Dealing with model uncertainty: FVCOM

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Principles

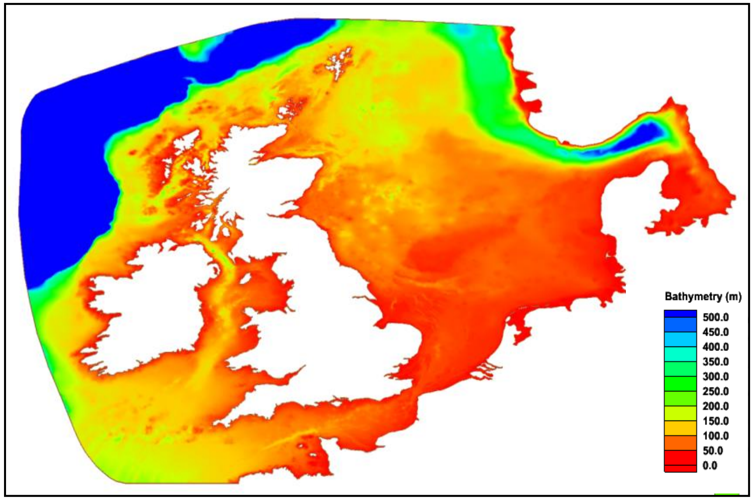
- Numerical Ocean Models are principally regarded as deterministic, however there may be uncertainty in correctly modelling key processes
- External forcing can introduce uncertainty e.g. atmospheric model ensemble
- Friction and turbulent closure, which model sub-grid-scale processes, are treating essentially stochastic processes. These are secondary forces, depending on the flow, but there is still uncertainty in the parameterisation

Uncertainty in climate model predictions (Hawkins and Sutton, 2009)

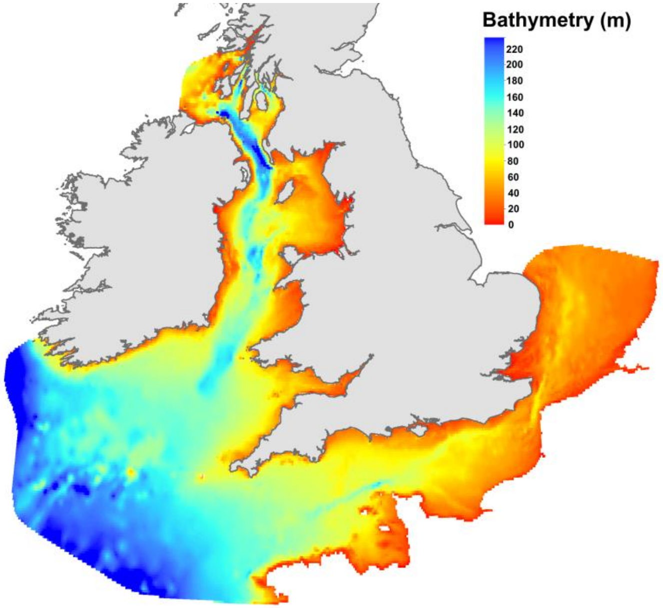
- Internal uncertainty of the climate system (natural variability), shorter time and space scales e.g. in regional models of times less than a couple of decades
- model uncertainty - response of the system to a certain level of GHG emissions
- scenario uncertainty i.e. uncertainty in the emissions scenarios.

FVCOM modelling

- Scottish Shelf Model



- ARCoES model



The advantage of the unstructured grid approach is that it fits the coastline in an optimal way and reduces uncertainty in coastal locations e.g.in comparison with POLCOMS

Areas of Uncertainty and Ways of treating them

- Bathymetry
- Turbulence closure
- Bottom friction
- External forcing
  - Tides
  - Boundary/initial conditions
  - Met forcing

- Use best available
- Test options, validate tides
- Carry out sensitivity study
- Use best available models
  - TPXO7.2
  - POLCOMS/NEMO AMM
  - Met Office Unified Model (mesoscale, 12km), ERA-Interim, high frequency time/space, potentially ensemble

Future Climate:
Questions to be addressed

- What are projected changes in storms under a warming climate?
- Can these be modelled accurately in the latest climate models (CMIP5)?
- Are there significant changes between CMIP3 and CMPI5?
- Will these be converted to significant changes in waves and surges on the Atlantic coast of Europe?
- Can we distinguish between natural variability and the climate signal?
- What novel adaptation/mitigation methodologies can be deployed?

North Atlantic storms in CMIP5 (Zappa et al., 2013)

- winter-time North Atlantic storm tracks (compared to CMIP3) are still either **too zonal or displaced southwards**
- there are improvements both in number and intensity of North Atlantic cyclones, in the higher resolution CMIP5 models. 3 groups of models:
  - small biases in winter-time position, median latitude consistent with reanalysis data: EC-Earth, GFDL-CM3, HadGEM2 and MRI-CGCM3
  - southern displacement of the winter-time storm track: BCC-CSM, CMCC-CM, CNRM-CM5, CSIRO, FGOALS-g2, IPSL-LR, and MIROC-ESM
  - Remainder of CMIP5 models too zonal
- winter-time southward displacement of the North Atlantic storm track leads to too few and weaker cyclones over the Norwegian Sea and too many cyclones in central Europe
- Note: **Models generally perform better in summer!**

Other factors

- Model error: consistency and convergence
- Missing processes (known and unknown unknowns)
- Non-linearity – positive or negative feedbacks
- Drift e.g. SST: disconnect between atmospheric and oceanic values
- Threshold and tipping-points, multiple equilibria
- Use of ensemble predictions – multi-model or perturbed parameter
- Model emulators – simplified models