Figure S1. Ocean meridional streamfunctions (Sv : Sverdrup) are shown for the Atlantic (left) and Pacific (right). The contour interval is 1.5 Sv. The model output is averaged over a period of 100 years before and after the year of interest.
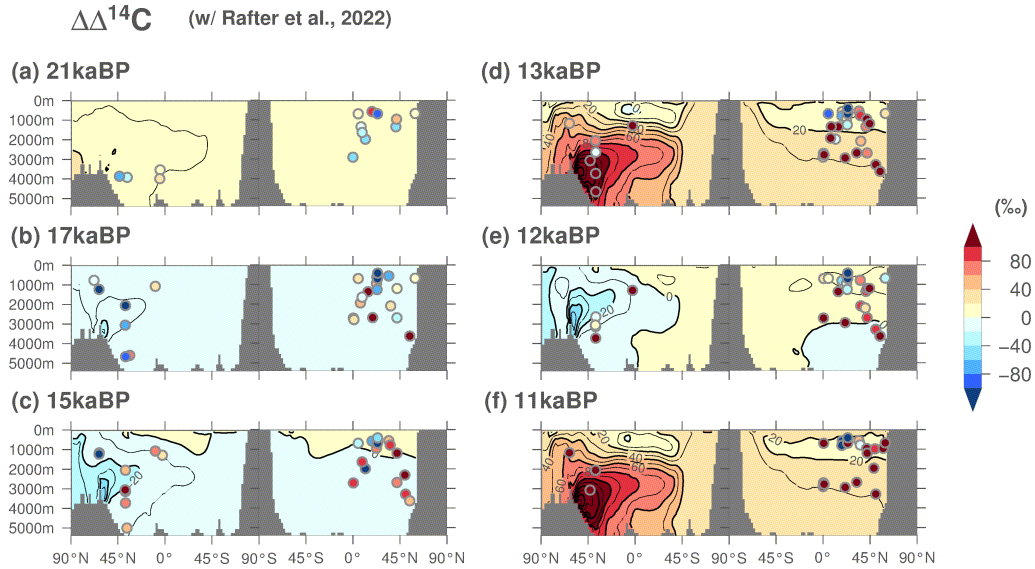
Figure S2. Oceanic zonal mean distribution of the difference in $\Delta\Delta^{14}$C between the period of interest and the average of the 18–21 kaBP period in the Atlantic and Pacific oceans. The specific periods of interest include (a) the Last Glacial Maximum (21 kaBP), (b) Heinrich Stadial 1 (17 kaBP), (c) just before the Bølling-Allerød (BA) transition (15 kaBP), (d) the Bølling-Allerød (BA) warm period (13 kaBP), (e) the Younger Dryas (12 kaBP) and (f) the Holocene (11 kaBP). The contour interval is 10 ‰. The sediment core records used in the figure are compiled in Rafter et al. (2022). Model results are averaged over 200 years, i.e., 100 years before and after each target year. However, for 21 kaBP, the average is taken from results spanning 21.0–20.9 kaBP; for 11 kaBP, the average is taken from results spanning 11.1–11.0 kaBP. The figure also includes a compilation of sediment core records where reconstructed values are plotted for 250 years before and after the target year. The vertical section represents all dat within the relevant ocean basins.
