MCCIP Marine Climate Change Impacts Partnership

Key UKCP09 marine and coastal variables explained

Introduction

This short document is intended to summarise the key marine and coastal variables that are available in UKCP09. All variables discussed are included in both the marine and coastal projections report and available on the UKCP09 user interface (unless stated otherwise).

The last section of this document briefly explores why changes in these variables might be important to the functioning of our marine ecosystem, issues that will be explored in much greater detail in the next MCCIP report card, due for launch in mid-2010.

Multi – level ocean data

Projections of changes for the following marine variables are included in the coastal and marine report, and were added to the user interface on 30th November 2009.

- **Water temperature**: Changes in seasonal mean sea surface temperature and near bottom temperature are included.
- **Salinity**: Changes in sea surface and near bed salinity are included.
- **Stability of the water column**: Changes in the mean start and breakdown of seasonal stratification (layering of the water column, which limits mixing between surface and deeper layers), along with the total number of stratified days per annum are included. Changes in location of stratification are also discussed.
- **Currents**: Changes in mean surface currents are included in the published reports.

The projections have been obtained by using the unperturbed member of the Met Office Hadley Centre regional model ensemble (known as the PPE) to provide the meteorological forcing for the Proudman Oceanographic Laboratory Coastal Ocean Modelling System.

Key points about the multi-level ocean data:

- Data is available at a resolution of 12 km marine grid squares.
- Results are presented for the time periods 1961–1990 and 2070–2098.
- Future projections are for the unperturbed member of the medium emissions scenario.

As the techniques employed here are new, no attempt has yet been made to incorporate uncertainty into the future marine projections. Instead the single scenario used provides a physically plausible illustration of one future that might be realised under the medium emissions scenario. Additional work is needed before we can estimate the range of uncertainty in future changes.

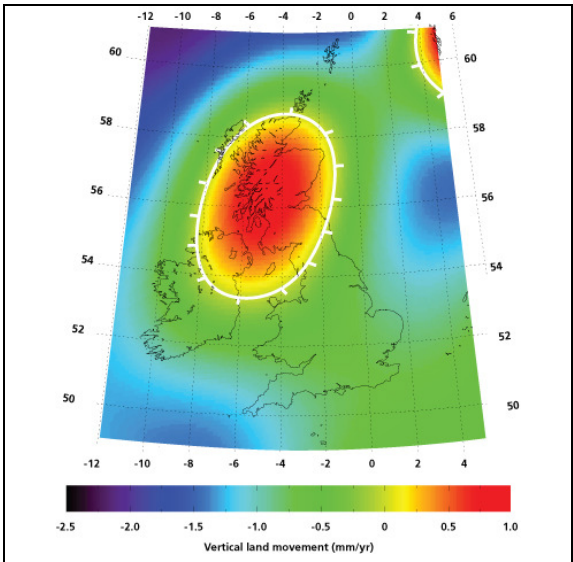
For further explanation of the differences between the UKCP09 marine and atmospheric projections, particularly why the atmospheric projections are 'probabilistic' and these multi-level ocean projections are not, refer to the MCCIP 'marine projections summary' document.

Sea level change, storm surges and waves

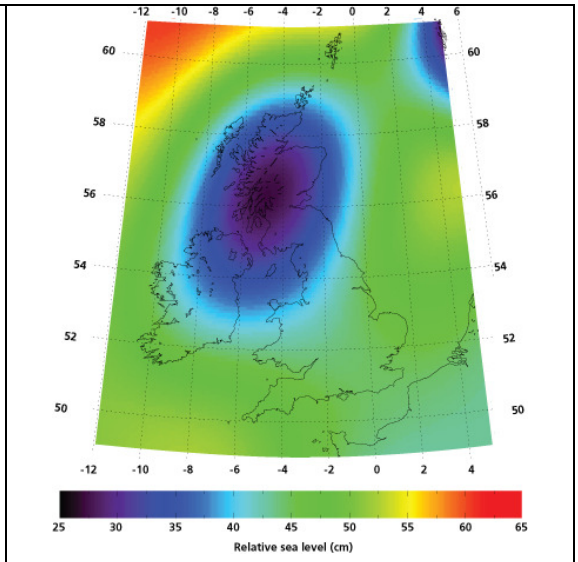
Sea level

Vertical land movements and sea level change

The vertical movement of the land varies around the UK coastline. Taking this into account gives slightly larger sea level rise projections relative to the land in the more southern parts of the UK where land is subsiding, and somewhat lower increases in relative sea level for the north.



Vertical land movement (mm/yr) for the UK. Adapted from Bradley et al. (2008). © UK Climate Projections 2009.



