BGCWG Highlights

THE 27th ANNUAL CESM WORKSHOP

WG Co-Chairs:
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13 JUNE 2022

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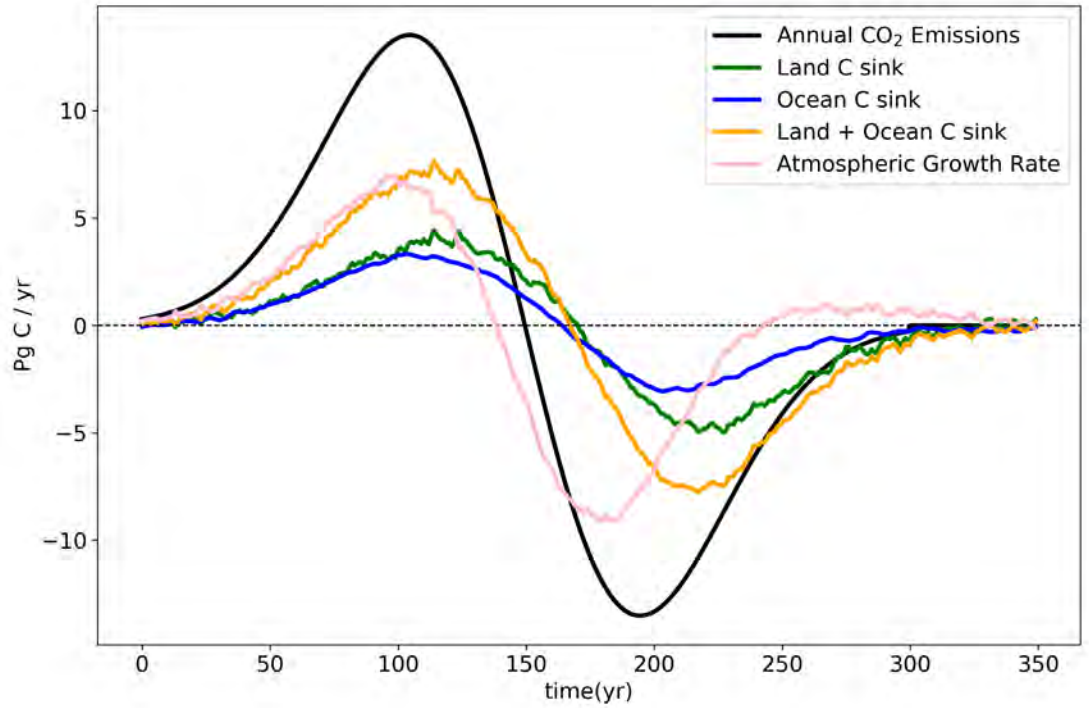
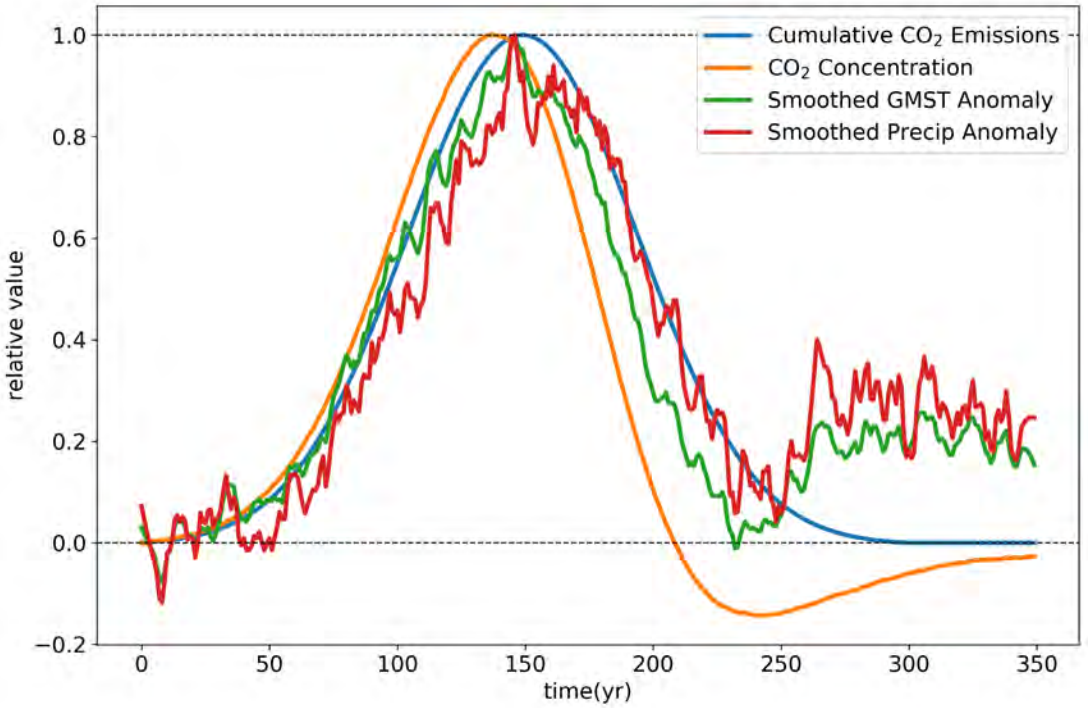
Understanding lags and symmetries of the Earth system response to CDR using an idealized emissions-driven CO_2 reversal experiment

Carbon fluxes



Earth system response to cumulative CO_2 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

