Whakatane sunshine data comparison

NIWA Client Report: WLG2009-26

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Whakatane District Council

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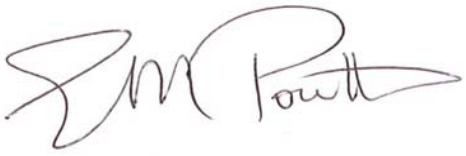

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Executive Summary

Whakatane District Council (WDC) installed a Kipp & Zonen CSD3 sunshine duration sensor and associated data logging equipment in December 2006 to provide daily sunshine totals for the town. Previous sunshine records for Whakatane exist for the years 1957–1982, 1984–1987, and 1993–2001.

The WDC equipment recorded a very high annual sunshine hours total for 2008 (2703 hours). Whakatane has never had an annual sunshine hours total as high as the recorded 2008 total in 41 years of recorded data (the 2008 total was 150 hours more than the previous highest annual total recorded in 2007). The Whakatane 2008 total was also much higher than the corresponding data at the nearest site (Tauranga airport, 2355 hours), and nearly 200 hours greater than the next highest for all of New Zealand (Blenheim, 2505 hours). The extremity of the 2008 total called into question its validity, and, as it is standard scientific practice to check extreme anomalous values for validity, a decision was made to install a duplicate identical instrument at the same site, and compare the values from both instruments over the period of approximately one month.

The data comparison revealed a likely overestimation in the WDC sunshine hours. The average difference between the WDC daily totals and the NIWA daily totals over the 30 day period from 11 March to 9 April inclusive was +12.1 minutes per day. However there is a marked variability in the differences from day to day, which may be related to the weather conditions. On 15 March, when there was persistent stratiform cloud over the Bay of Plenty and a light easterly to north-easterly airstream, the WDC sunshine recorder measured 57.6 minutes more sunshine than the NIWA instrument (greatest difference) while on 3 April, when conditions were mostly sunny, the difference was 2.1 minutes (least difference). There is no way of accurately determining the amount of overestimation in the daily, monthly and annual sunshine totals for 2007 and 2008 and up to April 9 2009. The only conclusion that can be made is that the totals are likely to be too high.

The reason for the overestimation is most likely due to the way the WDC data logger was set up to record continuous sunshine periods, rather than record sunshine in hourly time-steps as is standard for other sunshine (and other meteorological variables) instruments throughout New Zealand and accords with World Meteorological Organisation (WMO) standards. In practice, the way the sunshine is recorded and logged should not make any difference when values are totalled over a day (or month or year), but it is shown here that it probably has made a difference, implying there may be a software problem with the data logger.

Now that the WDC logger is set up to record sunshine in hourly time-steps it is likely that the overestimation bias has been removed. Sunshine hours are now consistent with the adjacent sunshine recorder installed by NIWA for the purposes of undertaking this comparison. It is recommended that the NIWA instrument remain in place for another couple of months to check that the bias in the logged data has indeed been removed.

1. Background

A NIWA-owned sunshine recorder (a Kipp & Zonen CSD3 Sunshine Duration Sensor – identical to the Whakatane District Council (WDC) instrument) was installed at the WDC sunshine recorder site on 10 March 2009, and the data logger was set up to log sunshine duration on an hourly basis as is the standard set up for all loggers on NIWA and MetService sunshine recorders (and other meteorological instruments) throughout New Zealand.

However, it should be noted that the data logger associated with the WDC instrument was set up differently from the NIWA logger. The WDC logger recorded the duration of continuous bright sunshine periods. For example, a daily sunshine total could be logged as being made up of a continuous sunshine period lasting for 5.6 hours (i.e. from sunrise to a time 5.6 hours later when cloud obscured the sun for the remainder of the day). The WDC logger would have recorded one value, 5.6 hours, for this day. The NIWA logger would have logged the sunshine on this day (in hours) as 1 + 1 + 1 + 1 + 1 + 0.6 (i.e. in hourly increments). The total for the day is the same, but the way the data are recorded throughout the day is different. The WDC data logger had been set up to log continuous sunshine periods when the sunshine recorder was installed at its current site in December 2006.

