The impact of the rotational direction of a wind turbine on its wake

Antonia Englberger¹, Andreas Dörnbrack¹, and Julie K. Lundquist²,³

¹ Institut für Physik der Atmosphäre, Deutsches Zentrum für Luft- und Raumfahrt, Oberpfaffenhofen, Germany
² Dept. Atmospheric and Oceanic Sciences, University of Colorado Boulder, CO
³ National Renewable Energy Laboratory, Golden CO
The turbine wake consists of a counter-rotating vortex, preferentially bringing high-momentum air down on one side of the wake.

Blades rotate clockwise

Near wake rotates counter-clockwise

looking downwind at a turbine
Northern Hemisphere observations indicate veer > 0.2 ° m⁻¹ occurs in stably stratified conditions

1 year of 10-116m tower obs, Texas
3 mo. of 40-120m lidar obs, Iowa
3 mo. of 40-120m lidar obs, offshore Massachusetts

Sanchez Gomez & Lundquist 2019, Wind Energy Science Discussions
Bodini, Lundquist, Kirincich 2019, Geophysical Research Letters
a) veering inflow + counterclockwise rotating wake (CCW) → change of rotational direction of the flow in the wake
b) no veering inflow + CCW
c) veering inflow + no rotating turbine
c) no veering inflow + no rotating turbine
e) veering inflow + clockwise rotating wake (CW) → no change of the rotational direction of the flow in the wake
f) no veering inflow + CW
Veering inflow $V +$ CCW (counterclockwise rotating flow)

$\rightarrow$ change of rotational direction of the wake flow

$V +$ CW (clockwise rotating flow)

$\rightarrow$ no change of the rotational direction of the wake flow

Flow rotation of $v$ and $w$ at 3D, 5D, and 7D behind the disc for $V_{\text{CCW}}$, $V_{\text{NR}}$, and $V_{\text{CW}}$. The red dot marks the rotor centre and the blue contour the rotor region.
Change of rotational direction of the wake flow in V_CCW has an impact on the velocity in the wake at a certain distance downstream. (compare to V_CW)

→ impact on the performance of a downstream wind turbine

Coloured contours of the streamwise velocity in m/s at hub height, averaged over the last 10~min. The black contours represent the velocity deficit at the same vertical location.
Conclusions:

- Rotational direction of a wind turbine has an impact on the rotational direction of the wake flow
  - Rotational direction in the near wake determined by rotational direction of the rotor
  - Rotational direction in the far wake determined by the veering inflow
- Rotational direction of a wind turbine has an impact on the velocity at a certain downstream distance influencing the performance of a downwind turbine
  - Higher velocity at a possible downwind turbine location in case of V_CW (counterclockwise rotating wind turbine rotor)