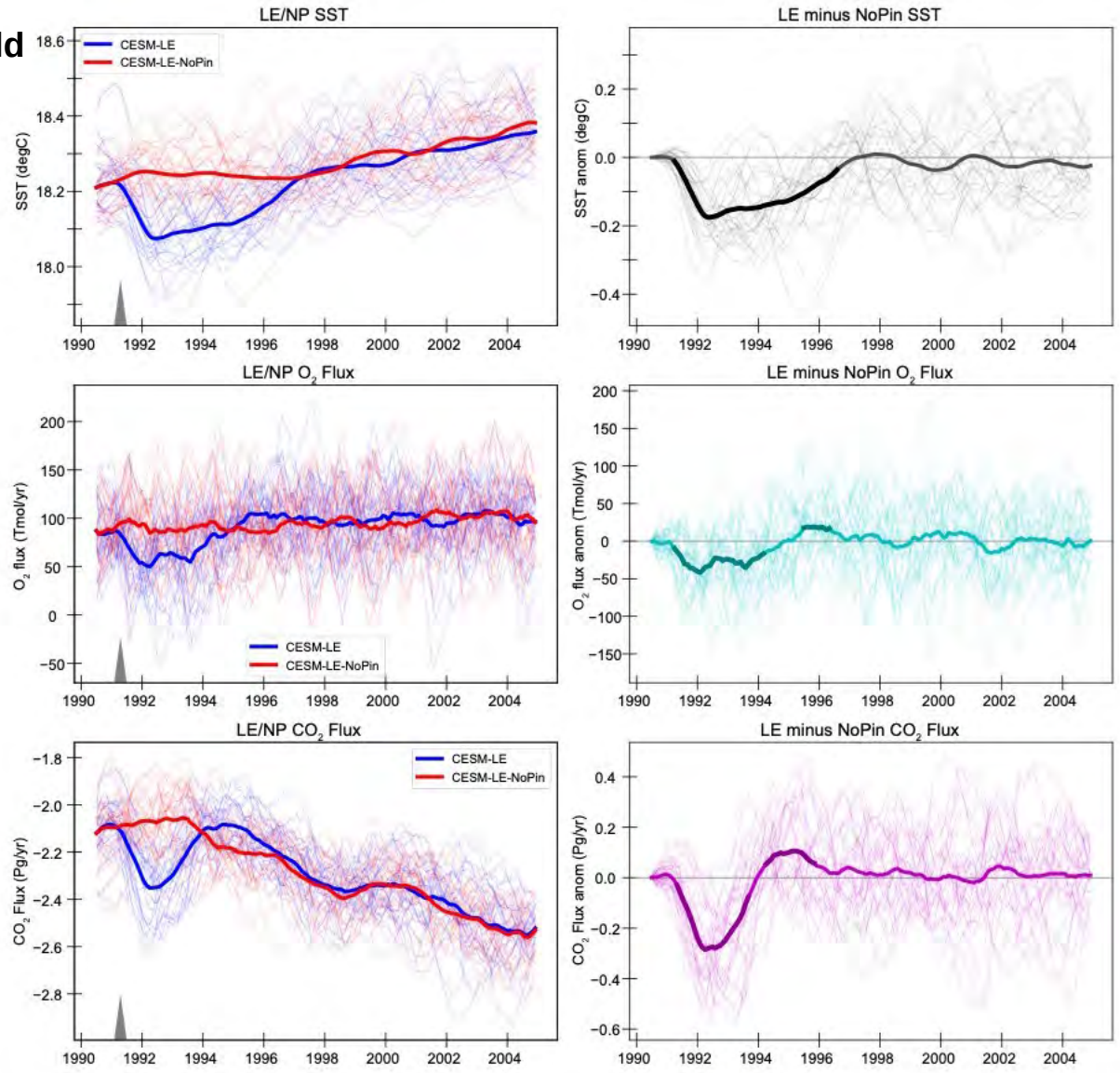
Full field

Mt Pinatubo Effect

SST

O_2 flux

CO_2 flux



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

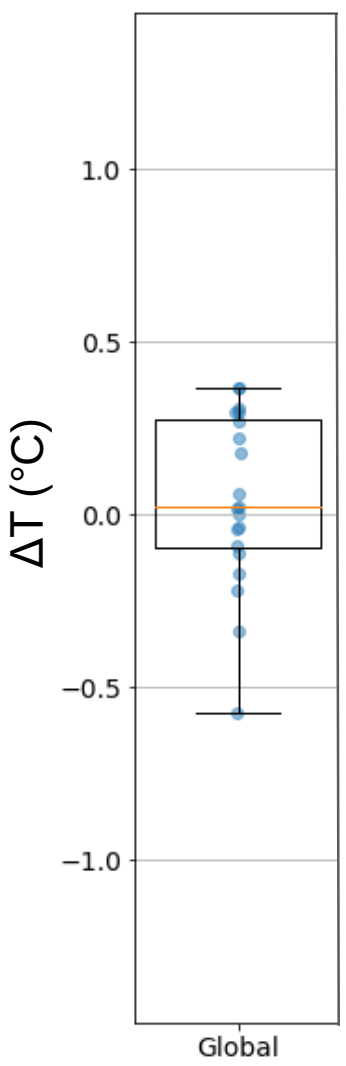
Courtesy of Amanda Fay (Columbia)

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



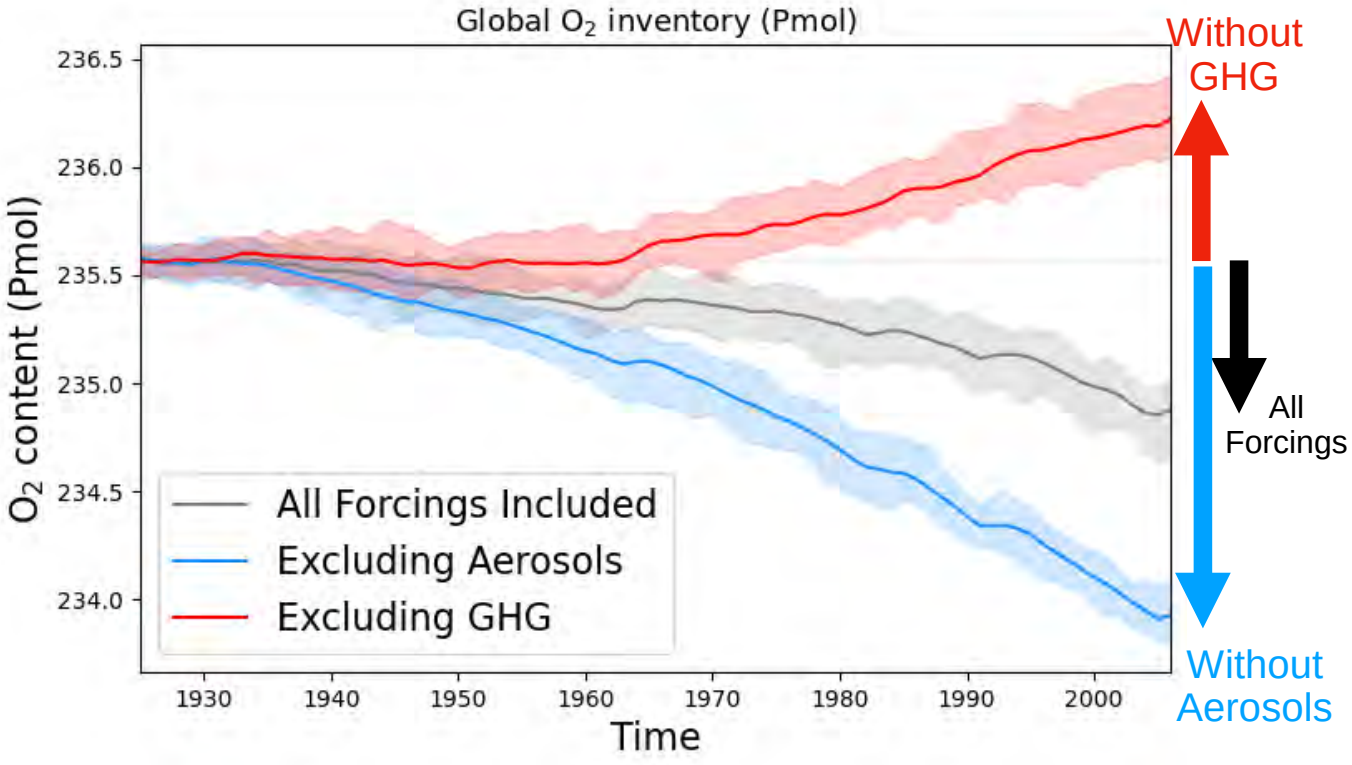
0.94°C Range in ***global*** temperature (including ocean) across parameters

