All of the co-authors would like to thank the referee for the time which he/she has allocated to the detailed revision of this paper, taking the time and effort to provide us with generally positive and constructive feedback. and the well-supported comments about our work. We sincerely value the work done in this review and we are grateful for this. We hope our responses and the improved version of the manuscript will meet the expectations.

Please, find below our point-to-point response with comments of the referee in **black** and our response in **blue**.

General comments

The authors of this study thank the reviewer for the general comments, which have highlighted numerous inaccuracies in our article. The main concern was the lack of a clear objective, which is evident upon rereading the article and has been noted by all reviewers. Initially, it seemed interesting to study both the ability of operational satellites to track oceanic extremes and the response of French coastlines to the exceptional summer of 2022. However, the study was conducted with the goal of characterizing the response of SSTs to multiple heat waves.

Therefore, the article has been revised to focus on this objective and determine the contribution of various atmospheric variables to this response. To achieve this, the structure of the paper has been revised to include necessary information for a more comprehensive study of ocean-atmosphere heat exchange interactions. Thereby, we conducted an analysis of the contribution of several atmospheric variables using a modelling approach. Hence, Materials & Methods, Results and Discussions have been largely modified.

In order to not start from scratch on the analysis of temperature data, we have kept the OSI SAF data and added details on comparison with the products used for climatology construction.

Minor comments

Across the manuscript, please clearly state how do you calculate anomalies. Are you comparing daily OSI/SAF SST values with monthly climatology? I couldn't get the point. As mentioned by the reviewer, it is unclear how we calculated our anomalies. We, thus, provided more details about the process in the corresponding paragraph (section 2.3.3 on page 5).

We computed daily and monthly anomalies. For each, we compared daily (resp. monthly) ESA CCI product to the corresponding daily (resp. monthly) OSI SAF product. Thus we did not compare SST value that are on different time period.

Figures are too small. Please, make bigger figures.

Figures have been updated to be more readable.

Other comments

Lines 45-54 should not be included in the Introduction Section. A "Synoptic description/atmospheric characterization/..." section is needed and should go into greater detail.

A specific section has been added to describe the synoptic conditions. P8, L.232 to P10, L250

Figures 1-2: I assume they are monthly anomalies although not stated. Maps are too small.

Figures have been modified. In fact, the anomalies shown are comparison of each heatwaves periods to the corresponding one of the 1991-2020 climatology.

Figure 3: Please, improve caption by stating the subdivisions are stated for the SST analysis

As suggested by the Reviewer.2 we decided to remove this Figure and to display the subareas in Figure 4. We included the following sentence in the legend:

"The English Channel (EC), the Bay of Biscaye (BB) and the North-western Mediterranean Sea (NWM) used in to analyse SST pattern throughout the 2022 meteorological summer are plotted on the subplot (a)."

Lines 69-71. Please, rewrite this sentence to improve the English language (missing verbs, concordance,...).

P3, L83-85.

"This area is directly influenced by Mistral and Tramontane regional winds which drive recurrent upwelling phenomena, making it of particular interest in comprehensive studies of the Mediterranean water cycle and its implications for climate studies (Drobinski et al., 2014; Ruti et al., 2016)"

Lines 76-77: Change "Both hourly and monthly were used" to "Both hourly and monthly data/values were used" (general remark: please, carefully check English grammar and spelling)

We finally removed this sentence as we included a specific paragraph to detail the construction of anomalies.

Line 142: Please change "3°CC" Corrections made

Line 153: Reference to "Table 4" but this one does not exist. Maybe A1?

P13, L284. Correction has been made. There was a mismatch between references, here we intended to refer to the Figure 3.

Lines 160-164: Do these sentences refer to single point values? The 7.9°C anomaly, is referred

to local or mean climatology? This is not clear for me. If this is compared to mean areal climatology this would not be the right way to compare daily values to climatology

This sentence aims to focalise on a single point and give further insights into the range of response and extremes values reached during the event that are hidden when analysing mean values.

However, the anomaly in question referred to the analysis of the local measured SSTs to the single point 1982-2011 climatology.

We propose the following corrected sentences:

P13, L294 – P13, L300.

"We investigated the local response to the marine heatwave in each basin by calculating the 1982-2011 daily climatology for every single point within each region. Our analysis revealed that the maximum recorded temperature was 30.8°C on August 4th in the NWM area, 23.6°C on August 12th in the EC area, and 26.4°C on August 11th in the BB area. In terms of anomalies, the NWM basin exhibited the minimal anomaly of 2.2°C, whereas the EC and BB basins exhibited negative anomalies of -1.5°C and -2.1°C, respectively. The maximum anomalies were 7.9°C in NWM, 3°C in EC, and 3°C in BB, indicating the extensive response of the NWM basin and the range of sea surface temperature (SST) variability within and between each basin. The stronger SST variability in both BB and EC regions was notable."

