Ocean Heat Budget analysis in OGCMs

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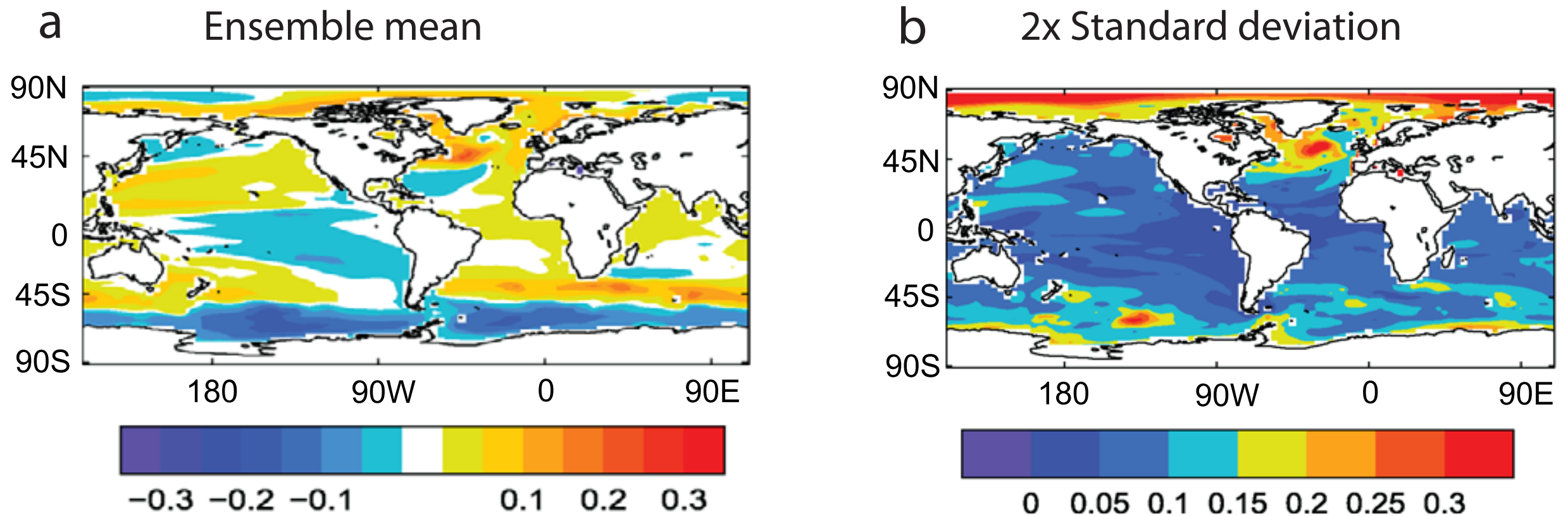*Supervisor team:*
Catia Domingues
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Large uncertainty in sea level rise projections from AOGCMS

a   Ensemble mean

b   2x Standard deviation

Bouttes & Gregory (2014)

- **Ocean heat uptake** and vertical/lateral **transport**

- Long standing scientific question of great societal importance
  (WCRP Grand Challenge Regional Sea Level and Coastal Impacts)

