RADARSAT GEOPHYSICAL PROCESSOR SYSTEM

DATA USER'S HANDBOOK

(Version 0.1)

DRAFT

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<u>Document Change Control</u>

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1. Introduction

The RADARSAT Geophysical Processor System (RGPS) produces Level 2 data products that contain descriptions of the Arctic Ocean sea ice cover derived from Synthetic Aperture Radar (SAR) imagery acquired by RADARSAT.

There are fifteen RGPS products containing the following derived information:
1. Lagrangian ice motion.
2. Ice age histogram (winter only).
3. Interpolated ice age histogram (winter only; 3-day categories).
4. Area/open water fraction (summer only).
5. Ice thickness histogram (winter only).
6. Backscatter histogram.
7. Gridded ice age histogram (winter only).
8. Gridded ice thickness histogram (winter only).
9. Gridded backscatter histogram.
10. Gridded area/open water fraction (summer only).
11. Gridded ice motion.
12. Eulerian ice motion.
13. Melt Onset/Freeze up.
14. Gridded wind/temperature/pressure.
15. Ice deformation.

Seven products are produced directly from the Lagrangian ice motion record; they contain properties of material elements on the ice cover derived from their deformation and backscatter characteristics. Six gridded products (on a lower resolution 50 km grid) contain averaged properties derived from the higher resolution datasets. One other product contains gridded sea level pressure, surface wind and temperature estimates used in the analysis of the SAR data.

1.1 Purpose

The purpose of this handbook is to provide the necessary information for the use of the data products generated by the RGPS. This includes an overview of the algorithms, description of the characteristics of the products and more importantly, descriptions of data fields in these products. The format and specifications of the actual products can be found in JPL Document D-13448.

1.2 Data Archive/Software

During the verification phase of the RGPS (between 1999-2000), all products are staged on the RGPS website at JPL (URL: http://www-radar.jpl.nasa.gov/rgps). The RGPS product archive will be migrated to the Alaska SAR Facility at a future date. This website also contains the latest information on RGPS processing plans and status. Software for reading the data product can be found here.

1.3 Questions

If you have any questions, contact:

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1.4 Acknowledgments

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1.5 Related Documents

Kwok, R, G. Cunningham and L. Nguyen, ASF RADARSAT Geophysical Processor System Product Specification, JPL D-13448.

Kwok, R. and G. F. Cunningham. ASF Geophysical Processor System Data User's Handbook , Version 2.0, JPL Document D-9526.

2. Map Projection/Gridding

The natural planimetric orientation of the image output of a strip map SAR processor is typically defined by the range and azimuth directions, where the azimuth direction is along the spacecraft groundtrack and the range direction (for a side-looking radar) is approximately orthogonal to that of the groundtrack. This is not the most convenient planimetric representation for geophysical analysis because of the inherent geometric characteristics and distortions. It does not allow for ease of registration of the data with SAR datasets collected with different imaging geometries and datasets acquired by other sensors. Furthermore, the projection characteristics (e.g. scale, orientation, etc.) are typically defined within the extent of the image frame and therefore are not slowly varying and consistent for construction of large mosaics.

All the image data used in RGPS are geocoded. Geocoding is the process of resampling the image samples of a given planimetric representation, in this case the SAR range-azimuth projection, into one that is defined by a standard cartographic projection. The planimetric distortions of standard map projections are well-defined and slowly varying with respect to the size of the image frames considered here. The process of geocoding involves the estimation of the geographic location (latitude, longitude) of each SAR image sample and then mapping it into the projection best-suited for a particular application. The polar stereographic projection used here is identical to the one used by the gridded Special Sensor Microwave/Imager (SSM/I) products. The rationale for this selection is that the RGPS products would be geometrically registered to the gridded SSM/I products without resampling of the data fields.

2.1 SSM/I Polar Stereographic Projection

The reference latitude of the SSM/I polar stereographic projection is located at 70^{o}N. The decision to lower the tangent plane from the pole to the 70^{o} latitude was made to minimize geometric distortions in the marginal ice zone. The origin of the Cartesian grid is at the pole. The map vertical (or the ordinate) and the abcissa of the grid are defined by the 135^{o}E and 45^{o}E meridians. Planimetrically, this is a conformal projection with true scale at the reference latitude. The scale is 0.97 at the pole. The Hughes ellipsoid is used as the datum for the projection. Details of the SSM/I polar grids can be found in [DMSP, 1996].

2.2 Grid Definition

There are four grid sizes defined by the original SSM/I polar grids. For both polar regions, a 100km grid cell is centered at the pole. The 12.5 km, 25 km, 50 km and 100 km grids all share the same outer boundary with the smaller grid cells being partitions of the 100km grid. For example, there are four 50km grid cells within every 100km grid cell. A 5 km and 10 km grid have been added to the polar grids to allow for the higher resolution sampling required by the RGPS products.

2.3 Geolocation Accuracy

Many factors affect the consistent and absolute map location of a grid point. By far, the dominant source of error in the location an image sample is the uncertainty in the ephemeris of the RADARSAT platform. The Canadian Space Agency (CSA) provides the Alaska SAR Facility with restituted state vectors after reception of a data take. These state vectors have location accuracies better than that of the orbits predicts. Based on comparison of the estimated location of corner reflectors in a SAR image and the location of these reflectors (measured with hand held GPS receivers), the location uncertainty of the products generated at ASF is on the order of 100m for descending passes and 200m for ascending passes. Also, it was found that these errors are highly correlated between ascending passes and between descending passes. The random component of these errors is approximately 50m which includes uncertainty introduced in the measurement process. The pixel location accuracy quoted here is based on preliminary evaluation of the commissioning phase data. There is continuing effort to characterize and improve this quantity in future data products.

3. RGPS Observations

3.1 Repeat Coverage of the Arctic Ocean

The 460 km swath ScanSAR Wide B (SWB) mode of RADARAT [Raney et al, 1992] is selected to provide routine coverage of the Arctic Ocean for the RGPS system. The radar data are downlinked in real-time while the satellite is within line-of-sight of the ASF or Tromso reception stations. Outside the two stations masks, the radar data are acquired and stored on the onboard tape recorder (OBR) and downlinked to Canadian gound stations at a later time. The planned coverage of the Arctic Ocean over a 24-day *cycle* (the number of days it takes for the spacecraft to retrace the same orbit) shown in Fig. 1. The Arctic Ocean within the ASF mask is covered once every three days and within the Tromso mask once every six days.

3.2 Observations derived from the Image Data

The measurements derived directly from sequential RADARSAT ScanSAR Wide B (SWB) imagery are: ice motion, backscatter, multiyear ice and open water fractions. The ice age, ice thickness estimates are derived from these records. The measurements made at each time step are stored in three database tables maintained in the RGPS system (Table 1). These tables are: the grid point trajectory table, connectivity table and the cell attributes table.

Grid point trajectory Table. At each time step, the geographic location of that grid point is recorded. Birth date is the date that grid point was created. When that grid point is deleted, the death date is recorded. This table is updated each time a grid point is tracked to a new location. Displacement vectors are computed from differences in their geographic locations.

Connectivity Table. We keep track of the number of points of a polygon used to define a *cell* in this table. For each cell, the unique grid point identifiers of each vertex of the polygon are stored. Birth date is the date the cell was created. Initially, a cell is defined by a polygon with four vertices. Grid points are added as the length of the sides of the polygon increases. This table is updated when a grid point or cell is added or deleted. For example, when a grid point is deleted, the cells that are defined by that grid point are no longer valid and thus cause the death of the cells associated with this grid point. A grid point is deleted when the point is advected out of the region of interest or that point could no longer be identified by the ice tracker.

