Mapping inundation with ALOS SCANSAR data and monitoring biomass in N. America

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Jet Propulsion Laboratory, California Institute of Technology

Science Team meeting #16 – Phase 3 Kick-off
JAXA TKSC/RESTEC HQ, Tsukuba/Tokyo, October 17-21, 2011

Collaborations

- The JAXA team
- Kyle Mcdonald (PI of Measures task)
- Laura Hess
- Ronnie Schroeder
- Mahta Moghaddam and Jane Whitcomb
- CMS: Sassan Saatchi
  - A large team involved

Outline

- Identifying inundated wetlands
- Carbon Monitoring System
- Reporting

NASA Measures

The NASA "MEASURES" program has funded a task lead by Kyle McDonald to develop inundated wetlands products from ALOS PALSAR and other instruments

Objectives:

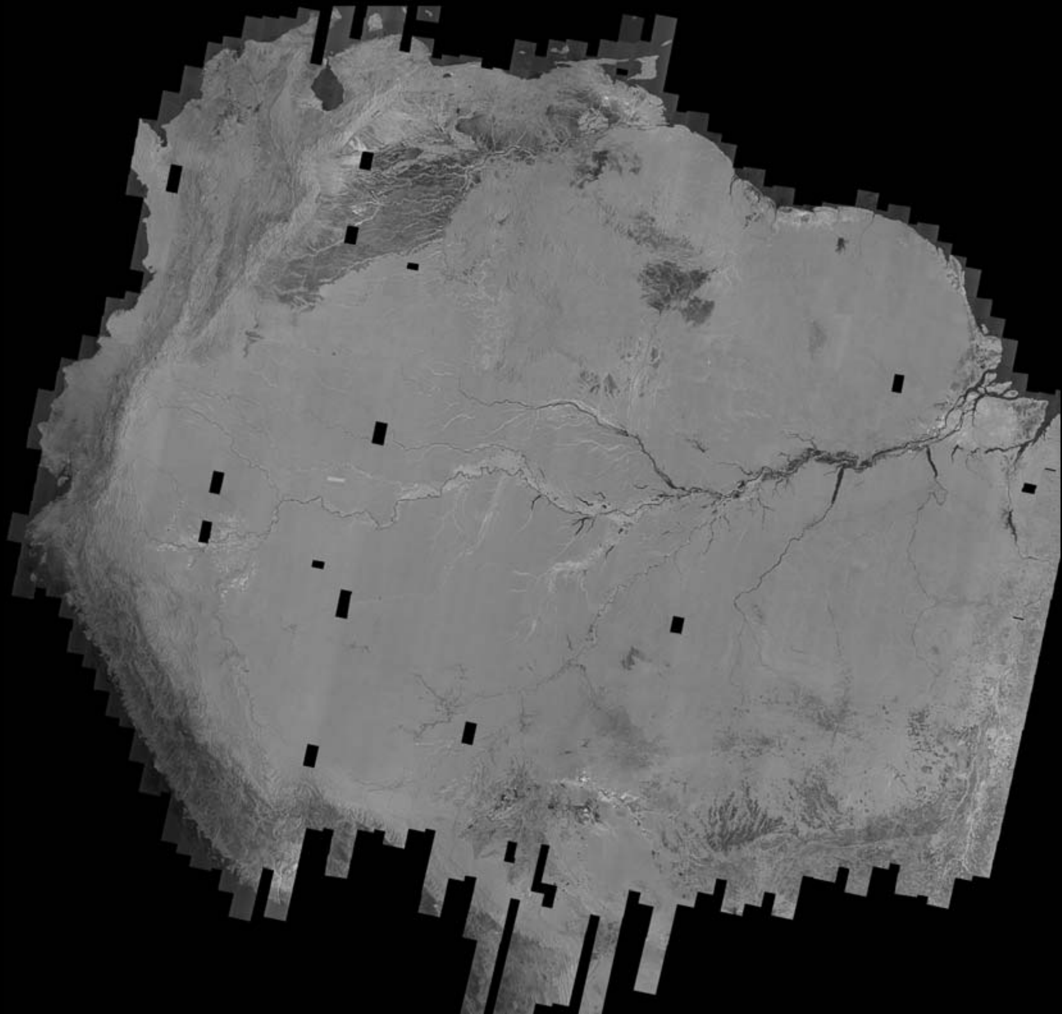
1) Regional inundated data sets
   - ✓ from Synthetic Aperture Radar
   - ✓ Spatial Coverage: Major Global Wetland Areas, 100m resolution
   - ✓ temporal coverage: 1-2 year time series at 46 day intervals
2) Global monthly inundation data sets
   - ✓ derived from multiple satellite data sources
   - ✓ Spatial coverage: Global, 25 km resolution
   - ✓ Temporal Coverage: monthly monitoring with annual summaries

ALOS SCANSAR and FBD data for mapping inundated wetlands

- The dual polarization “FBD” mode will be used to determine forest structure
  - One coverage
  - Non-vegetated, Herbaceous, Shrub, Woodland, Forest
- The “SCANSAR” mode data will be used to monitor inundation state
  - Inundated, not inundated
  - Coverage every 46 days
  - Focused on large wetland regions (Amazon basin, etc)
- Currently developing products for N/S America

Using SAR to image wetlands

In the late 1990s, the JERS-1 SAR was used to image the Amazon river at both high and low flood season

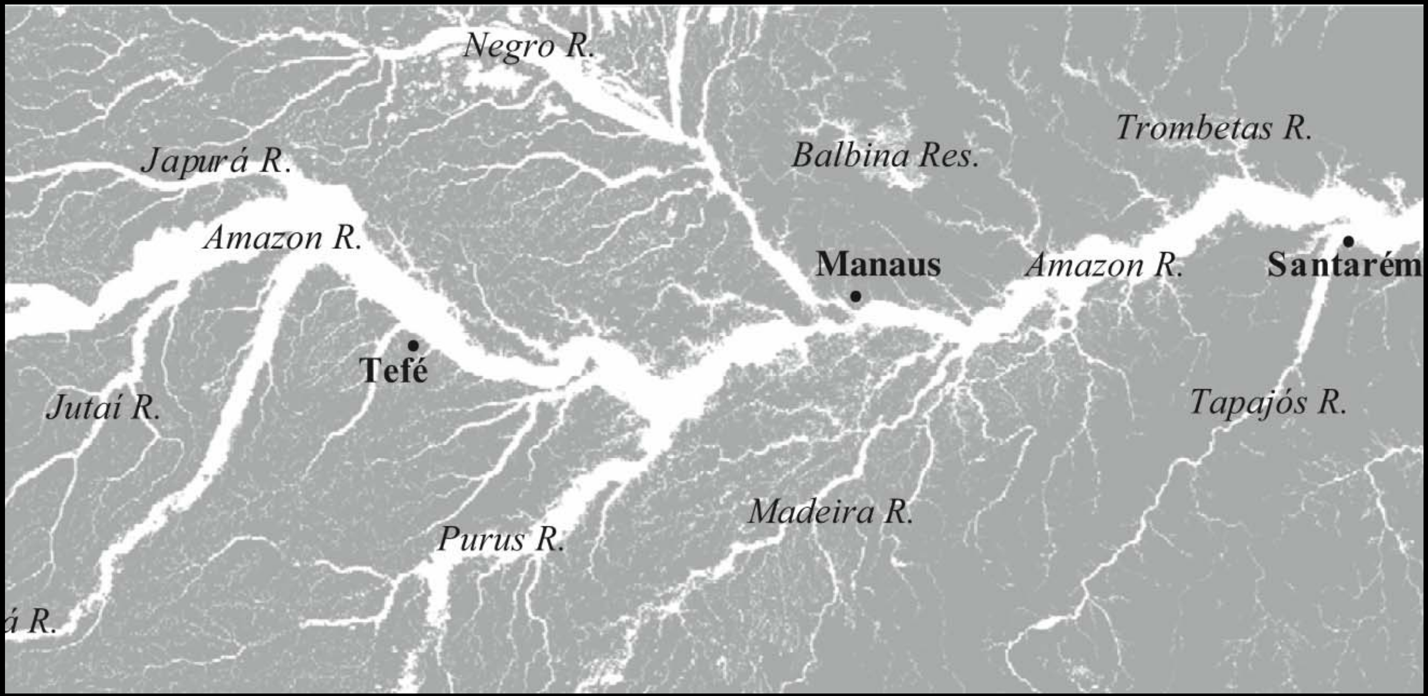


JERS-1/GRFM ©JAXA/METI

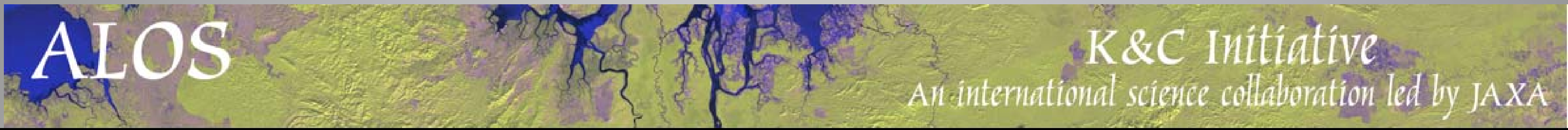
Global Rain Forest Mapping Project

Using SAR to image wetlands

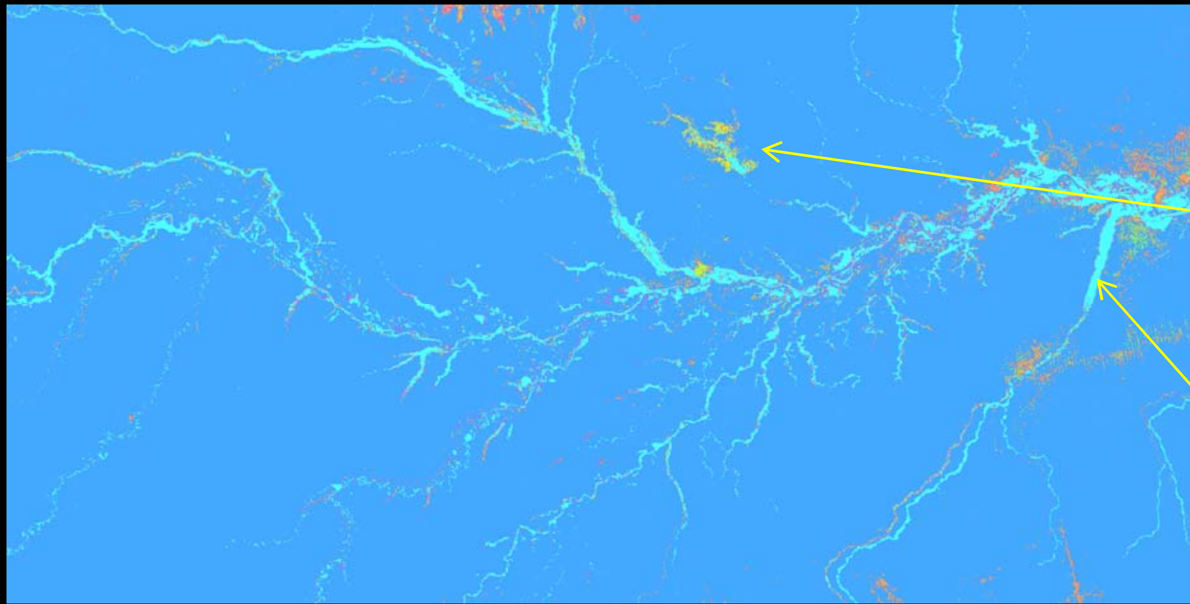
The JERS-1 SAR image was used to estimate maximum flood extent (17% of area shown).



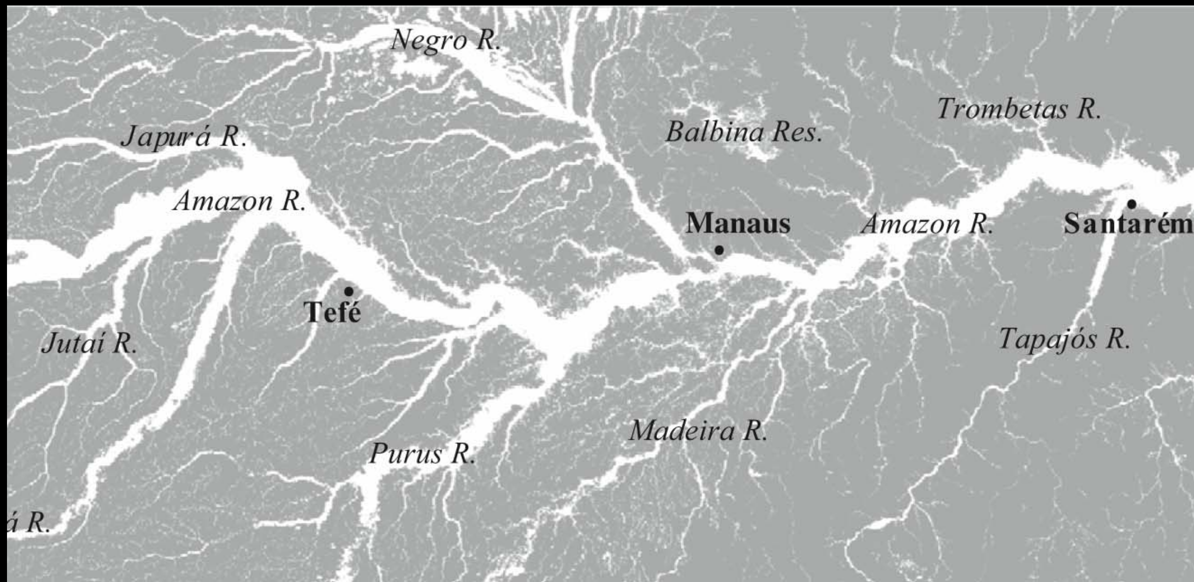
Hess et al, 2003



IGBP global land cover classification
(17 land cover types including permanent wetlands)



JERS-1 SAR based wetlands mask



Optical imagery has drawbacks

- Difficult to get seasonal coverage due to clouds
- Not very sensitive to below-canopy inundation

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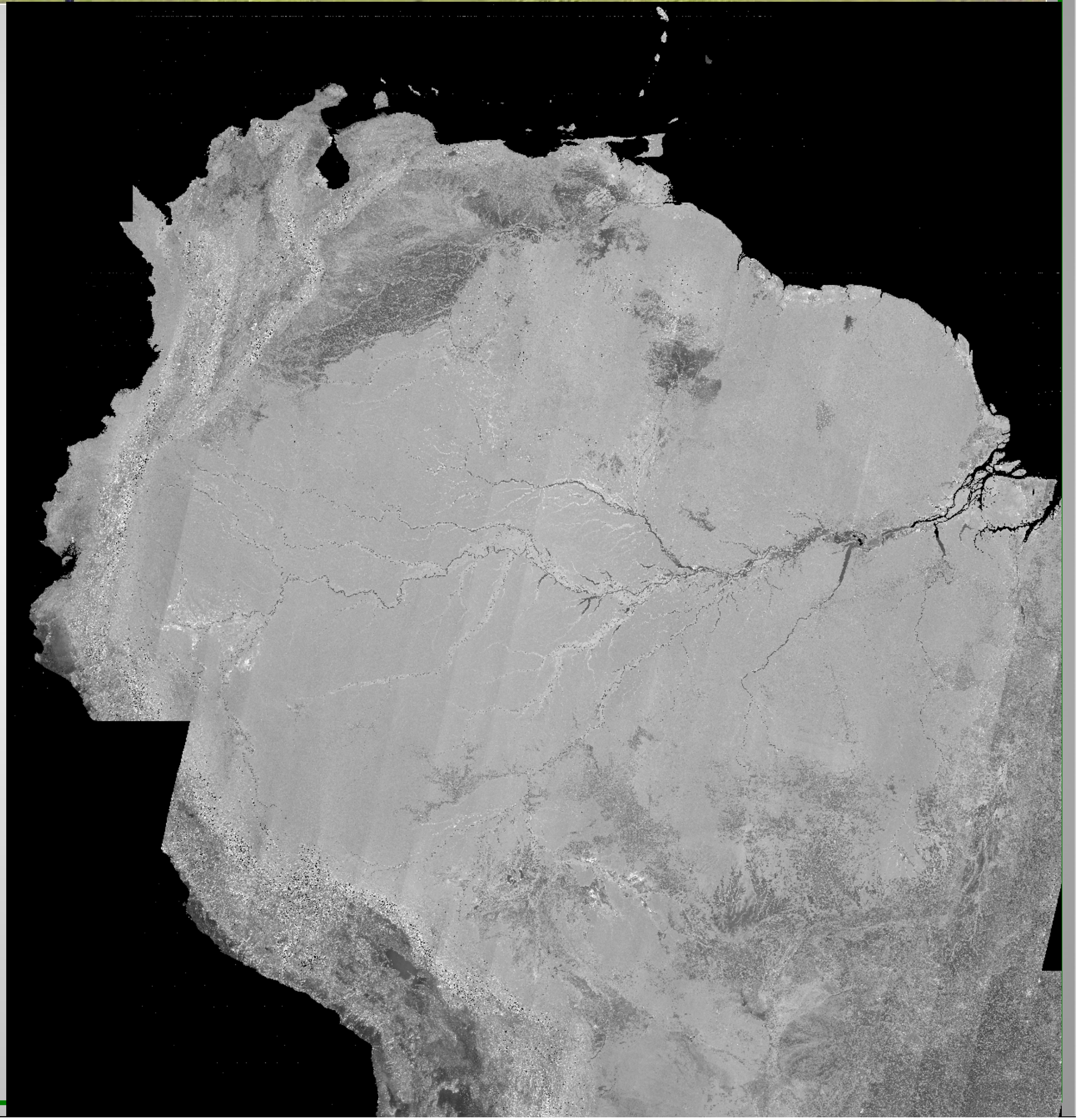
SCANSAR mosaic 2007

