Wind Energy Science wes-2025-130
Responses to Reviewers

Dear Dr. Xiaolei Yang, Handling Associate Editor of Wind Energy Science

With these responses to the associate editor, we submit an original research article entitled "Bidirectional wakes over complex terrain using the SCADA data and wake models" by Sasanuma, N., Honda, A., Bak, C., Troldborg, N., Gaunaa, M., Nielsen, M., and Shimada, T.

We have revised the manuscript carefully according to the associate editor's comment. The authors' responses to the associate editor's comment are described below. The symbol "**Author response**" means the author's response.

We have thoroughly checked the manuscript for wording and clarity and made the necessary revisions. We have corrected the minor error in the plot of the wind roses in Figure 3 and related numerical values. However, these corrections do not affect the results or the conclusions of this study.

We thank the reviewers for carefully reading our manuscript and the associate editor for providing constructive comment and overseeing the review process of our manuscript.

Sincerely,

Nanako Sasanuma
Graduate School of Science and Technology, Hirosaki University

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Responses to Associate Editor

The referees' comments have been satisfactorily addressed by the authors. Before the manuscript can be accepted for publication, in Appendix A, it is suggested to add brief descriptions for the 12 wake models tested in the authors' work, with necessary expressions, values of model parameters, and explanations on whether or not the effects of complex terrain are accounted for in the model and how (if yes).

Author response: We appreciate your time and effort in reviewing our manuscript and providing supportive and valuable comment. We have incorporated your suggestions into the revised manuscript. Considering your comment, our responses are summarized as follows.

- To clarify the differences among the 12 wake models, we added a new paragraph at the end of Section 3.2 and Appendix C as below. In the paragraph, we summarize the reproducibility of the 12 wake models based on Figs. 11, 12, 13, B1 B2, C1, and C2. In Appendix C, we present and compare the vertical structures of the wakes simulated by the 12 wake models over the complex terrain for northeasterly wind and southwesterly wind. Moreover, we revised the descriptions of the wake model results in Appendix B.

- We use the default parameter values for all wake models available in PyWake 2.5. The main parameters that govern the reduction in wind speed are thrust coefficient (Ct), wake width (σ), wake expansion rate (k), and turbulence intensity (TI). However, the wake models use more parameters in their formulations, and the equations would be necessary to show the parameters. Thus. We considered that listing the values of all parameters in a single appendix would be beyond its intended scope.

- Instead of listing the parameters in the wake models, we considered it more beneficial to compare the simulation results of the 12 wake models. We added Appendix C to show the difference in vertical structures of the wakes simulated by the 12 wake models. A clear difference can be observed even when the default parameter values are used. This fact suggests that the differences in fundamental formulation or concepts of the wake models are important.

(The last paragraph of Section 3.2)

From the results obtained so far, we consider the differences among the wake models. The degree of wake reproducibility depends on inflow wind speed (Figs. 11, B1, and B2). Terrain effects induce a systematic bias in the reproducibility of wakes (Figs. 12, 13, B1, and B2). From the perspective of wake structure, the differences among the wake models lie in the downstream extents of the wakes and the magnitude of the wind speed reduction immediately behind the wind turbine (Figs. C1 and C2). In particular, the downstream extents of the wakes are key for obtaining results consistent with the SCADA observations in this study. Although the simulation results might depend on parameter settings of the wake models, the present results suggest that the major differences arise from the model formulation. These results highlight the importance of selecting appropriate wake models and considering topographic situations.

(Appendix C)

Appendix C: Vertical structures of wakes simulated by the 12 wake models

We compare the vertical structures of wakes over complex terrain among the 12 wake models for northeasterly wind and southwesterly wind, respectively (Figs. C1 and C2). In Figs. C1a, C1b, C2a, and C2b, the wakes show linear downstream extensions and no vertical variation. The Fuga wake model exhibits the reduction in wind speed outside the rotor areas (Figs. C1c and C2c). The other wake models produce Gaussian-shaped wakes, whereas the simulated results differ in their wake extents and the reduction in wind speed immediately behind the wind turbines. The Bastankhah wake model and the TurboGaussian wake model show that the wakes generated by the upstream wind turbines reach the rotor of the downstream wind turbines without significant attenuation (Figs. C1d, C1i, C2d, and C2i) and that the simulated results reasonably capture the observed results.

