

ECCO infrastructure, activities, and science at MIT

ECCO26, UT Austin, TX

Outline

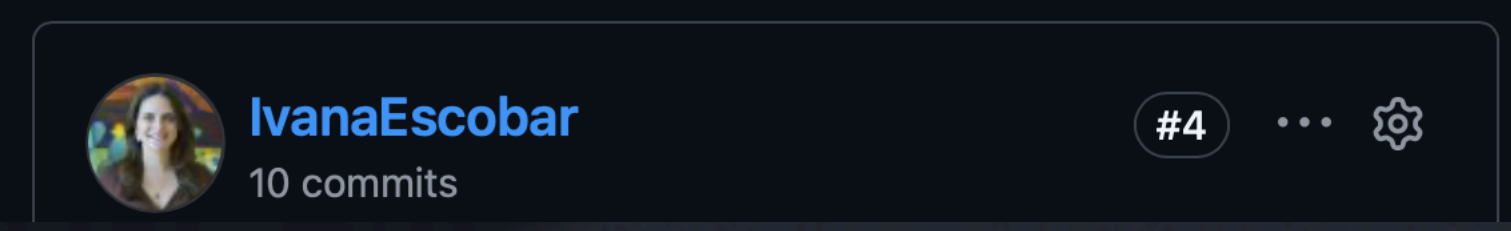
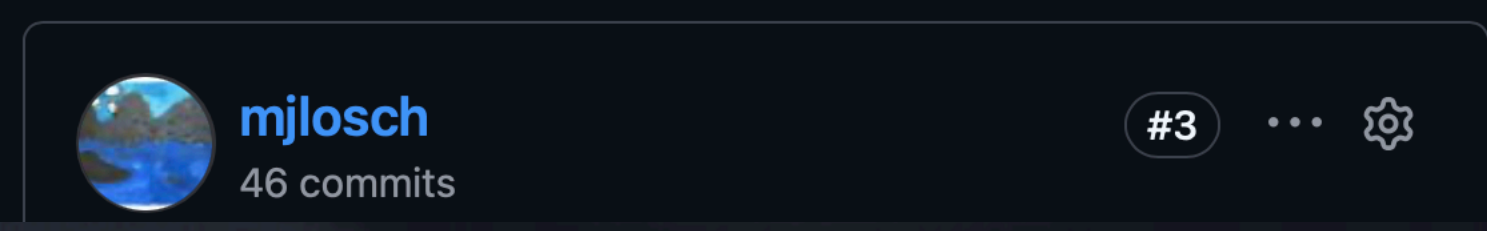
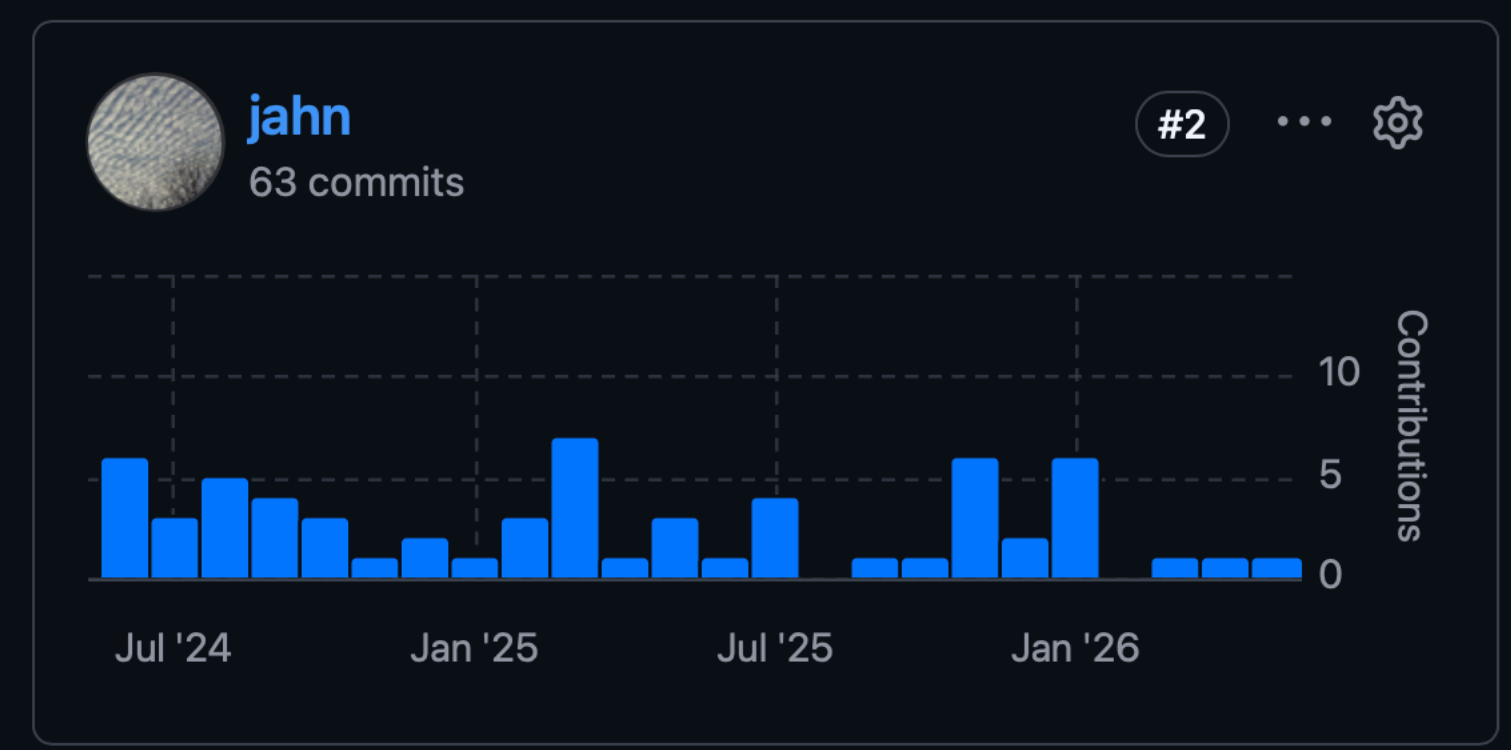
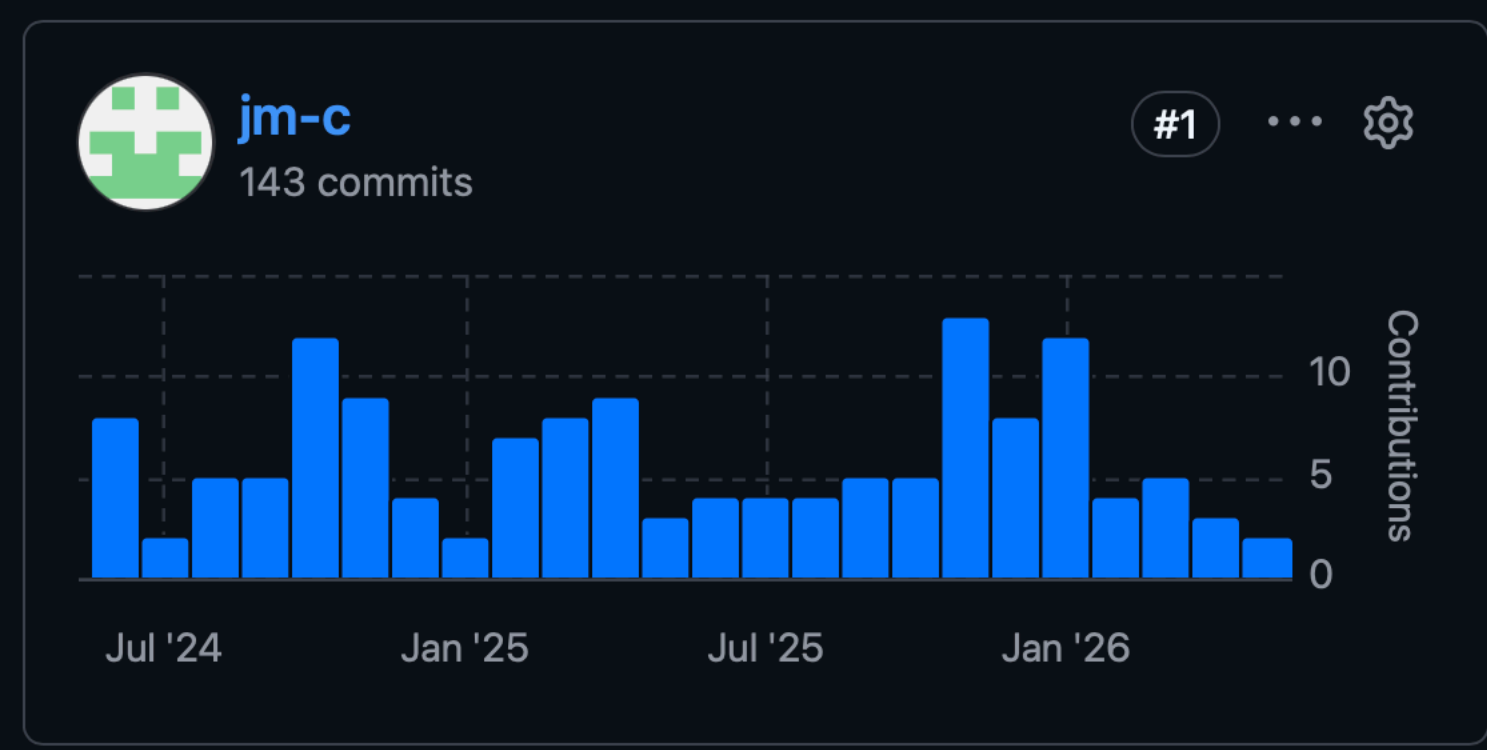
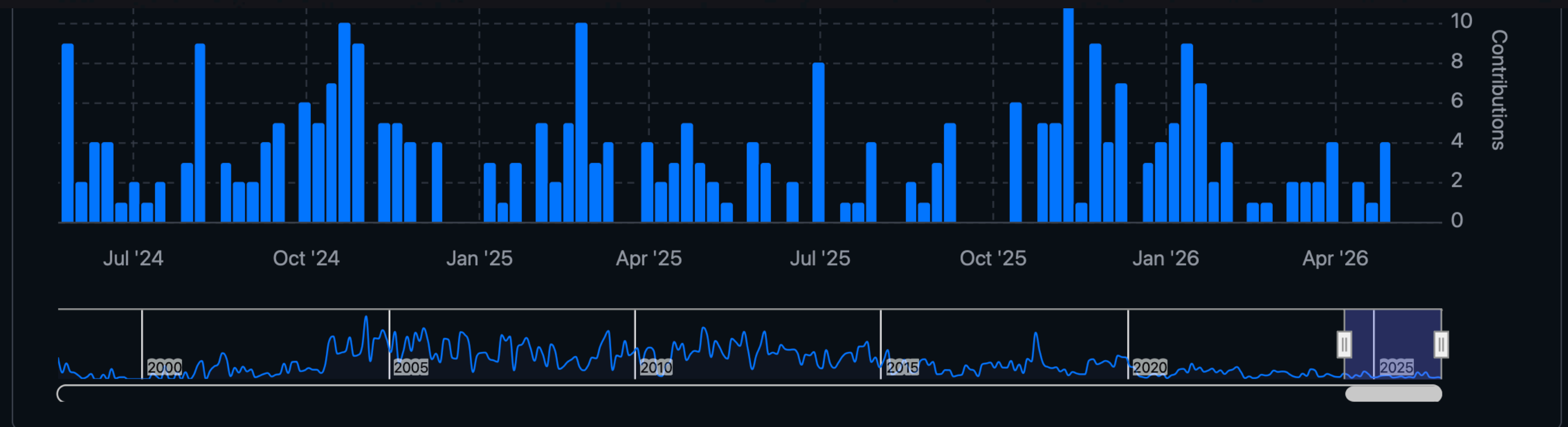
- Infrastructure
- Activities
- Science

