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1. INTRODUCTION

The Global Sea Level Observing System (GLOSS) is an international programme conducted under the auspices of the Joint Technical Commission for Oceanography and Marine Meteorology (JCOMM) of the World Meteorological Organisation (WMO) and the Intergovernmental Oceanographic Commission (IOC). GLOSS aims at the establishment of high quality global and regional sea level networks for application to climate, oceanographic and coastal sea level research. The programme became known as GLOSS as it provides data for deriving the 'Global Level of the Sea Surface'. The main component of GLOSS is the 'Global Core Network' (GCN) of approximately 300 sea level stations (Figure 1) around the world for long term climate change and oceanographic sea level monitoring. The Core Network is designed to provide an approximately evenly-distributed sampling of global coastal sea level variations. GLOSS can be considered a component of IOC's Global Ocean Observing System (GOOS), and particularly as a major contributor to its Climate and Coastal Modules.

![Figure 1: GLOSS Global Core Network (GCN2010)](image)

In appreciation of the multiple uses of tide gauges, GLOSS has also sought to provide sea level data that meets the standards and requirements for tsunami warning and storm surge monitoring. Numerous GLOSS GCN stations have for many years contributed to the Pacific Tsunami Warning System (PTWS) and, following the 2004 Sumatra Earthquake, the IOC in consultation with GLOSS, has taken an active role in coordinating and implementing the sea level network for the Indian Ocean Tsunami Warning System (IOTWS).

One of the main functions of GLOSS is to provide for the smooth flow of sea level data from gauges together with associated metadata, to national and international centres, and to provide efficient and seamless access to the data for scientists, operational users and others.

The IOC Data Exchange Policy applies to the GLOSS data streams and Member States who have committed their tide gauges to the GLOSS Core Network should comply with that policy, Clause 1 of which states: “Member States shall provide timely, free and unrestricted access to...
all data, associated metadata and products generated under the auspices of IOC programmes”
(See Annex 1 for the complete policy). It should be stressed that GLOSS operates on a public
service/public good basis.

There are currently five main data streams for tide gauge data to which countries committed to
GLOSS are required to provide data:

(i) **Mean Sea Level (MSL) data to the Permanent Service for Mean Sea Level (PSMSL):**
all monthly and annual MSL data, metadata and associated documentation, should be provided
to the PSMSL. If possible, data should be sent by July of the year following the data-year, and
by September at the latest. This applies to all sea level stations, not just those designated as
GLOSS.

(ii) **Delayed-mode high frequency data to the GLOSS Data Archive Centre at PSMSL/ British Oceanographic Data Centre (BODC):** Send hourly (or sub-hourly) values of sea
level, together with ancillary variables (e.g. atmospheric pressure) where these are available,
from the GLOSS Core Network, GLOSS-LTT (long term trends), and GLOSS-OC (ocean
circulation) databases. These should be supplied by September of the year following the data-year together with comprehensive metadata (including benchmark information). The Delayed-mode centre relies on Member Countries to provide the final version of the hourly (or sub-hourly) time series with all quality control assessments applied and documented.

(iii) **Fast higher frequency data to UHSLC (GLOSS Fast Centre):** In this context, ‘fast’
means data to be provided within 4 to 6 weeks, but if possible within one week, enabling
assimilation of data into the new generation of ocean models (e.g. GODAE models) and for
rapid use in altimeter calibration. The GLOSS Fast Centre was established by GLOSS in 1999
at UHSLC as a logical evolution of UHSLC’s previous WOCE fast-delivery role and circular
letters to IOC Member States have encouraged countries to engage in this data stream.

(iv) **Real-time data monitoring:** In addition, GLOSS seeks to provide sea level data that
meets the standards and requirements for tsunami warning and storm-surge monitoring. The
Flanders Marine Institute (VLIZ) has developed a status monitoring service to which real-time
sea level data should be provided either directly via the Global Telecommunication System
(GTS) or by e-mail, ftp, etc. This service provides information about the operational status of
global and regional networks of real time sea level stations and also provides a display service
for quick inspection of the raw data stream from individual stations. The status is checked
every 5 minutes. No assessment of the quality of the transmitted data is carried out.

(v) **GPS Tide Gauge Benchmark Monitoring (TIGA) data**
The GPS Tide Gauge Benchmark Monitoring project is operated by the TIGA Working Group
of the International GNSS Service (IGS) for establishing a service to analyse GPS data from
stations at or near tide gauges on a continuous basis. The primary products of the service are
daily sets of coordinates for analyzing vertical motions of Tide Gauge Benchmarks (TGBM).
The products are made public to support and encourage other applications, e.g. sea level
studies. In particular, the products from the service facilitate the distinction between absolute
and relative sea level changes by accounting for the vertical uplift of the station, and are,
therefore, an important contribution to climate changes studies. The service may further
contribute to calibration of satellite altimeters and other oceanographic applications. Further
information is available from the TIGA web-site (adsc.gfz-potsdam.de/tiga/index_TIGA.html)

1.1 Why do we need quality control?
Information relating to quality control of tide gauge data has been included in the IOC Manuals
on Sea Level Measurement and Interpretation (Volumes I - IV), but this is the first time that
detailed information on quality control procedures has been assembled into one document.
Data from many countries are contributed to GLOSS - and in particular to the GLOSS Data
Centres and to the PSMSL. Thus it is beneficial to publish the current good practice and
distribute the information widely in order that a more standardized approach can be realised.

Data quality control essentially has the following objective:

“To ensure the data consistency within a single data set and within a collection of data sets
and to ensure that the quality and errors of the data are apparent to the user who has sufficient
information to assess its suitability for a task.” (Unesco, 1993)

If done well, quality control brings about a number of key advantages:

- **Maintaining Common Standards**
  There is a minimum level to which all sea level data should be quality-controlled. There is
  little point archiving data just because they have been collected; the data must be qualified
  by additional information concerning methods of measurement and subsequent data
  processing to be of use to potential users. Standards need to be imposed on the quality and
  long-term value of the data that are accepted). If there are guidelines available to this end,
  the end result is that data are at least maintained to this degree, keeping common standards
  to a higher level.

- **Acquiring Consistency**
  Data within data centres should be as consistent to each other as possible. This makes the
  data more accessible to the external user. Searches for data sets are more successful as
  users are able to identify the specific data they require quickly, even if the origins of the
  data are very different on a national or even international level.

- **Ensuring Reliability**
  Data centres, like other organisations, build reputations based on the quality of the services
  they provide. To serve a purpose to the research community and others their data must be
  reliable, and this can be better achieved if the data have been quality controlled to a
  ‘universal’ standard. Many national and international programmes or projects carry out
  investigations across a broad field of marine science which require complex information
  on the marine environment. Many large-scale projects are also carried out under
  commercial control such as those involved with oil and gas and fishing industries.
  Significant decisions are made, and theories formed, on the assumption that data are
  reliable and compatible, even when they come from many different sources.

The quality control procedures include checking for unexpected anomalies in the time series, or
in the derived tidal parameters, and in the filtering of the raw data to provide monthly mean
values (which are submitted to the Permanent Service for Mean Sea Level (PSMSL) which forms the basis of most climate-change related studies of sea level variations).

Quality control extends beyond the procedures mentioned above. The documentation of datum information (e.g. relationship of the recorded sea levels to the level of benchmarks on land) is essential. Diagrams, maps and other metadata also must be provided. However, there is at present little standardisation of methods for consolidating and archiving such information.

Quality control is also related to issues such as the availability of data in real-time. If data are inspected every day or, in advanced systems, if data can be flagged for errors by automatic software, then faults can be rapidly attended to and fixed. This contrasts with the traditional form of sea level recording on paper charts, where errors are detected a considerable time after they occur. However for tsunami warning it is of utmost importance that the data are made available rapidly and quality control is not a prime consideration.

Application of standardised sea level quality control, and agreed filtering techniques, will ensure that data supplied to the global sea level databanks (e.g. PSMSL and UHSLC) are consistent, and of a known accuracy. This will allow future researchers to better define confidence limits when applying these data.

This manual draws on existing documents such as the relevant IOC Manuals, the experience gained by the WOCE Sea Level Data Assembly Centres, EU MyOcean project in situ TAC near real time quality control procedures, EuroGOOS Recommendations for RTQC procedures, ESEAS Quality Control Manual, other international programmes (e.g. IOC’s International Oceanographic Data and Information Exchange (IODE) programme, JCOMM Data Management Programme Area (DMPA) and the International Council for the Exploration of the Sea’s Working Group on Data and Information Management (ICES WGDIM)) and national expertise to derive a set of recommended standards for quality control of tide gauge data. This will result in data sets of sea level which have been acquired and processed to agreed standards and which have thereby obtained GLOSS quality endorsement. These quality control procedures should be reviewed and updated at regular intervals.

