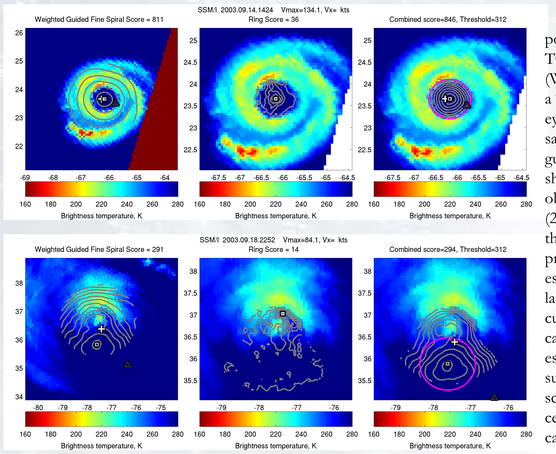
COMPARATIVE TROPICAL CYCLONE CORE STRUCTURE CLIMATOLOGY FROM RECONNAISSANCE AND SATELLITE OBSERVATIONS

JOSH COSSUTH (JHC06@MY.FSU.EDU) AND ROBERT HART

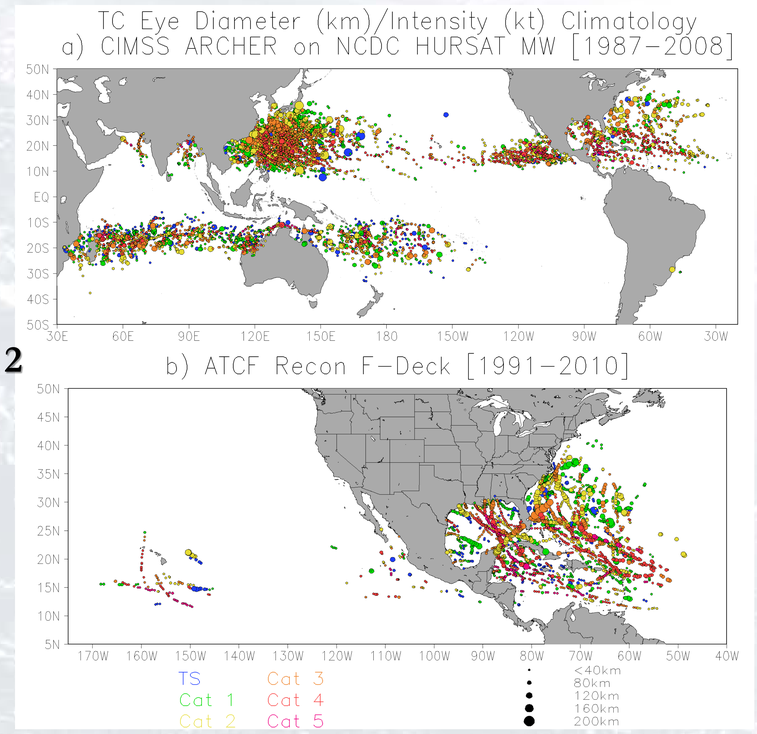
FLORIDA STATE UNIVERSITY, DEPARTMENT OF EARTH, OCEAN, AND ATMOSPHERIC SCIENCES

ARCHER TECHNIQUE



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, cases that surpassed the ARCHER threshold score and had coverage of the center were used for all satellite cases (unless noted).

LOCATIONS OF TC EYESIZE/INTENSITY



INTRODUCTION AND METHODOLOGY

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 variety of core features of a TC.

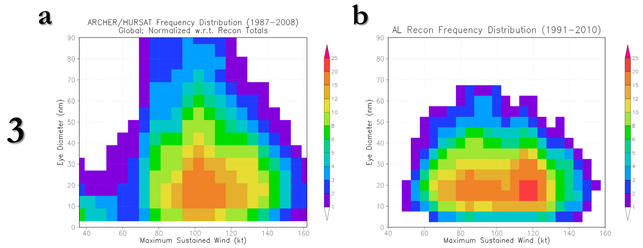
The following study first examines the relationship between intensity and eye size from aircraft reconnaissance, building on previous work (e.g. Murray 2009) that demonstrated predictive statistical skill using such measurements. An analogue in satellite imagery, using ARCHER software (Wimmers and Velden 2010; see Figure *1*), is then compared to recon and analyzed to quantify TC structure globally (Figures *2-3*). The relationship between structure and intensity changes (Figure *4*) can potentially augment current efforts that define the TC core and use those observations to increase predictive power. The remainder of this presentation focuses on concepts that exclusively use satellite microwave data to expand upon currently available structural metrics.

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 eye size measured by recon is related to the current and future intensity changes of the measured system.

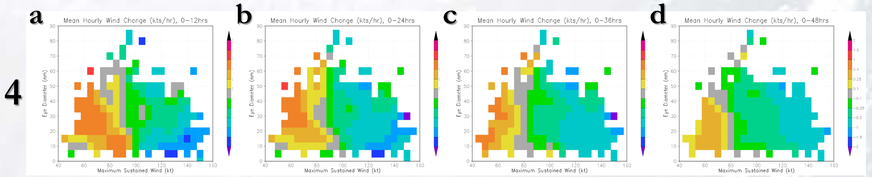
To facilitate the analysis of TC core characteristics without the sampling limitation of recon, the HURSAT-MW data set (Knapp 2008) is explored. Global SSM/I 85-GHz observations centered on TCs from 1987-2008 are analyzed. However, while the center of the storm is determined by interpolation between 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.

