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Discussions

Interactive comment on "Modeling *p*CO$_2$ variability in the Gulf of Mexico" *by* Z. Xue et al.

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First of all we would like to thank referee #1 for your constructive comments and suggestions. We indeed realize these problems during preparation of this manuscript. Currently the regional ocean carbon modeling community is facing this initial and boundary condition issue as well as the challenge from sporadic pCO2 observations as for model evaluation purpose. Nevertheless, we think our manuscript has pointed out these issues and we are undertaking more experiments to improve model-data comparison. Our detailed answers are as following:

1. Regarding the initial and boundary condition. We admit that the model is sensitive to initial and boundary conditions. A similar situation has also been identified by Hoffman et al. (2011) in a northeast Atlantic study. So we use the first year, 2004, as model spin

up, and all analysis in this manuscript are based on result of the following six years (2005-2010). Currently the DIC/Alkalinity initial and boundary condition (1/1/2014) is derived from the relationship from in-situ observations (Cai et al., 2011 for northern Gulf of Mexico, and Lee et al. 2000 and 2006 for the open ocean). As there is no realistic boundary condition provided by any global models, this is the best solution so far. And since this in-situ data covering our modeling period, we think they should be able to reflect the realistic condition/relationship between DIC/Alkalinity and temperature/salinity. And we urge the ocean carbon community to work together and provide a global solution for regional studies; 2. For the atmospheric forcing, initially we would like to use the data in LEDO database. However, as we are using the LEDO database for model validation purpose, so we chose the global secular curve. We would like to provide a comparison between the pCO_2 concentration based on available observation in the Gulf and the global secular curve in the revised manuscript; 3. We indicated in the manuscript that model validation is challenging as the in-situ observations in the northern Gulf of Mexico is still sporadic (See Huang et al. 2013). The pCO_2 in the northern Gulf of Mexico is highly variable due to numerous effects, including plume dynamics, wind condition, primary production, etc., which is also pointed out by Referee #2. We are working on more model experiments to further improve the model-data comparison. The purpose of this study is to provide an overall pCO_2 budget based on the mean of our multi-year simulation. Indeed our model has a good agreement with in-situ data about the CO_2 influx. The intra-annual variability will be communicated by a latter correspondence; 4. For the open ocean, we think our model did a good job in terms of capturing the seasonal cycle of the ocean surface pCO_2. The reason why we use mean value is still because of the spatial and temporal heterogeneity of these in situ measurements. Specifically, the current LEDO database has very limited coverage of the Mexican waters (also pointed out by Referee #2), so we would rather to use our current model solution in stead of to overtune the model to "match" the limited pCO_2 data. As suggested by Referee #2, we will also add in a discussion about the data gap lies in Mexico waters and how this will effect our estimation of pCO_2 flux.

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