TOWARDS SPATIALLY CONSTRAINED GUST MODELS

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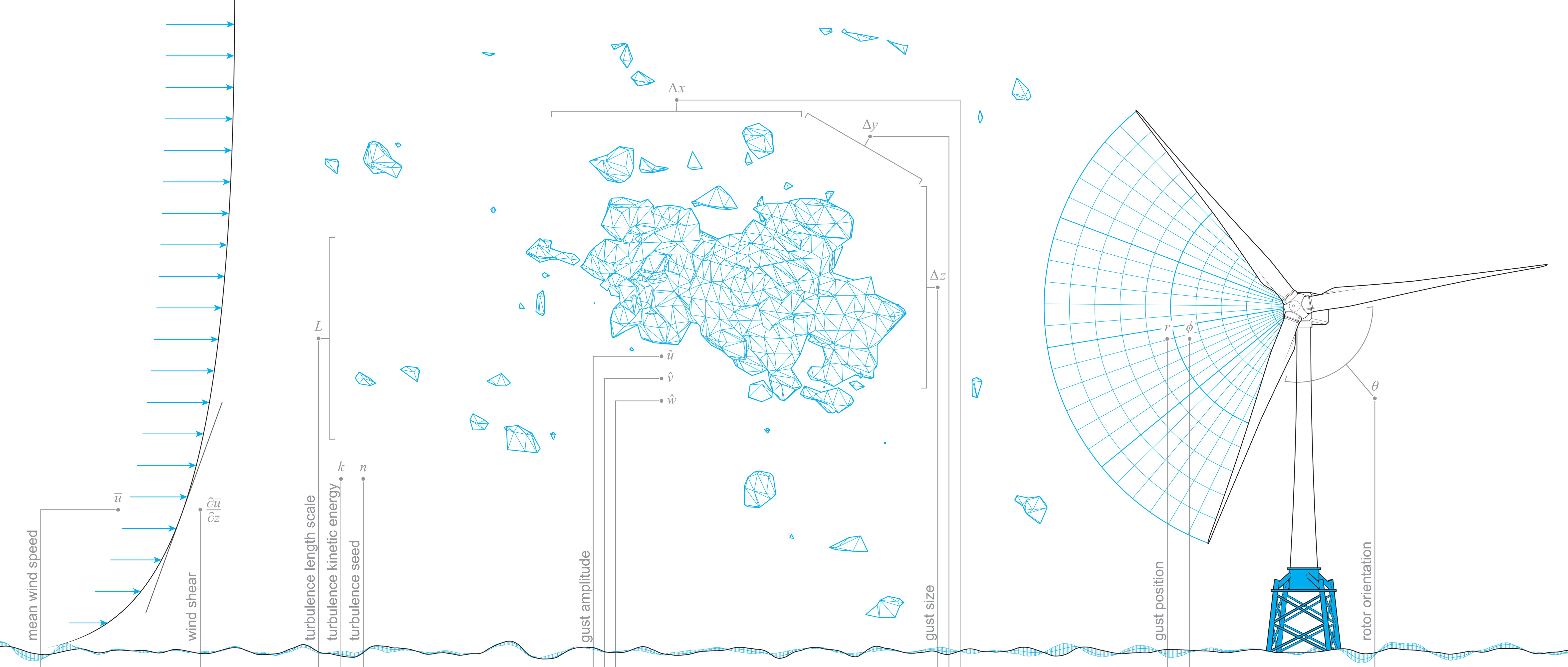
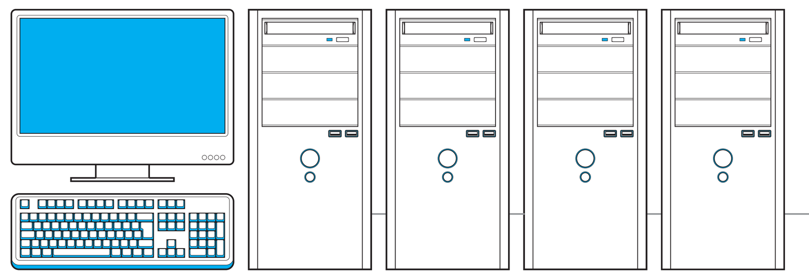
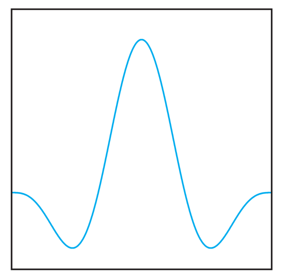
ABSTRACT

