SRM360

Strategic Climate Risks Initiative

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Prepared by SRM360 and the Strategic Climate Risks Initiative

SRM & the AMOC

The Atlantic Meridional Overturning Circulation (AMOC) is a major system of ocean currents that is at risk of collapse due to climate change. What impacts would this have and could sunlight reflection methods (SRM) help?

Key messages

A crucial system

The AMOC plays a vital role in the Earth's climate, bringing heat northwards from the equator.

A potential shutdown

The AMOC is weakening due to climate change, and its collapse this century cannot be ruled out. Such a collapse would have devastating impacts globally.

A possible intervention?

Studies suggest that SRM could play a role in tackling the risks of AMOC collapse, but there are large uncertainties and any deployment would bring new risks and side effects.

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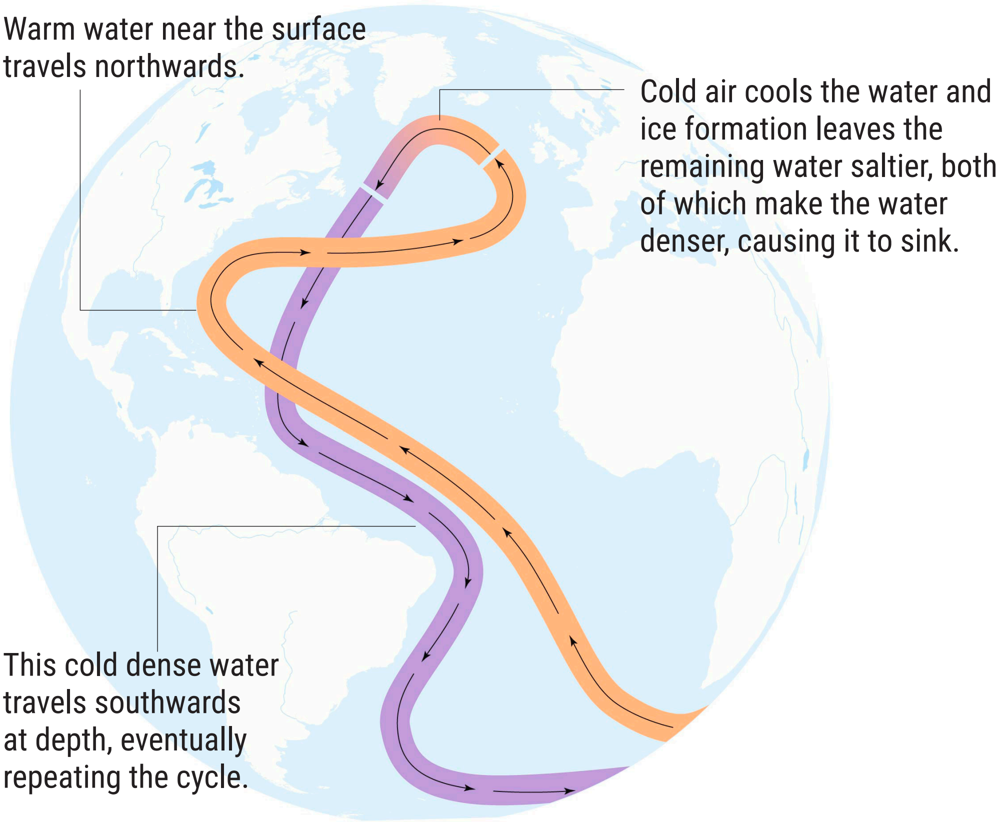
A view of the Atlantic Ocean from the coast of Iceland.
(Oriental Image via Reuters Connect)

What is the AMOC?

The AMOC is a major system of ocean currents spanning the length of the Atlantic Ocean. Warm water flows northwards close to the surface and cools, eventually sinking near Greenland before returning southwards at depth. The circulation is driven by differences in saltiness and temperature. The AMOC is sometimes confused with the Gulf Stream, a surface-level, largely wind-driven current that makes up a part of the AMOC.

Atlantic Meridional Overturning Circulation (AMOC)



Source: Woods Hole Oceanographic Institution

The heat transported by the AMOC plays a significant role in determining the climate across large parts of the world, particularly for northwestern Europe.[1] The AMOC also carries nutrients that marine life and fisheries depend on.[2]

Could the AMOC collapse?

Scientists study the AMOC's strength through direct and indirect measurements and computer modelling. It has remained relatively stable for thousands of years,[3] though it may have weakened in recent decades.[4]

The Coast of Maine, USA (Karen Focht/ZUMA Press Wire)

As the climate warms due to greenhouse gas emissions, increasing ice melt in Greenland adds fresh water to the North Atlantic Ocean, which reduces the water's saltiness. This – along with rising ocean temperatures, increased precipitation, and reduced ice formation – leaves the water less dense and slows the rate of its sinking, weakening the overall flow of the AMOC.

This weakening could worsen to a point where feedback mechanisms make its shutdown unavoidable – known as the AMOC tipping point.[5] If this tipping point were reached, the shutdown could unfold over 50-100 years.[6]

Projections show that the AMOC will likely weaken by over 30% this century,[4] but the risk of its collapse remains highly uncertain.[1] Studies have found a range of results, from the AMOC reaching its tipping point within decades[7] to remaining weakened but stable even under high emissions scenarios.[8]

What would the impacts be?

