Knowledge Sharing Seminar: Monitoring Wetland Extent with Satellites

Presenters:

Nancy HF French, PhD

Michael Battaglia

Michael Merchant

Dana Redhuis

Michigan Tech Research Institute

Ducks Unlimited Canada

NASA Jet Propulsion Lab

Collaborators: Environment Canada, Wilfrid Laurier University

November 29, December 1, and December 19, 2023

A NASA ABoVE Funded Project

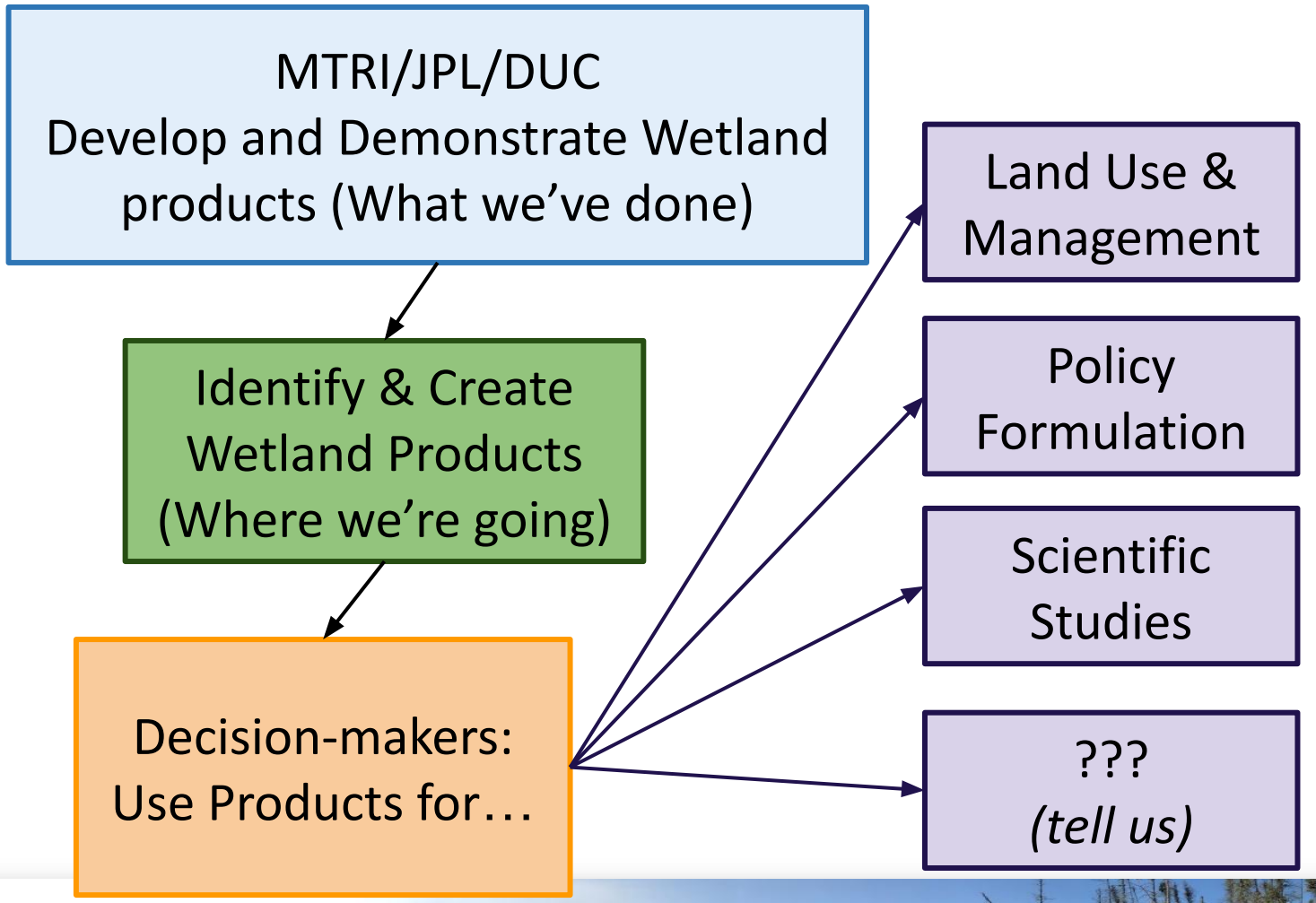
Agenda

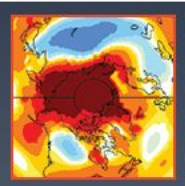
- Introduction & Goals for Seminar
- Review of Project
  - What we've done and where we're going
  - What we need from you
- Intro to Satellite Earth Observation and Remote Sensing
- Wetland products developed
- Applications of ABoVE Products using Remote Sensing Methods
- Next Steps
  - Project Activities Going Forward
  - Opportunities for In-Field Validation
- Questions and Brainstorming session - learn from you what will be valuable

Fieldwork near Fort Resolution, 2019

Goals for Seminar

- Review the project and products developed by this research
- Identify the value of wetland maps for communities and decision-makers
  - For example: fish habitat, water level maps, others.






ABoVE

ARCTIC BOREAL VULNERABILITY EXPERIMENT

Vulnerability and Resilience Framework

CAUSES OF CHANGE

Many factors from the local, to regional, to global scales drive changes to ecosystems. Examples include: natural disturbances such as fires and insects; and increasing temperature and CO_2.

CHANGES TO ECOSYSTEMS

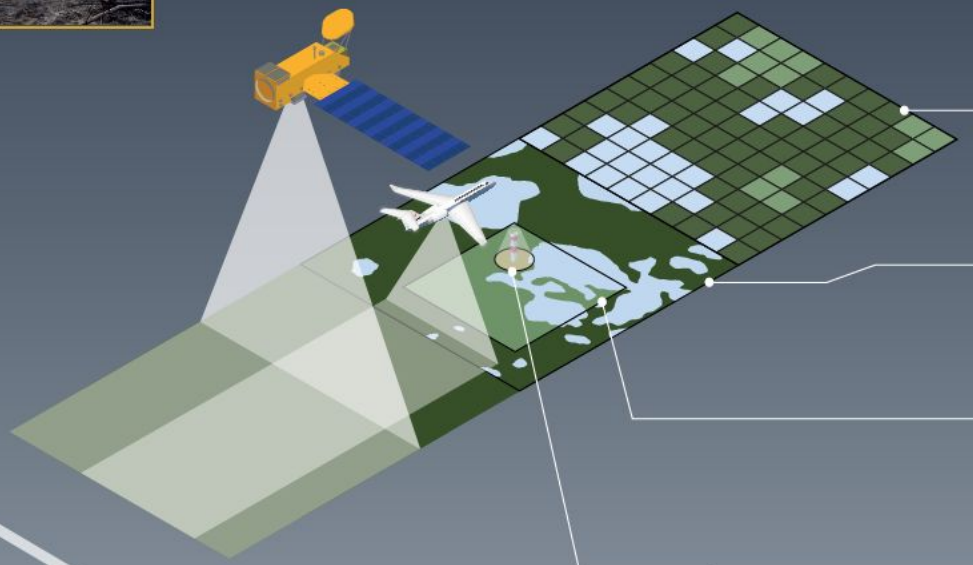
Ecosystem structure and function are impacted by drivers that are both external (e.g., climate, invasive sprecies) and internal (e.g., fire, animal disease, mining, infrastructure).

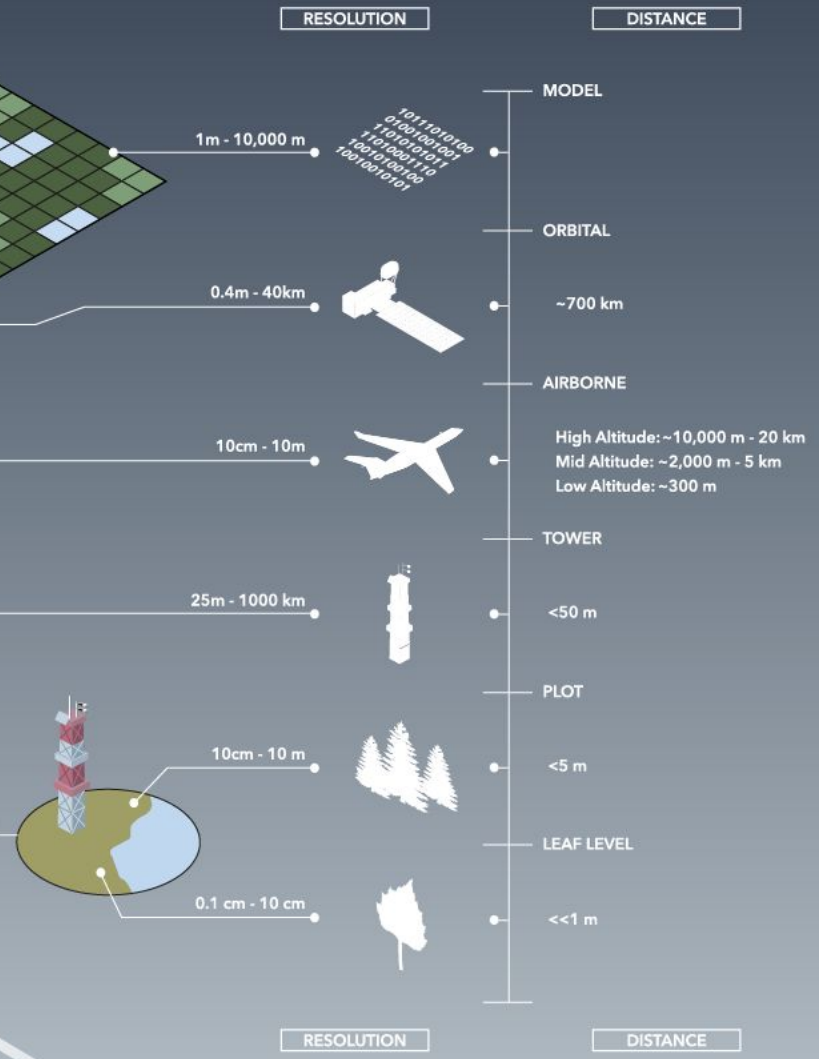
ECOSYSTEM SERVICES

Ecosystem services are the benefits and value that people derive from the environment that sustains us. Examples include: food and freshwater production and indigenous wildlife harvest.

SOCIAL SYSTEMS

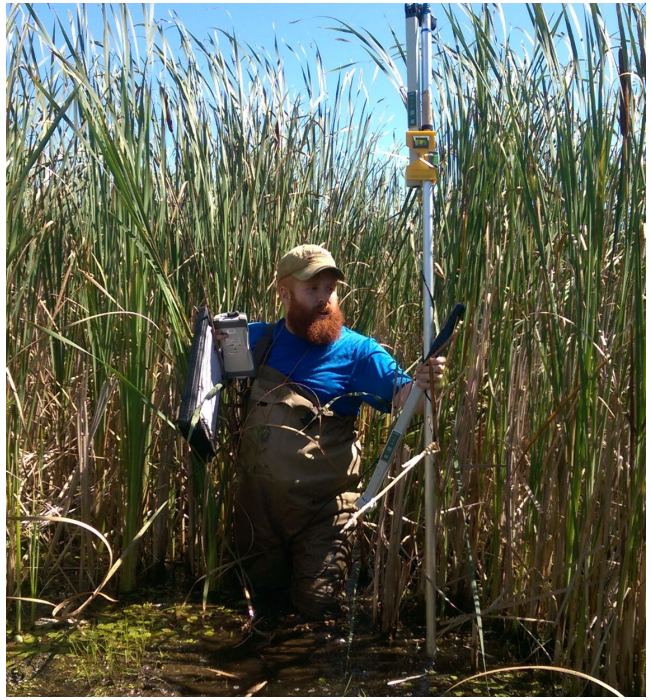
People respond to these changes in many ways. Individuals and households may change their behavior, for example relying more heavily on store-bought food than subsistence hunting.





