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SKYWARN NEWSLETTER

National Weather Service

STATE COLLEGE, PA

The Winter of 2018-19 in Review

John La Corte – Lead Meteorologist

Another winter is in the books, and most of us are probably glad it was a largely unremarkable one. When meteorologists speak of "winter", for record keeping purposes we refer to the months of December through February. That's *meteorological winter*.

Like so many recent winters, the winter of 2018-19 was warm and relatively snow-free. A quick look back to forecasts issued last fall shows we can say that the seasonal predictions worked out quite well overall.

TEMPERATURES

Figure 1 shows that for all but a small part of eastern Pennsylvania (Schuylkill County), temperatures were warmer than normal, in many areas as much as 3-4 degrees above normal in fact.

Except for a couple of short periods toward the end of January and early February (the dead of winter), cold weather was pretty sparse. Long lived and persistent cold was just not to be found this year.

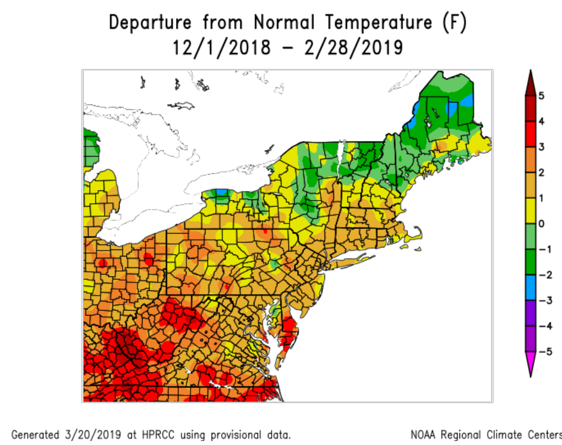

Figure 1. Temperature Departures Winter 2018-19

PRECIPITATION

Continuing the trend from last year, the winter was wetter than normal, though that didn't necessarily translate into snow. When we consider precipitation, it includes rainfall and the melted equivalent of snow. Figure 2 shows that wetter than normal conditions were common over the vast majority of Pennsylvania, in fact with small exceptions, it was wet from the Ohio Valley to the Carolinas north into northern New England. No single month stood out as particularly wet or dry, all three months contributed to the above normal numbers.

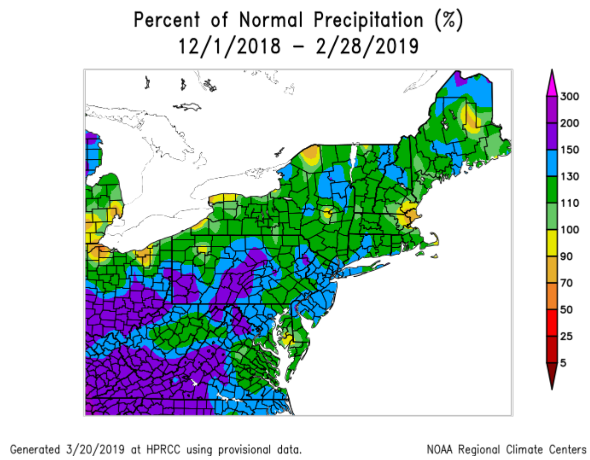

Figure 2. Precipitation Departures Winter 2018-19

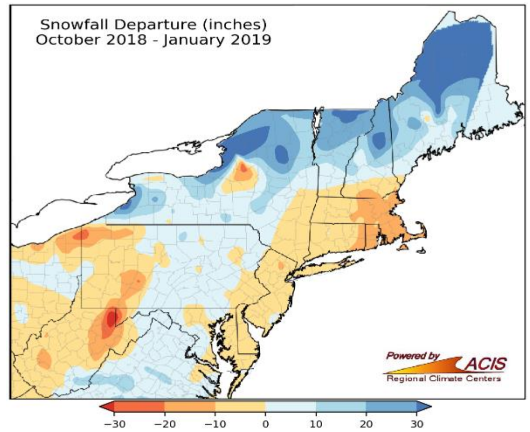

Figure 3. Snowfall Departures Winter 2018-19

Figure 3 shows that most of the region was near to well below normal for snowfall for the season. You have to look to northern New York and New England to see areas that enjoyed a snowy winter.

