Supplementary Material

Text S1: Equation of DIC balance

The variation of the DIC inventory in the upper layer between times t_1 and t_2 ($\Delta\ DIC\ I_{upper}$), is equal to the sum of all DIC fluxes within the deep convection area (DCA) between t_1 and t_2:

$$\Delta DIC\ I_{upper} = DIC\ I_{upper,t1} - DIC\ I_{upper,t2} = \int_{t_1}^{t_2} \left(F_{DIC,air-sea} + F_{DIC,lat} + F_{DIC,vert} + F_{DIC,bgc}\right)\ dt \qquad \text{(S1)}$$

where $F_{DIC,lat}$ and $F_{DIC,vert}$ are the lateral and vertical exchange fluxes at the boundaries of the deep convection area, $F_{DIC,air\text{-}sea}$ is the air-sea CO_2 flux, and $F_{DIC,bgc}$ is the biogeochemical flux.

$DIC\ I_{upper,t}$ was computed from:

$$DIC_{upper,t} = \iiint_{(x,y)\in DCA/z\in\ upper\ layer} DIC(x,y,z,t)\ dx\ dy\ dz \qquad \text{(S2)}$$

where (x,y,z) belongs to the upper layer (150 m to the surface) of the deep convection area.

The lateral exchange flux was computed from:

$$F_{DIC,lat} = \iint_{(x,y,z)\in A} DIC(x,y,z,t) v_t(x,y,z,t)\ dA \qquad \text{(S3)}$$

where v_t is the current velocity normal to the limit of the deep convection area (in m s^{-1}), A (in m^2) is the area of the section from the base of the upper layer (150 m) to the surface of the deep convection area.

The $F_{DIC,air\text{-}sea}$ was computed from:

$$F_{DIC,air-sea} = \iint_{(x,y)\in DCA} CO_2 flux(x,y,t)\ 10^{-3} dx\ dy \qquad \text{(S4)}$$

where CO_2flux (in µmol C m^{-2} s^{-1}) is the air-sea flux given by Eq. (3).

$F_{DIC,bgc}$ was computed from:

$$F_{DIC,bgc} = \iiint_{(x,y)\in DCA/z\in\ upper\ layer} BGCflux(x,y,z,t)\ dx\ dy\ dz \qquad \text{(S5)}$$

where *BGCflux* is the biogeochemical flux given by Eq. (1).

Finally, the vertical transport flux, $F_{DIC,vert}$, was derived from all other terms of Eq. (S1).

The computation of DIC balance in the deeper layer is computed in a similar way, with the inventory variation as the sum of the lateral and vertical exchanges flux at the boundaries, and biogeochemical flux. Here the fluxes at the sea-sediment interface were neglected in respect to the other terms of the balance.

Table S1: Sensitivity tests to the parameterization of gas transfer velocity, the variability of the mole fraction of CO_2 in the atmosphere, and the calcification processes on the annual CO_2 air-sea flux estimate.

Sensitivity tests		**Annual air-sea flux (mol C m^{-2} yr^{-1})**
Sensitivity to the parameterizations of gas transfer velocity	**Parameterizations of gas transfer velocity**	
	Wanninkhof (1992) used in the standard run	0.47
	Liss and Merlivat (1986)	0.25
	Woolf (1997)	0.55
	Wanninkhof and McGillis (1999)	0.60
	Nightingale et al. (2000)	0.35
	Wanninkhof et al. (2009)	0.34
	Stanley et al. (2009)	0.55
	Liang et al. (2013)	0.42
	Wanninkhof (2014)	0.37
	Mean (SD)	0.43 (0.12)
Sensitivity to the mole fraction of CO_2 in the atmosphere	**Added value to the mole fraction used in the standard run**	
	-3 ppm	0.33
	+3 ppm	0.61
	Mean (SD)	0.47 (0.20)
Sensitivity to $CaCO_3$ production	**Added term to Eq. 1**	
	Based on PIC:TOC production	0.72
	Based on Lajaunie-Salla et al. (2021)	0.58
	Mean (SD)	0.65 (0.10)

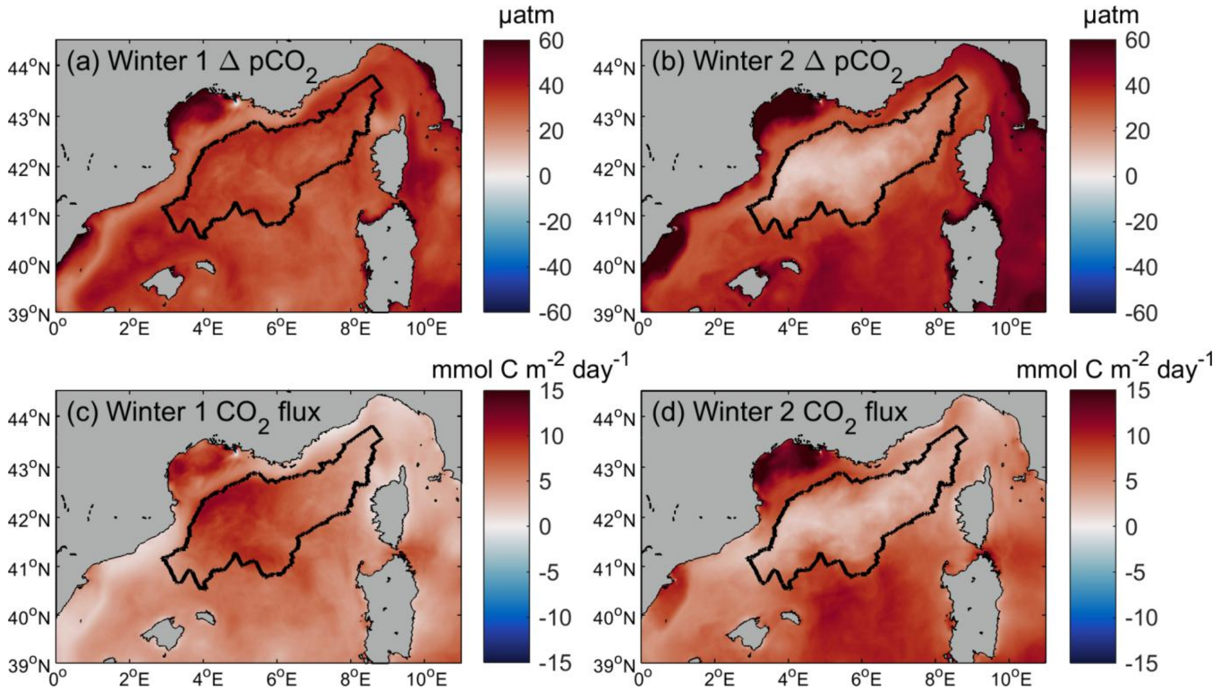

Figure S1: (a,b) pCO_2 difference ($pCO_{2,atm}$ - $pCO_{2,sea}$, in µatm) and (c,d) air-to-sea CO_2 flux (mmol C m^{-2} day^{-1}), averaged over winter 1 (28 November-15 January) and winter 2 (16 January-23 March) sub-periods. The black line indicates the limit of the deep convection area.