Replies to Referee 2

In this manuscript, the authors presented a new dataset of inundation dynamics, GIEMS-MethaneCentric. The authors improved the previous dataset by using updated input data and a revised systematic data production process. They compared the new data with other data (WAD2M based on SWAMPS) and obtained consistent results.

Major comments

Accurate inundation (methane-emitting aquatic surface) maps are undoubtedly important for the emission evaluation of methane, a potent greenhouse gas and short-lived climate forcer. However, uncertainties in the inundation dataset have been a serious problem in the global methane budget. The dataset presented in this study is remarkable, because it captured spatial heterogeneity by using updated satellite data and land surface maps. The GIEMS-2 data also covers a long period from 1992 to 2020, allowing us to assess interannual to decadal dynamics of inundation and resultant methane emissions. Moreover, in producing the dataset, the authors used new freshwater and paddy field data to avoid double counting, which is a serious problem in the global methane budget. The dataset is clearly useful for wetland and methane researchers; the spatial resolution (quarter degree) and time step (monthly) may be coarse for field studies but useful for regional to broader assessments.

Thank you for your comments and the time taken to review this manuscript. Hereafter, point-by-point replies to your concerns, and the corresponding changes in the manuscript.

I have a minor concern about the quality of the dataset. Namely, the results (e.g., Figure 3) show that peatlands made a substantial contribution to the global extent especially in tropical and northern latitudes. Nevertheless, the peatland extent was derived from static maps like PeatMap, and therefore interannual variability in peatland inundation could be underrepresented in the dataset. For example, in Figure 8, the anomalies were not largely different between GIEMS-MC_{ISW} and GIESM-MC_{ISW+P} except for variability due to snow cover in northern areas (Ob). In section 5.2.3., the authors discussed a problem with peatland integration but focused on the separation of inundated and saturated areas. As discussed in section 5.2.2. about rice paddy fields, the authors should discuss the temporal variability of peatlands; this can be serious in Southeast Asia (see Figure 7), where peatlands are prevailing and meteorological variability like ENSO is influential.

The peatland inundation variation should be captured in GIEMS-MC_{ISW} as peatlands are not removed from inundated surfaces (inundated peatlands are included in inundated wetland definition). Indeed, inundated peatlands are detected by GIEMS-2. The difference between GIEMS-MC_{ISW} and GIEMS-MC_{ISW+P} is the integration of non inundated peatlands.

Overall, the manuscript is well prepared. The methodological description is adequate, and the dataset is presented nicely. I conclude that the manuscript is acceptable for publication after minor revision.

Minor comments

- I agree that the ERA5 is widely used meteorological dataset, but I am not sure the quality of snow density and depth in the dataset. Did you check it by comparing with observational data?

Note: As Referee 1 asked a similar question, we have given the same answer to both reviewers.

The ERA5 snow mask is used in the production of GIEMS-2, and for consistency, we applied the same mask in GIEMS-MC. ERA5 offers the advantage of global coverage and an uninterrupted long-term record (from 1970 to the present, with ongoing updates). In our processing, ERA5 snow data is used to filter out pixels affected by snow, as snow has complex and highly variable behavior in passive microwave observations, which are used to estimate surface water. The goal is to prevent any contamination of surface water estimates by snow.

Our approach is deliberately conservative in identifying snow-covered areas, which may result in missing some regions near the snow margin. Yet, this is expected to have minimal impact on global methane emission estimates, as temperatures in these areas are typically low (close to 0°C).

We acknowledge that ERA5 snow cover is not a perfect dataset. However, it has been found to be more consistent in terms of trends than, for instance, the NOAA CDR reanalysis product (Urraca et al., 2023). ERA5 effectively captures interannual variations (Kouki et al., 2023), and after 2004, it has been shown to provide the highest accuracy compared to ground measurements among available datasets (Urraca et al., 2023). Some discontinuities in the time series have been reported, particularly around 2004 (Urraca et al., 2023). However, we verified that this does not impact GIEMS-MC surface water extent in northern basins where the snow mask has the greatest influence. For example, no discontinuity is observed in 2004 in the Ob basin, as illustrated in Figure 9 of the paper. It is worth noting that ERA5 generally estimates a larger snow cover extent than other datasets, primarily due to higher values in mountainous regions (Kouki et al., 2023). However, these regions are also poorly represented in other long-term datasets, including remote sensing products (Bormann et al., 2018).

We added in section *2.4 Snow-covered pixel masking* of the manuscript a paragraph to discuss the snow mask importance (lines 498 to 503 of the track changes document):

"For consistency with the snow mask used in GIEMS-2 production, we have used the same mask here in the GIEMS-MC generation. This mask is derived from the ERA5 product, which might overestimate the extent of snow cover but still captures interannual changes well (Kouki et al., 2023). The snow mask in GIEMS-MC is only a filter for pixels potentially contaminated by the presence of snow. The potential overestimation of snow

cover extent should have limited implications for methane missions, as methane emissions in these regions during the snow season should be a small fraction of global emissions, as discussed in the previous section."

- Line 223: I agree to apply a clearing process to reduce the artifacts in coastal areas. However, I suspect that it resulted in the removal of riverine estuaries where are potentially important methane sources. Is my understanding correct?

Your understanding is correct, estuaries, deltas (such as lakes, rivers) are methane emitting areas that are not considered in GIEMS-MC's two dynamic wetland maps (ISW and ISW+P). In fact, estuaries and deltas are coastal areas and then suffer from the limitation of microwave observations in the coastal area (ocean contamination). To assess estuarine methane emissions in particular, and coastal methane emissions in general, users should make better use of other products with higher resolution. For example, optical products derived from MODIS could provide dynamic observations over coastal areas and sparse vegetation. GLWDv2 also provides static information on estuaries and deltas. In response to two reviewers comments, estimates of estuaries and deltas from GLWDv2 are added to the GIEMS-MC variables, following the same approach used for lakes, rivers, and reservoirs, (GIEMS-MCv1.1).

Note : We realized that only estuaries and not deltas had been removed as open surface waters in the GIEMS-MC process. This has been changed in the new manuscript and database. This modification is minor (~2% and ~1% in terms of MAmax on GIEMS-MC_{ISW} and GIEMS-MC_{ISW+P}) and does not change the conclusions.

- Figure 3: Please show the period for the data used in the figure.

This has been added.

- Line 484: Can you give a rough estimation of how much the new dataset improves the evaluation of global wetland methane emissions? For example, a +10% larger inundation area may lead to correspondingly larger emissions.

GIEMS-MC provides approximately the same mean global wetland extent as WAD2M : the absolute global wetland methane emission may then depend mainly on the methane emission model used and its scaling factor. GIEMS-MC should hopefully be used in the Global Methane Budget to assess the impact of the new map on CH4 emission estimates. Compared to existing datasets, the key advantage of GIEMS-MC lies in its improved temporal variations, capturing seasonal and interannual dynamics without discontinuity, while also enhancing spatial patterns. These improvements can enhance methane budget estimates, particularly if new gridded wetland emission datasets based on GIEMS-MC are integrated into inversion models. We have revised the paragraph to better highlight the relevance of GIEMS-MC for the methane research community (lines 530 to 533 of the track changes document):

“Despite significant advances in methane measurement and modelling, accurate mapping of wetland extent remains a key challenge. In this context, we introduce GIEMS-MethaneCentric (GIEMS-MC). It is a new product that improves the temporal variability of the wetland extent by accurately capturing seasonal and interannual dynamics without discontinuities, while also enhancing spatial patterns.”