The seasonal snowfall map doesn't quite capture the lack of snow since it actually encompasses the whole cold season starting in October. Table 1 shows that for many locations in central Pennsylvania, the biggest single snow storm of the season actually occurred in November, before meteorological winter began.

SNOWFALL

Despite the wetter than normal winter, snow lovers were largely disappointed with the amount of snow received. While we averaged warmer than normal, it did end up being just cold enough from January through the end of February that we saw relatively long periods with some "snow on the ground." Technically that means we had an inch or more present on the ground each day at 7 am.

Station	Snowfall	Date(s)
Harrisburg	8.8	Nov 15-16
Williamsport	10.6	Nov 15-16
Altoona	11.3	Nov 15-16
State College	11.5	Nov 15-16
Bradford	9.3	Jan 20
Lancaster	7.8	Nov 15-16
Laporte	11.3	Nov 15-16
Wellsboro	11.3	Jan 20-21

Table 1. Date(s) of the Biggest Snow Storm

SUMMER 2019 OUTLOOK

The Climate Prediction Center is tasked with providing seasonal outlooks. Their Climate Modeling System is predicting a warmer than normal summer over the eastern United States for the meteorological summer months of June through August. This can be seen in Figure 4 in the "warm" colors.

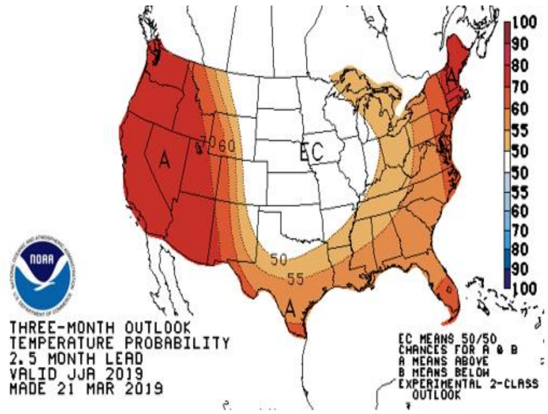

Figure 4. Temperature Departure Forecast Summer 2019

It might be noted that the western US is given a high probability of being warmer than normal as well. If this verifies, it could be a harbinger of another very active wildfire season out west.

The precipitation forecast is leaning toward wetter than normal conditions over about the

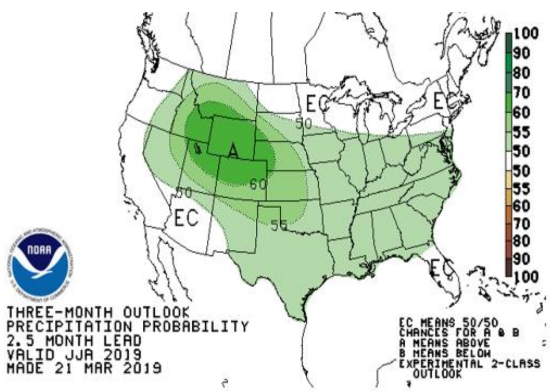

Figure 5. Precipitation Departure Forecast Summer 2019

south half of the area, while northern portions are what the CPC defines as “EC”, or equal chances. That just means there is no atmospheric signal that has shown any skill regarding the rainfall forecast. This can be seen in Figure 5.

Whatever ends up happening, we hope everyone has a very nice summer. We’ll see you in the fall to once again summarize what happened and look forward to what to expect.

https://www.climate.gov/news-features/understanding-climate/climate-change-minimum-arctic-sea-ice-extent

Some Cold and Snowy Winters for North America…An Overview

David Martin – General Forecaster

The last few years have featured rather tame winters for central Pennsylvania and much of the country. Some years we have seen an active lake effect snow season downwind of the Great Lakes. This has been the case for spots like Erie Pennsylvania and Buffalo New York. Other seasons have seen an active storm pattern that results in heavy snow across the mid-Atlantic.