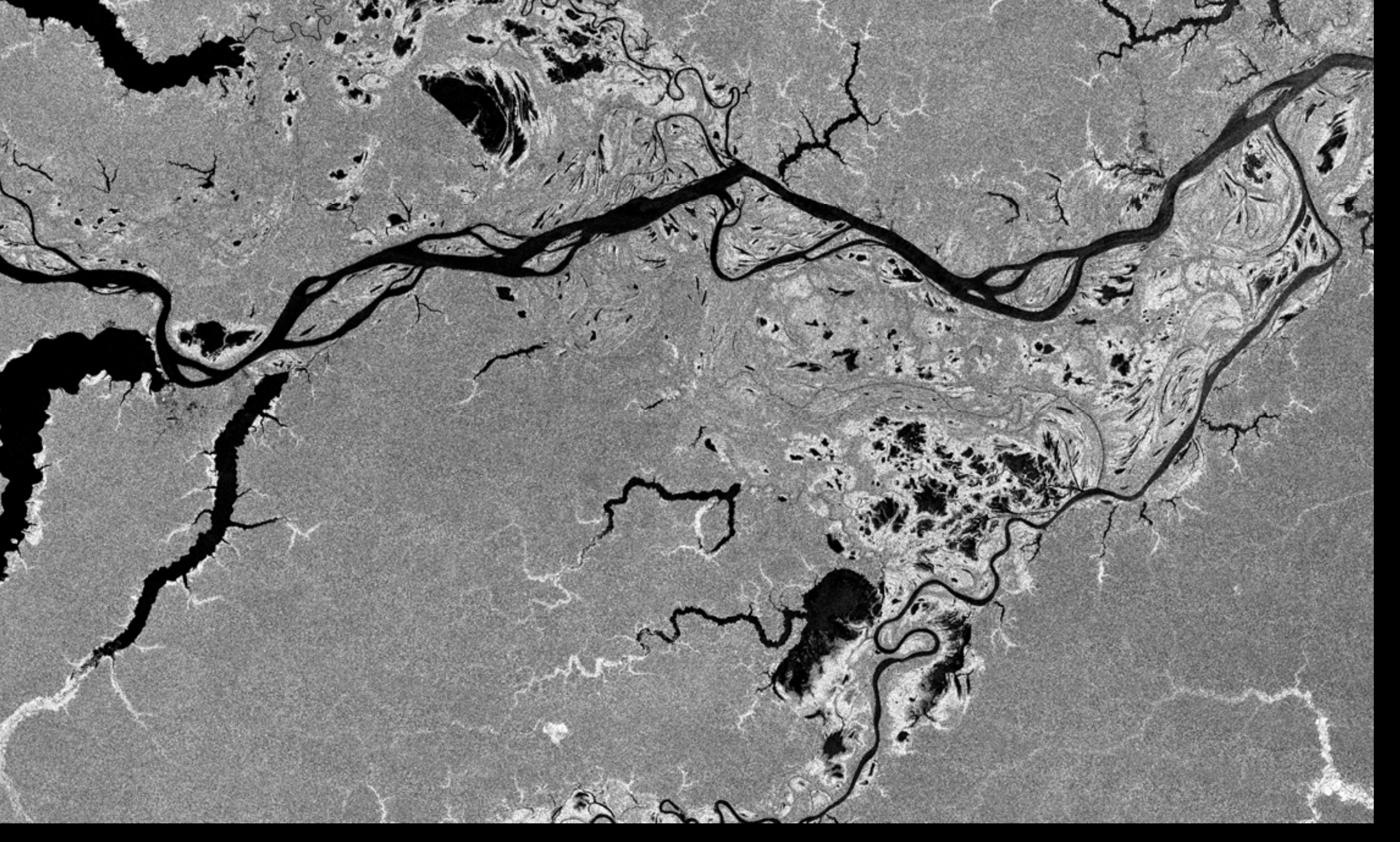
3 arcsecond postings (~90m)
(same as SRTM)

The Amazon river basin was imaged ~every 46 days by ALOS (2006-2011), so that inundation dynamics can be monitored



SAR detection of inundated vegetation

Feb 4, 2007



SAR detection of inundated vegetation

Jun 22, 2007

SAR detection of inundated vegetation

Shaded relief
from SRTM

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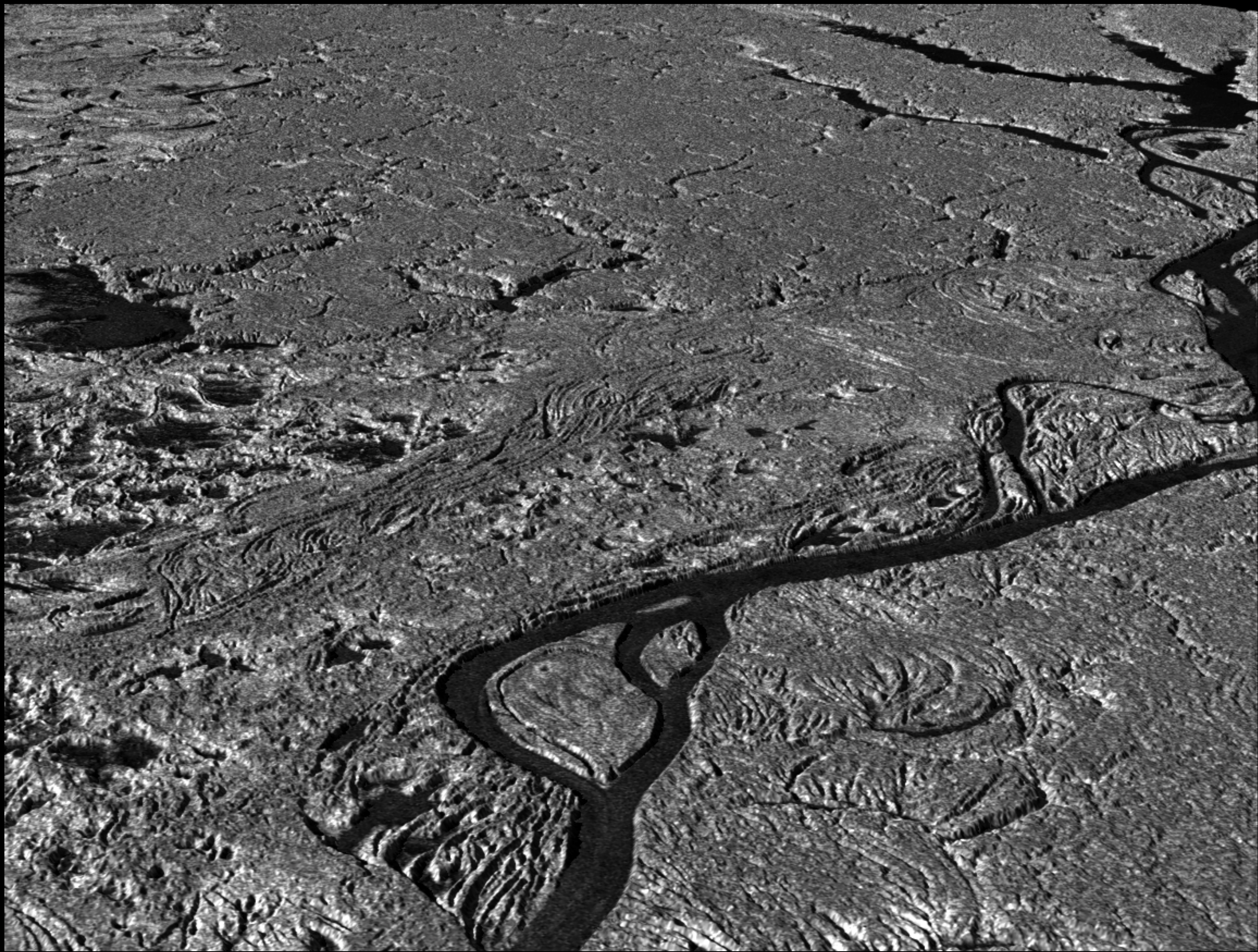
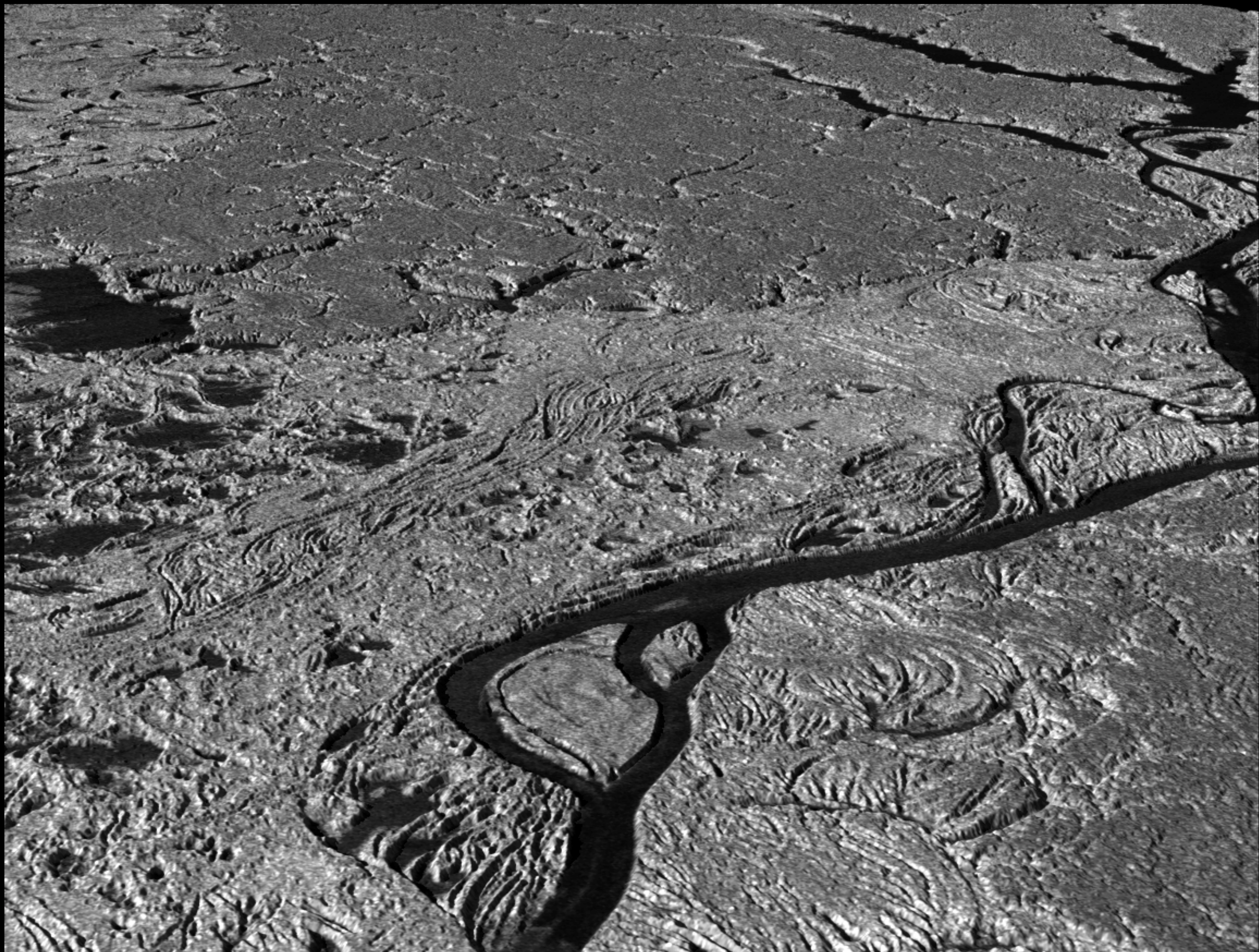
3D visualization

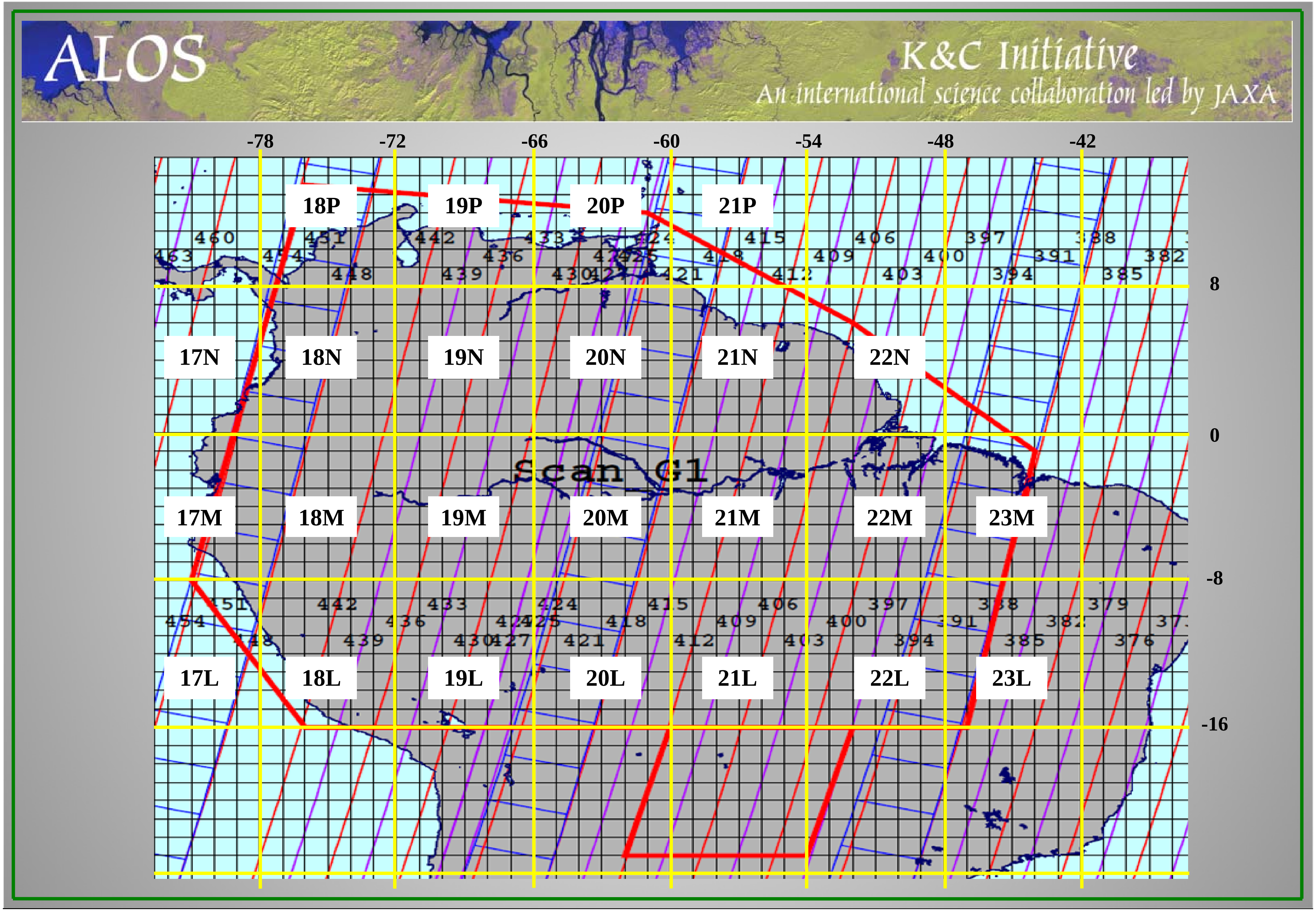
Feb 4, 2007



3D visualization

Jun 22, 2007

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-78
-72
-66
-60
-54
-48
-42
8
0
-8
-16
18P
19P
20P
21P
17N
18N
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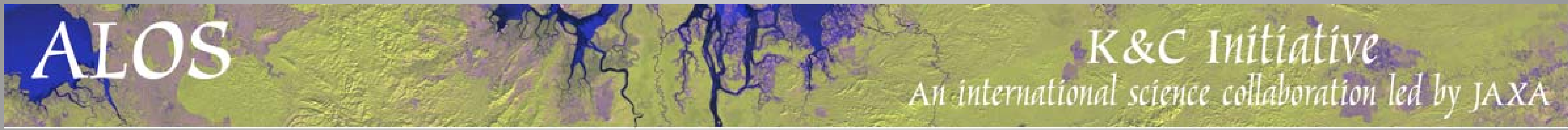
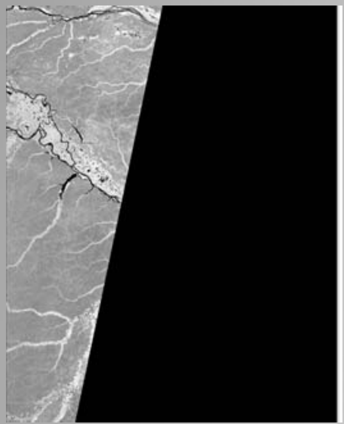


RSP 415



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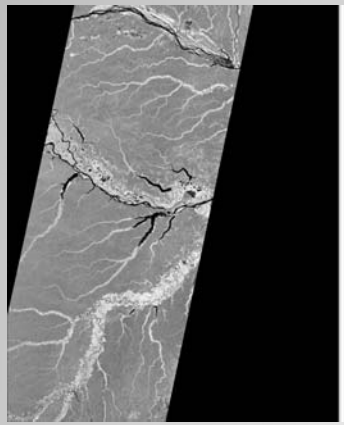
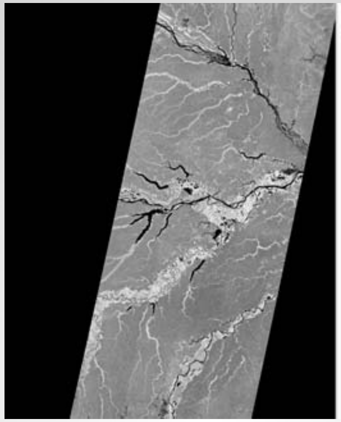
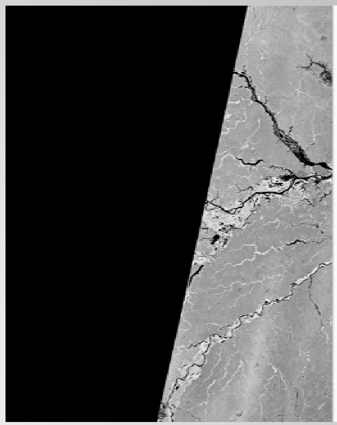


