Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas, 1993-2004, Version 1

USER GUIDE

How to Cite These Data

As a condition of using these data, you must include a citation:

Eicken, H., L. Shapiro, A. G. Gaylord, A. Mahoney, and P. W. Cotter. 2009. *Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas, 1993-2004, Version 1*. [Indicate subset used]. Boulder, Colorado USA. NSIDC: National Snow and Ice Data Center. https://doi.org/10.7265/N5SB43P0. [Date Accessed].

FOR QUESTIONS ABOUT THESE DATA, CONTACT NSIDC@NSIDC.ORG

FOR CURRENT INFORMATION, VISIT https://nsidc.org/data/G02173

National Snow and Ice Data Center

TABLE OF CONTENTS

In the Beaufort and Chukchi Seas, the most significant sea ice anomalies have occurred in the summer ice extent (Eicken et al. 2006). In addition, there has been a considerable decline in the multiyear ice pack in this region (Eicken et al. 2006). To help understand these anomalies, this data set contains information on recurring spring leads and landfast ice extent in this area. This data set maps and documents the spatial and temporal distribution of recurring leads and landfast ice off the coast of northern Alaska in the Chukchi and Beaufort Seas (Eicken et al. 2006). The leads data span from 1993 through 2004 and are based on visible and infrared Advanced Very High Resolution Radiometer (AVHRR) data onboard the NOAA 12, 14, 15, 16, and 17 satellites. The landfast ice extent data extend from 1996 through 2004 and are based on RADARSAT-1 Synthetic Aperture Radar (SAR) imagery. The data are available in a number of formats including ArcGIS geodatabases (`.mdb`), shapefiles (`.shp`), ArcGIS grids (`.adf`), ArcGIS grids in ArcInfo interchange format (`.e00`), and GeoTIFFs (`.tif`). Statistics are also provided in Microsoft Excel spreadsheets (`.xls`) and metadata in several formats including XML (`.xml`), SGML (`.sgml`), HTML (`.html`), and ASCII text (`.txt`). Quick-view browse images in JPEG (`.jpg`) format are provided for the shapefiles, grids, and GeoTIFFs.

1 DETAILED DATA DESCRIPTION

1.1 Background

Recurring leads in the Beaufort and Chukchi Seas signal the deformation of the ice pack and impact the ocean-atmosphere heat exchange and polar ecosystems (Eicken et al. 2006). Landfast ice lessens the impact of coastal erosion, impacts travel and hunting for the local communities, and is utilized for oil and gas development (Mahoney et al. 2007).

In Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas, Eicken et al. (2006) say:

The Arctic sea-ice cover has undergone significant changes in the past two decades. These changes include a reduction in summer ice extent (with four consecutive record minima attained between 2001 and 2005) as well as substantial thinning of the ice pack. The western Arctic, i.e., the Chukchi and Beaufort Seas, has seen the largest anomalies in summer ice extent, as well as a substantial reduction in the amount of multiyear ice over the Beaufort and Chukchi shelves. The present project was aimed at mapping and documenting changes in the spatial and temporal distribution of spring lead systems and landfast ice extent off the coast of northern Alaska. In addition to providing baseline data against which to evaluate further changes, the work also examined present-day conditions in relation to earlier studies conducted in the 1970s as part of the Outer Continental Shelf Environmental Assessment Project and discussed the role of different

forcing mechanisms in controlling spatial and temporal patterns of variability in lead distribution and landfast ice extent (Eicken et al. 2006).

1.2 Parameters

Because of the intricacies involved with identifying landfast ice extent and leads, precise definitions of both parameters are explained below.

1.2.1 Landfast Ice Extent

In general, landfast ice can be defined as sea ice that is mostly stationary and attached to land. For this data set, a more specific definition is used from Mahoney et al. (2005). Specifically, landfast ice is defined as ice that is contiguous with the coast and ice that lacks detectable motion for approximately 20 days.

1.2.2 Leads

Leads are defined as "any fracture or passage-way through sea ice which is navigable by surface vessels" (Eicken et al. 2006). This definition is expanded using Lindsay and Rothrock (1995) to include thin ice (0.15 m to 2 m thick). The definition of leads in this data set does not discriminate between open linear leads and areas covered by thin ice.

1.3 Spatial Coverage

The majority of the study area covers the Beaufort Sea and to a lesser extent the Chukchi Sea. Specifically, the study area is off the coast of northern Alaska in the Chukchi and Beaufort Seas between Wainwright bordering the Chukchi Sea and the Mackenzie River Delta in the Canadian Beaufort Sea. Figure 1 shows the spatial coverage. Leads were examined within regions 1 through 12, and landfast ice extent identified within regions 2 through 11. The spatial coordinates of the area are listed below:

Northernmost Latitude: 73.957687° N
Southernmost Latitude: 68.482036° N
Easternmost Longitude: 129.877138° W
Westernmost Longitude: 164.080843° W

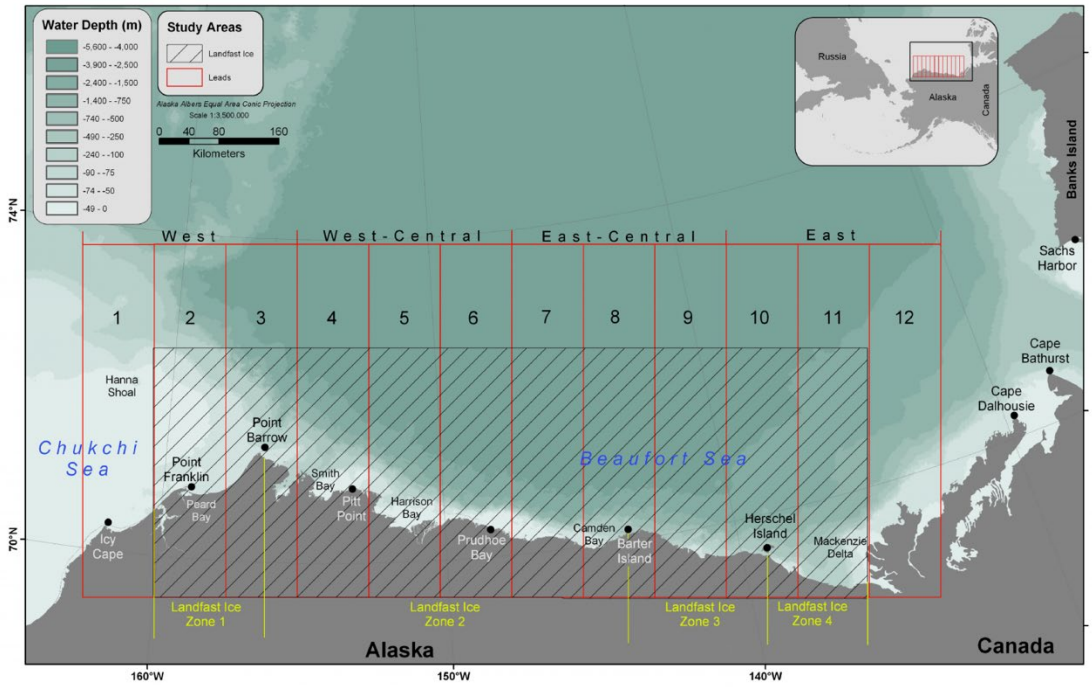

Figure 1. Spatial Coverage Map of the Study Area

The areas outlined in red are the subregions where leads were examined; and the black, hatched areas are the subregions where landfast ice was identified.

1.3.1 Spatial Resolution

The AVHRR source data for the leads have a 1.1 km resolution.

The RADARSAT-1 SAR source data for the landfast ice extent have a 100 m resolution.

1.3.2 Projection

The data in this data set have been geolocated (geolocation error less than three km) and reprojected into an Albers Conical Equal Area projection with a 100 m grid cell size for SAR data and 1.1 km grid cell size for AVHRR data using the North American Datum of 1983 (NAD 1983). Following are the detailed projection and datum parameters:

Map Projection Name:	Albers Conical Equal Area
Standard Parallel:	55.000000
Standard Parallel:	65.000000
Longitude of Central Meridian:	-154.000000
Latitude of Projection Origin:	50.000000
False Easting:	0.000000
False Northing:	0.000000

Planar Coordinate Information	
Planar Distance Units:	Meters
Coordinate Encoding Method:	Coordinate pair
Coordinate Representation	
Abscissa Resolution:	0.002048
Ordinate Resolution:	0.002048
Geodetic Model	
Horizontal Datum Name:	North American Datum of 1983
Ellipsoid Name:	Geodetic Reference System 80
Semi-major Axis:	6378137.000000
Denominator of Flattening Ratio:	298.257222

1.4 Temporal Information

1.4.1 Landfast Ice Extent

The landfast ice extent data span 1996 to 2004. RADARSAT-1 SAR images are acquired for the months October through July approximately every 10 days.

1.4.2 Leads

The lead data span 1993 to 2004. AVHRR images are acquired for the months December through June at irregular intervals. During certain years, some months (October to December) may be omitted if clouds obstructed the visible AVHRR imagery.

1.5 Data Format

This data set is distributed in a number of formats. Most files are compressed into zip files to conserve space and to bundle like files. To more easily describe the different formats and how they interrelate, the Data Format section is organized in the same way that the files are organized into directories on the HTTPS site: https://noaadata.apps.nsidc.org/NOAA/G02173/. For example, on the HTTPS site, the data are divided into three main directories: one for landfast ice extent data, one for lead data, and one for supplemental information. Here, and in other sections of this document, the content is broken down in the same way. Follow the links below to navigate the Data Format section. For more information about the directory structure, see the Directory Structure section of this document.

- Landfast Ice Extent
- Leads

- Supplemental Information

The file extensions of all of the formats in this data set are listed in Table 1.