This season we saw below normal snowfall across portions of western Pennsylvania and more an active pattern that gave the Lower Susquehanna Valley several days of light to moderate snowfall in late February into early March.

One event that occurred this winter was the persistent cold across the northern tier states. While southern New England saw a slow start to the winter, northern New England saw plenty of snowfall. This area of heavy snowfall extended westward across northern Michigan to the northern Great Plains. In some areas this was one of the deepest snow packs on record. The combination of heavy rain and snowmelt has resulted in record flooding across portions of the Midwest. Some areas may remain flooded until at least early May.

For central Pennsylvania, the winter of 1993-1994 featured a lot of snow and record cold in January. Some areas had temperatures as cold as 20 below zero.

Another winter with a lot of snow was 1995-1996 season. That year got busy with a snowstorm in mid-November. This was followed by several large storms in January 1996. Upwards of 2 to 3 feet of snow was on the ground, when a significant warm up and rain event on January 19th resulted in severe flooding across the area.

Other winters that come to mind were the harsh winters of 1976-1977 and 1977-1978. These seasons featured record cold and stormy conditions with record lake effect snows. The winter of 1978-1979 was the coldest on record for the lower 48 states. The cold wave of January 1977 was the most extreme on record for the 20th century. Another extensive cold wave occurred in 1979. This was followed by the January 1982 cold wave. Other cold waves were noted in December 1983 and January 1985. The push of cold air went well into the southeast states on January 21, 1985. The temperature fell to minus 9 (station record) at Raleigh, North Carolina during that cold wave. Winds were strong and interstate 40 was covered with ice, as the temperature fell more than 20 degrees in just a few minutes with one particularly potent cold front.

December 1989 was very cold across the central and eastern states. This was one of the coldest Decembers on record for these areas.

Other winters of note occurred in 1916-1917 and again the next year in 1917-1918. The period of October 1916 to March 1917 was the coldest on record for the West and Midwest. The winter of 1917-1918 was very cold across the east. The cold spread into the Midwest during January 1918. Many record lows were set, which still stand today.

February 1934 was very cold across the northeast states. Much of Lake Ontario was covered by ice. For parts of New England, it is the longest period of cold weather ever experienced. The average temperature in northern New England was only around zero for the month of February.

So as you can see, most of the cold winters from the “good old days” were indeed in the past, and it seems real cold weather these days is an increasingly rare event.

Update on Warm Season Hazards

David Martin – General Forecaster

TICKS

We mentioned here last year, ticks can carry the little known Powassan virus. The Powassan virus is not as common as Lyme disease, but has no cure. Unlike Lyme, the tick only has to be on a person for a few minutes for transmission. After several hours of being bitten by a tick infected with the Powassan virus, one may experience headaches, nausea, vomiting, muscle weakness, memory loss, and problems with speech. Unlike Lyme, no rash forms. The good news is that so far, very few folks have got this virus.

Also noted last spring, a new problem has been observed in nearby New Jersey with the East Asian tick that has been spotted in several counties. This tick can carry the SFTS virus that causes Severe Fever and Thrombocytopenia (low blood platelet count).

SPOTTED LANTERNFLY

A new pest problem has been noted in southeastern Pennsylvania in recent years.

The Spotted Lanternfly is an invasive sap-feeding plant hopper. This pest was first found in Pennsylvania in 2014 and has spread into Dauphin County as of early spring. This insect damages crops and trees by leaving behind a large amount of excrement. This feeding routine also weakens the plants and trees they feed on. Aside from Grape vines, these insects feed on tree fruit, and hard wood trees. Eggs are laid on any solid surface in the fall. They hatch in the spring season.

If you are concerned, you should check with the Pennsylvania Department of Agriculture for up to date information.

