



Ocean Circulation and Climate Change

Source: [SD](#)

Why in News?

Recently, a study published in Nature Communications has gained attention for its unexpected findings about the **ocean's role in [climate change](#)**.

- The study reveals that a **weaker ocean circulation might increase atmospheric CO₂ levels**, contrary to previous assumptions.

What is the Relation Between Climate Change and Ocean Circulation?

- **The Role of Overturning Circulation:** Ocean overturning circulation acts as a [global conveyor belt](#), moving water and nutrients across the ocean. It is a two-fold process.
 - As **surface waters absorb CO₂ and cool**, they become denser and sink into the deep ocean, **transporting carbon away from the atmosphere**.
 - **Deep waters upwell, bring nutrients and carbon** back to the surface, where they **support marine life** and help regulate atmospheric CO₂ levels.
- **Traditional Views on Ocean Circulation and Climate Change:** As climate change progresses, scientists predict a weakening of ocean overturning circulation due to various factors.
 - **Melting Ice Sheets:** Particularly around [Antarctica](#), melting ice sheets add freshwater to the ocean, disrupting circulation patterns.
 - **Temperature Changes:** [Global warming](#) affects ocean temperature gradients, further impacting circulation.
 - The traditional view is that weaker circulation would mean **less carbon is stored in the deep ocean**, but the ocean's carbon sink effect would **stay balanced due to less carbon coming back up**.
- **New Insights from Research:** New research reveals a **complex feedback mechanism involving ocean circulation**, iron availability, microorganisms, and ligands, showing that weaker ocean circulation could increase atmospheric CO₂ levels contrary to previous beliefs.
 - **Ligands are organic molecules** that bind with iron to keep it soluble and accessible for [phytoplankton](#) growth, but their **availability can limit the effectiveness** of iron fertilization efforts globally.
- **Implications for Climate Change Mitigation:** The study highlights the need to **reconsider the ocean's role in climate change mitigation**, as weaker ocean circulation could reduce [carbon sink](#) effectiveness, leading to higher atmospheric CO₂ and exacerbating global warming.

OCEAN WARMING

The ocean absorbs most of the excess heat due to global warming caused by greenhouse gas (GHG) emissions, leading to rising ocean temperatures

Increase in Ocean Temperature

1.2°C from 1950 to 2020

Projected to Future Increase

1.7°C to 3.8°C from 2020 to 2100

Causes of Ocean Warming (due to Global Warming)

- 🕒 **GHG Emissions:** Fossil fuels burning releases CO₂ and GHG
- 🕒 **Deforestation:** Lesser trees → More CO₂ & GHG → Global Warming → Warming of Ocean
- 🕒 **Industrial Activities:** Emit various pollutants that contribute to greenhouse effect
- 🕒 **Agricultural Practices:** Produces methane and nitrous oxide – potent greenhouse gases
- 🕒 **Heat Absorption by Oceans:** Oceans absorb ~90% of excess heat generated by GHGs

