Tropical Cyclones and precipitation in 25 Km CAM4 and CAM5

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*Thanks to DoE, Warren Washington for computer time*
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*Spectral Element Dycore implemented*
Existing High-Resolution Experiments

CAM 4:

*FV dycore 0.23x0.31*
- 1979-present. 2 runs, 1 with GFDL tracking data available 6-hrly, 1 with everything recoverable but U850,V850.
- Future time-slice 2080-2100 (present day climo SSTs)+(CMIP5 RCP8.5 perturbation) **HadISST SSTs**

CAM5:

*FV dycore 0.23x0.31*
- 1979-present (*Michael Wehner LBNL, prescribed BAM aerosols*)
- 18 month runs (2005-6) (*Both prescribed BAM and predicted MAM aerosols*)
- 18 month run w/out deep convection scheme
- 18 month runs w/precipitation loading effects

*Spectral element (SE) dycore ~25km*
- 12+ months (climo ssts)

*Spectral element (SE) dycore ~12.5km*
- Ongoing AMIP run 2004-
Precipitation and tropical cyclone comparisons

Future (RCP8.5)

Present day

CAM4

CAM4 CAM5

TC analysis in CAM4 just beginning
**Total precip.**

PRECT  Global mean=3.2 mm d\(^{-1}\)

**Large Scale precip.**

PRECL  Global mean=1.6 mm d\(^{-1}\)
CAM4-future  **Total precip.**
08/2100  PRECT  Global mean=3.1 mm d\(^{-1}\)
PRECT  Global mean=3.1

CAM4-present
**Total precip.**
PRECT  Global mean=3.0 mm d\(^{-1}\)
PRECT  Global mean=3.0

**Large Scale precip.**
PRECL  Global mean=2.1 mm d\(^{-1}\)
PRECL  Global mean=2.1

**Large Scale precip.**
PRECL  Global mean=1.9 mm d\(^{-1}\)
PRECL  Global mean=1.9
PDFs of instantaneous precipitation intensity 30°S-30°N (August)
PDFs of instantaneous precipitation intensity 30°S-30°N (August)
Tropical storm - Category 5 1982-2000 (CAM5)
Tropical storm-Category 5 2003-2005

(CAM4)
Problems in Central Pac both CAM4 and CAM5
Tropical storm - Category 5 2003-2005

Significantly reduced TCs in N Atl in CAM4

CAM4
Tropical storm - Category 5
2005 JJASON

(CAM4)

(CAM5)

(IBTrACS)
Time spent at Categories by tropical cyclones (hours)
All basins

Northern hemisphere TC season June – Dec

IBTrACS 2004, 2005
CAM5 (2 runs)
CAM4 present 2003+2004+2005

Tracking algorithm misses features in earliest phase
Four storms with highest wind speeds CAM4 2004 JJASOND

Shown: Precipitation within 350 km radius of storm center, every 24 hours
Four *W Pacific* storms with highest wind speeds CAM5 2005 JJASOND

Shown: Precipitation within 350 km radius of storm center, every 24 hours
Time series of precipitation following storms in CAM5; *core* \( r < 50 \text{km} \) (black) and *storm exterior* \( 500 \text{km} > r > 250 \text{km} \)

*Convective and large-scale precipitation separated*
Time series of precipitation following storms in CAM5; **core** $r<50\text{km}$ (black) and **storm exterior** $500\text{km}>r>250\text{km}$

Convective and large-scale precipitation separated
Precipitation time series in **storm cores** (black), **storm exteriors** (red). Convective precip (dashed), Large-scale precip (solid). Thin blue lines show surface pressure. **Note overwhelming dominance of LS in cores**.
Time spent at Categories by tropical cyclones (hours)

All basins

Northern hemisphere TC season June – Dec

IBTrACS 2004, 2005
CAM5 (2 runs)
CAM4 present 2003+2004+2005
Time spent at Categories by tropical cyclones (hours)
All basins

Northern hemisphere TC season June – Dec
2003,2004,2005 vs. 2097,2098,2100

CAM4 present

CAM4 future
2003, 2004, 2005 vs. 2097, 2098, 2100

CAM4 present

CAM4 future

N.E. Pacific more active
2003, 2004, 2005 vs. 2097, 2098, 2100

CAM4 present

CAM4 future

N. Atlantic remains inactive
2003, 2004, 2005 vs. 2097, 2098, 2100

CAM4 present

CAM4 future

Cat 4 in Persian Gulf
TS anomaly; JJASON 2097,2098,2100 vs. climo (2080-2100)
Topographic effects on precipitation with increasing resolution
Much improved spatial pattern and magnitude of rainfall

- Western India and Bay of Bengal
- Longstanding wet bias over Yemen, Oman and Saudi Arabia
- Somali jet more realistic

Courtesy Rich Neale
CAM4 US Precipitation

Winter (DJF)

Observed (TRMM)

CAM4 (0.25°)

CAM4 (1°)

Elevation (meters)

- 200
- 500
- 1000
- 2000

mm/day
High-resolution/rough topography. Flow steered north into SE US carrying moisture
Total Precipitation (JJA)

(mm day$^{-1}$)

Initial implementation of CAM-SE uses very smooth topography. Reduces improvement in precipitation patterns related to topography.

Courtesy Rich Neale
Conclusions

Cyclogenesis with CAM4 physics weaker than with CAM5 physics, especially in North Atlantic basin
  -tropical storms sizes more similar in CAM4?

RCP8.5 seems to produce only weak impacts on CAM4 TC climatology

Simulated tropical cyclone cores are completely dominated by large-scale precipitation

There is probably a trade-off between topographic smoothing and regional improvements in precipitation w/ resolution
Questions and Future Work

Time slices with CAM5

Is weak cyclogenesis with CAM4 physics vs CAM5 related to large-scale variables or to physics? Calculate potential intensity diagnostics etc..

Implement GFDL cyclone tracking codes