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Oxygen and nitrogen cycling in the northeast Pacific – Simulations and observations at Station Papa in 2003/2004

by N. Steiner[1,2], S. Vagle[3], K. Denman[3,1] and C. McNeil[4]

ABSTRACT

A long-term air-sea exchange mooring has been maintained in the North Pacific near Ocean Station Papa (OSP, 145W, 50N) since September 2002 as part of the Canadian Surface Ocean Lower Atmosphere Study (C-SOLAS). The mooring provides a new long-term data set for gas measurements. In addition to Conductivity, Temperature and Depth (CTD) recorders at two depths, the mooring is equipped with ProOceanus Gas Tension Devices (GTDs) measuring the total gas pressure at four different depths, two oxygen sensors, two fluorometers for chlorophyll estimates, and an upward-looking 200 kHz echo-sounder for bubble measurements. Chlorophyll data have been added using SeaWiFS imagery and occasional bottle casts. Data collected from June 2003 to June 2004 are compared with simulations from a 1-D coupled atmosphere-ocean-biogeochemical model. The coupled model consists of an atmospheric Single Column Model (SCM), based on the CCCma AGCM (Canadian Centre for Climate Modelling and Analysis-Atmospheric General Circulation Model), the General Ocean Turbulence Model (GOTM) and a 7-component ecosystem model embedded in GOTM. The ecosystem model also includes oxygen, nitrogen, carbon, and silica cycling. The study focuses on simulated and observed N_2 and O_2 variability. The comparison of these gases allows for separation of physical and biological processes; which can then be evaluated in more detail with the aid of model simulations. The model also tests different parameterizations for saturation and gas exchange, including a formulation for gas injection via bubbles, which affects gas concentrations within the whole mixed layer. For most of the time the model shows good agreement with observations. However, in summer 2003 the observations reveal a strong oxygen and chlorophyll event, which is not reproduced in the standard model run. A weaker signal is seen in May 2004. OSP is a High Nutrient Low Chlorophyll (HNLC) region, limited by the micronutrient iron. Increases in usually low chlorophyll values occur occasionally due to natural iron enrichment (dust deposition, eddy transport, below surface layer transport). Although limitations of 1-D modeling become apparent here, an assumed input of iron in the model explains the differences between simulated and observed oxygen and chlorophyll maxima. The model provides information on the strength and duration of potential iron contribution. No obvious dust events or eddy traverses to supply iron were recorded during this time period. An alternative explanation is entrainment from deeper waters, where occasional iron enrichment is known to occur due to off-shelf transport via eddies or recirculation from the Alaskan shelf.

1. Canadian Centre for Climate Modelling and Analysis, University of Victoria, 3964 Gordon Head Rd., Victoria, BC, Canada.
2. Corresponding author. ***email: nadja.steiner@ec.gc.ca***
3. Fisheries and Oceans Canada, Institute of Ocean Sciences, Sidney, BC, Canada.
4. Graduate School of Oceanography, University of Rhode Island, Narragansett, Rhode Island, 02882, U.S.A.