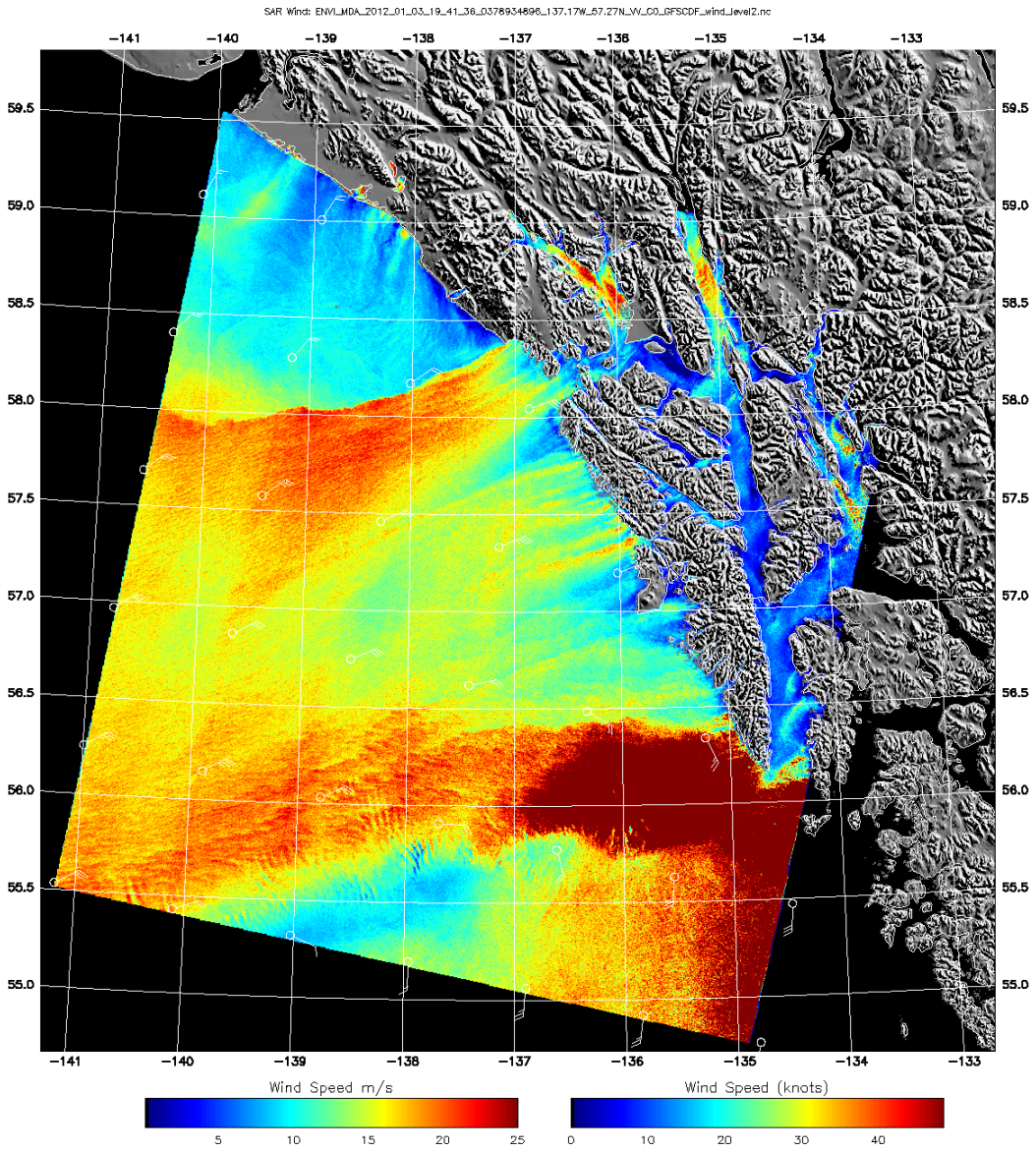
SAR-Derived High-Resolution Wind Products within NOAA CoastWatch



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

Gulf of Alaska - Southeast Alaska coast

SAR-Derived High-Resolution Wind Products within NOAA CoastWatch

William Pichel — NOAA/NESDIS/Center for Satellite Applications and Research

Frank Monaldo — The Johns Hopkins University Applied Physics Laboratory

Christopher Jackson — Global Ocean Associates

John Sapper — NOAA/NESDIS/Office of Satellite and Product Operations

Xiaofeng Li — IMSG at NOAA/NESDIS

Phillip Keegstra — SP Systems, Inc.

SAR-Derived High-Resolution Wind Products within NOAA CoastWatch

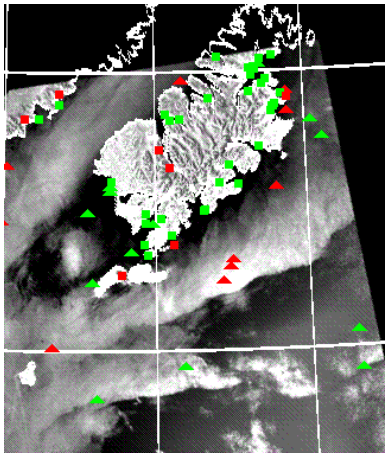
OUTLINE

1. SAR Wind Product Development

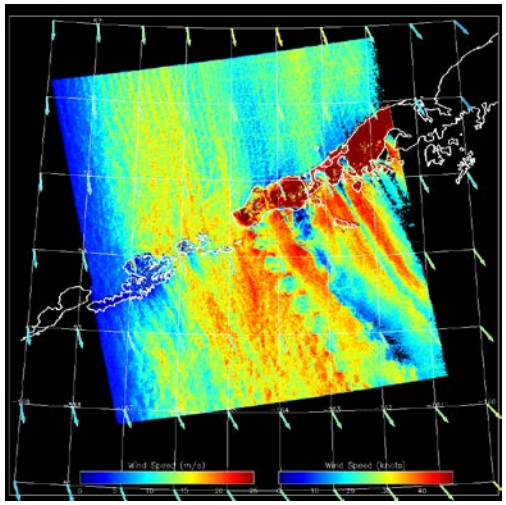
2. Operational SAR Wind System
   - Architecture
   - Improvements during implementation
   - CoastWatch output
   - Product Validation

Alaska SAR Demonstration(AKDEMO) Began in 1999

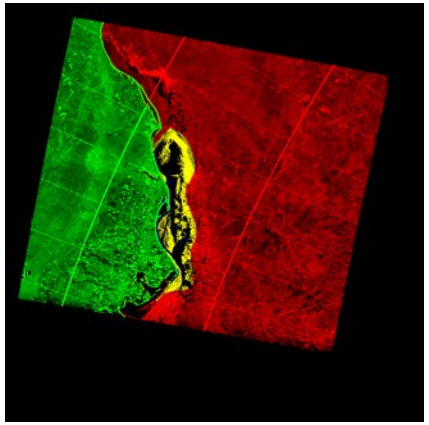
AKDEMO APPLICATIONS



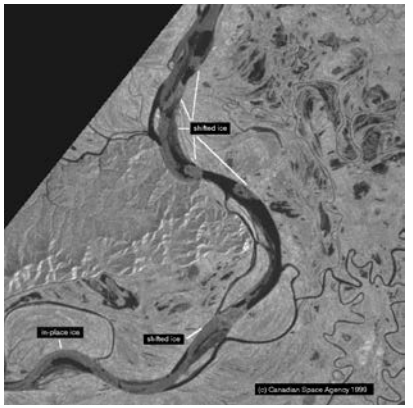
Vessel Detection



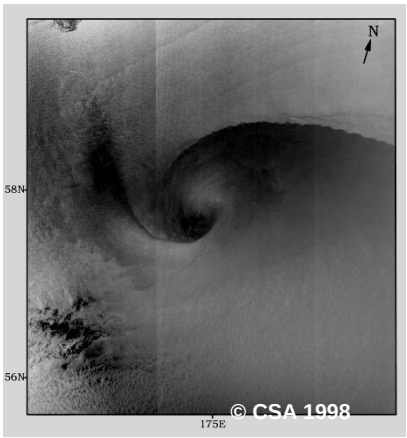
Quantitative Coastal Winds



Ice Masks



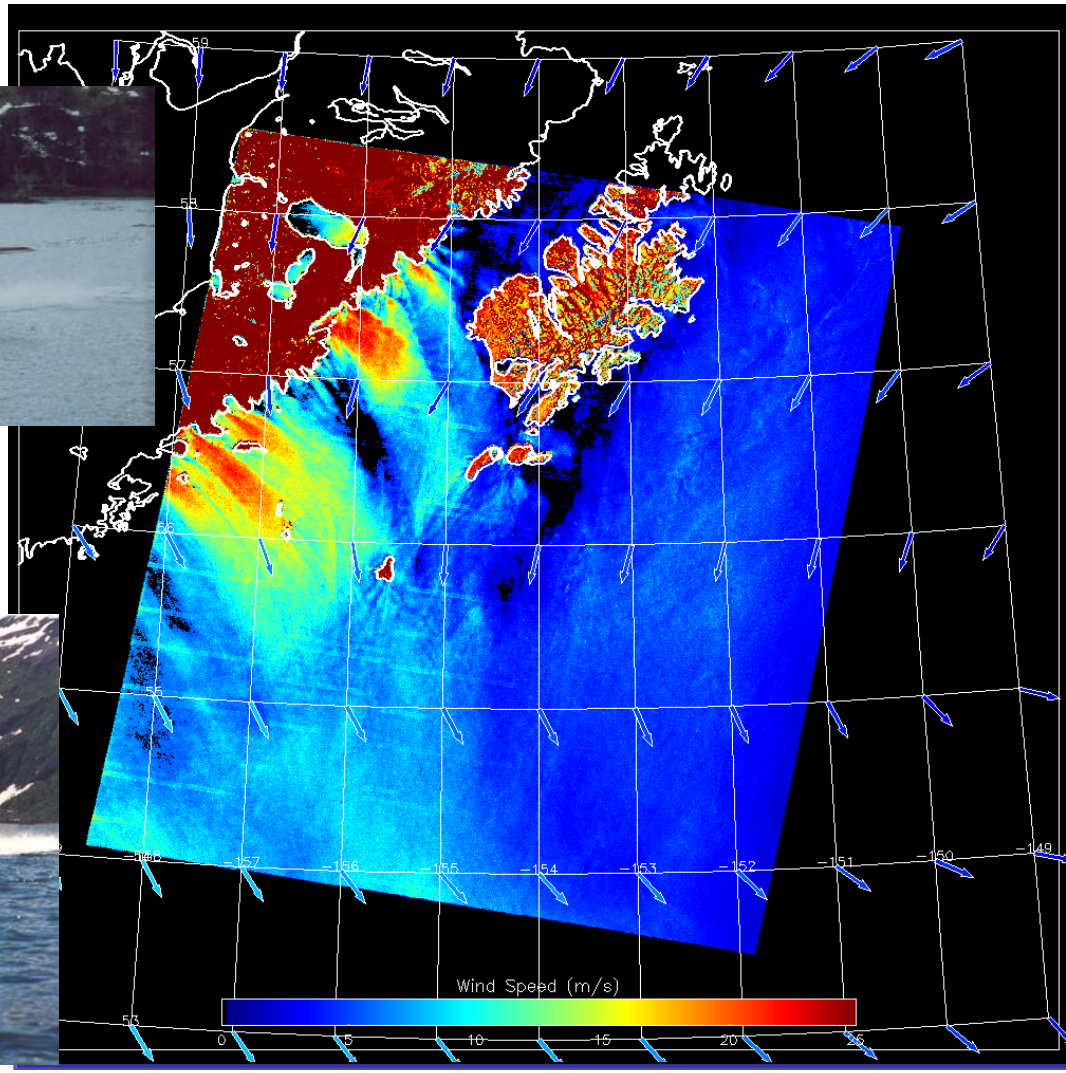
River Ice Spring Breakup



Mesoscale Wind Features

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 Coastal Wind Product Developed by The Johns Hopkins University Applied Physics Lab

