2018 OMWG Winter Meeting

A New Dataset for Forcing Ocean – Sea-ice simulations: JRA55-do

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Who M. Kim

R. J. Small, S. Yeager, G. Danabasoglu (NCAR)

H. Tsujino, (JMA-MRI), and CLIVAR OMDP

Outline

✓ Description of JRA55-do (v1.3)

- Adjustments applied to raw JRA55
- Derived surface fluxes in comparison to those from CORE-IAF
- Manuscript submitted to Ocean Modeling (*Tsujino et al. 2018*)

✓ Simulations

- Current status of JRA55-do simulations using POP2-CICE5

COREs

- ✓ The Coordinated Ocean-ice Reference Experiments (COREs) have provided common protocols for performing ocean–sea-ice simulations.

- ✓ The forcing dataset based on *Large and Yeager (2009)*
  - CORE-I (CORE-NYF) and CORE-II (CORE-IAF)
  - Easily accessible
  - Used for a variety of research topics (e.g., NA: *Danabasoglu et al. 2014 & 2016; SO: Farneti et al. 2015 ; Sea level: Griffies et al. 2014*)
  - Widely used to evaluate ocean and sea-ice models

Why Are We Switching Forcing?

- ✓ Not been updated since 2009 largely due to discontinuity in satellite-based radiation fields

  → Not suitable for studies focusing on recent climate events (e.g., Arctic Sea-ice decline, and recent El Nino event)

- ✓ Based on NCEP, coarse resolution (~200 km/6 hourly)

  → Not ideal for high-resolution and regional simulations

- ✓ It's been a decade, time to revisit the methodologies and reference datasets

- ✓ CLIVAR OMDP decided to adopt the Japanese 55-year Reanalysis (JRA55) as the new source dataset.

A Quick JRA55-do and CORE Comparison

✓ Higher (temporally and spatially) resolution; self-consistent; near real-time

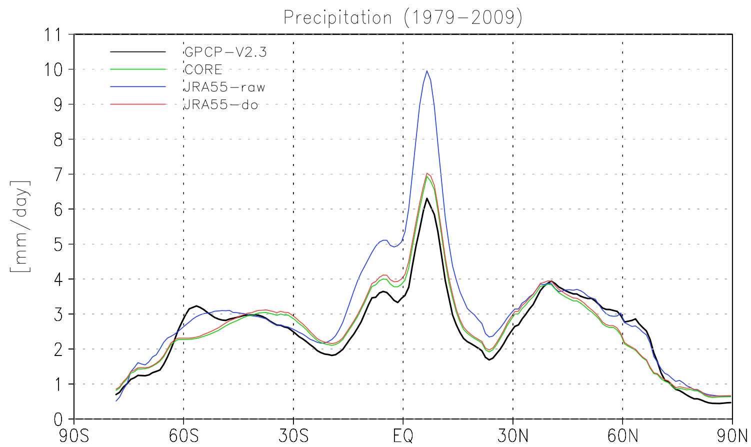
	JRA55-do (~55 km)	CORE-IAF (~200 km)
Atm. State (T, q, U, & SLP)	JRA55 (**3-hr**)	NCEP (**6-hr**)
Radiation (Q_{SW} & Q_{LW})	JRA55 (**3-hr**)	GISS ISCCP-FD (**daily**)
Precipitation	JRA55 (**3-hr**)	GPCP/CMAP/Serreze (**monthly**)
Runoff	*Suzuki et al. (2017)* (JRA55-based; **daily**)*	*Dai et al. (2009)* (**monthly climatology**)
Available Period	1958 - present	1948 – 2009#
Adjustment strategy	Time-dependent (Phase I-III)	Time-invariant

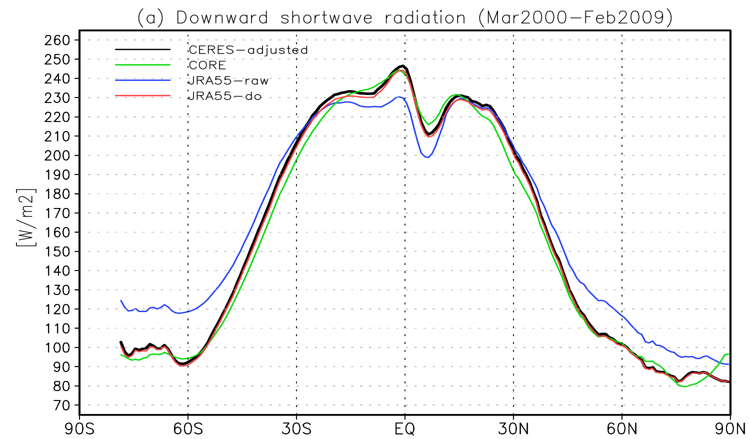
* In addition, observed solid and liquid runoffs from Greenland and Antarctica are included

Interannually varying only after 1979 and 1983 for precipitation and radiation, respectively

Adjustments

- ✓ Adjustments toward obs were applied to reduce biases as in CORE

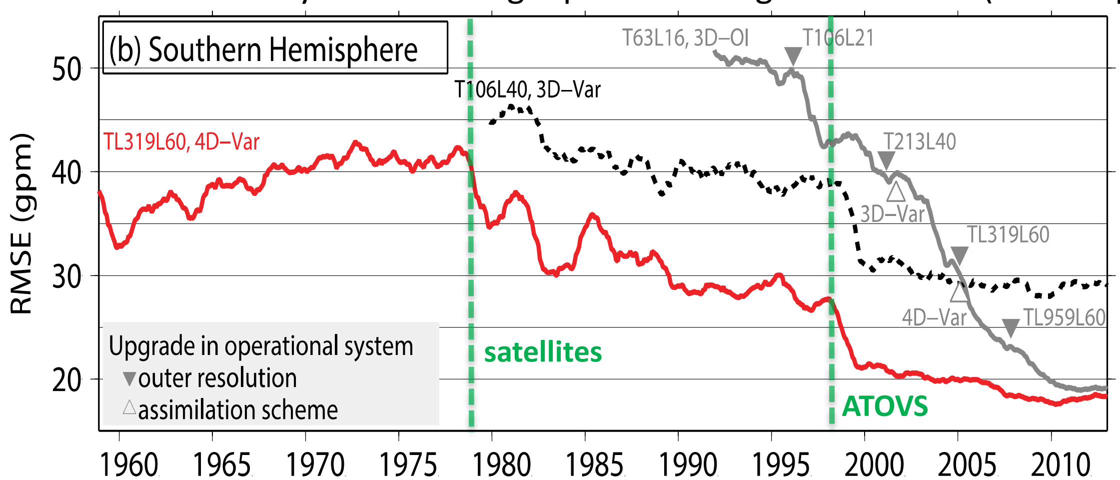




Tsujino et al. (2018)