The 2008 sunshine total recorded by the WDC instrument was called into question by NIWA scientists during the preparation of the 2008 Annual Climate Summary. The total number of sunshine hours observed was 2703 hours. This total was far greater than any other total recorded at Whakatane in 41 years of past observations (at various locations around Whakatane and from different types of instruments – see Table 1); the 2008 total recorded at Tauranga Airport (the nearest sunshine recording site to Whakatane – see Table 1); and the next three highest 2008 sunshine totals recorded anywhere in New Zealand (Blenheim, Nelson, and Lake Tekapo – see Table 1).

A decision was made not to publish the Whakatane 2008 sunshine hours total in the Annual Climate Summary for 2008 as the extremity of the value called into question its validity. A plan was put into place immediately to discuss the decision with Whakatane District Council (WDC) and determine a course of action whereby the instrument could be tested and the data could be validated.

Two simple initial tests were suggested to WDC. The first involved a field visit to the site by a NIWA technician to simply test if the recorder was measuring the correct number of “sunshine minutes” when it was indeed sunny. The instrument passed this test. The second field-based test was to cover the sensor on the instrument and check

to see that no sunshine was being recorded. The instrument passed this test as well. However, there was no way to determine in the field whether the instrument was correctly calibrated so that it was recording *only* bright sunshine (unimpeded by cloud), or whether it was recording partially cloudy periods as completely sunny.

Two further tests were suggested to WDC to test whether the instrument was properly calibrated (i.e., was recording sunshine only when there was bright sunlight). The first suggested test was to remove the instrument, take it to a controlled laboratory (i.e., at NIWA in Lauder, Central Otago, or potentially to send it back to the manufacturer in The Netherlands), and check that it was indeed still performing to its correct specifications. This suggested test is not ideal, as removal of the instrument will leave a gap in the data record. The second suggested test was to install a factory-calibrated identical instrument at the same site, have both instruments operate for one month (to make sure a wide variety of weather types were sampled; e.g., fully sunny, partially sunny, high cloud only, completely cloud-covered), then compare the data from both instruments to see if there are any discrepancies. This second suggestion was agreed upon. The NIWA instrument was installed on 10 March 2009. NIWA has covered all the costs of installing the duplicate instrument.

The WDC automatic sunshine recorder is not maintained by NIWA, nor are the data automatically sent to NIWA directly (e.g., via telemetry). The daily sunshine totals are logged by WDC and then sent to NIWA at the end of each month. While NIWA was consulted over the type of instrument to purchase, it was not involved with site selection or installation.

Table 1: Comparison of annual sunshine totals

WDC Sunshine Recorder current site (automatic sunshine recorder)	2007 total 2008 total	2550 hours 2703 hours
Three previous sites at Whakatane (manual sunshine recorders)	1993 – 2001 1984 – 1987 1957 – 1982	Average annual total = 2277 hours Highest total = 2420 hours (1994) Average annual total = 2427 hours Highest annual total = 2477 hours (1986) Average annual total = 2325 hours Highest annual total = 2518 hours (1957)
Tauranga Airport Sunshine Recorder (nearest site to Whakatane; manual sunshine recorder)	2008 total	2355 hours
Top 3 sunshine hours locations in 2008 (as listed in the NIWA Annual Climate Summary for 2008)	Blenheim Nelson Lake Tekapo	2505 hours 2472 hours 2444 hours

2. Data Comparison

This report compares the sunshine data from the two instruments over the period 11 March to 19 April inclusive. Note that at the time of writing this report, the NIWA instrument has not been removed from the site and as is still recording hourly sunshine totals.

