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

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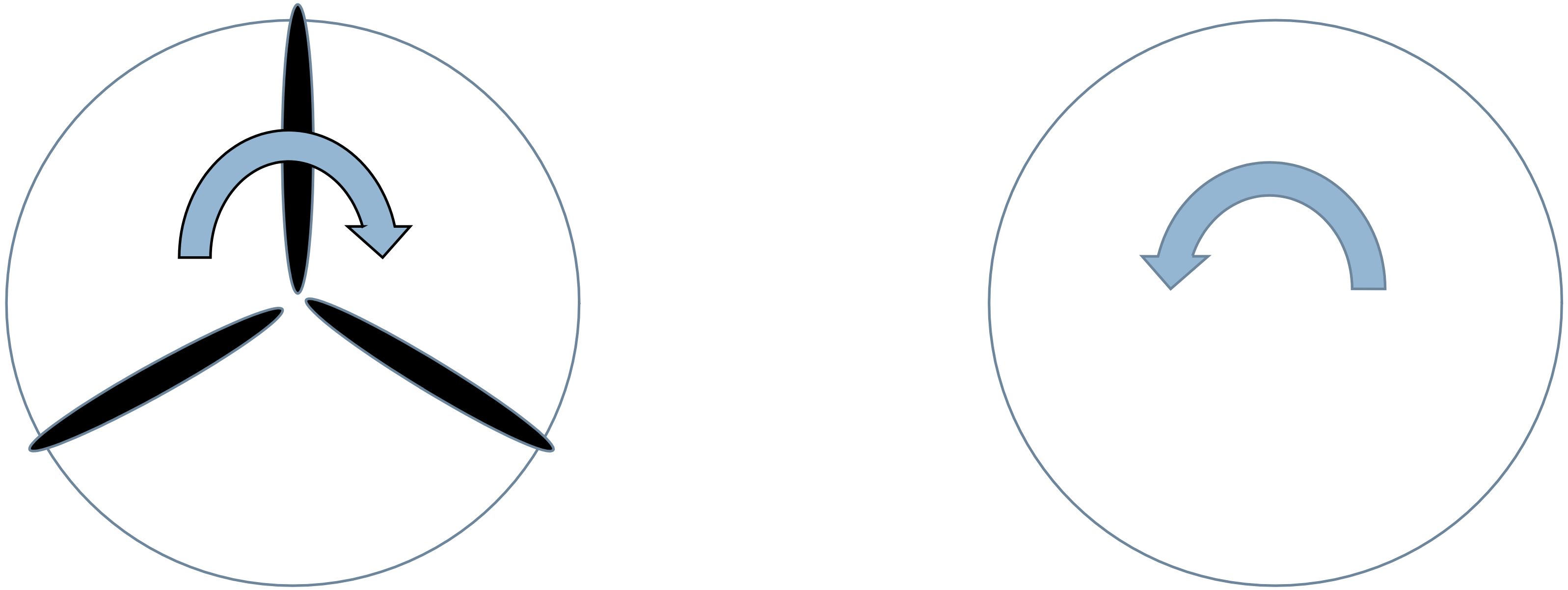
The turbine wake consists of a counter-rotating vortex, preferentially bringing high-momentum air down on one side of the wake



Blades rotate clockwise

Near wake rotates counter-clockwise

looking downwind at a turbine

Northern Hemisphere observations indicate veer > 0.2 º m $^{-1}$ occurs in stably stratified conditions

