

CLIMATE CHANGE

HOW THE OCEAN SLOWS CLIMATE CHANGE

Without the ocean, climate change would proceed far more quickly. The massive volumes of water in the seas greatly influence the changes occurring in our atmosphere.

Climate change, particularly global warming, is mainly caused by the CO₂ we release into the atmosphere by burning fossil fuels like coal and oil. Since the beginning of industrialization in the 19th century the amount of CO₂ in the atmosphere has risen by 40 percent. CO₂ is a greenhouse gas. If not for the ocean, temperatures would be even higher than they are now. That is because the ocean currently absorbs a quarter of the CO₂ released into the air. The atmosphere and the ocean are linked by a self-balancing concentration gradient. When the concentration of CO₂ in the atmosphere rises, the ocean absorbs more to restore the balance. The colder the seawater is, the more effectively the process works.

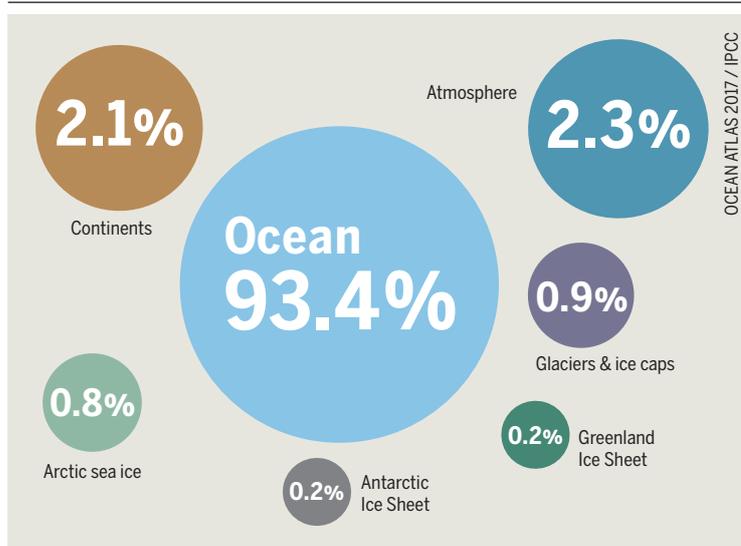
In the Labrador Sea and Greenland Sea as well as in regions near the Antarctic coast, large quantities of surface water sink into the deep sea where the CO₂ is stored for long periods of time. The lion's share of the CO₂ stored in this manner since the start of the Industrial Revolution will take centuries to return to the surface of the ocean again. Part of it will remain fixed in the sediment of the sea floor. That is how the ocean significantly slows climate change. The ability of the ocean to sequester CO₂ is not unlimited, though, and it varies. For example, while CO₂ absorption in the Southern Ocean declined between 1980

and 2000, it has increased in the years since. The ocean does more than absorb a considerable amount of our excess CO₂—it also soaks up nearly all of the additional warmth resulting from the manmade greenhouse effect. Over the last 40 years it has absorbed an astounding 93 percent of the excess heat—increased atmospheric temperatures are attributable to just three percent of this additional thermal energy and would be much greater if not for the ocean. The extra warmth is essentially hidden in the ocean, where it slowly spreads through the depths. Because of this, the surface temperature only increases at a snail's pace.

But all this has a price. Absorbing excess CO₂ leads to the progressive acidification of the ocean, while absorbing excess heat contributes to the rising sea level and troubling changes in marine ecosystems. And the warming of the oceans contains another risk: positive feedback loops. For example: when the rate of evaporation on the ocean surface increases, it produces more water vapor, which causes temperatures to rise, which causes the rate of evaporation to increase. That's because water vapor is a greenhouse gas like CO₂—in fact, it is even more effective than CO₂. In itself, that's not a bad thing: around two-thirds of the natural greenhouse effect, which has made the Earth inhabitable for millions of years, is caused by water vapor; only a quarter of it is caused by CO₂. But if we release too much CO₂ into the atmosphere, the feedback loop described above greatly amplifies its effects.

