ESSD-2025-514: Reply to comments from Referee #2
(Reviewer comments in bold, author responses in blue)

I have decided to discontinue my review after reading through line 215 of the manuscript. The presentation up to this point is confusing, incomplete, and in places incorrect, making it difficult to follow the authors' reasoning. I provide examples of each of these below, but I emphasize that these are only illustrative—addressing them alone will not, in my opinion, make the manuscript publishable. I agreed to review this paper because I am genuinely interested in the application of machine learning to the detection of ocean fronts. However, based on what I have read so far, I believe I would struggle to understand the algorithm as currently presented. I would be willing to review a substantially revised version of the manuscript if the authors make a serious effort to present their work in a clearer and more coherent manner.

We fully accept your decision to conclude the review and sincerely apologize for the deficiencies in clarity, completeness, and accuracy in the current manuscript. We will thoroughly revise the manuscript based on all of your comments, correcting all errors, with the aim of presenting the research work clearly and coherently in the revised version. We appreciate your attention to our research direction and your willingness to review a substantively revised version in the future.

I also note that the authors do not mention any use of AI tools—specifically large language models—in preparing the manuscript. Given the lack of clarity both because of the English and because of the structural organization of the manuscript, they might consider using such tools to assist in revising the text. Copernicus Publications does not prohibit the use of large language models for language assistance, but it does require that their use, if any, be disclosed in the manuscript.

We thank the reviewer for the reminder regarding the use of AI tools. In this revision, we did not employ large language models (LLMs) for generating or restructuring manuscript content. To fundamentally address issues of linguistic clarity and structural logic, we engaged a professional academic editing service to conduct a thorough edit and optimization of the entire text. The service focused on enhancing the professionalism and fluency of the English expression, as well as the overall readability of the article. All scientific content, data, conclusions, and academic arguments remain the sole responsibility of the authors and were finally confirmed by us.

Terminology (Lines 22-24) “Ocean front refers to a narrow transitional zone between two or more types of water bodies with significantly different properties, which is a jumping zone of marine environmental parameters and can be described by the horizontal gradient of seawater temperature.” I assume that jumping zone means a step in the observed property but this is certainly not standard usage.

Thank you for your correction. We fully agree that "jumping zone" is a non-standard and ambiguous expression. In accordance with your suggestion, we have rewritten the definition in lines 22-24 as follows:

"An ocean front refers to a narrow transition zone between two or more water masses with significantly different properties, where oceanographic parameters such as the temperature, salinity, and water colour experience sharp changes. It can be characterized by the horizontal gradient of the sea surface temperature."

(Lines 80-82) “With the application of depth learning in the field of image recognition (Nogueira et al. 2016), in view of the shortcomings of traditional ocean front detection methods, the ocean front detection algorithm based on depth learning has become a research hotspot.” It’s deep learning, not depth learning. I realize that English is not the first language of the authors hence the suggestion that they use a generative AI chatbot to help with the English.

Thank you for your correction on this key terminology error. You are absolutely correct, and it should be "deep learning". We have now corrected this typographical

error and all similar occurrences throughout the manuscript. Furthermore, to systematically improve the English quality of the text, we have engaged a professional academic editing service for a thorough language polish. We sincerely apologize for any confusion caused by linguistic inaccuracies in the original version.

Overgeneralized and misleading (Lines 25-27) “These fronts are the places where different air masses (usually cold and warm humid air) interact, not only having profound impacts on meteorology and climate, but also playing key roles in ecology, resource management, and climate regulation.” This may be the case but is not necessarily so. In fact, for sub-mesoscale fronts it is likely rarely the case and for mesoscale fronts it will depend on the properties defining the front; e.g., it’s unlikely to be the case of a strong salinity front with a thermal expression due, say, to river runoff, or to a chlorophyll front resulting from an open ocean bloom. What makes this sentence particularly confusing is that it conflates atmospheric fronts with oceanic ones.

We fully accept this important critique. The two points you raised regarding conceptual confusion (incorrectly applying features of atmospheric fronts to ocean fronts) and an overly generalized and absolute conclusion are completely valid. The original sentence contained fundamental errors, for which we sincerely apologize. We have deleted the incorrect statement.