1 year of 10-116m tower obs, Texas

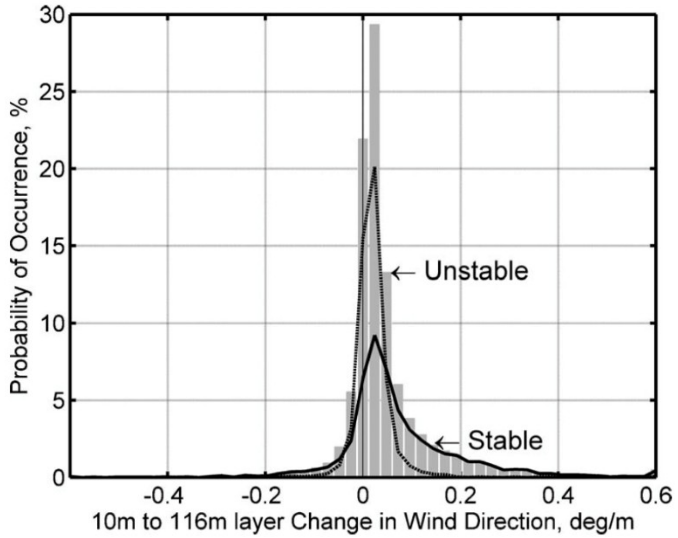
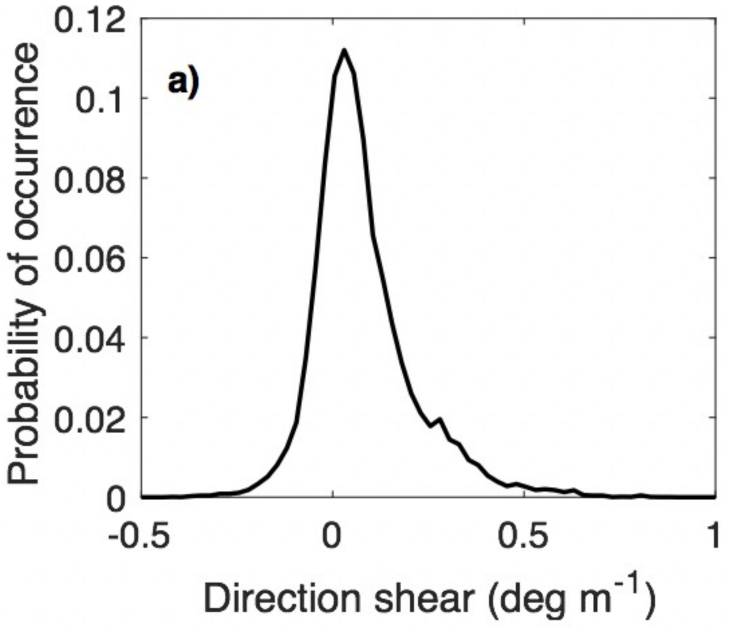


Fig. 3 Probability distribution for direction shear in the 10–116 m layer for all data (gray bars), unstable observations only (dashed line), and stable observations only (solid line)

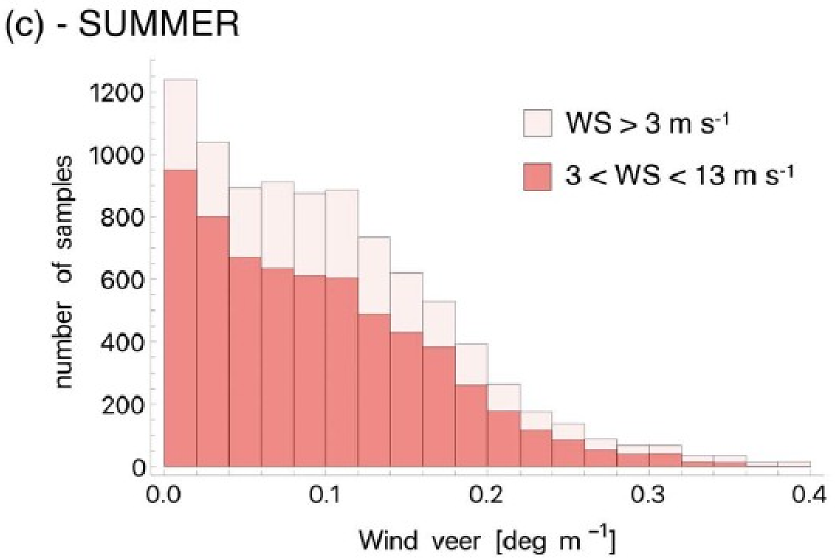
Walter et al. 2009, *J. Sol. Energy Eng.*

