

Final Report: Urban Heat Island: Measure, visualise, change

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URBAN HEAT ISLAND

Measure, visualise, change



Phase 3: Final Report
June 2023



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Acknowledgement of Country

We acknowledge the people who are the Traditional Custodians of the Land on which this project stands. We pay respect to the Elders, past, present and emerging, and extends that respect to other Aboriginal and Torres Strait Islander Peoples.

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Griffith University conducts research in accordance with the National Statement on Ethical Conduct in Human Research.

If potential participants have any concerns or complaints about the ethical conduct of the research project they should contact the Manager, Research Ethics on 373 54375 or

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Albedo: is the measurement of solar radiation reflected off a surface. It ranges from 0 (full absorption, e.g. black surface) to 1 (full reflection).

Anthropogenic heat flux: is the heat generated by human activities in the urban canopy layer.

Aspect Ratio (AR): is the ratio of the width to the height of the street

Comfort Zone: is the range of temperature and relative humidity where humans experience a thermal neutral sensation, for heat or cold

Density: is the degree of compactness of a substance

Emissivity: is the ratio of the energy radiated from a material's surface to that radiated from a perfect emitter, known as a blackbody, at the same temperature and wavelength and under the same viewing conditions.

Evapotranspiration: is the sum of water evaporation and transpiration from a surface area to the atmosphere.

Humidex: describes how hot, humid weather feels to the average person. It combines temperature and humidity into one index to reflect the perceived temperature.

Irradiance: is the radiant flux (power) received by a surface per unit area.

Leaf angle distribution (LAD): is a property which influences the spectral reflectance and radiation transmission properties of vegetation canopies, and hence interception, absorption and photosynthesis. It is a fundamental parameter of radiative transfer models of vegetation at all scales.

Microclimate: is the climate of a very small or restricted area, especially when this differs from the climate of the surrounding area.

Pseudocolor image: is an image derived from a grayscale image by mapping each intensity value to a color according to a table or function.

Sky View Factor (SVF): is the ratio of sky hemisphere visible from the ground (not obstructed by buildings, terrains or trees).

Solar access: could be defined as sunlight onto walls and other surfaces of a building or area being investigated.

Surface Albedo (SA): quantifies the fraction of the sunlight reflected by the surface.

Thermal admittance: is a measure of a material's ability to absorb heat from, and release it to, a space over time

Urban canyon: place where the street is flanked by buildings on both sides creating a canyon-like environment (like in a natural landscape)

Urban Cool Island (UCI): where the air temperature of the urban area is cooler than in the surrounding rural area.

Urban design (UD): is both the process and outcomes of designing and shaping the physical features of cities, towns and villages.

Urban heat Island (UHI): where the air temperature of the urban area is warmer than in the surrounding rural area.

Virtual Reality (VR): the computer-generated simulation of a three-dimensional environment that can be interacted with.

The City of Ipswich has partnered with Griffith University and the University of the Sunshine Coast to conduct a three-year analysis about the identification of Urban Heat Island (UHI), the residents' perceptions about urban heat and how changes in urban design might mitigate these effects.

Methodologically, three sites were selected as case studies, showcasing old urban fabric (Ipswich centre: Bell St, Brisbane St and Limestone St) and new urban fabric (Joy Chamber Circuit in Ripley). Our mixed- method approach included weather data collection, urban design analysis, surveys, workshops and Virtual Reality experiences to provide the evidence-based analysis constituting this report. Previous reports (Reports 1 & 2) detailed all these methods but the workshops and VR experiences that are presented here.

This Phase 3 Final Report is threefold. It presents

- 1. the results of the work undertaken between March 2022 and April 2023**
- 2. the triangulation and synthesis of all the findings since the start of the project in 2021**
- 3. the recommendations emerging from this longitudinal study**

Four major findings can be highlighted.

First, this longitudinal study demonstrated the variations of temperatures between the data recorded on site (whether CBD or Ripley) and those of the Bureau of Meteorology (BoM). This is not surprising as the BoM weather stations are rarely located in urbanised areas. However, it highlights the need to understand the level of variations to provide climate-responsive design and policies that are locally relevant.

Second, all our case studies indicate the existence of UHI conditions (for different reasons and with different degrees), although these case studies included old and new urban fabrics. This means that policies and planning regulations should support better climate-responsive design.

Third, residents are already knowledgeable and aware about the effects of urban heat, not only regarding their own well-being but also how it impacts their relationship with the built environment. However, even if residents and developer stakeholders are eager to engage in heat mitigation, they need practical support from council and incentives to engage with heat mitigation.

At last, 16 recommendations emerged from this 3-year project, amongst which 7 to support residents/stakeholders to mitigate urban heat, 6 to support better planning and 3 to implement heat mitigation for the three case studies.

The following pages provide a detailed account of these findings, including the methods that were implemented.

1. CONTEXT

The Intergovernmental Panel on Climate Change (IPCC) has just released its final report synthesising and highlighting the severity of climate change and its impacts (<https://www.ipcc.ch/report/ar6/syr/>). Although the 2023 IPCC report acknowledges some consistent progress in policies and laws addressing mitigation, as well as in adaptation planning and implementation, it also outlines that urgent actions are required. For example, the increase of temperatures will increase the risk of mortality to individuals.

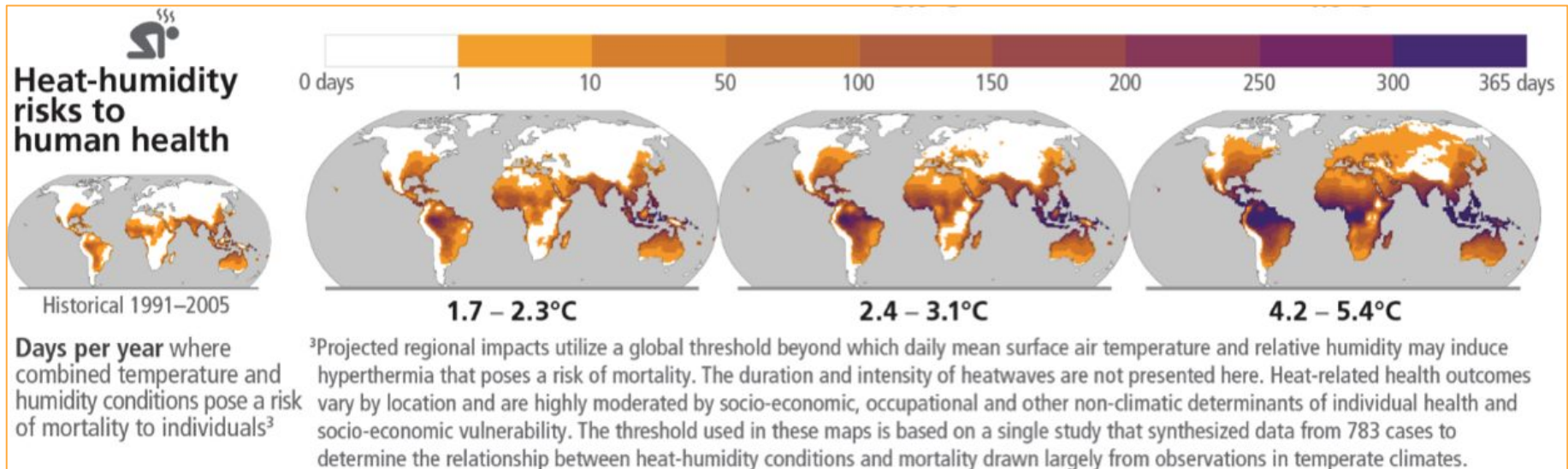


Figure 1: Heat-humidity risks to human health © IPCC 2023

Previous studies suggests that, on average globally, UHI is likely to be around half the warming caused by climate change by 2050. This means that a city that experiences 2°C of warming from climate change, would have its UHI increased by 1°C.

At the same time, heatwaves are Australia's deadliest natural hazard (Coates et al., 2014) and Ipswich ranked in the top three of the most heat exposed areas ([Qld State Heatwave risk assessment 2019](#), p15) among the 10 LGAs that have been analysed in Queensland regarding heatwaves. It is the reason why it is important to investigate UHI in Ipswich to enhance the liveability and sustainability of Ipswich territory and increase better resilience and healthier outcomes.

Traditionally known as Tulumur in the local Yagara language, Ipswich is located 40 km south-west of Brisbane's CBD. One of Queensland's oldest provincial cities, Ipswich has served many roles and functions over the years, such as a mining region and centre for agriculture. Ipswich is one of the nation's fastest growing regions – adding just under 100,000 new residents in the ten years to 2020. Despite already being home to 220,000 people, Ipswich is predicted to grow even more, with some estimates suggesting that the city will expand to more than 400,000 residents by the mid-2030s (.id, 2021). The total land area is about 1,090 km², including the CBD of 4.2 km².

According to Köppen–Geiger climate classification, Ipswich (27°37'S and 152° 45'E) has a 'warm temperature, hot summer and fully humid climate' (Rubel & Kottek, 2010). The City of Ipswich lies 21m above sea level and 54 km away from the ocean with an average temperature of 20.1°C and about 964 mm of precipitation falls annually.

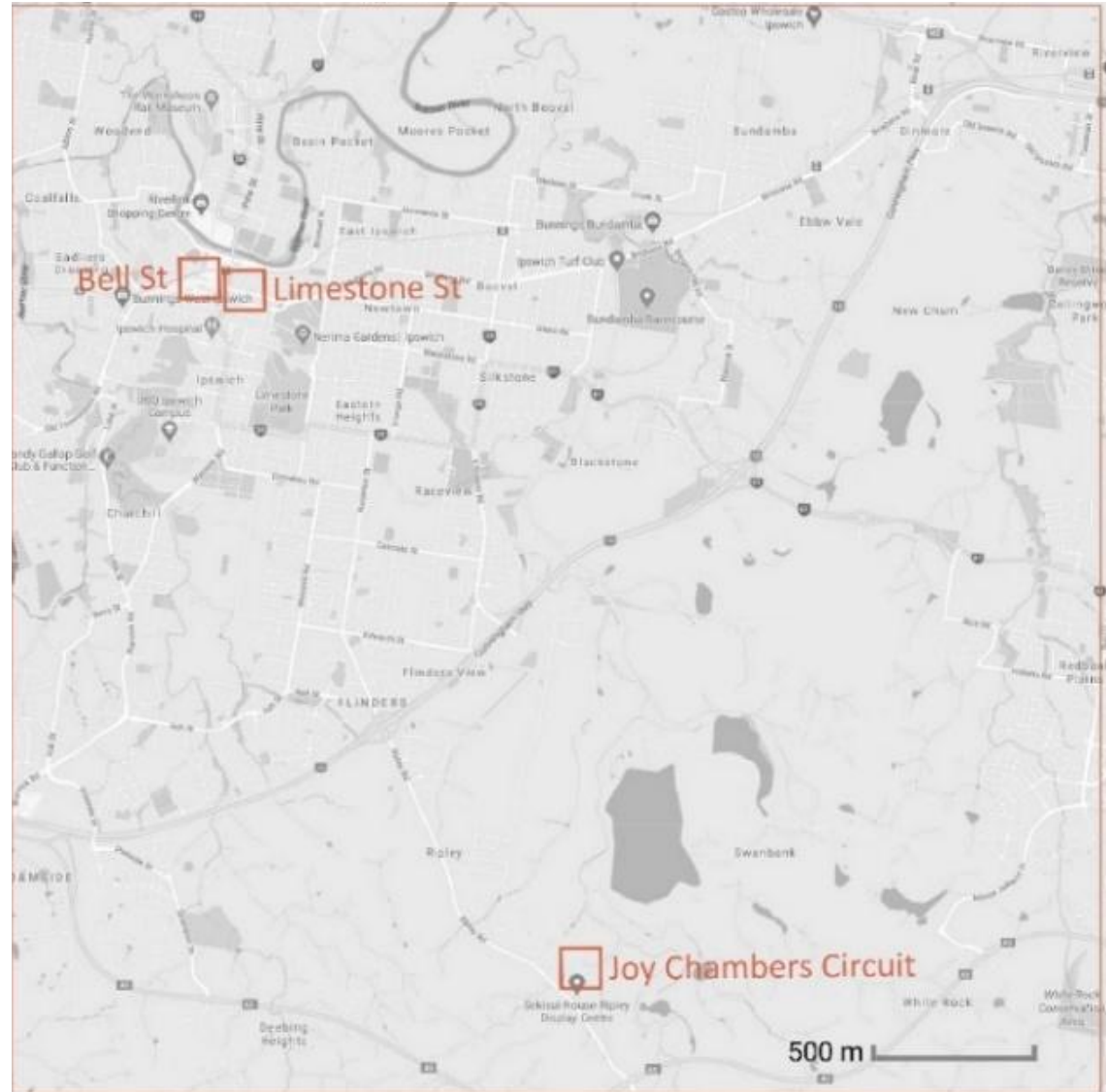


Figure 2:
Location of the case studies in red

The objective of this study is to identify possible solutions to mitigate UHI and other undesirable climate change-related impacts. This 3-year project has three key objectives:

1. Provide an evidence-based analysis of urban microclimate in key areas of Ipswich.
2. Provide an UD analysis that relates the identified urban microclimate and possible UHIs with design solutions.
3. Provide insights into the relationships between people's experience of place and their microclimates

Previous reports (1 & 2) have presented the first results regarding the three key investigations.

The next section focuses specifically on the activities undertaken from March 2022 to April 2023.

It includes the updates of the climate analysis and the results from the VR experience and workshop with communities and developers.

2. Year 2023 RESULTS

2.1 Local microclimate analysis

2.2 Stakeholder input

2.1.1 STUDY DESIGN

This study used air temperature and relative humidity sensors (HOBO MX2301A) protected by a solar radiation shield to ensure the temperature recorded was not impacted by direct sunlight. The study design aimed at capturing the temperatures at street level, which differs to the weather data collected by the Australian Bureau of Meteorology. This difference regards the resulting urban microclimate, impacted by buildings and built forms.

The 11 sensors (Fig.3) were placed on council light poles at around 3m high to account for the microclimatic experience of public space users, while being above the line of sight, and lower when the infrastructure was shorter. Sensors were configured to capture data every 20 minutes and have collected data from February 24th, 2021 to March 24th, 2023.

