2.4 INTEGRATING MULTIPLE SENSORS TO STUDY ALGAL BLOOMS IN THE EASTERN GULF OF MEXICO

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1. INTRODUCTION

The National Oceanic and Atmospheric Administration (NOAA)/National Environmental Satellite, Data, and Information Service (NESDIS) is finishing the second year of a two-year demonstration of Synthetic Aperture Radar (SAR) derived products named the Alaska SAR Demonstration (AKDEMO) (Pichel, 2000). This demonstration provides near real-time SAR data and derived products, including wind images and vectors, hard target locations, and other ancillary data, to the government community. Data are provided to users on a web site and via a web-based interactive data fusion utility. We plan on developing a similar experimental multi-sensor data fusion system for the Gulf of Mexico region. The Gulf of Mexico Experiment (GoMEx) will provide monitoring tools for near real-time applications, although it will initially focus on research using archived data. A valuable use of this system is expected to be detecting and monitoring algal blooms in the Gulf of Mexico. An example of a possible algal bloom along Western Florida will be presented using the multi-sensor approach afforded by this system.

2. SYSTEM

The NOAA NESDIS GoMEx system will run on the same system that is currently being used for the NOAA/NESDIS AKDEMO; i.e., the World Wide Web Image Processing Environment (WIPE). WIPE is a product of Applied Coherent Technology Corporation (ACT) and allows the user to access a large database of geo-spatial data over a web based GIS-like user interface. It facilitates data manipulation, fusion, and creation of high level products to be used in research or operation. The GoMEx system receives and stores its data at NOAA NESDIS and can be used password protected from anywhere on the web. The central dataset on this system, as with the AKDEMO, is Synthetic Aperture Radar (SAR) data. At the moment this is RADARSAT-1 data. In 2002/2003, it is planned that ENVISAT SAR data will also be added. Other data sets that will be available to the GoMEx, include: infrared and visible imagery from the NOAA Geostationary Operational Environental Satellite (GOES) imager and the NOAA satellite Advanced Very High Resolution Radiometer (AVHRR); ocean color and chlorophyll measurements from the Oribital Sciences Corporation SeaStar Sea-viewing Wide Field-of-view Sensor (SeaWiFS) and the NASA Terra Platform Moderate Resolution Imaging Spectroradiometer (MODIS), and wind measurements from the NASA QuikSCAT SeaWinds scatterometer. Besides imagery, point data such as topography, bathymetry, buoy meterological and oceanographic data, wind barbs, and detected ship positions are available as layers to view over the satellite imagery. Some of these products (such as winds and ship positions) are derived from SAR data at NOAA/NESDIS as part of the project. The WIPE system easily facilitates fusion of data, which is extremely useful

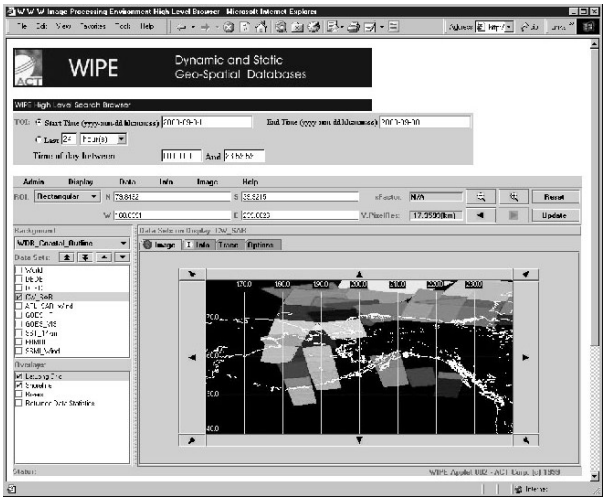

Figure 1. Example showing search results using the WIPE system

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to the researcher working with many large and complicated data sets. A view of the WIPE interface is shown in Fig. 1. This example shows the results of a search for SAR data during a specific time period. After a search has been completed and matching data sets are found, the user selects an area of data to view and the imagery associated with that data is viewable in a second browser window. It is at this stage that point data can be added as an overlay.

3. BACKGROUND

Algal Blooms happen naturally and their occurrences are mentioned even in the bible. But it is believed that they are occurring more frequently in current times, possibly due to human impact. Along Florida's west coast, algal blooms consisting of Karenia brevis (formerly known as Gymnodinium breve) appear almost yearly. Kerenia brevis can cause shellfish poisoning and fish kills which negatively impact the commercial and recreational fishing and tourism economy. It is thought that these blooms along the Florida shelf are a source of blooms that spread throughout Northern Gulf of Mexico (Tester et al., 1991). Blooms frequently begin along the mid- to outer continental shelf in late summer (Tester and Steidinger, 1997) and are linked to meanders of in the Loop Current. The extent of the loop current and its meanders affect the severity of the bloom (Haddad and Carder, 1979; Lee et al., 1994)

4. CASE STUDY

On May 13, 2000, a RADARSAT-1 standard mode SAR image (30 meter resolution, 100 km swath width) taken off of Naples, Florida shows a dark region from about 25.3N to 26N. This is seen in Fig. 2 which as an output from WIPE with latitude and longitude used as an overlay. The dark area can be studied more closely in Fig. 3 which corresponds to the portion of the SAR image within the white rectangle in Fig. 2. There are many reasons why an area may appear dark (i.e. low backscatter values) on a SAR image. These phenomena include low wind speed, heavy precipitation, grease ice, natural films and oil spills. The dark region appears to spread as curvilenear filaments which are an unlikely SAR signature resulting from wind related effects (which tend to be linear). It instead resembles low-backscatter features resulting from oil or natural surfactants. One cause of these natural slicks is the presence of large concentrations of algae; i.e., an algae bloom. The AVHRR SST data for this time is cloudless over this small area, but does not show any SST deviations. NEXRAD radar does not show a large rain event in this area, so it is also unlikely that the dampening is caused by rain.

