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Highly stratified mid-Pliocene Southern Ocean in PlioMIP2

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Supplementary Tables and Figures

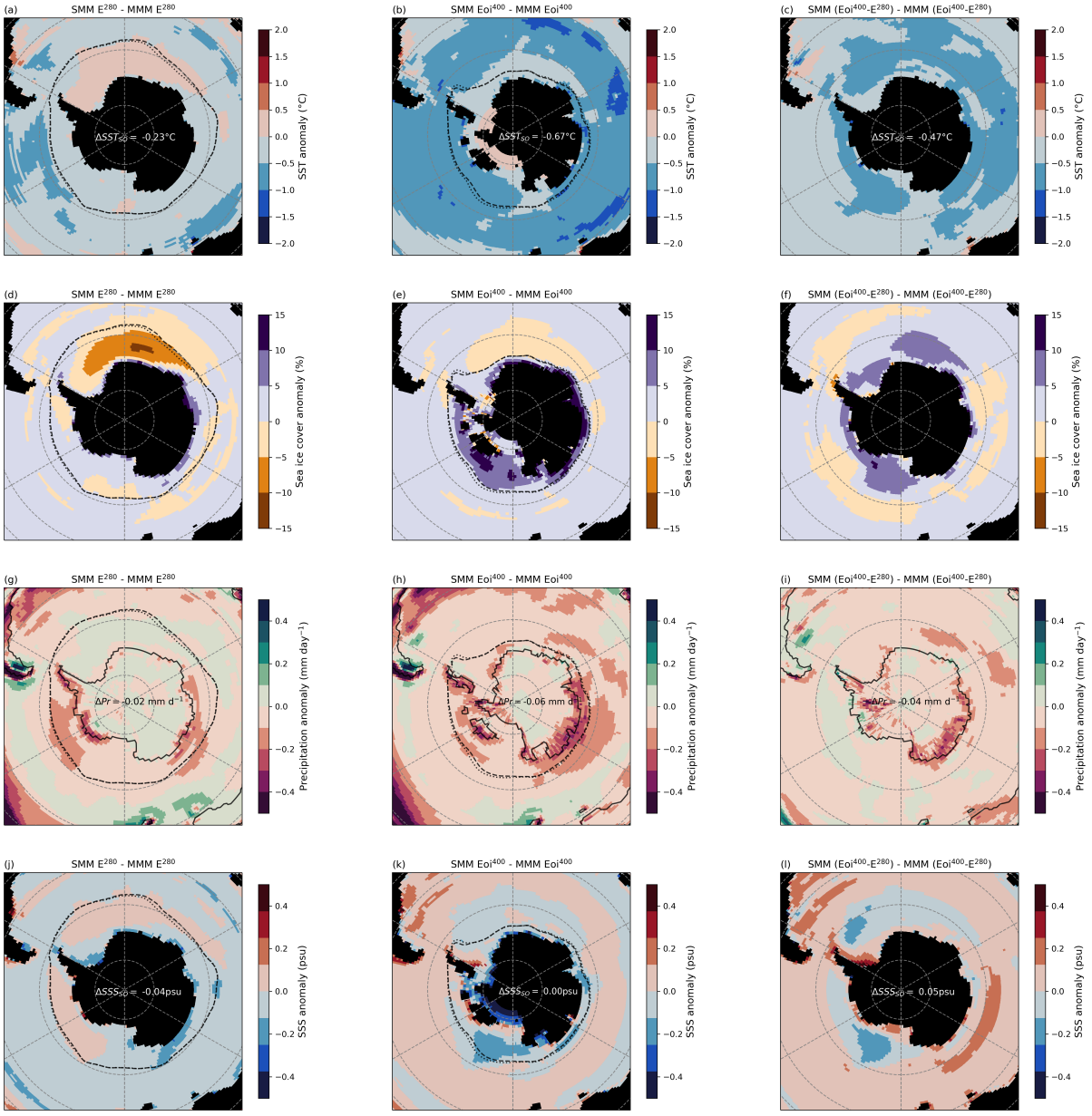

Figure S1. (a)-(c) SMM-MMM sea surface temperature (SST) anomalies for E^{280}, Eoi^{400} and Eoi^{400}–E^{280}, respectively. Dotted and dashed lines show the SMM and MMM sea-ice edge (15% sea-ice cover). The Southern-Ocean-average SST anomaly is printed. (d)-(f) SMM-MMM sea-ice cover anomalies for E^{280}, Eoi^{400} and Eoi^{400}–E^{280}, respectively. (g)-(i) Same as (a)-(c) for precipitation. The percentage change printed in (g), (h) and (i) is with respect to the MMM E^{280}, MMM Eoi^{400} and MMM Eoi^{400}–E^{280} precipitation, respectively. (j)-(l) Same as (a)-(c) for sea surface salinity (SSS).

