Dear Reviewer,

We would like to thank you for your remarks and comments, which have helped us to clarify and improve the manuscript. Please find below our answers (marked in bold).

This paper presents an investigation of the trends to the significant wave height based on the combined Copernicus L4 altimeter product comprising seven altimeter missions.

Abstracts should be in the present tense, avoid the use of abbreviations and ideally should not have references. It should succinctly summarise the findings in the paper. Please remove motivational text like "The analysis of global ocean surface waves and of long-term changes is important to climate research".

The abstract was rewritten in the present tense; most abbreviations were suppressed, and the reference was suppressed as you suggested. We removed the initial motivational text. Please find below the revised abstract.

"The analysis of global ocean surface waves and of long-term changes requires accurate time series of waves over several decades. Such time series have previously only been available from model reanalyses or from in situ observations. Now, altimetry provides a long series of observations of significant wave heights (SWHs) in the global ocean. The aim of this study is to analyse the climatology of significant wave heights and extreme significant wave heights derived from remote sensing in the global ocean and their long-term trends from 2002 to 2020 using different statistical approaches as the mean, the 95^{th} percentile and the 100-year return level of SWH. The mean SWH and the 95^{th} percentile of SWH are calculated for two seasons: January, February and March, and July, August and September and for each year. A trend is then estimated using linear regression for each cell in the overall grid. The 100-year return levels are determined by fitting a Generalised Pareto distribution to all exceedances over a high threshold. The trend in 100-year return level is estimated using the transformed-stationary approach, which, to our knowledge, is used for the first time to draw a global map based on altimetry. Predominantly large positive trends over 2002-2020 for both SWH and extreme SWH are mostly found in the southern hemisphere, including the South Atlantic, the Southern Ocean and the southern Indian Ocean, which is consistent with previous studies. In the North Atlantic, SWH has increased poleward of 45°N, corroborating what was concluded in the fifth IPCC Assessment Report, however SWH has also largely decreased equatorward of 45°N in wintertime. The 100-year return levels of SWH have significantly increased in the North Atlantic and in the eastern tropical Pacific, where the cyclone tracks are located. Finally, in this study we find trends of SWH and 95^{th} percentile of SWH over 2002-2020 to be much higher than those indicated in the literature for the period 1985-2018."

The paper is quite well written and is a nice summary of the Copernicus L4 product. I think it is important to acknowledge that although the series represents a high-quality data set of altimeter measurements, it is still very short for EVA. The data set considered by Ribal and Young (2019) was much longer, covering the period 1985-2018. Would it be possible to combine the two?

As you noted, a series of 19 years, even of high quality, is still very short for EVA. This is why we also considered merging the two series from the start of our

study and we contacted the two authors. Unfortunately, it may not be possible to combine the two series as they are calculated differently.

In the discussion we emphasize the differences that appear between the time series resulting from the multi-mission product (which is not consistent over time, merging from 1 to 4 satellites at a time) and the time-series from a product combining only two satellites. The differences appear even more when we consider the extreme values of SWH.

Combining the two time series could add even more heterogeneities in the time series and impact the resulting values. This is why we restricted ourselves to the 19-year-old series.

The claim that "The EVA allowed us to study 100-year SWH with only a 19-year long altimetric time series. All the values of SWH exceeding the 95th percentile and separated by at least 72h were selected according to the peaks-over-threshold method" grates on me. It is not so that the transformation to a trend-free series in itself will get you off the hook. The period 2002-2018 could still be exceptional compared to a much longer series if slowly changing processes are at play, or by pure coincidence. I would like to see 95% confidence estimates or credibility intervals (if a Bayesian approach is taken). Please include a more detailed description of the transformed stationary method as I'm sure the casual reader will not be too disturbed by a couple of equations. More importantly, I would like to see a discussion of the weaknesses of this method, and in particular, re my previous comment, what are your concerns when applying it to such a short series?

A 95% confidence interval was estimated for the 100-year return level of SWH (displayed Fig 3a). The differences between the 100-year return level and the corresponding lower bound and upper bound were displayed separately Fig 3.c and Fig 3.d. The largest confidence intervals are found in the typhoon region where the greater return levels were found.

Please find the revised figure with the confidence estimation in the supplements.

We included a more detailed description of the transformed stationary method. Please find below the revised paragraph.

