An itemized response (blue words) to reviewer's comments and suggestions

We sincerely thank the reviewer for the thoughtful and constructive comments on our manuscript entitled "Impact of anticyclonic eddies on the spatial distribution and emission of non-methane hydrocarbons in the northern South China Sea" [Paper # egusphere-2026-1212]. In the revised manuscript, we have expanded the background description of mesoscale eddies in the South China Sea, and clarified the identification and tracking methodology of the anticyclonic eddy. Imprecise or redundant statements have been revised throughout. We have also refined the figures and tables to improve readability and consistency. All modifications are highlighted in blue, and our specific responses to the reviewer's comments are presented as follows.

This manuscript discussed the impact of an anticyclonic eddy on the distribution, production, and emission of NMHCs in the South China Sea. The study combines field observations and deck incubation experiments, providing valuable insights into the coupling between physical oceanographic processes and marine trace gas variability. However, several issues need to be addressed, particularly regarding the clarity of interpretation, the description of methodological details, and redundancy in certain parts of the text. Some conclusions require more precise wording to avoid potential overinterpretation. Overall, the manuscript is well structured, and the results are potentially of interest to the community. After these issues are carefully addressed, it could be suitable for publication.

Reply:

We sincerely thank the reviewer for the positive and constructive evaluation of our manuscript. We have carefully addressed all the issues raised by the reviewer, including clarifying interpretations, improving methodological descriptions, eliminating redundancy, and refining wording to avoid overinterpretation. We believe these revisions have significantly improved the quality of the manuscript.

Major comments:

Line 22: "which further diminished ozone and secondary organic aerosol generation by 59% and 60%" it may be misleading and could be interpreted as referring to total atmospheric O_3 and SOA production. It is more likely that these reductions apply only to the fraction attributable to NMHC emissions from the ocean. The authors should revise this statement to explicitly indicate that the reported decreases refer to NMHC-derived contributions, in order to avoid overinterpretation.

Reply:

Thank you for this important clarification. To avoid overinterpretation, we have revised the sentence to explicitly indicate that the reported reductions apply specifically to the NMHC-derived contributions.

Line 22-24:

"The sea-to-air fluxes of NMHCs within the eddy were 56% lower than reference sites, which reduce their potential contributions to ozone and secondary organic aerosol by 59% and 60%, respectively."

Line 49: "exerting substantial impacts on atmospheric chemical processes within the marine boundary layer." are there any specific impacts about atmospheric chemical processes from the reference? it seems repetitive of the statement in Line 28 the "exert substantial influences on atmospheric reactivity and global climate patterns". The authors are encouraged to either specify the distinct processes (e.g., OH reactivity, ozone formation pathways, etc.)

Reply:

Thanks for this constructive comment. We have added a brief description of how NMHCs affect atmospheric chemical processes in the marine boundary layer.

Line 51-55:

"Specifically, once released from the ocean into the atmosphere, NMHCs rapidly react with •OH, thereby influencing the overall oxidizing capacity of the MBL (Elshorbany et al., 2022). Furthermore, in the MBL of remote marine regions, NMHCs play an important role in the formation of organic aerosol and contribute to the occurrence of new particle formation events (Tripathi et al., 2024)."

References:

Elshorbany, Y., Zhu, Y., Wang, Y., Zhou, X., Sanderfield, S., Ye, C., Hayden, M., and Peters, A. J.: Seasonal dependency of the atmospheric oxidizing capacity of the marine boundary layer of Bermuda, Atmos. Environ., 289, 119326, https://doi.org/10.1016/j.atmosenv.2022.119326, 2022.

Tripathi, N., Girach, I. A., Kompalli, S. K., Murari, V., Nair, P. R., Babu, S. S., and Sahu, L. K.: Sources and distribution of light nmhcs in the marine boundary layer of the northern Indian Ocean during winter: implications to aerosol formation, J. Geophys. Res. Atmos., 129(3), e2023JD039433, https://doi.org/10.1029/2023JD039433, 2024.

Line 67-79: The background description of mesoscale eddies in the South China Sea is somewhat limited. Authors should provide more information about the eddies in SCS, like numbers, types, frequent, already reported eddies impacts on marine biogeochemistry, etc.

Reply:

We thank the reviewer for this constructive comment. The impacts of eddies on marine biogeochemistry have already been discussed in the preceding paragraph (Line 62-68). Therefore, we have added information on the numbers, types, and spatial distribution of eddies in the SCS, while avoiding repetition of biogeochemical impacts.

