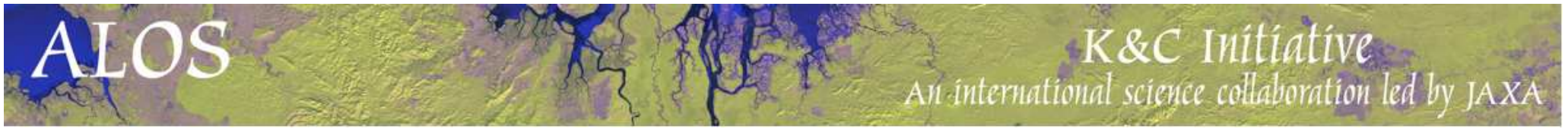



# *Mapping Global Wetlands and Boreal Freeze/Thaw with ALOS PALSAR*

*Kyle C. McDonald*

*Environmental Crossroads Initiative and CREST Institute*
*Department of Earth and Atmospheric Sciences*
*The City College of New York*
*New York, NY 10031  U.S.A.*

# Objectives

**A continuation of our wetlands mapping efforts, extending from boreal to global-scope**

**A development of a new, high resolution time series landscape freeze-thaw state mapping across the domain of the ASF-processed ScanSAR data.**

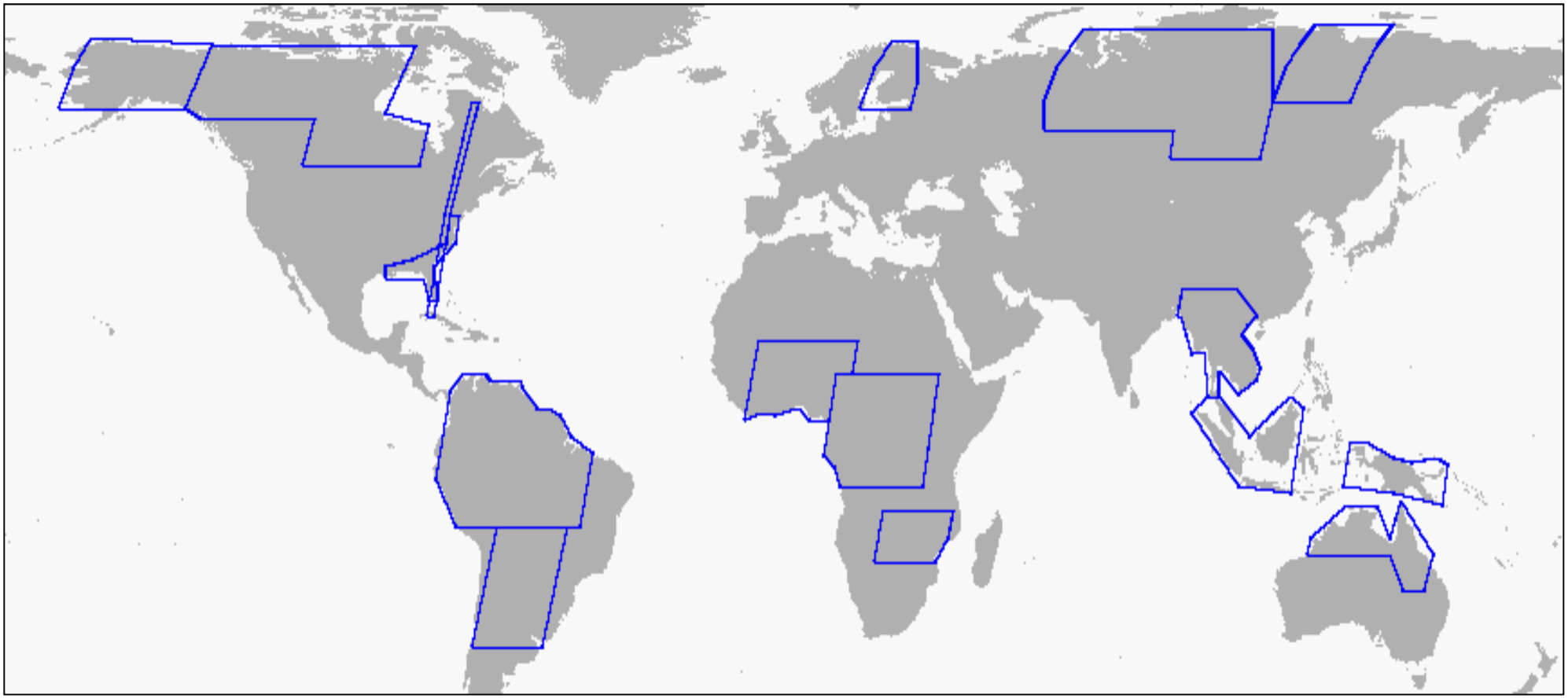
# An Inundated Wetlands Earth System Data Record: Global Monitoring of Wetland Extent and Dynamics

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.

# An Earth System Data Record for Land Surface Freeze/Thaw State: Quantifying Terrestrial Water Mobility Constraints to Global Ecosystem Processes

Objective: Construction of a consistent, systematic long-term global record of land surface freeze/thaw state dynamics for all vegetated regions where low temperatures are a major constraint to ecosystem processes.

# Project Areas: ScanSAR regions



# Components of the Inundated Wetlands Earth System Data Record

| |
|---|
| **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, 1992-2009 †** |
| **1. Globally gridded (25km) inundated area fraction (10 day intervals)** |
| **2. Globally gridded (25km) 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.

## Science Products:

- Inundated wetland area (swath-by-swath)
- Principal wetland vegetation classes (non-vegetated, herbaceous, shrub, woodland, forest)
- Seasonally based summary products describing timing and extent of wetland inundation
- ScanSAR coverage has a 46-day repeat cycle with ~17-day sub-cycles

# Support to JAXA's global forest mapping effort

- Incorporate our error assessment protocols within the context of the PALSAR global forest product generation scheme to support time series and area scaling assessment of errors

  These protocols should ensure improved global forest products, or as a minimum, an improved understanding of the global forest product accuracy.

- Ground data utilized in generation of our wetlands and freeze-thaw products.

  In the USA, this includes data sets from the National Wetlands Inventory and other associated archives.

- Complete data sources or references to publically-available data sources will be provided sufficient for an investigator to generate the wetlands and freeze/thaw products independently, and to adapt these data sources to development of similar data sets associated with e.g. the generation of the global forest products.

# Deliverables

- Wetlands vegetation maps of Alaska from PALSAR FBD data
- Initial Freeze/thaw products over ASF region

- Wetlands inundation dynamics for North America from ScanSAR
- Freeze/Thaw products from ASF region

- Wetlands vegetation maps of Canada from PALSAR FBD data
- Wetlands vegetation maps of Eurasian sub-regions

# ALOS

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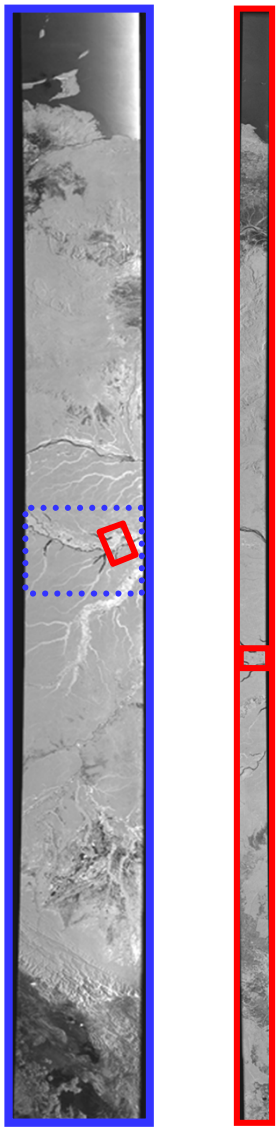
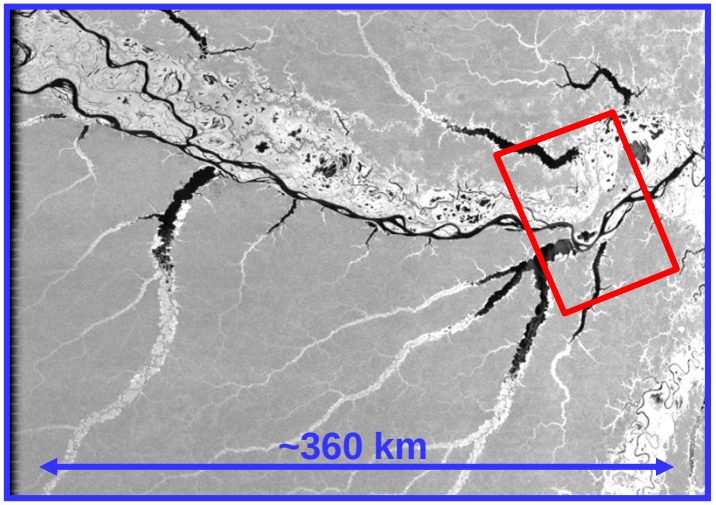


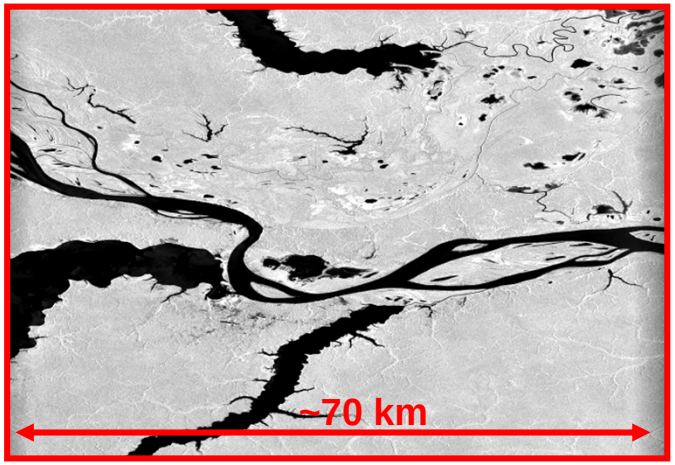
WB



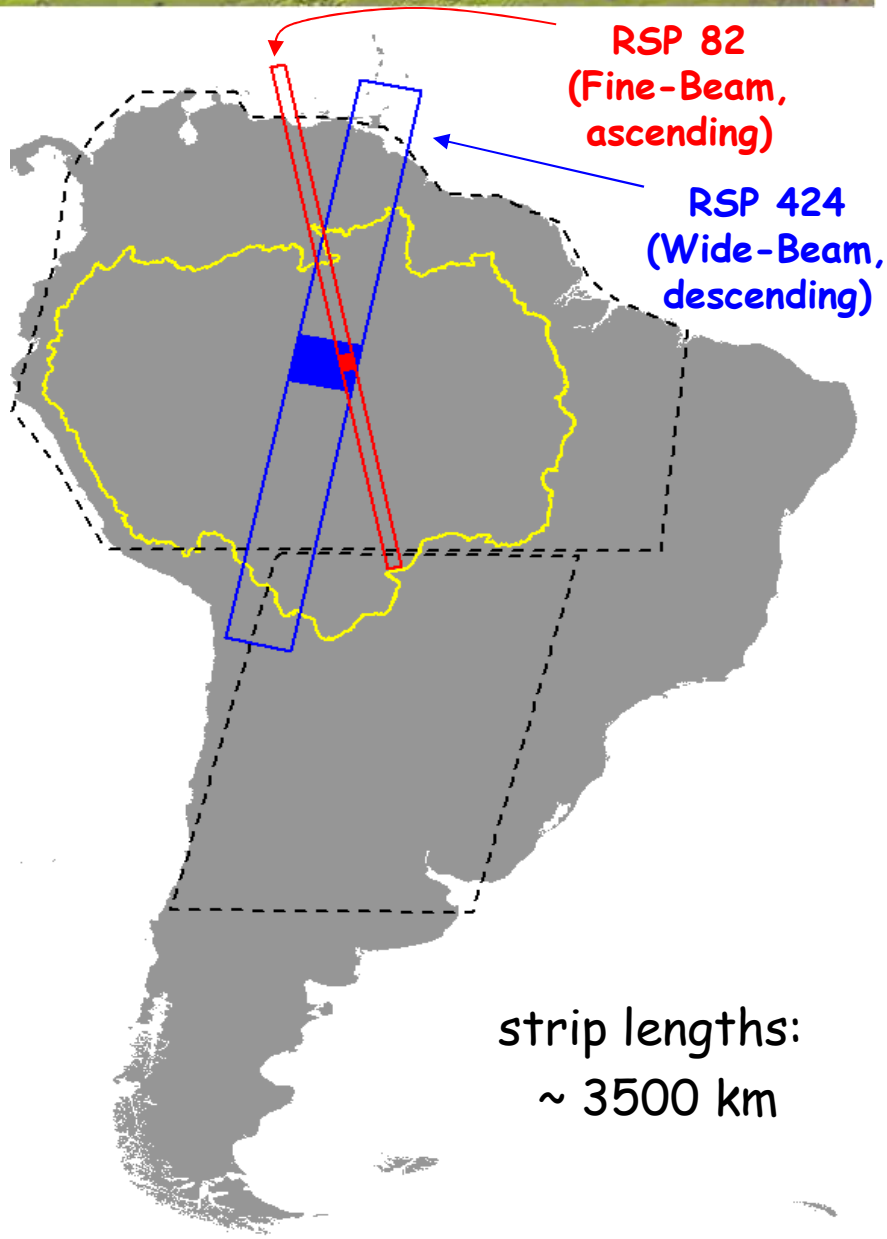
FB




Wide-Beam, slant range, ~100 m




Fine-Beam, slant range, ~50 m




strip lengths:
~ 3500 km

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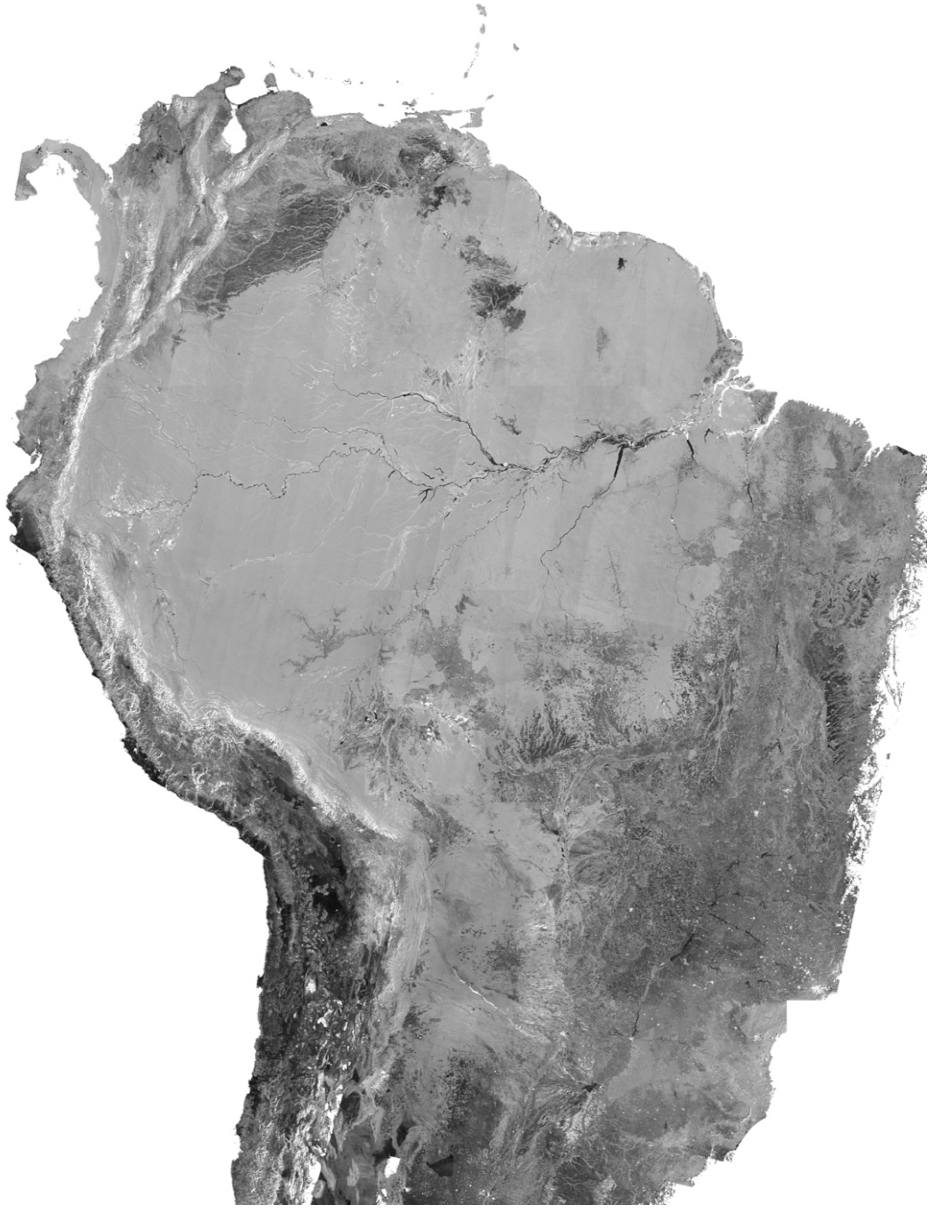


