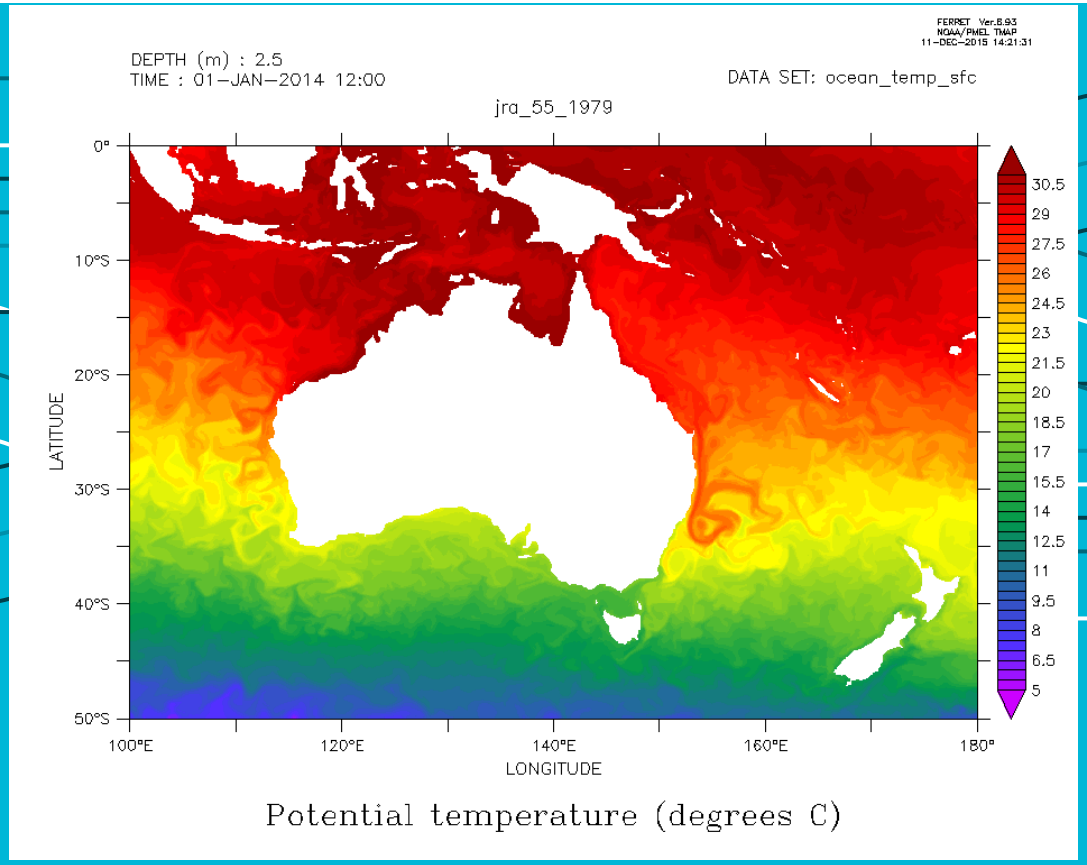
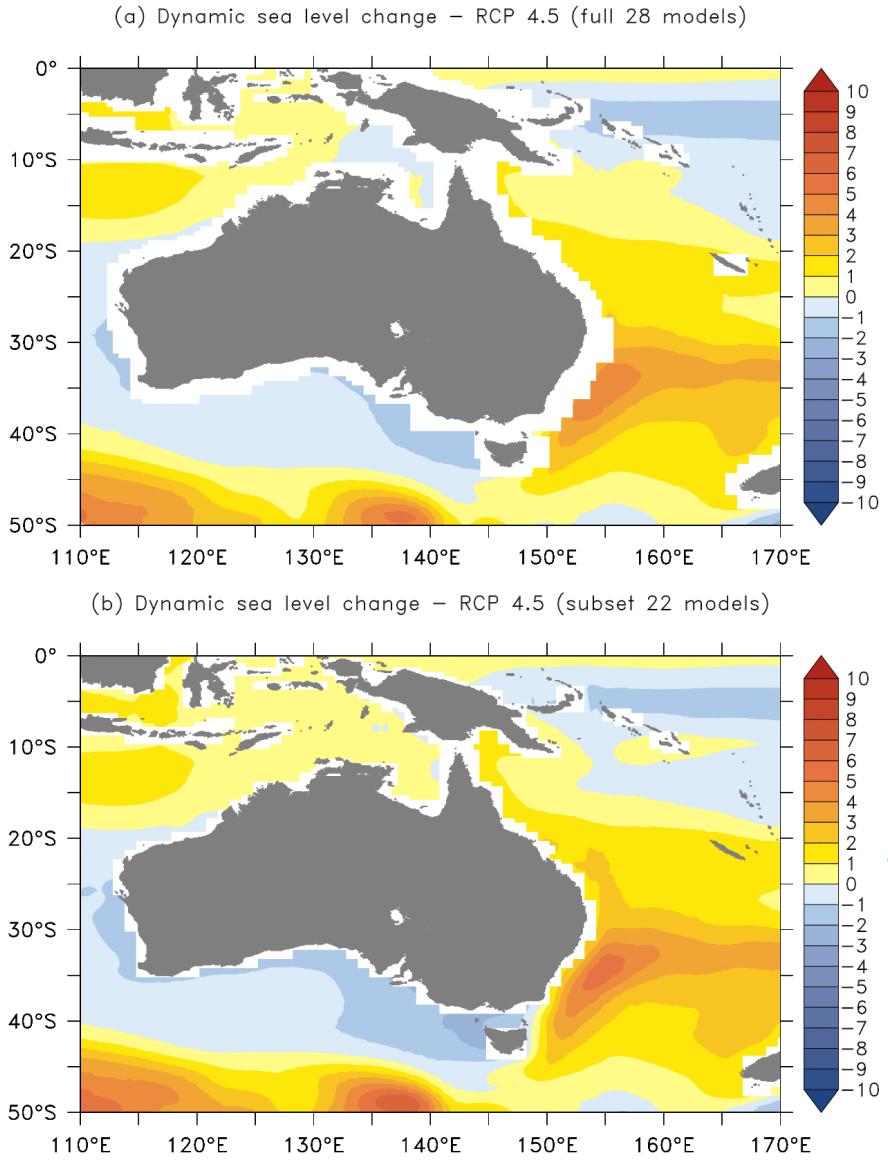


Dynamical downscaling of climate changes with a 1/10° OGCM

OCEANS AND ATMOSPHERE
www.csiro.au

Xuebin Zhang, *Peter Oke, Ming Feng, John Church, Richard Matear, Andreas Schiller, Chaojiao Sun, Matt Chamberlain, Russ Fiedler, Didier Monselesan and Clothilde Langlais*

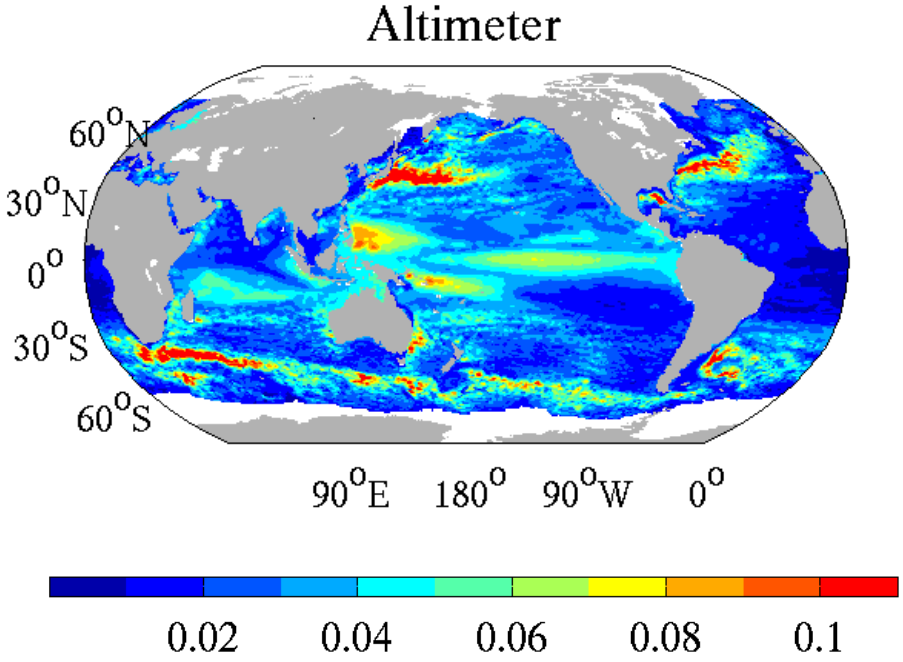
Example - dynamic sea level change (cm) from CMIP5 models under RCP4.5