From each tide gauge station three basic data sources should ideally be available (Figure 2): raw sea level data, in digital or graphical form, the calibration data (normally manual data obtained at the site during each calibration) and levelling information. Sometimes ancillary data are also present. These will be essential for the quality control and processing of historical sea level series.

Sea level data are obtained by a process depending on the acquisition system in case of sensors with digital output or by digitizing in case of graphical records. In the first case raw sea level data are usually obtained at a particular sampling interval lower than 1 hour (e.g. 5 minutes, 6 minutes, 10 minutes, etc.); these raw higher frequency data are processed to Level 1 (L1) quality control (defined below in Section 2), in order to be used for operational purposes. Hourly values are obtained by means of an adequate filter (or by manual smoothing when digitizing graphical data), from which harmonic constants and mean sea levels will be computed. Extreme values (observed highs and lows and ranges) are derived from the higher frequency quality controlled data. The data flow scheme is represented in Figure 2.
Figure 2: Scheme of principal data available from a tide gauge station and the processing normally applied to sea level data. Most present day sensors will provide digital output.

2. QUALITY CONTROL

The errors that can arise in the sea level data and related parameters could be random errors (for example, transposition of numbers in manual recording or recording of observations in the wrong column), or could arise from electronic noise in measurements, problems in the communications, sensor calibrations, etc. But there can also be systematic errors, for example, the inhomogeneity type errors which arise primarily when there is a change in observational practices, or a change of instrumentation. Changes of instrument location can result in sharp discontinuities in the sea level data. Changes in the environment surrounding the station, such as harbour constructions, land movements, etc., can produce trends in the data or changes in the tide parameters.

The initial process of quality control consists of (i) performing various checks on the original series (normally with time intervals lower than 1 hour) whilst maintaining the original data with flags that qualify them and (ii) creating a new modified time series that corrects or modifies some of the errors detected (e.g. interpolation). It is important to remark that, although data may be modified as a result of a quality control process, the original series must always be preserved. For both series the data should be flagged according to pre-defined quality control codes. Although particular quality flags may be fixed in the original raw data for identifying the type of error, and this may be different depending on the organisation, this is acceptable provided that they are defined.

Quality control of sea level data is undertaken using automatic tests, by visual inspection and more sophisticated analysis. This chapter is structured as follows: (i) a summary of the data streams and a brief outline of the associated quality control is given; (ii) quality control flags are defined and described; (iii) automatic quality control checks are described, usually used for
(near) real-time data; (iv) delayed-more or “scientific” quality control procedures are described; and finally additional quality control techniques with particular emphasis on historical data are given.

**Real-time:** For real-time data provided as part of the tsunami monitoring system, with latencies under 1 minute, very little quality control is required. It is of prime importance that the data are provided without delay to the IOC Sea Level Station Monitoring Facility ([www.ioc-sealevelmonitoring.org](http://www.ioc-sealevelmonitoring.org)). Care must be taken to ensure that any quality control carried out on real-time data does NOT remove tsunami events by rejecting out of range data. A few simple checks may be carried out in real time: for example, detecting when the tide gauge stops reporting data, so that it can be fixed as soon as possible. When the final regional tsunami warning centres are in operation, data should be checked by experienced personnel prior to entering any tsunami alert process. Further checks can be done in delayed-mode prior to archiving the data.

**Near-real-time (L1):** Data are considered to arrive in near-real time for latencies usually between 1 hour and several weeks, and this is normally the situation for storm surge forecasting or altimetry data calibration. This larger latency allows the implementation of some level of automatic quality control (L1 quality control) prior to archiving and use of the data. L1 quality control consists of detection of: strange characters, wrong assignment of date and hour, detection of spikes, and gaps (including interpolation of short gaps), out of range values (ideally based on extremes included in the metadata for each station), stability test (flagging values where there is no change in the magnitude of the sea level value after a number of time steps, the number of values to flag depending on the time interval), and, depending on the application even filtering to hourly values and computation of residuals.

**Delayed Mode (L2):** This is the case of long time series, which require a more complete checking and analysis procedure, including computation of all derived sea level products such as harmonic constants, extremes, mean sea levels, tide ranges, etc. One of the critical points in this case, especially for long term mean sea level studies, is datum control and detection of reference changes, with the study of operational history and maintenance incidences at the tide gauge.

In addition to the L1 quality control, a second level of data processing is performed, called L2. This is normally applied to one or more years of data, and includes: tidal analysis, computation and inspection of residuals, generation of basic statistics (highs and lows, extremes), computation of daily, monthly and annual means, comparison with neighbouring tide gauges, comparison with models or predictions, and detection of reference changes.

**Further details on how L1 and L2 quality control checks are actually applied are described in sections 2.2 and 2.3.**

**2.1 Quality control flags**

The GLOSS data set should be composed, whenever possible, of the processed data provided by the originator (i.e. wrong values already eliminated and/or interpolated), with the exception of real-time data provided as part of tsunami monitoring systems. The quality controlled data are used for various applications. Thus, after real-time and delayed-mode quality control procedures, extensive use of flags to indicate the data quality is vital since the end user will select data based on quality flags amongst other criteria. These flags need to always be
included with any data transfer that takes place to maintain standards and to ensure data consistency and reliability.

Table 1 below shows the recommended single character qualifying flags which may be associated with one or more individual parameters within a GLOSS time series of sea level data. It is important to note that from this scheme, the codes 1 (correct value), 4 (bad data) and 9 (missing value) are mandatory for the real-time quality control procedures. If no quality control has been carried out, data values should be labelled with code 0 (no quality control). The list of quality control flags, which was used by the European Sea Level Service Research Infrastructure (ESEAS-RI) project, has been aligned with the EU SeaDataNet quality flag scheme. It is also used by MyOcean, and is derived from other internationally agreed quality flag schemes (as used by global projects, e.g. Argo, GTSSP, etc.).

<table>
<thead>
<tr>
<th>Flag</th>
<th>Meaning</th>
<th>Definition</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>No quality control</td>
<td>No quality control procedures have been applied to the data value.</td>
</tr>
<tr>
<td>1</td>
<td>Good</td>
<td>Good quality data value that is not part of any identified malfunction and has been verified as consistent with real phenomena during the quality control process.</td>
</tr>
<tr>
<td>2</td>
<td>Probably good (previously 'correct but extreme’)</td>
<td>Data value that is probably consistent with real phenomena but this is unconfirmed.</td>
</tr>
<tr>
<td>3</td>
<td>Probably bad (previously ‘doubtful’)</td>
<td>Data value recognised as unusual during quality control that forms part of a feature that is probably inconsistent with real phenomena.</td>
</tr>
<tr>
<td>4</td>
<td>Bad (previously isolate spike or wrong value)</td>
<td>An obviously erroneous data value.</td>
</tr>
<tr>
<td>8</td>
<td>Interpolated</td>
<td>This value has been derived by interpolation from other values in the data object.</td>
</tr>
<tr>
<td>9</td>
<td>Missing</td>
<td>The data value is missing. Any accompanying value will be a magic number representing absent data.</td>
</tr>
</tbody>
</table>

Table 1: Recommended numerical quality flag values for GLOSS.

- Data with a quality control flag = 0 should not be used without a quality control made by the user.
- only measurements with QC flag = 1 can be used safely without further analyses
- if a quality control flag = 4 then the measurements should be rejected
- if a quality control flag = 2 the data may be good for some applications but the user should verify this
- if a quality control flag = 3 the data are not usable but the data centre has some hope to be able to correct them in delayed mode

2.2 Automatic real-time quality control procedures (L1)
The intrinsic nature of sea level data means that the quality control procedures have some special characteristics. It is essential to ensure that date and times are correct. This should be done by carrying out the following checks.
(i) Valid date and time check
Date and time are essential information for each time series record, so it is normally the first check carried out. The way date and time is assigned to the measurement is different depending on the tide gauge (by the sensor itself, by a data logger or by a PC), and ideally should correspond to a regular time interval. However this is not always the case and sometimes, apart from the check for validity and continuity of the values (calendar accordance), an additional interpolation is needed to obtain an exact regular time interval. Use of UT is recommended and should be specified. If UT is not used then the time zone must be stated.

If an important gap is detected during this check (e.g. hours, days, weeks) the corrected time series will incorporate the corresponding missing records in the same format but with the corresponding flag and missing value for the parameter.