South America
ALOS SCANSAR multi-temporal image mosaic

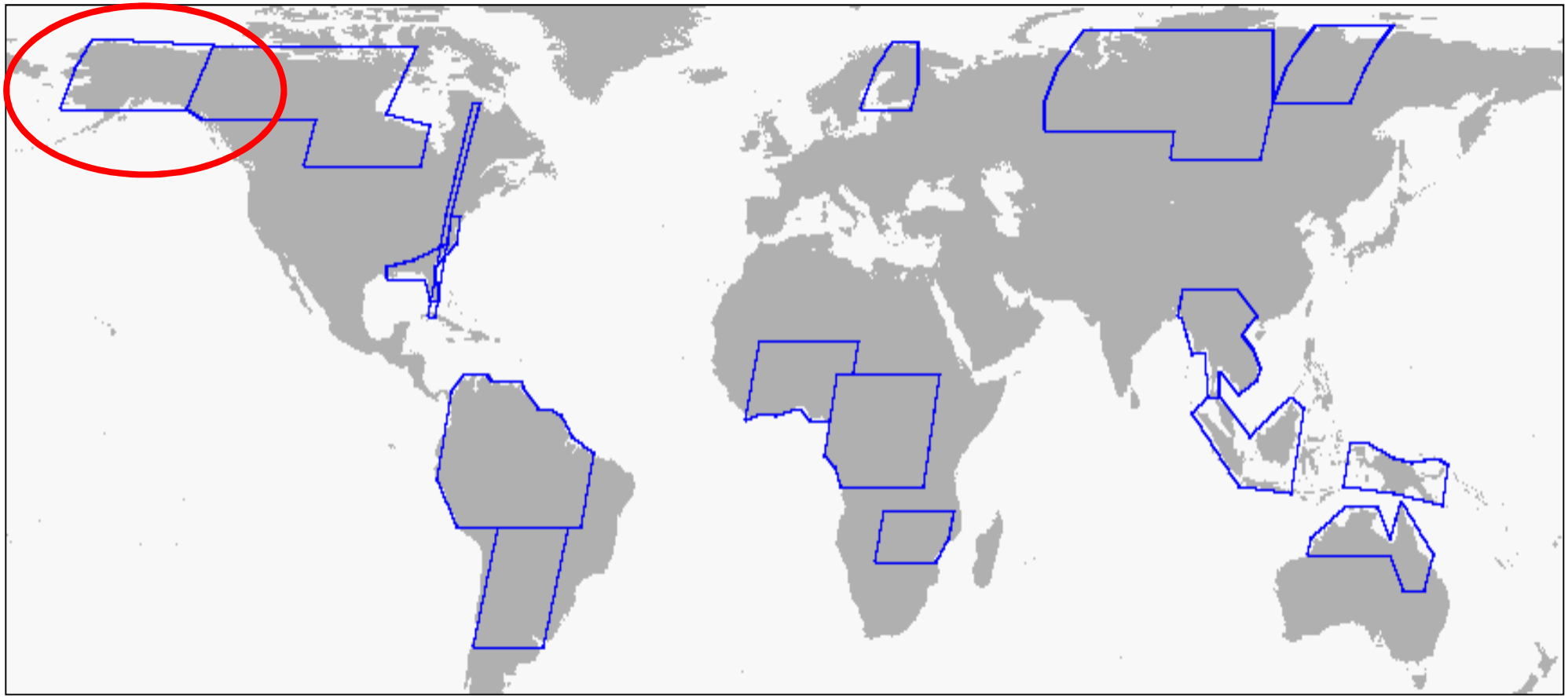
Generated from 323 SCANSAR image strips*
Data from late 2006 to mid 2010.
Often 10 or more images per pixel

Orthorectified
Terrain calibrated
Imagery and products available as

- KMZ (tiles exactly the same as SRTM)
- GEOTIFF (tiles exactly the same as SRTM)
- Binary with ENVI header

*Typically 400km x 3000km at 90 m resolution
1 million $km^2$ each

# Project Areas: ScanSAR regions

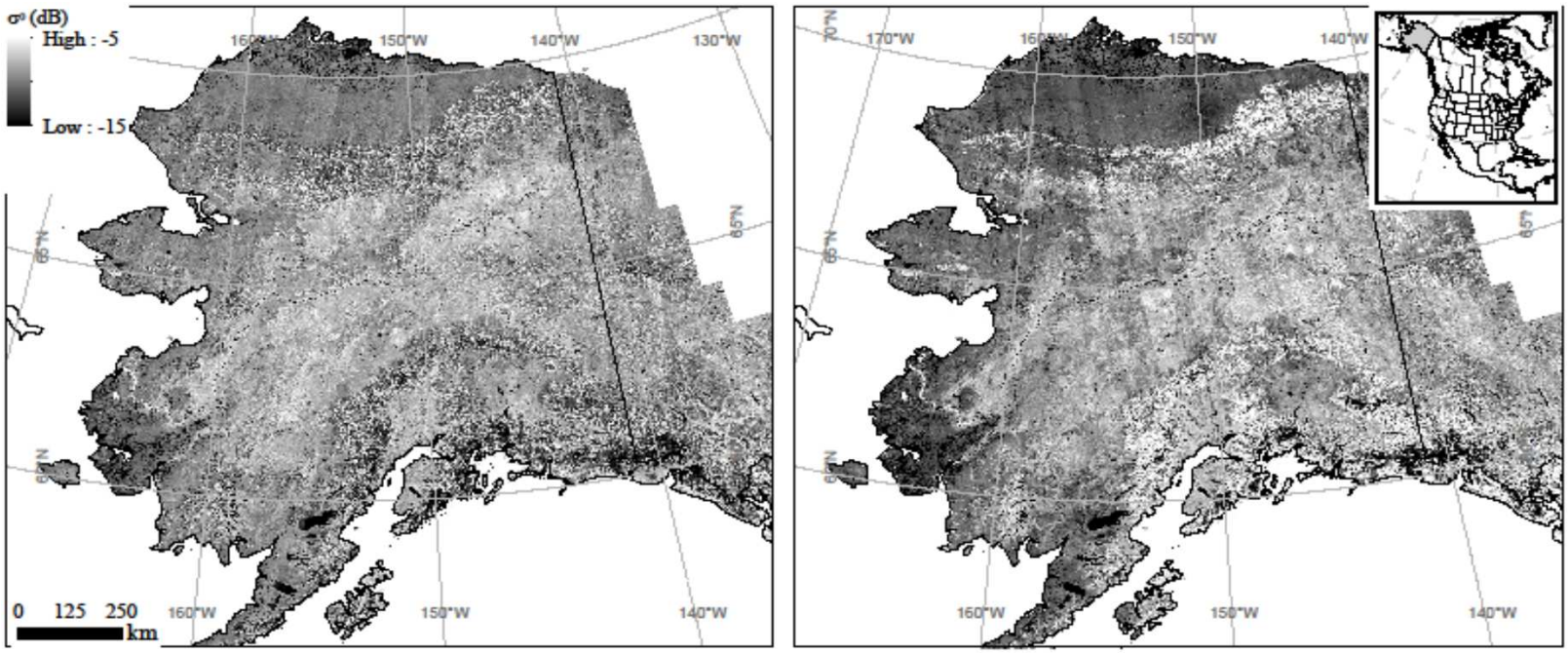


# Wetlands Mapping: A Decade of Change

## JERS-1 Mosaics

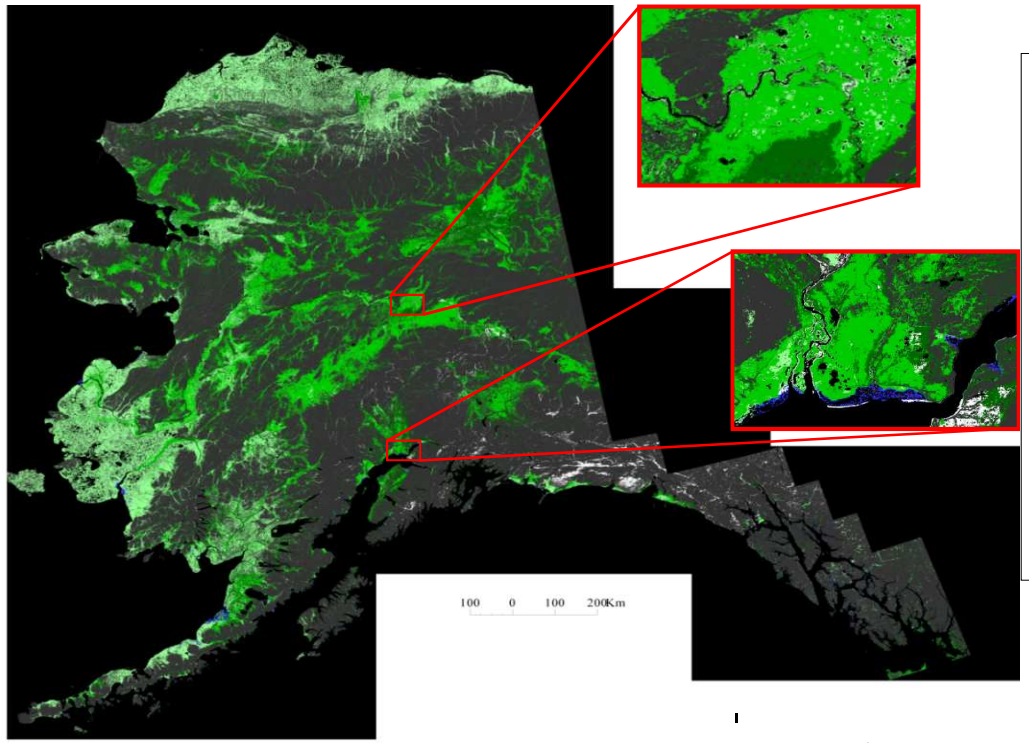
Winter

Summer



# Late 1990s Map: Based on JERS-1 Imagery

## Previously used summer and winter JERS-1 imagery to develop a thematic map of wetlands throughout Alaska




NON-WETLAND:
- Barren
- Upland

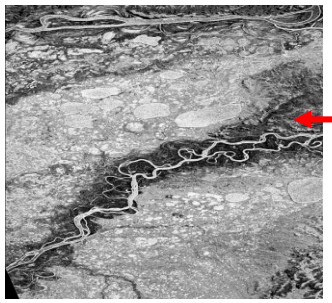
WETLAND:

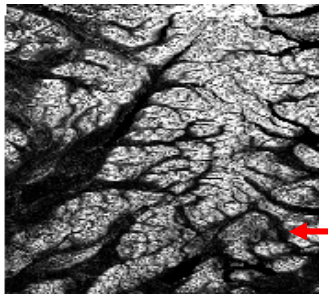
| Herbaceous | Woody | Non-vegetated |
|---|---|---|
| Moss/Lichen: Palustrine | Scrub/Shrub: Estuarine | Open water |
| Emergent: Estuarine | Scrub/Shrub: Palustrine | |
| Emergent: Lacustrine | Forested: Estuarine | |
| Emergent: Riverine | Forested: Palustrine | |
| Emergent: Palustrine | | |

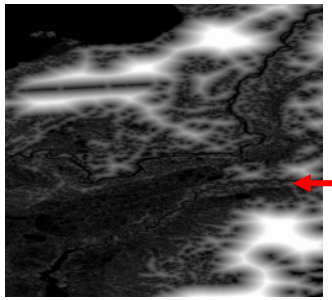
- Aggregate accuracy approximately 89.5%
- Used to generate tally of wetlands for Alaska

Whitcomb, J., Moghaddam, M., McDonald, K., Podest, E., Kellndorfer, J., Wetlands Map of Alaska Using L-Band Radar Satellite Imagery, Canadian Journal of Remote Sensing, 2009, Vol. 35, pp. 54-72 (winner of Best-Paper-of-Year award)

# Ancillary Data Used in Wetlands Classification

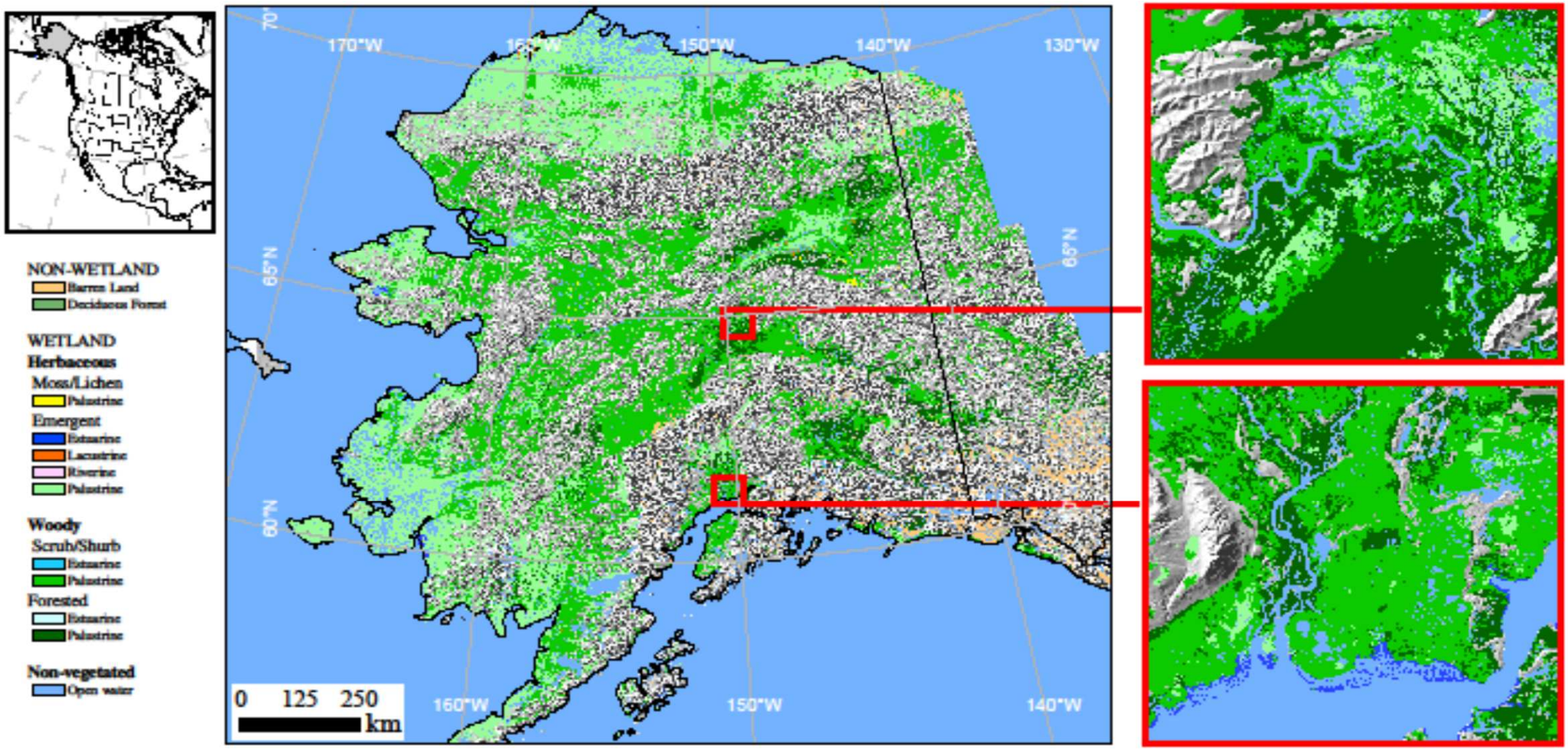






| Data | Purpose | Source |
|---|---|---|
| SAR texture | provides measure of SAR brightness variability | Derived from SAR imagery |
| SAR date-of-collection | allow adjustment for temporal differences between swaths | Provided with imagery |
| DEM | accounts for local terrain altitude | NED |
| Slope | masks out areas of high slope (> 3°), provides local surface orientation | Derived from DEM |
| Open water mask | masks out areas of open water | Derived from SAR imagery |
| Proximity to water | allows adaptation for waterside ecosystems | Derived from water mask |
| Latitude | captures effects of geographic location | Generated by GIS software |

