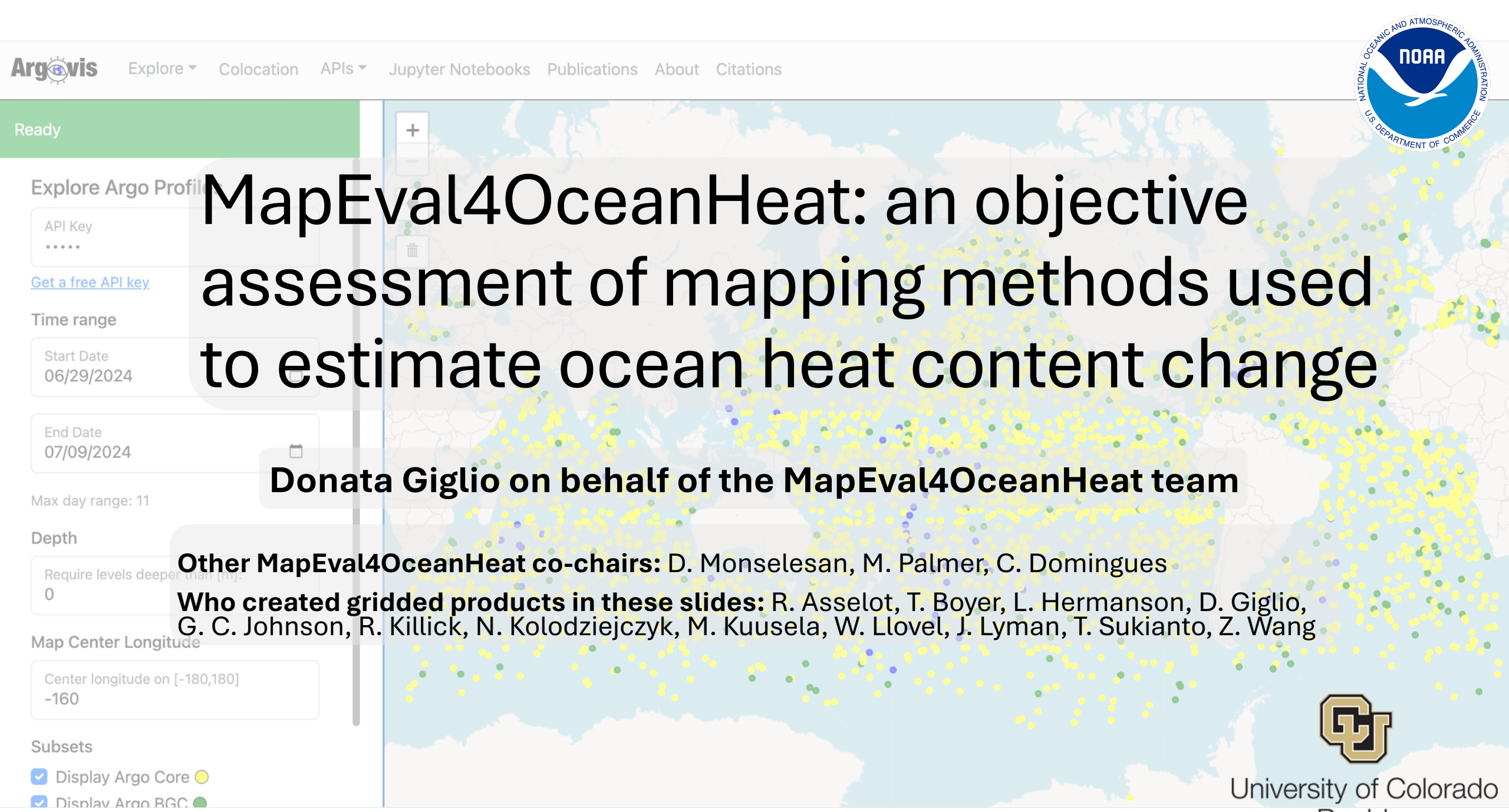


MapEval4OceanHeat: an objective assessment of mapping methods used to estimate ocean heat content change

Donata Giglio on behalf of the MapEval4OceanHeat team

Other MapEval4OceanHeat co-chairs: D. Monselesan, M. Palmer, C. Domingues

Who created gridded products in these slides: R. Asselot, T. Boyer, L. Hermanson, D. Giglio, G. C. Johnson, R. Killick, N. Kolodziejczyk, M. Kuusela, W. Llovel, J. Lyman, T. Sukianto, Z. Wang

University of Colorado Boulder

Outline

- Motivation
- Method
- Results
- Summary

Estimating spatially complete fields from **sparse in situ obs** is essential to many climate applications

Ocean temperature profiles available for the 0-700 m layer based on the EN4 dataset

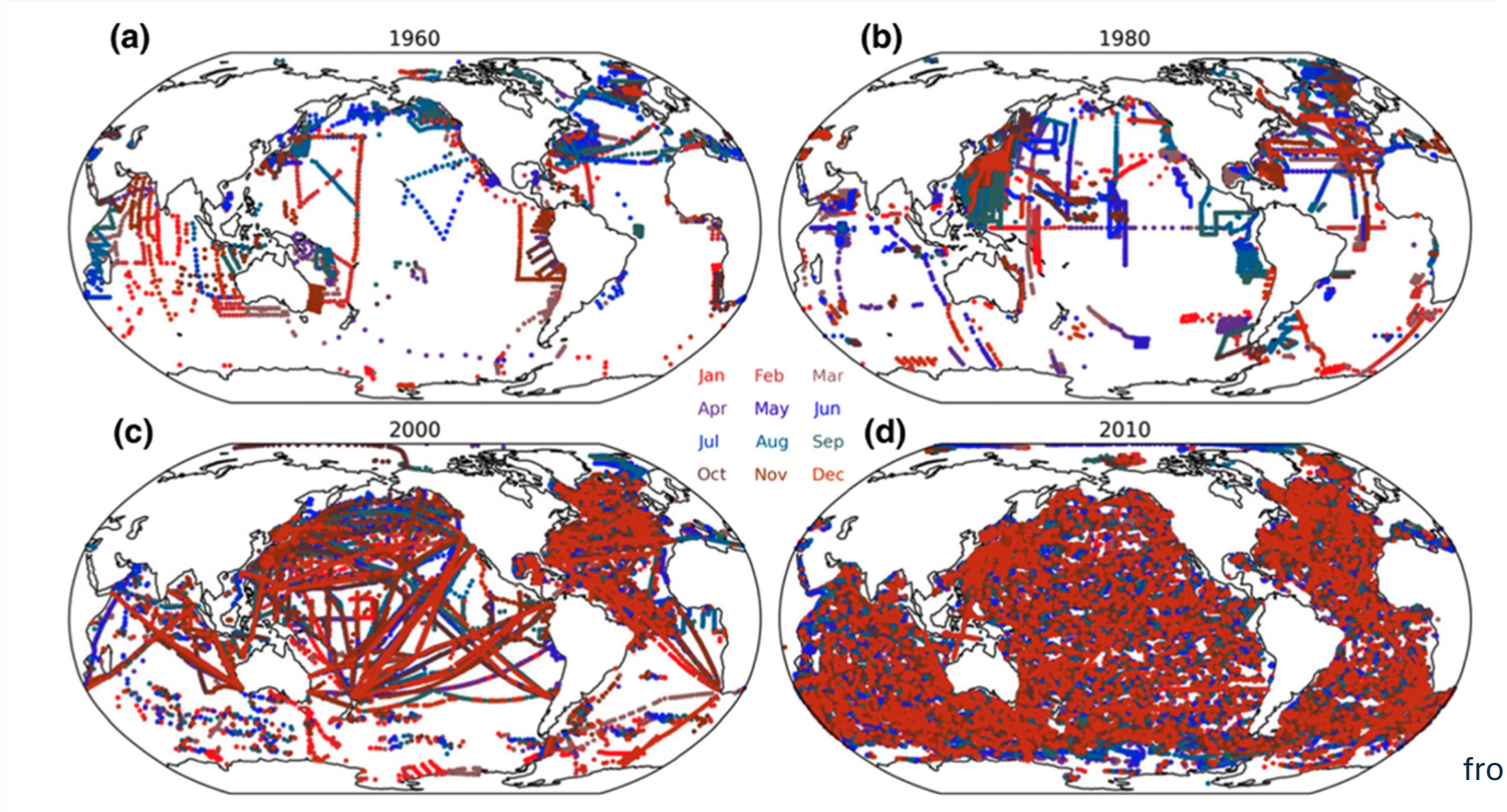
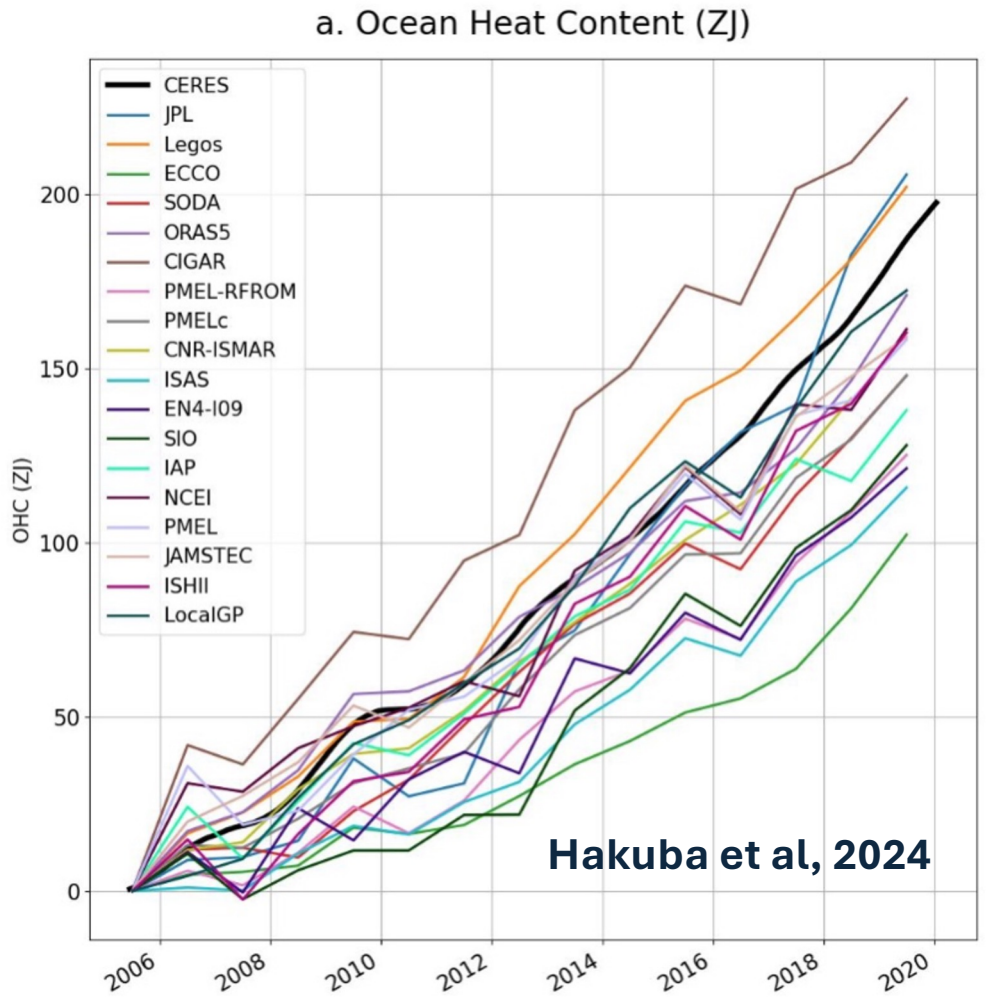


