Project Title: Southern ocean seasonal net production from satellite, atmosphere, and ocean data sets.

ABSTRACT

A new climatology of monthly air-sea O₂ flux was developed using the net air-sea heat flux as a template for spatial and temporal interpolation of sparse hydrographic data. The climatology improves upon the previous climatology of Najjar and Keeling in the Southern Hemisphere, where the heat-based approach helps to overcome limitations due to sparse data coverage. The climatology is used to make comparisons with productivity derived from CZCS images. The climatology is also used in support of an investigation of the plausible impact of recent global warming on oceanic O₂ inventories.

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The purpose of this project was to construct chemical budgets for dissolved oxygen and inorganic carbon in the surface waters of the Southern Ocean for the purpose of constraining productivity algorithms and improving estimates of air-sea CO₂ exchange. This project resulted in two publications:


In the first publication, we examine correlations between air-sea O₂ and heat exchanges on seasonal time scales and use these correlations to construct a new O₂ flux climatology. The study relies on hydrographic data for dissolved O₂, salinity and temperature archived as of 1998 at the National Ocean Data Center (NODC), plus additional selective data compilations. It also relies on the air-sea gas exchange formulation of Wanninkhov (1992), and climatological winds and heat fluxes from the European Centre for Medium-Range Weather Forecasting (ECMWF). Although the new climatology is global in extent, the main improvements relative to the previous climatology of Najjar and Keeling (1997,1999), are in the Southern Ocean, where the newer approach helps to overcome difficulties resulting from the sparse data coverage in this region. The improved representation of the Southern Hemisphere O₂ fluxes is evident in comparisons with atmospheric O₂/N₂ data. We used the new climatology to make comparisons with
productivity derived from Coastal Zone Color Scanner (CZCS) images. The new seasonal \( \text{O}_2 \) flux climatology is archived and available through the JGOFS office.

In the second publication, we build on the results of the first study to estimate the plausible impact of recent global warming on the oceanic \( \text{O}_2 \) inventory (Keeling and Garcia, 2002). The study starts by noting that air-sea heat and \( \text{O}_2 \) fluxes are correlated over a range of space and time scales, with a ratio of order 5 nmol \( \text{O}_2 \) J\(^{-1}\). This ratio accounts both for \( \text{O}_2 \) exchanges driven by solubility changes, as well as for \( \text{O}_2 \) exchanges linked to stratification-induced changes in ocean biology and mixing. The study then adopts the "null" hypothesis that the same ratio may apply to secular warming over the last few decades due to increasing greenhouse gases. This then implies that the ocean \( \text{O}_2 \) inventory should have decreased over the last few decades at a rate of around \( 0.3 \times 10^{14} \) mol \( \text{O}_2 \) yr\(^{-1}\), which must have been balanced by an outgassing of \( \text{O}_2 \) to the atmosphere of the same magnitude. The study points out that \( \text{O}_2 \) changes of this magnitude would be large enough to impact global carbon budgets based on either (1) changes in atmospheric \( \text{O}_2/\text{N}_2 \) ratio or (2) changes in oceanic dissolved inorganic carbon (DIC). The latter method is impacted because the changes in DIC are typically normalized against dissolved \( \text{O}_2 \), as a means of filtering variability.

It was originally our intention to employ the seasonal \( \text{O}_2 \) flux/heat flux correlations as a basis for improving global p\( \text{CO}_2 \) climatologies. In the third year, however, it became evident that the work required to complete a \( \text{CO}_2 \) study to the point of publication would have extended beyond the project end-date. Since continued funding beyond this date was not available for Hernan Garcia (the postdoc employed at Scripps for this project), the decision was made to focus on the manuscript revisions and database preparations related to work already in progress, as described above.

REFERENCES


1. REPORT DATE (DD-MM-YYYY) 2. REPORT TYPE
1-May-02 Final
5a. CONTRACT NUMBER
5b. GRANT NUMBER
NAG5-6668
5c. PROGRAM ELEMENT NUMBER
5d. PROJECT NUMBER
5e. TASK NUMBER
5f. WORK UNIT NUMBER

4. TITLE AND SUBTITLE
Southern ocean seasonal net production from atmosphere and ocean data sets

6. AUTHOR(S)
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7. PERFORMING ORGANIZATION NAMES(S) AND ADDRESS(ES)
The Regents of the University of California Scripps Institution of Oceanography La Jolla, CA 92093-0210

8. PERFORMING ORGANIZATION REPORT NUMBER
97-1503

9. SPONSORING/MONITORING AGENCY NAME(S) AND ADDRESS(ES)
Office of Naval Research Attn: Closeout Unit 4520 Executive Drive, Suite 300 San Diego, CA 92121-3019

10. SPONSOR/MONITOR'S ACRONYM(S)
CNR

11. SPONSORING/MONITORING AGENCY REPORT NUMBER

12. DISTRIBUTION AVAILABILITY STATEMENT
Approved for Public Release; Distribution is unlimited

13. SUPPLEMENTARY NOTES

14. ABSTRACT
A new climatology of monthly air-sea O2 flux was developed using the net air-sea heat flux as a template for spatial and temporal interpolation of sparse hydrographic data. The climatology improves upon the previous climatology of Najjar and Keeling in the Southern Hemisphere, where the heat-based approach helps to overcome limitations due to sparse data coverage. The climatology is used to make comparisons with productivity derived from CZCS images. The climatology is also used in support of an investigation of the plausible impact of recent global warming on oceanic O2 inventories.

15. SUBJECT TERMS
air-sea oxygen flux, global ocean productivity, southern ocean, global carbon budget

16. SECURITY CLASSIFICATION OF:
   a. REPORT Unrestricted
   b. ABSTRACT Unrestricted
   c. THIS PAGE Unrestricted

17. LIMITATION OF ABSTRACT
   a. NUMBER OF PAGES None

18. NUMBER OF RESPONSIBLE PERSON
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Standard Form 298 (Rev. 8-98)