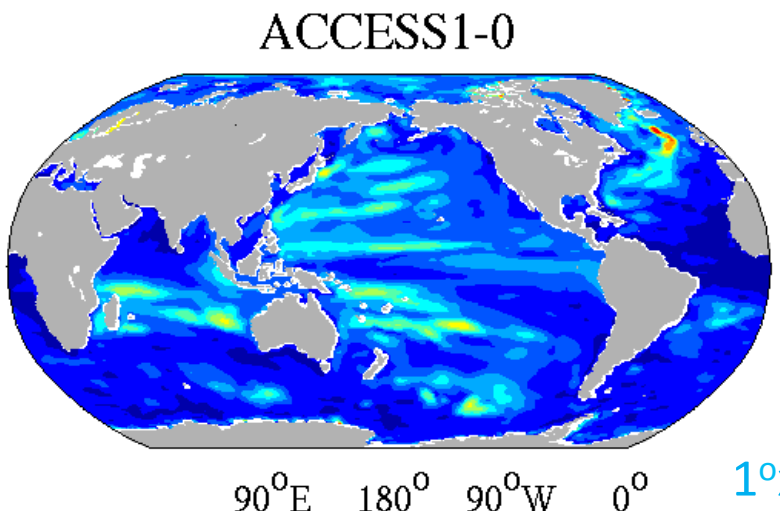
Full set (28 models)

Subset (with finer resolution)

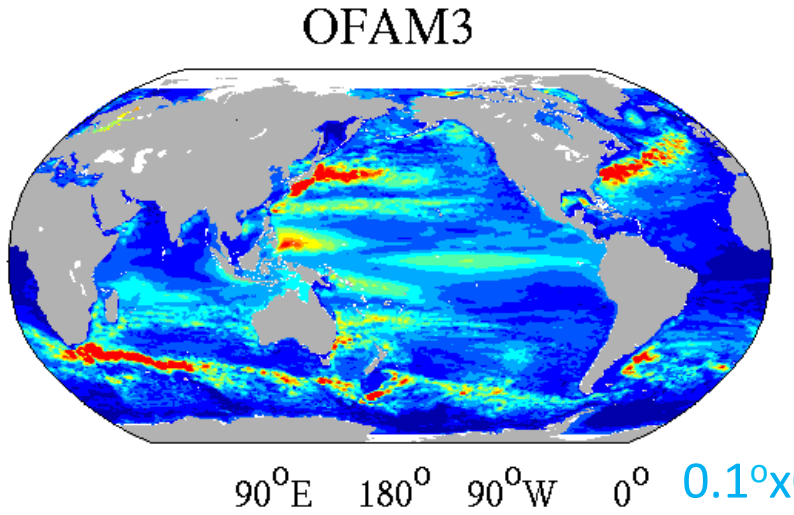
Standard deviation of annual sea level (m)



(AVISO 0.25°x0.25°)



1°x1°



0.1°x0.1°

Ocean downscaling strategic project

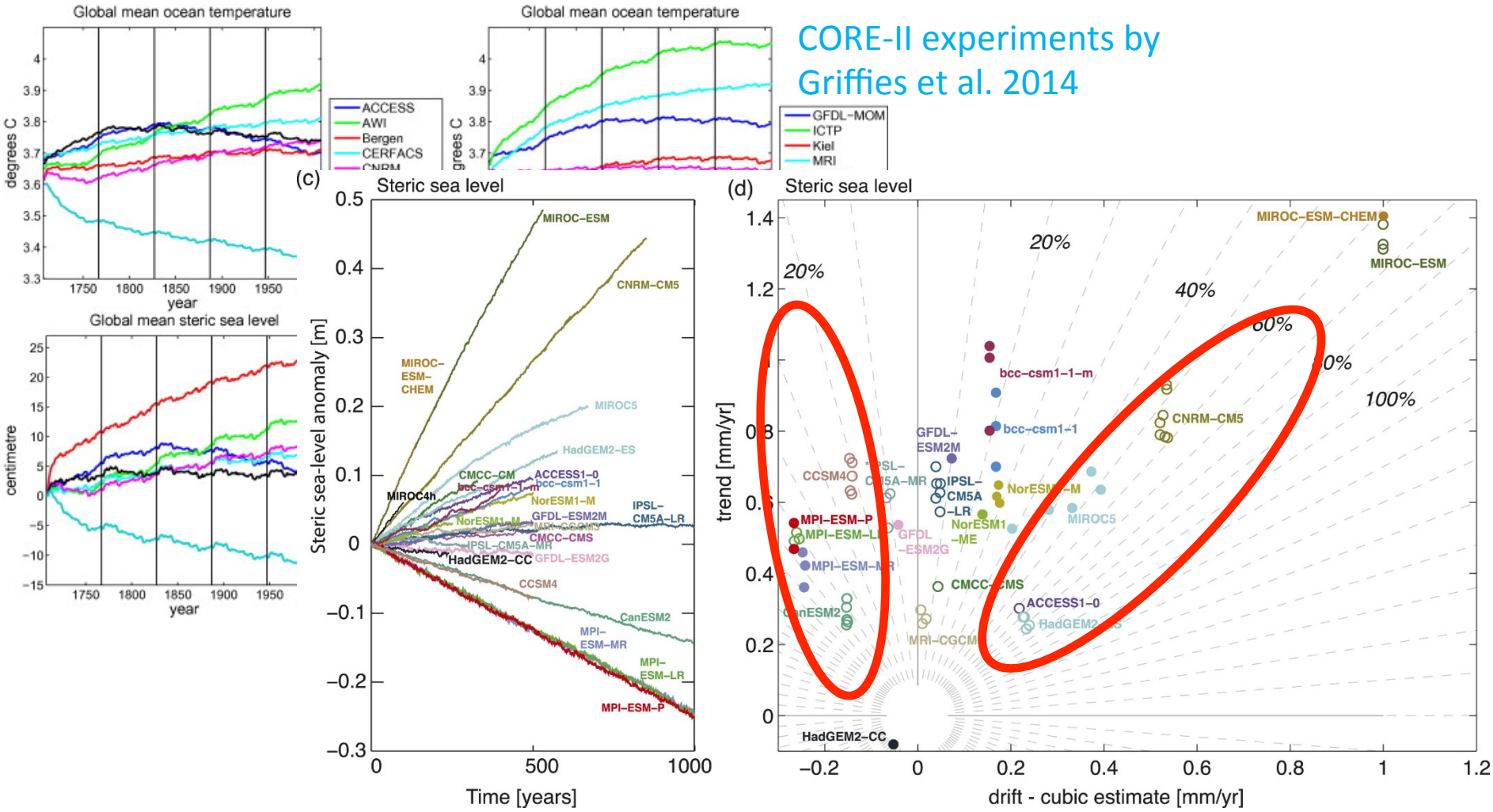
- ***Mission**: Provide high-resolution climate change and variability information in the ocean over the past several decades and in the future, for better understanding, adaptation and mitigation purpose.*

- ***Methodology - Dynamical downscaling:***

  How does the OGCM respond to climate change "perturbation" derived from CMIP climate models

  - Derive current ocean climate: integrate a near-global 1/10^{o} OGCM (OFAM3) with atmospheric reanalysis products $\mathbf{F_{current}}$
  - Estimate climate change signals from CMIP5 climate models: $\mathbf{\Delta F_{CMIP5}}$
  - Derive future ocean climate: integrate OFAM3 with merged future forcing $\mathbf{F_{future} = F_{current} + \Delta F_{CMIP5}}$.
  - Derive ocean state changes in future period relative to current ocean state, which are regarded as the "downscaled" ocean changes.