On 10 April a significant and important change was made to the way the WDC data logger processed the sunshine. At the request of NIWA, and with the compliance and assistance of the WDC appointed technician, the WDC data logger was set to record data in hourly increments, consistent with the NIWA instrument and other sunshine observations throughout New Zealand which comply with World Meteorological Organisation (WMO) standards.

The daily sunshine hours totals for each instrument for the overlapping period 11 March to 19 April inclusive are shown in Table 2. The daily difference (WDC minus NIWA) in hours and minutes is shown in columns 4 and 5, and the daily difference in minutes is plotted in Figure 1.

Table 2: Comparison of daily sunshine hours totals

Date	WDC Sunshine (hours)	NIWA Sunshine (hours)	Difference (hours)	Difference (minutes)
11/03/2009	7.78	7.47	0.31	18.6
12/03/2009	9.55	9.34	0.21	12.6
13/03/2009	8.47	8.12	0.35	21.0
14/03/2009	4.30	3.87	0.43	25.8
15/03/2009	8.00	7.04	0.96	57.6
16/03/2009	8.25	7.75	0.50	30.0
17/03/2009	4.50	4.32	0.18	10.8
18/03/2009	6.48	6.34	0.14	8.4
19/03/2009	6.53	6.35	0.18	10.8
20/03/2009	11.00	10.87	0.13	7.8
21/03/2009	10.47	10.35	0.12	7.2
22/03/2009	8.65	8.53	0.12	7.2
23/03/2009	8.18	8.07	0.11	6.6
24/03/2009	11.52	11.35	0.17	10.2
25/03/2009	11.60	11.43	0.17	10.2
26/03/2009	11.57	11.40	0.17	10.2
27/03/2009	10.37	10.28	0.09	5.4
28/03/2009	9.12	8.99	0.13	7.8
29/03/2009	10.98	10.86	0.12	7.2
30/03/2009	11.47	11.33	0.14	8.4
31/03/2009	8.13	7.92	0.21	12.6
1/04/2009	8.82	8.67	0.15	8.8
2/04/2009	8.38	8.28	0.10	6.0
3/04/2009	10.83	10.80	0.04	2.1
4/04/2009	11.17	11.06	0.11	6.7
5/04/2009	10.95	10.82	0.13	7.8
6/04/2009	11.13	11.00	0.13	8.0
7/04/2009	6.72	6.67	0.05	3.2
8/04/2009	4.55	4.38	0.17	10.2
9/04/2009	6.36	6.12	0.24	14.5
10/04/2009	9.96	10.05	-0.09	-5.2
11/04/2009	10.79	10.79	0.00	0.0
12/04/2009	10.38	10.42	-0.04	-2.4

13/04/2009	7.46	7.54	-0.08	-4.8
14/04/2009	9.89	9.89	0.00	0.0
15/04/2009	8.64	8.22	0.42	25.2
16/04/2009	8.87	9.01	-0.14	-8.4
17/04/2009	10.28	10.29	-0.01	-0.7
18/04/2009	6.66	6.71	-0.04	-2.7
19/04/2009	2.18	2.15	0.03	2.0

