

LEGEND for the review:

- REVIEWER'S COMMENT
- RESPONSE BY CORRESPONDING AUTHOR
- NEW / UPDATED TEXT

General comment by corresponding author:

Many thanks for spotting typos, errors, and sentences that lacked clarity. All the minor changes have been addressed and the DOI has been updated for all available references.

Issues requiring further clarification and changes to formatting:

Lines 15-20: More clarification and contextual detail on the Key Points, so they can be read independently of the main manuscript by non-specialist readers. Some suggestions are given below.

Key Points; Line 18 : Clarify 'ocean pCO₂'; (e.g., by rewording to 'surface ocean partial pressure of CO₂', or similar).

Key Points: Line 19 : Clarify "...high emissions amplify this signal"; e.g., to add contextual detail on the Shared Socio-economic Pathways (SSPs) emissions scenarios that were used in the analysis.

Thank you for these suggestions. We thought of not adding The key points have been rephrased to:

Lines 17-20:

- Due to summer retention, surface OAE reverses the seasonal cycle of alkalinity and it decreases ocean surface ocean partial pressure of pCO₂, turning the system into a year-round carbon sink
- OAE drives the strongest CO₂ uptake enhancement in winter, while a scenario with higher greenhouse gas emissions amplify this signal'

Line 82: Should 'seasonal driver' be reworded as 'seasonal drivers' or 'main seasonal driver'? As noted in lines 69-77, there is more than one seasonal driver.

Thank you for pointing this out. The 'drivers' are indeed plural. We modified the text to:

Lines 78-79:

'The location of OAE deployment may be affected by the seasonal drivers...'

Line 115, Line 148, etc. : Is the resolution 0.5 o ? If so, please write it out in decimal (not fractional) notation, for these lines and other similar instances.

Thank you for this point. The text referring to the model's resolution has been changed:

Lines 113-114:

'The ocean is divided into 46 vertical layers with a horizontal resolution of 0.5° and the atmosphere is composed of 95 vertical layers with a horizontal resolution of ~1.8°.'

Line 148:

'As the model runs with a horizontal resolution of 0.5°, ...'

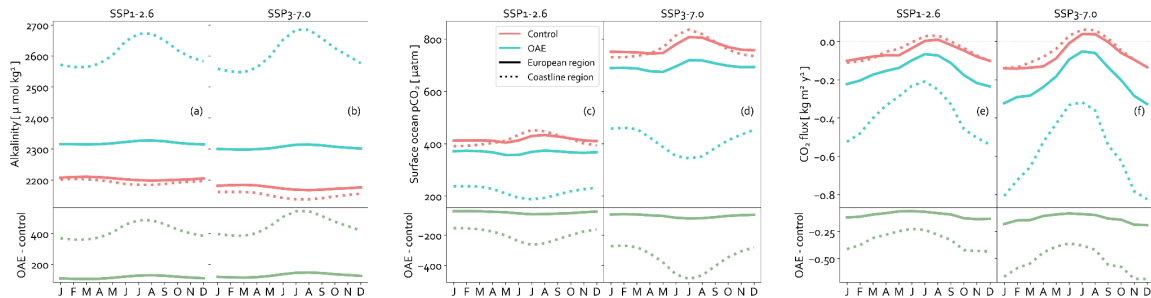
Lines 162:

‘However, model fidelity lowers towards the coasts, which are less resolved with a 0.5° resolution.’

Lines 151 - 153, etc. : Check formatting of units (e.g., 1 Gt y⁻¹) and make sure indices are superscripted, for these lines and other similar cases. There are several instances, throughout the manuscript, where the superscript indices are not formatted correctly. Please address all of these cases.

