Temporal Reduction of the ECSU Ice Shelf in Pine Island Bay Antarctica: 1972-2003

ECSU Ice Shelf Investigation Team

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Abstract

In an effort to determine whether the amount of ice is growing or diminishing over long time intervals, Dr. Robert Bindschadler led an international team of glaciologists and computer scientists, including Elizabeth City State University (ECSU) students, to obtain an accurate measure of the area of the Antarctic ice sheet. Before the ice sheet's area was determined, the grounding line (GL), or boundary dividing the ice sheet resting on land from floating ice, was located by combining 2003 Landsat imagery and satellite based laser altimetry.

Landsat image data contemporary with that used to create the grounding line was compared to earlier Landsat imagery of the same area. A small ice shelf—now known as the *ECSU Ice Shelf*—near the eastern entrance to Pine Island Bay was previously identified as having diminished over an approximate 31-year span and the progressive reduction of its area qualitatively characterized. Here we report our calculation of the ECSU ice shelf area change history, during the period 1972 to 2003 using archived Landsat imagery and the circa 2003 groundling line.

Abstract Continued

Departures from perfect geographic pixel registration in Landsat imagery of the *ECSU Ice Shelf* collected before 2003 was corrected with ITT's Visualization Information Solutions' ENVI image processing software using a 2003 Landsat 7 Enhanced Thematic Mapper (ETM) image as a reference. Older images from Landsat 4,5 Thematic Mapper (TM) and Landsat 7 ETM

registered to conform to the common fixed control points visible on both images. By overlaying the GL on the registered (warped) images, the area changes in the ice shelf were computed based on a standard common reference. An average ice shelf area was determined from repeated measurement trials for each of the pre-2003 Landsat image.

Landsat Images from 2003 used in creating the GL were obtained from the United States Geological Survey (USGS) archive (lima.usgs.gov). The older, cloud free Landsat 4,5 TM and 7 ETM images of the Pine Island Glacier region were obtained from another USGS archive (glovis.usgs.gov).

Results yielded: 1. A quantitative description of the disappearance of the ECSU Ice Shelf up through 2003; 2. Validation of the grounding line's actual location; 3. A survey of Antarctic coastal features that may have experienced climate related change.



- Landsat
- ENVI
- Glacier
- Ice Shelf
- Grounding Line

Background

• "Research by the U.S. Geological Survey has documented the retreat of every ice front in the southern part of the Antarctic Peninsula from 1947 to 2009"...



Background

In subsequent research, an ECSU student team discovered that an ice shelf—now known as the *ECSU lce Shelf*—had completely disappeared by the time that the grounding line was established in 2003. Prior work provided a qualitative description of the ice shelf's disappearance. The actual area reduction of the ECSU Ice Shelf remained to be quantitatively evaluated.

Methodology

Through the use of ENVI software, Landsat images obtained from USGS archives were geo-registered to receive an accurate measure of the ECSU Ice Shelf's area.



Methodology

- Downloaded images from the years: 1972, 1981, 1986, 1989, 1991, 1997, 2000, 2001, and 2003.
- Images do not have the same pixel to coordinate registration as the older Landsat archived imagery.

Image-to-Image Registration

- 2003 Landsat 7 images were used as reference images
- Five common geographic points in each image were selected as ground control points to which the new images could be warped or co-registered

Determining the Area

- Once the new co-registered image was created, the GL was overlain upon it
- Multiple, individual iterations of the area were made, and an average was taken
- A standard deviation formula was used to establish the data's variability



Results

- First trial no specified limiting geographic points
- Second trial two specified limiting geographic points: one lying to the SE of the ice shelf at 73°57'25'', 102°16'00'' West and one lying NW of the ice shelf at 73°55'55'' South, 102°27'50'' W.