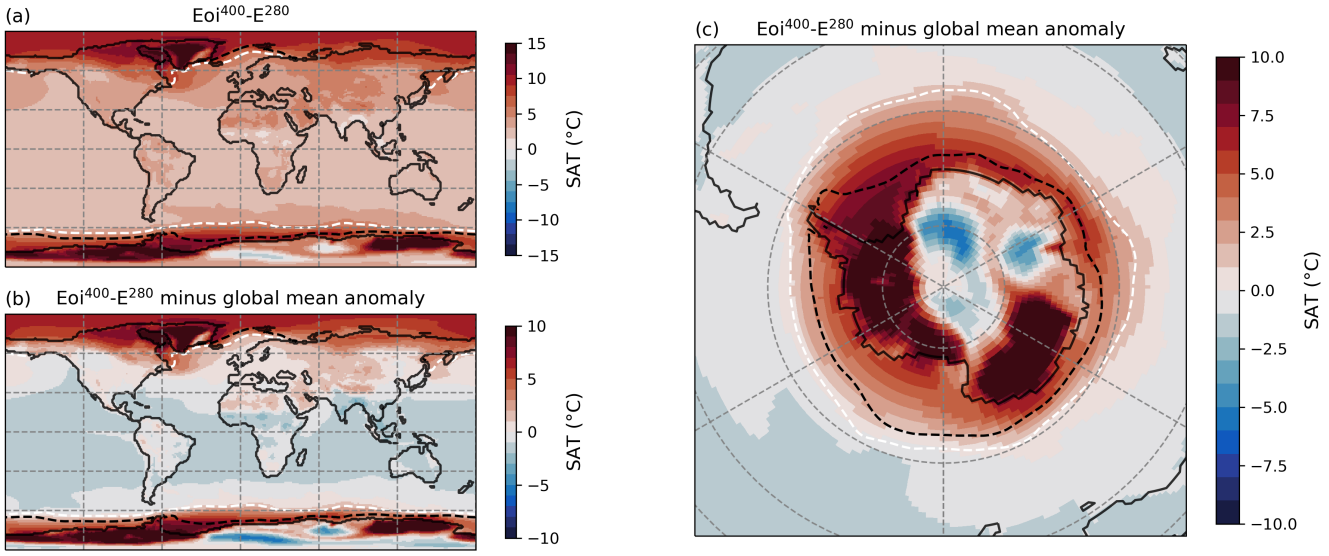

Figure S2. (a) MMM Eoi^{400}–E^{280} surface air temperature (SAT) anomaly. (b) MMM Eoi^{400}–E^{280} SAT anomaly minus the MMM global mean SAT anomaly. (c) Same as (b) but on an orthographic projection centered in Antarctica. White and black dashed lines show the MMM sea-ice edge (15% sea-ice cover) in E^{280} and Eoi^{400}, respectively.