Relative sea level change (cm) around the UK over the 21st century. This map shows estimates of relative sea level change (i.e. sea level rise plus vertical land movements) by 2095, using the 'central' estimate under a medium emissions scenario. © UK Climate Projections 2009

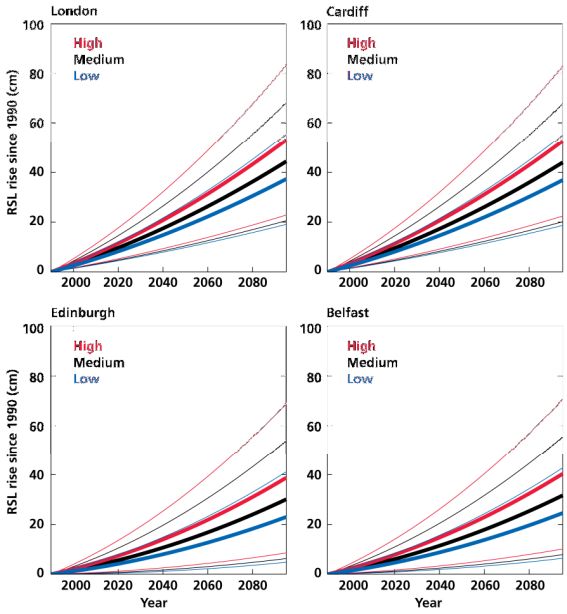
Sea-level rise data is provided both for 'absolute' change (i.e. looking at sea level rise only and ignoring vertical land movements) and 'relative' change (i.e. including allowances for vertical land movements).

Other key points about sea level change data:

- Sea level rise data is based upon analyses of a range of international climate change models.
- Information is available for low, medium and high emission scenarios.
- Data is available at a resolution of 12km coastal gridsquares.
- Sea level change for each gridsquare is presented as a continuous curve to 2100 for all 3 emission scenarios at 5th, 50th and 95th percentiles.

The 'percentile' figures used in the marine report describe the percentage of the model runs within the ensemble that are *less* than the figure provided. As the skill of the individual ensemble members is not used to weight the final distribution, these figures are not probabilities as in the probablisitic atmospheric report. However, they do provide a quantification of the model uncertainty. The figures essentially give 3 curves for each emission scenario. This 'range' of change expressed by the 3 curves (i.e. that falling between the 5th and 95th percentiles) should be considered a more reliable indictor of change by users than simply taking the central estimate (i.e. the 50th percentile figure).

A low probability, 'High++' sea level range is included in the marine and coastal report, based on geological records of past sea level high-stands and plausible constraints on ice sheet dynamics.



Relative sea level (RSL) rise over the 21st century showing central estimate values (thick lines) and 5th and 95th percentile limits of the range of uncertainty (thin lines) for four sample locations around the UK. Values are relative to 1990.

Storm surges

Changes in storm surges (short-lived increases in local water level above that of the tide) are provided for changes in return levels for return periods of 2, 10, 20 and 50 years. A return level can be loosely described as the level expected to be to be exceeded on average once during the return period and is useful in planning for extreme conditions. Surge information has not been 'scaled' to include high and low emissions (as was the case for sea level rise, with estimates, 'scaled' from the medium emission scenario) due to uncertainties about how the surge emission scenarios should be scaled.

Other key points about storm surge information:

- The user interface provides access to projections of trend in storm surge for UK waters, based on long term trends from 1951-2099.
- This data is provided for a medium emission scenario only for 12km coastal grid boxes.
- These are presented as return period plots (2, 10, 20 and 50 years) at 5th, 50th and 95th percentiles.

A combined low probability high++ sea level and surge estimate is included in the marine and coastal report only to show what plausible extreme water levels could occur around the UK. The top of this range is considered very unlikely to be realised during the 21st century.

