

Assessing the Impact of Climate Change on the UK's Wave Energy Resource

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Aim

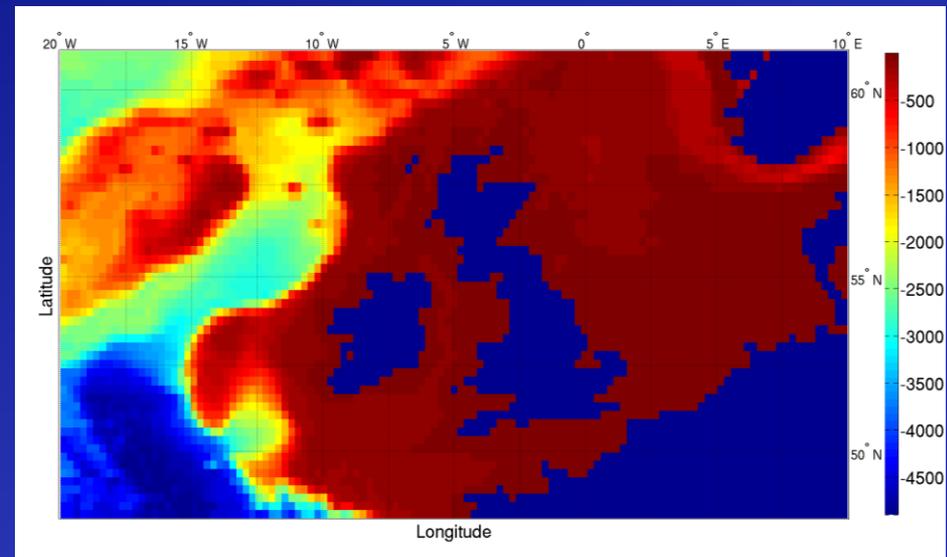
- To project the wave climate around the UK for the 21st century for high, medium and low emissions scenarios and investigate the existence of a **causal link** with atmospheric greenhouse gas concentrations

Methodology

- Using a calibrated wave model for the North Atlantic and UK, simulate current and projected wave climate (height, energy period and direction) for the high, medium and low GHG emissions scenarios
- Establish the capability of Wavewatch III v4.18 model through:
 - Validation of contemporary climate against observations
 - Comparison of spatial trends between projections and contemporary climate
- Assess the magnitude of changes in absolute and relative terms
- Investigate the existence of a causal link between the wave climate changes and GHG levels using the Analysis of Variance (ANOVA) method