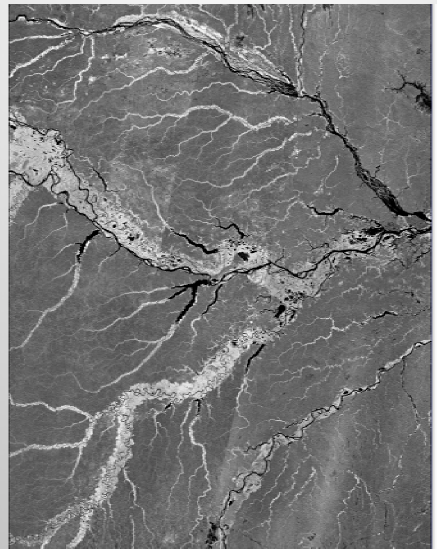
RSP 421



RSP 424



RSP 427



Mosaicking eliminates overlapping coverage

UTM tile 20M

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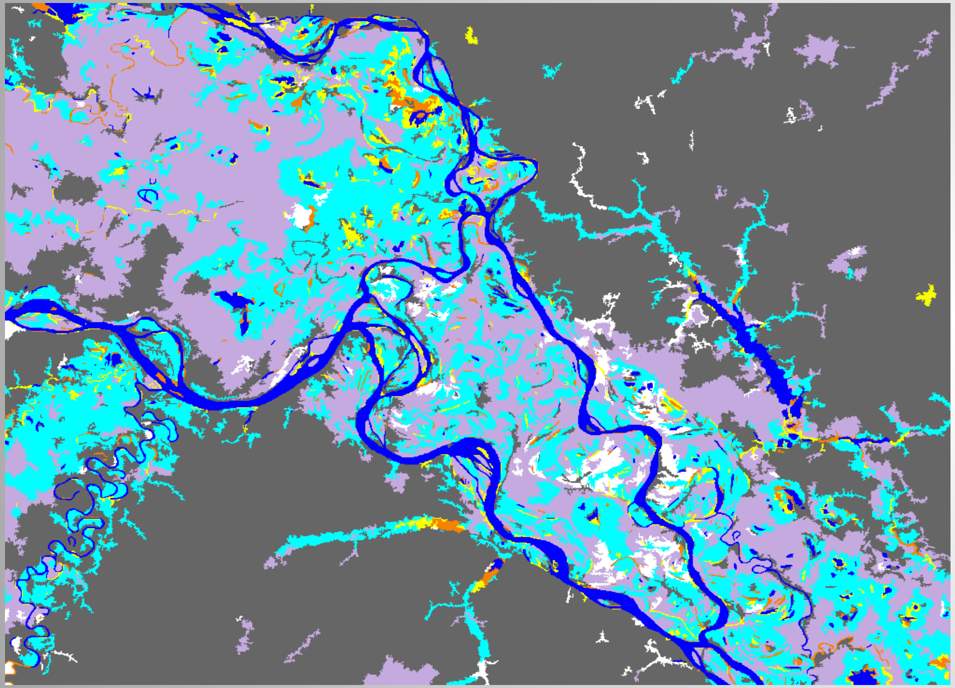
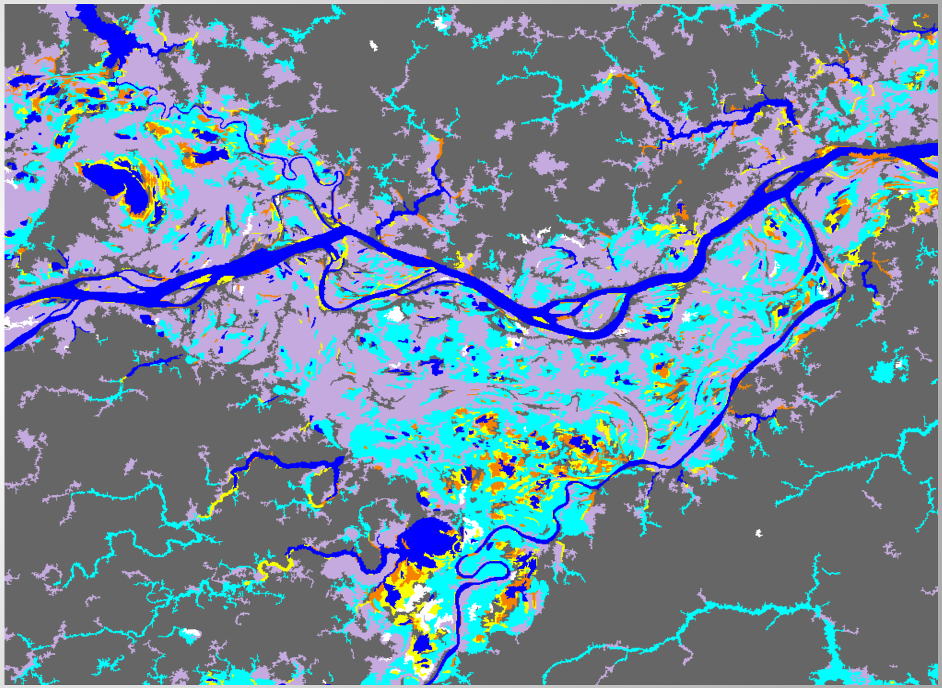
Wetland Habitat Mapping for Várzea Sustainable Development Reserves

Mamirauá

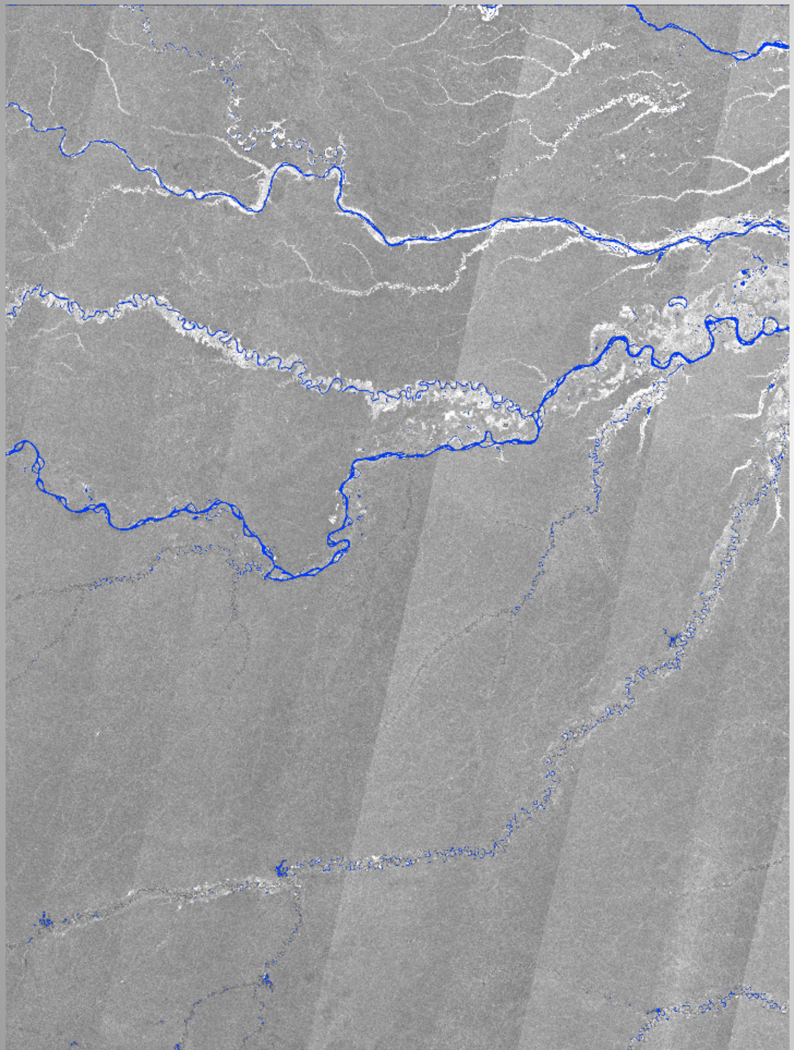


Piagaçu-Purus

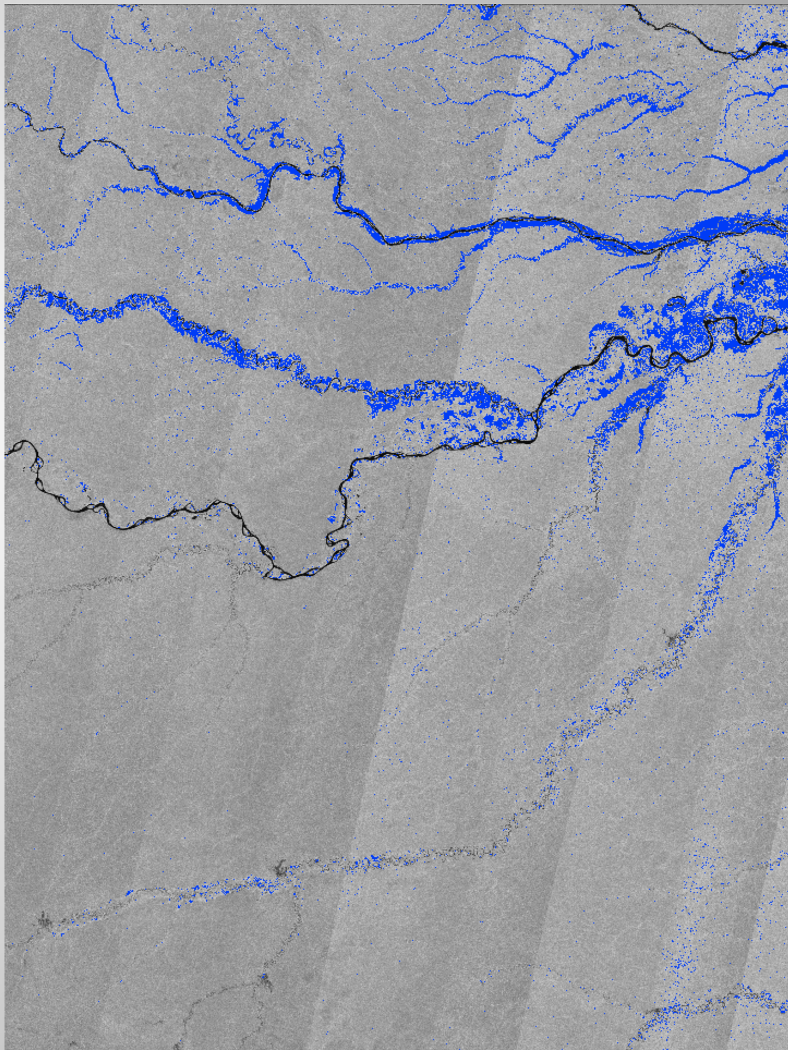


- Open water
- Aquatic macrophyte
- Shrub
- Non-wetland
- Forest, flooded 1-2 m/a
- Forest, flooded 3-6 m/a
- Forest, flooded > 6 m/a

Simple thresholds for identifying open water and inundated vegetation



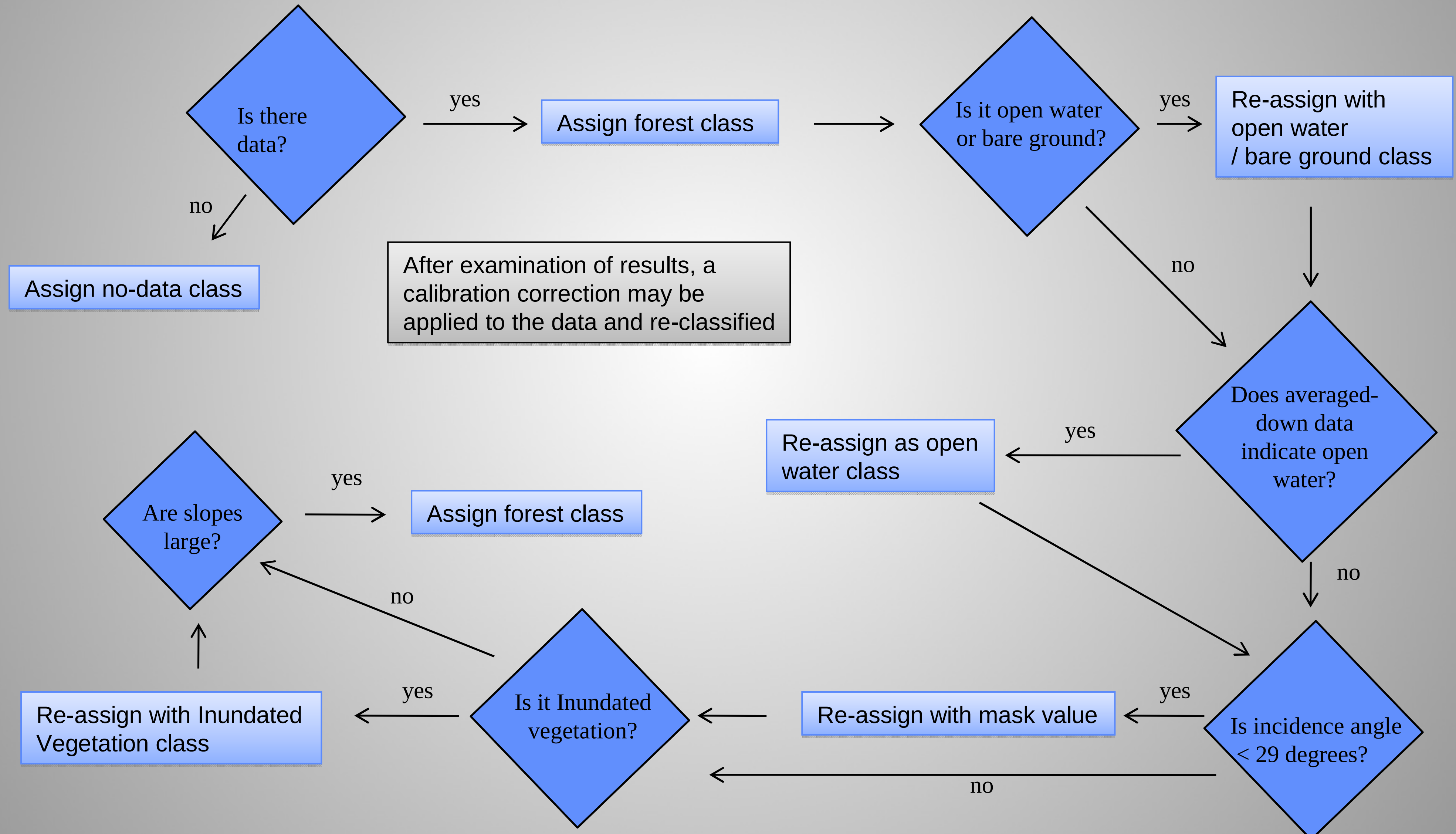
Open water → less than -10dB



Inundated Vegetation → greater than -6 dB

19M

Simple threshold-based classification



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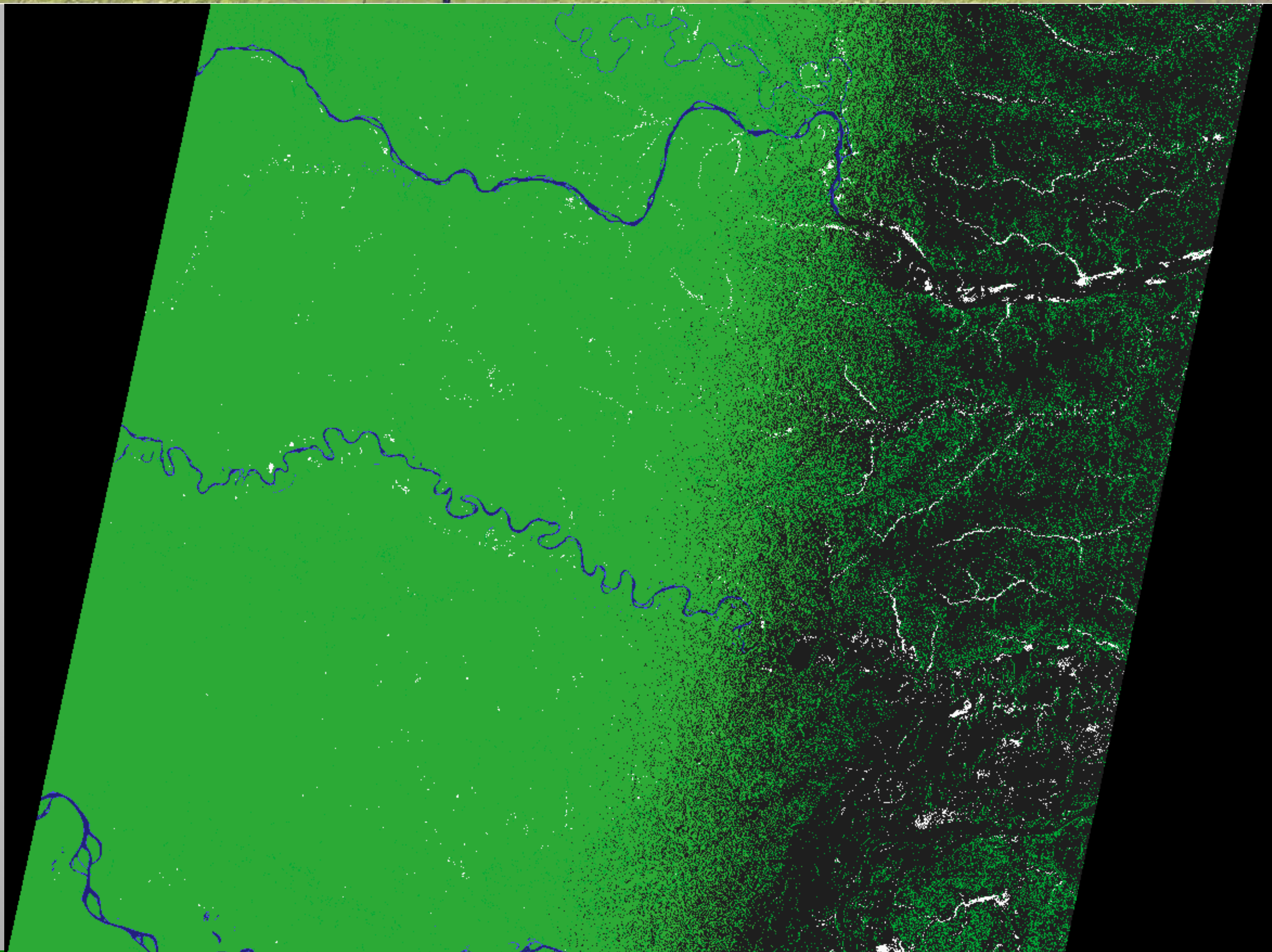