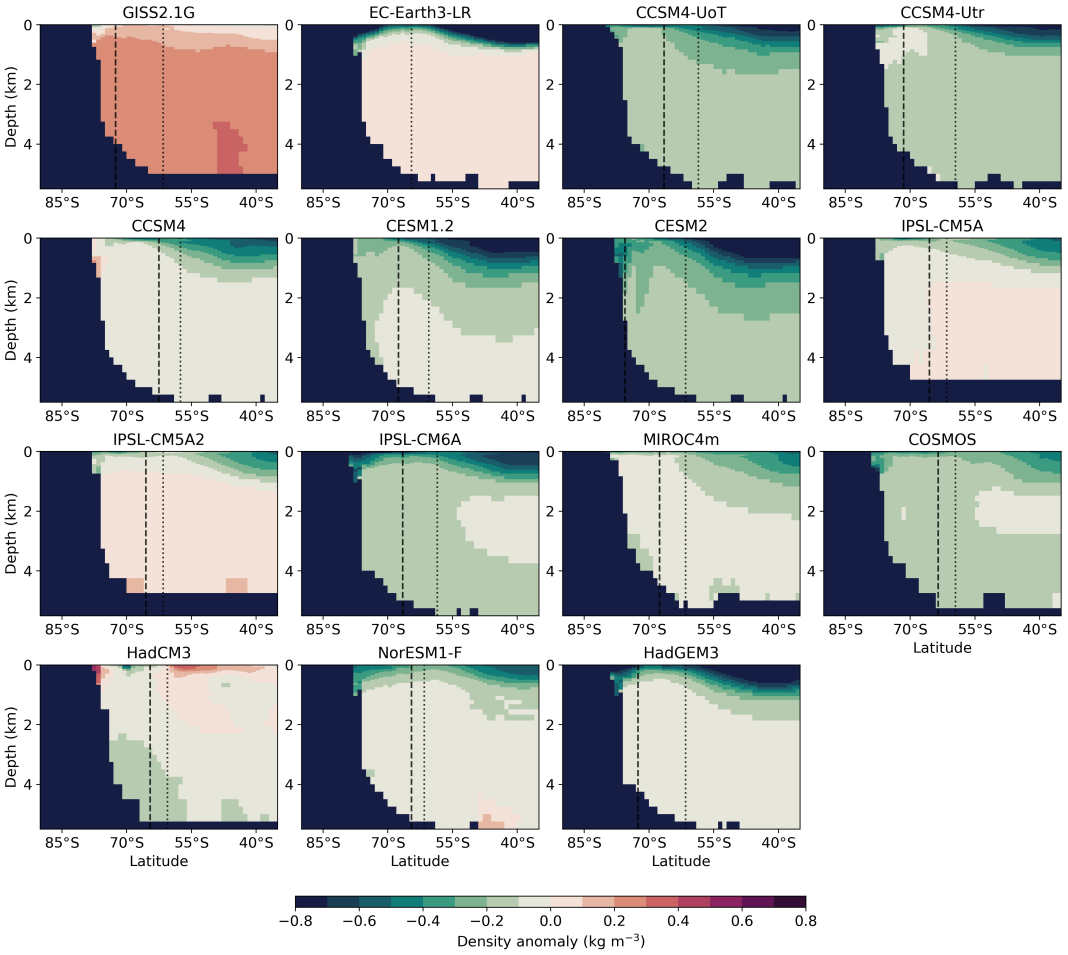

Figure S3. Indiviual model Eoi^{400}–E^{280} potential density anomalies. Vertical dotted and dashed lines indicate the MMM zonal mean sea-ice edge (15% sea-ice cover) in E^{280} and Eoi^{400}, respectively.

