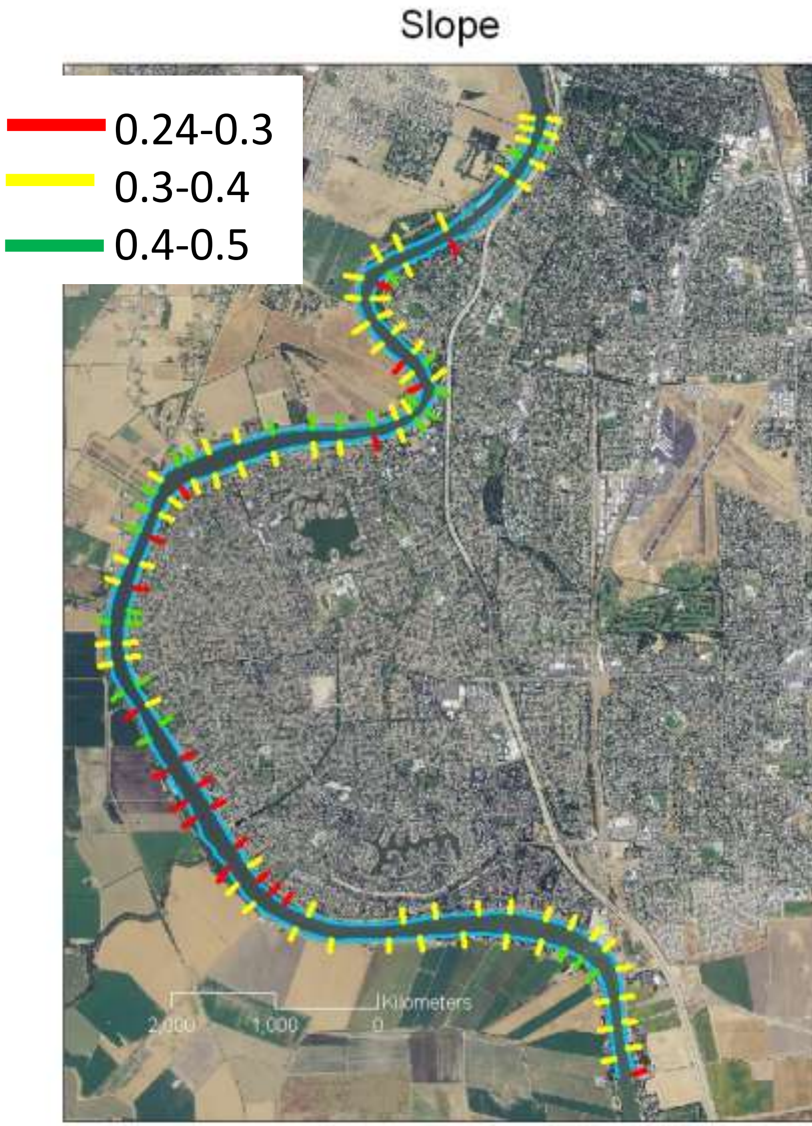
US Army Corps of Engineers (USACE)



Results: Stability Parameter Maps







Generalized Levee Stability Map

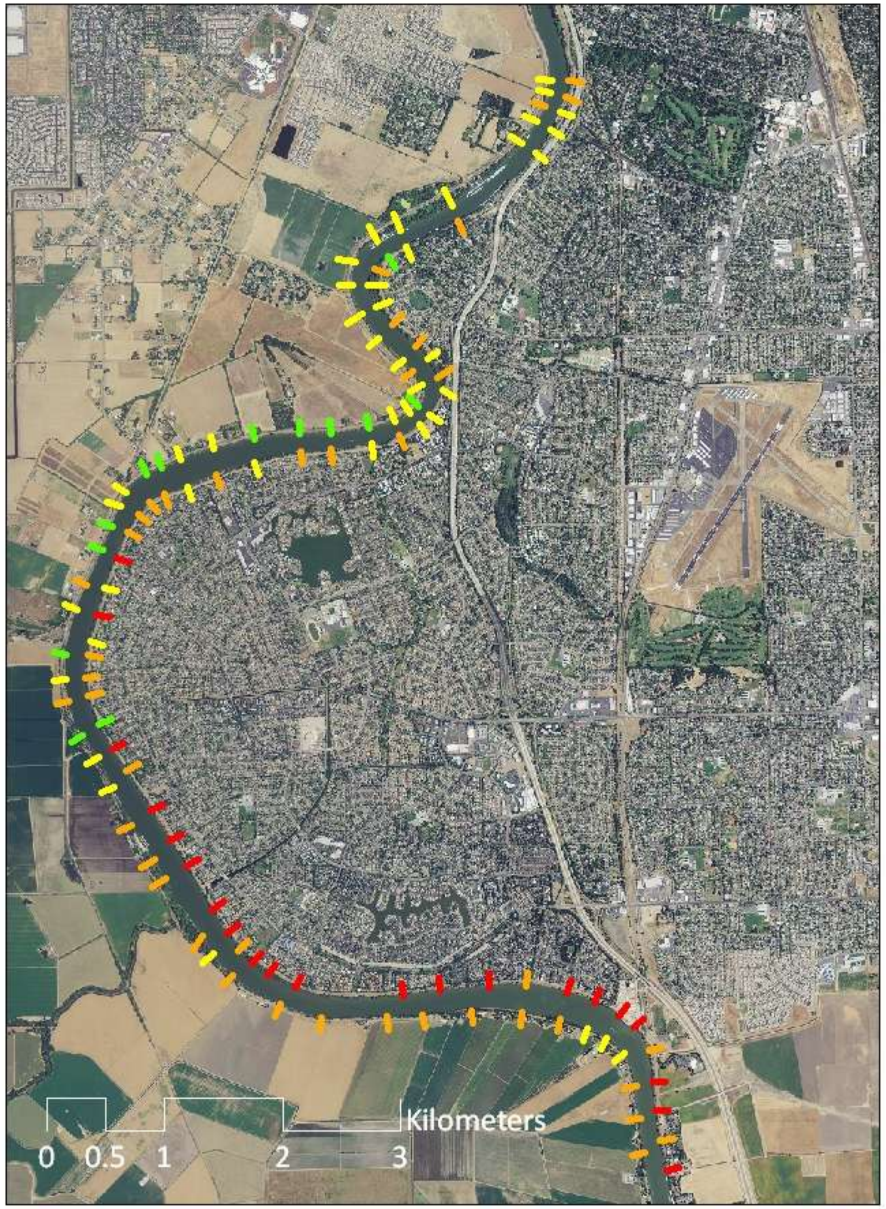
Sum of below standard conditions

<u>Stability Level Definition:</u>
Crown Width – Good > 4.5 m
Slope – Good > 45 %
Elevation – Good > 10.6 m

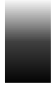
Stability level

- Good (0/3)
- Fair (1/3)
- Bad (2/3)
- Unstable (3/3)

Stability Level	% of transects
Good	1.7 %
Fair	31.4 %
Bad	46.6 %
Instable	20.34 %



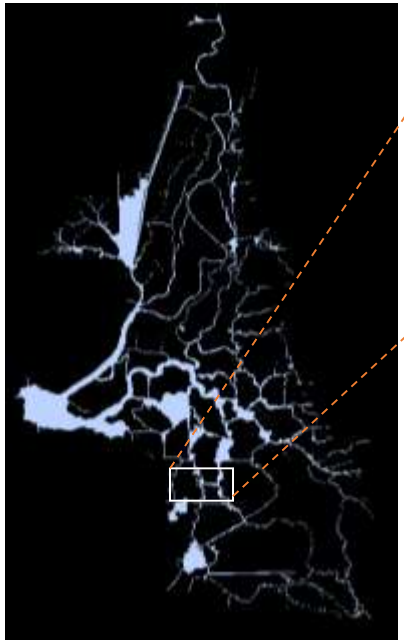
Lidar Images of Bare Earth and Canopy Topography