Table 1. File Format Extension Descriptions

File Format Extension	File Type
.001	Ancillary file for the ArcGIS grids
.adf	ArcGIS grid file
.aux	Ancillary file for ArcGIS grids or metadata for certain GeoTIFF files
.dat	Ancillary file for the ArcGIS grids
.dbf	DBase format for ArcView and ArcGIS database files
.dir	ArcGIS directory file for grids
.e00	ESRI ArcInfo interchange file
.html	HyperText Markup Language file
.jpg	JPEG image file
.jpg.aux	Extra file that can be ignored
.jpg.xml	Metadata for the associated JPEG file
.mdb	ArcGIS geodatabase - the geodatabases are held in Microsoft Access files
.nit	Associated file for the ArcGIS grid file
.prj	Projection file
.rrd	Reduced Resolution Data
.sbx	Index file for shapefiles
.sbn	Shapefile spatial index
.sgml	Standard Generalized Markup Language file
.shp	Shapefile
.shp.xml	XML file for the shapefile
.shx	Support file for shapefiles
.tfw	World File associated with certain GeoTIFF files, contains coordinates that describe the location, scale, and rotation of an image formatted as a .tif image; used by geographic information systems (GIS) software
.tif	Geographic Tagged Image File Format (GeoTIFF) file
.tif.xml	Metadata for certain GeoTIFF files
.txt	ASCII text file
.xls	Microsoft Excel file
.xml	Extensible Markup Language file
.zip	Compressed archive file

1.5.1 Landfast Ice Extent

The landfast ice extent data are grouped into the following four categories:

- Annual Geodatabase Files
- RADARSAT-1 SAR Imagery (Source Data)
- XML Metadata Templates
- Monthly Averages

1.5.1.1 Annual Geodatabase Files

The annual geodatabase files are GIS vectorized outlines of the seaward landfast ice edge (SLIE) for each annual ice season (for example, the 1996/1997 ice season) from the source RADARSAT-1 SAR imagery. The files are in ArcGIS geodatabase format (the geodatabases are held in Microsoft Access files (`.mdb`) and have been compressed into zip files (`.zip`). All files reside in the `landfast1996-2004/annual_geodb directory`.

1.5.1.2 RADARSAT-1 SAR Imagery (Source Data)

ARCGIS GRIDS, SHAPEFILES, AND GEOTIFF MOSAICS

These images are provided in three formats: ArcGIS grids in ArcInfo interchange format (`.e00`), shapefiles (`.shp`), and GeoTIFF mosaics (`.tif`). Low resolution browse images of each of these is provided in JPEG format (`.jpg`). The GeoTIFFs do not have the geographic information embedded in the file. This information is included in a .aux file associated with each GeoTIFF. The GeoTIFFs also have associated metadata in a `.tif.xml` file. Also included with each shapefile and grid are metadata files provided in a number of formats: SGML (`.sgml`), ASCII text (`.txt`), XML (`.xml`) and HTML (`.html`). Most files have been compressed together in zip files to conserve space and to bundle like files. All files reside in the `landfast1996-2004/data/yyyy/mmm` directories.

Note: The Canadian Space Agency holds the intellectual property and copyright permissions for the RADARSAT-1 SAR images.

BINARIZED GEOTIFF

The images of the landfast ice extent have also been binarized and converted to GeoTIFF format (`.tif`). In the images, the landfast ice extent is represented in white and the coast and open ocean are black. These GeoTIFF files do not have the geographic information embedded within the file. Instead, they are distributed with their associated world file (`.tfw`) which contains the geographic information. All files reside in the `landfast1996-2004/data/binarized_geotiffs` directory.

1.5.1.3 XML Metadata Templates

The XML metadata templates for the landfast ice extent data are four, FGDC-compliant metadata files in XML format (`.xml`) that provide an XML template of the metadata for four different types of landfast data files. The XML files reside in the `landfast1996-2004/metadata_templates` directory and are explained in Table 2.

Table 2. Landfast XML Metadata Template Descriptions

XML File	Description
monthyavg_slie_shape_templ.xml	XML template for the landfast monthly averaged shapefiles (max_mmshape.zip files in the landfast1996-2004/monthly_averages directory)
radarsat_template.xml	XML template for the RADARSAT GeoTIFF mosaics (rYY_ddd_dddmos.zip files in the landfast1996-2004/data/YYYY/mmm directories)
monthlyavg_slie_grid_templ.xml	XML template for the landfast ArcGIS monthly averaged grid files (monthly_stats_grids.zip files in the landfast1996-2004/monthly_averages/ directory)
slie_grid_template.xml	XML template for the landfast binarized GeoTIFFs in ArcInfo Interchange format (rYY_ddd_ddd.zip files in the landfast1996-2004/data/YYYY/mmm directories)

Note: These XML metadata templates differ slightly from the metadata provided with the data. The abstract, supplemental information, and processing description are worded differently, but all other content is the same.

1.5.1.4 Monthly Averages

The monthly averages files provide mean, median, maximum, and minimum averages of landfast ice extent for each month derived from the RADARSAT-1 SAR imagery. The data are provided in ArcGIS grids (`.adf`), shapefiles (`.shp`), ArcGIS geodatabases (the geodatabases are held in Microsoft Access files (`.mdb`), and GeoTIFF files (`.tif`). Most files are zipped together by month and data format (grid, shapefile, geodatabase, or GeoTIFF) and have the `.zip` file extension. All ancillary and auxiliary files needed to open the shapefiles and grids such as `.prj` or `.dbf` are included in the zip files. The GeoTIFFs do not have the geographic information embedded in the file. This information is included in a `.aux` file associated with each GeoTIFF. Browse images in JPEG format (`.jpg`) of the mean, median, maximum, and minimum monthly shapefiles and the monthly GeoTIFFS are available unzipped for quick viewing. All files reside in the `landfast1996-2004/monthly_averages` directory on the HTTPS site.

Note: Some GeoTIFF images may appear black when viewed. Landfast ice pixels were assigned a value of 1 and non-landfast ice pixels were assigned a value of 0, so the images appear black when viewed on a scale of 0 to 255. Rescale or threshold the image to view it properly.

1.5.2 Leads

1.5.2.1 Annual Geodatabase Files

The annual geodatabase files are GIS vectorized lead outlines in ArcGIS geodatabase format (the geodatabases are held in Microsoft Access files (`.mdb`) created from the source AVHRR imagery. The geodatabases organize the lead data by ice season. All files reside in the `lead1993-2004/annual_geodb` directory.

1.5.2.2 AVHRR Imagery (Source Data)

ARCGIS GRIDS, SHAPEFILES, AND GEOTIFF FILES

Data derived from the source AVHRR imagery are provided in three formats. This includes the AVHRR image in an ArcGIS grid in ESRI ArcInfo interchange format (`.e00`), shapefiles (`.shp`), and GeoTIFF format (`.tif`) with a land mask overlaid. Low resolution browse images of each of these is provided in JPEG format (`.jpg`). The GeoTIFFs do not have the geographic information embedded in the file. This information is included in a .aux file included with each GeoTIFF. The GeoTIFFs also have associated metadata in a .tif.xml file. Also included with each shapefile and grid are metadata files provided in a number of formats: SGML (`.sgml`), ASCII text (`.txt`), XML (`.xml`) and HTML (`.html`). All files have been bundled together in zip files and reside in the lead1993-2004/data/YYYY/mmm directories.

BINARIZED DATA

The images of the leads have also been binarized and converted to GeoTIFF format (.tif). In these GeoTIFF files, the geographic information has been embedded within the file (no extra metadata file is needed). Areas that are black are leads and areas that are white are ice and land mask. See the Processing Steps section of this document for information on how these files were created. All files reside in the `lead1993-2004/data/binarized_data` directory.

1.5.2.3 XML Metadata Templates

The XML metadata templates for the leads data are FGDC-compliant metadata files in XML format (`.xml`) that provide an XML template of the metadata for three different types of lead data files. The XML files reside in the `leads1993-2004/metadata_templates` directory and are explained in Table 3.

Table 3. Lead XML Metadata Template Description

XML File	Description
avhrr_template.xml	XML template for the AVHRR imagery GeoTIFFS (cYYdddmos.zip files in the leads1993-2004/data/YYYY/mmm directories)
leads_grid_template.xml	XML template for the AVHRR imagery ArcGIS grids (cYYdddgrid.zip files in the leads1993-2004/data/YYYY/mmm directories)
leads_shape_template.xml	XML template for the AVHRR imagery shapefiles (cYYdddshape.zip files in the leads1993-2004/data/YYYY/mmm directories)

Note: Some file naming convention information in the metadata files is inaccurate; follow the naming conventions provided in the File Naming Convention section of this document.

1.5.2.4 Stacked Leads

The stacked leads files represent the sum of all binarized lead images for each month in the study area and are provided in GeoTIFF format (`.tif`). In these GeoTIFF files, the geographic information has been embedded within the file (no extra metadata file is needed). The pixel value represents the number of images in which a lead was observed at that location during a particular month from 1993 to 2004. These were converted to probabilities by dividing by the total number of images stacked for each month (Eicken et al. 2006). The darker the area the higher the lead occurrence frequency. The white along the bottom of the image is the Alaskan coast mask. All files reside in the `lead1993-2004/stacked_leads` directory.

1.5.2.5 Summary Statistics

Two Microsoft Excel spreadsheets (`.xls`) are provided with this data set: `mean.xls` and `lead_fraction.xls`. The statistics in these files include calculations of total and mean lead fraction; the geographic location, area, perimeter, and major/minor dimensions of individual leads; and derived statistics including lead number densities and size distributions for each ice season. All files reside in the `lead1993-2004/summary_statistics` directory.

1.5.3 Supplemental Information

Two supplemental documents supplied as Microsoft Excel files provide a catalog of the file names of the original AVHRR and RADARSAT-1 SAR scenes. The AVHRR files are cataloged in `avhrr_catalog.xls` and the RADARSAT-1 SAR files are cataloged in `sar_catalog.xls.`

1.6 Directory Structure

The data files in this data set are available via HTTPS: https://noaadata.apps.nsidc.org/NOAA/G02173/. This section describes the directory structure of the HTTPS site. The top level of the directory structure, `G02173`, is divided into three main directories. Two for the parameters (landfast ice extent and leads) and a third directory for supplemental information. Landfast ice extent data reside in the `landfast1996-2004` directory, lead data reside in the `lead1993-2004` directory, and the supplemental information resides in the `data_catalogs` directory. The landfast and lead directories are further broken down into subdirectories. Figure 2 shows the top level directory structure. Table 4 describes the `landfast1996-2004` directory, and Table 5 describes the `lead1993-2004` directory.