Trials w/ unspecified geographic points

Trials w/ specified geographic points

Julian Day	Instrument - Path/Row	Base image (File name)	Avg Area (km²)	Stndrd Dev.	Julian Day	Instrument - Path/Row	Base image (File name)	Avg Area (km ²)	Stndrd Dev
1972.94	LM1 - 001/112	LE70031122003024EDC00	6.94	0.024	1972.94	LM1 - 001/112	LE70031122003024EDC00	6.18	0.052
1981.95	LM3 - 251/113	LE70011132001004EDC00	6.53	0.152	1981.95	LM3 - 251/113	LE70011132001004EDC00	6.21	0.105
1986.97	LT5 - 001/113	NLAPS_LE7002113000301	7.78	0.102	1986.97	LT5 - 001/113	NLAPS LE7002113000301	7.43	0.095
1989.97	LT4 - 001/113	NLAPS_LE7002113000301	5.35	0.429	1989.97	LT4 - 001/113	NLAPS LE7002113000301	5.12	0.075
1991.15	LT5 - 004/112	NLAPS_LE7002113000301	4.44	0.155	1991.15	LT5 - 004/112	NLAPS LE7002113000301	4.22	0.165
1997.09	LT5 - 001/113	NLAPS_LE7002113000301	3.11	0.285	1997.09	LT5 - 001/113		3.22	0.257
2000.18	LE7 - 001/113	NLAPS_LE7002113000301	2.35	0.532	2000.18	LE7 - 001/113	NLAPS LE7002113000301	1.96	0.256
2001.01	LE7 - 001/113	NLAPS_LE7002113000301	2.52	0.114	2001.01	LE7 - 001/113	- NLAPS LE7002113000301	2.37	0.106
2003.05	002/113	NLAPS_LE7002113000301	0	0	2003.05	LE7 - 002/113	- NLAPS LE7002113000301	0	0.000

Trial 1 (without geographic limits)



Trial 2 (with specified limiting geographic points)



Trial 1 vs. Trial 2



Conclusion

- Shelf area decreased from 1972 to ≈ 1981.
 - Shelf Area increased
 1981 to ≈ 1986;
 - Shelf Area declined until it disappeared ≈ 2003.
 - Subsequent Landsat images shows *no ice shelf* return.

Julian Day	Instrument - Path/Row	Base image (File name)	Avg Area (km²)	Stndrd Dev.
1972.94	LM1 - 001/112	LE70031122003024EDC00	6.18	0.052
1981.95	LM3 - 251/113	LE70011132001004EDC00	6.21	0.105
1986.97	LT5 - 001/113	NLAPS LE7002113000301	7.43	0.095
1989.97	LT4 - 001/113	- NLAPS LE7002113000301	5.12	0.075
1991.15	LT5 - 004/112	- NLAPS LE7002113000301	4.22	0.165
1997.09	LT5 - 001/113	- NLAPS LE7002113000301	3.22	0.257
2000.18	LE7 - 001/113		1.96	0.256
2001.01	LE7 - 001/113	- NLAPS LE7002113000301	2.37	0.106
2003.05	LE7 - 002/113		0	0.000

Conclusion (continued)

2. Grounding Line Location was validated

3. Sea lce cover is episodic

Veer	Instrument -	Seasonal
rear	Path/Row	Ice (Y/N)
	LM1 -	
1972	001/112	Yes
	LM3 -	
1981	251/113	Yes
1986	LT5 - 001/113	Yes
1989	LT4 - 001/113	Yes
1991	LT5 - 004/112	No
1997	LT5 - 001/113	No
2000	LE7 - 001/113	Yes
2001	LE7 - 001/113	Yes
2003	LE7 - 002/113	No
2005	LE7 - 001/113	Yes
2007	LE7 - 001/113	Yes
2009	LE7 - 001/113	Yes
2010	LE7 - 001/113	No
2011	LE7 - 001/113	No

Future Research

- Investigate the remaining Pine Island Bay coastline and Larson Ice Shelf region
- Continue grounding line validation and survey of Antarctic coastline
- Examine using new NASA Goddard software
- Examine as many data sets as possible
 - Incorporate other satellite image data sources:
 - SPOT-image,
 - Better spatial resolution than Landsat
 - IKONOS
 - Better spatial resolution than Landsat
 - AQUA & TERRA (MODIS)
 - Lower spatial resolution than Landsat

References

- GloVis: glovis.usgs.gov
- LIMA: lima.usgs.govs
- ENVI: http://www.ittvis.com/language/en-us/productsservices/ envi.aspx
- The Landsat Program: http://landsat.gsfc.nasa.gov/
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