

ACCESS-OM2 contribution to ocean-only FAFMIP

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青岛海洋科学与技术国家实验室
Qingdao National Laboratory for Marine Science and Technology



What's FAFMIP?

- One of the CMIP6-endorsed MIPs
- Motivated by uncertainties in projections of ocean climate change

The Flux-Anomaly-Forced Model Intercomparison Project (FAFMIP) contribution to CMIP6: investigation of sea-level and ocean climate change in response to CO₂ forcing

Jonathan M. Gregory^{1,2}, Nathaëlle Bouttes³, Stephen M. Griffies⁴, Helmuth Haak⁵, William J. Hurlin⁴, Johann JungCLAUS⁵, Maxwell Kelley⁶, Warren G. Lee⁷, John Marshall⁸, Anastasia Romanou⁶, Oleg A. Saenko⁷, Detlef Stammer⁹, and Michael Winton⁴

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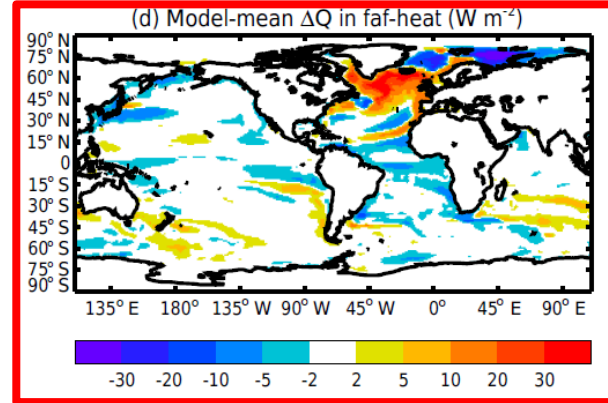
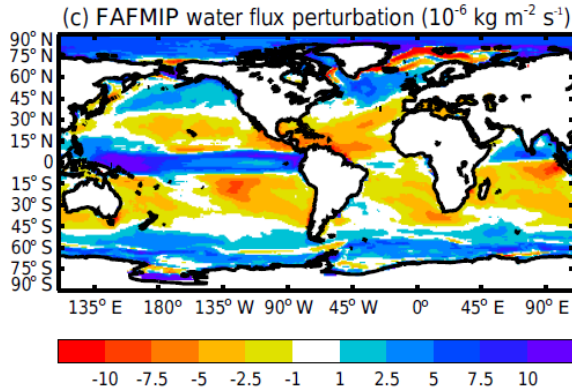
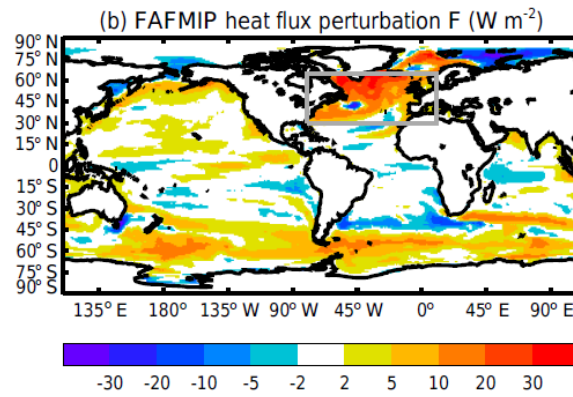
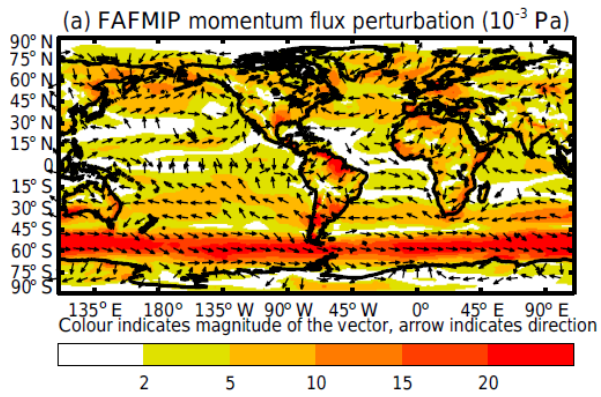
⁶Goddard Institute for Space Sciences, Columbia University, New York, USA

