



The Surface Ocean CO₂ Mapping intercomparison (SOCOM) initiative

Alizée Roobaert and the SOCOM phase 2 (SOCOMv2) team

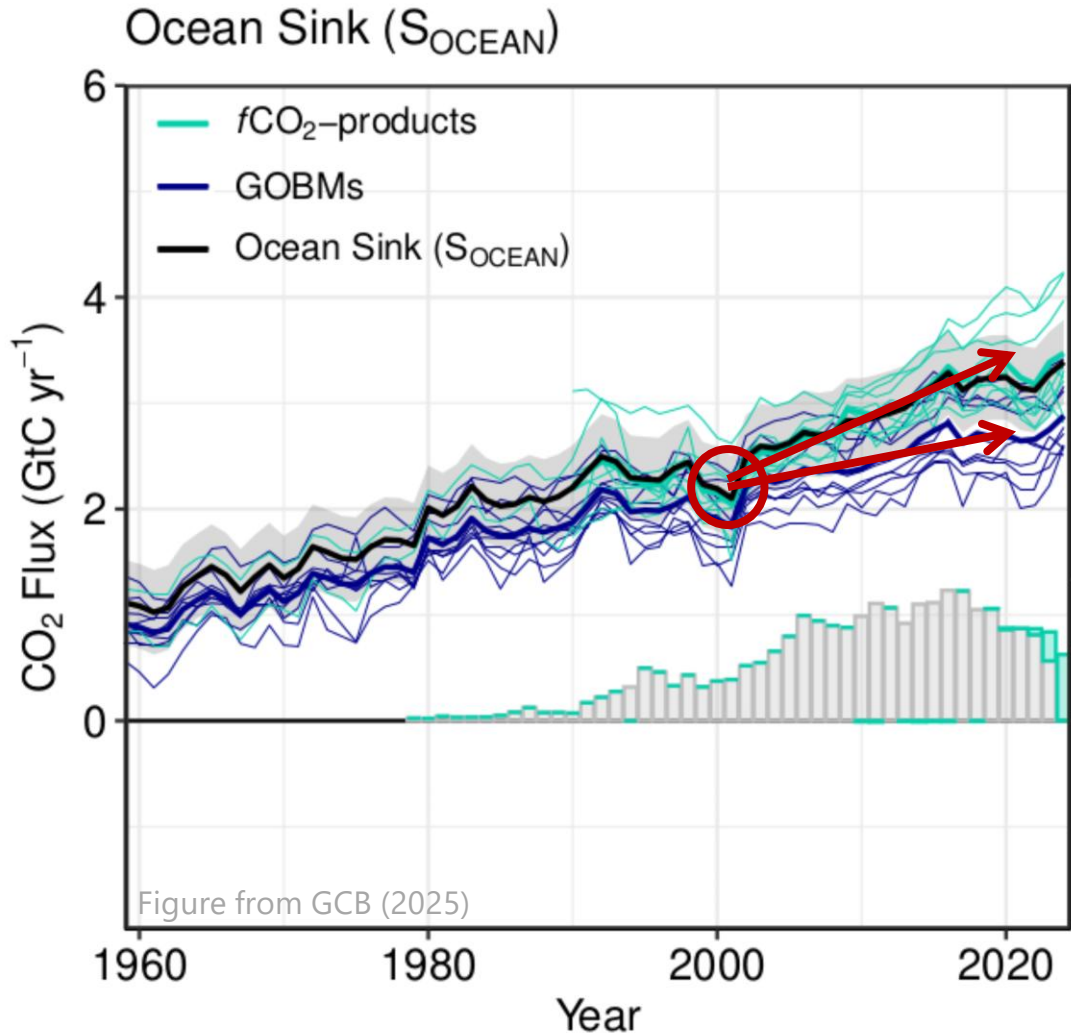
SOCOMv2 : A. Roobaert, D. J. Ford, M. G. Sreeush, G. A. McKinley, J. Hauck, A. Barton, L. Bopp, F. Chevallier, L. M. Jeuthouang, A. R. Fay, M. Gehlen, L. Gregor, N. Gruber, T. H. Heimdal, Y. Iida, A. Jersild, M. Keppens, C. Rödenbeck, J. Rogerson, J. Schwinger, C. A. Shaum, H. Tsujino, A. Watson, J. Zeng, J. D. Shutler, and P. Landschützer

Motivation of SOCOMv2

Coordinated, community-driven framework to evaluate sfCO₂ reconstruction skills and derived air–sea CO₂ fluxes under realistic observational constraints

