

# Methodology and Data Collected for Great Lakes Winter Experiment (GLAWEX) '17

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Yinghui Liu<sup>2</sup>, Arron Letterly<sup>2</sup>, Matthew Welshans<sup>6</sup>, and Grant Gunn<sup>3</sup>

1 - NOAA/NESDIS/STAR/SOCD

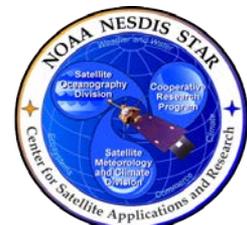
2 - NOAA/NESDIS/STAR/CIMSS & UW

3 – Michigan State University

4 – NASA Jet Propulsion Lab., CalTech

5 – NOAA/OAR/GLERL

6 – US National Ice Center





# GLAWEX Participants

## Wisconsin (Green Bay):

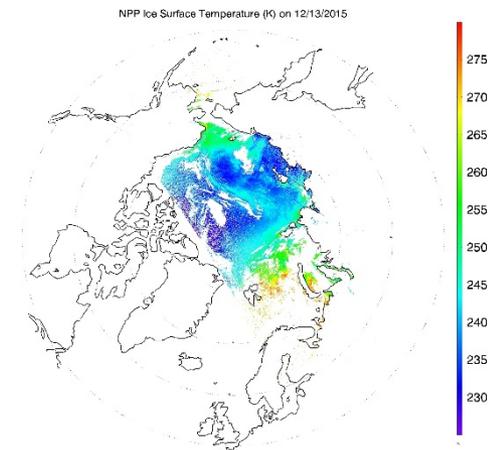
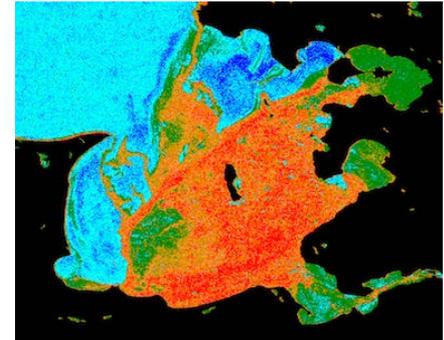
- Cooperative Institute for Meteorological Satellite Studies (CIMSS), University of Wisconsin (Yinghui Liu, Aaron Letterly)
- NOAA/NESDIS/STAR (Jeff Key)
- National Ice Center (Sean Helfrich, NESDIS/STAR; Matt Welshans)
- Great Lakes Environmental Research Lab (GLERL; George Leshkevich)
- NASA Jet Propulsion Lab (JPL; Son Nghiem for field work, Lisa Nguyen for SAR processing)
- U.S. Coast Guard (Icebreaker Mobile Bay support)
- University of Washington, Applied Physics Lab (Ignatius Rigor)

## Upper Michigan:

- Michigan State University (Dorothy Hall, NASA/GSFC retired; Grant Gunn)

