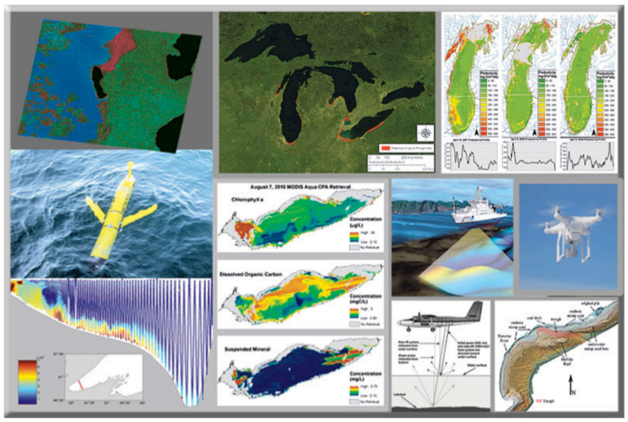
CoastWatch Satellite Research & Product Development

George Leshkevich
Observing Systems & Advanced Technology



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Illustrations include (left to right) satellite SAR ice type classification, phragmites mapping, primary productivity, UAS in situ measurements, satellite color producing agent (CPA) retrievals, ship-based sonar measurements, airborne lidar measurements.

This work aligns with the following NOAA Goals:

Science: Climate Adaptation and Mitigation
Improved scientific understanding of the changing climate system and its impacts
Science: Weather-Ready Nation
Improve freshwater resource management
Improve transportation efficiency and safety
Science: Healthy Oceans
Improved understanding of ecosystems to inform resource management decisions
Science: Resilient Coastal Communities and Economies
Comprehensive ocean and coastal planning and management
Safe, efficient and environmentally sound marine transportation
Improved coastal water quality supporting human health and coastal ecosystem services
Education: Science-Informed Society
Youth and adults from all backgrounds improve their understanding of NOAA-related sciences by participating in education and outreach opportunities
Formal and informal educators integrate NOAA-related sciences into their curricula, practices, and programs
Formal and informal education organizations integrate NOAA-related science content and collaborate with NOAA scientists on the development of exhibits, media, materials, and programs that support NOAA's mission
Education: Organizational Excellence
NOAA develops and supports a coordinated portfolio of products, programs, and partnerships that improves education opportunities in NOAA-related content areas for underserved audiences

Need for Great Lakes Satellite Research

Great Lakes specific algorithms are needed for satellite retrieval of key parameters owing to several factors:

- Ocean algorithms often do not work well in time or space on the Great Lakes
- Ocean algorithms often are not tuned to the parameters we need (eg. ice types)
- Vast difference in resolution and spatial coverage needs
- Freshwater vs. saltwater

Radarsat-2

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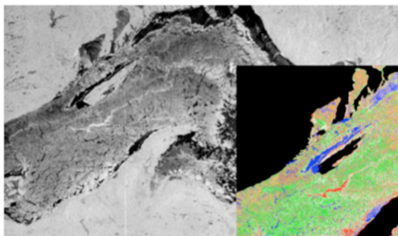
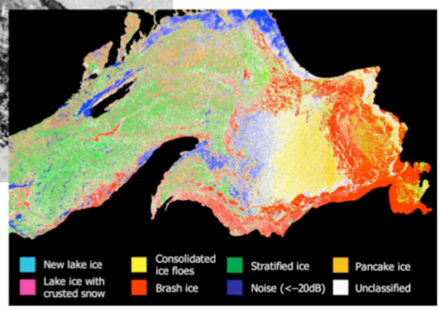
Prototype Great Lakes Ice Type Classification Product

Parameter: Lake ice type and location
Decision Support: Safety of lake transportation



RADARSAT-1
© CSA, 1997
March 22,1997
During GLAWEX'97
(GLERL)

Lake Superior
Research Ice Classification



Description of this work:

Development of Great Lakes specific algorithms to create image products from existing and new satellite and airborne sensors

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Currently transferring Great Lakes ice type classification algorithm to NOAA NESDIS for evaluation to produce operationally for the Great Lakes.