- ✓ **Time-dependent adjustments** because of shifts in raw JRA55 due to changes in observation systems

RMS errors of 2-day forecasts of geopotential height at 500 hPa (extratropics)



Kobayashi et al. (2015)

Summary of Adjustments

	1958-1972	1973-1997	1998-present
T (ice)	IABP-POLSE	IABP-POLSE	IABP-POLSE
T&q	Ensemble mean of Reanalyses	Ensemble mean of Reanalyses	Ensemble mean of Reanalyses
Wind Speed	SSMI	SSMI	QuikSCAT
Wind direc	QuikSCAT	QuikSCAT	QuikSCAT
Rad	CERES-EBAF	CERES-EBAF	CERES-EBAF
Prec	CORE (GPCP/CMAP/Serreze)	CORE (GPCP/CMAP/Serreze)	CORE (GPCP/CMAP/Serreze)

1978

40ºN: Addition of "anomaly" of CORE relative to adjusted JRA-55 T&q (up to 1978); Smoothing T&q in the marginal sea ice region

50ºS: Addition of "anomaly" of CORE relative to adjusted JRA-55 T&q (up to 1978); Smoothing T&q in the marginal sea ice region, Cut-off of extremely low temperatures

- ✓ To close long-term heat and freshwater flux budget, an global adjustment is applied to downwelling radiations and precipitation, respectively.
- ✓ For the detailed methods of adjustments, see *Tsujino et al. (2018)*

Runoff Data

✓ A river-routing model (0.25º) forced by the input runoff from the land-surface component of JRA55 (*Suzuki et al. 2017*)

✓ Greenland runoff: monthly climatology (1961-1990) from Bamber et al. (2012)

→ **An order higher than CORE runoff (0.028 Vs. 0.002 Sv)**

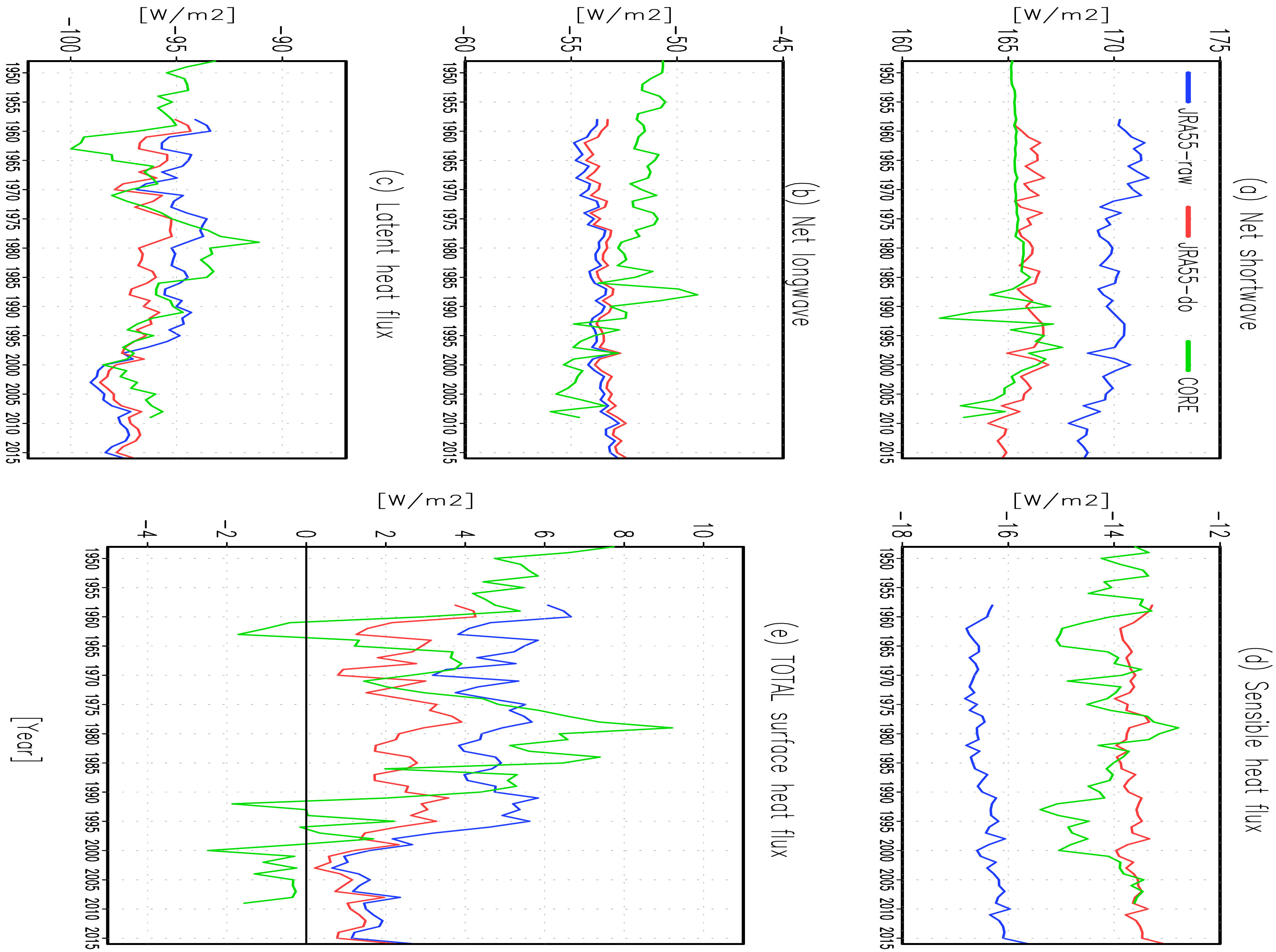
✓ Antarctic runoff: annual mean from Depoorter et al. (2013)

