

Sea Level Rise

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Sea Level Rise

All across the world, sea levels are expected to rise in response to climate change. However, for the state of Delaware, sea level rise is especially concerning due to the state's flat topography, low mean elevation, and heavy reliance on large scale investments in coastal activities, like tourism and infrastructure development. With the rate of sea level rise only expected to increase over the next century, Delaware will become susceptible to a series of environmental phenomena, including increased coastal inundation and erosion, accelerated saltwater contamination of ground and surface waters, and loss of critical coastal habitats unless proper mitigative strategies are implemented.



Figure 1. A sign warning drivers that the Blackbird Creek may flood the road ahead following the October 2025 nor'easter. Photo by Jennifer Volk

Global Mean Sea Level Rise and Relative Sea Level Rise

Global mean sea level rise (GMSLR) refers to the increase in sea-surface height across all of the world's oceans, while relative sea level rise (RSLR) refers to the increase in sea-surface height relative to the land at a specific location.

Global Mean SLR

Global changes in sea level are primarily attributed to the following two factors:

1. Land-based ice melt
2. Thermal expansion of seawater

Melting Ice Sheets and Mountain Glaciers

As air temperatures rise, the melting of continental ice sheets and mountain glaciers can add significant amounts of freshwater into the oceans. According to the National Snow & Ice Data Center, an ice sheet consists of glacial land ice that extends for more than 50,000 square kilometers (20,000 square miles). On Earth today, two main ice sheets exist: the Greenland and Antarctic ice sheets. Together, they contain more than 99% of the freshwater ice on the planet.

Though both the melting of the Antarctic and Greenland ice sheets have contributed to GMSLR over the past century, the Greenland ice sheet has had a larger impact on global sea levels than the Antarctic. Based on data from the Intergovernmental Panel on Climate Change's (IPCC) Sixth Assessment Report, between 1992-2020, Greenland likely lost $4,890 \pm 460$ gigaton of ice and contributed 13.5 ± 1.3 millimeters to GMSLR. Over the same period, the Antarctic ice sheet likely lost $2,670 \pm 530$ gigaton of ice, but only

contributed 7.4 ± 1.5 mm to GMSLR. If the entire Greenland ice sheet were to melt, scientists estimate that global sea levels would rise approximately 24 feet (7.4 meters).

In addition to ice sheet melt, melting from mountain glaciers has also made significant contributions to rises in global sea levels. These distinct masses of ice cover an area of approximately 439,000 square miles globally and can potentially raise global sea levels by 1.3 feet (0.4 meters). Currently, the glaciers that have had the most considerable impact on global sea levels include those located in Alaska and the Arctic, as well as the melting ice fields in the Patagonia region of South America.



Figure 2. A view of the Greenland ice sheet. Photo by David Yu

Thermal Expansion

While increasing atmospheric temperatures can cause ice sheets and glaciers to melt, they can also increase the temperature of the oceans' seawater, causing it to expand as its density decreases. Referred to as *thermal expansion*, this natural climatic process occurs throughout all of the world's oceans and has helped explain 50% of GMSLR between 1971 and 2018.

Relative SLR

Though global sea levels continue to rise on average, it is essential to note that sea levels in coastal regions and communities are not all rising at the same rates. Since 1920, global mean sea level (GMSL) has risen by approximately 17 centimeters, while relative sea level (RSL) averaged along the contiguous United States has risen by 28 centimeters over the same period. In Delaware alone, according to tide gauge

data collected in Lewes, sea levels have risen more than 13 inches since 1900 (0.13 inches per year), a rate that is nearly double the global rate of sea level rise (0.07 inches per year).

