Climatology of Recon and HURSAT Data to Diagnose Hurricane Core Characteristics: Toward their Use in Short-Term Intensity Prediction

Josh Cossuth[1] (jcossuth@fsu.edu), Robert Hart[1], and Andrew Murray[2]

[1] Florida State University, Department of Earth, Ocean, and Atmospheric Sciences [2] University of South Alabama, Department of Earth Sciences

Introduction

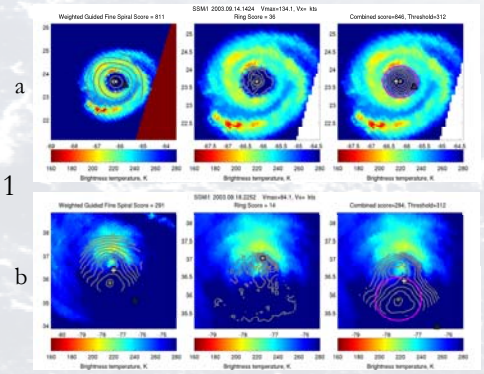
Despite impressive increases in track forecasting skill by the NHC, similar progress in intensity forecasts have been elusive thus far. Although there may be many reasons for such a disparity, diagnosis and evolution of tropical cyclone (TC) structure is under-analyzed compared to the surrounding environment. This is chiefly due to a lack of routine observations that characterize the core of a TC. The following study examines the relationship between intensity and eye size from aircraft reconnaissance, building on previous work (Murray 2009) that demonstrated predictive statistical skill using such measurements. An analogue in satellite imagery, using ARCHER software (Wimmers and Velden 2010), is then compared to recon and analyzed to quantify TC structure globally. The relationship between structure and intensity changes can potentially augment current efforts that define the TC core and use those observations to increase predictive power.

Methodology

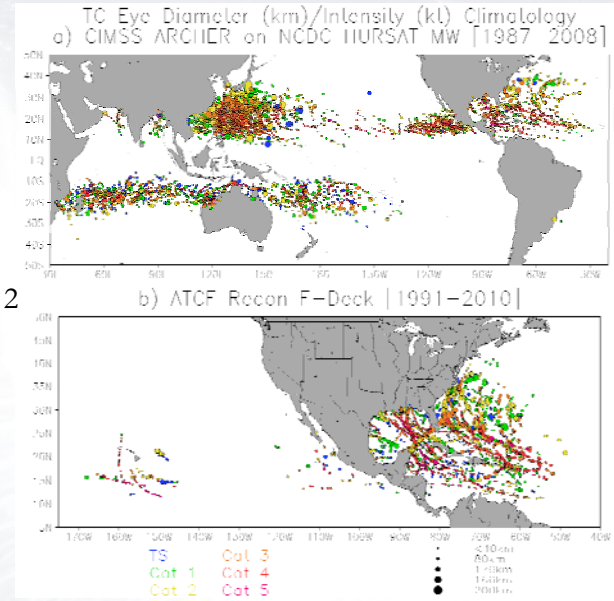
Analysis of aircraft reconnaissance data follows the work of Piech (2007) and Murray (2009) and extends it to the 2010 season. Vortex data messages preserved in the ATCF F-deck are united with operational estimates of TC intensity at the nearest prior synoptic time from the ATCF A-deck, simulating available information in a forecast environment. The diagnosis of core structure from recon is related to the current and future intensity changes of the measured system.

To facilitate the analysis of TC core characteristics without the sampling limitation of recon, the HURSAT-MW data set (Knapp 2008) is explored. Global SSM/I observations centered on TCs from 1987-2008 are analyzed. However, while the center of the storm is determined by interpolation between NHC/JTWC best track, post-season analysis techniques such as smoothing make this a first order estimate of the TC's actual center during a satellite overpass. To correctly diagnose the position and core metrics of the TC, the ARCHER technique (Wimmers and Velden 2010) uses a TC's spiral banding and likely eye 'ring' position to determine a satellite-based center from a first guess location. Figures *1a* and *1b* show two different SSM/I observations of Hurricane Isabel (2003). In the former case, both the spiral and the ring scores produce a confident revised estimate of position. However, the latter case shows how lack of a curvature signal (e.g. due to shear) can create an erroneous center estimate. In this study, only cases that surpassed the ARCHER threshold score and had coverage of the center were used.