→ **similar in total magnitude, but spatial distribution is different**

Heat Fluxes*

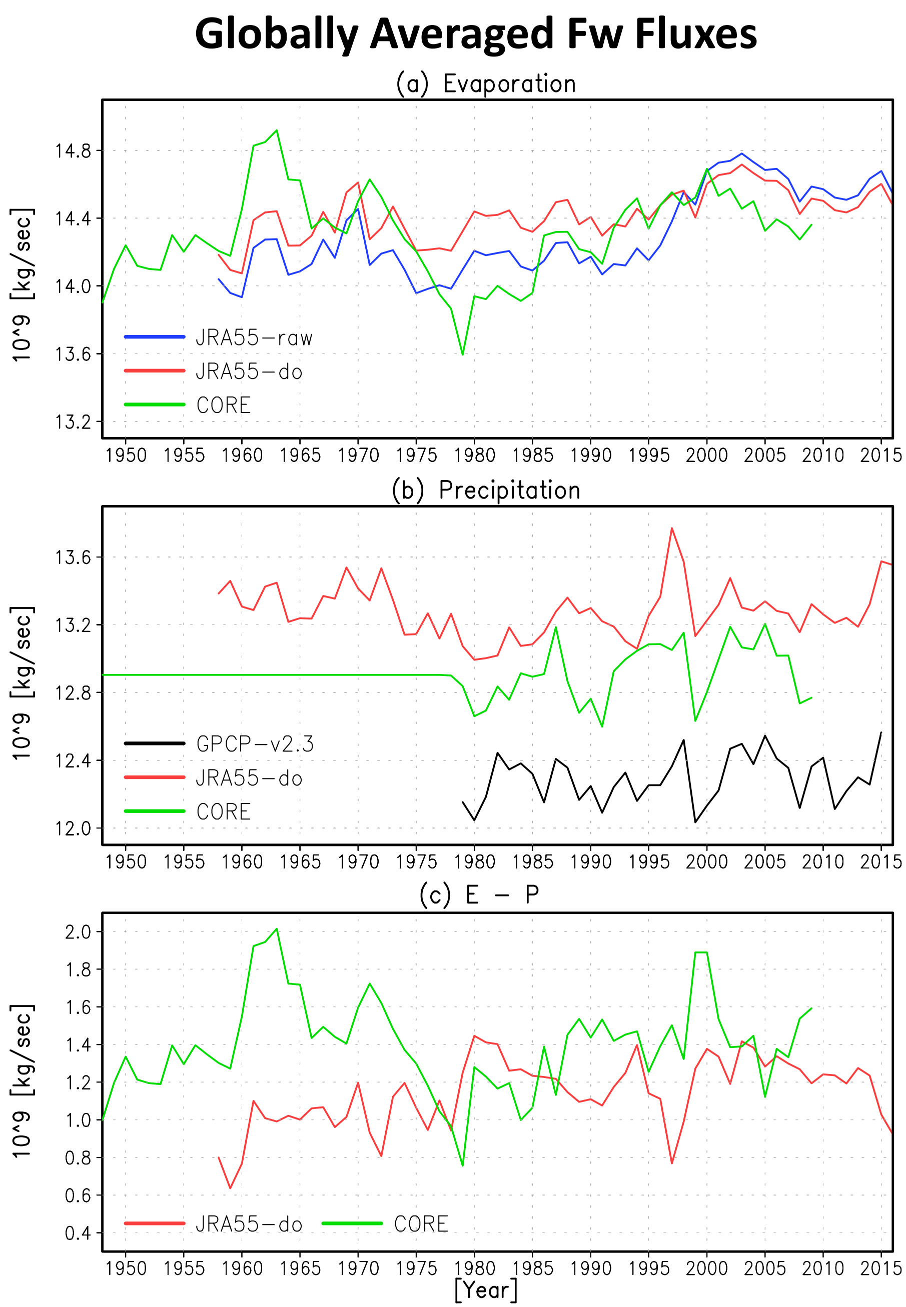
* **Lower boundary conditions: COBESST**

Globally Averaged Heat Fluxes



Tsujino et al. (2018)

Fw Fluxes

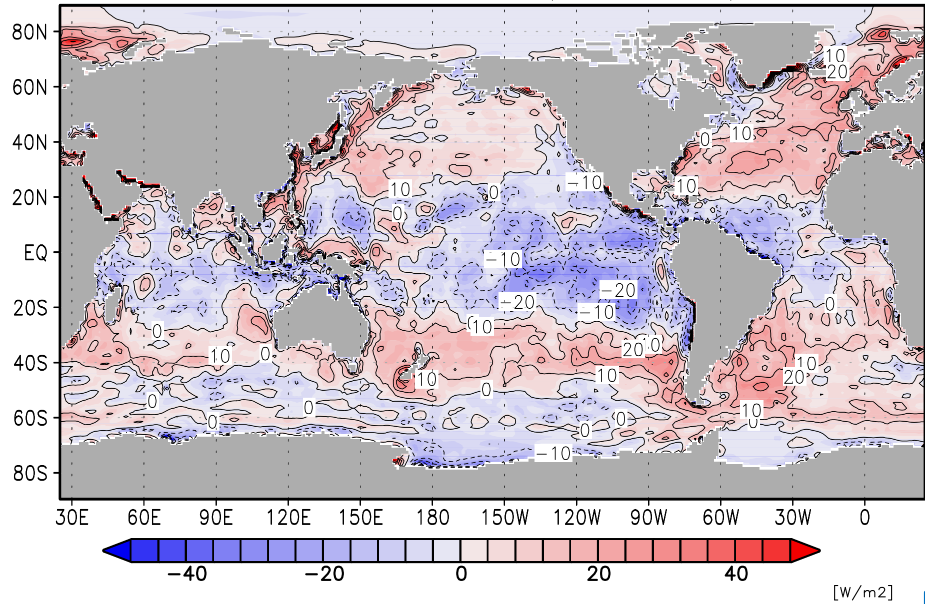


Tsujino et al. (2018)

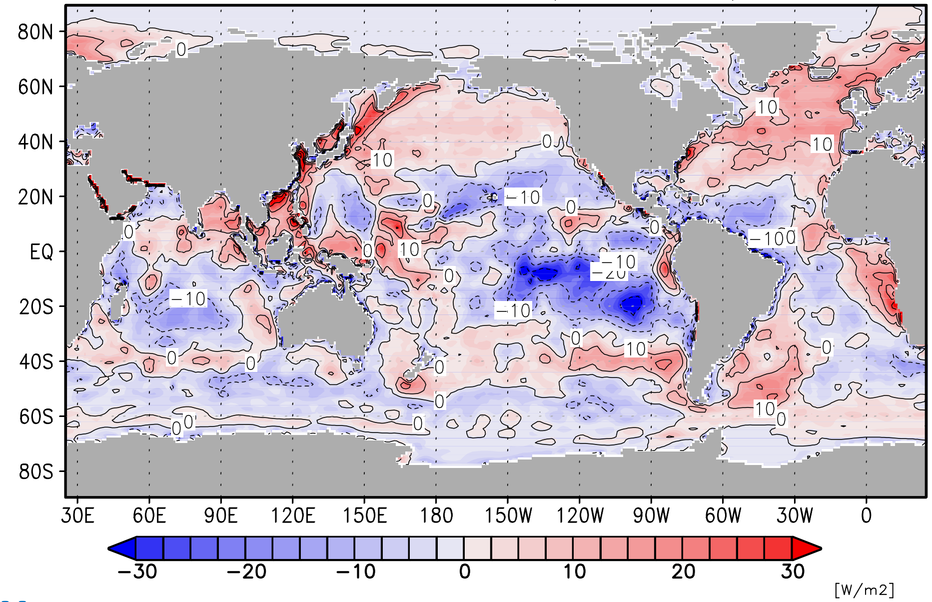
Long-term Mean

Heat

Total
JRA55−do − CORE (1988−2007)