Line 79-85:

"Statistical analyses based on satellite altimetry data spanning nearly three decades have revealed that approximately 230 mesoscale eddies occur annually in the SCS, with cyclonic eddies (52.2%) slightly outnumbering anticyclonic eddies (47.8%) (Jin et al., 2024). Eddy activity exhibits notable spatial heterogeneity. Particularly active regions include the area west of the Luzon Strait, and the offshore region east of Vietnam (Wang et al., 2003). Some eddies in these regions are recurrent, appearing at similar locations and during similar months each year, and are classified as persistent strong eddies (Jin et al., 2024)."

References:

Jin, Y., Jin, M., Wang, D., and Dong, C.: Statistical analysis of multi-year South China Sea eddies and exploration of eddy classification, Remote Sens., 16(10), 1818, https://doi.org/10.3390/rs16101818, 2024.

Wang, G., Su, J., and Chu, P. C.: Mesoscale eddies in the South China Sea observed with altimeter data, Geophys. Res. Lett., 30(21), 2121, https://doi.org/10.1029/2003GL018532, 2003.

Line 89: more information about AE is needed. Clarify how to determined its life? What kind of data is depending on? "sampled at the end of its intensification" how many stages are typically defined in eddy evolution, and what criteria were used to define these stages in this study? A clearer description of the formation, evolution, and decay of the AE would strengthen the interpretation of the results.

Reply:

Thank you for this constructive suggestion. We have revised the manuscript to provide a clearer description of the formation, evolution, and decay of the AE, and have explicitly provided the criteria used to define its life stages.

Line 99-107:

"The AE was identified and tracked using satellite altimetry data from the Copernicus Marine Environment Monitoring Service (CMEMS), following the closed-contour method (Chelton et al., 2011), which defines an eddy by its outermost closed SLA contour. The eddy formed through a merger event at the end of July, when a closed SLA contour appeared. The AE was tracked continuously until its SLA signature could no longer be distinguished from the background field, yielding a total lifespan of approximately 100 days before its dissipation in early November. According to established eddy stage classifications defined by lifespan, for example, < 1/3, 1/3–2/3, and 2/3–1 for the intensification, mature, and decay stage, respectively (Sweeney et al., 2003; Zhou et al., 2020), AE was sampled at the end of its intensification."

References:

Chelton, D. B., Schlax, M. G., and Samelson, R. M.: Global observations of nonlinear mesoscale eddies, Prog. Oceanogr., 91(2), 167–216, https://doi.org/10.1016/j.pocean.2011.01.002, 2011.

Sweeney, E. N., McGillicuddy, D. J., and Buesseler, K. O.: Biogeochemical impacts due to mesoscale eddy activity in the Sargasso Sea as measured at the Bermuda Atlantic Time-series Study (BATS), Deep-Sea Res. Pt. II, 50(22–26), 3017–3039, https://doi.org/10.1016/j.dsr2.2003.07.008, 2003.

Zhou, K., Dai, M., Xiu, P., Wang, L., Hu, J., and Benitez-Nelson, C. R.: Transient enhancement and decoupling of carbon and opal export in cyclonic eddies, J. Geophys. Res. Oceans, 125(9), e2020JC016372, https://doi.org/10.1029/2020JC016372, 2020.

Line 109: Only 8 species of NMHCs were measurement. I think it is crucial to point this study focus on limited species in the abstract, e. g., “eight C2-C5 NMHCs”, so that readers can better understand the scope of the results.

Reply:

Thank you for this helpful suggestion. We have revised the abstract to specify that our study focused on eight C_2–C_5 NMHC species.

Line 15-17:

“Herein, we characterized the distributions and emissions of eight C_2–C_5 NMHCs in the South China Sea, with emphasis on the impacts of an anticyclonic eddy.”

Minor issues:

Line 25: change “consequences” to effects.

Reply:

We thank the reviewer for the suggestion. We have changed “consequences” to “effects”.

Line 24-26:

“Overall, our findings elucidate the regulatory role of mesoscale eddies in NMHC dynamics, highlighting their critical function in shaping marine trace gas cycling and associated environmental effects.”

Line 53: “well established”? I think it is only well recognized that eddies have important influence on marine biogeochemistry.

Reply:

We thank the reviewer for this comment. We have revised the sentence by changing “well established” to “well recognized”.

Line 58-60:

“It is well recognized that mesoscale eddies significantly influence ocean biogeochemistry (McGillicuddy et al., 1998; Dai et al., 2020; Liu et al., 2020; Zhang et al., 2023; Zhou et al., 2023).”