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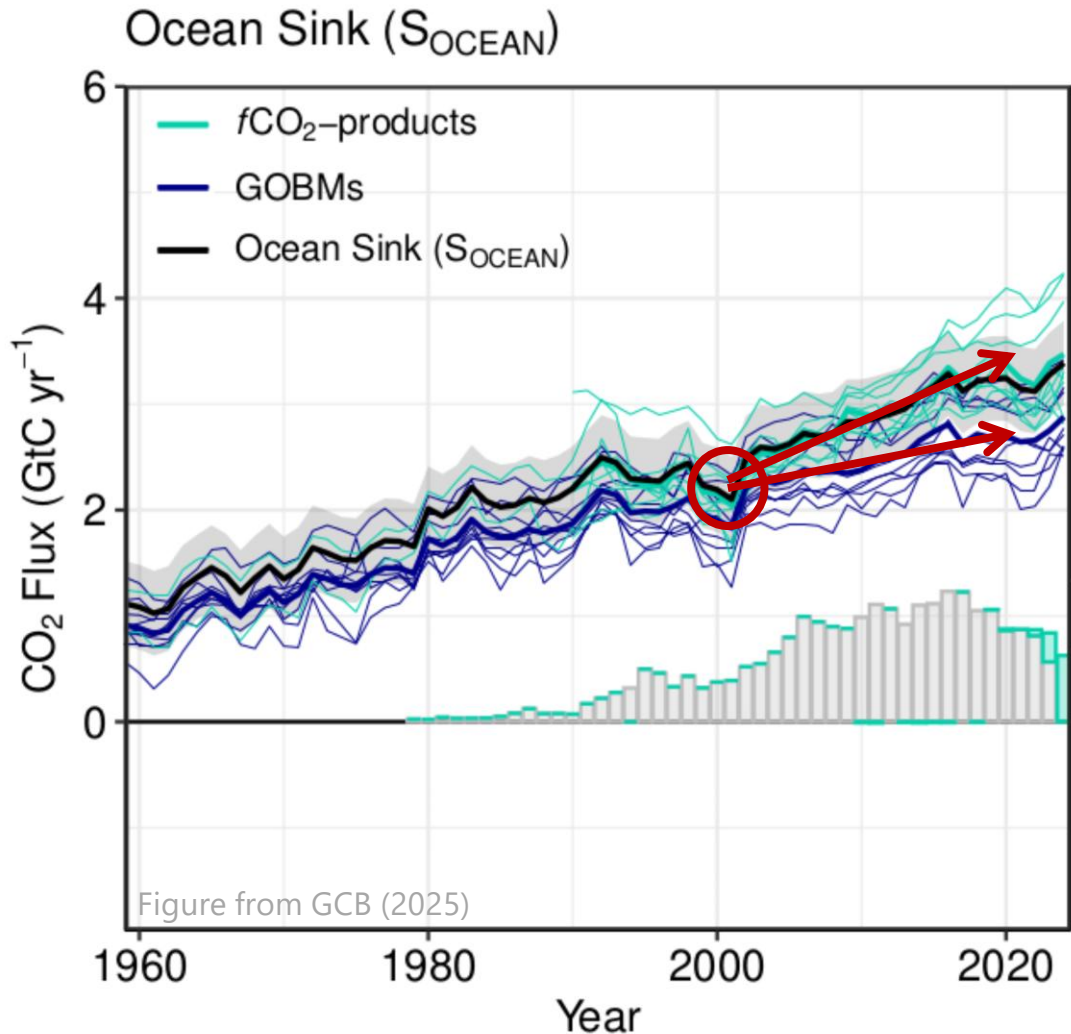


6 experiments:

- (1) Comprehensive geospatial uncertainty analysis**
- (2) Multiple hindcast testbed for realistic climate variability**
- (3) Large ensemble testbed for diverse potential climate states**
- (4) Climatological testbed**
- (5) Near-surface vertical temperature corrections**
- (6) Coastal testbed**

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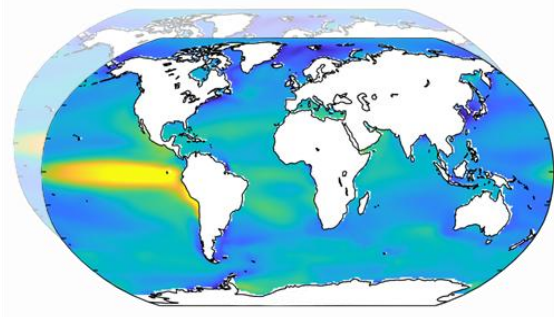
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Testing sfCO₂ reconstructions against a known ocean

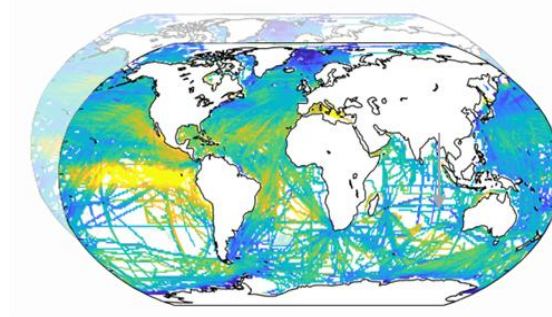
1. Five Global Ocean Biogeochemistry Model (GOBMs) as a virtual ocean

- CESM ETHZ1
- FESOM2 REcoM
- IPSL r1
- MRI ESM2
- NorESM



2. Subsampled as SOCATv2023 tracks

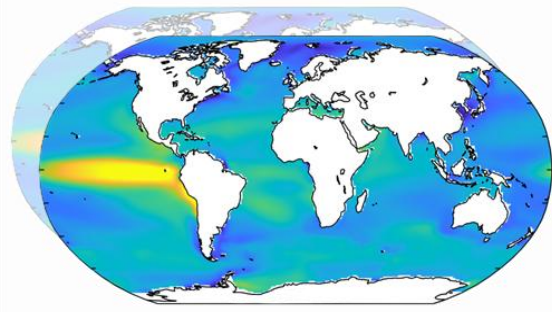
- Irregular space-time sampling
- sfCO₂
- Environmental proxies



