Ocean current system seems to be approaching a tipping point

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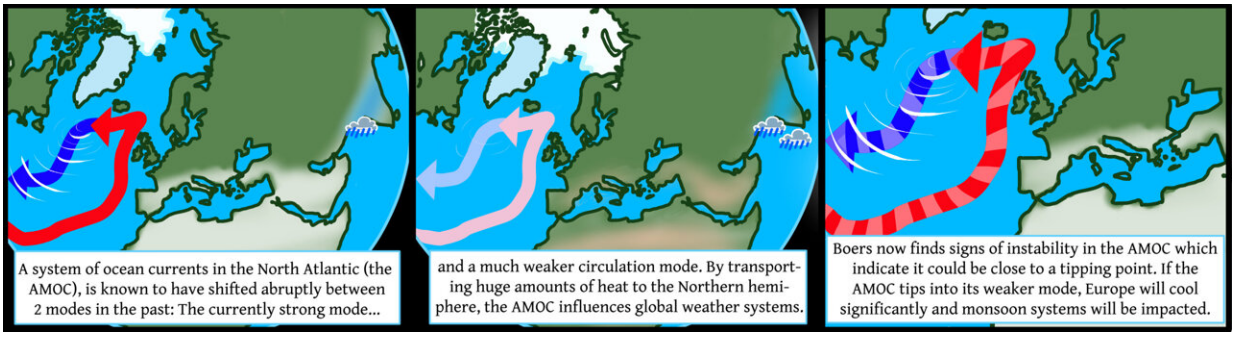

Signs of instability in ocean current system. Credit: TiPES/HP

The Atlantic Meridional Overturning Circulation (AMOC) may have been losing stability in the course of the last century, a new study by Niklas Boers, published in *Nature Climate Change*, suggests. The finding is worrying as well as a surprise. The AMOC, to which also the Gulf stream belongs, is responsible for the relatively mild temperatures in Europe and influences weather systems worldwide. A collapse of this ocean current system, which has so far not been considered likely under the current levels of global warming will therefore have severe consequences on global and especially European weather and climate. The study is part of the European TiPES project, coordinated by the University of Copenhagen, Denmark and the Potsdam Institute for Climate Impact Research, Germany.

Tipping the AMOC

The AMOC is the key circulation system of the Atlantic Ocean. It moves heat from the Tropical region to the Northern hemisphere by transporting warm water masses northward at the ocean surface, and returning as a cool current southward at the bottom of the ocean.

Model simulations and data from so-called paleoclimate proxy records suggest that the AMOC can be in two distinct modes: A strong mode, which is currently attained—and an alternative, substantially weaker mode of operation. This bi-stability implies that abrupt transitions between the two circulation modes are in principle possible.

At its weakest

Because the AMOC redistributes heat, it influences weather patterns globally. A collapse from the currently attained strong circulation mode would therefore—among other impacts—cool Europe substantially as well as strongly impact the tropical monsoon systems.

It has been shown previously that the AMOC is currently at its weakest in more than 1000 years. However, so far it has remained unclear whether the observed weakening only corresponds to a change in the mean circulation state, or whether it is associated with an actual loss of dynamical stability.

"The difference is crucial. Because the loss of dynamical stability would imply that the AMOC has approached its critical threshold beyond which an abrupt and potentially irreversible transition to the weak mode could occur," says Niklas Boers, author of the study.

Fingerprints of a collapse

Long-term observational data of the strength of the AMOC does unfortunately not exist. But the AMOC leaves so-called fingerprints in sea-surface temperature and salinity patterns of the Atlantic ocean. It is a detailed analysis of these fingerprints that now suggests that the AMOC weakening during the last century is indeed likely to be associated with a loss of stability, and thus with the approaching of a critical threshold beyond which the circulation system could collapse.

The finding is not only worrying but also quite surprising as an abrupt transition of the AMOC has so far been expected to occur at global warming levels much higher than the current 1.2 degrees Celsius.

"Most evidence suggests that the recent AMOC weakening is caused directly by the warming of the northern Atlantic ocean. But according to our understanding, this would be unlikely to lead to an abrupt state transition. Stability loss that could result in such a transition would be expected following the inflow of substantial amounts of freshwater into the North Atlantic in response to melting of the Greenland ice sheet, melting Arctic sea ice and an overall enhanced precipitation and river runoff," Boers explains.

Freshwater inflow and especially Greenland meltwater runoff has indeed accelerated in the last decades. However, although a first sign of regional destabilization of the Greenland Icesheet has been detected, recent Greenland runoff should not be sufficient for destabilizing the AMOC.

To understand this in-depth we need to find ways to improve the representation of the AMOC and polar ice sheets in comprehensive Earth system models and to better constrain their projections. I hope that the results presented here will help with that!" Boers concludes.

More information: Observation-based early-warning signals for a collapse of the Atlantic Meridional Overturning Circulation, *Nature*

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