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Antarctic Peninsula warming triggers enhanced basal melt rates throughout West Antarctica

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Table S1
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Table S1: Ice-shelf basal melt rates (mean and standard deviation, STD) for the Bellingshausen and Amundsen seas, as diagnosed from the WAIS 1080 model control run for 1993—2019 (left columns). Observational estimates of ice-shelf melt rates from Rignot et al. (*50*) for 2003—2008 (right columns) are also provided.

Ice Shelf	**Model**		**Observations**	
	Mean m yr^{-1}	**STD m yr^{-1}**	**Mean m yr^{-1}**	**STD m yr^{-1}**
Wordie	2.4	0.8	23.6	1.0
Wilkins	0.8	0.3	1.5	1.0
Bach	0.9	0.2	2.3	0.3
George VI	2.9	0.4	3.8	0.7
Stange	1.4	0.2	3.5	0.7
Feringo	49.1	11.2	43.4	17.0
Venable	10.7	1.7	6.1	0.7
Abbot	2.5	0.8	1.7	0.6
Cosgrove	2.4	0.6	2.8	1.0
Pine Island	22.4	2.1	16.2	1.0
Thwaites	22.9	3.2	17.7	1.0
Crosson	18.7	2.8	11.9	1.0
Dotson	9.4	1.2	7.8	0.6
Getz	5.1	0.5	4.3	0.4
Land	2.4	0.3	5.9	2.0
Nickerson	1.1	0.3	0.6	0.3
Sulzberger	2.4	0.3	1.5	0.3
Swinburne	3.5	0.2	4.2	0.6
Withrow	0.9	0.3	0.5	0.6

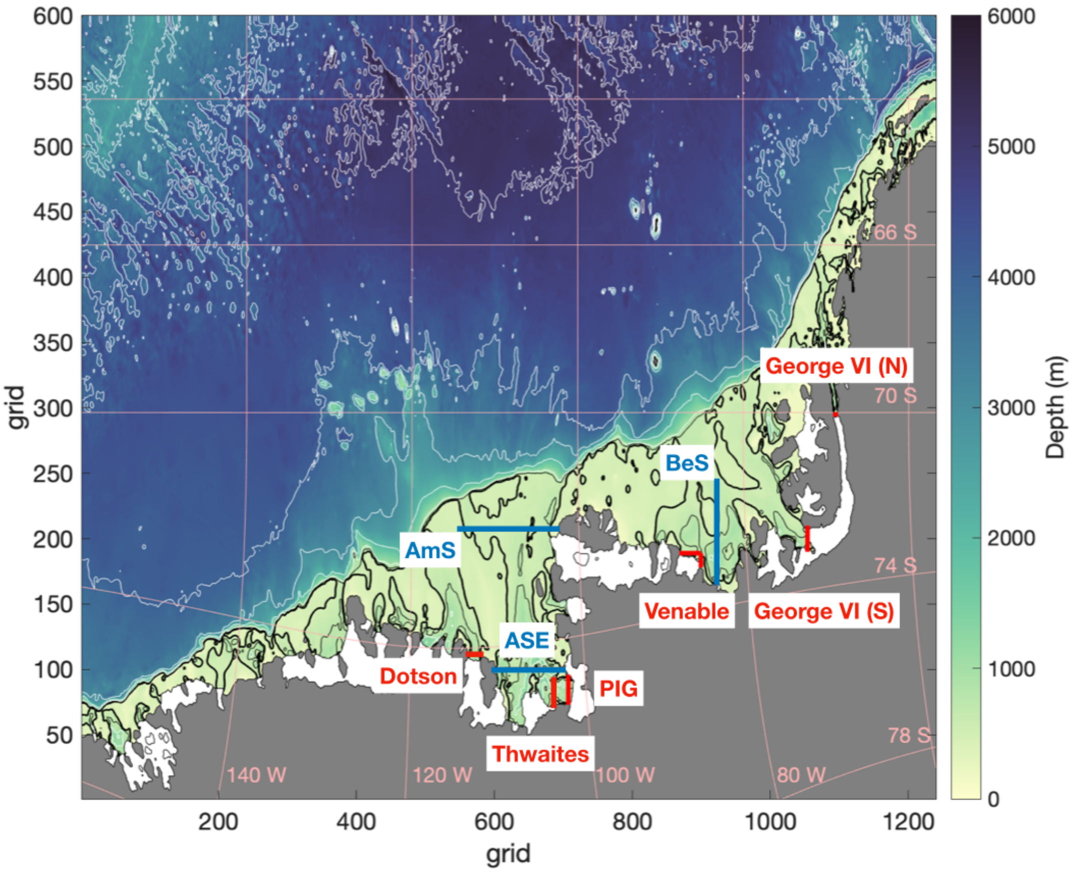


Fig. S1. Bathymetry of the WAIS 1080 model domain.