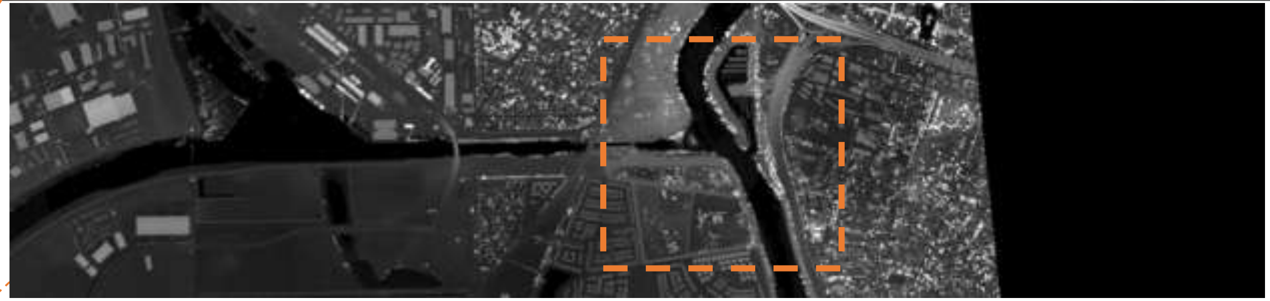


Relative Elevation

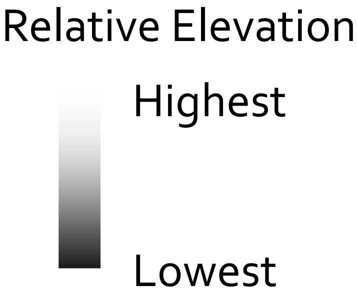
Objects > 2m above bare earth

LiDAR Improves Classification Performance



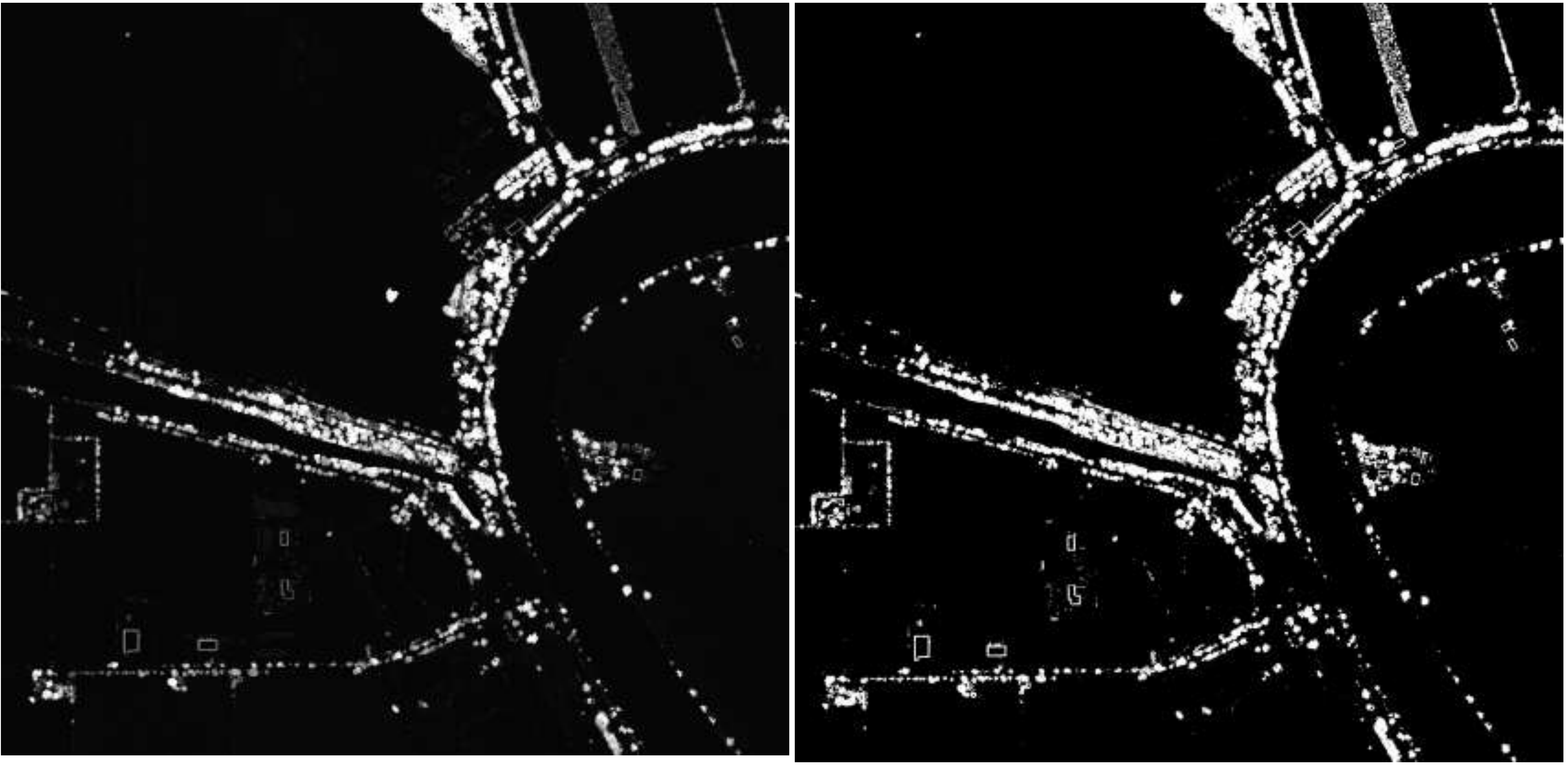


LiDAR – DEM 1st Return



Tree Crown Mapping

DSM – DGM = Vegetation Height

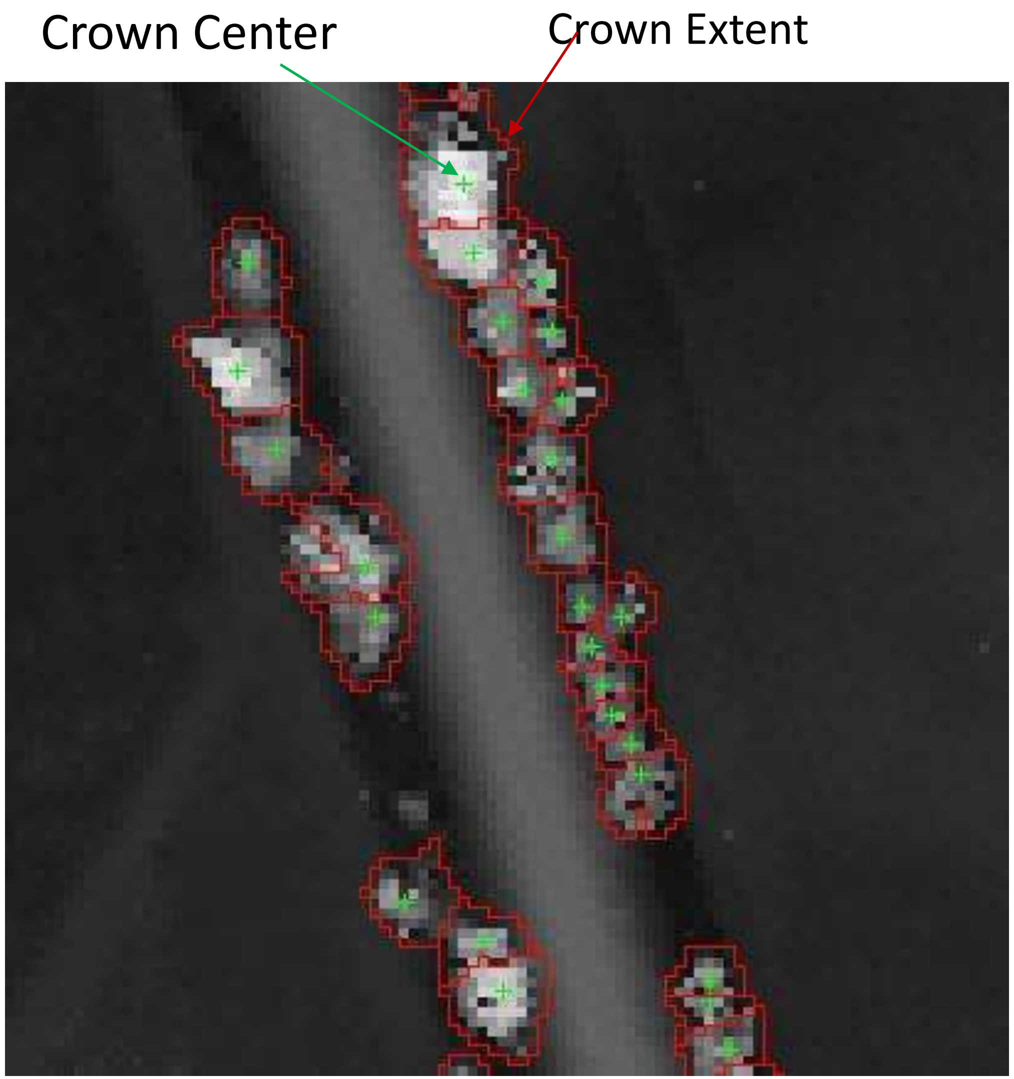


Hymap – True Color

Fusing Lidar and Hyperspectral Data

Tree Mapping Algorithm

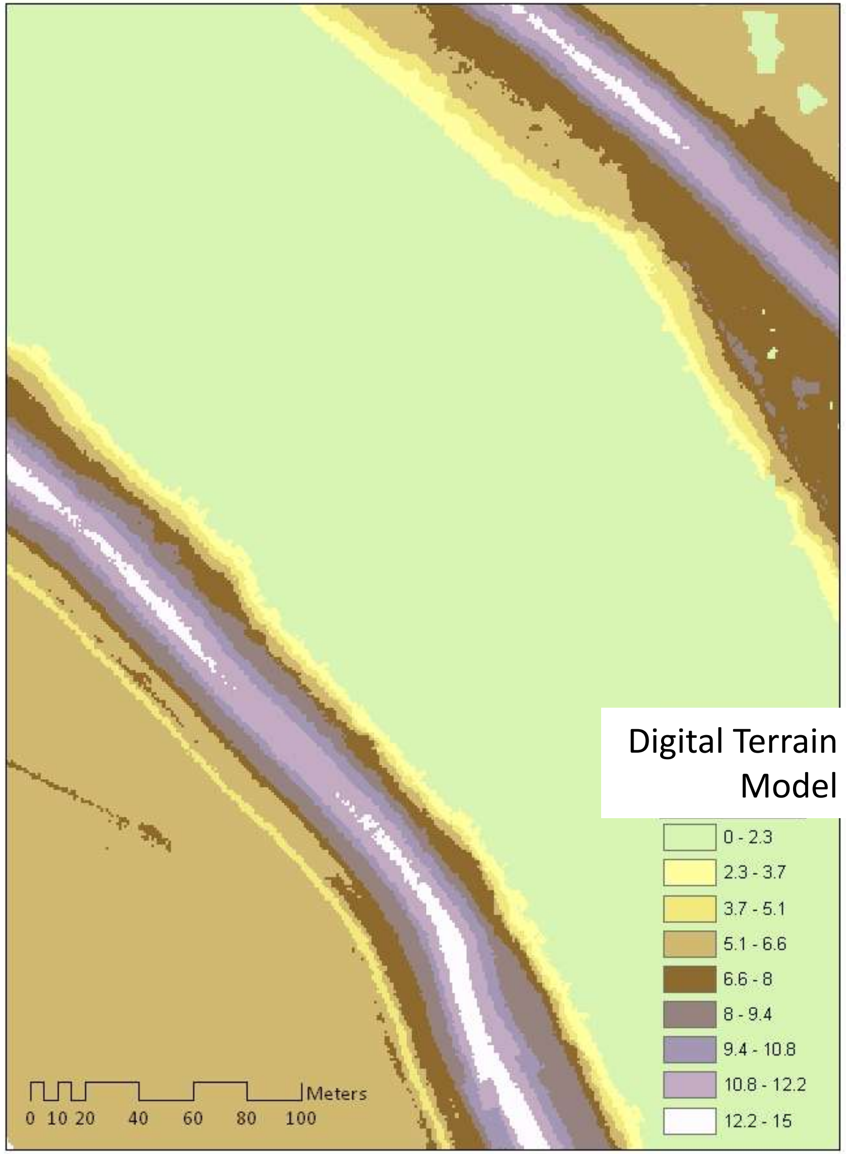
- Crown growing and valley following techniques are adapted.
