Offshore precipitation climate
How can we monitor?

Workshop on Main Factors for Leading Edge Erosion
DTU Wind Energy (Risø Campus), 22 February 2018
Flemming Vejen, DMI
Offshore precipitation climate, definition of erosion classes

Overall objectives of activities at DMI:

- To increase knowledge about offshore precipitation climate (especially interested in frequency of hail and heavy rain), i.e. erosion climate
- To develop methods for short term prediction of eroding conditions

This presentation will focus on MEASUREMENT TECNIQUES

How can we establish the required data series for the analyses to be carried out?
One approach is to establish point measurements of drop size distribution.

<table>
<thead>
<tr>
<th>parameter</th>
<th>Parcivel²</th>
</tr>
</thead>
<tbody>
<tr>
<td>Precip type</td>
<td>X</td>
</tr>
<tr>
<td>Reflectivity</td>
<td>X</td>
</tr>
<tr>
<td>Rain rate</td>
<td>X</td>
</tr>
<tr>
<td>Rain amount</td>
<td></td>
</tr>
<tr>
<td>Energy of precipitation</td>
<td>X</td>
</tr>
<tr>
<td>DSD</td>
<td>X</td>
</tr>
<tr>
<td>Fall speed spectrum</td>
<td>X</td>
</tr>
</tbody>
</table>

A drawback might be, that disdrometers are point data.

Representativeness??

Plus survey on global DSD/erosion climate.
Alternative approach: Spatial info from weather radar data

Parameters we can calculate from radar data:
- Rain rate
- Duration of “impact”
- Hydrometeor type

Can we estimate kinetic energy and potential erosion from radar data?

DMI’s radar network:
- 5 dual-polarization radars
- Resolution: 5-10 min, 500 m pixels
- (1 minute, interpolation between radar frames)
About the conversion between radar Z and rain rate R

Radar reflectivity is related to number of drops $n$ and diameter $D$ in 6’th power:

$$Z = \sum n_i D_i^6$$

Many empirical Z-R relations:

$$Z = AR^b$$

E.g. Marshall-Palmer:

$$Z = 200R^{1.60}$$

Using a standard Z-R relation results in biased conversion between Z and R

Widely used method: Adjustment of radar data using raingauges
Sources of error on radar data and radar QPE

QPE = Quantitative Precipitation Estimate

Uncertainty of radar QPE comes from two aspects: bias and noise

Errors of radar data:
- False echoes
- Radar beam propagation issues
- Melting layer (bright band)
- Blocking/shielding
- Beam broadening

Errors of raingauge data:
- Wind induced bias
- Uncertainty related to radar-raingauge adjustment
Estimation of radar rain parameters

Relative rain-rate from radar images – adjustment against raingauges

Spatial distribution of rain

Evaluation statistics

Adjusted time series

1-minute resolution
Calculation of offshore statistics based on radar data

Calculation of radar rain-rates:

- Along coast line of Jutland
- Study rain rate frequency/PDF’s

Relationship between drop size distribution and rain rate:

In practice more convenient to use radar rain rates for calculation of kinetic energy and erosion class
Preliminary near offshore rain rate frequency, June-August 2017

- Relatively small spatial differences in rain rate for stratiform rain
- Low frequency of high rain rates (convective rain)
- But even a few hours of very high rain rates in combination with strong wind may cause blade erosion
- Largest rain rates may be related to false echoes in radar data

**Mainly stratiform rain**

**Mainly convective**

![Graphs showing rain rate frequency and distribution for June-August 2017.](image-url)
Precipitation type (10-min resolution) at DMI weather stations, 2017

<table>
<thead>
<tr>
<th>type</th>
<th>intensity</th>
<th>offshore</th>
<th>inland</th>
</tr>
</thead>
<tbody>
<tr>
<td>drizzle</td>
<td>slight</td>
<td>3197</td>
<td>1162</td>
</tr>
<tr>
<td></td>
<td>moderate</td>
<td>3327</td>
<td>374</td>
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<tr>
<td></td>
<td>heavy</td>
<td>82</td>
<td>38</td>
</tr>
<tr>
<td>rain</td>
<td>slight</td>
<td>7987</td>
<td>11433</td>
</tr>
<tr>
<td></td>
<td>moderate</td>
<td>1325</td>
<td>1715</td>
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<tr>
<td></td>
<td>heavy</td>
<td>147</td>
<td>226</td>
</tr>
<tr>
<td></td>
<td>violent</td>
<td>0</td>
<td>8</td>
</tr>
<tr>
<td>rain/snow</td>
<td>slight</td>
<td>83</td>
<td>248</td>
</tr>
<tr>
<td></td>
<td>moderate</td>
<td>5</td>
<td>7</td>
</tr>
<tr>
<td>snow</td>
<td>slight</td>
<td>575</td>
<td>1889</td>
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<tr>
<td></td>
<td>moderate</td>
<td>0</td>
<td>935</td>
</tr>
<tr>
<td>freezing rain</td>
<td>all</td>
<td>35</td>
<td>135</td>
</tr>
<tr>
<td>ice pellets</td>
<td>all</td>
<td>24</td>
<td>26</td>
</tr>
<tr>
<td>snow grains</td>
<td>all</td>
<td>14</td>
<td>0</td>
</tr>
<tr>
<td>hail</td>
<td>all</td>
<td>3</td>
<td>1</td>
</tr>
</tbody>
</table>

- Very few hail observations!
- Heavy/violent rain accounts for 0.9-1.4% of all observations (≈ 25-39 hours)
- Freezing rain/ice pellets/snow grains: 0.4-1.0% of all observations (≈ 13-27 hours)
Closing remarks

Further work and improvement:

• Improve model for calculation of radar rain rates + establish long data series
• Evaluate radar rain-rates against independent data

• Include radar hydrometeor classification in analyses
• Evaluate hydrometeor classification against disdrometers/weather stations

• Study historical (violent) events to further develop ideas/models

• Establish offshore rain climate statistics
• Develop model for calculation of potential risk of erosion
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Thank you for your attention!