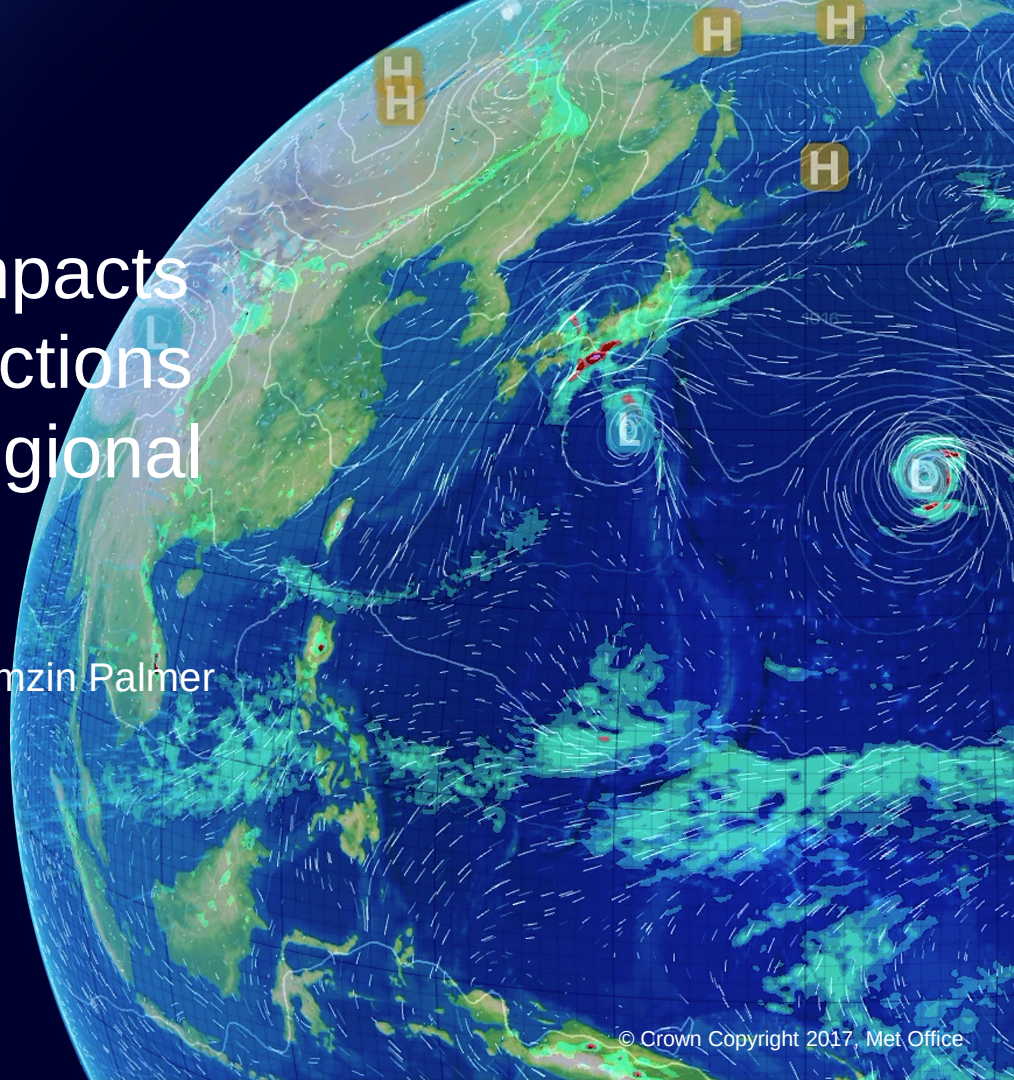
Process and resolution impacts on UK coastal wave predictions from operational global-regional wave models

Andy Saulter, Jian-Guo Li, Chris Bunney and Tamzin Palmer

Met Office

Email: andrew.saulter@metoffice.gov.uk



Summary

- Three operational wave models have been compared against in-situ observations in offshore and coastal waters around the UK – the models vary in terms of the scale of their coastal cells (1.5km to 7km) and their use of surface current forcing
- Little or no benefit is seen offshore – the main contributions to error will come from the forcing wind field and the model source terms
- Estimates of bulk wave energy (significant wave height) are generally improved in the coastal zone when model resolution is increased; the key benefits are in sheltered embayments
- In contrast, wave period statistics are poorer at a number of sites; this may be connected to sensitivities in the statistics to bimodal sea-states during low wave energy events and incorrect representation of spectral evolution in the model, plus variability associated with increasing the resolution of the current field
- Generally skill in the coastal zone lags that offshore, so there is plenty still to do...

Focus of the study

- Much of the Met Office ‘public task’ for wave modelling concerns users operating within ‘inshore waters’ (within 12km of coast) or coastal communities – clear driver for wave forecasts that resolve the coastal domain
- Traditionally, operational wave models have not directly serviced this need; due to the large computational resource required and complexity of model maintenance (codes, configurations)
- More HPC resource and increasingly flexible configuration choices in WAVEWATCH III mean that coastal zone wave forecasting direct from a limited set of operational model configurations is a realistic prospect
- The aim of this study is to clarify how large the gap to good coastal forecast performance is with the present generation of model configurations
- Waters around the UK provide an excellent testing area due to a high density of coastal observations, variable wave climate and strongly tidal waters