Cell Attributes Table. The attributes of each cell e.g. backscatter histogram, multiyear ice fraction, area, etc at each time step are stored in this table. These attributes are listed in Table 1.

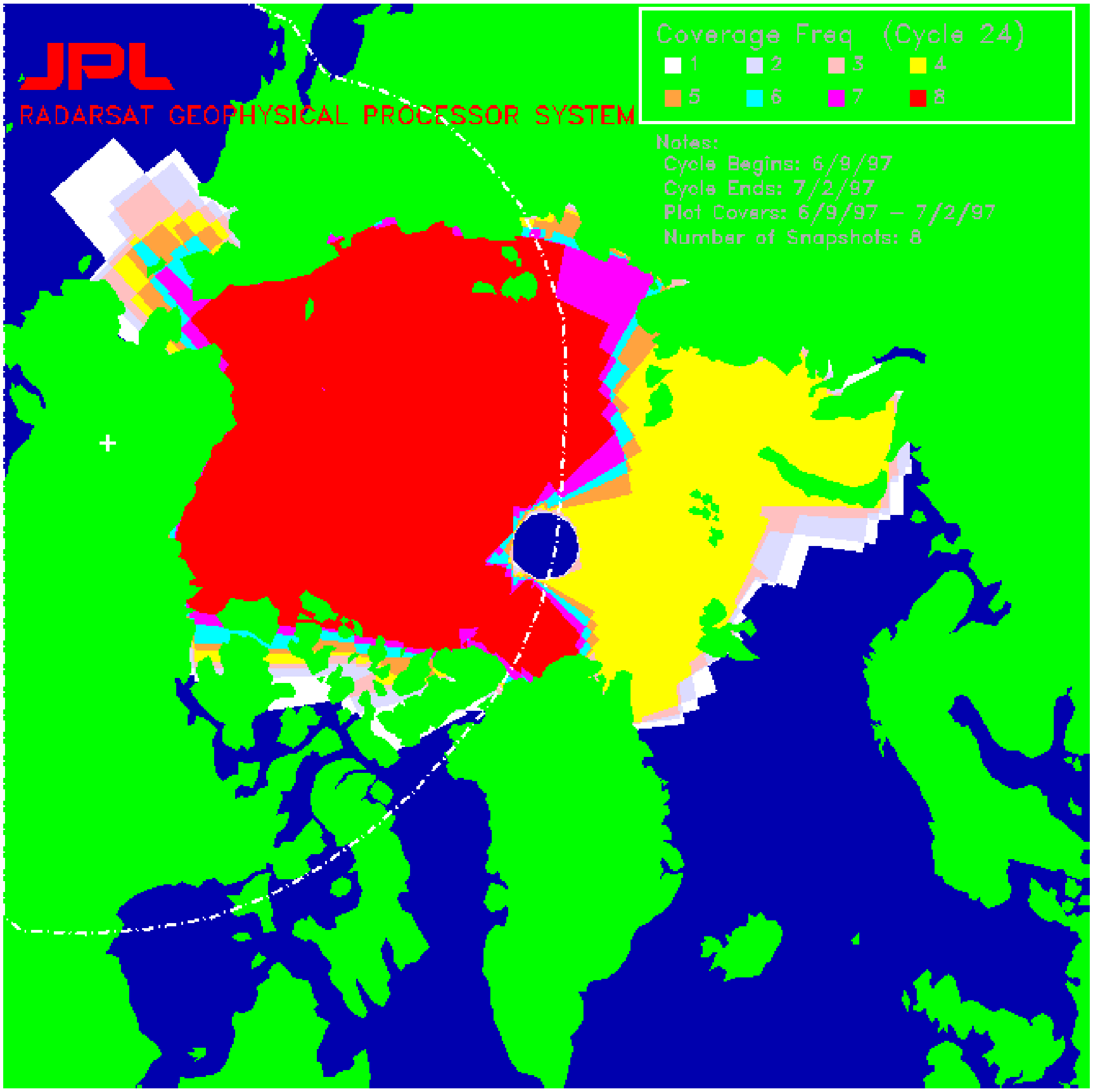

Fig 1. Nominal repeat coverage of the Arctic Ocean over a 24-day cycle.

Table 1

RGPS Database Tables

Grid Point Trajectories	
Grid Point identifier 1	Time of Observation Latitude Longitude Birth Date Death Date
Grid Point identifier 2	Time of Observation
:	:

Grid Connectivity Table	
Cell identifier 1	Number of Vertices (N) Grid point identifier 1 : Grid point identifier N Birth Date Death Date
Cell identifier 2	Number of Vertices (N)
:	:

Cell Attributes Table	
Cell identifier 1	Time of observation Area Air Temperature Wind u,v Winter: multiyear ice are Summer: open water fraction Incidence angle Backscatter histogram
Cell identifier 2	Time of observation
:	:

4. Products - Terminology/Organization

4.1 RGPS Processing - Grid Point and Cell Data

For a given stream, we process one n-day snapshot of the Arctic Ocean at a time. An n-day *snapshot* is the coverage of a selected region using a collection of datatakes over a duration of n days. Nominally, n=3 for repeat coverage in the ASF mask and n=6 for repeat outside the mask.

Sequential image data from the n-day snapshots are processed as separate stream*s*. The product from a *stream* contains the trajectories of all grid points and time-varying cell attribute information of points and cells defined on the image frames of an initial datatake. Fig. 2 shows a sample grid. The image frames of the first datatake in a sequence define the spatial coverage of the initial grid of that particular stream. No grid points are created automatically after the first grid is established. Ice motion of these points and cell attributes are sampled in subsequent n-day snapshots. Each stream is processed independently of one another.

Two initial grids are established in each stream to sample the ice motion and cell attributes. A 25 km coastal grid covers the region between the land boundaries and 100 km off the coast. A finer grid, either 10 km or 20 km, is used to sample ice motion away from the coast.

The products and their temporal and spatial sampling characteristics are shown in Table 2.

4.2 Products with Variable Spacing

We produce products A through F and O in Table 2 at the end of every cycle (a cycle is 24 days) of observation of the Arctic Ocean. Product M is produced only twice a year. A product of a specific type contains all the data from the beginning of a stream to date of production. The exception is the backscatter product that contains only the latest field of backscatter histograms for those Lagrangian cells.

4.3 Gridded Products

The gridded products are produced on a weekly basis. These products summarize the Lagrangian observations of the grid points and cells on a coarsely-spaced uniform grid.

The Eulerian ice motion product contains the ice motion field derived from two sequential images sampled on a 5-km uniformly-spaced grid.

