https://doi.org/10.5194/essd-2025-767
Preprint. Discussion started: 28 December 2025

Open Access Earth System Science Data Discussions

SHELDA: Sub-hourly European Quality Controlled Sea Level Dataset

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Abstract.

Availability of high-quality sub-hourly sea level data is essential for understanding of a wide range of oceanic processes, including tidal oscillations, seiches, storm surges, tsunamis (including meteotsunamis), and their impact on sea level extremes and coastal flooding. Freely accessible sea level databases often contain time series measured with hourly or even longer sampling step, or they contain high-frequency data that have not undergone quality control procedures. To address this gap, the SHELDA (**S**ub-**H**ourly **E**uropean Quality Controlled Sea **L**evel **DA**taset) has been created. This dataset comprises 257 individual tide gauge records in NetCDF format (https://doi.org/10.14284/764, Balić and Šepić, 2025), each representing quality-controlled sea level time series sampled at intervals between 1 and 15 minutes, along with residual time series derived by removing tidal components. This paper outlines the rigorous quality control procedures implemented and describes the spatial and temporal coverage of the dataset, along with technical specifications. SHELDA enables precise identification and analysis of sea level variability at timescales from minutes to multi-yearly along the European coasts, including Greenland, Canary Islands, Israel, Lebanon and Türkiye.

1 Introduction

Sea level variations are affected by a combination of various physical processes encompassing a broad spectrum of time scales. These processes, typically distinguished by their period, wavelengths, amplitudes, repeatability, and manifestation, include short-term phenomena like surface gravity waves lasting from 1 to 20 seconds, infragravity waves, long ocean waves, seiches, and tsunamis with periods ranging from minutes to over an hour, tidal oscillations peaking at ~1/2 day and ~1 day, and other sea level variations which occur due to meteorological, hydrological and circulation effects that last from several days to years (including interannual and decadal fluctuations), as well as long-term changes of mean sea level due to planetary, geological and climatological factors (IOC, 2006; Pugh and Woodworth, 2014). To accurately distinguish and analyse these processes, it is essential to measure sea level using sampling intervals and instruments appropriately suited to the specific temporal and spatial scales of interest.

The first sea level measurements were conducted in 1679 at Brest, France (Picard and de la Hire, 1680) and later at various locations across northern Europe such as Amsterdam in 1682 (van Veen, 1954), Liverpool in 1768 (Woodworth, 1999) and Stockholm in 1774 (Ekman, 1988), using either visual observations of graduated markings on stone walls of docks (Woodworth et al., 2015) or wooden graduated rods, called tide poles, with both of these located at points where observers could read off the instantaneous sea level height at any given time (Woppelmann and Pirazzoli, 2019). Initially, sea level measurements were conducted with sampling intervals between one reading per month and one per week. In the mid-19th century, the sampling interval of these measurements increased to 1-2 times per day, focusing specifically on high and low water levels and their respective timings (Cartwright, 1999). Naturally, sea level variations occurring at periods shorter than 2-4 days were not distinguishable by such measurements.

The development of the first automatic or "self-registering" tide gauge in the UK around 1830 (Palmer, 1831) marked a significant milestone in sea level measurement history, enabling the production of continuous sea level traces for the first time. These traces were, at best, digitized with an hourly resolution allowing for the analysis of tides, storm surges, and long term mean sea level changes. However, oscillations occurring at periods shorter than 2 hours, including wind waves, infragravity waves, tsunamis, and other long ocean waves, could not be discerned from hourly values (IOC, 2006). To assess these shorter period oscillations, one had to digitize sea level traces with a higher resolution - a strenuous procedure which was only sporadically applied on episodes of high interest (e.g., Šepić et al., 2012). The wind waves, though, could not be obtain by this procedure, as they are filtered out from the sea level records during the measurement phase. This is because tide gauges typically measure sea level in stilling wells in which oscillations of the shortest periods are dumped. Modern sea level measuring instruments also usually neglect wind waves due to some kind of averaging procedure which is applied within the instrument software.

For more than two decades, various new technologies have been developed to accurately and reliably measure sea levels with a minute or even shorter time steps. These technologies include floats connected to digital converters, bottom pressure recorders, and acoustic and radar systems (IOC, 2006; IOC, 2016). Nonetheless, measuring sea level with an hourly time step endured as a standard approach in most countries, in accordance with the GLOSS program's initial requirements (IOC, 1990; IOC, 1997), at least until the catastrophic Indian ocean tsunami in 2004 (Lay et al., 2005). In response to this devastating event, the Intergovernmental Oceanographic Commission (IOC) of UNESCO took swift action and established multiple Intergovernmental Coordination Groups to implement effective tsunami warning systems and advised the installation of new sensors with a reduced sampling frequency (1 minute or less). In addition to greatly improving tsunami warning services, it also enabled enhanced research of high-frequency sea level oscillations, encompassing tsunamis (including meteotsunamis), infragravity waves, and seiches (IOC, 2006). The upgrade was facilitated by advancements in technology, particularly the further improvement and development of measuring sensors and communication links (Pérez et al., 2013).

Nowadays, sea level data can be found in various databases. These include global, regional and national databases, some of which are freely available, while others are accessible under specific conditions. Unfortunately, certain databases are

https://doi.org/10.5194/essd-2025-767
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unavailable due to data ownership restrictions, which strictly limit data exchange (e.g., indicated in Pérez Gómez et al., 2022 for the Mediterranean). The following data centres and databases contain freely available global sea level data acquired from tide gauge observations:

1. Permanent Service for Mean Sea Level (PSMSL; https://www.psmsl.org/, last access: 10 December 2025) collects and publishes monthly and annual mean sea level values from the global network of tide gauges operated by local and national authorities (Holgate et al., 2013);
2. University of Hawaii Sea Level Centre (UHSLC; https://uhslc.soest.hawaii.edu/, last access: 10 December 2025) provides fast delivery (4-6 weeks) of preliminary quality controlled hourly sea level data and delayed mode research quality hourly sea level data through the Joint Archive for Sea Level (JASL) (Caldwell et al., 2001);
3. British Oceanographic Data Centre (BODC; https://www.bodc.ac.uk/, last access: 10 December 2025) maintains high-frequency (i.e., hourly or more frequent) delayed mode quality-controlled data from the UK tide gauge network and international sea level data available as a combination of data gathered under the Global Sea Level Observing System (GLOSS), the World Ocean Circulation Experiment (WOCE) and the Climate Variability and Predictability (CLIVAR) programmes;
4. Intergovernmental Oceanographic Commission Sea Level Station Monitoring Facility (IOC SLSMF, https://www.ioc-sealevelmonitoring.org/, last access: 10 December 2025) hosted by the Flanders Marine Institute (VLIZ), provides a web-based global sea level station monitoring service for a quick inspection of the real time raw data from individual stations and offers information on the tide gauge network's operational status; available data is mostly of 1 minute sampling frequency, but data measured with shorter and longer sampling intervals can also be found within this database;
5. Global Extreme Seal Level Analysis dataset (GESLA; https://www.gesla.org/, last access: 10 December 2025) contains higher-frequency (i.e., hourly or more frequent) sea level records obtained from many international data suppliers providing data with different levels of quality control (Haigh et al., 2022);
6. Système d'Observation du Niveau des Eaux Littorales (SONEL; https://www.sonel.org/, last access: 10 December 2025) offers daily, monthly, and annual mean sea levels and integrates tide gauge data with GNSS (Global Navigation Satellite System);
7. Minute Sea Level Analysis dataset (MISELA; https://www.vliz.be/en/imis?dasid=6673&doiid=457, last access: 10 December 2025) comprises of 1-minute quality-controlled and high-pass filtered (cut off period of 2 hours) sea level records of nonseismic (tsunamis) sea level oscillations from 331 tide gauges worldwide (Zemunik et al., 2021).

Among the databases and datasets mentioned, the IOC database stands out as the most frequently updated one (as it collects data in real time). PSMSL, UHSLC, BODC, and SONEL databases are also actively maintained and receive regular updates. In comparison, GESLA is updated less often, with new releases occurring every 5 or 6 years (Menéndez and Woodworth,

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2010; Woodworth et al., 2017; Haigh et al., 2022; GESLA-4, https://gesla787883612.wordpress.com/downloads/, last access: 10 December 2025) and the MISELA dataset covers a period of 2004–2019, and has not yet been updated.

In addition to the previously mentioned data portals and databases, sea level time series are also available through integrated repositories. Notable examples include the European Marine Observation and Data Network (EMODnet; https://emodnet.ec.europa.eu/en/physics, last access 10 December 2025), which offers global coverage and the Copernicus Marine Environment Monitoring service in Situ TAC (CMEMS INS TAC; https://marineinsitu.eu/, last access 10 December 2025) which primarily covers Europe. The tide gauge intercomparison tool, TGCAT (Tide Gauge CATalogs; https://www.sonel.org/tgcat, last access 10 December 2025), serves as a valuable resource for the comparison of fundamental tide gauge information (e.g., coordinates, names) across diverse data repositories, especially given the increasing number of such repositories. Sea level data can be accessed, not only from global and regional databases, but also through the websites of national data providers. For instance, in the USA, sea level data measured at 1-minute, and 6-minute time step is freely available on the National Oceanic and Atmospheric Administration (NOAA) website (https://tidesandcurrents.noaa.gov/products.html, last access 10 December 2025).

One of the main challenges with the databases mentioned earlier, as well as sea level measurements in general, is data quality and latency. Often, real time and near real time data, which are indispensable for navigation, port management, storm surge forecasting, and tsunami warning systems, are of unverified quality. In these situations, immediate data transmission and data sampling intervals of one minute or less (IOC, 2006) are more important than rigorous quality control, which is often not feasible. However, real time monitoring can include simple checks such as detecting when a tide gauge stops transmitting data (UNESCO/IOC, 2020). Real time data are, e.g., available through the IOC SLSFM website and the National Tidal and Sea Level Facility (NTSLF) website (https://ntslf.org/data/uk-network-real-time, last access 10 December 2025) for the UK Tide Gauge Network.

Higher quality data includes fast mode data, which is required on timescales of days to weeks, and is subject to mostly automatic quality control procedures, such as identifying and correcting obvious spikes. Such data is essential for the calibration of satellite altimeter data (Mitchum, 2000) and for forecasting ocean circulation and properties. These data are, e.g., available through the University of Hawaii Sea Level Center. On the other hand, delayed mode data is generally considered to be of the highest quality. It is primarily used for scientific research and subsequently for practical applications and is available at various time steps, through e.g., MISELA (for 1-min data, although only filtered series), UHSLC, JASL, GESLA (all three primarily hourly data, with some higher resolution data in GESLA), PSMSL (monthly and annual data), and through national data providers.

In this manuscript and related dataset, we present the delayed mode dataset of sea level series measured with a time step of 1-15 minutes along the European coasts, including Greenland, Canary Islands, Israel, Lebanon and Türkiye. Our dataset originates entirely from the IOC SLSMF dataset of real-time sea level data. Prior to publishing the dataset, all data were subjected to strict automatic and visual quality control procedures. This was deemed necessary as real time data are prone to various quality issues, such as mean and date shifts, artificial spikes, gaps, and others (e.g., Šepić et al., 2015; Vilibić and

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Šepić, 2017; Woodworth, 2017; Zemunik et al., 2021). Ultimately, our objective was to establish a high-quality dataset that enables the precise identification and analysis of sea level variations occurring at periods from minute to multi-yearly along the majority of European coastlines.

This paper is structured as follows. Section 2 describes the data source for the SHELDA dataset and outlines the quality control procedures implemented. Section 3 presents the dataset itself, detailing the spatial and temporal coverage of the quality-controlled time series, along with the technical specifications of the dataset. The paper subsequently includes a data availability statement and concludes with a discussion on the applications of the dataset and potential areas for improvement.

2 Data and methods

2.1 Data source

The Intergovernmental Oceanographic Commission Sea Level Station Monitoring Facility (IOC SLSMF), established in 2006, was developed in collaboration between Flanders Marine Institute (VLIZ) and the ODINAFRICA project of IODE (The International Oceanographic Data and Information Exchange) (Flanders Marine Institute (VLIZ) and Intergovernmental Oceanographic Commission (IOC), 2025). The service began with an emphasis on operational monitoring of sea level stations in Africa and was later expanded to stations involved in the IOC programs, including the Global Sea Level Observing System Core Network and the networks under the regional tsunami warning systems in the Indian Ocean (IOTWS), North East Atlantic, the Mediterranean and adjacent seas (NEAMTWS), Pacific (PTWS), and Caribbean and adjacent regions (CARIBE-EWS).

The IOC database contains sea level data acquired in real time at sampling intervals ranging from less than a minute to 15 minutes. To ensure accuracy, redundancy, and cross-calibration, many tide gauge sites, from which data are provided to the IOC SLSMF database, have duplicate or multiple sensors (Aarup et al., 2019). For instance, the Italian national tide gauge network Rete Mareografica Nazionale is fitted with both float and radar sensors (Nardone et al., 2020). Other national tide gauge networks incorporating multiple sensors include, for example, the UK National Tide Gauge Network, the Swedish Sea Level Network, the Spanish National Geographic Institute Sea level network. Data suppliers are not required to provide data from multiple sensors to the IOC SLSMF, so in most cases, only data from the primary sensors are available, however, for certain stations, data from multiple sensors can be downloaded as well. Additionally, some stations are equipped with both internet and satellite real-time transmission systems, which can result in duplicate series from the same station in the IOC SLSMF database.