Datasets and Modelling

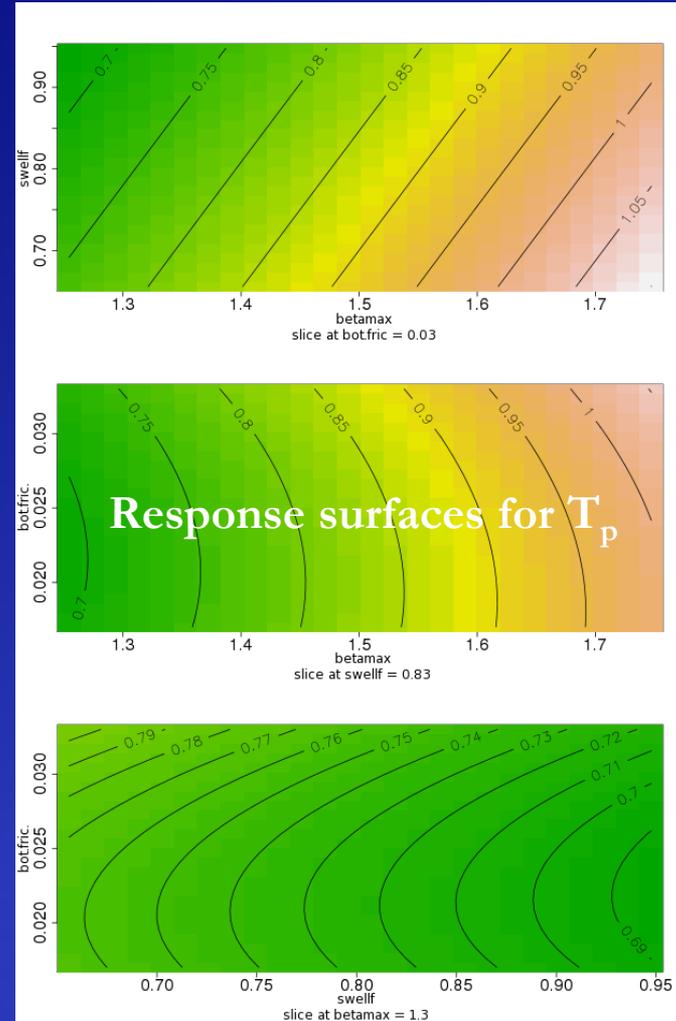
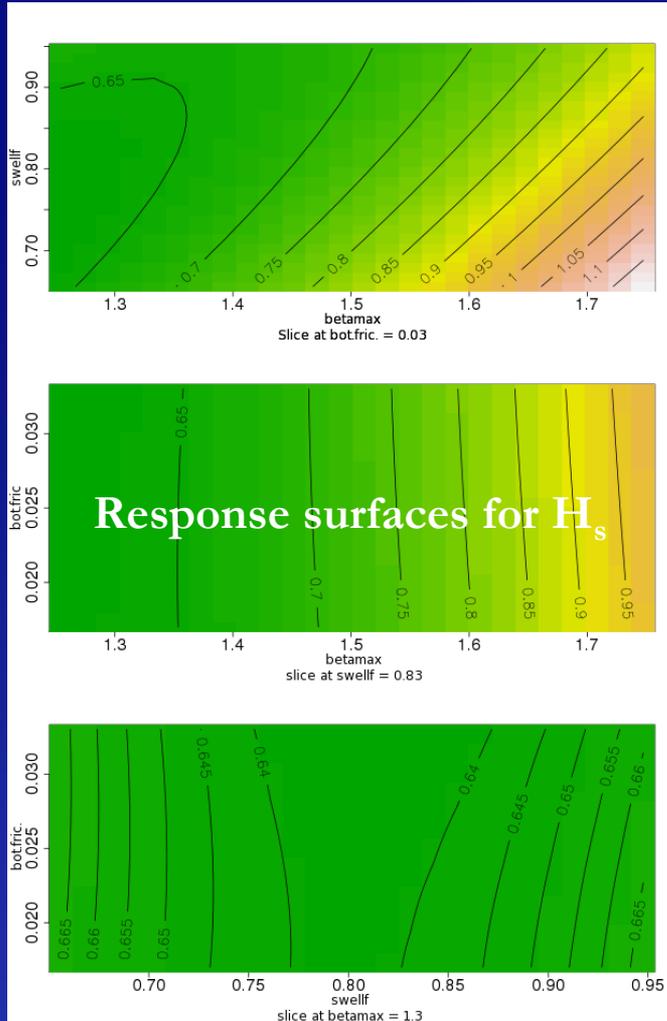
- Wave data simulated using WAVEWATCH III v 4.18
- Hourly gridded wave data at $0.25^\circ \times 0.25^\circ$ spatial resolution
- Tuning parameter values obtained from response surface optimisation were used
- NCEP 20th Century Reanalysis (20CR) wind data used for simulating the historical ‘observed’ wave climate
- ECHAM5 GCM wind data for climate change scenarios