(ii) Time-consecutive check (delta-check):
This is the most frequent and simple algorithm and consists of checking that the difference of the variable at time t does not exceed a particular tolerance from the value at time t-1. For the tolerance value, if the tide is significant, one can consider the following: $tolerance = 2\pi.amp.dt/720$, where $amp$ is the amplitude of the tide and $dt$ the time interval, and for non-tidal data, $tolerance = 0.58.\sigma.\sqrt{dt}$.

For automated quality control, usually carried out in near real-time, the process is split into two parts: first RTQC1 – highly recommended – that enables detection of bad or suspicious data and the second part RTQC2 including the rest of the modules in the complete quality control (Figure 3) that enable the provision of a better product to users. Organismo Público Puertos del Estado (OPPE), Spain has developed software that implements the full procedure which it is willing to share with interested parties.

2.2.1 Real-time quality control: RTQC1 - Highly recommended
This module enables:
- Strange characters detection (in which case the record is discarded)
- Checking for and flagging of out-of-range values (based on on predefined upper and lower limits (i.e. extremes) dependent on the station, included in the metadata for each station). Seasonal limits are usually set at 2-sigma from the mean climatological value for a specific area and month. Each sea level value is checked to be between these two limits; if not, it is flagged with the corresponding flag and not considered for subsequent checks.
- Algorithm for detection of spikes (explained below)
- Stability test: adding a quality flag value when there is no change in the magnitude of sea level after a number of time steps. The number of data values or time steps to begin to flag depends obviously on the time interval. A typical value, for example, is 3 for 5 minute data.
- Date control
The algorithm for detection of spikes is the main component of the QC-module: it is based on the fit of a spline to a moving window of around 12–16 hours. The reason why this cannot be applied in real time (latencies of 1 minute) is because it needs this long moving window to be able to detect spikes correctly and not flag real phenomena such as sudden high frequency oscillations due to “seiches” or tsunamis. The degree of the spline (which is normally 2) and the size of the window can be selected and determined depending on the characteristics of the tide, the data sampling, etc.

The algorithm flags as spikes the values that differ more than N sigmas from the fit (normally N=3, although this can also be selected in the configuration file). Repeating the process for non-tidal residuals (obtained as total observed sea level minus predicted astronomical tide) is crucial to detect less obvious spikes not detected in the first step; this is why the QC-module is applied again when the residuals are obtained (Figure 4). This algorithm has proved to be very efficient during recent years at OPPE, Spain, as can be seen in Figure 4, detecting more than the 95% of the wrong values of a very “bad” series.

Figure 3: Scheme of the automatic software for quality control (QC) in near-real time now in place at Organismo Público Puertos del Estado (OPPE). Highly recommended and highly desirable modules.
(i) Interpolation Module
Most of the raw data from a tide gauge arrives with a data sampling of several minutes, although for many applications in operational oceanography normally 1 hour is considered enough; besides, this data sampling is not always regular and, for example, 5 minute data supposed to arrive at 00, 05, 10… start arriving at 02, 07, 12. This is just an example of what can be found in the raw data.

The interpolation module has the following objectives:
- checking and adjusting the time interval
- interpolation of wrong values previously flagged in the QC-module
- filling the gaps with new records with the correct date assignment and null-values for the sea level
- interpolation of very short gaps (smaller than 10 – 25 minutes, depending on the tidal range)

The output is a “clean” time series, called “interpolated series”, ready to enter the filter and harmonic analysis programs, i.e., it will be the one used for the rest of the data processing.

2.2.2 Real-time quality control: RTQC2 - Highly desirable
The following modules complement RTQC1 to guarantee reliable quality control.

(i) Filter module
The next step is to compute hourly values by means of the adequate filter, depending on the original data sampling. In the case of 5-minute data, as is the case of OPPE, Spain, REDMAR data, a symmetrical filter of 54 points, following the expression:

$$X_f(t) = F_0 \cdot X(t) + \sum_{m=1}^{M} F_m [X(t+m) + X(t-m)]$$

Where $X(t)$ is the hourly filtered value and $F_{0\ldots m}$ the weights applied to the high frequency values. Details can be found in Pugh, 1987.

The selection of the filter is made taking into account the experience at OPPE, Spain, and is also one of the recommended filters found in the MyOcean, EuroGOOS and ESEAS Quality Control manuals. Figure 5 shows the differences between original and filtered data for Las
Palmas station, showing that the algorithm eliminates just the frequencies larger than 0.5 cycles/hour.

(ii) Tide-surge module
The next stage is to compute the astronomical tide for the window of data, and then the surge component subtracting the tide to the original sea level. The software developed by OPPE, Spain, carries this by means of the Foreman method for tidal prediction (Foreman, 1977), and it requires the availability of the main harmonic constituents at each particular station, obtained off-line from ideally 1 year of data. This is important because it implies the need for access to these previous data in order to compute a reliable set of harmonic components.

As it has been said, once the first residuals are computed, the QC-module is applied again to surge data (see Figure 3), in order to detect less obvious spikes. If detected, these new wrong values are flagged again in the total sea level series and the rest of the process repeated to obtain the final products: interpolated series and hourly levels, surge and tide. Then the time series is ready to enter, for example, a storm surge forecasting system.

2.2.3 Metadata
In order to carry out the procedures described above, some basic additional information (metadata) must be included for each particular tide gauge station, as input for the quality control procedures, as well as for archiving and exchange of data. This metadata must be provided by the data producer.

(i) Metadata required for RTQC1 level
- Name of data provider
- Country of data provider
- Instrument type
- Geographic location (latitude, longitude, coordinate system)
- WMO code of the station or if no WMO code, name of the station
- Datum information (chart datum, national datum)
Metadata required for RTQC2 level
The following information is necessary to apply the desirable quality control RTQC2:

- 1 year of data
or:
- Harmonic constants of one year of data (at least 68 constituents) (this is for tide-surge module).
- Maximum – minimum expected levels (for out of range detection)
- Maximum – minimum expected surge

2.3 Delayed mode or ‘scientific’ quality control (L2)
As part of the “scientific” or delayed mode quality control (L2), more detailed processing of sea level data is performed, applied to longer time series (typically 1 year) that include not only the steps described for L1, but also filtering to hourly values, computation of annual harmonic constants, residuals, extremes and means, if this has not already been carried out. The results of this process are themselves useful products from the station, but also the examination of their quality is crucial for the detection of problems and malfunction in the tide gauge. The primary quality control of sea level is based on the visual inspection of both recorded data and residuals (i.e. observed – predicted values); inspection of residuals is especially useful for detecting instrumental faults such as timing errors, datum shifts and spikes. Automated spike detection software as described in Section 2.2 can also be used to aid and complement visual inspection of the data.

On the other hand, the harmonic constants may be severely corrupted if the site is characterized by highly nonlinear tides, influence of rivers or estuaries and particularly complex basin configuration. To produce more accurate predicted tides, it is advisable to compute ‘fresh’ tidal constants from recent data and not simply rely upon historical values. Tidal analysis can be performed by means of the software packages developed by the University of Hawaii Sea Level Center (UHSLC), USA, and Organismo Público Puertos del Estado (OPPE), Spain, that facilitate the use of the Foreman tidal analysis and prediction programs of the Institute of Ocean Sciences, Victoria, British Colombia (Foreman, 1977) or by the PSMSL/National Oceanography Centre (TASK2000 Package) and the Australian National Tidal Facility, which utilise the TIRA tidal analysis programs (Murray, 1964). Tidal constants used in tide predictions should never be mixed between different packages.

Suspect tidal profiles should be checked against records of a nearby site (also known as “buddy checking”), to see if the suspect values are due to a tide gauge fault or to station conditions. In case of a fault, data should be corrected or interpolated (if possible), otherwise must be maintained unchanged and the event noted. If possible, more than one sensor should be operated at the same site in order to allow direct comparison, and on occasion to fill gaps.

2.3.1 Recommended delayed-mode quality control procedures
(i) Filtering to hourly values
Raw data are normally registered at time intervals between 1 minute and 1 hour, the most common being 5, 6 and 10 minutes; only in regions where “seiches” occur frequently, or where phenomena such as tsunamis are to be detected, are the sea level registered at less than 1 minute intervals. Apart from the convenience of keeping higher frequency signals for other purposes, it is always necessary to obtain filtered hourly values before proceeding with the sea level processing.
The filtering process will eliminate higher frequencies depending on the frequency cut-off. As noted in Section 2.2, Pugh (1987) describes useful filters that can be applied to the sea level data at intervals of 5, 10 or 15 minutes to obtain the hourly heights whilst preserving the tidal phenomena. In Godin (1972) there is an extensive discussion on tidal filters. Section 2.2 also describes a suitable filter for this process.

