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Communicating future sea-level rise uncertainty and ambiguity to assessment users

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Supplementary Information to "Communicating future sea-level rise uncertainty and ambiguity to assessment users"

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This document contains Table S1, comparing representative quotes from IPCC reports chapters and Summaries for Policy Makers, and Table S2, summarizing regional assessments that interpreted AR5's quantitative sea-level projections, as well as a gallery (Figures S1-S13) of key sea-level projections figures and tables from IPCC and regional assessments.

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Table S1. Representative IPCC chapter and Summary for Policymakers (SPM) quotes describing assessment of ambiguity in the ice sheet contributions to sea level.

Report	Chapter Text	Summary for Policymakers Text
First Assessment Report (1990)[1,2]	"A rapid disintegration of the West Antarctic Ice Sheet due to global warming is unlikely within the next century."	"Within the next century it is not likely that there will be a major outflow of ice from West Antarctica due directly to global warming."
Second Assessment Report (1995)[3,4]	"Concern has been expressed that the West Antarctic Ice Sheet might 'surge', causing a rapid rise in sea level. The current lack of knowledge regarding the specific circumstances under which this might occur, either in total or in part, limits the ability to quantify the risk. Nonetheless, the likelihood of a major sea level rise by the year 2100 due to the collapse of the West Antarctic Ice Sheet is considered low."	"In these projections, the combined contributions of the Greenland and Antarctic ice sheets are projected to be relatively minor over the next century. However, the possibility of large changes in the volumes of these ice sheets (and, consequently, in sea level) cannot be ruled out, although the likelihood is considered to be low."
Third Assessment Report (2001)[5,6]	"The range of projections given above makes no allowance for ice-dynamic instability of the WAIS. It is now widely agreed that major loss of grounded ice and accelerated sea level rise are very unlikely during the 21st century."	"Concerns have been expressed about the stability of the West Antarctic ice sheet because it is grounded below sea level. However, loss of grounded ice leading to substantial sea level rise from this source is now widely agreed to be very unlikely during the 21st century, although its dynamics are still inadequately understood, especially for projections on longer time-scales."
Fourth Assessment Report (2007)[7,8]	"It must be emphasized that we cannot assess the likelihood of any of these three alternatives [(steady, reduced, or scale up ice discharge)], which are presented as illustrative. The state of understanding prevents a best estimate from being made."	"For example, if [the ice flow] contribution were to grow linearly with global average temperature change, the upper ranges of sea level rise for SRES scenarios shown in Table SPM.3 would increase by 0.1 to 0.2 m. Larger values cannot be excluded, but understanding of these effects is too limited to assess their likelihood or provide a best estimate or an upper bound for sea level rise."
Fifth Assessment Report (2013)[9,10]	"Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century. This potential additional contribution cannot be precisely quantified but there is *medium confidence* that it would not exceed several tenths of a meter of sea level rise during the 21st century."	"Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century. There is *medium confidence* that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century."

Continued on next page…

Table S1 (continued). Representative IPCC chapter and Summary for Policymakers quotes describing assessment of ambiguity in the ice sheet contributions to sea level.

Report	Chapter Text	Summary for Policymakers Text
Special Report on the Ocean and Cryosphere in a Changing Climate (2019)[11,12]	"Processes controlling the timing of future ice-shelf loss and the extent of ice sheet instabilities could increase Antarctica's contribution to sea level rise to values higher than the *likely* range on century and longer time-scales (*low confidence*). Evolution of the Antarctic Ice Sheet beyond the end of the 21st century is characterized by deep uncertainty, as ice sheet models lack realistic representations of some of the underlying physical processes... There is *low confidence* in threshold temperatures for ice sheet instabilities and the rates of GMSL rise they can produce."	"Processes controlling the timing of future ice-shelf loss and the extent of ice sheet instabilities could increase Antarctica's contribution to sea level rise to values substantially higher than the *likely* range on century and longer time-scales (*low confidence*). Considering the consequences of sea level rise that a collapse of parts of the Antarctic Ice Sheet entails, this high impact risk merits attention."
Sixth Assessment Report (2021)[13,14]	"Higher amounts of GMSL rise before 2100 could be caused by earlier-than-projected disintegration of marine ice shelves, the abrupt, widespread onset of marine ice sheet instability and marine ice cliff instability around Antarctica, and faster-than-projected changes in the surface mass balance and discharge from Greenland. These processes are characterized by deep uncertainty arising from limited process understanding, limited availability of evaluation data, uncertainties in their external forcing and high sensitivity to uncertain boundary conditions and parameters. In a low-likelihood, high-impact storyline, under high emissions such processes could in combination contribute more than one additional metre of sea level rise by 2100."	"Global mean sea level rise above the *likely* range – approaching 2 m by 2100 and 5 m by 2150 under a very high GHG emissions scenario (SSP5-8.5) (*low confidence*) – cannot be ruled out due to deep uncertainty in ice-sheet processes."

Chapter text is written by the report author teams and incorporates feedback from expert and government review. Summary for Policymakers text is drafted by report author teams, incorporates feedback from expert and government review, and adopted by governments in IPCC plenary session.

Table S2. National and subnational assessments building upon AR5 sea level projections.

Assessment	Includes an AR4 or AR5 author as co-author	Interpretation of AR5 *likely* range	Consideration of marine-based sector collapse?
Canada 2014[15]	No	90%	Yes, acknowledges AR5 caveat and includes high-end scenario to represent
Connecticut 2019 [16]	No	90%	Yes, using sources other than AR5 [17,18]
Louisiana 2017 [19]	No	66-100%	Yes, using sources other than AR5 [20,21]
Netherlands 2014 [22]	Yes	90%	Yes, using sources other than AR5 [23]
North Carolina 2015 [24]	No	90%	No
Norway 2015 [25]	Yes	66-100%	Yes, acknowledges AR5 caveat and uses probabilistic approach to assess high-end outcomes
Singapore 2015 [26,27]	Yes	66-100%	Yes, acknowledges AR5 caveat and includes high-end scenario
United Kingdom 2018 [28]	Yes	66%	Yes, acknowledges AR5 caveat and uses post-AR5 literature [29,30] to illustrate in appendix

This table summarizes the interpretation of AR5 sea-level projections in several national and subnational assessments that were developed in the aftermath of AR5 and that use AR5 as a quantitative point of reference. The AR5 *likely* ranges were intended by the AR5 author team as having roughly a 66% probability, but were derived from the central 90% of model simulations. The canonical IPCC definition of *likely* is 66-100% probability.

