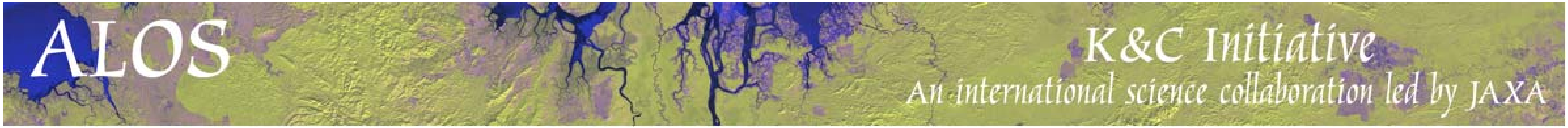

K&C Phase 4 – Status report

Mapping Wetlands, Surface Structural Attributes, and Boreal Freeze/Thaw at Regional Scales with JAXA SAR Datasets

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Science Team meeting #22
Tokyo, Japan, February 16-18, 2016

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Mapping Wetlands, Surface Structural Attributes, and Boreal Freeze/Thaw at Regional Scales with JAXA SAR Datasets

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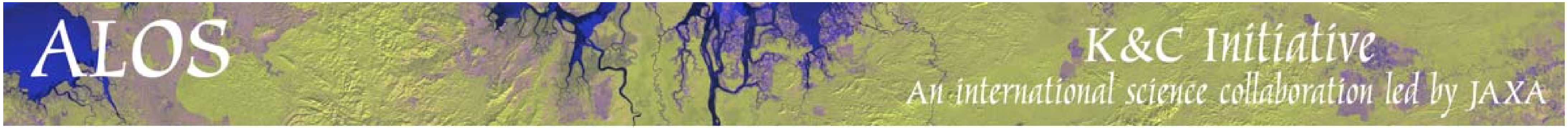
Kat Jensen, Brian Lamb, Aaron Davit,
Jessica Rosenqvist, Jessika Alvarez, Rehnuma Islam



Project Objectives

Wetlands

Extension of on-going wetlands work

- 30-year record: JERS, PALSAR, PALSAR2

  Alaska, Canada

  South America

  Great Lakes

  Africa

New Wetlands Regions

  Chesapeake Bay – Estuarine carbon, Land-ocean exchange

  New England (Maine) – Land-ocean carbon exchange

  River Deltas – Carbon & Conservation

  Boreal peatlands - Canada

Project Objectives

Biodiversity and Structure

Amazon and Brazilian Atlantic Coastal Forest

– Biodiversity

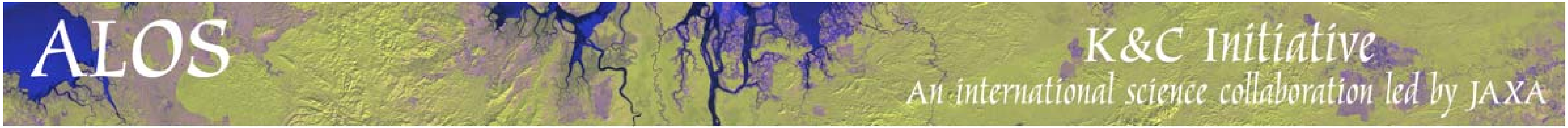
– Biome classification, landcover structure

Freeze/Thaw

Alaska, Canada, Northern Europe

– Thermokarst studies

– Permafrost carbon cycle



Objective: Development of a data set to facilitate global and regional studies of the role of inundated wetlands in studies of climate biogeochemistry, hydrology, and biodiversity.

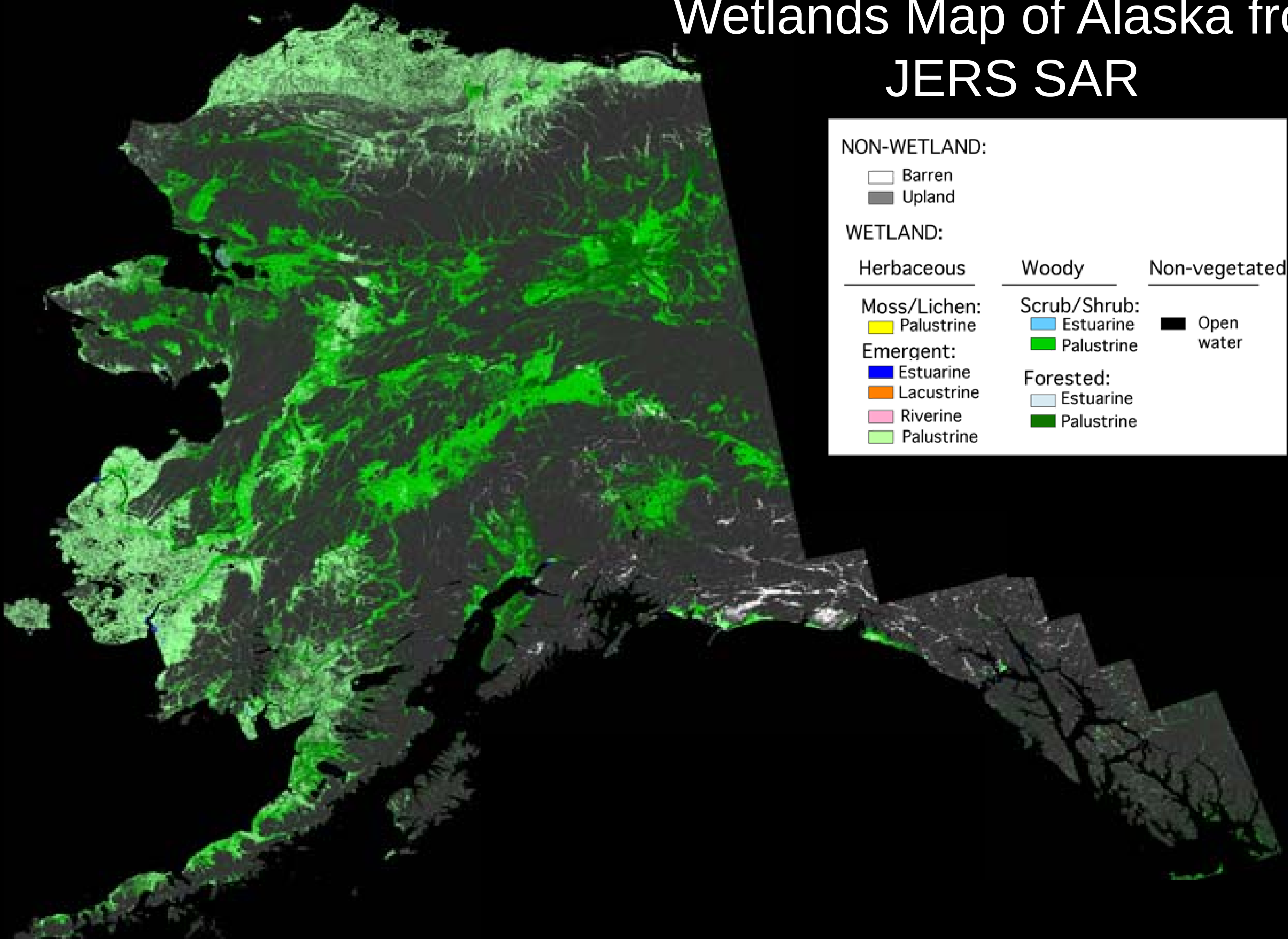
I. Regional inundated wetlands data sets from Synthetic Aperture Radar (SAR)
- Spatial coverage: Major global wetland regions, 100m resolution
- Temporal coverage: 1-2 year time series at 17-to-46 day intervals during 2006-2009 † ‡
- Retrospective 1990's-era from archived JERS data covering Alaska, Canada, Amazon
1. Wetland extent (maximum inundatable area, including water bodies).
2. Wetland vegetation type (Non-vegetated, Herbaceous, Shrub, Woodland, Forest).
3. Inundation state (Flooded, Non-flooded; 17-46 day intervals) ‡
4. Annual inundation duration

II. Global monthly inundation data sets derived from multiple satellite data sources
- Spatial coverage: Global, 25 km resolution
- Temporal coverage: Monthly monitoring with annual summaries, 1992-2013 †
1. Globally gridded monthly inundated area fraction
2. Globally gridded annual inundation duration

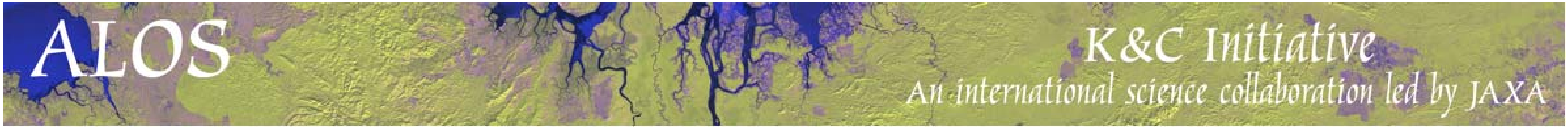
† The domain of the 25-km and 100-m data sets excludes permanently frozen regions and seasonally frozen landscapes
during the frozen season, although data from frozen seasons is used to improve classification accuracy.

‡ PALSAR ScanSAR mode has 46-day exact repeat orbit with 17-day sub-cycles.

Wetlands Map of Alaska from JERS SAR

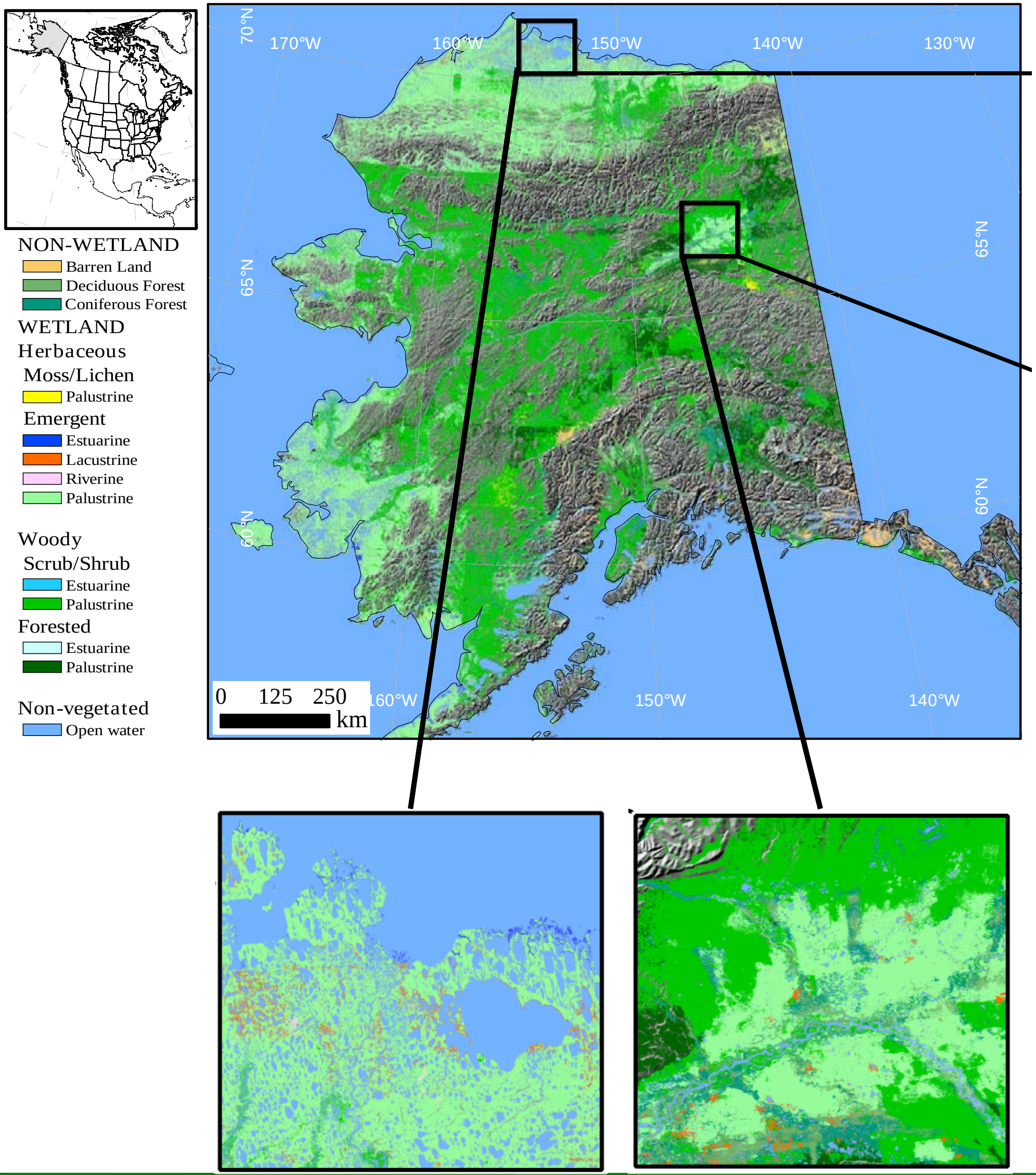


Whitcomb, Moghaddam, McDonald, Kellndorfer, and Podest, Canadian Journal of Remote Sensing, 2009



An updated map of wetlands in Alaska from PALSAR data

- 50 m spatial resolution map, using dual-polarization 2007 data
- Trained using National Wetland Inventory (NWI) data.
- Accuracy of geomorphology-vegetation classes 84 %
- Accuracy of wetland / non-wetland discrimination 94 %
- 0.59 million km^2 of wetlands mapped



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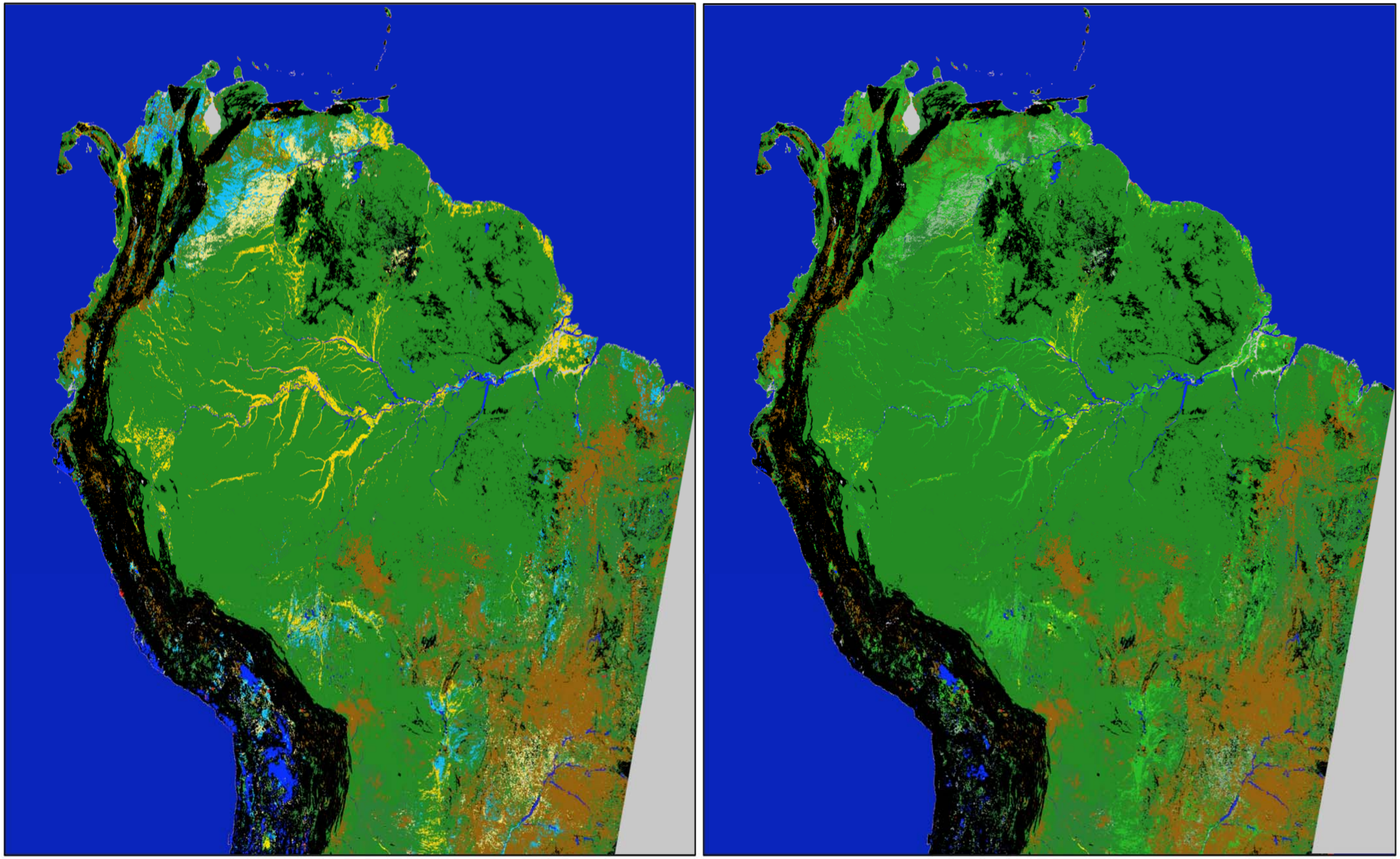
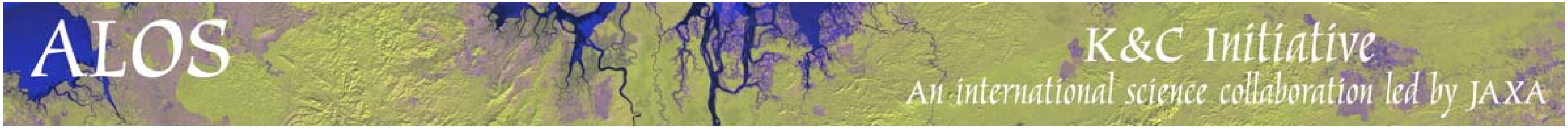
Seasonal Maximum/Minimum Inundation from ALOS ScanSAR

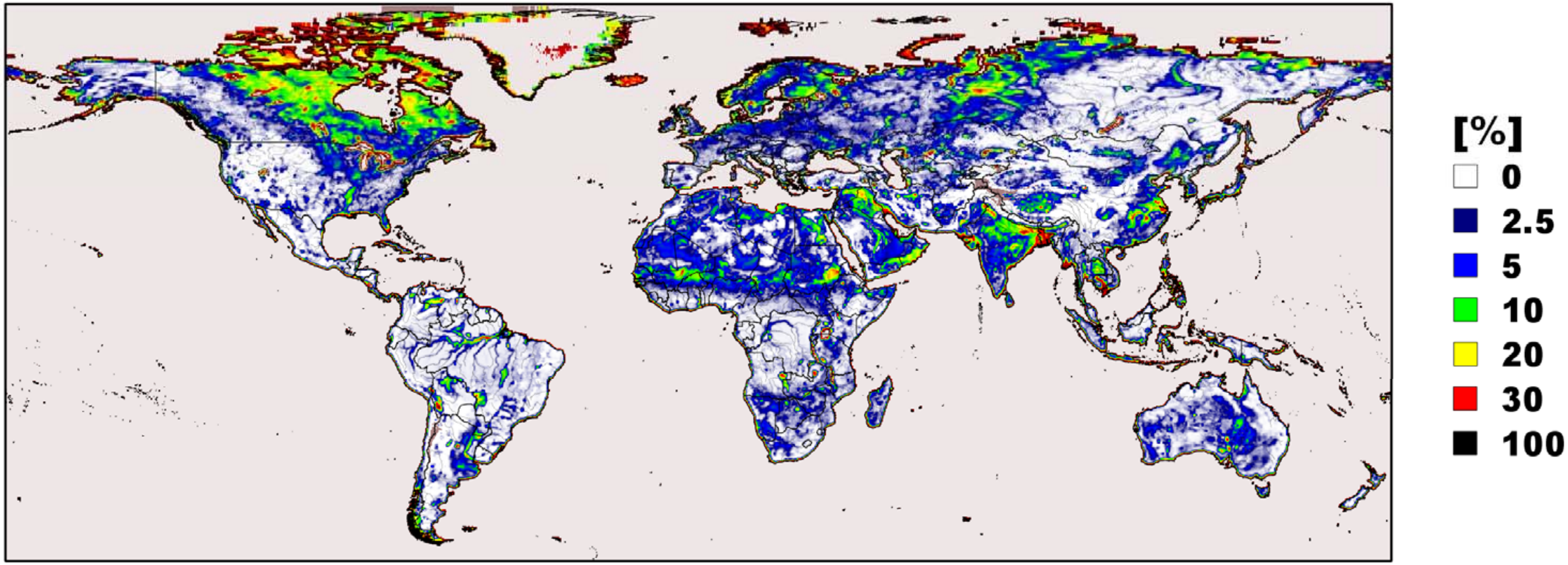


Chapman et al, 2015



Surface Water Microwave Product Series (SWAMPS)

