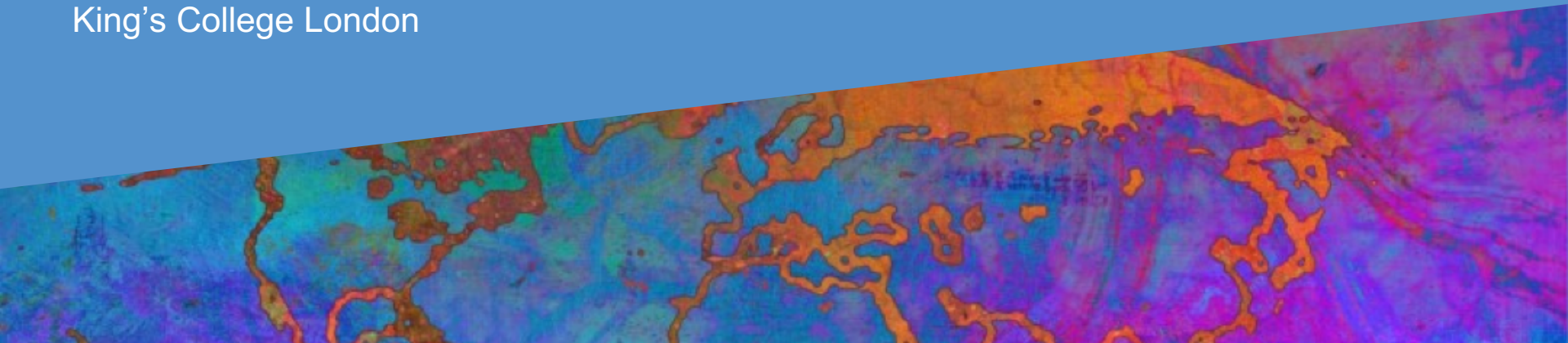


Projections for the Antarctic ice sheet contribution to sea level change

Tamsin Edwards
King's College London



What's new in the literature?

- Lots of new literature since AR5 – even since SROCC
- Wide range of model projections, particularly to 2100:
 - **ISMIP6** multi-model projections [Seroussi et al. (2021); Payne et al. (2021)]
 - Emulated [Edwards et al. (2021)]
 - **LARMIP-2** multi-model response functions (dynamic only) [Levermann et al. (2020)]
 - **Marine Ice Cliff Instability** (MICI) projections [DeConto et al. (2021)]
- Differences largely explainable by:
 - assumed probability distribution of basal melt sensitivity to ocean warming
 - ice sheet response to basal melt sensitivity and/or ice shelf collapse
- Plus **Structured Expert Judgement** (SEJ) [Bamber et al. (2019)]

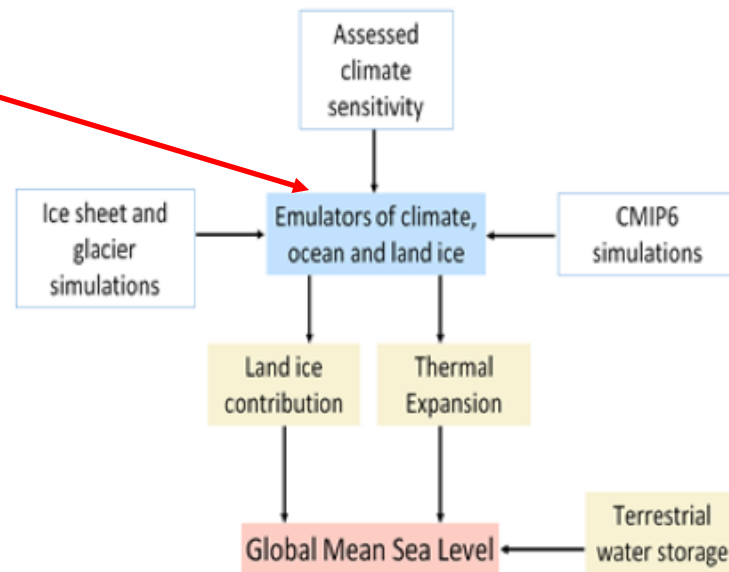
What's new in AR6?