Model Drift



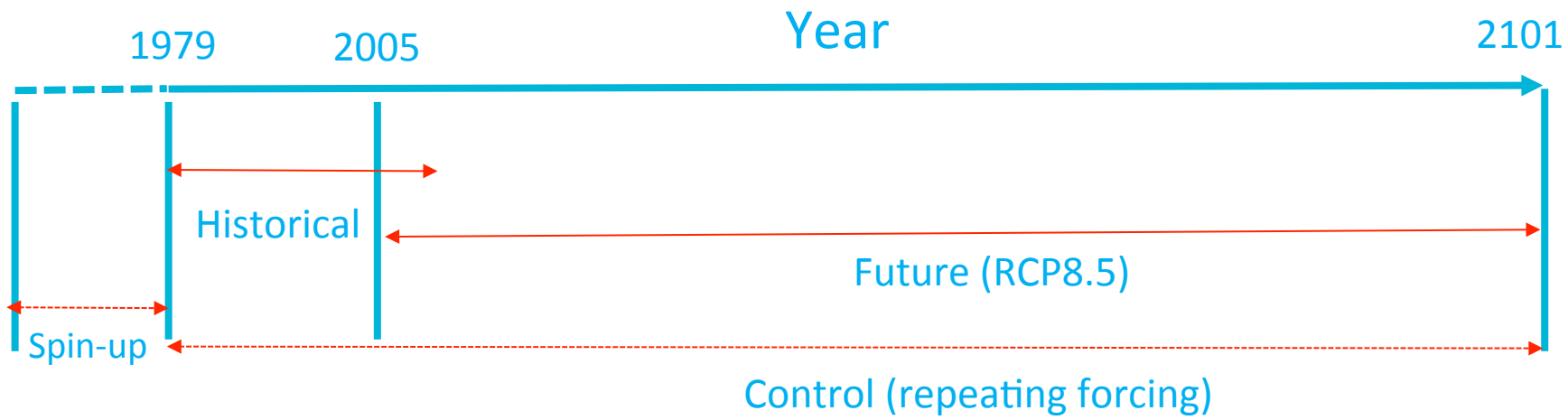
CORE-II experiments by Griffies et al. 2014

CMIP5 models by Sen Gupta et al. 2013

Near-global 1/10^{o} Ocean Model – OFAM3 (Oke et al. 2013; Zhang et al. 2016)

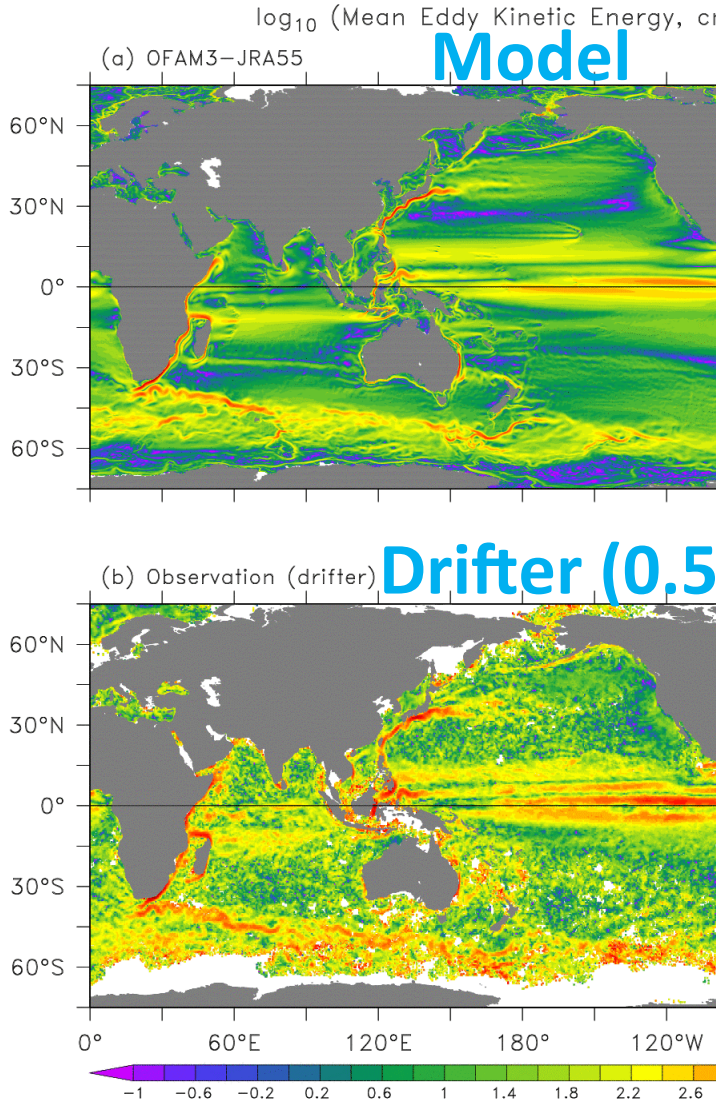
- based on GFDL MOM4p1
- Near-global domain (w/o Arctic, sea-ice), 75^{o}S – 75^{o}N, 0.1^{o}x0.1^{o}
- 51 vertical layers, 5 m resolution down to 40 m, then 10 m resolution down to 200 m.
- Bulk formula forcing with JRA-55 Reanalysis
- Restoring of T/S in the deep-ocean below 2000 m (adaptive during spin-up, non-adaptive during historical experiment)
- Adjust surface heat flux (time- and space- constant correction to the downward longwave radiation)