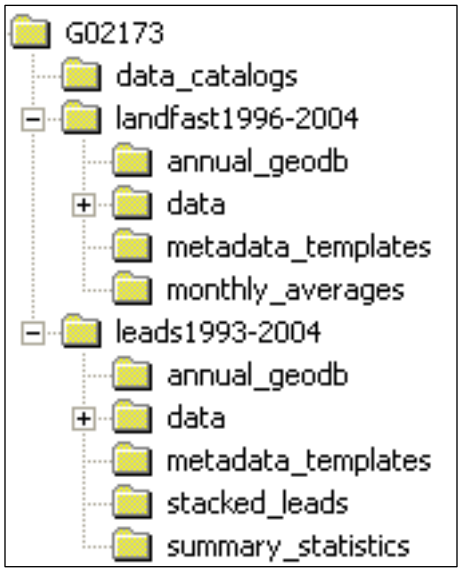

Figure 2. Top Level Directory Structure
This image shows the G02173 directory expanded to first- and second-level subdirectories.

1.6.1 Landfast Ice Extent

Table 4. Description of the landfast1996-2004 Directory and Subdirectories

Directory Name	Definition
landfast1996-2004	Contains data files pertaining to landfast ice. This directory contains four subdirectories: annual_geodb, data, metadata_templates, and monthly_averages.
annual_geodb	Contains the ArcGIS geodatabases with vectorized outlines of the landfast ice extent for each annual ice season.

Directory Name	Definition
data	Contains the RADARSAT-1 SAR grids, shapefiles, GeoTIFF mosaics, and binarized GeoTIFF images. This directory is further broken down into subdirectories, one for each year that data was collected (1996-2004) labeled as the 4-digit year (YYYY) and a directory called binarized_geotiffs. The year directories are subdivided into directories labeled by the 3-character month abbreviation (mmm) and contain the RADARSAT-1 SAR grids, shapefiles, and GeoTIFF mosaics. The binarized_geotiffs directory contains the binarized RADARSAT-1 SAR GeoTIFFs. See Figure 3.
metadata_templates	Contains the XML files with FGDC-compliant metadata templates.
monthly_averages	Contains the statistics for the landfast data including mean, median, maximum, and minimum averages for each month.

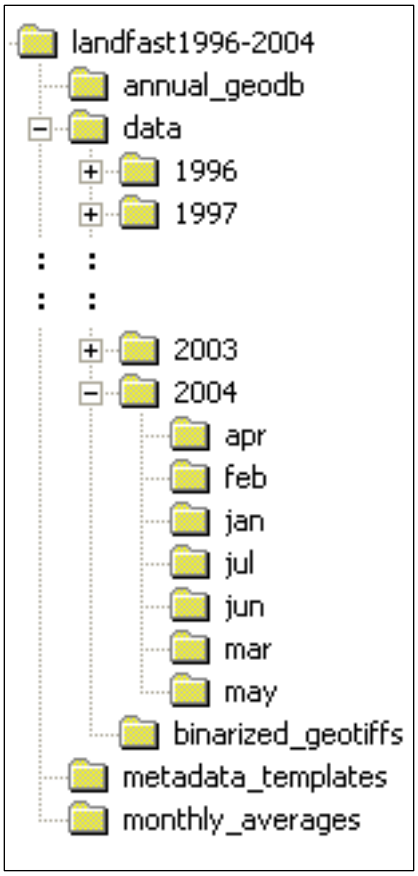

Figure 3. Landfast Directory Structure

1.6.2 Leads

Table 5. Description of the lead1993-2004 Directory and Subdirectories

Directory Name	Definition
lead1993-2004	Contains data files pertaining to leads in sea ice. This directory contains five subdirectories: annual_geodb, data, metadata_templates, stacked_leads, and summary_statistics.
annual_geodb	Contains GIS vectorized lead outlines for each ice season.
data	Contains the original AVHRR grids, shapefiles, GeoTIFF images, and binarized GeoTIFF images. This directory is further broken down into subdirectories, one for each year that data was collected (1993-2004) labeled as the 4-digit year (YYYY) and a directory called binarized_data. The year directories are subdivided into directories labeled by the 3-character month abbreviation (mmm) and contain the original AVHRR grids, shapefiles, and GeoTIFF images. The binarized_data directory contains the binarized AVHRR GeoTIFFs. See Figure 4.
metadata_templates	Contains the XML files with FGDC-compliant metadata templates.
stacked_leads	Contains the stacked leads for each month in the study area.
summary_statistics	Contains the mean and areal fraction of leads statistics.

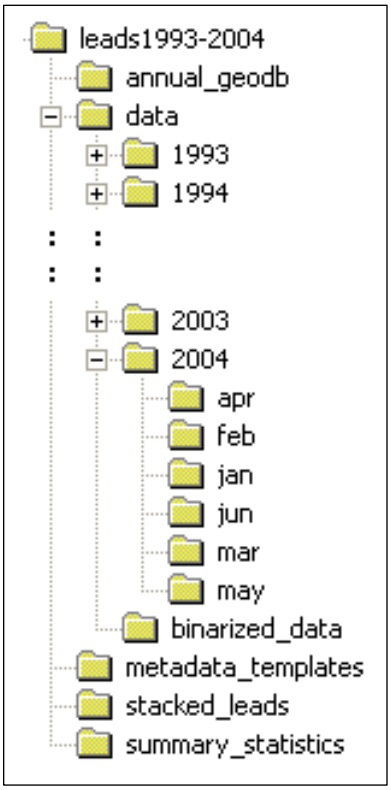

Figure 4. Leads Directory Structure

1.7 File Naming Convention

This section explains the file naming conventions. To access the different sections, follow the links below:

- Landfast Ice Extent
  - Annual Geodatabase Files
  - RADARSAT-1 SAR Imagery (Source Data)
  - Metadata Templates
  - Monthly Averages
- Leads
  - Annual Geodatabase Files
  - AVHRR Imagery (Source Data)
  - Metadata Templates
  - Stacked Leads
  - Summary Statistics

1.7.1 Landfast Ice Extent

1.7.1.1 Annual Geodatabase Files

The annual geodatabase files containing the vectorized landfast data have been compressed into zip files. All files reside in the `landfast1996-2004/annual_geodb` directory. The zip files are named according to the following convention:

Zipped File: `YYYY-YY_vector_geodb.zip`

Once unzipped, the files are named as follows. Table 6 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped File: `YYYY-YY_Vector_GeoDB.mdb`

Table 6. Naming Convention for Landfast Ice Extent Annual Geodatabase Files

Variable	Description
YYYY	4-digit year of the start of the data
YY	2-digit year of the end of the data
vector_geodb/Vector_GeoDB	Identifies this as a vectorized geodatabase file
.zip	Identifies that this file has been zipped
.mdb	Identifies this file as an ArcGIS geodatabase file - the geodatabases are held in Microsoft Access files.

1.7.1.2 RADARSAT-1 SAR Imagery (Source Data)

ArcGIS Grids, shapefiles, and GeoTIFF Mosaics

The RADARSAT-1 SAR ArcGIS grids, shapefiles and GeoTIFF mosaics have been compressed into zip files. The zip files, along with quick-view browse images in JPEG format (`.jpg`), reside in the `landfast1996_2004/data/YYYY/mmm` directories. The zip files are named according to the following convention:

Zipped File: `rYY_ddd_dddtype.zip`

Once unzipped, the files are named as follows. Table 7 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped Files: `rYY_ddd_dddtype.xxx`

Table 7. Naming Convention for Landfast Ice Extent Shapefiles, GeoTIFF Files, and Grids

Variable	Description
r	Identifies this as RADARSAT-1 SAR data
YY	2-digit year
ddd	3-digit day of year, the first ddd is the start day and the last ddd is the stop day of the data
type	File format or type none: ArcGIS grid shape: shapefile mos: GeoTIFF mosaic
.zip	Identifies that this file has been zipped
.xxx	File extensions inside each type of zip file Grids: .e00, .rrd, .html, .txt, .sgml, .jpg Shapefiles: .shp, .dbf, .shx, .sbn, .sbx, .shp.xml, .prj, .aux, .html, .jpg, .sgml, .txt GeoTIFFs: .tif, .aux, .tif.xml, .html, .rrd, .jpg, .jpg.xml, .jpg.aux, .sgml, .txt, .xml See Table 1 for a description of the file extensions

Note: A .rrd file does not exist in every zip file. The .rrd file is simply a pyramid file that draws the files more quickly and is not required. Upon opening the files in any ESRI software, a user will be prompted to create pyramids to enhance draw speeds for future use.

Quick-View Browse Images:

The quick-view browse images provide a way to quickly view a thumbnail of the contents of the zip files for the grids, shapefiles, and mosaics without having to unzip the files. These thumbnails also

reside in the zip files. Table 8 provides a description of the quick-view browse images. Note: Not all files have a quick-view browse image.

Table 8. Naming Convention for Landfast Ice Extent Quick-View Browse Image Files

File Name	Description
rYY_ddd_dddmos.jpg	JPEG quick-view browse image for the AVHRR GeoTIFFS
rYY_ddd_dddshape.jpg	JPEG quick-view browse image for the shapefiles
rYY_ddd_ddd.jpg	JPEG quick-view browse image of the grid files

Binarized GeoTIFFs

The binarized landfast ice extent GeoTIFF images are compressed into zip files by ice season. All files reside in the `landfast1996-2004/data/binarized_geotiffs` directory. The zip files are named according to the following convention:

Zipped File: `rYYYY_YY_slie.zip`

These zip files contain GeoTIFFs (`.tif`) and metadata in their associated world file (`.tfw`). The world files reside in a directory called `TFWs`. Note: You can ignore all files and directories that begin with ._ as they are just a byproduct of processing. Once unzipped, the files are named as follows. Table 9 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped Files:

Files in the top level directory are named according to the following convention:

`rYYYYddd-ddd_slie.tif`

Files in the TFWs directory are named as follows:

`rYYYYddd-ddd_slie.tfw`

Table 9. Naming Convention for Landfast Ice Extent Binarized GeoTIFF Files

Variable	Description
r	Identifies this as RADARSAT-1 SAR data
YYYY	4-digit start year of data
YY	2-digit end year
ddd	3-digit day of year, the first ddd is the start day and the last ddd is the stop day of the data
slie	Identifies this file as containing SLIE data
.zip	Identifies that this file has been zipped

Variable	Description
.tif	Identifies this as a GeoTIFF file
.tfw	Identifies this as a World file

1.7.1.3 XML Metadata Templates

There are four landfast metadata templates that reside in the `landfast1996-2004/metadata_templates` directory with the following names:

- monthlyavg_slie_grid_templ.xml
- monthyavg_slie_shape_templ.xml
- RADARSAT-1_template.xml
- slie_grid_template.xml

1.7.1.4 Monthly Averages

The monthly averages are divided into four categories by format and all files reside in the landfast1996-2004/monthly_averages directory.