Scaling Observations from Leaf to Orbit

Presenter Introductions



Mike Battaglia

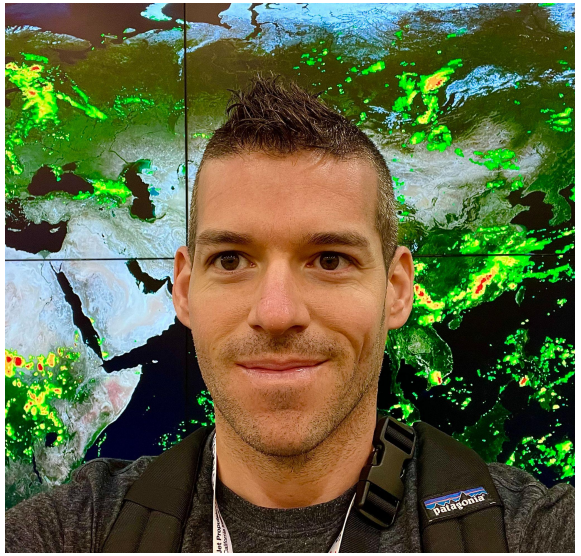
Research Scientist
MTRI

Dana Redhuis

Research Scientist
MTRI

Nancy French

Senior Scientist & Fellow
MTRI



Michael Merchant

Remote Sensing Scientist - DUC

Project Team

Michigan Tech Research Institute

Nancy HF French, Michael Battaglia, Dana Redhuis, Alicia Sendrowski, Jeremy Graham, Dorthea VanderBilt, Laura Bourgeau-Chavez

Ducks Unlimited Canada

Michael Merchant, Vanessa Harriman, Stuart Slattery, Rebecca Edwards, Sonny Lenoir

NASA Jet Propulsion Lab

Bruce Chapman

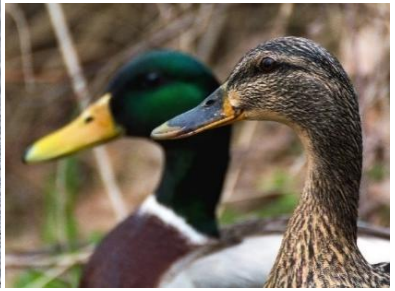
Collaborators:

Christopher Spence, ***Environment Canada;*** *Jennifer Baltzer,* ***Wilfrid Laurier University***

Project Results to Date

"What We've Done"

Demonstrated use of remote sensing, <u>focused on the use of Synthetic Aperture Radar (SAR),</u> to improve modeling of wetland habitat change and waterfowl distribution in the Peace-Athabasca and Slave River Deltas



Outcomes:

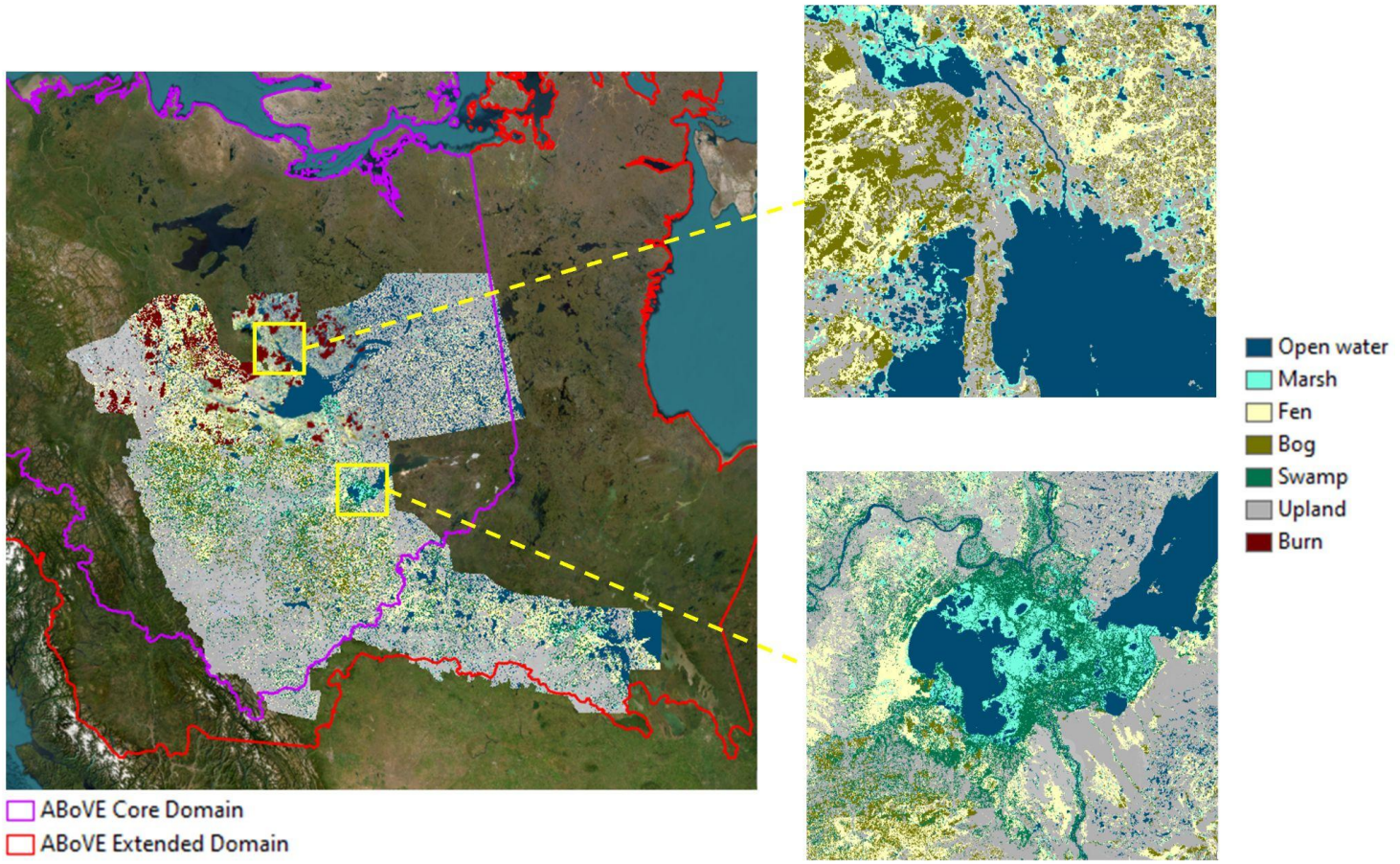
- **Map wetland type** → decadal changes in wetlands for the two demonstration regions
- **Map vegetation flooding** → inundation/flooding status, wetland hydroperiod, wetland flooding dynamics
- **Demonstrate waterfowl abundance modeling and mapping** using the wetland products
- **Initial development of NASA wetland dynamics products**

© DUC

Next Steps:
"Where We're Going"

Improve access for interested communities* to wetland change information for informed management and use of wetlands

**decision-makers, subsistence hunters, scientists, and researchers*



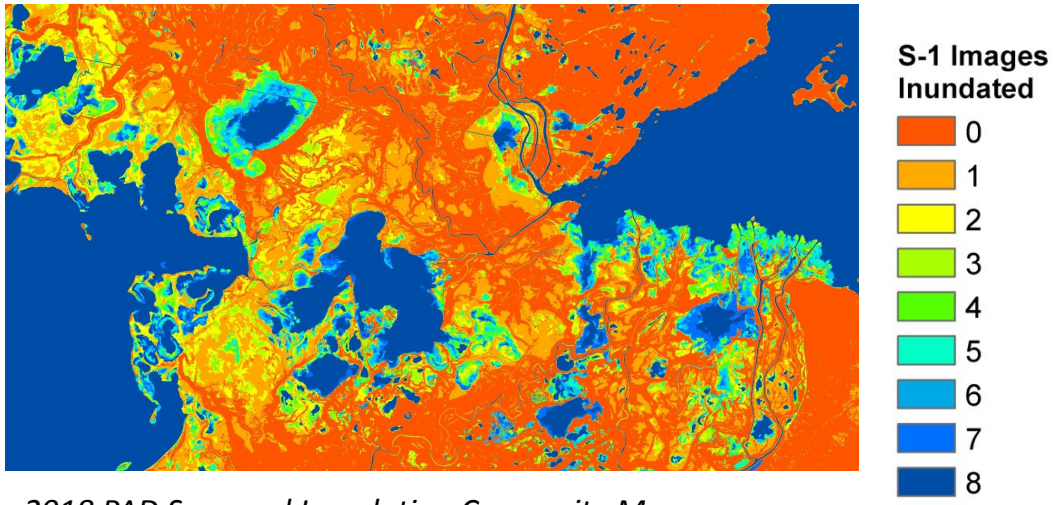
Areas in northern Canada with existing high-quality wetland maps

Community Needs and Questions

"What we need from you"

- What is the issue in water resource management that you are interested in improving? What is the temporal/spatial scale needed?
- What are the gaps in your ability to monitor and manage wetlands?
- What wetland information would be valuable to you/your organization?
- What would you use these maps for?

Link to Jamboard



2018 PAD Seasonal Inundation Composite Map

Intro to Satellite Earth Observation and Remote Sensing

Michael Battaglia, MTRI

Intro to Satellite Earth Observation as a Resource for Mapping

- What is **REMOTE SENSING**?
- "Remote Sensing is the science and art of **obtaining info about an object**, area, or phenomenon through the analysis of data acquired **by a device that is not in contact with the object**, area or phenomenon under investigation"
  -[*Remote Sensing and Image Interpretation, Lillesand et al. 2004*]

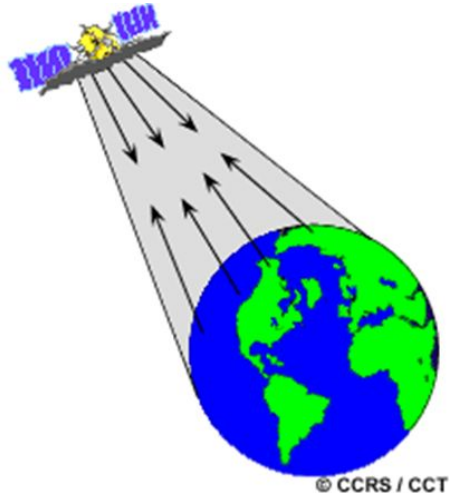



- Two types of Remote Sensing: PASSIVE and ACTIVE

Intro to Satellite Earth Observation as a Resource for Mapping

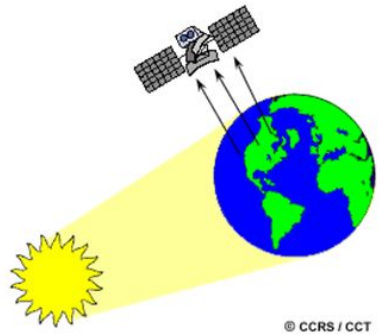
What is **ACTIVE** remote sensing?

- Active sensors provide their own energy to illuminate the object or scene they observe. They send a pulse of energy from the sensor to the object, and then receive the radiation that is reflected back.
- Synthetic Aperture Radar (SAR) is a type of active data collection where a sensor produces its own energy and then records the amount of that energy reflected back after interacting with the Earth.

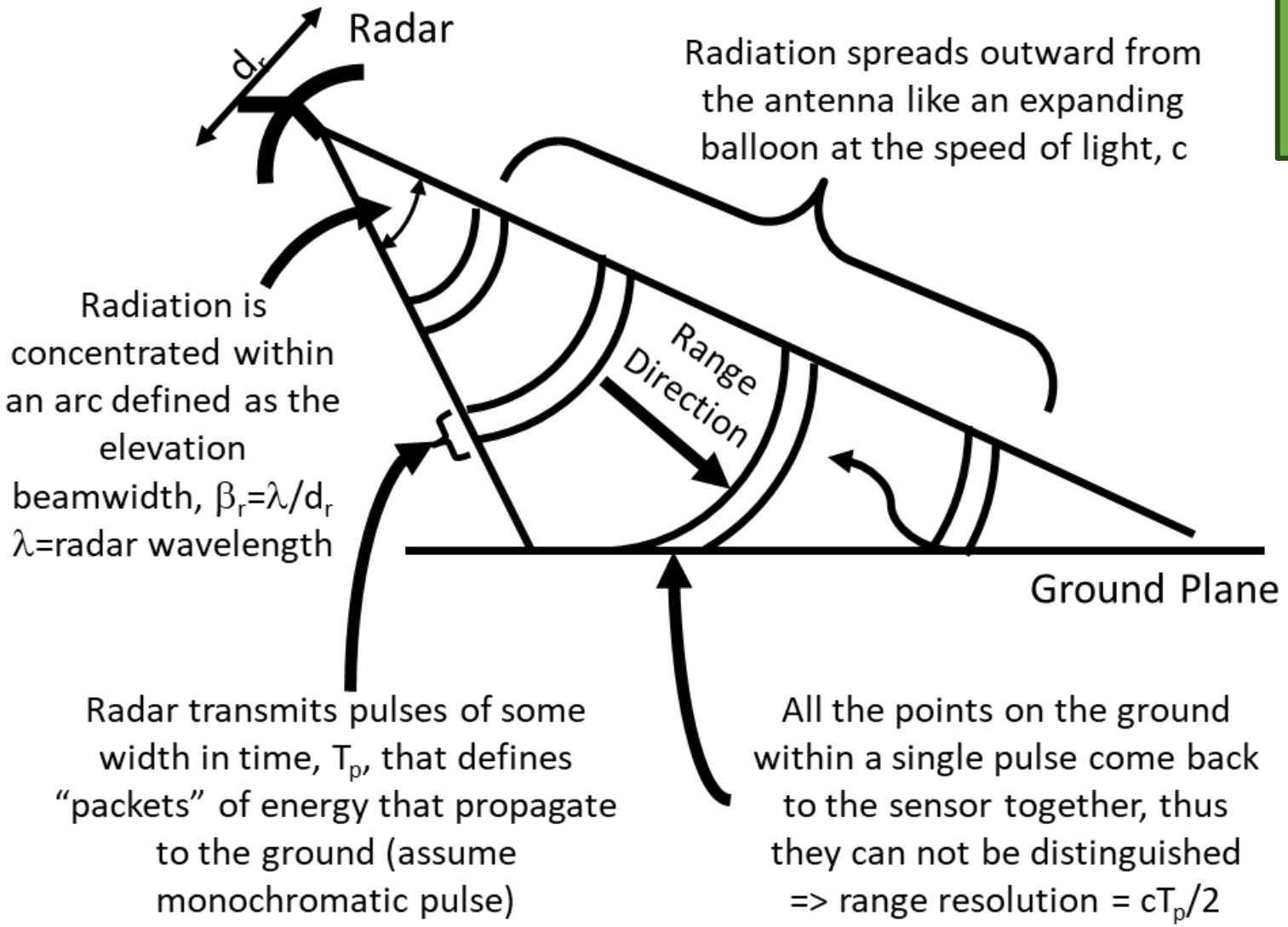


What is **PASSIVE** Remote Sensing?