Deep troughs in the continental shelf connect the open ocean to the main ice shelves (labeled in red). The thick black contour shows the 500 m isoline. White contours show bathymetry isolines with 1000-m separation, starting from 1000 m depth. Parallels and meridians are shown as pink contour lines. Sections in front of ice shelves analyzed in this study are marked in red. Additional sections are marked in blue: the Amundsen Sea Embayment (ASE) section is shown in Fig. 6; the Bellingshausen Sea (BeS) section (along 87 ^{o}W) is shown in fig. S6; the shelf break section in the Amundsen Sea (AmS) is shown in fig. S10.

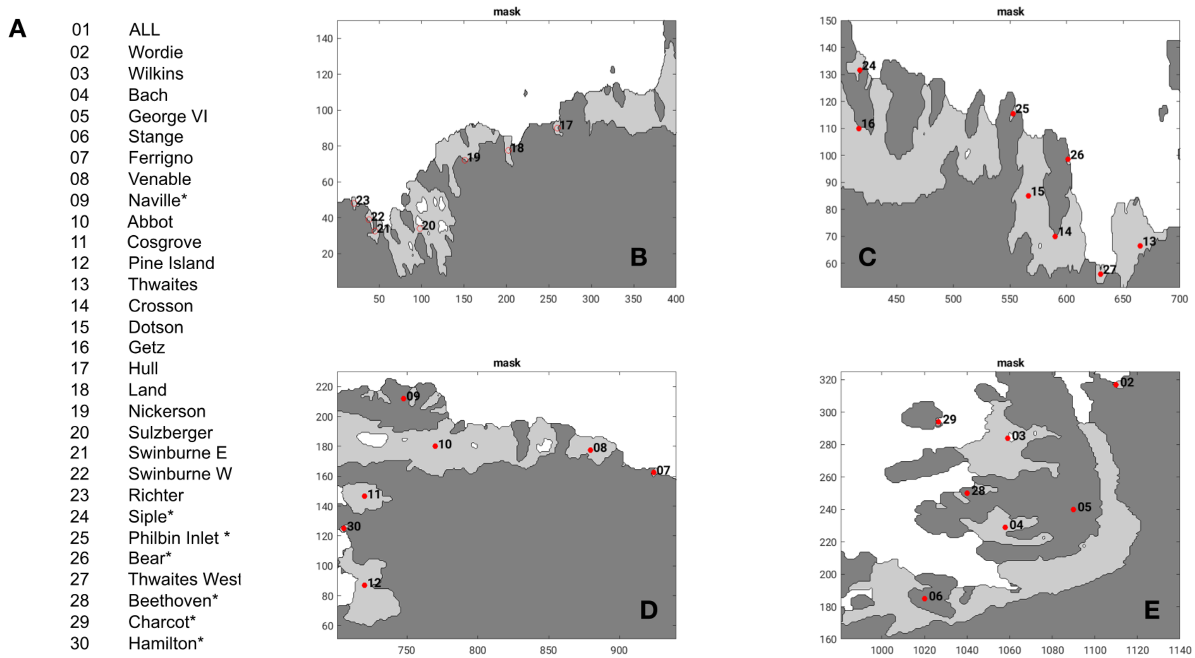
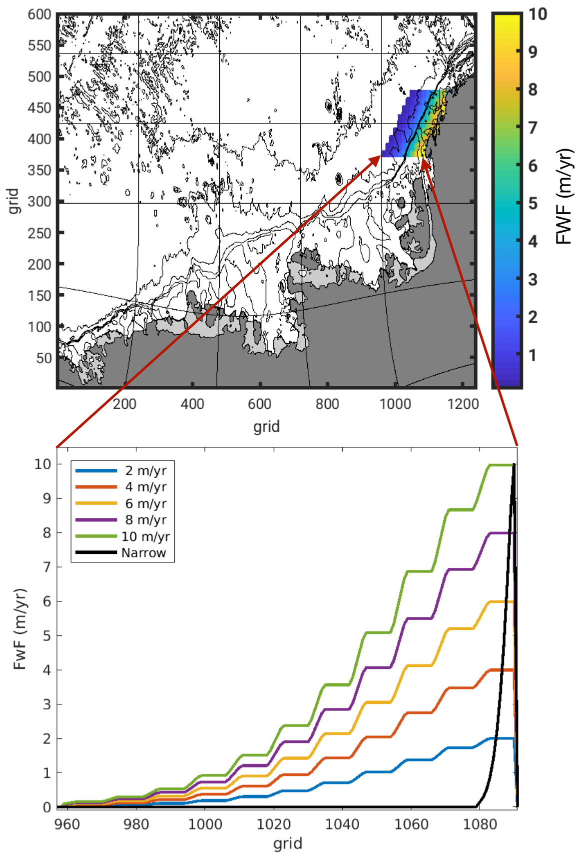


Fig. S2. Detail of WAIS ice shelves included in WAIS 1080 model.

