Estimates of Sea Ice Floe Velocities Characterizing Whaling Seasons Using Satellite Imagery of the Chukchi and Beaufort Seas, Spring 2000 and 2001

Summary

This data set formed the basis for estimating sea ice floe velocities covering two spring whaling seasons with markedly different rates of success from March to June in 2000 and 2001 in the Chukchi and Beaufort Seas near Barrow, Alaska. Synthetic Aperture Radar (SAR) images from the RADARSAT and the European Remote Sensing Two (ERS - 2) satellites and broadband visible (VIS) and infrared (IR) images from the Advanced Very High Resolution Radiometer (AVHRR) satellite were used. Sea ice floe velocity and sea ice reflectance are the parameters used in this data set.

The temporal resolution of these images were from one to seven days with a mean of three days. The spatial resolution was 30 m to 1.6 km. These images were georeferenced and reproduced in Microsoft PowerPoint format; thus, PowerPoint is necessary to view these images. Data and browse images are available via FTP.

Citing These Data

Norton, David W. 2006. *Estimates of Sea Ice Floe Velocities Characterizing Whaling Seasons Using Satellite Imagery of the Chukchi and Beaufort Seas, Spring 2000 and 2001*. Boulder, Colorado USA: National Center for Atmospheric Research, ARCSS Data Archive.

Overview Table

Category	Description
Data format	Microsoft Windows PowerPoint format *.ppt.
Spatial coverage and resolution	Southernmost Latitude: 65° N Northernmost Latitude: 80° N Westernmost Longitude: 180° W Easternmost Longitude: 141° W Spatial resolution: 30 m to 1.6 km
Temporal coverage and resolution	The satellites made variable interval passes every one to seven days with a mean of three days from 01 March 2000 to 25 June 2001.
File naming convention	*.ppt
File size	The PowerPoint files for this data set range from 1.51 MB to 24.2 MB.
Parameter(s)	Sea ice floe velocity and sea ice reflectance

Procedures for obtaining data	Data is available for ordering through NCAR.

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1. Contacts and Acknowledgments

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2. Detailed Data Description

Format and File Naming Convention

The images for this data set were georeferenced and reduced to Microsoft Windows PowerPoint format. This data set contain the following PowerPoint files:

File Name	Description	File Size
1999wainwrightfullswath.ppt	RADARSAT Images, 14 April 1999 to 14 December 1999	3.21 MB
2000mayjune600000scale.ppt	ERS-2 and RADARSAT Images, 30 May 2000 to 04 June 2000	1.52 MB
2000SARvectors.ppt	ERS-2 and RADARSAT Images and topo maps, 22 April	14.9

	2000 to 04 June 2000	MB
2000wainwrightfullswath.ppt	RADARSAT Images, 15 April 1999 to 14 December 2000	3.42 MB
2001Full_RADARSAT.ppt	RADARSAT Images, 21 March 2001 to 18 May 2001	5.62 MB
2001SARvectors.ppt	ERS-2 and RADARSAT Images and topo maps, 18 March 2001 to 17 May 2001	23.6 MB
AVHRRsupportimages.ppt	NOAA AVHRR VIS Band and IR, 20 April 2000 to 25 June 2001	3.88 MB

Spatial Coverage

Southernmost Latitude: 65° N
Northernmost Latitude: 80° N
Westernmost Longitude: 180° W
Easternmost Longitude: 141° W

Horizontal resolution: 30 m to 1.6 km

Temporal Coverage

Data covers two spring whaling seasons from March to June in 2000 and 2001.

Temporal Resolution

The temporal resolution of these images were from one to seven days with a mean of three days.

Parameter or Variable

Parameter Description

Sea ice floe velocity and sea ice reflectance are the primary variables of this data set.

