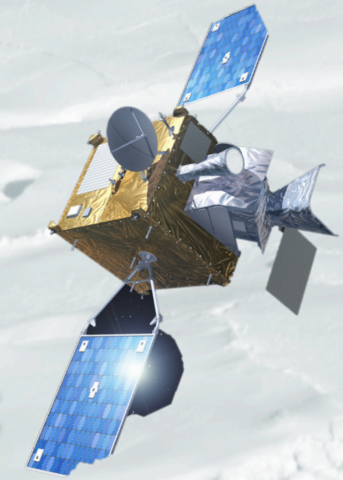
Winter-time Remotely-sensed Monitoring of Lake Ice- "North Hydrology" ESA-STSE Project



Homa Kheyrollah Pour
Claude Duguay

WATERLOO ENVIRONMENT

Laura Rontu
Kalle Eerola
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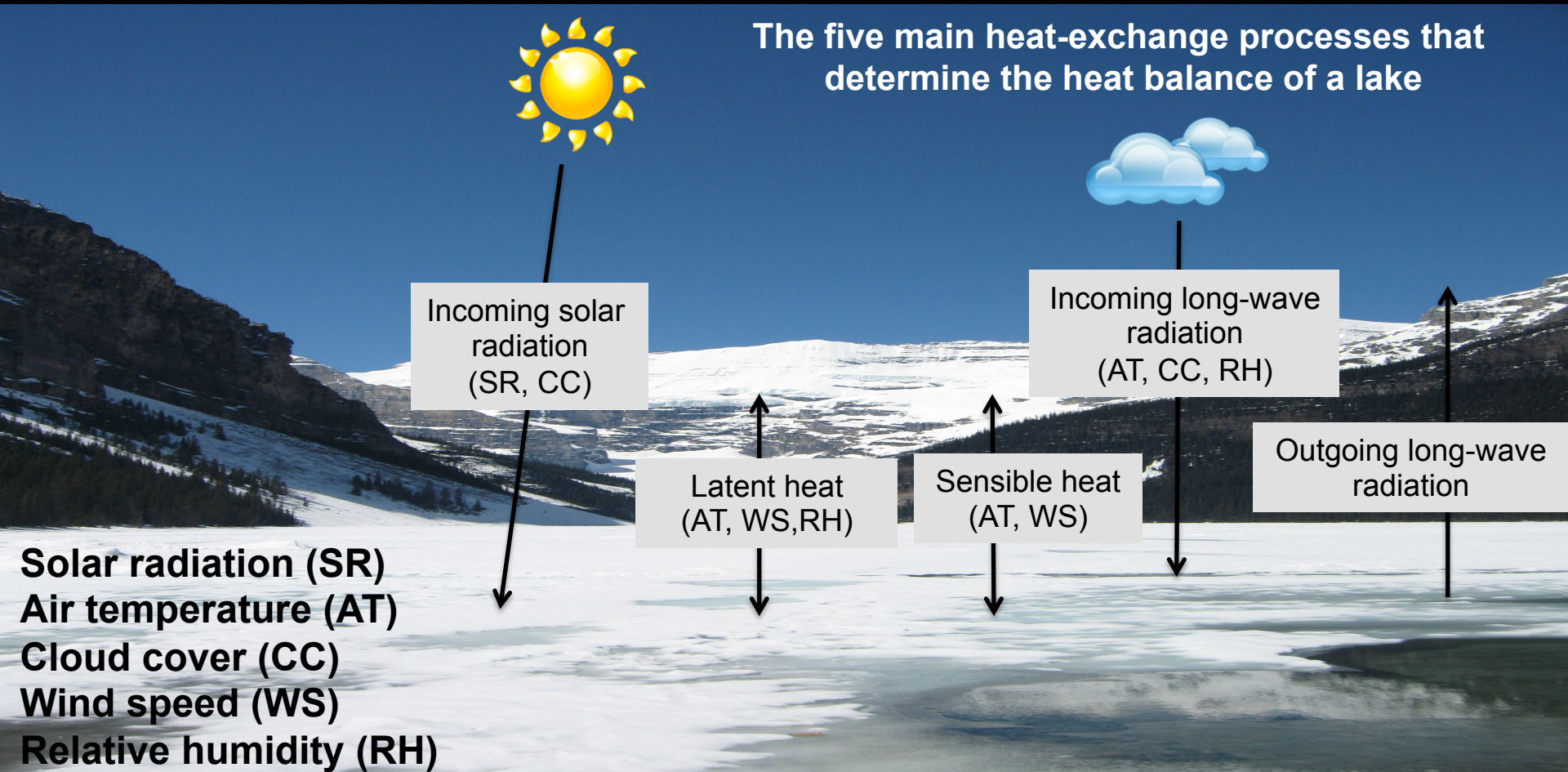
FINNISH METEOROLOGICAL INSTITUTE

cost esa STSE
EUROPEAN COOPERATION IN SCIENCE AND TECHNOLOGY
Support To Science Element

Role of lake ice in regional weather and climate

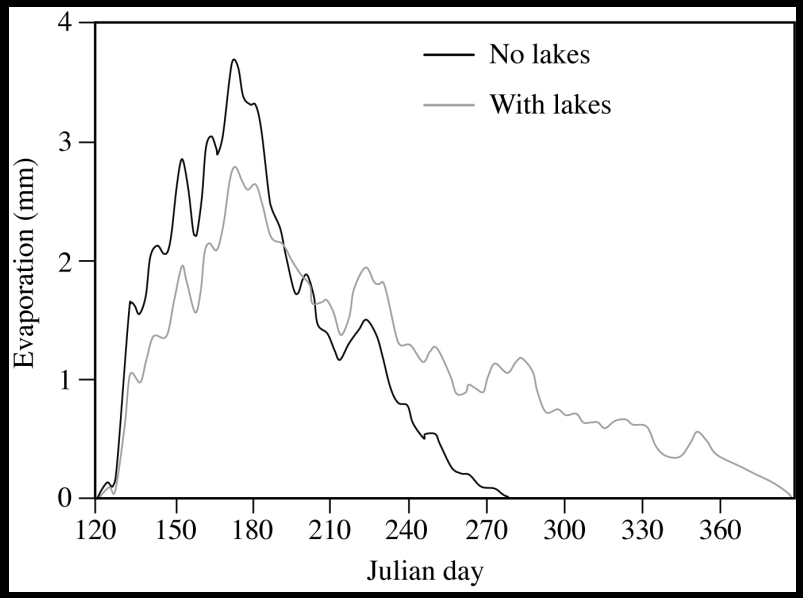
- Lake surface properties such as **water temperature** and **ice cover** are two important parameters when considering lake-atmosphere interactions.