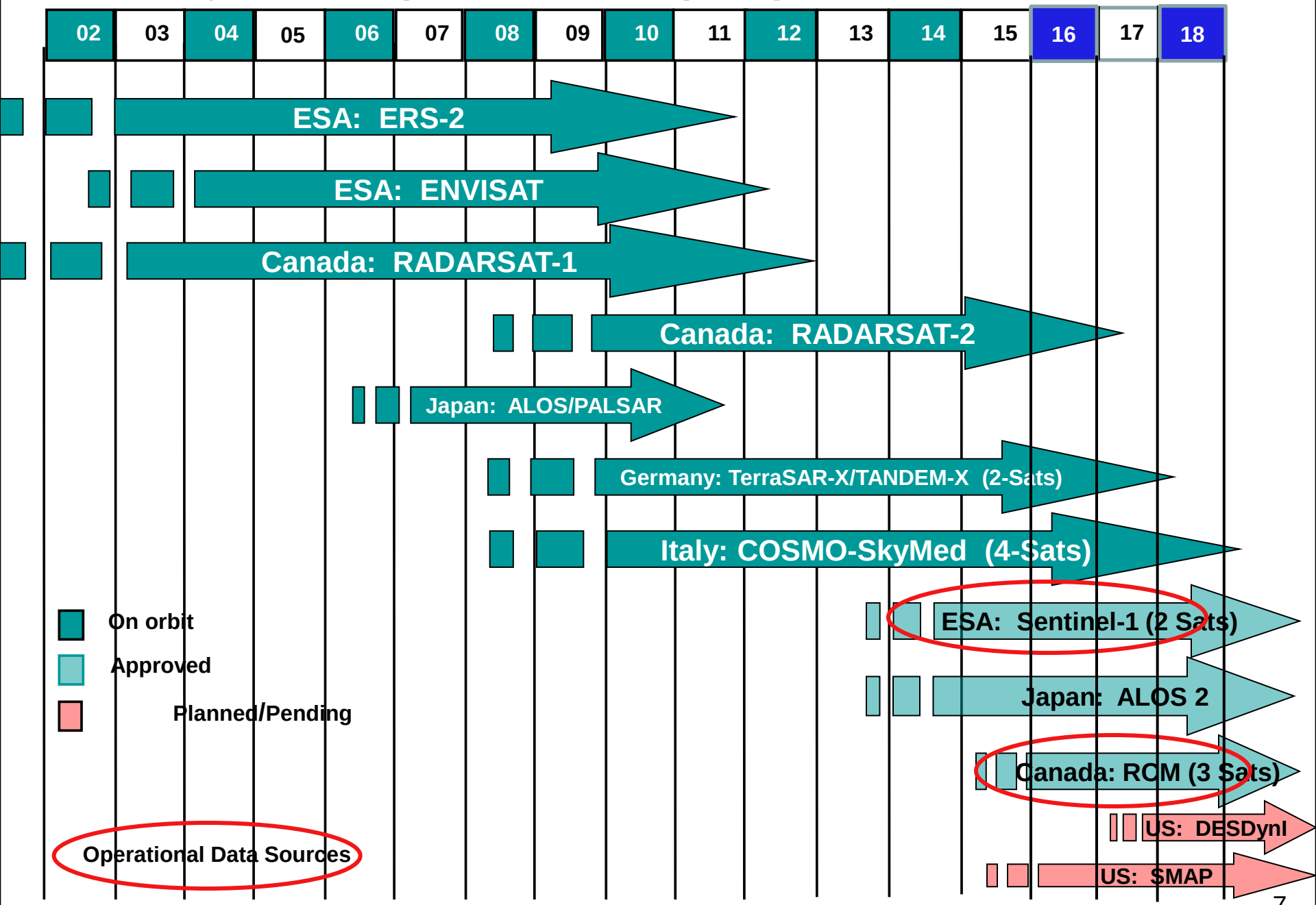


SAR WIND SPEED PRODUCT – Sept 1999

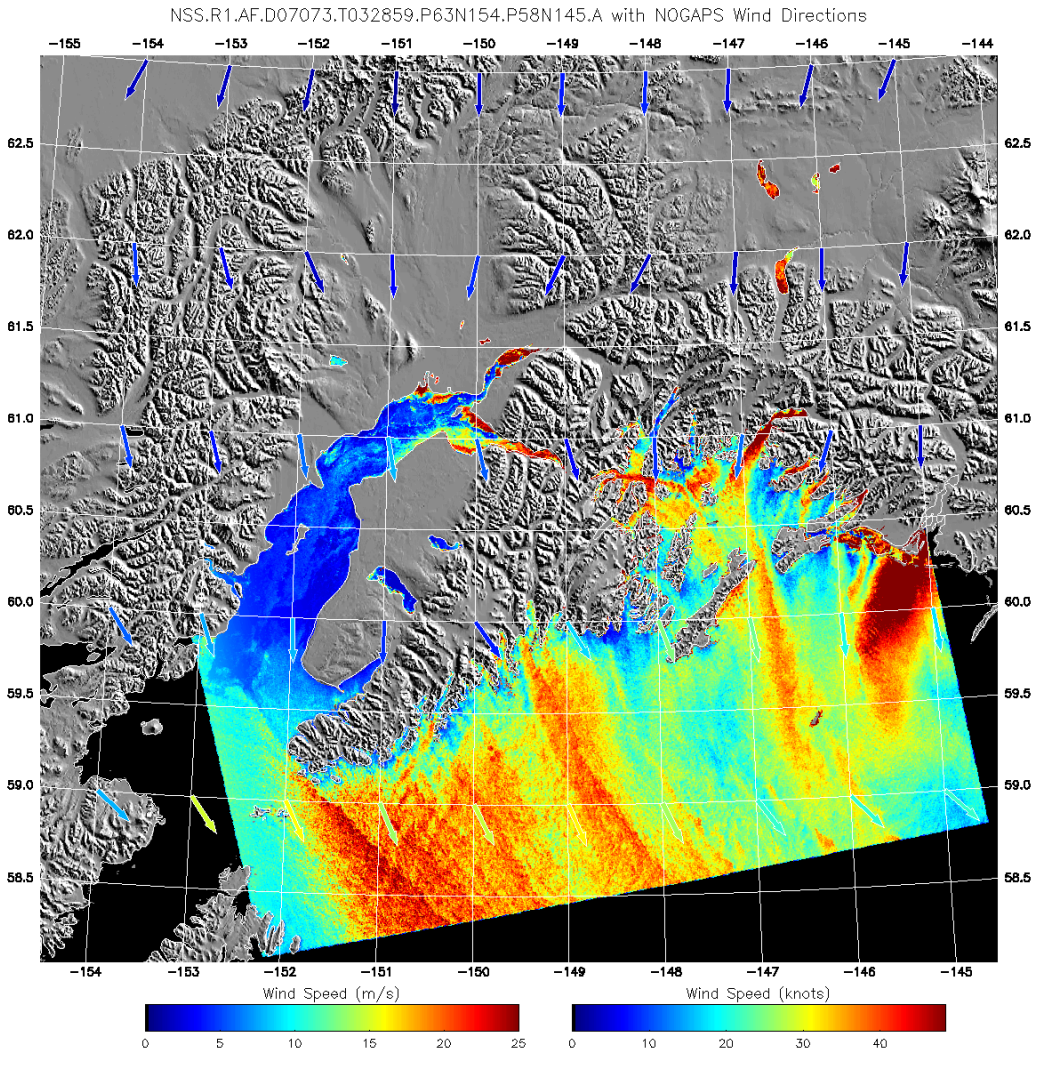
STEPS TOWARD OPERATIONAL WINDS in NOAA

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
6. Operational Winds Design Review – 2009
7. Operational Winds System Development – 2010-2012
8. Added RADARSAT-2 Winds (not validated yet) - 2012
9. SAR Wind Operational Implementation - Now

Synthetic Aperture Radar (SAR) Satellite Missions



SAR Winds Operational Implementation Product Overview



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

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

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)