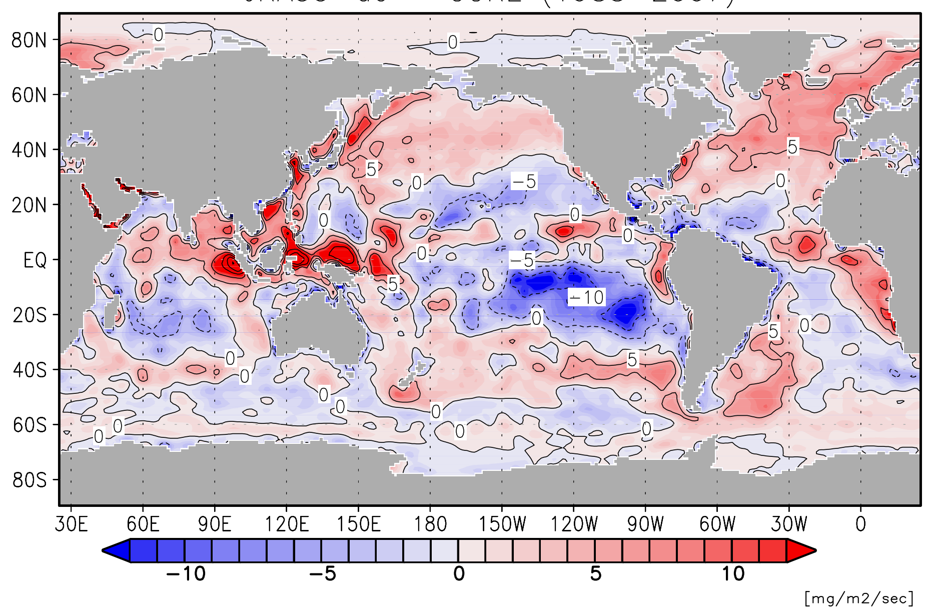


Latent
JRA55−do − CORE (1988−2007)

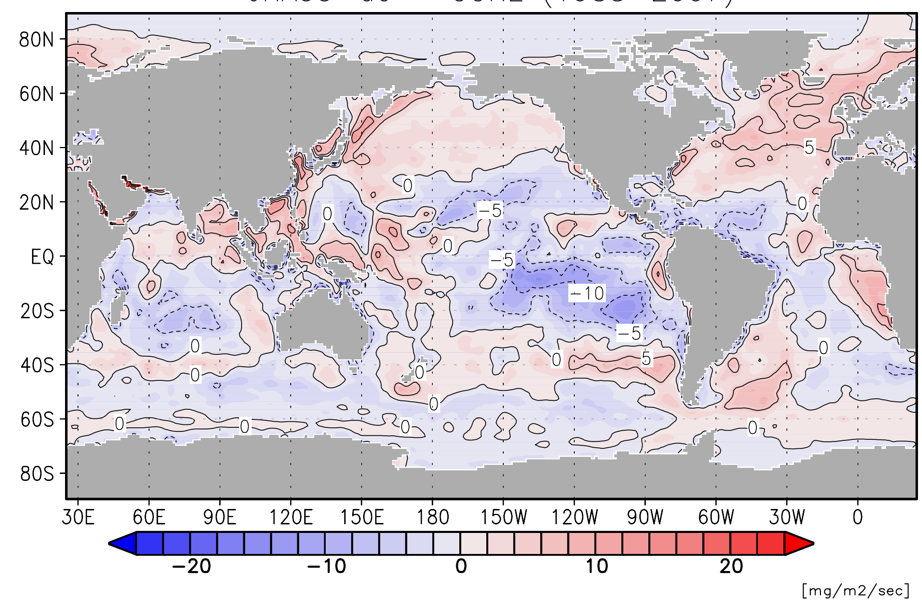


Fw

Total
JRA55−do − CORE (1988−2007)

