The characteristics and uncertainties of *sterodynamic* sea level change i.e. due to ocean density and circulation change

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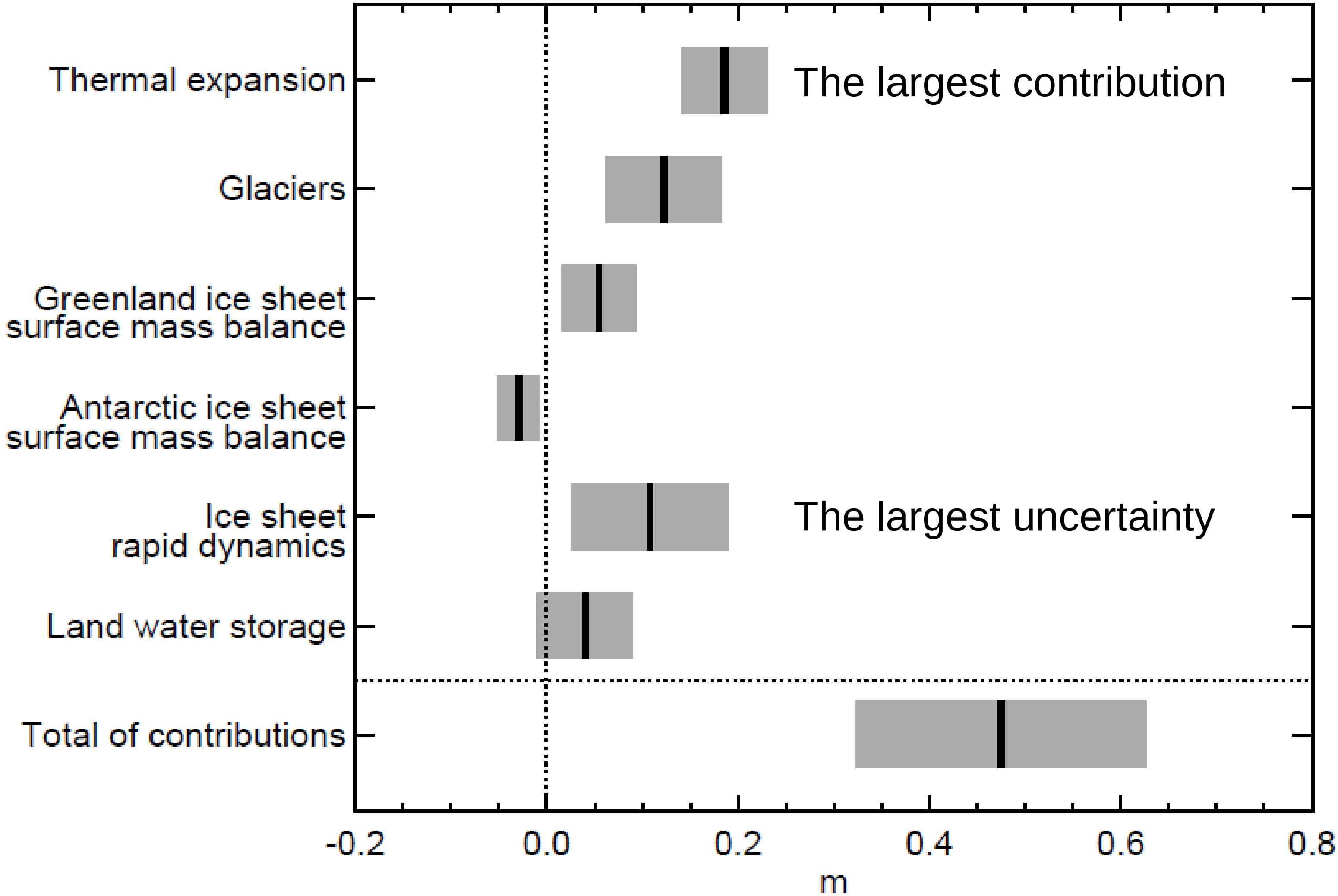
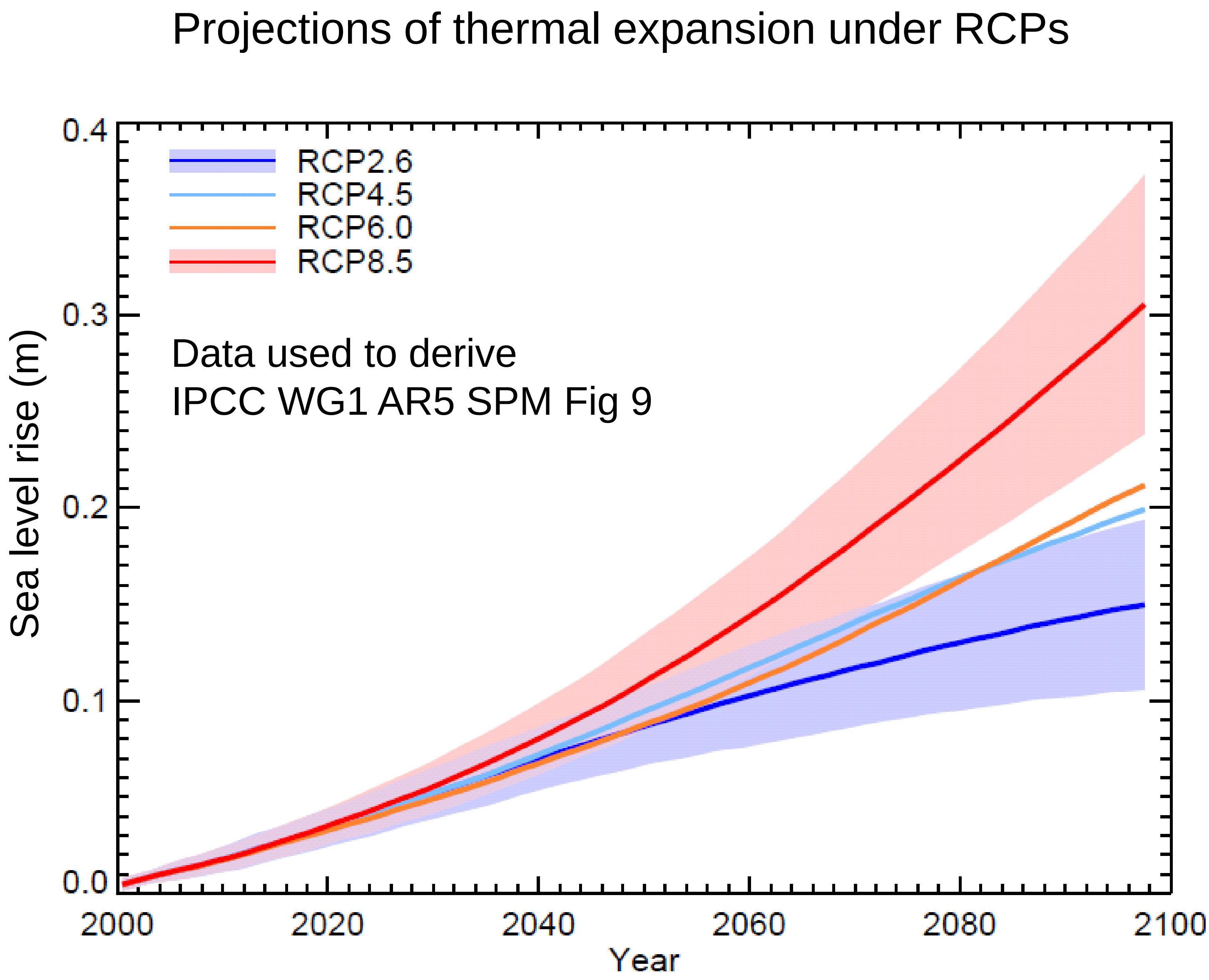
Gregory et al. (2016, *Geosci. Model Devel.*)

