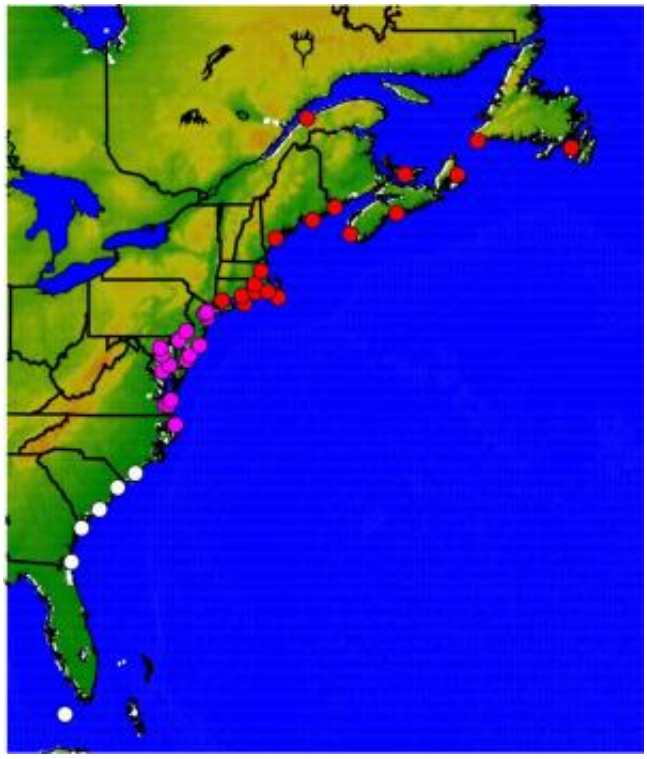
Sea level spiked for 2 years along northeastern North America

24 February 2015



By using historical data from the 40 tide gauges shown on this map, University of Arizona geoscientist Paul Goddard and his colleagues figured out that sea level rose four inches (100 mm) from New York to Newfoundland (red dots) in 2009 and 2010. Gauges from New York south to Cape Hatteras (pink dots) showed a smaller spike in sea level for the same time period. No sea level spike was recorded on the gauges (white dots) south of Cape Hatteras. Credit: Paul Goddard/ University of Arizona department of geosciences

Sea levels from New York to Newfoundland jumped up about four inches in 2009 and 2010 because ocean circulation changed, a University of Arizona-led team reports in an upcoming issue of *Nature Communications*.

The team was the first to document that the extreme increase in sea level lasted two years, not just a few months.

"The thing that stands out is the time extent of this event as well as the spatial extent of the event," said first author Paul Goddard, a UA doctoral candidate in geosciences.

Independent of any hurricanes or winter storms, the event caused flooding along the northeast coast of North America. Some of the sea level rise and the resulting flooding extended as far south as Cape Hatteras.

The paper is also the first to show that the unusual spike in sea level was a result of changes in ocean circulation.

Co-author Jianjun Yin, UA assistant professor of geosciences, said, "We are the first to establish the extreme sea level rise event and its connection with ocean circulation."

Goddard detected the two-year-long spike in sea level by reviewing monthly tide-gauge records, some of which went back to the early 1900s, for the entire Eastern Seaboard. No other two-year period from those records showed such a marked increase.

The team linked the spike to a change in the ocean's Atlantic Meridional Overturning Circulation and also a change in part of the climate system known as the North Atlantic Oscillation.

The researchers then used computer climate models to project the probability of future spikes in sea level.

The team found that, at the current rate that atmospheric carbon dioxide is increasing, such extreme events are likely to occur more frequently, Goddard said.

Goddard's and Yin's research paper, "An Extreme

Event of Sea Level Rise along the Northeast Coast of North America in 2009-2010," is scheduled for online publication in *Nature Communications* on Feb. 24. Stephen Griffies and Shaoqing Zhang of the National Oceanographic and Atmospheric Administration's Geophysical Fluid Dynamics Laboratory in Princeton, New Jersey, are also co-authors. NOAA funded the research.

Yin's previous work on climate models suggests that weakening of the Atlantic Meridional Overturning Circulation could cause sea levels to rise faster along the northeast coast of North America.

Yin wondered whether such sea level rise had actually been observed, so he asked Goddard to compile the tide-gauge records for the east coast of North America. The 40 gauges, spanning the coast from Key West, Florida, north to Newfoundland, have been recording sea levels as far back as the 1920s.

Goddard's work revealed a surprise - that during 2009 and 2010, sea level between New York and Newfoundland rose an average of four inches (100 mm). Sea level from Cape Hatteras to New York also had a notable spike, though not as dramatic.

"The sea level rise of 2009-2010 sticks out like a sore thumb for the Northeast," Goddard said.

His research also confirmed that, as others have reported, sea level has been gradually rising since the 1920s and that there is some year-to-year variation.

About the time Goddard finished analyzing the tide-gauge records, another group of researchers reported that the Atlantic Meridional Overturning Circulation, or AMOC, had a 30 percent decline in strength in 2009-2010. Those researchers reported the decline started just two months before the tide gauges started recording the spike in sea level.

"To me, it was like putting together a puzzle," Goddard said.

The more he and his colleagues examined the timing of the AMOC downturn and the subsequent increase in sea level, the more it fit together, he said.

The AMOC brings warm water from the tropics and the southern Atlantic Ocean to the North Atlantic and the polar regions. The water then cools and sinks, eventually flowing south in the deep ocean. Yin's climate model predicted that when the AMOC weakened, sea level in northeastern North America would rise.

In addition to the weakening AMOC, during 2009-2010 the region's atmosphere was in a very negative phase of the climate mode called the North Atlantic Oscillation. The NAO flip-flops between negative and positive phases.

"The negative North Atlantic Oscillation changes the wind patterns along the northeast coast, so during the negative NAO the winds push water onto the northeast coast," Goddard said.

Although the NAO has resumed flipping between positive and negative states, observations show that the AMOC, while somewhat stronger, has still not recovered its previous strength.

Even now, sea level is still higher than before 2009, Yin said. He's not surprised, because most of the climate models predict a weakening of the AMOC over the 21st century.

Yin said that at the current rate of increase in greenhouse gases, most climate models predict a weakening of the AMOC over the 21st century. Therefore, such extreme sea level rise events and coastal flooding are quite likely to occur along the densely populated northeast coast of North America more often.

Provided by University of Arizona