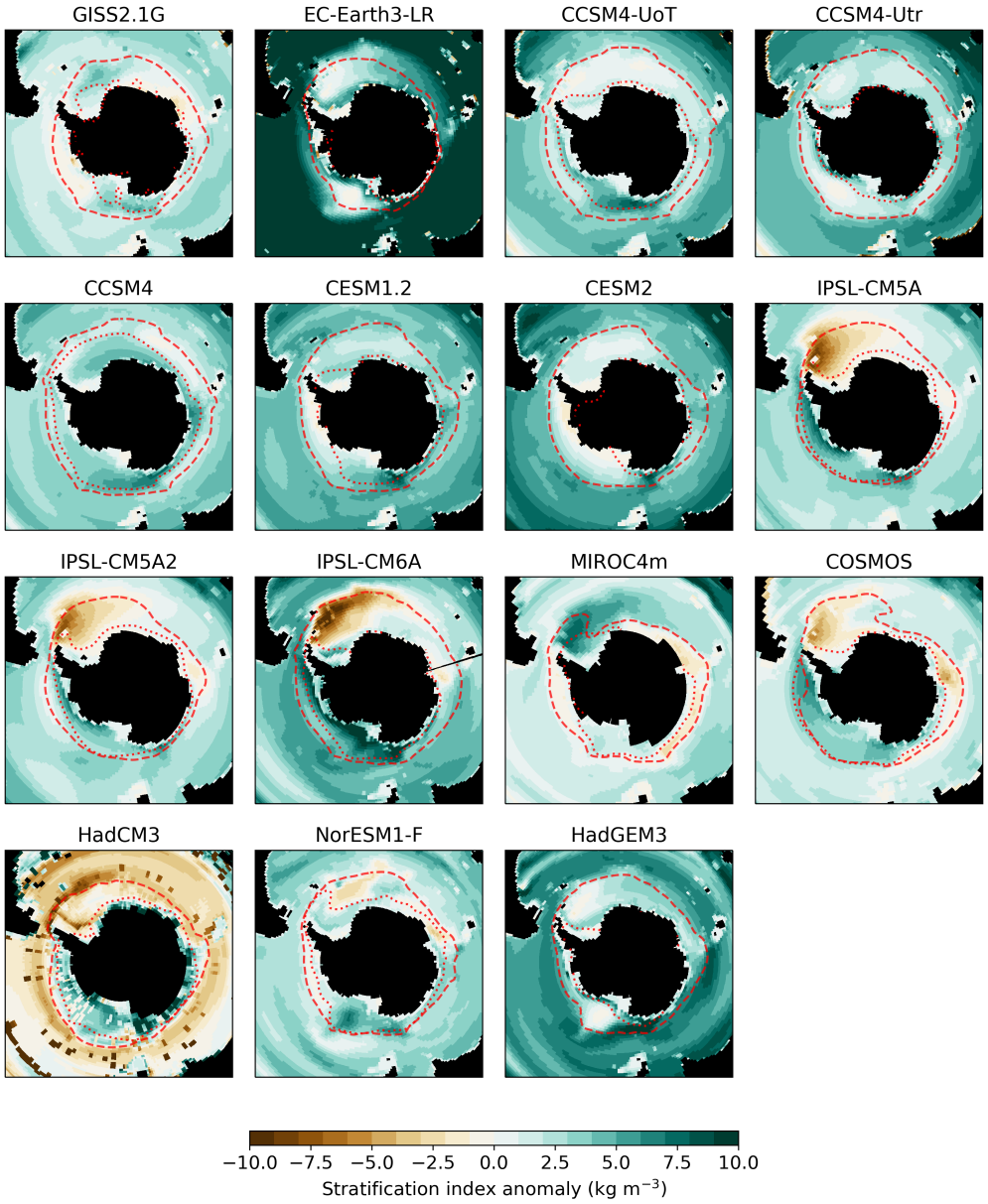

Figure S4. Individual model Eoi^{400}–E^{280} stratification index anomalies. Red dashed and dotted lines show the MMM sea-ice edge (15% sea-ice cover) in E^{280} and Eoi^{400}, respectively. The stratification index is calculated for each grid cell according to Equation 1.

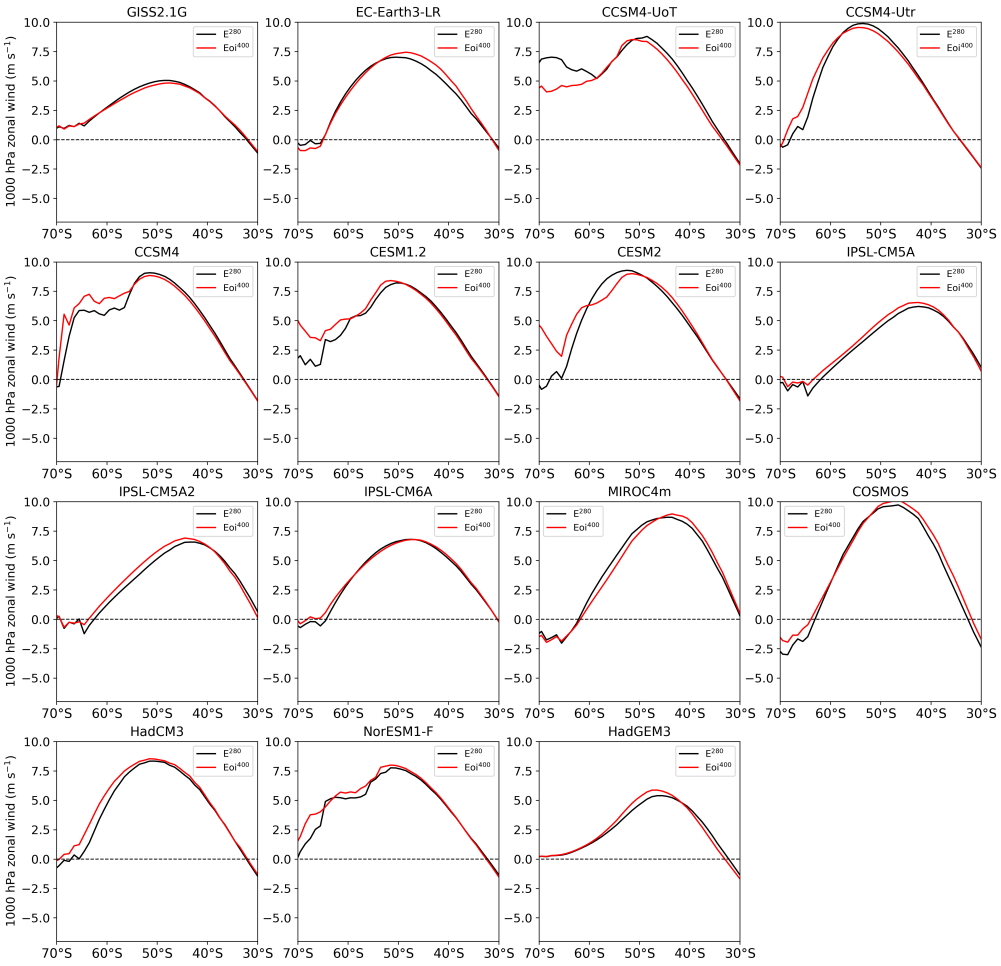

Figure S5. Individual model Eoi^{400} and E^{280} zonal-mean 1000 hPa zonal wind.