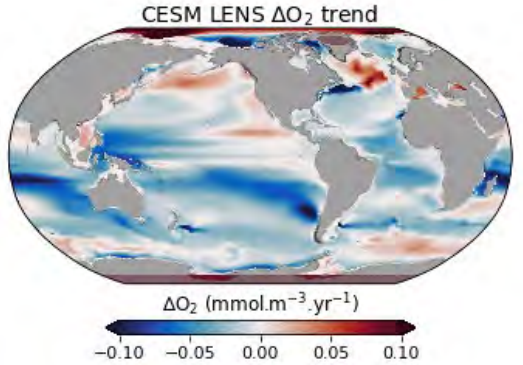
3°C Approx range in preindustrial temperature across CMIP5 models (Hawkins and Sutton 2016)

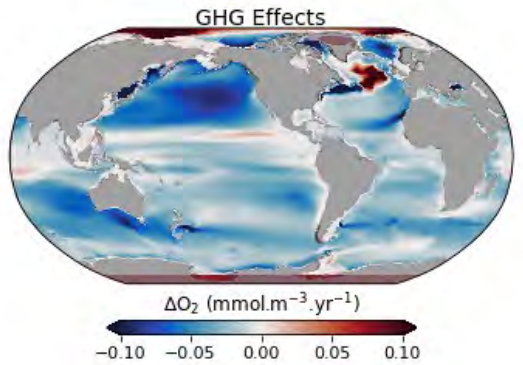
Zarakas & Swann et al. *in prep*

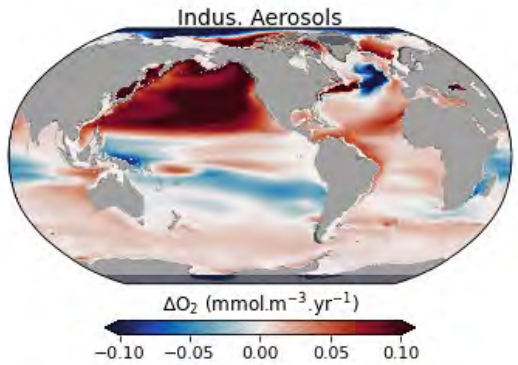
Slowdown of Ocean Deoxygenation by Aerosols during the 20th Century