Models

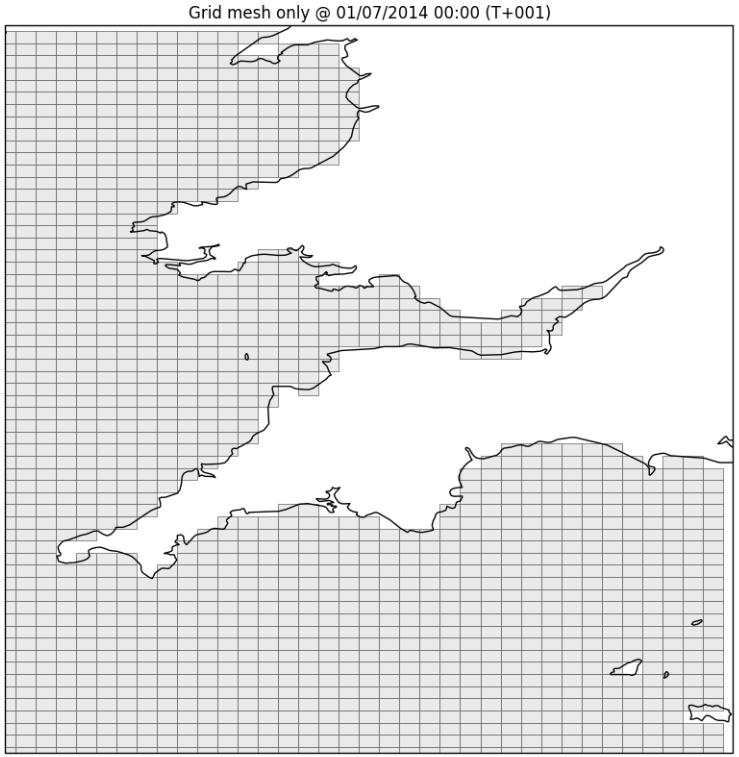
- Three operational configurations, using different mixes of grid set-up and current forcing
- In the trials, all configurations were forced using the same 17km Met Office analysis wind field

Table 1. Summary of wave model configurations

Configuration Name	Domain Coverage	Grid Type (lat-lon)	Resolution(s)	Surface Current (resolution)	ST4 BETAMAX
S36125	Global	SMC	25-12-6-3km	No	1.36
AMM7CO6	NW European Shelf	Regular	7km	7km	1.45
UKSCO7	NW European Shelf	Rotated pole SMC	3-1.5km	3km	1.45

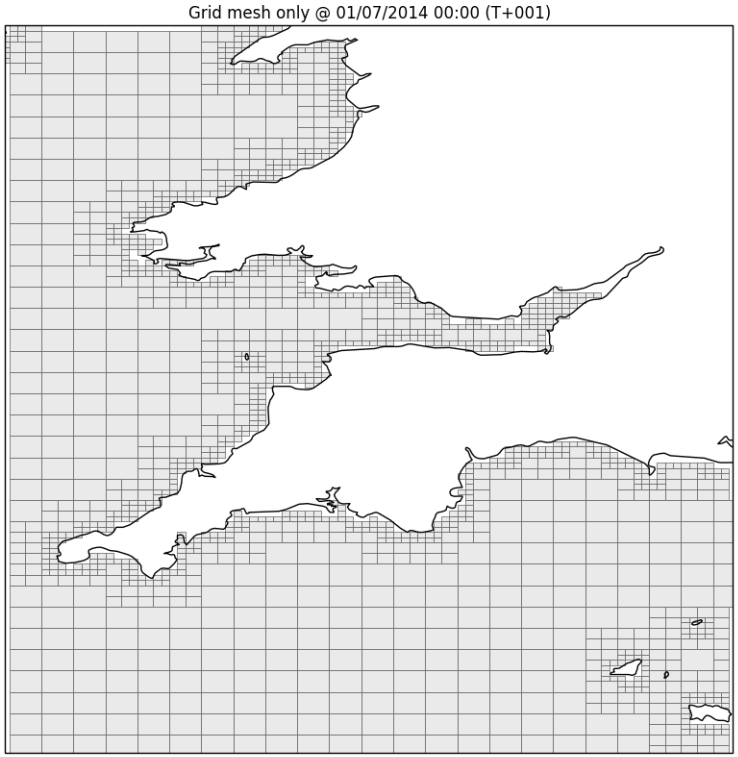
Model Grids

- Grid scheme, AMM7CO6: 7km regular lat-lon
- Not expected to have good coastal performance!



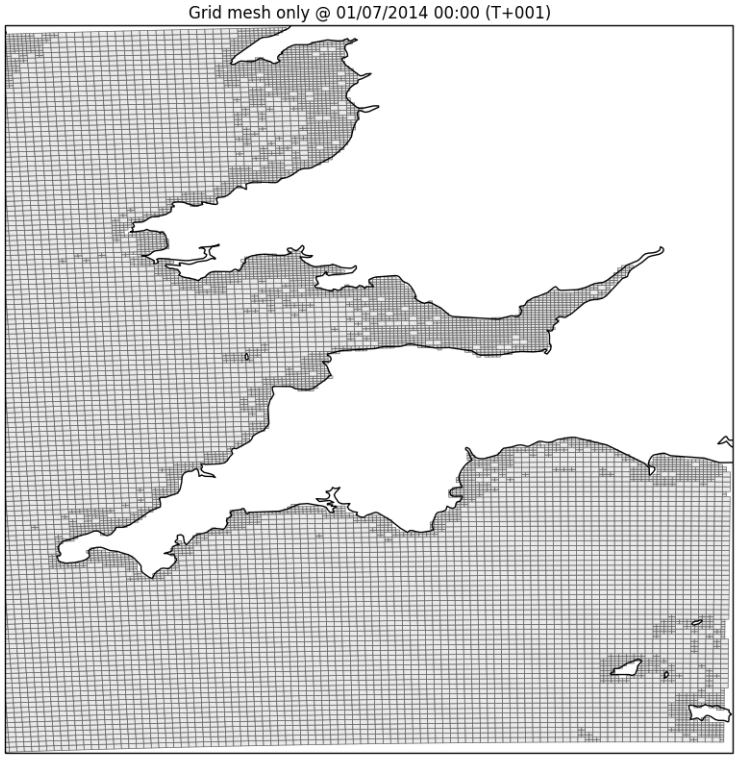
Model Grids

- Grid scheme, S36125: 25-12-6-3km Spherical Multiple-Cell
- Main aim of scheme is to improve flow of energy around coasts and fetch representation



