Notes about the Moturiki Annual Mean Sea Level Data

Last updated 16 February 2023

1. Tide gauge (TG) data at Moturiki was first collected in the period 7 February 1949 – 15 December 1952. This data was meaned in order to establish the Moturiki Vertical Datum 1953 (MVD 1953). The mid-point of this data set (in terms of time) is approximately 1 January 1951. Historically, this levelling datum has been used as the basis for providing MSL heights throughout the Coromandel and Bay of Plenty region.

2. The former Ministry of Works and Development (MWD) began operating a float/stilling well TG on Moturiki Island on 27 May 1971. When MWD was dis-established in 1988, some elements of the organisation were merged with parts of the former Deptartment of Scientific and Industrial Research (DSIR) to form the National Institute of Water and Atmospheric Research (NIWA). NIWA has maintained the gauge ever since. As of 1998, the TG was a digital Fischer and Porter water-level recorder that sampled at 15 min intervals (Bell and Goring, 1998). The gauge currently has a Unidata digital encoder and a 5 minute logging interval.

3. Whilst the zero of the Moturiki tide gauge data 1487 mm below Moturiki Vertical Datum 1953, the annual MSL values refer to chart datum being 4.103 metres below B.M. BC 84 (LINZ code B309).

4. While all the digital data has been sourced from NIWA, the derivation of the MSL data files (daily, monthly and annual means) is not straight-forward. Much of the pre-1990 data was derived from digitised TG charts with some missing months apparently infilled using a regression between Moturiki Island and another TG at the tug berth in Tauranga Harbour. This was certainly true for the 1977 annual MSL (Bell, personal communication). All monthly MSLs prior to 1990 have been supplied by Bell. No daily MSL values are available.

5. All the daily, monthly and annual MSLs from 1990 onwards have been processed using the University of Hawaii sea level processing software (Caldwell, 1998).

6. Outside of the four main ports, this is one of the longest continuous tide gauge records in New Zealand.

7. Each annual MSL value has been assigned a standard deviation as described in the accompanying notes regarding current international data standards

References

Bell, R.G., and Goring, D.G., (1998). Seasonal variability of sea-level and sea surface temperature on the north-east coast of New Zealand. Estuarine, Coastal and Shelf Science, 46, 307-318.

Caldwell, P., (1998). Sea level data processing on IBM-PC compatible computers, Version 3.0. JMAR Contribution No. 98-319, University of Hawaii at Monoa, School of Ocean and Earth Science Technology, Honolulu, Hawaii. (2014: Updated to v4.0 – SLP64, available from http://ilikai.soest.hawaii.edu/UHSLC/jasl/slp64/slp64.html).

Current International Data Standards

J. Hannah, April 2022

The current international standards for data sets associated with climate change/sea level studies are not fully consistent – particularly in their completeness of data criteria. The WMO standard for surface meteorological observations (WMO, 2017) assume that daily mean values for sea level pressure are calculated from either eight evenly spaced 3-hourly observations or six evenly spaced 4-hourly observation. It is accepted that the calculation of daily mean temperatures may differ, dependent upon country. However, they do recommend that where a monthly value is the mean of that month's daily values, it should not be calculated if either of the following criteria are satisfied:
– Observations are missing for 11 or more days during the month;
– Observations are missing for a period of 5 or more consecutive days during the month.

Standards governing sea level data are different. Daily MSLs are calculated from hourly means by passing them through a filter such as the 39-hour Doodson filter, a 71-hour Demerliac filter, or some other appropriate filter. This filter removes the tidal energy at diurnal and higher frequencies (UNESCO/IOC, 2020). The resulting data are then quality assured against a predicted tide.

A simple arithmetic monthly mean is calculated from the daily means. The PSMSL recommends discarding the month if over 15 days are missing. Some software, however, such as the University of Hawaii software (Caldwell, 1998), will only calculate a monthly mean automatically if seven or fewer days of data are missing. The PSMSL calculates annual means as a weighted mean of the monthly values, with each month weighted by the number of days present. If over one month is missing, the annual mean is not calculated.

Much of the early work on the New Zealand data sets was undertaken prior to the development of the above international data standards. Fortuitously, the processes used largely meet the PSMSL standard. The fact that the hourly data has been filtered using the University of Hawaii software generally results in a monthly mean being calculated when only seven or fewer daily means are missing.

The one major point of difference in the existing datasets with respect to the PSMSL standards, relates to the annual MSLs. Wherever at least one month of data is available a MSL is recorded. However, it has been assigned a standard deviation derived as follows:

a) Where the data record is based upon very reliable and well-maintained tide gauges with few outages, the associated standard deviation is calculated from the equation:

$$\sigma_{MSL} = \frac{0.09\,m}{\sqrt{n}} \qquad \text{where n = number of months of data.}$$

In other words, an annual mean with one month of good, consistent data will have a standard deviation of 0.09 metres, whilst an annual mean with 12 months of data will have a standard deviation of 0.025 m. The standard deviations have all been rounded down to the nearest 0.005 m. This weighting system was determined by a posteriori variance analysis and is documented in Hannah (2004).

b) Where the tide gauge has a poor maintenance history or over periods when the data record seems less reliable, the 0.09 m in the above equation is replaced by 0.11 m. Conversely, when the digitised record has shown good consistency, even if the overall gauge maintenance has not been good, the 0.011 m has been replaced by 0.09 m.

c) Due to its derivation process, a MSL derived from a Mean Tide Level is considered even less reliable again.

This weighting procedure was chosen so that all the annual MSL data could be used in a weighted least squares estimation process from which the linear sea level trends could be calculated. Standard deviations for each annual MSL are shown in the data files.

References

Caldwell, P., (1998). Sea level data processing on IBM-PC compatible computers, Version 3.0. JMAR Contribution No. 98-319, University of Hawaii at Monoa, School of Ocean and Earth Science Technology, Honolulu, Hawaii. (2014: Updated to v4.0 – SLP64, available from http://ilikai.soest.hawaii.edu/UHSLC/jasl/slp64/slp64.html).

Hannah, J., (2004). An Updated Analysis of Long-Term Sea Level Change in New Zealand. Geophysical Research Letters, 31, L03307, 4 pp.

UNESCO/IOC (2020). Quality Control of in-situ Sea Level Observations: A Review and Progress towards Automated Quality Control, Vol. 1. Paris, UNESCO. IOC Manuals and Guides No. 83. (IOC/2020/MG/83 Vol. 1).

WMO (2017). WMO Guidelines for the Calculation of Climate Normals. WMO-No. 1203, available from https://library.wmo.int/doc_num.php?explnum_id=4166.