

ASSESSMENT OF THE SEA ICE ELEVATION AND THE MECHANICAL PROCESSES THAT INFLUENCE ICE THICKNESS USING THE ICE CLOUD AND LAND ELEVATION SATELLITE (ICESAT)



Burcu O. Cicek

04/29/2005

SCOPE OF THIS PRESENTATION

1. Introduction

- » Overview the Ice Cloud and Land Elevation Satellite (ICESAT) (The Need, Mission, and Objective)
- » Describe ICESAT's Instrument: GLAS
- » Describe GLAS Data Products

2. Research Topic: **ASSESSMENT OF THE SEA ICE ELEVATION AND THE MECHANICAL PROCESSES THAT INFLUENCE ICE THICKNESS USING THE ICE CLOUD AND LAND ELEVATION SATELLITE (ICESAT)**

- » Purpose of this Research Project
- » Purpose of the Class Project

3. ICESAT Data Analysis

- » Downloaded ICESAT Products
- » Utilized IDL Visualizer Software for ICESAT

WHAT IS ICESAT?

ICESat (Ice, Cloud and Land Elevation Satellite) is new data, collected around the globe, has given scientists the ability to see the way many things around the Earth change, from the polar ice sheets and oceans to rainforests.

Launched Jan 12, 2003



OBJECTIVE OF ICESat

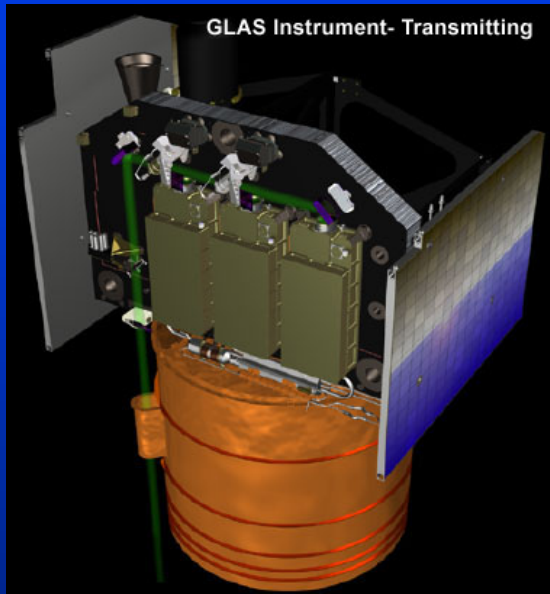
The main objective of the ICESat mission is to measure ice sheet elevations and changes in elevation through time.

Secondary objectives include measurement of cloud and aerosol height profiles, land elevation, vegetation cover, and sea ice thickness.



ICESat

The Ice, Cloud, and Elevation Satellite



- First laser-ranging instrument for continuous global observations of Earth
- Data can be obtained from the National Snow and Ice Data Center

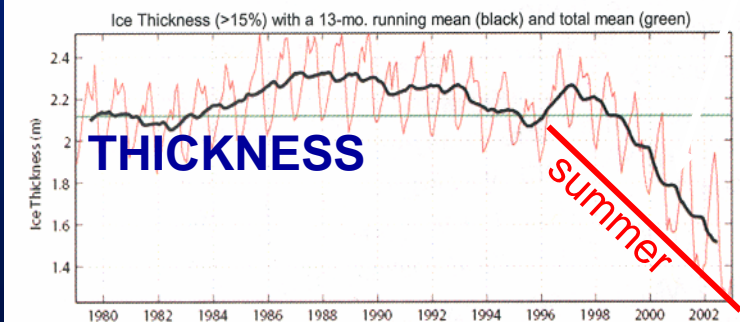
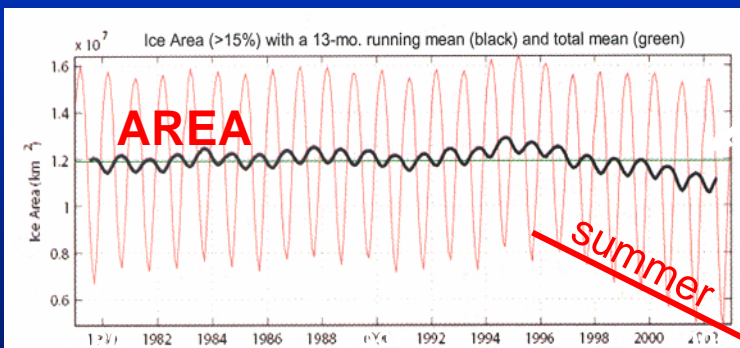
GLA01,05,06 2003-02-20 through 2003-03-20 and 2003-09-25 through 2003-11-18
GLA12-15 2003-02-21 through 2003-03-19 and 2003-09-25 through 2003-11-18



Shrinkage of Arctic Sea Ice Pack



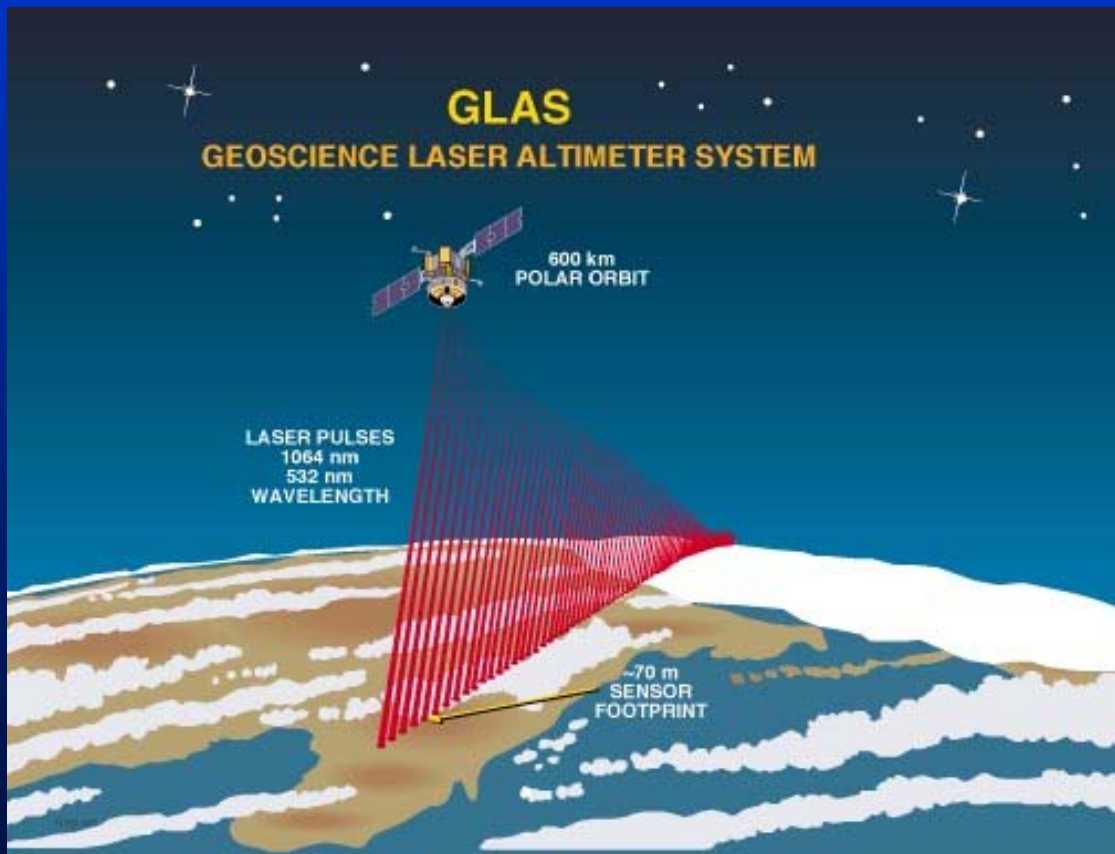
Area of Arctic sea ice in summer has been declining >10%/decade.