(**A**) A full list of ice shelf abbreviated names used in Figure 3E. The symbol, *, indicates names of ice shelves/glaciers that we introduce in this study as their names were not found in the literature. (**B-E**) Regional maps showing the location of each ice shelf represented in the WAIS 1080 model grid.

A Freshwater input at the WAP



B List of sensitivity runs

Run	Runoff (volume flux per km of coastline)	Total FW volume flux (m3/s)	Ice discharge* (Gt/yr)	Runoff wrt LLC270
Control	0	0	0	0
Narrow	1.5	2779	80	1.9
Gardner et al. (52)	--	--	*75-103*	--
2 m/yr	2.6	4870	141	3.3
4 m/yr	5.2	9741	282	6.7
Seasonal	5.4	10146	293	7.0
6 m/yr	7.8	14611	423	10
8 m/yr	10.4	19481	563	13.4
10 m/yr	13.0	24351	704	16.7

Fig. S3 Freshwater forcing at the West Antarctic Peninsula.

(**A**) The freshwater flux (FWF, color shading) is imposed at the ocean surface as continental runoff. Maximum values occur at the coast and decrease exponentially for 300 km offshore. The FWF perturbation is applied along 1881 km of coastline. Top panel: Horizontal distribution of the freshwater forcing in the 10 m yr^{-1} run. Bottom panel: Zonal distribution of the FWF for the various sensitivity runs. (**B**) List of sensitivity runs, with freshwater flux imposed at the WAP (given as volume flux per km of coastline and as volume flux in m^3 s^{-1}) and glacier ice discharge equivalent (for reference purposes). The equivalent ice discharge is calculated using an ice density of 917 kg m^{-3}. For reference, the estimated discharge at WAP from observations (italics) is 88±13 Gt yr^{-1} in 2008 and 91±12 Gt yr^{-1} in 2013, leading to an overall range of 75-103 Gt yr^{-1} for the 2008-2013 period (*52*). Also, for reference purposes, the freshwater runoff imposed in each sensitivity run is given with respect to the current steady state freshwater flux estimate from the WAP used in the LLC 270 ocean state estimate.

