

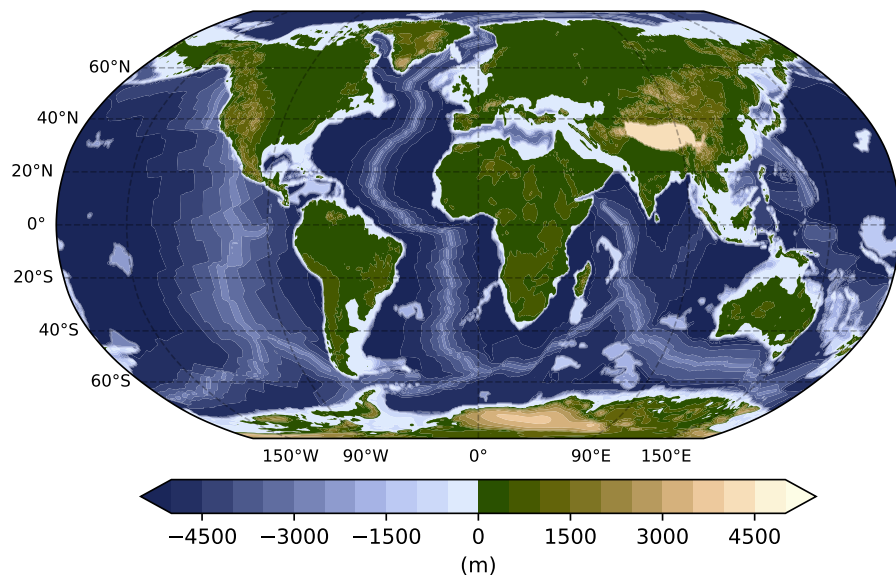


Figure S1. Mid-Miocene paleogeography used for the simulation (from Goldner et al. 2014).

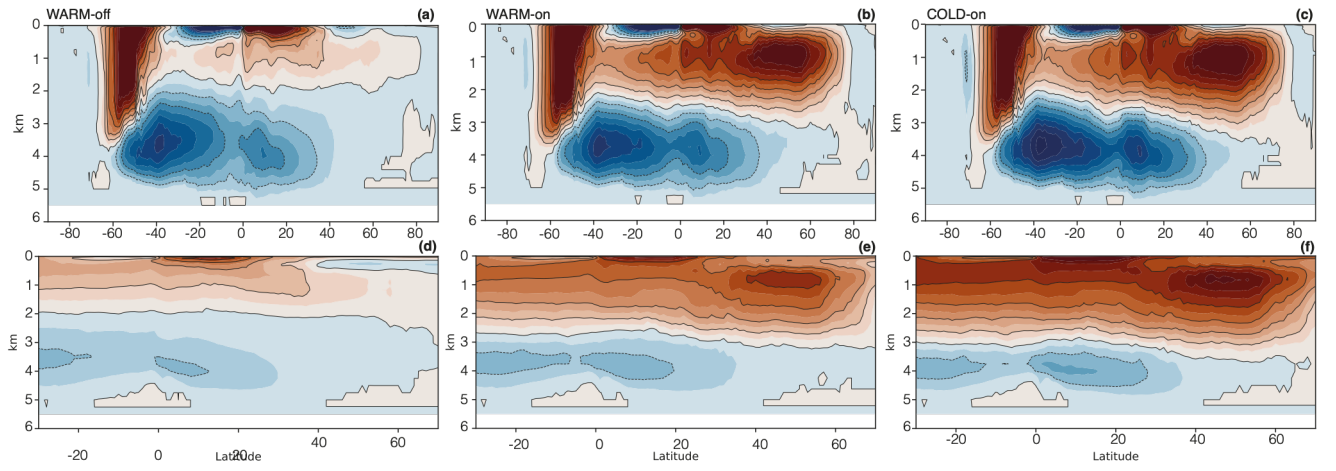


Figure S2. Global (GMOC) and Atlantic Eulerian Meridional Overturning Circulation (AMOC) for WARM-on (a, d), WARM-off (b, e) and COLD-on (c, f) cases.

