Case study of the winter 2013/2014 extreme wave events off the west coast of Ireland

Jelena Janjić, Sarah Gallagher, and Frédéric Dias
Wave Energy Extraction

- Wave Energy Converters
- Extreme waves off the west coast of Ireland
- Survivability
Winter 2013/2014 (Dec, Jan, and Feb)

3rd January 2014 by George Karbus

12th Feb, Pic: Valerie O’Sullivan

3rd January 2014 by George Karbus

Deric Ó h’Artagáin • @deric_hartigan • Feb 12
#TV3Weather “@andrewcareylc: Probably the scariest picture you will see from #limerick in the wake of #StormDarwin pic.twitter.com/Jsw885olfB”
Hindcast

Unstructured grid around Ireland (see Gallagher et al., 2016a)

Varying resolution from 10 km to 225 meters

ERA-Interim 2D wave spectra

MÉRA 10 m winds
Methodology

- M4, Killard, and Kinsale (blue pins) – locations of wave measurements

- Malin Head, Mace Head, and Sherkin Island (red pins) – Met Éireann Synoptic (TUSCON) stations

- Three storms

- Atmospheric conditions

- Wave conditions
**Validation**

<table>
<thead>
<tr>
<th>Dec &amp; Jan</th>
<th>Killard</th>
<th>Kinsale</th>
<th>M4</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>CC</strong></td>
<td>0.94</td>
<td>0.98</td>
<td>0.97</td>
</tr>
<tr>
<td>$\sigma_A$ (m)</td>
<td>1.92</td>
<td>1.8</td>
<td>1.83</td>
</tr>
<tr>
<td>$\sigma_B$ (m)</td>
<td>2.21</td>
<td>1.86</td>
<td>2.92</td>
</tr>
<tr>
<td>Bias (m)</td>
<td>0.09</td>
<td>0.05</td>
<td>0.34</td>
</tr>
<tr>
<td><strong>Slope</strong></td>
<td>0.82</td>
<td>0.98</td>
<td>0.85</td>
</tr>
<tr>
<td><strong>SI</strong></td>
<td>0.17</td>
<td>0.11</td>
<td>0.16</td>
</tr>
<tr>
<td><strong>n</strong></td>
<td>1487</td>
<td>1480</td>
<td>377</td>
</tr>
</tbody>
</table>

CC – correlation coefficient  
$\sigma_A$ – standard deviation (model values)  
$\sigma_B$ – standard deviation (measured values)  
SI – scatter index  
n – number of records
Dec 5th 2013 ("Xaver") storm

- First storm
- Wreaked havoc over parts of northern Europe
- Low pressure in the north-west (967 hPa)

Near Warnemünde, Germany
by Jonas Rogowski
Dec 5\textsuperscript{th} 2013 ("Xaver") storm

Tucson Graphs for Malin Head (TUCSONID = 17)

Tucson Graphs for Mace Head (TUCSONID = 2)

Wind Speeds and Gusts
Horizontal lines show mean speed boundaries.
- Speed (kt) ---
- Gust (kt) ---
- Strong (22kt) ---
- Gale (34kt) ---
- Storm (48kt) ---

Wind Speeds and Gusts direction
- 'upper pen' ---
- 'lower pen' ---
Dec 5\textsuperscript{th} 2013 ("Xaver") storm
Jan 26th 2014 storm

- Heavy rain caused flooding
- Low pressure system of 947 hPa
- M4 record (highest wave ever recorded at an M-buoy) 23.4 m wave
Jan 26th 2014 storm

Tucson Graphs for Mace Head (TUCSONID = 2)

Wind Speeds and Gusts
Horizontal lines show mean speed boundaries.

- Speed (kt) ---
- Gust (kt) ---
- Strong (22kt)
- Gale (34kt) ---
- Storm (48kt) ---

Wind Speeds and Gusts direction

- 'upper pen' ---
- 'lower pen' ---
Jan 26th 2014 storm

Hs(m) 25-01-2014 00:00:00

Dp(°) 25-01-2014 00:00:00

Tp(s) 25-01-2014 00:00:00
Feb 12th 2014 ("Darwin") storm

- Hurricane force winds with up to 159 km/h gusts
- Fallen trees, structural damage, land and air transport disruption, and power losses
- Mean Sea Level Pressure of 952 hPa
- 25 m wave recorded at Kinsale Gas Platform

Boat Storage Facility at Limerick Boat Club
(https://www.youtube.com/watch?time_continue=8&v=RB1EG_BH6Fg)
Feb 12th 2014 ("Darwin") storm

- Wind direction south to southwest
- Mace Head wind of 72 kt (133 km/h) with gusts of 84 kt (156 km/h)
Feb 12th 2014 ("Darwin") storm
Feb 1\textsuperscript{st} and 12\textsuperscript{th} 2014 storms

- Wave height depends on the wind speed, how long the wind blows and the distance over which the wind blows
Conclusions & Future plans

• 12 major storms

• Coastal destruction, flooding, transport disruptions, and fatalities

• Underestimation of maximum values of wave events

• Phenomenal waves (above 14 m of Hs) recorded at M4 and Kinsale Gas Platform

• The advantages of hindcast data

• ECMWF Operational archive 2D wave spectra

• Extend the hindcast to the present day to include storms Emma and Ophelia


This work is supported by Science Foundation Ireland (SFI) through Marine Renewable Energy Ireland (MaREI), the SFI Centre for Marine Renewable Energy Research-(12/RC/2302). Authors wish to thank the Irish Centre for High-End Computing (ICHEC) for the provision of computational facilities.