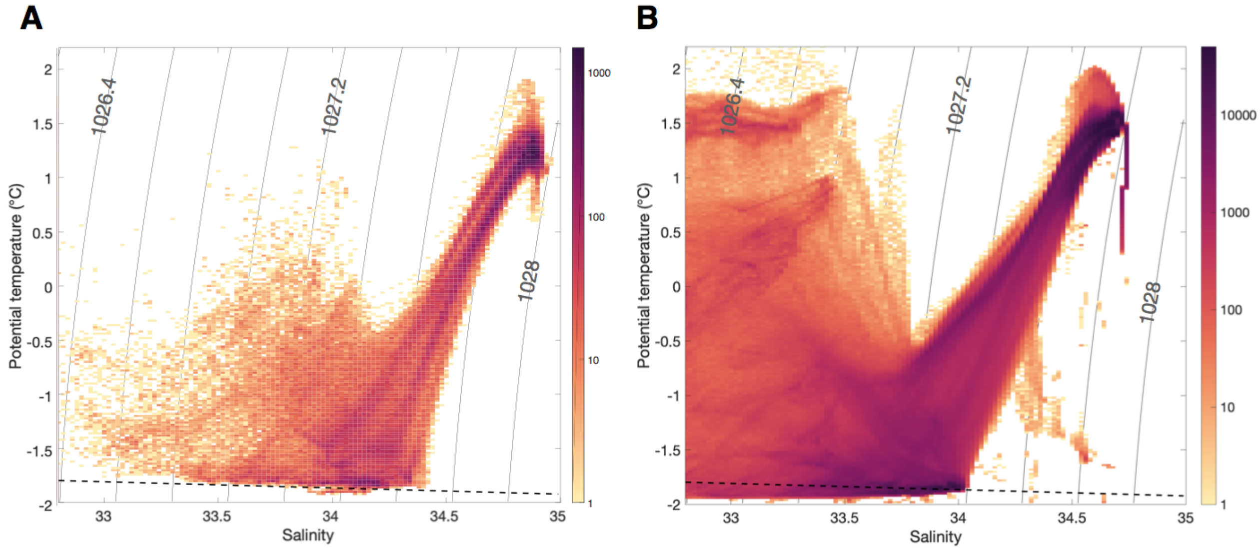


Fig. S4. Comparison of temperature and salinity data between model and seal observations. Histogram of temperature and salinity data from (**A**) instrumented seals and (**B**) model output. Panel (**A**) uses all seal data available in the Bellingshausen Sea south of 72 °S and between 72 °W—90 °W. Panel (**B**) uses the temperature and salinity fields from year 1998 from the WAIS 1080 model without a freshwater perturbation (FWF = 0 m yr^{-1}) for the same regional subdomain. Potential density (kg m^{-3}) contours are shown as black lines, with contour intervals each 0.2 kg m^{-3}. The dashed black line at the bottom of each diagram is the surface freezing point temperature.

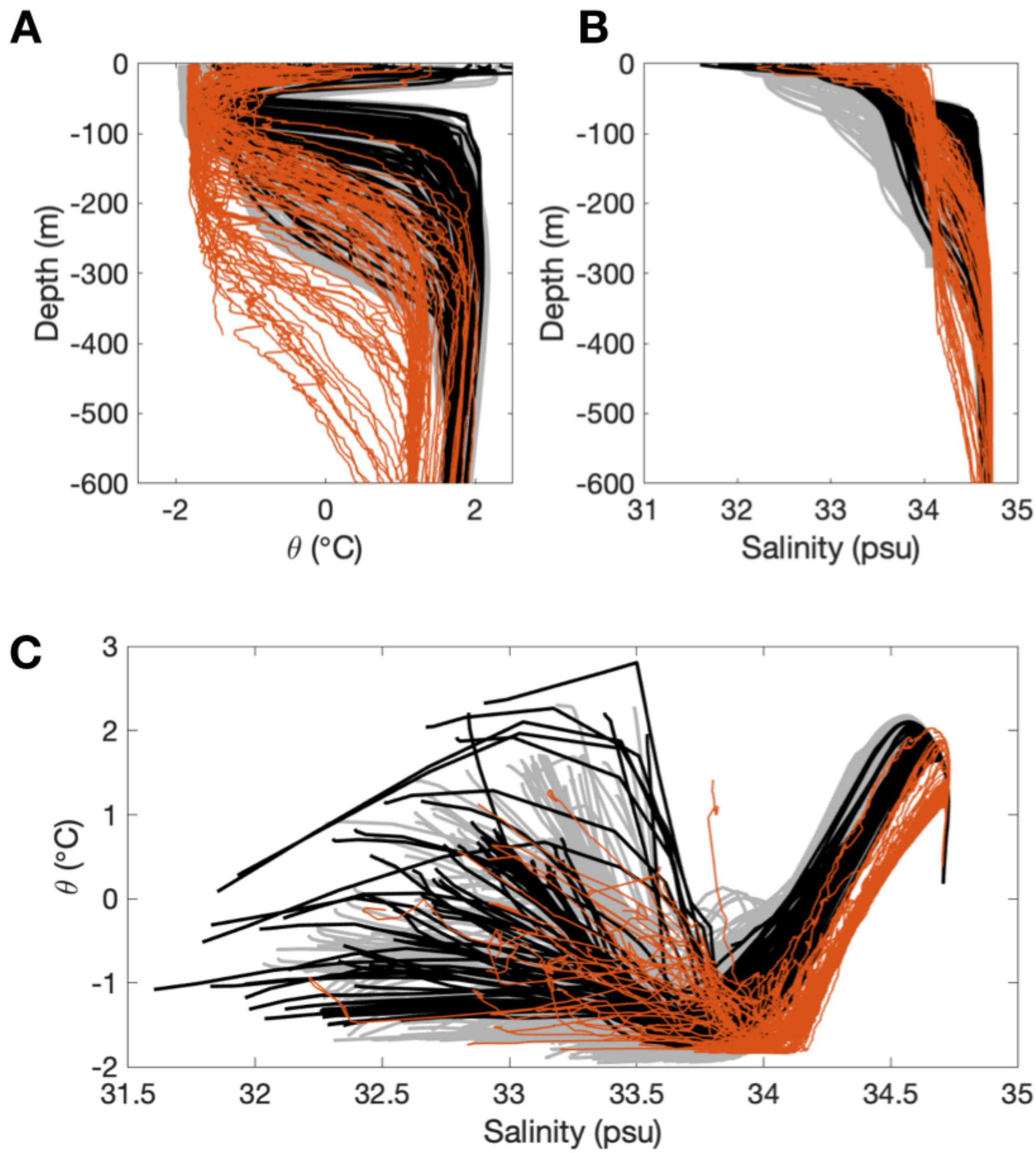


Fig. S5. Comparison of temperature and salinity data between CTD observations and model. (**A**) Potential temperature, (**B**) salinity, and (**C**) potential temperature-salinity diagram comparing CTD profiles obtained from cruise NBP1901 in January 2019 (in orange) to modeled data for the control run obtained at the same location and same month for January 2019 (in black). Modeled data from January to December 2019 is shown in gray.