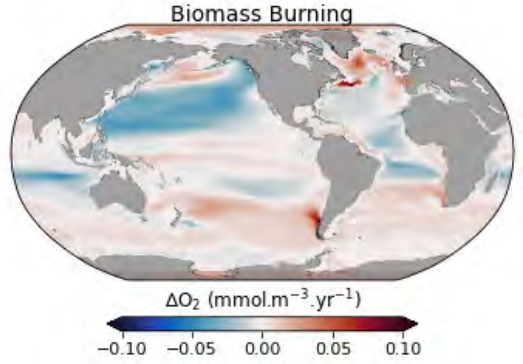
Eddebbar, *in Prep*





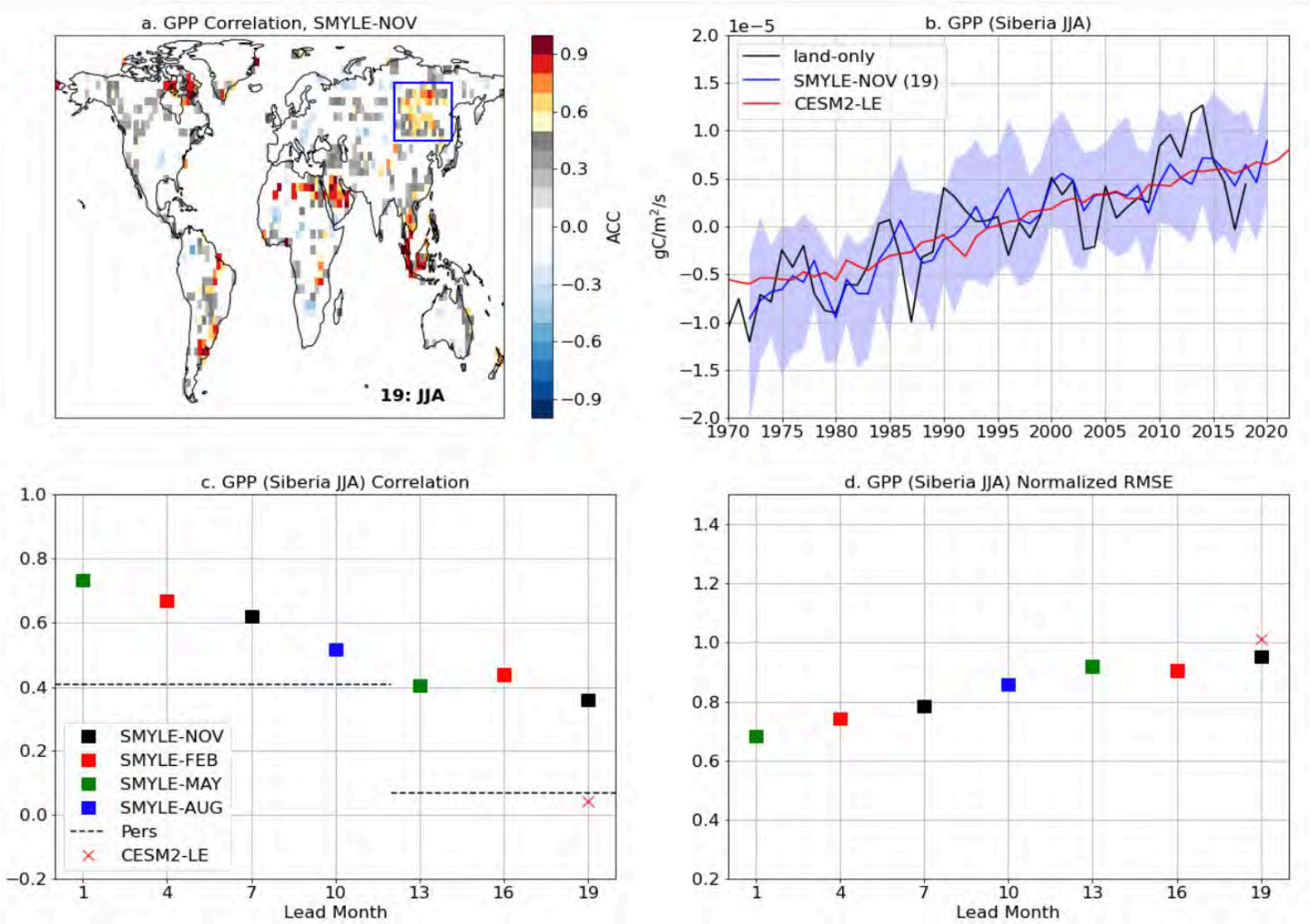






1. CESM Single Forcing LENS shows aerosols lead to substantial (50%) slowdown of ocean deoxygenation over 20th Century
2. Uptake of oceanic O_2 due to aerosols tied to aerosol spatial evolution (dominated by Pacific); driven by solubility effects and changes in circulation

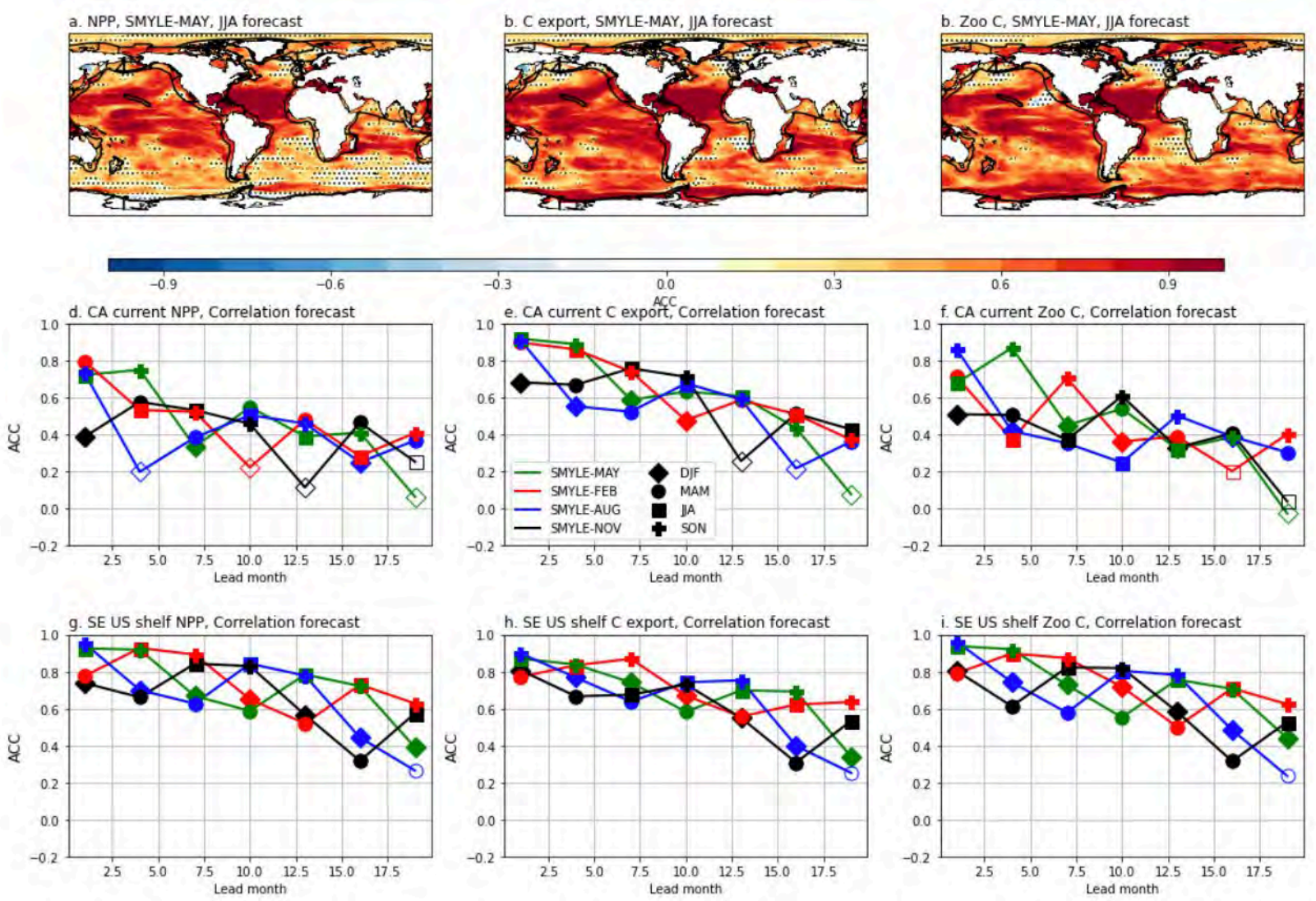
Seasonal to multi-year prediction: GPP



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

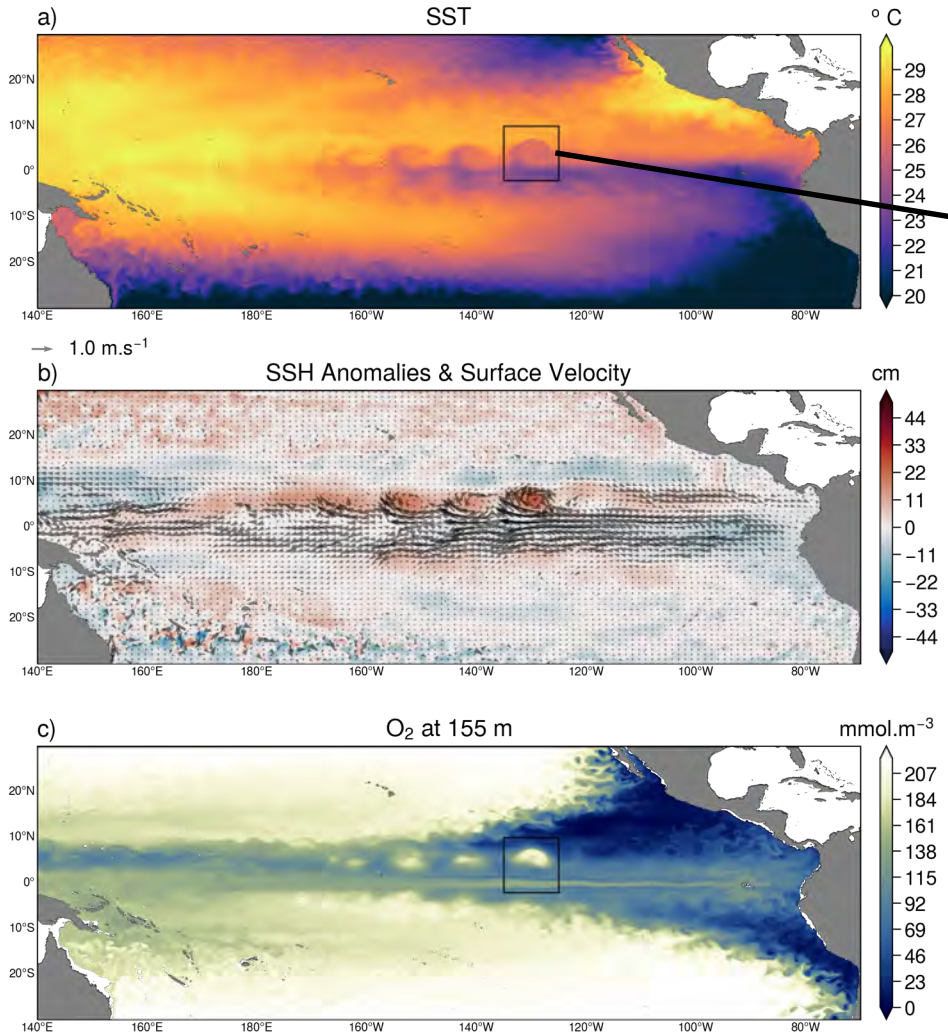
New Hindcast CESM Hi Res Run:

