Department for Environment Food & Rural Affairs | Department for Energy Security & Net Zero | Department for Science, Innovation, & Technology | Met Office Hadley Centre | Environment Agency

UKCP18 Factsheet: Sea level rise and storm surge

Updated: November 2025

This factsheet summarises the key information currently available on the UKCP18 marine projections for sea level rise and storm surge. Read this before using any products as it describes the data availability, the main future climate changes (if any) that you should see and the caveats and limitations.

We recommend that you read the UKCP18 Science Overview (Lowe et al, 2018) to understand the different components of the projections. For a comprehensive description of the underpinning science, evaluation and results see the UKCP18 Marine Projections Report (Palmer et al, 2018). We provide results for the future emissions scenarios used in the Intergovernmental Panel on Climate Change's 5th Assessment Report (IPCC AR5). These are the Representative Concentration Pathways (RCPs) further information is available in the RCP Guidance on the UKCP18 website.

Results overview

- We present a new set of sea level projections, rooted in the climate models and methods from the IPCC AR5
- Global sea level has risen over the 20th century and will continue to rise over the coming centuries.
- UK tide gauge records show substantial year-to-year changes in coastal water levels (typically several centimetres). We recommend that coastal decision makers account for this variability in risk assessments, particularly for shorter-term planning horizons.
- The UKCP18 sea level projections are consistently larger than in the previous set of UK climate projections, UKCP09 (see Lowe et al, 2009), for similar emissions scenarios. However, UKCP18 also includes a lower emissions scenario that assumes more mitigation. For a detailed comparison see Section 5 of Palmer et al, (2018).
- The amount of sea level rise depends on the location around the UK and increases with higher emissions scenarios (see Table 1 and Figure 1).
- Based on exploratory results to 2300, sea levels continue to increase beyond 2100 even with large reductions in greenhouse gas emissions.
- We find no evidence for significant changes in future storm surges, although you may wish to carry out sensitivity tests with our scenarios.

- Sea level rise over the coming centuries may affect tidal characteristics substantially (including tidal range). However, the atmospheric contribution to storm surges is unlikely to change.
- Extreme sea levels will increase due to the rise in mean sea level. However, our best estimate suggests no additional change due to the atmospheric contribution to extreme sea level.

	RCP2.6		RCP4.5		RCP8.5	
	5th	95th	5th	95th	5th	95th
London	0.29	0.70	0.37	0.83	0.53	1.15
Cardiff	0.27	0.69	0.35	0.81	0.51	1.13
Edinburgh	0.08	0.49	0.15	0.61	0.30	0.90
Belfast	0.11	0.52	0.18	0.64	0.33	0.94

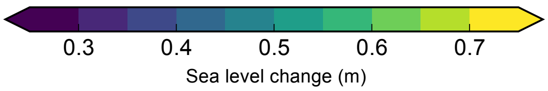

Table 1. Range of sea level change (m) at UK capital cities in 2100 relative to 1981-2000 average for a low (RCP2.6), medium (RCP4.5) and high (RCP8.5) emissions scenario from table in Section 1.2 in Palmer et al (2018).

Sea level rise and storm surges: what are they and why are they important?

Sea level rise is the primary mechanism by which we expect coastal flood risk to change in the UK in the future. It describes the phenomenon of increases in the level of the world's seas and oceans as global temperatures rise. In UKCP18, we provide the relative sea level rise, i.e. the local sea level rise experienced at a particular location including land movements.

In addition, there is potential for changes in the severity of future storm surge events (see section 3.2 of Palmer et al, 2018). However, the UKCP18 model results suggest a relatively small contribution from storm surge changes and we don't yet know whether storm surges will become more severe, less severe or remain the same. The response of the storm track under climate change is an important driver of storm surge changes and this is an active area of research.

When combined with local information on sea defences and coastline structure, the sea level and storm surge projections enable vulnerability assessments along the UK coastline to be made. Examples of the use of previous sea level and storm surge information include the Environment Agency's climate change allowances[1], coastal and flood defence management for the Thames Estuary 2100 project[2] and the UKCP18 demonstration project on coastal erosion management (Walkden, 2018).