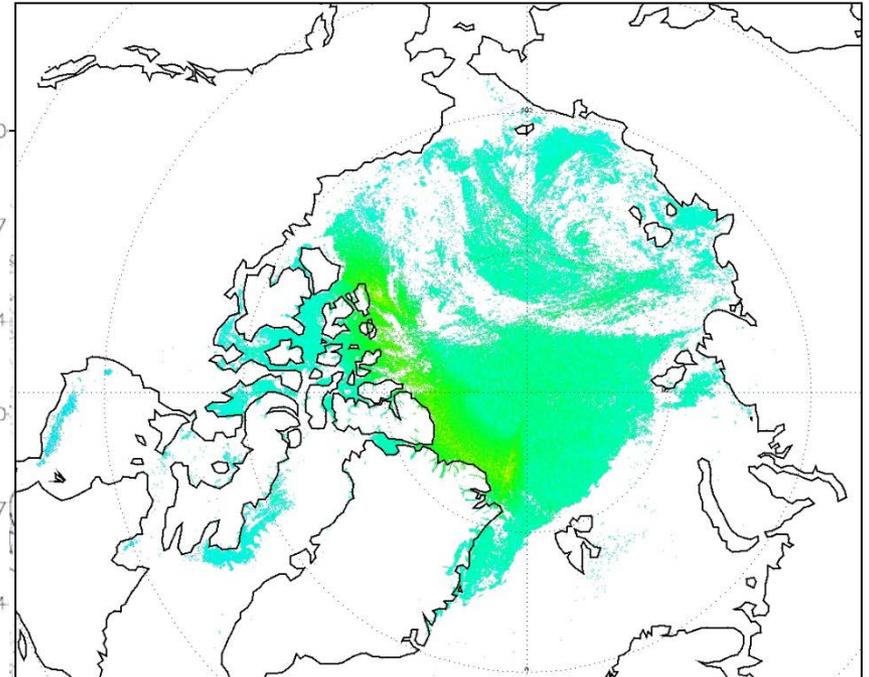
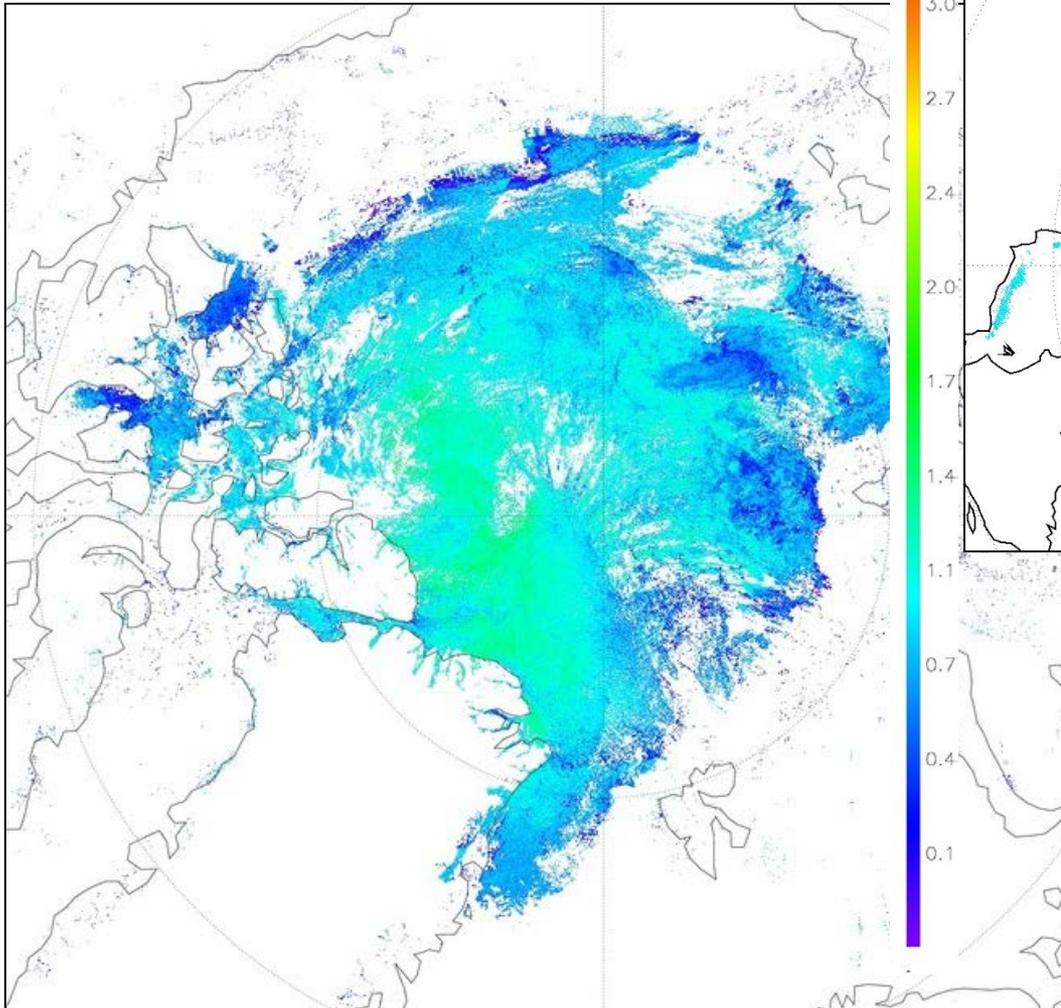
# GLAWEX 2017 Objectives

- JPSS (S-NPP) product validation, particularly for ice thickness (IT) and ice surface temperature (IST);
- GOES-16 ABI Baseline and Future Product validation during the GOES-16 Post Launch Test (PLT), particularly IT and IST;
- Improve ice type and thickness classification (both bare ice and snow-covered ice) which is critical for shipping and thus the overall economy of the Great Lakes region
- Measure snow water equivalent in a range of forest densities and snow depths using satellite and airborne instruments in different parts of the electromagnetic spectrum;
- Develop an improved understanding of MW interactions with snow cover on land vs lake ice for backscatter modeling



# VIIRS Ice Thickness Product

Oct 8, 2016



July 11, 2016

*Courtesy of Wang, Key and Lui*

# VIIRS Ice Thickness Intercomparison

Statistical results of the comparison in sea ice thickness between S-NPP and NASA IceBridge (aircraft lidar + snow radar) for matched locations (S-NPP pixels).

