CLIVAR Ocean Model Development Panel (OMDP)

- Why include an OMIP (along with AMIP and LMIP) in CMIP DECK?
- Remarks for ocean model resolutions
- Importance of TOA heat flux tuning; ocean initialization; and specified minimum integration length for the pre-industrial control simulations

Sampling the Physical Ocean in CMIP6 Simulations

CLIVAR Ocean Model Development Panel (OMDP)
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Abstract

We present recommendations for sampling physical ocean fields for the World Climate Research Program (WCRP) Coupled Model Intercomparison Project #6 (CMIP6) and its suite of satellite MIPs, including the CLIVAR Coordinated Ocean-ice Reference Experiments (CORE). Our aim is to precisely define a suite of ocean model diagnostics related to physical properties and processes within the simulated ocean and associated ocean boundary fluxes. The audience for this document includes the WCRP Working Group for Coupled Modeling (WGCM), CLIVAR Scientific Steering Group (SSG), CLIVAR Ocean Model Development Panel (OMDP), scientists contributing model results to CMIP, and scientists analyzing ocean climate simulations.

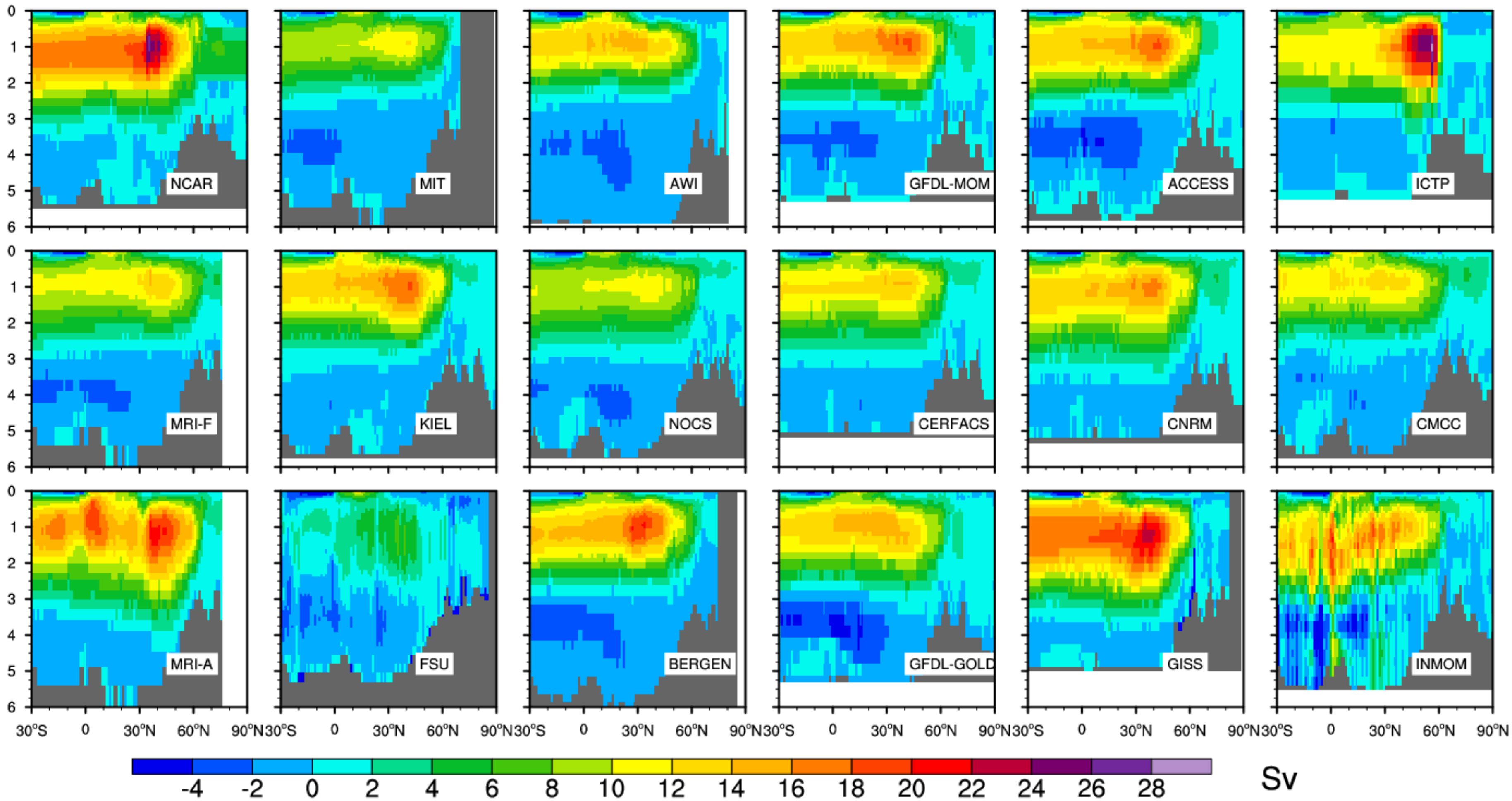
CORE-II for OMIP

An experimental protocol for ocean – ice coupled simulations forced with inter-annually varying atmospheric data sets for the 1948-2007 period (Large and Yeager 2009). This effort is coordinated by the CLIVAR Ocean Model Development Panel (OMDP)

