Accumulation Radar

Summary

The Accumulation Radar data set contains L1B Geolocated Radar Echo Strength Profiles over Greenland, Canada, and Antarctica taken with the CReSIS accumulation radar.

The L1B data set includes echograms with measurements for time, latitude, longitude, elevation, as well as flight path charts and echogram images.

The accumulation radar data have been collected on an ongoing basis since 1999 using grant funding from NASA and NSF. The most recent data were collected as part of the NSF Science and Technology Center grant (ANT-0424589) and the NASA Operation IceBridge field campaign (NNX10AT68G).

The data are stored in MATrix LABoratory (MATLAB) files with associated JPG, CSV, and PNG files.

The data are available at ftp://ftp.cresis.ku.edu/ and http://ftp.cresis.ku.edu/. These two sites serve the same data, but use the ftp (port 21) and http (port 80) protocols respectively.

FAQ

The most convenient way to browse the imagery quickly is through the JPG files in the images directory.

The quickest way to plot the whole dataset is to look at the browse files (KML or CSV) for the whole season in the kml and csv directories respectively.

The standard L1B files are in the CSARP_qlook directory. These are located in ftp://ftp.cresis.ku.edu/snow/{$season_name}/.

For the highest quality and most complete browsing of the data, use the Matlab image browser at ftp://ftp.cresis.ku.edu/picker/. The guide for the picker also explains the picking process.

Mathworks MAT file readers for C and IDL including documentation from Mathworks are located at ftp://ftp.cresis.ku.edu/mat_reader/.

Data Organization

The radar data are divided into segments. A segment is a contiguous dataset where the radar settings do not change. A day is divided into segments if the radar settings were changed, hard drives were switched, or other operational constraints required that the radar recording be turned off and on. The segment ID is YYYYMMDD_SS where YYYY is the 4-digit year (e.g. 2011), MM is the 2-digit month from 1 to 12, DD is the 2-digit day of the month from 1 to 31, and SS is the segment number from 0 to 99. Segments are always sorted in the order in which the data was collected. Generally SS starts with 1 and increments by 1 for each new segment, but this is not always the case: only the ordering is guaranteed to match the order of data collection.

Each segment is broken into frames (analogous to satellite SAR scenes) to make analyzing the data easier. Most frames are 2-3 km long. Currently frames are aligned with raw data files (frame number matches raw file index), but this may not always be the case for future missions. Once the frame boundaries are defined, they will not change from one release to the next or one processing method to the next. The frame ID is a concatenation of the segment ID and a frame number and follows the format YYYYMMDD_SS_FFF where FFF is the frame number from 000 to 999. Generally the FFF starts with 0 or 1 and increments by 1 for each new frame, but this is not always the case: only the ordering is guaranteed to match the order of data collection.

In a data casting sense, the data granule for L1B data is the frame.

File Descriptions

On the ftp.cresis.ku.edu/accum page, L1B are in the accumulation radar folder (accum), arranged by Season ID (e.g. 2011_Greenland_P3). Since L1B files are specific to a season and contain only accumulation radar data, these files are stored together in the season ID folders under the directory snow.

L1B products

CSARP_{$processing_type}/{$segment_id}/Data{$image_id}_{$frame_id}.mat

For each data frame there may be many different L1B products depending on how waveforms, and channels are combined and how the processing is done. More details about the standard outputs are given in the Methods section. An example filename is:

CSARP_qlook/20110516_01/Data_0110516_01_006.mat

The {$processing_type} is a string. Currently the only processing type is qlook.

The {$segment_id} is explained in the Data Organization section.

The {$image_id} is a string which is always empty at this point.

The {$frame_id} is explained in the Data Organization section.