Projections

- Forcings for ISMIP6 emulator and LARMIP = AR6 global mean temperature projections!
- Applications of existing methods beyond 2100:
 - LARMIP extension to 2300
 - constant rate of ice sheet loss

Uncertainty assessment

- p-box approach to combine estimates
- Ice sheet processes that are very uncertain / may not be fully represented in models presented separately:
 - Low Likelihood High Impact (LLHI), *low confidence*, 17th-83rd percentiles not *likely* ranges





[Credit: Shari Gearheard | NSIDC]

“ Projections to 2100

Methods: Table 9.7

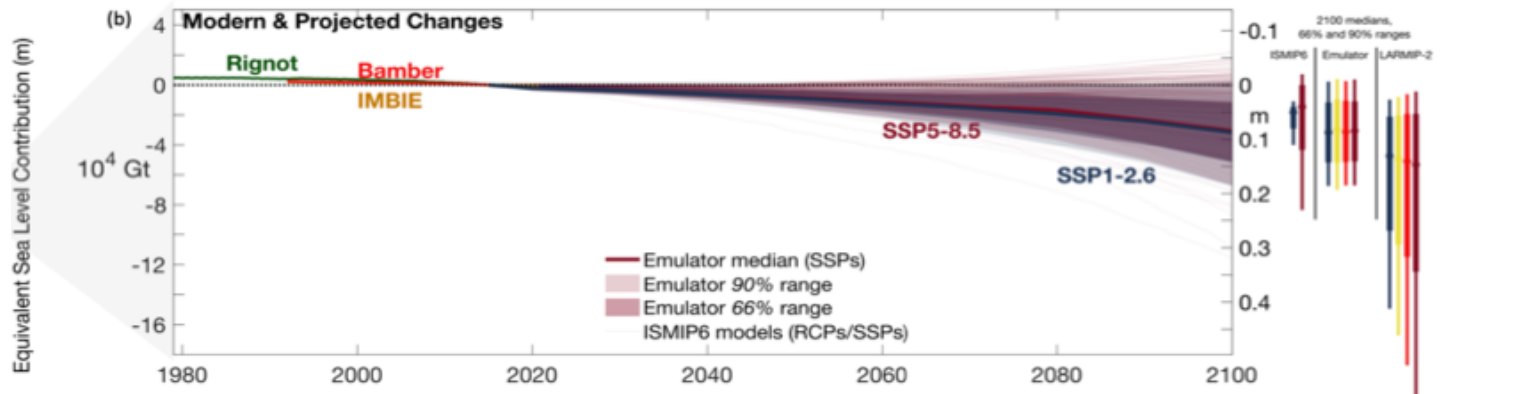
Source	AR6 Projection method
Antarctic ice sheet (excluding peripheral glaciers)	<p><i>Medium confidence</i> processes up to 2100 *:</p> <p>p-box of</p> <p>(1) Emulated ISMIP6</p> <p>(2) LARMIP-2 + AR5 surface mass balance model applied to CMIP6 models</p> <p><i>Low confidence</i> processes**:</p> <p>(1) Marine Ice Cliff Instability</p> <p>(2) Structured Expert Judgement</p>

* Forced with AR6 two-layer model GSAT projections

** 17th-83rd percentile range from p-box of *medium* and *low confidence* processes, **not an assessed *likely* range**

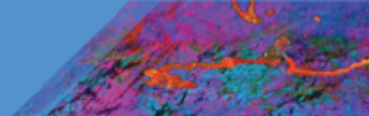
Continued ice loss over the 21st century is *likely* for the Antarctic Ice Sheet