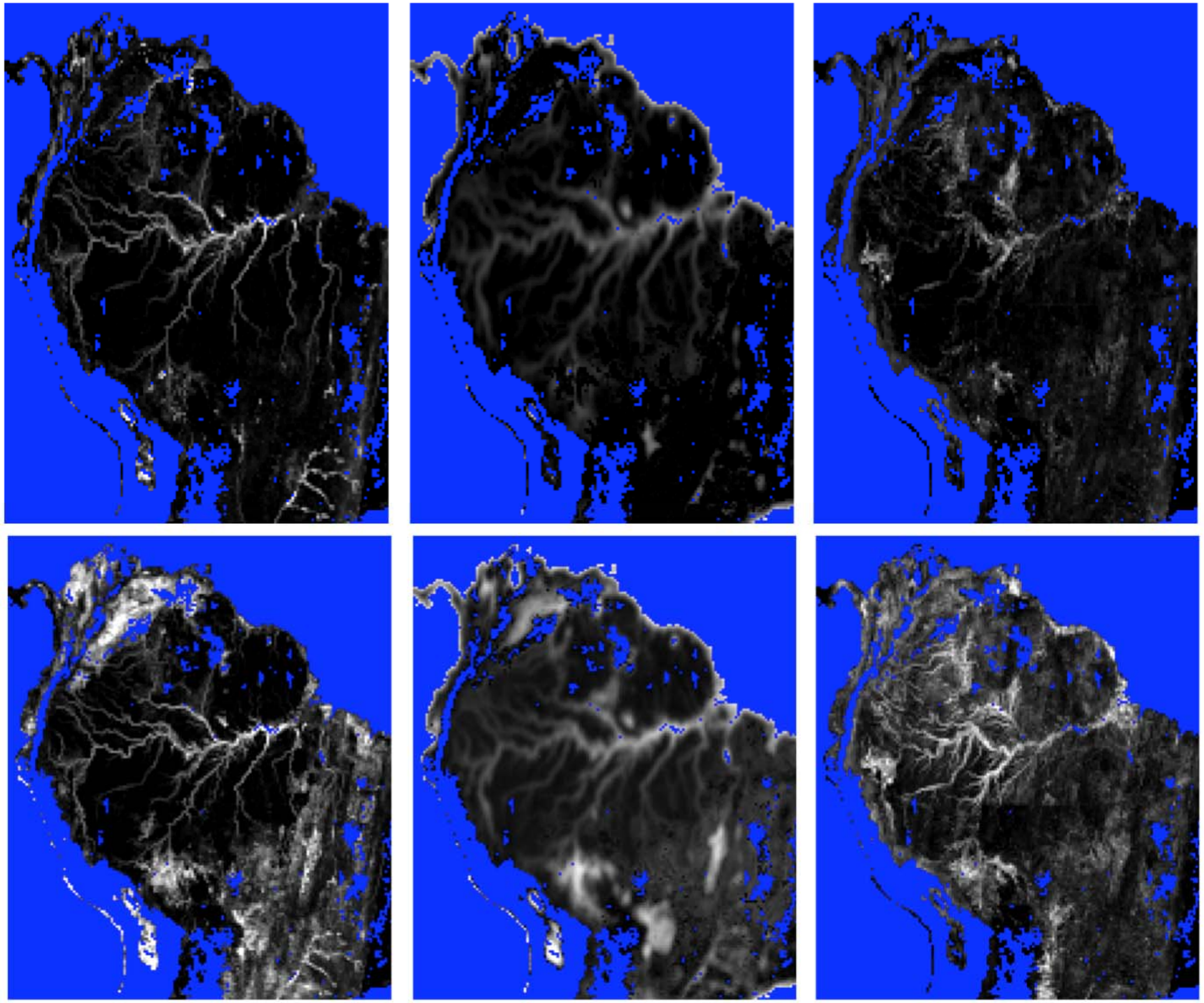
20+ Years of Daily Global Mappings of Inundation Extent at ~25 km Resolution for the Period 1992-2013

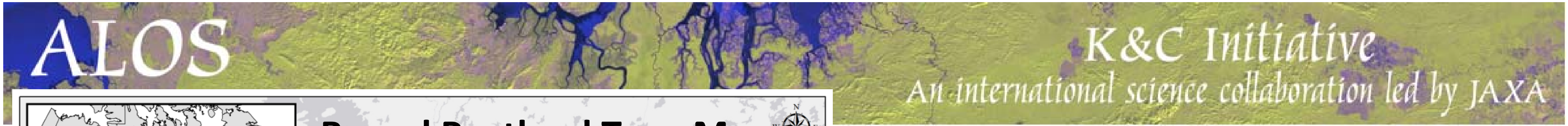


Schroeder et al 2015

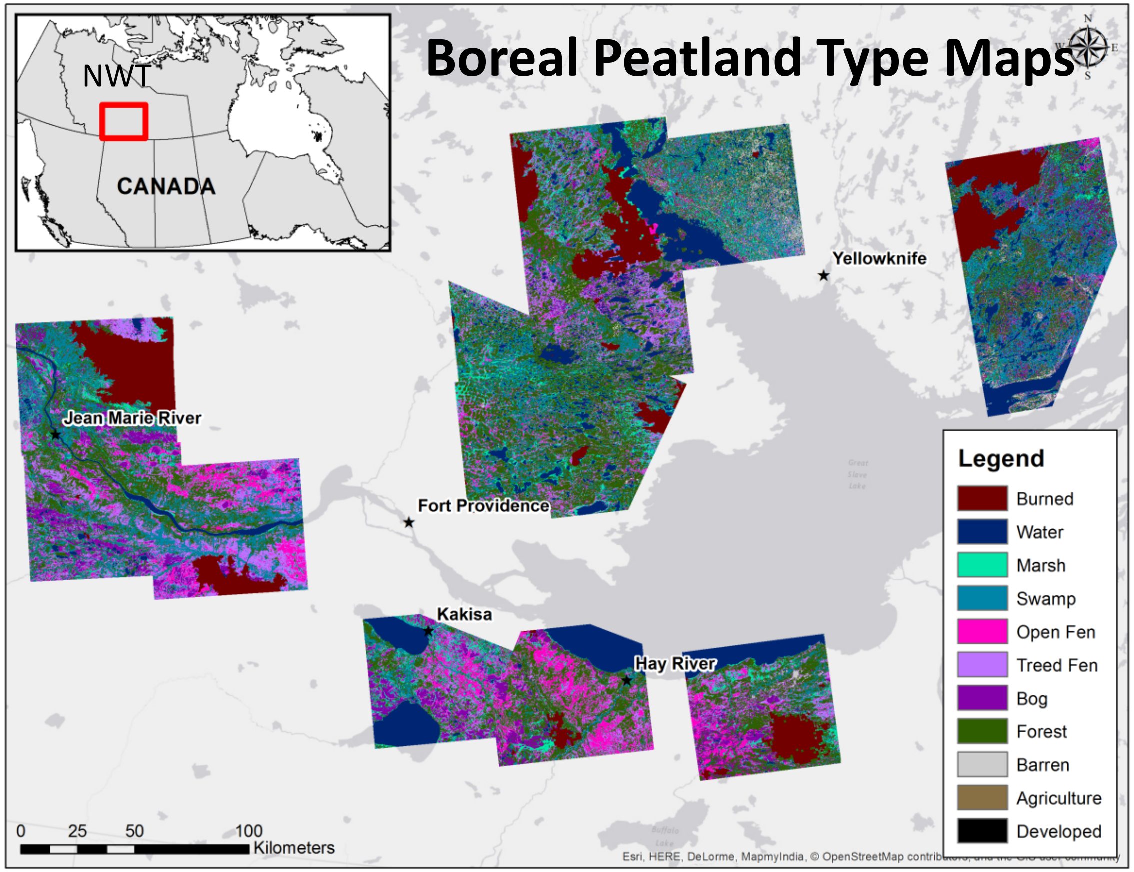
Cross-Product Verification

Comparison of fractional open surface water area from coarse resolution sensors with ALOS SCANSAR open surface water fraction and inundated vegetation fraction

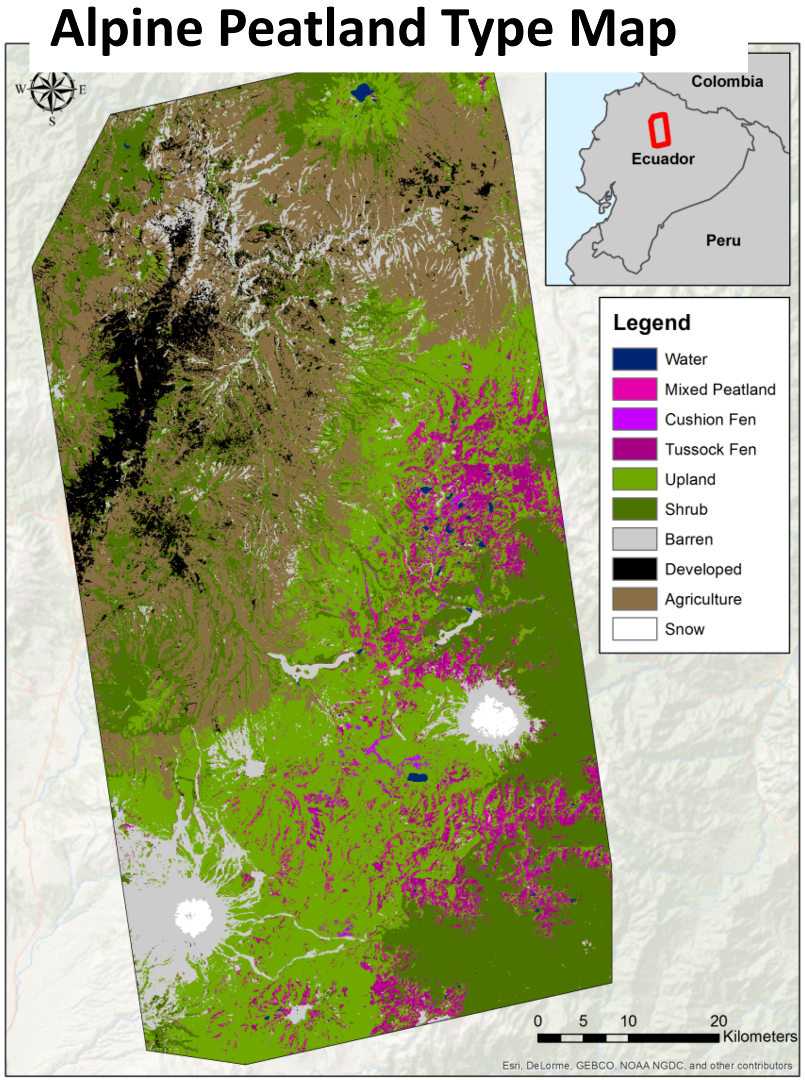


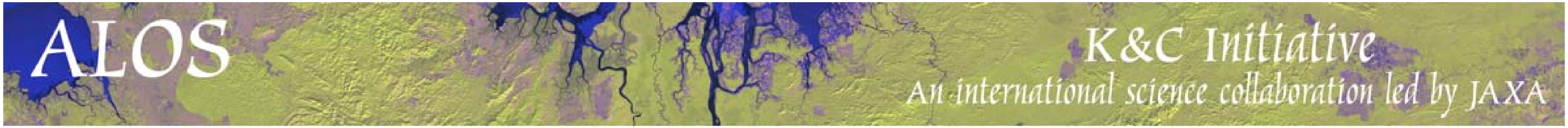


Tropical and Boreal Peatland Type Mapping from PALSAR-Landsat multi-season Data



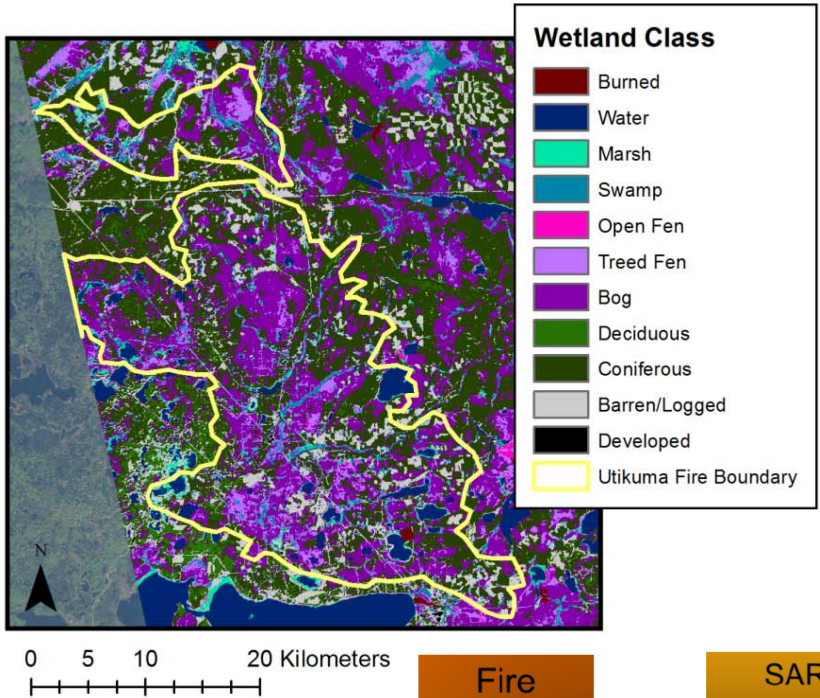
- Peatlands store large amounts of carbon belowground
- Important to know where and what type of peatland for accurate carbon estimates
- Peatland type maps created using multi-date PALSAR and Landsat fusion
- NWT Canada experienced 3.4 million hectares of broadscale wildfire in 2014, consuming many peatlands. Peatland maps are under development



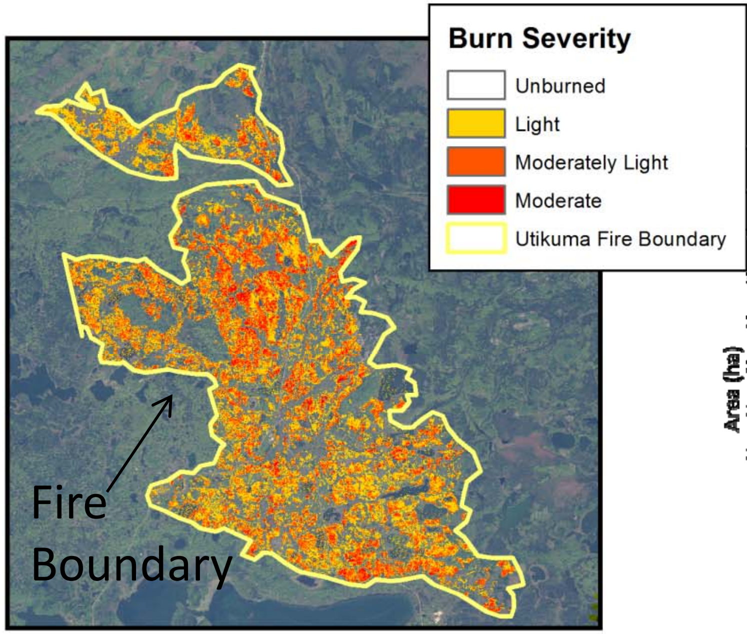


Carbon Emissions Estimates from Boreal Peat Wildfires are Improved with PALSAR-Landsat Peatland Type Maps

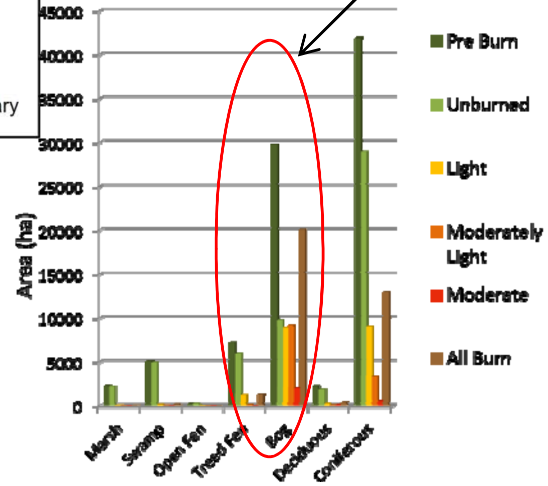
Peatland Type Map

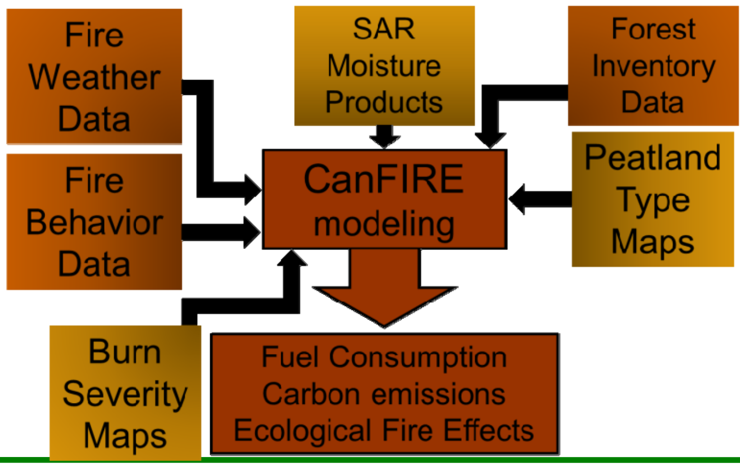


Peat Burn Severity Map



Peat Bogs burned more area of this wildfire

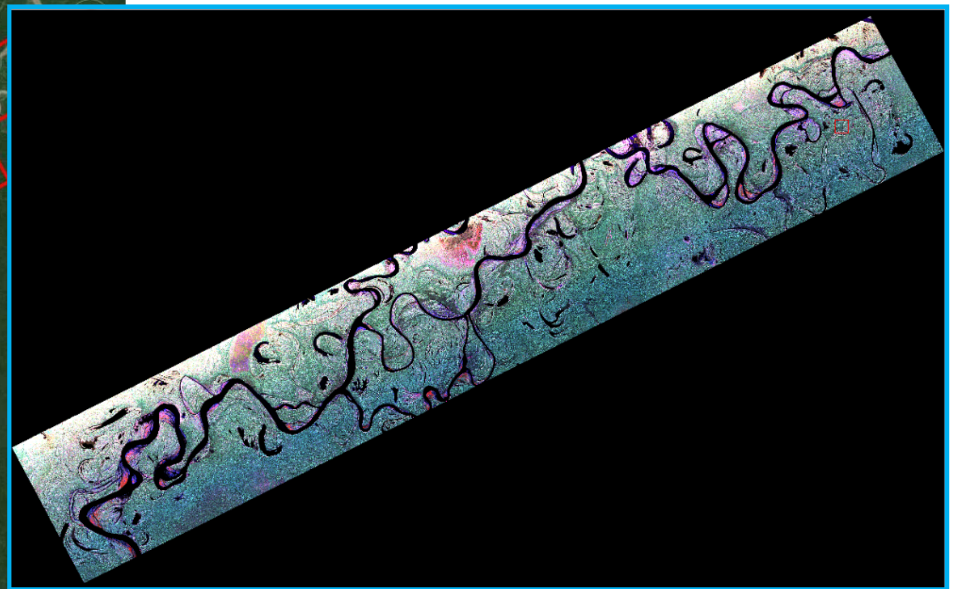




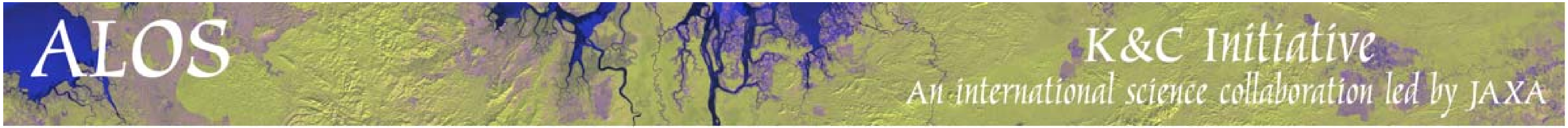
Integrated remote sensing products, field data and modeling answer regional scale research questions such as “do peatlands burn as frequently as uplands?” and “how does seasonality affect fuel consumption in peatlands?” “What are the emissions from Peatlands vs. Uplands?”