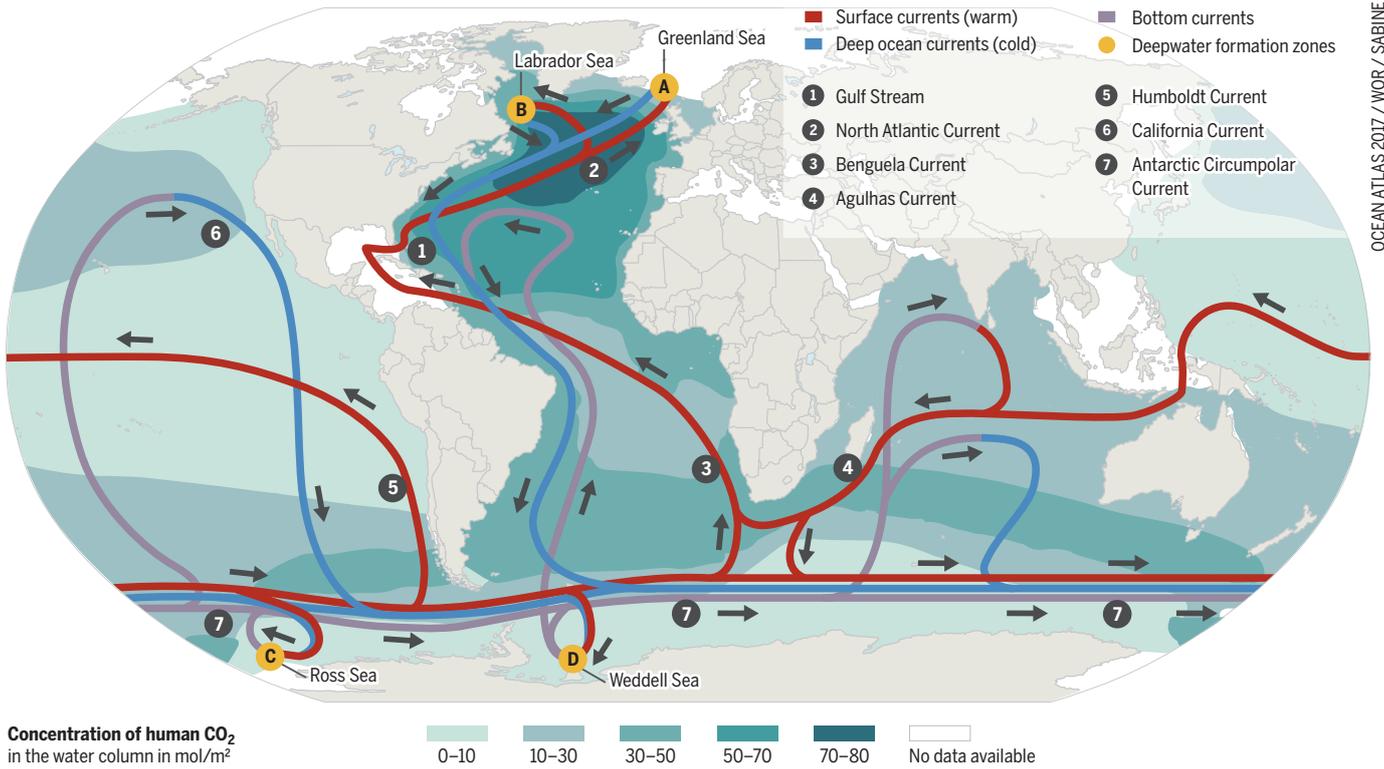
Another positive feedback loop is created by the melting of sea ice, which is also caused by rising temperatures. Arctic and Antarctic sea ice acts like a protective shield—it reflects up to 90 percent of the sun's rays. But because of the rising temperatures, the sea ice is continually shrinking. And where there's no ice in the ocean, there's water. Since water is dark it absorbs sunlight rather than reflecting it—up to 90 percent of it. As it does so, it warms up. The result: more ice melts. These positive feedback loops can accelerate global warming in ways that are difficult to predict—one more reason not to further burden the ocean system. For this reason, meeting the goal of limiting global warming to two degrees agreed, upon at the Paris Climate Conference, is essential. ●

Where Does the Warmth Go?



