BOREAS FOLLOW-ON DSP-04 1994 ERS-1 LEVEL-4 LANDSCAPE FREEZE/THAW MAPS, VER. 1.0

Get Data

Summary

The BOREAS DSP-4 team acquired and analyzed imaging radar data from the ESA's ERS-1 over a complete annual cycle at the BOREAS sites in Canada in 1994 to detect shifts in radar backscatter related to varying environmental conditions. Two independent transitions correlating with snow melt and soil thaw onset, and possible canopy thaw were revealed by the data. The results demonstrated that radar provides an ability to observe thaw transitions at the beginning of the growing season, which in turn helps constrain the length of the growing season. The data presented here are gridded maps of landscape freeze/thaw state derived from backscatter change maps. The backscatter change maps were computed from radar backscatter images covering the southern BOREAS sites. The freeze/thaw classifications were determined through application of a change detection threshold based on temporal backscatter change relative to a winter-time frozen reference state. The data are provided as both ASCII text and as binary image (*.gif) format files.

Data Citation

Cite this data set as follows (citation revised on October 30, 2002):

McDonald, K., and J. Nickeson. 2001. BOREAS Follow-On DSP-04 1994 ERS-1 Level-4 Landscape Freeze/Thaw Maps, Ver[sion] 1.0. Data set. Available on-line [http://daac.ornl.gov] from Oak Ridge National Laboratory Distributed Active Archive Center, Oak Ridge, Tennessee, U.S.A.

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1. Data Set Overview

1.1 Data Set Identification

BOREAS Follow-On DSP-04 1994 ERS-1 Level-4 Landscape Freeze/Thaw Maps, Ver. 1.0

1.2 Data Set Introduction

Synthetic Aperture Radar (SAR) data acquired by the European Space Agency's (ESA's) Earth Remote Sensing Satellite (ERS-1) over a complete annual cycle at the BOReal Ecosystem-Atmosphere Study (BOREAS) test sites in Canada in 1994 were analyzed to detect changes in radar backscatter related to varying environmental conditions. The data set presented here consists of maps of estimated landscape freeze/thaw state registered to the BOREAS grid. Data provided were acquired during 1994 over the southern BOREAS sites.

1.3 Objective/Purpose

The aim of the study was to demonstrate that imaging radar could be utilized to detect the onset of the thaw process during spring transitions. It has previously been demonstrated that imaging radar can be utilized to discern the freeze transition in the fall season (Rignot and Way, 1994). Knowing the dates of onset of freeze/thaw events is useful in determining the length of the growing season, and has obvious implications for hydrologic, meteorological, and ecosystem functional processes (e.g. carbon exchange). These ERS-1 SAR data were compared to in situ air temperature, soil temperature, and xylem flow data (see Section 1.6) collected at the Southern Study Area (SSA) Old Black Spruce (OBS), Old Aspen (OA), and Old Jack Pine (OJP) sites.

1.4 Summary of Parameters

Gridded landscape freeze/thaw classification as determined through application of a backscatter thresholding scheme applied to Freeze/Thaw Backscatter Change Images (see section 1.6 Related Data Sets). Each grid cell indicates percent of the cell that is frozen, percent thawed, and percent consisting of lakes or open water. Determination of lake and open water regions was performed with a Landsat-based classification map and are provided only over the region covered by the Landsat map (see Section 7, Data Description).

1.5 Discussion

None given.

1.6 Related Data Sets

BOREAS RSS-17 1994 ERS-1 Level-3 Freeze/Thaw Backscatter Change Images
BOREAS RSS-17 Dielectric Constant Profile Measurements
BOREAS RSS-17 Stem, Soil, and Air Temperature Data
BOREAS RSS-17 Xylem Flux Density Measurements at the SSA-OBS Site
BOREAS TE-18 Landsat TM Maximum Likelihood Classification Image of the SSA

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2. Investigator(s)