Case no	Date	S-NPP		IceBridge		S-NPP minus IceBridge		percent (%)	matched pixels
		mean	STD	mean	STD	mean	STD		
1	2014.03.12	1.18	0.52	1.45	0.69	-0.27	0.55	-5.34	495
2	2014.03.13	2.48	0.55	2.24	0.52	0.24	0.55	16.49	438
3	2014.03.24	1.88	0.78	2.33	0.48	-0.45	0.78	-6.31	803
4	2014.03.31	2.28	0.21	2.56	0.35	-0.28	0.43	-8.97	37
5	2015.03.24	2.06	0.59	2.45	0.43	-0.39	0.75	-11.63	1050
6	2015.03.29	1.72	0.43	1.88	0.54	-0.16	0.74	-1.69	5153
Average		1.93	0.50	2.15	0.50	-0.22	0.63	-2.91	7976 (total)

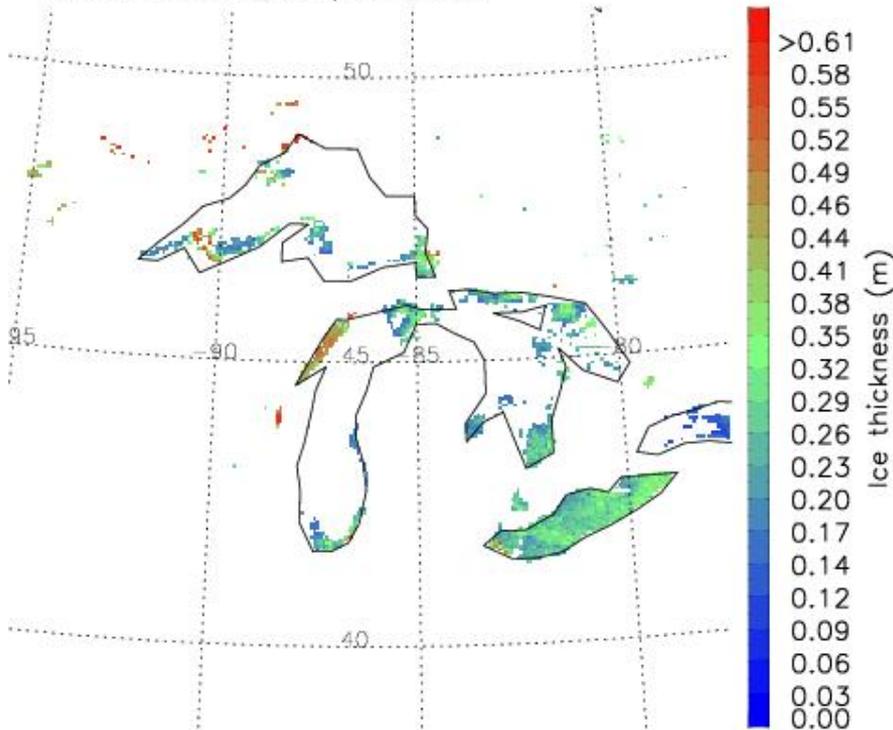
From 24 cases of S-NPP granule data when IceBridge has measurements, 6 cases out of the total 24 cases from S-NPP have good overlapped locations with IceBridge where they both have ice thickness values for comparison.

# Geostationary Ice Thickness / Age

Courtesy of Key et al.