Data collection and analysis included:

1. Placement of sensors and data collection
2. Analysis of maximum and minimum temperatures compared to those of BoM
3. Analysis of Human Comfort Index (Humidex)
4. Analysis of climate-responsive design strategies



Figure 3: Google Earth pictures showing the location of the sensors on Bell Street (left), Ripley (top right) and Brisbane and Limestone Streets (bottom right)

Data has been collected and analysed for the period between 24th February 2021 and 24th March 2023. While the intention was to collect data for full two years, the study had some limitations, including:

- The disappearance of one sensor (#577 on Bell St)
- Failure of batteries for several sensors for a period of time (e.g. only 446 days for sensor #569)
- Failure of the sensor #571 on Brisbane St (stopped working)

For these reasons, the new data analysed in this report does not include sensors #577 and #571 (no new data retrieved after 9th December 2021 and as reported in Report 2). Despite these limitations, all the other 10 sensors had data for all months being analysed, covering at least one year of data. Nevertheless, to provide full reference, the graphs and charts are included in the appendices.

Sensor	Start	Stop	Start	Stop	Total days of data collection
Bell Street #569	24 th Feb 2021	9 th Dec 2021	9 th Oct 2022	24 th Mar 2023	446
Bell Street #574	24 th Feb 2021	3 rd Oct 2022	23 rd Nov 2022	24 th Mar 2023	709
Bell Street #577	24 th Feb 2021	9 th Dec 2021	----	----	289
Bell Street #580	24 th Feb 2021	15 th Aug 2022	23 rd Nov 2022	24 th Mar 2023	660
Brisbane Street #571	24 th Feb 2021	8 th Dec 2021	----	----	288
Brisbane Street #575	24 th Feb 2021	15 th Aug 2022	23 rd Nov 2022	24 th Mar 2023	660
Limestone Street #570	24 th Feb 2021	4 th Nov 2022	23 rd Nov 2022	24 th Mar 2023	739
Limestone Street #576	24 th Feb 2021	24 th Mar 2023	----	----	759
Ripley #142	24 th Feb 2021	24 th Mar 2023	----	----	759
Ripley #572	24 th Feb 2021	24 th Mar 2023	----	----	759
Ripley #573	24 th Feb 2021	24 th Mar 2023	----	----	759
Ripley #578	24 th Feb 2021	24 th Mar 2023	----	----	759
Ripley #579	24 th Feb 2021	3 rd Nov 2022	23 rd Nov 2022	24 th Mar 2023	740

Table 1: Working periods for each sensor

2.1.2 MAX & MIN TEMPERATURE ANALYSIS

In summary, 4 main findings emerged from the maximum temperatures (day analysis) and minimum temperatures (night analysis) comparison between our sensors and BoM weather stations, as follows:

1. Limestone and Brisbane St sensors showed temperatures similar to BoM during the day.
2. Bell St (more shaded than Brisbane and Limestone St) showed lower temperatures than BoM during the day.
3. During the night (minimum temperatures), all CBD areas perform similar and show **significantly higher temperatures** than BoM. Moreover, during the warmer months, particularly between November 2021 and May 2022, the difference between these minimum temperatures is less significant. This means there is a **more prominent deficient cooling performance** during the summer when the sun is higher and there are more surfaces exposed to the sun, therefore generating more heat and consequent UHI.
4. In Ripley, as the area is more open than the CBD, the temperatures during day and night are more consistent with BoM data, indicating it gets warmer easier during the day, but also cools down quicker during the night configuring a less prominent UHI.

The detailed analysis of two sensors, one from each type of urban fabric (CBD and a new development), is presented hereafter while the entirety of the analysis can be found in Appendix 1.

For sensor 576, located in Limestone St (CBD), and over the full period investigated, it can be noted that

- The maximum reported temperature during the day was 40.8°C on 12 February 2023
- The minimum reported temperature during the night was 4.24°C on 11 June 2022
- The average maximum temperature over the whole period was 28.61°C
- The average minimum temperature over the whole period was 16.02°C

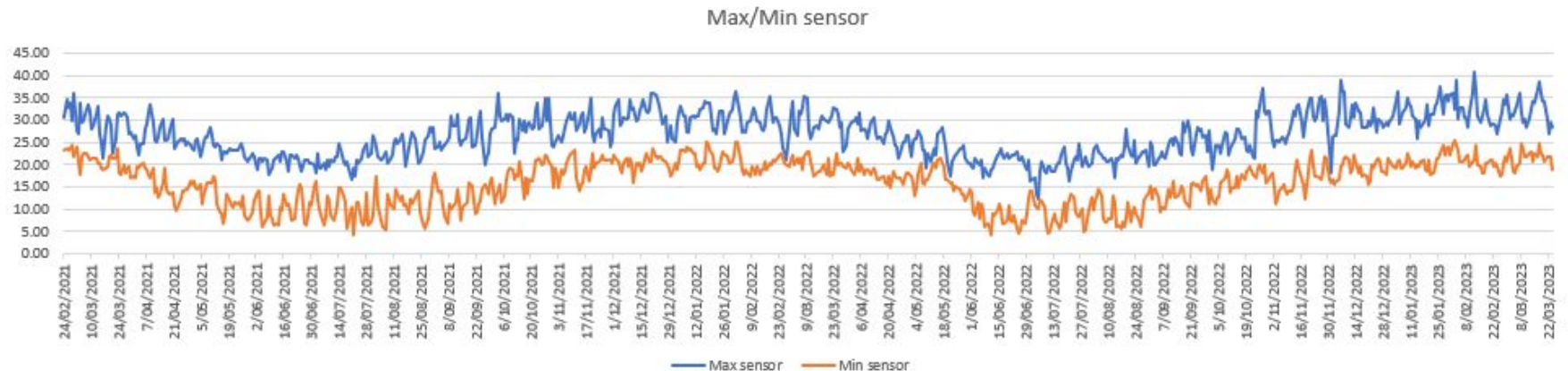


Figure 5 provides the comparison between maximum and minimum temperatures for sensor 576 in Limestone St (CBD) and BoM data from 24/02/2021 to 24/03/2023. It shows that:

- While for this sensor similar temperatures have been identified during the day on the site when compared to BoM weather station, there are a significant number of points in which BoM shows higher temperatures. It is also important to note that Sensor 576 has been chosen as it represents the full period of data collection (759 days), however due to its location in a southern façade the surfaces around it are not exposed to the sun during long periods of time (as would be the case for the Brisbane St sensors), therefore other sensors located in the CBD show more significant differences between the data collected by the sensors and BoM.
- During the night (minimum temperatures) the sensor data shows consistently and significantly higher temperatures than BoM. Moreover, during the warmer months, particularly between November 2021 and May 2022, the difference between these minimum temperatures is less significant. This means there is a prominent deficient cooling performance during the summer generating UHI.

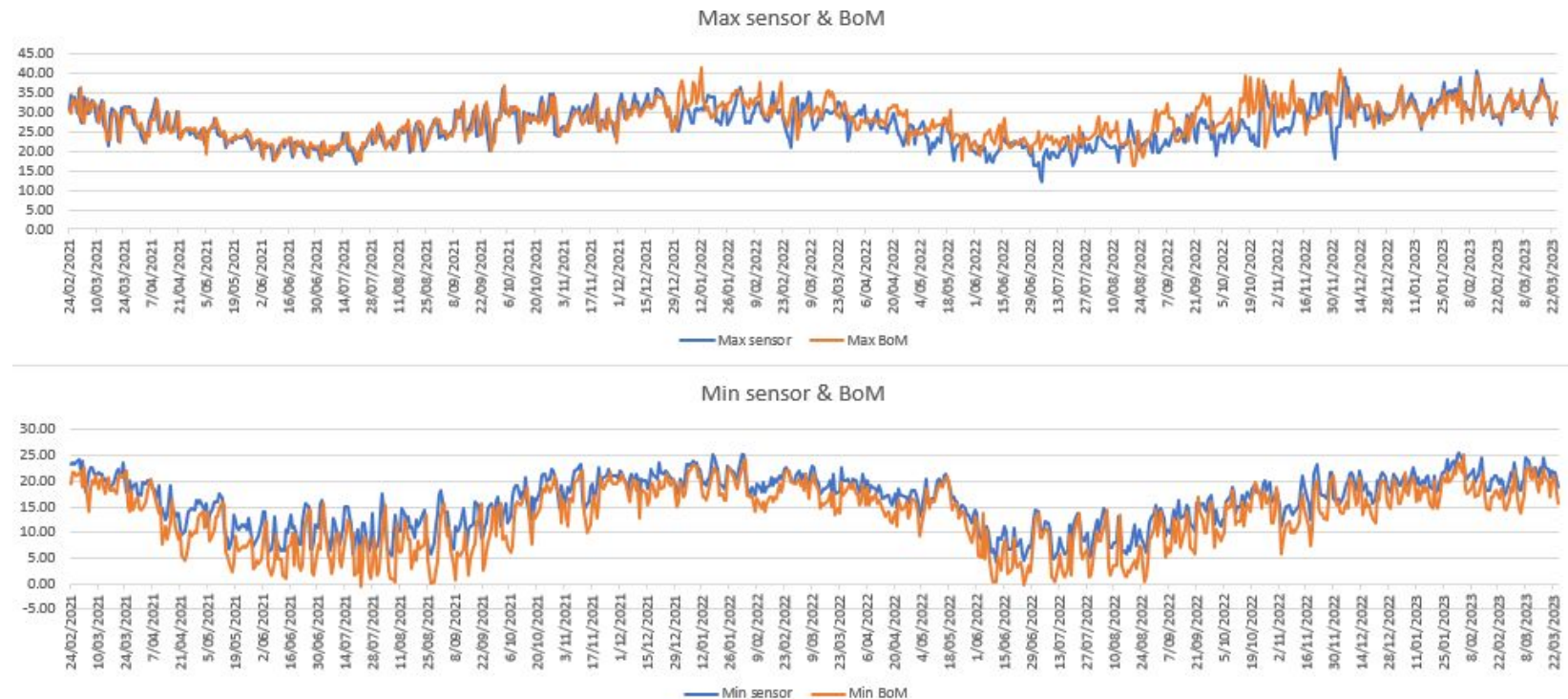


Figure 5: Comparison between maximum and minimum temperatures for sensor 576 in Limestone St (CBD) and BoM data from 24/02/2021 to 24/03/2023

For sensor 572, located in Joy Chamber Circuit (Ripley new development), and over the full period investigated, it can be noted that:

- The maximum reported temperature during the day was 35.18°C both on 25 March 2021 and 29 October 2022
- The minimum reported temperature during the night was 0.06°C on 22 July 2021
- The average maximum temperature over the whole period was 25.65°C
- The average minimum temperature over the whole period was 13.44°C

These results mean that all temperatures - absolute maximum and minimum, as well as average maximum and minimum - are lower than the temperatures observed in the CBD (specifically for sensor 576).

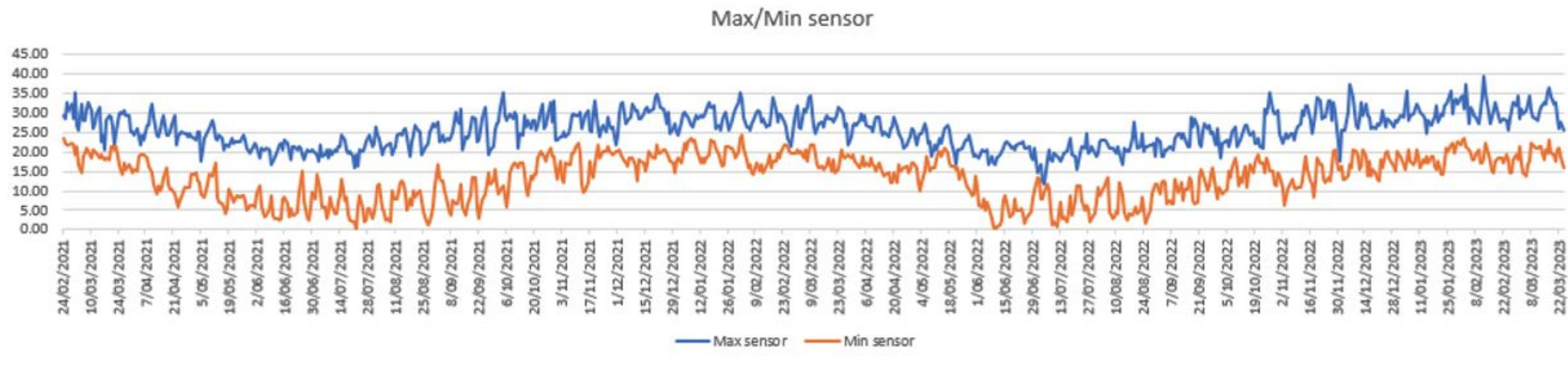


Figure 6: Maximum and minimum temperatures for sensor 572 in Ripley, from 24/02/2021 to 24/03/2023

Figure 7 provides the comparison between maximum and minimum temperatures for Ripley sensor 572 and BoM data from 24/02/2021 to 24/03/2023. It shows that:

- Maximum temperatures data is consistently lower than BoM data
- Minimum temperatures BoM data still shows lower temperatures than the ones observed in Ripley, indicating deficient cooling performance. However the difference is much smaller than the minimum temperature difference observed in the CBD.

These results show that, while urbanisation impacts the localised climate **generating a cooling deficiency during the night**, this deficiency is related to the capacity of the urban form to dissipate the heat. Ripley with its lower built form, increased greenery and open spaces means the climate conditions observed are closer to BoM and less prone to UHI formation than the CBD.