These hindcast simulations provide a framework for

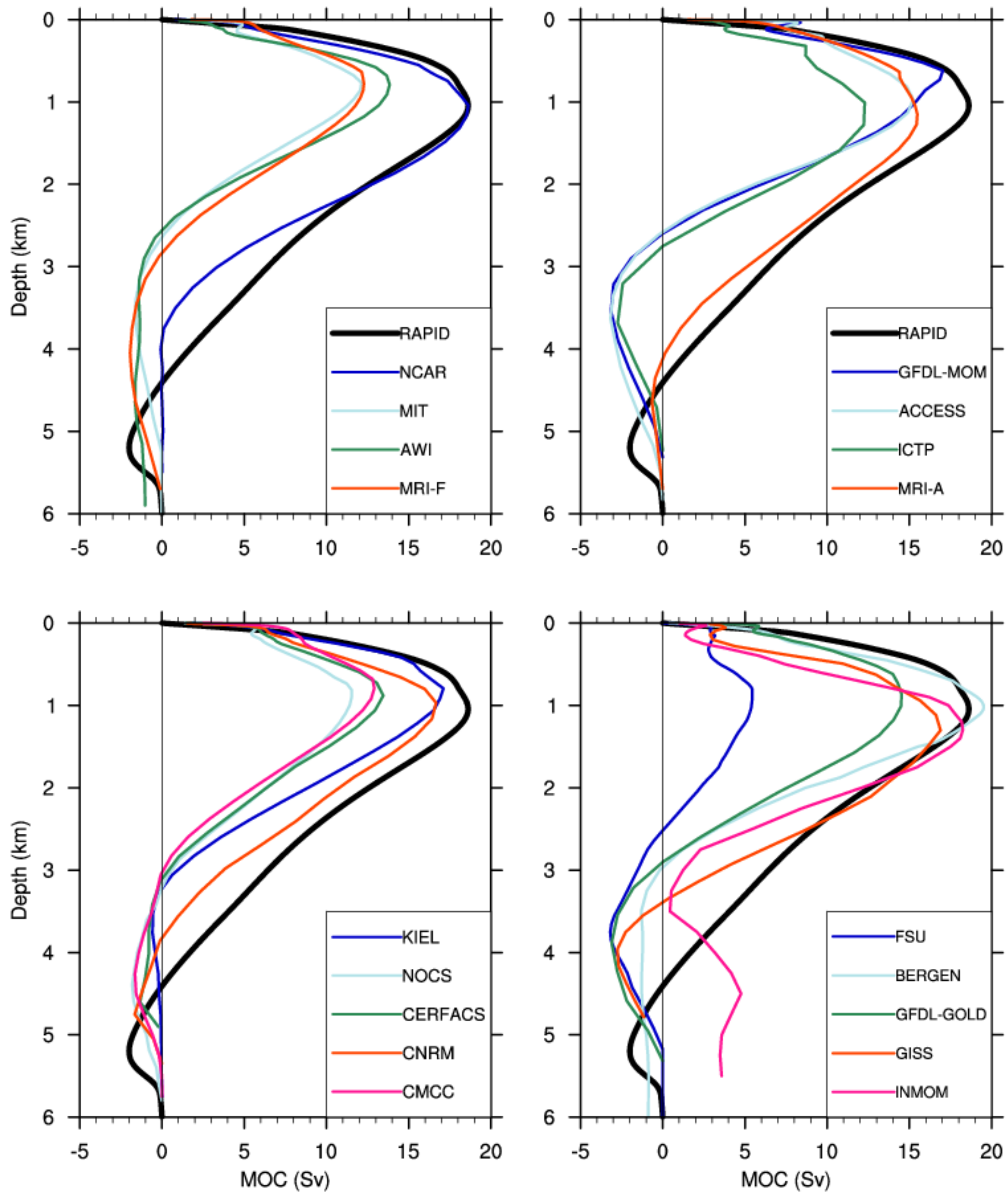
- evaluation, understanding, and improvement of ocean models,
- investigation of mechanisms for seasonal, inter-annual, and decadal variability,
- evaluation of robustness of mechanisms across models,
- complementing data assimilation in bridging observations and modeling and in providing ocean initial conditions for climate (decadal) prediction simulations.

