Long-term Antarctic ice sheet projections with a historically-calibrated ice-sheet model

OR How can the past decades help up better understand future Antarctic ice loss?

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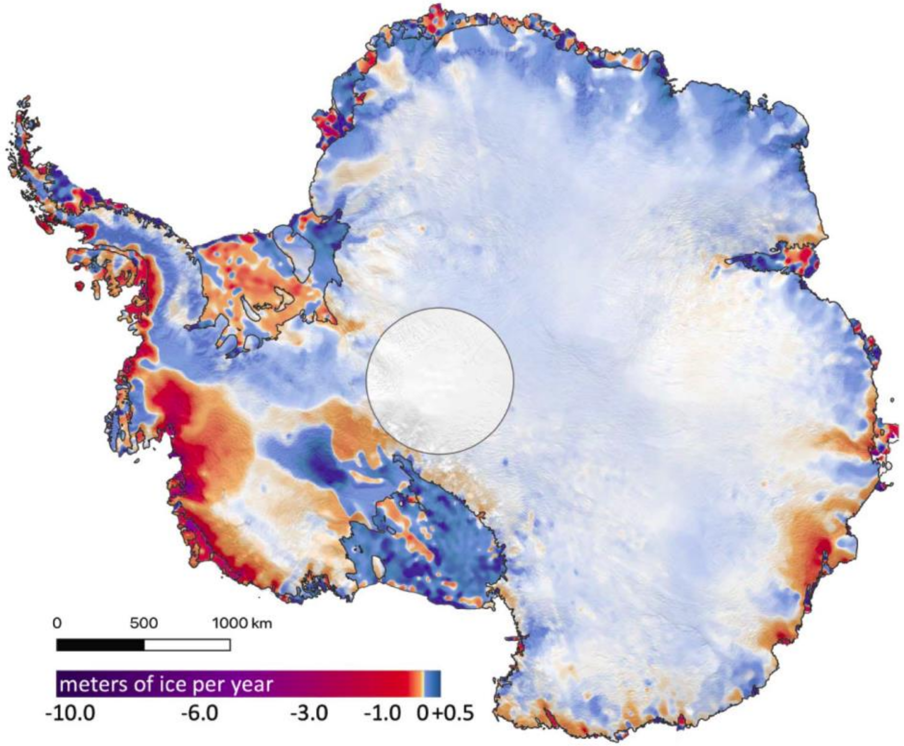
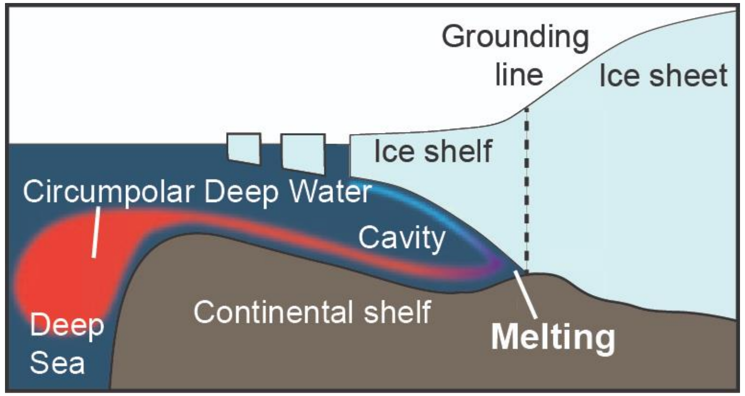
Current Antarctic ice loss is mainly driven by the ocean...

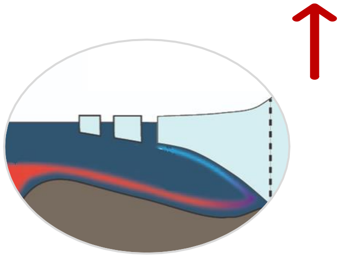
Mass loss from
Antarctica (2003 to 2019)
From Smith et al., 2020





From www.bas.ac.uk

... but its future evolution under a warming climate remains uncertain

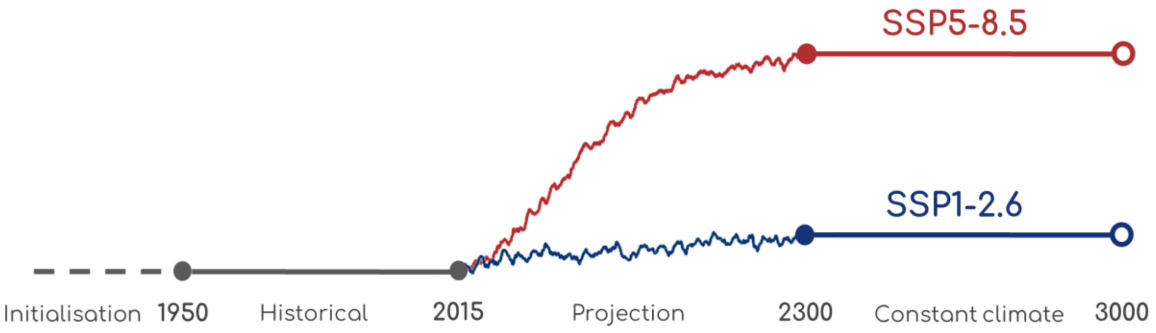


sub-shelf melt

snow accumulation

surface runoff

Using the ice-sheet model Kori, we run an ensemble of simulations covering uncertainties in ice-ocean and ice-atmosphere interactions

