Reply to Reviewers Comment: Reviewer 1

Comments on 'Extension of high temporal resolution sea level time series at Socoa (Saint Jean-de-Luz, France) back to 1875' by Khan et al. (ESSD)

Text colour codes: Review (black), Reply (blue)

Comment: I have no major objection to this paper. It is clear that a large amount of work has been done to provide the new data set from the Socoa tide gauge. However, all this work is rather let down by providing a draft that is full of minor English-type oddities which detract from reading it. The co-authors should really have helped the lead author with the writing. Therefore, I have done my best to correct things using track changes included in the attached pdf. I have also made some comments in capitals in the pdf. I will also send these directly to the lead author.

Reply: We sincerely appreciate your thorough review, and we apologize for the English-type oddities that have affected the readability of the manuscript. In the revised manuscript we have considered the suggestions you have provided through track-change, as well as in comments.

As the revised manuscript went through major structural changes, we refrain from quoting all the changes here and provide the track-change version of the manuscript.

Other comments, both provided in the review and in the manuscript is addressed below.

Comment: Otherwise, I don't think all the detail of section 3.2.1 is needed. There is an excellent Wikipedia page for example which describes the equation of time. And also you can quote for example:

Hughes, D. W., Yallop, B. D., and Hohenkerk, C. Y.: The equation of time, Mon. Not. R. Astron. Soc., 238, 1529–1535, https://doi.org/10.1093/mnras/238.4.1529, 1989.

But I agree there needs to be something to show the differences in timing in this section. You should make it clear that MST at this point is local mean time.

Reply: We have substantially reduced the section 3.2.1. The revised section now reads as follows –

From 1875 to 1893, the ledger records are in local AST. Afterwards, until 1920 the records are in local MST. We have first converted the AST to MST by adding their difference over the year, known as equation of time, E, to AST (Hughes et al. 1989, Müller 1995). Here E is computed using the formulation published by Bureau Des Longitudes (2011):

$$
\begin{aligned}
E \quad &= 7.362 \times sin(M) - 0.144 \times cos(M) + 8.955 \times sin(2 \times M) + 4.302 \times cos(2 \times M) \\
&+0.288 \times sin(3 \times M) + 0.133 \times cos(3 \times M) + 0.131 \times sin(4 \times M) + 0.167 \times cos(4 \times M) \\
&+0.009 \times sin(5 \times M) + 0.011 \times cos(5 \times M) + 0.001 \times sin(6 \times M) + 0.006 \times cos(6 \times M) \\
&-0.00258 \times t \times sin(2 \times M) + 0.00533 \times t \times cos(2 \times M)
\end{aligned}
$$

with, t is the time difference to 2000-01-01 00:00:00 (in year, negative for earlier years), and $M = 6.240060 + 6.283019552 \times t$ (in radians). Although the equation given by the Bureau Des Longitudes (2011) is fitted for 1900-2100, We have used the same equation for the period late 1800, which induces only minor errors (order of seconds). To convert from MST to UTC, a correction of 4 minutes per degree of longitude difference between Socoa and Greenwich (zero-longitude) was applied. This amounts to 404 seconds to be added to the MST recorded in Socoa to get the time in UTC.

Comment: In sections 3 and 4.1, you can check for bad times or dates easily by comparison to tidal predictions that are based on a modern record you can trust. Errors of an hour (say) are easy to spot in the resulting tidal residuals. I suspect you must have done that but it is not clear – you just say a lot of tests were made. General reference could be given in this section to the Pugh and Woodworth 2014 book.

Reply: We have indeed used tidal prediction to identify errors, which is discussed in 4.2 Quality control and corrections. We have revised the concerned paragraph to further clarify the process and added the reference to Pugh and Woodworth (2014). The revised paragraph now reads as follows –

"Once the obvious height corrections were applied, a tidal harmonic analysis based on validated data was performed, and the recorded water levels were compared with the predicted water levels visually week-by-week (Pugh and Woodworth 2014). This comparison process was useful to identify days with a wrong date (switched with the previous or the following curve in the chart) during transcription, as well as incorrect high and low tides with respect to the tide gauge journal (Section 2.5). The tide gauge journal was checked, and corrections were made if necessary. The high and low tide corrections were typically between 10 and 20 cm."

Comment: I am not sure that all the sub-figures are explicitly referred to in the text as they should be – the lead author can check.

Reply: We have noted (and verified) your feedback that not all sub-figures were explicitly referred to in the text. In the revised version of the manuscript, we rechecked that all sub-figures are explicitly referenced.

Followings are the comments and reply from the manuscript -

L102: Chazallon tide gauge was operational until 1920 when most tide gauges around the French coast were discontinued – why?

Reply: It appears to be an administrative decision to not continue tide gauge operation by Service Hyrdrographique de la Marine (SHM) (Pouvreau 2008). However, in the context of this paper, we refrained from attribute any cause to this discontinuity in operation.

L157: Which one?

The correspondence is mainly between the ministry of public works (le Ministre des Travaux Publics), and the ministry of marine and colonies (Le Ministre de la Marine et des Colonies).

We have now revised the sentence to incorporate this information -

“During the rescue process administrative documents were found in the archive in which the Socoa tide gauge was mentioned. These documents include tide gauge journals for the Chazallon period containing log of tide gauge operations, the correspondence with the ministry (ministry of public works, and ministry of marine and colonies), the engineering and hydrographic survey reports, the quotes for works, drawings etc. The hydrographic survey reports were of particular interest to assess the datum continuity of the tide gauge records (Section 3.3). All the documents form an ancillary part of the available metadata and are provided as supplementary files to the dataset.”

L257: If by “only” we meant all year?

Reply: Yes. We have revised the line to clarify that –

“Post WW2, France switched to using GMT+1 throughout the year on 18 November 1945.”

L282: What does this brackets mean?

Reply: The text inside the brackets were reference to corresponding archive documents. We have revised the line to make it clear.

“The first levelling related to the tide gauge was performed in 1873, which established the ZH to be 20cm below ZP, and 7.50m below the dike level. This information was reported in regional department archive AD64- Béarn (Document id: AD64-4S 33) and SHD Vincennes (Document id: DD2-2053). From another published document (Annuaire de marées de 1900, Archive Shom), ZH level was reported to be -1.903m relative to the first national levelling and the associated datum of France established by Bourdaloue (NGF-Bourdaloue) in 1857-1864.”

L290: Unclear last bit.

Reply: We have revised the sentence for clarity –

"Following the investigation in 1963, the ZH was maintained at -2.17m NGF Lallemand, and the ZP was measured to be 24cm above the ZH."

Figure 4: Is the entrance the same as the ancient wooden door? Passage may be a better word than channel?

Reply: Yes, the entrance is the same as the ancient wooden door. We have revised the caption as follows –

"Figure 1: (a) Schematic of the current stilling well. (b) View from above inside the stilling well. (c) Entrance to the stilling well (at about 1m above water level). (d) From the entrance, inside the passage to the stilling well. Images collected during the fieldwork in 2017 (Poirier et al. 2017)."

Figure 5: "Phase" on the figure and the caption should be "phase lag".

Reply: "Phase" in figure label and caption is now updated to "Phase lag".

L414: Is this a 1-sigma uncertainty?