(ii) Harmonic analysis
A common procedure is to compute the harmonic constants for each year of observed data. Some of these constants may be particularly affected by meteorological conditions, and so will show important variations from one year to the next. This occurs for example for the longer term harmonic constituents such as Sa and Ssa. Sometimes also the presence of problems in the data series appears as strange values of the normally stable harmonics (e.g. clock errors). In any case, an inspection of the variation through the years of the harmonic constants is interesting both for detecting problems and also for having information about changes on the station. For example, changes in the configuration of a harbour can affect the tide parameters, and this occurs very often.

![Figure 6: The vector representation is useful to observe the annual variations of the harmonic constants; in black the arrows representing the amplitude and phase of each year for the constituent; in red the mean vector for the vectors of the different years and the values of mean amplitude and phase.](image)

In order to choose adequate harmonic constants for tide prediction, one can perform the vector mean and statistics of the annual values for several years (provided they are computed for nearly complete years and so the same number of constituents have been resolved) and select for prediction only the mean of those constituents which do not present a variability that above a fixed and reasonable tolerance.

A very useful representation is to plot the harmonic constants as vectors, as can be seen in Figure 6 above.

(iii) Computation of residuals
As mentioned before, the inspection of residuals is a very useful tool for the quality control process. All fundamental types of errors that a sea level series can present are easily detected in the residual plot. An example of the presence of a clock malfunction (oscillations in the residuals) and a reference change can be observed in Figure 7.
Of course, the presence of a spike is also very obvious in the residual series, which is why some of the automatic algorithms for the detection of spikes are based on both the original and the residual data.

(iv) Correction of clock malfunction
This type of error is very easy to correct if there is a constant time shift. The problem becomes more difficult to solve when there is a drift in the lag between observed and predicted tide.

![Figure 7: Example of the trace of a clock malfunction and a reference jump in the residuals.](image)

Apart from the inspection of the residuals, a constant lag can be exactly determined by means of lag-correlation analysis between observed and predicted data (lag of maximum correlation), or by comparing the values of the phase of M2 harmonic before and after the shift. Once determined, the part of the series that it is affected must be shifted accordingly to correct the error; if the lag is a multiple of the time interval, the shift is just a movement of data in time; if not, an interpolation to the correct time has to be performed.

This type of correction is not automatic for any of the software currently available, although the UHSLC Sea Level Software includes a program which can make the correction if the lag is a constant value and is a multiple of the time interval.

(v) Gap filling
Depending on the application, filling gaps in a series may or may not be reasonable. During the first stage of quality control of the higher frequency data, very short gaps of several minutes can be linearly interpolated and single point spikes removed and the resulting gap interpolated. Gap filling for hourly values is less clear. The UHSLC interpolates gaps of less than 24 hours before computing daily and monthly means; this is done by computing the residual series, linearly interpolating by using the residual values at the extremes of the gap, and adding on the astronomical prediction to the interpolated values. The maximum length of data that is reasonable to fill should not be more than 24 hours depending on the station. Interpolation of this kind should be undertaken with great caution, and the data values flagged accordingly.

(vi) Detection of reference changes
Improper maintenance operation, an accident, or even a natural phenomenon such as an earthquake may produce a sudden jump in the reference level. Most of these jumps are readily identifiable in hourly residual plots if the magnitude is large enough. Once detected, a proper way of correction is through the inspection of the scatter diagram of the tide staff or electric
sound readings and corresponding tide gauge values, taken during the maintenance campaigns (Van de Casteele test, see section 2.4).

As described later, these jumps can also be detected by plotting the differences between daily and monthly means from adjacent stations or from redundant sensors. As a rule, the UHSLC considers changes greater than 1.5 cm as significant and worthy of an investigation to guarantee level stability.

A change in reference level must only be corrected and documented when firm confirmation has been established. Data values should be flagged accordingly.

(vii) Statistics
Basic statistics from historical data are computed or updated annually and some of these parameters are used for the quality control process. For example:

- upper and lower limits or historical extremes (for range check).
- tidal and observed sea level ranges
- extremes, mean and standard deviation of hourly values, meteorological residuals, ranges or mean sea levels
- tables of monthly and annual extremes
- density function for hourly values, tide predictions and residuals

2.4 On-site quality control and the Van de Casteele test
To estimate the quality of sea level measurements, the Van de Casteele test can be performed as part of the maintenance visits. This on-site test consists of taking manual readings (generally with an optical probe whose accuracy is well known) simultaneous to the tide gauge readings during a tidal cycle (IOC, 1985). The two resulting time series will then be used to produce a diagram by plotting the tidal height (Y axis) against the difference between the two time series (X axis). Assuming that the manual readings are accurate and that the tide gauge is working properly, then the diagram should be a straight line centred in the same X value (i.e. the difference between the two time-series should be constant). Otherwise, the shape of the diagram will allow detecting and identifying different types of instrumental faults affecting the data quality (Martin Miguez et al., 2007). Additionally, as previously mentioned this test is also useful to detect and correct jumps in the reference level.

2.5 Quality control and processing of historical data
When working with historical data, even if the station is well documented, check sheets may not be available with which to perform a confident quality check on the reference level. Furthermore, system measurement problems, changes in the instrumentation or in the environment surrounding the station can generate a discontinuity, which may appear as a datum shift or a trend. In this case some additional checks should be performed to obtain a unique reference. The normal procedure for this kind of higher level quality control is to work with several daily or monthly means sea level series from nearby stations and then reconstruct the time series of the heights.

Different algorithms are explained below that can help to detect this type of discontinuity or reference problems in historical data. All of them normally require the quality assessment of an expert before taking the final decision to correct the data. Apart from the more immediate
computation of differences between levels of adjacent stations, which may clarify about the existence of a problem, there are other possibilities as described below.

(i) Correlations
Correlations can be computed both between data from different stations or sensors and between different parameters at the same station (wind, atmospheric pressure, etc). In any case this is a valuable tool for detecting problems. The correlation analysis is also useful for filling gaps. This can be done as follows:
1. Calculate the Pearson's correlation coefficient between residual series
2. Select nearby stations with correlation coefficients above 0.7
3. Calculate the linear regression between them and fill the gaps. (Only fill gaps within the time series; not at the beginning or end of the series)

(ii) Standard Normal Homogeneity Test
Several tests have been described in the literature, which can be used to detect inhomogeneities in data series. Alexanderson (1986) developed the Standard Normal Homogeneity Test (SNHT) which is widely used in climatic time series studies. The SNHT gives the points where an inhomogeneity exists and provides information about the probable break magnitude. However, the inhomogeneity could be due to an error or to an anomalous, but real, behaviour of the variable. For this reason, the series are only corrected following comparison with other series in the same climatic region and supported by historical information about other incidences in the tide gauge record.

![Original series. SNHT for the original series. Tmax indicates the shift that can be seen in the original series. Red line is the confidence level.](image)

Figure 8: Time series and the result of SNHT

(iii) EOF Analysis
The Empirical Orthogonal Functions (EOFs) analysis applied to a group of time series stations can be used not only to find special coherent signals or regional variability but also to detect possible errors in the time series. In fact, relevant differences on the variance of the first EOF may indicate errors in one or more time series. This technique is well documented in “Development of a Quality Checked Tide Gauge Data Set” (Shaw, et al, 2008) and in “Consistency of long sea level time series in the northern coast of Spain” (Marcos, et al, 2000).
2.5.1 Additional useful delayed-mode quality control procedures for historical data

(i) Drift

This error may be due to a defect in the measurement system as is the case with some magnetic encoders with precision of millimetres, but also a faulty installation where the cable of a mechanical float gauge is slipping little by little. The problem identified is that the measured values are systematically lower or higher than the real levels. The first step in correcting this error is to calculate the number of observations in a specific period of measurement, that in the case of digital output depends on the sampling interval, and in the case of graphical output depends on the digitising interval. Thus:

Step 1: \( n_{reg} = \frac{n_{min}}{\Delta t}; \)

Step 2: Process the following algorithm

\[
\text{read data}_{\text{measured}}
\]
\[
\text{If} \mod (i_{\text{con}},n_{reg})=0, \text{then we calculate } v_{\text{err}} = \frac{(i_{\text{con}}/n_{reg})*\text{dif}}\
\]
\[
\text{data}_{\text{corrected}} = \text{data}_{\text{measured}} + v_{\text{err}}
\]
\[
\text{write data}_{\text{corrected}}
\]
\[
go \text{to read}
\]

where:

\( n_{reg} = \text{number of records}, n_{min}: \text{number of minutes}, \Delta t: \text{sampling interval} \)
\( i_{\text{con}} = \text{counter of number of the records} \)
\( \text{dif} = \text{difference between the direct measurement and the measure by the tide gauge for the period corresponding to } n_{reg}. \)

This problem is illustrated by a simulated drift of 10mm per 300 records for a measuring interval of 5 minutes. This represents a drift greater than 1 centimetre per day.