Methodology for Great Lakes Ice Classification Prototype

Library of backscatter signatures from different ice types on Lake Superior measured using Jet Propulsion Lab C-band scatterometer during Great Lakes Winter Experiment.

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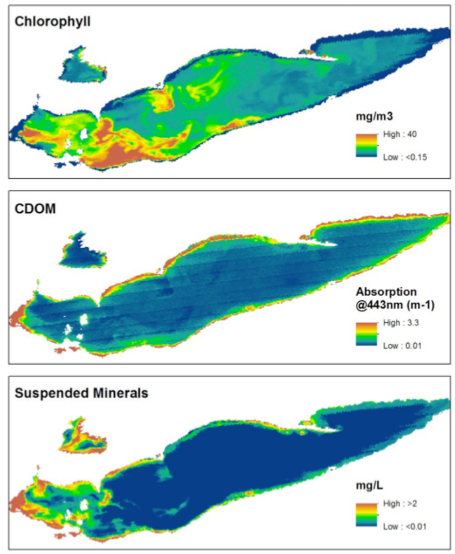
Prototype for Great Lakes Color Producing Agents Product

Lake Erie VIIRS CPA-A Retrievals from August 2012



Key Scientific Drivers:

Can satellite and airborne remotely sensed data provide accurate, synoptic retrievals of key Great Lakes parameters?

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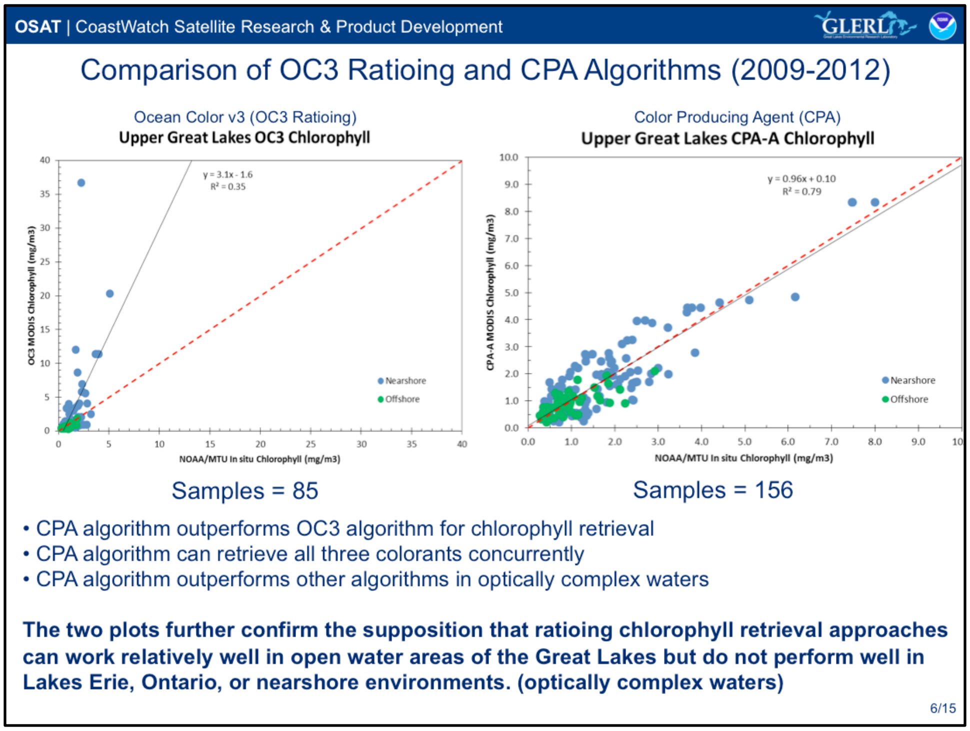
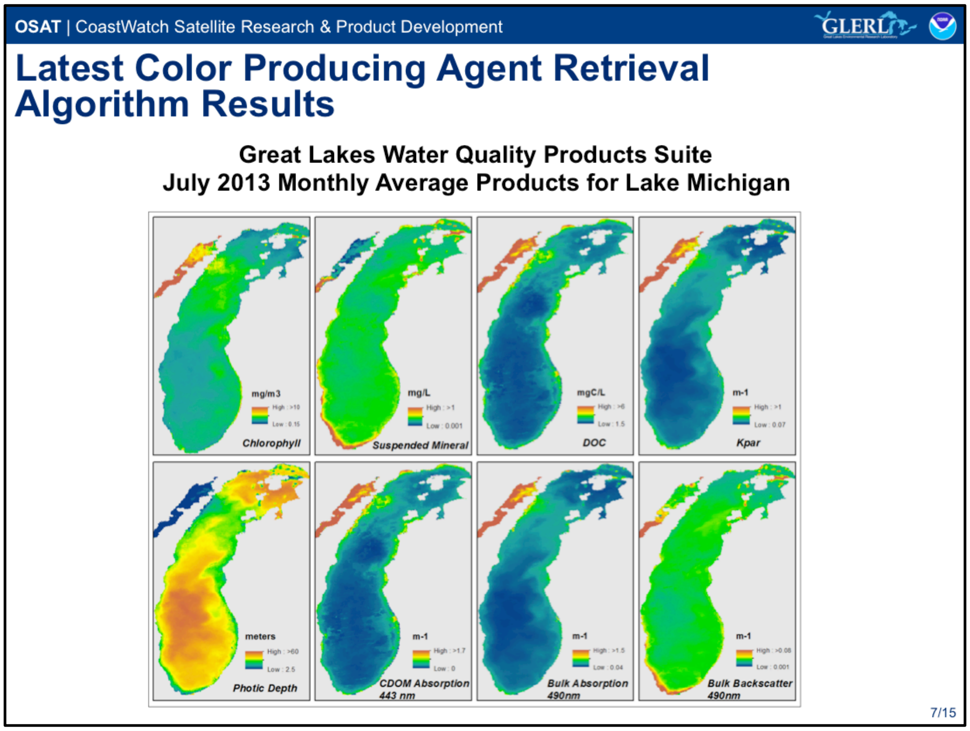
Chlorophyll retrieval ratioing algorithms found not to work well in the Great Lakes in time or space. Our CPA algorithm is based on hydro-optical models of the Great Lakes. The Visible Infrared Imaging Radiometer Suite (**VIIRS**) collects visible and infrared imagery and radiometric measurements of the land, atmosphere, cryosphere, and oceans. CDOM = color dissolved organic matter.