Calibration

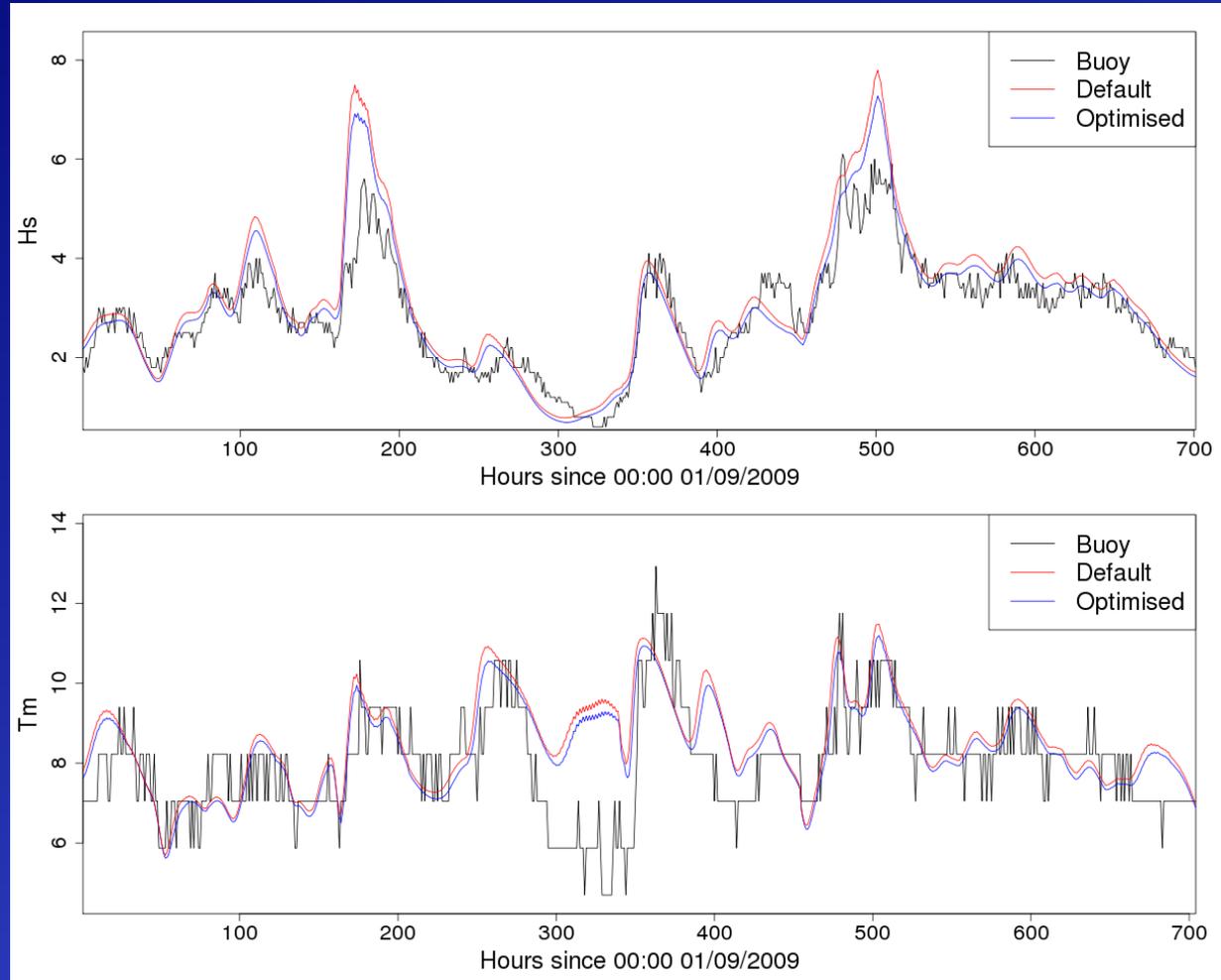
- A Monte-Carlo type experiment was designed to calibrate the wave model, including:
- Experiment to tune the values of the wind growth term (β), swell attenuation factor (s) and the JONSWAP bottom friction coefficient (Γ)
- 500 trials designed using the Latin Hypercube sampling scheme to optimise computational effort and accuracy
- Response surfaces were generated to examine parameter effect on significant wave height (H_s) and peak wave period (T_p)
- Response surfaces were simultaneously optimised to minimise the bias between model and buoy measurements

Calibration



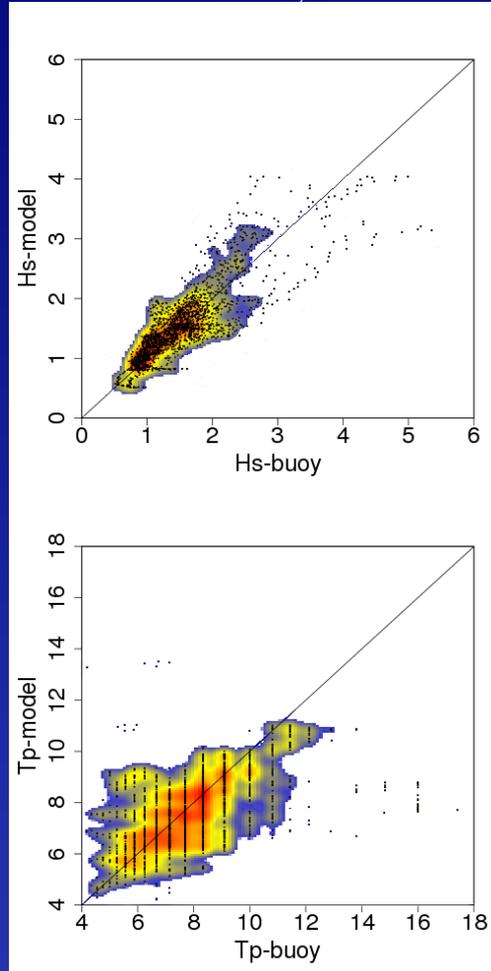
Validation

Comparison of wave model output for default and optimised parameter values compared with buoy observations for the location West of Hebrides

