The reviewer comments are in black and our responses are given below in blue.

This is an excellent paper that contributes substantially to the important problem of how tropical cyclones form within easterly waves. The "marsupial" paradigm of Dunkerton, Montgomery, and Wang is to my knowledge the only existing framework that systematically addresses the dynamics and thermodynamics of the process. These ideas appear to give considerable insight in idealized simulations like those in Montgomery et al. (2009, Journal of the Atmospheric Sciences). Applications to invariably noisy and complex systems in the real atmosphere are a much greater challenge. Real-data complexities have been addressed in previous papers by Dunkerton, Wang, and Montgomery. This paper provides additional insight into how to apply these ideas operationally.

I like what the authors have done in this paper as well as in previous papers on the subject. I agree fully with the authors' analysis of the lack of importance of the monsoon trough and upper TUTT cells in the formation of Typhoon Nuri. [With regard to the monsoon trough, I would argue the term is meaningful only for time-averaged flow, and has no meaning on a day- to-day basis, when the vorticity of individual disturbances is 1-2 orders of magnitude larger than that of the monsoon trough.] I very much like the discussion concerning differences in the circulation center location in the resting and moving frame. Many misunderstandings come in operational practice from not using the moving frame. The marsupial paradigm will I hope change that practice. The section of the paper on using operational numerical forecasts to identify the pouch is helpful and worthwhile. My questions relate to other aspects of real time application of these ideas.

1. In the marsupial paradigm, vertical wind shear seems to be treated as an external parameter, but in fact the easterly wave might influence the vertical shear as much as it influences the incipient tropical cyclone. The pouch provides protection from lateral intrusion of dry air at a given level, but in a sheared environmental flow the pouch presumably varies with elevation. Along these lines, two questions arise:

a. For forecasting, how does one choose what level to evaluate the pouch? Wang et al. (2009 GRL) used 700 hPa, but the current paper uses 925 hPa. Would one simply choose the level at which the wave was strongest? If so, would the level of analysis have to change with time if the maximum amplitude of the wave changed to another level?

See response below.

b. Is there any useful information in the vertical variation of the location of the "sweet spot"?

We argue below that the answer is yes.

Would a similar location at multiple levels make genesis more likely, and differing locations less likely?

If we could observe the temporal evolution of different center locations, then we suggest that the answer to this is likely yes.

In general, do the locations of the pouch and sweet spot often vary substantially with elevation?

For precursor wave disturbances that become tropical storms, we suggest below that the answer is no.

In both questions above, the intent is to find a way to make use of the vertical wind shear in interpreting the sweet spot and the pouch, rather than as an independent parameter.
For the 55 case studies of individual developing storms examined using the marsupial paradigm (DMW09), the vertical level used for identifying the precursor wave was typically the wave's maximum amplitude. This decision is based in the underlying dynamics of the precursor wave disturbance, and supports the choice of different levels in the two studies mentioned. For the case of pre-Hurricane Felix, the precursor disturbance was an African Easterly Wave (Wang et al., 2009, Parts I & II, in press); the authors' choice to follow the wave at 700 hPa was therefore appropriate. For the western North Pacific cases evaluated during TCS-08, the easterly waves (or westward propagating disturbances) always had their maximum amplitude lower in the troposphere than found typically in the main development region of the Atlantic basin. The TCS-08 observations are consistent with past observations of synoptic-scale disturbances in the tropical west North Pacific sector (e.g., Reed and Recker, 1971; Chang, 1970). For these reasons, real-time forecasting during the TCS-08 field campaign focused on the 850 hPa level. During post analyses of the Typhoon Nuri case, it was found that a stronger wave/pouch signal was evident at 925 hPa. However, the same analysis at the 850 hPa level revealed qualitatively similar results.

In real-time applications, we suggest to track features continuously in time, at the same vertical level. We also advocate examining the vertical structure and thermodynamic properties of the pouch. For reasons articulated below we believe a vertically coherent, diabatically-activated pouch is very favorable for tropical cyclone formation.

In general, we have found that the locations of the pouch and sweet spot do not vary substantially with height (DMW09; Felix - Parts I and II (Wang et al. 2009), and the Nuri case). Although DMW09 did note differences in the orientation of stagnation points with height, the center of the pouch and sweet spot did not vary substantially with height for incipient wave disturbances that spawned named tropical storms. For the case of Typhoon Nuri, the location of the sweet spot becomes more vertically aligned in the lower troposphere as genesis approaches.

In this paper we do not tackle the problem of developers versus non-developers. Nor do we propose specific metrics for the forecaster that can help identify 'false positives.' These are obviously important problems that the upcoming field experiment entitled Pre-Depression Investigation of Cloud Systems in the Tropics (PREDICT) can and will examine. We nevertheless offer a plausible explanation as to why developing disturbances must inevitably possess vertically coherent pouches.