The file format is Matlab .MAT version 6.

images/{$segment_id}/{$frame_id_range}_HHmmSS_{0maps,1echo}.jpg

For each data frame there is a flight path file (0map) and an echogram file (1echo). The background images for 1) sea ice flights are the Bremen sea ice concentration maps in the projection that is used by the Geotiff's from this site, or 2) Landsat-7 natural color imagery in polar stereographic format (70 deg true scale latitude, -45 deg longitude is center for Greenland/Canada and -71 deg true scale latitude, 0 deg longitude is center for Antarctica). The {$frame_id_range} field is either a regular frame ID or a frame ID with four additional characters in the form _FFF. The second four characters allow a range to be specified. For example:

images/20110507_01/20110507_01_001_110941_0maps.jpg
images/20110507_01/20110507_01_001_110941_1echo.jpg

specified a single frame was used to generate the image, but

images/20110507_01/20110507_01_001_004_110941_0maps.jpg
images/20110507_01/20110507_01_001_004_110941_1echo.jpg

specifies that frames 1-4 were used. HHmmss is the GPS time stamp for the first range line in the image where HH is 00-23 hours, mm is 00-59 minutes, and ss is 00-59 seconds.

The echograms are generated from the qlook data product.

The file format is JPEG.

L2 products

csv/{$segment_id}/Data_{$frame_id}_HHmmss.csv

FILES NOT CURRENTLY AVAILABLE.

Contains the ice surface and layering information. There is one file per data frame. An example filename is:

csv/20110407_06/Data_20110407_06_001_151055.csv

HHmmss is the GPS time stamp for the first range line in the csv file where HH is 00-23 hours, mm is 00-59 minutes, and ss is 00-59 seconds.

The file format is comma separated variable (CSV).

csv/Data_{$segment_id}.csv

FILES NOT CURRENTLY AVAILABLE.

These files are provided for ease of download and file transfer. They are the same format as the individual data frame CSV files. These files have all the individual frames from the segment concatenated together. An example filename is

csv/Data_20110331_09.csv

csv/{$season_id}.csv

FILES NOT CURRENTLY AVAILABLE.

These files are provided for ease of download and file transfer. They are the same format as the individual data frame CSV files. These files have all the individual frames from the whole season concatenated together.

The {$season_id} is a string that is formatted as YYYY_location_platform, YYYY is the 4-digit year *of when the season began*, location is the geographic location (e.g. Greenland or Antarctica), and platform is the airborne system used (e.g. P3, TO, DC8, Ground).

An example filename is:

csv/2011_Greenland_P3.csv

csv/Browse_Data_{$segment_id}.csv

The same as the segment CSV file except only the first point is taken from each frame to keep the file size small.

csv/Browse_Data_20110331_09.csv

layerData/{$segment_id}/Data_{$frame_id}.mat

For each data frame there is a layer data file. This file contains the full layer information for the ice surface and any other layers that have been picked *and is required by the image browser/layer picker*. An example filename is:

CSARP_layerData/20110516_01/Data_20110516_01_006.mat

The file format is Matlab .MAT version 6.

Browsing Files

kml/Browse_Data_{$segment_id}.kml

KML versions of the segment browsing CSV files.

{$radar_id}_param_{$season_id}.xls

This spreadsheet file allows all of the radar and processing parameters to be browsed conveniently. These parameters are encapsulated in the L1B data files, but this spreadsheet provides another way to access this information. An example filename is:

accum_param_2011_Greenland_P3.xls

The {$radar_id} is a string containing the radar ID which is one of icards, mcrds, mcords, or mcords2.

General utilities and documents

ftp://ftp.cresis.ku.edu/gps_ins/

See guide in this folder for more details. The individual GPS/INS files are stored with this naming convention:

{$season_id}/gps_YYYYMMDD.mat

A few examples are:

2011_Greenland_P3/gps_20110507.mat
2011_Greenland_P3/gps_20110516.mat

The file format is Matlab .MAT version 6.

ftp://ftp.cresis.ku.edu/matlab_MAT_reader/

Matlab MAT file reader for Matlab, C, and IDL. See guide in this folder for more details.

ftp://ftp.cresis.ku.edu/picker/

Echogram browsing tool (currently requires Matlab). See guide in this folder for more details

ftp://ftp.cresis.ku.edu/geographic_search/

Basic geographic search tool (currently requires Matlab). Convenient for searching all of the seasons of data and listing all of the frames and segments of interest.

ftp://ftp.cresis.ku.edu/loader/

Echogram loader tool (currently requires Matlab). See guide in this folder for more details. This tool has not been released yet since it is an alpha version, but is available upon request.

ftp://ftp.cresis.ku.edu/segy/

SEGY and SEG2 converter tool (currently requires Matlab). See guide in this folder for more details. This tool has not been released yet since it is an alpha version, but is available upon request.

ftp://ftp.cresis.ku.edu/rds/accum_readme.doc

The most recent version of this readme file.