ECCO team @ MIT :

Gael Forget, Jean Michel Campin, Oliver Jahn,


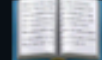
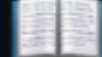





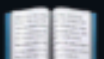
Yuanyuan Song, Wenrui Jiang, Yueyang Lu

And Colleagues



JuliaOcean & JuliaClimate

▼ Data (Julia)

- [Climatology.jl](#)  : accessing, reading, displaying, and analyzing climate data sets stars 20
- [OceanRobots.jl](#)  : analysis and simulation of data generated by ocean robots stars 30
- [ArgoData.jl](#)  : Argo data processing and analysis stars 23
- [ClimateModels.jl](#)  : uniform interface to climate models of varying complexity stars 48
- [MITgcm.jl](#)  : framework to interact with MITgcm (setup, run, output, plot, ...) stars 38
- [MeshArrays.jl](#)  : gridded Earth variables, global domain decomposition, and C-grid support stars 47
- [ECCO.jl](#)  : package enables with automatic differentiation and optimization packages stars 7
- [Drifters.jl](#)  : trajectory simulations for point particles in the Ocean and Atmosphere stars 106
- [PlanktonIndividuals.jl](#)  : simulation of plankton communities and their interaction with environmental factors stars 32

MITgcm.jl

Running ECCO from Julia

```
using MITgcm

params=read_toml(:ECCO4)
MC=MITgcm_config(inputs=params)

#providing input folder (optional)
push!(MC.inputs[:setup][:main], "/path/to/input/folder")

#modifying run time options
#MC.inputs[:pkg][:PACKAGES]

setup(MC)
build(MC)
launch(MC)
```

Darwin3 Model (1D)

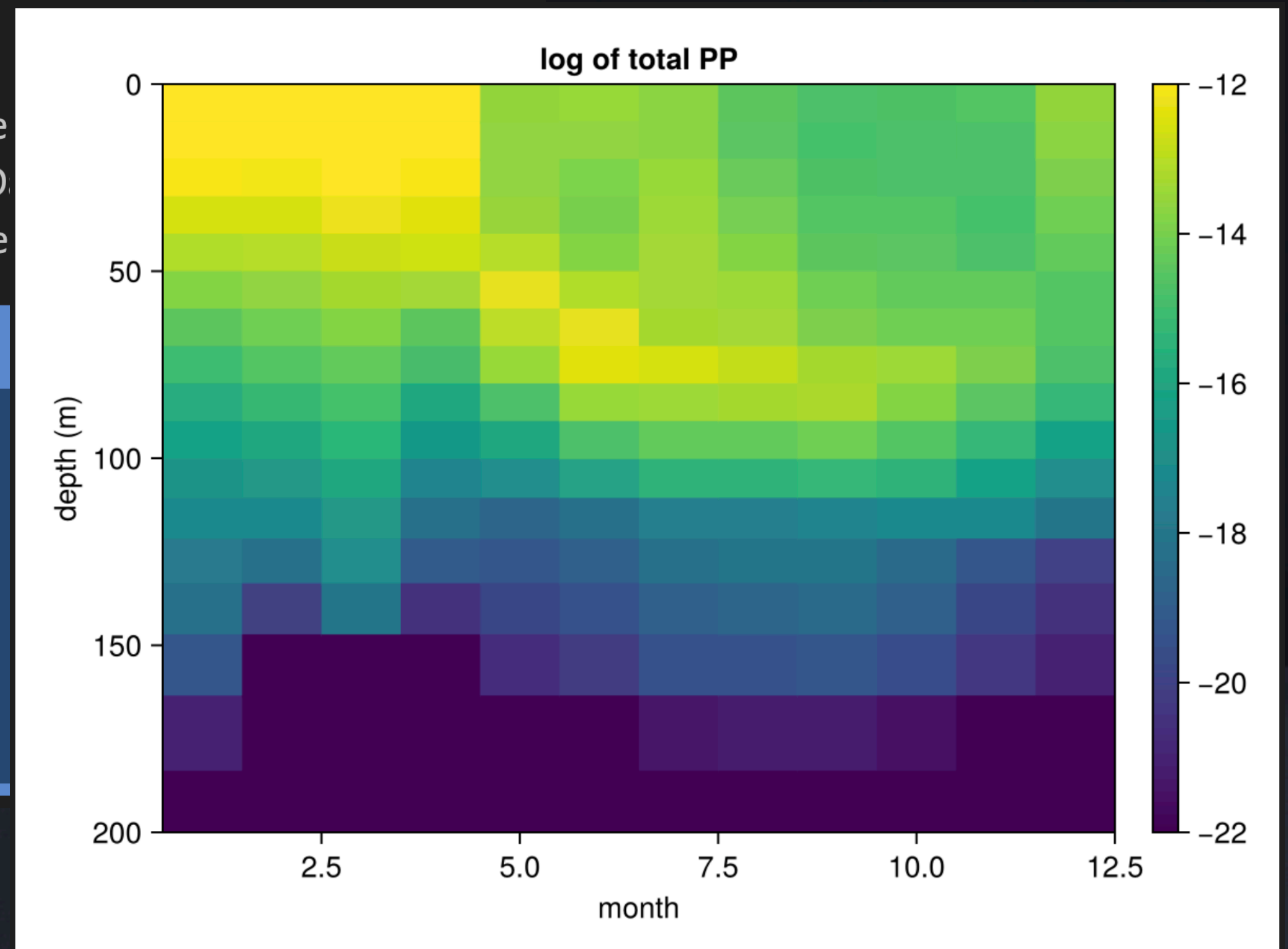
Contributors:

- Stephanie Dutkiewicz provided the
- Oliver Jahn and collaborators the D
- Gaël Forget the MITgcm.jl interface

Note

For more information, please refer to

- [darwin3.readthedocs](https://darwin3.readthedocs.org)
- darwinproject.mit.edu
- cbiomes.org
- [MITgcm.readthedocs](https://MITgcm.readthedocs.org)
- MITgcm.jl