Role of lake ice in regional weather and climate

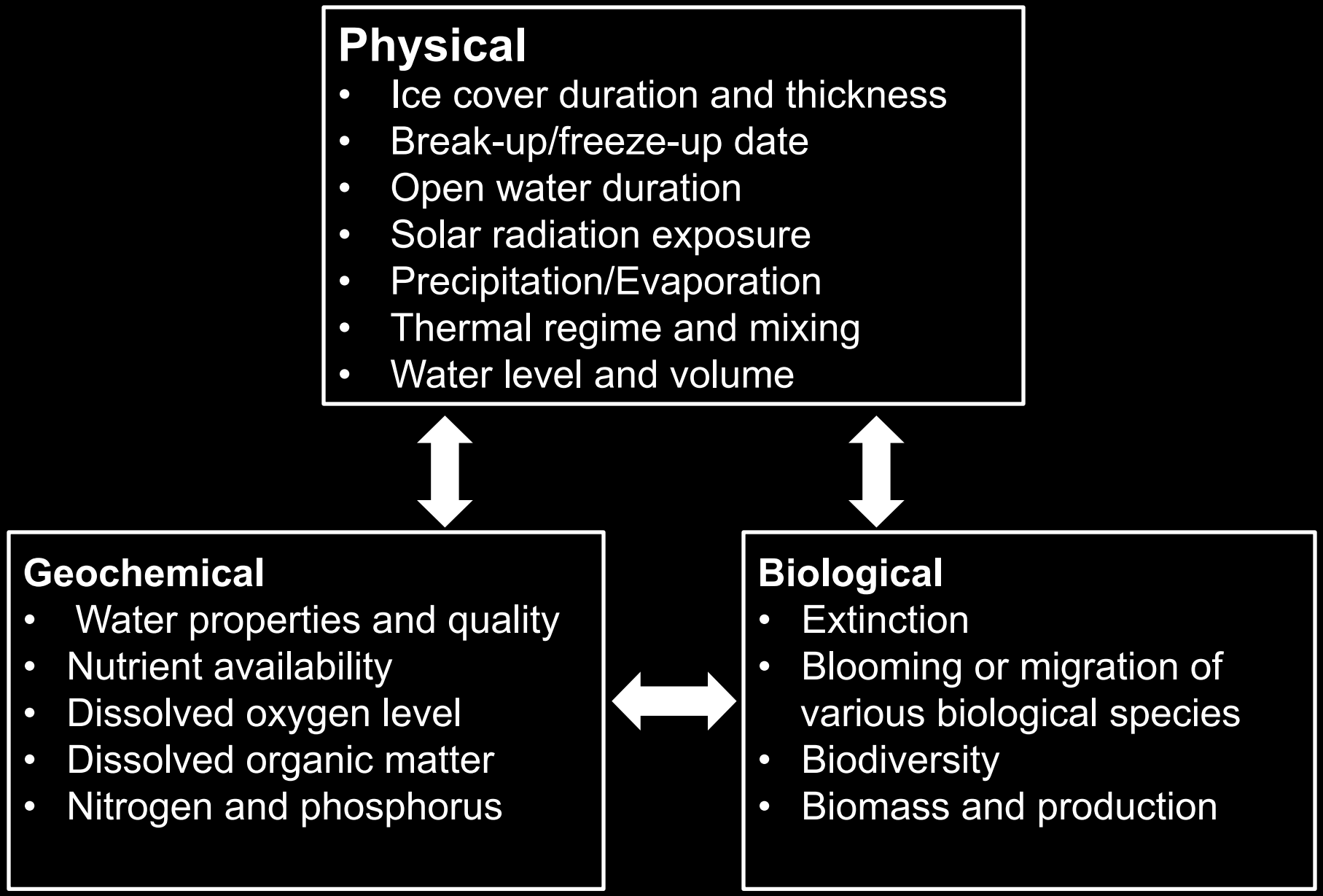
Consideration of lake-atmosphere interactions is an important issue in climate modeling and numerical weather prediction (NWP)

- Many models do not include lakes, or only large lakes
- Ice free season affects evaporation in the summer/fall



Average evaporation patterns for a region with no lakes and a region with lakes
Source: Rouse *et al.* (2008)

Response of lake ice to regional weather and climate



Objectives

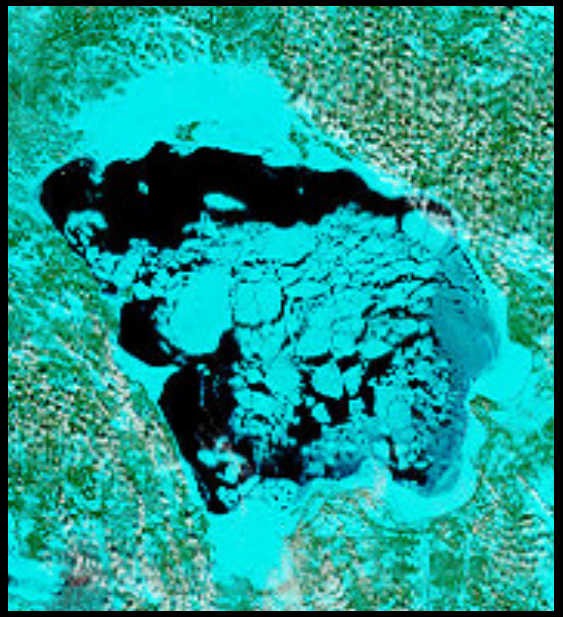
- The European Space Agency (ESA) through its Support To Science Element (STSE) Programme was funded a 24-month initiative, called ***North Hydrology***.

- ***North Hydrology*** aimed to develop a portfolio of novel multi-mission geo-information products to respond to the scientific requirements of the operational requirements of the weather and climate in regional to global scale.

