High-Resolution Simulation of the Succession of Hurricanes in 2008

Poster #: 405

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Abstract. The succession of the Atlantic hurricanes from August to September 2008 is used to assess the ability of the Weather Research and Forecasting model to simulate the simultaneous development of multiple tropical storms and their interactions. We discuss the potential of using the global Community Atmosphere Model along with high-resolution regional downscaling (or nesting) for projecting tropical-storm activity at seasonal to climate timescales.

Background

- The atmosphere over the Atlantic basin in 2008 favored enhanced tropical storm activity.
- Hurricanes Gustav, Hanna, Ike and tropical storm Josephine developed simultaneously and peaked less than one week apart (see Table 1).
- All three hurricanes and Josephine originated from tropical waves coming off the African coast.

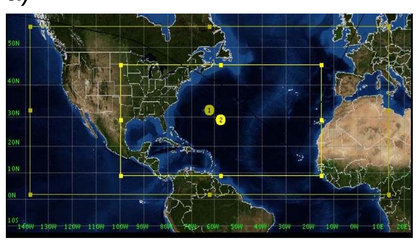
Table 1. Origin and Peak Time of the Hurricanes/Storm

	Date Wave Enters Atlantic	Peak Time	State on 27 Aug.
Gustav	13 Aug.	22Z, 30 Aug.	Tropical storm
Hanna	19 Aug.	00Z, 2 Sep.	Tropical Wave
Ike	28 Aug.	06Z, 4 Sep.	N/A
Josephine	31 Aug.	15Z, 3 Sep.	N/A

WRF Simulations

- Two-domain nesting with a 4 km x 4km resolution domain spanning the entire tropical Atlantic (Fig. 1a).
- WRFV3.0 driven by NCEP final analysis (FNL, 1 x 1).
- Simulations started on 27 Aug. at 00Z (initial sea level in Fig. 1 b), when the hurricanes/storm are at distinctly different stages of development (Table 1, column 4).
- Explicit convection for the high-resolution domain.
- Simulations done on New York State Computing Center (NYSCC)'s Bluegene/L.

a)



b)

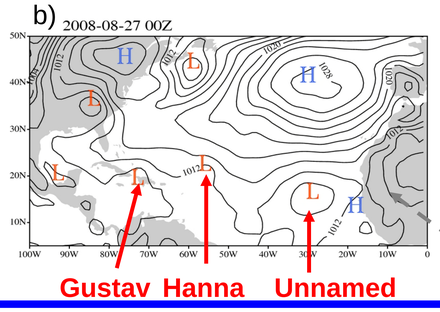


Fig. 1. a) The two-domain nesting (20 km x 20 km and 4 km x 4km) for WRF simulations. b)The sea-level pressure at the model start time from FNL analysis. Arrows point to the lows that are the positions of Gustav and Hanna at start time. The unnamed low would move westward but failed to develop further. The waves that eventually developed into Ike and Josephine had yet to move off the African coast.

WRF Results

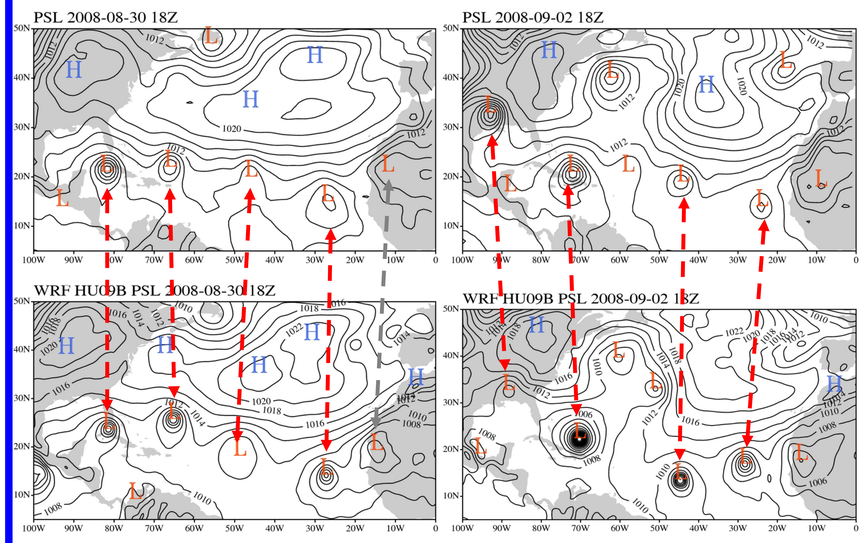


Fig. 2. Snapshots of sea-level pressures from FNL (top) and WRF (bottom) at 18Z, 30 Aug. and 18Z, 02 Sep., which show the simultaneous and successive development of storms. The arrows link the storms between the observations and simulations from left to right: Gustav, Hanna, unnamed, Ike, and Josephine. The unnamed low dissipated in the right panel.