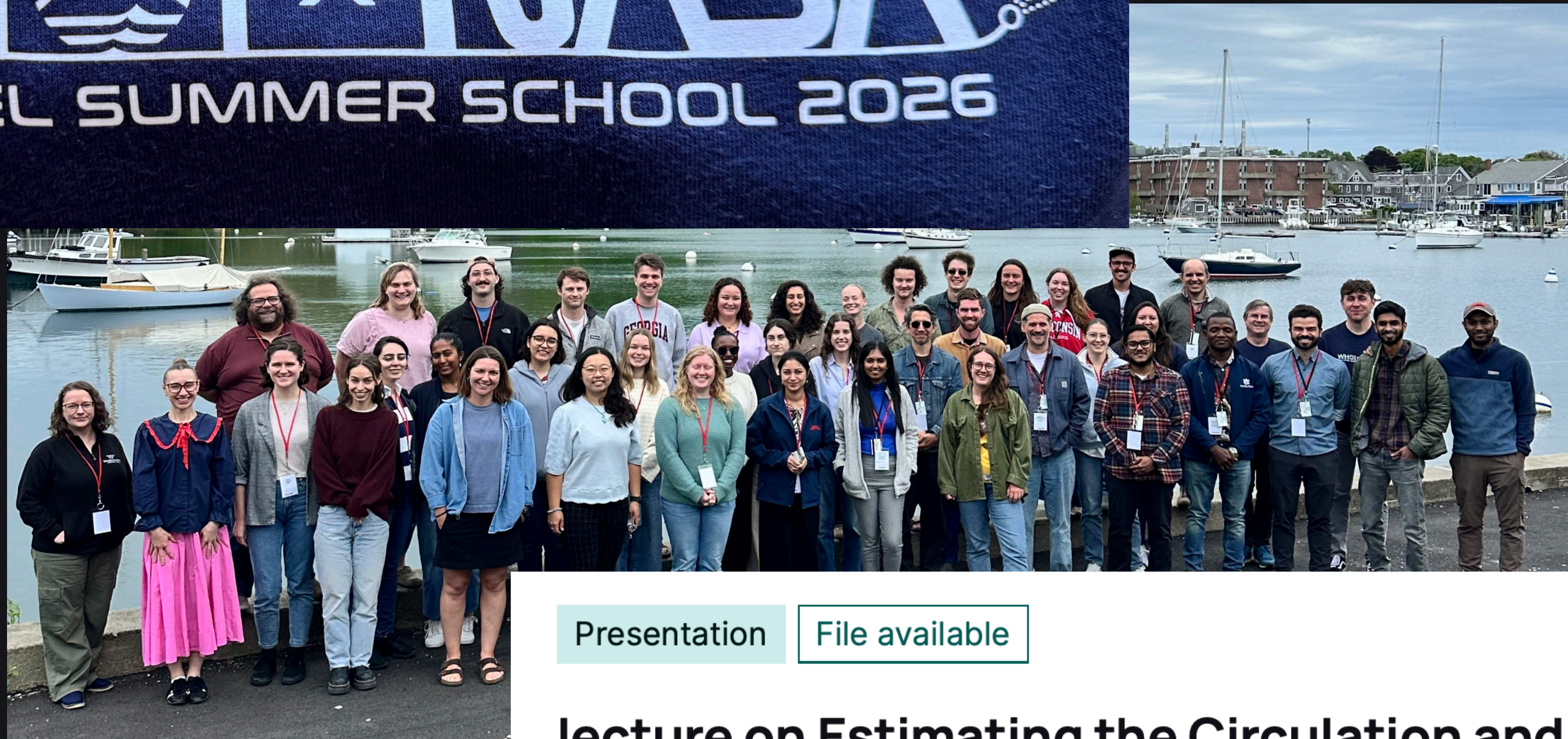


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WHOI x NASA

SEA-LEVEL SUMMER SCHOOL 2026



Organized by Chris.
Piecuch & team

Presentation

File available

lecture on Estimating the Circulation and Climate of the Ocean @ 2026 WHOI-NASA Summer School in Sea Level Science

May 2026

DOI: [10.13140/RG.2.2.28126.60489/1](https://doi.org/10.13140/RG.2.2.28126.60489/1)

Conference: WHOI-NASA Summer School in Sea Level Science · At: MBL, Woods Hole

<https://doi.org/10.13140/RG.2.2.28126.60489/1>

Thanks to Drs
Yuanyuan Song,
Yueyang Lu for
leading the tutorials.

Thanks to Dr Ian Fenty
for contributing slides,
Dr Ou Wang for
contributing to the
tutorials, the ECCO
community, and to
NASA for their
support.

- A pdf version of the lecture on **Estimating the Circulation and Climate of the Ocean (ECCO)** is available @ <https://doi.org/10.13140/RG.2.2.28126.60489/1>
- Below is the information on tutorials and suggested exercises

Notebooks we will go over and try out together

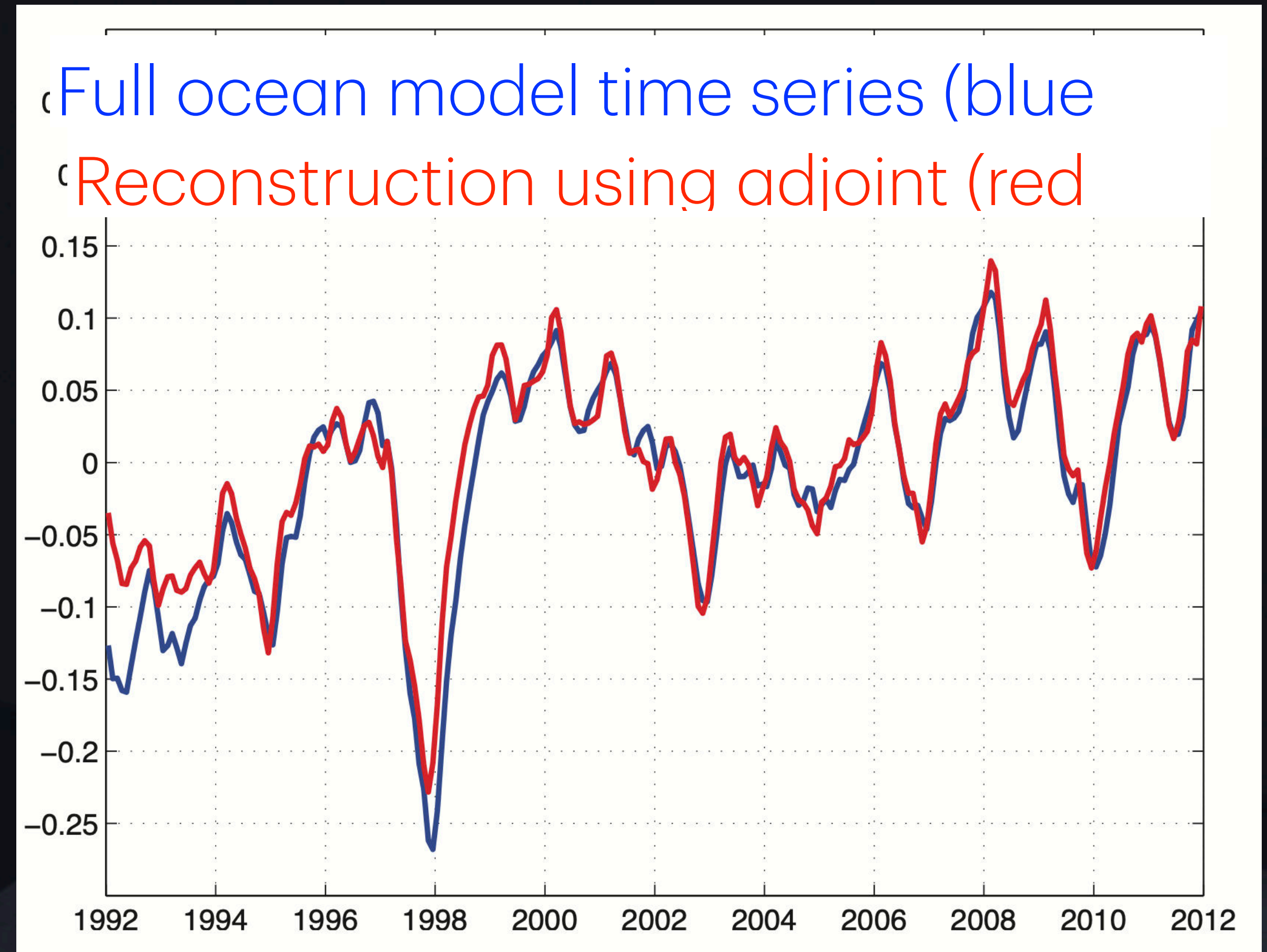
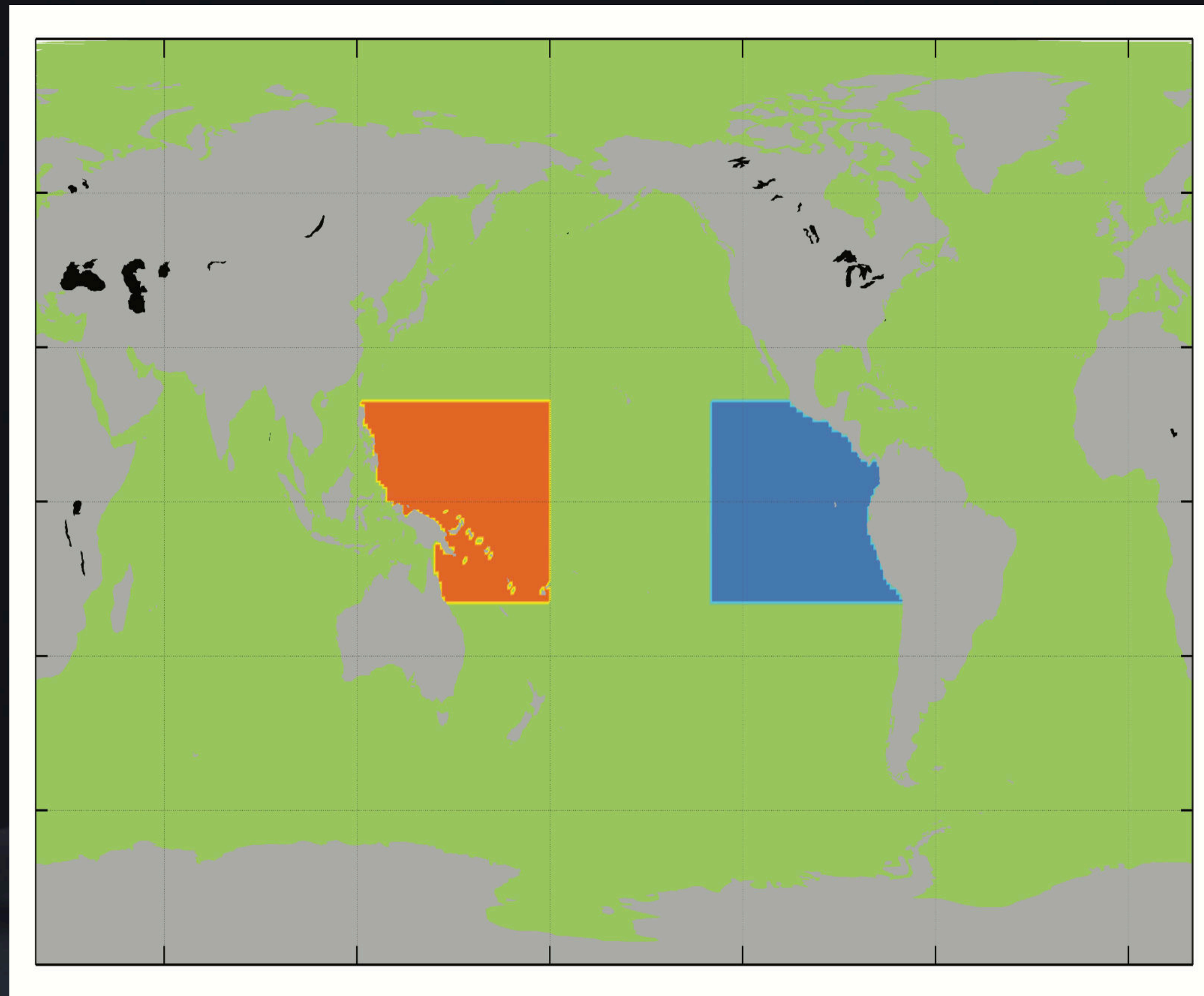
- explore standard ECCO diagnostics interactively via Pluto/Julia using [Climatol](#)
- adjoint reconstruction in python or julia notebook (notebook & data prep)
- reference ECCO recipes to analyze sea level from gridded output
 - <https://ecco-v4-python-tutorial.readthedocs.io/StericSeaLevel.html>
 - <https://ecco-v4-python-tutorial.readthedocs.io/BottomPressure.html>
 - <https://ecco-v4-python-tutorial.readthedocs.io/SeaLevel.html>