4.4 Product file naming convention

File Name: PnpppSYYDDDddd.TF

where

Pn: Platform and number ("R1")
ppp: Product ID (1-999)
S: Data stream ID (a-z, A-Z)
YY: Start year of the product
DDD: Start julian day of the product
ddd: Duration (in days) that the product spans
T: Product code, according to the code described in Table 2
F: File type ("P" for product, "M" for metadata)

Table 2

RGPS Data Products
(The initial spacing of the Lagrangian grids are either 10 km or 20 km)

Product Code	**Description**	**Season**	**Grid Spacing**	**Temporal Samping (nominal)**
A	Lagrangian motion trajectories	Winter/Summer	Variable	3-6 days
B	Ice age histogram	Winter	Variable	3-6 days
C	Ice age histogram (interpolated)	Winter	Variable	3-6 days
D	Area/open water fraction	Summer	Variable	3-6 days
E	Ice thickness histogram	Winter	Variable	3-6 days
F	Backscatter histogram	Winter/Summer	Variable	3-6 days
G	Gridded ice age histogram	Winter	50 km	N/A
H	Gridded ice thickness histogram	Winter	50 km	N/A
I	Gridded backscatter histogram	Winter/Summer	50 km	N/A
J	Gridded open water fraction	Summer	50 km	N/A
K	Gridded ice motion	Winter/Summer	50 km	N/A
L	Eulerian ice motion	Winter/Summer	5, 10 km	N/A
M	Melt Onset/Freeze Up	Winter/Summer	Variable	3-6 days
N	Gridded Wind/Temp/Pressure	Winter/Summer	50 km	Daily
O	Ice deformation	Winter/summer	variable	3-6 days

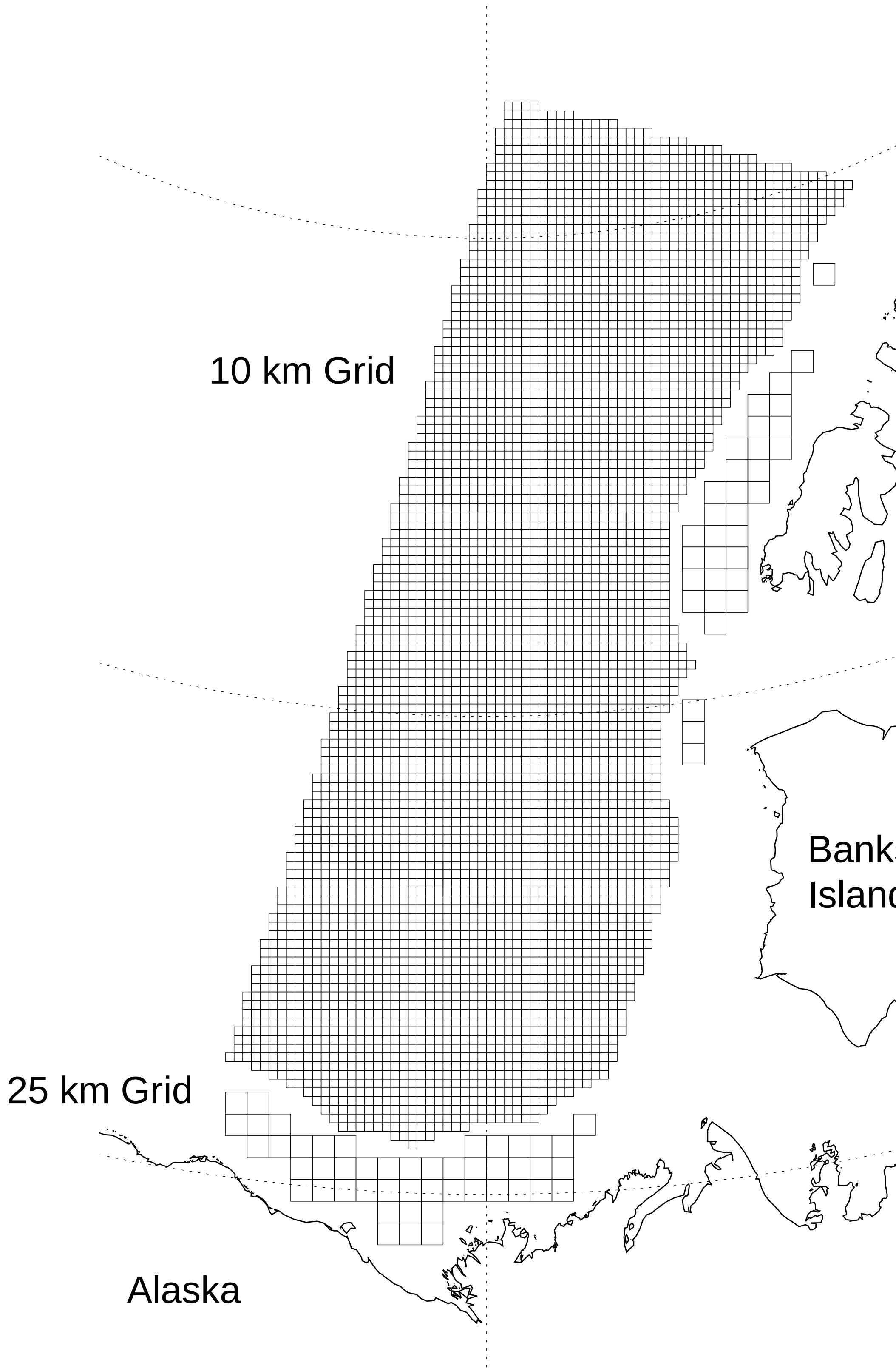

Fig. 2 Example of an initial grid overlaid on a ScanSAR datatake at beginning of a stream.

5. Lagrangian Ice Motion (Product A)

5.1 Algorithm Overview

The ice motion tracker is based on the procedure described in *Kwok et al.* (1990). The ice tracking algorithm operates on pairs of images separated in time. It uses area matching techniques to follow an array of points (defined as the center of an area on an image) from a source image to a set of target images. The time separation between repeat observations is variable and is based on available coverage. Initially, a regular array of points is defined on the first set of images covering a region. The common ice features are identified in sequential image frames by the ice tracker. Each point acquires its own trajectory as these points move with the ice cover. This differs from the ERS-1 GPS ice tracking strategy, in which the motion between image pairs are referred to an Earth-fixed grid, giving a quasi-Eulerian picture of the displacement field. Here, the RGPS uses the ice tracker to follow the same set of points over an ice season, giving a densely sampled Lagrangian picture of ice motion identical to the trajectories derived from drifting buoys.

5.2 Description (Product A) - Lagrangian Ice Motion

This product contains the trajectories of all the grid points within a stream over a time interval between *SEASON_START_YEAR/TIME* and *SEASON_END_YEAR/TIME*. This product is produced on a routine (weekly or per cycle) basis.

5.2.1 Lagrangian Ice Motion: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_IMAGES	Number of images used in the creation of this product.
N_TRAJECTORIES	Number of trajectories contained in this product.
PROD_TYPE	'Winter' or 'Summer' Product
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SW_LAT, SW_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

5.2.2 Lagrangian Ice Motion: Image Description Data Records

The image description data contain one record for each image used in the construction of the ice motion trajectories. All the images used in the creation of this product are stored here. This can be used to locate a grid point on a particular image.

Field Name	Description
IMAGE_ID	ASF image identifier.
IMAGE_YEAR, IMAGE_TIME	Time/year of image center.
MAP_X, MAP_Y	The map location of the image center.

5.2.3 Lagrangian Ice Motion: Gridpoint/Trajectory Description Data Records

The gridpoint description data contain one record for each gridpoint and its trajectory.