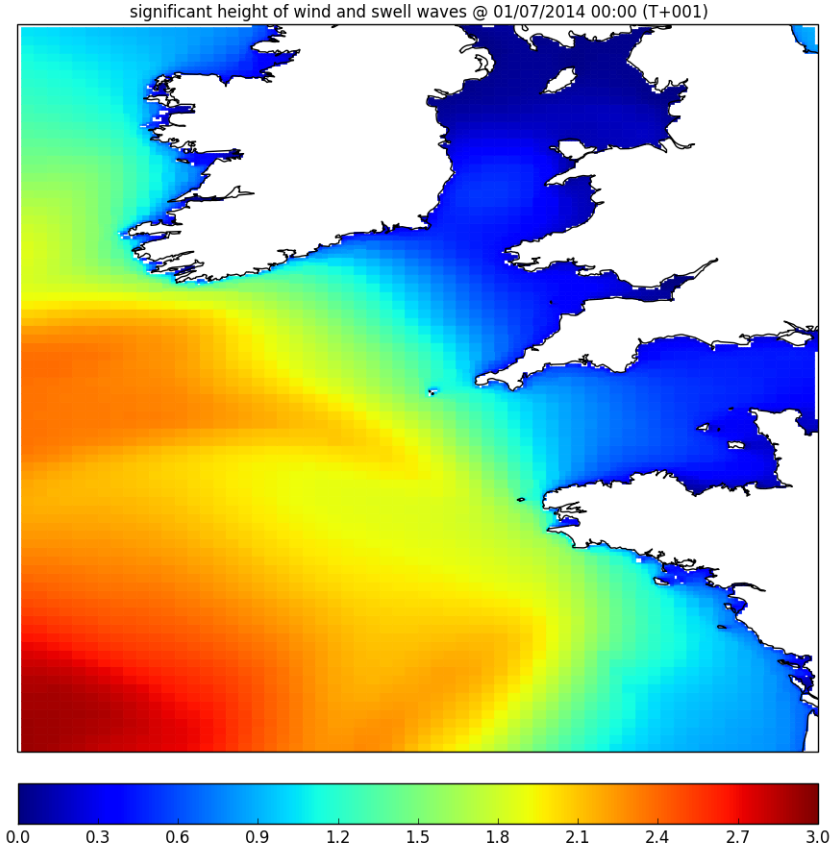
Model Grids

- Grid scheme, UKSCO7: 3-1.5km Spherical Multiple-Cell on rotated pole
- 1.5km cells applied for depths less than 40m
- On the edge of being a sensibly scaled model for coastal forecasting...



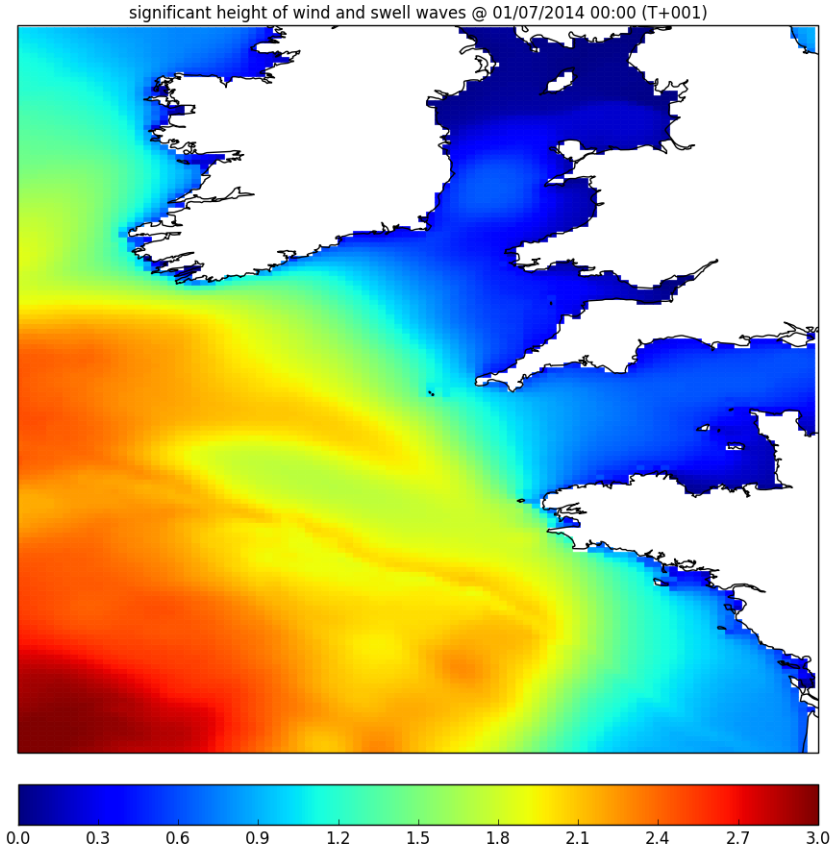
Effects of currents

- Grid scheme, S36125:
No currents!