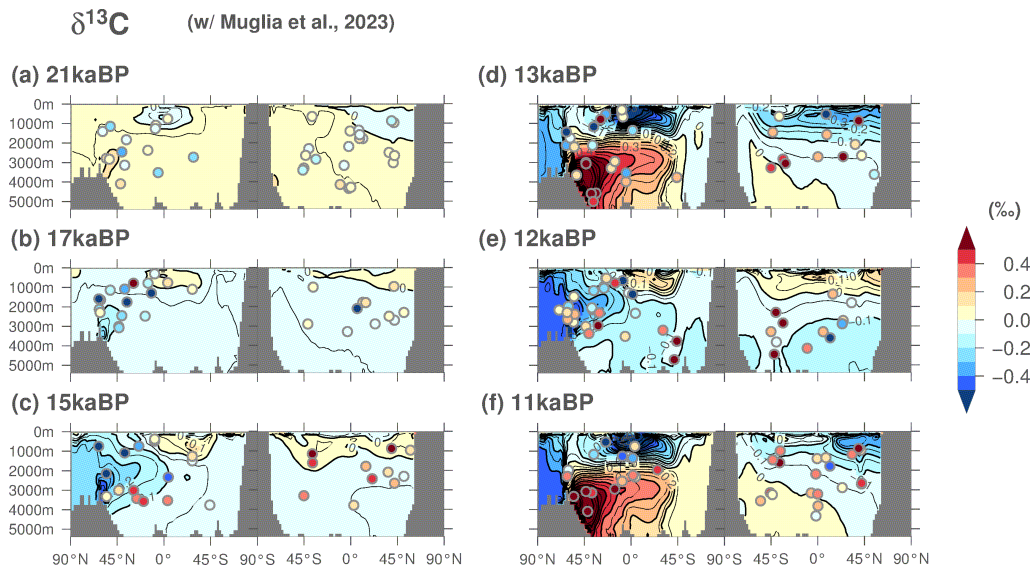
Figure S3. Oceanic zonal mean distribution of the difference in δ^{13}C between the period of interest and the average of the 18–21 kaBP period in the Atlantic and Pacific oceans. The contour interval is 0.05 ‰. The sediment core records used in the figure are compiled in Muglia et al. (2023). The period over which the model output is averaged is 100 years before and after the year of interest. The reconstructed values are also plotted for 100 years before and after the year of interest.
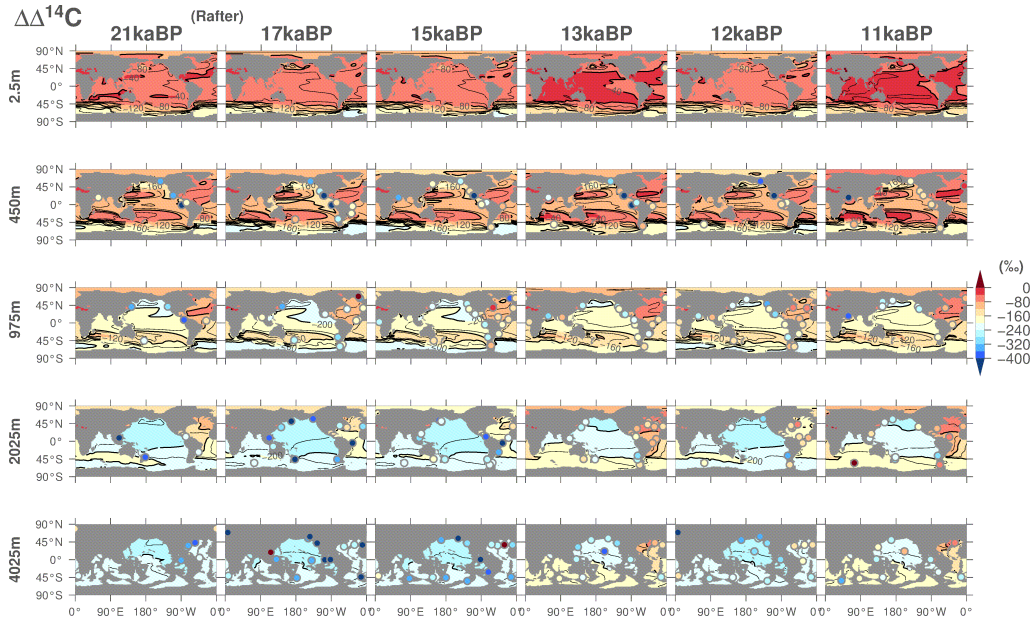
Figure S4. Oceanic distribution of $\Delta\Delta^{14}$C (‰) at specific depths (2.5m, 450m, 975m, 2025m, and 4025m) during key periods of the last deglaciation. The specific periods of interest include the Last Glacial Maximum (21 kaBP), Heinrich Stadial 1 (17 kaBP), just before the Bølling-Allerød (BA) transition (15 kaBP), the Bølling-Allerød (BA) warm period (13 kaBP), the Younger Dryas (12 kaBP) and the Holocene (11 kaBP). The contour interval is 40 ‰. The sediment core records used in the figure are compiled in Rafter et al. (2022). Model results are averaged over 200 years, i.e., 100 years before and after each target year. However, for 21 kaBP, the average is taken from results spanning 21.0–20.9 kaBP; for 11 kaBP, the average is taken from results spanning 11.1–11.0 kaBP. The figure also includes a compilation of sediment core records where reconstructed values are plotted for 250 years before and after the target year. The vertical section represents all dat within the relevant ocean basins.