- ❑ Sea Ice-Ocean model driven by known atmospheric forcing suggests that thickness of sea ice is reducing even faster than the area (W. Maslowski, Naval PS).
- ❑ Observational verification of thickness change is critical need to estimate when the Arctic Ocean may be “ice-free” during summer.

ICESat's Instrument: GLAS

The Geoscience Laser Altimeter System (GLAS) on ICESat has a 1064 nm laser channel for surface altimetry and dense cloud heights and a 532 nm lidar (light detection and ranging) channel for the vertical distribution of clouds and aerosols.



The predicted accuracy for the surface elevation measurements is 15 cm, averaged over 70 m diameter laser footprints spaced at 172 m alongtrack. The orbital altitude is around 600 km at an inclination.

GLAS

GLAS is the first polar orbiting satellite laser altimeter ICESat's instrument. GLAS laser turned on in February 20, 2003.

It sends out pulses in Infrared and color-green. GLAS Laser operating in the near infrared (1064 nanometers) is used for the measurement of surface topography and ice altimetry. Backscattered light in the green (532 nanometers) is used for measurement of aerosols and other atmospheric characteristics.

GLAS has Level 1 and Level 2 laser altimetry products and atmospheric lidar products.

ICESat GLAS Data Products

The 16 standard data products (GLA01 to GLA16) are created by the ICESat Science Investigator-led Processing System (I-SIPS).

All products are

- time-ordered
- as collected along track
- distributed in granules (files)

Metadata (time, location, quality, etc) are provided with each granule, so the metadata can be searched using NSIDC tools to determine which granules to order.

ICESat Standard Data Products

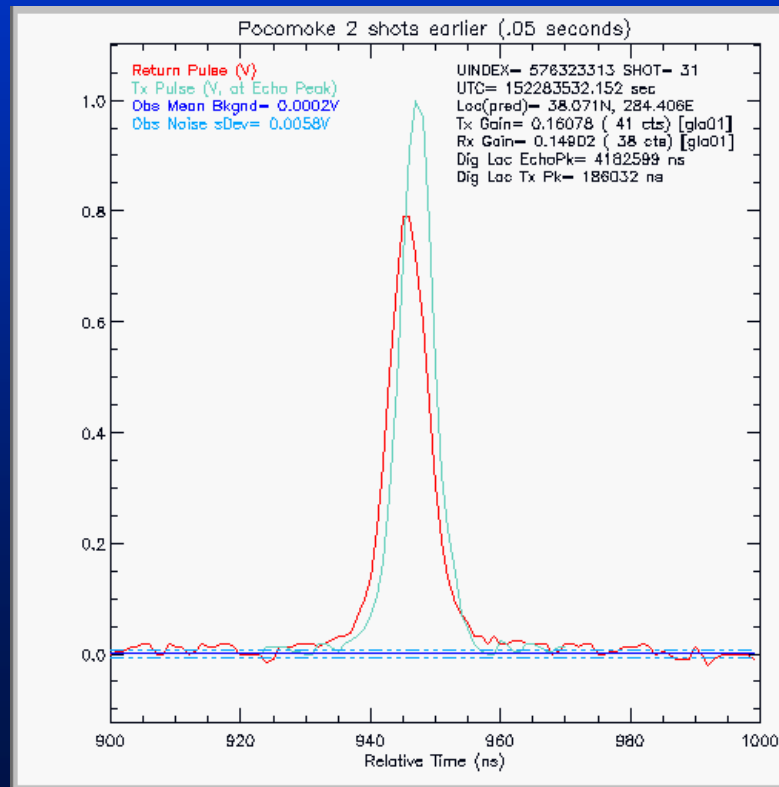
- **Seven Altimetry Products**
 - **GLA01, GLA05-06, GLA12-15**
- **Six Atmosphere Products**
 - **GLA02, GLA07-11**
- **Two Engineering Products**
 - **GLA03-04**

ICESat Standard Data Products

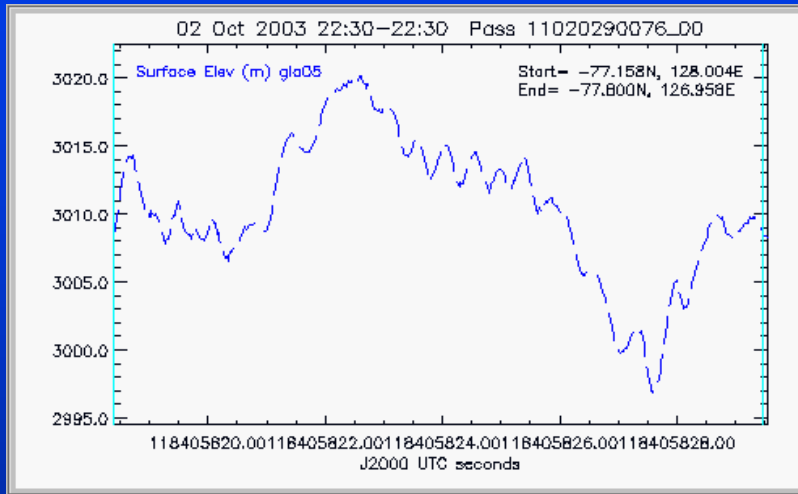
Short Name	Long Name	File size	Granules per day
GLA01	L1A Global Altimetry Data	9 MB	56
GLA02	L1A Global Atmosphere Data	671 MB	7
GLA03	L1A Global Engineering Data	19 MB	7
GLA04	L1A Global Laser Pointing Data	2 MB - 386 MB	7
GLA05	L1B Global Waveform-based Range Corrections Data	25 MB	56
GLA06	L1B Global Elevation Data	7 MB	56
GLA07	L1B Global Backscatter Data	827 MB	7
GLA08	L2 Global Planetary Boundary Layer and Elevated Aerosol Layer Heights	7 MB	1
GLA09	L2 Global Cloud Heights for Multi-layer Clouds	82 MB	1
GLA10	L2 Global Aerosol Vertical Structure Data	289 MB	1
GLA11	L2 Global Thin Cloud/Aerosol Optical Depths Data	13 MB	1
GLA12	L2 Global Antarctic and Greenland Ice Sheet Altimetry Data	104 MB	1
GLA13	L2 Global Sea Ice Altimetry Data	107 MB	1
GLA14	L2 Global Land Surface Altimetry Data	209 MB	1
GLA15	L2 Global Ocean Altimetry Data	279 MB	1

GLA01 L1A Global Altimetry

GLA01 contains all altimetry information transmitted from spacecraft, include long and short waveforms.

