Using SAR to Characterize the Winter State of Ponds and Lakes

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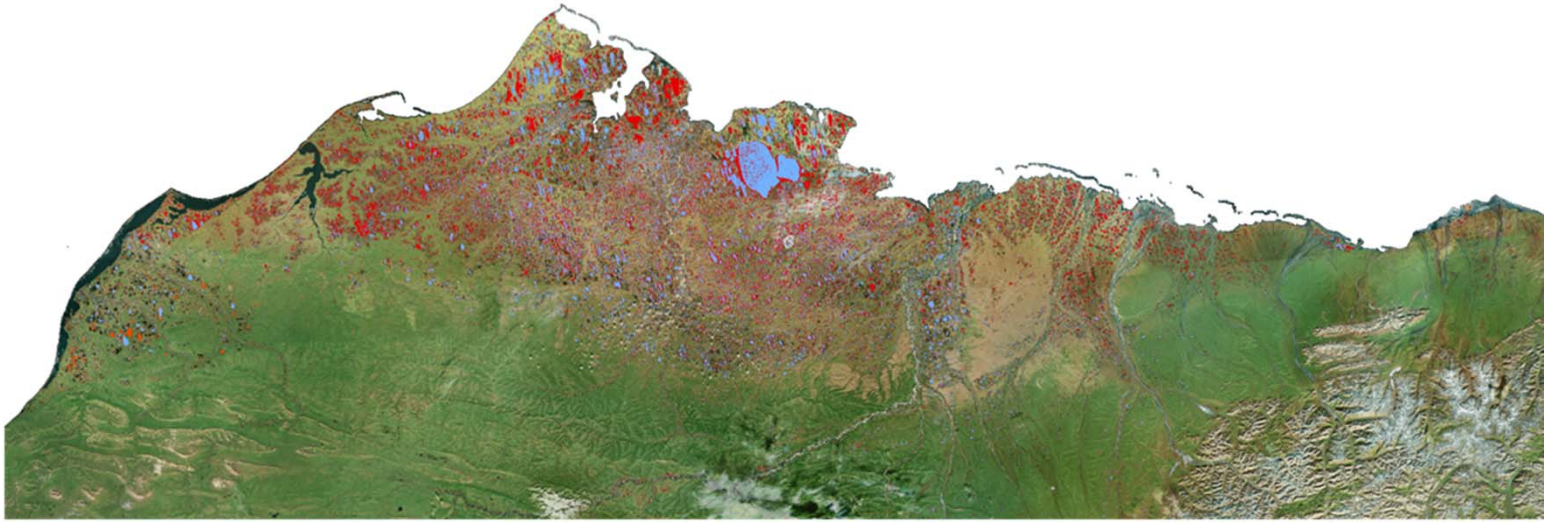
Project Description

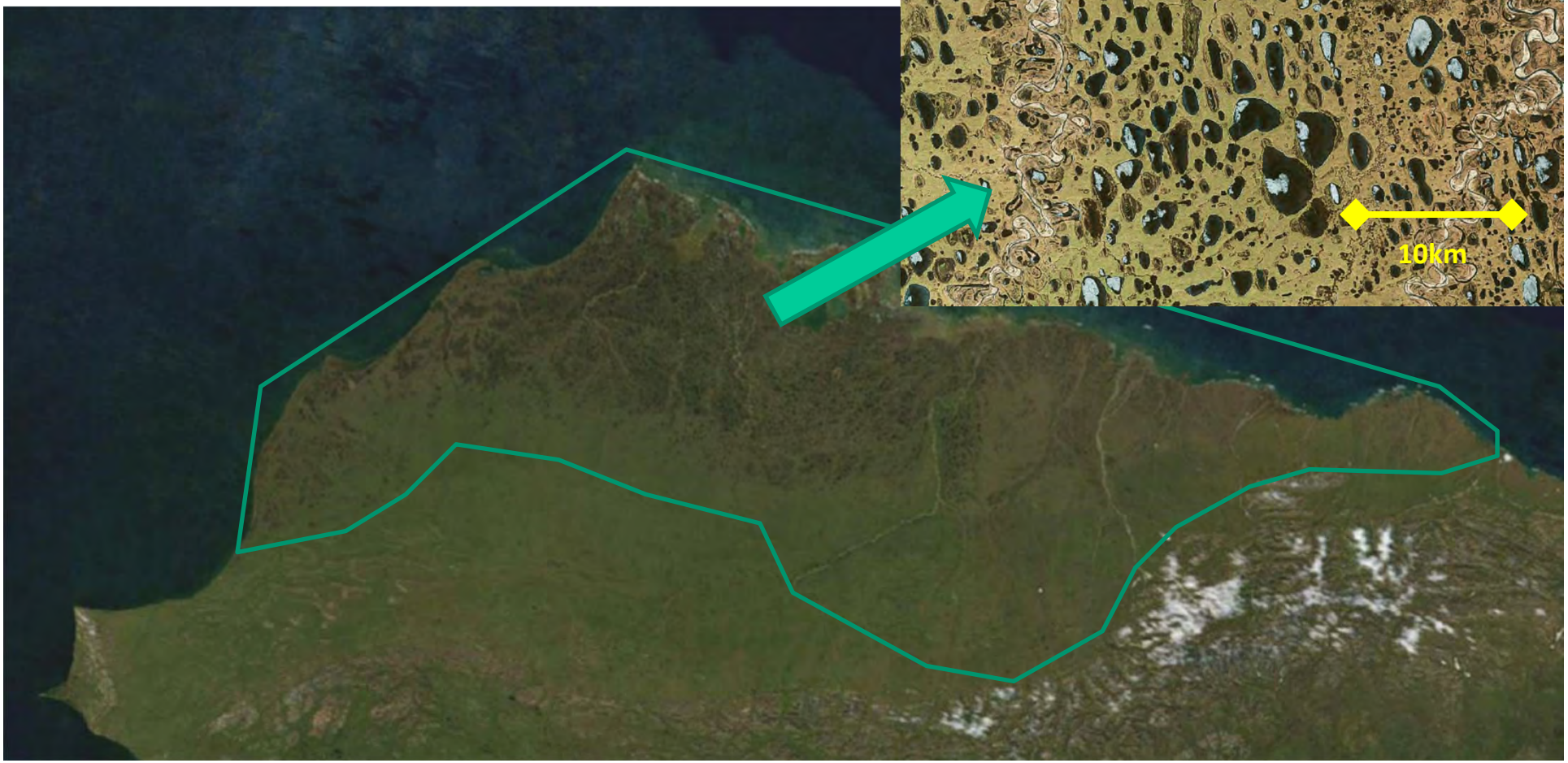
- Funded by National Fish and Wildlife Foundation
  and the North Slope Science Initiative (NSSI)

- Perform a survey of all North Slope lakes to determine which contain liquid water throughout the winter.
  - Make data publicly available.
  - Explore potential for computing lake volumes
  - Refine remote sensing methods for lake characterization

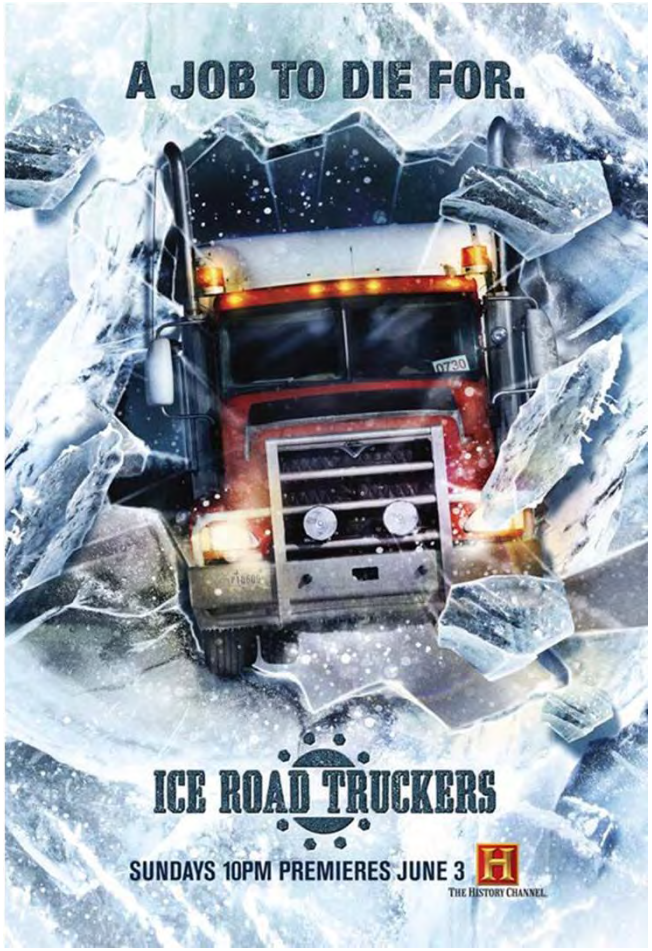


Alaska's North Slope

- Semi-arid permafrost wetland
- > 160, 000 lakes and ponds
- Critical habitat for migrating birds
- Site of increasing development for oil & gas



Project Motivation



Goal is to find:

- freshwater for ice roads and industrial facilities

- Over-winter habitat for fish, and thus breeding/nesting habitat for birds such as yellow-billed loon

Yellow-billed Loon Photo Credit: Susan Earnst/USGS

Synthetic Aperture Radar

ERS-2
- Launched 1995 by ESA
- 5.6 cm (C-Band)
- VV Polarization
- 100km swath
- 30m resolution
- 35 day Repeat Cycle

Sensor of choice for project is Synthetic Aperture Radar (SAR)