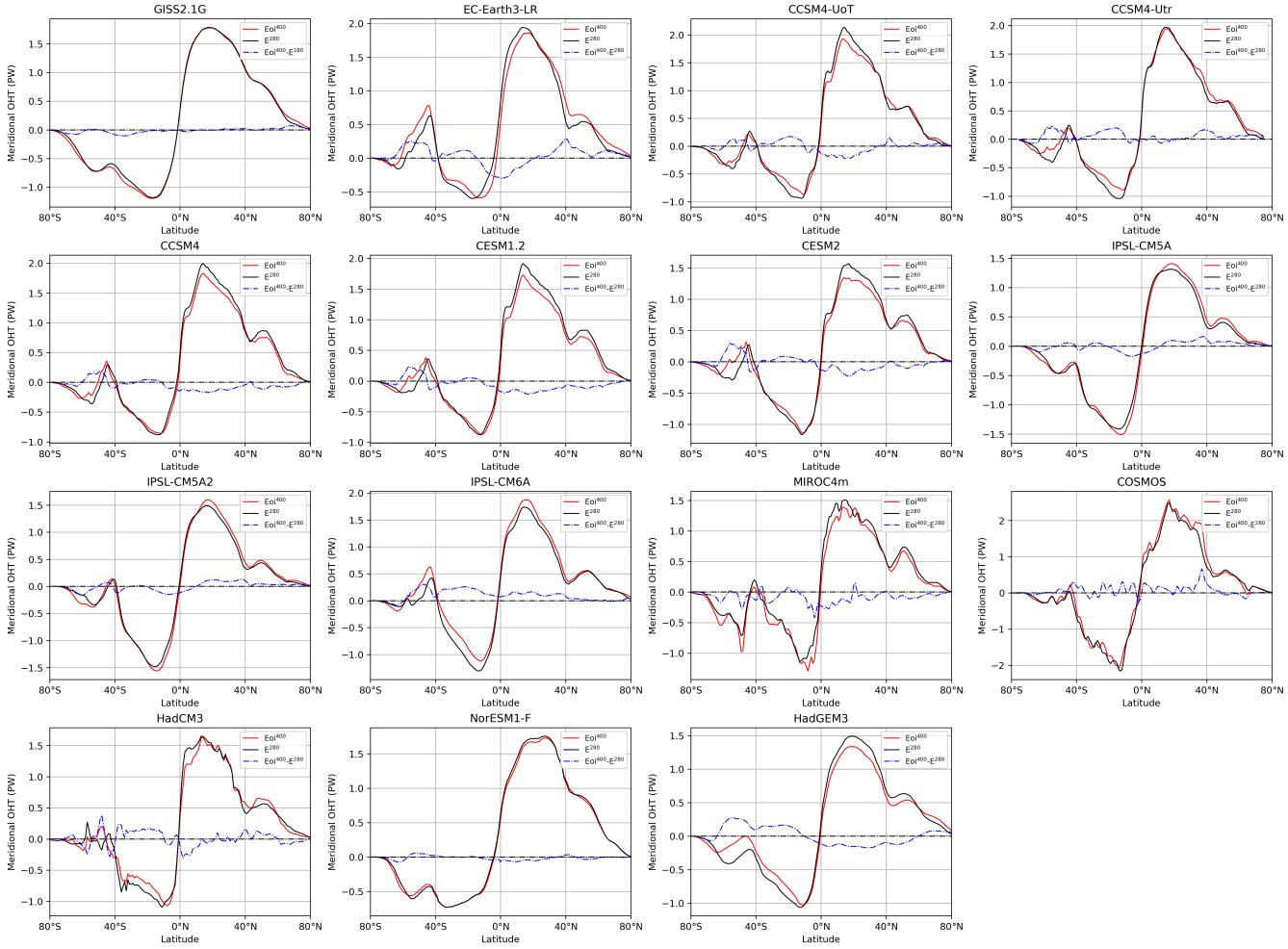

Figure S6. Individual model meridional ocean heat transport for E^{280}, Eoi^{400} and Eoi^{400}–E^{280}.

