T85 and T341 Fully-Coupled CESM Simulations: Climatology Comparisons and Present-Day Transient Initialization Strategy.

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Overall Goal

Evaluate the veracity of both T341/0.1° and T85/1° CESM pre-industrial simulations by comparing them with:

- Observations, especially those of vertical ocean structure.
- Existing coupled simulations at comparable resolutions i.e. standard resolution CCSM4 and Atlas 0.25°/0.1° CCSM4.
Overview

1. Compare Atlas CCSM4 simulation (0.25° CAM3.5 (FV)/CLM, 0.1° POP/CICE, McClean et al. 2011) and T341/0.1° CESM.

2. Global veracity of T341/0.1° CESM: particularly using Argo monthly climatologies (Holte and Talley, 2010; Roemmich and Gilson, 2008)

3. Comparisons of T341/0.1° and T85/1° CESM in regions where eddies are important.

4. Compare T85/1° (CAM4) and CCSM4 (CAM4 FV/1°): different dycores.

5. Initialization Strategy for fine resolution CESM present day transients. Test with T85/1°.
T85/1° Fully-Coupled CESM

- T85 Eulerian Spectral dycore
- CAM4 physics
- Otherwise as in CSSM4 (Gent et al. 2011)
- Ocean initialization: PHC2
- Ice initialization: spun-up ice state from coupled climate simulation (standard release)
- Land initialization: CCSM4
SST from Hadley PI climatology, T341 for years 34-43 (LHS), and Atlas for years 13-19 (RHS)
Annual Ice concentration (%) from Atlas (LHS) and T341 (RHS) and SSM/I
Annual Wind Stresses Vectors and Their Magnitudes from QuikSCAT and T341 for Years 34-43 (LHS) and Atlas years 13-19 (RHS)
NCEP Reanalysis

T341-NCEP

Atlas-NCEP

DJF Sea-level Pressure (millibars)

DJF 500 mb heights ($10^2$ m)

Excessive polar vortex contraction and deepening much reduced
DJF Zonal Wind (m/s)

Overly strong polar night jet eliminated.

NCEP Reanalysis

T341-NCEP

Atlas-NCEP
RMS SSHA (CM) from AVISO (upper) and 7-daily SSHA from T341 (lower)
Temperature and Salinity averaged over top 10-100 dbar, Argo: 2004-2008

(a) TEMP 100dbar ave (degC): ARGO
(b) TEMP 100dbar ave (degC): T341
(c) TEMP DIFF (degC): (T341 - OBS)
(d) SALT 100dbar ave (g/kg) ARGO
(e) SALT 100dbar ave (g/kg): T341
(f) SALT DIFF (g/kg): (T341 - OBS)
Meridional Overturning Circulation for T85 (LHS) and T341 (RHS)
Zonally-Averaged Temperature and Salinity in top 2000 m

http://sio-argo.ucsd.edu/RG_Climatology.html
Mixed Layer Depth: Density threshold of 0.03 kg/m$^3$, following de Boyer Montégut et al., 2004.
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Southern Ocean Mixed Layer Depths from ARGO and T341 February and August climatologies.

(a) MLD (m): ARGO OBS FEB

(b) MLD (m): T341 034–043 mean FEB

(c) DIFF (m): (T341 − OBS) FEB

(d) MLD (m): ARGO OBS AUG

(e) MLD (m): T341 034–043 mean AUG

(f) DIFF (m): (T341 − OBS) AUG
Southern Ocean Mixed Layer Depths from ARGO and T85 February and August Climatologies
North Pacific Mixed Layer Depths from ARGO and T341 February and August climatologies

(a) MLD (m): ARGO OBS FEB
(b) MLD (m): T341 034-043 mean FEB
(c) DIFF (m): (T341 - OBS) FEB
(d) MLD (m): ARGO OBS AUG
(e) MLD (m): T341 034-043 mean AUG
(f) DIFF (m): (T341 - OBS) AUG

Shallow model MLDS
North Pacific Mixed Layer Depths from ARGO and T85
February and August climatologies

(a) MLD (m): ARGO OBS FEB

(b) MLD (m): T85 034–043 mean FEB

(c) DIFF (m): (T85 - OBS) FEB

(d) MLD (m): ARGO OBS AUG

(e) MLD (m): T85 034–043 mean AUG

(f) DIFF (m): (T85 - OBS) AUG
Worthington Volumetric Temperature-Salinity Census

PHC2
Volumetric PT/S (km$^3 \times 10^3$)

T85
Volumetric PT/S (km$^3 \times 10^3$)

T341
T341 Volumetric PT/S (km$^3 \times 10^3$)

CCSM4
Volumetric PT/S (km$^3 \times 10^3$)

Pacific
Atlantic
AABW
Volumetric Temperature-Salinity Census: Observations - Model

- Excessive ice formation producing higher salinity AABW
- Modest Freshening
- T341 for yrs 34-43
- T85 and CCSM4 for yrs 176-200

Excessive ice formation producing higher salinity AABW
Conclusions and On-Going Work

• Anomalous strengthening & deepening of the winter-time NH polar vortex not as severe in T341 as Atlas, nor is is getting worse.
• T341 upper ocean generally shows a warm bias in mid-latitudes & tropics.
• Mixed layer depths in T341 more realistic in SO and KE relative to T85.
• AABW better represented in T85 and T341 relative to CCSM4.
• More study is required to determine sources of the T341 biases especially in salinity.
• Evaluate T85 transients.