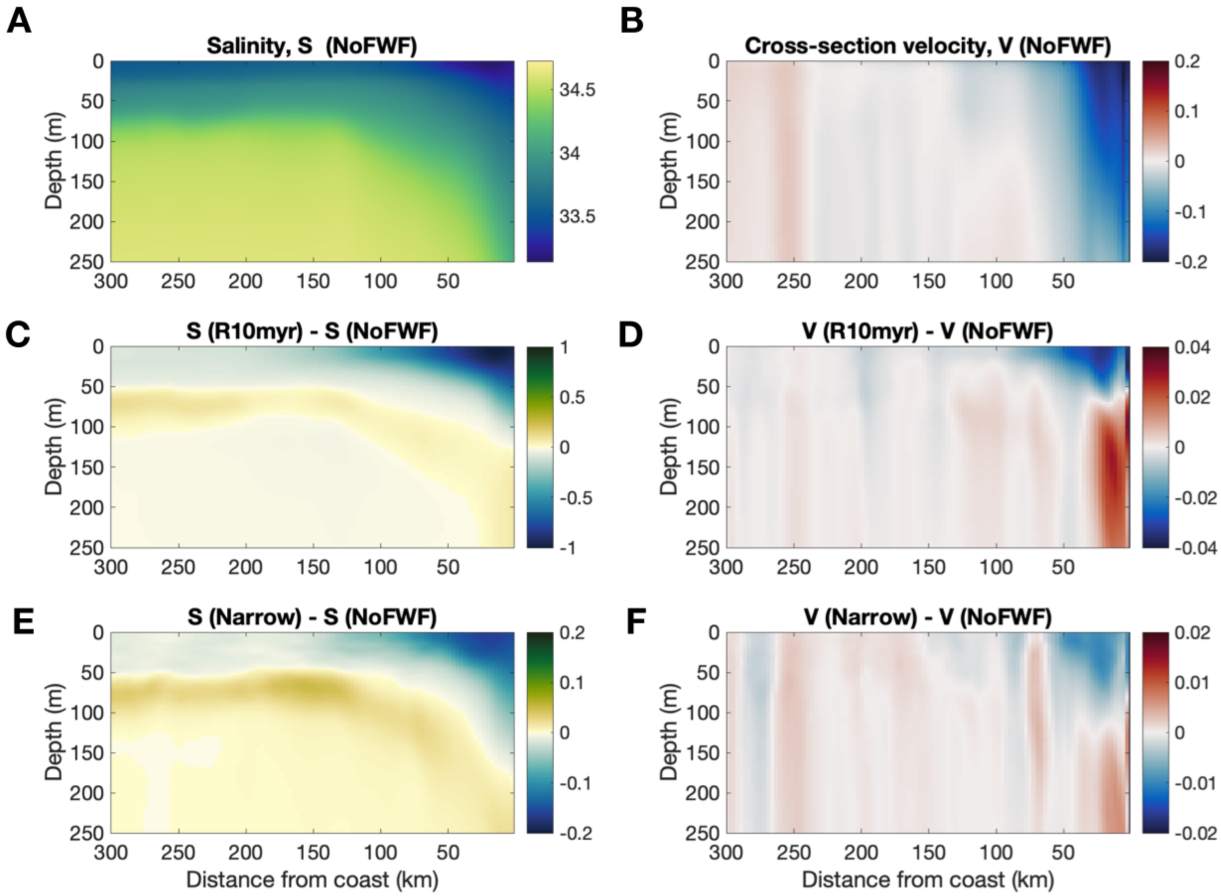


Fig. S6. Structure of the Antarctic Coastal Current (AACC) in the Bellingshausen Sea. Time-mean (1993-2019) meridional section along 87°W in the Bellingshausen Sea (section *BeS* in fig. S1). Top panels show (**A**) salinity and (**B**) zonal velocity (in m s^{-1}) from the WAIS 1080 control run (no freshwater input). Middle panels show the differences in (**C**) salinity and (**D**) velocity between the 10 m yr^{-1} run and the control run. Bottom panels show the differences in (**E**) salinity and (**F**) velocity between the narrow (30 km) 10 m yr^{-1} run and the control run.