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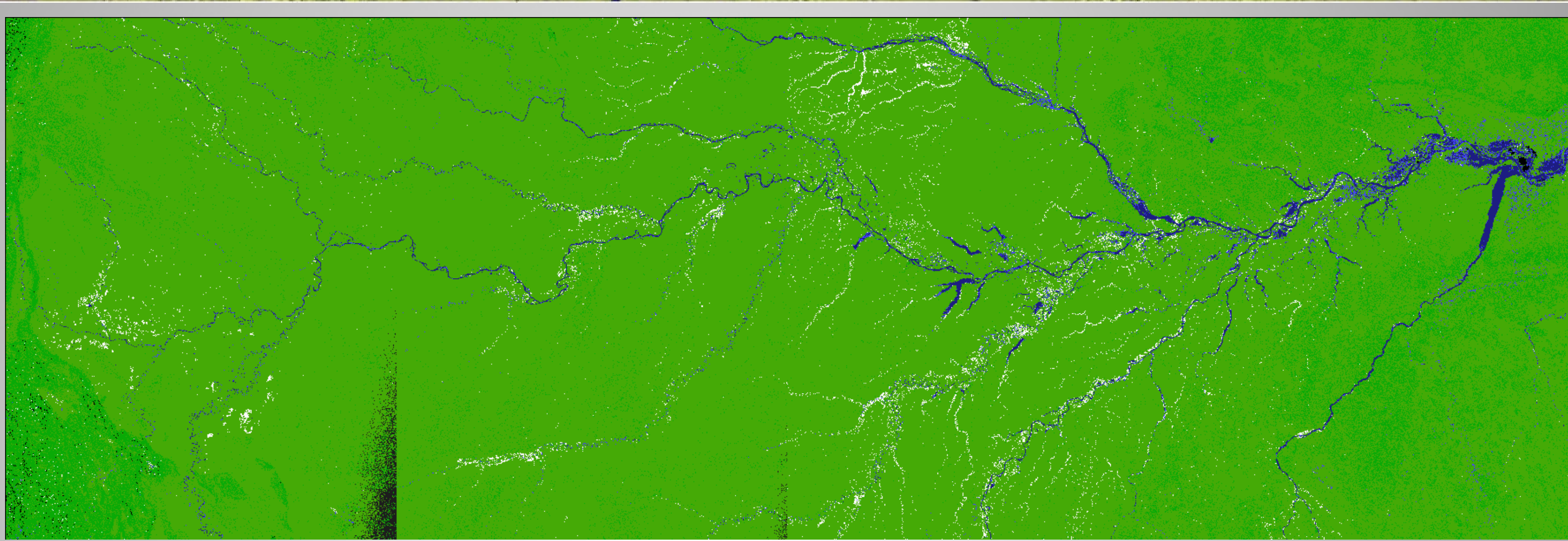
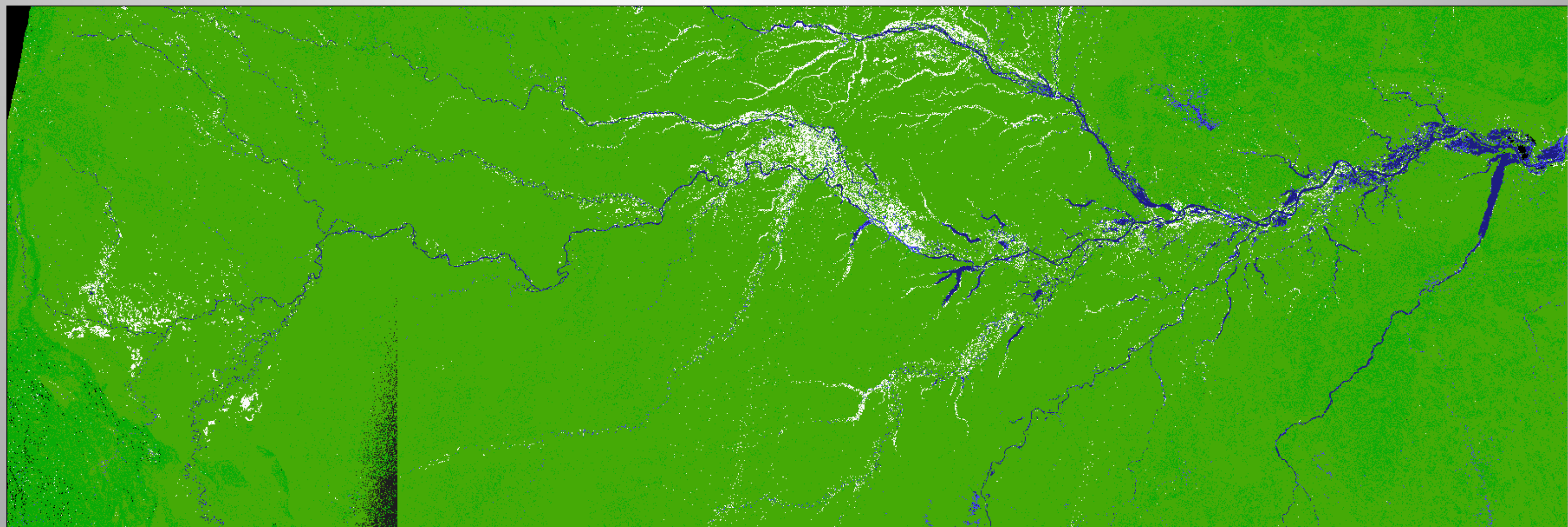
Early 2007

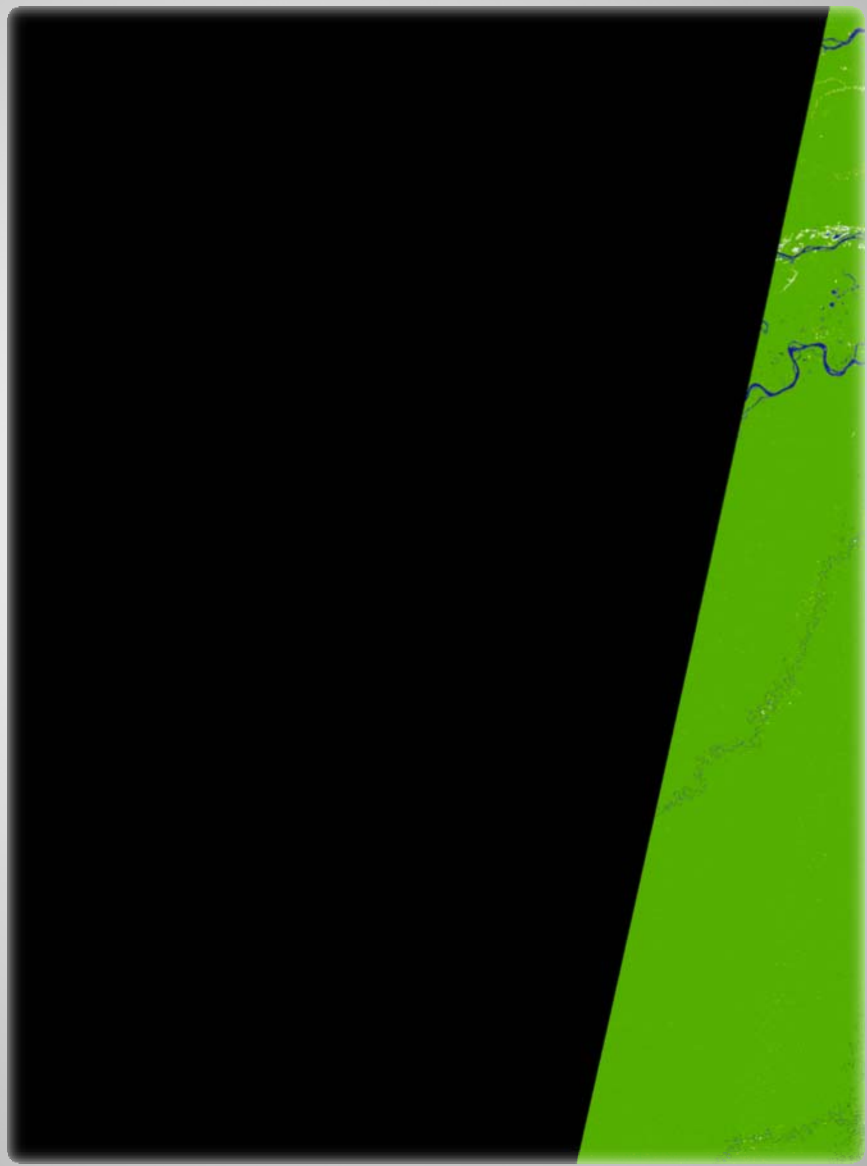


Mid 2007



Tile 19M

January 2007 - October 2008



Forest

Inundated vegetation

Open water or bare soil

Open water

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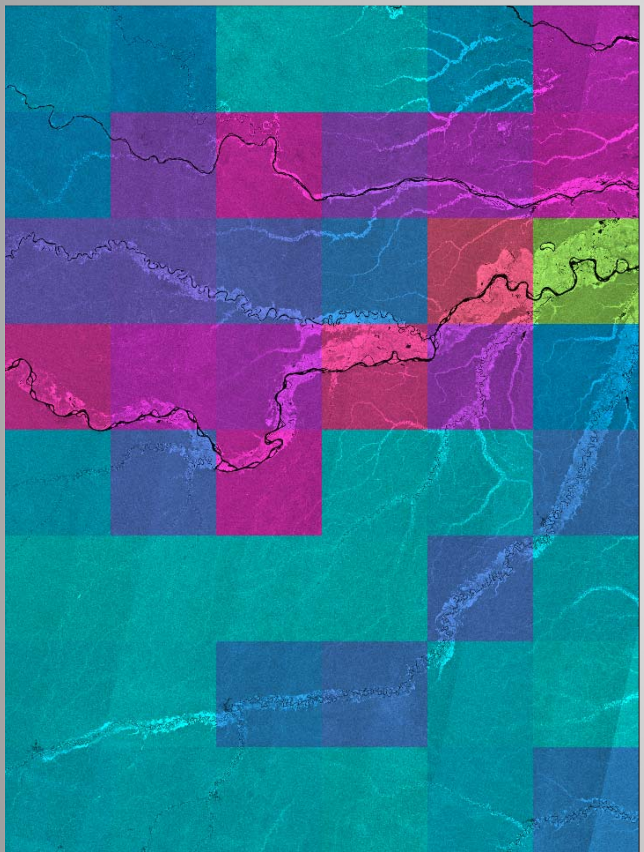
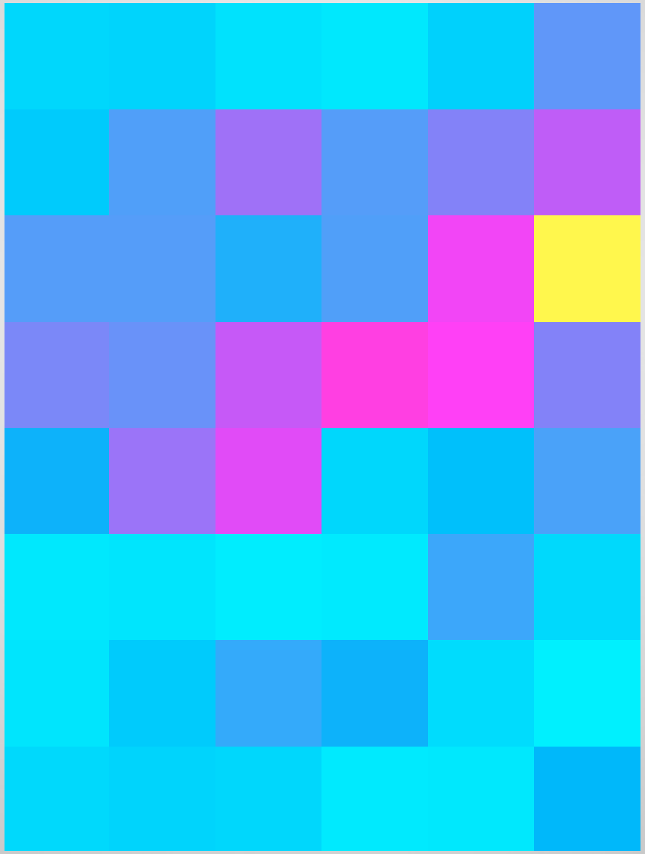
May-June 2007