2.1 Investigator(s) Name and Title

Dr. Kyle McDonald, Research Scientist

2.2 Title of Investigation

Freeze/Thaw Transitions as Observed with ERS-1 Imaging Radar at BOREAS

2.3 Contact Information

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3. Theory of Measurements

At microwave frequencies, freezing results in a dramatic decrease of the dielectric constant of soil and vegetation, which significantly alters their radar scattering properties. ERS-1 SAR data collected over boreal regions have been used to map spring and fall seasonal transitions as related to landscape freeze/thaw state (Way et al., 1997; Rignot and Way, 1994). The technique employed utilizes repeat-pass observations to monitor radar backscatter change relative to a reference state representative of winter-time (frozen) conditions. A temporal series of co-registered SAR images is used to compute backscatter change relative to the frozen reference image. Freeze/thaw state is estimated through application of a threshold on a pixel-by-pixel basis. With the exception of open water areas, this technique has been shown to be relatively independent of landcover type, although over forested terrain, the change in radar backscatter corresponding to freeze/thaw transitions may be slightly lower in magnitude than that recorded on non-forested areas. Where available, a mask is applied to remove regions of open water. The resulting maps are spatially gridded with each grid cell providing percent frozen area, percent thawed area, and where available, percent open water.

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4. Equipment

4.1 Sensor/Instrument Description

ERS-1 was launched on 17-Jul-1991 by an Ariane 4 launcher from Kourou, French Guiana. Its total mass is 2157.4 kg, 888.2 kg from the payload and 1257.2 kg from the platform. The peak power supplied to the payload is 2600 W; payload average power is at most 550 W. The voltage of the power supply varies between 23 V and 37 V, with a maximum onboard energy of 2650 WH. ERS-1 is a three-axis stabilized spacecraft with a design lifetime of 2 to 3 years.

ESA sponsored the mission. The prime contractor is Dornier (Federal Republic Germany). Co-contractors include Fokker (The Netherlands), Laben (Italy), Matra (France), MDA (Canada), Marconi (United Kingdom), and Selenia (Italy).

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AMI Image-Mode (SAR) Characteristics:
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Antenna Size:                 10 m x 1 m
Peak Power:                   4.8 kW
Frequency:                    5.3 GHz (C-Band)
Bandwidth:                    15.55 +/- 0.1 MHz
PRF Range:                    1640-1720 Hz in 2-Hz steps
Polarization:                 Linear-Vertical (LV)
Long Pulse:                   37.12 +/- 0.06 microseconds
Compressed Pulse Length:      64 nanoseconds
Sampling Window:              296 microseconds (99-km telemetered swath)
Analog/Digital
   Complex Sampling:          16.96 million samples/second
Quantization:                 5I, 5Q if range compression on ground
                              (nominal 6I, 6Q if range compression onboard)
Data Rate:                    < 105 Mbit/s
Spatial Resolution:           30 m x 30 m
Radiometric Resolution:       2.5 dB at sigma-naught = -18 dB
Noise-Equivalent
     Sigma-Naught:            -23 dB
Incidence Angle:              23° at mid-swath
Swath Stand-Off:              250 km to side of orbital track
Swath Width:                  100 km
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4.1.1 Collection Environment

The ERS-1 satellite orbits Earth in a sun-synchronous, polar, near-circular orbit at a mean altitude of 785 km and an inclination of 98.5 degrees.

4.1.2 Source/Platform

ERS-1 has a sun-synchronous, polar, near-circular orbit at a mean altitude of 785 km and an inclination of 98.5 degrees. During the initial 3 months of the commissioning phase, the satellite had a 3-day repeat cycle at an altitude of 785 km (this is known as the reference orbit). Subsequent satellite height adjustments have provided two multidisciplinary phases with a 35-day repeat cycle, two ice phases with 3-day repeat cycles, and two geodetic phases with 168-day with cycles. The majority of the mission has been performed in the 35-day repeat cycles. ERS-1, operating in tandem with ERS-2, is expected to remain in a 35-day repeat cycle for the rest of its mission. Since ERS-1 has no onboard recorders except for an onboard tape recorder for bit rate data, Active Microwave Instrumentation (AMI) data can be obtained only if there is a ground station in view of the orbiting satellite.

4.1.3 Source/Platform Mission Objectives

ERS-1 is an ESA satellite devoted to remote sensing from a polar orbit. It provides global and repetitive observations of the environment using techniques that allow imaging to take place irrespective of weather conditions. ERS-1 has a sun-synchronous, polar, near-circular orbit with a mean altitude of 785 km.

List of Sensors/Instruments:

1 AMI:

AMI combines the functions of a SAR and a Wind Scatterometer (WNS). The AMI measures wind fields and wave spectra over the open ocean and records all-weather, fine-resolution images over the ocean, polar ice, coastal zones, and land. The AMI has an image mode (swath) SAR. SAR mode and Wind/Wave mode are mutually exclusive during operation.

