Hulme Library Weather Station Closure

DESC 08/10/2013

Background

- Hulme Library weather station (HLM) had been on the MET Office's "at risk" list for some time and is due to close on the 31/10/2013

- HLM provides the weather data for LDZ's NW and WN

- A substitute station is necessary

- As suggested in the WSSM, a shortlist of the 5 closest stations to HLM should be identified and analysed when making a decision of the most suitable station. DESC at a meeting on 19/07/2013 selected Rostherne 2 as a replacement in case HLM closed

Assessment of correlation between HLM and the replacement

Following the decision by DESC on 19 July 2013 selecting Rostherne No. 2 as the preferred substitute for Hulme Library, we carried out our initial analysis based on this.

Summary of data:

All of the data analysed was:
 In Local Time
 Gas Day
 2 hourly data (07:00, 09:00, 11:00…05:00)

 Hulme: 01/05/1996 – 15/07/2013
 Rostherne 2: 01/11/2012 – 15/07/2013

 The distance between Hulme and Rostherne2 14.68km

As there is not at least a years worth of overlapping data, the representativity of Rostherne 2 needs to be estimated using the best fit equations as defined in the WSSM (pages 14-15), by inserting the appropriate parameter values for Hulme Library and Rostherne 2.

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Best Fit Equations

Equation 1: Temperature

$$\hat{R} = 0.9945 - 3.747e^{-4}\,d - 4.768e^{-5}|a_t - a_s| - 4.475e^{-4}|c_t - c_s|$$

Equation 2: Wind Speed

$$\hat{R} = 0.9076 - 1.499e^{-3}\,d - 2.218e^{-4}|a_t - a_s| - 1.030e^{-3}|s_t - s_s| - 1.084e^{-3}|c_t - c_s|$$
$$- 2.678e^{-4}|u_t - u_s|$$

Equation 3: Wind Direction

$$\hat{R} = 0.8344 - 1.995e^{-3}\,d - 1.032e^{-3}|s_t - s_s|$$

Equation 4: Solar Radiation

$$\hat{R} = 0.974 - 9.674e^{-4}\,d + 1.073e^{-6}d^2 - 9.785e^{-5}|a_t - a_s| - 2.108e^{-4}|c_t - c_s|$$

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Best Fit Equations

Equation 5: Precipitation

$$\hat{R} = 0.7482 - 1.122e^{-2}\,d + 9.046e^{-5}d^2 - 2.464e^{-7}d^3 - 6.613e^{-5}|a_t - a_s|$$

Equation 6: Relative Humidity

$$\hat{R} = 0.9808 - 2.734e^{-3}\,d - 4.799e^{-4}|a_t - a_s| - 2.653e^{-3}|c_t - c_s|$$

where $\hat{R}$ is the estimated correlation coefficient, d is the distance (km) from the target station to the substitute station, a_t and a_s are the altitude (m amsl) of the target and substitute stations respectively, s_t and s_s are the terrain shape of the target and substitute stations, c_t and c_s are the sea percentage of the target and substitute stations, and u_t and u_s are the urban percentage of the target and substitute stations.

(Source: Weather Station Substitution Methodology v4 pg15)

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Hulme vs. Rostherne 2

Best Fit Equation – Results:

1. **Temperature:**

   R = 0.9945 - (0.0003747*14.68) – (0.00004768*2) – (0.0004475*0)

   R = 98.89%   Class 2

2. **Wind Speed:**

   R = 0.9076 – (0.001499*14.68) – (0.0002218*2) – (0.001030*8.4) – (0.001084*0) – (0.0002678*87.9)

   R = 85.30%   Class 2

3. **Wind Direction:**

   R = 0.8344 – (0.001995*14.68) – (0.001032*8.4)

   R = 79.64%   Class 3

4. **Solar Radiation:**

   R = 0.974 – (0.0009674*14.68) + (0.000001073*14.68^2) – (0.00009785*2) – (0.0002108*0)