⁷Canadian Centre for Climate Modelling and Analysis, Victoria, British Columbia, Canada

⁸Department of Earth, Atmospheric and Planetary Sciences, Massachusetts Institute of Technology, Cambridge, USA

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Gregory et al. 2016

Induced
surface heat
flux feedbacks
in coupled
climate model

FAFMIP perturbations applied to the ocean in coupled climate model: surface flux anomalies under doubled CO₂ derived from CMIP5 ensemble mean 1% CO₂ experiment

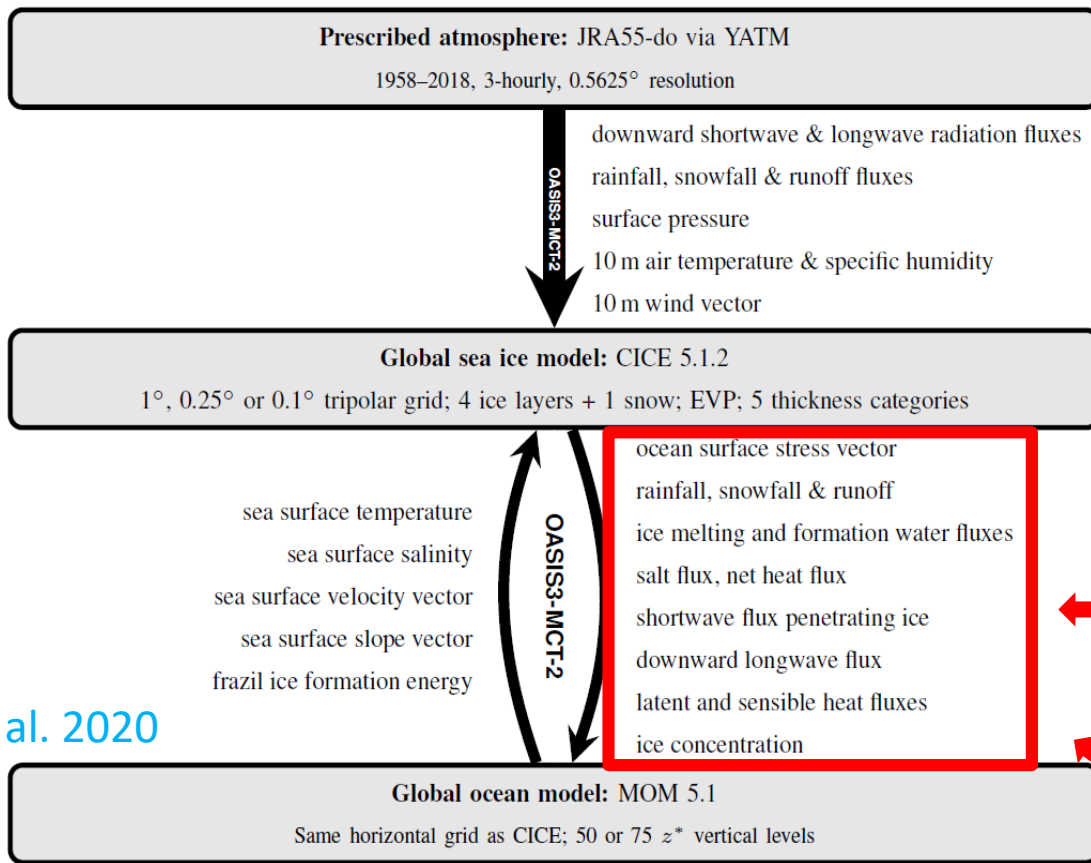
Ocean-only FAFMIP

- The purpose is to reveal “pure” ocean responses to the applied flux perturbations
- What is the effect of atmospheric feedbacks on ocean climate change?
- How much of the spread in regional dynamic sea level and ocean heat content changes in coupled GCMs is due to the use of different ocean models?