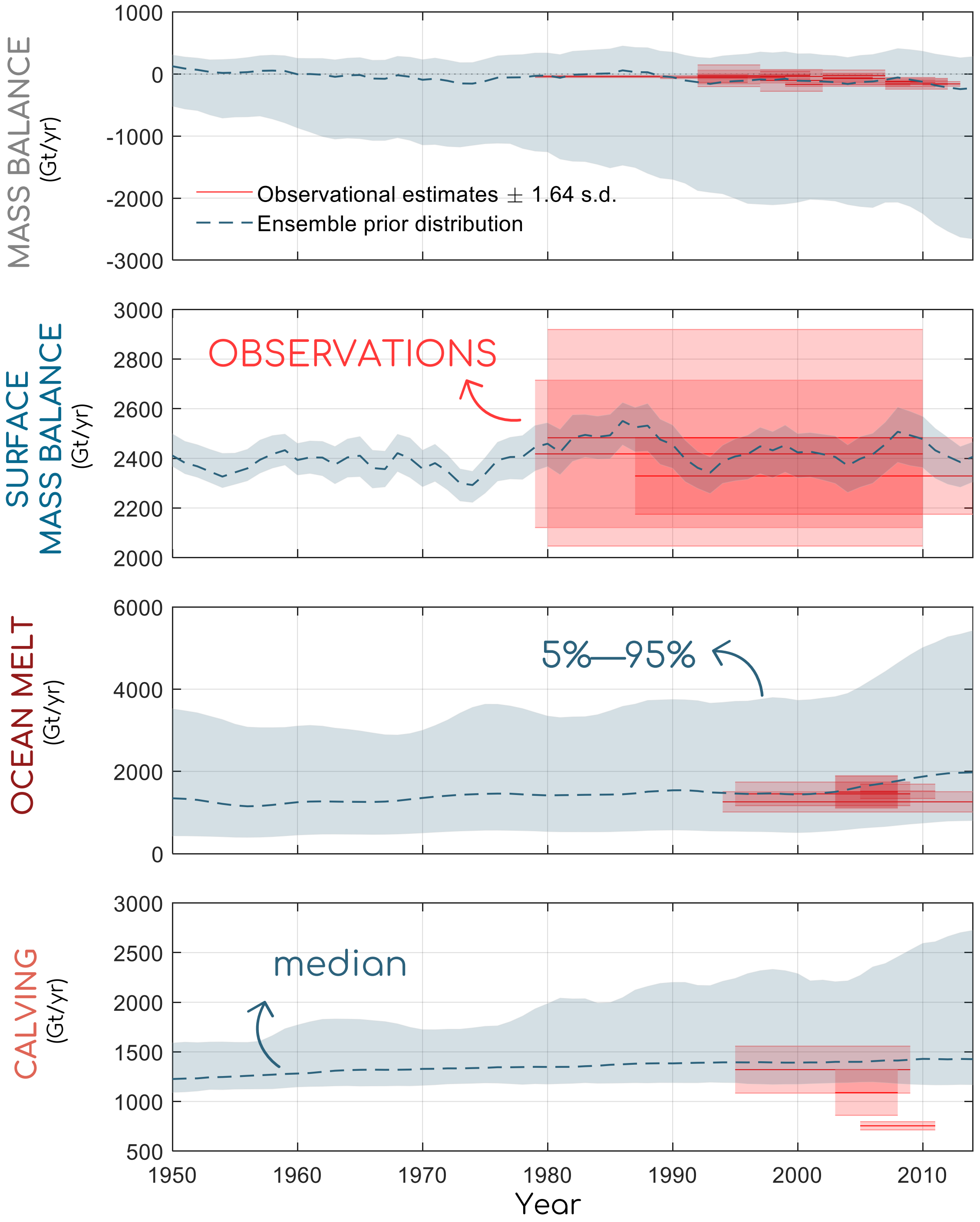


CMIP6 GCM applied for the climate forcing	MRI-ESM2-0 UKESM1-0-LL CESM2-WACCM IPSL-CM6A-LR	
Atmospheric present-day climatology	RACMO2.3p2 MAR3.11	
Atmospheric lapse rate	5-12 °C/km	
Refreezing thermally-active layer	0 - 15 m	
PDD ice melt factor	4 - 12 w.e. mm/PDD	
PDD snow melt factor	0 - 6 w.e. mm/PDD	
Oceanic present-day climatology	Schmidtko et al. (2014) ISMIP6 (Jourdain et al., 2020)	
Sub-shelf melt parameterisation	PICO model (Reese et al., 2018) Plume model (Lazeroms et al., 2019) Quadratic local (Burgard et al., 2023) ISMIP6 non-local (Jourdain et al., 2020) ISMIP6 non local slope (Jourdain et al., 2020)	
Effective ice-ocean heat flux	γ_T^* $C_d^{1/2}\Gamma_{TS}$ K γ_0 γ_0	0.1 – 10 x 10^{-5} m/s 1 – 10 x 10^{-4} 1 – 10 x 10^{-4} 1 – 4 x 10^{4} m/yr 1 – 4 x 10^{6} m/yr

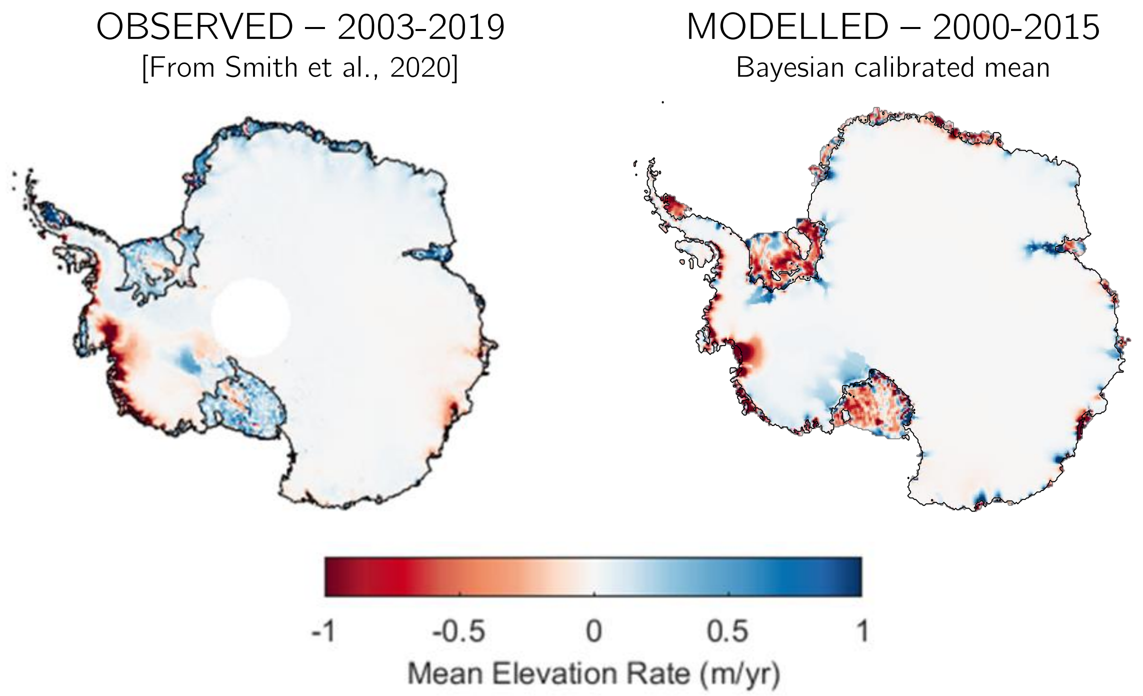
We perform a Bayesian calibration using satellite-based estimates of regional mass balance over the historical period