Assessment with NASA UAVSAR Datasets

Classify and analyze high resolution imaging radar from the NASA UAVSAR mission, identifying wetlands components



Polarimetric Radar Backscatter
[R: HH, G: HV, B: VV]



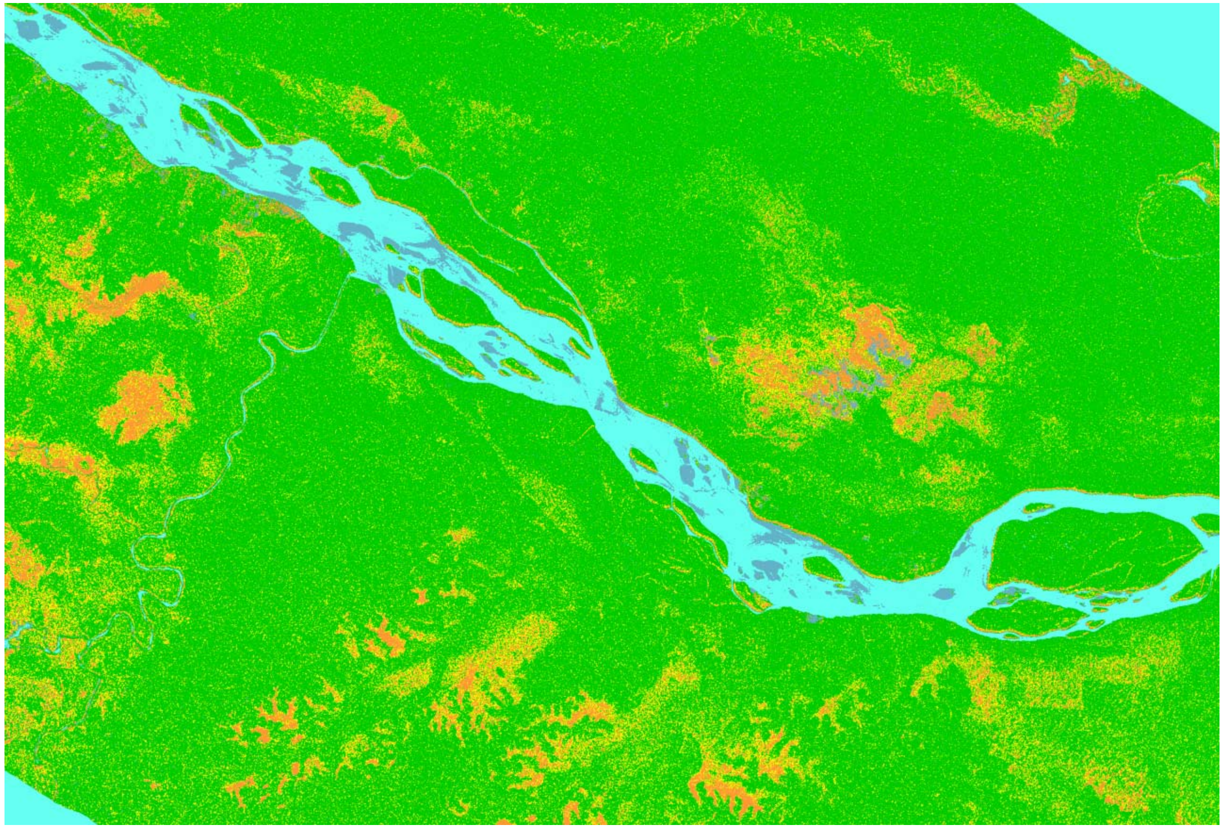
Classification of UAVSAR data over Napo River in Peru (2013)

Vegetation inundation state determined along two transects within 2 days of UAVSAR data acquisition

Classification derived from Van Zyl decomposition of L-band Quad Pol data UAVSAR

Classification verified along field transects

This image spans incidence angles from 20° to over 60° (as determined from the SRTM DEM)

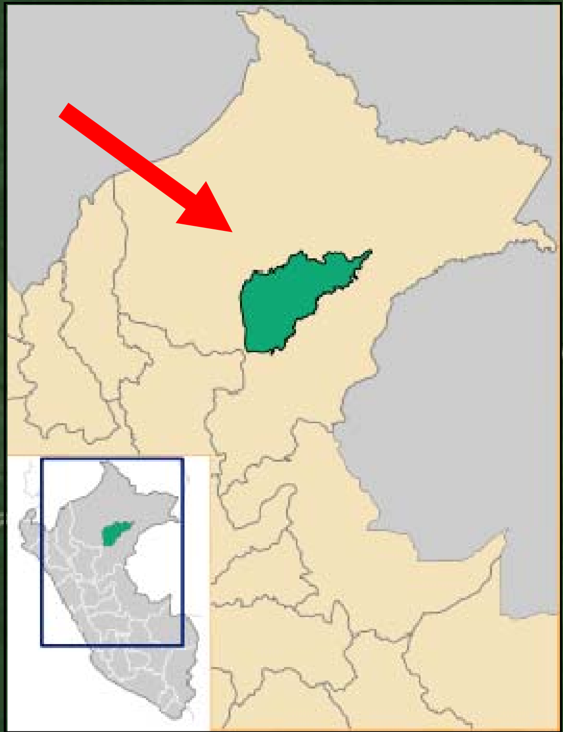


UAVSAR Inundation Classification : Green: not inundated
Yellow and Orange: inundated vegetation
Light and Dark Blue: open water/bare ground

UAVSAR data acquired
March 31, 2013

Chapman et al, "Validation of forested inundation extent revealed by L-band polarimetric and interferometric SAR data", IGARSS 2014, Quebec, Canada July 2014

Pacaya-Samiria National Reserve, Peru

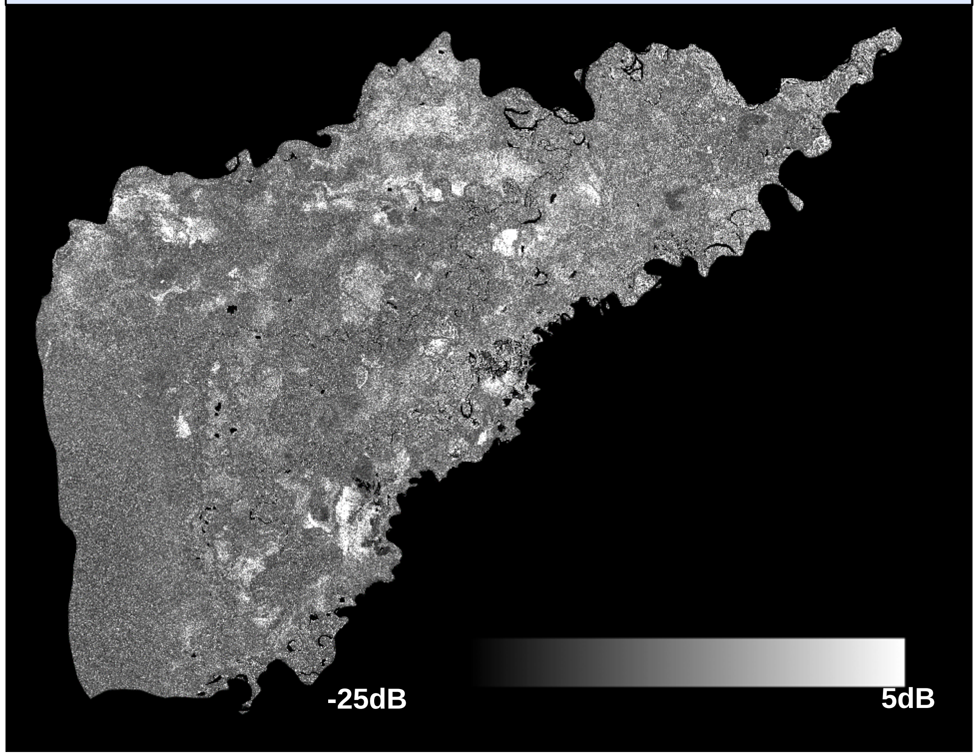


- Most extensive tropical flooded forest in the Peruvian Amazon
- Spans area of more than 20,000 km²
- Hosts rich biodiversity!

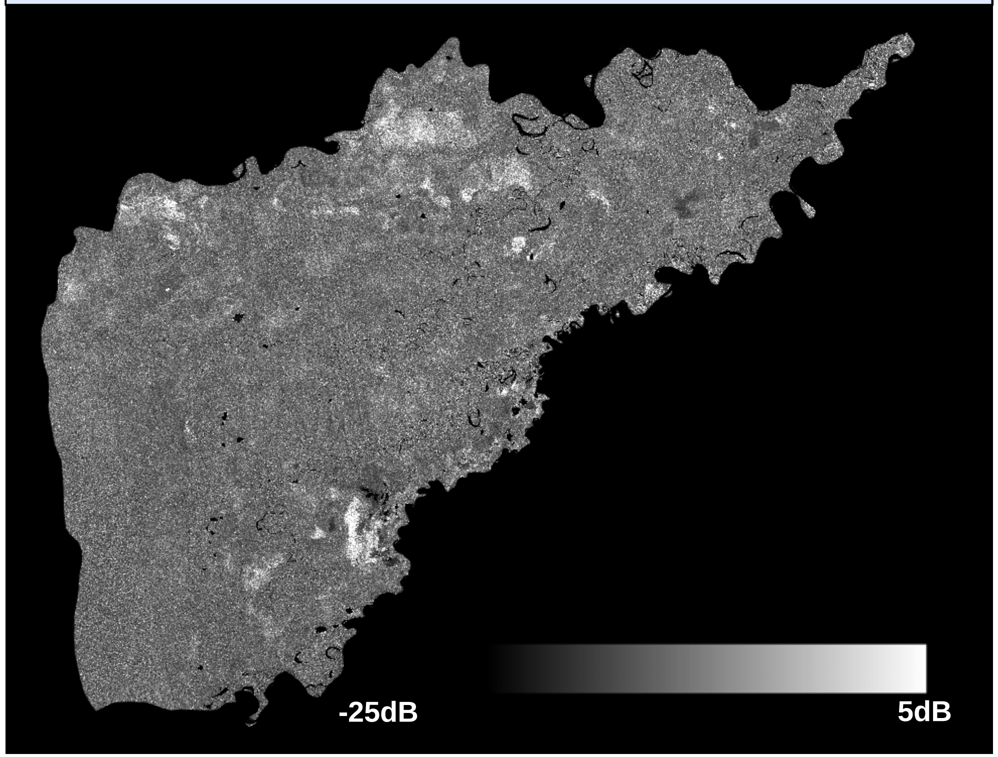
Mapping of wetlands in Pacaya Samiria Reserve, Peru

Seasonality of inundation patterns

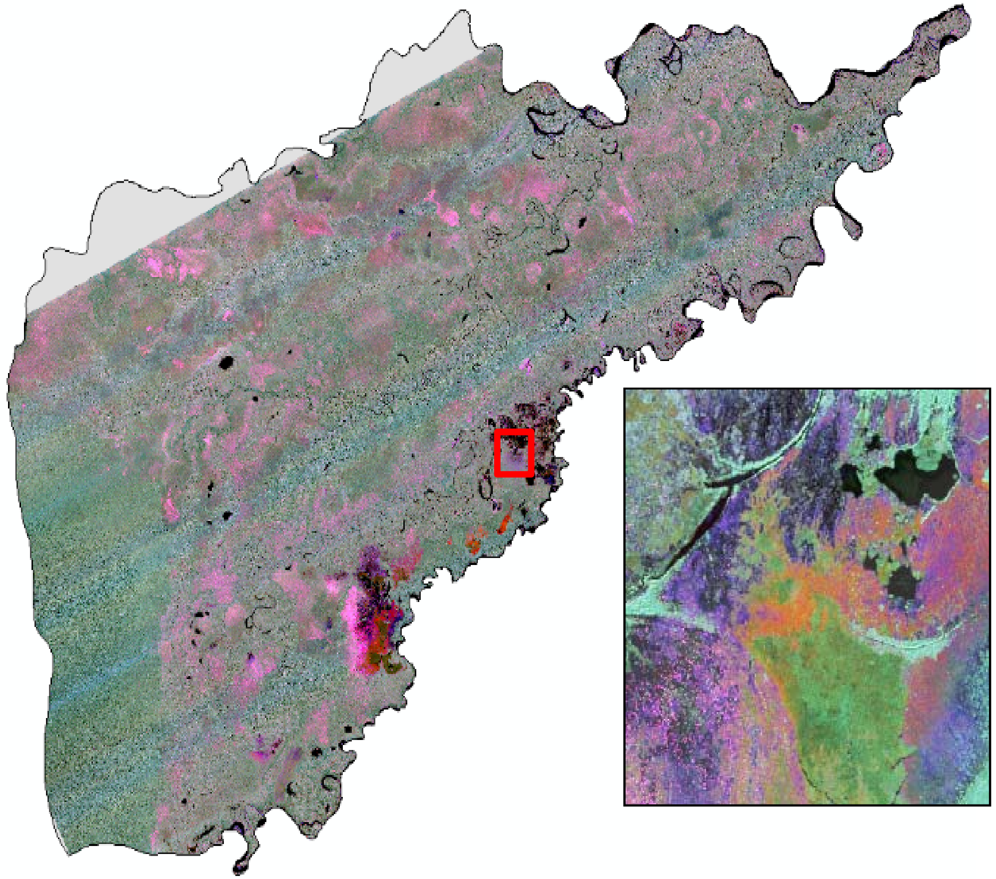
Wet Season [Mar-Apr 2009]
HH-polarized ALOS PALSAR Fine-Beam



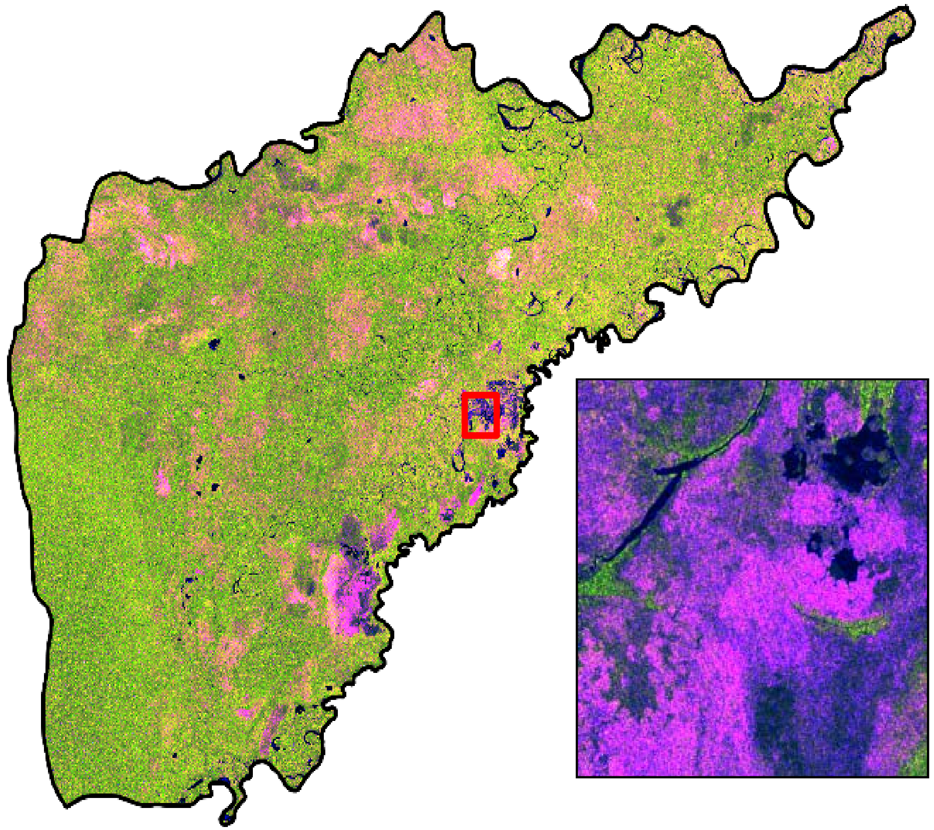
Dry Season [Jul-Aug 2010]
HH-polarized ALOS PALSAR Fine-Beam

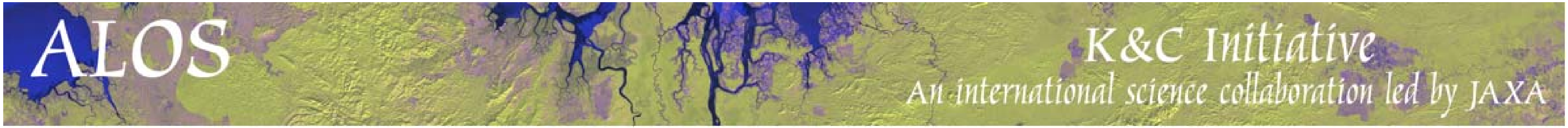


UAVSAR False Color Mosaic, normalized for incidence angle
March 17 2013
R: HH, G: HV, B: VV
(grey indicates no data collected)

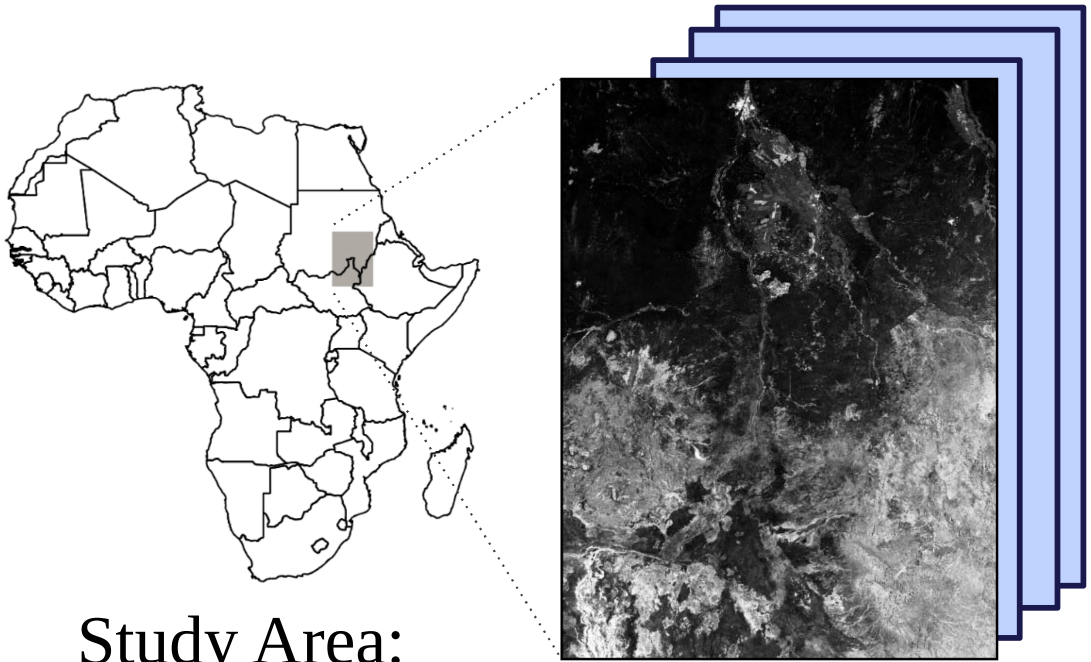


ALOS PALSAR False Color Fine Beam Mosaic
March - April 2009
R: HH, G: HV, B: HH - HV





Inundation monitoring in East Africa



Study Area:
UTM Zone
36P

Classification of ALOS PALSAR ScanSAR

- Land cover is highly heterogeneous:
  - Sahel desert in the north
  - Prominent agriculture between the Blue and White Nile Rivers
  - Sudd wetlands in the south west
- 55 PALSAR ScanSAR acquisitions between Dec 2008 – Nov 2010 [HH polarization only]
- Applied various classification algorithms on all 55 images:
  - K-means clustering
  - Decision tree
  - Maximum likelihood
  - Random forest

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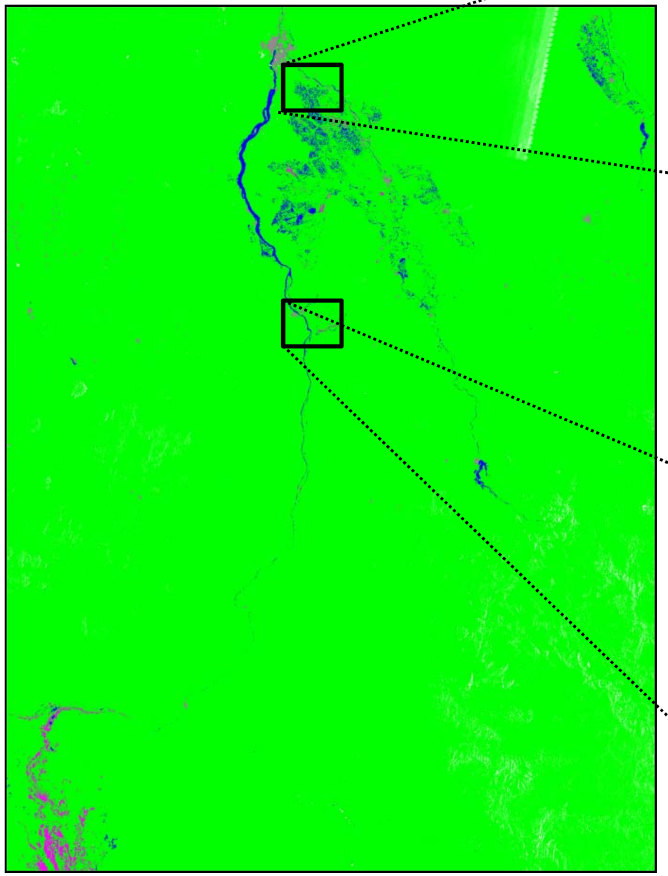
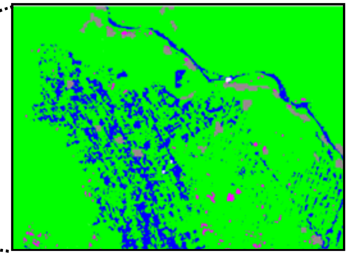
Inundation monitoring in East Africa

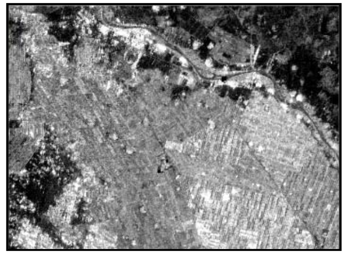
Google Earth

Decision-Tree Result

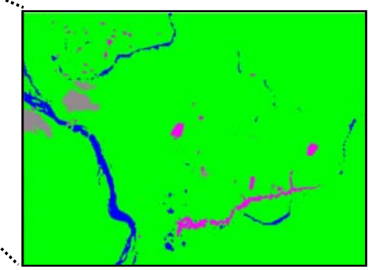


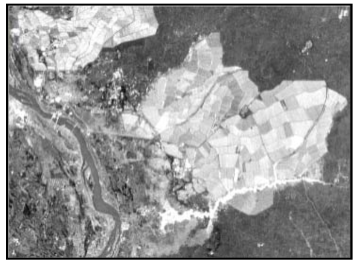
Rice paddies





Cotton fields





o surface water pen water Inundated Vegetation rban

Classification of ALOS PALSAR ScanSAR

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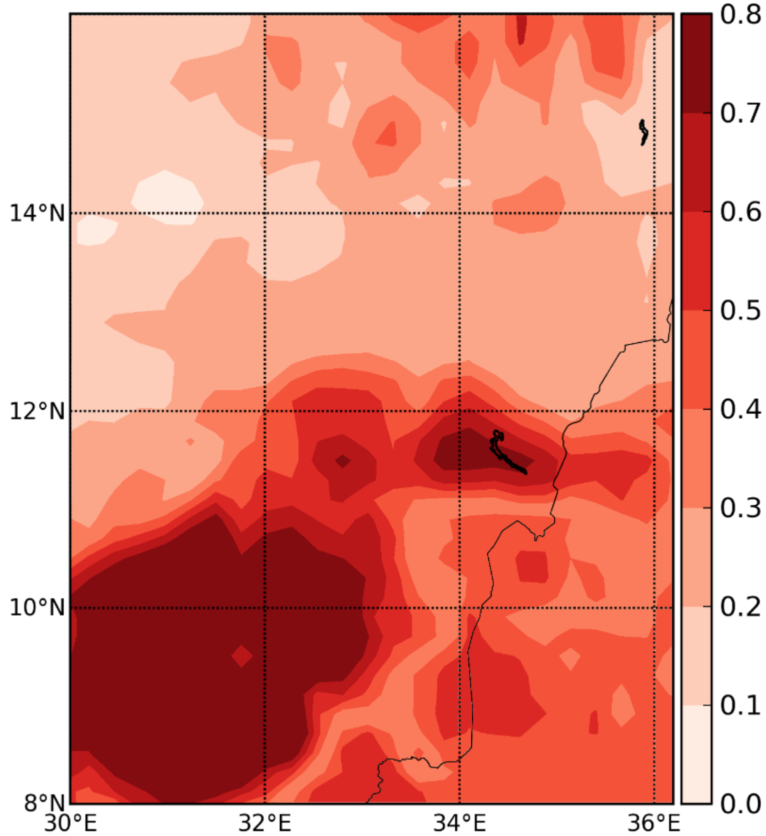
Inundation monitoring in East Africa

Comparison of mean SWAMPS and resampled classified SAR water fraction

The classified data are resampled to the 25km EASE grid, counting the number of pixels classified as Open Water and Inundated Vegetation and estimating the surface water fraction.

