High-resolution climate modeling: A tool to study extreme weather on decadal timescales

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High-Resolution Climate Modeling: Spatial Scale of Sandy

OLR (W/m²)

August 9th, 2017  Courtesy of Colin Zarzycki (NCAR)
CAM5 - 100 km
Storm Tracks - AMIP

August 9th, 2017

[Wehner et al. 2014, JAMES]
CAM5 - 25 km
Storm Tracks - AMIP

[Wehner et al. 2014, JAMES]
Observed vs. CAM5
Annual Mean Precipitation

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[Wehner et al. 2014, JAMES]
Observed vs. CAM5
Precipitation Distribution

(a) Global
(b) Global Land
(c) Tropics
(d) CONUS

[Wehner et al. 2014, JAMES]

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mm/day
Observed vs. CAM5
Extreme Precipitation

Annual Maximum
5-day Accumulated Precipitation (Rx5day)

Wehner et al. 2014, JAMES
General Design of Decadal Simulations

- National Center for Atmospheric Research’s (NCAR) Community Atmosphere Model version 5 (CAM 5).
- General, two dynamical core options, FV or SE with 30 vertical levels is used at the horizontal resolution of:
  - $\Delta x = 0.25^\circ$; ne=120; ~25 km
  - See Reed et al. (2015) for dynamical core impact on tropical cyclones.
- Full physics with Atmospheric Model Intercomparison Project (AMIP) protocols for 1980-2005 (thru 2012 in some cases). Then 2070-2100 for RCP8.5 climate.
- Prescribed observed (or projected) SSTs, ozone, CO$_2$, solar forcing, etc.
- The impact of aerosol model and airborne dust is explored.
North Atlantic Tracks: Comparison of Aerosol Config.

- Large differences between CAM5 and observations, and amongst the models.
- But general distribution of TC is reasonable.
Landfalling TCs in Eastern US

Track Density over Land

Observations

CAM5-FV-BAM

CAM5-FV-MAM

Landfalling Storm Density

IBTrACS Landfalling TCs Track Density

BAM Landfalling TCs Track Density

MAM Landfalling TCs Track Density

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Connection Shown in Observations

- There is a correlation between dust and hurricanes in the observational record.

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[Evan et al. 2006 and Dunion & Velden 204]
Correlation between TC count and average AOD over Main Development Region is negative (-0.43 to -.49) in observations.

Only prognostic aerosol (MAM) configuration captures this negative correlation (-0.34) well.

What if dust is removed from MAM?
Future Climate Scenarios: Global Statistics

Note: These are now with the CAM5-SE configuration.
• Appears to be a robust decrease in storms in the North Atlantic.
• Though, the magnitude of the decrease is dependent on the sea surface temperatures.

Note: These are now with the CAM5-SE configuration.

[Bacmeister et al. 2016, Climatic Change]
• **Project Focus:** Understand which metrics are most important to stakeholders and assess regional climate datasets in this context.

• **Stakeholder outreach:** Representation in the project from water managers in each region plus USGS, Army Corps of Engineers, Bureau of Reclamation.
Meteorological Metrics:
- **Precipitation Character and Extremes:** Origins of rainfall (large-scale vs. convective, coastal storms, NAMS, MCS). 90, 95 and 99 percentile rain events.
- **Mesoscale Convective Systems:** Representation of mid-level vortices and propagation relative to observations.
- **North American Monsoon System:** Timing and character of the monsoon system.
- **Atmospheric Rivers:** Landfall location, total overland precipitation, frequency.
- **Coastal Storms:** Storm frequency, spatial structure, size, overland precipitation, rain/snow partitioning.
- **Sea Breeze:** Occurrence and strength.

Hydrological Metrics
- **Mountain Snowpack:** Total snow water equivalent, snow cover, windward/leeward partitioning of snowpack, total snow per watershed.
- **Streamflow:** Annual maximum simulated flow, Nash Sutcliffe model efficiency
- **Flooding:** Flood occurrence frequency and intensity
- **Aridity:** Standardized Precipitation Index, Palmer Drought Severity Index

Integrated Metrics
- **Water Demand:** Combining temperature and precipitation with simplified models of water demand based on observations.
Atmospheric Models
- Dynamical Downscaling (WRF and RegCM), Hybrid Downscaling, Variable-Resolution Modeling (CESM and ACME), Statistical Downscaling

Links with Hydrologic Models
- WEAP, ALM-MOSART, CLM-PAWS

Time Periods
- Baseline Historical: 1986 - 2015
- Near-Term Future: 2016 - 2055
• The decadal CAM5 simulations compare reasonably well to global hurricane counts (and other extreme weather events). BUT, there are still biases regionally.

• We can start to use these models to explore climate controls of TCs (and other extremes) at decadal timescales.

• Significant work has been done by other modeling groups (i.e., US CLIVAR Hurricane Working Group, HiResMIP) and for other extremes (as we have seen this week).

• The number of TCs decreases globally in a warming climate in CAM5, while the intensity of the strongest storms increases. This is also true in individual regions.

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