# JERS1 – Wetlands Product



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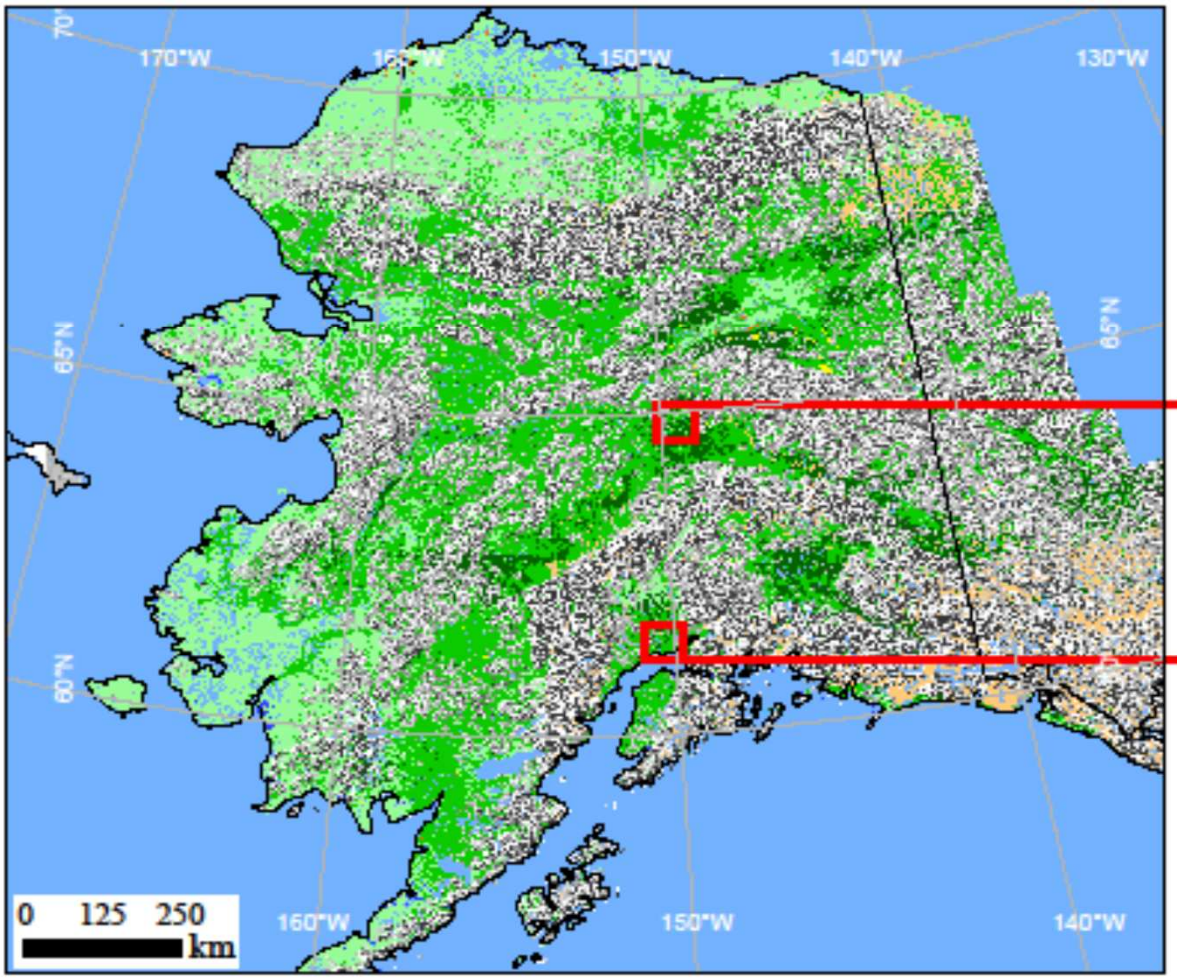
# ALOS-PALSAR – Wetlands Product



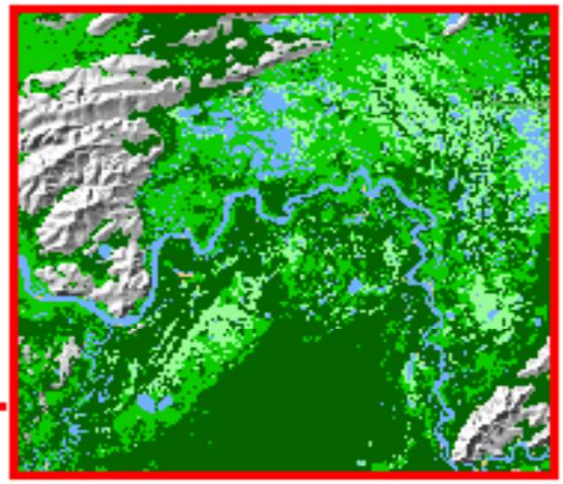

NON-WETLAND
- Barren Land
- Deciduous Forest

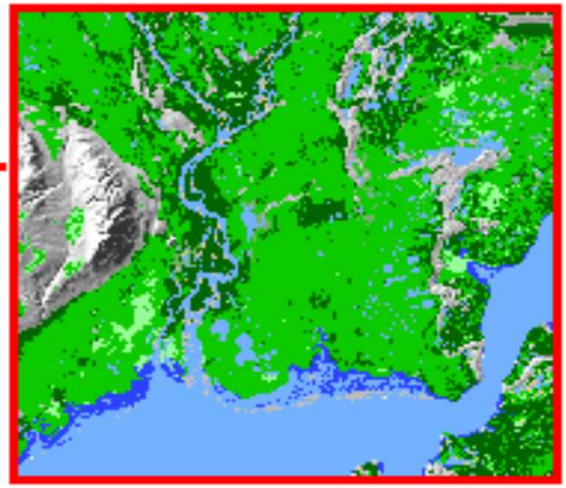
WETLAND

Herbaceous
- Moss/Lichen
  - Palustrine
- Emergent
  - Estuarine
  - Lacustrine
  - Riverine
  - Palustrine

Woody
- Scrub/Shurb
  - Estuarine
  - Palustrine
- Forested
  - Estuarine
  - Palustrine

Non-vegetated
- Open water





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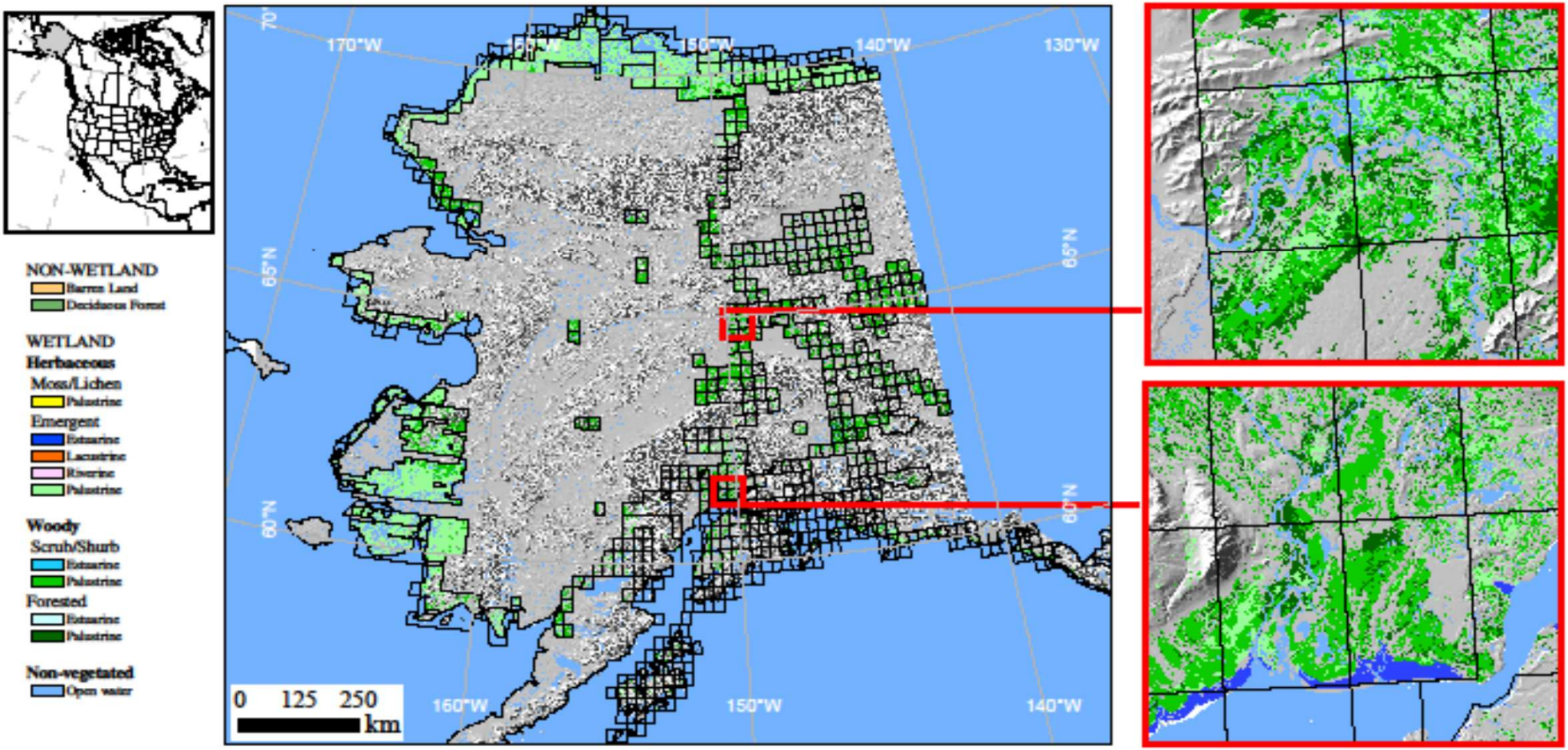
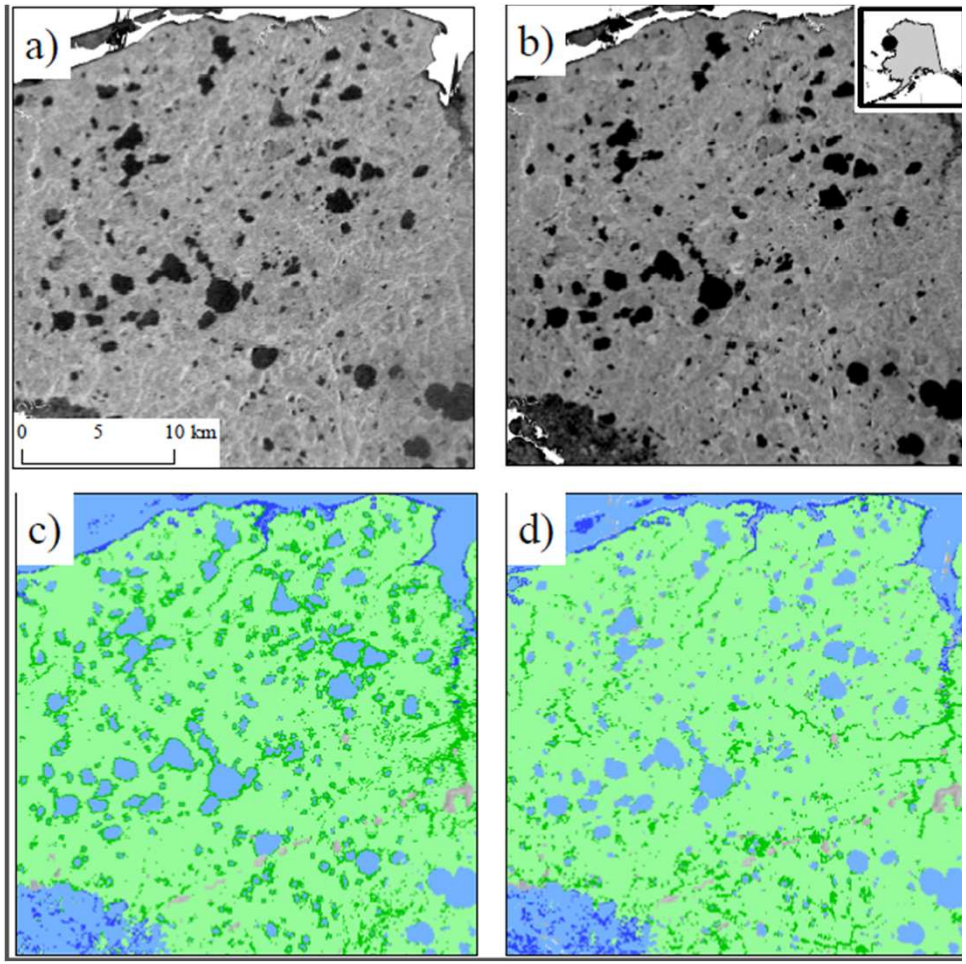


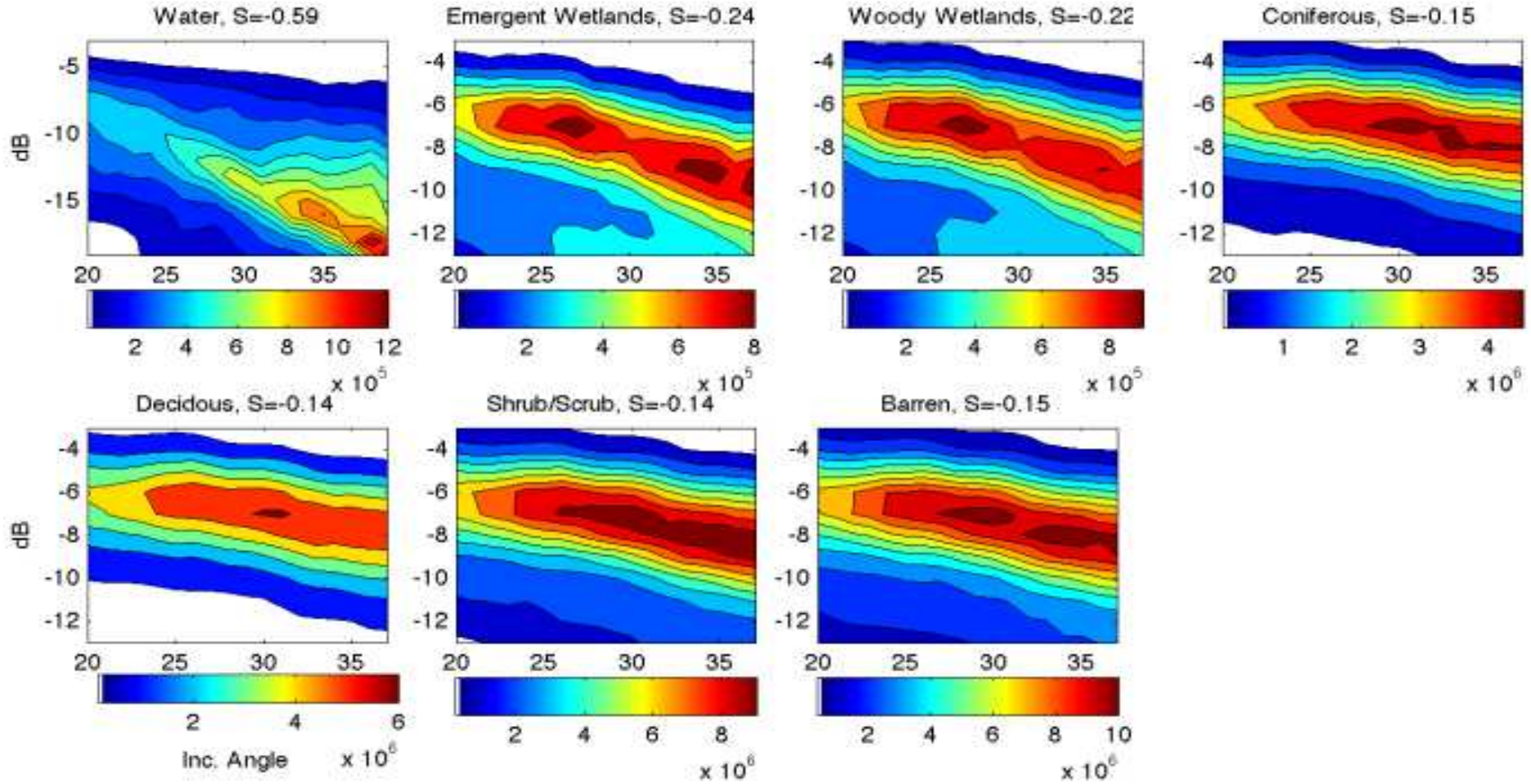

Complete ground reference data used for the classification, comprising mainly National Wetlands Inventory (NWI) data with the National Land Cover Database (NLCD) used to fill in non-wetland data. Polygons show map quadrangles for the NWI data. Subsets show sections near Fairbanks (upper) and Anchorage (lower).

