

# Future wave conditions of North West Europe in response to high-end climate change scenarios

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**RISES-AM-**  
EU Research Project



National  
Oceanography Centre  
NATURAL ENVIRONMENT RESEARCH COUNCIL

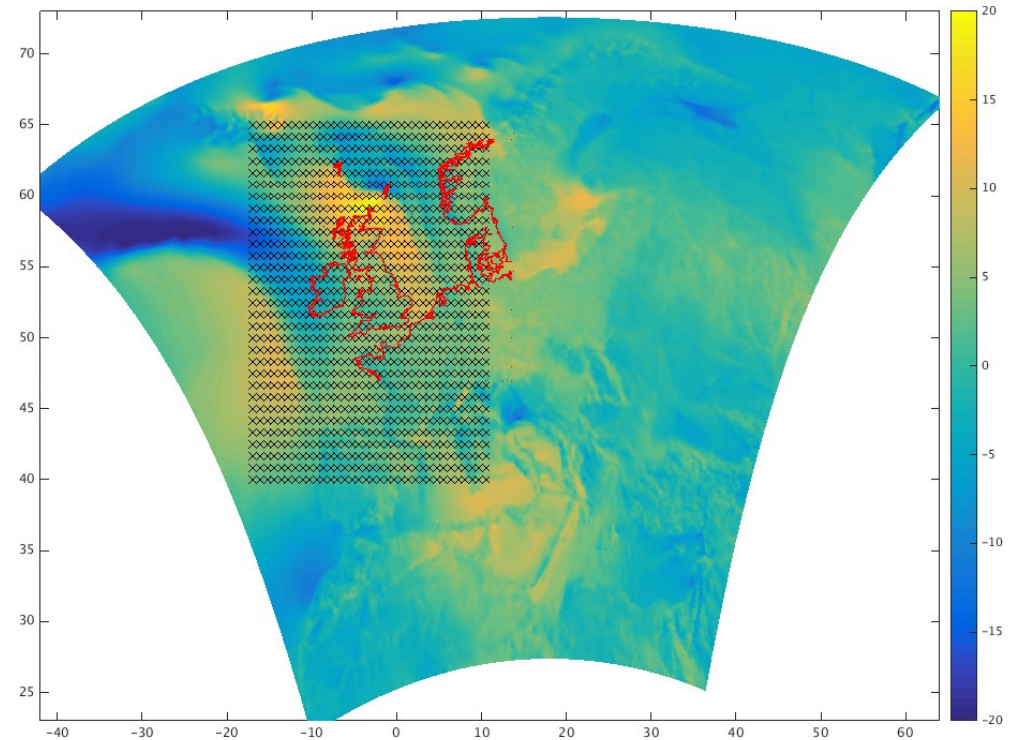
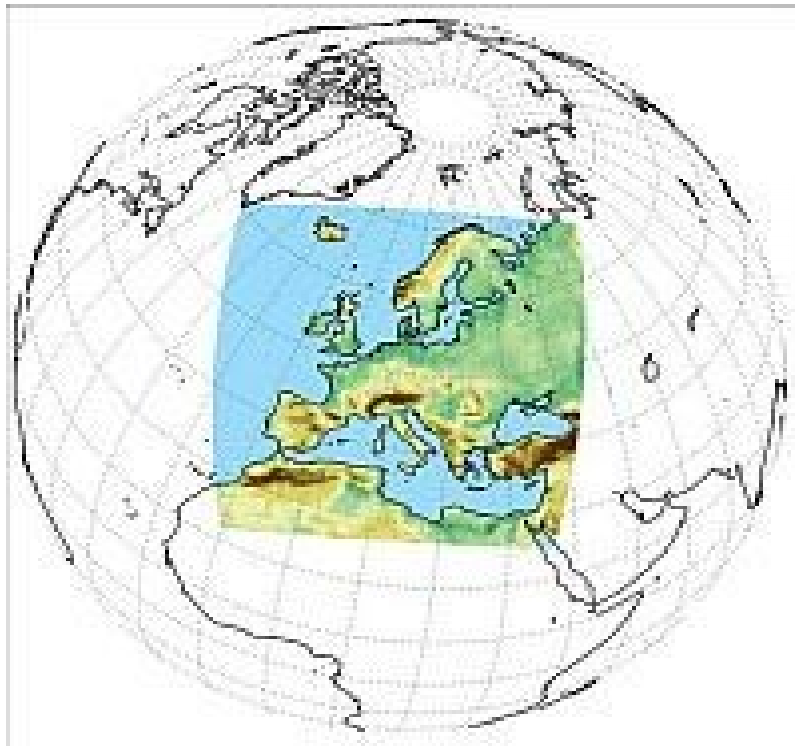
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**NERC** SCIENCE OF THE  
ENVIRONMENT

# Summary

- 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 projections at global and regional scales for surface wave climate by 2100 with RCP4.5 and RCP8.5 scenarios.
- The impact of dynamical downscaling is assessed.

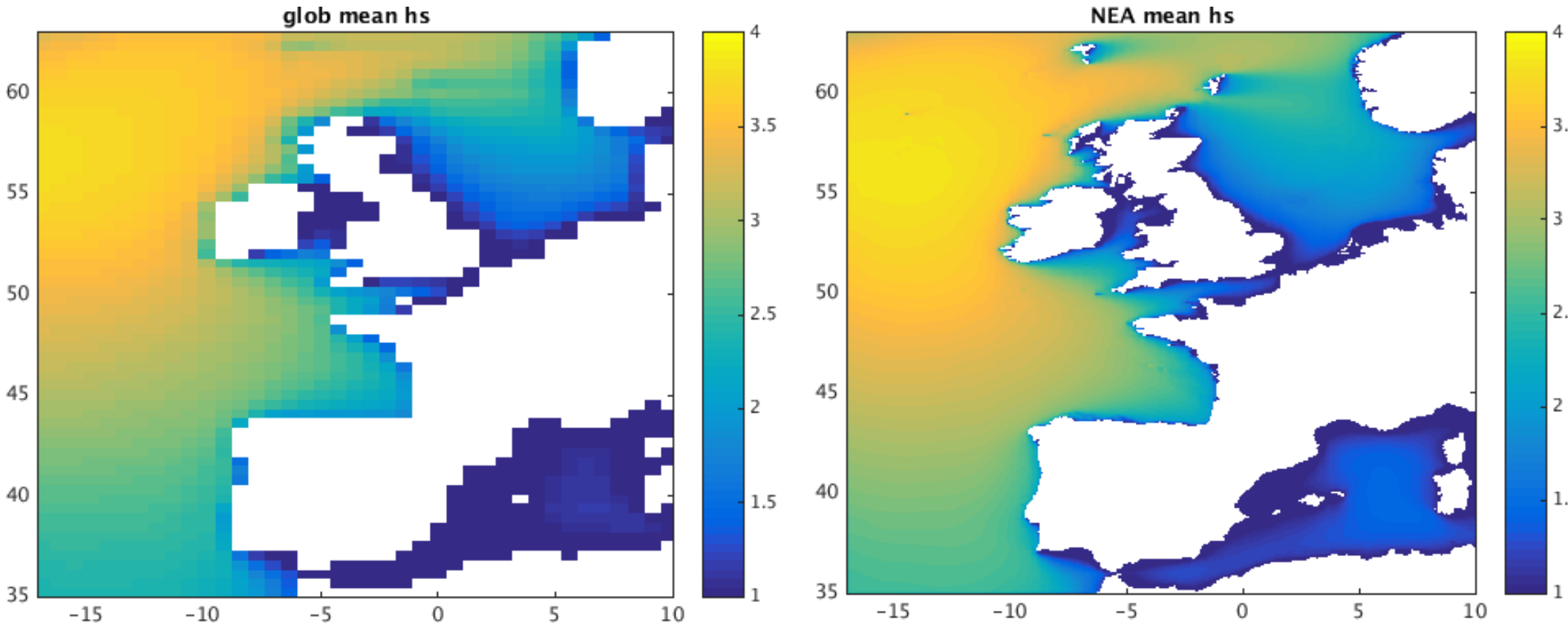
# WaveWatch models of future wave climate



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.



