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Climate tipping points and investor implications

The AMOC Tipping Point: Implications for Financial Risk and Portfolio Resilience

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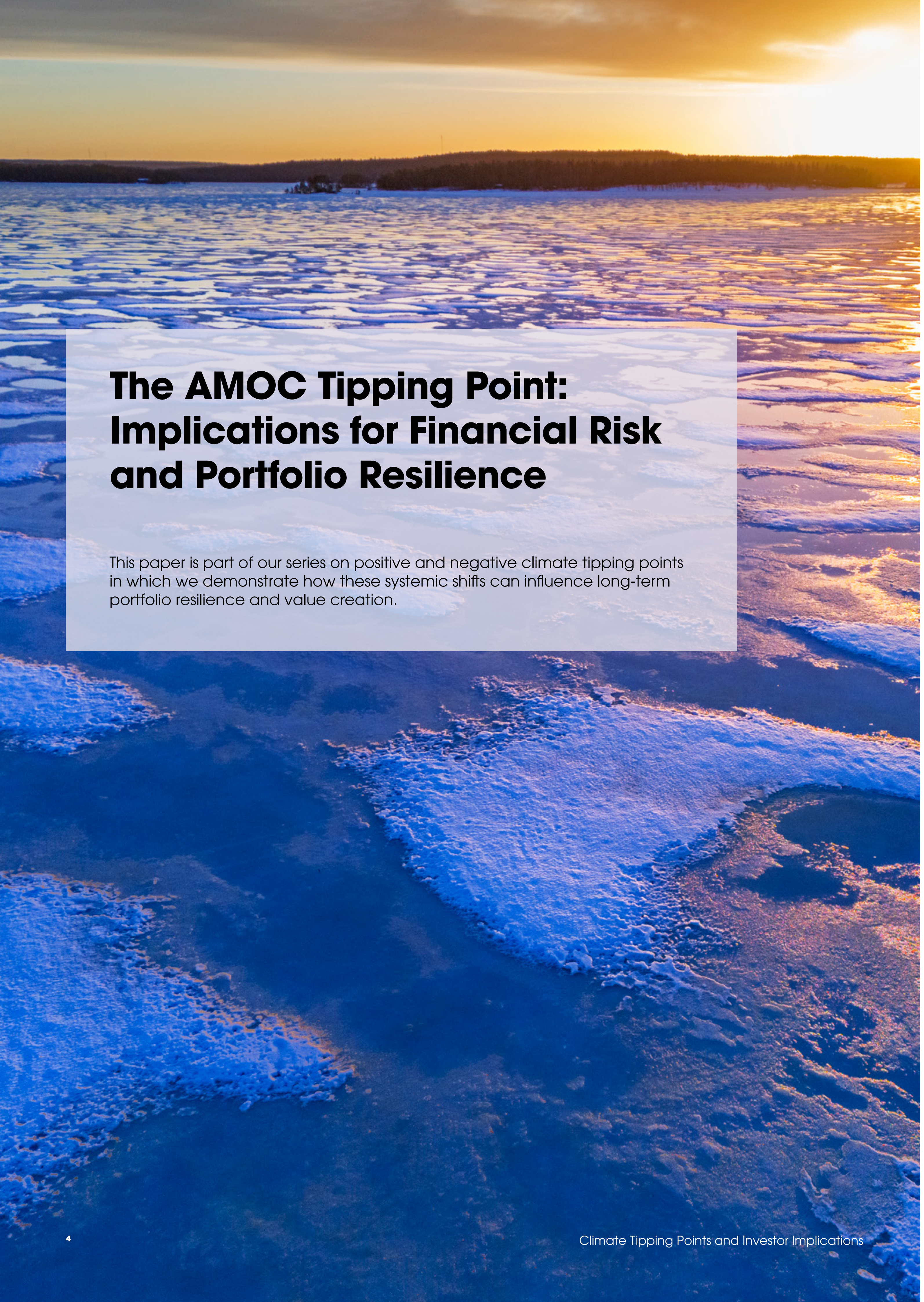

The AMOC Tipping Point: Implications for Financial Risk and Portfolio Resilience

This paper is part of our series on positive and negative climate tipping points in which we demonstrate how these systemic shifts can influence long-term portfolio resilience and value creation.

1
Introduction

The sustained weakening, and potential collapse, of the Atlantic Meridional Overturning Circulation (AMOC) is a critical but underpriced risk. While collapse is a low-probability, high-impact event, even the more likely reality of a gradual weakening could trigger abrupt and cascading climate and economic disruptions within investable timeframes. To protect long-term portfolio resilience, we present several recommendations for investors throughout this paper, including the need to integrate findings from non-linear Earth systems science into investment and climate risk strategies.

Investors should treat changes in the AMOC as a highly material, long-term financial risk. This means focusing on gradual shifts in ocean temperature, salinity, and current strength rather than reacting to short-term data spikes. Monitoring these trends can provide early warning windows of 5–15 years for potential AMOC weakening or collapse, giving investors time to adjust portfolios accordingly.

Combining the theory outlined within this paper with near-term outlooks, investors are advised to stress test portfolios for risk exposure both around the Atlantic and globally, shifting capital away from vulnerable assets and into investments aligned with the low-carbon transition to mitigate risk accordingly.

2

AMOC's role in global natural cycles and potential tipping points

The Atlantic Meridional Overturning Circulation (AMOC) is a large system of ocean currents that transports water within the Atlantic Ocean towards the Earth's poles. As warm surface water travels from the tropics northward, it cools, becomes denser, sinks in the North Atlantic, then flows back southward at depth, eventually resurfacing and warming again. This process is displayed in Figure 1.