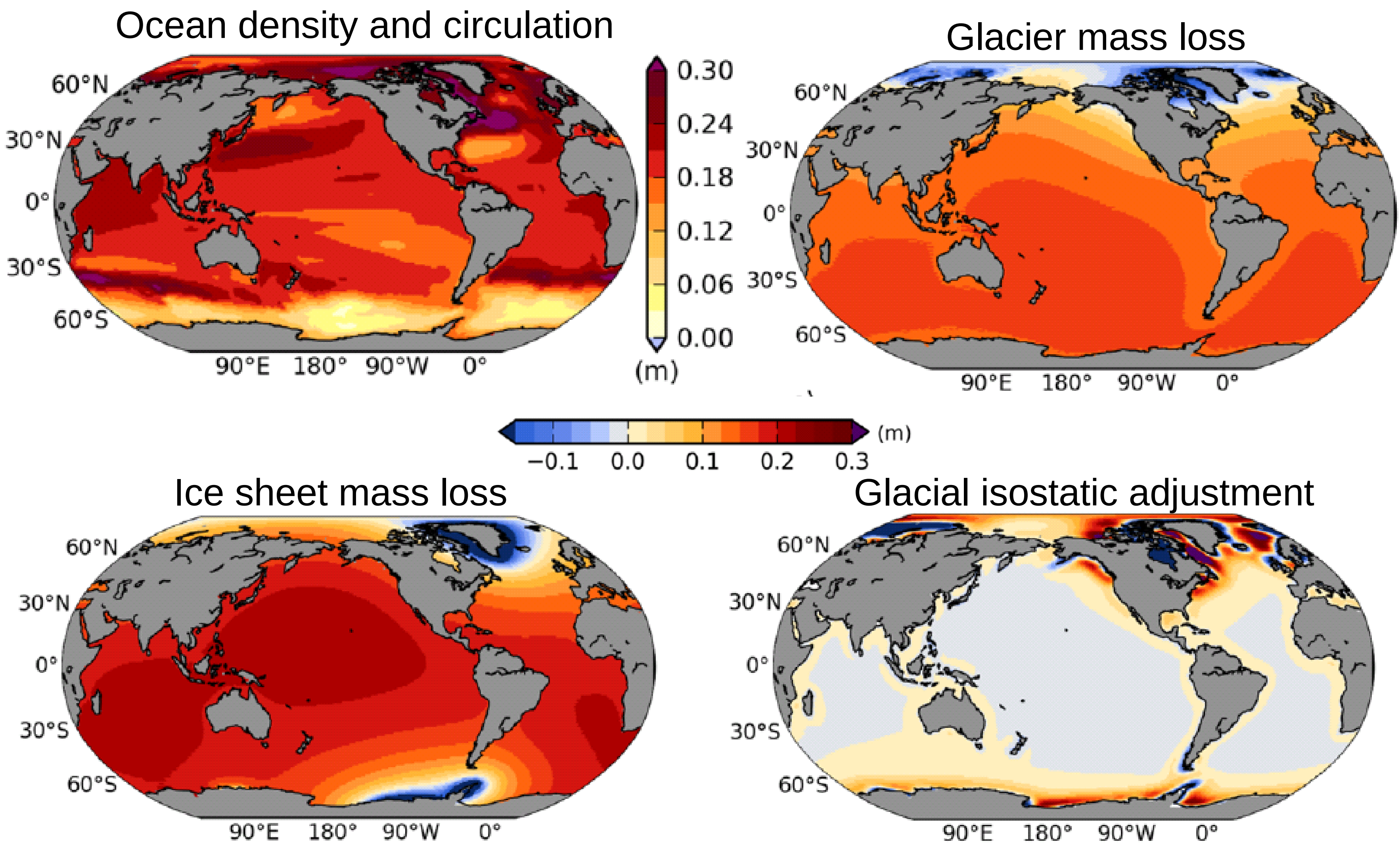
Projections for 2081-2100 under RCP4.5



Data from IPCC WG1 AR5 Table 13.5


Projections of thermal expansion under RCPs
RCP2.6
RCP4.5
RCP6.0
RCP8.5
Data used to derive
IPCC WG1 AR5 SPM Fig 9
Sea level rise (m)
0.0
0.1
0.2
0.3
0.4
2000
2020
2040
2060
2080
2100
Year

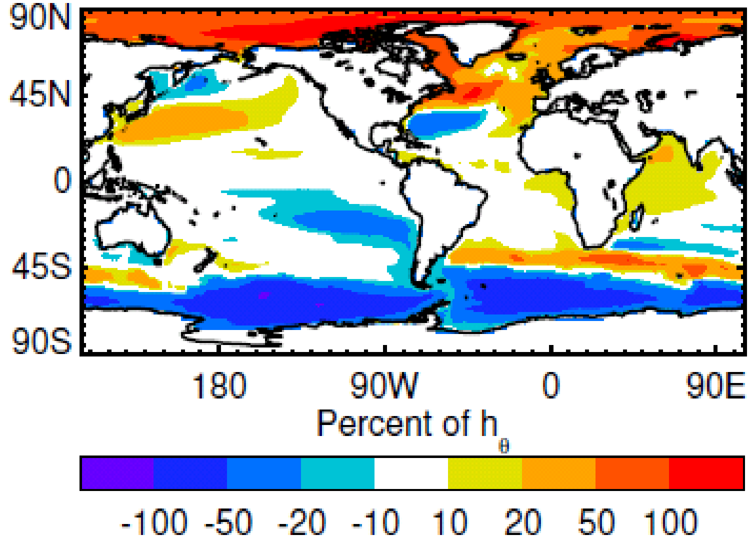
Contributions to the geographical variation of sea level rise