# Dynamical downscaling

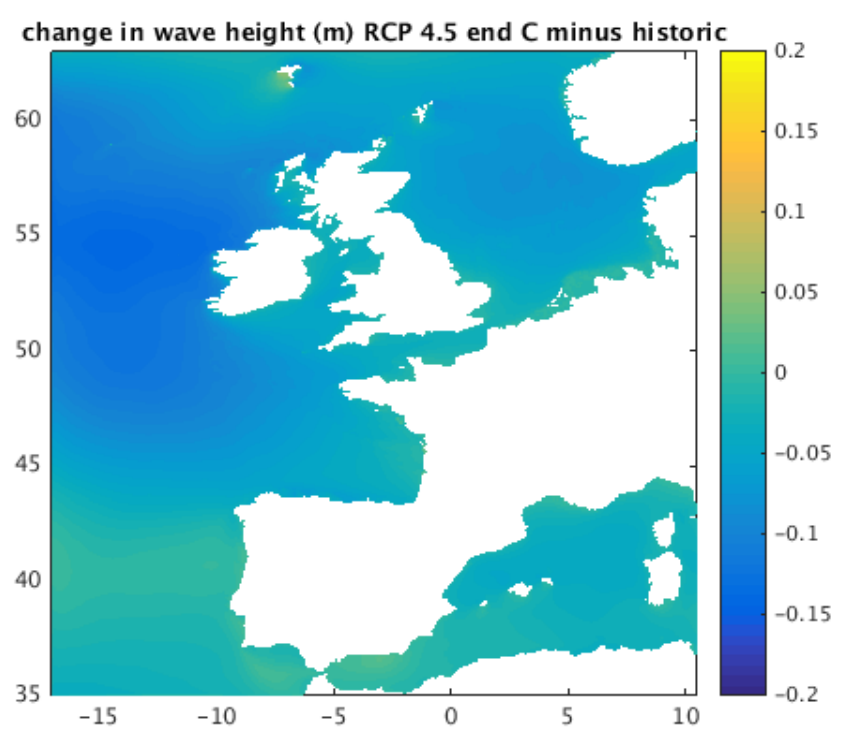
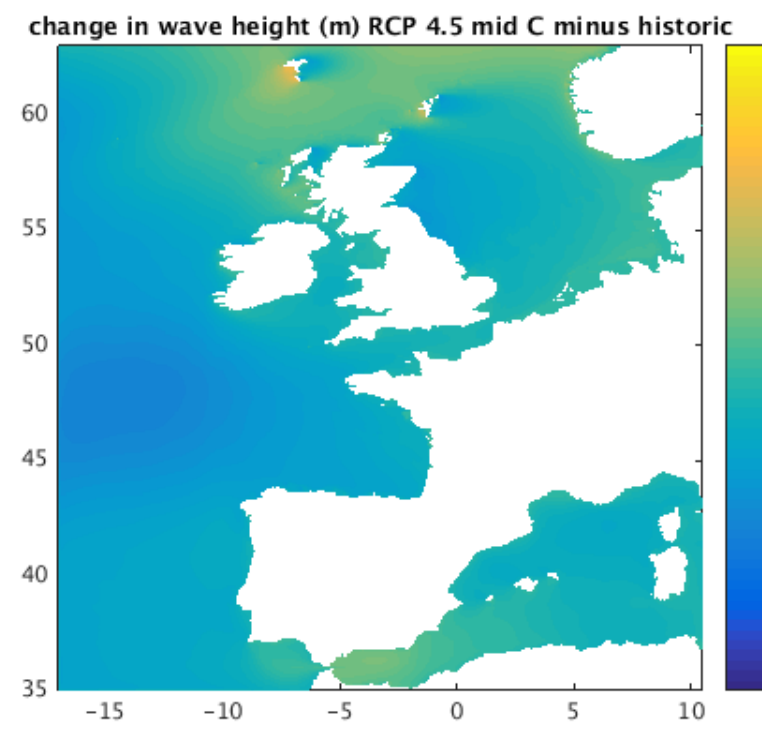
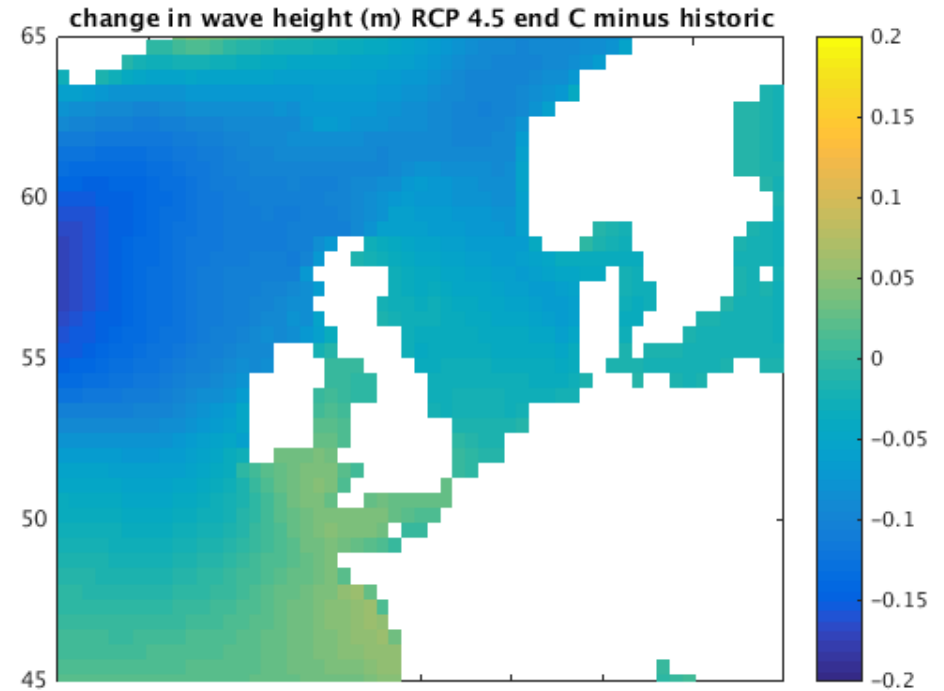
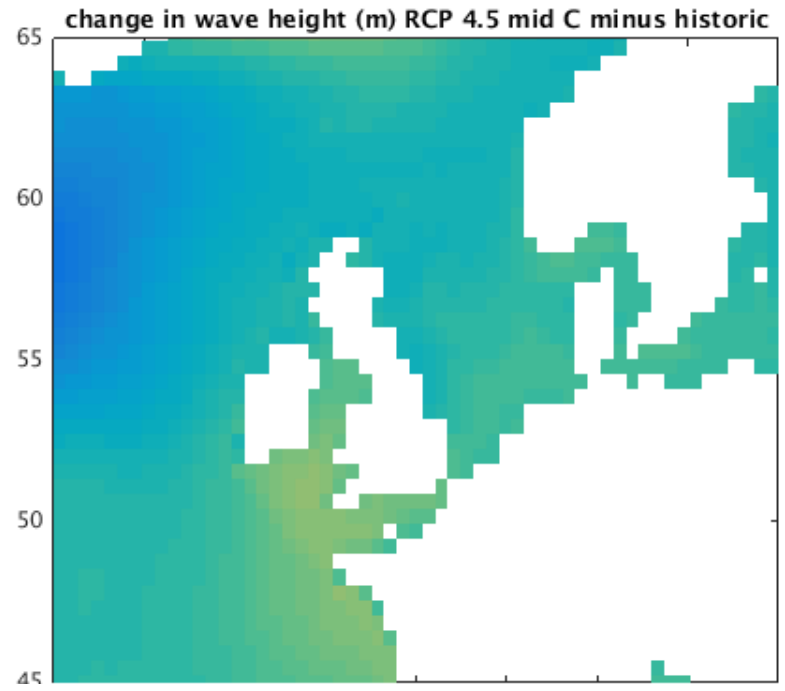


Non-local effects: swell waves maybe generated far offshore, so dynamical downscaling is required