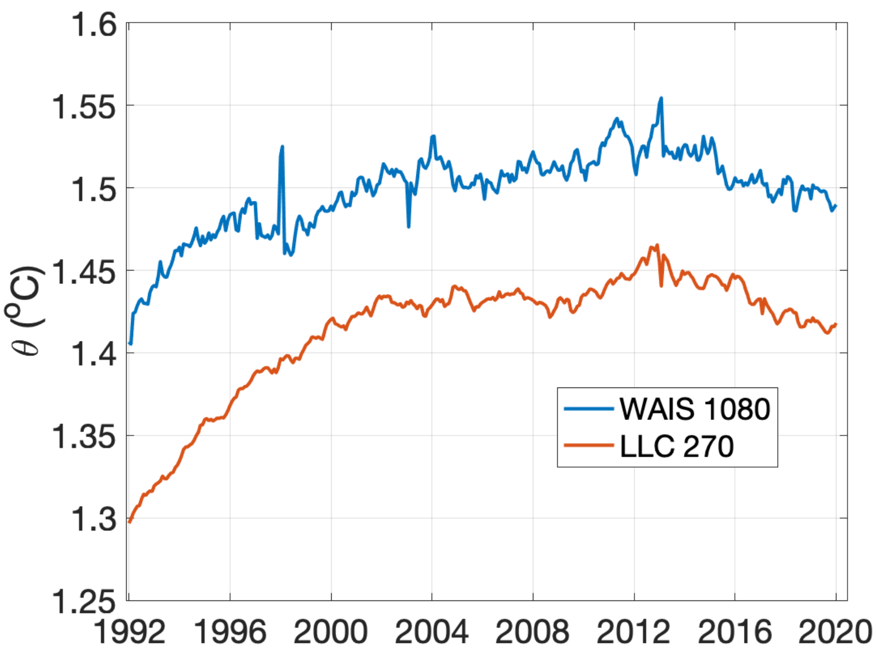


Fig. S7. Temperature evolution of Circumpolar Deep Water in the Antarctic Circumpolar Current from WAIS 1080 and LLC 270 simulations.

Mean temperature of water bounded between the 1°C isotherm over a zonal section along 71.5°S and between 110°W—143°W. The blue line shows WAIS 1080 model output from the control run (no freshwater input) and the orange line shows LLC 270 model output.

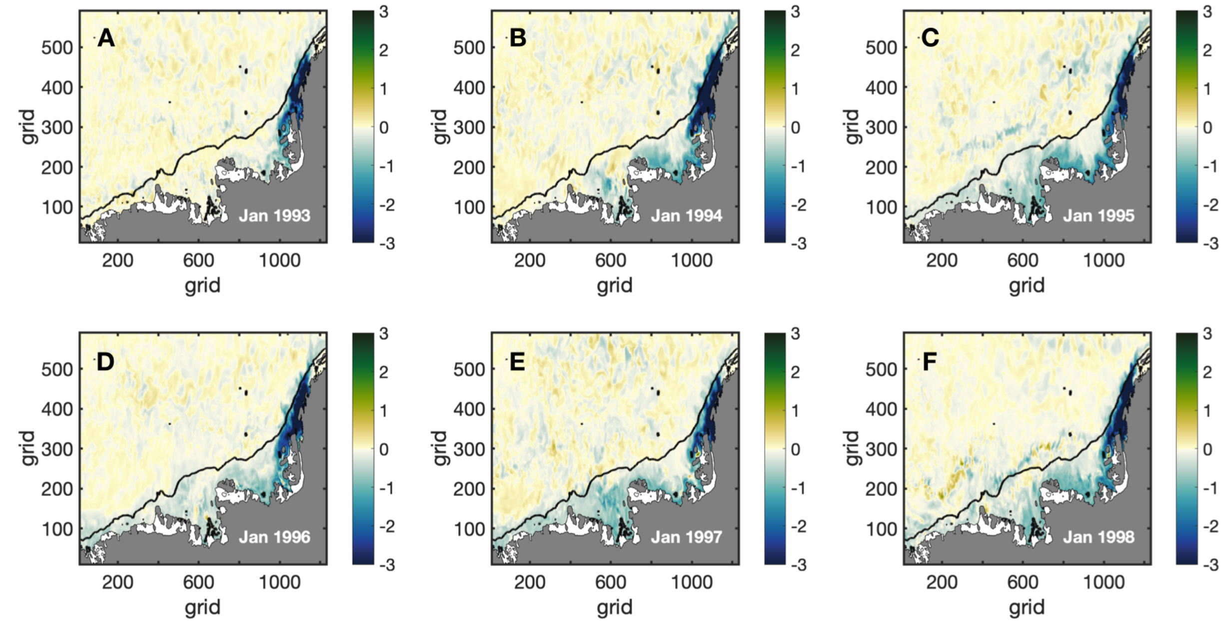


Fig. S8. Sea surface salinity anomalies for the WAIS 1080 simulations.
(**A-F**) Monthly-averaged sea surface salinity anomalies, calculated as the 10 m yr^{-1} run minus the control run, for each January from 1993 to 1998.