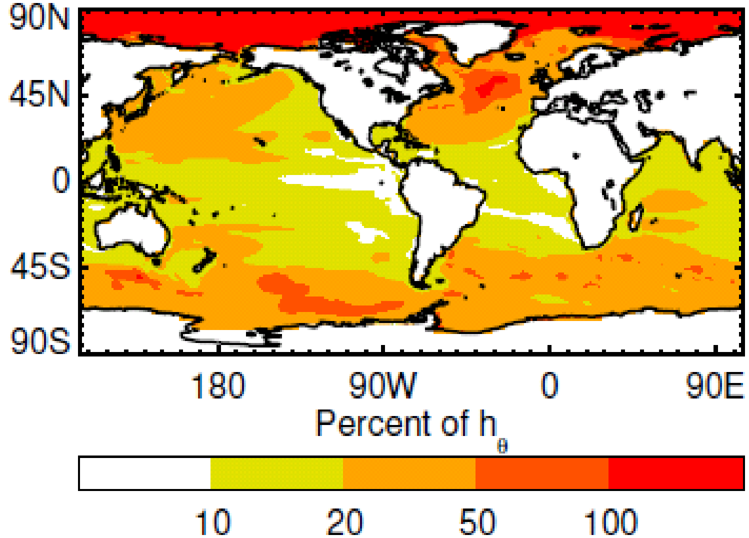
Figures 13.16 and 13.18, for RCP4.5 2081-2100

Dynamic sea-level change Δζ (% of global mean thermosteric SL rise) in the CMIP5 ensemble for 2081-2100 under RCP4.5

Ensemble mean



Ensemble standard deviation



CMIP6 Flux-anomaly-forced model intercomparison project (FAFMIP)

The goal is to account for the spread in simulated ocean response to changes in surface fluxes resulting from CO_2 forcing.

Specific interests are

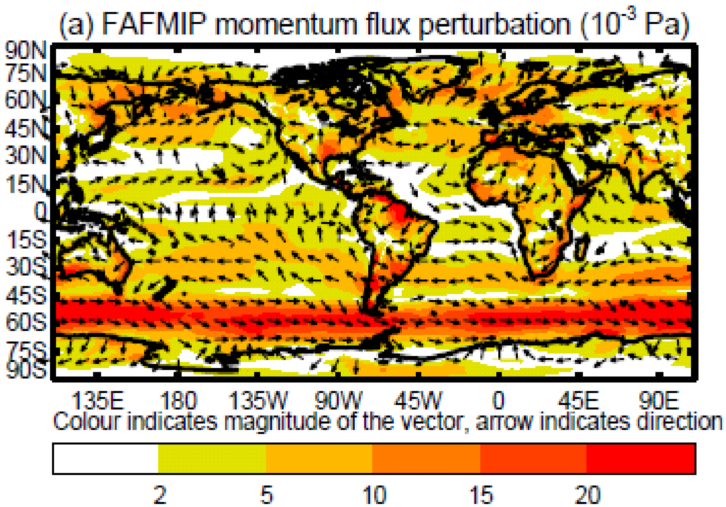
- The model spread in geographical patterns of predicted sea level change due to ocean circulation and density change.
- The global ocean heat uptake efficiency, which affects global mean sea level rise due to thermal expansion.
- The magnitude of change in the AMOC, which affects regional climate.
- The ocean's role in determining patterns of SST change and ocean temperature change near to ice-shelves.

FAFMIP involves 70-year AOGCM experiments, exactly like piControl (including atmospheric composition), except that surface flux perturbations are applied to the ocean in addition to the fluxes computed interactively by the atmosphere.

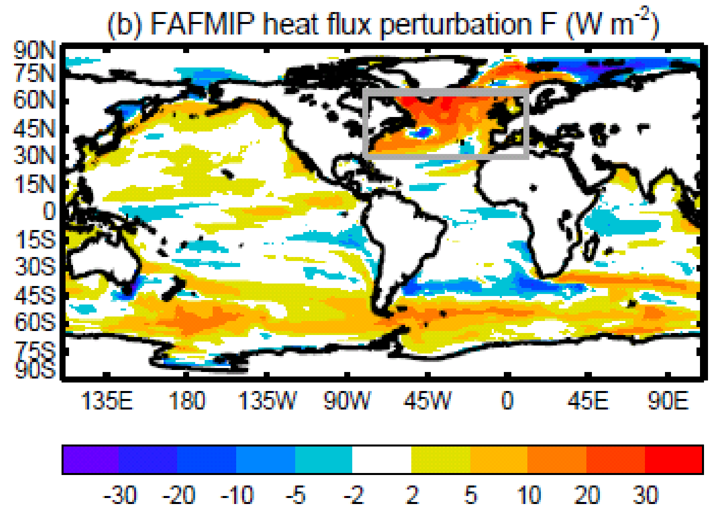
The surface flux perturbations are the CMIP5 model-mean changes in surface fluxes at the time of 2xCO2 in 1pctCO2.

FAFMIP surface flux perturbations (annual means)