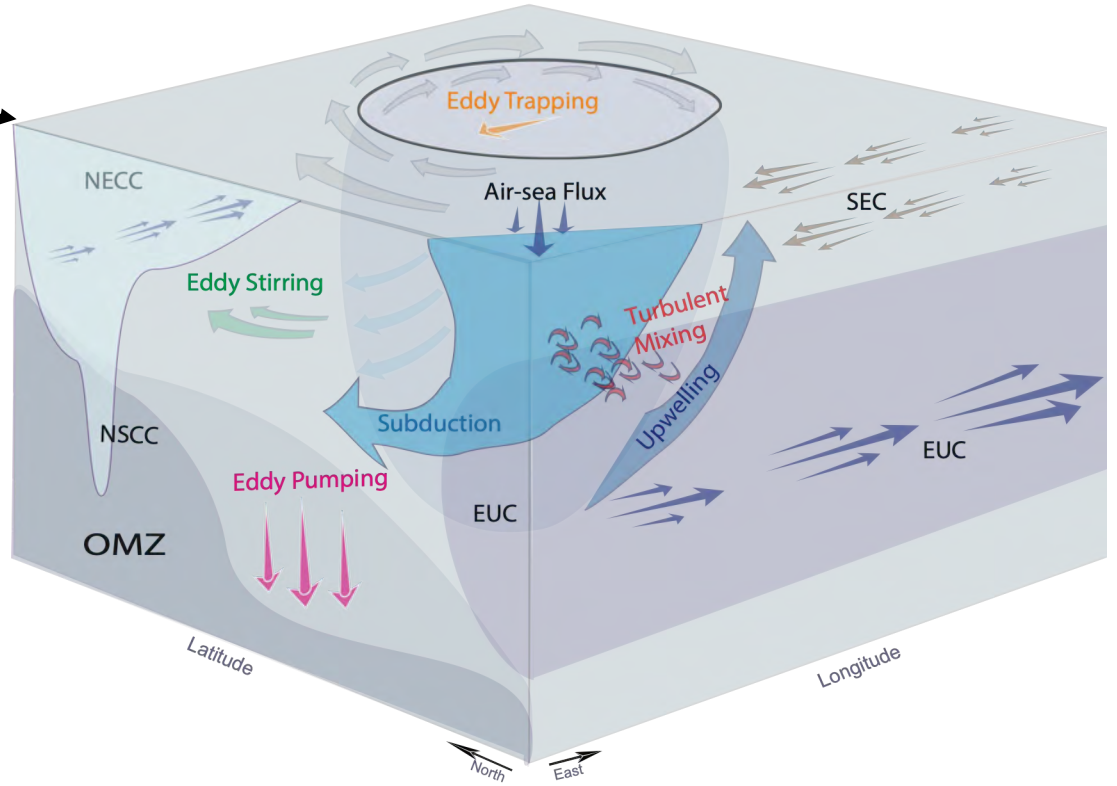
- CESM2 0.1º (POP
- JRA-55 Reanalysis

Courtesy of Y. Eddebbar (Scripps)

Seasonal Modulation of Eq. Pacific O_2 by Tropical Instability Vortices (TIVs)

(Eddebbar et al. 2021. JGR Oceans)





- CORE-forced CESM 0.1º 5-year simulation shows TIVs have major influence on tropical Pacific O_2 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

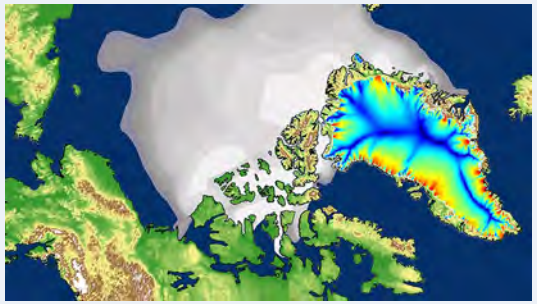
JAMES | Journal of Advances in Modeling Earth Systems

Simulations With the Marine Biogeochemistry Library (MARBL)

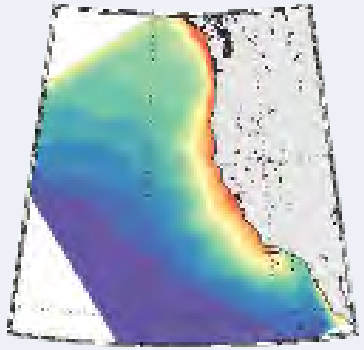
Matthew C. Long[1], J. Keith Moore[2], Keith Lindsay[1], Michael Levy[1], Scott C. Doney[3], Jessica Y. Luo[1,4], Kristen M. Krumhardt[1], Robert T. Letscher[5], Maxwell Grover[1], and Zephyr T. Sylvester[6]

Implementations

CESM (POP2 & MOM6)



