

Survey of the NASA basal stress boundary in the vicinity of Elizabeth City State University Bay and West Antarctic Peninsula

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Abstract

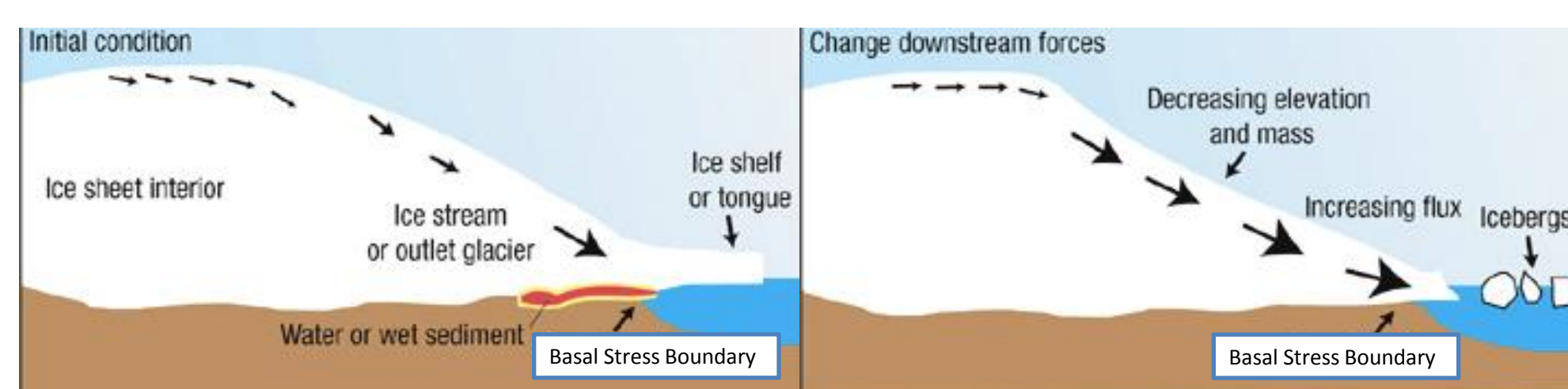
Gradual reduction of a small ice shelf in the Pine Island Bay area was discovered and examined using eleven Landsat images spanning 1972 to 2003. Measurements of Ice shelf area made possible by the NASA sponsored development of a circa 2003 Antarctic basal stress boundary data set indicate that it expanded slightly during the first two decades of observations from approximately 6.19 km² measured on December 7, 1972 to a maximum of about 6.82 km² observed in 1986. This maximum was followed by a nearly continuous decrease in area and ultimate disappearance of the ice shelf by January 17, 2003. No ice shelf has reappeared since 2003 as observed in subsequent Landsat images.

Ten of the eleven Landsat images were co-registered and warped to one of a pair of 2003 geographic reference images before area measurement. Individual study team members made independent measurements of the ice shelf area apparent in each image.

The average of these measurements had a standard deviation of 0.14 km². The small, previously unnamed ice shelf formerly occupied what is now known as the Elizabeth City State University Bay. The specific cause of the disappearance of the ice shelf occupying Elizabeth City State University Bay is unknown, but is probably related to increased basal melting by warmer ocean waters reaching Pine Island Bay. Intrusions of warm 'circumpolar deep water' are related to ice shelf and outlet glacier thinning and retreat as reported throughout the Amundsen Sea region. This is the first report of complete ice shelf loss so far south or in the Amundsen Bay region and suggests that the advent of the NASA ASASD basal stress boundary will be a useful tool for performing a similar historical survey of other parts of the West Antarctic coastline that may be subject to similar changes. Presentation will focus on the methodology employed in the original research and expansion of the research scope to determine inaccuracies in current knowledge of the basal stress boundary or any instances of its change revealed by methods of passive and active remote sensing at other Antarctic coastal locales.