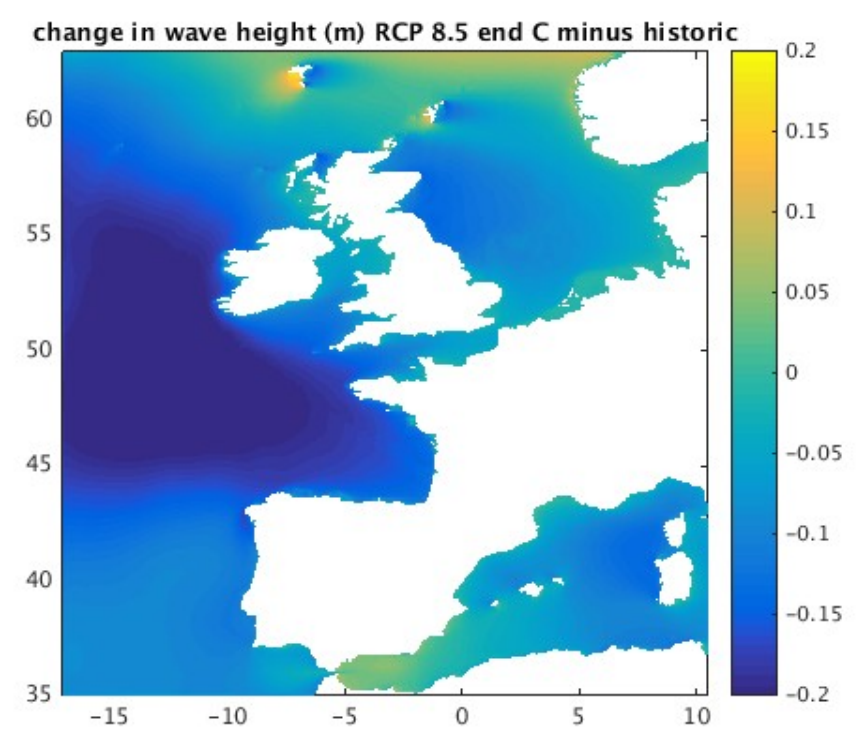
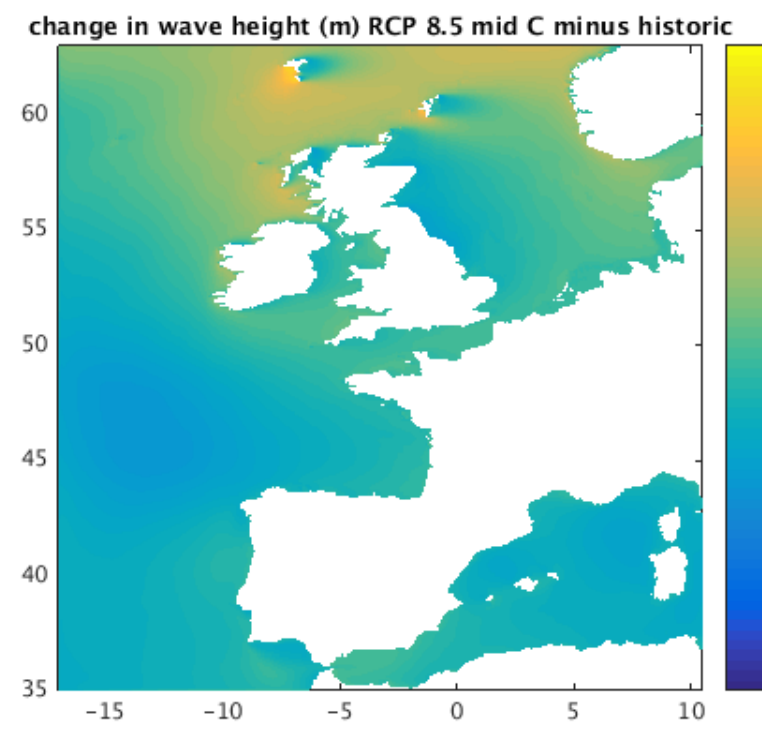
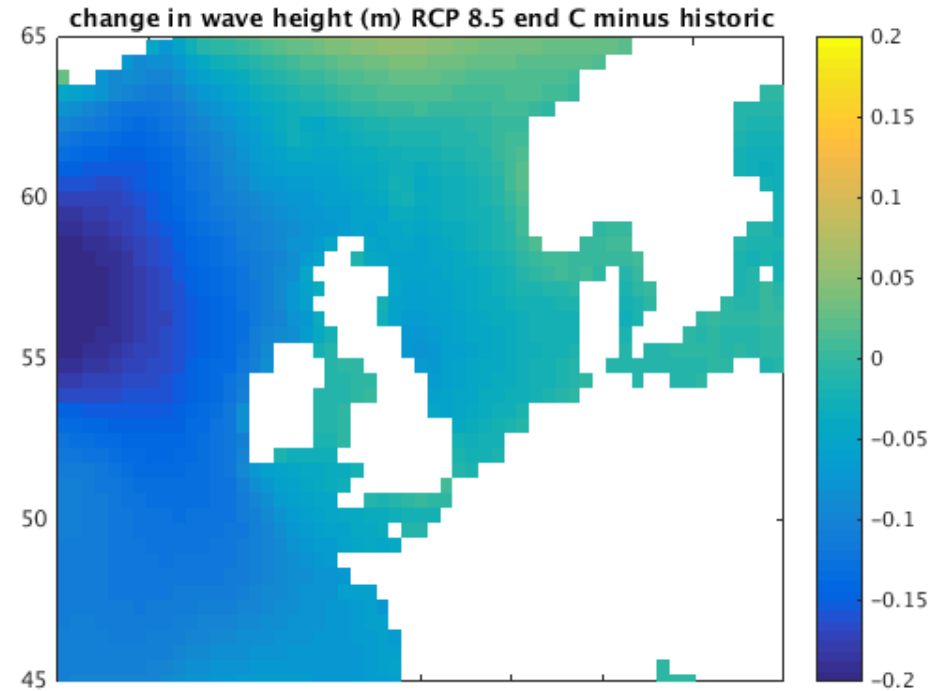
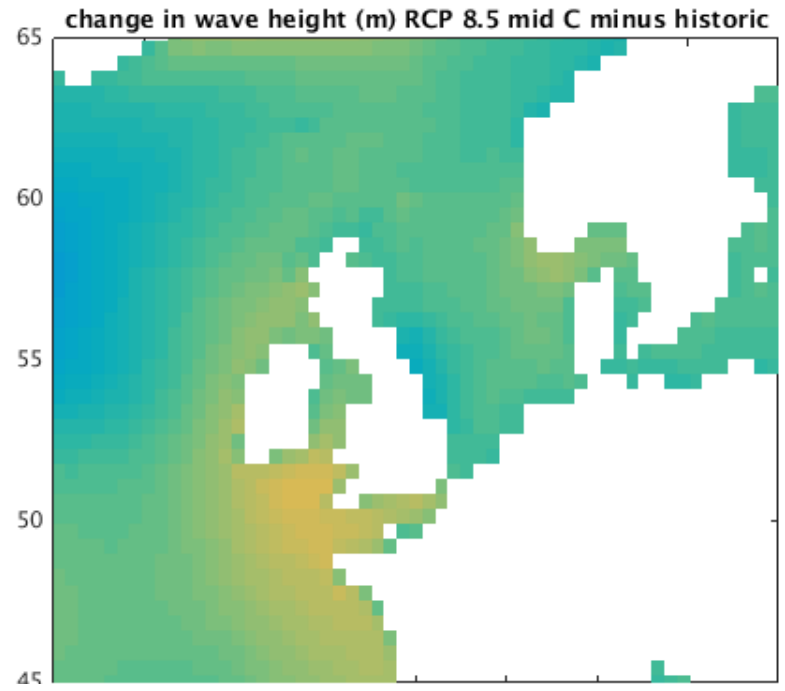
Extra resolution particularly important in coastal areas, partial obstruction to represent missing islands

(Ignore the Med please!)

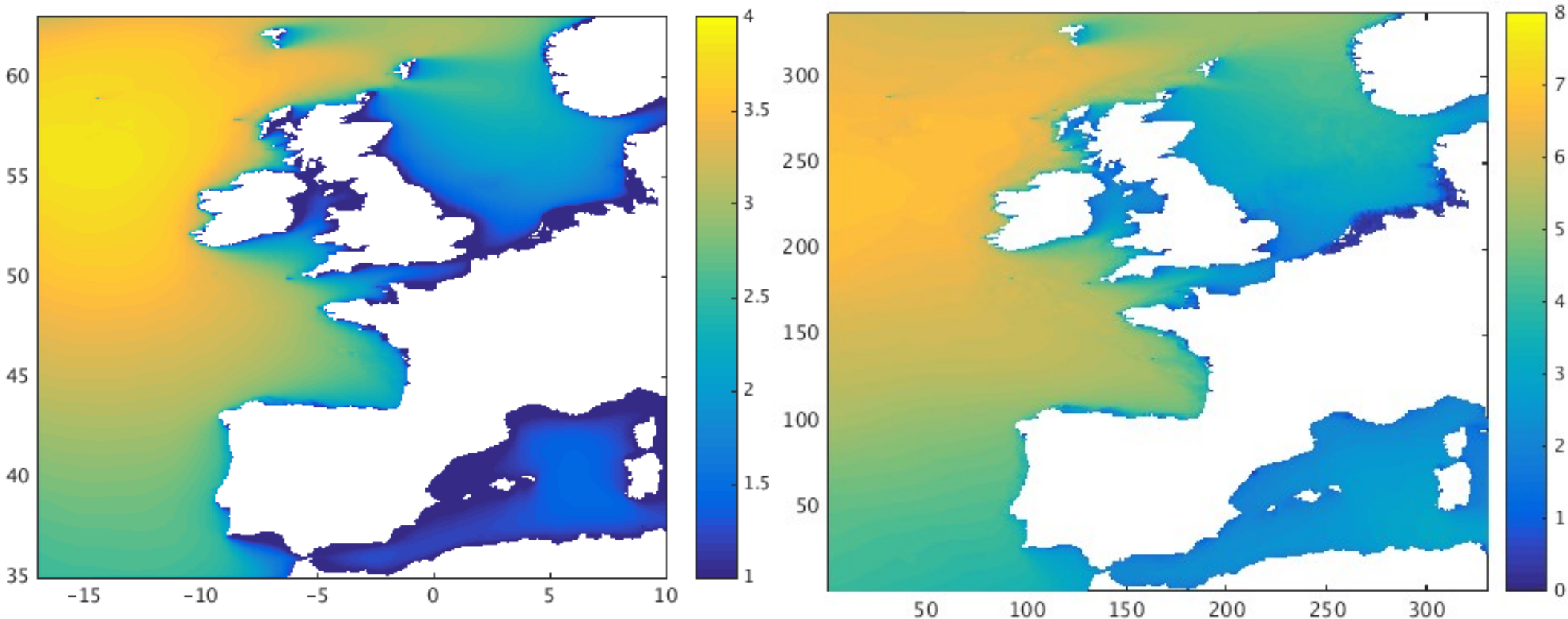
# Means diff (30 year means) for RCP 4.5 futures