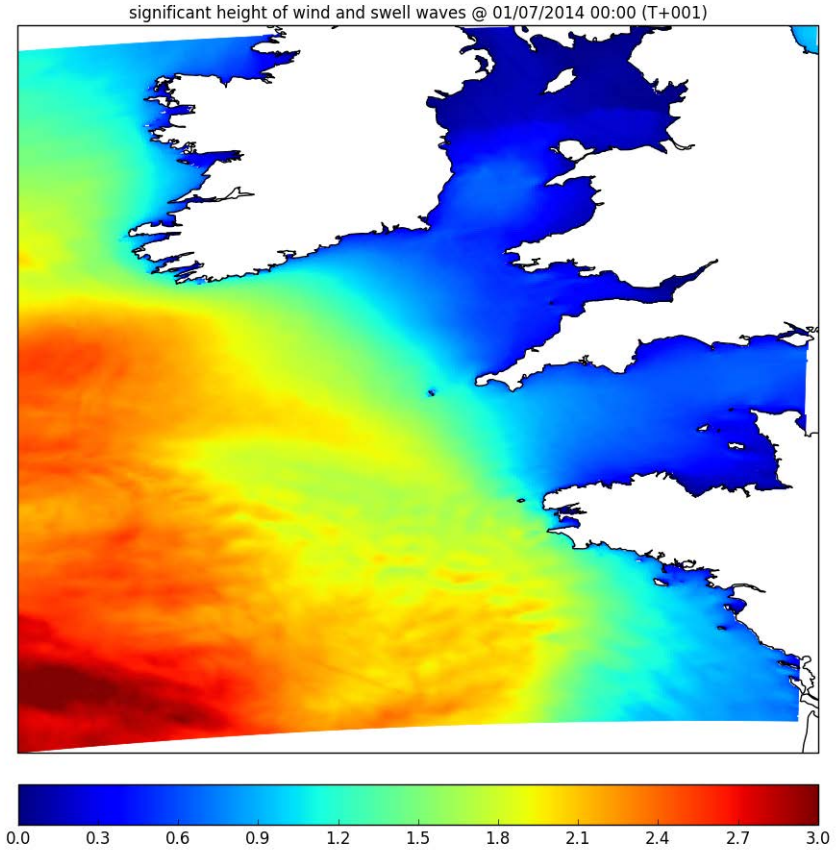
Effects of currents

- Grid scheme, AMM7CO6: 7km scaled currents



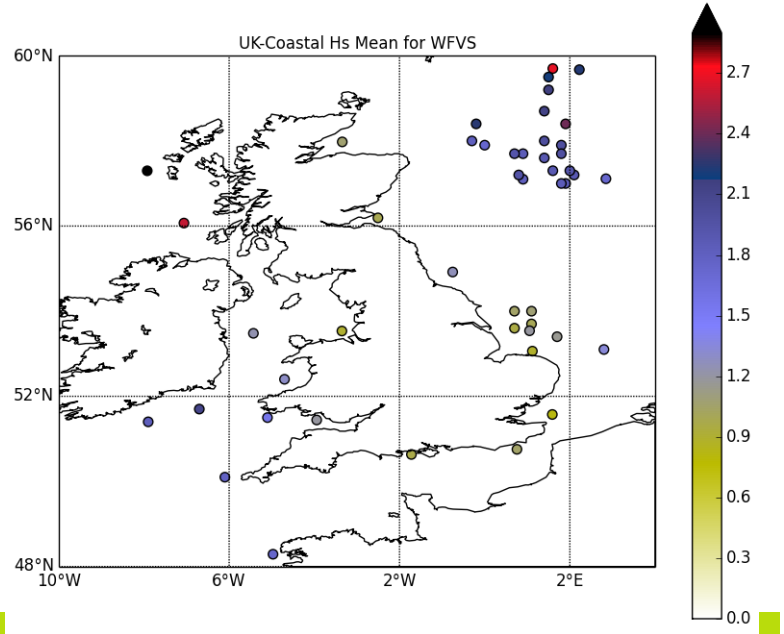
Effects of currents

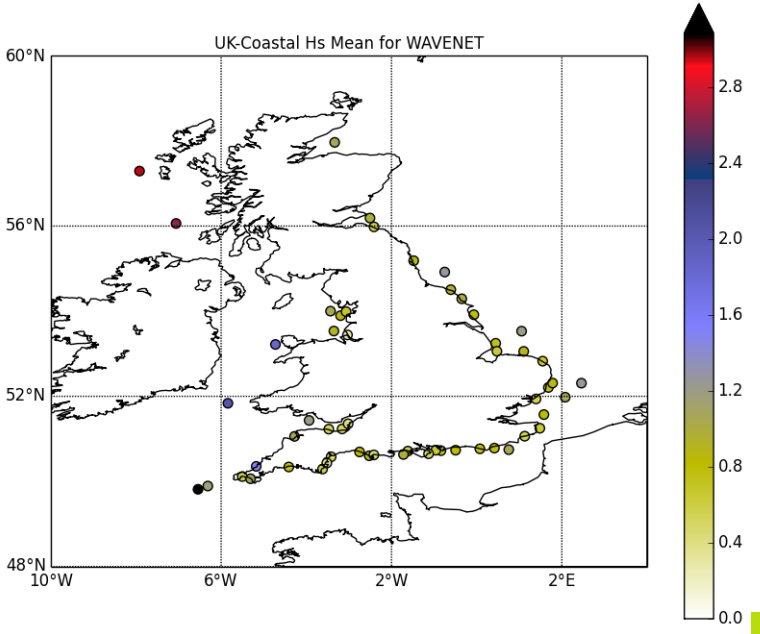
- Grid scheme, UKSCO7: 3km scaled currents from 1.5km hydrodynamic model
- Note major structures over continental shelf break



In-situ observations

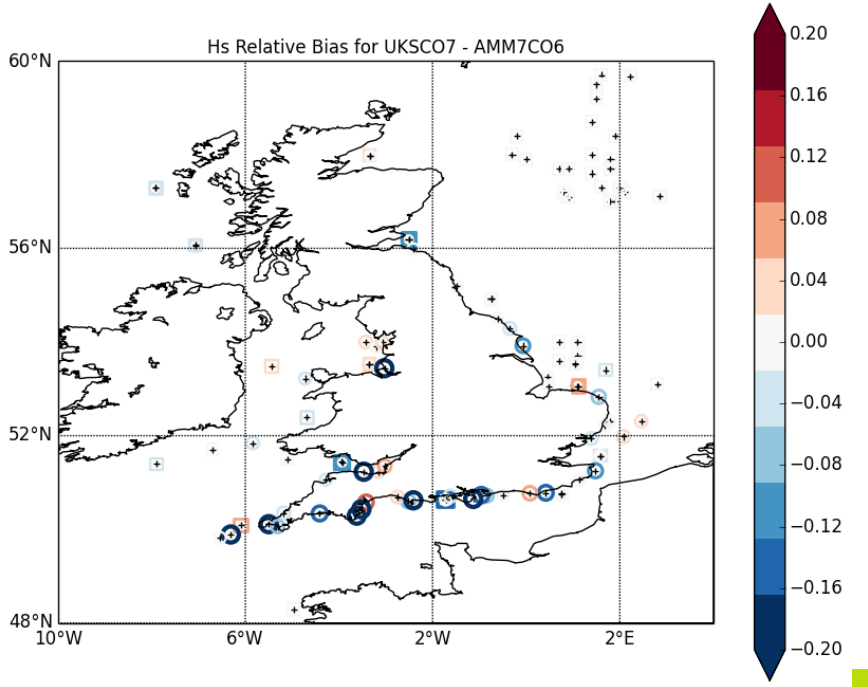
- Datasets from JCOMM Wave Intercomparison (WFVS) for offshore sites, amalgam of WaveNet and Channel Coastal Observatory for coastal sites (WAVENET)