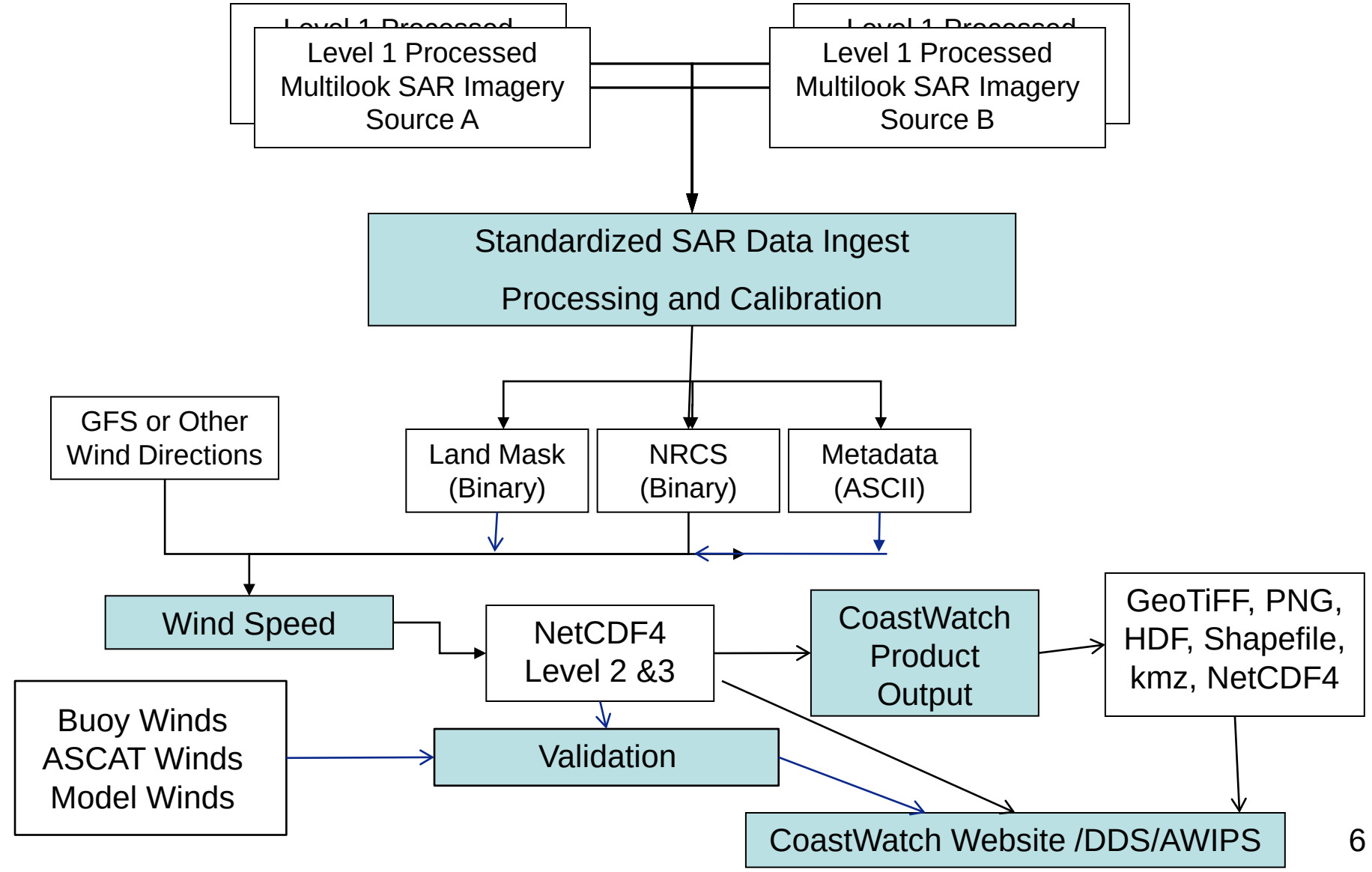
SAR Data Averaging:
Average to 0.5 km resolution, regardless of SAR data resolution

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

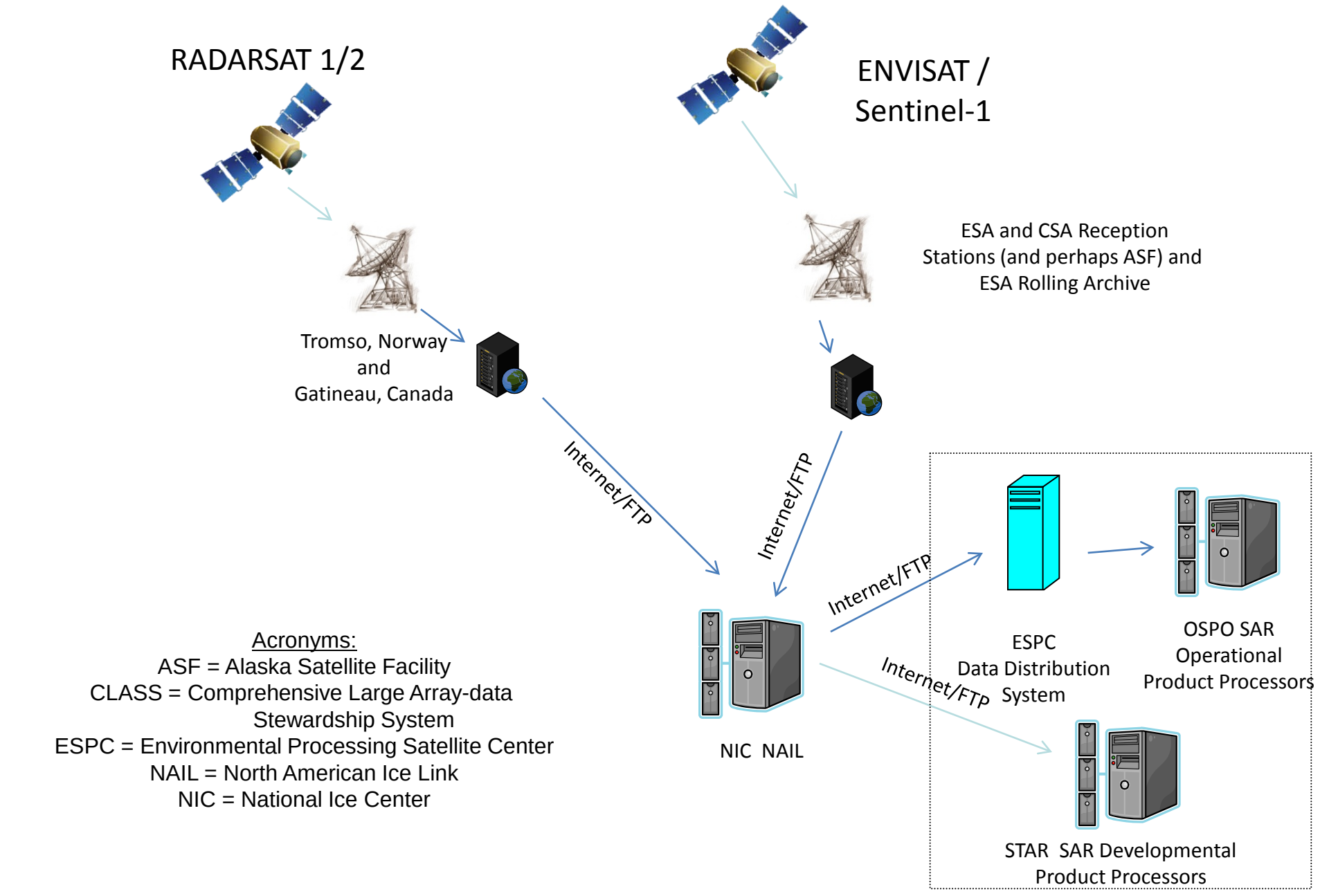
Polarization Ratio (needed to apply VV GMF to HH SAR data):
C-band: Mouche; L-band: Need to develop; X-band: X Mod 0 (APL)

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



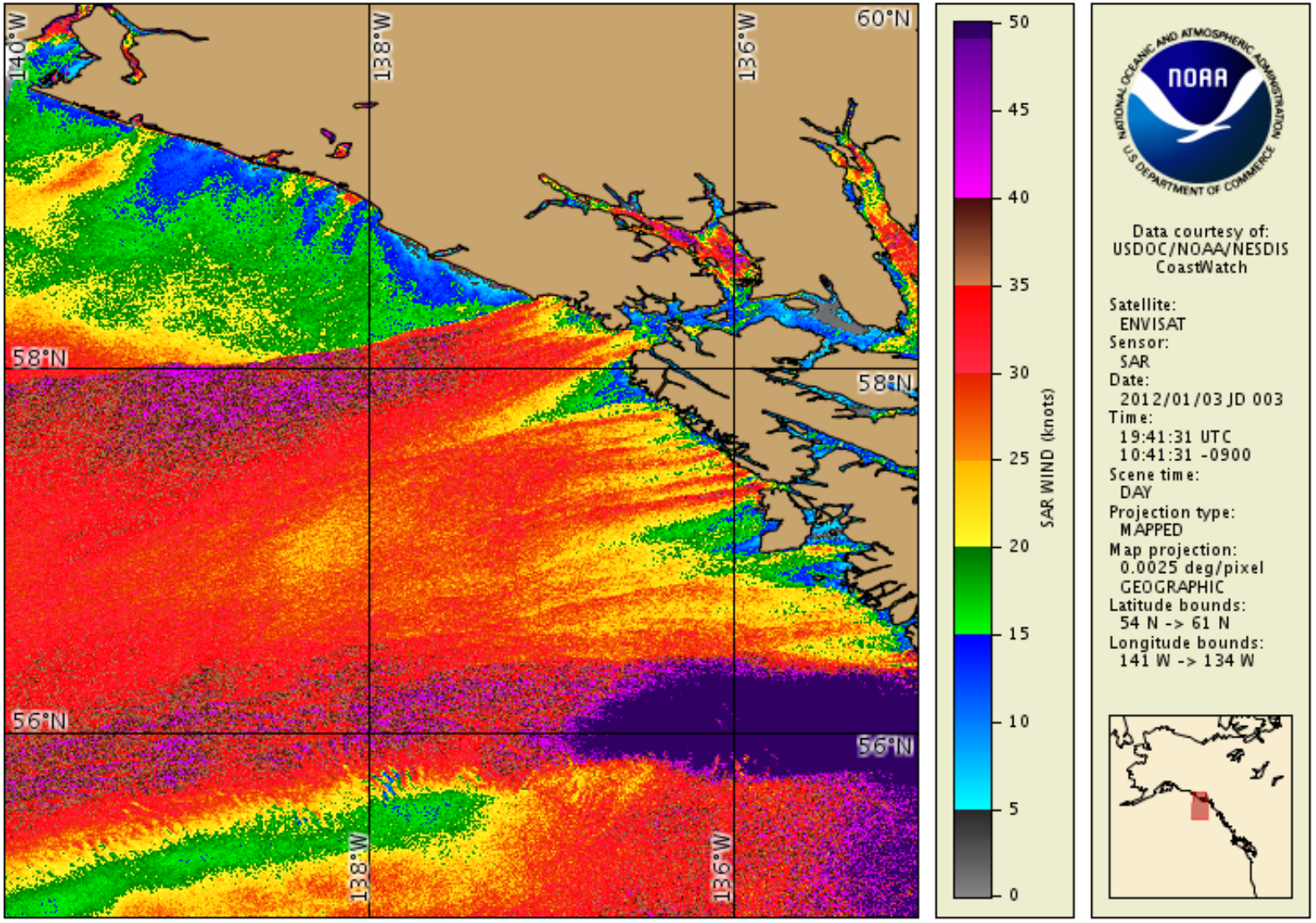
SAR Operational Data Flow (2012)



