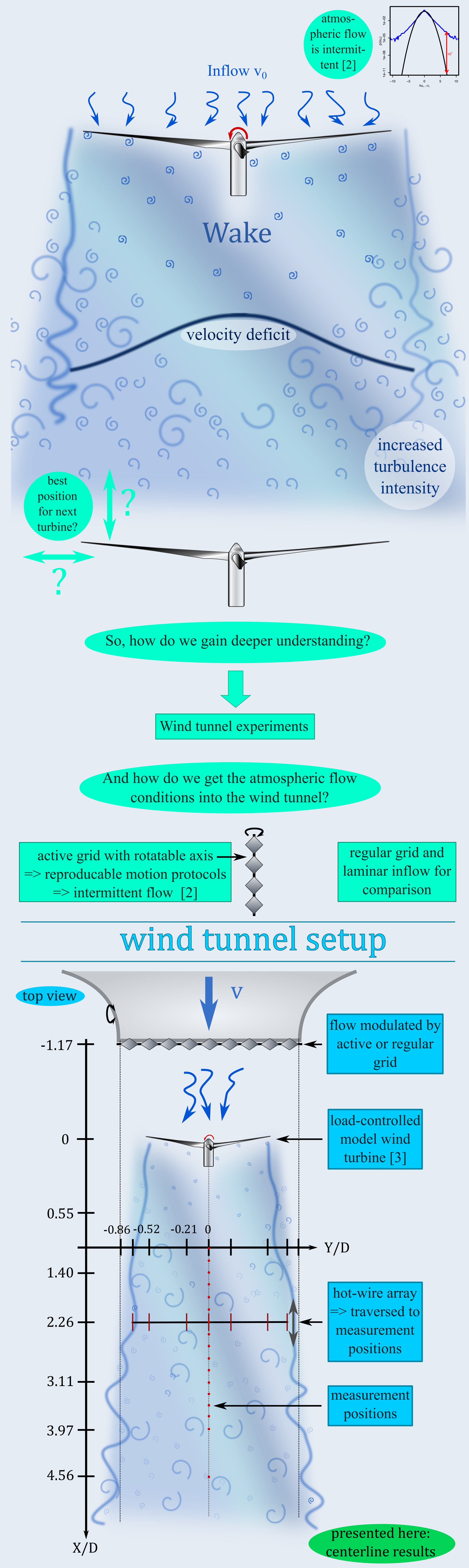
Effect of intermittency on a model wind turbine's wake recovery

I. Neunaber[1], J. Schottler[1], J. Peinke[1] and M. Hölling[1]

[1]ForWind - Center for Wind Energy Research, University of Oldenburg, Germany

Motivation & Methods

We present an experimental examination of the influence of different inflow turbulences on the wake of a model wind turbine.