   R = 95.98%   Class 2

Hulme vs. Rostherne 2 cont…

5. **Precipitation:**

R = 0.7482 − (0.01122*14.68) + (0.00009046*14.68^2) − (0.0000002464*14.68^3) − (0.00006613*2)
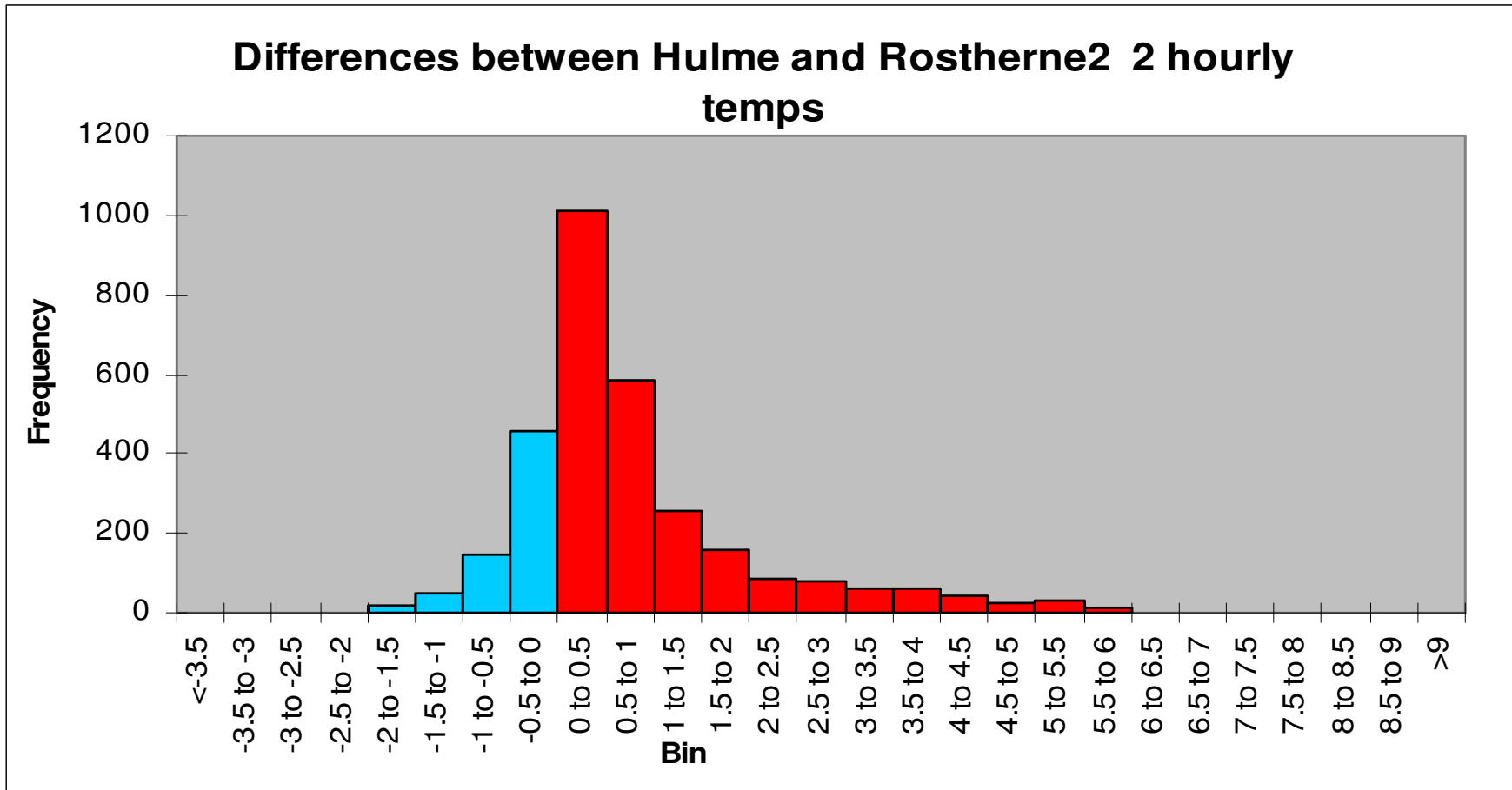
R = 60.21%   Class 1

6. **Relative Humidity:**

R = 0.9808 − (0.002734*14.68) − (0.0004799*2) − (0.002653*0)

R = 93.97%   Class 1

For the class selection criteria, refer to the relevant section in the WSSM depending on the variable being measured.

