‘UNSTOPPABLE COLLAPSE’ OF THE WEST ANTARCTIC ICE SHEET IS NOT HAPPENING

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A New York Times headline reads “Scientists Warn of Rising Oceans From Polar Melt” and goes on to say: “A large section of the mighty West Antarctica ice sheet has begun falling apart and its continued melting now appears to be unstoppable, two groups of scientists reported on Monday. If the findings hold up, they suggest that the melting could destabilize neighboring parts of the ice sheet and a rise in sea level of 10 feet or more may be unavoidable in coming centuries.” The story, based on studies of the Pine Island and Thwaites glaciers in West Antarctica, went ballistic in the news media with dire predictions of the ‘unstoppable’ catastrophe about to unfold.

The authors of the Pine Island paper, Justin Gillis and Kenneth Chang say in their paper: “...we find no major bed obstacle that would prevent the glaciers from further retreat and draw down the entire basin.” In a second paper, “Marine Ice Sheet Collapse Potentially Underway for the Thwaites Glacier Basin, West Antarctica,” the authors (Joughin, Smith, and Medley) also infer that the entire West Antarctic ice sheet will soon disappear, resulting in a sea level rise of up to 10 feet. The governor of California is now suggesting moving LAX and San Francisco airports.

![Figure 1. Antarctica. The East Antarctic ice sheet makes up more than 90% of Antarctic ice and has been growing. The West Antarctic ice sheet accounts for only 8½ % of Antarctic ice and the Pine Island glacier (red dot) makes up only about 10% of that. (NASA image) ](image-url)
WHAT’S HAPPENING NOW

Since last week’s press releases, thousands of Antarctic photos and text items on the internet have been relabeled, and you can scarcely find any mention of Antarctica now without reference to ‘the unstoppable, collapsing Antarctic ice sheet.’ From all of the media hype, you would think that the West Antarctic ice sheet is presently in the process of collapsing and drastic sea level rise is imminent. **THE WEST ANTARCTIC ICE SHEET IS NOT COLLAPSING!** The retreat of the Pine Island and Thwaites glaciers is NOT caused by global warming, and sea level is NOT going to rise 10 feet.

The two papers predict that it could collapse in several hundred years, based on retreat of two outlet glaciers that drain part of the ice sheet. The authors contend that recent retreat of the Pine Island and Thwaites glaciers has occurred because warm ocean water has caused melting of ice on the underside of the glaciers, causing them to thin and calve more rapidly. Because the base of most of the West Antarctic ice sheet lies below sea level, the authors contend that ocean water will melt its way up several small embayments under the ice sheet, which is more than 1000 miles across, and cause it to collapse abruptly. They refer to this as “unstoppable” because the glacier base is below sea level and they claim that there is nowhere that the glacier can ground so it will all collapse into the sea.

Figure 2. Pine Island outlet glacier and the northwestern part of the West Antarctic ice sheet.
(modified from Google Earth)

The prediction of catastrophic collapse of the entire West Antarctic ice sheet is based on several lines of evidence:

1. The Pine Island and Thwaites glaciers have shown recent increases in calving and retreat of their termini.
2. The base of the West Antarctic ice sheet is mostly 1,000 m (3,300 ft) below sea level, so warm ocean water can cause melting of basal ice at the terminus, resulting in calving and rapid retreat of the ice terminus. As the terminus enters deeper water, it can retreat much faster.
3. As the ice retreats, there are no more grounding line positions, so calving will accelerate and cause collapse of the ice sheet.
4. If a large sector of the West Antarctic ice sheet has gone into irreversible retreat, the entire West Antarctic ice sheet will collapse, raising sea level 10 feet.
These assertions are not new—36 years ago, Mercer (1978) suggested that the West Antarctic ice sheet was potentially unstable and others have commented on it before and since then. Here is what some have said: Calving of large icebergs is a natural process unrelated to warming—this ice shelf and others spawn huge icebergs every 6-10 years. Releasing a huge iceberg, by itself, is a normal process. Collapse of Pine Island glacier, if it did occur, would take 1000-2000 years, but it is unlikely to contribute to more than 2.7 cm of sea level rise over the next 100 years. Every 10 years or so ice shelves calve large icebergs, which are not worrisome. This ice stream is unlikely to collapse in our lifetime.

THE BIG PICTURE--THE GEOLOGIC SETTING

To get a perspective of what is happening now and what might or might not happen in the future requires a look at the overall geologic setting and the scale of the size and thickness of the West Antarctic ice sheet relative to the Pine Island and Thwaites glaciers. The East Antarctic ice sheet makes up more than 90% of Antarctic ice. The West Antarctic ice sheet (Figure 1) makes up only about 8½ % of Antarctic ice, and the Pine Island glacier makes up about 10% of the West Antarctic ice sheet. Most of the West Antarctic ice sheet lies SE of the Pine Island glacier and at its SW margin is about 1000 miles from the Pine Island and Thwaites outlet glaciers. Ice in the SE region flows into the Ross Sea, making the Ross Ice Shelf, and has little if anything to do with the part of the ice sheet that flows through the Pine Island and Thwaites outlet glaciers. The Pine Island and Thwaites glaciers are not independent glaciers—they are ice streams from the NW part of the West Antarctic ice sheet flowing through narrow embayments bounded by mountains. Their termini calve into the Amundsen Sea, but the rest of the ice sheet is grounded and all of the southwestern part discharges into the Ross Sea (Figures 3,4). The entire western and southern margins of the West Antarctic ice sheet are separated from the ocean by mountains so these are virtually the only outlets for the ice. The total width of the Pine Island and Thwaites outlet glaciers makes up only about 60 miles of the 2,500 miles of coastline along the western and southern margins of the ice sheet. The major ice discharge from the SW margin into the Ross ice shelf is not affected by what goes on in the northern part of the ice sheet. Scale is important—only when looking a map of the size of the West Antarctic ice sheet does it become apparent just how tiny the Pine Island and Thwaites outlet glaciers are relative to the size of the West Antarctic ice sheet (Figures 3,4).
Figure 3. West Antarctic ice sheet.

