Reviewer 2:

Overall: This is an interesting study with valuable insights into particle motion throughout the MABL. It points out many relevant and meaningful gaps in existing SSA research related to the transport of these giant particles from the surface throughout the MABL. I think it represents novel research that deserves to be published. Below, I've posted a few questions to consider that I think could be meaningful discussions/alterations to the manuscript.

Methods:
I understand the method releases a singular aerosol plume event to observe the evolution of these particles throughout the LES, however, I wonder if you continually released particles and allowed them to loop through the periodic boundary conditions if the mixing eventually reaches some sort of homogeneity? In the intro, you preface that this research could impact/provide insights into proposed in situ sampling strategies and that something like cloud streets might have some impact on where whitecaps are being generated. While SSA are produced by these plumes, they exist within a background concentration of previously produced aerosol. If you were to continually release these particles throughout the whole domain (or say, at a length scale of every whole number of T_eddy/T_neut to represent increased production at these eddy lengths), how prevalent are these "near-absence of particles near the surface" (line 387)? Is the focus on the lowest surface layer in this statement? If so, I believe this can be made more clear.

This is an excellent point, and centers on a point which is one of the central themes of this work. The homogeneity the reviewer speaks of is very relevant to the Eulerian-based measurements that one might make. Indeed, newly generated particles would get mixed into the already-laden MABL.

However, the question is: if you sample particles at some height in a well-mixed MABL, how long have they been there? Which have been recently released? In that sense, the "near-absence of particles" refers to the near-absence of *newly created* particles (even if there are plenty of others which have been sampled). It is this Lagrangian perspective that we are trying to understand. We have added a brief explanation in this regard in the manuscript where the particle injection is described:

"We emphasize that while the particles in the simulations are released as a single pulse, this is not meant to literally represent such an event, which is a rather unrealistic situation. Rather, this technique allows us to automatically reference the individual particle trajectories and lifetimes to a common reference point; i.e., the statistics presented below could be exactly generated with a continuous release of particles at the surface, where Lagrangian statistics are computed relative to an individual particle's generation. So while in the real MABL newly generated aerosol particles would be continuously injected into a populated background, this technique allows us to speak directly to the individual fate of a single new particle and distinguish its lifetime and position relative to other nearby particles. This has strong implications for Eulerian-based sampling strategies and interpretations of particle observations, including assumptions made about their exposure time and distance from their source."

An additional question I have is what percentage of these particles exist within the primary (trapped at the surface) vs. the secondary (entrained into the MABL) modes? If you have statistics on this, those are really novel and particularly interesting in understanding how many of these giant particles are functionally being entrained.

Response: We thank the reviewer for this insightful question regarding the partitioning between the two transport modes. Indeed, this quantification provides important insights on coarse mode aerosol entrainment efficiency. To address this, we analyzed our particle trajectory data using the following criterion: particles are classified as "first mode" if their maximum altitude never exceeds 100m (approximately the surface layer depth), while "second mode" particles are those that reach above 100m and thus experience MABL-scale circulation. The 100m threshold was chosen based on inspection of Figures 5 and 6, where the transition between surface-trapped and vertically-transported particles becomes evident. While we acknowledge the somewhat arbitrary nature of this threshold, it provides a practical metric for quantifying the transport mode partitioning, and a more sophisticated classification metric is beyond the scope of the present study.

Based on this analysis, the mode partitioning is as follows:

- Neutral conditions: 26.0% first mode, 74.0% second mode
- Slightly unstable: 26.4% first mode, 73.6% second mode
- Unstable: 21.7% first mode, 78.3% second mode