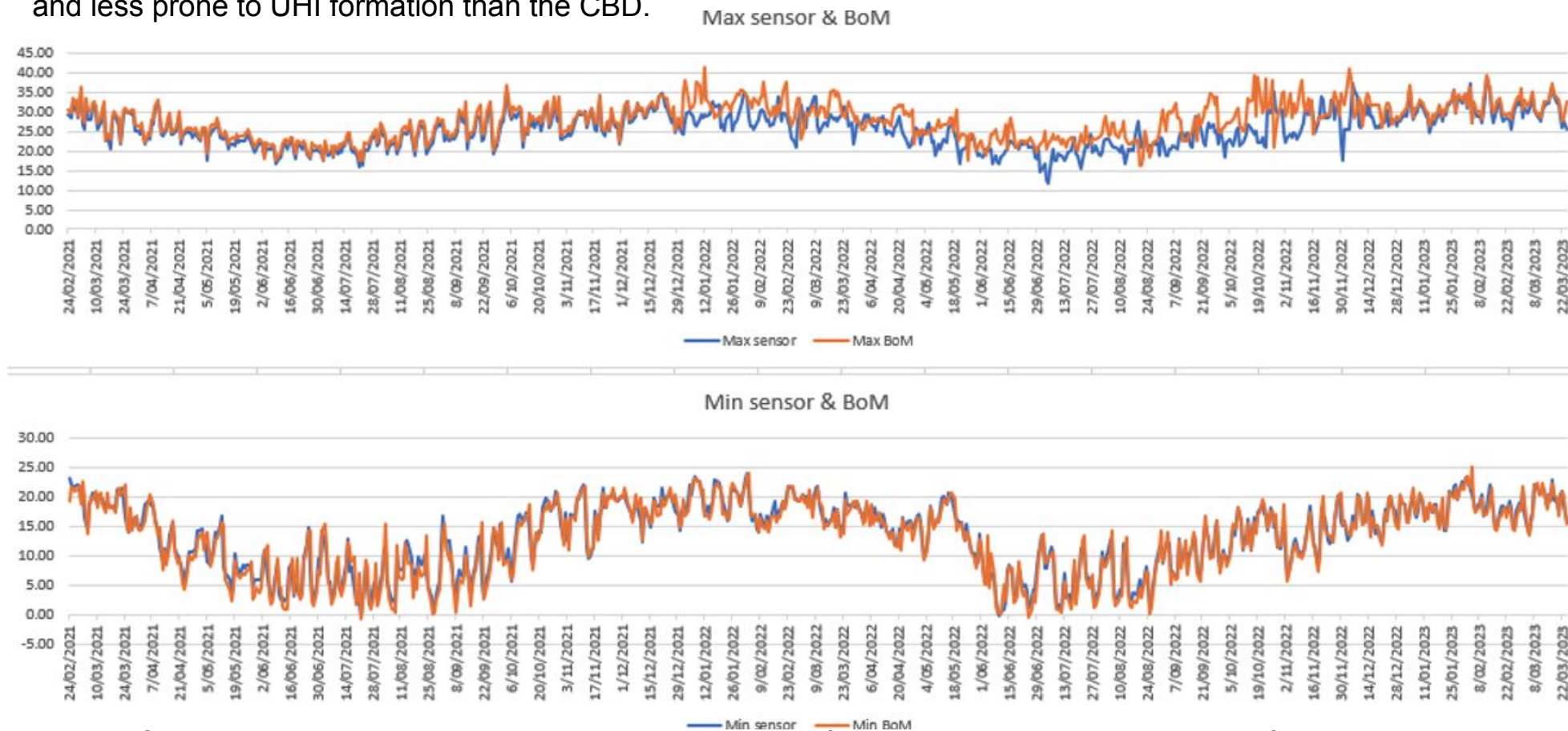


Figure 7: Comparison between maximum and minimum temperatures for sensor 572 in Ripley and BoM data from 24/02/2021 to 24/03/2023

2.1.3 HUMIDEX ANALYSIS

For the Human Thermal Comfort analysis, we used Humidex analysis which **combines temperature and humidity into one index and reflects how hot and humid the weather feels to the average person (also called the perceived temperature).**

The Humidex chart (Figure 8) only applies to temperatures above 14°C and indicates the degrees of comfort, ranging from 'no discomfort' (blue zone) to 'heat stroke imminent' (red zone). In terms of public health, the optimum situation is to provide public spaces within the blue zone degree of comfort.

For our study, the number of points vary as the data points collected in each sensors also vary. Sensors with uninterrupted data collection are: 576, 142, 572, 573, 578.

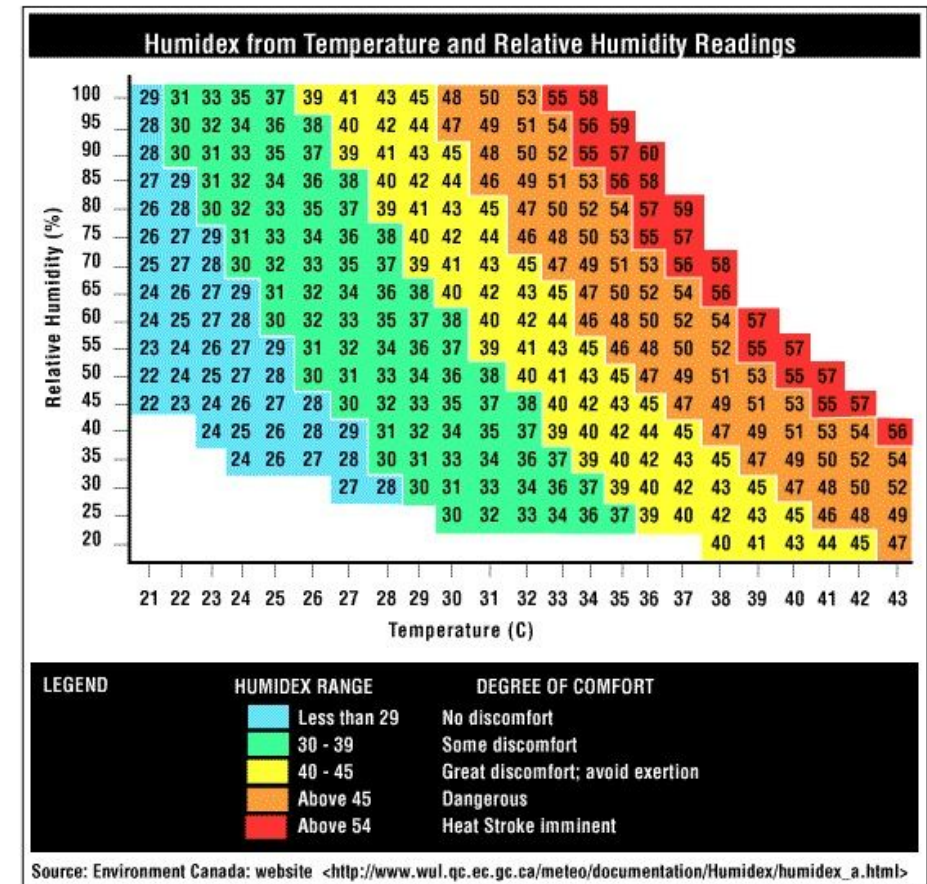


Figure 8: Humidex chart

Overall, as the number of data points collected is large, the relative frequency of the points in the dangerous zone is negligible.

However, it is important to note that the **combination of temperature and humidity shows many points in the dangerous zone.**

Most uncomfortable areas (Table 2) were recorded in

- Brisbane Street (sensor 575) with 70 data points in the dangerous comfort zone (as shown in next page in detail);
- Ripley (sensor 142) with 69 points and sensor 578 with 56 points in the dangerous zone;
- Bell street (sensor 574) with 58 points.

These findings show that human comfort is not better in new development.

The detail of each sensor Humidex data is presented in Appendix 2.

Sensors	No discomfort	Some discomfort	Great discomfort	Dangerous
Bell St 569	20239	11284	542	23
Bell St 577	15921	8215	384	15
Bell St 580	29324	15224	738	7
Bell St 574	30967	16475	909	58
Brisbane St 571	14438	6550	279	2
Brisbane St 575	25729	17658	1328	70
Limestone St 570	31952	17460	1238	37
Limestone St 576	32714	17399	1175	33
Ripley 142	31747	15665	884	69
Ripley 572	33172	14246	537	12
Ripley 573	31483	15240	833	50
Ripley 578	31324	15779	817	56
Ripley 579	32102	14304	482	9

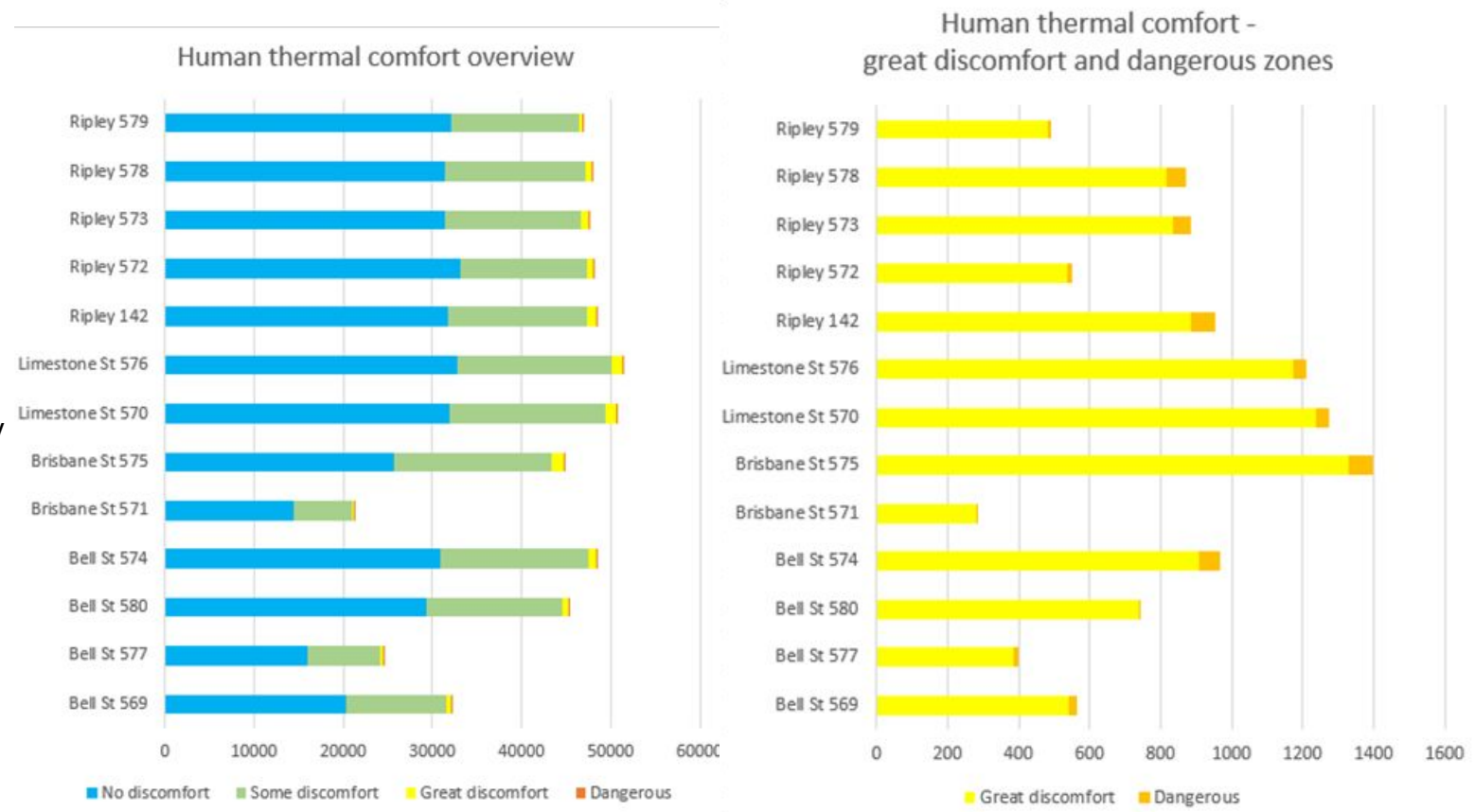
Table 2: Data distribution in each thermal comfort zone according to Humidex

The charts below show an overview of the distribution of data points in each humidex zone (Figure 9 left) and a summary of data points specifically in the 'great discomfort' and 'dangerous' zones (Figure 9 right).

Brisbane Street (sensor 575) registered the highest number of data points in the dangerous comfort zone (70 points) and overall the largest number of points in the 'great discomfort' and 'dangerous zones' combined. It is important to note though, that while it registered the highest number of critical human comfort conditions, this is a sensor which did not have the full data set, meaning this number could have been even higher. This is also the case for sensor #574 in Bell St (58 points)

Ripley sensors 142 (69 points) and 578 (56 points) had data for the full period and a high number of data points in the 'dangerous' zone, however when combining the 'great discomfort' and 'dangerous' zones (Figure 9 right), they had less points indicating discomfort than the sensors in the CBD (particularly 570, 575 and 576). This suggests that although Ripley had a high number in the 'dangerous' zone, overall the CBD conditions are less comfortable.

Figure 9:
overview of the
distribution of
data points in
each humidex
zone (left) and
summary of data
points specifically
in the 'great
discomfort' and
'dangerous'
zones (right)



Example of data representation: Sensor 575 - Brisbane St

Humidex	Frequency		
14	106		
15	405		
16	716		
17	1047		
18	1216		
19	1246		
20	1482		
21	1659		
22	1898		
23	1906		
24	2054		
25	2054		
26	2068		
27	2482		
28	2616		
29	2880	Total	25729
30	2824		
31	2607		
32	2339		
33	2071		
34	1917		
35	1741		
36	1523		
37	1168		
38	884		
39	584	Total	17658
40	462		
41	397		
42	213		
43	123		
44	79		
45	54	Total	1328
46	42		
47	21		
48	7	Total	70

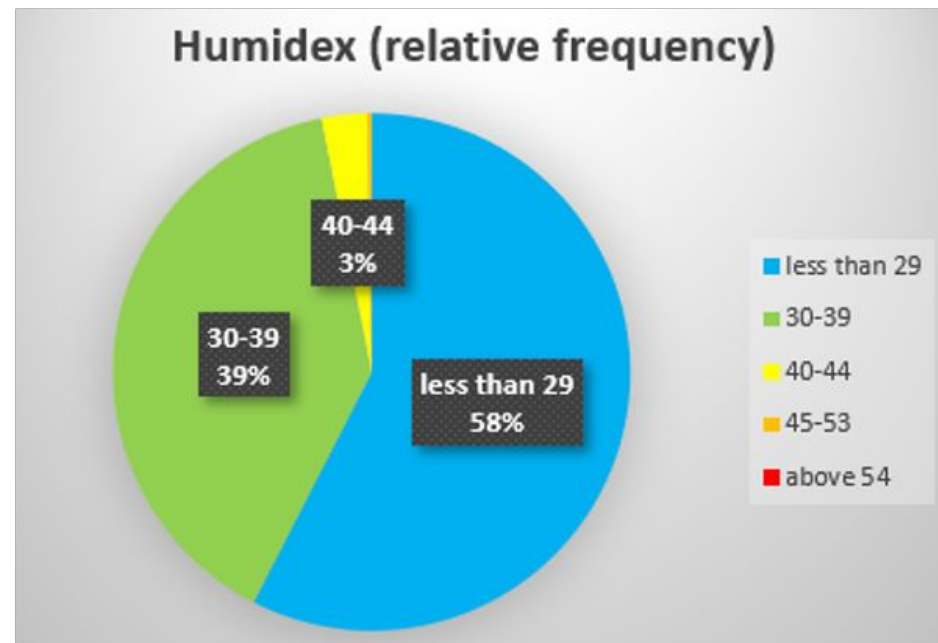
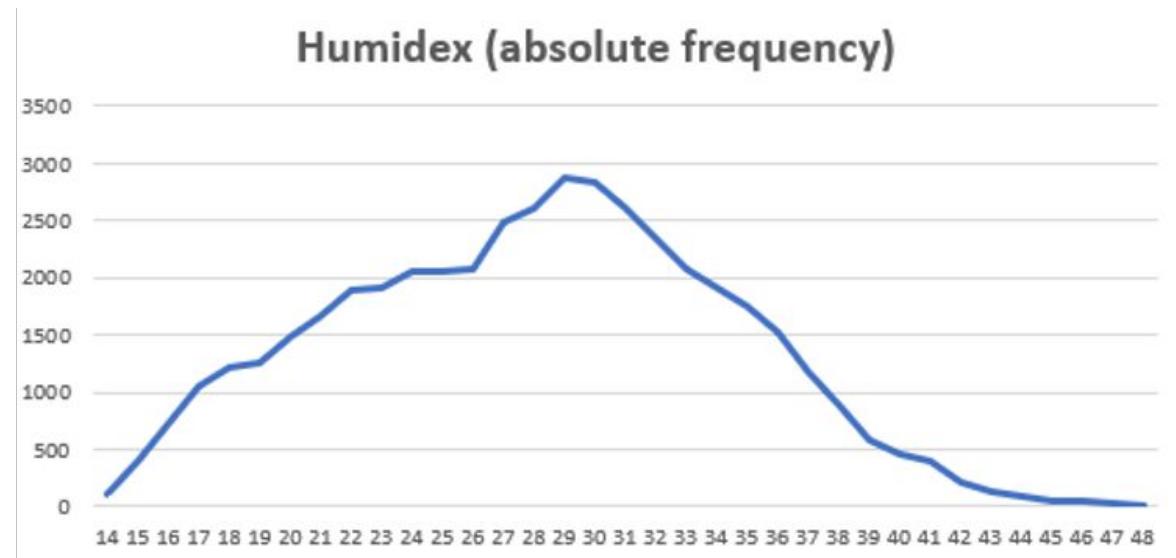


