

RC2: ['Comment on egusphere-2026-1488'](#), Anonymous Referee #2, 22 May 2026

The paper presents a unique dataset and well-structured fieldwork analyses of methane fluxes across seasons and compares seagrass meadows with sandy environments in coastal Taiwan. This type of research is important for improving our understanding of the role of seagrass meadows in methane emissions and coastal methane cycling. The fieldwork and analytical approaches are generally well-designed however, the manuscript requires major revisions to adequately represent the study's scope and significance.

Reply: We sincerely thank the reviewer for the positive evaluation of our study and for recognizing the value of the dataset, fieldwork design, and analytical approach. We appreciate the reviewer's assessment that this work contributes to a better understanding of methane emissions and coastal methane cycling in seagrass ecosystems.

We also appreciate the reviewer's constructive critique regarding the presentation of the study's scope and significance. We agree that several aspects of the manuscript could be improved to more accurately reflect the strengths and limitations of the dataset and to better communicate the scientific implications of our findings. In response, we have carefully revised the manuscript, including restructuring the Results and Discussion sections, clarifying the distinction between observations and literature-based interpretations, moderating conclusions where appropriate, and more explicitly acknowledging the temporal and methodological limitations of the study. We believe these revisions have substantially improved the clarity, rigor, and overall presentation of the manuscript.

We thank the reviewer for the thoughtful comments, which have helped us strengthen the manuscript considerably.

Comments:

Introduction: The Introduction is currently too broad, contains substantial redundancy, and lacks a sufficiently clear explanation of the study's motivation, knowledge gaps, and objectives. The section requires restructuring. In addition, several citations do not refer to the original studies appropriately. The entire Introduction is a single paragraph and should be divided into logically structured paragraphs.

Line 27-30: The information is somewhat redundant in the opening paragraph. It may be better to move more directly toward the relevance of seagrass meadows.

Reply: We thank the reviewer for this suggestion. We agree that the information in the opening paragraph was somewhat repetitive and delayed the introduction of the study's primary focus. In the revised manuscript, we have streamlined the opening section by

reducing redundant background information and moving more directly to the relevance of seagrass meadows as important components of coastal carbon cycling and potential methane emission hotspots. We believe this revision improves the flow of the introduction and better establishes the context and motivation for the study.

Line 39: Consider including numerical values to better demonstrate how exceptional these systems are.

Reply: We thank the reviewer for this helpful comment. We agree that adding specific numerical values reinforces the significance of these systems. We have revised the sentence.

The sentence now reads:

“Seagrass meadows serve as vital blue carbon reservoirs in coastal ecosystems; despite covering less than 0.2% of the global ocean area, they account for approximately 10% of the ocean’s organic carbon burial, playing a crucial role in climate mitigation due to this exceptional capacity for carbon capture and storage (Fourqurean et al., 2012; Lovelock and Duarte, 2019; Mcleod et al., 2011).”

Line 40: This process is essentially photosynthesis, therefore, repetition of the previous sentence.

Line 41: maybe even millennia

Reply: We thank the reviewer for this helpful suggestion. We have revised the text accordingly. The text now reads as follows: “Through photosynthesis, they convert light energy into organic matter while utilizing dissolved inorganic carbon, enabling long-term carbon sequestration in their sediments for centuries even millennia (Rosentreter et al., 2021b; Yau et al., 2023).”

Line 44: SGWP: abbreviation does not seem necessary

Reply: We thank the reviewer for this suggestion. We have completely replaced the abbreviation and modified the sentence.

Now the text reads: “However, these ecosystems are also recognized as sources of CH₄, a potent GHG with a sustained-flux global warming potential 45 times greater than that of CO₂ over a 100-year timescale, and up to 96-time greater over a 20-year timescale on a mass basis (Neubauer and Megonigal, 2015).”

Line 48: Consider replacing Bange et al. with a more recent reference.

Reply: We thank the reviewer for the suggestion. We have updated the reference to a more recent study (Weber et al., 2019) and revised the text to reflect these recent estimates.

The sentence now reads: “Recent estimates indicate that CH₄ ebullition from continental shelf sediments (0-200m) alone likely falls between 18 and 48 Tg yr⁻¹, with a most probable rate of ~35 Tg yr⁻¹ (Weber et al., 2019)”

Line 57-58: Redundant information

Reply: We thank the reviewer’s comment. We have removed the redundant information.

Line 70: “Intensive field campaign” should be supported with numerical details

Reply: We agree with the reviewer's suggestion. We have revised the sentence to include the specific numerical details of our sampling timeline and strategy.

The sentence has been modified as follows: “Through a series of intensive field campaigns in three seasons (Spring, Summer and Autumn) with each sampling period lasting 5 days, we combined surface water sampling, in situ benthic chamber incubations, and porewater profiling to investigate CH₄ processes in both seagrass and adjacent bare sand habitats.”