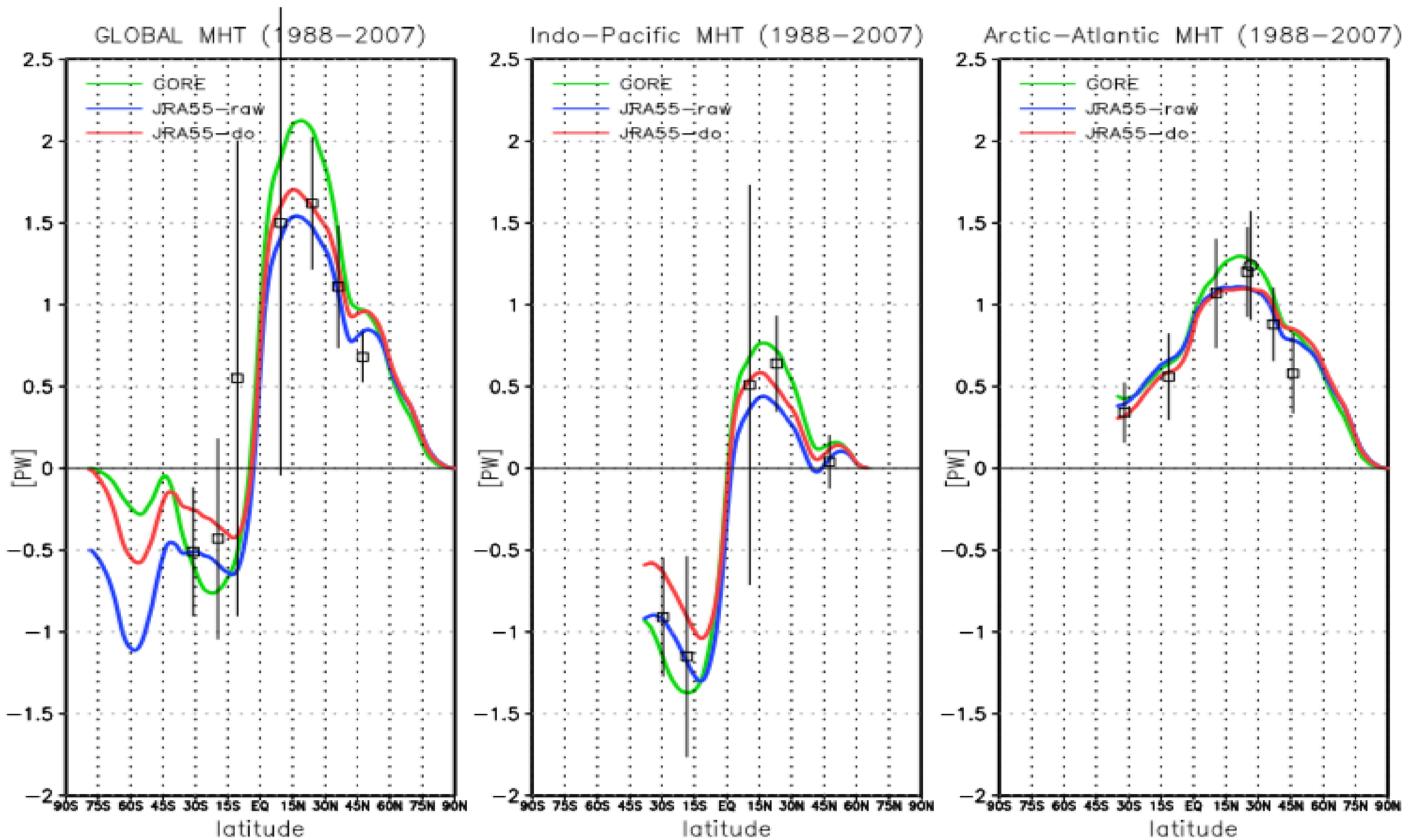


Evap
JRA55−do − CORE (1988−2007)



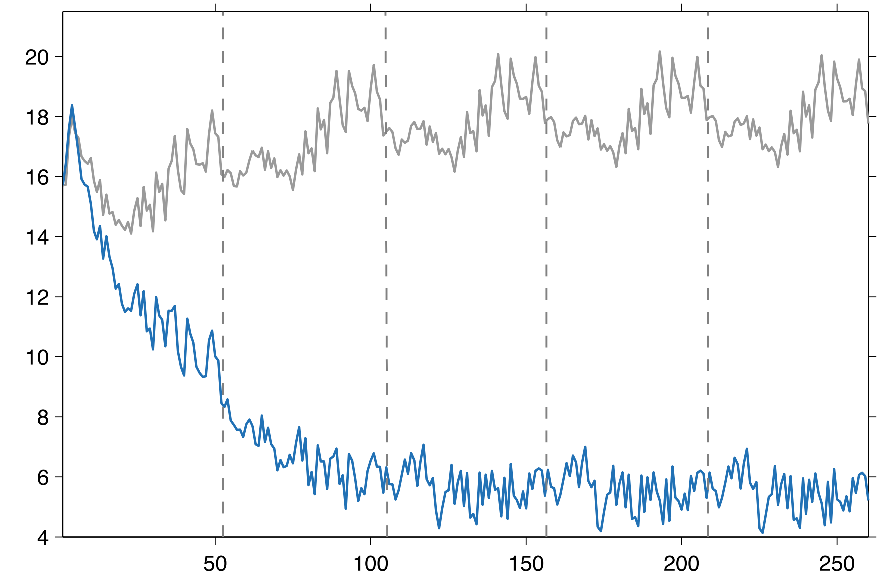
Tsujino et al. (2018)

Implied Heat Transport

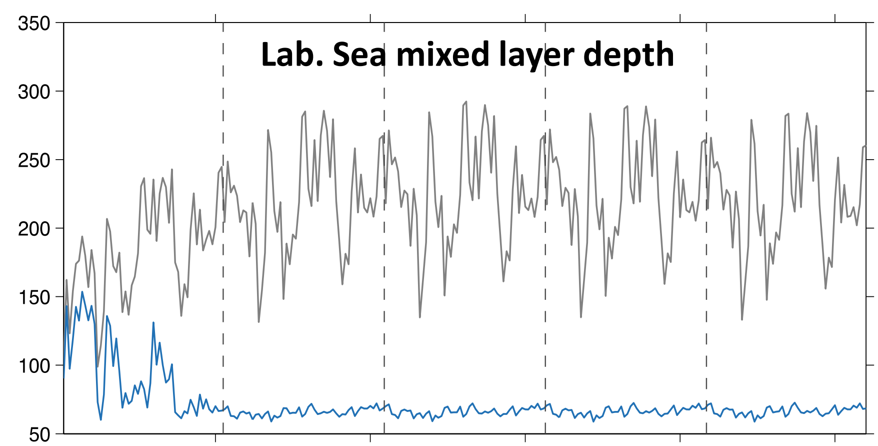


JRA55-do Simulations

- ✓ In **CORE-II** simulations, AMOC is healthy with default setup
- ✓ In **JRA55-do** simulations, AMOC collapses with the same setup

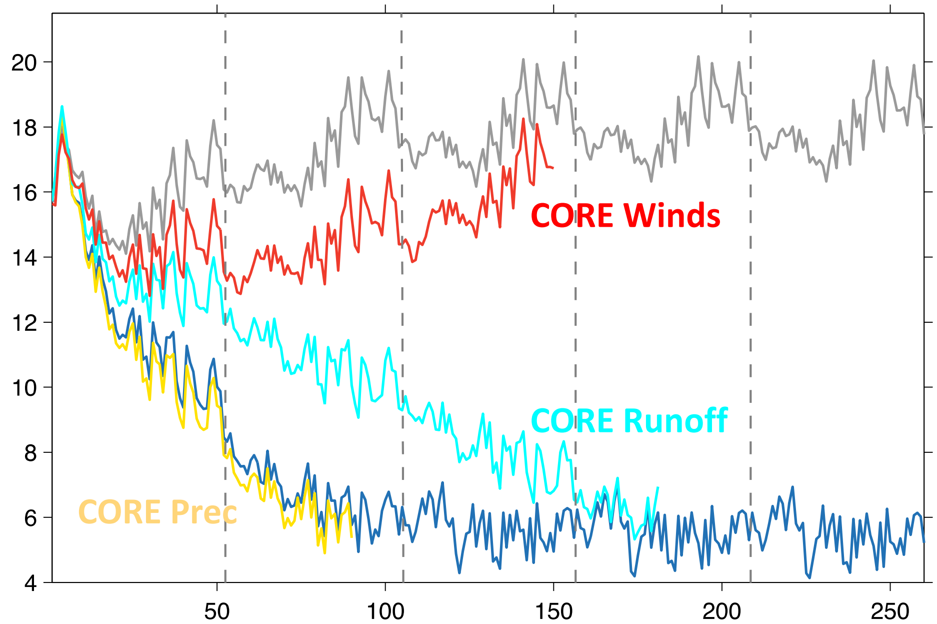


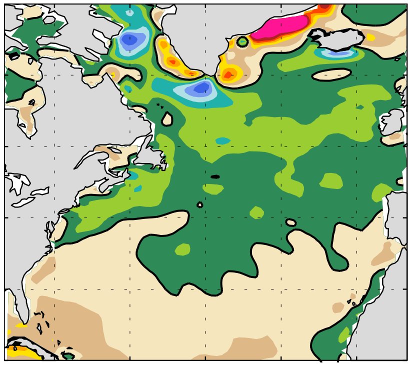
*** Both experiments are run for 5 cycles by repeating the 1958-2009 period (52 yrs)**