Reply: Yes, this is 1-sigma uncertainty, computed as the square-root of the diagonal terms in the variance-covariance matrix. This is now clarified in the text in the beginning of the paragraph –

"From the hourly time series for Brest and Socoa, we have computed yearly mean using the yearly PSMSL rules (at least 11 monthly means for a year) and estimated the trends estimate and associated 1-sigma uncertainty (Table 2)."

Table 2: Are these using annual mean value?

Reply: Yes, we are using annual mean value, computed using PSMSL rule. This is clarified in the manuscript as follows –

"From the hourly time series for Brest and Socoa, we have computed yearly mean using the yearly PSMSL rules (at least 11 monthly means for a year) and estimated the trends estimate and associated 1-sigma uncertainty (Table 2)."

Reply to Reviewers Comment: Reviewer 2

Comments on 'Extension of high temporal resolution sea level time series at Socoa (Saint Jean-de-Luz, France) back to 1875'

Text colour codes: Review (black), Reply (blue)

Abstract

This paper presents the extension of sea level data at Socoa (France) back to 1875. New sea level data come from historic ledgers (i.e. record books with handwritten hourly sea levels) and charts (i.e. paper maregrams from old mechanical tide gauges). Both these supports were recovered from national and local archives, through extensive research. Important efforts were undertaken to reconstruct a continuous and consistent time series. Documents were scanned and digitalized, either manually or semi-automatically. Time data were converted to UTC time system. Successive vertical datum were investigated, to check that there was no jump between historic datasets vertical reference. An intensive quality control allowed to correct the data when needed (e.g. height or time correction). In addition, the sea level data were flagged when doubtful, e.g. during periods of slowing down of the clock, during periods of siltation of the stilling well (1956-1963 and late 1990's) or when the floating device seemed to possible malfunction. The final hourly sea level dataset consists of ??? [not mentioned in the paper ?] years of data (instead of 54 years (not mentioned in the paper?) at present), spanning from 1875 to 2021. This new historic dataset will be useful for sea level climate studies, investigating variability, trends and long-term changes in mean sea level, tide and/or extreme surges.

General comments

This work is an important effort of data archaeology, which is essential for climate studies, and we strongly recommend to publish it. The data were not only recovered, but also corrected and flagged when wrong or doubtful (which is a very time-consuming task). The paper is well structured and generally quite easy to follow. However, some parts are not always very clear and the general writing could be improved (see below in detailed comments). Some arguments could also be added to demonstrate in a stronger way the importance of data archaeology, see for example Talke and Jay (2017). Another general comment: the results of this study being the sea level datasets, the raw and final datasets should be described more precisely in the Data availability section (or somewhere else in the paper), and in the given repository (see below in detailed comments). For example, the temporal resolution (5', 15' or 1h) of each dataset (raw data, digitized data, final dataset) is not always very clear (see details in specific comments). Finally, the perspectives could be further developed, detailing for example how many stations could be recovered along the French coasts and/or how many station-years are available in archives. This could potentially motivate future investigations.

Reply: Thank you for your thorough review of our paper on the extension of sea level data at Socoa (France) back to 1875. We appreciate your positive feedback and the recommendation to publish our work after revision. We have carefully considered your comments and suggestions, and we have address them as follows:

- Writing and organization: Several changes has been suggested in the "Specific comments" regarding the organization of certain segments of the manuscript. We agree that these changes will improve the readability. We have carefully reviewed the entire manuscript and make necessary revisions to improve the writing clarity and overall structure. We acknowledge that the introduction and the conclusions can benefit for further development, the subsection of the time conversion can be reduced, and trend analysis can be further developed. These changes are now incorporated in the manuscript and provided in track-change mode. The changes are also detailed further in the reply to specific comments. We have incorporated the references that you suggested regarding the importance of data archaeology (e.g., Talke and jay 2017).

- Description of data availability: We agree that the "Description of the data availability" does not clearly indicates the various timeseries that we produced. We have improved the description of data availability by clarifying the associated files for raw and final dataset, incorporating a detailed header on the final dataset, and expanding the readme in the data repository to explain the content of the files.
- Specific comments: We have revised current manuscript based on the other suggestions provided in "Specific comments". A point-by-point reply to the Specific comments are given below.

Specific comments.

- line 9 "ledgers and charts" we suggest to precise somewhere what we are talking about, describing ledgers (record books with handwritten hourly sea levels) and charts (paper marigrams from old mechanical tide gauge)

Reply: We have revised the abstract for clarity. The revised abstract now incorporates this precision -

"We conducted a comprehensive research of national and local archives to catalogue water level records stored in ledgers (handwritten record books) and charts (marigrams from mechanical float gauge), along with other associated documents (metadata)."

and the terms are further elaborated in Section 2.1 :

"Like most of the float gauges, the displacement of the float is reduced through a mechanical system and the resulting sea level variation is recorded on a paper chart controlled by a clock (IOC 1985)."

…

Two types of historical water level records have been found for the Chazallon tide gauge period – 1) a subset of charts, 2) ledgers. The ledgers are 32x49cm paper documents containing transcriptions of water levels obtained by inspection of the charts by an operator."

- line 12 "at hourly (for ledgers) to 5-minutes (for charts) sampling" it is not clear what is the temporal resolution of the raw dataset/final dataset, once corrected and flagged. This could be clarified in the paper, for example Table 1 (with 2 columns, sampling of raw data/sampling of the final data), or in the Data availability section, as the choice is made further to digitize only hourly values.

Reply: Thanks for pointing this out. The corresponding line in the revised abstract now reads as follows –

"The Socoa time series has been extended back to 1875, with more than 58 station-year of additional data, using this large set of rescued documents. The final time series has hourly sampling, while the raw dataset has finer sampling frequency up to 5 minutes."

- line 13 "Analysis of the precise levelling information reveals that the datum of the tide gauge site has been stable", it should be mentioned that were are talking about vertical datum continuity, to avoid any confusion with the vertical stability of the ground.

Reply: We have revised the line as following to avoid any confusion.

"By analysing precise levelling information, we assessed the continuity of the vertical datum. We also compared the new century-long time series to nearby tide gauge data to ensure its datum consistency."

- line 15 the data flag could be mentioned in the abstract: despite "siltation is found to be a recurrent problem of the stilling well", such periods were successfully identified, and corresponding data were flagged as doubtful

Reply: Following your suggestion, have rewritten the statement in line 15 as following –

"While the overall quality of the time series is generally good, siltation of the stilling well has occasionally affected certain parts of the record. We have successfully identified these impacted periods and flagged the corresponding data as doubtful."

- line 29 "data archaeology" (without capital letter), possible additional reference to:

UNESCO/IOC 2020. Workshop on Sea Level Data Archaeology, Paris, France, 10-12 March 2020. Paris, UNESCO, IOC Workshop Reports, 287, 39 pp. English. (IOC/2020/WR/287) https://unesdoc.unesco.org/ark:/48223/pf0000373327

Reply: "Data archaeology" is changed to "data archaeology" in the revised manuscript. We have added the suggested reference to the previous line as following –

A subset of these long time series has become accessible to the scientific community through discovery, digitization, and reconstruction of new or extended sea level time series from archival records – a procedure which is known as sea level data archaeology (Woodworth 1999, UNESCO/IOC 2020).