- 63% of the test area observed statistically significant correlation between inundated fractions derived from SWAMPS and those from classified PALSAR images

- Low R^2 values were observed predominantly in highly arid regions



Pixel-wise R^2 coefficients between SWAMPS and resampled classified PALSAR images.

Inundation monitoring in East Africa

- Public health is a major concern in Africa where malaria epidemics are a burden on population and economies

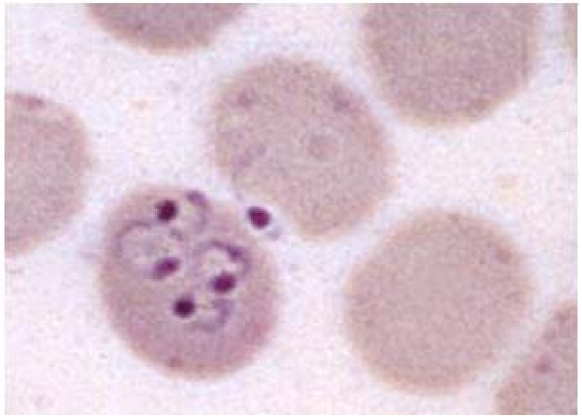
- Vector-borne diseases are driven by environmental conditions that harbor specific vector habitat conditions such as:
    - 1) specific air temperature
    - 2) humidity for adult mosquito survival
    - 3) surface water for reproduction

    - Natural disasters such as floods can also jeopardize the control systems and infrastructures developed in countries to fight infectious diseases

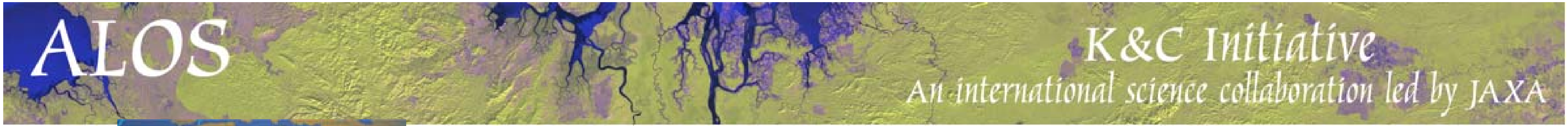
    - **Project goal**: Deliver new and improved spatio-temporal characterization of surface water products to support the Ministries of Health in detecting risk areas of vector-borne disease transmission

Source: International Federation of Red Cross/Red Crescent

Source: CDC

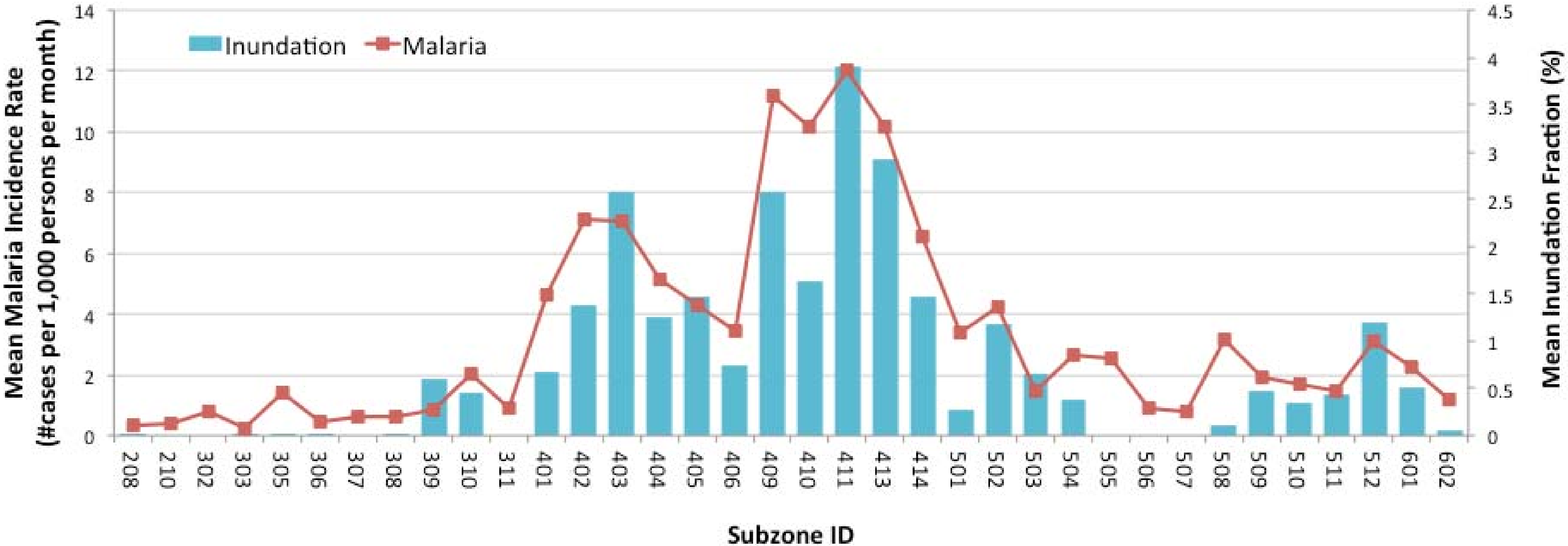


Source: CDC

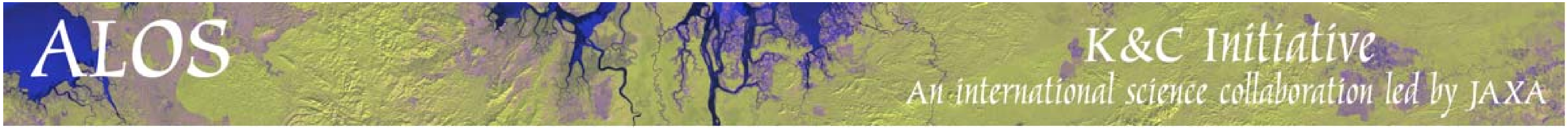


Inundation monitoring in East Africa

Correlative analysis of historical monthly malaria incidence rates (#cases per 1,000 persons) for subzones in the eastern African country Eritrea for 1996-2003



Spatial distribution of mean surface water fraction [SWAMPS] and mean malaria incidence rate across subzones of Eritrea (excluding coastal zones), 1999-2003.



Monitoring change and threat to River Deltas Systems: Mekong Delta

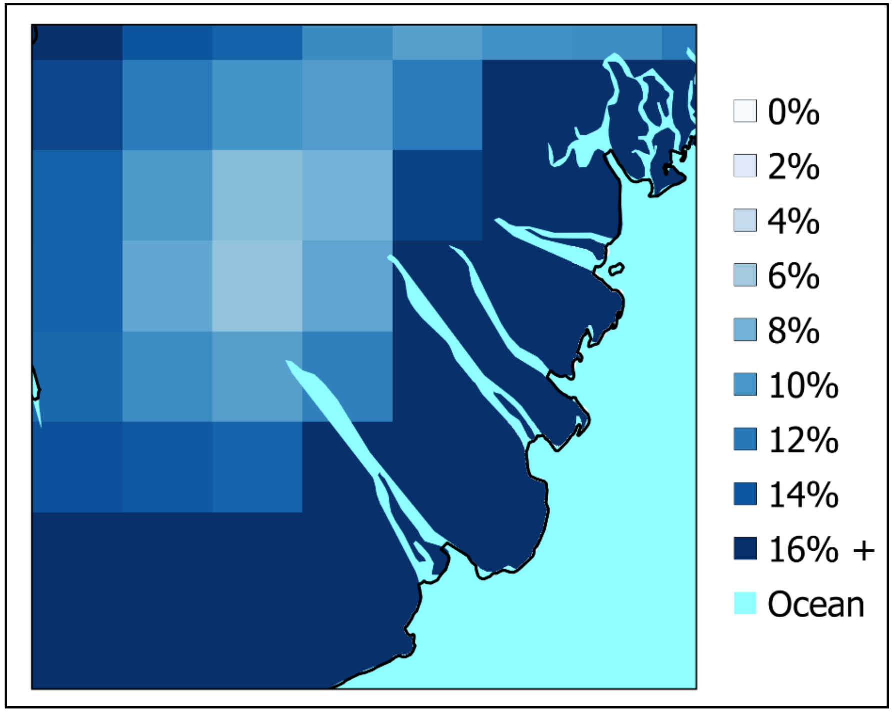
- The Mekong River delta is the world’s 3rd largest delta
  - densely populated
  - considered as Southeast Asia’s “most important food basket”
  - rich in biodiversity at the world scale
- Increasingly affected by human activities and exposed to subsidence and coastal erosion
- Several dams have been constructed upstream of the delta and many more are now planned
- GOAL: Can we link landcover/land-use changes with inundation patterns using remote-sensing?

Mekong Delta in **red**

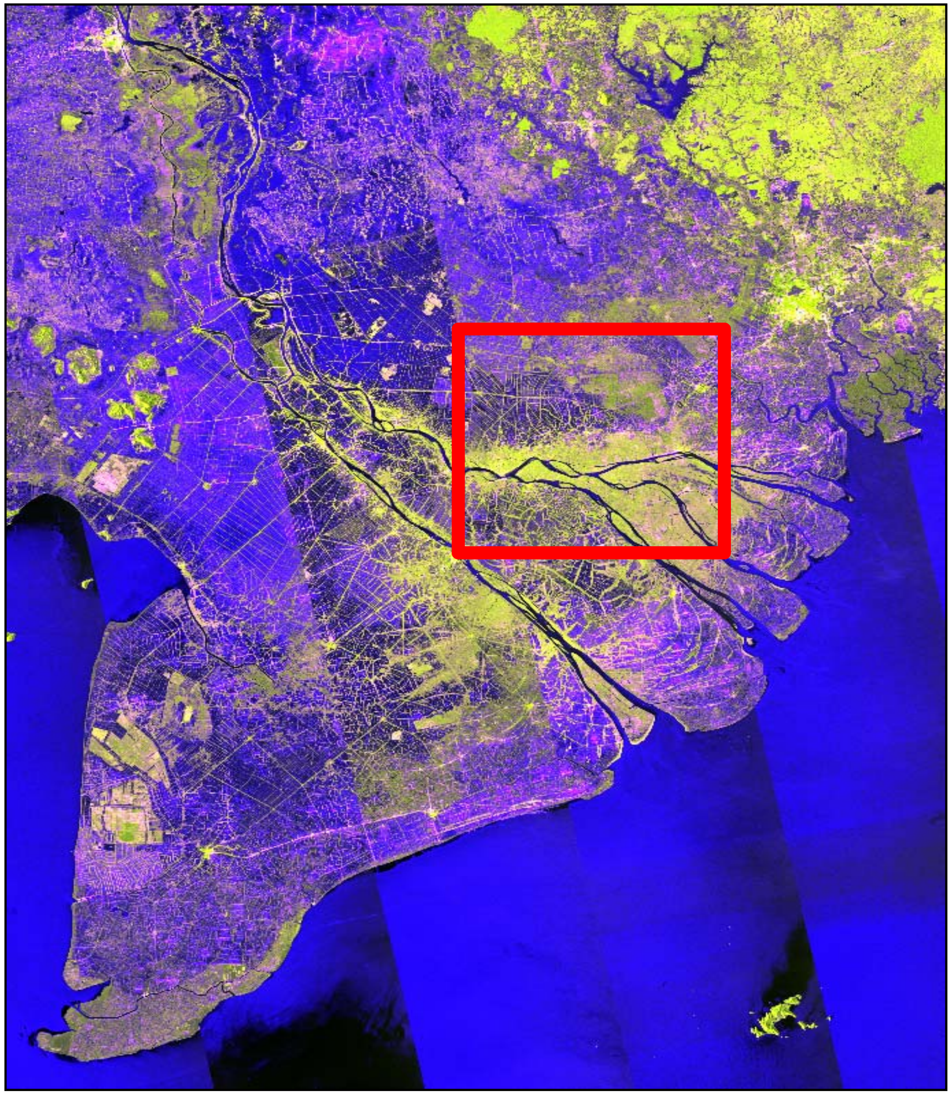
Source: National Geographic

Source: National Geographic

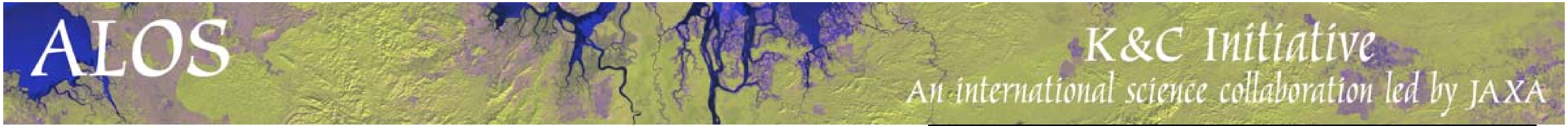
Mekong River Delta, Indochina



SWAMPS 25km f_w, Mekong River Delta, Jul 1-8 2009



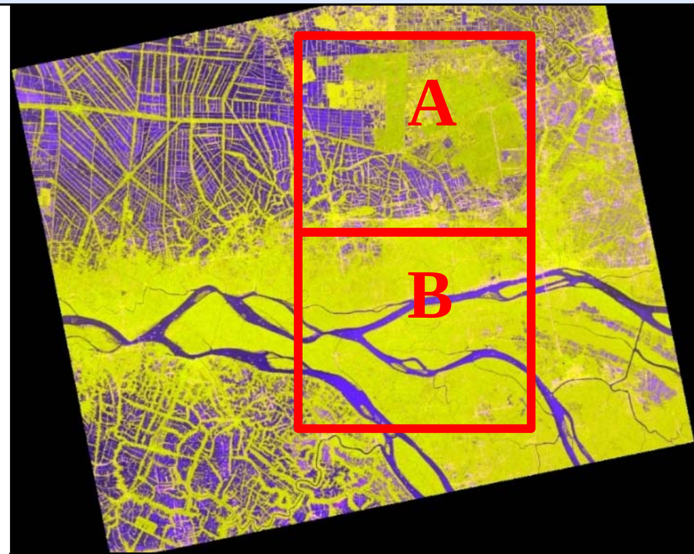
ALOS PALSAR RGB backscatter mosaic, Jun – Aug 2009. R: HH, G: HV, B: HH-HV. 30m spatial resolution. Red box indicates region used in this study.



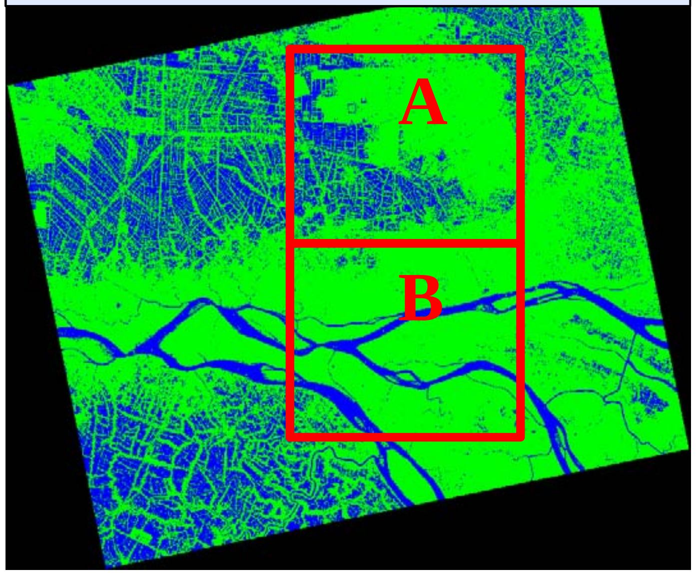
Re-scaling of coarse resolution inundation area fraction

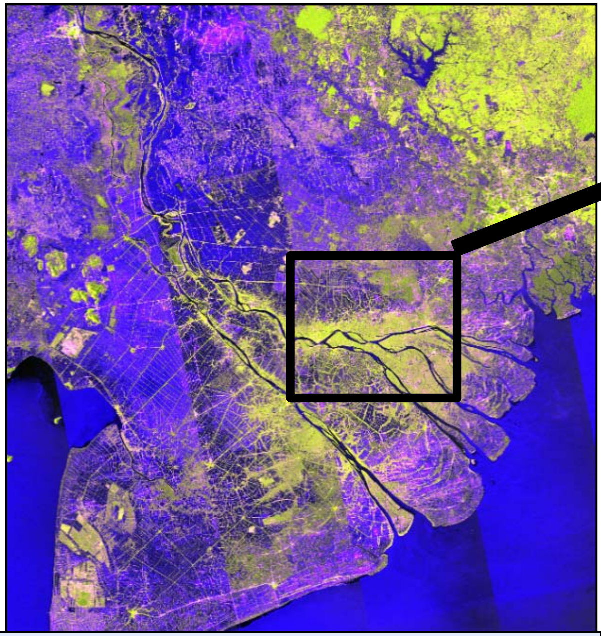
- **Static physical information (e.g. topography) alone is not enough for accurate downscaling**
- **Use of ALOS PALSAR observations as ancillary input:**
  - **Identify biases in SWAMPS data product**
  - **Combine with machine learning algorithms to “learn” from SAR observations**

PALSAR FBD, 11/18/10 [R: HH, G: HV, B: HH – HV]



Decision Tree Classification
Blue= Open Water, Green = Non-Inundated

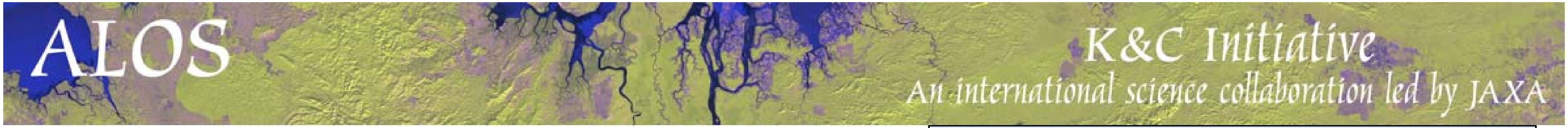




PALSAR FBD mosaic, Mar-May 2009
[R: HH, G: HV, B: HH – HV]
30m spatial resolution

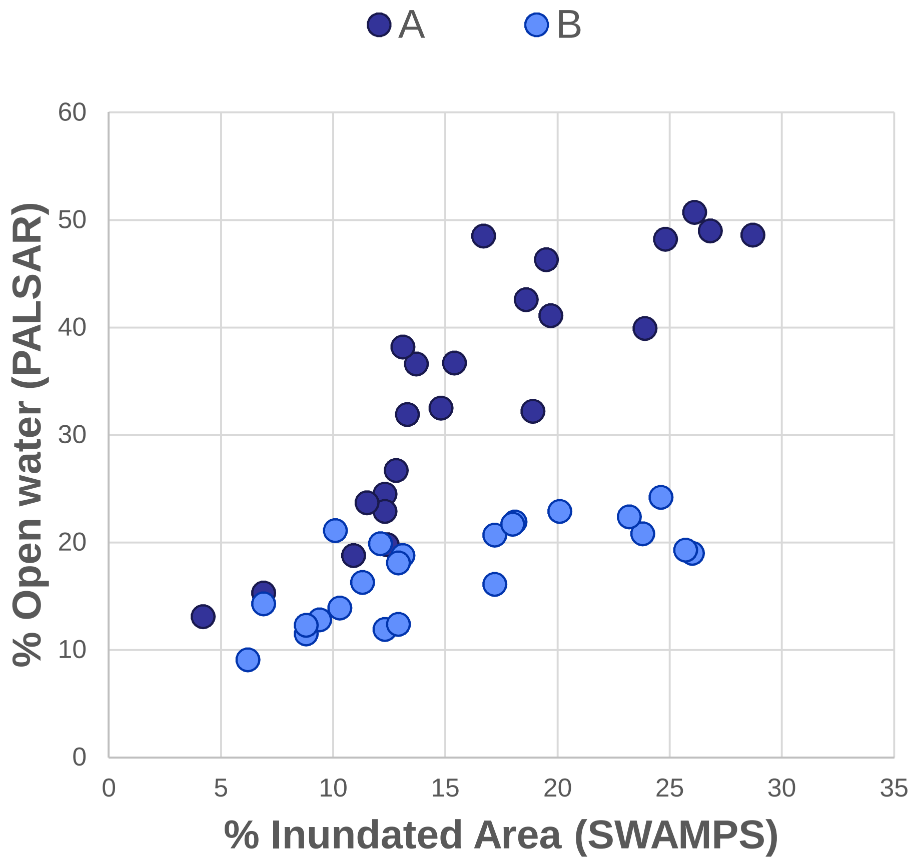
Classified open water in 24 reoccurring ALOS PALSAR fine-beam images (Feb 2007 – Jan 2011)

Aggregated 30m values of % classified as open water within two ease-grid cells (A & B) that are completely contained in image

