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Effects of benthic and pelagic biochemical processes on air-sea CO_2 flux

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Abstract

Shallow-coastal ecosystems (SCE) have the function of climate change mitigation (CCM). CO_2 gas exchange between the atmosphere and the ocean (CO_2 air-sea flux) is an important factor of CCM that constitutes a series of processes in which coastal ecosystems take up, secure, and store carbon from the atmospheric CO_2. CO_2 air-sea flux is governed by the partial pressure of CO_2 (pCO_2), and it fluctuates due to the biochemical production/consumption of dissolved inorganic carbon (DIC) and total alkalinity (TA). In SCE with high biological productivity, biochemical DIC and TA production/consumption are large in both pelagic and benthic systems, however, it is unclear how much they contribute to pCO_2. The purpose of our study is to elucidate the dominant factors of biochemical processes on the CO_2 air-sea flux from the viewpoint of the comprehensive carbon cycle in the pelagic-benthic coupled ecosystem. To achieve this purpose, we used the benthic-pelagic coupled ecosystem model (EMAGIN-B.C) describing carbon secures associated with planktons/benthic faunas metabolism, carbon storage through sedimentation/burial of carbon to the benthic system, carbonate dynamics among pCO_2, pH, DIC, and TA driven by biochemical processes. The model was applied to Tokyo bay, an urbanized SCE in Japan. As a result of analysis, if pelagic DIC biochemical production/consumption were eliminated, CO_2 air-sea flux changes from the absorption of 5.5 mol/m^2/yr to the emission of 10.1 mol/m^2/yr in average, annually. If benthic TA biochemical production/consumption were eliminated, CO_2 air-sea flux changed from the absorption of 5.5 mol/m^2/yr to the emission of 7.3 mol/m^2/yr. The main causes of the changes of pelagic DIC and benthic TA are DIC consumption by phytoplankton photosynthesis, and TA production by anoxic mineralization of benthic detritus respectively. These results suggest that DIC and TA dynamics both in the pelagic and benthic ecosystems strongly affects CO_2 air-sea flux.

Keywords

benthic-pelagic coupling, climate change mitigation, blue carbon, ecosystem model