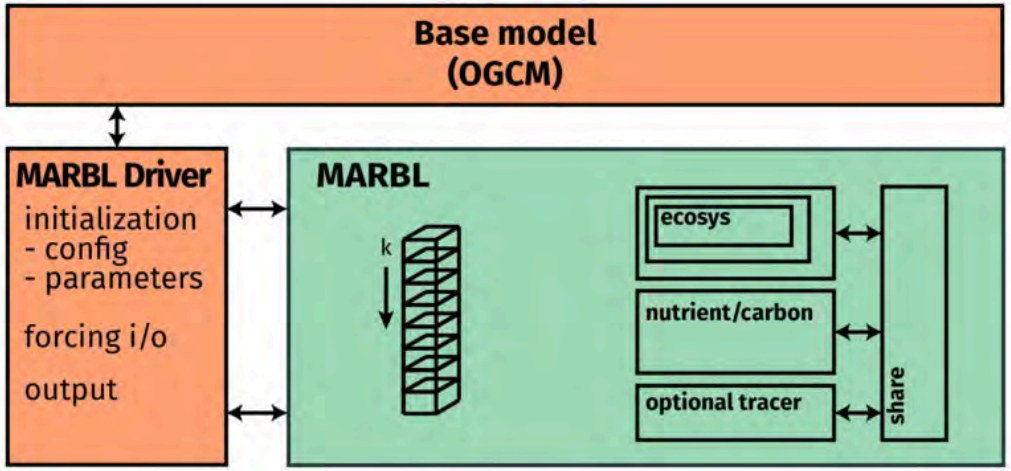
ROMS
(under development)



E3SM Energy Exascale Earth System Model

MPAS-O

Modular ocean biogeochemistry model



$$\frac{\partial \varphi}{\partial t} + \nabla \cdot (\vec{u}\varphi) - \nabla \cdot (K \nabla \varphi) = J(\varphi)$$

NSF

DEPARTMENT OF ENERGY · UNITED STATES OF AMERICA

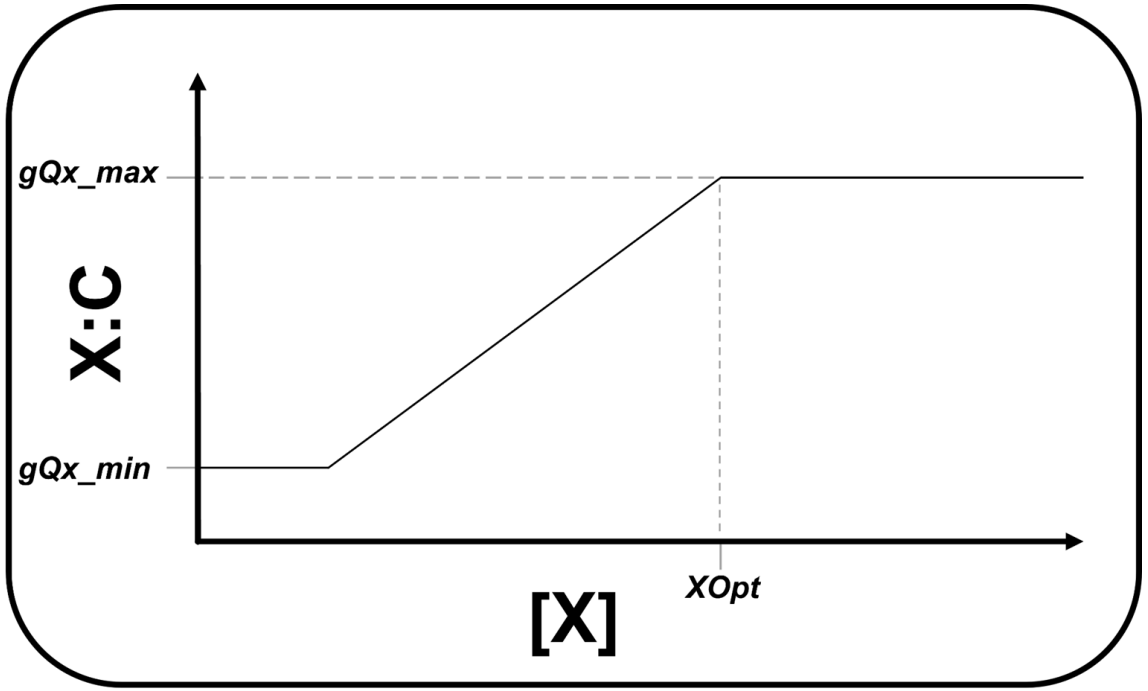
Long, Moore, Lindsay, et al., *JAMES* (2021)

CESM-BEC: Now with Fully Variable Stoichiometry!

Phytoplankton nutrient uptake parameterized as follows:

X = N, P, Fe, or Si

- gQx_max: Maximum X:C
- XOpt: Optimal X for
- gQx_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

	Diatoms	Small Phyto	Diazotrophs
C:N	6-9	6-9	6-7
N:P	15-25	90-180	120-315
C:P	90-225	90-180	120-315
Fe:C	3-90	3-90	6-180
Si:N	0.33-5		

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)

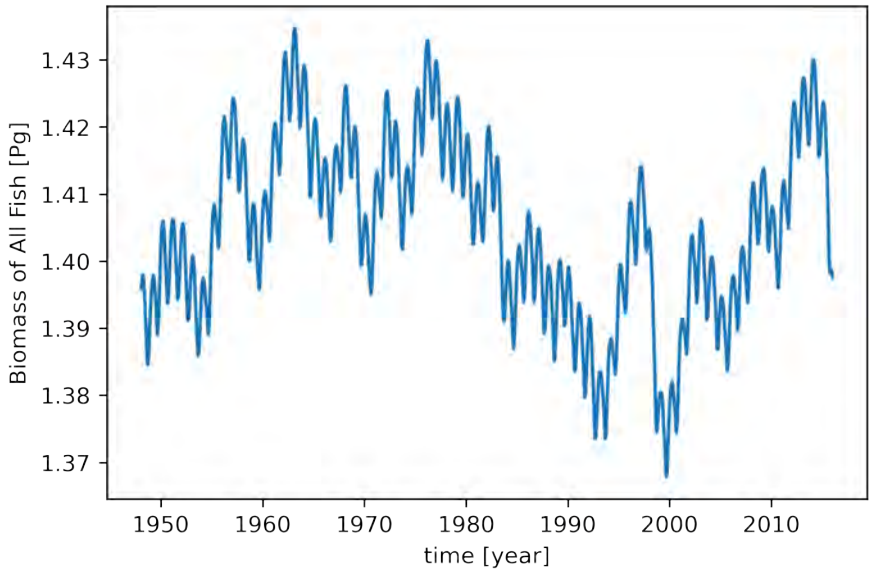
Fe:C range constrained by observations from Ben Twining and others (Wiseman et al., submitted to GBC)