Field Name	Description
GPID	Unique gridpoint identifier assigned when the grid is defined on the initial datatake.
BIRTH_YEAR, BIRTH_TIME	The year/time of the first observation.
DEATH_YEAR DEATH_TIME	The year/time when this gridpoint was deleted. A grid point is deleted when it could no longer be tracked by the motion tracker. This terminates the trajectory of this grid point but the available observations trajectory remain in the product.
N_OBS	This number of observations of this gridpoint in this product.
OBS_YEAR_1, OBS_TIME_1	The year/time of the first observation.
X_MAP_1, Y_MAP_1	The map location of the gridpoint during this observation.
Q_FLAG_1	Quality flag (I_m)- an output of the tracker. Lower values indicate that the confidence of the matches are high. ρ = correlation of the image patches. m,σ = mean and standard deviation of all the matches between two images. I_m=1 if $m < \rho$; I_m=2 if $m - 0.5\sigma < \rho < m$; I_m=3 if $m - \sigma < \rho < m - 0.5\sigma$; I_m=4 if $m - 1.5\sigma < \rho < m - \sigma$; I_m=5 if $m - 2.0\sigma < \rho < m - 1.5\sigma$; I_m=6 if $m - 2.5\sigma < \rho < m - 2.0\sigma$.
. . .	. . .
OBS_YEAR_N, OBS_TIME_N	The year/time of the *N*th observation.
X_MAP_N, Y_MAP_N	The location of the grid point during this observation.
Q_FLAG_N	Quality flag - an output of the tracker.

6. Ice Age (Products B, C and G)

6.1 Algorithm Overview

The ice *age distribution* specifies the fractional area covered by ice in different age categories at a given time. We note here that the algorithm works only during the winter months (ice growth season) and that the procedure resolves the age categories at the young end of the distribution [*Kwok et al*., 1995]. Here, we describe how we associate cell area changes to ice age. A *cell* is the area within an image defined by the straight-line segments connecting *n* grid points. Then, we discuss a computational procedure to determine the age distribution of ice within a cell. We want to estimate the areal contribution $B_{k,j}$ of each age category j at time t_k to the total observed area. The age resolution is dependent on the frequency of observation of a given cell. The sampling interval is between observations does not have to be constant.

6.1.1 Age from Cell Area Changes

In the ice age algorithm, we monitor the time series of area changes of the cells. An increase in area indicates that new ice was formed in the cell. A negative change is assumed to have ridged the youngest ice in the cell, reducing its area. The assumption here is that once ridging starts, the deformation tends to be localized in the thinner, weaker ice that recently formed in the lead systems. The age classes are determined by the lengths of the time steps. The multiyear ice area within the cell is estimated from the backscatter histogram from within the cell. These data are recorded and tabulated. Each record applies to the time of one scene and records the change since the last observation. These are the fundamental data for computing the age distribution. The age distribution, $B_{k,j}$, is a set of areas of different age classes. $B_{k,j}$ denotes the area of ice at time t_k of age category *j*. That is, the age of the ice satisfies the inequalities

$$t_k - t_{k-(j-1)} < age_{k,j} < t_k - t_{k-j} \quad for \;\; j = 2 \; to \;\; k-1 \, .$$

Actual numerical examples can be found in [*Kwok et al*., 1995]. The index *k* denotes time t_k; the index *j* denotes age class, increasing with age class. T_k denotes the mean temperature during the time interval $[t_k, t_{k-1}]$; A_k is the area of the cell at time t_k.

The quantity $B_{k,MY}$ is the area of multiyear (MY) ice in the cell at time t_k, as determined from the backscatter within the cell. We use the ice classification algorithm in the GPS for this purpose. Theoretically this should not depend on *k* (time) because not MY ice should be created in the winter, but errors in the classification of multiyear ice can result from wind-blown open water or frost flowers.These confounding effects can be identified and removed by considering the time series of the multiyear ice area: $B_{1,MY}, B_{2,MY},\ldots, B_{k,MY}$. This filtering problem is discussed later. The quantity $B_{k,FY}$ is the area of ice in the cell at time t_k older than $t_k - t_1$ but younger than multiyear ice, i.e. it is the older first-year (FY) ice. The oldest ice (other than FY and MY) which is observed in this procedure is dependent on the length of time required to `integrate' out the initial conditions (discussed in Section 4). At time t_1, the area $B_{1,MY}$ is computed from the backscatter within the cell.

6.1.2 Age Distribution within a cell

Suppose that the complete age histogram is known at time t_{k-1}

$$B_{k-1,1},\ Bk_{-1,2},\ \ldots,\ B_{k-1,k-2},\ B_{k-1,FY},\ B_{k-1,MY}$$

The computational procedure to obtain the histogram $B_{k,j}$ at time t_k is as follows:

1) The first step is a shift of the histogram that represents the aging process.

$$B_{k,j} \leftarrow B_{k-1,j-1} \text{ for } j=2 \text{ to } k-1$$

For example, the first equation $B_{k,2} \leftarrow B_{k-1,1}$ says that the area of ice at time t_{k-1} (which was older than 0 but younger than t_{k-1} - t_{k-2} is transferred into the class of ice that is older than t_k t_{k-1} but younger than t_k - t_{k-2}. In other words, we have added $\Delta t = t_k - t_{k-1}$ to the upper and lower bounds of the age class. A similar interpretation applies to the other equations. Note that $B_{k,1}$ is not defined yet. It is determined in the next step.

2) Compute the new total cell area, A_k, from the new positions of the grid points. Compute the change in cell area since the previous time: $\Delta A = A_k - A_{k-1}$. The area of the youngest ice class is now $B_{k,1} = max\ (0,\Delta A)$. In other words, if new area was created $(\Delta A>0)$ then set the area of the youngest class to ΔA. If area was lost $(\Delta A<0)$ then set the area of the youngest class to zero. Step 4 accounts for any loss in area.

3) If $\Delta A \geq 0$ then skip to step 5.

4) This step is only executed when the cell area decreases $(\Delta A < 0)$. We need to remove the area ΔA from the histogram. We first remove area from the next class $B_{k,2}$ and then older classes, as necessary, until a total area reduction of ΔA is achieved. The assumption is that we are ridging the youngest ice first. The ridging process is fully described in the Section 7.

5) The area of multiyear ice $B_{k,MY}$ is computed from the backscatter within the cell using the GPS ice classification algorithm [*Kwok et al*., 1992].

6) Although we do not provide an estimate of $B_{k,FY},$ it can be estimated as follows:

$$B_{k,FY} = A_k - [B_{k,1} + B_{k,2} + \ldots + B_{k,k-1} + B_{k,MY}]$$

Since $B_{k,MY}$ is an independent estimate, it is possible that the area of first-year ice computed could be less than 0.

This completes the determination of the areas $B_{k,j}$ at time t_k. The procedure is repeated whenever Lagrangian observations of grid points are available. We refer to time interval between sequential images as a time step. During each time step, the cell areas are computed.. The area of ice in each age class in each cell is updated at each time step. In this manner, we keep track of the age distribution of the young ice within every cell.

6.1.3 Multiyear Ice Estimate

As previously noted, the presence of wind-blown open water or frost flowers on thinner ice could cause the ice classifier to over-estimate the area of multiyear ice even though the winter signature of multiyear ice has been shown to be remarkably stable [*Kwok and Cunningham*, 1994]. Using the history of multiyear ice estimates of a particular cell, these mis-classification events can be identified as positive spikes or humps in the multiyear ice fraction. Filtering out these events leaves the background or true multiyear ice area. This MY fraction may not be perfectly constant since the cell boundaries (straight lines connecting the corner nodes) are not necessarily material boundaries and these moving edges can cause ice to shift into or out of a cell. We use a simple procedure, assuming that multiyear ice within a cell is constant throughout the winter, to arrive at the best estimate of the average multiyear ice area [*Kwok et al*., 1995].

