SAR-Derived High-Resolution Wind Products within NOAA CoastWatch

ENVISAT SAR Wind Image
January 5, 2012  19:41Z

Gulf of Alaska - Southeast Alaska coast
SAR-Derived High-Resolution Wind Products within NOAA CoastWatch

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OUTLINE

1. SAR Wind Product Development

2. Operational SAR Wind System
   Architecture
   Improvements during implementation
   CoastWatch output
   Product Validation
AKDEMO: A pre-operational demonstration of near real-time coastal and marine products for Alaskan waters, derived from satellite synthetic aperture radar (SAR) data.

AKDEMO APPLICATIONS

- Vessel Detection
- Ice Masks
- River Ice Spring Breakup
- Quantitative Coastal Winds
- Mesoscale Wind Features

AKDEMO began in 1999.
AKDEMO Coastal Wind Product Developed by
The Johns Hopkins University Applied Physics Lab

SAR WIND SPEED PRODUCT – Sept 1999
1. Initiated AKDEMO with RADARSAT-1 SAR Winds – 1999

2. Published Wind Validation Results – 2001 - 2004

3. Added ENVISAT Winds - 2006

4. NWS Request to Transition Winds to Operations – 2008

5. Added ALOS Winds - 2009


8. Added RADARSAT-2 Winds (not validated yet) - 2012

9. SAR Wind Operational Implementation - Now
Synthetic Aperture Radar (SAR) Satellite Missions

Canada: RCM (3 Sats)

On orbit
Approved
Planned/Pending

TerraSAR-X (2 satellites)

Operational Data Sources

Canada: RADARSAT-1

Canadian: RADARSAT-2

Japan: ALOS/PALSAR

Germany: TerraSAR-X/TANDEM-X (2 Sats)

Italy: COSMO-SkyMed (4 Sats)

ESA: ERS-2

ESA: ENVISAT

Japan: ALOS 2

US: DESDynl

US: SMAP

ESA: Sentinel-1 (2 Sats)

Canada: RCM (3 Sats)

US: SMAP
**SAR Winds Operational Implementation**

**Product Overview**

**SAR Wind Product**
- Derived from the calibrated normalized radar cross section of a SAR image (C-, L-, or X-band) using *a priori* information on wind directions
- Horizontal resolution: 500 meters
- Accuracy: 1 m/s (bias) < 2.5 m/s (RMS) for wind speeds of 3-15 m/s, less accurate for 16-50 m/s
- Timeliness: 1-4 hrs
- Coverage Priority
  - Alaska
  - Washington State
  - Great Lakes
  - Gulf of Mexico during hurricane season

*Radarsat-1 ScanSAR Wide  03/14/2007 03:29 UTC*  
Kenai Peninsula and Prince William Sound, AK
SAR Wind Algorithm Details

SAR Data Calibration:
Using calibration that comes with SAR data

SAR Data Earth Location:
Accept quick-look earth locations in SAR image

SAR Data Land Masking:
Global Self-consistent Hierarchical High-resolution Shoreline (GSHHS)

SAR Data Averaging:
Average to 0.5 km resolution, regardless of SAR data resolution

Geophysical Model Functions (GMF):
C-band: CMOD5; L-band: JAXA Algorithm (Shimada); X-band: X Mod 0 (APL)

Polarization Ratio (needed to apply VV GMF to HH SAR data):
C-band: Mouche; L-band: Need to develop; X-band: X Mod 0 (APL)

A Priori Wind Directions (required for GMF):
GFS model 10-m surface wind directions
After more research, incorporate wind-aligned wind directions from SAR data along with model directions
Opn’l SAR Product Processing Chain

Level 1 Processed Multilook SAR Imagery Source A

Level 1 Processed Multilook SAR Imagery Source B

Standardized SAR Data Ingest Processing and Calibration

GFS or Other Wind Directions

Land Mask (Binary)
NRCS (Binary)
Metadata (ASCII)

Wind Speed

NetCDF4 Level 2 & 3

CoastWatch Product Output

GeoTIFF, PNG, HDF, Shapefile, kmz, NetCDF4

Buoy Winds
ASCAT Winds
Model Winds

Validation

CoastWatch Website /DDS/AWIPS
SAR Operational Data Flow (2012)

RADARSAT 1/2

ENVISAT / Sentinel-1

Tromso, Norway
and
Gatineau, Canada

Internet/FTP

ESA and CSA Reception
Stations (and perhaps ASF) and
ESA Rolling Archive

Acronyms:
ASF = Alaska Satellite Facility
CLASS = Comprehensive Large Array-data
Stewardship System
ESPC = Environmental Processing Satellite Center
NAIL = North American Ice Link
NIC = National Ice Center