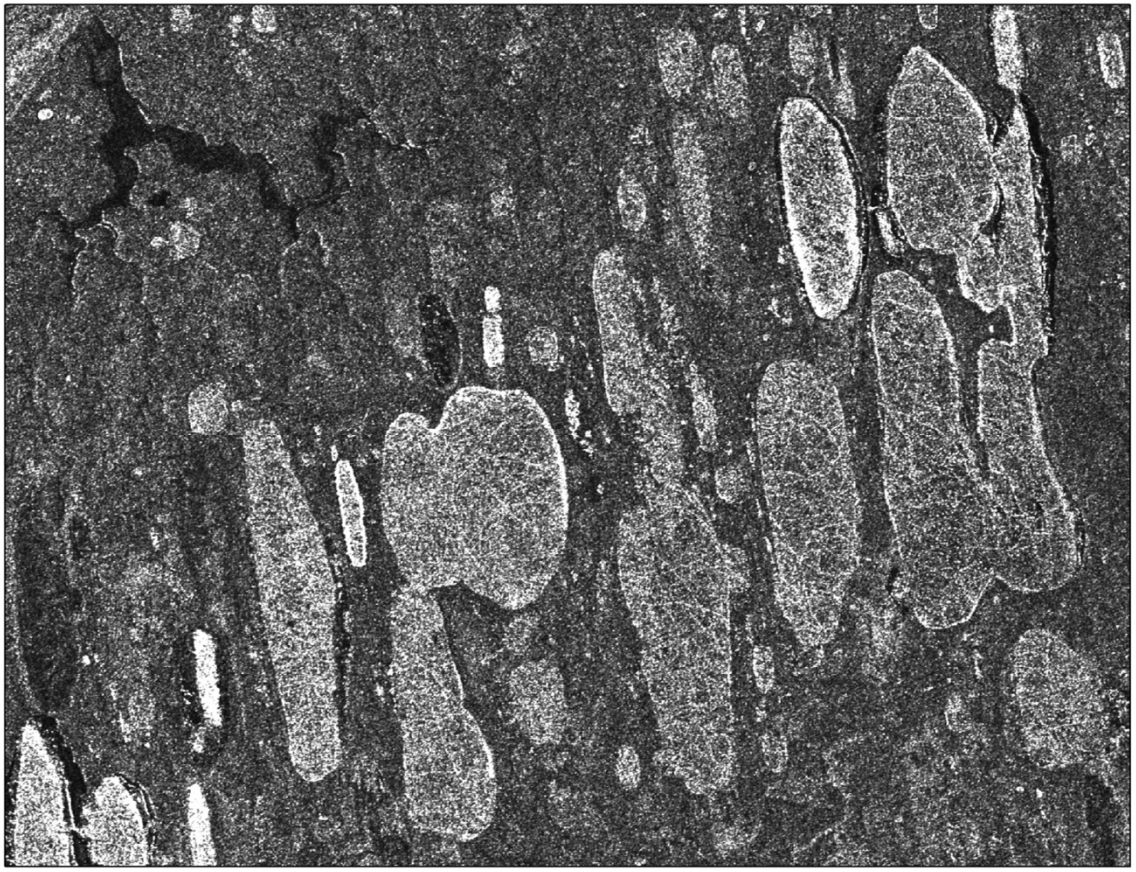
- Day/night and All-weather capability
- Extensive coverage of Alaska's North Slope
- Unique ability to determine status of lake ice
- Multi-decadal data archive permits investigation of temporal trends in above ground water