![Figure 9: A drift of 10 millimetres every 300 records](figure9.png)
(ii) Values outside of the measurement range of the instrument.
When equipment, such as an optical encoder measuring range (0-4.095 meters), is not well calibrated to the Lowest Astronomical Tide (LAT), then there may be sea level values exceeding the upper and lower limits of the range encoder measurement. For values above 4095, the encoder will start from zero. For values less than zero, the encoder will start from 4095.

**Example for values below zero**
To correct the recorded time series, the data should be visualized in order to determine the upper limit above which all values are wrong. That is, those data which correspond to levels below zero.

The correction algorithm is:

```
if(data_encoder.gt. vmax) data_corrected=data_encoder-4.095.
```

*Upper limit of valid values =3 (vmax=3)*

![Figure 10: Values out of range of the instrument](image)

(iii) Constant values in High and Low Waters: Interpolation of short gaps
In classical float systems, exceptionally, when the float cable is misplaced, sea level values can be found above or below the range of the scale of the graduated bar, restricting the measurements to a constant value, although it is likely that the cable will break down quickly and the measures are no longer valid.

To correct these data, constant values are replaced (interpolated) by the corresponding values of astronomical tide to which the corresponding daily mean residual have been added. The residuals corresponding to the constant observed values are not taken into account for the calculation of the daily mean residual.
(iv) Calibration constants or ratio of lineal displacement
In some measurement systems, in order to obtain the final values of the sea level measured by the instrument is necessary to implement a polynomial equations in which are included the calibration constants of the sensors, as is the case of pressure gauges, or the ratio of linear displacement of the wires, such is the case of the installation of a Thalimedes gauge. Here the encoder measures the counterweight wire instead of in the float wire, in order to prevent cable slippage and provide greater stability to measuring system.

Errors in the data may appear when these equations have not been processed. The error can be detected, as in the case of the scale factor, for the difference in the amplitude of the main harmonic. For example: Data measured by a Thalimedes gauge which has been installed as described above. The algorithm to correct the data is:

\[
data_{corrected} = data_{encoder} + (data_{encoder} - data_{calibration}) \times \frac{KTE}{data_{calibration} - value where the measurement made with direct reader matches the (measured) by the encoder.}
\]

Thus, for an installation that is calibrated to a value of 1.51m and the ratio of linear displacement of the wires is 0.091/0.909. The algorithm will be:

\[
data_{corrected} = data_{encoder} + (data_{encoder} - 151) \times 0.091/0.909
\]
The difference found between high and low water is about 4 centimetres higher in the corrected series. The differences are relevant not only in the extreme values, but also for mean sea level and tidal amplitude. Amp (M2) = 0.17 meters original series and 0.19 meters corrected series.

3. METADATA

Alongside the sea level data, additional information (metadata) is needed not only for quality control and archiving, but also for exchanging data or integrating them into a regional or global data set. Recently there has been an increasing recognition of the importance of metadata, at several different levels of detail. The International Standards Organisation (ISO) has published its standard for discovery metadata (ISO19115 for geo-spatially referenced data) and sea level data sets should be described in compliance with this standard. For example, discovery metadata descriptions for sea level data sets should be provided to the Global Change Master Directory (GCMD, gcmd.nasa.gov), which uses this standard, or for European sea level data sets, descriptions should be provided to the European Directory of Marine Environmental Data Sets (EDMED, http://www.seadatanet.org/Metadata/EDMED).

However, this level of metadata is for the discovery of data sets and more detailed metadata are required at every stage of the process from initial data collection, real-time or near-real-time data transmission, for automatic and scientific quality control and for long term stewardship of the data. A comprehensive set of tables has been drawn up by the GLOSS Data Centres (see Annex 2), showing the metadata required at different stages of the collection, quality control and archiving.

As described in Section 2.2, some basic metadata are required for each tide gauge station, as input for the quality procedures. Basic quality control of these metadata includes checking that some of them have reasonable values, as is the case for latitude and longitude, the start and end dates of a record, etc. The units employed for each parameter must belong to the Système International (SI). Internationally agreed codes are available or under development, for example within IOC/IODE, which has established the SeaVox e-mailing list to extend and
further develop the GF3 code tables established in the 1980s. Further information relating to SeaVox can be found at: [www.bodc.ac.uk/data/codes_and_formats/seavox/](http://www.bodc.ac.uk/data/codes_and_formats/seavox/).

Metadata are also required to allow assessment of the usefulness of a time series for a particular application and to ensure that the data are fully documented. It is thus necessary to ensure that as much relevant information about the tide gauge, datums and benchmarks, including maps, diagrams and photographs are stored alongside the data as described in Section 4 below.

4. SITE HISTORY AND DOCUMENTATION:

Sufficient documentation should accompany each data series so as to ensure that the data are adequately described and may therefore be used with confidence by a variety of users. Such documentation should be stored alongside the data, and where applicable, should cover:

**Site**
- Brief description of location of tide gauge (including maps, photos)
- Description of tide gauge benchmarks (including maps, photos)
- Datum relationships
- Datum history

**Data sampling/processing:**
Brief description of processing procedures used to obtain data values including:
- Sampling scheme e.g. continuous recording, instantaneous, averaged
- Interval between samples and duration of individual samples (raw data)
- Nominal interval of processed data
- Gaps in the data record
- Timing and/or datum corrections applied
- De-spiking/smoothing/interpolating methods and editing procedures

**Instrument**
- Instrument description, manufacturer, model, principle of measurement, method of recording - refer to publication or briefly describe
- Instrument modifications and their effect on the data
- Method and times of calibration, calibration factors
- Frequency of cleaning, control of biological fouling
- Operational history
- Pertinent instrument and installations characteristics; for example, for a conventional stilling well, information should include well diameter, orifice depth below mean sea level and orifice height above sea bed; for a bubbler gauge - tube length, tube diameter, orifice diameter, density value used to convert to elevation, acceleration due to gravity and the formula used to compensate for tube length.

**Report on data quality**
Report any quality control applied by the data supplier to the data set (manual or automatic) or any additional information of use to users which may have affected the data or have a bearing on its subsequent use (e.g. effects of sea state, subsidence, etc.).
All quality control procedures applied to a data set should be fully documented. In addition, details of all quality control applied to a data set should accompany that data set. All problems and resulting resolutions should also be documented. A history record should be produced detailing any data changes (including dates of the changes) made.

Two examples of tide gauge site documents are given in Annex 3.

5. SOFTWARE PACKAGES FOR SEA LEVEL QUALITY CONTROL AND PROCESSING

Many organizations have developed their own processing software to validate incoming data in varied formats and media that are specific to their requirements. However, five organisations have developed standalone software as a contribution to GLOSS with the aim of enabling participating countries to be able to process and validate their own records. These organisations are:

- Organismo Público Puertos del Estado (OPPE) sea level software, which has been developed in OPPE for automatic quality control checks.

- IOLR (Israel Oceanographic and Limnological Research) sea level software for Windows.

- T_TIDE (Pawlowicz et al. (2002)). A re-write in MATLAB of the harmonic analysis of oceanic tides FORTRAN package created by Mike Foreman (IOS, Canada). The package is available at: http://www.eos.ubc.ca/~rich/t_tide/t_tide_v1.1.zip

- The University of Hawaii Sea Level Center UHSLC), which has produced a package, which is probably the most commonly used package within the GLOSS community for sea level data quality-control purposes.

- The PSMSL/National Oceanography Centre (NOC), which has produced a package called TASK-2000 (Tidal Analysis Software Kit) which is based on the TIRA, etc., programmes used at NOC for many years. Available on-line.
7. REFERENCES:

Alexanderson, H. 1986. A homogeneity test applied to precipitation data. Journal of Climatology, 6, 661-675


ICES. 2006. ICES WGMDM Guidelines for Water Level Data (www.ices.dk/datacentre/guidelines/DataTypeGuidelines/DataTypeGuidelines.asp)


25


UNESCO. 1993. Joint IAPSO-IOC Workshop on Sea Level Measurements and Quality Control. IOC Workshop Report No.81


ANNEX 1: IOC Oceanographic Data Exchange Policy

Preamble The timely, free and unrestricted international exchange of oceanographic data is essential for the efficient acquisition, integration and use of ocean observations gathered by the countries of the world for a wide variety of purposes including the prediction of weather and climate, the operational forecasting of the marine environment, the preservation of life, the mitigation of human-induced changes in the marine and coastal environment, as well as for the advancement of scientific understanding that makes this possible.