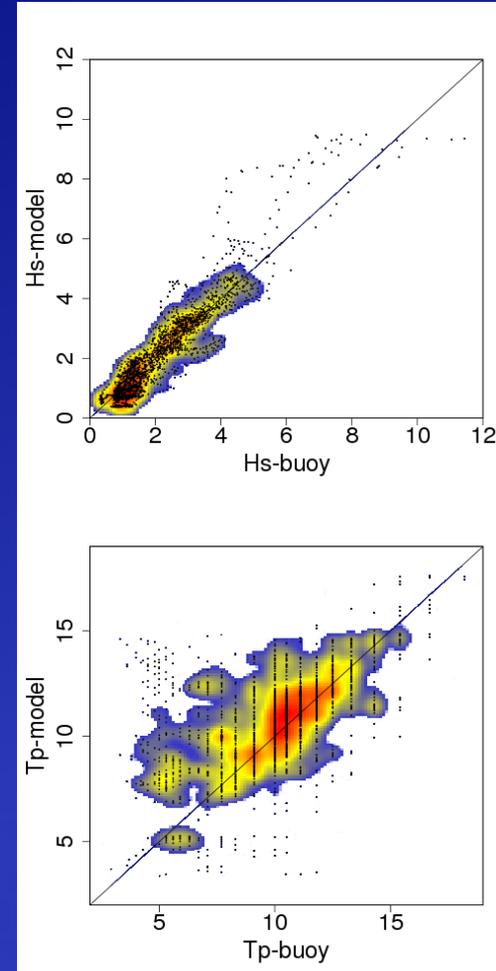


Validation

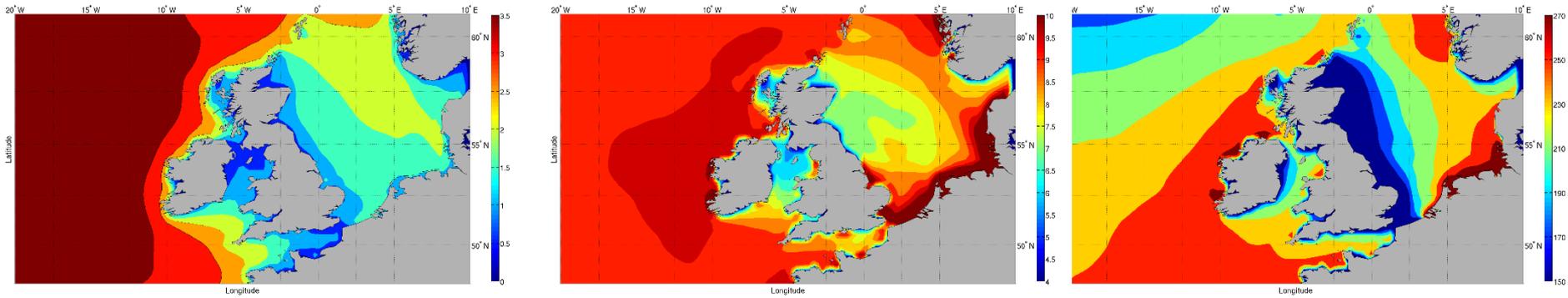
NDBC buoy 41048



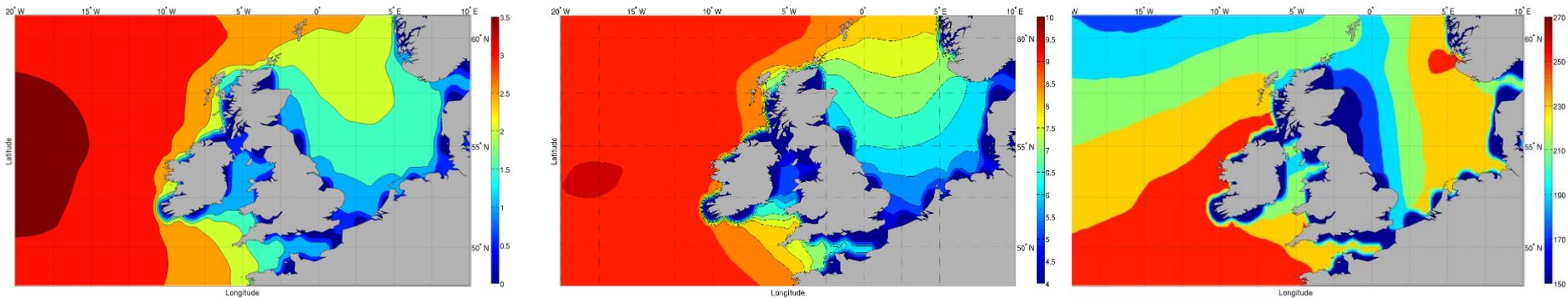
West of Hebrides



Validation: ERA-Int

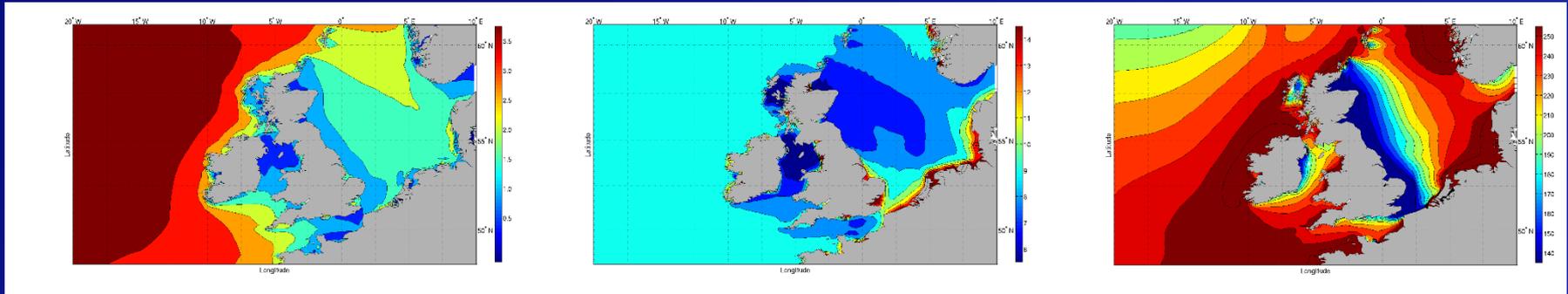


Wave data from reanalysis winds (20CR)

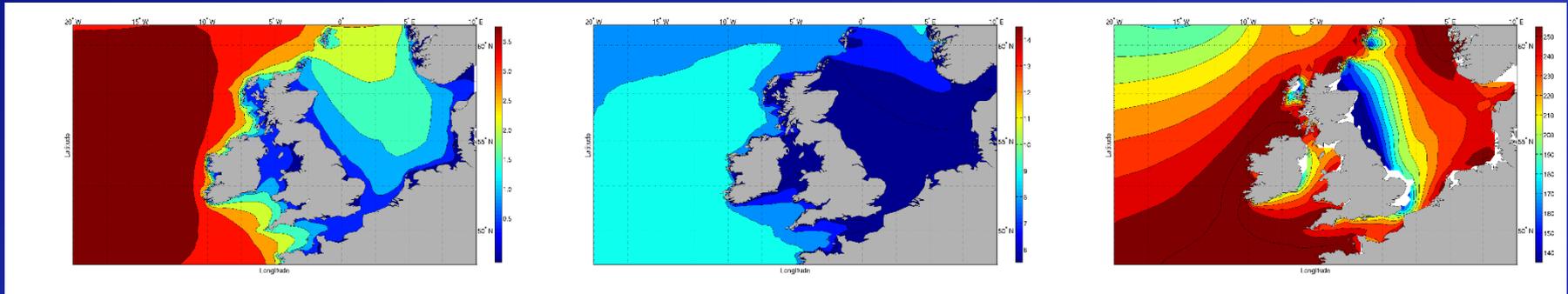


Wave data from ECMWF ERA-I

