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Interactive comment on "Sonar Gas Flux Estimation by Bubble Insonification: Application to Methane Bubble Fluxes from the East Siberian Arctic Shelf Seabed" *by* Ira Leifer et al.

Anonymous Referee #2

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The East Siberian Arctic Shelf (denoted in the paper as ESAS) produces a huge amount of methane through the degradation of the permafrost on the shallow sea bed. The importance of this process for the global clime change is substantiated in the thoroughly "Introduction" accompanied with appropriated references.

The direct estimation of the methane flux in the water and in atmosphere in this region is of great importance. The well known sonar surveys are without a doubt effective method for such measurements. The authors apply this approach to the sonar data obtained with single beam echosounder (SBES) and multi beam echosounder (MBES) with high working frequencies 200 kHz and 260 kHz respectively. Instead the "theoretical" calculation of the volumetric flux Q transported by ascending bubbles based on the

back scattering strength σ of the bubble plume, bubble size distribution (BSD) and rise speed of the bubbles (Weber et al., 2014 and additional ref. [1,2] bellow) the authors use the direct calibration of the sonar systems. Calibration curve was obtained using artificial bubble jet of nitrogen and demonstrates non-linear connection between gas flux Q and back scattering section σ of the bubble jet (denoted in the paper as "sonar return") and a significant differences at the different layers of the bubble plume.

Calibration was carried out for both SBES and MBES echosounders. It is not clear how it was made for multi-beam system. Was it made for one vertical beam only or for several beams near the vertical direction or for all 128 beams in the fan in the resolution cells corresponding to the equal depth?

The authors try to explain the properties of the calibration curve with help of the "bubble-bubble acoustical interaction". This term appears already in the abstract and than pass as a "red thread" through the whole text of the paper. Corresponding to (Leifer and Tang, 2007) the "bubble-bubble acoustical interaction" is manifested as a shift of resonant frequency if the bubbles are disposed at distances less than 20*rb. In my opinion this effect does not play the role in the scattering, because in the broad BSD always are the bubbles with the resonant radii corresponding to the frequency of the echosounder.

Certainly the effects of multiple scattering, as it is described in "Discussion" (lines 544-561), determine the properties of the acoustical back scattering of the bubble plume. For example, the absorption of the acoustic energy in the over part of the plume (acoustical shadowing) due to the very small bubbles resonating on the high transmitted frequency can reduce significantly the sonar return of the underlying parts of the plume. But, in my opinion, the qualitative argumentation of the authors concerning the back scattering from the bubble plume is not convincing. For the better understanding of this problem the deep quantitative theoretical consideration is needed.

It is also not clear why the paragraph "COP seep field precursory study" (lines 269-284 and 334 – 348) is included in the paper. Of course, this investigation is very interesting as itself, but it does not contribute to the better understanding of the main scope of the paper. In this case the plume was insonified with the fan of beams from the side, but in the ESAS sonar survey and calibration – from the above. Furthermore, the fig.6 is difficult to understand and the axis "σ, dB" contains the values 102-106 in contrast to the negative values for "σ, dB" in all other figures.

The section "3.2. Bubble Dissolution Rates and Volume Flux" (lines 455-495) contains the brief description of the numerical model of the BSD transformation with the depth due to the gas exchange between bubbles and surrounding water. The authors write that it is necessary to disseminate the results of the calibration (obtained with nitrogen) on experimental data obtained with a different gas (methane) and at other depths. But it is not clear from the text of the section how it was made.

The headline of the paper reads: "Sonar Gas Flux Estimation by Bubble Insonification: Application to Methane Bubble Fluxes from the East Siberian Arctic Shelf Seabed" and the reader is entitled to expect a presentation of the results, covering significant part of the ESAS.

Really, the fig.4 demonstrates three polygons of the research cruise covering a big region of the Laptev Sea. But, from the other hand, only small regions with plumes are represented on the fig.14. The position of this area on the whole ship route is given neither is the text nor on the figure 14. Does it mean that only this plumes area were discovered?

Some technical remarks. At first, authors use the term "occurrence" for the histograms $\Psi(\ldots)$ of the sonar return σ and gas flux in the plume Q. I think, "histogram" will be better for the understanding. Second, the explication to the Minnaert equation (lines 234 and 235) must be corrected.

I think that the paper may be published after clarification of certain points in the text and correcting technical errors.

1. S. I. Muyakshin and E. Sauter. The Hydroacoustic Method for the Quantification of the Gas Flux from a Submersed Bubble Plume // Oceanology, 2010, Vol. 50, No. 6, pp. 995–1001.

2. M. Veloso, J. Greinert, J. Mienert, M. De Batist. A new methodology for quantifying bubble flow rates in deep water using splitbeam echosounders: Examples from the Arctic offshore NW Svalbard //Limnology and Oceanography: methods. 2015, v.13, pp.267-287.

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