TEMPORAL REDUCTION AND LOSS OF AN ICE SHELF IN PINE ISLAND BAY, ANTARCTICA: 1972 - 2003

Malcolm LeCompte[1], Robert Bindschadler[2], Joyce Bevins[1], Ya' Shonti Bridgers[1], Jessica Brownlow[3], Robyn Evans[1], Kirsten Hawk[4], Michael Jefferson [1], Ryan Lawrence[1], Dr. Linda B. Hayden[1]

[1] Elizabeth City State University, 1704 Weeksville Rd, Box 672, Elizabeth City, North Carolina 27909

[2] NASA Goddard Space Flight Center, Greenbelt, MD

[3] Mississippi Valley State University, Itta Bena, MS

[4] Spelman University, Atlanta GA

Observed changes in the Antarctica ice sheet have caused global concern that sea level rise driven by continued and possibly accelerated ice loss will increase the stress on coastal regions around the world. Changes in Antarctic ice loss are strongly concentrated in coastal regions of the ice sheet, in general, and in the Antarctic Peninsula and the Amundsen Sea regions, in particular (Rignot et al., 2008). Ice shelves are the floating extensions of grounded Antarctic outlet glaciers and are directly involved in retaining the ice sheet and controlling the rate of grounded ice discharge (Thomas, 1973; Joughin et al., 2010). In the Antarctic Peninsula, the sudden loss of entire ice shelves has preceded, and is held to be responsible for, large and sustained accelerations of the glaciers feeding those former ice shelves (Scambos et al., 2004; Rignot et al., 2004). In the Amundsen Sea region, indeed anywhere south of the Antarctic Peninsula, ice shelf thinning has been reported, but not complete ice shelf loss. This paper reports the first loss of an entire ice shelf south of the Antarctic Peninsula.

The gradual reduction of an ice shelf in Pine Island Bay is measured using 9 Landsat images spanning the years 1972 to 2003. Ice shelf area changes little in the first decade from the 6.18 km^2 areas measured on December 7, 1972 with slight growth to a maximum area of 7.78 km^2 observed in 1986. This maximum is followed by a nearly monotonic decrease in area and ultimate disappearance by January 17, 2003. No ice shelf has reappeared since 2003. Area measurements were preceded by coregistration and

warping of each image to a pair of 2003 images used as geographic references. Four independent measurements of ice shelf area were made on each image with an average standard deviation of 0.14 km^2 when lateral limits were imposed on the ice shelf.

The specific cause of this ice shelf disappearance is unknown, but is probably related to increased basal melting by warmer waters in Pine Island Bay, believed responsible for ice shelf thinning and outlet glacier retreat and thinning reported throughout the Amundsen Sea region. This is the first report of complete ice shelf loss either so far south or in the Amundsen Bay region.

This previously unnamed ice shelf is referred to in this paper as the Elizabeth City State University (ECSU) Ice Shelf.

Although the temporal record of ice shelf area is sparsely sampled, it suggests an initial decade of relative stability, followed by growth to a maximum ice shelf area of 7.78 km^2 in 1986 followed by a period of sustained and more rapid retreat until the ice shelf completely disappeared by 2003 (see Figure 1). Additional changes in area during the 1970s and 1980s are certainly possible. Episodic calving of ice shelves creates sudden areal losses (but not sudden areal gains). Small icebergs are evident in a number of the images, but their total area is never more than a few percent of the total area, so episodic calving probably does not alter the measured temporal record of area significantly and we feel that the major feature of sustained ice shelf loss from 1986 to 2003 is robust.

The significance of these observations lies in their location: Pine Island Bay, a coastal locale much farther south than the Antarctic Peninsula. Despite the dramatic activity of ice in this region of Antarctica, the ice shelves seem to be receiving sufficient volumes of ice to sustain them, albeit with episodic calving events. The complete loss of this ice shelf stands out as a unique circumstance and may express the more general consequence of an increase in the amount of warm water circulating in Pine Island Bay. Recent observations in Pine Island Bay have indicated both an increase of circumpolar deep water entering the sub-ice-shelf cavity beneath Pine Island Glacier's ice shelf as well as a shallower pycnocline effectively warming waters at shallower depths (Jacobs et al., 2011), providing a potential mechanism for ice shelf loss.

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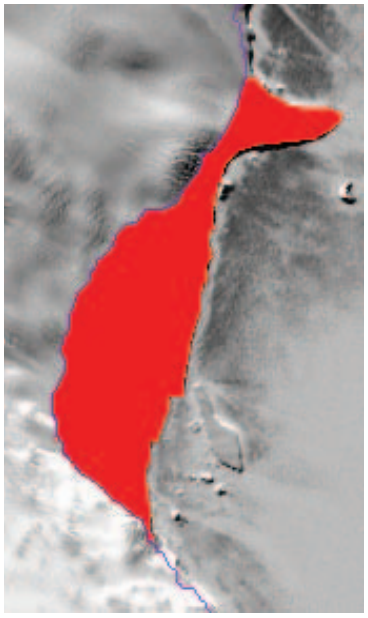
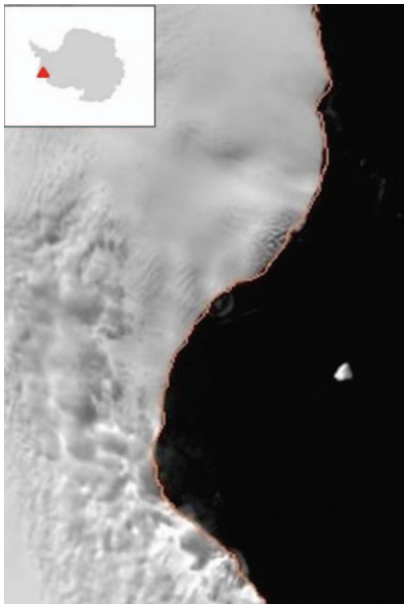


a



b

Figure 1. Comparing LANDSAT images from 1986 (a) showing ECSU Ice Shelf maximum extent and 2003 (b) after it disappeared. Grounding line is in purple or pink.