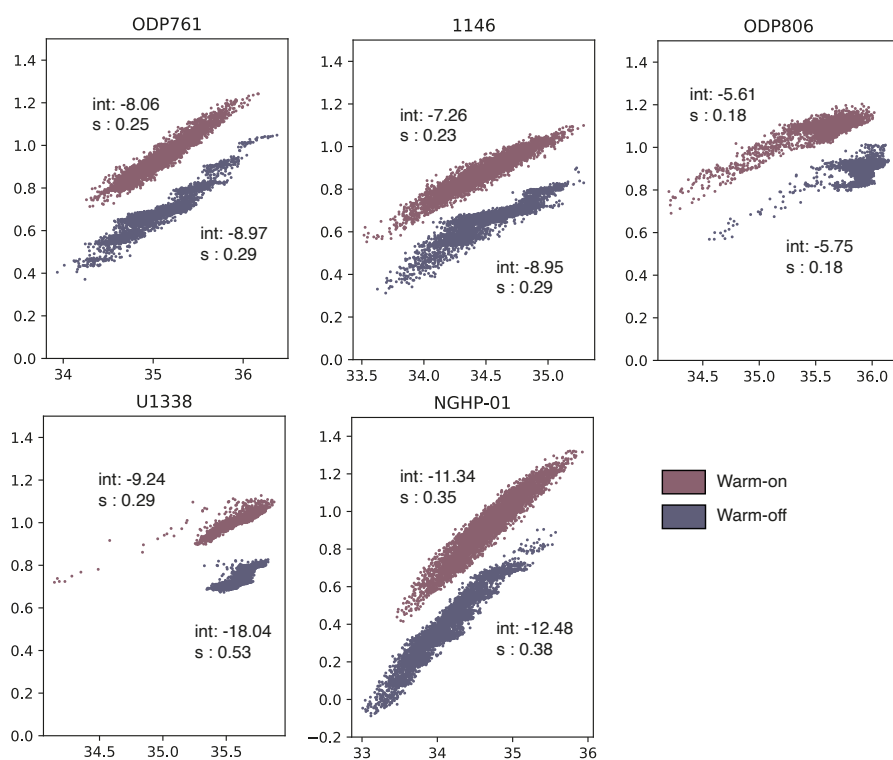


Figure S3. $\delta^{18}\text{O}_{\text{sw}}$ versus salinity (50-80 meters) at site locations for WARM-on and WARM-off. Sites are located on Fig. 1 and Fig. S1. Regressions are provided in Table S1.