L1B Matlab Files

Data filenames start with “Data_” followed by the frame ID.

- Data_20091224_01_001.mat

Each Matlab (.mat) file has the following variables:

Name	Data
Size/Axes	M by N single array where M is fast time and N is slow time
Units	Relative received power (Watts)
Range	Full single range
Null Value	0
Description	Radar echogram data.

Name	Time
Size/Axes	M by 1 double vector where M is fast time
Units	Seconds
Range	Full double range
Null Value	NA
Description	Fast time (zero time is the beginning of the transmit event calibrated to within one range resolution cell)

Name	GPS_time
Size/Axes	1 by N double vector where N is slow time
Units	Seconds
Range	Full double range
Null Value	NA
Description	GPS time when data were collected (seconds since Jan 1, 1970 00:00:00). This is the ANSI C standard.

Name	Latitude
Size/Axes	1 by N double vector where N is slow time
Units	Degrees
Range	-90 to +90
Null Value	Not a Number (indicates that no GPS information is available)
Description	WGS-84 geodetic latitude coordinate. Always referenced to North. Represents the location of the origin of the trajectory data which is generally not the radar's phase center, but some other point on the aircraft (e.g. the GPS antenna or the INS).

Name	Longitude
Size/Axes	1 by N double vector where N is slow time
Units	Degrees
Range	-180 to +180
Null Value	Not a Number (indicates that no GPS information is available)
Description	WGS-84 geodetic longitude coordinate. Always referenced to East. Represents the location of the origin of the trajectory data which is generally not the radar's phase center, but some other point on the aircraft (e.g. the GPS antenna or the INS).

Name	Elevation
Size/Axes	1 by N double vector where N is slow time
Units	Meters
Range	Full double range
Null Value	Not a Number (indicates that no GPS information is available)
Description	Referenced to WGS-84 ellipsoid. Positive is outward from the center of the Earth. Represents the location of the origin of the trajectory data which is generally not the radar's phase center, but some other point on the aircraft (e.g. the GPS antenna or the INS).

Name	Surface
Size/Axes	1 by N double vector where N is slow time
Units	Seconds
Range	Full double range
Null Value	Not a Number (indicates that no surface information is available)
Description	Estimated two way propagation time to the surface from the collection platform. This uses the same frame of reference as the Time variable.

Name	*param* (multiple variables with a name containing the string “param”)
Size/Axes	NA, data structures
Units	NA
Range	NA
Null Value	NA
Description	Contains: 1) Radar and processing settings, 2) Processing software version and time stamp information. Fields of structures are not static and may change from one version to the next.

L2 Matlab Files

Name	GPS_time
Size/Axes	1 by N double vector where N is slow time
Units	Seconds
Range	Full double range
Null Value	NA
Description	GPS time when data were collected (seconds since Jan 1, 1970 00:00:00). This is the ANSI C standard.

Name	Latitude
Size/Axes	1 by N double vector where N is slow time
Units	Degrees
Range	-90 to +90
Null Value	Not a Number (indicates that no GPS information is available)
Description	WGS-84 geodetic latitude coordinate. Always referenced to North. Represents the location of the radar echogram data phase center. It may not be the actual measurement location due to motion compensation

Name	Longitude
Size/Axes	1 by N double vector where N is slow time
Units	Degrees
Range	-180 to +180
Null Value	Not a Number (indicates that no GPS information is available)
Description	WGS-84 geodetic longitude coordinate. Always referenced to East. Represents the location of the radar echogram data phase center. It may not be the actual measurement location due to motion compensation

