Near Real-Time RADARSAT Data System for NOAA CoastWatch Applications

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Abstract -- The National Oceanic and Atmospheric Administration (NOAA) in partnership with other U.S. Government agencies has augmented existing satellite reception and processing facilities at the Alaska SAR Facility (ASF) to provide near real-time access to synthetic aperture radar (SAR) data for U.S. Government operational applications. Access is available for RADARSAT SAR data acquired by the ASF in Fairbanks, Alaska, by the Canadian readout stations in Gatineau, Quebec and Prince Albert, Saskatchewan, and by the Norwegian station in Tromso. Qualified user access to these data is provided by the NOAA Satellite Active Archive (SAA). A major user of SAR data in NOAA is the CoastWatch program. This paper will provide an introduction of this near real-time RADARSAT data system and some preliminary results of the use of RADARSAT data for ocean applications.

INTRODUCTION

Current remote sensors aboard the U.S. civilian weather satellite system do not provide all the ocean measurements required by the U.S. operational and research communities. In order to remedy this situation in a cost effective manner, NOAA's National Environmental Satellite, Data, and Information Service (NESDIS) has been developing interagency and international agreements and data access systems to obtain data and products from Department of Defense (DoD) and foreign satellites. This activity is being coordinated and funded by the NOAA Satellite Ocean Remote Sensing (NSORS) project within NESDIS.

The NOAA CoastWatch program has the objective of making satellite data and in-situ data from NOAA environmental satellites and buoys available to Federal, state, and local marine scientists and coastal resource mangers for decision making. The NSORS project has the goal of providing not only NOAA satellite data, but also non-NOAA satellite data, such as RADARSAT SAR data, to qualified users in many participating Governmental agencies and research organizations. SAR instruments have very diversified applications, such as ice and coastal ocean monitoring, vessel surveillance, cartography and land use, as well as applications in geology, hydrology, agriculture, and forestry. SAR instruments are particularly useful for operational applications, since they operate through clouds and day or night.

NOAA, in partnership with the U.S. Navy through the U.S. National Ice Center (NIC), has been constructing a system which allows operational access to SAR imagery from the Canadian Space Agency RADARSAT satellite. Building on existing ground acquisition stations, NOAA and the Navy have co-funded processing, communications, data storage and display system enhancements in order to provide the U.S. Government with these data in near real-time. Initially, the major users of this system will be the NIC and NOAA CoastWatch; however, other Government agencies, such as the Department of Agriculture and U.S. Coast Guard, will also be assessing the operational utility of SAR imagery.

The goals of the NOAA/Navy operational RADARSAT data system efforts are to: (1) implement a near real-time processing, delivery, and access system for SAR imagery from RADARSAT for NIC, NOAA, and other U.S. Government operational agencies, (2) develop SAR workstation software for image display and product generation for use in an operational environment, (3) demonstrate and operationally implement practical applications of SAR imagery, and (4) experiment with the data fusion of SAR, ocean color, and thermal and visible imagery [1].

In order to apply SAR data to ocean research and applications, NOAA is cooperating with ocean and ice scientists of the National Aeronautics and Space Administration (NASA) Goddard Space Flight Center (GSFC), and the Jet Propulsion Laboratory (JPL). Cooperative projects include coastal ocean research, wavelet software development and applications to oceans, and exploration of algorithms for sea/lake ice cover mapping, classification, and monitoring. Examples of mesoscale feature mapping and tracking are demonstrated in this paper using a two-dimensional wavelet technique developed by NASA. The development of the wavelet software [2] is still in the research phase, but the goal is to transfer the technique into an operational environment. An example of lake ice cover

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classification and mapping using RADARSAT SAR data will also be demonstrated.

SYSTEM DESCRIPTION

RADARSAT is equipped with an advanced SAR operating at a single microwave frequency, C band (5.3 Ghz frequency or 5.6 cm wavelength). RADARSAT transmits its microwave energy in horizontal orientation and the energy that returns to its sensor is captured using the same polarization (HH polarization system). There are seven image sizes, termed beam modes, ranging from Fine (50x50 km coverage) to ScanSAR Wide (500x500 km coverage), with resolutions ranging from 10 m to 100 m, respectively.

The architecture and data flow of the operational near real-time RADARSAT data system is shown in Figure 1. Data will be acquired and processed into imagery principally at three acquisition stations: (1) Fairbanks, Alaska, (2) Gatineau, Quebec, and (3) Tromso, Norway. Some other data will probably be acquired at Prince Albert, Saskatchewan (processed in Gatineau) and at McMurdo in Antarctica (processed in Fairbanks). Data obtained via the on-board tape recorder, normally acquired by Gatineau, will be processed in Canada or sent via courier to Fairbanks for processing. SAR imagery then is forwarded electronically from the three processing centers to either the NOAA Satellite Active Archive or the NIC.