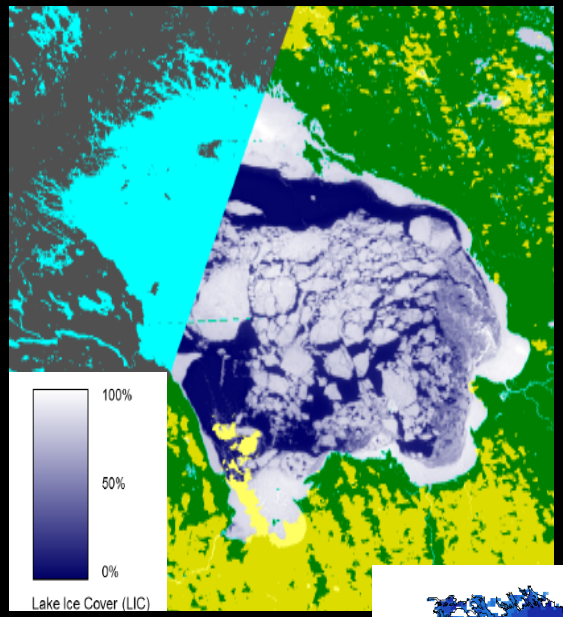
- EO products was developed based on the use of data from ESA (ERS-1/2 and ENVISAT) and non-ESA satellite missions (NASA Aqua/Terra, RADARSAT, TerraSAR-X).

Ice cover using MERIS ice fraction in comparison with MODIS snow products/LSWT

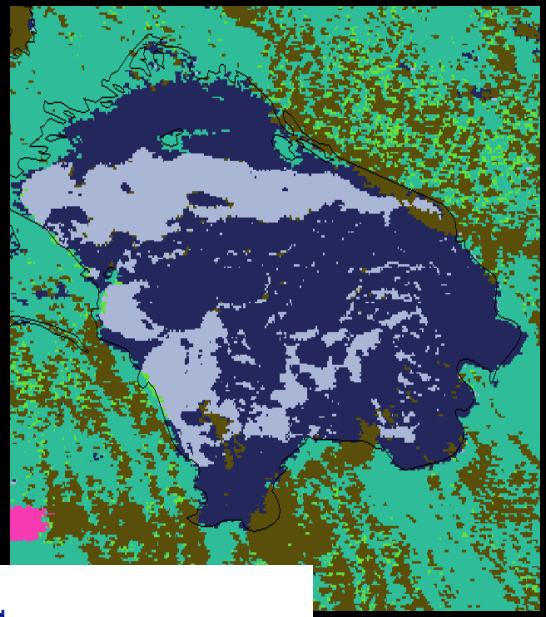
MODIS visible image

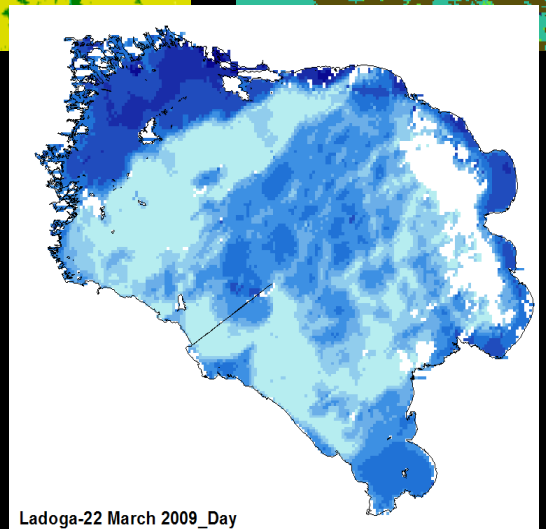


MERIS Ice Cover



MODIS snow product





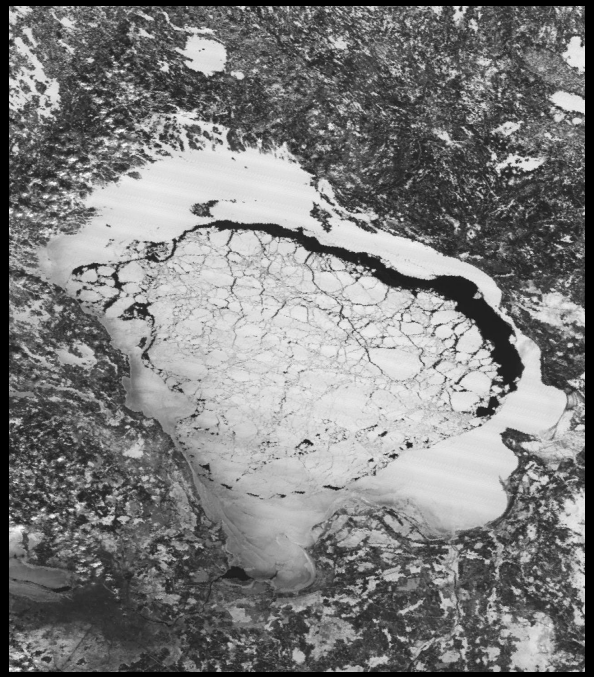
MODISLSWT

263.049 - 264.58
264.58 - 266.72
266.72 - 267.97
267.97 - 268.94
268.94 - 269.79
269.79 - 270.76
270.76 - 271.81
271.814 - 273.35

