Wind Energ. Sci. Discuss.,
https://doi.org/10.5194/wes-2019-7-RC2, 2019

WIND ENERGY SCIENCE DISCUSSIONS

Interactive comment on "Improving mid-altitude mesoscale wind speed forecasts using LiDAR-based observation nudging for AirborneWind Energy Systems" *by* Markus Sommerfeld et al.

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Received and published: 2 May 2019

1 General comments

This paper about an airborne wind energy resource assessment is a valuable contribution. The focus is clearly on the improvement of the wind speed forecast at higher altitudes using LiDAR data. A relatively small part is about the use of this wind data for the prediction of power production from AWES.

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Discussion paper

The description of the simplified power production model in Section 4.7 is unclear and inhomogeneous. On the one hand, very specific derivation steps of the original derivation are mentioned (geometric relation of aerodynamic force components and apparent wind velocity components) that are not of interest within the scope of this paper and would require proper illustrations and more background information. Other aspects that would be important are however not discussed, for example assumptions and specific choices. I recommend to carefully revise this part of the paper.

The original model of Schmehl et al (2013), that was also used as a basis for many other studies, is independent of tether length, as it is also apparent from your Equation (5). What was then the reason for you to choose a constant tether length of 1500 m? And how does the tether length come into play? This should be clearly described. If you would account for tether drag, the performance of the AWES would decrease with increasing tether length (compared to the idealized case of no tether drag). Tether drag could, for example, be taken into account by an additional drag contribution and lumping this to the kite, as some authors do. A possible reference could be van der Vlugt (2019). But I assume that this was not done in the paper, for the purpose of simplicity? If so, please state this, as it is important when considering large ranges of tether length.

For a implemented real AWES it makes generally sense to fly on a shorter tether when flying at lower altitudes, to reduce the effect of tether drag. For a pumping AWES, which is considered here, the tether length continuously varies. Assuming a constant tether length is seemingly in contradiction with this and should thus be motivated better. Just "Here we assume a constant tether length" is not sufficient in my opinion. I would also like to know, if the choice of the constant tether length could possibly influence the results displayed in Fig. 13 (for this is must be clarified how tether length actually enters the modeling).

2 Specific comments

Authors

I believe that the Fraunhofer IWES location at Bremerhaven, Germany, is meant, and not Oldenburg?

Abstract

I would spell out WRF once, as you do with AWES.

Introduction

Add a reference to Bechtle et al (2019). This could for example be done on p. 2, l. 14, just after Archer and Caldeira (2009).

Uwe Fechner (2016) describes in his dissertation and a later book chapter (https://doi.org/10.1007/978-981-10-1947-0_15) a turbulence model for AWES, based on the Mann turbulence model. As you shortly mention conventional spectral wind models (Burton, 2011) this might be worth a discussion point.

p. 2, l. 23: You state "No mid-altitude measurement device can reliably gather long term, high frequency data." but do not give any reason for this. This statement should also be better embedded in the surrounding text.

p. 2, l. 25: Your reference to future work (complementation of TI estimates with LES data) is better for the conclusions section.

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Discussion paper

p. 2, l. 28: Add a reference to the Onkites II project report, available from https://doi.org/10.2314/GBV:1009915452 Can the measurement data of OnKites II be made publicly available, as a data reference to complement this and the earlier paper? This would increase the value of this research tremendously (reproducibility!).

Mesoscale Modeling Framework

p. 4, l. 16: For the non-experts of this specific technique it would make sense to elaborate on the "non-physical forcing term". Why non-physical? Why not physical?

p. 4, l. 18: It is unclear what the use of 3 nested domains is. Please clarify. What is η-pressure? (also ""η-levels" in l. 23)

p. 4, l. 25: Again for the non-experts: what is the difference between "observation nudging" and "analysis nudging"? Maybe a pointer to the respective subsections, where you explain this, is sufficient.

p. 5, l. 4: What is the meaning of "q_m interpolated"? And what means "(q_0)"?

p. 5, l. 9: "hydrostatic"? This paper is about atmospheric flows.

p. 5, l. 13: The time expression in the bracket is not correctly written. It is not the mathematical constant 2.71828 that is meant here, because this would lead to 9 seconds.

Results

Elaborate on how unavailability of LiDAR data is handled for the nudged simulations.

p. 8, l. 3: RSME is missing in legend.

p. 8, l. 5: The reduction of the spread of the bias is hard to observe by eye.

p. 8, l. 9: Doesn't nudging reduce the error? So, reduced nudging would result in larger error?

p. 9, l. 14: Please elaborate on this sentence.

p. 9, l. 11: Bechtle et al (2019) have used a similar representation as the one described here, using dots to show the optimal altitude for operation of an AWES. A reference should thus be added, and possibly also a discussion of the usefulness of this measure added (i.e. an AWES will generally sweep an altitude range, which means that this single point characterization is only a very rough measure.)

p. 9, l. 14: How do you see that the LLJ and the .... are weaker? I can hardly see anything.

p. 11, l. 7: You write "remain the same". Shouldn't ΔV be zero?

p. 11, l. 8: You write "change in wind speed": is this observed by the gradient?

p. 14-15, Figs. 7 and 8: Why are contour plots of Fig. 7 not as smooth as respective plots of Fig. 8. The caption mentions "filtered": aren't these "unfiltered"?

p. 20, l. 3: You write "We chose": how do you control this?

p. 21, l. 8: "Misalignment" is between TETHER and wind direction. It should be clear that the azimuth and elevation angles describe the angular position of the kite or aircraft with respect to the ground station. Renaming of θ as elevation angle is dangerous, because it is generally use for the polar angle.