Input data

- For the tutorial on ECCO reconstruction, the files needed are @ <https://zenodo.org/records/20301468>
- For the tutorial on steric sea level and bottom pressure in ECCO, the files needed are @



Reconstruction / Attribution Tutorial



ECCO 2017 annual meeting : Adjoint And Cloud Applications Of The ECCO V4 Framework
<https://doi.org/10.13140/RG.2.2.13115.46889>

Biogeochemical Transport Matrix Modelling Workshop

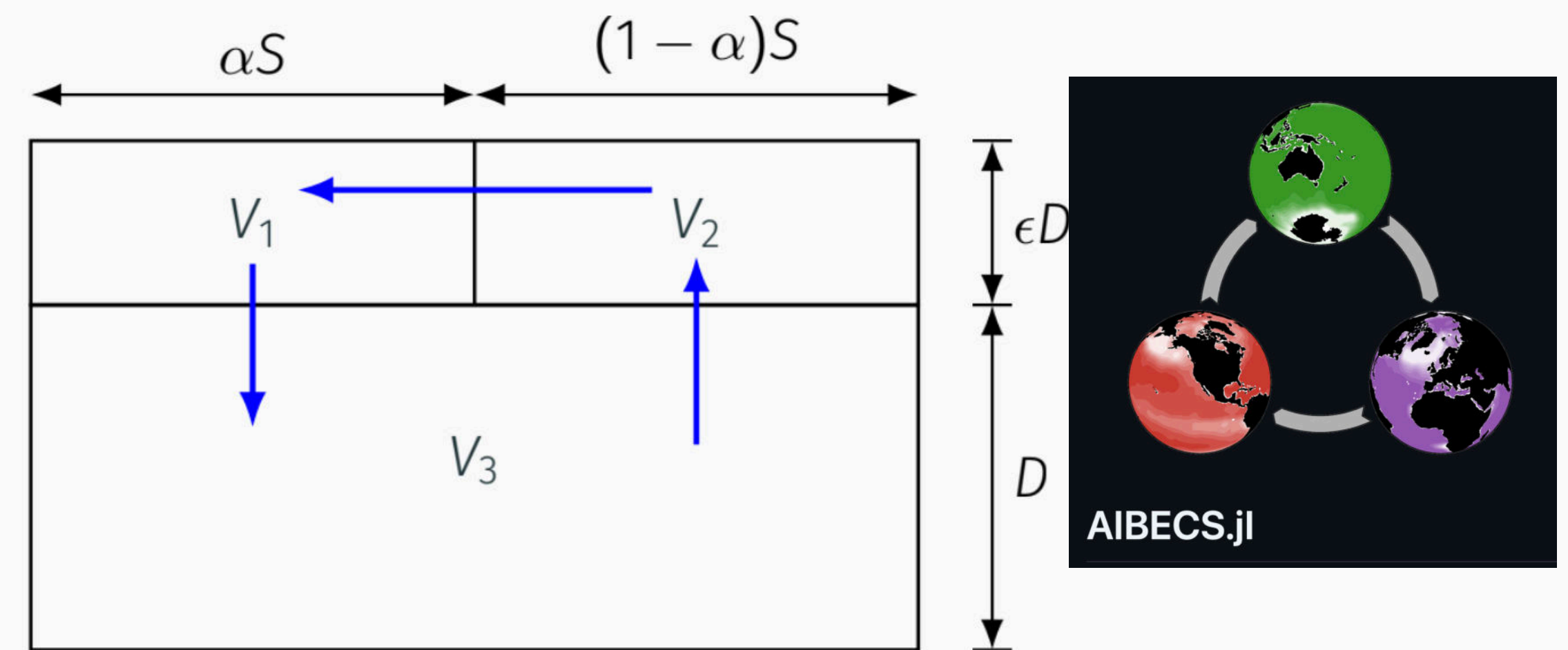
ECCO for Transport Matrix Applications

<https://doi.org/10.13140/RG.2.2.22429.47844/1>



Organized by G Britten, F Primeau, Benoit Pasquier, & team

Slide credits : François Primeau



$$\frac{d}{dt} \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} + \underbrace{\begin{bmatrix} V_1 & 0 & 0 \\ 0 & V_2 & 0 \\ 0 & 0 & V_3 \end{bmatrix}^{-1} \begin{bmatrix} -q & q & 0 \\ 0 & -q & q \\ q & 0 & -q \end{bmatrix}}_{\mathbf{T}} \begin{bmatrix} c_1 \\ c_2 \\ c_3 \end{bmatrix} = \begin{bmatrix} S_1 \\ S_2 \\ S_3 \end{bmatrix}$$

Collaborative Opportunities for ECCO

Marine Environment Reanalyses – Evaluation Project (MER-EP)

MER-EP is a project endorsed by the [UN Ocean Decade](#).

[ABOUT](#) [FOCUS](#) [SCIENCE](#) [TEAMS](#) **[UN DECADE](#)** [EVENTS](#) [NEWS](#)

- List of MER-EP Science Steering Committee members. Co-chairs are marked in bold.

First name	Surname	Affiliation (Project)
Romain	Bourdallé-Badie	MOi/France (co-chair)
Marie	Drévilon	MOi/France (co-chair)
Chunxue	Yang	CNR/Italia (co-chair)
Gaël	Forget	MIT/USA
Yosuke	Fujii	MRI-JMA/Japan
Matthew	Martin	MetOffice/UK
Peter	Oke	CISRO/Australia
Magdalena	Balmaseda	ECMWF, U. Reading/ UK
Gokhan	Danabasoglu	NCAR/USA
Annette	Samuelsen	NERSC/Norway



JuliaEO
Global Workshop on Earth Observation with Julia **2026**



IWS Internal Waves Service **WORKSHOP 2026**



International Quality-controlled Ocean Database (IQOD)

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Our Goal
To construct a climate-quality ocean temperature database using a consistent and unified Quality Control Standard

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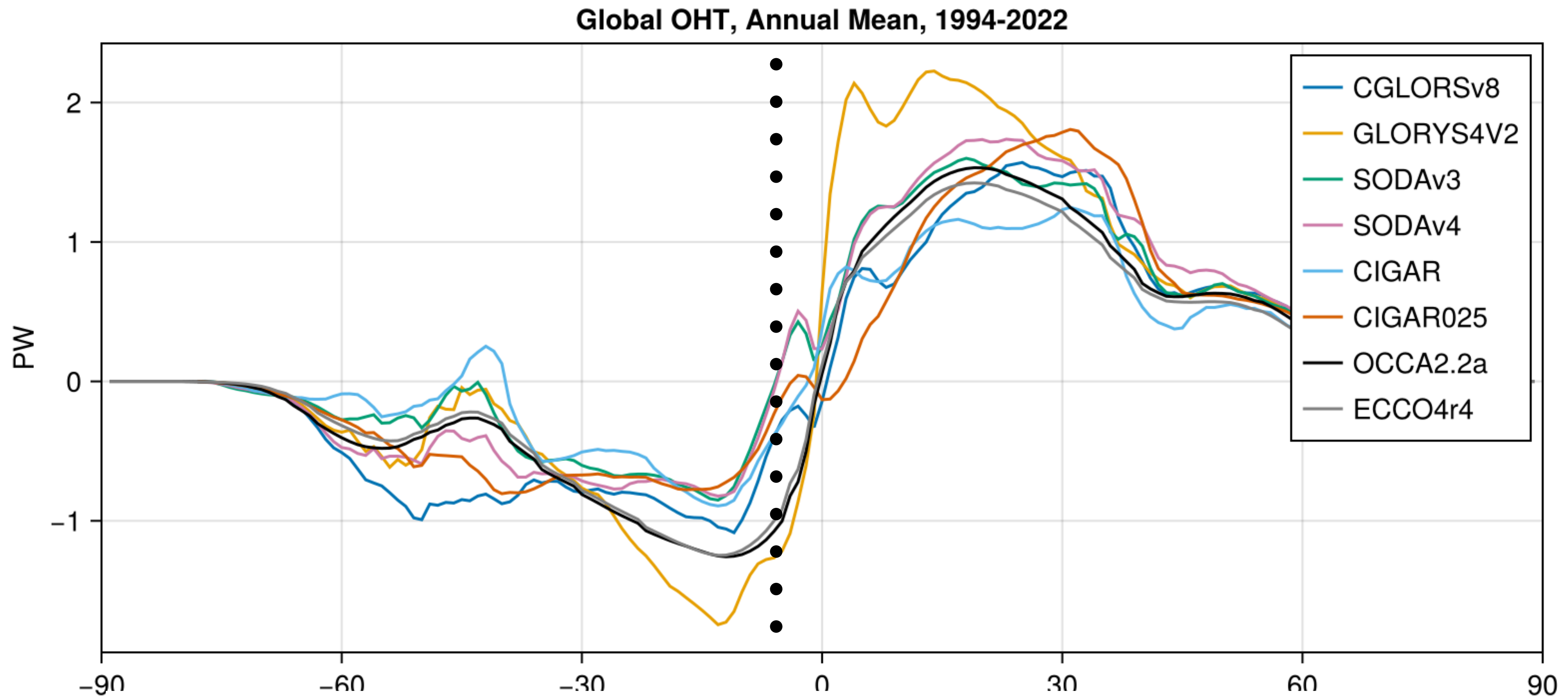
Photo by [unreadable]