6.2 Description (Product B) - Ice Age Histograms

This product contains the latest ice age histograms of all the cells in the database at the time this product was produced. The ice age categories do not have uniform age intervals.

6.2.1 Ice Age Histograms: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells used in the creation of this product.
CREATE_YEAR *CREATE_TIME*	The year/time this product was created by the RGPS system.
SEASON_START_YEAR *SEASON_START_TIME*	The year/time of the first observation.
SEASON_END_YEAR *SEASON_END_TIME*	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
N_W_LAT, N_W_LONG *N_E_LAT, N_E_LONG* *S_W_LAT, S_W_LONG* *S_E_LAT, S_E_LONG*	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

6.2.2 Ice Age Histograms: MY-Keep Record

The MY-Keep record contains the number of MY ice fraction values kept for each cell record. We use this information to filter out the positive spikes and bumps in the multiyear ice fraction.

Field Name	Description
N_MYKEEP	The number of MY ice fraction values kept for each cell.

6.2.3 Ice Age Histograms Histogram Data

The histogram data contain one record per cell observed. The records are in row order. Each record has the following format.

Field Name	**Description**
CELL_ID	Unique cell identifier.
OBS_YEAR, *OBS_TIME*	The year/time of this observation.
BIRTH_YEAR, *BIRTH_TIME*	The year/time this cell was created.
X_MAP, *Y_MAP*	The center location of this cell.
C_TEMP	Air temperature at cell center.
FDD	Accumulated freezing degree days since cell creation.
I_AREA	Initial cell area.
C_AREA	Current cell area.
N_AGE	Number of age categories up to and including the oldest observation.
AR_1	Age range (youngest ice) of first category.
FAR_1	Fractional area in 1st age range.
FDD_1	Accumulated freezing degree days of 1st age range.
. . .	. . .
AR_N	Age range of category (N_AGE)
FAR_N	Fractional area within (N_AGE) age range
FDD_N	Accumulated freezing degree days of (N_AGE) age range
FAR_FYR	Fractional area within ridged-FY category
FAR_MY	Fractional area in radiometric MY category
FAR_MY1	First element of the N_MYKEEP smallest myfrac values
. . .	. . .
FAR_MYN	Last element of the N_MYKEEP smallest myfrac values
N_RIDGE	Number of ridging event records
RIDGE_AR_1	Age range of ice in ridging event 1
RIDGE_FAR_1	Fractional area of ice in ridging event 1
RIDGE_FDD_1	Accumulated freezing degree days of ice in ridging event 1
RIDGE_FLAG_1	*0 = old ridge, 1 = new ridge* A new ridge is one formed during this time step. An old ridge is one formed a previous time step.
. . .	. . .
RIDGE_AR_N	Age range of ice in ridging event N_RIDGE
RIDGE_FAR_N	Fractional area of ice in ridging event N_RIDGE
RIDGE_FDD_N	Accumulated freezing degree days of ice in ridging event

	N_RIDGE
RIDGE_FLAG_N	*0 = old ridge, 1 = new ridge*

6.3 Description (Product C) - Interpolated Ice Age Histograms

This product contains the latest ice age histograms of all cells at the time this product was produced. The ice age categories here have uniform age intervals.

6.3.1 Interpolated Ice Age Histograms: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells used in the creation of this product.
CREATE_YEAR *CREATE_TIME*	The year/time this product was created by the RGPS system.
SEASON_START_YEAR *SEASON_START_TIME*	The year/time of the first observation.
SEASON_END_YEAR *SEASON_END_TIME*	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
N_W_LAT, N_W_LONG *N_E_LAT, N_E_LONG* *S_W_LAT, S_W_LONG* *S_E_LAT, S_E_LONG*	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

6.3.2 Interpolated Ice Age Histograms: MY-Keep Record

The MY-Keep record contains the number of MY ice fraction values kept for each cell record. We use this information to filter out the positive spikes and bumps in the multiyear ice fraction.

Field Name	Description
AGE_STEP	The age range of each category
N_MYKEEP	The number of MY ice fraction values kept for each cell.

6.3.3 Interpolated Ice Age Histograms: Histogram Data

The histogram data contain one record per cell observed. The data pertain to the last observation of the cell up to the time of the product. The records are in row order. Each record has the following format.

Field Name	Description
CELL_ID	Unique cell identifier.
OBS_YEAR, *OBS_TIME*	The year/time of this observation.

BIRTH_YEAR, *BIRTH_TIME*	The year/time this cell was created.
X_MAP, *Y_MAP*	The center location of this cell.
C_TEMP	Air temperature at cell center.
FDD	Accumulated freezing degree days since cell creation.
I_AREA	Initial cell area.
C_AREA	Current cell area.
N_AGE	Number of age categories up to and including the oldest observation.
AR_1	Age range (youngest ice) of first category.
FAR_1	Fractional area in 1st age range.
FDD_1	Accumulated freezing degree days of 1st age range.
. . .	. . .
AR_N	Age range of category (N_AGE)
FAR_N	Fractional area within (N_AGE) age range
FDD_N	Accumulated freezing degree days of (N_AGE) age range
FAR_FYR	Fractional area within ridged-FY category
FAR_MY	Fractional area in radiometric MY category
FAR_MY1	First element of the N_MYKEEP smallest myfrac values
. . .	. . .
FAR_MYN	Last element of the N_MYKEEP smallest myfrac values

6.4 Description (Product G) - Gridded Ice Age Histograms

This product contains ice age histograms of cells on a uniformly spaced 50 km by 50 km Earth fixed grid.

6.4.1 Gridded Ice Age Histograms: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells used in the creation of this product.
CREATE_YEAR *CREATE_TIME*	The year/time this product was created by the RGPS system.
SEASON_START_YEAR *SEASON_START_TIME*	The year/time of the first observation.
SEASON_END_YEAR *SEASON_END_TIME*	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.

6.4.2 Gridded Ice Age Histograms: Interpolated Age Range Record

Field Name	Description
AGE_STEP	The age interval covered by each category.

6.4.3 Gridded Ice Age Histograms: Histogram Data

The histogram data contain one record per grid cell. Each record has the following format.

Field Name	Description
N_OBS	Number of observations in grid cell.
OBS_YEAR_0	Earliest year of observation in grid cell
OBS_YEAR_1	Latest year of observation in grid cell
OBS_TIME_0	Earliest time of observation in grid cell
OBS_TIME_1	Latest time of observation in grid cell
BIRTH_YEAR_0	Earliest birth year in grid cell
BIRTH_YEAR_1	Latest birth year in grid cell
BIRTH_TIME_0	Earliest birth time in grid cell
BIRTH_TIME_1	Latest birth time in grid cell
X_MAP_CENTER,	Map location of cell center - x

Y_MAP_CENTER	
C_TEMP	Temperature at cell center.
I_AREA	Sum of initial cell areas in grid cell.
N_AGE	Number of age categories in this cell.
FAR_1	Fractional area within first age range
. . .	. . .
FAR_N	Fractional area within (N_AGE) age range
FAR_FYR	Fractional area within ridged-FY category
FAR_MY	Fractional area in radiometric MY category

7. Ice Thickness (Products E and H)

7.1 Algorithm Overview

With records of the near surface air temperature, the young end of the age distribution is converted to a thickness distribution using a simple empirical relation between accumulated freezing-degree days and ice thickness [*Maykut*, 1986]. We note that this scheme does not provide estimates of the the thickness of first-year or multiyear ice.