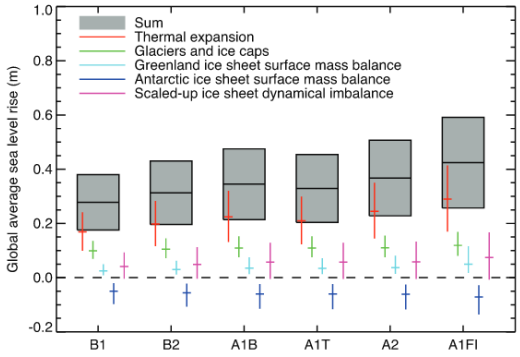

Figure 10.33. *Projections and uncertainties (5 to 95% ranges) of global average sea level rise and its components in 2090 to 2099 (relative to 1980 to 1999) for the six SRES marker scenarios. The projected sea level rise assumes that the part of the present-day ice sheet mass imbalance that is due to recent ice flow acceleration will persist unchanged. It does not include the contribution shown from scaled-up ice sheet discharge, which is an alternative possibility. It is also possible that the present imbalance might be transient, in which case the projected sea level rise is reduced by 0.02 m. It must be emphasized that we cannot assess the likelihood of any of these three alternatives, which are presented as illustrative. The state of understanding prevents a best estimate from being made.*

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Table 10.7. *Projected global average sea level rise during the 21st century and its components under SRES marker scenarios. The upper row in each pair gives the 5 to 95% range (m) of the rise in sea level between 1980 to 1999 and 2090 to 2099. The lower row in each pair gives the range of the rate of sea level rise (mm yr^{-1}) during 2090 to 2099. The land ice sum comprises G&IC and ice sheets, including dynamics, but excludes the scaled-up ice sheet discharge (see text). The sea level rise comprises thermal expansion and the land ice sum. Note that for each scenario the lower/upper bound for sea level rise is larger/smaller than the total of the lower/upper bounds of the contributions, since the uncertainties of the contributions are largely independent. See Appendix 10.A for methods.*

		B1		B2		A1B		A1T		A2		A1FI	
Thermal expansion	m	0.10	0.24	0.12	0.28	0.13	0.32	0.12	0.30	0.14	0.35	0.17	0.41
	mm yr^{-1}	1.1	2.6	1.6	4.0	1.7	4.2	1.3	3.2	2.6	6.3	2.8	6.8
G&IC	m	0.07	0.14	0.07	0.15	0.08	0.15	0.08	0.15	0.08	0.16	0.08	0.17
	mm yr^{-1}	0.5	1.3	0.5	1.5	0.6	1.6	0.5	1.4	0.6	1.9	0.7	2.0
Greenland Ice Sheet SMB	m	0.01	0.05	0.01	0.06	0.01	0.08	0.01	0.07	0.01	0.08	0.02	0.12
	mm yr^{-1}	0.2	1.0	0.2	1.5	0.3	1.9	0.2	1.5	0.3	2.8	0.4	3.9
Antarctic Ice Sheet SMB	m	-0.10	-0.02	-0.11	-0.02	-0.12	-0.02	-0.12	-0.02	-0.12	-0.03	-0.14	-0.03
	mm yr^{-1}	-1.4	-0.3	-1.7	-0.3	-1.9	-0.4	-1.7	-0.3	-2.3	-0.4	-2.7	-0.5
Land ice sum	m	0.04	0.18	0.04	0.19	0.04	0.20	0.04	0.20	0.04	0.20	0.04	0.23
	mm yr^{-1}	0.0	1.8	-0.1	2.2	-0.2	2.5	-0.1	2.1	-0.4	3.2	-0.8	4.0
Sea level rise	m	0.18	0.38	0.20	0.43	0.21	0.48	0.20	0.45	0.23	0.51	0.26	0.59
	mm yr^{-1}	1.5	3.9	2.1	5.6	2.1	6.0	1.7	4.7	3.0	8.5	3.0	9.7
Scaled-up ice sheet discharge	m	0.00	0.09	0.00	0.11	-0.01	0.13	-0.01	0.13	-0.01	0.13	-0.01	0.17
	mm yr^{-1}	0.0	1.7	0.0	2.3	0.0	2.6	0.0	2.3	-0.1	3.2	-0.1	3.9

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Table SPM.3. *Projected global average surface warming and sea level rise at the end of the 21st century. {10.5, 10.6, Table 10.7}*

Case	Temperature Change (°C at 2090-2099 relative to 1980-1999)[a] Best estimate	*Likely* range	Sea Level Rise (m at 2090-2099 relative to 1980-1999) Model-based range excluding future rapid dynamical changes in ice flow
Constant Year 2000 concentrations[b]	0.6	0.3 – 0.9	NA
B1 scenario	1.8	1.1 – 2.9	0.18 – 0.38
A1T scenario	2.4	1.4 – 3.8	0.20 – 0.45
B2 scenario	2.4	1.4 – 3.8	0.20 – 0.43
A1B scenario	2.8	1.7 – 4.4	0.21 – 0.48
A2 scenario	3.4	2.0 – 5.4	0.23 – 0.51
A1FI scenario	4.0	2.4 – 6.4	0.26 – 0.59

Table notes:
[a] These estimates are assessed from a hierarchy of models that encompass a simple climate model, several Earth System Models of Intermediate Complexity and a large number of Atmosphere-Ocean General Circulation Models (AOGCMs).
[b] Year 2000 constant composition is derived from AOGCMs only.

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39 **Figure S1.** Tables and figures summarizing GMSL projections from the IPCC Fourth Assessment Report
40 [7,8].

