JRA-55 based data set for driving ocean - sea ice model (JRA55-do)

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1. Background (Why do we switch to JRA-55)

• **CORE (and OMIP)** is a common facility that supports ocean and climate modelers to perform hindcast simulations of the past Ocean-Sea ice climate variability

• To study recent climate extreme events (e.g., Arctic sea ice reduction, GW hiatus, 2015-16 El Nino, ...) using Ocean-Sea ice models, the forcing data set should be preferably kept up to date

• The current data set (Large and Yeager 2009, hereinafter LY09) was produced more than ten years ago (in 2004), having been updated only to 2009

• LY09 is based on the NCEP/NCAR reanalysis (T62 ~ 200 km horizontal resolution) and may not be suitable for simulations that use high (eddy permitting / resolving) horizontal resolution

• An idea to renew the dataset based on a modern reanalysis (JRA-55) is supported by OMDP. Adjustment (bias correction) methods have been investigated in the past two years.
2. Features of “JRA55-do”

- All elements are based on JRA-55 (Kobayashi et al. 2015). They are *tailored* for driving Ocean-Sea ice models.
- Long period (1958-present), high resolution (55 km, 3 hourly).
- Surface atmospheric states of JRA-55 (except for SLP) are adjusted relative to reference datasets.
- Continental river discharge is provided by running a river model using run-off from the land surface component of JRA-55.
- Global balance of surface heat and freshwater fluxes.
- Updated near real-time. Planned to be made available from ESG.
Schematic of adjustment on raw JRA-55

1958-1972
- Addition of “anomaly” of CORE relative to adjusted JRA-55 T&q for 1958-1978
- Adjustment factor for this period is determined by comparing JRA-55C(*) of later years with:
  - Prec: CORE (1979-1996)

40°N

1973-1997
- Adjustment relative to:
  - Prec: CORE (1979-1996)
- Smoothing T&q in the marginal sea ice region

1998-present
- Adjustment relative to:
  - T&q: ensemble mean of reanalyses (1999-2014)
  - Winds: QuikSCAT (1999-2009)
  - Prec: CORE (1999-2009)
- Smoothing T&q in the marginal sea ice region, Cut-off of extremely low temperatures around Antarctica

50°S

- Adjustment factors do not change within each period
- Smooth transition of adjustment factors between periods

(*) Note:
- JRA-55 (1958-present): All available observational data are used
- JRA-55C (1958-2012): Only conventional observations are used (no satellite, aircraft)
- JRA-55 and JRA-55C are common for 1958-1972
3. Evaluation and adjustments on JRA-55

Air temperature and Specific humidity

2 m temperature and specific humidity averaged over the ocean

Ensemble mean
- JRA55anl
- MERRA2
- ERA-interim
- NCEP-CFSR
- NCEP-R1
- NCEP-R2
- 20CRv2

JRA55-raw is the cold outlier
Adjustment (offset) factor for the raw JRA55 (JRA55‐raw) air temperature

Specific humidity is shifted with air temperature adjustment by keeping relative humidity, then adjusted wrt the reference data (ensemble mean)

- Cold bias in low to mid latitudes
- Warm bias over Arctic Sea Ice (adjusted wrt IABP‐NPOLES)

Adjustment (multiplication) factor for JRA55‐raw specific humidity (after temperature adjustment)

✓ JRA‐55’s atmospheric model is known to have moist bias
Vector Wind

\[
\begin{pmatrix}
\frac{u_{do}}{v_{do}}
\end{pmatrix}
= R_S(\lambda, \phi)
\begin{pmatrix}
\cos \delta & -\sin \delta \\
\sin \delta & \cos \delta 
\end{pmatrix}
\begin{pmatrix}
\frac{u_{raw}}{v_{raw}}
\end{pmatrix}
\]

Multiplicative factor for wind speed (1999–2015)

Counter-clockwise rotation factor (v0.8)

- **CORE** wind is strong
- Strong (weak) wind in mid (low) latitude for JRA55-raw

Zonal mean neutral wind at 10 m (Nov 1999–Oct 2009)

CORE
JRA55-raw
JRA55-do
RSS-QuikSCAT
Downward SW and LW radiation

- Small (large) downward SW in low (high) latitudes for JRA55-raw
- LW generally compensates for SW
Precipitation

Precipitation multiplicative factor (v0.8 1999–2015)

High precipitation in tropical convergence zones for JRA55-raw
Globally averaged surface fluxes after applying globally constant, time independent factors on downward fluxes

**surface heat flux**

(a) Net short wave

(b) Net long wave

(c) Latent heat flux

(d) Sensible heat flux

(e) TOTAL surface heat flux

**surface fresh water flux**

Evap (solid line) Precip (dashed line) E-P (= Run off minus Sublimation)

**Evaporation - Precipitation**
Interannual variability of basin-wise river run-off to the ocean (Units: Sverdrups)

Run off from land of JRA-55 is adjusted wrt Dai et al. (2009) before inputting to the river model

black: w/o adjustment, blue: after adjustment, red: Dai et al. (2009)
4. Results of MRI global Ocean-Sea ice model simulations forced by CORE, JRA55-raw, and JRA55-do

(focusing on the Atlantic Sector)
MOC and ACC (Units: Sverdrups)

- Single peak of A-MOC for CORE and JRA55-do, two peaks for JRA55-raw
- Intense ACC for JRA55-raw, similar ACC for CORE and JRA55-do
Transport at some Straits (Units: Sverdrups)

Positive Eastward / Northward

(a) Florida Strait

(b) Denmark Strait

(c) Davis Strait

(d) Strait of Gibraltar

CORE
JRA55-raw
JRA55-do
SST anomaly relative to PHC (WOA)

- forced by CORE
- JRA55-do-run minus CORE-run

- General improvement near the eastern boundary with JRA55-do forcing
Wind stress curl along the western coast of Africa

More confined region of negative wind stress curl for JRA55-do
5. Summary

Features not covered by the current forcing dataset (LY09) are supplemented by JRA55-do

CORE and JRA55-do give similar simulation results

Several unfavorable features contained in JRA55-raw (e.g., two-peak A-MOC and transports at some Straits) are corrected by JRA55-do
Additional adjustments

&\& q are smoothed in the marginal sea ice region, because JRA-55 does not show partial sea ice cover.

Extremely low air temperature is cut off around Antarctica.

Time series of monthly difference of T&\& q between the adjusted JRA-55 and ORE for latitudes higher than 40\(^\circ\)N or 50\(^\circ\)S is added to the adjusted JRA-55 field for 1958-1978.

Precipitation on Mediterranean for 1958-1978 is adjusted based on GPCC precipitation.

Downward fluxes are adjusted to achieve global balance of surface heat and freshwater fluxes under observed sea surface temperature (1988-2007).
Wind stress curl

JRA55-do

Risien and Chelton (2008)