Near-term predictions of ocean biogeochemistry in the Community Earth System Model

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Why predict ocean biogeochemistry?

Reliable near-term predictions of ocean biogeochemistry can aid in resource management decision-making.
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Reliable near-term predictions of ocean biogeochemistry can aid in resource management decision-making.

Near-term predictions can enable scientific discovery and process-based understanding of the biogeochemical system.

Get ready to measure - here comes the Blob!
Ocean biogeochemical variables of interest

Marine phytoplankton  Ocean acidity  Air-sea carbon flux
Unique aspects of ocean biogeochemical prediction

1. We have BIG trends to worry about
Unique aspects of ocean biogeochemical prediction

2. We have almost no observations

surface ocean pCO$_2$ (µatm)


Bakker et al. (2016), Sabine et al. (2013)
Predictable plankton

Net Primary Production -- Forecast lead time: 1 year

Krumhardt et al. (2020)
Ocean acidification in the California Current

Brady et al. (2020)
Global air-sea CO$_2$ flux

Initialization beats other forecast methods until...

Lovenduski et al. (2019)
New directions in ocean BGC prediction

1. We have many more “observations” to assess skill

interpolated surface ocean $\text{pCO}_2$

interpolated surface ocean pH

interpolated subsurface carbon

Landschützer et al. (2016)  
Gregor and Gruber (2021)  
Keppler et al. (in prep.)
New directions in ocean BGC prediction

2. We are considering multiple, simultaneous ecosystem stressors

Temperature + Acidity

Mogen et al. (in prep)
New directions in ocean BGC prediction

3. Phytoplankton may become more predictable in the future

![Graph showing trends in total biomass carbon concentration and coefficient of variance over time.](image-url)
New directions in ocean BGC prediction

3. Phytoplankton may become more predictable in the future

[Graph showing changes in total biomass carbon concentration and internal variability from 1920 to 2100, with ensemble spread marked.]

Change in internal variability
2000-2100

Ensemble spread

Δmean (%) Total Biomass Carbon Concentration (mmol C m⁻²)

Δσ (%) Total Biomass Carbon Concentration

Elsworth et al. (in prep.)
Ocean biogeochemical prediction is an emerging and exciting research field with multiple potential applications and much to be learned.

Analysis of near-term predictions with the CESM reveal the potential for predictability in marine phytoplankton, ocean acidification, and ocean carbon absorption.

Future research directions for ocean biogeochemical prediction include real-world skill assessment, a multi-stressor and/or event-based predictability framework, and the possibility of “easier” predictions at the end of the century.