- Segmentation based on elevation information from LIDAR height raster.
- Conic shape model for tree crown delineation.
- Spectral characteristics are involved to filter false positives from complicated background.

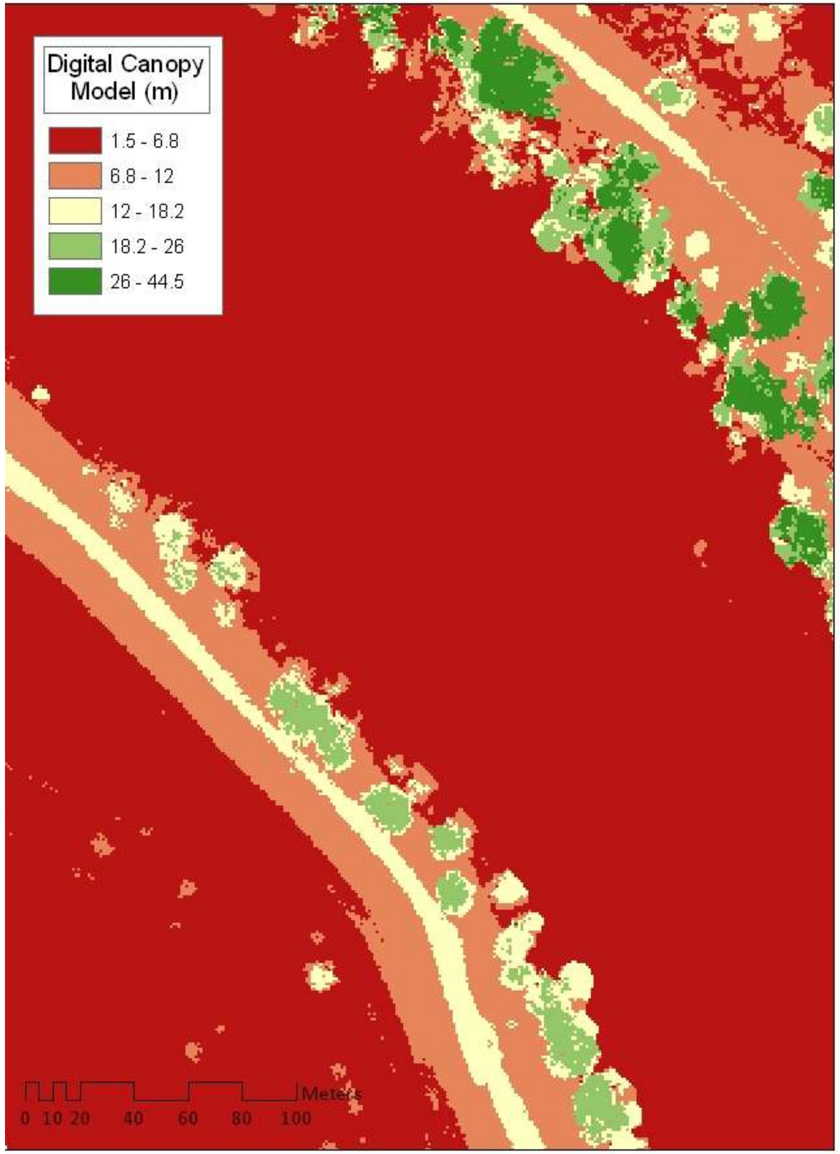


Juei Wren Ho

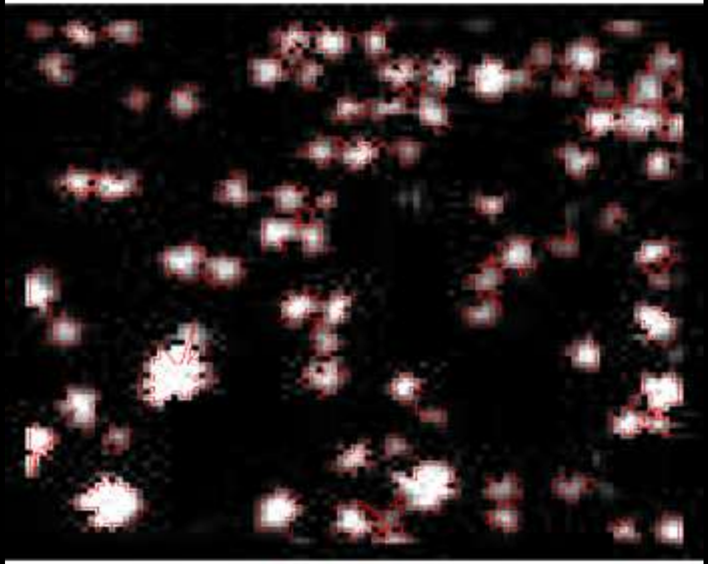
Microtopography & Levee Stability

(1) Assess levee stability by characterizing the superficial levee configuration using LiDAR data
(2) Assess the role of vegetation as a possible instability factor using LiDAR data