The IOC SLSMF offers a display service designed to enable quick visual examination of real time data from a specific station over user-selected timeframes (i.e., 12 hours, 1 day, 7 days, or 30 days). Each station's profile includes essential details such as a unique identifier, geographical coordinates of the tide gauge location, and its respective country. Furthermore, contact details for the local agency responsible for station management are provided, alongside technical specifications regarding sensor type and sampling frequency.

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2.1.1 Data acquisition

Sea level time series from 325 tide gauges along the European coasts, with a sampling resolution ranging from 1 second to 15 minutes, were obtained from the IOC SLSMF website for the period from the beginning of station activity until 00:00 on 1 January 2021 (or until the end of station activity, if it occurred prior to 1 January 2021). The data were retrieved using an automated process developed by Ruić et al. (2023). The code downloads sea level time series by fetching one month at a time, reformats the data by stripping away extraneous content, and continues this process until all the data is collected. Ultimately, it merges all the monthly files into a single file in the desired format. From here on, the term “record” will refer to the time series of sea levels measured by a specific tide gauge.

Some stations are listed twice on the IOC SLSMF website because most of the SHOM (French Naval Hydrographic and Oceanographic Service) operated tide gauges from the RONIM network are equipped with dual real-time transmission systems (Pérez Gómez et al., 2022). In those cases, when duplicates from one station were available, we selected the longest record with the lowest percentage of data gaps, which resulted in the elimination of 26 records (leaving us with 299 records). For the relatively few stations (21) that had data from duplicate sensors, we opted for the longest record with the lowest percentage of data gaps. This choice did not affect the total number of records, since data from different sensors at the same station were already stored together in one file. Additionally, we excluded 42 records of low quality from further analysis. Following these initial modifications, we ended up with 257 records in the SHELDA dataset. Each of these records has at least 30 days of measurements, the minimum required for deriving harmonic tidal constituents and validating numerical models (Fig. 1).

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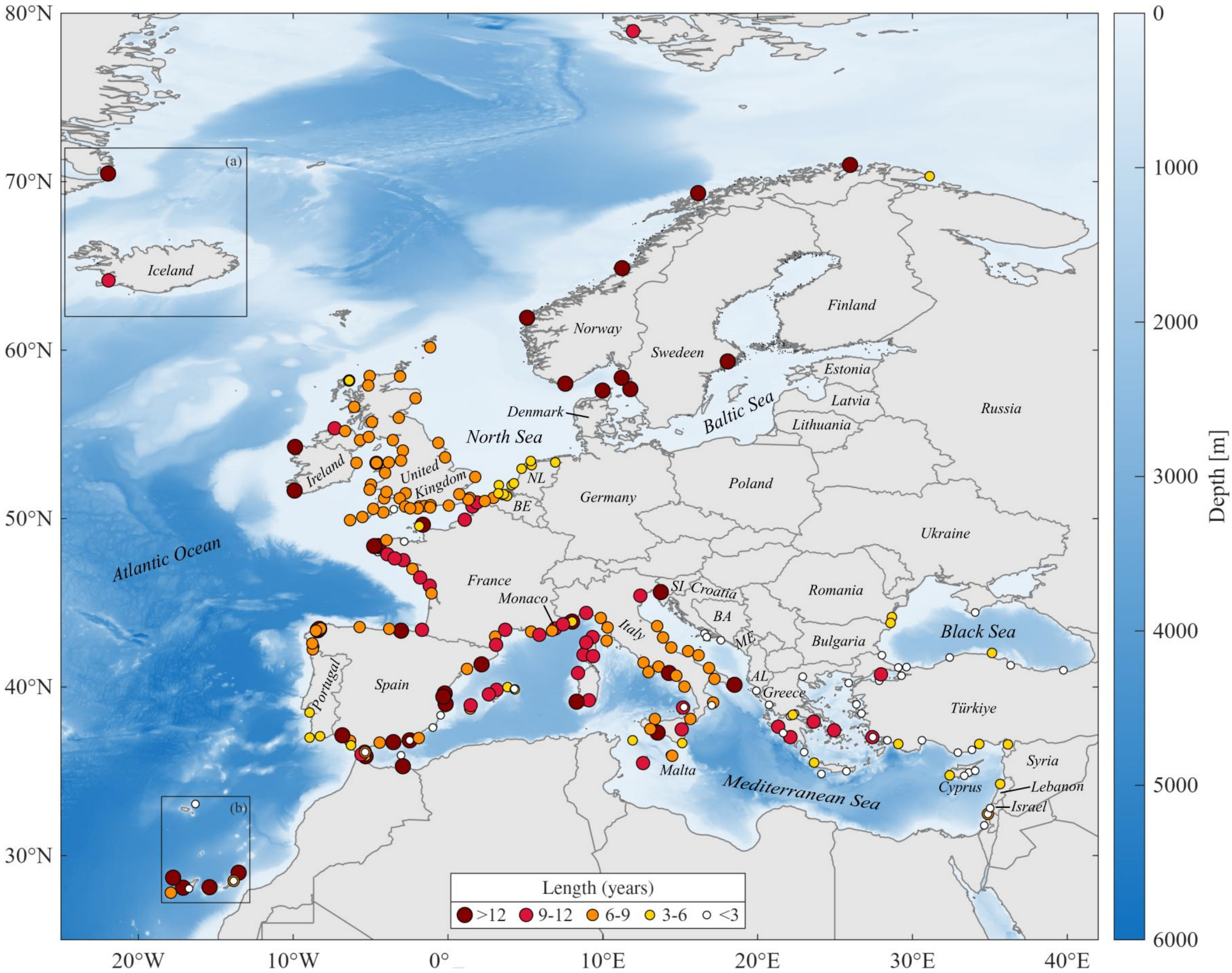

Figure 1. Map of SHELDA station locations. The length of the time series is represented by the size and colour of the circle. Iceland and Greenland are highlighted with frame (a), and Canary Islands with frame (b). Bathymetry is plotted using GEBCO 2024 grid (GEBCO Bathymetric Compilation Group, 2024). Following country abbreviations are used: AL for Albania, BA for Bosnia and Herzegovina, BE for Belgium, ME for Montenegro, NL for Netherlands and SL for Slovenia.

2.2 Quality control procedures

As stated on their website, the IOC SLSMF data are not subjected to any quality control procedure and are archived and available for download to interested individuals and organizations in the format provided by the data suppliers. The quality and reliability of sea level measurements are thus occasionally impacted by common errors present in tide gauge sea level data (Fig. 2), including out-of-range values, gaps, flat lines, isolated and clustered spikes, drifts, time errors, and datum changes. Thus, further processing must be conducted before data can be utilized for research. These errors are caused by

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various factors such as electronic noise in measurements, problems in sensor calibration, stabilization, clock failures, drifts, transmission mistakes, etc (UNESCO/IOC, 2020).

Figure 2. Examples of errors commonly encountered in raw sea level time series: (a) vertical shifts; (b) spikes; (c) gaps and spikes; (d) spurious data, flat lines, and clustered spikes.

We next explain pre-processing and quality control procedures applied to downloaded SHELDA data, but first, we note that 71 records obtained from the IOC SLSMF database were previously partially quality controlled by Vilibić and Šepić (2017) and Zemunik et al. (2021) (up to June 2018). Quality control flags from the MISELA dataset (Zemunik et al., 2021) were employed to remove spurious/false values from these records which we downloaded from the IOC SLSMF website. In this study, these records have been further extended to December 2020 and processed in accordance with the QC procedures outlined here.

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2.2.1 Pre-processing

Pre-processing included: (i) splitting raw records with variable sampling frequencies into segments of continuous frequency; (ii) obtaining 1-minute time series from records measured with a time step shorter than 1 minute; (iii) calculating and removing the mean value and (iv) creating records with a regular time step.

(i) 17 raw records, exhibiting changes in sampling frequency over time (e.g., the record's first segment was sampled every 10 or 15 minutes, whereas the last segment was sampled every minute), were divided into 35 segments (e.g., one record was split into three segments) each representing a period of continuous frequency, increasing the number of records subjected to quality control from 257 to 275. Each segment underwent separate pre-processing and quality control. Processed segments were then combined into a single file representing the complete record. Further details on these records can be found in the Appendix A. (ii) To ensure consistency with one-minute intervals, 37 records with a sampling frequency higher than one minute were averaged to a 1-minute series. (iii) Removal of mean values was done as sea level heights, depending on the country/station, are given with respect to a different reference level, which is furthermore not indicated in the IOC SLSMF database. Mean values are stored in the SHELDA dataset for each station – allowing for reproduction of original sea levels. (iv) Regarding the creation of records with regular time step, occasional missing timesteps and sea level values occur, likely due to factors like system errors or problems with data transmission. In cases where timestamps were missing, regular time records were created, and the associated missing sea level measurements were marked with a NaN (Not a Number) value. Issues such as temporary and permanent datum shifts were not addressed, as this would necessitate access to information currently unavailable on the IOC SLSMF website.

2.2.2 Removing spurious data

Significant portions of the raw dataset had various data quality issues (i.e. spikes, shifts, drifts) so a quality control procedure consisting of five steps was implemented: (i) correction of major vertical shifts; (ii) removal of out of range values; (iii) application of spike detection algorithms; (iv) visual quality control; (v) buddy checking.

(i) Noticeable vertical shifts caused by inconsistencies in measurements were visually identified and corrected by subtracting the mean value computed for the specific period affected by the vertical shift. (ii) Values that were out of range, i.e., values with a 50 cm difference from a neighbouring value and a 30 cm difference from both neighbouring values, were eliminated as part of the automatic quality control, following a procedure and threshold already used on the IOC SLSMF data by Vilibić and Šepić (2017) and Zemunik et al. (2021). This procedure was applied specifically to 1-minute data. For the remaining data with sampling intervals greater than 1 minute, 1-meter distance from neighbouring value was used to avoid overly strict criteria that might exclude high-quality data.

(iii) Automatic spike detection procedures, developed by Williams et al. (2019), were applied exclusively to 1-minute records. Following the author's recommendation, the procedures were applied twice, as a single run did not account for all spurious spikes. The Williams et al. (2019) algorithms eliminate all values that deviate more than three standard deviations from a spline fitted to sea level time series using the least squares method. Although highly effective, automated quality control procedures did not solve all data quality issues. The main remaining problems included: (a) identifying spikes in the proximity of other spikes, (b) detecting clusters of spikes, and (c) accounting for shifts and constant sea level values over time. (iv) To address the remaining issues, a visual inspection of all records was conducted. Each record was examined over a 10-day window, and most of the remaining spurious values were visually identified and removed.

(v) In specific records (11 in total), particularly those with 10- and 15-minute sampling frequencies, during the visual inspection, larger portions of potentially inaccurate data were observed, including attenuated signals, and variations in phase and amplitude. However, as we could not with certainty confirm that these data were "false" just from looking at a single time series, we also performed "buddy checking", whereby measurements were compared with those from the two nearest tide gauges (Fig. 3). Based on this comparison, it was determined whether the observed changes were caused by an event that propagated along a coastline or were non-physical and thus required to be removed.

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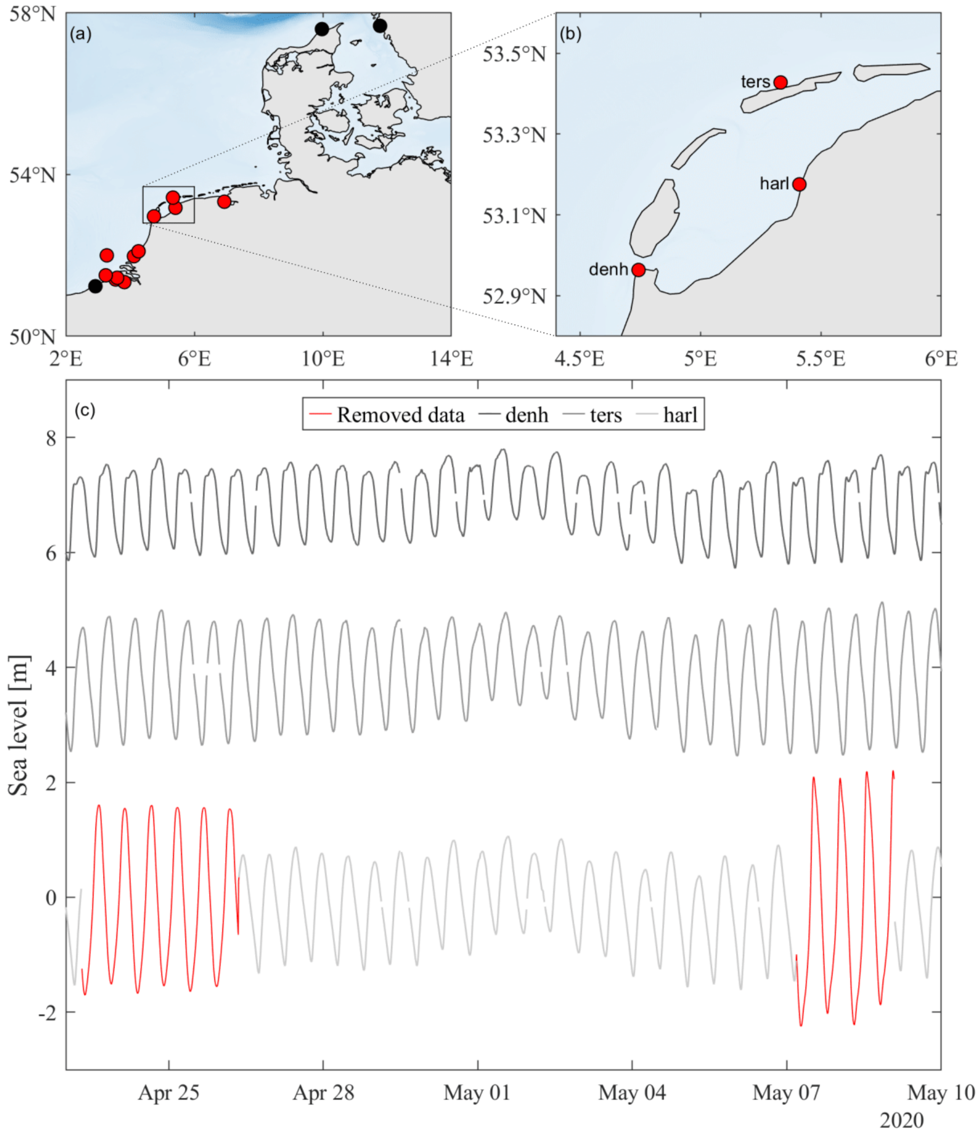

Figure 3. (a) Bathymetric map of the North Sea region showing the distribution of tide gauge stations, with red markers indicating Dutch stations that underwent buddy checking and black markers representing stations in neighbouring countries. The rectangular box highlights the area of interest containing three stations selected as examples for buddy checking; (b) Closer view of three stations: Den Helder (denh), Harlingen (harl), and Terschelling Noordzee (ters); (c) Records for three stations harl, ters (vertically offset for 4m to allow for clearer representation) and denh (vertical offset 7m), with red segments indicating problematic data identified through cross-comparison.