Key Terms

- ENVI – a software application used to process and analyze geospatial imagery
- Ground Control Points - a system of distinct geographic features that is recognizable on images and used to facilitate image to image pixel registration
- Basal Stress Boundary - (Previously known as GL) the last portion of an ice sheet that is supported by land before it becomes a floating ice shelf (Figure 1)
- Hinge point - the inflection point between ice shelf and ice sheet
- Landsat 7 Enhanced Thematic Mapper Plus (Landsat 7 ETM+) - the satellite used to collect data used in the team's research
- Landsat Image Mosaic of the Antarctica (LIMA) is the first true-color, high-spatial-resolution image of the seventh continent
- Pine Island Bay (PIB) - the latitude and longitude for the basal stress boundary investigation
- Geoscience Laser Altimeter System (GLAS) - A laser altimeter is an instrument that is used to learn about the topography, or the shape of the surface, of a planet.
- Landsat Image Mosaic of Antarctica (LIMA) - the first true-color, high-spatial-resolution image of the seventh continent.



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. In subsequent research, an ECSU student team discovered that an ice shelf—now known as the *ECSU Ice Shelf*—had completely disappeared by the time that the grounding line (basal stress boundary) 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.

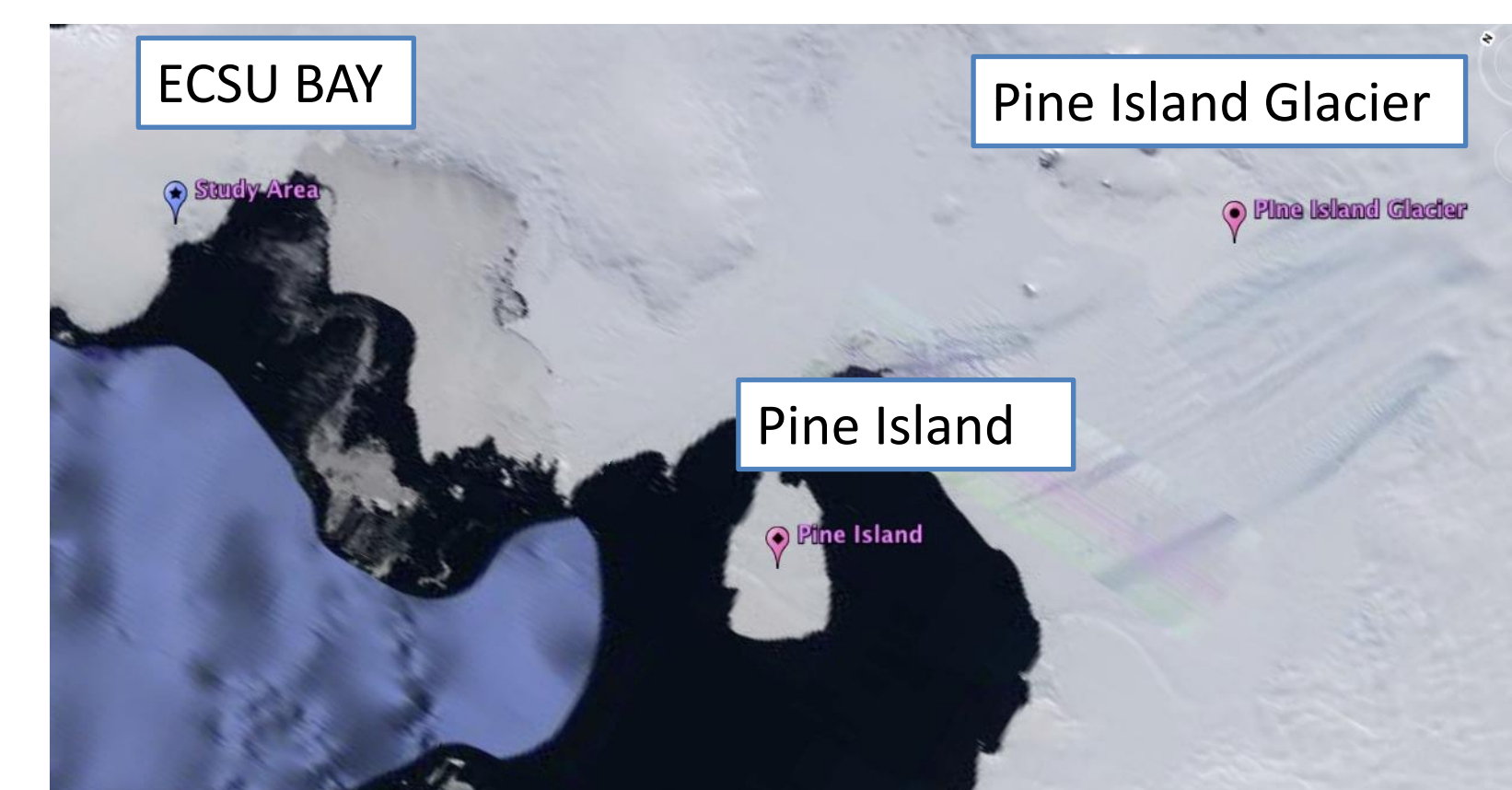
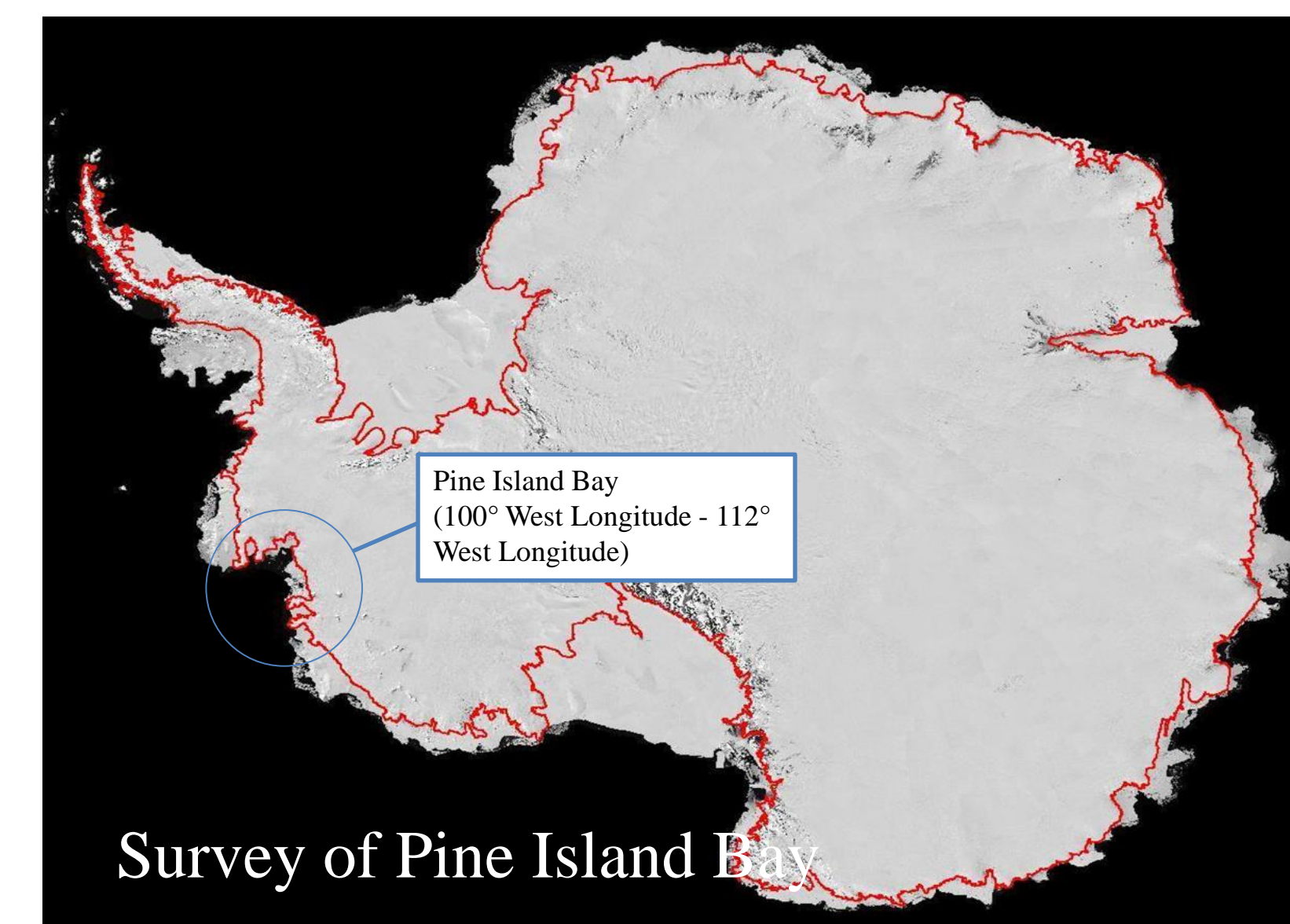