2 Radar Altimeter (RA):
RA provides measurements of altitude, significant wave heights, and surface wind speed over the ocean, and various parameters over sea ice and ice sheets.

3 Along-Track Scanning Radiometer (ATSR):
ATSR is an experimental four-channel infrared radiometer that provides precise and accurate measurements of sea surface temperatures and cloud top temperatures.

4 Microwave Sounder (MWS):
MWS is a two-channel passive microwave radiometer that provides information on the total precipitable water vapor and the total liquid water content of the atmosphere.

5 Precise Range and Range-rate Equipment (PRARE):
PRARE is an experimental instrument providing high-precision orbit data in support of the altimeter mission. This instrument does not work.

6 Laser Retroreflector (LR):
LR permits the use of ground based laser ranging to determine precise orbit and calibration information in support of the altimeter mission.

4.1.4 Key Variables
Radar backscatter.

4.1.5 Principles of Operation
In image mode, the SAR obtains strips of high-resolution imagery 100 km in width to the right of the satellite track. The 10-m-long antenna, aligned parallel to the flight track, directs a narrow radar beam onto Earth's surface over the swath. Imagery is built up from the time delay and strength of the return signals, which depend primarily on the roughness and dielectric properties of the surface and its range from the satellite.

The SAR's fine resolution in the range direction is achieved by phase coding the transmit pulse with a linear chirp and compressing the echo by matched filtering. Range resolution is obtained from the travel time. Azimuth resolution is achieved by recording the phase as well as the amplitude of the echoes along the flight path. The set of echoes over a flight path of about 800 m is processed (on the ground) as a single entity, giving an azimuth resolution equivalent to a real aperture 800 m in length. This is the 'synthetic aperture' of the radar.

Operation in image mode excludes the other AMI operating modes, and power considerations limit operating time to a maximum of 10 minutes per orbit. Because the data rate of 100 Mbit/s is far too high to allow onboard storage, images are acquired only within the reception zone of a suitably equipped ground station.

4.1.6 Sensor/Instrument Measurement Geometry
ERS-1 operates a C-band (5.7-cm wavelength), vertical receive and transmit polarization SAR, illuminating the surface at a 23-degree incidence angle from nadir. The swath width is 100 km x 100 km, with 30-m resolution for four looks. The data were processed at a 200-m resolution for this regional study.

4.1.7 Manufacturer of Sensor/Instrument
ESA sponsored the ERS-1 mission. The prime contractor is Dornier (Federal Republic Germany). Co-contractors include Fokker (The Netherlands), Laben (Italy), Matra (France), MDA (Canada), Marconi (United Kingdom), and Selenia (Italy).

Some of the major participants include:

Dornier Systems
P.O. Box 1420
D-7790 Friedrichshafen 1
Federal Republic of Germany
0 75 45 8-0 (tel)

Marconi Thomsom
(United Kingdom Branch)
Anchorage Road
Portsmouth Hampshire
P035PU England
44 705 66 49 66 (tel)

4.2 Calibration

The ERS data were collected, processed, and fully calibrated at NASA's Alaska SAR Facility (ASF) to yield slant-range radar backscatter images. Earlier engineering tests and experiments demonstrated that the data were calibrated with an absolute precision of about 2 dB and a relative accuracy of 1/3 dB (which is the stability of the ERS-1 system).

4.2.1 Specifications

Calibration of the AMI is undertaken in two steps. An internal calibration unit continuously monitors the out put power and receiver gain of the AMI over short intervals, and in SAR modes, the phase characteristics of the transmit signal. Antenna patterns and gains were measured on the ground and then, from time to time, in orbit. In the SAR modes, corner reflectors are used.

4.2.1.1 Tolerance

The parameter derived from the SAR image mode is the normalized radar backscattering coefficient, sigma-naught. ESA engineer Henry Laur has shown that the ERS-1 image mode SAR relative accuracy is 0.18 dB (1 sigma). ASF ERS-1 SAR image data are sufficiently monitored and calibrated to ensure +/- 1.0 dB relative accuracy and +/- 2.0 dB absolute accuracy.

4.2.2 Frequency of Calibration

Each ERS satellite's image mode SAR is checked against external calibration targets as often as the orbit and acquisition schedules allow. The orbit phases have repeat times of 3 days, 35 days, and 168 days. The latter two phases provide coverage over the ASF calibration sites more than once per repeat time period. Scheduling conflicts, equipment failures, and other factors reduce the number of available calibration passes. SAR image mode data are checked for miscalibration every 2 weeks.