- Passive sensors detect radiation emitted or reflected by an object from a source other than the instrument, i.e. the sun
- Satellite imagery, such as multispectral or hyperspectral data, is a form of passive remote sensing



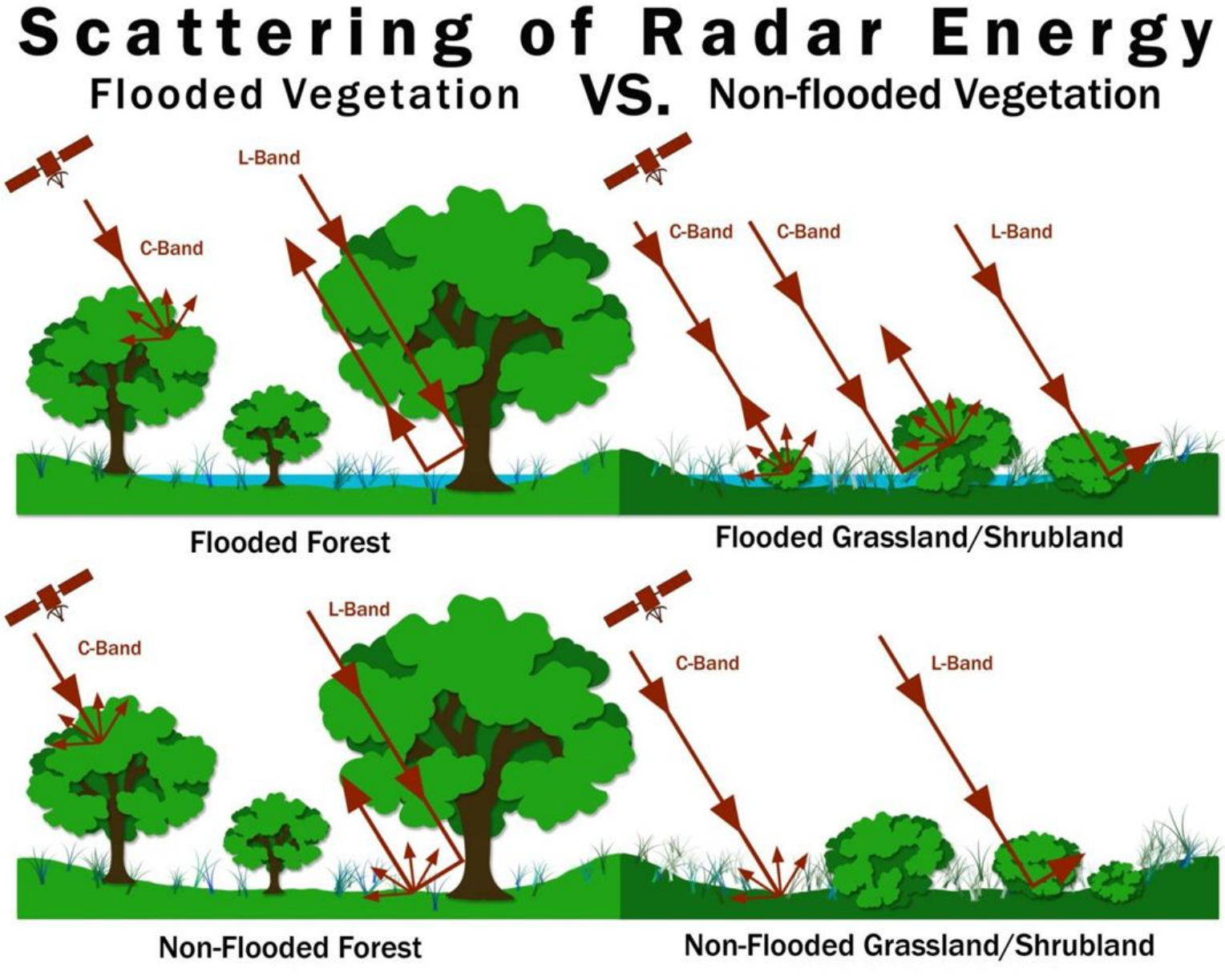
How Imaging Radar works



Radars are active Sensors that Transmit Microwave Radiation in Pulses then record Backscattered Energy

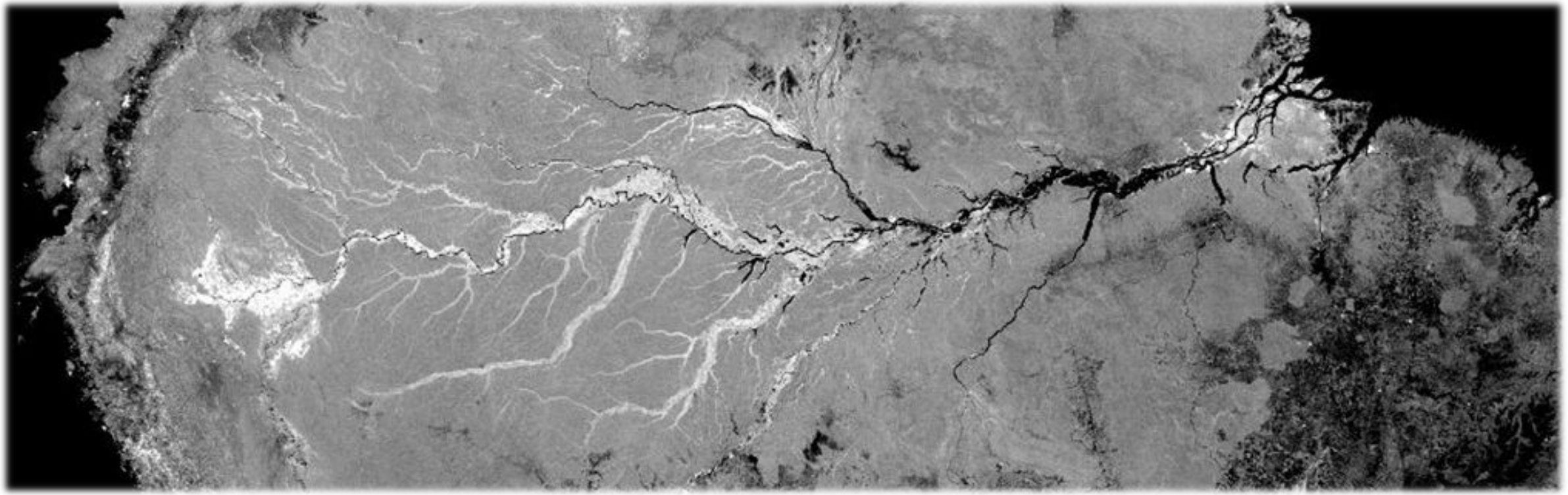
Points on the ground scatter back to the radar when the pulse reaches them => points at different ranges return at different times.

How Backscatter works



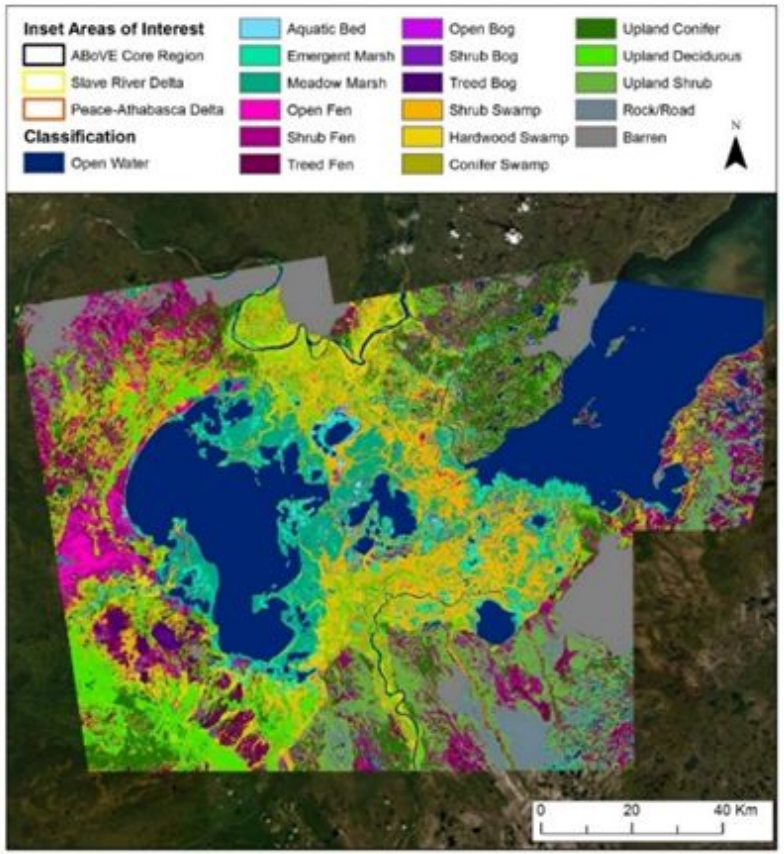
Examples of Radar Interaction

SMAP Radar Mosaic of the Amazon Basin
April 2015 (L-band, HH, 3 km)

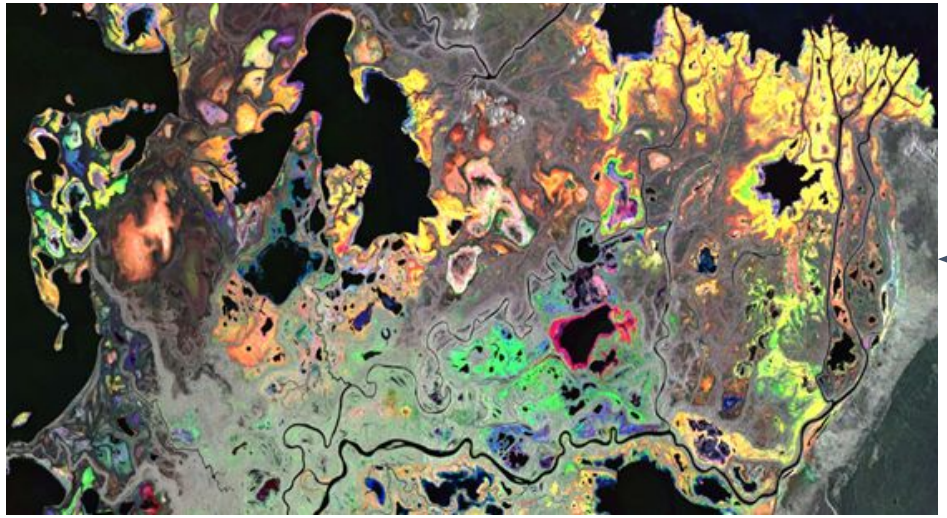


Wetland Products Developed

Mapping Wetland Type and Extent: Critical for Waterfowl Habitat



Wetland type maps created using a machine learning approach with Landsat and L-band SAR to assess changes in duck habitat.

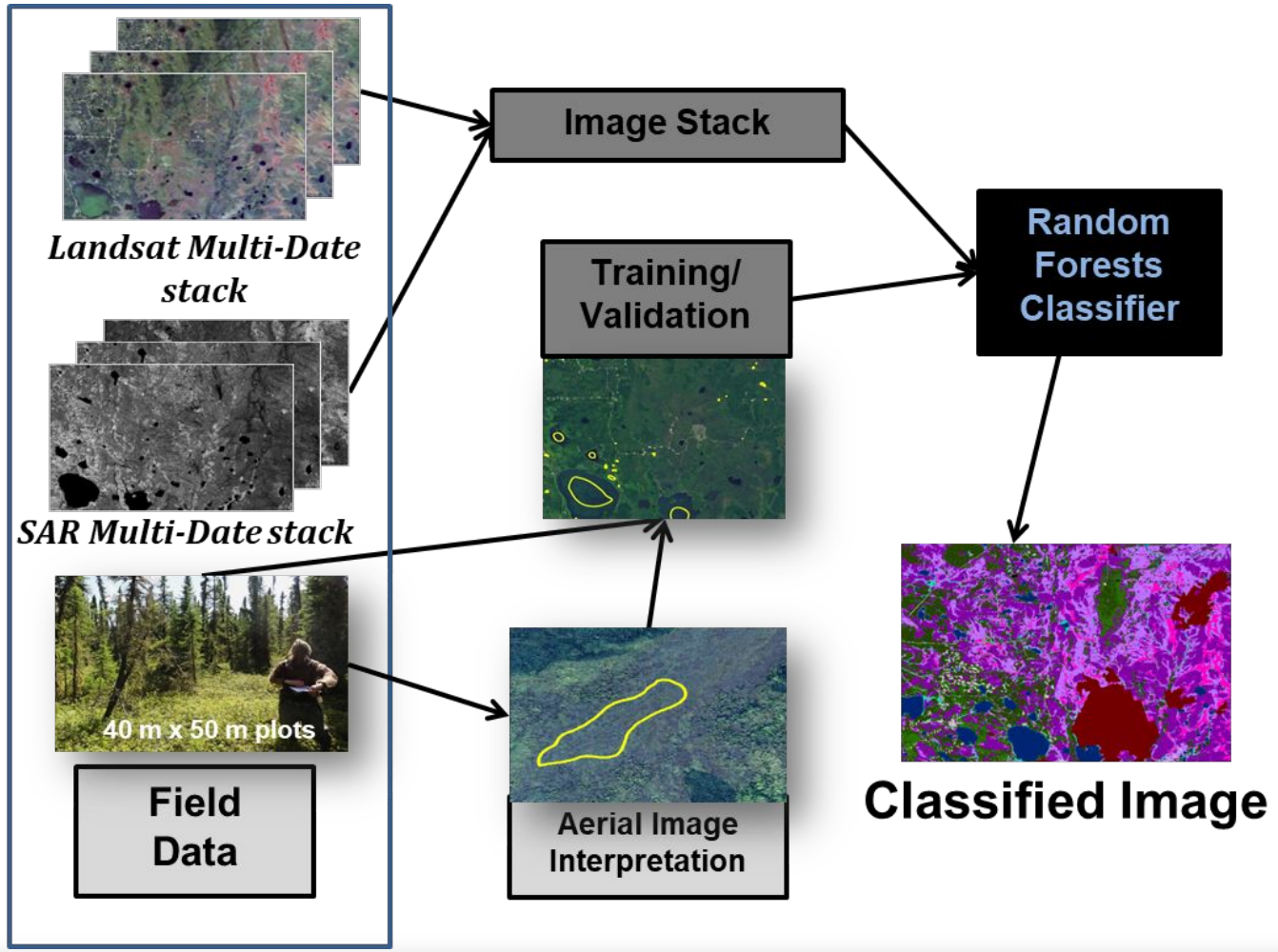


SAR-derived 3-year annual inundation composite.