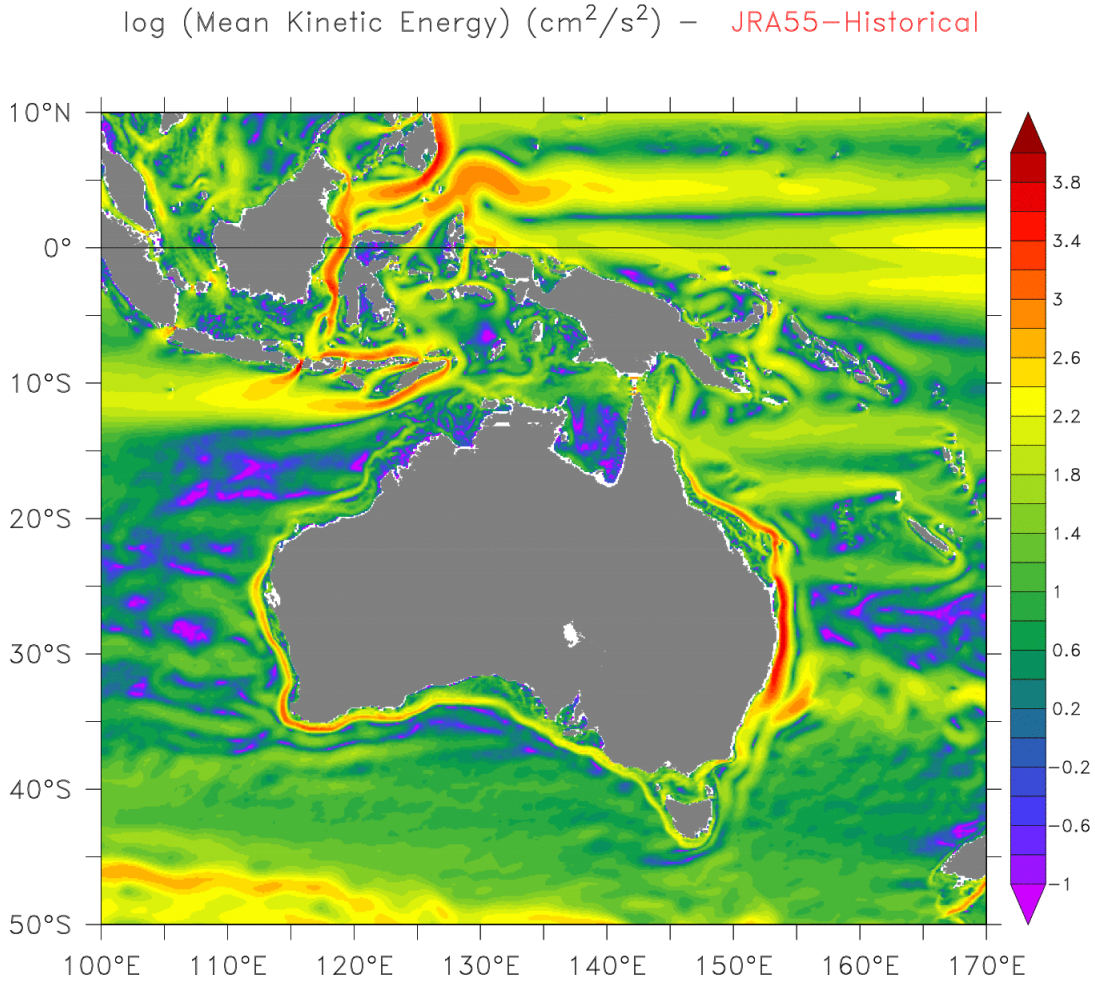
Model experiments



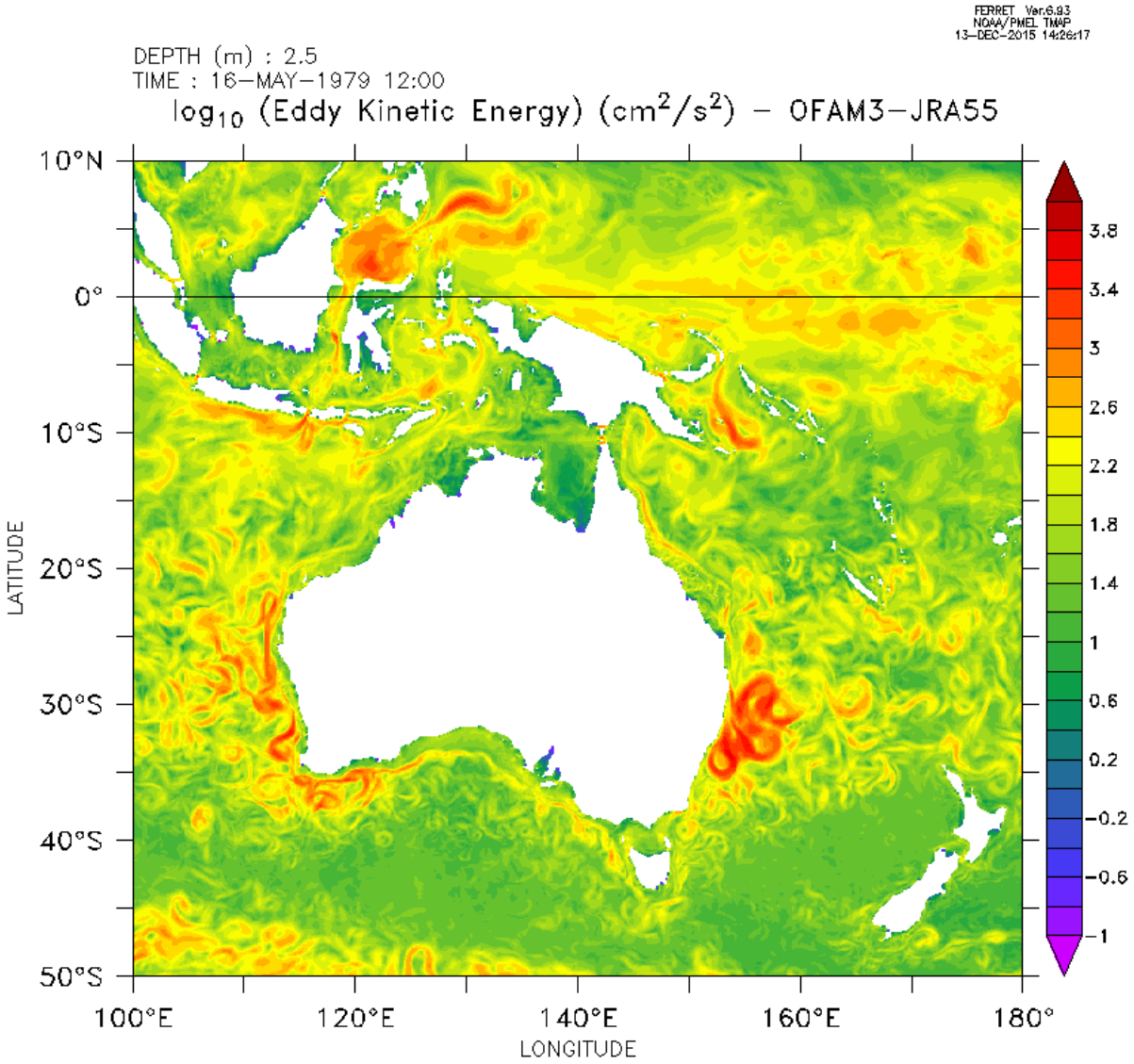
Total years of model simulation: ~270 Years!