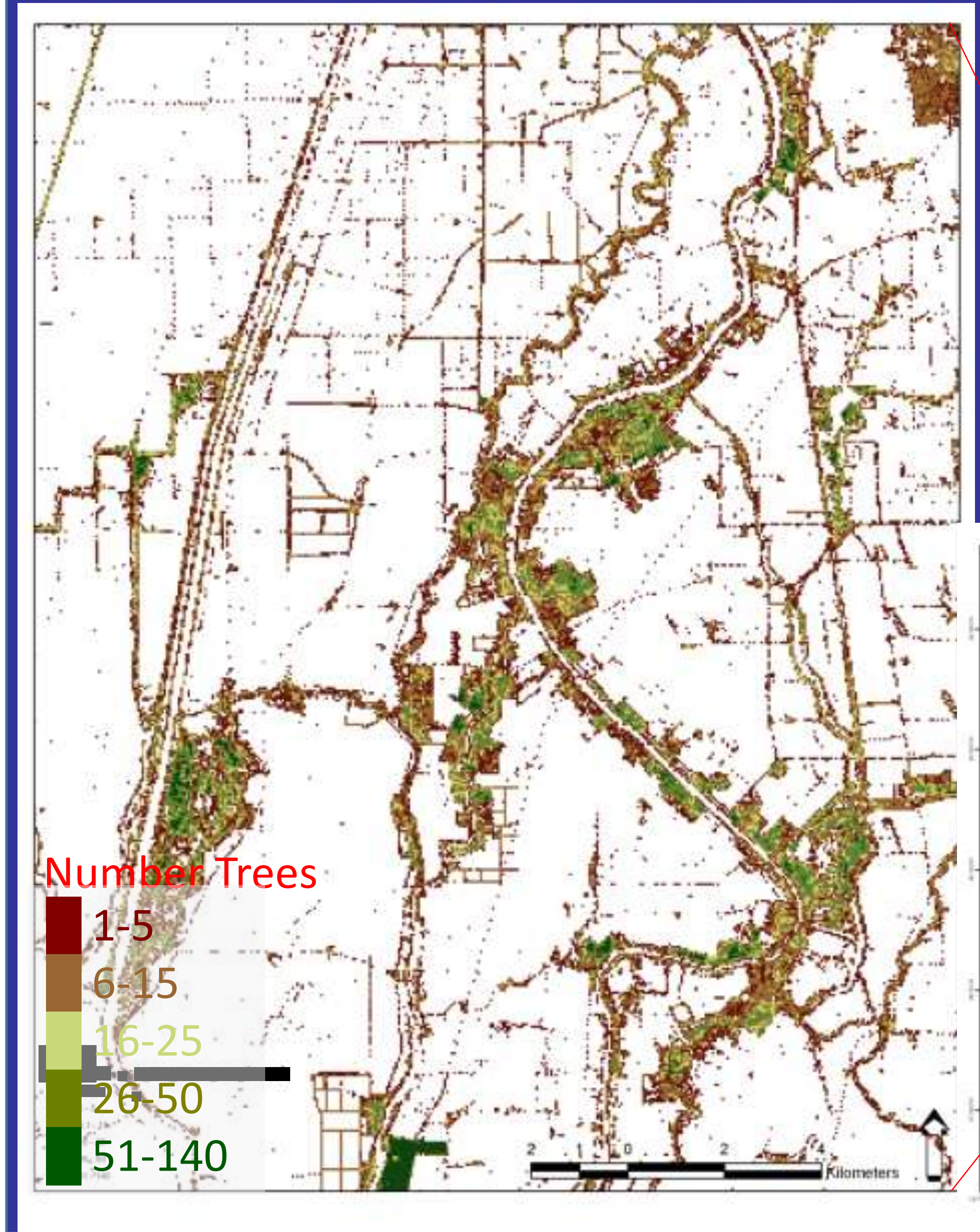


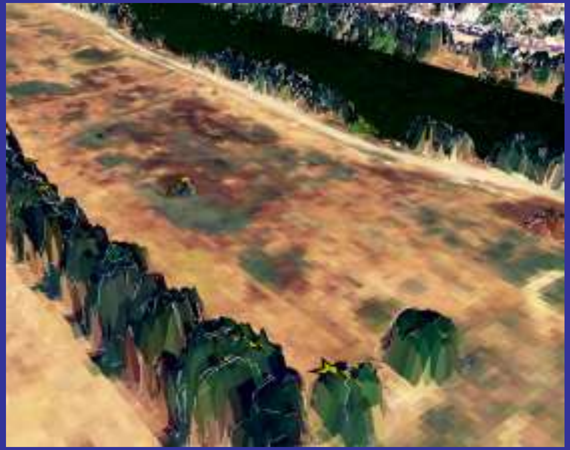
Delta Levee Trees

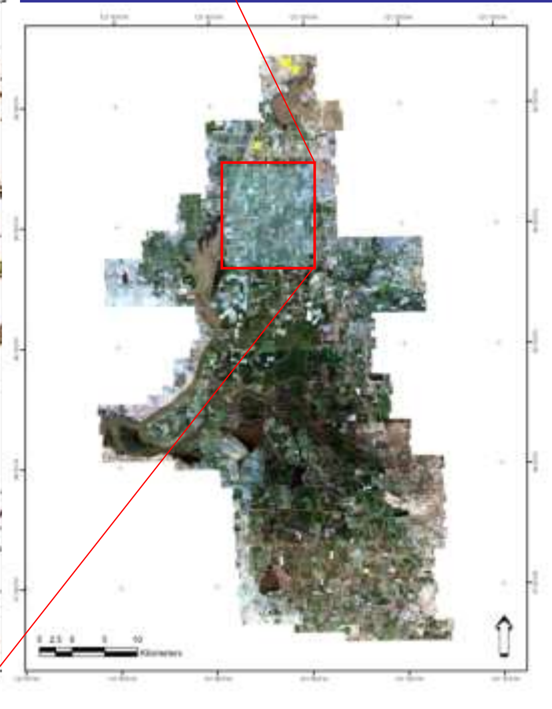


Juei-Wen Ho

Delta Tree Map: 4,173047 tree “clusters”







Juei Wren Ho

Relationship between tree structure and occurrence with the stability level of the levees

I) Vegetation Presence & Stability

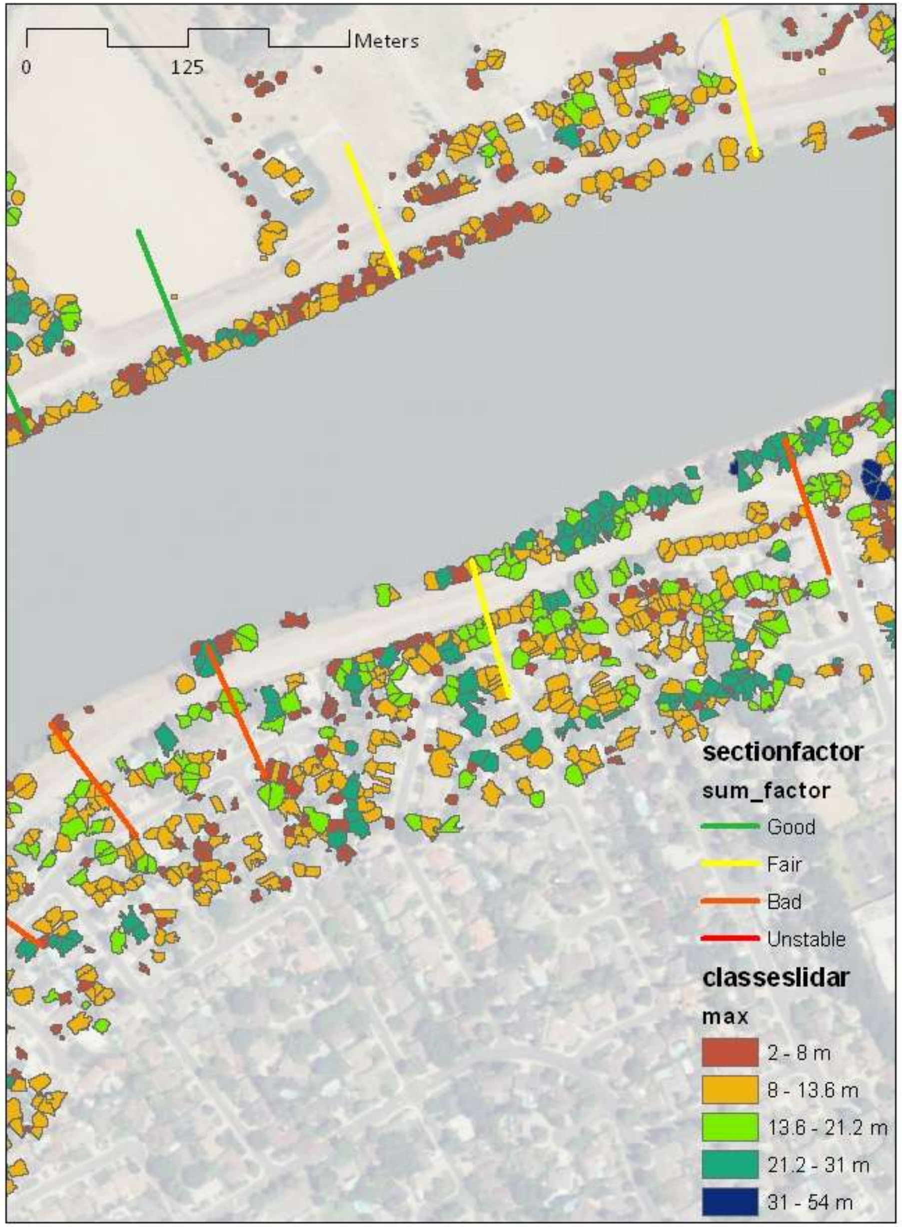
Stability Level	% of non-vegetated	% of vegetated
Good	10%	0%
Fair	5%	36.73%
Bad	**45%**	**47%**
Unstable	40%	16.32%

