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Biogeosciences Discussions

Interactive comment on "CO_2 exchange in a temperate marginal sea of the Mediterranean Sea: processes and carbon budget" *by* G. Cossarini et al.

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Dear editor, please find below our answers to the reviewers' comments. The main concerns raised by the two reviewers are a poor description of the model and the lack of its validation. We propose the addition of two new appendixes and a new version of section 3.2, as well as other changes made to the manuscript. In particular, Appendix A reports a detailed description of the coupled model including the full list of the biogeochemical model parameterizations; other details will be added in section 2.1 and 2.2 as detailed in the next points. Appendix B reports the model validation. In par-

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ticular, satellite MODIS surface chlorophyll-a data, from three published climatological data sets, and an extensive review of the published data have been used to corroborate the ability of the coupled model to reproduce the space and time variability of the major biogeochemical parameters (e.g.: chlorophyll-a, dissolved inorganic phosphorus, dissolved organic phosphorus, dissolved oxygen) and ecosystem processes (e.g.: primary production, bacteria production, sinking), which influence the continental carbon pump that occurs in the Adriatic Sea. Of course, data availability does not match the temporal and spatial domain covered by the simulation, so that, rather than a full formal validation of all model variables, the comparison should be considered as a corroboration (data does not falsify the model). However, this is a limitation that is common to all studies based on 3D coupled transport-biogeochemical models. Furthermore, the companion paper (Querin et al., 2012), which discusses the physical aspects of the dense water formation and spreading, reports a comparison of the sea surface temperature structures obtained by the physical model and by remotely sensed data. It also compares the time evolution of the thermohaline structure of the basin with the experimental observations described in a recent paper by Cardin et al., 2011. The manuscript Querin et al., 2012 has been accepted for publication (pending a few minor revisions), and it has been attached (for the editor and the reviewers) to this reply. However, let us also stress that our investigation is meant to compare the response of a marine ecosystem to two different case studies, representative of different atmospheric conditions. In this context, 2007 and 2008 are used as proxies of years characterized by a 'warm winter' and an 'almost normal winter', respectively. Therefore, the capability of the model to reproduce "exactly" actual observations of a given year is not critical to the present study, insofar the model is able to produce a coherent and reasonably acceptable description of the system and to capture the difference between the 'almost normal' and the 'warm' year. Finally, the new version of section 3.2 reports a description of the modelled dynamics that can be of interest for understanding the carbon pump in the Adriatic Sea. The former Table 1 and Figure 4 have been deleted, since validation has been moved to Appendix B. A new Figure 4 reports the maps of simulated integrated primary production and community respiration.

It is worth to report that the simulation have been run again, since a few changes have been made to the physical part. Following the suggestions given by the two reviewers of the paper by Querin et al., a few changes have been made to the boundary conditions (nudging coefficients) and to the parametrization of the bottom stress (bottom drag coefficient). Further, a comparison of the simulated alkalinity and DIC with the values reported in Luchetta et al. (2010) and Touratier et al. (2012; this data referred to Ionian Sea) highlighted the partial inadequacy of the Scheinder et al. (2007) relationship to estimate alkalinity from salinity in the Adriatic Sea, and, consequently, the DIC from alkalinity. Therefore, new alkalinity and DIC initial conditions have been estimated by means of a 2 years spin up run, and new boundary conditions for alkalinity and DIC have been computed adjusting the previous conditions. Unfortunately, we could not incorporate in the manuscript the data of alkalinity and DIC gathered during 2008 (Vector project cruises) which we were able to see as a personal communication, but which were not made available for our study. The new results differ from the ones given in the previous version of our manuscript, but the design of the modelling experiment as well as the main findings have not changed. In particular, Tab. R1 (that will replace Tab.2) and Fig. R1 (that will replace Fig.6) show lower values of the CO2 fluxes for the sub-basins. This is due to the underestimation of surface DIC concentration of the previous run. Nevertheless, the new results confirm that the Adriatic Sea is a sink of CO2, and the presence of a strong north-to-south gradient in CO2 absorption. The new results also confirm that the efficiency of the carbon sequestration of the Adriatic Sea depends on the winter conditions. The warm winter 2007 is characterized by a lower CO2 flux at the air-sea interface than winter 2008 (which is more similar to the current climatic conditions) because of the lower efficiency of the solubility pump. Besides, during winter 2007, the transport of organic and inorganic carbon (generated by the biological pump) into the interior of the southern Adriatic Pit is lower than that of the following year because of the lower rate of formation and spreading of dense water. Several parts of the manuscript will be changed according to the new results. Further, the new simulation allowed us to compute a rough estimation of the uncertainty in CO2 flux. This result will be included in the discussion section.

In the next sections of the interactive discussion we reply to all the remarks raised by the two reviewers. In this part of interactive discussion (general comments) we upload the two new appendixes (Appendix A "model formulation" and Appendix B "model validation") and the new section 3.2.

References:

Cardin, V., Bensi M., Pacciaroni M.: Variability of water mass properties in the last two decades in the South Adriatic Sea with emphasis on the period 2006–2009, Continental Shelf Reserch, doi:10.1016/j.csr.2011.03.002, 2012.