# Means diff (30 year means) for RCP 8.5 futures

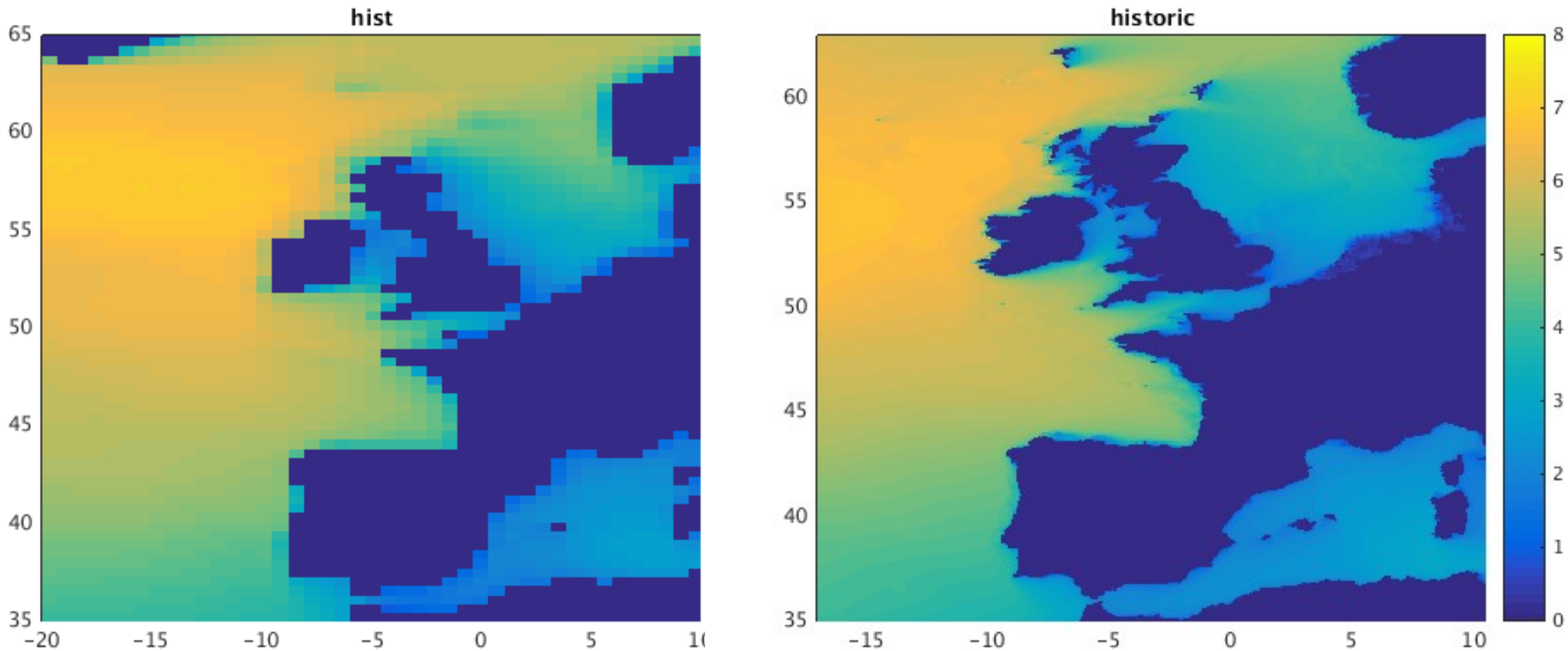


# Mean Hs (left) and mean annual maximum (right) for a historic 30 year period



NB maximum waves are of the order twice as large as the mean significant wave heights (Hs). All values are in metres

# Impact of downscaling on mean Annual Maxima Hs; 30 year means for historic run 1970 – 1999



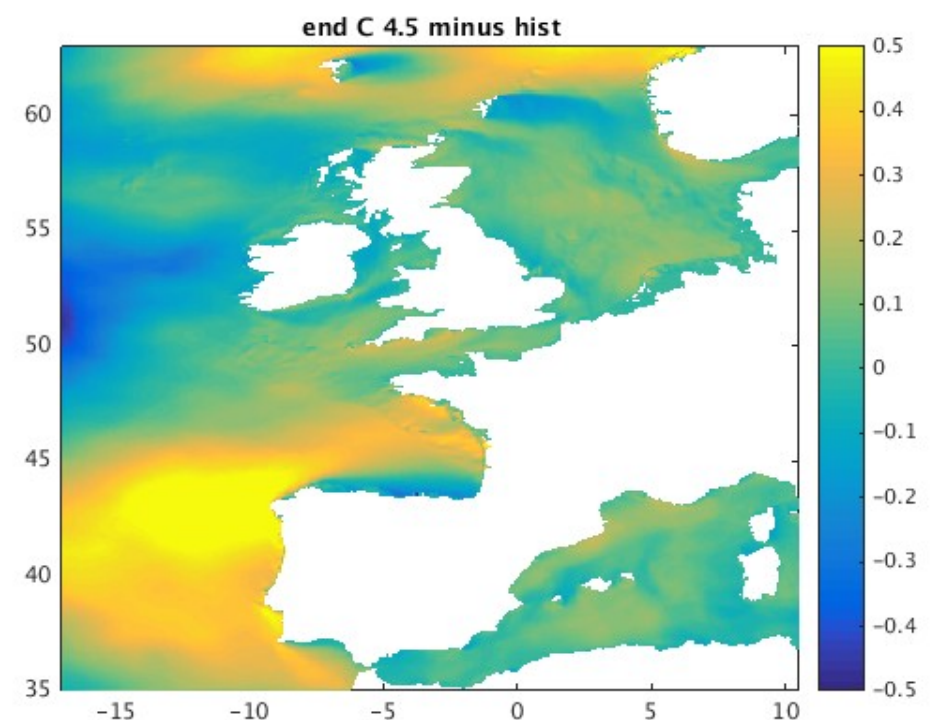
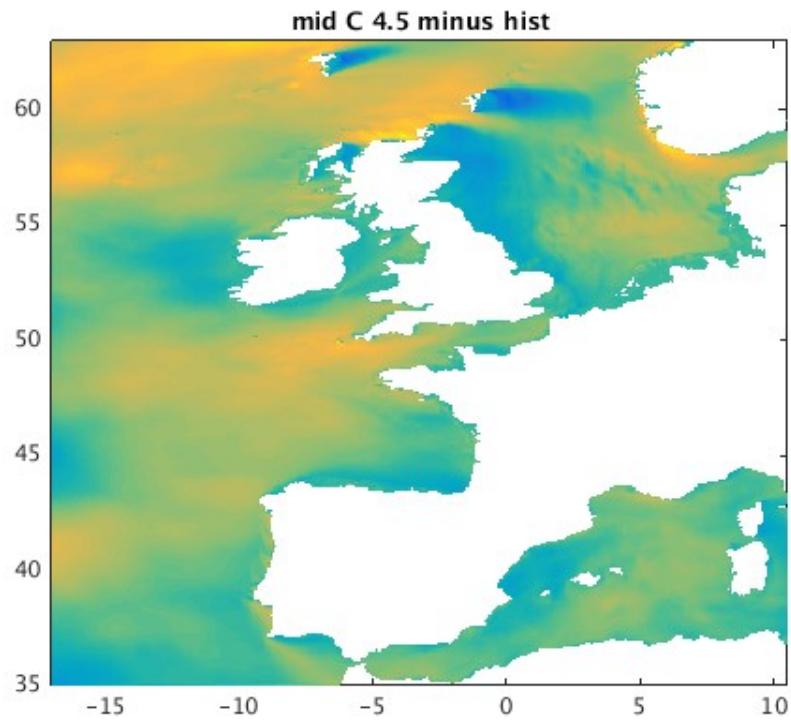
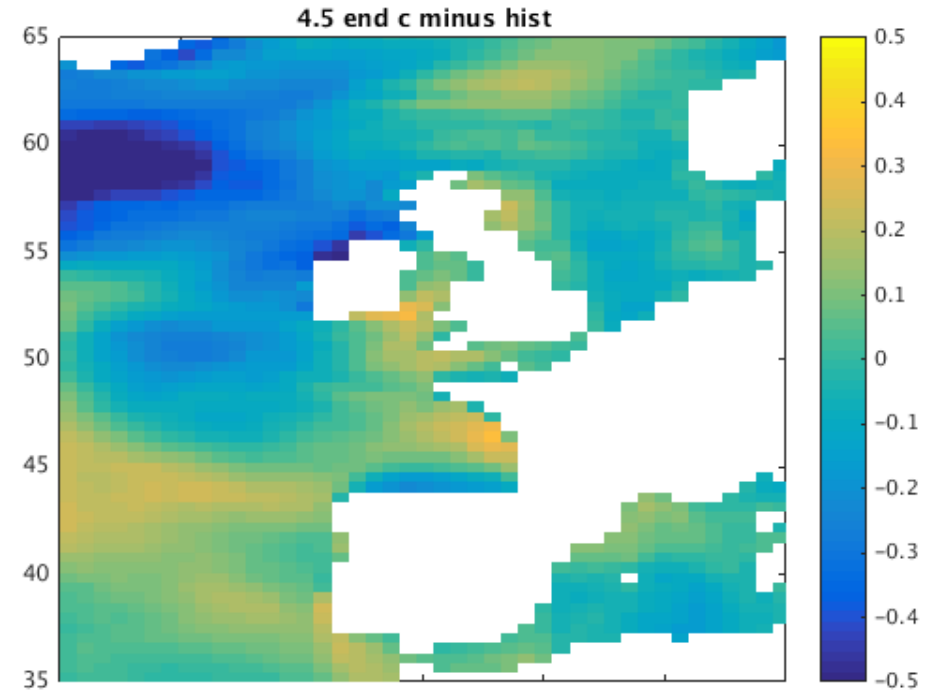
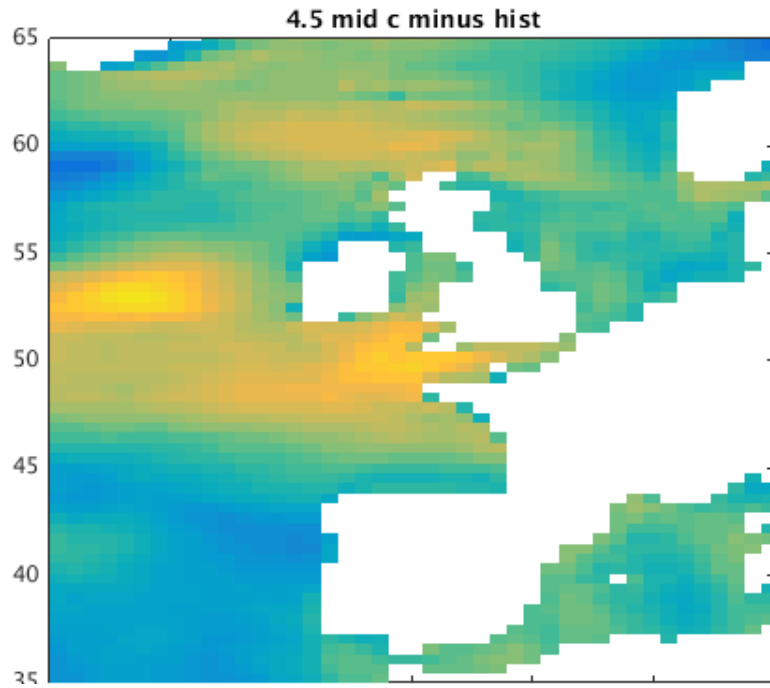
Global model (left) resolution  $\sim 0.83^\circ$

