TCs in Coupled Models at GFDL

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1-NOAA/GFDL 2- Princeton U. 3-WillisRE 4-UCAR

At: First Workshop of the US-CLIVAR Working Group on Hurricanes and Climate

Image: NASA.
Improved representation of GOM eddies improves intensity forecast in GFDL model – added after 2005 season

SST change in following TC

**Scientific Goals:**

- Developing improved models (higher resolution, improved physics and numerics, reduced bias) for studies of variability and predictability on intra-seasonal to decadal time scales
- Explore impact of atmosphere and ocean on climate variability and change using a high resolution coupled model
- New global coupled models: CM2.4, CM2.5, CM2.6, ...

<table>
<thead>
<tr>
<th></th>
<th>Ocean</th>
<th>Atmos</th>
<th>Computer</th>
<th>Status</th>
</tr>
</thead>
<tbody>
<tr>
<td>CM2.1</td>
<td>100 Km</td>
<td>250 Km</td>
<td>GFDL</td>
<td>Running</td>
</tr>
<tr>
<td>CM2.3</td>
<td>100 Km</td>
<td>100 Km</td>
<td>GFDL</td>
<td>Running</td>
</tr>
<tr>
<td>CM2.4</td>
<td>10-25 Km</td>
<td>100 Km</td>
<td>GFDL</td>
<td>Running</td>
</tr>
<tr>
<td>CM2.5</td>
<td>10-25 Km</td>
<td>50 Km</td>
<td>GFDL/GAEA</td>
<td>Running</td>
</tr>
<tr>
<td>CM2.6</td>
<td>4-10 Km</td>
<td>50 Km</td>
<td>GAEA</td>
<td>Running</td>
</tr>
</tbody>
</table>

*Delworth et al. (2012, J. Clim., in press)*
TC Tracks in CM2.5 and Obs.

(a) IBTrACS

(b) CM2.5

Kim et al. (2012, in prep.)
50-Year Genesis per Basin

Kim et al. (2012, in prep.)
Mean Regression to SOI


GFDL-CM2.5 Cyclone Density (Yrs. 31-100)

Cyclone Density: Gale-force days per Year per 5°x5° gridcell

Observed Cyclone Density

GFDL-CM2.5 Cyclone Density

Impact of La Niña: Regression of TS Density to SOI (TS-day/5°x5°)

Kim et al. (2012, in prep.)
Global Surface Temperature Response to 2xCO$_2$

1% per year

CO$_2$ increase

CO$_2$ held fixed at twice initial value

Delworth et al (2011)
Global Surface Temperature Response to 2xCO₂

CM2.1 (lo-res)

CM2.5 (hi-res)

CM2.5 C03 (2xCO2 minus 1xCO2)

(a) The number of TC Genesis

(b) The number of TC Passage

(c) Days of TC occurrence

(d) PDI

unit: yr^{-1}

unit: days yr^{-1}

unit: 10^4 (m/s)^3 + days yr^{-1}

Kim et al. (2012, in prep.)
In CM2.5, seasonal phase-locking of MDR SSTA variability shifts in response to 2xCO2: interannual variability of Natl TCs increases.

(a) Standard deviation of interannual variations of SST averaged in MDR (°C)

- Control run
- 2xCO₂ run

<table>
<thead>
<tr>
<th></th>
<th>(a) Mean $\sum_{y=91}^{y=140} f(y) / 50$</th>
<th>(c) Warm SST$_{MDR}$ years</th>
<th>(d) Cold SST$_{MDR}$ years</th>
</tr>
</thead>
<tbody>
<tr>
<td>Observation</td>
<td>6.51</td>
<td>+0.95</td>
<td>-1.28</td>
</tr>
<tr>
<td>CM2.5-Control</td>
<td>6.56</td>
<td>+2.12</td>
<td>-1.07</td>
</tr>
<tr>
<td>CM2.5-CO₂ doubling</td>
<td>5.88</td>
<td>+2.55</td>
<td>-1.42</td>
</tr>
<tr>
<td>CO₂ doubling run minus Control run</td>
<td>-0.68</td>
<td>+0.43 (±20%)</td>
<td>-0.35 (-33%)</td>
</tr>
</tbody>
</table>

Doi and Vecchi (2012, in prep.)
Thought for addt’l experiment

• Force AGCMs with MME pattern of SSTA from coupled models’ CO2 response + CO2 doubling in AGCM.

MME either from:

• CMIP3/CMIP5
• High-res CGMCs
Coupled version of Zhao et al. HiRAM
Figure 1. Tropical cyclone tracks for 50 years of observations (IBTrACS, 1960–2009) and model simulations (CM2.5, 1910–2040). Boxes denote the sub regions.

TC Tracks in CM2.5 and Obs.  

Kim et al. (2012, in prep.)
Figure 5. Composite of all TCs in CM2.5 control run. (a) surface wind speed, (b) precipitation, (c) sea level pressure, and (d) relative vorticity at 850 hPa.

Kim et al. (2012, in prep.)
Some Aspects of Tropical Climate Improve with Resolution

Annual Tropical Precipitation on 2.5x2.5 Grid

Adapted from Delworth et al (2011)
Interannual standard deviation of SST

(a) Obs (ERSST.v3 1949–2008)

(b) CM2.1 1990 Control Run (1–300)

(c) CM2.5 1990 Control Run (1–280)

Delworth et al. (2012, J. Clim., in press)
Figure 17 DJF 200-hPa geopotential height anomalies regressed onto DJF NINO3 SSTA\textsuperscript{s}, computed using (a) the NCEP/NCAR Reanalysis (Kistler et al. 2001) for 1961-2001; (b) the CM2.1 1990 control run for years 11-290; (c) the CM2.5 1990 control run for years 11-0270. The zero contour is omitted. Green shading in all panels indicates the positions of the observed extrema over the North Pacific and Canada. Prior to computing the seasonal anomalies and regressions, all time series were detrended by removing a 20-yr running mean.