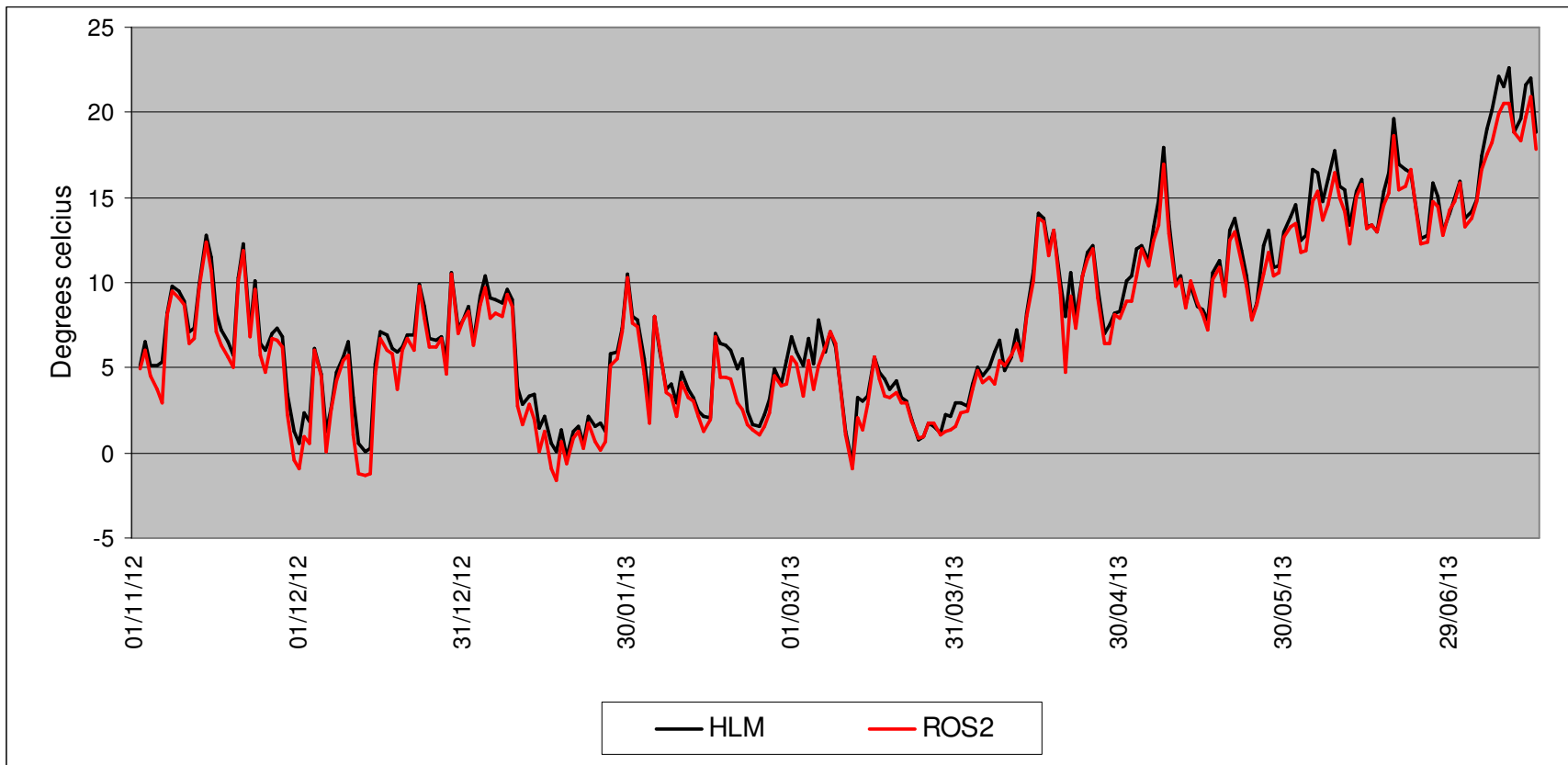# Differences between Hulme and Rostherne2 2 hourly temps

The majority (93%) of the differences are positive, suggesting Hulme is warmer with 5% of the differences being 0.