- line 46: "GMSL rise also raises questions regarding associated long-term changes in tide" the beginning of the sentence (GMSL rise) suggests that GMSL rise is the main driver for changes in tide, but it is not the only one, and the following examples (Pouvreau et al., 2006; Colosi and Munk, 2008) do not really conclude that MSL rise is the driver of observed changes in tide: Pouvreau et al. (2006) did not find any significant trend in M2, but rather an oscillation of amplitude 1.1 cm and period 141 years, which remains unexplained; Colosi and Munk (2006) attributed changes at Honolulu to a 28◦ rotation of the internal tide vector in response to ocean warming. Other papers discuss more directly the impact of MSL rise on tide (e.g. Pickering et al., 2012, Idier et al., 2017; Schindelegger et al., 2018). We rather suggest a general introduction to this paragraph (as for ESLs, see next paragraph), e.g. "Long-term sea level datasets are needed to investigate changes in tide…".

Reply: Thank you for your suggestions regarding this paragraph. We agree that for the message we are trying to convey, e.g., evaluation of the impact of long-term sea level rise and associated changes in tide, this paragraph is not well-suited. We revised this paragraph accordingly by considering your suggested references (this comment, and the following two), and the paragraph line. Additionally, we also revise the discussion to better communicate the necessity of long records for studying the changes in tide.

The new paragraph on tide now reads as follows –

"In long term, tide has also been through changes – which requires high-frequency (typically hourly or less) data to analyse (Woodworth, 2010b, Haigh et al. 2020). During the first half of the 19th century automatic mechanical tide gauges started appearing, paving the way for systematic continuous measurements of water levels at high frequency (Wöppelmann et al 2006b). Taking advantage of the archaeology of such high-frequency long-term sea level records, Pouvreau et al. (2006) analysed the secular trend in the evolution of M2 (the main lunar semidiurnal tide) at Brest. They reported no significant trend but long-period oscillations with 141 years period. Recent research on the tidal change shows that the long-term changes are not linear (Ray and Talke 2019). Pan and Lv (2021) reported a quasi 60-year oscillation in the global tide from a global set of long high-resolution sea level time series. These non-linear changes are sometimes with break points around late 19th century (Pineau-Guillou et al. 2021). These contemporary results further highlight the necessity for long high frequency sea level time series for studying the evolution of tide."

- line 49: "Pouvreau et al. (2008)" should be Pouvreau et al. (2006) or Pouvreau (2008)?

Reply: That's correct, it is corrected to Pouvreau et al. (2006).

- more generally for this paragraph on tide changes, some research works show that changes are not linear but rather with break points, which is a strong argument to go back to the XIXth century when possible. This could be discussed further in the introduction. See for example the values of M2 at Eastport, Portland, New-York in the 1860s, which are not consistent with the large increase observed in the XXth century (Talke et al., 2014; Ray and Talke, 2019; and Fig 2b in Pineau-Guillou et al., 2021).

Reply: This comment is incorporated in the comment above.

- more generally, for the paragraph on extreme sea levels, it is well known that extremes vary at first order with MSL. Letetrel et al. (2010) is mentioned here for Marseille, but many others demonstrated it at larger scale, e.g. Menendez and Woodworth (2010), Wahl and Chambers (2015), Marcos and Woodworth (2017). The same way, IPCC (2021) reported that sea level rise is the first driver of changes in extremes sea levels. More interesting, once this contribution is removed, storm surges display large strong interannual and multidecadal variability, and it is challenging to separate the long-term trend from the natural variability (i.e. climate variability in link for example with the North Atlantic Oscillation). In other words, trends detected on a short period could be the signature of the multidecadal variability rather than a long-term trend. These are strong arguments to go back to the XIXth century in sea level data, and could also be discussed further in the introduction. Another argument is that for extreme value analysis, longer times series means uncertainties reduction, which means a better risk assessment.

Reply: Thank you for the suggestions on our paragraph on the ESL, and discussions on the necessity for long-term sea level records for better understanding of the ESL drivers. We incorporate your suggested discussion into the introduction in the revised manuscript. The paragraph now reads as follows –

"High frequency past tide gauge time series are also very useful for the analysis of extreme sea level (ESL), which is a major societal concern due to ongoing sea level rise (Oppenheimer et al. 2019). Dedicated studies have been conducted to understand the dynamics and the drivers of ESL at local (Letetrel et al. 2010, Talke et al. 2014, Talke et al. 2018), regional (Wahl and Chambers 2015, Marcos et al. 2015, Marcos and Woodworth 2017), and global scales (Menéndez and Woodworth 2010). Among various factors, sea level rise is shown to be the first order driver of the observed ESL change in most of the coastline (Menéndez and Woodworth 2010) and projected to be the major factor for future ESL changes globally (Muis et al. 2016, Fox-Kemper et al. 2021). However, ESL variability also varies regionally depending on the local and regional processes (Menéndez and Woodworth 2010). Long high-resolution sea-level time series are particularly interesting to unravel the contribution from mean sea level change (Letetrel et al. 2010), seasonal and decadal variability (Menéndez and Woodworth 2010, Marcos et al. 2015), and local changes (Talke et al. 2014, Talke et al. 2018). Indeed, it is concluded with high confidence (meaning high agreement and robust evidence in the available literature) that consideration of localized storm surge processes is essential to monitor the trend in ESL (Oppenheimer et al. 2019). Such monitoring requires reliable long high-resolution observations. A long time series provides an additional benefit by reducing the uncertainty of ESL analysis (Coles 2001), which equates to better flood risk assessment.

Global high-resolution dataset, like GESLA (Global Extreme Sea Level Analysis; Woodworth 2016, Haigh et al. 2020) has been instrumental for the current global, as well as regional scale studies on ESL. Such a dataset also allowed global and regional analysis of tide (Piccioni et al. 2019), the non-linearity of tide-surge interaction (Arns et al. 2020), as well as data driven modelling of surge (Tadesse et al. 2020). Yet, most of the stations in GESLA have a time series less than 50-year long. As demonstrated by previous studies (Wöppelmann et al. 2014, Talke et al. 2014, 2018, Talke and Jay 2017), data archaeology offers a solution to this scarcity of long-term data by tapping into the potential of rescuing numerous instrumental records worldwide (Bradshaw et al. 2015)."

- line 58 "They illustrate how long-term sea level can help to separate the relative contribution of climate, and local changes." I would rather say that they separated the contribution of the natural variability (climate variability linked with the North Atlantic Oscillation) with a long-term trend (which remains unexplained).

Reply: This paragraph has now been re-written (c.f. previous comment). In the revised manuscript we have dropped this statement for the sake of focusing on the need for long-term high-resolution observation data.

- lines 73-74: the temporal resolution (hourly?) of present Socoa record could be added

Reply: The temporal resolution of the dataset is mostly hourly, with high-resolution (1min) data available for the recent period (from 2011). We have revised the corresponding line to following –

"... (Arnoux et al. 2021). The available data is hourly before 2011, and afterwards both the high-frequency (1min) and the hourly data is available."

- line 91: move "rescued" before "in this study", and this unclear sentence should be rephrased

Reply: We have rephrased this line into :

"In the following sub-sections, we provide descriptions of each instrumentation period, along with detailed information about the data and the metadata."

- lines 102-104 this paragraph could be moved at the end of previous paragraph (line 99), which also describes the tide gauge. Next paragraph rather refers to water level records.