These two plots summarize the performance of the completed CPA-A algorithm for the upper three Great Lakes (Lakes Superior, Michigan, Huron). The plot on the right utilized 156 independent in situ chlorophyll measurements compared to near simultaneous CPA-A chlorophyll retrievals (+/- 2 days). The plot indicates the robust performance of the CPA-A in both nearshore and offshore locations. The plot on the left is the NASA standard OC3 chlorophyll retrievals for the same dataset. Note the reduced performance of the OC3 and inability to successfully retrieve all 156 locations.

The two plots further confirm the supposition that standard chlorophyll retrieval approaches work relatively well in offshore areas of the Great Lakes but perform non-optimally in the nearshore environment.

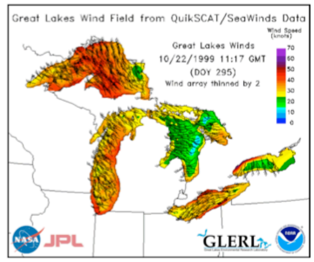


Currently transferring CPA algorithm to NOAA NESDIS for evaluation to produce operationally for the Great Lakes.

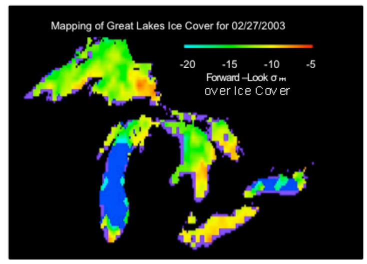
Prototype of CoastWatch Great Lakes Scatterometer Wind and Ice Cover Products

What are the specific products and/or services resulting from this work?