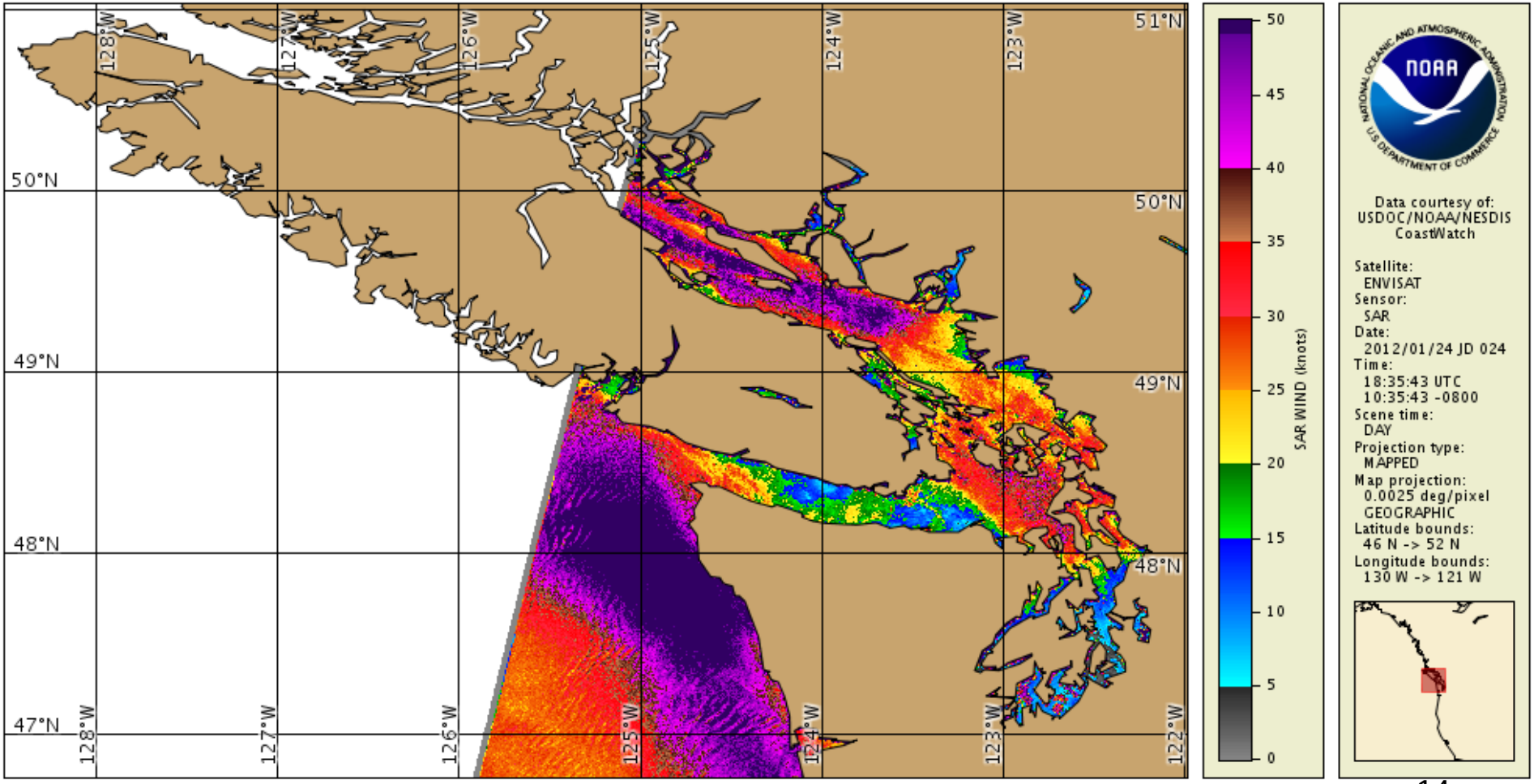
System Upgrades During Transition to Operations