AMOC in depth space (1988-2007)



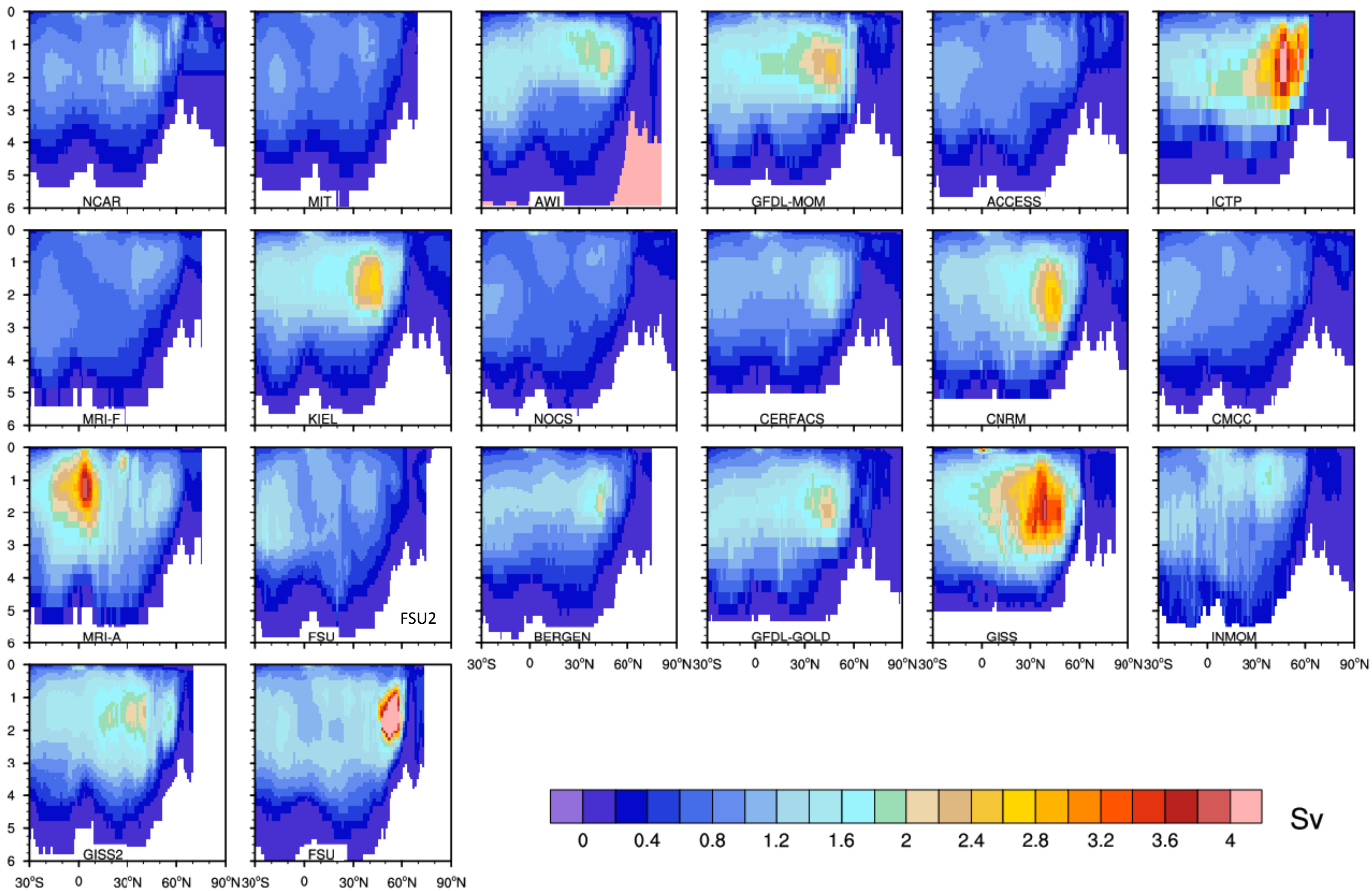
Danabasoglu et al. 2014, *Ocean Modelling*, **73**, 76-107, 10.1016/j.ocemod.2013.10.005

AMOC at 26.5°N (2004-2007)