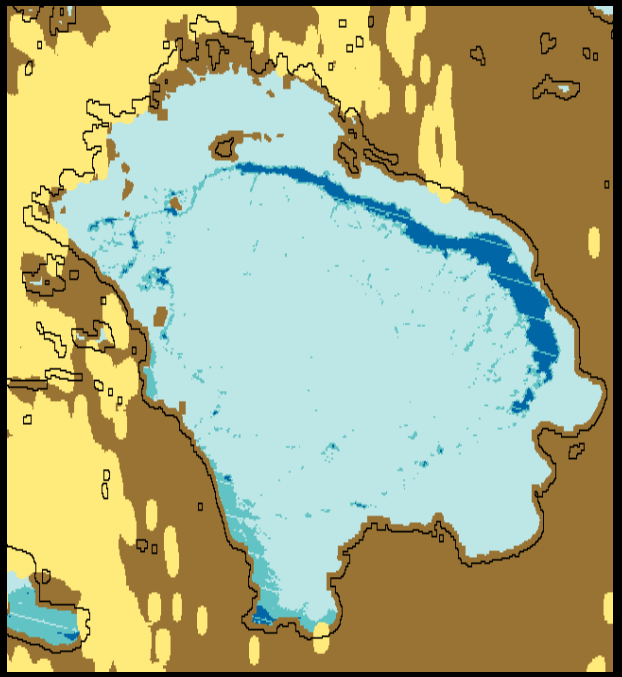
Lake Ladoga
22 March, 2009

Ice cover using AATSR ice fraction in comparison with MODIS LSWT

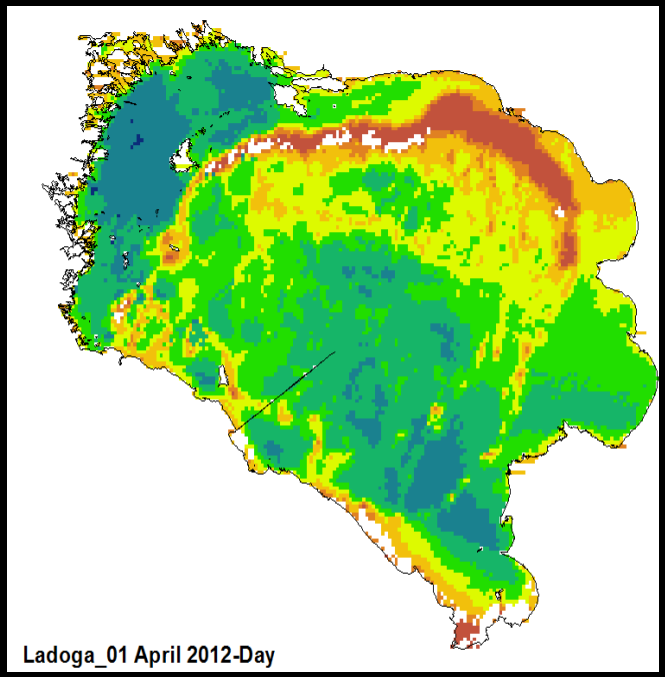
MODIS visible image



AATSR Ice Fraction

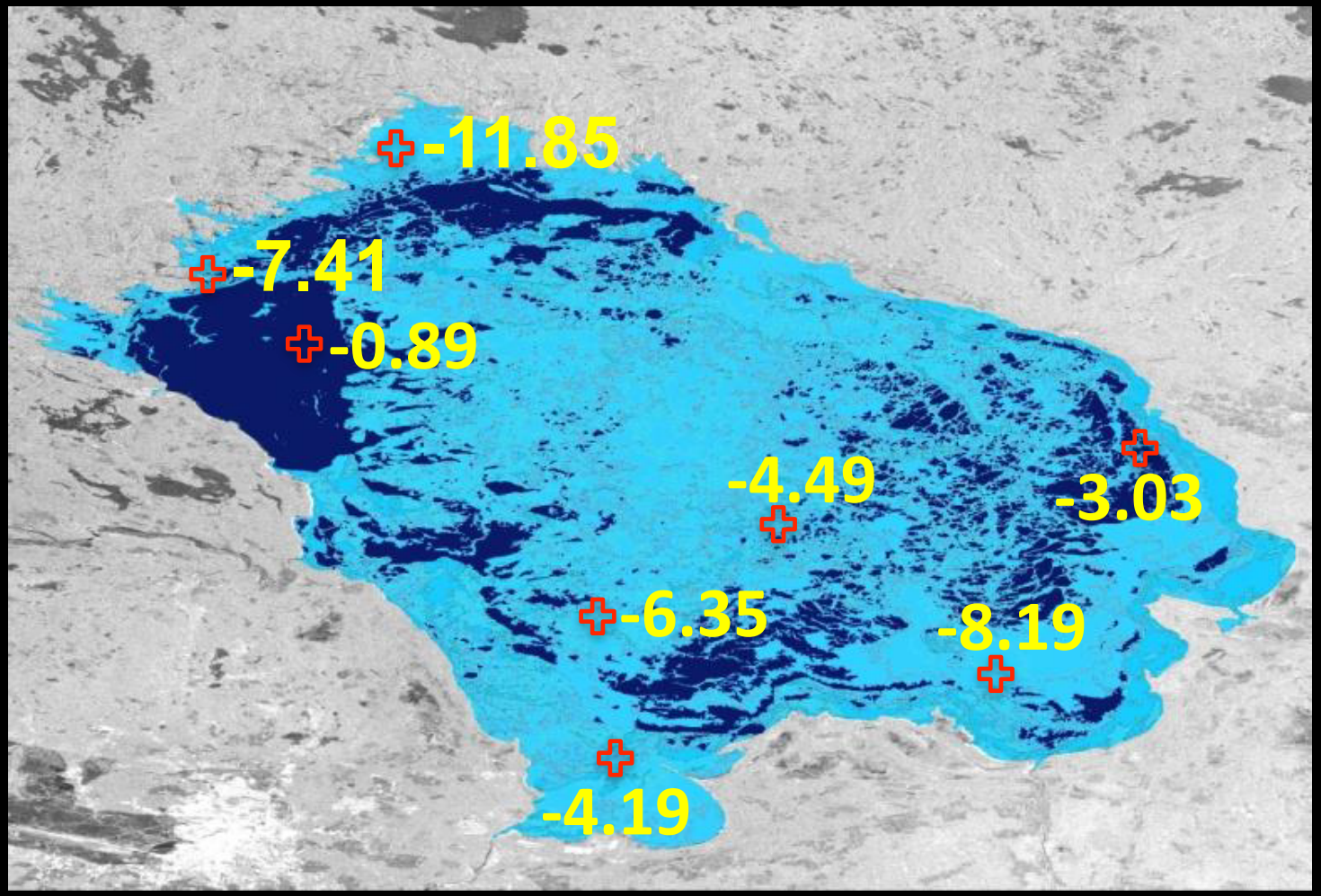


MODIS LWST



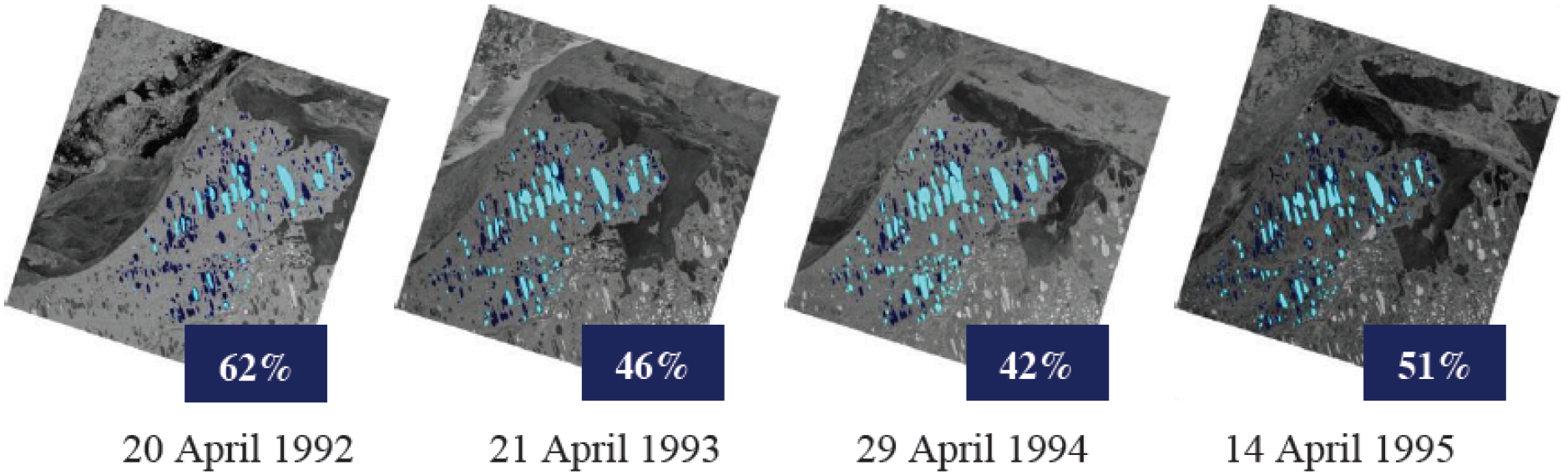
Lake Ladoga
01 April, 2012

Ice fraction for Lake Ladoga derived from MAGIC classification of SAR scenes



