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Interactive comment on "Simulated anthropogenic CO_2 uptake and acidification of the Mediterranean Sea" *by* J. Palmiéri et al.

Anonymous Referee #2

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This paper discusses model results from a model that simulates the ventilation and circulation of the Mediterranean Sea, with emphasis on two passive tracers (CFC-12 and DIC). The paper does a careful and very nice comparison of model results to data based results. It also calculates fluxes of anthropogenic carbon through the Strait of Gibraltar, and draw relevant conclusions on the ocean acidification of the Mediterranean Sea. The paper is very well written and an effort to join model and observational estimates in a common frame-work. The paper certainly merits publication in BG. However, I do have some concerns about the model / data comparison that needs serious attention, and a number of minor suggestions that should be easy to correct for.

The most serious considerations concerns 1) the comparison of data based TTD derived estimates with the modeled deltaDIC and TTD(MW), and 2) the conclusion of the

lower limit for Cant storage in the Mediterranean Sea. 1) I wonder why the model have 10 umol/kg lower Cant in the surface (section 3.5). The TTD method assumes (per definition) that the age of the surface water is zero, and the anthropogenic carbon content is only a matter of thermodynamics with a given alkalinity, temperature and pCO2. The 68 umol/kg of surface Cant is roughly what you would expect from thermodynamic considerations of the carbonate system. This suggests to me that the model finds kinetic restrictions to the saturation of Cant so that the air-sea equilibrium has changed over the anthropogenic time-period with roughly 15%. Can you verify or comment on this. It is surprising that such a large deltadeltapCO2 is found. The same is valid for the discussion in section 4.1; why do you conclude that the TTD(MW) is an overestimate, and not the other way around (i.e. the deltaDIC from the model) an underestimate? I am not saying that is the case, but it is strange to me that the model is able to reproduce the surface CFC-12 concentrations very well, but the TTD(MW) is still lower than the observational based TTD values? Are you using the same routines and supporting variable values for these calculations? The base of this question is: why is the TTD(data) different from the TTD(MW) when the CFC-12 values are the same? 2) We know that the model underestimates the strength of the deep overturning circulation in the Mediterranean from the too low CFC-12 values in the model. The model is roughly half of the observations over close to 2000 meter depth interval. Presumable the too low CFC-12 concentration in the model corresponds to a too low Cant concentration in the model. However, no attempt is made to quantify this difference. I can imagine many ways to do this, from "tuning" the model to match observations (of CFC-12), or more simple calculations based on relationship between CFC-12 and Cant for the Med. At any rate this should be done for the model Cant inventory calculations. As it stands now you present a value of Cant that you KNOW is an underestimate and state since this is lower than the TTD(data) estimate, the TTD(data) estimate has to be an upper limit. You might be correct with that statement, but it is not proven with the current data. Also, the point brought up above (1) suggest that the model Cant inventory is an underestimate by even more than the too low CFC-12 values suggest. These two

points requires some careful analysis and discussion, and might have implications for discussion on pH and flux through the Strait of Gibraltar.

Specific comments: Abstract and possibly elsewhere: Are you referring to uptake (as in air-sea exchange) or to increased interior storage of DIC? The term uptake is maybe not what you want to say, please check and modify. Maybe storage would be a better word to use. Page 6464, line 18:I am not sure the “south of” is correct here. I suggest to leave that out since the deep water is/was actually formed in the Adriatic and in the Aegean (including south of the Aegean during the EMT). Figure 1: The sections of the two Cant estimates are identical, so why is the average profile of TrOCA much more shallow than the TTD profile? Please make them comparable. Supplementary material: I do appreciate that you publish the scripts used for the calculations and the constants. However, please put some effort into making this easily readable in a pdf version as well (keep the dat and R files since I assume they can be directly read by the code). I could not find table A1, for instance. Page 6471, line 20: Please remove “exactly”, same for page 6473, line 5. Page 6474, line 11: Do you mean that the DIC was in equilibrium with the atmosphere, rather than the alkalinity? Please reformulate. Section 3.4: Would it be appropriate to call this section “modelled deltaCT inventory”? Page 6478, line 25: Please state that (again) that you are referring to modelling “data” wrt poor ventilation; the observations seems to be different. Section 3.5: I had some problems keeping the “model underestimate the data based estimates” terminology in this section. Maybe it would help rephrasing (on several occasions) to state “the model deltaCT is lower than the data based TTD results”, or something like that. Page 2478, line 25: change “ estimated from” to “ based on” Section 3.6: The low Cant in the modelled surface, see above discussion on low Cant in the surface, also impact this discussion that might need to be reconsidered. Figure 14: Please change legend in the right hand panel to “deltaDIC TTD(MW)” Page 6488, line 3: add “poorly ventilated vs. observations- It could be appropriate to cite studies comparing various data based Cant estimates somewhere in the discussion where the TrOCA, DeltaC* and TTD results are compared (for instance (Yool et al., 2010;Álvarez et al., 2009;Vázquez-Rodríguez et al.,

2009)).

References Álvarez, M., Lo Monaco, C., Tanhua, T., Yool, A., Oschlies, A., Bullister, J. L., Goyet, C., Metzl, N., Touratier, F., McDonagh, E., and Bryden, H. L.: Estimating the storage of anthropogenic carbon in the subtropical Indian Ocean: a comparison of five different approaches, Biogeosciences, 6, 681-703, 2009. Vázquez-Rodríguez, M., Touratier, F., Lo Monaco, C., Waugh, D. W., Padin, X. A., Bellerby, R., Goyet, C., Metzl, N., Ríos, A. F., and Pérez, F. F.: Anthropopgenic carbon distributions in the Atlantic Ocean: data-based estimates from the Arctic to the Antarctic, Biogeosciences, 6, 439-451, doi:10.5194/bg-6-439-2009, 2009. Yool, A., Oschlies, A., Nurser, A. J. G., and Gruber, N.: A model-based assessment of the TrOCA approach for estimating anthropogenic carbon in the ocean, Biogeosciences, 7, 723-751, doi:10.5194/bg-7-723-2010, 2010.

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