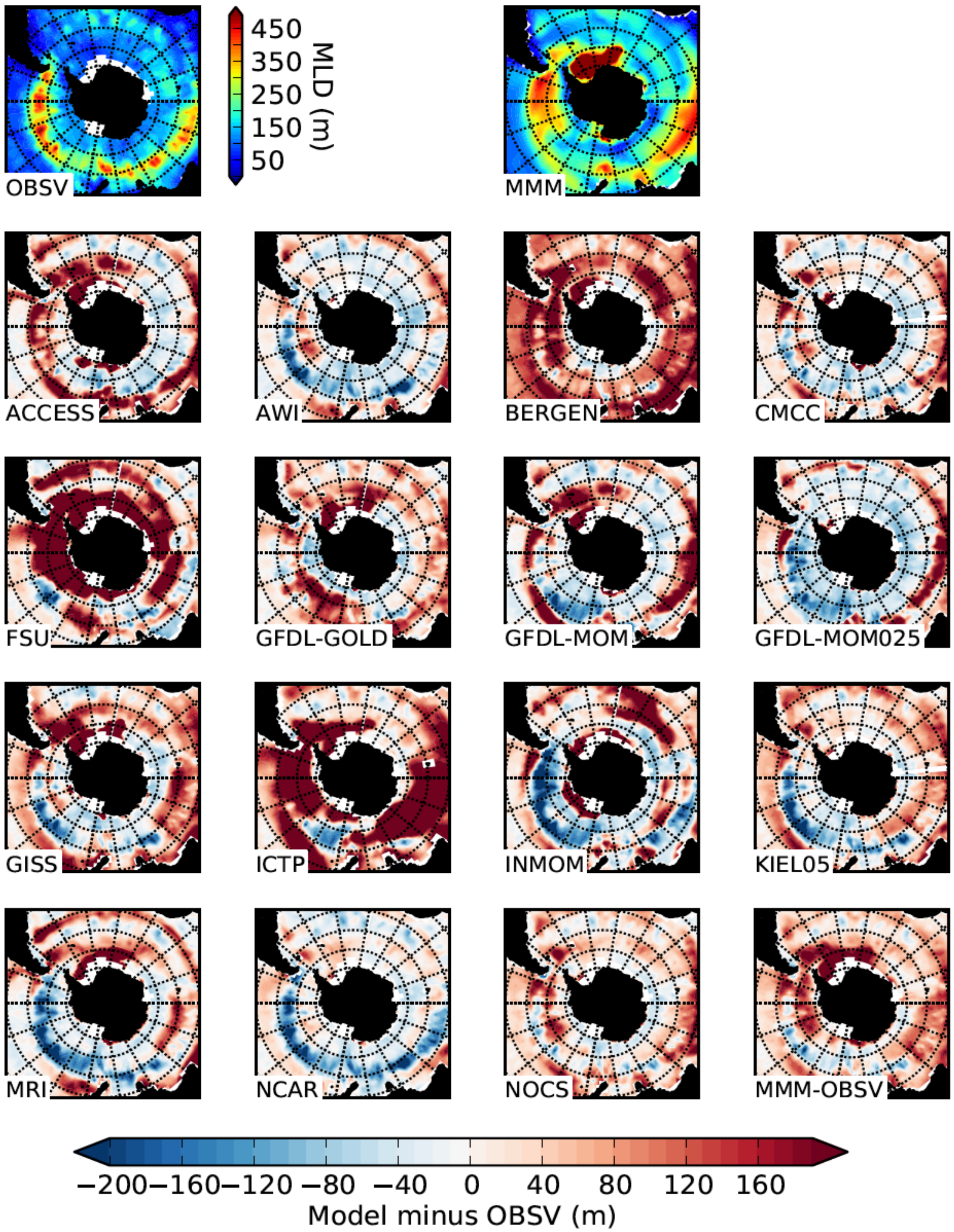


Danabasoglu et al. 2014, *Ocean Modelling*, **73**, 76-107, 10.1016/j.ocemod.2013.10.005

AMOC standard deviation (1958-2007)



Danabasoglu et al. 2014b (in preparation)



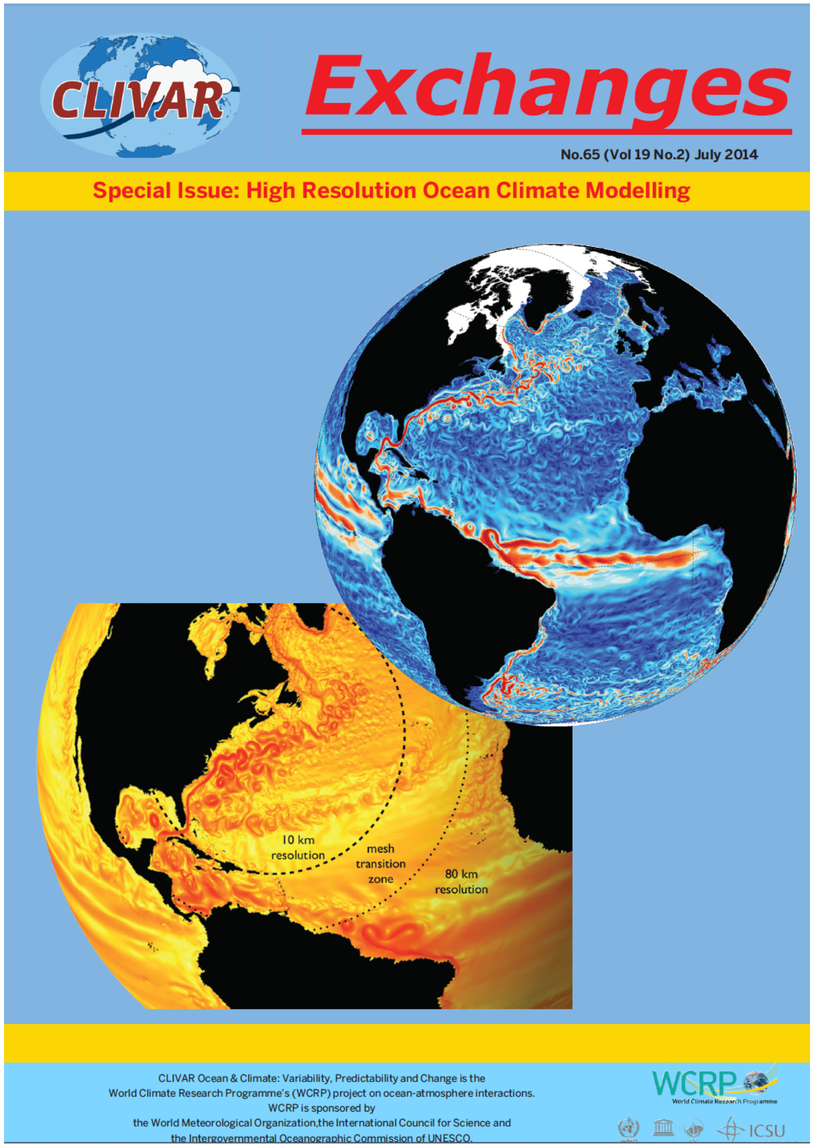
Mixed layer depth: September-mean for 1988-2007

