Replies to Referee 3

This study presents an updated global inundation area dataset spanning 1992 to 2020, providing monthly data at a spatial resolution of 0.25°×0.25°. The dataset differentiates coastal areas and rice paddies, thereby mitigating the overestimation of wetland areas and improving data accuracy. This product has significant value for quantifying methane emissions from global wetlands. Overall, the article is concise and well-structured, accordingly I have only several comments requiring further clarification:

We are grateful for your review of the manuscript and for your comments, which we have responded to below.

Both peatland area and methane emission intensity are highly influenced by soil moisture saturation and water table. Thus, water table playing a crucial role in peatland area variation. How does the study address this issue?

We are aware that the water table is an important parameter for peatland/wetland methane emissions. The literature on wetland methane emission modelling presents two main approaches to account for wetland extent (Bohn and Lettenmaier, 2010):

- Method 1 (*uniform scheme)*: Use of a static wetland extent (maximum wetland extent). In this case, the methane emission of the wetland is determined by the water table over the wetland parts of the whole pixel (> 0.5°x0.5°). e.g., Walter et al., 2001.
- Method 2 (*wet-dry scheme*): Use of a dynamic wetland extent, which constrains the wetland area that is inundated or saturated, excluding "dry" zones. e.g., UpCH4 (McNicol et at, 2023).

Both methods are simplifications with their own advantages and disadvantages. Method 1 must use modelled groundwater levels, as this variable cannot be observed globally. In addition, this method neglects the effects of spatial heterogeneity in water table depth (and therefore methane emissions), as considering water table at the resolution of land surface models (>25 km) is less relevant for wetland hydrology (Bohn and Lettenmaier, 2010).

Method 2 can use remote sensing based products such as GIEMS-2/GIEMS-MC. However, it neglects emissions from "drier" unsaturated topsoil wetlands, which depend on the depth of the water table.

The use of GIEMS-MC would be useful in Method 2, with its advantages and disadvantages. GIEMS-MC detects inundated but also soil surface saturation, but it does not provide direct information about water table depth in unsaturated areas. A possible useful information to enhance these two approaches would be a high resolution global dynamic product of the water table to produce a per pixel distribution of the water table in wetlands. A high resolution product of water table depth was proposed by Fan et al. (2013) for 2004 (the only global one to our knowledge), but 1. it was only seasonal (for 1 year) and 2. it showed inconsistent patterns with GIEMS and other surface water datasets. At this stage, we decided not to include it.

GIEMS-MC users could use additional information to model methane emissions from other sources, such as embedded groundwater level distribution from a land surface model or future high-resolution groundwater products. GIEMS-MC provides an observation that could be used by land surface models to improve their internal simulations of groundwater depths, improving on the approach from Fan et al. (2013).

As shown in Figure 3, peatlands contribute significantly to wetland areas in high-latitude and tropical regions. In high-latitude areas, snow cover changes can partially explain the interannual variability of peatlands, but this approach is clearly unsuitable for low-latitude regions. How can the variability in low-latitude peatlands be better understood? Could this issue be discussed further?

Regarding the variations of peatland inundation, these variations should already be included in GIEMS-MC_{ISW} (Inundated and Saturated Wetlands): the variations in the inundated peatland are detected by GIEMS-2 (as all other water surfaces) and including in the GIEMS-MC_{ISW} dataset. Only in GIEMS-MC_{ISW+P}, all peatlands are included, inundated or not. The seasonal variability of GIEMS-MC_{ISW+P} visible in Figure 3.a (color filling) is consistently smaller than that of GIEMS-MC_{ISW}, as GIEMS-MC_{ISW+P} should theoretically not account for changes in peatland inundation (all peatlands are included).

Would subtracting coastal area directly from wetland areas result in the underestimate of wetland area by excluding riverine estuaries?

The passive microwave satellite data used to derive the surface water extent are very sensitive to all water surfaces, including ocean surfaces. Over coastal areas, the effect of the ocean surface can extend further inland, due to the detection of ocean contamination by the antenna side lobes. To minimize ocean contamination, a conservative solution is suggested by firstly suppressing coastal regions with a high ocean fraction (>10%) and secondly correcting of the coastal pixels. The reviewer is right that this process excludes estuaries and deltas, which are considered separately from wetlands in GIEMS-MC. In response to two reviewers comments, the static estimates of estuaries and deltas from GLWDv2 are now added to the GIEMS-MC variables, following the same approach used for lakes, rivers, and reservoirs, (GIEMS-MCv1.1).

Rainfed rice exhibits seasonal and interannual variations in their inundation status, though its contribution to total wetland area is relatively minor. Could this be discussed further?

This was added to the discussion about rice uncertainties Section 5.2.2 (lines 437 to 446 of the track changes document) :

"Finally, subtracting the MIRCA2000 climatology in the GIEMS-MC processing and not taking into account the inter-annual variation of rice paddies and their inter-annual changes in inundation over the period

1992-2020 can lead to misclassification of rice paddies as wetlands (and the opposite). First, rainfed rice paddies in particular show significant inter-annual changes in inundation. Furthermore, the surface covered by rice paddies also changes over the years. The MIRCA2000 product is compared in Fig. 11 with the estimates from the Food and Agriculture Organization (FAO) of the United Nations estimates FAOSTAT (https://www.fao.org/faostat/en/#data/QCL, access 30/06/2023). FAOSTAT is widely used for global estimates of methane emissions from rice paddies, notably in the Emissions Database for Global Atmospheric Research (EDGAR ; Janssens-Maenhout et al. (2019)). The cropland area of rice paddies is increasing in South-East Asia, with FAOSTAT estimating +60 103 km2 between 1992 and 2020 in this region, which corresponds to the increasing trend of ~+50 103 km2 in GIEMS-MC$_{ISW}$ over this period (Sect. 4.3.2)."

Finally, could the article delve into the specific advantages of using an update dataset that classifies inundation areas into distinct types for accurately estimating global wetland area and its methane emissions?

We believe that the point about the benefit of having harmonized maps to avoid problems of double counting and non-counting between wetlands and other inundated areas has been mentioned throughout the text (Introduction lines 35-38 of the track changes document, Rice discussion lines 450-454 and Conclusion lines 545-546).

References have been added in section 3.3 to justify the need of vegetation/wetland types consideration (lines 280 to 281 of the track changes document) :

"This vegetation information is added in GIEMS-MC as it is expected to help improve the estimation of wetland methane emissions (Pangala et al., 2017; Vroom et al., 2022; Feron et al., 2024; Girkin et al., 2025; Ge et al., 2024)."

We have also changed a sentence in the conclusion about the interest of also distinguishing wetland and vegetation types by adding these variables in GIEMS-MC (lines 543 to 544 of the track changes document):

"Information on the dominant vegetation and wetland type for each pixel is also provided, as these factors help improve the understanding and accurate modeling of methane emissions from wetlands."