# JERS and PALSAR: A Decade of Change



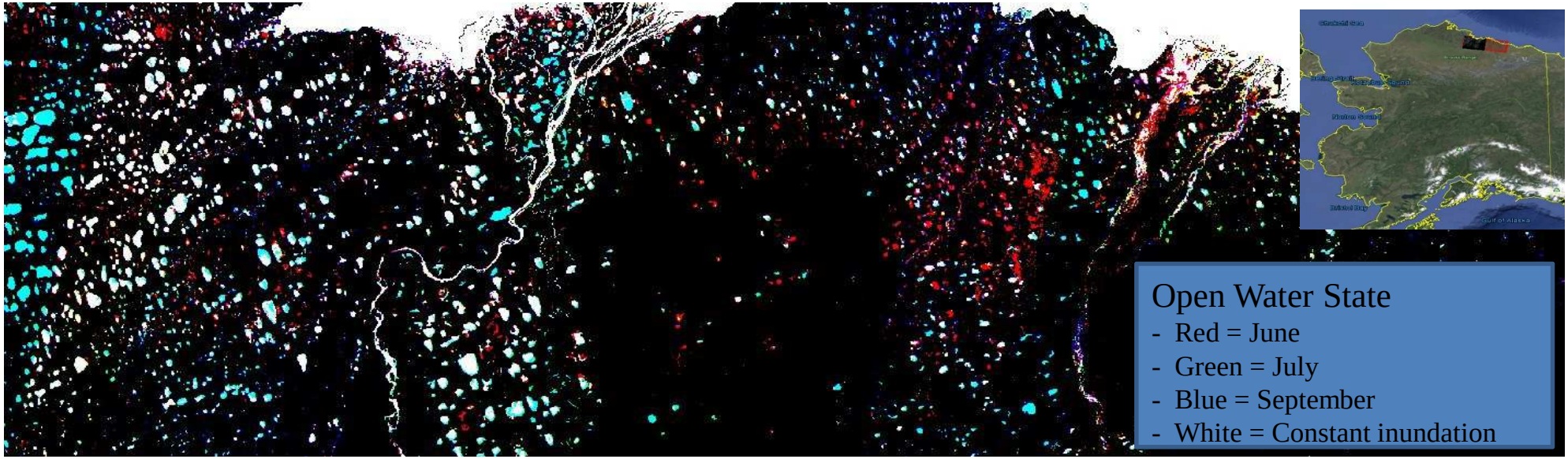

Comparison of a) JERS-1 and b) PALSAR data with derived c) JERS-1 and d) PALSAR classifications for 1998 and 2007 showing changes to the extent, and in some case the disappearance, of lakes between the two datasets and derived classification.

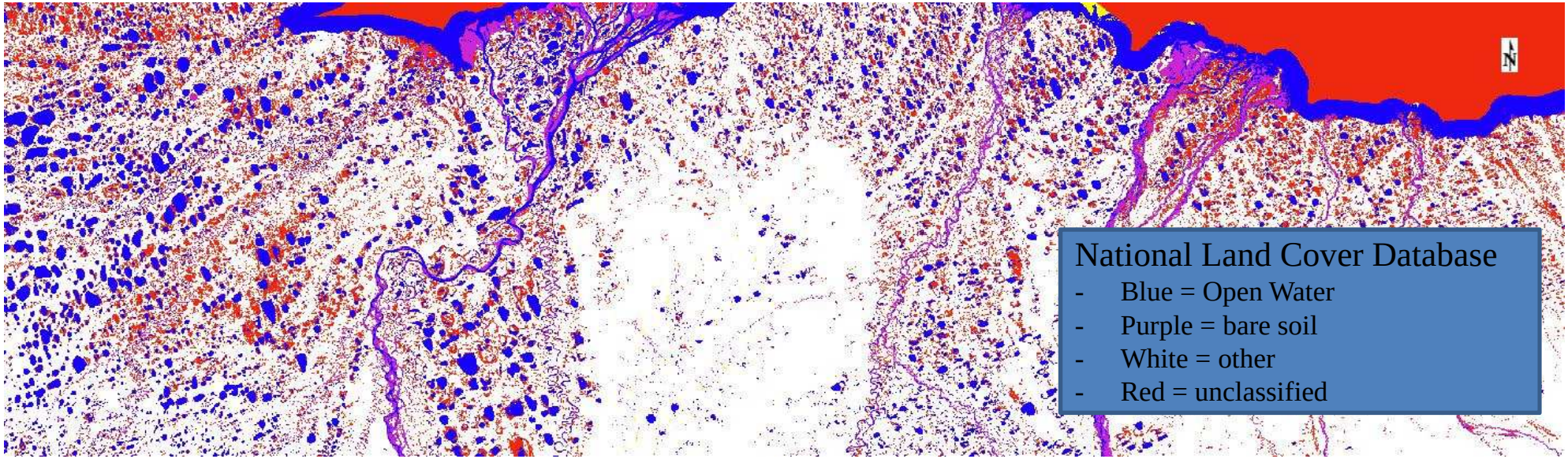
# Average slopes using simplified AGDC classes



# ALOS-PALSAR: Wetlands Inundation Dynamics

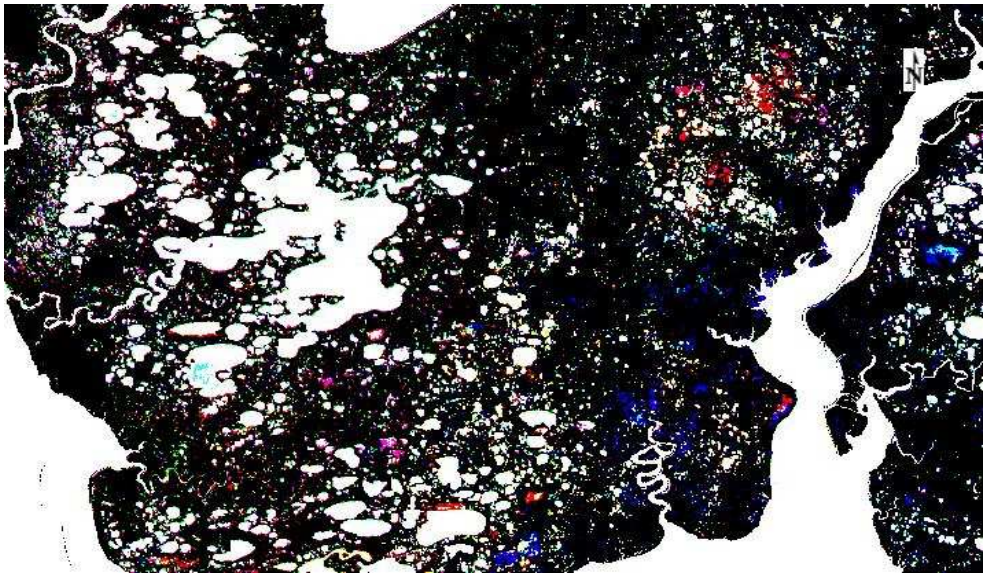
## Combined 2007 + 2010: North Slope, Alaska



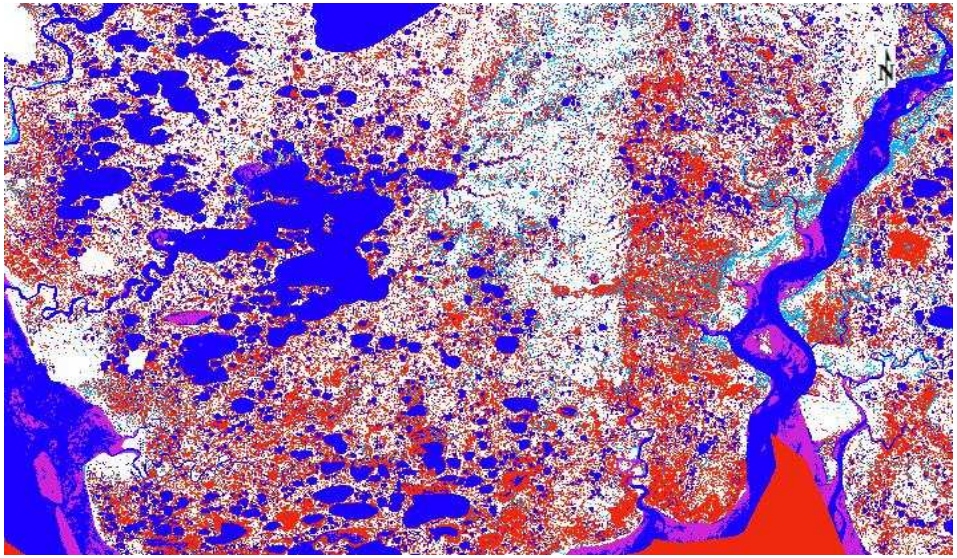
# ALOS-PALSAR: Wetlands Inundation Dynamics

## Combined 2007 + 2010: Bethel, Alaska




Open Water State

- Red = June
- Green = July
- Blue = September
- White = Constant inundation

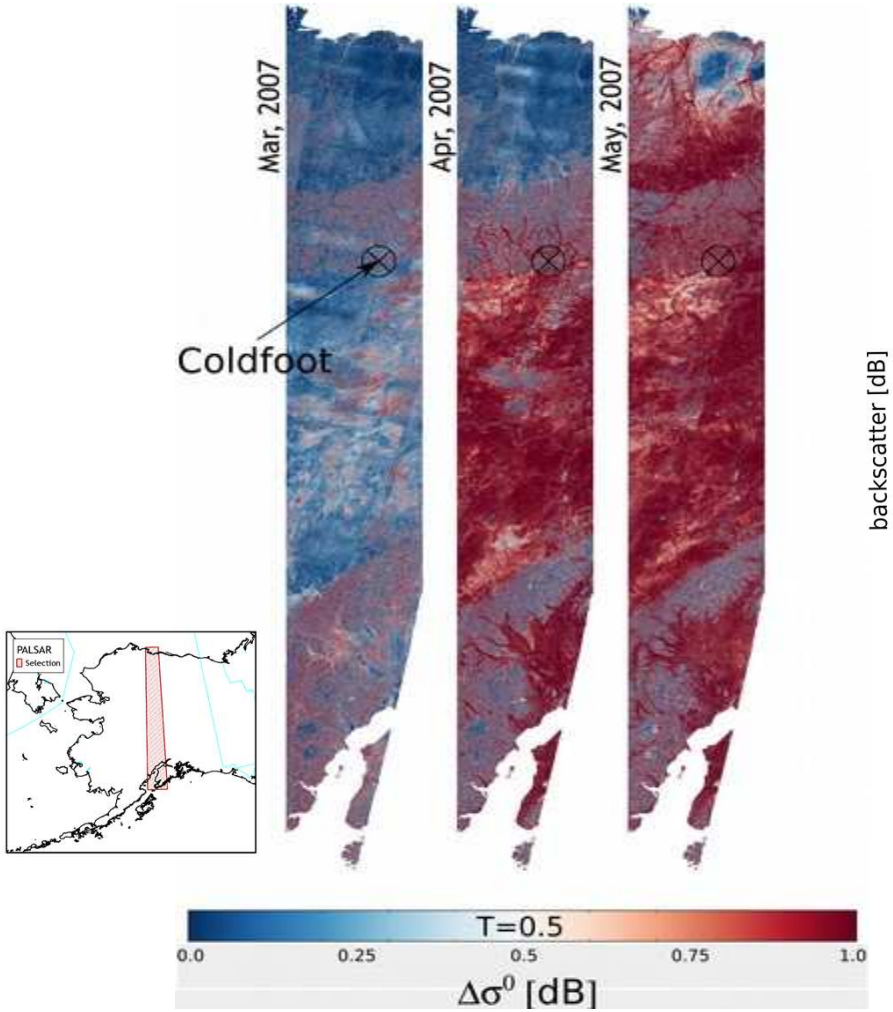


National Land Cover Database

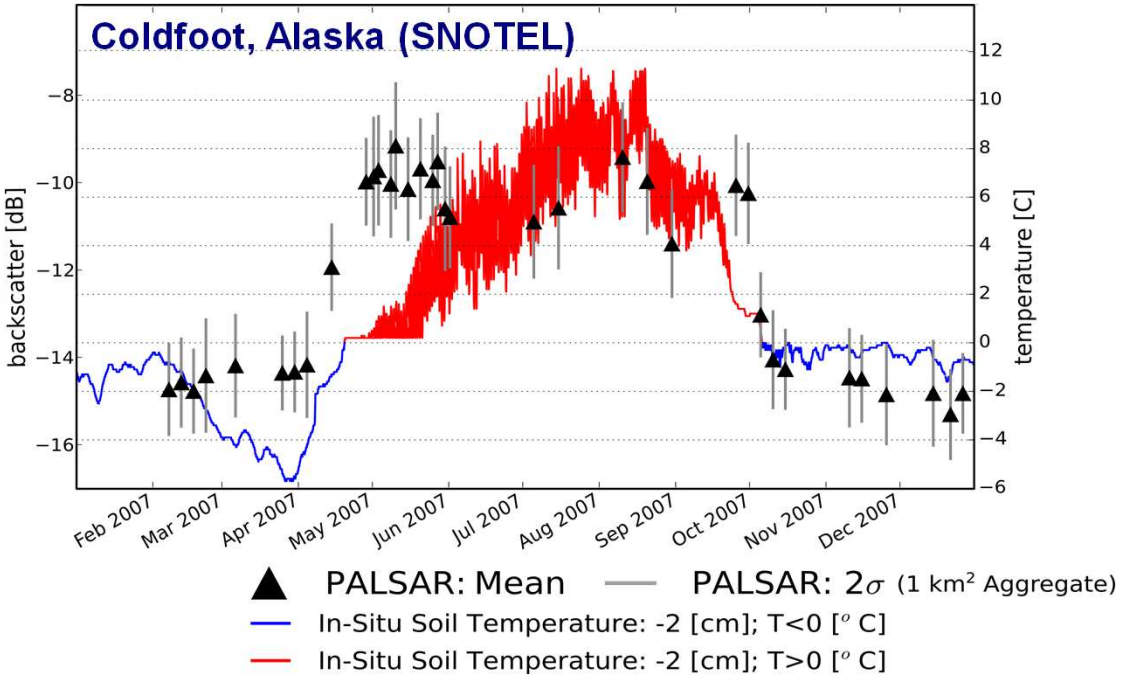
- Blue = Open Water
- Purple = bare soil
- White = other
- Red = unclassified