Figure credit:
Simon Good;
from Palmer (2017)

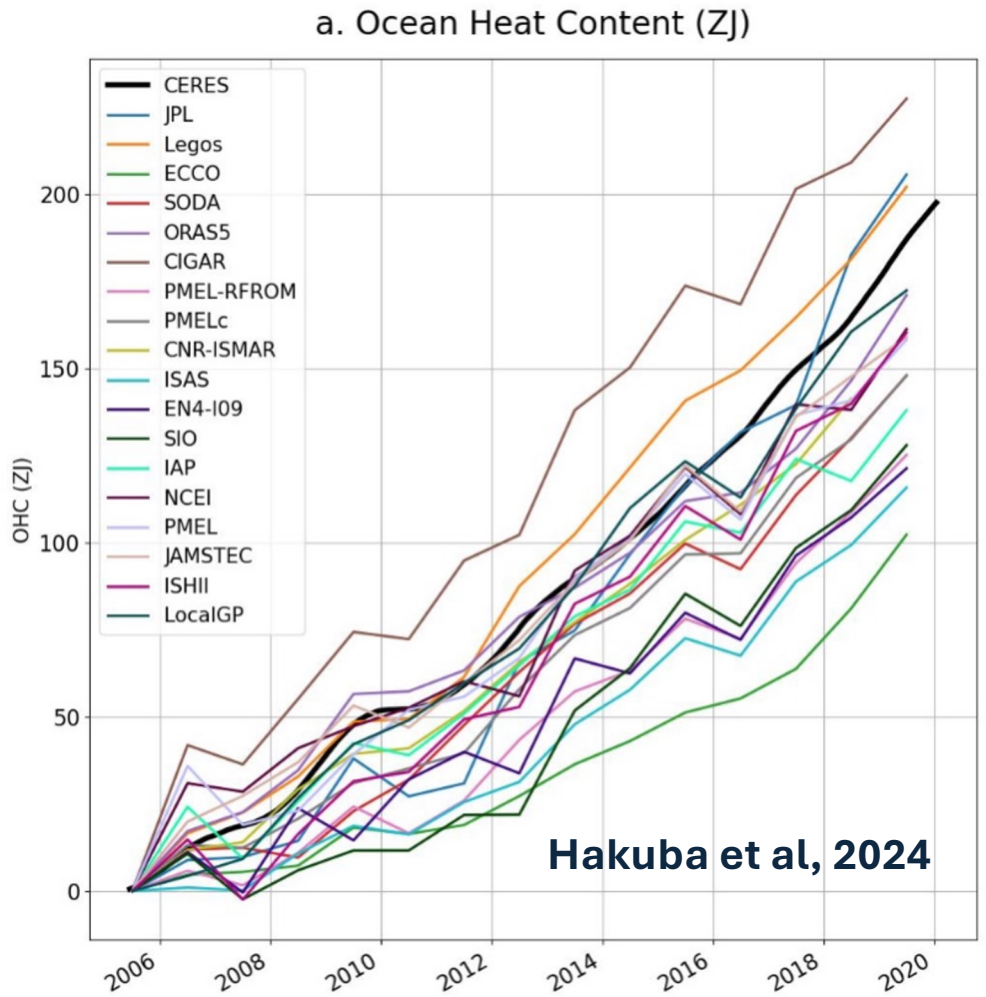
Estimating **spatially complete fields** from sparse in situ obs is **essential to many climate applications**

- Monitoring global ocean heat uptake



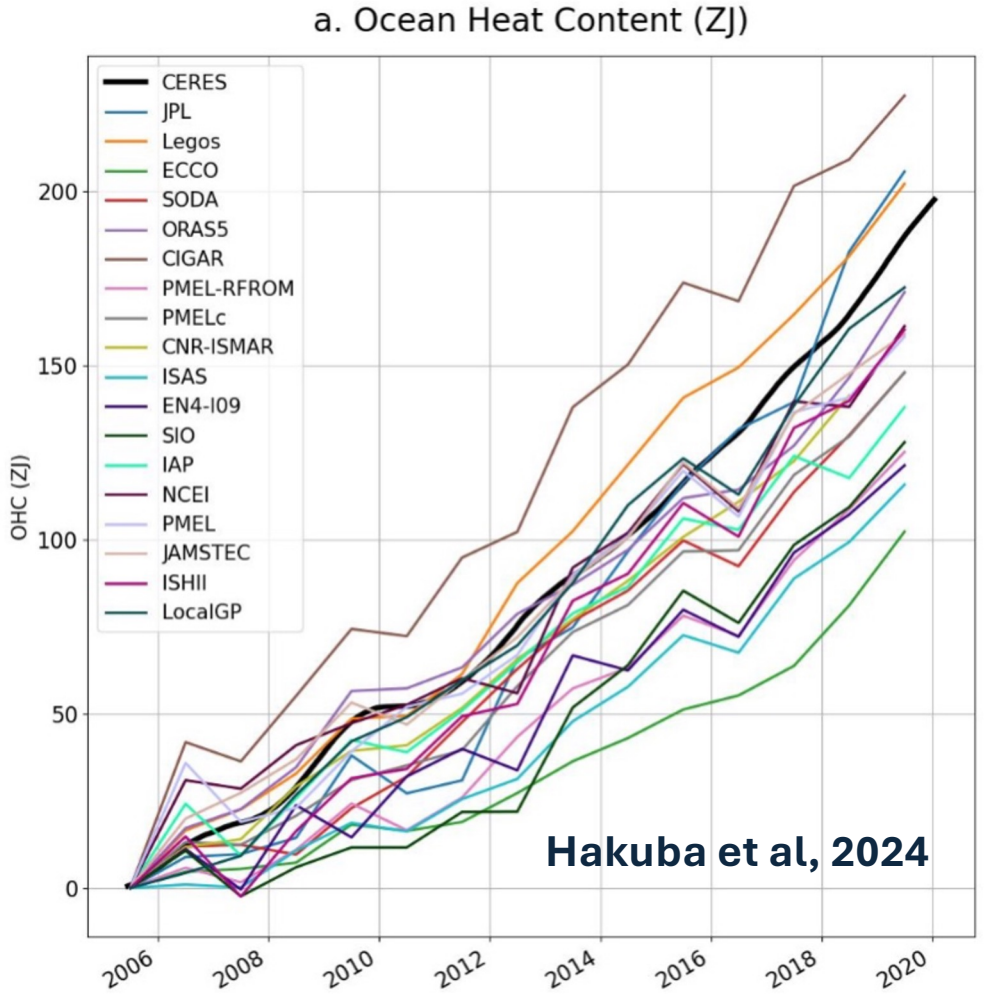
Estimating **spatially complete fields** from sparse in situ obs is **essential to many climate applications**

- Monitoring global ocean heat uptake
- Observational constraints on climate projections (c.f. IPCC AR6)



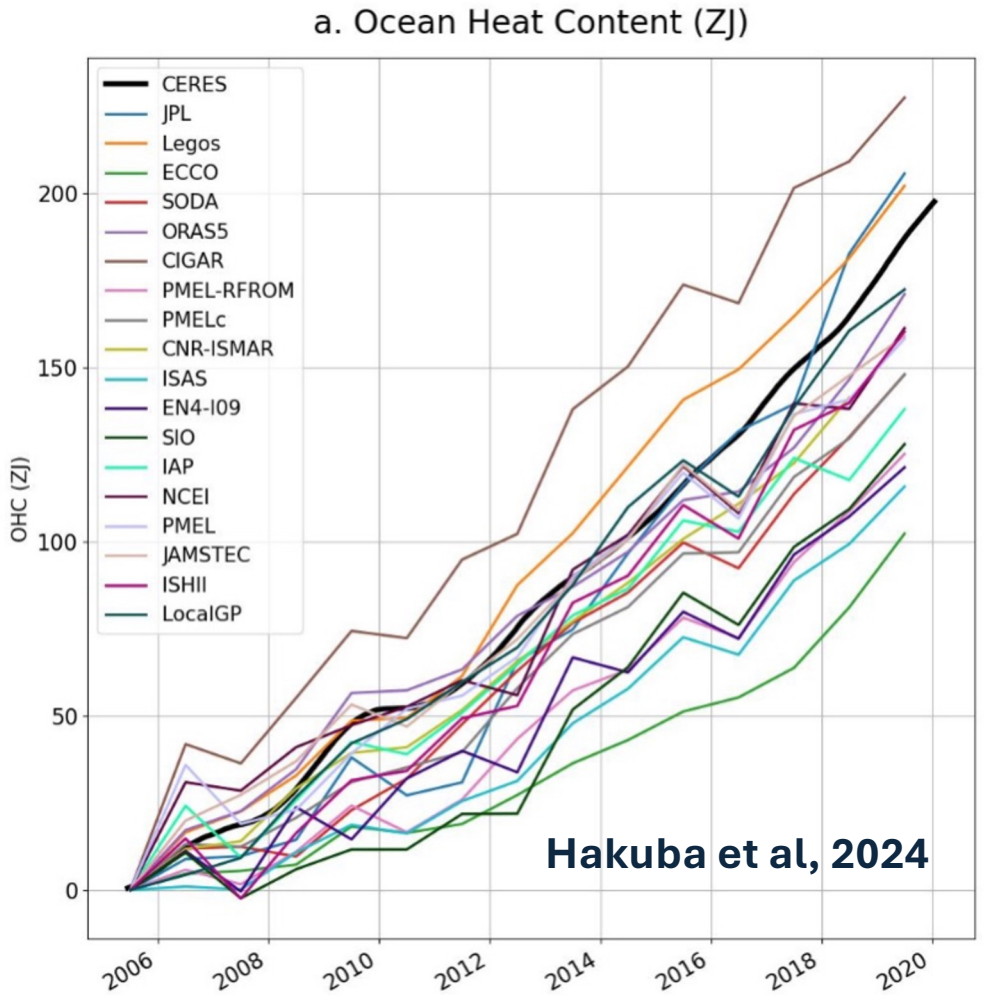
Estimating **spatially complete fields** from sparse in situ obs is **essential to many climate applications**

