Time-mean Sea-level Projections Update: Technical Note

1. Summary

In August 2022, an issue was discovered with the UKCP18 processing code, which meant that the adjustment needed to convert from the Intergovernmental Panel on Climate Change (IPCC) Fifth Assessment Report (AR5) baseline of 1986-2005 to the baseline period of 1981-2000 used in UKCP18 was not fully implemented for the site-specific time-mean sea-level projections. This issue has now been resolved and sea-level projection datasets updated accordingly. The update results in about a 1 cm (or 0.01 m) increase for all UKCP18 site-specific sea-level projections over all timescales (e.g., projected sea-level rise at 2030 + 1 cm, projected sea-level rise at 2100 + 1 cm). While this does affect headline projection ranges at 2100 by + 0.01 m, the change is small and unlikely to be decision relevant. UKCP users are encouraged to adopt the updated projections where this is practical. The updated data will be the default version made available via CEDA and the UKCP User Interface from March 2023.

2. Description of the issue

The UKCP18 time-mean sea-level projection methods are rooted in CMIP5 climate model simulations that are expressed relative to a baseline period of 1986-2005 (M. Palmer et al., 2018; M. D. Palmer et al., 2020). It was therefore necessary to apply a small adjustment to these sea-level projections to express them relative to the 1981-2000 baseline as described in section A1.1.1 of the UKCP18 Marine Report:

> *"Since the IPCC AR5 GMSL projections were formulated relative to a baseline period of 1986-2005 it is necessary to carry out a small adjustment to the component time series to provide projections across UKCP18 for a common baseline period of 1981-2000. This is achieved on the basis of the average difference between the two baseline periods computed using four tide-gauge reconstructions of GMSL (Church & White, 2011; Hay et al., 2015; Jevrejeva et al., 2014; Ray & Douglas, 2011). The result is an offset of +0.011m for the total sea level, which is then applied across components according to the proportion of sea level change that each accounts for in the first decade of the projections (assuming that these are representative of the earlier period). These proportions are: 40.5% for Thermal Expansion; 9.5% for Antarctica; 12.5% for Greenland; 27% for Glaciers and 10.5% for Land Water."*

While this adjustment was successfully applied for the UKCP18 global mean sea level (GMSL) projections, a flaw in the processing code meant that this adjustment was not carried across to the site-specific UK sea-level projections.

3. Correction and checking

The correction needed to the processing code was minimal and involved some simple refactoring of a few lines so that baseline adjustments applied to the GMSL Monte Carlo data object were explicitly passed through to the site-specific projections. The code fix was implemented by M.D. Palmer and then independently checked by T. Howard. Following the refactoring of the code, the UKCP18 sea-level projections were initially run for the four UK capital cities to check that the differences to the original projections were consistent with the expected increase of approximately 1 cm, as discussed below. Once this was confirmed, the code was re-run on all UKCP18 coastal grid boxes and checked against the original projection data files. Finally, the updated projections were run on two independent software architectures and the data files were cross-referenced and found to be a perfect match.

Since the baseline adjustment needed for GMSL was +1.1 cm it was anticipated that correction of the processing code would lead to an approximately +1 cm (or 0.01 m) increase in site-specific projections on all timescales. However, there is some additional subtlety due to the baseline adjustment being carried out by individual sea-level components (see quoted text in section 2) and being convolved with the corresponding spatial patterns of GRD (Gravity, Rotation and solid-earth Deformation, (Gregory et al., 2019)) and local scaling between global and local expressions of sea-level change simulated by CMIP5 models (e.g., M. D. Palmer et al., 2020). These subtleties result in some small time/space dependence of the approximate +1 cm offset. At 2100, the differences across all percentiles between the updated and original UKCP18 projections show a range of about 0.8 cm to 1.3 cm (or 0.008 to 0.013 m, Figure 1). For the exploratory extended UKCP18 projections at 2300, the range is about 0.4 cm to 1.8 cm (or 0.004 to 0.018 m, not shown).