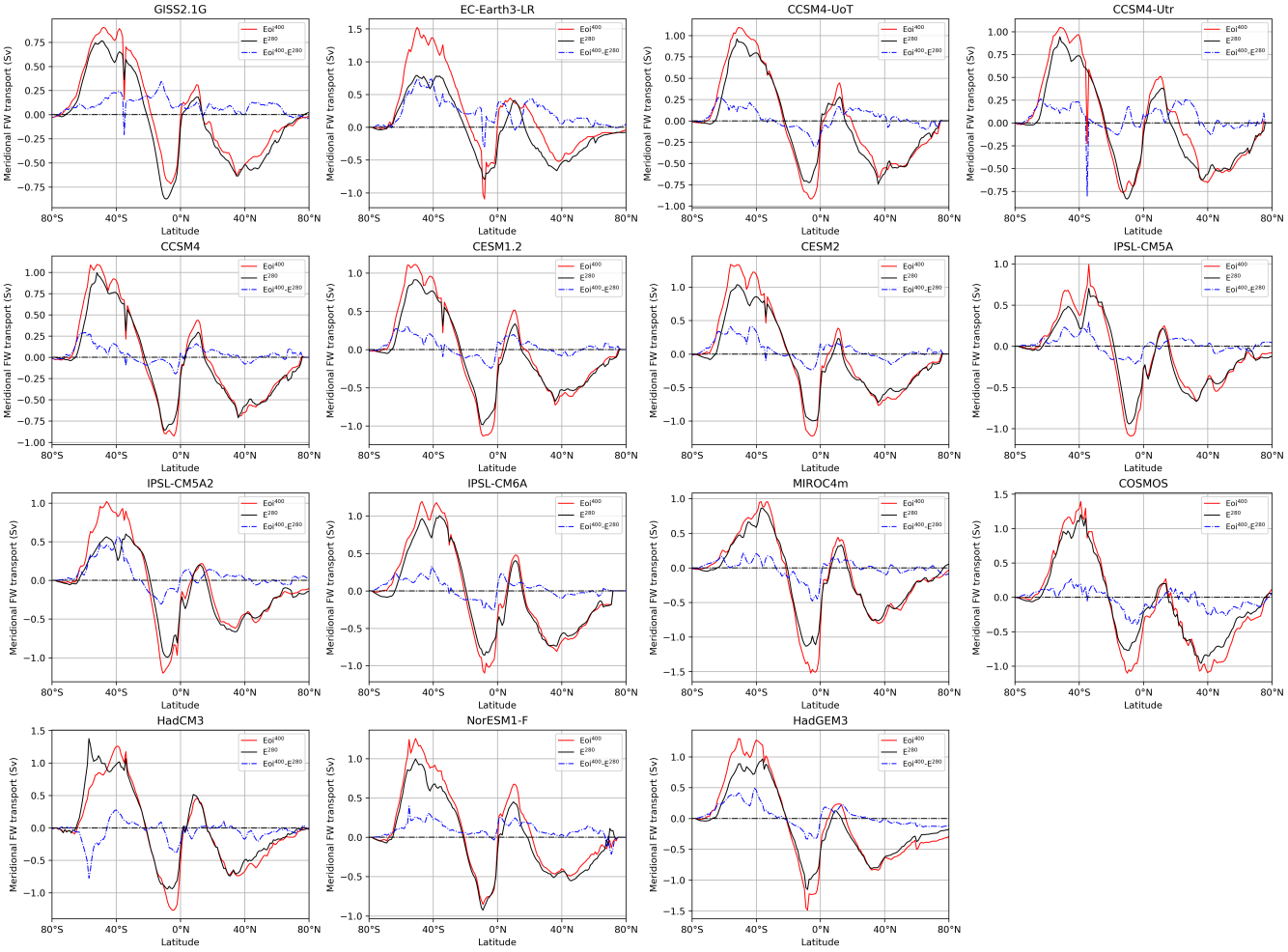

Figure S7. Individual model meridional freshwater transport for E^{280}, Eoi^{400} and Eoi^{400}–E^{280}.

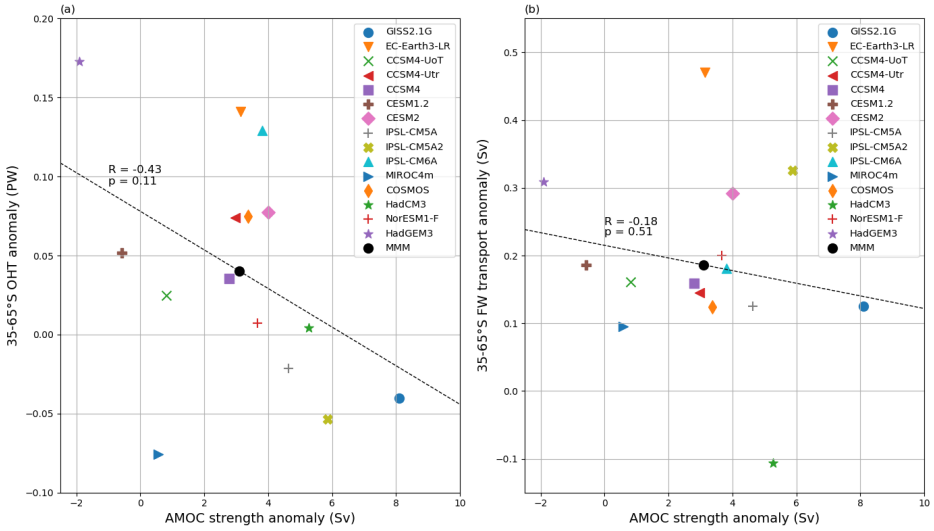

Figure S8. (a) Scatter plot of the individual model Eoi^{400}–E^{280} AMOC cell strength anomaly against the 35-65°S-average global ocean heat transport (OHT) anomaly. (b) Scatter plot of the individual model Eoi^{400}–E^{280} AMOC cell strength anomaly against the 35-65°S-average global freshwater transport (FWT) anomaly. Dashed lines show a linear least-squares fit to the individual model data, with indicated correlation R- and p-values.