Let's see what SAR can discern

Temporal Evolution

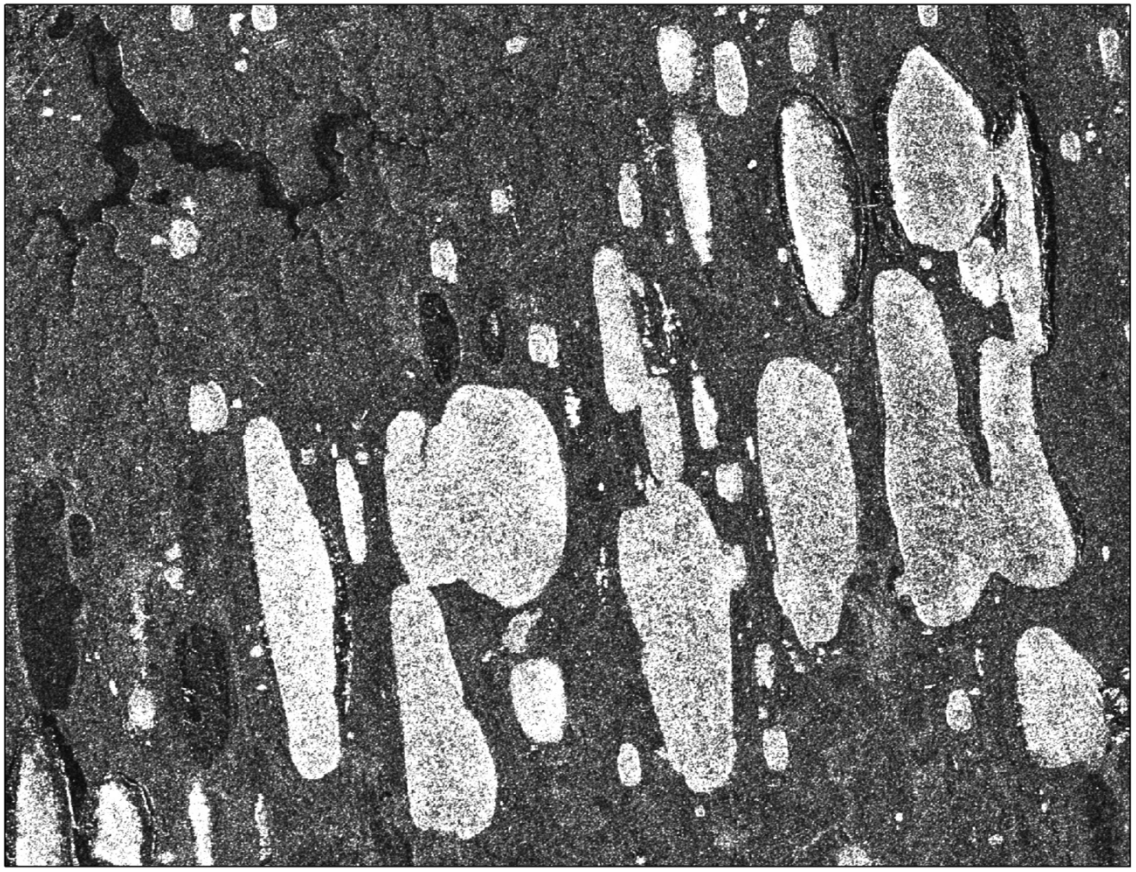
November 11, 2009

Temporal Evolution



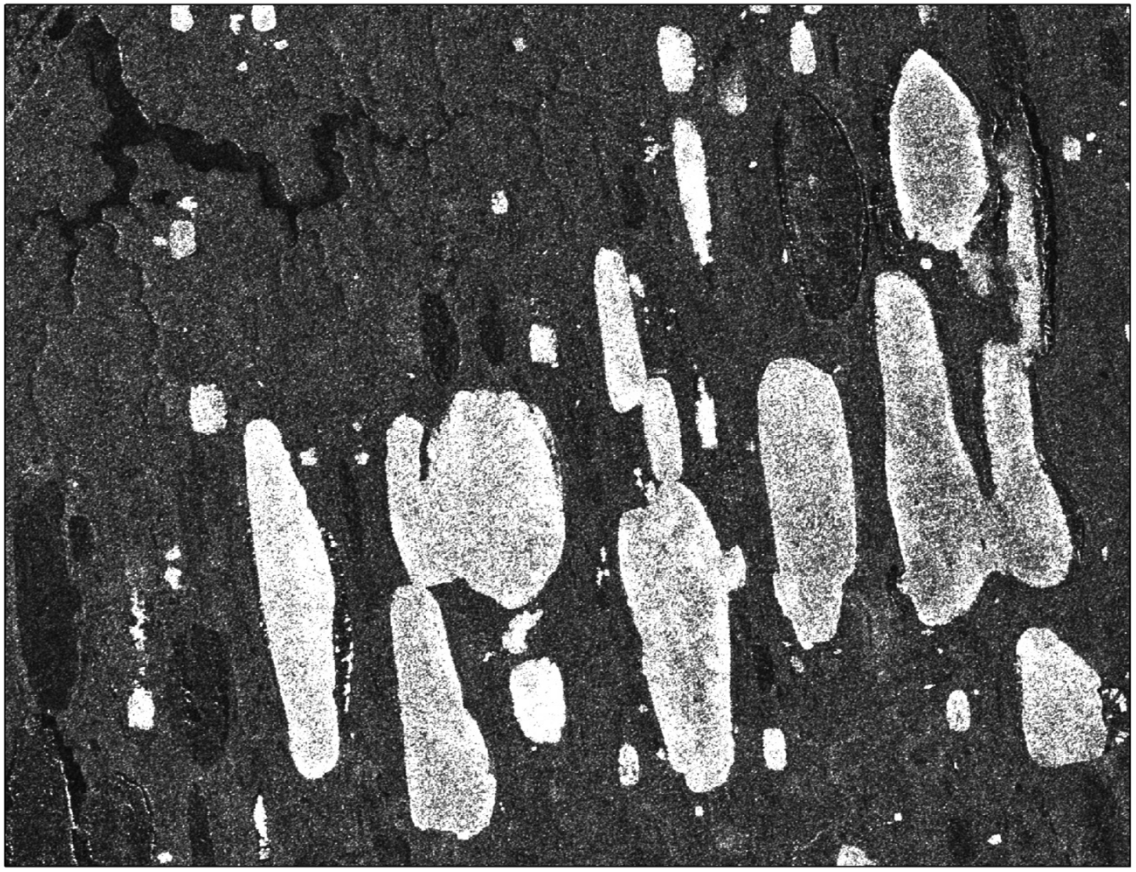
December 6, 2009

Temporal Evolution



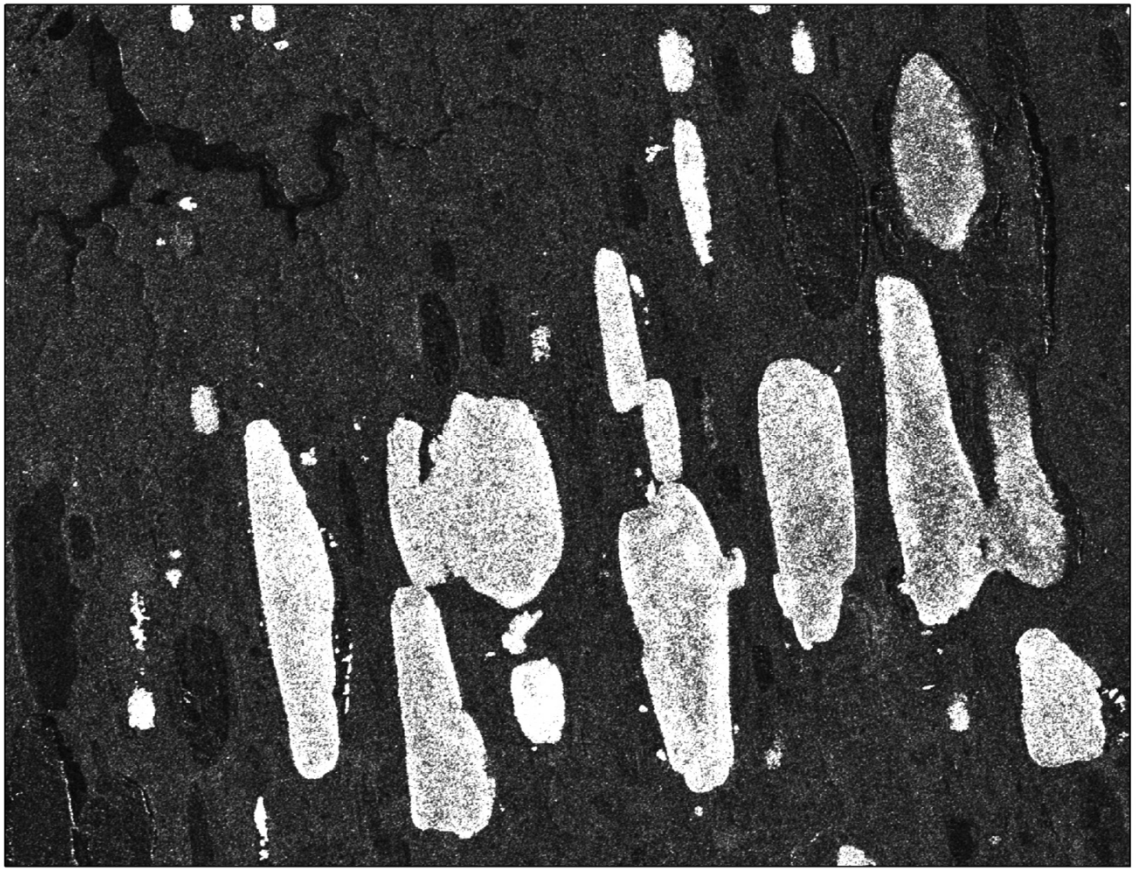
January 10, 2009

Temporal Evolution



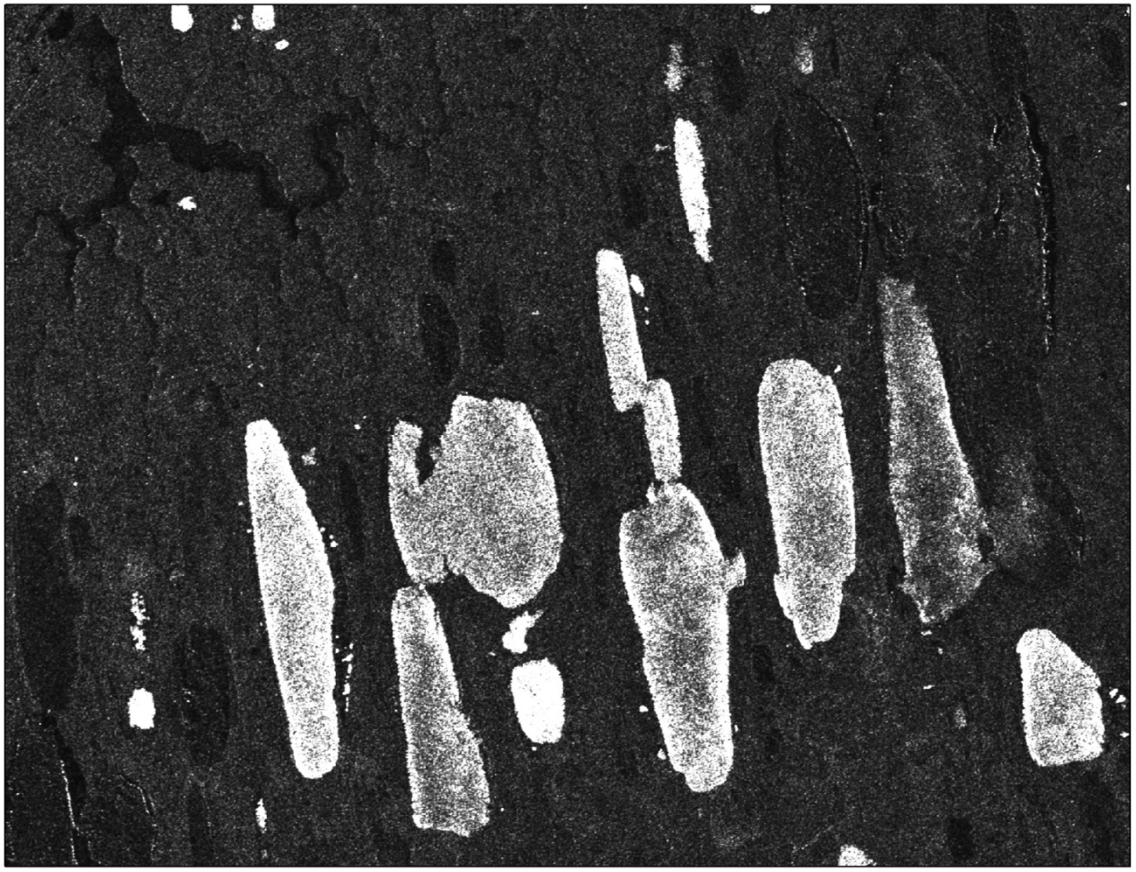
Feb 14, 2009

Temporal Evolution



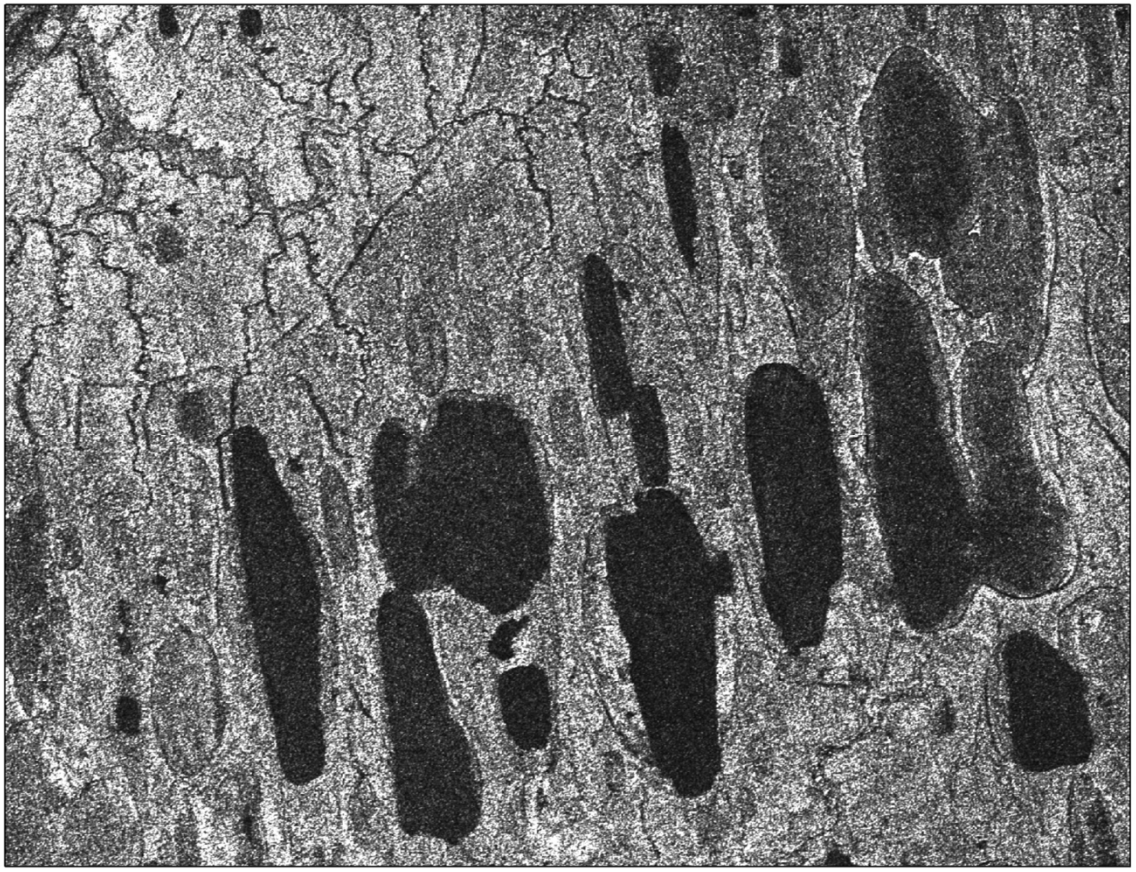
March 21, 2009

Temporal Evolution