- Monitoring global ocean heat uptake
- Observational constraints on climate projections (c.f. IPCC AR6)
- Decadal forecast initialization and system development
- Ocean and climate model development and evaluation

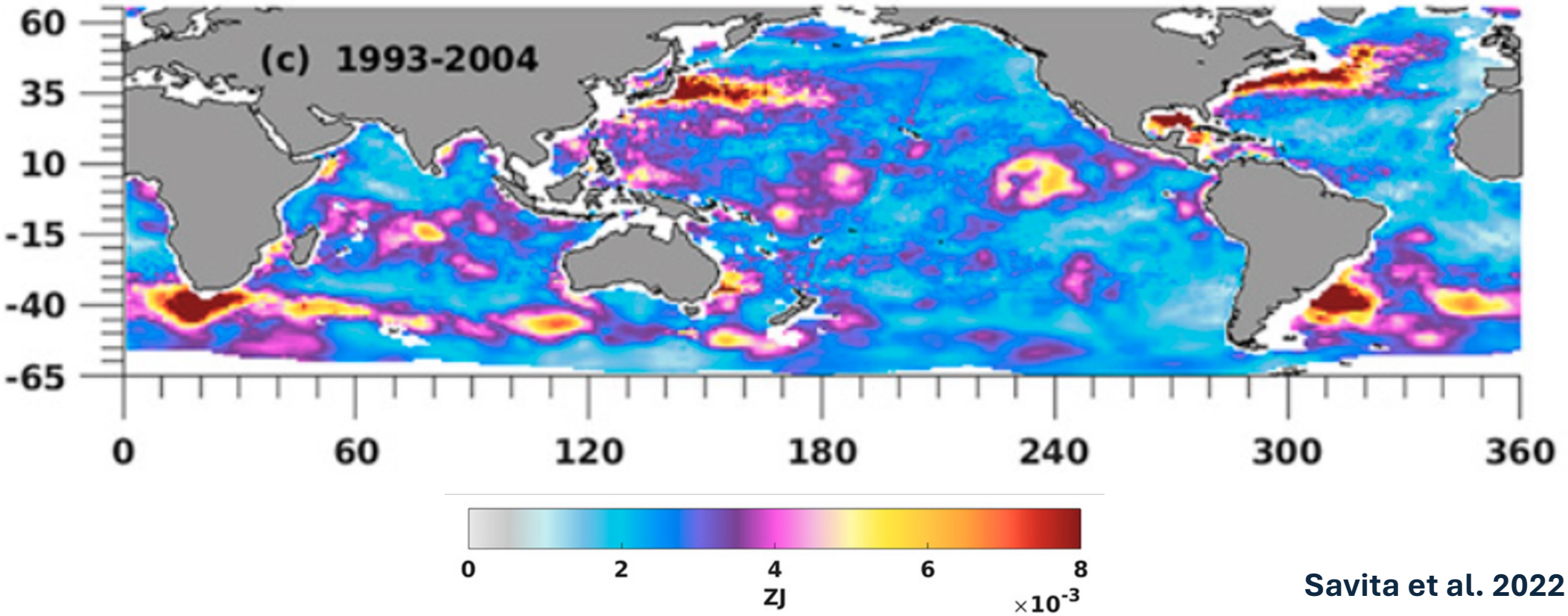


Estimating **spatially complete fields** from sparse in situ obs is **essential to many climate applications**

- Monitoring global ocean heat uptake
- Observational constraints on climate projections (c.f. IPCC AR6)
- Decadal forecast initialization and system development
- Ocean and climate model development and evaluation
- Studying regional changes in temperature, salinity, mixed layer depth, sea level, …



Choice of mapping method: a large source of spread among OHC estimates in upper 700 m of the ocean



Savita et al. 2022

MapEval4OceanHeat Goals

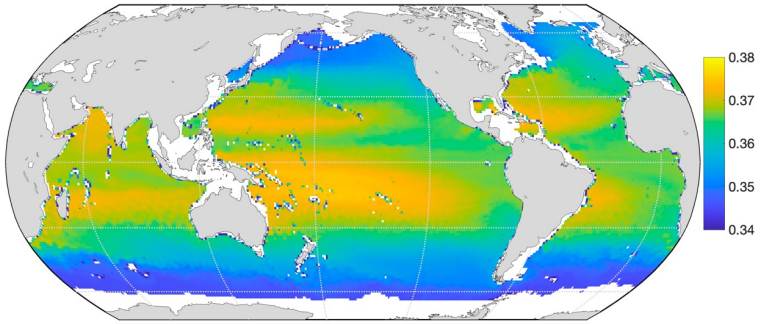
- Development of optimal mapping approaches for a range of ocean and climate applications
  - Evaluate strengths and limitations of OHC mapping methods
- Assess our ability to constrain OHC change at global and regional scales
- Establishment of community best practice approaches and improved data products
  - Bringing together scientists with a diverse set of expertise, e.g. in oceanography, climate, models, statistical methods, machine learning methods

Method

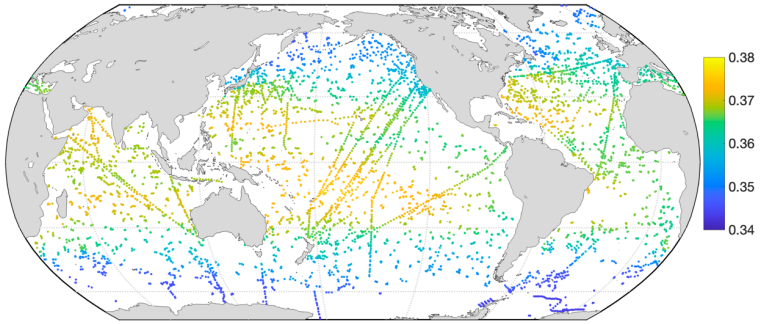
- Synthetic observations from a 1/10 degree model are used to estimate OHC using different methods
- Resulting OHC fields are compared with the model truth to assess each method

OHC, TJ/m^2

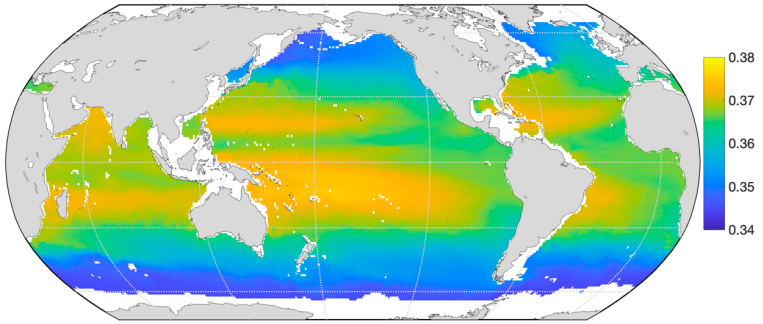
Model



Synthetic profiles



Mapped product



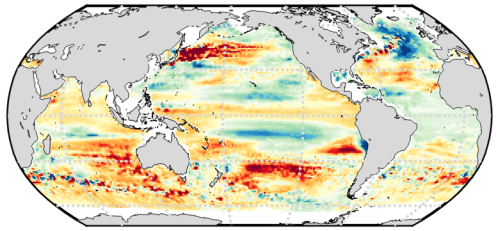
Method

- Synthetic observations from a 1/10 degree model are used to estimate OHC using different methods
- Resulting OHC fields are compared with the model truth to assess each method
    * 3 vertical layers (approximately top 300 m, 300-700, 700-2000)
    * 3 time periods (1979-2014, 1993-2014, 2005-2014)
    * temperature profiles and (in one case) SST/SSH

Method

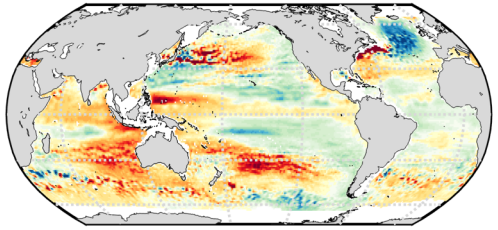
- Model validation, e.g. linear trend

Model trend, W/m^2 (0.242)