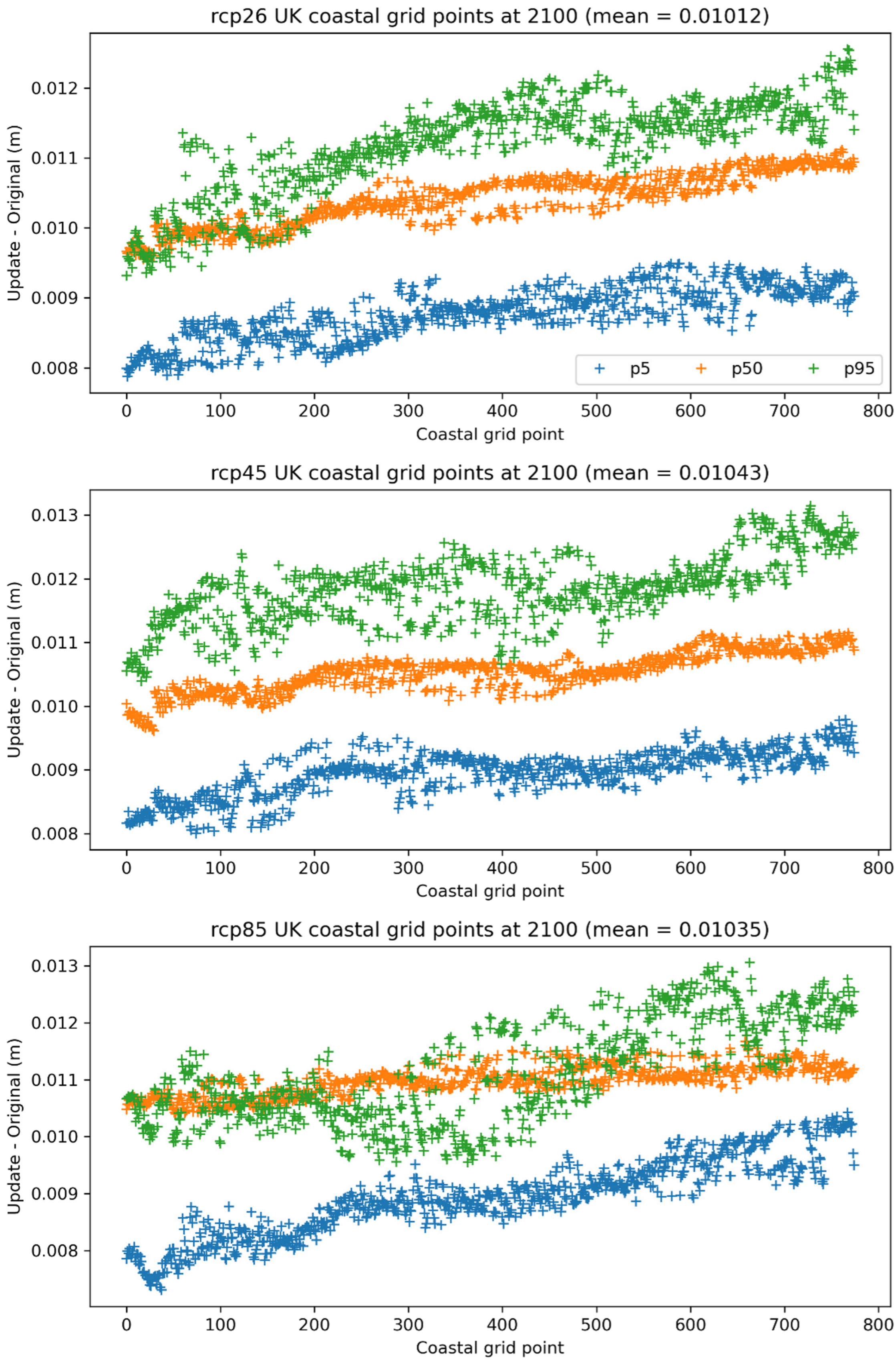

Figure 1 (Scatter plot of differences between the 5th, 50th and 95th percentile projections (m) at 2100 for all coastal grid points for the RCP2.6 (top), RCP4.5 (middle) and RCP8.5 (bottom) climate change scenarios. Percentiles are indicated in the figure legend. The coastal grid point represents the location around the UK coastline.