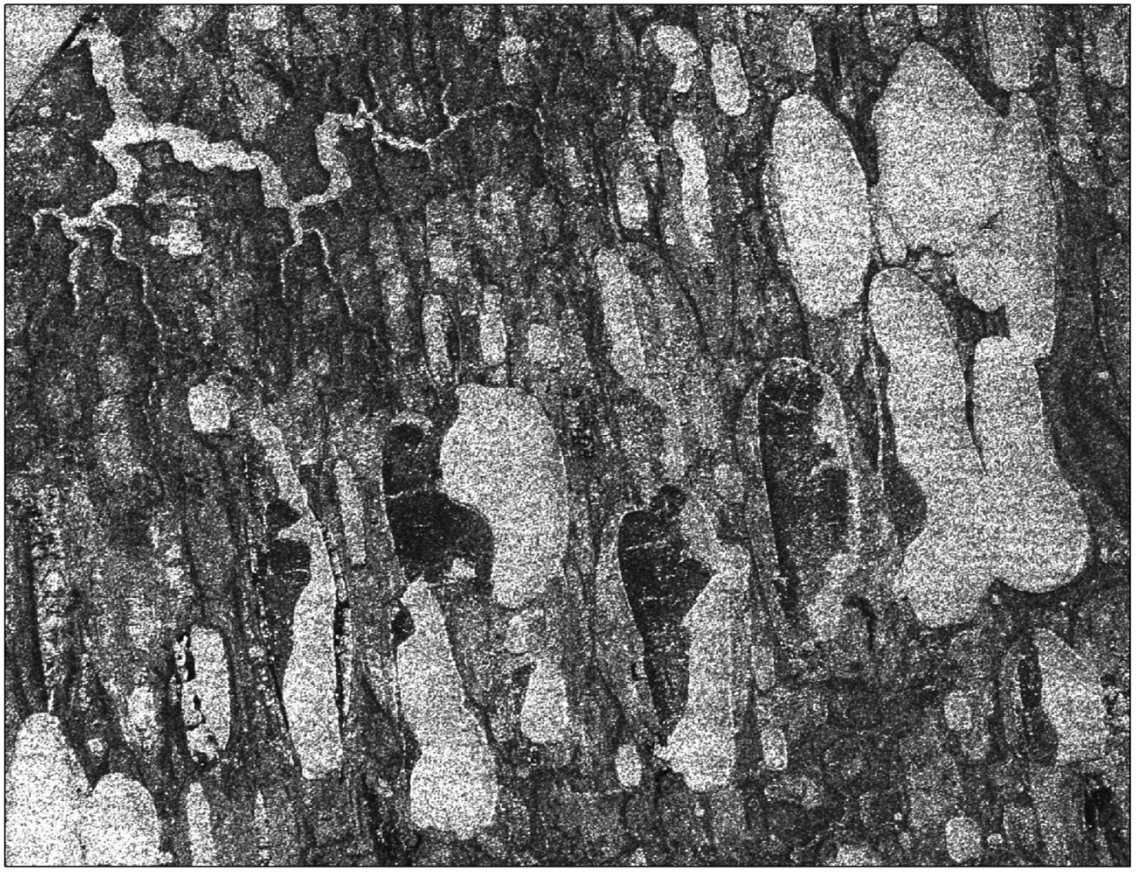
April 25, 2009

Temporal Evolution



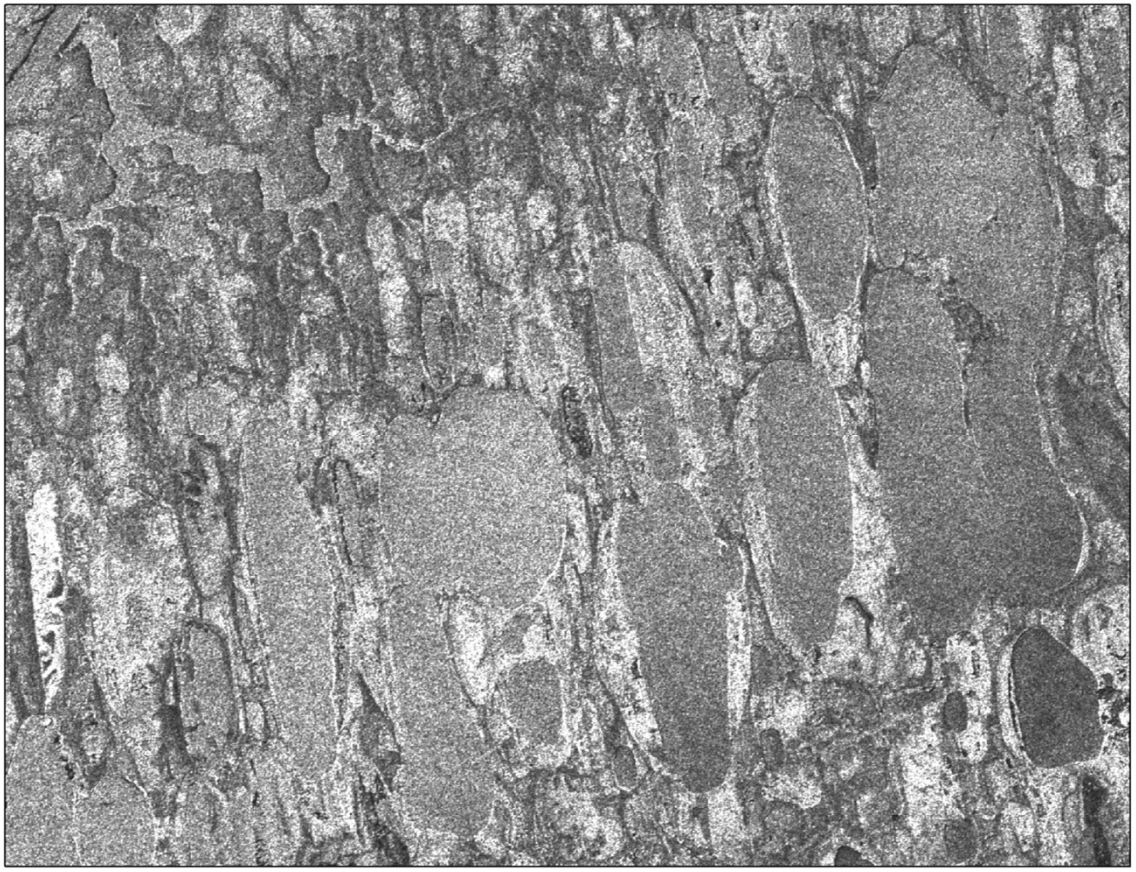
May 30, 2009

Temporal Evolution



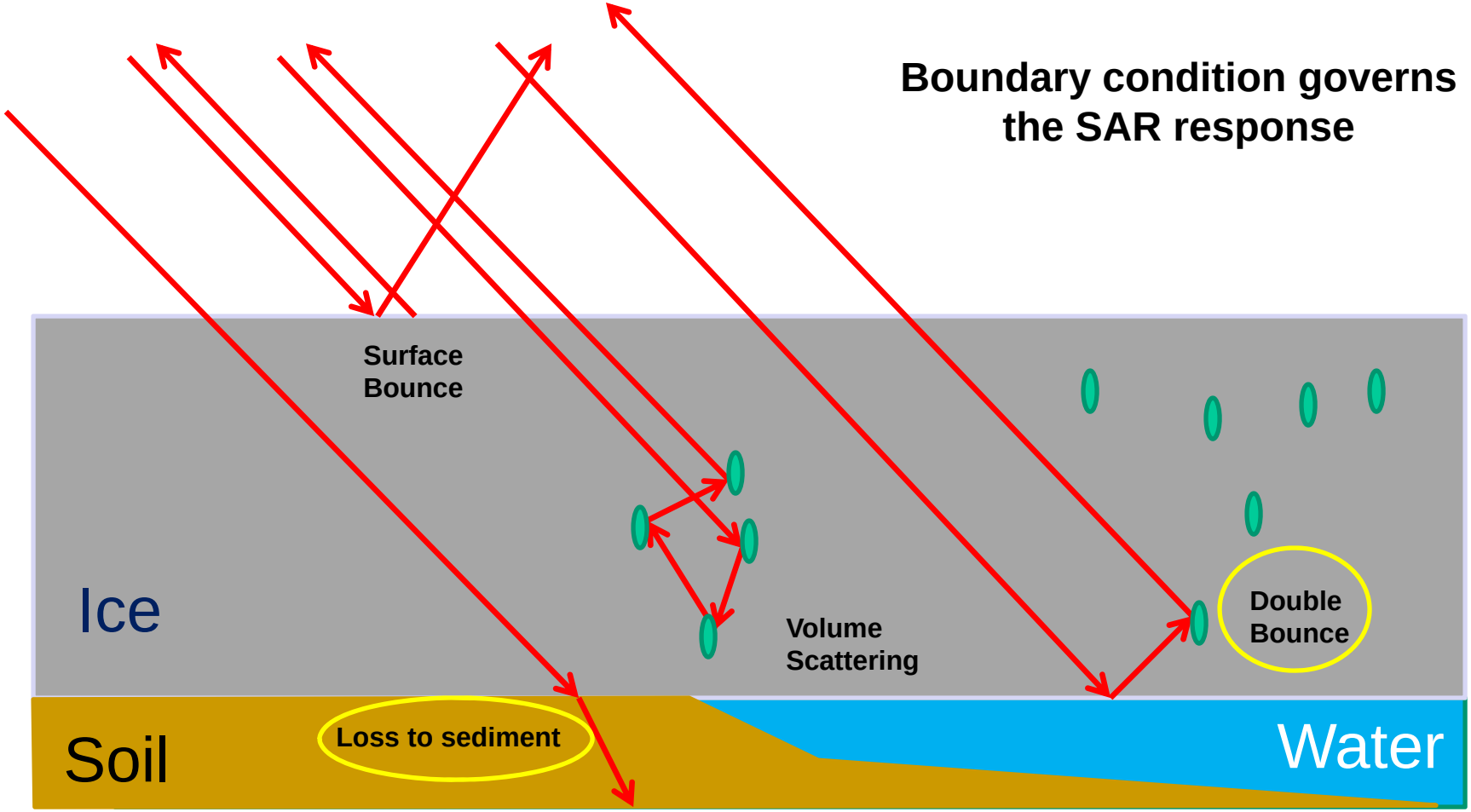
July 4, 2009

Temporal Evolution

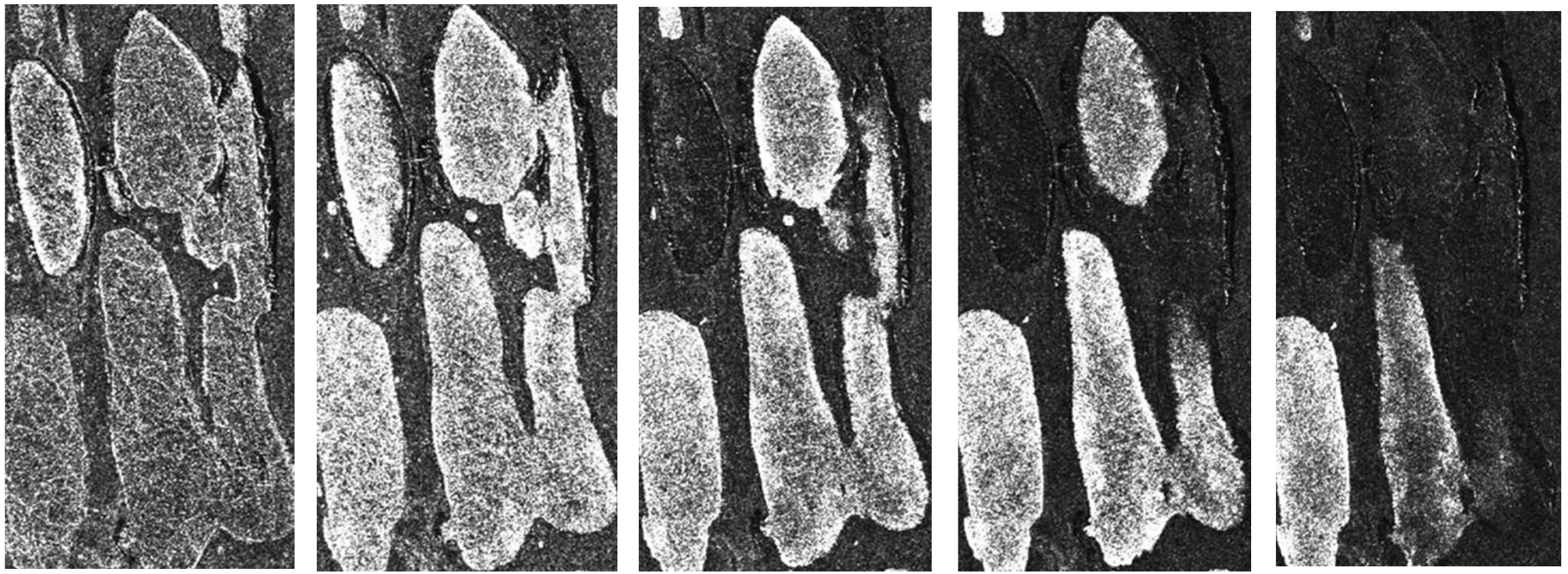


August 8, 2009

Microwave Interactions



Detecting Grounded Ice



December January February March April

0.5m >>>>>>>>>>>> Increasing Ice Thickness >>>>>>>> 2.0 m