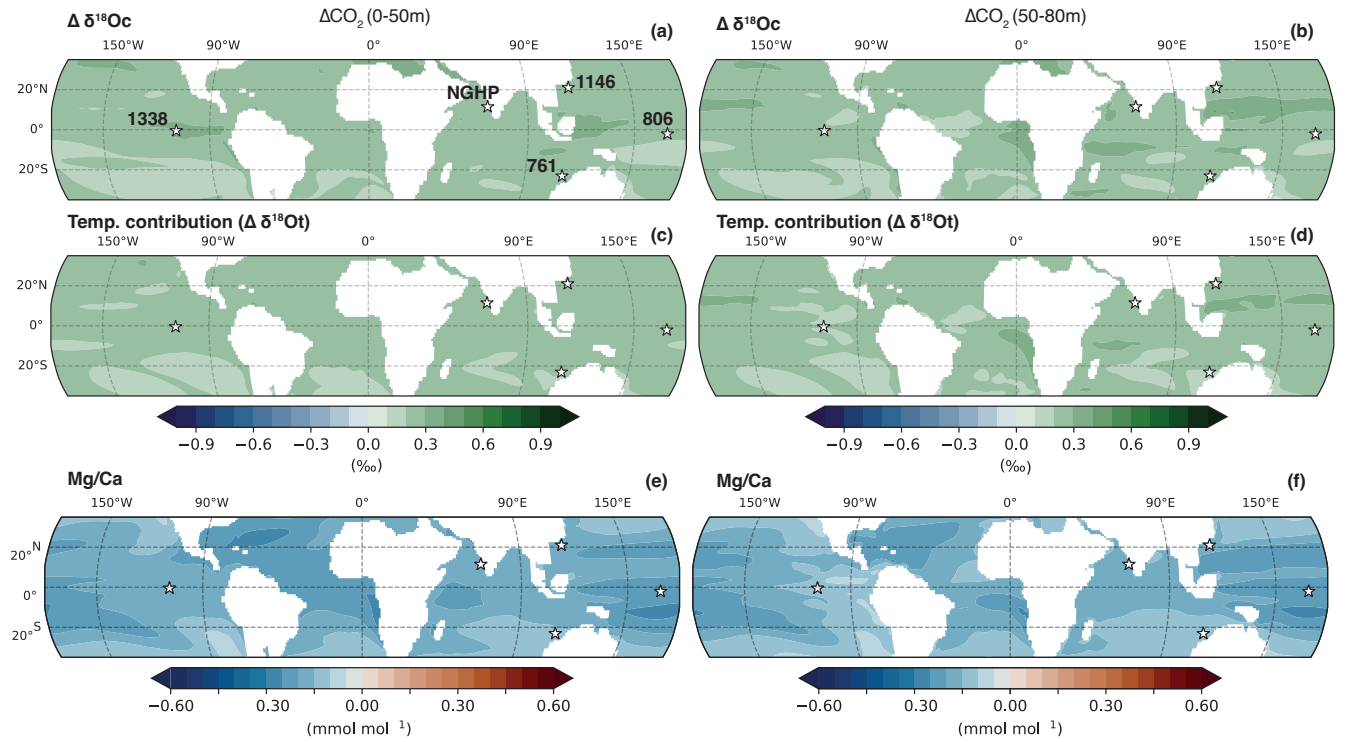


Figure S4. Mean forward modelled $\delta^{18}\text{O}_c$ (a-b), temperature contribution to $\delta^{18}\text{O}_c$ ($\delta^{18}\text{O}_t$) (c-d) and Mg/Ca (e-f) for the ΔCO_2 scenario averaged between 0-50m (middle) and 50-80m (right). Stars indicate the location of drilling sites with published records (see Sect. 2.3). Stars indicate the location of drilling sites with published records (see Sect. 2.3) – ODP 806, ODP 1146, ODP 761, NGHP-01-01A and IODP 1336.