Table 13.5 | Median values and *likely* ranges for projections of global mean sea level (GMSL) rise and its contributions in metres in 2081–2100 relative to 1986–2005 for the four RCP scenarios and SRES A1B, GMSL rise in 2046–2065 and 2100, and rates of GMSL rise in mm yr^{-1} in 2081–2100. See Section 13.5.1 concerning how the *likely* range is defined. Because some of the uncertainties in modelling the contributions are treated as uncorrelated, the sum of the lower bound of contributions does not equal the lower bound of the sum, and similarly for the upper bound (see Supplementary Material). Because of imprecision from rounding, the sum of the medians of contributions may not exactly equal the median of the sum. The net contribution (surface mass balance (SMB) + dynamics) for each ice sheet, and the contribution from rapid dynamical change in both ice sheets together, are shown as additional lines below the sum; they are not contributions in addition to those given above the sum. The contributions from ice-sheet rapid dynamical change and anthropogenic land water storage are treated as having uniform probability distributions, uncorrelated with the magnitude of global climate change (except for the interaction between Antarctic ice sheet SMB and outflow), and as independent of scenario (except that a higher rate of change is used for Greenland ice sheet outflow under RCP8.5). This treatment does not imply that the contributions concerned will not depend on the scenario followed, only that the current state of knowledge does not permit a quantitative assessment of the dependence. Regional sea level change is expected in general to differ from the global mean (see Section 13.6).

	SRES A1B	RCP2.6	RCP4.5	RCP6.0	RCP8.5
Thermal expansion	0.21 [0.16 to 0.26]	0.14 [0.10 to 0.18]	0.19 [0.14 to 0.23]	0.19 [0.15 to 0.24]	0.27 [0.21 to 0.33]
Glaciers[a]	0.14 [0.08 to 0.21]	0.10 [0.04 to 0.16]	0.12 [0.06 to 0.19]	0.12 [0.06 to 0.19]	0.16 [0.09 to 0.23]
Greenland ice-sheet SMB[b]	0.05 [0.02 to 0.12]	0.03 [0.01 to 0.07]	0.04 [0.01 to 0.09]	0.04 [0.01 to 0.09]	0.07 [0.03 to 0.16]
Antarctic ice-sheet SMB[c]	–0.03 [–0.06 to –0.01]	–0.02 [–0.04 to –0.00]	–0.02 [–0.05 to –0.01]	–0.02 [–0.05 to –0.01]	–0.04 [–0.07 to –0.01]
Greenland ice-sheet rapid dynamics	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.04 [0.01 to 0.06]	0.05 [0.02 to 0.07]
Antarctic ice-sheet rapid dynamics	0.07 [–0.01 to 0.16]	0.07 [–0.01 to 0.16]	0.07 [–0.01 to 0.16]	0.07 [–0.01 to 0.16]	0.07 [–0.01 to 0.16]
Land water storage	0.04 [–0.01 to 0.09]	0.04 [–0.01 to 0.09]	0.04 [–0.01 to 0.09]	0.04 [–0.01 to 0.09]	0.04 [–0.01 to 0.09]
Global mean sea level rise in 2081–2100	0.52 [0.37 to 0.69]	0.40 [0.26 to 0.55]	0.47 [0.32 to 0.63]	0.48 [0.33 to 0.63]	0.63 [0.45 to 0.82]
Greenland ice sheet	0.09 [0.05 to 0.15]	0.06 [0.04 to 0.10]	0.08 [0.04 to 0.13]	0.08 [0.04 to 0.13]	0.12 [0.07 to 0.21]
Antarctic ice sheet	0.04 [–0.05 to 0.13]	0.05 [–0.03 to 0.14]	0.05 [–0.04 to 0.13]	0.05 [–0.04 to 0.13]	0.04 [–0.06 to 0.12]
Ice-sheet rapid dynamics	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.10 [0.03 to 0.19]	0.12 [0.03 to 0.20]
Rate of global mean sea level rise	8.1 [5.1 to 11.4]	4.4 [2.0 to 6.8]	6.1 [3.5 to 8.8]	7.4 [4.7 to 10.3]	11.2 [7.5 to 15.7]
Global mean sea level rise in 2046–2065	0.27 [0.19 to 0.34]	0.24 [0.17 to 0.32]	0.26 [0.19 to 0.33]	0.25 [0.18 to 0.32]	0.30 [0.22 to 0.38]
Global mean sea level rise in 2100	0.60 [0.42 to 0.80]	0.44 [0.28 to 0.61]	0.53 [0.36 to 0.71]	0.55 [0.38 to 0.73]	0.74 [0.52 to 0.98]
Only the collapse of the marine-based sectors of the Antarctic ice sheet, if initiated, could cause GMSL to rise substantially above the *likely* range during the 21st century. This potential additional contribution cannot be precisely quantified but there is *medium confidence* that it would not exceed several tenths of a meter of sea level rise.					

Notes:

[a] Excluding glaciers on Antarctica but including glaciers peripheral to the Greenland ice sheet.

[b] Including the height–SMB feedback.

[c] Including the interaction between SMB change and outflow.

Figure S2. Chapter table summarizing GMSL projections from the IPCC Fifth Assessment Report [9]

Table SPM.2 | Projected change in global mean surface air temperature and global mean sea level rise for the mid- and late 21st century relative to the reference period of 1986–2005. {12.4; Table 12.2, Table 13.5}

		2046–2065		2081–2100	
	Scenario	**Mean**	***Likely* range**[c]	**Mean**	***Likely* range**[c]
Global Mean Surface Temperature Change (°C)[a]	RCP2.6	1.0	0.4 to 1.6	1.0	0.3 to 1.7
	RCP4.5	1.4	0.9 to 2.0	1.8	1.1 to 2.6
	RCP6.0	1.3	0.8 to 1.8	2.2	1.4 to 3.1
	RCP8.5	2.0	1.4 to 2.6	3.7	2.6 to 4.8
	Scenario	**Mean**	***Likely* range**[d]	**Mean**	***Likely* range**[d]
Global Mean Sea Level Rise (m)[b]	RCP2.6	0.24	0.17 to 0.32	0.40	0.26 to 0.55
	RCP4.5	0.26	0.19 to 0.33	0.47	0.32 to 0.63
	RCP6.0	0.25	0.18 to 0.32	0.48	0.33 to 0.63
	RCP8.5	0.30	0.22 to 0.38	0.63	0.45 to 0.82

Notes:

[a] Based on the CMIP5 ensemble; anomalies calculated with respect to 1986–2005. Using HadCRUT4 and its uncertainty estimate (5–95% confidence interval), the observed warming to the reference period 1986–2005 is 0.61 [0.55 to 0.67] °C from 1850–1900, and 0.11 [0.09 to 0.13] °C from 1980–1999, the reference period for projections used in AR4. *Likely* ranges have not been assessed here with respect to earlier reference periods because methods are not generally available in the literature for combining the uncertainties in models and observations. Adding projected and observed changes does not account for potential effects of model biases compared to observations, and for natural internal variability during the observational reference period {2.4; 11.2; Tables 12.2 and 12.3}

[b] Based on 21 CMIP5 models; anomalies calculated with respect to 1986–2005. Where CMIP5 results were not available for a particular AOGCM and scenario, they were estimated as explained in Chapter 13, Table 13.5. The contributions from ice sheet rapid dynamical change and anthropogenic land water storage are treated as having uniform probability distributions, and as largely independent of scenario. This treatment does not imply that the contributions concerned will not depend on the scenario followed, only that the current state of knowledge does not permit a quantitative assessment of the dependence. Based on current understanding, only the collapse of marine-based sectors of the Antarctic ice sheet, if initiated, could cause global mean sea level to rise substantially above the *likely* range during the 21st century. There is *medium confidence* that this additional contribution would not exceed several tenths of a meter of sea level rise during the 21st century.

[c] Calculated from projections as 5–95% model ranges. These ranges are then assessed to be *likely* ranges after accounting for additional uncertainties or different levels of confidence in models. For projections of global mean surface temperature change in 2046–2065 *confidence* is *medium*, because the relative importance of natural internal variability, and uncertainty in non-greenhouse gas forcing and response, are larger than for 2081–2100. The *likely* ranges for 2046–2065 do not take into account the possible influence of factors that lead to the assessed range for near-term (2016–2035) global mean surface temperature change that is lower than the 5–95% model range, because the influence of these factors on longer term projections has not been quantified due to insufficient scientific understanding. {11.3}

[d] Calculated from projections as 5–95% model ranges. These ranges are then assessed to be *likely* ranges after accounting for additional uncertainties or different levels of confidence in models. For projections of global mean sea level rise *confidence* is *medium* for both time horizons.

Figure S3. SPM table summarizing GMSL projections from the IPCC Fifth Assessment Report [10].

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Feet above 1991-2009 mean	MEDIAN	LIKELY RANGE	1-IN-20 CHANCE	1-IN-200 CHANCE
Year / Percentile	*50% probability SLR meets or exceeds…*	*67% probability SLR is between…*	*5% probability SLR meets or exceeds…*	*0.5% probability SLR meets or exceeds…*
2030	0.4	0.3 — 0.5	0.6	0.8
2050	0.9	0.6 — 1.1	1.4	1.9
2100 (RCP 2.6)	1.6	1.0 — 2.4	3.2	5.7
2100 (RCP 4.5)	1.9	1.2 — 2.7	3.5	5.9
2100 (RCP 8.5)	2.5	1.6 — 3.4	4.4	6.9
2100 (H++)	10			
2150 (RCP 2.6)	2.4	1.3 — 3.8	5.5	11.0
2150 (RCP 4.5)	3.0	1.7 — 4.6	6.4	11.7
2150 (RCP 8.5)	4.1	2.8 — 5.8	7.7	13.0
2150 (H++)	22			

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47 **Figure S4.** Table summarizing RSL projections for San Francisco, CA, from the 2017 California sea level
48 assessment [31].
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TABLE 1: Projected Sea-Level Rise (in feet) for San Francisco

Probabilistic projections for the height of sea-level rise shown below, along with the H++ scenario (depicted in blue in the far right column), as seen in the Rising Seas Report. The H++ projection is a single scenario and does not have an associated likelihood of occurrence as do the probabilistic projections. Probabilistic projections are with respect to a baseline of the year 2000, or more specifically the average relative sea level over 1991 - 2009. High emissions represents RCP 8.5; low emissions represents RCP 2.6. ***Recommended projections for use in low, medium-high and extreme risk aversion decisions are outlined in blue boxes below.***

		Probabilistic Projections (in feet) (based on Kopp et al. 2014)					*H++ scenario (Sweet et al. 2017) *Single scenario*
		MEDIAN	**LIKELY RANGE**		**1-IN-20 CHANCE**	**1-IN-200 CHANCE**	
		50% probability sea-level rise meets or exceeds...	*66% probability sea-level rise is between...*		*5% probability sea-level rise meets or exceeds...*	*0.5% probability sea-level rise meets or exceeds...*	
				Low Risk Aversion		**Medium - High Risk Aversion**	**Extreme Risk Aversion**
High emissions	2030	0.4	0.3 -	0.5	0.6	0.8	1.0
	2040	0.6	0.5 -	0.8	1.0	1.3	1.8
	2050	0.9	0.6 -	1.1	1.4	1.9	2.7
Low emissions	2060	1.0	0.6 -	1.3	1.6	2.4	
High emissions	2060	1.1	0.8 -	1.5	1.8	2.6	3.9
Low emissions	2070	1.1	0.8 -	1.5	1.9	3.1	
High emissions	2070	1.4	1.0 -	1.9	2.4	3.5	5.2
Low emissions	2080	1.3	0.9 -	1.8	2.3	3.9	
High emissions	2080	1.7	1.2 -	2.4	3.0	4.5	6.6
Low emissions	2090	1.4	1.0 -	2.1	2.8	4.7	
High emissions	2090	2.1	1.4 -	2.9	3.6	5.6	8.3
Low emissions	2100	1.6	1.0 -	2.4	3.2	5.7	
High emissions	2100	2.5	1.6 -	3.4	4.4	6.9	10.2
Low emissions	2110*	1.7	1.2 -	2.5	3.4	6.3	
High emissions	2110*	2.6	1.9 -	3.5	4.5	7.3	11.9
Low emissions	2120	1.9	1.2 -	2.8	3.9	7.4	
High emissions	2120	3	2.2 -	4.1	5.2	8.6	14.2
Low emissions	2130	2.1	1.3 -	3.1	4.4	8.5	
High emissions	2130	3.3	2.4 -	4.6	6.0	10.0	16.6
Low emissions	2140	2.2	1.3 -	3.4	4.9	9.7	
High emissions	2140	3.7	2.6 -	5.2	6.8	11.4	19.1
Low emissions	2150	2.4	1.3 -	3.8	5.5	11.0	
High emissions	2150	4.1	2.8 -	5.8	5.7	13.0	21.9

**Most of the available climate model experiments do not extend beyond 2100. The resulting reduction in model availability causes a small dip in projections between 2100 and 2110, as well as a shift in uncertainty estimates (see Kopp et al. 2014). Use of 2110 projections should be done with caution and with acknowledgement of increased uncertainty around these projections.*

Figure S5. Table summarizing RSL projections for San Francisco, CA, from the 2018 California sea level rise guidance, highlighting the selection of specific trajectories for different levels of risk aversion [32].

