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Thank you for reviewing the manuscript and providing constructive comments again. We have made edits to the manuscript incorporated with your suggestions. Reviewers' comments are shown in black, our response to each comment is shown in blue, and changes to the manuscript are shown in red.

Reviewer #3:
Review of "Comparison of Single Doppler and Multiple DopplerWind Retrievals in Hurricane Matthew (2016)" General comments: This paper evaluates the accuracy of the generalized velocity track display (GVTD) technique by comparing the wind field obtained from the airborne tail Doppler radar (TDR) data. The evaluation of the GVTD technique in a real case has not been done so far and has been desired. Additionally, this paper re-derives the GVTD technique to obtain a more accurate wind field. Generally speaking, it is hard to compare the difference between observations from different measurements because it is necessary to consider the strengths and weaknesses of each observing capability. The authors did a great job working on this difficulty by carefully looking at the retrieved wind field. This paper is well written, and the purpose and results of this study are clear. Although I have some questions to better understand the GVTD technique, I recommend acceptance once the authors address the questions.
Recommendation: Minor revisions

Specific comments:

L180: Here, I'd like to make sure which variables can actually be retrieved from Eqs. 15-19. The sentence describes that the GVTD provides the along-beam component of the mean flow (i.e., Eq. 15), axisymmetric tangential wind (i.e., Eq. 16), axisymmetric radial wind (i.e., Eq. 17), and asymmetric tangential winds (n=1-2) (i.e., Eqs. 18 and 19). But, how can we obtain axisymmetric radial wind and the along-beam component of the mean flow? Eq. 15 includes axisymmetric radial wind on the right hand side and Eq. 17 includes the along-beam component of the mean flow on the right hand side. Rearranging Eqs. 15 and 17 is needed to obtain axisymmetric radial wind and the along-beam component of the mean flow. Here, VM|| indicates VM cos (), α indicates R/RT, and the storm motion is assumed to be zero. Eq. 15:

$$V_M \,||= A_0 - \frac{R}{R_T} V_R C_0 + \frac{1}{2} V_T S_1 - \frac{1}{2} V_R C_1 - U_S cos\theta_T - V_S sin\theta_T$$

$$V_R C_0 = \frac{A_0 + A_1 + A_2 + A_3 + A_4}{1 + \frac{R}{R_T}} - V_M cos(\theta_T - \theta_M) - V_R C_1 - V_R C_2 - V_R C_3 - \frac{R}{R_T}(U_S cos\theta_T + V_S sin\theta_T)$$

Substituting Eq. 17 into Eq. 15 yields VM|| = A0 – α × ((A0+A1+A2+A3+A4)/(1+α) – VM||) + A2 + A4 (1–α) × VM|| = A0 + A2 + A4 – α × (A0+A1+A2+A3+A4)/(1+α) Then, VM|| = (A0+A2+A4)/(1–α) – α × (A0+A1+A2+A3+A4)/(1–α^2) Substituting VM|| into Eq. 17 yields VRC0 = (A0+A1+A2+A3+A4) *(1–α)/(1–α^2) – (A0+A2+A4)/(1–α) – α × (A0+A1+A2+A3+A4)/(1–α^2)
Then, VRC0 = – (A0+A2+A4)/(1–α) + (A0+A1+A2+A3+A4)/(1–α^2) Is this derivation wrong?

Thank you for the comment. We have derived the $V_R C_0$ term to the same formula independently, but did not include that in the original manuscript. The $V_M cos(\theta_T - \theta_M\ )$ term can be further derived after the computation of $V_R C_0$. We have added the equation to the manuscript.

Plugging Eq. 16 into Eq. 15 to derive Eq. 20:

$$V_R C_0 = \frac{A_0 + A_1 + A_2 + A_3 + A_4}{(1 - \frac{R^2}{{R_T}^2})} - \frac{A_0 + A_2 + A_4}{(1 - \frac{R}{R_T})}$$
$$- V_R C_2 - \frac{\frac{R}{R_T}}{1 - \frac{R}{R_T}} V_R C_4 - \frac{1}{2}(\frac{1}{1 - \frac{R}{R_T}})(V_T S_5 - V_R C_5)$$

Equations 15 - 19 correspond to equations (16)-(20) in [Jou et al., 2008] with the additional terms of storm motion on Eqs. 15 - 17. Equation 20 is an updated version of Eq. 15 to minimize the unknown terms after plugging in the $V_M cos(\theta_T - \theta_M)$.

Additionally, I wonder why the authors don't evaluate the accuracy of axisymmetric radial wind in this study. If we find that both axisymmetric tangential and radial winds can be retrieved from the GVTD technique with acceptable accuracy, then the GVTD-retrieved winds can be useful for diagnosing a possibility of changes in storm size.

Thank you for the comment. As shown in the manuscript, the retrievals of A_2, A_3 are variable due to the propagation of wavenumber 2 winds. Since the axisymmetric radial wind is influenced by the harmonic 2 and 3 components, we cannot fully validate the axisymmetric radial wind retrieval. We have added a comment to the manuscript.

Since the axisymmetric radial wind is influenced by the harmonic 2 and 3 components (Eq. 20), we cannot fully validate the axisymmetric radial wind retrieval with the current dataset. The evaluation for the accuracy of the axisymmetric radial wind retrieval is not included in this study.

L218: This is just a comment. In my experience, a method from Bell and Lee (2012) provides better centers in terms of time consistency. That being said, I understand that you use the dynamic centers.

Thank you for the comment. We have tested the objective centers using Bell and Lee 2012 method, but the results are not optimal. The simplex centers are variable, so the objective method cannot get the best fit of the centers in this case.

