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Interactive comment on "Response of the Black Sea methane budget to massive short-term submarine inputs of methane" *by* O. Schmale et al.

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Title: "Response of the Black Sea methane budget to massive short-term submarine inputs of methane" Authors: O. Schmale, M. Haeckel, and D. F. McGinnis

This manuscript details a modeling effort surrounding an unknown and incredibly interesting scientific question. How does the ocean respond to massive and short-term methane inputs? With methane being such a potent greenhouse gas and the ocean being such a massive reservoir of this gas, there is wild speculation on this potential climatic feedback. While there is some data on longer-term, slower-rate natural methane seeps, there is little data on these massive short-term events. The main reason for this is because these massive events have never been recognized until well after the short-term release has ended. That is until recently, no one has been able to

study one of these events from birth to death. The Deepwater Horizon incident in the Gulf of Mexico provided the first glimpse into the biogeochemical cycling of a massive and short-term (anthropogenic) methane release (Kessler et al., 2011), however, this was in oxic waters, while the Black Sea, the world's largest anoxic basin and seawater methane reservoir, is clearly anoxic.

While several factors are clearly involved (e.g. bubble size, hydrate skin, oil coatings on bubbles, etc.), two major factors control the release of methane to the atmosphere from a seafloor emission: (1) water depth and (2) the microbial response to the emitted gas. This manuscript builds upon models and data previously presented in Reeburgh et al. (1991), Kessler et al. (2006, EPSL), and McGinnis et al. (2006). I suggest that the authors also investigate Kessler et al. (2006, GBC), as it presents a higher resolution model to the one in Kessler et al. (2006, EPSL). This is an incredibly exciting manuscript, worthy of publication, however, before that publication occurs, I suggest that these two major factors be investigated in more detail.

(1) Water Depth. At present, the manuscript looks at a massive methane emission at 2000m depth and 700m depth. I suggest they run their non-steady state model 20 different times instead of only two different times. Have the massive short-term methane emission not just occur at 2000m and 700m, but at all depth intervals from 2000m to 100m spaced at intervals of 100m. On each of these simulations, determine the air-sea flux and the concentration of methane in the surface 100m. Then, a graph can be made of the flux to the atmosphere (and methane concentration in the surface waters) vs. depth of massive emission.

(2) Microbial response. The present version of the manuscript models methane oxidation with first order kinetics. Based on measurements by Reeburgh et al. (1991) and Ward et al. (1987), they assume that the relative rates (i.e. methane oxidation rates normalized to the local methane concentration, which is also known as the first-order rate constant) are constant with time. (They are different at different depths, but constant at each depth range. This means that the overall methane oxidation rates will

increase as concentrations increase, and decrease as the concentrations decrease, but the rate constants will remain the same.) This is identical to what Kessler et al. (2006) assumed based on the results of Ward et al., (1987). However, as Kessler et al. (2011) displayed in the (oxic) Gulf of Mexico, the rate constants increased (and then decreased) with time in response to a bacterial bloom of methylotrophs that responded to a massive short-term methane release into oxygenated waters. While the Black Sea is anoxic, a massive release will most likely cause a bloom in the bugs responsible for anaerobic methane oxidation and increase the first-order rate constant. This will have a two-pronged effect: (1) it will decrease the lifetime of this methane perturbation and (2) it will mean that potentially shallower emissions will not make it to the atmosphere as the microbes respond. It will be difficult to model this process because no one has ever measured this phenomenon in anoxic waters and the Gulf of Mexico example obviously involves different organisms. However, this is a modeling manuscript, which means additional simulations can be run to (hopefully) span the range of possible rate constants. I would recommend increasing the rate constants by a factor of 2, 5, 10, and 100 to see the influence on the lifetime of this methane perturbation. A graph of this effect (rate constant vs. lifetime) would be most interesting. I'm also interested to see how increasing the rates constants would influence the air-sea flux and the concentration of methane in the surface 100m (basically rerunning the analysis I recommend in section (1) Water Depth, but with these increased rate constants).

Overall, this is a good manuscript worthy of publication. It attempts to solve an oceanographic and climate change issue that definitely needs to be solved. But the manuscript left me hungry for more, and if these additional analyzes can be performed, I think it would greatly strengthen the manuscript, making a much more comprehensive paper.

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