Though the state's sea levels will continue to be influenced by global contributors, like those mentioned above, processes specific to the Mid-Atlantic region will also play a large role in increasing sea-surface height across Delaware's coastlines. Two processes affecting relative sea level rise are:

1. Geologic land subsidence
2. Changing ocean circulation patterns

Glacial Isostatic Adjustment and Subsidence

As sea levels continue to rise, Delaware and the rest of the Mid-Atlantic states have actually begun to sink, thanks to two related geologic processes: glacial isostatic adjustment (GIA) and subsidence. During the last Ice Age, an incredibly large mass of ice, known as the Laurentide ice sheet, covered much of North America. With thicknesses of up to 2.5 miles (4 km) in some areas, portions of land caught beneath the ice sheet became compressed due to its immense weight, while land on the outskirts of the sheet experienced uplift. Over time, however, as atmospheric temperatures have risen, much of the ice sheet has melted away, triggering a reverse adjustment in land level. Put simply, due to the ice sheet retreat, areas that were once compressed are now slowly returning to their previous level, while areas that experienced uplift are beginning to sink back down. This entire process is known as *glacial isostatic adjustment (GIA)*, with the gradual sinking of the land referred to as *subsidence*. Since Delaware is close to the southern limit of the now-collapsed Laurentide ice sheet, over the last 10,000 years, the state has experienced a general rise in relative sea level as its land area has continued to sink gradually. In addition to Delaware, other places along the East Coast of the United States, like the land surrounding the Chesapeake Bay, will sink by as much as half a foot over the next century due to subsidence caused by

past glacial activity, based on estimates from the Geological Society of America.

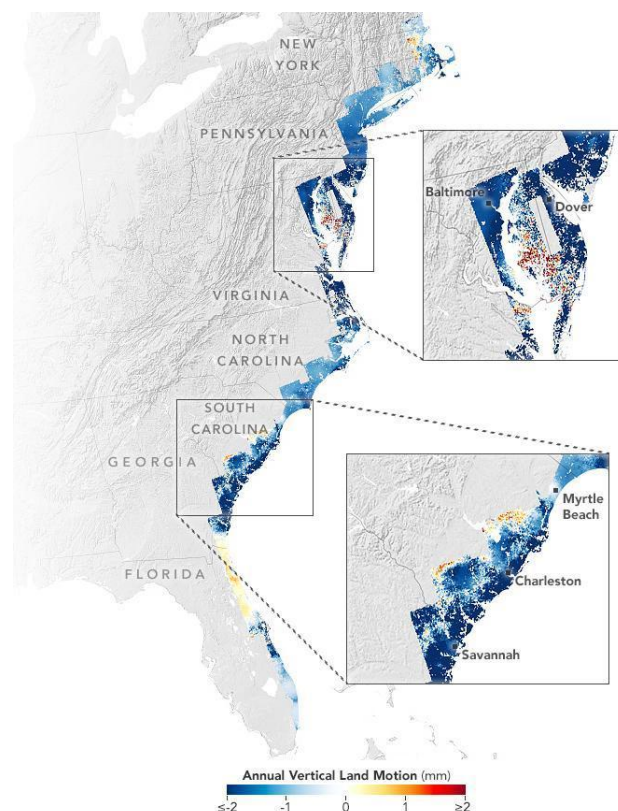


Figure 3. Geologic changes along the East Coast are causing land to sink, thus exacerbating the flood-inducing effects caused by sea level rise. Credit: NASA earthobservatory.nasa.gov

Changing Ocean Circulation Patterns

According to numerous climate models, a collection of ocean currents in the Atlantic Ocean known as the Atlantic Meridional Overturning Circulation (AMOC) are expected to weaken as ocean waters continue to warm and expand. The AMOC resembles an oceanic conveyor belt that transports warmer waters northward to higher latitude regions. There, the water comes into contact with colder air temperatures and stronger winds, causing it to become both colder and denser. As the colder water sinks into the deep ocean, it is quickly cycled back southward at depth, completing the circulation.

Much research has been conducted within the scientific community on how the AMOC is affected by rising air and ocean temperatures. Climate models that simulate conditions under a warming future

climate suggest that a weakening of the AMOC would reduce the amount of heat brought to the North Atlantic and concentrate it along the eastern and southern coasts of North America. As a result of this redistribution, scientists believe that the east coast of the United States, along with most of the Atlantic basin, could experience accelerated rates of sea level rise.