- 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

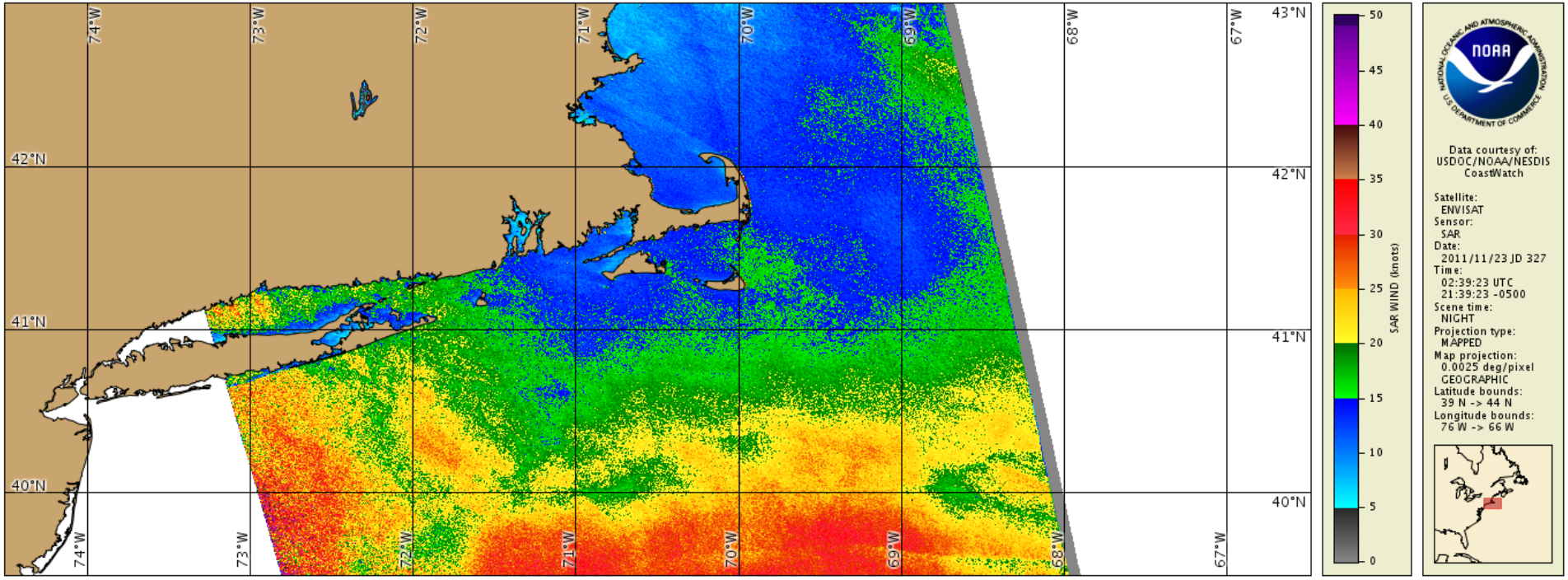
CoastWatch SAR Wind Image - Alaska



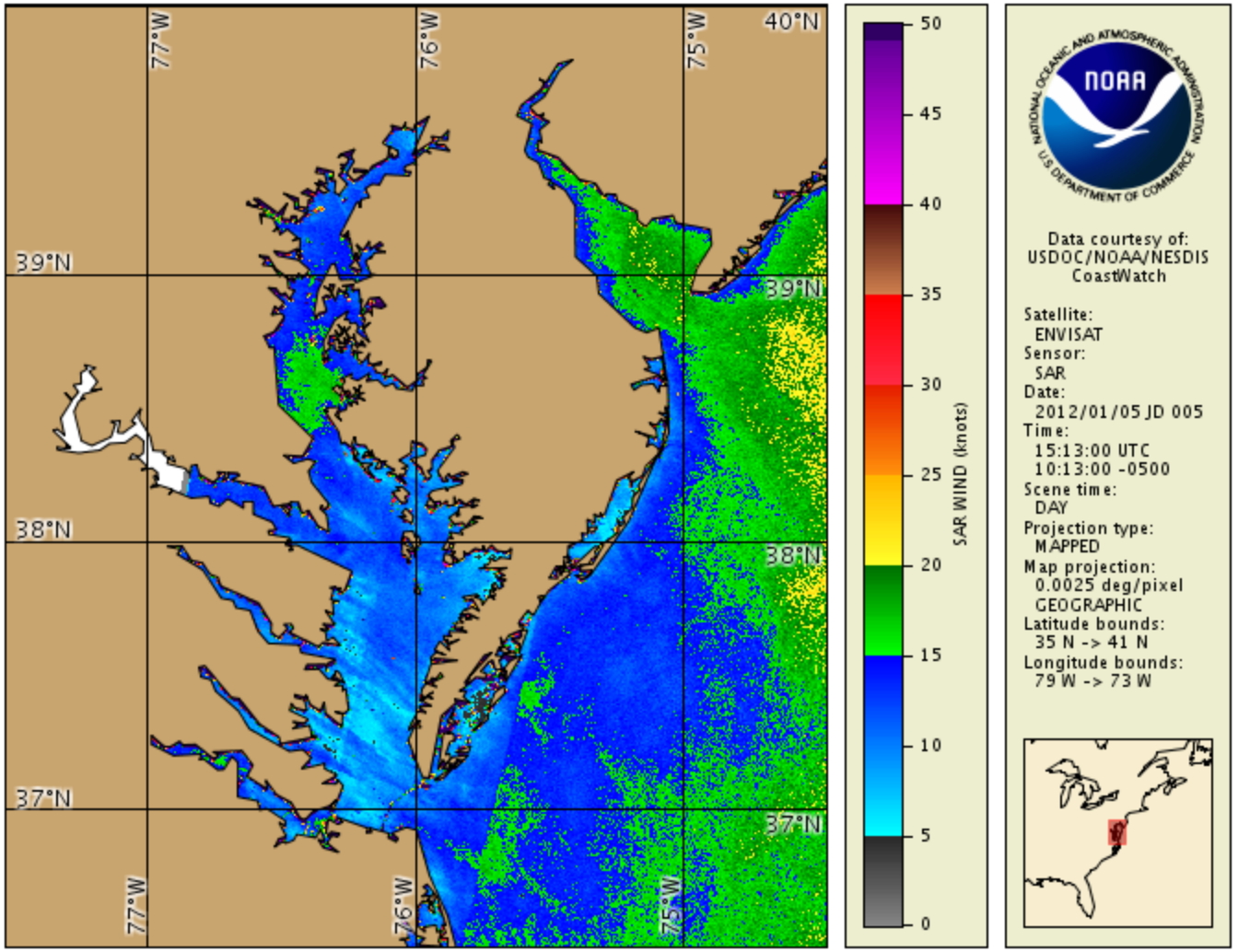
CoastWatch SAR Wind Image - Northwest



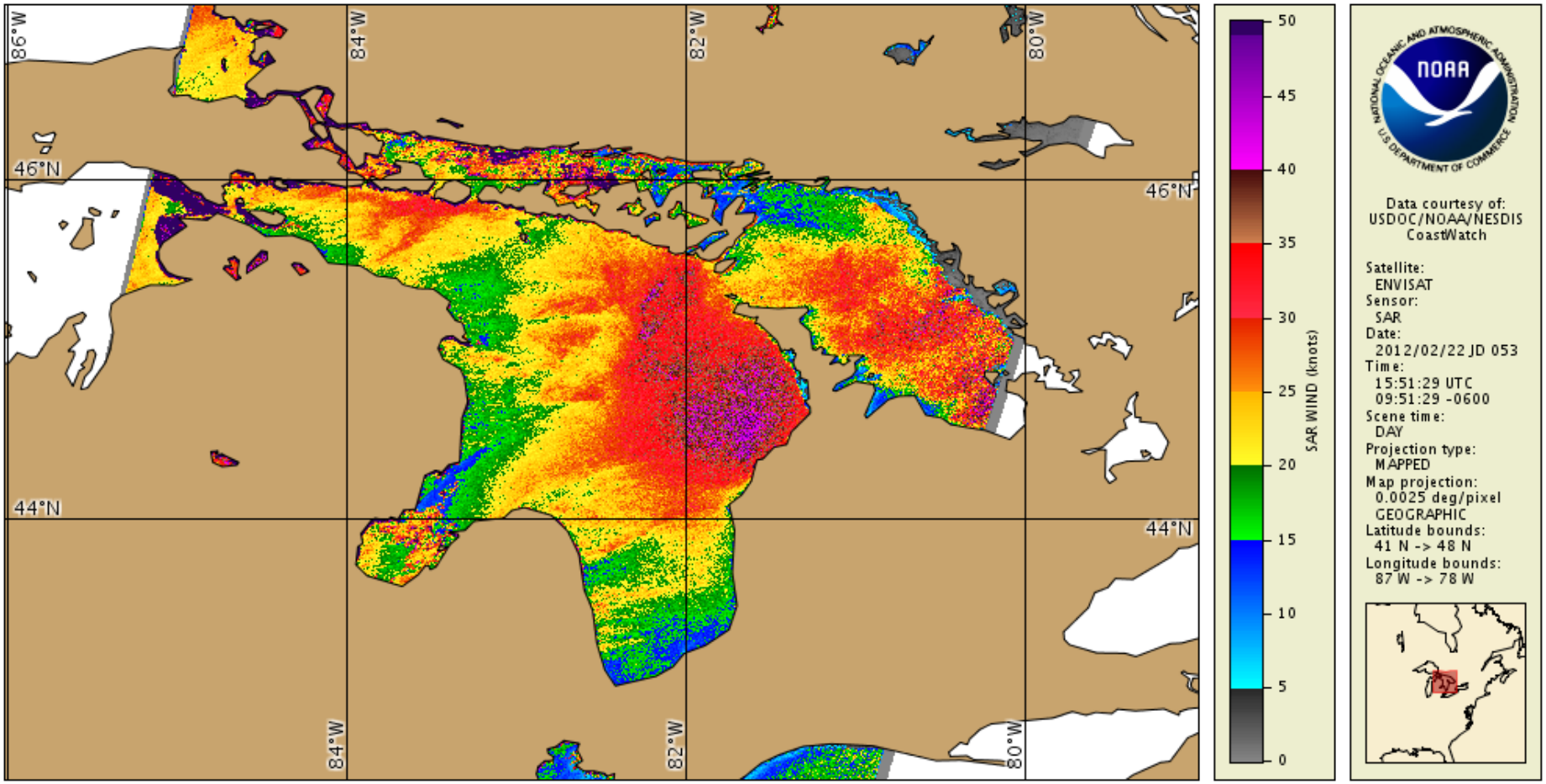
CoastWatch SAR Wind Image - Northeast



CoastWatch SAR Wind Image – East Coast

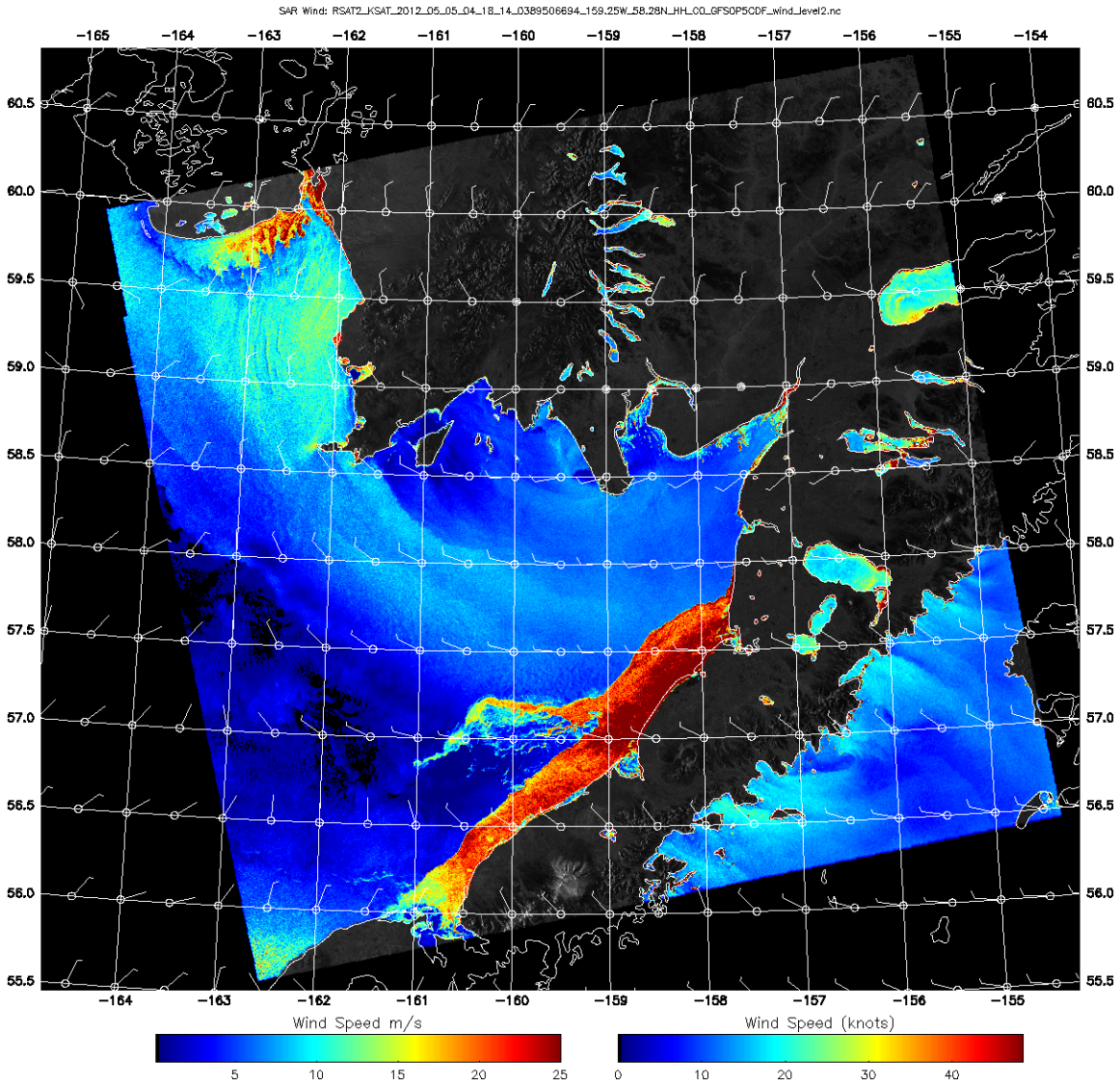


CoastWatch SAR Wind Image – Lake Huron