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Standard Ocean Heat Transport

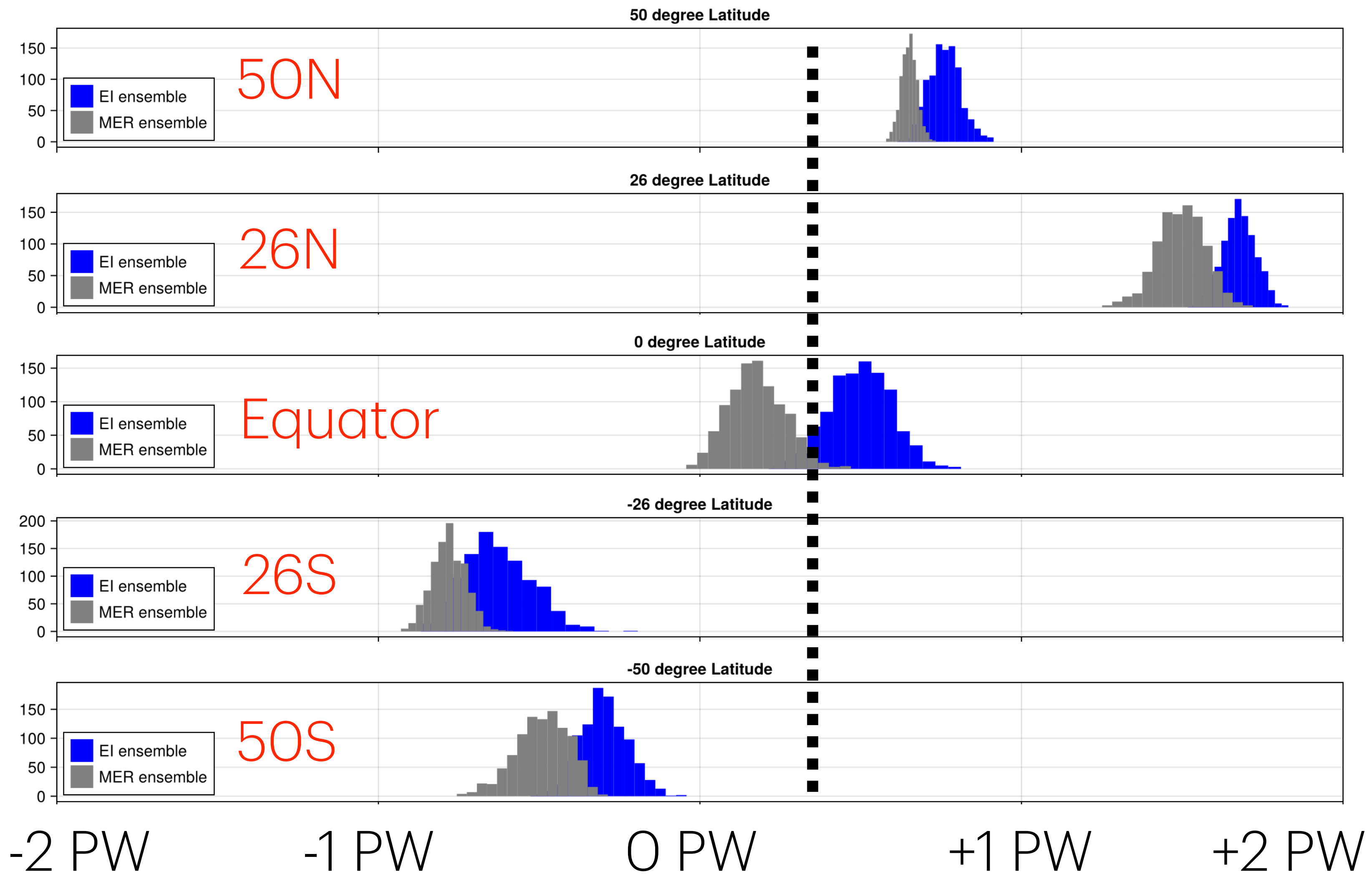
From ocean reanalyses using velocity and temperature fields



Credits : Susanna Winkelbauer and Yuanyuan Song

Uncertainty Quantification

Via *Bootstrap Resampling* for Example



Forget et al
(in prep)