4.2.3 Other Calibration Information

Image calibration coefficients vary with image type, processor gain setting, etc., and are provided in the metadata accompanying each image produced by the ASF. The radiometric calibration has never needed to be adjusted.

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5. Data Acquisition Methods

The input data were obtained as standard products from the Alaska SAR Facility.

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6. Observations

6.1 Data Notes
See Way et al., 1997.

6.2 Field Notes
None given.

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7. Data Description

7.1 Spatial Characteristics

7.1.1 Spatial Coverage

Data are provided over the region of the BOREAS Southern Study Area (SSA) for which SAR coverage was acquired. The products however, have been projected onto a 60 line by 66 column latitude/longitude 5 by 10 minute grid covering most of the BOREAS region.

The spatial coverage of freeze/thaw data within that grid is currently being expanded to cover the full BOREAS regional image area, see section 15 for information regarding the availability of subsequent data sets.

For the Freeze/Thaw maps provided here, the grid corner coordinates are:

Corner	Latitude (degrees)	Longitude (degrees)
NW	57°N	107°W
NE	57°N	96°W
SW	52°N	107°W
SE	52°N	96°W

The North American Datum of 1983 (NAD83) corner coordinates of the BOREAS region are:

Corner	Latitude	Longitude
Northwest	59.979°N	111.000°W
Northeast	58.844°N	93.502°W
Southwest	51.000°N	111.000°W
Southeast	50.089°N	96.970°W

The NAD83 corner coordinates of the SSA are:

Corner	Latitude	Longitude
Northwest	54.319°N	106.227°W
Northeast	54.223°N	104.236°W
Southwest	53.513°N	106.320°W

```
Southeast    53.419°N     104.368°W
```

The northwest corner of the TM image used as a water mask was located at -106.50 degrees longitude and 54.42 degrees latitude. The mask image was 4115 rows by 4809 samples, with north-south resolution of 0.00030 degrees per pixel, and east-west resolution of 0.00045 degrees per pixel.

7.1.2 Spatial Coverage Map

Not available.

7.1.3 Spatial Resolution

Although these products were derived using 200 meter resolution ERS-1 SAR imagery, this data set has been projected onto a lower resolution 5 minute vertical (latitude) by 10 minute horizontal (longitude) grid.

7.1.4 Projection

Products are provided in a geographic (latitude/longitude) grid projection.

7.1.5 Grid Description

The products have been projected onto a latitude/longitude grid extending from 107.0 to 96.0 degrees West longitude, in 66 longitudinal (10 minute) bins, and from 57.0 to 52.0 degrees North latitude, in 60 latitudinal (5 minute) bins. This is consistent with the grid defined and used by the BOREAS Hydro-Meteorological Processes Working Group.

7.2 Temporal Characteristics

7.2.1 Temporal Coverage

Files were produced using ERS Synthetic Aperture Radar (SAR) imagery from 1994, beginning on day-of-year 45 and extending to day-of-year 347. Data files are provided for each day for which ERS data are available over the region of the SSA. The dates of coverage and the corresponding day-of-year are:

Day of year, 1994	Date
045	14-February-1994
048	17-February-1994
054	23-February-1994
057	26-February-1994
060	01-March-1994
063	04-March-1994
066	07-March-1994
069	10-March-1994
072	13-March-1994
075	16-March-1994
078	19-March-1994
087	28-March-1994
099	09-April-1994
102	12-April-1994
119	29-April-1994
122	02-May-1994
139	19-May-1994
156	05-June-1994
159	08-June-1994

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176             25-June-1994
196             15-July-1994
213             01-August-1994
216             04-August-1994
230             18-August-1994
233             21-August-1994
250             07-September-1994
253             10-September-1994
287             14-October-1994
290             17-October-1994
307             03-November-1994
324             20-November-1994
344             10-December-1994
347             13-December-1994
```

7.2.2 Temporal Coverage Map

See section 7.2.1.

7.2.3 Temporal Resolution

The temporal resolution of ERS-1 SAR data was limited by its orbital geometry and swath width. Not all orbits were acquired by ASF. The highest temporal repeat coverage was acquired during periods that the satellite was in a three day repeat orbit.

7.3 Data Characteristics

7.3.1 Parameter/Variable

The parameters contained in the data are:

```
Percent frozen land area
Percent thawed land area
Percent open water area (where discrimination was available using Landsat data)
```

7.3.2 Variable Description/Definition

Percent frozen landscape represents the fraction of landscape area, on percent area basis, that contains water in a solid phase.

Percent thawed landscape represents the fraction of landscape area on percent area basis, that contains water in a liquid phase.

Percent open water area represents the fraction of landscape area on percent area basis, that is covered by open water. This information is provided only for that area of the dataset covered by the Landsat scene used in classification of open water area.

The GIF files (*.gif) corresponding to each of the *.dat files are pictorial representations of the data provided in the *.dat files. Each bin is shown in a combination of red, blue, green and black, where:

```
red = area fraction of the grid cell that is thawed
blue = area fraction of the grid cell that is frozen
green = area fraction of the grid cell that is lake (open water)
black = area fraction of the grid cell that has no data or is missing data.
```

Some cells (records in the .pct files) have percent frozen, thawed, and lake area that do not sum to 100%. This is caused by missing data, and is represented by black area in the .gif images. Missing data correspond to portions of grid cells for which no ERS data are available during that day. This occurs in the 200-meter resolution ERS-1 backscatter data that are aggregated into the larger 5 by 10 minute resolution grid cells, and accounts also for the large black regions in the GIF images and zeros in the .pct files for areas further outside the ERS swath.

7.3.3 Unit of Measurement

Variables are provided on a percent by area basis.

7.3.4 Data Source

European Remote Sensing Satellite, ERS-1.

7.3.5 Data Range

The range of values of each variable is 0 to 100 percent.

7.4 Sample Data Record

The following is an example of data extracted from a DAT file. Data shown are from records 1190-1210 of file "94-03-01_ers_ft.dat". The data for each DAT file are arranged with the grid cells beginning in southwest corner and proceeding W->E first. Upon finishing the first latitudinal (x-direction) image line (66 cells or lines/records in .pct file), the data then move up an image line (N latitudinal, y-direction), and begin again at the western edge and again proceed eastward to the end of the second line, and so on. The final entry in each DAT file corresponds to the northeastern-most grid cell. The columns represent:

```
(column 1) percent frozen landscape
(column 2) percent thawed landscape
(column 3) percent open water area

      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.489040     0.0832409    1.24514
     76.4728      14.8863       2.98114
     70.4806      17.6201      11.8993
     58.2489      23.5921      18.1590
     88.0869      10.7535       1.15960
     94.7569       5.04092      0.202177
     91.9158       8.00836      0.0758165
     89.0510       9.12650      1.82251
     86.3066      13.6555       0.0379082
     93.0833       6.71745      0.199261
     49.8449       4.51666      0.997278
      0.00000      0.00000      0.446151
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
      0.00000      0.00000      0.00000
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8. Data Organization

8.1 Data Granularity

The data file names are given by the format "yy-mm-dd_ers_ft.dat" and "yy-mm-dd_ers_ft.gif", where yy is the year (94 = 1994), mm is the month number, and dd is the day of month. Each pair of *.dat and *.gif files provides composite data corresponding to ERS-1 SAR observations obtained on the corresponding year and day-of-year.

8.2 Data Format(s)

The data set consists of 33 pairs of data files, representing observations from 33 days in the thaw and freeze-up periods of 1994. The DAT files (*.dat) provide ASCII data for each day, each file with 66x60 lines (3960 records/grid cells) containing the three columns below:

1. percent frozen landscape (column 1)
2. percent thawed landscape (column 2)
3. percent open water area (column 3)

Missing data and are not indicated in the ASCII files. The grid begins in the southwest corner of the region covered and proceeds eastward first.

The GIF files (*.gif) corresponding to each of the *.dat files are graphical representations of the data provided in the *.dat files. Each bin is shown in a combination of red, blue, green and black, where:

- red = area fraction of the grid cell that is thawed
- blue = area fraction of the grid cell that is frozen
- green = area fraction of the grid cell that is lake (open water)
- black = area fraction of the grid cell that has no data or is missing data

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9. Data Manipulations

9.1 Formulae

9.1.1 Derivation Techniques and Algorithms

The technique used to derive the backscatter change images is described in Rignot and Way (1994). The freeze/thaw classifications were determined through application of a change detection threshold based on temporal backscatter change relative to a wintertime frozen reference state.