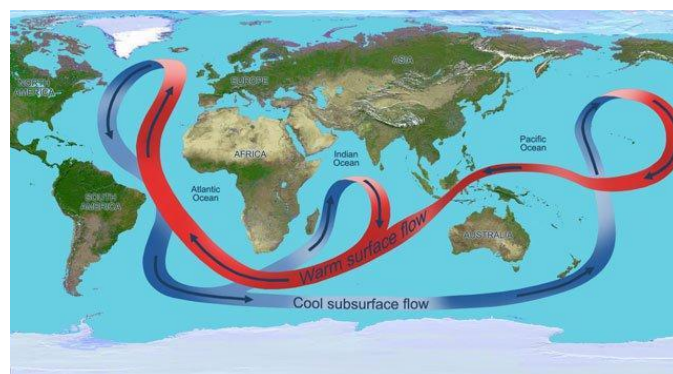


Figure 4. Illustration depicting the overturning circulation of the global ocean. Throughout the Atlantic Ocean, the circulation carries warm waters (red arrows) northward near the surface and cold deep waters (blue arrows) southward. Credit: NASA/JPL www.jpl.nasa.gov

Sea Level Rise Impacts on Delaware

Since Delaware is affected by multiple factors contributing to both GMSLR and RSLR, it and the entire Mid-Atlantic region have become known as a “hotspot” for sea level rise. As a result, the state has already begun to feel the effects of sea level rise across various areas, including agriculture, natural resources, infrastructure, and human health.

Each impact description below has been adapted from the 2021 Delaware Climate Action Plan and the 2017 Delaware Sea-Level Rise Technical Committee’s “Recommendation of Sea-Level Rise Planning Scenarios for Delaware” report. Please view these impacts in the context provided by the primary source documents:

1. [Delaware’s Climate Action Plan](#)
 - [Executive Summary](#)

[2. Recommendation of Sea-Level Rise Planning Scenarios for Delaware Technical Report](#)

Agriculture

Under natural conditions, the movement of freshwater towards the sea prevents saltwater from encroaching on stores of underground freshwater, known as aquifers. However, as sea levels rise, the boundary between underground salt and freshwater begins to move inland, enabling saltwater to intrude into underground water supplies. This process, commonly referred to as a saltwater intrusion, can heavily degrade the quality of underground freshwater used for human consumption and irrigation. For example, if an irrigation well is located near the boundary, the groundwater will not be usable for irrigation, thereby decreasing crop yields while raising farmers' costs to access usable water. Additionally, if saltwater floods onto agricultural fields, the health of the soil and its ability to support crops could be completely undermined by the increased salt content (even after being exposed temporarily).

For more information about how sea level rise is impacting and will continue to impact Delaware agriculture, please see the [Salt Impacted Agricultural Lands](#) page.



Figure 5. A flooded crop field in Sussex County, Delaware. Photo by Michele Walfred

Natural Resources

Delaware contains 73,000 acres of tidal wetlands, each of which provide numerous benefits to both humans

and native biodiversity, including habitat for commercially important species, sediment and pollutant removal, and protection from storm surges and flooding. Unfortunately, if these wetlands are unable to increase their elevation or migrate inland, projections indicate that with just 1.5 feet of sea level rise, 97% of them could become inundated.

In addition to wetlands, wildlife areas, state parks, and forests are also at risk from sea level rise. Though coastal forests, for example, are composed of trees that stand far above any encroaching floodwaters, if the water table gets too high, the roots of said trees will drown, causing them to perish. This process leads to the formation of new, lifeless ecosystems known as *ghost forests*. Ghost forests form when saltwater enters into a freshwater system, typically a tidal wetland or coastal forest that is often marked by specific vegetation and tree species, like the Atlantic white cedar. The Atlantic Coast has quickly become a hotspot for ghost forest formation. According to recent research from the Virginia Institute of Marine Sciences, over the past century, the death of coastal forests has accelerated every decade and is now occurring three times faster. In the Chesapeake Bay region alone, more than 150 square miles of coastal forests have already been converted into ghost forests and marshland.