- Synthetic aperture radar (SAR) ice type classification and mapping
- Satellite retrieval of chlorophyll, CDOM (DOC), and suspended mineral
- Scatterometer ice mapping
- High resolution scatterometer winds
- Ice thickness mapping (airborne)
- Early HAB detection (hyperspectral)
- Upwelling detection / classification
- Real-time ice reconnaisance (drone)



Prototype of Great Lakes wind-field product derived from Scatterometer Data



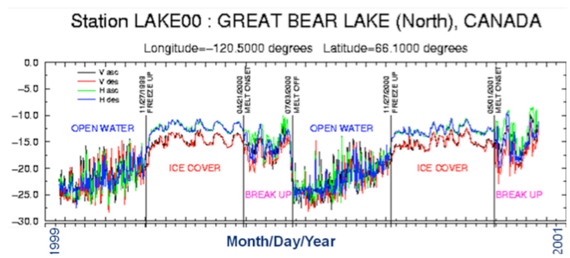
Prototype of Scatterometer Ice Cover Product for the Great Lakes

A radar scatterometer is designed to determine the normalized radar cross section (sigma-0) of the surface. Scatterometers operate by transmitting a pulse of microwave energy towards the Earth's surface and measuring the reflected energy.

Users of Great Lakes CoastWatch Products

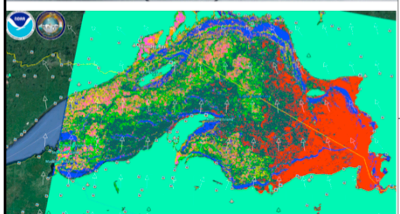
- Support GLERL internal research projects
- Support operational mandates within NOAA and sister agencies
- Support Regional users via the NOAA CoastWatch Great Lakes Node
  - Environmental science
  - Decision making
  - Supporting research
- Support educational and recreational activities

Application to Climate Research



Using scatterometer data, the dates of ice freeze-up and break-up can be determined – useful for regional climate change analysis

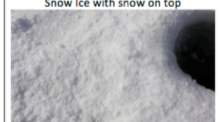
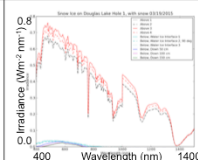
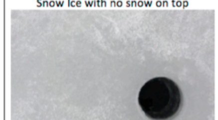
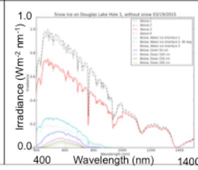
Measuring Light Transmittance Through Ice Cover