# Microwave-Based Freeze/Thaw Classifications

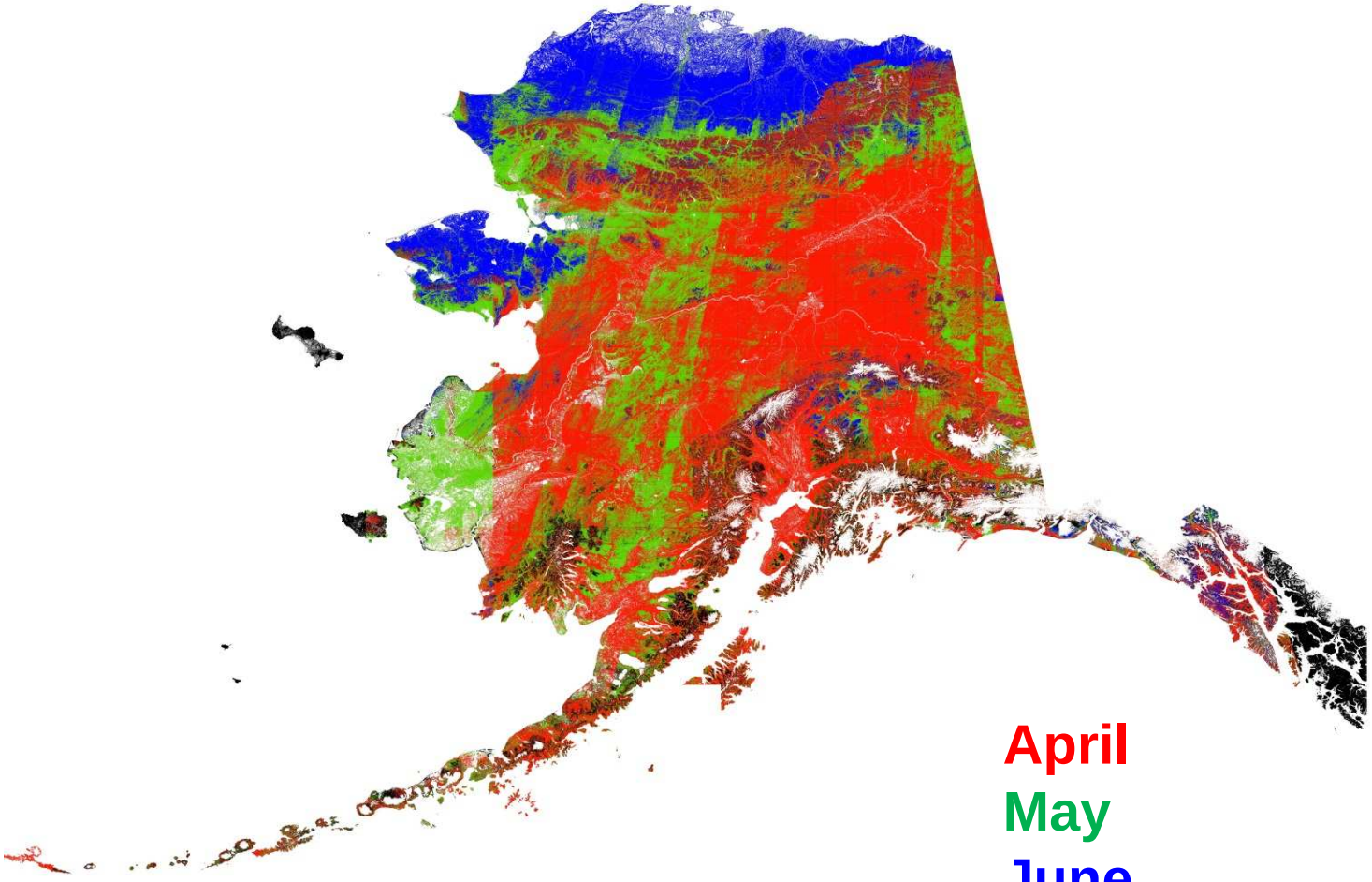
## PALSAR Transect: Monthly Aggregates

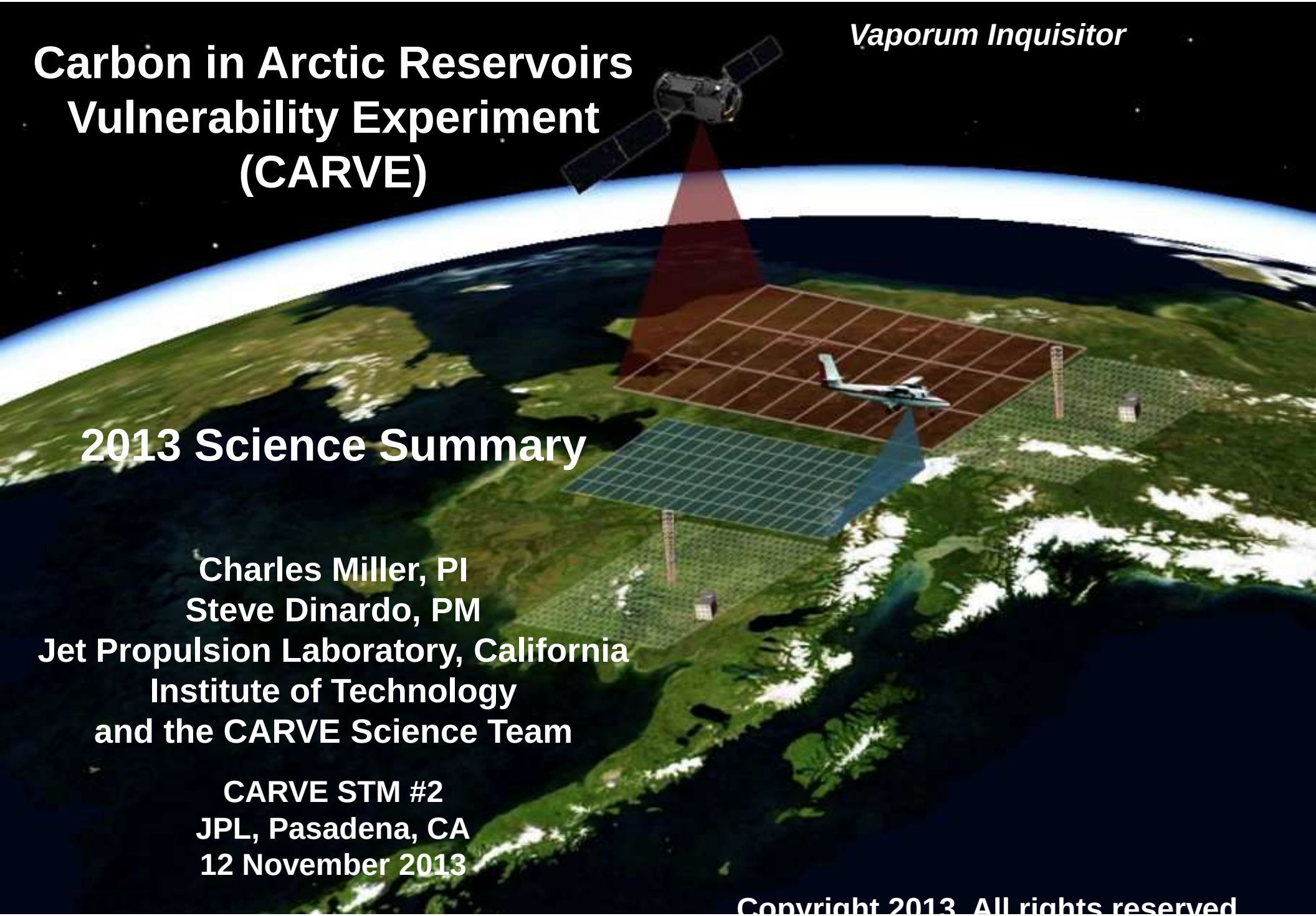



## Seasonal Scaling Algorithm: Validation with In Situ Surface Networks ALECTRA, SNOTEL, SCAN



# April-May- JuneThaw map






# Carbon in Arctic Reservoirs Vulnerability Experiment (CARVE)

## 2013 Science Summary

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

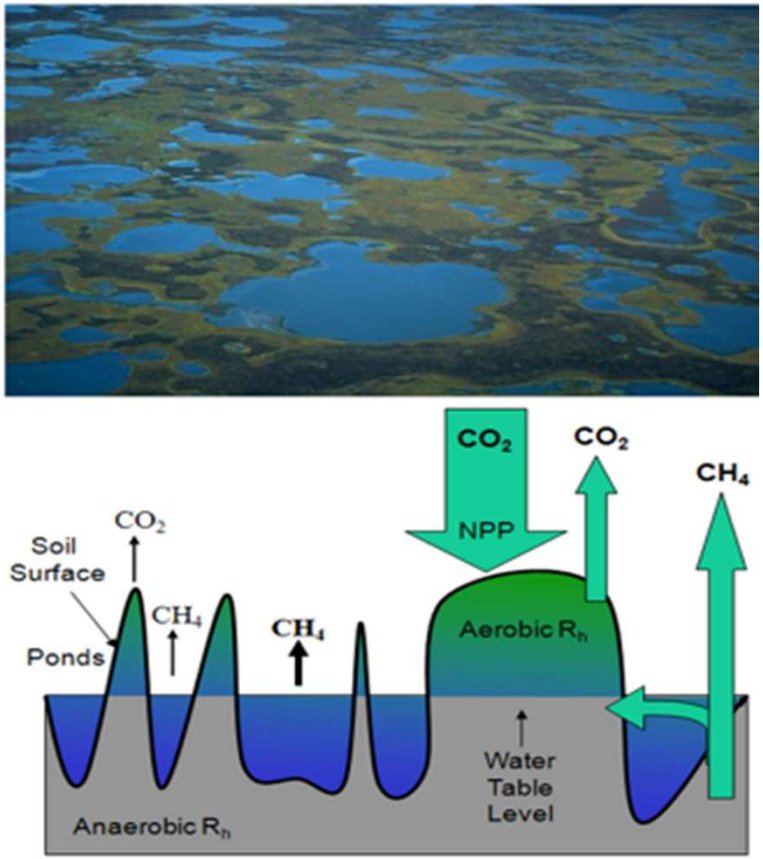
CARVE STM #2
JPL, Pasadena, CA
12 November 2013

# 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.

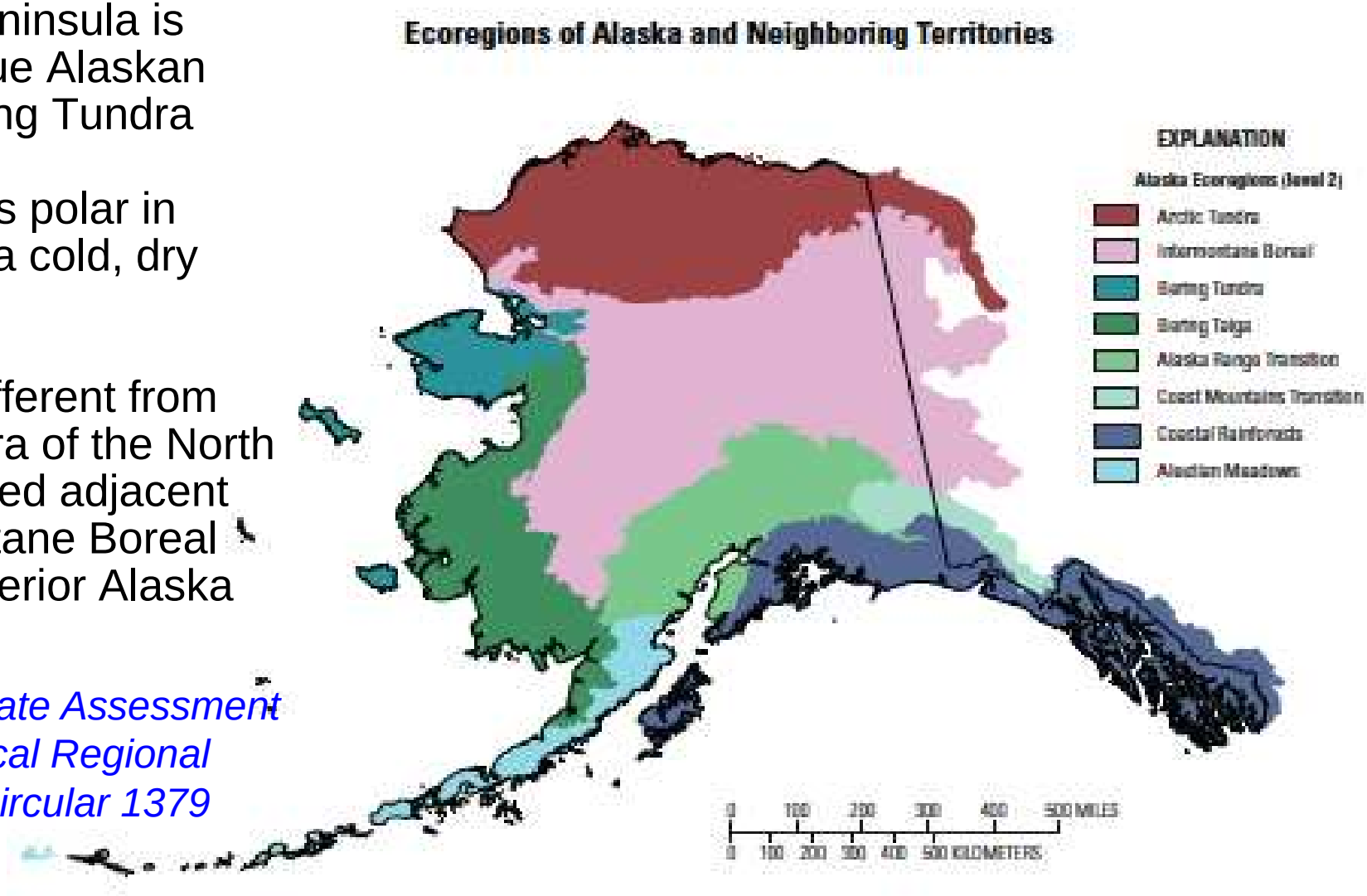
# 13 August 2013 CARVE Science Flight
# Seward Peninsula

The Seward Peninsula is home to a unique Alaskan ecoregion: Bering Tundra

Bering Tundra is polar in character, with a cold, dry climate

It is distinctly different from the Arctic Tundra of the North Slope and located adjacent to the Intermontane Boreal ecoregion of Interior Alaska

*US National Climate Assessment — Alaska Technical Regional Report - USGS Circular 1379 (Nov 2012)*



# CARVE Operations Strategy: Frequent & Sustained Observations

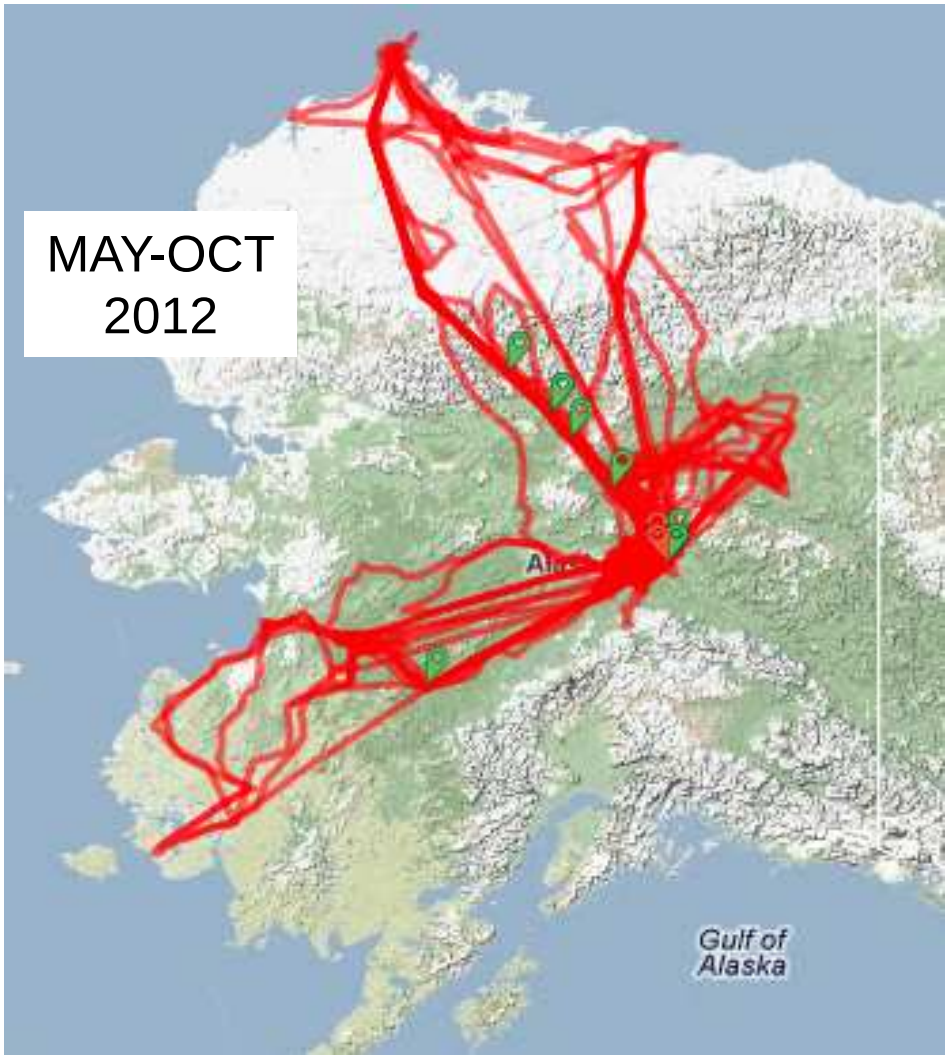
May – October 2012 – CARVE Science flights in Alaska

- 32 flights & ~240 Science flight hours
- 2 weeks/month each month
- 4-10 flights/campaign

•Observed Springtime CO2 & CH4 bursts from thawing permafrost

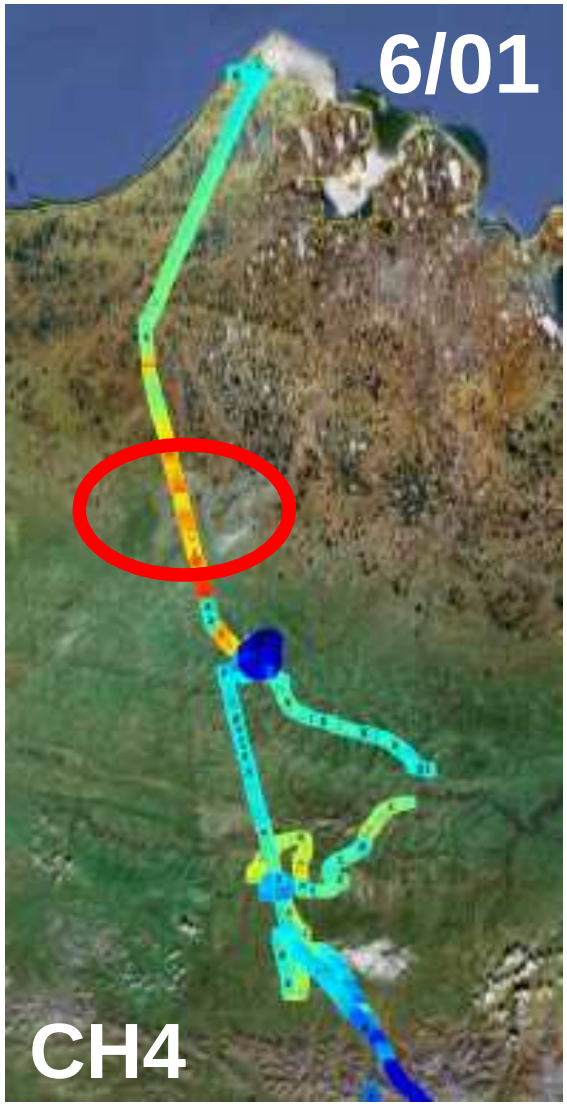
• Observed CH4 enhancements of 100 – 200+ ppb over regional scales (5000 – 10,000 $km^2$)

• Characterized variability of Arctic carbon cycle dynamics across the growing season