Reply: We have updated this paragraph to follow the paragraph in line 98 (of original manuscript) as suggested in the revised manuscript. The updated paragraph now appears as –

"...the recording device was installed. The Chazallon tide gauge was operational ... (Shom, https://www.shom.fr/)."

- line 106: what is the difference between Chazallon/Brillie tide gauge, is it the same mechanism?

Reply: Yes, they have similar mechanisms, but different implementations (Figure 2c,d).

- line 107: “large type model”, are there other models?

Reply: There are two models, large type, and small type – as described in Roubertou (1955). The main difference is in the size of the paper, 50cm and 20cm height for large and small type gauges respectively. Consequently, by design large type model allows a larger reduction ratio (water level range to paper height) compared to the small type.

- line 120-126: this refers to a tide gauge from 1942-1944, whereas the paragraph is “1950 to 2004” which is confusing. This could be moved to another subsection. It could also be rewritten more clearly, and it could be mentioned explicitly that these data are finally considered (though the tide gauge location is different).

Reply: Since no other documentation was found regarding this tide gauge, we merged this as an additional information to 1950-2004 period. We agree that this action made the text a bit confusing. To rectify it, following your suggestion, we have inserted a new short sub-section at 2.2 describing this data segment only. The text reads as follows –

“2.2 Temporary tide gauge during World War II period: (1942 to 1944)

In the currently available archives, e.g., Shom, or Permanent Service for Mean Sea Level (PSMSL, Holgate et al. 2013), there are data available during the World War II (WWII) period – from November 1942 to May 1944. While 44 charts were found in the Shom archive at Brest covering this period, the, rescued metadata do not report any tide gauge operating at Socoa. After inspection, we found a different paper size of these charts compared to Brillie or Chazallon, which indicates that it was a different tide gauge. In addition, the paper charts bear German markings. Local historians confirm that it was indeed another tide gauge, installed by the Germans, on the other side of the Socoa bay. The data during WWII appears to be consistent with the rest of the record, as confirmed by a tidal analysis. No record was found between this German tide gauge (1944) and the Brillie tide gauge (1950).”

- line 125: “the other side of the Socoa bay”, location on Fig. 1?

Reply: This information is based on the account of local historians, and no accurate location is known. Hence, we refrained from showing the location in Fig. 1.

- lines 127-151: what is the temporal resolution of modern instrumentation?

Reply: The modern instrumentation currently has a sampling period of 1min, with multiple data flows (not currently mentioned in the manuscript). We have revised the section to incorporate the information regarding the current temporal resolution –

“This tide gauge is currently maintained by Shom. Its sea level data and metadata are available at the Shom data portal (https://data.shom.fr) in both raw and post-processed quality-controlled form. Raw data is sampled at 1-minute. Data from the tide gauge is accessible through the Global Telecommunication System (GTS) network, which enables a real-time data flow."

- Table 1: we suggest a separate column for the "Sampling" and "Time System"

- Table 1: "Sampling" column, are we talking about the sampling of raw data? Digitized data? Final dataset? This is not clear in the text.

- Table 1: What means "Highres and hourly" mentioned in column 1 since 2011, whereas the corresponding "Sampling" is 1 hour?

Reply: The objective of the Table 1 is to list the various instrumentation periods, data medium, and temporal sampling of the raw observation. We have updated Table 1 in the revised manuscript with the following modifications :

1. Sampling is divided into two separate header – "Source" and "Digitized" to indicate the sampling in the source and the digitized sampling.
2. Time system is now renamed to Source time system.
3. The table caption is updated to "Overview of the instrumentation periods, original data storage medium, sampling period of the source and digitized data, and time system of the source observations.". We have also updated the paragraph at line 150 to clarify the column names, and their relation to the data analysed in the paper.
4. The sampling of charts is updated to 'continuous' to reflect that the temporal resolution of the recorded data.
5. The last two rows are updated to reflect the availability of the high-res data (available since 2011).

- Fig. 2 (b): Chazallon, Brillie and modern instrumentation periods could be mentioned on the figure (suggestion)

Reply: Thank you for your suggestion. We have now added this information into Fig. 2(b).

- lines 166-216: the structure of these two paragraphs is not clear. "3.1.1 Ledgers" rather introduces the Chazallon period (ledgers and charts description, even if charts are not used) and "3.1.2 Charts" introduces the Brillie charts. Please restructure moving the charts description from 3.1.1 to 3.1.2, or change the titles accordingly.

Reply: After carefully considering this suggestion, we have removed the sub-sub-sections titles - '3.1.1 Ledgers' and '3.1.2 Charts', and merged the text under one subtitle '3.1 Scanning and digitization'. This change simplifies the section-structure and makes the texts more aligned with the title.

- line 176 "hourly intervals" for ledgers (to speed up the digitization process), whereas as 15 mn is the sampling in Table 1, again please clarify the temporal resolution of each dataset (see previous comment)

Reply: We recognize the confusion here. We have updated Table 1 as described above to incorporate more segmented information on the temporal resolution on the source and the temporal resolution after digitization.

- line 184: the whole recovered archive "is scanned" could be "was of sufficient quality to be scanned", which was not the case for Chazallon-era charts.

Reply: We have revised the line as follows –

"Unlike the early Chazallon-era, the whole recovered archive of the charts covering 1942-2004 period was scanned (with a photo-scanner) and rescued."

- line 187: "for applying corrections, where appropriate" it is not clear here which corrections are we talking about

Reply: We recognize that the statement is not clear here. Essentially, the metadata were used to properly reference the time of the charts during the digitization process, and to correct deviation related to clocks. L187 is simplified into the following –

"Most of these charts were accompanied by check sheets. These documents contain relevant information on time and water level at the time of replacing the chart paper. The available check sheets were converted into digital form by a photo camera and later used as metadata for identifying problems, especially related to the slowing down of the clock (See Section 4.2)."

- line 194: "several categories" could be detailed as an introduction of the paragraph, for example "3 categories depending on their conditions (good, mildly or strongly damaged from mould, faded)"

Reply: We have updated the line with the following -

"During the scanning phase, the charts were visually sorted into 3 categories depending on their conditions (good, mildly or strongly damaged from mould, and faded).

- line 210: "the overall process was time-consuming", yes, and this could even be a separate paragraph to underline this aspect (suggestion)

Reply: We have revised and restructured the whole section to better illustrate the process and indicate the challenges. For brevity, the revised section is not quoted below, but only the major changes are summarized –

1. We have broken down long-paragraphs into several small paragraphs for clarity.
2. We have moved the paragraph on categorization of the charts to top.
3. The application of NENIEAU is moved after the categorization is discussed.
4. The paragraph on the chosen time interval is now moved after the paragraph discussing the processing of various categories of charts.
5. The last paragraph is now dedicated to the time-consuming nature of the digitization process.

- lines 227-246: this paragraph on time conversion is quite long and not very concise, it could be rewritten in a simpler way. The equation of time E(t) gives the time difference between Apparent and Mean Solar Time, it can be expressed as a function of (M,t), with M=6.240060 + 6.283019552t. We consider the formulation of the Bureau des Longitudes (2011) for E(t), despite it is applied for 1900-2100.

- line 246 “minor errors”, which order of magnitude?

