Earth's Future

Supporting Information for

Meeting user needs for sea-level information: a decision analysis perspective

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Contents of this file

Text S1
Figure S1
Table S1

Additional Supporting Information (Files uploaded separately)

Dataset S1

Introduction

In this supplementary information, we describe the methodology of the sea-level change projections and the computation of the time of scenario divergence. In addition, we provide results for extreme sea levels and a different parameter choice. Finally, we provide the underlying dataset with values for each tide gauge location.

Text S1.

The scenario divergence is based on the regional sea level projections from AR5 for emission scenarios RCP2.6 and RCP8.5 (Church et al., 2013). This data is distributed in netCDF format by the Integrated Climate Data Center (ICDC, icdc.cen.uni-hamburg.de) University of Hamburg, Hamburg, Germany.

Inter-annual sea level variability is derived from the GESLA2 dataset (Woodworth et al., 2016). Locations are selected where hourly tide gauge data adheres to two criteria: at least 20 years of data must be available, and these data must be at least 70% complete. As many records have discontinuities, inter-annual variability is approximated by the median of a sliding standard deviation. A window of four years is chosen, which produces estimates of inter-annual variability which agree well with those derived from altimetry. The inter-annual variability is combined with the uncertainty in mean sea level projections through a Monte Carlo approach. For the mean sea level projection at each year in the 21st century, the mean and inter-model difference is computed for the surrounding 20 years using a running average. By assuming a normal distribution for both the mean sea-level projections and the observed inter-annual variability, 10,000 samples are constructed and combined to give a total distribution for the mean sea level at each year, for each selected tide gauge location, and for scenarios RCP 2.6 and RCP 8.5.

Extreme sea level (ESL) distributions are derived from the sub-annual variability in the tide gauge record. Independent events are selected using a peaks-over-threshold method with a threshold of 99% of all hourly data. These peaks are declustered by prescribing a minimum time-between-peaks of 72 hours in order to approximate independence of the extreme events. A Generalized Pareto Distribution is fitted through these extremes, using a maximum likelihood estimator. From the co-variance in scale and shape parameters, 100 sets of parameters were derived. And from each of these sets, 100 extremes were sampled from the corresponding Generalized Pareto Distribution. This method produces 10,000 extremes which incorporate the uncertainty in the fit of the distribution. Through another Monte Carlo approach, these extremes are combined with the 10,000 samples of mean sea level to produce annual distributions of extreme sea levels.

A time of divergence is defined using a 10% threshold in the statistical distance between the two distributions, which can be graphically interpreted as the first year in which at least 10% of the area under the PDF of RCP8.5 lies outside of the area under the upper half (i.e. above the 50th percentile) of the PDF of RCP2.6, as visualised in Fig. S1.

Table S1 and Figure S1 displays results.

The reported time of divergence should be considered as an 'early estimate', because few tide gauge records are sufficiently long to capture all modes of climatic variability. As all records cover at least 20 years, seasonal variability should be well-represented in the extreme sea level distributions. Sub-decadal inter-annual variability such as the El Nino-Southern Oscillation and the high-frequency components of the North Atlantic Oscillation are partly captured. However, mean sea level variability due to (multi)decadal modes such as the Pacific Decadal Oscillation and the Atlantic Multidecadal Oscillation is lacking in most tide gauge records.

Note also that the range of forcing scenarios is assumed to be captured by using RCP2.6 and RCP8.5. When using a wider range of scenarios (e.g., up to RCP10), the year of divergence moves closer to present day.