Line 179: Which is the "whole domain"?

The whole domain refers to France.

P14, L319 – P14, L321.

"The mean total cloud cover anomaly over France reaches -17% while the North of France and specifically Brittany have undergone the maximum average anomaly of -37%"

Figure 7: Not stated but I understand that the maps show anomalies for the days in August 22 heatwave days, respect to 1991-2020 august monthly values? To the same period (31/07-13/08) for the 1991-2020? Please add this information in the figure caption and text.

We calculated the anomalies in respect to the corresponding period of the 1991-2020 climatology. This precision has been added in the figure caption and text.

Legend of Figure 5 on P.16 "Anomalies are compared to the same period in the 1991-2020 climatology."

Line 209: in response to the atmospheric heatwaves that affected France during the 2022 summer. Results and analysis are mostly centred in the August event, maybe not valid for the rest of summer.

Even if we centered part of our study on the August event, we also analysed the signal over the summer months.

We proposed the following sentence:

P22, L435-438. "Despite the significant lack of data, particularly in the early summer and in the EC area, we found a clear warming signal of SSTs during the summer of 2022 that was evident in all studied areas. All three areas exhibited positive SST anomalies throughout the summer, with record-breaking daily anomalies indicating that 2022 was one of the warmest summers in terms of SSTs, which also started early in the season."

Lines 209-213: "The strongest response was found 210 on the NWM basin (with a maximum average SST anomaly of 4.3°C) which is in line with observations (Bensoussan et al., 2019) and modeled evolution (Darmaraki et al., 2019b) confirming the Mediterranean Sea is a "hotspot" for climate change (Giorgi, 2006)". A single extreme event does not confirm the hotspot, although I agree with the sense of your assumption and that it is in line with the cited references. Please, rewrite this sentence.

We agree on this comment and on the fact that a single event does not prove that the Mediterranean Sea is a climate hotspot. To get more in line with the references and detail our thoughts we proposed this corrected sentence:

P.22, L449 – 455.

"The Mediterranean Sea is recognized as a "hotspot" for climate change (Giorgi, 2006), which will face warmer summer seasons (Adloff et al., 2015). Our findings support the idea that the occurrence of heatwaves throughout the summer would cause the

NWM Sea to respond strongly to these atmospheric forcings. Indeed, results indicate that even during non-heatwave periods, the SSTs in the NWM area were consistently warmer than the climatological average, even when the net heat flux was close to normal. These results are also in line with the with observations (Bensoussan et al., 2019) and modeled evolution (Darmaraki et al., 2019) of the continuous warming of the Mediterranean Sea."

Lines 227-244: These lines are not a discussion/conclusion but should be part of the introduction section. No work has been done regarding MHWs across the manuscript

We completely agree with this remark. In line with the general comment of Reviewer 1 and to a comment of Reviewer 2 that had the same questioning we decided to completely revised the Discussions/Conclusions section. The section integrates previous discussions with the addition of new features that are linked to the attribution results. The section starts P21, L429.

L246 : "To prevent the detection of anomalously warm SSTs". To prevent? We propose the revised sentence: P24, L506. « To anticipate the detection of anomalously warm SSTs »

Lines 250-256: Rephrase to improve reader understanding As the section has been completed revised, this sentence is no longer present. All of the co-authors would like to thank the referee for the time which he/she has allocated to the detailed revision of this paper, taking the time and effort to provide us with generally positive and constructive feedback. and the well-supported comments about our work. We sincerely value the work done in this review and we are grateful for this. We hope our responses and the improved version of the manuscript will meet the expectations.

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Therefore, the article has been revised to focus on this objective and determine the contribution of various atmospheric variables to this response, allowing for a more seamless reading experience. To achieve this, the structure of the paper has been revised to include necessary information for a more comprehensive study of ocean-atmosphere heat exchange interactions. Thereby, we conducted an analysis of the contribution of several atmospheric variables using a modelling approach. Hence, Materials & Methods, Results and Discussions have been largely modified.

In order to not start from scratch on the analysis of temperature data, we have kept the OSI SAF data.

On the specific point about using two different SST data. As explained before, we started by analysing the response of the SST in an operational framework which explained why we kept these data in our study. In any case, both measurements are comparable as they reflect the nighttime SST (or corrected by the diurnal cycle on the specific case of ESA CCI CDR).

We added in the text an explanation on how they are correlated.

Line by line comments

<u>Abstract</u>

(1-3) These initial sentences should be more precise. From the beginning of which measurements? The seasonal average of 22.7°C is intended as surface air temperature, or what? Multiple record-breaking heatwaves over which period?