"All the values of SWH exceeding the 95th percentile and separated by at least 72h were selected according to the peaks-over-threshold method. A Generalised Pareto Distribution (GPD) could then be fitted to the exceedances (see equation below). The return levels associated with the 100-year return period were estimated from this GPD.

$$F(x) = 1 - [1 + \frac{\xi(x - \mu)}{\sigma}]^{-\frac{1}{\xi}}$$

With μ , ξ and σ are the location, shape and scale parameters.

The EVA has a major disadvantage in that it usually requires the time series to be stationary. The transformed-stationary approach overcomes this issue by transforming the non-stationary altimetric time series $y(t)$ into a stationary one $x(t)$ through standardization (Eq.1). The EVA is then applied to $x(t)$, and the location μ_x and scale σ_x parameters of the GPD are estimated by maximizing the likelihood function. The reverse transformation (Eq. 2, 3) is finally used to recover the time-varying parameters $\mu_y(t)$ and $\sigma_y(t)$ associated with $y(t)$, enabling us to obtain the non-stationary extreme SWH distribution and to assess its trend. The transformation from y(t) to **x(t) and the reverse transformation of the shape, location and scale parameters associated with the non-stationary series** are given by:

$$x(t) = \frac{y(t) - T_y(t)}{S_y(t)} \quad (1)$$

$$\mu_y(t) = S_y(t)\mu_x + T_y(t) \quad (2)$$

$$\sigma_y(t) = S_y(t)\sigma_x \quad (3)$$

$$\xi_y = \xi_x \quad (4)$$

where $T_y(t)$ and $S_y(t)$ are the trend and the standard deviation of $y(t)$, and μ_x, ξ_x and σ_x are the parameters associated with the stationary series which are not dependent on time."

As you suggested we added a small discussion addressing your concerns, in particular on the issue of applying EVA to such a short series as you explained. Find below that corresponding discussion.

"Finally, the EVA gave us a good initial estimate of SWH extremes based on altimetry measurements, in line with the literature. However, these results must be treated with caution, as the altimeter series is very short (less than twenty years), so few measurements could be selected to estimate the GPD parameters. Similarly, the measurement period is not necessarily representative of a longer time series. This ultimately leads to large confidence intervals for the extreme values estimated. In addition, the transformed-stationary approach used assumes that the GPD shape parameter is constant, which is valid in most cases but may prove false in some."

I think the paper may be acceptable given a major revision which addresses these concerns.

Specific (minor) comments:

Thank you for your careful proofreading.

Abstract: The first line, "The analysis of global ocean and coastal applications. Indeed, waves contribute to flooding, coastal erosion, extreme sea level events and ocean circulation. They also play a role in air-sea and sea-ice interactions." This is better suited for the introduction.

The first line of the abstract was suppressed as it was redundant with the introduction.

Abstract: "Specify in the abstract that significant wave height is meant when stating "climatology of wave heights and extreme wave heights"

The correction has been made.

L 73: hasn't -> has not

The correction has been made.

L 75: (Herbasch et al., 2023) should be Hersbach et al (2020). This error is repeated elsewhere.
The correction has been made.

L 158: "For comparison, the same figures were produced using ERA5 and WAVERYS data." Where?

We decided not to show the figures produced using ERA5 and WAVERYS as they were in line with the existing literature and did not add any new information. The mention "(not shown)" was added after this sentence.

However, you may find complementary figures displayed for WAVERYS in supplements.

You shall find later the revised manuscript.

