

ATLANTIC MERIDIONAL OVERTURNING CIRCULATION: GEOGRAPHY

NEWS: Europe faces deep winter freeze if Atlantic current collapses, study finds

WHAT'S IN THE NEWS?

The Atlantic Meridional Overturning Circulation (AMOC), a key ocean current system regulating global climate, is weakening due to climate change, with potential catastrophic impacts like colder European winters and disrupted global rainfall patterns.

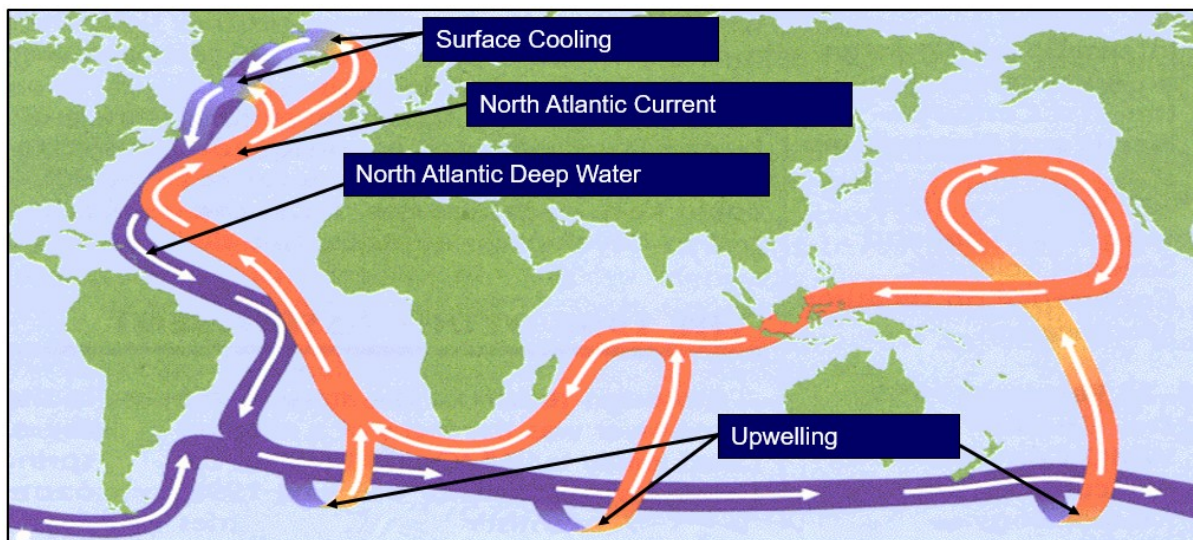
Its collapse may trigger a major climate tipping point, altering monsoon systems, sea-level rise, and oceanic heat distribution.

Context and Trigger

- A recent climate study warns that the potential collapse of the Atlantic Meridional Overturning Circulation (AMOC) could lead to extreme winter conditions in Europe, despite global warming.
- The warning comes amid growing concerns about Earth's approaching climate tipping points due to anthropogenic global warming.

About AMOC (Atlantic Meridional Overturning Circulation)

- AMOC is a vital component of the Earth's global climate system.
- It acts like a massive conveyor belt in the Atlantic Ocean, transporting warm surface waters from tropical regions toward the North Atlantic, and returning cold, dense water toward the south.
- The process maintains the heat balance across continents and supports marine ecosystems, sea-level regulation, and weather stability.



Working of AMOC

- Part of the global thermohaline circulation.

- Warm, salty water travels northward via currents such as the Gulf Stream.
- On reaching polar regions, the water cools and becomes denser, sinking into deeper ocean layers.
- This dense water flows back southward at the ocean's depths, completing the overturning cycle.
- This circulation redistributes heat and nutrients globally and moderates climate variability.

Current Status and Threats to AMOC

- Scientific models show AMOC has slowed significantly since the mid-20th century.
- Projected to weaken by 18–43% by the end of the 21st century under current climate change trends.
- Melting of Greenland's ice sheet adds large volumes of freshwater into the North Atlantic, reducing the salinity and density of ocean water—critical drivers of AMOC.
- This disruption threatens to destabilize the overturning mechanism of the AMOC.

Tipping Point of AMOC

- A tipping point refers to a critical threshold beyond which a system undergoes drastic, often irreversible change.
- AMOC has two known tipping mechanisms:
 1. Salt-transport feedback: A reduction in salinity weakens the current and further reduces salinity—a self-reinforcing loop.
 2. Deep ocean convection breakdown: Disrupts the sinking process of dense waters, breaking the circulation loop.
- Crossing these tipping points could collapse AMOC entirely.

Climate Tipping Points

- Defined as thresholds where small perturbations can lead to dramatic system changes.
- Crossing a tipping point triggers irreversible feedback loops.
- Can lead to catastrophic disruptions across ecosystems, rainfall patterns, temperature regimes, and global hydrological cycles.