Name	Elevation
Size/Axes	1 by N double vector where N is slow time
Units	Meters
Range	Full double range
Null Value	Not a Number (indicates that no GPS information is available)
Description	Referenced to WGS-84 ellipsoid. Positive is outward from the center of the Earth. Represents the location of the radar echogram data phase center. It may not be the actual measurement location due to motion compensation

Name	layerData{layer_idx}
Size/Axes	1 x P cell array of structures, where P is the number of layers
Units	NA
Range	NA
Null Value	NA
Description	The first layer (layer_idx = 1) is the ice surface. For the depth sounder, the second layer (layer_idx = 2) is the ice bottom.

Name	layerData{layer_idx}.name
Size/Axes	character array, arbitrary length
Units	NA
Range	NA
Null Value	NA
Description	Name of the layer (“surface” and “bottom” are reserved for ice surface and ice bottom respectively)

Name	layerData{layer_idx}.value{pick_idx}
Size/Axes	1 by 2 cell array of structures
Units	NA
Range	NA
Null Value	NA
Description	There are two pick types: the manual picks are stored in pick_idx = 1 and the automated picks are stored in pick_idx = 2.

Name	*layerData{ layer_idx}.value{pick_idx}.data*
Size/Axes	1 by N double vector
Units	Seconds
Range	Full double range
Null Value	Not a Number (indicates that no surface information is available for this particular index and pick type)
Description	Estimated two way propagation time to the layer from the collection platform.

Name	*layerData{ layer_idx}.quality*
Size/Axes	1 by N double vector
Units	NA
Range	1, 2, or 3
Null Value	NA
Description	Quality level of the data (1-3), 1 represents high confidence, 2 represents low confidence or large error bars, and 3 represents a derived or estimated result based on information beyond just the present data frame

Theory of Measurements:

Several radars for measuring accumulation rates have been fielded by CReSIS (e.g. Kanagaratnam 2002, Kanagaratnam 2004, Lewis 2010). Only the most recent system is discussed here. However, the type of measurement and the theory behind how it works is the same for each system. The ice sheet can be modeled as a layered media at least locally. This is because environmental conditions are spatially correlated over large areas. The primary transitions giving rise to the layering are caused by the change in environmental conditions between winter and summer and the amount of contaminants in the air during deposition. The accumulation radar was designed to measure these transitions and track their depth over large areas with the primary science goal to produce an accumulation rate map when combined with ice cores within the surveyed area. This is possible because the electromagnetic constitutive properties of the layers are different and changes in these properties mean that the transitions will scatter electromagnetic energy. There are two important advantages to be had as long as the assumption of a layered media holds. The first is that the layers produce specular reflections. Because of the geometry of the discontinuity (specifically its flatness) the scattered energy adds coherently producing a larger response proportional to range squared. Secondly, since the only dimension of variability is the z-dimension, the along and cross track resolution of the radar are not critical, and only the range resolution is important. Disruptions in the layered media generally act like point targets on the other hand and require along track and cross track resolution to resolve and have scattered energy proportional to range cubed. The center frequency was chosen to balance the fact that lower frequencies attenuate more slowly in ice (important to detect deep internal layers), but higher frequencies allow a larger bandwidth to be obtained.

The radar architecture is a combined stepped-chirped system. The complete bandwidth from 565 to 885 MHz is divided into 16 overlapping subbands (550-600, 570-620, …, 850-900). Pulsed chirps are recorded on each subband in a round robin fashion. In post processing, the subbands are combined into a single frequency band from 565 to 885 MHz.

Radar System

The following tables list the nominal properties of the radar system. The P-3 has 3 dB of one way antenna feed cabling loss and the TO has about 1 dB cabling loss. The transmit power is 5 W and these losses are included. The noise figure does not include these cable losses. Both the P3 and the TO use a monostatic antenna configuration and a TR switch is used to switch the antenna from transmit to receive after each pulse is transmitted. The antenna beamwidths are estimated from the physical aperture size and are not measured values.