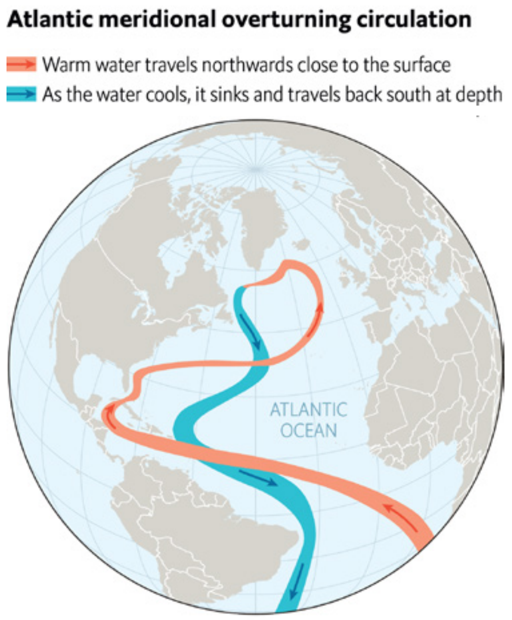

Figure 1. Source: Potsdam Institute for Climate Impact Research; Met Office.

What does it do?

Every second, the AMOC transports 30 million cubic meters of water, which is more than all the terrestrial rivers of the world combined.

This circulation regulates global heat, accounting for 90% of the total northward ocean heat transport across the Atlantic and influencing the 1-2°C temperature difference between the Northern and Southern hemispheres. It also transports dissolved gases from the surface to the deep ocean, influencing how much CO_2 remains in the atmosphere, as well as circulating nutrients and microscopic organisms vital for ocean biodiversity.

Finally, the AMOC northwardly shifts the Intertropical Convergence Zone, a band of low pressure that encircles the Earth and influences the strength of thunderstorms and heavy rain in the tropics. Overall, the AMOC plays a crucial role in regulating the Earth's climate, carbon cycle and water cycle.

How is it regulated and what is disrupting it?

The AMOC is driven by differences in temperature and density between warm tropical waters and cold North Atlantic waters. It is particularly sensitive to changes in the North Atlantic where surface water must cool and sink to drive the circulation. Climate change weakens the AMOC's drivers by warming North Atlantic waters and adding freshwater from melting ice and increased rainfall. This reduces the temperature and salinity differences needed for water to sink and circulate, a process known as "salt transport feedback".

As sinking slows, so does the AMOC. This can disrupt major ocean currents, reduce the ocean's ability to absorb carbon dioxide and leave more greenhouse gases in the atmosphere thereby accelerating climate change in a harmful feedback loop. This cycle is visually depicted by Figure 2 and raises clear long-term financial implications for investors.

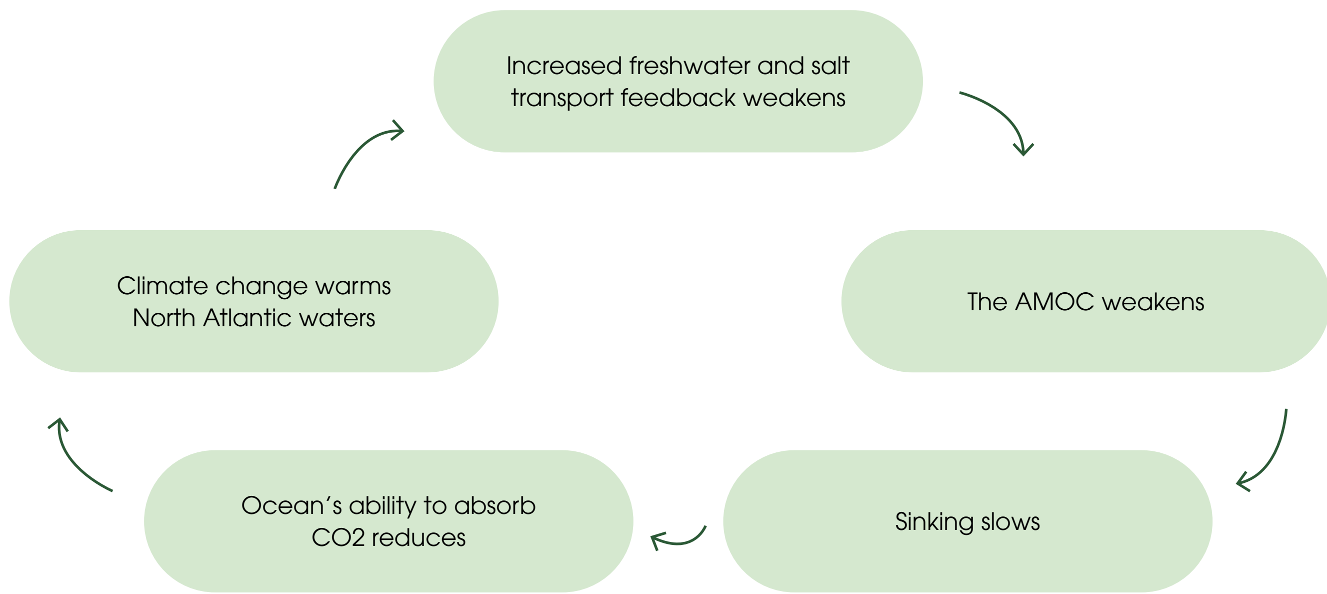

Figure 2. The AMOC and the negative climate feedback loop.

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Forecasting the AMOC's limits under global warming scenarios

Historical records evidence that the North Atlantic is a region where rapid climatic variations can occur. Paleo-records also show the AMOC has abruptly switched between stronger and weaker states during recent glacial periods over timescales that span decades rather than centuries or millennia.

