

Interactive comment on “How does turbulence change approaching a rotor?” by Jakob Mann et al.

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This is a very interesting paper as there is not much previously published showing measurements of the turbulent velocity field and spectra in the in-flow region of a full-scale HAWT together with numerical simulations which resolve the main blockage and distortion effects on the turbulent in-flow. The results are particularly interesting because they show clearly that the spectral power of the streamwise turbulent velocity component (u) at low frequencies and below-rated wind speeds where the induction factor is large, reduces significantly as the rotor disc is approached while the power at high frequencies changes much less. This is seen in both the measurements and the accompanying LES computations. In a recent paper, commented on in the present paper, [Rapid distortion of turbulence into an open turbine rotor, Graham, JFM 2017],

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RDT theory is shown to predict a strong amplification of the spectral power of u at low frequencies as the rotor disc is approached, increasingly so the smaller the length-scale of the turbulence. At high frequencies the amplification reduces to insignificance. As observed by the authors in section 2.2 of the present paper this difference is most likely because the RDT calculation does not include the unsteady potential flow blocking effect of the rotor. This was excluded deliberately because the RDT calculations were intended to provide a correction for the incident turbulence velocity boundary condition used by lower fidelity computations which assume that the turbulence arrives 'frozen' at the rotor disc. The quasi-steady (QS) theory presented in the present paper to calculate the effects on the low frequency turbulence is an example of this and it is observed that it tends to over-predict the reduction. As is commented at the end of the present paper this may be because the amplification due to distortion is missing and that better agreement might be obtained if the RDT distortion correction were to be combined with the QS theory. The prediction of very little amplification or reduction of the spectral power of u at high frequency may be consistent similarly. Although the RDT predicts insignificant distortion in this region the unsteady potential blocking field also falls off with increasing rapidity ahead of the rotor disc for components of increasing frequency. These comments all refer to the below-rated results. It is more difficult to be sure why the power spectra of u in the in-flow clearly show considerable amplification in above-rated conditions in both the measured data and in the LES computations. In above-rated conditions the induction factor is considerably smaller and while the resulting blocking action reducing the power in the u -component is less, the effect of smaller induction factor is also to cause the distortion amplification to be much smaller. As said above this is an interesting paper presenting good quality results which I hope will stimulate further analysis on the topic of inflow turbulence.

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