Figure 2: Close up of the area of interest, the Pine Island Glacier

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.

Downloaded images from the years: 1972, 1981, 1986, 1989, 1991, 1997, 2000, 2001, and 2003, 2010.

Images did not have the same pixel to coordinate registration as the older Landsat archived imagery.

Figure 1. Visual representation of the basal stress boundary

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

More points in the registration were used in images with slight cloud cover and or few significantly visible geographic points

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

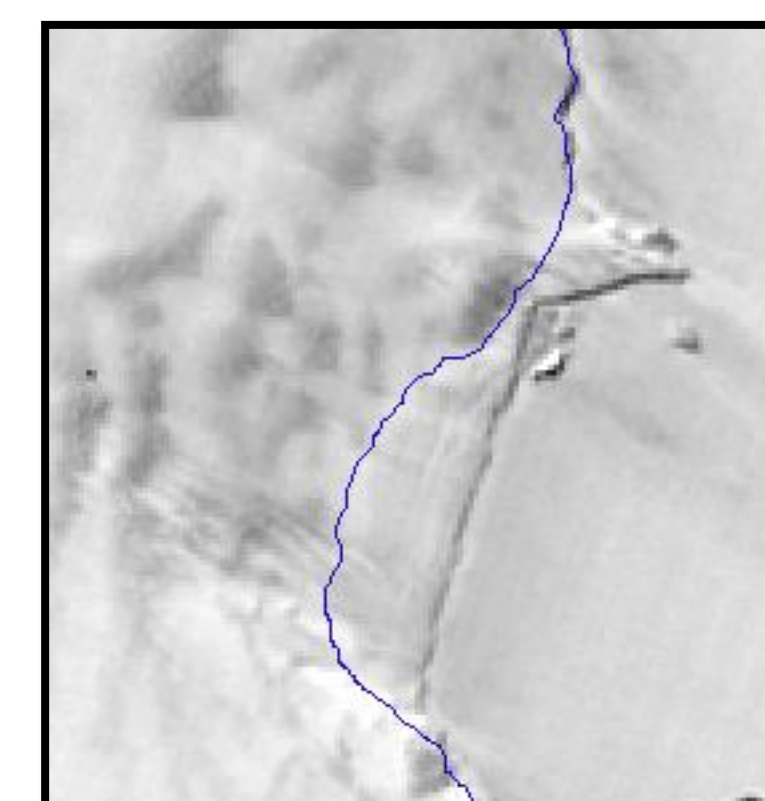


Figure 3. LANDSAT 5 image of the ice shelf in 1986

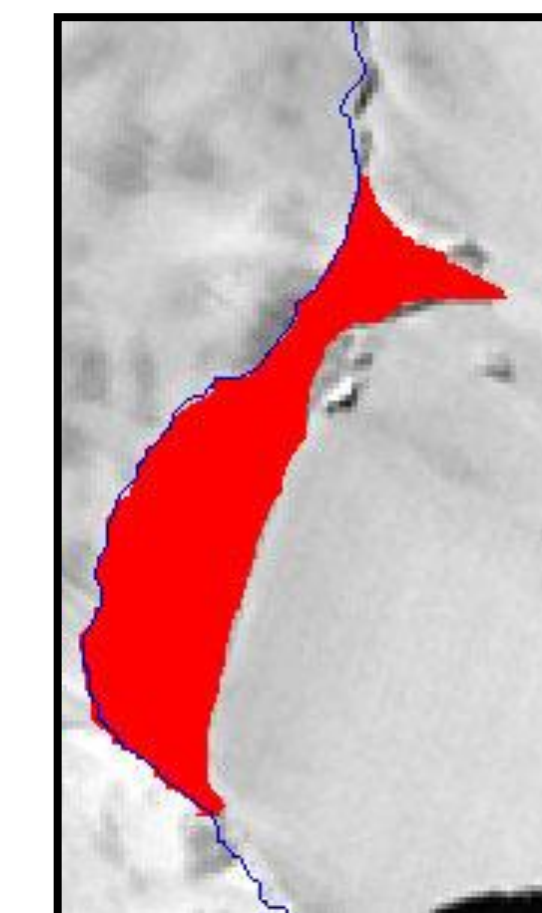


Figure 4. 1986 LANDSAT 5 image with the ice shelf area now shown in red

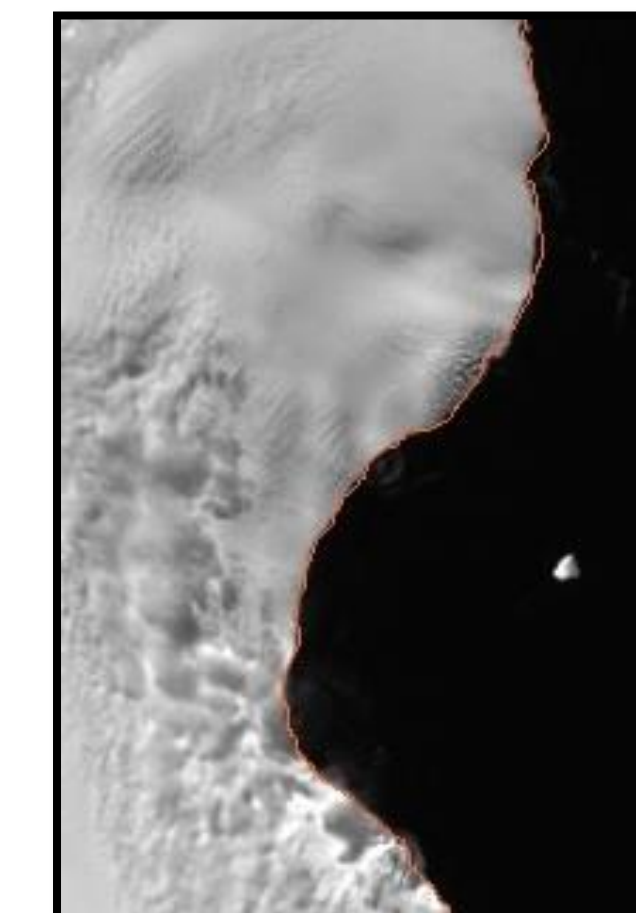


Figure 5. LANDSAT 7 image showing the current situation from 2003 through 2011, where the ice shelf has disappeared

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" S, 102°16'00" W and one lying NW of the ice shelf at 73°55'55" S, 102°27'50" W.