L225: Specify the mean wind component is an unknown variable or a given value? If it is a given value, how did the authors obtain it?

Thank you for the comment. The mean wind magnitude and direction were derived from the airborne dual Doppler analysis, following the procedure proposed by [Marks et al., 1992]. The storm-relative horizontal wind field (V_r)in a cylindrical coordinate system centered on the storm can be decomposed into:

$$V_r(r, \theta, z) = \bar{V_r}(z) + V'(r, \theta, z) \quad (1)$$

where r is radius, θ is azimuth, z is height, $\bar{V_r}(z)$ is the horizontally averaged wind vector over the radius and azimuth, and $V'(r,\theta,z)$ is the deviation from $\bar{V_r}(z)$. $\bar{V_r}(z)$ can be expressed as:

$$\bar{V_r}(z) = \frac{1}{2\pi}\int_0^{2\pi}\int_0^{r_{max}} V_r(r,\theta,z)drd\theta \tag{2}$$

If the horizontal wind field is from a circular symmetric vortex with no steering flow, $\bar{V_r}(z)$ would be zero. Nevertheless, if the vortex is embedded in the steering flow, the averaged horizontal wind field would equal the mean wind component. Thus, the local wind shear can be approximated by subtraction of the mean wind component at different altitudes. In our study, we calculated the mean wind component averaged from the vortex inner core area within the radius of 60 km. We have clarified how we derived the mean wind component in the manuscript.

The mean wind (V_M) is the horizontal average of the environmental flow at each altitude following the procedure proposed by [Marks et al., 1992], which can be used to calculate the vertical wind shear.

Figs. 3a and b: KAMX is not located at the center of the figure.
Figs. 3c and d: There is no caption about these figures.

Thank you for the comment. We have revised the caption.

Doppler velocity at z = 4 km (a) observed by KAMX radar at 1921 UTC, and (b) resampled from dual Doppler analysis synthesized from 1855 - 1940 UTC. Reflectivity at z = 4 km (c) observed by KAMX radar and (d) derived from dual Doppler analysis. The timing of (c) and (d) are the same as (a) and (b), respectively. The black star denotes the TC center, and the dashed circle denotes the radius of maximum wind of 18 km.

L303: This description appears to me that the problem comes from the airborne "dual" Doppler analysis method, which essentially uses the fore/aft scanning technique. However, I don't think that the problem here is from the steady-state assumption in the dual Doppler analysis. As described in section 1, the forward and aft scannings are conducted within a few seconds, allowing for a nearly simultaneous observation, at least, near the aircraft (thus, the steady-state assumption is valid). I thought the problem here is that retrieved wind vectors observed at different times within 45 min are synthesized into one picture in SAMURAI software, assuming that they are steady-state (e.g., Fig. 3b). Is my understanding wrong?

Thank you for the comment. This is an excellent point. We have now clarified that there are in effect two different types of sampling errors that arise from the steady state assumption – the first is due to the time lag between fore and aft beams, and the second is due to the length of time used to composite the multi-Doppler into a single snapshot. While both produce some errors, the latter is more consequential when considering low-wavenumber asymmetries since it takes longer to capture the larger scale structure, resulting in evolution over the flight pass. The 'local' wind may be correct, but the overall structure is distorted by collapsing to a single time. We hypothesize that the discrepancies of retrieved wavenumber 1 and 2 tangential winds are due to the steady state assumption in the dual Doppler wind synthesis into one snapshot, not the fore/aft lag.

We hypothesize that the discrepancies of retrieved wavenumber 1 and 2 tangential winds are due to the steady state assumption in the dual Doppler wind synthesis into one snapshot. Two different types of sampling errors in effect arise from the steady state assumption – the first is due to the time lag between fore and aft beams, and the second is due to the length of time used to composite the multi-Doppler into a single snapshot. While both produce some errors, the latter is more consequential when considering the temporal evolution of the phenomena is faster than the period of data collection, resulting in evolution over the flight pass. The "local" wind may be correct, but the overall structure is distorted by collapsing to a single time. For example, the propagation velocity of a wavenumber 2 vortex Rossby wave (VRW) is half of the symmetric tangential wind velocity [Lamb, 1932, Guinn and Schubert, 1993, Kuo et al., 1999]. A propagating wavenumber 2 asymmetry could then alias onto other wavenumbers, contributing to a discrepancy in wavenumber 1 tangential wind.

References

[Bell and Lee, 2012] Bell, M. M. and Lee, W.-C. (2012). Objective tropical cyclone center tracking using single-Doppler radar. *Journal of Applied Meteorology and Climatology*, 51(5):878–896.

[Guinn and Schubert, 1993] Guinn, T. A. and Schubert, W. H. (1993). Hurricane spiral bands. *Journal of the Atmospheric Sciences*, 50(20):3380–3403.

[Jou et al., 2008] Jou, B. J.-D., Lee, W.-C., Liu, S.-P., and Kao, Y.-C. (2008). Generalized VTD retrieval of atmospheric vortex kinematic structure. Part I: Formulation and error analysis. *Mon. Wea. Rev.*, 136(3):995–1012.

[Kuo et al., 1999] Kuo, H.-C., Williams, R., and Chen, J.-H. (1999). A possible mechanism for the eye rotation of Typhoon Herb. *J. Atmos. Sci.*, 56(11):1659–1673.

[Lamb, 1932] Lamb, H. (1932). *Hydrodynamics*. Cambridge university press.

[Marks et al., 1992] Marks, F. D., Houze, R. A., and Gamache, J. F. (1992). Dual-aircraft investigation of the inner core of Hurricane Norbert. Part I: Kinematic structure. *J. Atmos. Sci.*, 49(11):919–942.