Incorrect/misleading (Lines 40-43) “The main methods for calculating temperature gradients are Gradient method and Sobel gradient algorithm.” The main methods for front detection are population-based and gradient-based. Sobel gradients are one form of gradient-based algorithms. Canny’s work is also based on gradients. Cayula and Cornillon’s work is population-based.

Thank you for correcting this important conceptual and classification error. We fully agree that the original statement was logically confusing and misleading, failing to accurately reflect the mainstream classification system of ocean front detection methods.

Following your guidance, we have completely rewritten the content in lines 40-43. We have adopted the standard classification framework of "gradient-based" and "population-based" methods and cited key references accordingly.

Incomplete and a bit misleading criticism of previous front detection algorithms (Lines 43-43) “However, these algorithms may not effectively distinguish between genuine ocean fronts and other image features or artifacts.” This is only one form in which front detection algorithms may fail. The discussion of issues with current algorithms is incomplete. Furthermore, I would be surprised if the fronts detected by the algorithm presented in this paper did not also fail in this regard. As noted above I have not reviewed the algorithm itself but…

Thank you for your suggestion. It is indeed correct that using deep learning for

ocean front detection may encounter similar challenges. We have revised the previously incomplete and misleading commentary on earlier front detection algorithms in the manuscript.

(Lines 58-60) “In summary, traditional methods for extracting ocean fronts suffer from limitations such as subjective threshold selection, inadequate handling of complex fronts, dependency on edge detection algorithms, and limited adaptability to changing conditions.” But all of the methods you discuss from line 40 on are gradient-based. The reason that the population-based method of Cayula and Cornillon was developed was to address some of the issues you raise. Admittedly, their method has other issues but, because the primary mechanism is not based on gradients, it doesn’t suffer from some of the problems you mention.

Thank you for your careful review and crucial comments. We acknowledge the significant issues in our previous statement and have now thoroughly revised and polished the article. Considering the distinct differences between water masses on either side of an ocean front, Cayula and Cornillon (1995) proposed the SIED (single-image edge detection) algorithm based on histogram analysis. This algorithm demonstrates effective detection performance and has been widely applied in ocean front detection.

Inappropriate reference (Lines 35-36) “…the main methods for extracting ocean fronts based on remote sensing data include statistical histogram method (Belkin and Cornillon 2003)” The authors do discuss the application of a histogram based algorithm to extract the fronts of interest but a more appropriate reference would have been to the original manuscripts describing the method.

Thank you for your suggestion. Citing the original literature that first described the method is indeed a more appropriate approach, and we have implemented this change in the manuscript.

Sloppy (Lines 469-473) I. M. Belkin and P. J. P. O. Cornillon, "SST fronts of the Pacific coastal and marginal seas," 2003. L. C. Breaker, T. P. Mavor, and W. W. J. C. S. G. C. P. Broenkow, "Mapping and Monitoring Large-Scale Ocean Fronts Off the California Coast Using Imagery from the GOES-10 Geostationary Satellite," 2005. A. G. Kostianoy, A. I. Ginzburg, M. Frankignoulle, and B. J. J. o. M. S. Delille, "Fronts in the Southern Indian Ocean as inferred from satellite sea surface temperature data," vol. 45, no. 1-2, pp. 55-73, 2004. I’m pretty sure that these initials are not correct and most of the references seem to have similarly bizarre initials.

Thank you for pointing out these citation format errors. You are correct that the author initials and journal abbreviations in the references you listed were incorrect. We have now carefully checked and corrected the entire reference list to ensure that all author names, journal titles, and publication details are accurate and consistently formatted.

(Lines 128-132, Equations 1-3) There are mistakes in two of the three equations.