2.2.3 Tidal analysis

Following automatic and visual detection and removal of erroneous data, the MATLAB software package T_Tide (Pawlowicz et al., 2002) was used to estimate the tidal signal. An estimate was made for all significant tidal components.

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However, analysis of the residual signal (the original records minus the tidal signal) revealed that the tidal signal was not estimated/removed properly at seven Norwegian stations. Additionally, these stations exhibited a vertical offset that had been mentioned previously.

Our initial analyses suggested that the issue was mainly due to a clock shift (from standard time to daylight saving time, and vice versa) occurring twice a year and not accounted for by some providers. Further investigation, in collaboration with the Norwegian data provider Kartverket, confirmed that although the data were reported as being in UTC on the IOC portal, they were in reality in UTC+1 (with the correction for Daylight Saving Time).

Temporal corrections were applied and time stamps adjusted based on daylight saving time status (−2 hours during DST, −1 hour during standard time). Corrections were applied only to data between the onset of the vertical offset and 17 March 2020, 22:50 UTC, which marks the point when data providers started transmitting records in the correct UTC reference frame to the IOC. The correction procedure was validated by comparing the corrected time series for two stations with observations directly downloaded from the Kartverket web service (https://vannstand.kartverket.no/tideapi_en.html, last access: 10 December 2025), confirming the reliability of the applied temporal adjustments.

The comprehensive quality control procedure is illustrated in Fig. 4, and some key steps in the data processing workflow are demonstrated using a portion of the record from one tide gauge, as shown in Fig. 5.

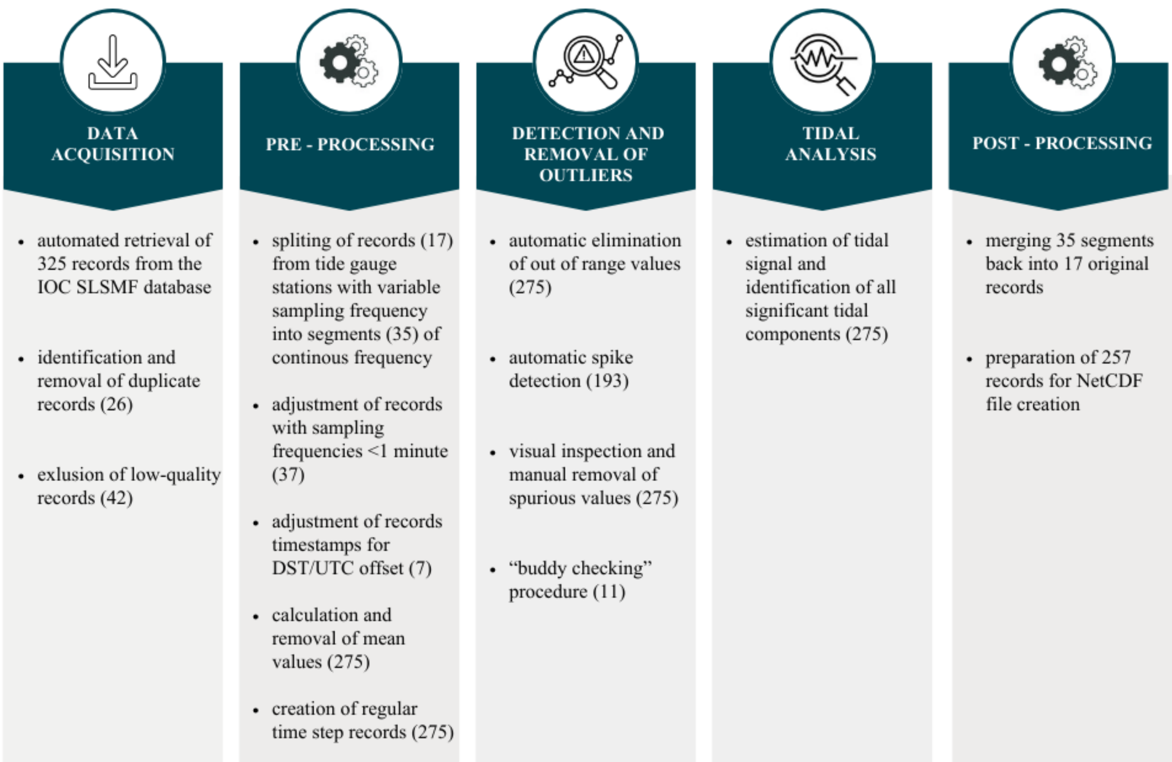

Figure 4. Flow chart of data processing. The numbers in parentheses indicate how many records have passed each step. Automatic spike detection (193) was applied only to 1-minute time series.

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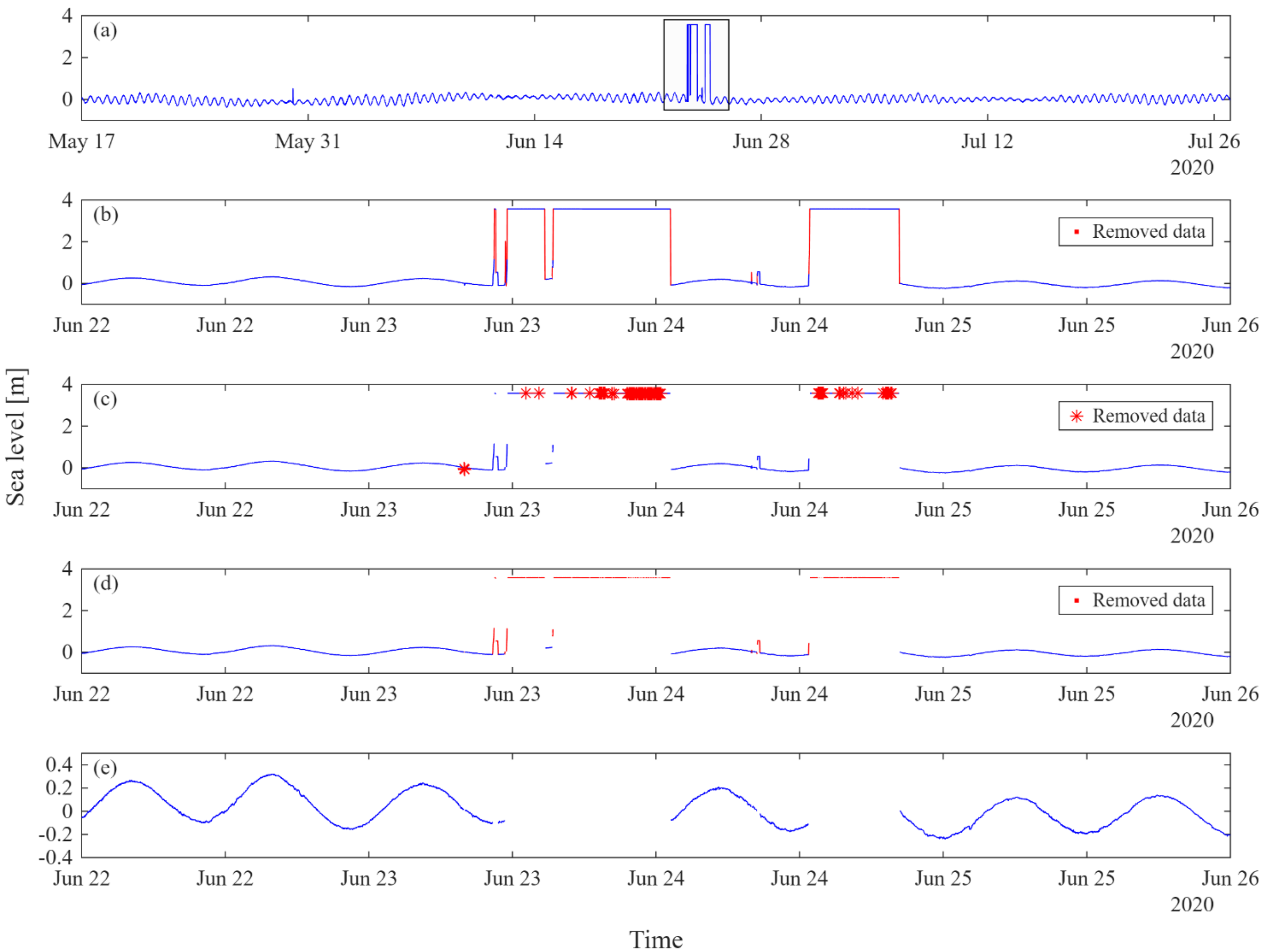

Figure 5. The key steps involved in data processing using the example of Aigio station in Greece. (a) The raw record adjusted to a regular time interval, with the mean value subtracted. The portion of the record that is of interest is indicated within the rectangle. Erroneous data points, indicated in red, are identified during the following procedures: (b) the out-of-range correction method, (c) the automatic spike detection and (d) visual inspection. (e) The final record after quality control steps.

2.2.4 Quality control statistics

To get a clear picture of the SHELDA dataset's quality we further discuss how much data was considered "high-quality", and how much data was missing or removed across 275 records. Percentages are given with respect to the length of the time series. The results, as illustrated in Fig. 6a, demonstrate that the majority of stations had reliable records. About 250 records had less than 5% missing data during their observation periods, and 129 records had less than 10% of their data removed. When it comes to the percentage of high-quality data, around 80 records contained between 90% and 95% of high-quality data, and an additional 40 records exceeded 95% of high-quality data. On average, 79.64% of the total data in the dataset is classified as high-quality, 18.75% as missing, and only 1.61% has been removed during the quality control.

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In Fig. 6b, we show the proportions of data removed during (ii) – (v) quality control steps: out-of-range value detection, spike detection, and visual control (including buddy checking). The percentages are given with respect to the removed data, and not with respect to the length of the total time series. For the 71 stations for which quality control flags were obtained from the MISELA database, information regarding the number of data points removed at each stage of the quality control process is unavailable. Consequently, statistical analyses for these stations were conducted using data from 15 June 2018 until the end of the respective time series. Most records have a low percentage (0–5%) of removed data for both automated methods. In contrast, visual control shows more diverse distribution: there are lots of records with either very little (0–5%) or almost all (95–100%) of their excluded data removed during this step. This suggests that for some records, almost all the erroneous data is detected and removed during visual checks, while for others, the automated steps detect and remove most spurious data, and visual control isn't necessary. Looking at the overall contribution of each step to the total amount of data removed, visual control accounts for 55.31%, spike detection for 23.38%, and out-of-range value detection for 21.31% of removed data. It is also important to mention that most of the data removed following visual control is due to specific issues previously discussed in Section 2.2.3.