This has resulted in some of the most dramatic and abrupt climate shifts on record. It also means that if the AMOC was to switch into another state the effects would be fully felt within short-term investible time scales.

While the probability of collapse is still subject to ongoing research and is considered low compared to continued weakening, the high-impact nature of such a tipping event makes it an important risk to consider.

Direct measurements of the AMOC's strength only began in 2004, which limits certainty about its future. While this emphasises the need for continued monitoring and cautious debate, early warning indicators suggest the AMOC is approaching critical thresholds, with its decline being recorded by both the Global Tipping Points Report[1] and the Intergovernmental Panel on Climate Change (IPCC), as shown in Figures 3 and 4.

[1] Global Tipping Points Report 2025

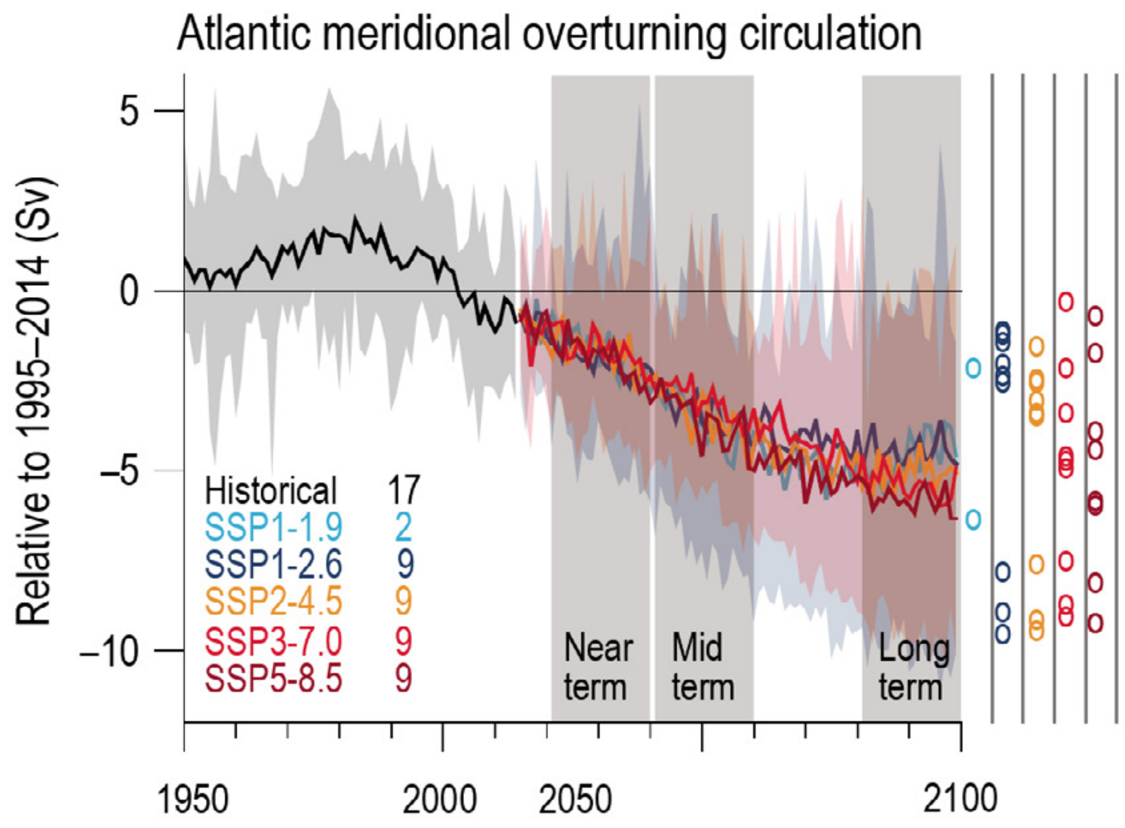

Figure 3. Source: IPCC, Climate Change 2021: The Physical Science Basis.