Mean surface Kinetic Energy (cm^2/s^2) - OFAM3-JRA55

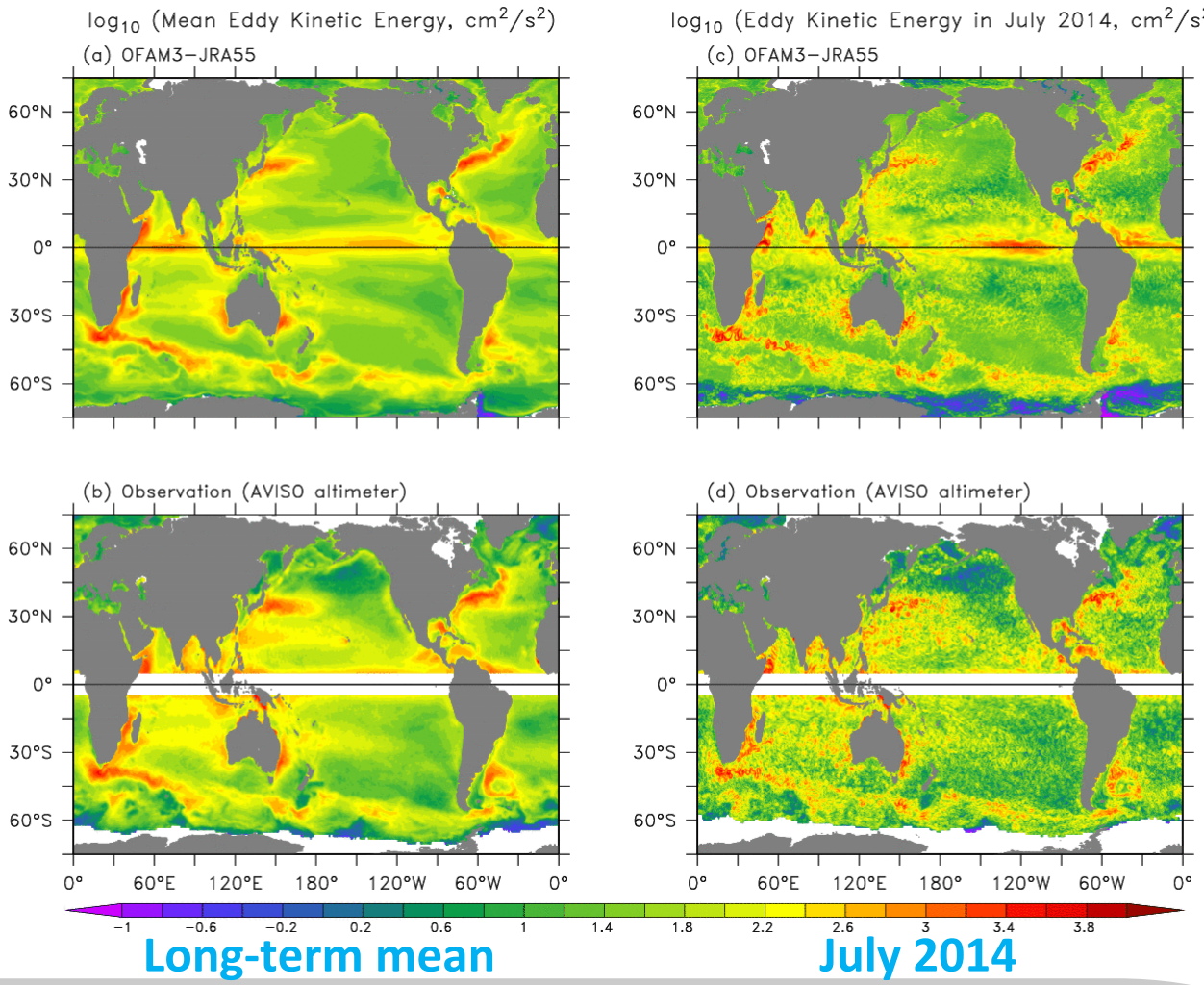




Surface eddy Kinetic Energy (cm^2/s^2) monthly-averaged



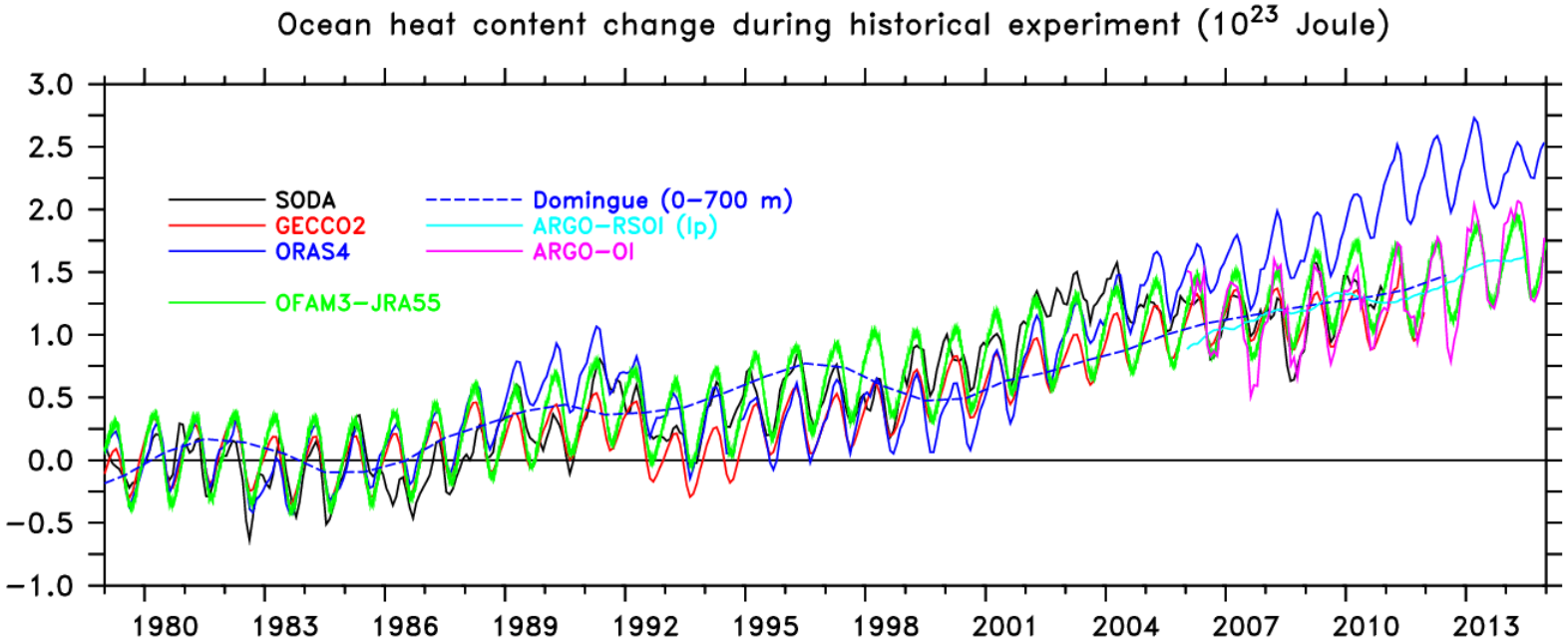
Long-term mean (left) and monthly (right, in July 2014) Eddy Kinetic Energy (EKE)



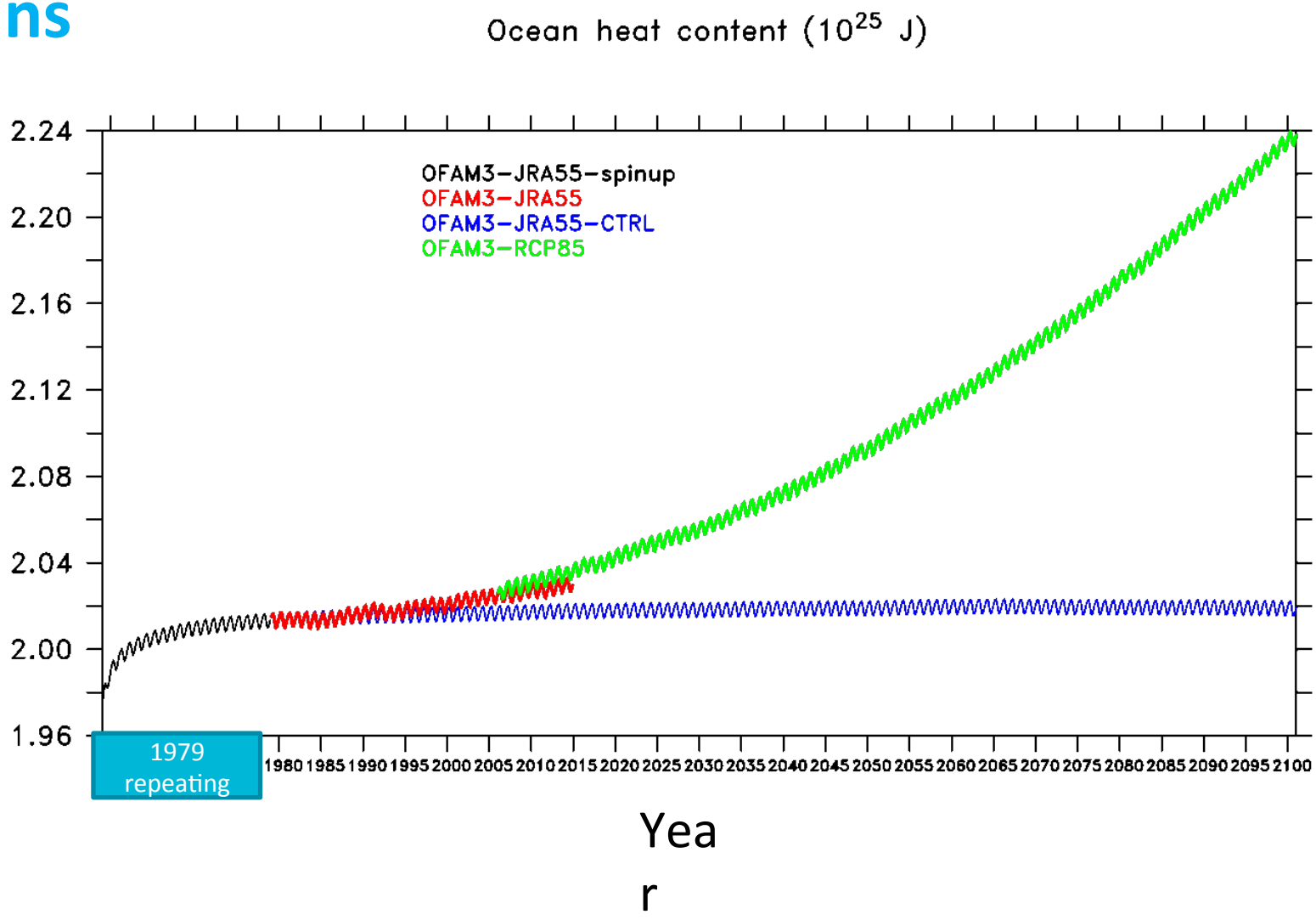
Model

Altimeter

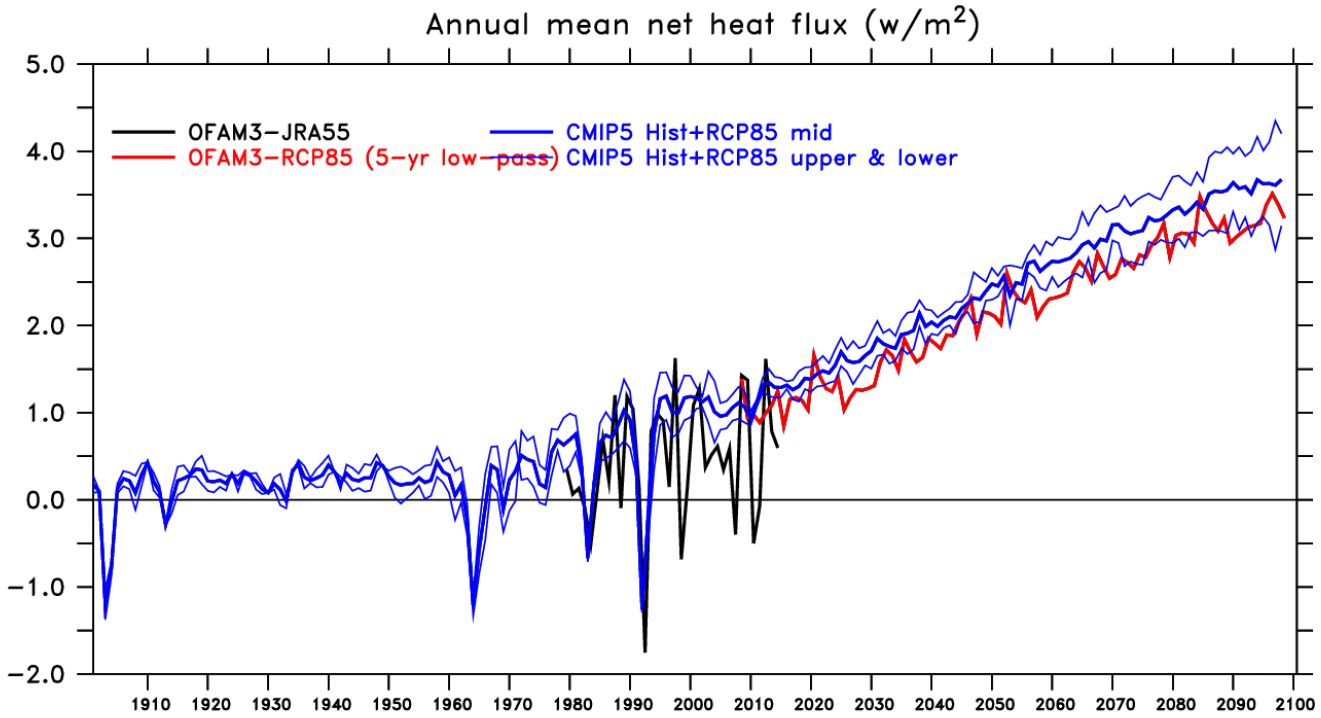
Global ocean heat content from OFAM3-JRA55 historical run and three ocean reanalysis products, two Argo products, and one historical reconstruction (Domingues et al. v3.1)



