The amazing possibilities in generating user-defined turbulent flows using active grids

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The generation of user-defined flows is not only of interest for basic turbulence research but also for applied problems such as mixing processes or in the field of wind energy. The latter has several goals for wind field generation in wind tunnel investigations. On the one hand, temporally distinct structures are used to measure the reaction dynamics of model turbines or to further develop control strategies. On the other hand, the interaction of wind turbines with turbulent flows and their influence on the power output, the resulting forces on rotor blades and other turbine components, the development of the wake, etc. is important for the design of turbines as well as the layout of wind farms. With the help of active grids these two areas can be covered. We present results from wind tunnel experiments carried out in the large turbulent wind tunnel at the University of Oldenburg. The wind tunnel has an outlet of 3x3m[2] and a total length of 30m in a closed measurement section. The active grid consists of 80 shafts, on which square flaps with an edge length of about 10cm are mounted. The motion of each shaft can be controlled individually by means of DC motors. Specially developed motion protocols for the motors can be used to generate not only temporal structures such as IEC wind gusts (Figure 1, left), but also turbulent flows that develop behind the grid and eventually exhibit a -5/3 behaviour over an exceptionally long range in the spectrum (Figure 1, right). The related method additionally offers the possibility to predict to some extend the expected statistical properties such as turbulence intensity and higher moments of the flow on the computer and thus to develop user-defined wind fields.

[1] Neuhaus et al., *Experiments in Fluids* **62**(6), 1-12 (2021).
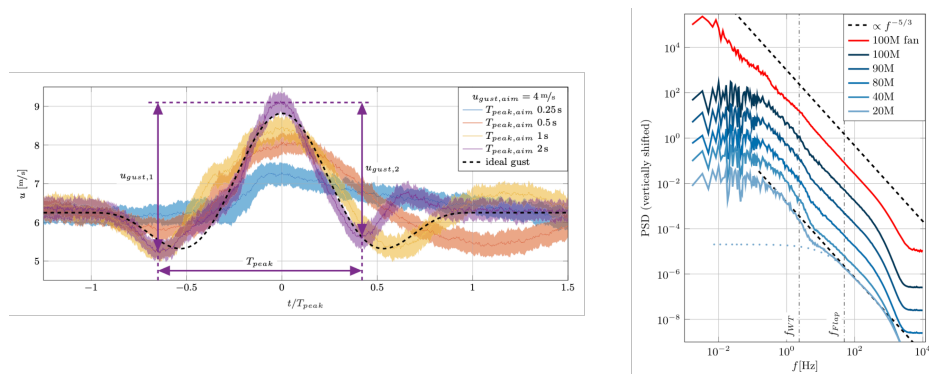[2] Neuhaus et al., *Physical Review Letters* **125**(15), 154503 (2020).

Figure 1: Left: Mexican hat wind gust for different time scales[1]. Right: Evolution of turbulence spectrum for increasing distances to the active grid[2].