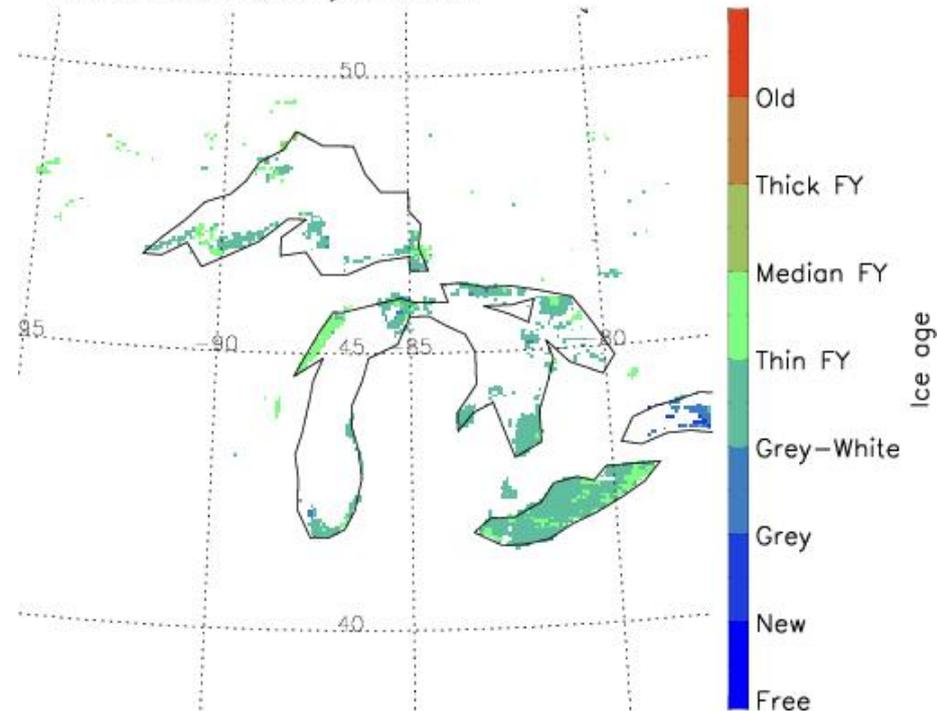
## Ice Thickness

MODIS Data, February 24 2008



## Ice Age

MODIS Data, February 24 2008



**Description:** same algorithm as JPSS, uses MODIS as proxy

# Green Bay Measurement Assets

## NRL P3

- SnowSAR radar
- AESMIR (passive MW)
- Imaging IR (320 x 256 pixels = 346 x 276 m across x along track)
- IR thermometer (TBD)
- Cloud and Aerosol Radiometer (CAR) for BRDF



## Coast Guard Icebreaker Mobile Bay

- Will deploy two drifting buoys (from UWashington/APL)
- Instruments for ice thickness, type, characteristics, surface temperature, meteorological conditions
- Visual obs for validation of SAR and NIC's ice classification

## People wandering the snow/ice

- Instruments for ice thickness (*augers, rulers*), characteristics (*deformation*), Surface Temp (*IR temp, Thermocouple, probe*), Snow Depth, meteorological conditions (*wind, cloud cover, air temp*)
- Visual obs for validation of SAR and NIC's ice classification



# Other Observations

## Sentinel 1A/1B

- C-Band Dual Pol – VV, VH

## RadarSat 2

- C-Band Dual Pol – HH, HV

## TerraSAR X

- X-Band Dual Pol – VV, VH

## GOES 16 Preliminary Obs

- Imagery
- Ice Concentration
- Ice Thickness
- Ice Surface Temp

## MODIS

- Imagery from Terra and Aqua

## SNPP

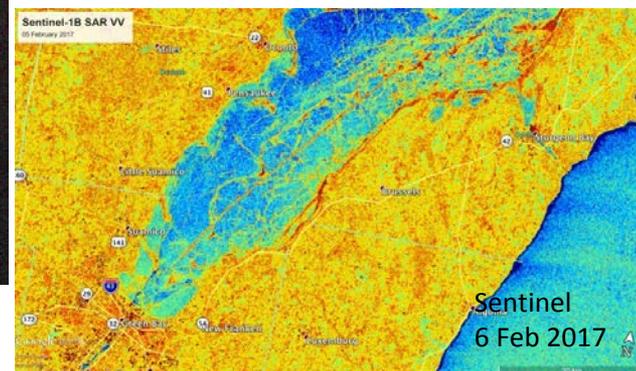
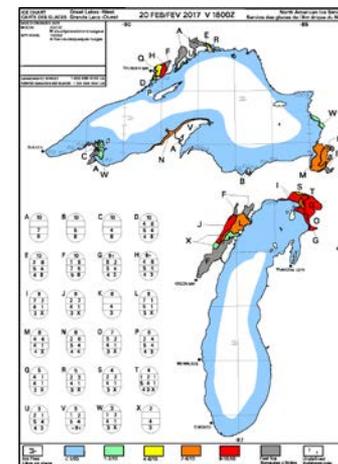
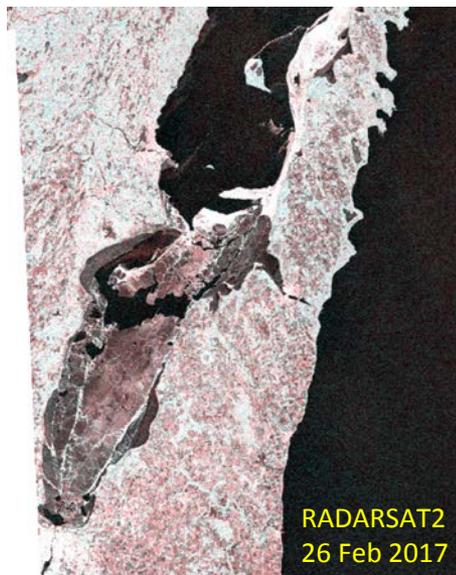
- Imagery
- Ice Concentration (VIIRS and ATMS)
- Ice Thickness
- Ice Surface Temp