The biggest difference was 6.6^{o}c on the 12/07/2013 at 01:00

Comparison of daily weighted temps

The above graph shows the difference between the daily weighted temps for HLM and ROS2. From observing the graph it is evident that HLM is warmer on average than ROS2. The average temperature for HLM on all data analysed is 8.2c and the average temperature for ROS2 is 7.5c

Correlation between Hulme and Rostherne 2
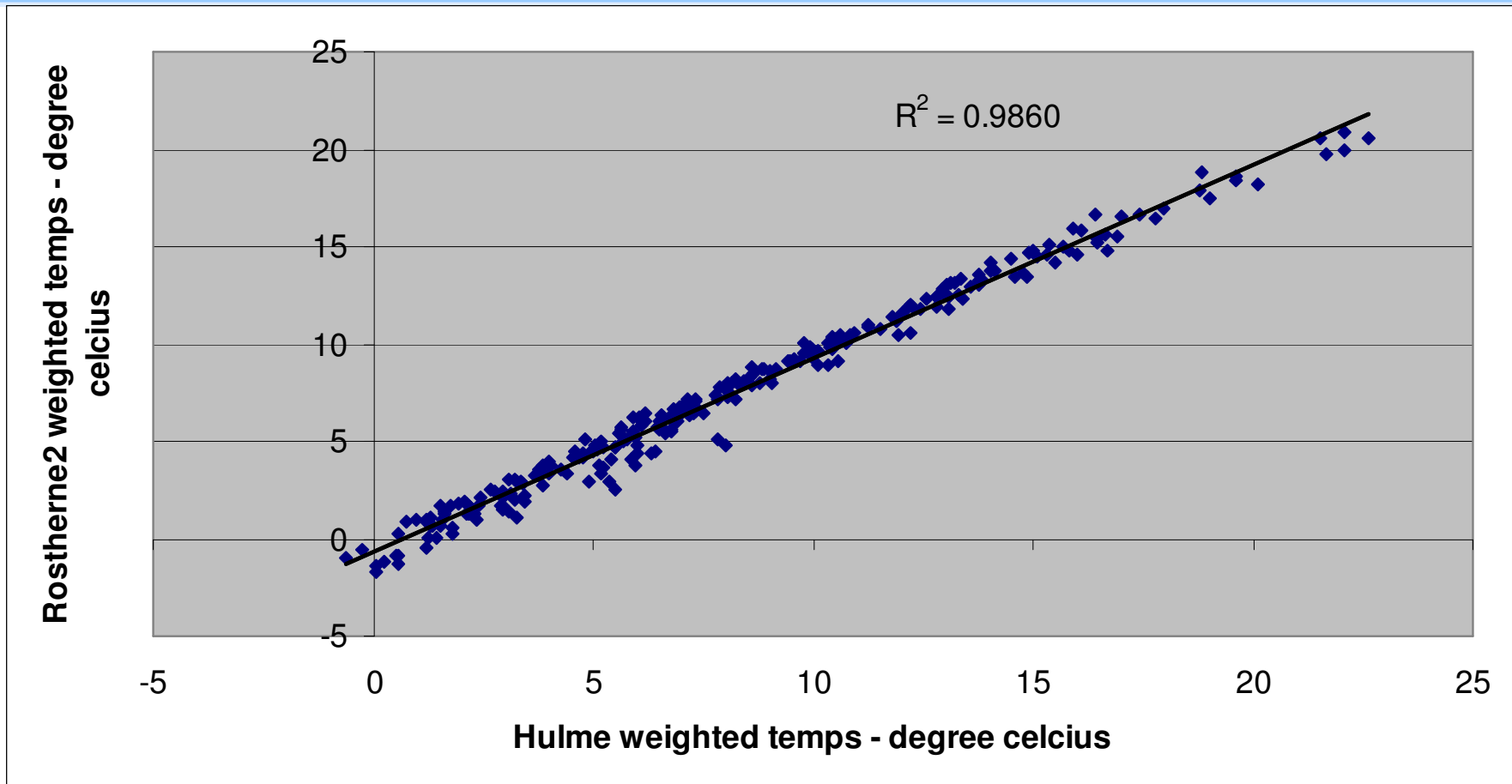
The above graph has been plotted using the daily weighted temps for HLM and ROS2. The graph shows that there is a strong positive linear relationship between HLM and ROS2 which suggests ROS2 would be a suitable substitute station.

Bias Adjustments

As DESC have selected Rostherne 2 as their preferred substitute station – it is necessary to calculate the bias between the two sites as we are already aware that Hulme is warmer than Rostherne 2.

