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The documentation for this data set was provided solely by the Principal Investigator(s) and was not further developed, thoroughly reviewed, or edited by NSIDC. Thus, support for this data set may be limited.

AMSRIce06 Airborne Topographic Mapper (ATM) Lidar Data

Summary
This data set contains lidar measurements of sea ice in the Chukchi and Beaufort Seas of the Arctic Ocean, and of snow cover off the northern coast of Alaska, USA. Lidar measurements were obtained by the Airborne Topographic Mapper (ATM) instrument mounted on a P3 aircraft during three days in March 2006. The data set includes airborne laser-ranging data, aircraft attitude, and GPS positioning information organized in 32-bit (4-byte) scaled binary format. Also included are ASCII text files containing processing scripts, latitude/longitude coordinates, and surface elevation corresponding to the ATM data. These data were collected as part of the joint in situ and aircraft AMSRIce06 campaign. The total volume of this data set is approximately 11 gigabytes. All files are available via FTP.

These data were collected as part of a validation study for the Advanced Microwave Scanning Radiometer - Earth Observing System (AMSR-E). AMSR-E is a mission instrument that was launched aboard the NASA Aqua Satellite on 04 May 2002.

Citing These Data
To broaden awareness of our services, NSIDC requests that you acknowledge the use of data sets distributed by NSIDC. Please refer to the citation below for the suggested form, or contact NSIDC User Services for further information.

The following example shows how to cite the use of this data set in a publication. List the principal investigators, year of data set release, data set title, and publisher.

Krabill, William B. 2010. *AMSRIce06 Airborne Topographic Mapper (ATM) Lidar Data.* Boulder, Colorado USA: NASA DAAC at the National Snow and Ice Data Center.

Overview Table

Category	Description
Data format	Binary ATM files ASCII text files
Spatial coverage	Southernmost Latitude: 64.8929° Northernmost Latitude: 71.9577° Westernmost Longitude: -166.1468° Easternmost Longitude: -148.2055°
Temporal coverage	21, 22, 25 March 2006
File naming convention	File names vary; refer to Table 1 for more information.
File size	ATM Data Files: 13 – 54 MB ASCII Text Files: 1 KB – 26 MB
Parameter(s)	Snow Cover Ice Extent Ice Roughness
Procedure for obtaining data	Data are available via FTP.

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1. Contacts and Acknowledgments:

Principal Investigator:
William B. Krabill
National Aeronautics and Space Administration (NASA)
Wallops Flight Facility
Building N159 Room E20
Mailstop 972.0
Wallops Island, VA 23337
Email: William.B.Krabill@nasa.gov

Technical Contact:
NSIDC User Services
National Snow and Ice Data Center
CIRES, 449 UCB
University of Colorado
Boulder, CO 80309-0449 USA
Phone: (303) 492-6199
Fax: (303) 492-2468

2. Detailed Data Description:

Description of ATM Output Data:

ATM data is generally distributed in the output format of the processing program, called qfit, which combines airborne laser ranging data and aircraft attitude from the INS with positioning information from a processed kinematic differential GPS trajectory. The qfit output files are organized as 32-bit (4-byte) binary words, equivalent to a C or IDL long integer, which are scaled to retain the precision of the measurements. The format and the scaling factors are presented below. The qfit program is run on a Sun Sparc workstation. Accordingly, it is written in a big-endian format and must be byte-swapped to be read with a PC which uses a little-endian format to store 32-bit integers.

The files are organized into fixed-length logical records. The beginning of the file contains a header of one or more records followed by a data segment, in which there is one record per laser shot. It is not necessary to interpret the header to use the laser data.

The first word of the header (and the file) is a 32-bit binary integer giving the number of bytes in each logical record. Usually qfit files have 14 words per record and this integer will be the number 56. The remainder of the initial logical record is padded with blank bytes (in this case 52 blank bytes).

The remainder of the header is generally a series of logical records containing the processing history of the file. In these logical records, the initial word contains a 32-bit binary integer with a value between -9000000 and -9000008. The remaining bytes in each header record are filled with a string of ASCII characters containing information on file processing history. In this case, the byte offset (as a long-word integer) from the start of file to the start of laser data will be the second word of the second record of the header. **Note:** The header records can be removed by eliminating records that begin with a negative value since the first word of records in the data segment is always a positive number.

In the data segment of the file, the information contained in words 1-9 of the output record pertains to the laser pulse, its footprint, and aircraft attitude. Words 10-13 pertain to the passive brightness signal, which is essentially a relative measure of radiance reflected from the earth's surface within the vicinity of the laser pulse. The horizontal position of the passive footprint is determined relative to the laser footprint by a delay formulated during ground testing at Wallops. The elevation of the footprint is synthesized from surrounding laser elevation data. **Note:** The passive data are not calibrated and their use, if any, should be qualitative in nature. Use of these data may aid the interpretation of terrain features. The measurement capability was engineered into the ATM sensors to aid in the identification of the water/beach interface acquired with the instrument in coastal mapping applications.