- line 254: no capital letter at “typically”

- for this section on time conversion, it should be clearly mentioned at the beginning of the section that the objective is to convert the time in UTC (if correct)

Reply: Thank you for your suggestions. The other reviewer also expressed a similar opinion about this section being too long. We have revised the section as follows –

“From 1875 to 1893, the ledger records are in local AST. Afterwards, until 1920 the records are in local MST. We have first converted the AST to MST by adding their difference over the year, known as equation of time, E, to AST (Hughes et al. 1989, Müller 1995). Here E is computed using the formulation published by Bureau Des Longitudes (2011):

$$\begin{aligned} E \quad &= 7.362 \times sin(M) - 0.144 \times cos(M) + 8.955 \times sin(2 \times M) + 4.302 \times cos(2 \times M) \\ &+0.288 \times sin(3 \times M) + 0.133 \times cos(3 \times M) + 0.131 \times sin(4 \times M) + 0.167 \times cos(4 \times M) \\ &+0.009 \times sin(5 \times M) + 0.011 \times cos(5 \times M) + 0.001 \times sin(6 \times M) + 0.006 \times cos(6 \times M) \\ &-0.00258 \times t \times sin(2 \times M) + 0.00533 \times t \times cos(2 \times M) \end{aligned}$$

with, t is the time difference to 2000-01-01 00:00:00 (in year, negative for earlier years), and $M = 6.240060 + 6.283019552 \times t$ (in radians). Although the equation given by the Bureau Des Longitudes (2011) is fitted for 1900-2100, We have used the same equation for the period late 1800, which induces only minor errors (order of seconds). To convert from MST to UTC, a correction of 4 minutes per degree of longitude difference between Socoa and Greenwich (zero-longitude) was applied. This amounts to 404 seconds to be added to the MST recorded in Socoa to get the time in UTC.”

The choice of Equation of time proposed by Bureau des Longitudes (2011) to convert time before 1900 only causes an error in the order of a second, hence negligible. We have incorporated this in the revised manuscript as –

“We have used the same equation for the late 1800, which induces only minor errors (order of seconds).”

In the revised version, we also clearly mention the objective of the section being the conversion of the time to UTC as follows –

“...listed in Table 1. The following subsections describe the detail of the conversion from each time system to UTC.”

- line 267: 3.3 should rather be “Vertical datum continuity” ?

Reply: We have revised the title to “Vertical datum continuity”.

- line 274: “it was possible to reconstruct the relationship of the tide gauge and tide pole zeros to the current benchmarks” not clear what is the tide gauge zero here, are we talking about the Chart Datum?

Reply: By tide gauge zero, we meant the ZH (zéro hydrographique) – line 268, which is the chart datum. The tide gauge was also equipped with a tide-pole for visual monitoring and comparison. The zero level of the tide-pole (ZP) was not at ZH and not the same throughout the recording period. We have revised line 274 to better reflect when we are talking about the ZH (chart datum) and about the ZP.

We have revised the line as following –

“...it was possible to reconstruct the relationship between the ZH and ZP to the current benchmarks, and subsequently to assess the continuity of the ZH at Socoa (Figure 3).”

- lines 288-290 the origin of the difference of 18 cm for Chart Datum is not clear, does that come from heavy siltation?

Reply: Yes. In the 1961 survey (Brie 1961), the tide gauge was heavily silted, which caused the difference. This discrepancy is then rectified 2 years later, during another survey in 1963.

We have revised the corresponding line as following –

“In a hydrographic survey done in 1961, the ZH was estimated 18 cm above the originally established ZH (Brie 1961). A follow-up investigation in 1963 reveals that the tide gauge was suffering heavy siltation and blockage of the connection with the sea during the survey of 1961, causing the deviation (Roubertou 1963). Following the investigation in 1963, the ZH was maintained at -2.17m NGF Lallemand, and the ZP was measured to be 24cm above the ZH.”

- line 291-292: "It appears that this tide pole is a different from the tide pole during (1873-1920), and the hydrographic zero at 24cm below the zero of the tide pole." The sentence is not clear, and should be rephrased. Possibly, the presence of the two tide poles could be introduced earlier, rather that at the end of the paragraph?

Reply: We have revise the section with the following changes –

1. "...Additionally, the practice in France is to include a tide pole and set its zero-measurement mark to the ZH (Wöppelmann et al. 2006b), but this procedure was not adopted for Socoa tide poles. We have found two records of tide poles over the full observation period. For each tide poles, the zero-measurement mark of the poles (ZP) are referenced at different height from the ZH."
2. Revised line 291-292: "Following the investigation in 1963, the ZH was maintained at -2.17m NGF Lallemand, and the ZP was measured to be 24cm above the ZH.".

- lines 293-300: this paragraph is not very concise, and could be rephrased

- line 301: this is the main result of the section, it could be mentioned at the beginning of the paragraph, for more clarity

Reply: We propose to keep all the content of the said paragraph as it was one of the main contradictory information from the historical document. To better convey the message, we have rephrased as following -

"All available documents suggest there was no change in the definition of ZH at Socoa. One false alarm was a letter, dated 9 October 1968 addressed to Shom, where it was mentioned that "the zero of the tide pole" (zero de l'echelle) was located -2.178m relative to NGF Lallemand datum, and the primary benchmark is located 5.822m above NGF Lallemand datum. This was identified as a mistake based on the survey done in 2007, which measured the height of OaK3L3-4-II to be 5.805m IGN69 (Tiphaneau et al. 2007). NGF-IGN69 is the current levelling datum established by IGN during 1962-1969. The reported difference between the datum of NGF Lallemand and NGF-IGN69 at Socoa is 0 m (Grid 1245, https://geodesie.ign.fr/contenu/fichiers/grillesorthonormales/GrilleOrthoNormale_Ouest.pdf, last accessed 19-07-2020). Currently, the hydrographic zero (ZH) is reported to be 7.975m below the OaK3L3-4-II benchmark, and 2.171m below NGF-IGN69 datum (Poirier et al. 2017)."

- lines 308-319: this paragraph on flags could be a dedicated subsection "Data quality flag".

Reply: In the revised manuscript, we restructured this paragraph in a dedicated "Data quality flag".

- line 304 "Following these two steps..." the sentence is unclear, it should to be rephrased

Reply: We have revised line 304-305 as following –

“In the previous section, we discussed the method used to reduce the records to a common time system and vertical datum (ZH). These two steps resulted in a merged time series, which was subsequently assessed to detect any potentially erroneous or suspicious water levels (IOC, 2020).”

- line 316: “The idea is like…” it should be reformulated

Reply: We have reformulated the line as follows –

“This concept is similar to the flag accompanying the PSMSL data (https://www.psmsl.org/data/obtaining/psmsl.hel).”

- line 328: “tide gauge journal”, ledger?

Reply: During Chazallon tide gauge period, a journal was kept at the tide gauge (now added to Section 2.4.1), which is referenced here. In the revised manuscript a cross-reference to Section 2.5 is incorporated to avoid confusion.

“This comparison process was useful to identify days with a wrong date (switched with the previous or the following curve in the chart) during transcription, as well as incorrect high and low tides with respect to the tide gauge journal (Section 2.5).”

- lines 339-342: this paragraph should be moved to the end of the section, as it introduces the following section

Reply: This reorganization is now incorporated into the revised manuscript.

