Interactive comment on "Lagrangian coherent structures in tropical cyclone intensification" by B. Rutherford et al.

General comments

The authors presented a novel and original study which allows better understanding of recently advanced paradigm for tropical cyclone intensification in three dimensions. The paradigm recognizes the importance of rotating deep convection (Vortical Hot Towers - VHTs) and considers the interaction of moist convection with the system-scale circulation. The paper is focused on structural aspects of the intensification process for which purpose Lagrangian methods are applied. Essential asymmetries and highly time-dependent turbulence, which characterize the new pathway of tropical cyclone intensification, need the Lagrangian techniques applied for their investigation to be three-dimensional and finite-time ones. To this purpose the authors summarized new Lagrangian techniques developed for three-dimensional turbulence, they noticed that their own, earlier elaborated and tried approach is more efficient, and used it to study VHT and equivalent potential temperature phenomenology.

The most important significance of the paper is that the new approach allowed the authors discovering new features of rotating moist convection in the tropical atmosphere which could not be found by use of any other methods known earlier. Also, the Lagrangian methods used in this study are applicable to a variety of time-dependent vortex flows from small scale turbulence to the system-scale circulation.

Despite the paper is not easy to read and be understood by wide audience in tropical cyclone investigations because of its Lagrangian aspects and terminology, I think that those readers who are really interested in new knowledge and deeper insights in tropical cyclone intensification will be able to overcome such challenges.

In summary, this work provides new and important information of processes observed during a hurricane vortex formation and highlights an intrinsic multi-scale nature of the problem when focusing on VHTs and their contribution. **Therefore, this work deserves publication.**

Specific comments

There is, however, a question that looks interesting to ask the authors and discuss before publication.
If we recall paper by Nguyen et al., 2008 (namely, 3.1.5. Relative-vorticity structure) as it has lots in common with paper of Montgomery et al., 2009, whose exact model data are used in the reviewed work, we can find there a detailed description of vorticity field and its evolution. The field consists of vorticity dipoles with strong cyclonic vorticity anomalies and much weaker anticyclonic vorticity anomalies. Vorticity of both signs is described by Nguyen et al., 2008 as contributing to the vortex dynamics. However, I have not been able to find any discussion on anticyclonic structures in this paper.
Does the proposed Lagrangian method allow examining them ?

P. 28126, lines 11-13: My comment may seem subjective, however, the previous wording
“Recently developed finite-time Lagrangian methods can locate time-dependent structures effectively, but are designed for two-dimensional flows with weak time dependence rather than

the highly time-dependent, three-dimensional, turbulence associated with the VHTs. ” was better understandable to me. Mentioning shear might be included within it.

P. 28126, lines 21-24: It looks like something is missed in “Extensions of boundary layer coherent structures grow above the boundary layer during episodes of convection are responsible for organizing the remnants of the convective vortices.”

Technical corrections

P. 28129, lines 14-15: (e.g., Willoughby, 1979; Schubert and Hack, 1982)

P. 28133, lines 5-6: (Haller and Poje, 1997; Haller, 2000; Haller and Yuan, 2000) …

P. 28133, lines 11-12: In Sapsis and Haller (2009), Rutherford et al. (2010a), and Rutherford et al. (2010b), … or In Sapsis and Haller (2009), Rutherford et al. (2010a,b)

P. 28139, line 6: What does it mean “TNB” ?

P. 28150, line 27: “vortical remnants that remain intact **”**