Fraction for each 1deg x 1deg cell

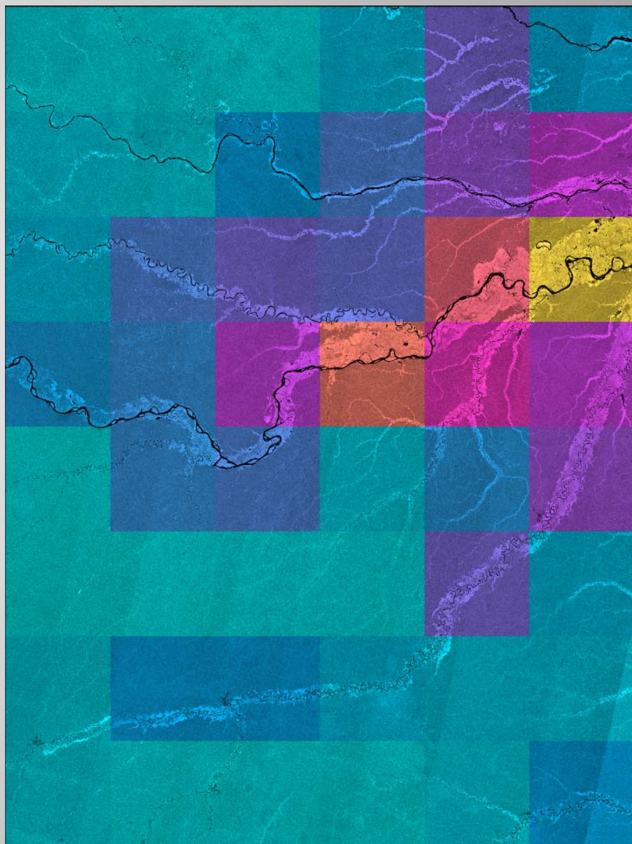
ALOS Open Water



AMSR-E/QSCAT Open Water



ALOS Inundated Vegetation



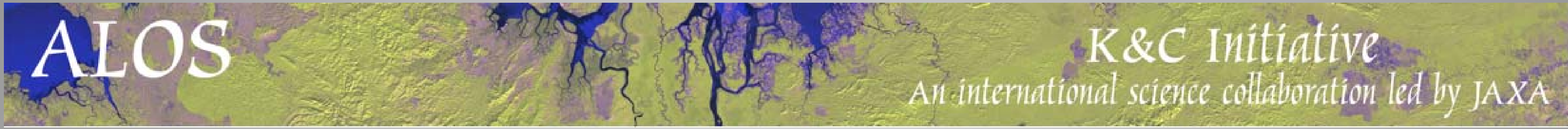
19M

Fraction open water

0% 5%

Fraction inundated vegetation

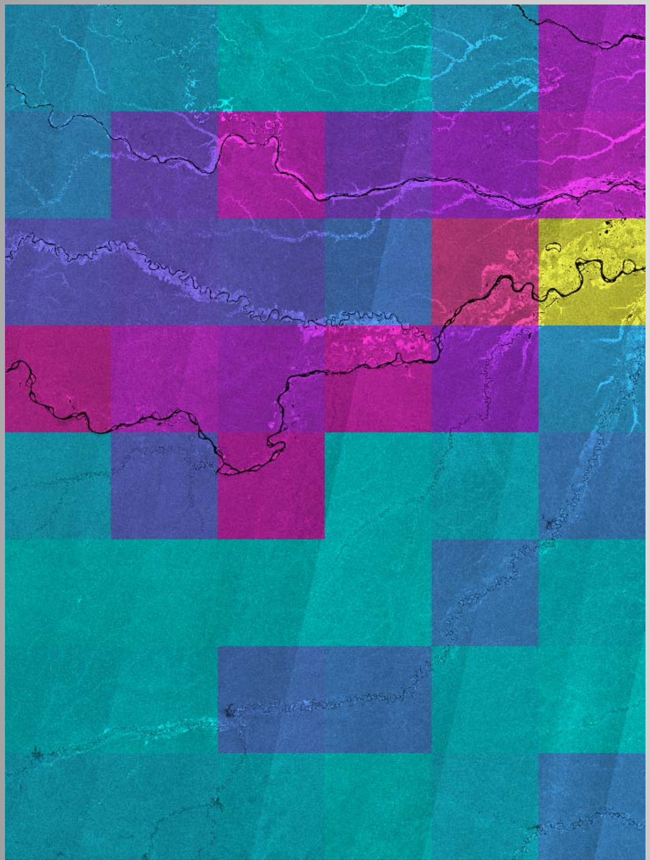
0% 40%



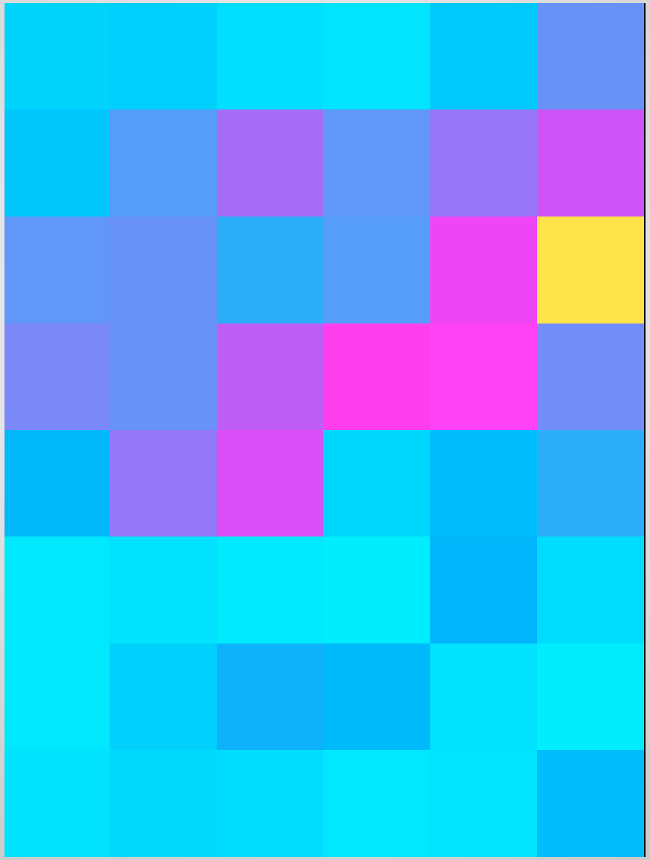
Fraction for each 1deg x 1deg cell

July 2007

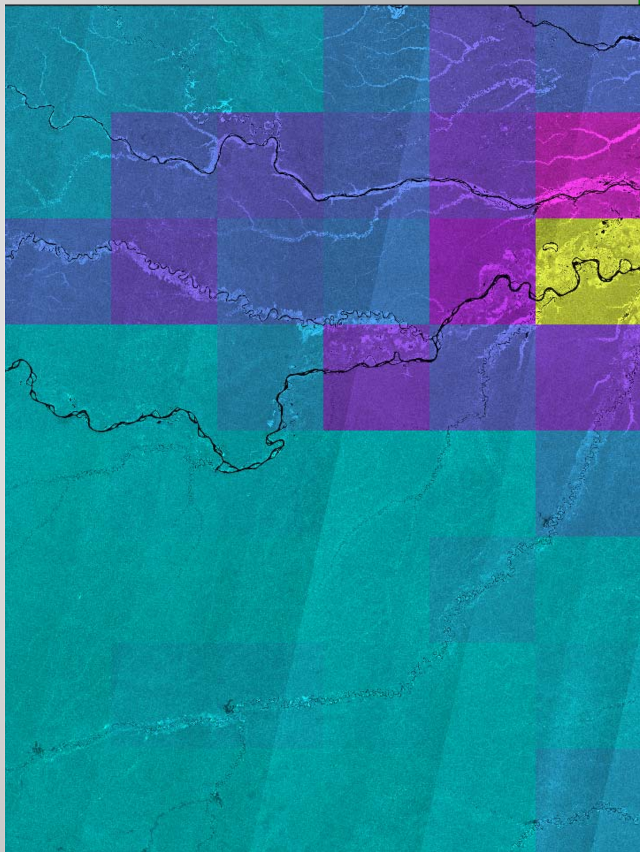
ALOS Open Water



AMSR-E/QSCAT Open Water



ALOS Inundated Vegetation



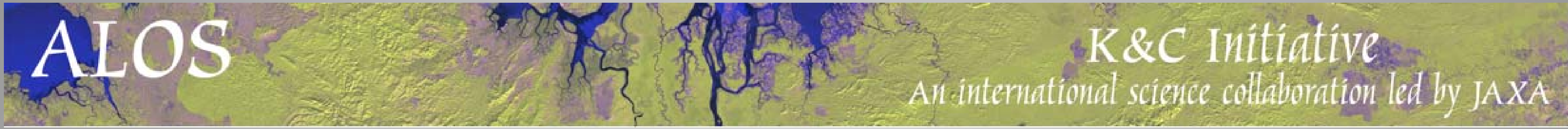
Fraction open water

0% 5%

Fraction inundated vegetation

0% 40%

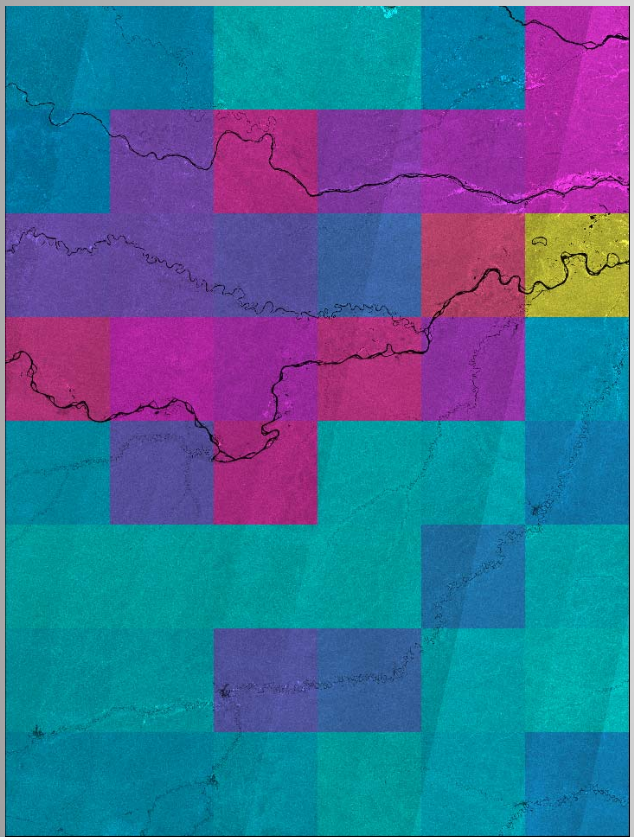
19M



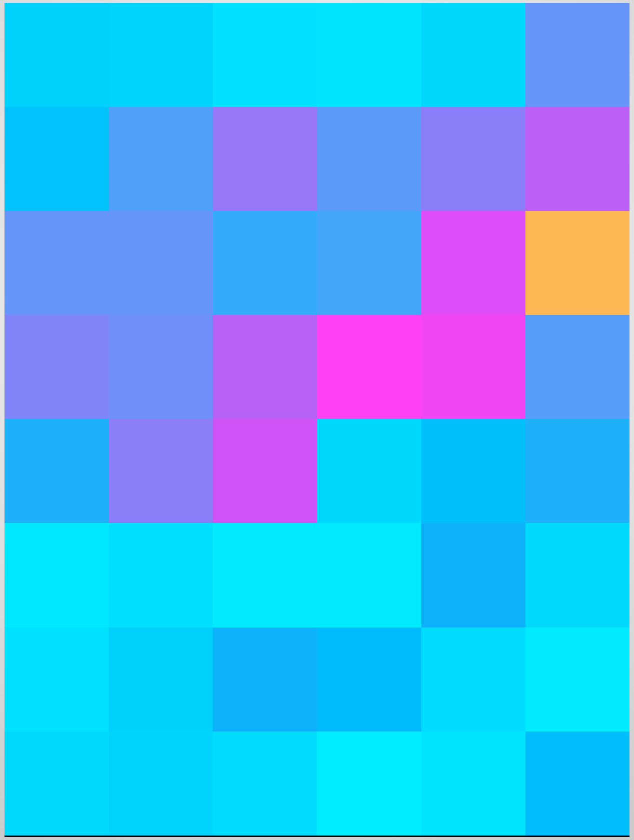
Fraction for each 1deg x 1deg cell

Aug-Sept 2007

ALOS Open Water



AMSR-E/QSCAT Open Water



ALOS Inundated Vegetation

19M

Fraction open water

0% 5%

Fraction inundated vegetation

0% 40%

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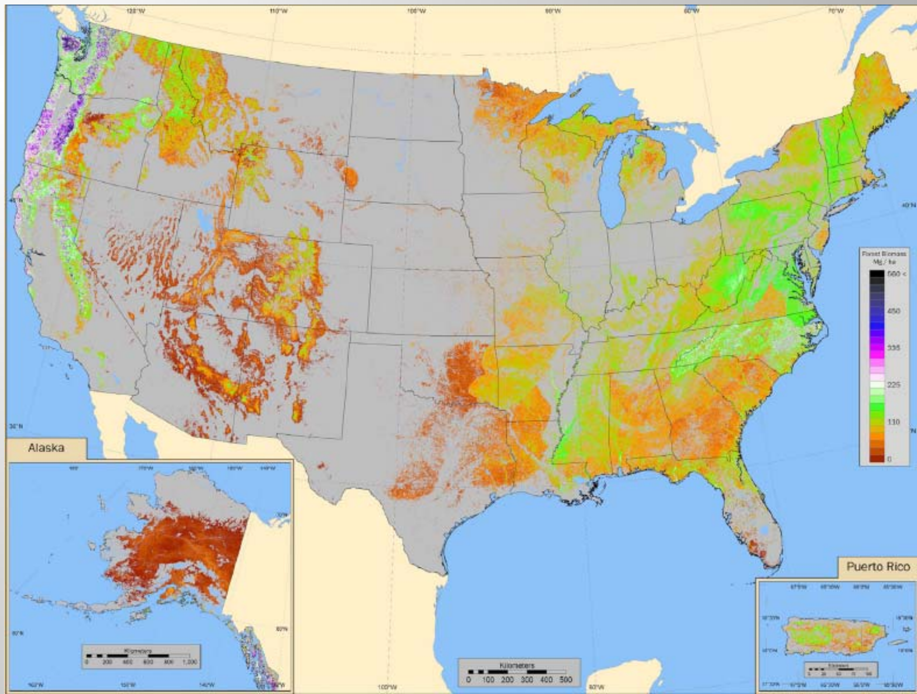
National Biomass Pilot Project

Estimating Biomass and Carbon Storage by Combining Satellite and Ground Observations

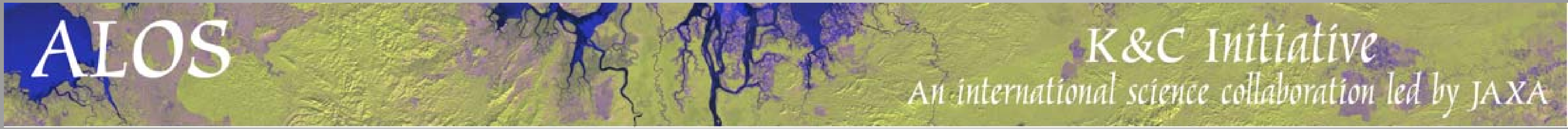
Center Leads:
Sassan Saatchi (JPL)
Rama Nemani (ARC)
Jeff Masek & Compton Tucker (GSFC)

Co-investigators:
Richard Birdsey (USDA/FS)
Michael Lefsky (CSU)

NASA/HQ Program Lead:
Diane Wickland



Project Domain



Terrestrial Biomass Pilot Project

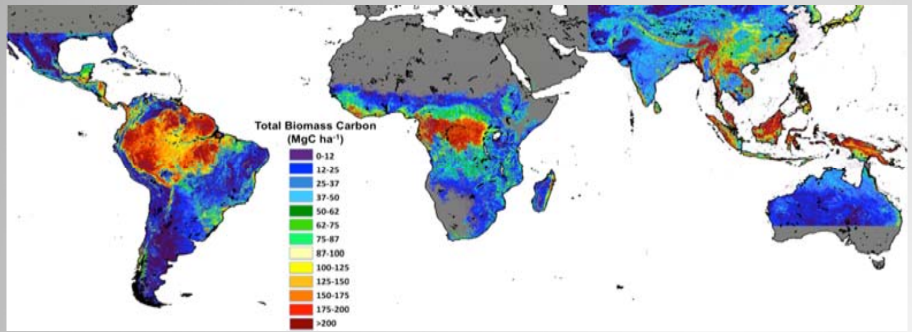
Goal:

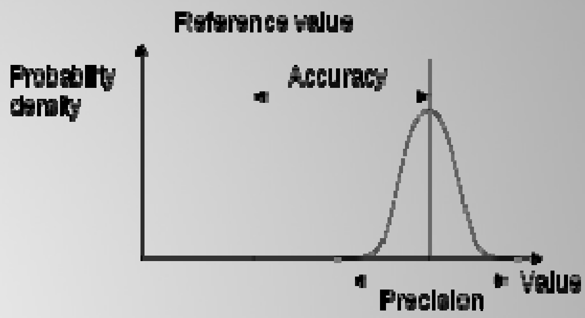
Provide geospatially explicit, consistent estimates of aboveground terrestrial vegetation biomass and carbon storage for the U.S. by combining advanced satellite products with ground observations and evaluate how well these estimates meet the nation's need for monitoring carbon storage and changes in carbon storage.

Objectives:

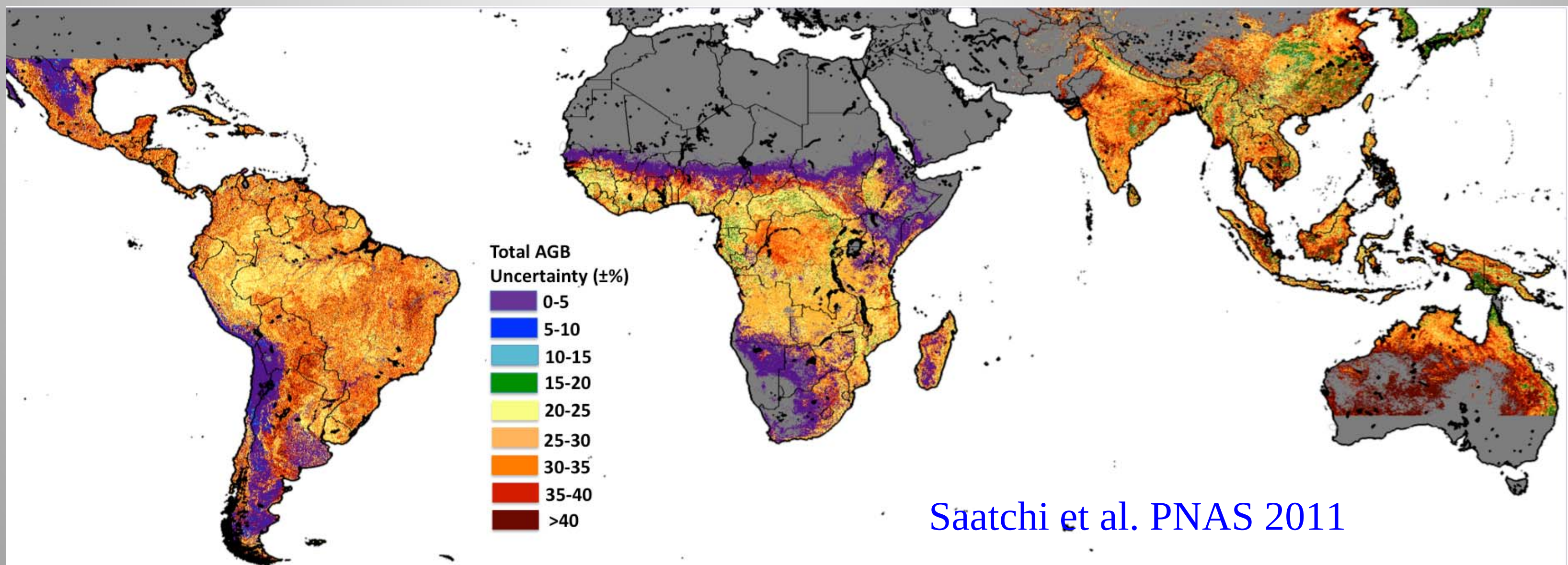
- **Develop prototype data products of national and global biomass (and carbon storage/change) that can be assessed with respect to how they meet the nation's need for monitoring (also reporting and verification) of carbon inventories.**
- **Demonstrate our readiness to produce a consistent global biomass/carbon stock distribution using the existing *in situ* and satellite observations to meet the monitoring (MRV) requirements.**