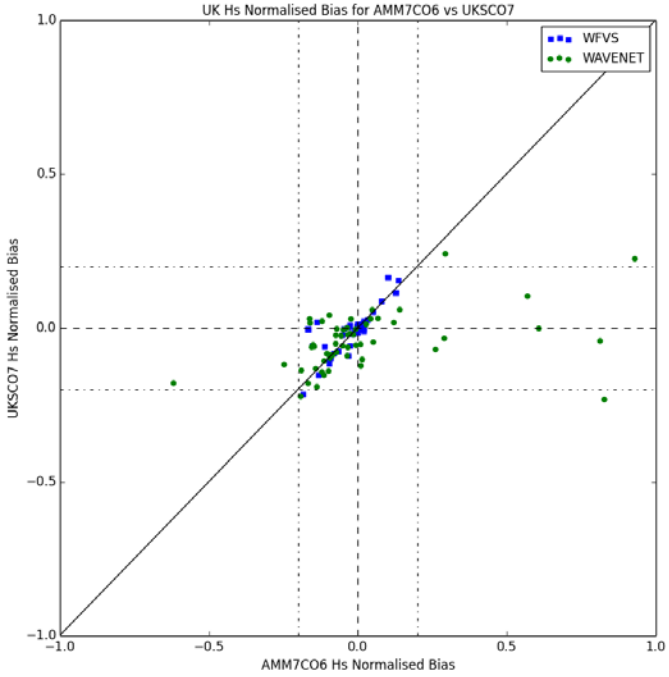




Key results - Hs

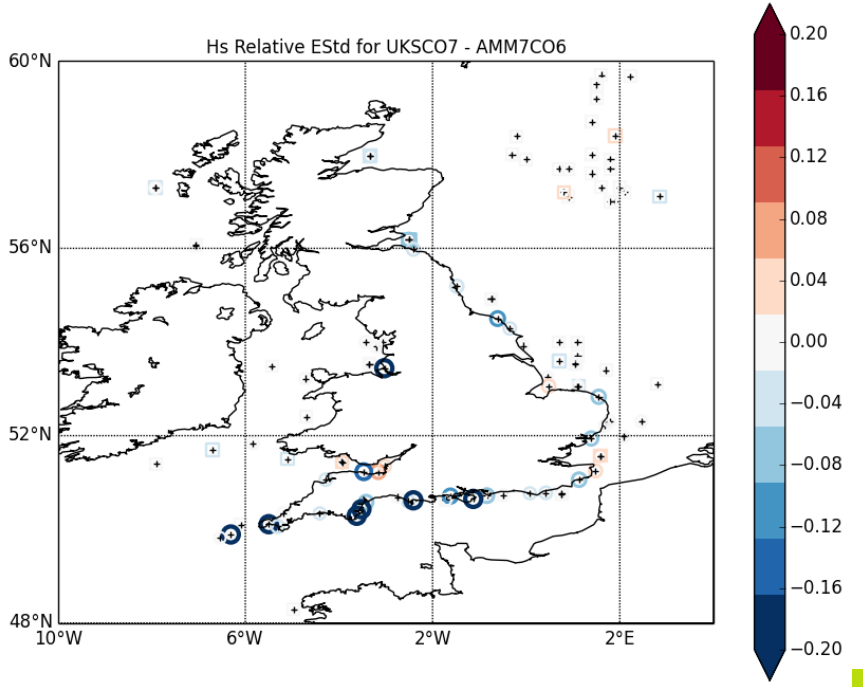
UKSCO7 vs AMM7CO6 – little bias change offshore, some large improvements in coastal zone