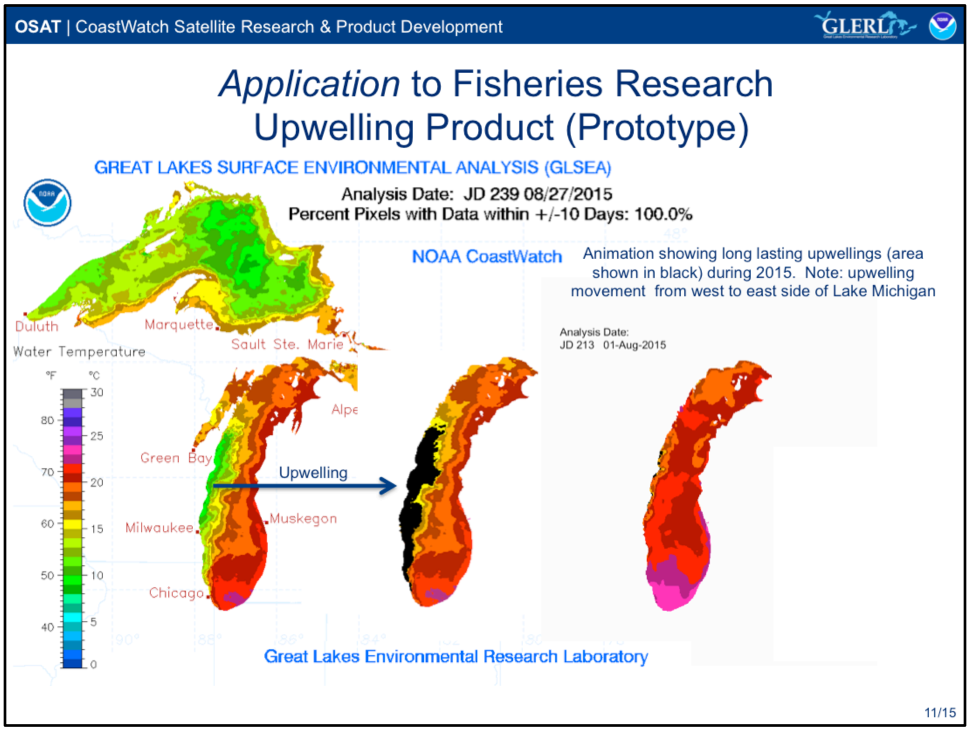


Lake Superior ice types - March 20, 2014 from RADARSAT-2
Ice type classification maps can be matched with average transmission loss for each ice type to produce maps of lake-wide light transmission

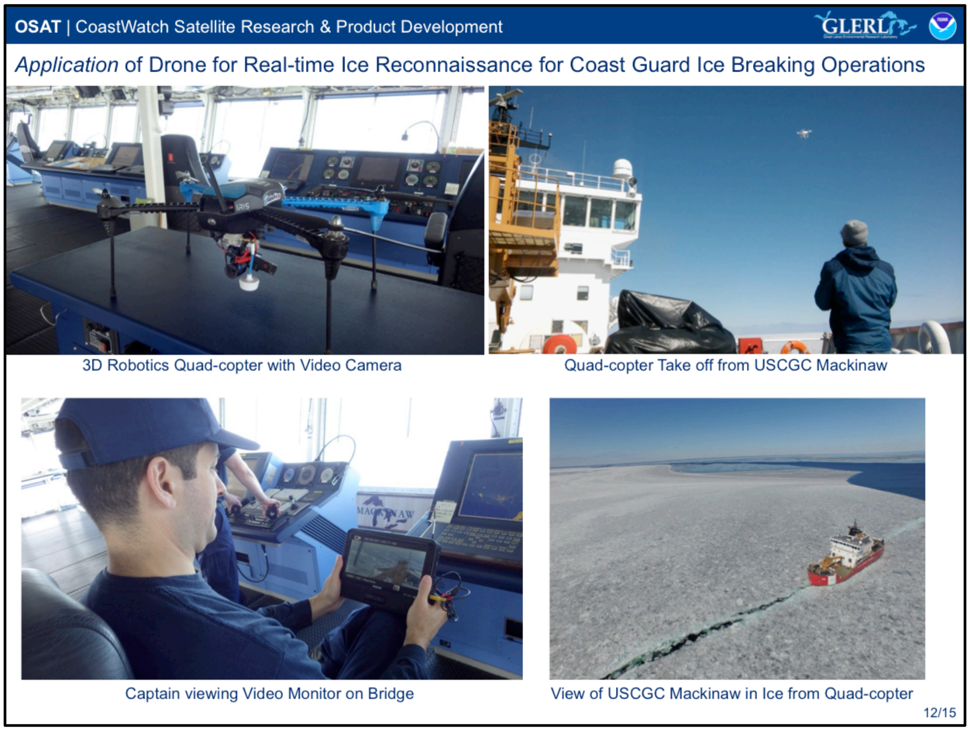
Application to Under Ice Ecology (Winter Primary Productivity)