“What we’ve done” Wetlands and Radar

Mapping Methods used successfully to map wetlands in the Great Lakes, tropics, and boreal region

- Landsat and PALSAR multi-date imagery
- Image classification (Random Forests) is trained and validated with field-data and aerial-image interpretation of the wetland types
- Outputs heavily dependent on quality input data



Wetland Mapping

Summary & Accuracy

Slave River Delta (SRD)

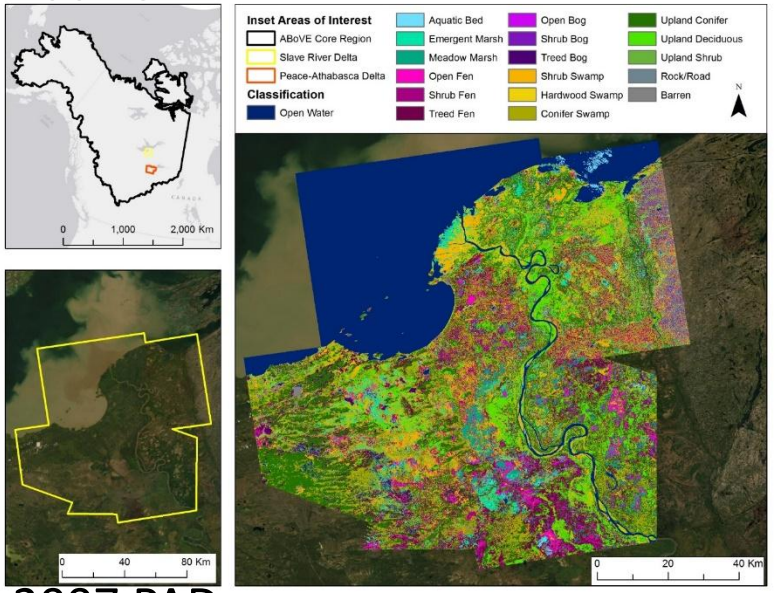
2007: 11,789 km^{2,} 83.4% accuracy

2017: 4,762 km^{2,} 86.5% accuracy

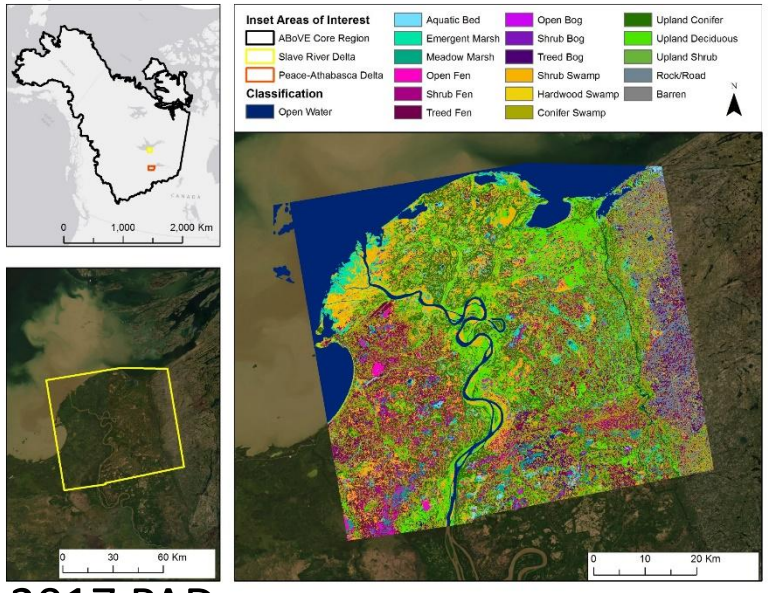
Peace Athabasca Delta (PAD) 2007: 14,247 km^2, 96.8 % accuracy

2017: 6,985 km^{2,} 97.8% accuracy

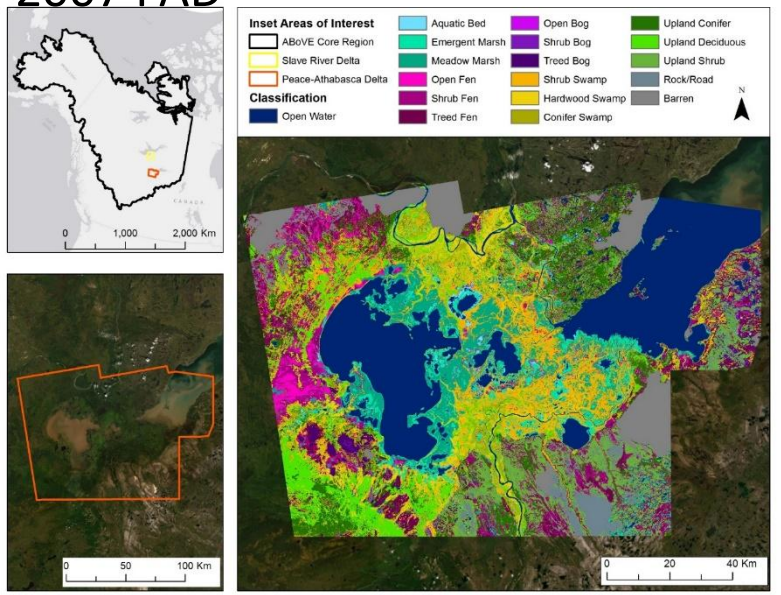
2007 SRD



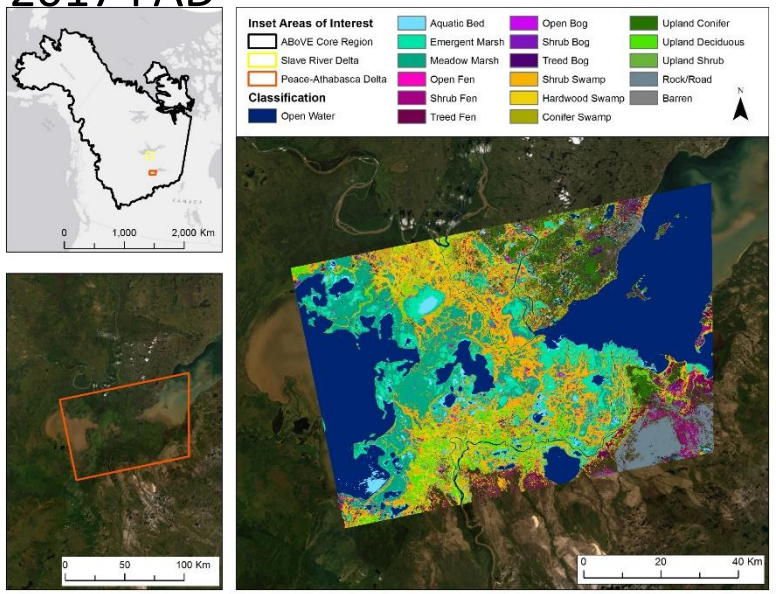
2017 SRD



2007 PAD



2017 PAD

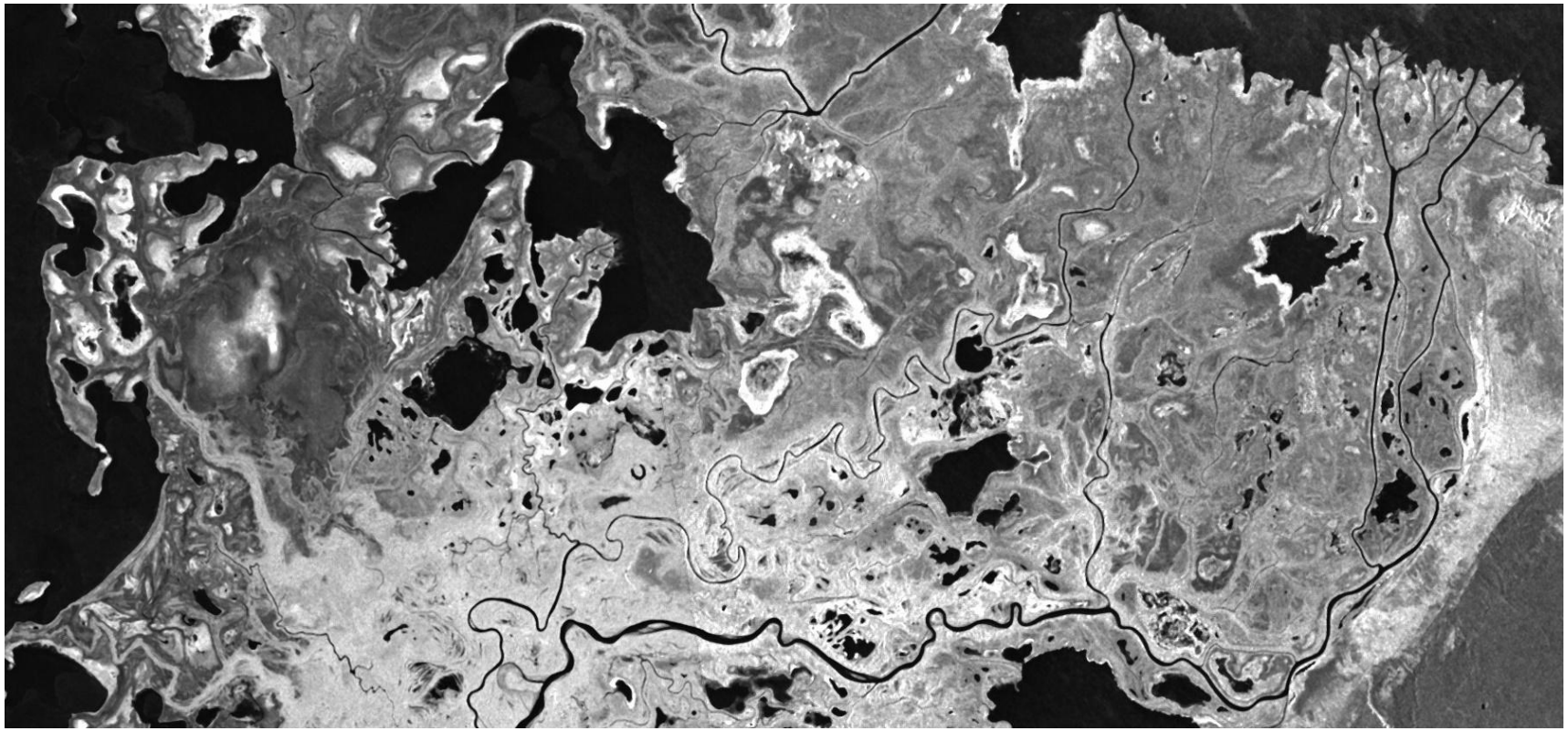


Vegetation Flooding Mapping

Using Satellite Radar Images (Sentinel-1)

Products developed:

1. Single-date inundation/flooding status
2. Seasonal flooding composite map (hydroperiod): number of times flooded in a season
3. Annual flooding average and variation of flooding from year to year

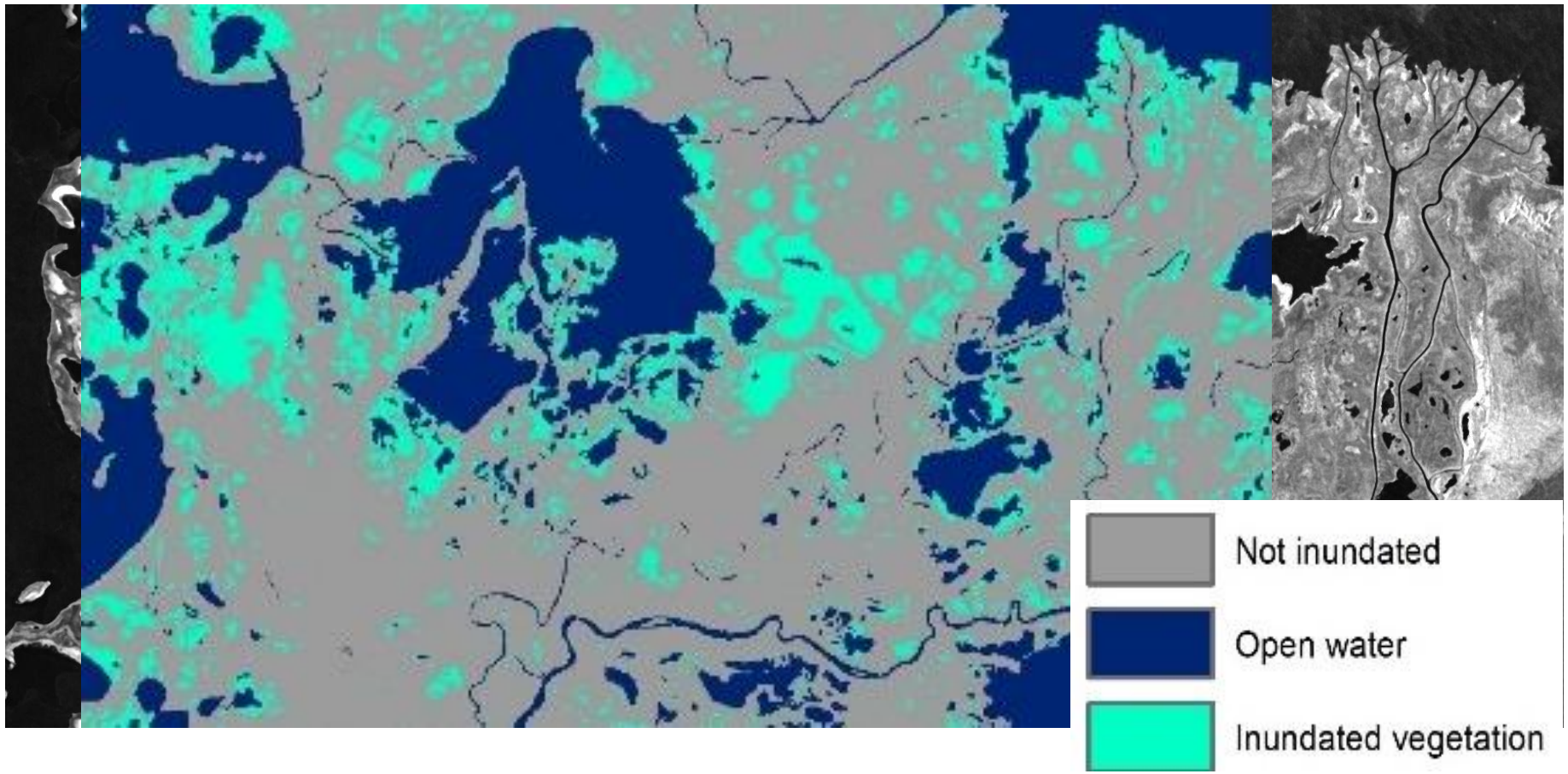


Vegetation Flooding Mapping

Products developed:

1. Single-date inundation/flooded vegetation

Can be used for matching to specific days or weeks

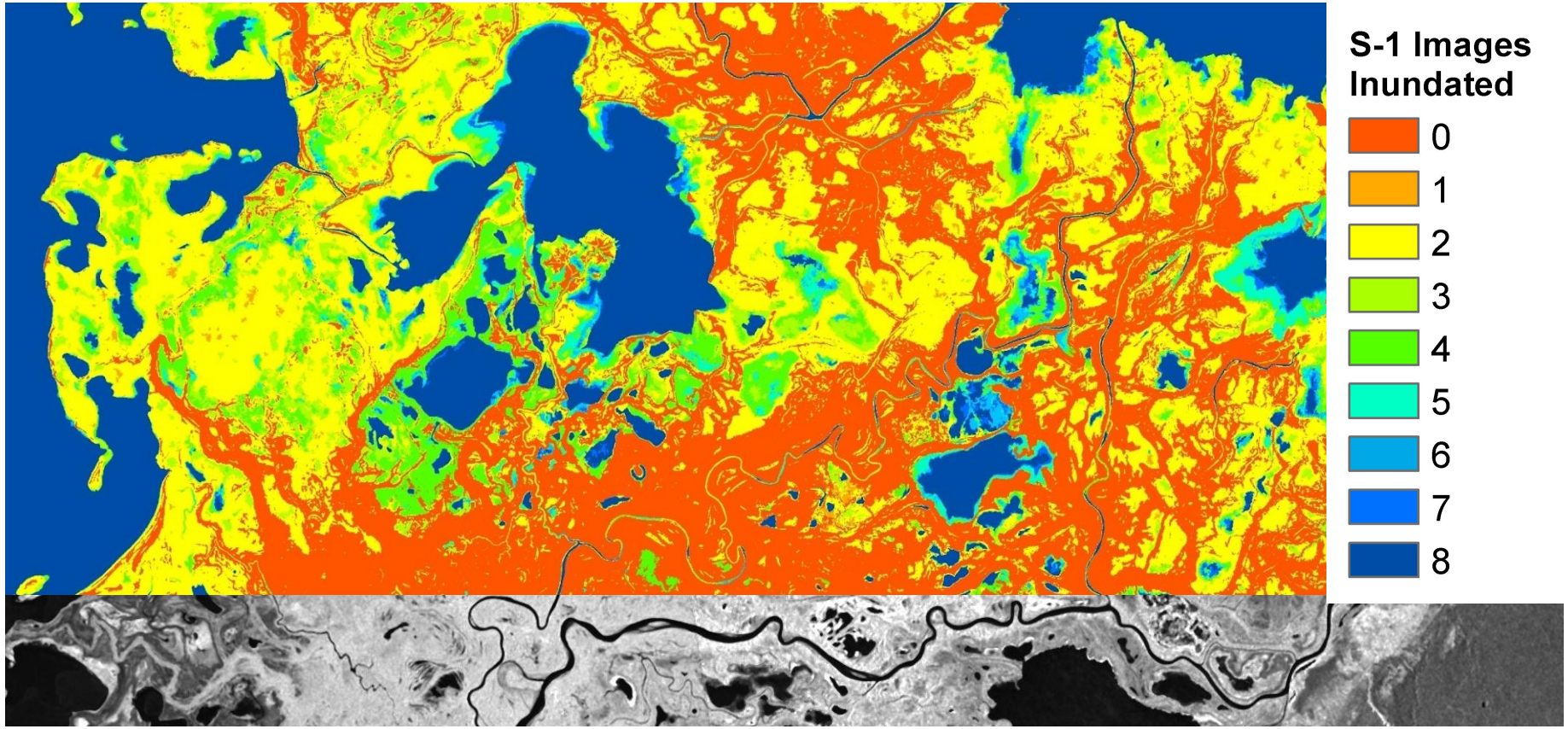


Vegetation Flooding Mapping

Products developed:

2. Seasonal vegetation flooding composite map (hydroperiod): number of times flooding in a season

Can be assessed for seasonality and persistence

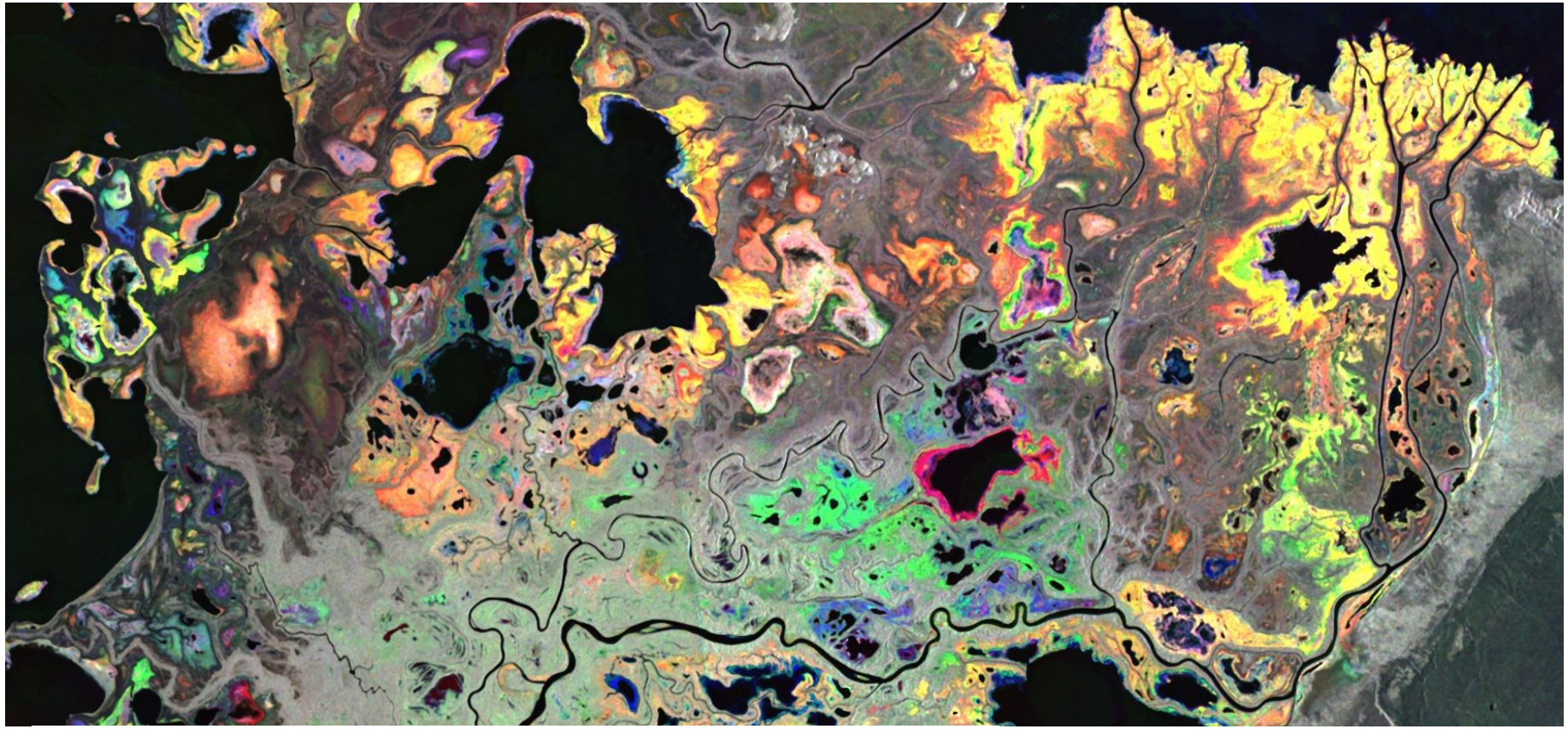


Vegetation Flooding Mapping

Products developed:

3. Annual flooded vegetation: average and change from year to year

Can be used to understand dynamics from year to year and identify highly dynamic sites