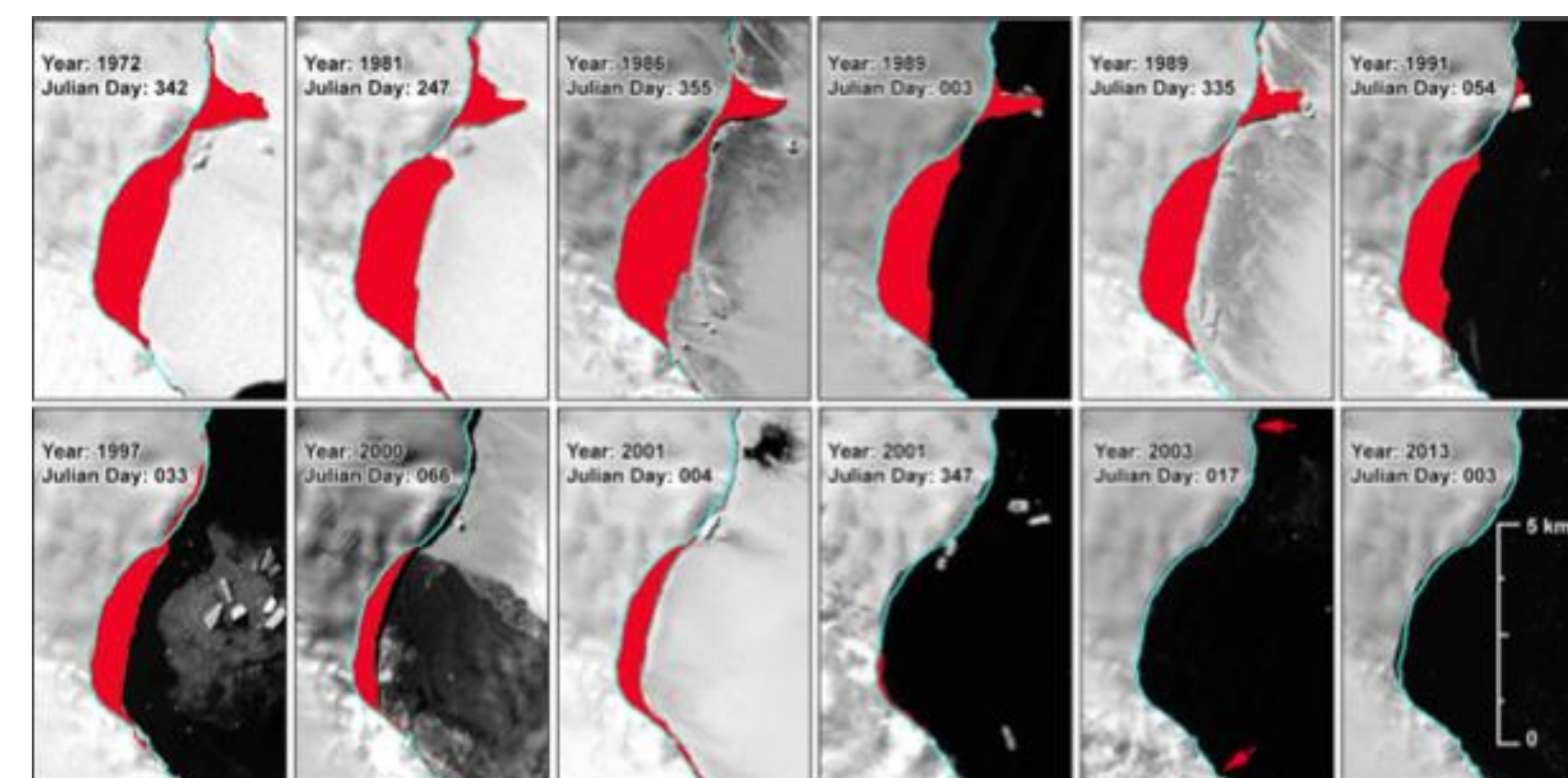


Figure 6. 1972-2013 Elizabeth City State University Bay ice retreat.

Year Image Recorded	Julian Day	Decimal Year Date	Decimal Base-1972 Date	Temporal Interval	Average Area (km ²)	Ice Shelf Total Mass Estimate (MT)	Annual Ice Mass Change (MT)
1972	342	1972.94	0.94	0	6.519	1,173	0
1981	251	1981.69	9.69	8.75	6.526	1,175	1
1986	355	1986.97	14.97	5.28	6.820	1,226	53
1989	003	1989.01	17.01	2.04	5.219	939	-288
1989	355	1989.97	17.97	0.96	5.019	903	-36
1991	054	1991.15	19.15	1.18	3.729	671	-232
1997	033	1997.09	25.09	5.94	3.107	559	-112
2000	066	2000.18	28.18	3.09	1.792	323	-237
2001	004	2001.01	29.01	0.83	2.463	443	121
2001	347	2001.95	29.95	0.94	0.527	95	-348
2003	017	2003.05	31.05	1.10	0.000	0	-95

Table 1. 1972-2013 Table representation of the results including temporal intervals, average areas, and total mass estimates.