Lake Ladoga
22 February 2009

Ice cover on small, shallow lakes from MAGIC classification of ERS-1/2 SAR images



Lakes near Barrow, Alaska

Surdu et al., 2014

MODIS/AATSR LSWT & MERIS Ice Fraction

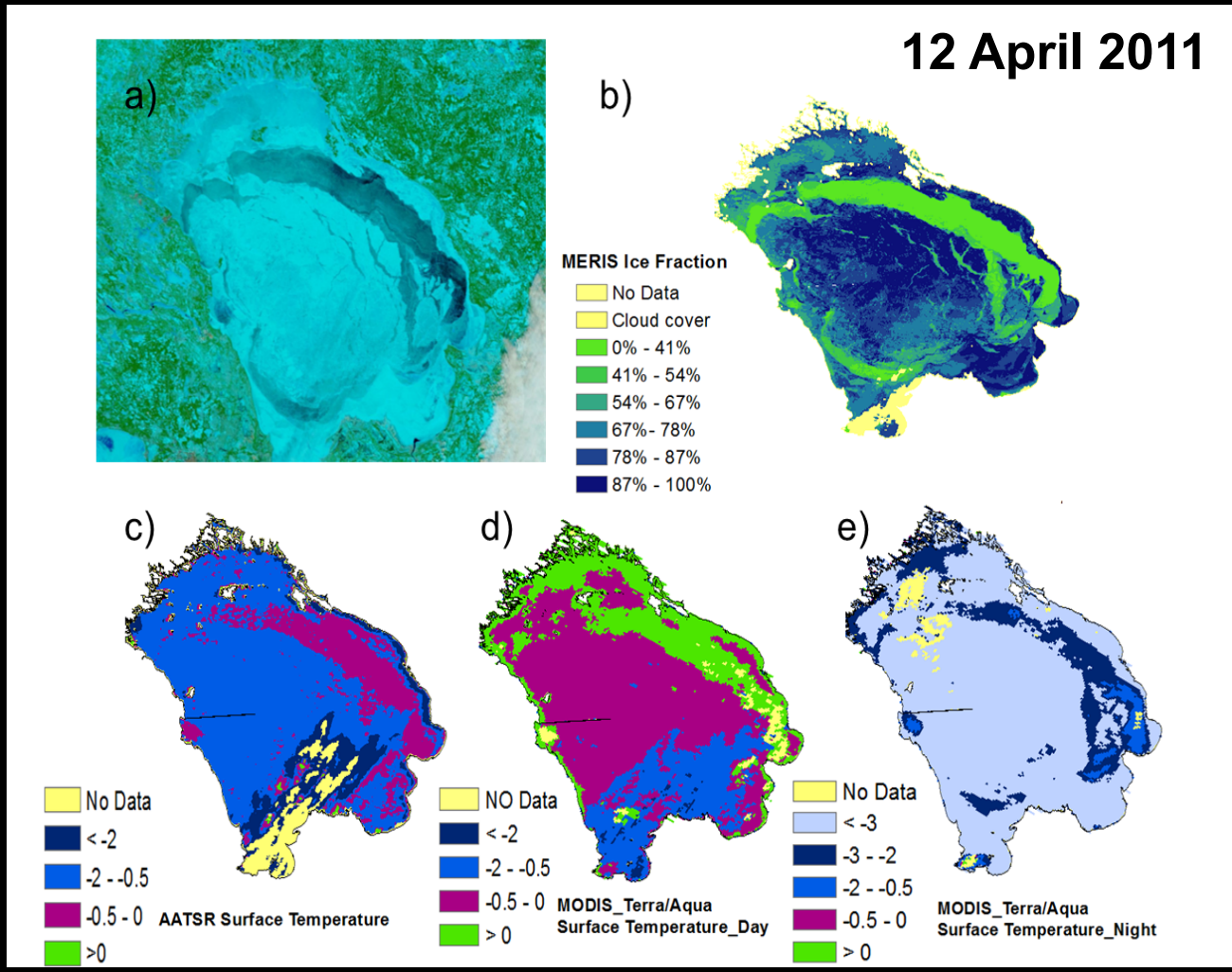
a) MODIS visible image

b) MERIS ice fraction

c) AATSR surface temperature (between 8-10 AM local time)

d) MODIS day time (between 10 AM -12 PM local time)