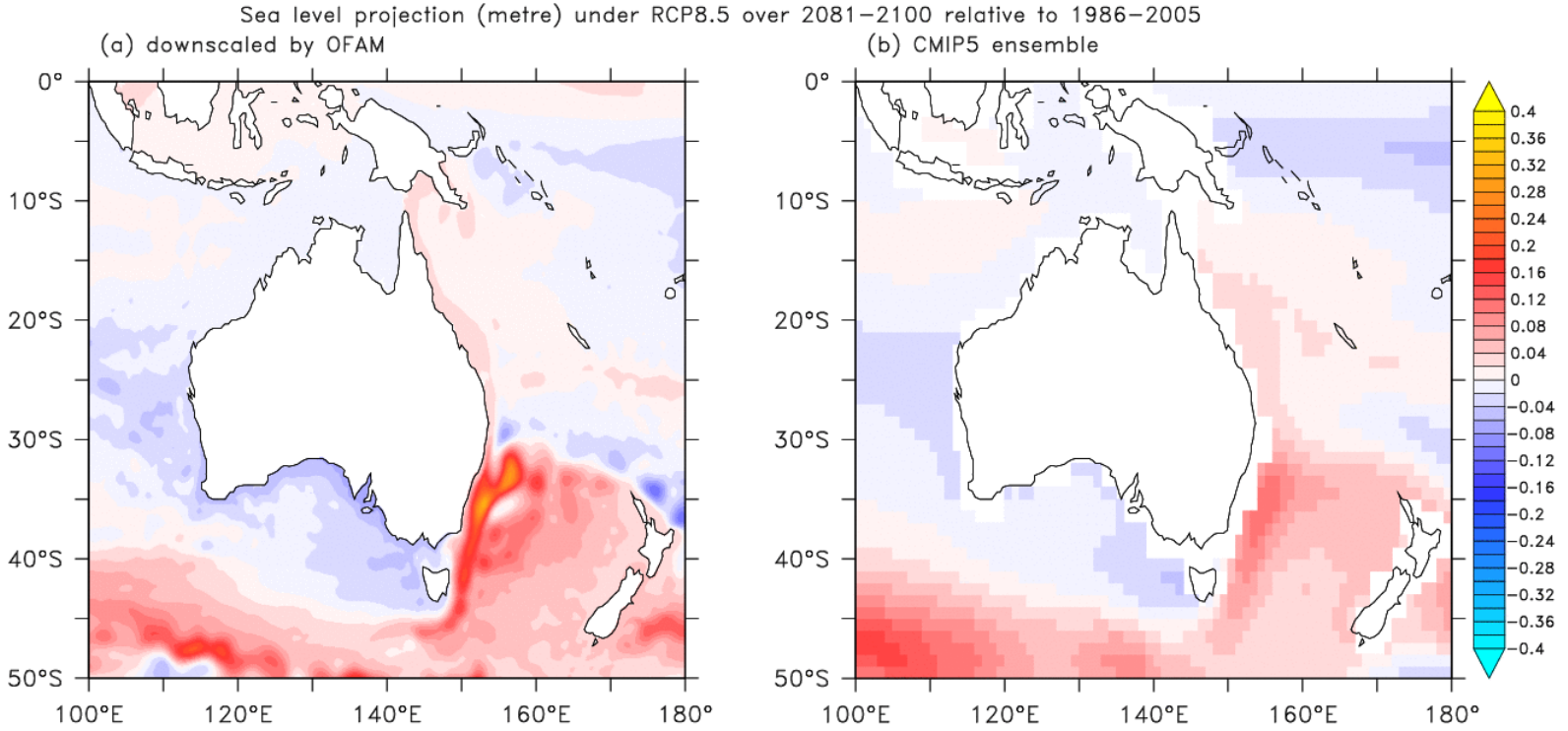
OHC from spin-up, historical, future and control runs



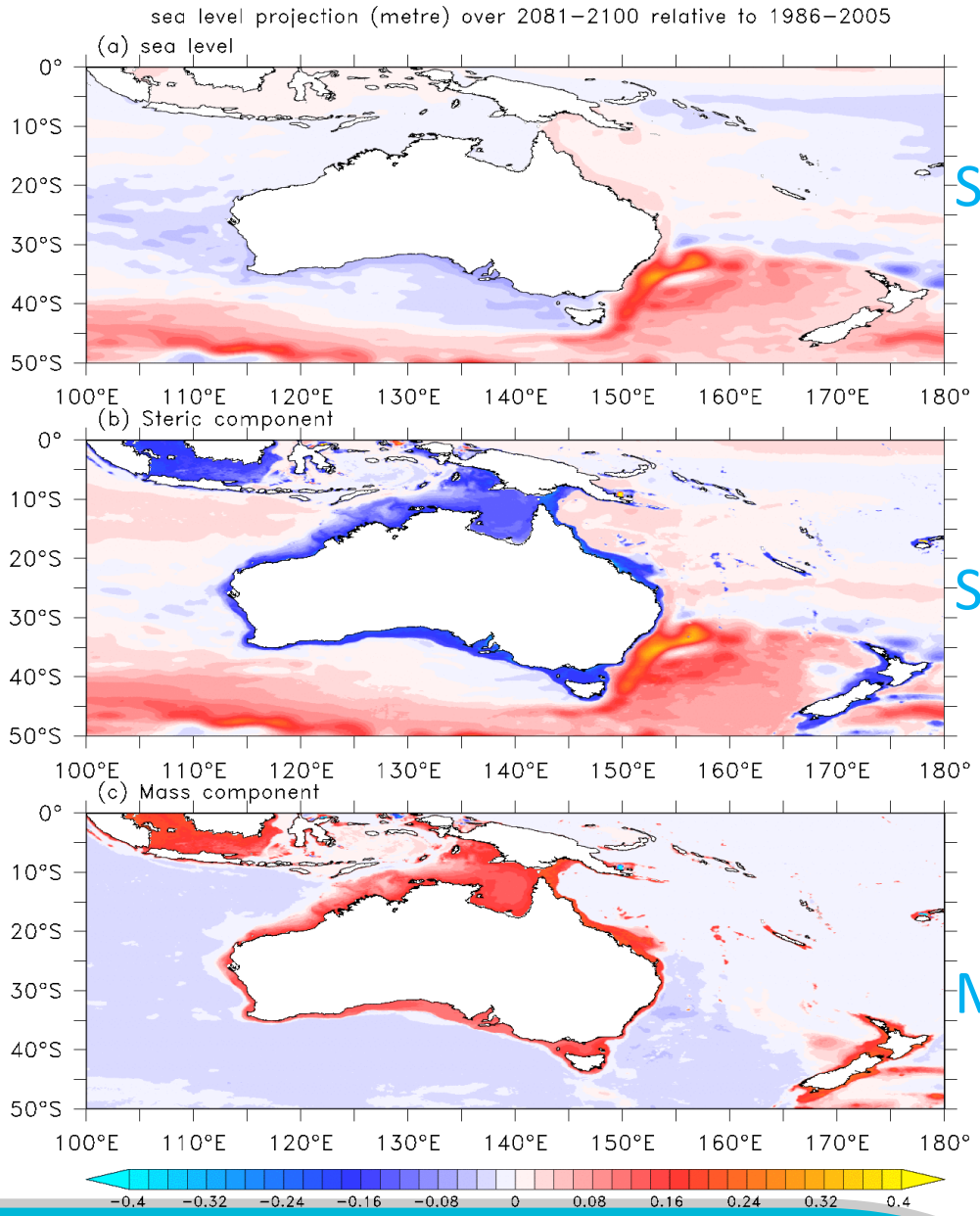
Annual mean surface heat flux from model in comparison with CMIP5 RCP8.5 runs