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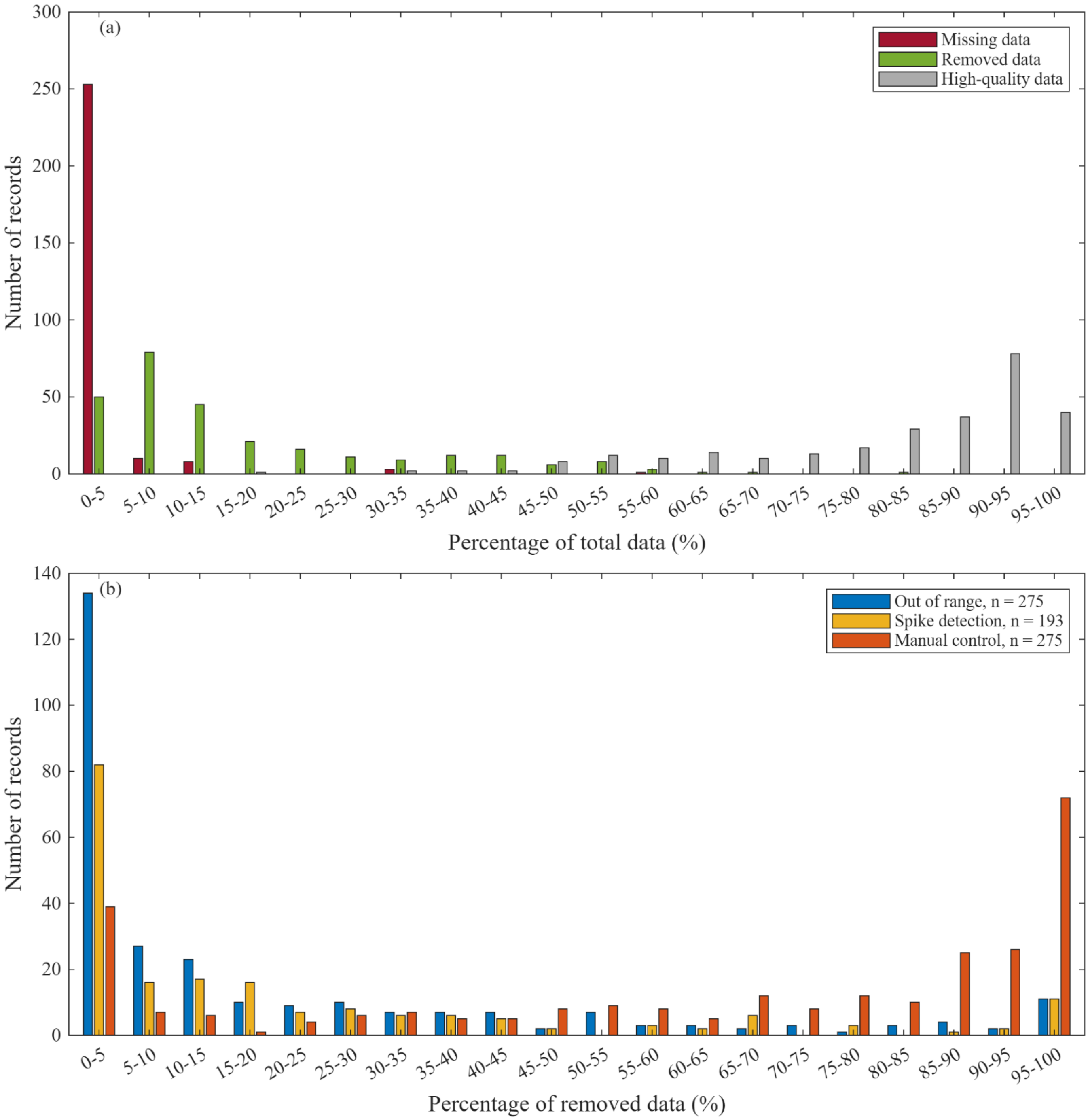

305 **Figure 6. (a) Distribution of records by percentage of data quality categories: missing data, removed data and high-quality data; (b) Distribution of records by percentage of data removed during each of three quality control steps with each step represented by a distinct colour, as shown in the legend. The percentages in (b) are given with respect to removed data, and not with respect to total length of time series. The number of records (n) processed in each quality control step is indicated in the legend.**

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3 Dataset description

The dataset consists of 257 quality-controlled sea level time series in the NetCDF format, each representing data from an individual tide gauge station along the European coastlines. Each file is named according to the station code specified on the IOC SLSMF website and contains four variables: (i) "time" - expressed in seconds since 1 January 2000 00:00:00 UTC; (ii) "sea_level_qc" - the quality-controlled sea level time series; (iii) "residual" - quality-controlled record minus the tidal signal; (iv) "qc_flags"- quality control flags, where 1 indicates high-quality data, and 0 denotes missing or removed data.

The global attributes include metadata on the station name (IOC code and full station name), geographic location (country, latitude, and longitude), sampling interval and temporal coverage of the quality-controlled records. Additional attributes specify the mean value removed from the raw data, the original data source, and contact information. When applicable (e.g. in cases involving variable sampling frequencies in the raw data or corrections for vertical shifts), a disclaimer is included to explain the additional global attributes. A simplify example of the NetCDF file structure used in the SHELDA dataset is provided in Table 1.

SHELDA dataset contains nearly 1816 station years of sea level data of 1-15 minute frequency, coming from 257 records across 22 different countries (Fig. 1). These records cover the period from 2 December 2007 to 1 January 2021, depending on station, with an overall average record length of 7.1 years. However, the duration of individual records varies significantly among stations, ranging from as short as one month to as long as 13 years.

The distribution of sea level monitoring stations (for which data is available in the IOC database) across European coastal regions shows significant geographical differences (Fig. 1). The United Kingdom, France, Spain, and Italy have high station coverage with records of various lengths. Despite their extensive coastlines, Norway and Sweden show low station density. Similarly, along the coastlines of Ireland, Iceland, Portugal, Croatia, and the Black Sea coastlines, there is limited data availability within the IOC database. Notable gaps are evident across several European countries, with Finland, Estonia, Latvia, Lithuania, Poland, Slovenia, Montenegro, Albania, and Bulgaria completely absent from the IOC database, while Germany, although present in the IOC database, is excluded from the SHELDA dataset due to insufficient data quality.

Analysis of record durations shows that stations with longer records (over 10 years) are predominantly found in the Baltic region, France, Italy, and Spain. In contrast, those with shorter records (less than 4 years) are mainly located in the Eastern Mediterranean and the Black Sea. The longest records in the SHELDA dataset are from 3 tide gauges in Sweden. Stations with shorter time series may be newer installations, may have only operated for a short period, or may have been recently added to the IOC database. In some cases, records are shorter than the available raw data because erroneous data points were removed during extensive quality control, particularly at the beginning and/or end of the records.

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Table 1. Example of SHELDA NetCDF file

File name: ball.nc

Global attributes:	
IOC station code	ball
Station full name	Ballyglass pier, Belmullet
Country	Ireland
Latitude	54.25 degree N
Longitude	9.89 degree W
Disclaimer	The original tide gauge record was divided into two segments due to a change in sampling frequency. Each segment was individually processed and quality controlled, with corresponding start and end dates, sampling frequencies, and mean values documented. The final NetCDF file merges both segments into a continuous record.
Start date segment 1	2008-06-11 10:06:00
End date segment 1	2018-03-13 08:54:00
Sampling interval segment 1	6 min
Mean value segment 1	0.0368 m
Start date segment 2	2018-03-13 09:00:00
End date segment 2	2020-10-24 02:20:00
Sampling interval segment 2	5 min
Mean value segment 2	0.0827 m
Original data	http://www.ioc-sealevelmonitoring.org/bgraph.php?code=ball
Contact person	Marijana Balić, Faculty of science, University of Split, Split, Croatia mbalic@pmfst.hr balic.marijana@hotmail.com
Dataset information	This file is a part of the SHELDA (Sub-hourly European quality-controlled sea level dataset) dataset, providing quality-controlled sea level records and corresponding residual time series at 1–15 minute intervals from 257 tide gauges along European coastlines. The dataset enables the precise identification and analysis of sea level variations occurring at periods from minute to multi-yearly along the majority of European coastlines.
Variables:	
time	long name = Time units = seconds since 2000-01-01 00:00:00 UTC
sea_level_qc	long name = Quality-controlled sea level time series units = m
residual	long name = Residual time series units = m
qc_flags	long name = Quality control flags flag meaning = 1 High-quality data 0 Missing or removed data

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Besides spatial distribution, the following regional close-up views (Fig. 7-9) reveal detailed insights about the infrastructure supporting sea level monitoring. The figures show locations, technological preferences (i.e. type of sensor) and operational characteristics (i.e. sampling frequency) of stations in three regions: a) Region 1: Central and Eastern Mediterranean Sea and Black Sea regions (98 stations; Fig. 7); b) Region 2: Western Mediterranean, Western European coasts, and Canary Islands (84 stations; Fig. 8); c) Region 3: Northern European coasts, including the United Kingdom, Ireland, Iceland, Greenland, Norway, Sweden, Denmark, the Netherlands, and Belgium (75 stations; Fig. 9).

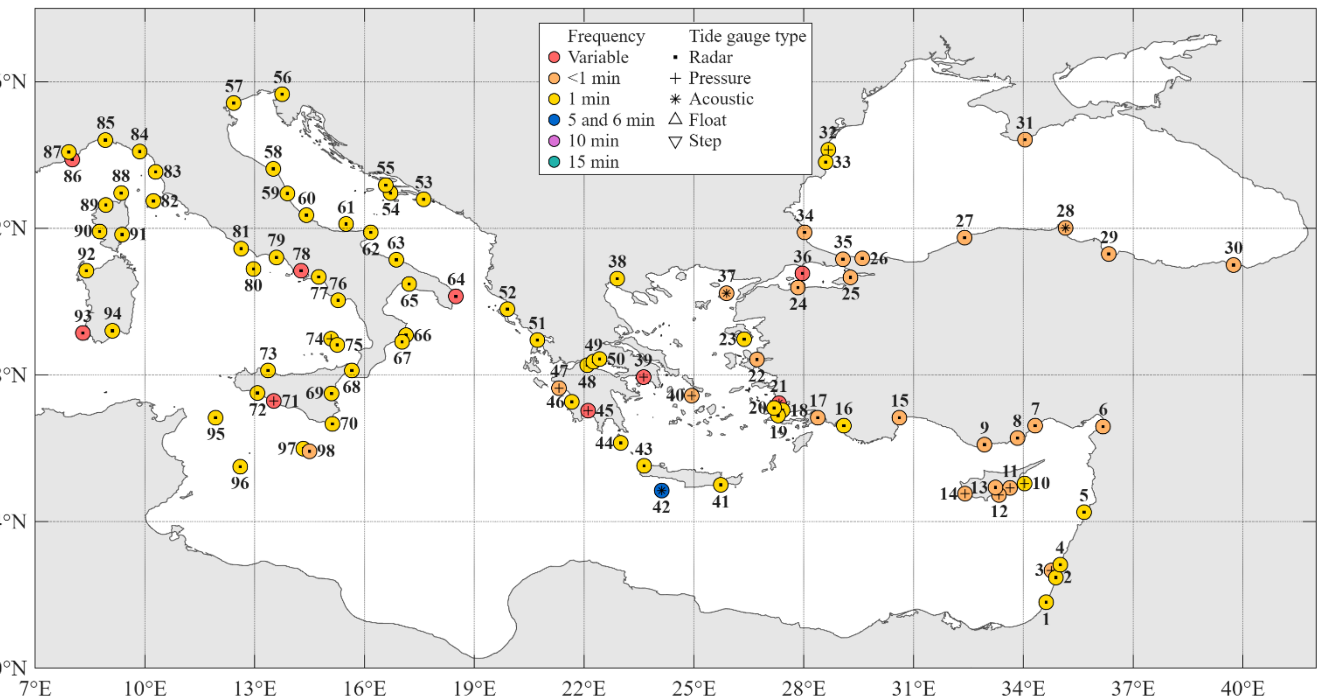

Figure 7. Distribution and characteristics of tide gauge stations in the Central and Eastern Mediterranean and Black seas as of January 2021. Marker colours indicate sampling frequency while internal symbols denote the type of tide gauge instrumentation. Station names and metadata are provided in Appendix A, table A1. Note that stations 3, 13, 20, 21, 74, and 87 are slightly repositioned from their true geographical coordinates to improve visibility on the map.

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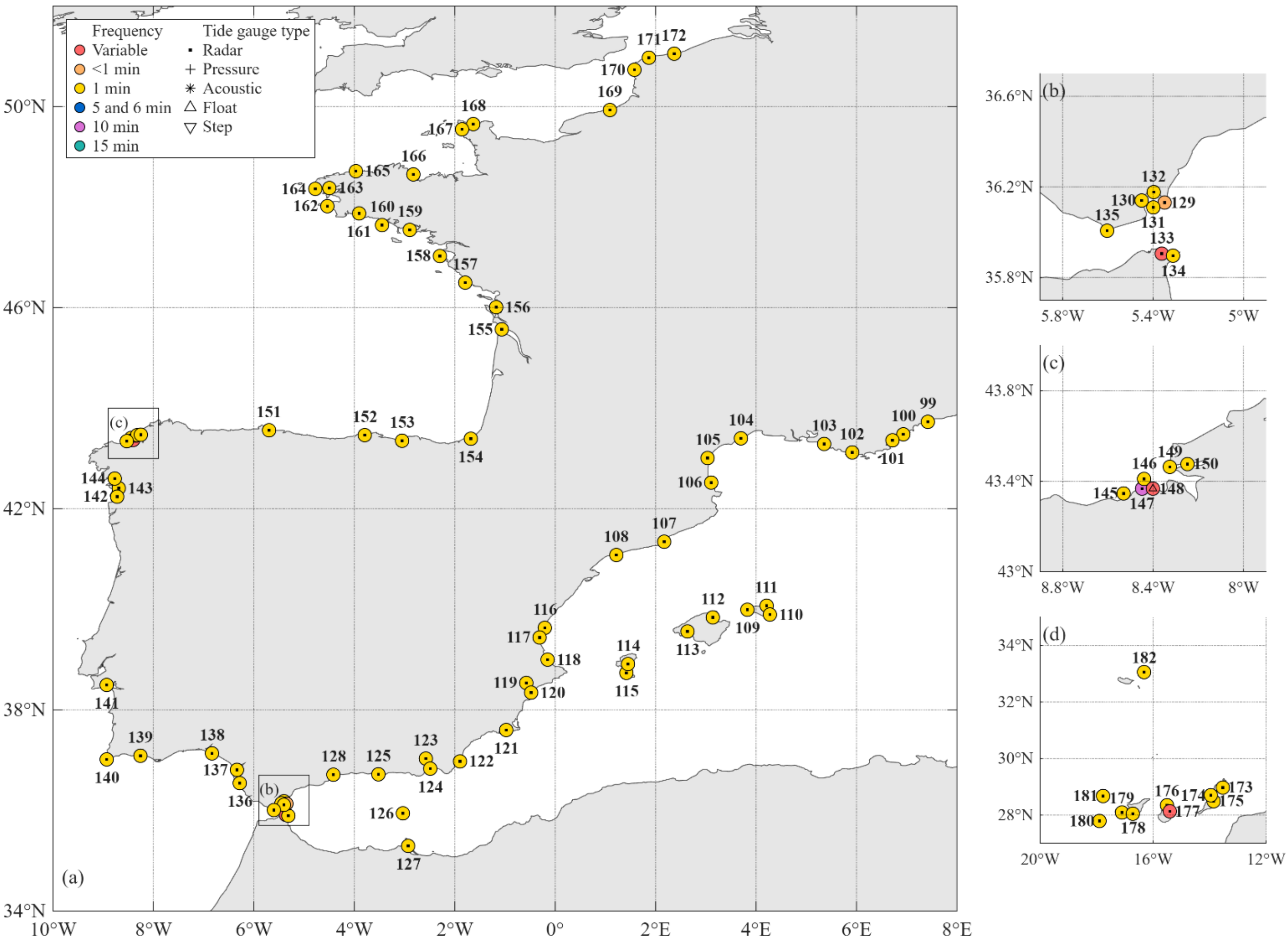

Figure 8. Same as in Figure 7 but for (a) the Western Mediterranean and western European coasts, with panels (b) and (c) displaying zoomed-in views of selected regions, and (d) the Canary Islands (precise location is indicated in Figure 1). Station names and metadata are provided in Appendix A, table A2. Note that stations 111, 119, 123, 130, 131, 133, 146, 147, 174 and 176 are slightly repositioned from their true geographical coordinates to improve visibility on the map.