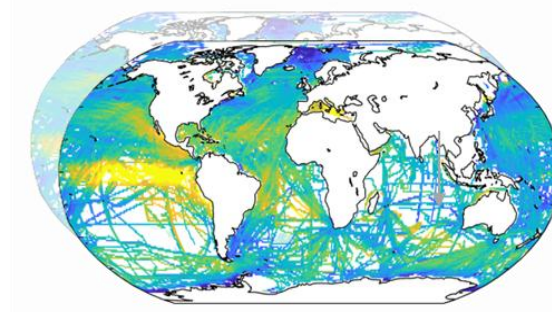
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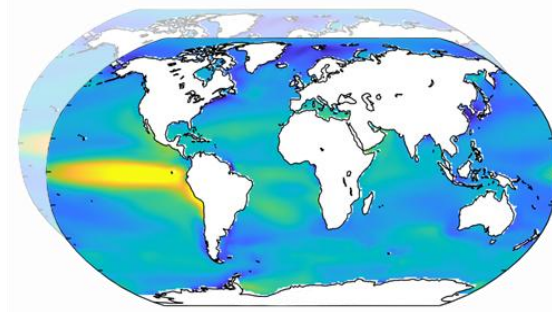
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3. For each GOBM, nine sfCO₂ reconstructions

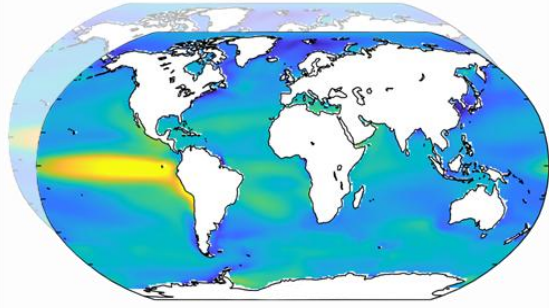


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- CSIR-ML6
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- UExp-FNN-U
- VLIZ-SOMFFN
- NIES-ML3
- CMEMS-LSCE-v2

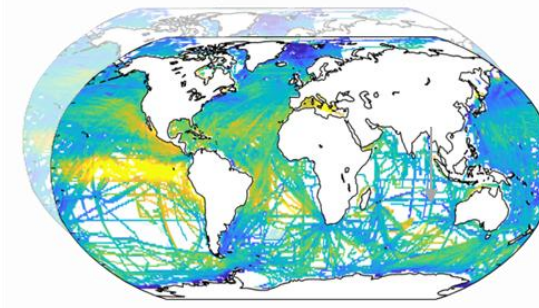
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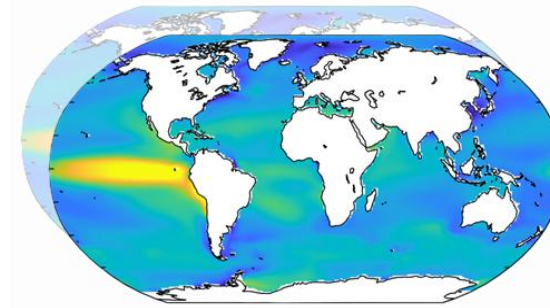
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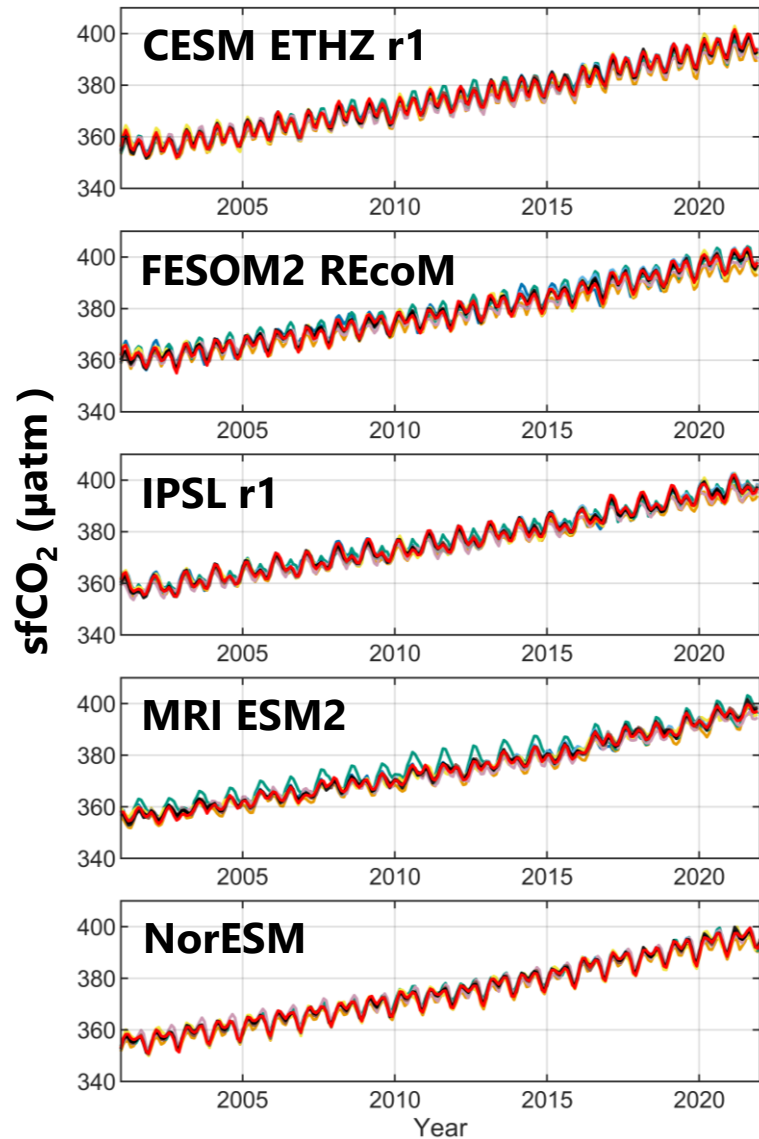
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4. Isolate reconstruction-driven uncertainty

