One more chip. West Antarctica is losing ice at an accelerating rate as glaciers rush to the sea.

GLACIOLOGY

Experts Agree Global Warming Is Melting the World Rapidly

Glaciologists are still far from divining the fate of Earth's ice in a warming world, but they have finally agreed on what the past century's warming has done to the great ice sheets, and it isn't pretty. Researchers had been sizing up the millions of cubic kilometers of ice stored in Greenland and Antarctica using four different techniques applied to different regions at different times, but they just weren't getting it together. So 47 experts put their heads together over all the data to arrive at a community consensus.

The globe's icy bottom line: a current annual loss of 344 billion tons of glacial ice, accounting for 20% of current sea level rise. Greenland's share—about 263 billion tons—is roughly what most researchers expected, but Antarctica's represents the first agreement on a rate that had ranged from a far larger loss to an actual gain. The new analysis, published on page 1183 of this issue, also makes it clear that losses from Greenland and West Antarctica have been accelerating, showing that some ice sheets are disconcertingly sensitive to warming.

"They got a number of heavy hitters in the field to sit down and agree that the numbers agree," says glaciologist Richard Alley of Pennsylvania State University, University Park, who was not involved in the work. "To me, that says they know what they're doing. And that's a very important step for forecasting ice's behavior in the future."

It hadn't always been clear that researchers in the sometimes fractious field of gauging ice sheets knew what they were doing. In trying to measure ice sheet changes of 1 part in 100,000 per year, small errors loomed large. "There were so many numbers published out there, how could one not get confused?" says glaciologist Robert Bindschadler of NASA's Goddard Space Flight Center in Greenbelt, Maryland. In the past 15 years, at least 29 studies have estimated how quickly the ice sheets had been losing or gaining mass. The numbers were all over the map, allowing an overall change in ice sheet mass ranging from a loss of a whopping 676 billion tons per year to a gain of 69 billion tons (*Science*, 22 July 2011, p. 401).

In 2011, scientists working on the upcoming climate assessment by the Intergovernmental Panel on Climate Change decided someone had to try something new. The result was the Ice Sheet Mass Balance Intercomparison Exercise (IMBIE) supported primarily by NASA and the European Space Agency, the agencies that fly the satellites that had returned all that confusing data.

IMBIE's 47 participants from 26 institutions—headed by glaciologists Andrew Shepherd of the University of Leeds in the United Kingdom and Erik Ivins of NASA's Jet Propulsion Laboratory in Pasadena, California—tried to make sense of published changes in the ice sheets that were based on four different techniques. Each technique gauges the changing amount of ice as snowfall adds ice to an ice sheet and melting and glacier flow to the sea removes it.

In two of the techniques, a satellite repeatedly bounces a radar or laser signal off an ice sheet to measure its changing height and thus its changing volume. The Gravity Recovery and Climate Experiment (GRACE) mission estimates ice sheet mass by measuring the changing pull of gravity on its two satellites as one and then the other passes over. And the one nonsatellite technique depends on regional climate models to estimate input from snowfall and losses from melting. This input-output method also requires satellite radar measurements of the speed of flowing glaciers.

In the end, reconciling the diverse ice-loss estimates proved to be more straightforward than had been feared. It turned out that gains and losses of ice can vary greatly from season to season and from place to place. So surveys made over different, albeit overlapping, time periods and regions yielded rather different loss rates. Once the data were adjusted to uniform regions and periods and a few other modifications were made, "there's no reason to believe the data sets are saying different things at all," Shepherd says. "They're showing the same thing."

By the new reckoning, the Greenland ice sheet lost 263±30 billion tons of ice per year from 2005 to 2010. Overall, Antarctica lost about 81 billion tons per year in the same period; the huge East Antarctic portion of the ice sheet registered a small gain, more than offset by losses in West Antarctica and the adjacent Antarctic Peninsula. Since 1992, the two ice sheets lost enough ice to raise sea level by about 0.6 millimeters per year on average, out of the observed 3 millimeters per year. (Most of the rest of the sea level rise came from melting mountain glaciers and from the expansion of seawater due to warming.)

The IMBIE results "represent a maturation of the community," Bindschadler says. "Before, groups were somewhat antagonistic toward each other; this represents a willingness to come together. It reconfirms that these changes in the ice sheets are real. The giants of the West Antarctic and Greenland ice sheets are waking up to changing climate at an increasing rate."

Glaciologists are especially concerned about the acceleration of losses. The acceleration in the north shows that "Greenland is pretty sensitive to [air] temperature," Alley says. "If we make it too hot, Greenland is in real danger of melting away." In West Antarctica, the accelerating loss comes from the accelerating rush of glaciers to the sea, probably brought on by warmer seawater melting the underside of the glaciers' floating ice shelves. "That shows the real sensitivity of these [glacier] flows to ocean temperature," Alley adds. The next chore for glaciologists is to incorporate this new understanding into models that can predict future ice sheet behavior in a warming world. None can today.

–RICHARD A. KERR