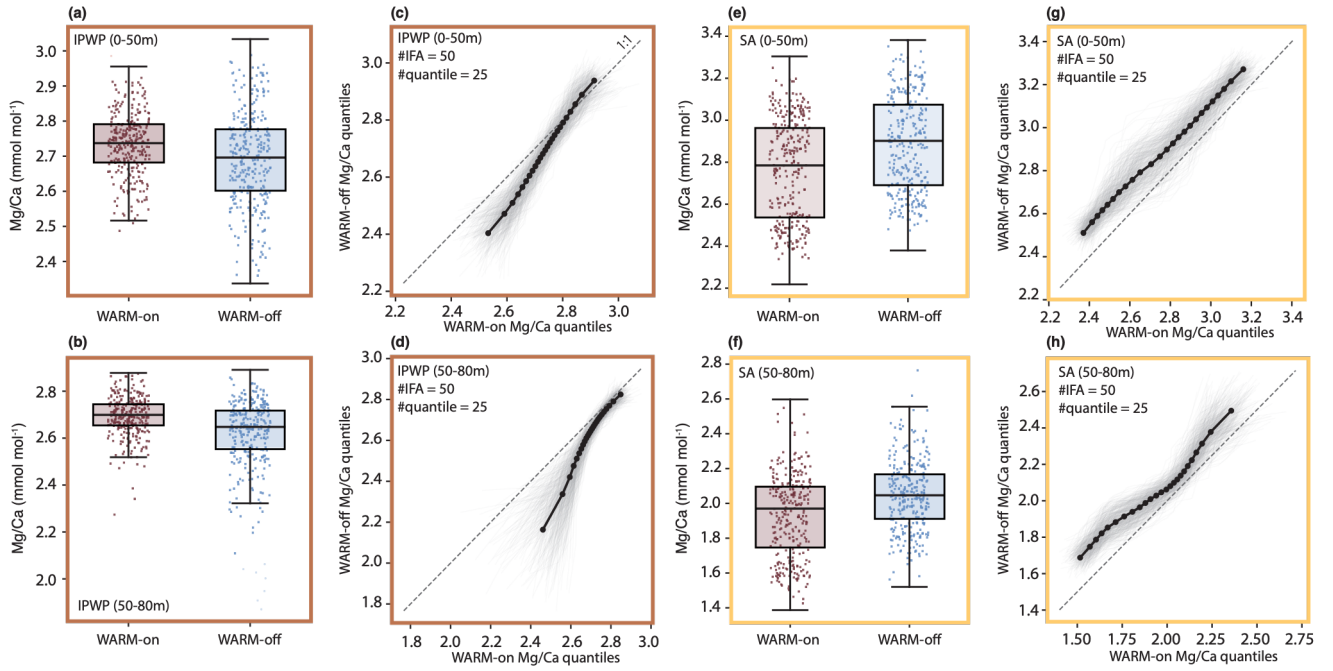


Figure S5: Forward-modelled individual foraminiferal analyses of Mg/Ca (IFA-Mg/Ca) distributions for WARM-on versus WARM-off scenarios at sites in the Indo-Pacific Warm Pool (IPWP—4°S, 122°E; a–d) and the southern tropical Atlantic (SA—7°S, 3°W; e–h), for 0–50 m (a, c, e, g) and 50–80 m (b, d, f, h) depth intervals. Mg/Ca is forward-modelled from monthly iCESM1.2 temperature and salinity values using the Gray and Evans (2019) *Trilobatus sacculifer*_multivariate calibration and scaled to middle-Miocene seawater Mg/Ca (see Sect. 2.2). Box-and-swarm panels (a, b, e, f) show monthly distributions (box: median and interquartile range; points: a 300-value subsample of the 4,800 monthly values). Quantile–quantile (Q–Q) panels (c, d, g, h) compare WARM-on against WARM-off from a bootstrap IFA procedure (1,000 iterations, 50 "picked" IFA per iteration, 25 quantiles, ± 1 % analytical uncertainty—see Methods for details): the black line depicts the median Q–Q relationship, grey lines the individual bootstrap realisations, and the grey dashed line is the 1:1 line.

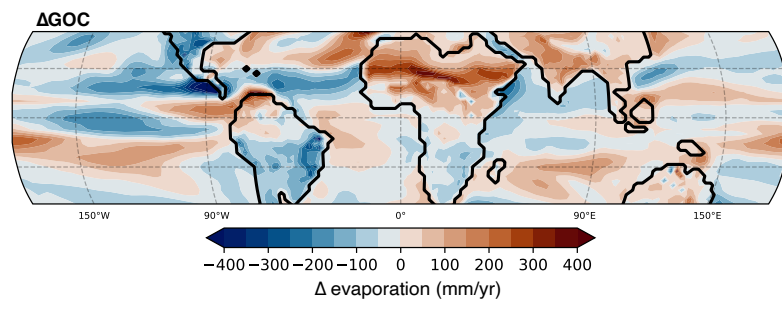


Figure S6. Mean annual difference in evaporation (mm/day) for Δ GOC scenario.

