



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.

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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

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

Causes of Ocean Warming (due to Global Warming)

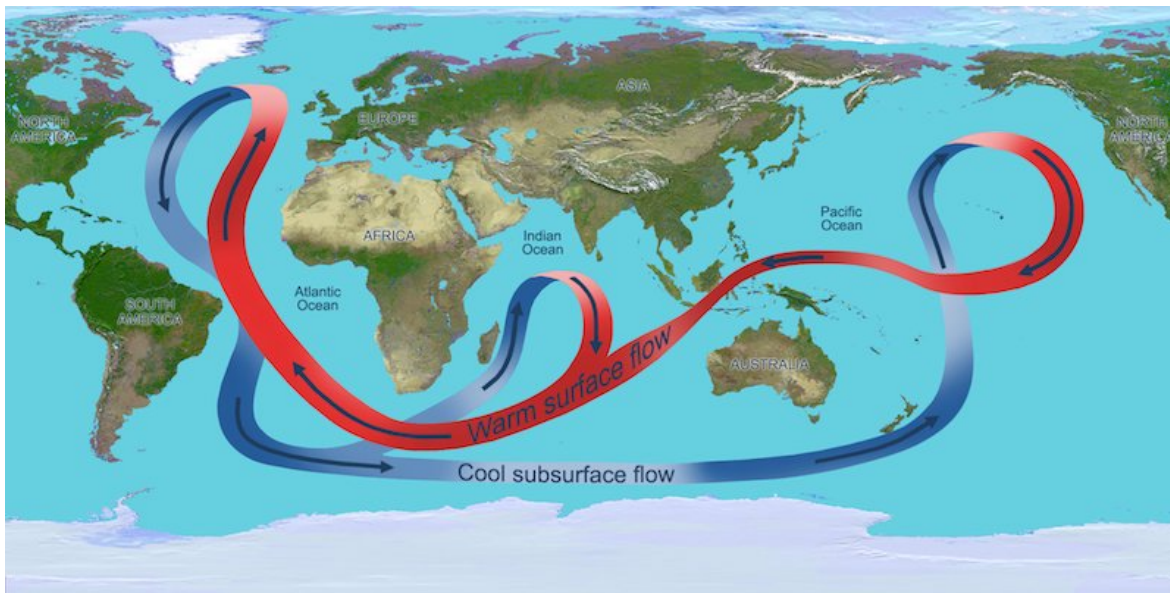
- ↳ **GHG Emissions:** Fossil fuels burning releases CO₂ and GHG
- ↳ **Deforestation:** Lesser trees → More CO₂ & GHG → Global Warming → Warming of Ocean
- ↳ **Industrial Activities:** Emit various pollutants that contribute to greenhouse effect
- ↳ **Agricultural Practices:** Produces methane and nitrous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



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)

