Biogeochemical Southern Ocean State Estimate Data assimilation of carbon and other biogeochemical constraints

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SCRIPPS INSTITUTION OF OCEANOGRAPHY

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Unlocking the mysteries of the Southern Ocean

Southern Ocean Climate and Carbon Observations and Modelling

State estimation

4D-Var, "adjoint" method





B-SOSE: biogeochemical + physical state optimized together



ecco.jpl.nasa.gov

Biogeochemical model



"N-bling"

all prognostic and diagnostic variables are estimated; can be compared / constrained to observations

B-SOSE product

2008-2012, 1/3 degree

Verdy and Mazloff (2017), A data assimilating model for estimating Southern Ocean biogeochemistry, JGR-Oceans



2013-2017 in production (with SOCCOM floats constraints)

B-SOSE vs climatology with SOCCOM float observations



B-SOSE vs climatology with SOCCOM float observations



Validation

* = assimilated

Comparisons with gridded products

- * ocean color (chl, POC)
- * altimetry
- * microwave SST
- * sea ice

Argo monthly mapped product GLODAPv2, WOA13, SOCAT climatologies Landschützer monthly mapped product







Comparisons with in situ observations

- * Argo profiles (T,S)
- * calibrated bgc-Argo (O₂)
- * SOCCOM floats
- * SOCAT (pCO₂)
- * GLODAPv2 (carbon, nutrients)
- * CTD (T, S, O₂, chl)
- * XBT, MEOP, PIES
- GEOTRACES



Comparisons with in situ observations

7 m O₂ in B-SOSE 2013-2017 is compared to bgc-Argo



pCO₂ in Drake Passage



Monthly-averaged pCO₂ in Drake Passage (75°W to 55°W, south of 50°S) from SOCATv4 observations (black) [Bakker et al., 2016; Munro et al., 2015a, 2015b], and from B-SOSE (area average in pink; subsampled at the location of observations in red). Summer months are shaded gray.

Assimilating ocean color observations

cost function = surface chlorophyll from VIIRS satellite, 2013



red = where adding iron would reduce the misfit with observations

Higher resolution, multi-grid assimilation

CO2 flux, 2010 mean

mol/m2/yr





Budgets

DIC in the top 650 m, 2008-2012



Rosso et al. (2017), Space and time variability of the Southern Ocean carbon budget. JGR-Oceans.

Budgets

as a tool for explaining observed C:N ratios

Preditield DIC

plots show *seasonal variability* of DIC and NO₃ in B-SOSE (black) and SOCCOM floats (red) in latitude bands





budget analysis shows how different mechanisms are



What explains deviations from Redfield?



- (1) dilution is dominant at high latitudes (sea ice)
- (2) gas exchange is important in mid-latitudes
- (3) ocean dynamics (advection + mixing) is non-negligible

Getting the products

- B-SOSE output: sose.ucsd.edu
- + validation
- + documentation



MITgcm BLING model and adjoint: github.com/MITgcm/MITgcm

summary



Snapshot of the simulated dissolved inorganic carbon (DIC) concentration at 100 m on 2/1/09

use **model + observations** to estimate carbon system over the past ~10 years

multi-year estimate = a continuous model run, which has **closed budgets** for mass / heat / salt / BGC tracers (DIC, O₂, NO₃, ...)

the output is available online (**sose.ucsd.edu**) for analysis and comparisons with models