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Japan Agency for Marine-Earth Science and Technology

Decadal Increases in Anthropogenic CO_2 in the Oceans - Greater Uptake rate in the South Indian Ocean -

Overview

Researchers from the Research Institute for Global Change at the Japan Agency for Marine-Earth Science and Technology(JAMSTEC) discovered that an oceanic uptake of anthropogenic carbon dioxide(CO_2) was twice as large in the South Indian Ocean than the North Pacific Ocean over eight years from 1995 to 2003, and the increase in CO_2 absorption reached waters deeper than previously observed. The finding was made available through analysis of high-quality hydrographic data obtained along the subtropical South Indian Ocean during the BEAGLE(*1) cruise by JAMSTEC in 2003.

The team also provided estimates of twofold uptake rate of anthropogenic CO_2 and evidence of its deep penetration in the South Pacific Ocean. The study provides an important insight into the needs of decadal inventory of anthropogenic CO_2 in the ocean, a parameter indispensable for climate change projection.

Their study will appear in the December 21 issue of Journal of Geophysical Research-Oceans.

Title: Decadal increases in anthropogenic CO_2 along 20°S in the South Indian Ocean

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Background

Accurate estimation of the anthropogenic CO_2 storage in the ocean is an essential tool to better project atmospheric CO_2 increases and global warming. The ocean absorbs 30% of the CO_2 emissions by human activity. Yet a quantitative analysis of the oceanic CO_2 absorption has not been available due to the scarcity of high-quality data necessary to quantify the oceanic CO_2 concentration and related properties, including alkalinity, dissolved oxygen, and nutrients.

At this juncture, an international program (*2) to collect high-quality measurements of oceanic CO_2 concentration and the related properties is

underway over the full water column, in order to clarify decadal changes in the uptake and storage of anthropogenic CO_2 in the ocean.

The study was conducted as part of this global survey program.

Summary of methods

The team collected high-quality hydrographic measurements in the South Indian Ocean to quantitatively estimate the anthropogenic CO_2 uptake in the ocean. The same method of estimation was also used for data collected from the North Pacific, South Pacific and the South Atlantic to compare anthropogenic CO_2 uptake and accumulation. For the South Indian Ocean, the data were compared with those documented before 1995 to analyze temporal changes in anthropogenic CO_2 in the region.

The survey was carried out from December 2003 to January 2004 along 20°S in the South Indian Ocean, using JAMSTEC's oceanographic research vessel "MIRAI"(Fig. 1). Water samples were collected from a maximum of 36 depths throughout the water column (from surface to seabed) in order to obtain high-quality measurements of salinity, dissolved oxygen, nutrients, dissolved inorganic carbon(*3), alkalinity, and other properties. Values of dissolved inorganic carbon were corrected using salinity measurements to exclude the influence of changes in dissolved substance concentrations associated with fresh water influx. The influence of biological activity was also eliminated using dissolved oxygen measurements. The same approach to data correction was used for the observation data previously obtained by the American research team in 1995, and the difference in CO_2 estimates between 1995 and 2003 was considered as the uptake rate of anthropogenic CO_2.

Results and discussions

An oceanwide uptake of anthropogenic CO_2 since the onset of the industrial revolution to the mid-1990s is estimated to have been 6-7grams of carbon per square meter per year. By contrast, the uptake rate of anthropogenic CO_2 estimated for the subtropical region of the South Indian Ocean was 12g/m2/yr, double the previous estimate(Fig.2). Furthermore, the uptake rate of the recent years (1995 – 2003/2004) was found to be greater than that of the former period (1978 -1995) (Fig.3). This suggests that the accumulation of human-induced CO_2 in the ocean is not happening at a constant rate but rather changeable on a decadal scale. This highlights the importance of decadal inventory of anthropogenic CO_2 in the ocean, which plays an essential role in global warming projection.

Future perspective

The study revealed higher anthropogenic CO_2 uptake rates in the South Indian and South Pacific Oceans, which were twice the global average. The uptake rate in the South Indian Ocean has doubled in the past decade. Such large increases have never been assumed before and thus were not projected in the IPCC assessment. The sharp increase urges on a drastic reassessment of the roles and impacts of the oceanic absorption of anthropogenic CO_2.

The doubling absorption rate is considered to be attributed to the anthropogenic CO_2 transport from the Southern Ocean, but this hypothesis contradicts previous reports that CO_2 uptake has been decreasing in the Southern Ocean.

