

SAR-Derived Coastal Winds



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The coastal waters of Alaska, as well as mountainous coastal areas elsewhere in the U.S. and Canada, are subject to wind extremes, both in velocity and spatial variability. Coastal areas of the Gulf of Alaska and Bering Sea can experience winds that vary from almost calm to over 25 m/s in only a few kilometers along the shore. This high spatial variability results from winds blowing and accelerating through mountain gaps, downslope winds from glaciers and mountains, as well as wind sheltering by islands and coastal topographic features.

Better knowledge of these coastal wind variations can improve safety of marine transportation (for example oil tankers leaving Prince William Sound), commercial and charter fishing activities, and low-flying aircraft. Many wind features in these coastal regions result from the interaction of lower tropospheric winds with coastal topography. These wind features include: mountain lee waves, wakes (mountain, island, and point), vortex streets (i.e., lines of counter-rotating vortices downstream from a mountain), barrier jets, gap flows (both upstream and downstream of the gap), and williwaws (i.e., downslope winds).

These phenomena show considerable wind variability at scales of a kilometer or two to tens of kilometers. Neither wind measurements from sparse networks of buoys nor lower-resolution satellite passive microwave radiometer or scatterometer wind measurements can resolve the details of these phenomena. High-resolution satellite, synthetic aperture radar (SAR) wind measurements from RADARSAT-1 and ENVISAT, however, show these coastal wind details, as well as details of atmospheric boundary layer phenomena and storm morphology in the open ocean (such as atmospheric frontal dynamics,

storm center location and structure, convection patterns, wind rows, gust fronts, and atmospheric gravity waves).

In October 1999, the National Oceanic and Atmospheric Administration (NOAA) National Environmental Satellite, Data, and Information Service (NESDIS) in partnership with the Alaska Satellite Facility (ASF), the NOAA National Weather Service (NWS), and the U.S. Coast Guard began a near-real-time applications demonstration (called the Alaska SAR Demonstration, or AKDEMO) of SAR-derived environmental products, including SAR winds. Winds have been

produced since that time in a quasi-operational near-real-time fashion. Winds are produced from Quick-Look SAR image data processed by ASF within a few hours of satellite overpass time. Currently, winds are calculated at NOAA/NESDIS and The Johns Hopkins University Applied Physics Laboratory (JHU/APL). Also, ASF has begun generating SAR wind products experimentally with the goal of providing wind products more quickly to the NWS offices in Alaska. Figures 1 and 2 are examples of the wind products. Tens of thousands of these wind images have been produced since 1999, and they are available with sufficient temporal coverage

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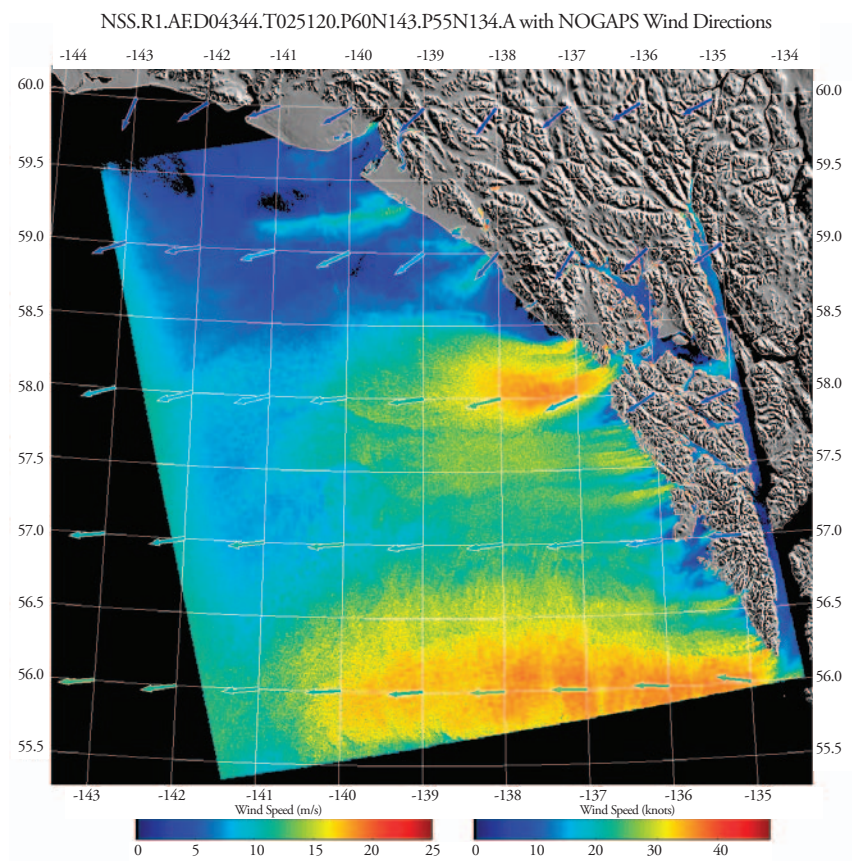
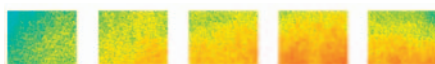