- ArcGIS Grids
- Shapefiles
- ArcGIS Geodatabases
- GeoTIFFs

ArcGIS Grids

The monthly averages ArcGIS grid files containing landfast data have been compressed into zip files. The zip files are named according to the following convention:

Zipped file: `monthly_stat_grids.zip`

These zip files contain an ArcInfo workspace containing 10 ArcGIS grids, one for each month that data was obtained (October through July). For more information on ArcGIS grids, visit the ESRI ArcGIS Desktop Help: About the ESRI Grid Format Web page. Once unzipped, you will see a number of files in the top-level directory, a directory called info, and 10 coverage directories of the form `stat_MM` (one for each ArcGIS grid). This structure must be preserved so that ArcGIS can open the files properly. See Figure 5 for a screenshot of an unzipped file. Unzipped files are named according to the convention below. Table 10 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped files:

Files in the top level directory are named according to the following convention:

- stat_MM.xxx

Files in the info directory:

- arc.dir
- arcXXXX.dat
- arcXXXX.nit
- arcPPPPr.001

Files in coverage directories (stat_MM):

- dblbnd.adf
- hdr.adf
- log
- metadata.xml
- prj.adf
- sta.adf
- vat.adf
- w001001.adf
- w001001x.adf

Table 10. Naming Convention for Landfast Ice Extent Monthly Averages ArcGIS Grids

Variable	Description
monthly	Identifies these file as containing monthly averaged data
stat	Statistic in this file (maximum/max, mean, median, or minimum/min)
MM	2-digit month
grids	Identifies this as an ArcGIS grid file
arc	Identifies this as an ArcGIS info file
XXXX	ArcGIS index for shapefile (0000 to 0029)
PPPP	ArcGIS index for shapefile (0002, 0005, 0008, 0011, 0014, 0017, 0020, 0023, 0026, and 0029)
.zip	Identifies that this file has been zipped
.adf	ArcGIS grid files that reside in the coverage directories (stat_MM)
.xxx	File extension (.rrd, .aux, .html, .jpg, .txt, .xml) See Table 1 for a description of the file extensions

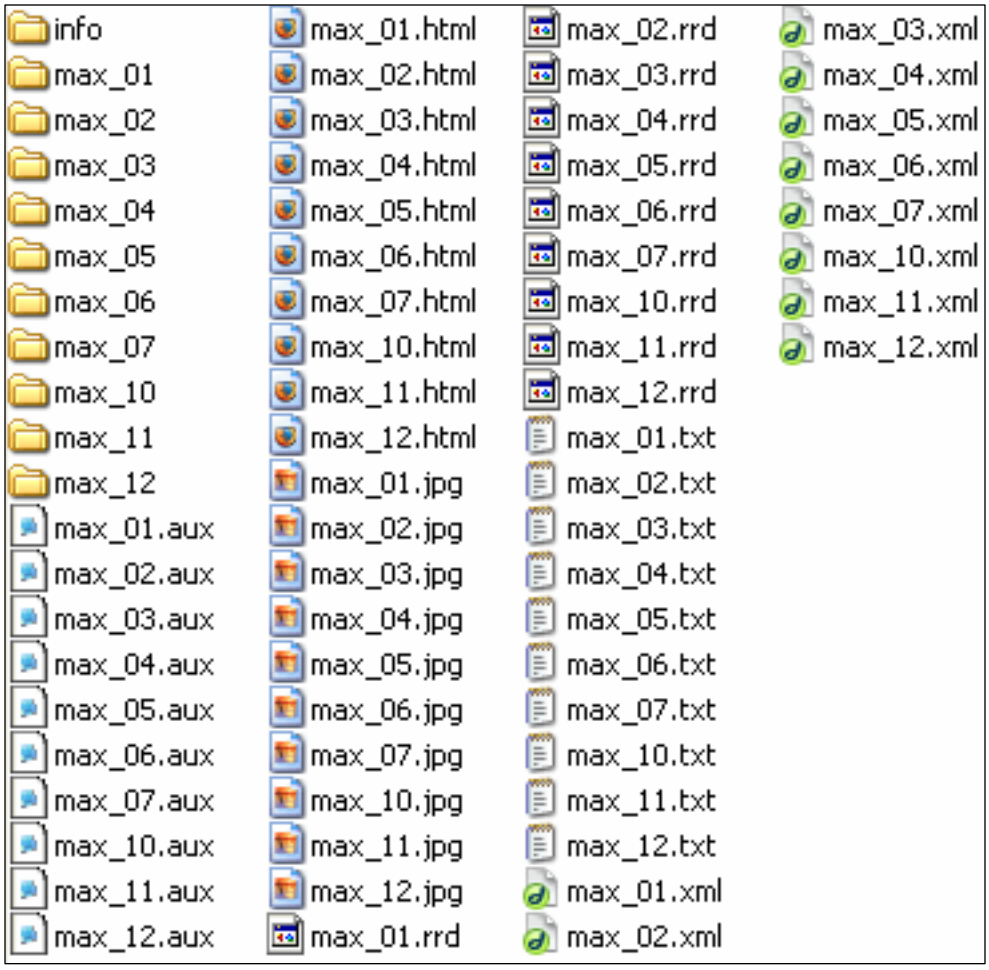

Figure 5. Screenshot of the Contents of monthly_maximum_grids.zip

Shapefiles

The monthly averages shapefiles containing landfast data have been compressed into zip files. The zip files are named according to the following convention:

Zipped file: `stat_MMshape.zip`

These zip files contain multiple files of varying formats. Once unzipped, the files are named as follows. Table 11 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped files: `stat_MMshape.xxx`

Table 11. Naming Convention for Landfast Ice Extent Monthly Averages Shapefiles

Variable	Description
stat	Statistic in this file (max, mean, median, or min)
MM	2-digit month

Variable	Description
shape	Identifies this as an shapefile
.zip	Identifies that this file has been zipped
.xxx	File extension (.shp, .dbf, .shx, .sbx, .sbn, .shp.xml, .prj, .jpg, .aux, .txt, .html, .xml) See Table 1 for a description of file extensions

ArcGIS Geodatabases

The monthly averages ArcGIS geodatabases containing landfast data have been compressed into zip files. The zip files are named according to the following convention:

Zipped file: `slie_monthly_stat.zip`

Once unzipped, the files are named as follows. Table 12 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped file: `SLIE_Monthly_stat.mdb`

Table 12. Naming Convention for Landfast Ice Extent Monthly Averages ArcGIS Geodatabase Files

Variable	Description
slie_monthly/SLIE_Monthly	Identifies this as a file containing derived monthly SLIE data
stat	Statistic in this file (Maximum/maximum, Mean/mean, Median,/median, or Minimum/minimum)
.zip	Identifies that this file has been zipped
.mdb	Identifies this as an ArcGIS geodatabase file - the geodatabases are held in Microsoft Access files.

GeoTIFFs

The monthly averages GeoTIFF files containing landfast data have been compressed into zip files. The zip files are named according to the following convention:

Zipped file: `monthly_stat_geotiffs.zip`

These zip files contain GeoTIFF images and their associated .aux file. Once unzipped, the files are named as follows. Table 13 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped files: `stat_MM.xxx`

Table 13. Naming Convention for Landfast Ice Extent Monthly Averaged GeoTIFF Files

Variable	Description
monthly	Identifies these file as containing monthly averaged data
stat	Statistic in this file (max, mean, med, or min)
geotiffs	Identifies this as a Geotiff file
MM	2-digit month
.zip	Identifies that this file has been zipped
.xxx	File extension (.tif, .aux, or .rrd) See Table 1 for a description of the file extensions

Note: A `.rrd` file does not exist in every zip file. The `.rrd` file is simply a pyramid file that draws the files more quickly and is not required. Upon opening the files in any ESRI software, a user will be prompted to create pyramids to enhance draw speeds for future use.

1.7.2 Leads

1.7.2.1 Annual Geodatabase Files

The annual geodatabase files containing the vectorized lead data have been compressed into zip files. All files reside in the `lead1993-2004/annual_geodb` directory. The zip files are named according to the following convention:

Zipped File: `leads_YYYY-YY_vector_geodb.zip`

Once unzipped, the files are named as follows. Table 14 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped File: `Leads_YYYY-YY_Vector_GeoDB.mdb`

Table 14. Naming Convention for Leads Annual Geodatabase Files

Variable	Description
leads/Leads	Identifies this file as containing lead data
YYYY	4-digit year of the start of the data
YY	2-digit year of the end of the data
vector_geodb/Vector_GeoDB	Identifies this as a vectorized geodatabase file
.zip	Identifies that this file has been zipped
.mdb	Identifies this file as an ArcGIS geodatabase file - the geodatabases are held in Microsoft Access files.

1.7.2.2 AVHRR Imagery (Source Data)

ArcGIS Grids, shapefiles, and GeoTIFF files

The AVHRR source data imagery have been compressed into zip files. All files reside in the `lead1993-2004/data/YYYY/mmm` directories. The zip files, along with quick-view browse images in JPEG format (`.jpg`), reside in `leads1993_2004/data/YYYY/mmm`. **Note**: Some months may not contain data for a specific year due to the cloud coverage. The zip files are named according to the following convention:

Zipped file: `cYYdddtype.zip`

Once unzipped, the files are named as follows. Table 15 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped file: `cYYdddtype.xxx`

Table 15. Naming Convention for AVHRR Imagery Grids, Shapefiles, and GeoTIFF Files

Variable	Description
c	Channel v: visible, AVHRR channel 1 t: thermal, AVHRR channel 4
YY	2-digit year
ddd	3-digit day of year
type	File format or type grid: ArcGIS grid file shape: shapefile mos: GeoTIFF file with land mask applied Note: Once files of the type mos are unzipped, mos is not in the filename.
.zip	Identifies that this file has been zipped
.xxx	File extension inside of each type of zip file Grids: .e00, .html, .txt, .sgml, .jpg Shapefiles: .shp, .dbf, .shx, .shp.xml, .prj, .html, .jpg, .sgml, .txt GeoTIFFs: .tif, .aux, .tif.xml, .jpg, .html, .sgml, .txt See Table 1 for a description of file extensions

Quick-View Browse Images:

The quick-view browse images provide a way to quickly view a thumbnail of the contents of the zip files without having to unzip the files. These thumbnails also reside in the zip files but have a slightly different file name. See Table 16 for a complete description of the quick-view browse images.