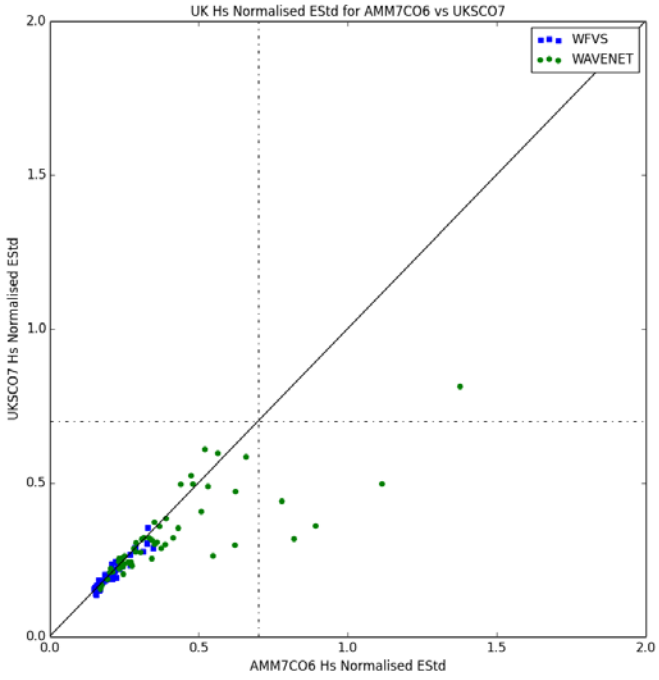




Key results - Hs

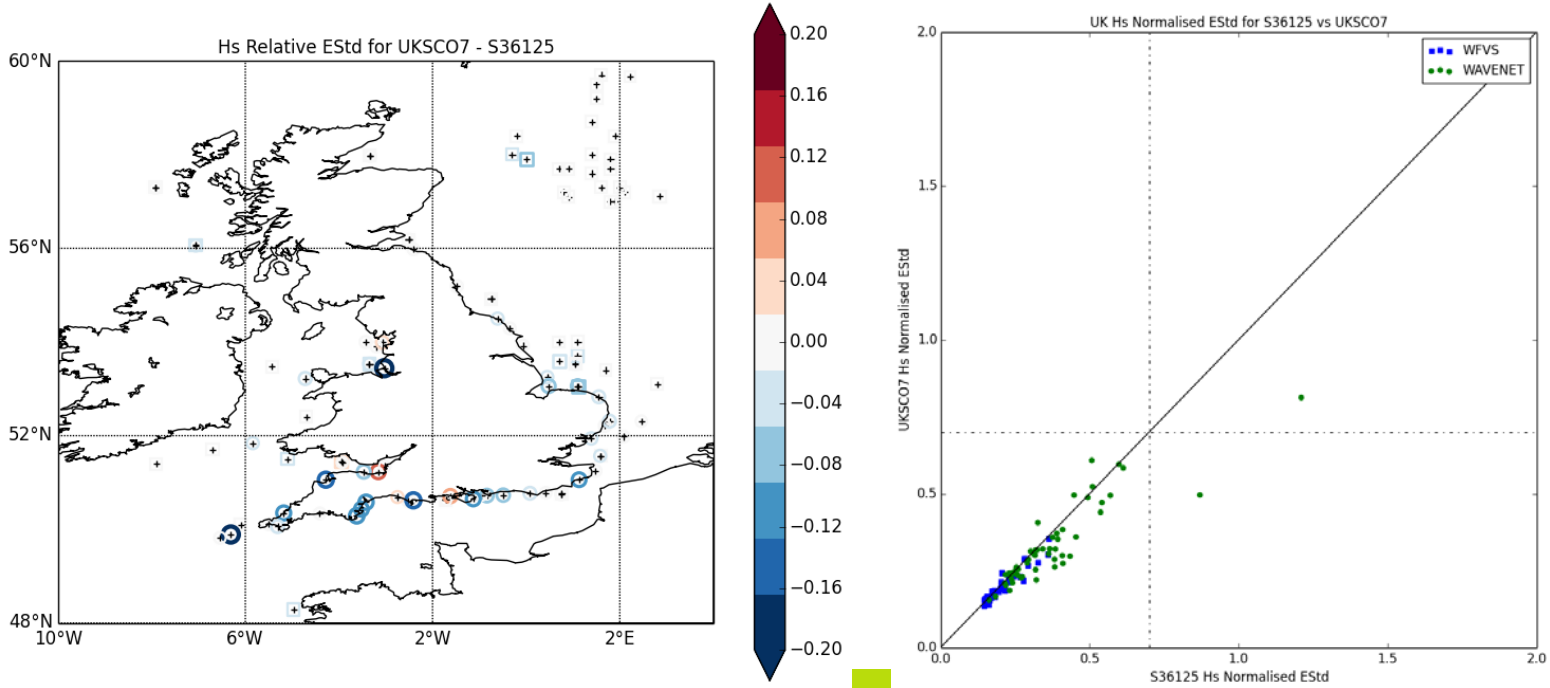
UKSCO7 vs AMM7CO6 – little SI change offshore, some large improvements in sheltered bays