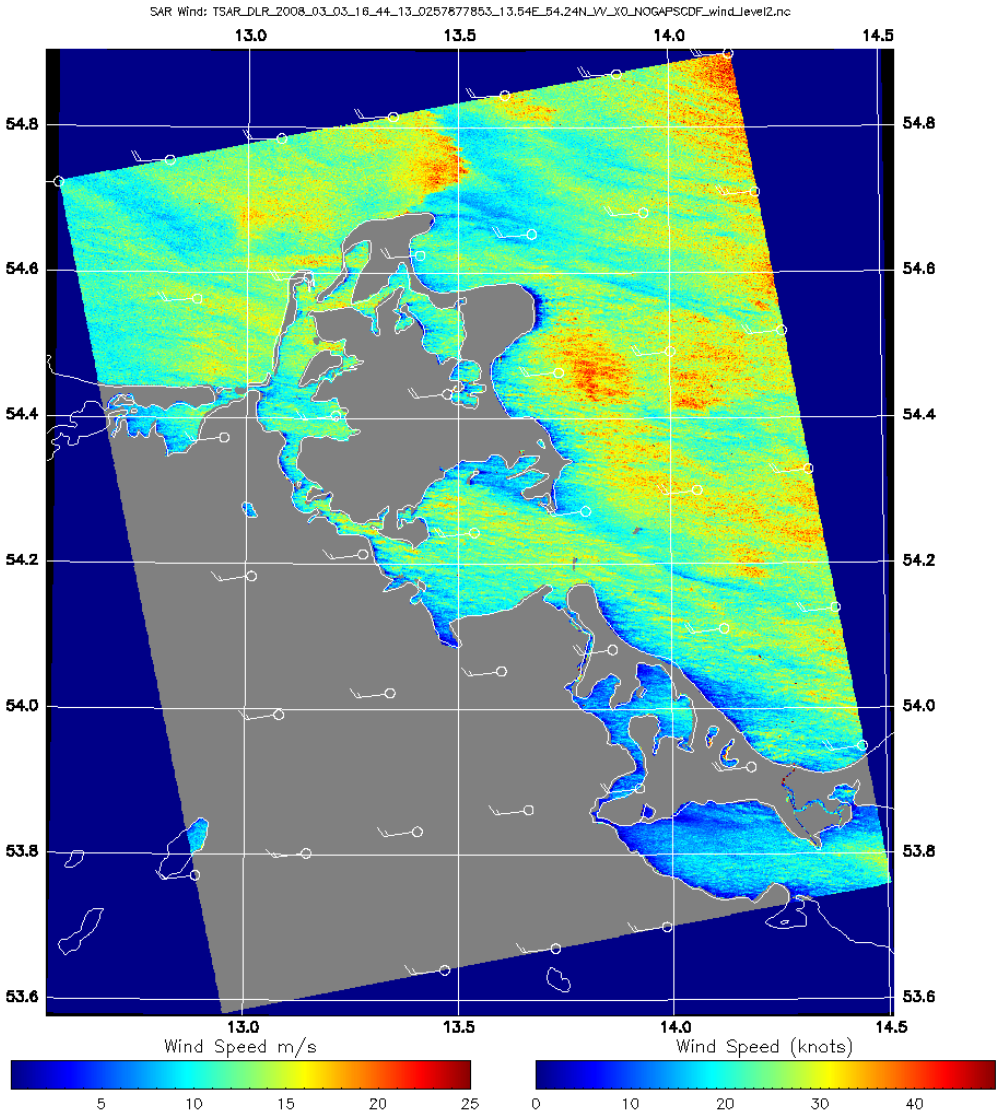
ENVISAT Feb 22, 2012 15:51 UT

RADARSAT-2 SAR Wind Image



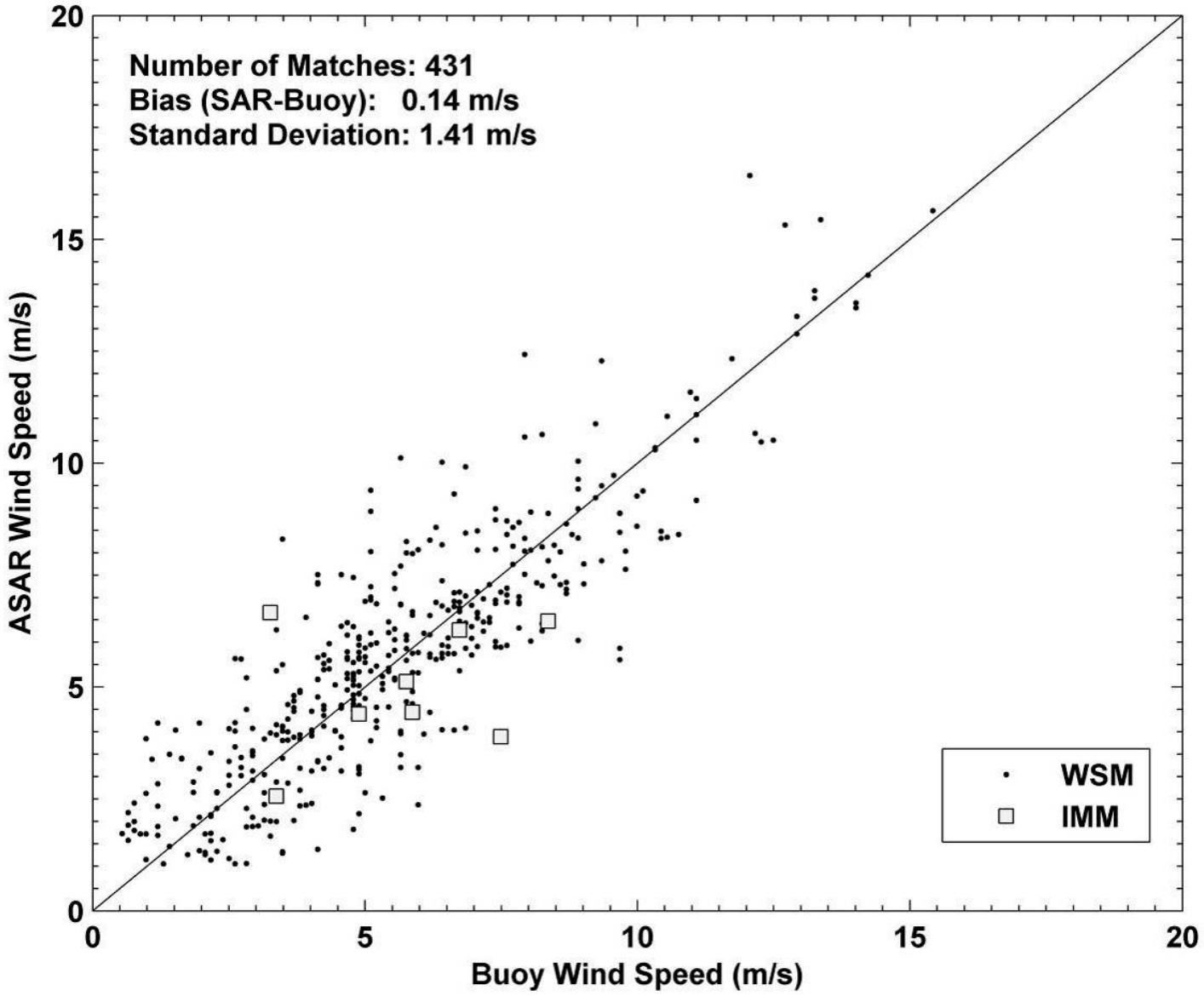
RADARSAT-2
May 5, 2012 04:18 UT
Alaska Peninsula and
Bristol Bay

TerraSAR-X SAR Wind Image

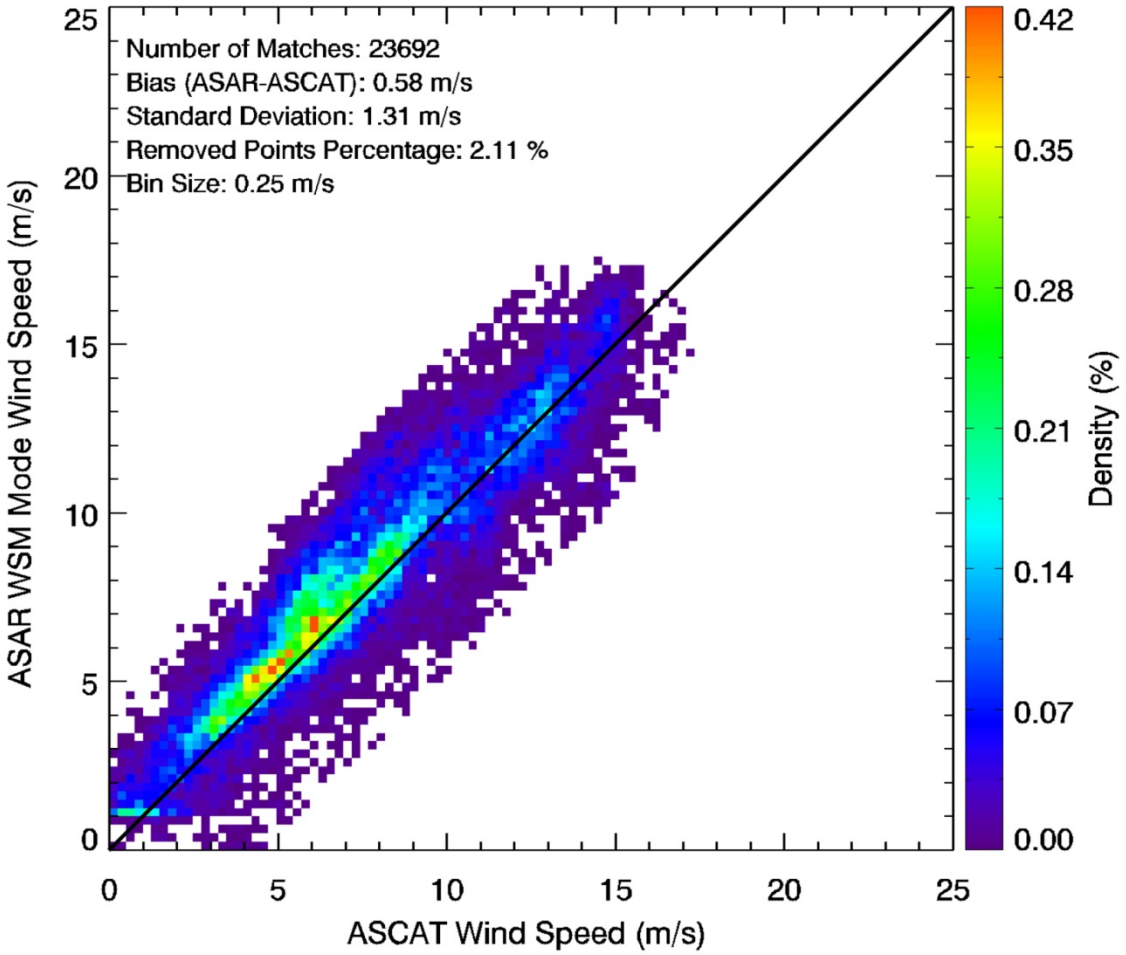


TerraSAR-X March 3, 2008 - Denmark

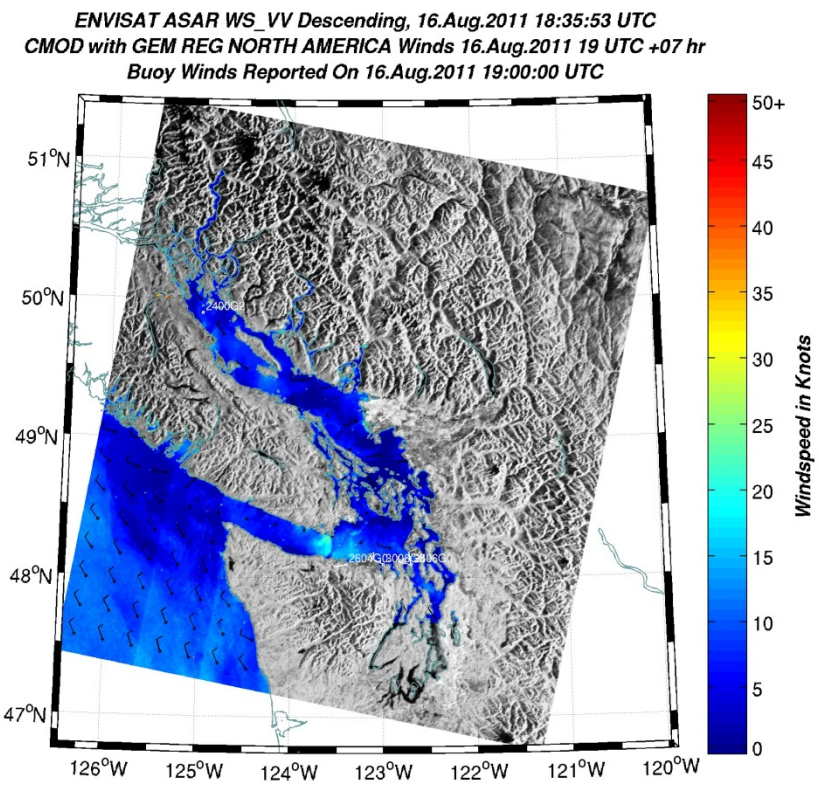
ENVISAT ASAR Validation – Comparison with Buoy Winds



