**Experiment 1A: Sensor resolution**

A straightforward option to increase the period the sensors can be used in the field is to adjust the resolution at which the sensors make their observations. The iButton Hygrochron (DS1923)[[1]](#footnote-1) can make temperature measurements at 8- or 11-bit resolution (0.5°C or 0.0625°C), and humidity measurements at 8- or 12-bit resolution, which is either 0.6% or 0.04% RH. The readings, however, are either stored in 8- or 16-bit, with the total memory for this sensor being 8192 bytes. According to the specifications, the temperature accuracy is better than ±0.5°C for most of the range (-10°C to +65°C), while the accuracy of the humidity measurements is ±5% RH. By using a lower resolution sensor for both temperature and humidity, the sensor can store double the number of observation at the same time interval as would be possible at the higher resolution (*see figure 1*). An experiment has been done with a total of 30 sensors, making observations at 5-minute interval during one week. The sensors have been placed in a certified weather station, which also houses an official observation instrument, to make sure the conditions would be the same for all sensors. Half the sensors have been set at the highest temperature and humidity resolution, while the other half has been set at the lower resolution. The sensors have been paired throughout the weather station and linear interpolation has been used to get the value at 1-minute intervals. The resulting plots from this one-week experiment can be found in *Annex 1*. From the visual analysis it is clear that the higher resolution temperature data provides a much smoother graph, while the difference for the humidity data is less clear.

**Figure 1: Number of observations and possible observation period at different resolutions**

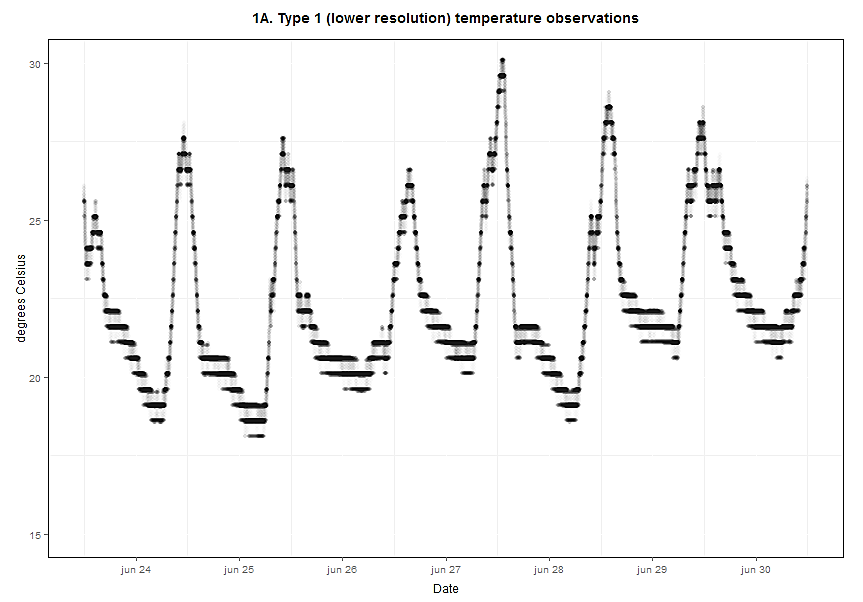
|  |  |  |  |  |  |
| --- | --- | --- | --- | --- | --- |
|  | Number of observations | Time covered at 2-hour interval | Time covered at 1-hour interval | Time covered at 30-min interval | Time covered at 15-min interval |
| *1 unit at low-res* | 8192 |  |  |  |  |
| *1 unit at high-res* | 4096 |  |  |  |  |
| *1 unit at low-res & 1 unit at high-res* | 3072 |  |  |  |  |
| *2 units at high-res* | 2048 |  |  |  |  |

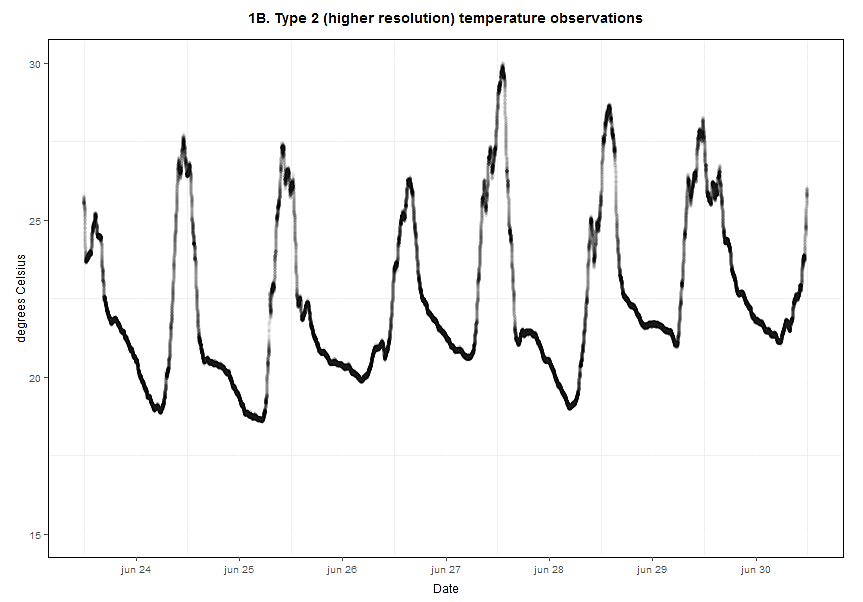
Analysing the sensors provides more detailed information; the temperature range for the low-res sensors is 18.11 – 30.12°C, while this is 18.54 – 30.02 for the high-res sensor; the range is 0.54°C larger for the low-res sensors. For humidity the range is 64.33 – 99.94% RH for the low-res and 63.86 – 100.23% RH for the high-res sensors[[2]](#footnote-2), making the range 0.75% higher for the high-res sensors. The mean temperature and humidity for the low-res sensors are 22.37°C and 90.45% RH; for the high-res sensors these values are 22.35°C and 90.93% RH, which is all within a very small range. Another important issue to take into account is the variability between sensors; the visual analysis shows that this is especially an issue for the low-res temperature observations. The standard deviation has been calculated for every row of the data-set (which is 1 minute), which contains 15 sensors and 10.800 observations for each sensors. After this, the mean has been taken from all the standard deviations at the row-level. The standard deviation for the low-res temperature sensors is 0.26°C, while this is < 0.05°C for the high-res sensors. For % RH, the standard deviation is 1.13 for the low-res sensors, whereas this is surprisingly higher (1.20) for the high-res sensors.

