Oceans absorb 6% more carbon thanks to rain, study reveals

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The ocean plays an important role in the global carbon cycle by absorbing about one-quarter of the carbon emitted by human activities every year. A study published recently in *Nature Geoscience* and co-

authored by a University of Hawai‘i at Mānoa oceanographer revealed about 6% of the total uptake of carbon dioxide (CO_2) by the ocean is due to rainfall.

"The impact of rain on air-sea CO_2 fluxes hasn't been systematically examined, but understanding it gives us a more complete picture," said David Ho, study co-author and professor in the UH Mānoa School of Ocean and Earth Science and Technology.

"This is especially important since rainfall patterns over the ocean are expected to shift with climate change, and that could impact the ocean carbon sink."

Ocean, atmosphere exchanges

Exchanges between the ocean and the atmosphere are governed by chemical, physical, and biological properties and processes. Rainfall alters these properties of the ocean surface, promoting the exchange of CO_2 between the air and the sea.

Rain impacts this carbon exchange in three different ways. First, as it falls on the ocean surface, it generates turbulence that facilitates water just below the surface being in contact with the atmosphere. Secondly, it dilutes the seawater at the surface, altering the chemical equilibrium within the oceanic carbon cycle and enabling seawater to absorb greater quantities of CO_2. Finally, raindrops directly inject into the ocean the CO_2 absorbed during their fall through the atmosphere.

The new study, led by Laetitia Parc, a doctoral student at Ecole Normale Supérieure (ENS; France), is the first to provide a global estimate of these three effects of rain. The research team relied on an analysis of satellite observations and reanalysis of global climate and weather data over an 11-year period from 2008 to 2018.

Rain's effect on carbon sinks

Their investigation showed that rain increases the oceanic carbon sink by 140 to 190 million tons of carbon per year. This represents an increase of 5% to 7% in the 2.66 billion tons of carbon absorbed annually by the oceans. The increase in surface exchanges due to turbulence and seawater dilution plays a role of comparable order of magnitude to the direct injection of dissolved carbon in raindrops.

However, the regions where these processes are significant differ. Turbulence and dilution primarily increase the CO_2 sink in tropical regions characterized by heavy rainfall events associated with weak winds, which induces noticeable salinity and CO_2 dilution. In contrast, the deposition by raindrops is significant in all regions with heavy precipitation: the tropics, of course, but also the storm tracks and the Southern Ocean.

The results of this study suggest that the effect of rain should be explicitly included in the estimates used to construct the global carbon budget, which is compiled annually and integrates anthropogenic emissions, the growth of atmospheric CO_2, and natural carbon sinks.

More information: Laetitia Parc et al, Global ocean carbon uptake enhanced by rainfall, *Nature Geoscience* (2024). DOI: 10.1038/s41561-024-01517-y

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