Figure 4. Location of the Pine Island and Thwaites glaciers (red dots) and the West Antarctic ice sheet. The ice sheet is bounded along its entire south coast by mountains so most of the ice discharges into the Ross ice shelf and several narrow gaps in the mountains where ice discharges into the Amundsen Sea. Note how much larger the ice sheet margin is at the Ross Sea outlet than that of the Amundsen Sea outlet. (Modified from Wikipedia).
The base of most of the West Antarctic ice sheet lies below sea level (Figure 5) and it is because of this that the West Antarctic ice sheet is predicted to collapse. The deepest parts of the subglacial basin are mostly about 1000 m (3,300 ft) deep and lie beneath the central portion of the ice sheet where the ice is the thickest (Figure 6). More important than just depth below sea level is how thick the ice is relative to the depth below sea level.

Figure 5. Subglacial topography in Antarctica. Most of the West Antarctic ice sheet lies below sea level, shown in dark and light blue. (modified from Wikipedia)

THICKNESS OF THE WEST ANTARCTIC ICE SHEET

Figure 6 shows the thickness of the West Antarctic ice sheet. The ice is more than 3,000 feet thick in the darker red areas and most of the ice sheet is more than 2,000 feet thick. The importance of ice thickness is that virtually all of the ice sheet is considerably thicker than the depth below sea level to bedrock, so the ice is grounded and will not float.
Also important is the source area of the outlet glaciers. Figure 7 shows ice divides and ice drainage areas. The Pine Island outlet glacier drains only a relative small portion of the West Antarctic ice sheet so it is difficult to see how events there could result in collapse of the entire Antarctic ice sheet.
Figure 7. Ice divides and ice drainages in the West Antarctic ice sheet. Light green is the area of ice draining into the Pine Island glacier; dark green is ice draining into the Thwaites glacier; light and dark blue is ice draining into the Ross Sea (modified from http://icesat4.gsfc.nasa.gov/cryo_data/Rignot_velocity_maps.php)

ARGUMENTS AGAINST POTENTIAL COLLAPSE OF THE ENTIRE WEST ANTARCTIC ICE SHEET

The authors assert that “…we find no major bed obstacle that would prevent the glaciers from further retreat and draw down of the entire basin.” but that is contrary to what is shown on Fig. 8.

Figure 8 is a profile of the West Antarctic ice sheet from the east coast to the Transantarctic Mts., showing thickness of the ice sheet, sea level, and the subglacial floor. At its deepest part, the subglacial floor is 2,000 m (6,500 ft) below sea level, but almost all of the subglacial floor in this profile is less than 1,000 m (3,300 ft) below sea level. The ice is mostly more than 2,500 m (8,000 ft) thick, so basic physics tells us it will not float in 1,000 m (3,300 ft) of water nor will sea water melt its way under the ice.

1. At least half a dozen potential grounding lines may be seen in Figure 8.
2. 200 km (125 miles) up-ice from the terminus, the ice sheet is about 1600 m (5,200 ft) thick and the subglacial floor is above sea level.
3. 300 km from the terminus, the subglacial floor is 1,000 m (3,300 ft) above sea level.
4. About 700 km (2,300 ft) from the terminus, the ice is about 1,700 m (5,500 ft) thick and the subglacial floor is near sea level.
5. About 800-950 km (500-600 miles) from the terminus, three potential grounding lines occur from near sea level to a few hundred meters.
6. About 1,050 to 1,150 km (650-700 miles) from the terminus, bedrock occurs at sea level.
CONCLUSIONS

The evidence above shows that:

1. The Pine Island and Thwaites outlet glaciers drain less than half of the West Antarctic ice sheet, so it is not apparent how they could cause collapse of the entire ice sheet.

2. The Pine Island and Thwaites outlet glaciers are only about 30 miles across so draining 2.2 million km$^3$ of ice through their narrow channels or sending sea water 1,000 miles under the ice sheet doesn’t seem plausible.

3. Most of the ice sheet is much thicker (2,500 m (8,000 ft) than the depth of the subglacial floor below sea level (1,000 m (3,300 ft) so the ice will not float and sea water will not extend under the ice.

4. Even if the ice sheet were to recede significantly, there are at least half a dozen potential grounding lines at which the glacier would stabilize.

5. The West Antarctic ice sheet is NOT collapsing, the retreat of these small glaciers is NOT caused by global warming, and sea level is NOT going to rise 10 feet.