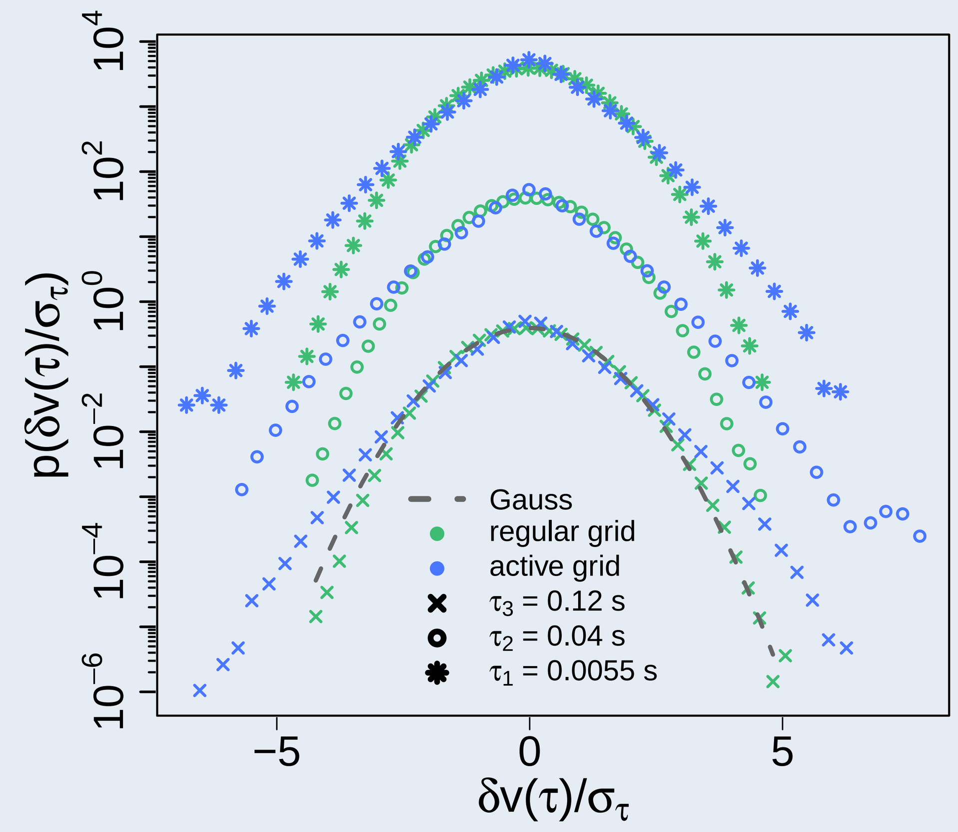


Mean velocity $\bar{v}_0$ and turbulence intensity TI_0 of the different inflow conditions at rotor position (no turbine installed)

	laminar	regular grid	active grid
$\bar{v}_0$ / m/s	7.56	7.28	8.07
TI_0 / %	1.36	6.72	12.81