- line 344: “hourly values” again, please mention more clearly the time resolution of the datasets (e.g. Table 1 refers to 15 mn, see previous comments)

Reply: The revised manuscript now reflects the changes (explained in previous comments and replies) on Table 1 and associated text to better separate the characteristics of the recorded data, and the data that has been used.

We have also added an additional line as follows –

“…timestamp was surrounded by valid data points. This interpolated hourly dataset is the main outcome of this data archaeology exercise and used in the subsequent analysis (See also Data availability).”

- line 349: “The applicable corrections are applied as described above.” Why mention this here, whereas previous section (4.1) already focused on corrections?

Reply: We have revised the subsection. The revised lines reads as follows –

“Thanks to the check sheets, the consistency of the clock at the beginning and the end of a recording period of a chart were able to be cross-checked (Supplementary Figure S6). In some cases, the start time of the clock was found to be correct with a slow-down at the end.”

- line 351: it is difficult “to” apply

Reply: This typo now corrected.

- line 352: “These values are flagged as values with low confidence (third bit in the flag set to 1)”, which order of magnitude of the slowing down of the clock? Is it possible to mention how many of the data are concerned? (for example in %).

Reply: This is only a small percentage of the data (around 3%). The magnitude varies from 1-2 minutes to as high as 10-12 minutes. We have added this relevant information into the text –

“...Only a small portion of the data (less than 2%) are affected by this problem.”

“...Less than 1% of the recovered data is concerned with this problem. Another part of malfunctioning of the float is assigned to co-occurrence of siltation (next subsection) and malfunctioning of the floating device, which concerns about 8% of the total recovered hourly data.”

“...Based on the metadata, we apply a siltation flag (fourth bit set to 1) to the data from 1875-11-12 to 1883-08-31. Based on the above-mentioned harmonic analysis we also flag the data from 1955 to 1963, and 1998-1999 period. These amounts to about 29 percent of the total recovered hourly data flagged as impacted by siltation.”

- lines 354-357: The title “Delayed rising/falling curve” should rather be “Possible malfunctioning of the float device” (to be consistent with other titles, referring to the potential problems rather than their impact on data). Does this malfunctioning of the floating device leading to delayed rising/falling curve has been already reported and referred? If yes, the references could be added.

Reply: We have updated the “Delayed rising/falling curve” with “Occasional malfunction of the floating device”. In our knowledge, this problem has not yet been reported but sometimes noted in the metadata.

- lines 358-392: “4.2.3 Siltation” This paragraph on siltation could be more concise, giving clearly the periods with problems of siltation, and mentioning which data were flagged accordingly.

- line 361: “The first major siltation problem with the data recording was noticed within the first few years of operation” which years? This problem of siltation does not seem to appear on Fig. 5?

- line 365: “After starting the reoperation of the tide gauge in 1950, the stilling well exhibited siltation and blockage related problems (Robertou 1963).” Same question, on which period exactly? Are we talking about 1956-1963?

- lines 380-382: siltation problems are mentioned during 1956-1963 and 1996-2000. It is not clear how these problems were solved, was there any intervention on the tide gauge? This could lead for example to recommendations to avoid this type of problems.

Reply: Following your suggestions in the above-mentioned 4 comments, we have rewrote this section in the revised manuscript by explicitly mentioning the times, and when the flags are applied.

We have added a new paragraph at the end of the section to introduce information on periodic interventions to clean the stilling well and a recommendation for transition to a new installation. The text reads as follows –

“The siltation problem discussed above persists to this date. Currently, the stilling well is cleaned, typically yearly, to maintain an acceptable quality of the data. However, access to the stilling well is challenging, and the cleaning operation is costly. The maintenance is also often perturbed by administrative complications and unforeseen events (e.g., Covid-19 lockdown in 2020-2021). The stilling well, under current condition, also does not conform to the recommended 2m depth of water at Lowest Astronomical Tide (IOC 2016). For Socoa tide gauge, which is currently equipped with a guided wave radar, we recommend a transition from the installation on the stilling well to an installation mounted on the quay of the dike with an unguided open-air radar.”

- line 383: “4.3 Buddy checking” this section is mainly “Buddy checking for vertical datum continuity” and could be part of Section 3.3 Vertical datum continuity (or at least, the title could be more precise)

Reply: We have revised the title to “Assessment of the vertical datum continuity”.

- line 385: “The difference with nearby...” precise monthly mean sea levels differences

Reply: We have revised the line as follows –

“One of the commonly used quality control techniques for sea level is the so-called ‘buddy checking’, which relies on comparison with mean sea level time series from nearby sites (Pugh and Woodworth, 2014). The difference in monthly mean sea level with nearby tide gauge essentially removes the common part of spatially coherent modes of variability and can reveal malfunctioning at one of the gauges – for instance, step-like features associated with vertical datum discontinuity (Woodworth 2003, Hogarth et al. 2020).”

- Fig 6: the legend is unclear and should be rewritten. Difference between monthly MSL at Socoa and Brest (black) and Santander (red). The fact that MSL over the period 1965-2000 has been removed should also be mentioned.

Reply: We have now updated the legend with clear labels. Similar to other authors (e.g., Marcos et al. 2021, Ozturk et al. 2018) – we replaced "Brest-Socoa" with "Brest" and "Santander-Socoa" with "Santander".

The information that the mean has been removed is currently in the text (line 395-396, initial manuscript). We have revised the figure caption to incorporate this information as follows –

"Figure 6: Difference in monthly MSL at Brest (black) and Santander (red) relative to Socoa. The mean over 1965-2000 is removed from each station for comparison."

- line 408: "However, in the Santander minus Socoa timeseries (red), we see a jump during (1976-1980), indicating a potential shift of 5 cm during that time at Santander." It is not useful to repeat again "in the Santander minus Socoa timeseries (red)" (already in previous sentence)

Reply: We have revised the sentence as follows –

"The Santander minus Socoa time series also does not indicate any datum shift and is generally consistent with the Brest minus Socoa time series. However, we see a small consistent deviation of 5cm on average during 1976-1980."

- line 408: why focus on this "jump", whereas there are others similar, as for example in the 1990's?

Reply: We focused on this jump due to its persistence over multiple years. As we stated in the previous line, difference with Santander typically follows the difference with Brest, which includes the sharp differences in 1990. On the other hand, during 1976-1980 period, one can spot a consistent shift in the mean difference.

Following previous comment, we have revised the sentence to communicate the observation more concisely.

- line 409-411 "Recently, Marcos et al. (2021)...for Socoa." this comment should rather be at the beginning of the paragraph, when introducing the data (line 395 for example).

Reply: In the revised manuscript this line is reorganized as suggested.

- lines 412-425 the section “5. Trend analysis” is very short (around 10 lines), it is difficult to consider it as a full section, and it does not seem to be completely finished. Supplementary “5 Inflexion point analysis” could be added in this section (rather than in the Supplementary). Why is this analysis conducted only over the 1875-1920 period rather than on the full period? What are the possible causes of these inflexion points?