Light Attenuation Through Snow Ice on Lake Ice With and Without a Snow cover

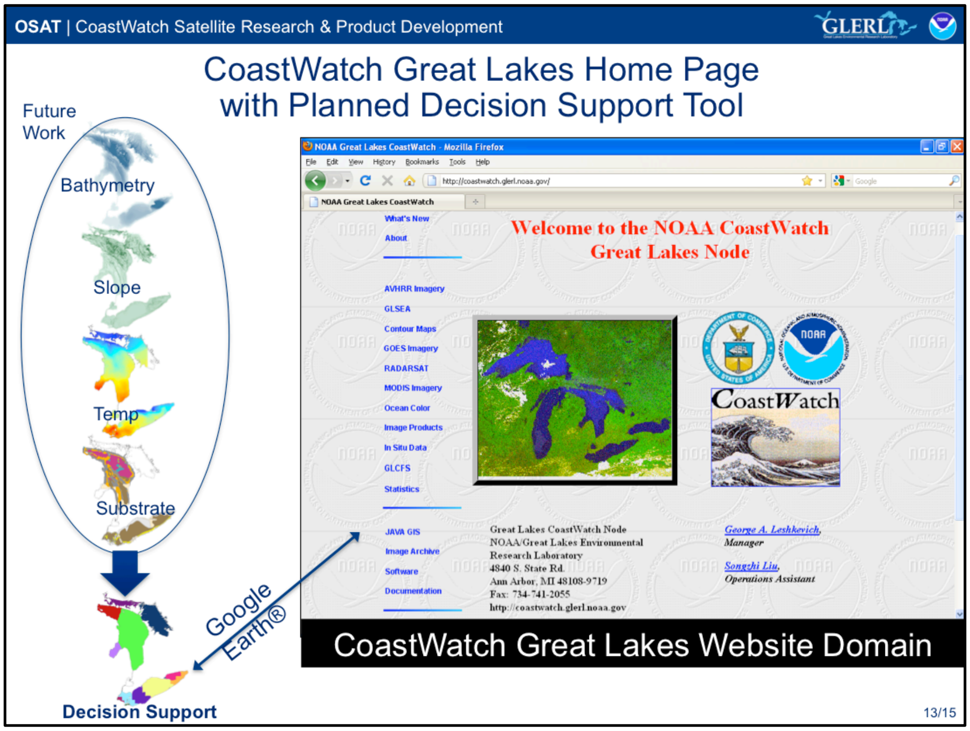
Hole	Ice Type and Picture	Irradiance Curves	% light Transmitted through ice (400-750 nm)
DL_1	Snow Ice with snow on top 		4.7
DL_1 no snow	Snow Ice with no snow on top 		23.6



New upwelling classification algorithm for the Great Lakes can identify and map upwellings important to fisheries management and research



At request of the Coast Guard, demonstration of drone (quad-copter) capability for real-time ice reconnaissance in support of Coast Guard ice breaking operations. Demonstration aboard the USCGC Mackinaw in the Straits of Mackinac and Green Bay during March 1-3, 2016. A video camera was used to send real-time imagery to the bridge of the USCGC Mackinaw. Other sensors, such as a ground penetrating radar (GPR) for transects of ice thickness, may be used depending on the size and capability of the drone.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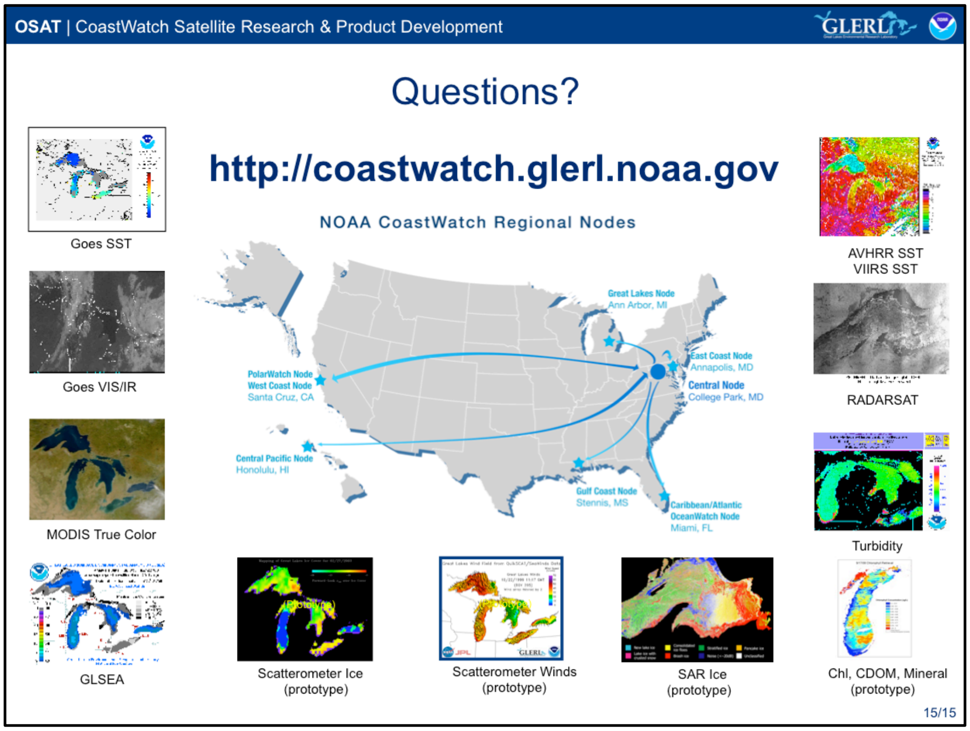
Collaborators

