Dear Matthew,

Thanks for the revised manuscript, which is much improved, also due to the help of the very useful comments by both referees. I am satisfied with your responses to the reviewers and the new version. There are only some final technical issues that I have listed below.

- Thank you for your support for this manuscript and the comments which have also helped tidy up a few loose ends.

L137 Earlier the unit of v was given as % °C-1. Please be consistent. And please write: in units of per temperature (note: x-1 only for symbols)

- Changed to % $°C^{-1}$

L286 It would be helpful to spent one sentence on what PyCO2SYS actually is and stands for. Not every reader may be familiar with this software.

- Added a short paragraph to the start of section 2.3:
  "PyCO2SYS is a free and open source Python package which can be used to solve the marine carbonate system, that is, to calculate the equilibrium balance of the main acid-base systems in seawater and related properties (Humphreys et al., 2022). PyCO2SYS was originally based on the MATLAB/GNU Octave program CO2SYS.m (v2.0.5; Orr et al., 2018), itself part of a family of similar software tools beginning with the original CO2SYS for MS-DOS (Lewis and Wallace, 1998)."

L328 It would be good to give some info on the data set. There are several other data sets available as well, and therefore the choice for this one should be justified.

- Added a couple of sentences to the start of section 2.4:
  "OceanSODA-ETZH provides fields of several marine carbonate system and other hydrographic parameters gridded across the surface ocean (1° × 1°) and through time (monthly from 1985 to 2018). The parameter fields were generated using an ensemble cluster-regression approach based on observations in SOCAT (Bakker et al., 2016) and GLODAP (Lauvset et al., 2016). Other similar data products exist, but the main patterns and variability in surface ocean carbonate chemistry are well enough constrained that the choice of a particular data product will not significantly affect the global-scale and time-averaged analyses conducted here."

L328 Please use date format 4 December 2023 throughout the paper

- Done

L364 It is somewhat confusing that eq. 19 is mentioned for determining vh , as vh does not occur in eq. 19. Please change wording to make this clear. It also occurs at other places following.

- Some (but not all) of these should probably be referring to Eq. (20). Have updated, and added a note in Sect. 3.1.1 that (19) is the integrated form of (20):

"Equation (20) cannot be fitted directly to fCO_2 data because υ represents the derivative with respect to temperature; instead, we need to fit Eq. (19) to obtain the unknown b_h which can then be used in Eq. (20) for υ_h."

L390 delete one of the two "that"
L450 delete slightly, as this is a difference of 25

- Both done

I have one suggestion which you may consider applying. The theory and reasoning in this manuscript is not easy stuff (it is a challenging read, as one of the referees mentioned it) and the paper is quite long. Therefore, you may consider to write in the conclusions section, an instruction of what to do if one wants to adjust the temperature of pCO2 measurements to the in situ temperature. In the Takahashi paper everyone can simply see how to do this. It would be good when such a clear instruction would also appear here.

- I added a paragraph to the start of the Conclusions with an instruction of specifically how to do this, which equations need to be used:
  "Seawater fCO_2 data can be adjusted to different temperatures using either Eq. (2) or Eq. (4) (which are mathematically identical) with an appropriate expression for Y, which is υ integrated over the temperature range of interest. The new approach proposed here uses Y_h as defined in Eq. (21), which has one unknown coefficient (b_h). The value of b_h can be found by fitting to experimental data where available (e.g., Table 1), but spatiotemporal variability in b_h should be accounted for, for example with the parameterisation in Eq. (35). This approach, as well as the earlier linear and quadratic approaches of Takahashi et al. (1993), have been built into the PyCO2SYS software as of v1.8.3."

Thanks and with best wishes
Mario

Additional private note (visible to authors and reviewers only):
This is a relatively long paper. To increase the readability, I would encourage to shorten where possible. I realize that this may be difficult, but maybe you see some possibilities. If you think this is not possible, I am fine with it as well. I just think that the paper will be read better when it is not too long.

- I agree in principle and did read through the manuscript with this in mind, but to reduce the length by any significant amount now would require a substantial amount extra work to ensure that everything still flows and is complete, which is going to be very difficult to fit in with other commitments at the present time, so I have not made any cuts here.

Additional changes:

- Updated GLODAP citation to the most recent version (Lauvset et al., 2022 => Lauvset et al., 2024).