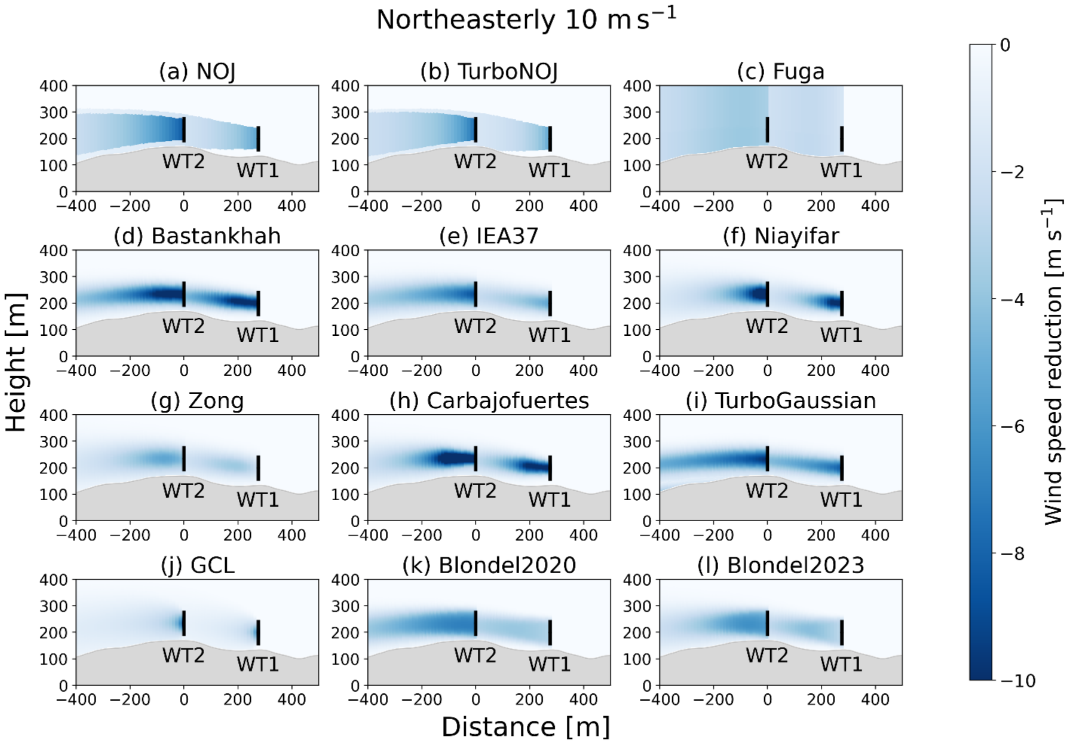

Figure C1. Reduction in horizontal wind speed due to the wakes simulated by the 12 wake models for northeasterly. The inflow wind speed far upstream is set to 10 m s^{-1}. The color shading represents the difference in horizontal wind speed between wake conditions and no-wake conditions. The black lines indicate the positions of the rotors of the wind turbines. The data from WAsP CFD are available from 5 m above ground level.

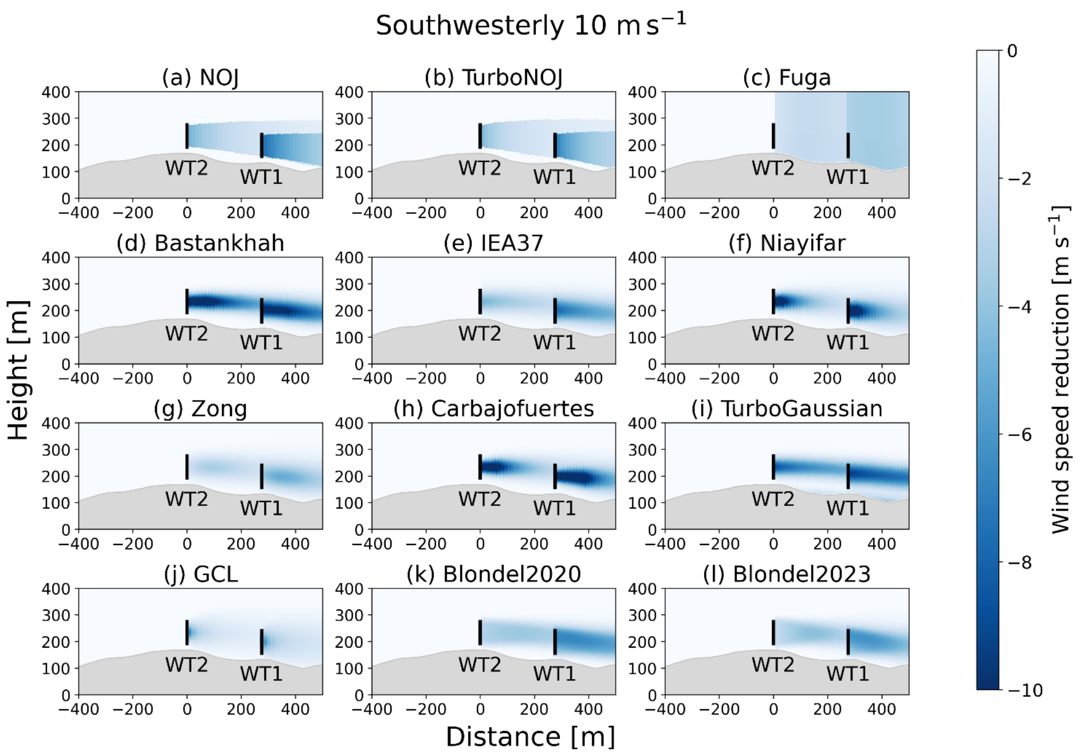

Figure C2. The same as in Fig. C1, but for southwesterly wind.