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Major comment:

I have found the fundamental problem in Section 2.7.1. Henry's law, used in 2.7.1, must be applied between the concentrations per se and not between the concentrations calculated from the amount of CH₄ (either gas or dissolved) per the whole system volume. The concentrations used in Eqs. 16-19 are now for the whole system. What is the concentration per se?

It is the amount of CH₄ per volume of the phase concerned, i.e. the amount of the dissolved CH₄ per the volume occupied by the liquid and the amount of gaseous CH₄ per volume of the gaseous phase, including also possibly air, water vapour etc. Henry's law gives the ratio of those concentrations.

This distinction is very fundamental and important and the misuse can lead to unphysical situations.

I give an example: if one single, small bubble exists in the large volume of liquid, the concentration in the sense used in the manuscript (MS) would be practically zero, but the concentration per se would not be. The concentration inside the bubble (that is the concentration per se) would be determined by the Henry's law and the concentration per se of the liquid phase, which in this example would be practically the same as the concentration in the MS, since the liquid volume is much larger than the gaseous volume. Applying now the philosophy used in the MS, the formulas would predict increase of the gaseous CH₄, either increasing the size of the single bubble or formation of new bubbles. However, Henry's law does not say anything about the total amount of the gaseous phase dispersed in the liquid, Henry's law would tell only the equilibrium concentration per se for the gaseous phase, which would not depend on the bubble size or number of bubbles.

I do not know how to solve the problem in 2.7.1. To calculate the amount of gaseous phase would need the dynamic model for bubble formation by nucleation and their subsequent growth. It could be possible that the model in 2.7.1 provides reasonable results compared with the observations, but it is then coincidence since it is based on the wrong physics.

I am very sorry for raising this nasty question, but I do not see how the model would work correctly at the present form. My motivation is that I would like to apply the model also in my own research and would like to know how to make it correctly, but at the moment I do not know how to calculate the total amount of gaseous CH₄ dispersed in the peat matrix. In addition, minor comment, the iteration procedure is not clear for more, it should be explained more thoroughly.

Minor comment:

Eq. 11 assumes the linear relationship between the gas phase diffusivity and the temperature. However, by the tools of statistical thermodynamics it can be shown the diffusivity is proportional to the temperature $D \propto T^a$ where the factor a is always between 1.5 and 2 (e.g. Reid et al., 1987, Properties of gases and liquids, 4th ed., McGraw-Hill, New York). However, the unphysical linear temperature fittings may be valid for the limited temperature range of the original diffusivity data, but any values outside the fitted range must be taken by caution.