Theoretical Background

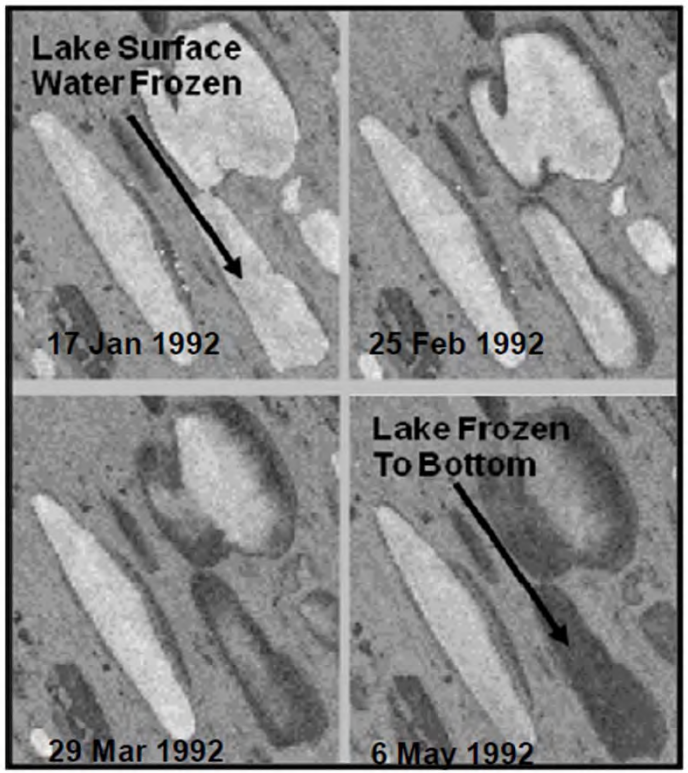
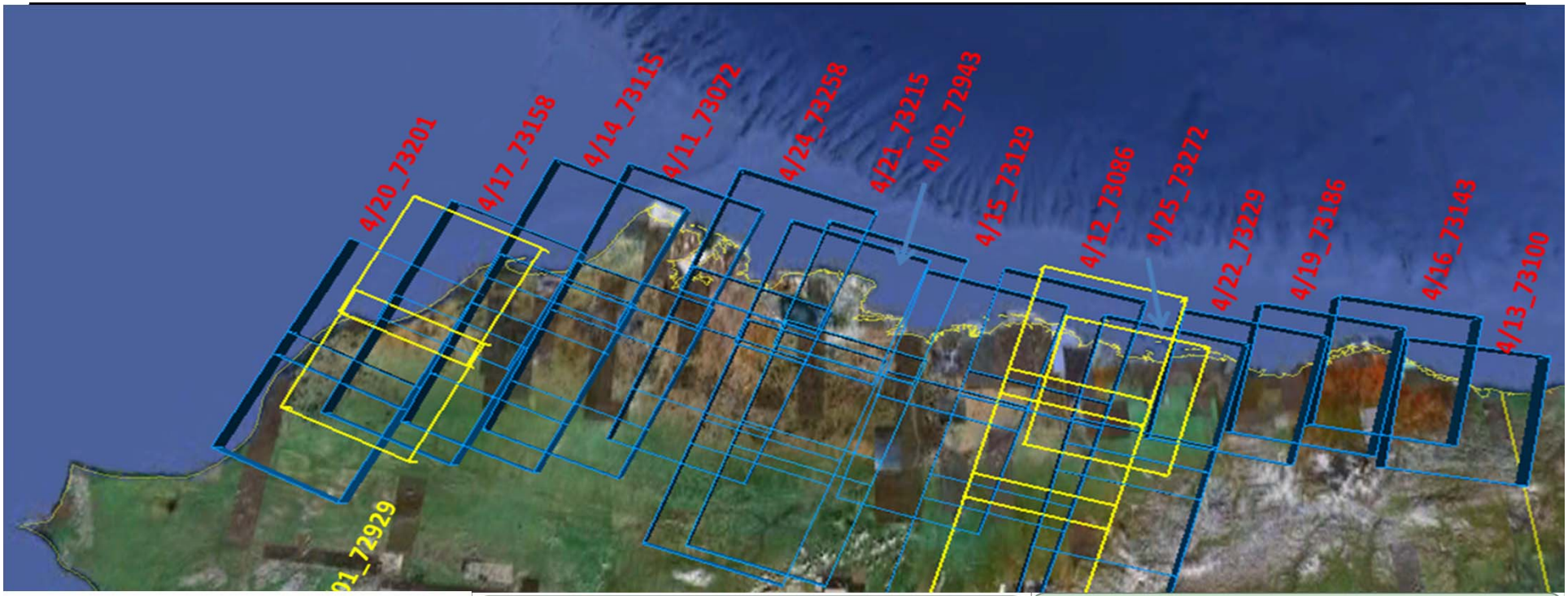


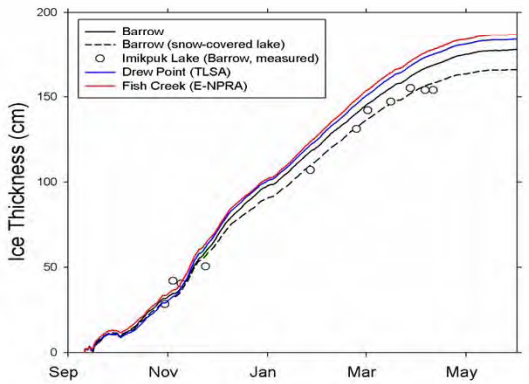
Figure 1: Lake Freeze-Up Over Time in SAR Imagery (Courtesy of Martin Jeffries).

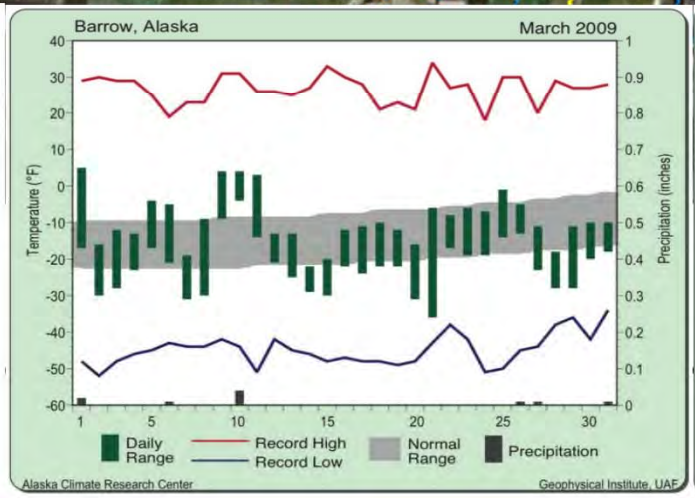
Sellman, P.V., W.F. Weeks and W.J. Campbell, 1975. Use of Side Looking Airbonrne Radar to Determine Depth on the Alaska North Slope. US Army Cold Reg. Res and Eng. Lab. Rept. 230.

