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Interactive comment on "Potential vorticity structure of embedded convection in a warm conveyor belt and its relevance for the large-scale dynamics" *by* Annika Oertel et al.

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Summary:

This paper presents an analysis of the potential vorticity (PV) structures that accompany ascending air particles in a warm conveyor belt (WCB) simulated in the COSMO model. The analysis features a partitioning of WCB trajectories into ''slantwise" and ''convective" groups distinguished by their rates of ascent. A compositing technique is applied to identify the dynamical and thermodynamical structures associated with each of these groups. The convective air particles are associated with large PV dipole anomalies in the upper troposphere that are oriented horizontally with the negative

pole located to the left of the thermal wind. In contrast, the slantwise air particles are associated with much weaker PV anomalies. It is also shown that the convectively-generated negative PV anomalies comprise a coherent elongated region of low PV that is transported poleward towards the periphery of the jet.

This paper will make a valuable contribution to the literature. Of particular importance is the identification of the convective PV structure as well as its potential for influencing the synoptic scale. While previous studies have described convectively-generated horizontal PV dipoles, this paper is, to my knowledge, the first to demonstrate their importance in the context of extratropical cyclone dynamics. The results also have implications for numerical weather prediction (NWP); convection is difficult to simulate accurately, and if convection embedded in the WCB can have upscale influences on the synoptic evolution, then it is possible that convective-scale errors could degrade medium-range forecasts.

Overall, the paper is very well written. The analysis was conducted with meticulous attention to detail. I can find no major errors, but I have a few comments on the interpretation of results which I express below.

General Comments:

1. The headlining results in this paper concern the different behavior of convective versus slantwise trajectories. It is presumed that the convective nature of one group of particles is responsible for the deeper, larger-amplitude, coherent PV structures that accompany those particles. I would like to offer an alternative perspective for the authors to consider. In addition to being distinguished by their rate of ascent, the two groups of trajectories are also located in different regions of the WCB at their time of maximum ascent; specifically, the convective particles are located equatorward of the slantwise particles. The environments in which these two groups of particles ascend may therefore be different. Could the differences in environmental shear be primarily responsible for the different PV dipole structures? Is it possible that the shear vector

is oriented parallel to the front on the equatorward end of the front, whereas the shear vector is directed across the front on the poleward end? If so, then the PV dipoles should straddle the front on the equatorward end, whereas on the poleward end of the front they should be oriented along the front. According to this view, when compositing is performed, the dipoles on the equatorward side should retain a large amplitude PV dipole structures since there is less variance in the cross-frontal structure. On the other hand, the dipoles on the poleward side are subject to interference from neighboring dipoles along the front, resulting in a weaker PV structure in the composites. I suspect that the convective nature of the particles and the environmental shear are both important in determining the amplitude and structure of the PV anomalies.

2. While I agree with the authors contention that the horizontally-oriented PV dipoles are most likely due to heating in the presence of background shear (e.g. Figure 1), an alternative explanation for the structures (e.g., in Fig. 6e) is that they are associated with a vertically-oriented dipole in PV tendency that is subject to non-linear advection in the cross-frontal plane that results in the horizontally-oriented dipoles in total PV that we see. Have the authors examined either the PV tendencies or the cross-frontal advection to eliminate this possibility?

Specific comments:

1. In addition to calculating the composite mean maps, have the authors analyzed the variance? Variance maps could establish whether the mean maps are robust. For example, where the composite mean amplitude is large but the variance is low, the mean fields could be considered robust.

2. Figure 2 gives the impression that there is a large separation in time and space between the slantwise and convective particles, but the figure only shows the times and locations of maximum ascent. At any fixed time, would these groupings of particles occupy distinct regions of the WCB, or are they distributed more uniformly?

3. Line 169. Does the 2000 to 7000 split in the number of convective versus slantwise

particles imply that 3.5 times more mass ascends slantwise?

4. In Figure 5c, it is very difficult to distinguish the thick black lines from the thick blue lines.

Technical corrections:

1. Line 277. Should SWC and RWC be swapped?

2. Line 426. “is” -> “are”? (or make “hydrometeors” singular?)

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