



Using TCSP Observations to Evaluate Model Simulations of Hurricane Dennis (2005)

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1. Motivation

- Hurricane intensity forecasts have shown minimal improvement in last 20 years (Franklin 2007)
- Many factors limit our understanding of hurricanes. Methods of improving understanding include:
 - Incorporating more detailed representation of microphysics in numerical models
 - Quantifying temporal and spatial distribution of latent heating and how it impacts hurricane evolution

This study uses TCSP airborne radar and radiometer data to evaluate the performance of a numerical model with advanced microphysics for simulating cloud fields of Hurricane Dennis (2005) at 3 different stages of evolution: Tropical depression, tropical storm, and cat. 1 hurricane after Cuban landfall

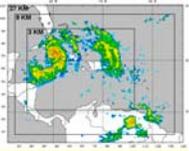


Fig 1. Model grid layout

2. Simulation Overview

- The Advanced Research Weather Research and Forecasting (WRF-ARW) model, version 2.2 is used with the following options:
 - NCEP GFS initial, boundary data
 - Simulation times: 00Z 4 July, 2005 to 00Z 10 July, 2005.
 - Three grids: dx = 27, 9, and 3 km. Nests placed July 5, 00Z or July 5, 12Z
 - Vertical levels: 54
 - Cumulus parameterization: Kain-Fritsch, outer grid only
 - Explicit microphysics: Thompson (2006) with 2007 updates

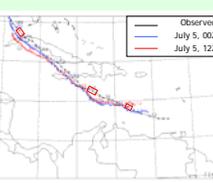


Fig 2. Observed and modeled hurricane tracks

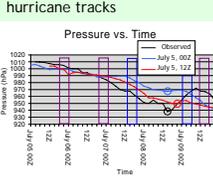


Fig 3. Observed and modeled min. central pressure. Purple boxes: TCSP observation times. Blue boxes: simulation times used for comparison (focusing on July 5, 00Z case). Circles: Cuban landfall.

3. Simulated and Observed Reflectivity

Statistically compare observed and modeled Z using contoured frequency by altitude diagrams (CFADs) (Yuter and Houze 1995) at 2 different stages of development

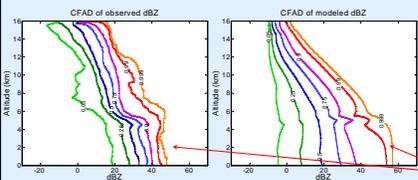


Fig 4. CFAD of dBZ from EDOP (left) and model (right) for comparison at tropical storm stage

Model over-predicts largest dBZ compared to ER-2 Doppler radar (EDOP)

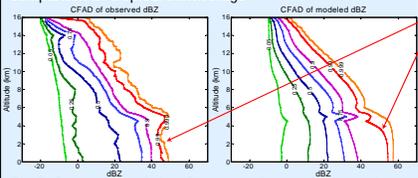


Fig 5. Same as Fig. 4, but for comparison at category 1 stage

- Model fails to capture differences seen in observed dBZ for observations made at 2 different intensities → Model does not capture changes in hydrometeor fields

4. Simulated and Observed T_b

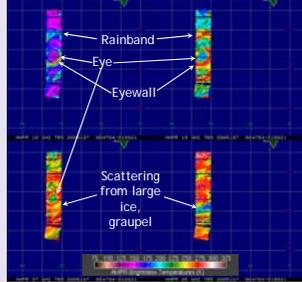


Fig 6. AMPR T_b with features of hurricane structure

- T_b computed from modeled fields using Kummerow radiative transfer model
- Additional calculation ($q_g = 0$) removes graupel contribution to T_b to determine if over-prediction of graupel noted in previous studies (e.g. McFarquhar et al. 2006) exists
- Clear pixels removed from observed and modeled T_b data using mask based on Hood et al. (2006) classification

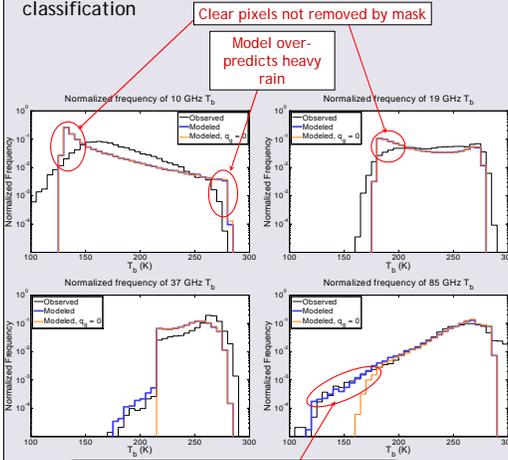


Fig 7. Normalized frequency histograms of T_b at 10, 19, 37 and 85 GHz for observation (black), model (blue) and model with graupel effects removed (red) for comparison at tropical storm stage

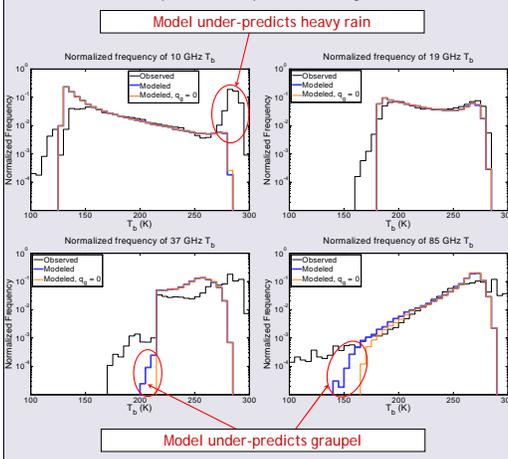


Fig 8. Same as Fig. 7, but for comparison at category 1 stage

- To extent presence of supercooled water does not affect interpretation of data, over-prediction of rain and graupel noted in past studies not present at later, more intense stages.

5. T_b Sensitivity to N_0

- Kummerow radiative transfer model assumes fixed intercept parameter (N_0) for snow, graupel
- N_0 dependent on mixing ratio in Thompson microphysics

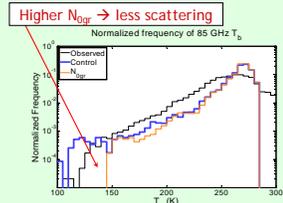


Fig 9. 85 GHz T_b for observation, control ($N_{0gr} = 8 \times 10^9$), and sensitivity test ($N_{0gr} = 8 \times 10^8$)

- Lack of variable N_0 can affect model/observed comparison
- Range of N_0 chosen to match ranges expected in modeled fields

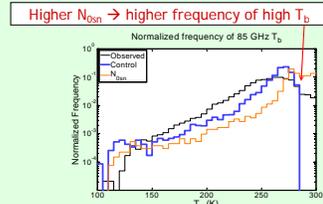


Fig 10. Same as figure 7, but for snow control ($N_{0sn} = 1.6 \times 10^7$) and sensitivity ($N_{0sn} = 1.6 \times 10^5$)

6. Summary

- TCSP ER-2 measurements were compared to simulated reflectivity, T_b to assess WRF results for 2 stages of Dennis (tropical storm and cat. 1 hurricane)
- Over-prediction of graupel, rain not noted for later observation of Dennis (cat. 1 hurricane)
- Model fields change little between tropical storm and cat. 1 stages, unlike observations
- Analysis tools for model data need to be consistent with model assumptions
- Introduce variable N_0 into Kummerow RT Model for consistency with microphysics
- Improve reflectivity algorithm to improve comparison with EDOP

7. Future Work

- Conduct 1 km simulations utilizing moving nest
- Incorporate highly-detailed microphysical parameterization (Straka Gilmore 2008)

8. References

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