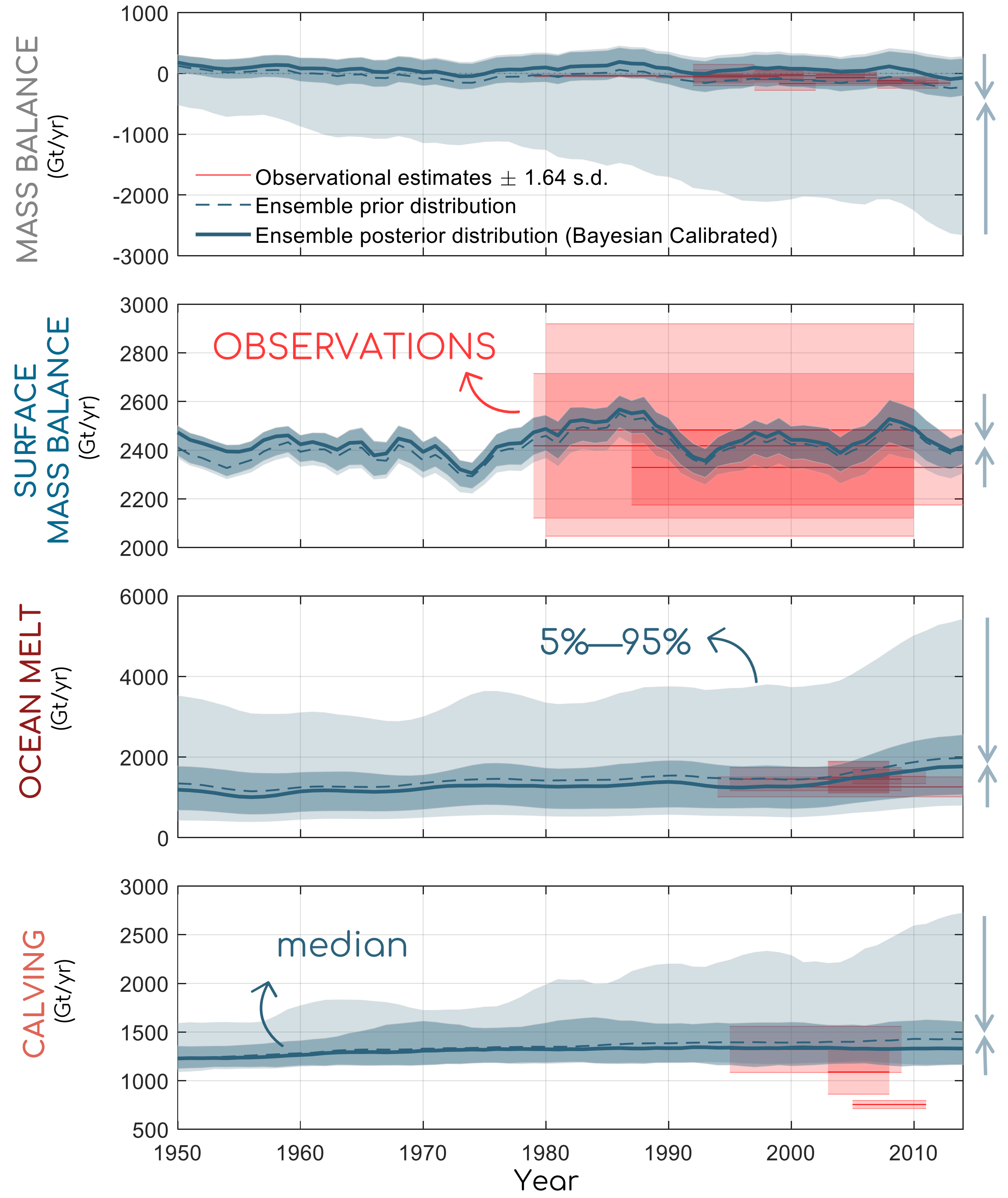
Data used for the calibration: rates of ice sheet mass change
(IMBIE – Otosaka et al., 2023)

	WAIS (Gt/yr)	EAIS (Gt/yr)	Peninsula (Gt/yr)
1992 – 1996	-37 ± 19	-27 ± 33	-7 ± 11
1997 – 2001	-42 ± 19	21 ± 32	2 ± 11
2002 – 2006	-64 ± 20	21 ± 34	-20 ± 11
2007 – 2011	-129 ± 23	19 ± 36	-21 ± 12