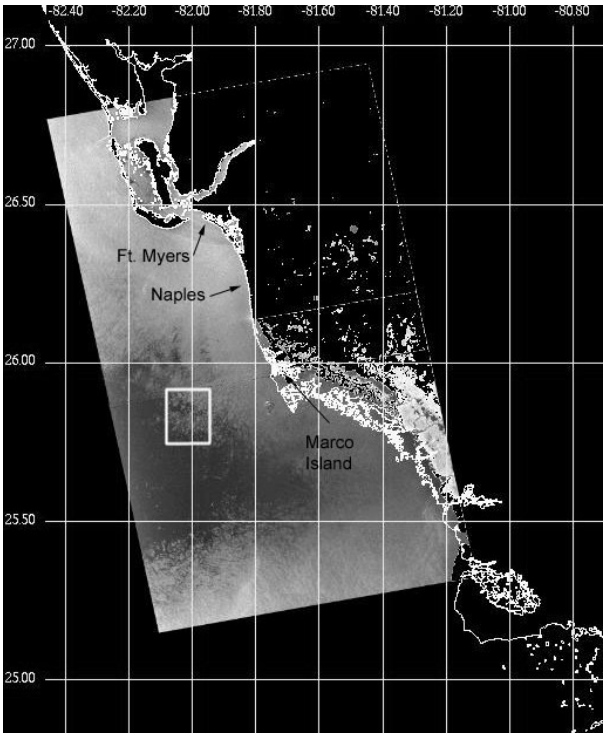

Figure 2. RADARSAT-1 SAR image taken on May 13, 2001, off the coast of Western Florida. White box corresponds to Fig. 3. Copyright Canadian Space Agency, 2001

SAR can detect slicks caused by algal blooms because the algae produce surface films which in turn dampen the small-scale surface waves, therefore resulting in a low backscatter value. This has been seen in studies done by Gade et. al (1998) and Espedal et al (1995). The high resolution of the data and its ability to be taken without dependency on sunlight or cloud-free conditions make it particularly useful. A major drawback with SAR is that there are many conditions besides oil or natural slicks that can cause low backscatter. It is for this reason that a suite of data sets used in unison, with a tool such as WIPE, is particularly useful.

Landsat data can also be used when looking at algal blooms, but these data were only available without clouds between 5 and 11 days removed from May 13, 2000, and they did not show any

unusual signatures that would indicate an algal bloom. It is believed, however, that an algal bloom may have occurred near May 13, 2000 because the Florida Marine Research Institute announced a red tide near Marco Island from December through at least March 2000. Marco Island is just south of Naples, Florida and within our SAR imagery.

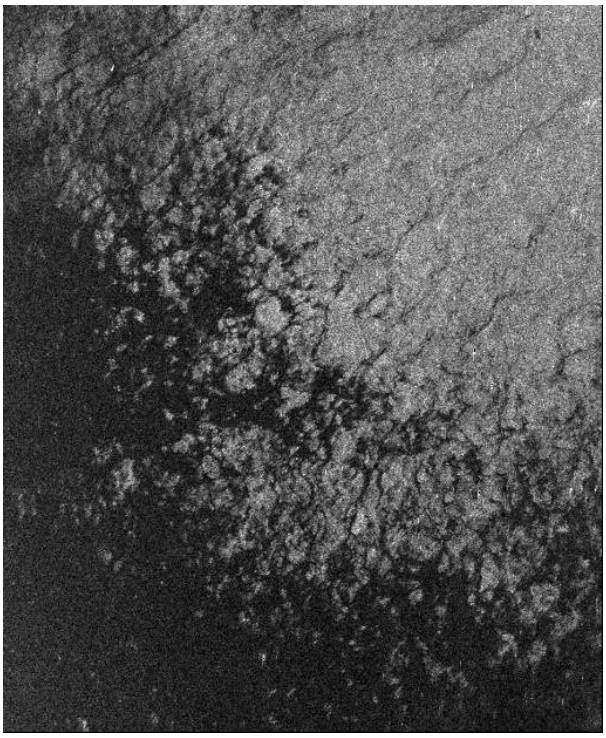

Figure 3. A closer look at "slicks" from Fig. 2. Copyright Canadian Space Agency, 2001

SeaWiFS data is another data source that can be used to observe algal blooms. A very effective use of SeaWiFS is to process it with a chlorophyll algorithm. SeaWiFS data for the three days around May 13, 2000 has been received, but as of press date, the processing is not yet complete. This will hopefully be a very useful data set to incorporate into WIPE.

5. CONCLUSIONS

The example of a possible algal bloom observed with SAR on May 13, 2000 did not yield conclusive results to explain the observed area of low backscatter. It did serve as an introduction to the WIPE system that will be used in the NOAA/NESDIS GoMEx project. When the system is complete and the expected data sets are available, this tool should be of great use in studying phenomena of this kind in the Gulf of Mexico region, as it has been in Alaska with the AKDEMO. SAR imagery is a very useful data set, but without ancillary data, a lot of questions can be left unanswered. This leads to the need for the data to be easily compared with other data sets that are georeferenced to the same projection and that can be served up on a user accessible platform such as WIPE.

6. ACKNOWLEDGEMENTS

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