- Lack **mechanistic view** of the **physical processes**
  (diagnostics & international coordination) => CMIP6/FAFMIP (Flux-Anomaly-Forced MIP) and OMIP
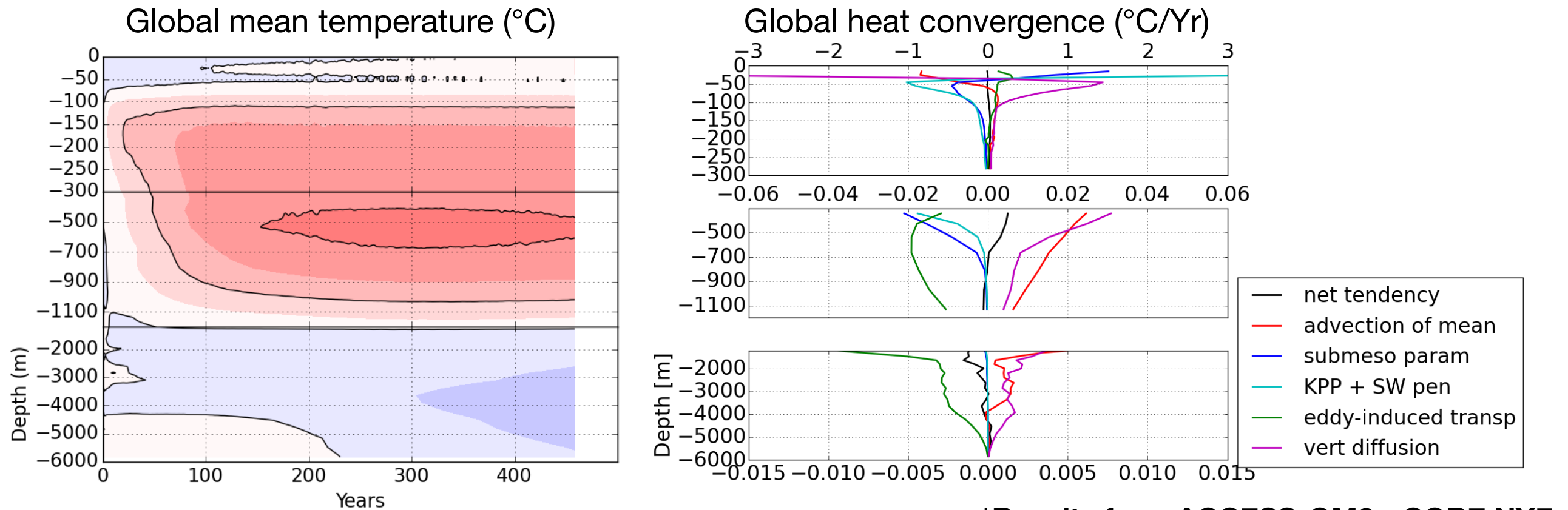
Ocean heat budget analysis

$$\rho_0 c_p \frac{\partial \Theta}{\partial t} = -\nabla . (F_{ADV} + F_{EIT} + F_{KPP} + F_{SW} + F_{SUBMESO} + F_{VDIFF} + F_{OVERFLOW})$$

- **Temperature equation**

  - LHS - net heat tendency

  - RHS - Transport convergence terms:

    - **ADV** = resolved advection

    - **EIT** = Eddy-induced transport (advection + diffusion)

    - **KPP** = nonlocal K-profile parametrisation (mixed layer physics)

    - **SW** = Shortwave penetration

    - **SUBMESO** = Submesoscale restratification on the mixed layer

    - **VDIFF** = Vertical (diapycnal diffusion)

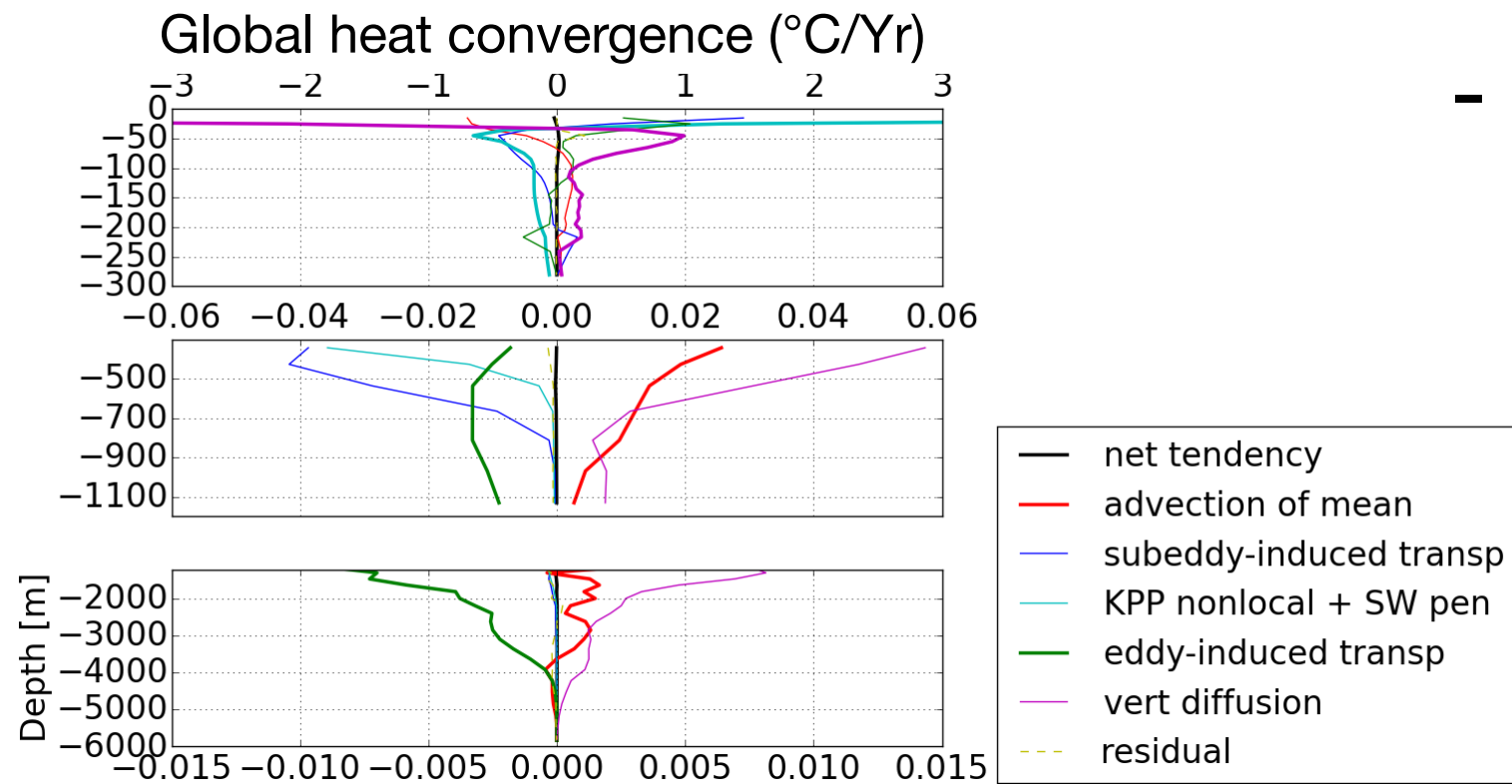   - **OVERFLOW** = Overflow of dense waters parametrisation