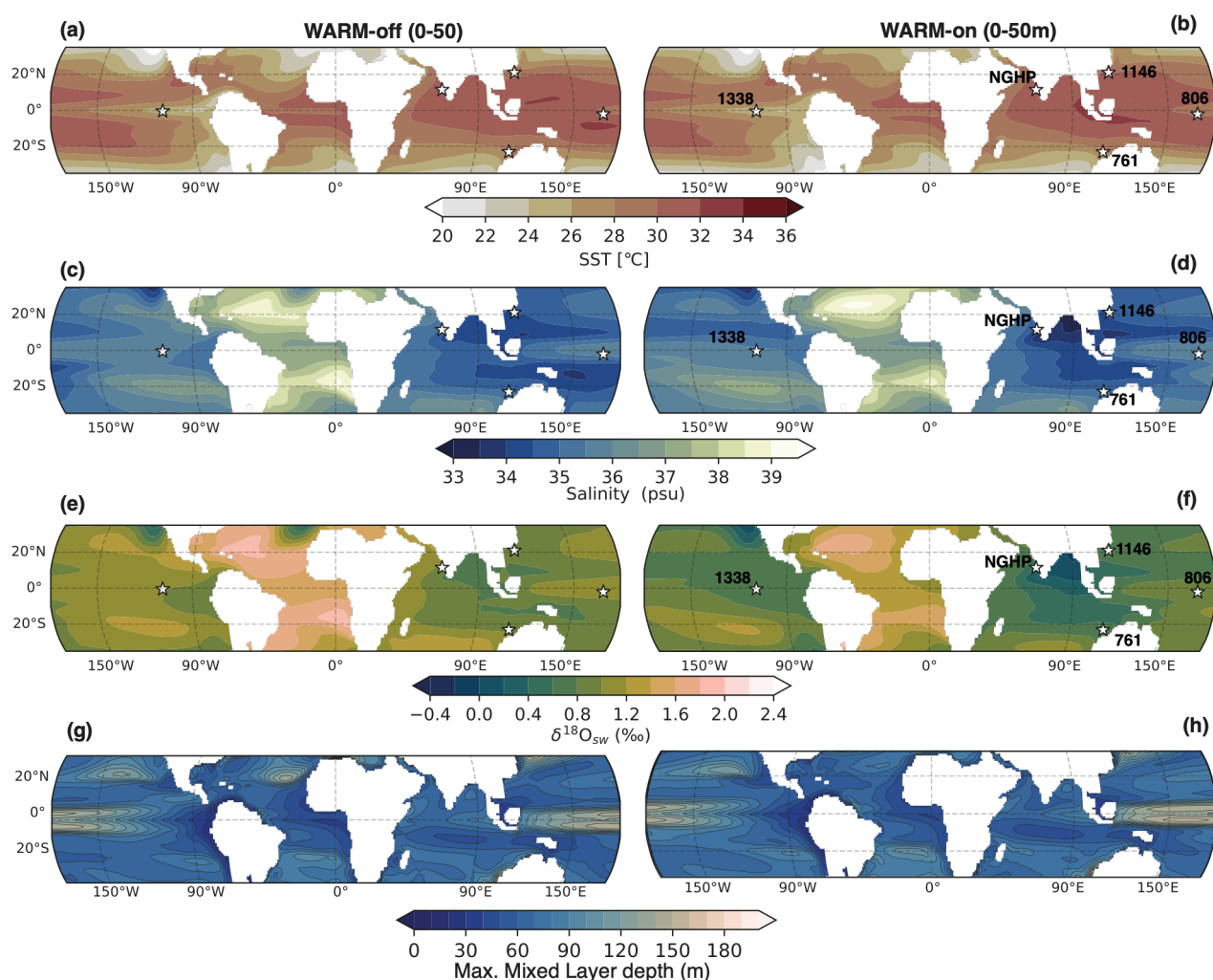


Figure S7. Temperature (°C) (a-b), salinity (psu) (c-d) and $\delta^{18}\text{O}_{\text{sw}}$ (‰) (e-f) (averaged between 0 and 50 m) and maximum mixed layer depth (m) (g-h) for and WARM-off and WARM-on. Stars indicate the location of drilling sites with published records (see Sect. 2.3) – ODP 806, ODP 1146, ODP 761, NGHP-01-01A and IODP 1336.