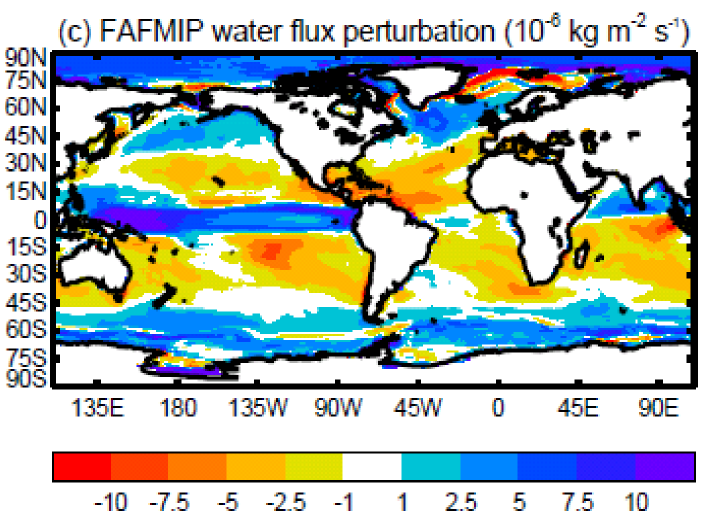
faf-stress



faf-heat



faf-water

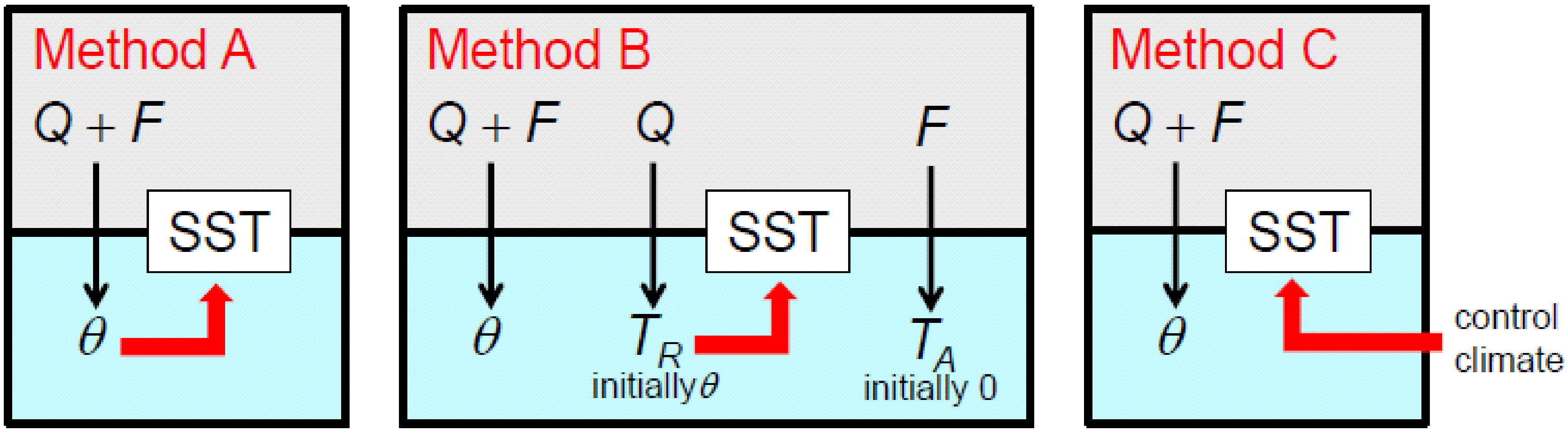


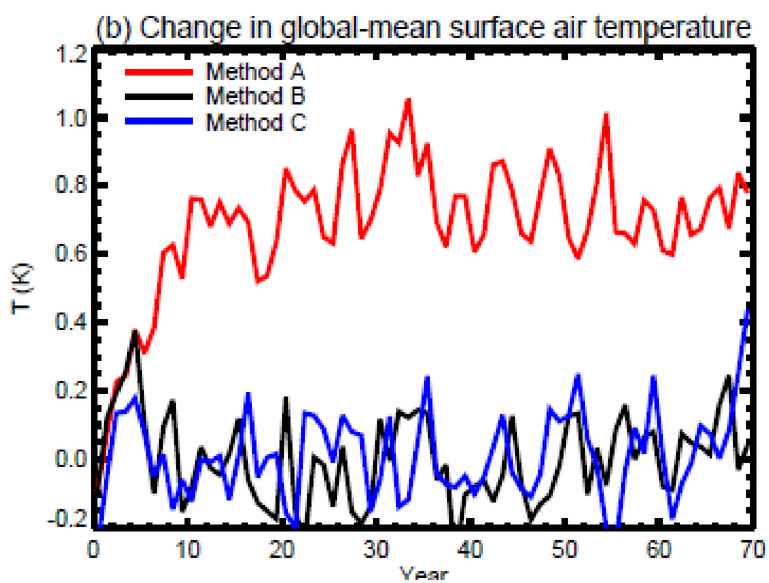
There are two tier-2 experiments:

