Extreme Wind Calculation Applying Spectral Correction Method – Test and Validation

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Abstract
The spectral-correction method estimates extreme winds on basis of short-term local measured wind data of only a year (sometimes even down to a few months) by combining with a long-term reference time series (typically a re-analysis time series of 20 years or more) to represent the long-term fluctuations. The test and validation of the method, as implemented in DTU standard-software, is based on wind measurements from four sites in Denmark, one in the Netherlands and one in the USA, comprising both onshore and offshore sites. CFDDA-reanalysis wind data were used as the long-term wind data.

Objectives
For the six sites, the test and validation is performed by comparing spectral-correction extreme wind estimates to traditional extreme wind estimates using measurements only by the Annual-Maximum (AM) and the Peak-over-threshold (POT) method.

Theory by Larsen et al. [1]

\[ U_{lw} = \bar{U} + \sigma \sqrt{\frac{\bar{m}}{2\pi}} \]

\[ \sigma = \sqrt{\frac{m_2}{m_1}} \]

\[ m_2 = \int \sigma^2 \phi(\sigma) \, d\sigma \]

\[ m_1 = \int \sigma \phi(\sigma) \, d\sigma \]

\[ T_S = \frac{U_{lw} - \bar{U}}{\sqrt{\frac{\bar{m}}{2\pi}}} \]

\[ U_{lw} = \frac{U_{lw} - \bar{U}}{\sqrt{\frac{\bar{m}}{2\pi}}} \]

Implementation in DTU software
- Both short-term measured and long-term modelled time series were generalised by the Wind Atlas method [5, 6] to standard conditions of 10m height over flat, homogeneous terrain, 5cm roughness length before applying spectral correction.
- Long-term time-series: reanalysis CFDDA data series [1], generalised using local roughness length, derived from vertical profile.
- Corrected extreme wind (generalised) \( U_{lw} \) transformed to local site conditions by Wind Atlas method.

Test and validation

for each of the six sites:
Comparison of spectral-correction extreme wind estimates based on single-year measurements (a) to AM (b) and POT (c) estimates (d) based on the entire measured time-series. Examples of Short-term and Hybrid power spectra compared to long-term power spectrum are shown as well.

Conclusions
- Accuracy: The “good” Spectral-Correction predicted extreme wind speeds (“good”-based on years with data recovery/90%) are – within the relatively small error bars – in agreement with the observed AM and POT extreme wind speeds.
- Consistency: The standard deviations of the collection of “good” Spectral-Correction predicted extreme wind speeds are within 0.6 m/s, i.e. very low. Therefore, for all six sites the Spectral Correction method is very consistent when applied to one-year on-site wind data periods.
- The above conclusions are restricted to the use of CFDDA data as the long-term reference data.

References