Conclusions

I am missing some conclusions of Section 4.7 on the AWES power estimation.

3 Language & style comments

General spelling

- Use of dashes should be checked (e.g. "high-resolution data" or "long-term statistics" would be correct)

- Do not capitalize abbreviations (see https://www.aje.com/en/arc/editing-tip-capitalization-when-defining-abbreviations/).

Title

p.1: "Airborne Wind Energy" should be "Airborne wind energy".

Abstract

p. 1, l. 9: I would add an "it" between "but" and "becomes".

Introduction

p. 2, l. 4: "Airborne Wind Energy Systems" should be "Airborne wind energy systems".

p. 2, l. 4: I would say that AWES are a class of renewable energy technologies, and not a source of energy. The source is the wind.

p. 2, l. 10: Instead of "marketplace" I would just write "market".

p. 2, l. 11: ...none are YET commercially available.

p. 2, l. 13: "power" should be "power output" as you list wind energy technologies here.

p. 2, l. 23: ... variations to resolved quantities are parametrized. The "resolved" sounds wrong and the meaning of this sentence is also not clear to me.

p. 2, l. 25: "here presented" -> "presented in this study"

p. 2, l. 27: Year is missing in reference.

p. 3, l. 1: "power" -> "power output".

Measurement campaign

p. 4, l. 2: Year is missing in reference.

p. 4, l. 3: Should be "emphasizes".

p. 4, l. 6: Should be "... the WRF-calculated...". The entire expression "WRF-calculated sensible surface heat flux (SHF)" sounds incomprehensible to me. What is the role of the "sensible"?

p. 4, l. 9: Should be "... the SHF".

I would move Fig. 1 to the next section and remove the reference to the white X here. Because in the next section you explain the 3 hierarchically nested domains used for the WRF. Here, in this section, the figure introduces more questions than answers.

Mesoscale modeling Framework

p. 4, l. 14: Year is missing in reference. It is also not clear whether the "section 2" in the referenced paper or the present one is meant.

p. 4, l. 15: Year is missing in reference.

p. 4, l. 17: Why discussing here spatial resolutions when this is all given in Table 1?

p. 4, l. 23: "Turbulent Kinetic Energy" should be "Turbulent kinetic energy". Add "(TKE)" here and use the abbreviation in the next sentence.

p. 4, l. 29: Maybe a footnote link with the URL is better? This bibliographic reference looks strange.

p. 5, l. 20: Something is wrong after W_xy.

Results

p. 6, l. 5: Should be "differences".

p. 7, Fig. 2, legends: text and number should be separated by a space and also a comma.

p. 9, l. 2: Replace "bias" by "error".

p. 17, l. 3: Reference missing (?).

p. 19, Table 2: last three columns in % of time would be better readable.

p. 20, l. 4: "additional two" -> "two additional"

p. 20, l. 5: Figure reference is missing (??).

p. 21, l. 6: Why do you use a subscript "air" for the density? This study is only about atmospheric flows, so the index can be safely omitted.

p. 21, l. 7: Set equation in displaymode.

p. 21, l. 10: "... are assumed constant are ...": something is wrong here.

Conclusions

p. 23, l. 7: Six months OF LiDAR .....

p. 23, l. 13: Dot behind "decreases" is missing.

Appendices

p. 25, Figure A1: what means the question mark at the end of this caption? "U profile" -> "velocity profile".

p. 25-26, Table A1: Include in the caption to which software & version, possibly also model, these settings refer.

References

There are many references for which the DOI is occurring twice, as "doi:..." and as URL "https://doi.org/...".

p. 28, l. 13: what is this oCLC number? I would use either ISBN or DOI.

p. 28, l. 19: Publisher or standard-issuing organization is missing.

p. 29, l. 15: Correct the URL.

p. 29, l. 23: Add DOI.

p. 29, l. 27: Insert comma/dot and space between "2016" and "At".

p. 30, l. 3: "Statistik" should be starting with a capital "S", according to German spelling. Consider choosing an English textbook as reference.

p. 30, l. 8: This is a contributed chapter in a book. Accordingly the reference should be Schmehl, R., Noom, M., van der Vlugt, R.: Traction Power Generation with Tethered Wings. In: Ahrens, U., Diehl, M., Schmehl, R. (eds.) Airborne Wind Energy. Springer, Berlin Heidelberg, 2013. doi:10.1007/978-3-642-39965-7_2

p. 30, l. 14: Update this.

4 References

van der Vlugt, R., Bley, A., Noom, M., Schmehl, R.: Quasi-Steady Model of a Pumping Kite Power System". Renewable Energy, Vol. 131, pp. 83-99, 2019. doi:10.1016/j.renene.2018.07.023

Bechtle, P., Schelbergen, M., Schmehl, R., Zillmann, U., Watson, S.J.: Airborne wind energy resource analysis. Renewable Energy, Vol. 141, pp. 1103-1116, 2019. doi:10.1016/j.renene.2019.03.118

Mann, J.: The spatial structure of neutral atmospheric surface-layer turbulence. Journal of Fluid Mechanics273, 141 (1994). doi:10.1017/S002211209400188620

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