3 mo. of 40-120m lidar obs, Iowa

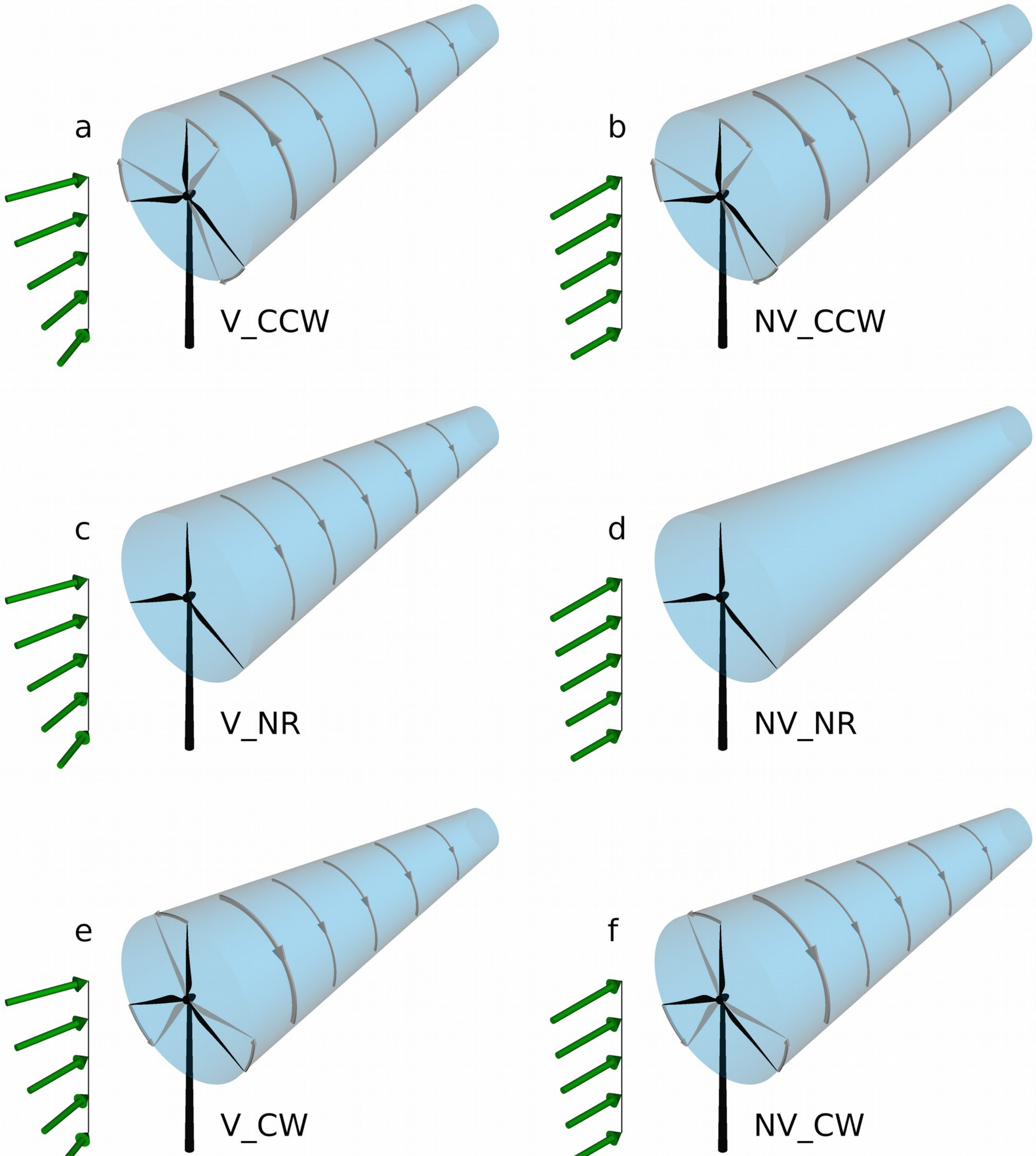


Sanchez Gomez & Lundquist 2019,
Wind Energy Science Discussions

3 mo. of 40-120m lidar obs, offshore Massachusetts



Bodini, Lundquist, Kirincich 2019,
Geophysical Research Letters



a) veering inflow + counterclockwise rotating wake (CCW)
→ **change of rotational direction of the flow in the wake**

