Hurricane prediction using initialized high-resolution CESM

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TCs (hurricanes) and resolution

Defense Meteorological Satellite Program (DMSP) image of Hurricane Isabel at 1315 UTC 12 Sep 2003

~ 1000 km

Slide inspired by Kevin Reed
TCs (hurricanes) and resolution

Defense Meteorological Satellite Program (DMSP) image of Hurricane Isabel at 1315 UTC 12 Sep 2003
CAM-SE “forecast mode”

- 0.5° (~55 km)
- 0.125° (~13 km)
CAM-SE “forecast mode”

- CAM 5.2 (CESM 1.2.0)
- Every 12 hours (00Z and 12Z) from August 1\textsuperscript{st} to November 1\textsuperscript{st} for 2012-2013
- Initialization (psuedo-“cold” start)
  - **Atmosphere**: GFS analysis, forward DFI (Fillion \textit{et al.}, 1995)
  - **Ocean**: Prescribed SSTs/ice (GFS analysis) -> PERSISTENCE
  - **Land**: active (initial cycled spinup, then 12 hourly forecast used for init)
- 8 day forecast = \(~1.5\) hours of wall clock time on 800 cores (YS)
  - \(~10\)x cheaper than a globally-uniform 13 km forecast

Sandy TPW: INIT 12Z
10/25/12
Some “cold” start notes...

- SE dycore -> less implicit diffusion, gravity wave noise from cold starts, need digital filter initialization (DFI)
- Not as big of an issue with dycores with implicit diffusion (FV, MPAS, FV3, etc.)

- DART in CESM -> more faithful representation of TC on native grid?
- Talk to Kevin Raeder!
Resolution comparison

Sandy 500 hPa vorticity: INIT 00Z 10/23/12
Resolution comparison

Sandy 500 hPa vorticity: INIT 00Z 10/23/12

2012-10-28-00000

V-R, 55 km -> 13 km
Uniform 13 km
Uniform 55 km

Zarzycki et al., 2015, MWR
Measuring forecast skill

CAM-SE Isaac Init: 00Z 08 21 2012

Valid: 00Z 08 29 2012

850 mb wind (color, m/s), SLP (contour, mb)

Intensity error
Track error
CAM-SE “forecast mode” control

- Refinement improves both track, intensity skill
- Track behavior of TCs looks good...
  - Within envelope of operational NWP models!
- ... CAM exhibits a high bias in TC intensity, especially as the solution moves away from initial state
CAM-SE “forecast mode” sensitivity

- Sensitivity simulations
  - Choose 20 worst CAM forecasts (high wind bias)
    1. Turn off deep convection (CAMY)
    2. Decrease dtime (and deep convective relaxation time) by 4x (CAMX)

Zarzycki et al., 2015, MWR
Hurricane Sandy forecasts

U.S. forecast's late arrival stirs weather tempest

Will U.S. Hurricane Forecasting Models Catch Up to Europe?
A year after Hurricane Sandy, Europe's forecasting technology is still tops.

Hurricane Sandy shows Europe widening forecasting lead
Hurricane Sandy forecasts

Sandy Numerical Forecasts

20121022_000000

20121022_120000

20121023_120000

20121023_000000

Observations

CAM members
CAM ens. mean
CAM-CLUBB

GFS (oper.)
GEFS members
GEFS ens. mean

Zarzycki et al., 2015, MWR
Hurricane Sandy forecasts

Sandy Numerical Forecasts

20121024_000000

Observations

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Zarzycki et al., 2015, MWR
Hurricane Sandy forecasts

CAM uses **same** initial conditions as GFS, correctly forecasts recurvature -> exonerates data assimilation?

Dycore impact? Possibly, but more than likely, choice of **physical parameterizations** key in track differences (ex: Bassill 2014)

Zarzycki et al., 2015, MWR
Surface energy biases

- Part of “high bias” in initialized CAM TCs due to non-interactive ocean
- New “slab ocean” with turbulence param.
- Issue? TCs sensitive to biases in mean SST

Summary

• Using initialized CAM/CESM with variable-resolution...
  • Verifies V-R dynamics
  • Allows for understanding/verifying/tuning very-high resolution configurations

• Future directions:
  • Continued initialized experiments with CAM6/CESM2 to explore high-res behavior
  • Couple to slab ocean w/ mixing and/or address ocean biases
  • Seasonal-to-subseasonal (S2S) prediction
    • Unique niche for CESM to exploit?