Review of : WES-2021-109
Detecting and Characterizing Sea Breezes Over the U.S. Northeast Coast with Implication for Offshore Wind Energy by Xia et al. Description:

The study applies a new two-step classification method for sea breezes using simulations with the WRF regional model. The approach is used with a year of high resolution, 2 km, simulation over the area of New York. The method is used to identify pure, corkscrew, and backdoor breezes, analyze their statistics of occurrence and their impact on energy production.

General comment:

I think that the purpose of the paper is valuable. It is well written in structure and provides relevant results and discussion. I support publication after the minor comments that follow below.

Response: Thank you for your positive views on our paper. We sincerely appreciate the time you spent reviewing this work. In this revision, we have revised the paper substantially based on yours and other reviewer's comment. The key changes are

- The title of the paper has changed to *Detecting and Characterizing* ***Simulated*** *Sea Breezes Over the U.S. Northeast Coast with Implication for Offshore Wind Energy*.
- An additional analysis has been conducted to examine the variability of individual sea breeze cases.

Specific comments

SC1 Section 2.1. Experiment design. A ratio of 3:1 is most often used in the design of the model domains. I suggest the authors include some comments about the use of a 5:1 ratio. Some arguments on the final resolution selected would also be welcome. For instance, a downscaling enhancing the resolution from the ca. 27 Km of ERA5 to 9 and 3 km would be another possibility, even down to 1 km. Also, some arguments about the selection of parameterizations would be good, specifically the use of microphysics. Overall, it would be good to include some rationale about the model configuration selected.

Response: Thank you for your comment. In general, the WRF developers recommend using odd ratio – typically 3:1 or 5:1. The 5:1 ratio has been suggested years ago. The same WRF configuration has been used in a different study (Pronk et al. 2021). Corresponding reference has been added to the revised manuscript.

Reference:

Pronk, V., Bodini, N., Optis, M., Lundquist, J. K., Moriarty, P., Draxl, C., Purkayastha, A., and Young, E.: Can Reanalysis Products Outperform Mesoscale Numerical Weather Prediction Models in Modeling the Wind Resource in Simple Terrain?, Wind Energ. Sci. Discuss. https://doi.org/10.5194/wes-2021-97, in review, 2021.

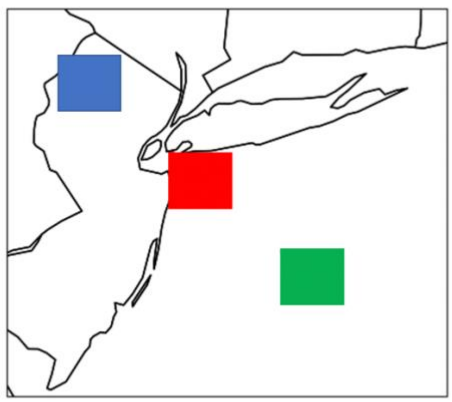
SC2 This is not a model evaluation paper. However, it would be an asset that figures 6 and 7 of the composite averages would also show some observed values. This would allow for assessing consistency with observations. One single station would allow for verifying the wind rotation.

Response: Thank you for your comment. As you can tell, this paper is not about model evaluation or model validation. This is also the reason why we change the title to better reflect our purpose.

Validating with observations is certainly the second step of this work but is too much to cover in this paper as there are over 60 identified simulated sea breeze cases. Such analysis would be better fitted for a case study where we focus on comparing not just the wind field but also the other metrological aspects (e.g., temperature, vertical structure) between the simulated and observed sea breeze.

SC3 I think it would be important to provide some information on the representativeness of the average maps in figs 6 and 7. It would be useful to provide some evaluation of the variability of each hour within the composite, for instance, with the map of local variances. Alternatively, a wind rose for a point in the center of the domain could be shown using all the days of the composite.

Response: Thank you for your comment. In this revision, we have conducted additional analysis to examine the variability of simulated sea breeze events to address your concern. Our results suggest that the temporal development of the calm zone for the pure sea breeze and the positioning of the coastal jet for the corkscrew sea breeze is rather consistent across their identified cases respectively.



To do that, we have defined three regions to quantify the variability of the identified sea breeze cases (as shown in the figure). They are located on land (blue), over the coast (red) and over the ocean (green). The size of region is about 3 % of the entire regional domain. For each sea breeze type, we calculate the standard deviation of WS10 and WD10 from the identified sea breeze events over all three regions from 08 LT to 20 LT, and the results are shown in the tables below.

Table1 : Variability of simulated pure sea breeze cases over land, coast region and ocean

Standard Deviation of WS10(m/s) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	1.4	1.3	1.2	1.1	1.2	1.3	1.4	1.3	1.1	0.9	1.0	0.8	0.8
Coast	2.3	2.0	1.8	1.6	1.5	1.4	1.3	1.4	1.4	1.4	1.3	1.2	1.4
Ocean	3.0	2.8	2.5	2.1	1.8	1.7	1.7	1.6	1.5	1.6	1.7	1.8	1.8
Standard Deviation of WD10 (degree) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	119	111	94	77	62	58	58	62	63	63	56	51	55
Coast	102	119	114	105	92	78	65	60	55	54	53	62	51
Ocean	118	129	112	108	107	116	115	110	106	97	85	78	76

For the pure sea breeze cases (Table1), the variability of WS10 is largest during the morning hours and decreases after that. Overall, the variable of WS10 is greater over the ocean than that on land. As for WD10, the variability is large during the morning hours. Note that, based on our methodology and the shape of the coastline, the pure sea breeze is identified from potential days of three different wind regimes (Northwesterly, Northly and Westly). Therefore, it is not a surprise that variability of WD10 is large during the morning hour. However, variability of WD10 drastically decreases after the morning hour due to the influence of sea breeze development. Note that the standard deviation of WD10 over the ocean is relatively large until late afternoon. This is mainly due to the development of the calm zone (Figure 6 of the manuscript). After the calm zone moved away from the coast, standard deviation of WD10 reduces significantly (16 LT to 20 LT).