Table 16. Naming Convention for AVHRR Imagery Quick-View Browse Image Files

File Name	Description	Name in Zip File
cYYddd_tha.jpg	JPEG quick-view browse image for the AVHRR GeoTIFFS	cYYddd.jpg
cYYddd_thb.jpg	JPEG quick-view browse image for the shapefiles	cYYdddshape.jpg
cYYdddgrid or cYYddd.jpg	JPEG quick-view browse image of the grid files	cYYdddgrid.jpg

Binarized Data

There are two binarized AVHRR source imagery files: one for the visible channel and one for the thermal channel. All files reside in the `lead1993-2004/data/binarized_data` directory. The files have been compressed into zip files and are named according to the following convention:

Zipped files:

- AVHRR_Thermal.zip
- AVHRR_Visible.zip

Once unzipped, the files are named as follows. Table 17 describes the file naming convention variables for both the zipped and unzipped files.

Unzipped file: `cYYddd.tif`

Table 17. AVHRR Binarized Data File Naming Convention

Variable	Description
AVHRR	Identifies that this file contains AVHRR data
Thermal	Identifies that this file contains AVHRR thermal channel (channel 4) data
Visible	Identifies that this file contains AVHRR visible channel (channel 1) data
c	AVHRR channel used v: visible (channel 1) t: thermal IR (channel 4)
YY	2-digit year

Variable	Description
ddd	3-digit day of year
.zip	Identifies that this file has been zipped
.tif	Identifies this as a GeoTIFF file

1.7.2.3 XML Metadata Templates

There are three lead metadata templates that reside in the leads1993-2004/metadata_templates directory. They have the following names:

- avhrr_template.xml
- leads_grid_template.xml
- leads_shape_template.xml

1.7.2.4 Stacked Leads

The stacked lead files reside in the `lead1993-2004/stacked_leads` directory. They are named according to the following convention and as described in Table 18:

`stacked_leads_mmm.tif`

Table 18. Stacked Leads File Naming Convention

Variable	Description
stacked_leads	Identifies this file as containing stacked lead data
mmm	3-character month abbreviation
.tif	Identifies this as a GeoTIFF file

1.7.2.5 Summary Statistics

There are two files containing statistics about the lead data. They reside in the `lead1993-2004/summary_statistics` directory.

- lead_fraction.xls
- means.xls

1.8 File Size

1.8.1 Landfast Ice Extent

The file sizes for each type of landfast ice extent data file is shown in Table 19.

Table 19. Landfast Ice Extent File Size

File Type	Size
Annual Geodatabase Files	Zipped: 16.9 - 22.7 MB per file Unzipped: 64.6 - 85.9 MB per file
RADARSAT-1 SAR Imagery	Zipped: 100 KB - 29.1 MB per file Unzipped: 1 KB - 30.2 MB per file
Metadata Templates	22.9 KB - 128 KB per file (files are not zipped)
Monthly Averages	Zipped: 610 KB - 7.58 MB per file Unzipped: 1 KB - 29 MB per file

1.8.2 Leads

The file sizes for each type of lead data file is shown in Table 20.

Table 20. Leads File Size

File Type	Size
Annual Geodatabase Files	Zipped: 1.23 MB - 8.62 MB per file Unzipped: 7.1 MB - 40.3 MB per file
AVHRR Imagery	Zipped: 37.7 KB - 1.55 MB per file Unzipped: 3 KB - 2 MB per file
Metadata Templates	15.8 KB - 18.8 KB per file (files are not zipped)
Stacked Leads	426 KB per file (files are not zipped)
Summary Statistics	436 KB - 532 KB per file (files are not zipped)

1.9 Sample Data Record

This section shows examples of the data files in this data set.

1.9.1 Landfast Ice Extent

1.9.1.1 Annual Geodatabases

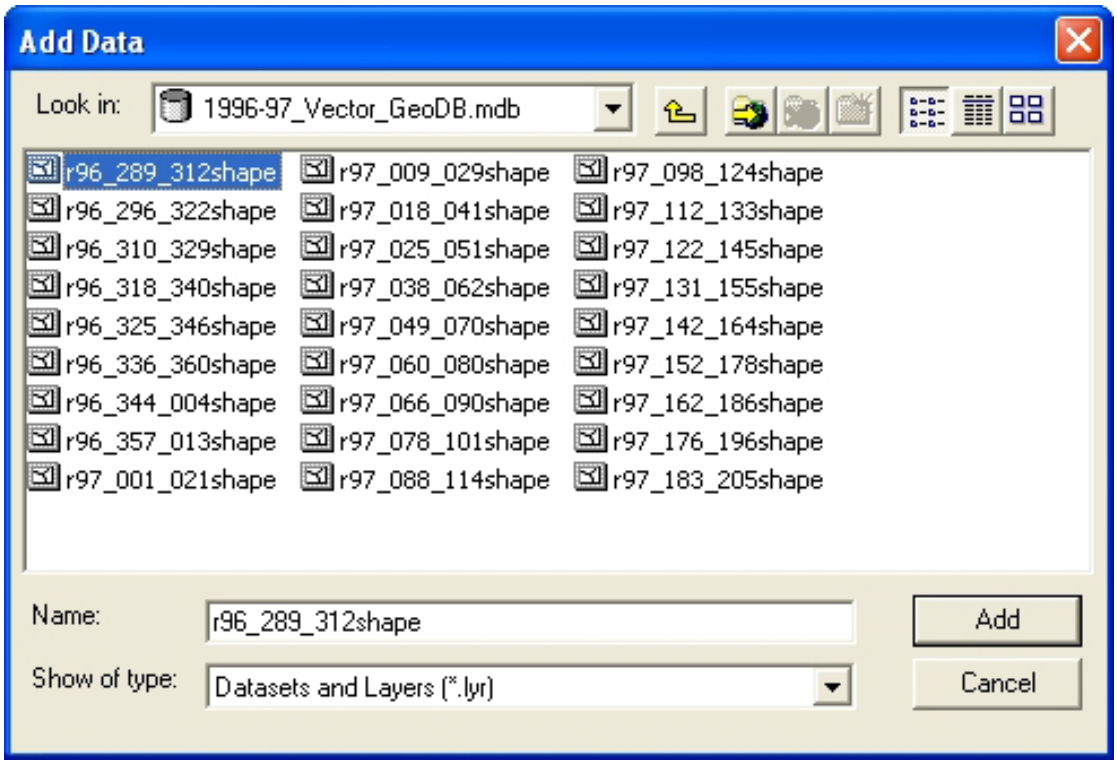

Figure 6. Screenshot of 1996-97_Vector_GeoDB.mdb

Shows the geodatabase for the 1996/1997 ice season in ArcGIS.

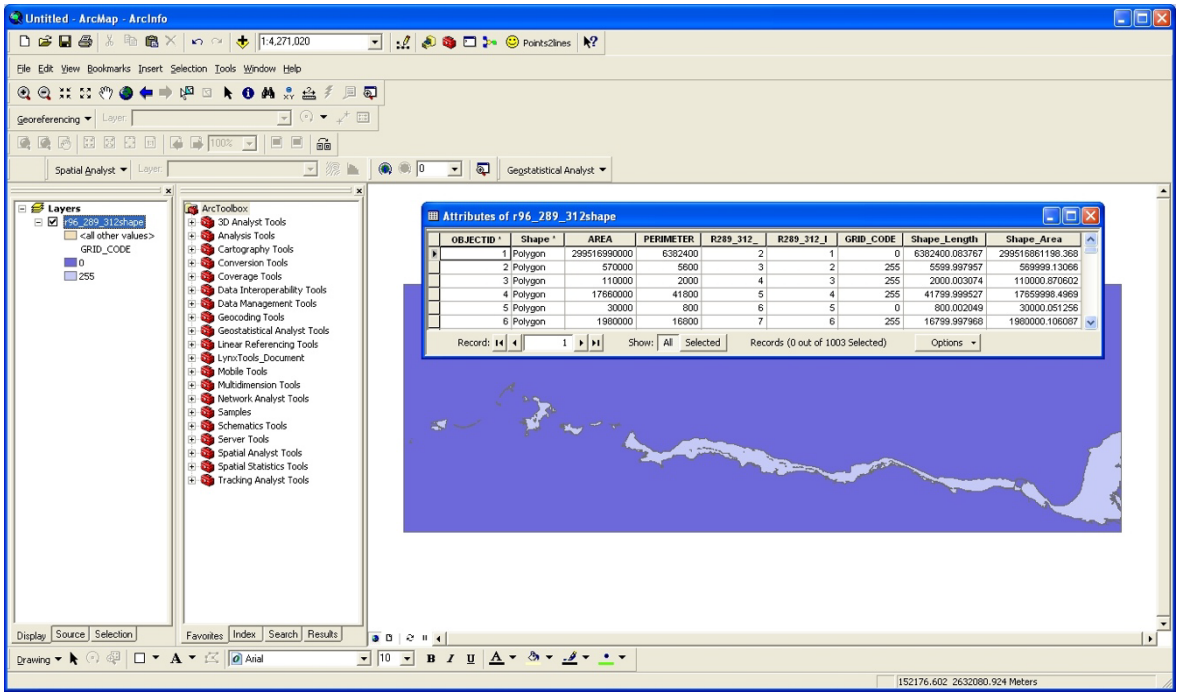

Figure 7. Screenshot of the r96_289_312shape Layer and Attribute Table

Shows the shape layer for 15 Oct - 07 Nov 1996 in ArcGIS.