Figure 6. Coastal wetlands in high sediment areas and large tidal range such as the Bay of Fundy have the potential to survive accelerated rates of sea level rise. Courtesy of www.usgs.gov

Regarding vegetation and plant life, saltwater intrusions and increased flooding can force many plant species to move farther inland, thus allowing saltmarsh plants to move in and take their place. This process is known as *saltmarsh migration*. Though salt marshes are among some of the most productive ecosystems on the planet, growing concern exists about whether they can withstand the accelerated sea level rise created by climate change. In Delaware, numerous wetland studies conducted by the DNREC Wetland Monitoring and Assessment Program indicate that common reed (*Phragmites australis*) colonizes flooded areas before saltmarsh plants can even migrate in.



Figure 7. View of a salt marsh and creek located along the Junction and Breakwater Trail near Cape Henlopen State Park. Photo by Art Anderson

Water Resources

Since most of Delaware's drinking water comes from underground water supplies, saltwater intrusions sparked by rising sea levels can greatly increase the salt content of groundwater, making these vital water sources potentially unusable by the Delaware public. Above ground, sea level rise can also affect Delaware's freshwater river and stream networks, which provide drinking water and habitat for recreational and commercial fish species, like

American shad and striped bass, that rely on freshwater rivers for spawning.

Infrastructure

Public Infrastructure: Sea level rise impacts on infrastructure can be particularly problematic when combined with heavy rainstorm events, making access to roads and evacuation routes even more difficult when needed. A 5-foot rise in sea levels could inundate 5% of the state's roads and bridges and 6% of evacuation routes, thus affecting the ability of people to travel safely across the state and provide essential goods and emergency services. Additionally, rising sea levels can impact the state's wastewater infrastructure. Since many wastewater treatment facilities are located along waterways, sea level rise could increase their susceptibility to flooding. Likewise, since many of the state's electrical substations and transmission lines are located in areas at risk of sea level rise, many of these facilities can be damaged by flooding and become inaccessible during storm events, increasing the risk of lengthy power outages.



Figure 8. A road damaged by flooding from Hurricane Irene at Prime Hook National Wildlife Refuge.

Private Property: According to a 2018 study conducted by the Union of Concerned Scientists, within the next 10-15 years, 147,000 coastal homes and 7,000 commercial properties are at risk of being inundated an average of 26 times a year, or more. Due to chronic inundation, homeowners risk being unable

to capitalize on one of their greatest assets as their homes are subjected to continuous flood damage, making them less desirable (and potentially unsellable) on the real estate market. Even if homes are located just outside the inundation zone, their proximity to other at-risk properties could cause them to experience significant declines in property value.

Human Health

Health and injury risks in coastal areas are directly related to an individual or community's exposure and vulnerability to climate hazards, like sea level rise. While flooding can increase risks of drowning and injury, the excess dampness left behind by floodwaters can accelerate indoor mold growth, triggering numerous respiratory issues. Similarly, saltwater intrusions into drinking water are linked to increased risks of hypertension, and standing water has the potential to increase vector-borne diseases.

In addition to the direct human health impacts associated with sea level rise, it is essential to recognize that, due to specific social and economic inequities, some individuals and communities will become more susceptible to the impacts of sea level rise than others. Many low-income individuals lack proper disaster insurance and access to resources that aid in recuperating from property loss. Consequently, this places them at greater risk for destabilization and displacement from flooding. For residents who are forced to leave their homes, relocation may prove to be stressful if it becomes difficult to find alternative places to live that are affordable and provide access to jobs, schools, and other amenities.

Adaptation Strategies

Since it is evident that both natural ecosystems and man-made infrastructure are impacted by the changes occurring in our oceans, the implementation of adaptation strategies that limit vulnerability to sea level rise is essential. With respect to sea level rise, the Delaware Sea Level Rise Advisory Committee recommends the following four adaptation strategies:

1. Avoid building in the coastal zone by limiting new development in these areas through easements, setbacks, and transfers of development rights.



Figure 9. Flooded streets in Mariner's Cover during October 2025 nor'easter (Courtesy of Driscoll Drones)

2. Accommodate for sea level rise by raising homes and structures along the coast and managing drainage with green infrastructure like rain gardens, bioswales (linear grassed or vegetated channels for conveying stormwater), and naturally designed water retention ponds.
3. Protect coastal lands from floodwater damage and inundation by constructing bulkheads, dikes, and living shorelines and carrying out beach nourishment projects.
4. Retreat and relocate coastal developments away from the shoreline through managed retreat, rolling easements, and land acquisition to protect them from inundation.