Plate 1: Data distribution in each thermal comfort zone according to Humidex, with absolute frequency (top) and relative frequency (bottom)

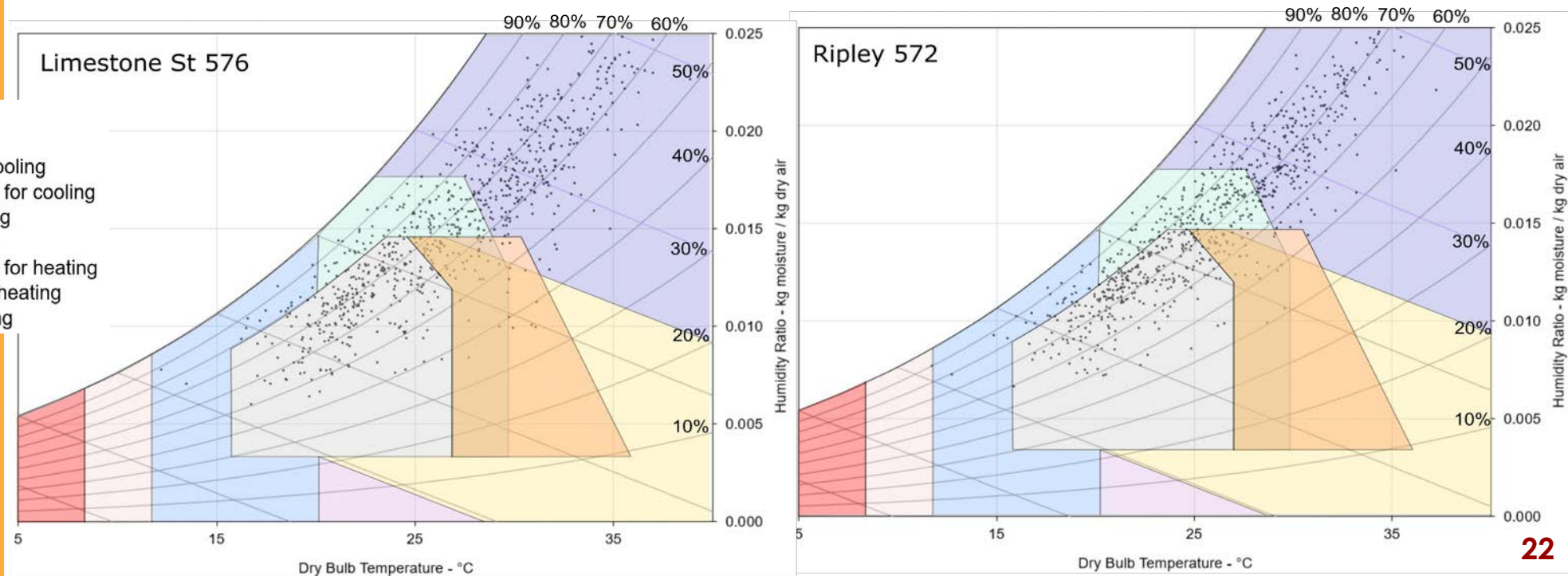
DESIGN STRATEGIES ANALYSIS

While the analysis of the maximum and minimum temperatures and the Humidex indicate differences between the CBD sites and the new development, the design strategies identified for both sites are similar. The analysis of design strategies based on the psychrometric chart was done based on the average temperature and humidity conditions for each day of data collection. The results (Figure 10) show that overall:

- Many days are in the Comfort zone, providing thermal comfort for users of those specific public areas
- Many days sit in the Ventilation zone, meaning that an increase in breeze corridors and wind speed would improve human thermal comfort
- Many days in the Artificial Cooling zone, therefore active cooling strategies are needed such as thermal induced air circulation
- Some days are in the Thermal Mass for Cooling, indicating cool materials with high reflection and small heat storage capacity are beneficial
- Some points in the Thermal Mass for Heating meaning that discomfort is generated by the cold and ways to keep the spaces warm in those periods of time are needed.

It is important to note that no analysed day would benefit from humidification, and that the humidity tends to be high in days with high temperatures too.

Figure 10:
Design
strategies



The third key objectives of this longitudinal study is to provide insights into the relationships between people's experience of place and their microclimates, specifically urban heat. Following surveys in the three case study sites, Report 2 showed that Ipswich **residents are already knowledgeable and aware about the effects of urban heat, not only regarding their own well-being but also how it impacts their relationship with the built environment.** This is extremely positive and demonstrates that **education on that general matter does not need to be the priority focus, but rather on the specifics** so that residents can compare and make informed decisions. To confirm (or not) these results further, two new investigations were undertaken: VR experience and stakeholder workshops. The following sections present the methodology and results for each of them.

2.2.1. Virtual Reality Experience

The aim of the VR experience was

- to collect the reactions of participants when experiencing the change of environment
- to discuss with participants which other changes they could think of to mitigate urban heat



Figure 11: VR experience at Nicholas Street © City of Ipswich

After a call made to Ipswich residents by the communication office of City of Ipswich and online registration, the VR experience took place on

- October 19th, 2022 for a duration of 4 hours at Nicholas Street; **XX** persons attended
- October 29th, 2022 for a duration of 3 hours at Ripley Town Centre; **XX** persons attended

The VR experience simulated a before/after environment from two existing case study streets (Brisbane street in Ipswich CBD and one section of the Joy Chamber Circuit in Ripley). The 'after environment' showed some urban design changes to mitigate urban heat (e.g. trees in planters in Figure 5).



Figure 12: Brisbane street, before (left) and after (right)

Practically, the participants virtually 'walked' the existing street one way ('before environment') and then walked back the same street which showed the changes ('after environment') (Figure 12), while answering the 6 same questions each way (see list below). They could change the time of day, month and year, as well as the weather (e.g sunny, small rain, heavy rain, snow). They also had the capacity to move around, stop, turn, etc.

List of questions

1. Could you please describe this space/what you see around?
2. What do you like about it?
3. What do you dislike about it?
4. Do you feel safe in this environment? Why?
5. Do you feel comfortable in this environment? Why?
6. What do you think could be improved?

The urban design changes implemented in each street took into consideration the recommendations that stemmed from the urban design analysis previously undertaken (and found in Report 1).

For Brisbane Street, these changes included

- More greenery (trees in planters, green walls, new planted trees) to increase shadows and moisture, while decreasing temperatures (= bioclimatic control)
- Change in building height for some buildings and more awnings to increase shadows and decrease temperatures
- Change of materials and colors on some building facades to increase solar reflection and decrease solar absorptance
- More sittings

For Joy Chamber Circuit, the urban design changes were

- The introduction of a fully covered pathway to reduce temperatures and increase shadows
- More greenery (new planted trees and shrubs) to increase shadows and moisture, while decreasing temperatures (= bioclimatic control)
- Addition of water fountains to reduce the heat



Figure 13: Joy Chamber Circuit, before (left) and after (right)

Four main results emerged from the VR experience as follows

1. Participants readily and easily engaged with the experience and enjoyed it, finding it useful to understand the proposed changes > this means that VR is an effective tool for community consultation
2. Participants could easily pinpoint what did not work well in the existing environments and could easily spot the proposed changes > this confirms the survey results re their urban heat literacy
3. Participants were proactive in their suggestions and eager to see the changes being implemented > this means that VR is an effective tool to facilitate community response and adhesion to the project
4. Suggestions not only addressed urban heat mitigation, but also included safety issues and other urban design elements to add (e.g. add more sittings, a new toilet, etc.) > this shows that VR can generate larger discussion and become a useful tool for community engagement and better design

In conclusion, the use of VR proved to be useful to talk about urban heat and urban design, providing unexpected benefits for design and strategic planning. It also confirmed that Ipswich residents are eager to engage with strategies that can help mitigate urban heat.

Follow-up workshops were then organised in a last step to synthesize the results and discuss mitigation priorities and strategies.

2.2.2. Workshops

The aim of the follow-up workshops was to present a synthesis of this 3-year study and discuss the results with various stakeholders to identify recommendations and barriers. A call for participation and registration was issued by the communication office of City of Ipswich. Two workshops were organised: one with Ipswich residents (31/01/2023, 13 participants) and one with staff from Stockland, one of the current residential developers in Ripley and Springfield (06/03/2023, ? participants).

The knowledge of participants regarding urban heat and its mitigation was tested with questions throughout the workshop, while the summary results were presented and discussed. The Impact Effort Matrix (Schillaci, 2018) was used to hierarchise recommendations and priorities (Figure 15).



Figure 14: Workshop with residents

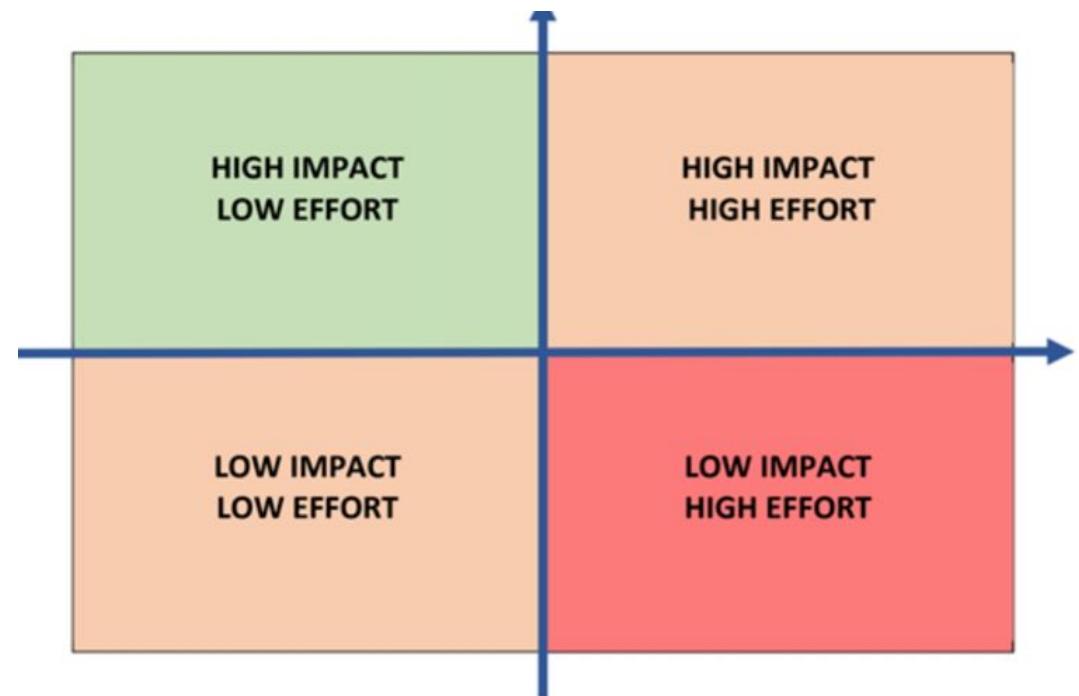


Figure 15: the Impact Effort Matrix

Regarding the **residents workshop, overall, most participants had a good to sound knowledge regarding urban heat and were eager to engage with mitigation** (as demonstrated by their attendance to this workshop). However, it was also evident that although everyone was confident about the benefits of shades, there was a lack of knowledge regarding the specifics (e.g. which materials to choose to reflect away heat? Which one is more performant?). The financial aspect of health-related long-term benefits were also discussed, showing that in majority participants rarely thought about urban heat mitigation as a mean to invest into their health. For example, when given the choice to choose between changing their fridge or change the roof of their house for a more reflective one at the same cost, almost all of them chose the fridge. Participants also noted that energy cost and energy price influence their cooling down consuming behaviour. Overall, **this shows that education about urban heat needs to be detailed and practical.**

Seven major barriers and 15 recommendations were identified by the residents (see summary in table 3 next page). Overall they felt that **they would need to better know/ understand the process** to engage in any work that would contribute to heat mitigation (e.g. changing roof materials, adding awning, plant more trees on their property, etc). They felt the current website for building application was not clear enough and could not help them step by step, nor was updated regularly.

They also identified that council communication (and media communication in general) and education campaigns were **not providing enough knowledge about the benefits to mitigate urban heat**, thus hindering engagement. In the same way, participants suggested that better incentives (e.g. tax incentive, \$5,000 budget for any resident doing something, etc.) could be offered.

Participants strongly felt that **competing priorities were the results of not presenting the problem properly and lack of evidence-based rationale**. For example, there is common resistance against council when the latter proposes to sacrifice some car parks to plant trees to improve thermal comfort. Participants felt that this resistance will decrease if council could communicate *before hand* how much the decrease of heat-humidity would mitigate health risks and mortality.

In the same way, participants suggested better **costs clarification** and evidence of the council engagement towards heat mitigation.

At last, participants identified that **insufficient governmental structures, outdated knowledge and policies, as well as general poor attitude were some other barriers to mitigate urban heat**. Regarding governmental structure specifically, they felt that there was a lack of laws and policies to support urban heat mitigation. Concerning the 'poor attitude', they also noted it included both individuals and bigger stakeholders (e.g. developers greed, governmental corruption).