MONARCH BUTTERFLY

Good news for a change. There has been over a 140 percent increase in the breeding population of the Monarch Butterfly this year compared to previous years. So it is estimated that upwards of 300 million butterflies in northern Mexico will make the annual journey north this summer. In recent years, the number of butterflies had been on the decrease.

Fellow conservationists are encouraged to preserve and plant native milk weed. Monarch Butterflies need this plant to survive and breed.

How the warming Arctic is creating a worldwide transformation

By Bathsheba Demuth

THE WILLOWS DID not, at first, look like anything remarkable. It was March 2006, and I was 80 miles north of the Arctic Circle, not far from the village of Old Crow. I was back for a visit with the host family that had taught me years before to run sled dogs, and more generally to love the Arctic. And I was stuck. Or more precisely, my dogsled's runners were snagged in a thicket of willows.

For the rest of the story about the warming Arctic click:

https://www2.bostonglobe.com/ideas/2019/04/20/the-arctic-present-with-all-its-uncanniness-likely-future-everywhere/mAXxGJqxy2Ue7dlhyX9N6K/story.html

A Guide to Plastic in the Ocean

It's a problem, but it's one we can do something about.

Article published in National Ocean Service

Plastic is everywhere: In your home, your office, your school — and your ocean. Among the top 10 kinds of trash picked up during the 2017 International Coastal Cleanup were food wrappers, beverage bottles, grocery bags, straws, and take out containers, all made of plastic. How did it all get there? Why is it a problem? What can we do?

The problem with plastic

While it's tough to say exactly how much plastic is in the ocean, scientists think about 8 million metric tons of plastic enter the ocean every year. That's the weight of nearly 90 aircraft carriers.

These plastics come in many different forms. Just think about all the plastic items you use daily: the toothbrush you grab first thing in the morning, the container your lunch comes in, or the bottle you drink water from after your workout.

All these things get used and, eventually, thrown out. Many plastic products are single-use items that are designed to be thrown out, like water bottles or take out containers. These are used and discarded quickly. If this waste isn't properly disposed of or managed, it can end up in the ocean.

Unlike some other kinds of waste, plastic doesn't decompose. That means plastic can stick around indefinitely, wreaking havoc on marine ecosystems. Some plastics float once they enter the ocean, though not all do. As the plastic is tossed around, much of it breaks into tiny pieces, called micro plastics.

The first thing that comes to mind for many people when they think of micro plastics are the small beads found in some soaps and other personal care products. But micro plastics also include bits of what were once larger items.

Microfibers, shed from synthetic clothing or fishing nets, are another problematic form of micro plastic. These fibers, beads, and micro plastic fragments can all absorb harmful pollutants like pesticides, dyes, and flame retardants, only to later release them in the ocean.

What can you do?

There are many ways to keep plastic out of the ocean! Here are two strategies:

- **Reduce plastic use.**

Think about all the plastic items you use every day. Can you count them all? Look around you. How many plastic things can you see? Being more aware of how and why you use the plastics that you do is the first step to reducing plastic use. Commit to changing your habits by reducing your use of disposable and single-use plastic items, reusing items and/or recycling them.

- **Participate in a cleanup.**

Volunteer to pick up marine litter in your local community. Find a cleanup near you!

NOAA's Marine Debris Program (MDP) works to understand how plastics — and other marine debris — get into our ocean, how they can be removed, and how they can be kept from polluting our marine environment in the future.

For the entire article with graphics, click:

https://oceanservice.noaa.gov/hazards/marinedebris/plastics-in-the-ocean.html

Antarctica is colder than the Arctic, but it's still losing ice

By Michon Scott

March 12, 2019

To see the entire article including graphics and references, click:

https://www.climate.gov/news-features/features/antarctica-colder-arctic-it%E2%80%99s-still-losing-ice

Compared to the Arctic, Antarctica is responding less rapidly to climate change. Water's melting point, 32°F, is a critical threshold for rapid change in Polar Regions, and only a small fraction of the snow on Antarctica's miles-high ice sheet reaches that temperature in summer. Antarctica is also surrounded by a vast ocean, and it's buffered by winds and weather patterns that tend to isolate it from large warm-air intrusions. Still, the frozen continent has become warmer, and has lost billions of tons of ice as a result. Its future responses to warming air and ocean could have worldwide consequences.