## North American Ice Services Ice Charts

- Ice Concentration and Ice Type

## Other Imagery

- GCOM – (Imagery and AMSR 2)
- Metop A & B
- NOAA 15, 18, 19
- WorldView

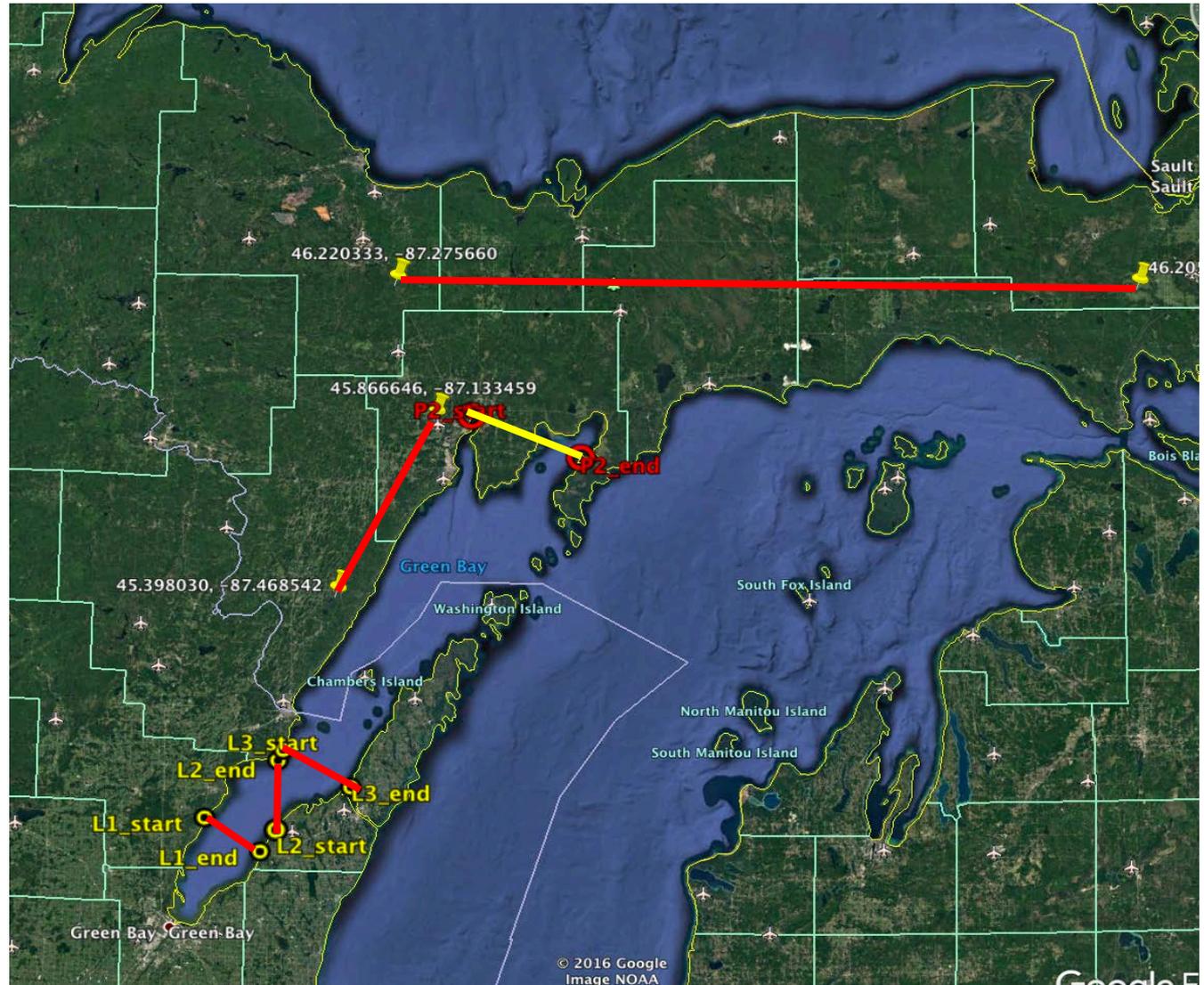


# Planned NRL P3 Sensor Ground Tracks

3 Flight lines in Green Bay south of Sturgeon Bay for measurements over ice