Comparison of Contemporary Climate



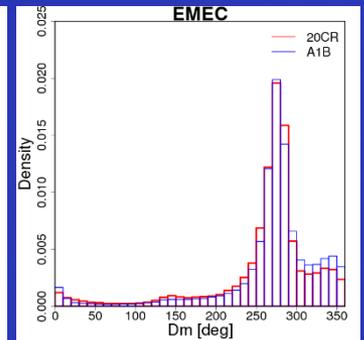
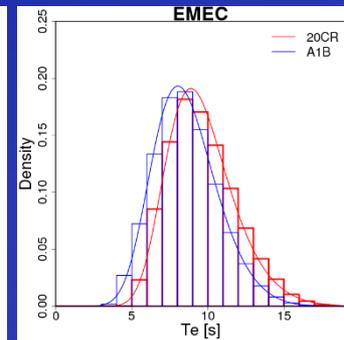
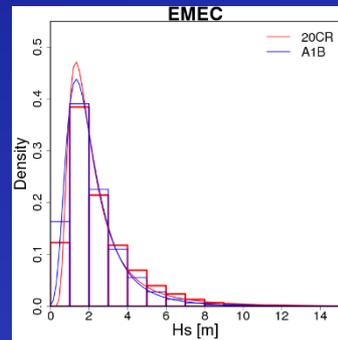
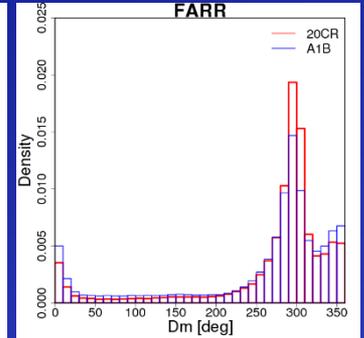
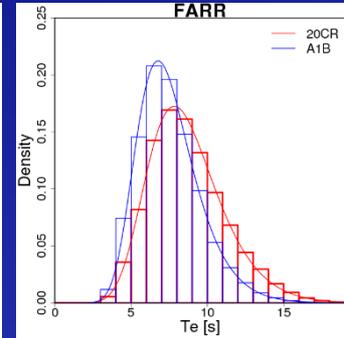
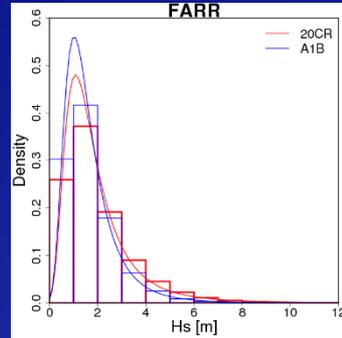
Wave data from reanalysis winds (20CR)



