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Atmospheric Chemistry and Physics Discussions

Interactive comment on "Methane at Svalbard and over the European Arctic Ocean" *by* Stephen M. Platt et al.

Anonymous Referee #2

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The manuscript by Platt et al. describes a large data set of land and sea based atmospheric methane concentrations as well as some values of gas hydrates. The atmospheric methane concentrations increase since 2001. Using the FLEXPART model, the authors found anthropogenic emissions and wetlands to be the main sources. The authors discuss the data and relevant processes in detail and further conclude that gas hydrate dissociation/marine seepage is currently not significantly influencing atmospheric CH4 concentrations. They observed one peak of numerous shown in figure S2 that they argue to originate from methane seepage. Thus their manuscript adds to similar conclusions drawn by e.g. Wallmann et al. (2018), Mau et al. (2017), Berndt et al. (2014), Graves et al. (2015) based on various scientific results in the same research area.

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Discussion paper

The manuscript is well structured and easy to read and follow. However, I have some comments and suggestion that the authors should consider. Mainly the discussion of marine seepage causing the one methane peak should be reviewed. They cannot definitely prove this suggestion. They discuss that the C1/(C2+C3) ratio and δ13C-CH4 are not unique tracers for hydrate sourced methane as both ratios can be changed by mixing and microbial oxidation in the water column. I agree with that. However, they suggest that their estimated sea-air flux is a reasonable one for seepage sites. I disagree and rather think that it illustrates the offset between estimates derived from atmospheric data and estimates from oceanic data. The comparison with the Eastern Siberian shelf with water depth of 20-50 m water depth ignores that the proposed source region described by Geissler et al. (2016) is located in $\sim$170 m water depth. Bubble dissolution, water column stratification, and microbial oxidation would significantly diminish methane concentration in the surface mixed layer above bubble emission sites in water depth >100 m as was shown by e.g. McGinnes et al. (2006), Mau et al. (2012), and Graves et al. (2015). The calculated high surface concentration (555 $\pm$ 297 nM) in an area of $\sim$170 m water depth is rather unlikely. Especially, as the sea-air fluxes mentioned in the introduction (page 3, line 6-9), similar findings by Damm et al. (2007) and Mau et al. (2017), and the values mentioned in Geissler et al. (2016) indicate much lower methane concentrations and thus fluxes. Overall, there is no definite link between the atmospheric methane peak and marine seepage. The authors should mention it as it is as well as the offset in the sea-air-flux estimates.

Apart from this aspect, I have only a few more comments and minor changes.

Comments:

I recommend including if the methane increase in the Arctic research area is higher or lower than the global increase of atmospheric methane in the abstract.

Please mention that numerous papers argue against the hypothesis forwarded by Westbrook et al. (2009) that ocean warming caused the retreat of the GHSZ; one

of the opposing papers is the publication by Wallmann et al. (2018).

Consider an independent interpretation of the summer and winter atmospheric methane concentrations. What increases are higher, the summer or the winter ones? This might help to distinguish what source (anthropogenic emissions or wetlands) dominates.

Exhaust emission were excluded from the on-board collected methane concentrations by removing spikes of CO2 that occur with CH4 perturbations. Do you mean increasing or decreasing CH4 concentrations?

Typos and figures: often CH4 and CO2 are written without the numbers to be subscript

instead of Hartmann et al., 2013, reference IPCC

page 2, line 34: . . .can store large amounts of CH4 under low temperature. . ., no comma before temperature

page 5, line 8: The data were collected is a harmonized way with those. . . odd sentence, correct for better readability

page 7, line 29: These regions are responsible for 20% of the world's natural gas and leak rates may be as high as 10%...' odd sentence

page 10, line 6: change to: Pisso et al. (2016) describe

page 10, line 15: correct Yr-1 to yr-1

page 11, line 22: as far as I know, submitted papers are not allowed to cite

page 11, line 31f: reword sentence as it includes the word 'reasonable' several times

page 12, line 27 and 29: change Serov et al., 2017 to Serov et al. (2017)

page 13, line 23: delete 'od' in the sentence starting with 'Using a C1/(C2+C3) ratio for gas hydrates..'

page 15, line 25: δ missing in front of 13C-CH4

Fig. 1: smaller dots and triangles, these are as big as an island in the figure

Fig. 4B: 60°N instead of 60N and rename the legend to anthropogenic, wetland, and biomass burning

Fig. 5: use same scale from 1800 to 2020 ppb CH4 for all four figures, otherwise looking at the graphs can lead to misinterpretation

References: Berndt, C., Feseker, T., Treude, T., Krastel, S., Liebetrau, V., Niemann, H., Bertics, V. J., Dumke, I., Dünnbier, K., Ferré, B., Graves, C., Gross, F., Hissmann, K., Hühnerbach, V., Krause, S., Lieser, K., Schauer, J., and Steinle, L.: Temporal constraints on hydrate-controlled methane seepage off Svalbard, Science, 343, 284-287, 2014.

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Mau, S., Heintz, M. B., and Valentine, D. L.: Quantification of CH4 loss and transport in dissolved plumes of the Santa Barbara Channel, California, Cont. Shelf Res., 32, 110-120, 2012.

Mau, S., Römer, M., Torres, M. E., Bussmann, I., Pape, T., Damm, E., Geprägs, P., Wintersteller, P., Hsu, C.-W., Loher, M., and Bohrmann, G.: Widespread methane seepage along the continental margin off Svalbard - from Bjørnøya to Kongsfjorden, Sci. Rep., 7:42997, 1-13, 2017.

McGinnis, D. F., Greinert, J., Artemov, Y., Beaubien, S. E., and Wuest, A.: Fate of rising methane bubbles in stratified waters: How much methane reaches the atmosphere?, J. Geophys. Res., 111, 15, 2006.

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