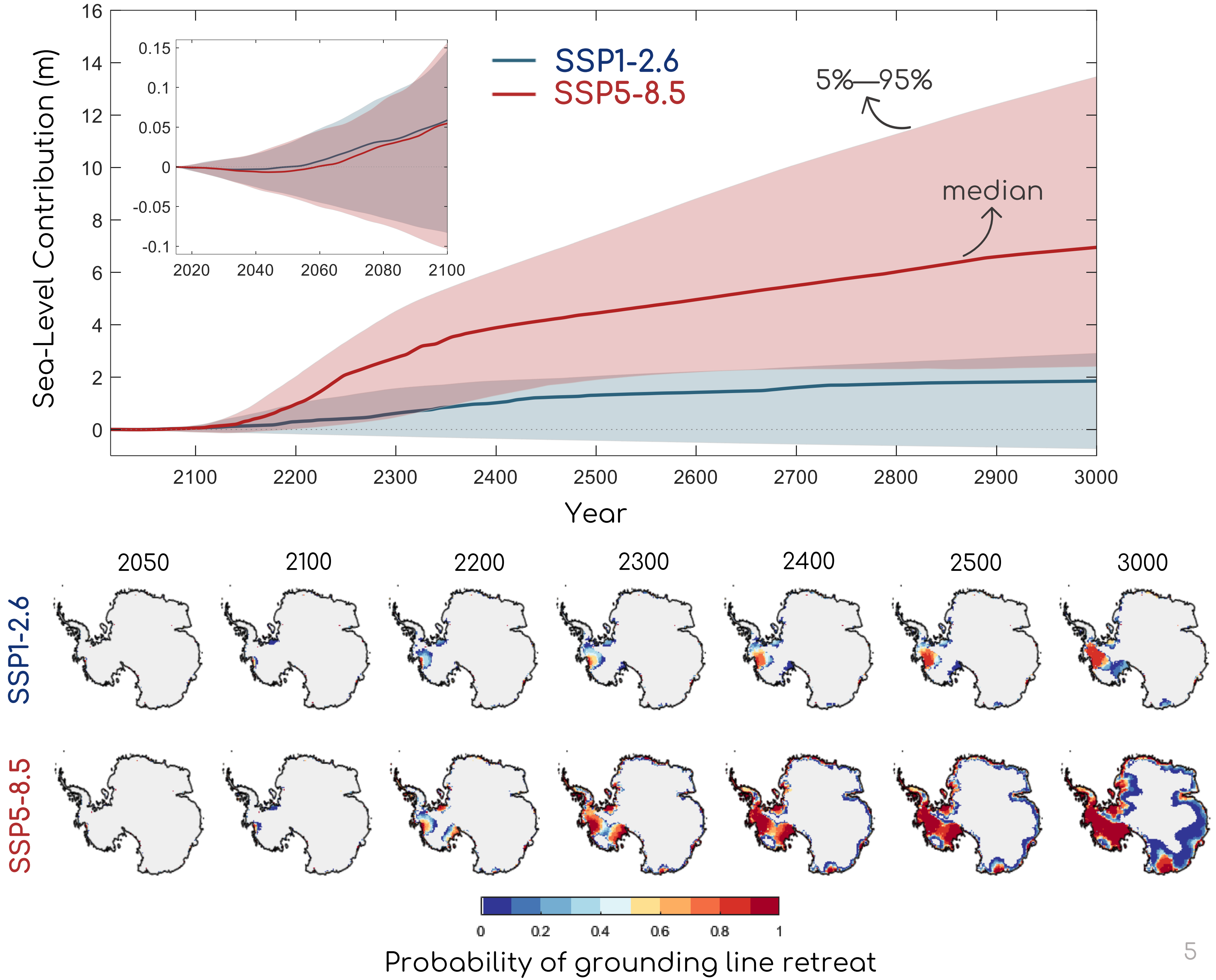


- Calibrating allows to reduce the spread in ice-sheet response.
- The calibrated ensemble reproduces the historical trends in good agreement with observations