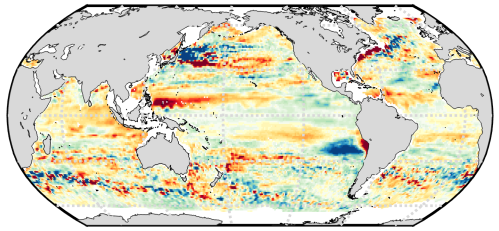


Gridded product minus model

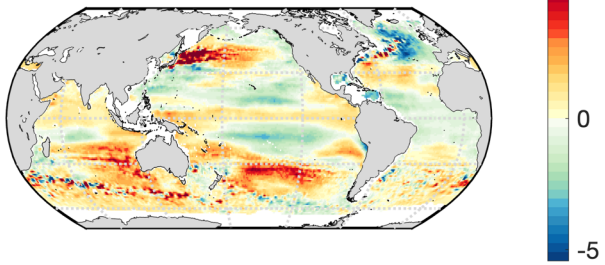
RFROMv2.1obs, W/m^2 (0.250)



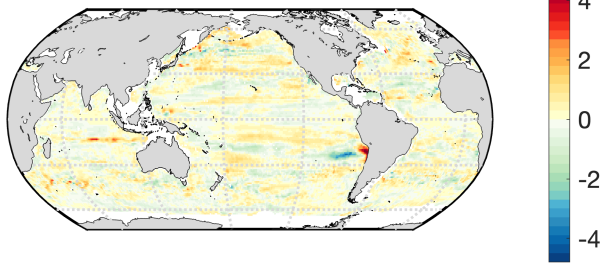
RFROMv2.1obs, W/m^2



expCmask_RFROMv2.1, W/m^2 (0.244)

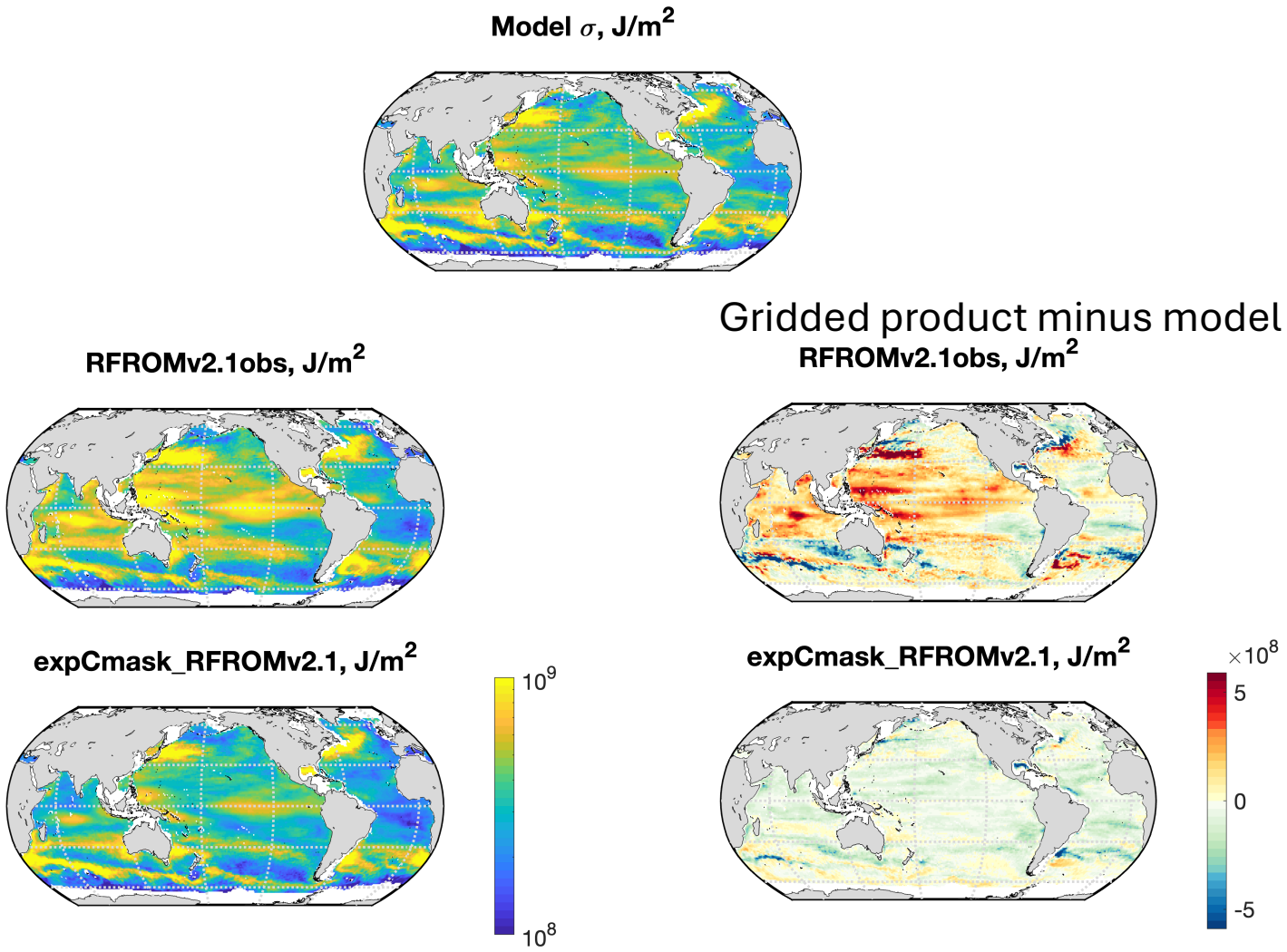


expCmask_RFROMv2.1, W/m^2



Method

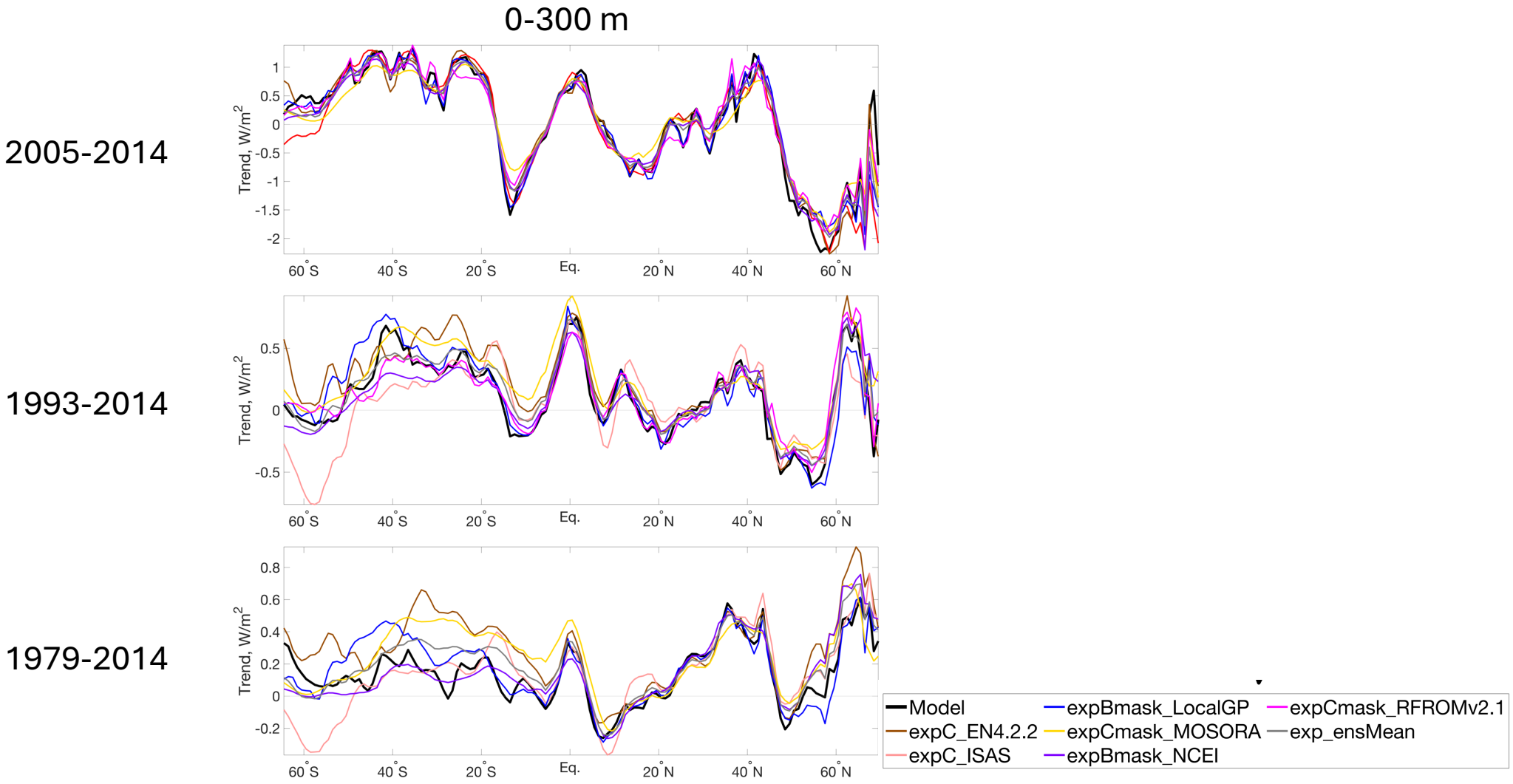
- Model validation, e.g. standard deviation of monthly anomalies