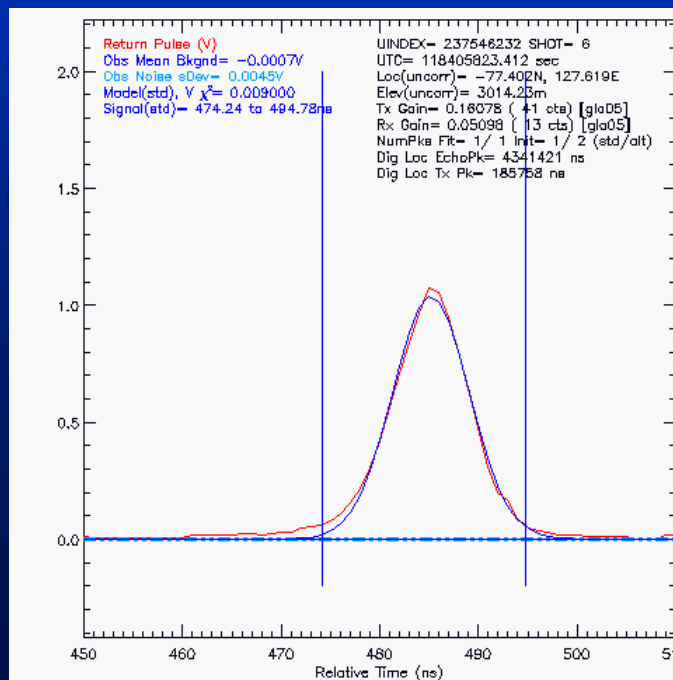


GLA05 L1B Global Waveform-Based Range Corrections



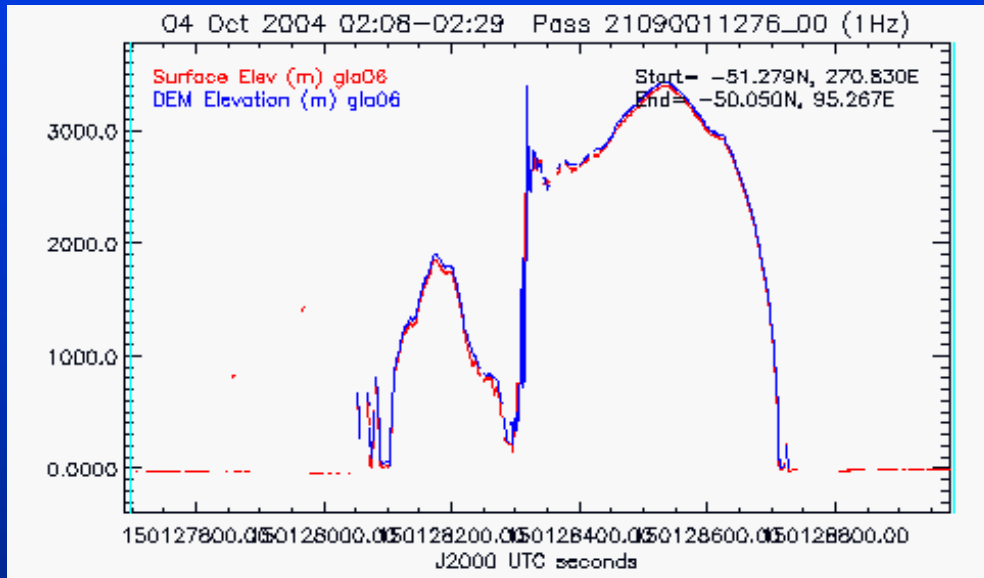
GLA05 is an intermediate product that contains important information calculated from the waveform.

GLA05 is used for creating GLA06 and level-2 elevation products.



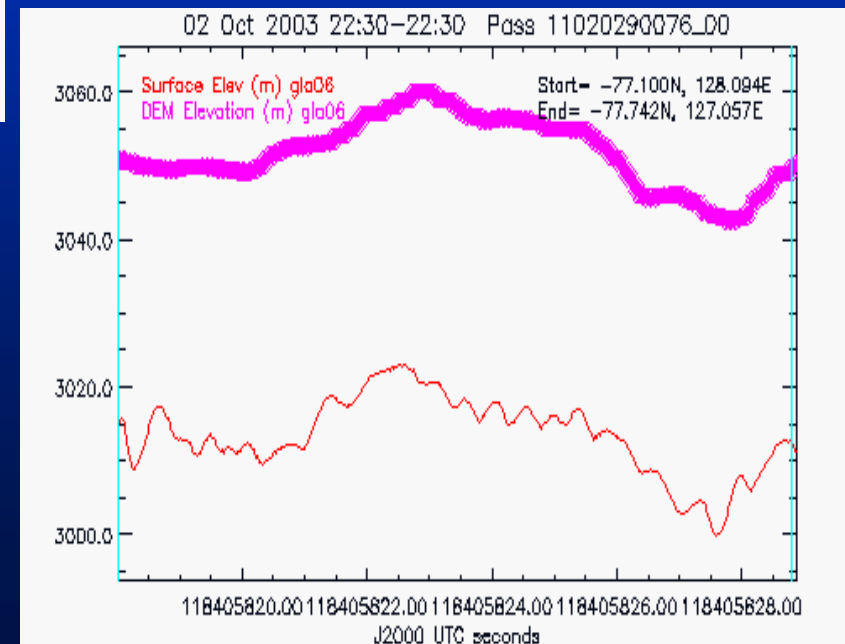
GLA06 L1B Global Elevation Data

Antarctica Track 1276

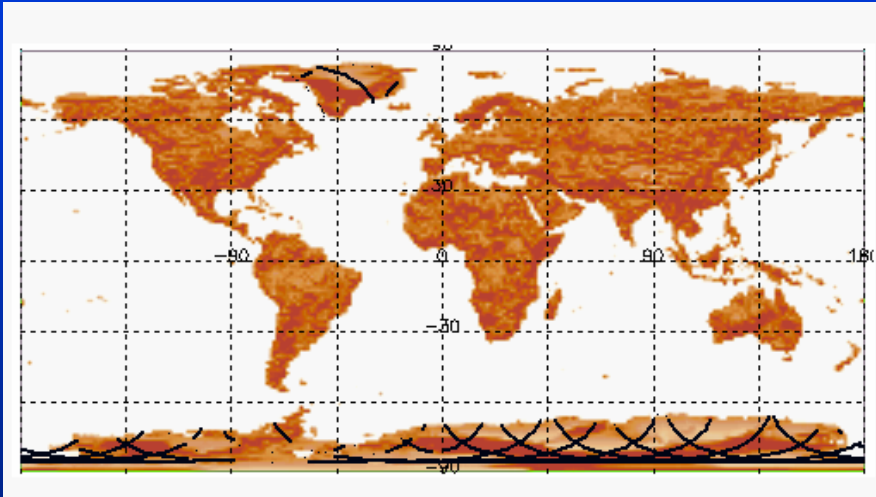


In this product elevation is calculated using ice sheet parameterization.

Additional information allow user to calculate an elevation based on land, sea ice, or ocean algorithms.