This sentence has been modified as following :

P1. L1-3

« Summer 2022 was memorable and record-breaking, ranking as the second hottest summer in France since 1900, with a seasonal surface air temperature average of 22.7°C. In particular, France experienced multiple record-breaking heat waves during the meteorological summer. »

(9-10) I would not introduce the core of your study saying that "the contribution of other atmospheric variables is not negligible". This sounds like an a-priori consideration. I believe, instead, that the choices of variables to investigate have a clear motivation and should be better introduced and made more attractive in the Abstract.

The sentence has been removed and replaced by : P1. L6-7 « Beyond the direct relation between sea surface temperatures and the surface air temperatures, we explored the leading driving factors affecting the upper-layer ocean heat budget and determined the magnitude of such atmospheric factors. »

Introduction

(Figures 1 & 2) The images should be larger, could aid having titles referring to the months. How did you compute the 1991-2020 climatology to which you define anomalies? Since the main rationale of your work in exactly the anomaly in surface air temperature, consider if to switch order of Figures 1 & 2, or if to add a single Figure before these showing the mean spatial anomaly over whole summer, or if a time series.

Fig 1 & 2 have been modified by adding months in the titles. Order has been switched. We thought about the proposition of adding a single Figure either as a map or a time series. In our opinion, two figures give complementary information about the atmospheric circulation over the summer and the consequences on the surface air temperature.

(25-32) You longly talk about OHC and the reader it brought to think he/she will see some analysis on OHC, which instead is not present. I suggest you shorten OHC description, or you add an analysis of the field in summer 2022.

We completely agree on this comment, thus this section has been removed as it is not related to the topic of this study.

(45-48) As presented this part sounds as if you are describing already some results, because you go specific on dates and causality of events with no reference. I suggest you keep introduction to be more descriptive, eventually recalling in results more specific relations of causation.

Thanks for this valuable comment which we completely agree on. As proposed by both reviewers we added a specific section describing in details the synoptic condition. Paragraph starting on P8, L232.

Study sites

(64) Since you introduce the SST acronym at line 37, you should not repeat sea surface temperature as a long name after that (it happens in several other points in the manuscript)

P3, L78. This has been modified.

(Figure 3) [not necessary, but suggested] I find that putting a single Figure only to show the regions studied is a quite unhappy choice. To economise I should suggest to plot a field of interest for the presentation (e.g. average SST anomaly, at your preference) and

overplot the chosen basins. Also, I wouldn't talk about a subdivision since you are not considering the whole European Mediterranean subdivided in regions, instead you are choosing specific areas of interest.

As proposed we removed the Figure 3 and overplotted studied areas on the Figure 4 (P15).

Data/Methods

Title has been changed

(76-78) not very interesting nor informative. Also, here you state that you use monthly data to compute the 1991-2020 climatology, then at (112) you say you use daily averages for climatology for the period 1982-2011. You should be clearer and consistent in the presentation.

We agree with the reviewer about the inconsistencies throughout the paper about how we calculated the anomalies. In the present version, we made the calculation procedure clearer and we dissociated the description of the atmospheric climatology from the oceanic one.

To improve the readability of the anomalies computation we decided to have a distinct section (P5, L122 – L133).

(subsection 3.2.1) This section is very detailed. If the purpose of your work is to demonstrate the ability of NRT SST to capture response giving all this information could be justified. At the present version of the manuscript it sounds too detailed.

P4, L97-L113. This section has been shortened in order to be consistent with the objective of this study.

(subsection 3.2.2) it is misleading to entitle the section "SST analysis", as this sounds like you will give some results of your analysis already. You should opt for entitling it as "ESA CCI SST product" or "Satellite derived SST". Indeed, you have section 3.2.3 devoted to describe climatology computation, here you should introduce the product only. P4, L114. We changed this subsection to detail the ESA CCI product only.

(122) replace "calculating" with "calculated". Replace "long-term value one" with "long-term one"

As we modified the subsection 'SST climatology and anomaly », this sentence no longer exists.

<u>Results</u>

L125 remove "use by the"

P11, L253.

"The primary objective of an operational product is to provide daily monitoring for use by forecasting services."

(125-128) This description is badly written. You talk about ideal case without saying what this means (that is complete data coverage). Please revise accordingly. Also, what do you mean with the basins missing data in percentage? Over the whole period considered? Please specify.

This section has been improved to improve the readability. A reference to the section detailing what are the missing data has been also added.

P6. L125-128.

"The first objective of an operational product is to provide a daily usable monitoring for use by the forecasting services. However, these conditions are ideal cases and are therefore not met in all basins every day. Thus a significant part of the data is not available depending on multivariate conditions (clouds, aerosols, low quality data). This share varies for each basin and is compiled in the Figure 4."