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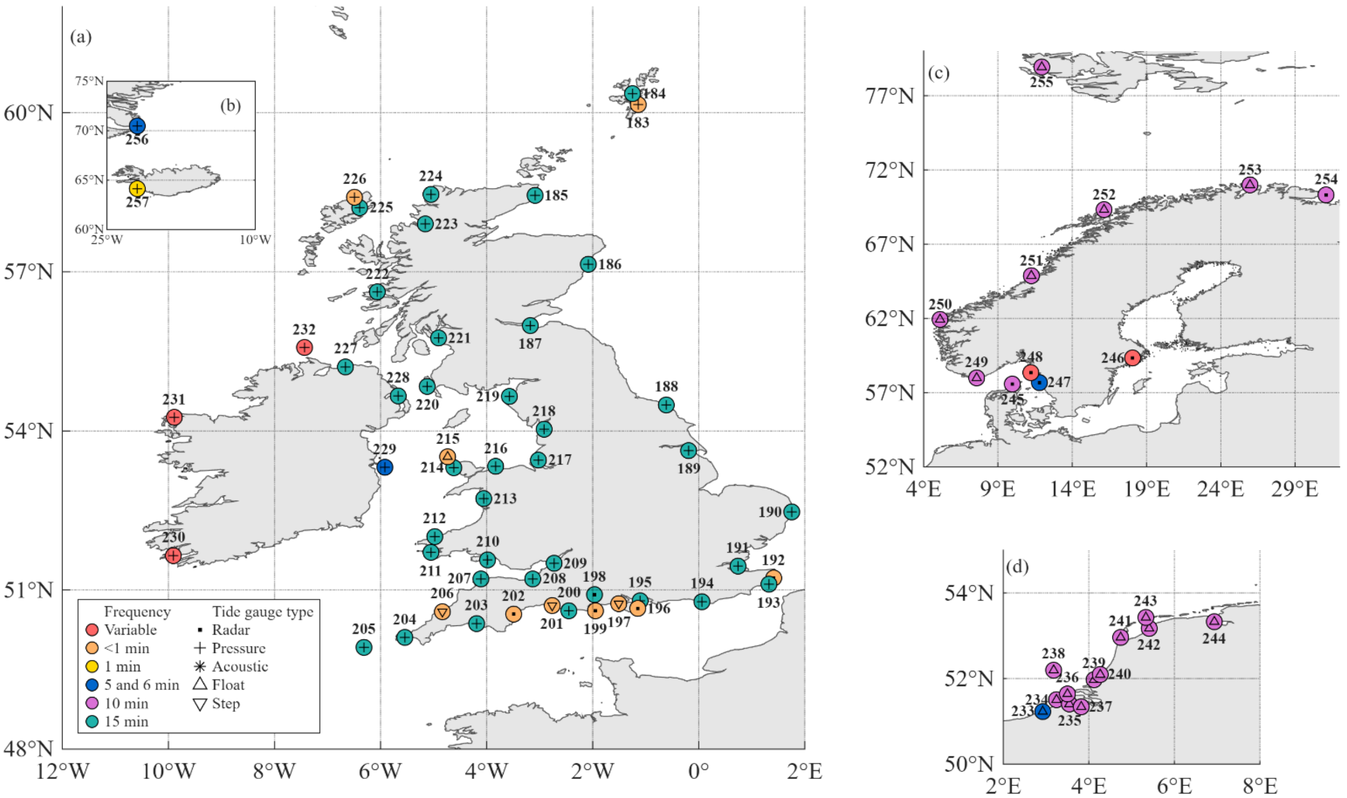

Figure 9. Same as in Figure 7 but for (a) UK and Ireland, (b) Iceland and Greenland (precise location is indicated in Figure 1), (c) Norway, Sweden and Denmark, (d) The Netherlands and Belgium. Station names and metadata are provided in Appendix A, table A3. Note that stations 184, 198, 215, 226, 232, 236 and 238 are slightly repositioned from their true geographical coordinates to improve visibility on the map.

The bar charts in Fig. 10 give an overview of the distribution of records across different countries, showing the cumulative years of data available for each country, the periods those records cover, the starting year of records, and specific technical information about the tide gauges featured in the dataset. As shown in Fig. 10a, Spain stands out as the top contributor, with 50 records and just over 400 years of accumulated data, closely followed by the United Kingdom. Italy and France contribute fewer records (30 – 37) but still exceed 270 years of accumulated data. When comparing the number of records to the total years of data collected for each country, significant differences are found. For instance, Türkiye and Greece have a relatively high number of records but shorter cumulative durations, indicating shorter records. Other countries have considerably less data, highlighting regional differences in data accessibility.

The temporal distribution of records shows variation in time series length (Fig. 10b); while some records span over a decade, there are also records shorter than three years. Additionally, information on the starting year of records (Fig. 10c) provides important context for understanding the development and expansion of the IOC database over time. Peaks in 2008 and 2012 correspond to the addition of Italian stations (16 of 36) and UK stations (42 of 47) to the network, respectively.

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From a technical point of view, a 1-minute sampling frequency is the most common temporal resolution, as illustrated in Fig. 10d. This frequency aligns with modern oceanographic standards and international protocols. It is the dominant sampling frequency observed in Region 1 (Fig. 7) and Region 2 (Fig. 8). In contrast, in Region 3 (Fig. 9), instruments with sampling frequencies of 10 and 15 minutes are predominantly used. The final chart presents information about instrumentation choices and categorizes records based on the tide gauge type (Fig. 10e). A significant portion of the network is equipped with radar sensors, which account for 68.1% of all sensors. This aligns with the IOC recommendations for upgrading tide gauge networks. The analysis of tide gauge types shows that radar sensors are the dominant choice in both Region 1 (Fig. 7) and Region 2 (Fig. 8), while bottom pressure recorders and float tide gauges are more commonly used in Region 3 (Fig. 9).

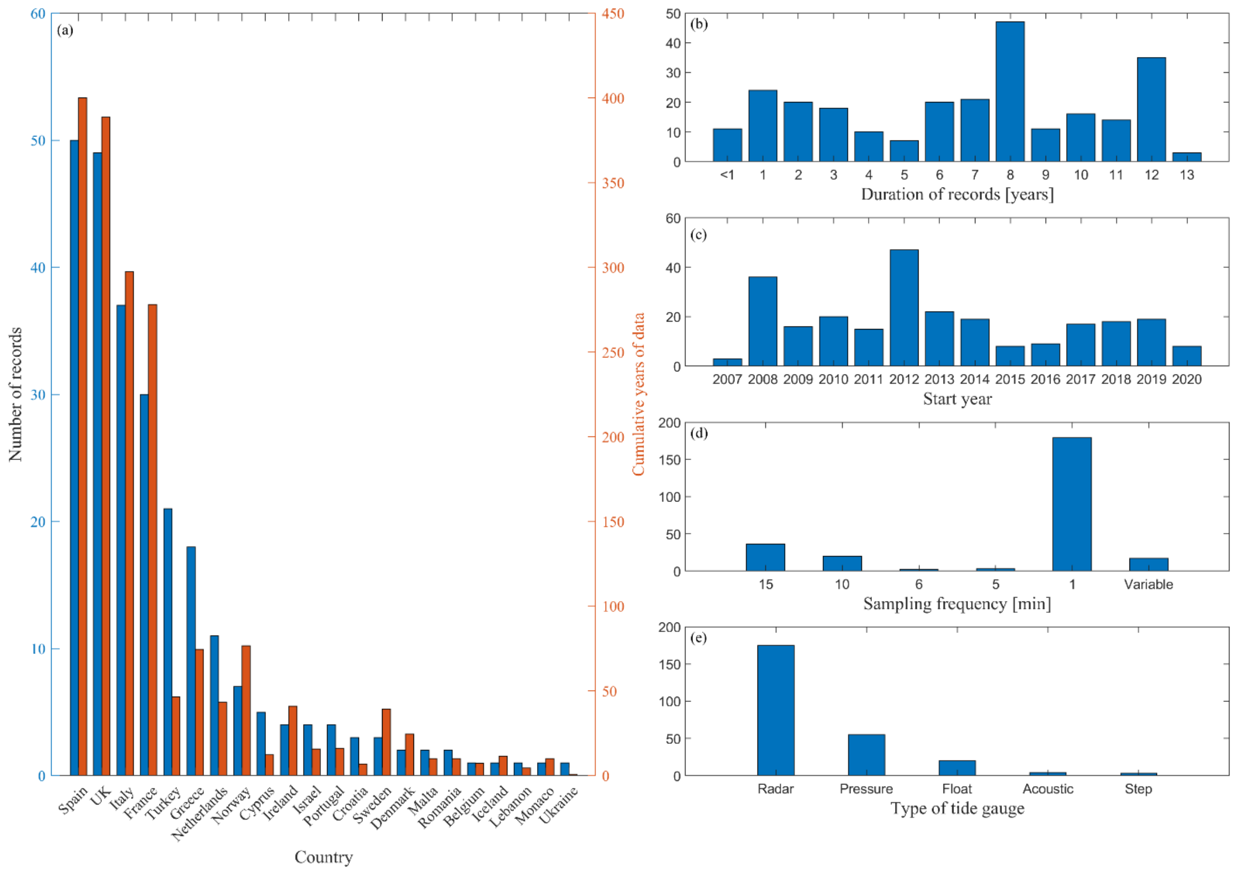

Figure 10. (a) The total number of records (blue bars) and the cumulative years of data (red bars) available for each country; (b) Number of records categorized by duration in years; (c) Number of records with data starting in a specific year; (d) Distribution of records based on sampling frequency; (e) Distribution of records according to tide gauge type.

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4 Data availability

Data described in this paper can be accessed through the Marine Data Archive of the Flanders Marine Institute (VLIZ) at https://doi.org/10.14284/764 (Balić and Šepić, 2025).

5 Discussion and conclusions

The Sub-Hourly European Sea Level Dataset (SHELDA) provides a valuable resource for analysis of sea level variations occurring at periods from minutes to multi-yearly along European coastlines. The utilization of such data for research purposes requires the previous implementation of rigorous quality control procedures to ensure the prevention of misinterpretation of findings and dissemination of inaccurate conclusions. By performing quality control procedures on raw sea level time series from the IOC SLSMF database, we have created a high-quality research dataset containing nearly 1816 stations years of sea level data sampled with a 1–15-minute time step and originating from 257 records across 22 countries. The procedures used for quality control of the SHELDA dataset involved several steps that combined both automated and visual control methods. Automated methods were used so the same criteria could be easily and quickly applied across all data, and visual inspection had to be included because there were some erroneous data that the automated processes missed. Particularly challenging were spurious data points, such as flat lines and clustered spikes, and special issues like attenuated signals. Statistical analysis of the quality control process indicated that visual inspection remains essential despite automated procedures, accounting for 55.31% of the total data removals. This underscores the limitation of our automated quality control algorithm and highlights the potential for developing techniques that will automatically detect the aforementioned problems. The development of those advanced algorithms will significantly improve and accelerate quality control, making visual inspection less time consuming compared to our previous experience.

A comparison of SHELDA with similar existing datasets, GESLA (Haigh et al., 2022) and MISELA (Zemunik et al., 2021), shows the differences between them. While GESLA mainly consists of global hourly sea level measurements with different levels of quality control, SHELDA focuses on European sea level records sampled with a 1-15 minute time step, implementing rigorous quality control procedures. Compared to MISELA, which provides 1-minute quality-controlled records, with an applied high-pass filter with a 2-hour cut-off period, SHELDA is more appropriate for the analysis of sea level processes across a wide range of timescales because it preserves the full spectral content of measurements. Access to high-quality sea level data of a 1–15-minute time step is important for improving our understanding of coastal flooding hazards, which often result from complex interactions between different sea level components across multiple timescales (Woodworth et al., 2019; Idier et al., 2019). The SHELDA dataset is particularly valuable for investigating contribution of high-frequency phenomena to flooding.