Antarctic Ice Sheet Cumulative Mass Change & Equivalent Sea Level Contribution



ISMIP6 LARMIP-2
+
emulated

Medium confidence
processes



AR6 compared with AR5/SROCC at 2100: Table 9.8

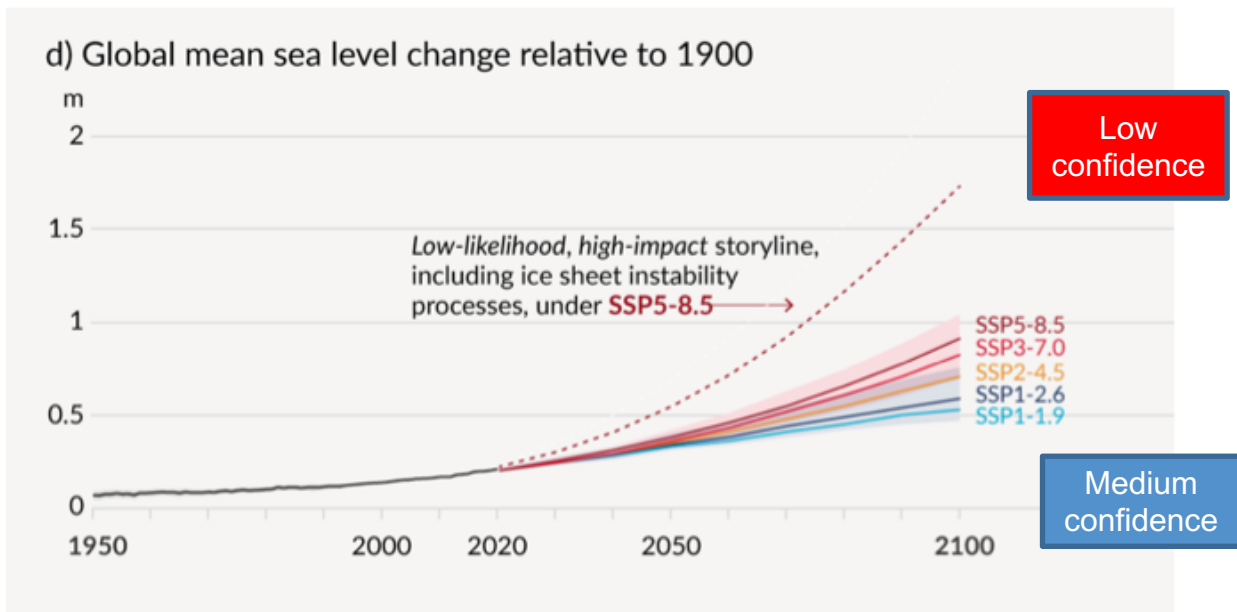
	RCP 2.6		SSP1-2.6		
m rel. to 1995-2014	AR5	SROCC	Medium confidence processes	MICI	SEJ
Antarctica	0.06 (-0.04-0.16)	0.04 (0.01-0.11)	0.11 (0.03--0.27)	0.08 (0.06--0.12)	0.09 (-0.01--0.25)

	RCP 8.5		SSP5-8.5		
	AR5	SROCC	Medium confidence processes	MICI	SEJ
	0.04 (-0.08-0.14)	0.12 (0.03-0.28)	0.12 (0.03--0.34)	0.34 (0.19--0.53)	0.21 (0.02--0.56)

Compared with SROCC:

- Low emissions: higher median and upper end
- Very high emissions: same median, higher upper end
- *Low confidence*: SEJ is also in SROCC

It is *virtually certain* that global mean sea level will continue to rise over the 21st century



84th percentile “approaching 2m”

p-box of *low confidence* ice sheet processes (SEJ and MICI):
SEJ defines this (i.e. MICI lies within it)

p-box of *medium confidence* processes (Antarctica: ISMIP6 and LARMIP2+SMB)



[Credit: Shari Gearheard | NSIDC]

“ Projections beyond 2100

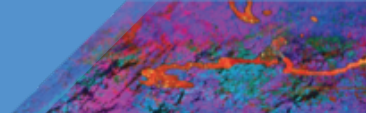
Methods: Table 9.7

Source	AR6 Projection method
Antarctic ice sheet (excluding peripheral glaciers ^a)	<p>Medium confidence processes after 2100*:</p> <p>p-box of:</p> <p>(1) AR5 parametric Antarctic ice sheet model</p> <p>(2) LARMIP-2 + AR5 SMB model</p> <p>extrapolated based on »</p> <p>(a) constant post-2100 rates, or</p> <p>(b) quadratic interpolation to multi-model assessed** 2300 range</p> <p>Low confidence processes***:</p> <p>(1) Marine Ice Cliff Instability</p> <p>(2) Structured Expert Judgement</p>

* Forced with AR6 two-layer model GSAT projections

** Post-SROCC literature assessed:
 Rodehacke et al., (2020); Lipscombe et al. (2021);
 DeConto et al. (2021); Extension of LARMIP-2 + SMB with AR6 forcing

*** as before



Projections at 2300: Table 9.11

Underlined = in Figure SPM.8 (add 0.16 m as rel. to 1900)

	Low	RCP 2.6	SSP1-2.6			
m rel. to 1995-2014	AR5	SROCC	No ice-sheet acceleration after 2100	Assessed ice-sheet contribution	MICI	SEJ
Antarctica		0.21-0.25	-0.05- 1.14	-0.14-- 0.78	0.71-- 1.35	-0.11-- 1.56

