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Stochastic simulation of spatial wind gusts

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Over the past decades, wind turbines have been increasing in both size and capacity. With 8 MW machines now entering production and 10–20 MW concepts lying on the drawing board, rotor diameters are growing beyond the size of the largest turbulent eddies. As a result, the fully uniform transients that are commonly used to model gusts are becoming less and less physical.

In the design phase of a wind turbine, individual gusts are often taken as a reference to predict the response to extreme wind speeds. This is required for limit state design, but also helps to test and optimize control algorithms. However, extracting the few extreme events from a collection of measurements can be a tedious process and provides only a weak basis for extrapolation. An alternative approach is to rely on *constrained stochastic simulation* (Bierbooms, 2005), which is an established tool that can be used to generate a time series given some specific constraint (e.g. a velocity amplitude). This makes it possible to match extreme gusts from long-term weather records with stochastic turbulence fields. In addition, it allows for much more efficient Monte Carlo simulations, opening the door to better predictions with less computational effort.

The present work aims to extend this method to three-dimensionally bounded gusts in order to make it suitable for very large wind turbines. First, we will outline the general theory. Second, a comparison is made with gusts obtained from turbulent wind data. Finally, an outlook for future developments is presented.