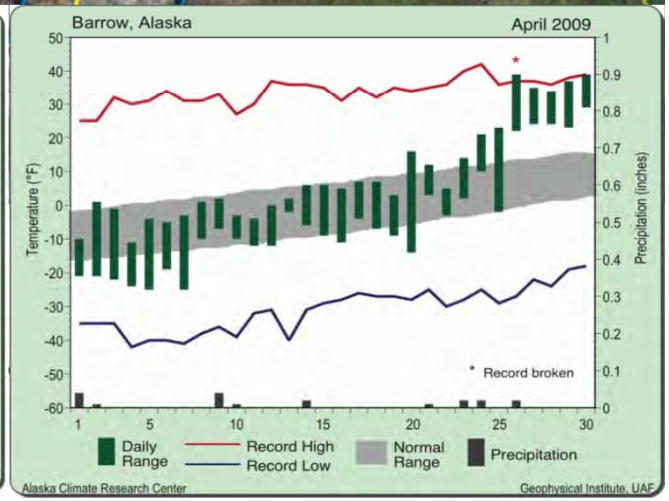
Mellor, J.C., 1982. Remote Sensing Inventory of Alaskan Lakes. American Fisheries Society.

ERS-2 Coverage for April 2009





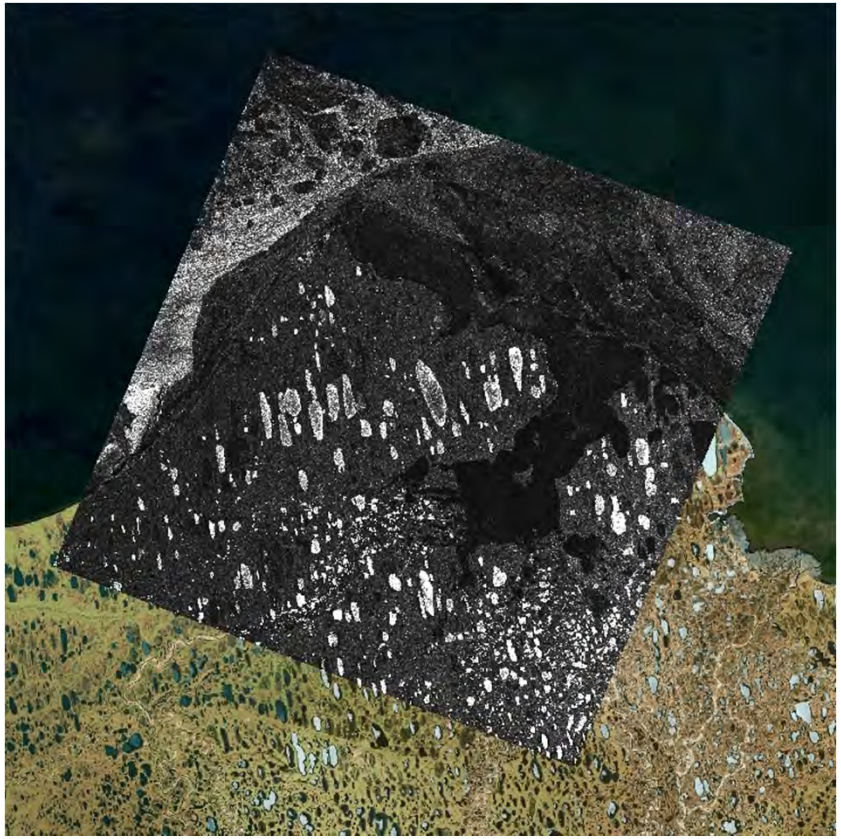




Lake Assessment Procedure

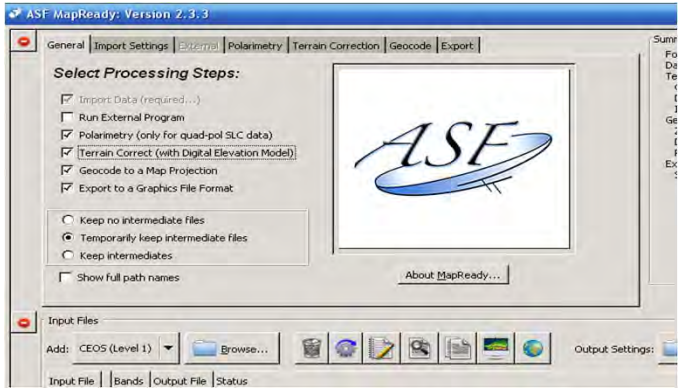
- Convert SAR data to terrain-corrected GeoTIFFs
- Manually georeference data to High-Res optical data
- Mask SAR data using National Hydrogrology Dataset (NHD)
- Apply Threshold to discriminate liquid water
- Polygonize raster data to create a Liquid Water shapefile

Creating GeoTIFFs



MapReady is a free, open-source tool for converting SAR data to GIS-ready GeoTIFFs

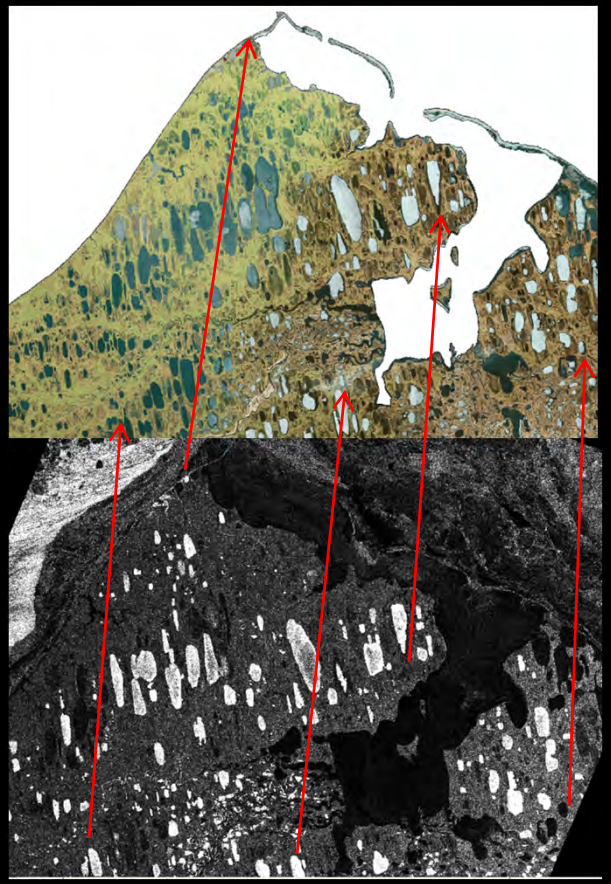
- Terrain-correction using NED DEM (2 arcsecond posting)
- Albers Equal Area projection
- 12.5m pixel resolution



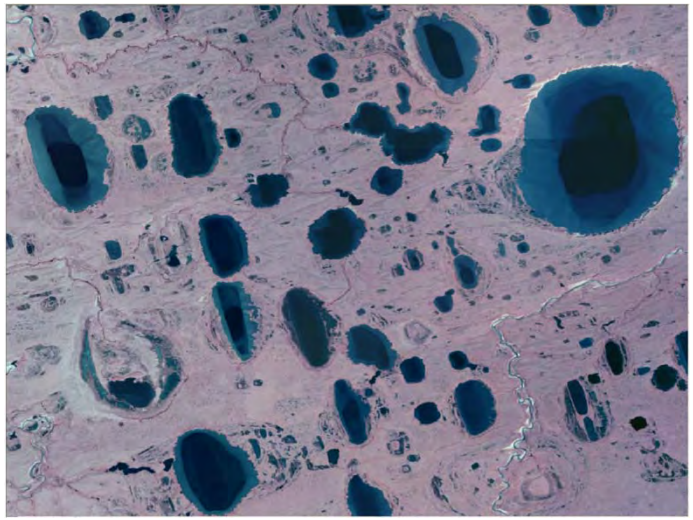
Swath	Frame	Date	Points	RMS (m)	
73315	277	4/28/2009	5	38.21	m
73315	275	4/29/2009	4	29.1	m
73315	273	4/30/2009	0	0	
73272	277	4/25/2009	4	2.66	
73272	276	4/26/2009	5	16.73	
73272	274	4/27/2009	5	16.62	
73258	274	4/24/2009	5	15.72	
73258	273	4/25/2009	6	10.84	
73258	271	4/26/2009	4	34.1	*
73229	274	4/22/2009	7	39.55	m
73215	276	4/21/2009	6	31.23	m
73215	274	4/22/2009	5	49.33	m
73215	272	4/23/2009	6	16.72	*
73201	275	4/20/2009	5	21.39	
73201	273	4/21/2009	5	22.61	
73186	274	4/19/2009	4	21.35	
73158	274	4/17/2009	8	38.6	
73158	272	4/17/2009	8	41.82	*
73143	274	4/16/2009	4	11.9	
73129	275	4/15/2009	7	35.14	
73129	273	4/15/2009		19.62	
73115	274	4/14/2009		26.09	
73115	273	4/15/2009	5	18.1	
73115	271	4/16/2009	4	31.42	*
73100	275	4/13/2009	4	19.89	
73086	277	4/12/2009	6	21.56	
73086	275	4/12/2009	6	18.95	
73086	273	4/12/2009	5	6.59	
73072	274	4/11/2009	5	12.14	
73072	273	4/11/2009	4	10.85	
73072	271	4/11/2009	5	12.27	
72943	276	4/2/2009	14	42.5	m
72943	274	4/2/2009	11	37.37	m
72943	272	4/2/2009	10	16.33	
72929	274	4/1/2009	11	23.61	
72929	272	4/1/2009	12	34.78	*