High resolution (right) resolution  $\sim 12\text{km}$

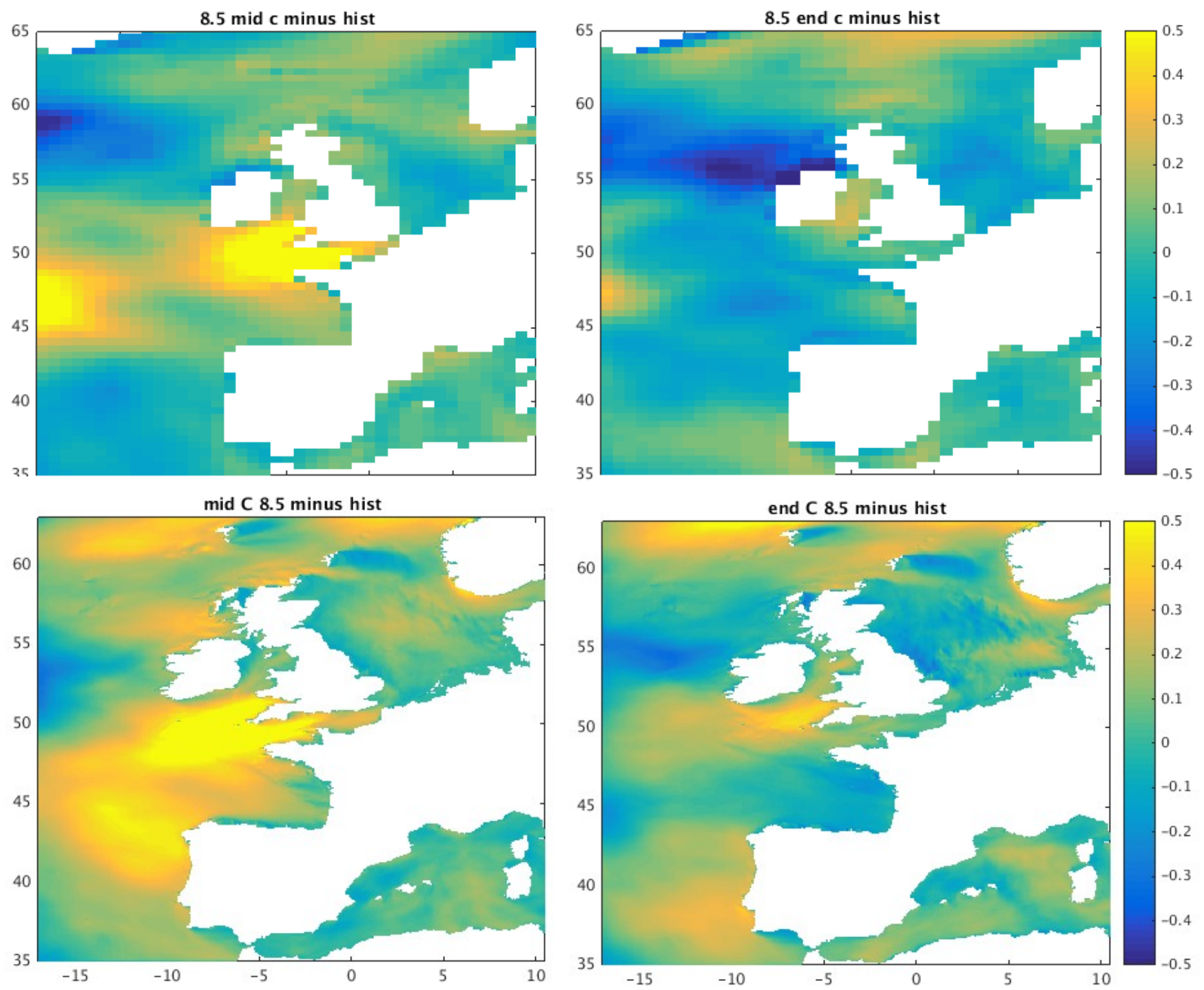
Note: both plots on the same colour scale [0 – 8m]



