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REVIEW of Palmiéri et al. (2014): Simulated anthropogenic CO_2 uptake and acidification of the Mediterranean Sea.

This work deals with a relevant topic for the Mediterranean Sea environment. This marginal sea suffers a high human pressure in different social, economical and environmental issues. The present work tries to estimate the anthropogenic CO_2 uptake and storage and the directly derived pH decrease (acidification) in the water column in this practically closed system using a modelling approach. This issue is of particular interest to the referee. I agree that the work tries to address relevant questions for the oceanographic community working the MedSea but also for policy makers and it deserves publication in Biogeosciences but first it needs some MAJOR IMPROVEMENTS regarding the comments below.

MAJOR ISSUES

I guess that applying your model results to one or other data base in the Mediterranean Sea is not a major issue if the cruises are recent and coherent in the CO_2 data. Although I am biased, I really miss some reference to Álvarez et al. (Oc. Science 2014), this data was available in CDIAC from mid 2012 (http://cdiac.ornl.gov/oceans/Coastal/Meteor_Med_Sea.html) and it could have been used to get a better resolution of alkalinity, combining both 2001 and 2011 data sets. I am aware of other basin-scale cruises but the data is not so easily available.

Although no TTD results are available for the 2011 data set, the directly measured tracer concentrations are contained in the data base.

1) One of my main concerns is commented in the Introduction, last paragraph in page 6464 and first paragraph in page 6465: the MedSea is warming and getting saltier at higher rates than any other ocean, ventilation of deep waters is much faster as well, in addition, it has a very peculiar CO_2 chemistry (Álvarez et al., 2014). So I wonder if your model approach is somehow simplistic (I am not a modeller, so please excuse me!), does your model consider changes in salinity and temperature and how they affect the CO_2 chemistry (TA for example), and even more, we know that the Revelle factor increases as pCO_2 increases, making the waters less able to store CANT. I know it is complicated but the options in the model GLO-TA as in the global ocean, Med: mean TA equal to MedSEa values and VAR: salinity variations taken into account although interesting, could go a

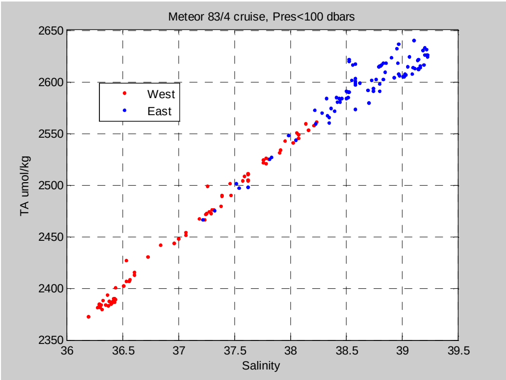
little bit further. What happens to the VAR option if including temperature & salinity increase and the feedback in the CO_2 system?. Maybe using the temporal change in the buffer factors (as defined in Egleston et al. but formulated correctly in Alvarez et al 2014) could help to calculate the change in the CO_2 system.

2) Section 2.2.2 Anthropogenic carbon.

I am sorry but I do not get the message from here. The driver is the pCO_2 atmospheric increase, δpCO_2ocean is calculated from the only tracer that is carried in the model δC_T (page 6470, lines 14-15) using Eq. 12 & 13 . So why do you calculate δpCO_2ocean?, is it needed in the model for something additional?. I do understand that δC_T is calculated as the difference between the preindustrial value and the new one in time x as a function of pCO_2 air in time x, TA, temperature and salinity (page 6471). And in the VAR simulation TA is calculated from Eq 11, in the other two is constant. SO I do not get why do you need δpCO_2ocean and the empirical Eq. 13.

From the GLODAP 2 second QC exercise, TA in 2001 is about 10 umol/kg lower. Is this relevant?.

Using the 2011 TA data will clearly improve the TA relationship with salinity because deviations from linearity are clear, mainly in the eastern basin (See Fig 12a in Álvarez et al (2014)) and here below.



Additional information about the influence of Rivers in TA can be found in Luchetta et al (2010) and Cantoni et al (2012) see Álvarez et al (2014) for the complete references.

3) Section 2.3 Looping.

Sorry again but I am afraid that only modellers would understand this section It could be nice to explain for lay people what means “run off-line, looping through the circulation fields…”.

4) Section 2.4 δpH.

For surface or deep waters you would need to clarify if δpH refers to in situ pH or to pH is referred to any temperature, pH is mostly temperature dependent, but also pressure. I understand that the pH decrease in the water column is calculated for in situ temperature and pressure. But I think it needs to be clearly stated.

5) Section 3.2 Air-sea flux.

Please make clear that you refer to CANT air-sea fluxes and the way they are calculated: do you calculate the storage (inventory), the transport across the Strait and then the air-sea is derived from them, or the other way, the air-sea CANT flux and storage are calculated from the model and the transport across the Strait is derived from them.

6) Section 3.3 Budget.

I understand in Fig.8 that the light blue solid curve (inventory) is the sum of the green solid one (air-sea flux) plus the Gibraltar transport (solid purple). But I do not understand Fig. 9, what is the light blue dashed line (total storage) here?. I would plot the rate of change of the storage with time and the % contribution to it of the air-sea flux and the Gibraltar transport.

7) Section 3.6 δpH.

It might be interesting to present the GLO results just to show that the MedSea is particular, but presenting the MED and VAR results as well it is a bit blurring. The consequence of smaller pH changes in warm waters with a higher TA is a direct consequence of the CO_2 chemistry, eastern MedSea waters have the lowest DIC/TA ratio and consequently are more resistant to changes due to a DIC increase due to air-sea CO_2 exchange (DIC increase, TA constant). This is shown in Alvarez et al. (2014).

I think is very simplistic the last phrase in this section. If the pH change is so similar with any model simulation why bother to perform them. I do not think is identical, I do think that the spatial variations matter. But I would also ask if the yearly temporal changes are comparable to the seasonal changes?.

8) Section 4.1 δC_T in the MedSea.

I am not a TTD expert but I miss some details about the TTD setting in Schneider et al. (2010), although also discussed in this paper, the Δ/Γ ratio matters to calculate CANT. This ratio needs to be commented regarding the 2010 paper and the settings in the model.

9) Section 4.2 Transfer across the Strait of Gibraltar

Page 6481, lines 26-27: I totally disagree with this statement, in the global ocean the transport of CANT matters a lot, and there is a wealth of reference dealing with this point.

This section is too long for the final conclusion achieved, it might be good to reduce the information given with numbers.

10) Section 4.3 Sensitivity to TA

As commented previously, using the better resolution of the M84/3 2011 data to constrain TA and the information given in other papers for the contribution of riverine TA would improve the model results.

I think that discussing the GLO results is trivial. This section needs to be reduced.

11) Section 4.4 Change in pH.

Page 6486, line 2-4: sorry to say, but your sensitivity test do not demonstrate anything, the direct consequence of the low DIC/TA ratio in the eastern MedSea is the lower change in pH (due to air-sea CO_2 exchange) compared to waters with a higher DIC/TA ratio, this is shown in Alvarez et al with the 2011 data, but is a direct consequence of the CO_2 chemistry, anybody could simulate this using DIC, TA, Temp and salinity from the MedSea.

I encourage the authors to answer the questions and improve the paper with the proposed suggestions as it deals with an issue particularly interesting for the chemical and biological oceanographic community working in the MedSea, and this marginal sea is very sensitive to human pressure.