A Bit of Icy Antarctica Is Sliding Toward the Sea

The latest gauging of West Antarctic glaciers confirms that when the ocean eats at one end of a glacier, it can draw far-distant ice toward the sea, with potentially dangerous consequences

As the global climate warms up, glaciologists' big worry is polar ice, especially the ice sheet of West Antarctica, the muscular arm that juts from the huge mound of ice in East Antarctica. They aren't concerned about warmer air per se; even the thinner West Antarctic Ice Sheet (WAIS) would hold out against its effects for millennia. But researchers have long wondered whether warming could somehow get at the WAIS indirectly, destabilize it, and send its ice into the sea to melt, raising sea level up to a disastrous 5 meters in a few centuries. With the publication online (www.sciencemag.org/cgi/content/abstract/1099650) of the latest survey of glaciers flowing into West Antarctica's Amundsen Sea, most glaciologists now allow that there probably is a way for warming to accelerate the movement of at least some of the WAIS ice toward the sea.

Glaciologist Robert Thomas of NASA contractor EG&G at the Wallops Island facility in Virginia and colleagues confirm that the half-dozen glaciers flowing into the Amundsen Sea have been getting thinner and thinner the past 15 years, and that one of them—the Pine Island Glacier—has been flowing faster and faster for more than 100 kilometers inland. "It's not necessarily a sign of [WAIS] collapse," says glaciologist Richard Alley of Pennsylvania State University, University Park, "but it could lead to a collapse."

However, no one can say whether the recent glacial acceleration will continue, whether it could reach more distant ice if it does continue, or whether other, more voluminous parts of the WAIS could suffer similar effects. "We're not running for the hills," says Alley, but "this is the wake-up call for the scientific community to get serious about it all."

Since the start of the 1990s, glaciologists have been closely monitoring the flow of ice from the Pine Island Glacier and nearby glaciers using motion-sensing radar, ice-penetrating radar, and laser and radar altimeters mounted on satellites and aircraft. By the end of the decade, the ice in at least some glacial channels nearing the sea seemed to be thinning and accelerating.

To learn more, Thomas and his colleagues, in cooperation with Centro de Estudios Científicos in Valdivia, Chile, rode an instrument-laden Chilean Navy P-3 aircraft 2700 kilometers to the remote Amundsen Sea coast. The onboard ice-penetrating radar found that the ice is far thicker than thought, on average 400 meters deeper than previously estimated near the coast. Combined with satellite radar velocity estimates from the late 1990s, those greater thicknesses implied that the glaciers are hauling away about 253 cubic kilometers of ice per year. That's about 90 cubic kilometers more than accumulates each year from snowfall.

By analyzing recent satellite radar data, Thomas and colleagues confirm that ice withdrawals have been accelerating, at least through the Pine Island Glacier, the largest of the group. They calculate that it sped up by 3.5% between April 2001 and early 2003, making for a 25% increase since the mid-1970s. And the drawdown is not limited to areas near the coast. The P-3 data show a thinning, presumably induced by the faster flow, that extends along the main trunk of the Pine Island Glacier and averages about 1.2 meters per year between 100 and 300 kilometers inland.



Ice parade. Some West Antarctic glaciers are flowing faster to the sea, breaking into more icebergs, and raising sea level faster.

These latest results from West Antarctica confirm an unsettling view of glacier behavior. For 30 years, glaciologists have debated whether one part of a glacier can "feel" what's happening in a distant part of the same glacier. At the coastal end of the Pine Island Glacier, for example, warmer water seems to be melting the underside of the glacier's floating ice shelf (*Science*, 24 July 1998, pp. 499 and 549), pushing landward the point at which the advancing glacier floats off the sea floor.

If an ice shelf pinned against an embayment's shore and floor helps slow a glacier's flow—as was hypothesized in the 1970s—and if changes at the coast could make themselves felt far up the glacier, then the Pine Island Glacier's so-called grounding line retreat would accelerate glacier flow well upstream. The researchers think that's what they're seeing. "I'm convinced the glacier feels what is happening a long way away," says Thomas. Similar accelerations struck after two other floating ice tongues recently broke up in West Antarctica and Greenland (*Science*, 30 August 2002, p. 1494).

"It's a very impressive piece of work," says Alley. "Too many different lines of evidence are agreeing now" for them to be wrong about the thinning or the speedup of the past 10 to 15 years. "Ice shelves may well play a role in the dynamics of glaciers," agrees geoscientist Michael Oppenheimer of Princeton University in New Jersey. But the next problem is that "we don't know why things are melting away at Pine Island Glacier." Oceanographers can't say whether the ocean warming that seems responsible is part of a cycle that will reverse itself or a long-term trend driven by greenhouse warming. And they can't say whether the WAIS's two largest ice shelves—the Texas-size Ronne and Ross ice shelves—could be melted as well.

Even if glaciologists knew what the ocean was going to do, their models for predicting glacier behavior are still so rudimentary that they can't say whether more distant, slower moving ice feeding the main ice streams will respond too. So plenty of uncertainties remain, notes Oppenheimer, but he adds, "I'm starting to get worried."

–RICHARD A. KERR

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