Recognising the vital importance of these purposes to all humankind and the role of IOC and its programmes in this regard, the Member States of the Intergovernmental Oceanographic Commission agree that the following clauses shall frame the IOC policy for the international exchange of oceanographic data and its associated metadata.

Clause 1: Member States shall provide timely, free and unrestricted access to all data, associated metadata and products generated under the auspices of IOC programmes.

Clause 2: Member States are encouraged to provide timely, free and unrestricted access to relevant data and associated metadata from non-IOC programmes that are essential for application to the preservation of life, beneficial public use and protection of the ocean environment, the forecasting of weather, the operational forecasting of the marine environment, the monitoring and modelling of climate and sustainable development in the marine environment.

Clause 3: Member States are encouraged to provide timely, free and unrestricted access to oceanographic data and associated metadata, as referred to in Clauses 1 and 2 above, for non-commercial use by the research and education communities, provided that any products or results of such use shall be published in the open literature without delay or restriction.

Clause 4: With the objective of encouraging the participation of governmental and non-governmental marine data gathering bodies in international oceanographic data exchange and maximizing the contribution of oceanographic data from all sources, this Policy acknowledges the right of Member States and data originators to determine the terms of such exchange, in a manner consistent with international conventions, where applicable.

Clause 5: Member States shall, to the best practicable degree, use data centres linked to IODE’s NODC and WDC network as long-term repositories for oceanographic data and associated metadata. IOC programmes will co-operate with data contributors to ensure that data can be accepted into the appropriate systems and can meet quality requirements.

Clause 6: Member States shall enhance the capacity in developing countries to obtain and manage oceanographic data and information and assist them to benefit fully from the exchange of oceanographic data, associated metadata and products. This shall be achieved through the non-discriminatory transfer of technology and knowledge using appropriate means, including IOC’s Training Education and Mutual Assistance (TEMA) programme and through other relevant IOC programmes.

Definitions

‘Free and unrestricted’ means non-discriminatory and without charge. “Without charge”, in the context of this resolution means at no more than the cost of reproduction and delivery, without charge for the data and products themselves.

‘Data’ consists of oceanographic observation data, derived data and gridded fields.

‘Metadata’ is ‘data about data’ describing the content, quality, condition, and other characteristics of data.

‘Non-commercial’ means not conducted for profit, cost-recovery or re-sale.

‘Timely’ in this context means the distribution of data and/or products, sufficiently rapidly to be of value for a given application

‘Product’ means a value-added enhancement of data applied to a particular application.
ANNEX 2: Metadata Template for the Sea Level Station Catalogue (SSC)  
Draft 2 March 2010

One set of the following for each unique station defined by location. A station metadata record can have multiple sensors that come and go with time and multiple series if spans of time are not linked to the same reference level. There is some leniency in movement of the station if it is the only sea level station in the area. If multiple stations are close (~few km), then each station should have a unique metadata record.

The metadata are organized by tables and sub-tables with the goal of building a relational-type database.

Time Mode: R: real, near-real time or “fast”, D: delayed-mode  
Need for inclusion in metadata: M: mandatory, O: optional

Types: S: character string (alpha-numeric), N: numeric, B: binary (yes/no)  
D: Date-time as YYYY-MM-DD HH:MM

Other Acronyms:
SSC: sea level station catalogue, a collaboration of GLOSS Data Centers

<table>
<thead>
<tr>
<th>Metadata Maintenance History Sub-table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
</tr>
<tr>
<td>----------------</td>
</tr>
<tr>
<td>Date-Time</td>
</tr>
<tr>
<td>Person</td>
</tr>
<tr>
<td>Agency</td>
</tr>
<tr>
<td>Action</td>
</tr>
</tbody>
</table>

Comments: This sub-table will accompany every field of each primary table to keep track of changes.

<table>
<thead>
<tr>
<th>Location Information Table</th>
</tr>
</thead>
<tbody>
<tr>
<td>Field</td>
</tr>
<tr>
<td>-----------------</td>
</tr>
<tr>
<td>SSC Station Name</td>
</tr>
<tr>
<td>Country</td>
</tr>
<tr>
<td>Originators</td>
</tr>
<tr>
<td>Station Name</td>
</tr>
<tr>
<td>Location Description</td>
</tr>
<tr>
<td>Nearest Ocean</td>
</tr>
<tr>
<td>Specific Basin</td>
</tr>
<tr>
<td>Latitude</td>
</tr>
<tr>
<td>Longitude</td>
</tr>
</tbody>
</table>
Position Source | O | O | S | How coordinates were determined | GPS, eye-balled off map, unconfirmed
Precision of Position | O | O | N | Position precision in meters | 5 m
Horizontal Datum | O | O | S | Geodetic reference in horizontal | WGS84, NAD, etc.
Time Zone and UTC Offset | O | M | S | Local time zone of station and offset from GMT (UTC) | 090W, GMT – 6 hr

Comment: Add a separate country code field for standardisation and interoperability (e.g. ISO3166).

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originator</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Agency responsible for data collection</td>
<td>Port Authority of Auckland</td>
</tr>
<tr>
<td>Contributor</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Agency that provided data to international data center(s)</td>
<td>Land Information New Zealand</td>
</tr>
<tr>
<td>Other</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>If any other agency supported the creation of the final data (repeatable)</td>
<td>University of Waikato</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Originator ID</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>As used by originating agency</td>
<td>8771450</td>
</tr>
<tr>
<td>SSC ID</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Needed as key for SSC management</td>
<td>1234567</td>
</tr>
<tr>
<td>Other</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Repeat as necessary</td>
<td>217 (eg. GLOSS as field)</td>
</tr>
</tbody>
</table>

Comment: a row can be inserted for any potential association (GLOSS, PSMSL, DCP, NOS, OTT12, BGAN, GCOS, JASL, CLIVAR, etc.)

Should there be an SSC station ID as mandatory that would serve as a keyword for the database?

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Existing</td>
<td>O</td>
<td>O</td>
<td>B</td>
<td>Does station have instrumentation, structure?</td>
<td>Y</td>
</tr>
<tr>
<td>Operational</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>Is station presently working</td>
<td>Y</td>
</tr>
<tr>
<td>Tsunami warning capable</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>alert transmissions, high frequency samples?</td>
<td>Y</td>
</tr>
<tr>
<td>Realtime access</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>Access ~ hour</td>
<td>Y</td>
</tr>
<tr>
<td>Committed to GLOSS</td>
<td>O</td>
<td>O</td>
<td>B</td>
<td>Part of GLOSS core network</td>
<td>Y</td>
</tr>
<tr>
<td>Committed to GCOS</td>
<td>O</td>
<td>O</td>
<td>B</td>
<td>Part of GCOS network</td>
<td>Y</td>
</tr>
</tbody>
</table>
Committed to Fast Delivery | O | O | B | Is station part of UHSLC fast delivery system | Y  
Committed to TIGA | O | O | B | Has CGPS and part of TIGA system | Y

### Sea Level Instrumentation Type Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor 1 Type</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>General type (float/well, radar.)</td>
<td>Radar</td>
</tr>
<tr>
<td>Sensor N Type</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Repeat for each</td>
<td>Float/well</td>
</tr>
</tbody>
</table>

There will be one sub-table for each Sensor Type

### Sea Level Instrumentation Type Specifics sub-Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Make</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Make of sensor</td>
<td>Aquatrak</td>
</tr>
<tr>
<td>Model</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Model of sensor</td>
<td>611-A</td>
</tr>
<tr>
<td>Date Installed</td>
<td>M</td>
<td>M</td>
<td>D</td>
<td>When installed</td>
<td>2001-03-23 00:00</td>
</tr>
</tbody>
</table>

Comment: Should table and associated sub-tables need to be incorporated into real-time tables below? What about historic gauges?