2 flights over land for in UP and west of Green Bay for measurements over snow

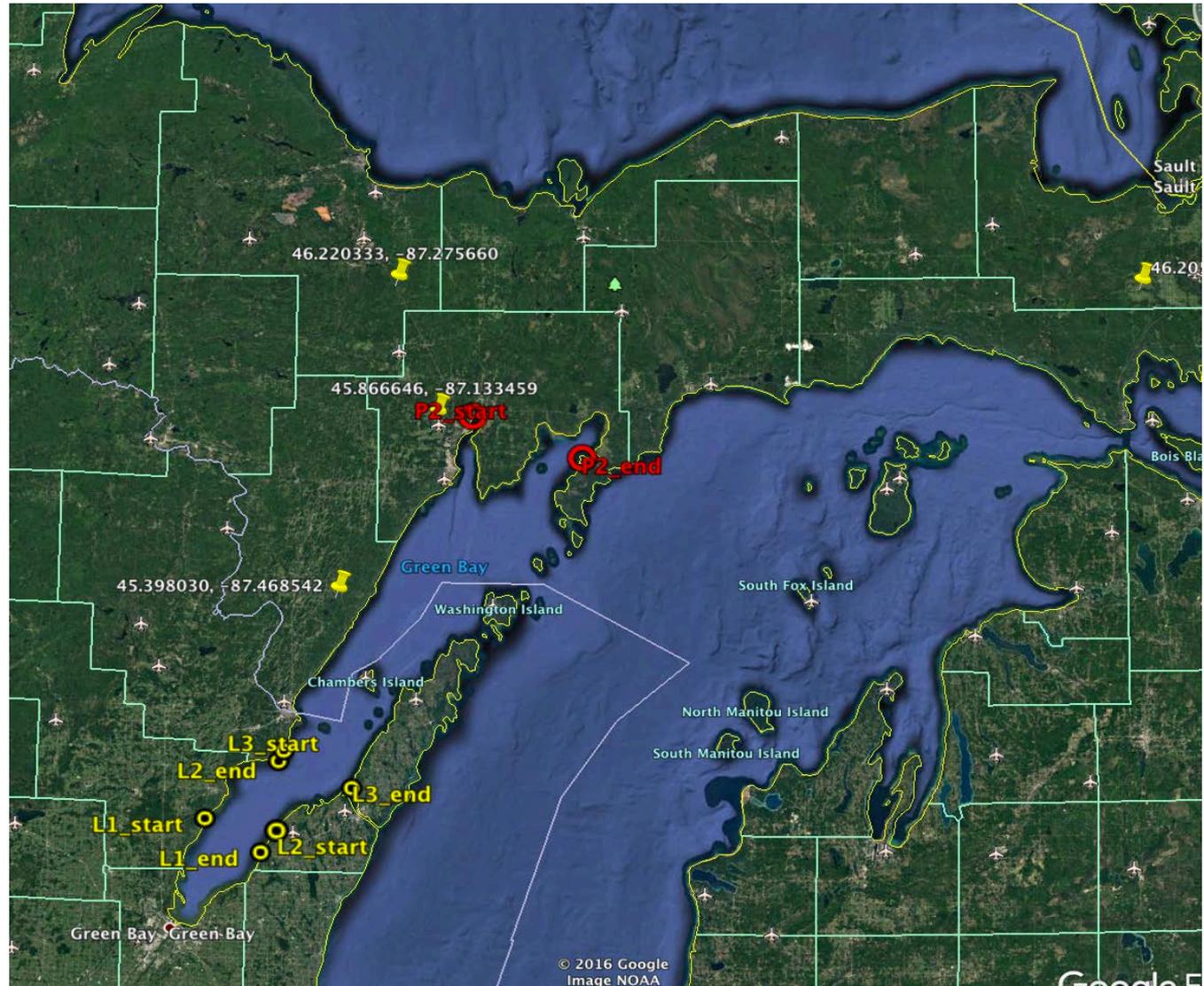
1 potential alternative flight over Bay de Noc



# Actual NRL P3 Sensor Ground Tracks

0 Flight lines

Cracked Wind Shield on the NRL P3 prevented flight during the field measurement on Feb 26-27, 2017

