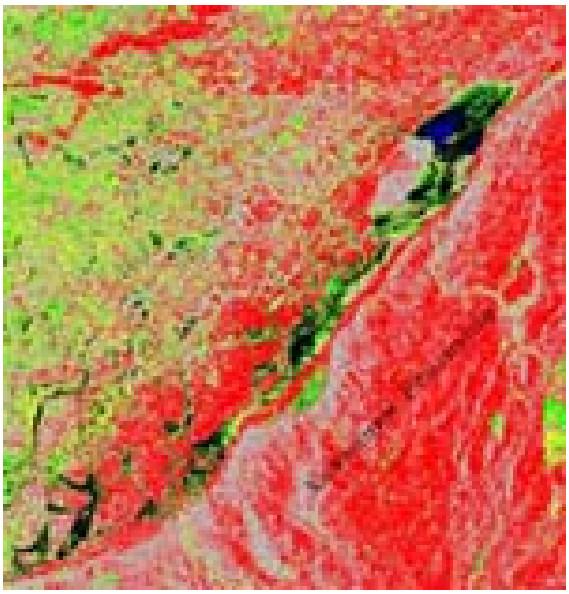
Great Lakes CoastWatch Research and Product Development

Primary Investigator: George Leshkevich - NOAA/GLERL

Objectives

Within Great Lakes CoastWatch, research and applications development utilizing imagery from new satellite sensors such as synthetic aperture radar (SAR) for ice classification and mapping and ocean color sensors such as the Sea Viewing Wide Field-of-View Sensor (SeaWiFS) for ocean color (chlorophyll) products complements the Great Lakes CoastWatch Program. These improvements are needed to enhance the Great Lakes CoastWatch product suite, to develop regional products and applications for the Great Lakes, and to contribute to the operational responsibilities of sister agencies such as the U.S. Coast Guard and National Weather Service.



- Rough consolidated ice floes (yellow)
- Brash ice (red)
- Patchy snow cover on snow-ice covered lake ice (green)
- Calm water (blue)

(Note: calm water is identified classified in this scene)

Classified ERS-2 Scene (22 March 1997) Corrected for Power Loss and Local Incidence Angle Effect

2004 Plans

Three research initiatives within **CoastWatch Research and Product Development** are continuing with the launch of the ENVISAT satellite, the acquisition of RADARSAT SWA calibration software, the collaboration with researchers at the German Aerospace Center (DLR) on testing a neural net algorithm for the Great Lakes, and the collaboration with researchers at the University of Toledo to develop an improved turbidity product and data base:

1. SAR research and field experiment in FY2003 involving ground truth data collection on Lake Superior (concurrent with RADARSAT and ENVISAT overflight) for
   a. validation of ice type classification algorithm for SAR data
   b. development of interferrometric methods for ice thickness measurements
   c. experimentation with ENVISAT dual polarized data for ice classification problem areas validation of ice type classification algorithm for QuikSCAT scatterometer data.
2. Collaboration with researchers at the German DLR is being explored to investigate the application of a neural network based on a bio-optical model to the retrieval of chlorophyll, suspended sediment, and dissolved organic matter in the Great Lakes from satellite ocean color imagery (SeaWiFS or MODIS).

2003 Accomplishments

Ocean Color Research: Collection of optical data and water samples continues to enhance the data base for statistical purposes. However, based on the previous analysis of measured chlorophyll data compared with output from four SeaWiFS chlorophyll algorithms (no atmospheric effects) and output from SeaDAS processed SeaWiFS satellite data (with atmospheric correction), it was found that returned chlorophyll values were highly variable in time and space. This could be due to what appears to be three coastal regimes in the Great Lakes: Case I (open ocean of second order), Case II (coastal), and Case III (highly turbid) and that chlorophyll is often not the major colorant. Although atmospheric correction algorithms have been improved, it appears that the chlorophyll ratioing algorithms themselves and not the atmospheric correction are the cause of the variable chlorophyll values (as the input remote sensing reflectance values were measured (in situ) values having no atmospheric affects).