Table 3: Summary results of the resident workshop

BARRIERS	RECOMMENDATIONS
1.Knowing the process	1.1. Creation of a digital platform (e.g. website) that will clearly inform about the process, step by step. 1.2. Make sure this platform is always updated 1.3. Overall, improve the communication to empower residents
2.Knowing the benefits	2.1. Education of all residents organised by council 2.2. Increase the use of social media 2.3. Constantly clarify what residents can gain from mitigating urban heat 2.4. Tease out the incentives for residents to engage in mitigating urban heat (e.g. tax incentive, \$5,000 awardt for any residents doing something, etc.) 2.5. For new building, similar to a car-package, present the building with all the options and then inform of the consequences when you opt out from some options.
3.Competing priorities (e.g. shall we plant a tree or keep the car park?)	3.1. Systematically clarify the end goal by communicating about the bigger question (e.g. trees improve thermal comfort = keep residents healthy) 3.2. Provide evidence-based rationale 3.3. Lead with innovative solutions and thinking out of the box (e.g. can't we have both trees and car park if trees on top of a parking?)
4.Cost	4.1. Make sure to present properly the information in relation to the bigger question and targeted outcome (e.g. Urban heat mitigation is a Health budget) 4.2. Council to analyse current budget distribution and decide where a fraction could go to urban heat mitigation
5.Insufficient governmental structure	5.1. Strengthen and develop laws and policies to support urban heat mitigation
6. Outdated knowledge & policies	6.1. Provide a regularly updated website with best practices examples regarding urban heat mitigation projects
7. Poor attitude: both from individuals and bigger structures	

Regarding the **developer workshop**, most participants had a good to professional knowledge **regarding urban heat and were eager to engage with mitigation**. However, none of them had heard of and trained with the latest and most efficient climate simulation and analysis software (ENVI-met).

They also identified **2 major barriers and provided 3 recommendations** (table 4). Basically, they noted that one key obstacle they often face is that when they put forward new ideas to the ultimate asset owners (e.g. Local Government Authorities), because these new ideas don't fit into the 'tried and tested' performance criteria, they are vetoed and developers have to revert back to delivering the same old. In addition, they also suggested it would be very helpful if they could find a list of best practices already implemented in the LGA territory.

Barriers	Recommendations
1. Insufficient support from LGA	1.1. Introduce some level of flexibility to the 'tried and tested' performance criteria to support new ideas and innovations 1.2. Rethink together current green management when developments are handed over to council to support netter turf area maintenance
2. Insufficient best-practice knowledge	2.1. Council to showcase on their website all their best practices regarding successful urban heat mitigation (e.g. canopy cover best practices, successful implementation/case studies showcasing solar lighting in Council-owned parks/walkways, etc.)

Table 4: Summary results of the developer workshop



When discussing potential actions with the Impact Effort Matrix, there was a clear consensus regarding what could have a high impact with low effort. It included

- undertaking climate analysis
- accessing the lessons learnt from previous developments
- undertaking turf area analysis (to improve maintenance and avoid dry spots)
- Undertaking ENVI-met simulation and analysis

In the same way, there was consensus regarding what could be considered high impact with high effort. It included

- undertaking psychrometric analysis
- design considerations to support reduction in heat island
- improving turf area management (watering)

These results are important because they show that developers are also ready to engage and eager to do so.

Figure 16: the Impact Effort Matrix filled in by participants

3. SYNTHESIS

This 3-year project had three key objectives:

1. Provide an evidence-based analysis of urban microclimate in key areas of Ipswich.
2. Provide an UD analysis that relates the identified urban microclimate and possible UHIs with design solutions.
3. Provide insights into the relationships between people's experience of place and urban heat

The following pages triangulate all the findings and present the final synthesis.

3.1 Regarding the urban microclimate, humidex and design strategies analysis

Maximum and minimum temperatures analysis indicates that:

- In general the CBD is largely cooler than the temperatures recorded by BoM during the day and warmer during the night, indicating the existence of UHI conditions
- New development shows temperatures closer to BoM both during the day and night, indicating that while it heats quicker, it also performs better in dissipating the heat overnight. The presence of vegetation is a factor that may play a role in this heat exchange.

Humidex analysis indicates

- Sensors placed in the CBD (Brisbane St 575) registered the highest number of data points in the dangerous comfort zone and overall the largest number of points in the 'great discomfort' and 'dangerous' zones combined.
- Ripley sensors had a high number of data points in the 'dangerous' zone, however when combining the 'great discomfort' and 'dangerous' zones they had less points indicating overall discomfort than the sensors in the CBD
- Although Ripley had a high number in the 'dangerous' zone, overall the CBD conditions are less comfortable.

The design strategies analysis indicate that:

- There are many days are in the Comfort zone, providing thermal comfort for users of those specific public areas
- Ventilation and artificial cooling strategies for public spaces are the main strategies to be adopted for providing human thermal comfort
- Discomfort as a consequence of cold weather conditions also play a role in compromising thermal comfort of public space users and attention to balancing strategies for hot and cold conditions is needed
- No analysed day would benefit from humidification.

3.2 Regarding the UD analysis

(Detailed results to be found in Report 1)

-In general, it was confirmed that urban form and design analysis can

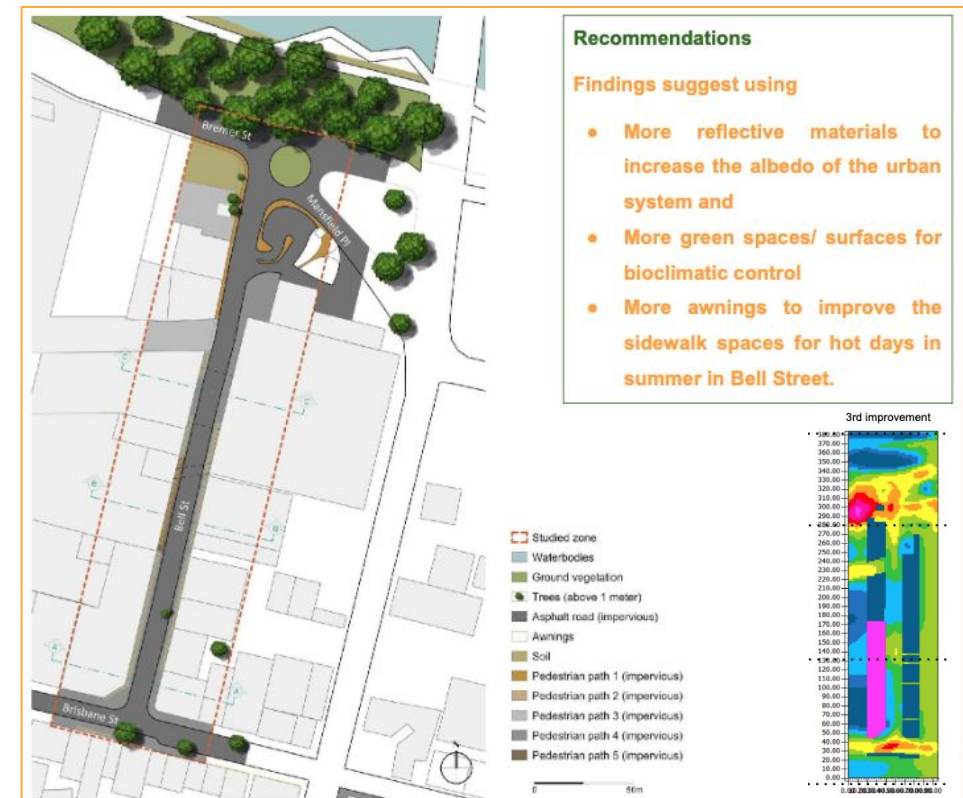
- evidence the level of comfort a street can provide to its users against heat
- assist in identifying practical solutions to mitigate urban heat (see top figure)

It was also evidenced that

- Materials matter, but so do urban form, urban design, urban ratio and existing microclimates, therefore heat mitigation strategies need to be holistic
- the combination of UD analysis and climate analysis provides opportunity for fine grained recommendations to mitigate urban heat
- ENVI-met simulations can provide scenario on how to decrease temperatures

-Specifically regarding the 3 case studies, it was found that

- new developments (Ripley) were not performing better than old ones (see table)
- solutions to mitigate urban heat in Bell St, Limestone St and Brisbane St are quite similar (e.g. emphasis on cooling strategies)



	Bell Street	Limestone Street	Joy Chambers Circuit
Aspect ratio	80% is 0.63 and lower, 20% is 0.87	0.37 on average	The area in Reg Grundy Street is 0.22, the rest have an open field either on one side or both sides of the street
Vegetation	3% of the open area vegetation, 4% of the open area soil	8% of the open area vegetation	25% of the open area vegetation, 35% of the open area soil
Impervious surfaces	93% of the open area	92% of the open area	40% of the open area
Open areas	48% of the studied area	50% of the studied area	84% of the studied area
Waterbody	Bremer river at the end of the street, but not in the studied area	N/A	Bundamba Creek on the east side of the site, but not in the studied area
Façade materiality	32% Glass 46% Concrete 11% Brick 11% Metal	28% Glass 16% Concrete 14% Brick 42% Composite panels/Metal	70% Concrete 30% Brick
Roofs materiality	8% Metallic 92% Concrete	19% Metallic 81% Concrete	All Metallic, usually dark color
Awnings	48% of the sidewalk	66% of the sidewalk	0
SVF	0.6 on average	0.8	0.8

3.3 Regarding people and urban heat

-Survey, VR experience and workshops show that

- residents are already knowledgeable and aware about the effects of urban heat, not only regarding their own well-being but also how it impacts their relationship with the built environment.
- residents and developer stakeholders are eager to engage in heat mitigation but need practical support from council and incentives

(Detailed results to be found in Report 1 and in the section 2.2 of this report 3)

3.4 Conclusions

These results show that several UHIs have been identified and cooling strategies need to be implemented in Ipswich, with a clear communication campaign to support the initiative, both for residents and developers.

The best way to avoid cooling strategies is to avoid developing new UHIs with relevant design and strategic planning. Our study showed that this needs yet to be implemented.

From a methodology perspective, this project shows that sensors provide insightful microclimates data at localised areas. However, there are limitations to their deployment at the full city scale: costs, reliability to internet and/or batteries, installation requirements and criminal behaviour (one of our sensors was stolen). Using Citizen Science projects, namely when the public voluntarily helps conduct scientific research (to know more see <https://citizenscience.org.au/>), could provide an interesting alternative and engagement opportunity.

At last, in most gentrified areas, the surface of privately owned and managed built areas is largely superior to that of public space (including streets). This means that these private stakeholders need to be supported to engage with urban heat mitigation, otherwise the single efforts of council won't be able to achieve the best mitigation outcome.

Since Local Governments are best placed in determining how local land uses are regulated, relevant heat mitigation changes in planning policies could provide the mean to support these private stakeholders.

Also, Greens have introduced an inclusionary zoning bill to State parliament. They propose that for all residential construction projects completed on or after 1 July 2024, at least 25% of the dwellings constructed for the project are to be reserved for transfer to the State for the purpose of providing public housing (<https://documents.parliament.qld.gov.au/tp/2023/5723T509-707E.pdf>). If this bill is acted, this means that relevant heat mitigation design needs to be approved at the development application level, to avoid extra costs for council on the long run as well as social and climate injustice.

4. RECOMMENDATIONS

Sixteen recommendations emerged from this 3-year project. They are presented below in 3 sections in relation to the expected outcome.

A. To support residents/stakeholders to mitigate urban heat

- 1. Create a specific council webpage/platform about heat mitigation** that will inform, facilitate processes, as well as display and collect best practices. It should be **regularly updated**.
- 2. Development of a Design guidelines/built environment measures for climate-responsive design.**
- 3. Organise heat mitigation workshops** that will provide hands-on knowledge and suggestions for actions, as well as support to achieve them
- 4. Develop a Citizen Science project** that will help raise awareness and engagement
- 5. Regularly communicate/educate about the impact of urban heat and the benefits of mitigation**
- 6. Propose incentives for actions mitigating urban heat**
- 7. Develop VR experiences as a communication and participation tool**

B. To support better planning

8. **Require climate studies for all development applications**
9. **Train the development applications assessors about climate-responsive design** and make sure they can advice the developers about the best design solutions to mitigate urban heat according to the climate study.This requires a case by case approach.
10. **Develop a ‘heat-mitigation package with all options’** to inform of the consequences when some options are opted out.
11. **Introduce an innovation criteria in the development application assessment** to support new ideas or solutions
12. **Develop a matrix for the systematic assessment of the impacts** regarding an urban heat-related policy/law at 1, 3, and 5 year milestone. It will provide evidences concerning the benefits of this policy/law and assist in decision-making.
13. **Develop a Citizen Science project** to collect data and help council to locate potential UHI and best practices

C. To support urban heat mitigation for the 3 case studies

14. In Bell street, add

- More reflective materials to increase the albedo of the urban system
- More green spaces/ surfaces for bioclimatic control

15. In Limestone and Brisbane streets, add

- Shading on pedestrian ways and northern façades (awnings, rows of trees, autorise higher height of buildings)
- Materials with higher reflectance and albedo, particularly in the northern façades
- Increase of green surfaces (would enhance evapotranspiration)
- Increase the canyon system albedo (therefore reduce the longwave radiation emitted by surfaces)

16. In Joy Chamber Circuit, add

- More tree canopy coverage to reduce the temperature by providing shading during the daytime and increase moisture
- Keeping air flow and heat release potential
- And/or more awnings

5. REFERENCES

-REPORT 1

Dupré, K., Tavares, S; Monnier, P; Hamedani, Z; Jacquot, L; Al Atawneh, D; Smith, B. (2021) *Urban Heat Island: Measure, visualise, change (Phase 1 report)*, City of Ipswich, 49p.

<https://research-repository.griffith.edu.au/handle/10072/411295>

-REPORT 2

Dupré, K., Tavares, S., Abuseif, M., Hamedani, R., Suzuki, M., Ghasemieshkaftaki, M., Al Atawneh, D., Smith, B. (2022) *Urban Heat Island: Measure, visualise, change (Phase 2 report)*, City of Ipswich.