4. Impact on headline UKCP18 messages

As expected, based on section 3, the updated UKCP18 projections typically result in a + 0.01 m (or 1 cm) increase in both the lower and upper values of the projected ranges at 2100 (Table 1). Since the projection values beyond 2100 are only reported to the nearest 0.1 m (or 10 cm), this only affects the headline projection ranges in three cases when the small difference results in a round-up instead of a round-down (Edinburgh at 2200 under RCP2.6, London and Belfast at 2200 under RCP4.5, Table 1).

	RCP2.6				RCP4.5				RCP8.5			
	2100*	2100	2200	2300	2100*	2100	2200	2300	2100*	2100	2200	2300
London (original)	0.29 – 0.70	0.29 – 0.71	0.5 – 1.5	0.6 – 2.2	0.37 – 0.83	0.35 – 0.82	0.6 – 1.8	0.8 – 2.6	0.53 – 1.15	0.51 – 1.11	1.1 – 2.8	1.5 – 4.3
London (update)	0.30 – 0.71	0.30 – 0.72	0.5 – 1.5	0.6 – 2.2	0.38 – 0.84	0.36 – 0.84	0.7 – 1.8	0.8 – 2.6	0.54 – 1.16	0.52 – 1.13	1.1 – 2.8	1.5 – 4.3
Cardiff (original)	0.27 – 0.69	0.27 – 0.70	0.4 – 1.5	0.5 – 2.2	0.35 – 0.81	0.34 – 0.81	0.6 – 1.8	0.8 – 2.6	0.51 – 1.13	0.49 – 1.10	1.1 – 2.8	1.4 – 4.2
Cardiff (update)	0.28 – 0.70	0.28 – 0.71	0.4 – 1.5	0.5 – 2.2	0.36 – 0.83	0.34 – 0.82	0.6 – 1.8	0.8 – 2.6	0.52 – 1.14	0.50 – 1.11	1.1 – 2.8	1.4 – 4.2
Edinburgh (original)	0.08 – 0.49	0.08 – 0.50	0.0 – 1.1	0.0 – 1.6	0.15 – 0.61	0.13 – 0.60	0.2 – 1.4	0.2 – 2.0	0.30 – 0.90	0.27 – 0.87	0.6 – 2.3	0.7 – 3.5
Edinburgh (update)	0.09 – 0.50	0.08 – 0.51	0.1 – 1.1	0.0 – 1.6	0.16 – 0.62	0.14 – 0.61	0.2 – 1.4	0.2 – 2.0	0.30 – 0.91	0.28 – 0.88	0.6 – 2.3	0.7 – 3.5
Belfast (original)	0.11 – 0.52	0.11 – 0.53	0.1 – 1.2	0.0 – 1.7	0.18 – 0.64	0.17 – 0.64	0.3 – 1.4	0.3 – 2.1	0.33 – 0.94	0.31 – 0.91	0.7 – 2.4	0.8 – 3.6
Belfast (update)	0.12 – 0.53	0.11 – 0.54	0.1 – 1.2	0.0 – 1.7	0.19 – 0.66	0.17 – 0.65	0.3 – 1.5	0.3 – 2.1	0.34 – 0.95	0.31 – 0.92	0.7 – 2.4	0.8 – 3.6

In timeseries plots that appear in UKCP18 materials, the difference between the original and updated projections is very subtle and only perceptible over the 21st century with a careful side-by-side comparison (Figure 2). The difference for the exploratory extended projections is even smaller, since the baseline adjustment represents less than 1% of the central estimates at 2300 (not shown).