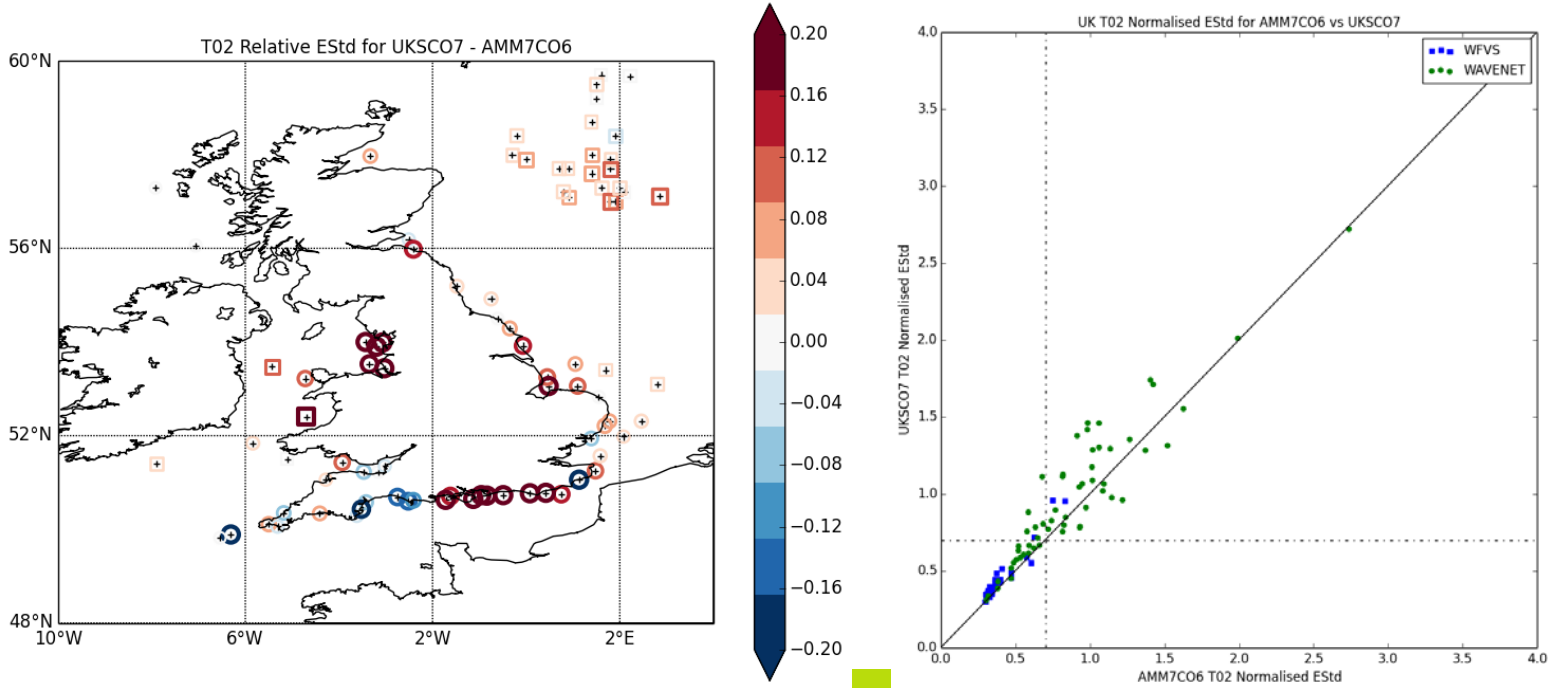
Key results - Hs

UKSCO7 vs S36125 – SI improvements in coastal zone, fewer outliers for S36125



Key results – T02

UKSCO7 vs AMM7CO6 – SI worse in high resolution model, but poor in coastal zone generically



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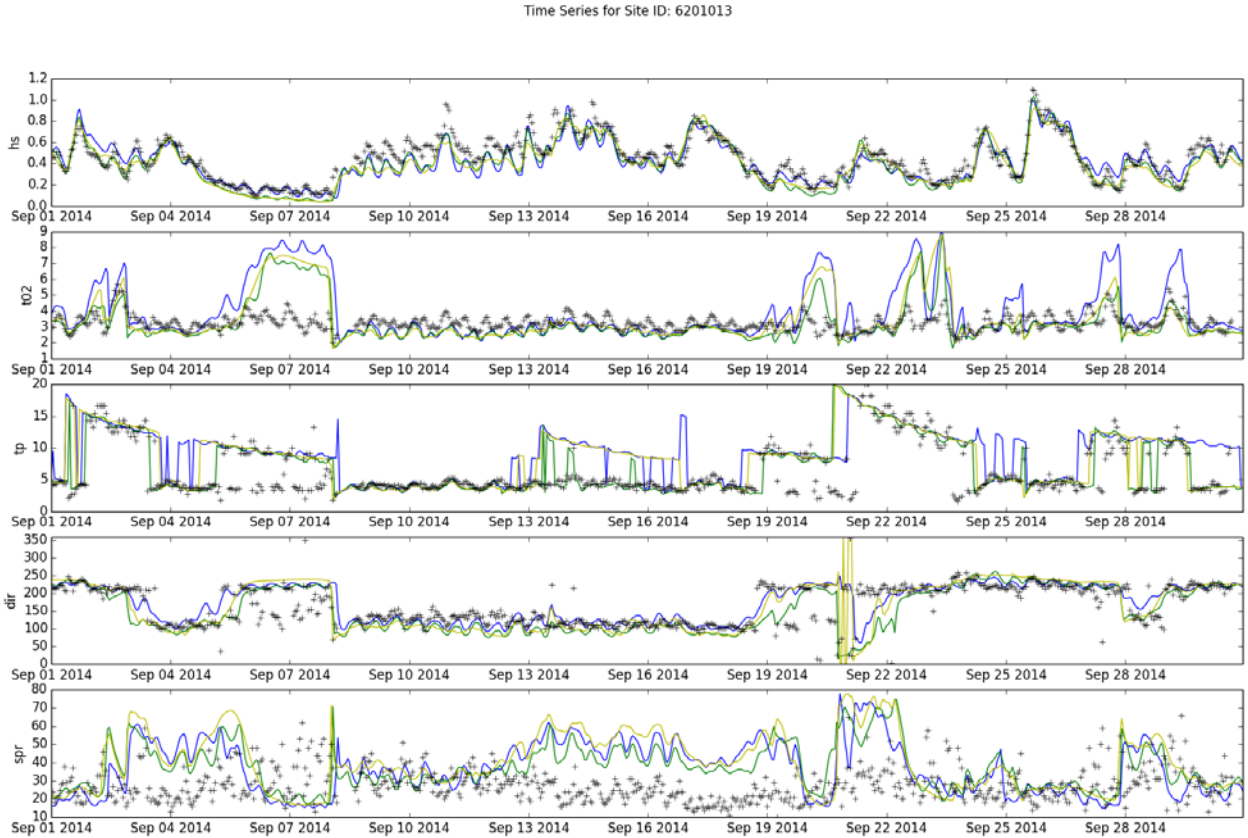
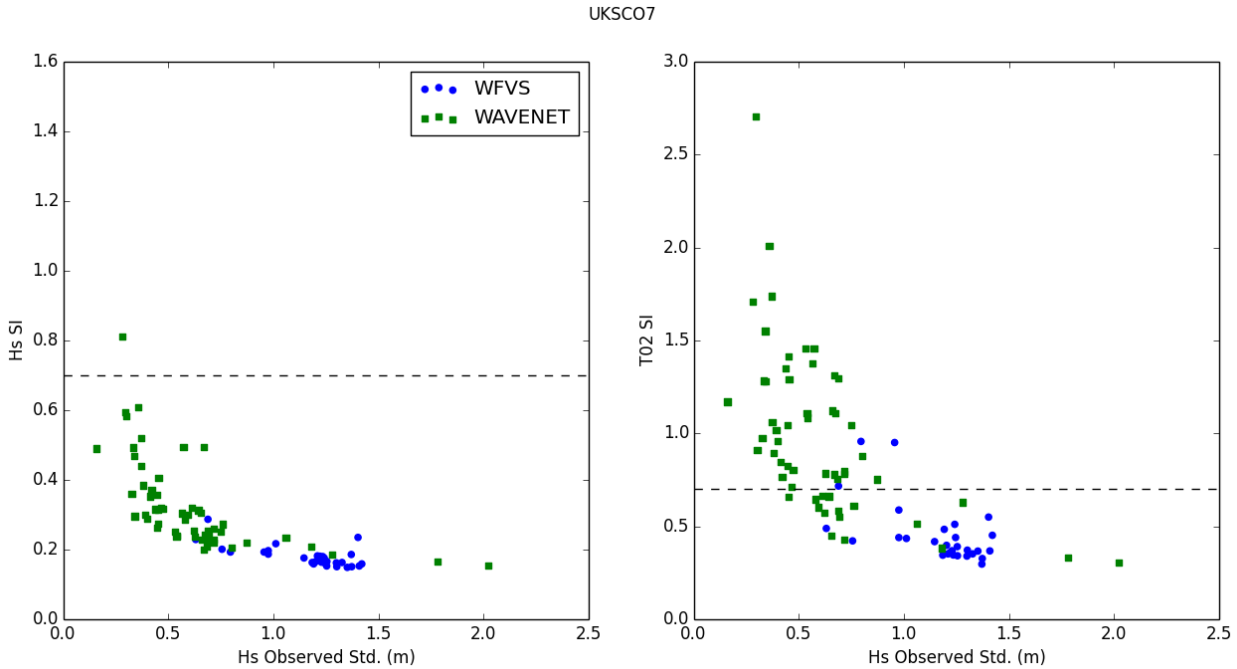
Coastal zone issues during low wave energy events