Finally, visualizations of TCs are explored in polar coordinates. The transform to a polar coordinate system offers many advantages in TC structure analysis. Examples shown include finding the eye size and shape, as well as determining moats and banding regions.

COMPARING INTENSITY WITH EYESIZE METRICS



In Figure *2*, 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*). Above, 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*.



Using the center locations provided by ARCHER when its criteria was met (Figure *5a*) and all HURSAT cases where the linearly interpolated best track position was used when ARCHER criteria was not met (Figure *5b*), the radius of the inner-core is plotted (where the inner-core is defined as the azimuthally averaged minimum in brightness temperature – see Figure *6*). Figure *5a* compares well with ARCHER-derived eye sizes found in Figure *3a*. Note, frequencies in the plot at right are actual counts and are not normalized or smoothed. ARCHER's ability to discriminate cases with better defined structure is seen in when compared to all HURSAT cases (in Figure 5b). Here, the full range of observed TCs and the radius of most intense convection is seen.

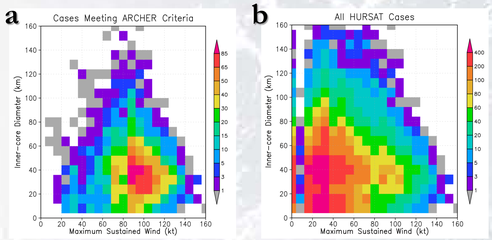
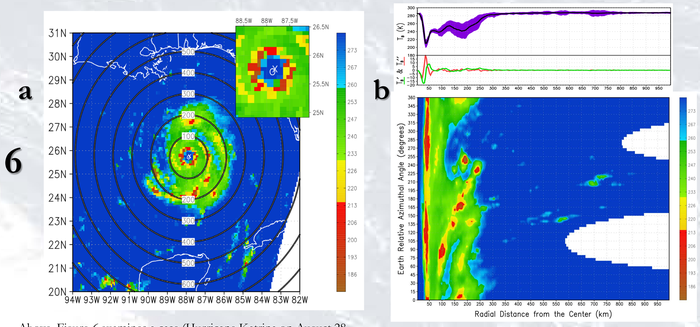


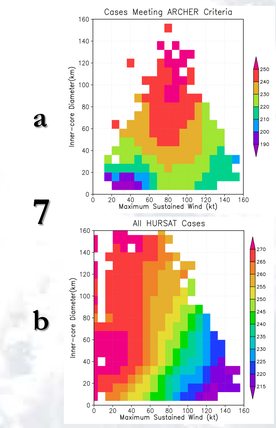
Figure *4*, below, examines the future change in intensity (kts/hr) after the synoptic time immediately preceding the Atlantic recon fix. Major hurricanes with smaller eyes tend to quickly weaken after the observation, while strong storms with large eyes will climatologically weaken at a faster rate at any shown time interval. TCs with medium eyes tend to strengthen faster and weaken more slowly. In general, there is a threshold intensity above which TCs climatologically weaken. As the forecast extends further in time, this threshold encompasses weaker storms.

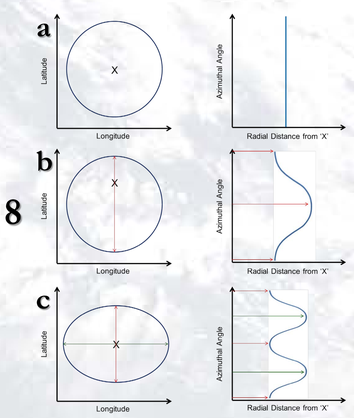
POLAR COORDINATE TRANSFORM



Above, Figure *6* examines a case (Hurricane Katrina on August 28, 2005, 1244z) in Cartesian and polar coordinates. In the inset of panel *a*, the 'X' is the linearly interpolated best track while the 'O' is the ARCHER position used in panel *b*. When examining a TC in polar coordinates, errors in the center position lead to distortions of size and shape in structure features. The line graphs at the top of panel b show the azimuthal average brightness temperature (with the standard deviation shaded about the line in purple), the first derivative of the azimuthal average (in green), and the second derivative of the azimuthal average (in red). Such profiles show characteristics of the TC that can be used to create boundaries that delineate structural metrics. In particular, the global minimum azimuthal average brightness temperature for each HURSAT case is plotted in Figure *5* and Figure *7*. Below, the azimuthal mean brightness temperature is shown for different radii where it was found and the intensity of the TC.

Polar coordinate transformation of TCs offers an advantage, in that it can be used to both diagnose mis-centering and define eye shape asymmetry. Figure *8* provides diagrams for three sample eye representation cases. The top example (*a*) demonstrates a circular eye with a "correct" center position, which is represented by a straight line in polar coordinates. When the center fix is displaced to the north though (*b*), a wavenumber 1 asymmetry is found in polar coordinates. A correction can be applied to this case by analyzing opposing angles (180° apart). Panel (*c*) offers a view of an elliptical eye with a "correct" center. Such a case presents a wavenumber 2 asymmetry and allows both the minor semi-axis (smallest diameter; 0-180°) and major semi-axis (largest diameter; 90-270°) to be measured.





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