Wave data from GCM data for the A1B scenario

Comparison of Contemporary Climate

- Good agreement between H_s and D_m at site and regional levels
- Lower confidence in T_e on account of differences at the site and regional levels



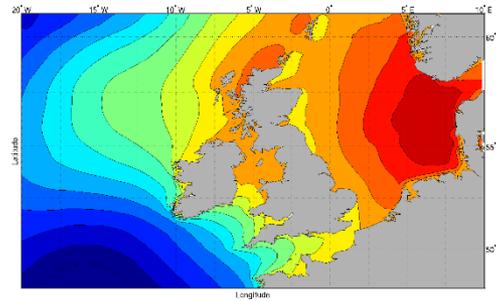
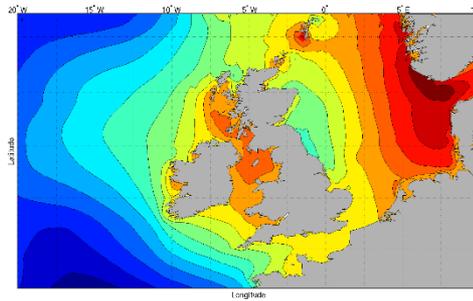
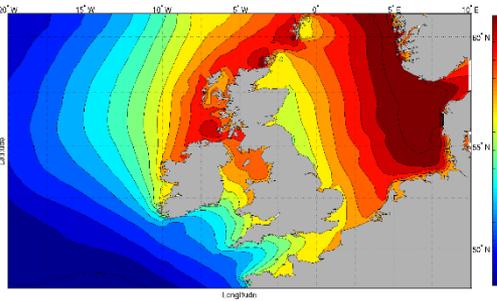
Changes in Wave Climate 2001 – 2100: H_s

A2

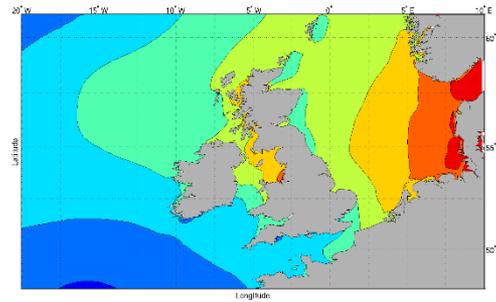
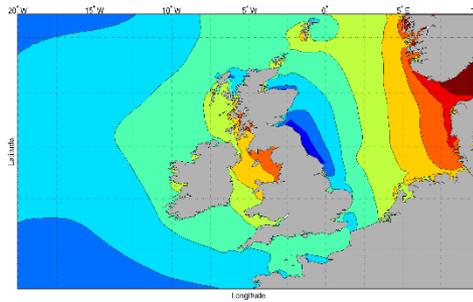
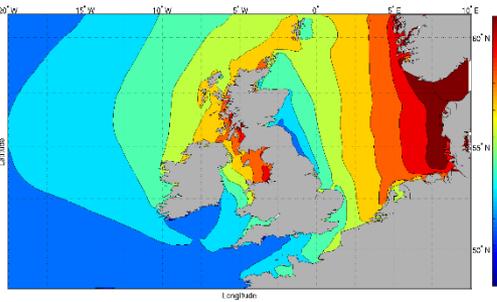
A1B

B1

Absolute



Relative



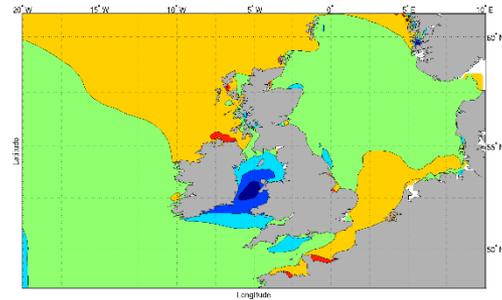
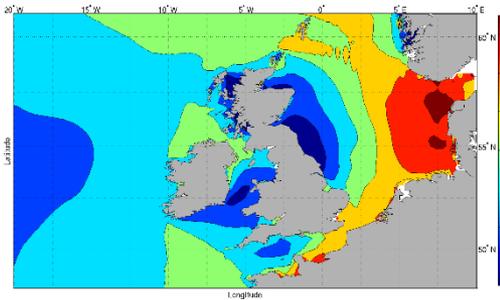
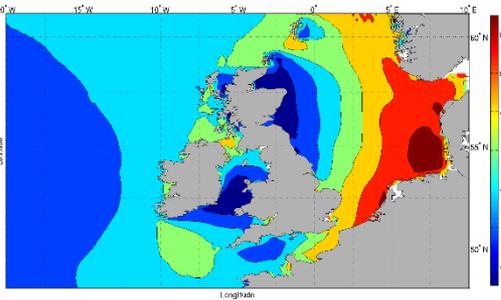
Changes in Wave Climate 2001 – 2100: T_e

