Tropical Pacific Climate & ENSO

_in the GFDL CM2/2.1 control simulations_

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Annual Mean: EUC

CM2Q U (cm/s) at Equator

Subsurface U (cm/s) at Equator
CM2Q, CM2.1U vs. TAO obs (ADCP & fixed-depth)
Annual Mean: Equatorial Temperature

Temperature (°C) at Equator
Assim (1980–2000), CM2Q (bias shaded)

Temperature (°C) at Equator
Assim (1980–2000), CM2.1U (bias shaded)
Annual Mean: Zonal Mean Temperature

Zonal Mean Temperature (°C)
Assim (1980–2000), CM2Q (bias shaded)

Zonal Mean Temperature (°C)
Assim (1980–2000), CM2.1U (bias shaded)
Seasonal Cycle at 110°W

Precip (mm/day) at 110°W

CMAP (1979–2001)  CM2Q  CM2.1U

SST (°C) at 110°W

NOAA OI.v2 (1982–2002)  CM2Q  CM2.1U
Seasonal Cycle at 110°W

$\tau_y$ (dPa) at 110°W

ERA40 (1979–2001)

CM2Q

CM2.1U

SST (°C) at 110°W


CM2Q

CM2.1U
CM2.1U: NINO3 SST Timeseries

(a) NINO3 SST CM2.1U–Control–1990–c2 (0001–0070): $s=1\text{degC}$

(b) Spectral density ($s^2 \text{ octave}^{-1}$)

(c) Mean spectra, early/late epochs

(d) Integrated variance: short $< 1.4\text{YR} <$ long

ave = 25.4
max = 30
min = 21
skewness = 0.27

tseries $\sigma^2 = 2.47$
wavelet $\sigma^2 = 2.37$ (9.6%)
ENSO Phase Locking to Seasons

Phase Locking of SST Anomalies
ENSO Precip Anomalies

(a) ECMWF reanalysis (1979–1993)

(b) CM2.1U_Control–1990_c2 (0001–0060)

(b)−(a)

corr(a,b) = 0.64  RMSD(a,b) = 0.93

(a) ECMWF reanalysis (1979–1993)

(b) CM2Q_Control–1990_e1 (0061–0160)

(b)−(a)

corr(a,b) = 0.78  RMSD(a,b) = 0.74
ENSO Zonal Stress Anomalies

Zonal wind stress (dPa) all months, regressed onto NINO3 SSTA (°C)

(a) ECMWF reanalysis (1979–1993)

(b) CM2Q_Control-1990_e1 (0061–0160)

(b)-(a)

correl(a,b) = 0.64  RMSD(a,b) = 0.047

(b) CM2.1U_Control-1990_c2 (0001–0060)

(b)-(a)

correl(a,b) = 0.78  RMSD(a,b) = 0.038
ENSO Heat Flux Anomalies

net heat flux down (W/m²)
all months, regressed onto NINO3 SSTA (°C)

(a) ECMWF reanalysis (1979–1993)

(b) CM2Q_Control-1990_e1 (0061–0160)

(b)–(a)

correl(a,b) = 0.56  RMSD(a,b) = 6.6

net heat flux down (W/m²)
all months, regressed onto NINO3 SSTA (°C)

(a) ECMWF reanalysis (1979–1993)

(b) CM2.1U_Control-1990_c2 (0001–0060)

(b)–(a)

correl(a,b) = 0.75  RMSD(a,b) = 5.4
ENSO Evolution

Lag–Regressions onto Niño3 SSTA

Assim 1980–2000
CM2Q
CM2.1U
Summary

Successes:
- reduced biases, reasonable ENSO
- a top CGCM for the tropical Pacific

Challenges:
- cold equator, double ITCZ, weak NECC
- diffuse thermocline
- surface waters too stable near Peru
- ENSO too strong, too far west
- ENSO not phase locked to seasons
Toward a Better Coupled Model

Analyses!
- Heat/momentum budgets
- Uncoupled & flux-adjusted runs
- Data override, sponged & restored runs
- Additional tests: ENSO hindcasts, paleo

Development
- Atmosphere: convection, PBL, clouds, resolution
- Ocean: vertical mixing, TIWs, color, resolution
Further Information

http://www.gfdl.noaa.gov/~atw/research/cm2/
    CM2Q/poster.pdf
    CM2.1U/poster.pdf
    CM2Q_vs_CM2.1U/talk_30min.pdf