1.9.1.2 RADARSAT-1 SAR Imagery (Source Data)

Figure 8. Example of RADARSAT-1 SAR Image Mosaic GeoTIFF
Image is for 16 March - 18 March 2000 (r00_076_078mos.tif).

1.9.1.3 Monthly Averages

Figure 9. Example of a Monthly Averaged Minimum GeoTIFF
Image is for the month of January from 1996 to 2004 (Min_01.tif from monthly_minimum_geotiffs.zip).

1.9.2 Leads

1.9.2.1 AVHRR Imagery (Source Data)

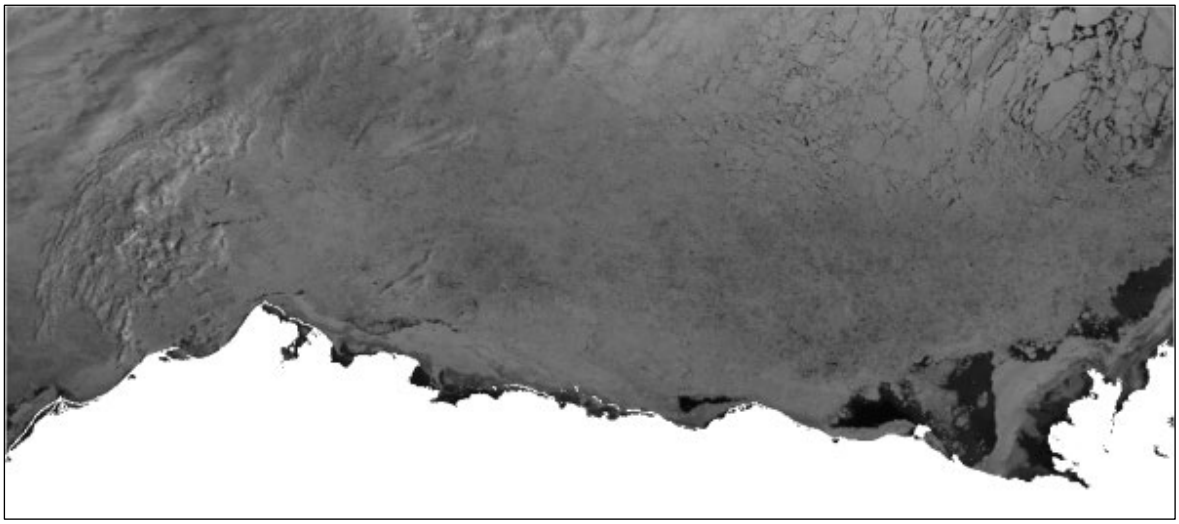

Figure 10. AVHRR GeoTIFF File

This is an example of a visible band AVHRR GeoTIFF file for 14 June 1996 (v96166.tif from v96166.zip). The associated .tfw world file contains the projection information for each corresponding GeoTIFF file. The Alaskan coast is shown in white due to a land mask that was applied.

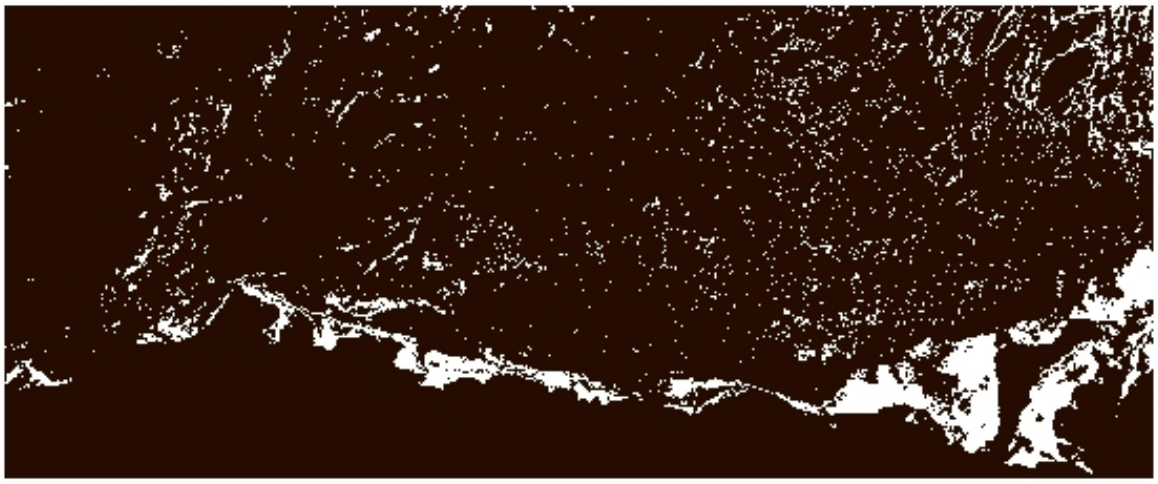

Figure 11. Binarized Lead

Binarized lead image for 14 June 1996 (v96166grid.e00).

1.9.2.2 Stacked Leads

Figure 12 is an example of a stacked leads image for the month of June from 1993 to 2004. The darker the area the higher the lead occurrence frequency. The white along the bottom of the image is the Alaskan coast mask.

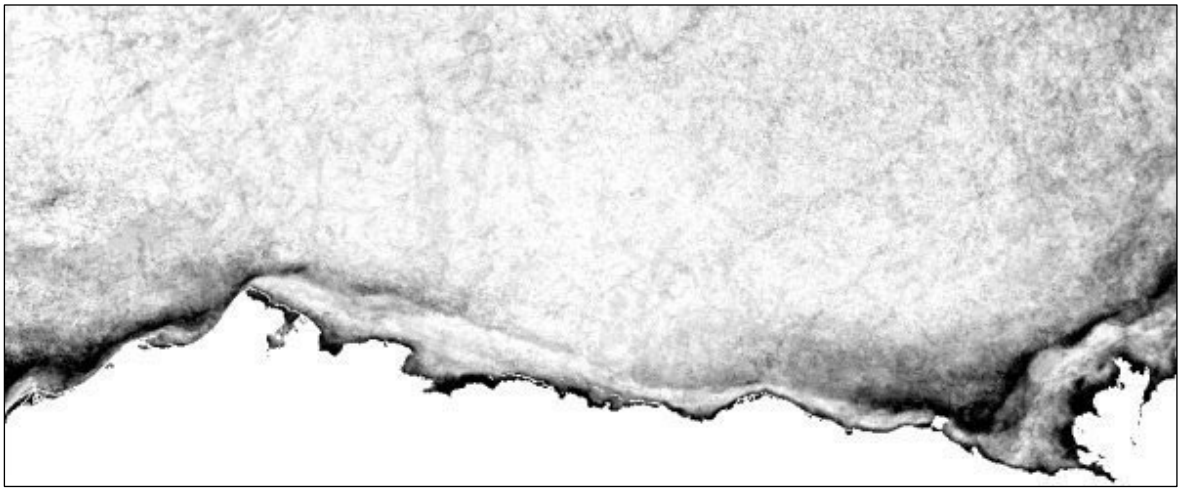

Figure 12. Example of Stacked Leads

Image is for the month of June from 1993 to 2004 (stacked_leads_jun.tif).

1.9.2.3 Summary Statistics

Fraction of Leads			Subregion													
File	Day of Year	Days since Sept 1	1	2	3	4	5	6	7	8	9	10	11	12	mean	std dev
t93343	343	99	0.017	0.039	0.054	0.007	0.010	0.015	0.020	0.026	0.026	0.045			0.026	0.016
t93356	356	112	0.135	0.123	0.075	0.016	0.011	0.005	0.012	0.019	0.016	0.014	0.041	0.037	0.042	0.045
t93364	364	120	0.024	0.066	0.060	0.010	0.008	0.013	0.016	0.083	0.060	0.103	0.066	0.048	0.046	0.032
t94004	4	125	0.053	0.081	0.071	0.001	0.010	0.028	0.105	0.130	0.147	0.095	0.049	0.021	0.066	0.047
t94005	5	126	0.118	0.071	0.049	0.010	0.005	0.011	0.059	0.050	0.079	0.043	0.032	0.019	0.045	0.034
t94006	6	127	0.031	0.056	0.045	0.007	0.002	0.002	0.038	0.042	0.060	0.045	0.030	0.016	0.031	0.020
t94007	7	128	0.036	0.024	0.032	0.005	0.007	0.002	0.011	0.015	0.035	0.033	0.018	0.016	0.019	0.012
t94008	8	129	0.053	0.056	0.064	0.017	0.005	0.008	0.008	0.004	0.003	0.008	0.003	0.003	0.019	0.024
t94009	9	130	0.052	0.068	0.079	0.016	0.015	0.001	0.000	0.001	0.003	0.003	0.005	0.006	0.021	0.029
t94010	10	131	0.021	0.027	0.065	0.017	0.008	0.003	0.000	0.000	0.010	0.007	0.027	0.030	0.018	0.018
t94011	11	132	0.010	0.019	0.048	0.009	0.009	0.006	0.000	0.000	0.005	0.009	0.023	0.025	0.013	0.013

Figure 13. Beginning Portion of lead_fraction.xls

std deviation of perimeter	std deviation of major axis	std deviation of minor axis	areal fraction of leads	lead density
77.0	12.3	2.6	0.042	0.001466
115.7	12.8	3.5	0.046	0.001315
126.0	15.2	3.8	0.066	0.001543
60.1	10.7	3.3	0.045	0.001499
51.3	10.1	2.7	0.031	0.00115
34.6	8.0	2.2	0.019	0.001011
52.6	8.9	2.2	0.019	0.000953
48.6	10.5	2.8	0.021	0.000713
71.7	11.9	3.5	0.018	0.000523
45.1	10.3	2.6	0.013	0.00059

Figure 14. Beginning Portion of means.xls

2 SOFTWARE AND TOOLS

Tools that work with this data are Geographic Information System (GIS) software, image viewing software, Microsoft Excel, and text editors. Zipped files can be unzipped with WinZip or other similar compression software.

Note to WinZip Users: In some versions of WinZip (WinZip 9.x or lower), the WinZip window does not preserve the directory structure of the zipped file. To see the directory structure, extract the files from WinZip to your computer, or obtain WinZip 10.x and higher which does preserve the directory structure within the WinZip window.