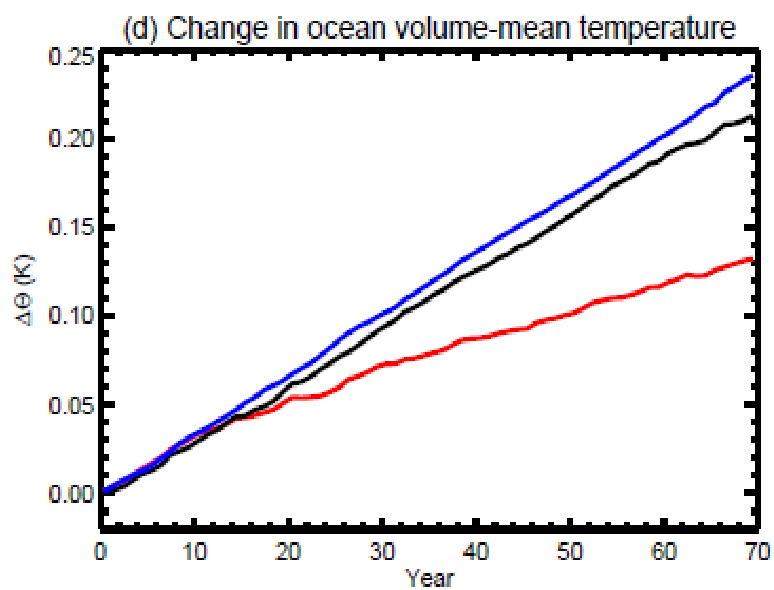
faf-all

faf-passiveheat

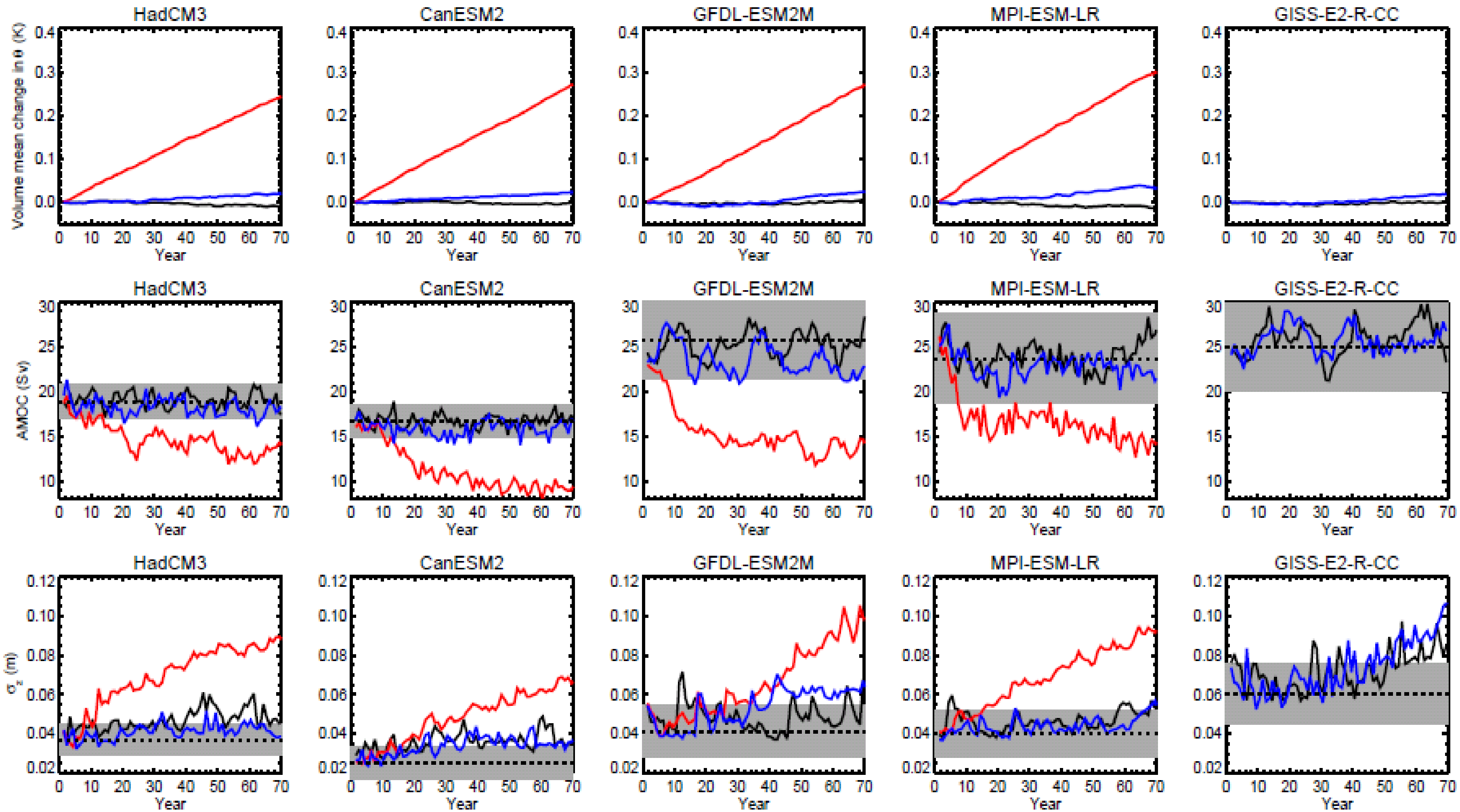
Methods for applying heat flux perturbation



