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Possible irreversible changes to sub-systems prior to reaching climate change tipping points

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Recently a pair of researchers with the University of Copenhagen published a paper in the *Proceedings of the National Academy of Sciences* describing their work looking into the possibility of changes to the Atlantic Meridional Overturning Circulation (AMOC) and the circumstances that could lead to such changes. In their paper, Johannes Lohmann and Peter Ditlevsen noted that climate models show that irreversible changes to sub-systems such as the AMOC, one of Earth's global sub-systems, can occur prior to a tipping point if changes occur at a fast pace.

They further noted that fresh water pouring into the Atlantic Ocean due to melting ice could result in just such an irreversible change. More recently, an international team of climate scientists has published a Perspectives piece, also in *PNAS*, outlining the harm that could result if irreversible changes occur prior to tipping points, and also what models suggest will happen if the Earth does start to reach certain tipping points.

In climate science, tipping points are climatic milestones that occur when changes are made to the worldwide ecosystem that result in other permanent changes. If too much carbon dioxide is injected into the atmosphere, for example, at some point, it would become too hot for animals to survive. Climate models suggest that under such scenarios, there is no turning back. Once a tipping point is reached, we cannot solve the problem by stopping carbon emissions. More recent research has suggested that there may be some pre-tipping points that could trigger climate changes on a smaller scale but which would still be irreversible. Fresh, cold water entering the North Atlantic, for example, could result in permanent changes to the AMOC. Notably, the AMOC is responsible for the mild temperatures in Europe.

In their paper, the authors of the Perspectives piece describe likely outcomes of different scenarios that could lead to pre-tipping point sub-system changes. They note, for example, that the world's oceans comprise sub-systems. In addition to rising water levels, the world's oceans are experiencing acidification due to carbon dioxide absorbed from the atmosphere. Acidification harms sea life. Additionally, prior research has shown that the upper part of the ocean absorbs heat from the atmosphere at a much higher rate than lower regions. The lower regions are only now beginning to feel the effects of warming, a long-term event that could change the entire underwater ecosystem—a change that would be irreversible.

The good news is that the researchers with the AMOC study and the authors of the Perspectives piece all agree that it is not too late to prevent such scenarios from unfolding. All that is needed to stop greenhouse gas emissions, and then for scientist to focus their energies on those parts of the planet that have already been harmed.

More information: Christoph Heinze et al. The quiet crossing of ocean tipping points, *Proceedings of the National Academy of Sciences* (2021). DOI: 10.1073/pnas.2008478118

Journal information: Proceedings of the National Academy of Sciences