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Interactive comment on "WRF-Simulated Low-Level Jets over Iowa: Characterization and Sensitivity Studies" *by* Jeanie A. Aird et al.

Anonymous Referee #1

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Summary:

The manuscript use Weather Research and Forecasting (WRF) to predict the climatology of low-level jets (LLJ) in Iowa. Using Mellor-Yamada-Nakanishi-Niino 2.5 PBL scheme, MM5 surface layer scheme, and Noah land surface model, authors limited the study to winds in the lowest 530 m of the atmosphere. Specifically, they studied climatology parameters in the vertical space where the rotor of a hypothetical wind turbine (hub height=100 m, rotor radius=50 m) would spin.

In the second part, authors performed sensitivity analysis to assess how LLJ wind speed profile, duration and frequency are affected by the selection of different types of algorithmic LLJ definitions.

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Discussion paper

The paper presents a topic of high interest and potential practical use, especially to guide the location of future wind energy projects. This is particularly important for Iowa, a state that has been carrying an ambitious program of wind energy developments in recent years. However, the article in the present form still has some important issues to address. The use of some bulk parameters may introduce some uncertainties and merit at least a deeper explanation to demonstrate their merits. In some parts, the narrative is not clear and grammar could be improved. The article is in good track for publication at a later stage, but for now, I would recommend authors to address/respond the following comments:

Major comments:

1. Line 114 (equation 1), line 119 (equation 2), line 197 (figure 4): Are z2 and z1 equal to 150m and 50m (the maximum and minimum height of the turbine rotor) respectively? If that is the case, then the value of wind shear can be very coarse, especially if the core of the jet is right within that rotor interval. In that situation, a bulk wind shear would misleadingly suggest a smooth trend in wind speed from one point to the other, thus masking the existence of a strong positive wind shear in the lower portion plus a strong negative shear in the upper section. For the same reason, the Richardson number calculation wouldn't be too accurate to represent the transition in atmospheric stability (see comment 4).

2. Line 150 (table2): The grouping of both criteria types seems artificial. For example, it is clear that both the 5 m/s-criterion and the 50%-criterion leave out of the analysis many LLJs, but they do that at a different rate, with the 50%-criterion killing one third more LLJs (1-0.0132/0.0198). Both criteria have been grouped together despite having very different "strictness" power. Why not creating groups of criteria with similar "strictness" power (e.g., 5 m/s-criterion with 44%-criterion)?

3. Line 150 (table 2): Why table 2 gives marginal probabilities of LLJs in a single cell, instead of using the entire domain D3? It seems to me that finding marginal

probabilities in the entire domain studied would be more comprehensive in terms of taking into account different conditions of terrain, climatology, etc.

4. Lines 181-182: This 15% seems statistically significant and may indicate that the critical value of Ri_rotor (the transition between stable and unstable atmosphere) is different from 0.25 (but still in the positive). That may be another indication that Ri_rotor, being a bulk parameter, is not very precise as a measure of stability when calculated between a height below and a height above a LLJ peak. The function would be ill-conditioned due to the sensitivity of the shear term in the denominator. It would be interesting to know which fraction of the total jets detected are peaking within the rotor area.

5. Lines 190-191: LLJ's wind speed being lower than non-LLJ's wind speed is curious. Once the atmospheric layers are decoupled, the flow often accelerates to super-geostrophic wind, thus forming the LLJ. Hence, one would expect the wind speed at the heights of the jet core to be substantially greater than the wind speed at the same heights if there were no LLJ. One possible explanation is that, if the jet peak is happening outside (and above) of the turbine rotor (and probably the algorithm is detecting a fair amount of those cases), the rapid decay in wind speed downward due to stable stratification may lead to speed values inside the rotor area that are not so high. However, I am more inclined to accept the explanations provided later in the same paragraph. Explanations (b) and (c) are physically sound, but I am more inclined to think that the criteria used are missing some of the stronger jets (see comment 6). By the way, figure 6 (line 255) show mean wind speed that are much greater than 8.02 m/s when using fixed criteria. Weren't fixed criteria included to calculate the value shown here in line 191?

6. Line 255 (figure 6): The strictest fixed criteria (5 m/s) misses weaker LLJs because their peak wind speeds are not enough to have such speed decrease along the rotor radius (50m). Hence, fixed criterion's mean wind profile is biased upward because criteria discriminate against weaker LLJs. The strictest variable criteria (50%) misses

stronger LLJs because the wind speed decrease (e.g., 0.5x18=9 m/s) is too much to be observed within the limits of the rotor radius (50m). Hence, variable criterion's mean wind profile is biased downward because the criteria discriminates against stronger LLJs. The question is: if each criterion misses some LLJ incidents, why not use the least strict criteria (group 1) rather that group 2?