In addition to these four adaptation strategies, other recommendations for how to personally respond to sea level rise, as well as how to build up the state's ability to adapt to sea level rise, are outlined in the 2013 document, "Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware." Prepared by the Sea Level Rise Advisory Committee and by staff of the Delaware Coastal Programs section of the Delaware Department of Natural Resources and Environmental

Control (DNREC), the document is intended to assist government agencies, businesses, and individuals alike in preparing and responding to the risks posed by sea level rise. The document also provides guiding principles for implementing the outlined adaptation measures. See both the full document and executive summary below to learn more about sea level rise in Delaware, as well as what adaptive measures can be taken to decrease the state's susceptibility to sea level rise in the future.

- [Preparing for Tomorrow's High Tide: Recommendations for Adapting to Sea Level Rise in Delaware](#)
 - [Executive Summary](#)

Delaware Sea Level Rise Resources

- [Coastal Inundation Maps for Delaware](#) – an easy-to-use sea level rise map developed by scientists at DNREC Coastal Programs and the University of Delaware that shows the possible inundation of Delaware land based on three sea level rise scenarios
- [Surging Seas Risk Finder](#) – an interactive toolkit, developed by Climate Central, that aims to provide citizens, communities, and policymakers with easily accessible, science-based, local information in order to inform responses to rising sea levels and coastal flooding
- [Recommendation of Sea-Level Rise Planning Scenarios for Delaware Technical Report](#) – prepared by the Delaware Sea-Level Rise Technical Committee, this report outlines the impacts that sea level rise will have, and is already having, on Delaware infrastructure, tourism, and tidal wetlands, as well as which framework the state should use
- [Delaware Sea Grant](#) – an education and outreach arm of the UD College of Earth, Ocean, and Environment, Delaware Sea Grant helps communities use, manage, and

conserve the state's coastal resources by prioritizing resilience and fostering environmental stewardship

- [Delaware Flood Planning Tool](#) – an interactive online mapping application designed by DNREC that helps citizens make informed decisions about the degree of flood risk for a specific area or property located within Delaware state boundaries
- [2022 Sea Level Rise Technical Report](#) – a technical report created by the Sea Level Rise and Coastal Flood and Tools Interagency Task Force that not only provides the most up-to-date sea level rise projections available for all U.S. states and territories, but also seeks to help communities assess and adapt to changes in average tide heights and height-specific threshold capacities

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References

Callahan, John A., Benjamin P. Horton, Daria L. Nikitina, Christopher K. Sommerfield, Thomas E. McKenna, and Danielle Swallow, Recommendation of Sea-Level Rise Planning Scenarios for Delaware: Technical Report, prepared for Delaware Department of Natural Resources and Environmental Control (DNREC)