Antarctica 101

Though it's about as far from the equator as the Arctic, and though it's also largely frozen, Antarctica is in many ways the Arctic's opposite. The Arctic is an ice-covered ocean basin surrounded by landmasses; Antarctica is a continent surrounded by a vast ocean. Roughly the size of the contiguous United States and Mexico combined, Antarctica extends from 60°S to the South Pole. Most of the continent lies within the Antarctic Circle, 66°33'39" south of the Equator. Geographers divide the continent into three regions: East Antarctica, West Antarctica, and the Antarctic Peninsula.

Separating East and West Antarctica, the Transantarctic Mountains include peaks over 14,000 feet, and an even higher peak—16,000+-foot Mt Vinson—rises near the Antarctic Peninsula. But mountains aren't what make Antarctica the highest-elevation continent on Earth. Ice is. Thanks to thick ice, Antarctic elevation averages more than 6,000 feet (more than a mile above sea level). The very highest parts of the ice sheet, near the center of East Antarctica, rival the height of its tallest mountains, at nearly 13,500 feet.

The coldest, driest continent

At South Pole Station, the average monthly summer temperature is −18°F, and the average winter monthly temperature is −76°F, according to the U.S. Antarctic Program. These temperatures are much colder than the North Pole's, which averages −40°F in winter and 32°F—right on the cusp of melting—in summer. In fact, Antarctica is home to the coldest place on Earth.

Antarctica's interior gets so little precipitation that it counts among the world's driest deserts. Air masses reaching the high-elevation interior are usually stripped of moisture. The U.S. Antarctic Program reports that, continent-wide, Antarctica receives an average of roughly 2 inches of precipitation per year. (Phoenix, Arizona, gets about 7.5 inches of annual precipitation.) But intense storms with hurricane-force winds near the coasts may drop heavy precipitation around the steep margins of the continent—up to 10 feet of water as snowfall! The snowiest parts of the continent are the Antarctic Peninsula and the northern coast of West Antarctica.

Air temperature changes

Like other continents, Antarctica feels the impacts of climate change at different rates in different places. Multiple studies have reported rising temperatures in West Antarctica. A 2013 study led by David Bromwich reported a temperature increase of 4.3 ± 2.2°F over 1958–2010. A 2014 study by Bromwich and Julien Nicolas reconstructed Antarctic near-surface monthly mean temperatures from 1958–2012 and concluded that annual temperatures rose 0.40 ± 0.22°F per decade across West Antarctica, and 0.59 ± 0.31°F per decade across the Antarctic Peninsula.

Over East Antarctica, which is much higher in elevation, temperature trends have been harder to assess. The 2014 Bromwich and Nicolas study concluded that temperatures rose by 0.11 ± 0.16°F per decade between 1958–2012, but the trend was not statistically significant. At the Amundsen-Scott Station at the South Pole—located in East Antarctica—temperatures have cooled in recent decades; a 2014 review paper in *Polar Record* suggested that the cooling trend could be due to fewer warm ocean air masses reaching the continent's interior.

The Intergovernmental Panel on Climate Change (IPCC) synthesis report published in 2014 found a warming trend over Antarctica, but expressed low confidence that the warming was caused by human activities. In the late twentieth century, the ozone hole and its effects on air circulation may have partly shielded the continent from the global warming influence of greenhouse gas emissions. Continued success in addressing the ozone hole, along with fossil fuel emissions, may cause Antarctic temperatures to rise more rapidly in future decades.

