Impact of Ocean Model Resolution on CCSM4 Simulations
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Outline

- **Motivation:**
  - Scale Interactions – How Do Ocean Eddies Impact the Large Scale Climate?
  - Minobe et al. (2008) - Nature
  - Number of Previous Studies Focused on Atmospheric Resolution
  - Recent focus on the Importance of Ocean Eddies
    - Toniazzo et al. (2009); Zheng et al (2009); McWilliams and Colas (2010)
  - McClean et al. (2010); Bryan et al. (2010)
    - Order 10-20 Year Simulations
Outline

• CCSM4*
  – Atmosphere: 0.5x0.5
  – Two Versions: 1x1 [LRC] and 0.1x0.1 [HRC*]
  – Initialization: Spun-Up Ocean, Interpolation

• Analysis To Date Largely Focused on Global Climate and Air-Sea Feedback
  – Global Perspective (Global Survey)
  – Regional Highlights: North Atlantic, North Pacific, Tropical Pacific, Tropical Atlantic
  – Coupled Feedback: Does the Coupling Matter???

• Movie, Future Work and Remarks

Not Coupled
Affect of Improved Parameterized Physics

- **CCSM3.0 vs CCSM3.5**
  - Atmosphere: T85; Ocean 1x1

![Graph showing SST comparison between CCSM3.0 and CCSM3.5](image-url)
Increasing AGCM Resolution: 
2x2 vs 0.5x0.5
Gent et al. 2010
Increasing OGCM Resolution: Eddy Permitting vs. Resolving
Affect of Resolved Ocean Eddies

- **CCSM4**
  - Atmosphere: 0.5x0.5
  - Two Versions: 1x1 [LRC] and 0.1x0.1 [HRC]
March Sea Ice Concentrations

15% HRC

15% Obs

15% LRC

15% Obs
September Sea Ice Concentrations

HRC

15% HRC

15% Obs

LRC

15% LRC

15% Obs
March Sea Ice Concentrations

15% HRC

15% Obs

15% LRC

15% Obs
September Sea Ice Concentrations

HRC

15% HRC

15% Obs

LRC

15% LRC

15% Obs
Surface Temperature Standard Deviation Ratio HRC/LRC

AGCM Grid
HRC, LRC

Observational Estimate

Surface Current Speeds
SST: HRC

SST: Observational Estimate
SST: HRC, and LRC

SST: Observational Estimate
North Pacific SST

SST: LRC

SST: Observational Estimate
SST: HRC, and LRC

SST: Observational Estimate
Surface Current Speed

Rainfall Differences: HRC-LRC
Surface Temperature Standard Deviation Ratio HRC/LRC

AGCM Grid
Changes in the 0-5N Annual Cycle
Equatorial SSTs

HRC

LRC
Equatorial Temperature Sections

Pacific

Indian

Atlantic

LRC

HRC08

HRC06

HRC08
Equatorial Pacific Variability Statistics

- Reduced Variance with HRC
- Eastward Shift in Variability
- Affects Global Teleconnections
NINO34-SSTA Point Correlation
Local SSTA-Latent Heat Flux Correlation

HRC

LRC
Local SSTA-Latent Heat Flux Correlation

HRC

HRC-LRC
Sea Surface Height Standard Deviation
Local SSTA Co-Variability with ENSO
Local SSTA Co-Variability with ENSO

HRC

HRC-LRC
Local SSTA-Latent Heat Flux Correlation

HRC

LRC

Legend: [-0.55, -0.3, -0.52, -0.45, -0.4, -0.35, -0.3, -0.28, -0.2, -0.15, -0.1, 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65]
Local SSTA-Latent Heat Flux Correlation
Local SSTA-Latent Heat Flux Correlation

HRC

OBS
Outline

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• Movie, Future Work and Remarks
Future Work – Mechanism for AMOC

CCSM3.0

Interactive Ensemble CCSM3.0
• Motivation:
  – Scale Interactions – How Do Ocean Eddies Impact the Large Scale Climate?

• Eddies Affect Large Scale Mean Climate
  – Significantly Warmer Climate
  – Noted Differences in North Atlantic SST, Rainfall and Current
  – North Pacific – Rainfall Differences Relatively Small
  – Tropical Pacific: Reduced Double ITCZ, Enhanced Monsoon, Modest Changes in Stratification

• Variability and Air-sea Feedbacks
  – Enhanced Variability in the Extra-Tropics
  – Reduced Variability in Tropical Pacific and Indian
  – ENSO Weakens, Shifts Eastward
  – Changes in ENSO-SSTA Teleconnections
  – Much Stronger Coupling Between Heatflux and SST

Concluding Remarks
Interactive Ensemble Approach

Ensemble of N AGCMs all receive same OGCM-output SST each day

AGCM_1
Sfc Fluxes_1

AGCM_2
Sfc Fluxes_2

... AGCM_N
Sfc Fluxes_N

average (1, ..., N)

Ensemble Mean Sfc Fluxes

OGCM receives ensemble average of AGCM output fluxes each day

SST

OGCM receives ensemble average of AGCM output fluxes each day

Average N members’ surface fluxes each day
Dependence on Model Formulation

CFS

COLA

CCSM3

SST Standard Deviation Ratio IE/Control
Equatorial SSTA Standard Deviation

Low Resolution: IE Control

Lower Resolution: IE Control
Contemporaneous Latent Heat Flux - SST Correlation

Observational Estimates

Control Coupled Model

Increased “Randomness”

Random Interactive Ensemble: Increased the Whiteness of the Atmosphere forcing the Ocean
CCSM3.0 Random Interactive Ensemble