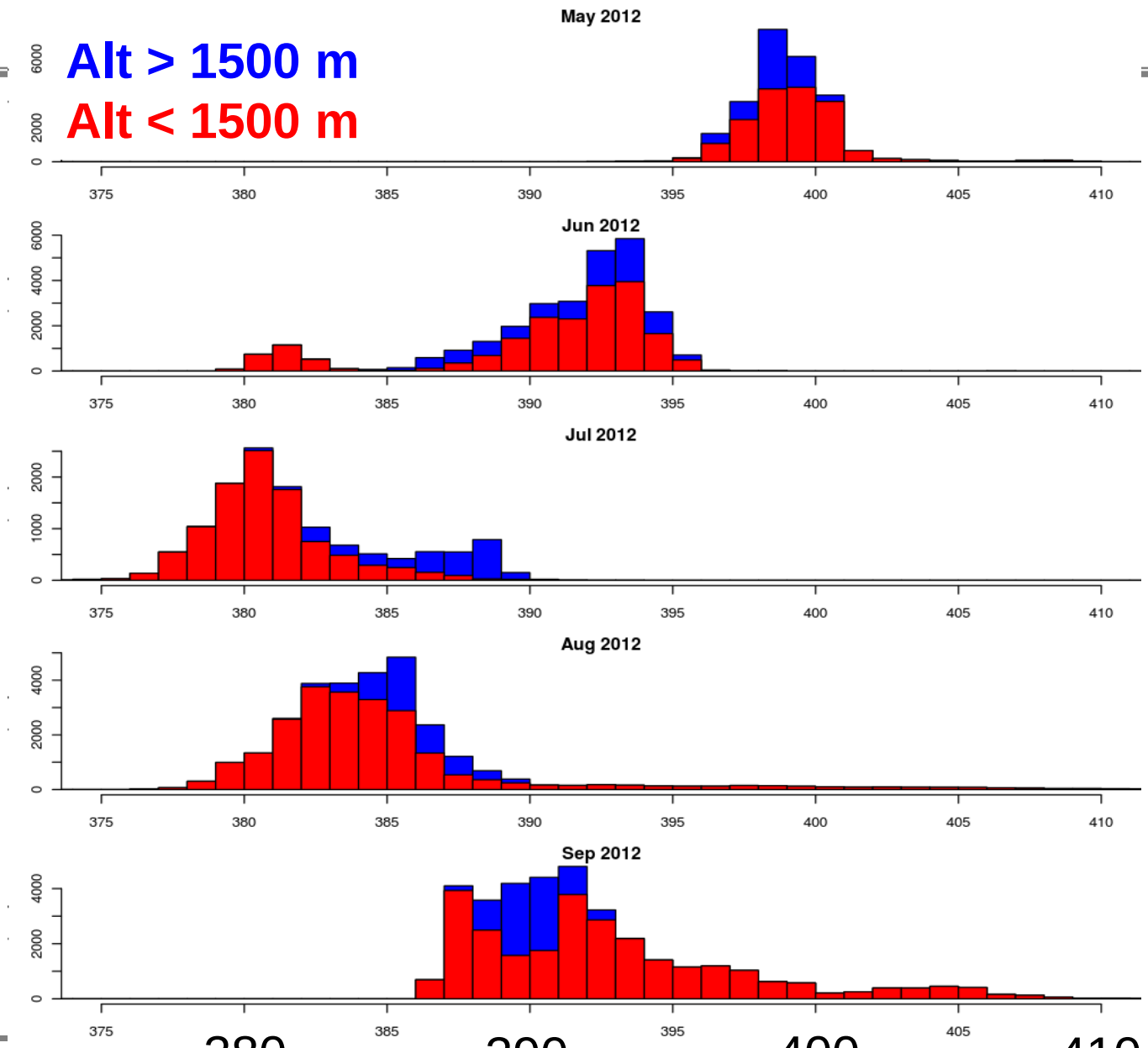



**CARVE 2012 Flight Tracks**

# CARVE Observes CH4 Bursts from the Spring Thaw Roll Across the North Slope


# CO2 Seasonal Uptake & Release




May

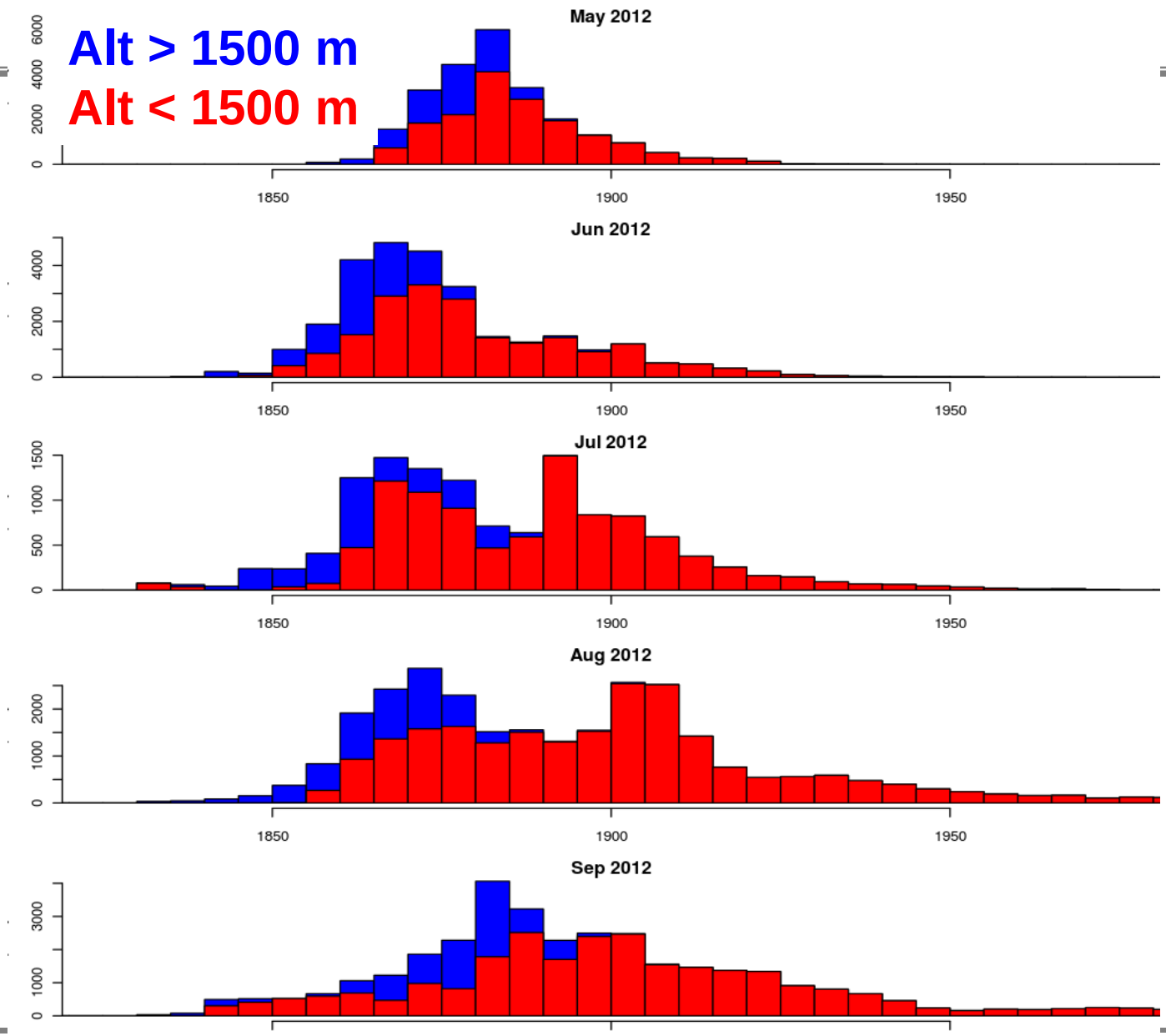
June

July

August

September

# CH4 Sources Peak in Late Summer




May

June

July

August

September

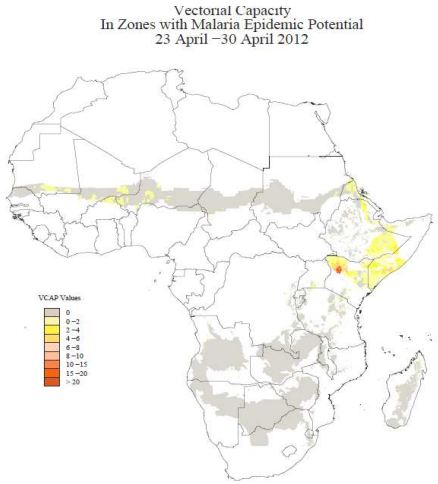
# Objective

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

**Products:**

**Static and dynamic open water bodies from MODIS 250m, ALOS PALSAR and JERS SAR**

**Vectorial Capacity Model**



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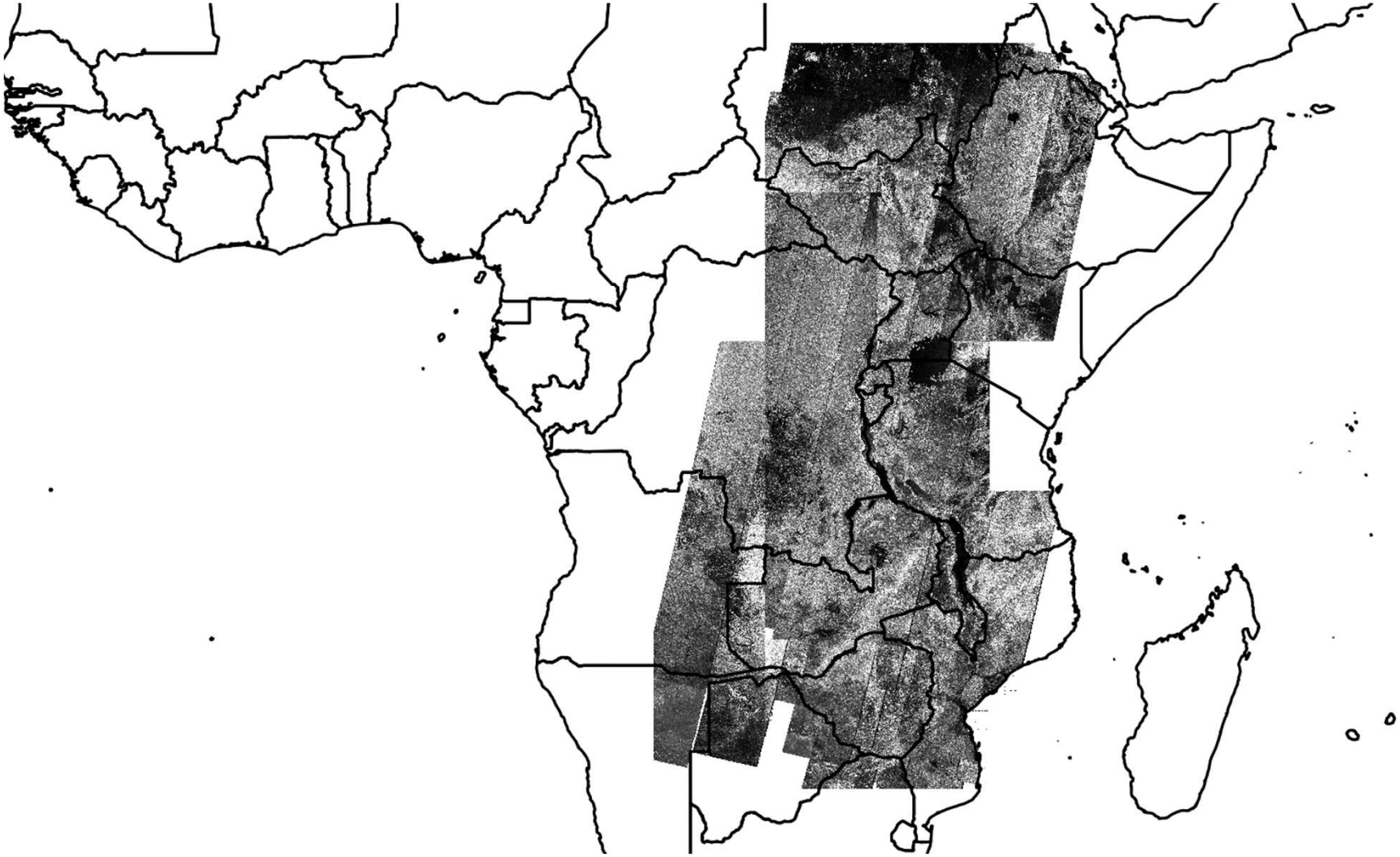
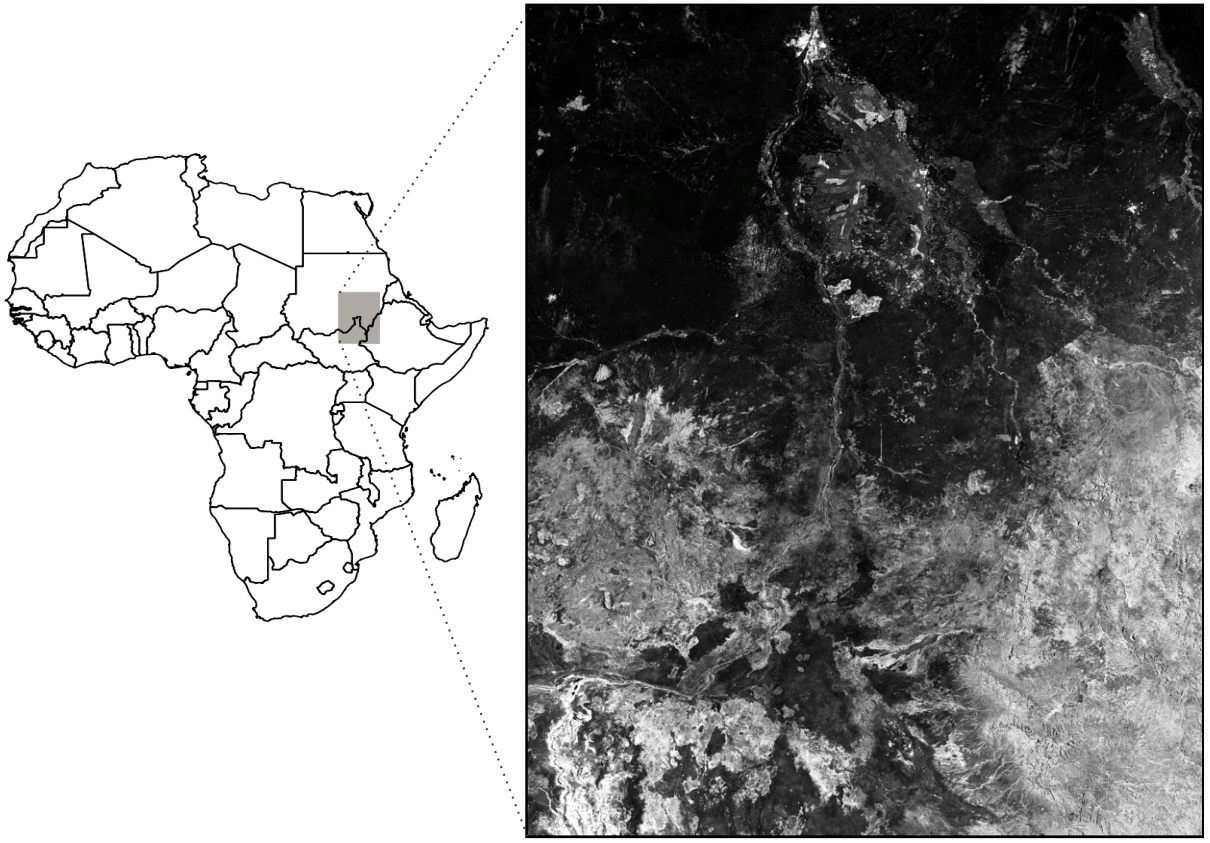
# Africa image mosaic from ALOS PALSAR SCANSAR data (90 image strips)