	High	RCP 8.5	SSP5-8.5			
m rel. to 1995-2014	AR5	SROCC	No ice-sheet acceleration after 2100	Assessed ice-sheet contribution	MICI	SEJ
Antarctica	0.02-0.19	0.60-2.89	-0.39--1.55	-0.28-- 3.13	6.87-- 13.54	0.03-- 3.05

Compared with SROCC:

- Wider ranges, particularly at upper end:
 - ~1m higher under SSP1-2.6
 - MICI **much higher** than DeConto and Pollard (2016) under SSP5-8.5, largely due to higher maximum ice-cliff calving rate

Beyond 2100, global mean sea level will continue to rise for centuries due to continuing deep ocean heat uptake and mass loss of the ice sheets (*high confidence*)

By 2300, GMSL will rise

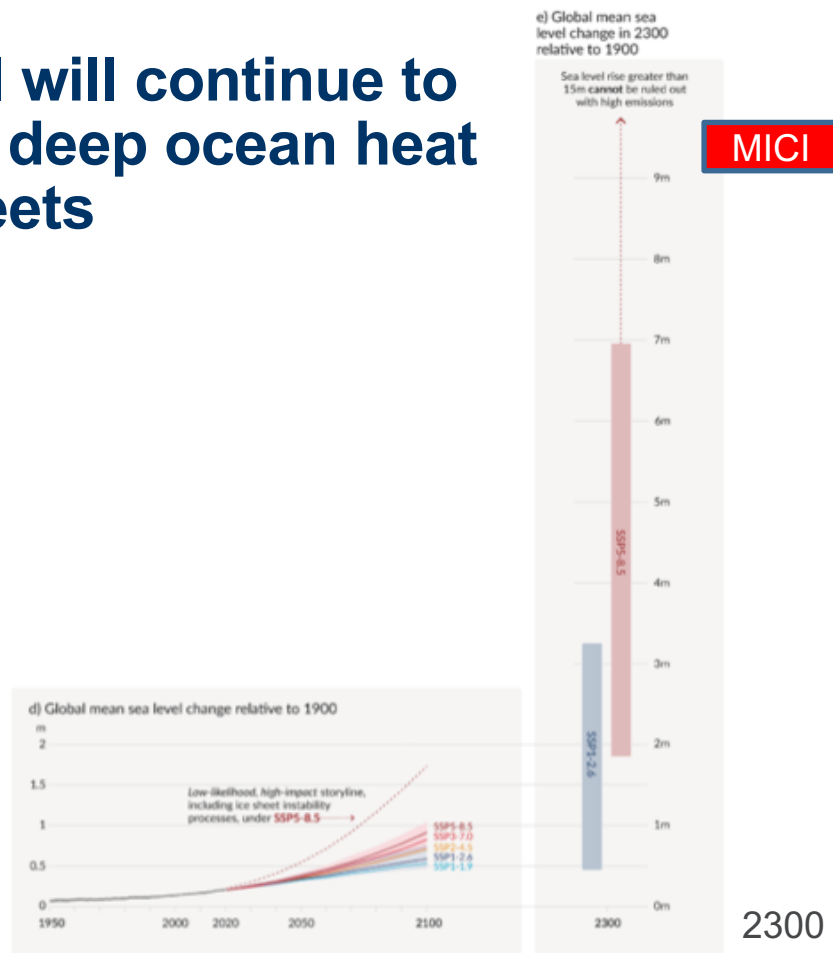
between 0.3 m and 3.1 m under SSP1-2.6

between 1.7 m and 6.8 m under SSP5-8.5 in the absence of Marine Ice Cliff Instability

and **greater than 15 m cannot be ruled out** under SSP5-8.5 considering Marine Ice Cliff Instability

(*low confidence*)

Figure SPM.8





[Credit: Shari Gearheard | NSIDC]

“ There’s no going back from some changes in the climate system. However, some changes could be slowed and others could be stopped by limiting warming.

SIXTH ASSESSMENT REPORT

Working Group I – The Physical Science Basis

Thank you.