7.1.1 Conversion of Ice Age to Ice Thickness

To convert age to ice thickness, we must know the freezing rate. We approximate this rate as being proportional to the number of freezing-degree days (FDD) associated with each age class of each cell. We convert the age distribution, to thickness distribution, with a simple procedure which utilizes the dependence of thickness, H, on freezing-degree days, F. For each category of young ice, there is an upper and lower bounds on the age of the ice due to the length of each time step: the opening in the ice could be created during the beginning or near the end of the time step. Consequently there are two values of F, upper and lower bounds, that apply to each age category. We do not keep track of F for the first-year and multiyear classes. We used Lebedev's parameterization (discussed in *Maykut*, 1986), with $H = 1.33\ F^{0.58}$.This relationship is based on 24 station years of observations from various locations in the Soviet Arctic. Lebedev's parameterization describes ice growth under "average" snow conditions, in contrast to others which describes ice growth with little or no snow cover. The thickness of the snow cover is an important parameter which controls ice growth, but there is at present no routine measurements of snow depth over the ice cover which could be used for better estimation of the growth rate.

The high rate of ice growth when the ice is young gives the largest uncertainty in the thickness in this youngest age class. This relative uncertainty improves as the ice ages and the growth rate decreases.

7.1.2 Thickness redistribution during ridging

The ridging process is dependent on the parameter that describes the ratio of the thickness of an ice ridge to the thickness of the ice being ridged. This parameter we define as $k = 5$ [Parmeter and Coon, 1972]. The ridging process uses this ratio k and ice volume is conserved in the process.

In the procedure, three types of ice are available for ridging: (1) young ice that has been created since the birth of the cell, (2) once-ridged young ice, and (3) ice present at the time of cell creation. When ridging is needed as prescribed by a decrease in area of a cell, the freezing-degree-days values of ice types (1) and (2) within the cell are examined. Ridged ice is given an equivalent freezing-degree-days value calculated from its thickness. The ice with the minimum FDD value is ridged first. The procedure continues until the necessary area change is attained. Younger ice is ridged once. The ridge continues to grow as it accumulates freezing-degree-days. If a ridge is ridged a second time, it is moved into a category we term "FY-ridged" and removed from further availability for ridging. When ridging is required and there are no type (1) or (2) ice within a cell, type (3) is ridged into the "FY-ridged" category. This category does not contain any ridge thickness information.

As described in the previous section, ridging only occurs when a cell undergoes a decrease in area , ΔA. Let us define the area to be removed as A_r. Initially, $A_r = \Delta A$. A_i, the area of type i ice, is ridged first. The area available for ridging is:

$$A_{avail} = A_i * (k-1) / k$$

since as soon as this much ice is ridged, the newly ridged ice is "piled" onto the remaining unridged ice within that area.

If $A_r < A_{avail}$, a single ridge is formed with thickness h_{R_i} with areal coverage A_{R_i} of:

$$h_{R_i} = h_i\, k, \qquad A_{R_i} = A_r / (k-1)$$

where h_i is the thickness of the ice that was ridged. The remaining area of the chosen ice category is updated to:

$$A_{i_{new}} = A_i - A_r - A_{R_i}$$

Since $A_{R_i}\, h_{R_i} + A_{i_{new}}\, h_i = A_i\, h_i$, the total ice volume is conserved.

If $A_r \geq A_{avail}$, a ridge is formed with thickness h_{R_i} and covers an area A_{R_i} where,

$$h_{R_i} = h_i\, k, \qquad A_{R_i} = A_i / k$$

The area of the chosen ice category that was ridged is then set to zero. The area that must still be removed is updated to $A_r = A_r - A_{avail}$. The next ice category is chosen and the procedure repeats until $A_r = 0$. In the case of ice type (3) being ridged, the ridge area is $A_{R_i} = A_r / (k - 1)$.

7.2 Description (Product E) - Ice Thickness Histograms

7.2.1 Ice Thickness Histograms: Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells contained in this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

7.2.2 Ice Thickness Histograms: Thickness categories

The interpolated thickness range record describes the thickness interval of each thickness category.

Field Name	**Description**
THICK_STEP	The range of each thickness category

7.2.3 Ice Thickness Histograms: Histograms

The histogram data contain multiple records. Each record contains the ice thickness histogram within a grid cell and the recent ridging events. The records are in row order. Each record has the following format.

Field Name	**Description**
CELL_ID	Cell identifier
OBS_YEAR, OBS_TIME	The year/time of this observation.
BIRTH_YEAR, BIRTH_TIME	The year/time this cell was created.
X_MAP, Y_MAP	The center location of this cell.
C_TEMP	2-m air temperature at cell center.

FDD	Accumulated freezing degree days at this cell.
I_AREA	Initial cell area.
C_AREA	Current cell area.
N_THICK	Number of age categories.
FAR_1	Fractional area in 1st thickness category.
. . .	. . .
FAR_N	Fractional area in the (N_THICK) thickness range
FAR_FYR	Fractional area in ridged-FY category
FAR_MY	Fractional area of MY coverage estimated from backscatter.
N_RIDGE	Number of ridging events
RIDGE_TR_1	Thickness range of ridging event 1
RIDGE_FAR_1	Fractional area ridged in ridging event 1
. . .	. . .
RIDGE_TR_N	Thickness range of ridging event N
RIDGE_FAR_N	Fractional area ridged in ridging event N

7.3 Description (Product H) - Interpolated Ice Thickness Histograms

This is a product containing the sum of the ice thickness histograms over a 50 km by 50 km Earth-fixed grid.

7.3.1 Interpolated Ice Thickness Histograms: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells contained in this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

7.3.2 Interpolated Ice Thickness Histograms: Ice Thickness Step

The interpolated thickness range record describes the thickness interval of each thickness category.

Field Name	Description
THICK_STEP	The range of each thickness category

7.3.3 Interpolated Ice Thickness Histograms: Histograms

The histogram data contain one record per grid cell. Each record has the following format.

Field Name	Description
N_OBS	Number of observations in grid cell
OBS_YEAR_0	Earliest year of observation in grid cell
OBS_YEAR_1	Latest year of observation in grid cell
OBS_TIME_0	Earliest time of observation in grid cell
OBS_TIME_1	Latest time of observation in grid cell
BIRTH_YEAR_0	Earliest birth year in grid cell
BIRTH_YEAR_1	Latest birth year in grid cell
BIRTH_TIME_0	Earliest birth time in grid cell

BIRTH_TIME_1	Latest birth time in grid cell
X_MAP_CENTER, *Y_MAP_CENTER*	Map location of cell center - x
X_MAP_UL, *Y_MAP_UL,* *X_MAP_UR,* *Y_MAP_UR,* *X_MAP_LL,* *Y_MAP_LL,* *X_MAP_LR,* *Y_MAP_LR*	Map location of upper left - x
C_TEMP	Temperature at cell center
I_AREA	Sum of initial cell areas in grid cell
C_AREA	Sum of current cell areas in grid cell
N_THICK	Number of thickness categories up to and including the thickest observation
FAR_1	Fractional area in 1st thickness range
. . .	
FAR_N	Fractional area in the (N_THICK) thickness range
FAR_FYR	Fractional area in ridged-FY category
FAR_MY	Fractional area in radiometric MY category

8. Ice Deformation (Product O)

This product contains cell area changes and spatial derivatives computed using ice displacements at the cell vertices.

