Point-by-point response

Reply to response on multicollinearity in Equation 6:
The author's response is understandable, but even if nTA is used, it is still completely dependent on SSS, since TA calculated with SSS is only corrected with SSS. Note that Takahashi et al., 2014 calculated TA + nitrate with SSS, so it is not fully dependent. Such non-independence among variables may lead to instability in each explanatory terms, even if the objective variable (pCO2) is consistent with measured values.
At least the Taylor expansion using the three parameters 1: SST, 2: DIC (nDIC) and 3: SSS or TA (nTA) should be estimated to check if the values of the term of SST and DIC are not significantly different from the four-parameter results.

We sincerely appreciate your insightful comment, which has helped us to delve deeper into the calculations and explore new perspectives. We fully understand that the procedure used to reconstruct A_T at the time of each observation may introduce inconsistencies in the Taylor expansion, as it relies on these estimated A_T values. As you point out, the issue stems from the expected multicollinearity between SSS and A_T. Given their strong correlation, the Taylor expansion may attribute seasonal changes in $fCO_{2,sw}$ redundantly or ambiguously, making it difficult to distinguish which part of the signal is strictly due to changes in salinity and which to A_T. Furthermore, the individual contributions of A_T or SSS could be biased, potentially leading to over- or underestimations.

While the Taylor expansion assumes statistical independence among the terms (SST, SSS, A_T, and C_T), using A_T (or NA_T) estimated from SSS inherently removes the statistical independence between A_T and SSS. However, it is important to note that the rest of the terms (SST and C_T) remain statistically independent and are not affected by this issue of bias or multicollinearity. Considering that the combined contribution of SST and C_T to the seasonal variability of $fCO_{2,sw}$ exceeds 80% (and even reaches up to 90% in some locations along our transect) the instability caused by the AT–SSS correlation would affect less than 20% of the reconstruction of the seasonal variability of $fCO_{2,sw}$

Your suggestion has been extremely valuable in helping us improve the robustness of our analysis and increase the certainty in our assessment of the mechanisms driving the seasonal variability of $fCO_{2,sw}$. In the revised version of the manuscript, we have refined the method used to estimate A_T from SSS. Specifically, we included a non-conservative term (ε) in the linear A_T-SSS relationship, which represents the residual (the difference between measured A_T values and those predicted from SSS) and captures the variability not explained by salinity. This ε term, along with the linear model parameters (slope and intercept) and their associated uncertainties, was propagated through our dataset using Monte Carlo simulations. As a result, the reconstructed A_T values are largely driven by salinity-related processes but also incorporate variability from non-conservative processes that are independent of SSS.

This methodological improvement is now described in detail in the new subsection 2.4.1.2, entitled *"AT determination and reconstruction"* (line 284). These updated A_T values are normalized to reference salinity following the approach of Friis et al. (2003), as we now explain in lines 397-399. The new A_T values were subsequently used to compute C_T with CO_{2SYS}, and we note that the resulting C_T values show only minimal differences (<0.5 µmol kg^{-1}) compared to those in the previous version of the manuscript.

We have recalculated all terms involved in the Taylor expansion and included an updated Figure 5 in the revised manuscript. Additionally, in this point-by-point response document, we provide a supplementary figure ("Figure 5 – aux"), which mirrors the structure of Figure 5 and shows a direct comparison between the previously reported and updated values of the $dfCO_2^X$.

We confirmed that there is no difference in d*f*CO_2^{SST} between the previous and revised calculations. The differences in d*f*CO_2^{CT} and d*f*CO_2^{SSS} are negligible. These small changes resulted from updates in the A_T input values used in CO_{2SYS}, which in turn resulted in slight modifications to the outputted C_T values. For d*f*CO_2^{AT} , we observed differences of less than 2.6 µatm in the S section and less than 7.7 µatm in the E section. These changes correspond to a variation in the relative contribution of A_T to d*f*CO_2 of approximately 1-6% compared to the values reported in the previous version.

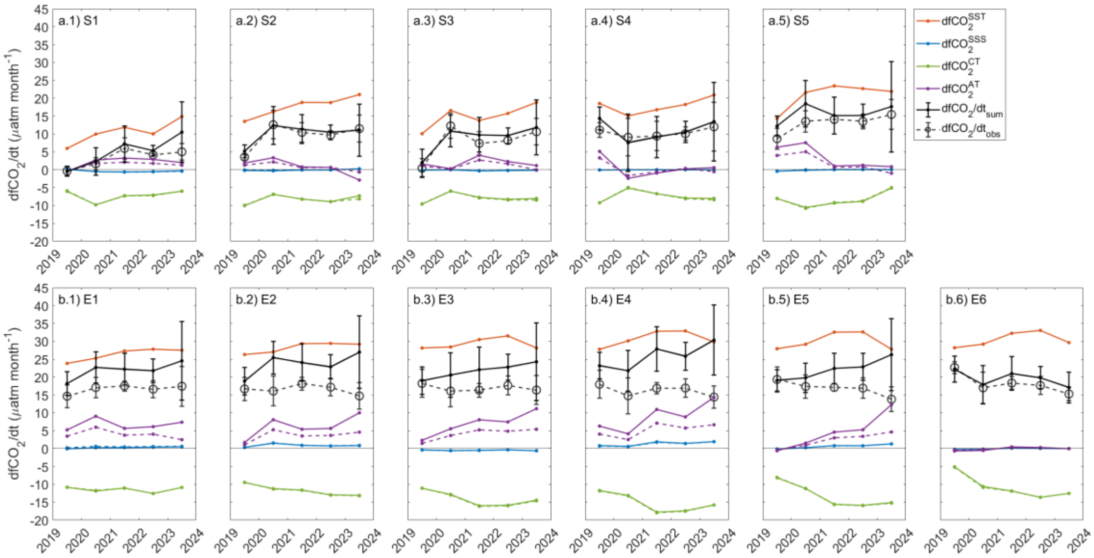

Figure 5 aux. Temporal evolution of the seasonal rates of *f*$CO_{2,sw}$ explained by each of its drivers within the five years of observation. The differences between monthly average data for February and September (where minimum and maximum SST and *f*$CO_{2,sw}$ were encountered) was considered to compute the seasonal trends. The standard deviation of the monthly average data was considered in the calculation of the seasonal changes and infers errors in the computation of *f*$CO_{2,sw}$, which are summarized in Table Sup3. The dashed purple, blue and green lines represent the d*f*CO_2^{AT}, d*f*CO_2^{CT} and d*f*CO_2^{SSS}, respectively, of the previos version of the manuscript.

Line 27
Isn't 0.97 -0.97?

It was a typo and was corrected in the revised version.

Line 305
Why do you conclude that nutrient-rich seawater influx reduced the influence of biological activity on TA?

We included that statement more as a hypothesis than as a conclusion, based on the existing literature regarding the inflow of Atlantic water into the Mediterranean. However, we acknowledge that it may be somewhat controversial. We have therefore removed the statement and revised the corresponding paragraphs in the methodology section related to the explanation of the AT reconstruction (see new subsection 2.4.1.2 starting on line 284).

Line 390
Bulk equation for air-sea flux was devised much earlier than 1983 (e.g., Whitmann, 1923; Liss and Slater, 1974). The bulk equation itself is a well-known theory, so there is no problem in omitting its citation.

Citation was removed