

A New Ice-Surface Temperature Dataset of the Great Lakes from MODIS

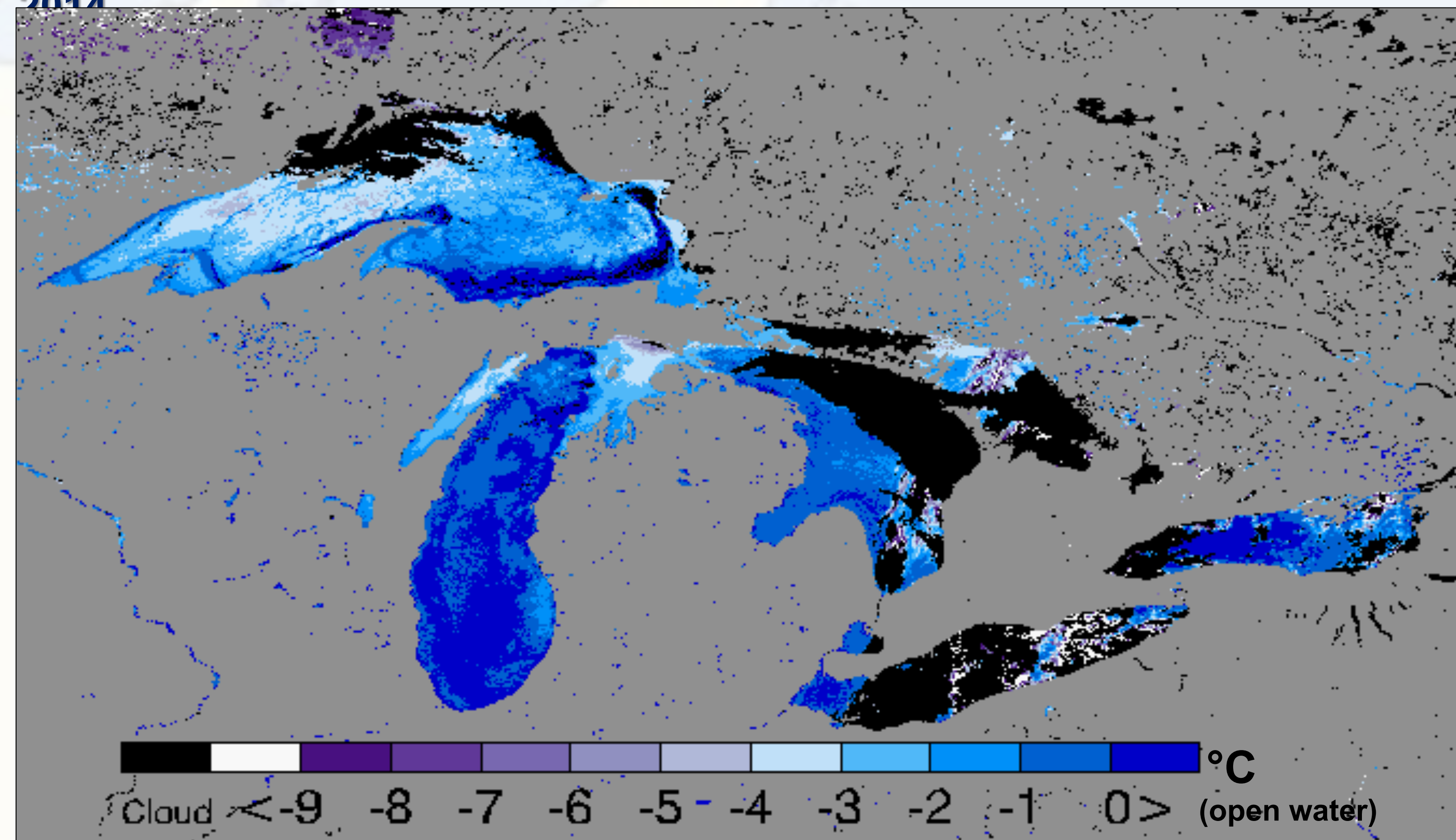
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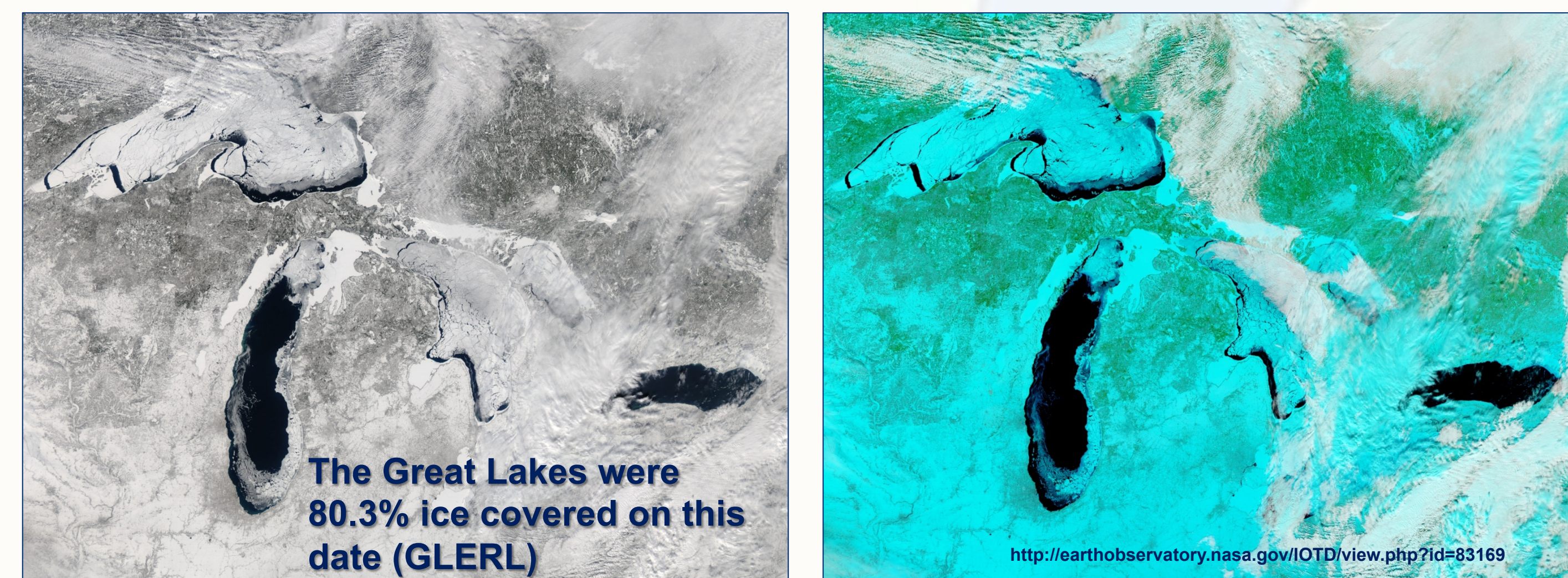
Introduction