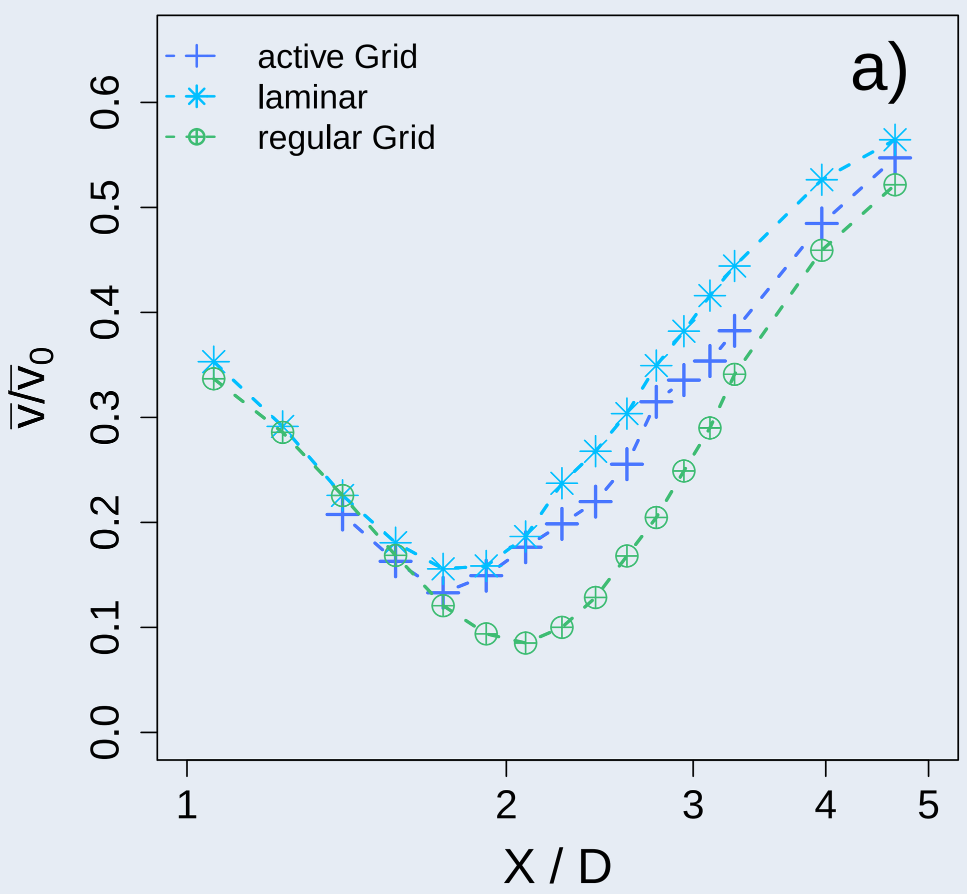
Results

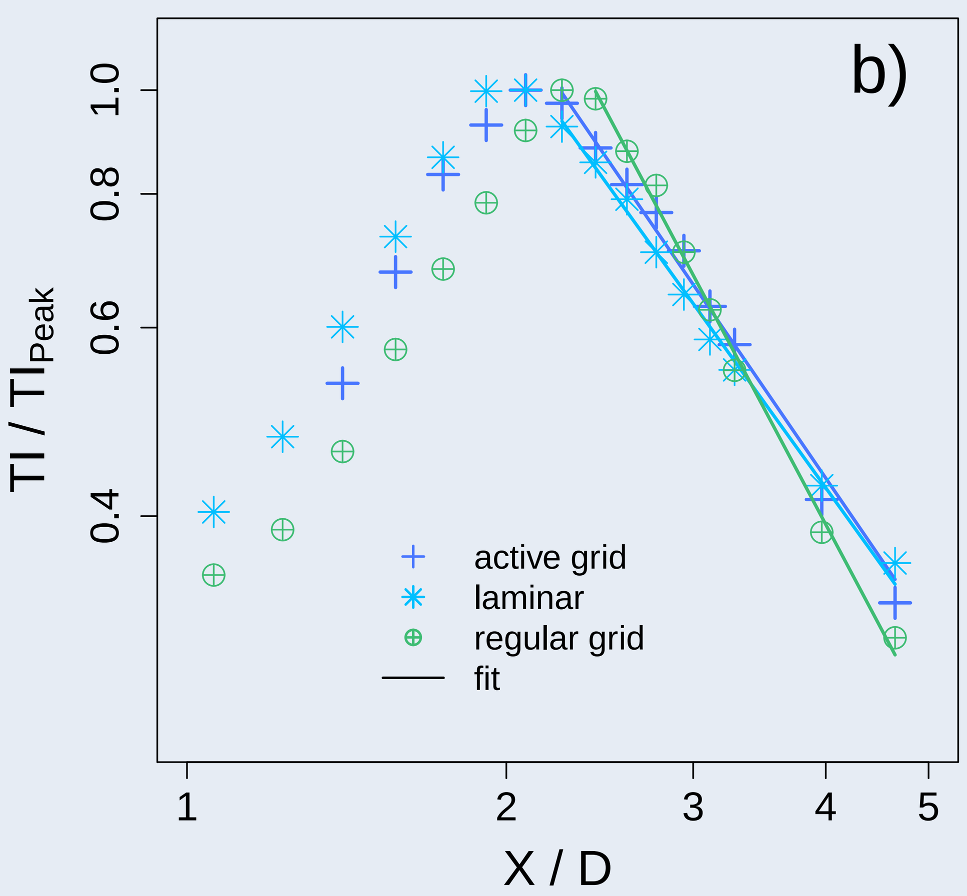
Probability density functions (PDFs) $p(\delta v(\tau))$ of velocity increments $\delta v(\tau) = v(t+\tau) - v(t)$ for different time lags τ and different turbulent inflow conditions



- Regular grid-generated inflow: Gaussian distributed increment PDFs
- Active grid-generated inflow: intermittent distribution

Development of the normalized mean velocity (plot a)) and the TI (plot b)) plotted logarithmically over X/D

