Coastal Ocean Applications Demonstrations of ALOS PALSAR Imagery for NOAA CoastWatch

William Pichel – Center for Satellite Applications and Research

Frank Monaldo – The Johns Hopkins University Applied Physics Laboratory

Christopher Wackerman – General Dynamics Advanced Information Systems

Christopher Jackson – Global Ocean Associates

Xiaofeng Li – IMSG at NOAA/NESDIS

Pablo Clemente-Colón - National Ice Center

Oscar Garcia-Pineda – Florida State University

ALOS PI Meeting
Kona, 11/9/2009
Coastal Ocean Applications Demonstrations of ALOS PALSAR Imagery for NOAA CoastWatch

Outline

• Research Goals

• CoastWatch

• Alaska SAR Demonstration (AKDEMO)

• Hurricane Hazard Response
(1) Develop quantitative and qualitative coastal and hydrologic applications of ALOS L-band SAR imagery for NOAA’s CoastWatch Program.
   • Ocean surface winds
   • Vessel positions
   • Oil spill mapping
   • Ocean Feature Detection
   • River Ice Monitoring

(2) To demonstrate these applications by conducting application demonstrations in near-real-time, if possible.
   • Alaska SAR Demonstration
   • Hurricane Hazard Response
CoastWatch:
A national program within NOAA to produce and distribute satellite-derived ocean products via regional NOAA laboratories that provide local user support to a diverse marine user community (Atlantic, Pacific, Gulf of Mexico/Caribbean, Great Lakes, Hawaii, and Alaska).

SAR Products will eventually be distributed by CoastWatch along with SST, Ocean Color, ocean surface winds and other satellite-derived ocean products.
AKDEMO: A pre-operational demonstration of near real-time coastal and marine products for Alaskan waters, derived from satellite synthetic aperture radar (SAR) data.
SAR Coastal Winds using ALOS PALSAR

Aleutian Islands, Alaska
L-Band PALSAR Wind Performance

PALSAR versus NOGAPS Model wind speed. Error bars are 90% confidence limits. Monaldo and Thompson, IGARSS 2008 using the PALSAR GMF from Isoguchi and Shimada, IGARSS 2007.

No Correction

With $\sigma_0$ Correction
ALOS “Vessel Positions”

ALOS PALSAR image for August 23, 2007 in Cook Inlet, Alaska, with automated vessel detection graphics. Squares are detections within 2 km of coast – usually land targets. Triangles are open ocean detections – in Cook Inlet these are a combination of ships and oil platforms. Green detections are strong, red detections are weak.
Status of use of ALOS in AKDEMO

• Progress:
  – Wind product development
  – Initial ALOS calibration correction
  – Vessel detection product development

• To be done:
  – Validation of ALOS winds
  – Routine generation of winds for National Ice Center
  – Short-duration near-real-time demonstration in Alaska
  – Implementation of updated vessel detection algorithm
  – River ice research including multi-polarization data
  – Other applications of multi-polarization data.
Hurricane Hazard Response – Started after 2005 Season

Research into Assimilation of SAR Winds into Hurricane Models

Oil Platform Change Detection

Oil Release

Oil spill imagery

SAR Hurricane Winds
Hurricane Rita

Hurricane Structure
Hurricane Rita
Oil Platform Change Detection

Purpose: To develop a method to rapidly identify changes (existence or position) in the oil and gas platforms located in the Gulf of Mexico after tropical events.

• Motivation: If wide-area assessments can be made of oil platform changes within 1-3 days after hurricane landfall, then reconnaissance flights can be carried out much more efficiently resulting in significant savings and increased safety.

• Requestors: National Ocean Service Remote Sensing Division
  Minerals Management Service
  U.S. Coast Guard
Data Sources

- NOAA obtains SAR data for the Hurricane Hazard Response applications demonstration from:
  - CSTARS, Univ. of Miami
  - Alaska Satellite Facility, Univ. of Alaska, Fairbanks
  - ESA Rolling Archive

Satellites
ERS-2
ENVISAT
RADARSAT-1/2
ALOS
TerraSAR-X
COSMO-SkyMed
Methodology - Overview

- Obtain and filter the MMS Platform data files to determine the current platform positions in the Gulf of Mexico.
- Process SAR imagery for target detection and wind speed
- Import results into the NOAA database and perform additional internal database processing and table updates
- Generate a list of “missing” platforms with platform type and prior detection probabilities
  - Find the SAR detections in a particular image that are within a few hundred meters of the MMS positions.

These results are shown graphically on slide 22

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Methodology (Detail)

MMS Database Files (ASCII) → MMS-C → Processing / Filtering → MMS Table Id/Lat/Lon/Type → Spatial Queries and Table Updates → Image Metadata Table Date/Time/Image Region # of Covered MMS Platforms → Detections Table Lat/Lon/Corrections → Conditions Table Platform Position Wind Speed/Direction/Geometry → Detections Results Table Lat/Lon/Corrections → Detection Processing (MATLAB)
2008 Hurricanes - Gustav

Gustav Track
(JHU/APL Hurricane Website)

AVHRR IR Channel 4
1 Sept 2008 07:04 UT
2008 Hurricanes – Ike

Gustav Track
(JHU/APL Hurricane Website)

AVHRR IR CH4
13 Sept. 2008, 04:02 UT
• 3363 platform positions recorded in the MMS database (Sept 2008) with no associated removal date
  – 3263 distinct positions with 3251 distinct complex identifications
SAR Coverage Post Ike
16-18 September 2008

- RADARSAT-1 Wide
  16-SEP-08
- ENVISAT Standard
  17-SEP-08
- ALOS Standard
  18-SEP-08

Destroyed (60)
Damaged (31)
PALSAR Results – 18 Sep 2008 Image 550

Red - Destroyed

- 136 MMS platform positions covered by this image
- 8 of 16 Destroyed platforms designated as missing (M)
- 8 Destroyed platforms with SAR returns
NOAA STAR has in place a working system that uses SAR imagery to identify oil platforms that are “missing” after tropical events in the Gulf of Mexico.