An alternate file format omits the passive brightness information. This format consists of 10 words per record, which correspond to words 1-9 and word 14 from the following list:

Word #	Content
1	Relative Time (msec from start of data file)
2	Laser Spot Latitude (degrees X 1,000,000)
3	Laser Spot Longitude (degrees X 1,000,000)
4	Elevation (millimeters)
5	Start Pulse Signal Strength (relative)
6	Reflected Laser Signal Strength (relative)
7	Scan Azimuth (degrees X 1,000)
8	Pitch (degrees X 1,000)
9	Roll (degrees X 1,000)
10	Passive Signal (relative)
11	Passive Footprint Latitude (degrees X 1,000,000)
12	Passive Footprint Longitude (degrees X 1,000,000)
13	Passive Footprint Synthesized Elevation (millimeters)
14	UTC Time packed (example: 153320100 = 15h 33m 20s 100ms)

Description of Continuous Airborne Mapping By Optical Translator (CAMBOT) Output Data:

Among the ASCII text files provided for this data set are .cam files. The Continuous Airborne Mapping By Optical Translator (CAMBOT) system was used to automatically take down-looking digital images with an associated latitude/longitude position. For more information regarding the CAMBOT system, refer to the Data Acquisition and Processing section of this document.

The .cam files accompany nadir-viewing photographs provided in the AMSRIce06 Aerial Photographs data set and were created during the processing of the laser data. The .cam files are useful for interpreting the nadir-viewing photographs.

An example of a few columns of a .cam file is shown here:

```
77322.74430 -68.738735 294.492330 1393.92  988.10  405.82 -1.888979  5.240478 31.431880
77322.79451 -68.738678 294.492422 1393.69  988.29  405.40 -1.910360  5.070164 31.320796
77322.84453 -68.738622 294.492513 1393.46  987.79  405.67 -1.925300  5.040712 31.288781
```

Where the fields are defined as:

1. Time of day (secs) - (in either GPS or UTC?)
2. Latitude (deg)
3. Longitude, east (deg)

4. Aircraft altitude (m) - position of camera above WGS84 ellipsoid
5. Altitude of aircraft above ground (m)
6. Surface height (m) - WGS84 elevation of ground topography measured by laser
7. Pitch of aircraft (degrees)
8. Roll of aircraft (degrees)
9. Heading of aircraft (degrees)

File Naming Convention:
The data files employ a variety of naming conventions. A few of the most common file name variables are described in Table 1.

Table 1. Description of File Name Variables

Variable	Description
YYYY	4-digit year
MM	2-digit month
DD	2-digit day
HH	2-digit hour
MM	2-digit minute
SS	2-digit second
.txt	Indicates this is a text file
.cam	Indicates this is a CAMBOT text file

File Size:
ATM QFIT data files range from approximately 13 to 54 megabytes. ASCII text files, such as CAMBOT (.cam) files, range from approximately one kilobyte to 26 megabytes.

Spatial Coverage:
Southernmost Latitude: 64.8929°
Northernmost Latitude: 71.9577°
Westernmost Longitude: -166.1468°
Easternmost Longitude: -148.2055°

Temporal Coverage:
Data were acquired on 21, 22, and 25 March 2006.

Parameter or Variable:
This data set is comprised of lidar measurements of snow cover and sea ice taken in support of the AMSRIce06 campaign.

3. Data Access and Tools:

Data Access:
Data are available via FTP at:
ftp://sidads.colorado.edu/pub/DATASETS/AVDM/data/cryosphere/AMSRIce06/aircraft/nsidc0461_AMSRIce06_ATM_LIDAR_v01/

Software and Tools:
ArcView, ENVI, or other similar software packages are appropriate tools for viewing the binary data. Any word-processing program or Web browser is sufficient for viewing the text files.

4. Data Acquisition and Processing:

ICESS Program Data:

The ICESS program fits a plane to a block of data from the ATM instrument which has been processed to the stage and in which each data point has a surface elevation (ellipsoid height) and a geographic location (latitude and east longitude). As commonly utilized, the data on the two sides of the aircraft are separately smoothed. The along-track distance smoothed is the distance which the aircraft moves in 0.5 seconds. The data output rate is 4/second so that there is 50% overlap between successively smoothed blocks. The program output is an ASCII file. The date of the data is contained in the first six characters of the file name.