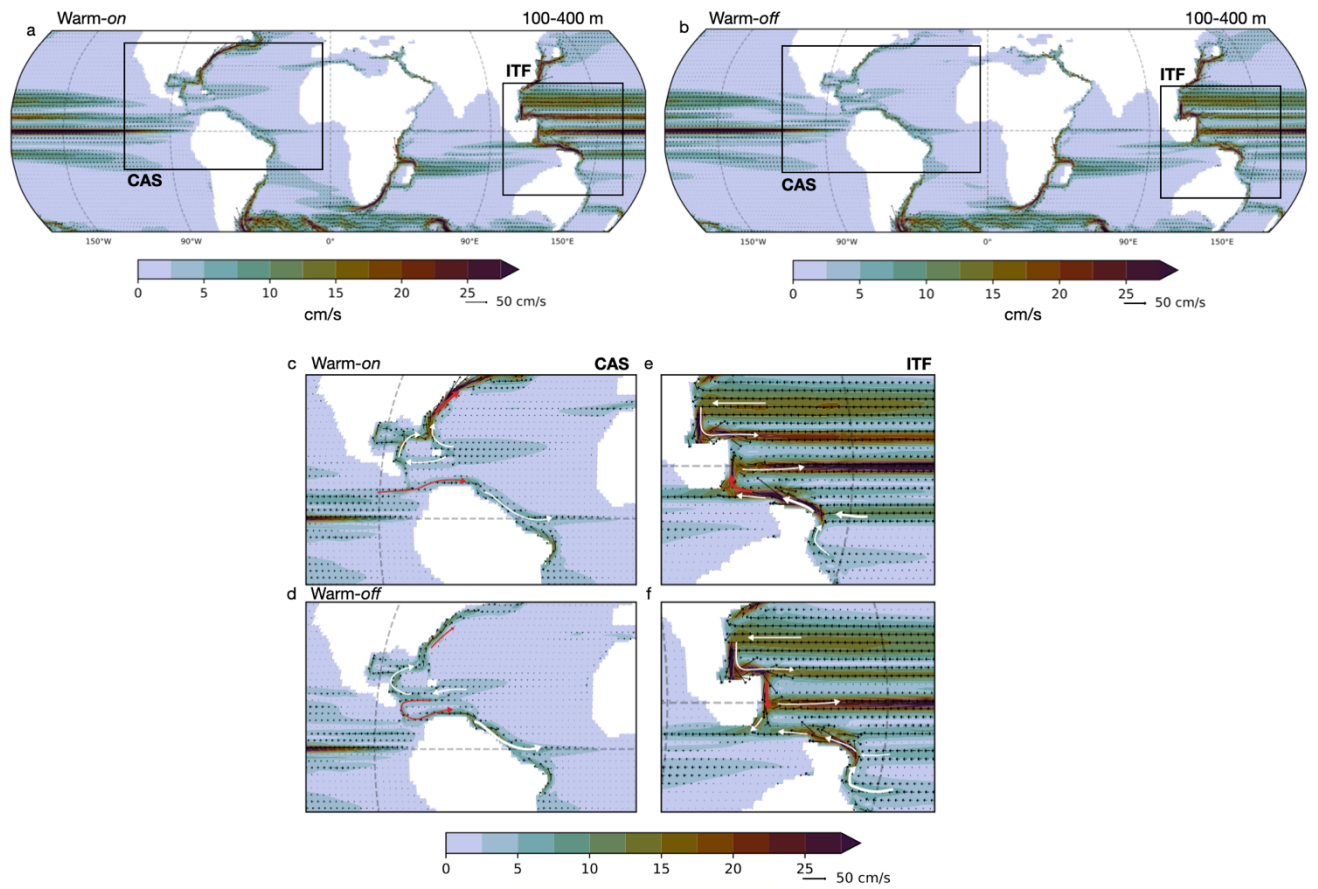


Figure S8. Circulation in the upper ocean (averaged between 100- and 400-meters depth). (a) *WARM-on*, (b) *WARM-off*. (c-d) zoom on the Central American Seaway region (CAS), (e-f) zoom on the Indonesian Throughflow region (ITF) for *WARM-on* and *WARM-off*.

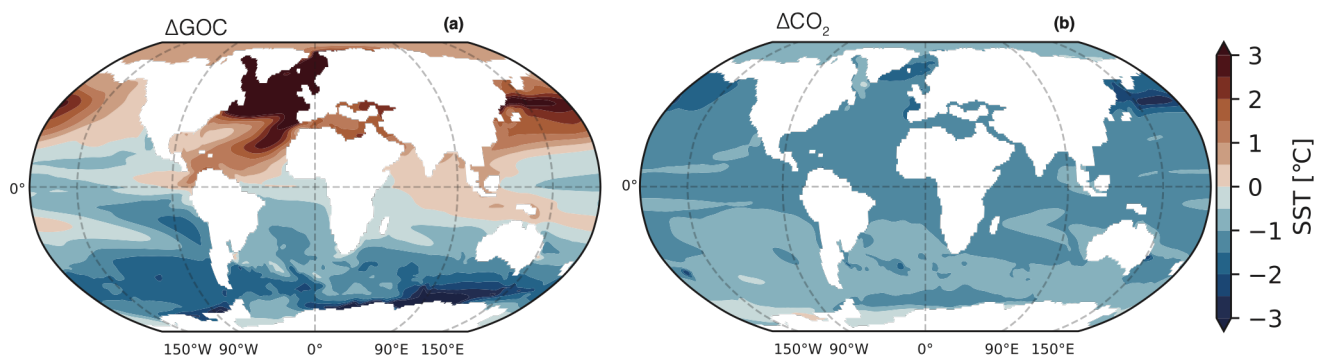


Figure S9. Global sea surface temperature (0-50m, °C) difference in (a) ΔGOC and (b) ΔCO_2

Table S1. $\delta^{18}\text{O}_{\text{sw}}$ – SSS regression (50–80 m) at site locations for WARM-*on* and WARM-*off*. Sites are located on Fig. 1 and Fig. S1. Paleocoordinates have been extracted using pyGplates (Mather et al., 2024) and plate rotation model from Seton et al. (2012) (Sect. 2.3).

Site	Modern site location	Paleo-coordinates (14Ma)	WARM- <i>off</i>			WARM- <i>on</i>			LS06	
			int.	slope	r ²	int.	slope	r ²	slope	int.
NGHP-01	70.9°E, 15.31°N	67.4°E, 11.4°N	-11.34	0.35	0.94	-12.48	0.38	0.95	-5.31	0.16
ODP 761	115.5°E, 16.7°S	111.6°E, 23.1°S	-8.97	0.29	0.94	-8.06	0.25	0.88		
IODP U1338	118°W, 2.5°N	108.7°W, 0.4°S	-9.24	0.29	0.85	-18.04	0.53	0.63	-8.88	0.27
ODP 1146	116.3°E, 19.4°N	114.7°E, 20.9°N	-8.95	0.29	0.87	-7.26	0.23	0.83		
ODP 806	159.4°E, 0.3°N	168.5°E, 2.1°S	-5.61	0.18	0.73	-5.75	0.18	0.40		