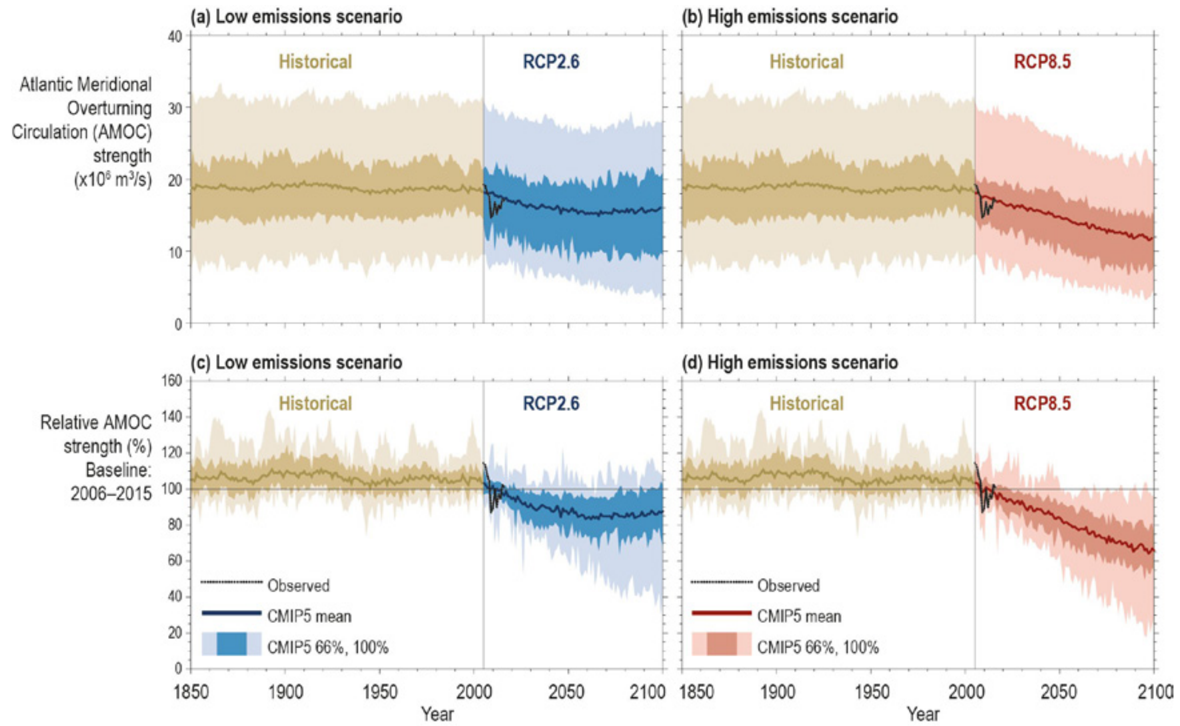

Figure 4. Source: IPCC, Special Report on the Ocean and Cryosphere in a Changing Climate.

The IPCC's latest assessment report[2] (AR6) confirms that the AMOC has weakened since its strong 1850–1900 state and forecasts that it is "very likely" to weaken further this century under all plausible warming scenarios. This is because any amount of warming will make it tougher for North Atlantic waters to cool and sink. While a full collapse is currently considered less likely than continued weakening, the potential for abrupt and severe impacts from this tipping point makes it a critical risk that should not be overlooked by investors.

Older climate models often fail to capture the complex interactions that could trigger a full collapse, including interactions between global warming trends, temperature, salinity, and freshwater inflows, alongside links and feedback loops with other tipping points in the global system. More recent research[3] is attempting to address these gaps via the use of proxy estimates, and findings increasingly suggest the AMOC could reach a tipping point this century if global warming trends continue.

The most widely cited threshold for collapse is around 4°C warming above pre-industrial levels, and this is corroborated by leading research . However, the most conservative models suggest a tipping point could occur at warming as low as 1.4°C, a level which has already been recorded based on the global average surface temperature by the World Meteorological Organization in 2024.

The potential for an accelerated collapse of the AMOC means investors cannot afford to be reactive. After all, climate risk management strategies require planning for worst-case scenarios in addition to best-case outcomes.

Even under medium-confidence forecasts, the AMOC could collapse within 15 years, well within typical investment horizons and investors should consider the possibility that such a disruption could occur within this timescale.

Aside from global temperature modelling, monitoring the AMOC's strength will involve a mixture of observational and proxy indicators that reflect ocean circulation stability. Scientists already have technologies located in the Atlantic Ocean measuring various indicators in real-time, including temperature, salinity, and current strength, which can infer early changes to the AMOC's state. However, the AMOC's substantial size means short-term fluctuations can occur naturally and that the whole system responds slowly to these forces i.e. confirming long-term changes to the AMOC's strength takes many years.

"Climate risk management strategies require planning for worst-case scenarios in addition to best-case outcomes"

[2]IPCC Sixth Assessment Report
[3]e.g. Boers, 2021 and Ditlevsen & Ditlevsen, 2023
[4]McKay et al, 2022

"At current global emissions rates, we will exceed the carbon budget for 4°C of warming within 70 years"

Time horizons under different scenarios of AMOC collapse

Taking the most widely cited threshold for AMOC collapse of around 4°C warming above pre-industrial levels, we can approximate the cumulative emissions needed to reach this point. Based on the IPCC's AR6 and its SSP5-8.5 emissions scenario analysis[5], this "very high emissions scenario" could be a reality in the latter half of this century.

At the current global emissions rate of 37 gigatons CO2 per year[6], we will exceed the total carbon budget for 4°C (estimated to be in the range 2,600–3,300 gigatons CO_2) within roughly 70 years.

Existing literature specifically focused on AMOC collapse suggests that it is more likely we will reach a tipping point in the mid-21st century. Once this threshold is exceeded, models estimate the collapse will occur over 50 years, though confidence intervals remain broad for both estimates.

The timeline for reaching a tipping point for the AMOC could well shorten. For example, if global greenhouse gas emissions rise at a higher rate than anticipated due to a failure of climate policy, or if interactions and feedback loops with other climate tipping points (such as permafrost thawing) prove to have a greater than anticipated impact.

Despite the complex and non-linear nature of predicting AMOC collapse, it is vital that financial systems recognise and plan for different scenarios. Given the potential for collapse within this century, as well as the non-linear, high-impact and irreversible consequences, AMOC collapse represents a material risk for pension funds, sovereign wealth funds and other long-term investors. While this analysis is focused on the most likely outlook for AMOC collapse, it is also important to consider the short-term (0-15 years) implications of AMOC weakening.

[5]IPCC AR6, Chapter 4: Future Global Climate: Scenario-based Projections and Near-term Information
[6]based on 2024 Statista data

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Cascading, irreversible and global consequences

According to Professor Johan Rockström, lead author of the Planetary Boundaries framework, the collapse of the AMOC presents one of the greatest Earth systems risks we face due to the probability of its occurrence and the severity of associated impacts.

The IPCC supports this statement, arguing that if AMOC collapse was to occur it would "very likely cause abrupt shifts in the regional weather patterns and water cycle, such as a southward shift in the tropical rain belt, and could result in weakening of the African and Asian monsoons, strengthening of Southern Hemisphere monsoons, and drying in Europe".

