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Numerical Modeling of a Heavy Rainfall Event in a Future Climate

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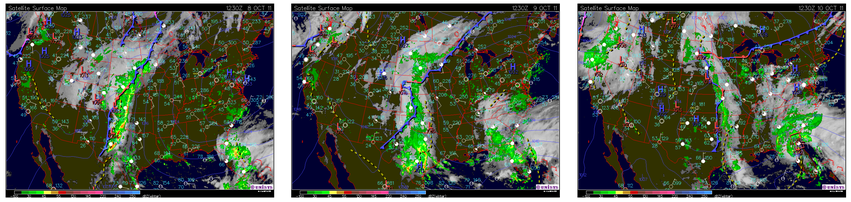
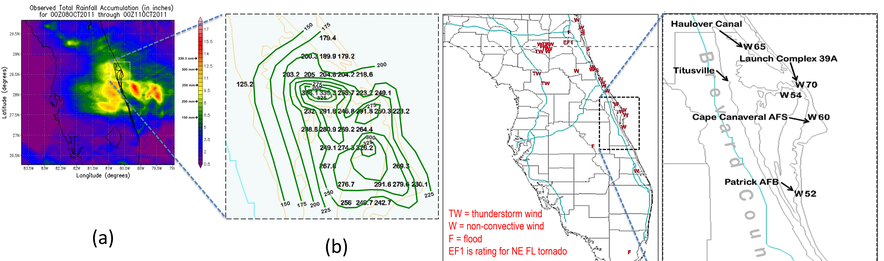
Introduction

Follow-on to Lanicci et al. (2017) observational-numerical study of 2011 Columbus Day Weekend Hybrid Storm over Florida (see Figs. 1 and 2 for overview), as part of extreme rainfall study for NASA Kennedy Space Center



(a) (b) (c)

Fig. 1. 1230 UTC satellite-radar-surface composite analyses for a) 8 Oct; b) 9 Oct; and c) 10 Oct



(a) (b) (c) (d)

Fig. 2. 3-day rainfall over a) Florida (in.), and b) KSC complex (mm); storm-damage reports over c) Florida, and d) KSC complex

WRF Simulations of Columbus Day Weekend Storm

Standard Configuration (same for all model runs)

- 75 vertical levels
- 1-D ocean physics
- YSU PBL scheme
- NCEP FNL Reanalysis for initial conditions

Microphysics, cumulus parameterizations, and nesting varied in order to determine optimum configuration for present-day climate simulations of case

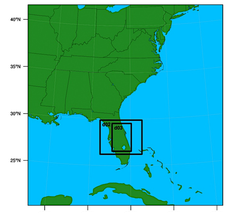
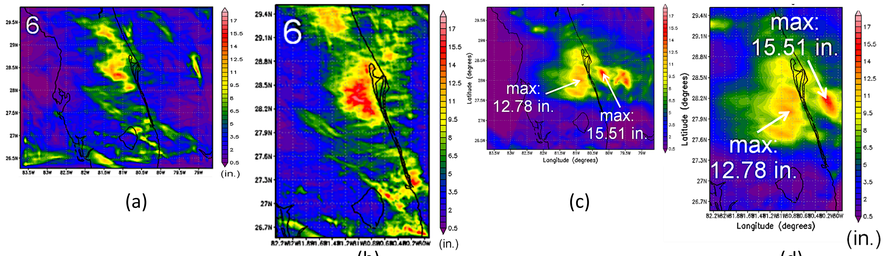


Fig. 3. Model domain showing triple nest:
d01: 12 km horiz. spacing
d02: 4 km horiz. spacing
d03: 1.33 km horiz. spacing

- Lin microphysics, BMJ cumulus scheme, and one-way nesting gave most accurate simulation of case in present climate (Lanicci et al. 2017)

Present-day Climate Simulation Results



(a) (b) (c) (d)

