Wind Energ. Sci. Discuss., referee comment RC1
https://doi.org/10.5194/wes-2022-50-RC1, 2022

Comment on wes-2022-50

Anonymous Referee #1

Referee comment on "Wind turbine wake simulation with explicit algebraic Reynolds stress modeling" by Mads Baungaard et al., Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2022-50-RC1, 2022

This paper discusses the use of an Algebraic Reynolds Stress Model for the simulation of wind turbine wakes. The paper validates the model for some simpler test cases before considering the wake and multiple wake cases. The paper is well written and technically correct. The turbulence model being considered is actually fairly simple, but every application goes through this sort of evolution to more complex turbulence models, and it is useful for the applications to know what the turbulence model cost and accuracy trade-offs are for their particular application.

Line 86: This a somewhat odd description of k-omega vs k-epslon. The SST k-omega model is a fixed-up version that is a blend of k-epsilon and k-omega and that gets most of the advantages of each.

Line 119: “In the freestream of a neutral ASL, fP = 1,”

It looks like it = 2*f0 , not 1.

Table 1: The Ce2 value is the “old fashioned” and too high value. The Ce1 is far too small (should be close to 1.5 to get lengthscales right), and this is probably why C_mu is far too small. When this model fails later is it because of the linear eddy viscosity assumption, or because of the poor model constants? Table 2 has much better (more modern) model constants.

Line 160: “ensures good model predictions in nonequilibrium conditions”

Equilibrium means different things to different turbulence modelers. All ARSM are assuming a form of equilibrium. They are assuming that the turbulence anisotropy instantly responds to the mean flow (is in equilibrium with the mean flow). Non-equilibrium is captured by a full RST model (solving a transport model for the Reynolds stress anisotropy with a time derivative and an advection term). An example of non-equilibrium turbulence (for many modelers) is a stagnation point or boundary layer separation point (on an airfoil). Where the strain is zero, and the turbulence anisotropy is non-zero (because it is advected or diffused there).

Line 200: “was later abounded for”

change to abandoned

Section 2.4 (or a new section) maybe should discuss the boundary conditions. The k-epsilon system presented doesn’t work properly near a solid surface. Also how are k and epsilon specified at inlets? K can never be zero - or the model fails.

Section 3.1 This test case reveals very little. The constants in the models were explicitly chosen to fit this test case.

Table 3 can be deceptive. The goal of these models is to predict the mean flow well, not the anisotropy. Only the accuracy of the divergence of the anisotropy really matters. LES models, function similarly. They predict the unresolved stresses terribly, but the resolved flow reasonably (because their divergence is roughly correct). Figure 4 confirms this understanding. Only a13 really matters and the most recent constants have been tuned to get that stress correct at the expense of the stresses that don’t matter.

General comments:

The Gaussian shape of the axisymmetric turbulent wake can be obtained by using similarity theory and assuming an eddy viscosity that is constant across the wake (but varies in the streamwise direction). This knowledge can provide a strong hint as to why a model works in a wake and why it doesn’t (does it produce near-constant eddy viscosity). The ARSM results are quite bad for the wake velocity given that a Prandtl mixing length model (eddy-viscosity = constant * wake width * velocity deficit) works better.

There is an old axisymmetric vs planar jet modeling problem (Durbin text book probably has it). Few models can predict both cases well. Is it possible you have an ARSM tuned for planar shear flows that now struggles in the axisymmetric wakes you actually want to model.