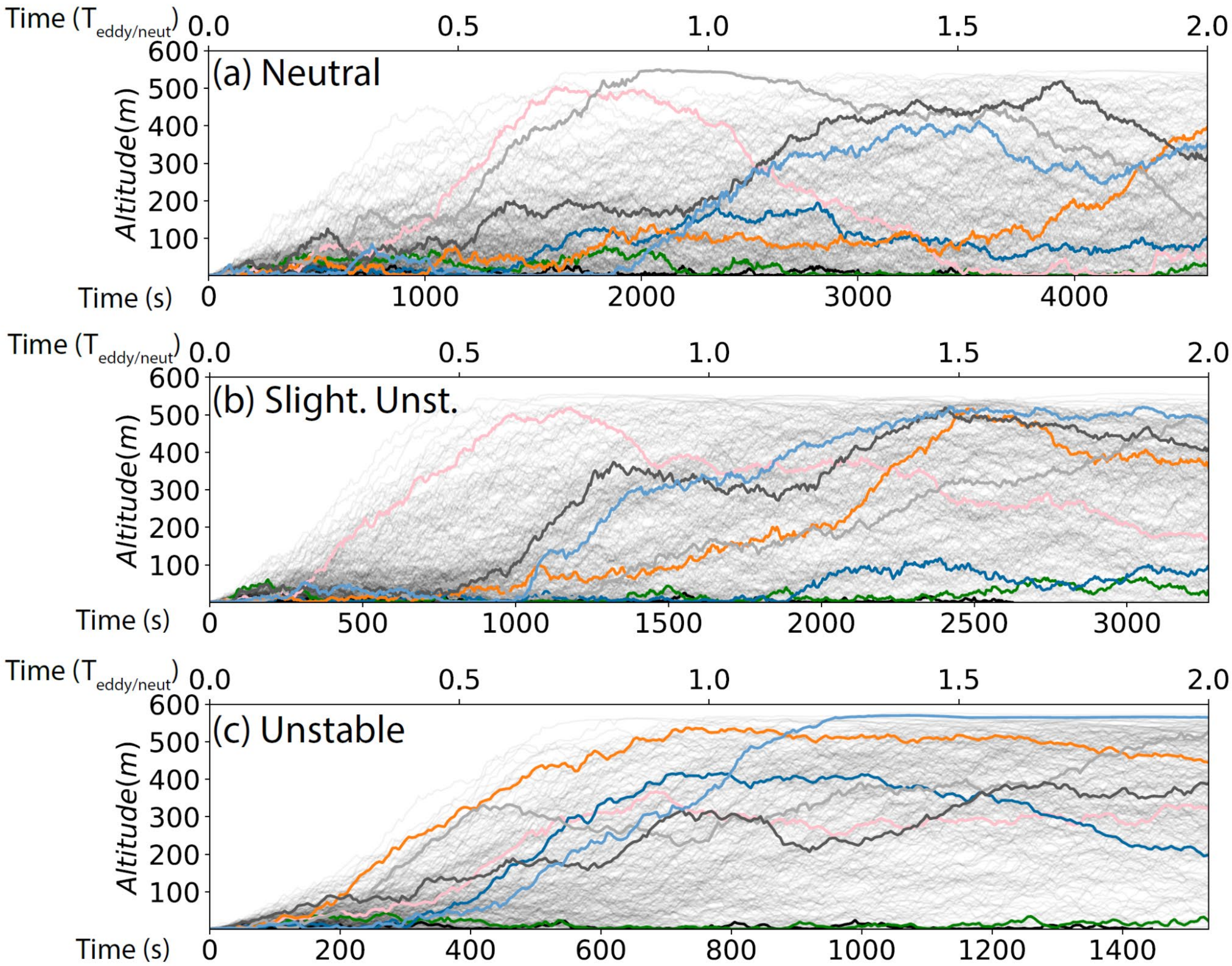
We have added these statistics to Section 3.3 (line X), following the discussion of Figure 6: “To quantify this bimodal transport behavior, we classified particles based on whether their maximum altitude exceeded 100m. This threshold was chosen based on visual inspection of Figures 5 and 6, which suggest that around this height there is a transition point where particles either remain trapped near the surface or become entrained into the mixed layer circulation. This analysis reveals that 26.0%, 26.4%, and 21.7% of particles never escape above 100m in neutral, slightly unstable, and unstable conditions respectively, confirming that instability fundamentally alters the balance between surface-trapped and MABL-entrained particle populations. The complementary fractions (74.0%, 73.6%, and 78.3%) that do reach the mixed layer correspond to the second mode particles whose extended lifetimes arise from their participation in MABL-scale circulation.”