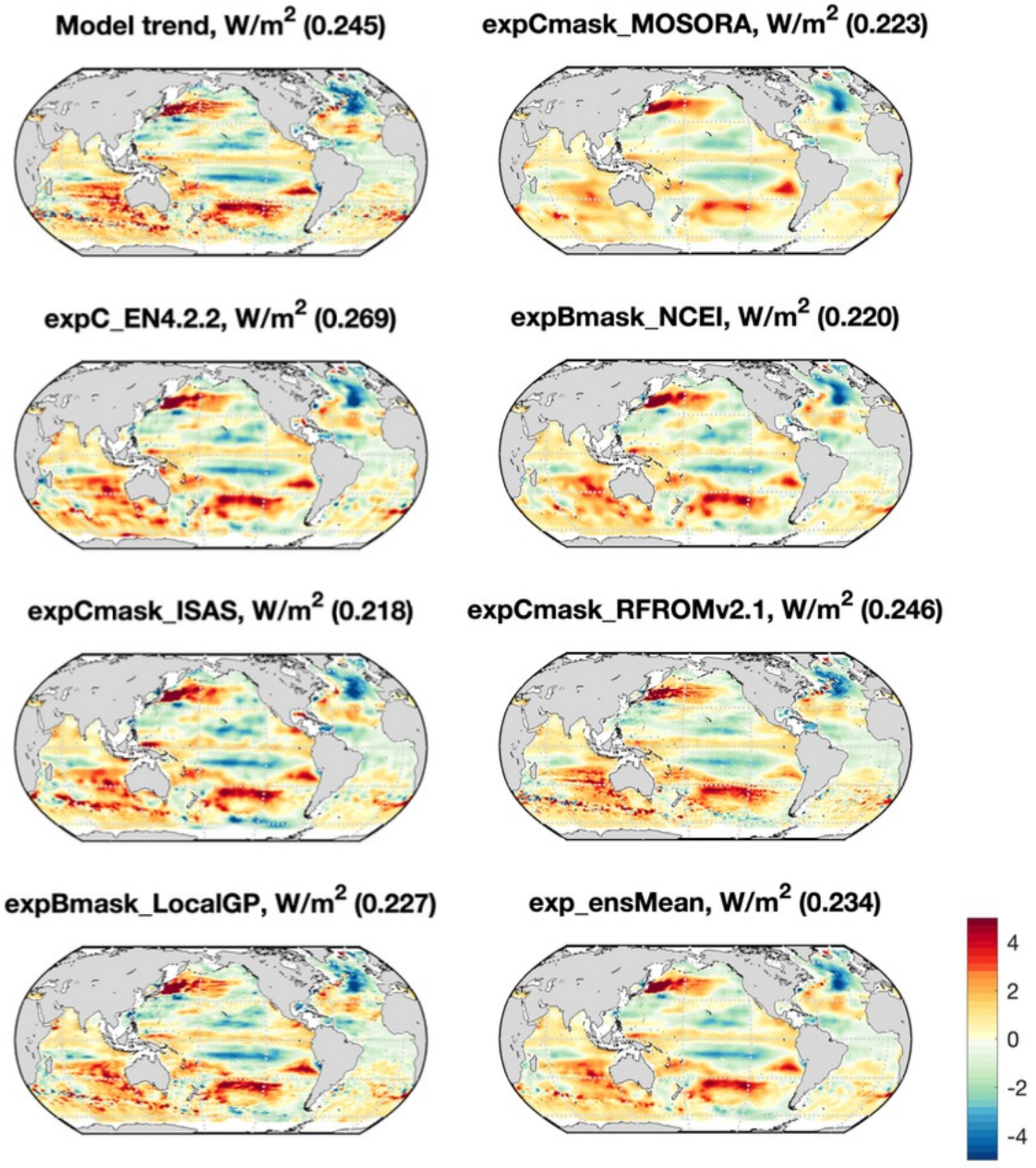
Think-pair-share

- Are ME4OH experiments still helpful to evaluate mapping methods and their uncertainties if the model (used to create synthetic profiles) has biases? Why?
  - What if regions of high variability in the model do not coincide with regions of high variability in the real ocean?

Linear trend: over- or under-estimated, especially pre-Argo

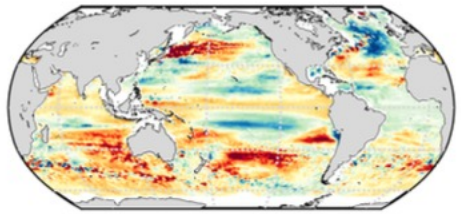


Linear trend (2005-2014): over- or under-estimated

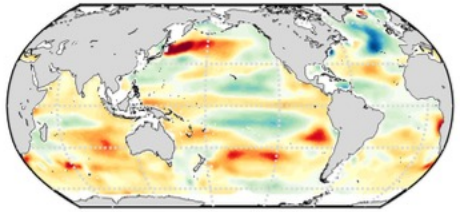


Linear trend (2005-2014): over- or under-estimated

Model trend, W/m^2 (0.245)

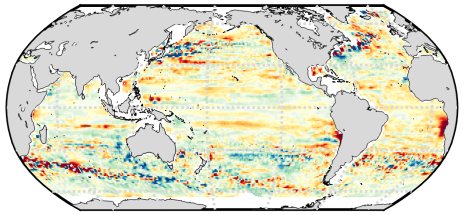


expCmask_MOSORA, W/m^2 (0.223)

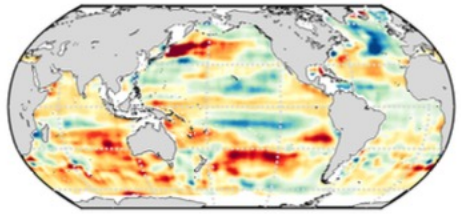


What are the differences and similarities in the maps of differences?

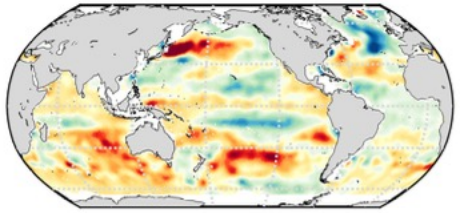
expCmask_MOSORA, W/m^2



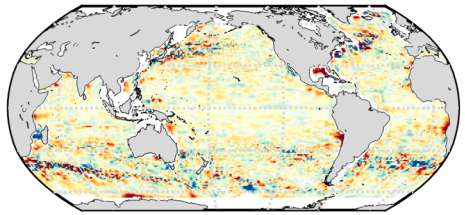
expC_EN4.2.2, W/m^2 (0.269)



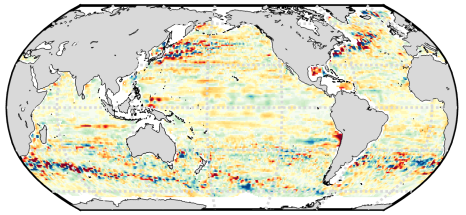
expBmask_NCEI, W/m^2 (0.220)



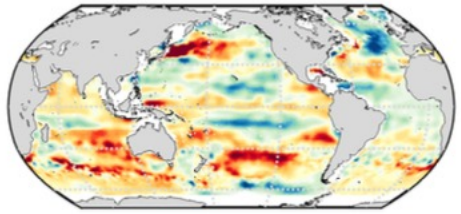
expC_EN4.2.2, W/m^2



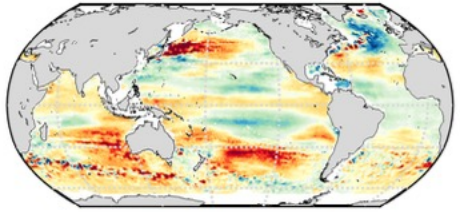
expBmask_NCEI, W/m^2



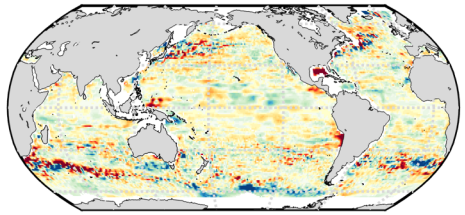
expCmask_ISAS, W/m^2 (0.218)



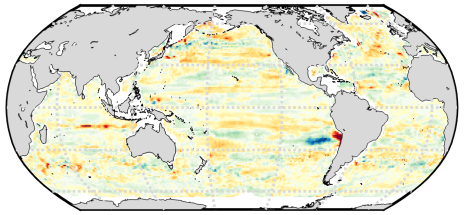
expCmask_RFROMv2.1, W/m^2 (0.246)



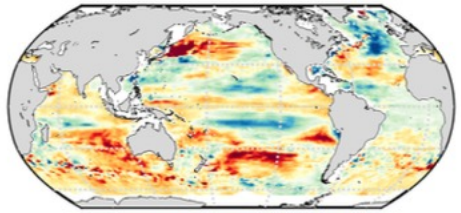
expCmask_ISAS, W/m^2



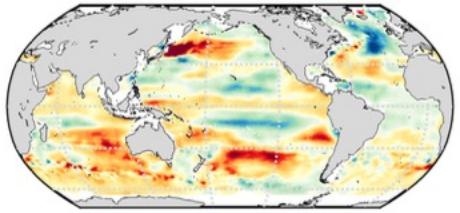
expCmask_RFROMv2.1, W/m^2

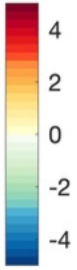


expBmask_LocalGP, W/m^2 (0.227)

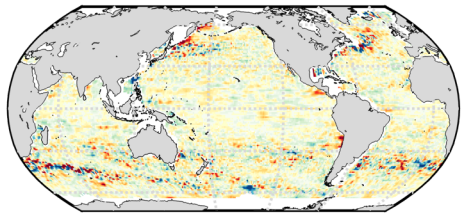


exp_ensMean, W/m^2 (0.234)