- Compare reconstructed sfCO₂ fields to the model "truth"
- How reconstruction uncertainty propagates into FCO₂

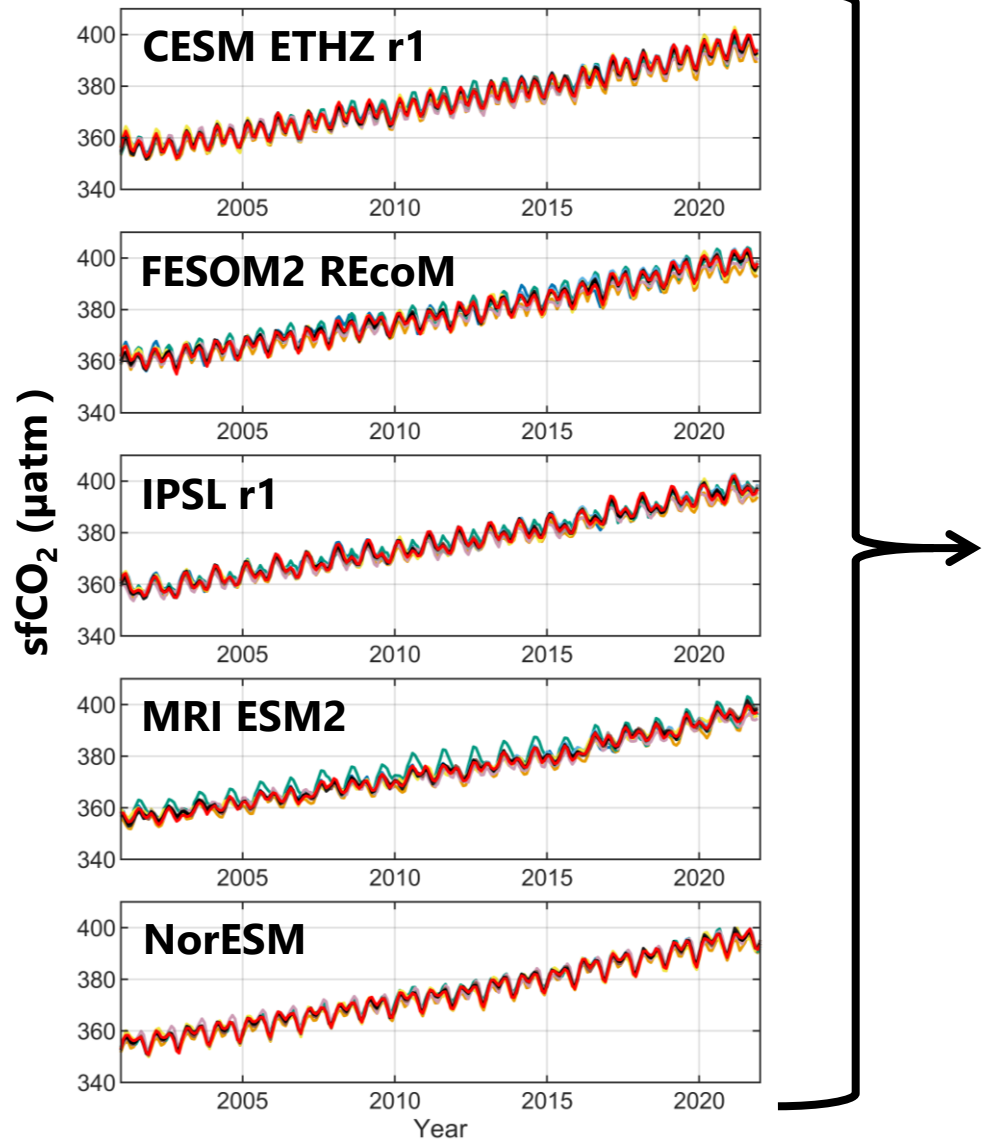
sfCO₂ reconstructions capture global variability