The Antarctic Peninsula—lower in elevation and closer to the equator—experienced rapid temperature increases for several decades in the twentieth century. Then, in the late 1990s, temperature increases slowed, and since 2000, the Peninsula has actually cooled. Studies published in *Nature* and *Nature Climate Change* in 2016 concluded that the recent cooling can be explained by natural variability and trends in Pacific Ocean temperatures. Despite the recent cooling, the northern parts of the Antarctic Peninsula remain much warmer than they were in the middle of the last century.

Ocean warming

Although seasonal cycles and historically low sample sizes have complicated scientists' attempts to detect long-term temperature changes in the Southern Ocean, a temperature record extending back to 1925, with frequent measurements, exists around South Georgia Island. Those measurements show a warming of 4.1°F over 81 years in the upper 500 feet of the ocean, according to a 2013 review paper in *Polar Record.*

West of the Antarctic Peninsula, measurements dating back to the 1950s show a strong warming trend in the upper ocean: nearly 2.7°F. Meanwhile, waters of the Arctic Circumpolar Current (ACC), far below the surface, have warmed faster than the rest of the global ocean. Between depths of 1,000 and 3,000 feet, ACC temperatures rose by 0.11°F per decade between the 1960s and the 2000s. Between the 1980s and 2013, ACC temperatures at those depths rose by 0.16°F per decade.

Sea ice variability, but no long-term change

Due to basic geographic differences, Antarctic sea ice extents are smaller than the Arctic's in summer, and larger in winter. Over 1981–2010, Antarctic sea ice has averaged over 7 million square miles at its winter maximum, usually in September, and about 1 million square miles at its summer minimum, usually in late February or early March.

In contrast with the Arctic—where climate change is amplified, and sea ice shows a clear declining trend over time—Antarctic sea ice does not show a significant overall trend in either the summer or the winter. One region, south and west of the Antarctic Peninsula, has shown a persistent decline, but this trend is small relative to the high variability of the other Antarctic sea ice regions. In 2015, sea ice experts concluded that the small gains in Antarctic sea ice in some seasons were not enough to cancel out Arctic losses, and so globally, sea ice was declining. That basic conclusion remains true in early 2019.

In just the last decade, Antarctic sea ice has exhibited the two highest maximum extents on record (2013 and 2014) and the two lowest minimum extents on record (2017 and 2018). Antarctic sea ice behavior to date appears to have more to do with natural variability, including annual and decadal cycles in the surrounding Southern Ocean, than with human-caused climate change.

Ice sheets are losing mass

Antarctic snowfall has accumulated over millions of years to build the world's biggest ice sheet, essentially a massive glacier flowing in all directions. The Antarctic Ice Sheet extends over nearly 5.4 million square miles, and it's about 13,000 feet thick at its summit, over the East Antarctic Plateau. The ice sheet covers virtually all of the Antarctic land area, reaching the ocean through scores of glaciers. Some glaciers terminate right at the coastline, and some extend well out over the ocean in floating shelves.

Ice sheets gain mass through snowfall and, to a miniscule amount, rainfall. They lose mass in three ways: ablation (ice evaporation), iceberg calving, and melting, either on the surface or from the underside of ice shelves that are in contact with the ocean. When average annual ice loss through melt and other means is equaled by snowfall, the ice sheet is in balance. Otherwise, the ice sheet either gains or loses mass.

Its sheer size makes precise measurement of mass changes in the Antarctic ice sheet difficult because at present, those changes are small relative to the ice sheet's natural gains and losses each year. Until very recently, the consensus view has been that ice sheets across West Antarctica and the Antarctic Peninsula are losing mass, while East Antarctica has been relatively stable or even gaining mass. For instance, a 2012 Science study led by Andrew Shepherd reconciled different estimates—from models, mass-budget calculations, elevation changes, and satellite-based gravity measurements—and concluded that East Antarctica gained 14 ± 43 gigatons of ice over 1992–2011, West Antarctica lost 65 ± 26 gigatons, and the Antarctic Peninsula lost 20 ± 14 gigatons.