- National Aeronautics and Space Administration (NASA)
  - Goddard Space Flight Center
  - GLENN Research Center
- Jet Propulsion Laboratory (JPL)
- Michigan Tech Research Institute (MTRI)
- Nansen International Environmental and Remote Sensing Center, St. Petersburg (NIERSC)
- Upstate Freshwater Institute (UFI)
- Cooperative Institute for Limnology and Ecosystem Research (CILER)
- U.S. Coast Guard (USCG)
- Canadian Coast Guard (CCG)
- Environmental Protection Agency (EPA)
- NOAA National Environmental Satellite, Data, and Information Service (NESDIS)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Questions?
http://coastwatch.glerl.noaa.gov
NOAA CoastWatch Regional Nodes
Great Lakes Node
Ann Arbor, MI
East Coast Node
Annapolis, MD
Central Node
College Park, MD
PolarWatch Node
West Coast Node
Santa Cruz, CA
Central Pacific Node
Honolulu, HI
Gulf Coast Node
Stennis, MS
Caribbean/Atlantic
OceanWatch Node
Miami, FL
Goes SST
Goes VIS/IR
MODIS True Color
GLSEA
Scatterometer Ice
(prototype)
Scatterometer Winds
(prototype)
SAR Ice
(prototype)
Chl, CDOM, Mineral
(prototype)
AVHRR SST
VIIRS SST
RADARSAT
Turbidity
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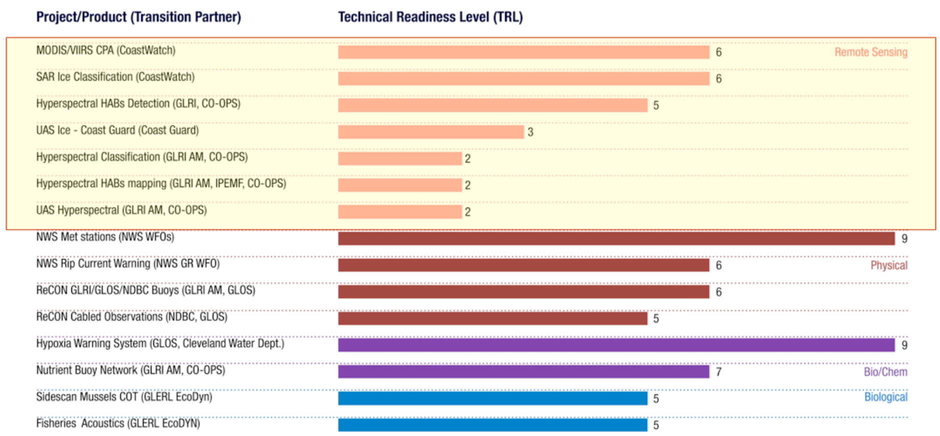
Technical Readiness Level of OSAT Products



Technical Readiness Level (TRL) Definitions

1: Basic principles have been observed and reported.

2: Technology concept and/ or application has been formulated.

3: Analytical and experimental critical function and/or characteristic proof-of-concept.

4: Component/subsystem validation in laboratory environment.

5: System/subsystem validation in relevant environment.

6: System/ subsystem model or prototyping demonstration in a relevant end-to-end environment.

7: System prototyping demonstration in an operational environment.

8: Actual system completed and "mission qualified" through test and demo in operational environment.

9: Actual system "mission proven" through successful operations.

Additional Information