(based on 0.03 kg m^{-3} density change from surface)

deBM: de Boyer Montegut et al. (2004)
MMM: Multi-model mean

Downes et al. 2014 (submitted)

Remarks for ocean model resolutions:



WCRP Grand Challenges and CLIVAR priority topics:

Dynamics of regional sea level variability and upwelling; decadal variability and prediction; climate information at regional scales

1° and coarser: non-eddy-resolving

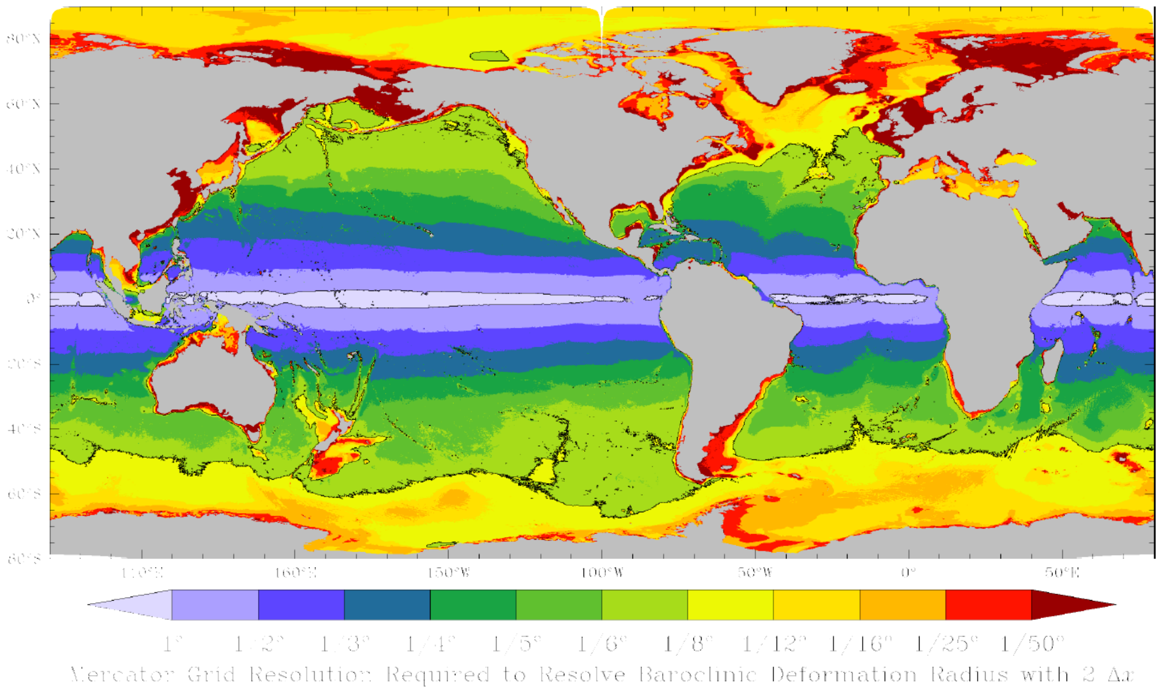
0.1° and finer: eddy-permitting; eddy-resolving

0.1° - 1°: no man's or no woman's land, i.e., in between eddy permitting and non-eddy-resolving

20 groups present raised following challenges to progress in high res ocean modeling:

- Model spin up and initialization: with costly high resolution ocean models, this becomes a burning issue. Which techniques can make initialization shorter, less computationally expensive? How to initialize coupled climate forecasts with eddy permitting or resolving ocean components?
- Parameterizations: which subgrid-scale parameterizations are adequate? How should they be modified depending on ocean model resolution? What is the appropriate choice of parameterizations and numerical schemes?
- Forcing the ocean/coupling to the atmosphere: what are the appropriate methods, e.g., for calculations of wind stress and freshwater fluxes? What are the best datasets?
- Technical issues: how much data from the high resolution simulations needs to be stored for model analysis? Is regridding or coarsening stored data a way forward? Where do we stand in terms of code scalability on massively parallel machines? How do we develop more efficient analysis tools?
- Strategies regarding resolution and regionalisation: how to choose the resolution in the ocean and in the atmosphere for coupled simulations? Do we need to increase resolution globally or rather use nesting techniques? How to ensure a better representation of local processes (e.g., marginal seas, shelf seas)?
- Model validation and testing: how to tune parameters and test parameterizations when ocean models become computationally very expensive? Do we have adequate observational datasets to validate high resolution ocean models?

Rossby radius to gauge mesoscale representation



Hallberg (2013) *Ocean Modelling*

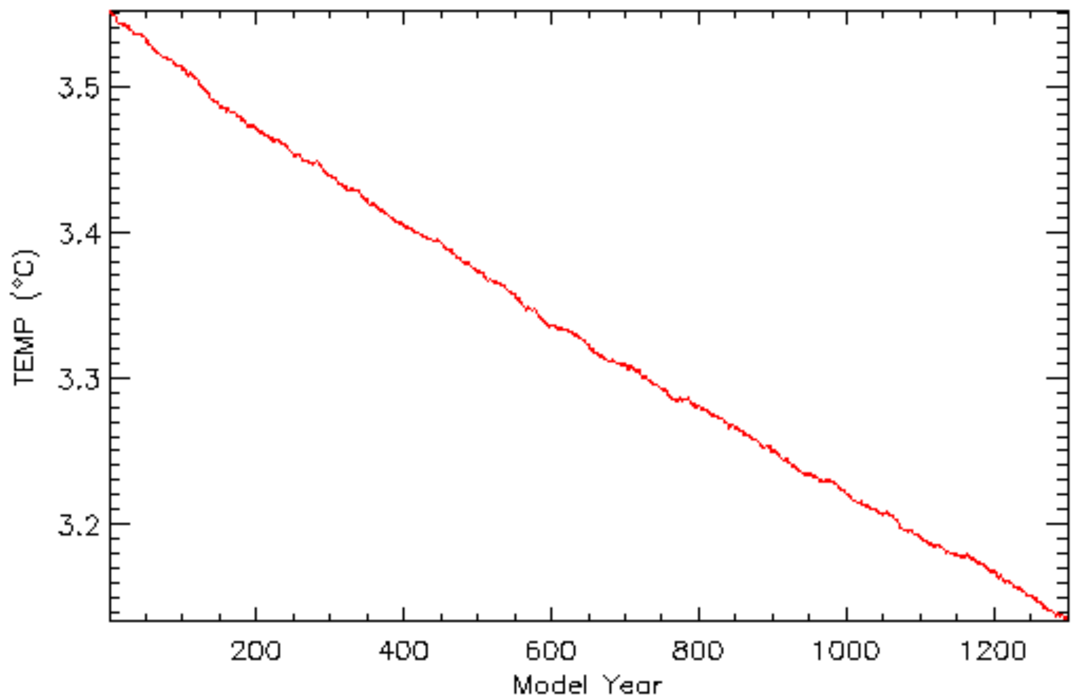
- $2\Delta \leq \lambda_1$ needed to resolve mesoscale eddies.
- Map indicates the necessary Mercator spacing for $2\Delta = \lambda_1$.
- Need even finer grid spacing to accurately represent eddy flux convergences.

Are simulations with eddies more scientifically useful?

- Utility implies trust, which requires experience, evaluation, and experimentation.
  - Relatively little experience w/ eddy-rich climate simulations.
  - Often too expensive to do routine hypothesis driven experiments.
  - Eddies $\Longrightarrow$ more kinetic energy. ☺
  - Eddies $\not\Longrightarrow$ better water masses, if model biases are large. ☹
- Do models admitting eddies need fewer parameterizations?
  - Yes in principle; in practice simulations are sensitive to SGS.
    - Is this because of inadequate numerics (e.g., transport)?
    - Is this because of inadequate parameterizations (e.g., dissipation)?
    - Is this because of inadequate representation of boundary interactions (e.g., boundary current separation)?
    - All of above?
  - We are far from DNS of global ocean climate!
- Need intelligent numerics and physics when admit eddies:
  - monotonic and high order tracer advection
  - robust vertical coordinates (Arbitrary Lagrangian-Eulerian)
  - thoughtful multi-scale SGS methods.