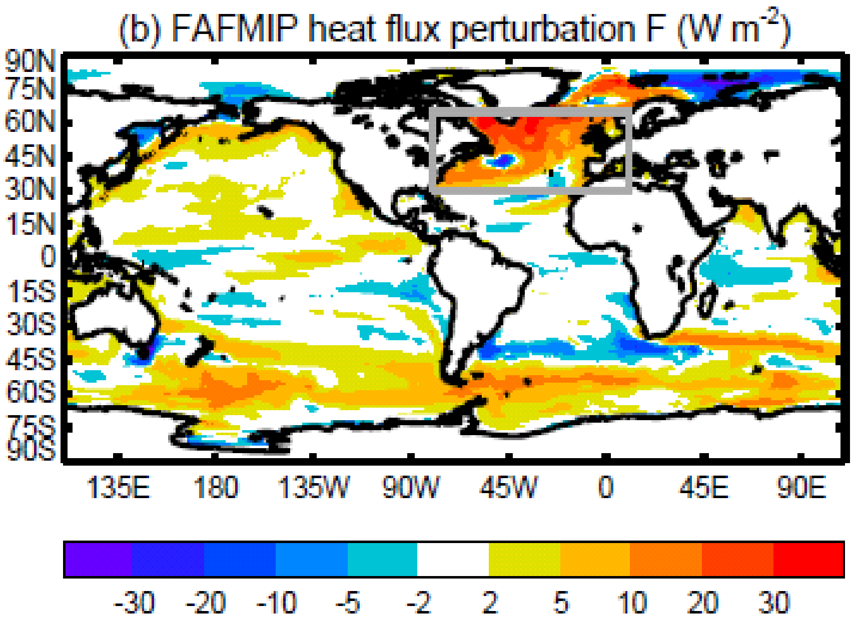


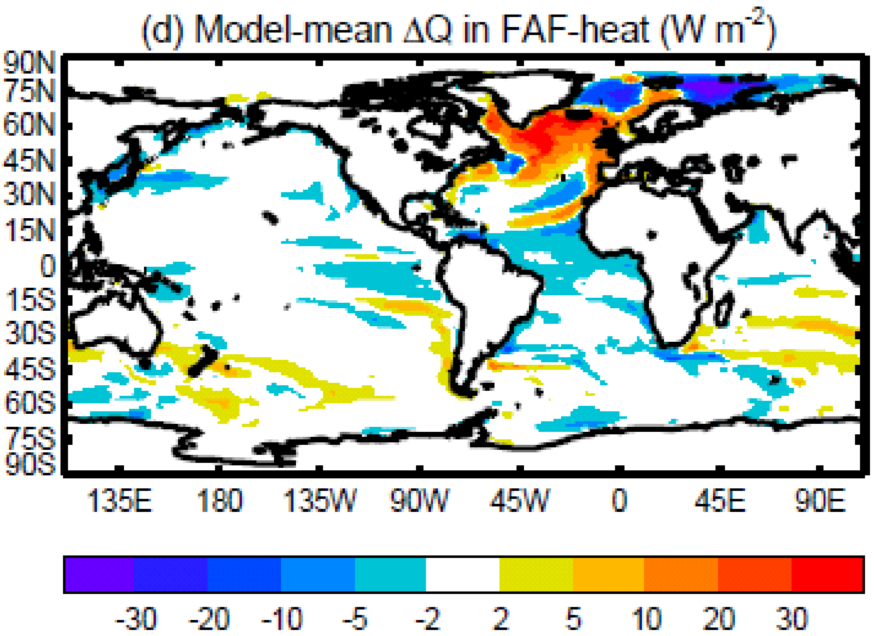


Global ocean heat uptake, AMOC change and σ_ζ

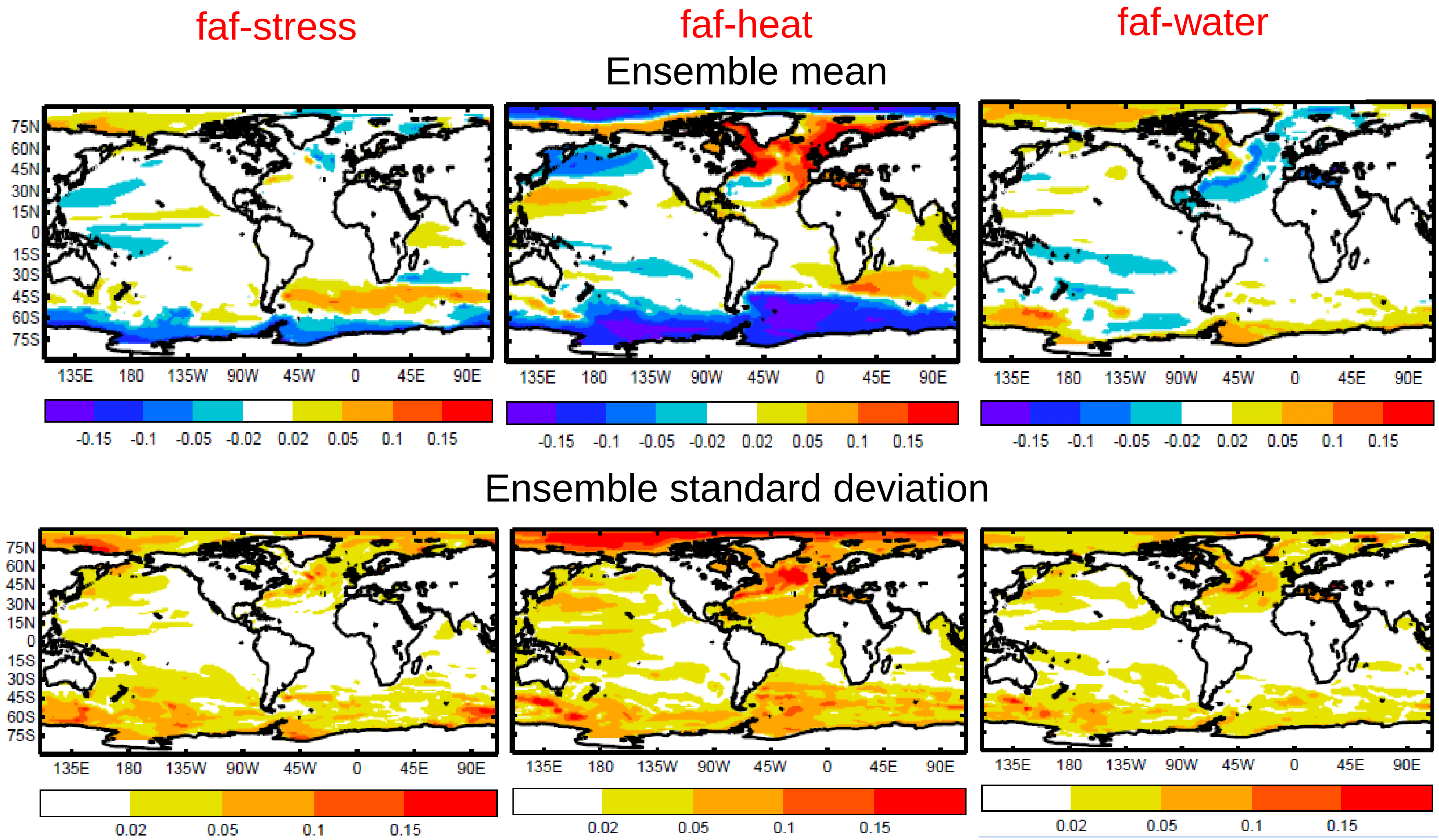


Effect of heat flux perturbation on surface heat flux





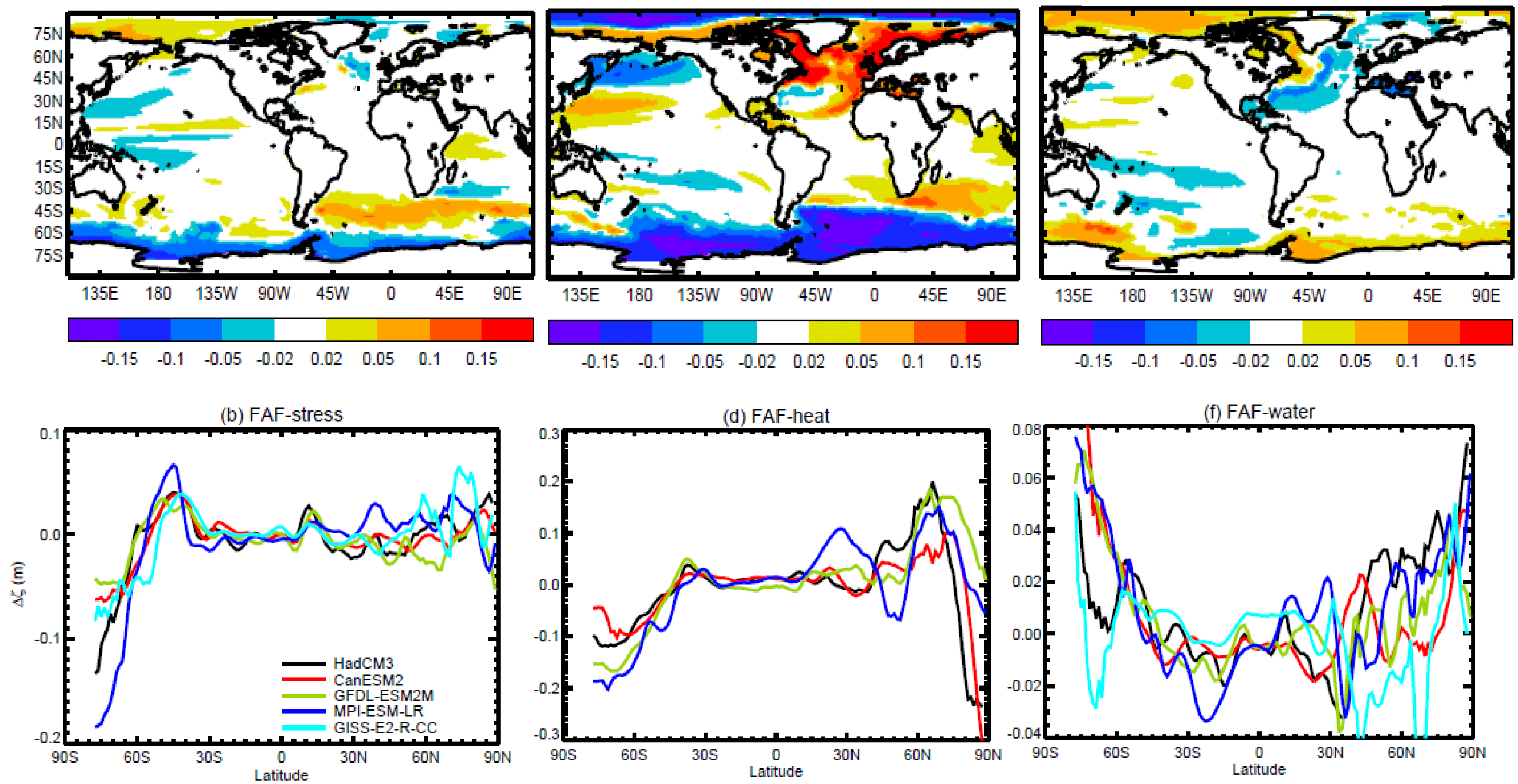
Dynamic sea-level change Δζ (m)
in the FAFMIP ensemble (time-mean of last decade of seven)