We are developing an ice-surface temperature (IST) product of the Great Lakes using Moderate-Resolution Imaging Spectroradiometer (MODIS) Terra and Aqua data based on the standard MODIS IST algorithm. This standard algorithm has been used to map the surface temperature of sea ice and the Greenland ice sheet (Hall et al., 2012). We compare IST maps with classified maps from the Great Lakes Environmental Research Laboratory (GLERL) developed using synthetic aperture radar (SAR) data from RADARSAT-2 (Leshkevich and Nghiem, 2007 & 2013; Nghiem and Leshkevich, 2007), with the objective of improving the mapping of ice type on the Great Lakes, to aid transportation.

Ice-surface temperature (IST) map derived from the Aqua MODIS for 19 February 2014



Aqua MODIS natural-color (left) and false-color (right) image of the Great Lakes – 19 February 2014

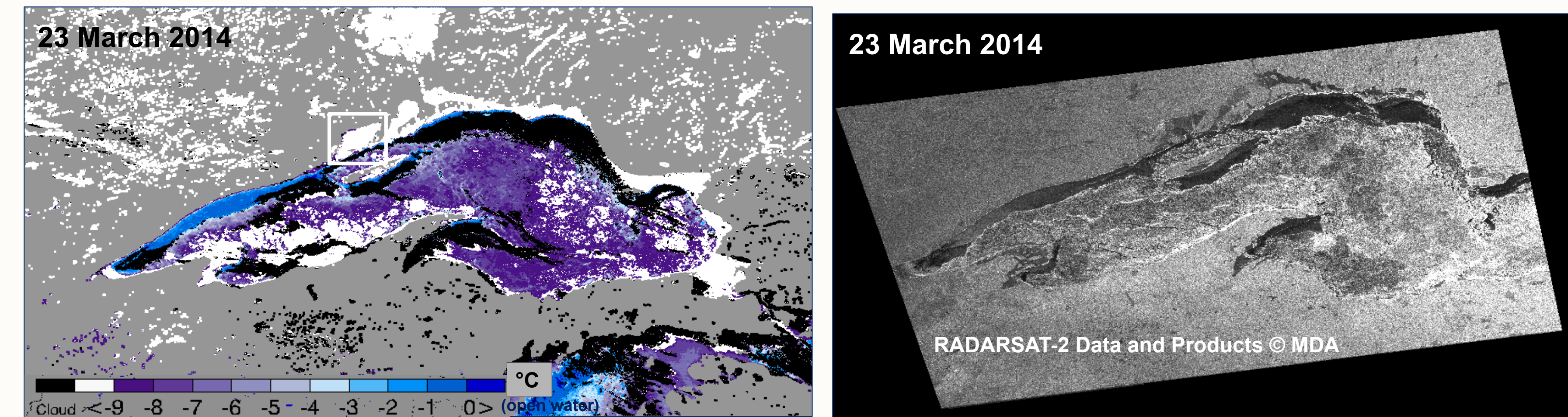


Some Highlights of the Great Lakes Ice Cover for 2014

- The second highest amount of ice cover on the Great Lakes since 1973 occurred on 6 March when 92.5% of the lake surfaces were ice covered*
- There were two maxima of ice cover on the Great Lakes – the first occurred on 12-13 February where 88.4% of the lakes were ice covered, and the second occurred on 6 March
- Lakes Superior, Michigan, Huron & Erie were 90% or more ice covered for the first time since 1994
- The ice season started early (end of November vs. mid-December) with a large amount of ice cover forming
- Lake Michigan reached 93.3% ice cover on 8 March, setting a new record
- Official ice out date – 6 June

*In 1979 the maximum ice coverage of the Great Lakes was 94.7%.