Pan-tropical Carbon Stock Distribution of Uncertainty



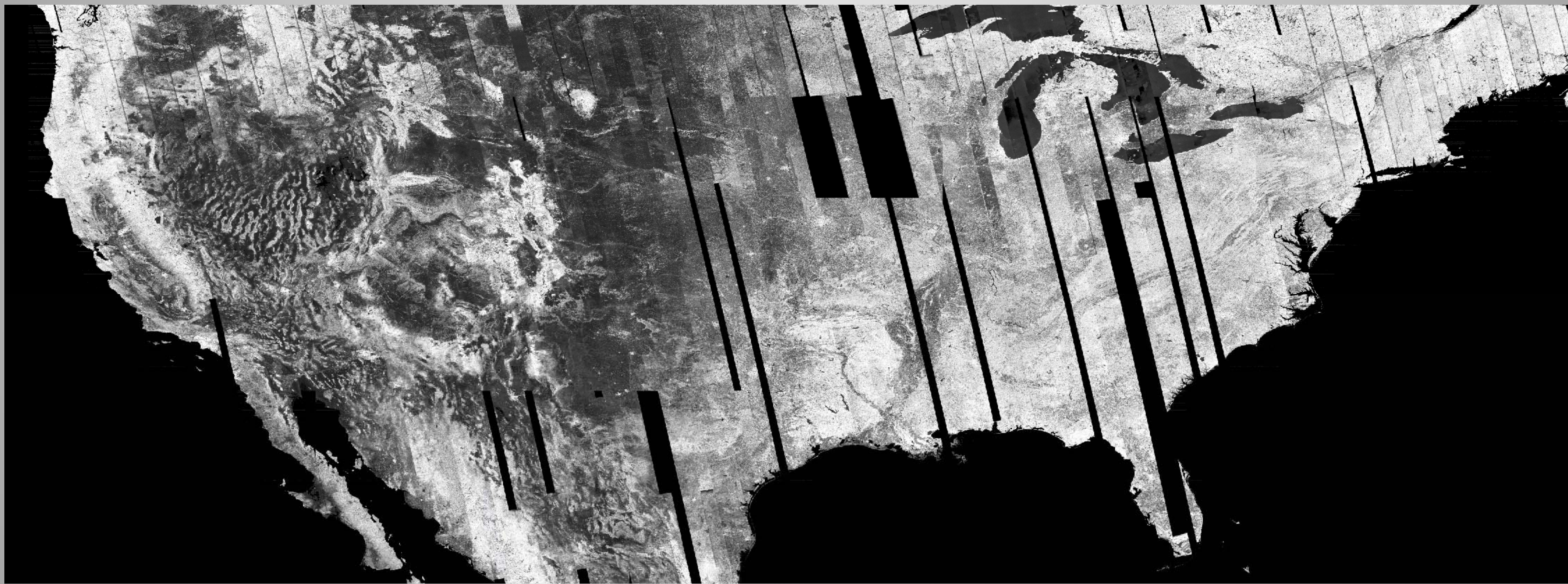


Errors: Measurement error (allometry), Sampling error, Prediction error



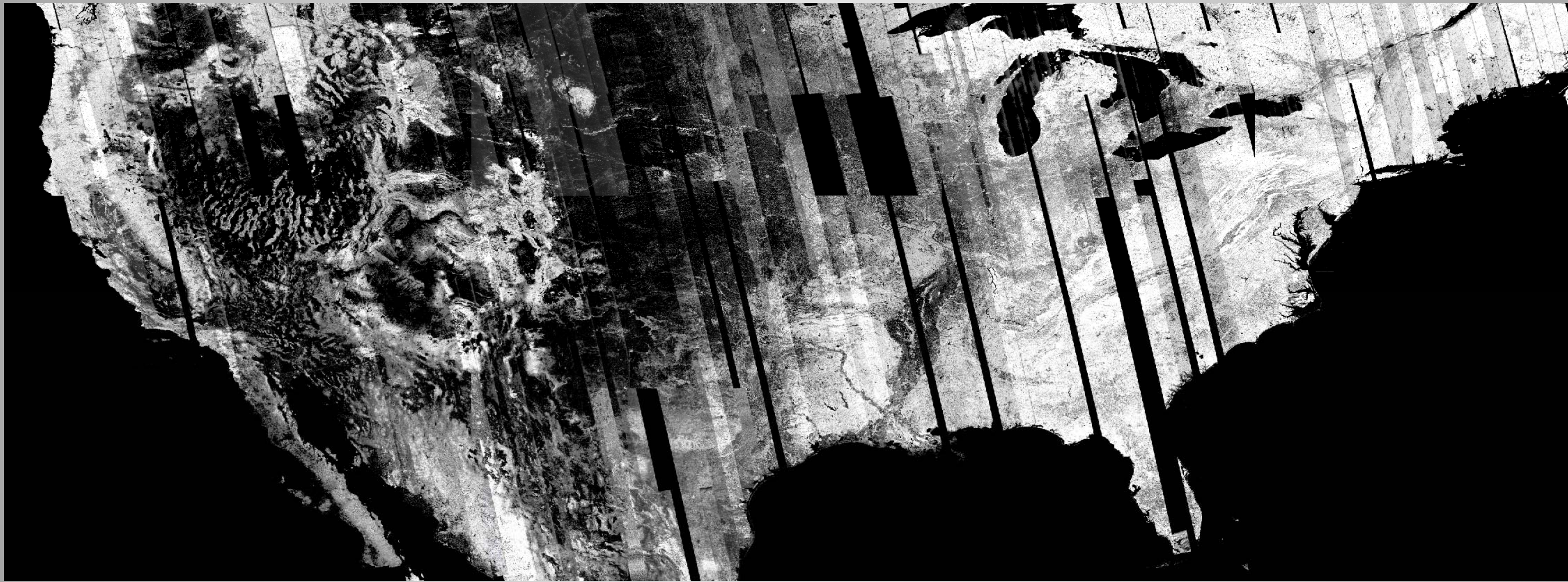
Saatchi et al. PNAS 2011

Continental HH US mosaic
full resolution: 90 m



Above 40 degrees, ALOS observations switch from every orbit to every other orbit. There is less overlap between images, and some banding at edge is introduced.

Continental HV US mosaic
full resolution: 90 m



Occasional absolute calibration error that must be corrected manually.

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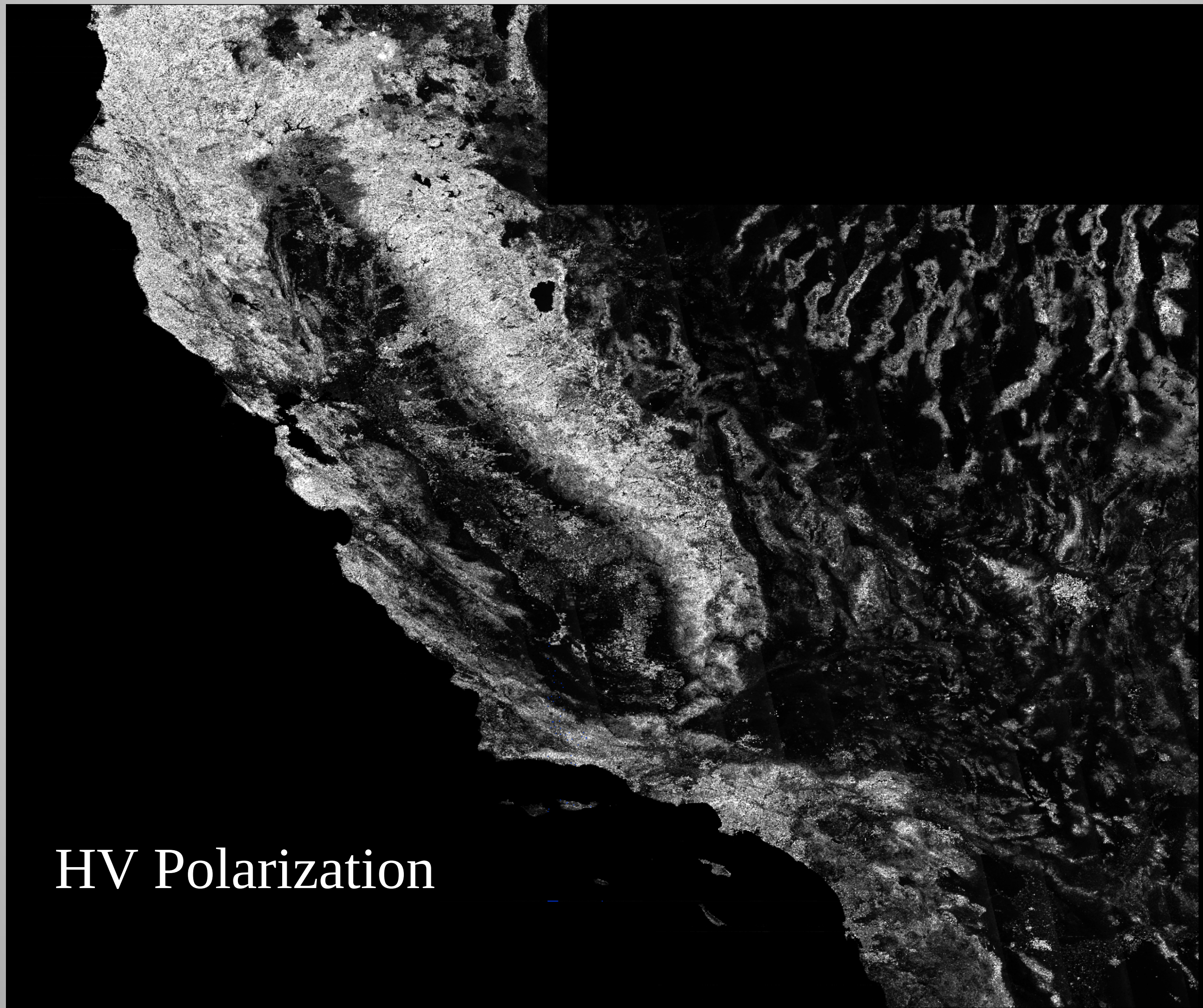
ALOS PALSAR California Mosaic



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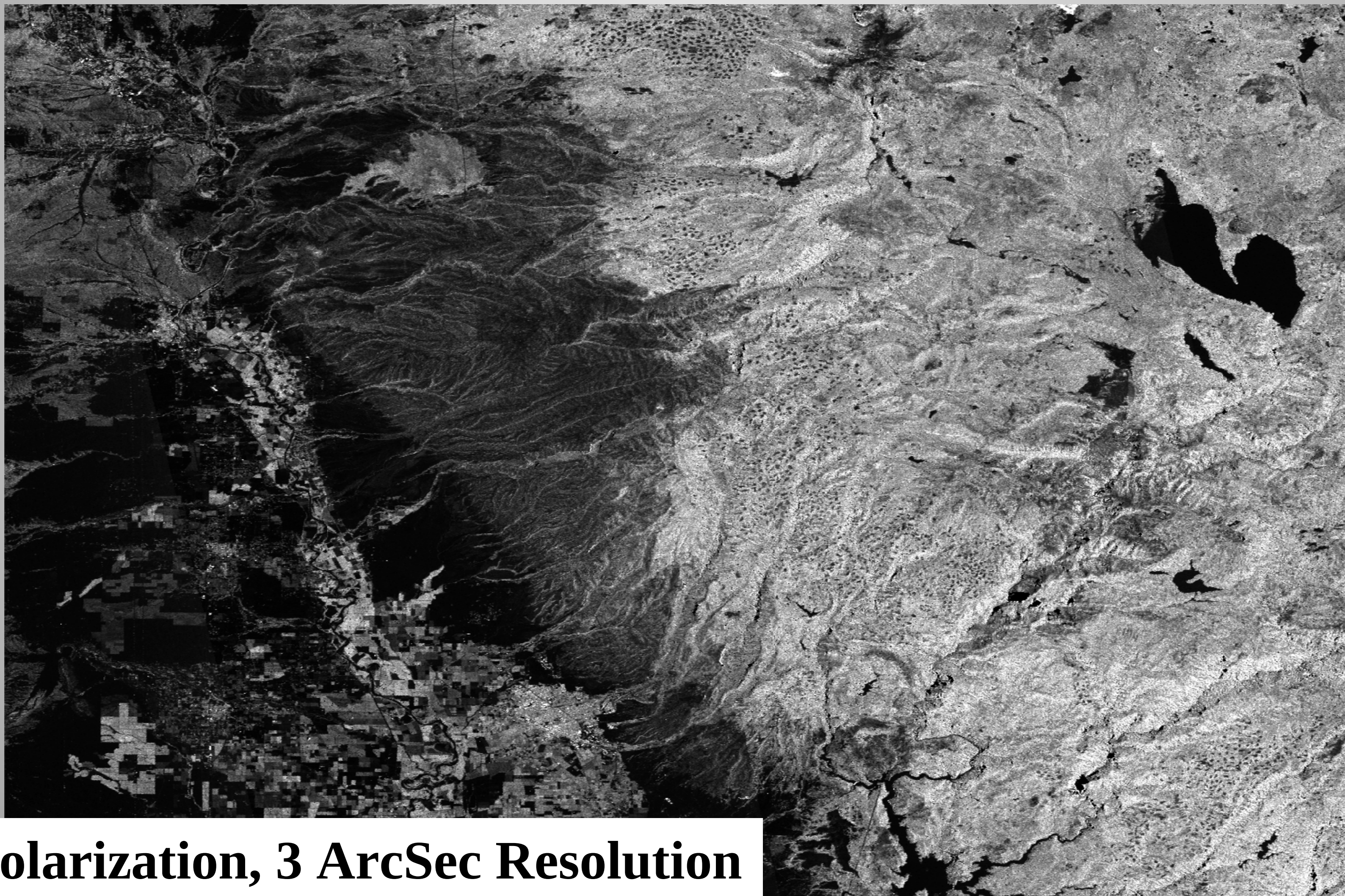
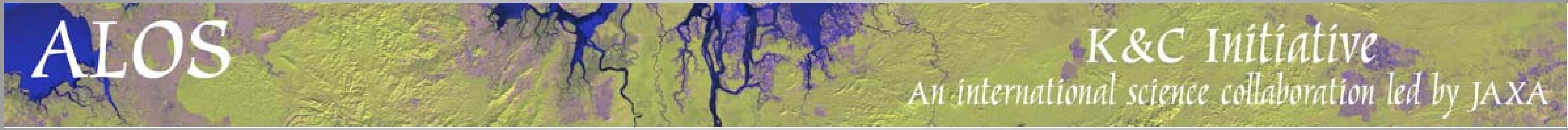
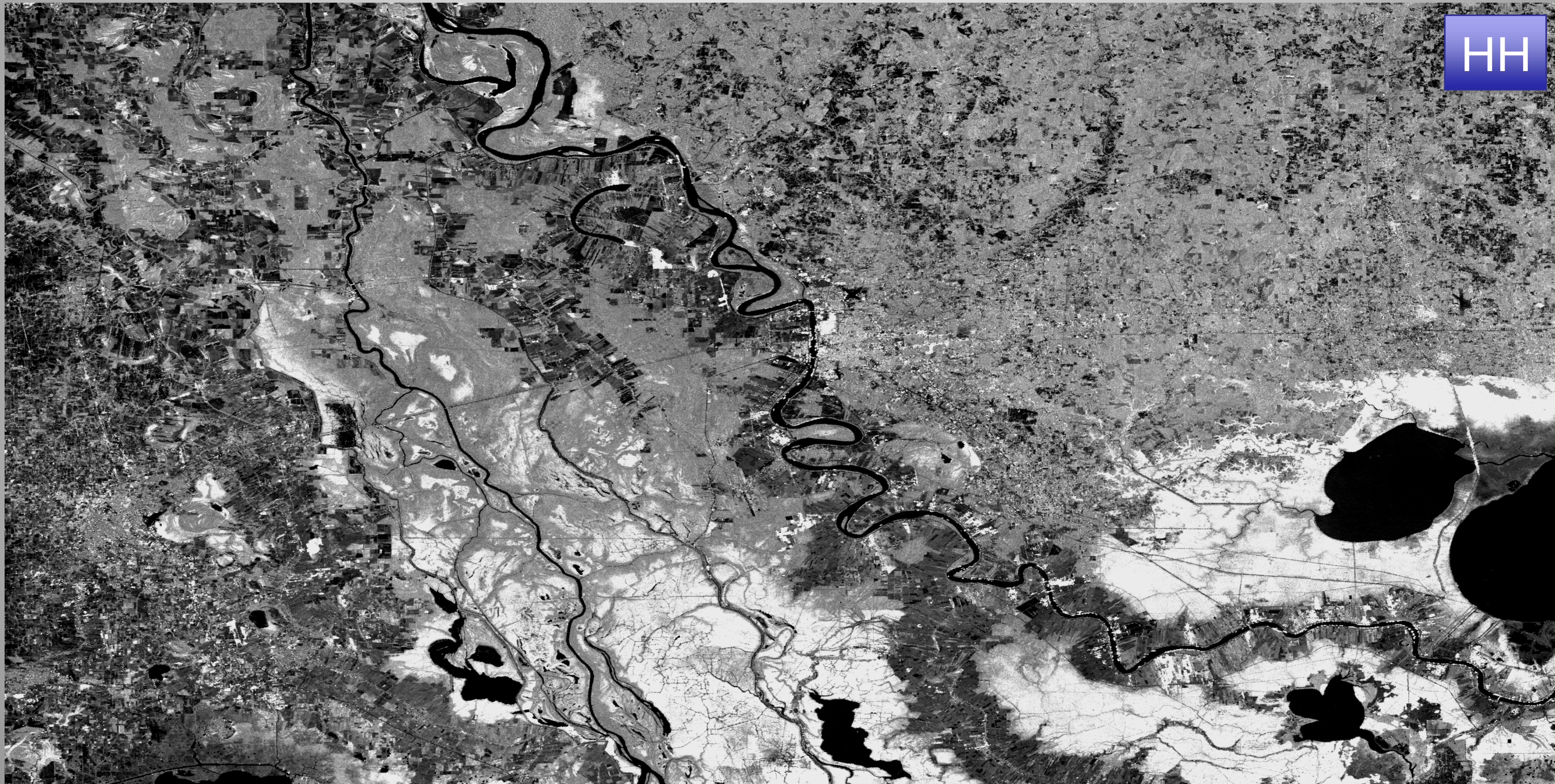
ALOS PALSAR California High Resolution