9.2 Data Processing Sequence

9.2.1 Processing Steps

Frozen and thawed states, and lake-covered landscape, were quantified on a pixel-by-pixel basis using a temporal series of georeferenced, co-registered ERS SAR imagery. The temporal sequence of SAR images were co-registered to a regional ERS SAR mosaic representative of wintertime frozen conditions.

A Landsat TM classification was co-registered to the mosaic and used to identify the location of lakes (open water). The lake mask only partially covered the study region. The northwest corner of the TM image is located -106.50 degrees longitude and 54.42 degrees latitude. The lake mask was 4115 rows by 4809 samples, with north-south resolution of 0.00030 degrees per pixel, and east-west resolution of 0.00045 degrees per pixel. Outside of the TM mask region, the effect of lakes was ignored in production of the freeze/thaw products, with open water regions being treated the same as the surrounding landscape.

Landscape freeze/thaw state was estimated on a pixel-by-pixel basis using 200 meter resolution ERS SAR images, with the lake regions masked out. A 1 dB threshold was used in estimating the landscape freeze/thaw state such that:

1. a pixel is assumed thawed if ERS SAR backscatter increased by 1 dB or more over the wintertime frozen condition.
2. a pixel is assumed frozen otherwise.

The resulting pixel-by-pixel estimates (with lake regions masked out) were aggregated to the 66x60 grid such that:

- percent frozen area = 100*(number of frozen non-lake pixels in grid cell)/(total pixels in grid cell)
- percent thawed area = 100*(number of thawed non-lake pixels in grid cell)/(total pixels in grid cell)
- percent lake area = 100*(number of lake pixels in grid cell)/(total pixels in grid cell)

Some cells (records in the .pct files) have percent frozen, thawed, and lake area that do not sum to 100%. These are due to missing data (black area in the .gif images) in the input 200-meter resolution ERS-1 backscatter data that were aggregated to the 5 by 10 minute resolution grid. When data were redundant for a bin (due to repeat coverage within a single day), the ERS SAR pass with the smallest number of missing values was used.

9.2.2 Processing Changes

None.

9.3 Calculations

9.3.1 Special Corrections/Adjustments

None.

9.3.2 Calculated Variables

None.

9.4 Graphs and Plots

None.

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10. Errors

10.1 Sources of Error

Given the stability of the ERS instrument, instrument errors are unlikely to cause erroneous changes in radar backscatter from the surface. Environmental factors may, however, complicate the interpretation of the data. When cold and dry, the snowpack found in the BOREAS region is nearly transparent to C-band radar signals. During warm episodes prior to the onset of final spring thaw or after the fall freeze-up, snow may become wet, leading to a marked change in its radar backscatter. In these circumstances and in the absence of ancillary information, melting snow may be more difficult to distinguish from freeze/thaw transitions in other landscape components.

Another source of error results from noise introduced by freezing and thawing of open water and bogs. Backscatter response to freeze/thaw transitions for open water and boggy regions can vary dramatically from that of forested landscape. The error introduced by the open water effect is significantly reduced over the region where the Landsat water mask was applied prior to the classification of landscape freeze/thaw state. Generally, heterogeneous landscapes will lead to increased error in the freeze/thaw classification results. The scale of heterogeneity that influences the classification scheme are higher or on the order of the spatial resolution of the baseline SAR imagery (200 meters).

Rain events may also significantly alter the landscape backscatter, influencing the accuracy of the freeze/thaw classification if the SAR imagery were obtained during or shortly after periods of rainfall.

10.2 Quality Assessment

10.2.1 Data Validation by Source

ERS-1 data are calibrated within 1/3 dB (Rignot et al., 1994; Rignot and Way,1994). Freeze/thaw classification results have been compared with in situ vegetation and air temperature station data at the SSA-OBS, SSA-OJP and SSA-OA sites (See Section 1.6, Related Data Sets.)

10.2.2 Confidence Level/Accuracy Judgment

Based on comparison with in situ vegetation and air temperature station data, we estimate the freeze/thaw estimates to have maximum error of about 10-12% over the validation sites, depending upon the density and distribution of lakes and bogs. This accuracy degrades outside the bounds of the open water mask. However, trends in landscape freeze/thaw transition during spring thaw and autumn freeze-up are still accurately defined.

10.2.3 Measurement Error for Parameters

None.

10.2.4 Additional Quality Assessments

None.

10.2.5 Data Verification by Data Center

None.

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11. Notes

11.1 Limitations of the Data

None given.