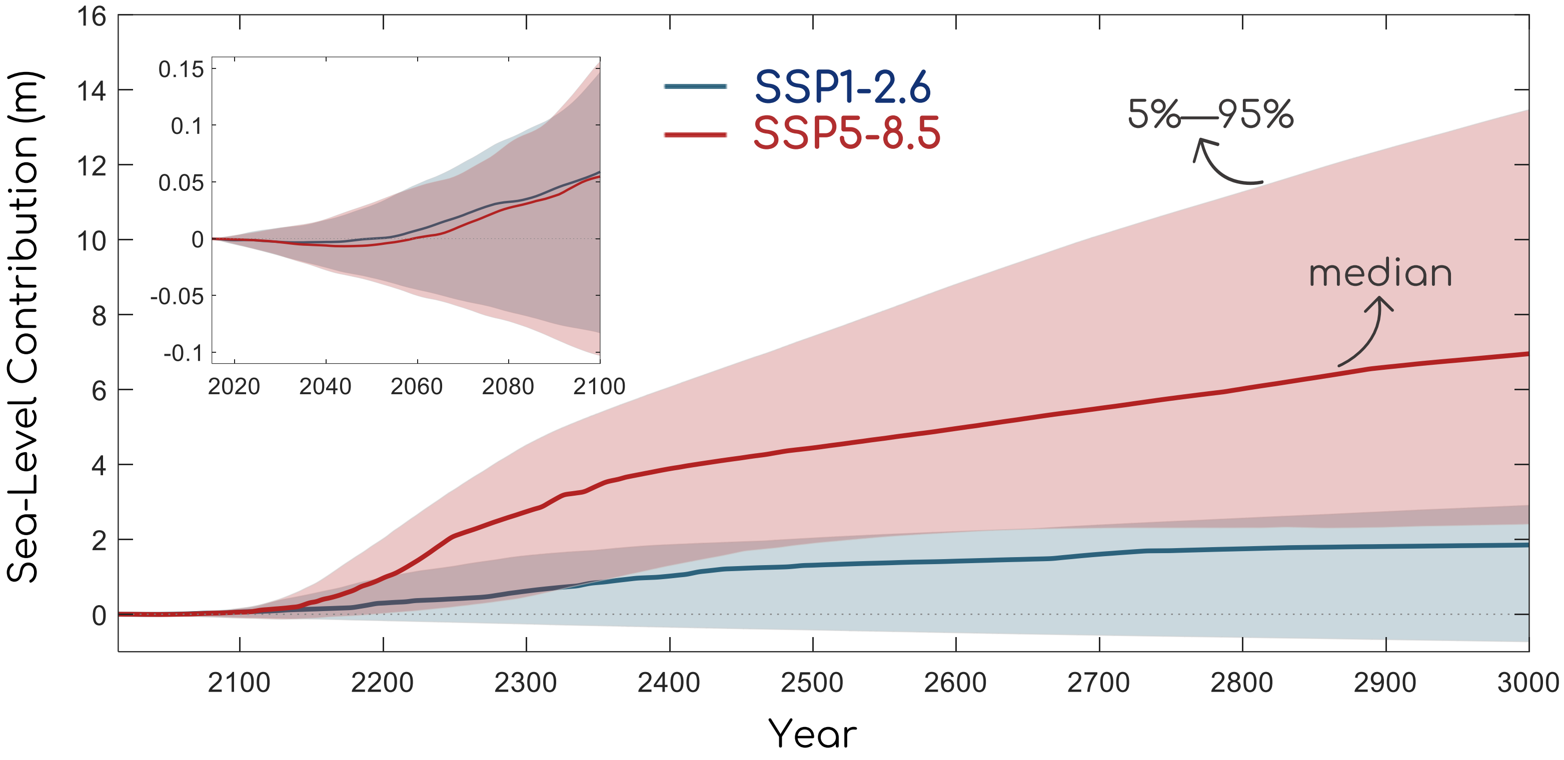


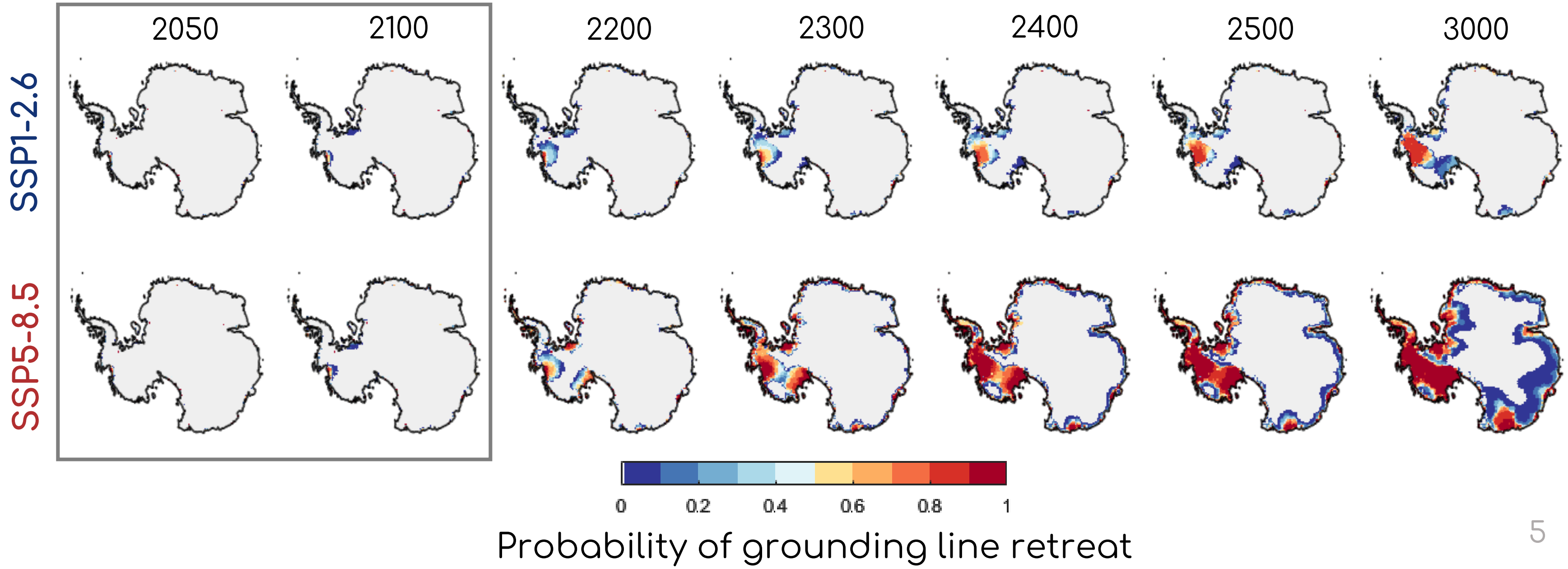
Calibrated projections



Calibrated projections

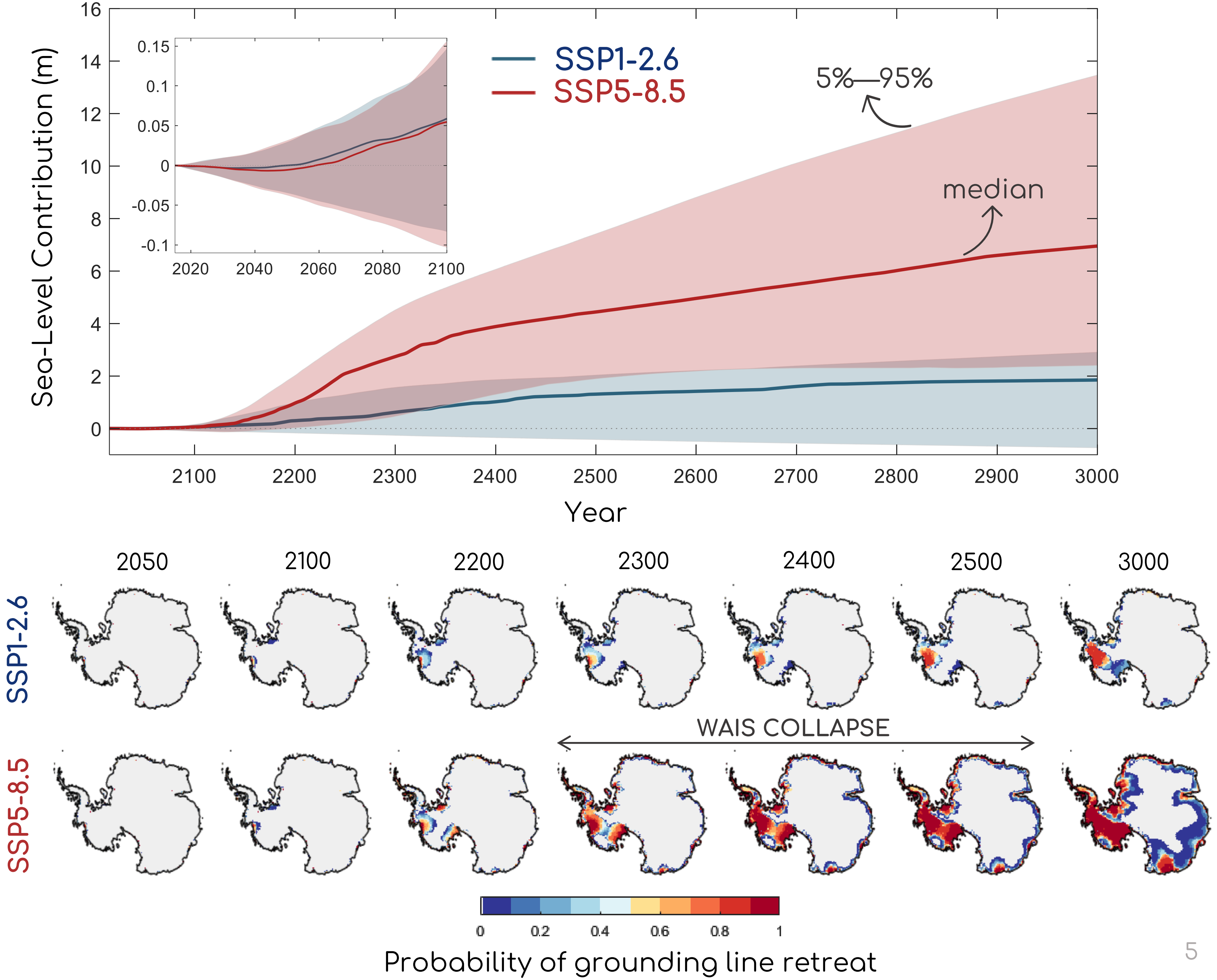
- No clear dependence on scenario by **2100**