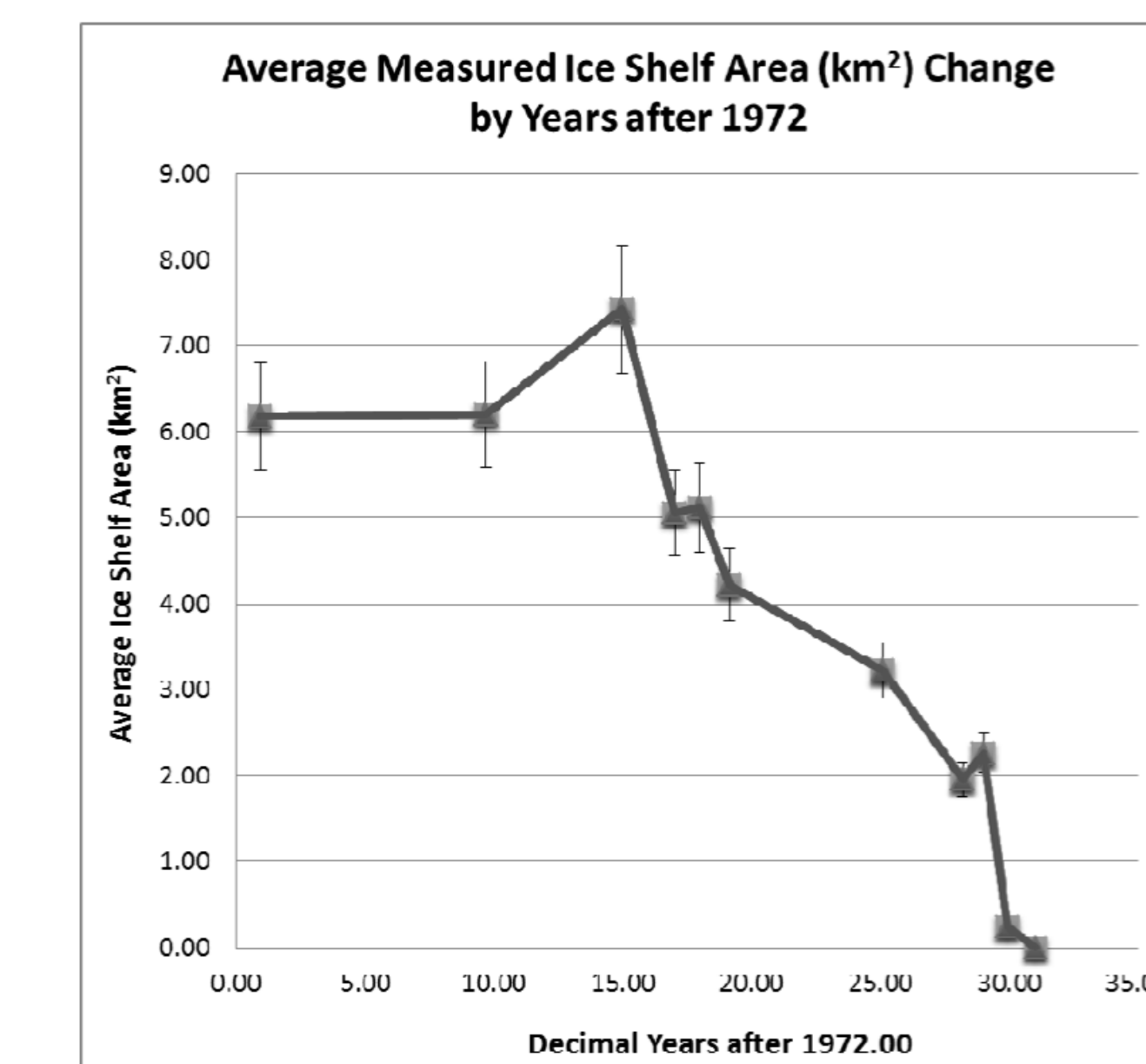


Figure 7. 1972-2013 Elizabeth City State University Bay ice retreat. Decimal Years after 1972 vs. Ice Shelf Area in Km².