Table 3.2. New York City sea level rise projections, including the new Antarctic Rapid Ice Melt (ARIM) scenario, relative to 2000–2004 (in feet)

	NPCC2 2015 sea level rise projections[a] Projections of record for planning			NPCC3 ARIM scenario[b] Growing awareness of long-term risk
Baseline (2000–2004) 0"	Low estimate (10th percentile)	Middle range (25–75th percentile)	High estimate (90th percentile)	ARIM scenario[a]
2020s	0.17 ft	0.33–0.67 ft	0.83 ft	–
2050s	0.67 ft	0.92–1.75 ft	2.5 ft	–
2080s	1.08 ft	1.50–3.25 ft	4.83 ft	6.75 ft
2100	1.25 ft	1.83–4.17 ft	6.25 ft	9.5 ft

[a]The 10th, 25th–75th, and 90th percentile projections are taken from NPCC2 (2015); the six sea level rise components upon which they are based include global and local factors (see Section 3.4.2 and NPCC (2015)). Use of NPCC2 sea level rise projections is confirmed for decision making at this time. The ARIM scenario is based on DeConto and Pollard (2016), Kopp *et al.* (2014; 2017) and informed expert judgments with regard to maximum plausible ice loss rates from Antarctica (see above and Sweet *et al.*, 2017). See this section and Appendix 3.B for full ARIM scenario and explanation.

[b]ARIM represents a new, physically plausible upper-end, low probability (significantly less than 10% likelihood of occurring) scenario for the late 21st century, derived from recent modeling of ice sheet–ocean behavior to supplement the current (NPCC, 2015) sea level rise projections. In the 2020s and 2050s, the ARIM scenario does not lie outside the pre-existing NPCC 2015 range and therefore NPCC 2015 results apply to these two earlier time slices. The ARIM scenario contains uncertainties stemming from incomplete knowledge of ice-sheet processes and atmosphere, ocean, and ice–sheet interactions.

Figure S6. Table summarizing RSL projections for New York, NY, from the 2019 New York City Panel on Climate Change report [33].

Table 2. Projected sea-level rise estimates above 2000 levels for Maryland based on the Baltimore tide-gauge station. Columns correspond to different projection probabilities and rows represent to time horizons and emissions pathways. See caveat in the text concerning potentially greater sea-level rise late this century under higher emissions pathways.

Year	Emissions Pathway	Central Estimate 50% probability SLR meets or exceeds:	Likely Range 67% probability SLR is between:	1 in 20 Chance 5% probability SLR meets or exceeds:	1 in 100 Chance 1% probability SLR meets or exceeds:
2030		0.6 ft	0.4 – 0.9 ft	1.1 ft	1.3 ft
2050		1.2 ft	0.8 – 1.6 ft	2.0 ft	2.3 ft
2080	Growing	2.3 ft	1.6 – 3.1 ft	3.7 ft	4.7 ft
	Stabilized	1.9 ft	1.3 – 2.6 ft	3.2 ft	4.1 ft
	Paris Agreement	1.7 ft	1.1 – 2.4 ft	3.0 ft	3.2 ft
2100	Growing	3.0 ft	2.0 – 4.2 ft	5.2 ft	6.9 ft
	Stabilized	2.4 ft	1.6 – 3.4 ft	4.2 ft	5.6 ft
	Paris Agreement	2.0 ft	1.2 – 3.0 ft	3.7 ft	5.4 ft
2150	Growing	4.8 ft	3.4 – 6.6 ft	8.5 ft	12.4 ft
	Stabilized	3.5 ft	2.1 – 5.3 ft	7.1 ft	10.6 ft
	Paris Agreement	2.9 ft	1.8 – 4.2 ft	5.9 ft	9.4 ft

An important caveat using these projections: In not accounting for the prospect of greater polar ice sheet loss, the K14 projections probably underestimate sea-level rise beyond 2050 under higher emissions pathways. While the DP16 projections might be over-estimates, they can serve to inform decisions for which risk aversion is relatively high. Under the Growing Emissions pathway the median (and Likely) sea-level rise projections are 3.6 feet (2.7-4.9 feet) for 2080 and 5.7 feet (4.2-7.9 feet) by 2100. Under the Stabilized Emissions pathway, DP16 projections begin to significantly diverge from K14 after 2080, with median (and Likely) sea-level rise of 3.7 feet (2.6-5.0 feet) for 2100.

Figure S7. Table and text summarizing RSL projections for Baltimore, MD, from the 2018 Maryland sea level rise assessment [34].

Table ES-1: New Jersey Sea-Level Rise above the year 2000 (1991-2009 average) baseline (ft)*

		2030	2050	2070			2100			2150		
				Emissions								
	Chance SLR Exceeds			Low	Mod.	High	Low	Mod.	High	Low	Mod.	High
Low End	> 95% chance	0.3	0.7	0.9	1	1.1	1.0	1.3	1.5	1.3	2.1	2.9
Likely Range	> 83% chance	0.5	0.9	1.3	1.4	1.5	1.7	2.0	2.3	2.4	3.1	3.8
	~50 % chance	0.8	1.4	1.9	2.2	2.4	2.8	3.3	3.9	4.2	5.2	6.2
	<17% chance	1.1	2.1	2.7	3.1	3.5	3.9	5.1	6.3	6.3	8.3	10.3
High End	< 5% chance	1.3	2.6	3.2	3.8	4.4	5.0	6.9	8.8	8.0	13.8	19.6