# Mean Annual Maxima diff (30 year means) for RCP 4.5 futures



# Mean Annual Maxima diff (30 year means) for RCP 8.5 futures

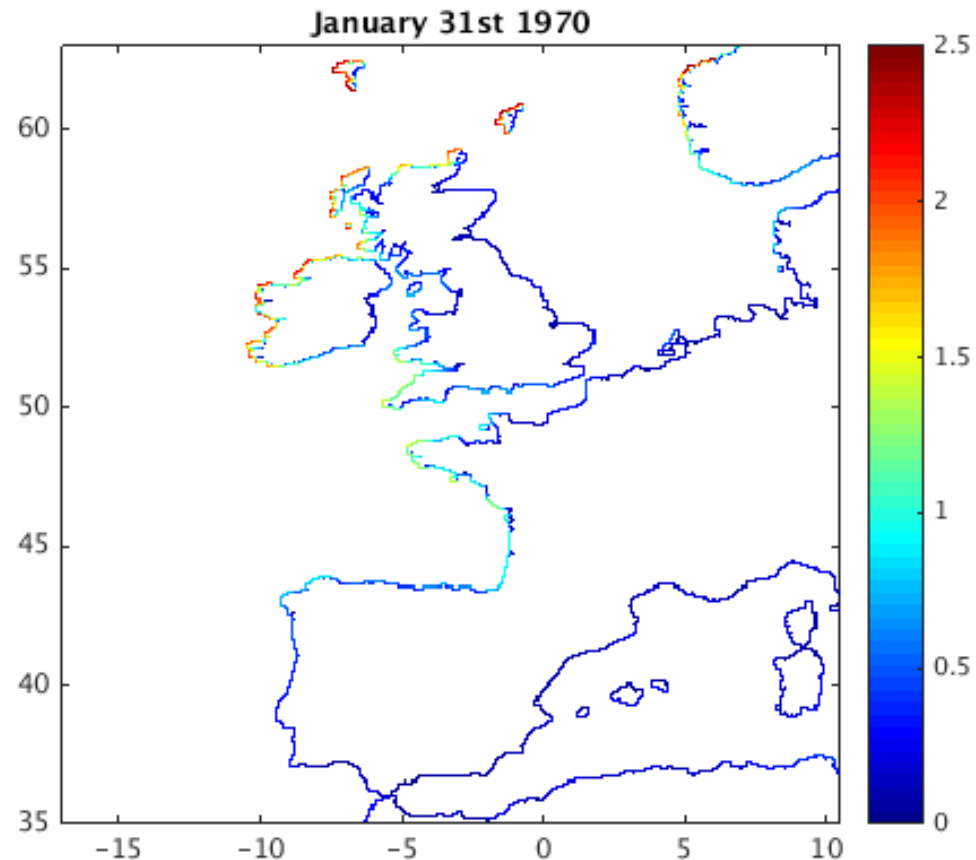


# Coastal strip methodology

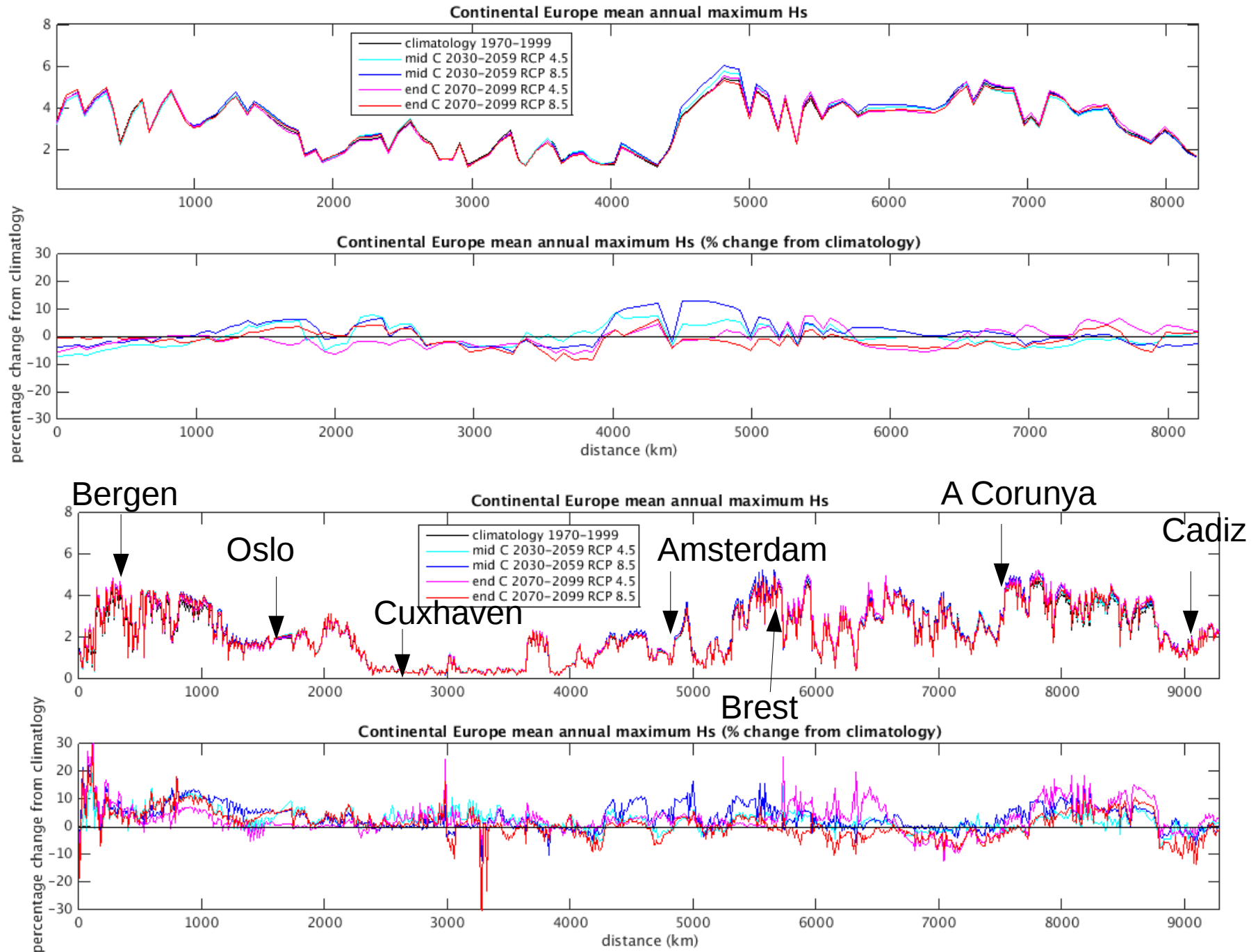
Extract coastal points only, and 'unwrap' the strip to examine changes at the coast.

Because we are interested in the high-end changes to extreme waves, which are more damaging, we will look at the largest event in each year.

The plots on the following slides show changes in Mean Annual Maximum

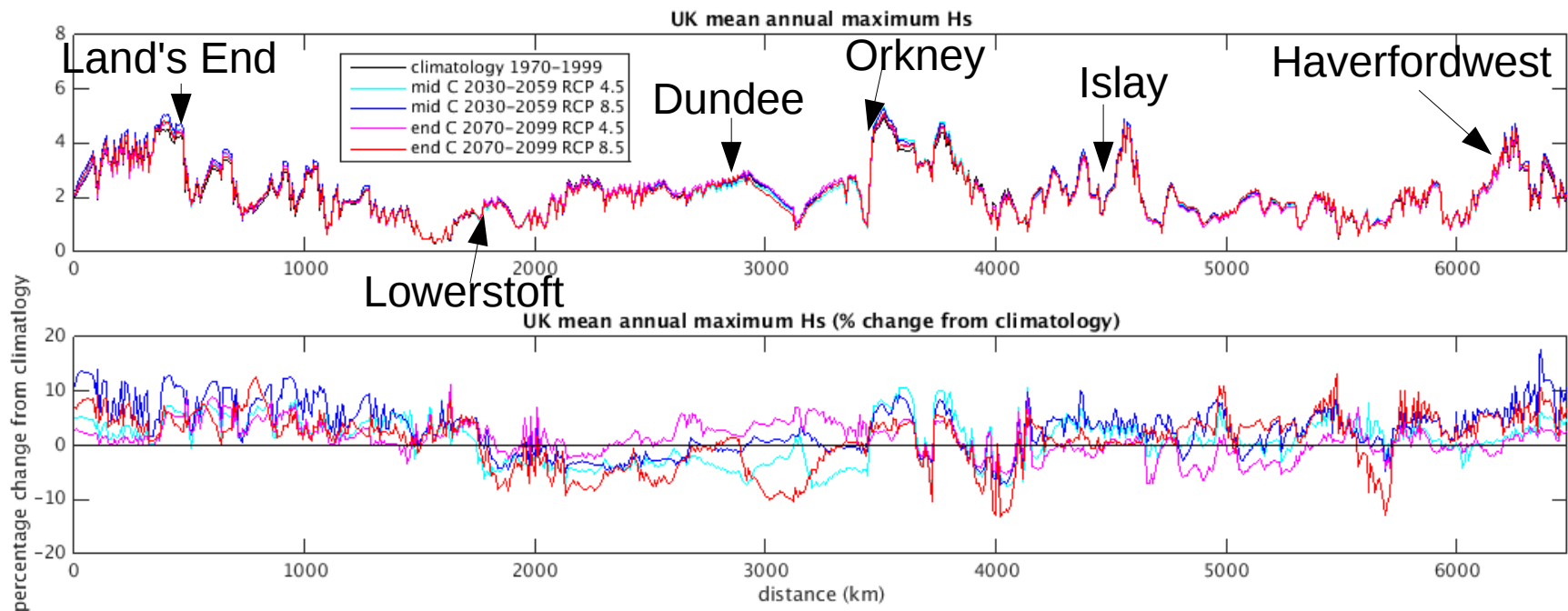
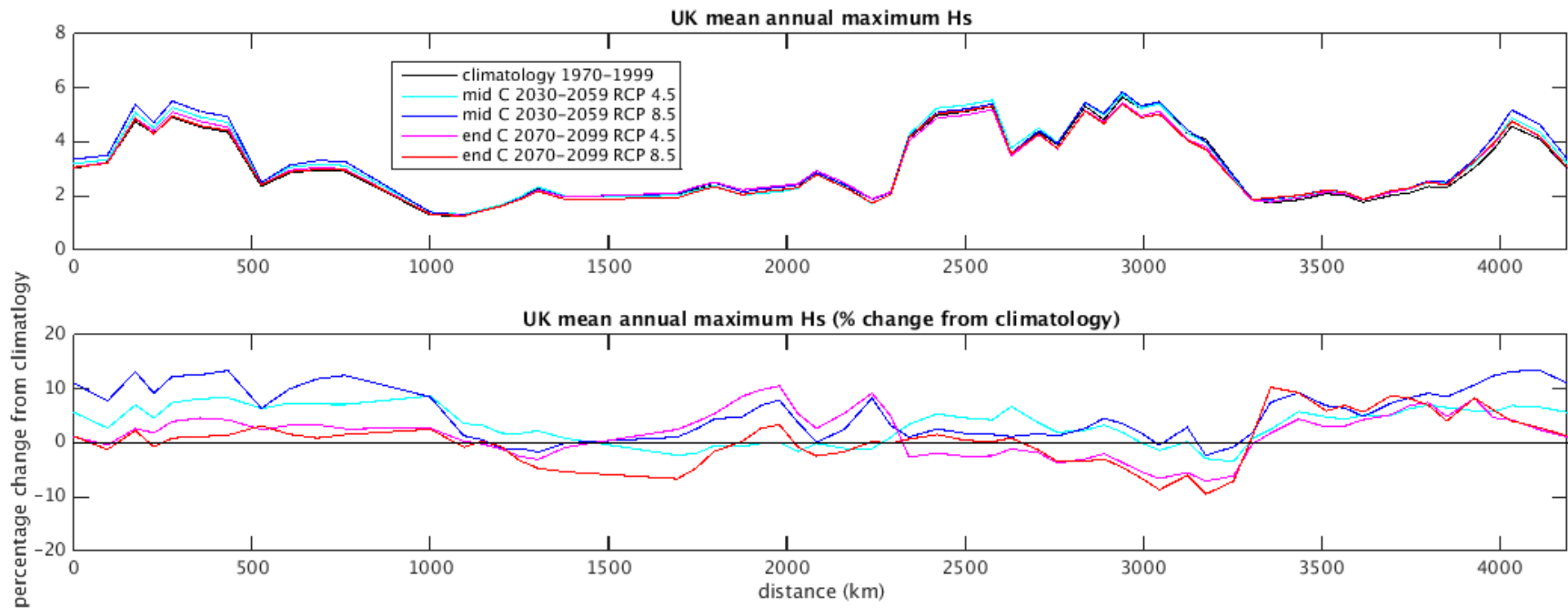