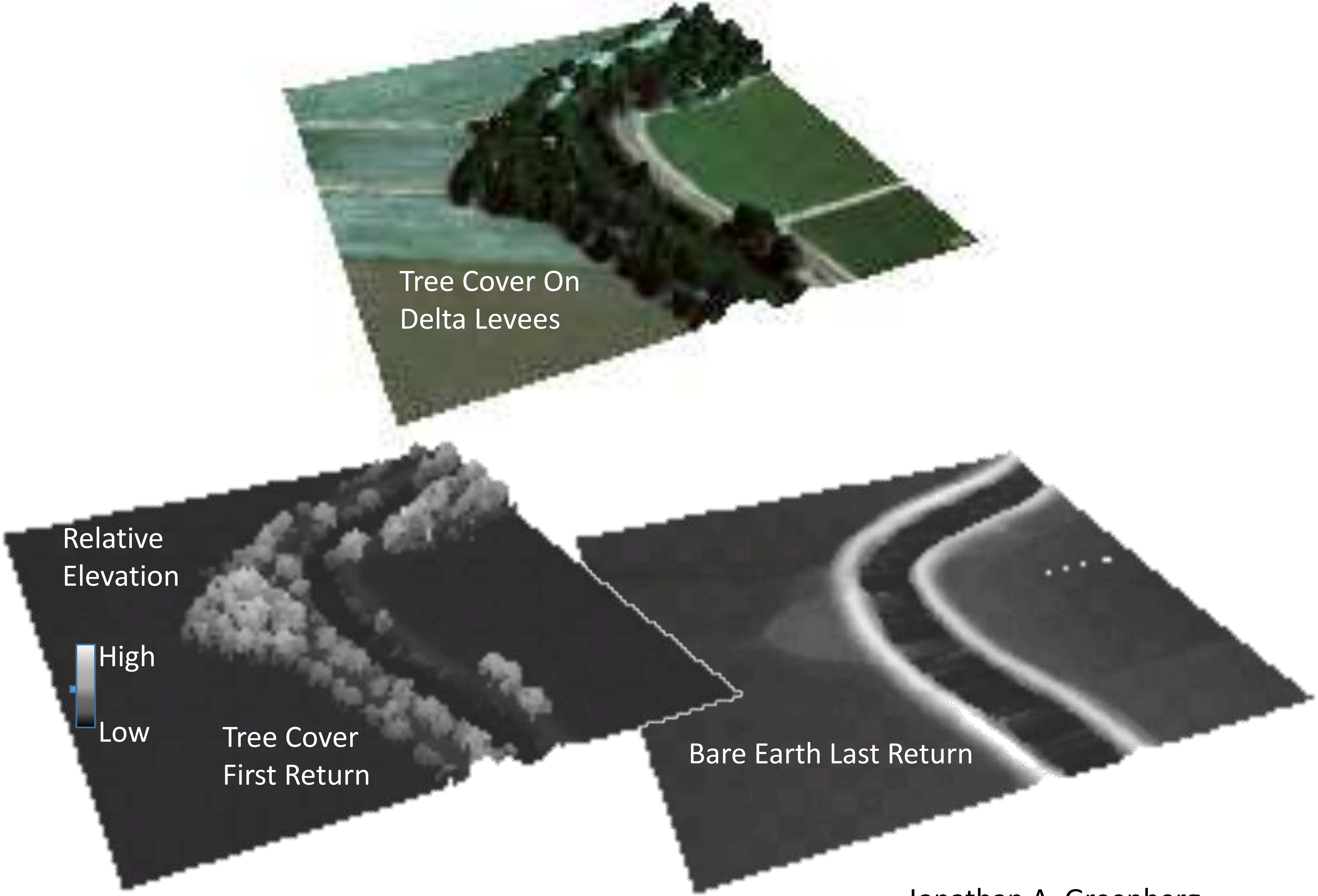
II) Maximum Vegetation Height & Stability

Vegetated Levees				
Stability Level	Maximum vegetation height			
	[2 - 5 m]	[5 - 10 m]	[10 - 20 m]	[> 20 m]
Good	0%	0%	0%	0%
Fair	33.33%	43.48%	40%	28%
Bad	46.67%	34.78%	45.71%	60%
Unstable	20%	21.74%	14.29%	12%

* Vegetation threshold >2m height

Maximum vegetation height (m)

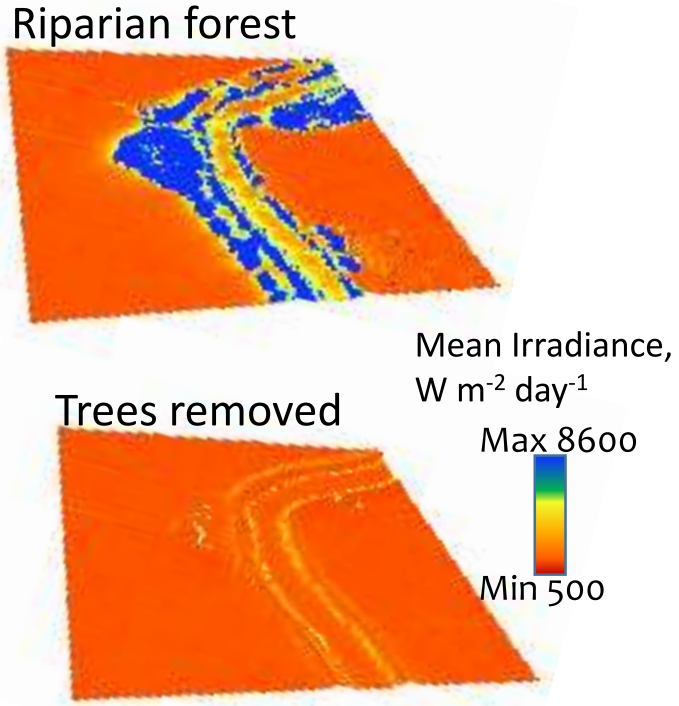




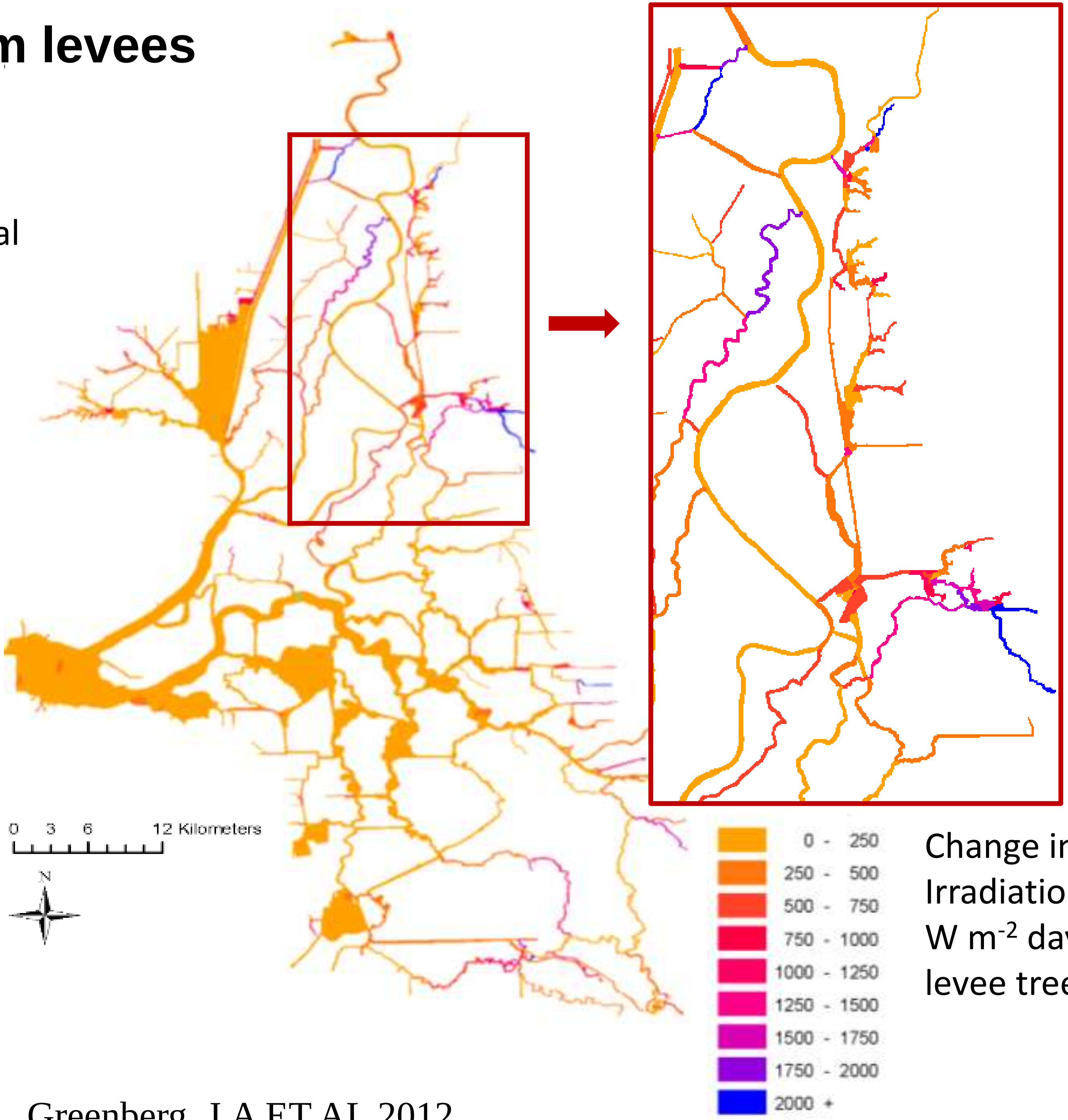
Jonathan A. Greenberg

Effect of tree removal from levees on water irradiation

Ave. Daily Summer Irradiation
on Water before and after tree removal



Solar radiation of a wooded river bend with trees (current conditions),(top) and if trees are removed (bottom).