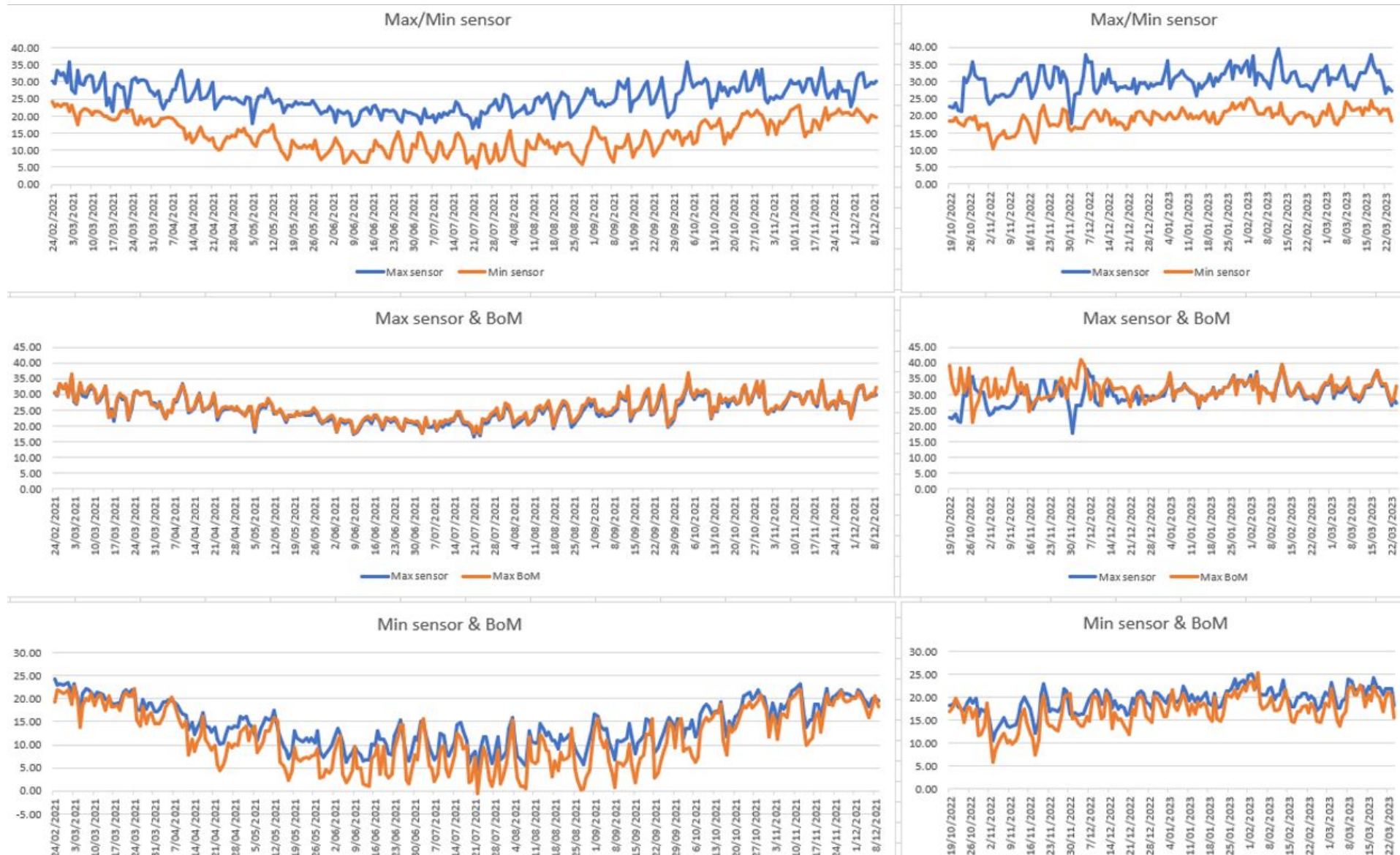
<https://research-repository.griffith.edu.au/handle/10072/414692>

-Schillaci, Domenico 2018. "That Time We Brought Design Sprint to the Ninth World Urban Forum." Medium. 2018. <https://medium.com/@sigfreedo/that-time-we-brought-design-sprint-to-the-ninth-world-urban-forum-ea9bf69af63e>

6. APPENDICES

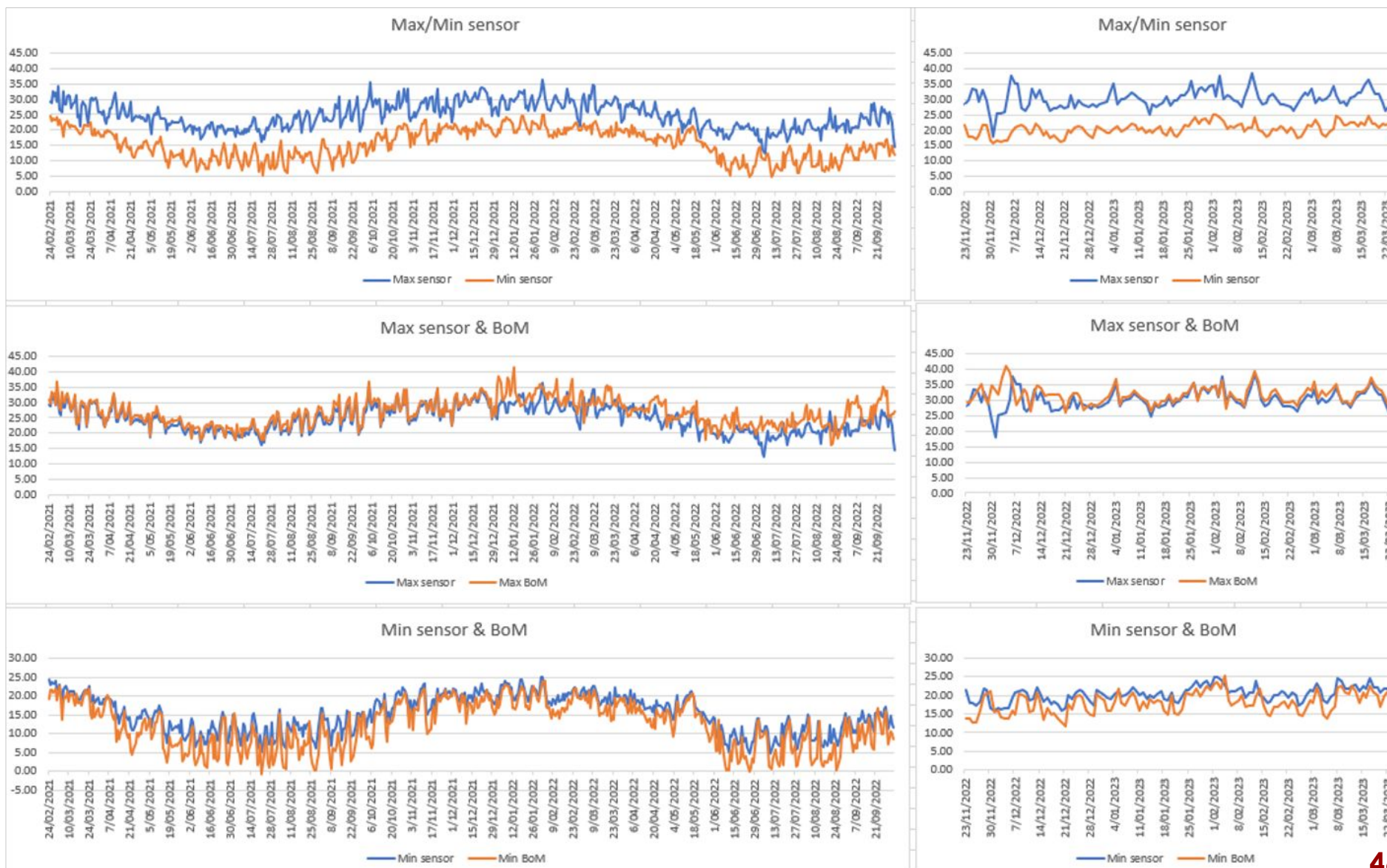
Bell St #569

- Data collection period: 24 February 2021 to 9 December 2021 and 9 Oct 2022 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM very similar, with slightly lower temperatures registered by the sensor. More significant differences were observed between October & December 2022
- Minimum temperature (during the night) BoM conditions are significant cooler



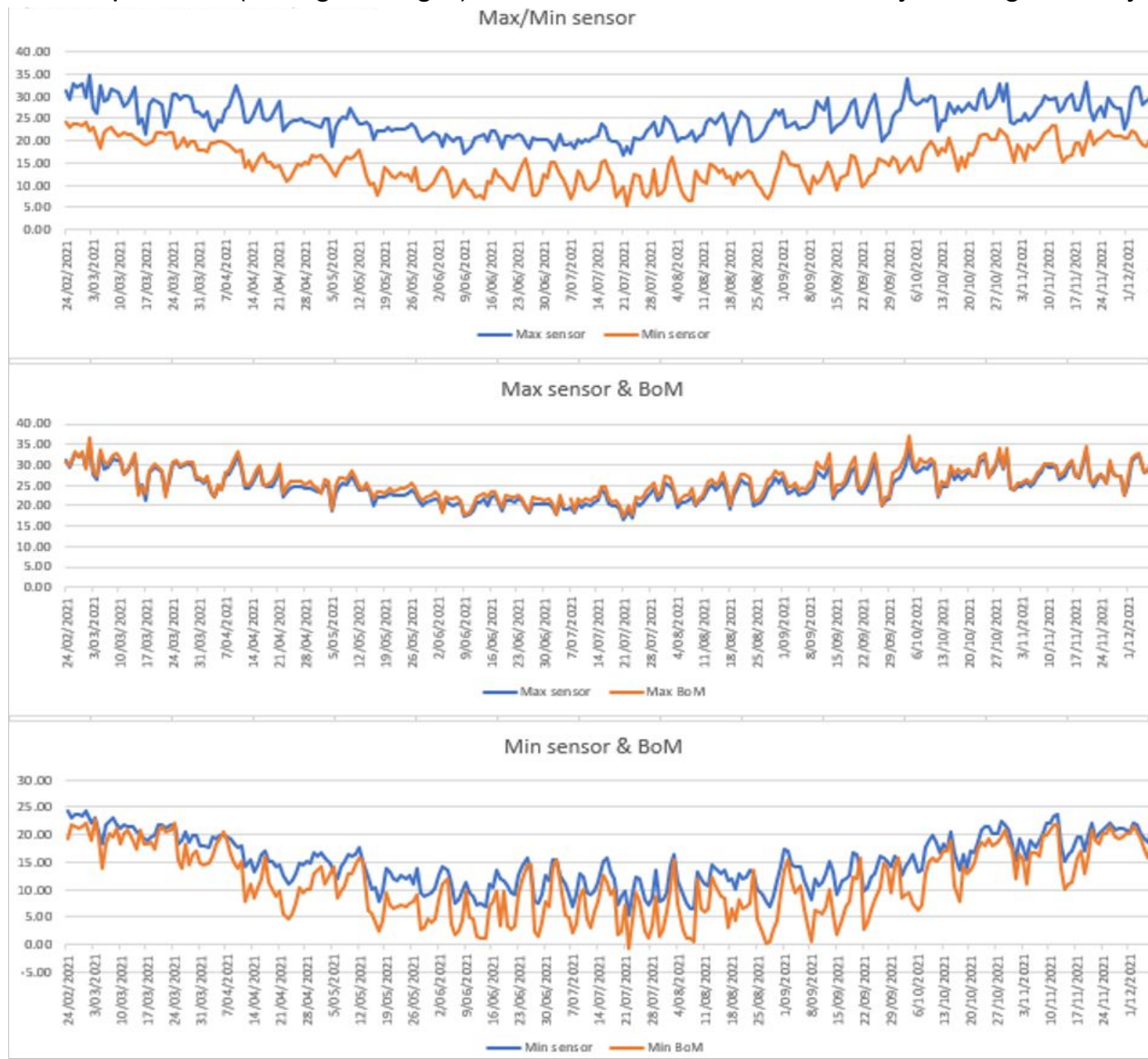
Bell St #574

- Data collection period: 24 February 2021 to 3 Oct 2022 and 23 Nov 2022 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered by the sensor
- Minimum temperature (during the night) BoM conditions are significant cooler



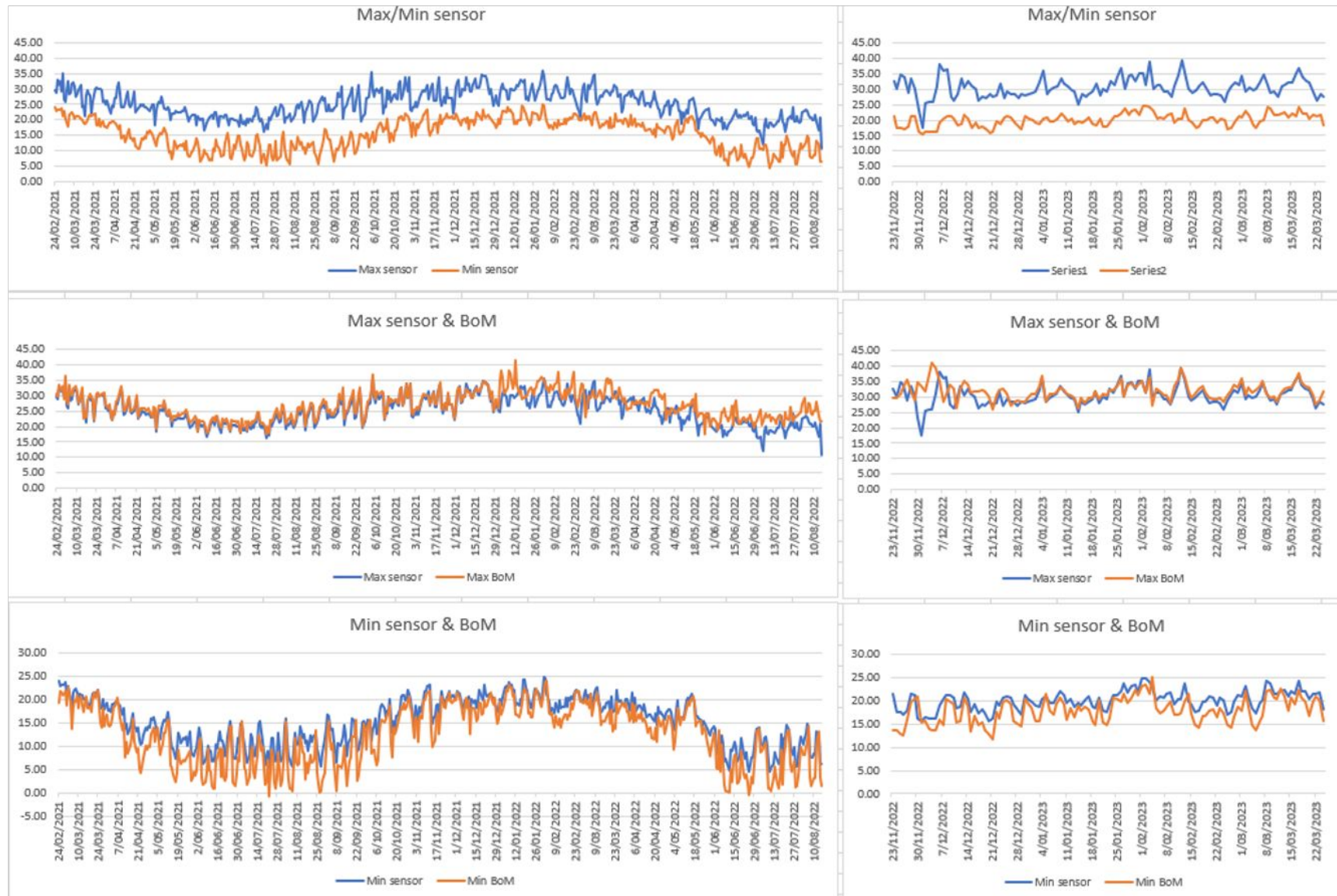
Bell St #577

- Data collection period: 24 February 2021 to 9 December 2021
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered by the sensor
- Minimum temperature (during the night) BoM conditions are consistently and significantly cooler