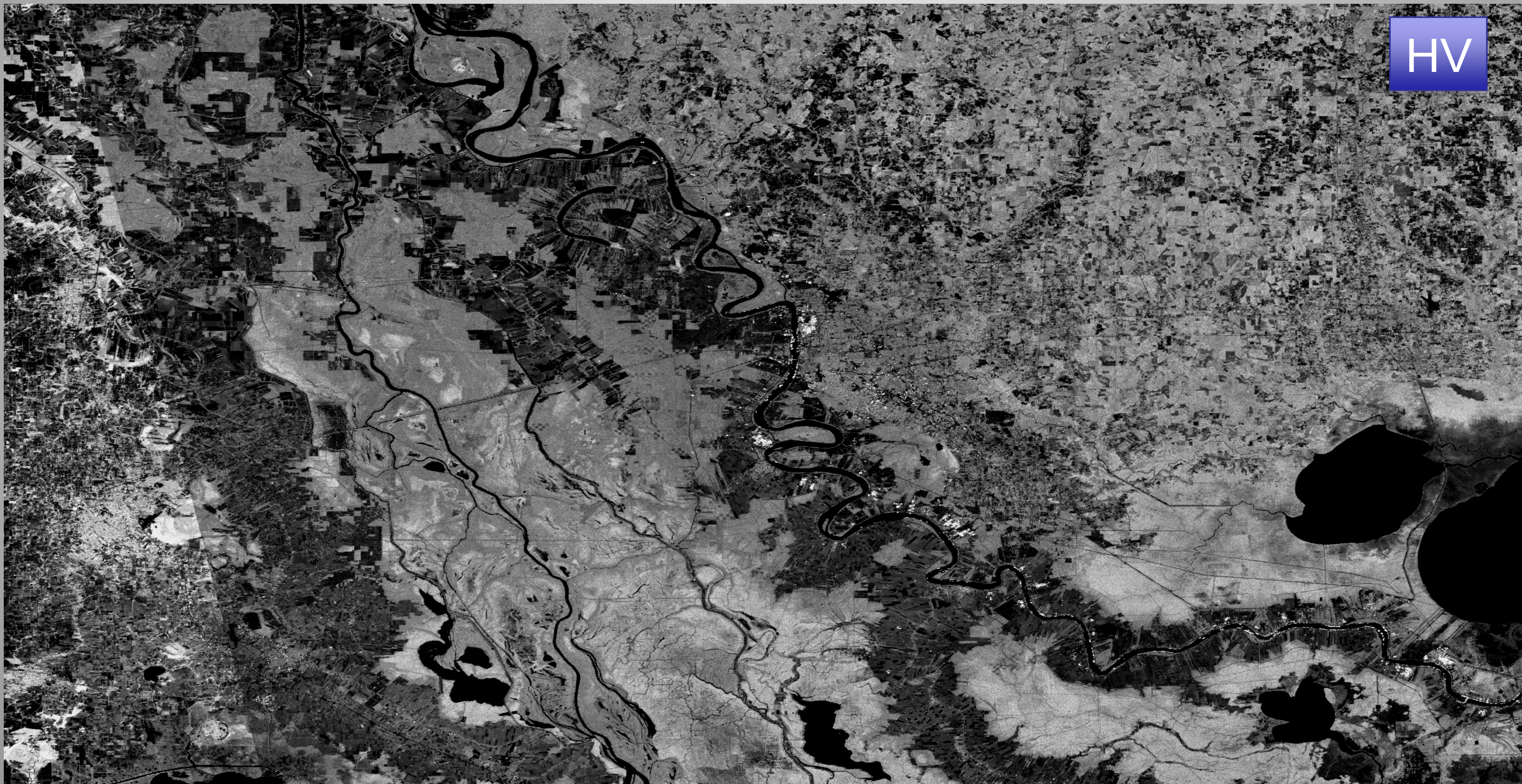
HV Polarization, 3 ArcSec Resolution



ALOS PALSAR Mississippi Delta



ALOS PALSAR Mississippi Delta



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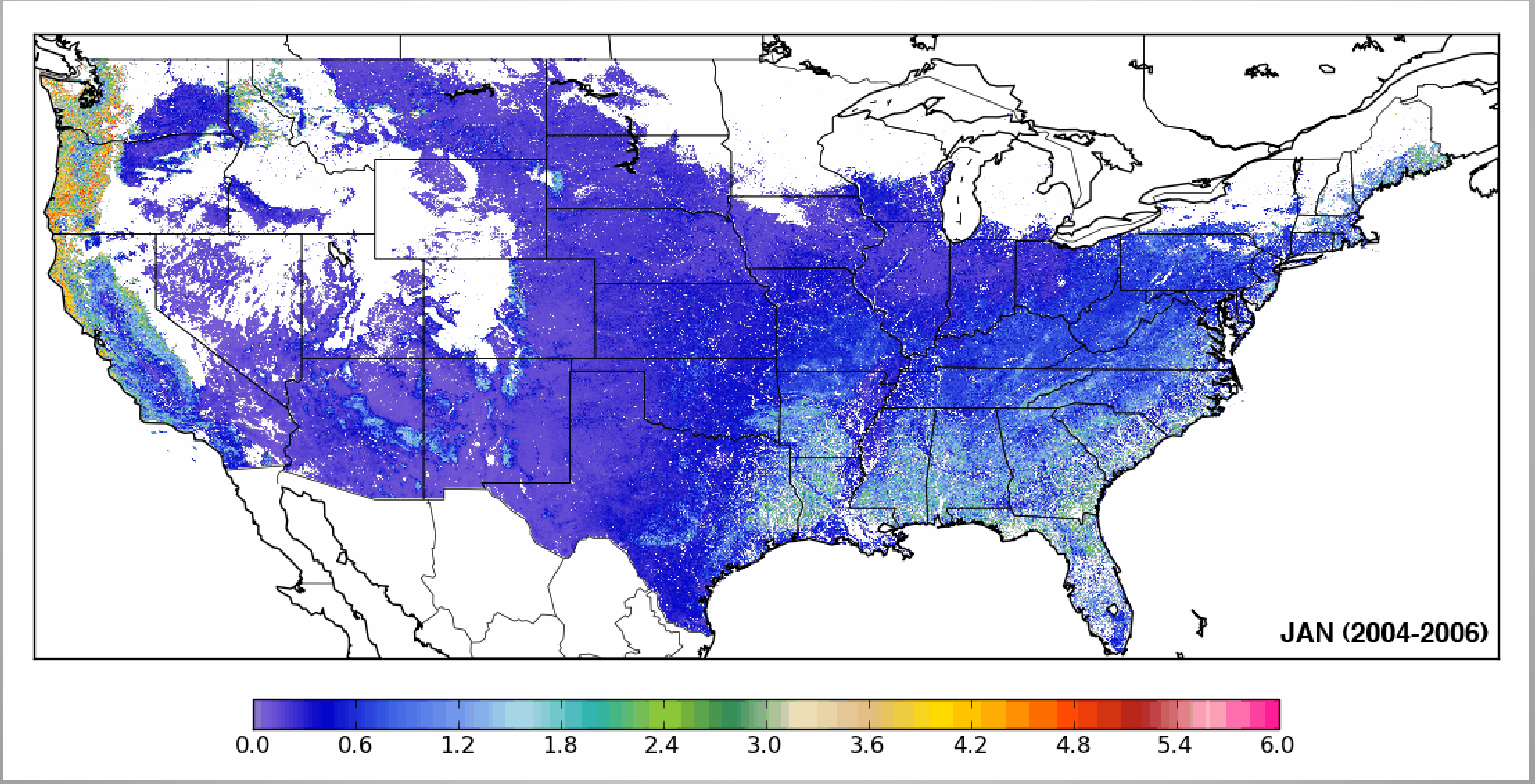
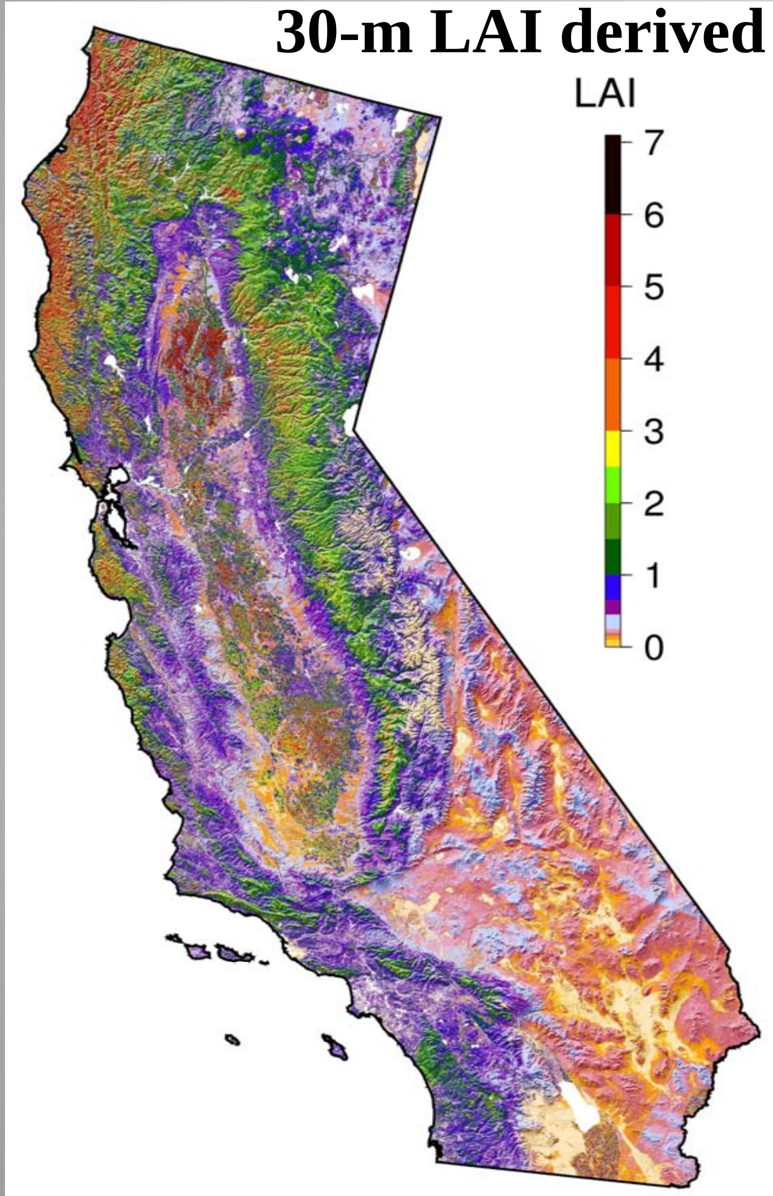
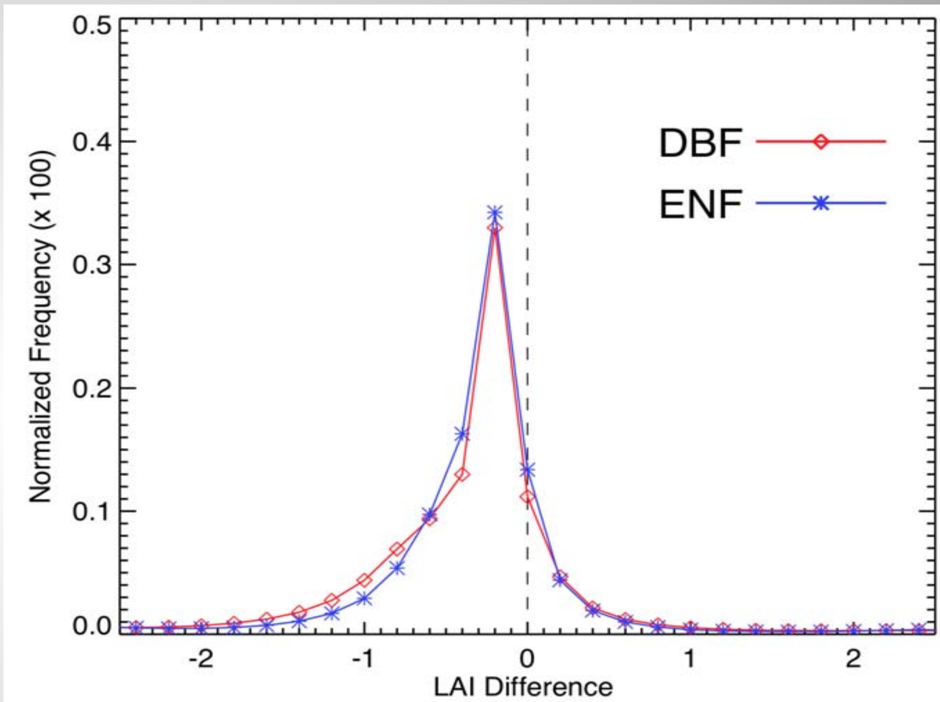
250-m LAI derived from MODIS

- MODIS monthly LAI Mosaic is provided at 250 m resolution
- Three years (2004-2006) of MODIS data were processed to improve image quality
- LAI estimation was implemented using the NLCD land cover map.



30-m LAI derived from Landsat and NLCD

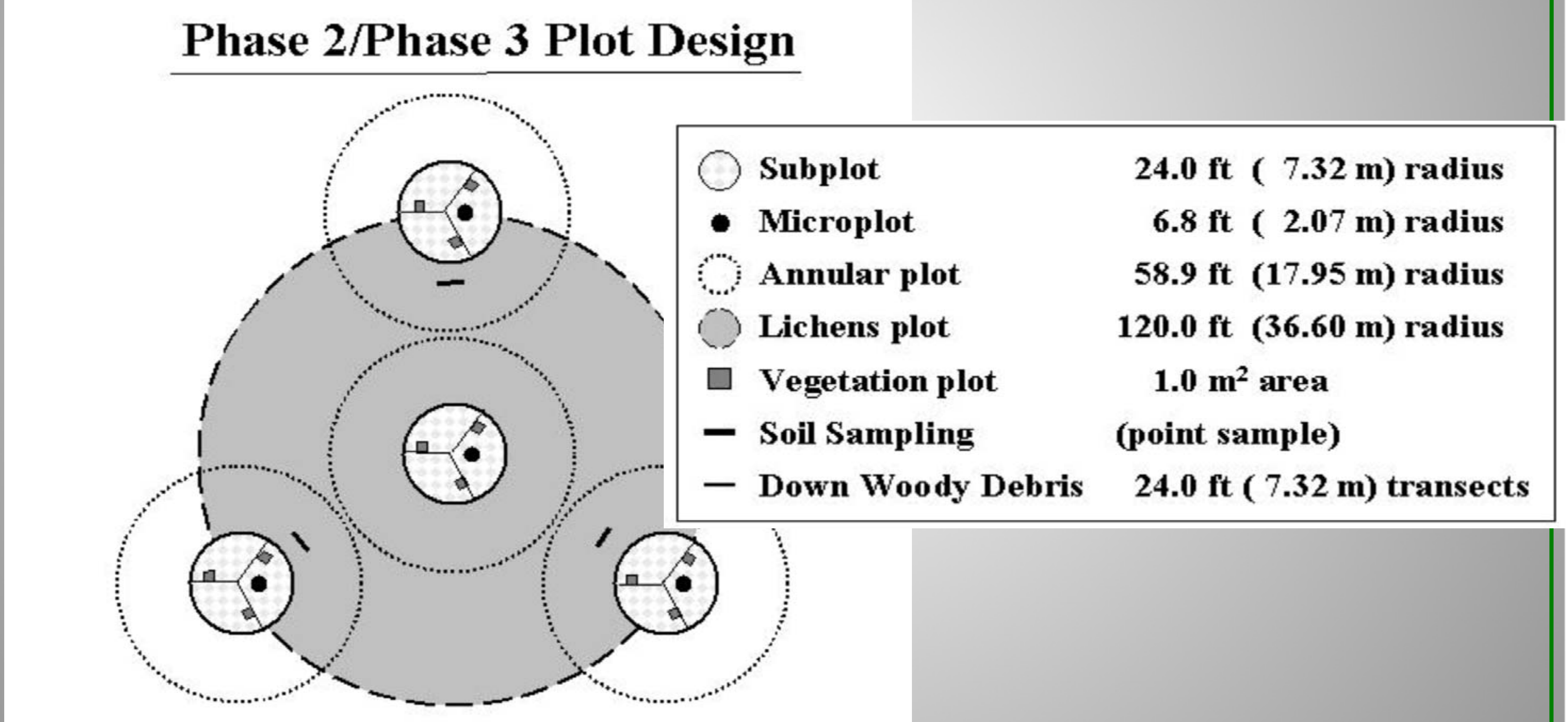




LAI difference between a 3-band inversion and 2-band inversion for pixels classified as DBF and ENF for California. The NLCD 2001 map is used to classify the forest pixels.

FIA Plot Design

Forest Spatial Variability and differences in Remote Sensing Pixel Size create significant errors in calibration and validation results



Non Parametric Model (MaxEnt)

1. Develop probability maps for a series of AGB ranges. The maps provide a probability values for suitability of each pixel for the prescribed biomass range (P_i)

2. Develop an estimator to choose the maximum probability of biomass range for each pixel.

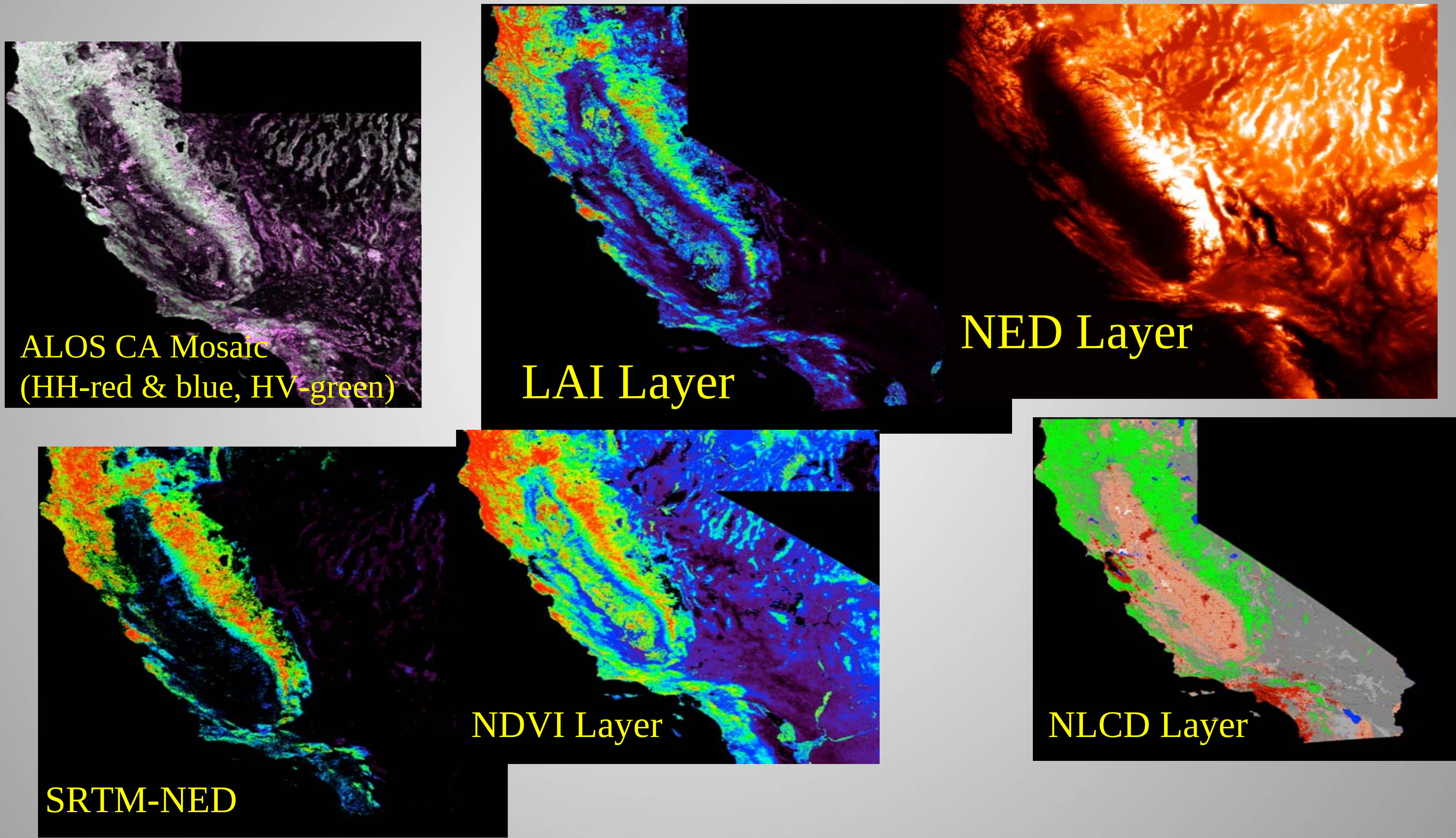
   Biomass range i (50-100 Mg/ha) has a median biomass value of B_i=75 Mg/ha and a probability of (P_i). A probability weighted estimator can be in a form of:

$$\hat{B} = \frac{\sum_i^N B_i P_i^n}{\sum_i^N P_i^n}, \qquad for \quad n = 1, 2, 3, \ldots\ldots\ldots.$$