[1] www.gov.uk/guidance/flood-risk-assessments-climate-change-allowances
[2] www.gov.uk/government/publications/thames-estuary-2100-te2100

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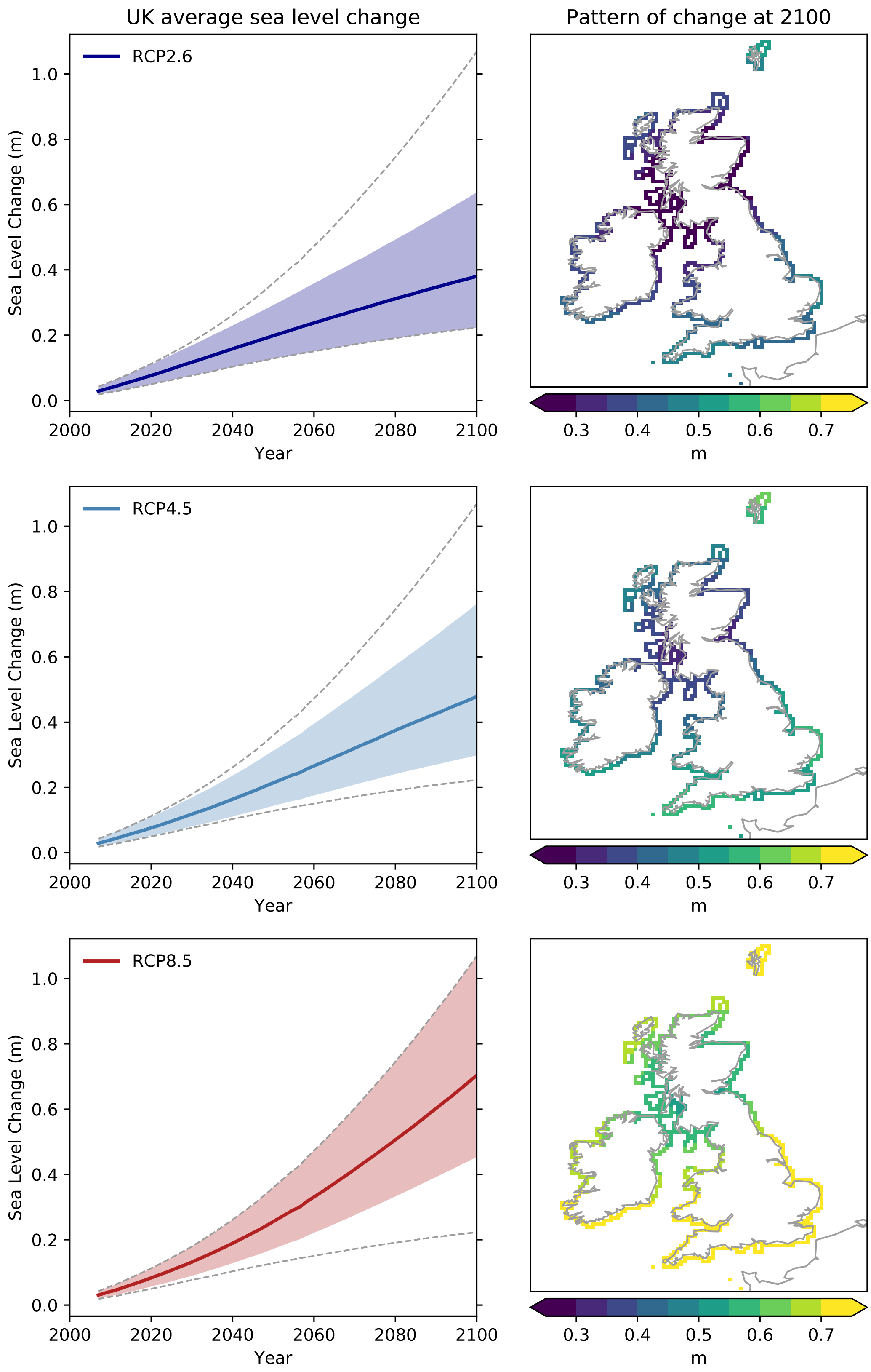

Figure 1. Left panels: time series of mean annual sea level change for the UK compared to present (1981-2000) for a high emissions scenario (RCP8.5). The bold lines are the median change and the shaded area the likely range (5^{th}-95^{th} percentile). The dotted line shows the range across low to high emissions scenarios (RCP2.6, RCP4.5 and RCP8.5). Right panels: regional relative sea level change around the UK and Ireland coastline in 2100 for RCP8.5. From Figure 3.1.3 of Palmer et al, (2018).

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What data are available and where can you find it?

