Notes about the Nelson Annual Mean Sea Level Data

Last updated 18 November 2022

1. The 1941 data point was found in archived Lands & Survey data files. It was the mean of approximately three-and-a-half years of data collected from 12 June 1939 to 12 October 1942 in order to form the zero point for the 1941 Nelson Mean Sea Level (MSL) levelling datum. Further details can be found in Hannah and Bell (2012).

2. The raw hourly MSLs were provided by Port Nelson Ltd. This hourly data has been processed into daily and monthly means using the University of Hawaii sea level processing software (Caldwell, 1998).

3. Data from the old tide gauge (TG) files compiled by the former Department of Lands & Survey, indicate that the TG zero has remained at the same level throughout the entire period that the gauge has been operating. In addition, analysis of local bench mark records indicates site stability (see Hannah and Bell, 2012).

4. The 2016 Kaikoura earthquake impacted the Nelson area. As a result the recorded sea level data have been reduced by 21 mm, starting from 00:00 hours on 14 November 2016. This was done in accordance with the reverse patch update for NZGD2000, Version 20171201 that determined a 21 mm subsidence for the local geodetic mark AC4T.

5. To account for further incremental quake induced subsidence and commencing 1 January 2018, a further reduction of 17.9 mm (i.e., a total reduction of -21-17.9 = - 39 mm) has been applied by Toitū Te Whenua Land Informtion New Zealand (LINZ) to the recorded data.

6. For a monthly MSL to contribute to the calculation of an annual MSL value, the University of Hawaii software (Caldwell, 1998) requires at least 75% of the hourly data within the month to be present. Because of the paucity of data currently available at Nelson, this requirement was reduced to 66%. A further seven monthly MSLs (July 1987, November 1999, January and March 2000, July 2006, February 2007 and May 2013) were thus able to be included in the analyses. The monthly means were then used to form the annual MSLs.

7. Regional continuous GPS results (reported in NIWA, 2018) give no clear picture of regional tectonic trends. A neutral effect has been assumed.

8. Each annual MSL value has been assigned a standard deviation as described in the accompanying notes regarding current international data standards. The reference for the MSL values is 5.733 metres below B.M. N 1 (LINZ code AC4T).

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., and Bell, R.G., (2012). Regional sea level trends in New Zealand. JGR Oceans, Vol. 117, Issue 1, doi: http://dx.doi.org/10.1029/2011JC007591.

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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 Permanent Service for Mean Sea Level (PSMSL) recommends discarding the month if over 15 days are missing. Some software, however, such as the University of Hawaii software (Caldwell, 1998), will calculate a monthly mean automatically only 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:

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

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).

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.