	Frequency Spectrum (MHz)	Pulse Duration (µs)	Transmit Power (W)	Noise Figure (dB)	Antenna Beamwidth Along x Cross (deg)
2009 Antarctica TO	550-900	2	3.15	4.06	104 x 46
2010 Greenland P3	550-900	2	1.25	4.06	21 x 18
2011 Greenland TO	550-900	2	3.15	4.68	104 x 46
2011 Greenland P3	550-900	2	1.25	4.68	21 x 18
2011 Antarctica TO	550-900	2	3.15	4.68	104 x 46

	Pulse Repetition Frequency (Hz)	Subbands	Hardware Averages Per Subband	Polarization Along-track
2009 Antarctica TO	50000	16	16	E-plane
2010 Greenland P3	50000	16	16	E-plane
2011 Greenland TO	50000	16	16	E-plane
2011 Greenland P3	50000	16	16	E-plane
2011 Antarctica TO	50000	16	16	E-plane

L1B Processing Steps:

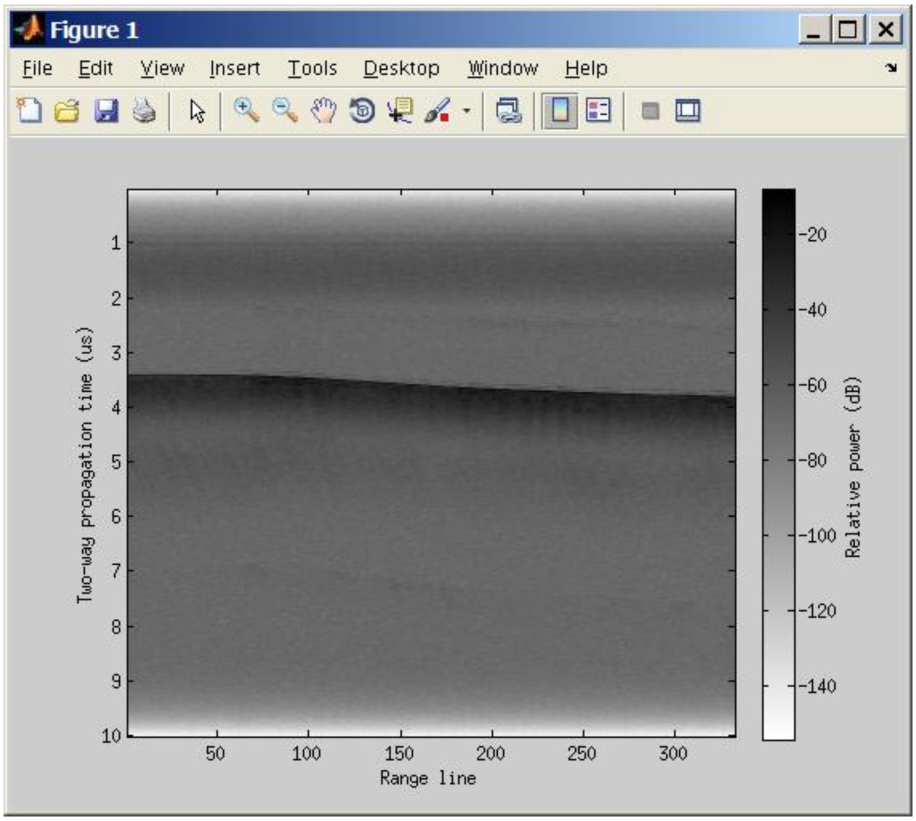
The following processing steps are performed.

1. Set digital errors to zero (error sequences are 4 samples in length and occur once every few thousand range lines)
2. Synchronization of GPS data with the radar data using the UTC time stored in the radar data files
3. Conversion from quantization to voltage at the ADC input
4. Removal of DC-bias by subtracting the mean from each record
5. The quick look output is generated using presumming or unfocused SAR processing for a total of 160 coherent averages which includes hardware and software averages.
6. Channel compensation between each of the 16 subbands. This includes amplitude mismatches only.
7. Pulse compression with time domain window which matches transmitted time domain window and an additional frequency domain window
8. Sixteen subbands are combined into a single band.
9. A 1 range-bin by 10 along-track-range-line boxcar filter is applied to the power detected data and then decimated in along-track by 5.
10. The quick look output is used to find the ice surface location (fully automated).

