How Well Do Global Climate Models Simulate the Variability of Atlantic Tropical Cyclones Associated with ENSO?

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Outline

1. Background
2. Models & data
3. Results: AMIP vs. OBS
   - Model statistics
   - Track density & origins
   - Vertical wind shear
4. Conclusions
Background Information

ENSO influence on the variability of Atlantic TCs

Kim, Webster, and Curry, Science (2009):
Impact of shifting patterns of Pacific Ocean warming on North Atlantic TCs
US CLIVAR Hurricane Working Group
Interannual Experiments

AMIP runs: 1982–2009 (28 years), prescribed HadSST

ENSO events during 1982–2009
Questions to be addressed

- How is the overall performance of global climate models in simulating the variability of Atlantic TCs?
- What are the characteristics of Atlantic TCs associated with ENSO in the models?
- What are the possible explanations for the differences between the models and OBS?
## Models

**4 models, 12 ensemble members**

<table>
<thead>
<tr>
<th>Model</th>
<th>Number of runs</th>
<th>Data grid</th>
</tr>
</thead>
<tbody>
<tr>
<td>FSU</td>
<td>3</td>
<td>384 × 192</td>
</tr>
<tr>
<td>GFDL</td>
<td>3</td>
<td>576 × 360</td>
</tr>
<tr>
<td>NASA GSFC</td>
<td>1</td>
<td>576 × 361</td>
</tr>
<tr>
<td>NCEP GFS</td>
<td>5</td>
<td>360 × 181</td>
</tr>
</tbody>
</table>

Resolution: 0.5° ~ 1°

**MME:** (1) ensemble means for each model
(2) average of the individual ensemble means
Data

Observations
- Best Track Data (HURDAT2)
- HadSST
- CMAP Precipitation
- NCEP–DOE Reanalysis (R2)

Model data
- Track density
- TC origin
- Precipitation
- U200–U850

ASO seasonal mean
A, B, C, D – ensemble mean of individual models
MME – average of the ensemble means of individual models
# TC Statistics

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>Trend</th>
<th>AC</th>
<th>RMSE</th>
<th>Rank</th>
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<tbody>
<tr>
<td><strong>OBS</strong></td>
<td>11.7</td>
<td>3.9</td>
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<tr>
<td><strong>MME</strong></td>
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<td>2.1</td>
<td>0.82</td>
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<td>Model A</td>
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<td>Model C</td>
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<td>2.2</td>
<td>0.75</td>
<td>11.5</td>
<td>5</td>
</tr>
</tbody>
</table>

**AC** – anomaly correlation  
**Trend** – increase of TCs per decade  
**MME** – average of ensemble means of all individual models
## TC Statistics

### Number of TCs (per season)

<table>
<thead>
<tr>
<th></th>
<th>Mean</th>
<th>EP El Nino</th>
<th>CP El Nino</th>
<th>La Nina</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>OBS</strong></td>
<td>11.7</td>
<td>6.8</td>
<td>10.0</td>
<td>14.9</td>
</tr>
<tr>
<td><strong>MME</strong></td>
<td>14.8</td>
<td>12.2</td>
<td>13.9</td>
<td>16.0</td>
</tr>
<tr>
<td>Model A</td>
<td>10.3</td>
<td>7.6</td>
<td>11.2</td>
<td>9.5</td>
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<tr>
<td>Model B</td>
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<td>11.0</td>
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<tr>
<td>Model C</td>
<td>13.5</td>
<td>11.8</td>
<td>12.0</td>
<td>15.3</td>
</tr>
<tr>
<td>Model D</td>
<td>22.7</td>
<td>19.8</td>
<td>21.2</td>
<td>23.9</td>
</tr>
</tbody>
</table>

### Mean – 1982–2009 climatology
### ENSO – mean value for each ENSO category
### % – percent of climatological mean value
Sampling issue
Grid for track density (1° × 1°)
Model A

**Track Density**

Climatology

EP El Nino

CP El Nino

La Nina

**Anomaly**

EP El Nino

CP El Nino

La Nina

Ensemble mean for each model
Model B

Track Density

Climatology

EP El Nino

CP El Nino

La Nina

Anomaly

EP El Nino

CP El Nino

La Nina
Model D

Track Density

Climatology

EP El Nino

CP El Nino

La Nina

Anomaly

EP El Nino

CP El Nino

La Nina
MME

Track Density

Climatology

EP El Nino

CP El Nino

La Nina

Anomaly

EP El Nino

CP El Nino

La Nina
Track Density Anomaly

Model A
EP El Nino
CP El Nino
La Nina

Model B
EP El Nino
CP El Nino
La Nina

Model C
EP El Nino
CP El Nino
La Nina

Model D
EP El Nino
CP El Nino
La Nina
5-yr total for each ENSO category
ASO U200–U850

Climatology  OBS

U200 – U850
Mean Bias

Model A – OBS

Model B – OBS

Model C – OBS

Model D – OBS

-10 -8 -6 -4 -2 0 2 4 6 8 10
Precipitation
Changes in vertical wind shear associated with the shift of El Nino SSTA from Nino3 region to Nino4
Conclusions

1. Each model has different mean biases in terms of track density and TC origin. Model B is the best model.

2. The MME has the highest anomaly correlation (AC) for TCs.

3. Overall the models simulate the variability of Atlantic TCs well with weaker activities during EP El Niño and stronger activities during La Niña.

4. For CP El Niño, there is an increase in TCs as compared with EP El Niño. The spatial distribution is less consistent among the models.

5. The differences between the models and OBS may be due to the mean bias, as well as the bias of circulation response to the shift of tropical heating associated with CP El Niño.