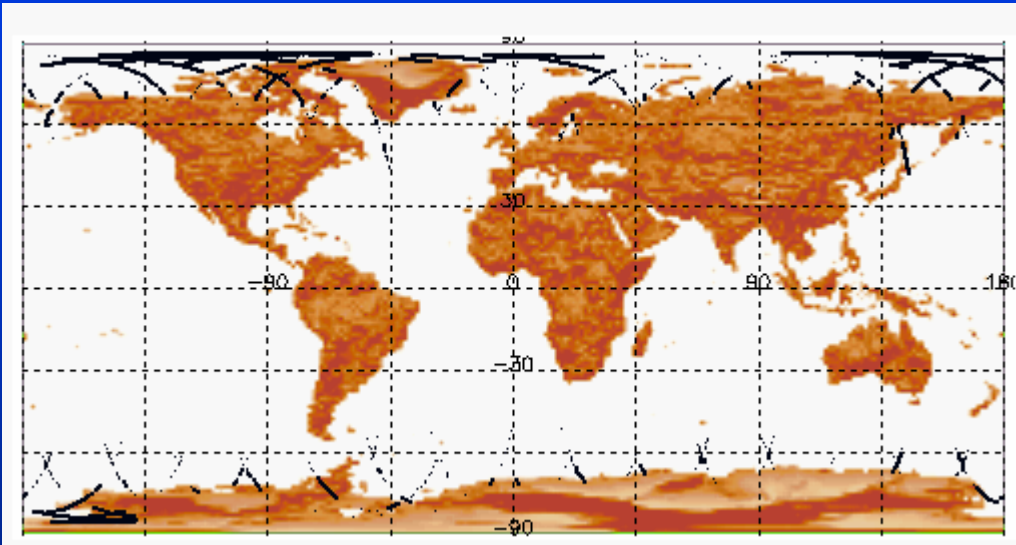


GLA12 L2 Ice Sheet Altimetry



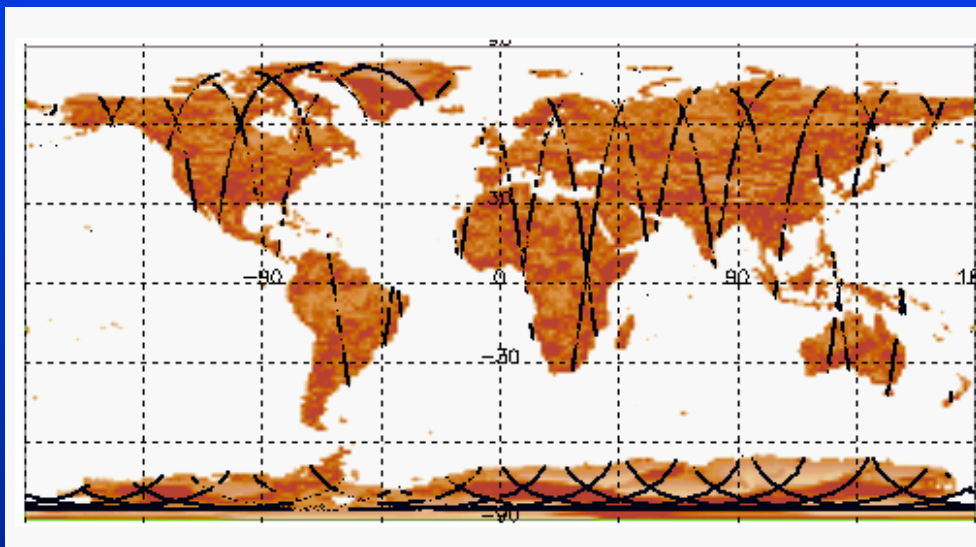
- Data specifically processed to provide the best Ice Sheet elevation
- Subset for Data contains Antarctic and Greenland only.

GLA13 L2 Sea Ice Altimetry



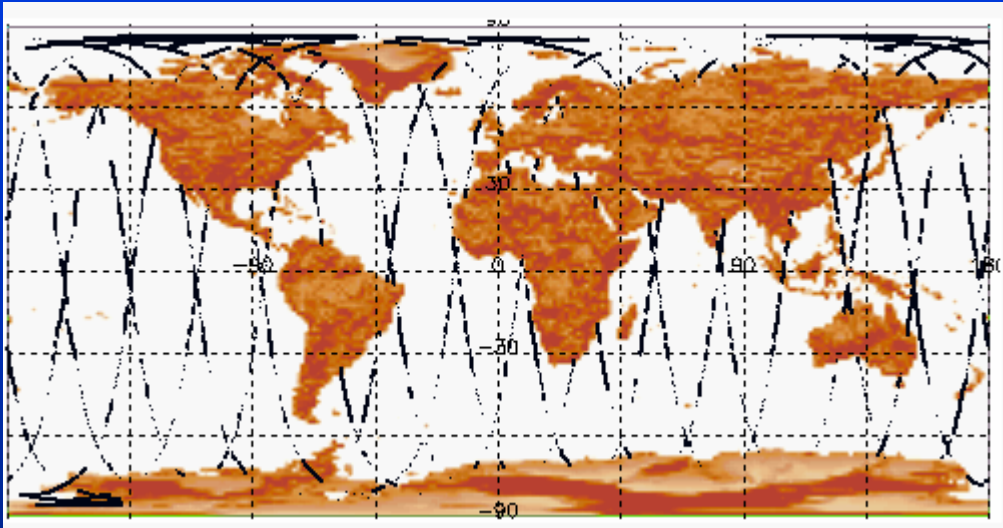
- Data specifically processed to provide the best Sea Ice elevation
- Subset for Data contains only possible Sea Ice areas only.

GLA14 L2 Land Surface Altimetry



- Data specifically processed to provide multi-return detection for surface elevation and vegetation tops
- Subset for Data contains only land surfaces.

GLA15 Ocean Altimetry



- Data specifically processed to provide best Ocean surface elevation
- Subset for Data contains only ocean surfaces.

RESEARCH OBJECTIVE

- This project is to focus on the assessment of the sea ice thickness and the mechanical processes that influence ice thickness using the ICESat on Antarctic region.

OBJECTIVE OF THE CLASS PROJECT

- The class project is a subset of the main topic.
- Performed initial research on the Use of ICESAT products for the measurement.
- Studied the analysis of ICESAT products using IDL Visualizer Software package.
- The outcome of the class project will be used to prepare and submit proposal(s).

PROCESSING SOFTWARE FOR ICESat

IDL visualizer

The visualizer software works under an IDL license.
Read data from an ICESat/GLAS file and view graphical summaries of variables.



IDL VISUALIZER

GLA01&GLA05 (2003-09-26)

GLAS Manual Data Set Selector

Data Release: 21

You may select one file for each product. Click a Pick button to browse. (If you pick GLA04, please choose GLA01 product also)

Default Directory: ?

GLA01: <input type="text" value="opGLA01_019_1102_028_0099_1_01_0001.DAT"/> <input type="button" value="pick"/> ?	GLA09: <input type="text"/> <input type="button" value="pick"/> ?
GLA02: <input type="text"/> <input type="button" value="pick"/> ?	GLA10: <input type="text"/> <input type="button" value="pick"/> ?
GLA03: <input type="text"/> <input type="button" value="pick"/> ?	GLA11: <input type="text"/> <input type="button" value="pick"/> ?
GLA04: <input type="text"/> <input type="button" value="pick"/> ?	GLA12: <input type="text"/> <input type="button" value="pick"/> ?
GLA05: <input type="text" value="opGLA05_019_1102_028_0099_1_01_0001.DAT"/> <input type="button" value="pick"/> ?	GLA13: <input type="text"/> <input type="button" value="pick"/> ?
GLA06: <input type="text"/> <input type="button" value="pick"/> ?	GLA14: <input type="text"/> <input type="button" value="pick"/> ?
GLA07: <input type="text"/> <input type="button" value="pick"/> ?	GLA15: <input type="text"/> <input type="button" value="pick"/> ?
GLA08: <input type="text"/> <input type="button" value="pick"/> ?	GLA16: <input type="text"/> <input type="button" value="pick"/> ?

?

?

Groundtracks

Pass ID: ?

Select Region:
 WORLD ANTARCTICA GREENLAND

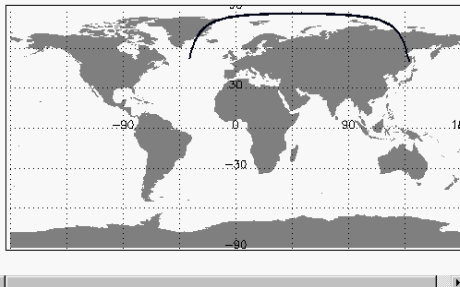
Select Map Style:
 Map DEM ?

Max Lat (N): Max Lon (E):
Min Lat (N): Min Lon (E):

Click "Replot Map" after making selections

?

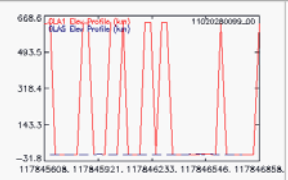
ZOOM the Map By Clicking and Dragging the mouse.



Elevation PROFILES

Plot Properties: ? ? km vs J2000 UTC seconds

Left Click on Profile for Plots: Right Click Profile to show on groundtrack



GLAS WF_CHAR: Pass 11020280099_00

GLAS Profile, indices: 231944082 to 231956872

?