Line 60: how to understand “reshape phytoplankton community dynamics”, delete “dynamics”

Reply:

Thanks for this suggestion. We have deleted the word “dynamics”.

Line 63-65:

“Conversely, by driving upwelling and transporting subsurface nutrients to the euphotic zone, cyclonic eddies may enhance primary productivity and reshape phytoplankton community (Zhou et al., 2020; An et al., 2024).”

Line 61: change “phytoplankton productivity” to “primary production” or “phytoplankton biomass”

Reply:

Thank you for this precise terminological suggestion. We have changed “phytoplankton productivity” to “primary production”.

Line 66-68:

“Therefore, mesoscale eddies can significantly modulate primary production within the euphotic zone and influence DOM concentrations and their associated carbon export flux (Zhou et al., 2013, 2020; Liang et al., 2025).”

Line 84: how can “survey period” revealed those? Rewrite this sentence.

Reply:

Thanks for this comment. We have rewritten the sentence as follows:

Line 94-96:

“During the survey period, sea surface height was higher in the southeastern and western areas than those in the central and northern areas.”

Line 119: provide the calibration curves in the SI

Reply:

Thanks for this suggestion. We have added the calibration curves for all eight target NMHCs to the supplementary information as Figure S1. Each curve shows the linear regression of peak area against concentration, with the corresponding regression equation and correlation coefficient.