As a years worth of overlapping data is not available, the bias for the temperature variable is estimated using the long term climatology of the two sites based on gridded datasets (see WSSM section 4.2.6 for the method used).

Below is a table summarising the % difference between Hulme and Rostherne 2 over the suggested time slots: 00-05:00 (Night), 06-11:00 (Morning), 12-17:00 (Afternoon), 18-23:00 (Evening).

% difference between Hulme - Rostherne 2	Night	Morning	Afternoon	Evening	Overall
November	14.6%	13.6%	7.1%	13.2%	11.8%
December	18.9%	16.1%	9.2%	19.3%	15.5%
January	22.2%	18.9%	9.9%	20.9%	17.5%
February	41.2%	28.2%	7.4%	28.3%	30.1%
March	70.3%	32.5%	9.3%	24.7%	27.0%
April	31.0%	11.9%	5.0%	13.6%	13.4%
May	16.6%	4.9%	4.2%	9.4%	8.2%
June	17.4%	4.7%	3.5%	8.4%	7.9%
up to 15th July 2013	21.7%	4.9%	3.3%	11.8%	9.7%

Bias Adjustments cont...

From observing the previous table, it is apparent that the biggest differences appear over night (00-05:00).

We then applied the suggested bias to the Rostherne 2 data.

The below table summaries the impact of applying the bias. As we can see, in some cases the bias has made the temperature values worse but overall it has improved the difference between the stations.

| % difference between Hulme - Rostherne 2 bias adjusted	Night	Morning	Afternoon	Evening	Overall
November	15.2%	11.6%	5.9%	8.6%	10.0%
December	25.5%	16.8%	8.4%	16.5%	16.1%
January	21.3%	14.0%	7.8%	14.1%	13.9%
February	37.7%	23.8%	6.8%	21.8%	20.1%
March	59.9%	32.4%	9.3%	20.7%	24.8%
April	22.4%	13.1%	4.9%	10.4%	11.3%
May	14.7%	7.0%	5.3%	6.1%	7.8%
June	12.1%	5.4%	3.7%	6.0%	6.4%
up to 15th July 2013	15.0%	4.7%	3.3%	9.5%	7.7%

(The cells highlighted in green show where there has been an improvement made in the % differences between HLM and ROS2 bias adj. The cells highlighted orange show where it has become worse).

