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Fluxes of N_2, O_2, and CO_2 in nearshore waters off Martha's Vineyard

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Abstract

Accurate, high-resolution time series measurements of aqueous CO_2, O_2, and N_2 were used to investigate the fluxes and transformations of these gases in a complex and dynamic nearshore environment. The measurements were made at 5-m depth over 10 days in June 2002 at the Martha's Vineyard Observatory, MA (41°19.722′ N and 70°33.096′ W). The average depth of the water column at this location was 13 m. Supporting measurements include water temperature, salinity, fluorescence, and local meteorological conditions. For the analysis, the data set was partitioned into discrete events characterized by similar environmental conditions. Approximately 30% of the total data set was chosen for detailed analysis: two 'wind events' where $5 < U_{10} < 11\,\mathrm{m\,s^{-1}}$, and one 'calm period' where $U_{10} < 5\,\mathrm{m\,s^{-1}}$. Heat and salt budgets were used to select data appropriate for analysis using a 1-D interpretation. During the wind events, budgets of biologically inactive N_2 provided estimates of air–sea gas transfer rates, which were then scaled using appropriate air–sea gas exchange models, and used to calculate air–sea CO_2 and O_2 fluxes. Variability in O_2 and CO_2 during the stratified calm period were used to estimate biologically controlled carbon fluxes. The air–sea carbon fluxes during the wind events were 9% and 34% of the biological fluxes during the calm period. A second estimate of air–sea O_2 flux was derived from the non-biologically controlled O_2 variability, based on Redfield ratios and knowledge that dissolved O_2 will equilibrate with the atmosphere via air–sea gas exchange faster than CO_2. For one wind event, when fluxes were large, both estimates agreed to within 37%. These observations provide quantitative estimates of air–sea gas exchange rates in the complex nearshore zone, elucidate the role of biophysical interactions in controlling air–sea CO_2 and O_2 exchange, and demonstrate the feasibility of new methods to quantify air–sea gas fluxes. While this study was conducted in nearshore waters, the methods can also be applied to waters of the continental shelf and open ocean.
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Keywords: Coastal zone; Carbon cycle; Air–sea exchanges; Biological production; Respiration; Oxygen; Total dissolved gas

1. Introduction

The global coastal ocean plays a significant role in the global biogeochemical cycles of carbon, nitrogen, and oxygen (Wollast, 1991; Smith and

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