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## ***Interactive comment on “A two-dimensional model of the passive coastal margin deep sedimentary carbon and methane cycles” by D. E. Archer et al.***

### **Anonymous Referee #2**

Received and published: 8 May 2012

Archer and co-workers present a two-dimensional model of sediment column geophysics and geochemistry that is designed to simulate the carbon and methane cycling, as well as the size of the potential methane hydrate inventory in passive margin sediments. The model is used to test the sensitivity of the hydrate inventory to a wide range of geophysical and geochemical factors. The proposed model approach is novel and could potentially provide new insights into the coupled, margin-wide carbon cycling over geologically relevant timescales.

However, the authors should clearly show how their model approach differs from existing basin models. They should summarise the type of applications they envisage in the future and discuss the strengths and advantages of their model approach as compared to existing approaches. In addition, and most importantly, they have to provide a well structured and comprehensive description of their model approach. The

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manuscript is not very well structured, sometimes confusing and, therefore, difficult to understand. The model description is incomplete and scattered. Essential key information on model formulation, parametrisation, numerical solution and model performance are not provided. The provided equations and parameter values are often not well referenced or justified. For instance, the dependence of POC content on sea level change is neither explained in detail nor justified. Arguments, such as "simplifying liberty" or "getting the model to work" are not very convincing scientific arguments and should be at least supported by a critical discussion. In addition, the sensitivity experiments are not well explained and I quickly lost the overview of the experiment's details and purpose. Acronyms, such as POC, SO<sub>4</sub> or CH<sub>4</sub> are not explained. Furthermore, the authors give little credit to published work. For instance, in section 2.5.6 "Methane Bubbles and Hydrates", the authors do not discuss or reference the approaches described in published articles by, for instance, Boudreau et al., 2001; Mogollon et al., 2009; or Haeckel et al. 2004 to describe methane gas transport in marine sediments.

Although the presented approach is novel and may result in exciting new insights into the complex carbon cycling across the slope, it is very difficult to evaluate its relevance and validity without a comprehensive, clear and well documented model description. The authors have to provide such a comprehensive description of the complex, multi-dimensional, coupled SpongeBOB model. Therefore, I would suggest to re-structure the two manuscripts. A first manuscript could provide a comprehensive model description and a critical discussion of the baseline simulations- in particular with respect to observational data. More technical journals, such as, for instance, Geoscientific Model Development or Computers Geosciences provide ideal platforms for such a manuscript. The extensive and very interesting sensitivity study for both active and passive margins could be then be outlined in a second manuscript that simply refers to the detailed technical description in the first manuscript.

Boudreau, B.P., Gardiner, B., and Johnson, B. - 2001 - Rate of growth of isolated bubbles in sediments with a distributed diagenetic source of methane. - Limnology and Oceanography, 46, 616-622. (See also the Erratum in the same issue)

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Haeckel M., Suess, E., Wallmann, K., and Rickert, D., 2004, Rising methane gas bubbles form massive hydrate layers at the seafloor: *Geochimica et Cosmochimica Acta*, v. 68, p. 4335–4345, doi:10.1016/j.gca.2004.01.018

Mogollon J.M., I. L'Heureux, A.W. Dale and P. Regnier. Methane gas-phase dynamics in marine sediments: a model study. *American Journal of Science* 309, 189–220, 2009. DOI 10.2475/03.2009.01

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