Dataset	Description	Emissions scenarios	Time period	Domain
Time mean sea level at 12km	Projections of future changes in time-mean sea water level	RCP2.6 RCP4.5 RCP8.5	2007-2100	UK, Ireland, Channel Islands and Isle of Man coastlines
	Exploratory projections of future changes in time-mean sea water level	RCP2.6 RCP4.5 RCP8.5	2007-2300	UK, Ireland, Channel Islands and Isle of Man coastlines
Storm surge trend at 12km	Projections of trend in extreme still water level due to storminess change alone	RCP8.5	2007-2099	UK, Ireland, Channel Islands and Isle of Man coastlines
Storm surge simulations	Time series of gridded historical and future simulations of sea surface elevation due to tides only and tides and surge	RCP8.5	June 1970-June 2099	UK, Ireland, Channel Islands and Isle of Man coastlines
Short event case studies	Time series of gridded historical and future simulations of sea water level for three events (6 Dec 2013, 3 Feb 2014, 11 Jan 2015)	N/A	6 Dec 2013, 3 Feb 2014, 11 Jan 2015	UK, Ireland, Channel Islands and Isle of Man coastlines
Projected future still water return levels	Projected future still water return levels at tide gauges around the UK coastline*	RCP2.6 RCP4.5 RCP8.5	2020-2300	UK tide gauges
Potential changes in tide characteristics	UKCP18 simulated impact of mean sea level change on tidal characteristics around the UK**	N/A	N/A	Sea around the UK, Ireland, Channel Islands and Isle of Man
Global Time-mean Sea level projections	Annual time series of the projected change in the time-mean coastal water level relative to the average value for the period 1986-2005	RCP2.6 RCP4.5 RCP8.5	2007-2300	Selected global tide gauges
Projected extreme sea levels	Projected future extreme sea levels at approximately 2km spacing using 21st century time-mean sea-level projections	RCP2.6 RCP4.5 RCP8.5	2020-2100	UK, Channel Islands and Isle of Man coastlines
	Projected future extreme sea levels at approximately 2km spacing using exploratory extended time-mean sea-level projections	RCP2.6 RCP4.5 RCP8.5	2020-2300	UK, Channel Islands and Isle of Man coastlines
	Projected future extreme sea levels at selected tide gauge locations using exploratory extended time-mean sea-level projections	RCP2.6 RCP4.5 RCP8.5	2020-2300	UK tide gauges

Table 2. Summary of UK Climate Projections marine projections data. The annual time-mean sea level here is the average height of the sea over a year, with the shorter-term variations of tides and storm surges averaged out. * based on the latest EA Coastal Flood Boundary Conditions.** the spin-up period has been included in this dataset. For realistic tides, the first 48 hours of data should not be considered. Additionally, a land-sea mask has not been applied to the data and there is a rim of zeros around the edge of the data which should be ignored.

You can access the time mean sea level data and visualisations up to 2100 and 2300 via the UKCP18 User Interface.

You can access the storm surge simulations and all other datasets via the CEDA Data Catalogue but note that this requires the technical skill to analyse large datasets.

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How well do the models reproduce the past?

- The models underpinning the sea level rise and storm surge projections are able to reproduce many aspects of observed sea level change.
- We use an exploratory method to illustrate the possible changes in sea level beyond 2100. There is deep uncertainty on the contribution from the Antarctic Ice Sheet on these timescales.

We use the climate models that fed into the IPCC AR5 to calculate sea level (i.e. the CMIP5 climate models). They are able to reproduce the majority of the rise observed at tide gauge locations around the world over the 20th Century and capture its acceleration since the 1960s. The models capture trends in regional sea level well with best agreement during the latter half the 20th Century. Inter-decadal and sea-level variability are also captured (see Section A.2.1 in Palmer et al, 2018).

Our storm surge model is similar to the one used operationally by the Met Office to provide coastal flood warnings in the UK as part of the Storm Tide Forecasting Service. Model performance is routinely monitored by comparing forecast results with observations. The storm surge model performs well, exhibiting a similar relationship between changes of intensity and changes of frequency of extreme events to that relationship seen in the tide-gauge record for any given site (see Section A2.3 in Palmer et al, 2018).

What do you need to be aware of?