**2010 (2001-2019 average) Observed = 0.2 ft*

Notes: All values are 19-year means of sea-level measured with respect to a 1991-2009 baseline centered on the year indicated in the top row of the table. Projections are based on Kopp et al. (2014), Rasmussen et al. (2018), and Bamber et al. (2019). Near-term projections (through 2050) exhibit only minor sensitivity to different emissions scenarios (<0.1 feet). Low and high emissions scenarios correspond to global-mean warming by 2100 of 2°C and 5°C above early Industrial (1850-1900) levels, respectively, or equivalently, about 1°C and 4°C above the current global-mean temperature. Moderate (Mod.) emissions are interpolated as the midpoint between the high- and low-emissions scenarios and approximately correspond to the warming expected under current global policies. Rows correspond to different projection probabilities. There is at least a 95% chance of SLR exceeding the values in the 'Low End' row, while there is less than a 5% chance of exceeding the values in the 'High End' row. There is at least a 66% chance that SLR will fall within the values in the 'Likely Range'. Note that alternative methods may yield higher or lower estimates of the chance of low-end and high-end outcomes.

Figure S8. Table summarizing RSL projections for New Jersey from the 2019 New Jersey Science and Technical Advisory Panel Report [35].

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Table 2.3: Global mean sea level and contiguous United States scenarios, in meters, relative to a 2000 baseline.

Global Mean Sea Level				Contiguous United States			
	2050	2100	2150		2050	2100	2150
Low	0.15	0.3	0.4	Low	0.31	0.6	0.8
Intermediate-Low	0.20	0.5	0.8	Intermediate-Low	0.36	0.7	1.2
Intermediate	0.28	1.0	1.9	Intermediate	0.40	1.2	2.2
Intermediate-High	0.37	1.5	2.7	Intermediate-High	0.46	1.7	2.8
High	0.43	2.0	3.7	High	0.52	2.2	3.9

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Table 2.4: IPCC warming level–based global mean sea level projections. Global mean surface air temperature anomalies are projected for years 2081–2100 relative to the 1850–1900 climatology. Sea level anomalies are relative to a 2005 baseline (adapted from Fox-Kemper et al., 2021). The probabilities are *imprecise probabilities*, representing a consensus among all projection methods applied. For imprecise probabilities >50%, all methods agree that the probability of the outcome stated is at least that value; for imprecise probabilities <50%, all methods agree that the probability of the outcome stated is *less than or equal to* the value stated.

Global Mean Surface Air Temperature 2081–2100	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	Unknown Likelihood, High Impact – Low Emissions	Unknown Likelihood, High Impact – Very High Emissions
Closest Emissions Scenario–Based GMSL Projection	Low (SSP1-2.6)	Low (SSP1-2.6) to Intermediate (SSP2-4.5)	Intermediate (SSP2-4.5) to High (SSP3-7.0)	High (SSP3-7.0)	Very High (SSP5-8.5)	Low (SSP1-2.6), *Low Confidence* processes	Very High (SSP5-8.5), *Low Confidence* processes
Total (2050)	0.18 (0.16–0.24)	0.20 (0.17–0.26)	0.21 (0.18–0.27)	0.22 (0.19–0.28)	0.25 (0.22–0.31)	0.20 (0.16–0.31)	0.24 (0.20–0.40)
Total (2100)	0.44 (0.34–0.59)	0.51 (0.40–0.69)	0.61 (0.50–0.81)	0.70 (0.58–0.92)	0.81 (0.69–1.05)	0.45 (0.32–0.79)	0.88 (0.63–1.60)
Bounding Median Scenarios in 2100	Low to Intermediate-Low	Intermediate-Low to Intermediate	Intermediate-Low to Intermediate	Intermediate-Low to Intermediate	Intermediate-Low to Intermediate	Low to Intermediate-Low	Intermediate-Low to Intermediate
Probability > Low (0.3 m) in 2100	92%	98%	>99%	>99%	>99%	89%	>99%
Probability > Int.-Low (0.5 m) in 2100	37%	50%	82%	97%	>99%	49%	96%
Probability > Int. (1.0 m) in 2100	<1%	2%	5%	10%	23%	7%	49%
Probability > Int.-High (1.5 m) in 2100	<1%	<1%	<1%	1%	2%	1%	20%
Probability > High (2.0 m) in 2100	<1%	<1%	<1%	<1%	< %	<1%	8%

71

72 **Figure S9.** Tables summarizing GMSL and contiguous US-average RSL scenarios from the 2022 US
73 Interagency Sea Level Scenarios report (Table 2.3) and linking the 2022 US Interagency Sea Level
74 Scenarios to the IPCC Sixth Assessment Report projections (Table 2.4) [36].