Many thanks for pointing out the unit formatting. All units have been changed by removing the ‘-’ and superscripting the indices, in the text and in the figures. Here’s an example of Figure 4 and of a paragraph where this issue was addressed:

Line 278:



Lines 365-375:

‘In the European region, with OAE deployment the ocean’s CO₂ uptake potential is enhanced at all seasons: it ranges from 0.235 (0.327) kg CO₂ m² yr⁻¹ in winter to 0.076 (0.053) kg CO₂ m² yr⁻¹ in summer under SSP1-2.6 (SSP3-7.0). As OAE drives largest CO₂ drawdown during winter, it enhances the seasonal CO₂ flux, with a new amplitude of 0.168 kg CO₂ m² yr⁻¹ in SSP1-2.6 and 0.292 kg CO₂ m² yr⁻¹ in SSP3-7.0, compared to their respective controls (0.111 kg CO₂ m² yr⁻¹ and 0.18 kg CO₂ m² yr⁻¹). This results in a seasonal amplitude enhancement of 51% and of 62% in the low- and high-emission scenario, respectively. In the coastline region, the signal is larger than in the European region: the CO₂ flux seasonal amplitude is 0.329 kg CO₂ m² yr⁻¹, therefore more than doubling the amplitude in the control run, which amounts to 0.114 kg CO₂ m² yr⁻¹. With an amplitude of 0.505 kg CO₂ m² yr⁻¹, the OAE seasonal CO₂ flux in SSP3-7.0 is more than 2.5 times larger than the control (0.199 kg CO₂ m² yr⁻¹)’

Lines 255-259, Table 1: Check that formatting of units in table is correct (e.g., indices superscripted for units of Alkalinity and Air-sea CO₂ flux).

Thank you for pointing this out. Here’s the revised table:

	European region				Coastline region			
	SSP1-2.6		SSP3-7.0		SSP1-2.6		SSP3-7.0	
	Control	OAE	Control	OAE	Control	OAE	Control	OAE
Alkalinity [$\mu\text{mol kg}^{-1}$]	(2198, 2210)	(2315, 2327)	(2167, 2184)	(2298, 2314)	(2184, 2203)	(2563, 2672)	(2138, 2162)	(2547, 2685)
Surface ocean pCO ₂ [μatm]	(404, 433)	(357, 374)	(745, 807)	(674, 719)	(391, 452)	(188, 238)	(730, 836)	(344, 461)
Air-sea CO ₂ flux [$\text{kg m}^{-2} \text{y}^{-1}$]	(-0.102, 0.009)	(-0.235, -0.067)	(-0.142, 0.038)	(-0.327, -0.053)	(-0.111, 0.03)	(-0.539, -0.209)	(-0.139, 0.061)	(-0.823, -0.318)
Mixed layer depth [m]	(15, 135)	(15, 141)	(14, 107)	(14, 106)	(15, 76)	(15, 75)	(14, 68)	(14, 66)

Lines 265-268: This sentence is long and not very clear, with possible grammar errors (e.g., the colon ‘:’ should be replaced with a comma or other punctuation). Consider splitting into one or more separate sentences for clarity.

Thank you for your suggestion. Here’s the revised version of this sentence:

Lines 268-272:

‘In the OAE runs, alkalinity increases in all seasons. While control values in SSP1-2.6 are higher than in SSP3-7.0, OAE increases surface alkalinity relatively less under lower emissions. In summer, when OAE enhances alkalinity the most in both scenarios, values are increased by 117 $\mu\text{mol kg}^{-1}$ and by 130 $\mu\text{mol kg}^{-1}$ for the low- and high-emission scenario, respectively.’

Lines 286-290: This sentence is long and not very clear, with possible grammar errors. Consider splitting into one or more separate sentences for clarity.

Thank you for pointing out the lack of clarity in this sentence. Here’s the revised text:

Lines 290-294:

This reversed pattern is highlighted in Fig. 5, where seasonal alkalinity is shown as a function of depth. Under natural conditions, alkalinity increases with depth and winter mixing helps replenish the upper ocean from deeper layers. However, in the OAE simulations, alkalinity is added at the surface in our simulations, and stronger vertical stratification in summer leads to greater alkalinity retention, favoured by a shallower MLD.

Line 309: Should the words ‘and highest’ be in brackets ? i.e., ‘(and highest)’. This would make it consistent with the rest of the sentence.