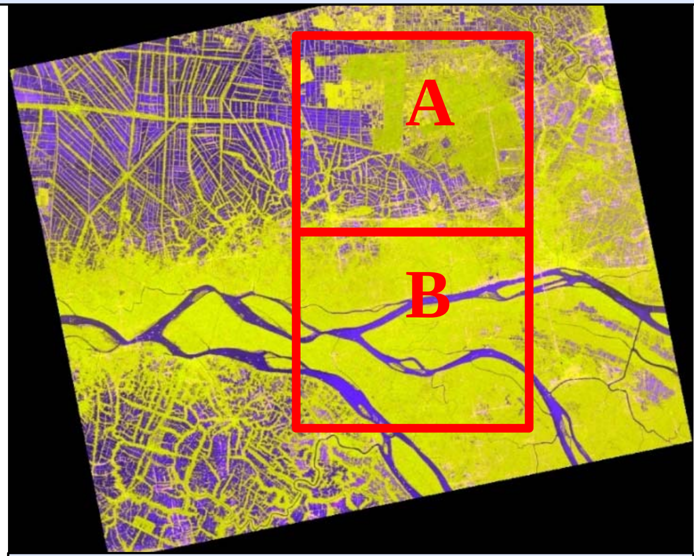


Re-scaling of coarse resolution inundation area fraction

% Inundated Area Fraction [SWAMPS]
vs.
% Classified as Open Water [PALSAR]



PALSAR FBD, 11/18/10 [R: HH, G: HV, B: HH – HV]



Decision Tree Classification
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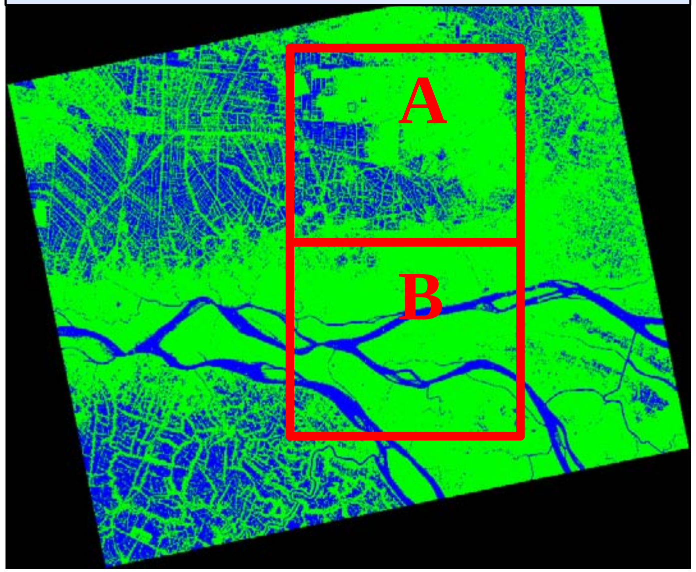

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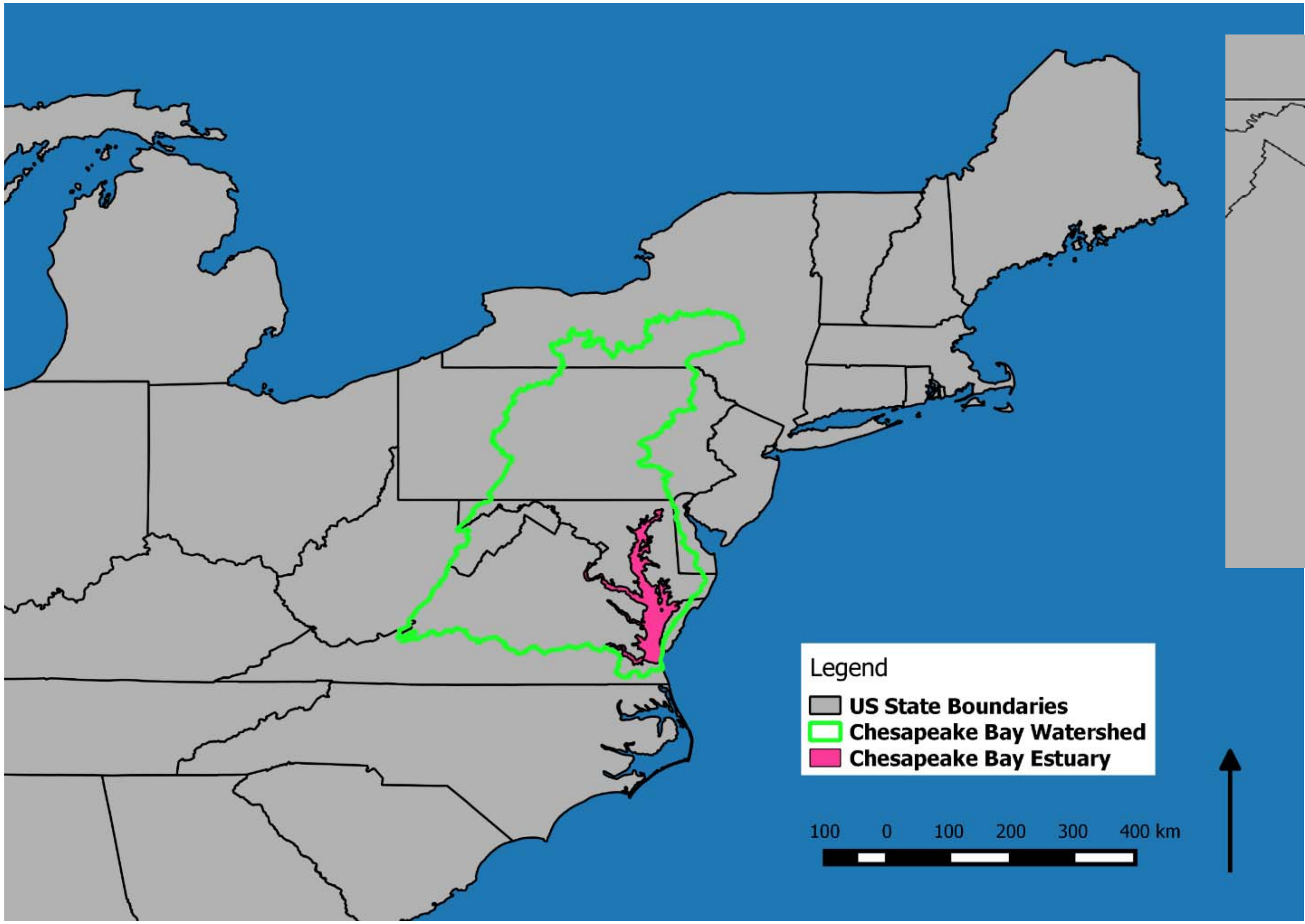
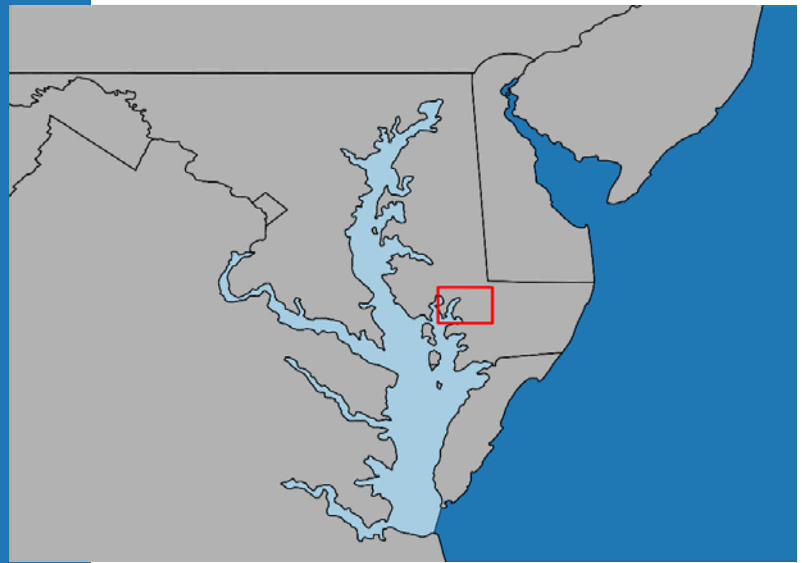
Carbon exchange in tidal estuary systems: Chesapeake Bay





ALOS

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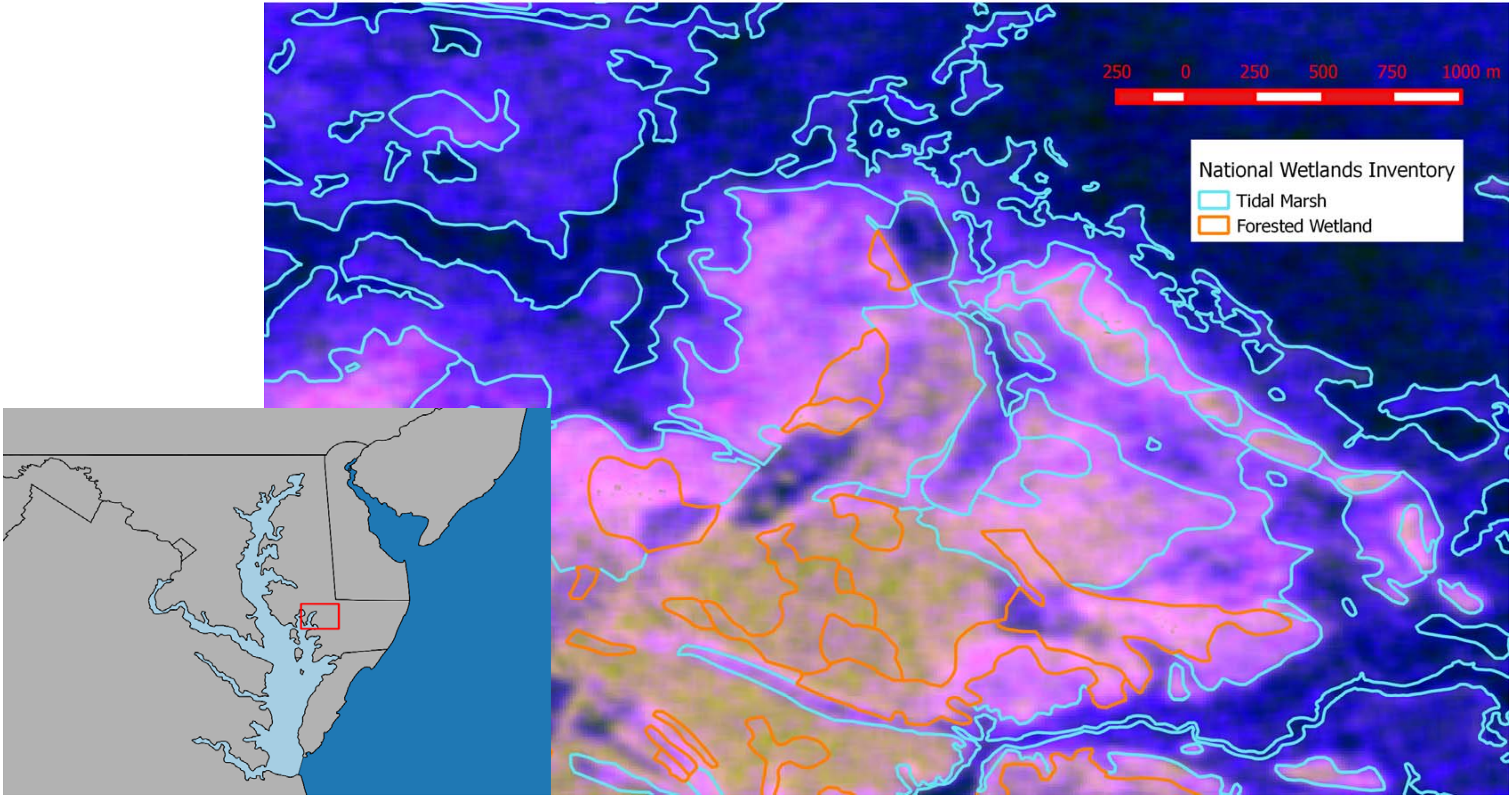
PALSAR-1 False Color RGB (HH, HV, HH-HV): Blackwater National Wildlife Refuge



ALOS

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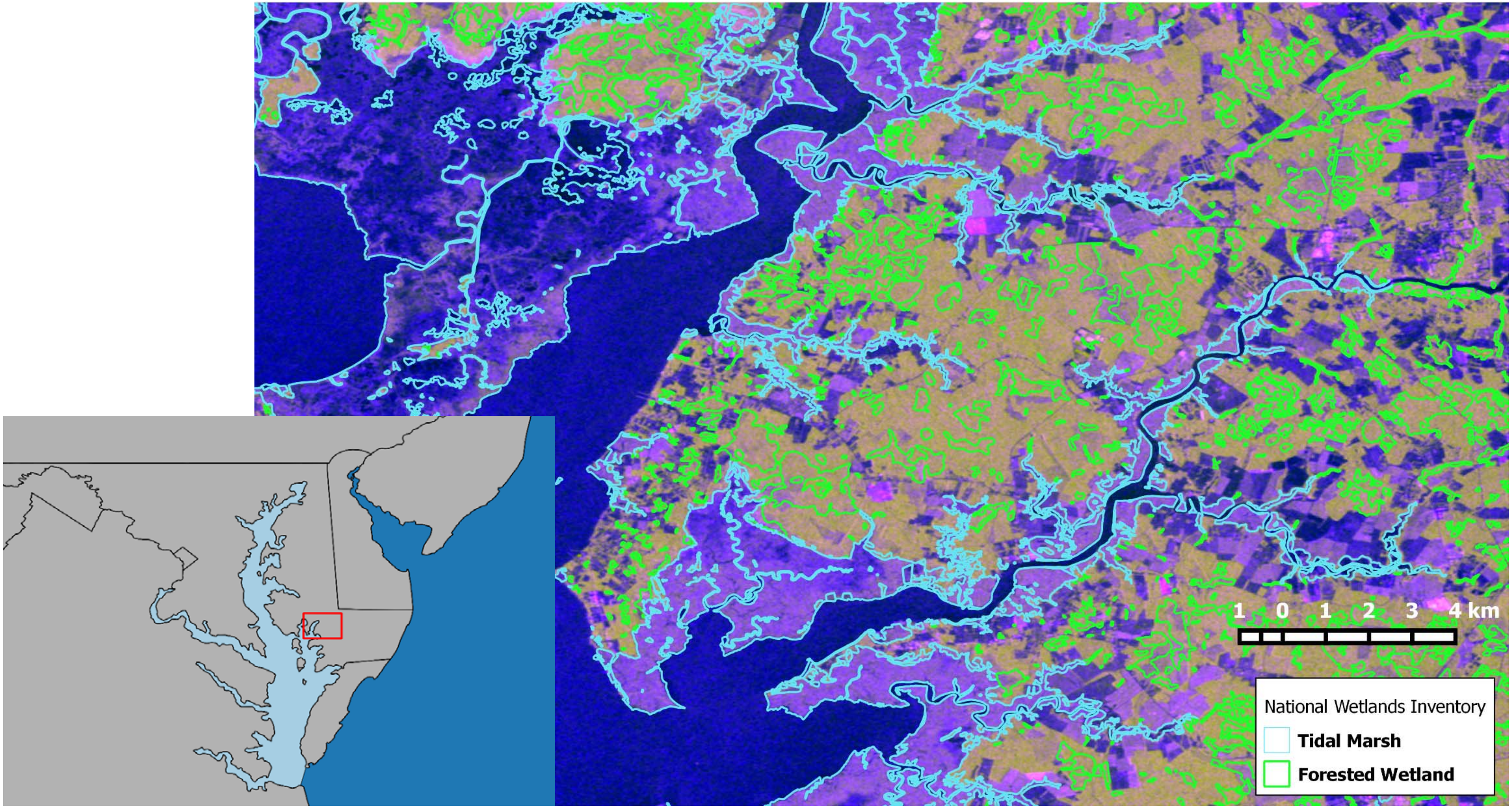
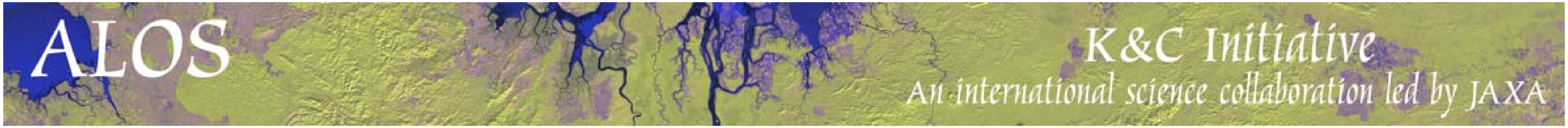
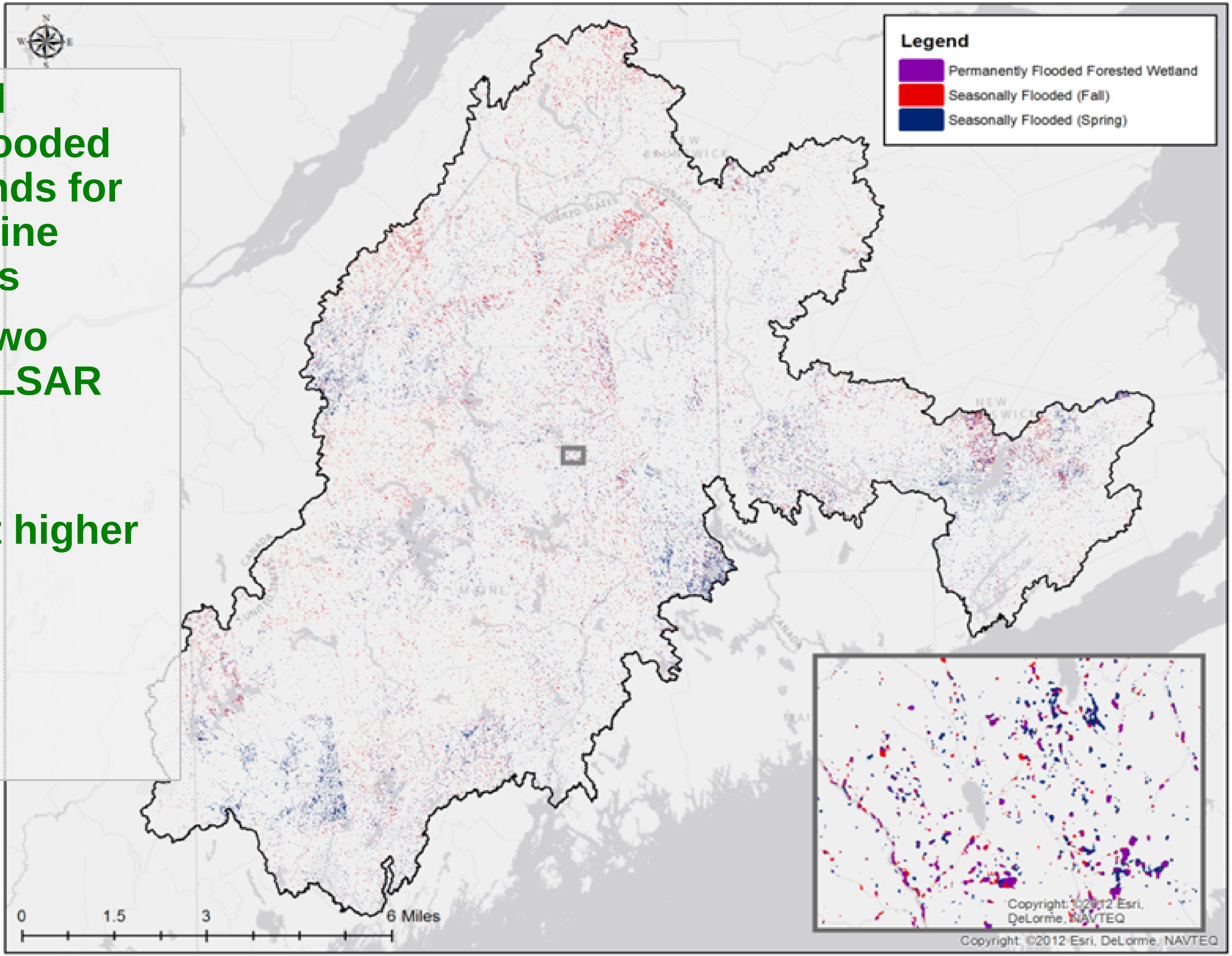
PALSAR-1 False Color RGB (HH, HV, HH-HV). July 2009. Maryland, Eastern Shore

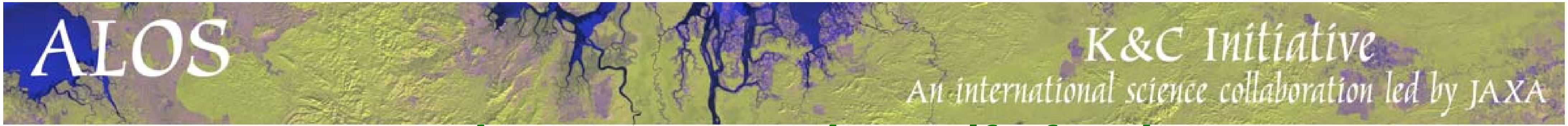




PALSAR-mapped forested wetland flood condition

- Seasonally and permanently flooded forested wetlands for four Gulf of Maine drainage basins
- Mapped from two seasons of PALSAR images.
- Inset shows an example site at higher resolution.

