Changes in wave contribution to total sea-level in response to high-end climate scenarios

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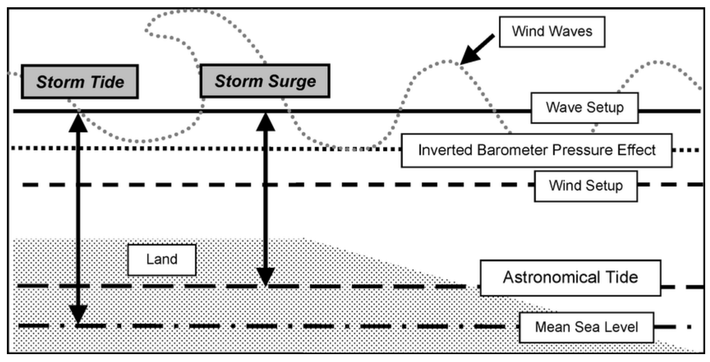
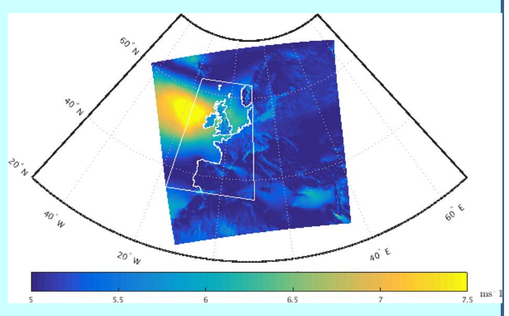
Context and Motivation

Total water level at the coast is made-up of a combination of mean-sea level, and time varying effects. As well as decadal scale sea-level rise caused by global warming and thermal expansion, the short-term contributions can also be impacted by climate change. Components of tide, storm surge, and waves all combine to give a total sea-level at the coast.

The RISES-AM- project aims to address coastal impacts of climate change for high-end emissions scenarios i.e. where global average warming is projected to exceed 2°C with respect to pre-industrial temperatures. We review physical projections at global and regional scales for surface wave climate by 2100 with RCP4.5 and RCP8.5 scenarios.



Modelling Future Waves

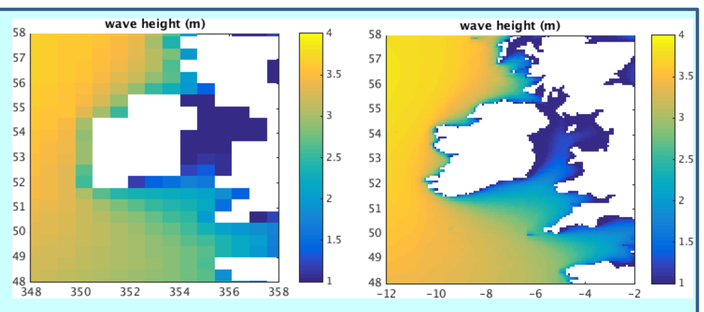


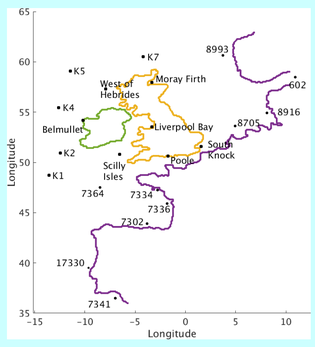
An ensemble of 7 CMIP5 models is used to drive a global wave model in order to explore potential changes in wave climate around Europe. The historic wave climate is compared with projections from RCP4.5 and RCP8.5 over the 21st Century. The change in both average and extreme wave conditions are considered, with the latter most pertinent to coastal erosion and flood events. In addition a regional atmosphere and regional wave model are used to provide downscaled climate projections for a single CMIP5 model. The EC-Earth model, downscaled through EURO-Cordex is used to force the wave models. The global wave model is forced with 3-hourly winds, and the nested European model is forced with 6-hourly winds, and hourly swell-waves.

How will average and extreme waves change around Europe in the coming century?

