17A.4 AN OBJECTIVE METHOD TO SELECT A CONSISTENT SET OF TROPICAL CYCLONE CIRCULATION CENTERS DERIVED FROM THE GBVTD-SIMPLEX ALGORITHM

Michael M. Bell * Wen-Chau Lee
National Center for Atmospheric Research
Boulder, CO 80307 USA

1. INTRODUCTION

The GBVTD technique has been shown to accurately retrieve the circulation of a tropical cyclone (TC) from a single Doppler velocity field given a correct estimate of the circulation center (Lee and Marks 2000). The GBVTD-simplex algorithm can objectively estimate this TC circulation center by determining the location that maximizes the GBVTD-retrieved mean tangential wind (or vorticity) for a ring of specified radius. The algorithm conducts the search for the vorticity centers of multiple rings starting from different initial guesses. The mean center location and mean vorticity for each radius are then calculated from the solutions. The TC circulation center can then be selected by determining the radius of maximum wind (RMW) and the corresponding vorticity center.

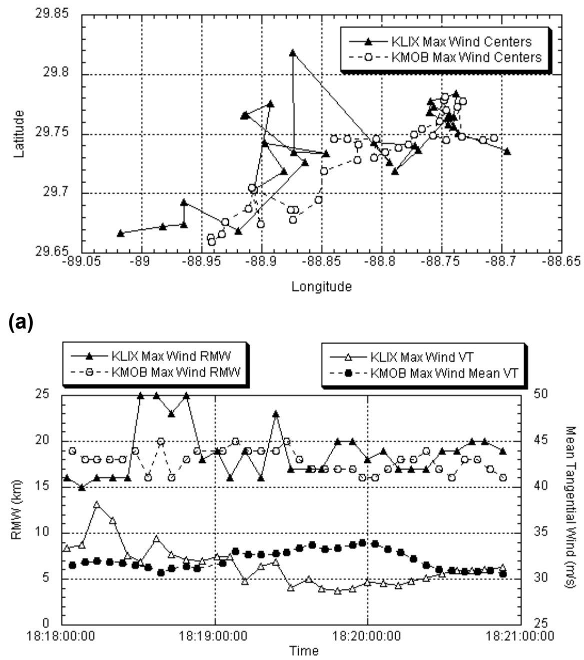
An easy determination of the RMW and best center estimate are not always possible however, depending on the characteristics of the TC and the quality of the radar data. Factors such as weak velocity gradients, radar data gaps, and strong TC asymmetries may make the RMW ambiguous. In addition, the mean center location calculated from multiple simplex results may be skewed by errant solutions.

Lee and Marks have demonstrated that a center estimate uncertainty of less than 2 km is desired in order to resolve the wavenumber one asymmetry of a TC with minimal error. Their analysis of Typhoon Alex (1987) suggested that the uncertainty in center estimates for this TC was less than 2 km, but without a way to verify the centers to this accuracy it is difficult to confirm that this is the case.

Hurricane Danny, a slow-moving category one storm, provides a unique opportunity to test the effectiveness of the GBVTD-simplex algorithm since two radars were able to view the same TC from a near perpendicular angle. The GBVTD-simplex algorithm was performed on datasets from the NEXRAD radars in Slidell, LA (KLIX) and Mobile, Alabama (KMOB) during the period 18:00-21:00 UTC on 18 July 1997, using 16 initial guesses in a 12 x 12 km initial grid and a radius varying from 10 to 25 in 1 km increments.

* Corresponding author address: Michael M. Bell, NCAR Research Technology Facility, Boulder, CO 80307. NCAR is sponsored by the National Science Foundation.

The center finding algorithm should be able to determine proximate center estimates from both radars independently, but when the RMW and centers are selected from mean center calculations using only the maximum tangential wind as a criterion for the RMW there are some discrepancies. Figure 1 shows the selected centers, RMWs, and mean tangential winds from the two analyses. A statistical analysis of the distance between the selected centers is shown in Table 1. The mean distance is higher than the 2 km uncertainty recommended by Lee and Marks, suggesting that a better selection method is required.



(a)

(b)

Figure 1. **(a)** Mean circulation centers at 1km height selected by using maximum tangential wind as the only criterion for RMW determination. **(b**) RMW and mean tangential wind of selected centers over the three-hour analysis period.

Distance Between Center Estimates Using Maximum Tangential Wind Selection Method	
Mean	3.694 km
Median	3.034 km
Std. Dev.	2.486 km

Table 1. Statistical analysis of the distance between circulation center estimates from KLIX and KMOB radars using maximum wind selection method. Calculations were made on linearly interpolated centers at one minute intervals to account for different radar scan times.