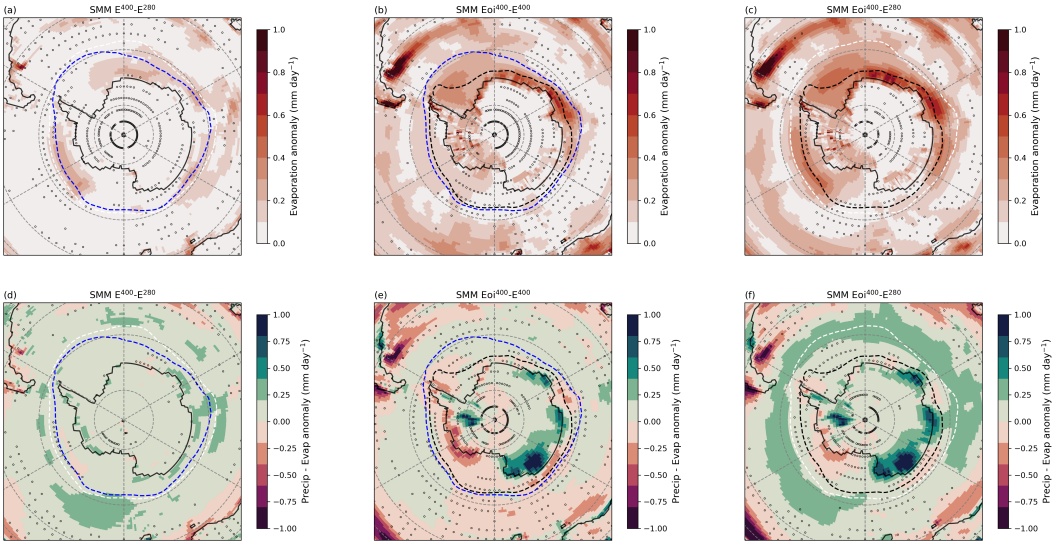

Figure S9. (a) SMM E^{400}–E^{280} precipitation minus evaporation (PmE) anomaly. (b),(c) Same as (a) for Eoi^{400}–E^{400} and Eoi^{400}–E^{280}. White, blue and black dashed lines show the SMM sea-ice edge (15% sea-ice cover) in E^{280}, E^{400} and Eoi^{400}, respectively. Stippling indicates that less than 5 out of 7 (<70%) of the models included in the SMM agree on the sign of change.