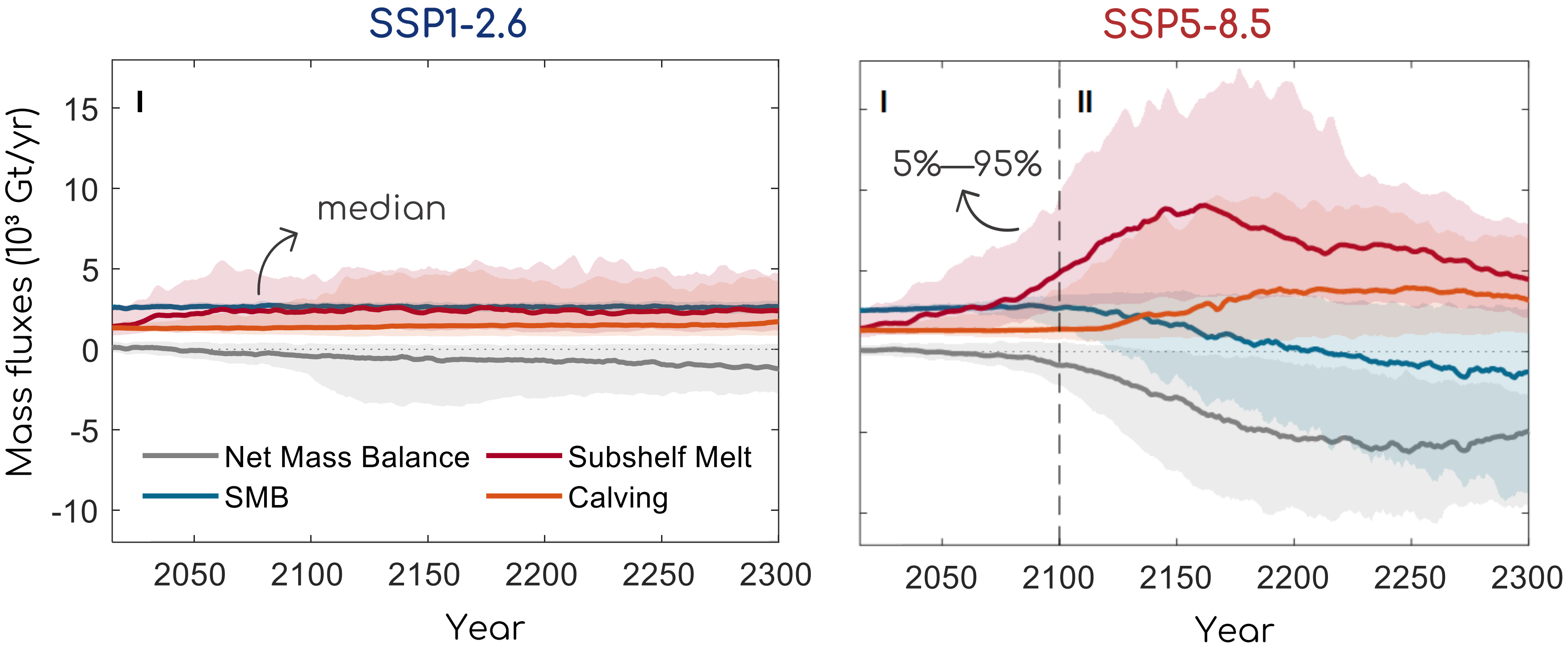


Calibrated projections

- No clear dependence on scenario by **2100**
- **Retreat in the ASE,** even under limited warming
- **WAIS collapse** expected to be completed between 2300 and 2500 under **SSP5-8.5**