Correlation between Hulme and Rostherne 2 bias adjusted
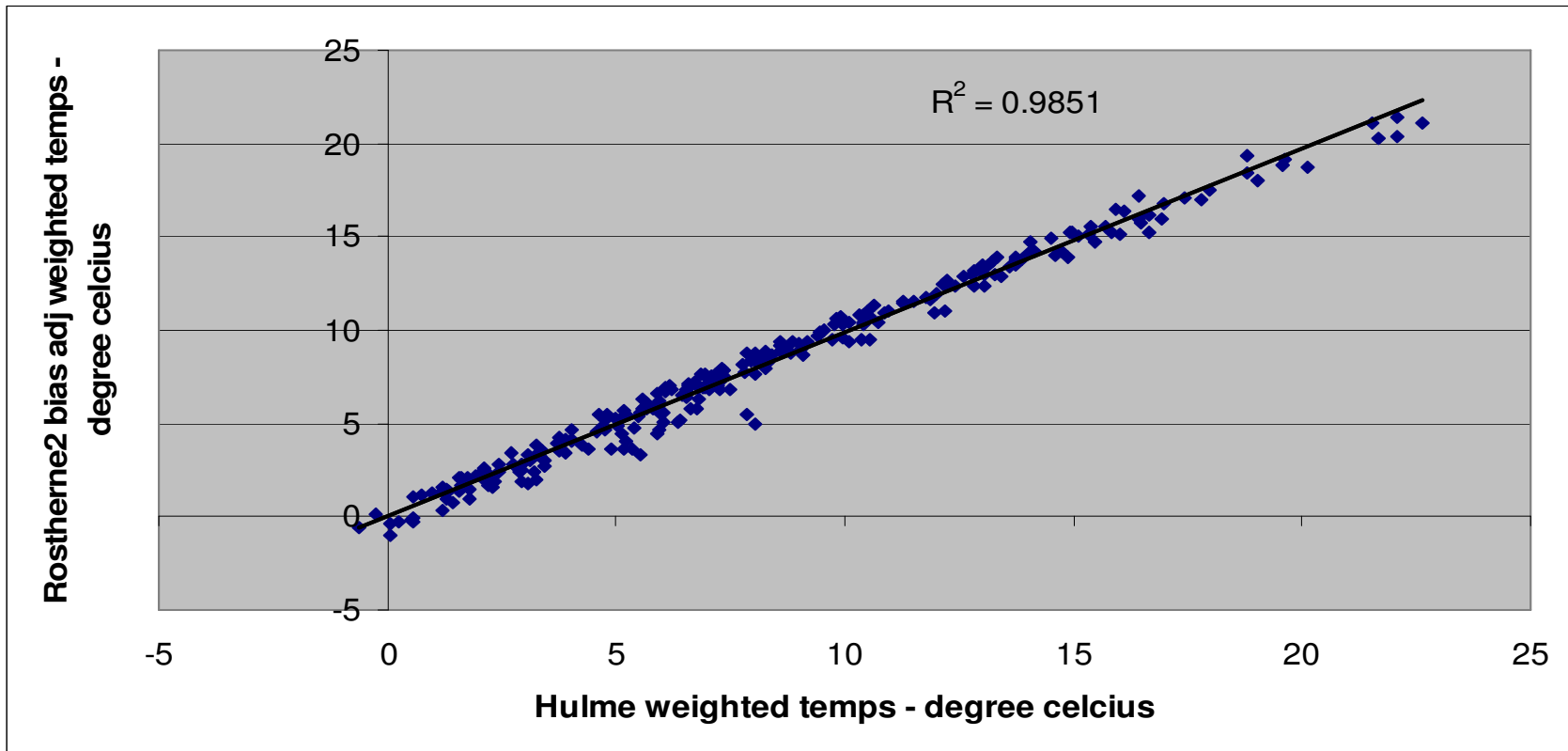
When analysing the relationship between HLM and ROS2 and HLM and ROS2-bias adjusted, it appears that the correlation between Hulme and Rostherne 2 is slightly stronger.
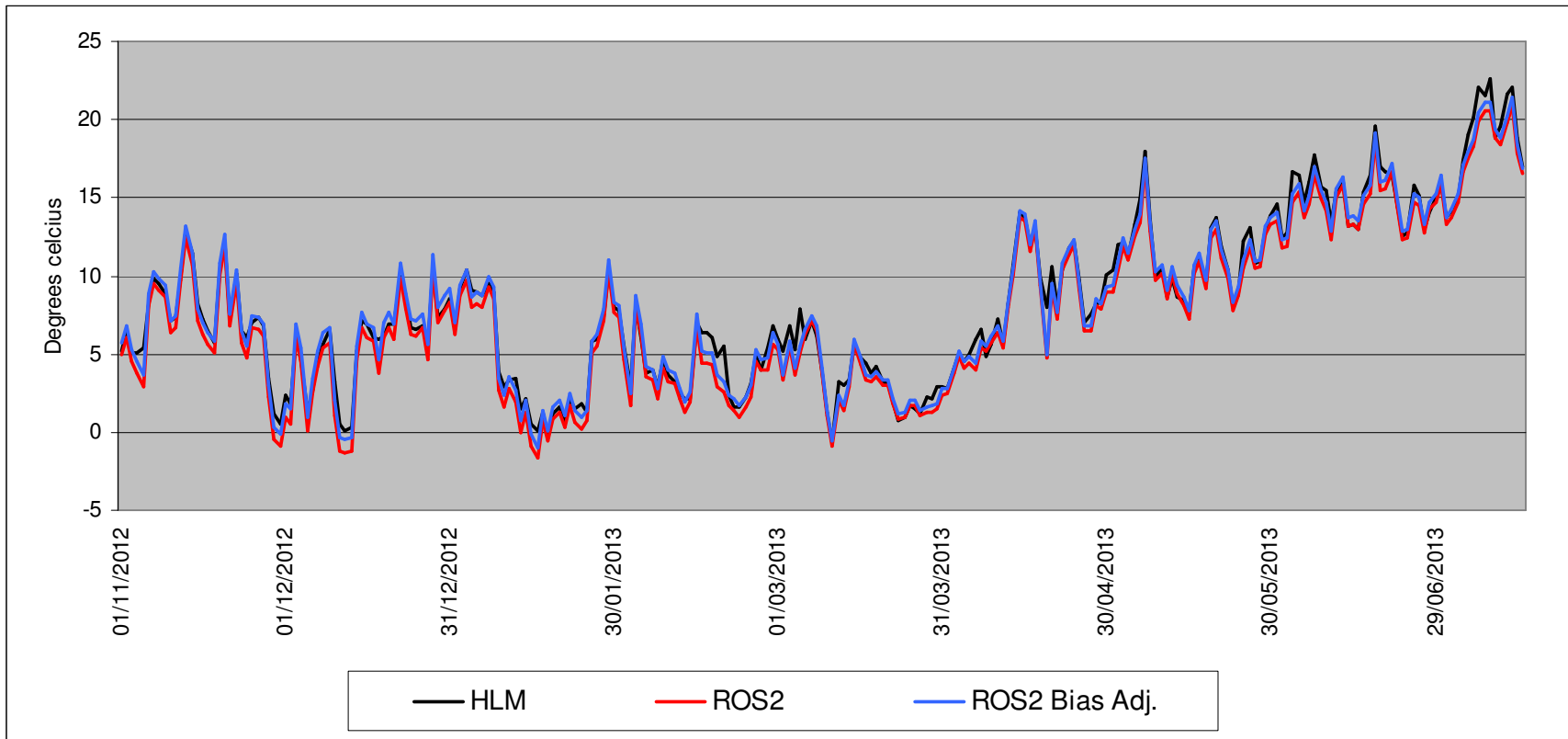
When we did the analysis on the Edgbaston closure, the correlation between Winterbourne and Edgbaston weather stations was 0.997. This was with overlapping data of 22 months.

