BGCWG Highlights

THE 27th ANNUAL CESM WORKSHOP

WG Co-Chairs:
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Matthew Long (NCAR/CGD)
Abigail Swann (Univ. Washington)

13 JUNE 2022
Understanding lags and symmetries of the Earth system response to CDR using an idealized emissions-driven CO₂ reversal experiment

Carbon fluxes

Earth system response to cumulative CO₂ emissions

Koven et al., in prep.
Contact Charlie Koven cdkoven@lbl.gov if interested in CESM2 output
CESM1 Large Ensemble without Mt. Pinatubo Eruption: Global mean impact

Full field

SST

Mt Pinatubo Effect

O₂ flux

CO₂ flux

Contact Matt Long if interested in output: mclong@ucar.edu

Courtesy of Amanda Fay (Columbia)
Spread in global mean surface temp due to range of 9 plant parameters = ~1/3 spread across all CMIP5 models

Leveraging the perturbed parameter work from Daniel Kennedy et al. to choose parameters that impact the atmosphere

Preindustrial runs w/ CAM-CLM-slab ocean

9 plant parameters run at high and low values compared to default value

0.94°C Range in global temperature (including ocean) across parameters

3°C Approx range in preindustrial temperature across CMIP5 models (Hawkins and Sutton 2016)

Zarakas & Swann et al. in prep
1. CESM Single Forcing LENS shows aerosols lead to substantial (50%) slowdown of ocean deoxygenation over 20th Century

2. Uptake of oceanic O$_2$ due to aerosols tied to aerosol spatial evolution (dominated by Pacific); driven by solubility effects and changes in circulation
Seasonal to multi-year prediction: GPP

Yeager et al. (2022)

See https://doi.org/10.5194/gmd-2022-60
Seasonal to multi-year prediction: Marine NPP, Export, Zooplankton

Yeager et al. (2022)

See https://doi.org/10.5194/gmd-2022-60
New Hindcast CESM Hi-Res Run:
- CESM2 0.1º (POP + CICE4 + MARBL)

Courtesy of Y. Eddebbar (Scripps)
Seasonal Modulation of Eq. Pacific O₂ by Tropical Instability Vortices (TIVs)

- CORE-forced CESM 0.1° 5-year simulation shows TIVs have major influence on tropical Pacific O₂ balance and seasonal variability through eddy advection and modulation of vertical mixing along equatorial Pacific

Courtesy of Y. Eddebbar (Scripps)
MARBL: The Marine Biogeochemical Library

Simulations With the Marine Biogeochemistry Library (MARBL)
Matthew C. Long, J. Keith Moore, Keith Lindsay, Michael Levy, Scott C. Doney, Jessica Y. Liao, Kristen M. Krumhardt, Robert T.Letscher, Maxwell Grover, and Zephyr T. Sylvester

Implementations
CESM (POP2 & MOM6)
ROMS (under development)

Modular ocean biogeochemistry model
Base model (OGCM)
MARBL

\[
\frac{\partial \phi}{\partial t} + \nabla \cdot (u \phi) - \nabla \cdot (K \nabla \phi) = J(\phi)
\]

Long, Moore, Lindsay, et al., JAMES (2021)
CESM-BEC: Now with Fully Variable Stoichiometry!

Phytoplankton nutrient uptake parameterized as follows:

\[ X = N, P, Fe, \text{ or } Si \]

- \( gQx_{\text{max}} \): Maximum \( X: C \)
- \( XOpt \): Optimal \( X \) for
- \( gQx_{\text{min}} \): Minimum \( X: C \)
- \([X]\): Nutrient concentration

Allows for variable C:N:P:Fe:Si

P Quotas: When nitrate is low, N and P uptake are both reduced in order to maintain N/P uptake appropriate for ambient phosphate levels

Si Quotas: When [Si] ↓, Si:C ↓

[Si] replete, [Fe] ↓, Si:C ↑

Courtesy N. Wiseman (UCI)
Current BEC Setup, porting to MARBL (3p1z) this summer

C:N:P ranges constrained by GO-SHIP POM observations (Tanioka et al., in review)

N:P by inverse model estimates (Wang et al. 2019)

Fe:C range constrained by observations from Ben Twining and others (Wiseman et al., submitted to GBC)

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<tr>
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<th>Diatoms</th>
<th>Small Phyto</th>
<th>Diazotrophs</th>
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<tbody>
<tr>
<td>C:N</td>
<td>6-9</td>
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<td>6-7</td>
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<tr>
<td>N:P</td>
<td>15-25</td>
<td>90-180</td>
<td>120-315</td>
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<tr>
<td>C:P</td>
<td>90-225</td>
<td>90-180</td>
<td>120-315</td>
</tr>
<tr>
<td>Fe:C</td>
<td>3-90</td>
<td>3-90</td>
<td>6-180</td>
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<tr>
<td>Si:N</td>
<td>0.33-5</td>
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Courtesy N. Wiseman (UCI)
Another Flying Leap*: Building toward fully prognostic fish

FEISTY Total Fish Biomass Simulations

CESM Forced Ocean Sea-Ice Integration (w/ fish offline)

Annual mean of total fish biomass

Coefficient of variation (σ/μ) of total fish biomass

Petrik et al., Prog. Oceanog. (2019)

*Inez Fung
Expanding the MARBL marine ecosystem to link to a fisheries model

- Partitioning zooplankton group into microzooplankton and mesozooplankton
- Offers improved estimates of food resources for fish and other higher trophic levels
- Societally-valuable fish prediction

FEISTY fish model

Courtesy of Kristen Krumhardt
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Courtesy of Kristen Krumhardt
Thanks!

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