Ocean-only FAFMIP: Understanding Regional Patterns of Ocean Heat Content and Dynamic Sea Level Change.

Alexander Todd¹, Laure Zanna^{2,1}, Matthew Couldrey³, Jonathan Gregory^{3,4},
Quran Wu³, John Church⁵, Riccardo Farneti⁶, René Navarro-Labastida^{6,7},
Kewei Lyu⁸, Oleg Saenko⁹, Duo Yang⁹, Xuebin Zhang⁸

manuscript submitted to *Journal of Advances in Modeling Earth Systems (JAMES)*

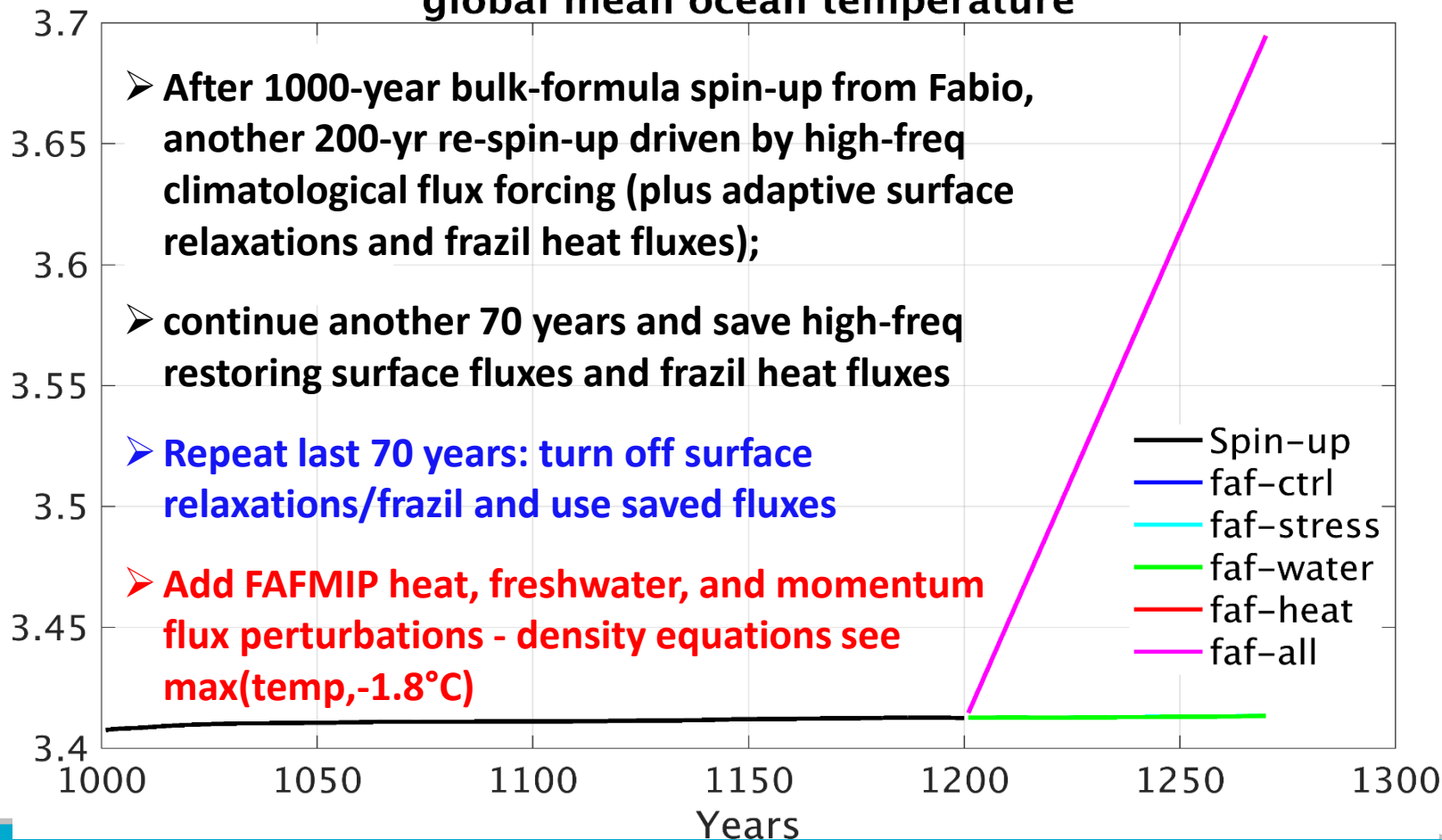


Using climatological
air-sea and sea ice
fluxes to override
interactive bulk
formula via `data_table`