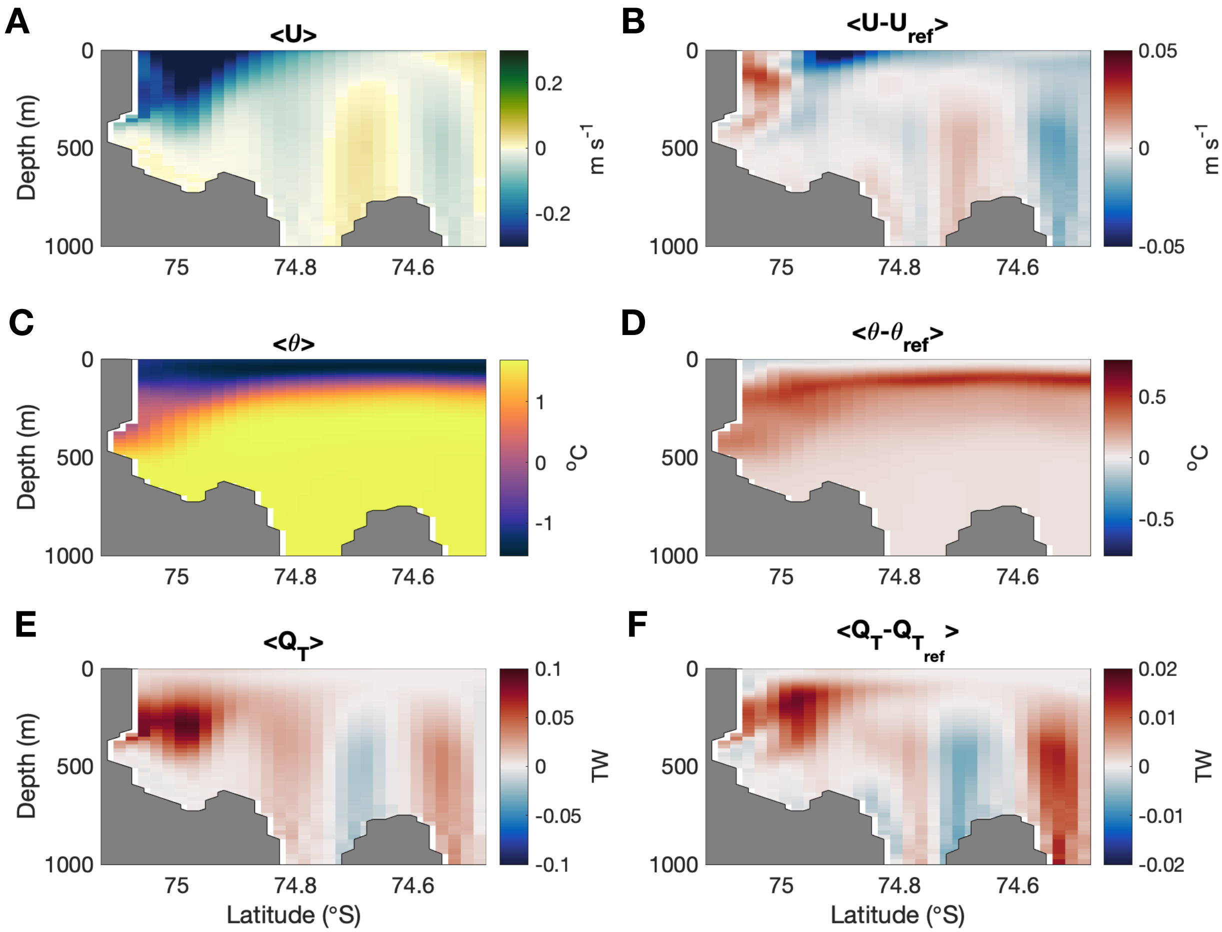


Fig. S9. Hydrography and lateral heat transport upstream of Thwaites Ice Shelf.
Same as Figure 5 in the main text, but for a meridional section upstream of Thwaites Ice Shelf (see location in figure S1), showing (**A**) velocity (m s^{-1}; positive eastwards), (**C**) potential temperature (^{o}C), and (**E**) heat transport, Q_T (TW; positive into the cavity) from the 10 m yr^{-1} run. (**B, D, F**) Same as (A, C, E), for the difference between the 10 m yr^{-1} run and the control run. Symbol < > indicates time-averaged fields over years 2000-2019; “ref” indicates fields from the control run (without FW input).