Materials and methods:

Line 86- Sampling during late May and mid-June does not sufficiently represent two distinct seasons. If seasonal comparisons are intended, additional regional information describing seasonal environmental variability should be provided.

Reply: We thank the reviewer for the comment. We agree that the distinction between late spring and early summer may not be immediately apparent without additional regional environmental context.

To address this concern, we have expanded the description of seasonal conditions in southern Taiwan. In this region, spring generally extends from March to May and is characterized by gradually increasing temperatures. During late spring, frontal systems associated with the rainy season frequently bring substantial precipitation. In contrast, summer extends from June to August and is characterized by persistently high temperatures and average monthly rainfall of approximately 200 mm. However, precipitation can increase dramatically to 1,000–2,000 mm during periods influenced by typhoons. We have incorporated this information into the revised manuscript to better justify the seasonal classification of our sampling periods and to provide readers with a clearer understanding of the environmental differences between the sampling campaigns.

Line 121- More detailed information is required regarding the atmospheric CH₄ data, how these data were obtained, including data source, spatial and temporal resolution, and interpolation methods, if applicable. Since atmospheric CH₄ is a key component in flux calculations, this methodological aspect warrants a more comprehensive description.

Reply: We thank the reviewer for this valuable comment and agree that the atmospheric CH₄ data used in the flux calculations should be described in greater detail. In the revised manuscript, we have expanded the Methods section to provide additional information on the source and application of the atmospheric CH₄ data.

Specifically, atmospheric CH₄ concentrations were obtained from the NOAA Global Monitoring Laboratory. Because atmospheric CH₄ concentrations exhibit relatively small spatial and temporal variability compared to the much larger variability observed in surface seawater CH₄ concentrations, we used the NOAA atmospheric CH₄ record as the atmospheric boundary condition for the sea-to-air flux calculations. The revised manuscript now includes details regarding the data source, temporal coverage, and the rationale for its use. We believe these additions improve the transparency and reproducibility of the flux calculations.

Results and discussion: This section should be separated into two sections. In the current structure, most subsections begin with a presentation of results, followed by broad, loosely connected discussion paragraphs. Many discussion points are insufficiently linked to the study's actual findings. A clearer structure that presents all results first, followed by a dedicated discussion section that directly refers to those findings, would substantially improve the manuscript.

Reply: We thank the reviewer for this insightful comment and agree that the original structure did not provide a sufficiently clear distinction between the presentation of results and their interpretation. As written, the integration of results with literature-based discussion may have obscured the connection between our observations and the broader processes being discussed.

To address this issue, we have restructured the manuscript by separating the Results and Discussion into two independent sections. The revised Results section focuses exclusively on the observations and analyses from the present study, while the Discussion section interprets these findings within the context of previous studies and relevant biogeochemical processes. We have also revised the discussion to more explicitly link each interpretation to the corresponding results and removed or condensed discussion points that were not directly supported by our observations.

We believe these changes substantially improve the clarity, logical flow, and scientific rigor of the manuscript.

Line 172. "Collectively" is vague. Which specific results support this statement? Flux estimates, spatial variability, or seasonal differences?

Reply: We appreciate the reviewer's diligence in pointing out this ambiguity. We have removed the word "collectively" and revised the sentence to explicitly specify the parameters supporting this statement, namely our benthic flux estimations, potential production rates, and porewater profiles.

The text has been revised to read as follows: “Taken together, our CH₄ benthic flux estimations, production rates and porewater CH₄ profiles demonstrate the role of seagrass ecosystems as critical biogeochemical hotspots for CH₄ production and release, with important implications for coastal GHG budgets and climate mitigation strategies.”

Line 193-211. This section lacks a direct reference to the results presented and reads more like general background information. It should be rewritten to connect to the study's findings. There are also several overstatements.

Reply: We thank the reviewer for this valuable critique. We agree that the original section was overly focused on general background information and did not sufficiently relate the discussion to the findings of the present study. We also acknowledge that several statements were too broad and could be interpreted as overstatements.

To address these concerns, we have completely restructured and rewritten this section. In the revised manuscript, the discussion is now explicitly linked to our observed results, with interpretations grounded in the data presented in this study. We have also moderated the language throughout the section, removed unsupported generalizations, and clarified where interpretations are based on previous studies rather than direct observations. We believe these revisions have strengthened the scientific rigor of the discussion and improved its relevance to the study's findings.

Line 222-224: There is insufficient evidence presented to support this statement.

Line 225-237: No clear reference is made to the current study results.

Reply: We agree with the reviewer that this section lacked explicit integration with our findings. We have thoroughly revised this paragraph.

