Ph.D. Defense Announcement
Naufal Razin
Wednesday, October 27, at 2:30 p.m. MT

Naufal Razin
Ph.D. Defense

October 27, 2021
2:30 p.m. MT

Defense
ATS Large Classroom (101 ATS) or in Zoom (full meeting information below)

Post Defense Meeting
Riehl Conference Room (211 ACRC)

Committee:
Michael Bell (Adviser)
Christian Kummerow
Kristen Rasmussen
Michael Kirby (Mathematics)

Satellite-based Investigation of Convection and Precipitation in Tropical Cyclone Intensity Change

Multiple hypotheses on the role of convection and precipitation in tropical cyclone intensity change have been proposed, but a scientific consensus has not yet been obtained. Some recent studies emphasize the importance of asymmetric deep convection in intensification, while others emphasize the importance of more symmetric precipitation that is not necessarily deep. To help provide clarity on this issue, this dissertation analyzes a large dataset of satellite passive microwave observations in order to obtain a sufficient sample size, which enables us to minimize the impact of the tropical cyclone environmental variability on intensity.

The first part of this dissertation involves compiling an extensive research-quality and open-access dataset of low-Earth orbit (LEO) satellite passive microwave observations centered on tropical cyclones, called the Tropical Cyclone Precipitation, Infrared, Microwave, and Environmental Dataset (TC PRIMED). TC PRIMED consists of tropical cyclone-centric 1) inter-calibrated, multi-channel, multi-imager microwave brightness temperatures, 2) retrieved rainfall from NASA's Goddard Profiling algorithm (GPROF), 3) nearly coincident geostationary satellite infrared imagery, and 4) auxiliary data such as tropical cyclone position and intensity, ERA5 fields and derived environmental diagnostics, and satellite precipitation radar variables. TC PRIMED includes observations from over 168,000 LEO satellite overpasses of 2,101 tropical cyclones from 1998 to 2019. A simple composite analysis demonstrates the huge potential of TC PRIMED.

The second part of this dissertation uses the Global Precipitation Measurement (GPM) satellite observations from TC PRIMED to train a random forest model to classify the precipitation type (i.e., convective and stratiform). The model uses raw and derived passive microwave brightness temperature variables as input predictors and observations from the GPM dual-frequency precipitation radar as reference. This approach leverages the wider swath of the GPM passive microwave observations to obtain a larger sample size of precipitation type observation for the subsequent study on the importance of convection and precipitation in tropical cyclone intensity change. The random forest model performs very well at delineating clear air from stratiform and convective precipitation, and captures key features like the tropical cyclone eye, eyewall, and primary rainbands. However, the model struggles to detect some finer features like randomly scattered convection. Analysis of the model's performance demonstrates the importance of passive microwave texture information for precipitation type classification.

The final part of this dissertation uses the tools developed in parts one and two to investigate the distribution of convection and precipitation in tropical cyclone intensity change. This analysis minimizes the impacts of the environmental variability on intensity by only selecting observations of tropical cyclones in favorable environments. Results reveal that intensifying minor tropical cyclones have a more symmetric distribution of rainfall that is not necessarily convective, while intensifying major tropical cyclones have more numerous and intense deep convection in the upshear quadrants. The results lead to the following hypotheses: i) for minor tropical cyclones, a more symmetric distribution of rainfall is more efficient at intensifying the tropical cyclone, and ii) the occurrence of deep convection in the upshear quadrants of major tropical cyclones is optimal for intensification.

Topic: Ph.D. Defense: Naufal Razin
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