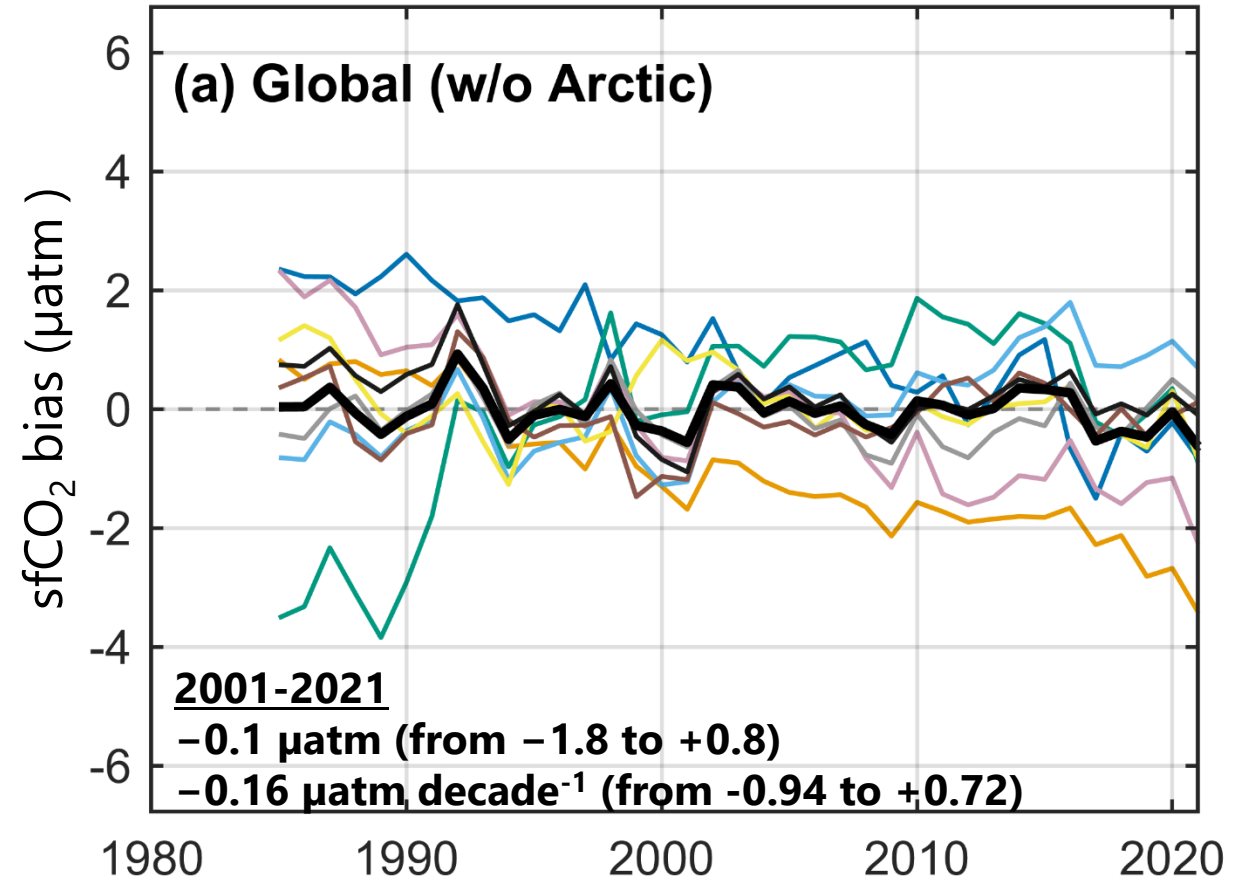
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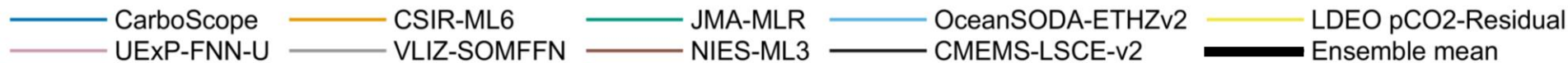
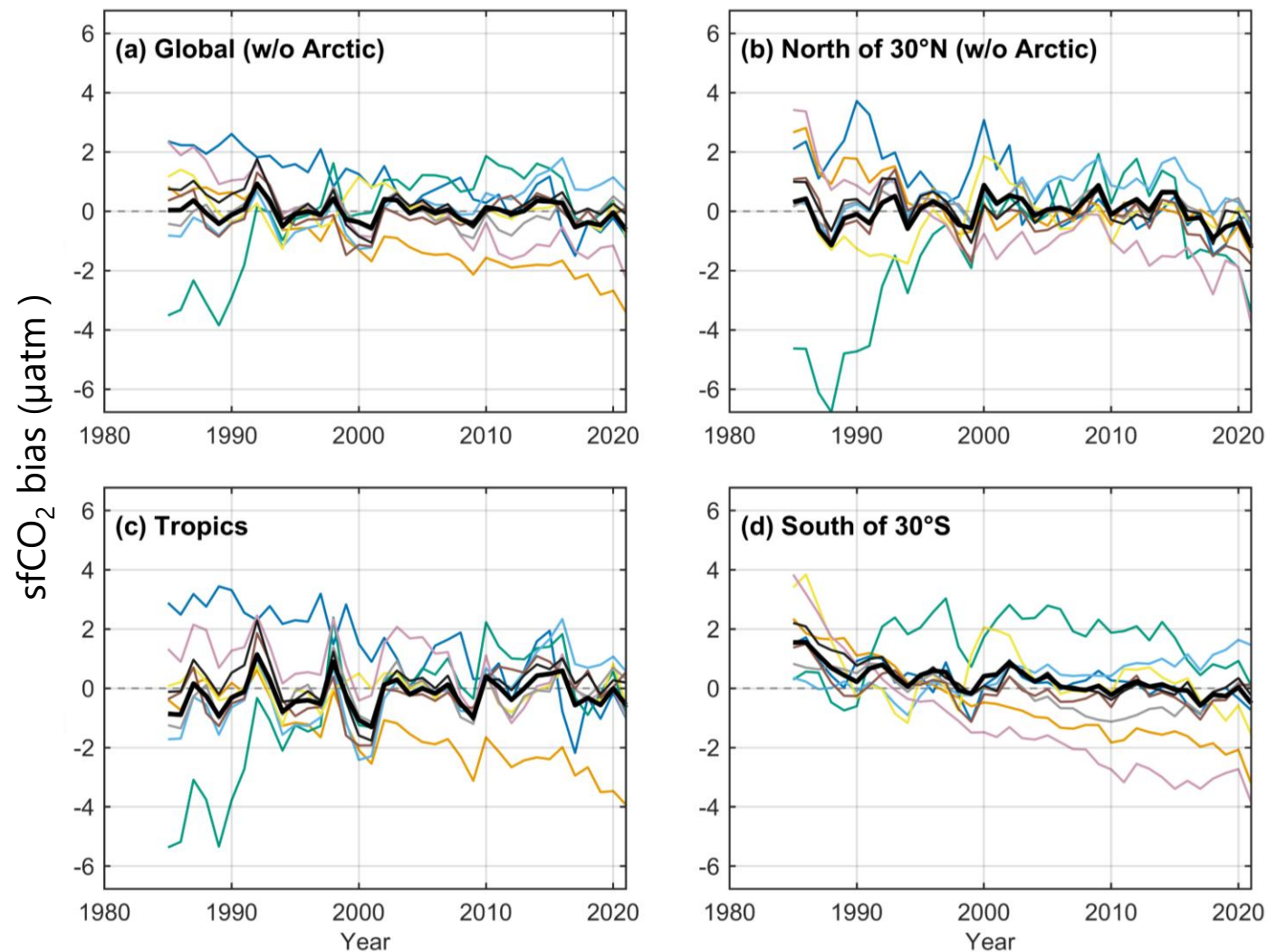
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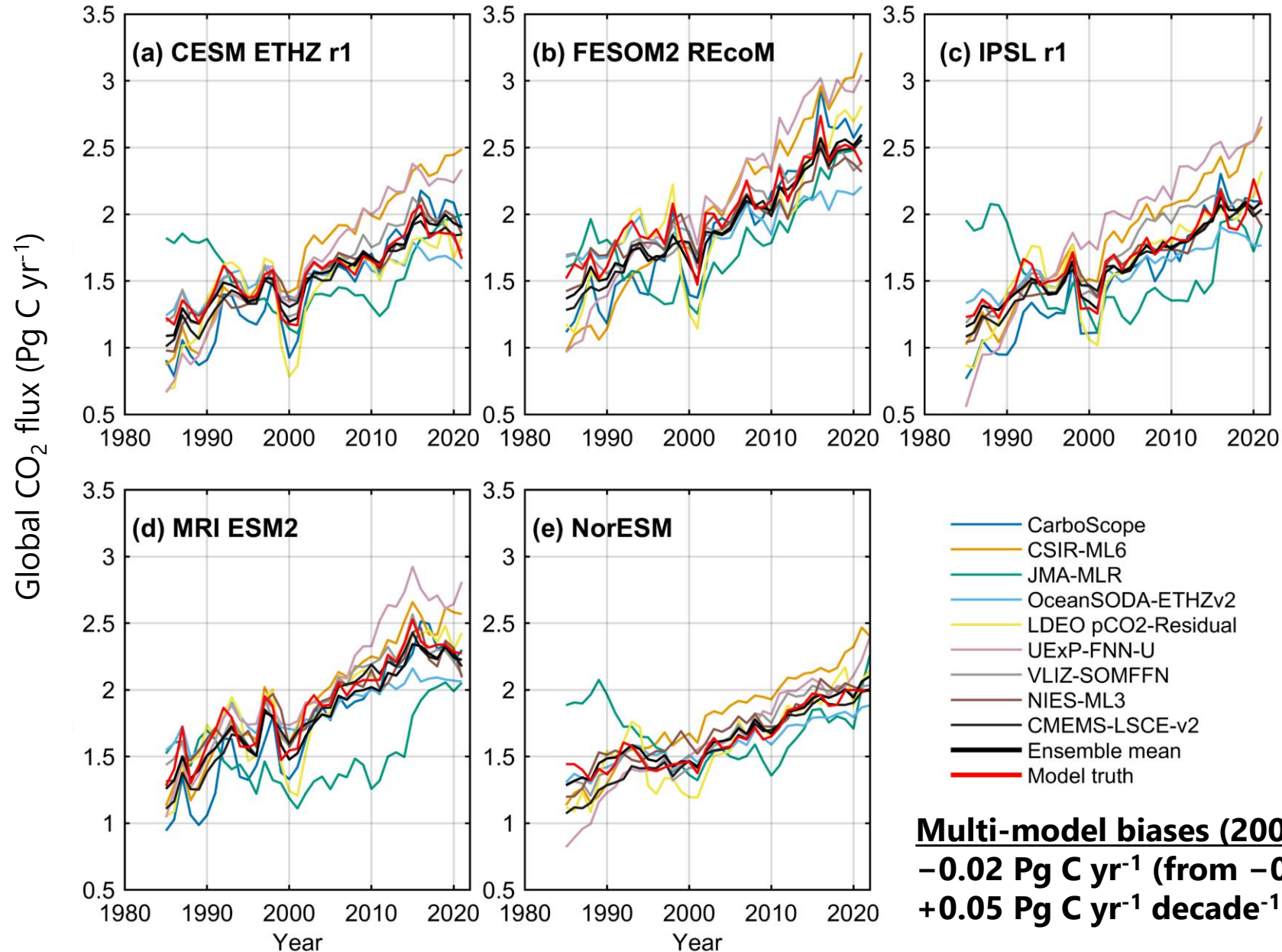
Multi-model mean sfCO₂ biases