Reply: Thank you for your suggestion on expanding this section. We have updated the paragraph to expand the trend analysis as follows:

“In the last two rows of Table 2, the estimated trend computed over two periods separated by 40 years - Chazallon era (1876-1920) and Brillie era (1963-1997) – is shown. The sea level trend at Socoa during Brillie era (1.95±0.61 mm/year) is noticeably increased (i.e., acceleration) compared to Chazallon era (0.82±0.37 mm/year). Similar magnitude of trend is found at Brest too. During Chazallon era, the trend at Brest is higher compared to Socoa, which is opposite during the Brillie era. Analysis of the factors that contributes to this observed change in trend is out of the scope of this data paper. However, this leads us to another benefit of a long time series, which allows investigating the non-linear evolution of mean sea levels and associated trends. This benefit is illustrated below through the analysis of inflexion points in the trend at Socoa and Brest.”

As we were referring to the work by Woppelmann et al. (2006a), and Woodworth (1999) where reported an inflexion point around1880s, we focused on analysing the 1875-1920 period. In the revised manuscript, we have revised the figure to include 1975 – 2000 period. We have applied a criterion to drop segments where there is more than one consecutive missing year, hence the missing years in the plot. The revised plot is shown below –

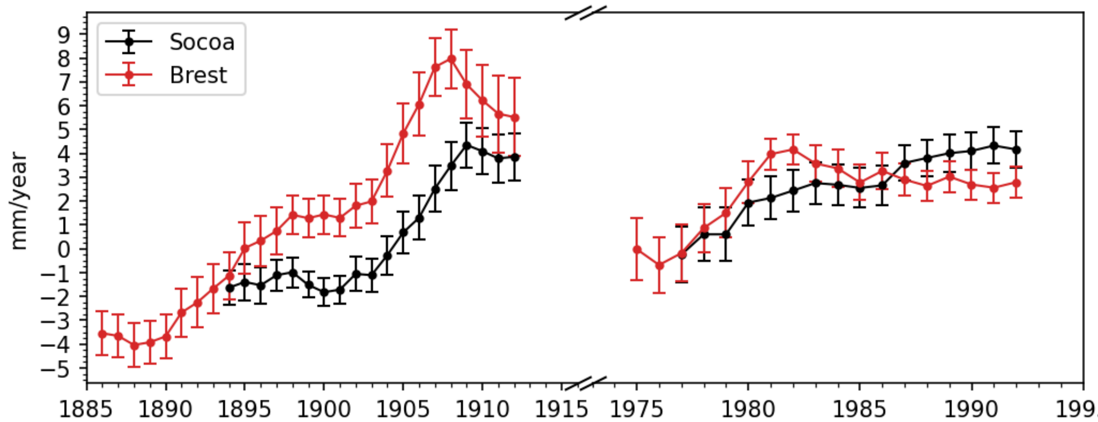

Figure 7. Running trend estimates (20-year windows) for Socoa (black) and Brest (red) during 1875 – 2000. Error bar shows the standard error of the trend estimate. Break lines indicates the skipped period when not enough continuous data is available for the analysis.

Multiple drivers may contribute to this inflexion point – decadal variability, long-term climate variability, sea level acceleration. We have now added dedicated text to cover it –

“Multiple drivers may contribute to this inflexion point – decadal variability, long-term climate variability, and climate change induced sea level acceleration. The decadal sea level variability during early 20th century, which is potentially the main contributing factor for inflexion point in trend, is found to be linked with the atmospheric modes of the North Atlantic (Calafat et al.

2012). Jevrejeva et al. (2008) shows that there is a prominent 60-year climatic variation in the trend (acceleration-deceleration), and during the analysis period (1875-1929), the global pattern is a deceleration until around 1910. However, the North-east Atlantic shows a strong deviation from the global pattern with an earlier reversal to acceleration around 1900 (Jevrejeva et al. 2008, Figure 3). Finally, the exact timing of the start of global acceleration of trend due to sea level rise is not accurately answered yet, but studies point towards sometime in the early 19th century (Church et al. 2006, Jevrejeva et al. 2008). Hence, the global trend in sea level rise may have further contributed to the timing of the inflexion point."

We have also moved the inflexion point analysis to the main manuscript with additional text –

"...However, this leads us to another benefit of a long time series, which allows investigating the non-linear evolution of mean sea levels and associated trends. This benefit is illustrated below through the analysis of inflexion points in the trend at Socoa and Brest.

The analysis is motivated by Wöppelmann et al. (2006a) who noted an inflexion point around 1890 at Brest, which is close to the inflexion point estimated for Liverpool around 1880 by Woodworth (1999). To find the inflexion point of the trend, we have analysed the same yearly time series at Socoa and Brest as above. A linear trend analysis is applied over a running window of 20 years. Windows containing two or more consecutive missing values were removed from the analysis. The trend (mm/year) and 1-sigma uncertainty range are shown in Figure 7. We reproduce an inflexion point at around 1887 in Brest, and an estimated inflexion point between 1895-1900 in Socoa.

Multiple drivers may contribute to this ..."

- line 412: "The trends estimates" Trends of which data? Hourly final datasets?

Reply: Yes, we used the final hourly dataset for Socoa, and reprocessed it using PSMSL rules into a yearly mean timeseries before computing the trend. We acknowledge that this is not explained in the manuscript. We have revised this section with this relevant processing information, reorganizing the inflexion point analysis to the main text –

"From the hourly time series for Brest and Socoa, we have computed yearly mean using the yearly PSMSL rules (at least 11 monthly means for a year) and estimated the trends estimate and associated 1-sigma uncertainty (Table 2)."

- Table 2 Period "Available", which is the period available for each harbour?

Reply: We have revised the table to incorporate the information as a footnote, as follows –

"* Available period for Brest is 1846-2021, for Socoa is 1875-2021".

- line 414: "The benefit of a long time series is clear here – longer the time series, tighter the error bar.", yes, another benefit is that changes are not always linear, and inflexion points can be investigated, as shown in the analysis below.

Reply: Yes, we agree. We have incorporated the argument in the text as follows –

"In the last two rows of Table 2, the estimated trend computed over two periods separated by 40 years - Chazallon era (1876-1920) and Brillie era (1963-1997) – is shown. The sea level trend at Socoa during Brillie era (1.95±0.61 mm/year) is noticeably increased (i.e., acceleration) compared to Chazallon era (0.82±0.37 mm/year). Similar magnitude of trend is found at Brest too. During Chazallon era, the trend at Brest is higher compared to Socoa, which is opposite during the Brillie era. Analysis of the factors that contributes to this observed change in trend is out of the scope of this data paper. However, this leads us to another benefit of a long time series, which allows investigating the non-linear evolution of mean sea levels and associated trends. This benefit is illustrated below through the analysis of inflexion points in the trend at Socoa and Brest."

- line 426 Data availability This section is of great importance as the final sea level dataset is the main result of the study. Details should be given to be more precise. Note that there are many files in the repository, the readme is quite short, and there is no detailed header in the final file.

This section could at least: give the name of the file corresponding to the final sea level dataset, as well as its vertical reference, time system, level units, start date, end date, number of years with data.

In addition, concerning the file itself, it would be very useful for users to have this essential information in the header (which is not the case in the repository), and add the 4-bit quality flag in a third column (Time/Sea Level/Flag)

Reply: We agree with your comments. We have revise the files to better incorporate the headers, containing station name, longitude, latitude, column units, flags and their meaning.

We decided to disseminate most of the necessary data to replicate this study (except the scanned documents). We acknowledge that this makes the repository quite heavy in terms of the number of files. We have now highlighted the final timeseries file in the Data availability section and we have revised the readme file in the repository to better explain the content of each file/directory.