The South Indian Ocean has lacked high-quality measurements of oceanic CO_2 concentration, and this study was the first to obtain its detailed information. Since the anthropogenic CO_2 storage in this area is influenced by dissolved inorganic carbon transported from the Southern Ocean, the team plans to conduct hydrographic surveys in the eastern Indian Ocean (December 4th, 2011 to February 8, 2012) and in the Southern Ocean the following fiscal year. They will also focus on elucidating the cause of the increases in CO_2 uptake rates and incorporate it into climate models to improve global warming projections.

***1 BEAGLE**
An around-the-world hydrographic survey cruise conducted by R/V MIRAI from August 2003 to February 2004. BEAGLE stands for Blue Earth Global Expedition.

***2 Global Ocean Ship-Based Hydrographic Investigations Program (GO-SHIP)** is an international initiative to collect high-quality measurements of oceanographic parameters. Eleven countries participate, including Japan, U.S., Germany, U.K. and France.

***3 Dissolved inorganic carbon** refers to collected terms for inorganic carbons. Inorganic carbons present in the form of CO_2, H_2CO_3, HCO_3^-, and CO_3^{2-}.

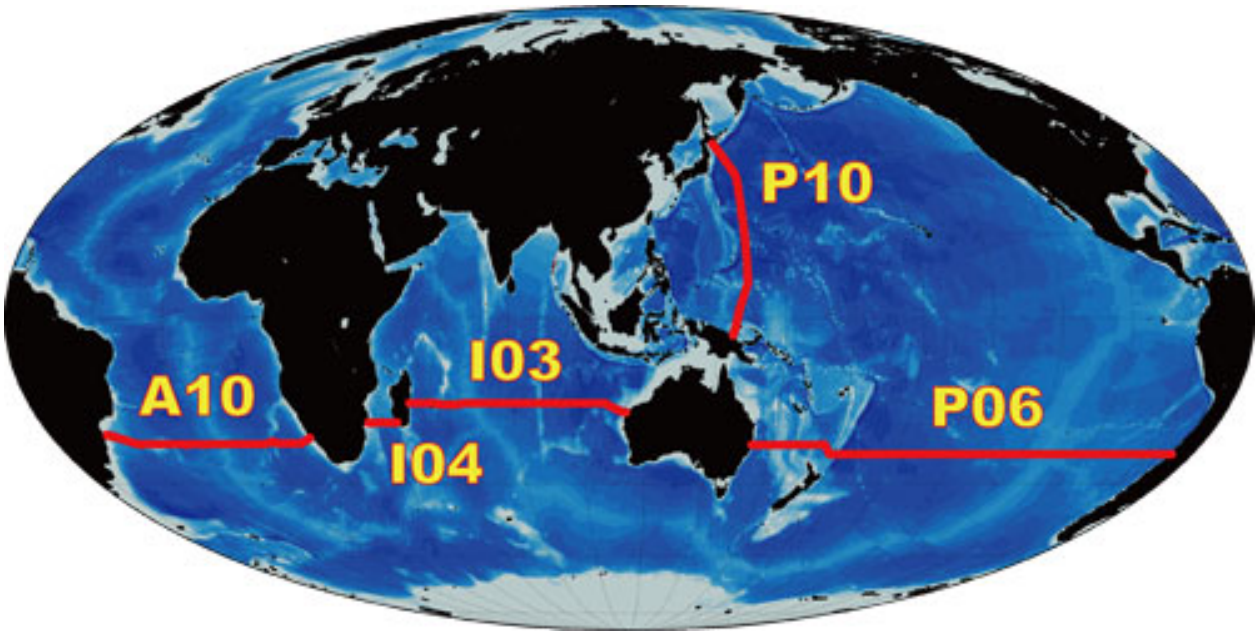

Figure 1. Survey lines for oceanic anthropogenic CO_2 increase study.