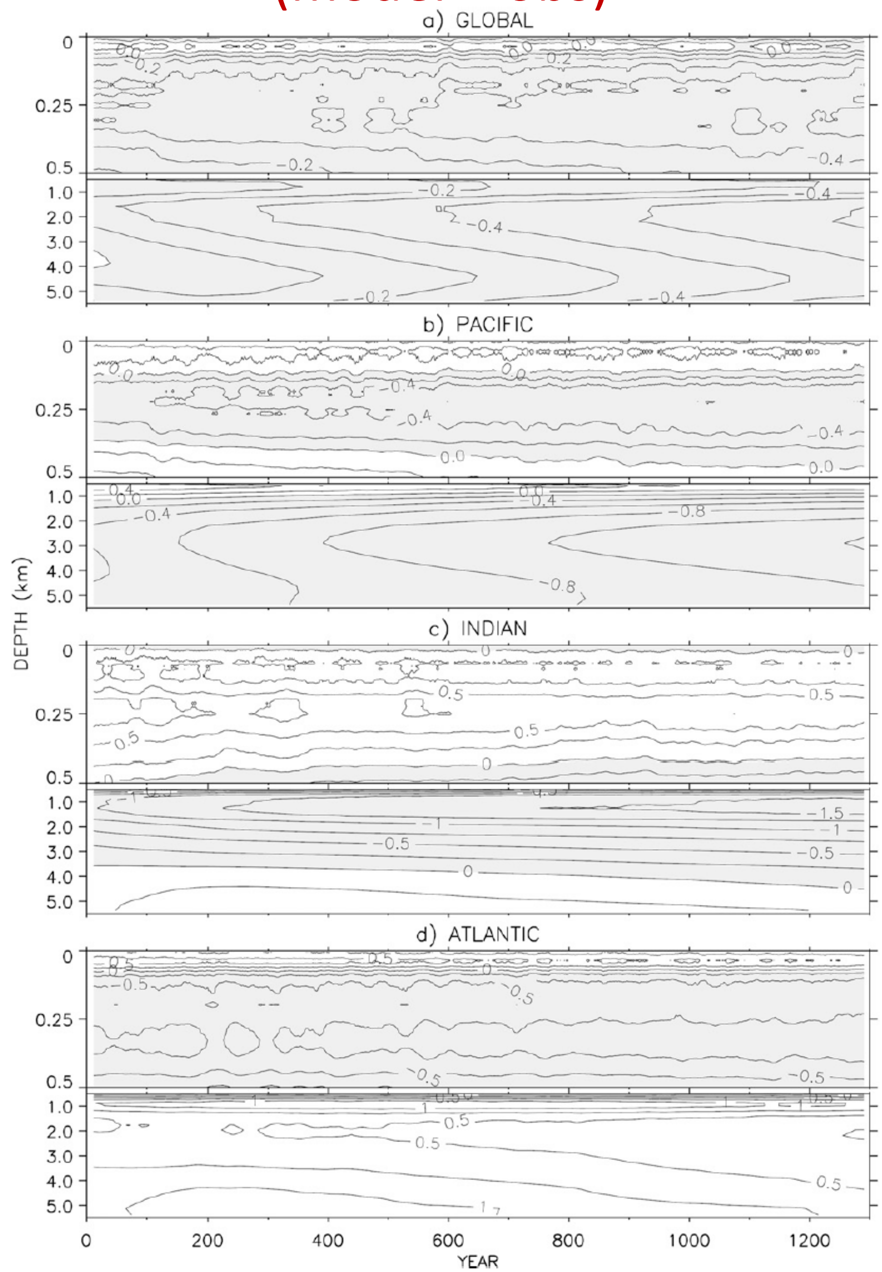
Importance of TOA heat flux tuning; ocean initialization; and specified minimum integration length for the pre-industrial control simulations

Ocean global-mean potential temperature time series from the CESM pre-industrial control simulation