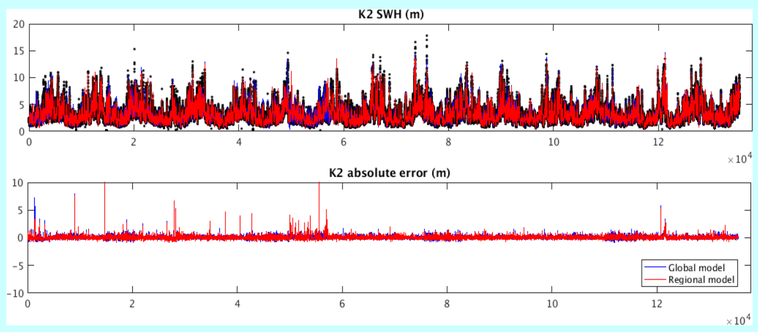
Model evaluation

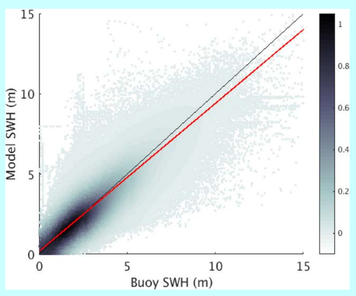
Dynamical downscaling and model nesting. Global model resolution ~ 0.83° High resolution (right) resolution ~ 12km. Downscaling improves coastal geometry and bathymetry resolution, and adds more detailed outputs at the coast. Global model provides incoming swell waves



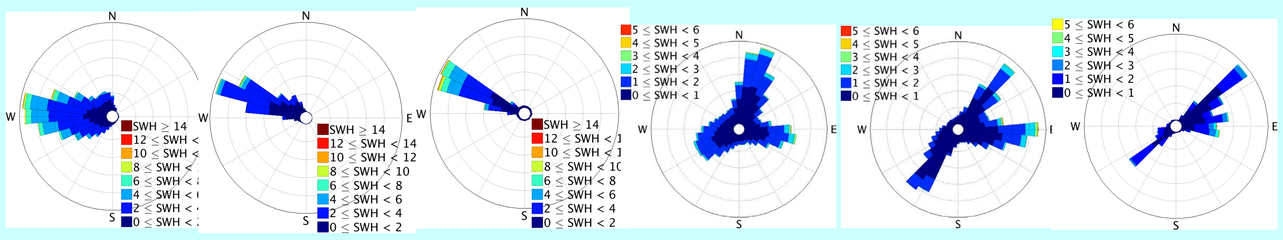


Thorough model evaluation of wave height, period, and direction is performed at 23 buoy sites around NW Europe. The model performs best in deep water, and at exposed sites. There is little improvement in wave height when downscaling, however the wave directions improve significantly. NB maximum waves are of the order twice as large as the mean significant wave heights (Hs).