Figure 1: Gap winds along the coast of Southeast Alaska
Winds blowing from inland accelerate as they pass through gaps in the mountainous terrain along shore and out to sea. Winds are derived from RADARSAT-1 data taken on 12/09/2004 at 02:51 UT. The wind vectors come from the Navy Operational Global Atmospheric Prediction System (NOGAPS).



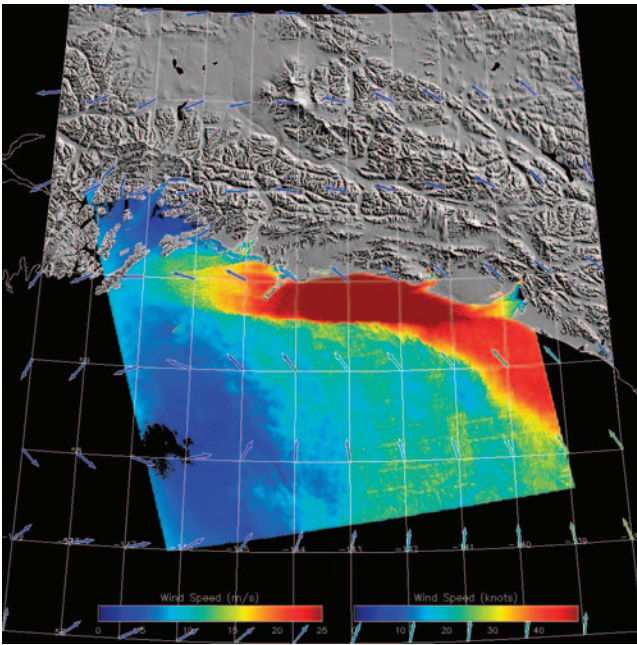


Figure 2: Barrier Jet in the Northern Gulf of Alaska
Winds blowing toward shore are blocked by the mountainous terrain and accelerate downwind in a high-velocity coastal jet. Winds are derived from a RADARSAT-1 image taken on 02/18/2000 at 03:11 UT.

SAR-Derived Coastal Winds *continued*

to be used in studies of coastal wind climatology, which may lead to more accurate weather forecasts.

Wind products are available as PNG imagery (like Figures 1 and 2), NetCDF files, and ASCII vector information. Wind vectors are also sent directly to the NWS office in Anchorage as files that can be displayed on their interactive forecast workstations. Products are generally available within 2 to 4 hours after acquisition by ASF.

The accuracy of SAR wind measurements has been determined from comparisons with buoy winds, model winds, and satellite scatterometer winds. These comparisons generally show root-mean-square errors less than 2 m/s. Links to presentations and papers concerning the wind algorithm and accuracy of the products can be found on the NOAA web site given below. In addition, a newly completed guide to understanding SAR wind imagery and lower tropospheric wind phenomena, entitled “High Resolution Wind Monitoring with Wide Swath SAR: A User’s Guide,” is available on line at the following web site: http://fermi.jhuapl.edu/sar/stormwatch/user_guide/.

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NIC Charts Smooth Sailing by Steve Balistreri

Many relationships with ASF provide unique data products for a great variety of users. One in particular has an especially longstanding and cooperative connection, providing ice breaking vessels with updated navigational information, researchers with products related to polar change, and the public with comprehensive sea-ice atlases and weekly ice data updates.

The National Ice Center (NIC) is a tri-agency, operational center including the United States Navy, NOAA, and the United States Coast Guard (USCG). Together with ASF, the NIC has created imagery unavailable elsewhere that is used for research, modeling, and analysis of polar regions.