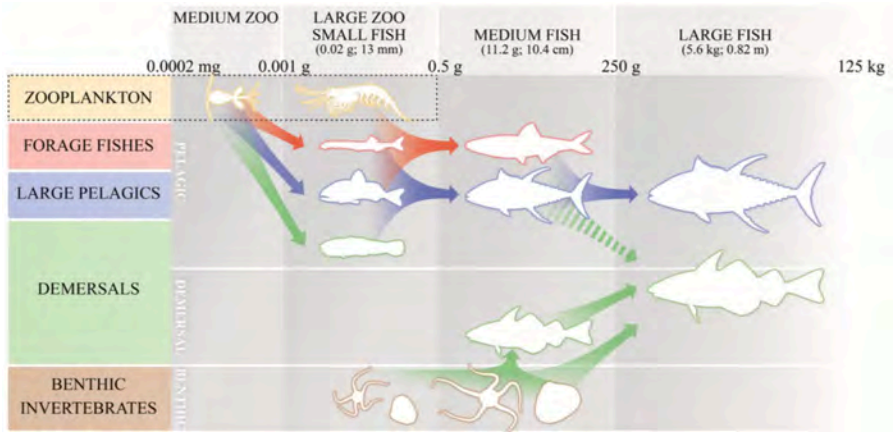
Courtesy N. Wiseman (UCI)