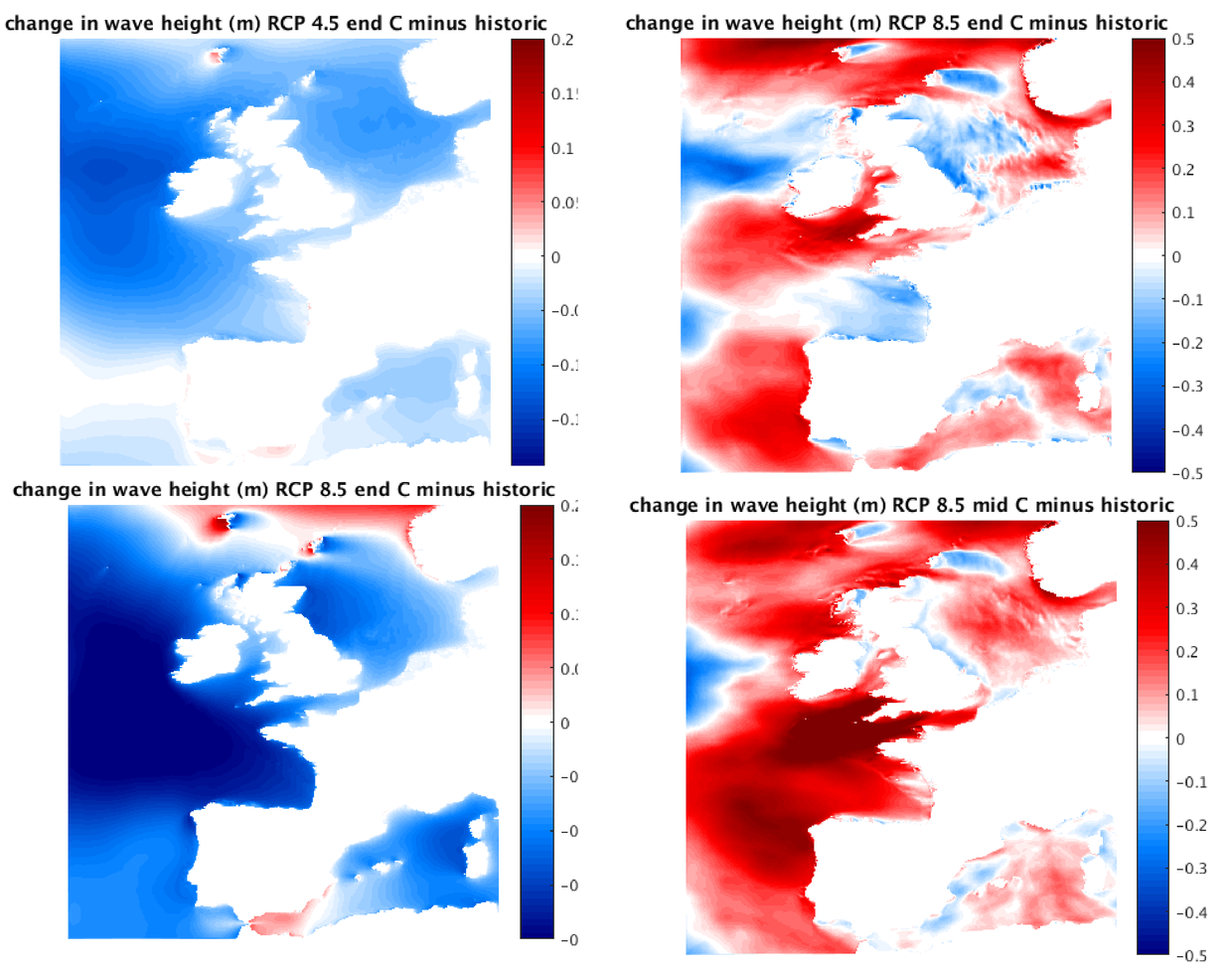




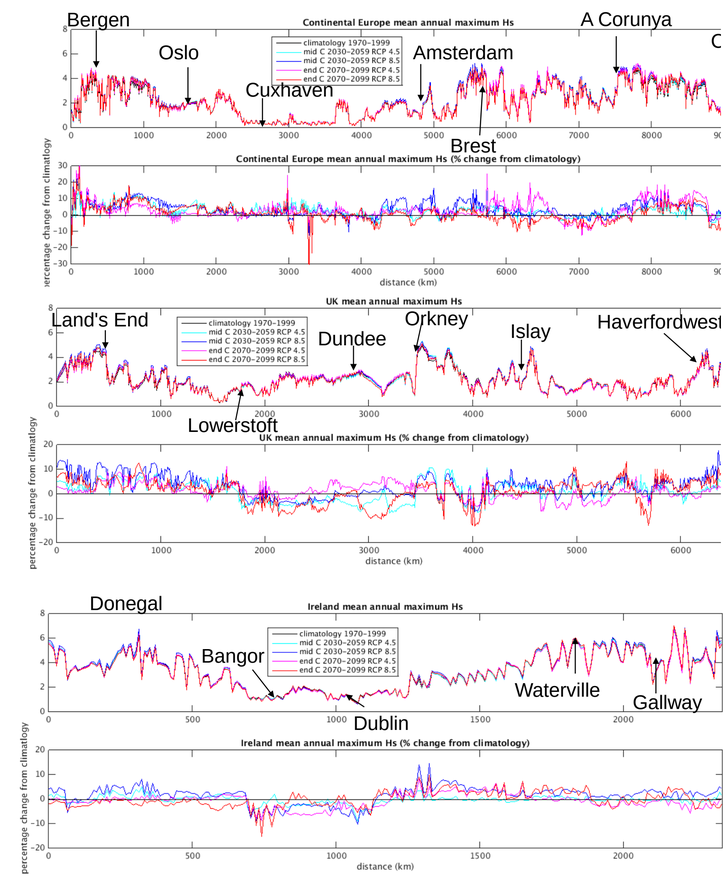
Wave roses from Belmullet (left) and Moray Firth (right) showing impact of model resolution. From left to right: global model, regional model, buoy