Several limitations of the SHELDA dataset must be acknowledged. First, the spatial distribution of tide gauges remains uneven across the European coasts. Expanding geographical coverage could involve adding more stations in underrepresented regions, which might require incorporating additional data sources beyond the IOC SLSMF database and

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collaborating with regional monitoring programs to improve data sharing. There is significant potential to update the dataset in the future, as at least 70 new stations have been added to the IOC database since January 2021 (e.g., 50 Swedish and 21 Norwegian sea level stations, added to the system in October 2021 and June 2023, respectively). Second, the temporal coverage varies significantly between stations, with 55 of them having records that span less than three years. This is particularly evident for the Croatian Adriatic coast and the eastern Mediterranean and Black Sea regions. While the availability of short time series, especially when they are new records, is welcome, short series resulting from discontinued tide gauge operations are concerning. Therefore, in addition to recommending the targeted addition of new tide gauges to the European sea level monitoring network and advocating for open data and free data access where data exists but is not shared due to local regulations (e.g., Pérez Gómez et al., 2022 for the Mediterranean), it is also necessary to focus on the maintenance of existing tide gauges to ensure that they continue to operate effectively in the future.

To ensure that the dataset remains useful for both operational and research purposes, it will need to be updated regularly. As mentioned earlier, the quality control process is particularly time-consuming, especially when involving visual inspections, so improving the algorithms for automated quality control would be extremely helpful. Therefore, it is worth noting that in spring 2025, VLIZ introduced a new API (Application Programming Interface) web service for the SLSMF, which provides access to automated quality-controlled sea level data (https://api.ioc-sealevelmonitoring.org/v2/doc, last access: 10 December 2025). Using this service could significantly simplify and accelerate our workflow, as the automated quality control methodology is compatible with our existing procedures. However, it is important to note that the API does not include visual inspection, so, if the highest data quality is required, an additional visual quality control step may still be necessary.

Extreme sea levels (Vousdoukas et al., 2017) and coastal flooding (IPCC, 2014; Hinkel et al., 2014) are growing threat to European coastlines, largely due to rising mean sea levels driven by climate change (Oppenheimer et al., 2019; Hamlington et al., 2024). In recent decades, the frequency of extreme sea level events has increased at many locations (Menéndez and Woodworth, 2010; Haigh et al., 2010). To predict these hazards, researchers use global models of tide, storm surges, and wave setup to obtain projections of episodic coastal flooding over the coming century (Kirezci et al., 2020). These models are validated against tide gauge data, highlighting the critical need for reliable, high-quality datasets like SHELDA. By sharing this quality-controlled dataset openly with researchers, we hope to make it easier to analyse the complex sea level phenomena behind coastal flooding, particularly in regions where high-frequency processes may dominate or significantly contribute to overall extremes. This improved ability to study processes across different timescales will be crucial for creating effective adaptation strategies and helping coastal areas become more resilient.

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APPENDIX A: Tide gauge stations metadata

Table A1. Tide gauge station metadata for Region 1. Station index (see Fig. 7), IOC code, full name, country, latitude, longitude, start and end dates for quality controlled records, the sampling interval of raw data (min) and sensor type are provided for all stations as of January 2021.

No.	*IOC code*	*Full name*	*Country*	*Latitude*	*Longitude*	*Start time*	*End time*	*Sampling interval*	*Type of sensor*
1	**ashd1**	Ashdod Marina	Israel	31,80	34,63	2.2.2018 5:02	8.6.2020 21:25	1	Radar
2	**hade2**	Hadera Port	Israel	32,47	34,88	31.1.2018 4:47	14.6.2020 14:21	1	Radar
3	**hade**	Hadera	Israel	32,47	34,86	10.5.2010 7:51	24.6.2018 21:02	< 1	Pressure
4	**haif**	Haifa	Israel	32,82	35,01	29.1.2018 4:42	1.1.2021 0:00	1	Radar
5	**batr**	Batroun	Lebanon	34,25	35,66	30.6.2016 6:47	1.1.2021 0:00	1	Radar
6	**iske**	Iskenderun	Türkiye	36,59	36,18	17.8.2016 7:25	1.1.2021 0:00	< 1	Radar
7	**erdem**	Erdemli	Türkiye	36,61	34,33	16.8.2016 10:52	23.5.2020 22:55	< 1	Radar
8	**tasu**	Tasucu	Türkiye	36,28	33,84	26.11.2019 22:03	1.1.2021 0:00	< 1	Radar
9	**bozy**	Bozcaada	Türkiye	36,10	32,94	16.8.2016 11:22	25.12.2017 21:16	< 1	Radar
10	**para**	Paralimni	Cyprus	35,04	34,04	8.5.2013 9:56	24.3.2015 8:43	1	Pressure
11	**larn**	Larnaca	Cyprus	34,92	33,64	8.5.2013 11:12	5.11.2014 19:57	< 1	Pressure
12	**zygy**	Zygi	Cyprus	34,73	33,34	7.9.2011 12:42	11.12.2013 4:37	< 1	Pressure
13	**zygy1**	Zygi	Cyprus	34,73	33,34	16.3.2018 4:20	17.12.2020 9:49	< 1	Radar
14	**papho**	Paphos	Cyprus	34,76	32,41	9.3.2011 14:58	18.3.2015 1:42	< 1	Pressure
15	**anta**	Antalya	Türkiye	36,84	30,61	26.11.2019 22:03	1.1.2021 0:00	< 1	Radar
16	**feth**	Fethiye	Türkiye	36,62	29,09	21.12.2015 9:16	9.5.2020 22:02	1	Radar
17	**mrms**	Marmaris	Türkiye	36,84	28,38	26.11.2019 22:04	1.1.2021 0:00	< 1	Radar
18	**bodri**	Bodrum (IDSL)	Türkiye	37,03	27,43	29.10.2019 5:48	1.1.2021 0:00	1	Radar
19	**kos2**	Kos Marina	Greece	36,89	27,30	16.9.2019 4:28	1.1.2021 0:00	1	Radar
20	**kos1**	Kos	Greece	36,90	27,29	10.7.2018 6:54	17.12.2020 12:00	1	Radar
21	**bodr**	Bodrum	Türkiye	37,03	27,42	27.11.2010 10:30 16.8.2016 10:53	17.11.2011 14:15 1.1.2021 0:00	Variable 15 < 1	Acoustic
22	**ment**	Mentes	Türkiye	38,43	26,72	4.11.2020 21:11	1.1.2021 0:00	< 1	Radar
23	**plom**	Plomari	Greece	38,97	26,37	18.12.2019 16:32	1.1.2021 0:00	1	Radar
24	**erdek**	Erdek	Türkiye	40,39	27,85	4.11.2020 21:05	1.1.2021 0:00	< 1	Radar
25	**yalo**	Yalova	Türkiye	40,66	29,28	4.11.2020 21:11	1.1.2021 0:00	< 1	Radar
26	**sile**	Sile	Türkiye	41,18	29,60	4.11.2020 21:16	1.1.2021 0:00	< 1	Radar
27	**amas**	Amasra	Türkiye	41,74	32,39	4.11.2020 21:06	1.1.2021 0:00	< 1	Radar
28	**sino**	Sinop	Türkiye	42,02	35,15	6.3.2017 14:00	1.1.2021 0:00	< 1	Acoustic
29	**sams**	Samsun	Türkiye	41,29	36,34	26.11.2019 22:03	26.12.2020 19:14	< 1	Radar
30	**trab**	Trabzon	Türkiye	41,00	39,74	26.11.2019 22:04	1.1.2021 0:00	< 1	Radar
31	**kaci**	Kaciveli	Ukraine	44,42	34,05	28.1.2011 8:26	3.11.2011 8:34	< 1	Radar
32	**csta2**	Constanta	Romania	44,15	28,67	5.12.2015 7:34	10.11.2020 10:52	1	Pressure

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33	**mang**	Mangalia	Romania	43,80	28,60	5.12.2015 7:34	1.1.2021 0:00	1	Radar
34	**igne**	Igneada	Türkiye	41,89	28,02	4.11.2020 20:58	1.1.2021 0:00	< 1	Radar
35	**ista**	Istanbul	Türkiye	41,16	29,07	4.11.2020 21:11	1.1.2021 0:00	< 1	Radar
36	**maer**	Marmara Ereglisi	Türkiye	40,77	27,97	16.2.2011 5:15 17.11.2011 12:42	17.11.2011 7:15 1.1.2021 0:00	Variable 15 1	Radar
37	**gokc**	Gokceada	Türkiye	40,23	25,89	24.11.2019 21:57	1.1.2021 0:00	< 1	Acoustic
38	**thes**	Thessaloniki	Greece	40,63	22,91	28.10.2018 20:49	13.10.2020 6:40	1	Radar
39	**peir**	Peiraias	Greece	37,93	23,62	20.11.2009 16:59 26.1.2018 8:10	21.1.2018 4:15 1.1.2021 0:00	Variable 1 5	Pressure
40	**syro**	Syros	Greece	37,44	24,94	20.11.2009 17:00	1.1.2021 0:00	< 1	Pressure
41	**iera**	Ierapetra	Greece	35,00	25,74	24.10.2018 8:44	1.1.2021 0:00	1	Radar
42	**gvd9**	Gavdos	Greece	34,85	24,12	12.9.2012 8:06	21.5.2015 13:18	6	Acoustic
43	**kast**	Kasteli	Greece	35,51	23,64	28.6.2010 12:38	16.5.2016 18:24	1	Radar
44	**kaps**	Kapsali	Greece	36,14	23,00	26.10.2017 17:30	29.1.2018 3:03	1	Radar
45	**kala**	Kalamata	Greece	37,02	22,11	20.11.2009 17:00 15.10.2017 21:50	17.11.2014 5:15 1.1.2021 0:00	Variable 1 5	Pressure
46	**kypa**	Kyparissia	Greece	37,26	21,66	21.10.2018 19:01	1.1.2021 0:00	1	Radar
47	**kata**	Katakolo	Greece	37,64	21,32	20.11.2009 17:00	1.1.2021 0:00	< 1	Pressure
48	**aigi**	Aigio	Greece	38,26	22,08	21.10.2018 20:29	1.1.2021 0:00	1	Radar
49	**pano**	Panormos	Greece	38,36	22,25	23.11.2017 15:49	1.1.2021 0:00	1	Radar
50	**itea**	Itea	Greece	38,43	22,42	21.10.2018 20:20	1.1.2021 0:00	1	Radar
51	**prev**	Preveza	Greece	38,95	20,73	20.7.2020 15:31	1.1.2021 0:00	1	Radar
52	**corf**	Kerkyra, Corfu	Greece	39,79	19,91	28.10.2018 20:49	25.11.2020 9:01	1	Radar
53	**sobr**	Sobra	Croatia	42,79	17,62	2.10.2018 21:01	1.1.2021 0:00	1	Radar
54	**vela**	Vela Luka	Croatia	42,96	16,72	2.10.2018 21:01	1.1.2021 0:00	1	Radar
55	**stari**	Stari Grad	Croatia	43,18	16,58	2.10.2018 21:01	1.1.2021 0:00	1	Radar
56	**TR22**	Trieste	Italy	45,65	13,76	29.9.2008 6:21	1.1.2021 0:00	1	Radar
57	**VE19**	Venice	Italy	45,42	12,43	17.2.2010 20:46	1.1.2021 0:00	1	Radar
58	**AN15**	Ancona	Italy	43,63	13,51	15.12.2013 14:11	1.1.2021 0:00	1	Radar
59	**SB36**	S.Benedetto Del Tronto	Italy	42,96	13,89	15.12.2013 13:56	1.1.2021 0:00	1	Radar
60	**OR24**	Ortona	Italy	42,36	14,41	15.12.2013 13:56	1.1.2021 0:00	1	Radar
61	**IT45**	Isole Tremiti	Italy	42,12	15,50	15.12.2013 13:56	1.1.2021 0:00	1	Radar
62	**VI12**	Vieste	Italy	41,89	16,18	15.12.2013 14:11	1.1.2021 0:00	1	Radar
63	**BA05**	Bari	Italy	41,14	16,87	15.12.2013 13:56	1.1.2021 0:00	1	Radar
64	**OT15**	Otranto	Italy	40,15	18,50	27.9.2008 7:30 17.2.2010 6:11	17.2.2010 6:10 1.1.2021 0:00	Variable 10 1	Radar
65	**TA18**	Taranto	Italy	40,48	17,22	15.12.2013 14:11	1.1.2021 0:00	1	Radar