Internet/FTP

Internet/FTP

Internet/FTP

Internet/FTP

ESPC Data Distribution System

OSPO SAR Operational
Product Processors

STAR SAR Developmental
Product Processors
System Upgrades During Transition to Operations

- Improved data flow
  - Data directly from the providers - eliminate CLASS from front end
- New front end data ingester
  - Read all satellite data formats and create a standard metadata / data file format for use by all product processing algorithms
  - Capability to handle much larger data sets (5k x 20k and larger)
- Improved Land Masking
- Improved Model Wind Directions
  - NCEP Global Forecast System replacing NOGAPS
  - SAR Derived Wind Directions (Future)
- Automate Validation
- NESDIS Code and External Documentation Standards
- Product Delivery via CoastWatch, DDS, and AWIPS
- Implement Parallel Processing
- Corporate Product Archive within NODC
CoastWatch SAR Wind Image - Northwest

Data courtesy of: USD/C/NOAA/NESDIS CoastWatch

Satellite: ENVISAT
Sensor: SAR
Date: 2012/01/24 JD 024
Time: 18:35:43 UTC
Scene time: DAY
Projection type: MAPPED
Map projection: 0.0025 deg/pixel GEORGIC
Latitude bounds: 46 N -> 52 N
Longitude bounds: 130 W -> 121 W
CoastWatch SAR Wind Image – East Coast

Data courtesy of: USDOC/NOAA/NESDIS CoastWatch

Satellite: ENVISAT
Sensor: SAR
Date: 2012/01/05 JD 005
Time: 15:13:00 UTC
10:13:00 -0500
Scene time: DAY
Projection type: MAPPED
Map projection: 0.0025 deg/pixel
GEOREPORTIC
Latitude bounds: 35 N -> 41 N
Longitude bounds: 79 W -> 73 W
CoastWatch SAR Wind Image – Lake Huron

ENVISAT Feb 22, 2012 15:51 UT
RADARSAT-2 SAR Wind Image

RADARSAT-2
May 5, 2012  04:18 UT
Alaska Peninsula and Bristol Bay
TerraSAR-X SAR Wind Image

TerraSAR-X March 3, 2008 - Denmark
ENVISAT ASAR Validation – Comparison with Buoy Winds

Number of Matches: 431
Bias (SAR-Buoy): 0.14 m/s
Standard Deviation: 1.41 m/s
ENVISAT ASAR Validation – Comparison with ASCAT Winds

- Number of Matches: 23692
- Bias (ASAR-ASCAT): 0.58 m/s
- Standard Deviation: 1.31 m/s
- Removed Points Percentage: 2.11%
- Bin Size: 0.25 m/s

![Coastal Winds Speed Comparison Graph](image-url)
Examples of Canadian Wind Products
West Coast

Washington

Oregon
External documentation for the Winds and Validation Modules of the SAR High-Resolution Coastal Wind System has been completed. This documentation consists of an Algorithm Theoretical Basis Document for SAR Winds, and required external documentation for the Winds and Validation Modules.

Algorithm Theoretical Basis Document (ATBD) for SAR Winds
Coastal Wind Climatology

Applications
- Met. Forecast Guidelines
- Wind Farm Location
- Ocean Engineering
- Coastal Decisionmaking

Barrier Jet Percent Occurrence along Northern Coast of Gulf of Alaska – JHU/APL
(Winstead et al., 2006; Monaldo et al., 2006, and Loescher et al, 2005)

RADARSAT-1 Sept. 04, 2000 0306 GMT
Wind Image of Barrier Jet (Beal et al., 2005)
Wind wakes shown by clouds downwind of the Horns Rev offshore wind farm, Denmark.
Radarsat-1 mean wind speed field from 1996–2008 at a 80-m height for neutral atmospheric stability – Mouth of Delaware Bay and portion of Delmarva Peninsula coast.

The data have been normalized so that no month is over represented.

Johns Hopkins University
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Operational SAR Products – Future Plans

1. Continue the process of transitioning SAR applications such as coastal winds, vessel positions, oil spill monitoring, Great Lakes ice classification, swell wave measurements, and coastal pollution monitoring from research and experimental operations to full operations using available SAR data.

2. Work with Environment Canada to develop MOUs for joint operational production of SAR winds and oil spills similar to agreements in place for ice products.

3. Pursue operational access to future foreign operational SAR missions, particularly RCM and Sentinel-1, but also ALOS-2, and perhaps others.

4. Work with NASA to obtain operational access to research SAR missions (i.e., DESDynI and SMAP).
The SAR winds product is expected to be the first of several SAR-derived products to be transitioned to automated operations.
The Future – Operational SAR Constellations

CSA RADARSAT Constellation Mission

ESA Sentinel-1