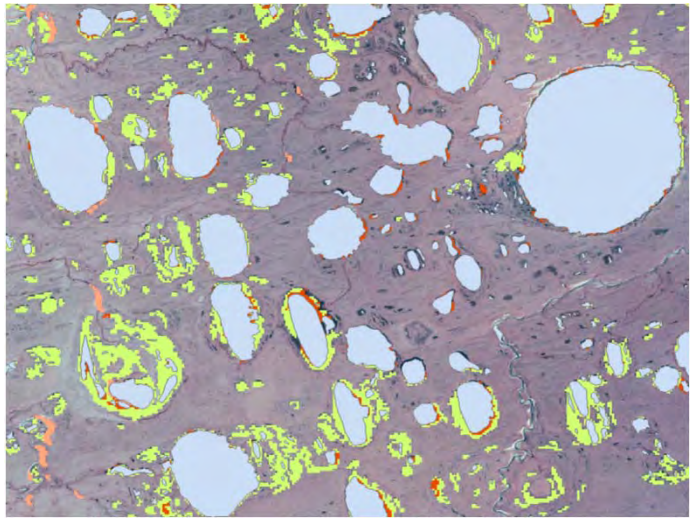
Register Ortho referenced SAR

Average RMS = 23.5 m



Lake Masking

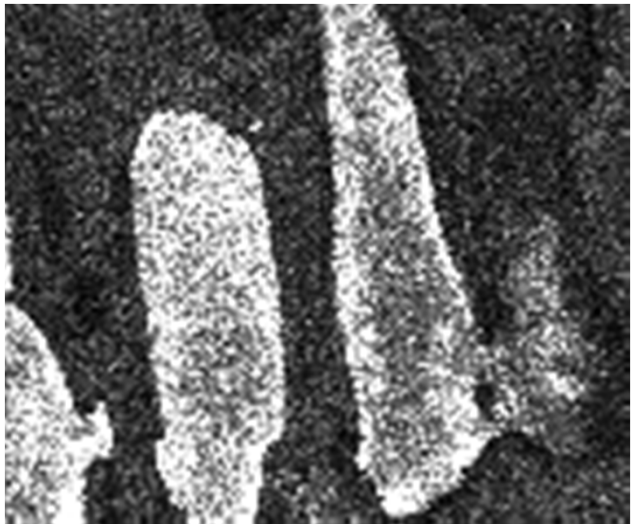


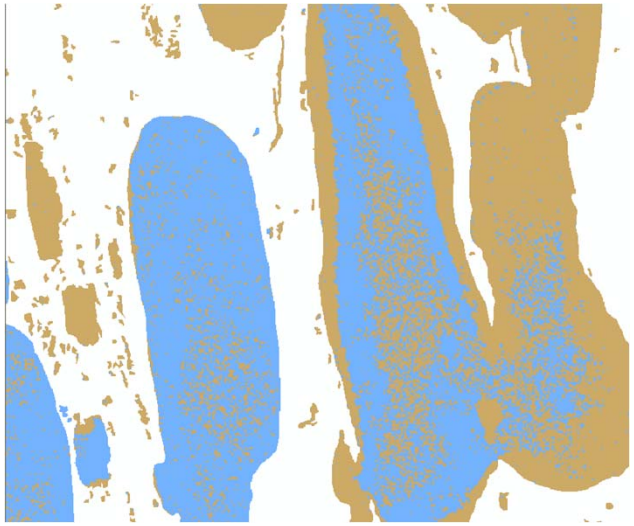


Use National Hydrology Dataset(NHD) for identifying water bodies

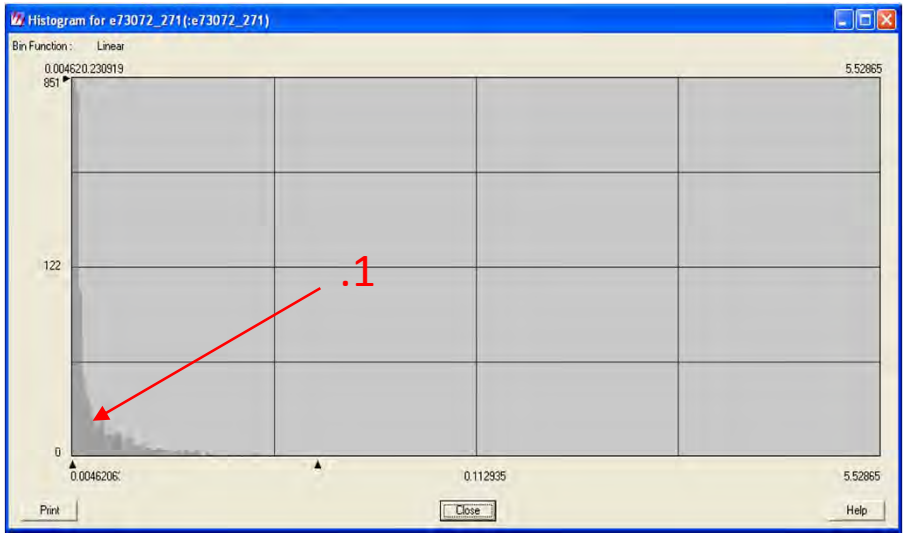
- Based on USGS maps
- Verified with Landsat imagery
- 30m resolution
- 160,000 water bodies on North Slope
- Does not include some ephemeral water bodies seen in NLCD 2001