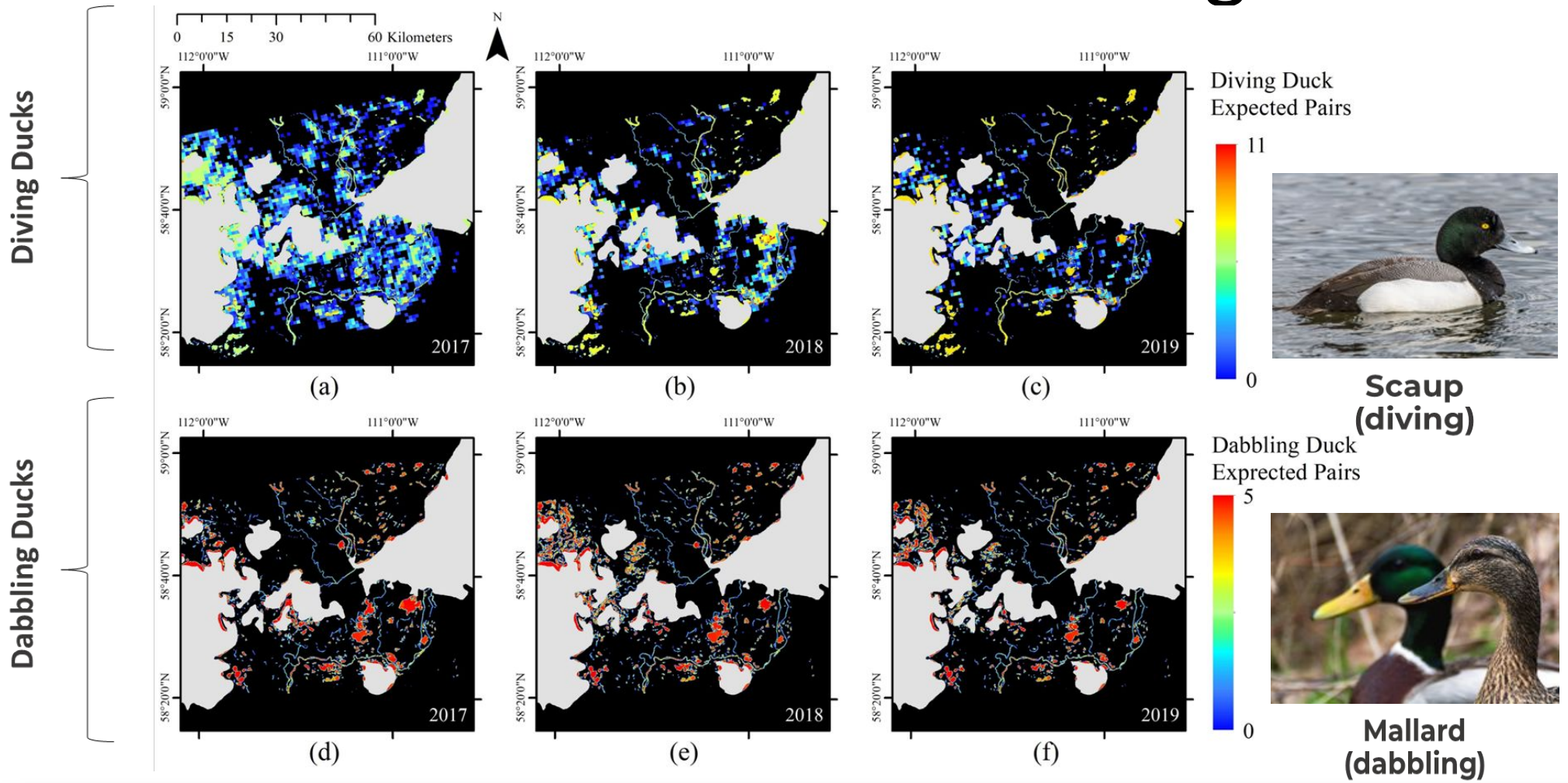


Red=2017 Green = 2018 Blue = 2019

Applications of ABoVE Products using Remote Sensing Methods

Michael Merchant, DUC

Waterfowl Abundance Modelling



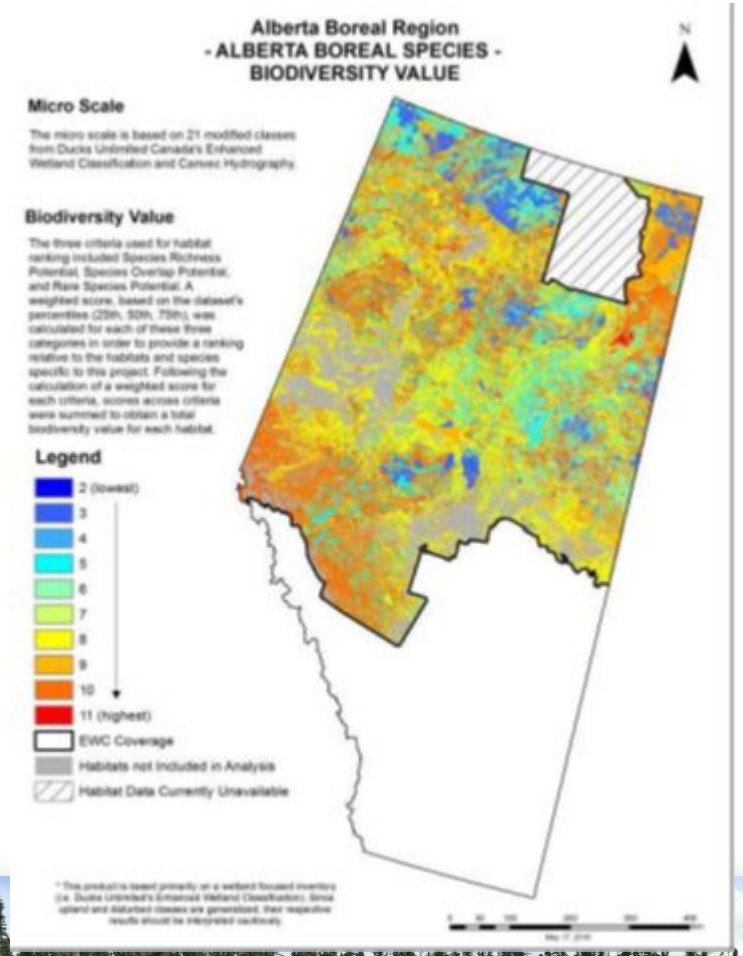
Scaup (diving)

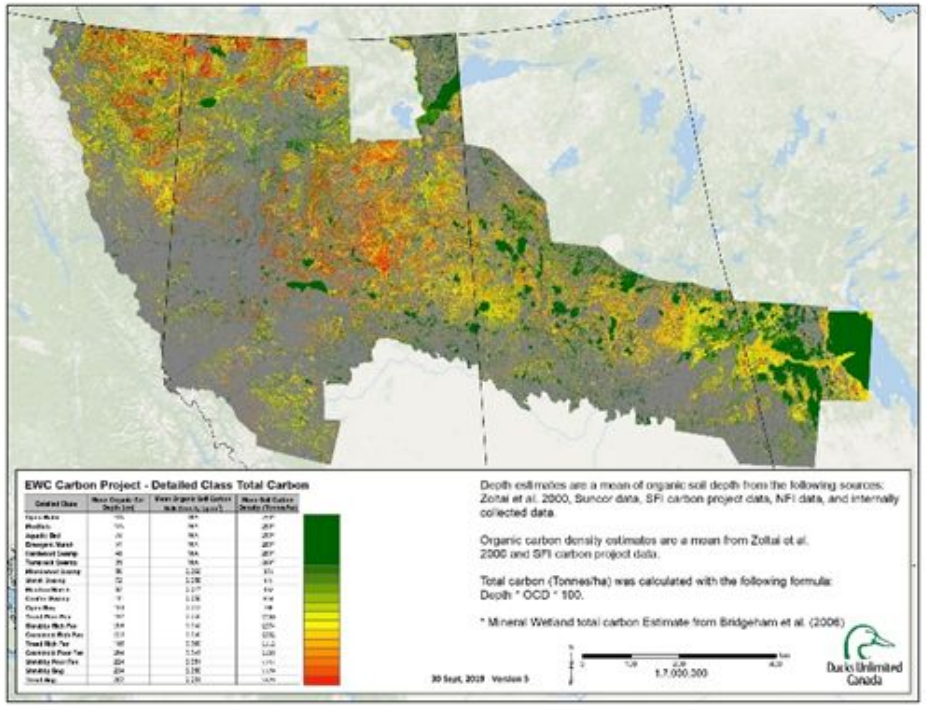
Mallard (dabbling)

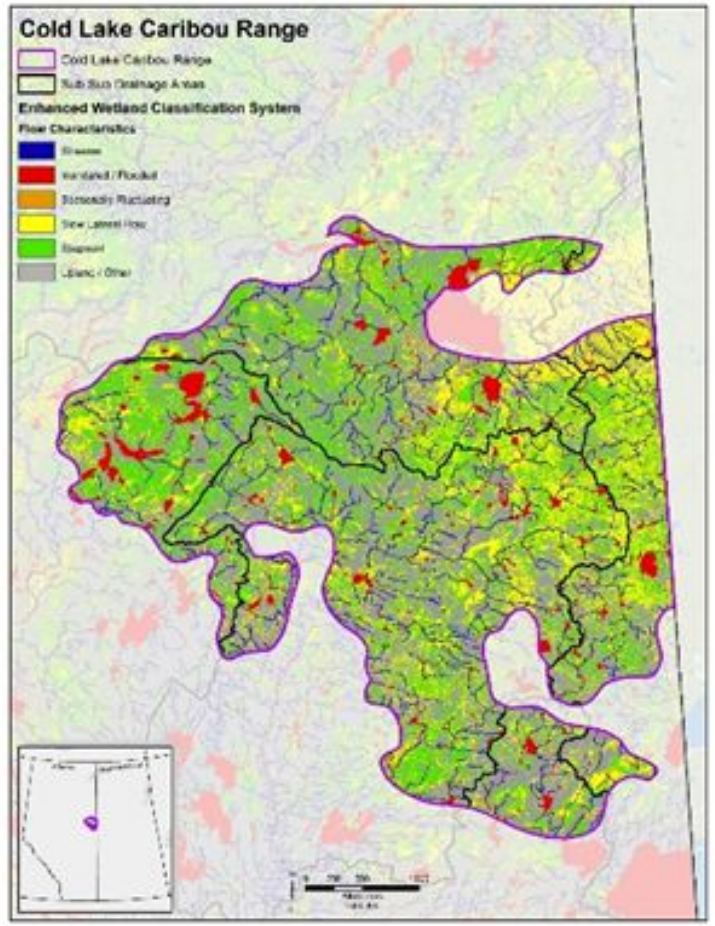
These wetland type maps and annual flooding information were used to:

- map waterfowl abundance of Diving and Dabbling ducks and
- provides unique information for duck habitat modeling

Others Applications of Wetland Maps by DUC

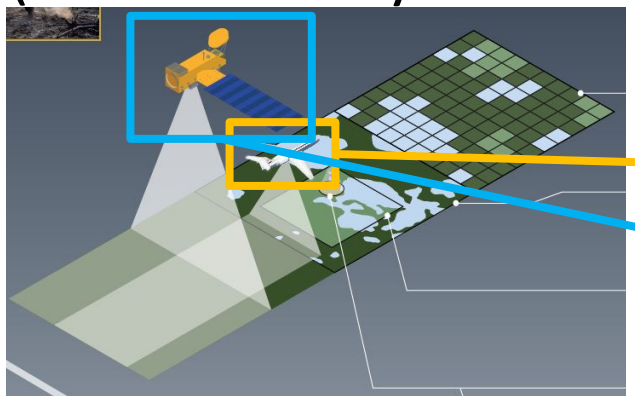






NISAR Wetland Flooding

(NASA-ISRO Synthetic Aperture Radar Satellite)



What we've done

→ Collected **Airborne (UAVSAR)** images to support **Satellite (NISAR)** product development

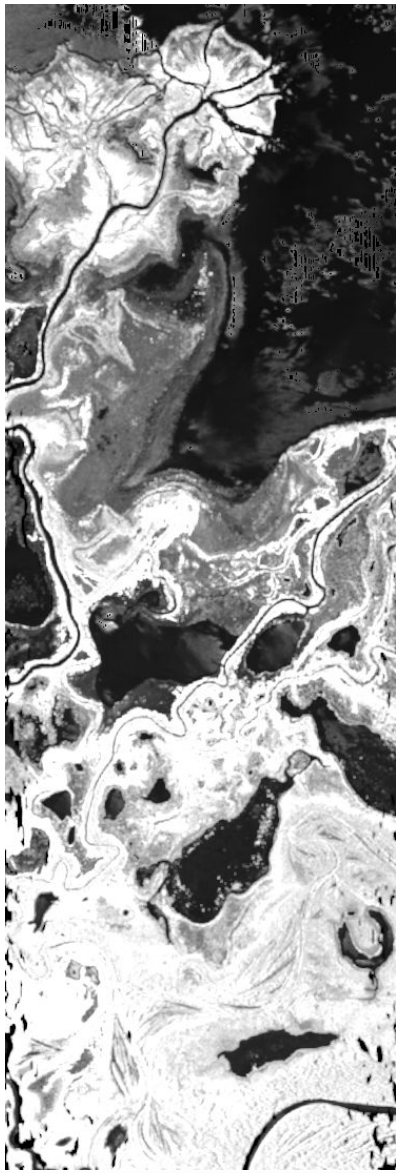
Where we're going:

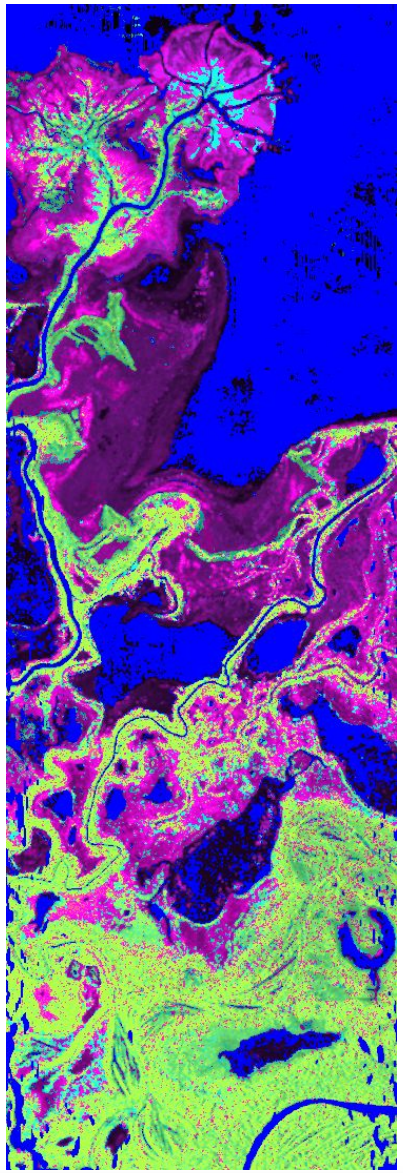
- NISAR-mapped wetland flooding
  - Satellite will launch in early 2024, first global acquisitions around July 2024.
  - Validate open water and inundated vegetation extent over selected validation sites.
  - Compare with other products, such as OPERA DSWx-HLS and DSWx-S1, UAVSAR polarimetric data.

NISAR Wetland Inundation

Peace-Athabasca Delta
June 13, 2017

NISAR-like HH image from UAVSAR





Classification inundation extent from quad pol UAVSAR

- UAVSAR is NASA's airborne L-band SAR
- Currently making simulated NISAR products from UAVSAR data collected by ABoVE

- Perform polarimetric decomposition to estimate ground scattering behaviour
- Classify results based on expected scattering behavior

NASA-JPL OPERA products

(Observational Products for End-Users from Remote Sensing Analysis)