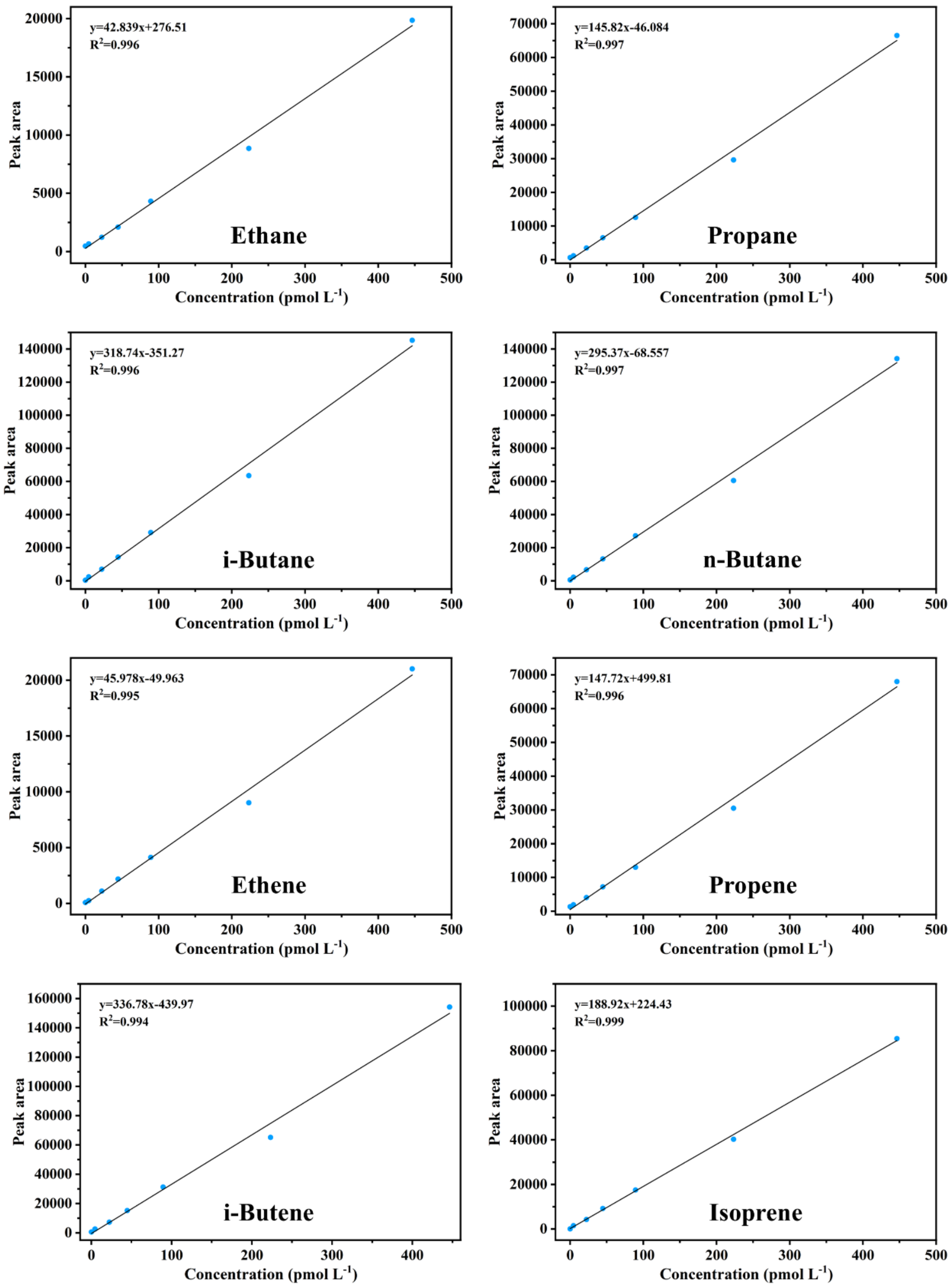

Figure S1. Calibration curves for the eight target NMHCs.

Line 223: “37.3 ± 25.1 129 ± 47.1,” missed a ,

Reply:

We thank the reviewer for catching this typographical error. We have added the missing comma in the revised manuscript.

Line 250-251:

"with mean values of 26.7 ± 15.4, 26.1 ± 17.4, 19.5 ± 13.6, 37.3 ± 25.1, 129 ± 47.1, 48.6 ± 19.3, 69.7 ± 30.3, and 34.1 ± 15.3 pmol L^{-1}, respectively."

Line 225: "85.8%–383% higher than those of alkanes" chang it to "xx-xx times higher than"

Reply:

Thanks for this helpful suggestion. We have revised the sentence by changing "85.8%–383% higher than those of alkanes" to "0.9–3.8 times higher than those of alkanes".

Line 251-253:

"Alkenes accounted for a relatively large proportion of total NMHCs, with concentrations being 0.9–3.8 times higher than those of alkanes with the same carbon number."

Line 227: change "AE-dominated" to "AE-affected"

Reply:

Thanks for this suggestion. We have changed "AE-dominated" to "AE-affected".

Line 253-255:

"The distribution of NMHCs was also significantly influenced by the eddy, with their mean concentrations in the AE-affected area (201 ± 101 pmol L^{-1}) being notably lower than those at the reference sites (433 ± 62.5 pmol L^{-1}) (t-test: $t = 5.645$, $p < 0.001$)."

Line 250: "far exceeding the changes observed for other compounds" list the specific changes of other compounds.

Reply:

We thank the reviewer for this constructive suggestion. We have revised the sentence by adding the specific increase ranges for the other compounds.

Line 275-277:

"C_2–C_4 alkenes exhibited the largest enhancement, with increases of 63%–210%, far exceeding the changes observed for other compounds (which increased by 25%–55%)."

Line 267: why are there so many empty cells in the table 1? Authors should provide the rates as mean ± standard deviation based on triplicate experiments.

Reply:

We thank the reviewer for these detailed and constructive comments on Table 1. The blank spaces indicate that the photochemical incubation experiments with distinct spectral band treatments (visible light, UVA, UVB) were not performed at these stations. In the revised manuscript, we have replaced the blank spaces with "-" and added a footnote below Table 1. For the experiments that were performed, we have now provided the rates as mean ± standard deviation based on triplicate incubations.

Table 1. Concentrations of C_2–C_4 alkenes in 0.2 μm-filtered seawater from the northern SCS under dark control and irradiated conditions after 6 hours of solar exposure, and the calculated photochemical production rates (mean ± SD, n = 3).