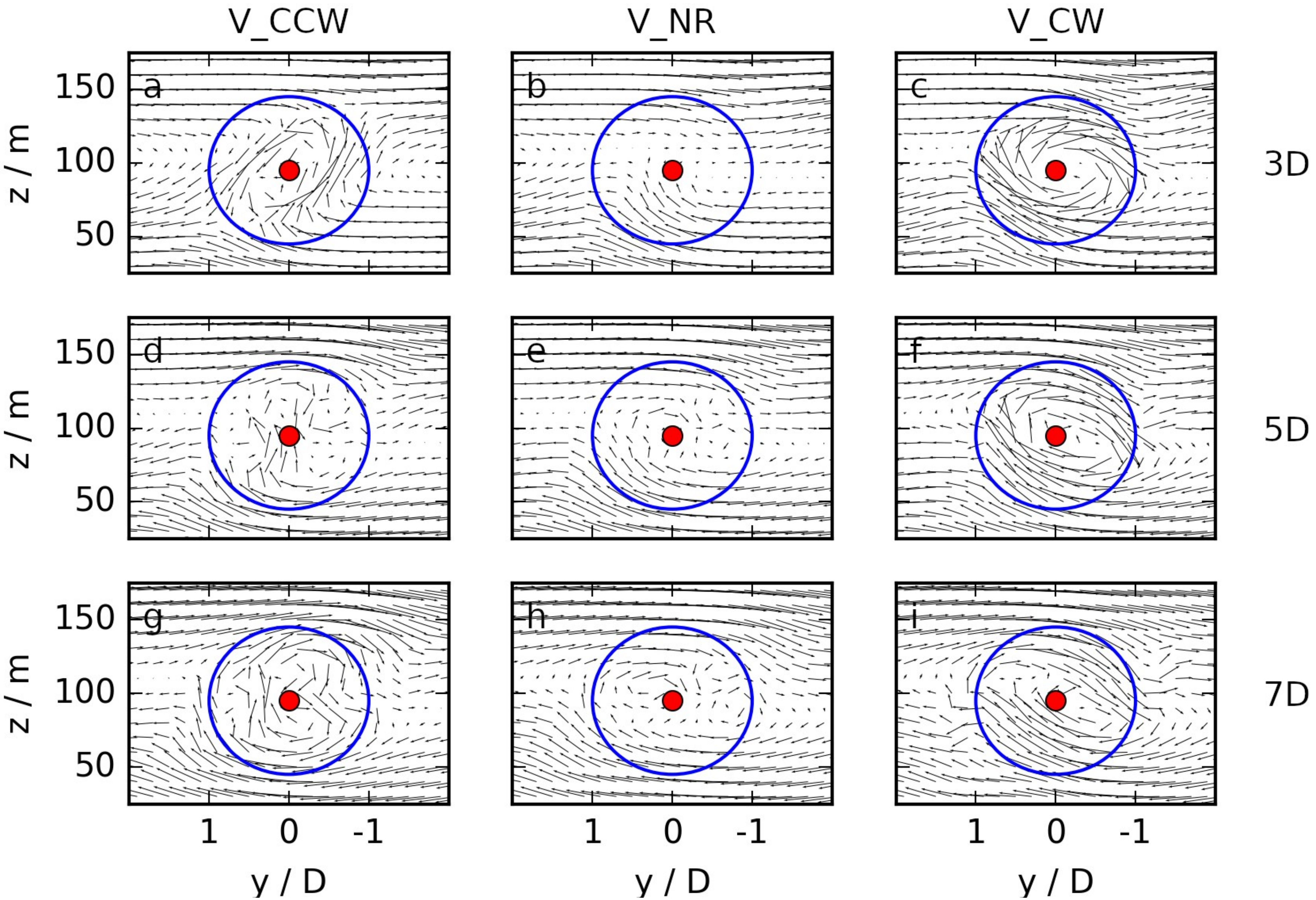
b) no veering inflow + CCW

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 +**

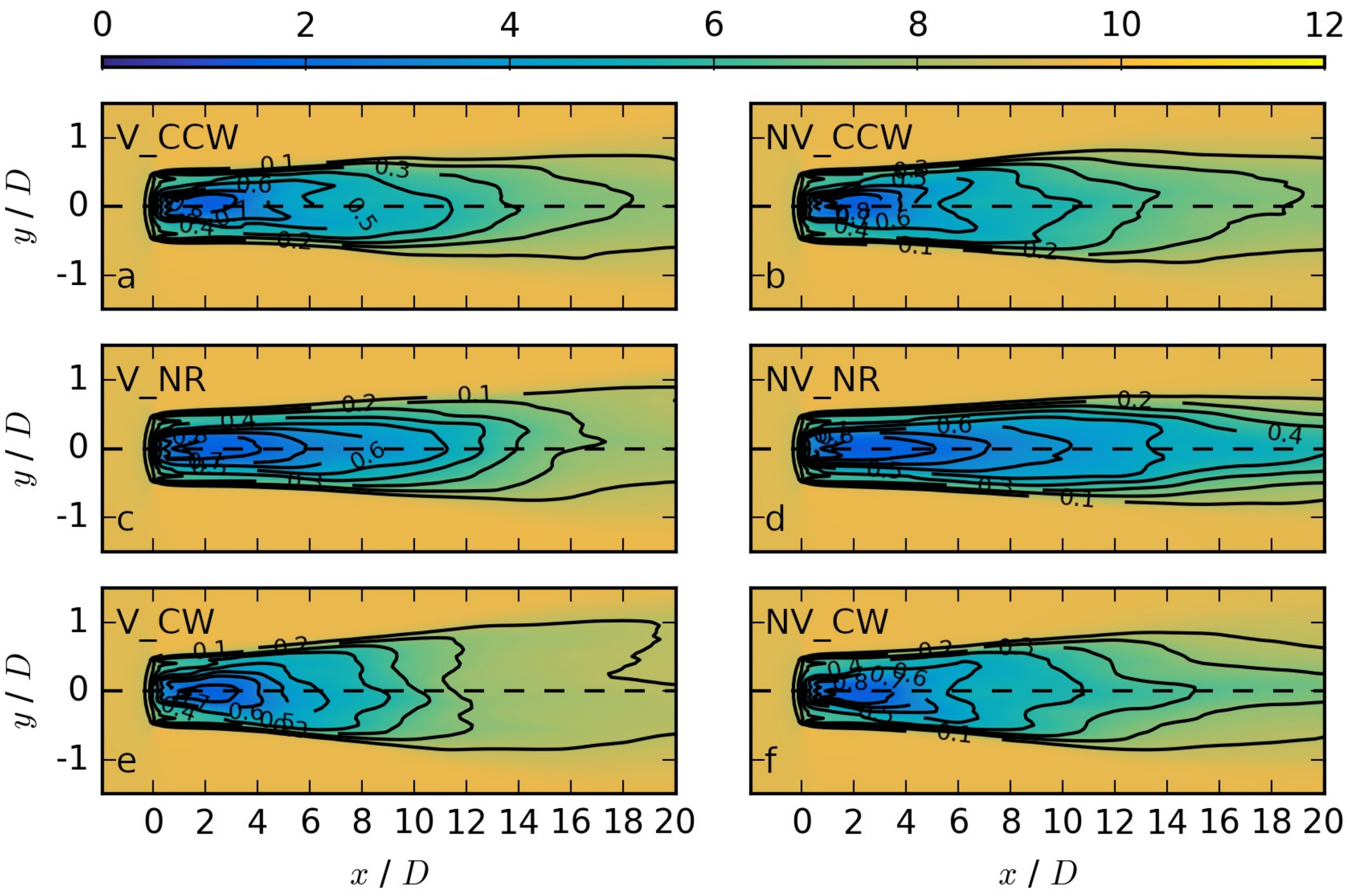
CCW
(counterclockwise rotating flow)

→ **change of rotational direction of the wake flow**

CW
(clockwise rotating flow)

→ **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_CCW, V_NR, and V_CW. The red dot marks the rotor centre and the blue contour the rotor region.



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.

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

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)

Englberger, A., Dörnbrack, A., and Lundquist, J. K.: Does the rotational direction of a wind turbine impact the wake in a stably stratified atmospheric boundary layer?, Wind Energ. Sci. Discuss., https://doi.org/10.5194/wes-2019-45, in review, 2019