The primary acquisition station for U.S. users of near real-time SAR imagery is the ASF located at the University of Alaska Fairbanks (UAF), sponsored by NASA, with software and hardware systems built by JPL. Data are acquired by the ASF Receiving Ground Station (RGS), and processed by either the Alaska SAR Processor (ASP), which is a hardware SAR processor, or the ScanSAR Processor (SSP), which is a software SAR processor running on three 8-node IBM SP-2 computers. The full-system throughput at ASF is 58 minutes of Standard Mode and 51 minutes of ScanSAR data per day. The images formed from the processors are then sent to the Information Management System/Data Archive and Distribution System (IMS/DADS) which forms the normal user interface. Then the near real-time data are sent automatically to the Advanced Earth Observing Satellite (ADEOS) Data Stripper where data are transmitted over a dedicated T1 (1.544 megabits/sec) communication link to the NOAA/NESDIS/SAA first and then passed to the NIC automatically (both in Suitland, Maryland). Data from Gatineau and Tromso will arrive first at the NIC and then be passed on to the SAA. The registered users are notified by e-mail when imagery arrives, and is ready for downloading over the Internet. The data will be on-line in SAA for a week, then written to 8 mm tape for longer-term storage. In Phase II of the SAA SAR system, scheduled for implementation by the end of 1997, imagery will be stored on near-line robotic tape storage so that users can access them electronically for up to a year. Imagery will be maintained on tape for about three years by the NOAA National Climatic Data Center (NCDC).

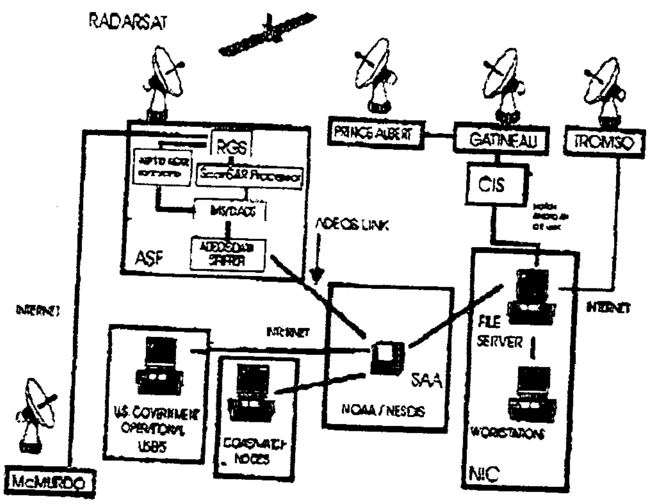

Figure 1. Architecture and Data Flow of the Operational Near Real-Time RADARSAT Data System

NOAA COASTWATCH APPLICATIONS

We have included here two RADARSAT images as examples. Figure 2, taken on February 26, 1997 along the east coast of Uruguay at the mouth of the Rio de la Plata, is a ScanSAR Narrow image with 25m pixel spacing. The Mexican hat wavelet transform was applied as an edge detector to separate high contrast boundaries. The possible location of an oil spill is characterized by darker areas circled by white lines in the upper part of the image. Similar patterns were also found in daytime AVHRR images in the form of higher skin sea surface temperature (the presence of oil spills needs to be confirmed by ground truth). In previous studies, under favorable oceanic and atmospheric conditions, the spilled oil was indicated by higher IR skin temperature than the surrounding water during daytime[3], and was revealed as darker areas in the SAR image due to a damping effect on the short surface waves [2]. This darker appearance is also found in low wind areas. Further studies of this oil spill case can be found in [5]. Figure 3, taken of western Lake Superior on March 16, 1996 is a ScanSAR Narrow image. Using the methodology of supervised, level slicing classification, the areas of open water, new lake ice, and snow ice have been identified [4].

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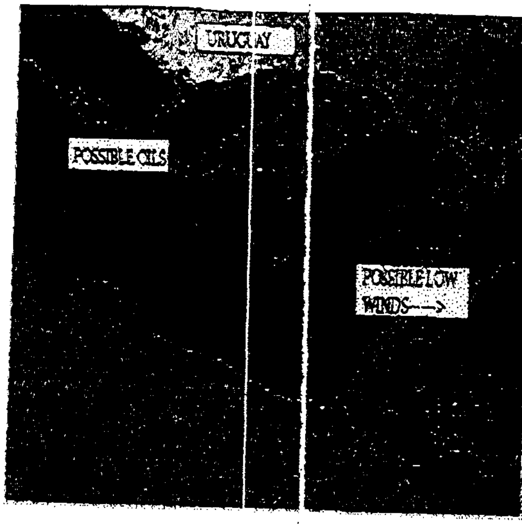