• Ike
  – Identified 12 of 25 platforms in the imaged area that were subsequently declared destroyed by MMS. The remaining 13 platforms all had strong SAR returns. Five platforms had associated oil spills
    • Destroyed does not equal not visible
  – There were an additional 28 “missing declarations” for an imaged region covering 598 platform positions

• We are investigating and characterizing the “missing declarations”
  – Platform is not detectable (Size/Type/Wind Conditions)
  – Believe it is related to platform size.
    • Many missing declarations are caissons/well protectors – pipes sticking out of the water

• A possible way to improve results is to systematically collect standard mode imagery over the region and develop a SAR derived platform location baseline / database
NOAA Development and Improvement Work

- Refine and streamline the platform detection technique
  - Determine the best method to ensure accurate pixel location to latitude/longitude conversion
    - Should be able to refine the proximity distance between SAR and MMS to better the 800 meters
  - Develop a method to improve the results from wideswath imagery
    - High near range returns overwhelm the target detection
  - Improve the prior detection probability calculation
    - Integrate environmental conditions (wind speed)
    - Investigate the roles of wind speed/resolution/polarization/incidence angle/platform size
      - Preseason survey would help with prioritizing post event results
  - Investigate the relative merits of C-band vs. L-Band (vs. X-band)

- Develop the capability to process, Radarsat-2, TerraSAR-X, and COSMO-SkyMed
Current Activities - 2009 Season

• **Work with MMS to get a better understanding of their current platform database**

• **Pre-season survey with ENVISAT/ALOS/RADARSAT-2**
  – Establish a SAR-based list of detected platforms
  – Gain experience with ALOS and RADARSAT-2

• **Have in place the system for scheduling acquisitions and obtaining the data**
  – Short lead time satellite acquisition programming incurs extra cost

• **Develop a post hurricane collection plan**
  – Determine where, relative to the hurricane track, to focus acquisitions
  – Develop capability to rapidly determine the best mix of acquisitions from the available SAR satellites
Filled on 14 July 2009 with a NGA sponsored Radarsat-2 collection
Concept of Operations

- To be most useful the post hurricane oil platform evaluation must be done in days 1-5 after an event
  - This timeline can only be accommodated by having access to all 9 of the commercially available SARs
    - No control over when and where the hurricane strikes vs. orbital phase of the satellites
    - Focus will be on high incidence angle 100 km swath imagery for oil platforms/rigs
    - If high incidence angle coverage is not possible we will collect large area wide swath coverage for evaluation of oil spills
- Approximately 72 hours before the storm reaches the oil platform region, a decision will need to be made on whether a post-event data collection will be done. This is necessary to get the first image on the day after the storm passes.
  - Minerals Management Service / FEMA decision
  - After deciding to collect NOAA NESDIS will work with MMS/FEMA to determine the collection region
  - With the collection region defined NOAA will then work with CSTARS or other acquisition stations to schedule data collections
    - Example on the following slide
Oil Spill Mapping

Purpose: To develop interactive methods of rapidly assessing whether there are any anomalies in the ocean that may be associated with oil spills or natural oil seeps, especially used following tropical events.

Motivation: If wide-area assessments can be made of oil spills within 1-3 days after hurricane landfall or ship accident while underway or docked, then reconnaissance flights can be carried out much more efficiently resulting in significant savings and perhaps increased safety.

Requestors: National Ocean Service Emergency Response Division Response agencies and companies Minerals Management Service U.S. Coast Guard
Texture Classifying Neural Network Algorithm
Oscar Garcia-Pineda - Florida State University

Analysis of Oil Spill with TCNNA (Envisat SAR image 07/26/09)

Oil Spill Area: 32 Km²
Texture Classifying Neural Network Algorithm (TCNNA)

Oscar Garcia-Pineda
Data Integration Approach

Four types of Data Integrated:

- Satellite Variables e.g. (Incidence Angle, Beam Mode)
- Texture Features
- Neighborhood
- Environmental Data
Mapping Oil Spills
Steps to Operations:

- Transition manual analysis and data scheduling/ordering to SAB from STAR
- Migrate the Canadian Ice Service ISTOP Oil Spill Analysis System to NESDIS/SAB
- Develop algorithms for oil slick mapping to be used as analyst tools
- Analyze spills in an experimental mode until operational SAR data are available
- Begin operational production with Sentinel-1, ALOS-2, and RADARSAT Constellation Mission
Summay

• ALOS PALSAR research in NOAA has resulted in:
  – Initial wind imagery
  – Vessel positions
  – Integration of ALOS into oil spill analysis activities
  – Use of ALOS PALSAR for post-hurricane oil platform change detection

• Work to be done:
  – Validation of winds and vessel positions with sea truth information
  – Operational processing systems development and implementation
    • By July 2011 for winds and oil spills
    • After that for vessel positions, oil platform change detection, river ice and other applications.
  – Use of multi-polarization PALSAR modes
1. Alaska SAR Demonstration:
   NOAA: http://www.orbit.nesdis.noaa.gov/sod/mecb/sar
   APL: http://fermi.jhuapl.edu/sar
   ASF: http://wind.asf.alaska.edu/windspeed/sar_web

2. GhostNet Home Page:
   http://www.highseasghost.net

3. SAR Marine Users Manual - Global Ocean Associates
   site: http://sarusermanual.com

4. SAR Wind User’s Guide - SSARGASSO site:
   http://fermi.jhuapl.edu/sar/stormwatch/user_guide/