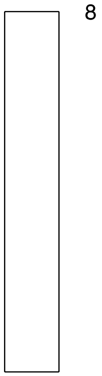


JRA55-do Simulations

✓ The AMOC collapse is ultimately related to winds



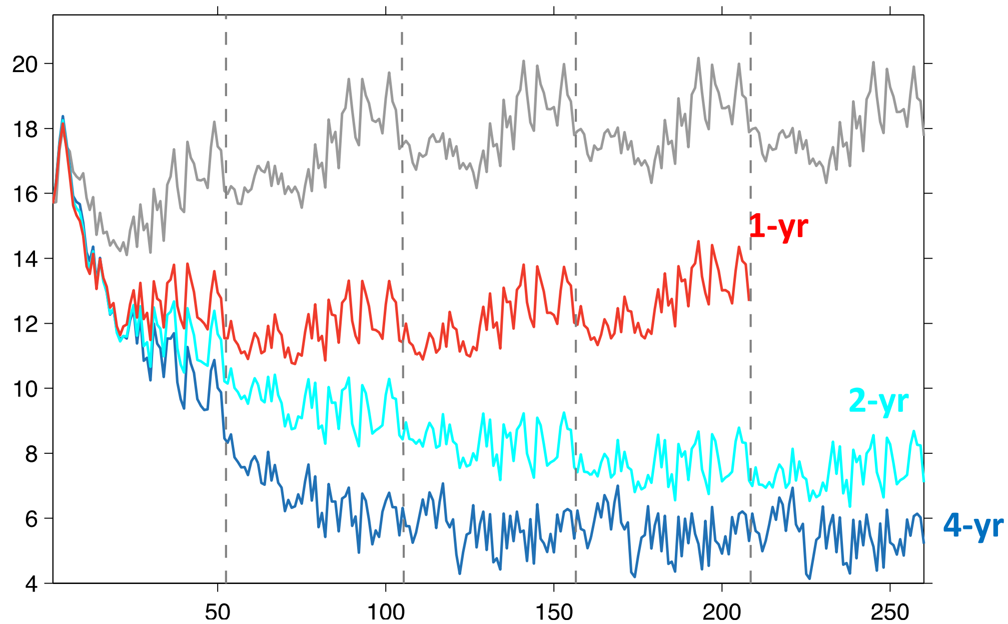


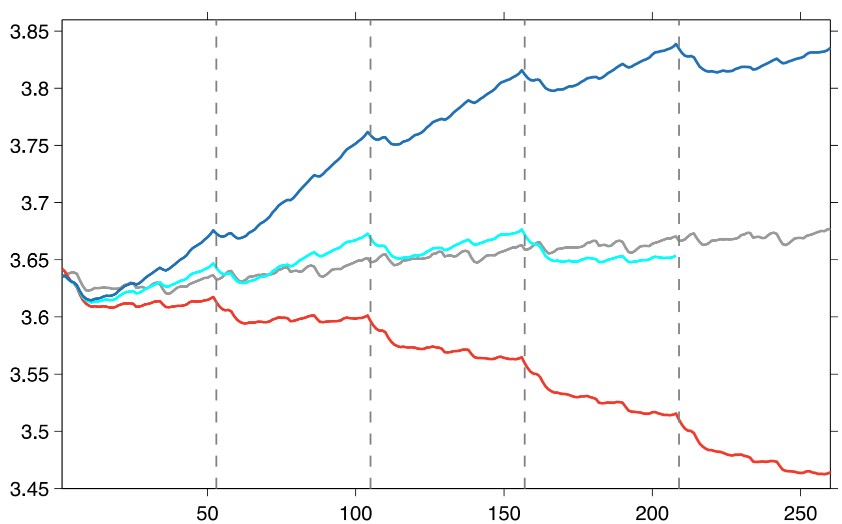


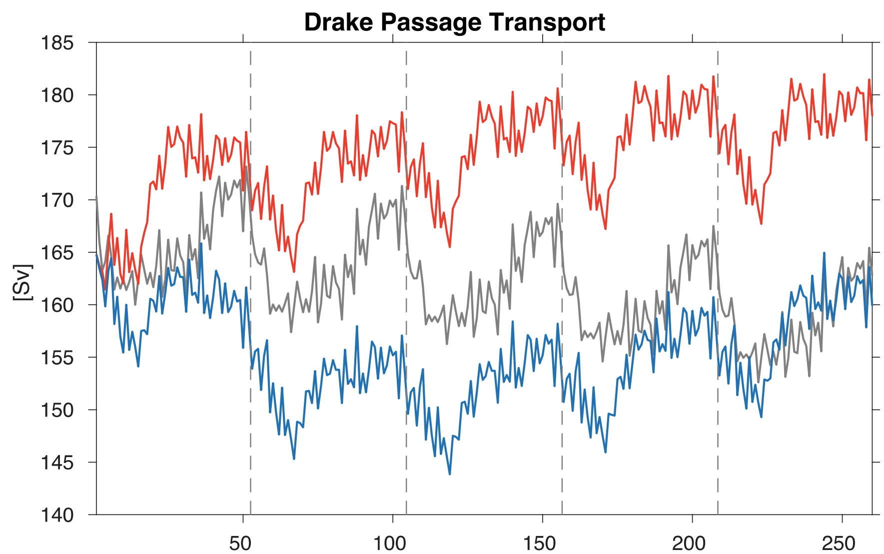
JRA55-do Simulations

✓ Tuning: 1) increasing salinity restoring time scale

→ *Currently 4-yr, but even 1-yr is widely used*





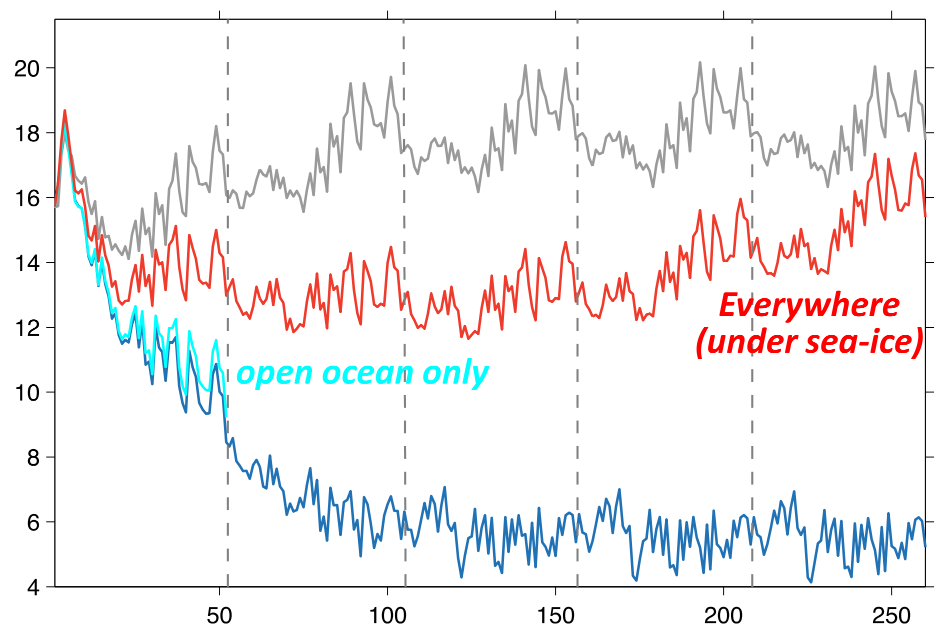


JRA55-do Simulations