Sea level projections over 2081-2100 relative to 1986-2005: Downscaled vs. CMIP5



Sea level projection over 2081-2100 relative to 1986-2005



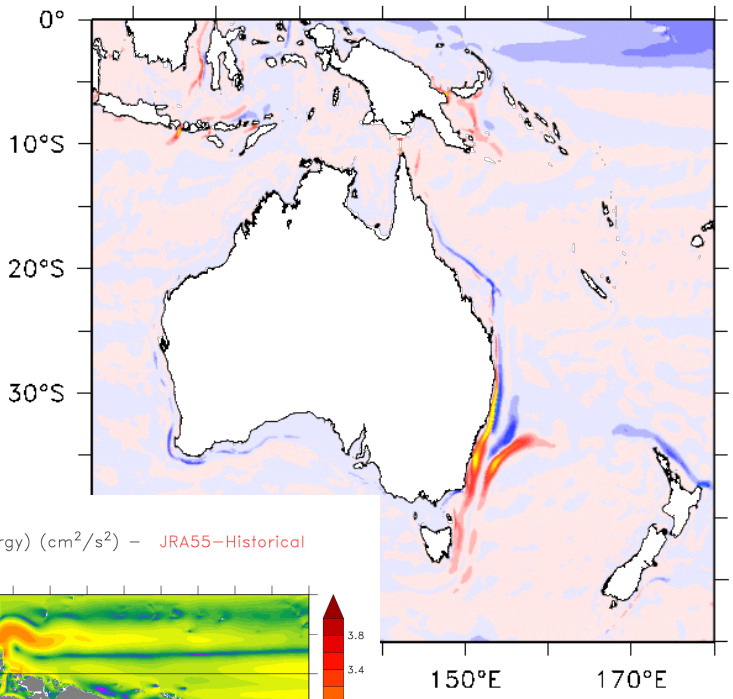
Sea level

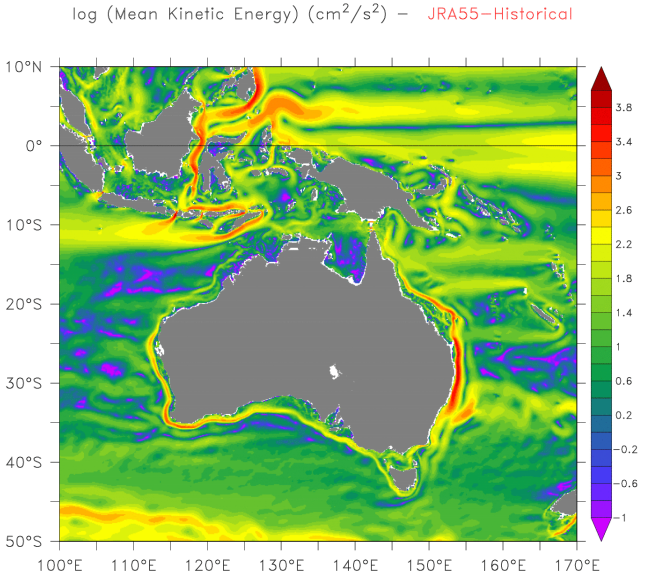
Steric

Mass

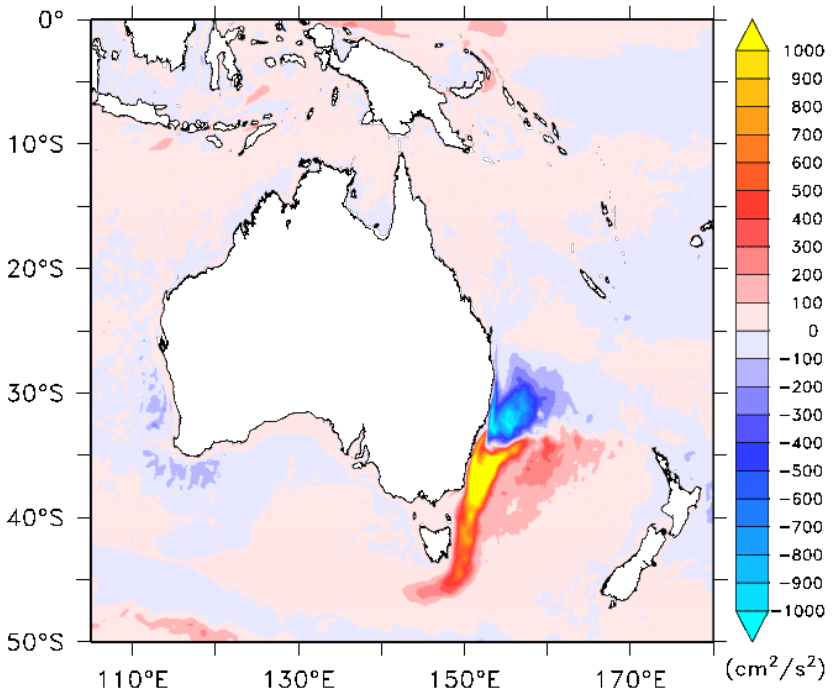
Projected change of MKE/EKE in the surface layer

Mean Kinetic Energy





20-yr average EKE



Thank you

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Model experiments

Experiments	Period	Initial condition (IC)	Forcing	T/S relaxation	Purposes
Spin-up	1979 (repeating for 20 years)	Cold start	Year 1979 forcing from JRA-55	Adaptive	Spin up the model and provide IC for other runs; derive T/S relaxation climatology
Historical	1979-2014 36 years	End of spin-up	JRA-55	Non-adaptive	Current-day ocean climate; IC for future run; validate model design with observations
Future	2006-2101 96 years	End of 2005 from historical run	Merged JRA-55 and CMIP5-RCP8.5	Non-adaptive	Future ocean climate
Control	1979-2101 123 years	End of spin-up	Year 1979 forcing from JRA-55	Non-adaptive	Quantify drifts in historical and future runs

Forcing decomposition

Current-day climate

$$F_C = F_{mean} + \begin{cases} F_{seasonal} \\ F_{non\text{-}seasonal} \end{cases}$$

$F_{non\text{-}seasonal}$ → $\begin{cases} F^{HF}_{non\text{-}seasonal} \text{ (weather, intraseasonal ... interannual)} \\ F^{LF}_{non\text{-}seasonal} \text{ (decadal ...)} \end{cases}$