- Time-series from Rustington on English south coast
- Imbalance between short and long period components of bi-modal seas – model favours longer periods; effect is enhanced in high resolution model
- UKSCO7 – blue
- AMM7CO6 – green
- S36125 - yellow



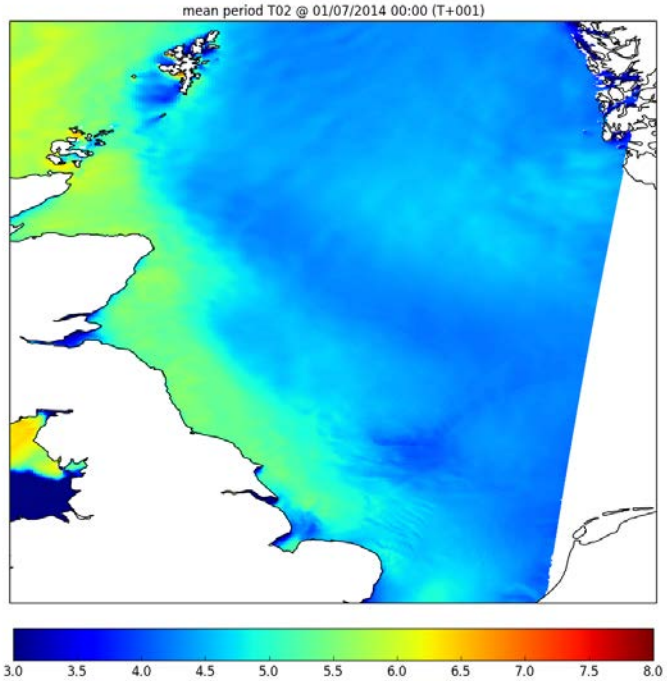
Coastal zone issues during low wave energy events

- General trend for worse performance at lower energy sites – albeit this is influenced by stats normalisation...
- Removing low energy (<0.4m Hs) events from the sample led to 15 further coastal sites showing useful skill for UKSCO7

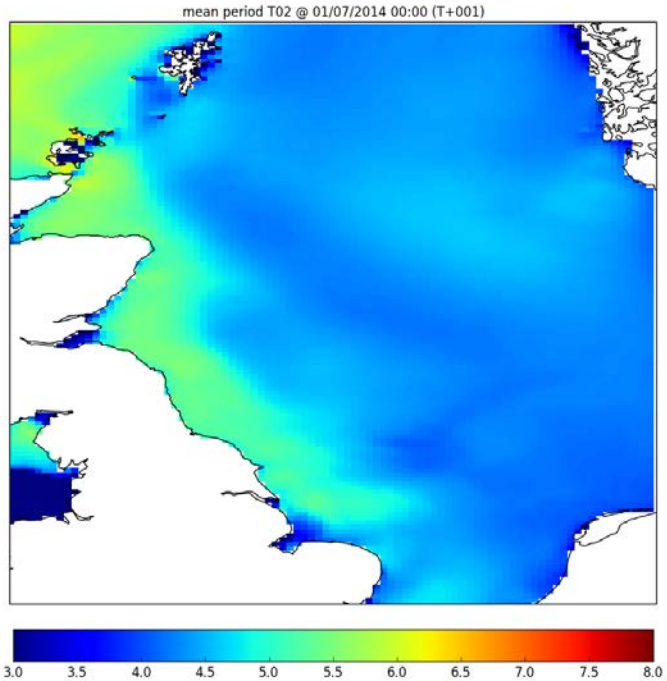


Current effects on wave period predictability offshore?

- Significantly more structure to Hs and period fields introduced with forcing by high resolution currents – possible double penalty effect vs lower resolution models?
- Are we comparing the right periods?



UKSCO7 T02



AMM7CO6 T02

Concluding remarks

- For bulk wave energy, the model improvements lead to the ‘correct’ result; i.e. a general improvement in bias and scatter index in the coastal zone
- The low impact of changes offshore is in line with the perceived wisdom that key uncertainties in open waters are derived from winds and source terms
- Source term uncertainties may also be significantly impacting coastal performance for parameters with more sensitivity to the wave spectrum – further exploration is required to test whether this is only a low-energy case problem
- Similarly, more work is needed to review the verification of wave period and potential effects of high resolution current structures on model predictability
- The results suggest that our UKSCO7 model is close, but does not generically meet the criterion for a good coastal forecast model – key issues are spectral detail in low energy conditions and performance in strongly tidal, constrained estuaries such as the Bristol Channel