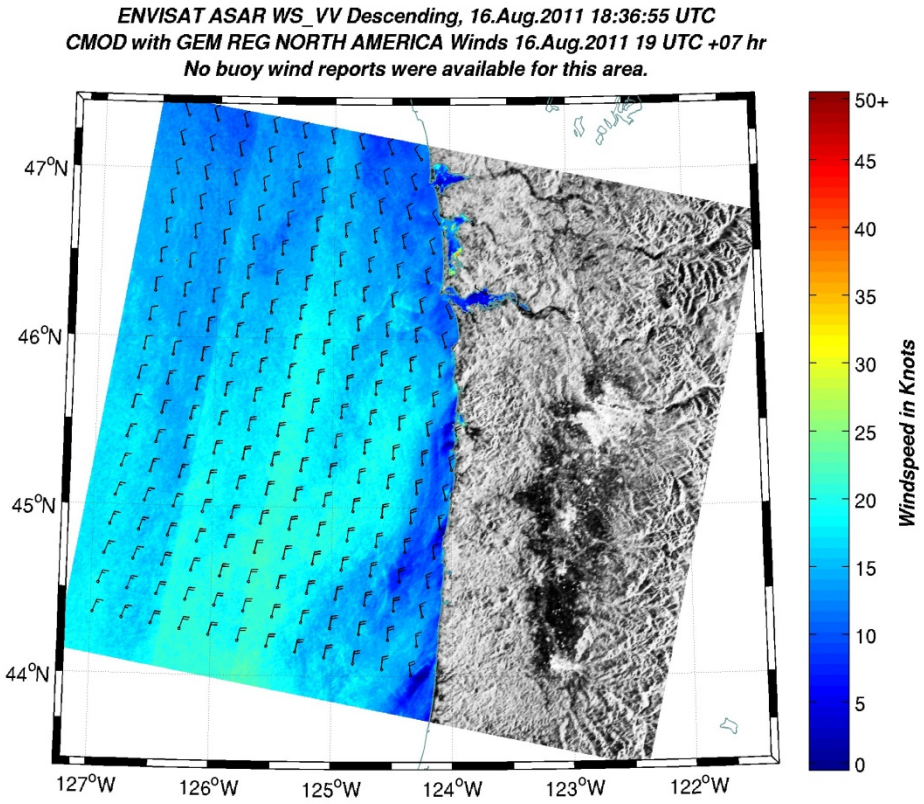
ENVISAT ASAR Validation – Comparison with ASCAT Winds



Examples of Canadian Wind Products
West Coast



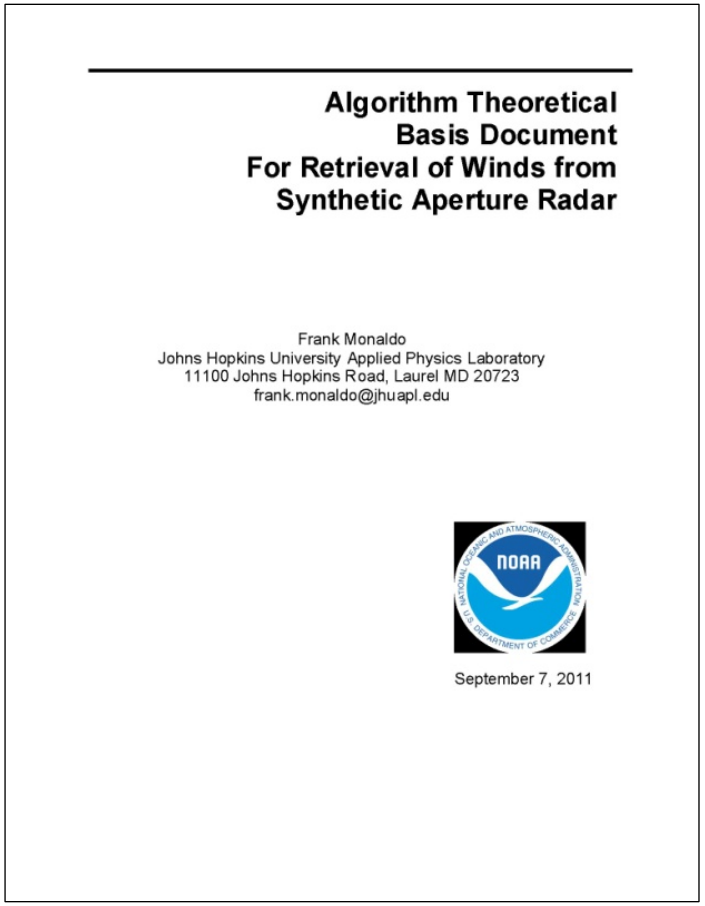
Washington



Oregon

SAR Operational Winds and Validation Modules External Documentation Complete

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.



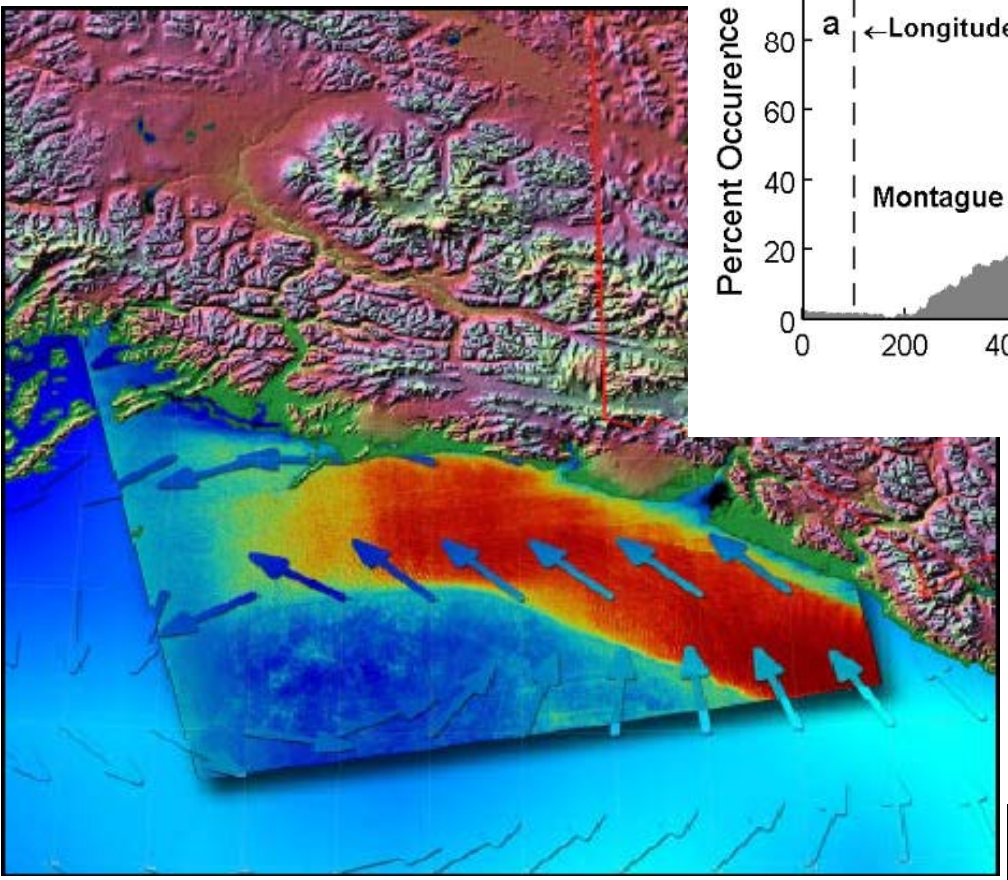
Algorithm Theoretical
Basis Document
For Retrieval of Winds from
Synthetic Aperture Radar

Frank Monaldo
Johns Hopkins University Applied Physics Laboratory
11100 Johns Hopkins Road, Laurel MD 20723
frank.monaldo@jhuapl.edu

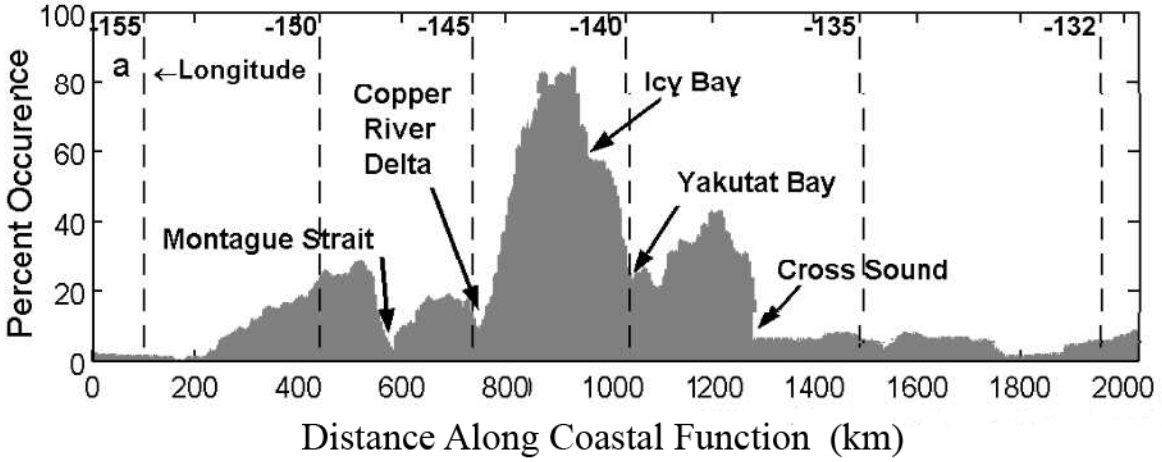
September 7, 2011

Algorithm Theoretical Basis Document (ATBD) for SAR Winds

Coastal Wind Climatology



RADARSAT-1 Sept. 04, 2000 0306 GMT
Wind Image of Barrier Jet (Beal et al., 2005)

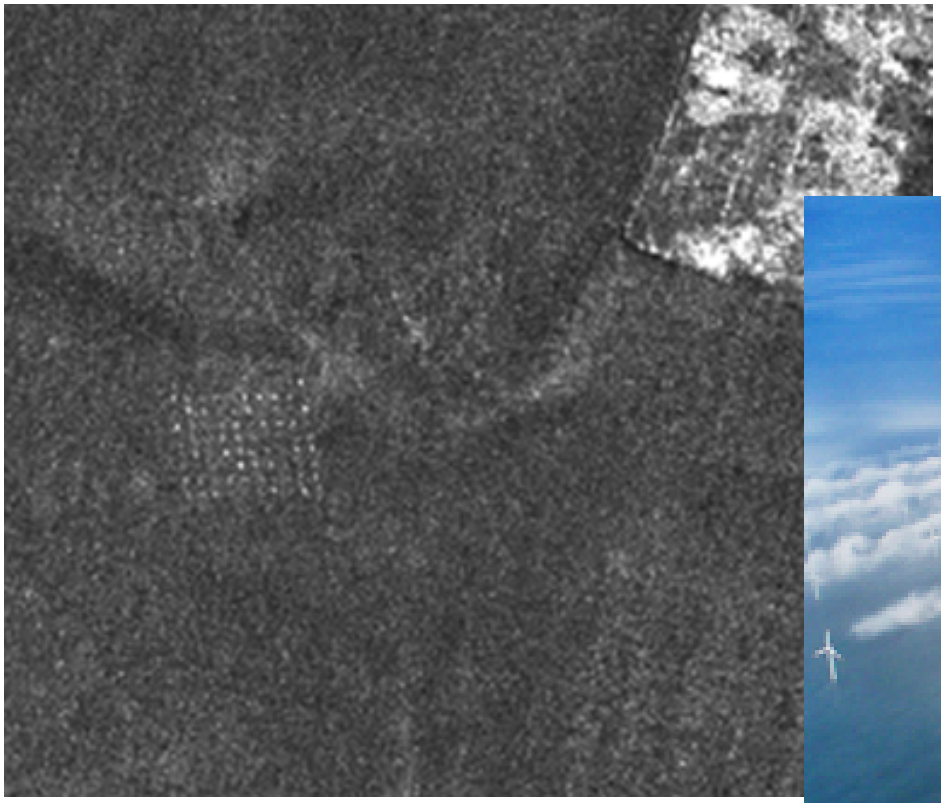


Barrier Jet Percent Occurrence along Northern Coast of Gulf of Alaska – JHU/APL (Winstead et al., 2006; Monaldo et al., 2006, and Loescher et al, 2005)