# Classification of Open Water with ScanSAR data over Eastern Africa

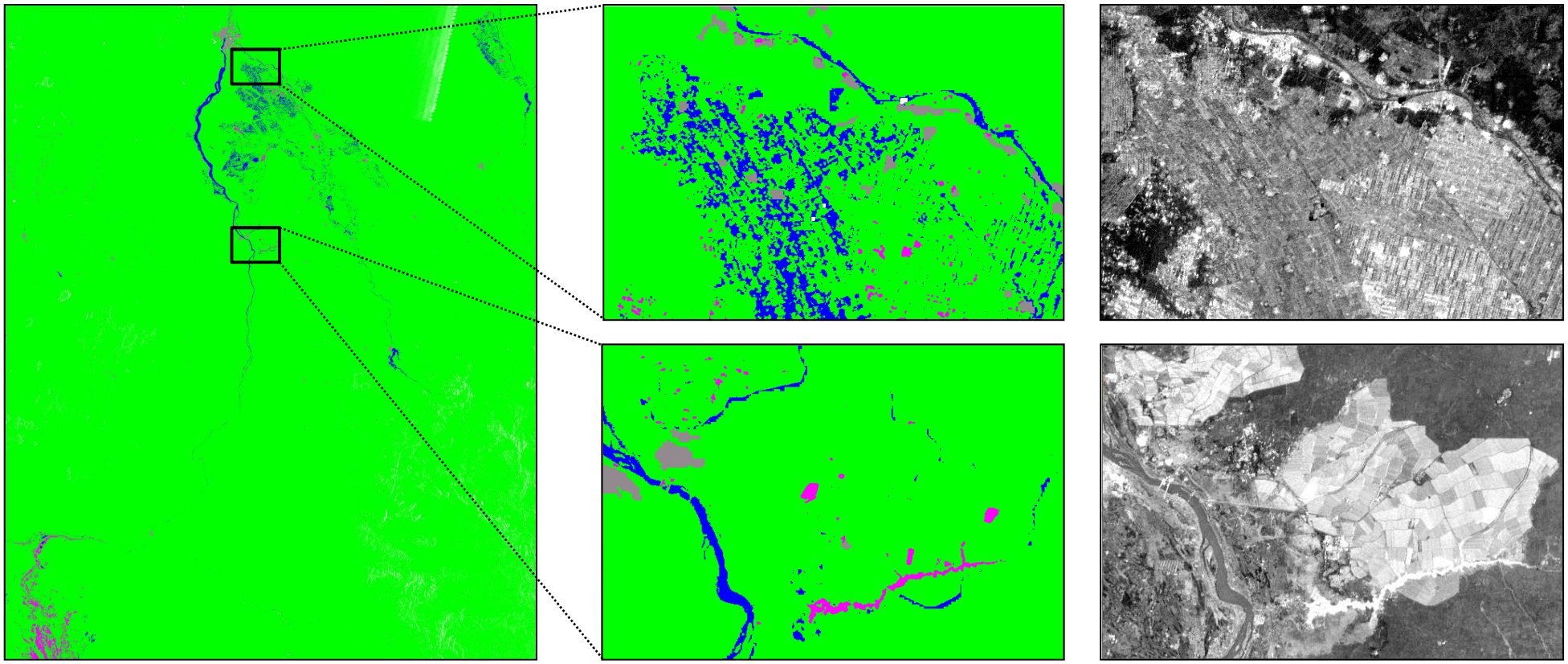
ScanSAR data we have :

- Covers across central and eastern Africa, but this analysis focuses on UTM zone 36P (shown right)
- HH polarization only
- 55 acquisitions over 36P, between 12/21/08 – 11/8/10



# Classification of Open Water with ScanSAR data over Eastern Africa

Revised decision tree results:



Eliminated most incorrect bare land classified as open water

However, open water is still overly classified – namely in regions of agriculture

# HH image mosaic
# Continental US

ALOS

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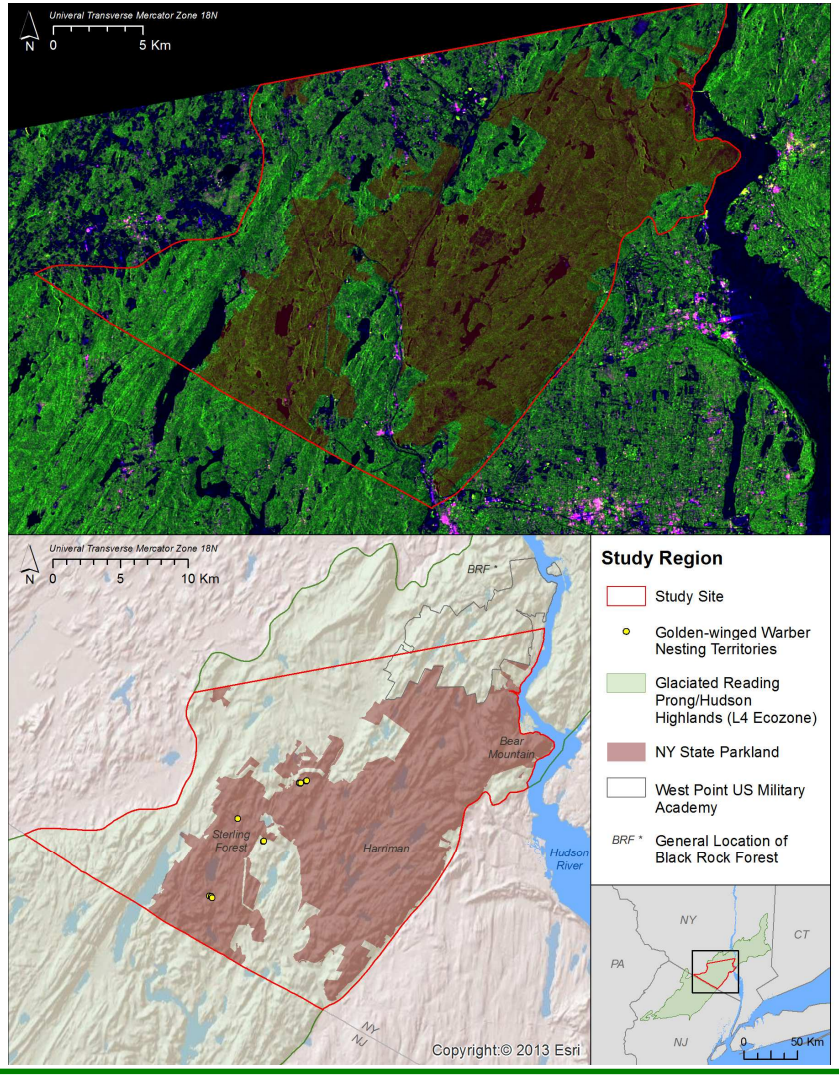
An international science collaboration led by JAXA

# Golden-Winged Warbler Swamp Forest Habitat in Hudson Highlands Ecoregion, New York.

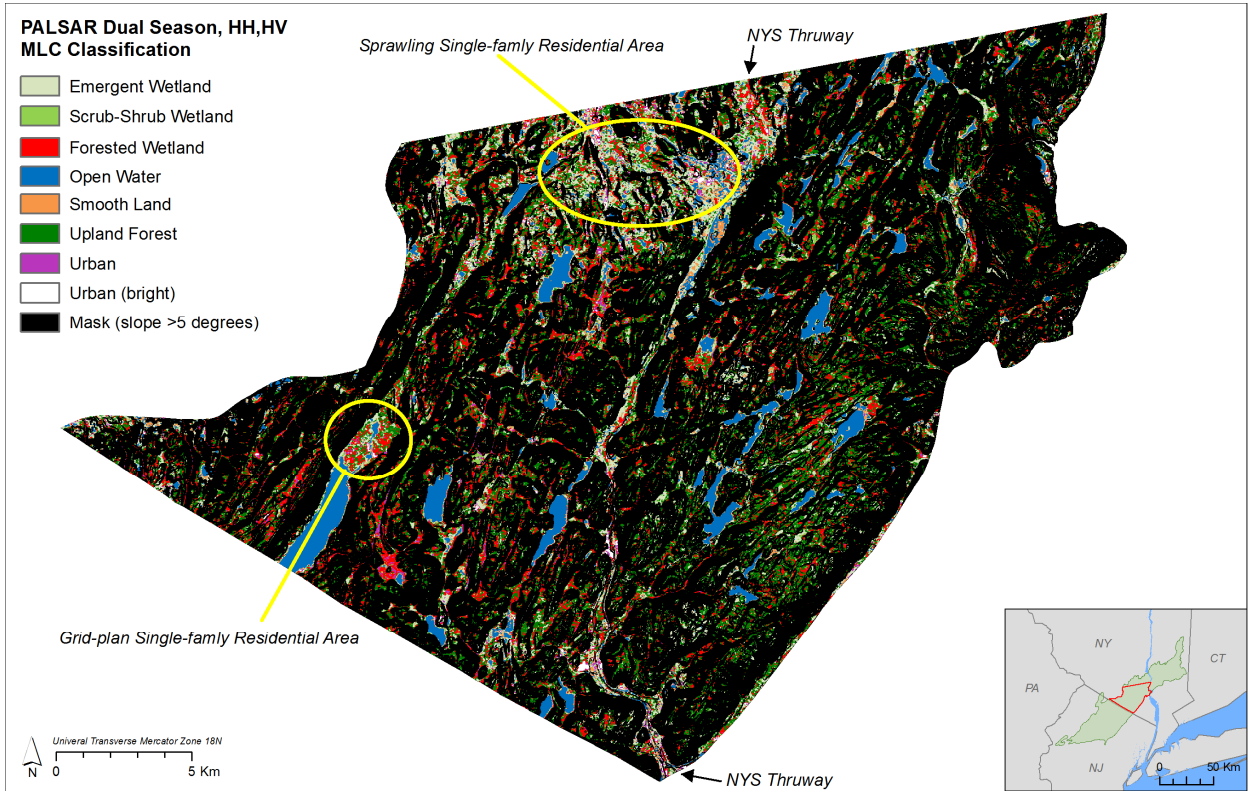




## Linda I. Pistolesi
## Hunter College, CUNY

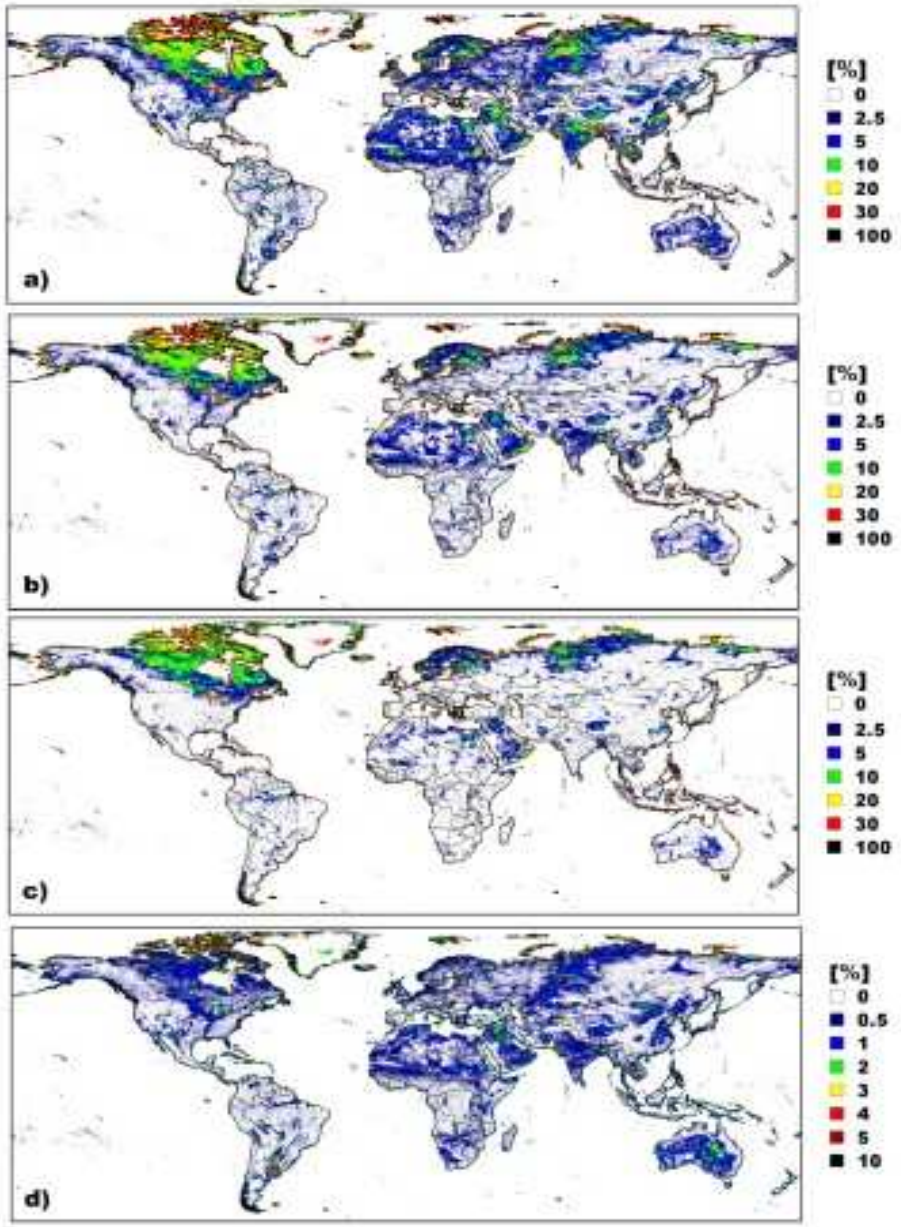

The study site as seen in a PALSAR color composite (R:HH,G:HV, B: HH/HV) image (top) and a relief map (bottom). In the PALSAR imagery, water is black, urban areas are violet, and forested land is green. The relief map shows the northeast trending ridges and valleys that define the highly variable terrain of the Hudson Highlands, and the locations of Golden-winged Warbler territories in Sterling Forest State Park. Both maps show the extent of New York State Parkland, which covers just over 50% of the study site area.

# Maximum Likelihood Classification from Dual-Season Dual-Polarization PALSAR




The MLC classification map for the dual-season dual-pol trial shows the classification captured the many lakes of the study area but misclassified known residential areas as a mosaic of wetlands. Approximately 70% of the study site was masked out due to mountainous terrain.