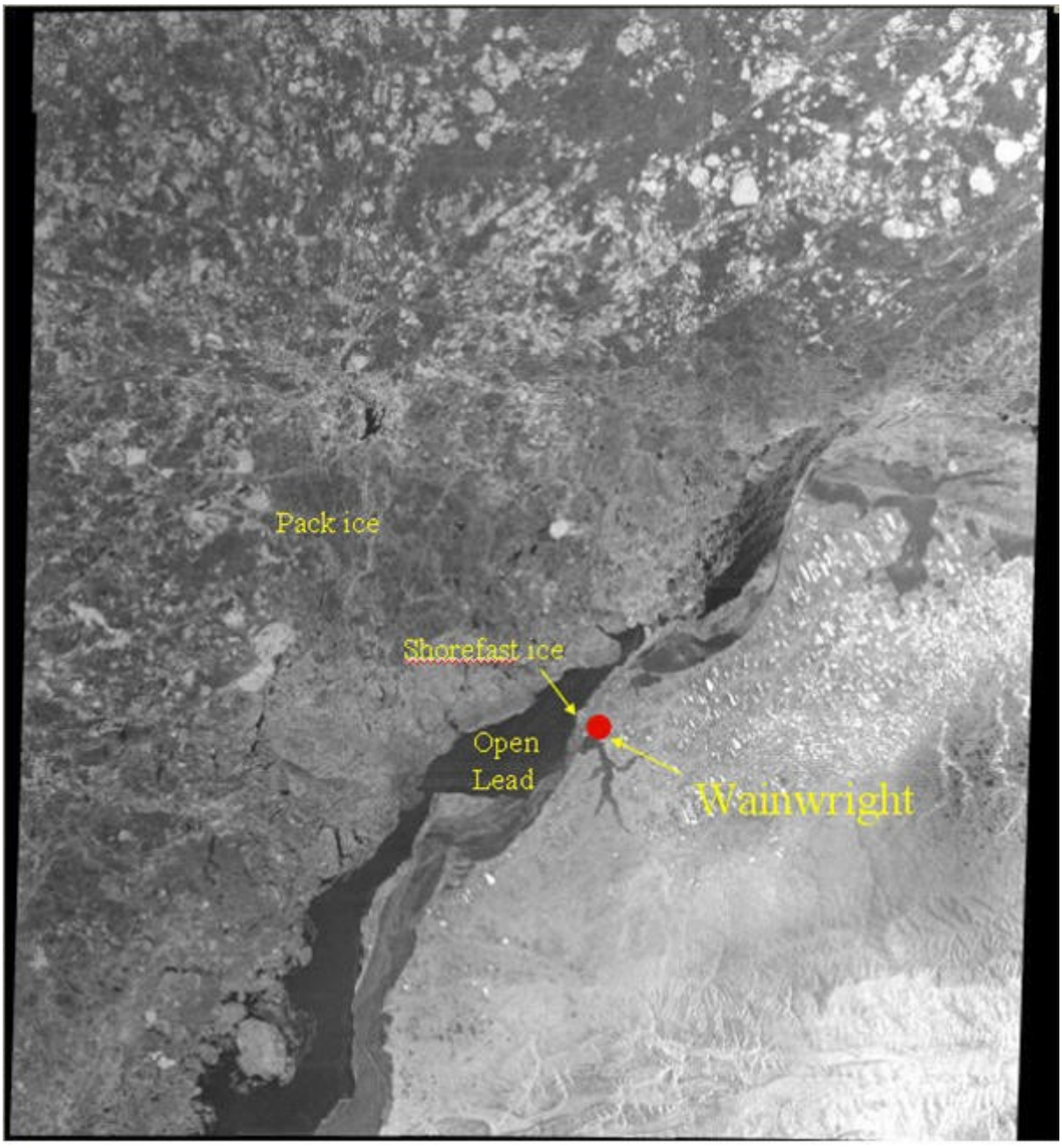

Figure 1: RADARSAT Image of Ideal Whaling Conditions Southwest of Wainwright

3. Data Access and Tools

Data Access

Data are available for ordering through NCAR.

Volume

The complete data set is approximately 56.2 MB.

4. Data Acquisition and Processing

Theory of Measurements

SAR imagery of the northern Chukchi Sea, western Beaufort Sea, and the adjacent perennial ice zone of the Arctic Ocean were used for field verification of ice behavior since these images have a higher resolution than images from the National Oceanic and Atmospheric Administration's (NOAAs) Advanced Very High Resolution Radiometer (AVHRR). SAR technology transmits pulsed microwave signals to the earth's surface and records patterns of reflected pulses. SAR images are independent of solar illumination and are not degraded by cloud cover. Unlike the thermal infrared bands of NOAA AVHRR imagery in which thermal distinctions between open water and ice diminish as ice warms in spring, SAR generally continues to distinguish water from ice surfaces. The minute textural detail preserved in SAR images from surfaces of ice floes allows re-identification of individual floes in successive images even when the floes rotate or break, or when their outlines are reshaped by abrasion at their edges. The objectives of this analysis are:

- to characterize the dominant regime(s), processes, and ice motions of the flaw zone in late winter between the outer edge of shore fast ice and the dense polar pack ice along Alaska's northern Chukchi Sea coast
- to describe departures from the dominant regime(s) and suggest causes for these excursions
- to relate ice events during the whaling season to the success of whaling and to risks taken or avoided by whaling crews
- to identify prerequisites for effective ice prediction that would enhance public safety for subsistence hunters in the region who depend on stable late-winter conditions in coastal ice (Norton and Gaylord 2004).

SAR satellite imagery is a form of remote sensing that allows the addressing of ice movement at a spatial scale familiar to traditional hunters. Case studies of ice-floe accelerations in the two contrasting seasons suggest that many variables influence ice motion such as weather, sea floor topography, currents, sea-level changes, and events that occurred earlier during an annual accretion of ice. Adequate prediction of threats to ice integrity in the northern Chukchi Sea requires adjustments of current concepts, including the following:

- recognizing the pervasive influence of the flaw zone
- replacing a focus on vessel safety in ice-dominated waters with an emphasis on ice integrity in high-energy environments
- chronicling ice motions through coordinated ground observations and remote sensing of March to June events in future field studies (Norton and Gaylord 2004).