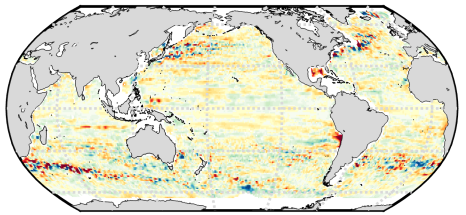


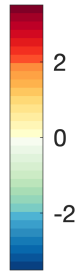


expBmask_LocalGP, W/m^2



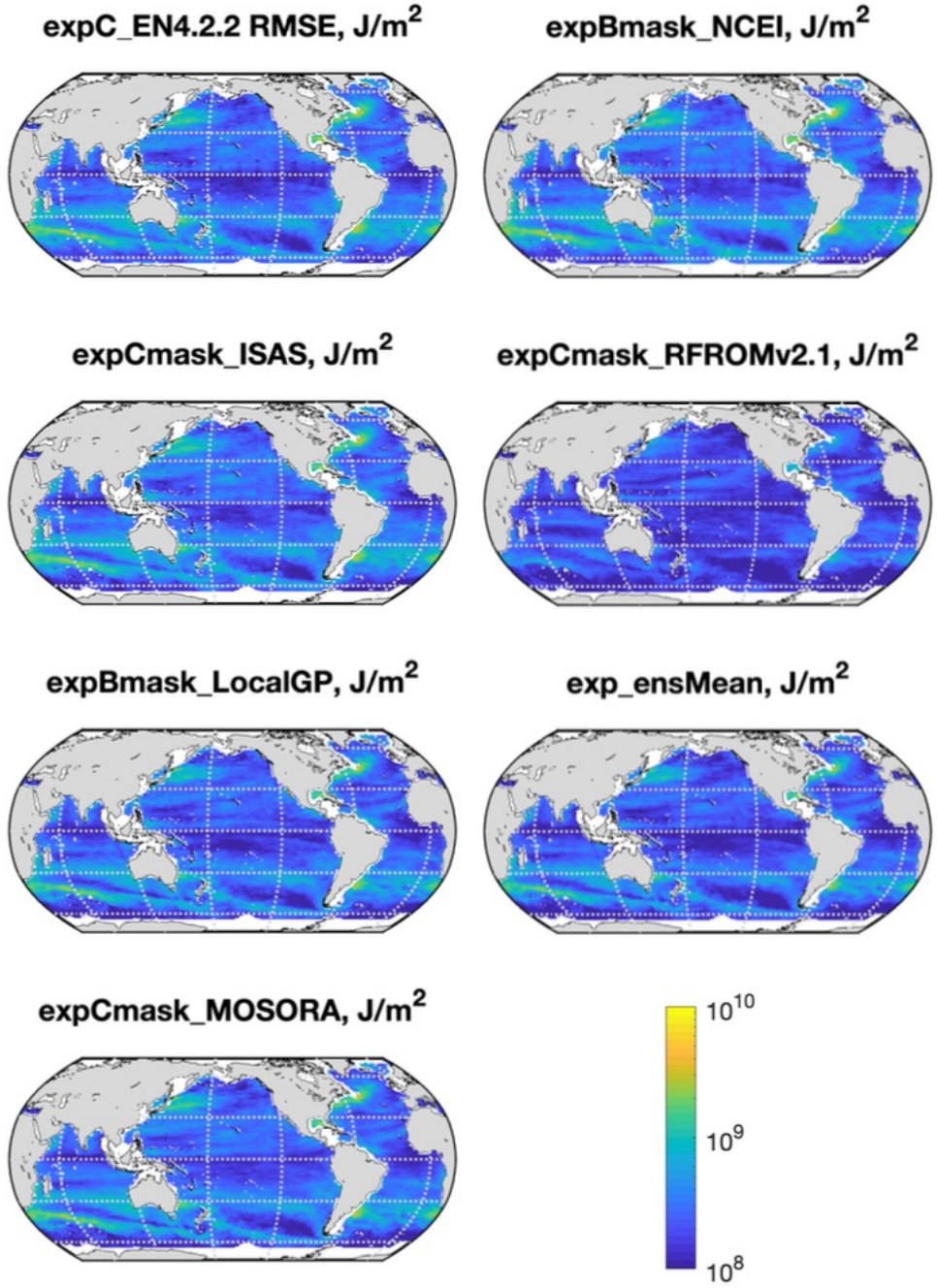
exp_ensMean, W/m^2





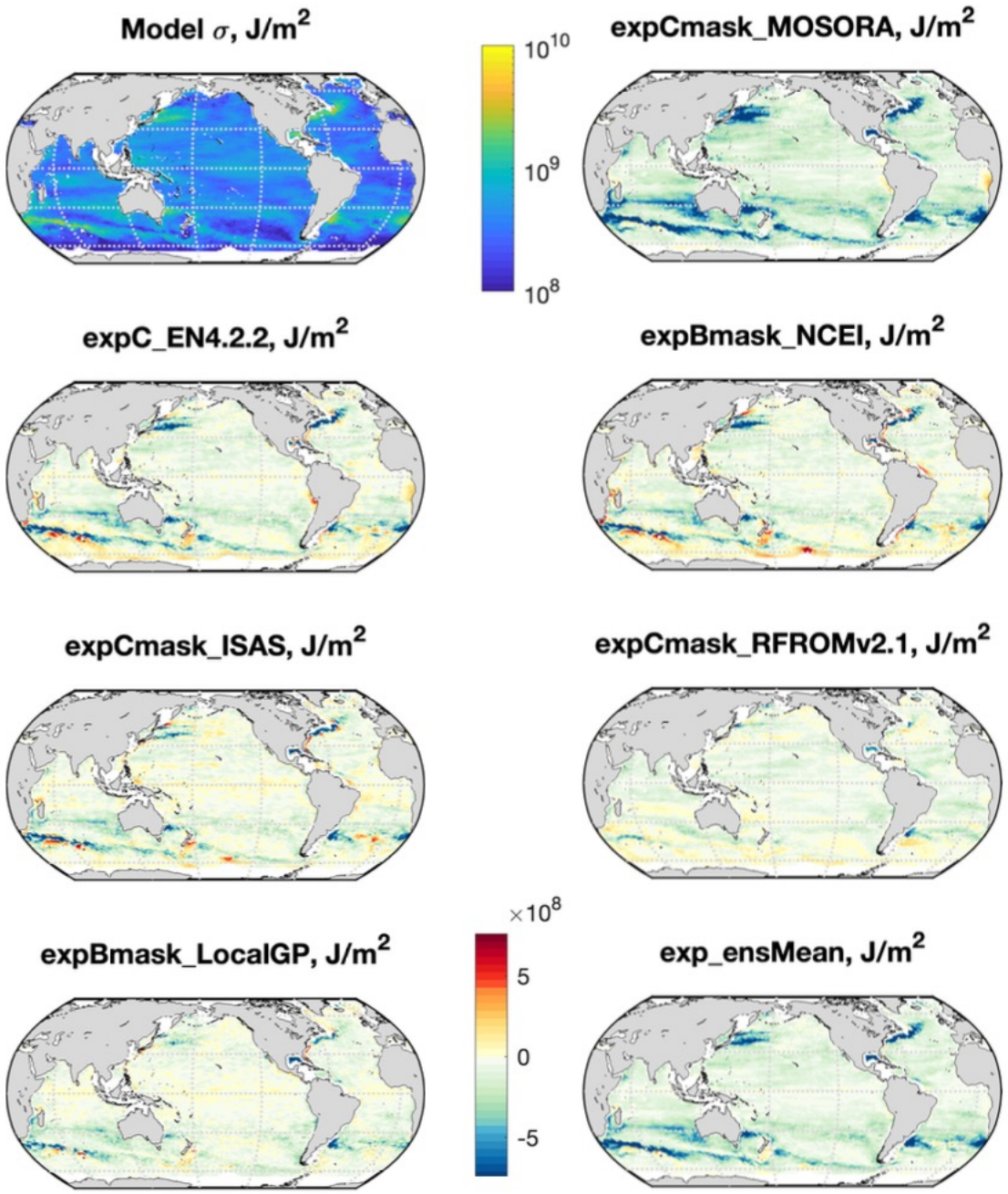
RMSE

- Largest along strong currents for methods using only profiles (no SST/SSH)