11.2 Known Problems with the Data

None.

11.3 Usage Guidance

None given.

11.4 Other Relevant Information

Freeze/thaw classifications and ERS change maps, which correspond to higher level derived product, can be utilized with no restriction.

ERS-1 data can only be distributed to ESA-approved investigators. To obtain ERS data, interested users need to contact ESA and in particular the ESA/ESRIN Facility in Frascatti, Italy. U.S. investigators interested in data available at the ASF should contact the Alaska SAR Facility, University of Alaska, Fairbanks in Fairbanks, AK.

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12. Application of the Data Set

These data can be used to determine the onset of freeze/thaw transitions, and as temporal series maps of landscape freeze/thaw state at the BOREAS southern study sites.

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13. Future Modifications and Plans

Development of similar data products over broader areas of the BOREAS region are in progress and at the time of the completion of this document are nearing release. Application of more robust freeze/thaw discrimination schemes are also underway. Similar analyses have been performed utilizing Ku-band scatterometer data from the NASA Scatterometer (NSCAT) and analyses are also underway utilizing SeaWinds data (Frolking et al. 1999; Kimball et al., 2001a,b; Running et al., 1999). Users interested in access to these products should contact Kyle McDonald at JPL (see contact information, Section 2.3).

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14. Software

14.1 Software Description

Software has been developed in IDL at the Jet Propulsion Laboratory (JPL) to generate the gridded data sets.

14.2 Software Access

None given.

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15. Data Access

15.1 Contact for Data Center/Data Access Information

These BOREAS data are available from the Earth Observing System Data and Information System (EOS-DIS) Oak Ridge National Laboratory (ORNL) Distributed Active Archive Center (DAAC). The BOREAS contact at ORNL is:

ORNL DAAC User Services
Oak Ridge National Laboratory
(865) 241-3952

ornldaac@ornl.gov
ornl@eos.nasa.gov

15.2 Procedures for Obtaining Data

BOREAS data may be obtained through the ORNL DAAC World Wide Web site at http://daac.ornl.gov [Internet Link] or users may place requests for data by telephone or electronic mail. 15.1.

15.3 Output Products and Availability

Requested data can be provided electronically on the ORNL DAAC's anonymous FTP site or on various media including, CD-ROMs, 8-MM tapes, or diskettes.

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16. Output Products and Availability

16.1 Tape Products

ESA has a policy that ERS-1 data may be distributed only to ESA-approved investigators. The ERS-1 SAR-based freeze/thaw products, which correspond to higher level derived products, can be utilized with no restriction.

16.2 Film Products

None.

16.3 Other Products

The BOREAS RSS-17 freeze/thaw image data are available on the original BOREAS CD-ROM series.

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17. References

17.1 Platform/Sensor/Instrument/Data Processing Documentation

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17.2 Journal Articles and Study Reports

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17.3 Archive/DBMS Usage Documentation

None.

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18. Glossary of Terms

None.

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19. List of Acronyms

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AMI      - Active Microwave Instrumentation
ASCII    - American Standard Code for Information Interchange
ASF      - Alaska SAR Facility
ATSR     - Along-Track Scanning Radiometer
BOREAS   - BOReal Ecosystem-Atmosphere Study
BORIS    - BOREAS Information System
CD-ROM   - Compact Disk-Read-Only Memory
DAAC     - Distributed Active Archive Center
DN       - Digital Number
DOY      - Day of Year
EOS      - Earth Observing System
EOSDIS   - Earth Observing System Data and Information System
ERS      - European Remote Sensing Satellite
ESA      - European Space Agency
GIS      - Geographic Information System
GSFC     - Goddard Space Flight Center
HTML     - HyperText Markup Language
JPL      - Jet Propulsion Laboratory
LR       - Laser Retroreflector
MDA      - McDonnell Detweiler Associates
MWS      - Microwave Sounder
NAD83    - North American Datum of 1983
NASA     - National Aeronautics and Space Administration
NSA      - Northern Study Area
OBS      - Old Black Spruce
ORNL     - Oak Ridge National Laboratory
PANP     - Prince Albert National Park
PRARE    - Precise Range and Range Rate Experiment
RA       - Radar Altimeter
RSS      - Remote Sensing Science
SAR      - Synthetic Aperture Radar
SSA      - Southern Study Area
URL      - Uniform Resource Locator
UTC      - Coordinated Universal Time
WNS      - Wind Scatterometer
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