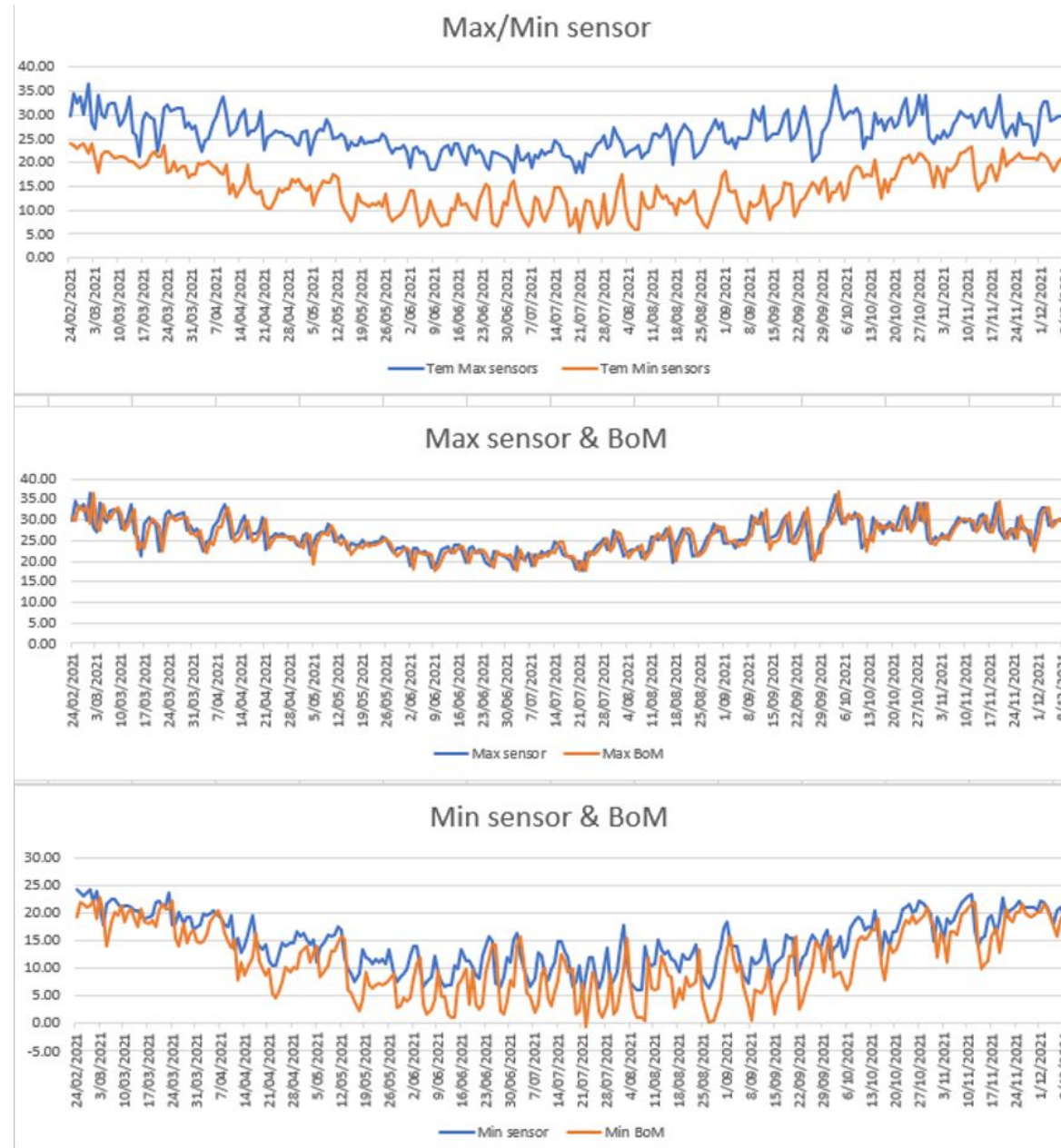
Bell St #580

- Data collection period: 24 February 2021 to 15 August 2022 and 23 Nov 2022 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered by the sensor
- Minimum temperature (during the night) BoM conditions are significant cooler
- During the warmer months, particularly between November 2021 and May 2022, the difference between the minimum temperatures registered by the sensor and BoM is less significant.



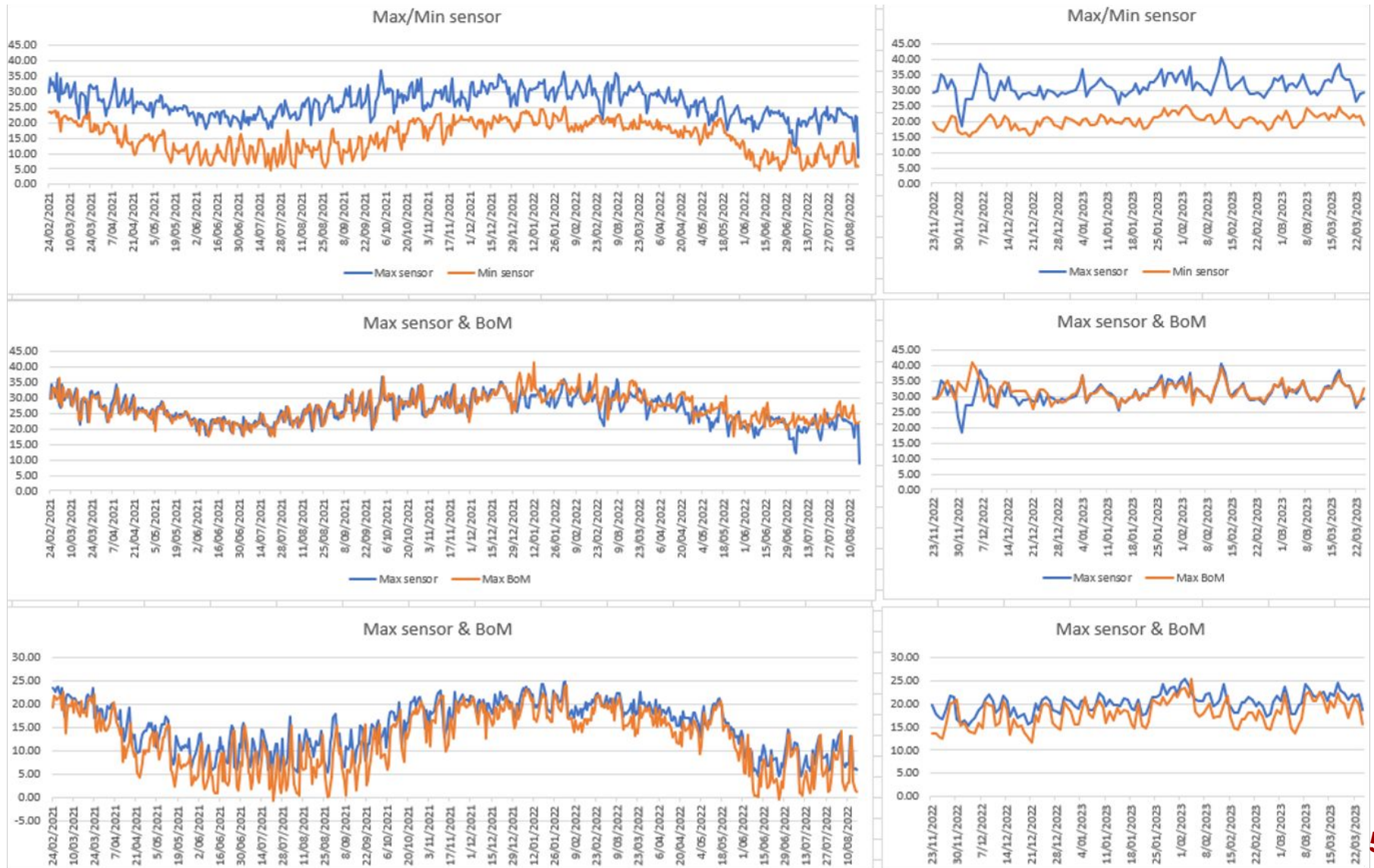
Brisbane St #571

- Data collection period: 24 February 2021 to 8 December 2021
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered by the sensor
- Minimum temperature (during the night) BoM conditions are consistently and significantly cooler



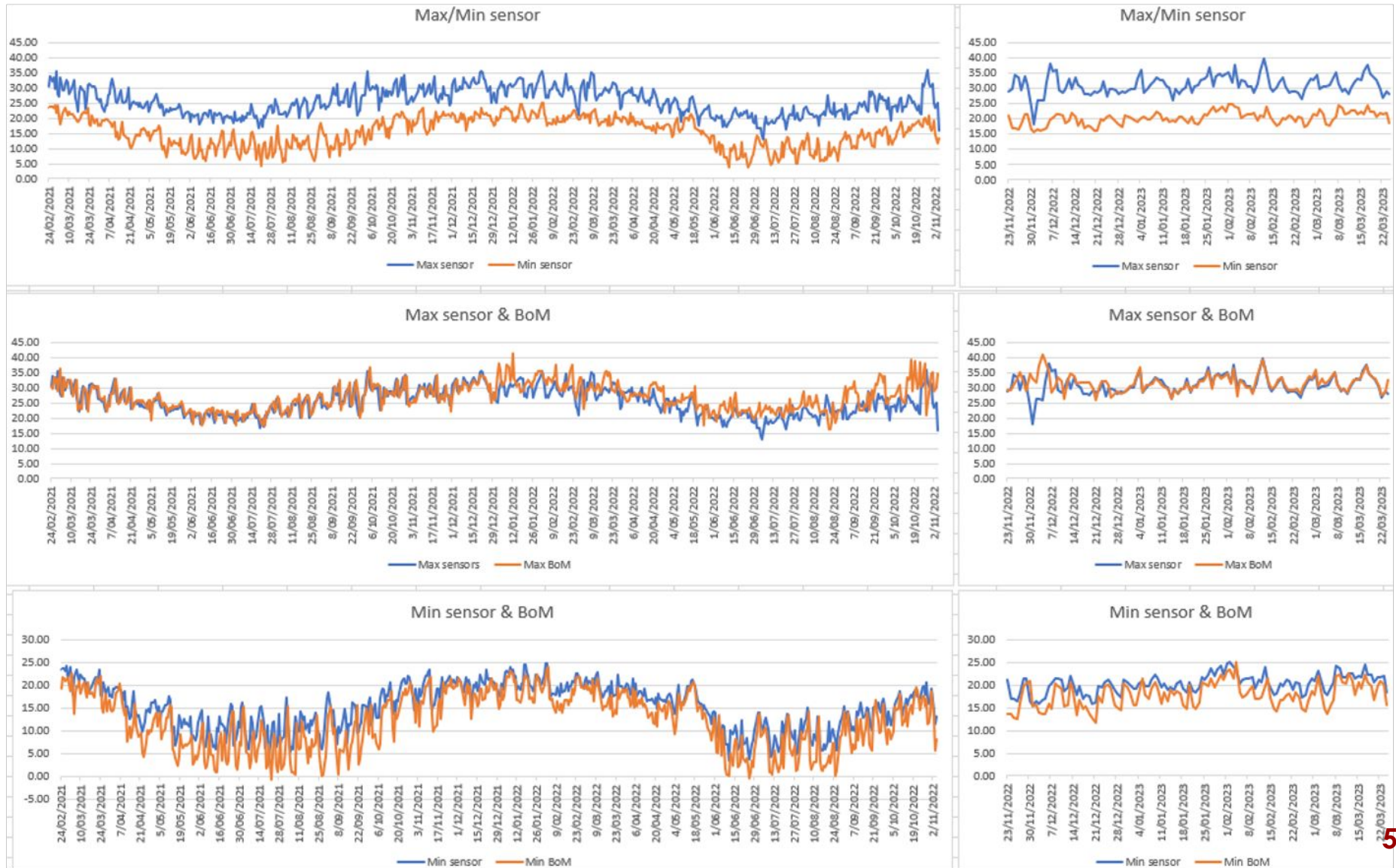
Brisbane St #575

- Data collection period: 24 February 2021 to 15 August 2022 and 23 November to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with sensor registering higher temperatures than BoM for periods of time
- Minimum temperature (during the night) BoM conditions are significant cooler
- During the warmer months, particularly between November 2021 and May 2022, the difference between the minimum temperatures registered by the sensor and BoM is less significant.