OPERA DSWx-HLS product

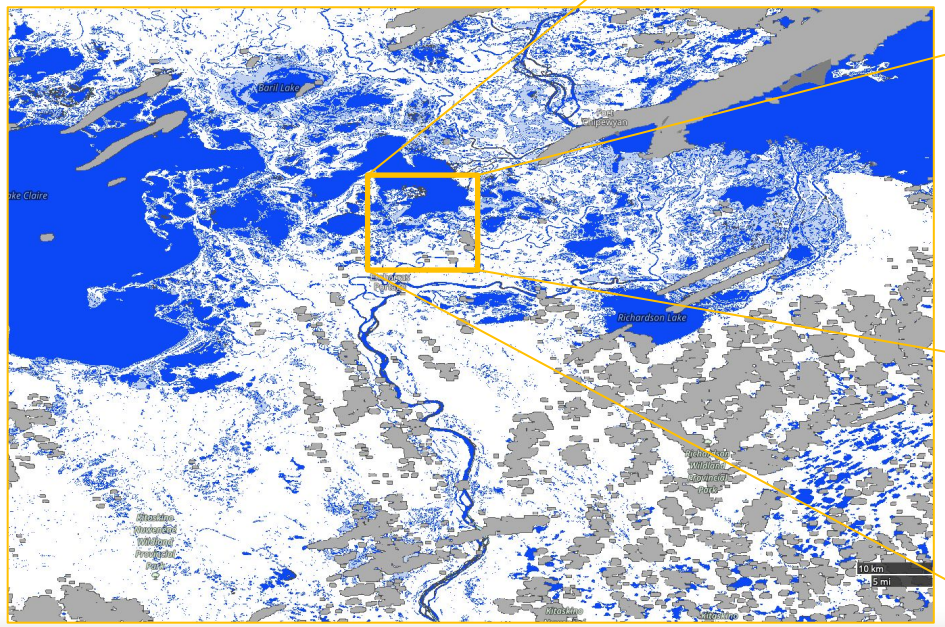
Peace-Athabasca Delta

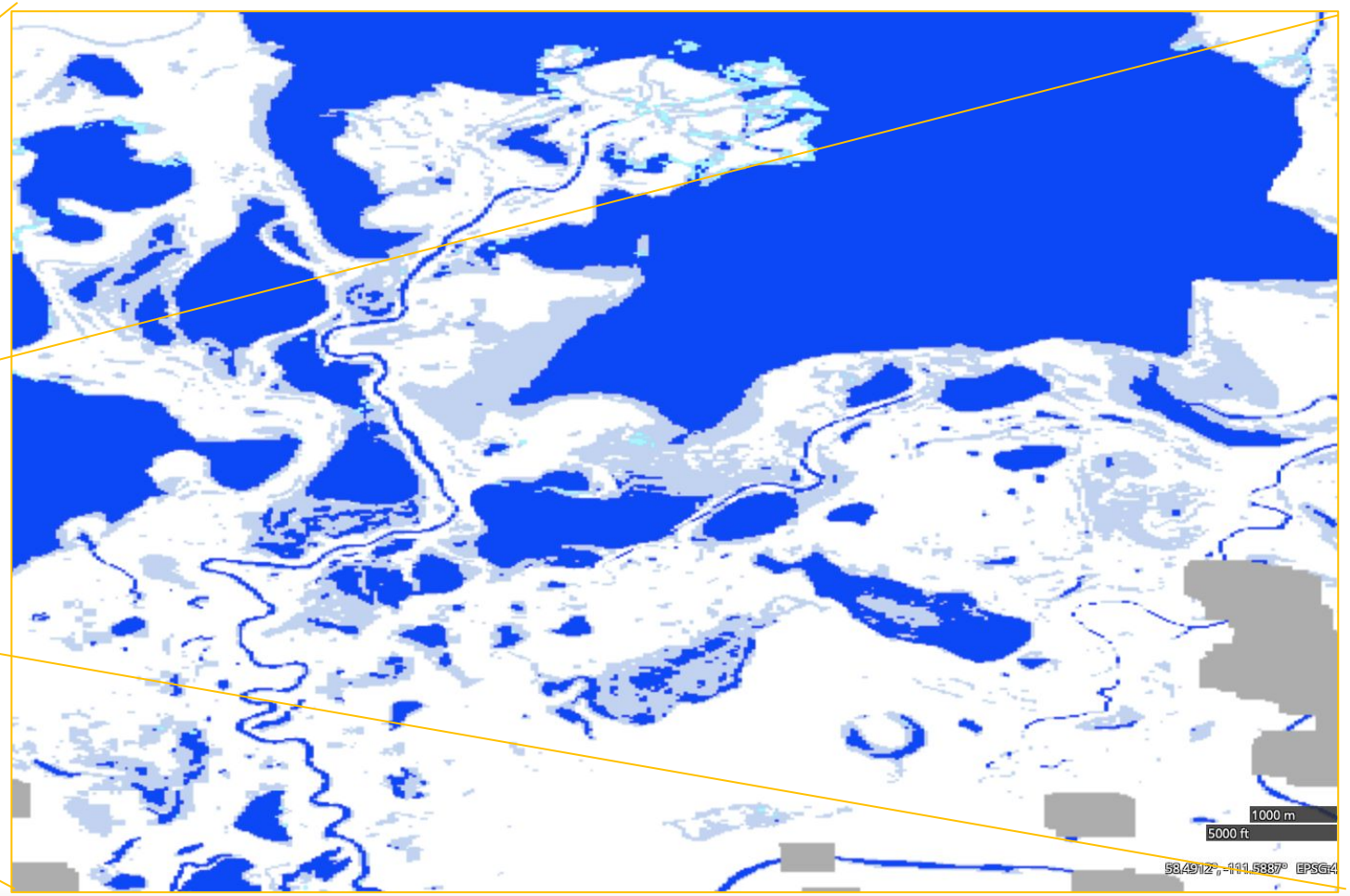
June 23, 2023

Open water

Partial surface water

Clouds

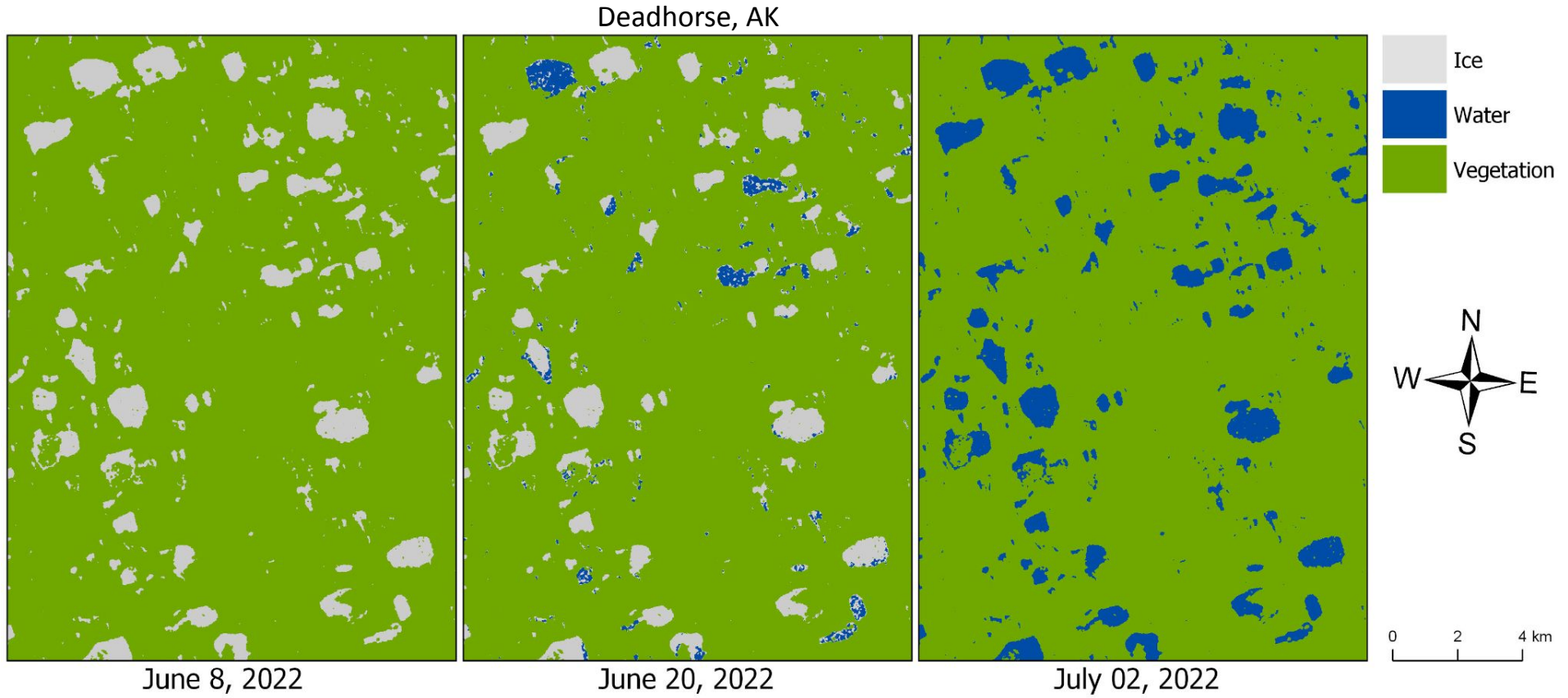




Examples of New Products

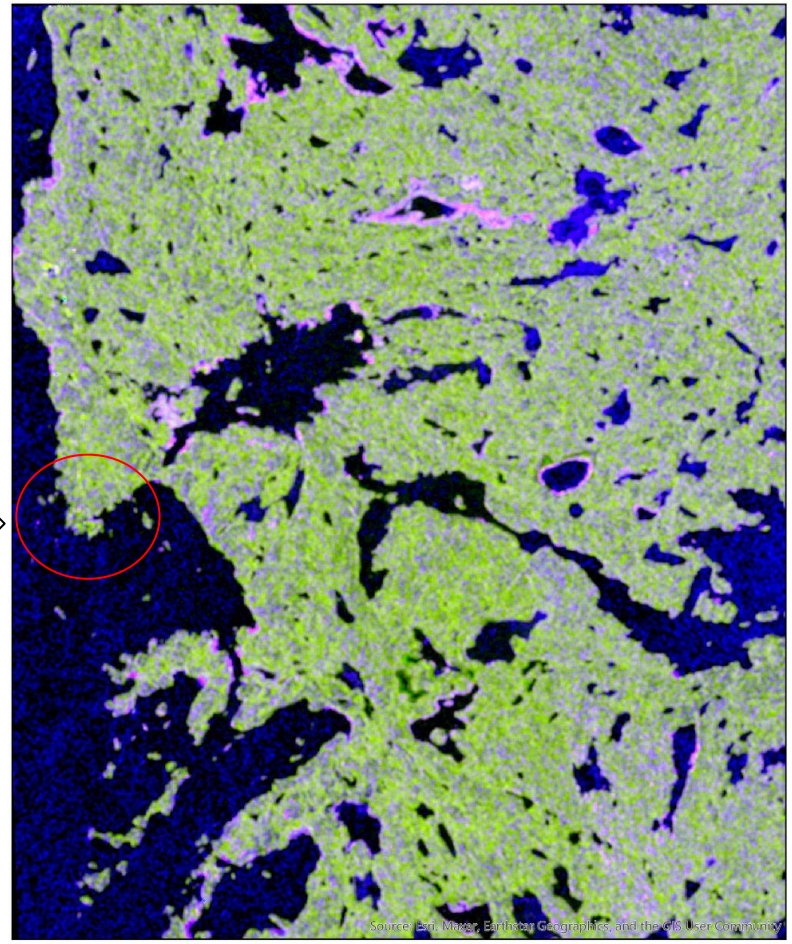
We used a version of our technique for identifying wetland dynamics to detect ice-off in small lakes

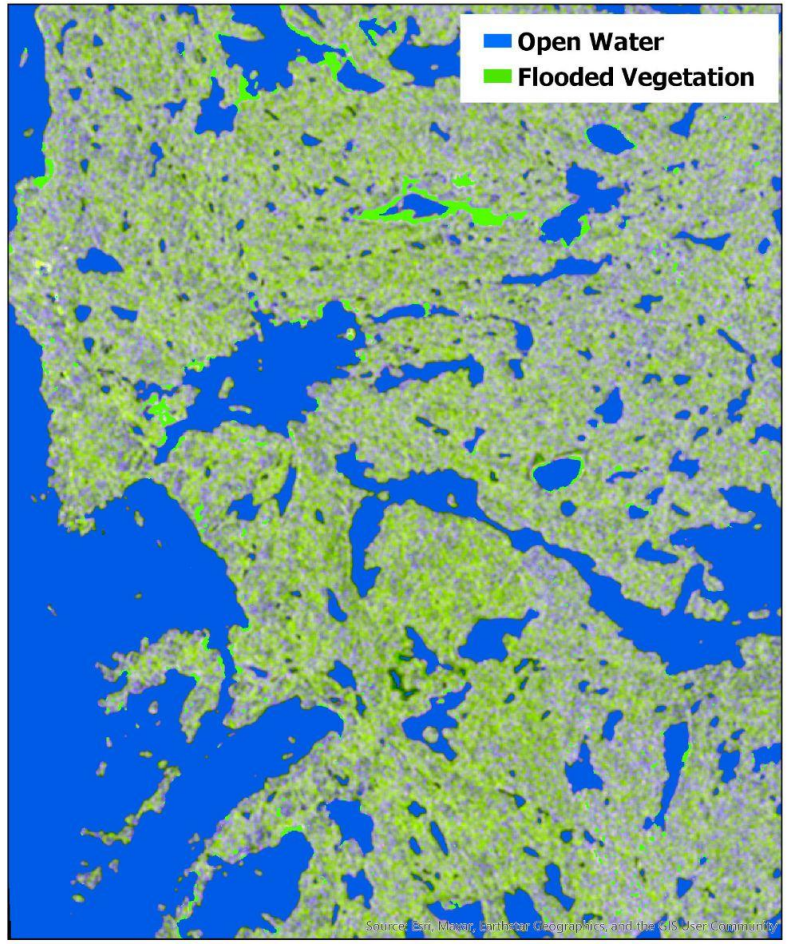
→ a factor in determining when migratory birds will begin to arrive in the north