A2

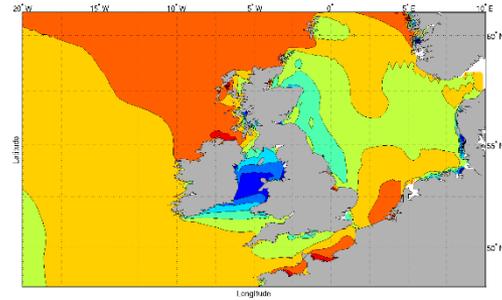
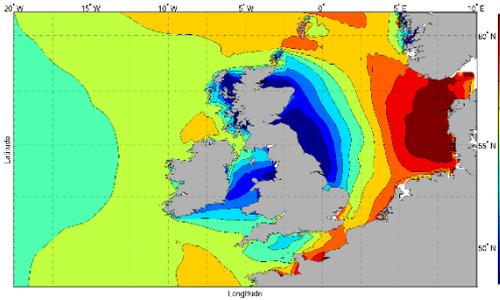
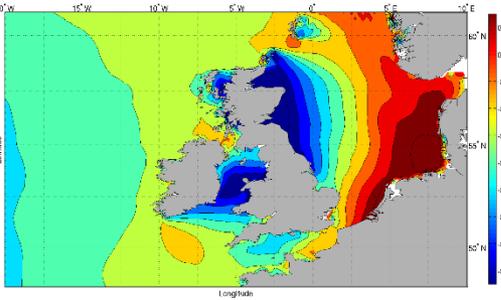
A1B

B1

Absolute



Relative



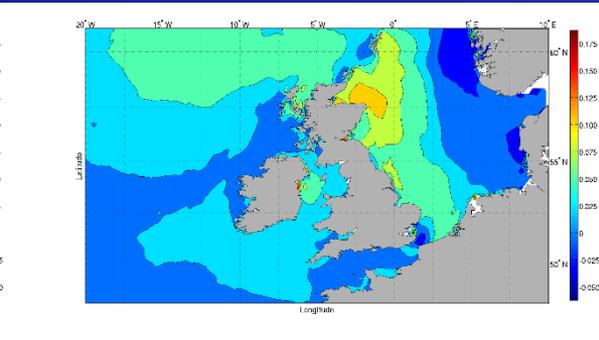
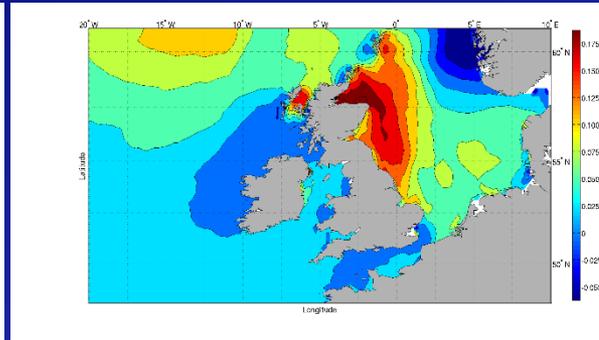
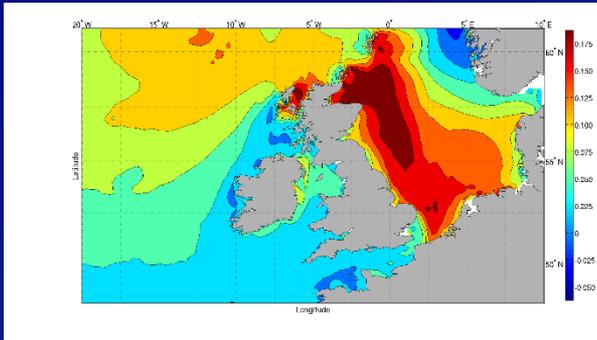
Changes in Wave Climate 2001 – 2100: D_m