3 DATA ACQUISITION AND PROCESSING

3.1 Data Processing Steps

The data processing section is divided into two sections: landfast ice extent and leads. Most of the content below came from Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas (Eicken et al. 2006).

3.1.1 Landfast Ice Extent

The landfast ice extent was determined by the distance between land (the Alaskan coast) and the SLIE that is derived from RADARSAT-1 SAR data from 1996 through 2004. Off the northern coast of Alaska, landfast ice extent starts advancing between October and November and then breaks up by July. The landfast ice extent exists for a majority of the year, and then the coastal area becomes ice-free for a couple of months (August and September). For the landfast ice extent region in this study, there are approximately 1,000 SAR scenes that were originally analyzed. Because one SAR scene does not cover the entire study area, three or four scenes were combined or mosaiced to cover the entire landfast ice extent study area (subregions 2-11). Refer to Figure 1. However, due to orbital constraints of the RADARSAT-1 satellite, the scenes were not acquired at the same time, each mosaic typically spans two to three days. Complete mosaics were produced approximately every 10 days. Sets of three consecutive RADARSAT-1 SAR mosaics, spanning a period of approximately 20 days, were then used to identify landfast ice extent. Figure 15 shows an example of a RADARSAT-1 SAR mosaic comprised of five individual SAR scenes.

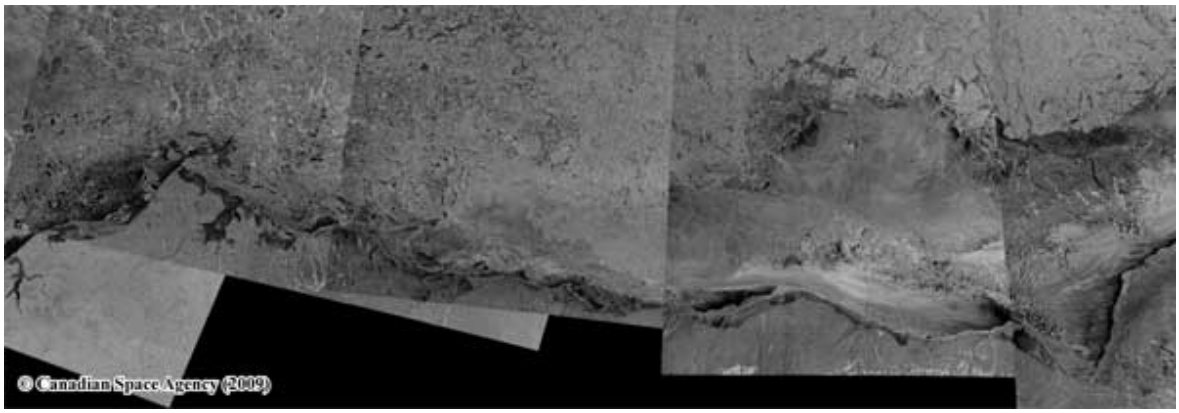

Figure 15. Example of RADARSAT-1 SAR Mosaic Covering the Entire Study Area
This mosaic is comprised of five individual SAR scenes for 01 December through 04 December 1996 (r96_336_340mos.tif from r96_336_340mos.zip). Image courtesy of the Canadian Space Agency.

Figure 16 shows three mosaics around Barrow, Alaska. The green line depicts the Alaskan shoreline and the red line shows the SLIE based on all three mosaics.

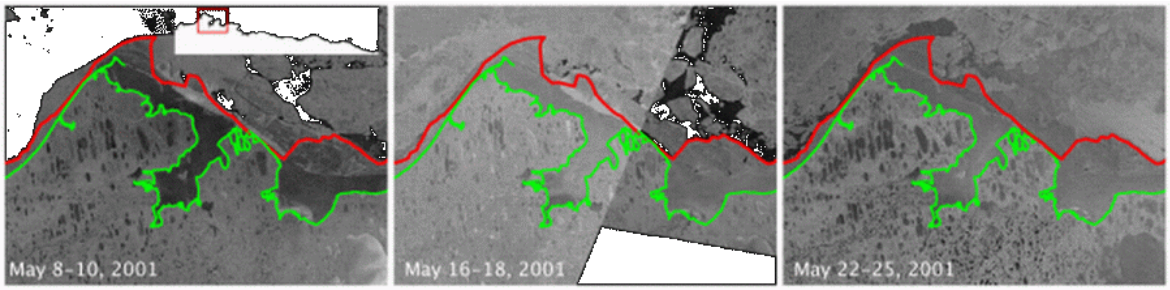

Figure 16. Three Consecutive RADARSAT-1 SAR Mosaics
These images are sub-regions of three consecutive RADARSAT SAR mosaics focused on Barrow, AK (dates are noted in each image). Images courtesy of Andrew Mahoney.

These RADARSAT-1 SAR images were processed into GeoTIFF format in the Alaska Statewide Albers equal-area conical map projection using Advanced Product Development SAR tools from ASF. An IDL script was then used to mosaic individual scenes together to cover the whole area.

To determine the regions of ice that met the landfast ice definition criteria in each set of three mosaics, a combination of automated and manual techniques was employed. As well as visual comparison of all three mosaics, a composite image was produced based upon the magnitude of the net difference in vector backscatter gradient between the mosaics. This gradient difference highlighted regions of change or motion and helped reduce the subjectivity of the analysis. In addition to not showing movement in three successive mosaics, the ice had to have a low gradient difference value in order to be considered landfast ice. Further details of this process are described by Mahoney et al. (2005) and Eicken et al. (2006).

3.1.2 Leads

The leads were derived from AVHRR data from 1993 through 2004. The AVHRR images were acquired from the UAF HRPT receiving station, with data from recent years augmented by NOAA Gilmore Creek receiving station during periods where the UAF station was down. At least one AVHRR image was analyzed and used each day during the period when leads in the Beaufort and Chukchi Seas are most prominent, which is from early December to late June. Both visible and infrared AVHRR images were used; visible images were used when sunlight was available and infrared (IR) images were used during dark months in Alaska. In months with some sunlight, both types of AVHRR images were used. AVHRR

In visible AVHRR data, land is white (due to a land mask that was applied), sea ice is gray, and leads are black. Refer to Figure 17. In IR AVHRR imagery, land is black (due to a land mask that was applied), sea ice is gray, and leads are shown in white.

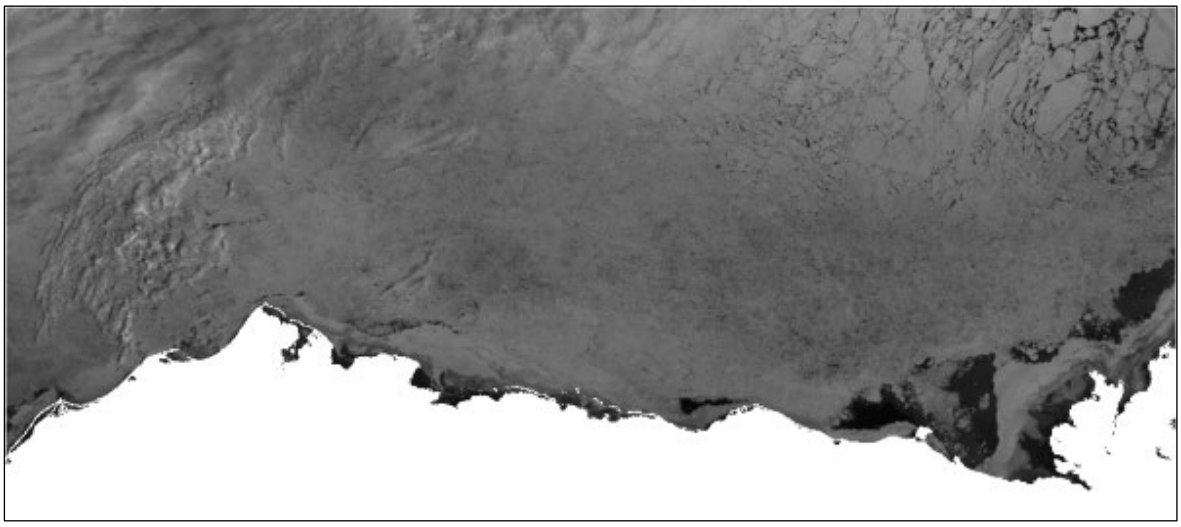

Figure 17. AVHRR Visible Band Image for 04 May 2004 (v04125.tif from v04125.zip)
Leads appear dark, ice and landfast ice appear grayish, and the Alaskan coast is white.

Approximately 2,000 AVHRR images were analyzed and visually examined. Each scene covers more than one subregion. If clouds were misidentified as leads or if an AVHRR image was mostly cloud covered over the study region, the images were either corrected by removing cloud covered sectors from the image or eliminated, meaning some months may not contain data for a specific year due to the cloud coverage. This resulted in a total of 385 AVHRR images in this data set. Figures 18 and 19 show the number of AVHRR images by region and month. Since most AVHRR scenes cover more than one subregion, Figure 18 illustrates that data coverage is slightly better in the middle of the study area. Figure 19 shows that the months were consistently sampled and that there are fewer cloud-free scenes during the transition months of December and June.

