Summary

This manuscript aims to dissect the effect of atmospheric gravity waves (AGWs) on wake dynamics, including both wake meandering and wake-generated turbulence. The author's use large-eddy simulation (SOWFA) to model a conventionally neutral boundary layer with the wind turbine(s) parameterized using an actuator disk with rotation. To account for AGWs, they use measurements from a lidar assimilated into the LES. The lidar profiles come from data obtained during the American Wake Experiment (AWAKEN). The main conclusions of the study are that AGWs increase wake meandering and wake recovery. In terms of power production, the leading turbine feels the brunt of the AGW with the wake then attenuating the energetic frequencies associated with the AGW. As a result, the effect of AGW fluctuations on power for downwind turbines is small. Overall, the paper is comprehensive for a single set of atmospheric conditions. Their methods do a great job of isolating AGW effects to arrive at their conclusions. I believe the manuscript could be improved with minor revisions including more detail and justification for modeling design choices.

Specific Comments

1. I do not believe that the AGWs shown in Fig. 2 are due to topography, but I also believe that the generation mechanism for the simulated AGWs is not relevant to the work. Unless the authors can provide compelling evidence that the AGWs are terrain-induced, any references stating that the AGWs are a result of topography should be removed or reworded. This starts with the first sentence of the abstract. The authors could state that there are a number of generation mechanisms for AGWs (which is why this is a relevant paper, because they can happen for so many different reasons). Lines 244-245 in the conclusion even briefly discuss how there are other trigger mechanisms.

   In the second sentence of the abstract, the authors refer to AGWs due to topography as transient phenomena; however, mountain waves are typically stationary, which is mentioned in line 63. I do not believe that the second part of the sentence that begins on line 63 to be correct (unless a citation can be provided). Mountain waves are stationary and can be broken down by the Froude number (Stull, 2017). The characteristics of mountain waves depend on the mean flow and mountain characteristics and as a result are just stretched or compressed but do not advect.

   All of this is just to say that for the manuscript, the generation mechanism is not important but that the author's should exercise caution in their justification/discussion of their simulated AGWs.

Reference: Stull, R., 2017: "Practical Meteorology: An Algebra-based Survey of Atmospheric Science" -version 1.02b. Univ. of British Columbia: https://geo.libretexts.org/Bookshelves/Meteorology_and_Climate_Science/Practical_Meteorology_(Stull)/17%3A_Regional_Winds/17.7%3A_Mountain_Waves

2. The author's simulate a conventionally neutral boundary layer; however, the decision to use a CNBL needs to be justified. During the period in which the lidar data is extracted, I assume that some information about stability could be extracted from other instruments at AWAKEN. How AGWs affect wake characteristics could vary significantly in stable or unstable conditions and this should be discussed.

3. At the end of Section 3.1, the authors state that the presence of AGWs increases both horizontal and vertical meandering. Why they increase vertical meandering is relatively intuitive; however, the manuscript does not provide any discussion or analysis on *why* they increase horizontal meandering. Additionally, Figure 4 is a nice visualization, but it would be nice to be helpful to see the large-scale AGWs in the flow. The AGWs shown in Fig. 2 span for 10s of kilometers in the lateral dimension, but Fig. 4 only shows ~250m in the lateral dimension. It would be nice for a reader to qualitatively compare the simulated and observed flow.

4. In Fig. 8, the higher frequency peak at 0.1 corresponding to the Strouhal number of the atmosphere requires more discussion. Why is there a peak corresponding to the boundary layer thickness? Is this something that is observed or has been seen in other simulations that the authors can reference?

5. In Section 3.4, why are the turbines only separated by only 4D? This seems to be quite a small separation distance. In Fig. 2, the propagation direction of the AGWs is to the northeast and the separation distances look quite large for the wind farms for that wind direction. The only time 4D would be appropriate would be for a due east or due west AGW propagation direction. Ultimately, the findings in this subsection are quite insightful and I feel like it would be very helpful to see a similar setup but with further separation distances.

   Also, considering that attenuation is discussed in this section, more plots of spectra are needed. It would be nice to see the TKE spectra for the inflow representing the downwind turbines or even for just the power signal. Then the attenuation can be quantified.

Minor Comments

- Line 21: I would suggest qualifying this statement with the caveat that it depends on the wind direction. Or at least clarifying that this is due to how wind turbines are sited within a wind farm.
- Line 53: The terrain at AWAKEN is not mountainous. In Fig. 1, the valleys and peaks are pronounced because of the colorbar. The greatest elevation difference looks like it is just over 100m over a distance of several kilometers.
- Figure 3: I appreciate that the contours are explained in the caption, but I think there needs to be a color bar because there are colors other than green and yellow and it is difficult to interpret values in between.
- Line 91: “onshore terrain” is too vague. State what the land is used for near AWAKEN. Is it agricultural? Or perhaps shrubland?
- Line 104: This claim should have a citation.
- Line 106: Is the turbine operating at 9 rpm specifically for this case? Typically, there is a range of rpm turbines operate at from cut-in to rated.
- Line 125: Please provide a citation for the definition of wake meandering for the interested reader.
- Figure 7: the legend entry for non-AGW almost makes it look like there is a third entry. Please rearrange the entries for clarity.
- Ine 184-185: delete “in the instantaneous wake flow”.
- Figure 9: I would suggest using a different colorbar for velocity and TKE (Fig. 6).