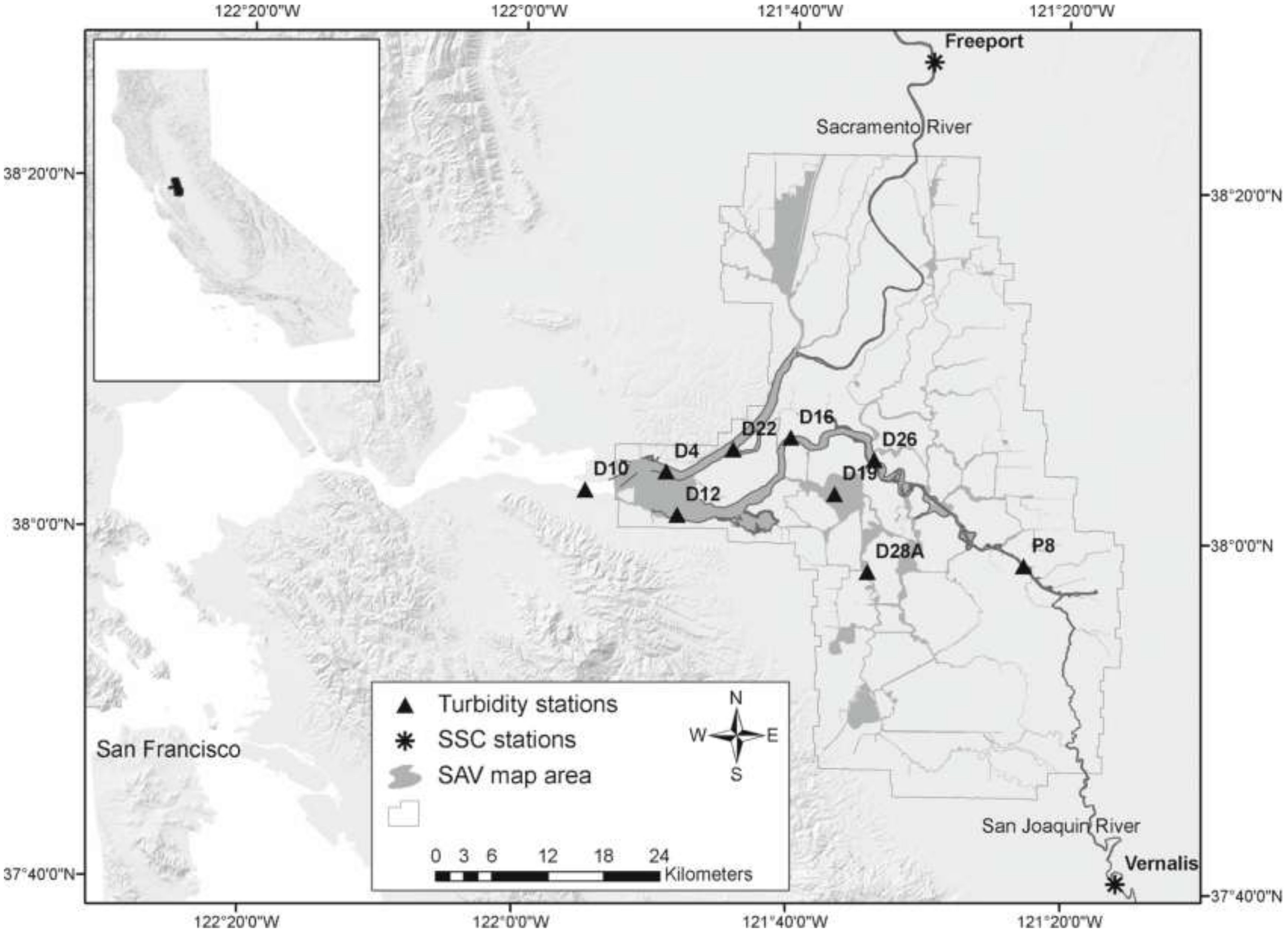
Change in Ave. Daily Summer Irradiation on Waterbodies, W m^{-2} day^{-1} after removal of levee trees.

