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Polar Paradox [1]

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Global warming could lead to another ice age.

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Scientists theorize that melt caused by climate warming may actually increase the extent of sea ice in the polar regions. A modest climate warming would increase summer melting of snow, glaciers, and sea ice, thus increasing the amount of freshwater entering the polar oceans. Freshwater has a higher freezing point than salty sea water, resulting in more extensive formation of sea ice, while increased warming might keep this ice pack from becoming as thick as usual during winter. The result might be an ice cover with greater variability from year to year, and greater sensitivity to changes in wind patterns.

As sea water freezes, salt is excluded from the crystalline structure of the newly formed ice. Consequently, this saline water sinks, causing vertical mixing between the ocean layers. Warmer, nutrient-laden lower layers of ocean waters convect upwards to replace the sinking waters.

However, in a more extensive climate warming scenario, ocean circulation and upwelling could be impeded. The excessive increase of freshwater, because it is less dense than the saline water, acts as a cap on the ocean surface. "Ice gets transported to different parts of the Arctic. When it melts it puts a freshwater flux into the ocean. For example, sea ice transported into the Greenland Sea has the ability to cap mixing of fresh and saline water by putting in a freshened surface layer which acts like an inversion on the ocean. It keeps some of the ocean water from rising up and exchanging its heat with the atmosphere," said Jim Maslanik, research scientist at the National Snow and Ice Data Center.

Concerns about the sensitivity of the polar oceans to climate change have prompted scientists to find new ways to monitor the ocean. Data are obtained via remote sensing from satellites and a network of sea ice buoys.

Satellites provide daily information on ice extent and movement. The radiant emission patterns of the ice are obtained by the satellite's sensor. As sea ice ages, its emission properties change. Sea ice age gives scientists a general indication of ice salinity; older ice is less saline than younger ice. In younger ice, the remaining trapped brine has not completely drained away. "Multiyear ice is known to have about two parts per thousand salt. First-year ice has eight or 10," said Mike Steele of the Applied Physics Laboratory, University of Washington.

Buoys are also used to monitor ice movement and characteristics of the polar sea ice. These stations are designed to monitor sea ice motion and transmit the information to satellites automatically.

The original purpose of these buoys was to provide ships in the Arctic with information on changes in ice cover and ice movement. Their additional benefit to scientists is the acquisition of data on ice pressure and temperature, recording of geographic position in the Arctic, and velocity at which sea ice moves.

Steele has used satellite and buoy data to develop a model of the Arctic Ocean's freshwater balance. His research stemmed from predictions of the effect that increasing CO2 levels have on deep water formation in the Arctic Oceans.

"Generally speaking, all of the world's currents move, at the surface, towards the North Atlantic, where the water sinks and replaces the deep water of the global ocean," said Steele. "Dr. Wallace Broecker at Lamont Douherty Earth Observatory in New York, first coined the term 'the global conveyor belt' to describe the average oceanic circulation."

Warm, salty waters from the Gulf Stream move northward across the Atlantic Ocean, and towards northern

Europe. As the water cools, it sinks and returns to become part of the deep water of the global ocean.

Steele's model looks at salinity fluxes between the layers of ocean waters to predict the effect of increased freshwater on the Arctic Oceans. Satellite and buoy data have been essential to locating such freshwater flux occurrences; satellite data are used to compare modeled ice concentrations and buoy data give information on ice flow velocity and direction.

Using these same data, University of Colorado investigators have developed a multiyear record of ice transport in the Arctic and Antarctic. Satellite and buoy data, used in tandem, offer a clearer picture of the circulation patterns in the Arctic.

"If the poles show an amplification of global warming, which is what the general circulation models tend to predict, then sea ice should respond to that warming," said Maslanik. "If we monitor its variability over time then we may be able to pick up some indication of a signal that is distinct from normal interannual changes. However, monitoring and climate change predictions need to take into account the effects of ice transport as well as melting and freezing if we want to detect or predict the response of the ice cover to global warming."

Using satellite and buoy data, it will be possible to obtain a better sense of how sea ice and the polar regions are likely to react to current climate trends, and how the polar regions may affect lower latitudes. Detailed models and maps created for these data provide an estimate of how the sensitive polar regions are changing in concert with climate change.

Ice Ages

Ice Ages could be switched on by extreme melt events and accompanying freshening of the North Atlantic waters, said Ted Scambos, research scientist at the National Snow and Ice Data Center. The effect of oceanic freshening caused by melting of sea ice and of the Greenland Ice Sheet raises an intriguing possibility as a cause for the onset of ice ages.

Based on ideas generated by Richard Alley, Wallace Broeker, and others, it is suggested that an extreme melt event might be capable of capping off the North Atlantic thermohaline circulation. The freshened upper surface waters would also increase sea ice formation. If the condition persisted over a few years, climate feedbacks due to increased albedo and increased ice cover would cause a major cooling of the high northern latitudes, potentially creating the beginning of a glacial epoch. Ironically, global warming could result in throwing us into an ice age, said Scambos.

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