Referee Comment on "A Generalised Gaussian Wake Model Based on Extended Actuator Disc Theory"

General comments

This manuscript presents a generalised Gaussian wake model based on extended actuator disc theory and proposes a new analytical criterion for identifying the transition from the near wake to the far wake based on the competing effects of pressure recovery and turbulent wake mixing, while explicitly incorporating blockage effects. The work is novel and potentially valuable, particularly because of the explicit treatment of blockage effects and the attempt to derive the transition location analytically. The manuscript is generally well written, the methodology is presented in a logical and coherent manner, and the authors provide a publicly available implementation of the proposed model.

I found the study scientifically interesting and relevant to the readership of *Wind Energy Science*. The inclusion of blockage effects and the systematic investigation of turbulence intensity, thrust coefficient, and blockage ratio constitute important strengths of the work. The results generally exhibit physically plausible trends and show good agreement with the RANS database considered.

The manuscript contains sufficient novelty and scientific merit to warrant publication in *Wind Energy Science*, provided that the concerns outlined below are satisfactorily addressed. Nevertheless, I have several concerns regarding the mathematical derivation, the physical interpretation of certain modelling assumptions, and the validation of the proposed transition criterion. In my view, these issues should be addressed before the manuscript can be considered for publication.

Major comments

1. Derivation of the transition criterion, Eqs. (22)–(28)

The derivation leading to Eqs. (22)–(28) constitutes the mathematical foundation of the proposed transition criterion and ultimately provides the analytical prediction for the transition location x_3. However, I found several steps of the derivation difficult to follow and not fully explained mathematically, which is particularly important given that the final expression incorporates blockage effects, one of the principal novelties of the work.

In particular, I found the mathematical treatment used between Eqs. (22) and (24), as well as the determination of the integration constant, insufficiently justified. While the physical arguments presented are intuitive, it is not entirely clear whether they provide sufficient mathematical justification for the resulting expression. I would appreciate a more detailed derivation and discussion of the assumptions involved.

2. Modified momentum expression introduced in Section 3.6

Section 3.6 introduces a modified momentum expression to improve agreement between the Gaussian wake representation and the RANS results. While the resulting predictions appear to improve agreement with the RANS data, the manuscript explicitly states that there is currently no strict explanation for the validity of the proposed expression.

I would appreciate further clarification regarding the physical basis of this modification. At present, it is not entirely clear whether the correction should be viewed as a consequence of the underlying theory or as a pragmatic modification introduced to improve agreement with the RANS simulations, whereas the manuscript generally presents the model as a physics-based analytical framework. I encourage the authors to clarify the rationale behind this modification, discuss its limitations, and explain whether it should be interpreted as a semi-empirical correction or as a consequence of the underlying theory.

3. Validation and interpretation of the proposed transition location

The proposed transition location x_3 represents one of the main contributions of the manuscript and is central to the novelty claim of the work. However, the validation of x_3 appears to be largely qualitative, relying primarily on comparisons between predicted and observed intersection points.

By contrast, the quantitative error analysis focuses primarily on centreline velocity predictions. While these results are valuable, they do not directly assess the accuracy of x_3 itself. It would therefore be useful to discuss more explicitly the sensitivity and predictive performance of the proposed x_3 criterion across the investigated parameter space.

I also encourage the authors to discuss how the proposed transition criterion relates to existing near-wake and far-wake transition concepts mentioned in the Introduction and the broader wake-modelling literature. I recognise that different studies define the near-to-far wake transition differently, and therefore exact agreement should not necessarily be expected. Nevertheless, discussing whether the proposed criterion reproduces trends similar to those reported by previous formulations with respect to turbulence intensity and thrust coefficient would help place the present work within the broader literature and clarify its added value.

4. Dependence on the turbulence closure

The proposed transition criterion is based on the quantity

$$\mathcal{R} = \nu_t \nabla^2 U,$$

which depends directly on the turbulent eddy viscosity.

The manuscript develops and validates the model within a modified k–ε RANS framework. It would be useful to discuss the extent to which the resulting transition location is expected to depend on the selected turbulence closure and whether the authors view the criterion as a general physical indicator or as one specifically associated with eddy-viscosity-based formulations. Such a discussion would help clarify the scope and applicability of the proposed approach.

Minor comments

1. Table 1 defines all simulation cases, but the corresponding case numbers are not referenced in the main text. Including the case number when discussing individual scenarios would improve

readability. Similarly, figure captions or annotations within the figures could explicitly identify the corresponding case numbers.

2. The caption of Figure 2 may benefit from verification. The caption refers to velocity-gradient profiles, whereas the figure appears to present only streamwise velocity profiles. In addition, the axis normalisation is not immediately clear at this stage of the manuscript and may benefit from earlier clarification.

3. The schematic representation of Stage 4 in Figure 3 is somewhat difficult to interpret. The symbol used may not clearly convey the intended far-wake recovery region. A shaded region or a more conventional wake representation might improve clarity.

4. The middle expression appearing in Eq. (28) is explained in greater detail only later in the manuscript. A short forward reference or additional explanation may improve readability.