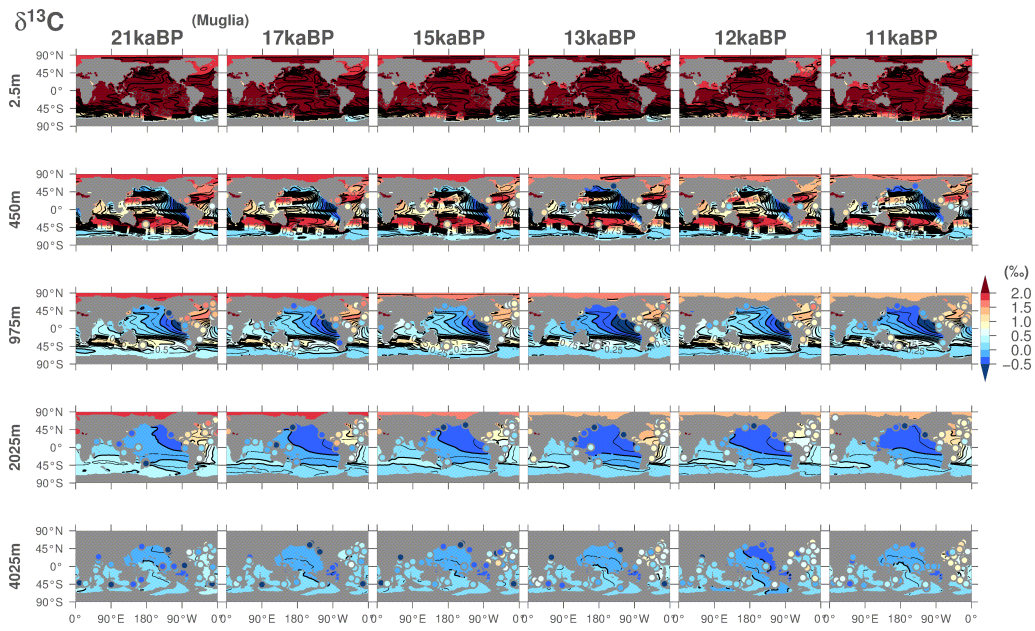
Figure S5. Oceanic distribution of δ^{13}C (‰) at specific depths (2.5m, 450m, 975m, 2025m, and 4025m) during the last deglaciation. The contour interval is 0.25 ‰. The sediment core records used in the figure are compiled in Muglia et al. (2023). The period over which the model output is averaged is 100 years before and after the year of interest. The reconstructed values are also plotted for 100 years before and after the year of interest.