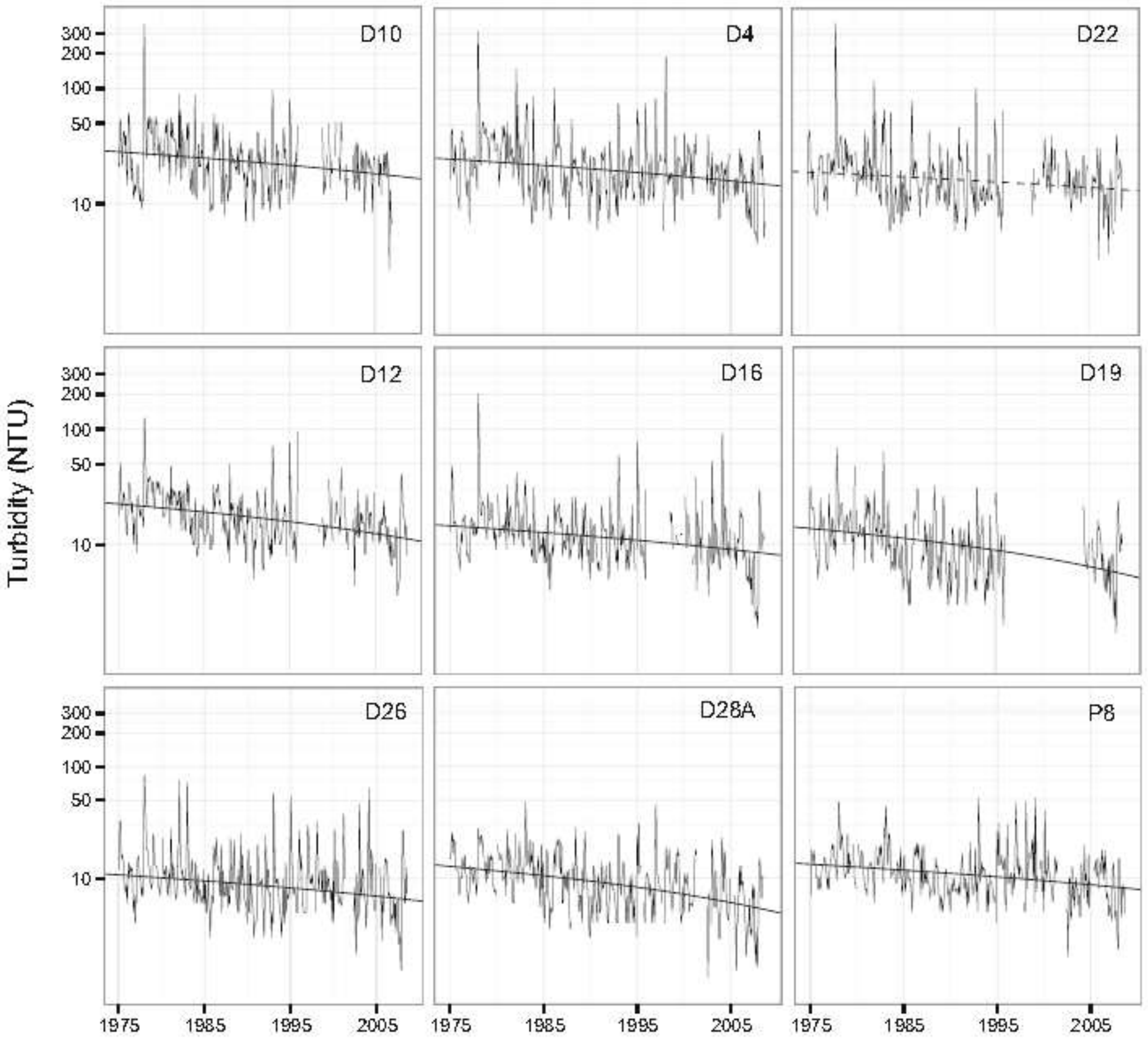
Greenberg, J.A ET AL 2012

Aquatic plant communities of the Sacramento- San Joaquin Delta

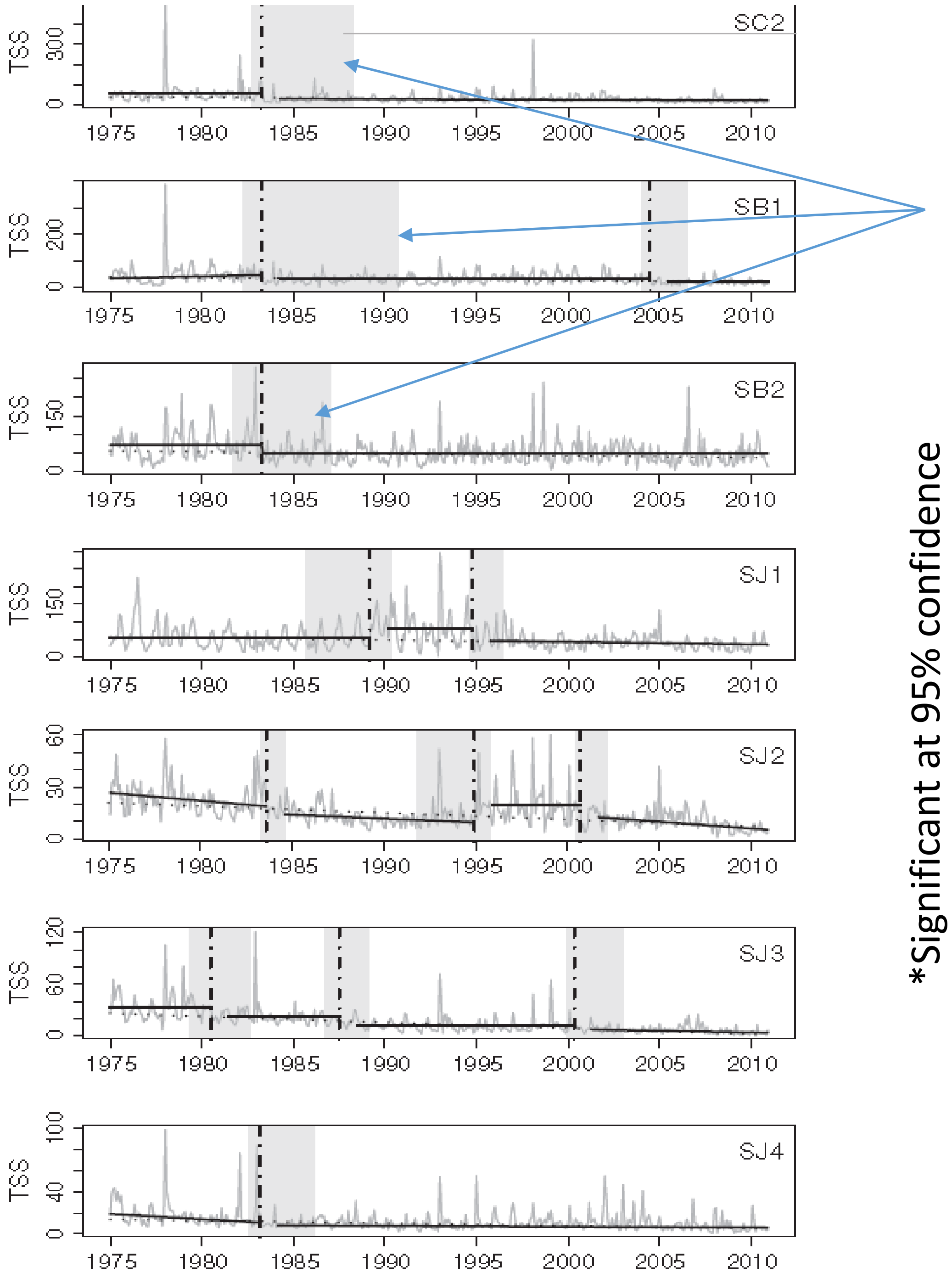
Turbidity in the Delta has been declining since the 1970s

- Dams on the Tributary Rivers
- Flushing of the last sediments from placer gold mining of the 1850s





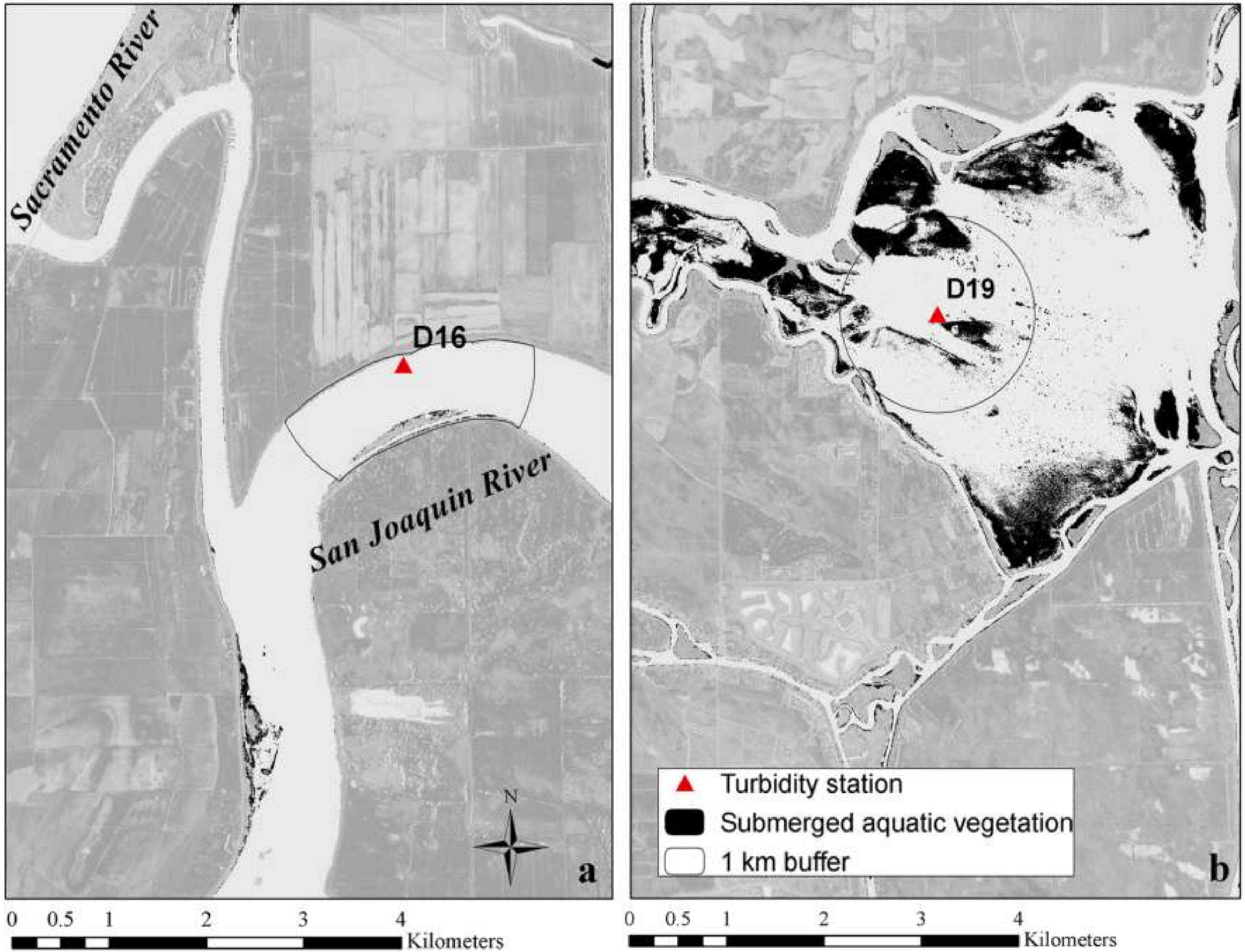
D10
D4
D22
D12
D16
D19
D26
D28A
P8
Turbidity (NTU)
300
200
100
50
10
1975
1985
1995
2005