For Western Europe and the UK, the AMOC currently transports warm water from the tropics northward, contributing to the relatively mild climate in this region. A collapse would disrupt this process and would likely result in significant regional cooling, which contrasts with global warming trends due to complex ocean-atmosphere interactions. At the same time, it is expected to cause an increase in winter storms.

Coastal regions, such as the UK and the US East Coast, could face accelerated sea level rise caused by changes in ocean heat distribution and thermal expansion, as well as altered Arctic Sea ice and permafrost distribution. Marine ecosystems would also be at threat of collapse as the transportation of key nutrients and oxygen to the deep ocean would be disrupted. In short, a collapse of the AMOC would have devastating, global consequences.

[7] IPCC AR6, Chapter 8: Water Cycle Changes

Even without a full collapse, continued AMOC weakening over the next 0–15 years is expected to have material financial consequences. For example, disrupted monsoon systems will likely intensify, affecting agriculture, water security, and economic stability in key regions. As such, exposure to changing AMOC dynamics within the next 15 years remains a strategically important consideration for portfolio risk management decisions today.

Likewise, any substantial weakening of the AMOC in the medium-term is projected to cause widespread impacts similar to those predicted for a full collapse. This includes a decrease in marine productivity, increased storm frequency in Northern Europe, less Sahelian and South Asian summer rainfall, and an increase in regional sea levels across the Atlantic[8].

Beyond regional effects, changes to the AMOC (i.e. weakening and collapse) could influence global climate feedback loops by altering heat and moisture distribution, as well as carbon dioxide uptake. This would impact the frequency and intensity of extreme weather events as well as major climate phenomena such as El Niño and the Indian Ocean Dipole. These effects would reshape economies, infrastructure resilience, and insurance liabilities, all of which are increasingly critical but still broadly underrepresented in global asset allocation decisions[9].

"A collapse of the AMOC would have devastating, global consequences"

[8] e.g. Liu et al, 2020, Boot et al, 2025 and Showstack, 2023
[9] Waidelich, Klaaßen and Steffen, 2024

5

Interlinkages with other negative climate tipping points

The risks associated with AMOC collapse should not be viewed in isolation. The interconnected nature of negative climate tipping points amplifies systemic risk, making a sustained weakening or collapse of the AMOC not just an isolated issue, but a non-linear and portfolio-wide risk.

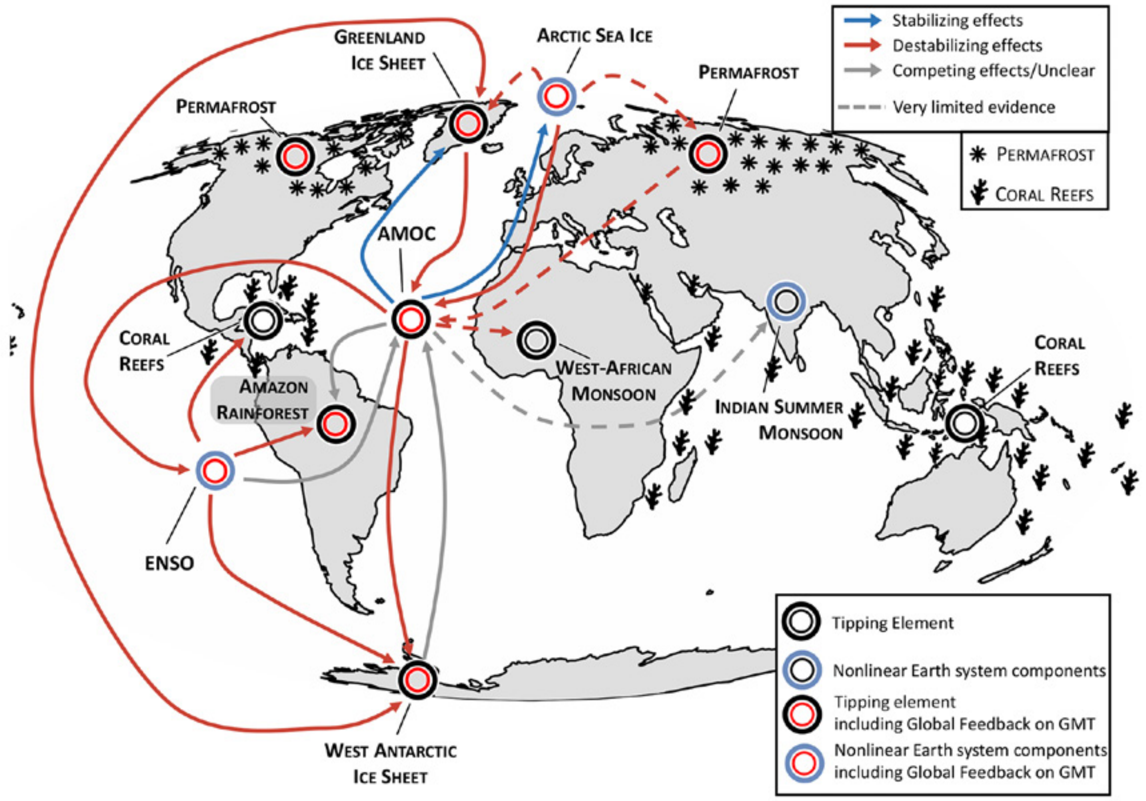
As shown in Figures 5 and 6, these interactions between the AMOC and other climate tipping points mostly have destabilising effects that can create cascading failures if linked elements weaken. While scientific understanding is still evolving, existing research reveals these feedback loops could be triggered under current warming pathways, making them critical for long-term risk assessment.

