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MODELING OF OCEANIC CARBON CYCLE (ABSTRACT)

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We develop an ocean general circulation model which includes biogeochemical processes (biogeochemical general circulation model, B-GCM). B-GCM can deal not only with current field, temperature, and salinity, but also with biogeochemical tracers such as phosphate, dissolved oxygen, alkalinity, total CO_2, $\delta^{13}C$, and $\Delta^{14}C$.

Here, we show results of three case-studies. First, our model is driven by the wind stress, sea surface temperature, and sea surface salinity (SSS) under the present annual mean condition. The steady state obtained in our model well reproduces the following principal observed features: The phosphate concentration and the $\Delta^{14}C$ value increase along the flow path of the deep circulation from the North Atlantic to the North Pacific. The oxygen concentration and the $\delta^{13}C$ value decreases along the deep circulation path. Phosphate maximum and oxygen minimum are at about 1 km depth, and the lysocline lies above the depth of 1 km in the North Pacific.

Second, our model is driven under the same condition as the first experiment except that the SSS condition in the North Atlantic is reduced by 3 psu from the present state. In this case, a weak and less saline intermediate water (North Atlantic Intermediate Water, NAIW) forms at about 1 km depth instead of forming North Atlantic Deep Water (NADW). The deep water under the depth of 1 km is stagnant (very weak Antarctic Bottom Water), which supports the hypothesis suggested from the Cd/Ca ratio (E.A. BOYLE; Nature, **331**, 55, 1988). The lysocline in the North Atlantic lies at about 1 km depth, which also partially supports Boyle's alkalinity hypothesis.

Last, transient states are calculated with alternating the flow fields in the previous two cases (we call these transition 1: NADW on→off or transition 2: NADW off→on). The following three stages are found: (1) gas exchange between the atmosphere and the sea surface layer within 1–30 years, (2) water exchange between the surface and deep layer in the Atlantic within 100–1000 years, (3) water exchange between the Atlantic and the Pacific within 1000–3000 years. The time scale of the second stage for transition 1 is 100–400 years, which is faster than the 200–1000 years for transition 2. The atmospheric CO_2 overshoots in the second stage. For example, for transition 2, the atmospheric CO_2 rapidly increases in the first stage, overshoots in the second stage, and slowly/slightly decreases in the third stage.

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