For hundreds of thousands of years, ice shelves along the Antarctic coast retreated and advanced unobserved by the human eye. In March 2002, however, a group of scientists had a front row seat for the largest ice shelf breakup in recent history.

An ice shelf is a floating platform of ice, usually fed by mountain glaciers or ice sheets. Typically, ice shelves advance over the ocean for several decades until they become unstable, at which point large icebergs break off, or calve, from the ice shelf front. Advancing and retreating in this manner is a normal process for maintaining mass balance, or ice volume. However, the splintering and shattering observed in some ice shelves is unprecedented in recent history.

The Larsen Ice Shelf complex stretches along the eastern edge of the Antarctic Peninsula — a finger of land pointing crookedly toward the tip of the South American continent. Scientists have divided the shelf into three sections: the Larsen A, B, and C Ice Shelves. The Larsen A and B shelves existed near the northern tip of the peninsula. The Larsen C Ice Shelf flows from the central portion of the peninsula and represents the southern section of the Larsen shelf complex.

Scientists had been observing the Larsen B for several years, assuming that it would eventually retreat. But they were stunned to see the ice shelf disintegrate in a mere 35 days. Between January 31 and March 7, 2002, the ice shelf lost 3,250 square kilometers (about 1,255 square miles) — an area somewhat larger than Rhode Island — sending a plume of icebergs into the Weddell Sea.

The disintegration of the Larsen B Ice Shelf followed several other ice shelf retreats over the past two decades. Scientists have come up with a number of theories to explain why these dramatic breakups are occurring. Some believe that various forces may compromise the internal strength of the ice shelves. Others profess that a decrease in sea ice coverage has left shelves vulnerable to ocean swells. Although many of the questions about ice shelf disintegration remain unanswered, satellite imagery is providing at least one perspective.

The recent Larsen B disintegration supports a theory developed by Ted Scambos, research scientist at the National Snow and Ice Data Center in Boulder, Colorado, and his colleagues, Christina Hulbe, associate professor at Portland State University, and Mark Fahnestock, assistant research scientist at the University of Maryland. The researchers theorized that melt water collecting on the ice shelf surface during unseasonably warm summers might be a primary mechanism in ice shelf breakup.

Most ice shelves exhibit some surface melting each summer, but the melting is usually not widespread.
Ice Shelves and Sea Level Rise

The disintegration of the Larsen B Ice Shelf will not affect sea level any more than a melting ice cube would raise the level of water in a glass of ice water. However, even though disintegrating ice shelves do not contribute directly to sea level rise, they might do so indirectly. Acting more or less as a brake, ice shelves hold back the glaciers or ice sheets feeding the ice shelves. For instance, scientists have detected increased flow speeds in glaciers that previously fed the Larsen A Ice Shelf. These glaciers now feed directly into the Weddell Sea, which leads to more icebergs being discharged into the ocean. While the amount of ice in these icebergs is itself inconsequential, the Larsen A provides a model for what may happen if a larger ice shelf like the Ross Ice Shelf were to collapse. Without the Ross Ice Shelf acting as a brake, the West Antarctic Ice Sheet could disgorge an amount of ice equivalent to about five meters (about 16 feet) of sea level rise.

For more information, visit Antarctic Ice Shelves at the National Snow and Ice Data Center DAAC.
might prove to be equally instrumental in ice shelf breakup.

“As the ice shelf warms up, the actual strength of the ice may change. Free water between the ice crystals could lubricate and promote fracture growth,” said Vaughan. “And when temperatures are warmer, there’s less sea ice protecting the ice shelf from the ocean swell.” Vaughan cites several other possibilities, including possible changes in atmospheric and ocean circulation in the Antarctic region.

Unlike the melt water fracturing theory, which is easy to monitor using satellite images, other theories require in situ measurements that can be difficult to obtain. A crewmember of the British Antarctic Survey research vessel, James Clark Ross, photographed the aftermath of the Larsen B breakup. But according to Vaughan, it was pure luck that the ship happened to be in the area. “Most ship research schedules are determined years in advance, making it virtually impossible for researchers to obtain a ship on short notice. In addition, not all ships have helicopter facilities, meaning researchers can’t be flown ashore,” he said.

Cracks lined the remaining Larsen B Ice Shelf south of the Seal Nunataks on March 13, 2002. (Image courtesy of Pedro Skvarca, Instituto Antártico Argentina)

“I don’t think we can look at these other processes using satellite data. If we’re actually trying to see how the material properties of ice shelves change as the temperatures increase, then we actually have to go there,” said Vaughan. Vaughan, Hulbe, and Scambos all cite the work of Pedro Skvarca, head of the Glaciological Division of the Instituto Antártico Argentino in Buenos Aires, who had been conducting field studies on the Larsen B Ice Shelf. “Now that the shelf is gone, the data that Skvarca collected over the last 10 or 15 years is treasure,” said Vaughan. Skvarca and his team were the last people to set foot on the northern part of the Larsen Ice Shelf.

Scambos and Hulbe plan to continue monitoring Antarctic ice shelves and surface melt ponds using MODIS and AVHRR. Vaughan plans to keep an eye on the Wilkins and Larsen C Ice Shelves, both of which may retreat if warm temperatures persist. He also hopes to investigate more thoroughly how ice shelves and dense, salty Antarctic bottom water affect ocean circulation.

While hesitant to blame the disintegration on global warming, many researchers agree that summer temperatures play a role in the unusual warming trend along the Antarctic Peninsula. “Climate seems to have been relatively stable on the Antarctic Peninsula for the past 1,800 years, but then 50 or 100 years ago, it began to change,” said Vaughan.

Indeed, weather records over the past 50 years show that regional air temperature increased 2.5 degrees Celsius (4.5 degrees Fahrenheit) — five times the rate of
warming measured for the rest of the world. And records from Orcadas Station (located in the South Orkney Islands, northeast of the peninsula) indicate that regional warming along the peninsula occurred as early as the 1930s. “That’s fairly strong evidence to suggest that this is not part of natural variability,” said Vaughan.

The disintegration of the Larsen B may simply be evidence of how quickly certain regions of the world can respond to relatively small climate changes. The regional warming observed in the Antarctic Peninsula represents a small part of a much larger picture, and scientists hope to gain a better understanding of the complex interactions between ice, oceans, and atmosphere.


Hulbe, C. Recent changes to Antarctic Peninsula ice shelves: What lessons have been learned? Accessed April 11, 2002.