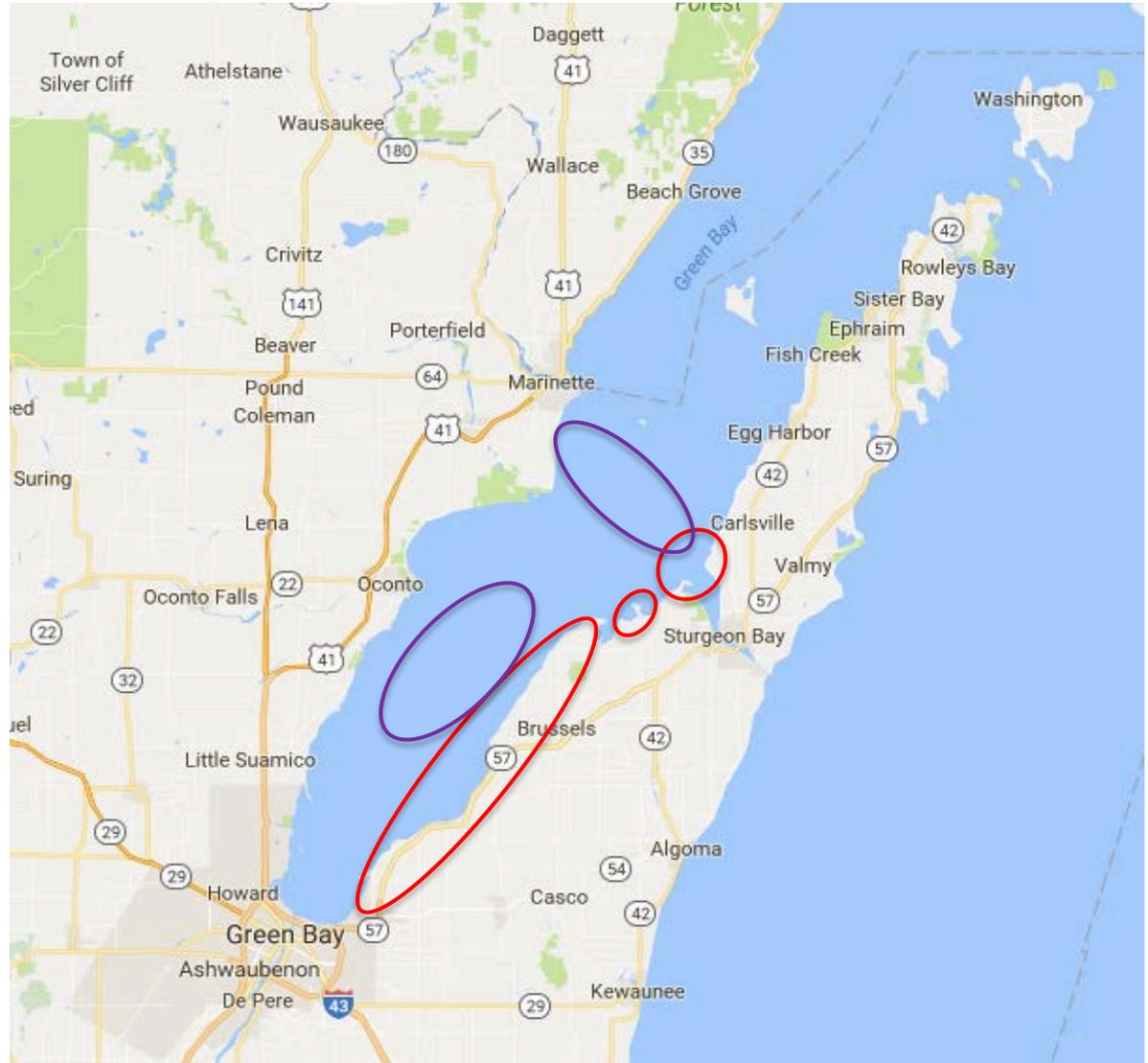


# Measurement Areas

In situ measurements were made in the areas shown on the map. The magenta oval represents the approximate area covered by the icebreaker.

Fractured ice cover would have prevented observations along the flight tracks anyway.

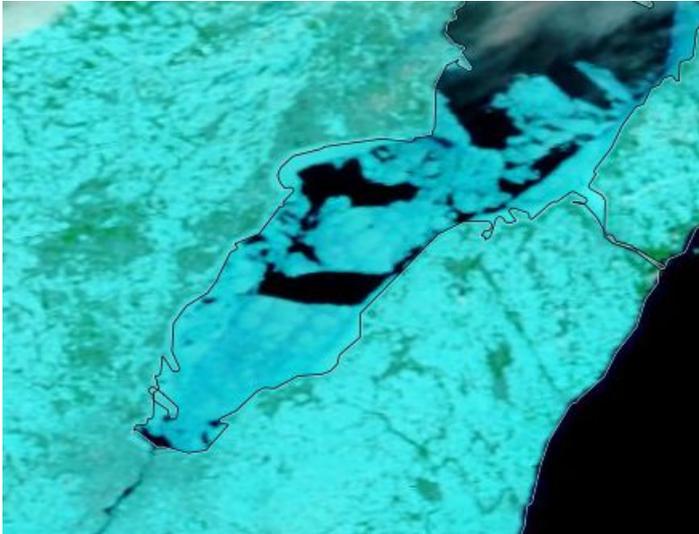
About 60 observations and different sites were sampled over 4 days.



# Field Measurements



# Field Measurement challenges



# Proposed SAR Ice Type ICECON Scale

ScanSAR Wide (HH)

20 deg. (19.5) to 49 deg. (49.5) Incident angle

<u>ICECON</u>	<u>Ice Type #</u>	<u>Description</u>	<u>Thickness</u>	<u>Color</u>	<u>Impacts to Vessels</u>
0 (or below noise floor)	25	Calm Water	0"	Blue	No Ice present or imminent
1	05	New Lake Ice	<2"	Cyan	Minimum ice concentrations and thickness, Does not present hindrance to commercial navigation.
2	27	Pancake Ice	2" - 6"	Orange	Light Ice conditions present. Still open water areas. May be some hindrance to less ice-capable ships.
3	12	<i>Consolidated Flows</i>	6" - >12" up to 28"	<i>Yellow</i>	Light-to-moderate ice conditions present. Less ice-capable ships may need icebreaker assistance for transit and/or be at risk for damage.
4	10	<i>Lake Ice w/patchy crusted snow</i>		<i>Magenta</i>	
4	21	<i>Snow/<u>SnowIce/LakeIce</u></i>		<i>Green</i>	
5	14	Brash	>28" up to 9-11m	Red	Heavy-to-extreme ice conditions. All transits require icebreaker escort. Approaching or exceeds capabilities of light icebreaker assets. Increased risk of damage to vessels.
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# USCG Supported Ship Track and Observations