Tracking Subducted Anomalies

Hersh, Wjiffels, Gebbie, Forget 2025

Argo Product

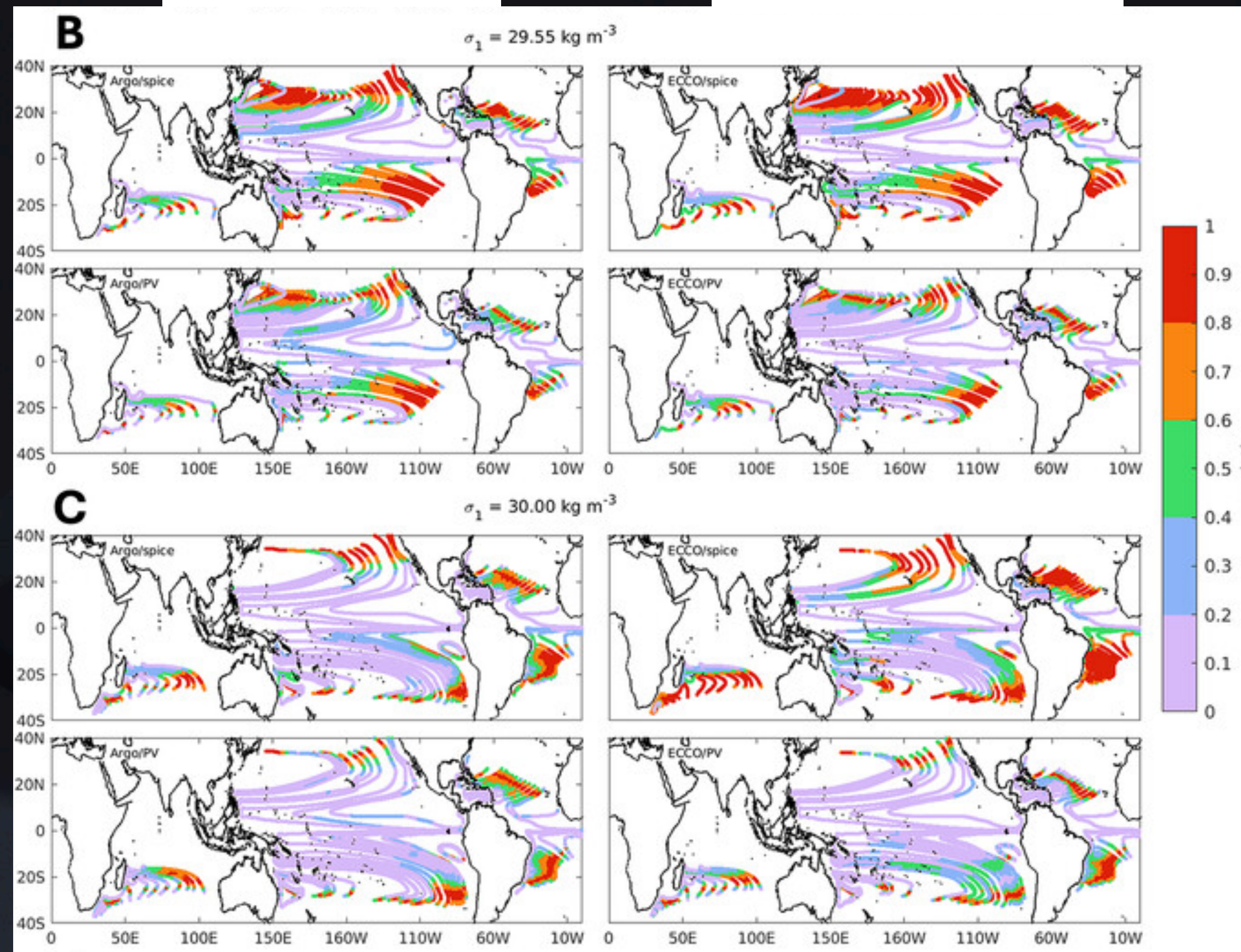
ECCO reanalysis

Spice Anomalies

PV anomalies

Spice Anomalies

PV anomalies

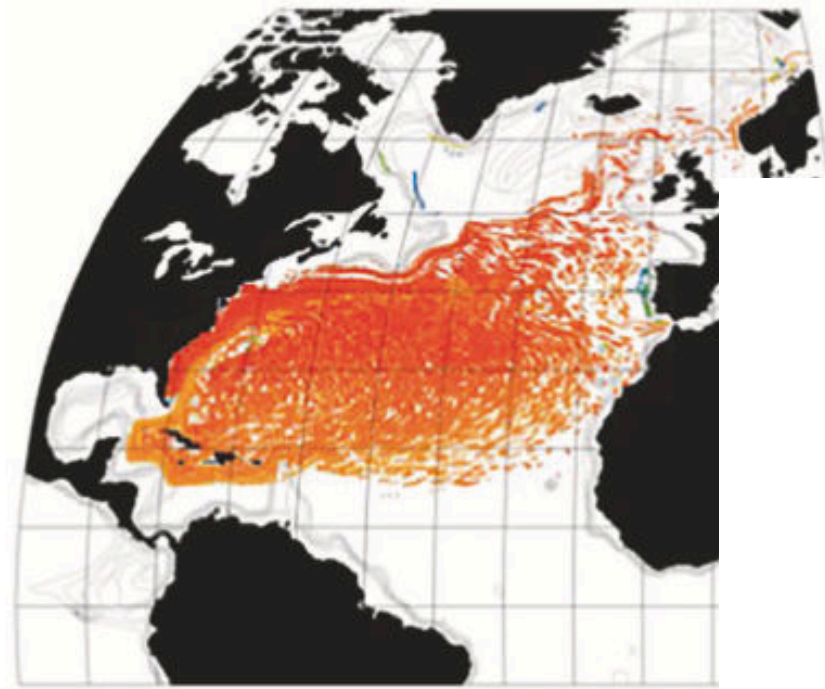


The biogeochemical transport by the Gulf Stream

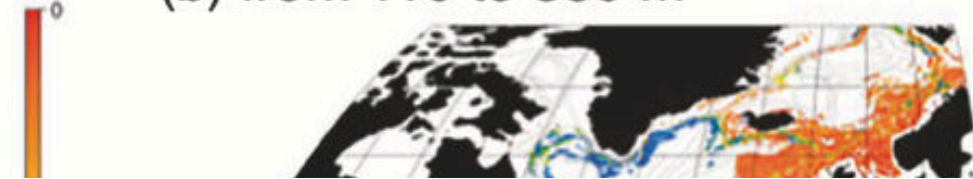
<https://doi.org/10.1038/s43247-025-03118-y>

Perspective

(a) float trajectories from 0 to 110 m



(b) from 110 to 380 m



(c) from 380 to 860 m

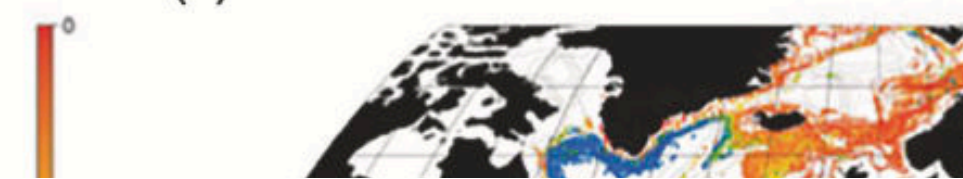
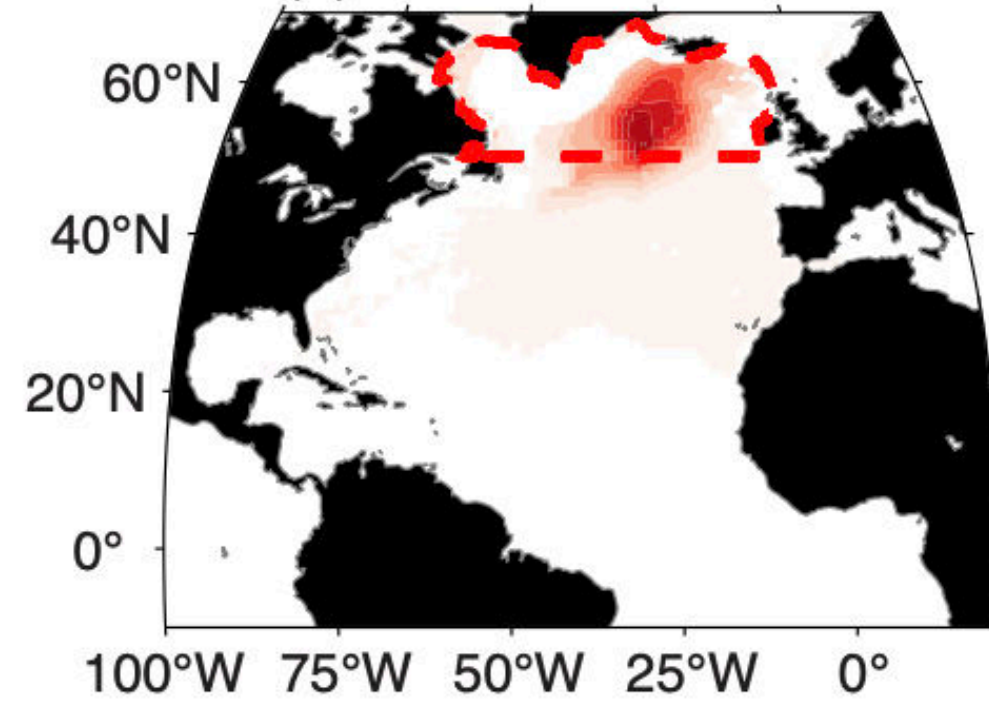
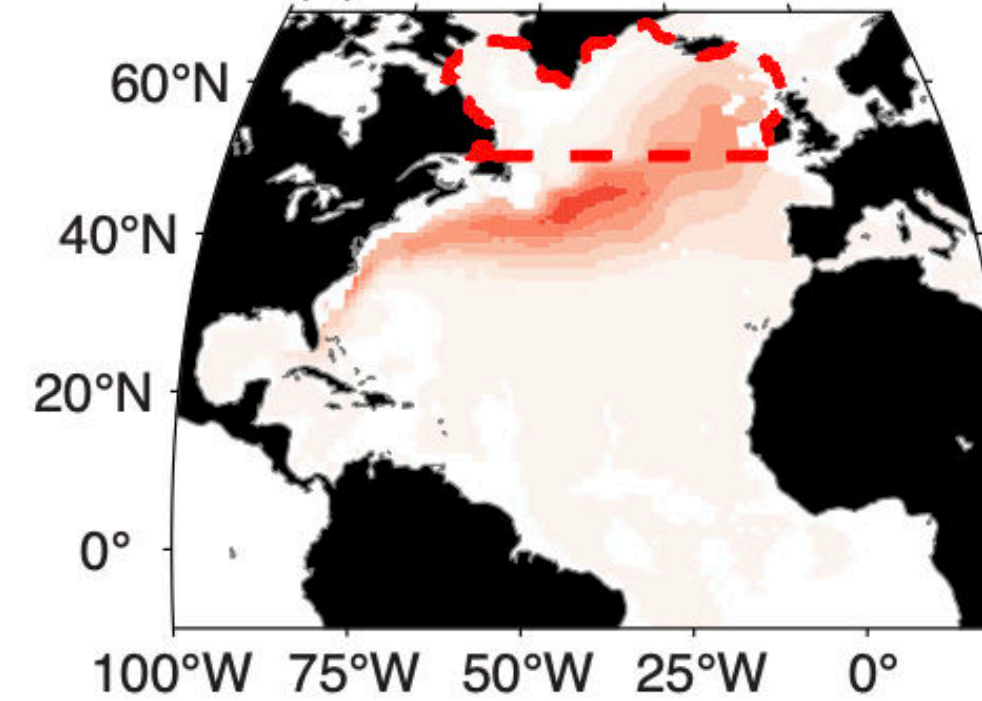


Fig. 5 | Pathways emanating from the Gulf Stream over a 10-year period. 10000 virtual floats were released at Florida Strait in three different depth ranges.

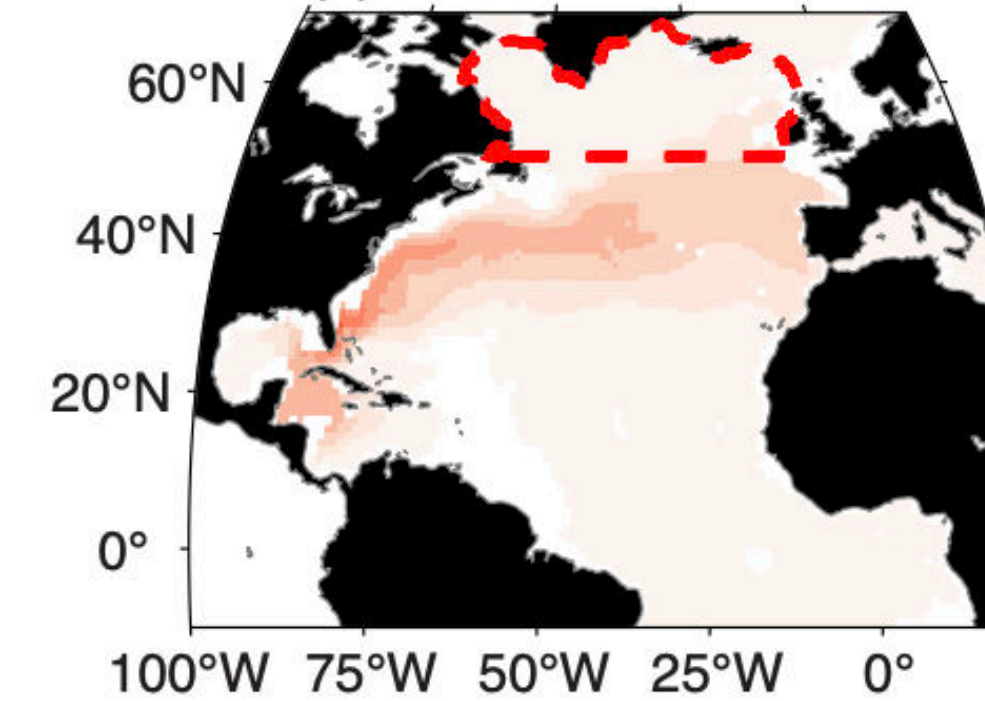
(a) Year 1 lead time



(b) Year 4 lead time



(c) Year 8 lead time



Normalised sensitivity

Fig. 7 | Sensitivity of the ocean carbon to the subpolar North Atlantic Ocean (within a potential density layer centred on 27.5 sigma-t).

