General comments:

The paper presents results from LES of canopy patches with 2 different configurations of spacing between canopy patches. The canopy patches are modeled with a drag formulation in the LES. The stated goal is to investigate if von Karman streets within the canopy, and Kelvin-Helmholtz instabilities above the canopy, are obtained in the LES despite the drag formulation. Several rather innovative analysis methods (POD, Shannon entropy and mutual information criteria, synchronization analysis) are used as a mean to investigate the presence of von Karman streets within the canopy and Kelvin-Helmholtz instabilities above the canopy. The conclusions remain however very hypothetical and too quickly stated. Overall, the paper lacks rigor in its presentation (description of the simulations as well as the methods) and in the interpretation of results. The analysis methods are (at least for some) not standard in the community and could be introduced more clearly.

We thank the reviewer for the constructive comments. We have improved the manuscript based on Your suggestions.

Specific comments:

LES description: The setting description of the canopy patches is confusing and no information is given on the spacing between patches for the two different settings, nor on non-dimensional distances of virtual towers to the vegetation patches. Yet the effect of spacing between patches is stated as a major question to be addressed by the analysis.

Thanks for pointing out. The spacing between the patches is indeed the important difference between the two configurations and they are now specified explicitly.

This question should be addressed rigorously with non- dimensional results with a range of spacing and normalized distance to a patch.

This is a great suggestion, however in a problem involving canopy patches (roughness transitions), there are a number of different length scales that can be invoked. So showing the results normalized by the canopy height - the only fixed length scale in the problem across different cases makes more sense. This is what we have done in figure 4.

The equation set could be written fully. The simulations include scalars (temperature and water vapour) but no mention is made on stability conditions, which will have a strong effect on structures. As described, the simulations would not be reproducible.

Thanks for this suggestion, we have created an appendix section where the full equations and boundary conditions are described in detail for reproducibility. There have been other significant works on the effect of stability and as Patton 2016 (referenced in the paper) notes, there is significant switching between cell and roll type structures as convective conditions change, which can be very well observed by visualizing w' fluctuations. However, in this work, variations of stability will add further variations on top of what are observed because of the three different configurations. Moreover, in this work we are more interested in simultaneous variations of different velocity components, so stability is held fixed. However the thermal and moisture boundary conditions are now mentioned in more detail.

- **The alternative, so-called 'weak' definition of the VK and KH motions is not introduced properly and should be presented with rigorous hypotheses.**

It is a widely accepted fact in atmospheric and engineering applications that velocity inflections are associated with KH type instabilities. From literature review it appeared to us that the presence of KHI is somewhat taken for granted in for canopy turbulence. For example, the well-known review paper Fininigan 2000 summarizes results from Raupach 1996 which calculated mean streamwise separation of coherent eddies near canopy top and presented a conceptual model which looks like figure 1.

Figure 1: Conceptual diagram of KHI as shown in Finnigan 2000.

They also conclude that although these structures evolve throughout the stages of turbulence development, the streamwise wavelengths are preserved. This motivates our current work in the sense that we want to confirm the presence of such structures directly from the velocity signals instead of the more abstract turbulence statistics that are usually found in the literature.

Similarly for the VK structures, it is an accepted fact that they evolve in a horizontal place across the flow behind the obstacle and for canopy turbulence, this is taken for granted although it is only the lab experiments with real obstacles that observe these. We wanted to examine how realistic are these assumptions for the drag formulation. The so called weak definitions are thus not found in the literature, and we construct them in the paper. What we mean is we want a more direct evidence from the velocity records themselves. We describe this in more clearly and also remove the terms 'weak definition' to avoid confusion.

Method descriptions: The Lorentz curve method is not explained. A parenthesis tries to summarize the idea in a rushed way that is not helpful nor reader friendly.

Although we had referenced it from an older paper, we present in an appendix for the sake of completion.

The synchronization analysis is poorly justified in the sense that using a model based on two oscillators to identify the presence of KH or VK phenomena in the simulation outputs is not supported by appropriate hypothesis. Do the authors assume linear wave theory to model the KH or VK phenomena using two oscillators? What is the protophase?

We agree that this synchronization analysis is not found in the canopy turbulence literature. We first introduced in another paper (De Roo 2017, JAS) and we think this is a powerful technique to understand amplitude independent, phase only synchronization between weakly coupled oscillators. The velocity components are not completely independent as they are modulated by the same physical mechanism, although they are orthogonal to each other. This makes them perfect candidates as weakly coupled oscillators as described by Rosenblum 2001. We have described this in more detail in the text and created an appendix to describe the method in more detail, including the description the protophase.

Interpretation of results: overall, the interpretation of results lacks rigor. The values of the different indicators (Shannon entropy, <u'w'>, local maxima of Iw) are not sufficiently linked to physical processes and are concluded to be signs of KH and VK activity. This is not convincing and comes out as overstatements.

Thanks for pointing out. We agree that these methods are not used much in the literature. We have recently shown their value in interpreting coherent structures in turbulent flows for other applications and expanded the discussion in this work to improve the understanding.

POD analysis: Patch 2 scenario is suddenly abandoned in the POD results section without justification. That the POD results are conclusive for the presence of von Karman street is not so clear from the figures.

We have now included the patch canopy 2 case as well in figure 5. It is true that from visual cues, it is not very clear whether VKS exist - that is why we proceed to the subsequent analyses. This is stated more clearly now.

MIC: large and small scales are poorly defined.

They are now explained better as the Lorenz curve method is described in more detail.

Virtual towers of 20Hz frequency are used to compare with field results, although field results are never discussed. Is there a reason why the authors decided to use a 30 minute period rather than stationary, less noisy results?

Similar LES setup in PALM are used in other publications to compare against field campaigns. Here we do not have any field reference, so we do not compare. However, turbulent statistics for the horizontal homogeneous case in figure 4 compares well with standard results in canopy turbulence such as Dias Junior 2015, Patton 2016, Shaw and Schumann, 1992. It is a standard practice in field measurements of atmospheric turbulence to use half hour statistics. We want to be consistent wit that practice so that if somebody collects data on similar configurations, they can compare.