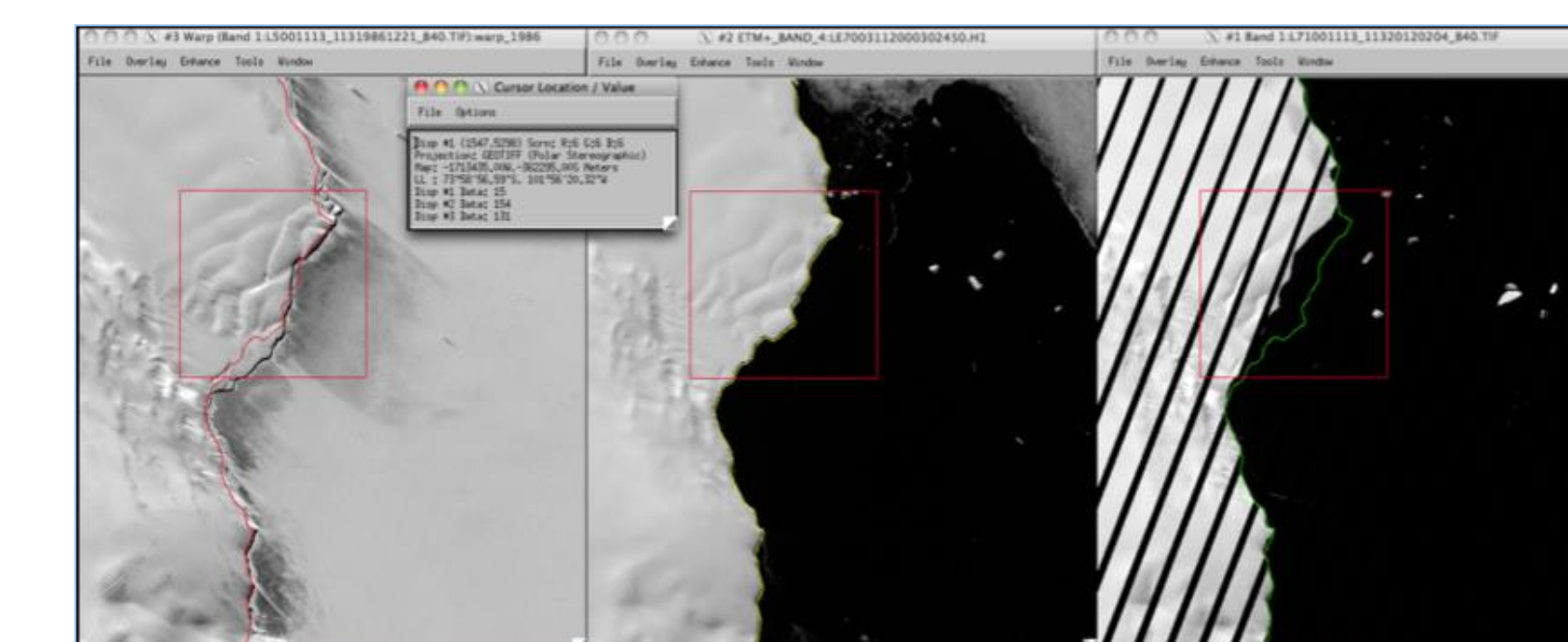


Figure 8. Comparison between the 1986, 2003, and 2012 clearly shows misplacement in the basal stress boundary as well as an evolutionary coastal ice retreat. (LANDSAT7 images from LIMA archive) GLOVIS, 2003 (LANDSAT7 image from LIMA archive), and 2012(LANDSAT7 image from LIMA archive) respectively.

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
- Basal Stress boundary was validated
- Sea Ice cover is episodic/seasonal

Future Work/Current Research

- Current research investigation is taking place on developing a thirty year history report for the Antarctic Peninsula.
- Continue basal stress boundary validation and survey of Antarctic coastline
- 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



Figure 9. The Antarctic Peninsula is the source of the next research investigation for a 30 history report of the basal stress boundary. This peninsula contained Larsen A and B before they dissipated. The peninsula also contains Larsen C which was stable throughout 2008 but is subject for research investigation.

Reference

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