8.1 Algorithm Overview

(This description was contributed by Harry Stern.)

The displacement gradients are calculated as follows. The Divergence Theorem in two dimensions states that

$$\iint \left[\frac{\partial P}{\partial x} + \frac{\partial Q}{\partial y} \right] dxdy = \oint [Pdy - Qdx]$$

(1)

Where the double integral on the left is taken over a region of area A, and the contour integral on the right is taken around the boundary of that region. Define the area-averaged value of some quantity *R(x,y)* as

$$\overline{R} = \frac{1}{A} \iint R(x,y) dxdy$$

(2)

With $P = u$ and $Q = 0$ in (1), and letting uχ denote the area-averaged value of $\partial u/\partial x$, equation (1) becomes

$$u_x = \frac{1}{A} \oint udy$$

(3)

With analogous definitions for the other partial devivatives are as follows:

$$u_y = -\frac{1}{A} \oint udx \qquad v_x = \frac{1}{A} \oint vdy \qquad v_y = -\frac{1}{A} \oint vdx$$

(4)

The integrals in equations (3) and (4) are approximated using the known positions and desplacements of the vertexes of the cell. Let (x , y) be the vertexes (in counterr-clockwise order) at the time prior to the current observation, and let (u , v) be the the displacements of those vertexes over the ensuing time interval (DELTA_TIME). Then the integral in equation (3) is approximated as

$$u_x = \frac{1}{A} \sum_{i=1}^{n} \frac{1}{2} (u_{i+1} + u_i)(y_{i+1} - y_i)$$

(5)

Where n is the number of vertexes, and the subscripts are cyclical (e.g. $u_{n+1}=u$). This results from the trapezoid integration rule, in which *u(x,y)* is approximated as a linear function between points I and I+1. Analogous formulas can be written down for the other partial derivatives. Incidentally, the area *A* is given by

$$A=\frac{1}{2}\sum_{i=1}^{n}\left(x_i y_{i+1}-y_i x_{i+1}\right)$$

(6)

This follows from equation (1) with *P*=*x and Q*=*y*.

8.2 Description (Product O) - Ice Deformation

This product contains cell area changes and spatial derivatives computed using ice displacements at the cell vertices.

8.2.1 Ice Deformation: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells contained in this product.
PROD_TYPE	'Winter' or 'Summer' Product
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

8.2.2 Ice Deformation: Area Change and Ice Motion Derivatives

The area change and ice motion spatial derivatives data contain multiple records. Each cell contains multiple observations of area change and ice motion spatial derivatives available up to the time of product creation. The records are in row order. Each record has the following format.

Field	Description
CELL_ID	Unique cell identifier assigned when the grid was created.
BIRTH_YEAR, BIRTH_TIME	The year/time of the first observation.
N_OBS	The number of observations of this cell.
OBS_YEAR_1, OBS_TIME_1	The year/time of the first observation.
X_MAP_1 Y_MAP_1	The map coordinates of the center of the cell.
X_DISP_1, Y_DISP_1	The displacement of the cell center between this and the last observation.
C_AREA_1	The cell area at the time of this observation.
D_AREA_1	The change in the cell area between this observation and the last

	observation.
DTP_1	The time interval between this and the last observation.
DUDX_1, *DUDY_1,* *DVDX_1,* *DVDY_1*	The derivatives of as defined above.
. . .	
OBS_YEAR_N, *OBS_TIME_N*	The year/time of the *Nth* observation.
X_MAP_N, *Y_MAP_N*	The map coordinates of the center of the cell.
X_DISP_N, *Y_DISP_N*	The displacement of the cell center between this and the last observation.
C_AREA_N	The cell area at the time of this observation.
D_AREA_N	The change in the cell area between this observation (*N*) and the last observation (*N-1*).
DTP_N	The time interval between this and the last observation.
DUDX_N, *DUDY_ N,* *DVDX_ N,* *DVDY_ N*	The derivatives as defined above.

9. Open Water Fraction (Products D and J)

9.1 Algorithm Description

The summer open water fraction within each cell is determined with an algorithm which uses the wind dependent backscatter characteristics of open water. We first compute the expected backscatter cross-section of open water using the surface wind speed and its direction relative to the radar look direction at each point. A C-HH model function (constructed from current C-VV model functions using the expected co-polarized response of open water) is used to provide the backscatter cross-section of open water. Summer ice (bare ice, ice with wet snow cover) has a very narrow range of backscatter, between -17dB and -12dB. At C-HH, depending on the wind velocity and incidence angle, the backscatter of open water could overlap, be above or below that of the ice. We anticipate that a refinement of this algorithm will be refined based on the backscatter of open water at C-HH. Also, we do not estimate the open water fraction if the backscatter of water overlaps with that of ice. At points where the open water backscatter is above or below that of the ice, we use backscatter thresholds computed using the model function to determine whether a pixel belongs to the open water category.

9.2 Description (Product D) - Open Water Fraction

This product contains the open water fraction at each cell.

9.2.1 Open Water Fraction: Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of images used in the creation of this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

9.2.2 Open Water Fraction: Area/Open Water Fraction Data

The area/open water fraction data contain multiple records. Each record contains the area/open water fraction estimates for a cell. The records are in row order. Each record has the following format.

Field	**Description**
CELL_ID	Cell identifier
OBS_YEAR, OBS_TIME	Year of observation
BIRTH_YEAR, BIRTH_TIME	
X_MAP, Y_MAP	
CELL_TEMP	Temperature at cell center
MDD	Cumulative melting degree days
I_AREA	Cumulative melting degree days
C_AREA	Current cell area
OW_FRAC	Open water fraction

9.3 Description (Product J) - Gridded Open Water Fraction

This is a product containing the sum of the open water fraction over a 50 km by 50 km Earth-fixed grid.

9.3.1 Gridded Open Water Fraction: Metadata Record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of images used in the creation of this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

9.3.2 Gridded Open Water Fraction: Open Water Fraction Data

The area/open water fraction data contain multiple records. Each record contains the area/open water fraction estimates within a grid cell. The records are in row order. Each record has the following format.

Field	Description
N_OBS	Number of observations in grid cell
OBS_YEAR_0	Earliest year of observation in grid cell
OBS_YEAR_1	Latest year of observation in grid cell
OBS_TIME_0	Earliest time of observation in grid cell
OBS_TIME_1	Latest time of observation in grid cell
BIRTH_YEAR_0	Earliest birth year in grid cell
BIRTH_YEAR_1	Latest birth year in grid cell
BIRTH_TIME_0	Earliest birth time in grid cell
BIRTH_TIME_1	Latest birth time in grid cell
X_MAP_CENTER, Y_MAP_CENTER	Map location of cell center - x
C_TEMP	Temperature at cell center
I_AREA	Sum of initial cell areas in grid cell

C_AREA	Sum of current cell areas in grid cell
OW_FRAC	Open water fraction.

