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Oxygen variability in the near-surface waters of the northern North Atlantic: Observations and a model

by Peter Lazarevich[1], Tom Rossby[2] and Craig McNeil[2]

ABSTRACT

As part of the World Ocean Circulation Experiment a major study was undertaken to determine the absolute circulation of the Subpolar North Atlantic using a large number of acoustically tracked isopycnal floats deployed on the 27.5 σ_θ surface. Fifty floats were equipped with sensors to study dissolved oxygen from a Lagrangian perspective. In this paper we comment on very large variations in oxygen along trajectories of fluid parcels that outcrop in winter and resubduct the following spring. We employ a one-dimensional model to interpret these in terms of biophysical processes at and near the surface.

In an attempt to understand the observed variability, we find that a modified form of the Price-Weller-Pinkel mixed layer model using NCEP-derived surface forcing accurately reproduces both the float-observed temperature and the meteorological-based sea-surface temperatures to within 1°C for an entire year, including the timing of the ventilation and restratification observed by the float. The model also employs satellite-derived observations to represent three processes of oxygen exchange: an air-sea gas flux dependent upon wind-driven turbulence, oxygen production in the mixed layer as a result from primary productivity, and oxygen consumption at depth as a result of net community respiration. The model accurately reproduces the observed ~3% supersaturation in the wintertime mixed layer, a level which is supported by the air-sea gas flux. We also find that later in the year, during springtime restratification, the model reproduces the observed decline from 105% to 92% oxygen saturation.

The good agreement between observation and model depends upon a one-dimensional balance in the vertical, i.e. the absence of horizontal advective effects. For floats outcropping in an area of horizontal thermal contrast, conspicuous errors in the predicted vertical structure arise, most likely due to horizontal advection or displacement of the float by surface winds, effects which cannot be assessed without additional information. This limitation notwithstanding, the agreement between model and observation indicates the power of Lagrangian techniques for understanding how the properties of surface waters are set and later modified as they subduct into the interior of the ocean.

1. Introduction

The variability of near-surface waters is of great interest to oceanographers. It is at the surface that most water-transformation occurs, driven not only by heat and salt exchanges,

1. Department of Oceanography, Florida State University, Tallahassee, Florida, 32306-4320, U.S.A. ***email: plazarev@fsu.edu***

2. Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island, 02882, U.S.A.