Category	Station	Species	Concentration (pmol L^{-1})				Photochemical production rate (pmol L^{-1} h^{-1})			
			Dark	Full spectrum	Visible light + UVA	Visible light	Full spectrum	UVB	UVA	Visible light
Eddy core	Z7	Ethene	80.3 ± 1.9	225 ± 14.2	122 ± 8.5	85.1 ± 1.7	24.1 ± 2.6	17.1 ± 1.3	6.1 ± 1.7	0.8 ± 0.2
		Propene	47.9 ± 2.8	79.5 ± 6.5	64.4 ± 3.3	53.2 ± 2.2	5.3 ± 0.6	2.5 ± 0.9	1.9 ± 0.8	0.9 ± 0.4
		i-Butene	37.9 ± 1.4	111 ± 7.9	64.7 ± 4.0	46.9 ± 0.8	12.2 ± 1.2	7.7 ± 0.7	3.0 ± 0.8	1.5 ± 0.3
Eddy edge	LX2	Ethene	108 ± 3.6	315 ± 10.0	163 ± 7.9	120 ± 4.0	34.6 ± 2.2	25.4 ± 2.6	7.1 ± 1.5	2.1 ± 0.6
		Propene	69.0 ± 1.2	198 ± 8.9	120 ± 9.8	82.4 ± 1.9	21.5 ± 1.3	13.0 ± 1.5	6.3 ± 2.0	2.2 ± 0.4
		i-Butene	93.6 ± 4.4	185 ± 7.6	146 ± 8.7	108 ± 4.5	15.3 ± 0.7	6.5 ± 1.4	6.3 ± 0.7	2.5 ± 0.9
Reference site	A4	Ethene	111 ± 4.2	344 ± 14.3	–	–	38.8 ± 3.0	–	–	–
		Propene	83.8 ± 2.3	219 ± 7.5	–	–	22.6 ± 1.5	–	–	–
		i-Butene	80.3 ± 3.6	155 ± 17.9	–	–	12.4 ± 3.0	–	–	–
Reference site	B9	Ethene	91.9 ± 3.5	279 ± 13.0	–	–	31.2 ± 2.6	–	–	–
		Propene	77.0 ± 6.7	215 ± 9.3	–	–	22.9 ± 2.1	–	–	–
		i-Butene	68.8 ± 4.8	161 ± 15.0	–	–	15.3 ± 2.7	–	–	–

"–" indicates that the corresponding experiments were not conducted.

Line 273: "Surface nutrients were nearly undetectable within the AE," if undetectable, say undetectable, else show the data

Thanks for this comment. We have revised the sentence by replacing "nearly undetectable" with the specific concentrations.

Line 302-303:

"Surface nutrients within the AE were very low (DIN: 0.30 ± 0.06 μmol L^{-1}; phosphate: 0.04 ± 0.03 μmol L^{-1}) but increased gradually with depth."

Line 281: provide the t-test results

We thank the reviewer for this important statistical comment. The Chl-*a* data for the DCM layer in the eddy edge and eddy core comprised only two and three samples, respectively, which are insufficient to perform a *t*-test. Therefore, we used Cohen's d to test the significance. The results showed a Cohen's d of 1.08 between the eddy core and reference sites (large effect), and a Cohen's d of 0.55 between the eddy core and eddy edge (medium to large effect). These effect sizes indicate that the observed differences are indeed substantial. In the revised manuscript, we have reported the effect sizes.

Line 310-313:

"Moreover, Chl-*a* concentrations within the DCM layer of the eddy core (0.25 ± 0.11 μg L^{-1}) were substantially lower than those at the eddy edge (0.31 ± 0.09 μg L^{-1}) (Cohen's d = 0.55, medium effect size) and reference sites (0.34 ± 0.06 μg L^{-1}) (Cohen's d = 1.08, large effect size)."

Line 300:" because the zonal extent of the study region was only 4°" It would be more intuitive to express the zonal extent in kilometers or nautical miles rather than 4°.

Thanks for this helpful comment. We have rewritten the sentence as follows:

Line 336-339:

"However, because the maximum latitudinal extent between the incubation stations was only approximately 330 km, the variations in solar irradiance among stations during the incubation period were minimal (852–895 W m^{-2}), which was insufficient to explain the inter-station differences."

Line 306: provide the t-test results

We thank the reviewer for this comment. The DOC concentrations reported here are single-point measurements at each station, which precludes appropriate significance testing. Therefore, we have deleted the word "markedly", and the sentence now simply reports the observed values without statistical claims.

Line 342-344:

"DOC concentrations at the eddy core (Z7: 62.6 μmol L^{-1}) were lower than those at the eddy edge (LX2: 89.8 μmol L^{-1}) and the reference sites (A4: 95.5 μmol L^{-1}; B9: 84.6 μmol L^{-1})."

Line 323: "Assessing the impact of NMHCs on global climate feedback requires precise estimates of their sea-to-air exchange fluxes." This sentence is meaningless in the beginning of the paragraph.

Thanks for this comment. We have deleted this sentence in the in the revised manuscript.

Line 348: change to "demonstrating that the anticyclonic eddy suppressed the release of NMHCs."

Thank you for this precise suggestion. We have revised the sentence accordingly.

Line 388-391:

"Calculations revealed a mean NMHC sea-to-air flux of 196 ± 170 nmol m^{-2} d^{-1} within the AE, representing a 56% reduction relative to the reference sites (447 ± 289 nmol m^{-2} d^{-1}; *t*-test: t = –2.720, p = 0.013), demonstrating that the anticyclonic eddy suppressed the release of NMHCs."