Add FAFMIP flux
perturbations

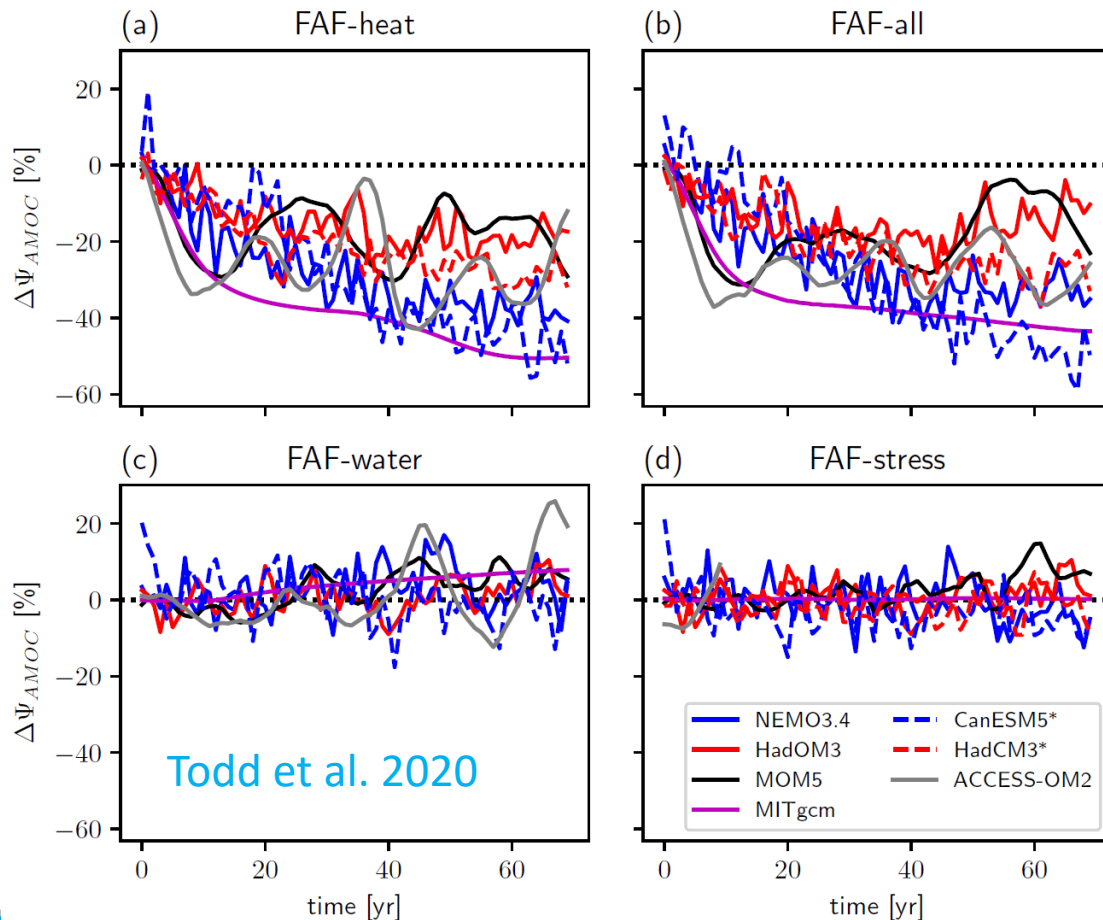
Kiss et al. 2020

global mean ocean temperature



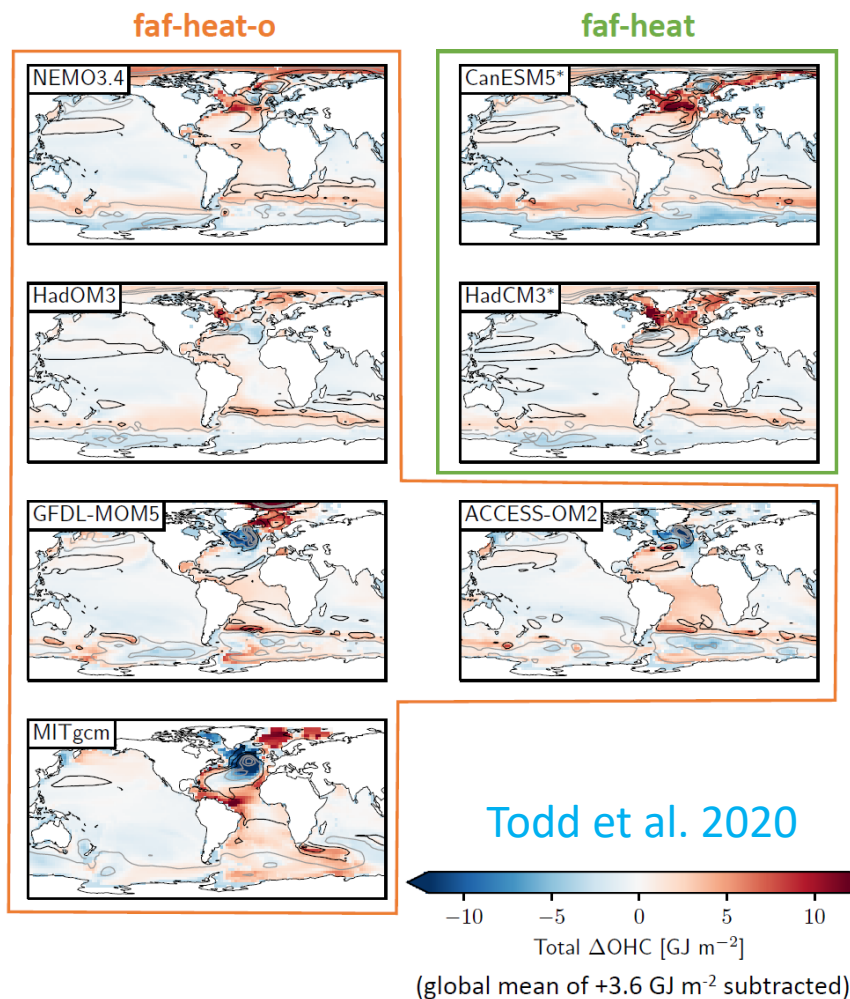
AMOC changes

- Heat flux dominates AMOC weakening
- Large spread among models 20-50% weakening
- AMOC weakening amplified by ~10% in CGCM relative to OGCM



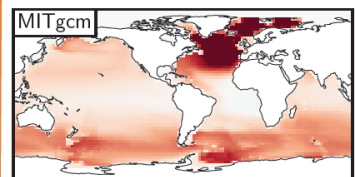
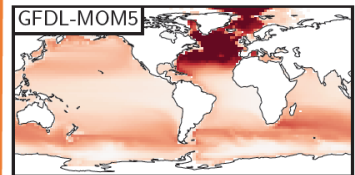
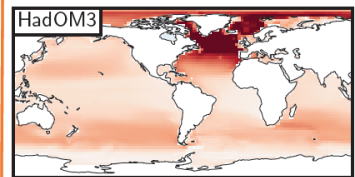
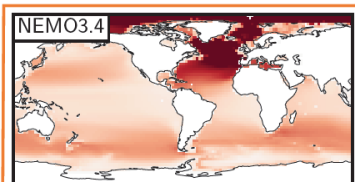
Ocean heat content changes

