Changes in extreme wave conditions around the UK in response to high-end climate scenarios

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Motivation

- Future storm conditions (high winds) drive waves.
- North Atlantic storminess is known to be hard to predict.
- Large natural variability, so how can we certain an observed change is real?
- Long observed data sets from buoys are rare, so we use a model.
- Waves can integrate storminess into swells
- Climate signal may emerge, even where there is no a clear change in the atmosphere

Questions

- How does climate change affect future waves?
- How does this manifest itself at the coast?
Outline Approach

● High resolution European modelling
  – Changes in mean and extreme waves
  – Coastal Impacts around Europe

● Global wave models
  – Context of eight model: meta-analysis
  – Robust predictions of future change

● Future probability of extreme wave events
  – Site specific forecasts
  – Changing distributions and damaging ‘tails’
Dynamical downscaling of EC-Earth climate model: 
RCP4.5 & RCP8.5 wave conditions for European coasts

Global WaveWatch III model (left) 
resolution ~ 0.83°

High resolution (right) 
resolution ~ 12km.

Nested configuration run from 1970 – 2100 
plus ‘real’ ERA-Interim run 1979-2015 for validation
Future changes in mean and mean annual maximum $H_s$ End century, RCP 8.5

Left: future mean wave height projected to decrease (up to 20 cm in places).
Right: future mean annual maximum more complex, with increase /decrease~ 50 cm

Shading indicates areas of low confidence (<75% grey, <50% black)
Coastal Specific Projections

Concentrate only on points of interest – close to coastal cities.
Coastal projections - UK wave climate
Mean / Max (top) mean change (middle) max change (below)
Just one model? How does this fit in context of a climate model ensemble?

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Future changes in wave conditions in 8 different models: end century RCP8.5

Relative change in mean wave height (+/- 25%)

Relative change in mean annual maxima (a measure of extreme waves) +/- 100%
Fractional change in future minus past mean wave height. Negative numbers indicate reduction in average wave height in future projections.
Fractional change in future minus past mean annual maximum wave height. Large spread of future projections around zero indicates large uncertainty in direction of change in extreme wave height in future projections.
Changing extreme waves

Comparison of probability distribution of historic and future wave conditions (West of Hebrides buoy site)
Changing extreme waves

Quantile-Quantile plots of the top 1% of significant wave height: historic (x-axis) against 2 futures (y-axis)
Linear fit diverges where the extreme wave climate changes in future.
Conclusion

• Dynamical downscaling adds value through high resolution winds, bathymetry, and coastal geometry.

• Mean wave height seen to decrease across most European seas. (except in the North - due to decreased Arctic sea-ice cover)

• Mean annual maximum waves are messy and more uncertain. both positive & negative changes are seen of up to 50cm.

• Global model ensemble supports the finding of an overall decrease in mean wave height, and large uncertainty in mean annual maximum.

• The full shape of the PDF distribution must be considered, especially the tails - representing extreme waves
Thanks for listening!

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• The Coordinated Ocean Wave Climate Project (COWCLIP) provides a set of wave climate projections. This community-based framework, inter-comparison project provides data for wave climate projections forced from CMIP5 datasets. The dataset is summarised in Hemer et al. (2015)

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References