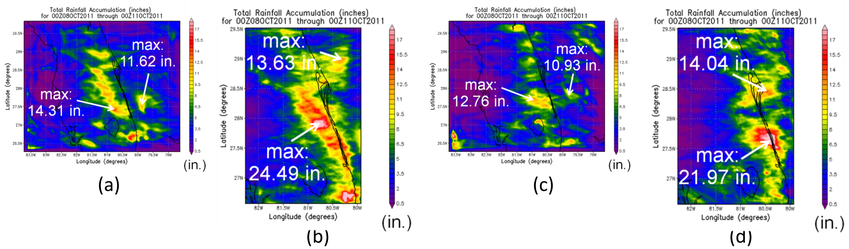
Fig. 3. 72-h predicted rainfall over a) d02; b) d03; 72-h observed rainfall over c) d02; d) d03.

- WRF-simulated rainfall over d02 (Fig. 3a) less than observed (Fig. 3c)
- WRF-simulated rainfall over d03 (Fig. 3b) agrees better with obs (Fig. 3d)
- WRF-simulated rainfall SE of Lake Okeechobee does not appear in obs
- WRF simulation did not capture rainfall over offshore areas S of KSC complex

Future Climate Simulations of Columbus Day Weekend Storm

- CMIP5 datasets (Taylor et al. 2012) used to generate WRF initial and boundary conditions; chose Representative Concentration Pathways RCP4.5 and RCP8.5
- After placing GCM data onto a common reference grid, "2090s – 1990s perturbations" calculated for temps following Nissenbaum et al. 2015 approach

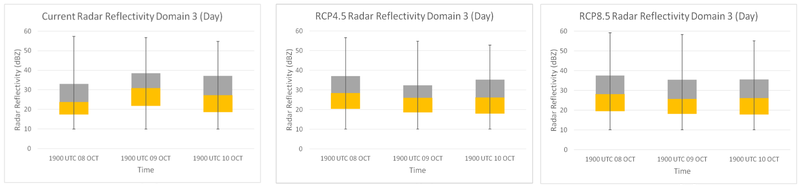
Future Climate Simulation Results



(a) (b) (c) (d)

Fig. 4. 72-h simulated rainfall accumulations (in.) for Columbus Day Weekend case: using RCP4.5 over a) d02 and b) d03; using RCP8.5 over c) d02 and d) d03.

Future Climate Simulation Results (-cont.)



(a) (b) (c)

Fig. 5. Box-and-whisker plots of simulated 975-hPa reflectivity (dBZ) for a) d03, current climate; b) d03, RCP4.5; and c) d03, RCP8.5. Each panel shows the reflectivity at 1900 UTC (1500 EDT) for 8, 9, and 10 October 2011. Grey areas on each plot denote the 3rd quartile range, while yellow areas denote the 2nd quartile range. The value separating the grey and yellow areas represents the median. Whiskers represent the maximum and minimum values.

Conclusions

- Mean RCP4.5 simulated rainfall is ***greater than*** the current climate simulation, with max grid point difference of 9.28 in. (235.7 mm) (Figs. 4a and b).
- RCP4.5 spatial rainfall patterns have a better-defined N–S rainfall maximum inland from the coastline than present-day climate simulation (Figs. 4a and b).
  - Suggests that RCP4.5 produced a better-defined and stronger sea breeze than the present-day climate simulation.
- Mean RCP8.5 simulated rainfall is ***lower than*** RCP4.5, a counterintuitive result given RCP8.5's warmer conditions than RCP4.5 (Figs. 4c and d).
- RCP8.5 spatial rainfall patterns suggest that sea-breeze front did not advance as far inland as it did during RCP4.5, is less well defined, and may explain the lower rainfall accumulations (Figs. 4c and d).
- Despite inconsistencies when comparing accumulated rainfall to simulated radar reflectivity (Fig. 5), the model runs suggest that future climates may be able to generate high, localized rainfall totals, even though the overall spatial averages may be lower than those in the present-day climate.

References

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