In an attempt to solve this problem, collaboration with researchers at the German DLR is being explored, as they are exploring the use of a neural network, based on a bio-optical model, to solve a similar problem found in European coastal waters

A high school summer student intern has reprocessed most of the 1997-98 optical measurements and a journal article is in preparation on current findings and results.

QuikSCAT scatterometer project: A site on Lake Superior (Granite Island near Marquette, MI) to mount a web cam to collect “ground truth” of ice type and movement was identified and installation of the camera took place during the 2002 winter season. Owing to a mild ice season last winter, no data was collected that season. As ice conditions were normal to severe this past

(2002-03) ice season, except for a short outage in February, images were collected every 30 degrees in a 270 degree field of view every hour during daylight hours. The images will be used to “ground truth” QuikSCAT scatterometer imagery in the development of an ice classification and mapping algorithm using QuikSCAT data. (See report: Great Lakes Ice Mapping With Satellite Scatterometer Data).

2002 Accomplishments

Ocean Color Research: Collection of optical data and water samples continues to enhance the data base for statistical purposes. However, based on the previous analysis of measured chlorophyll data compared with output from four SeaWiFS chlorophyll algorithms (no atmospheric effects) and output from SeaDAS processed SeaWiFS satellite data (with atmospheric correction), it was found that returned chlorophyll values were highly variable in time and space. This could be due to what appears to be three coastal regimes in the Great Lakes: Case I (open ocean of second order), Case II (coastal), and Case III (highly turbid) and that chlorophyll is often not the major colorant. Although atmospheric correction algorithms have been improved, it appears that the chlorophyll ratioing algorithms themselves and not the atmospheric correction are the cause of the variable chlorophyll values (as the input remote sensing reflectance values were measured (in situ) values having no atmospheric affects).

Synthetic Aperture Radar (SAR) Research: RADARSAT data acquired during our 1997 field experiment has been acquired and calibrated by Satlantic, Inc. Analysis of this data using our library of C band polarimetric backscatter data is continuing, but the ice classification algorithm needs further validation, which is planned for this winter season, as last season was a very mild ice season.

Moreover, working cooperatively with scientists at JHU/APL, software to calibrate the RADARSAT ScanSAR Wide A data (block averaged) received at GLERL near real-time via the National Ice Center has been obtained from the Johns Hopkins University Applied Physics Laboratory and configured to run on a SUN computer at GLERL. The JHU/APL developed the software in their effort to derive and map coastal winds from RADARSAT data, where accurately calibrated data is also needed. Output converted to dB will be tested with our library of ice signatures. If successful, ice classified, color coded RADARSAT images will be put on the web this ice season for NWS and USCG use.

Great Lakes Winter Experiment 2002 (GLAWEX’02): The Great LAkes Winter EXperiment 2002 conducted by George A. Leshkevich (NOAA/OAR/GLERL) together with colleague Son V. Nghiem (NASA/JPL) with the participation of NASA’s AIRSAR Science Team, Airborne Science DC-8 aircraft, and the U.S. Coast Guard icebreaker, USCGC Mackinaw, was successfully completed March 22, 2002. In over 40 hours of flight time, polarimetric and interferometric C, L, and P band Synthetic Aperture Radar (SAR) data was collected over various ice types/thickness in several locations on the Great Lakes along with concurrent in situ measurements of ice/snow type, ice thickness, and density. The ice/snow characteristics collected will be compared with the airborne AIRSAR data taken simultaneously. Data gathered during this experiment will be used to develop algorithms to map Great Lakes ice types and ice thickness using current and

future satellite sensors. This information has applications in ice forecasting and modeling, climate and winter ecology research, hazard mitigation, as well as operational use.

2001 Accomplishments

Synthetic Aperture Radar (SAR)

RADARSAT data acquired during our 1997 field experiment has been acquired and calibrated by Satlantic, Inc. Analysis of this data using our library of C band polarimetric backscatter data is continuing, but the ice classification algorithm needs further validation, which is planned for this winter season. Our proposal to NESDIS to map/classify Great Lakes ice cover using QuikSCAT scatterometer data was funded. A site on Lake Superior to mount a web cam to collect “ground truth” of ice type and movement has been identified and installation of the camera is proceeding for use this winter season.