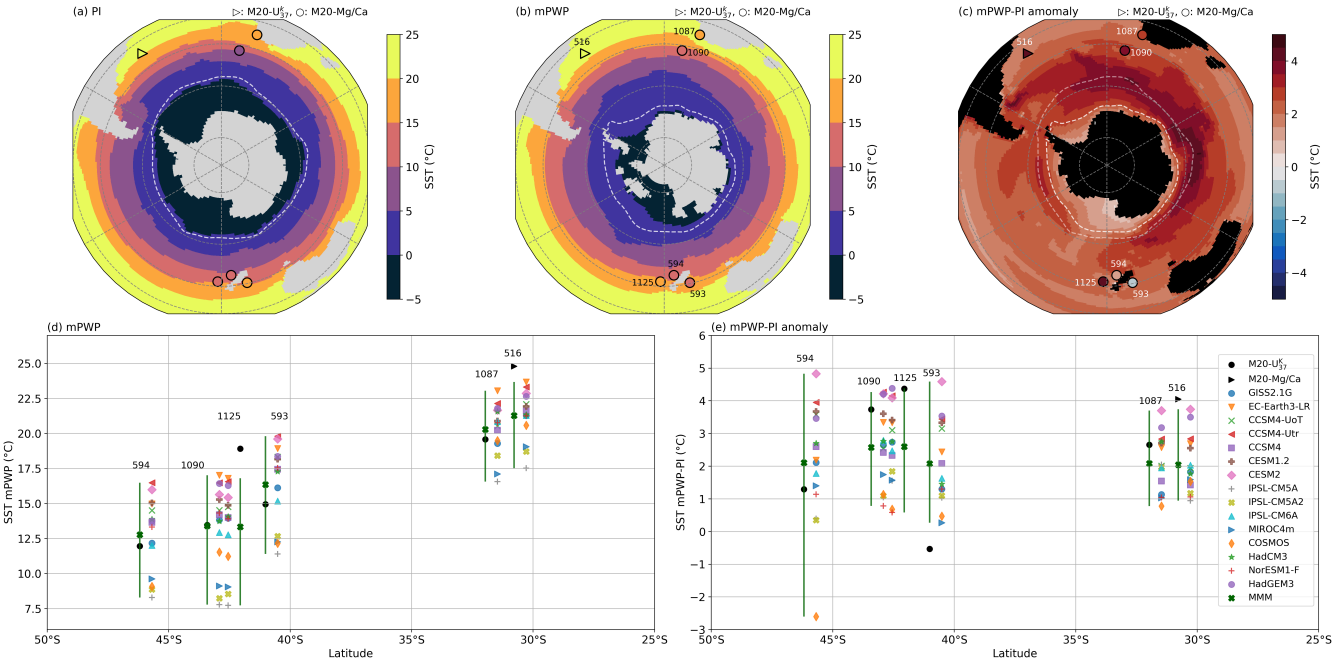

Figure S10. (a) Southern Ocean MMM E^{280} SST and pre-industrial ERSSTv5 SSTs (Huang et al., 2017) at proxy locations. (b) Southern Ocean MMM Eoi^{400} SST and KM5c mPWP SSTs reconstructed by McClymont et al. (2020) (M20) at proxy locations. M20-$U^{k'}_{37}$ and M20-Mg/Ca refer to the McClymont et al. (2020) SST reconstructions using $U^{k'}_{37}$ and Mg/Ca proxies, respectively. (c) Southern Ocean MMM Eoi^{400}–E^{280} SST anomalies and KM5c mPWP SSTs (McClymont et al., 2020) minus pre-industrial ERSSTv5 SSTs (Huang et al., 2017) at proxy locations. (d) Individual model mPWP (Eoi^{400}) SSTs and reconstructed mPWP SSTs (black) at proxy locations in or near the Southern Ocean. A vertical dark green line shows the model spread and the MMM is indicated by a dark green cross. (e) Individual model SST anomalies (Eoi^{400}–E^{280}) and reconstructed mPWP–PI SST anomalies (black) at proxy locations in or near the Southern Ocean. A vertical dark green line shows the model spread and the MMM is indicated by a dark green cross. Pre-industrial SSTs are computed with the pre-industrial ERSST5 1870-1900 data (Huang et al., 2017).

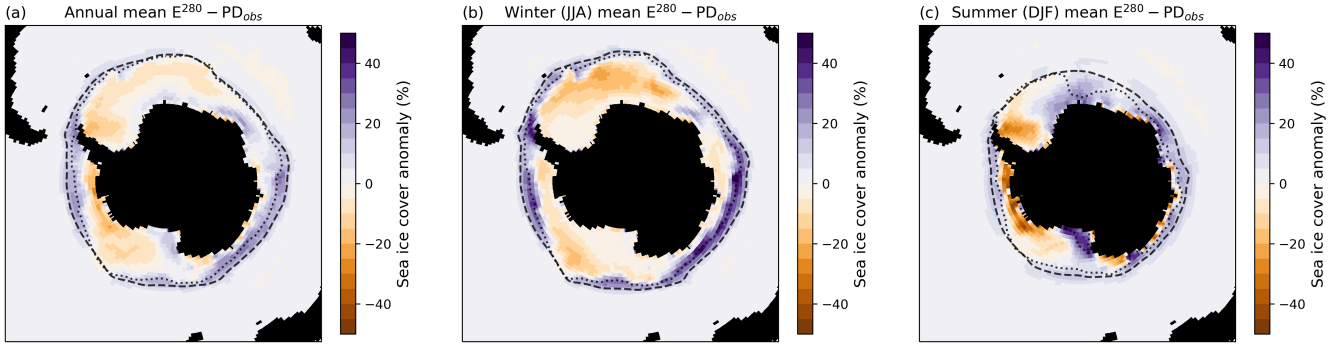

Figure S11. (a) Annual-mean MMM E^{280} – observed present-day (PD_{obs}, 1979-1999) sea-ice cover anomaly. (b) Winter-mean (JJA) MMM E^{280} – observed present-day (PD_{obs}, 1979-1999) sea-ice cover anomaly. (b) Summer-mean (DJF) MMM E^{280} – observed PD (1979-1999) sea-ice cover anomaly. Black dashed lines show the MMM E^{280} sea-ice edge (15% sea-ice cover) and black dotted lines show the PD_{obs} sea-ice edge.

Table S1. Individual model, MMM and SMM stratification index averaged over the high-latitude Southern Ocean (60–90°S).

Model	Average stratification index 60–90°S (kg m^{-3})				
	E^{280}	E^{400}	Eoi^{400}	Eoi^{400} – E^{280}	E^{400}–E^{280}
GISS-E2.1G	4.7		5.4	0.7	
EC-Earth3-LR	5.6		10.2	4.6	
CCSM4-UoT	4.7	5.9	6.2	1.5	1.2
CCSM4-Utr	5.1		6.8	1.7	
CCSM4	5.1		7.2	2.1	
CESM1.2	7.0		8.9	1.9	
CESM2	7.9	8.9	9.4	1.5	1.0
IPSL-CM5A	3.3		4.9	1.6	
IPSL-CM5A2	3.8	4.1	5.1	1.3	0.3
IPSL-CM6A	5.9		9.0	3.1	
MIROC4m	3.7	3.7	4.5	0.8	0.0
COSMOS	3.5	4.4	5.2	1.7	0.9
HadCM3	6.7	7.5	7.1	0.4	0.8
NorESM1-F	5.1	5.9	6.8	1.7	0.8
HadGEM3	4.7		8.5	3.8	
MMM	5.1		7.0	1.9	
SMM	5.1	5.8	6.3	1.2	0.7