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66	**CR08**	Crotone	Italy	39,08	17,14	15.12.2013 13:56	1.1.2021 0:00	1	Radar
67	**lcst**	Le Castella	Italy	38,91	17,03	10.7.2016 7:07	9.5.2019 21:16	1	Radar
68	**RC09**	Reggio Calabria	Italy	38,12	15,65	15.12.2013 13:56	1.1.2021 0:00	1	Radar
69	**CT03**	Catania	Italy	37,50	15,09	13.9.2010 23:25	1.1.2021 0:00	1	Radar
70	**ppcp**	Portopalo di Capo Passero	Italy	36,67	15,12	21.3.2016 15:44	29.11.2020 7:09	1	Radar
71	**PE09**	Porto empedocle	Italy	37,29	13,53	27.9.2008 7:30 14.9.2010 12:11	14.9.2010 12:10 1.1.2021 0:00	Variable 10 1	Pressure
72	**SC43**	Sciacca	Italy	37,50	13,08	15.12.2013 13:56	1.1.2021 0:00	1	Radar
73	**PA07**	Palermo	Italy	38,12	13,37	15.6.2014 7:21	1.1.2021 0:00	1	Radar
74	**GI20**	Ginostra (Isola di Stromboli)	Italy	38,78	15,19	14.11.2010 16:46	1.1.2021 0:00	1	Pressure
75	**ST44**	Strombolicchio	Italy	38,82	15,25	15.12.2013 14:11	13.1.2015 21:45	1	Radar
76	**PL14**	Palinuro	Italy	40,03	15,28	1.2.2014 14:31	1.1.2021 0:00	1	Radar
77	**SA16**	Salerno	Italy	40,68	14,75	15.12.2013 13:56	1.1.2021 0:00	1	Radar
78	**NA23**	Napoli	Italy	40,84	14,27	27.9.2008 7:30 17.2.2010 6:11	17.2.2010 6:10 1.1.2021 0:00	Variable 10 1	Radar
79	**GA37**	Gaeta	Italy	41,21	13,59	15.12.2013 13:56	1.1.2021 0:00	1	Radar
80	**PO40**	Ponza	Italy	40,90	12,97	15.12.2013 13:56	1.1.2021 0:00	1	Radar
81	**AZ42**	Anzio	Italy	41,45	12,64	15.12.2013 13:56	1.1.2021 0:00	1	Radar
82	**MC41**	Marina Di Campo	Italy	42,74	10,24	15.12.2013 13:56	1.1.2021 0:00	1	Radar
83	**LI11**	Livorno	Italy	43,55	10,30	10.6.2014 12:15	1.1.2021 0:00	1	Radar
84	**LA38**	La Spezia	Italy	44,10	9,86	19.11.2013 0:00	1.1.2021 0:00	1	Radar
85	**GE25**	Genova	Italy	44,41	8,93	13.9.2010 23:13	1.1.2021 0:00	1	Radar
86	**IM01**	Imperia	Italy	43,88	8,02	27.9.2008 7:30 17.2.2010 6:11	17.2.2010 6:10 1.1.2021 0:00	Variable 10 1	Radar
87	**im02**	Imperia 2	Italy	43,88	8,02	12.2.2015 20:35	1.1.2021 0:00	1	Radar
88	**cent2**	Centuri 2	France	42,97	9,35	11.1.2011 5:27	1.1.2021 0:00	1	Radar
89	**rous2**	Ile Rousse 2	France	42,64	8,94	29.8.2011 14:05	1.1.2021 0:00	1	Radar
90	**ajac**	Ajaccio	France	41,92	8,76	18.9.2009 10:31	29.12.2020 14:22	1	Radar
91	**sole**	Solenzara	France	41,84	9,37	2.11.2010 23:58	30.10.2020 8:57	1	Radar
92	**PT17**	Porto Torres	Italy	40,84	8,40	12.9.2010 16:01	1.1.2021 0:00	1	Radar
93	**CF06**	Carloforte	Italy	39,14	8,31	27.9.2008 7:30 17.2.2010 6:11	17.2.2010 6:10 1.1.2021 0:00	Variable 10 1	Radar
94	**CA02**	Cagliari	Italy	39,21	9,11	13.9.2010 23:25	1.1.2021 0:00	1	Radar
95	**pant**	Pantelleria	Italy	36,83	11,94	21.3.2016 15:45	13.4.2020 18:54	1	Radar
96	**LA23**	Lampedusa	Italy	35,50	12,60	12.9.2010 16:01	1.1.2021 0:00	1	Radar

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97	**malt**	Malta	Malta	35,99	14,33	29.10.2019 5:58	17.12.2020 18:59	1	Radar
98	**ptma**	Portomaso	Malta	35,92	14,49	16.2.2011 13:48	4.12.2019 16:02	< 1	Radar

Table A2. Tide gauge station metadata for Region 2. Station index (see Fig. 8), IOC code, full name, country, latitude, longitude, start and end dates for quality controlled records, the sampling interval of raw data (min) and sensor type are provided for all stations as of January 2021

No.	*IOC code*	*Full name*	*Country*	*Latitude*	*Longitude*	*Start time*	*End time*	*Sampling interval*	*Type of sensor*
99	**monc**	Monaco, Fontvieille harbour	Monaco	43,73	7,42	30.11.2010 23:58	31.12.2020 23:59	1	Radar
100	**figu**	La Figueirette	France	43,48	6,93	31.5.2011 23:57	31.12.2020 23:54	1	Radar
101	**ptfe2**	Port Ferréol 2	France	43,36	6,72	5.4.2012 13:40	1.1.2021 0:00	1	Radar
102	**toul2**	Toulon 2	France	43,12	5,91	9.4.2010 8:57	1.1.2021 0:00	1	Radar
103	**mars**	Marseille	France	43,29	5,36	27.10.2010 11:39	22.1.2019 2:32	1	Radar
104	**sete**	Sète	France	43,40	3,70	1.7.2011 9:18	31.12.2020 23:59	1	Radar
105	**ptln**	Port-La-Nouvelle	France	43,01	3,04	29.5.2013 12:04	31.12.2020 23:59	1	Radar
106	**ptve**	Port-Vendres	France	42,52	3,11	7.3.2011 0:00	31.12.2020 23:59	1	Radar
107	**barc**	Barcelona	Spain	41,34	2,17	27.2.2008 11:12	1.1.2021 0:00	1	Radar
108	**tarr**	Tarragona	Spain	41,08	1,21	10.1.2014 18:53	1.1.2021 0:00	1	Radar
109	**ciut**	Ciutadella	Spain	39,99	3,83	26.10.2017 8:38	1.1.2021 0:00	1	Radar
110	**maho**	Mahon	Spain	39,89	4,27	15.6.2018 5:33	1.1.2021 0:00	1	Radar
111	**lmma**	La Mola de Mahon	Spain	39,87	4,31	26.10.2017 13:04	1.1.2021 0:00	1	Radar
112	**alcu**	Alcudia	Spain	39,84	3,14	11.10.2009 21:45	1.1.2021 0:00	1	Radar
113	**palm**	Palma de Mallorca	Spain	39,56	2,64	15.10.2009 8:43	1.1.2021 0:00	1	Radar
114	**ibiz**	Ibiza2	Spain	38,91	1,45	11.10.2009 21:46	1.1.2021 0:00	1	Radar
115	**form**	Formentera	Spain	38,73	1,42	10.1.2014 18:59	1.1.2021 0:00	1	Radar
116	**sagu**	Sagunto	Spain	39,63	-0,21	25.3.2008 14:04	1.1.2021 0:00	1	Radar
117	**vale**	Valencia	Spain	39,44	-0,31	25.3.2008 14:04	1.1.2021 0:00	1	Radar
118	**gand**	Gandia	Spain	39,00	-0,15	27.2.2008 11:11	1.1.2021 0:00	1	Radar
119	**alac1**	Alicante 1	Spain	38,34	-0,48	1.12.2019 0:00	13.12.2020 6:02	1	Radar
120	**alac2**	Alicante 2	Spain	38,34	-0,48	1.12.2019 0:00	13.12.2020 6:00	1	Radar
121	**murc2**	Murcia	Spain	37,60	-0,97	1.12.2019 0:00	13.12.2020 6:02	1	Radar
122	**carb**	Carboneras	Spain	36,97	-1,90	10.1.2014 18:59	31.12.2020 23:58	1	Radar
123	**alme**	Almeria	Spain	36,83	-2,48	27.2.2008 11:12	1.1.2021 0:00	1	Radar
124	**alme2**	Almeria 2	Spain	36,83	-2,49	1.12.2019 0:00	13.12.2020 6:02	1	Radar
125	**motr**	Motril2	Spain	36,72	-3,52	25.3.2008 14:04	1.1.2021 0:00	1	Radar
126	**albo**	Alboran Island	Spain	35,94	-3,03	1.12.2019 0:03	13.12.2020 6:02	1	Radar
127	**meli**	Melilla	Spain	35,29	-2,93	27.2.2008 11:09	1.1.2021 0:00	1	Radar
128	**mal3**	Malaga	Spain	36,71	-4,42	10.1.2014 18:59	31.12.2020 23:40	1	Radar
129	**gibr**	Gibraltar (tsunami)	UK	36,13	-5,35	10.2.2009 16:21	7.1.2014 7:32	< 1	Radar

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130	**gibr2**	Gibraltar	UK	36,13	-5,35	17.9.2010 0:00	10.1.2019 9:53	1	Radar
131	**gibr3**	Gibraltar	UK	36,13	-5,35	15.1.2019 10:14	1.1.2021 0:00	1	Radar
132	**alge**	Algeciras	Spain	36,18	-5,40	15.10.2009 8:41	1.1.2021 0:00	1	Radar
133	**ceut**	Ceuta	Spain	35,90	-5,31	18.8.2008 0:00 18.10.2018 9:24	27.9.2018 7:10 31.12.2020 21:59	Variable 10 1	Radar
134	**ceut1**	Ceuta 2	Spain	35,90	-5,31	7.9.2017 20:50	1.1.2021 0:00	1	Radar
135	**tari**	Tarifa	Spain	36,01	-5,60	11.10.2009 21:45	1.1.2021 0:00	1	Radar
136	**cadi**	Cadiz	Spain	36,54	-6,28	1.1.2016 0:01	30.12.2020 17:21	1	Radar
137	**bon2**	Bonanza 2	Spain	36,80	-6,34	15.1.2014 3:13	1.1.2021 0:00	1	Radar
138	**huel**	Huelva5	Spain	37,13	-6,83	31.3.2008 16:00	1.1.2021 0:00	1	Radar
139	**albu**	Albufeira	Portugal	37,08	-8,26	1.1.2016 0:01	1.1.2021 0:00	1	Radar
140	**sagr**	Sagres	Portugal	37,01	-8,93	11.10.2015 15:57	1.1.2021 0:00	1	Radar
141	**setu**	Setubal	Portugal	38,49	-8,93	20.2.2015 8:49	28.5.2018 8:34	1	Radar
142	**vig2**	Vigo	Spain	42,24	-8,73	14.1.2014 4:48	1.1.2021 0:00	1	Radar
143	**mari**	Marin	Spain	42,41	-8,69	16.1.2014 8:53	1.1.2021 0:00	1	Radar
144	**vil2**	Villagarcia	Spain	42,60	-8,77	14.1.2014 4:48	1.1.2021 0:00	1	Radar
145	**lang**	Langosteira	Spain	43,35	-8,53	16.1.2014 9:25	1.1.2021 0:00	1	Radar
146	**cor2**	Acoruna	Spain	43,36	-8,39	16.1.2014 9:41	1.1.2021 0:00	1	Radar
147	**acor1**	A Coruña	Spain	43,36	-8,40	12.1.2019 0:00	4.2.2020 3:30	10	Radar
148	**coru**	La Coruña	Spain	43,37	-8,40	18.8.2008 0:00 3.6.2019 7:51	3.6.2019 7:50 1.1.2021 0:00	Variable 5 1	Float
149	**fer1**	Ferroll1	Spain	43,46	-8,33	1.4.2008 16:58	1.1.2021 0:00	1	Radar
150	**fer2**	Ferrol2	Spain	43,48	-8,25	10.1.2014 18:59	1.1.2021 0:00	1	Radar
151	**gij2**	Gijon	Spain	43,56	-5,70	16.1.2014 9:25	1.1.2021 0:00	1	Radar
152	**san2**	Santander	Spain	43,46	-3,79	10.1.2014 18:59	1.1.2021 0:00	1	Radar
153	**bil3**	Bilbao3	Spain	43,35	-3,05	1.4.2008 9:22	1.1.2021 0:00	1	Radar
154	**scoa2**	Socoa	France	43,40	-1,68	8.6.2011 10:32	31.12.2020 23:59	1	Radar
155	**port**	Port-Bloc	France	45,57	-1,06	2.7.2012 10:05	31.12.2020 23:59	1	Radar
156	**iaix**	Ile d'Aix	France	46,01	-1,17	23.5.2011 9:54	7.12.2020 7:17	1	Radar
157	**leso**	Les Sables d'Olonne	France	46,50	-1,79	1.4.2010 8:14	31.12.2020 23:59	1	Radar
158	**herb**	L'Herbaudière	France	47,03	-2,30	13.6.2014 10:19	31.12.2020 23:59	1	Radar
159	**lecy**	Le Crouesty	France	47,54	-2,90	27.5.2010 23:58	31.12.2020 23:59	1	Radar
160	**tudy**	Port-Tudy (Groix island)	France	47,64	-3,45	26.4.2011 23:56	31.12.2020 23:59	1	Radar
161	**conc**	Concarneau	France	47,87	-3,91	3.2.2010 0:00	31.12.2020 23:54	1	Radar
162	**audi2**	Audierne 2	France	48,02	-4,54	3.7.2018 14:09	1.1.2021 0:00	1	Radar
163	**bres**	Brest	France	48,38	-4,50	12.12.2008 0:01	31.12.2020 23:59	1	Radar
164	**leco**	Le Conquet	France	48,36	-4,78	12.12.2008 0:03	31.12.2020 23:59	1	Radar
165	**rosc**	Roscoff	France	48,72	-3,97	2.7.2012 10:05	31.12.2020 23:59	1	Radar
166	**stqy2**	Saint-Quay-	France	48,65	-2,82	10.10.2018 4:58	1.1.2021 0:00	1	Radar