• Model drift studies

Global mean temperature (°C)

Global heat convergence (°C/Yr)

Legend:
- net tendency
- advection of mean
- submeso param
- KPP + SW pen
- eddy-induced transp
- vert diffusion

*Results from ACCESS-OM2 - CORE NYF

- Improving model drift/bias:

  - subgrid-scale parametrisation

    - high-resolution solutions

  - advection, shortwave schemes

• **Ocean heat balance**

Global heat convergence (°C/Yr)

- **net tendency**
- **advection of mean**
- **subeddy-induced transp**
- **KPP nonlocal + SW pen**
- **eddy-induced transp**
- **vert diffusion**
- **residual**

0-300 m   300-1200 m   1200-6000 m

*Results from MOM5-SIS - CORE NYF
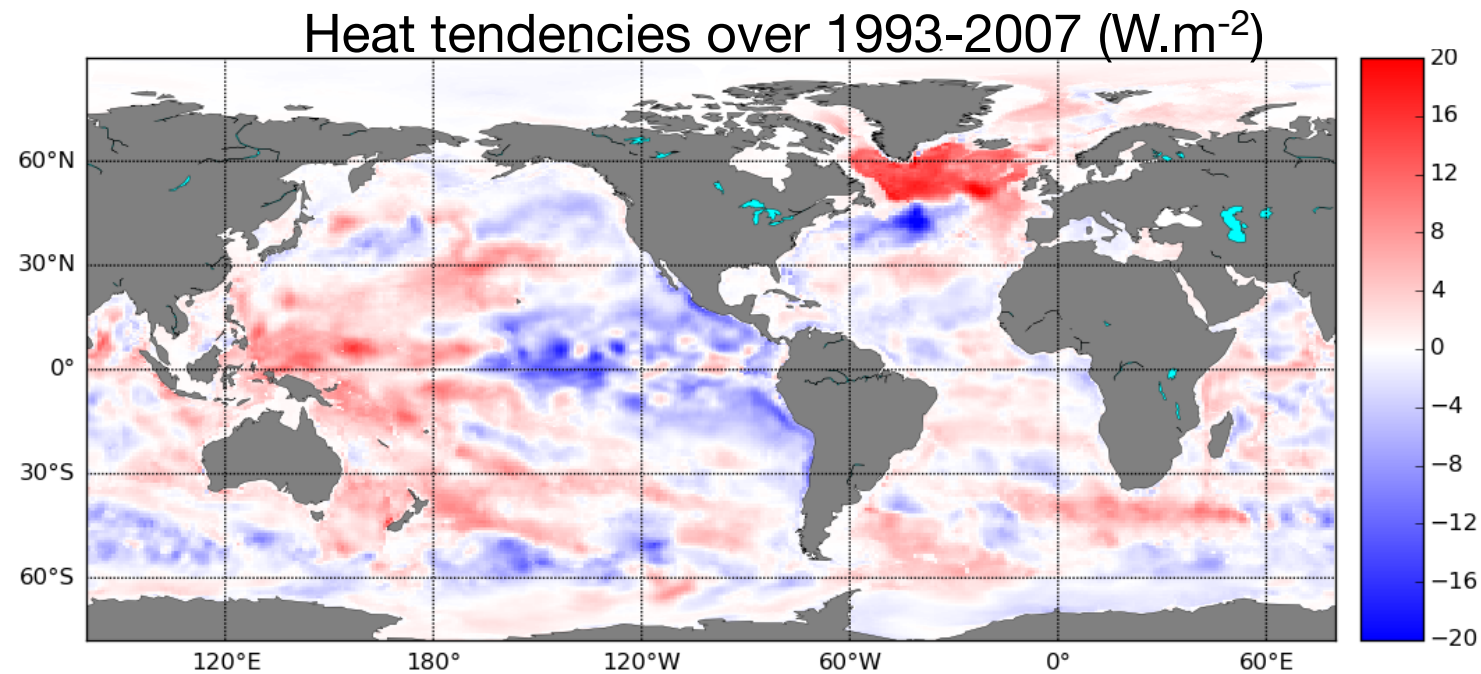
– Long spin-up = stable mean-state