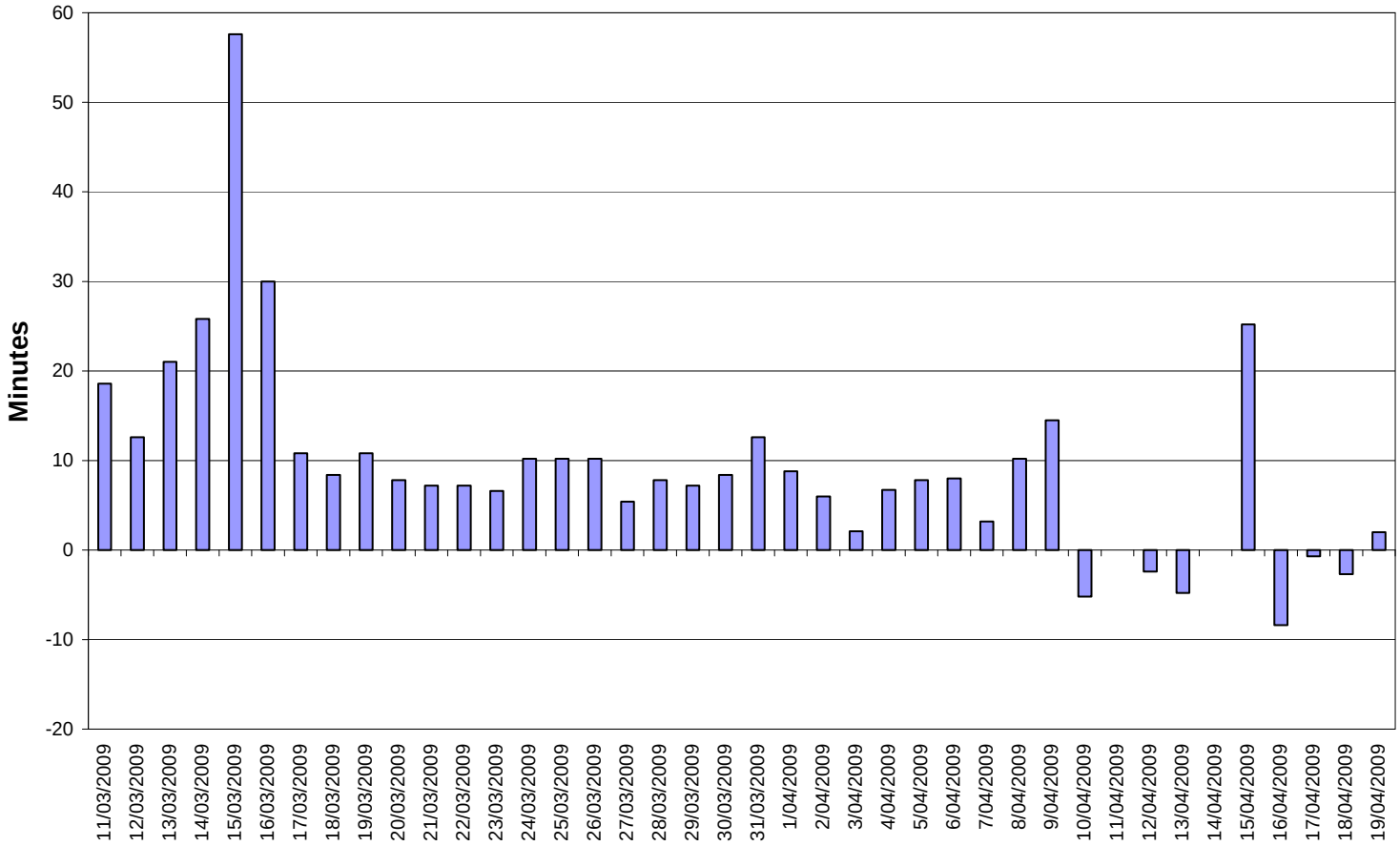

Figure 1: Plot of the daily sunshine hours difference (WDC minus NIWA)

A consistent positive difference (WDC higher than NIWA) throughout the period 11 March to 9 April inclusive is shown in Table 2 and Figure 1. On 15 March the difference is 57.6 minutes (greatest difference), while on 3 April the difference is 2.1 minutes (least difference). The average daily difference during this period is 12.1 minutes. On 10 April the NIWA instrument measured more sunshine that the WDC

instrument for the first time during the overlap period (by 5.2 minutes). The following four days had nil difference or a slightly higher NIWA value. On 15 April the WDC instrument recorded 25.2 minutes more than the NIWA instrument (see a more detailed discussion on this below). The following day shows the NIWA instrument higher by 8.4 minutes, then the remaining three days show very small differences (positive and negative).