UTC: Lat: Lon:

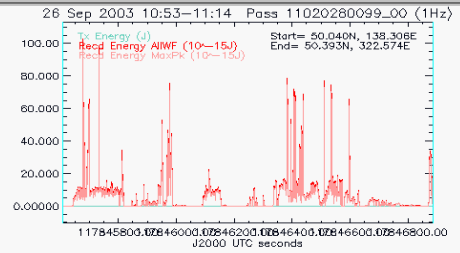
Zoom Range: to

26 Sep 2003 10:53-11:14 Pass 11020280099_00 (1Hz)

GLAS wf_chars

?

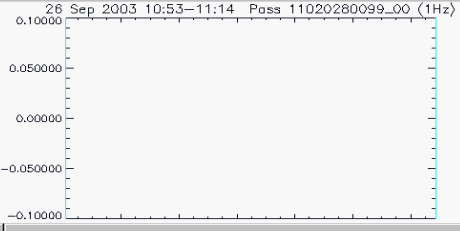
Left mouse: move Zoom bars
Right mouse: display lat/lon



26 Sep 2003 10:53-11:14 Pass 11020280099_00 (1Hz)

Differences

Left mouse: move Zoom bars
Right mouse: display lat/lon

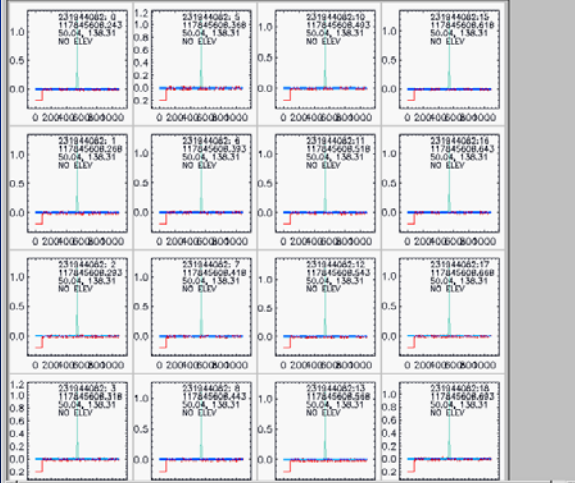


Right clicking on "Display Waveforms" will display the corresponding waveforms if GLA01 has been selected, beginning at the location of the red vertical cursor, with waveform parameterization results if GLA05 was also selected

WAVEFORMS: Pass 11020280099_00

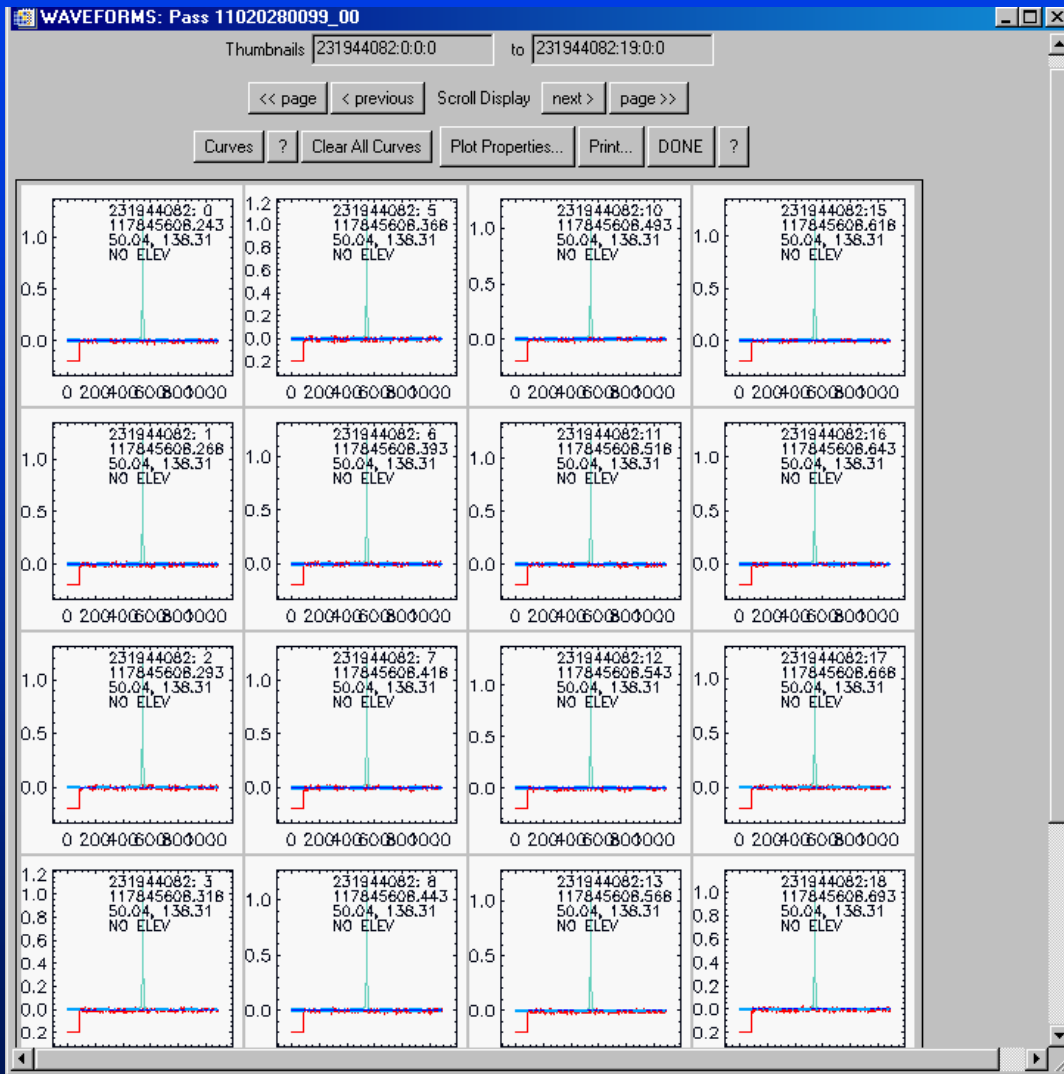
Thumbnail: 231944082.0:0.0 to 231944082.19:0.0

? ?



IDL VISUALIZER

GLA01&GLA05 (2003-09-26)



This figure shows Waveform thumbnails with parameterization results from GLA05. Annotations on each thumbnail are: unique index and shot number; shot time in J2000 seconds; latitude and longitude; and with GLA05 elevation. The X scale is relative time in nanoseconds.

IDL VISUALIZER

GLA01&GLA06&GLA13&GLA14 &GLA15 (2003-09-26)

GLAS Manual Data Set Selector

Data Release: 21

You may select one file for each product. Click a Pick button to browse. (If you pick GLA04, please choose GLA01 product also)

Default Directory: pick ?

GLA01: op\GLA01_019_1102_028_0099_1_01_0001.DAT	pick ?	GLA09: <input type="text"/>	pick ?
GLA02: <input type="text"/>	pick ?	GLA10: <input type="text"/>	pick ?
GLA03: <input type="text"/>	pick ?	GLA11: <input type="text"/>	pick ?
GLA04: <input type="text"/>	pick ?	GLA12: <input type="text"/>	pick ?
GLA05: <input type="text"/>	pick ?	GLA13: op\GLA13_021_1102_028_0099_0_01_0001.DAT	pick ?
GLA06: op\GLA06_021_1102_028_0099_1_01_0001.DAT	pick ?	GLA14: op\GLA14_021_1102_028_0099_0_01_0001.DAT	pick ?
GLA07: <input type="text"/>	pick ?	GLA15: op\GLA15_021_1102_028_0099_0_01_0001.DAT	pick ?
GLA08: <input type="text"/>	pick ?	GLA16: <input type="text"/>	pick ?