– "control" experiment

– Processes are in a balance
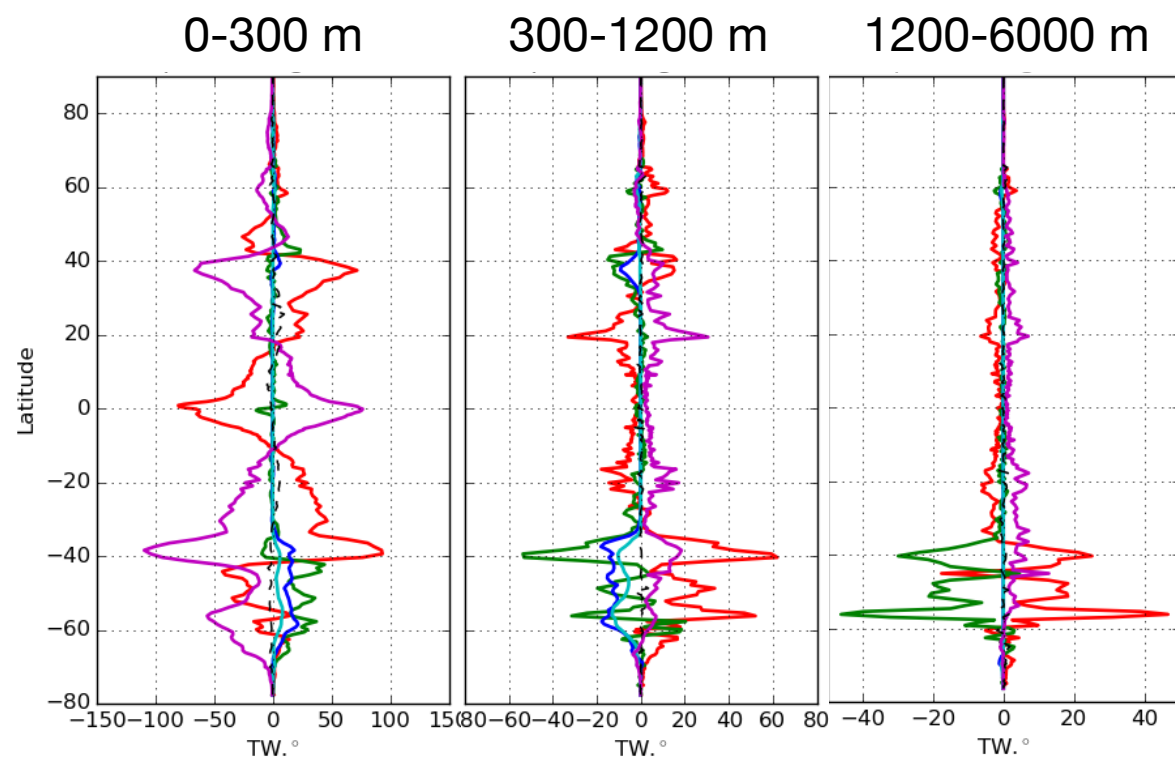
– Heat redistribution: regional processes

• Ocean heat uptake and redistribution

Heat tendencies over 1993-2007 (W.m⁻²)