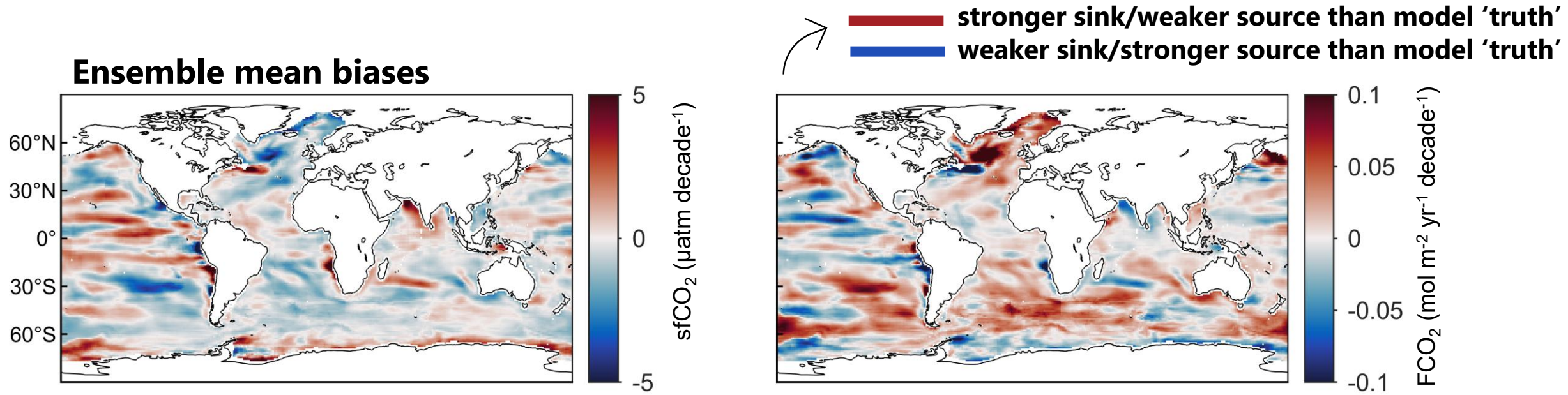
Important regional biases remain, particularly in the Southern Ocean and the tropics