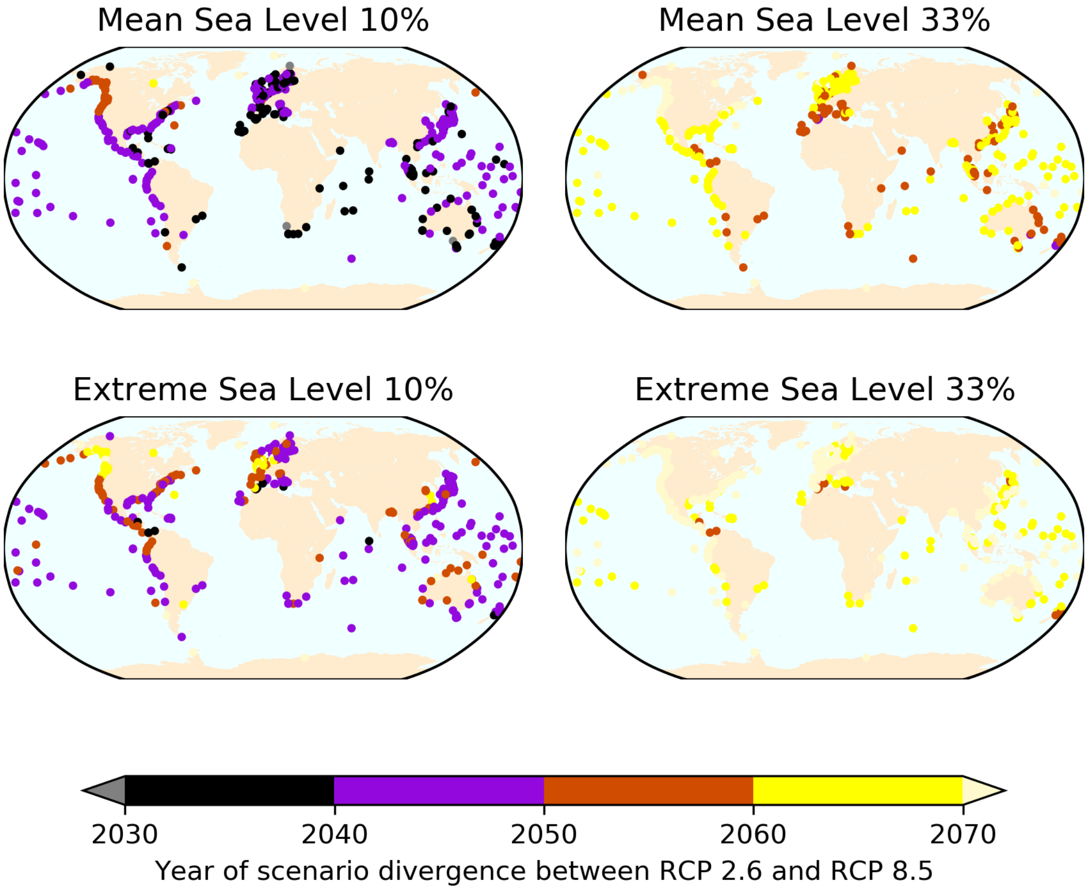

Figure S1. Time of scenario divergence across tide gauge locations analyzed for mean (top panels) and extreme sea-levels (bottom panels) and thresholds of 10 (left panels) and 33 (right panels). Note that the color code differs from the one used in Figure 3 in the main part of the manuscript.

	Threshold	before 2030	2030-2040	2040-2050	2050-2060	2060-2070	after 2070
Mean sea-levels	10%	2	33	56	8	0	1
Mean sea-levels	33%	0	0	2	26	56	16
Extreme sea-levels	10%	0	3	55	28	8	6
Extreme sea-levels	33%	0	0	0	4	24	72

Table S1. Relative number of tide gauge locations with scenario divergence in different time intervals for mean and extreme sea-levels and thresholds percentages of 10 and 33.

Data Set S1. The underlying data for each tide gauge location is available at the following open access repository:

https://doi.org/10.5281/zenodo.2531661

The file divergence.nc includes 1) the probability density functions (pdf) for scenarios RCP2.6 and RCP8.5 as a function of time and water level; 2) a set of quantiles (Z_quantile) in time; 3) the exceedance percentages (P_nooverlap) of RCP8.5 over RCP2.6 as a function of time; and 4) the derived year of divergence (T_divergence) for exceedance percentages of 10 and 33. Each variable contains data for each tide gauge location (station) and mean and extreme sea level (option).