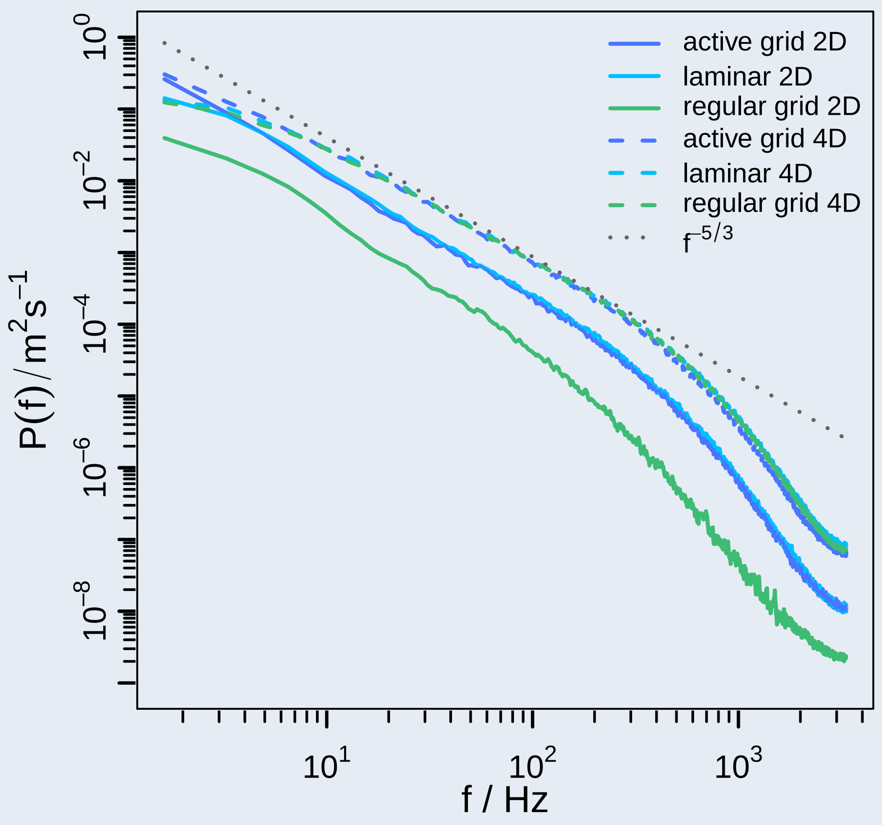




- Decreased recovery of mean velocity in case of intermittent inflow compared to Gaussian inflow - despite a higher inflow TI that is usually associated to be beneficial for the wake recovery [4][5]
- Decreased turbulence decay in case of intermittent inflow compared to Gaussian inflow
- Power-law decay of the turbulence intensity for $X/D > 2$
- An effect of the intermittency on the turbulence intensity is also shown. The normalized turbulence intensity decreases slower

Results

Power spectral density at $X/D = 2$ and $X/D = 4$ for both turbulent inflow conditions



- Dependence on the intermittency in the inflow is visible in the turbulence decay at $X/D = 2$ where the curves (—) for laminar and intermittent inflow collapse but deviate from the curve for regular grid-generated inflow turbulence
- Statistical characteristics of the inflow do not influence the turbulence decay in the far wake at $X/D = 4$ where all three curves (- -) collapse
- A wind tunnel study of Singh et al (cf. [1]) indicates that the intermittency is reduced by the turbine. Our study suggests, that this reduced intermittency might be beneficial for the wake recovery behind the second turbine. This has to be examined in the future.

Summary and conclusion

- Examination of the influence of inflow conditions with different statistical characteristics on the wake of a model wind turbine
- Evidence of effect of the intermittency in the inflow on the evolution of mean velocity and turbulence intensity in the wake
- Turbulence decay in far wake not influenced by statistical characteristics of inflow

In conclusion, different statistical characteristics do have an influence on the wake. Therefore, the statistics of the inflow have to be taken into account when studying the wake of a turbine. A description with mean velocity and turbulence intensity is not sufficient, as the intermittency is neglected in this description.

References

[1] Singh et al. 2014, doi:10.1063/1.4863983
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[5] Jin et al. 2016, doi:10.3390/en9100830

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Contact

Contact: ingrid.neunaber@uni-oldenburg.de