Atlantic Meridional Overturning Circulation

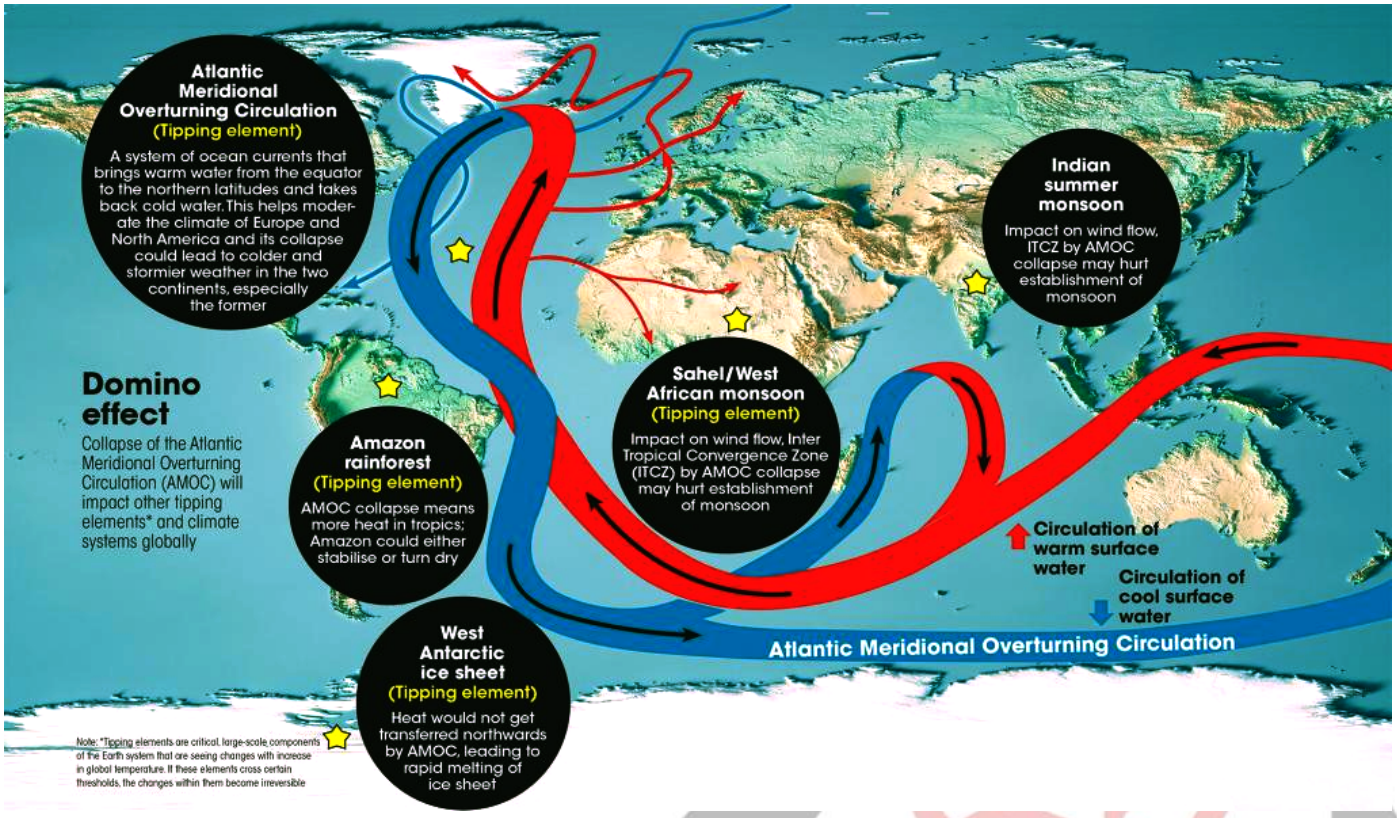
Source: DTE

Why in News?

The **Atlantic Meridional Overturning Circulation (AMOC)** is at risk of imminent collapse, with recent studies indicating that **anthropogenic emissions** could expedite this between **2025 and 2095.**

What is AMOC?

- **About:**
  - AMOC is a large-scale oceanic circulation system that transports **warm surface waters from the tropics** to the northern latitudes and returns cold, deep waters from the **North Atlantic** back towards the equator.
    - It plays a crucial role in redistributing heat globally, influencing regional and global climates, especially moderating temperatures in Europe, North America, and near the Equator.
- **Mechanism:**
  - **Warm Water Transport:** AMOC transports warm, salty surface waters from the tropics to the northern regions. These warm waters carry heat energy, contributing to the **warming** of regions like Europe.
  - **Cooling and Density Increase**: As the warm surface waters move towards the poles, they gradually cool due to heat loss to the atmosphere. Also, cold, fresh water from the melting ice of the **Arctic** is added to the cooler ocean.
  - **Downwelling:** Once cooled, the dense, cold water sinks to deeper layers of the ocean in a process known as downwelling.
    - This downwelling occurs primarily in the **North Atlantic Ocean,** where the dense water mass forms and begins its southward journey.
  - **Southward Flow:** The cold, dense water flows southward along the ocean floor, traversing vast distances across the Atlantic basin.
    - This southward flow represents the **deep limb of the AMOC**, where cold, dense water mass redistributes heat and nutrients throughout the ocean.
    - As the water resurfaces, it begins to warm up again, completing the circulation cycle of the AMOC.



- **Role of Indian Ocean:** As the **Indian Ocean warms** faster and faster, it **generates additional precipitation.** This draws more air from other parts of the world to the Indian Ocean, including the Atlantic. With so much precipitation in the Indian Ocean, there will be **less precipitation in the Atlantic Ocean.**
    - Less precipitation will **lead to higher salinity in the waters of the tropical portion of the Atlantic —** because there won't be as much rainwater to dilute it.
    - This saltier water in the Atlantic, as it comes north via AMOC, will get cold much quicker than usual and sink faster.
    - This would act as a jump start for AMOC, intensifying the circulation.
- **Contribution to Global Climate:** This cycle acts like a **heat conveyor belt,** warming the northern latitudes and cooling the southern latitudes, contributing to the overall stability of the Earth's climate.
- **Threat:** Rising precipitation and accelerated melting of the **Greenland ice sheet** have introduced more cold freshwater into the North Atlantic.
    - This influx has lowered water salinity and density, causing the colder ocean layer to expand while the warmer layer contracts.
    - Consequently, the AMOC is slowing down, posing a risk of collapse.
    - Also, anthropogenic activities, such as **greenhouse gas emissions,** can influence ocean temperatures and circulation patterns, further affecting the AMOC.
- **Potential Cascading Effects:**
    - AMOC collapse may **alter precipitation patterns,** potentially destabilizing the **southern Amazon rainforest** and transforming it into a savannah-like ecosystem.
    - Increased ocean heat in the southern hemisphere could accelerate the melting of the **West Antarctic ice sheet,** exacerbating sea-level rise.
    - Weakening of monsoon circulation in regions like South Asia and Africa could have far-reaching consequences for agriculture**, water resources, and regional climates.**