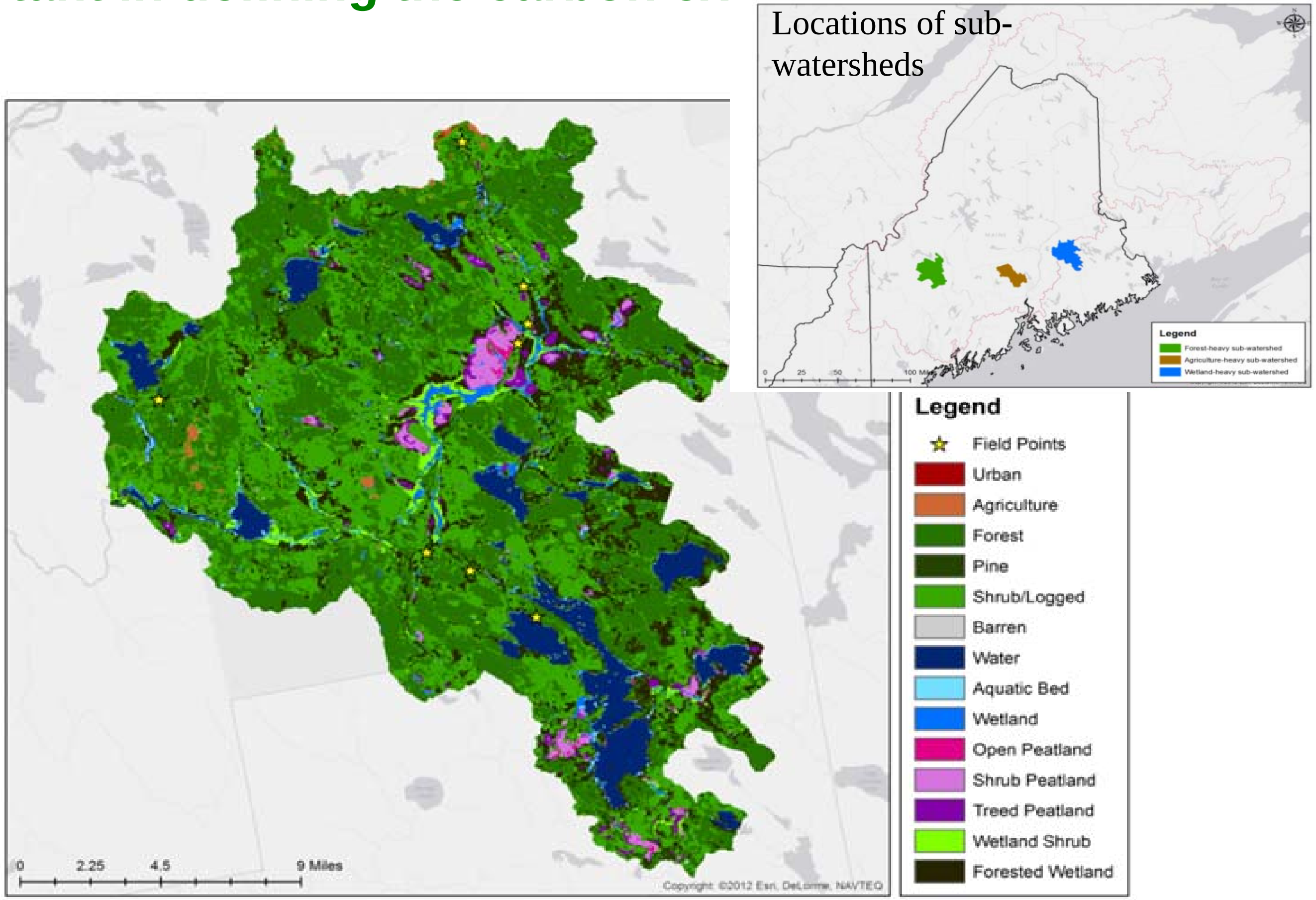


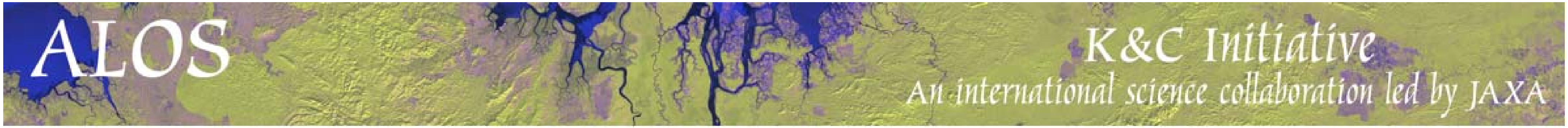


Carbon Export to the Gulf of Maine

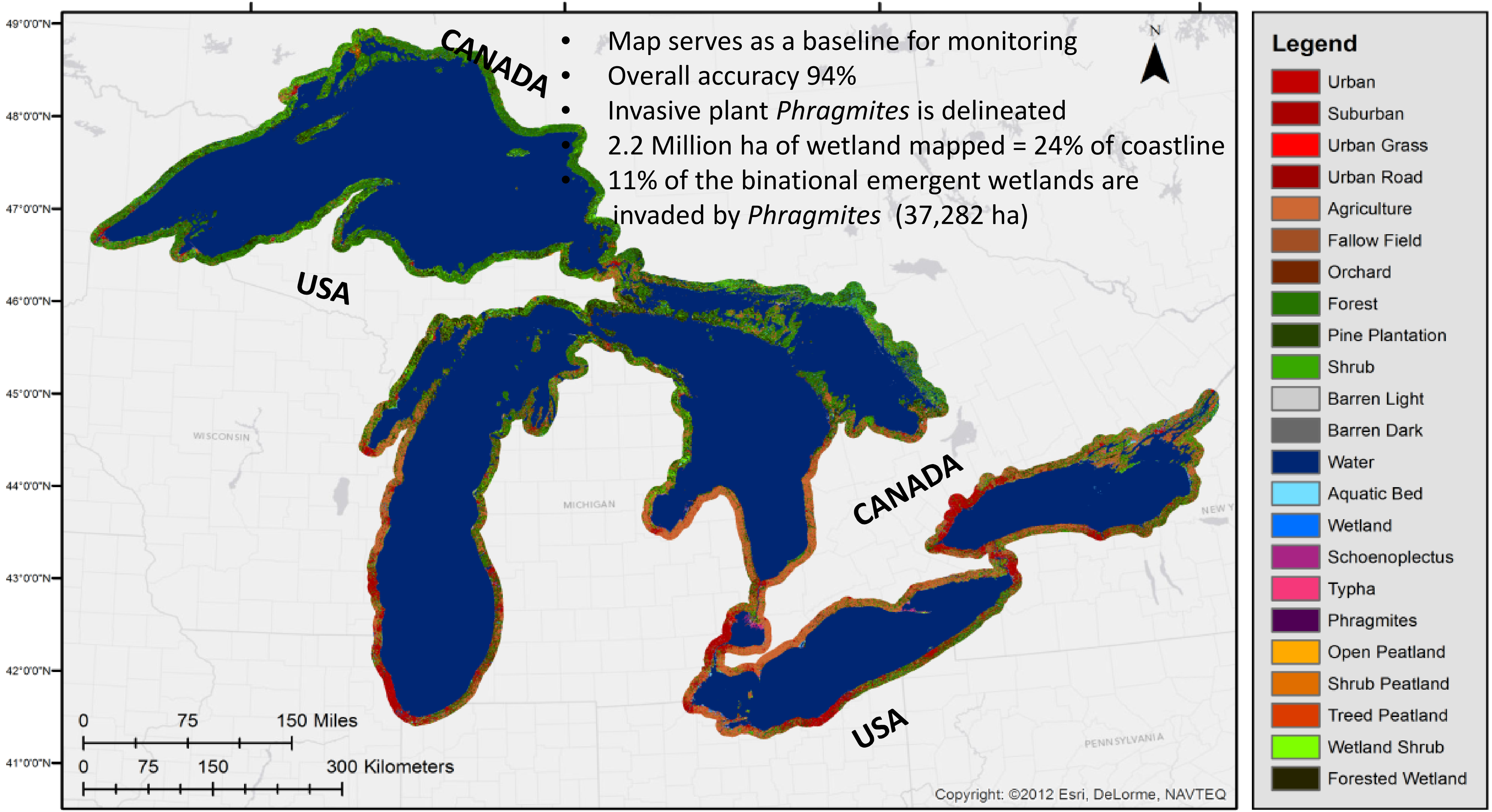
- Mapping the location of wetlands is important for carbon cycling because land cover and land use can impact the amount of carbon exported through streams and rivers. C models require accurate maps of wetlands and in particular forested wetlands to accurately estimate C export to the Atlantic Ocean.
- In Maine, forested wetlands were not well mapped with optical remote sensing methods, and they are important in defining the carbon export from the landscape.

- Two seasons of PALSAR-Landsat fusion were used to identify wetlands, including cryptic forested wetlands.
- This map included delineation of flooded forested wetlands (i.e. swamps) vs. soggy peatlands and open herbaceous wetlands





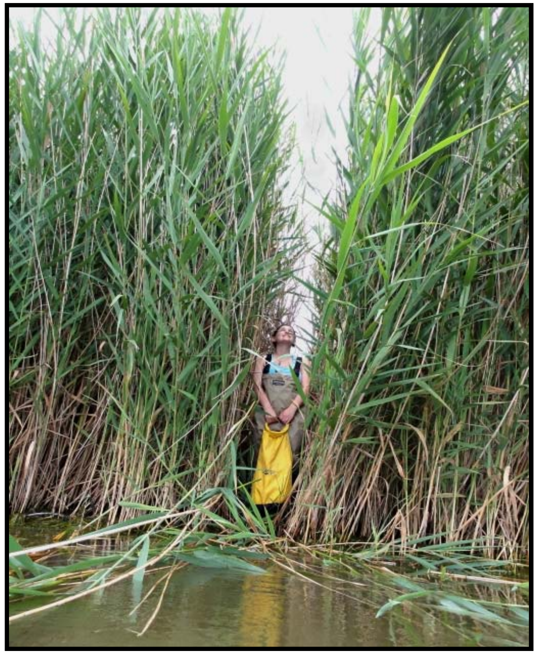
First Comprehensive Wetland Map of the Bi-National Coastal Great Lakes produced with Multi-season 2008-2010 PALSAR and Landsat fusion

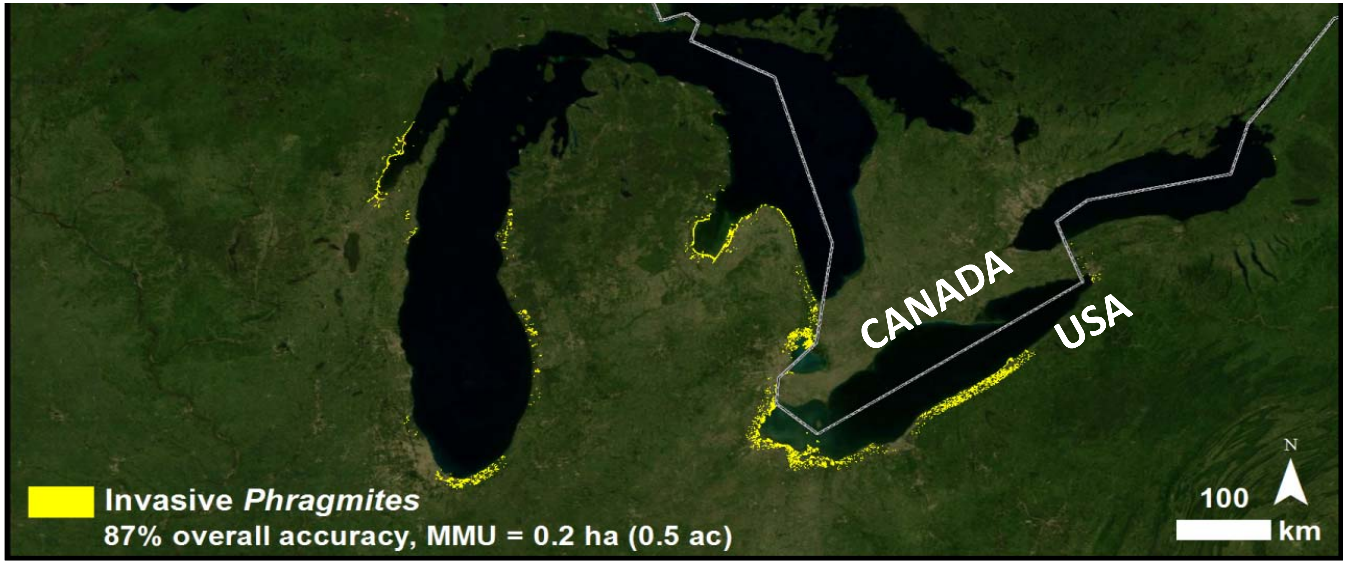


Bourgeau-Chavez et al. (2015) Remote Sensing

http://geodjango.mtri.org/coastal-wetlands/

U.S.A. PALSAR-Derived Map of Distribution of Invasive *Phragmites australis* within 10 km of Coastline



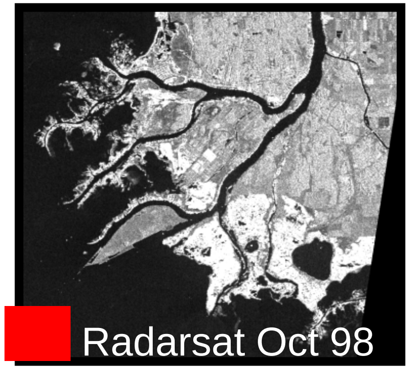


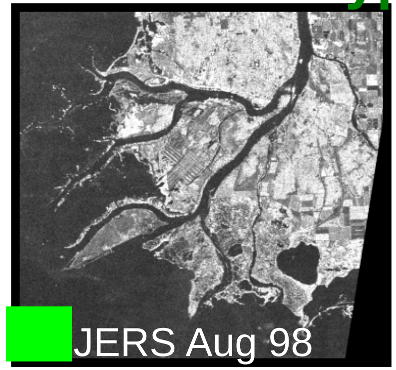
- **Invasive wetland plant, *Phragmites australis*, is a tall dense grass taking over coastal Great Lakes (and other regions nationwide) over the past 30 years**
- **This plant is an increased Carbon sink over native wetland plant species**
- **Mapping was based on multi-season PALSAR for the USA Great Lakes Coastline**
- **PALSAR detects the high biomass and inundation**

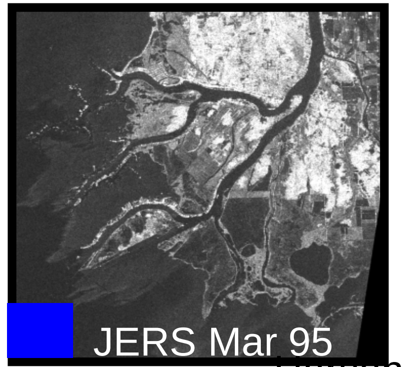
Great Lake	Total Mapping Area within 10 km of coastline	Hectares of *Phragmites* Mapped
Erie	96,862	8233
Michigan	578,320	6002
Ontario	102,056	13
Superior	*No Phramites mapped*	*No Phragmites*
Huron	75,402	10,395
Total	**852,640**	**24,643**

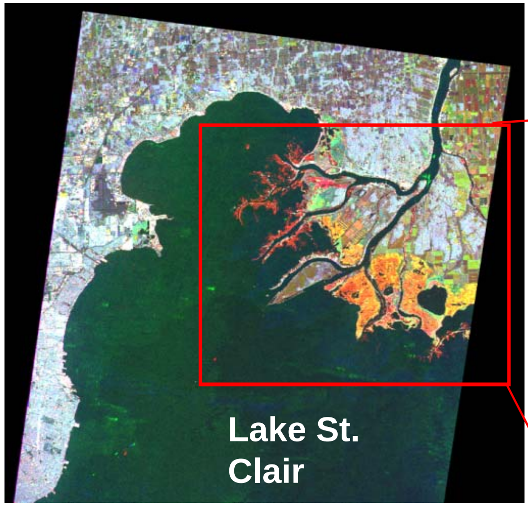
Bourgeau-Chavez et al. (2012) Journal of Great Lakes Research

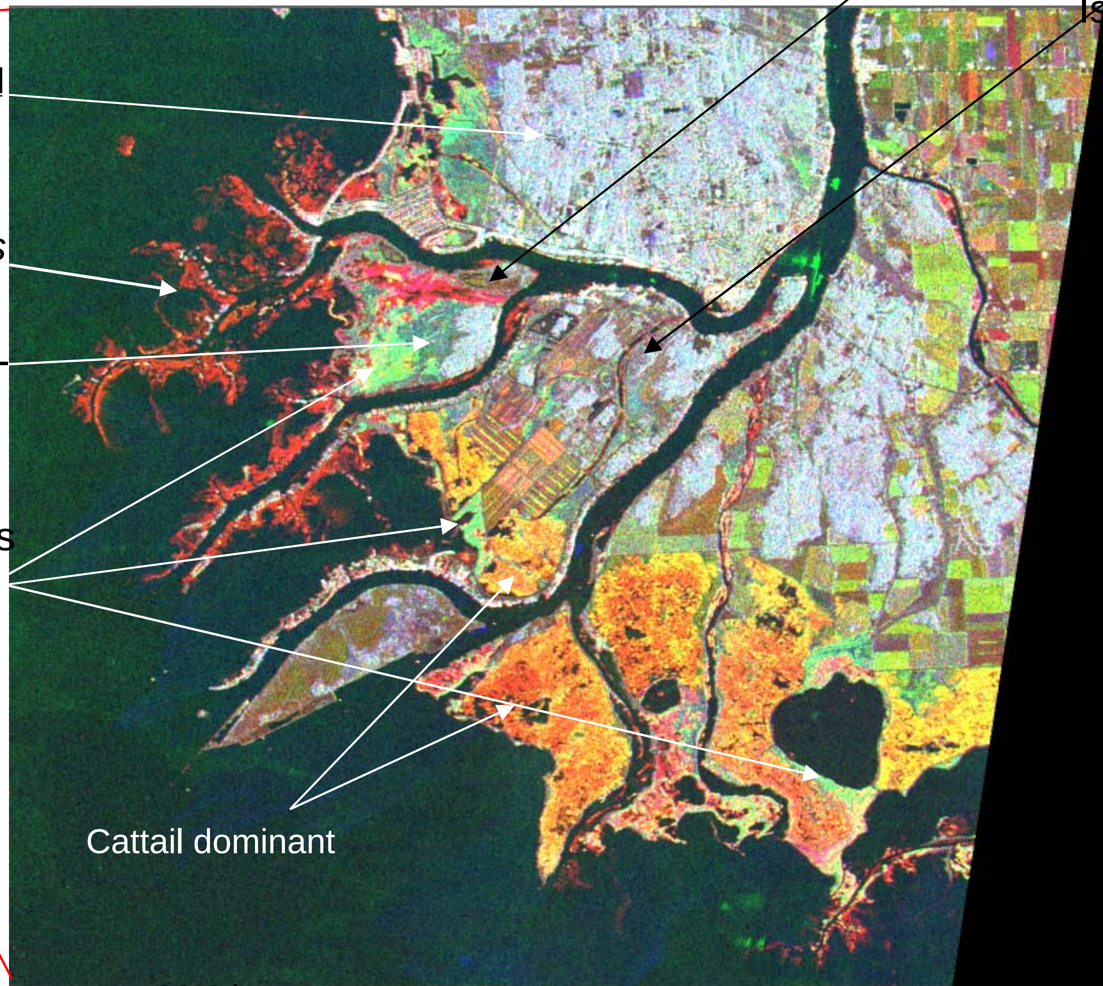
Multi-SAR Sensor Composite Distinguishes Wetland Plant Types





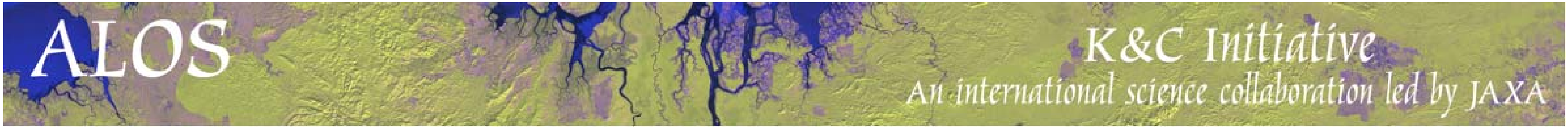






Multi-sensor L- and C-band radar composite depicts the biomass and flooding differences between the various emergent wetlands in this delta (factors relevant to Carbon stores and methane exchange).