10. Melt Onset/Freeze Up (Product M)

10.1 Algorithm Overview

The backscattering cross section of at Lagrangian cell is recorded at each time step. A time series of backscattering cross section histogram of each cell is used to determine the date of melt onset and freeze-up. The melt onset algorithm tracks the peak of the histogram for cells with more than 50% multiyear ice [Winebrenner et al., 1994, Winebrenner et al., 1996]. The detection criterion is when the peak value dips below a predetermined threshold. We estimate the date to be the time when the temporally interpolated peak crosses this threshold. The freeze-up algorithm also tracks the peak of the backscattering histogram. When this peak remains above a specified threshold for a period of N days, estimate M days prior to the threshold crossing to be the date of freeze.

10.2 Description (Product M) - Melt Onset/Freeze Up

This product contains the dates of melt onset or freeze up at each of the cells.

10.2.1 Melt Onset/Freeze Up: Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of images used in the creation of this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SE_LAT, SE_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

10.2.2 Melt Onset/Freeze Up: Dates

The dates are stored here.

Field Name	**Description**
CELL_ID	cell identifier
TRANSITION_YEAR, TRANSITION_TIME	Year/time of melt onset/freeze up.
X_MAP, Y_MAP	Center location of cell.

11. Gridded Wind/Temperature/Pressure (Product N)

This product contains the daily geostrophic wind, air temperature and pressure fields on a 50 km SSM/I grid. The wind and pressure fields are re-gridded from fields provided by the International Arctic Buoy Program (IABP). The 2-m air temperatures and provided by the POLES project [Martin and Munoz, 1997].

11.1 Description (Product N) - Wind/Temperature/Pressure

The gridded wind, temperature and pressure data are contained in the product.

11.1.1 Gridded Wind/Temperature/Pressure Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_GRIDS	Number of grid points used in the creation of this product.
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
MET_YEAR/MET_TIME	The year/time of the analysis.
SW_VERSION	The version of the RGPS software used to create this product.

11.1.2 Gridded Wind/Temperature/Pressure: Data

The meteorological data contain multiple records. Each record contains wind vector, pressure and temperature at each grid point. The records are in row order. Each record has the following format.

Field	**Description**
X_MAP, Y_MAP	Map location of grid points.
U_WIND, V_WIND	Geostrophic wind vector.
PRESSURE	surface air pressure.
TEMP	2-m air temperature.

12. Eulerian Ice Motion (Product L)

12.1 Description (Product L) - Eulerian Ice Motion

This product contains the results of ice motion derived from a pair of image frames.

12.1.1 Eulerian Ice Motion: Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
APID	Image A Product identifier.
BPID	Image B Product identifier.
ACENTYEAR *ACENTTIME*	The scene year/time of image A.
BCENTYEAR *BCENTTIME*	The scene year/time of image B.
A_TL_X, A_TL_Y *A_TR_X, A_TR_Y* *A_BR_X, A_BR_Y* *A_BL_X, A_BL_Y*	The corner point locations of image A.
B_TL_X, B_TL_Y *B_TR_X, B_TR_Y* *B_BR_X, B_BR_Y* *B_BL_X, B_BL_Y*	The corner point locations of image B.
PIXEL_SP	Pixel spacing
CREATE_YEAR *CREATE_TIME*	The year/time this product was created by the RGPS system.
GRID_W_OBS	Grid elements with observations.
NPIX_A, *NREC_A*	Number of pixels across/down image A.
NPIX_B, *NREC_B*	Number of pixels across/down image B.
AVG_DISP_X, *AVG_DISP_Y*	Average displacement in x and y.
D_TIME	Time separation between images.
GRIDSPACE	Grid element spacing.
SW_VERSION	The version of the RGPS software used to create this product.
ALGO_TYPE	Algorithm type

12.1.2 Eulerian Ice motion: Motion Data

Field	**Description**
A_GRID_X, *A_GRID_Y*	Grid point location on image A.
B_GRID_X, *B_GRID_Y*	Grid point location on image B.
DISP_X, *DISP_Y*	Displacement of grid point.
ROT_ANGLE	Rotation Angle.
Q_FLAG	Quality flag.

13. Backscatter Histograms (Products F and I)

13.1 Description (Product F) - Backscatter Histogram

This product contains the backscatter histograms of pixel samples within each cell.

13.1.1 Backscatter Histogram: Metadata Record

Field Name	**Description**
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells in this product.
PROD_TYPE	'Winter' or 'Summer' Product
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SW_LAT, SW_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

13.1.2 Backscatter Histogram: Backscatter range record

The backscatter range record describes the backscatter range of each category in the backscatter histogram.

Field	**Description**
BSR_1, BSR_2, ...BSR_25	Backscatter range within each category

13.1.3 Backscatter Histogram: Histograms

The histograms are stored here.

Field Name	**Description**
CELL_ID	Cell identifier
OBS_YEAR, OBS_TIME	The year/time of this observation.
BIRTH_YEAR, BIRTH_TIME	The year/time this cell was created.
X_MAP,	The center location of this cell.

Y_MAP	
C_TEMP	2-m air temperature at cell center.
I_AREA	Initial cell area.
C_AREA	Current cell area.
MYFRAC	Multiyear ice fraction
OWFRAC	Open water fraction
FBSR_1... FBSR_25	Fractional area in 1st backscatter
INC_ANG	Incidence angle at cell center

13.2 Description (Product I) - Gridded Backscatter Histograms

This is a product containing the sum of the backscatter histograms over a 50 km by 50 km Earth-fixed grid.

13.2.1 Gridded Backscatter Histograms: Metadata record

Field Name	Description
PID	RGPS product identifier (see section 4).
PROD_DESCRIPTION	Description of Product e.g. Lagrangian Ice Motion, Deformation etc.
N_CELLS	Number of cells in this product.
PROD_TYPE	'Winter' or 'Summer' Product
CREATE_YEAR, CREATE_TIME	The year/time this product was created by the RGPS system.
SEASON_START_YEAR, SEASON_START_TIME	The year/time of the first observation.
SEASON_END_YEAR, SEASON_END_TIME	The year/time of the last observation.
SW_VERSION	The version of the RGPS software used to create this product.
NW_LAT, NW_LONG, NE_LAT, NE_LONG, SW_LAT, SW_LONG, SW_LAT, SW_LONG	The corner points of the initial datatake. The initial gridpoints are created within these bounds.

13.2.2 Gridded Backscatter Histograms: Backscatter range record

The backscatter range record describes the backscatter range of each category in the backscatter histogram.

Field Name	Description
BSR_1, BSR_2, ...BSR_25	

13.2.3 Gridded Backscatter Histograms: Histograms

Field Name	Description
N_OBS	Number of observations in grid cell
OBS_YEAR_0	Earliest year of observation in grid cell
OBS_YEAR_1	Latest year of observation in grid cell
OBS_TIME_0	Earliest time of observation in grid cell
OBS_TIME_1	Latest time of observation in grid cell
BIRTH_YEAR_0	Earliest birth year in grid cell
BIRTH_YEAR_1	Latest birth year in grid cell

BIRTH_TIME_0	Earliest birth time in grid cell
BIRTH_TIME_1	Latest birth time in grid cell
X_MAP_CENTER, *Y_MAP_CENTER*	Map location of cell center - x
X_MAP_UL, *Y_MAP_UL,* *X_MAP_UR,* *Y_MAP_UR,* *X_MAP_LL,* *Y_MAP_LL,* *X_MAP_LR,* *Y_MAP_LR*	Map location of upper left - x
C_TEMP	Temperature at cell center
I_AREA	Sum of initial cell areas in grid cell
C_AREA	Sum of current cell areas in grid cell
FBSR1 ... FBSR25	

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