Each data record contains the following ten words:

Word 1: Time at which the aircraft passed the mid-point of the block (in seconds of the day)
Word 2: Latitude of the center of the block in degrees
Word 3: East longitude of the center of the block in degrees
Word 4: Ellipsoid height (WGS84 ellipsoid) of the center of the block
Word 5: South to North slope of the block (dimensionless)
Word 6: West to East slope of the block (dimensionless)
Word 7: RMS fit of the ATM data to the plane (in centimeters)
Word 8: Number of points used in estimating the plane parameters
Word 9: Number of points edited in estimating the plane parameters
Word 10: Distance of the center of the block from the centerline of the aircraft trajectory (in meters)

Note: The two slopes estimated are used to estimate surface elevations at points other than the center point through the use of the following algorithm:

ht(phi,lambda) = ht(phi0,lambda0)

+ SNslope * (phi - phi0) * 6378137 * pi/180

+ WEslope * (lambda - lambda0) * cos(phi0) * 6378137 * pi/180

where the center coordinates of the block are (phi0,lambda0).

CAMBOT System Data:

The CAMBOT system was used to automatically take down-looking digital images with an associated latitude/longitude position.

The CAMBOT system is comprised of:

- a Dell laptop running Redhat Linux,
- 2 Kodak DC4800 digital cameras,
- a GPS NMEA source,
- various programs and scripts.

CAMBOT operates in two modes, sequential and parallel. In sequential mode, one camera is operated at a time, giving a continuous rate of one image every 10 seconds. After the compact flash card in the camera fills, the system switches to the next camera while the previous camera is transferring the images to the computer. In parallel mode, both cameras are used simultaneously, giving a rate of one image every five seconds. However, no images can be taken while both cameras transfer their images, a process that takes several minutes.

Letter to Users from the PI:

Jim Yungel *05 November 2005*

The camget system was developed as a low-cost ancillary system to replace our NASA ATM video cameras. The video cameras (even so-called "digital video") result in lo-res images that need to be projected on TV style monitors, and do not result in digital images that can be searched by computer programs and displayed on computer screens.

Since we wanted searchable digital images to replace the video cameras, we developed an alternative. Rather than buying and operating an expensive digital photogrammetry system (difficult to fit in the small aircrafts with our ATM system), we used two low-cost Kodak digital cameras that could be commanded to take images and also could "listen" to the GPS data stream. The camget "raw data" file result is basically three pieces of information:

1) Higher resolution (than video) JPEG images
2) A file containing a list of images taken and GPS time
3) A file containing GPS data stream info

We process this data several ways to provide searchable databases of images (some of smaller size) that we can use to answer questions about ATM data. We do not correct the camget data for pitch/roll or geo-reference as it's never been necessary for the limited use we have for the images. The uncorrected images have always satisfied our needs for checking ATM data, and have been a very good replacement for downward-looking video cameras.

But some of our data customers have expressed a desire to try to geo-reference the images. Since the ATM system has a better GPS traj (obtained by differential GPS) than the NEMA GPS data recorded by camget, and the ATM also has pitch, roll, and heading data as measured by the Litton laser gyro we can go through that data and produce the .cam files. The .cam file contains this higher quality GPS data, pitch roll and heading, and times.

What our customers attempt to do is match the camget photo times with the information in the detailed .cam files and correct for pitch roll heading and produce geo-referenced images. We have not attempted this ourselves.

I think this can be carried out in a rough sense, but when one would get down to fine detail, there are several minor factors to overcome.

There are a number of other minor factors involved, particularly in that the camget cameras are not mounted in a photogrammetric style frame that is referenced to the INS (but are securely mounted to the airframe as is the INS) This means there is a small mounting bias between the camera's actual pitch roll and heading and the measured laser gyro pitch roll and heading. This bias should be consistent during missions in the same year, but will change from year to year. Also, there are two cameras used in the camget system and this bias will be different between cameras.

There are also some minor timing issues with time tagging the images. The image times depend on commanding the camera and reading the GPS data steam. There is some question of the exact time the digital camera shutter opens. Lab tests indicated that the shutter time of the cameras was fairly consistent and predictable and that's how we ended up with the times for each image, but this was "good enough" for our uses.

One other note:
The two camget cameras alternate taking photos on the P3. This was necessary to take photos fast enough for P3 speeds and have some chance of overlap between images. The downside is that there are 10 minutes gaps

when the two cameras memory card fill up and the images are downloaded to the laptop controlling the cameras. On the Twin Otter aircraft which flies slower, we can run one camera at a time and avoid gaps by having the other camera take over as the first camera fills up.

The best results I have seen to date though are by folks using "feature mapping" to join camget images together, and then matching that larger image to our laser elevation data.

I wasn't sure what end result you have in mind for the camget data, but felt that you should have this background info to know just how far to push this. In a rough sense, the images can be corrected to some level (maybe good enough for whatever you want to do). At some level you may encounter problems related to what I discussed above.

Hope this is of some help, and keep us informed of your progress.

-Jim

5. References and Related Publications:

For more campaign maps and more information on AMSRIce06, visit the Goddard Space Flight Center (GSFC) Sea Ice Remote Sensing: Arctic 2006 Web page: http://polynya.gsfc.nasa.gov/seaice_arctic2006.html.