Applications

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

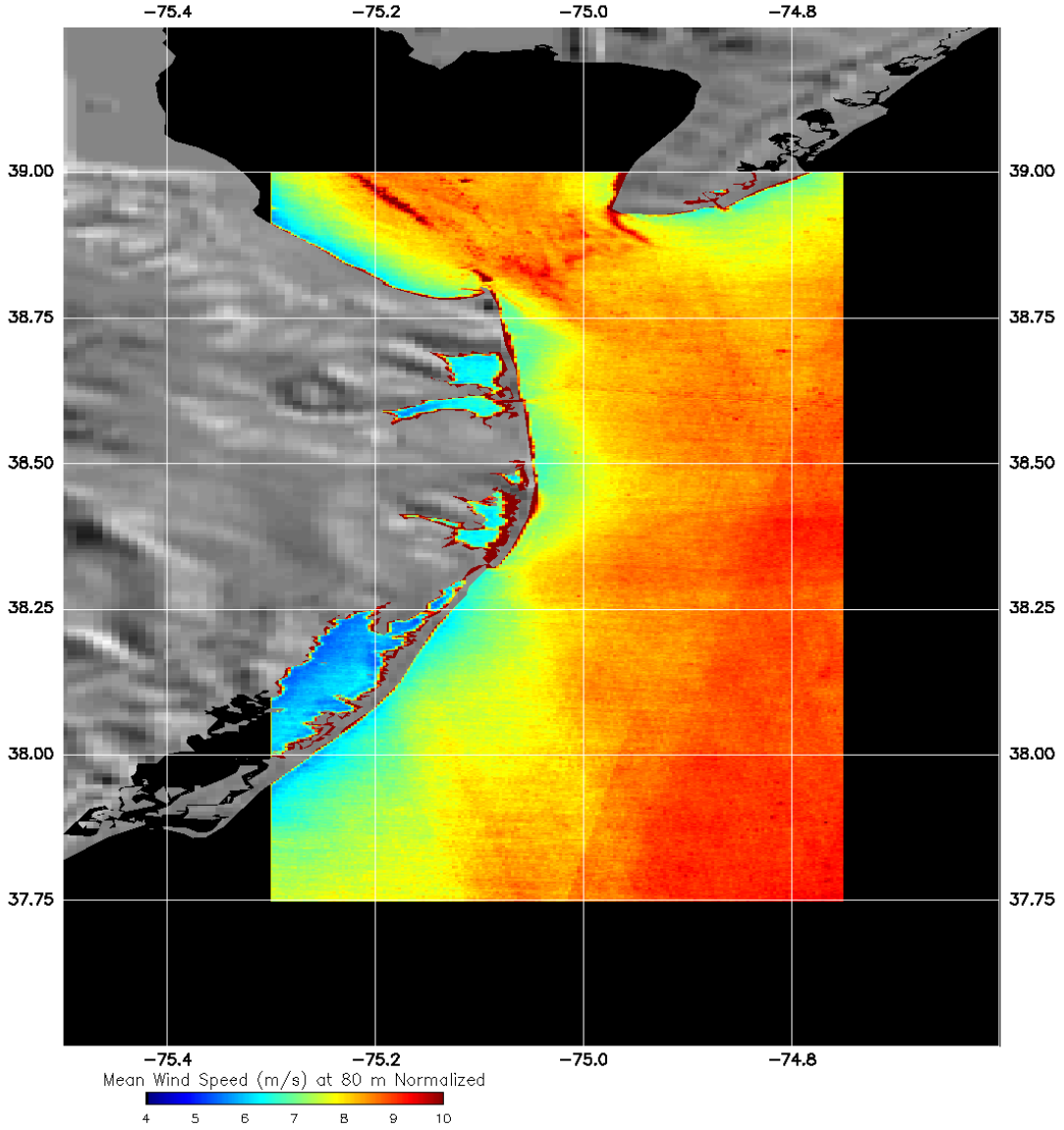
Horns Rev Wind Farm



ALOS PALSAR Image of Horns Rev Wind Farm, Denmark November 1, 2006 10:24:53 UT

Wind wakes shown by clouds downwind of the Horns Rev offshore wind farm, Denmark

Mean SAR Wind Speed for Offshore Wind Farm Studies



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
Applied Physics Laboratory

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.

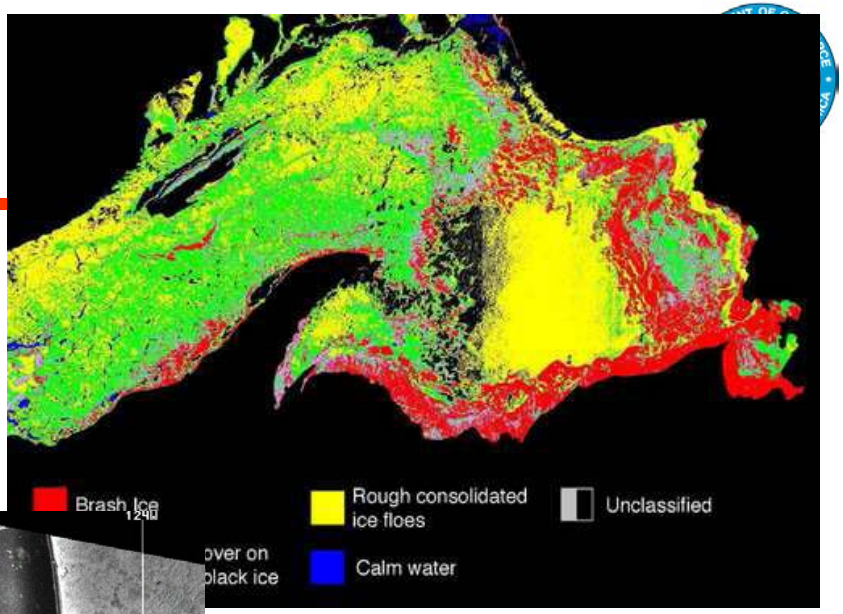
2. Work with Environment Canada to develop MOUs for joint operational production of SAR winds and oil spills similar to agreements in place for ice products.

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

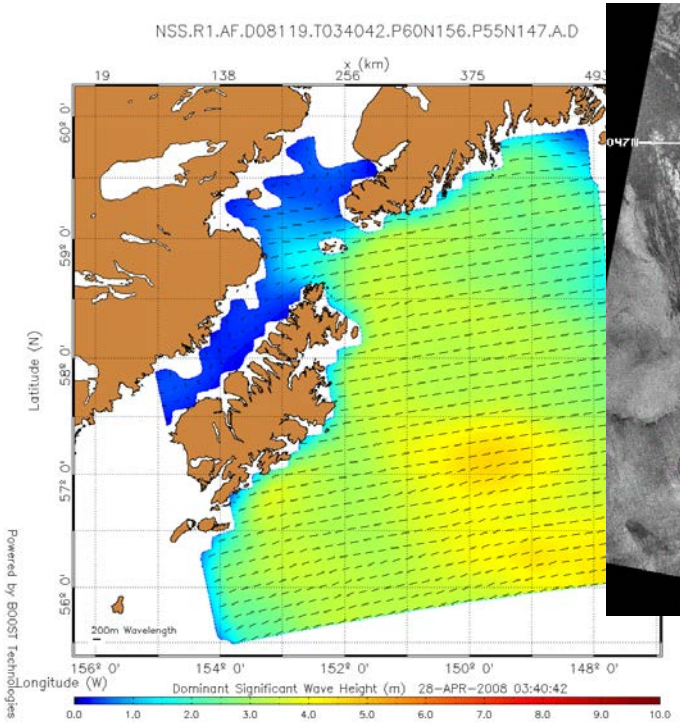
4. Work with NASA to obtain operational access to research SAR missions (i.e., DESDynI and SMAP).

SAR Marine Products System

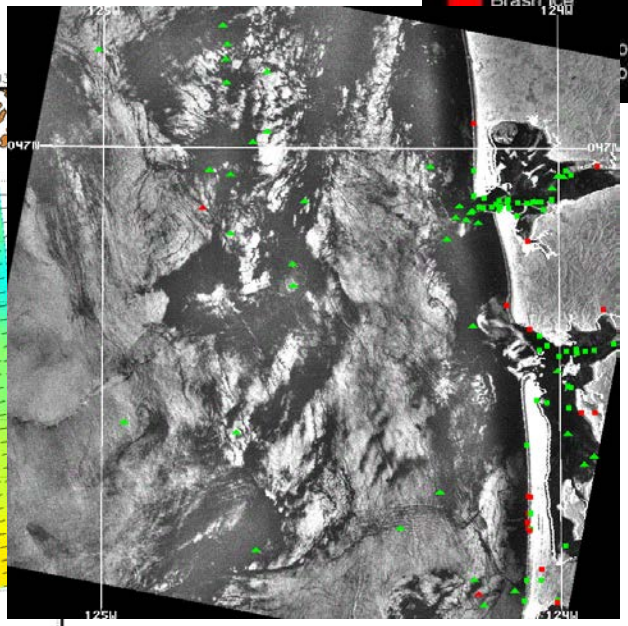
- The SAR winds product is expected to be the first of several SAR-derived products to be transitioned to automated operations



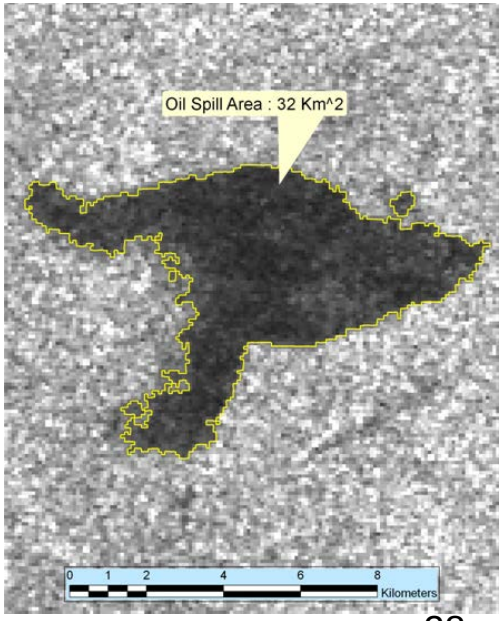
Great Lakes Ice Classification



Wave Parameters



Vessel Detection



Oil Spill Map

The Future – Operational SAR Constellations

ESA Sentinel-1

CSA RADARSAT Constellation Mission