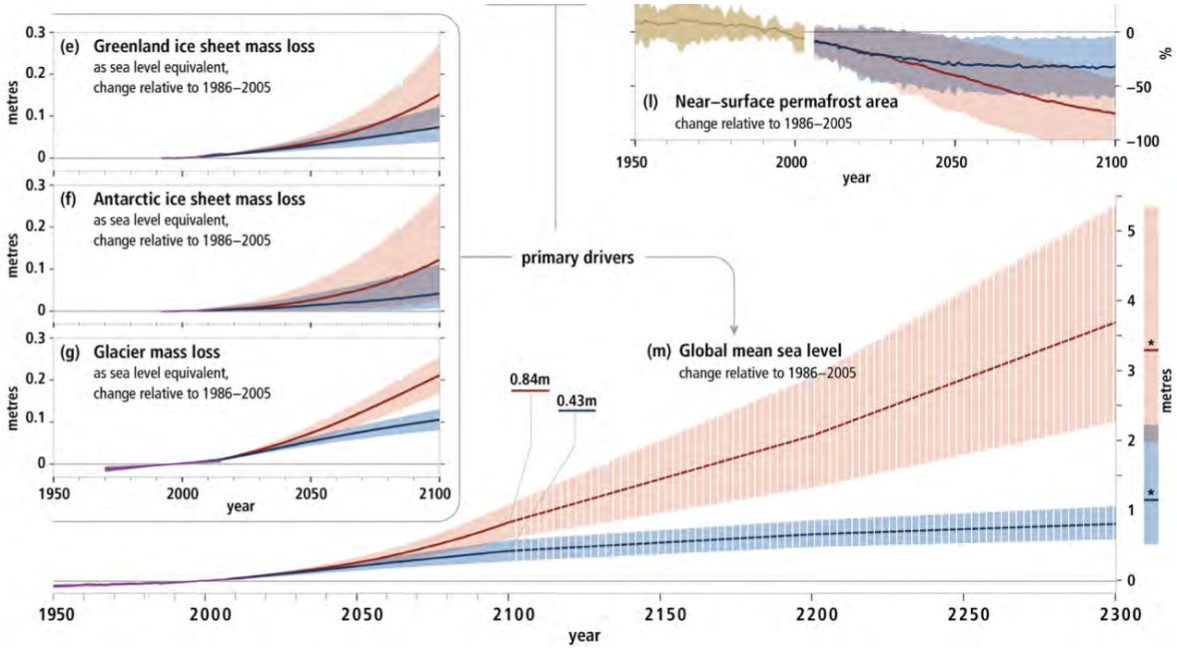

Figure S10. SPM figure from the IPCC SROCC, Figure SPM.1 [12].

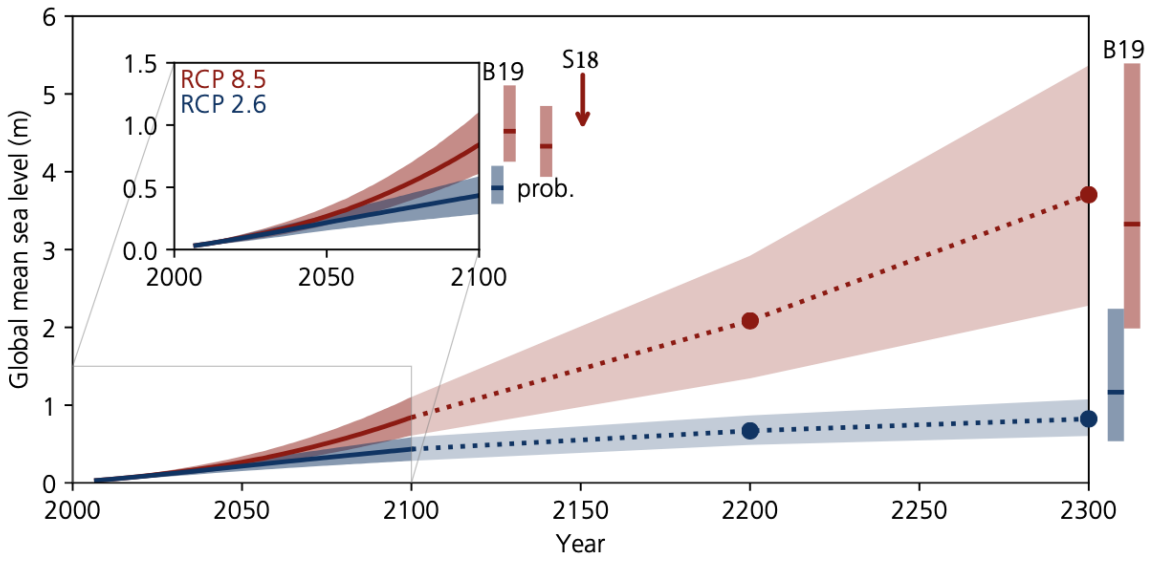

Figure 4.2: Projected sea-level rise until 2300. The inset shows an assessment of the *likely* range of the projections for RCP2.6 and RCP8.5 up to 2100 (*medium confidence*). Projections for longer time scales are highly uncertain but a range is provided (4.2.3.6). For context, results are shown from other estimation approaches in 2100. The two sets of two bars labelled B19 are from an expert elicitation for the Antarctic component (Bamber et al., 2019), and reflect the *likely* range for a 2 and 5°C temperature warming (*low confidence*; details section 4.2.3.3.1). The bar labelled "prob". indicates the *likely* range of a set of probabilistic projections (4.2.3.2). The arrow indicated by S19 shows the result of an extensive sensitivity experiment with a numerical model for the Antarctic ice sheet combined, like the results from B19 and "prob.", with results from Church et al. (2013) for the other components of sea level rise. S19 bars also show the *likely* range.

Figure S11. Chapter figure from the IPCC SROCC [11].

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Table 9.9 | Global mean sea level projections for five Shared Socio-economic Pathway (SSP) scenarios, relative to a baseline of 1995–2014, in metres. Individual contributions are shown for the year 2100. Median values (*likely* ranges) are shown. Average rates for total sea level change are shown in mm yr^{-1}. Unshaded cells represent processes in whose projections there is *medium confidence*. Shaded cells incorporate a representation of processes in which there is *low confidence*; in particular, the SSP5-8.5 *low confidence* column shows the 17th–83rd percentile range from a p-box including SEJ- and MICI-based projections rather than an assessed *likely* range. Methods are described in 9.6.3.2.

	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP5-8.5 *Low Confidence*
Thermal expansion	0.12 (0.09–0.15)	0.14 (0.11–0.18)	0.20 (0.16–0.24)	0.25 (0.21–0.30)	0.30 (0.24–0.36)	0.30 (0.24–0.36)
Greenland	0.05 (0.00–0.09)	0.06 (0.01–0.10)	0.08 (0.04–0.13)	0.11 (0.07–0.16)	0.13 (0.09–0.18)	0.18 (0.09–0.59)
Antarctica	0.10 (0.03–0.25)	0.11 (0.03–0.27)	0.11 (0.03–0.29)	0.11 (0.03–0.31)	0.12 (0.03–0.34)	0.19 (0.02–0.56)
Glaciers	0.08 (0.06–0.10)	0.09 (0.07–0.11)	0.12 (0.10–0.15)	0.16 (0.13–0.18)	0.18 (0.15–0.21)	0.17 (0.11–0.21)
Land-water Storage	0.03 (0.01–0.04)	0.03 (0.01–0.04)	0.03 (0.01–0.04)	0.03 (0.02–0.04)	0.03 (0.01–0.04)	0.03 (0.01–0.04)
Total (2030)	0.09 (0.08–0.12)	0.09 (0.08–0.12)	0.09 (0.08–0.12)	0.10 (0.08–0.12)	0.10 (0.09–0.12)	0.10 (0.09–0.15)
Total (2050)	0.18 (0.15–0.23)	0.19 (0.16–0.25)	0.20 (0.17–0.26)	0.22 (0.18–0.27)	0.23 (0.20–0.29)	0.24 (0.20–0.40)
Total (2090)	0.35 (0.26–0.49)	0.39 (0.30–0.54)	0.48 (0.38–0.65)	0.56 (0.46–0.74)	0.63 (0.52–0.83)	0.71 (0.52–1.30)
Total (2100)	**0.38 (0.28–0.55)**	**0.44 (0.32–0.62)**	**0.56 (0.44–0.76)**	**0.68 (0.55–0.90)**	**0.77 (0.63–1.01)**	**0.88 (0.63–1.60)**
Total (2150)	0.57 (0.37–0.86)	0.68 (0.46–0.99)	0.92 (0.66–1.33)	1.19 (0.89–1.65)	1.32 (0.98–1.88)	1.98 (0.98–4.82)
Rate (2040–2060)	4.1 (2.8–6.0)	4.8 (3.5–6.8)	5.8 (4.4–8.0)	6.4 (5.0–8.7)	7.2 (5.6–9.7)	7.9 (5.6–16.1)
Rate (2080–2100)	4.2 (2.4–6.6)	5.2 (3.2–8.0)	7.7 (5.2–11.6)	10.4 (7.4–14.8)	12.1 (8.6–17.6)	15.8 (8.6–30.1)