Impact of Ocean Warming

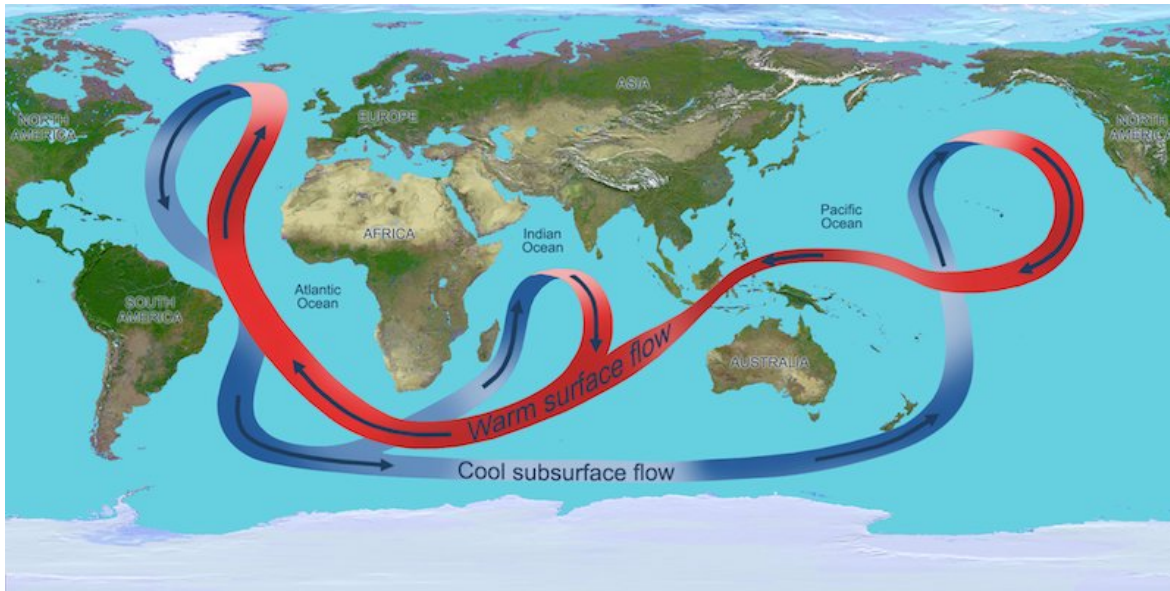
- 🕒 **Sea Level Rise:** Warmer water expands, causing sea levels to rise
- 🕒 **Coral Bleaching:** Corals expel the algae (zooxanthellae) living in their tissues and turn completely white
- 🕒 **Ocean Acidification:** Ocean absorbs ~1/4th of total CO₂ thus making it more acidic (non-metallic oxides - acidic in nature)
- 🕒 **Impacts on Marine Life:** Causes many marine species to shift towards the poles and disrupts food webs
- 🕒 **Impacts on Climate Patterns:** Influences atmospheric circulation patterns, such as El Niño and La Niña & extreme weather events



Drishti IAS

What is Meridional Overturning Circulation (MOC)?

- **Definition:** The [Meridional Overturning Circulation \(MOC\)](#) is a **crucial component of global ocean circulation**, moving water, heat, salt, carbon, and **nutrients primarily in the north-south direction** within and between ocean basins. It plays a **vital role in regulating the Earth's climate**.
- **Mechanism:**
 - **Northward Flow:** In the Atlantic Ocean, warm and salty surface water is transported from the South Atlantic **towards the Nordic Seas** (near Greenland, England, and Northern Canada). Here, it **cools, becomes denser**, and sinks to **form deep water currents** that flow southwards towards Antarctica.
 - **Antarctic Contribution:** Near Antarctica, **even denser waters are formed**. These waters flow north along the seafloor into the North Atlantic, where they **rise and mix with other waters** before flowing back to the south.
- **Significance:**
 - The MOC is responsible for about two-thirds of the oceanic **northward heat transport**, making it essential for climate regulation.
 - Changes in the MOC influence regional and global heat distribution, **affecting climate and weather patterns**.
- **Cycle Duration:** The entire circulation cycle of the MOC, also known as the **oceanic conveyor belt**, is **extremely slow**. It takes approximately **1,000 years** for a parcel (any given cubic meter) of water to complete its journey along the belt.



UPSC Civil Services Examination, Previous Year Question (PYQ)

Prelims:

Q. At the national level, which ministry is the nodal agency to ensure effective implementation of the Scheduled Tribes and Other Traditional Forest Dwellers (Recognition of Forest Rights) Act, 2006? (2021)

- (a) Ministry of Environment, Forest and Climate Change
- (b) Ministry of Panchayati Raj
- (c) Ministry of Rural Development
- (d) Ministry of Tribal Affairs

Ans: (d)

Q. Stiglitz Commission established by the President of the United Nations General Assembly was in the international news. The commission was supposed to deal with (2010)

- (a) The challenges posed by the impending global climate change and prepare a road map
- (b) The workings of the global financial systems and to explore ways and means to secure a more sustainable global order
- (c) Global terrorism and prepare a global action plan for the mitigation of terrorism
- (d) Expansion of the United Nations Security Council in the present global scenario

Ans: (b)

Mains:

Q. Assess the impact of global warming on the coral life system with examples. (2019)