### Real-time Station Generic Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data-stream</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>Protocol type</td>
<td>GTS</td>
</tr>
<tr>
<td>URL</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>url, ftp server, email sender; may contain parameters like %Y, ...</td>
<td>ftp.vliz.be</td>
</tr>
<tr>
<td>Transmit interval</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>time between each message transmission in seconds</td>
<td>60</td>
</tr>
</tbody>
</table>

### Real-time Station GTS-Specific Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>WMO type</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>WMO message type</td>
<td>SXXX32, SEPA40</td>
</tr>
<tr>
<td>Origin</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>GTS origin code</td>
<td>EUMS, EBOC</td>
</tr>
<tr>
<td>DCP ID</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>GTS DCP ID</td>
<td>9321870A</td>
</tr>
<tr>
<td>NOS ID</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>NOS ID</td>
<td>9461380</td>
</tr>
<tr>
<td>Ott12 ID</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>Ott12 ID</td>
<td>EG-ALEX-07</td>
</tr>
<tr>
<td>BGAN ID</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>BGAN ID</td>
<td>ID-CILA-00</td>
</tr>
<tr>
<td>Harmonics available</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>Are harmonic calculations available?</td>
<td>Y</td>
</tr>
<tr>
<td>First minute transmission</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Number of minutes after the hour to expect the first message</td>
<td>15</td>
</tr>
<tr>
<td>Format type</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>GTS format type</td>
<td>crexx</td>
</tr>
</tbody>
</table>

30
<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of sensors</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Calculated field</td>
<td>3</td>
</tr>
</tbody>
</table>

Comment: Input list of options, such as GTS format type (can be built by VLIZ)

### Real-time Station Internet-Specific Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Username</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>FTP username</td>
<td>mylogin</td>
</tr>
<tr>
<td>Password</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>FTP password</td>
<td>mypass</td>
</tr>
<tr>
<td>Folder</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>FTP folder, directory</td>
<td>/data/station/</td>
</tr>
<tr>
<td>Filename</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>Filename to access, may contain parameters like %d for day</td>
<td>Data-%Y-%m-%d.txt</td>
</tr>
<tr>
<td>Rename possible</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>To distinguish between not –and processed data</td>
<td>Y</td>
</tr>
<tr>
<td>Appended</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>New data being appended to existing file?</td>
<td>Y</td>
</tr>
<tr>
<td>Find</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>What string to search for, and replace afterwards</td>
<td>.txt</td>
</tr>
<tr>
<td>Replace</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>How to rename the file when processed</td>
<td>.txt.done</td>
</tr>
<tr>
<td>Last files to be requested</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>How many last files to retrieve (sorted by date)</td>
<td>5</td>
</tr>
<tr>
<td>Email_subject</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>Subject of the email</td>
<td>HEMBA data</td>
</tr>
<tr>
<td>Webservice method</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>HTTP method to use</td>
<td>GET</td>
</tr>
<tr>
<td>Upload GTS</td>
<td>M</td>
<td>O</td>
<td>B</td>
<td>Upload data to GTS?</td>
<td>Y</td>
</tr>
</tbody>
</table>

### Real-time Sensor GTS-Specific Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Type</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>String to look for in message</td>
<td>pr1</td>
</tr>
<tr>
<td>Samples</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Number of data samples or observations</td>
<td>30</td>
</tr>
<tr>
<td>Sampling interval</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Time between consecutive samples in minutes</td>
<td>5</td>
</tr>
<tr>
<td>Offset/I</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Start of data in message relative to string</td>
<td>13</td>
</tr>
<tr>
<td>Units</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>Units used</td>
<td>m</td>
</tr>
<tr>
<td>Scale</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Problem with some NOS, inverted RAD, etc</td>
<td>1.23</td>
</tr>
<tr>
<td>Time direction</td>
<td>M</td>
<td>O</td>
<td>N</td>
<td>Last data is first (-1) or lat (1) sample</td>
<td>1</td>
</tr>
</tbody>
</table>
### Regular expression

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Regular</td>
<td>M</td>
<td>O</td>
<td>S</td>
<td>expression</td>
<td>/\d{4}-\d{2}-\d{2}\t\d+/</td>
</tr>
</tbody>
</table>

### Space Geodetic Co-location Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Space geodetic technique</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Type system (repeatable)</td>
<td>GNSS, DORIS, etc</td>
</tr>
<tr>
<td>Nominal station name</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>As called by TIGA</td>
<td>Galveston</td>
</tr>
<tr>
<td>CGPS Latitude</td>
<td>M</td>
<td>M</td>
<td>N</td>
<td>Decimal (+N, -S)</td>
<td>29.32988068</td>
</tr>
<tr>
<td>CGPS Longitude</td>
<td>M</td>
<td>M</td>
<td>N</td>
<td>Decimal (+E, -W)</td>
<td>-94.73680897</td>
</tr>
<tr>
<td>CGPS Height</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Height in meters</td>
<td>-17.545</td>
</tr>
<tr>
<td>Reference frame of position</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Specific reference</td>
<td>ITRF2005</td>
</tr>
<tr>
<td>Ellipsoid</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Type ellipsoid</td>
<td>GRS80</td>
</tr>
<tr>
<td>Date of last processing</td>
<td>O</td>
<td>O</td>
<td>D</td>
<td>Keep track of processing</td>
<td>2009-08-01 00:00</td>
</tr>
<tr>
<td>Online source</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Where to obtain CGPS data</td>
<td>URL TIGA</td>
</tr>
<tr>
<td>Position accuracy</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Centimeters</td>
<td>&lt; 1</td>
</tr>
<tr>
<td>Originator ID</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Needed by TIGA (if exists)</td>
<td>GAL1</td>
</tr>
<tr>
<td>DOMES ID</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Needed by TIGA (if exists)</td>
<td>49872S001</td>
</tr>
<tr>
<td>Originator</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Who installed</td>
<td>US Coast Guard</td>
</tr>
<tr>
<td>Contributor</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Who provided data management</td>
<td>SIO</td>
</tr>
<tr>
<td>Installation date</td>
<td>O</td>
<td>O</td>
<td>D</td>
<td>When installed</td>
<td>1995-09-29 00:00</td>
</tr>
<tr>
<td>Decommissioned date</td>
<td>O</td>
<td>O</td>
<td>D</td>
<td>When terminated</td>
<td>2003-07-10 00:00</td>
</tr>
<tr>
<td>Distance to TGBM</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Meters</td>
<td>6800</td>
</tr>
</tbody>
</table>

Comments:
- Longitude and latitude in the previous tables: they may be valuable to locate the objects and compute the distances between TG and GPS, for example. However, to be worth they should be provided at the 1-10m accuracy level within the same geodetic system. Are we sure we will get the information at the required accuracy level and non ambiguous (geodetic system)? A suggestion could be to request GPS-navigation (standard wide-users GPS receivers) coordinates in WGS84 (the native geodetic system of GPS).

- Height and accurate Longitude and Latitude in the last table: I understand the information on accurate Height is desirable in the last table. However, we are not dealing anymore with metadata information (station information), but with results that may be questioned depending on the options adopted for high-precision GPS processing.
Ancillary Instrumentation Type Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sensor 1 Type</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>General type</td>
<td>barometer</td>
</tr>
<tr>
<td>Sensor N Type</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Repeat for each</td>
<td>Thermometer for air</td>
</tr>
</tbody>
</table>

Comment: There will be one sub-table for each Sensor Type

Ancillary Instrumentation Type Specifics sub-Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Parameter</td>
<td>O</td>
<td>O</td>
<td>O</td>
<td>Field measured</td>
<td>Barometric air pressure</td>
</tr>
<tr>
<td>Make</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Make of sensor</td>
<td>Andataco</td>
</tr>
<tr>
<td>Model</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Model of sensor</td>
<td>QC111</td>
</tr>
<tr>
<td>Date Installed</td>
<td>O</td>
<td>O</td>
<td>D</td>
<td>When installed</td>
<td>2001-03-23 00:00</td>
</tr>
<tr>
<td>Date Terminated</td>
<td>O</td>
<td>O</td>
<td>D</td>
<td>When removed (blank if not)</td>
<td></td>
</tr>
<tr>
<td>Originator</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Authority in charge of sensor</td>
<td>NOAA/NWS</td>
</tr>
<tr>
<td>URL to realtime data</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Link to data if available</td>
<td><a href="http://noaa.gov/8822882">http://noaa.gov/8822882</a></td>
</tr>
<tr>
<td>URL to historic data</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>If historic data are available</td>
<td><a href="http://ncdc.noaa.gov">http://ncdc.noaa.gov</a></td>
</tr>
</tbody>
</table>

Delayed-Mode Processing Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Calibration Methods</td>
<td>O</td>
<td>M</td>
<td>S</td>
<td>Describe how data calibrated</td>
<td>Tide staff readings and switch data</td>
</tr>
<tr>
<td>Data reduction</td>
<td>O</td>
<td>M</td>
<td>S</td>
<td>Describe techniques to reduce the sample interval</td>
<td>Hourly data acquired using a 3-pt Hanning</td>
</tr>
<tr>
<td>Gap-filling methods</td>
<td>O</td>
<td>M</td>
<td>S</td>
<td>If auxiliary sensor data used to fill gaps, or if data interpolated, describe</td>
<td>Predicted tides method</td>
</tr>
<tr>
<td>Quality control</td>
<td>O</td>
<td>M</td>
<td>S</td>
<td>Describe editing associated with quality control</td>
<td>Timing offsets of exact increments of 1 hour, spikes and short glitches &lt; 24 hours interpolated</td>
</tr>
<tr>
<td>Fastest interval</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>State shortest sample interval of research quality data</td>
<td>hourly</td>
</tr>
</tbody>
</table>

Comment: Perhaps this table is not necessary with the SSC. This would just be a readme.txt type file that accompanies data files.