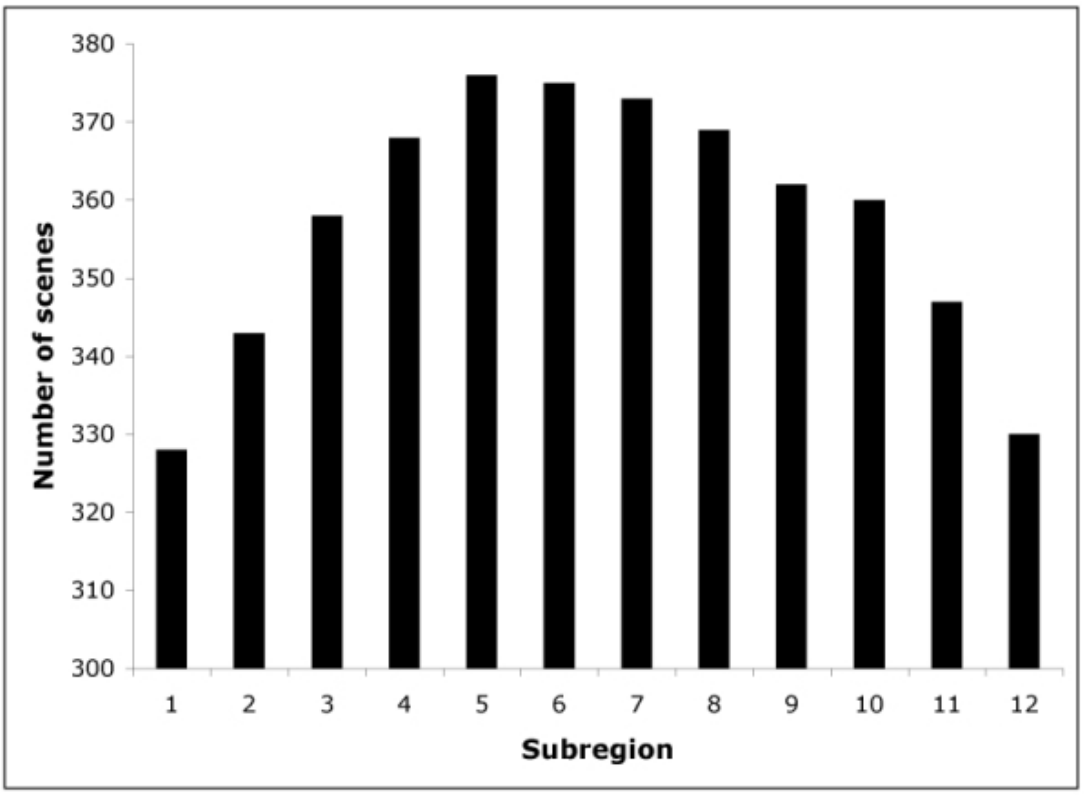

Figure 18. Number of AVHRR Scenes Analyzed per Subregion During the Study Period (1993-2004)

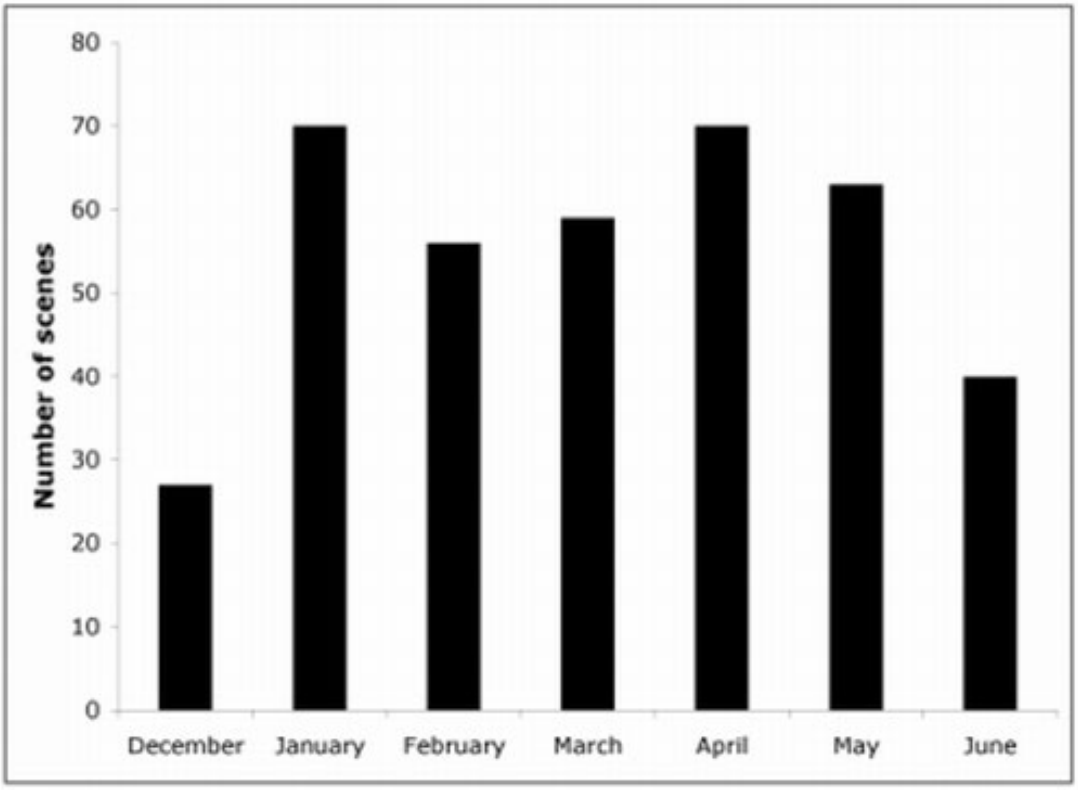

Figure 19. Number of AVHRR Scenes Analyzed Per Month from 1993-2004

Recurring lead patterns and features are identified and named. The way to distinguish whether a pattern or feature is persistent over time was to look for evidence of differential ice motion between AVHRR scenes, and to quantify the persistent occurrence of leads for each grid cell over a given time period.

AVHRR data were geolocated, calibrated, and reprojected in GeoTIFF format in the Alaska Statewide Albers equal-area conical map projection using TeraScan software. A coast mask was applied in ENVI. "The fraction of leads within each pixel was determined based on the brightness temperatures or reflectances of open water and the surrounding thick ice, as described by Lindsay and Rothrock (1995)" (Eicken et al., 2006). The data were corrected for regional differences in surface temperature and reflectance, as well as thin cloud cover, by determining the fraction of leads within a moving 50 by 50 pixel (55 km x 55 km) square window, with the fraction of thick ice based on the upper and lower quartile reflectance and brightness temperature, respectively. For a few cases of more expansive stretches of open water, manual adjustments of open water extent were made. The resulting image indicates the fraction of open water in each pixel. Each image is then classified, such that any pixel containing 25 percent or more open water or thin ice is designated as lead and any pixel containing less than 25 percent open water or thin is classified as ice. The resulting image is a binary image, containing only leads and ice with the land mask assigned the same value as ice. This information was then brought into NIH Image for derivation of lead location, shape and size statistics, open water fractions, and other information for the different study subregions. Stacked leads (monthly lead probabilities) were also produced based on the binarized leads. These stacked leads represent the sum of all lead images for each month in the study area. The darker the area the higher the lead occurrence frequency. The white along the bottom of the image is the Alaskan coast mask.

3.2 Error Sources

3.2.1 Landfast Ice Extent

The SLIE is located to within 500 m (geolocation accuracy). The timing of the SLIE is approximately +/- 5 days due to the time interval between mosaics. Radiometric errors are not a significant source of errors for landfast ice edge derivation because of the combination of spatial gradient and manual delineation approaches employed (Mahoney et al. 2006). One source of error is the ambiguous signature between open water and thin ice in the RADARSAT-1 data (Kwok and Cunningham 1994).

3.2.2 Leads

Geolocation errors for leads were determined to be less than 3 km and generally within 1.2 km (Eicken et al., 2006). Radiometric errors impact the detectability of leads, along with limitations

imposed by sensor resolution (Eicken et al., 2006). These error sources impact number densities and the lower end of lead size distributions, but are not as relevant for other derived quantities.

3.3 Quality Assessment

Note: NSIDC did not perform a quality assessment of the data.

3.3.1 Landfast Ice Extent

The manual process for identifying landfast ice extent has subjectivity. However, this subjectivity was reduced by using a gradient difference. Refer to the landfast ice extent Data Processing section of this document for more information on the gradient difference.

The following is a list of the quality checks performed on the landfast ice (Mahoney et al. 2005):

- Data were checked for adequate coverage over the study area (subregions 2-11).
- Images with a large geolocation error were identified and either corrected or disregarded.
- The geolocation accuracy could create collocation errors of up to 10 pixels or 1 km between parts of two mosaics.

3.3.2 Leads

The following checks were performed on the AVHRR data:

- Manually examined all scenes and excluded images or image sections with any trace of cloud cover or ambiguous lead/cloud features to keep the potential source of error due to clouds and fog to a minimum.
- Classified lead/ice images were compared to ship-based observations of lead fractions in May and June of 2004 and found to be in reasonable agreement with a deviation of two and one percentage-point, respectively.

3.4 Sensor or Instrument Description

3.4.1 Landfast Ice Extent

The instrument used to acquire the landfast ice extent images was the Synthetic Aperture Radar (SAR) onboard RADARSAT-1. It was launched on 04 November 1995 into a sun synchronous orbit and measured horizontally polarized (HH) C-band microwave radiation at 5.3 GHz to obtain data of the surface of the Earth.

3.4.2 Leads

The instruments used to acquire the leads data were the Advanced Very High Resolution Radiometers (AVHRR) on the NOAA 12, 14, 15, 16, and 17 satellites. The AVHRR sensor is a broad-band, 5- or 6-channel scanning radiometer (NOAA 12 and 14 - 5 channels; NOAA 15, 16, and 17 - 6 channels). It takes measurements in the visible, near-infrared, and thermal infrared portions of the electromagnetic spectrum.

4 REFERENCES AND RELATED PUBLICATIONS

For a more in depth description of the purpose and aim of this project and its data, download Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas Final Report (Eicken et al. 2006).

Eicken, H., L. Shapiro, A. G. Gaylord, A. Mahoney, and P. Cotter. 2006. Mapping and Characterization of Recurring Spring Leads and Landfast Ice in the Beaufort and Chukchi Seas. Final Report, Minerals Management Service OCS Study MMS 2005-068.

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4.1 Related NSIDC Data Collections

March through August Ice Edge Positions in the Nordic Seas, 1750-2002
National Ice Center Arctic Sea Ice Charts and Climatologies in Gridded Format
The Dehn Collection of Arctic Sea Ice Charts, 1953-1986

5 CONTACTS AND ACKNOWLEDGMENTS

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6 DOCUMENT INFORMATION

6.1 Document Authors

A. Windnagel, L. Ballagh, and D. Miller prepared this document based on correspondence with H. Eicken, A. Gaylord, A. Mahoney, and F. Fetterer. Eicken et al. (2006), Mahoney et al. (2005), and Mahoney et al. (2007) provided most of the background content upon which this document is based.

6.2 Publication Date

June 2009

6.3 Date Last Updated

August 2012: A. Windnagel clarified that a .mdb file is a Microsoft Access database file which is the format used for ArcGIS geodatabases.