Display Data ?

EXIT PROGRAM ?

Groundtracks

Pass ID: ?

Select Region:
 WORLD ANTARCTICA GREENLAND

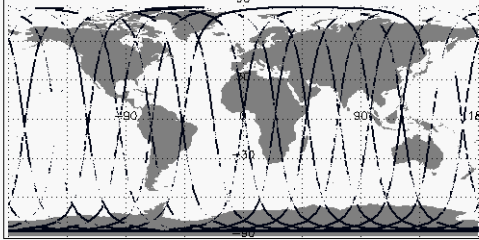
Select Map Style:
 Map DEM ?

Max Lat (N): 90.0000 Max Lon (E): 180.0000
Min Lat (N): -90.0000 Min Lon (E): -180.0000

Click "Replot Map" after making selections

Replot Map Print... Select User File to Display Locs on the Map ?

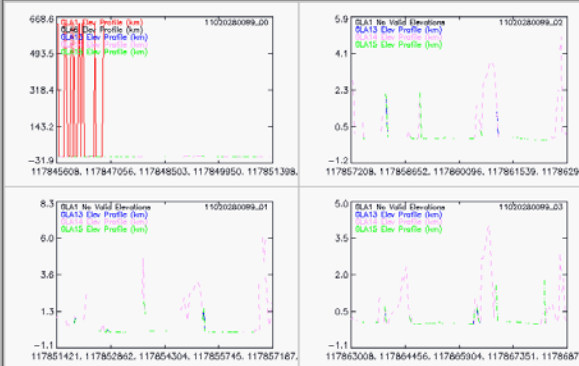
Disable Zoom ZOOM the Map By Clicking and Dragging the mouse.



Elevation PROFILES

Plot Properties: Prev. ? Return To GLAS Manual Data Set Selector ? km vs J2000 UTC seconds

Left Click on Profile for Plots: Right Click Profile to show on groundtrack.



Right-clicking on one of the backscatter images or elevation profiles will highlight that pass on the ground track window

Groundtracks

Select Region:
 WORLD ANTARCTICA GREENLAND

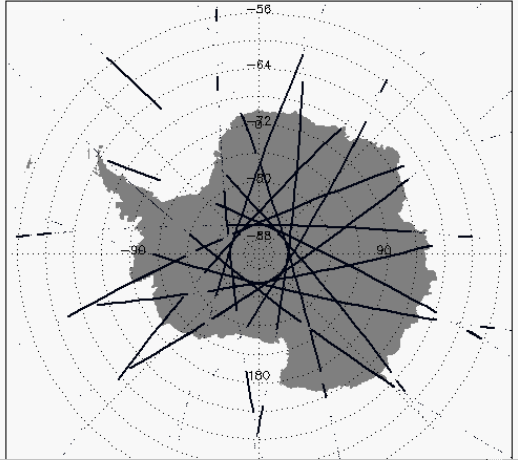
Select Map Style:
 Map DEM ?

Max Lat (N): 55.0000 Max Lon (E): 180.0000
Min Lat (N): -90.0000 Min Lon (E): -180.0000

Click "Replot Map" after making selections

Replot Map Print... Select User File to Display Locs on the Map ?

Disable Zoom ZOOM the Map By Clicking and Dragging the mouse.



Groundtracks

Select Region:
 WORLD ANTARCTICA GREENLAND

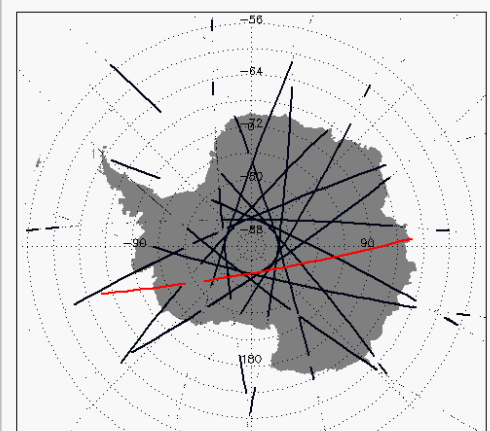
Select Map Style:
 Map DEM ?

Max Lat (N): 55.0000 Max Lon (E): 180.0000
Min Lat (N): -90.0000 Min Lon (E): -180.0000

Click "Replot Map" after making selections

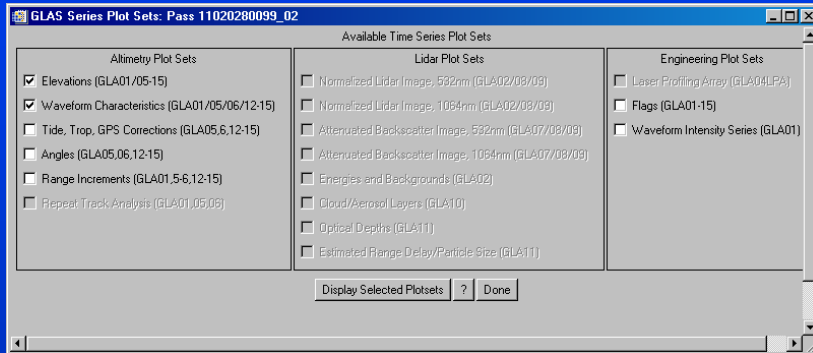
Replot Map Print... Select User File to Display Locs on the Map ?

Disable Zoom ZOOM the Map By Clicking and Dragging the mouse.

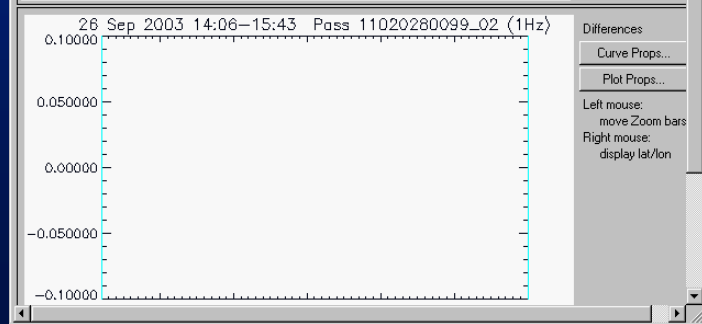
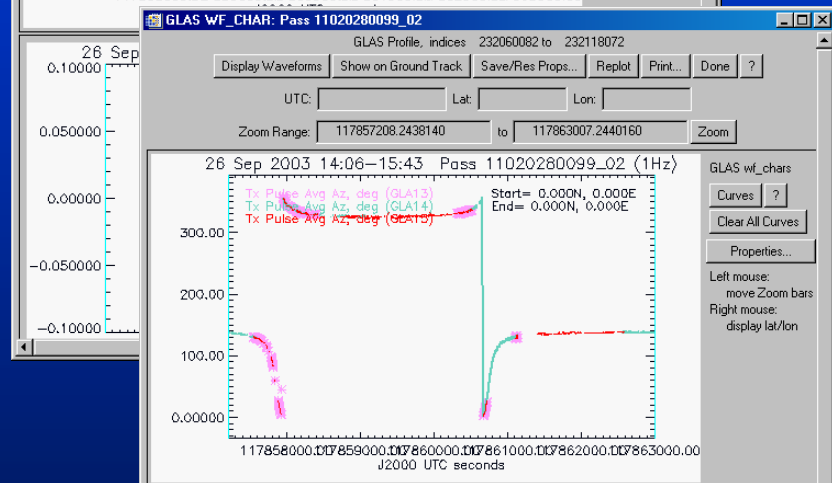
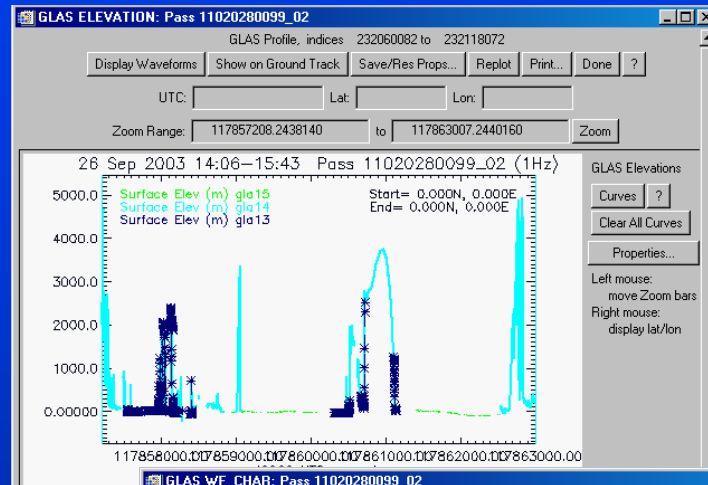