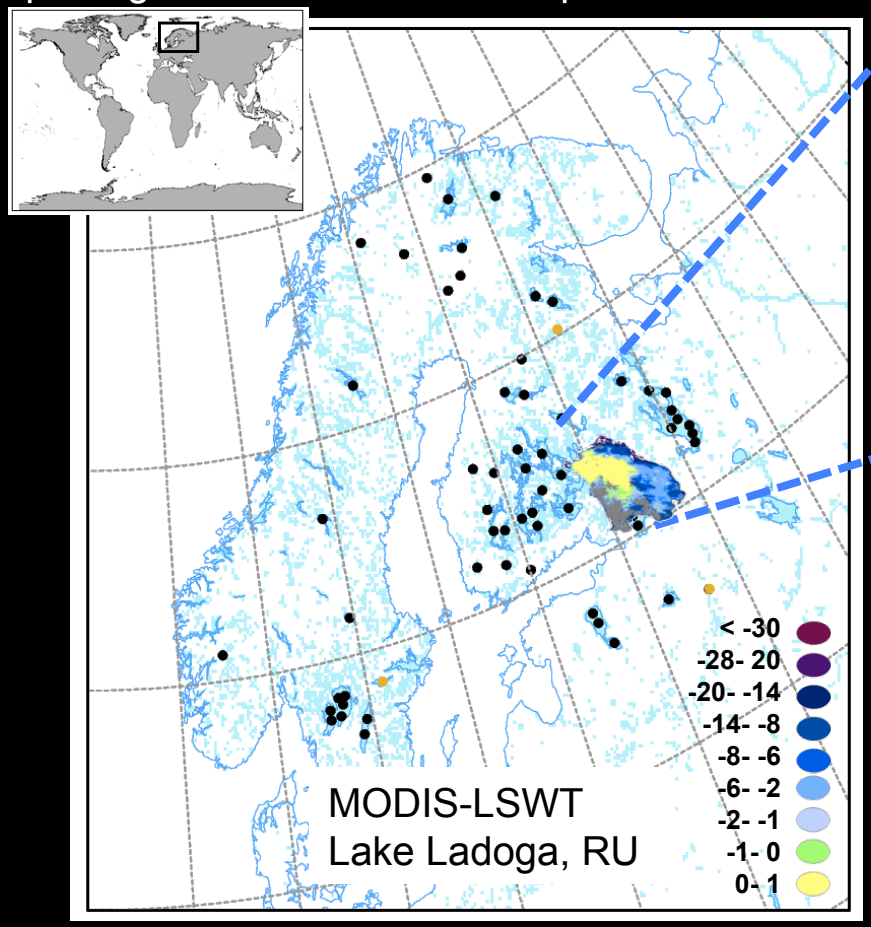
e) MODIS night time (between 10 PM - 3 AM local time)

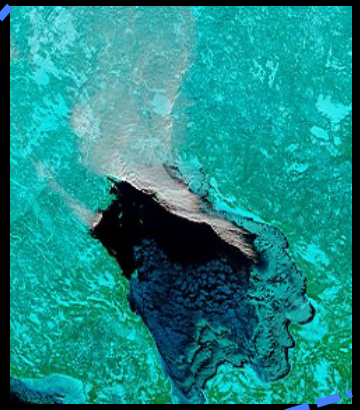


Kheyrollah Pour et al., 2014

Data Assimilation of Satellite-derived LSWT Observations into a NWP Model

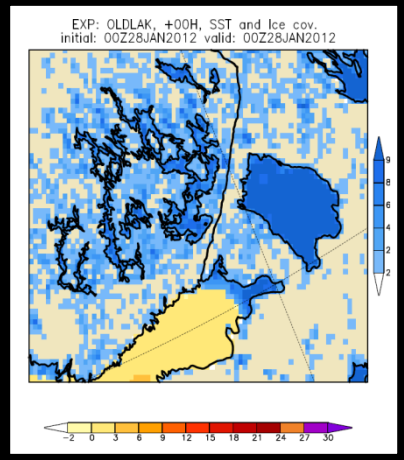
70 pixels over 41 lakes are chosen for picking remote-sensed LSWT pixels



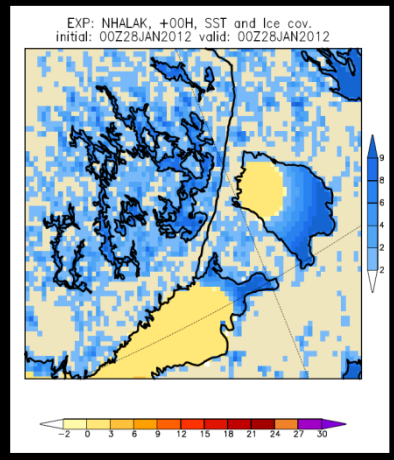


MODIS visible image
28 January 2012
Lake Ladoga, RU

Analyzed ice cover without assimilation



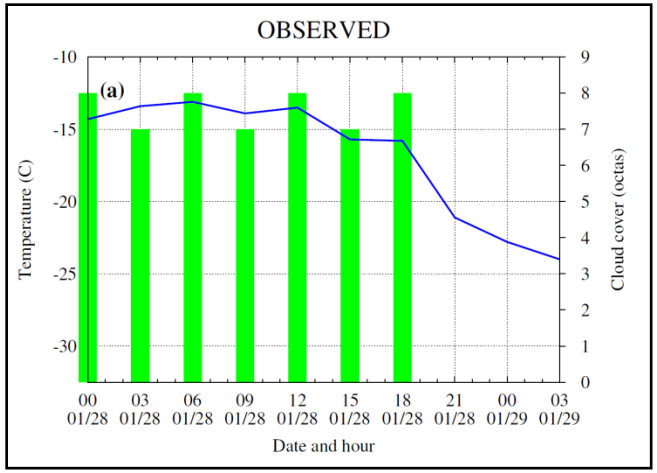
Analyzed ice cover with assimilation



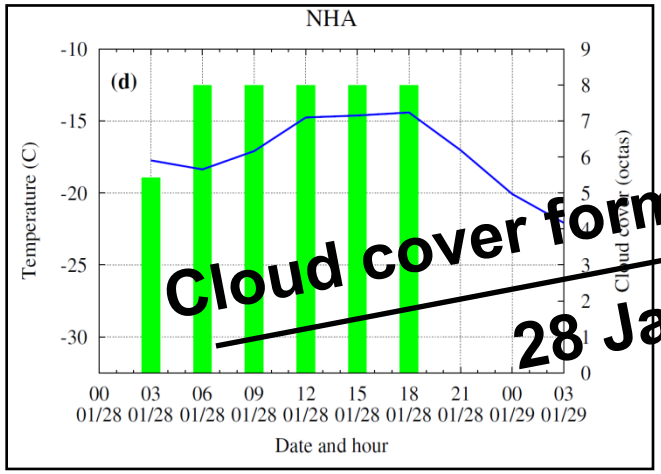
Eerola et al., 2014

Observed and predicted 2-meter air temperature and low-level cloud cover at Joensuu station