Absolute

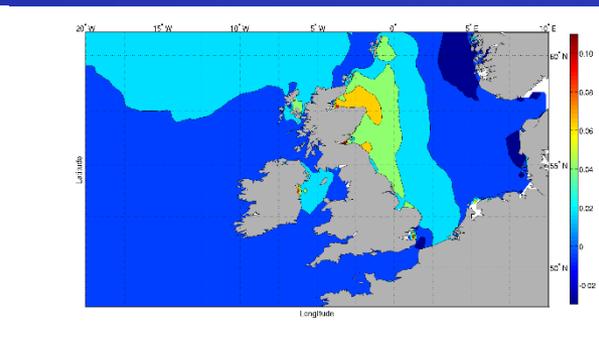
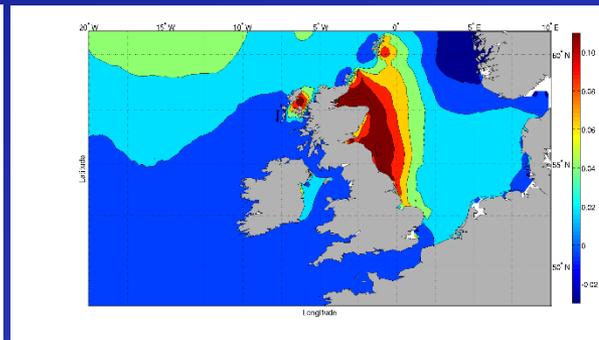
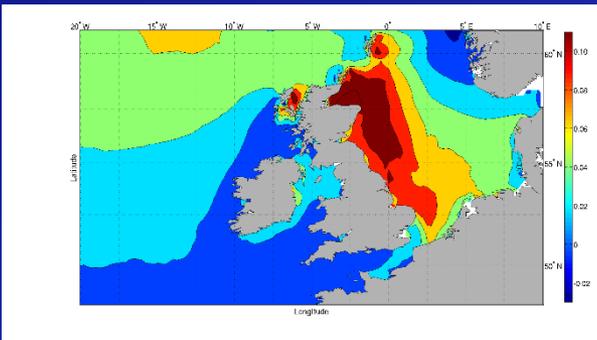
A2

A1B

B1

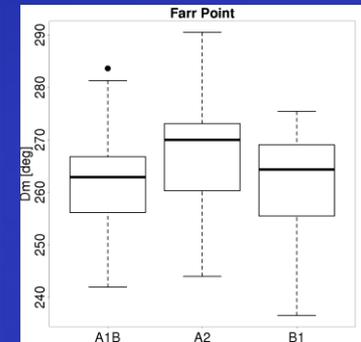
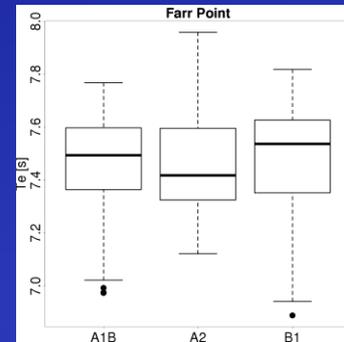
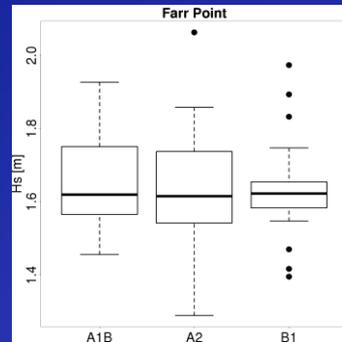
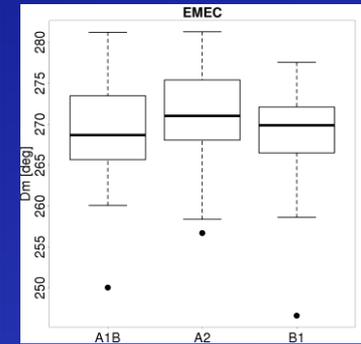
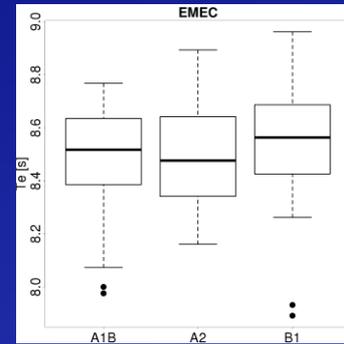
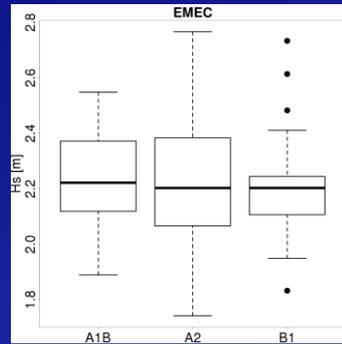


Relative



Analysis of variance

- ANOVA test applied to samples of wave data from 2071-2100 from the A2, A1B and B1 scenarios
- Results show no statistically significant differences between the samples
- Results indicate that based on the data available, it is unlikely that the wave climate it influenced by climate change forcings.



Conclusions

- Over the 21st century, some changes in magnitudes can be observed in the wave climate projections for the three selected scenarios from the contemporary climate
- However, based on the data and methods used, it cannot be concluded that these are linked with atmospheric greenhouse gas concentrations
- It is possible that these may be a result of the natural variability of the system

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