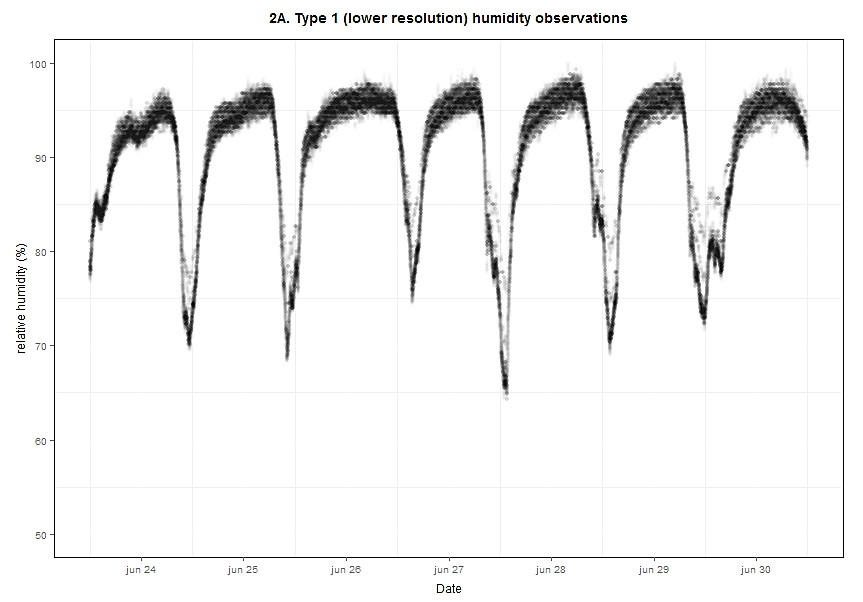
A preliminary conclusion which can be drawn from this experiment would indicate that working at a higher-resolution would not make a lot of sense for both temperature and humidity, as the reduced interval at which observations can be made will reduce the quality of the data-set more than this can be increased by the higher accuracy at higher resolution. Especially for relative humidity a high-resolution would not contribute anything. The range for the observations, as well as the standard deviation between the sensors is higher than is the case for the low-resolution. In this case, the low-resolution sensor seems to be better. For temperature, the mean is very similar (within 0.02°C), while there is a large difference between the standard deviation in both datasets. This is not necessarily a large problem, as the maximum deviation at any moment is less than 0.4°C. While it is already quite clear that measurements at low-res would be fine for relative humidity, the impact of the low-resolution on temperature would require study. In the case that measurements would only be made at a low-interval (1 or 2 hours), the differences might be exaggerated when using interpolation techniques to estimate the temperature at lower (e.g. 15 min) intervals

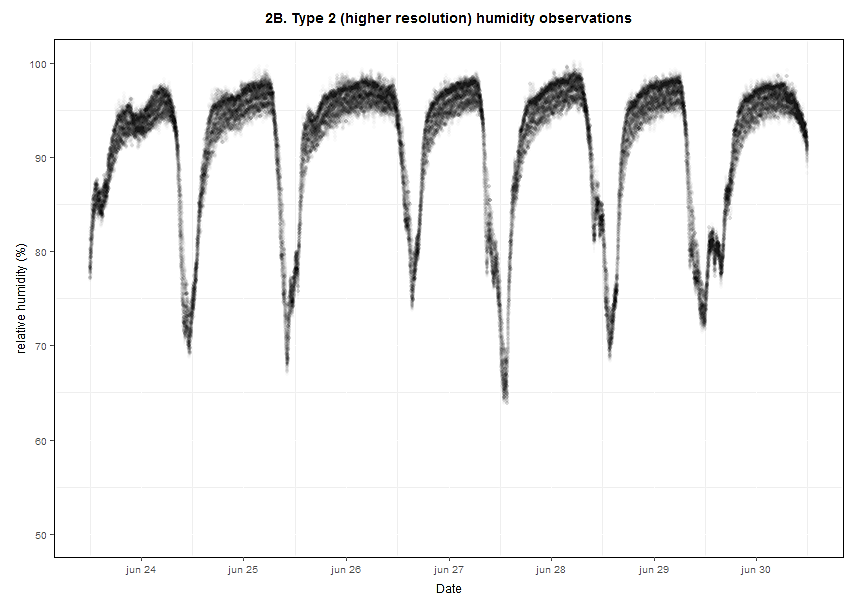
**Experiment 1B: Temporal resolution**

**Annex 1: Temperature & humidity observation at different resolutions**









1. http://datasheets.maximintegrated.com/en/ds/DS1923.pdf [↑](#footnote-ref-1)
2. It is not uncommon to have values > 100% RH for the sensors, especially on rainy days it can go over 100%. [↑](#footnote-ref-2)