GLAWEX 2017 - Green Bay  
RADARSAT-2 SAR on 2/26 - Ship tracks on 2/27/2017



Green Bay – February 27, 2017

10 km

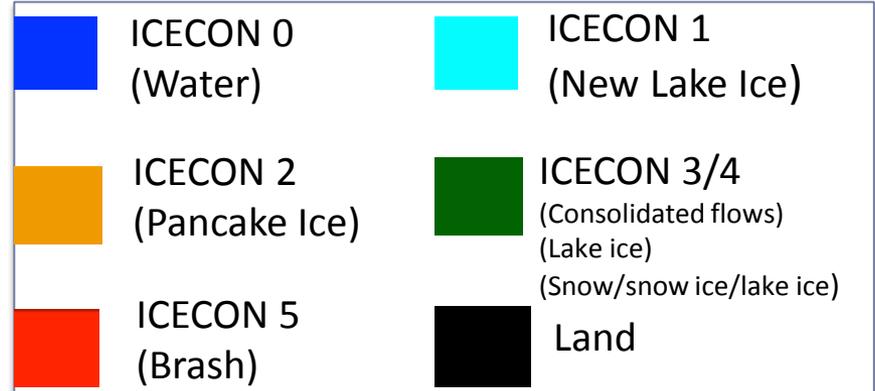
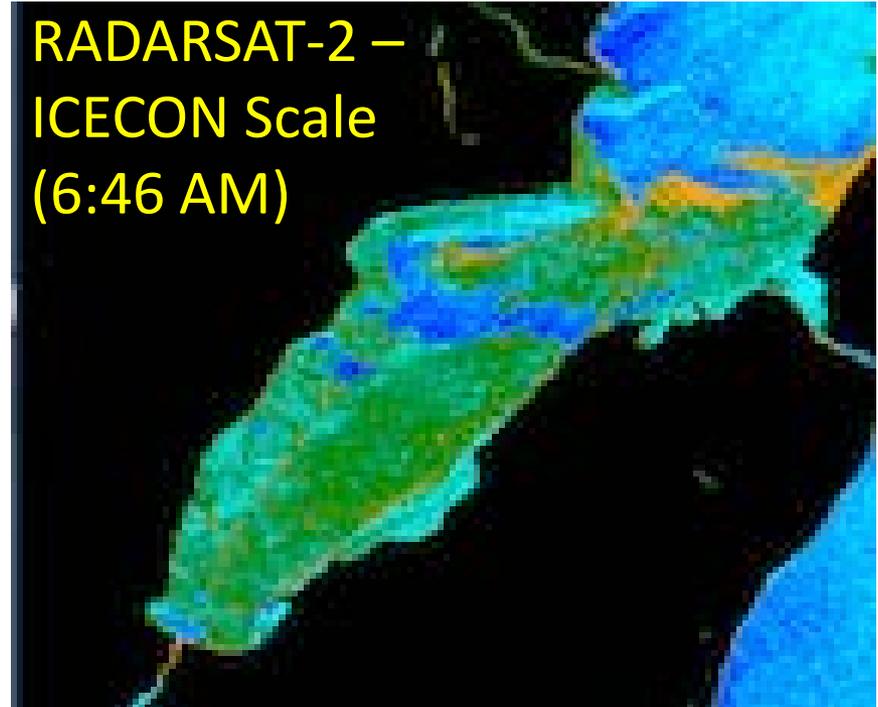
# SAR Based ICECON Classification

MODIS (2:18 PM)



Green Bay – February 26, 2017

**RADARSAT-2 –  
ICECON Scale  
(6:46 AM)**



# Snow Measurements in Curtis, MI

**Snowfield measurements were conducted near Curtis, Michigan, Upper Peninsula, to complement the SnowEx Colorado measurements**



Photo credit: Dorothy Hall / MSU

# Ice Measurements in Manistique Lake, MI

Measurements included lake surface temperature, snow depth, density and stratigraphy, and ice thickness/stratigraphy to identify small-scale ice roughness features that contribute to microwave backscatter



# Thank you for your attention

GLAWEX 2017 Website: <http://nex.nasa.gov/nex/projects/1405/>  
Methods, data descriptions, and datasets were uploaded, reviewed,  
and approved for public release on NASA NEX