Thank you for pointing this out. The sentence has been rephrased for clarity:

Lines 313-315:

‘Regarding the surface ocean pCO₂, the European region (Fig. 4c, d) is characterised by lowest of 404 µatm (745 µatm) in May and highest values of 433 µatm (807 µatm) in August under SSP1-2.6 (SSP3-7.0).’

Line 312: replace ‘at’ with ‘for’.

Thank you for this suggestion. We rephrased the sentence accordingly:

Lines 316-317:

‘In the OAE run, surface ocean pCO₂ decreases for all seasons...’

Lines 323-324: Please clarify with more detail what is meant by ‘when the control runs reach their peak’.

Thank you for this point. We rephrased the sentence to focus on the time match between highest alkalinity and lowest pCO₂ change:

Lines 328-329:

‘The largest change occurs in summer, when OAE-driven surface alkalinity has increased the most.’

Lines 336-340: This sentence is long and not clear. Consider splitting into one or more separate sentences for clarity (e.g., by replacing the colon and semi-colon with periods/full-stops (‘.’)).

Thank you for your suggestion. Below is the rephrased sentence, which has now been split in two:

Lines 327-329:

‘OAE reduces surface ocean pCO₂ in both the European region and in the coastline region, and under both emission scenarios. The largest change occurs in summer, when OAE-driven surface alkalinity has increased the most.’

Lines 344-350: This sentence is long and not clear. Consider splitting into one or more separate sentences for clarity (e.g., by replacing the colon and semi-colon with periods/full-stops (‘.’)).

Thank you for your suggestion. The whole paragraph has been rephrased to add clarity:

Lines 350-356:

‘Such a strong latitudinal and scenario divergence in the seasonal amplitude of surface ocean pCO₂ may be due to different factors. North of 60° N, where the air-sea CO₂ flux is driven by its biological component (Fig. 3d), the seasonal cycle could respond differently from the European region and the coastline region, where the CO₂ flux is controlled by SST. At lower latitudes in SSP3-7.0, the increasing seasonal amplitude of surface ocean pCO₂, which is spatially confined to the coastal shelves, is probably driven by an even stronger OAE-induced pCO₂ decline over summer, as it is the case for the coastline region in Fig. 4d.’

Line 427: Replace ‘at’ with ‘for’ or ‘in’.

Thank you for the suggestion. The sentence has been rephrased:

Lines 434:

‘Secondly, continuous OAE deployment induces surface ocean pCO₂ reduction in all seasons,...’

Line 429: Do you mean ‘during the summer’ ?

Thank you. We added your suggestion:

Lines 435-436:

‘...which is during the summer in the temperature-driven European region.’

Line 432: Replace ‘dissolutions’ with ‘dissolution’.

Thank you for spotting this. Here’s the new text:

Line 439:

‘...deepen the MLD and favour CO₂ dissolution in seawater. ‘

Line 469: should ‘face’ be ‘phase’ ?

Thank you for spotting this typo. The new sentence reads:

Line 476:

‘...MLD-integrated alkalinity seasonality becomes out of phase compared to the whole water column, ...’

Lines 481-484: This sentence is long and not very clear. Consider splitting into one or more separate sentences for clarity. Consider replacing ‘irrespective’ with ‘regardless’ or other similar word.

Line 513: should it be ‘which is an’ ?

Thank you for spotting this. The verb has been added to the sentence:

Line 520:

‘...which is an essential aspect to long-term OAE efficiency.’

Line 528: change ‘missing to discern’ to ‘missing the capability to discern’ (or similar wording).

Thank you for this suggestion. The sentence has been rephrased:

Line 535:

‘...therefore missing the capability to discern the influence...’

Line 535: Consider replacing ‘as it is partially displayed in Fig. 7.’ With ‘as is partially shown in Fig. 7.’

Thank you for the suggestion. The text has been modified accordingly:

Line 542:

‘... from the alkalinity injection sites, as is partially shown in Fig. 7.’