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Querin, S., Crise, A., DePonte, D., and Solidoro, C.: Numerical study of the role of wind forcing and freshwater buoyancy input on the circulation in a shallow embayment (Gulf of Trieste, Northern Adriatic Sea), J. Geophys. Res.-Oceans, 111, C03S16, doi:10.1029/2006JC003611, 2006.

Schneider, A., Wallace, D.W.R., and Kortzinger, A.: Alkalinity of the Mediterranean Sea, Geophys. Res. Lett., 34, L15608, doi:10.1029/2006GL028842, 2007.

Touratier F., Guglielmi, V., Goyet, C., Prieur, L., Pujo-Pay, M., Conan, P., Falco, C.: Distributions of the carbonate system properties, anthropogenic CO2, and acidification during the 2008 BOUM cruise (Mediterranean Sea), Biogeosciences Discuss., 9, 2709–2753, 2012

— Captions of the Table and Figure

Table R1. (that will replace Tab. 2).Carbon exchange rates [mmol CO2/m2/d] at the air-

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water interface for the three sub-basins during the two simulated years. The presented values are the annual, winter-spring and summer-autumn averages. Positive values indicate that the ocean acts as a CO_2 sink.

Fig. R1. (that will replace Fig. 6). Changes in the simulated CO_2 exchange rate at the air-sea interface over time for selected sub-basins of the Adriatic Sea (see Fig. 1 for a definition of the sub-basins). Positive values indicate that the ocean acts as a CO_2 sink.

Please also note the supplement to this comment:
http://www.biogeosciences-discuss.net/9/C6749/2012/bgd-9-C6749-2012-supplement.pdf

Interactive comment on Biogeosciences Discuss., 9, 10331, 2012.

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	NA (36 783 km^2)			CA (40 294 km^2)			SA (51 484 km^2)		
	annual	win-spr	sum-aut	annual	win-spr	sum-aut	annual	win-spr	sum-aut
2007	2.5	3.9	1.2	0.4	1.7	-0.8	-0.4	0.5	-1.1
2008	2.6	4.4	0.7	0.2	2.0	-1.6	-0.6	0.9	-2.1

Table R1. (New Tab. 1).Carbon exchange rates [mmol $CO_2/m^2/d$] at the air-water interface for the three sub-basins during the two simulated years. The presented values are the annual, winter-spring and summer-autumn averages. Positive values indicate that the ocean acts as a CO_2 sink.

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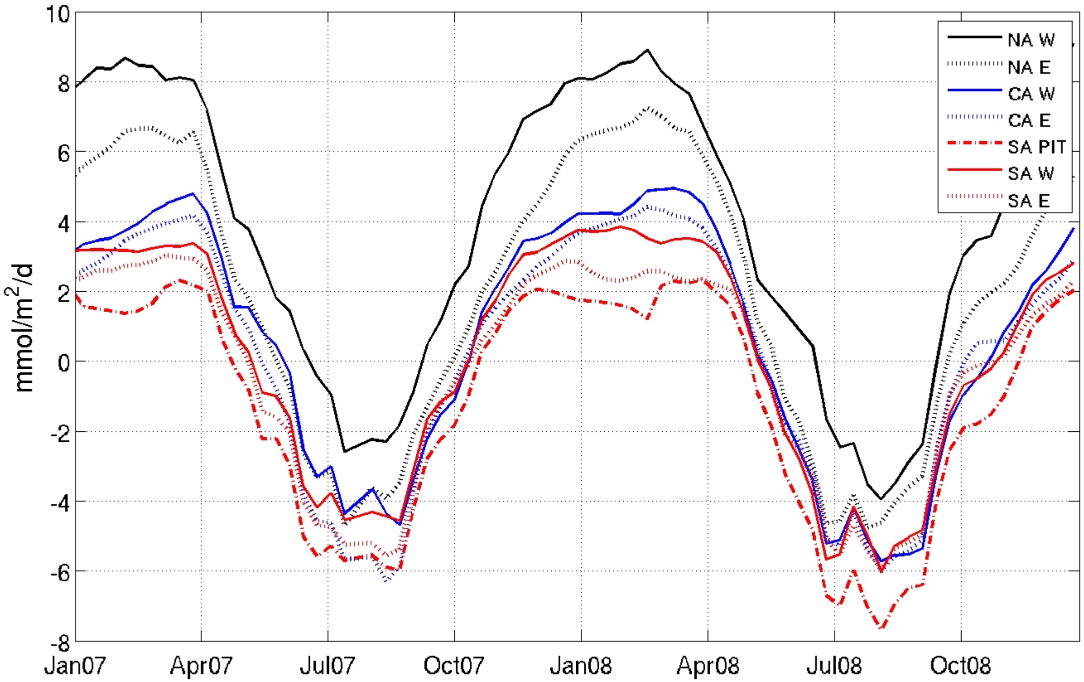

Fig. 2. Fig. R1. (New Fig. 6).

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