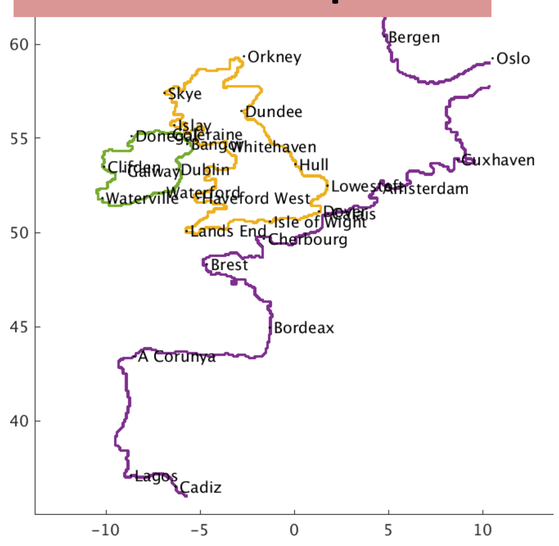
Future Wave Climate Projections



30 year future change in mean wave height (left) and mean annual maximum wave height (right). The top row shows changes between RCP 8.5 projections and the past, bottom row show changes between RCP4.5 and past. The historic period is from 1970 – 1999, and the future between 2070-2099.



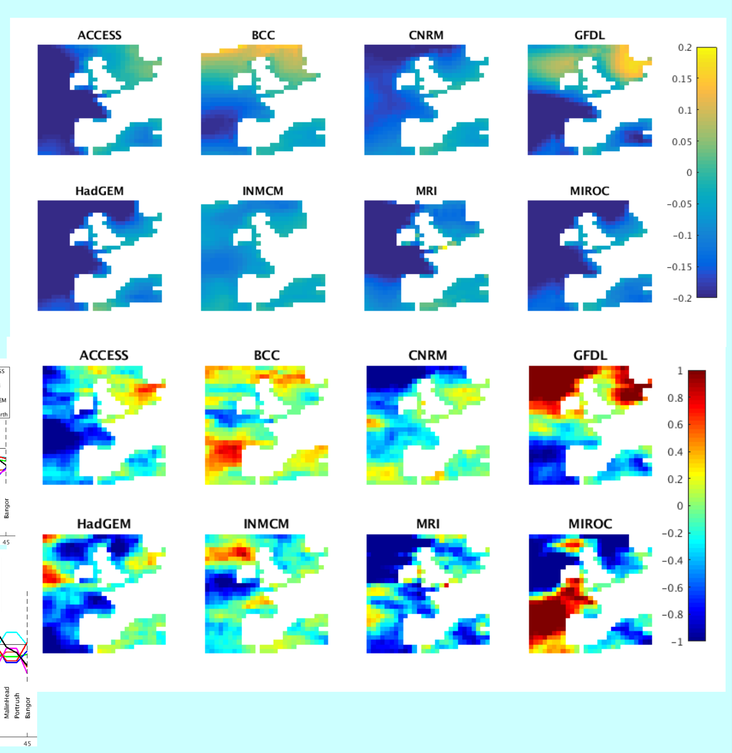
Coastal Impacts

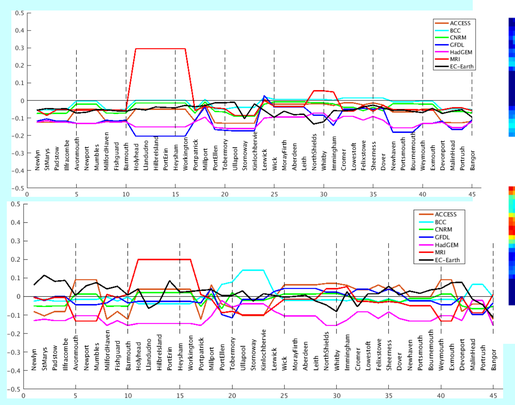


We can extract coastal points, and 'unwrap' the strip to examine changes at the coast. We are interested in extreme waves, which are more damaging, we will look at both mean and AnnMax significant wave height. The mean waves are seen to decrease on average in all scenarios, while the extremes have more spatial variability.

Multi-model analysis: COWCLIP

Global wave model projections are being shared under the Coordinated Ocean Wave Climate Project (COWCLIP). We analysed a further eight of these models, for the change in mean and extreme wave climate, to provide context for the EC-Earth forced result above.





Conclusions

Mean significant wave height projected to decrease in future around North West Europe. However, the extremes are projected to increase at many locations, due to decreasing sea-ice, and changing storm track. The decline in mean wave height is robust, but there is more uncertainty around the change in extreme waves, and a more complex spatial pattern. The downscaled results are supported by the analysis of a multi-model ensemble. Again, the reduction in mean wave height is clear, but changes in extremes are inconclusive. Hazards and impacts of extreme waves can be investigated by looking at projected changes close to the coast, and major cities.

Results to be published in UKCP18 and paper with JGR-Oceans

RISES-AM- EU Research Project

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UK CLIMATE PROJECTIONS