sfCO₂ reconstruction biases propagate to CO₂ fluxes

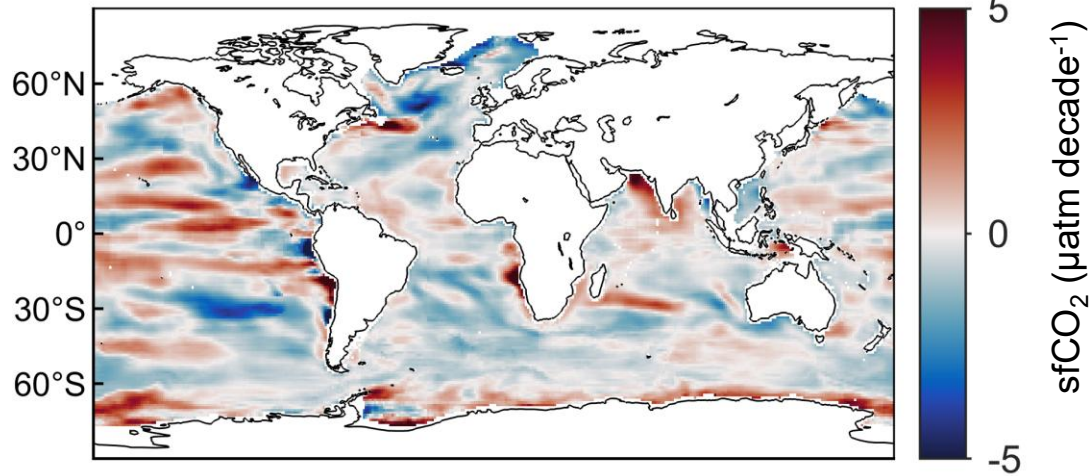


Regional averages hide large local errors - trend (2001-2021)