New sentences now read: “In the present study, CH₄ concentrations in porewater were higher than in the overlying water during autumn 2022 and summer 2023, reflecting diffusion from sediment to the water column as a primary transport pathway (Yu et al., 2024). Although sediments act as a source of CH₄, a substantial portion may be oxidized in the water column, especially under well-oxygenated conditions (Miller et al., 2017). In seagrass beds, oxygen released during photosynthesis can diffuse into sediments, supporting methanotrophic bacteria that oxidize CH₄ and reduce net emissions. Seagrass roots and rhizospheres may also enhance the transport of oxygen and other reactants, further stimulating CH₄ oxidation (Yau et al., 2023). Beyond diffusion, the literature indicates that ebullition can occur when porewater CH₄ partial pressure exceeds hydrostatic pressure, releasing bubbles directly into the water column (Sun et al., 2022). Ultimately, the porewater CH₄ dynamics observed in this study represent a complex balance influenced by methanogenesis, oxidation, and organic matter availability (Henriksson et al., 2024; Yau et al., 2023).”

Line 243-245: What evidence supports the conclusion that seagrass meadows are a persistent CH₄ source? Additionally, “severe weather conditions” should be defined more clearly.

Reply: We thank the reviewer for this comment and agree that the statement was insufficiently supported in the original manuscript. Our intention was not to imply that persistence was demonstrated solely by the present study, but rather to place our observations within the broader context of existing literature.

To clarify this point, we have revised the text and provided additional supporting references. Numerous studies have identified seagrass ecosystems as sources of CH₄, with reported methane emissions offsetting approximately 0.5–33.4% of the blue carbon sequestered in seagrass sediments, depending on seagrass species, geographic region, and environmental conditions (Rosentreter et al., 2021b; Yau et al., 2023; Eyre et al., 2023). In the revised manuscript, we have moderated the wording to avoid overgeneralization and clarified that the characterization of seagrass meadows as CH₄ sources is based on a growing body of evidence from multiple studies rather than solely on the results of the present study.

We have also revised the Line 243-245. Now the text reads: ‘The two sediment types exhibited distinct emission dynamics: seagrass sediments acted as steady CH₄ emitter during typical conditions, whereas sandy sediments exhibited irregular, weather-driven pulses of CH₄ release

Line 252-254: More information is required for the overall circulation in the area, and more comments on the lateral transport of methane.

Line 255: This statement is not adequately supported by evidence.

Reply: We thank the reviewer for these important comments. We agree that the original manuscript did not provide sufficient information regarding the hydrodynamic setting of the study area and the potential role of lateral methane transport. To improve clarity, we have added a conceptual figure illustrating the geographic setting of the study area and the potential pathways of methane transport. We have also expanded the discussion to better describe the possible influence of local circulation and lateral transport processes on methane distribution and fate within the seagrass meadow.

We also agree that the statement in Line 255 was not adequately supported by the available evidence. In particular, the annual evaluation was subject to considerable uncertainty because winter observations were not available and the dataset did not cover a complete annual cycle. To address this limitation, we have removed the annual evaluation from the revised manuscript and instead focus on seasonal flux assessments based on the periods that were directly sampled. We believe this revision provides a more robust and defensible interpretation of the data while avoiding conclusions that extend beyond the scope of our observations.

Line 257-263: The discussion again lacks direct reference to the observed results.

Line 264: This appears to introduce a new subsection or topic and may require restructuring.

Reply: We thank the reviewer for this helpful comment. We agree that the original discussion did not sufficiently refer to the results presented in the study and that the transition at Line 264 introduced a new topic without a clear structural framework.

To address these concerns, we have revised this section and restructured the manuscript. Specifically, we have separated the Results and Discussion sections and reorganized the discussion to ensure that interpretations are directly linked to the corresponding observations and findings from the present study. We have also revised the section beginning at Line 257 with direct reference and incorporated it into a more appropriate structure within the Discussion, improving the logical flow and clarity of the manuscript.

Line 277- 280: The interpretation appears overstated relative to the scope of the presented data.

Reply: We thank the reviewer for this comment and agree that the interpretation was stronger than warranted by the available data. Our intention was to provide a possible explanation for the observed patterns; however, we acknowledge that the original wording may have implied a level of certainty that was not supported by direct evidence.

Line 281“Taken together” is unclear. Which findings are being synthesized here? If this serves as a concluding statement, it may fit better in the conclusions.

Reply: We thank the reviewer’s comment. To improve the organization of the manuscript, we have relocated this concluding statement to the Conclusions section.

Line 293-295: This also contains overstatements.

Reply: We thank the reviewer for this comment and agree that the interpretation might be stronger than warranted by the available data. In the revised manuscript, we have moderated the language and reframed the interpretation as a potential mechanism rather than a demonstrated conclusion. We have also ensured that the discussion remains closely tied to the observations presented in this study and have explicitly acknowledged the limitations of the dataset where appropriate. We believe these revisions provide a more balanced and evidence-based interpretation of the results.

Line 304: “78.3 moles” requires a complete unit description (e.g., mol m⁻² yr⁻¹).

Reply: We thank the reviewer’s comment. We have removed the annual evaluation from the revised manuscript.

Line 310-311: The statement seems redundant

Reply: We thank the reviewer’s comment. We have removed the redundant statement from the revised manuscript.