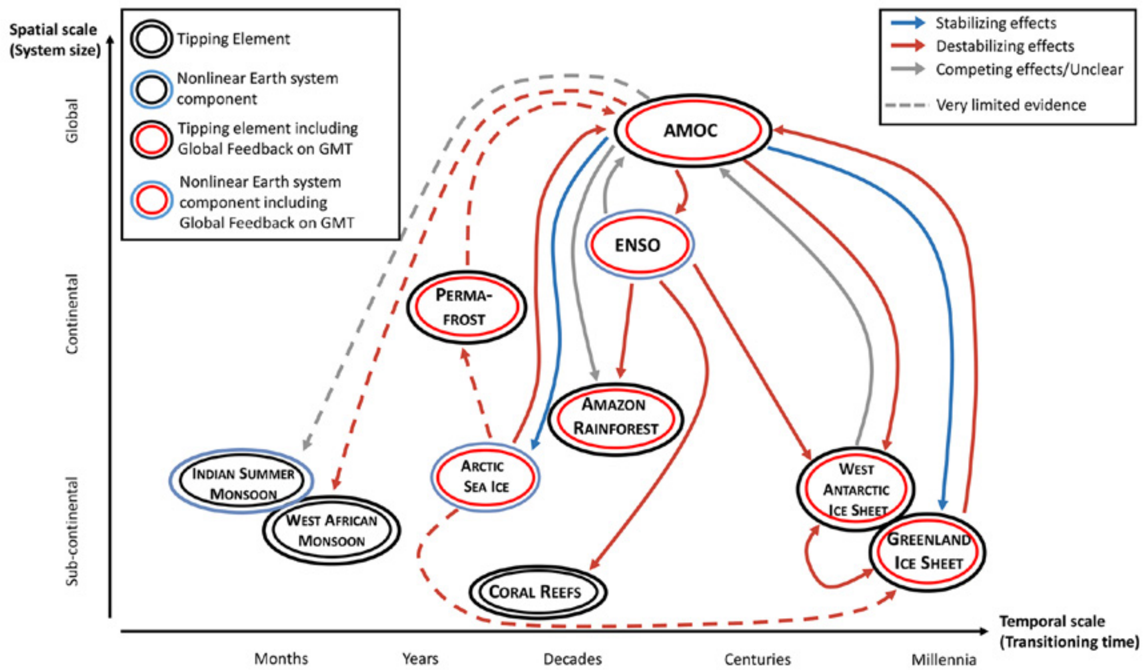
For example, a weakened AMOC affects global atmospheric circulation and trade winds, influencing the El Niño–Southern Oscillation (ENSO), a significant driver of annual climate variability. This can also displace the Intertropical Convergence Zone southward, disrupt monsoons, and intensify ENSO extremes. Shifting rainfall, heat distribution and wind patterns create significant knock-on effects for tropical ecosystems such as the Amazon. In recent years, extreme El Niño events, combined with global warming, have already driven severe drought, heat stress and dieback in the Amazon rainforest.

AMOC decline is also linked to tipping elements such as the stability of Arctic Sea ice and the Greenland ice sheet. Since 1993, melting from Greenland ice alone has released an additional 5000 km3 of freshwater into the North Atlantic, further weakening the AMOC.

This, in turn, may accelerate melting of the West Antarctic Ice Sheet through increased warming of the Southern hemisphere, creating reinforcing negative feedback loops. Conversely, North Atlantic cooling could help stabilise the Greenland ice sheet, though this interaction alone is unlikely to reverse ice melt entirely or cancel out other destabilising interactions.

These interactions highlight the complex, non-linear nature of climate tipping points. For investors, this means acknowledging that risks are not isolated and that a consideration of systemic climate risks is essential.





Figures 5 and 6. Source: Wunderling et al, Climate tipping point interactions and cascades: a review.

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What are the risks to investors today?

A resilient economy is one which maintains stability while adapting to environmental and social stresses. Long-term resilience is reinforced by aligning with the principles of sustainable development, which depends on the stability of Earth systems, including climate regulation. The AMOC, alongside other critical tipping elements such as the Amazon rainforest and polar ice sheets, plays a key role in regulating the climate, carbon cycle and water cycles.

Many financial models still rely on assumptions of gradual change and long-term stability, which can lead to systemic risk being mispriced across sectors and geographies. While some approaches attempt to capture non-linear dynamics, modern risk models often underweight the possibility and cascading impacts of abrupt climate tipping points[10]. This underestimation creates blind spots for investors regarding the potential for sudden disruptions to climate systems, asset values and economic stability.

Of the existing economic assessments of AMOC collapse, many have narrowly focused on its cooling effect on the Northern Hemisphere, shown in Figure 7, with a few studies suggesting potential short-term economic benefits. However, this framing overlooks more severe consequences. For instance, AMOC weakening impedes the ocean's capacity to absorb carbon dioxide, accelerating global warming and amplifying associated economic damages. Based on existing climate-economic modelling[11], this negative feedback loop could result in trillions of dollars in damages by 2100.

Direct physical impacts are particularly acute for financial risk analysis and asset valuation. In the case of AMOC weakening and collapse, these risks are both severe and geographically widespread.

Sea level rise

Accelerated sea level rise around the Atlantic basin (up to 70cm under an AMOC collapse scenario) could severely affect major urban and financial centres such as London and New York. This would damage coastal infrastructure, raise insurance premiums, and disrupt international trade.

"Many financial models still rely on assumptions of gradual change and long-term stability, which can lead to systemic risk being mispriced across sectors and geographies"

[10]Waidelich, Klaaßen and Steffen, 2024
[11]e.g. Dietz et al, 2021

Portfolios with exposure to coastal real estate, port infrastructure, and property insurers therefore risk valuation declines and higher liabilities. To fully understand and respond to these risks, investors should use appropriate engagement tools to encourage companies to disclose the extent of coastal flood exposure and their associated risk management strategies in these regions. In addition, investors can minimise risk by shifting capital towards adaptive infrastructure (e.g. flood-resistant buildings and energy grids) and resilient supply chain hubs.