2. METHOD

Handpicked centers can achieve a better level of agreement than the maximum wind selection method, but the significant time and effort involved, as well as the potential bias of subjective selection on TCs with only one radar dataset, make this a poor alternative. An objective method that can select consistent centers similar to those picked subjectively would therefore be ideal.

The proposed method improves the selection process by determining a best estimate of the RMW at each time using both the mean tangential wind and the statistical parameters from the GBVTD-simplex output, and then finding individual simplex solutions which best fit the mean center locations, RMW, and tangential wind profile over time. All steps in this method are performed independently at different altitudes, to account for vertical variation in center location.

The first step in this method is to normalize the GBVTD-simplex output parameters: mean tangential wind, number of converging centers, and standard deviation of those centers. A score of 1 is applied to the best value for that parameter at a given time, with remaining values scaled linearly. This is done in order to combine the parameters, with different units and magnitude, into a single value to be used for comparison. A weight scheme is applied to the normalized values to get a combined score for each radius, and the radius with the highest score is selected as the best estimate of the RMW. We can therefore have some confidence in our initial center estimates even when the velocity gradient is weak.

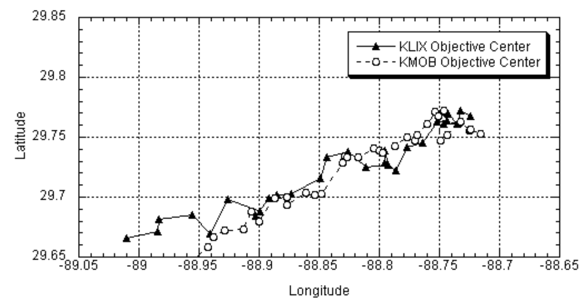
The second step is to apply least squares polynomial curve fits to the RMW, center coordinates, and mean tangential wind over an arbitrary period of time, yielding four independent curves. X and y are fitted independently so that nonlinear storm motion can still be determined. A statistical f-test is used to determine the polynomial degree that best fits the data.

The final selections are the individual simplex solutions that best fit the four resulting curves. A Gaussian membership function is created for each of the curves, based on the standard deviation of the least squares fit. A curve that fits the data well will have a narrow membership function, while a poor fit will be assigned a wider Gaussian function. The simplex solutions that have the highest total membership score from the resulting functions are selected.

3. RESULTS

Figure 2 shows selected centers and the corresponding TC information using the objective method. The objective selection method tracks are more consistent and compare better between the two radars than the maximum wind selection tracks. The RMW profiles are similar, but are less erratic than those in Figure 1, while the mean tangential wind profiles are nearly the same. The objective method selects spatially consistent centers while preserving the RMW and tangential wind information derived from the mean solutions.

The mean distance between the selected centers is shown in Table 2. The GBVTD-simplex algorithm, coupled with the objective selection method, can determine TC circulation centers for Danny with a mean distance ~2 km, verifying that the center uncertainty is near that proposed by Lee and Marks for accurate wind retrieval.



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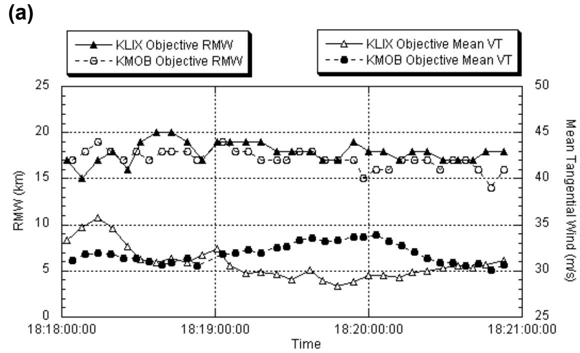

(b)

Figure 2. **(a)** Individual simplex center solutions at 1 km height selected with the objective method, using .9 mean tangential wind, .07 number of converging centers, and .03 standard deviation of centers as weights. **(b)** RMW and mean tangential wind of selected centers over three-hour analysis period.

Distance Between Center Estimates Using Objective Selection Method	
Mean	2.204 km
Median	1.983 km
Std. Dev.	1.265 km

Table 2. Statistical analysis of distance between circulation center estimates from KLIX and KMOB radars using objective selection method.

REFERENCES:

Lee, W.-C., and F.D. Marks, 2000: Tropical cyclone wind fields retrieved from single ground-based Doppler radar. Part II: The GBVTD-simplex center finding algorithm. *Mon. Wea. Rev.,* **128,** 1925-1936.