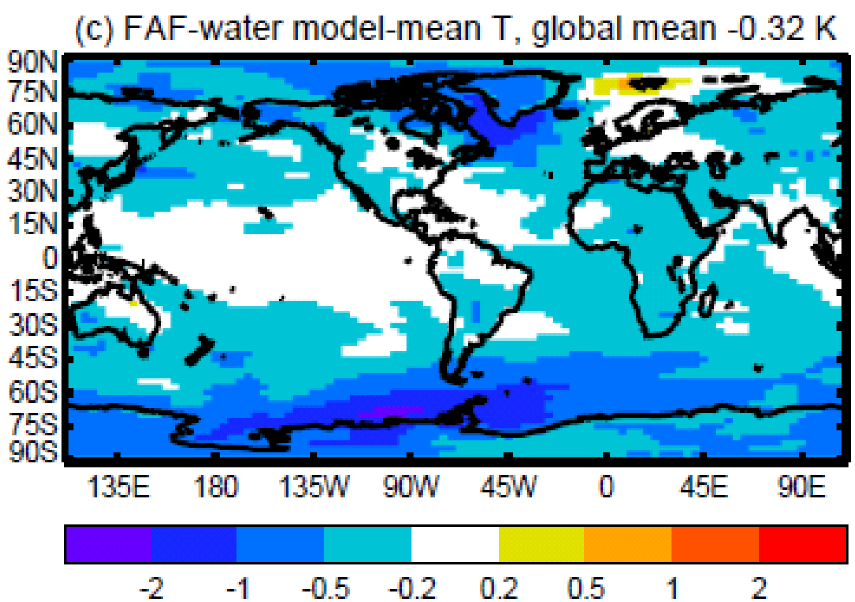
Dynamic sea-level change Δζ (m)
in the FAFMIP ensemble (time-mean of last decade of seven)