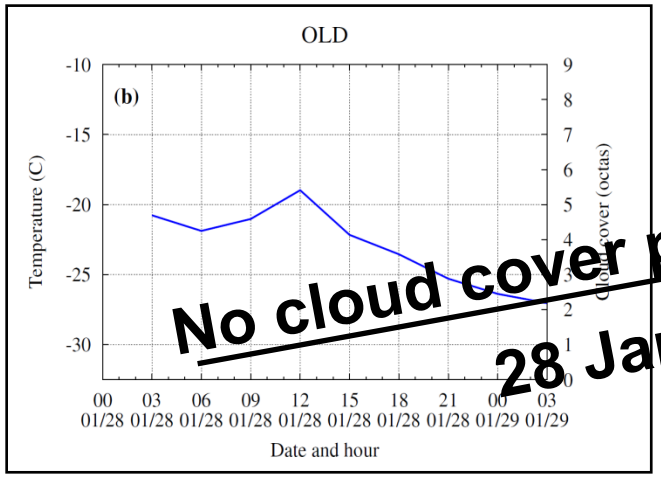
Joensuu station Observations



Predicted with assimilation

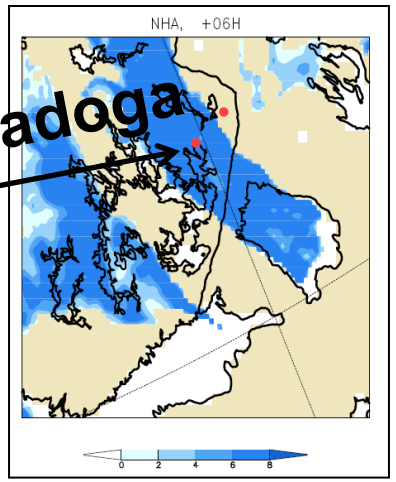


Predicted without assimilation



Cloud cover formation over Lake Ladoga

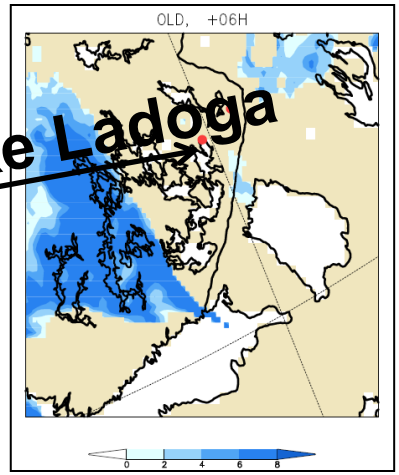
28 Jan 2012 - 06 UTC



Predicted with assimilation

No cloud cover predicted over Lake Ladoga

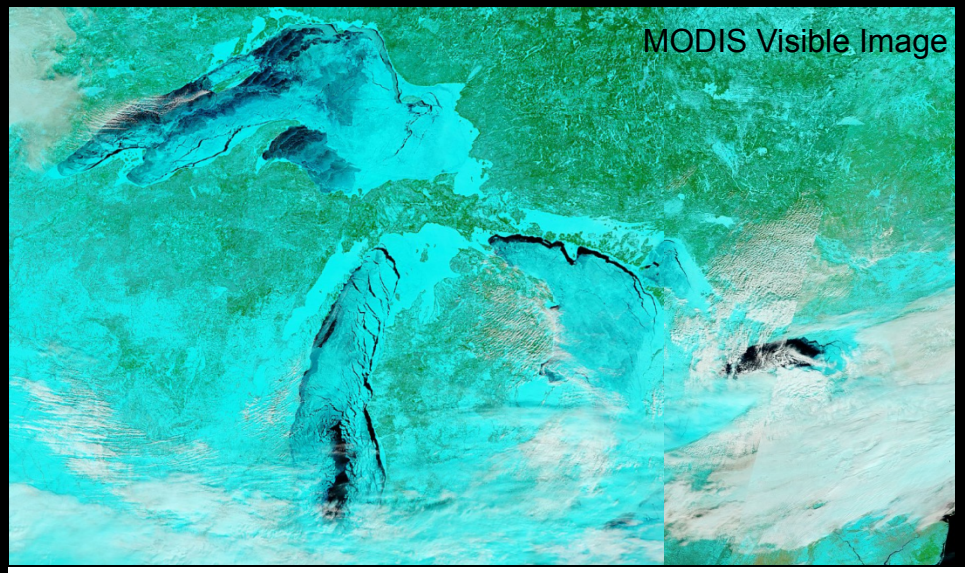
28 Jan 2012 - 06 UTC



Predicted without assimilation

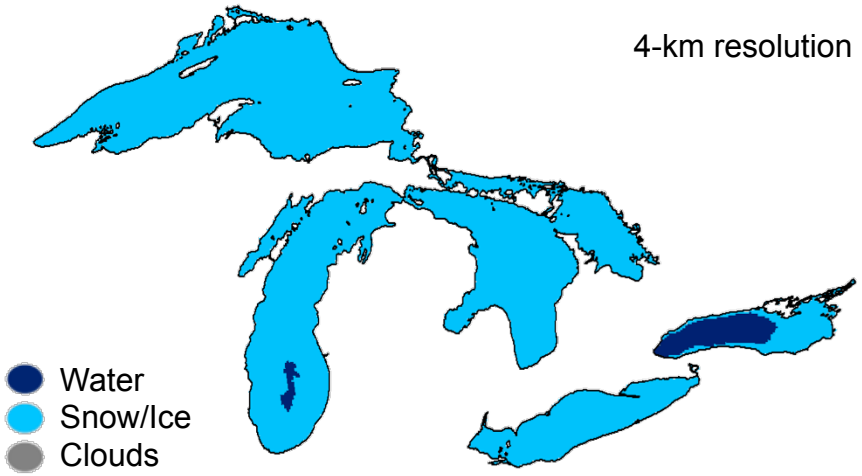
Animation of observed and predicted
2-meter air temperature and
low-level cloud cover

The Great Lakes Ice Cover
5 March 2014



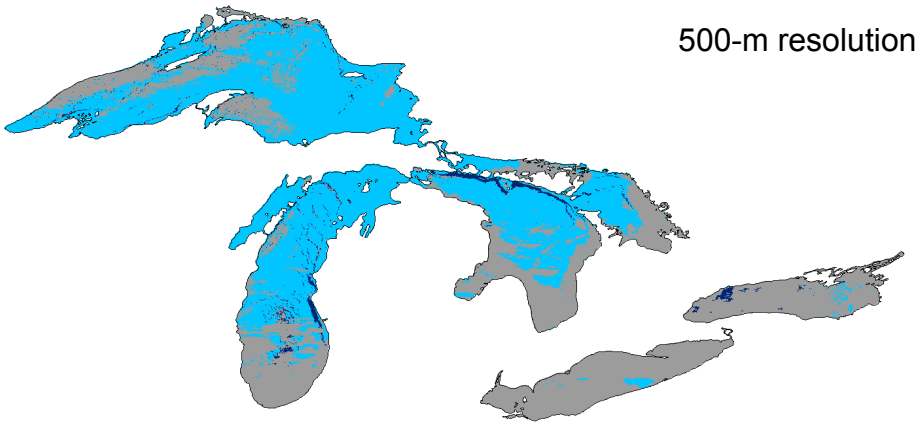
Interactive Multisensor Snow and Ice Mapping System (IMS)