Data Loading Example

```
accum = load('Data_20110416_01_200.mat');

figure(1); clf;
imagesc([],accum.Time*1e6,10*log10(accum.Data));
colormap(1-gray(256));
xlabel('Range line');
ylabel('Two-way propagation time (us)');
hc = colorbar;
set(get(hc,'ylabel'),'string','Relative power (dB)');
```



Resolution and Error Bounds

For a flat surface, the range resolution is:

$$\frac{k_t c}{2Bn}$$

where $B = 320$ MHz is the bandwidth (565 to 885 MHz), n is the index of refraction for the medium, c is the speed of light in a vacuum, and k_t is the window widening factor which is 0.88 for no windowing and 1.53 for 20% Tukey time-domain window on transmit and receive and a Hanning frequency-domain window on receive. The window widening factor was computed numerically. Windowing is applied to improve the isolation between targets at different ranges, but causes the resolution to become worst. The range resolution for several indices of refraction is given in this table.

Index of Refraction	Range Resolution (m)	Medium
1	0.72	Air
sqrt(2.0)	0.51	Snow
sqrt(3.15)	0.40	Solid ice

The index of refraction can be approximated by $n = (1+0.51\rho_{snow})^{3/2}$ where ρ_{snow} is the density of the snow in grams per cm^3. In the data posting, a dielectric of 2.0 is used which corresponds to a snow density of 0.51 g per cm^3.

In the along-track dimension, data are coherently averaged 160 times which includes both hardware and software averaging, and decimated by this same amount so that the along-track spacing between records with a platform speed of 140 m/s is 7.2 m. A 1 range-bin by 10 along-track-range-line boxcar filter is applied to the power detected data and then decimated in the along-track by 5 so the data product has an along-track pixel spacing of 35.8 m.

For a smooth or quasi-specular target (e.g. internal layers), the primary response is from the first Fresnel zone. Therefore, the directivity of specular targets effectively creates the appearance of a cross-track resolution equal to this first Fresnel zone. The first Fresnel zone is a circle with diameter given by

$$\sigma_{y,\mathrm{Fresnel-limited}} = \sqrt{2\left(H + T/\sqrt{3.15}\right)\lambda_c}\ ,$$

where H is the height above the air/ice interface, T is the depth in ice of the target, and λ_c is the wavelength at the center frequency. The table below gives the cross-track resolution for this case.

Center Frequency (MHz)	**Cross-track Resolution H = 500 m T = 0 m (m)**
750	20

For a rough surface with no appreciable layover, the cross-track resolution will be constrained by the pulse-limited footprint, which is approximately

$$\sigma_{y,\mathrm{pulse-limited}} = 2\sqrt{\frac{\left(H + T/\sqrt{3.15}\right)ck_t}{B}}\ .$$

The table below gives the cross-track resolution with windowing.

Bandwidth (MHz)	**Cross-track Resolution H = 500 m T = 0 m (m)**
320	53.6

For a rough surface where layover occurs, the cross-track resolution is set by the beamwidth, β_y, of the antenna array. The antenna beamwidth-limited resolution is

$$\sigma_{y,\text{beamwidth-limited}} = 2\left(H + \frac{T}{\sqrt{3.15}}\right)\tan\left(\frac{\beta_y}{2}\right)$$

where β is the beamwidth in radians, H is the height above ground level, and T is the depth in ice of the target.

The antenna installed in the bomb bay of the P-3 is a 2 by 4 antenna element array where each element is a printed circuit board elliptical dipole and the array is aligned so that there are 2 elements in the along-track direction and 4 elements in the cross-track direction. The dipoles are aligned with the fuselage so that the E-plane is along-track. The element spacing is 26 cm in cross-track and 37 cm in along-track. The approximate beamwidths are 21 deg in along-track and 18 deg in cross-track. For H = 500 m and T = 0 m, the footprint is 185 m in along-track and 158 m in cross-track.