Global heat convergence (°C/Yr)
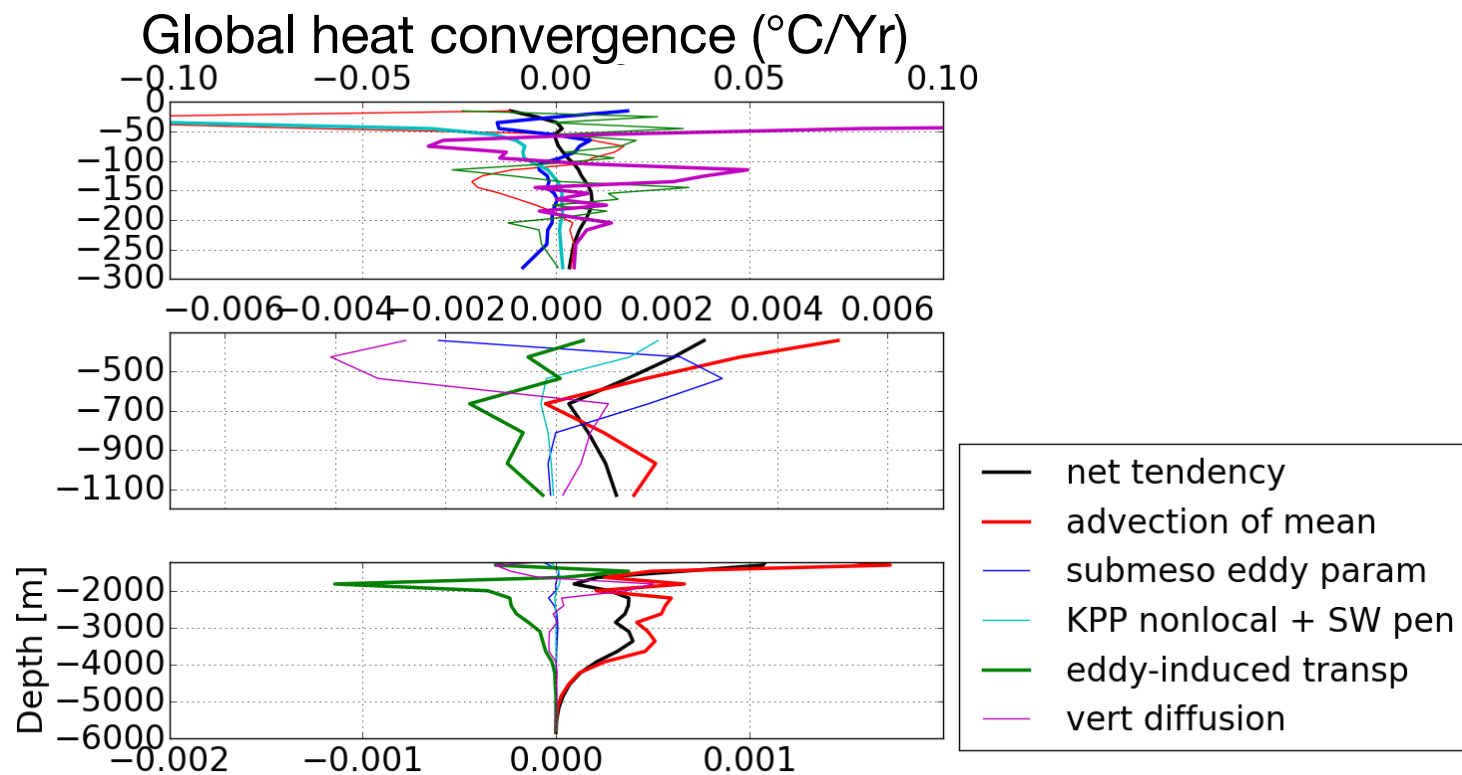
– Perturbed experiments:

  – Inter annual forcing

  – Idealised forcing (e.g. FAFMIP)

– Contrasted with control

  – how processes differ?

net tendency — net tendency
advection of mean — advection of mean
submeso eddy param — submeso eddy param
KPP nonlocal + SW pen — KPP nonlocal + SW pen
eddy-induced transp — eddy-induced transp
vert diffusion — vert diffusion

***Results from MOM5-SIS - CORE IAF**

Summary

- **Ocean heat budget analysis - useful tool for:**

  - **Scientific questions - ocean heat uptake and redistribution processes**

    - **ocean variability on different time scales**

    - **climate change scenarios**

  - **Model development - help to test features and reduce model drift**

- **Next steps:**

  - **complement analysis using thermohaline coordinates (water mass framework)**

  - **Idealised experiments like FAFMIP - climate change scenarios on OGCMs**