TOA heat flux = -0.15 W m^{-2};
ocean surface heat flux = -0.1 W m^{-2}

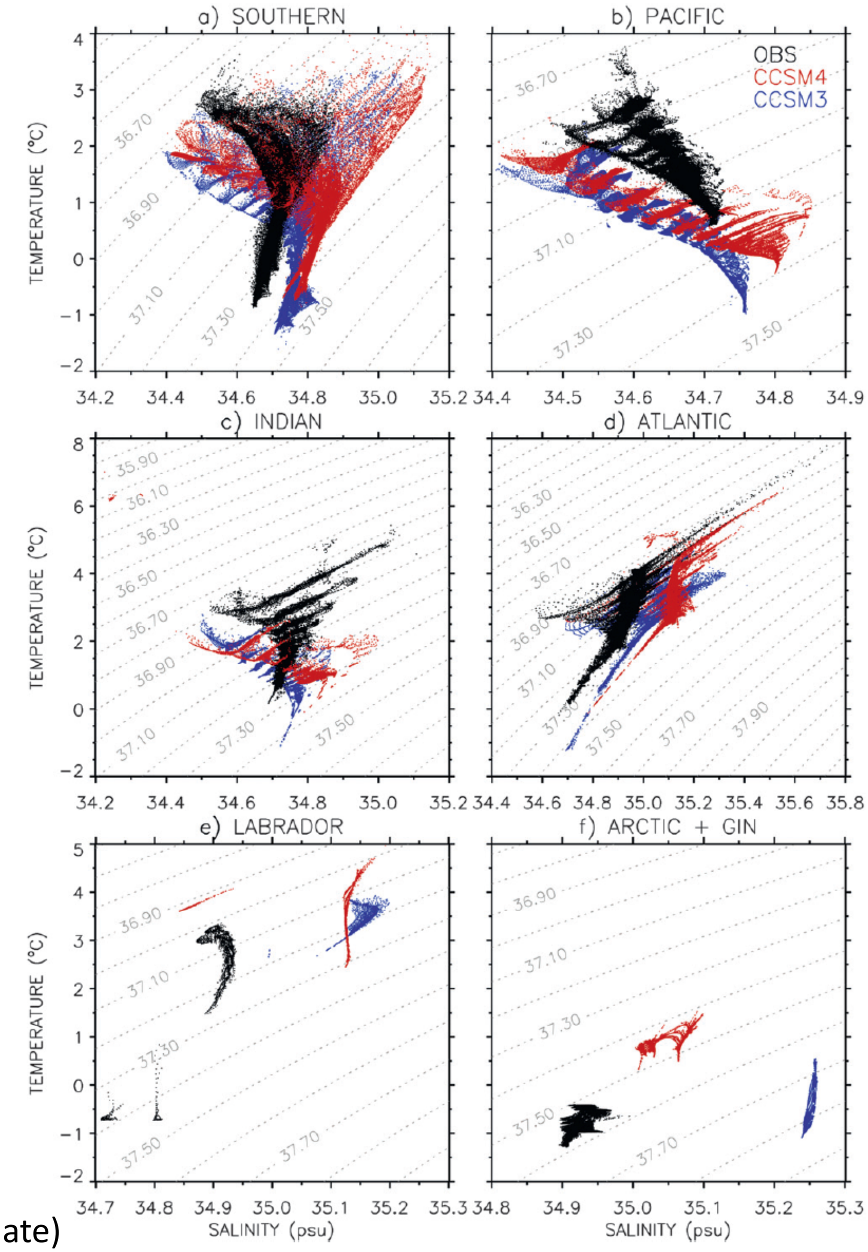
Horizontal-mean potential temperature time series (model – obs)



°C

Danabasoglu et al. (2012, J. Climate)

Potential temperature – salinity diagrams for depths > 1500 m



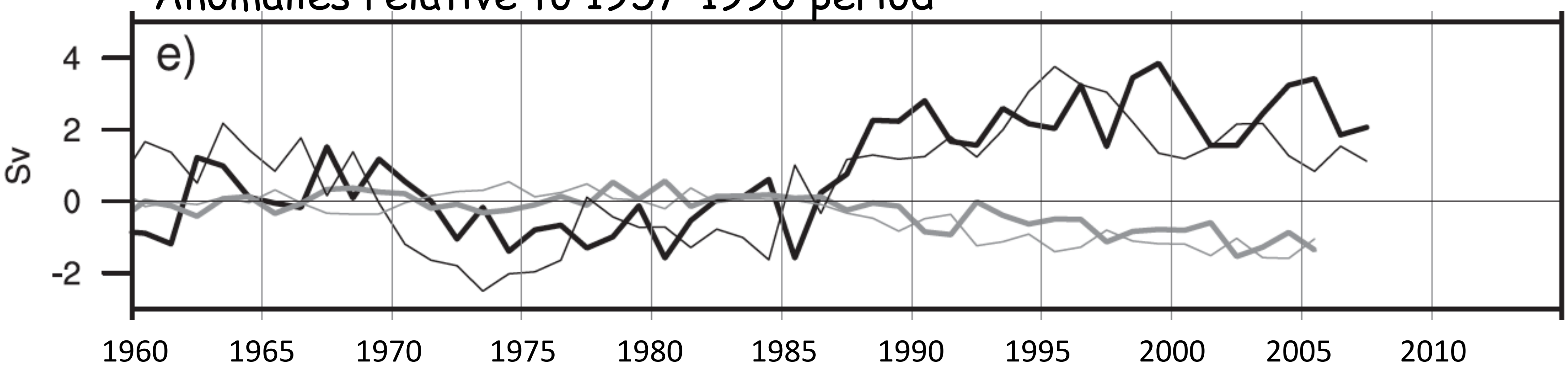
Danabasoglu et al. (2012, J. Climate)

For the pre-industrial control integration within DECK:

- A standard for ocean model initialization: January-mean "present-day" climatology from observations?
- A minimum integration length: 500 years?

COMPARISON OF AMOC AND SPG TRANSPORTS FROM 20C and CORE-II SIMULATIONS

Anomalies relative to 1957-1990 period



gray: 20C (CCSM4)
black: CORE-II

thick: AMOC
thin: - SPG

Yeager et al. (2012, J. Climate)