Dettah, August 2021

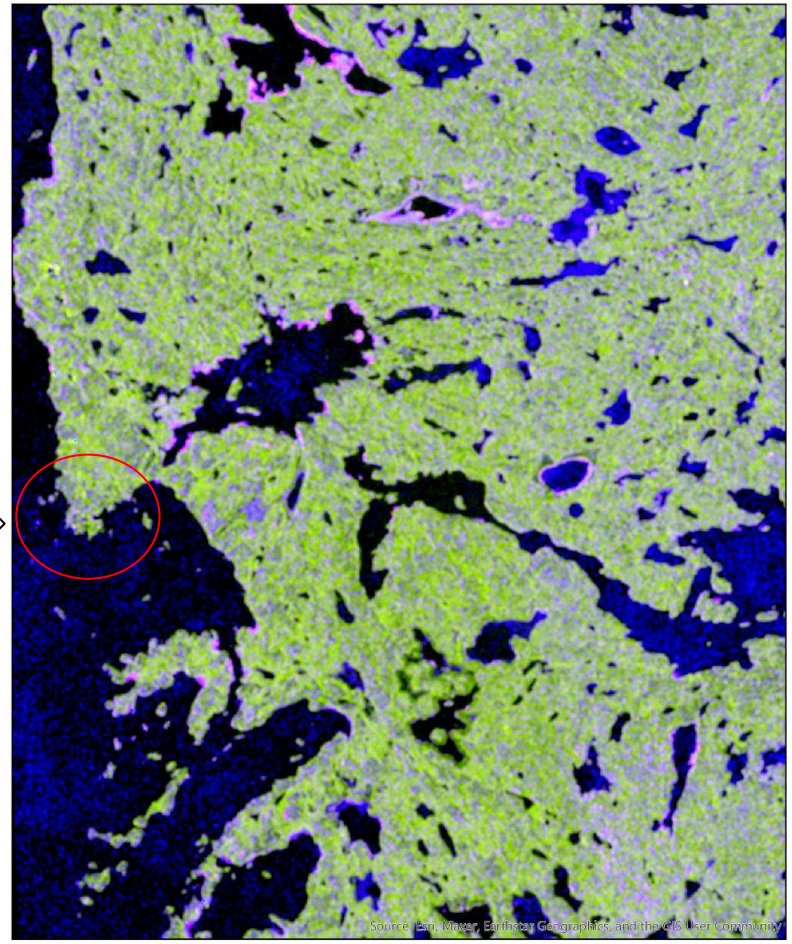
Dettah

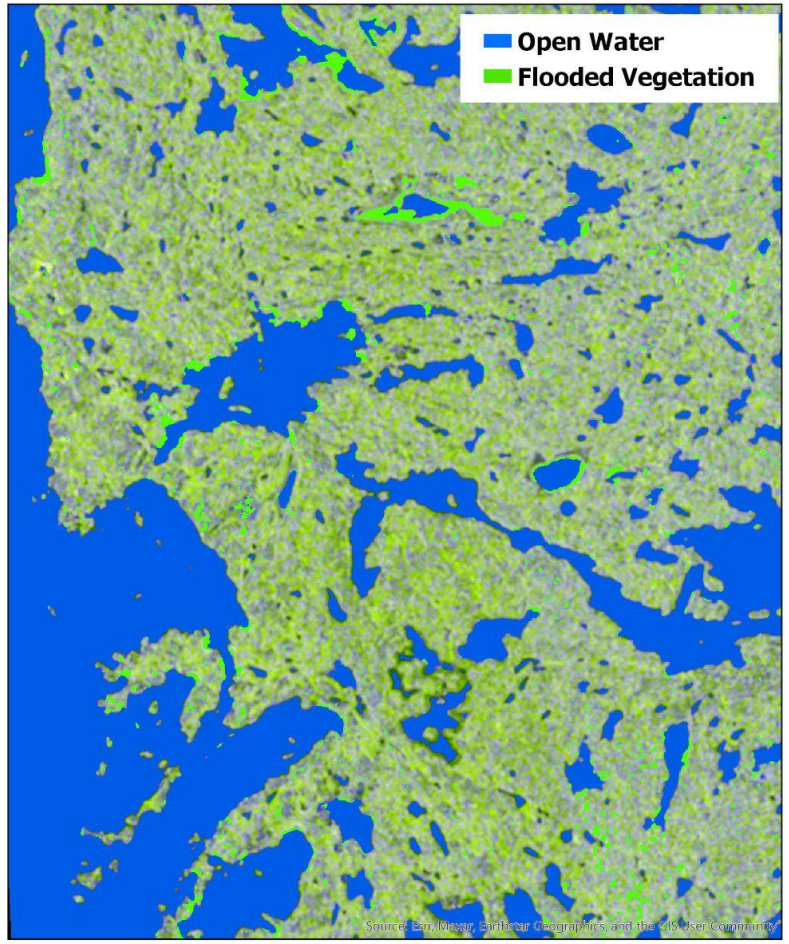




Dettah, August 2022

Dettah

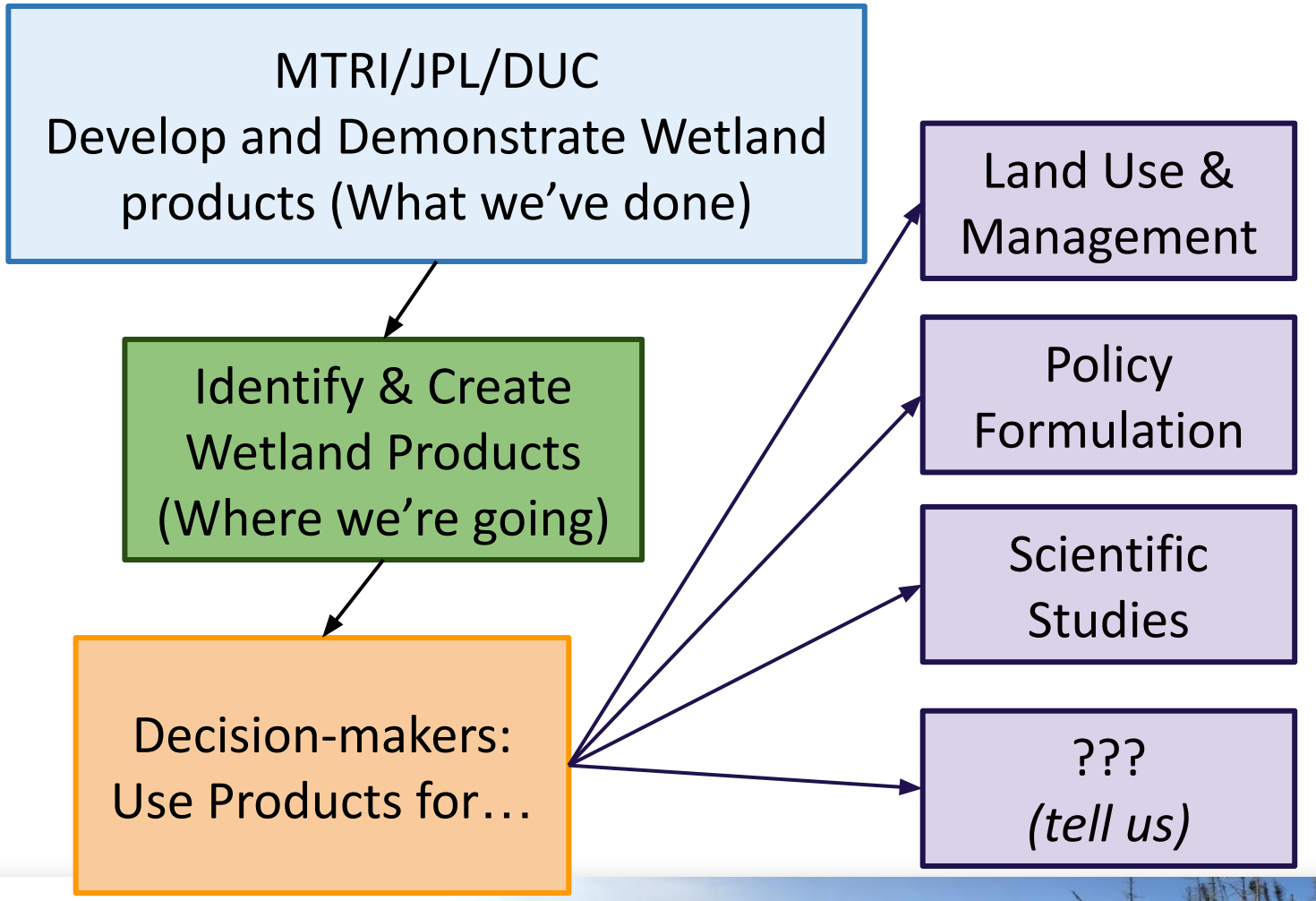




Next Steps

Project Goals Going Forward

- Review with communities the products developed by this research.
- Work with communities to find best products for decision-support and other uses.



Opportunities for Field-Checking of Maps (Validation)

As we produce wetland products, it is important that we are in the field to help create accurate and valuable products by:

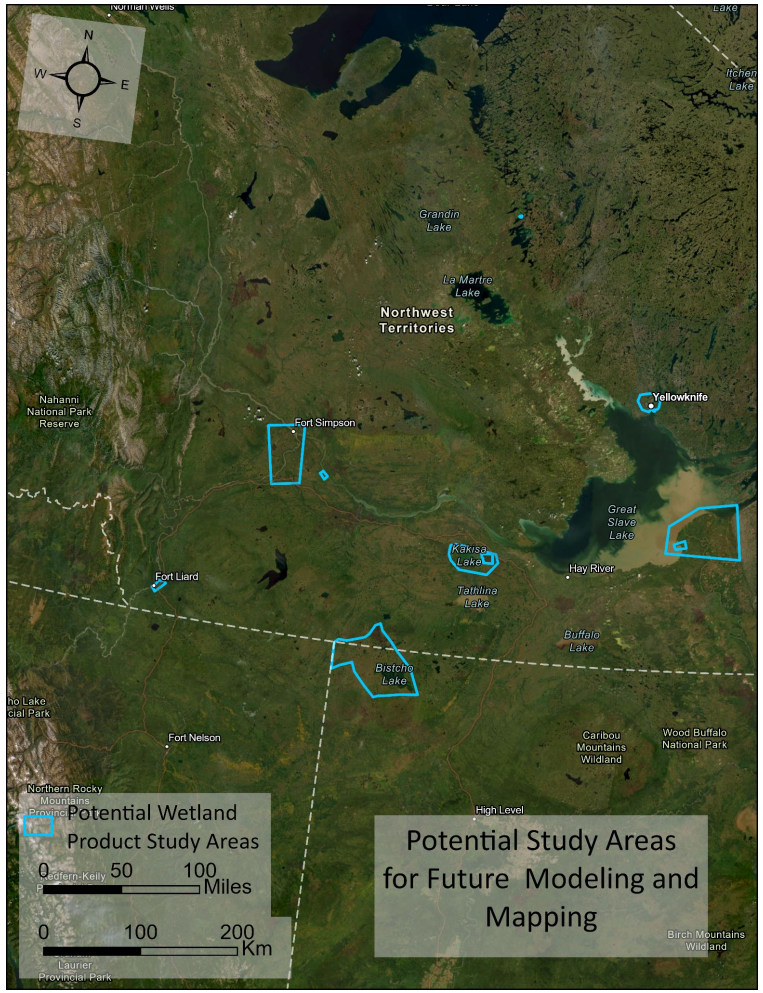
- Observing and measuring key characteristics in the field
- Field-checking the maps and products created

Challenges to data product validation

- Acquiring enough site-representative data
- Working in remote areas

DUC and MTRI hope to work with local communities for field validation

- Indigenous Guardians Program: Supports Indigenous rights and responsibilities in protecting and conserving ecosystems



In-Person Workshops

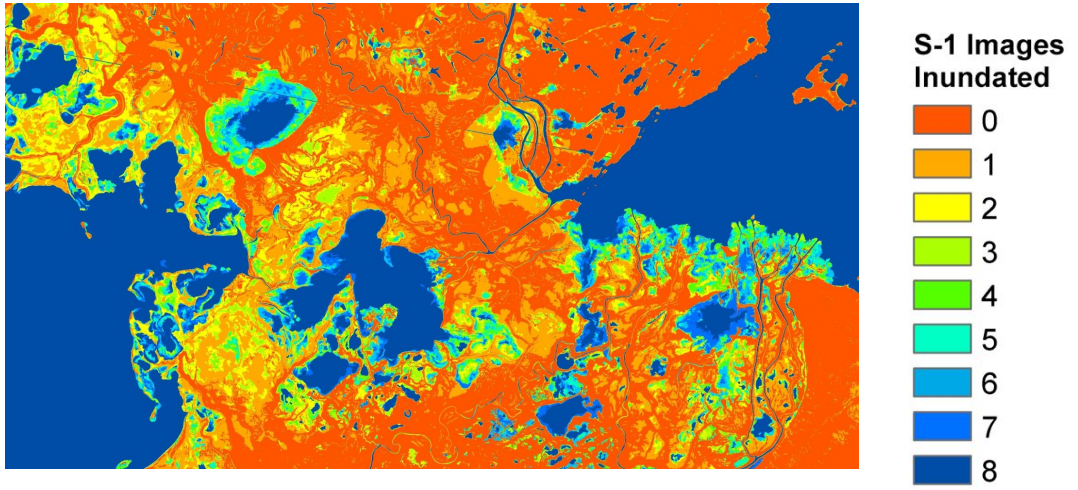
- DUC and MTRI hope to work with local communities to build in-person data collaboration and collection workshops
- Goals:
  - Validate existing datasets
  - Continue building a collaboration network
  - Provide learning opportunities

Fieldwork near Fort Resolution, 2019

Community Needs and Questions

- What is the issue in your water resource management that you are interested in improving? What is the temporal/spatial scale needed?
- What are the gaps in your ability to monitor and manage wetlands?
- What wetland information would be valuable to you/your organization?
- Submit your contact information

Link to Jamboard



2018 PAD Seasonal Inundation Composite Map

Contact Us

Nancy French - nhfrench@mtu.edu

Michael Battaglia - mjbattag@mtu.edu

Michael Merchant - m_merchant@ducks.ca

Dana Redhuis - dnvanhui@mtu.edu

Contact Information Form

All data, products, and algorithms produced will be freely available for download. Current data products from the ABoVE project are available from the NASA ABoVE data site - ORNL-DAAC: https://daac.ornl.gov/cgi-bin/dataset_lister.pl?p=34