Sensor or Instrument Description

RADARSAT Satellite

The RADARSAT Satellite is equipped with a SAR that can collect data over a 1,175 km wide area using seven beam modes. This provides users with superb flexibility in acquiring images with a range of resolutions, incidence angles, and coverage areas. The SAR instrument consists of a radar transmitter, a radar receiver, and a data downlink transmitter.

The radar transmitter and receiver operate through a steerable antenna that directs the transmitted energy in a narrow beam normal to the satellite track. The elevation angle and profile of the beam (beam position) can be adjusted so that the beam intercepts the earth's surface over the desired range of incidence angles. This capability is important because image characteristics vary with the incidence angle associated with each beam. In addition, different resolution and coverage can be achieved. The beam modes are each characterized by a specific beam elevation angle and profile. Within each RADARSAT beam mode, a number of incidence angle positions are available. These are called beam positions. For example, standard beam mode, which covers a 100 x 100 km area, has seven beam positions. By specifying a beam position, one of seven 100 x 100 km images within a 500 km accessible swath are collected.

European Remote Sensing 2 Satellite (ERS-2)

Built like ERS-1, ERS-2 is the European Space Agency's second environmental satellite, and it has an Active Microwave Instrument (AMI) that consists of a SAR and a wind scatterometer both in the C-band.

Advanced Very High Resolution Radiometer (AVHRR) Satellite

The AVHRR sensor is a broad-band, 4- or 5-channel scanning radiometer sensing in the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum; and it provides four- to six-band multi spectral data from the NOAA polar-orbiting satellite series. The objective of the AVHRR instrument is to provide radiance data for investigation of clouds, land-water boundaries, snow and ice extent, ice or snow melt inception, day and night cloud distribution, temperatures of radiating surfaces, and sea surface temperature. The AVHRR data collection effort also provides opportunities for studying and monitoring vegetation conditions in ecosystems, including forests, tundra, and grasslands with applications that include agricultural assessment, land cover mapping, production of large-area image maps such as country maps, continental maps, and world maps, and evaluation of regional and continental snow cover.

Data Acquisition Methods

SAR imagery covering each whaling period was acquired from the Alaska Satellite Facility (ASF) Distributed Active Archive Center (DAAC) at the Geophysical Institute of the University of Alaska Fairbanks. SAR images with 30 m and 100 m pixel resolution taken from ERS-2 and RADARSAT were acquired through a data acquisition request processed by the ASF. Thus, two types of SAR imagery from polar orbiting satellite sensors were acquired. Also, near-real-time data of the Quicklook imagery of the Barrow study area captured by RADARSAT and ERS-2 were acquired. The near-real-time data acquisition was scheduled to coincide with the period when the maximum number of whalers and scientific observers would be on the ice hunting or counting bowhead whales, which is from mid-March to mid-June (Norton and Gaylord 2004).

Processing Steps

After all unambiguous repeat sightings of indivdual sea ice floes were marked and ambiguous

repeats discarded, vectors were derived by plotting locations on an outline map of coastal features and bathymetry surrrounding Barrow. A parallel ruler was used to transfer angular bearings from prominent coastal features in georeferenced SAR images of various scales to the same features on outline maps. From subsequent re-plotted sea ice floe positions and the resulting vectors, distance and compass directions of displacements were derived and then converted to 24-hour displacements ($km.d^{-1}$) and hourly speeds ($km.h^{-1}$).

5. References and Related Publications

Norton, D. W. and A. G Gaylord. 2004. Drift velocities of ice floes in Alaska's northern Chukchi Sea flaw zone: Determinants of subsistence whaling success in 2000 and 2001. *Arctic* 57 (4): 347-362.

George, J. C., H. P. Huntington, K. N. Brewster, H. Eicken, D. W. Norton, and R. Glenn. 2004. Observations on shore fast ice dynamics in Arctic Alaska and the responses of the Inupiat hunting community. *Arctic* 57 (4): 363-374.

6. Document Information

Acronyms and Abbreviations

The following acronyms and abbreviations are used in this document:

ASF	Alaska Satellite Facility
ASCII	American Standard Code for Information Interchange
AVHRR	Advanced Very High Resolution Radiometer
DAAC	Distributive Active Archive Center
ERS	European Remote Sensing
FTP	File Transfer Protocol
IR	Infrared Band
JPEG	Joint Photographic Experts Group
NOAA	National Oceanic and Atmospheric Administration
NSF	National Science Foundation
NCAR	National Center for Atmospheric Research
OPP	Office of Polar Programs
RADARSAT	Radar Satellite
SAR	Synthetic Aperture Radar
URL	Uniform Resource Locator
VIS	Visible Band

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