Aqua MODIS IST (left) and RADARSAT-2 (right) images of Lake Superior

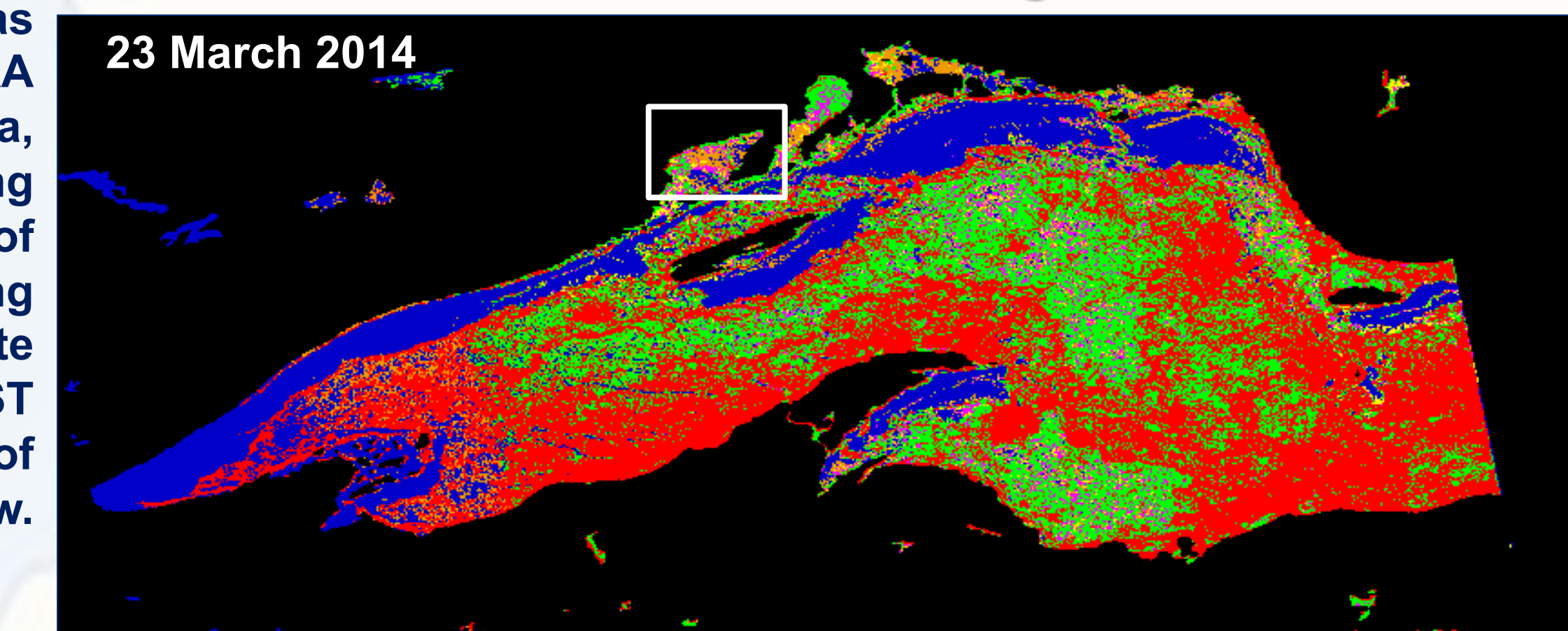


RADARSAT-2 has multiple polarization modes, including a fully polarimetric mode in which HH, HV, VV and VH polarized data are acquired. In ScanSAR Wide Beam HH mode, as seen at top right, the SAR images a nominal swath width of 500 km and has an imaging resolution of 100 m.

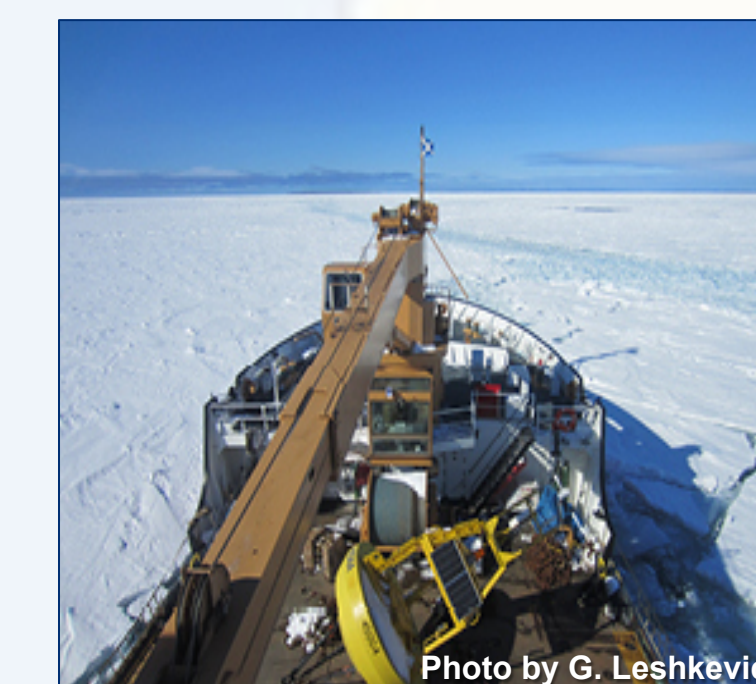
We use multi-polarization SAR data to improve ice-type discrimination and mapping over a wide range of wind speeds and directions, factors that cause ambiguity in ice/water discrimination using single polarization SAR data (Leshkevich & Nghiem, 2007 & 2013).

Classified RADARSAT-2 SAR image

Right – This RADARSAT-2 scene was calibrated and classified by NOAA National Environmental Satellite, Data, and Information Service (NESDIS) using the ice classification algorithm of Leshkevich and Nghiem (2013) during an operational demonstration. White box outlines Thunder Bay where the IST map (above left) shows temperatures of -9°C and lower, as discussed below.



Icebreaker on Great Lakes



- Open water or new ice
- Brash ice
- Pancake ice
- Stratified ice
- Lake ice with patchy, crusted snow
- Consolidated ice floes
- Land or unclassified

Results

We studied a MODIS-derived IST map of the Great Lakes, along with a classified SAR image for 23 March 2014. Results from the IST image of Lake Superior show variability in IST that is probably related to ice thickness, snow cover and water temperature (as well as air temperature). In Thunder Bay, and other protected bays in the northern part of Lake Superior, ISTs are generally colder than they are elsewhere on the lake (even within the same type of ice). Water temperature is known to be cold in those areas and that may contribute to the lower ISTs.

Open water and new ice are difficult to distinguish using the SAR alone, but using MODIS, we see a higher IST for open water, as compared to new lake ice. This has implications for shipping in the Great Lakes because an icebreaker can travel safely through areas of new (thin) ice but not through thicker ice such as brash ice.

According to this preliminary work, MODIS can distinguish thin ice from open water, but cannot map ice types using IST maps alone. However the RADARSAT-2 SAR can be used to map different ice types but has difficulty distinguishing open water from new ice. The main limitation of the MODIS IST product is cloud contamination.

References

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