The ocean absorbs the lion's share of the additional warmth resulting from human CO₂ emissions, which supplements the natural greenhouse effect.

The Global Conveyor Belt—How the Ocean Stores CO₂

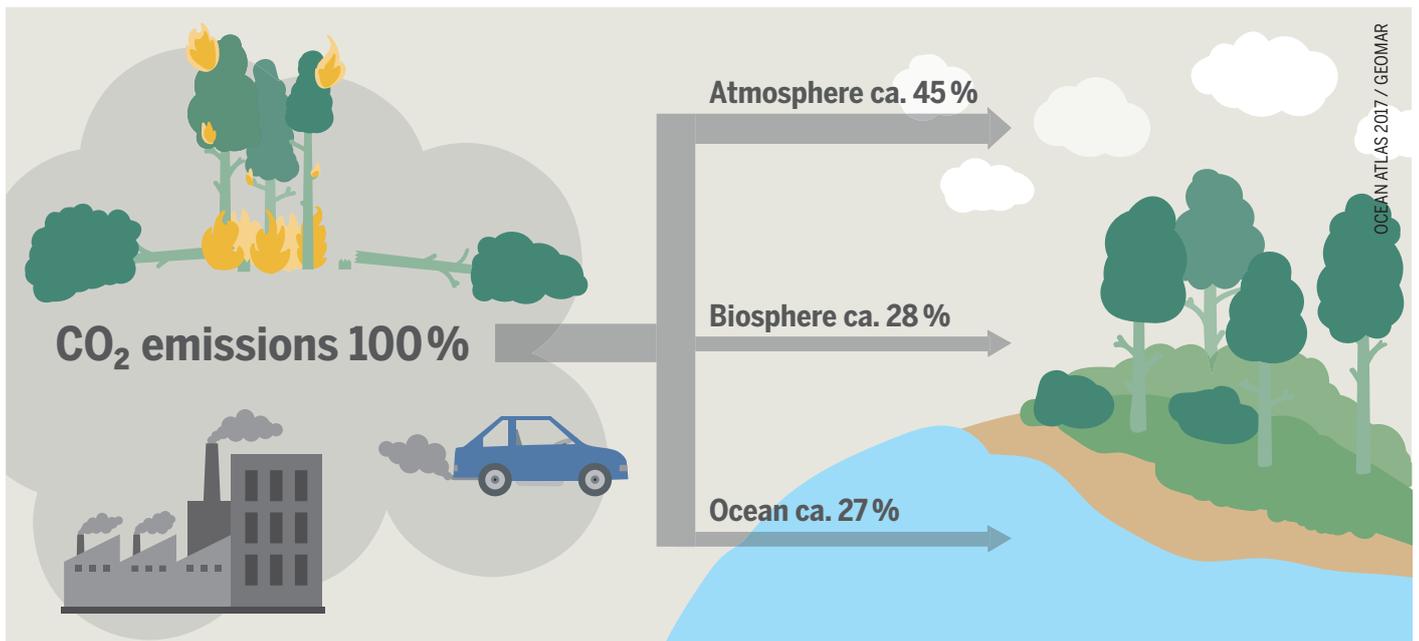


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CO₂ entrapment is made possible by large oceanic currents. Working like conveyor belts, they carry warm surface water, which absorbs CO₂ from the tropics in the Atlantic towards the colder poles. On the way, the water slowly cools and becomes saltier. When it arrives in the Greenland Sea **A**, the Labrador Sea **B**, and at the

Antarctic coast in the Ross Sea **C** and the Weddell Sea **D**, the heavy surface water sinks into the depths, taking the CO₂ with it. The CO₂-rich water then flows back towards the tropics. As it travels, the cold water slowly mixes with the warmer layers above and rises—very slowly—back to the surface.

Where Does the CO₂ Go?



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The CO₂ produced by people (i.e., in addition to natural emissions) is distributed as shown.