Table2 : Variability of simulated corkscrew sea breeze cases over land, coast region and ocean

Standard Deviation of WS10(m/s) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	1.1	1.0	1.1	1.1	1.1	1.0	0.9	0.8	0.6	0.8	1.0	0.6	0.7
Coast	1.8	1.7	1.6	1.7	1.9	1.7	1.8	1.7	1.8	1.8	1.7	1.6	1.8
Ocean	2.4	2.3	2.1	1.9	1.8	1.9	2.1	2.2	2.3	2.5	2.4	2.4	2.2
Standard Deviation of WD10 (degree) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	68	67	58	48	42	43	44	43	43	44	40	46	40
Coast	79	80	69	55	45	36	32	35	28	28	28	35	31
Ocean	67	78	85	75	75	78	66	62	60	57	48	36	31

Table 2 shows the results from the corkscrew sea breezes. In general, the characteristics are similar to that from the pure sea breeze cases. One important aspect is that the small variabilities of WD10 over the coast region during the late afternoon hours. This suggests that the position of the simulated jet core (Figure 7 of the manuscript) over this region is rather stable, which would have significant offshore wind energy implication in terms of wind turbine positioning.

Table3 : Variability of simulated backdoor sea breeze cases over land, coast region and ocean

Standard Deviation of WS10(m/s) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	0.9	1.1	1.6	1.7	1.6	1.7	1.7	1.7	1.8	1.4	0.8	0.4	0.3
Coast	2.4	2.3	2.2	2.4	2.5	2.4	2.3	2.3	2.3	2.3	2.2	2.3	2.4
Ocean	3.5	3.7	3.6	3.5	3.4	3.0	2.9	3.0	3.0	3.0	2.9	2.8	2.7
Standard Deviation of WD10 (degree) for the Identified Pure Sea Breeze Cases													
	08 LT	09 LT	10 LT	11 LT	12 LT	13 LT	14 LT	15 LT	16 LT	17 LT	18 LT	19 LT	20 LT
Inland	16	17	20	29	34	37	35	31	31	27	27	29	31
Coast	13	14	17	18	16	16	17	16	18	22	22	28	26
Ocean	107	94	42	37	58	65	78	62	36	24	17	22	29

Table 3 shows the results from the backdoor sea breezes. Because of low occurrence rate, It has the smallest variability, which also indicates that the development of the individual backdoor sea breeze does not differ much from the mean condition (Figure 8 of the manuscript).

Corresponding texts and tables have been added to the manuscript. Note that we have changed the alignment of three regions in other attempts, such as horizontal and vertical. However, that does not change the table results significantly.

SC4 Consider including in Table 2 the numbers of sea breeze events, and also unclassified events.

Response: Thank you for your comment. The unidentified case has been added to Table 2.

SC5 I like the discussion in Section 4. I think that some more comments arguing about the potential sensitivity of the results to changes in the WRF configuration or changes in the statistical approach to detect breezes would enrich the Section. The discussion includes an assessment of the sensitivity of the current approach to changes in the parameters used. What would arguably be the impact of other methods?. In any case, the fundamental conclusion that identifying different types of breezes is relevant for wind energy forecasts is not expected to change.

Response: Thank you for your comment: The following sentences have been added to enrich the discussion.

"*Other factors such as changes in the WRF configuration, statistical approach and targeted region, could have potential sensitivity to the overall number as well as the seasonal distribution for each type of sea breeze. Nevertheless, the importance of identifying the correct type of sea breeze for wind energy forecast would still be significant and serve as a high-priority research topic, especially for offshore wind energy*.

Minor comments

MC1 Abstract, lines 20-22: 'From the wind energy perspective, the power production associated with a 10 megawatts offshore wind turbine would produce approximately 3 to 4 times more electrical power during a corkscrew sea breeze event than the other two types of sea breezes' The sentence reads strangely to me. Alternative '... would be approximately 3 to 4 times larger during...'

Response: Thank you for your comment. Corresponding changes have been made.

MC2 Lines 75: '(Hersbach et al., 2020)'

Response: Thank you for your comment. Corresponding reference has been added.

MC3 In general the characters of the figures are small. Making them larger would produce a better reading experience if the manuscript is printed

Response: Thank you for your comment. Corresponding changes have been made.

MC4 In general the characters of the figures are small. Making them larger would produce a better reading experience if the manuscript is printed

Response: Thank you for your comment. Corresponding changes have been made.

MC5 '...between 08 to 20 local time (LT),...' I suggest using LST, local standard time, that here would be Eastern time. The chances that LT gets confused with saving time are low but I think it would be more appropriate

Response: Thank you for your comment. In general, LST stands for "Land Surface Temperature". So we keep the LT as acronym to avoid confusion.

MC6 '... WD10 for each individual quadrantS ...'

Response: Thank you for your comment. Corresponding changes have been made.

MC7 Figure 3 caption. Alternative: '...prevailing wind where SLP conditions favor the development of: a) pure sea breeze; b) backdoor sea breeze; c) corkscrew sea breeze. '

Response: Thank you for your comment. Corresponding changes have been made.