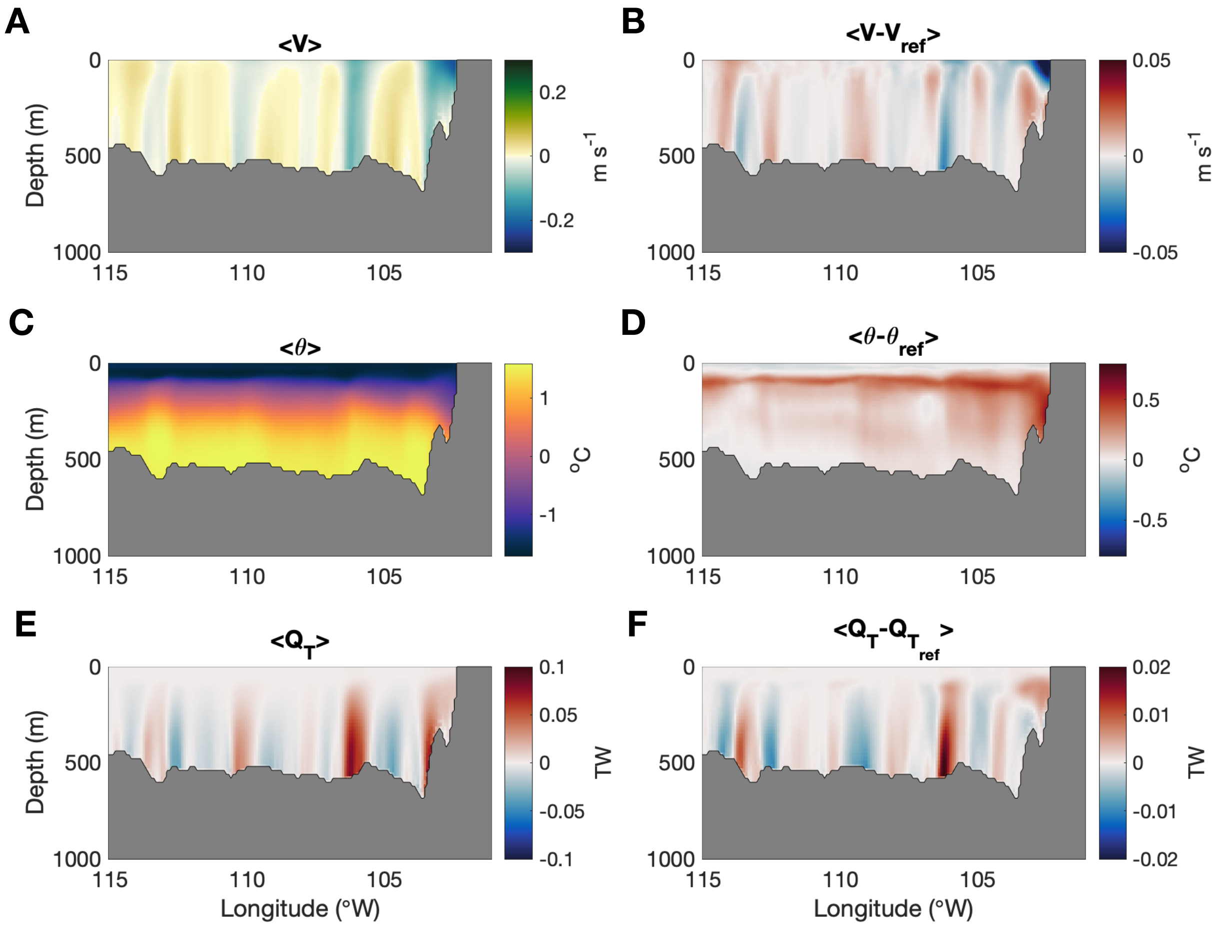


Fig. S10. Hydrography and lateral heat transport at the Amundsen Sea shelf break.
Same as Figure 6 in the main text, but for a zonal section in the Amundsen Sea taken at the shelf break (see location in figure S1), showing (**A**) velocity (m s^{-1}; positive northwards), (**C**) potential temperature (°C), and (**E**) heat transport, Q_T (TW; positive southwards, towards the ice shelves) from the 10 m yr^{-1} run (left panels). (**B, D, E**) Same as (A, C, E), for the difference between the 10 m yr^{-1} run and the control run. Symbol < > indicates time-average fields over years 1993-1997; "ref" indicates fields from the control run (without FW input).