Extreme variance vs. turbulence: What can the IEC cover?

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**Abstract**
Here we demonstrate the effect of extreme variance events on wind turbine loads. From ten years of data, we analyze periods with variance exceeding the IEC extreme turbulence prescription. The variance is mainly due to the events, not turbulence, and these events additionally incur extreme short-term shear. Loads from simulations of these events are compared with two design load cases of the IEC standard: the extreme turbulence (DLC 1.3) and the extreme shear (DLC 1.5).

**Selection criteria of the events**
Turbulence intensity (TI) of 10-minute horizontal wind speed measurements. The data is from a 100 m light mast in Høvsøre from a 10-year period. The curves show the IEC normal- and extreme turbulence model, class B (blue and green curves, respectively). The 40 selected events are TI values exceeding the extreme turbulence model (red data).

**Extreme variance events**
The events typically include a sudden rise in wind speed; such ramps are the primary contribution to the extreme variance. The figures show peak detection (stars) of the wind speed signal at 3 different measurement heights. Notice how the peaks are lagged in time between the different heights, resulting in extreme vertical wind shear. The sudden wind speed increase occurs simultaneously at two different measurement masts in Høvsøre, ∼400 m apart. Thus, these high-variance events are large coherent structures with a sudden wind speed increase, rather than extreme stationary turbulence.

**Conclusion**
- Wind speed variance is an important input parameter for wind turbine load simulations, not only due to turbulence.
- The extreme variance events detected in this analysis are not extreme turbulence, but rather large-scale meteorological (ramp-like) events.
- The observed ‘wind ramps’ occur with a lag between measurement heights, leading to high short-term shear.
- The mean extreme moments as a function of mean wind speed from each simulation. The mean extreme moments are averaged over the 6 turbulence seeds. The loads are higher for the extreme turbulence data set, except for the tower base fore-aft moment.

**Shear during the events**
The lagged of the peaks at the three different heights is evaluated for all the events. The average lag between 160 m and 60 m is ∼1 s. The lag of the peaks correlates well with the short-term shear, calculated at the time of the first peak in time. Here the shear exponent and the short-term shear are plotted against the lag, evaluated between between 160 m and 60 m.

**References**