The east-west difference in ice sheet changes was confirmed in a 2018 *Nature* study by the Ice Sheet Mass Balance Inter-comparison Exercise (IMBIE) team. The group of 80 polar scientists concluded that from 1992–2017, ocean melting and ice-shelf collapse caused the Antarctic Peninsula and West Antarctica to lose ice at increasing rates: accelerating from 53 ± 29 gigatons to 159 ± 26 gigatons per year in West Antarctica over the period, and from 7 ± 13 gigatons to 33 ± 16 gigatons per year on the Antarctic Peninsula. The authors were less certain of the rate of change in East Antarctica, but estimated that it had gained 5 ± 46 gigatons per year over 1992–2017.

A paper published in the *Proceedings of the National Academy of Sciences (PNAS)* in early 2019, however, challenged the consensus of West Antarctic losses and East Antarctic gains. Using newer data sources and an adjusted model for overall ice accumulation, the new study, led by Eric Rignot, examined ice mass changes over 1979–2017. He and his colleagues concluded that the rate of ice mass loss across the entire continent increased over each decade studied: 40 ± 9 gigatons per year in 1979–1990, 50 ± 14 gigatons per year in 1989–2000, 166 ± 18 gigatons per year in 1999–2009, and 252 ± 26 gigatons per year in 2009–2017. This study found mass loss in from all Antarctic ice sheets over 2009–2017. The authors concluded, "East Antarctica is a major participant in the mass loss." However, these newer figures have not yet been corroborated by satellite observations of gravity and elevation changes.

Ice shelves destabilizing

An ice shelf is a thick slab of floating ice, attached and grounded along a coastline and extending over the ocean water. In total, Antarctica has 15 major ice shelves, most of them fed by glaciers growing slowly outward toward the open ocean. Most of the time, an ice shelf and the glaciers feeding it form a relatively stable system, with flow from the glacier resisted by the ice shelf's connection to the coastline or island obstructions that poke up into it. Every so often, an ice shelf breaks off a large piece, forming an iceberg, which in Antarctica, may rival the size of a small U.S. state. Iceberg calving is a natural process. A more recent and unusual phenomenon is ice shelf disintegration.

On the eastern side of the Antarctica Peninsula, the Larsen Ice Shelf experienced its first satellite-observed disintegration in 1995. Roughly 580 square miles rapidly disintegrated into small, sliver-shaped icebergs. In 2002, the Larsen Ice Shelf experienced a bigger disintegration: about 1,250 square miles over the course of several weeks. On the western side of the peninsula, the Wilkins Ice Shelf also underwent a series of disintegration events starting in 1998. Though smaller in scale than the Larsen breakups, the Wilkins events were significant for their rapidity, including a miles-long retreat in a single day.

Multiple factors likely contribute to ice shelf disintegration. Warm summers can cause a layer of meltwater to form on the ice shelf surface. If the ice surface has cracks—and it often does due to the ice's movement and deformation over time—water fills those cracks. Because it's denser than ice, the water eventually slices through the ice, carving it into smaller pieces. And as warm air temperatures can melt ice shelves from above, warm ocean water can thin the ice shelf from below, making it more vulnerable to disintegration. Finally, sea ice floating in front of the ice shelf dampens wave action, but where sea ice retreats completely in late summer, ocean waves can flex an ice shelf and make it more vulnerable to breakup.

By itself, an ice shelf disintegration doesn't immediately raise ocean level. The slab of ice was already floating on the ocean surface, taking up roughly the same amount of space as it would when it melts. But ice shelf retreat can cause sea level rise indirectly by allowing the glaciers that fed the shelf to speed up.

Glacier acceleration

A key feature of the glacier-ice shelf system is the grounding line: the point where the ice shelf lifts off the bedrock and starts to float on the ocean surface. The location and shape of the grounding line depends on the underlying bedrock elevation. Although the ice sheet hides Antarctica's topography from view, its bedrock elevation ranges from thousands of feet above to thousands of feet below sea level, with below-sea-level rock being more common in West Antarctica.