# Mean Annual Maximum – Continental Europe – Coastal Strip

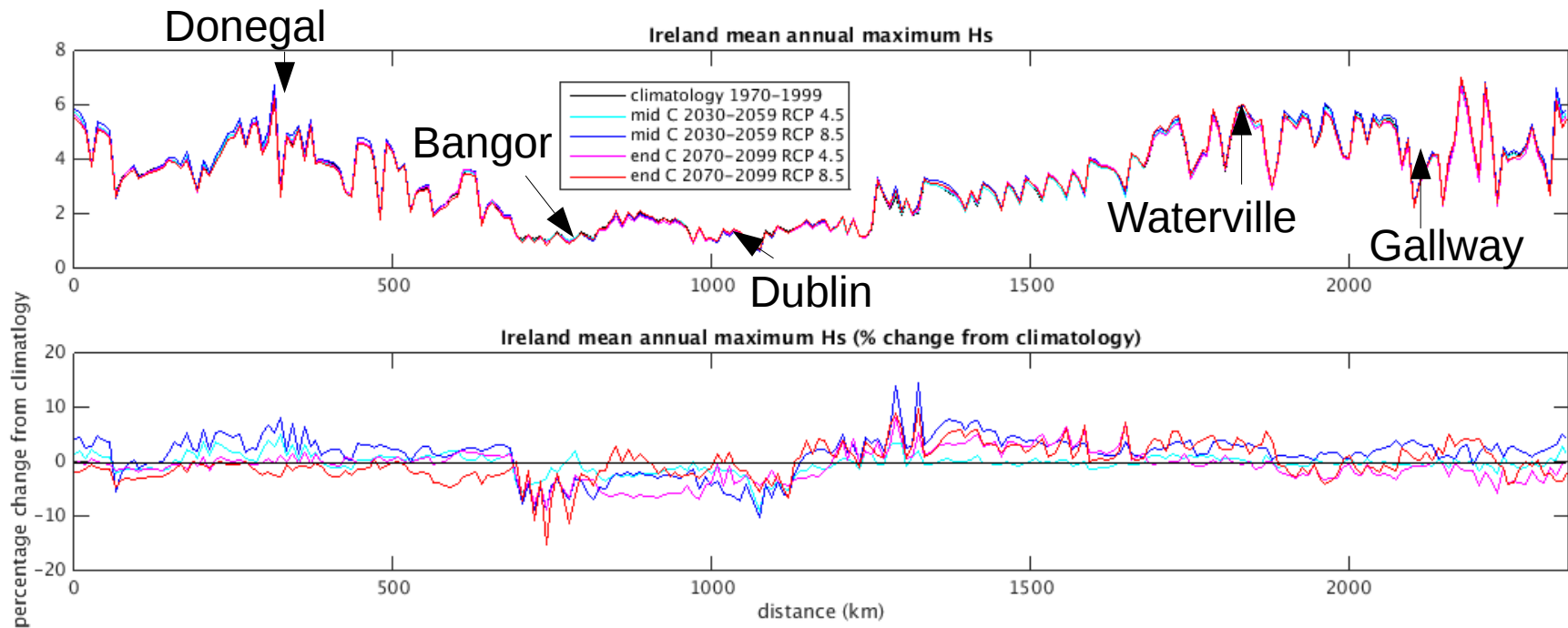
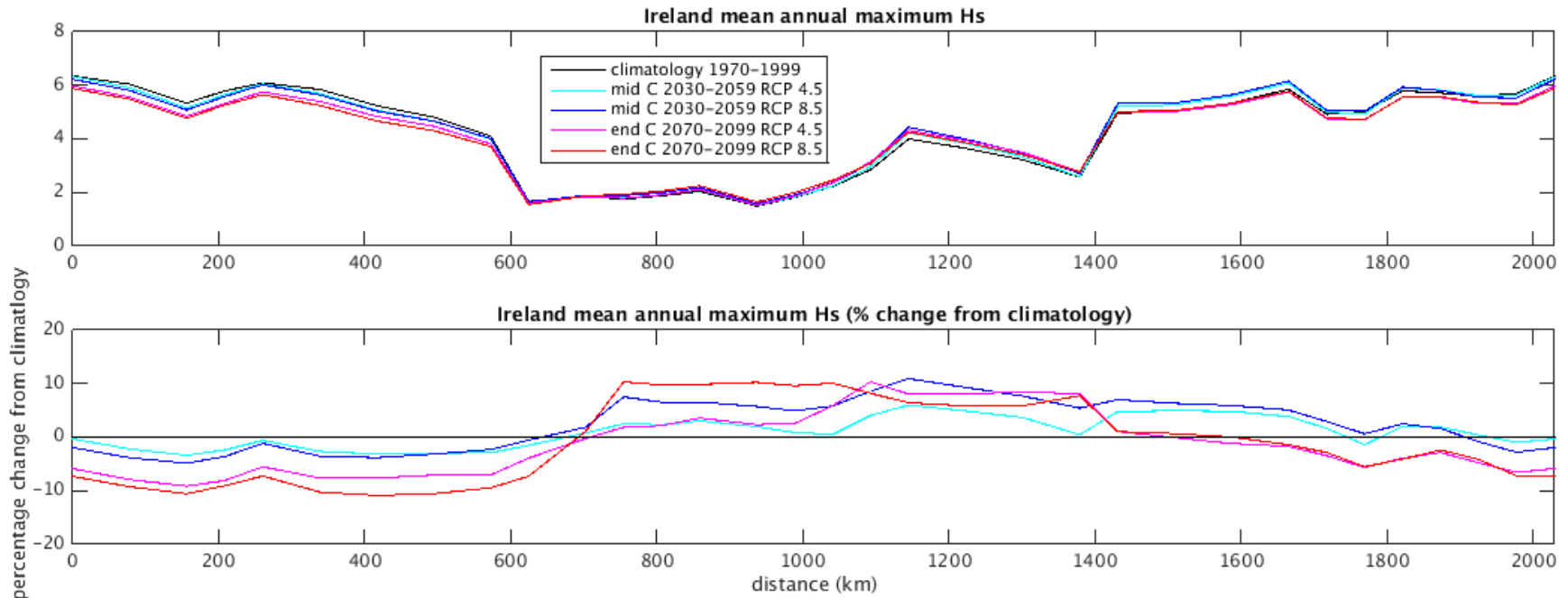