Earth System Components at Tipping Risk

- At least 16 major systems identified as vulnerable to tipping:
 - Greenland and West Antarctic Ice Sheets: Risk of rapid melt and sea-level rise.
 - AMOC: Disruption of global heat balance.

- Amazon Rainforest: Potential dieback due to moisture loss and deforestation.
- Arctic Permafrost: Methane and CO₂ release upon thawing.
- Coral Reefs: Collapse due to ocean acidification and warming.

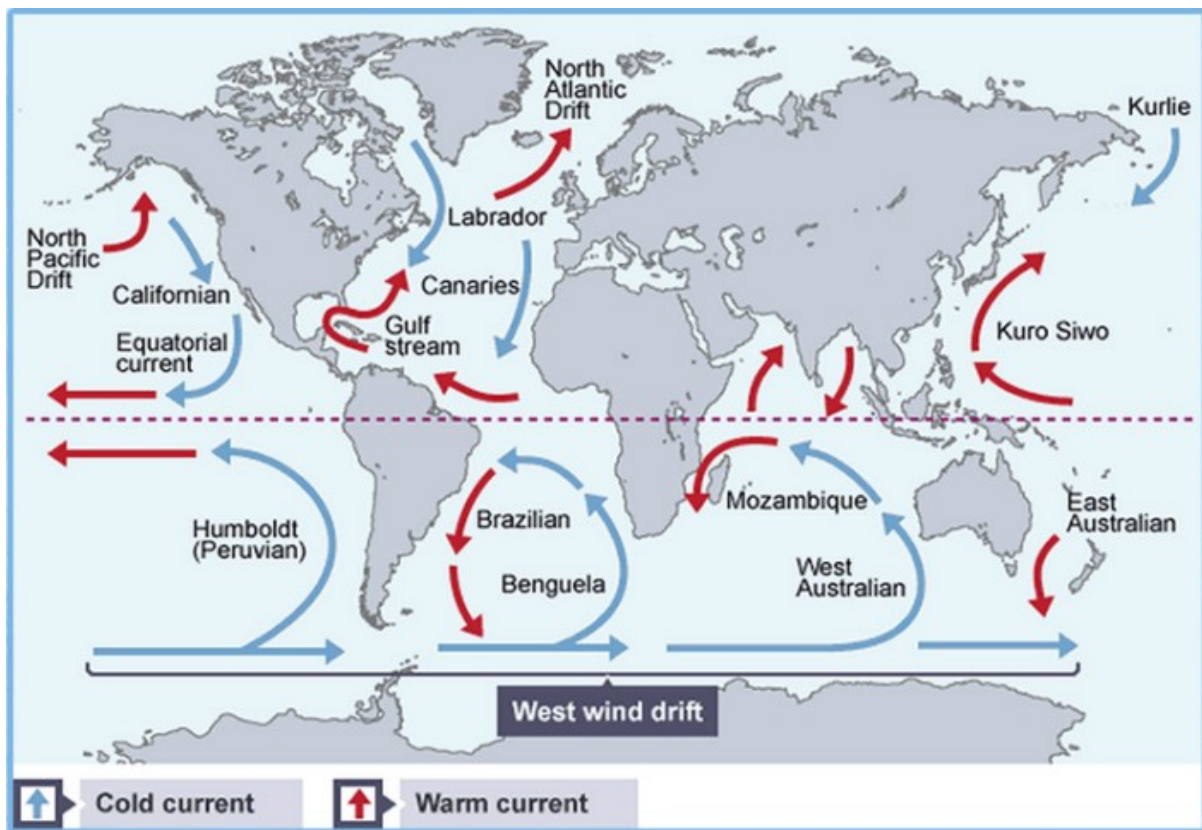
Potential Consequences of AMOC Collapse

- **Europe:** Colder winters and disrupted seasonal patterns due to cessation of warm ocean currents.
- **West Africa:** Monsoon weakening, adversely impacting agriculture and food security.
- **Eastern North America:** Accelerated sea-level rise due to thermal expansion and circulation change.
- **Amazon and South Asia:** Unpredictable rainfall and extended drought conditions.

Ocean Currents: Classification and Forces

- **Types:**
 - Surface Currents (driven primarily by wind and solar radiation).
 - Deep Water Currents (driven by thermohaline mechanisms—temperature and salinity).
- **Forces driving ocean currents:**
 - **Primary:** Wind, gravity, solar heating, and Coriolis effect.

- **Secondary:** Differences in water density due to temperature and salinity variations.



Conclusion

- AMOC plays a foundational role in regulating Earth's climate.
- Its weakening or collapse could have global ramifications, from sea-level rise and weather pattern disruption to ecosystem destruction.
- Urgent international climate action and mitigation strategies are essential to delay or prevent these outcomes.

Source: https://www.downtoearth.org.in/climate-change/europe-faces-deep-winter-freeze-if-atlantic-current-collapses-study-finds#google_vignette