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Table 9.10 | Global mean sea level (GMSL) projections and commitments for exceedance of five global warming levels, defined by sorting GSAT change in 2081–2100 with respect to 1850–1900. Median values and (*likely*) ranges are in metres relative to a 1995–2014 baseline. Rates are in mm yr^{-1}. Unshaded cells represent processes in whose projections there is *medium confidence*. Shaded cells incorporate a representation of processes in which there is *low confidence*; in particular, the SSP5-8.5 *low confidence* column shows the 17th–83rd percentile range from a p-box, including projections based on structured expert judgement (SEJ) and marine ice cliff instability (MICI) rather than an assessed *likely* range. Methods are described in 9.6.3.2.

	1.5°C	2.0°C	3.0°C	4.0°C	5.0°C	SSP5-8.5 *Low Confidence*
Closest SSPs	SSP1-2.6	SSP1-2.6/SSP2-4.5	SSP2-4.5/SSP3-7.0	SSP3-7.0	SSP5-8.5	
Total (2050)	0.18 (0.16–0.24) m	0.20 (0.17–0.26) m	0.21 (0.18–0.27) m	0.22 (0.19–0.28) m	0.25 (0.22–0.31) m	0.24 (0.20–0.40) m
Total (2100)	**0.44 (0.34–0.59) m**	**0.51 (0.40–0.69) m**	**0.61 (0.50–0.81) m**	**0.70 (0.58–0.92) m**	**0.81 (0.69–1.05) m**	**0.88 (0.63–1.60) m**
Rate (2040–2060)	4.1 (2.9–5.7) mm yr^{-1}	5.0 (3.7–7.0) mm yr^{-1}	6.0 (4.6–8.1) mm yr^{-1}	6.4 (5.0–8.6) mm yr^{-1}	7.2 (5.7–9.8) mm yr^{-1}	7.9 (5.6–16.1) mm yr^{-1}
Rate (2080–2100)	4.3 (2.6–6.4) mm yr^{-1}	5.5 (3.4–8.4) mm yr^{-1}	7.8 (5.3—11.6) mm yr^{-1}	9.9 (7.1–14.3) mm yr^{-1}	11.7 (8.5–17.0) mm yr^{-1}	15.8 (8.6–30.1) mm yr^{-1}
2000-yr commitment	2 to 3 m	2 to 6 m	4 to 10 m	12 to 16 m	19 to 22 m	
10,000-yr commitment	6 to 7 m	8 to 13 m	10 to 24 m	19 to 33 m	28 to 37 m	

82

83 **Figure S12.** Chapter tables from the IPCC AR6 [13].

84

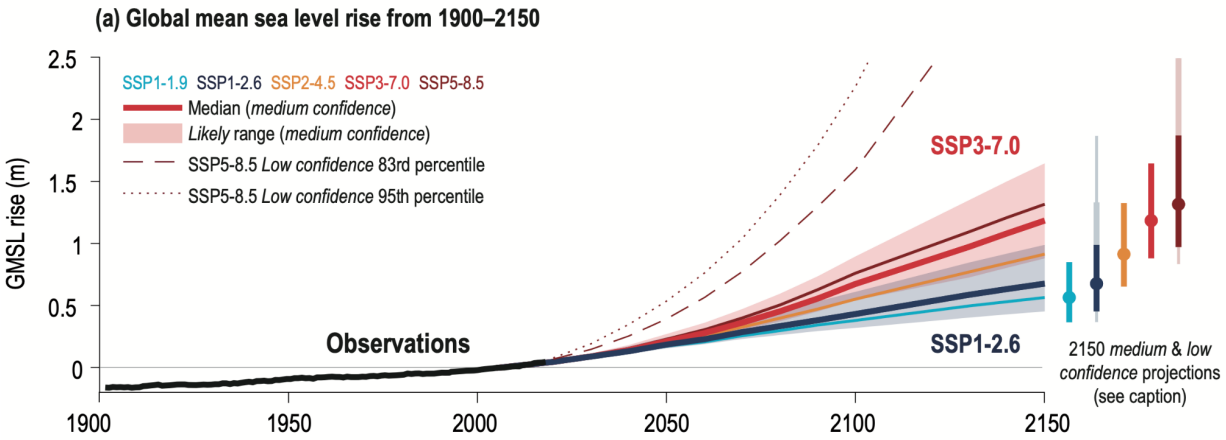

Figure S13. Technical Summary figure (Box TS.4, Fig. 1a) from the IPCC AR6 presenting GMSL time series [37]. Solid lines show median projections. Shaded regions show *medium confidence, likely* ranges from SSP1-2.6 and SSP3-7.0. Dark bars at right show 2150 *likely* ranges for all scenarios. Thick/thin lightly shaded bars show 17th-83rd/5th-95th percentile of *low confidence* projections for SSP1-2.6 and SSP5-8.5 (extending to 4.8/5.4 m for SSP5-8.5).

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