(136) take off "that affected these basins". Summer 2022 anomalies have not interested only your chosen basins. Corrections made

(Figure 4) Revise date labels regarding August and make them consistent with the others (08-10 instead of 08-09 and so on). Put titles regarding the basins on each panel. Could be informative to report the percentage of missing data somewhere in panels. Figure 4 has been improved thanks to your comment.

(140) Revise how you write dates. For example, "between the 6th of July and..." should be "between July 6th...", similarly onwards We have checked all the date to have a consistent and standardised format

L144 where are these anomalies shown?

Reference to the table 2 was missing thus we added it in the sentence. We also modified the table 2 to improve readability. We also added the variation of coefficient in addition to the standard deviation to get more insights in the variability of the SST anomalies.

P11, L274-276.

« This is also high-lighted by the variability, presented in the Table 2, which is comprised between 31% and 46% of the mean SST anomaly for a standard deviation between 0.5°C and 0.8°C »

L147 where is this given? Not evident to reader. Need to properly refer to figures.

We finally decided to remove this sentence and modify it to the following one:

P11, L276-279.

"With the exception of specific episodes. SSTs remain close to the climatological maximum of the period 1982-2011 (Fig.3). In addition, it is noteworthy that the NWM experienced 22 days, EC experienced 19 days, and BB experienced 4 days of SSTs exceeding the climatological maximum. It should be noted that the previous temperature record in the NWM dated back to 2003, underscoring the historical significance of the observed response."

(152) you report that temperatures are constantly above climatology by referring to Table, where only average values are given. State better Reference to the Figure instead of the Table has been done

P12-13, L283-284. « During this period, SSTs were abnormally high, with temperatures constantly above the climatological norm (as shown in the Fig 3). »

(Table 4 & Table A1). Table 4 does not exist, but only Table 1. I believe that confusion is made while describing content of tables. In text you say that Table 4 refers to July 31st - August 13th event, but caption of Table in text says differently. Revise accordingly. Consider to put them both in main text, to aid comparison and enable following values reported in text better.

As proposed by the reviewer, we put the table A1 in the main text (it is now referenced as Table 2).

The mentioned confusion comes from the mismatch between Table and Figure. We have corrected this by referring to the correct reference (Figure 3 instead of Table 4). We have revised the figure/table captions and the mentioned referenced in the text.

(158) where do you show the trend?? You are showing average values in Figure 5. This is a mistake in the text, actually we were not intended to talk about a trend. Our point is to show that this warming is uniform and affect all the studied areas as seen in Figure 4.

P13, L290-291.

«Positive temperature anomalies were found throughout the majority of the ocean surface and the trend of increase was spatially uniform (Fig. 4) »

(Figures 5 & 6) It could be useful to recall the regions selected overplotted on fields shown. Also, consider in showing only one of the two periods to not sound repetitive.

As proposed by the reviewer, we consider that adding the studied regions on this figure will help readers to follow the study. We also rearranged the figures to finally keep only one representing better the focus of our study.

(165-171) where are these results shown in figures? Are you talking about Figure 6 23rd – 30th July event or August event? It is not easy to follow as a reader.

This paragraph referred to the comparison between the Figure 4 and 5 related to the July 31th-August 13th heatwave. We add a precision in the text and make the reference to the correct figure.

« As previously mentioned in Section 5,1, SSTs were already abnormally warm before the August 31th to August 13th heatwaves. »

(Section 4.3) in my opinion contains very interesting comments. Consider to enlarge this description, deepening further the phenomenon and recalling it clearly in conclusive remarks.

Consequently to this comment and a similar one from Reviewer 1 we decided to get further insights into the contribution of atmospheric variables by adding further developments. To address this we conducted an attribution analysis based on a modelling approach. The results are presented in the section 4.4 starting on P16, L338.

(174) typo: *persistence Typo corrected

(179) specify that the anomaly you are talking about is of cloud cover

P14, L319-321.

"The mean total cloud cover anomaly over France reaches -17% while the North of France and specifically Brittany have undergone the maximum average anomaly of -37%"

Discussions

(198) typo: *studies Typo corrected.

(246) Not clear what you mean when you say "to prevent the detection of anomalously warm SST" P24, L506 « To anticipate the detection of anomalously warm SSTs »

Comments of the lines 204-206, 200-206 & 213/244

In addition to the newly introduced features that were added to the results section to reflect the sensitivity test, we have also reorganized and rephrased the Discussion/Conclusion section. Specifically, we incorporated the feedback provided by Reviewer 2 and removed all introductory comments to streamline the content.