Comparison of the daily weighted temps

The average temperature for HLM on all data analysed is 8.2c and the average temperature for ROS2 is 7.5c

The average temperature for ROS2 Bias Adjusted is 8.1c

(Post Meeting Update – Graph updated 10/10/13)

Hulme and Rostherne 2 – relationship to demand

Some further analysis was carried out to assess the relationship between the weather at Hulme and Rostherne 2 and NDM consumption for NW and WN.

All Data (01/11/2012 – 15/07/2013) using weighted temperatures:

y = ndm consumption NW

x = weighted temps Hulme

R^2 = 89.95%

y = ndm consumption WN

x = weighted temps Hulme

R^2 = 89.13%

y = ndm consumption NW

x = weighted temps Rostherne 2

R^2 = 88.61%

y = ndm consumption WN

x = weighted temps Rostherne 2

R^2 = 88.10%

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Hulme and Rostherne 2 – relationship to demand

Mon to Thu excluding holidays (01/11/2012 – 15/07/2013) using weighted temperatures:

y = ndm consumption NW

x = weighted temps Hulme

R^2 = 91.06%

y = ndm consumption NW

x = weighted temps Rostherne 2

R^2 = 89.47%

y = ndm consumption WN

x = weighted temps Hulme

R^2 = 90.15%

y = ndm consumption WN

x = weighted temps Rostherne 2

R^2 = 88.96%

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Options for NW / WN data from 1 November 2013

Options	Pros	Cons
1. Straight replacement of the weather stations with no adjustment made to Rostherne 2 data	Easier - no data manipulation	1. Drop in average CWV will impact WAALPs and AQs 2. Does not follow WSSM
2. Apply an adjustment to Rostherne 2 data:		
a. Bias adjustment as per WSSM	In line with WSSM	1. Feasibility confirmed with weather provider 2. Calculated bias does not appear to account for the whole difference
b. Observed bias adjustment	Creates a closer fit to HLM	1. Not in line with WSSM 2. Insufficient data to calculate bias accurately 3. Feasibility confirmed with weather provider
3. Restate the CWV parameters (with Rostherne 2 data instead of Hulme) - although there is a short period of data available	Parameters are optimised Rostherne 2 data	1. Insufficient data to complete optimisation 2. Insufficient time to calculate prior to closure 3. Not used directly in allocation, only AQ

Post Meeting Update – 10/10/13:

On the 08/10/13 DESC agreed to Option 2a as their preferred method

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