Perspective | [Open access](#) | Published: 12 February 2026

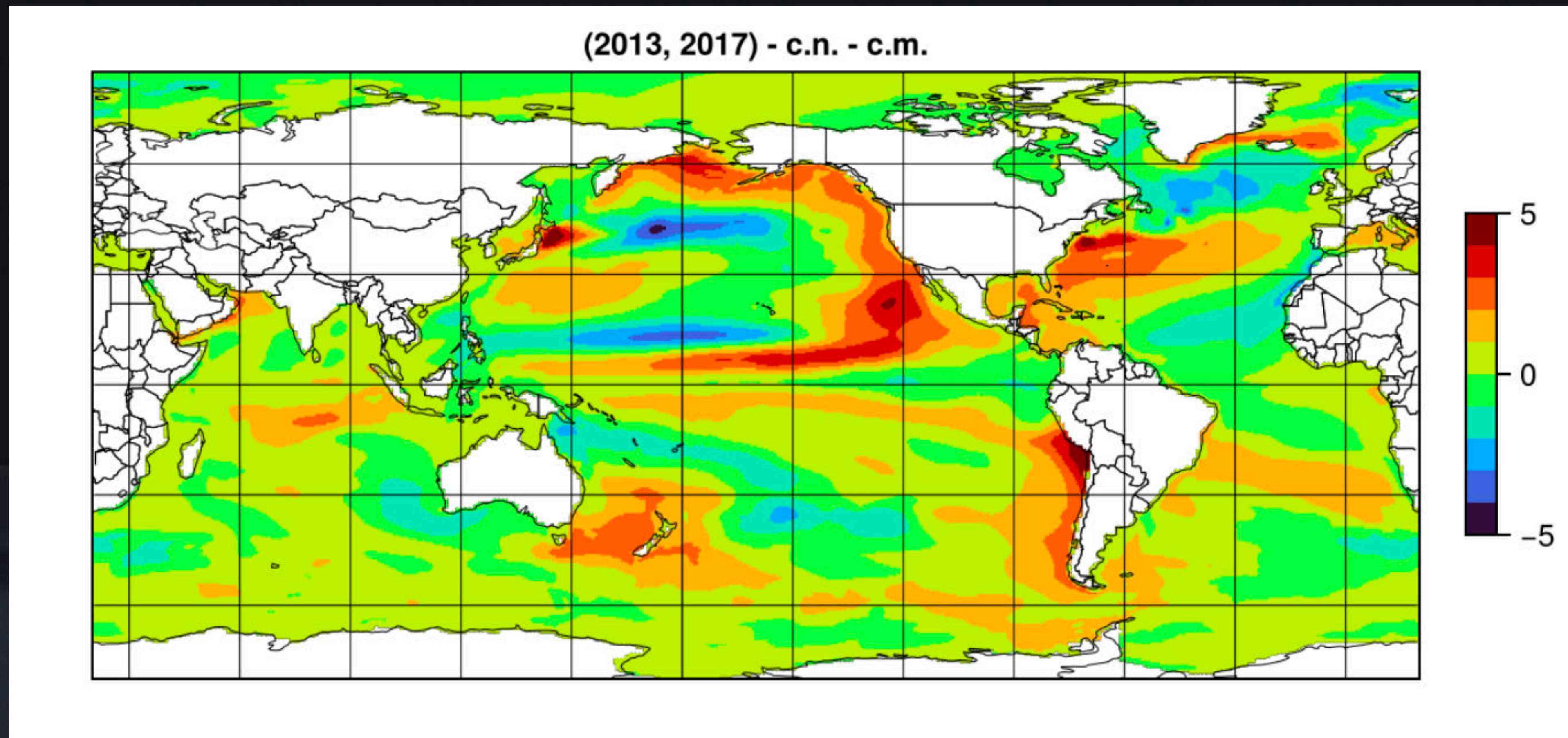
The biogeochemical transport by the Gulf Stream

[Richard G. Williams](#) , [Peter J. Brown](#), [Yohei Takano](#), [Gaël Forget](#), [Dani Jones](#), [Anna Katavouta](#), [Elaine McDonagh](#) & [Vassil M. Roussenov](#)

[Communications Earth & Environment](#) 7, Article number: 149 (2026) | [Cite this article](#)

Energy Imbalance in the Sunlit Ocean Layer

Forget (to be submitted)



Coupled air-sea interaction drove and sustained the 2013–2016 North Pacific Marine Heatwave

Wenrui Jiang^{1,*}, Gaël Forget², Yuanyuan Song², and Thomas W. N. Haine¹

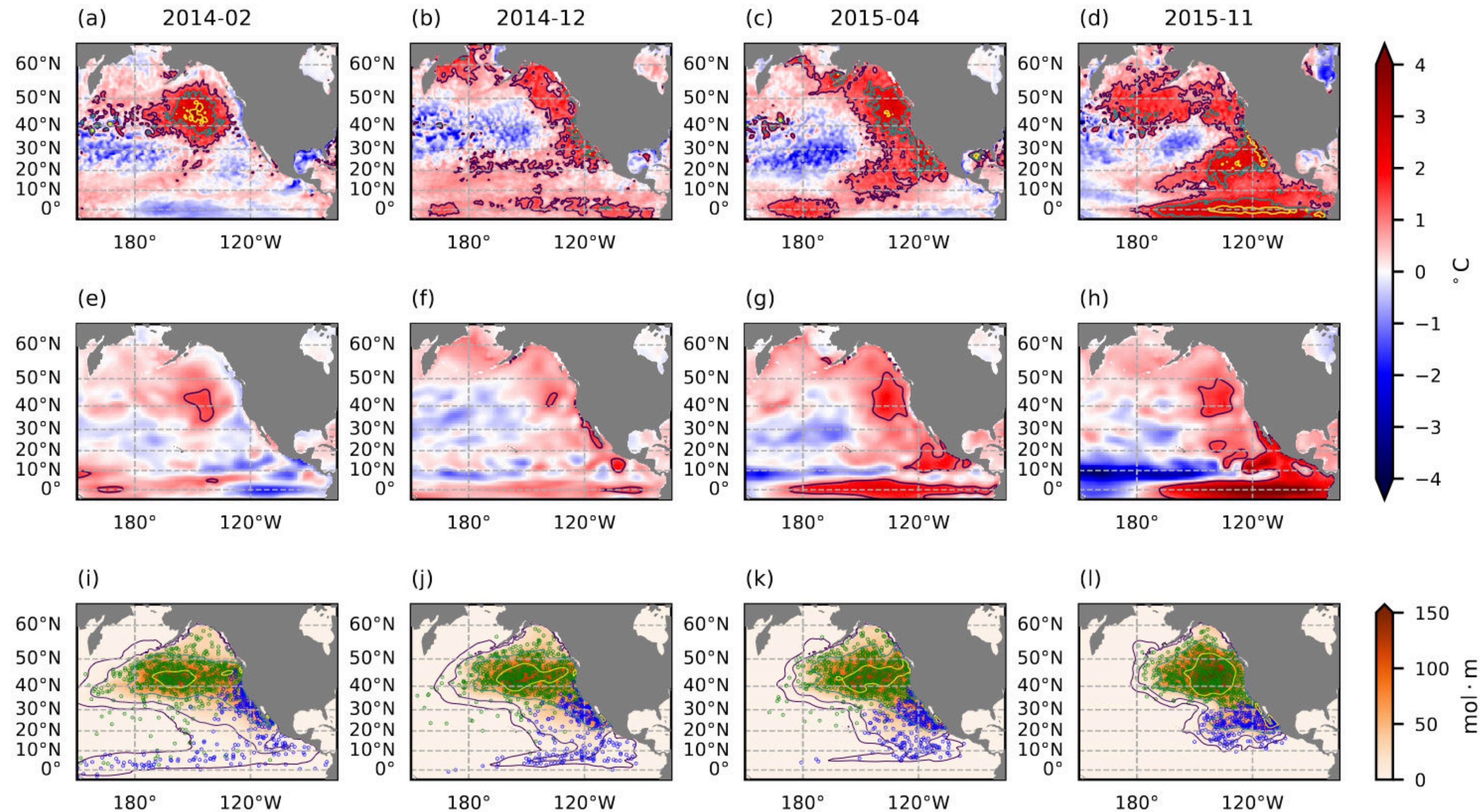
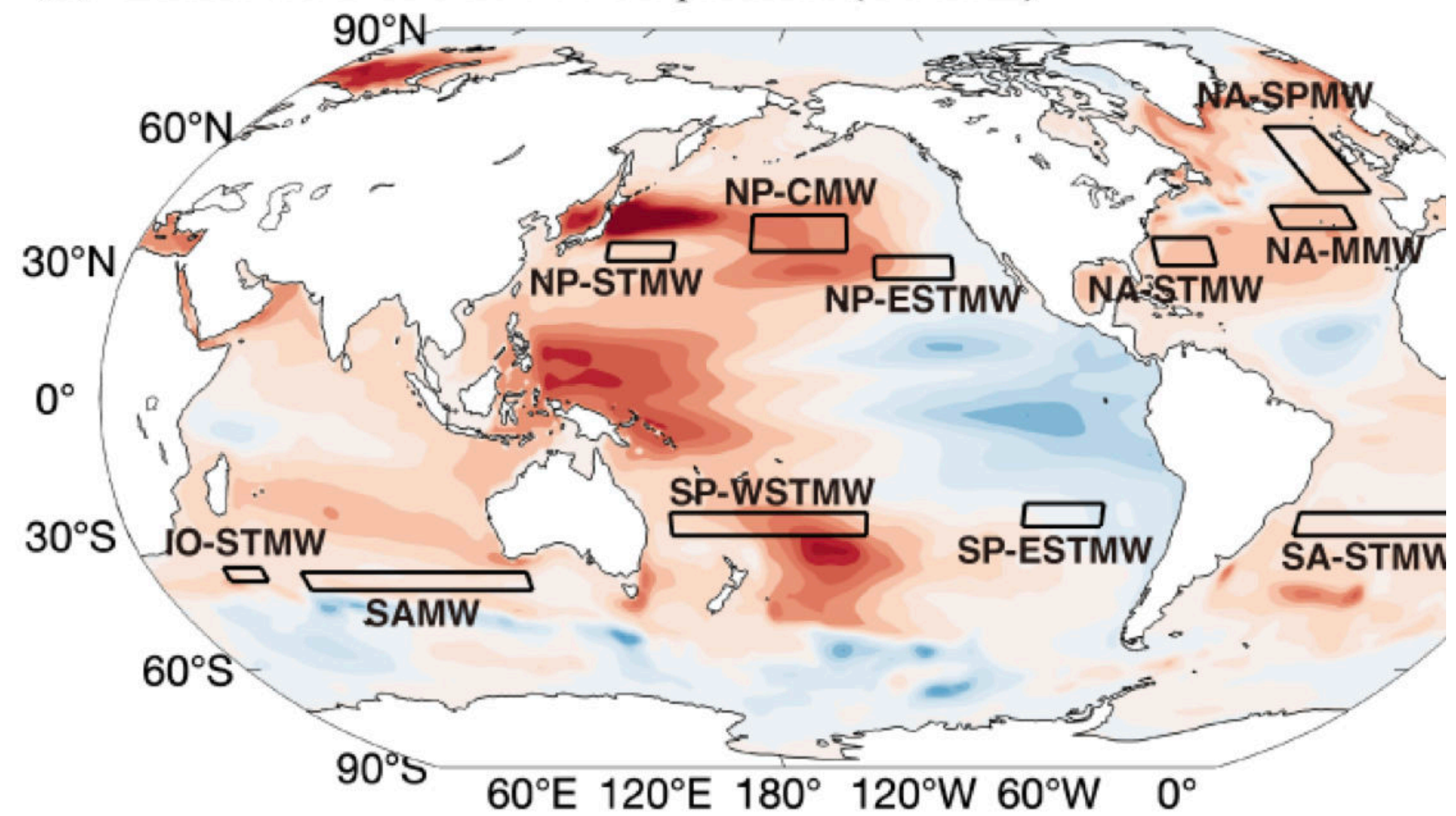