NIC Branch Chief, Marilene Kazior, plays a key role between the NIC and ASF. In addition to coordinating data acquisitions with ASF, Kazior administers the web site, www.natice.noaa.gov, which disseminates NIC images for public and

private use. The archives track weekly, monthly, and yearly annotated ice charts and RADARSAT-1 data images, as well as missions past and present.

“ASF is an integral part of the NIC,” says Kazior, “It’s something that has blossomed into more than a standard working relationship.”

USCG support is a major facet of the NIC operations. While cutters move through Arctic and Antarctic waters, the NIC provides updated ice coverage data, derived from ASF products to assist in navigation. This process has supported a number of missions over the years, including an emergency response to the Selendang Ayu oil spill, Antarctic supply mission Deep Freeze, and navigation coverage for the ice-breaking research vessels.

ASF has supported the USGC Cutter, Healy, during its annual cruises,

including the Arctic East, Arctic West, the Northwest Passage, and the 2005 trans-arctic cruise from Seattle, Washington to Tromso, Norway.

The missions reveal new challenges every year and 2005 was no exception. During the early stages of its trans-arctic cruise, USCG Cutter Healy was held up with an equipment problem. For this uncommon occurrence, ASF was able to acquire 50 m resolution imagery for the USCG Cutter Healy, effectively delivering ice data that enabled a navigable course.

ASF will continue to work with the NIC, supplying critical data for emergency responses, natural disasters, and research vessels. If not for the partnership of these two facilities, none of these products would be possible; products which are invaluable to those who use them. For that reason, says Kazior, “As far as the NIC is concerned, ASF is a friend.” ♦

NOAA's Synthetic Aperture Radar Marine User's Manual

by Christopher Jackson and Benjamin Holt

Beginning with the launch of SEASAT in 1978, SAR satellites have provided a global perspective on a wide range of diverse ocean and atmospheric phenomena. The finely-detailed imagery of the ocean's surface from SAR is assuredly the most complex and least understood data set that is provided by a remote sensing instrument. What to make of the unprecedented two-dimensional views of waves, currents and eddies, slicks, surface manifestations of subsurface features, brushed over by interactions with the boundary layer, has captivated and perplexed researchers for over three decades. Add to this mix, the ocean's motion during the SAR imaging process and one has quite a challenge to derive information on what these image patterns uniquely convey about the upper ocean processes and air-sea exchange.

To help people understand the types of information that may be obtained from SAR images of the ocean, the NOAA/NESDIS Office of Research and Applications sponsored the creation of the "Synthetic Aperture Radar (SAR) Marine User's Manual." The Manual was conceived by Dr. John Apel as a way to help educate potential users about the capabilities of SAR for ocean remote sensing. It is intended for non-expert, scientifically literate investigators who wish to use SAR data in their studies, but need assistance in understanding the features visible in the imagery.

The Manual is composed of 20 chapters and is divided into four sections (Background, Oceanic Measurements, Atmospheric and Boundary Layer Measurements, and Sea Ice Observations). Each chapter's authors are recognized experts in their respective fields.

The background material in Section I (Chapters 1 - 3) presents the basic properties of SAR as well as introduces the factors behind how the sea surface and sea ice are observed by microwave radiation and radar in particular. Section II (Chapters 4 - 12) looks at the manifestations of various

oceanic processes, including surface waves and spectra, internal waves, currents, upwelling, underwater topography, surfactants, and ship and wake detection. Section III (Chapters 13 - 17) is devoted to atmospheric and boundary layer measurements, including wind speed and direction, cellular convection, roll vortices, mesoscale storms, gravity waves, vortex streets, and rainfall. Section IV (Chapters 18 - 20) examines sea ice, the ice edge, and icebergs.