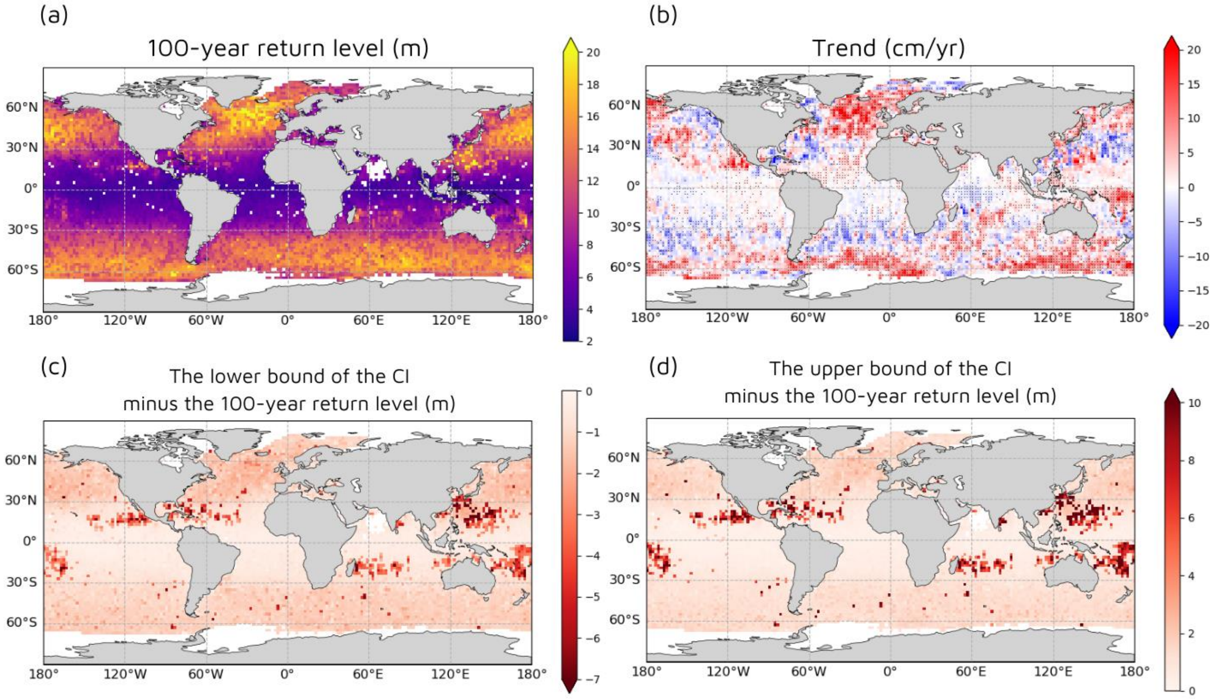
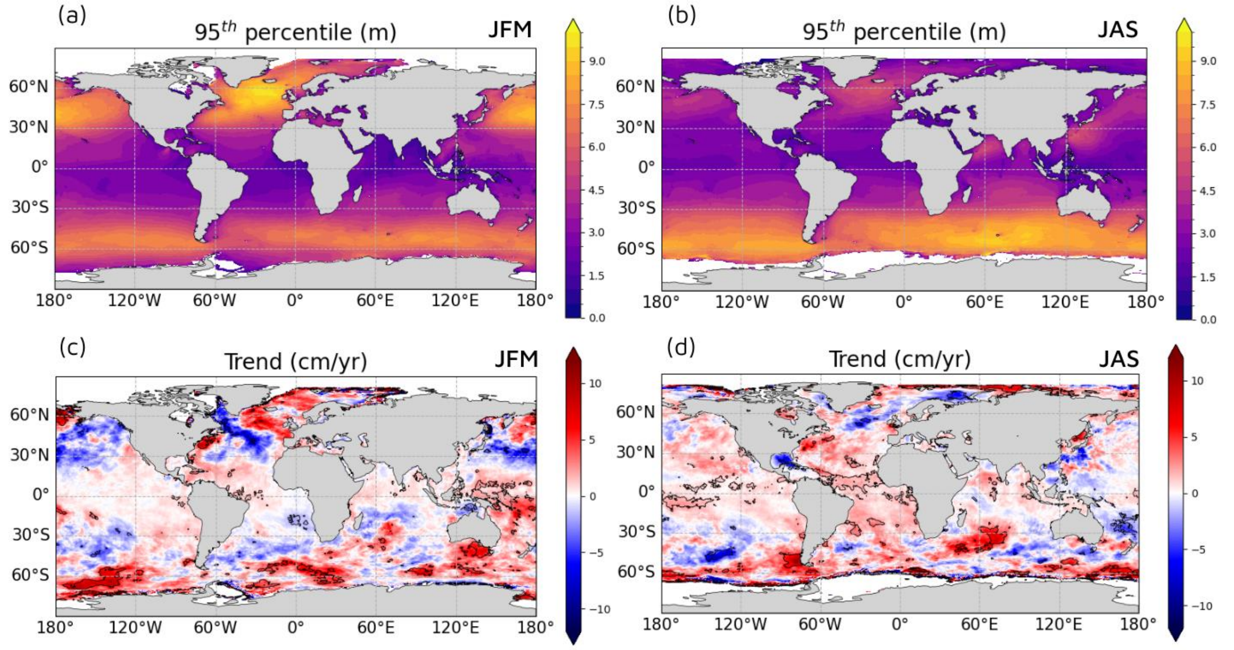
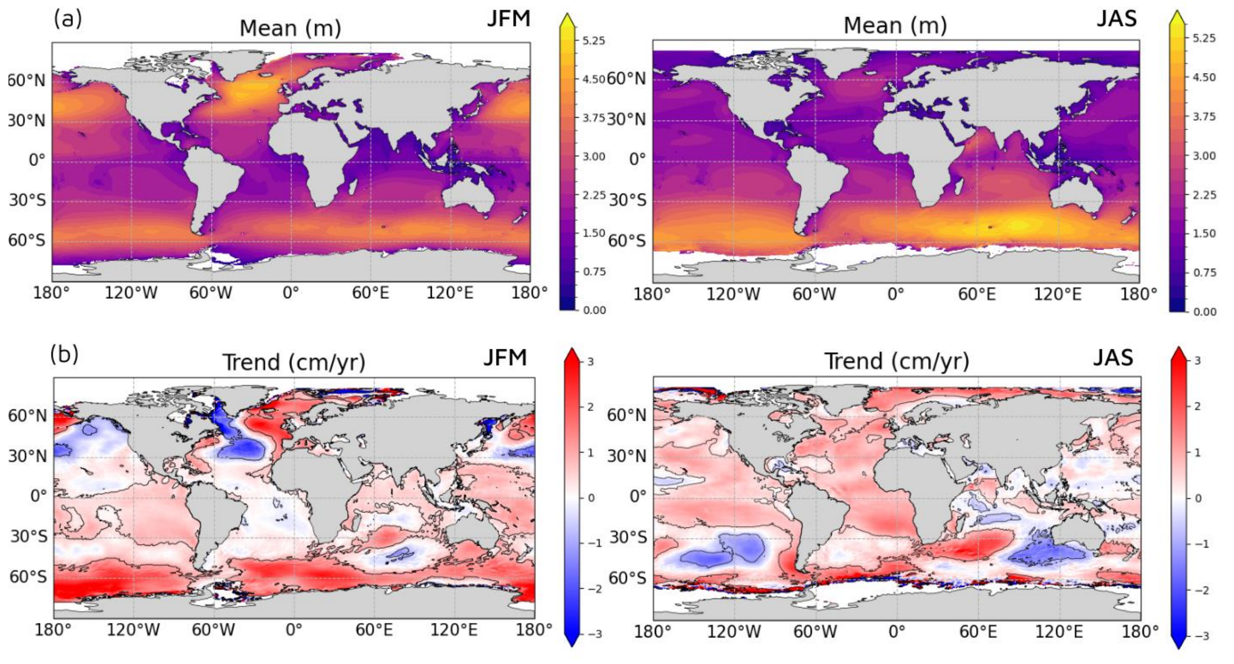


Figure 3 (revised): Average 100-year return levels and their trends over 2005-2018 from L4 altimetric time series (product reference 1) using the non-seasonal transformed stationary approach. Areas with trend statistically significant at the 95% level are indicated by grey dots. White pixels correspond to grid cells that do not meet the requirements for calculating return levels, such as the minimum number of points selected with the Peaks-over-threshold method. (c), (d) Difference between the 100-year return level and the lower and upper bounds of the 95% confidence interval.



Supplement 1: 95th SWH percentile (a, b) climatology (2002-2020) and (c/d) annual trend (2002-2020) for both JFM (left column) and JAS (right column) from WAVERYS. Areas with anomaly above 1.5 times the interannual variability are outlined in black. Areas with trend statistically significant at the 95% level are outlined in black.



Supplement 2: SWH (a, b) climatology (2002-2020) and (c, d) annual trend (2002-2020), for both JFM (left column) and JAS (right column) from WAVERYS. Areas with anomaly above 1.5 times the interannual variability are outlined in black. Areas with trend statistically significant at the 95% level are outlined in black.