Image Thresholding

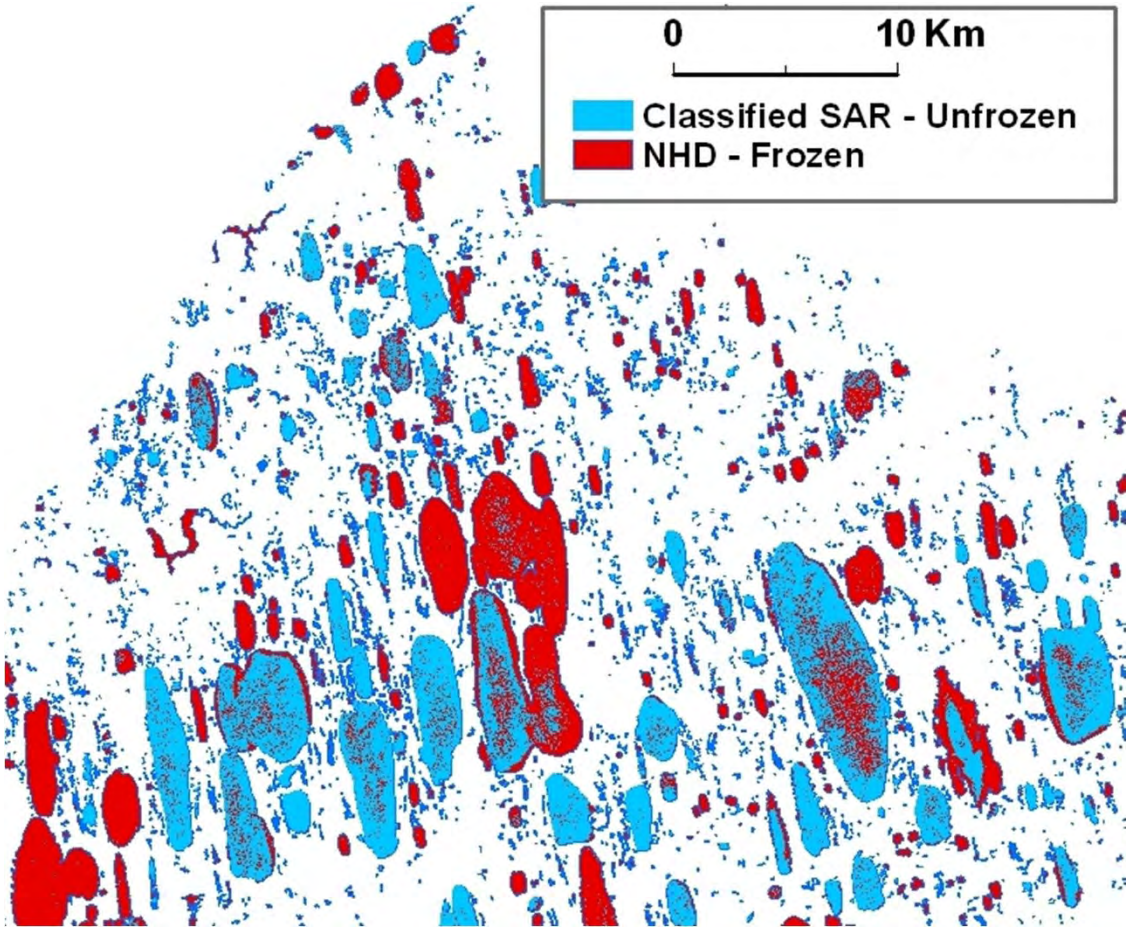




Establish a threshold value (P=0.1) that accurately delineates unfrozen water



Lakes Analysis

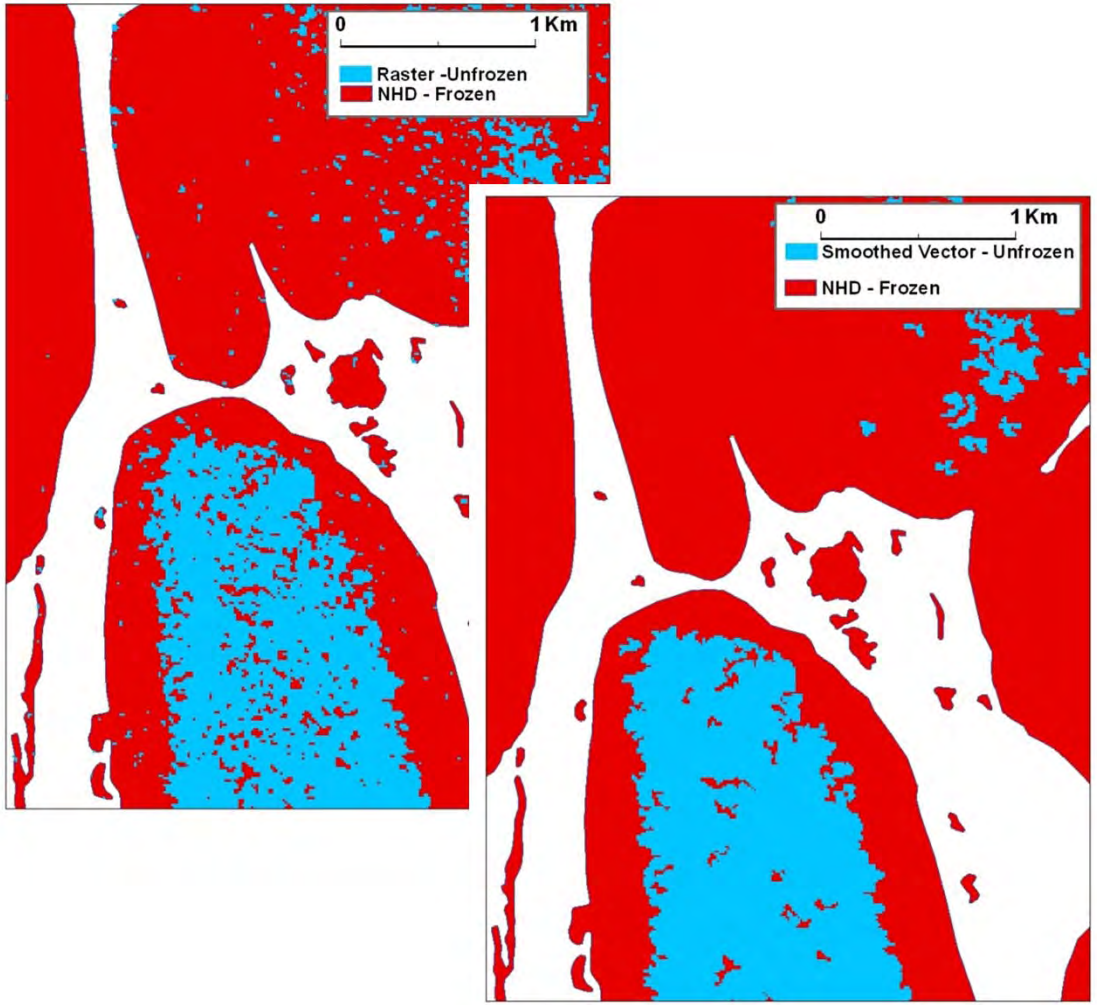


1) Georeference SAR to optical data

2) Mask land

3) Use intensity threshold to classify non-grounded ice

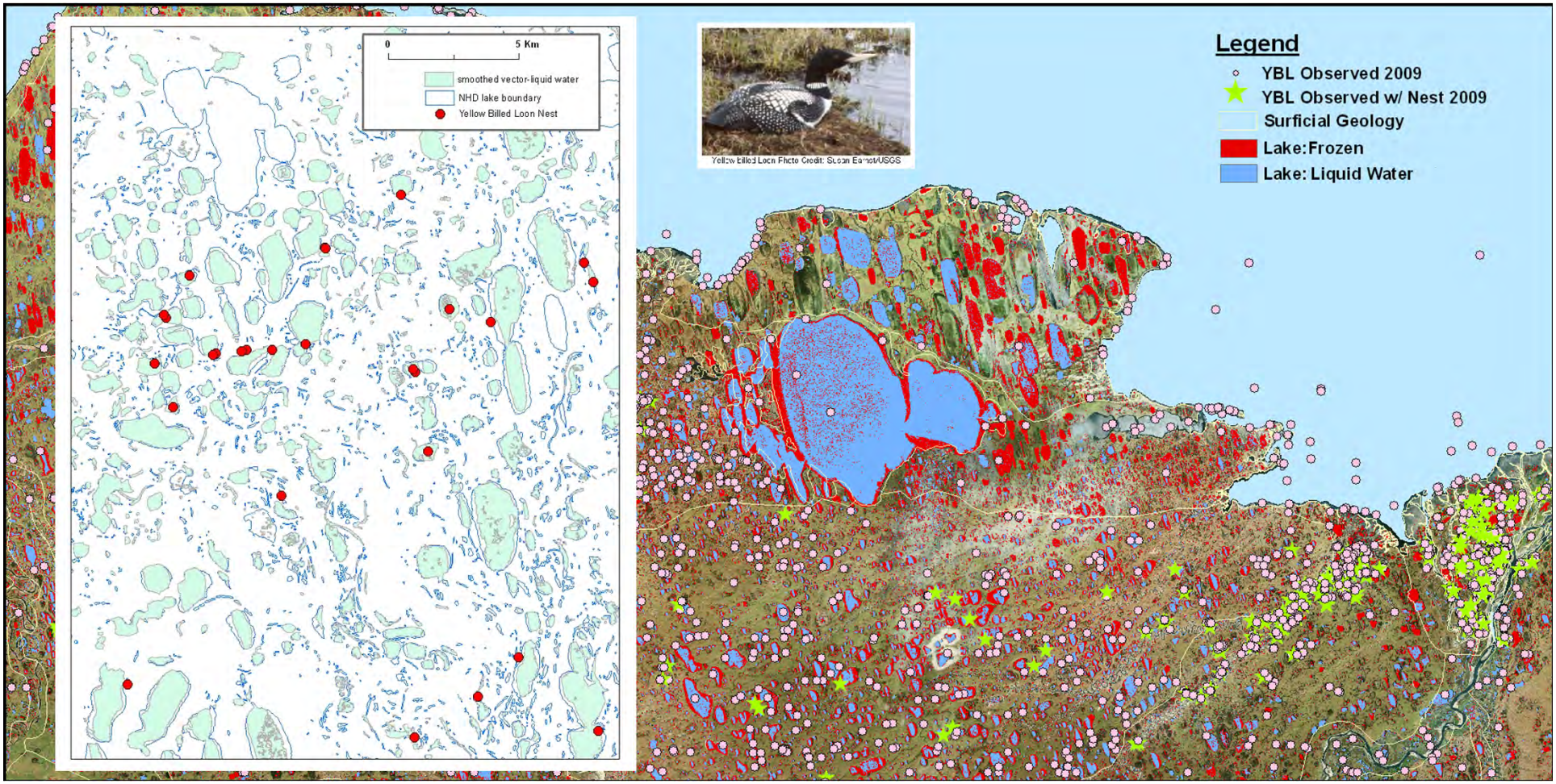
Lakes Analysis



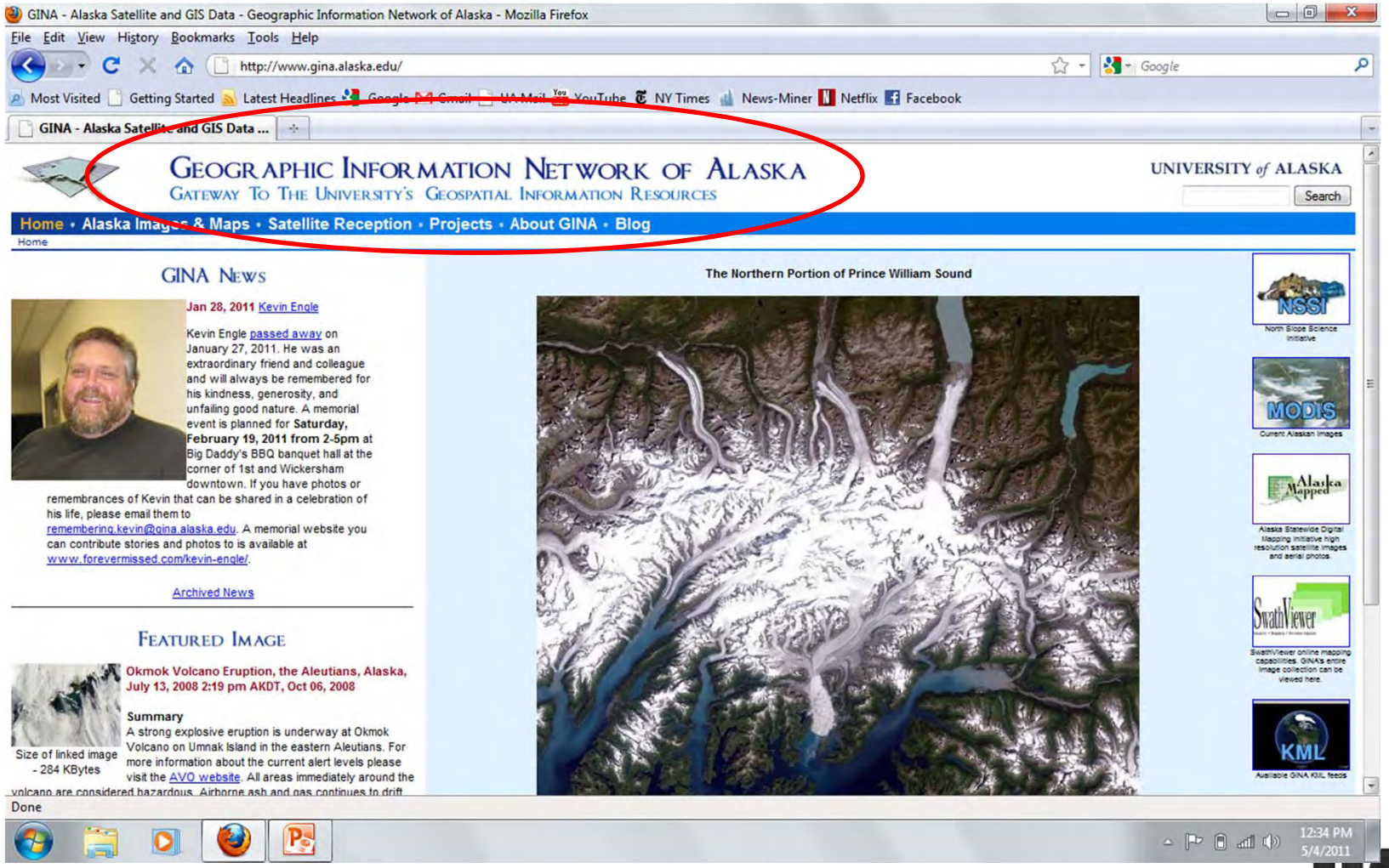
Final Steps:

- Convert raster to vector
- Dilations and erosion to eliminate all features smaller than 2500 m^2

Biological Relevance



Data Distribution



Concluding Remarks

• North Slope dataset offers important information for biologists and those developing petroleum resources

• Reliability of approach, coupled with archive going back to 1991, suggest viability of multi-decadal study of North Slope changes

• With knowledge of maximum ice thickness (~2m), bounds can be placed on the volume of North Slope surficial water

• Current availability of fully-polarimetric C-band SAR (RADARSAT-2) will permit more detailed analysis of lake ice scattering behavior

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