1

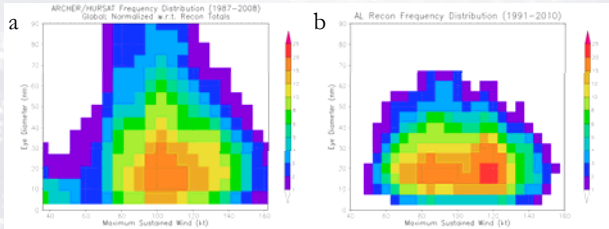


Eye size – Intensity Relationship



2

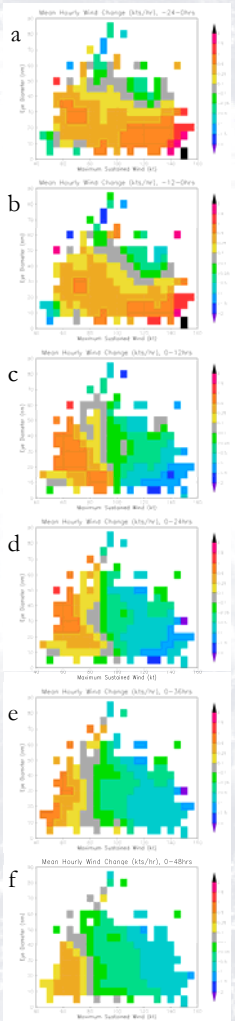
Above, locations of TCs are shown by best track intensity (colored; stronger storms are plotted over weaker storms) and eye-size (scaled by dot size) for systems in HURSAT-MW analyzed by ARCHER (Figure *2a*) and from reconnaissance (Figure *2b*). Below, Figure *3* shows the frequency distribution of TCs by intensity (kts; 1-minute) on the abscissa and eye diameter (nm) on the ordinate and is filtered once by a 9-point smoother. Figure *3b* encompasses all the points in the Atlantic basin from Figure *2b* and are in 5kt by 5nm bins, while Figure *3a* includes all points in Figure *2a* and is in 6kt by 6nm bins. In addition, Figure *3a* is scaled such that the total frequency and color scale match Figure *3b*.



3

Figure *4*, at right, examines the change in intensity (kts/hr) from before (panels *a-b*) and after (panels *e-f*) the synoptic time preceding the Atlantic recon fix. Major hurricanes with smaller eyes tend to quickly intensify up to the observation, while strong storms with large eyes will climatologically weaken at any shown time interval. After the recon fix, there is a threshold intensity above which TCs climatologically weaken. As the forecast extends further in time, this threshold encompasses weaker storms.

4



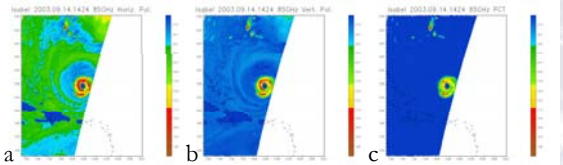
Satellite Analysis

Figures *5a* and *5b* demonstrate two channels provided by HURSAT-MW. The Polarization Corrected Temperature (PCT; Figure *5c*) removes signal from low-level and surface influences by taking the difference between the two channels. PCT is used in all HURSAT-MW work shown here.

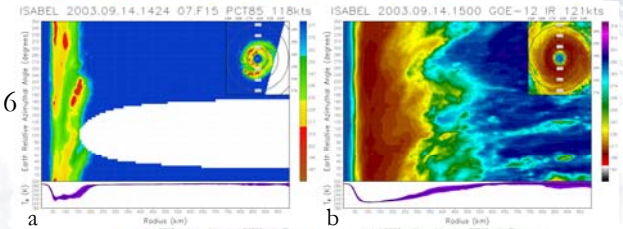
Figure *6a* transforms (or, 'unravels') the satellite overpass from latitude/longitude coordinates to polar coordinates. Evolution of the TC core, such as through concentric eye-wall replacement cycles, can be more easily visualized in a coordinate system more natural/physical for a TC. Figure *6b* shows the same system valid at 36 minutes later, but with the GOES-12 infrared channel from the HURTSAT-B1. The inset image shows a zoomed in picture of the TC core while the line graph below plots the azimuthal average, with standard deviation shaded purple about that line.

Figure *7* shades the azimuthal average for the lifetime of the storm, where radius from the center is the abscissa and storm age progresses up along the ordinate. Panel *a* shades radial evolution with each successive satellite pass, while panel *b* scales the true linear passage of time. Tools, such as Figures *6* and *7*, provide further means to more clearly and concisely compare the core structure of TCs. Intensity changes may then be associated with the identification of preferred convective patterns (as can be viewed in Figure *6*) or how the inner-core changes with time (Figure *7*).

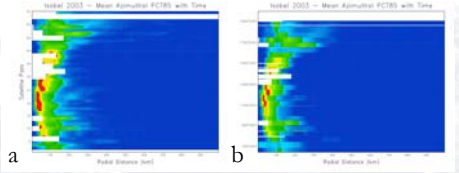
5



6



7



References & Acknowledgements

Knapp, K. R., 2008: Hurricane satellite (HURSAT) data sets: Low-earth orbit infrared and microwave data. Preprints, *28th Conf. on Hurricanes and Tropical Meteorology, Orlando, FL, Amer. Meteor. Soc.*, 4B.4.

Murray, D.A., 2009: Improved Short-Term Atlantic Hurricane Intensity Forecasts Using Reconnaissance-based Core Measurements. M.S. Thesis, Florida State University, 150 pp.

Piech, D., 2007: Atlantic Reconnaissance Vortex Message Climatology and Composites and Their Use in Characterizing Eyewall Cycles. M.S. Thesis, Florida State University, 139 pp.

Wimmers, Anthony J., Christopher S. Velden, 2010: Objectively Determining the Rotational Center of Tropical Cyclones in Passive Microwave Satellite Imagery. *J. Appl. Meteor. Climatol.*, **49**, 2013–2034.

An immense thank you goes to Ken Knapp and his team for creating and making available the HURSAT data set , in addition to answering numerous communications. Tony Wimmers and Chris Velden have been instrumental by providing their ARCHER technique, which has allowed a precise, automated method to determine the TC center from satellite imagery. We would also like to acknowledge Jeff Hawkins and the NRL Satellite Meteorological Applications group for their microwave color scale as well as Greg Galina and NESDIS/SSD for help in implementing their geostationary infrared colors.

NASA GRIP Grant #NNX09AC43G supported this research.