A Gas Tension Device with Response Times of Minutes

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ABSTRACT

The development and testing of a new, fast response, profiling gas tension device (GTD) that measures total dissolved air pressure is presented. The new GTD equilibrates a sample volume of air using a newly developed (patent pending) tubular silicone polydimethylsiloxane (PDMS) membrane interface. The membrane interface is long, flexible, tubular, and is contained within a seawater-flushed hose. The membrane interface communicates pressure to a precise pressure gauge using low dead-volume stainless steel tubing. The pressure sensor and associated electronics are located remotely from the membrane interface. The new GTD has an operating depth in seawater of 0–300 m. The sensor was integrated onto an upper-ocean mixed layer, neutrally buoyant float, and used in air–sea gas exchange studies. Results of laboratory and pressure tank tests are presented to show response characteristics of the device. A significant hydrostatic response of the instrument was observed over the depth range of 0–9 m, and explained in terms of expulsion (or absorption) of dissolved air from the membrane after it is compressed (or decompressed). This undesirable feature of the device is unavoidable since a large exposed surface area of membrane is required to provide a rapid response. The minimum isothermal response time varies from (2 ± 1) min near the sea surface to (8 ± 2) min at 60-m depth. Results of field tests, performed in Puget Sound, Washington, during the summer of 2004, are reported, and include preliminary comparisons with mass-spectrometric analysis of in situ water samples analyzed for dissolved N_2 and Ar. These tests served as preparations for deployment of two floats by aircraft into the advancing path of Hurricane Frances during September 2004 in the northwest Atlantic. The sensors performed remarkably well in the field. A model of the dynamical response of the GTD to changing hydrostatic pressure that accounts for membrane compressibility effects is presented. The model is used to correct the transient response of the GTD to enable a more precise measurement of gas tension when the float was profiling in the upper-ocean mixed layer beneath the hurricane.

1. Introduction

Dissolved gases in the ocean play important roles in the biogeochemical cycles of the elements carbon, oxygen, and nitrogen. Study of air–sea gas fluxes and dissolved gas transformations in the upper ocean, over a natural range of environmental conditions, requires reliable, accurate, and long-term stable dissolved gas sensors for use on moorings, drifters, and profilers. Several commercially available O_2 sensors have recently shown promise of providing reliable measurements in seawater over time scales of several months. This opens up the possibility of measuring dissolved O_2 on autonomous platforms in the open ocean (e.g., Joos et al. 2003; Körtzinger et al. 2004, 2005), as is presently done for

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