IDL VISUALIZER

GLA01&GLA06&GLA13&GLA14 &GLA15 (2003-09-26)



“Start” and “End” give the latitude and longitude of the endpoints of the displayed section. (This is not yet shown on every plotset)



IDL VISUALIZER

GLA06&GLA12&GLA13 (2003-09-26 / 2003-09-27)

GLAS Manual Data Set Selector

Data Release: 21

You may select one file for each product. Click a Pick button to browse. (If you pick GLA04, please choose GLA01 product also)

Default Directory: pick ?

GLA01: <input type="text"/> pick ?	GLA09: <input type="text"/> pick ?
GLA02: <input type="text"/> pick ?	GLA10: <input type="text"/> pick ?
GLA03: <input type="text"/> pick ?	GLA11: <input type="text"/> pick ?
GLA04: <input type="text"/> pick ?	GLA12: op\GLA12_021_1102_028_0113_0_01_0001.DAT pick ?
GLA05: <input type="text"/> pick ?	GLA13: op\GLA13_021_1102_028_0099_0_01_0001.DAT pick ?
GLA06: op\GLA06_021_1102_028_0099_1_01_0001.DAT pick ?	GLA14: <input type="text"/> pick ?
GLA07: <input type="text"/> pick ?	GLA15: <input type="text"/> pick ?
GLA08: <input type="text"/> pick ?	GLA16: <input type="text"/> pick ?

Display Data ?

EXIT PROGRAM ?

Groundtracks

Pass ID: ?

Select Region: WORLD ANTARCTICA GREENLAND

Select Map Style: Map DEM ?

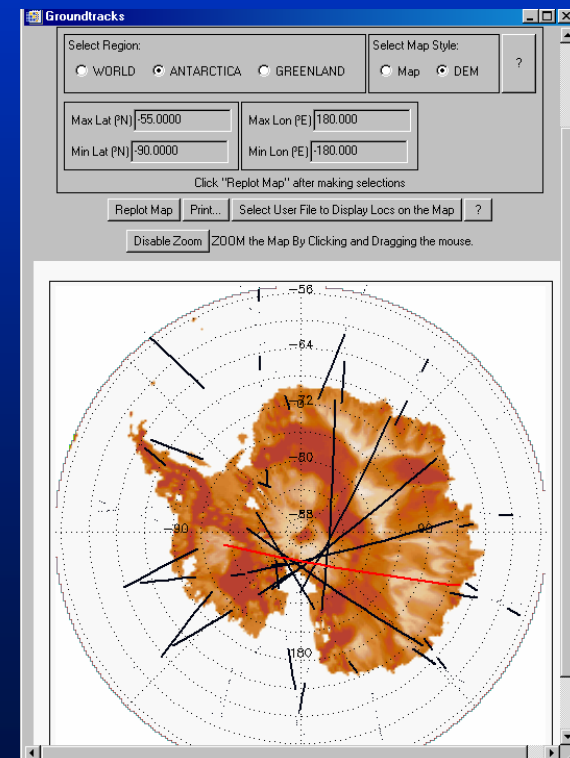
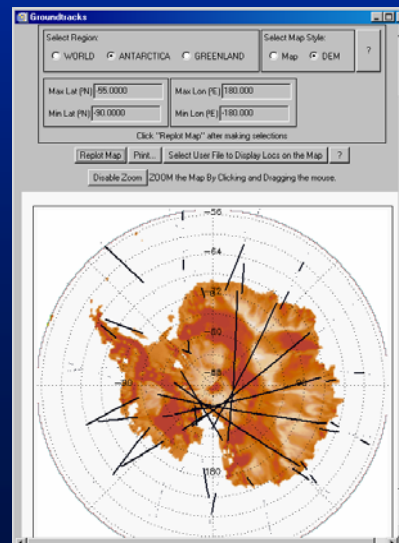
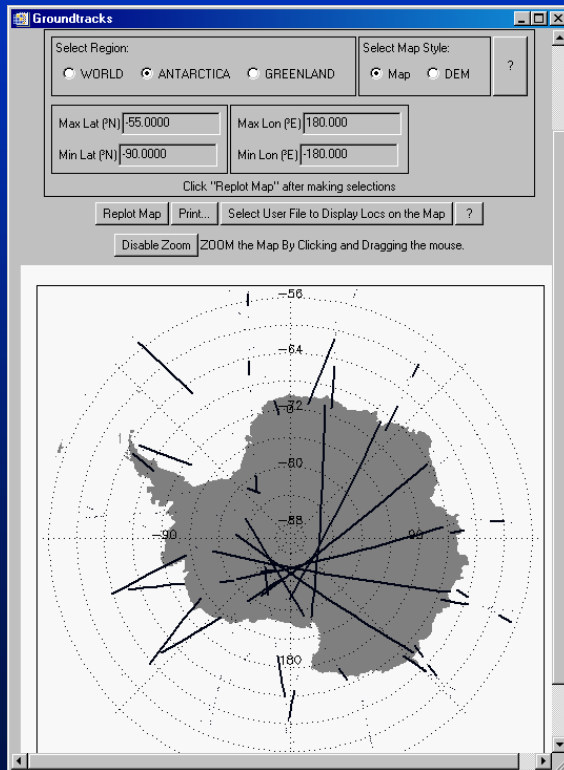
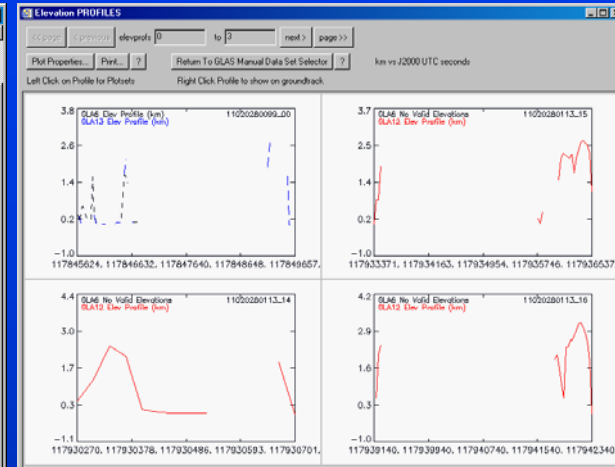
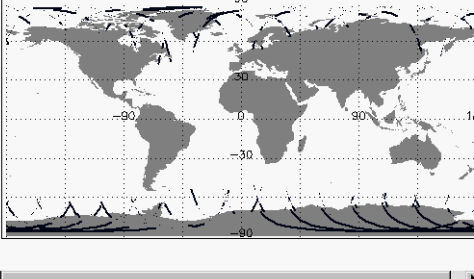
Max Lat (N) | 90.0000 Max Lon (E) | 180.0000