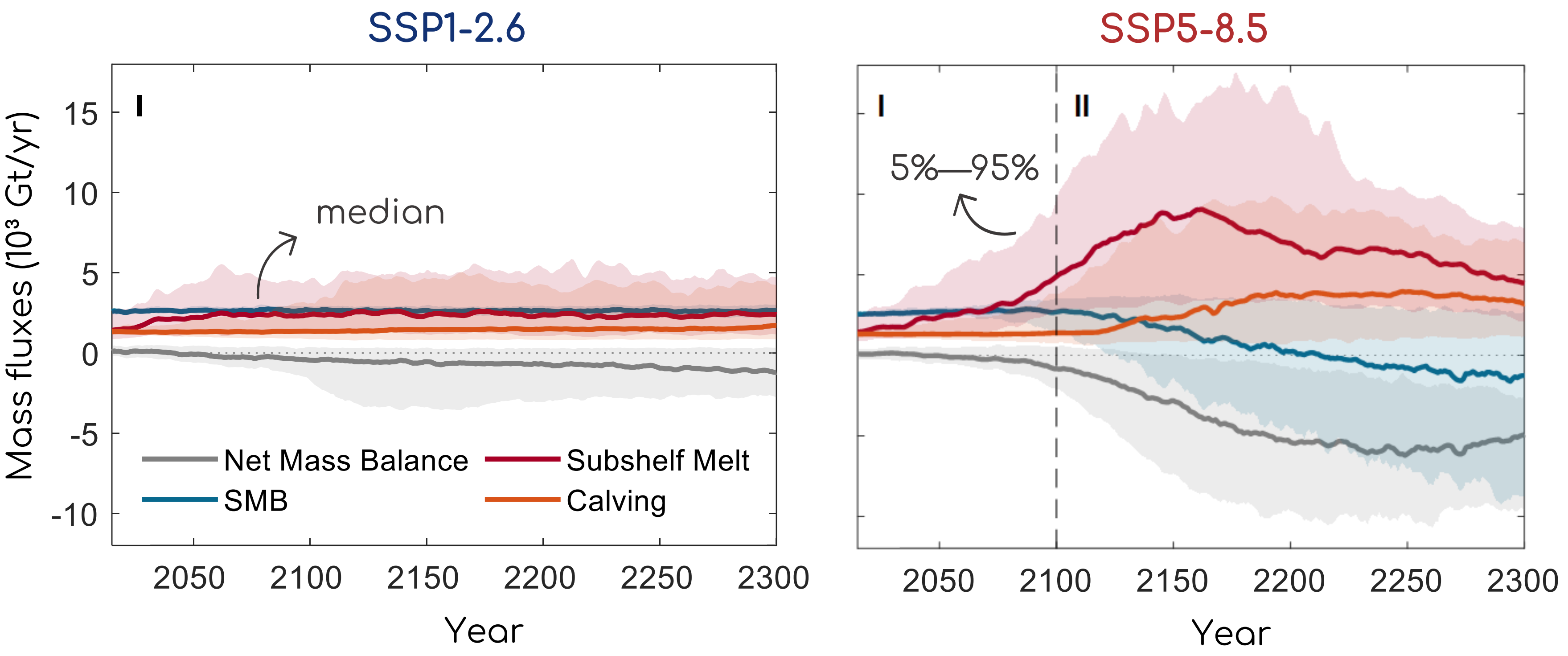


The drivers of ice loss



The drivers of ice loss

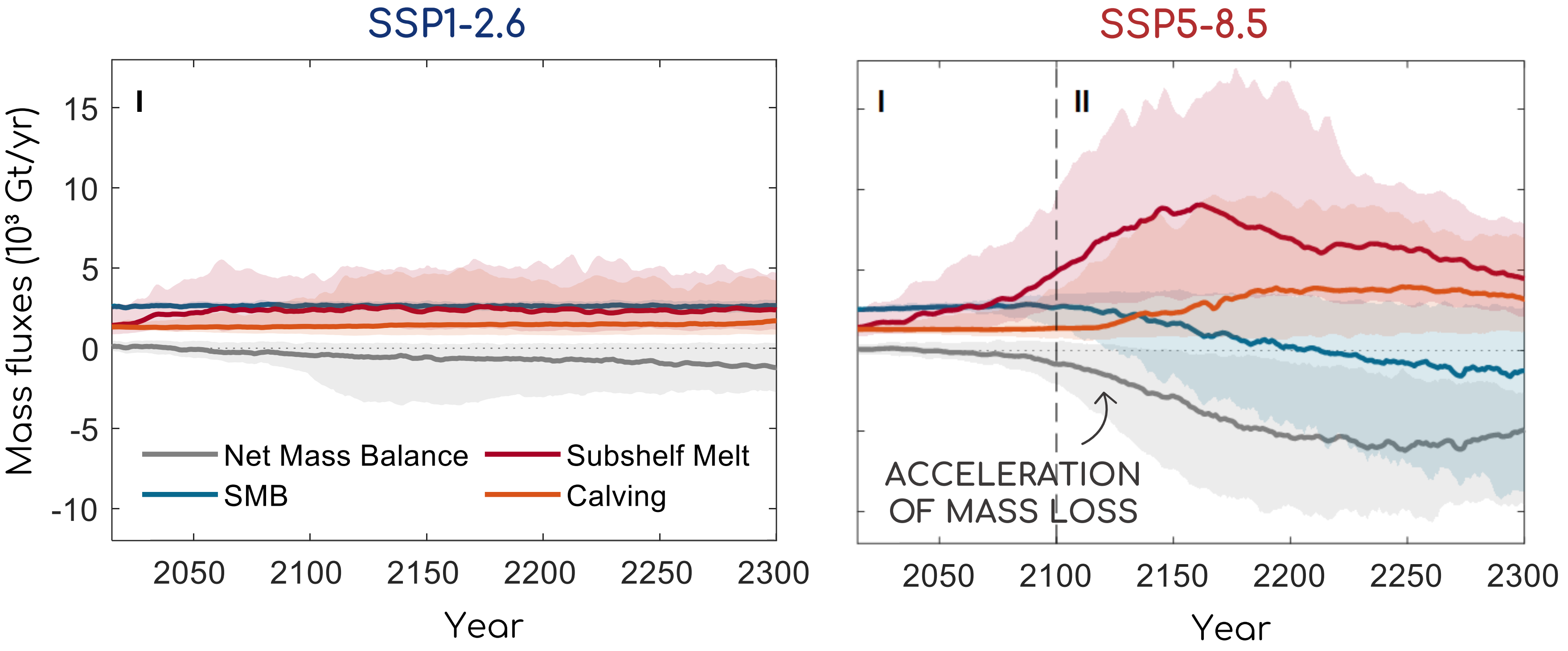
I. Short-term ice loss driven by the ocean, triggering retreat in West Antarctica, even under limited warming