Minor comments:

1. Lines 73-74: To moderate expectations, it should be made clear that WRF historically has shown some shortcomings in modeling LLJs, with several studies showing WRF underestimating the maxima. The situation has improved in recent years, but LLJs have always been challenging to model with WRF.

2. Line 76: However, I would suggest to succinctly explain the merits that convinced you to use the specific schemes selected (schemes only mentioned in lines 94-96).

3. Line 88: "once" or "one"?

4. Lines 100-101: "...hub height.....nominal rotor plane...". If I understand correctly, there is no wind turbine modeled in the analysis. Presenting wind turbine's terms with no context may confound the reader as to where there is actually a wind turbine involved. I recommend to previously explain this. My personal suggestion would be something like: "Parameters are calculated in a vertical length (from 50 m to 150 m) where a hypothetical wind turbine (not modeled here) may spin, and hereafter we call that span the nominal rotor height, and the height 100 m, the hub height."

5. Lines 110-119: You may prefer to use a consistent style to enumerate a, b, c, d; either all of them in a single paragraph or each one in separated lines.

6. Lines 120-121: "All variables ... are computed at a disjunct hourly time step ... Ri_rotor is computed using output disjunct at three hourly intervals." Would you provide more details as to how and why time steps are "disjunct"?

7. Lines 130-133: "The five values used are 1:1:5 m/s... The five thresholds used

are 10:10:50%." One can infer that you mean “The five values from 1 m/s to 5 m/s in increments of 1” and “The five values from 10 % to 50 % in increments of 10” but the notation may be unclear to many. Is the notation supported by a standard?

8. Lines 168-171: May you rephrase Figure 2 caption? "...during hour identified as exhibiting LLJ..." seems to indicate that the red curve was obtained during a specific, single hour. However, the next sentence ("These profiles are computed for all hourly profiles from all grid cells...") points to something like an average profile using, not only several cells, but also from several hours. Moreover, I am curious as to how LLJs taking place in different grids and at different hours (and therefore potentially peaking at variable heights) were averaged into a unique profile. One can infer that you selected a specific hour in which calculations showed LLJ happening in several cells, then you combined the normalized profiles from those cells into an average profile (the heights of the LLJ’s peaks should be very similar because they are happening in the same hour in not-so-distant locations), and finally did the same with the profiles in the grids with no LLJ happening to obtain the black curve. Is this interpretation correct?

9. Line 173: It is important to clarify that this modal value is obtained within the scope of this analysis (which only detected LLJs using wind speeds within the lowest 530 m of the atmosphere, as mentioned in section 2.1) and therefore cannot be interpreted as the modal value representing all LLJs in the region, which should also include LLJs peaking at higher altitudes. The modal value of all LLJs with core at any height would be probably higher.

10. Line 177: You may consider to spell out "WS" as "wind speed" if that is what it means. “WS” could also stands for “wind shear”, for example.

11. Line 192: "see below". You need to be more specific as to where in the text you are directing the reader. Is it to section 3.2?

12. Lines 112-113: "The mean winter flow direction for both LLJ and non-LLJ is westerly," The arrows don’t contrast much, but it seems that westerly flow direction is for

non-LLJs only, while LLJs exhibit much more spatial variability (Figure 5a).

13. Lines 113-114: "...while easterly flow is more common during the spring months." The arrows don't contrast much, but it seems that that easterly flow direction is for LLJs only, while non-LLJs seem to come mostly from south and southeast (Figure 5b).

14. Lines 212-220: Your cross-reference style is not consistent: Line 212: Figure 5(a) and (b). Line 218: Figure 5a. Line 220: Figure 5

15. Line 221 (figure 5): Would it be possible to use a more contrasting color for LLJ arrows in subfigures (a) and (b)?

16. Lines 222-224: If the color scale represents elevation and wind vectors are represented with arrows, then it is not clear which element in figures 5a and 5b is representing "contours of regions of highest 10% of LLJ frequency".

17. Lines 277-279: "The median LLJ height is higher by approximately 20 m when the fixed wind speed thresholds are applied than in use of any of the variable thresholds. . ." Revise sentence grammar.

18. Line 287: "...for applied for..." Check grammar.

Please also note the supplement to this comment:
https://wes.copernicus.org/preprints/wes-2020-113/wes-2020-113-RC1-supplement.pdf

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