JERS distinguishes the invasive plant *Phragmites australis* (medium green areas) which can be more than 5 m tall, and forms dense stands

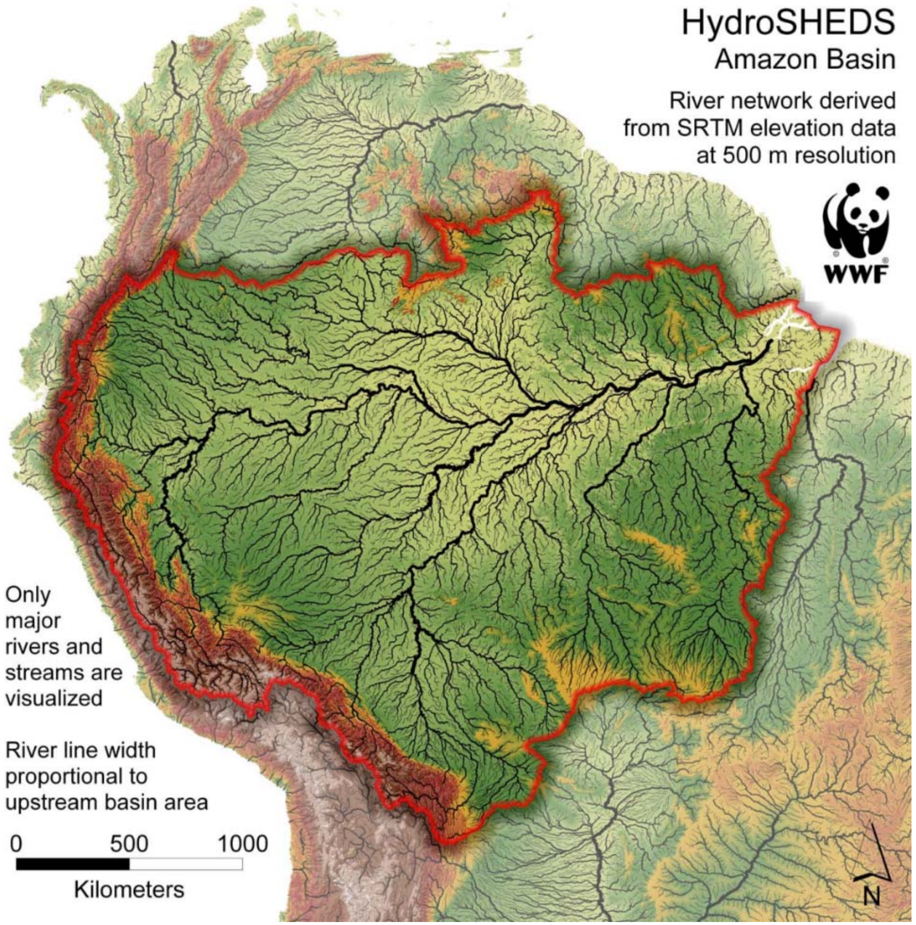


Characterization of the geological and environmental history of Amazonia

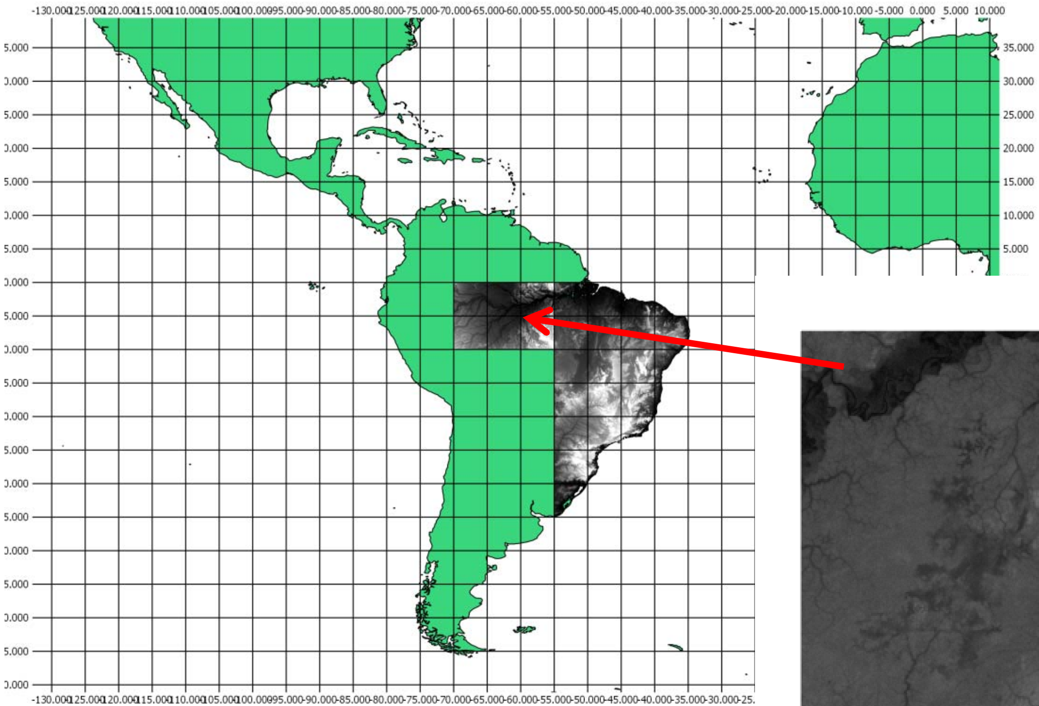
- What has been the history of environmental change across Amazonia from the late Neogene to present?

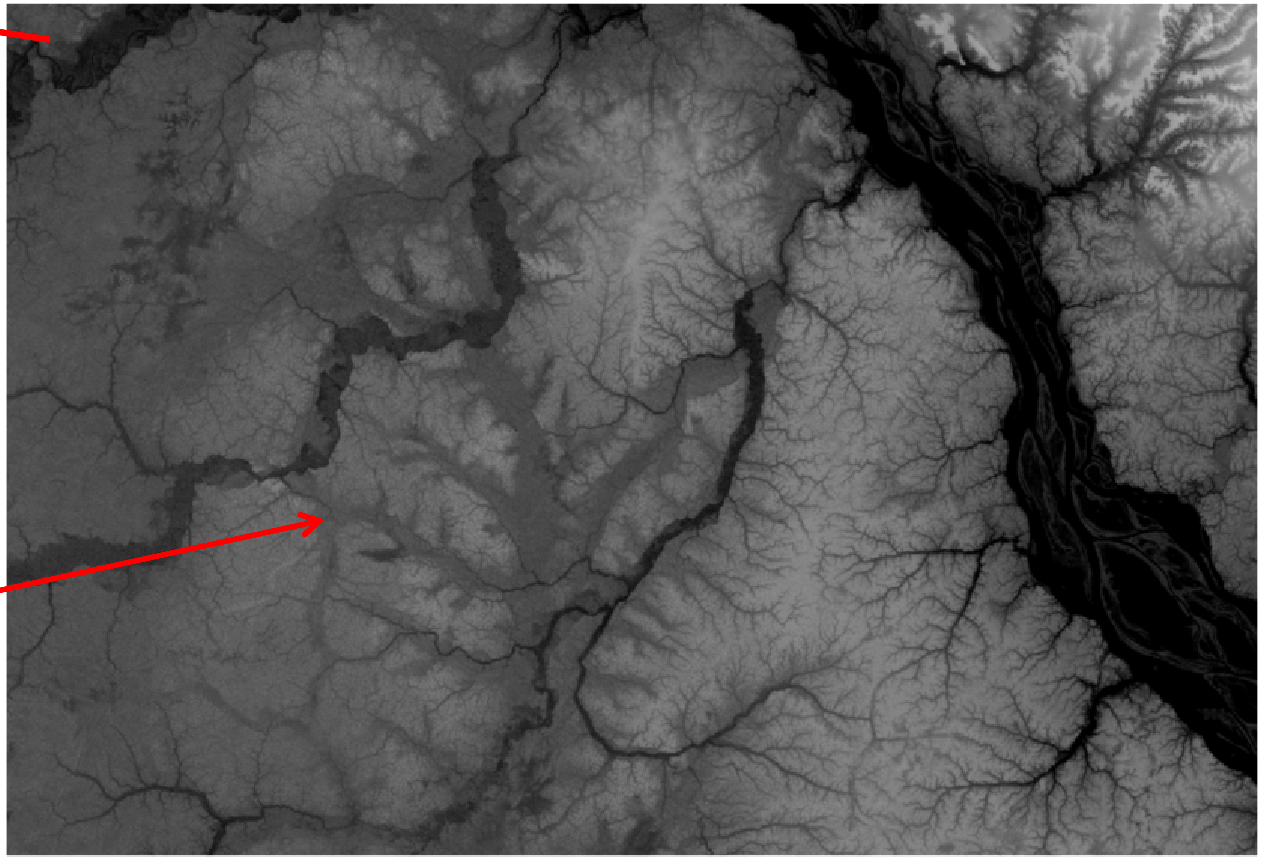
- When did the Amazonian river drainage form?

- What was the Amazonian landscape like before the Amazon river formed and how did it change after the river formation?



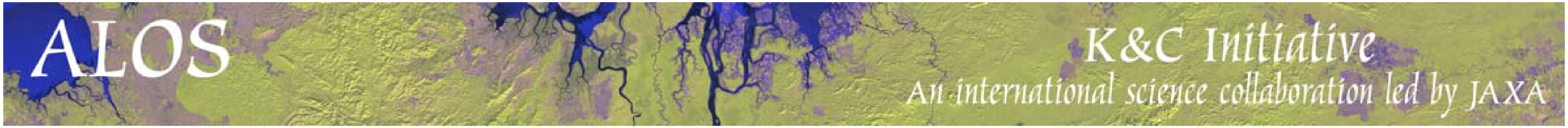
Integration using SRTM DEM: Amazon and the Atlantic Forest

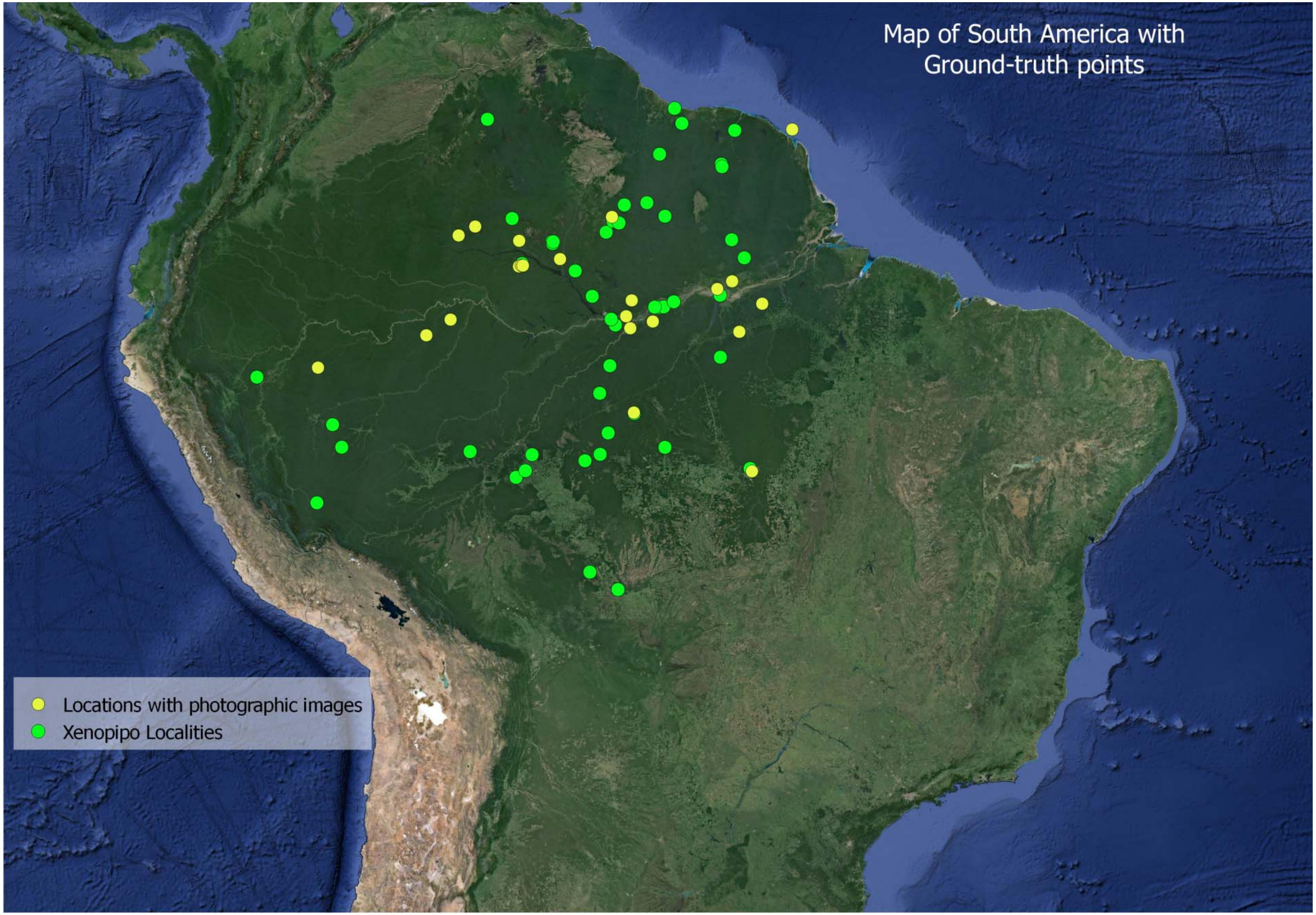




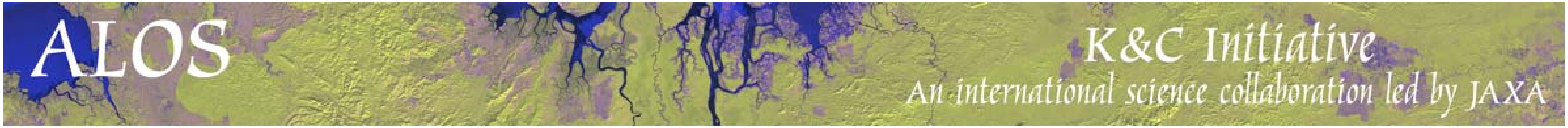
Ancient river system

based on Almeida-Filho & Miranda. 2007. *Remote Sensing Environ.* 110:387-392





Xenopipo (bird species endemic to white-sands) localities correspond to white-sand vegetation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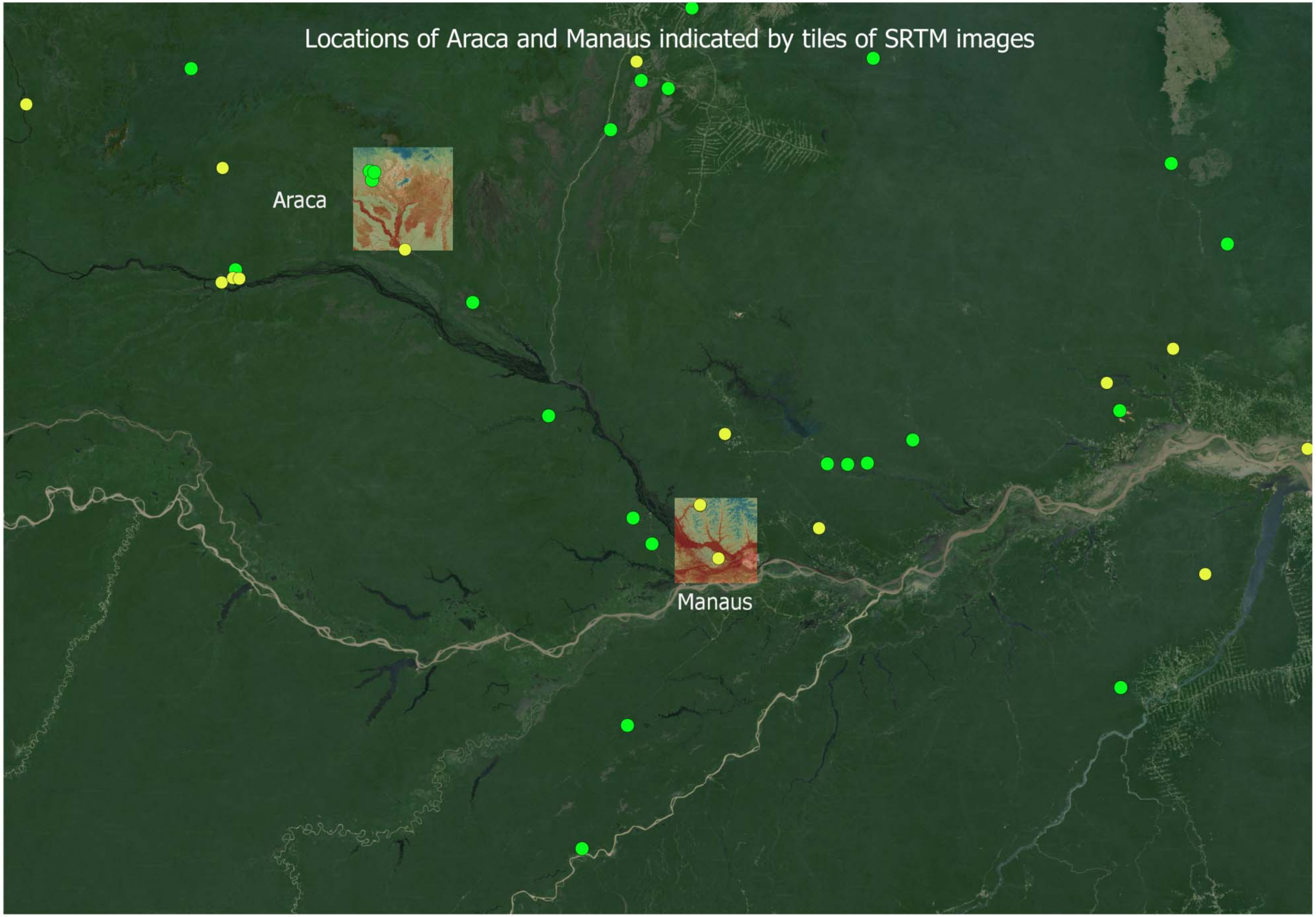
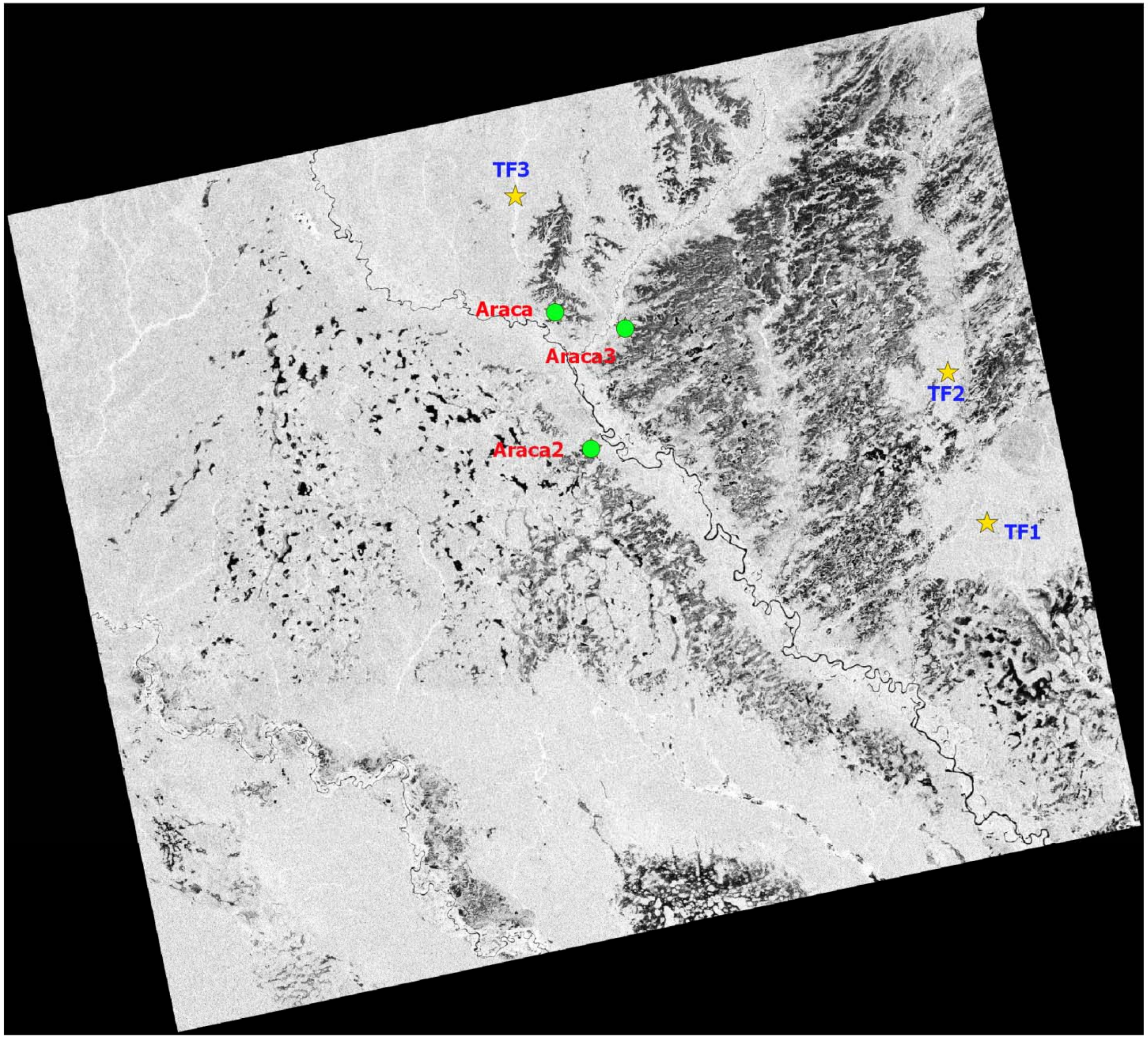

Locations of Araca and Manaus indicated by tiles of SRTM images
Araca
Manaus

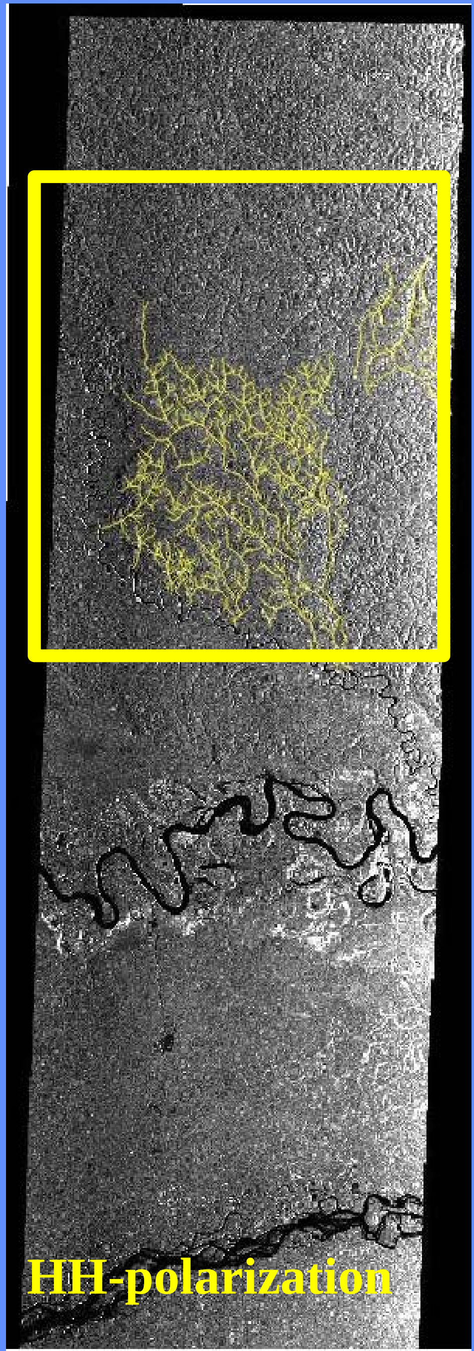
❖Photo credits: Eduardo Prata (INPA, Brazil)