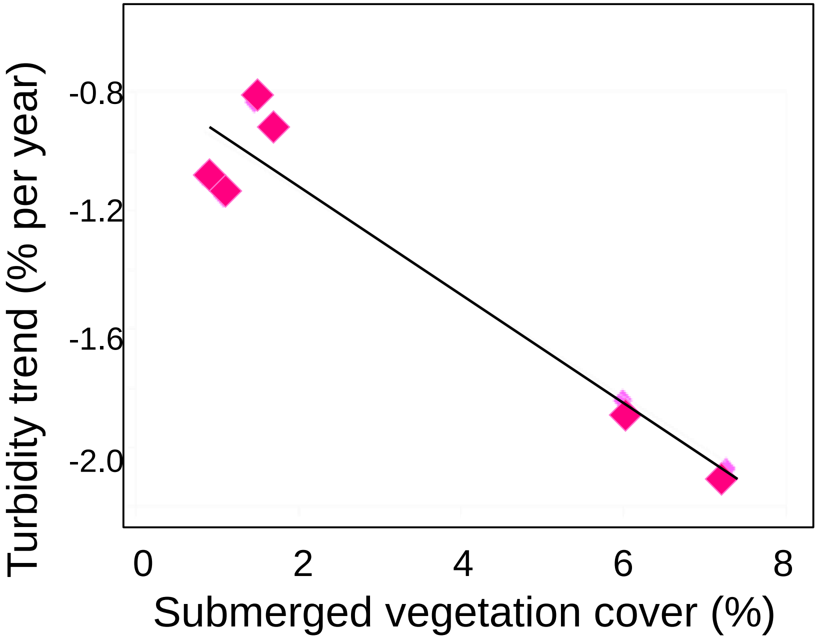


*Significant at 95% confidence

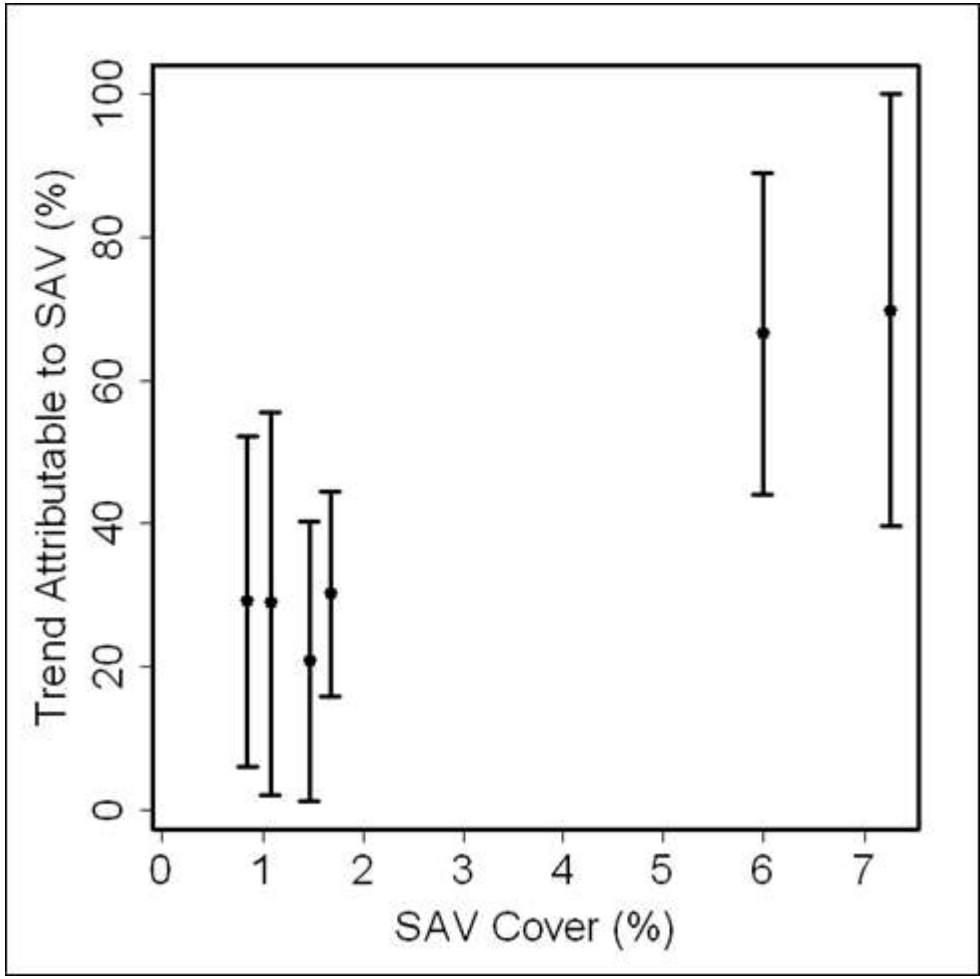
Turbidity decline experienced 2-3 step changes:

- After El Nino ~ 1985 (flushing event)
- 1990-2000 (rapid increase in SAV species)

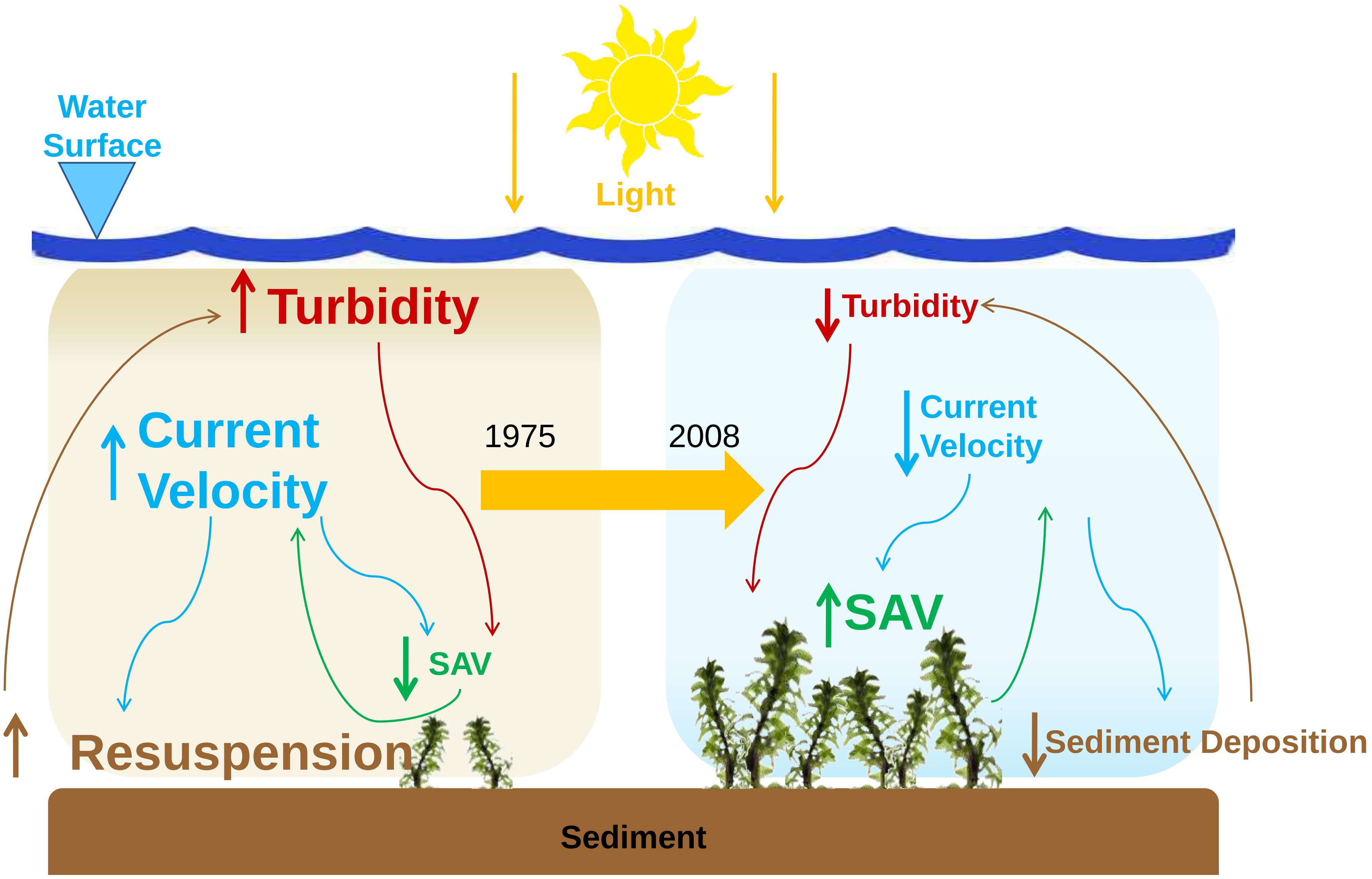

Sacramento River
D16
San Joaquin River
N
a
D19
Turbidity station
Submerged aquatic vegetation
1 km buffer
b
0 0.5 1 2 3 4
Kilometers
0 0.5 1 2 3 4
Kilometers



Turbidity trend (% per year)
-0.8
-1.2
-1.6
-2.0
0
2
4
6
8
Submerged vegetation cover (%)



Trend Attributable to SAV (%)
0
20
40
60
80
100
0
1
2
3
4
5
6
7
SAV Cover (%)



Water
Surface
Light
Turbidity
Current
Velocity
SAV
Resuspension
1975
2008
Turbidity
Current
Velocity
SAV
Sediment Deposition
Sediment