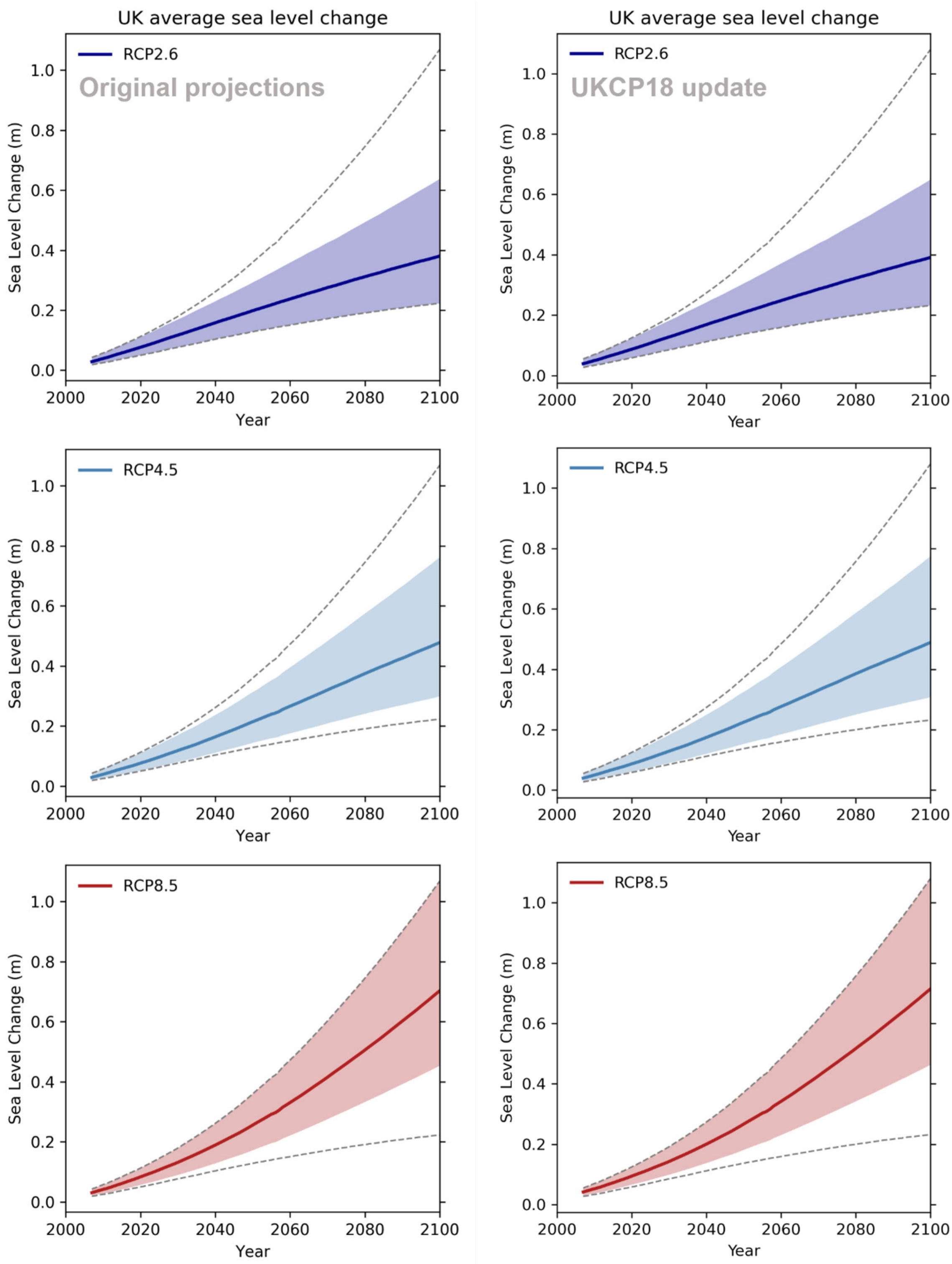

Figure 2 (left) The original UKCP18 21st century projections of total sea-level rise. Shaded regions indicate the 5th to 95th percentile range for the RCP2.6, RCP4.5 and RCP8.5 climate change scenarios. Dashed lines indicated the range across all scenarios. (right) The updated UKCP18 21st century projections. Adapted from Figure 3.1.3 of the UKCP18 Marine Report (Palmer et al, 2018).

Overall, the changes in projected values associated with the updated projections are small and unlikely to be decision relevant or necessitate re-evaluation of risk assessments based on the original data. However, UKCP users are encouraged to adopt the updated projections where this is practical. The updated data (version V20221219) will be the default version made available via CEDA and the UKCP User Interface from early 2023.

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