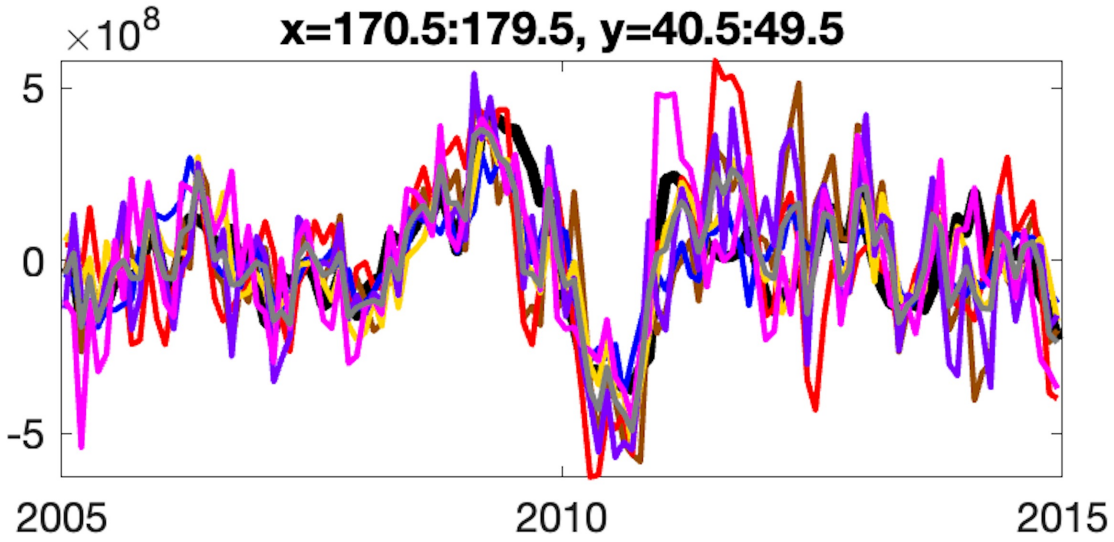
Standard deviation

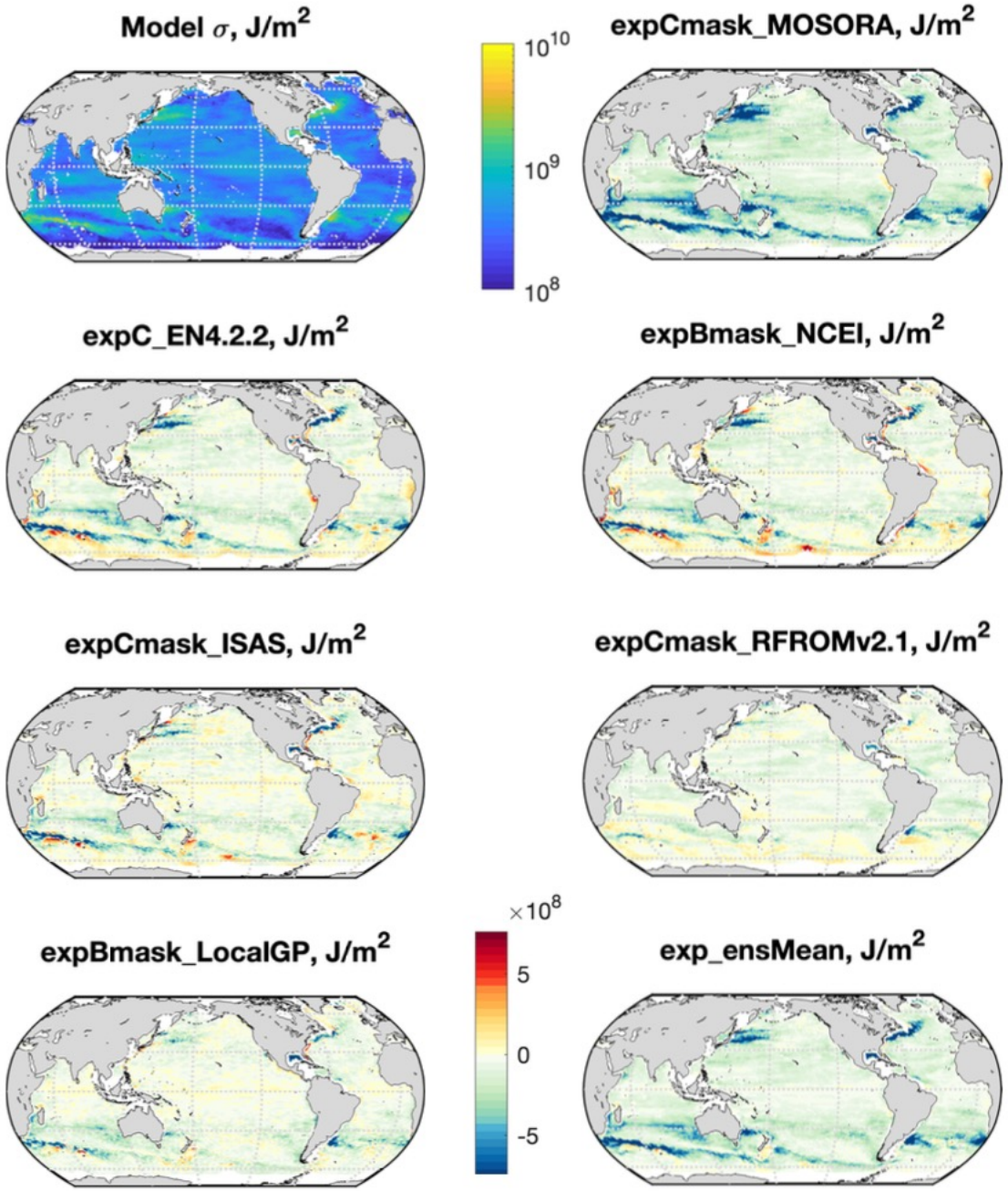
- Spurious month-to-month variations?



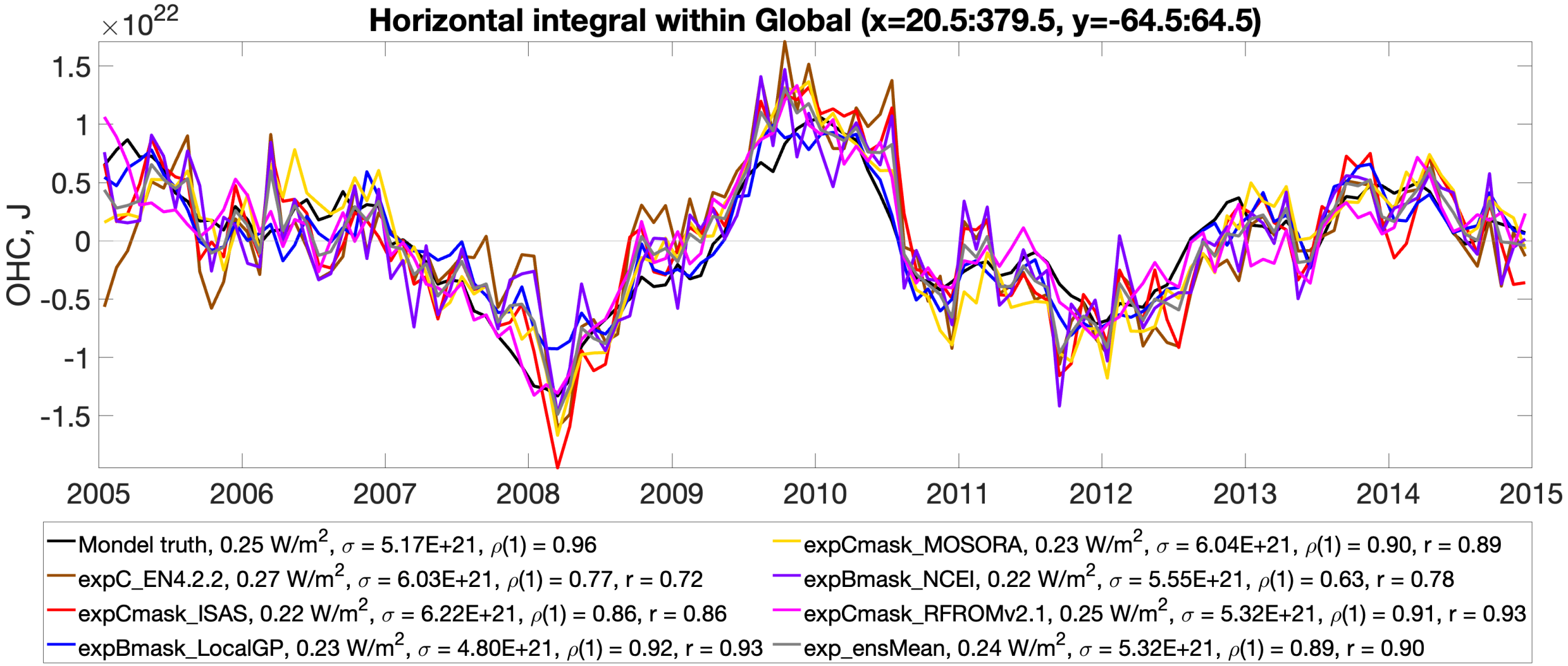
Standard deviation

- Spurious month-to-month variations? e.g. OHC (J/m^2)