The WDC logger was set to measure sunshine in hourly time steps on 10 April. Because of this, it was possible to examine the hour-by-hour data differences between the instruments throughout the period 10 April to 19 April inclusive. In general, the hourly totals from the two instruments were similar, with positive and negative differences interspersed randomly during each day. This is the kind of pattern consistent with a comparison of data from two instruments recording the same quantity (i.e. no two sunshine instruments set up in this configuration are likely to record exactly the same values, but any differences should be relatively small and randomly distributed in time).

The case on 15 April is special, as the data comparison shows a large difference in the data in one particular hour (between 2pm and 3pm; see Table 3). This large difference (19.35 minutes, accounting for the majority of the daily difference) is an unexplained anomaly. Continued monitoring of both instruments should reveal whether this is a one-off glitch or a recurring problem.

Table 3: Comparison of hourly sunshine for 15 April

Date	Time (at end of hourly period)	WDC Sunshine (minutes)	NIWA Sunshine (minutes)	Difference (WDC minus NIWA; minutes)
15/04/2009	6:00:00	7.72	8.9	-1.18
15/04/2009	7:00:00	36.85	37.5	-0.65
15/04/2009	8:00:00	60.0	60.0	0.00
15/04/2009	9:00:00	60.0	60.0	0.00
15/04/2009	10:00:00	60.0	60.0	0.00
15/04/2009	11:00:00	60.0	60.0	0.00
15/04/2009	12:00:00	60.0	60.0	0.00
15/04/2009	13:00:00	60.0	60.0	0.00
15/04/2009	*14:00:00*	*41.75*	*22.4*	*19.35*
15/04/2009	15:00:00	43.28	39.8	3.48
15/04/2009	16:00:00	23.65	19.8	3.85
15/04/2009	17:00:00	4.87	4.7	0.17

3. Discussion and Conclusions

The data comparison over the period 11 March to 19 April inclusive shows two distinct patterns. For the first 30 days (to 9 April inclusive) of the comparison period, the WDC instrument recorded consistently higher daily sunshine totals than the NIWA instrument (by an average of 12.1 minutes, but as high as 57.6 minutes and as low as 2.1 minutes). Of interest is why there is such a variation between days.

Satellite imagery captured every hour throughout the data overlap period shows that the weather during the high difference days (e.g. 13 to 16 March, inclusive) was dominated by persistent stratiform clouds with intermittent sunny periods in a light easterly to north-easterly airstream (see Figure 2 – the dark grey clouds are stratiform, while the bright clouds are high cloud generally associated with frontal systems). Such a persistent weather system was not seen over the remaining days of the overlap period. Thus it is possible that, for some inexplicable reason, this type of weather pattern has resulted in greater sunshine hour differences between the WDC and NIWA instruments.

