4B.3

THE ROLE OF RADIATION IN ACCELERATING THE GENESIS OF ATLANTIC HURRICANE MATTHEW (2016)

Warren P. Smith *
University of Colorado Boulder, Boulder, Colorado

1. INTRODUCTION

Despite active study, there is still much left to discover about the transformation from a tropical disturbance into a tropical depression, a process known as tropical cyclogenesis. Further advancements in our understanding of tropical cyclogenesis will allow for increased lead times for large-scale evacuations which may save lives. Several recent studies have found that the presence of radiation in numerical models has a very pronounced effect on accelerating tropical cyclogenesis in both idealized (Nicholls and Montgomery 2013, Nicholls 2015) and case study simulations (Melhauser and Zhang 2014, Tang and Zhang 2016). In idealized simulations this appears to be primarily due to a weak nocturnal transverse circulation brought about from differential radiative heating between the cloudy disturbance and the surrounding cloud-free region. This causes a slow lifting motion (with vertical velocity on the order of millimeters per second) in the core of the system and weak compensating subsidence in the surroundings. The transverse circulation slowly moistens the core of the disturbance and provides a favorable environment for additional convection, thus contributing to a faster rate of tropical cyclogenesis as compared to simulations without radiation (Nicholls 2015). A "burst" of convection is observed in the morning which is consistent with previous work by Gray and Jacobson Jr (1977) regarding the most active hours of maritime convection.

A case study of Atlantic Hurricane Matthew (2016) will be performed to illustrate that radiation accelerates tropical cyclogenesis, and to examine the transverse circulation mechanism to explore its validity in a case study.

2. HURRICANE MATTHEW

Hurricane Matthew was a Category 5 Atlantic storm that made devastating landfall in Haiti, Cuba, and the southeast coast of the United States in October 2016. Matthew began as an easterly wave which exited the west coast of Africa on September 23, 2016.

* *Corresponding author address:* Warren P. Smith, University of Colorado Boulder, Department of Atmospheric and Oceanic Sciences, Boulder, CO, USA 80309; email: warren.p.smith@colorado.edu

Matthew eventually underwent tropical cyclogenesis near the Lesser Antilles on September 28 and reached a maximum sustained wind speed of 74.6 m/s on October 1 at 0Z. The minimum pressure of 934 hPa was observed on October 4 at 0Z, as measured by a dropwindsonde. Matthew was responsible for 585 direct deaths and the evacuation of roughly 4 million people from coastal areas. Total damages were estimated at $15 billion US dollars, including about $10 billion along the coasts of Florida, Georgia, and the Carolinas (Stewart 2017). Because of the socioeconomic impacts of storms like Matthew, it is worthwhile to study the processes that lead to their development and intensification so that we may improve evacuation lead times, thereby reducing the loss of human life.

3. METHODOLOGY

Results will be presented from a numerical modeling case study of Hurricane Matthew's genesis near the Lesser Antilles and its early intensification using the Weather Research and Forecasting Model version 3.8 (WRF-ARW, Skamarock et al 2008). Sensitivity to choices of radiation scheme will be explored, including cases without radiation and shortwave and longwave only, compared to a control simulation with both longwave and shortwave radiation which closely matches Matthew's observed track and intensity. A comparison of these simulations will illustrate that radiation plays a critical role in the development of the tropical cyclone. The horizontal distribution of vertical relative vorticity and convection (Vortical Hot Towers, Hendricks et al 2004) will be examined to illustrate the role of the transverse circulation in moistening the system's core and accelerating tropical cyclogenesis in the presence of radiation. The low level tangential component of the wind and a smoothed sea level pressure minimum will be used for comparison of Matthew's intensity in WRF-ARW simulations with the National Hurricane Center's Best Track data.

3.1 Main Hypotheses

It is expected that the presence of radiation schemes will dramatically accelerate tropical cyclogenesis, consistent with a wide body of literature. It is also expected that longwave radiation has a more pronounced impact on the system than shortwave radiation, which will be illustrated in "shortwave only" and "longwave only" simulations. The previously discussed transverse circulation mechanism is most active overnight when shortwave radiation is absent, which will cause the “longwave only” simulation to be similar to the simulation with both longwave and shortwave radiation.

4. REFERENCES

Gray, W. M. and Jacobson Jr, R. W., 1977. Diurnal Variation of Deep Cumulus Convection. *Monthly Weather Review,* 105, 1171-1188.

Hendricks, E. A., Montgomery, M. T., and Davis, C. A., 2004: The Role of Vortical Hot Towers in the Formation of Tropical Cyclone Diana. *Journal of the Atmospheric Sciences,* 61, 1209-1232.

Melhauser, C. and Zhang, F., 2014: Diurnal Radiation Cycle Impact on the Pregenesis Environment of Hurricane Karl (2010). *Journal of the Atmospheric Sciences,* 71, 1241-1259.

Nicholls, M. E. and Montgomery, M. T., 2013: An Examination of Two Pathways to Tropical Cyclogenesis Occurring in Idealized Simulations with a Cloud-Resolving Numerical Model. *Technical Report, DTIC Document.*

Nicholls, M. E., 2015: An Investigation of how Radiation may cause Accelerated Rates of Tropical Cyclogenesis and Diurnal Cycles of Convective Activity. *Atmos. Chem. Phys. Discuss.,* 15, 6125-6205.

Skamarock, W. C., Coauthors, 2008: A Description of the Advanced Research WRF Version 3. *NCAR Technical Note / TN-475+ STR.*

Stewart, S. R., 2017: Hurricane Matthew (AL142016), *National Hurricane Center Tropical Cyclone Report.*

Tang, X., and Zhang, F., 2016: Impacts of the Diurnal Radiation Cycle on the Formation, Intensity, and Structure of Hurricane Edouard (2014). *Journal of the Atmospheric Sciences,* 73, 2871-2892.