

Interactive comment on “FLOWSTAR-Energy: a high resolution wind farm wake model” by Amy Stidworthy and David Carruthers

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(Reviewer comments are labelled ‘RC’ and numbered with the reviewer number and the comment number; the author comments are labelled ‘AC’ and numbered the same way. AC1.1 is the authors’ response to reviewer comment RC1.1 (the first comment from reviewer 1) etc.)

RC1.1: “There appears to be very little connection between FLOWSTAR and the superimposed wake deficit model. The downstream propagation of the wakes appears for example to be independent of the stream lines of the flow. I therefore recommend that the connection to FLOWSTAR is down-played until the validation in complex terrain is in place.”

AC1.1: The wake model and the FLOWSTAR flow model are integrated, in the same

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way that the plume model is integrated with FLOWSTAR in ADMS. The centreline of the wake does follow the streamlines of the flow; however this is not adequately explained in the paper and so amendments will be made.

RC1.2: “The manuscript does not include validation of the calculated shear-induced (wake added) turbulence. The connection between the model for shear-induced turbulence and wake deficit model appears to be one-way, such that the shear-induced turbulence model is not necessary for the description of the wake deficit. I therefore recommend that the description of the shear-induced turbulence model is removed until the output of this model is validated. Influencing this recommendation is the observation that many of equations in section 2.3 have generated specific or technical comments below.”

AC1.2: Although the authors agree with the reviewer that the shear-induced turbulence component has not been explicitly validated in this paper, we disagree with the reviewer’s statement that the description of the shear-induced turbulence model should be removed from this paper. The shear-induced turbulence in the wake model affects the dispersion of individual wakes, and impacts on the source characterisation and dispersion of downstream wakes; therefore the turbulence model is implicitly validated in the Nysted and Noordzee wind farm validation cases and to remove the description of the shear-induced turbulence model would render the model description incomplete. However, we acknowledge that this linkage is not adequately explained in the paper so amendments will be made to rectify this.

RC1.3: p5, line 13 “In eq. (8) it is unclear if sigma-shear is the turbulence contribution from one WTG or the accumulation of the wake-added turbulence from all upstream WTGs. The formula seems to suggest the former.”

AC1.3: Yes, sigma-shear is the turbulence from one WTG; the text will be amended to explain this better.

RC1.4: p5, line 22 “What is σ_{i+1} and how is it calculated?”

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AC1.4: $\sigma_{[i+1]}$ is the total turbulence at the $[i+1]$ th point, not including shear-induced turbulence from the current turbine. It does therefore include ambient turbulence and the shear-induced turbulence generated by upstream turbines. Again, the text will be amended to explain this.

RC1.5: p6, line 4 “Eq. (12) leads to a higher value of TI than the standard definition. Is the introduction of a non-standard definition intentional?”

AC1.5: Yes. The definition of turbulence intensity used for the calculation of shear induced turbulence accounts for the spatially-varying nature of the wind direction and the potential influence of complex terrain.

RC1.6: p3, line 24 “Reference is missing.” AC1.6: Apologies, errors with links were introduced when the paper was re-formatted for Wind Energy Science; all links and references will be re-checked and corrected prior to re-submission.

RC1.7: p4, line 25 “A ‘crosswind vertical slice’ is not an intuitive concept. Consider adding a sketch to illustrate the concept.”

AC1.7: Agreed, a sketch will be added. This section will be revised significantly in the light of comments from all three reviewers, so hopefully this will help clarify the methodology.

RC1.8: p5, line 1 “Eq. (7) appears to be missing a ys (corresponding to zs)”

AC1.8: (x,y,z) is a ground-based source-centred coordinate system, i.e. $x=0$ and $y=0$ at the source location, hence equation (7) is correct. However, this is not explained in the text. This section will be revised significantly, and an explanation of the coordinate system will be included.

RC1.9: p5, line 19 “In eq. (9) σ_{tot} should be $\sigma_{\text{tot}}[i]$ or $\sigma_{\text{tot}}[i+1]$?”

AC1.9: It should be $\sigma_{\text{tot}}[i]$. This will be corrected.

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