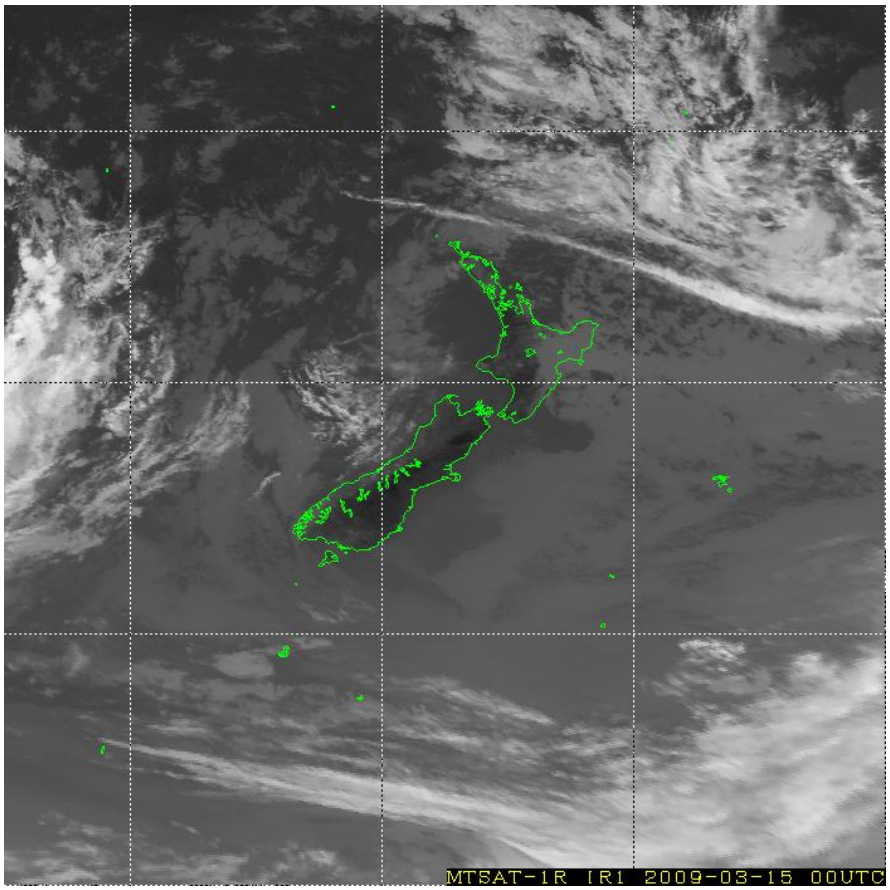

Figure 2: Satellite infrared image on 15 March at noon, local time.

For the period 10 April to 19 April inclusive, the differences between the two instruments were more randomly spread from day to day (consistent with the type of pattern that would be expected when two instruments are set up in this configuration). This abrupt change in pattern (from a persistent bias to a more random variation) corresponds with the date the WDC logger was changed from event-based to hourly incremental logging.

Based on the results shown here, it is most likely that the way the logger was set up to record continuous sunshine periods has led to a consistent overestimation of sunshine hours by the WDC instrument. It should be noted that in practice, the way the logger is set up to process data should not lead to this result. Either set up specifications should result in the same daily total – but this appears not to be the case. It is possible that the logger software may be at fault and it is suggested that the above results should be conveyed to the logger manufacturer.

The average bias during the period 11 March to 9 April inclusive is 12.1 minutes per day. Extrapolated to a full year (i.e. 12.1 minutes multiplied by 365 days), this amounts to an average overestimation of 74 hours of sunshine. However, this simple extrapolation does not take into account potential effects of variable day length throughout the year nor can it be known if the mix of weather types experienced over the 30-day overlap period is representative of a full year. There is, in fact, no way of accurately determining the amount of overestimation in the annual sunshine totals of 2007 and 2008. The only conclusion that can be made is that they are likely to be too high.

Now that the WDC logger is set up to record sunshine in hourly time-steps it is likely that the over-estimation bias has been removed. Sunshine hours are now consistent with the adjacent sunshine recorder installed by NIWA for the purposes of undertaking this comparison.

4. Recommendations

There are several recommendations stemming from this analysis.

1. The logging of sunshine from the sunshine recorder owned/operated by WDC should be left in its current configuration to continue to record hourly values;

2. The NIWA instrument remains in place for another month or two to continue to monitor the hourly sunshine values and check and log unusual differences;

3. WDC work with NIWA to set up an automatic feed of the hourly values into the NIWA National Climate Database (thus allowing the timely analysis of WDC sunshine data for the purposes of inclusion in NIWA's monthly, seasonal and annual climate reporting);

4. WDC contact the manufacturer of the WDC logger and convey the results of this comparison study;

5. NIWA enter a comment in the WDC sunshine recorder station comments file on the National Climate Database identifying the date of the change of the logger set up and a note that the sunshine data for this site prior to this date are likely to be overestimated;

6. NIWA set a quality flag (this appears as an asterisk when the data quality indicator is requested as an output of a data extraction) on the WDC sunshine data in the National Climate database up to 9 April 2009.

5. Acknowledgements

NIWA would like to gratefully acknowledge the cooperation of the Whakatane District Council (WDC) and its technical representatives for the supply of data from the WDC sunshine instrument.