The Twin Otter uses a 4 element Vivaldi antenna array with along-track aperture of 22 cm and cross track spacing of 12.5 cm spacing for each of the four elements. The approximate beamwidths are 104 deg in along-track and 46 deg in cross-track. The E-plane is aligned in the along-track. For H = 500 m, the footprint is 1280 m in along-track and 425 m in cross-track.

System loop sensitivity calculations section is not completed.

Season Specific Information

The data are not radiometrically calibrated. This means that they are not converted to some absolute standard for reflectivity or backscattering analysis. We are working on data processing and hardware modifications to do this.

The data have not been motion compensated. We are working on data processing modifications to do this.

2009 Antarctica TO

This section is not completed.

Field Team

Principle Investigator: Prasad Gogineni
Radar Installation: Cameron Lewis, Fernando Rodriguez-Morales
Radar Operation: Carl Leuschen, Cameron Lewis
Data Processing: Carl Leuschen, Cameron Lewis, Logan Smith
Data Backups and IT: Chad Brown, Keith Lehigh
Post Data Processing (for this release):

2010 Greenland P3

This section is not completed.

Field Team

Principle Investigator: Carl Leuschen
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Radar Operation: Cameron Lewis
Data Processing: Cameron Lewis
Data Backups and IT: Chad Brown
Post Data Processing (for this release):

2011 Greenland TO

This section is not completed.

Field Team

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Radar Operation: Daniel Gomez
Data Processing: Daniel Gomez
Data Backups and IT: Chad Brown
Post Data Processing (for this release): Not released yet

2011 Greenland P3

Field Team

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Radar Installation: Reid Crowe, Carl Leuschen, John Paden, Ben Panzer, Kevin Player, Fernando Rodriguez-Morales
Radar Operation: Austin Arnett, Reid Crowe, Ben Panzer, Kevin Player
Data Processing: John Paden
Data Backups and IT: Dan Hellebust, Justin Miller
Post Data Processing (for this release): Aric Beaver, Cameron Lewis, John Paden

Known Issues

The accum, snow, and kuband data acquisition systems have a known issue with radar data synchronization with GPS time. When the radar system is initially turned on, the radar system acquires UTC time from the GPS NMEA string. If this is done too soon after the GPS receiver has been turned on, the NMEA string sometimes returns GPS time rather than UTC time. GPS time is 15 seconds ahead of UTC time during this field season. The corrections for the whole day must include the offset (-15 second correction). GPS corrections have been applied to all of the data using a comparison between the accumulation, snow, and kuband radars which all have independent GPS receivers. A comparison to geographic features and between ocean surface radar return and GPS elevation is also made to ensure GPS synchronization. GPS time corrections are given in the vector worksheet of the parameter spreadsheet. This issue is closed.

Coverage

Not completed

Field Team

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Radar Operation: Austin Arnett, Carl Leuschen, John Paden, Ben Panzer, Kevin Player
Data Processing: John Paden
Data Backups and IT: Dan Hellebust, Justin Miller
Post Data Processing (for this release): Aric Beaver, John Paden

2011 Antarctica TO

This season has not completed yet.

Field Team

Principle Investigator: Prasad Gogineni
Radar Installation: Reid Crowe, Daniel Gomez, Fernando Rodriguez-Morales
Radar Operation: Daniel Gomez
Data Processing: Daniel Gomez
Data Backups and IT: Justin Miller
Post Data Processing (for this release): Not released yet

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Whenever the data are used, please include the following acknowledgement:

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Please cite data according to NSIDC standard.

Leuschen, Carl, Cameron Lewis, Prasad Gogineni, Fernando Rodriguez, John Paden, Jilu Li. 2011, updated current year. *IceBridge Accumulation Radar L1B Geolocated Radar Echo Strength Profiles*, [list dates of data used]. Boulder, Colorado USA: National Snow and Ice Data Center. Digital media.

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doi: 10.1109/IGARSS.2009.5417635

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