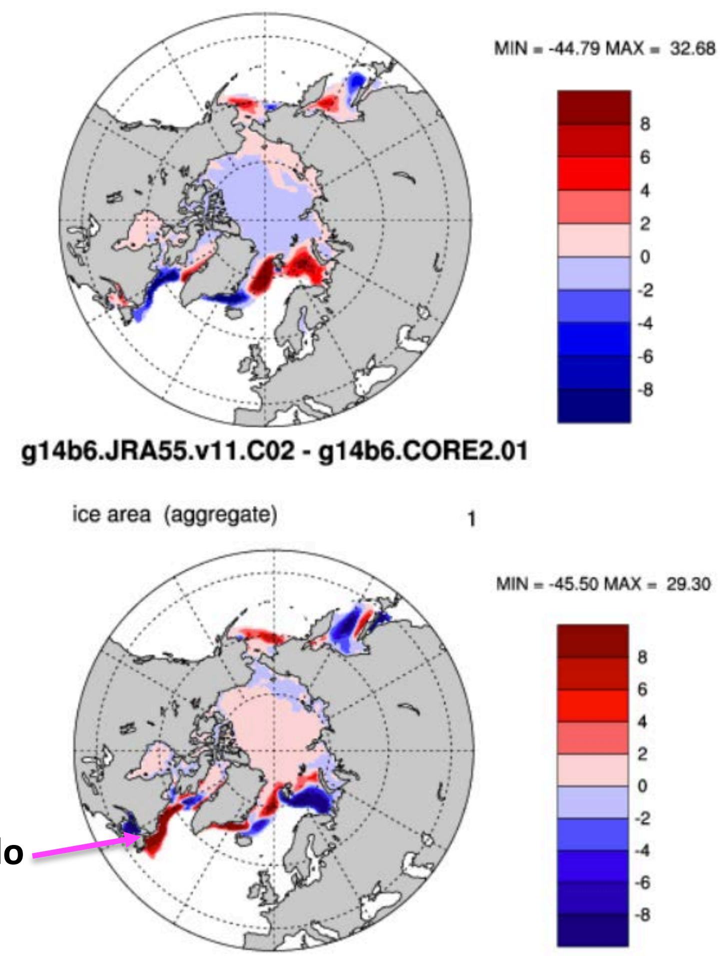
✓ Tuning: 2) No ocean currents in flux computation

→ $\Delta U = U_a - U_o$, but $\Delta U = U_a$ because U_a is already adjusted towards "relative" QuikSCAT

→ $\Delta U = U_a$ doesn't help for the AMOC strength, but **do improve equatorial current systems (see Yu-heng Tseng's talk)**



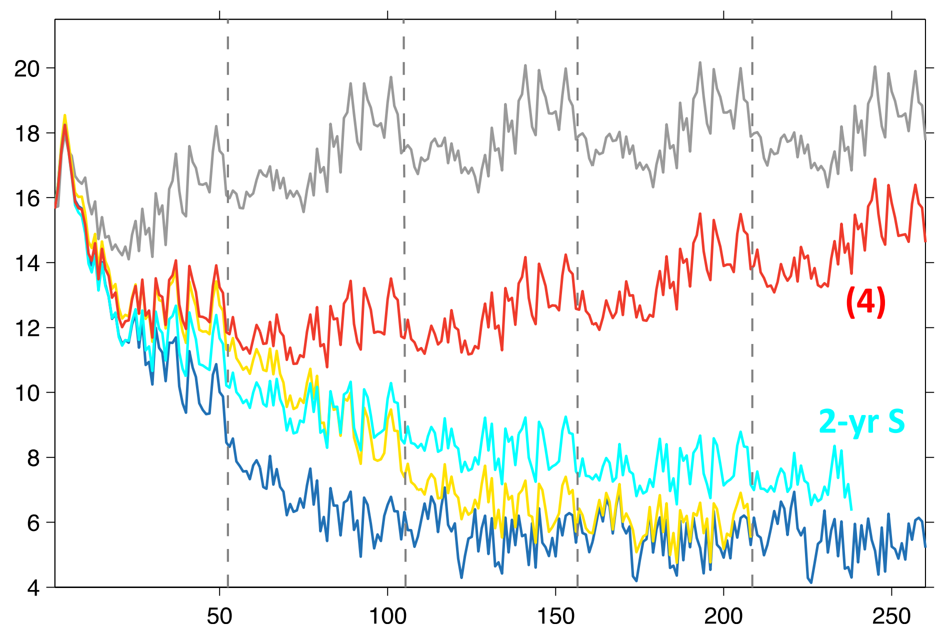
Sea-ice frac. diff. b/w $\Delta U = U_a$ & $\Delta U = U_a - U_o$