First, let us recall that for monotonic distributions of potential vorticity within the seedling pouch (wherein the Okubo Weiss parameter is positive), deformations of the pouch by the parent wave's horizontal shear will tend to be axisymmetrized in horizontal planes (McWilliams 1984; Melander et al. 1987; Montgomery and Kallenbach 1997)[1]. Related work on vortex alignment suggests that when the Rossby penetration scale is sufficiently large (Jones 1995), or equivalently, when the Rossby deformation radius is sufficiently small (Reasor and Montgomery 2001, Schecter et al. 2002, Reasor et al. 2004), moderate deformations of the pouch by the parent-wave's vertical shear will tend to be damped and the inner-region of the pouch should tilt in the left-of-shear direction as the vortex seeks an equilibrium position that minimizes the net shear (Jones 1995, Reasor et al. 2004).

Under ordinary circumstances in the trade wind belt, the *local* Rossby radius of deformation (~1500 - 1000 km) is large in comparison to the horizontal scale of the pouch. 'Dry' pouches will thus tend to succumb to irreversible deformation from the parent wave and stand little chance of supporting convective development within. If the pouch becomes diabatically activated, however, the effective static stability will tend to be reduced, which in turn will reduce the local Rossby deformation radius. The closer the mid- to lower-troposphere comes to a moist adiabat, the greater is the likelihood that the pouch will be able to resist differential vertical advection and maintain its vertical coherence (Schecter and Montgomery 2007, Schecter 2008). These considerations together suggest that a diabatically activated pouch will be more resilient to vertical shear and tend to be vertically aligned.

Vertical coherence of the pouch is thought to have important ramifications on the thermodynamics. A horizontally and vertically resilient pouch serves to protect the middle levels from dry air intrusions. It serves also to accumulate middle level moisture lofted by deep convection. Both effects mitigate the deleterious effects of downdrafts and the importation of low equivalent potential temperature into the marine boundary layer.

2. Again addressing the question of real-time use of the theory: it is of course critical to evaluate the wave motion accurately, since it plays a major role in the definition of the key regions. In this paper, multiple ways of defining motion are presented, but it is not clear which would be utilized in a real-time application. This also ties back to question 1(a) with regard to the level chosen for analysis.

For real-time forecasting during TCS-08, the three phase speeds that were evaluated typically showed little difference in value between tracking techniques. Generally, differences were within 1 ms^{-1} (criteria which DMW09 showed to have little influence on

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[1]In reality, the PV structure of the African easterly wave pouch exhibits a lens-like structure. Physical oceanographers often refer to analogous PV anomalies in the ocean interior as 'lenses'

the evolution of a wave pouch). The major difference between the tracking techniques lies in the relative strength of each signal (for reasons discussed in section 2 of the mss.). The real-time tracking parameter that appears to offer the most potential is TPW. This would be the variable of choice for the following reasons: i) it offers the most robust signal in real-time (especially in the Atlantic); ii) since it is a vertically integrated property, the need to select a level to evaluate is removed; and iii) it is observed by satellite and thus observations could be used in real-time versus analysis or forecast data. A new figure of TPW that has been added in the revised manuscript shows clearly the propagation of the precursor wave/vortex hybrid from the Central Pacific (Fig. 3)

3. Dunkerton et al. (2009) noted that the proposed pathway to genesis fit 53 of 55 cases, but that statistic does not address false alarms. The evolution of the sweet spot in Figures 3 through 8 of this paper is of interest. As the authors acknowledge, existence of a sweet spot was not sufficient to insure cyclogenesis in Typhoon Nuri for several days. Ultimately the frequency of false alarms must be addressed before operational applications can be developed.

We agree with the reviewer that false alarms must be addressed for operational applications. However, during the TCS-08 field program we successfully used our 'marsupial guidance' products to obtain insight into the likelihood of development or non-development of candidate disturbances. We used an upgraded version of these products this past summer during the dry run exercise for the upcoming NSF-NOAA-PREDICT and NASA-GRIP field experiments. Thus operational applications for these ideas are already under way!

4. No vorticity fields were shown. Because vorticity is unchanged in the resting or moving frame, it would not suffer the limitations of the circulation center location in the resting frame. My forecaster side asks the following: if I followed the vorticity maximum and predicted development when the vorticity maximum reached a region of large ocean heat content and relatively small vertical wind shear, would I produce a forecast of comparable value to the marsupial theory? The authors have addressed this question well in principle on but they did not show whether and how the locations of the vorticity maximum at 925 hPa differed from the locations of the sweet spot.

We would like to remind the reviewer that the marsupial paradigm from easterly waves does not hinge on tracking individual vorticity centers. Rather, it advocates tracking of synoptic and sub-synoptic scale wave features that exert a guiding hand influence on the smaller-scale vortical structures within the pouch.

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