We apologize for the error here. We have carefully reviewed and corrected the formulas, and have also conducted checks for other elementary mistakes throughout the manuscript.

$$G = \sqrt{D_x^2 + D_y^2} \tag{1}$$

$$D_x = \frac{T(i, j+1) - T(i, j-1)}{2\Delta x} \tag{2}$$

$$D_y = \frac{T(i+1, j) - T(i, 1-j)}{2\Delta y} \tag{3}$$

(Lines 134-135) “Labelme software was used to generate the ocean front labels First and foremost, data from remote sensing satellite images that show ocean fronts must be gathered, which are from various regions, times of year, and types of houses.” Hmmm… not sure where the authors are going with fronts related to types of houses.

Thank you for pointing out this confusing and erroneous sentence. The phrase "types of houses" is a typographical error and is completely irrelevant in this context. We sincerely apologize for this oversight and for any confusion it may have caused. We have made the necessary corrections in the manuscript.

Undefined concepts/terms (Line 50) “…proposed a dual I value ocean front recognition method based on the gradient I value method” I’m not familiar with the I value method. I did ask ChatGPT and was provided a description of it but I don’t believe that it is common usage so should be defined.

The expression "dual I value" is inappropriate, and we have corrected it in the original text.

Ping et al. (2014) proposed an ocean front detection method based on threshold intervals and Bayesian decision theory. This method uses the Sobel operator to compute the gradient map of SST images and determines the threshold interval by using a gradient histogram, ultimately achieving ocean front detection (Ping et al., 2014).

(Section 3.3, Lines 139-212) The above comments cover a range of specific issues related to the presentation. Of more concern is that the manuscript does not explicitly define (or, at least I couldn’t find such a definition) how an “ocean front” is represented in pixel space — e.g., whether it is treated as a line, a finite-width band, or a bounding box enclosing a high-gradient region. Because Mask R-CNN performs region-based segmentation and IoU is computed over areas, clarification is needed on how these concepts were adapted for the detection of essentially linear frontal features. The authors should also explain how fronts crossing tile boundaries were handled to ensure that detections are not truncated or duplicated across adjacent

patches. I emphasize that I did not read the manuscript beyond this point so they may have presented a definition later in the manuscript but, if the authors define this later, it should nonetheless be introduced in Section 3.3.

In our framework, the ocean front is represented as a pixel band with finite width (i.e., a narrow binary mask region), rather than a single-pixel wide line or a bounding box enclosing a high-gradient region. This approach better reflects the physical nature of the front as a transition zone between two water masses. As a connected region, it is directly compatible with the instance segmentation mask output by Mask R-CNN and the IoU area calculation. While the front is geographically quasilinear, modelling it as a “finite-width band” transforms the problem into a region segmentation task. The task of Mask R-CNN is to predict a corresponding binary mask for each front instance. Then, the IoU is calculated based on the area overlap between the predicted mask and the ground-truth mask, which is used to evaluate the detection performance. This process follows the standard evaluation procedure for instance segmentation. Additionally, we designed a non-maximum suppression (NMS) algorithm based on spatial location and mask similarity specifically for merging duplicate detections of the same front segment in overlapping areas with adjacent tiles and for connecting broken parts across boundaries, thereby forming a complete and continuous front vector.

What is mouth recognition and how is that different than image recognition?

The term "mouth recognition" is a grammatical error; the intended meaning is "target detection".

Do you mean Ocean fronts associated with week gradient?

“and Li et al. (2019) proposed an ocean front detection network based on the CNN to address the weak edges of ocean fronts.” The intended meaning here is the weak edge characteristics of ocean fronts.

Recognition sounds awkward to me. I would use a word like classification, identification, or detection

Thank you for your suggestion. We have revised the term from "Recognition" to "Detection," as it is a more suitable expression.

By ‘standard’, do you mean that the same regular grid is used for the entire data set or do you mean that it’s a specific type of grid like Mercator, Plate Carrée or something like that?

By "standard," we mean that the same regular grid is used for the entire dataset.

I would use something like this: The units are degrees Celsius; the temporal resolution is daily; and the spatial resolution is 1/12°.

Thank you for providing this precise and clear example. We agree that this formulation is more standard and professional. Following your suggestion, we have revised the sentence to: **" The units are °C; the temporal resolution is daily; and the spatial resolution is 1/12°."** We appreciate your help in improving the rigor of our manuscript's description.