The drivers of ice loss

I. **Short-term ice loss** driven by the ocean, triggering retreat in West Antarctica, even under limited warming

II. **Acceleration of ice loss in conjunction with a** decrease in surface mass balance



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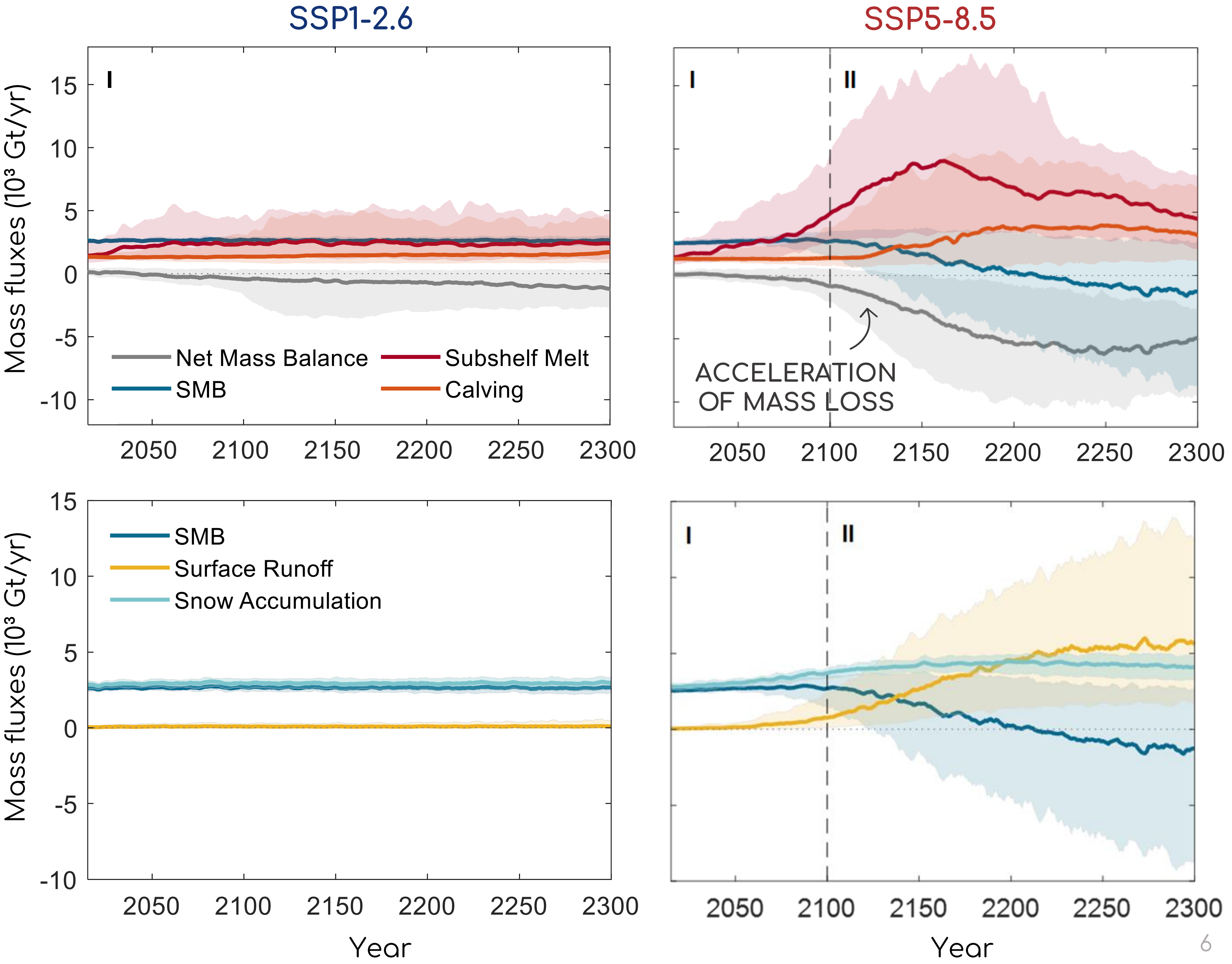
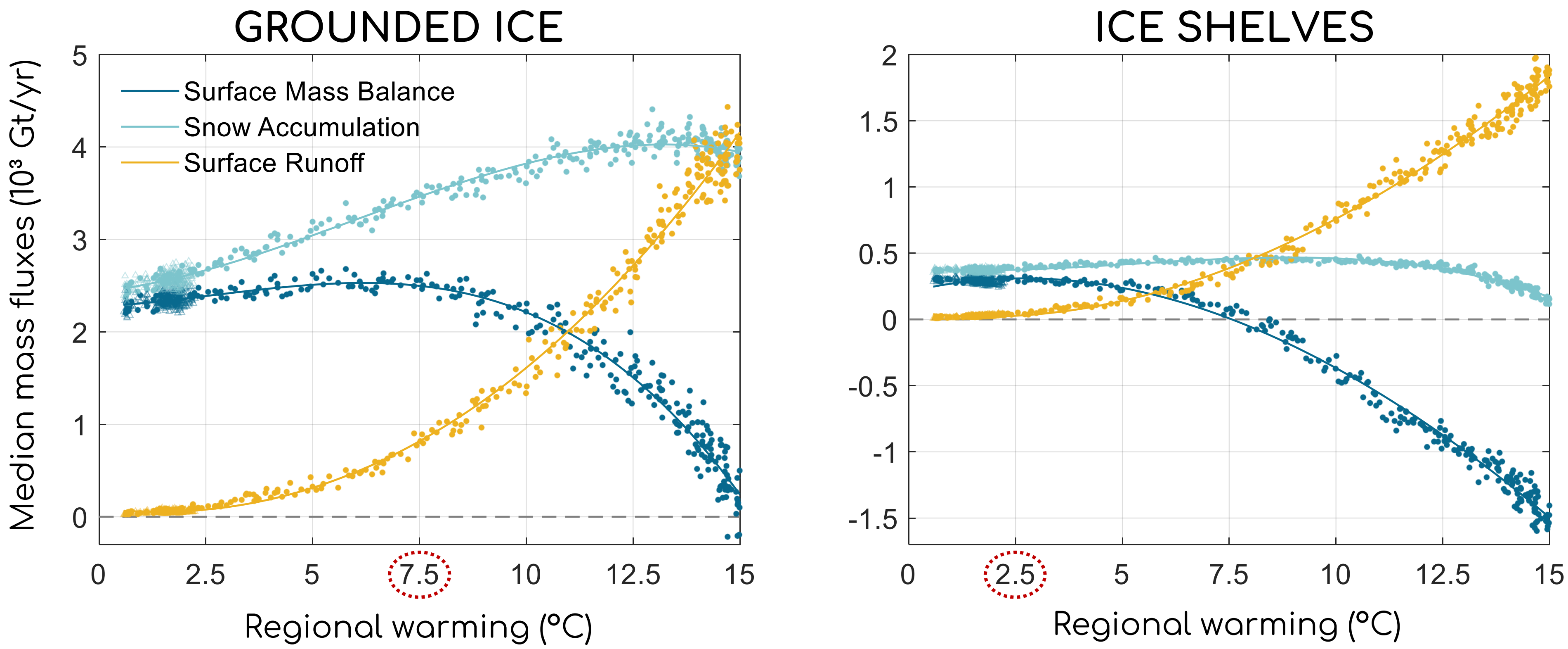


If near-surface warming exceeds +7.5°C, the **atmosphere** will **shift** from a **mitigating** to an **amplifying** factor of **Antarctic mass loss**



+7.5°C
regional warming

SMB sea-level **mitigating potential decreases** as **increase** in runoff outweighs **increase in** snow accumulation

SUMMARY

Check out our new preprint for more details!

- **New observationally-calibrated projections of long-term Antarctic ice loss**

- **Ocean main driver of Antarctic short term ice loss,** leading to significant retreat in the WAIS, even under limited warming

- **Major ice loss expected** when **increase in surface runoff outweighs increase in snow accumulation** (**+7.5°C** regional warming)

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