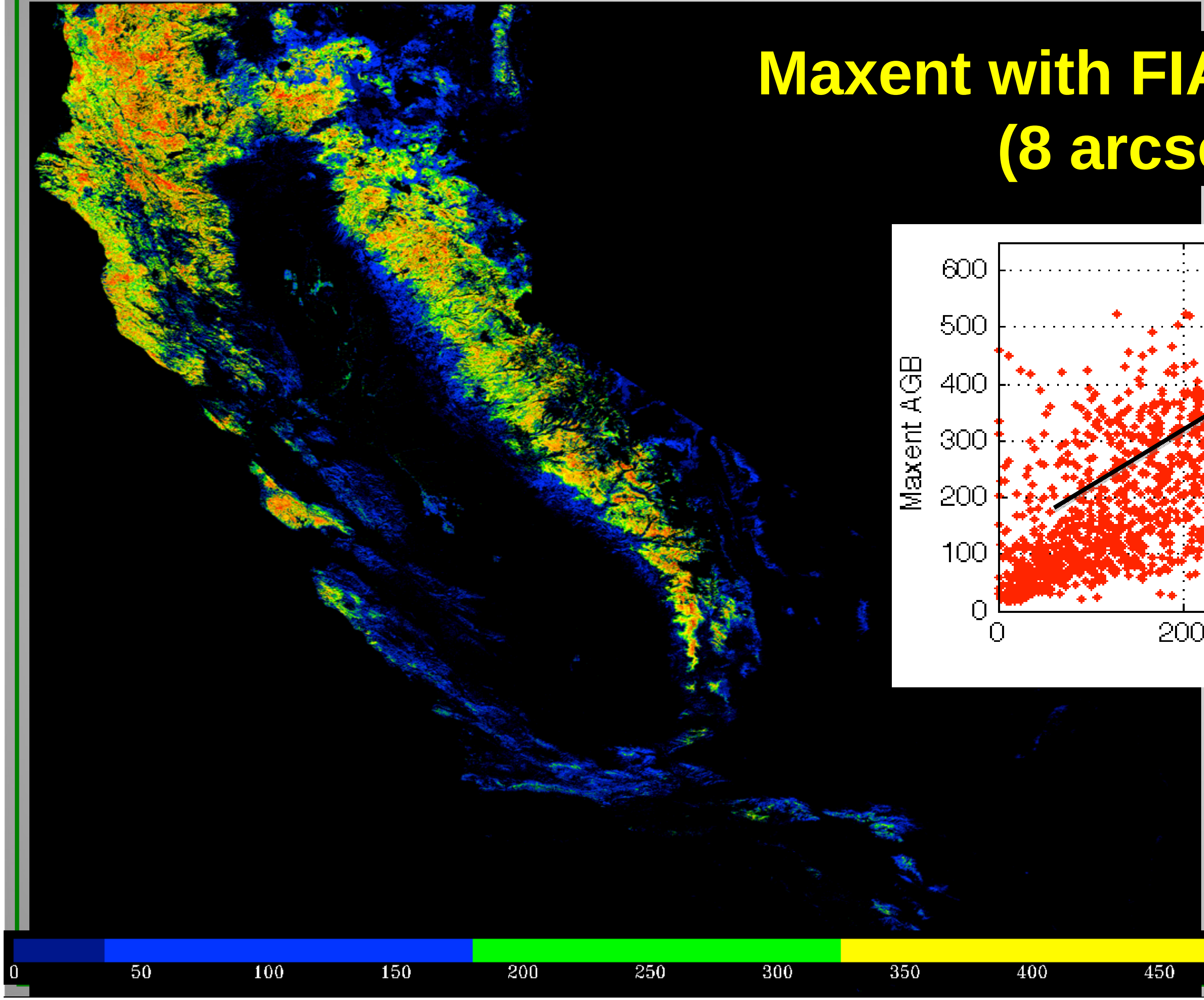
3. The RMSE associated with the estimator at each pixel is given by:

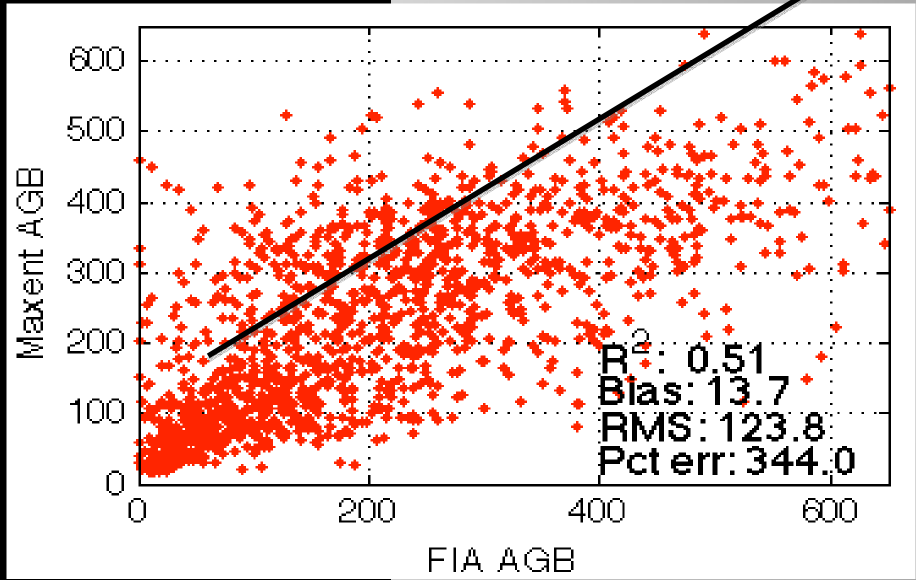
$$\sigma = \sqrt{\frac{\sum_i^N (B_i - \hat{B})^2 P_i}{\sum_i^N P_i}}$$

Non-parametric Model Implementation



Maxent with FIA Samples (8 arcsec)





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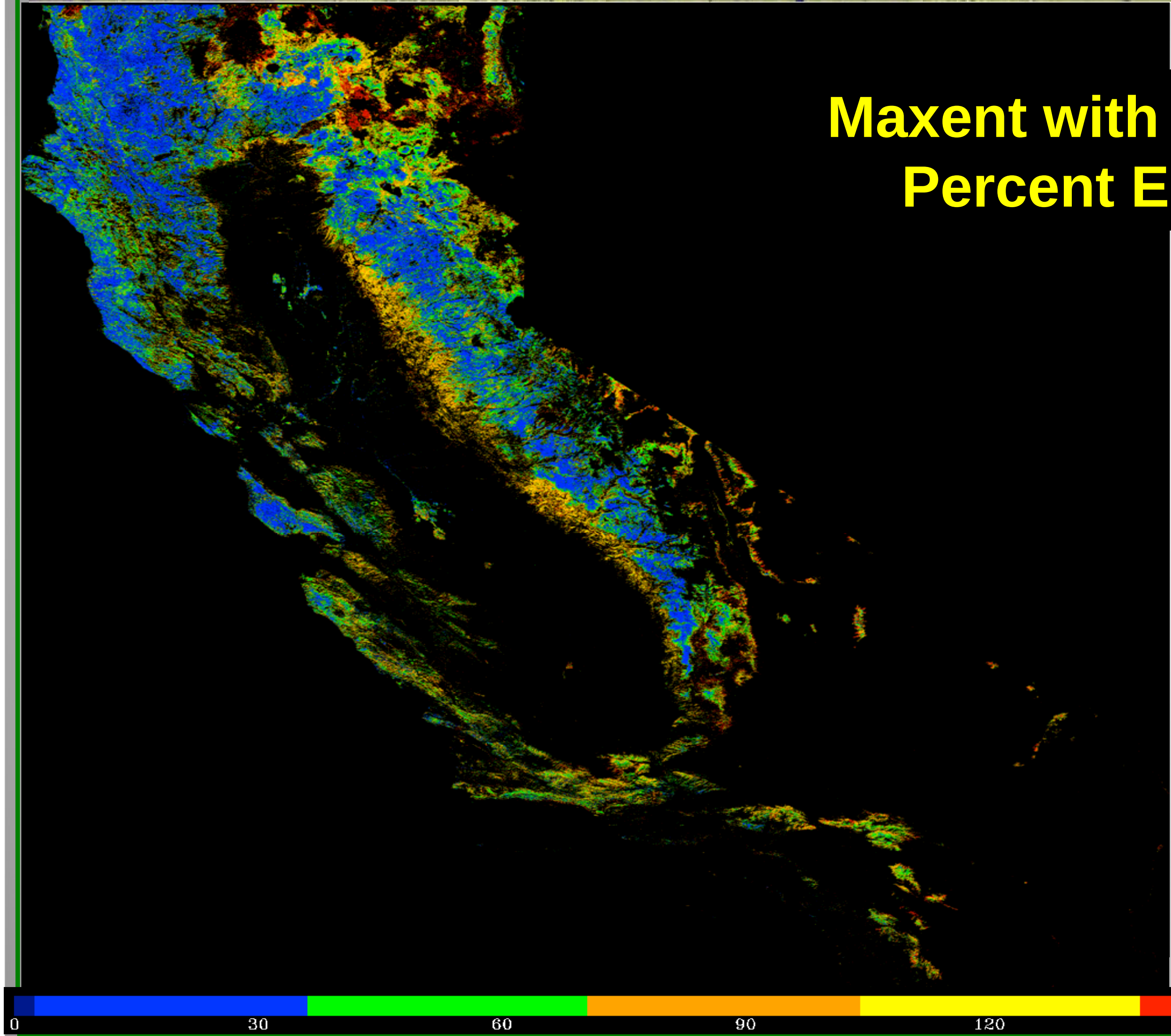
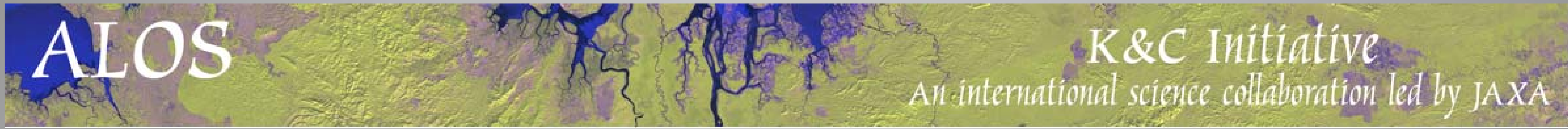
Maxent with FIA Samples Percent Error (8sec)



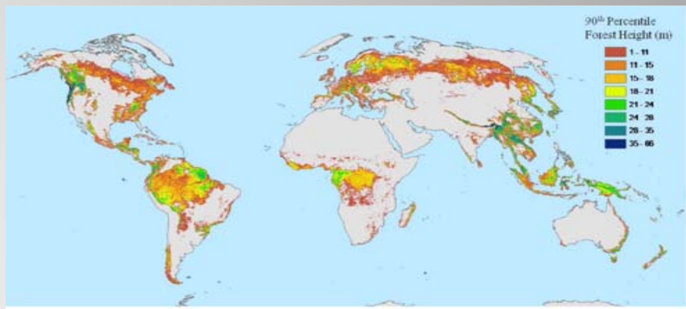


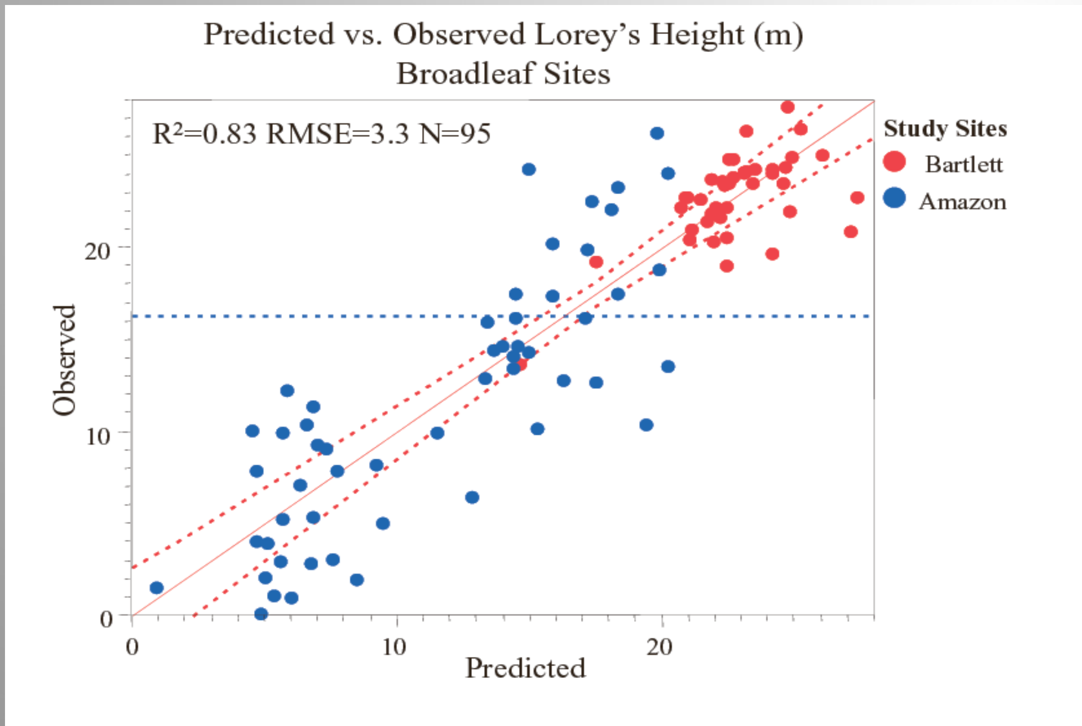
ICESAT GLAS Forest Height Metric

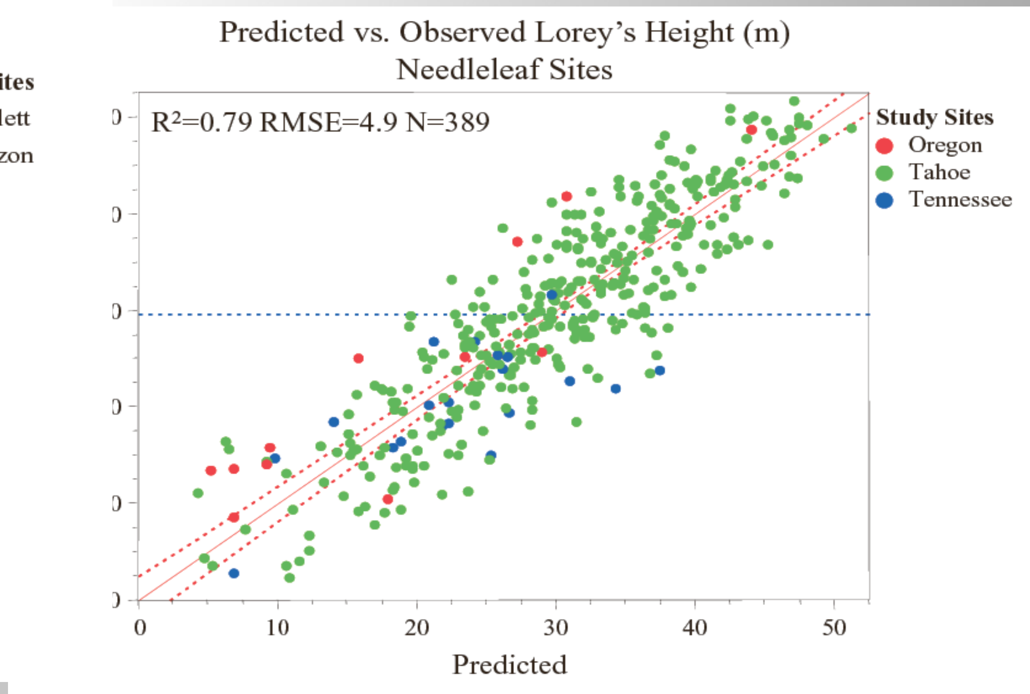
Lorey's Height Predicting Forest Biomass

(Lefsky et al., 2010)

$$H_{lorey} = \frac{\sum_{i=1}^{N} BA_i h_i}{\sum_{i=1}^{N} BA_i}$$ Basal area weighted height







Project Report

Project area(s)

- South America
  - in particular, the Amazon river basin
- Continental US and Alaska

- If possible, use acquired SCANSAR data to extend to other major wetland areas in Africa and Asia

Project objectives and schedule

Continue to orthorectify, calibrate, mosaic, and classify ALOS SCANSAR data over major wetland areas

Project Milestones:

- **Completed SCANSAR mosaics of S. America**
- **Wetland products – South America**
- **Completed FBD mosaics**
- **Biomass product for N. America**
- **SCANSAR mosaics of Boreal N. America**
- **Wetland products Boreal N. America**
- **Wetland products from other SCANSAR regions**

Support to JAXA's global forest mapping effort

- Compare the orthorectification results between the FBD and SCANSAR mosaic data and the orthorectified FBD 25 m mosaics in locations of overlap.
- Develop wetland extent products from SCANSAR data
- Provide biomass map for N. America from from NASA *Carbon Monitoring System*

Deliverables

Planned output

- **Calibrated and orthorectified SCANSAR data over S. America**
- **Inundation classification**
- **Calibrated and orthorectified FBD data over N. America**
- **Inundation classification**
- **Algorithm documentation**

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