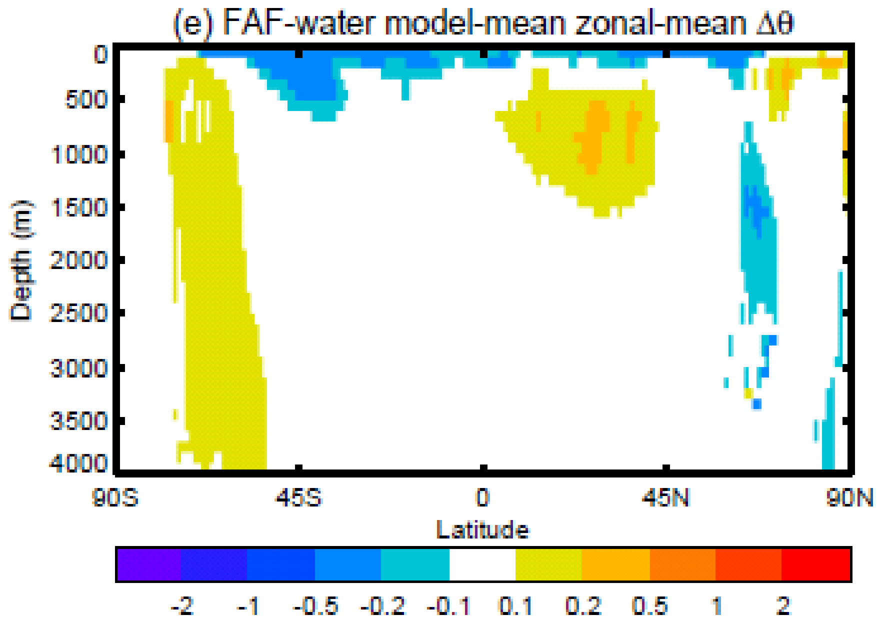
faf-stress faf-heat faf-water

Ensemble mean

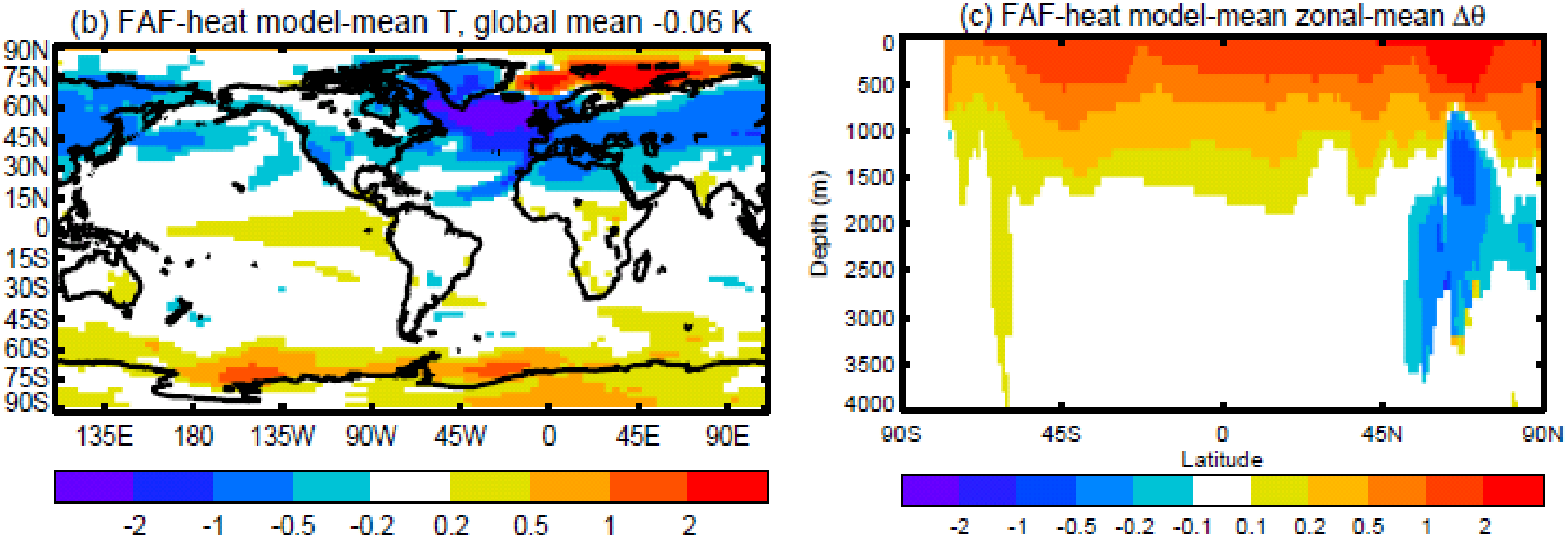


Effect of water flux perturbation on temperature

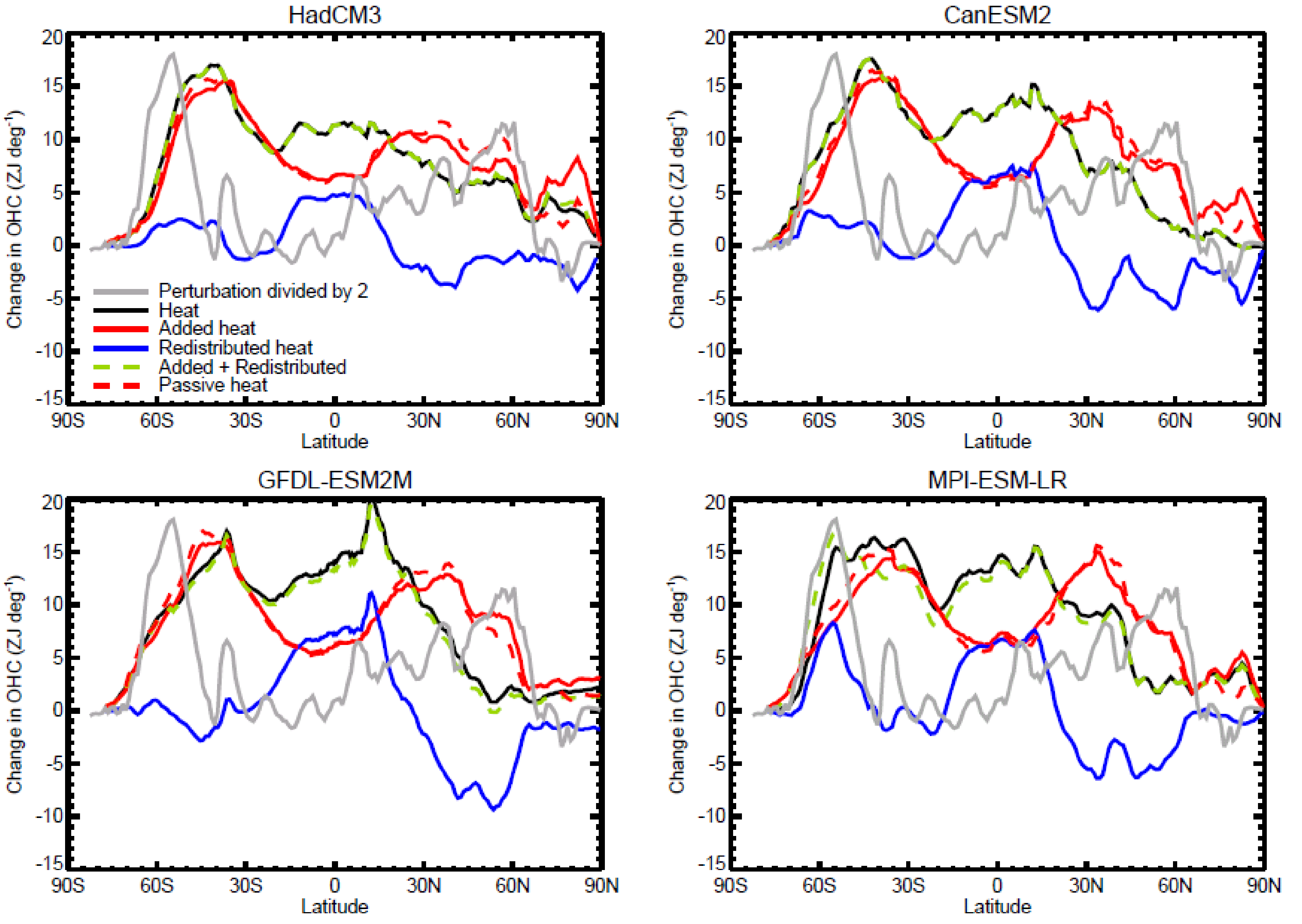




Effect of heat flux perturbation on temperature



Addition and redistribution of heat



Conclusions

The main intention of FAFMIP is to analyse why and how projections of regional SL change depend on the ocean model.

SL change in the S Ocean is caused by momentum and heat flux change, in the N Atlantic by heat and water flux change, and in the Arctic by water flux change.

The AMOC weakens in response to heat flux change, but not to momentum or water flux change. AMOC weakening is reinforced by a surface flux feedback. AMOC weakening causes redistribution of heat in the N Atlantic.

In the S Ocean, heat uptake is largely passive.

There is little global ocean heat uptake due to momentum or water flux change.

Water flux change causes surface cooling, especially at high latitude.

The magnitude and pattern of response is model-dependent.

In CMIP6 we will analyse these and other phenomena in a larger set of models, including process-based tendency diagnostics for *T* and *S*.