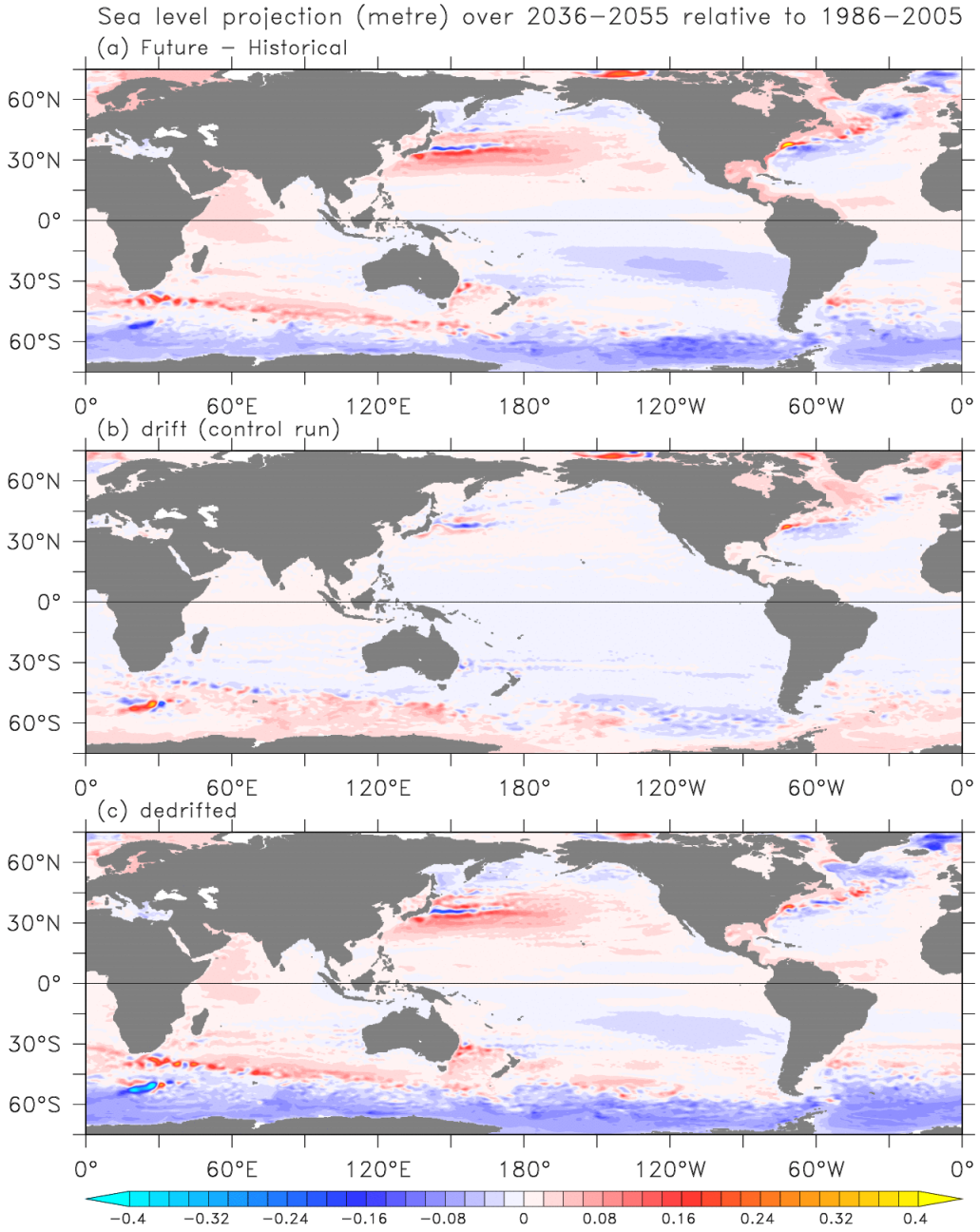
climate change signal

$$\Delta F = \Delta F_{mean} + \Delta F_{seasonal}\,? + \Delta F^{LF}_{non\text{-}seasonal}\,? + \Delta F^{HF}_{non\text{-}seasonal}\,?$$

Future climate

$$F_F \approx F_C + \Delta F$$

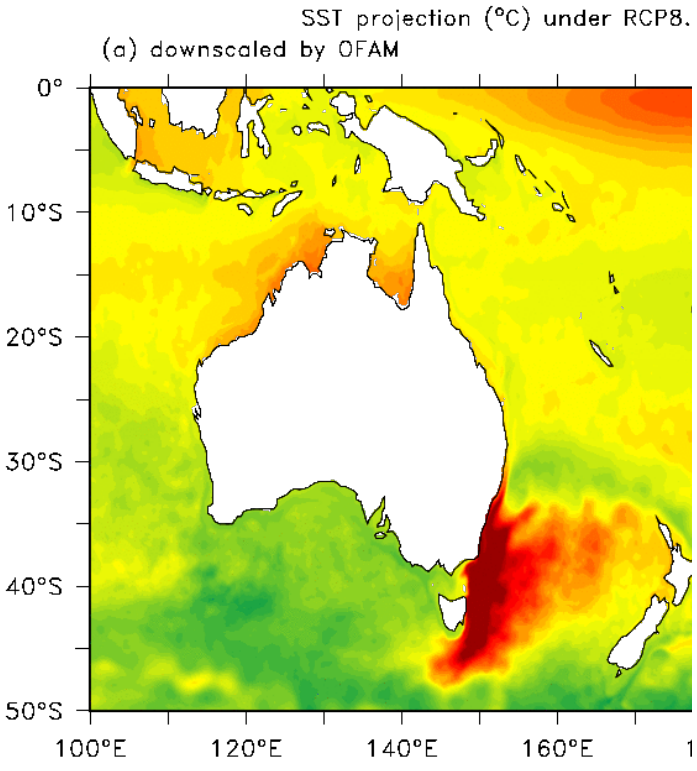
“Dedrited” sea level projections

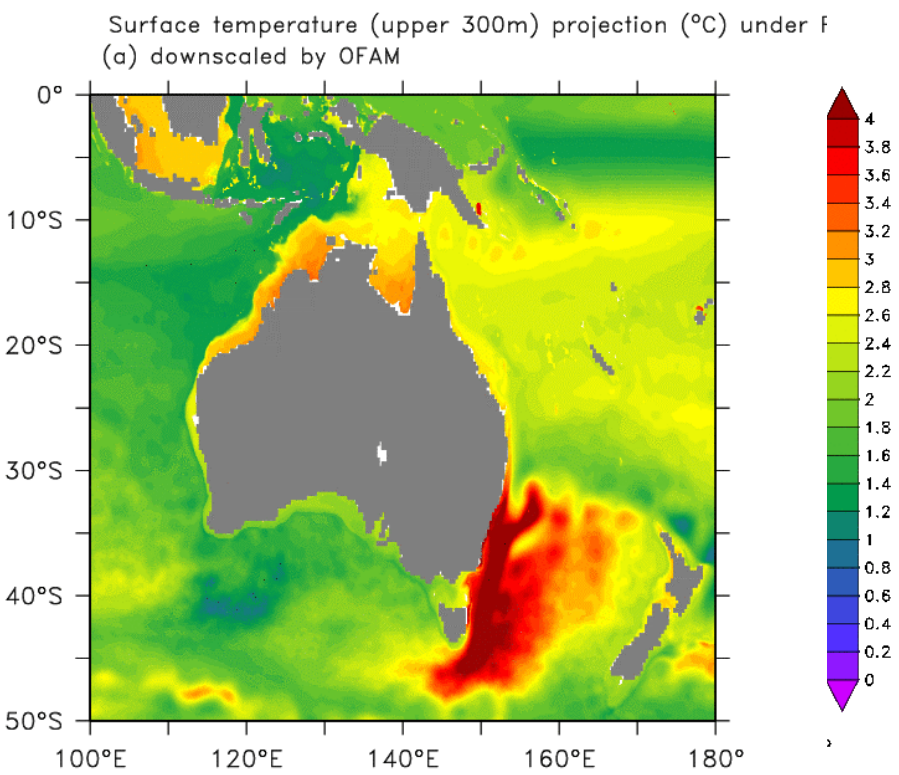


Drift

SST projection over 2081-2100 relative to 1986-2005: Downscaled vs CMIP5

0-300 m average

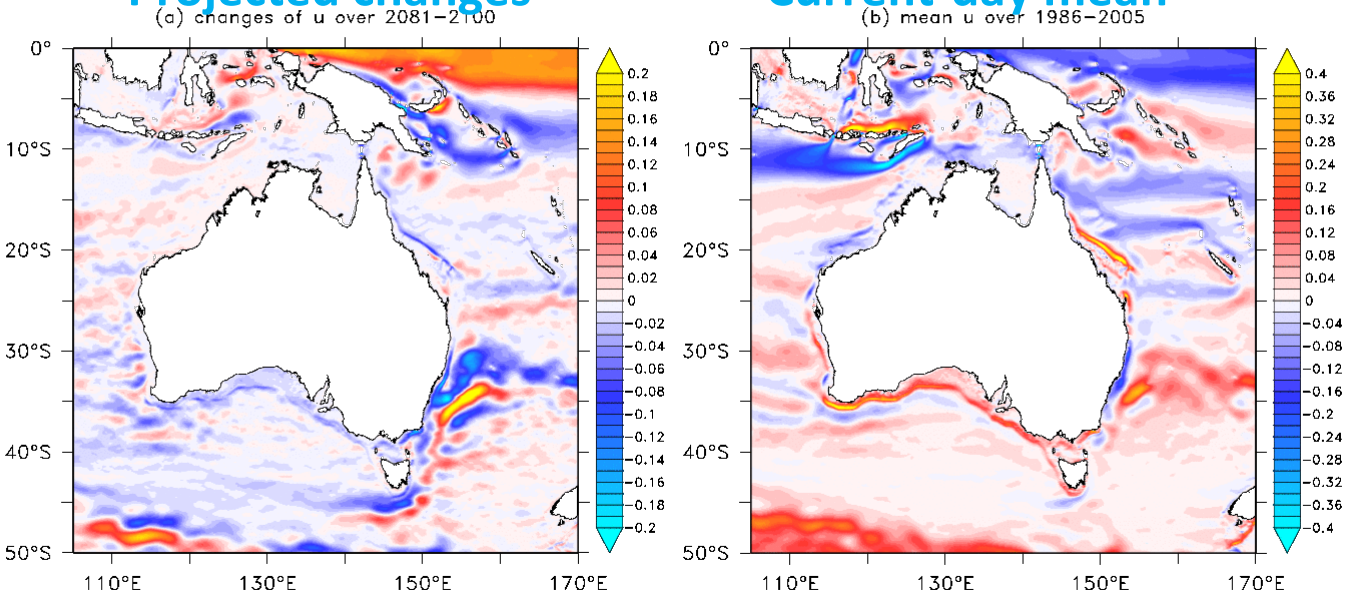




Projected changes

Current-day mean

u (0-50m)



V (0-50m)