I03/I04: South Indian Ocean (December 2003 to January 2004); P06: South Pacific Ocean(2003); A10: South Atlantic Ocean (2003); P10: North Pacific (2005)

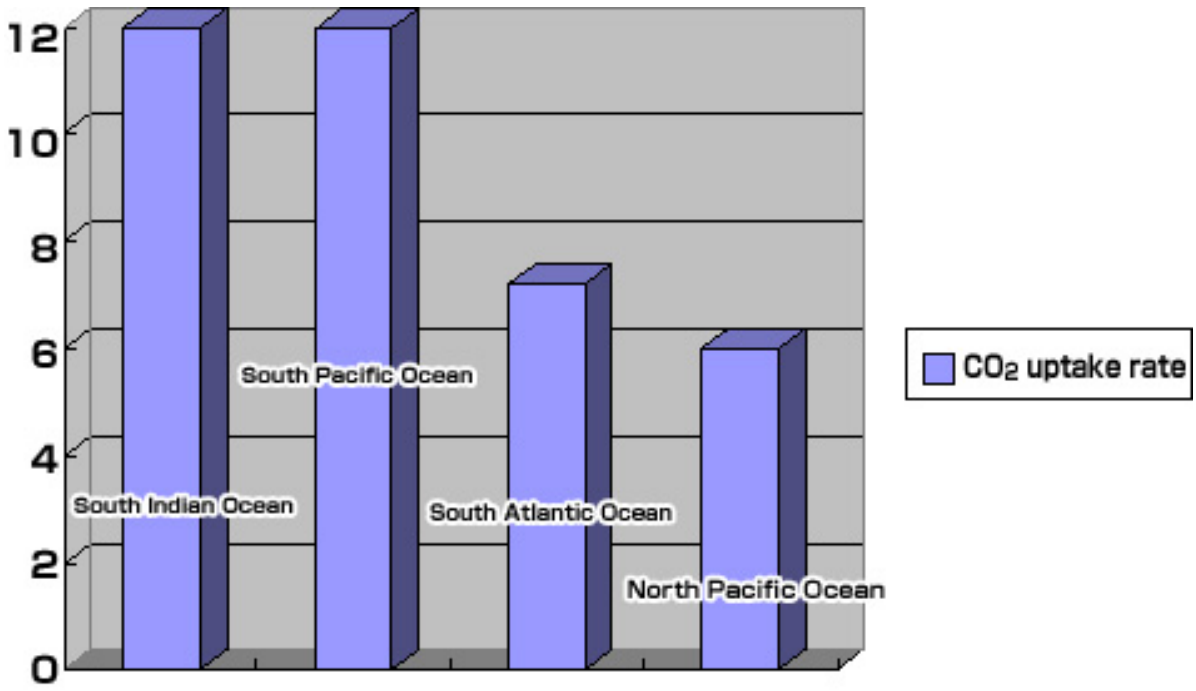

Figure 2. Anthropogenic CO_2 Uptake Rate by the Ocean from mid 1990s to mid 2000s(unit: $g/m^2/yr$).
The uptake rates are larger in the South Indian and South Pacific Oceans.

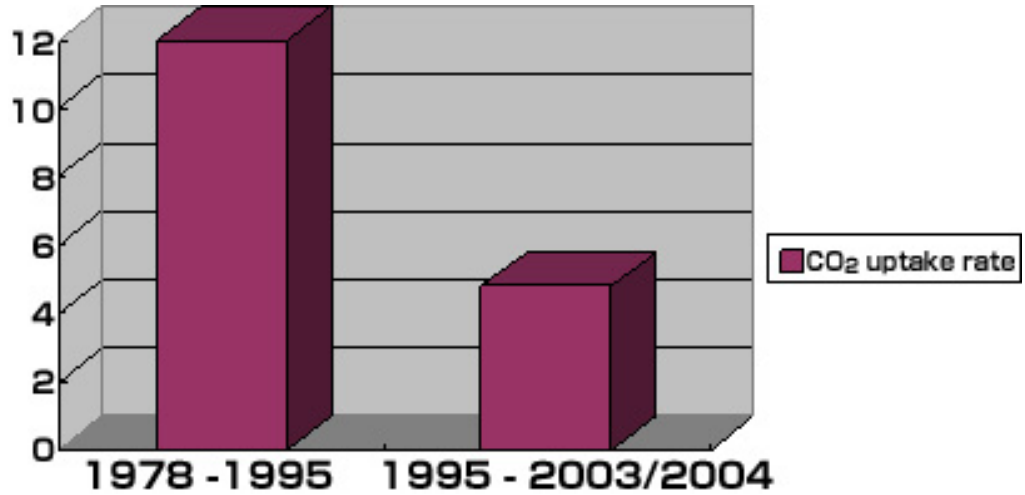

Figure 3. Anthropogenic CO_2 Uptake in the subtropical South Indian Ocean (unit: $g/m^2/yr$).
The uptake rate in recent years (from 1995 to 2003/2004) was greater than that of former years(from 1978 to 1995).

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