# Mean Annual Maximum – UK – Coastal Strip

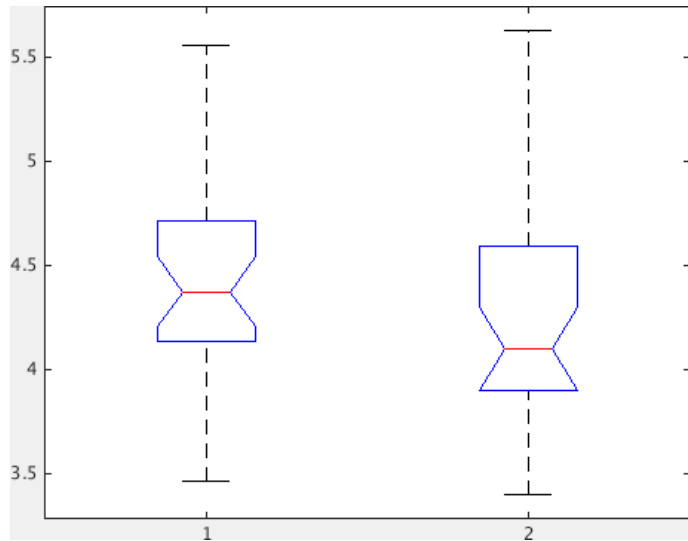


# Mean Annual Maximum – Ireland – Coastal Strip



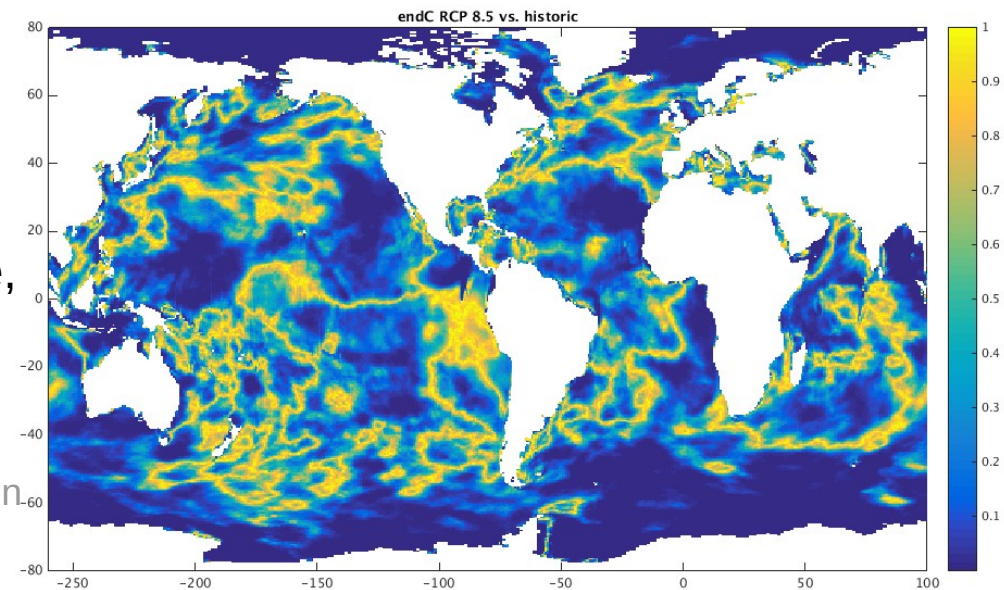
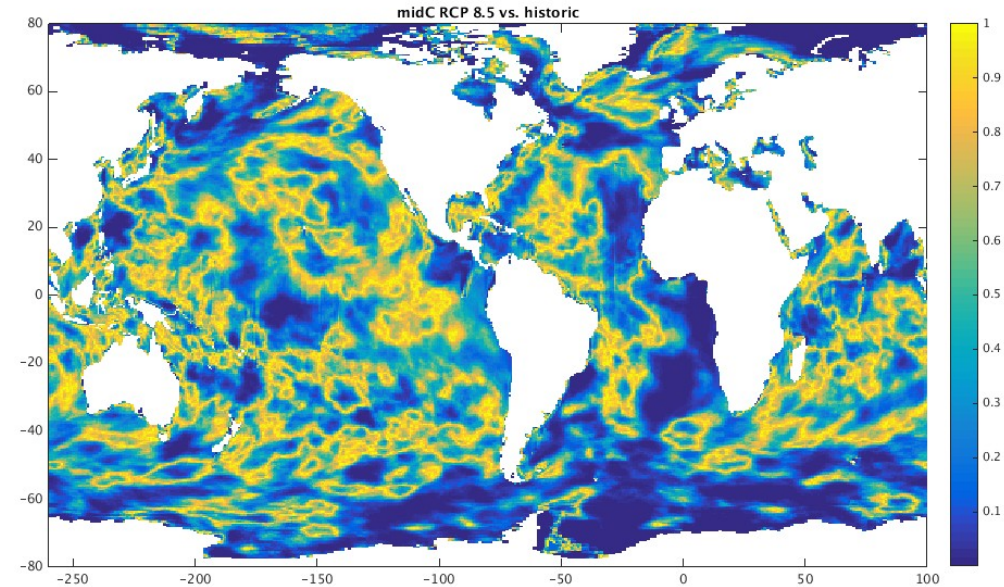
# Are these changes significant?

The Kruskal Wallis test compares two populations against the variability of the populations to see if they are statistically different.

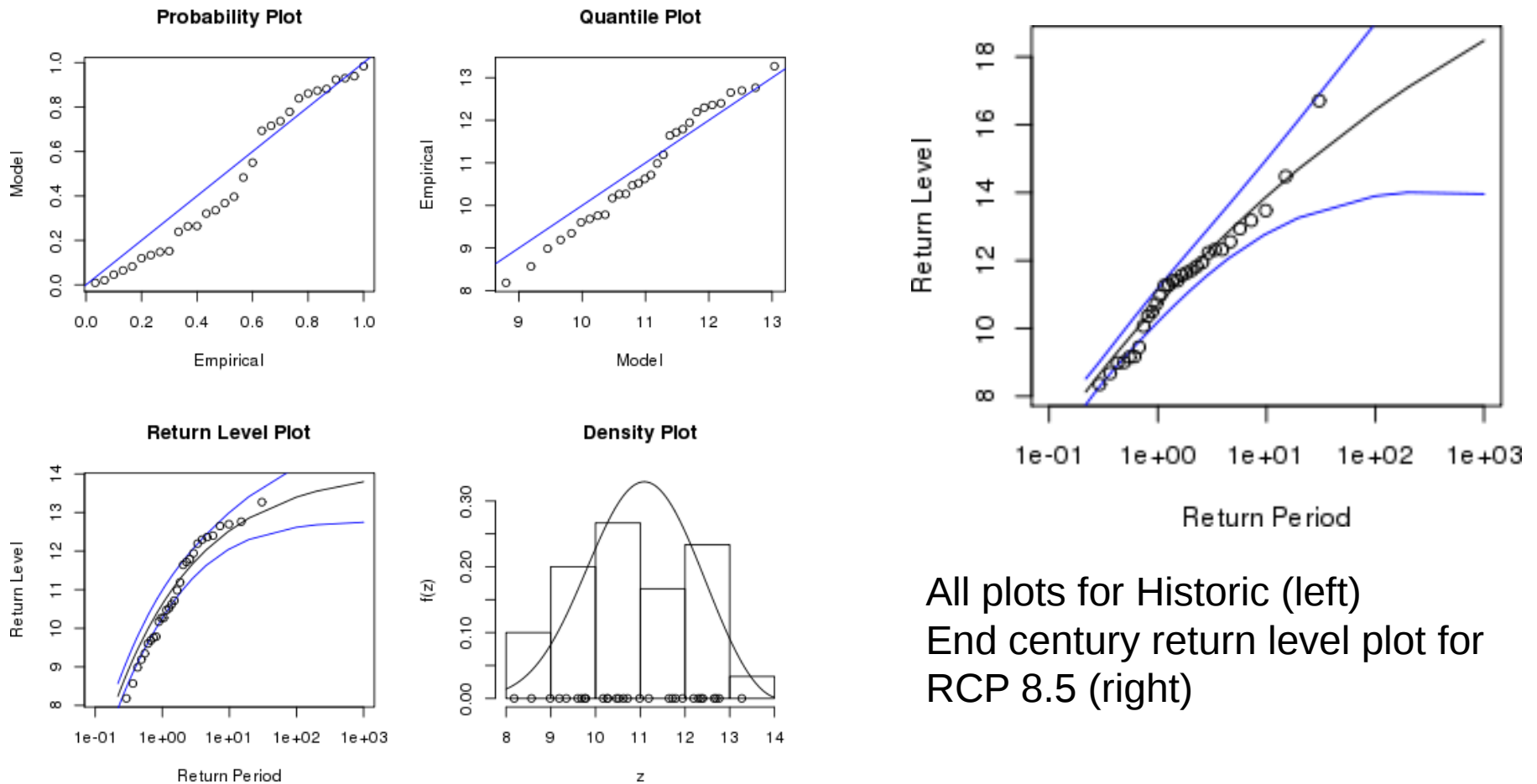


A value of 1: the populations are indistinguishable, the closer to zero, the more well separated the populations.

Kruskal, W.H., Wallis, W.A., (1952) 'Use of ranks in one-criterion variance analysis.' J. Am. Stat. Assoc. 47 (260), 583–621.



# Example return level plots – Scilly Isles



All plots for Historic (left)  
End century return level plot for  
RCP 8.5 (right)

Return level = largest significant wave height expected in a period. E.g. for a 1 in 100 year wave event, the historic return level is a wave height of 12m at this site.



# Conclusion

- High resolution dynamical downscaling is required to understand future changes in wave climate
- Mean wave climate projected to be lower in future, particularly by the end of 2100
- More can be learnt about extreme climate by considering mean annual maxima
- Extreme waves are projected to increase in future in places, though patterns are complex
- There are also differences between projected MAM in global / high resolution wave forecasts
- Changes at the coast may be more useful outputs for coastal planners
- A measure of significance is needed, to give weight to these results
- High resolution wave model will give more detailed projections at the coast, which can be combined with projections of population to calculate flood risk.

