Using a Langevin model for the simulation of environmental conditions in an offshore wind farm

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Introduction

- The optimization of operations and maintenance (O&M) is a focus of current research.
- Many simulation models/optimizations rely on artificially generated weather time series to test different strategies.
- We present a novel approach to modeling both the significant wave height and wind speed based on measurements from the site.
- We use a stochastic process called Langevin process. First, equations are fitted to the available data, which are then used to generate the artificial weather.

Langevin Process

- Deterministic contribution
  \[ F = D^{(1)} \]
- Stochastic contribution
  \[ G = \sqrt{D^{(2)}} \xi \]
- The stochastic contribution makes it easy to include uncertainty.

Conclusions and Future work

- The analysis shows that the Langevin process is an adequate alternative to other weather simulation models.
- The properties of the waves (distribution and persistence) are represented very well.
- Higher sampling frequency in the data improves the model.
- Multidimensional Langevin process might capture the correlation between wave heights and wind speeds is another topic for further research.

Data

- ECMWF: re-analysis, 6 hour resolution, Dogger Bank WF, 37 years
- Fino 1: measurements, 30min/10min means, Alpha Ventus, 6 years

Table: Statistics of the Fino 1 data and the simulations that are based on the data. For the simulation without seasonal effect, one system of equations was fitted for the whole year. In the seasonal simulation, each month was estimated separately.

<table>
<thead>
<tr>
<th>Wave height</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>1.44</td>
<td>0.93</td>
</tr>
<tr>
<td>Simulation</td>
<td>1.51</td>
<td>0.92</td>
</tr>
<tr>
<td>Simulation without seasonal effect</td>
<td>1.44</td>
<td>0.93</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Wind speed</th>
<th>Mean</th>
<th>SD</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data</td>
<td>9.99</td>
<td>4.66</td>
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<tr>
<td>Simulation</td>
<td>9.83</td>
<td>4.38</td>
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<tr>
<td>Simulation without seasonal effect</td>
<td>10.03</td>
<td>4.34</td>
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</tbody>
</table>

Selected References