The revised "Data availability" section now reads as follows –

"The raw digitized water level, the processed dataset, metadata, and the python notebooks used for processing are available openly at https://doi.org/10.5281/zenodo.7438469 (Khan et al. 2022). The data repository is organized into 4 sub-directories –

1. data/ : contains the raw and processed dataset for Socoa (data/socoa), and other auxiliary dataset (data/auxiliary) used in the analysis.
2. documents/ : contains inventory of the ledgers and charts (documents/inventory.xlsx), transcripts of metadata extracted from the regional archives (documents/archive_records), and selected transcripts from the tide gauge journal during Chazallon era (documents/tidegauge_journal).
3. figures/ : contains the generated figures used in the manuscript.

4. notebooks/ : contains the Python notebooks used to process and analyse the data.

The final hourly time series of water level in meters, vertically referenced to local hydrographic zero (ZH), with data quality flags discussed in this paper is distributed as a comma-separated file data/socoa/socoa_L4.csv with metadata in the header. The dataset starts from 1st November, 1875 and stops at 4th October, 2021 containing 101 years with data. This dataset is reproducible by applying time and height corrections on the raw uncorrected water level records for Socoa (data/socoa/socoa_raw.txt), using the data processing script (notebooks/01_data_processing.ipynb) and corrections (data/socoa/corrections.csv). Further detail of the files available in the data repository can be found in the include README.md text file.

A continuously updated time series of the Socoa sea level can be obtained from the Shom portal (http://dx.doi.org/10.17183/REFMAR#95)."

- lines 431-450 the conclusion section is also very short. It could be improved, with a better description of what has been done, and a development of possible perspectives. A synthesis of the corrections/flags would be appreciated. What are the main corrections? Which percentage of data is finally corrected? What are the periods flagged for siltation?

- line 434: "international sea level databanks", such as?

- line 437: "siltation" periods of siltation that are flagged?

- line 438: "associated corrections", synthesis of these corrections?

Reply: We have fully revised the conclusion, including the suggestions here. It is now a section with 7 paragraphs.

"We have done a thorough archival research, data-rescue, digitization, and metadata analysis and increased the coverage of the existing hourly sea level record at Socoa, Saint-Jean-de-Luz (France) back to 1875. Among the total 702 station-months additional data, 693 station-months are with more than 50% data per month. This extension of data amounts to about 58 years' worth of new data.

Data quality flags are assigned to the recovered and distributed final hourly dataset from careful inspection of metadata and dedicated analysis of the dataset. The amount of data where time and height corrections were needed and applied with confidence are small (less than 2% in total). Additional flags were assigned to indicate if time or height corrections were applicable but could not be applied confidently due to insufficient information. A very small proportion of data (<1%) is affected by this issue, without considering siltation related problems.

The largest proportions of the flagged data were related to siltation in the stilling well. A dedicated analysis of the data and metadata was done to identify and document periods with siltation. We have identified three main periods, from 1875 to 1893, 1951-1963, and 1998-1999. A dedicated flag was assigned to these periods, which affects 29% of the recovered hourly data.

Considering the gravity and the recurrent nature of the siltation problem in the stilling well, we recommend a transition from the stilling well to an open-air installation for this tide gauge. This transition should be supplemented with a study of the filtering characteristics of the stilling well to track any impact of the installation change on future sea level measurements.

This extended dataset will be communicated and deposited in international sea level databanks (e.g., PSMSL) to further increase the number of long-term sea level records extending back into the 19th century. One of the major features of this sea level record is its location, which has remained the same (buildings and stilling well) since its installation in 1875. The data recovered and rescued in this work would be useful for long-term sea level trend analysis (e.g., Gehrels and Woodworth 2013) and modelling at decadal to interannual scale (e.g., Calafat et al. 2012, Ding et al. 2021). Investigation into the extreme events will specially benefit from the high temporal sampling of the extended time series.

Besides the final hourly sea level dataset from 1875 to 2021, we also provide the raw data, associated corrections that are synthesized above, computational environment, and notebook as companion datasets (See Section 6). The objective of this is to promote reproducible research and to increase transparency by allowing validation of our computations.

In this data paper, we have not only extended the sea level time series at Socoa, but also showed that analysing the history of individual tide gauges can reveal important location-specific issues, like siltation, that might not be directly evident from the global dataset at this moment. During the current data archaeology work, we have also found unrecoverable deterioration of historical paper documents, which underlines the urgency of rescuing these invaluable records. Relevant metadata are also in the same danger of being deteriorated beyond rescue."

- line 438: "final sea level dataset" very brief description of the file (see previous comments)

- line 438 "raw data" very brief description of the file, as the differences between raw data and final data are not always very clear in the paper (see previous comments)

Reply: We have revised the Data availability section to incorporate this information, as replied in the previous comment.

- lines 448-450: "there are many more stations in France where the existing sea level record could be extended" this paragraph could be developed, which stations have already been identified? How old are these data? How many additional years could be extracted?

The perspectives could be further developed, at national and/or international scales. For example, Talke and Jay (2017) reported that "more than 6,500 station-years of previously lost or forgotten tide data have been identified" (http://archives.pdx.edu/ds/psu/21294)

Reply: While the actual available/rescuable data at a station is hard to quantify before doing the data inventory. For France an estimate could be found on the Shom inventory, available at http://refmar.shom.fr/dataRescue/. More than 60,000 documents have been identified and accurately inventoried in France (Latapy et al., 2022) and about 70% have already been scanned. However not all of them had been digitized and thousands of documents still remain to carefully inventory and scan.

Thank you for your suggestion on further developing this paragraph, and we have revised this paragraph to incorporate the above-mentioned information as follows:

“Finally, there is a vast amount of untapped tide data and associated metadata worldwide (Pouvreau 2008, Bradshaw et al. 2015, Talke and Jay 2017). Talke and Jay (2017) reported identification of more than 6,500 station-years of previously lost or forgotten tide data over United States. Over 60,000 identified documents have been inventoried in France (See Shom inventory, http://refmar.shom.fr/dataRescue), with 70% already rescued (e.g., scanned), but many remains undigitized (Latapy et al., 2022). Given the time critical risk of losing these valuable scientific and historic information, it is crucial to urgently rescue these datasets, digitize them, and make them available for the scientific community.”

Additional References:

Calafat, F.M., Chambers, D.P. and Tsimplis, M.N., 2012. Mechanisms of decadal sea level variability in the eastern North Atlantic and the Mediterranean Sea. Journal of Geophysical Research: Oceans, 117(C9).

Church, J.A. and White, N.J., 2006. A 20th century acceleration in global sea-level rise. Geophysical research letters, 33(1).

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Marcos, M., Puyol, B., Amores, A., Pérez Gómez, B., Fraile, M.Á. and Talke, S.A., 2021. Historical tide gauge sea-level observations in Alicante and Santander (Spain) since the 19th century. Geoscience Data Journal, 8(2), pp.144-153.

Ozturk, U., Marwan, N., von Specht, S., Korup, O. and Jensen, J., 2018. A New Centennial Sea-Level Record for Antalya, Eastern Mediterranean. Journal of Geophysical Research: Oceans, 123(7), pp.4503-4517.

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