Sometimes an ice shelf's grounding line occurs along an ice rise, an isolated high point in the bedrock, and behind the ice rise, the bedrock slopes downhill to well below sea level. When the ice shelf retreats past the ice rise, warm ocean water can quickly infiltrate the area, and rapidly melt the ice shelf from below.

Whenever a glacier-fed ice shelf retreats past any grounding line, there isn't much left to slow the glacier's flow. In the 18 months following the Larsen B Ice Shelf disintegration, glaciers feeding that ice shelf accelerated between three and eight times their original speed. Subsequent observations continued finding accelerated flow years later. Accelerated glacier flow *does* have implications for sea level because it introduces ice that was held above sea level and on land into the ocean, adding volume to the ocean that hadn't been there before.

Antarctica's role in sea level rise

Right now, Antarctica's contribution to sea level rise can be measured in millimeters. On the Antarctic Peninsula, where ice shelf collapses have led to measurable glacier acceleration, the effect on sea level is currently just a tenth of a millimeter—about the width of a human hair. But if glaciers draining the West and East Antarctic Ice Shelves begin to accelerate, the effect on global sea level could be significant. A joint United States-United Kingdom project to study Thwaites Glacier in West Antarctica is driven by the possibility that this Florida-sized glacier, which is already thinning rapidly, might collapse. The nearby Pine Island Glacier is flowing about 60 percent faster than it did in the 1970s, and also poses a potential hazard to coastal communities.

If the entire Antarctic Ice Sheet were to melt at once, it would raise global sea level more than 180 feet. Outside of an epic natural disaster such as an asteroid slamming into Antarctica, that ice sheet isn't going to melt entirely for centuries, but it will contribute to sea level rise over the next century. The question is: How much? The exact answer is elusive. The IPCC Fifth Assessment Report (AR5) states that the effect of Antarctic ice sheets on sea level rise over the coming century is a major unknown. Not only is the ice sheet melt rate challenging to measure precisely, but other events could accelerate sea level rise, and it's hard to know when or even if those events will occur.

The biggest projections of 21st-century sea level rise are driven by a phenomenon known as marine ice cliff instability (MICI). The hypothesized scenario is that, when an ice shelf retreats to a point where an ice cliff rises some 300 feet above the sea surface, that cliff is so unstable that its front is prone to topple — leading to a taller, even more unstable ice cliff and a runaway process of ice loss. A 2016 study by DeConto and Pollard argued that this process could contribute over three feet to sea level rise by the year 2100. However, the evidence for this process is indirect, such as an absence of any observed ice cliffs exceeding that height. A 2019 study led by Tamsin Edwards found that MICI wasn't needed to reproduce Antarctica-driven sea level changes that happened within the past few million years, and might not occur in the foreseeable future.

Another process that could accelerate ice loss is warm-water-driven melt on the underside of the ice. As the ice thins, warm water can reach further inland, thinning the glacier especially quickly in places where the bedrock is below sea level. A 2019 study led by Nicholas Golledge stated that warm-ocean-driven melt from Antarctica and Greenland combined could contribute up to 10 inches to global sea level by the year 2100. Antarctica is expected to respond slowly to underside melt at first, with an accelerating response later in the century. The authors stated that the ice-acceleration tipping point may have already been reached for parts of the West Antarctic Ice Sheet.

Simulations of future sea level rise highlight something regionally important: the sea level rise from a melting ice sheet won't necessarily be shared equally around the globe. Antarctic ice sheets are so massive that they exert a gravitational pull on the surrounding ocean, drawing local sea levels up higher onto the continent's shores. The loss of mass from a melting ice sheet is projected to cause local sea level to fall. Meanwhile, shorelines farther from the Antarctic Ice Sheet would see a relative rise in gravitational pull, and a corresponding rise in sea level. Among the regions projected to experience rapid sea level rise resulting from Antarctic Ice Sheet loss are the U.S. Eastern Seaboard and the Gulf of Mexico.