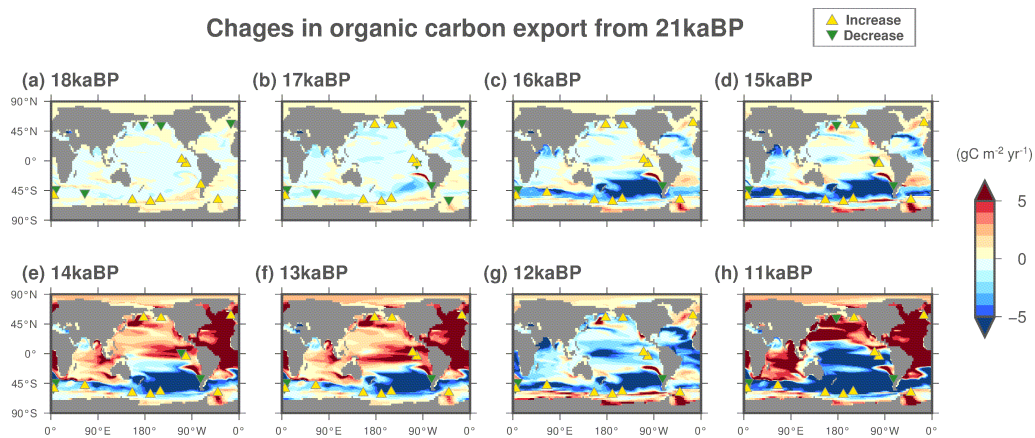
Figure S6. The calculated changes in organic carbon export $(\mathrm{PgC\,m^{-2}\,yr^{-1}})$ relative to the values at 21 kaBP are shown. The contour interval is $1\ \mathrm{PgC\,m^{-2}\,yr^{-1}}$. The triangles indicate qualitative increases (yellow) or decreases (green) in biological flux. These fluxes are reconstructed from proxies such as opal flux and alkenone flux in sediment core records (Chase et al., 2003; Anderson et al., 2009; Bolton et al., 2011; Kohfeld and Chase, 2011; Martinez-Garcia et al., 2014; Maier et al., 2015; Studer et al., 2015; Thiagarajan et al., 2019; Ai et al., 2020; Weber et al., 2021; Li et al., 2022).

Heinrich Stadial 1 (15ka - 18ka)
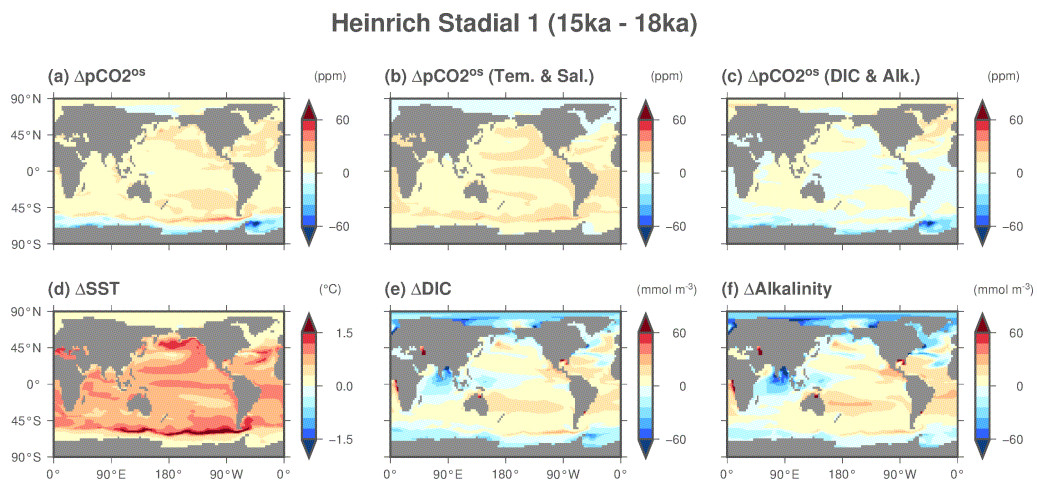
Figure S7. (a) Changes in partial pressure of sea surface CO_2 ($p{CO_2}^{os}$; ppm) between the early and late Heinrich Stadial 1 (differences between 15 and 18 kaBP) are shown. Changes in $p{CO_2}^{os}$ due solely to changes in (b) temperature and salinity and (c) dissolved inorganic carbon (DIC) and alkalinity, and changes in sea surface (d) temperature, (e) DIC, and (f) alkalinity between the same periods are also shown.