Another Flying Leap*: Building toward fully prognostic fish

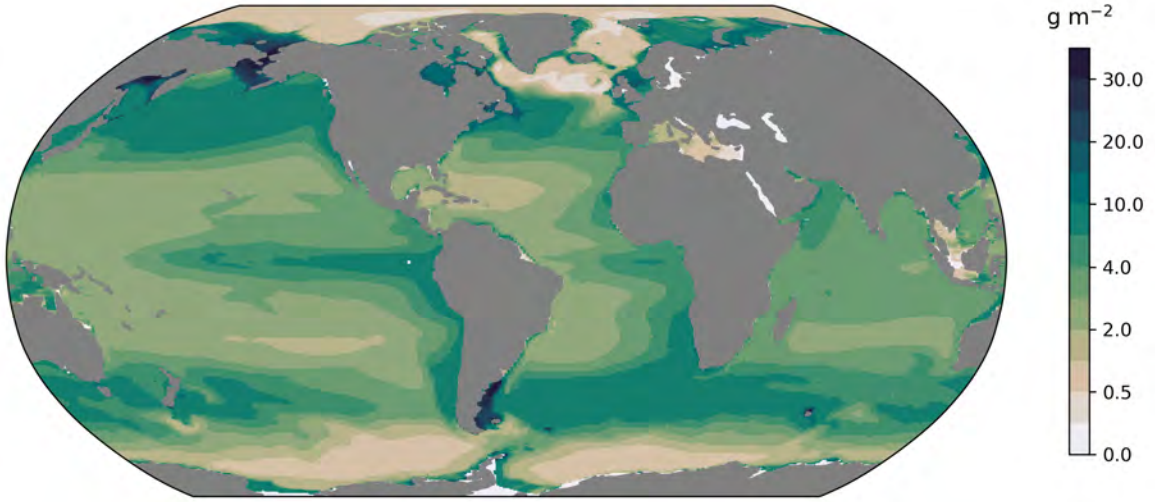
FEISTY Total Fish Biomass Simulations

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

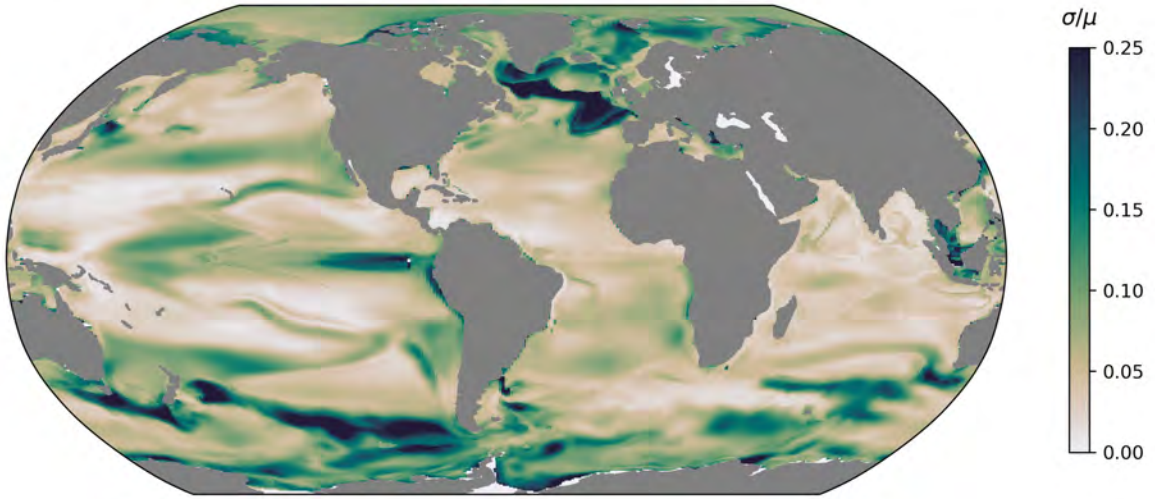




Annual mean of total fish biomass



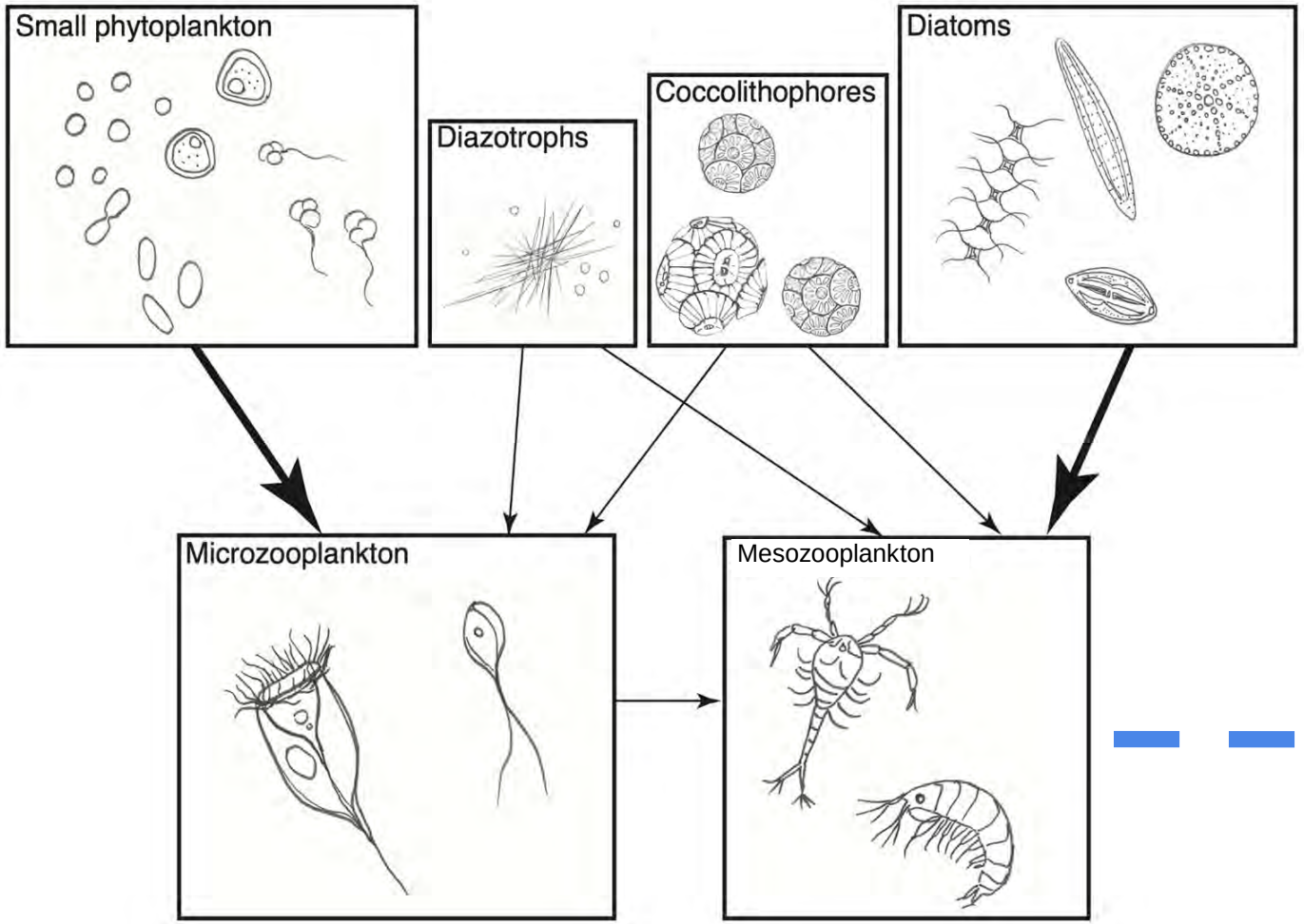
Coefficient of variation (σ/μ) of total fish biomass



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

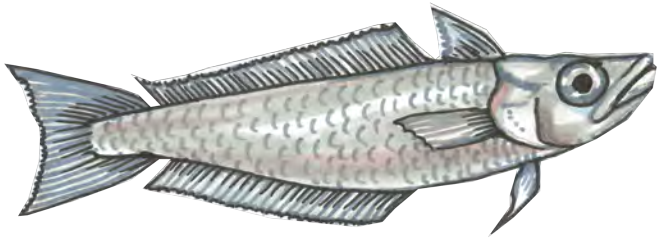
*Inez Fung

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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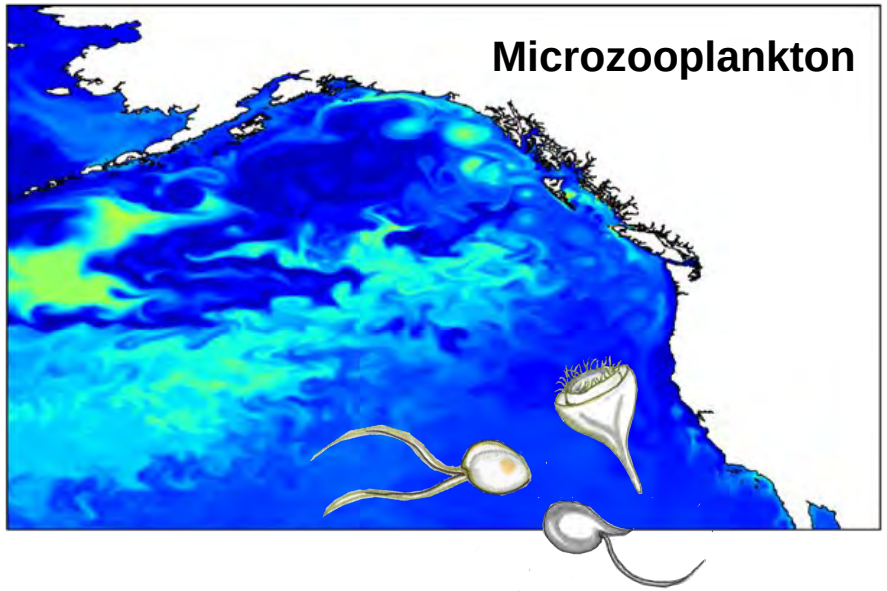

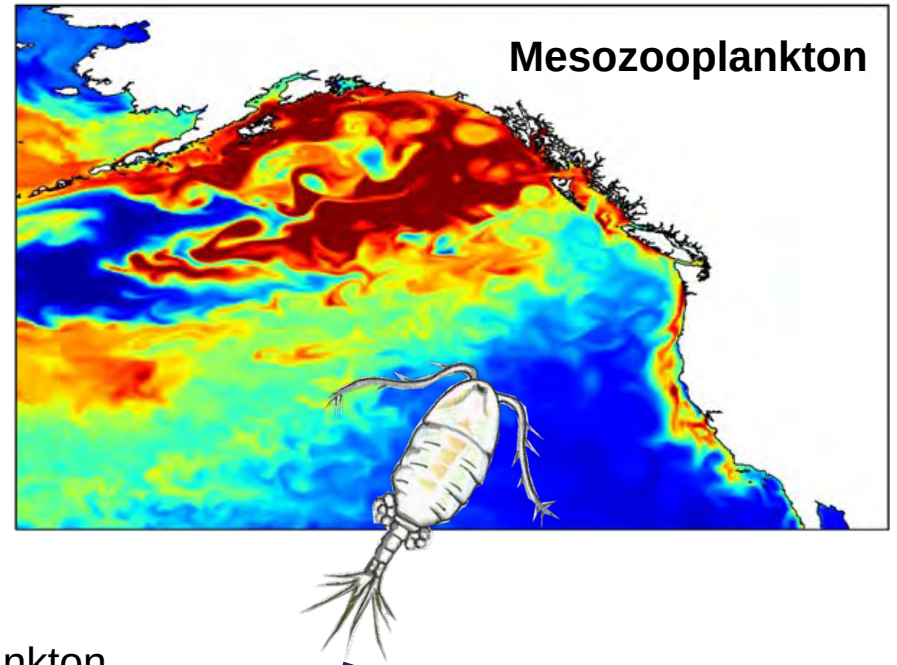

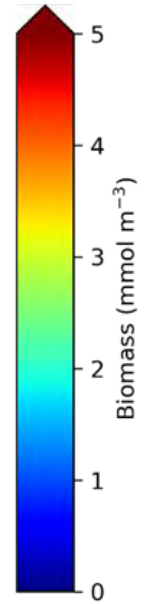

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FEISTY fish model

Courtesy of Kristen Krumhardt

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