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		Portrieux 2							
167	**diel**	Dielette	France	49,55	-1,86	30.9.2015 23:57	31.12.2020 23:59	1	Radar
168	**cher**	Cherbourg	France	49,65	-1,63	20.12.2008 12:03	31.12.2020 23:59	1	Radar
169	**diep**	Dieppe	France	49,93	1,09	15.4.2009 0:00	31.12.2020 23:59	1	Radar
170	**boul**	Boulogne-Sur-Mer	France	50,73	1,58	1.4.2010 0:01	31.12.2020 23:59	1	Radar
171	**cala**	Calais	France	50,97	1,87	22.10.2009 23:56	31.12.2020 13:00	1	Radar
172	**dunk**	Dunkerque	France	51,05	2,37	9.2.2012 19:41	31.12.2020 23:59	1	Radar
173	**arre**	Arrecife	Spain	28,97	-13,53	4.8.2008 21:47	1.1.2021 0:00	1	Radar
174	**fuer2**	Fuerteventura	Spain	28,50	-13,86	1.12.2019 0:00	13.12.2020 6:02	1	Radar
175	**fue2**	Fuerteventura	Spain	28,49	-13,86	20.2.2014 16:53	1.1.2021 0:00	1	Radar
176	**lasp**	LasPalmas2	Spain	28,14	-15,41	14.10.2009 21:47	1.1.2021 0:00	1	Radar
177	**pluz**	Puerto de la Luz	Spain	28,13	-15,41	18.8.2008 0:00 8.2.2011. 9:50 25.6.2015 9:15	28.4.2010 0:00 25.6.2015 9:10 31.12.2020 7:05	Variable 10 5 1	Radar
178	**tn031**	Arona, Tenerife	Spain	28,05	-16,72	1.12.2019 0:00	9.12.2020 11:56	1	Radar
179	**lago**	LaGomera	Spain	28,09	-17,11	18.4.2008 12:51	1.1.2021 0:00	1	Radar
180	**hie2**	ElHierro	Spain	27,78	-17,90	16.1.2014 9:25	1.1.2021 0:00	1	Radar
181	**lapa**	LaPalma	Spain	28,68	-17,77	31.3.2008 21:11	1.1.2021 0:00	1	Radar
182	**posa**	Porto Santo	Portugal	33,06	-16,31	11.5.2018 6:13	1.1.2021 0:00	1	Radar

Table A3. Tide gauge station metadata for Region 3. Station index (see Fig. 9), IOC code, full name, country, latitude, longitude, start and end dates for quality controlled records, the sampling interval of raw data (min) and sensor type are provided for all stations as of January 2021.

No.	***IOC code***	***Full name***	***Country***	***Latitude***	***Longitude***	***Data start***	***Data end***	***Sampling interval***	***Type of sensor***
183	**lerw**	Lerwick (tsunami)	UK	60,16	-1,15	6.3.2009 17:31	24.2.2018 19:32	< 1	Pressure
184	**lerw2**	Lerwick2	UK	60,16	-1,15	27.4.2012 10:15	1.1.2021 0:00	15	Pressure
185	**work**	Workington	UK	58,44	-3,09	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
186	**abed**	Aberdeen	UK	57,14	-2,08	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
187	**leit**	Leith	UK	55,99	-3,18	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
188	**whit**	Whitby	UK	54,49	-0,61	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
189	**immi**	Immingham	UK	53,63	-0,19	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
190	**lowe**	Lowestoft	UK	52,47	1,75	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
191	**shee**	Sheerness	UK	51,45	0,74	4.9.2012 13:15	1.1.2021 0:00	15	Pressure
192	**dlpr**	Deal Pier	UK	51,22	1,41	5.10.2012 9:09	21.12.2020 21:27	< 1	Radar
193	**dove**	Dover	UK	51,11	1,32	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
194	**nhav**	Newhaven	UK	50,78	0,06	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
195	**ptmt**	Portsmouth	UK	50,80	-1,11	3.9.2012 20:15	1.1.2021 0:00	15	Pressure

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196	**sdpr**	Sandown Pier	UK	50,65	-1,15	5.12.2012 0:06	25.9.2020 18:18	< 1	Radar
197	**lymg**	Lymington	UK	50,74	-1,51	5.10.2012 9:04	11.10.2020 10:24	< 1	Step
198	**bour**	Bournemouth	UK	50,71	-1,87	3.9.2012 20:15	1.1.2021 0:00	15	Radar
199	**swpr**	Swanage Pier	UK	50,61	-1,95	20.9.2012 19:57	19.3.2020 12:50	< 1	Radar
200	**weym**	Weymouth	UK	50,61	-2,45	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
201	**wbhb**	West Bay Harbour	UK	50,71	-2,76	4.10.2012 11:23	16.3.2020 1:36	< 1	Step
202	**tnpr**	Teignmouth Pier	UK	50,54	-3,49	20.9.2012 18:01	3.2.2014 8:28	< 1	Radar
203	**plym**	Plymouth	UK	50,37	-4,19	10.9.2012 16:00	1.1.2021 0:00	15	Pressure
204	**newl2**	Newlyn	UK	50,10	-5,54	5.10.2011 19:00	14.6.2020 7:15	15	Pressure
205	**stmr**	St Marys	UK	49,92	-6,32	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
206	**ptis**	Port Isaac	UK	50,59	-4,83	5.10.2012 9:09	19.12.2020 18:32	< 1	Step
207	**ilfa**	Ilfracombe	UK	51,21	-4,11	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
208	**hink**	Hinkley Point	UK	51,21	-3,13	3.9.2012 20:15	7.12.2020 14:00	15	Pressure
209	**avon**	Avonmouth Portbury	UK	51,50	-2,73	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
210	**mumb**	Mumbles	UK	51,57	-3,98	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
211	**mhav**	Milford Haven	UK	51,71	-5,05	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
212	**fish**	Fishguard	UK	52,01	-4,98	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
213	**barm**	Barmouth	UK	52,72	-4,05	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
214	**holy2**	Holyhead2	UK	53,31	-4,62	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
215	**holy**	Holyhead (tsunami)	UK	53,31	-4,63	22.1.2009 13:37	19.2.2019 15:18	< 1	Float
216	**llan**	Llandudno	UK	53,33	-3,83	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
217	**live**	Liverpool	UK	53,45	-3,02	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
218	**heys**	Heysham	UK	54,03	-2,92	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
219	**wick**	Wick Harbour	UK	54,65	-3,57	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
220	**porp**	Portpatrick	UK	54,84	-5,12	3.9.2012 20:15	31.12.2020 23:45	15	Pressure
221	**mill**	Millport	UK	55,75	-4,91	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
222	**tobe**	Tobermory	UK	56,62	-6,06	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
223	**ulla**	Ullapool	UK	57,90	-5,16	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
224	**kinl**	Kinlochbervie	UK	58,46	-5,05	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
225	**stor**	Stornoway	UK	58,21	-6,39	9.4.2012 13:30	1.1.2021 0:00	15	Pressure
226	**stor2**	Stornoway (tsunami)	UK	58,21	-6,39	12.12.2013 13:29	12.2.2019 9:20	< 1	Pressure
227	**prus**	Portrush	UK	55,21	-6,66	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
228	**bang**	Bangor	UK	54,66	-5,67	3.9.2012 20:15	1.1.2021 0:00	15	Pressure
229	**kis1**	Kish Bank Lighthouse	Ireland	53,31	-5,92	12.6.2008 22:00	12.3.2015 19:54	6	Pressure
230	**cast**	Castletownbere	Ireland	51,65	-9,90	16.6.2008 12:45 21.3.2018 11:35	21.3.2018 9:00 1.1.2021 0:00	Variable 15 5	Pressure

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231	**ball**	Ballyglass pier, Belmullet	Ireland	54,25	-9,89	11.6.2008 10:06 13.3.2018 9:00	13.3.2018 8:54 24.10.2020 2:20	Variable 6 5	Pressure
232	**mali**	Malin Head Peninsular	Ireland	55,37	-7,33	26.8.2011 13:06 12.3.2018 11:10	12.3.2018 10:00 1.1.2021 0:00	Variable 6 5	Pressure
233	**oste**	Ostend	Belgium	51,23	2,92	6.9.2013 0:00	1.1.2021 0:00	5	Float
234	**vlrn**	Vlakte v/d Raan	Netherlands	51,50	3,24	11.1.2017 19:50	1.1.2021 0:00	10	Float
235	**brsk**	Breskens Handelshaven	Netherlands	51,40	3,55	9.3.2017 9:10	1.1.2021 0:00	10	Float
236	**vlis**	Vlissingen	Netherlands	51,44	3,60	14.1.2017 14:40	1.1.2021 0:00	10	Float
237	**trnz**	Terneuzen	Netherlands	51,34	3,82	11.1.2017 20:10	1.1.2021 0:00	10	Float
238	**euro**	Europlatform	Netherlands	52,00	3,27	11.1.2017 19:50	1.1.2021 0:00	10	Float
239	**hoek**	Hoek van Holland	Netherlands	51,98	4,12	14.1.2017 14:50	1.1.2021 0:00	10	Float
240	**sche**	Scheveningen	Netherlands	52,10	4,26	11.1.2017 20:20	1.1.2021 0:00	10	Float
241	**denh**	Den Helder	Netherlands	52,96	4,74	14.1.2017 14:50	1.1.2021 0:00	10	Float
242	**harl**	Harlingen	Netherlands	53,18	5,41	14.1.2017 14:50	1.1.2021 0:00	10	Float
243	**ters**	Terschelling Noordzee	Netherlands	53,43	5,33	7.3.2017 11:20	1.1.2021 0:00	10	Float
244	**delf**	Delfzijl	Netherlands	53,33	6,93	14.1.2017 15:00	1.1.2021 0:00	10	Float
245	**hirt**	Hirtshals	Denmark	57,60	9,97	3.8.2008 12:20	1.1.2021 0:00	10	Radar
246	**sthm**	Stockholm	Sweden	59,33	18,07	2.12.2007 0:00 27.6.2019 13:49	26.6.2019 11:25 1.1.2021 0:00	Variable 5 1	Radar
247	**goto**	Goteborg Torshamnen	Sweden	57,68	11,78	2.12.2007 0:00	1.1.2021 0:00	5	Radar
248	**smog**	Smogen	Sweden	58,35	11,22	2.12.2007 0:00 20.3.2019 10:52	20.3.2019 8:55 1.1.2021 0:00	Variable 5 1	Radar
249	**treg**	Tregde	Norway	58,01	7,57	16.12.2008 23:00	31.12.2020 0:50	10	Float
250	**malo**	Måløy	Norway	61,93	5,12	17.12.2008 23:00	31.12.2020 0:40	10	Float
251	**rorv**	Rørvik	Norway	64,87	11,25	16.12.2008 23:00	31.12.2020 0:30	10	Float
252	**ande**	Andenes	Norway	69,32	16,15	16.12.2008 23:00	31.12.2020 0:40	10	Float
253	**honn**	Honningsvåg	Norway	70,98	25,98	17.12.2008 23:00	31.12.2020 0:40	10	Float
254	**vard**	Vardø	Norway	70,33	31,10	12.5.2015 6:00	31.12.2020 0:50	10	Radar
255	**nyal**	Ny Ålesund	Norway	78,93	11,95	5.4.2010 22:10	31.12.2020 0:40	10	Float
256	**scor**	Ittoqqortoormii, Scoresbysund	Denmark	70,48	-21,96	3.12.2008 12:15	31.12.2020 23:55	5	Pressure
257	**reyk**	Reykjavik	Iceland	64,15	-21,93	1.9.2008 0:00	20.3.2020 12:28	1	Pressure

Author contribution

JŠ supervised and led the development of the quality control methodology, MB implemented and performed the quality control procedures, MB and JŠ conceptualized the paper, MB wrote the initial draft of the text, and JŠ commented on, revised, and approved the final article.

Competing interests

The authors declare that they have no conflict of interest.

Acknowledgments

The authors sincerely thank the Intergovernmental Oceanographic Commission (IOC) Sea Level Station Monitoring Facility, along with all contributing data providers, station operators, and everyone involved in the collection, transmission, and maintenance of sea level data. We are deeply grateful to Leon Ćatipović, Ivica Vilibić and Petra Zemunik Selak for performing initial quality control of 71 time series. Special thanks are extended to Krešimir Ruić for generously sharing his code for downloading IOC SLSMF data with us. We gratefully acknowledge Oda Roaldsdotter Ravndal from Kartverket for providing valuable information and clarifications regarding the Norwegian sea level data. The authors also thank the data team at VLIZ for their assistance with data storage and management, with particular appreciation to Carolien Knockaert (VLIZ) and to Bart Vanhoorne (IOC SLSMF team) for their guidance and support throughout this step.

Financial support

The research has been supported by the ERC 853045 SHExtreme, the ERC PoC 101213756 MeD-Track, the Croatian Science Foundation projects IP-2019-04-5875 StVar-Adri and IP-2022-10-4144 CroClimExtremes, the STIM–REI 2.0 project (PK.1.1.10.0005), the ZMAJ project (IP-UNIST-4) funded by the European Union - NextGenerationEU, and the BioRes&App programme (1477-1-1/2025) supported by Javna ustanova za upravljanje Park šumom Marjan, Split.

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