- Large disagreement over warming/cooling of mid to high latitude North Atlantic
- Better agreement for Southern Ocean meridional pattern.
- CGCMs indicate more warming in North Atlantic relative to OGCMs

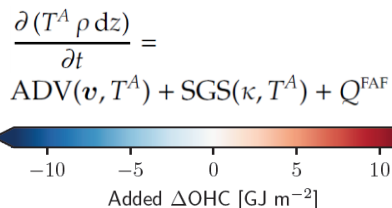
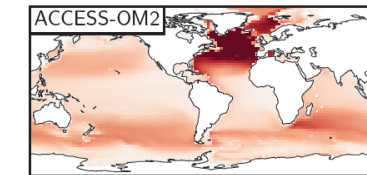
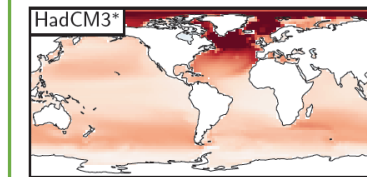
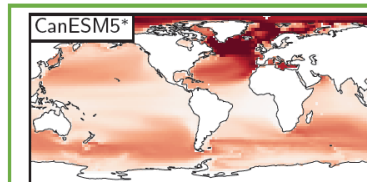


Added heat tracer

faf-heat-o

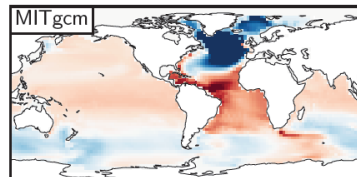
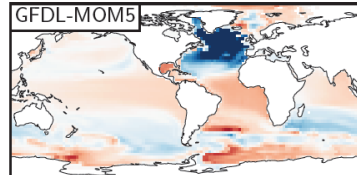
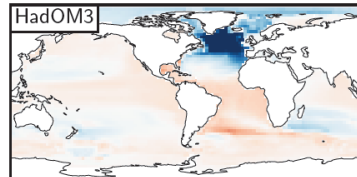
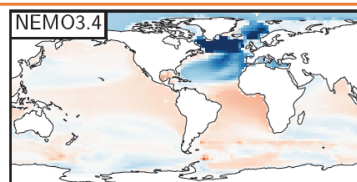


faf-heat

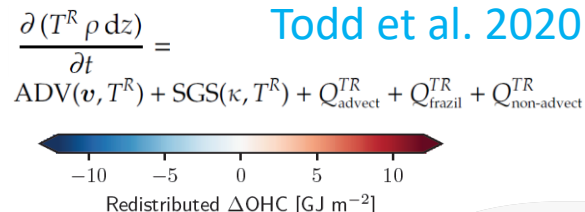
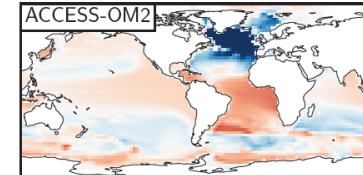
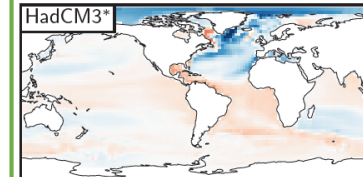
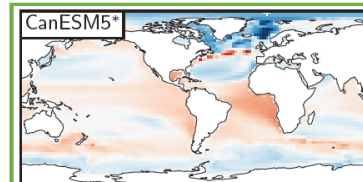