4-km resolution



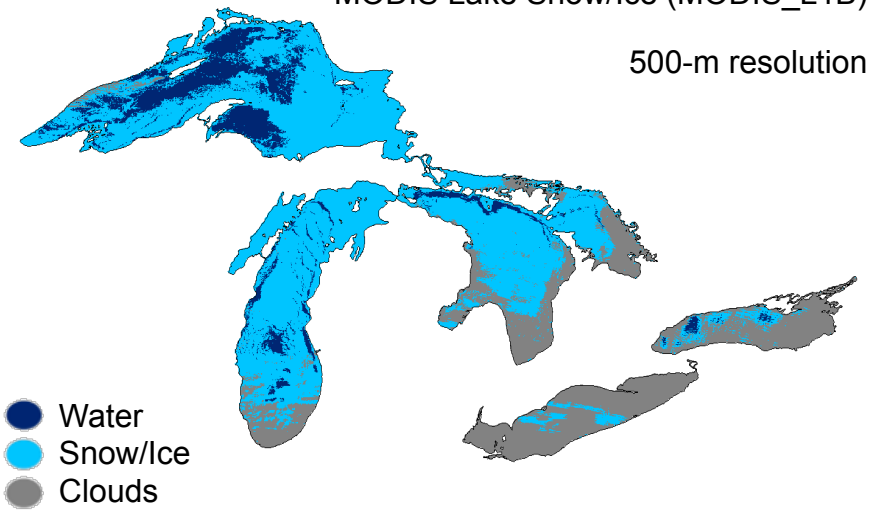
MODIS Lake Snow/Ice (MODIS_L3)

500-m resolution



MODIS Lake Snow/Ice (MODIS_L1B)

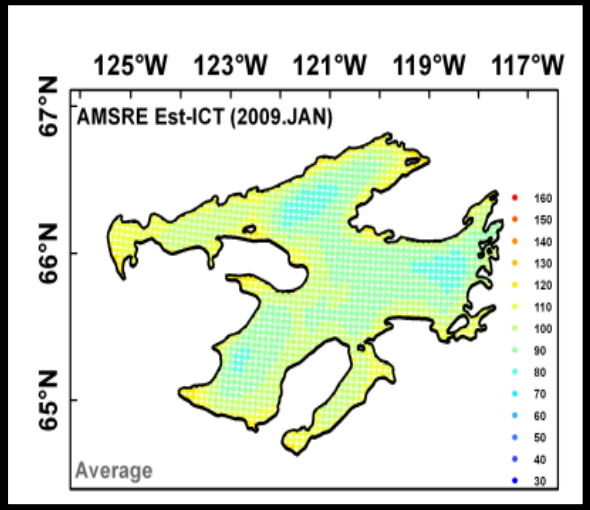
500-m resolution

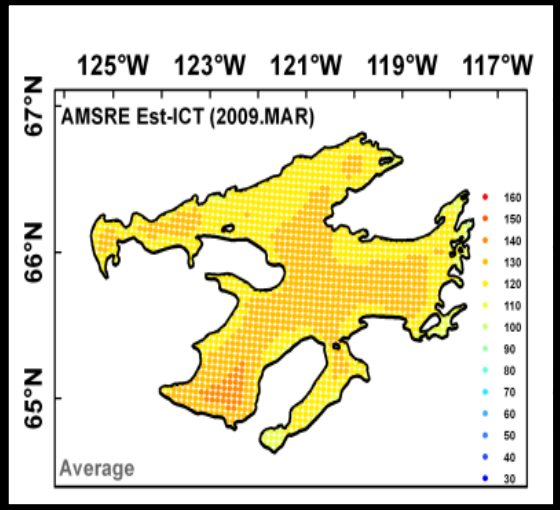


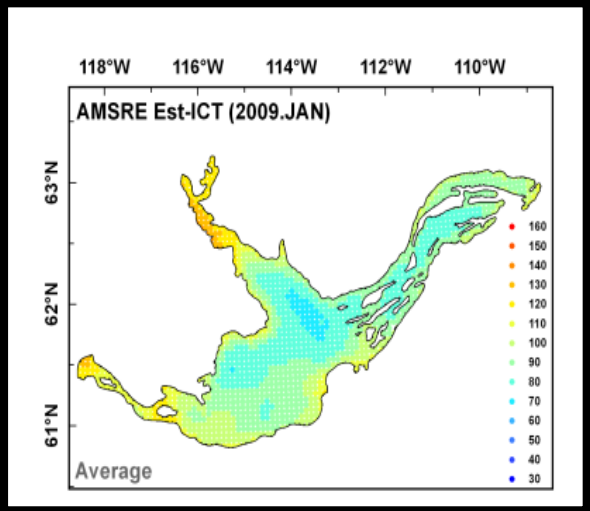
AMSR-E estimated lake ice thickness monthly maps

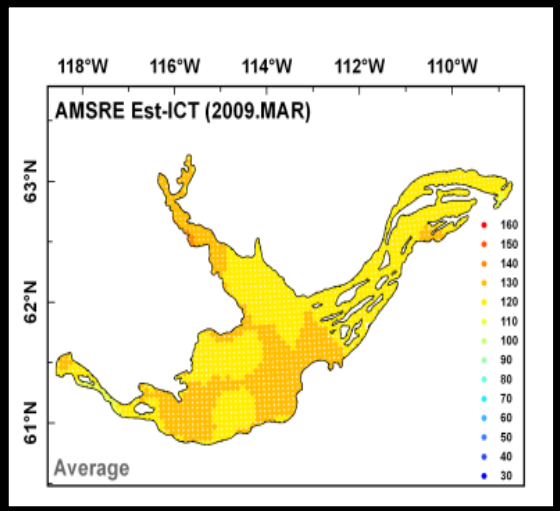
Great Bear Lake
Great Slave lake

January & March 09









18.7 GHz (V-pol)
Advanced Microwave Scanning Radiometer – Earth Observing System

Kang et al., 2014

Concluding remarks

- Introduction of space-borne observations led to an improvement of the description of lake surface state, especially during the melt period.
- Results from HIRLAM experiments demonstrated the need to intensify the development of lake products from multiple satellite platforms for data assimilation including LSWT, ice fraction, the timing of lake ice formation and disappearance, and ice thickness.
- The SAR data of floating and grounded ice in shallow lakes represent an important proxy index of Northern Hemisphere climate change.
- The ice thickness retrieval algorithm from passive microwave data (AMSR-E) provides the necessary high temporal (daily) resolution but the spatial resolution is too coarse for all but the largest lakes of the Northern Hemisphere.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