Comments on Coriolis Effect of Should wind turbines rotate in the opposite direction?

Antonia Englberger[1], Julie K. Lundquist[2,3], and Andreas Dörnbrack[1]

[1]German Aerospace Center, Institute of Atmospheric Physics, Oberpfaffenhofen, Germany
[2]Department of Atmospheric and Oceanic Sciences, University of Colorado Boulder, Boulder, USA
[3]National Renewable Energy Laboratory, Golden, Colorado, USA

Correspondence: Antonia Englberger (antonia.englberger@dlr.de)

Comment: Amazing that this is could have a significant impact on efficiency. The Coriolis effect gets stronger the larger the spatial extent becomes and so in the differential approximation it disappears. I didn't see any indication that the model was evaluated with respect to radius of the turbine blade. Is that possible to add?

Dear Dr. Paul Pukite,

Thank you for your interest in our research.

With respect to your first comment, about the length scale of Coriolis effects, we would like to point out that the ambient or background flow is indeed affected by the Coriolis force. The effect of the Coriolis force is considered by the shape of the hemispheric-dependent Ekman spiral in Eqs. 5 and 6, and therefore determines the meridional velocity component v of the inflow. The wake interacts with this inflow. Considering two simulations in the same hemisphere with both rotational directions (e.g. CR and CCR), the only difference between these simulations is the sign of the prefactor $\boldsymbol{\beta_v}$ in Eq. 1. Therefore, the rotational direction difference on the power output P only depends on the rotational direction.

The second question dealt with how these effects might vary with rotor size. An increase or a decrease of the rotor radius r impacts the rotor area A (and the rotor averaged zonal velocity $\overline{u_A}$), and therefore P in Eq. 9. As we think it is a very interesting question, we performed additional simulations. All simulations in the paper are calculated with $R = 50$ m. Now we added simulation with R = 40 m and 60 m for both rotational directions of the rotor and updated the cross-section plots (Fig. 1) (see Fig. 3 in the paper) and the plot representing the downstream development of $\overline{u_A}$ for both rotational directions (Fig. 2).

The increase of $\Delta\overline{u_A}$ for decreasing R could be related to a larger impact of the veering wind in the rotor region, as a similar dependency arises for different strength of wind veer over the rotor.

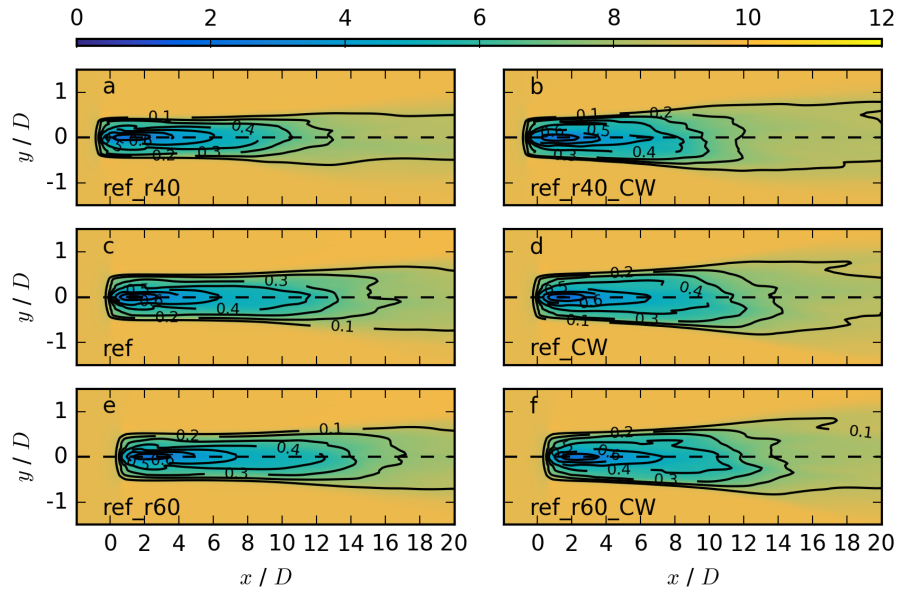

Figure 1. Coloured contours of the streamwise velocity $\overline{u_{i,j,k_h}}$ in m s^{-1} at hub height k_h, averaged over the last 10 min, for R = 40 m in a and b, R = 50 m in c and d, and R = 60 m in e and f. The left column represent a common clockwise rotating rotor CR or CCW and the right column corresponds to the CCR or CW simulations. The black contours represent the velocity deficit VD_{i,j,k_h} at the same vertical location.

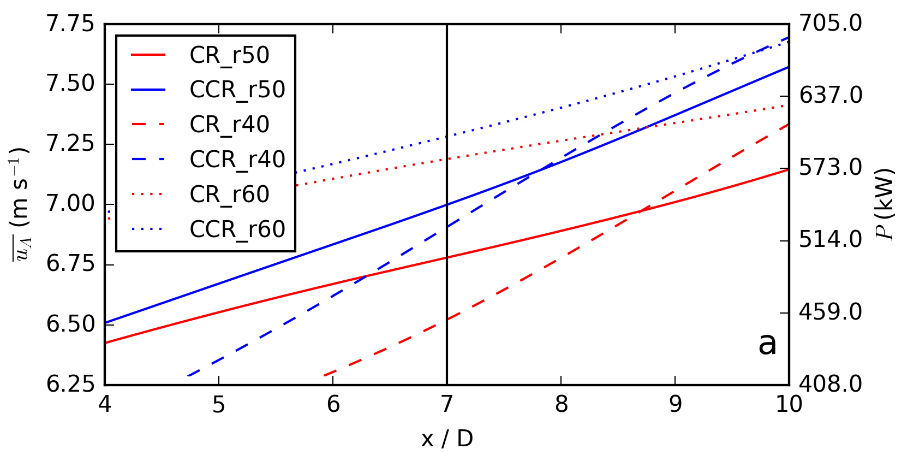

Figure 2. The rotor averaged streamwise velocity $\overline{u_A}$ and the power P of a hypothetical downwind turbine are presented for a downstream region of $[4\,D; 10\,D]$ for different R of 40 m, 50 m and 60 m for CR clockwise rotating rotor and CCR counter-clockwise rotating rotor.