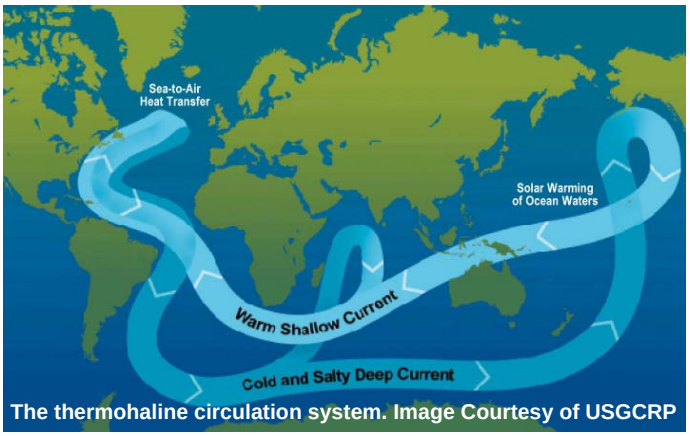
Earth Gauge
A National Environmental Education Foundation Program

Climate Change and Atlantic Circulation

THE ATLANTIC: GLOBAL CLIMATE LINCHPIN

From affecting tropical storm behavior to rainfall patterns to extreme winter temperatures, what happens in the Atlantic Ocean can strongly influence North America's weather. Also in the North Atlantic, the planet's thermohaline system, or the system of currents driven by differences in temperature and salinity, performs a critical "overturning" function, known as the Atlantic Meridional Overturning Circulation (AMOC). Warm shallow waters move from the Equator northward, releasing heat around Greenland, which keeps Europe relatively warm for its latitude. Cold water then sinks to the ocean bottom and runs to about 30 degrees South (the southern tip of Brazil) where it mixes with other ocean water streams.

This "overturning" is crucial for the functioning of the thermohaline system, which is necessary for distributing heat from the Equator to the poles, reducing extremes in Earth's climate. The overturning happens as the winter cooling of the waters near Greenland causes them to sink. Lack of sufficient winter cooling or the input of a sufficient amount of freshwater can both cause the overturning to stop, which in turn can affect the whole planet's climate. This is likely what happened about 12,800 years ago when a catastrophic input of fresh water from the St. Lawrence drainage system caused the ocean system to slow down and resulted in a three to six degree Fahrenheit temperature drop over Greenland. There are no trends indicating that this system has slowed over the last few decades.



The thermohaline circulation system. Image Courtesy of USGCRP

The Thermohaline System and the Atlantic Multidecadal Oscillation

The Atlantic Multidecadal Oscillation (AMO), or a 65-year periodic shift in the temperature of the North Atlantic, affects North America's climate:

- Positive (warm) AMO phases mean less vertical wind shear over the North Atlantic. Less vertical wind shear makes tropical cyclone development more likely.
- Positive AMO phases mean a drier western U.S., with more active fire seasons. On the other hand, positive phases mean more rainfall in the Mississippi River Basin.

The AMO is driven by the periodic strengthening and weakening of the AMOC. A stronger AMOC means a positive AMO, when Atlantic sea surface temperatures are relatively warm (i.e. the flow of warm shallow water into the Atlantic is strong) and subsurface temperatures in at least the tropical regions of the North Atlantic are relatively cool (i.e. the flow of cold deep water is also strong). A weaker AMOC means a negative (cool) AMO phase, with the opposite conditions prevailing. The AMO has been in a positive phase since the mid-1990's.

The Gulf Stream and the North Atlantic Oscillation

The North Atlantic Oscillation (NAO) is the periodic change in the difference in atmospheric pressure between a low pressure center around Iceland and a high pressure center around the Azores Islands, located about 900 miles west of Portugal. This oscillation affects the strength of the mid-latitude jet stream, with positive NAO phases (greater pressure difference) resulting in a stronger jet stream. During the winter, the jet stream "blocks" Arctic air masses from entering the lower latitudes. Winters in the U.S. are much harsher when this "blocking" mechanism is weaker (i.e. the NAO is negative). In Chicago, for example, there are on average three times as many days each year when the temperature drops below zero degrees Fahrenheit during negative phases, versus positive phases. The position of the Gulf Stream, which is a component of the thermohaline circulation, appears to affect the NAO. Years when the Gulf Stream is in a more southerly position are years when the NAO index is n a negative phase, whereas years when the Gulf Stream shifts northward are years when the NAO index is in a positive phase. The NAO has been predominately positive for the past 30 years, and is currently negative.

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