Figure 1: Temporal evolution of NEP MHW. (a–d) Monthly-averaged SST anomaly from OISST, (e–h) monthly-averaged upper 150 m temperature anomaly from ECCO4, and (i–l) snapshots of vertically-

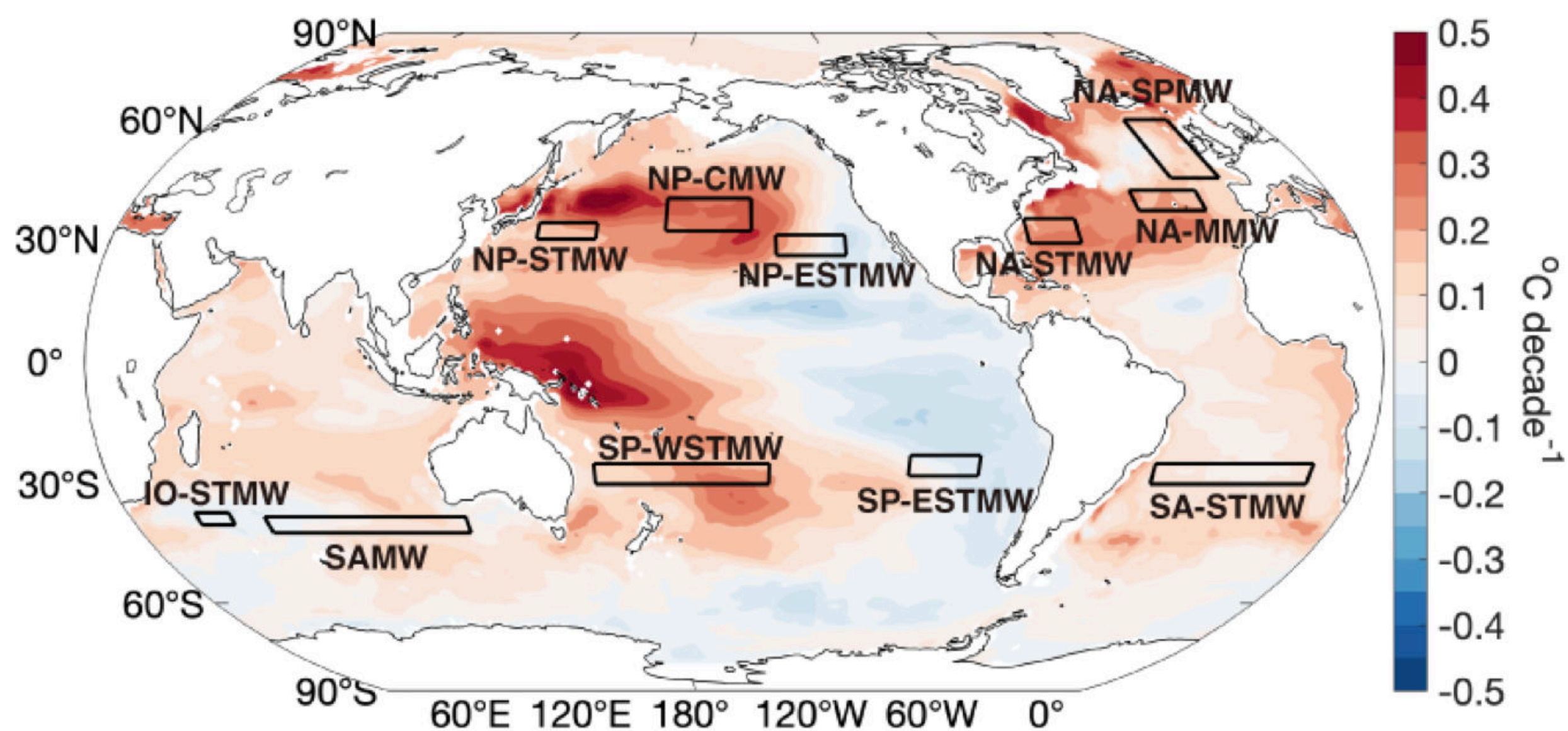
Temperature Change in Mode Water Source Regions

Yuanyuan Song¹, Gaël Forget¹

(a) Linear trend of 0-200 m temperature (OCCA2)



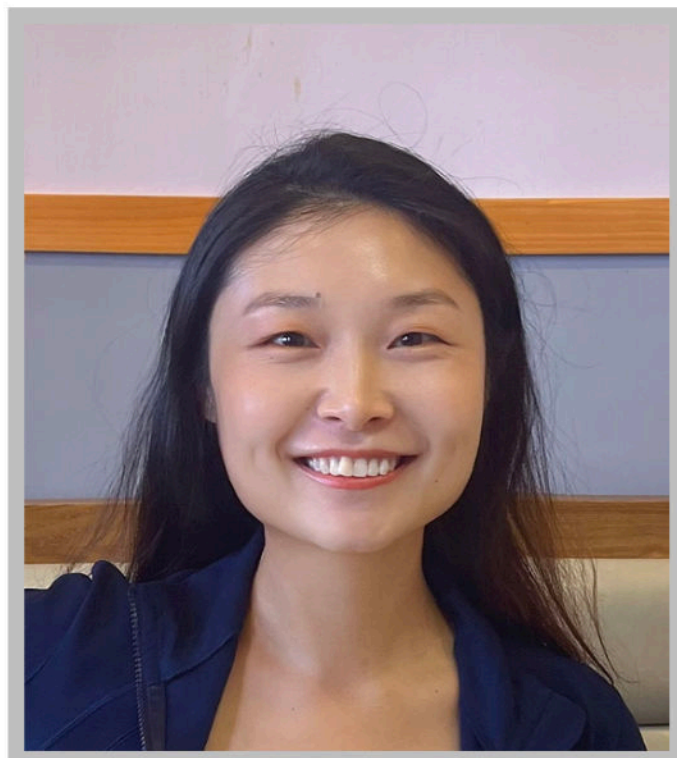
(b) Linear trend of 0-200 m temperature (IAPv4)



- Dr Yuanyuan Song (postdoctoral associate)

Mode Water Presentation

- I am a postdoc in Gaël Forget's group at MIT. My research broadly explores how the ocean, atmosphere, and sea ice interact — connecting tropical variability, mid-latitude extremes, and polar change. I work across a wide range of timescales, including seasonal, interannual, and decadal trends. Currently, I'm focusing on transport related to Eddy-Induced Mixing.



- Dr Wenrui Jiang (postdoctoral associate)

Lagrangian Budget Presentation

- I received my Ph.D. from Johns Hopkins University (2025). My research interests include tracer transport, Lagrangian dynamics, submesoscale processes, and AMOC. I am an avid open-source contributor.



- Dr Yueyang Lu (postdoctoral associate)

- My research explores ocean dynamics from small scales up to the global scale, with a focus on vertical mixing and mesoscale eddy-induced transport. I'm currently working on changes on continental shelves, including the sea-level variability on the European shelf and ocean warming in the Gulf of Maine. I am always happy to discuss and collaborate with different minds.

