Improved Understanding and Diagnosis of Tropical Cyclone Structure and Structure Changes

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The goal of the proposed work is to develop new tools that enhance the current capabilities to diagnose tropical cyclone (TC) structure and location using GOES-R advanced baseline imagery (ABI) and GOES lightning mapper (GLM) proxies. The GOES-R Algorithm Working Group presently supports but one TC algorithm, which estimates TC intensity. While intensity is an important operational TC metric, the diagnosis and forecasts of the wind field structure is also an operational requirement and is often considered equally important in determining the impacts of landfalling TCs, initializing numerical weather prediction models, emergency preparedness and disaster mitigation. To directly address the present lack of GOES-R TC structure algorithms, we propose the development of a suite of operationally relevant and pragmatic tools to better diagnose TC structure. In addition, the proposed research will lead to a better understanding of the climatological and environmental controls on TC structure variability. Significant progress has been made in the first year of this project and we will present our progress thus far and provide anticipated accomplishments in the second year of funding.

Satellite datasets are often the choice for studying tropical cyclones as their high temporal and spatial resolution compared to conventional data is often unavailable and only affords for the occasional case study. To understand tropical cyclone structure changes a number of observational dataset had to be interrogated and combined for this project. Much of the first year's observational efforts have been devoted to dataset, climatology and technique development. Details of this work to be presented include the development of radius of maximum wind (RMW) climatologies, analyses of the aircraft flight-level data, the development of a GOES IR-base objective technique for TC size, storm-relative analyses of total precipitable water (TWP) fields around storms, and analysis of the relationships between rainband activity detected in GOES IR data and structure change. World Wide Lightning Location Network (WWLLN) data is also being used as a proxy for the GOES Lightning Mapper (GLM) and storm-relative lightning density positions are being used to assist with center fixing algorithms. These datasets will be used in combination to study the climatological and episodic nature of TC structure changes in year 2.

Tropical cyclones, however, occur in remote regions and, while satellite data is important for understanding basic relationships, numerical modeling is a better way to

study sensitivities and processes. Following this line of reasoning, high-resolution TC simulations were run using the Weather and Research Forecast (WRF) model to study the impacts of the distribution of latent heating and TC structure on subsequent structure evolution. A forward radiative transfer model has been applied to the model dataset to create synthetic ABI brightness temperatures. These synthetic data provide a way to directly relate cloud-top properties and model processes. Sensitivity tests are being conducted to determine uncertainty bounds on the extent to which model-derived ABI-based products can apply to observational data. This modeling effort offers a nice complement to this project's observation-based investigations and offers direct application (via assimilating ABI data) to improving TC forecast.

By combining numerical modeling and observational approaches to develop new tools and conduct research related to TC structure in year-2 should lead to the capability and understanding necessary to develop a statistical-dynamical TC structure forecast system in the optional third year of funding.

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