More Information:

IPCC: www.ipcc.ch

Many thanks to:

Chapter scientists Gregory Garner & Tim Hermans

The Chapter 9 Author Team

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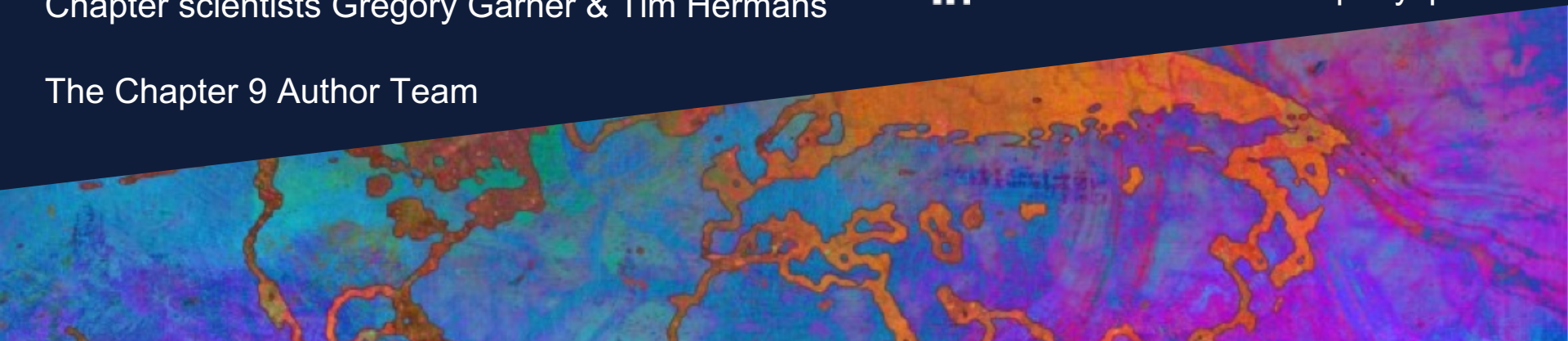
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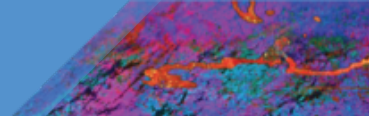


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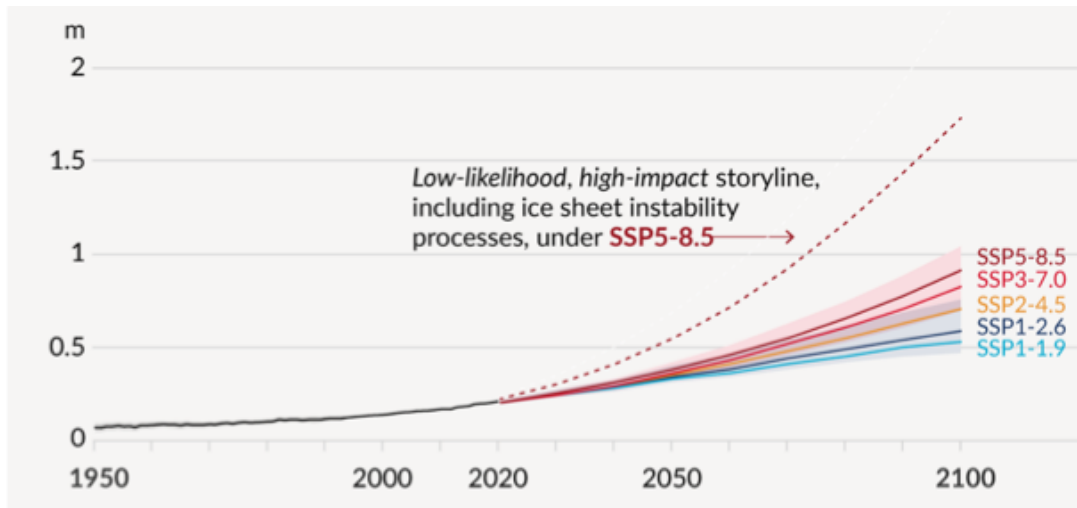
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GMSL projections at 2100: Table 9.9

	SSP1-1.9	SSP1-2.6	SSP2-4.5	SSP3-7.0	SSP5-8.5	SSP5-8.5 Low Confidence
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)
Total (2100)	<u>0.38</u> (0.28--0.55)	<u>0.44</u> (0.32--0.62)	<u>0.56</u> (0.44--0.76)	<u>0.68</u> (0.55--0.90)	<u>0.77</u> (0.63--1.01)	0.88 (0.63-- <u>1.60*</u>)