Heat distribution

Dramatic shifts in heat distribution present another critical risk. As shown in Figure 7, a severe weakening of the AMOC could lead to regional cooling. Historically, observers have recorded drops as large as 15°C in parts of the Northern Hemisphere due to massive freshwater inputs abruptly weakening the AMOC. If this were to occur within forecasted time horizons, agriculture, energy systems, and labour productivity could be strained within decades by rapid cooling and drying.

Resulting food inflation, energy demand volatility, and productivity shocks would hit earnings across agriculture, utilities, and manufacturing. When applying this to financial models, investors are encouraged to factor in higher regional energy demand volatility and labour costs, while stress-testing food system exposures, particularly across Northern Europe.

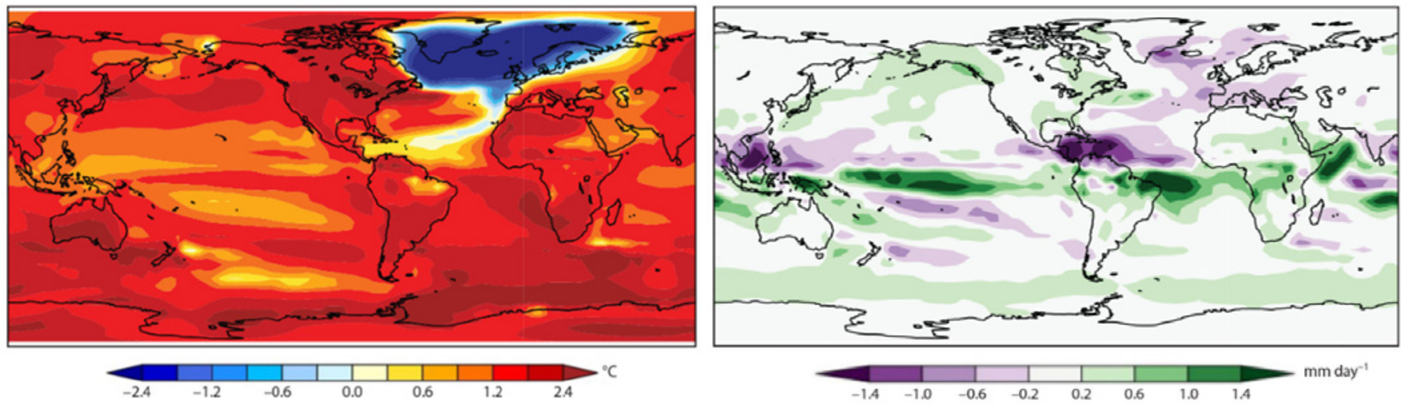

Figure 7. Source: Rahmstorf, S, Is the Atlantic Overturning Circulation Approaching a Tipping Point?

[8]e.g. Liu et al, 2020, Boot et al, 2025 and Showstack, 2023
[9]Waidelich, Klaaßen and Steffen, 2024

“AMOC weakening and collapse presents both a localised and systemic threat, capable of undermining global economic resilience and asset valuations”

Looking beyond the Atlantic

When considering the future of food and water systems, it is important to consider that the systemic risks associated with a weakening AMOC create consequences far beyond the Atlantic. Within oceans, disruptions to nutrient and oxygen cycles could trigger fisheries collapse in upwelling-dependent regions such as West Africa and South America, which rely on deep and nutrient-rich waters rising to the surface. This could threaten the supply chains of global seafood markets.

Meanwhile on land, shifts in precipitation patterns across Central and South America would destabilise agricultural production, creating volatility in global commodity markets. A southward shift in the Intertropical Convergence Zone would also disrupt monsoon patterns, threatening water security and staple crop production in regions home to over half the world’s population, including the African Sahel and parts of Asia. The changes to global precipitation patterns are displayed in Figure 7.

These interconnected shocks would create cascading impacts on both agriculture and aquaculture supply chains, disrupting corporate earnings across water-dependent sectors and driving food inflation significantly. Portfolios should therefore be stress-tested not just around the Atlantic but globally.

Companies should be engaged on risk exposure and resilience strategies across their operations and value chains, while capital should be directed toward diversified supply chains, climate-resilient agriculture, and water-efficient technologies. The economies of countries in climate-sensitive regions that are heavily dependent on agriculture face particular losses, meaning investors should further consider the risks to emerging market sovereign debt allocations.

AMOC weakening and collapse presents both a localised and systemic threat, capable of undermining global economic resilience and asset valuations. This requires investors to integrate these climate tipping-point risks into portfolio risk management and strategic allocation decisions.

7

Summary and recommendations for investors

The ongoing weakening and potential collapse of the AMOC are not just theoretical climate scenarios, they are blind spots in systemic risk management that continue to grow.

If global emissions follow a "very high" pathway leading to 4°C of warming, the most widely cited collapse threshold for the AMOC, then irreversible feedback loops could be triggered across Earth's systems. Widespread climatic changes would undermine global food security, drive mass migration, and increase the likelihood of conflict over resources. For investors, these consequences would be difficult to fully hedge against through investments, insurance, or adaptation solutions. Those who fail to account for these potentially abrupt and compounding impacts risk exposure to widespread losses.

Even without full collapse, a sustained weakening of the AMOC could still lead to systemic consequences. These include destabilised global value chains, sustained price volatility, and heightened corporate and sovereign default risk, particularly in exposed and fiscally constrained regions. The period prior to complete collapse, currently projected to unfold over the next 25 years, may also bring transition risks as markets reprice exposed assets such as coastal infrastructure, utilities, and manufacturing.

