



Comment on egusphere-2022-325

Anonymous Referee #2

Referee comment on "Seasonal study of the Small-Scale Variability of Dissolved Methane in the western Kiel Bight (Baltic Sea) during the European Heat Wave in 2018" by Sonja Gindorf et al., EGUsphere, <https://doi.org/10.5194/egusphere-2022-325-RC2>, 2022

The authors report a valuable time-series of CH₄ in Eckernförde Bay. Such a data-set is precious because long time-series of CH₄ are very rare in marine environments. Yet, surprisingly, the data-set of CH₄ concentrations shows little inter-annual variations and no clear response to the heat-wave of summer 2018

Is there a variability in salinity during the time-series from 2006 to 2018 (Figure 8) ?
Could strong variability of water masses "obscure" signals due to other factors (e.g. heatwave) ?

AC: The CH₄ concentration anomaly should be detectable in the surface (5 m water depth) layer. Changes of salinity in the surface layer are usually resulting from mixing events (by storms and/or upwelling). However, mixing of bottom waters brings CH₄-enriched waters to the surface and thus results in a pronounced CH₄ conc. anomaly in the surface layer (see Ma et al, 2020). However, we could not find a relationship between CH₄ surface conc. anomalies and surface temperature anomalies. Therefore, changes in salinities (water masses) are unlikely to obscure the heatwave signals.

While the authors have analyzed inter-annual variations and response to the heatwave of 2018 for CH₄ concentration they did not analyze the variability of the fluxes. Would it be possible to compute the fluxes and check if inter-annual changes in wind intensity lead to inter-annual changes of emissions of CH₄, even if this is not the case of concentration as suggested by Figure 8 ?

AC: Time series of CH₄ flux densities were computed for BE by Ma et al. (2020). Except for a few extremely high flux densities -which resulted from extremely high CH₄ surface concentrations in November 2013, February/March 2014 and December 2014- there were no interannual changes (or trends) in the flux densities.

Could it be possible to add information on air temperature close to study site and check if the heatwave of 2018 affected air temperature in the region ? If this is not the case, then it provides an explanation of the absence response of water temperature to the heatwave of 2018. If this is the case, however, it could be useful to try to figure out why the water temperature did not increase in response to a warmer air mass.

AC: There seems to be a misunderstanding. We do not claim to see an 'absence response of water temperature to the heatwave of 2018'. Indeed, we see a strong signal of the heatwaves in the surface water temperatures (e.g. for 2006 and 2018; see Fig 8 and lines 308 - 319).

L110 : what was the delay before analysis ? There could be issues related to long storage of samples (Wilson et al. 2018).

AC: the samples from the Alkor cruises were taken in 2018 and analyzed in 2020. (the samples for the intercomparison of static headspace equilibration and the purge and trap system were analysed within a month after sampling.) The Boknis Eck time series samples were analysed within a few months after sampling. The fact that the CH₄ concentrations were supersaturated does imply that there were no problems with contamination with ambient air (via leakage through septa) or preservation (samples have been poisoned and stored in the dark; and thus CH₄ production/oxidation were prevented). Please note that the discussion of the storage time in Wilson et al. (2018) is valid for samples with extremely low CH₄ concentrations which we did not encounter here.

L320 : Borges et al. also showed that water temperatures were distinctly higher in July 2018 than the previous 14 years. So there was a very distinct increase of water temperature during the 2018 heatwave off the Belgian coast. They also showed a very strong relationship between CH₄ and water temperature. I'm unsure the reasoning of Borges et al. can be qualified as "speculation" as stated here. They hypothesized that the response of CH₄ was related to higher temperature because it is well established in literature that methanogenesis strongly increases with warming.

AC: In contrast to Borges et al., we could not find a relationship between CH₄ concentration anomalies and surface water temperature anomalies at BE. Indeed, any temperature enhancement (i.e. warming) will affect microbial processes. CH₄ accumulation is the result of the balance between CH₄ production and CH₄ consumption processes. Therefore, warming may lead to enhanced CH₄ production but also may lead to enhanced CH₄ consumption (e.g. via CH₄ oxidation). Borges et al. only mentioned CH₄ production but did not discuss the effect of warming on CH₄ consumption. Therefore, their conclusion is speculative because they do not present time series of net CH₄ production rate measurements.

However, I suggest to try to discuss the reasons for such a difference. The coastal area studied by Borges et al. is very shallow and does not stratify thermally even in summer (permanently mixed). This might explain the different behavior with Eckernförde Bay where thermal stratification occurs in summer. This leads to a strong physical decoupling between mixed layer and the bottom water and sediments. Such decoupling does not occur in the very shallow area off the Belgian coast, so that warming of surface water

directly impact the bottom sediment, and conversely, enhanced CH₄ production in sediments directly propagates to an increase of CH₄ concentration in surface waters.

AC: We agree and will expand the discussion of the difference between our results those of Borges et al. We will include differences in the stratification regimes and the warming effect on both CH₄ production and consumption (see reply above).

I'm unsure that you can conclude that "Thus, CH₄ emissions to the atmosphere at Boknis Eck does not seem to be affected by the heatwaves." The data show that there is no response to the heatwave of 2018. Based on your data you cannot conclude that the site is not affected by heatwaves in general.

AC: We disagree. We do not conclude that BE is not affected by heatwaves. Indeed, there is also a strong temperature anomaly signal for the heatwave in 2006 (see Fig. 8). But this temperature anomaly is (as the signal in 2018) not reflected in the CH₄ concentrations (see discussion in lines 314-319). So, our conclusion is that heatwaves are visible in the temp. data set but obviously they do not affect CH₄ concentrations and the subsequent CH₄ fluxes to the atmosphere during the time period of our study (which spans 13 years).

In summer 2019, there was also a very strong heatwave in Europe that set all-time high temperature records in several EU countries including Germany (Sousa et al. 2020; Vautard et al. 2020). Any chance that CH₄ was also measured in 2019 and to add this information to the analysis ?

AC: Indeed, we continue to take monthly samples for CH₄ and measurements of the samples from mid 2019 to present are currently ongoing. Please note, however, that the scope of our manuscript is focussed on the results of our study in 2018.

There are several references missing from the reference list.

AC: Thank you for pointing this out. We are sorry for the incomplete reference list. We will correct the reference list.

References

Sousa, P. M., D. Barriopedro, R. García-Herrera, C. Ordóñez, P. M. M. Soares, and R. M. Trigo, 2020: Distinct influences of large-scale circulation and regional feedbacks in two

exceptional 2019 European heatwaves. *Commun. Earth Environ.*, 1, 48, <https://doi.org/10.1038/s43247-020-00048-9>.

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Wilson et al. (2018). An intercomparison of oceanic methane and nitrous oxide 545 measurements. *Biogeosciences*, 15(19), 5891–5907. <https://doi.org/10.5194/bg-15-5891-2018>