- We provide a range of values (5th to 95th percentiles) as provided by IPCC AR5. There may be a greater than 10% chance that the real-world response lies outside this range and this likelihood cannot be accurately quantified.
- We cannot rule out substantial additional sea level rise associated primarily with dynamic ice discharge from the West Antarctic Ice Sheet.
- The estimate for low probability, high impact range for sea level rise around the UK to 2100 (H++ scenario from UKCP09, see Lowe et al, 2009) is still a reasonable plausible high-end scenario based on our current interpretation of the evidence.
- We recommend that you make use of multiple strands of evidence, including H++ scenarios when assessing vulnerabilities to future extreme water levels.
- There are large year-to-year (and sub-annual) variations in sea level in UK tide gauge records. At present, observed tide gauge data can be found at the National Tide and Sea Level Facility at www.ntslf.org
- The results are subject to any inherent limitations of the underlying CMIP5 models and assumed climate change RCP scenarios.
- Our best estimate from a synthesis of simulations based on the current generation of climate models is one of no change in the atmospheric contribution to storm surge. However, some models suggest significant change and in the UKCP18 Marine Projections report (Palmer et al, 2018), we consider one such model to illustrate the size of possible changes.

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- We assume that the coastline and seabed do not change with time. We chose this experimental design to make the modelling more tractable given the grid resolution and lack of representation of changing water/land cells with changing water level. In addition, high quality coastline data and knowledge of future coastline evolution on 100 to 200-year timescales is sparse. Further studies should aim to explore the sensitivity of variable coastlines – but this was beyond the scope of the resource available for UKCP18.
- The geographic variations around the UK of sea level (including vertical land motion) are due to the effects of the last de-glaciation and the mass fingerprints associated with future loss of ice from Greenland.
- The UKCP18 marine projections do not account for other non-climatic processes that may influence regional sea level such as groundwater extraction.
- The UKCP09 multi-level temperature and salinity marine data have not been updated.

The UKCP18 21st Century time-mean sea level projections correspond to the IPCC AR5 “likely range”, as determined by their expert judgement. IPCC AR5 interpreted the 5th to 95th percentiles as having a “2/3 chance” of spanning the real-world sea level rise for any given RCP scenario (Church et al, 2013). As noted above, we cannot rule out substantial additional sea level rise associated primarily with dynamic ice discharge from the West Antarctic Ice Sheet.

The 21st Century storm surge projections are based upon relatively small CMIP5 model ensembles. It is unlikely that these simulations span the full range of CMIP5 model responses under climate change. These projections in particular should be viewed as indicative of the overall magnitude of changes we might see over the 21st Century. For both these sets of simulations, we cannot be sure of the relative influence of the climate change signal compared to natural variability.

The extended exploratory time-mean sea level projections have much lower confidence than the 21st Century Projections. They are designed to be used alongside the 21st Century projections for those interested in exploring post-2100 changes. These projections can be considered as sensitivity studies and should not be interpreted as showing the full range of post-2100 behaviour, or the most likely behaviour. The potential for additional sea level rise from Antarctic dynamic ice discharge is even more uncertain on these time horizons, with some studies suggesting several additional metres of rise by 2300 under RCP8.5.

The simulations of changes in tide and surge characteristics make the simple assumption of a fixed coastline and seabed under all levels of future sea level rise. The findings should be interpreted as illustrative of potential changes and further work is needed under more realistic model configurations in order to make progress in this research avenue.

Unlike some other components of UKCP18, the sea level projections and storm surge are not probabilistic. They provide a frequency distribution of projections based on results from the models that contributed to the IPCC Fifth Assessment Report. We treat each model as equally plausible. The 5th-95th percentile range is reported on, which should not be confused with the 10th and 90th percentiles of probability referred to in the climate projections report. When the 5th-95th percentile range is presented it should be interpreted as 90% of the modelled results lying between these bounds.

Further information on the caveats and limitations can be found in UKCP18 Guidance: Caveats and Limitations on the UKCP18 website.

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Where can you find more information?

For further information on UKCP18:

- Find a summary of the key results for sea level rise from the UKCP18 website.
- Download the sea level rise and storm surge data from the UKCP18 User Interface ukclimateprojections-ui.metoffice.gov.uk and the CEDA Data Catalogue.
- Find out more on wave projections, extreme event case studies as well as the underpinning science from the UKCP18 Marine Report (Palmer et al, 2018).

For a comparison of UKCP09 with UKCP18, see section 5 of the UKCP18 Marine Report (Palmer et al, 2018).

For general information on sea level:

- IPCC Fifth Assessment Report, Working Group 1 report The Physical Science Basis, Chapter 13 (www.ipcc.ch/report/ar5/wg1).
- A forthcoming report from the IPCC to be published in 2019. Special Report on the Ocean and Cryosphere in a Changing Climate (SROCC), (www.ipcc.ch/report/srocc).

This document is citable as Fung F, Palmer M, Howard T, Lowe J, Maisey P and Mitchell JFB (2018). UKCP18 Factsheet: Sea Level Rise and Storm Surge, Met Office Hadley Centre, Exeter.

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