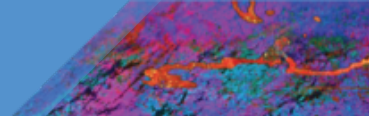
Antarctic *medium confidence*:
p-box of emulated ISMIP6 and LARMIP-2

Low confidence: p-box of *medium confidence*,
MICI for Antarctica, SEJ for ice sheets

Red = quoted in SPM text

* “approaching 2m”

Underlined = shown in Figure SPM.8
(add 0.16 m as rel. to 1900)

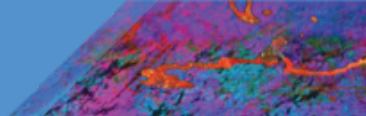


AR6 compared with AR5/SROCC at 2100: Table 9.8

	RCP 2.6		SSP1-2.6			RCP 8.5		SSP5-8.5		
m rel. to 1995-2014	AR5	SROCC	Medium confidence processes	MICI	SEJ	AR5	SROCC	Medium confidence processes	MICI	SEJ
Antarctica	0.06 (-0.04-0.16)	0.04 (0.01-0.11)	0.11 (0.03--0.27)	0.08 (0.06--0.12)	0.09 (-0.01--0.25)	0.04 (-0.08-0.14)	0.12 (0.03-0.28)	0.12 (0.03--0.34)	0.34 (0.19--0.53)	0.21 (0.02--0.56)
Total (2100)	0.41 (0.25-0.58)	0.40 (0.26-0.56)	<u>0.44</u> (0.32--0.62)	0.41 (0.35--0.48)	0.53 (0.38--0.79)	0.71 (0.49-0.95)	0.81 (0.58-1.07)	<u>0.77</u> (0.63--1.01)	0.99 (0.82--1.19)	1.00 (0.70-- 1.60)*

Red = in SPM text

Underlined = in Figure SPM.8
(add 0.16 m as rel. to 1900)



Projections at 2300: Table 9.11

Underlined = in Figure SPM.8 (add 0.16 m as rel. to 1900)

	Low	RCP 2.6		SSP1-2.6			
m rel. to 1995-2014	AR5	SROCC	Post-AR5 Published range	No ice-sheet acceleration after 2100	Assessed ice-sheet contribution	MICI	SEJ
Antarctica	0.21-0.25			-0.05-1.14	-0.14--0.78	0.71--1.35	-0.11--1.56
Total (2300)	0.38-0.82	0.57-1.04	<u>0.3</u> --2.9	0.8-2.0	0.6--1.5	1.4--2.1	1.0-- <u>3.1</u>

	High	RCP 8.5		SSP5-8.5			
m rel. to 1995-2014	AR5	SROCC	Post-AR5 Published range without (with) MICI	No ice-sheet acceleration after 2100	Assessed ice-sheet contribution	MICI	SEJ
Antarctica	0.02-0.19	0.60-2.89		-0.39--1.55	-0.28--3.13	6.87--13.54	0.03--3.05
Total (2300)	0.89-3.56	2.25-5.34	<u>1.7--6.8</u> (up to 14.1)	1.7-4.0	2.2--5.9	9.5-- <u>16.2*</u>	2.4--6.3

* “greater than 15m”

Estimates for AR6:

- No ice-sheet acceleration after 2100: extrapolation with constant rate of mass loss
- Assessed ice-sheet contribution: range of literature including extension of LARMIP-2

yellow = see next slide for studies

GMSL projections to 2300 in literature (Table 9.SM.8)

Study	Grouping	RCP 2.6		RCP 4.5		RCP 8.5	
		67%	90%	67%	90%	67%	90%
Kopp et al., (2014)	MED	0.3--2.9	-0.2--4.7	0.7--3.5	0.0--5.3	1.8--5.2	1.0--7.4
Nauels et al., (2017)	MED	0.8--1.4		1.8--2.3		3.4--6.8	
Palmer et al. (2020)*	MED	0.6--2.2		0.9--2.6		1.7--4.5**	
Kopp et al., (2017)	MICI	0.8--2.3	0.5--3.0	2.8--6.0	2.1--7.0	9.8--14.1	9.1--15.5
Bamber et al. (2019)‡	SEJ	1.2--3.6*	0.5--5.3			2.6--6.5	1.8--11.8
Horton et al. (2020)	Survey	0.54-2.15	0.24-3.11			1.67-5.61	0.88-7.83

* Corrected to 3.1 m using AR6 for non-land ice contributions

** 5-95th percentiles interpreted as 17th-83rd