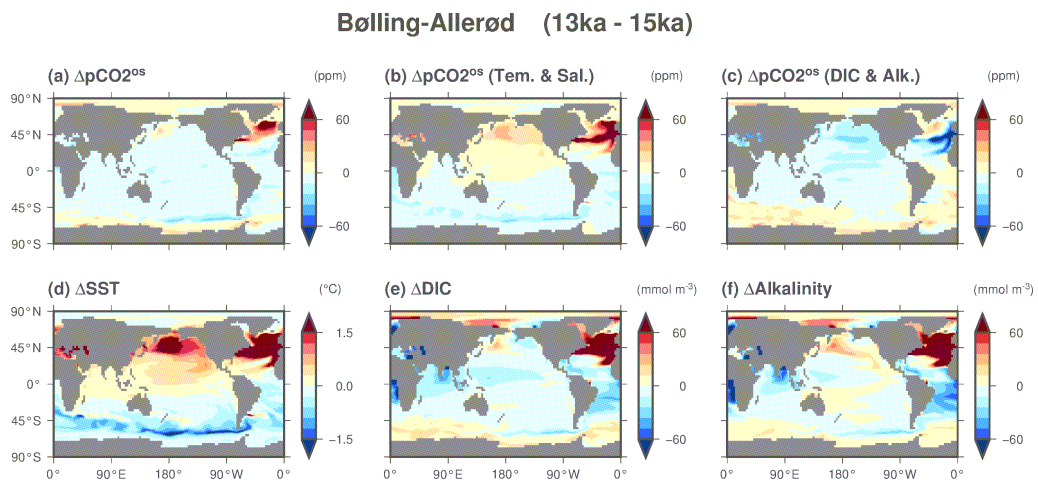
Figure S8. Same as Fig. S7 except for the Bølling-Allerød (differences between 13 and 15 kaBP).
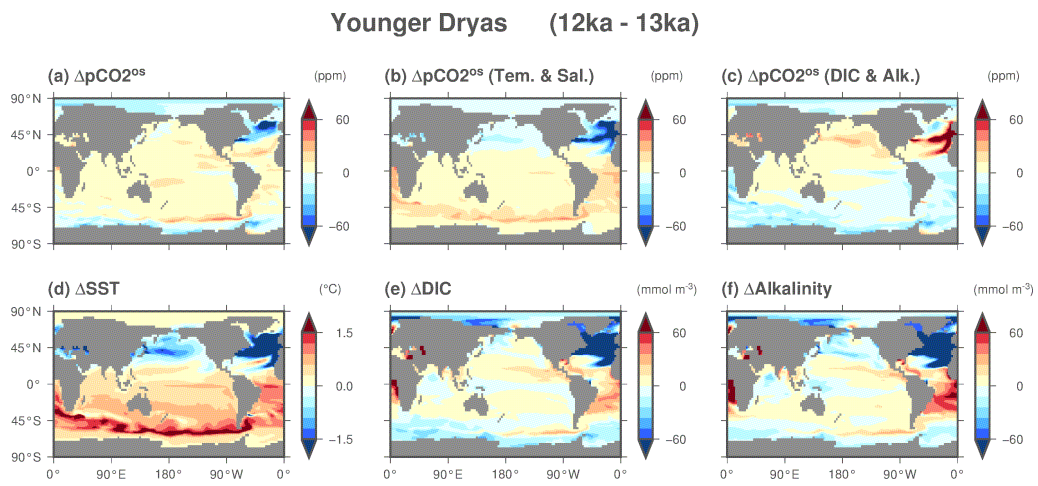
Figure S9. Same as Fig. S7 except for the Younger Dryas (differences between 12 and 13 kaBP).