Figure 2. RADARSAT ScanSAR Narrow image, taken on February 26, 1997, showing oil spills along the coast of Uruguay at the mouth of the Rio de la Plata (Copyright CSA, 1997)

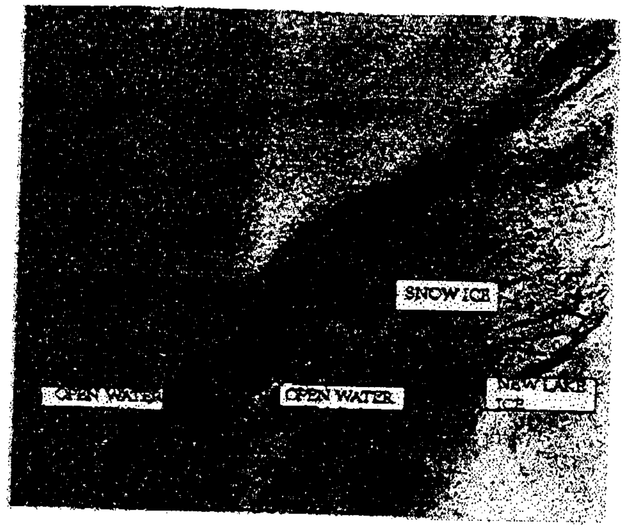

Figure 3. RADARSAT ScanSAR Narrow image, taken on March 16, 1996, showing open ice, new lake ice, and snow ice in Western Lake Superior (Copyright CSA, 1996)

Currently, within NOAA CoastWatch, the following applications of SAR data have been or will be assessed for operational utility and feasibility: (1) sea/lake ice applications, (2) fishery enforcement and applications, (3) ocean mesoscale feature detection, (4) wind and wave measurements, and (5) coastal hazards. Those CoastWatch sites participating in SAR studies are: the Anchorage Weather Service Forecast Office, the Great Lakes Environmental Research Laboratory, and the National Marine Fisheries Service Laboratories at Narragansett and at the Stennis Space Center.

ACKNOWLEDGMENT

The RADARSAT SAR system described above could not have been developed without the full partnership of the National Ice Center. Key NIC participants have been Ray Simmons, Cheryl Bertoia, Steve Rutherford, Mark Dunn, Frank Kniskern, Dave Howell, and John Dowdell. Special thinks to the Alaska SAR Facility staff including Carl Wales, Cindy Wilson, Greta Reynolds, Marc Forbes, and Dick Harding, and to Bruce Ramsay and John Falkingham at the Canadian Ice Service. Our thanks also to the large staff of Government and contract employees at NESDIS, NASA, NRL, and JPL who have and are still working toward the successful implementation and operation of this data system. We would like to thank the U.S. Coast Guard, Ninth District for providing ship and helicopter support. We also thank Dr. Sunny Wu of USRA for providing wavelet analysis in Figure 2. RADARSAT SAR images provided by the Canadian Space Agency are also acknowledged. This work was supported by the NOAA Coastal Ocean Program and NESDIS/NSORS Program.

REFERENCE

[1] W.G. Pichel, R.N. Stone, W. Tseng, P.Clemente-Colón, and D.S.Trush, "NOAA satellite ocean remote sensing near real-time system for providing synthetic aperture radar data for marine and coastal applications," *in Proc. Fourth International Conference on Remote Sensing for Marine and Coastal Environment*, 17-19, March 1997, Orlando, Florida, USA, Vol. I, pp. 331-340.

[2] A.K. Liu, C.Y. Peng, and S.Y.-S. Chang, "Wavelet analysis of satellite images for coastal watch," *IEEE Journal of Oceanic Engineering*, Vol. 22, NO. 1, 1997, pp. 9-17.

[3] W.Y. Tseng and L.S. Chiu, "AVHRR observations of Persian Gulf oil spills," in *Proc. IGARSS'94*, 1994, pp. 779-782.

[4] G.A. Leshkevich, S.V. Nghiem, and R. Kwok, "Satellite SAR remote sensing of Great Lakes ice cover using RADARSAT data," *in Proc. Fourth International Conference on Remote Sensing for Marine and Coastal Environment*, 17-19, March 1997, Orlando, Florida, USA, Vol. I, pp. 126-134.

[5] A.K. Liu, S.Y. Wu, and W.Y. Tseng, "Wavelet Analysis of Satellite Images for Coastal Monitoring," to be published in *Proc. IGARSS'97*, 1997.

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Preface

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Chapters

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