While the impacts of AMOC collapse are still uncertain, studies suggest severe effects at a planetary scale, including:

- **Changes to Europe's climate –** Reduced northward heat transport could cause temperatures across Europe to drop significantly – by 5–15°C (9–27°F) in some regions according to one study[9] – while other parts of the world could warm. Parts of Europe could also become far drier and stormier.[10]

- **Shifts in rainfall patterns –** Regional rainfall and tropical monsoons could be drastically impacted due to the changing temperature balance between the hemispheres.[11] For example, the Amazon rainforest could see its wet and dry seasons swapped.[1]

- **Impacts on food production –** The combined impacts of climate change and AMOC collapse could halve the suitable growing area for wheat and maize crops.[12]

- **Regional sea level rise –** Some coastal regions, such as the US East Coast, could see sea levels rise by over 70 cm (about 2 ft 4 in) as circulation changes redistribute the water.[9]

- **Loss of marine life –** Regional losses of marine biomass could exceed 30% as nutrient transport is impacted, affecting both marine ecosystems and food systems that millions of people rely on.[2]

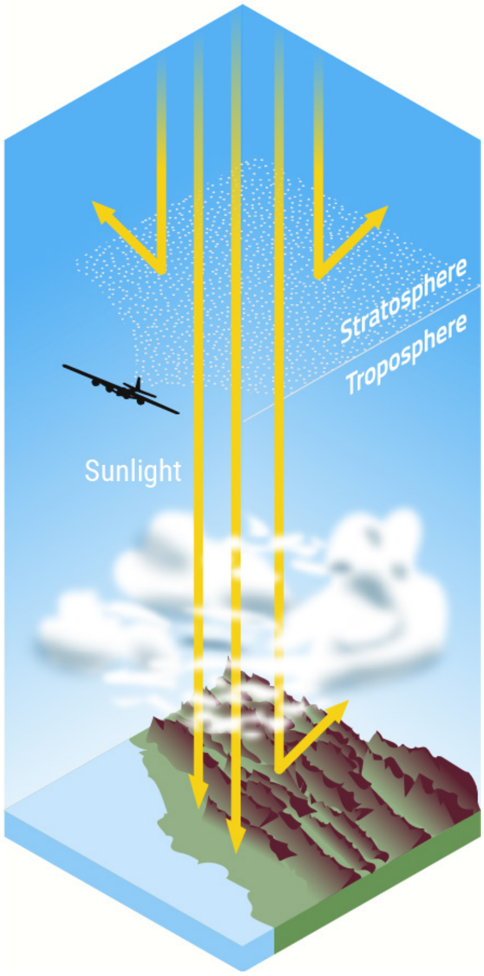
These physical impacts would have knock-on effects across social and economic systems, potentially creating destructive consequences far in excess of the initial physical damage.[13]

Given these impacts and their exposure, Iceland recently declared the potential collapse of the AMOC as a national security risk.[14] Meanwhile, the Nordic Council of Ministers sponsored an expert workshop to explore responses to AMOC risk. It recommended that there be continued research into climate intervention technologies – in addition to decarbonisation and adaptation – to address this risk.[15]

What are these technologies, and could they help?

How could SRM affect the AMOC?

Sunlight reflection methods (SRM), also known as solar geoengineering, are a set of potential approaches to cool the planet by increasing the amount of sunlight the Earth reflects back to space. If deployed wisely – and as a complement to, not a substitute for, emissions reductions, carbon removal, and adaptation – they could reduce many impacts of climate change, but they come with new risks and challenges.



The most researched approach is stratospheric aerosol injection (SAI), which would use high-flying jets to create a global layer of tiny reflective particles.[16]

There are a limited but growing number of studies that explore how SRM could affect AMOC risks. The uncertainties are large.[17]

Several studies suggest that SAI could be effective at reducing the weakening of the AMOC by cooling the ocean and limiting the added fresh water from ice melt.[18, 19] However, the impacts are not well understood and depend on how and where it is deployed.[19] Studies have also suggested that SAI could reduce the risk of the AMOC collapsing,[20,21] though it might not be able to reverse its shutdown once that process begins.[22]

Some research shows that SAI could overcompensate the AMOC's weakening, causing strengthening,[21] and that the increased heat transport could offset a substantial portion of its cooling effect in Iceland.[23]

SAI, and SRM more generally, also face a broader set of issues and challenges...

Issues & challenges

While SRM could reduce many climate impacts, it raises several concerns, including side effects and governance challenges.

Physical effects

- SAI could reduce the rainfall changes expected under climate change overall, but could worsen them in some places.[24] Deployed unevenly, SRM could produce substantial shifts in rainfall patterns.

- SAI could delay the recovery of the ozone hole and add a little to air pollution, though these risks may be small compared to the benefits of reduced heat.[25]

Sociopolitical concerns

- There is a concern that advancing SRM would undermine efforts to cut emissions, known as mitigation displacement or moral hazard.[26]

- SRM deployment would have impacts across the world and countries might not cooperate to make decisions fairly or effectively.[27] The benefits and risks of SRM would be uneven, which could increase tensions between countries.[28]

- Large-scale SRM would need to be reliably maintained, as an abrupt and long-lasting stop would cause a "termination shock" - a rapid increase in temperature with devastating effects for the planet.[29]

Thus, any decision on SRM must balance the risks it might alleviate against those it may drive. The potential to delay or stave off the AMOC tipping point could play a role in those deliberations, especially given the severe consequences of its collapse.

Additional reading

Learn more about sunlight reflection methods at SRM360.org — https://srm360.org

Check out our introductory guides:
https://srm360.org/guide/why-consider-srm/

Appendix

Endnotes

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About SRM360

SRM360 is a non-profit knowledge broker dedicated to informing people about sunlight reflection methods – or solar geoengineering – so they can contribute to critical decisions about its research, development, and governance.

About the Strategic Climate Risks Initiative

The Strategic Climate Risks Initiative (SCRI) is a think-and-do tank that builds tools and capabilities to navigate the new climate reality as complex environmental-driven risks escalate.