Global OHC interannual anomaly: spurious month-to-month variations

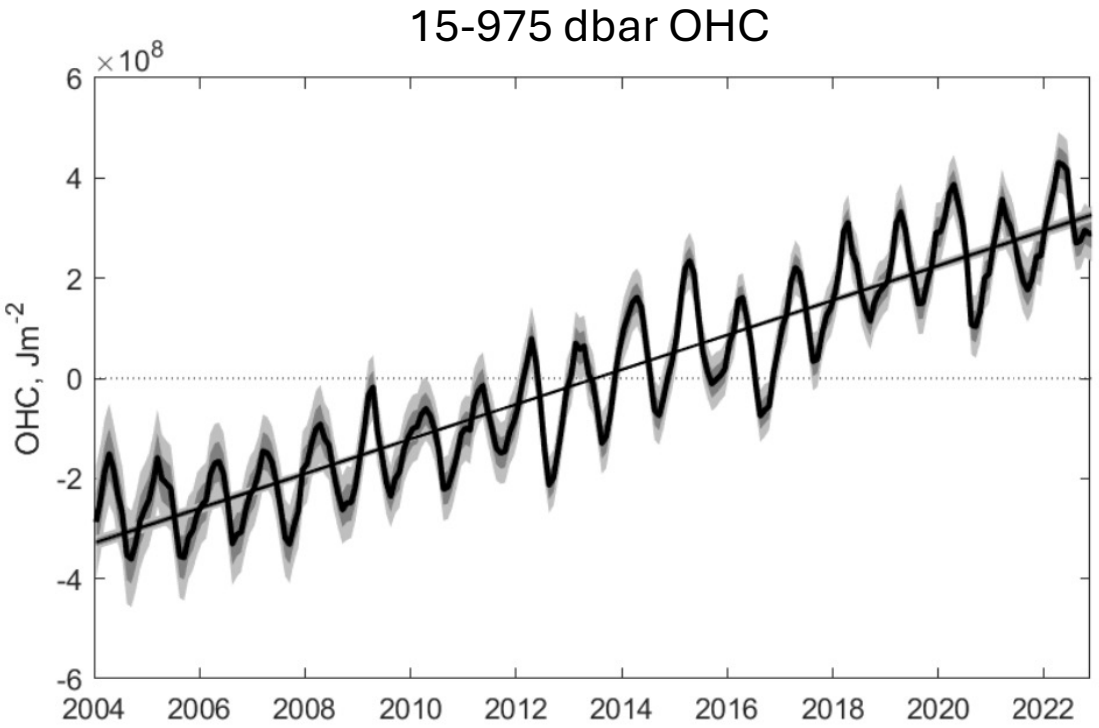


Think-pair-share

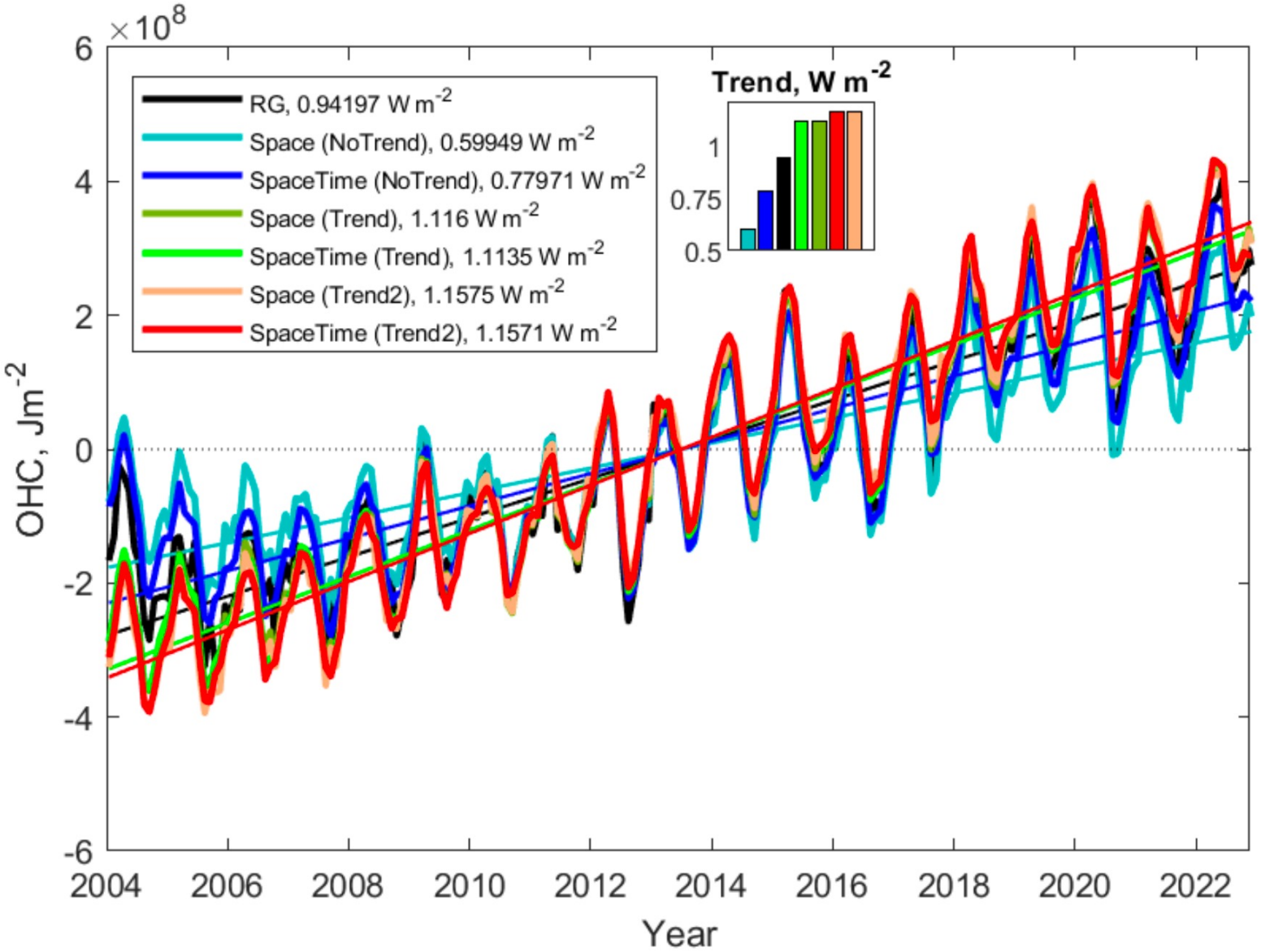
- How can the ME4OH framework help in improving OHC uncertainties?
  - Can it be used to evaluate the uncertainty of mapped fields? How?
  - Other ideas?

Think-pair-share

- How can the ME4OH framework help in improving OHC uncertainties?
  - Can it be used to evaluate the uncertainty of mapped fields? How?



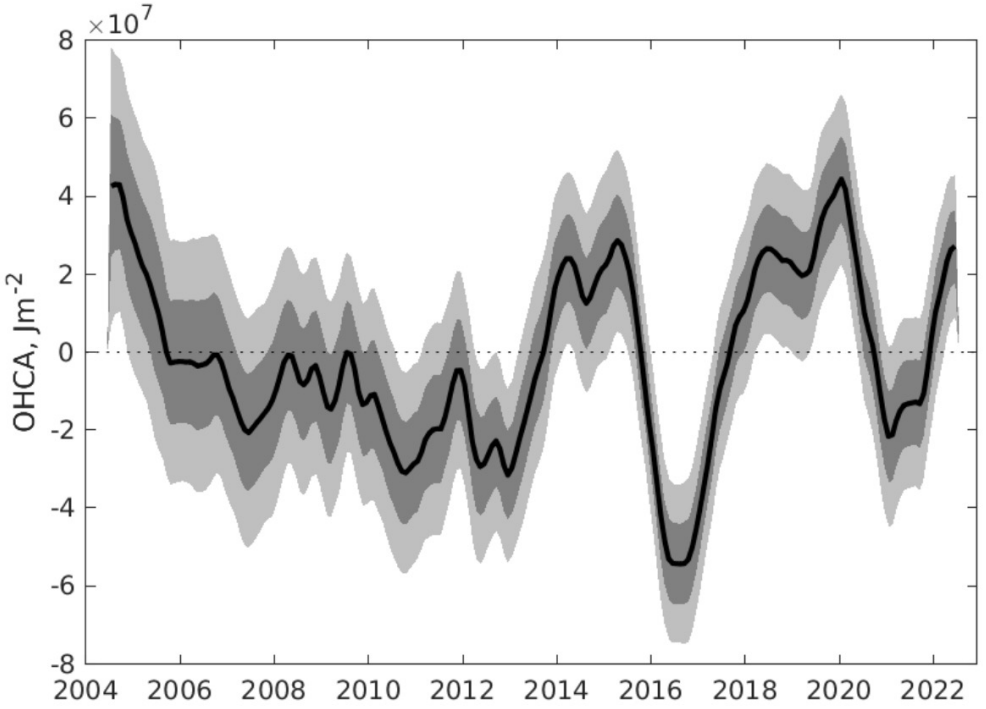
Reminder: how we model the mean field matters!



Think-pair-share

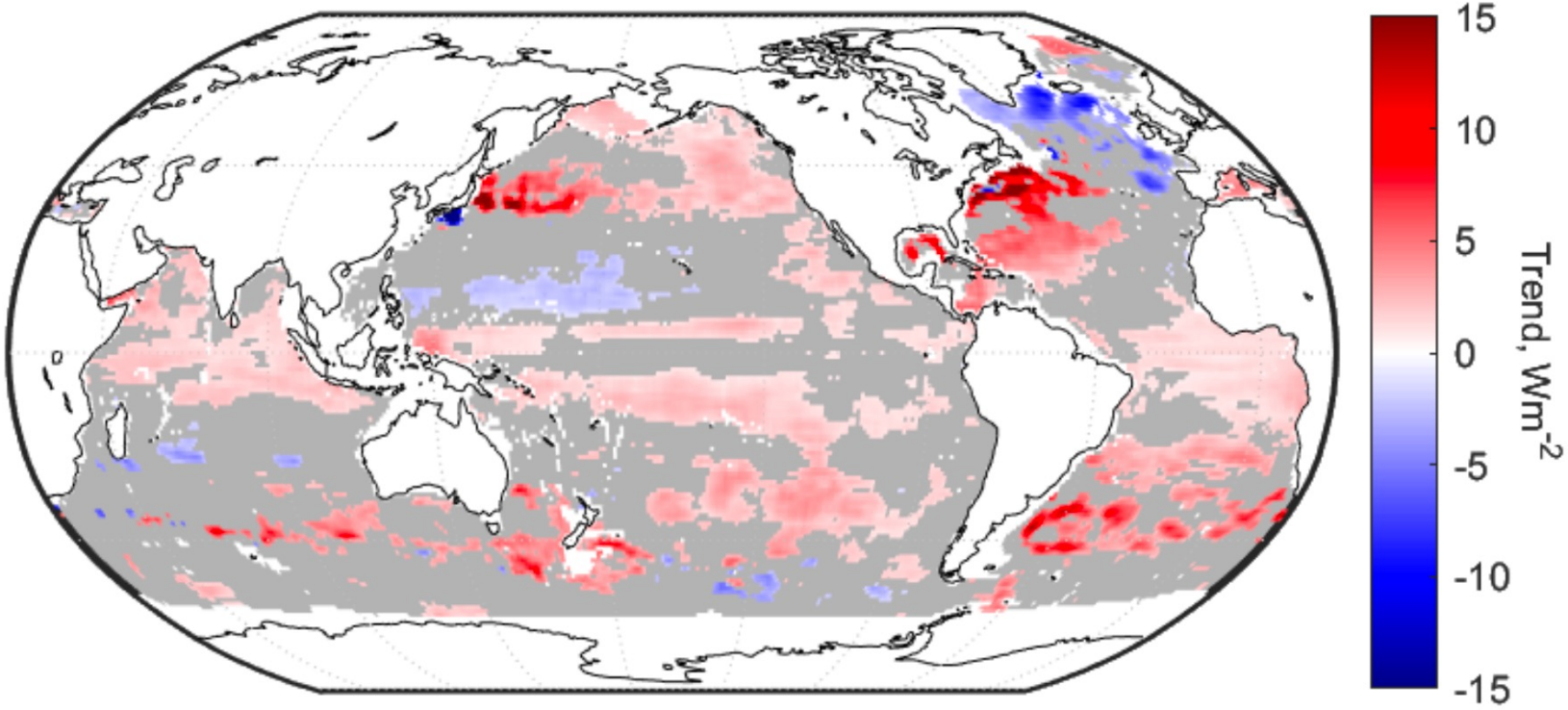
- How can the ME4OH framework help in improving OHC uncertainties?
  - Can it be used to evaluate the uncertainty of mapped fields? How?

15-975 dbar OHC, 12-month moving ave



Think-pair-share

- How can the ME4OH framework help in improving OHC uncertainties?
  - Can it be used to evaluate the uncertainty of mapped fields? How?



How can the ME4OH framework help in improving OHC uncertainties?

- Uncertainty evaluation for the uncertainty of mapped fields
- Creating an ensemble of solutions from methods that have been evaluated through the framework and (when possible) improved
  - Using the spread across methods
  - What if we use the spread across methods without such evaluation?

Summary

- Having a framework for the evaluation of mapping methods and their uncertainties is helpful to select a gridded product for your application
  - Details of the mapping method and uncertainty estimate matter!

- For OHC, ME4OH shows that, e.g.
  - Linear trend: over- or under-estimated, especially pre-Argo
  - RMSE: largest along strong currents for methods using only profiles (no SST/SSH)
  - Global OHC interannual anomaly: spurious month-to-month variations
  - In the future: more variables, more models, …