For investors looking to build long-term portfolio resilience to the risks of AMOC weakening and collapse, this will involve shifting from traditional financial models using linear global warming projections and integrating non-linear Earth system science into investment and climate risk management strategies.

Stress-testing portfolios over investible time periods should involve assessing a wide set of sectors (e.g. real estate, agriculture, insurance) under the identified impacts of sustained AMOC weakening. For example, investors may consider sea level rise and more frequent storm surges around the Atlantic basin as a key risk to property developers or insurers operating in coastal regions across the UK and USA.

Investors should monitor for research studies that flag multi-year changes to influences (e.g. temperature, salinity, current strength) in the North Atlantic, while avoiding overreacting to short-term data anomalies. In addition, investors should follow indicators related to interlinked tipping points. Tracking these indicators can provide early warning windows (i.e. 5–15 years) for potential AMOC weakening or collapse, reflecting necessary timescales for portfolio risk adjustments.

By applying this knowledge to specific holdings within portfolios, investors can mitigate potential losses by adjusting underlying investment exposure or by using engagement to encourage investees and policymakers to better understand and manage climate tipping point risks.

Ultimately, the most effective way to avoid these risks is to help stabilise the AMOC by reducing global greenhouse gas emissions. This will require aligning with a low-carbon transition. Policy responses may increasingly target high-emission sectors, accelerating asset repricing and the risk of stranded investments. Investors have a key role to play by reallocating capital, engaging companies on credible transition plans, and supporting innovation in low-carbon technologies, actions that can both protect portfolios and strengthen systemic resilience.

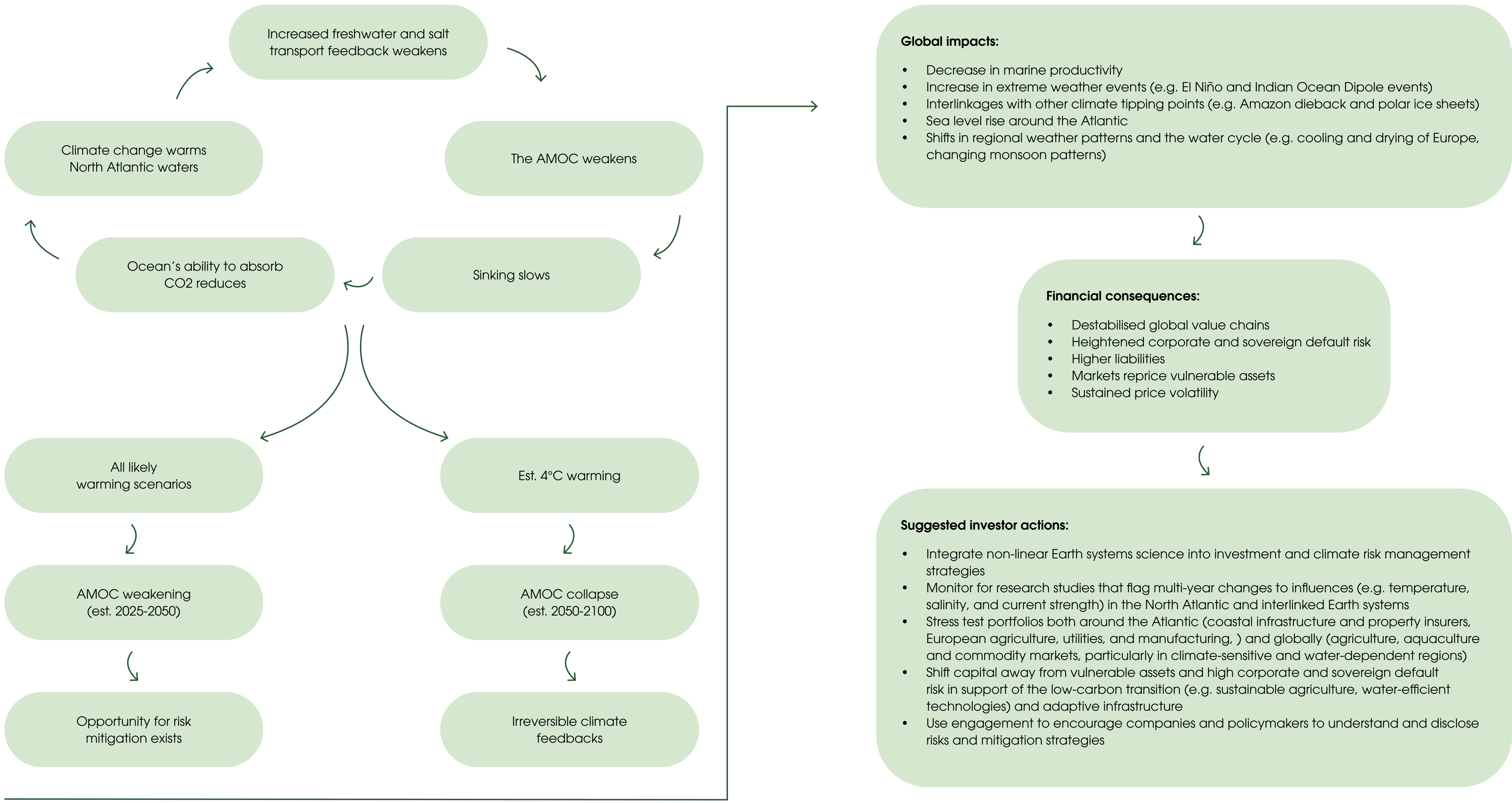

Figure 8. Investor risk pathways, from AMOC collapse to portfolio risks.

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