Section 2.2: What is the equivalent dry particle diameter/radius for this 10 micron aerodynamic diameter particle? Is it dry? If it's dry, a small discussion on how these giant SSA may act when their particles are deliquesced (say at different altitudes, with differing RH, within the MABL) would be interesting. These particles will grow and shrink through these many eddy cycles. How applicable are your PDFs of residence times at different regions in the MABL (Fig. 7) when these particles experience dynamic fall velocities as a function of changing size due to RH changes? Also, if your particles are dry, what is the equivalent sized particle in situ that this 10 um aerodynamic diameter size represent for an SSA particle at formation diameter (d_99), which is ~4x the diameter with a mass that is mostly water (~half the density of salt)? This has huge implications for in situ scientists trying to gauge which size this is relevant for. A quick back of the envelope estimate is that the particles in this study are likely representative of a < 3 um particle at formation diameter, which after undergoing evaporation outside the surface layer, become exceptionally well mixed throughout the MABL and aren't subject to much removal through dry deposition.

Response: This is an extremely good point, and one which is the subject of ongoing research. For the purposes of this manuscript, we avoid making the distinction between dry/wet diameter because we are neglecting swell/evaporation/condensation. Functionally the settling velocity is so small relative to eddy diffusivity that settling velocity is not a significant consideration for the work being demonstrated here. But everything the reviewer points out is relevant, especially as particles become close to the oceans surface or cloud base as discussed in the previous comment. The next set of simulations are currently being mapped out to generate similar statistics but with realistic humidity fields at the boundaries were the droplet size may start to be relevant.

Lines 346-350: Yes, the particles in the unstable case go through more cyclic motions in the 6000 s time, but isn't this just a function of the eddy roll lengths determined by the MABL stability? Say, if you were to generate the same graph as Figure 4 but with a normalized X-axis to T_eddy/T_neut, with Time (s) varying on the upper X-axis, would these graphs look much different from each other? Time is a valid means of presenting the research, but I wonder how different these results would look if presented from an eddy roll length perspective. For example, Figure 5 demonstrates the same " aerosol at approximately 2.5 T_eddy/T_neut for all three conditions (neutral, slightly unstable, and unstable) (highlighted).

Response: This is a good point, but only for a sufficiently strong unstable stratification. For decreasing stability, the definition of an “eddy roll length” loses meaning. As shown in Figure 3 of the manuscript, the w’ experience much less coherence as the stability approaches neutral. With this in mind, consider the figure below (Figure 4 of the manuscript but with the upper X-axis fixed to 2 eddy roll lengths depending on stability):



We see for (c) the particles' strong vertical transport due to the presence of coherent roll structures. This, in turn, leads to a state of an absence of particles near the surface most visually apparent in Fig 5(c). For the neutral configuration, there would be no such scenario however long of time the simulation progresses due to lower levels of vertical transport that lack vertical velocity coherence.

With appreciable instability, we do expect the motions to scale with T_{eddy}, and we have added comments accordingly in our discussion of Figures 6 and 8.

Overall Writing and Formatting: The writing is really great, which is interesting, because it's in direct contradiction to all of the copy-editing that needs to be done on this manuscript. The lack of attention to minor details in the writing as well as figures generates detracts from the paper. The formatting of the many unit notations is inconsistent across the paper (italicized, non-italicized, inconsistent spacing). I will try to provide some proposed copy-edits and inconsistencies I saw in the attached PDF, but ultimately this manuscript should be copy-edited professionally before any future submission. Additionally, the citation formatting is all over the place - I can't tell if these have been manually input or why there's such inconsistencies, but these need to be non-italicized and formatted properly, linking to their citations at the end of the paper. There's many things that need to be improved to comply with Copernicus publishing standards, including colorblind friendly figures and increasing the dpi of some figures (why does Figure 5 have a distorted aspect ratio?) - https://publications.copernicus.org/for_authors/manuscript_preparation.html#figurestables

Response:
We have gone through the manuscript with respect to the citation formatting and fixed minor details in the overall writing and figures. We hope to have addressed the reviewer's concern.