Partitioning uncertainty in ocean carbon uptake projections

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How much \( \text{CO}_2 \) will the ocean absorb?

Globally-integrated sea-air \( \text{CO}_2 \) flux

CMIP5 models

<table>
<thead>
<tr>
<th>Scenario</th>
<th>2010</th>
<th>2020</th>
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<th>2040</th>
<th>2050</th>
<th>2060</th>
<th>2070</th>
<th>2080</th>
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<tbody>
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</tr>
</tbody>
</table>
How much CO$_2$ will the ocean absorb?

California Current System average sea-air CO$_2$ flux

CMIP5 models
Sources of projection uncertainty

Internal variability

- El Niño
- La Niña

Model structure

- CESM1-BGC
  - atmosphere CAM4
  - ocean POP2
  - land CLM4
  - sea ice CICE4
  - coupler MCT
  - shared utilities

- GFDL-ESM2M
  - atmosphere
  - ocean
  - land
  - coupler

- IPSL-CM5A-LR
  - atmosphere LMDZ4
  - land ORCHMEE
  - ocean NEMO
  - coupler OASIS

Emission scenario

- Scenario categories:
  - RCP8.5
  - RCP6
  - RCP4.5
  - RCP2.6
- Historical emissions
- 2015 Estimate

climate.gov Global Carbon Project

Alexander and Easterbrook (2015)
CESM ensembles

Global-mean surface temperature

adapted from Kay et al. (2015) and Sanderson et al. (2015)
CESM ensembles

Globally-integrated sea-air CO$_2$ flux

Lovenduski et al. (in revision)
How uncertain is our projection?

CESM ensembles

How uncertain is our projection?

CESM ensembles

Lovenduski et al. (in revision)
Evolving sources of uncertainty

CESM ensembles

Lovenduski et al. (in revision)
Evolving sources of uncertainty

CMIP5

Lovenduski et al. (in revision)
Uncertainty on the biome scale

CESM ensembles

Lovenduski et al. (in revision)
Internal variability is the primary source of uncertainty until...

CESM ensembles

Global

When do the lines cross for each biome?

Lovenduski et al. (in revision)
Uncertainty on the biome scale

CMIP5

Lovenduski et al. (in revision)
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CMIP5

When do the lines cross for each biome?

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Conclusions

• Projections of the future ocean carbon sink are fraught with uncertainty, particularly at regional scales.
• The 3 sources of projection uncertainty vary with time, spatial averaging scale, and from region to region.
• In order to produce reliable projections on regional scales, we should invest in reducing model structure uncertainty.
Want to hear more CESM-LE ocean talks?

Thursday morning - OMWG session
• 11:15 Kristen Krumhardt
• 11:30 Amanda Fay
• 11:45 Riley Brady