With the trend of moving towards 10–20 MW turbines, rotor diameters are growing beyond the size of the largest turbulent structures in the atmospheric boundary layer. As a consequence, the fully uniform transients that are commonly used to predict extreme gust loads are losing their connection to reality and may lead to gross overdimensioning. More suiting would be to represent gusts by advecting air parcels and posing certain physical constraints on size and position. However, this would introduce several new degrees of freedom that significantly increase the computational burden of extreme load prediction. In an attempt to elaborate on the costs and benefits of such an approach, load calculations were done on the DTU 10 MW reference turbine where a single uniform gust shape was given various spatial dimensions with the transverse wavelength ranging up to twice the rotor diameter (357 m). The resulting loads displayed a very high spread, but remained well under the level of a uniform gust. Moving towards spatially constrained gust models would therefore yield far less conservative, though more realistic predictions at the cost of higher computation time.



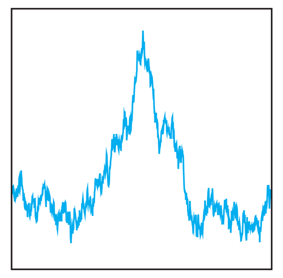


MONTE CARLO SIMULATION BUDGET



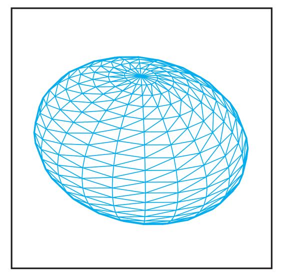
The extreme operating gust is a deterministic transient based on the Mexican hat wavelet. It has no spatial character and is therefore fully uniform over the rotor plane. Due to its deterministic nature, there is no uncertainty in the resulting gust load.

EXTREME OPERATING GUST
IEC 61400-1, 2005



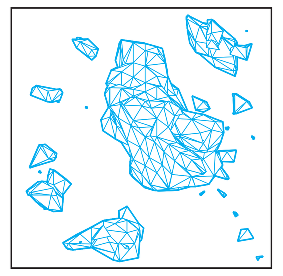
Constrained stochastic simulation is a method that allows a designer to generate a time series around some specific event. This way, particular extremes can be selected from the normal or extreme turbulence models (IEC 61400-1).