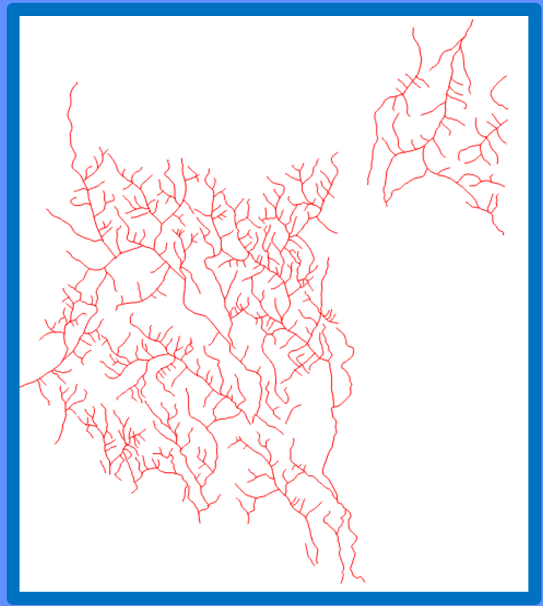
ALOS PALSAR
HH-polarisation
High-res terrain corrected FBD
Acquisition date: Oct-16 2010



White sand Vegetation
Terra Firme
7190_25177_HH (dB)
-30.603
-0.261416

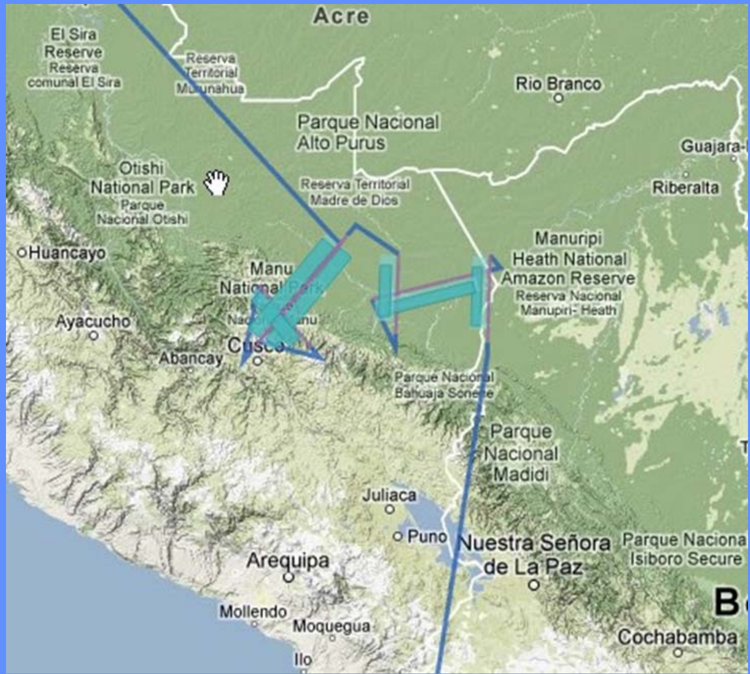
Defining river branching structure: Planalto Peru

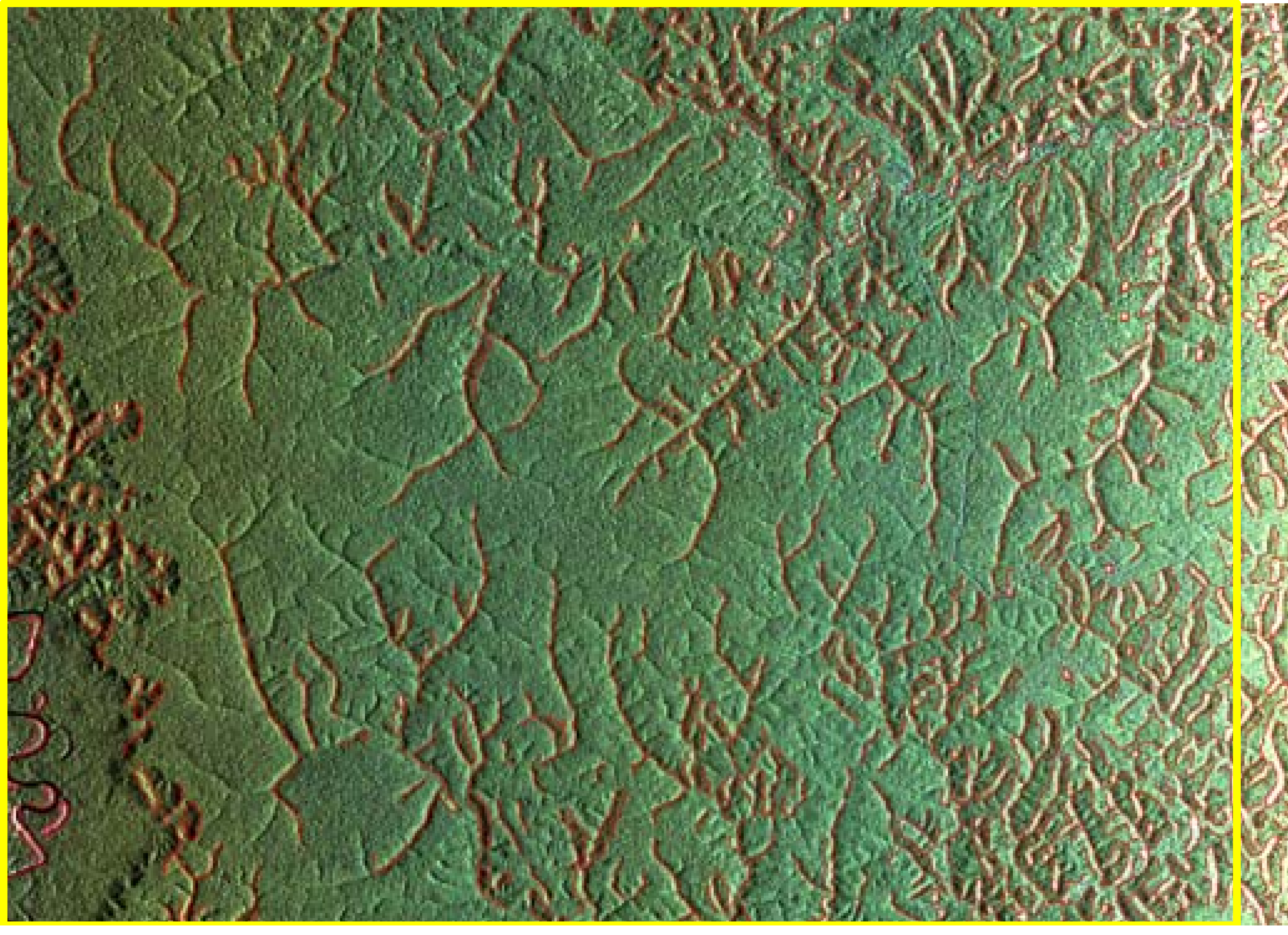




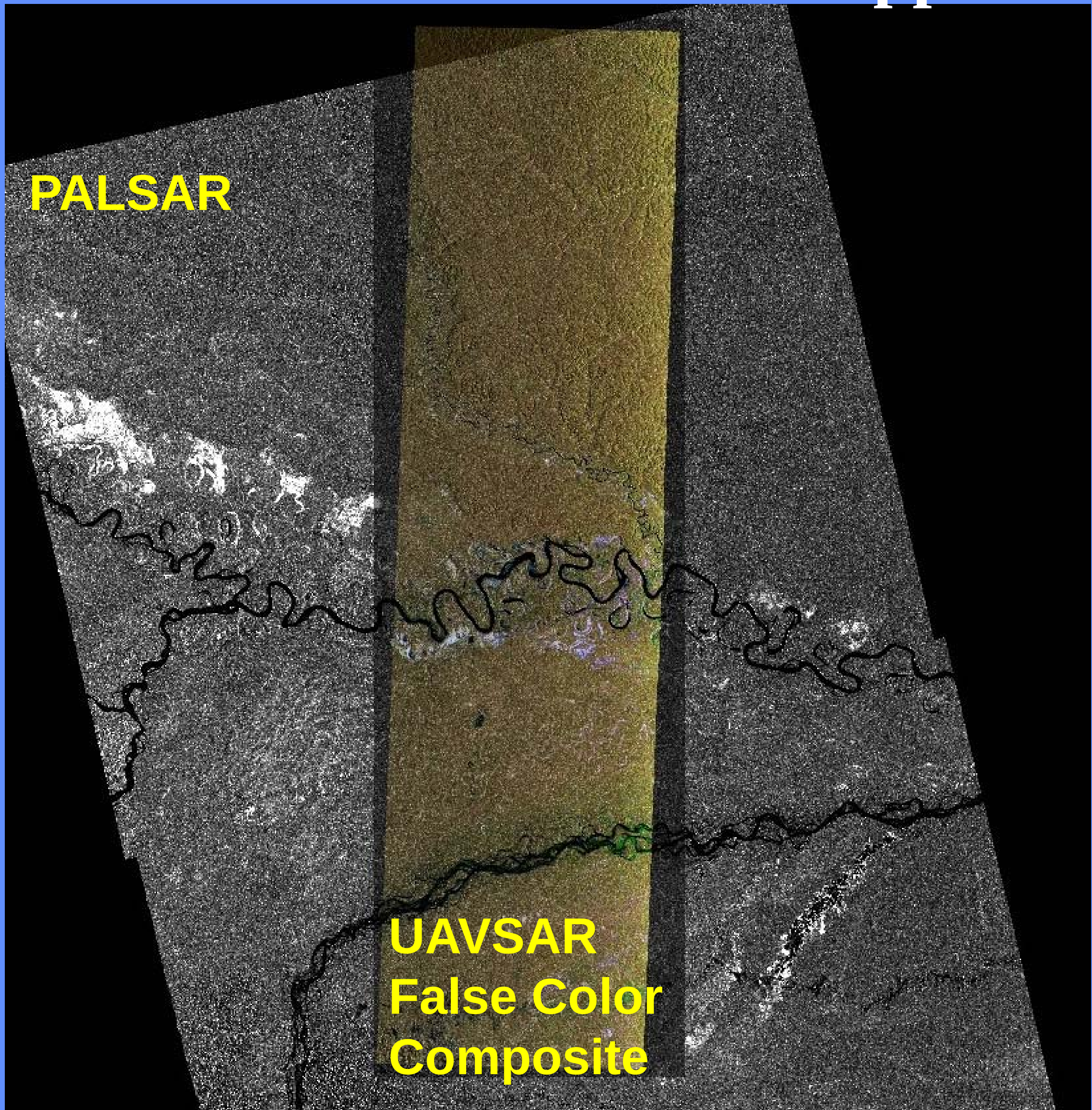
Edge detection algorithm applied to UAVSAR images

Manual clean-up applied to define structure





UAVSAR-PALSAR Fusion Supports Basin-scale Anaylses



Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

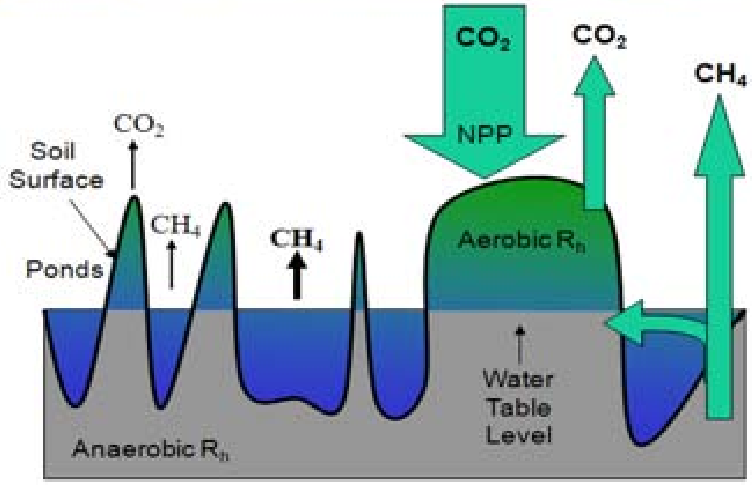
Charles Miller, PI
Steve Dinardo, PM
Jet Propulsion Laboratory,
California Institute of Technology
and the CARVE Science Team

CARVE Addresses
Key Unanswered Science Questions

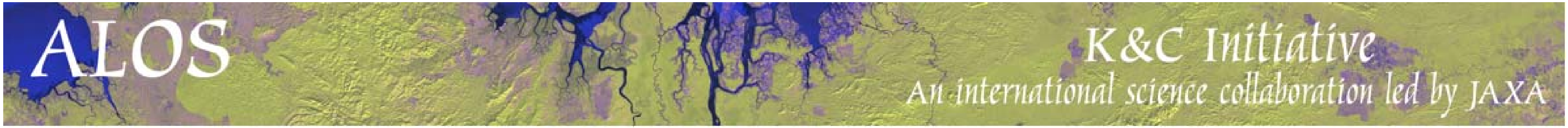
1) What are the sensitivities of the Alaskan Arctic carbon cycle and ecosystems to climate change?

2) How does interannual variability in surface controls (e.g., soil moisture) affect landscape-scale atmospheric concentrations and surface-atmosphere fluxes of CO_2 and CH_4 in the Alaskan Arctic?

3) What are the impacts of fire and thawing permafrost on the Alaskan Arctic carbon cycle and ecosystems?

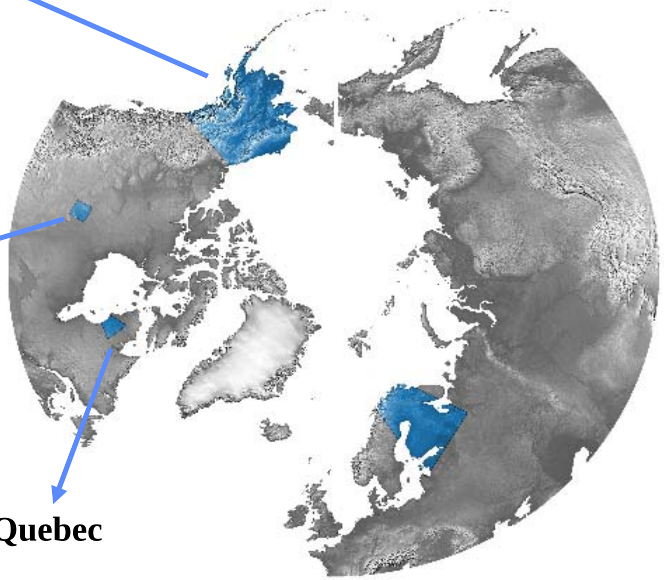


A mosaic of wet and dry areas is common for regions in the Arctic. Microtopography dictates the partitioning of soil respiration into aerobic processes (CO_2 release) and anaerobic processes (CH_4 release). The partitioning of carbon fluxes from Arctic ecosystems is not known accurately.



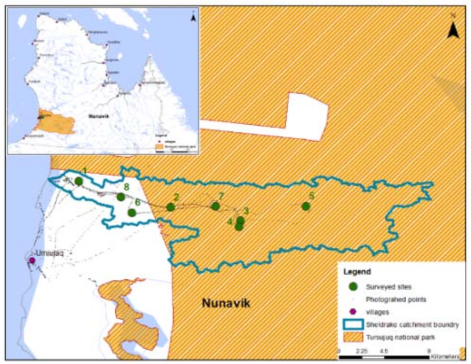
Boreal/Arctic Freeze-Thaw

SMAP F/T Domain

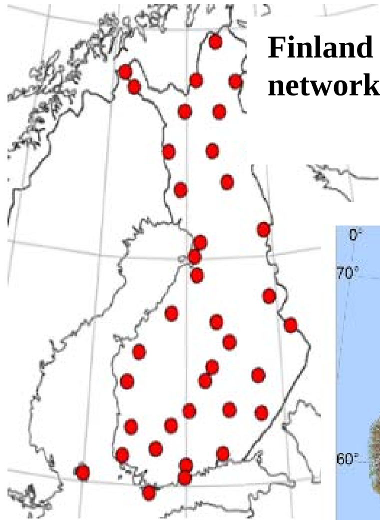


BERMS (Saskatchewan)

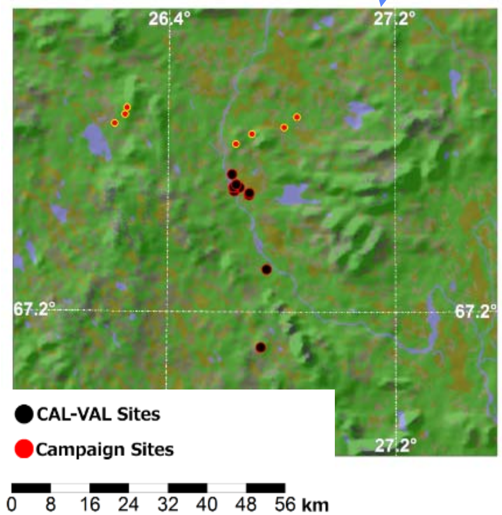
Umiujaq, Quebec

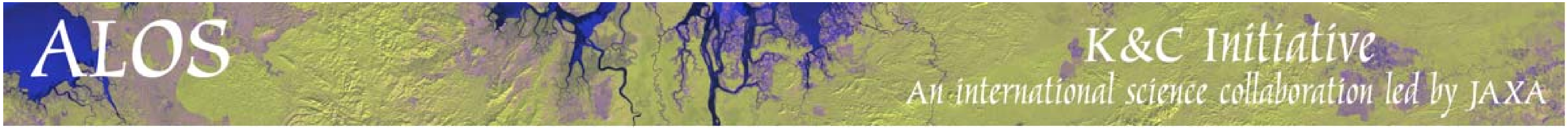


Finland frost tube network

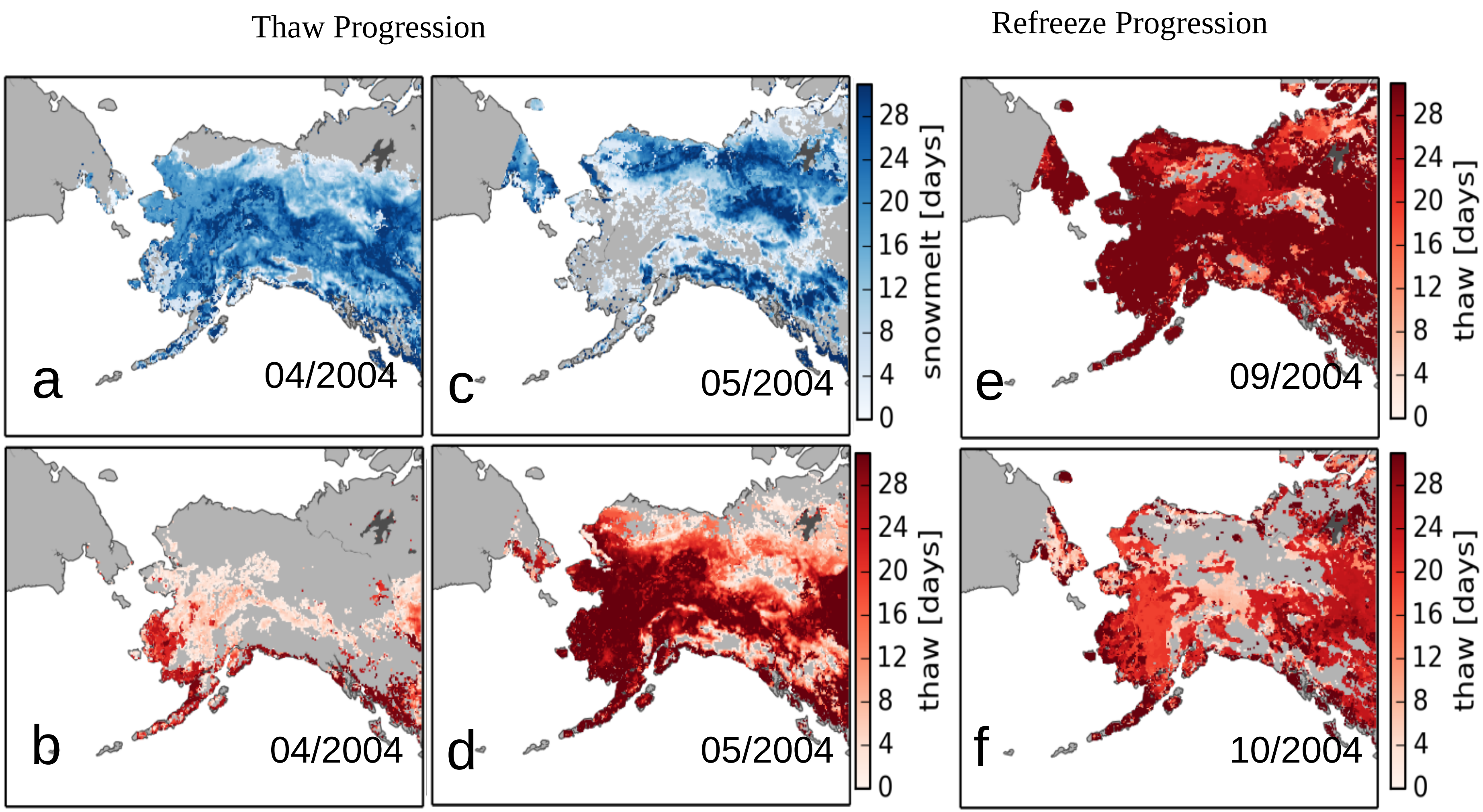


Sodankylä, Finland





Multi-frequency Freeze/Thaw algorithm development



Project Deliverables

- Updated wetlands maps from SAR datasets, providing 30-year record (Alaska, South America, Africa, Great Lakes)
- Global 25km resolution inundated area maps over 1992-2013 and updated annually, validated and assessed using PALSAR, PALSAR 2 and JERS SAR
- Wetlands map of the Chesapeake Bay estuary region.
- Biome maps of the Amazon basin and Brazilian Atlantic Coastal Forest.
- Prototype multi-sensor freeze/thaw state algorithm and maps for boreal study areas
- Delineation of contemporary land cover (vegetation) related to carbon and climate zonation for focused regions of the Amazon basin and the Brazilian coastal rain forest based on PALSAR and PALSAR 2.