- High-resolution WRF simulations show excellent agreement with observations in capturing the simultaneous development of multiple storms, the number of storms and their relative strengths at different times – even though the storms are at different stages when the simulation began and no bogus vortex is introduced. Even the aborted low between Hanna and Ike is reproduced. Eye-wall formations are clear at peak phases. These are shown clearly in the sea-level pressure (Fig. 2) and cloud images (Fig. 3).
- There is a strong tendency for storms to be overdeveloped except for Gustav (Figures 2 and 3, right panel). The cloud microphysical scheme may play an important role in the overdevelopment and will be investigated further.
- Ike and Josephine developed earlier than observed and the tracks are shifted to the south (Fig. 3 right panel and Fig. 4).

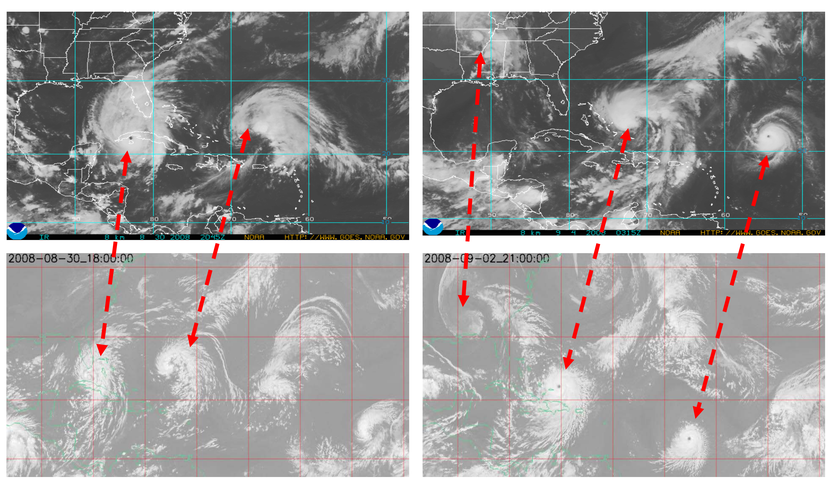


Fig. 3. Cloud images from satellite (top) and WRF (bottom) when Gustav and Ike peaked. Note that Ike developed early in model so the model image is from an earlier time.

WRF Results – *continued*

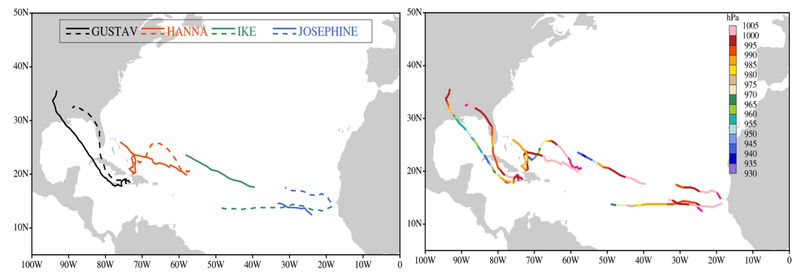


Fig. 4 The tracks of the observed (solid lines) and simulated (dashed lines) hurricanes/storm (left) and the minimum pressures along the tracks (right). The Gustav simulation is shifted eastward and is weaker than observed, Hanna is overdeveloped, and Ike developed much earlier.

CAM Simulations

- CAM5 initialized by NCEP final analysis (FNL, 1 x 1), SST from NOAA OISSTv2(weekly, 1 x 1)
- Simulations at coarse (T42, 2.8 x 2.8) and high (0.47 x 0.63) resolutions
- Simulations started on 27 Aug. 00Z, as for WRF.
- Waves in CAM at coarse resolution (not shown) are unable to develop to storm strength; the lifetime of lows are very short, much fewer storms, & little simultaneous development.
- CAM at high resolution has reasonable storm number and simultaneous development, though weaker in strength (Fig. 5).
- It is under way to use CAM forecast to drive high-resolution WRF, in order to explore how much the dynamical downscaling may improve simulation of the storm activities.

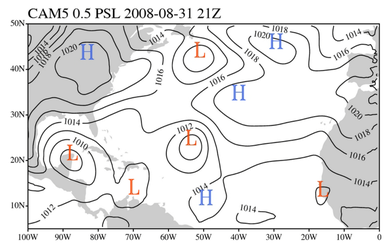


Fig. 5. Snapshot of sea-level pressure from the high-resolution CAM simulation that shows simultaneous development of storms corresponding to the succession of hurricanes in the observation.

Conclusion

- High-resolution WRF can properly simulate the simultaneous development of multiple hurricanes. The relative strength of the storms at different stages is well captured. Strength and track of individual storm appear to influence those of successive storms.
- CAM at coarse resolution has difficulty in simulating the simultaneous development of the storms. Individual storm tends to be underdeveloped, and the storm count underestimated. This poses a potential downscaling problem to reliably project storm activity, in particular with one-way approach. Two-way feedback may improve the storm seeding and development, and will be studied.
- Storms in CAM at high resolution, although still underdeveloped, are more realistic in terms of number and timing of simultaneous development.

Acknowledgement: This research is supported by DOE BER's ESM program to Stony Brook University.