- Delaware Coastal Programs (Dover, DE: DNREC Division of Energy and Climate, 2017).
- National Snow & Ice Data Center, “Quick Facts on Ice Sheets,” (Boulder, CO: National Snow and Ice Data Center, 2022).
- Sweet, William V., Benjamin D. Hamlington, Robert E. Kopp, Christopher P. Weaver, Patrick L. Barnard, David Bekaert, Michael Craghan, Gregory Dusek, Thomas Frederikse, Gregory Garner, Ayesha S. Genz, John P. Krasting, Eric Larour, Doug Marcy, John J. Marra, Jayantha Obeysekera, Mark Osler, Matthew Pendleton, Daniel Roman, Lauren Schmied, Will Veatch, Kathleen D. White, and Casey Zuzak, *Global and Regional Sea Level Rise Scenarios for the United States: Updated Mean Projections and Extreme Water Level Probabilities Along U.S. Coastlines*, (Silver Spring, MD: National Oceanic and Atmospheric Association, 2022).
- Fox-Kemper, B., H. T. Hewitt, C. Xiao, G. Aðalgeirsdóttir, S. S. Drijfhout, T. L. Edwards, N. R. Golledge, M. Hemer, R. E. Kopp, G. Krinner, A. Mix, D. Notz, S. Nowicki, I. S. Nurhati, L. Ruiz, J-B. Sallée, A. B. A. Slangen, Y. Yu, “Ocean, Cryosphere and Sea Level Change.” In: *Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [Masson-Delmotte, V., P. Zhai, A. Pirani, S. L. Connors, C. Péan, S. Berger, N. 14 Caud, Y. Chen, L. Goldfarb, M. I. Gomis, M. Huang, K. Leitzell, E. Lonnoy, J.B.R. Matthews, T.K. Maycock, T. Waterfield, O. Yelekçi, R. Yu and B. Zhou (eds.)] (Cambridge, ENG: Cambridge University Press, 2021).
- Lowe, J.A., Gregory, J.M., Ridley, J., Huybrechts, P., Nicholls, R.J., Collins, M. The role of sea-level rise and the Greenland ice sheet in dangerous climate change: Implications for the stabilisation of climate. In: Schellnhuber, H. J., Cramer, W. P., Nakicenovic, N., Wigley, T. M. L. and Yohe, G. (eds.) *Avoiding dangerous climate* (Cambridge, ENG: Cambridge University Press, 2006)
- Zemp, M., Huss, M., Thibert, E. et al. “Global glacier mass changes and their contributions to sea-level rise from 1961 to 2016,” *Nature* 568, 382–386 (2019). <https://doi.org/10.1038/s41586-019-1071-0>
- IPCC, 2022: Summary for Policymakers [H.-O. Pörtner, D.C. Roberts, E.S. Poloczanska, K. Mintenbeck, M. Tignor, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem (eds.)]. In: *Climate Change 2022: Impacts, Adaptation, and Vulnerability. Contribution of Working Group II to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change* [H.-O. Pörtner, D.C. Roberts, M. Tignor, E.S. Poloczanska, K. Mintenbeck, A. Alegría, M. Craig, S. Langsdorf, S. Löschke, V. Möller, A. Okem, B. Rama (eds.)]. (Cambridge, ENG: Cambridge University Press).
- De Mooy, Jennifer, Margaret Pletta, and Ian Yue, *Delaware’s Climate Action Plan*, (Dover, DE: Delaware Department of Natural Resources and Environmental Control, 2021).
- DeJong, B., Bierman, P., Newell, W., Rittenour, T., Mahan, S., Balco, G., and Rodd, D., “Pleistocene relative sea levels in the Chesapeake Bay region and their implications for the next century,” *GSA Today*, v.25, no.8 (2015). <https://doi.org/10.1130/GSATG223A.1>
- Christopher Piccuch, “Understanding Sea Level Rise,” (Woods Hole, MA: Woods Hole Oceanographic Institute, 2019).
- United States Geological Survey (USGS), “Saltwater Intrusion,” (Reston, VA: USGS, 2019).
- Lauria, Maddy, “Ghost forests tell the story,” *Delaware News Journal*. (Wilmington, DE: Delaware News Journal, 2019).
- Kirwan, Matthew L. and Gedan, Keryn B., “Sea-level driven land conversion and the formation of ghost forests,” *Nature Climate Change* 9, 450-457 (2019). <https://doi.org/10.1038/s41558-019-0488-7>
- Dorset, Erin, “When Saltwater Intrusion Meets Freshwater Wetlands...”, *Wetland Assessments* (Dover, DE: DNREC Wetland Monitoring and Assessment Program, 2018).
- Union of Concerned Scientists, “Underwater: Rising Seas, Chronic Floods, and the Implications for US Coastal Real Estate,” Union of Concerned Scientists (Cambridge, MA: UCS National Headquarters, 2018).

Public Health Institute, “Sea Level Rise, Climate Change and Health,” Center for Climate Change & Health (Oakland, CA: Center for Climate Change & Health, 2016).

Morello-Frosch, R., Pastor, M., Sadd, J., Shonkoff, S. The climate gap: Inequalities in how climate change hurts Americans & how to close the gap. (Los Angeles, CA: Program for Environmental and Regional Equity, 2009).

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