Biogeosciences Discuss., 11, C8983–C8986, 2015
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Biogeosciences Discussions
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Interactive comment on "Seasonal methane accumulation and release from a gas emission site in the central North Sea" *by* S. Mau et al.

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Received and published: 6 March 2015

Interactive comment on "Seasonal methane accumulation and release from a gas emission site in the central North Sea" by S. Mau et al. J. Kessler (Referee) john.kessler@rochester.edu Received and published: 13 February 2015

The authors provide a straightforward and clean analysis of the methane dynamics at a relatively shallow seep site in the central North Sea. Methane concentration and oxidation rates are provided and used with some modeling investigations to constrain seasonal changes in mixing, oxidation, and air-sea flux. The manuscript finds that (1) summer stratification allows methane to accumulate in the deeper waters, (2) methane oxidation is a minimal sink of methane during all seasons, (3) there is likely an enhanced release to the atmosphere following the termination of summer stratification,

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and (4) dispersion largely causes methane concentrations to decrease.

My specific comments focus on two main issues: sampling/measurements and explanation of conclusions.

Sampling/Measurements: 1) I would have liked more explanation on the air-sea flux measurements. For example, was the concentration of methane measured in the atmosphere directly or are average atmospheric values used in your calculations? If you are collecting atmospheric samples for methane analysis, at what height about the sea surface are you collecting the samples? At what height above the sea surface did you measure wind speed and did you correct for a 10 m height?

Author: The atmospheric value was calculated using the Bunsen solubility and measured ocean temperature and salinities. Wind speed was measured 22 m above sea level onboard. We forgot to correct the value, but will use the power law Vh/V10=(h/10)ˆ0.13 to do this. The corrected values will be included in Fig. 8, but they do not alter our interpretation. Thanks for pointing out this issue.

Also, I'm slightly concerned about the possibility of under-sampling the surface waters for methane concentration. Is there a possibility that elevated dissolved concentrations of methane in the surface waters were contained in fairly isolated plumes and thus you simply did not sample these regions? While using continuous, underway air-sea flux systems would have been nice (e.g. Du et al., Environmental Science & Technology, 2014) for a more comprehensive data set, a bit more discussion to justify that your discrete sampling was representative of this seep region would be helpful.

Author: Our intention was to compare the different fluxes. Although we have only a summer and winter snapshot picture based on a few discrete samples, still it is certain that e.g. wind speed is higher in winter and methane concentrations are lower in winter due to the enhanced mixing by wind. Therefore, the ratio of the flux estimates allow an evaluation of the importance of the different transport and loss processes of methane. A comprehensive data set such as the one you mentioned is needed to really quantify

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the sea-air flux and such an investigation would be necessary to be conducted at different wind speeds and covering a larger area. We will include a more detailed discussion in a revised version.

2) The authors do not provide any data on current velocity. ADCP data would have been beneficial and would have helped to determine if turbulent mixing is significant. For example, on page 18023, line 7-8, the authors state that "The advective transport by ocean currents was not estimated as this process does not decrease the concentration of methane, but solely transports methane from the seep site in direction of the current flow." That is only true if advective transport is uniform. Differences in current velocity and direction with depth would lead to turbulent mixing. These process may be contained in your vertical and horizontal eddy diffusion, but a bit more discussion on the magnitude and direction of the currents throughout the water column would have been beneficial.

Author: The second reviewer also suggested to present current measurements, although, as you pointed out, the turbulent mixing is included in the eddy diffusion. Unfortunately, we don't have any ADCP-measurements, solely modelled data by the Bundesamt für Seeschifffahrt und Hydrographie (BSH) using wind and air temperature forecasts. However, we will include a description and add a plot to the supplementary material showing the east-west and north-south velocities of the currents during the sampling campaigns. We will also include an estimate of the advective transport.

Both of my comments on the "Sampling/Measurements" above are meant to provide clarity to the reader. I do not anticipate they will change the conclusions of this manuscript significantly.

Conclusions: 1) Perhaps the most impactful finding of this manuscript is that methane oxidation was not a large sink of methane. I am very curious to learn more about why this is, especially during summer stratification. Do the authors have access to nutrient or trace metal data to suggest why this may be? From a different perspective,

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what increase would the authors have expected in the average k' value for methane oxidation during summer stratification? The lack of an increase in the k' values for methane oxidation is a significant discovery but without any explanation as to why this is occurring makes the manuscript feel incomplete.

Author: Similar to the finding of Tavormina et al., 2013, who observed that there is not a strong correlation between methane concentrations and putative methanotrophs, we also find that there is no strong correlation between methane concentrations and activity of methane oxidizing microorganisms. We agree with these authors that either these putative methanotrophs are facultative methanotrophs, not necessarily dependent on methane, or that there is a limitation by e.g. trace elements, which are mainly limited in the upper ocean. We will include such a statement for completion.

In conclusion, this is a strong manuscript that makes quality measurements of methane dynamics and does a meaningful interpretation of the data. I doubt that any my comments will lead to significant modifications to the conclusions in this manuscript. Nonetheless, they would provide a bit of clarity to the interested reader. I enjoyed reading this manuscript.

Interactive comment on Biogeosciences Discuss., 11, 18003, 2014.