Weaker along coast winds in JRA55-do

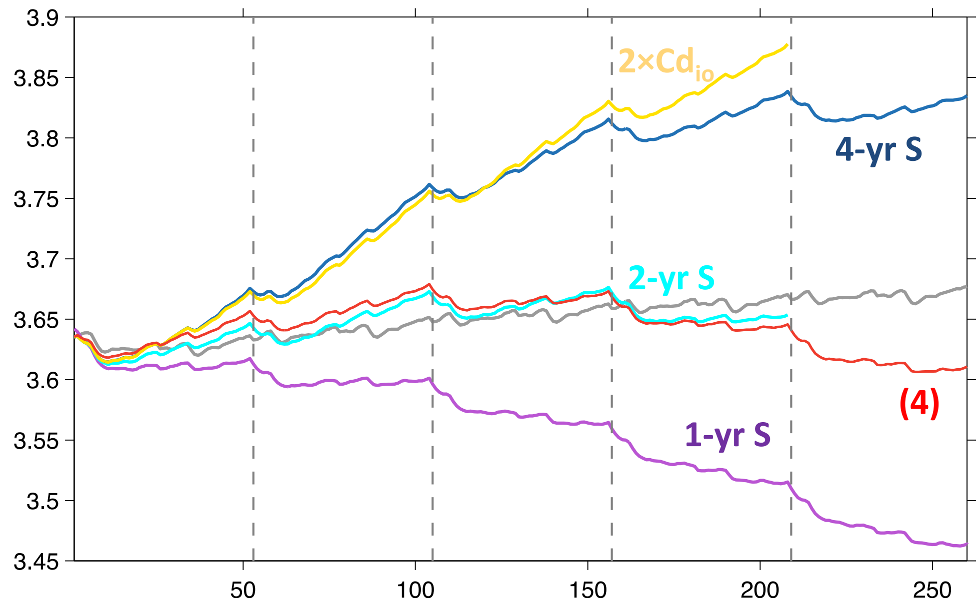
JRA55-do Simulations

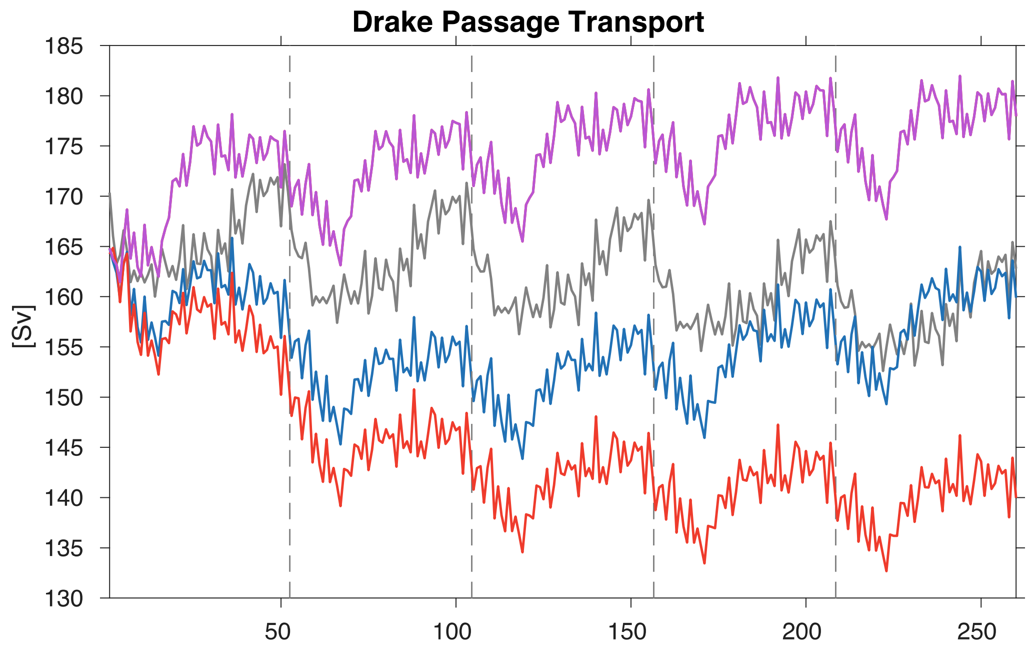
- ✓ Tuning: 3) Enhancing ice-ocean drag coefficient
  - → $\boldsymbol{\tau}_{io} \sim Cd_{io}(\mathbf{u}_i - \mathbf{u}_o)$, *increasing* Cd_{io} *has a similar effect as decreasing* U_o
- ✓ Tuning: 4) 2-yr salt restoring, $1.5\times Cd_{io}$, *&* $\Delta U = U_a$ *(over the open ocean)*



JRA55-do Simulations

- ✓ Tuning: 3) Enhancing ice-ocean drag coefficient (*Cd_{io}*)
  - → $\boldsymbol{\tau}_{io} \sim Cd_{io}(\boldsymbol{u}_i - \boldsymbol{u}_o)$, *increasing Cd_{io} has a similar effect as U_o=0*
- ✓ Tuning: 4) 2-yr salt restoring, *$1.5\times Cd_{io}$, & $\Delta U = U_a$*
  - → *50% Increase of Cd_{io} still within the observed range*





Simulation Summary & Challenges

- ✓ AMOC in JRA55-do simulation collapses with the default setup
- ✓ Changing salinity restoring strength is easiest and justifiable
  - → **1-yr: too cold; 2-yr: AMOC still took weak**
  - → **May take many (~10) cycles to obtain stable AMOC**
- ✓ Increasing Cd_{io} helps to maintain healthy AMOC (combined with stronger salinity restoring)
  - → **50% increase reasonable?**
  - → **Haven't tested in fully coupled simulations**
  - → **May lead to an inconsistency between forced and fully coupled configurations**
- ✓ *$\Delta U = U_a$ doesn't affect the AMOC strength, but appears to improve equatorial current systems (NECC)*
- ✓ Other options considered
  - → ***Starting from different initial conditions (default: WOA13)***
  - → **Going back to CESM1 setups (eg., weak deep isopycnal mixing)**

Final Remarks

- JRA55-do (v1.3) is ready for use
  - ✓ Finer temporal and spatial resolutions than the LY09
  - ✓ More self-consistent than LY09
  - ✓ Near real-time
  - ✓ Adjustments: updated reference data & time-dependent
  - ✓ Will complement/succeed LY09 for COREs/OMIP
- The description paper for the dataset (*Tsujino et al. 2018*) submitted to Ocean Modelling
- Compsets for JRA55-do will be available soon, once the model setup is finalized
- JRA55-do Repeat Year Forcing (RYF), equivalent to CORE-NYF, will be available soon