Ocean Color

Collection of optical data and water samples continued to enhance the data base for statistical purposes. However, based on the previous analysis of measured chlorophyll data compared with output from four SeaWiFS chlorophyll algorithms (no atmospheric effects) and output from SeaDAS processed SeaWiFS satellite data (with atmospheric correction), it was found that returned chlorophyll values were highly variable in time and space. This could be due to what appears to be three coastal regimes in the Great Lakes: Case I (open ocean of second order), Case II (coastal), and Case III (highly turbid) and that chlorophyll is often not the major colorant. Although atmospheric correction algorithms have been improved, it appears that the chlorophyll ratioing algorithms themselves and not the atmospheric correction are the cause of the variable chlorophyll values (as the input remote sensing reflectance values were measured (in situ) values having no atmospheric affects). In an attempt to solve this problem, I am currently working with research scientists at the GKSS Research Center in Germany who are working on a neural network, based on a bio-optical model, to solve a similar problem found in European coastal waters.

2000 Accomplishments

Synthetic Aperture Radar (SAR)

ERS-2 satellite SAR data acquired during the 1997 field experiment (together with the C-band ice backscatter measurements) was reprocessed using an improved calibration algorithm. The reprocessing using the new algorithm not only corrects for power loss (in the ERS-2 instrument) but also takes into account local incident angles (from 19.5 degrees to 26.5 degrees). The classified ERS-2 SAR image appears to be more accurate than the previous classification based on the ground truth data collected during the experiment, but the ice classification algorithm needs further validation, which is planned for the future.

Ocean Color

Collection of optical data and water samples continued to enhance the data base for statistical purposes. However, based on the previous analysis of measured chlorophyll data compared with output from four SeaWiFS chlorophyll algorithms (no atmospheric effects) and output from SeaDAS processed SeaWiFS satellite data (with atmospheric correction), it was found that returned chlorophyll values were highly variable in time and space. This could be due to what appears to be three coastal regimes in the Great Lakes: Case I (open ocean of second order), Case II (coastal), and Case III (highly turbid) and that chlorophyll is often not the major colorant. Although atmospheric correction algorithms have been improved, it appears that the chlorophyll ratioing algorithms themselves and not the atmospheric correction are the cause of the variable chlorophyll values (as the input remote sensing reflectance values were measured (in situ) values having no atmospheric affects).

1999 Accomplishments

Measured chlorophyll data was analyzed and compared with output of four ratioing chlorophyll retrieval algorithms (no atmospheric effects) and output from SeaDAS processed SeaWiFS satellite data (with atmospheric correction). Preliminary results show that the predicted chlorophyll concentration was variable (often high, sometimes low, sometimes near measured values) and that input wavelengths of remote sensing reflectance (443/555 vs 490/555) improved the chlorophyll values calculated from the “Coastal Algorithm.” Inadequate atmospheric correction algorithms and false assumption of zero water leaving radiance in the IR could contribute to the high satellite chlorophyll retrievals.

1998 Accomplishments

C-band backscatter data from different Great Lakes ice types were collected in the field (converted to sigma naught in dB) and applied to calibrated ERS-2 SAR data to classify ice types in the SAR data. Differences in vertical and horizontal C-band backscatter from Great Lakes ice types and open water were compared. This is the first known application of a backscatter lookup table applied to Great Lakes ice classification and mapping using satellite SAR data and will lead to automated operational ice classification/mapping algorithms.

Optical data (using Satlantic radiometer) and water samples (to obtain chlorophyll, TSM, DOC, POC) were collected on Lakes Superior, Michigan, and Erie for ground truth to allow ocean color algorithm development using SeaWiFS satellite data. This will lead to a remote sensing method for mapping chlorophyll distribution in the Great Lakes.

Products

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