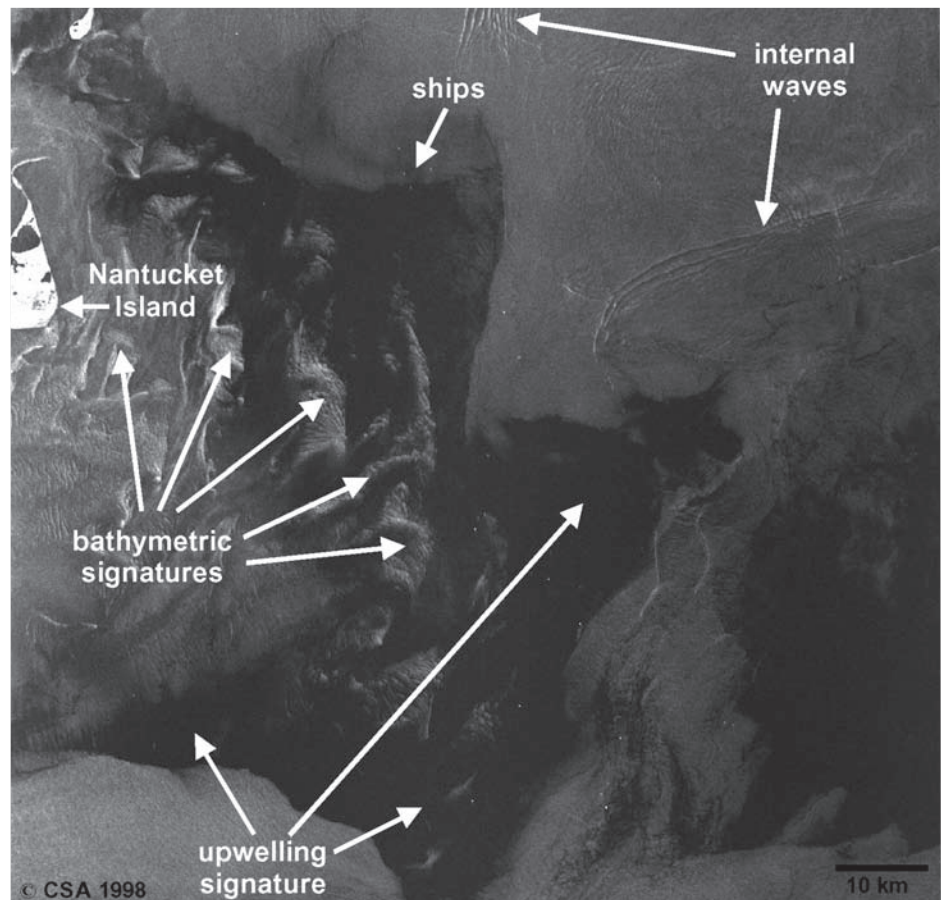
Where appropriate, information is included on how SAR is being used routinely to aid the operational mission of environmental agencies (Chapters 12, 13, and 20 discuss wind, ship and ice, respectively).

Overall the manual is 464 pages in length and fully indexed. It contains



over 240 images and figures, and more than 70 are in color. The Appendices describe the imaging modes and products of the major SAR satellites as well as providing a list of on-line SAR image archives and other resources.

The entire content of the Manual is available on line at www.sarusersmanual.com as a series of individual PDF files. The site also contains a link to purchase a hardcopy from the U.S. Government Printing Office's on-line bookstore. (Cost inside the U.S. is \$73.00) ♦



This is a section of a RADARSAT-1 Scan SAR Wide B (SWB) image acquired on August 13, 1998, off the coast of New England. Various marine features are detected and identified.

The views, opinions, and findings contained in this article are those of the authors and should not be construed as an official NOAA or U.S. Government position, policy, or decision.

These SAR wind products can be accessed by researchers, government agencies, and the general public via three web sites:

- (1) NOAA: <http://www.orbit.nesdis.noaa.gov/sod/mecb/sar>
- (2) JHU/APL: <http://fermi.jhuapl.edu/sar/stormwatch/index.html>
- (3) ASF: <http://wind.asf.alaska.edu>. ♦

Upcoming Events

Alaska Surveying and Mapping Conference

February 14 - 17, 2006, Anchorage, AK. <http://www.aksmc.org/>

Association of American Geographers

March 7 - 11, 2006, Chicago, IL. <http://www.aag.org/>

American Society for Photogrammetry & Remote Sensing Conference

May 1 - 5, 2006, Reno, NV. <http://www.asprs.org/reno2006/>

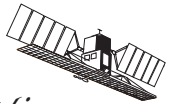
Circumpolar Remote Sensing Symposium

May 15 - 18, 2006, Seward, AK.
<http://alaska.usgs.gov/geography/conference/index.html>

International Geoscience and Remote Sensing Symposium

July 31 - August 4, 2006, Denver, CO. <http://www.igarss06.com/index.html>

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