Study reveals crucial role of mixing Atlantic and Arctic waters in global ocean circulation

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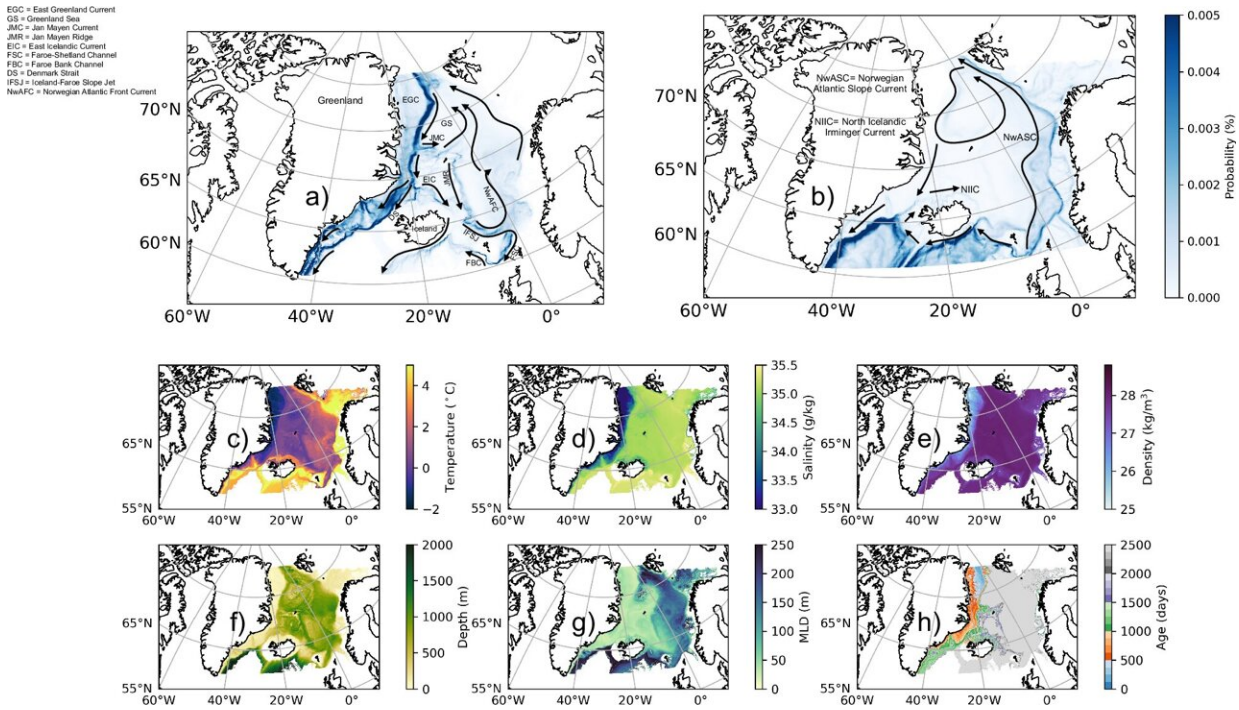

Lagrangian water transport pathways and the value of tracers along with it. Credit: *Nature Communications* (2024). DOI: 10.1038/s41467-024-51777-w

A new study sheds light on the vital role that the mixing of Atlantic and Arctic waters plays in sustaining the Atlantic Meridional Overturning Circulation (AMOC), which is crucial for regulating Earth's climate.

Researchers from the University of Southampton, the Indian Institute of

Technology Bhubaneswar, the National Oceanography Center and Stockholm University analyzed ocean data from 1979 to 2021 to better understand how the mixing of Atlantic and Arctic waters helps to maintain the AMOC.

The AMOC acts like a giant ocean conveyor belt moving warm water from the tropics north and cold water south, distributing heat around the planet. It helps to keep Northern Europe, including the U.K., relatively mild compared to other regions at similar latitudes.

The study, published in *Nature Communications*, found that the lower limb of the AMOC—the part of this "conveyor belt" consisting of deep, cold, dense water flowing southward in the Atlantic Ocean—is composed of 72 percent Atlantic waters and 28 percent Arctic waters.

"As the warm water reaches the cooler regions of the North Atlantic, it loses heat to the atmosphere, becomes denser, and sinks to great depths," explains Dr. Dipanjan Dey , lead author of the paper from the, who undertook the research as a postdoctoral researcher at the University of Southampton.

"We found that while some of this dense water immediately returns south, much of it travels northward, where it mixes with colder, fresher Arctic waters in regions like the Denmark Strait, between Iceland and Greenland. This mixing process makes the waters even denser before they too flow southward, contributing to the AMOC's strength."

The researchers estimate that the mixing of Atlantic and Arctic waters is responsible for 33% of the transformation of warm, salty, water into colder, fresher and denser water, with 67% attributed to interactions between the ocean and the atmosphere.

The study challenges previous assumptions that focused mainly on heat

loss in specific areas without accounting for the critical role of Atlantic-Arctic water mixing.

Models predict that the AMOC could slow down as the planet warms due to climate change. A weaker, shallower AMOC circulation, as happened during the last Ice Age, has major consequences for global climate patterns.

The new insights into the role of the mixing of Atlantic and Arctic waters help us to better understand these processes.

Professor Robert Marsh, a co-author on the paper from the University of Southampton, explains, "As the ocean surface warms and becomes fresher, the resulting increase in stratification (layering of water) hinders this crucial mixing between Atlantic and Arctic waters. This reduced mixing weakens the AMOC by decreasing the density and depth of its southward flow, potentially leading to an overall slowdown of the circulation.

"A slowdown in circulation of the AMOC would have major consequences, from much colder temperatures in Northern Europe to sea level rises along the eastern coast of the United States. If it weakens significantly, there could be abrupt, dramatic, and potentially irreversible changes to our planet's climate."

A weaker, shallower AMOC could also shorten the time carbon dioxide stays in the ocean before being released back into the atmosphere, potentially accelerating climate change and its impacts.

"Climate models need to accurately represent these water mixing processes to better predict future climate scenarios," says Dr. Dey. "Our study highlights the complex interplay between our climate and global ocean circulation processes. We need to urgently address global warming

to avoid crossing potential tipping points where the circulation could slow down significantly, or even collapse."

More information: Dipanjan Dey et al, Formation of the Atlantic Meridional Overturning Circulation lower limb is critically dependent on Atlantic-Arctic mixing, *Nature Communications* (2024). DOI: 10.1038/s41467-024-51777-w

Provided by University of Southampton