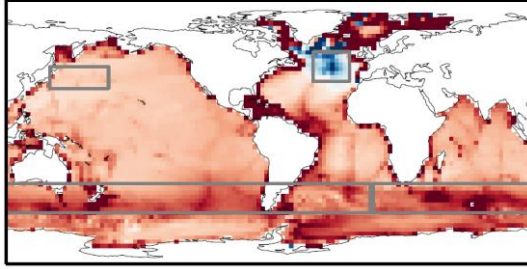
Redistributed heat tracer

faf-heat-o

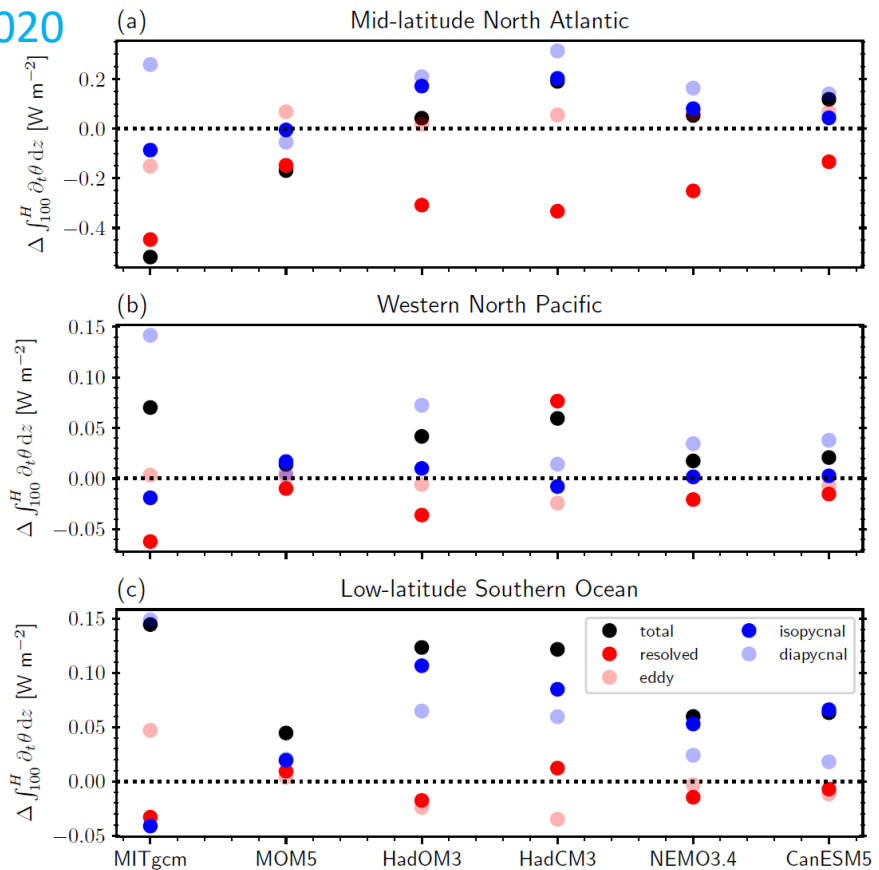


faf-heat



(b) $\Delta \int_{100}^H \partial_t \theta \, dz$ mean [W m^{-2}]

- Cooling in North Atlantic mainly due to advection change
- Contrasting processes in HadOM3/HadCM3 in Pacific
- Mainly diffusive processes in Southern Ocean



$$\Delta \partial_t \theta = \Delta \partial_t \theta_{resolved} + \Delta \partial_t \theta_{eddy} + \Delta \partial_t \theta_{isopycnal} + \Delta \partial_t \theta_{diapycnal}$$

Summary

- Large spread in regional sea level and ocean heat content changes by prescribing the same surface flux perturbations to different OGCMs
- FAFMIP coupled experiments introduce an air-sea feedback which amplifies AMOC weakening by $\sim 10\%$
- Heat budget terms show little agreement on which processes dominate ocean heat content changes on regional scales.
- More info can be found in a pre-print of the submitted manuscript Todd et al. (2020, JAMES) available online

Acknowledge: COSIMA, Russ Fiedler, Fabio Dias

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