CONSTRAINED STOCHASTIC SIMULATION
BIERBOOMS, 2005



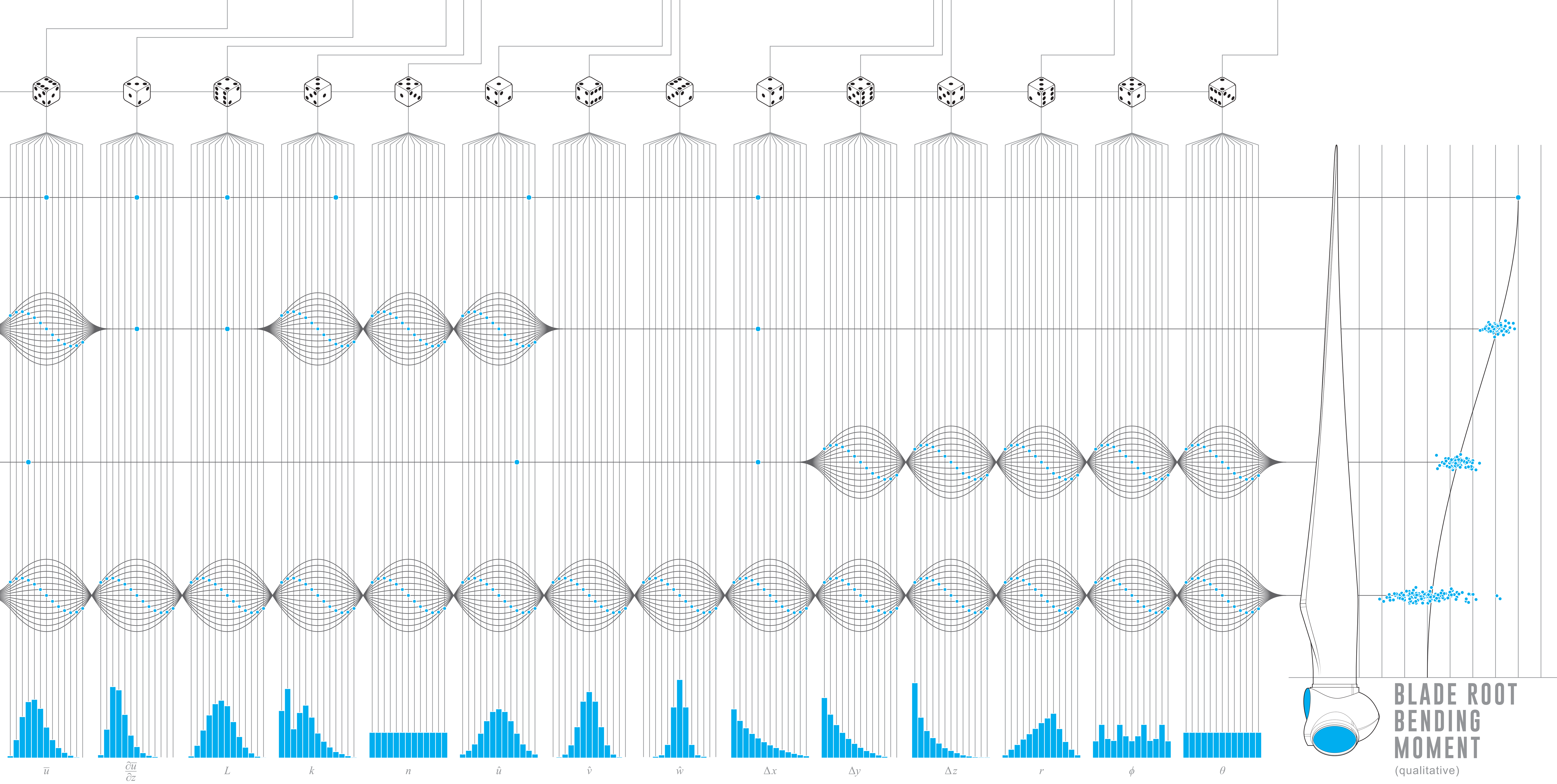
The gust model in this paper is a deterministic shape in a wind field without turbulence or shear. This helps to explore the effect of gust size, gust position, and rotor orientation at the moment of impact, parameters that are usually not taken into account.

SPATIALLY CONSTRAINED GUST
PRESENT WORK



Future work will focus on processing gusts generated from the spectral tensor. This allows a designer to get much closer to reality and avoids the assumption of uniform velocities. However, the many degrees of freedom lead to uncertainty in the loads.

SPATIALLY CONSTRAINED GUST
FUTURE WORK



ABOUT

This diagram visualizes the growing computational burden of stochastic gust models, compared to the conservative Mexican hat shape. Horizontal lines are associated with individual load cases within a complete Monte Carlo simulation. Lines may split up and fan out, representing repeated sampling of a particular stochastic variable. This leads to many different routes and, ultimately, a spread in the load distribution, sketched at the far right.

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