# Global Fw Distribution (from monthly means)



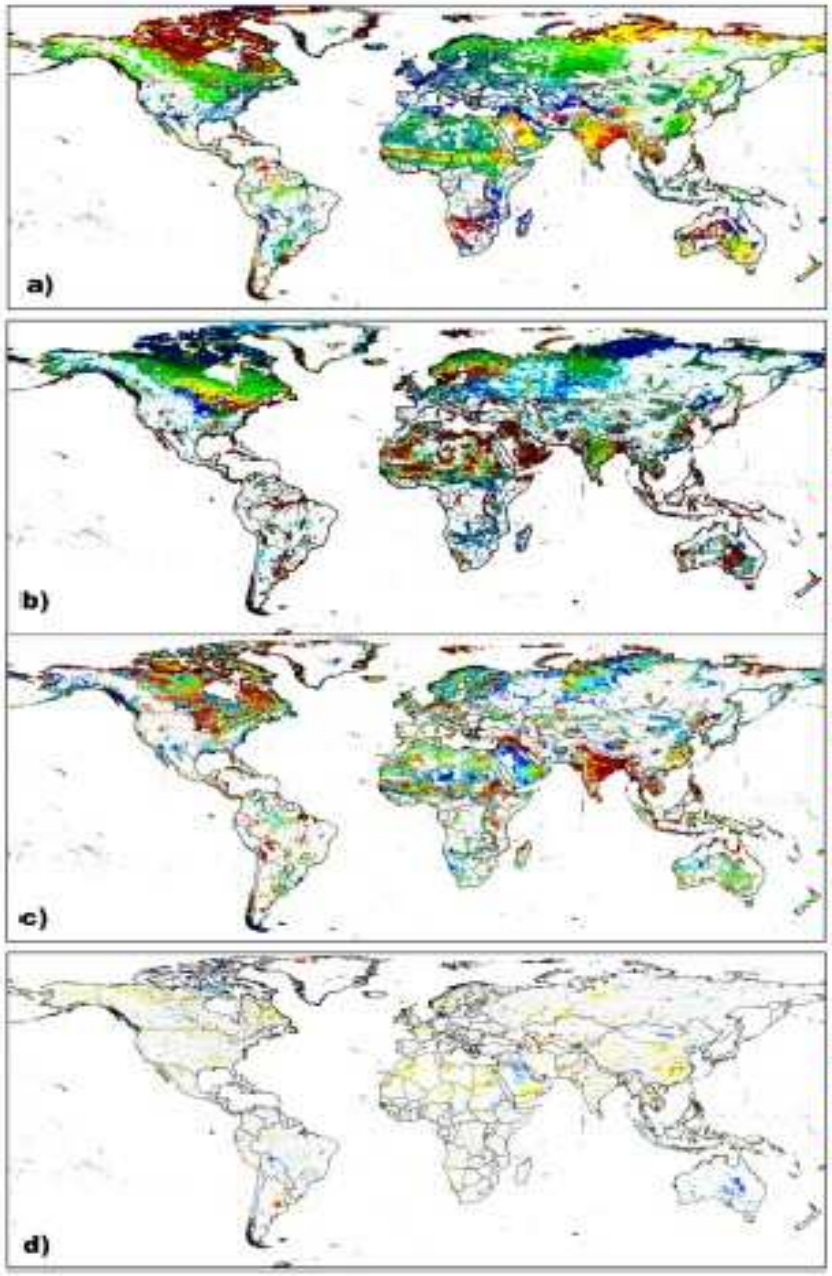

**Average Annual Maximum**

**Average Annual Mean**

**Average Annual Minimum**

**Variability of the Annual Mean (StdDev)**

# Global Fw (from monthly means, Fw > 1%)



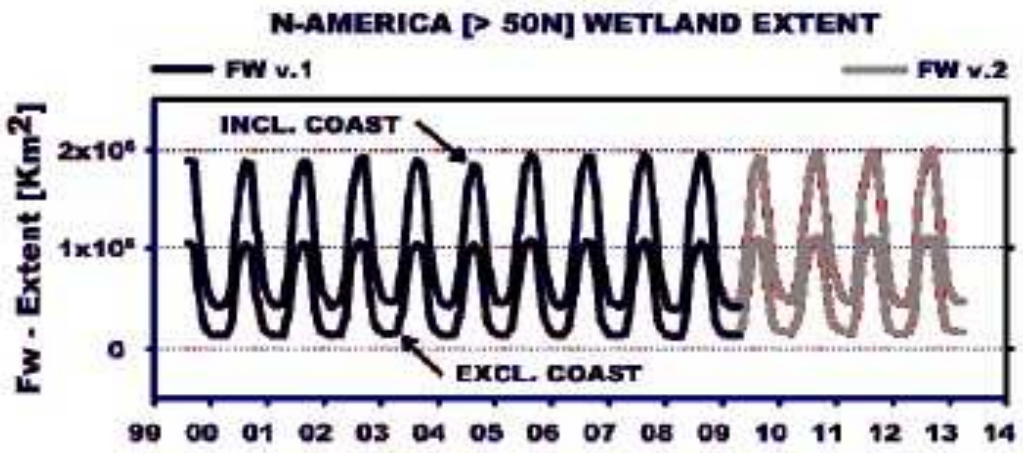

**Month of Maximum Fw**

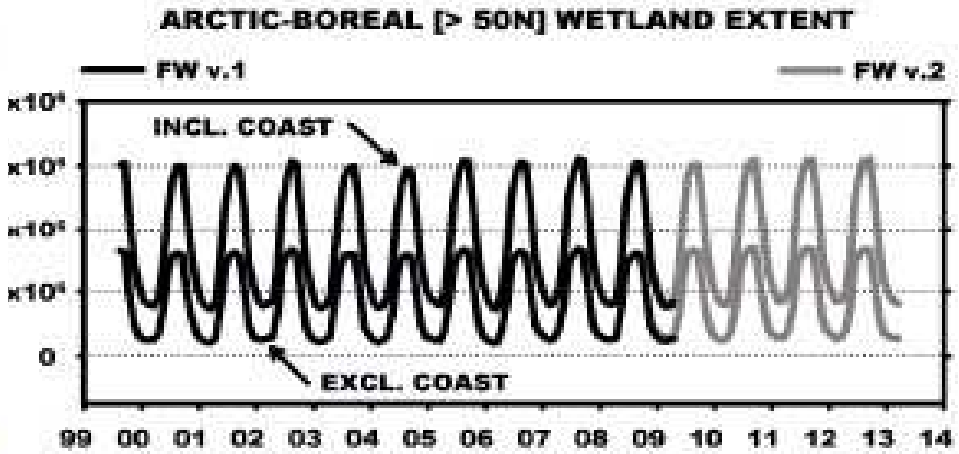
**Fw Duration**

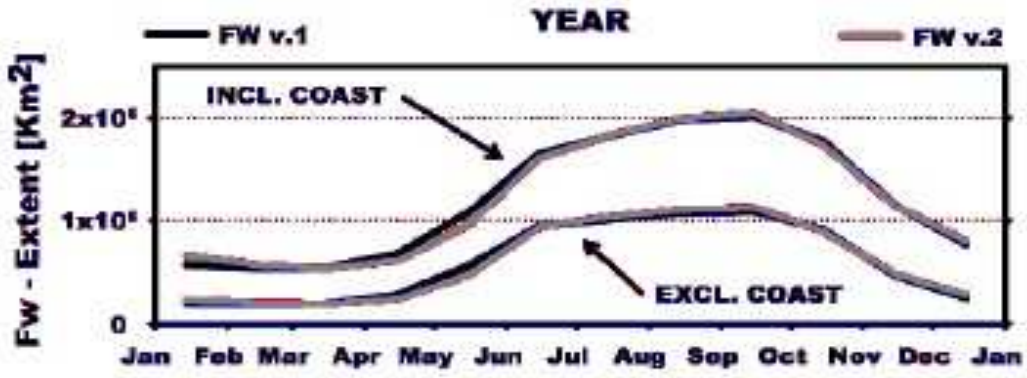
**Correlation Precipitation/Fw**

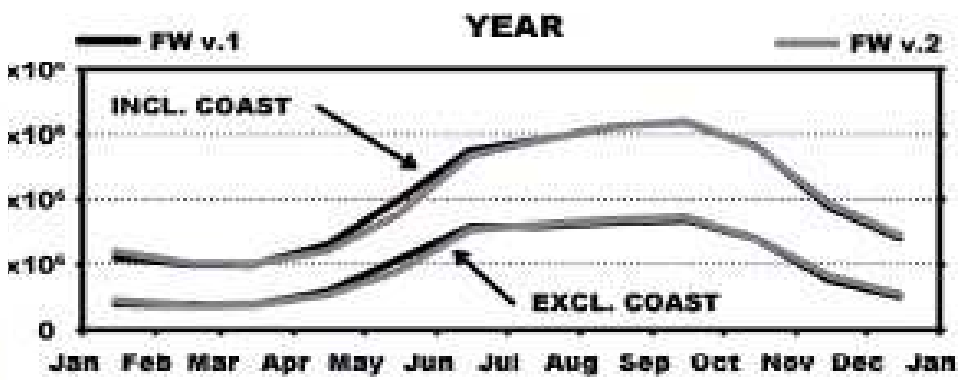
**Trend of Annual Means**

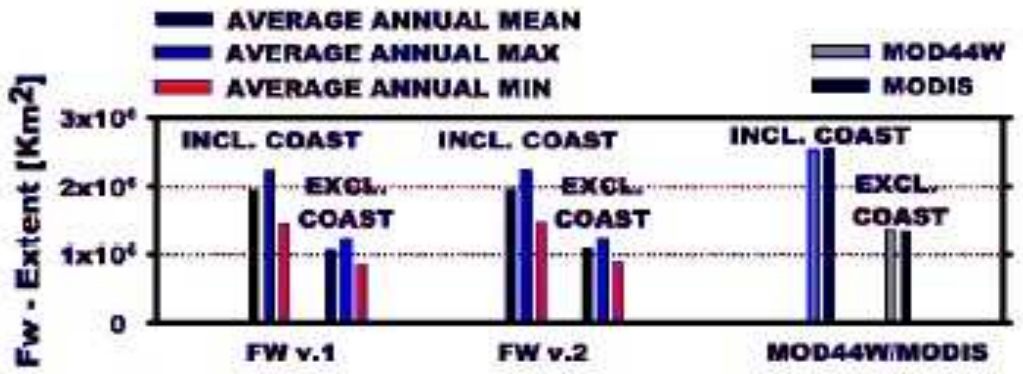
# Multi-year Fw Progression by Region

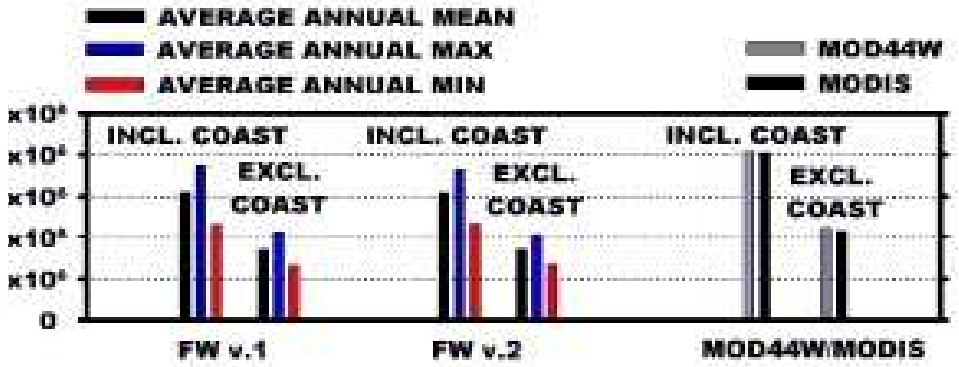


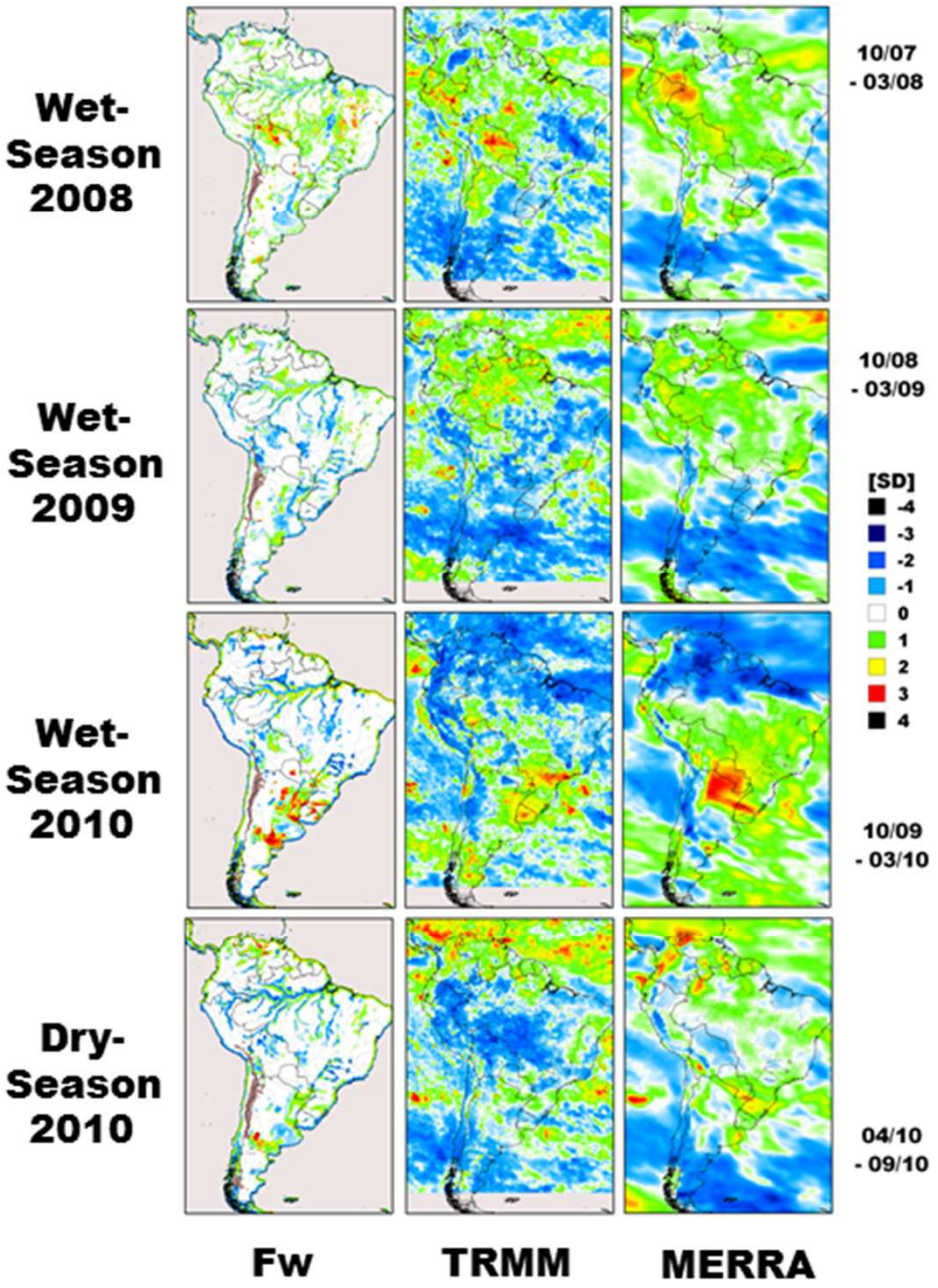



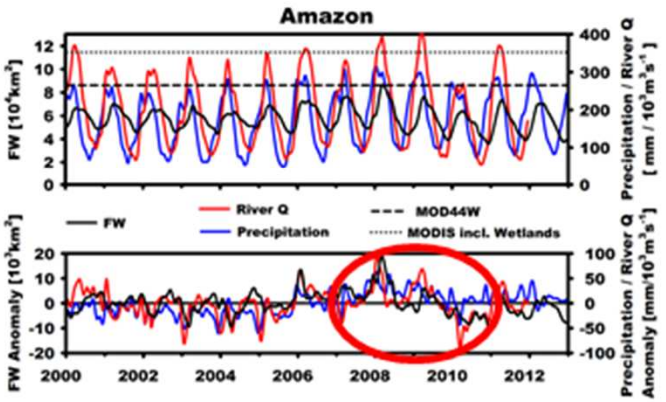



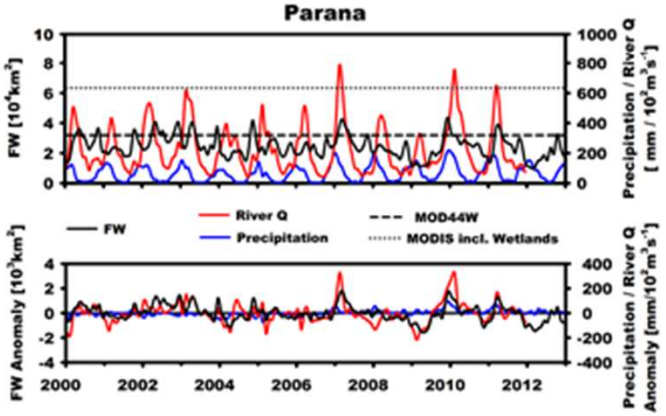



# 2009-2010 El Nino / 2010 Amazon Drought




**Amazon Basin**




**Parana Basin**

**2010 Amazon Dry-Season Drought (Lewis et al. 2011) not well documented in MERRA precipitation.**

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South America wetlands from 2007-08

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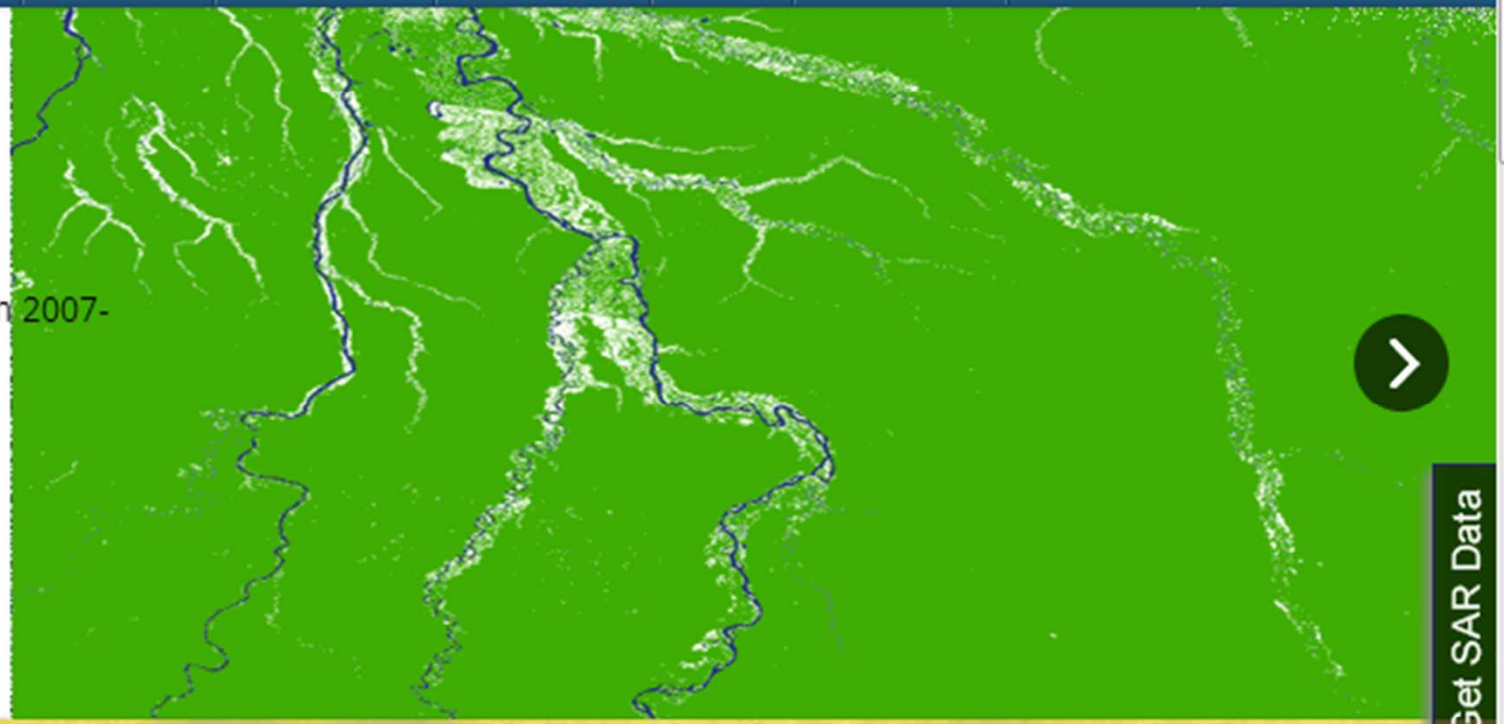

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