Delayed-Mode Data File Attributes Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Data units</td>
<td>O</td>
<td>M</td>
<td>S</td>
<td>Scientific units in</td>
<td>Millimeters (mm)</td>
</tr>
</tbody>
</table>
Comment: Perhaps this table is not necessary with the SSC. This would just be a readme.txt type file that accompanies data files.

### Bench Mark Description Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tide Gauge Bench Mark (TGBM)</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Description of marker and location</td>
<td>USACE disk stamped “8-201” set in sidewalk of NE corner of Harbor House</td>
</tr>
<tr>
<td>Bench Mark 1</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Description of marker and location</td>
<td></td>
</tr>
<tr>
<td>Bench Mark N</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Description of nth marker and location</td>
<td></td>
</tr>
</tbody>
</table>

Comment: For each entry above, a sub-table gives further attributes

### Bench Mark Specifics Sub-Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agency Responsible</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>Who maintains geodetic surveys</td>
<td>NOAA/NOS</td>
</tr>
<tr>
<td>Originator ID</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>ID used by originator</td>
<td>TGBM</td>
</tr>
<tr>
<td>Latitude</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Decimal latitude (N+, S-)</td>
<td>29.31666</td>
</tr>
<tr>
<td>Longitude</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Decimal longitude (E+, W-)</td>
<td>-94.80000</td>
</tr>
<tr>
<td>Position Source</td>
<td>O</td>
<td>O</td>
<td>S</td>
<td>How coordinates were determined</td>
<td>GPS, eye-balled off map, unconfirmed</td>
</tr>
<tr>
<td>Precision of Position</td>
<td>O</td>
<td>O</td>
<td>N</td>
<td>Position precision in meters</td>
<td>5 m</td>
</tr>
</tbody>
</table>
### Station Datum (SD) Definition Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Definition of SD</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Specific definition relative to a calculated datum</td>
<td>1.2m above mean sea level based on epoch 1983-2001</td>
</tr>
<tr>
<td>Originator datum Name</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Definition defined by originator</td>
<td>same</td>
</tr>
<tr>
<td>TGBM to SD</td>
<td>M</td>
<td>M</td>
<td>N</td>
<td>Relative height (m) TGBM above SD</td>
<td>2.643</td>
</tr>
<tr>
<td>Epoch of determination</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Define epoch</td>
<td>Based on 1983-2001</td>
</tr>
<tr>
<td>Accuracy criteria</td>
<td>M</td>
<td>M</td>
<td>N</td>
<td>Accuracy (m)</td>
<td>0.001</td>
</tr>
</tbody>
</table>

### Relationships Between Datum/Bench Marks Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td>Relationship 1</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Describe relationship in vertical between two reference points</td>
<td>Zero of SL data is 1.282 m below TGBM</td>
</tr>
<tr>
<td>Relationship N</td>
<td>M</td>
<td>M</td>
<td>S</td>
<td>Repeat as necessary</td>
<td>TGBM is 0.782 m below Aux. BM 1</td>
</tr>
</tbody>
</table>

Intentionally blank below (as a template for expansion)

### Header Table

<table>
<thead>
<tr>
<th>Field</th>
<th>R</th>
<th>D</th>
<th>T</th>
<th>Description</th>
<th>Example</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
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<td></td>
<td></td>
</tr>
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<td></td>
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</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
ANNEX 3: EXAMPLE DOCUMENTS

EXAMPLE 1: WHITBY, UK

Whitby (Yorkshire) Tide Gauge

Site of Gauge:
The tide gauge is located in the Harbour Master’s Office, Pier Road. The measuring points are positioned underneath the Quay adjacent to the Harbour Office. This site is affected by fresh water influx.

Benchmarks and Benchmark relationships:

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Grid Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGBM</td>
<td>NZ 8986 1141</td>
<td>E side of Pier Rd</td>
</tr>
<tr>
<td>Aux1</td>
<td>NZ 8992 1105</td>
<td>Bolt butt of Whitby Bridge</td>
</tr>
<tr>
<td>Aux2</td>
<td>NZ 8985 1134</td>
<td>Rivet quayside SE side of Pier Rd</td>
</tr>
<tr>
<td>Aux3</td>
<td>NZ 8983 1142</td>
<td>Rivet wall angle S side of road angle of lifeboat museum</td>
</tr>
</tbody>
</table>

TGZ = Admiralty Chart Datum (ACD)
TGZ = 3.00m below ODN
TGZ = 9.105m below TGBM
TGZ = 8.765m below Aux1
TGZ = 8.123m below Aux2
TGZ = 10.369m below Aux3

Datum information: All data are to UK Admiralty Chart Datum (ACD).

Data quality:
The primary data channel has been screened and quality controlled using BODC procedures and standards.
EXAMPLE 2: ANDENES, NORWAY

**Andenes Tide Gauge**

**Site of gauge**
The tide gauge is located on the "trafikk- og allmenningskai", not far from the Andenes Port Authorities (Hamnegata 71).

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**Benchmarks and benchmark relationships**

<table>
<thead>
<tr>
<th>Benchmark</th>
<th>Grid Reference</th>
<th>Description</th>
</tr>
</thead>
<tbody>
<tr>
<td>TGBM</td>
<td>L7 N42</td>
<td>About 5m S of mid street on the pier and about 13m E of lamp post.</td>
</tr>
<tr>
<td>Aux1</td>
<td>L7 N33</td>
<td>In rock between the houses in Lonkunholmen. 105m E of the street and 1m S of the southernmost wall on Fiskesamvirket's fisherman's shack.</td>
</tr>
<tr>
<td>Aux2</td>
<td>L7 N34</td>
<td>In rock furthest out and on the eastern side of Lonkanholmen. 12m N of Br.Aunes storehouse and 6m N of the nothernmost corner of oil tank. The BM is located on the site of Fiskesamvirke's.</td>
</tr>
</tbody>
</table>

TGZ = 5.245 m below TGBM
TGZ = 3.891 m below Aux1
TGZ = 3.463 m below Aux2
TGZ = 2.000 m below Normalnull 1954 (Land Survey Datum)

**Datum information**
All data are to TGZ.

**Data quality**
The primary data channel has been screened and quality controlled using the Norwegian Hydrographic Service (NHS) procedures and standards.
Annex 4: Acronyms

ASCII American Standard Code for Information Interchange
BODC British Oceanographic Data Centre
COARDS Cooperative Ocean/Atmosphere Research Data Service
DMPA Data Management Programme Area
EOF Empirical Orthogonal Function
ESEAS European Sea Level Service
EU European Union
GCN GLOSS Core Network
GCOS Global Climate Observing System
GLOSS Global Sea Level Observing System - 'Global Level of the Sea Surface'
GNSS Global Navigation Satellite Systems
GODAE Global Ocean Data Assimilation Experiment
GOOS Global Ocean Observing System
GPS Global Positioning System
GTS Global Telecommunication System
JCOMM Joint Technical Commission for Oceanography and Marine Meteorology
ICES International Council for the Exploration of the Sea
IGS International GNSS Service
IOC Intergovernmental Oceanographic Commission
IODE International Oceanographic Data and Information Exchange
IOLR Israel Oceanographic and Limnological Research
IOTWS Indian Ocean Tsunami Monitoring System
ISO International Standards Organisation
LAT Lowest Astronomical Tide
MSL Mean Sea Level
NOC National Oceanography Centre
netCDF Network Common Data Form
OPPE Organismo Público Puertos del Estado
PC Personal Computer
PSMSL Permanent Service for Mean Sea Level
PTWS Pacific Tsunami Warning System
QC Quality Control
REDMAR OPPE tide gauge network
RT Real-time
SeaVox International (IOC/IODE) governance forum for standardised vocabularies
SI Système International
SNHT Standard Normal Homogeneity Test
TASK Tidal Analysis Software Kit
TGBM Tide Gauge Bench Mark
TIGA GPS Tide Gauge Benchmark Monitoring Project
TIRA Tidal Institute Recursive Analysis
UHSLC University of Hawaii Sea Level Center
UNESCO United Nations Educational, Scientific and Cultural Organization
VLIZ Flanders Marine Institute
WGDIM Working Group on Data and Information Management
WMO World Meteorological Organisation
WOCE World Ocean Circulation Experiment