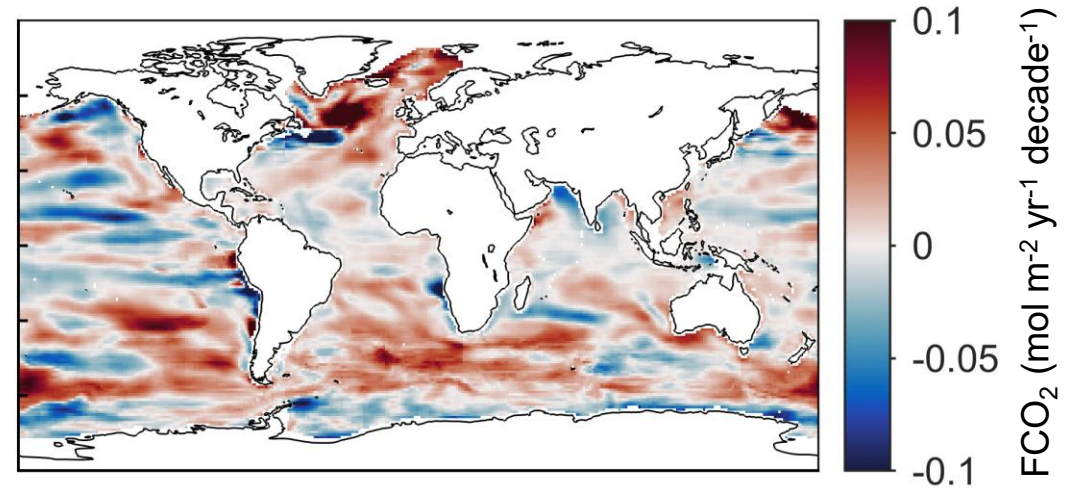


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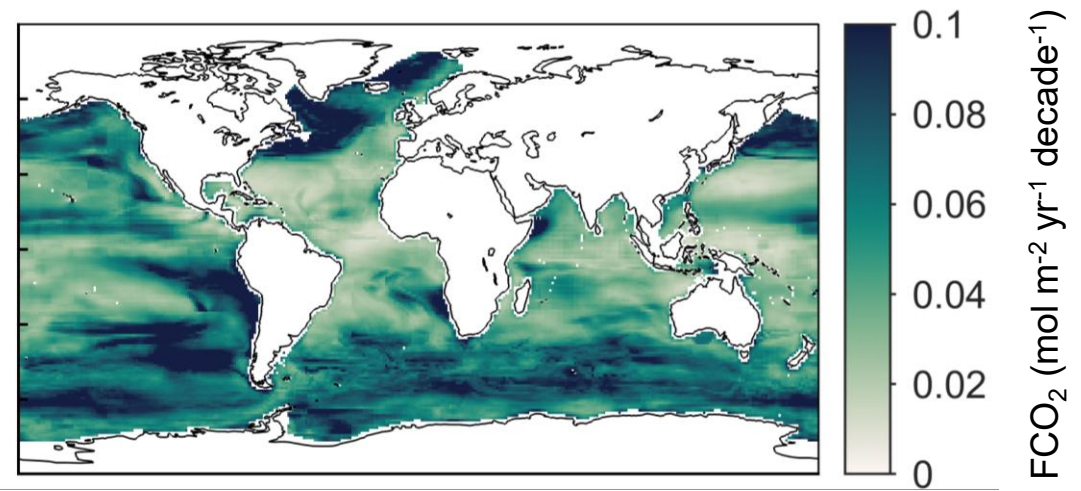
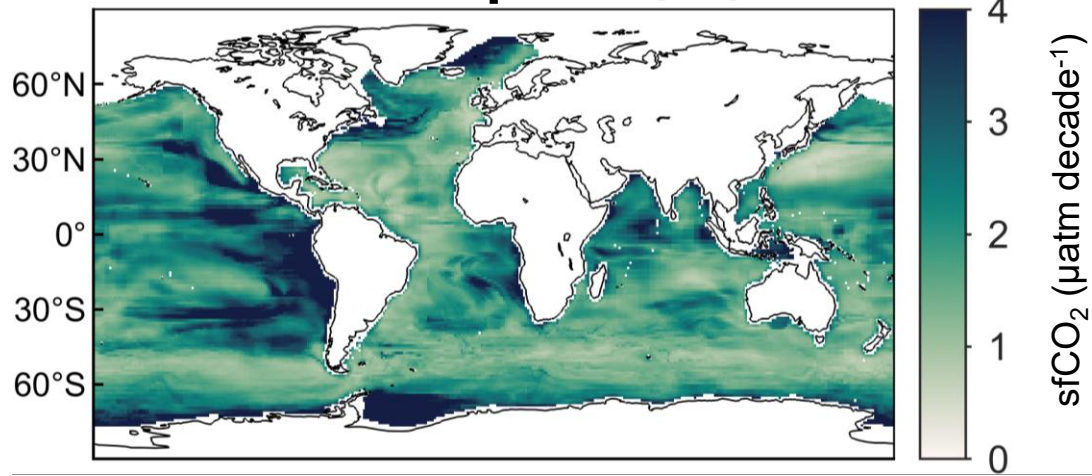
Ensemble mean biases



stronger sink/weaker source than model 'truth'
weaker sink/stronger source than model 'truth'



Inter-method spread (1σ)



What we learned from SOCOMv2



- 1. Under the SOCOMv2 framework of this study, ensemble averaging provides robust estimates of the global ocean carbon sink (mean state and trend)**
- 2. Individual sfCO₂ reconstruction methods differ substantially**
- 3. Regional averages can mask large local errors**
- 4. Reconstruction uncertainty explains part but not all of the divergence with the GCB**

Global GCB (2025)

0.59 Pg C yr⁻¹ (mean offset, 2015-2024)

0.19 Pg C yr⁻¹ decade⁻¹ (trend difference, 2002-2024)

This study

-0.02 Pg C yr⁻¹ (mean bias, 2001-2021)

+0.05 Pg C yr⁻¹ decade⁻¹ (trend bias, 2001-2021)