Waves

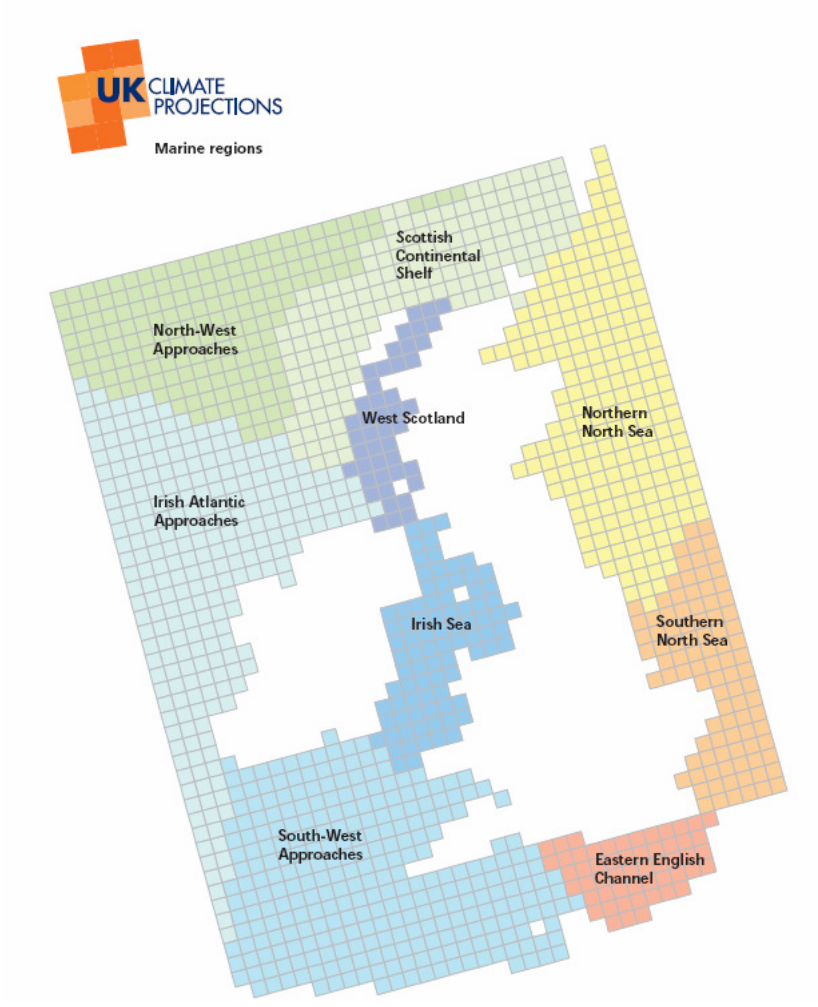
Changes in wave climate around the UK are included in the published reports only. The wave model used is well developed and uses a 12km grid model of the NW European continental shelf. All results are for the medium emission scenario only and change is expressed as seasonal differences in significant wave height for 2070-2100 compared to the 1961-1990 baseline.

Atmospheric projections 'over' the sea

Projections for the atmosphere over the sea are significantly more advanced than the marine projections themselves as they allow us to explore uncertainty in the climate modelling, and for the first time assigns a 'probability' to the different climate projections. These probabilities are based on the strength of evidence for a particular projection based on observational data sets and twelve different climate model projections. Projections are provided for seven future overlapping 30 year time periods (which helps reduce uncertainty) and for all three (low, medium and high) emission scenarios.

The following atmospheric variables are available for nine marine aggregated regions:

- Mean air temperature
- Sea level pressure
- Total cloud
- Precipitation rate



The nine 'aggregated' regions for the atmosphere over the sea. © UK Climate Projections 2009

Some key limitations of the marine and coastal projections

Whilst the marine projections in UKCP09 are an improvement on previous work, climate science cannot yet provide a complete picture of future changes to the marine environment. Of particular note are limitations associated with:

- The quality of the underlying global models that drive the marine simulations.
- Use of just the 'medium' emission scenario for most variables (except sea level).
- Trends in waves and sub-surface processes were derived from 30-year time periods; given the large natural changes observed for these variables, which span many decades, simulations spanning a full century would provide more robust estimates of 'extreme' values.
- Uncertainty in shelf sea and wave model variables.
- The limited sample of future wave conditions.
- Limited knowledge of deglaciation processes in Greenland and especially West Antarctica and their likely impact on sea level rise.

For more details on limitations go to: http://ukclimateprojections.defra.gov.uk/content/view/2010/519/

What might changes in these variables mean for the marine environment?

Changes described for the **marine multi-level data** (temperature, salinity etc..) might be expected to have important consequences for our marine ecosystem. Changes in sea temperature have already been linked to changes in marine species distributions (e.g. plankton and fish) with potential consequences for the entire marine foodweb (see for example the MCCIP 2009 ecosystem linkages report card section 'a view from above'. These changes could also have economic implications for fisheries and aquaculture, as might changes in salinity. Changes in stratification could affect primary productivity in the ocean, nutrient availability and pollution dispersal, as could changes in currents.

Changes in **sea level, surges and waves** could have important consequences for coastal flooding and coastal erosion, aswell as impacts for built structures both on- and off-shore.

Changes in some of the **atmospheric variables** could also have important consequences for the marine environment (e.g. rainfall, with potentially important changes to run-off and the input of pollutants and nutrients to the sea affecting water quality).

Many of these issues will be explored in greater detail for the 30 individual topics covered in the next MCCIP annual report card as we have specifically requested that authors consider the UKCP09 scenarios when completing their submissions. The next MCCIP report card is due to be launched in mid-2010.

This document was produced by the MCCIP secretariat in conjunction with UKCIP and the Met Office.