Min Lat (N) | -90.0000 Min Lon (E) | -180.0000

Click "Replot Map" after making selections

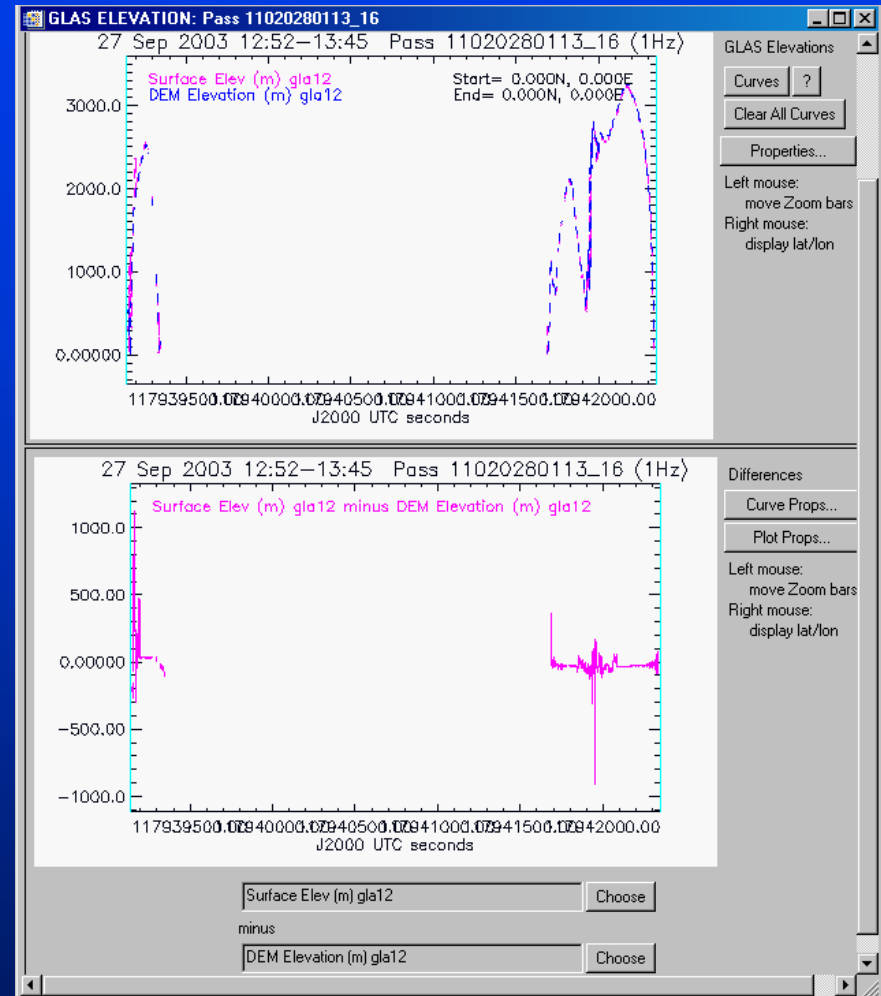
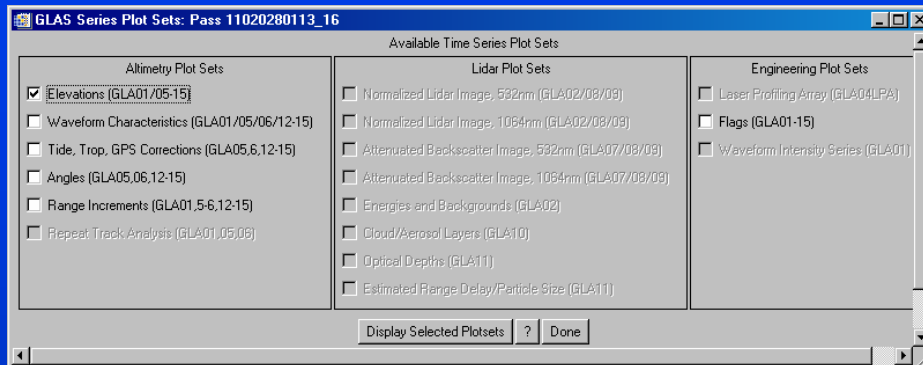
Replot Map Print... Select User File to Display Locs on the Map ?

Disable Zoom ZOOM the Map By Clicking and Dragging the mouse.



IDL VISUALIZER

GLA06&GLA12&GLA13 (2003-09-26 / 2003-09-27)



DEM Elevation: Elevation with respect to sea level as interpolated from a Digital Elevation Map at each footprint location

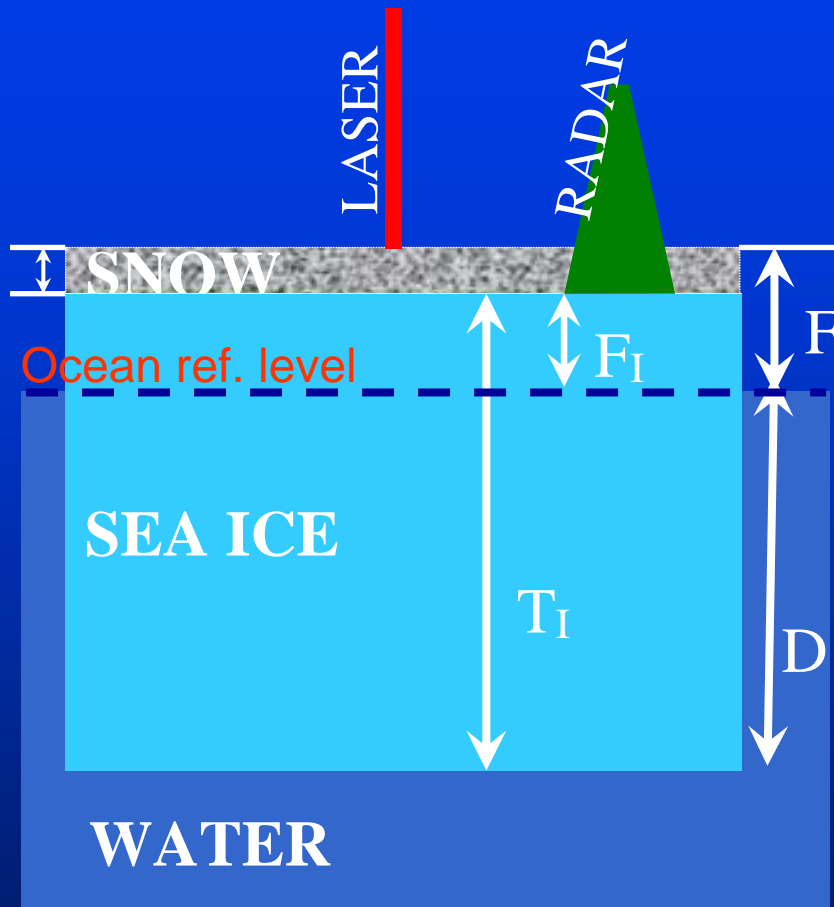
CONCLUSIONS AND DISCUSSIONS

- The Capabilities of ICESAT and GLAS were studied.
- ICESAT Products are studied.
- The Use of IDL ICESat data Analysis Software is utilized.
- This class research will be extended as a Ph.D. Research topic.

QUESTIONS?



Sea Ice Freeboard and Thickness



Sea Ice Thickness (T_I) = function of Freeboard (F) and snowcover (T_{sn} and ρ_{sn})

$$T_I = \rho_w / (\rho_w - \rho_i) \times F - (\rho_w - \rho_{sn}) / (\rho_w - \rho_i) \times T_{sn}$$

$$T_I = 9.411 \times F - 6.653 \times T_{sn} \quad \text{for } \rho_{sn} = 0.30$$

ρ_w : Water

ρ_i : Ice

ρ_{sn} : Snow

Freeboard is a measure of the height of sea ice above the ocean surface