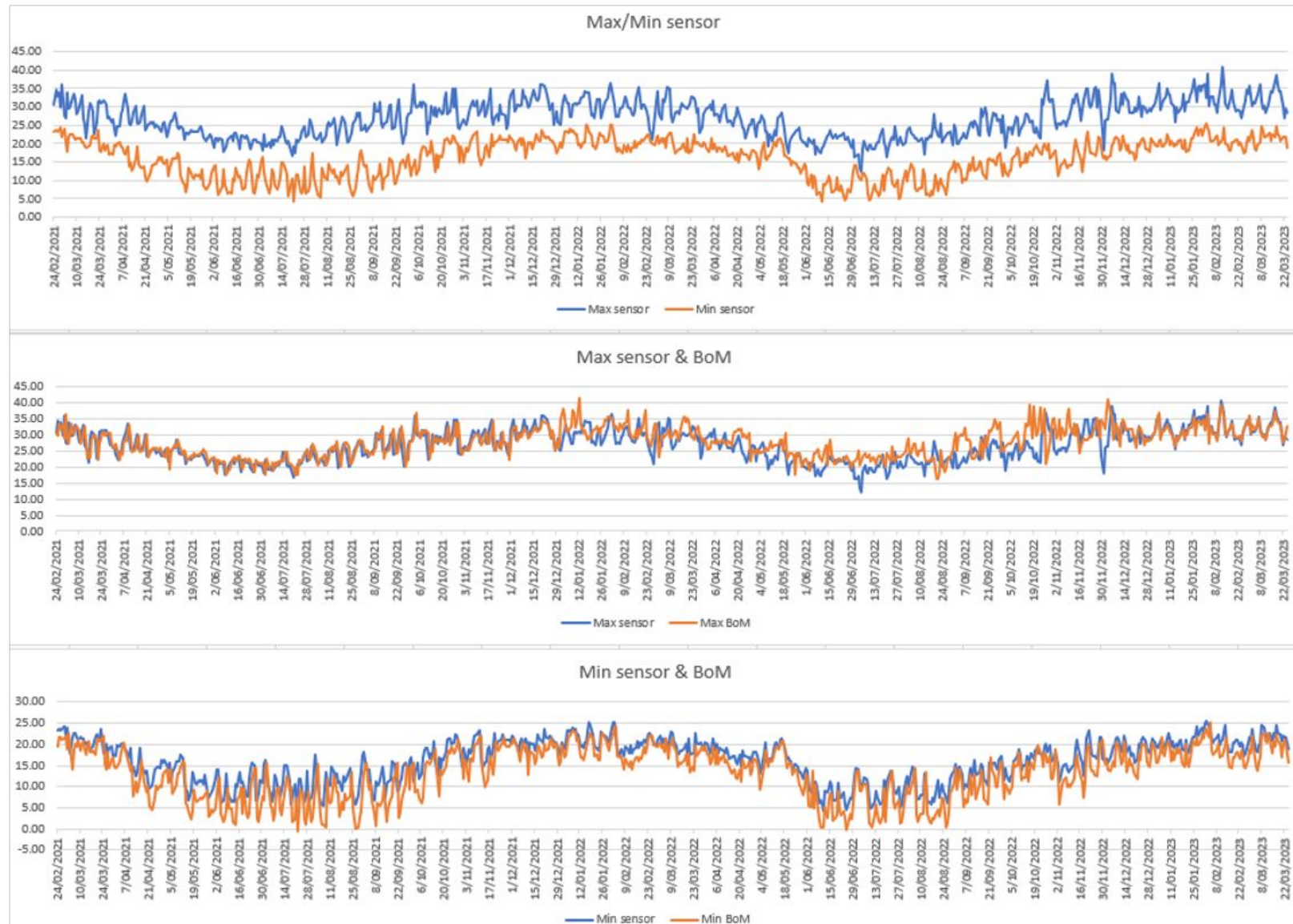
Limestone St #570

- Data collection period: 24 February 2021 to 4 November 2022 and 23 November to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with predominantly lower temperatures registered by the sensor
- Minimum temperature (during the night) BoM conditions are significant cooler
- During the warmer months, particularly between November 2021 and May 2022, the difference between the minimum temperatures registered by the sensor and BoM is less significant.



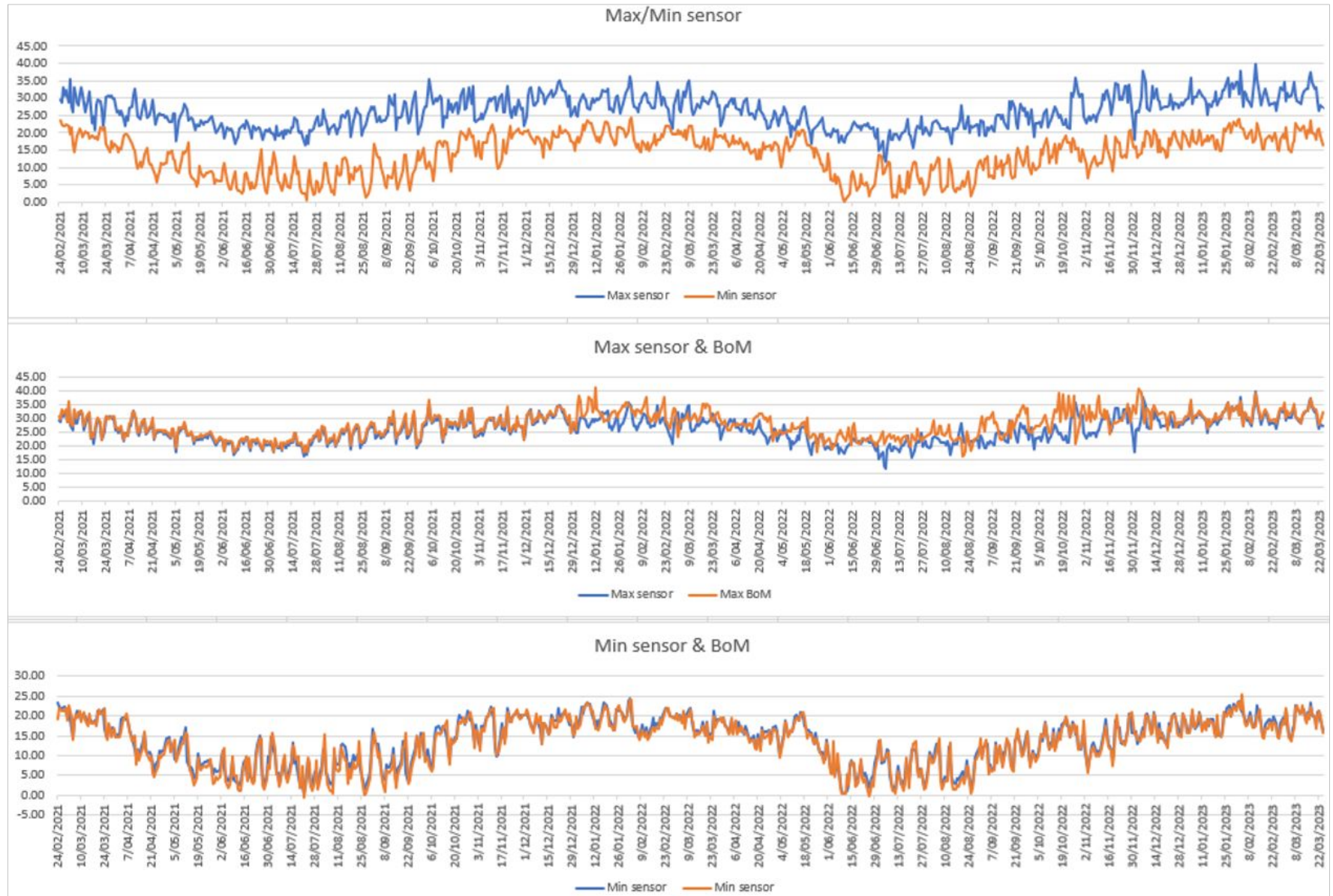
Limestone St #576

- Data collection period: 24 February 2021 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar with both data collection equipment registering higher temperatures at certain points in time
- Minimum temperature (during the night) BoM conditions are significant cooler
- During the warmer months, particularly between November 2021 and May 2022, the difference between the minimum temperatures registered by the sensor and BoM is less significant.



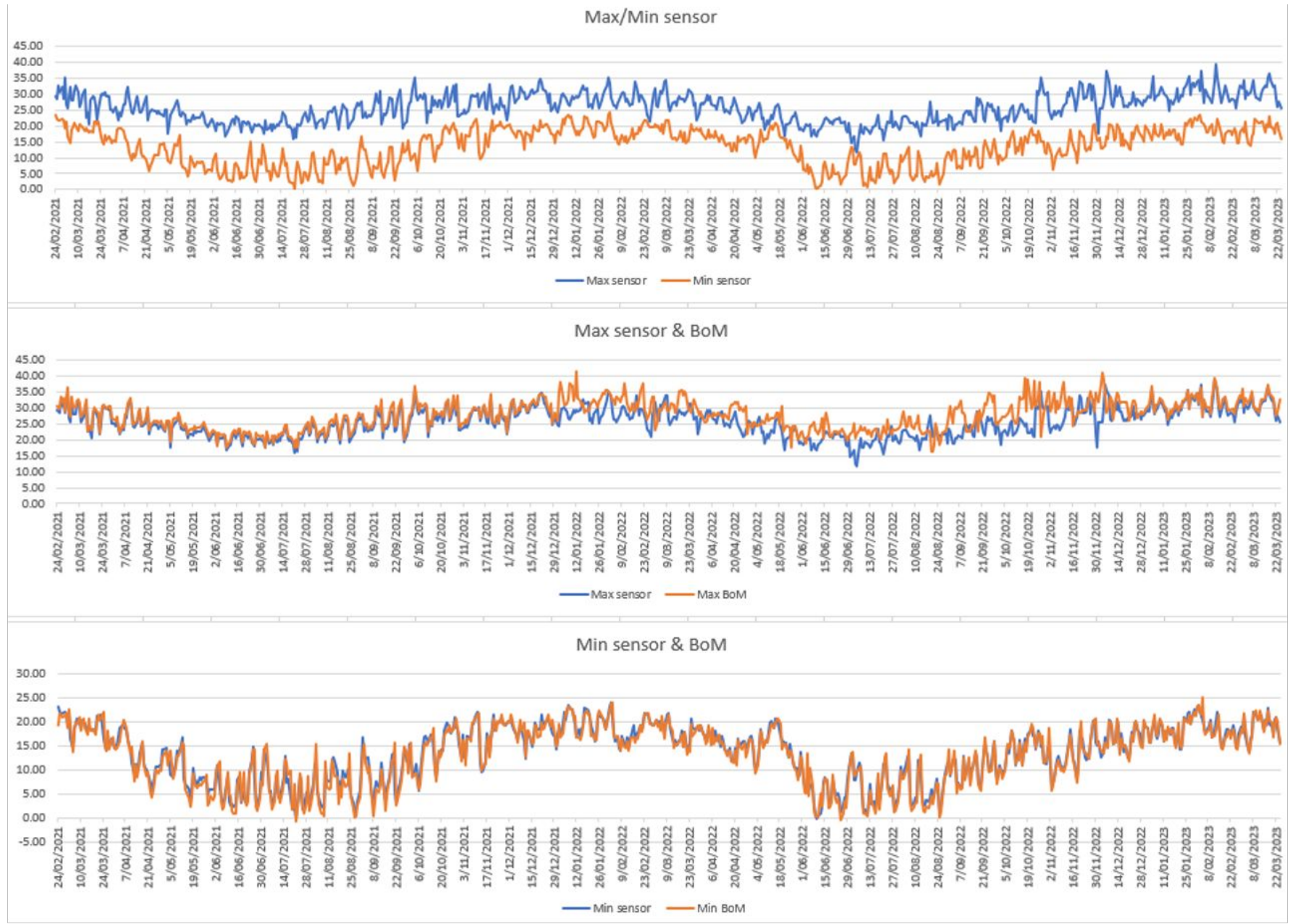
Ripley #142

- Data collection period: 24 February 2021 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with slightly lower temperatures registered by the sensor for the majority of the time of data collection
- Minimum temperature (during the night) are consistent between the sensor and BoM



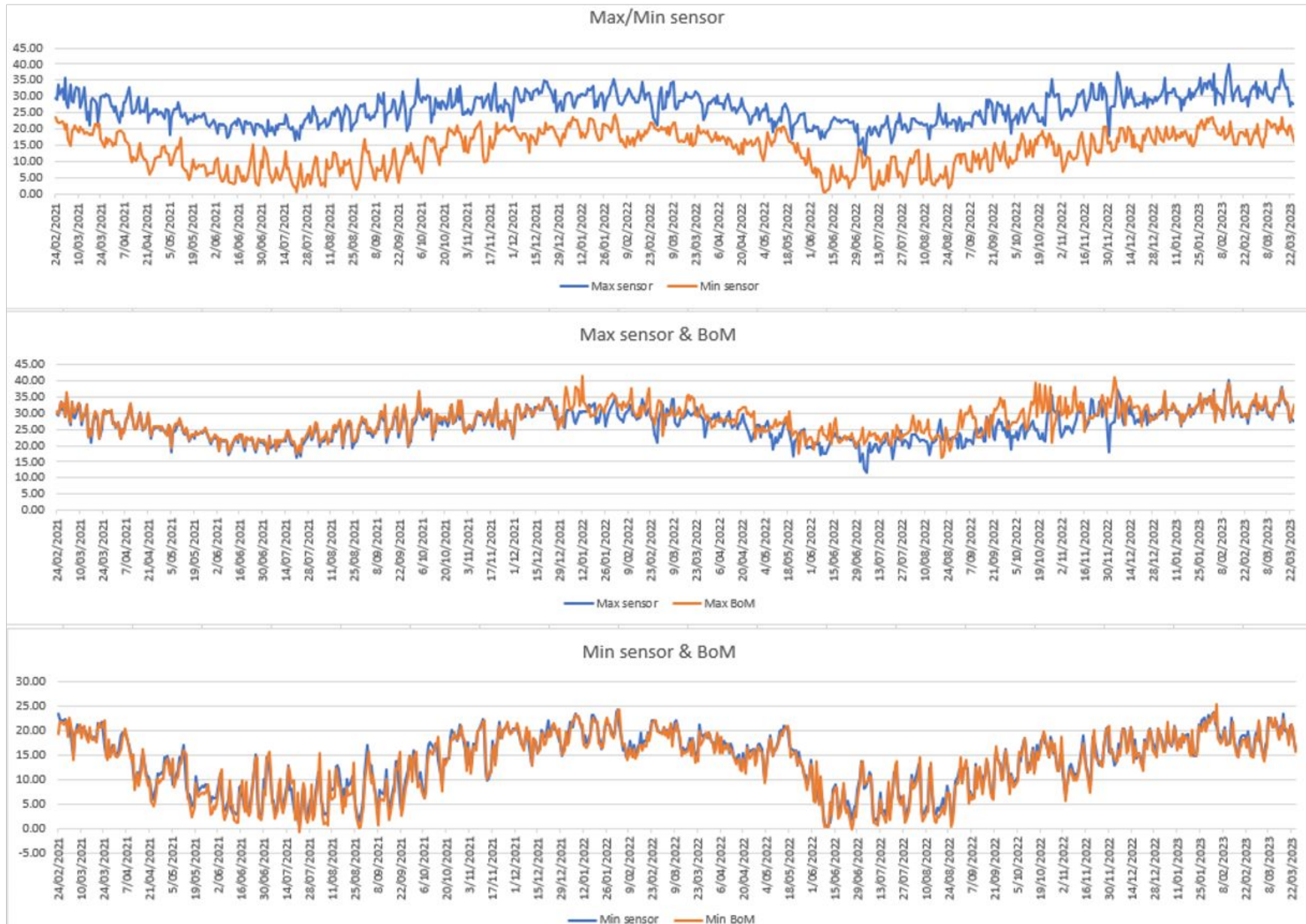
Ripley #572

- Data collection period: 24 February 2021 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered by the sensor for the majority of the time of data collection
- Minimum temperature (during the night) are consistent between the sensor and BoM



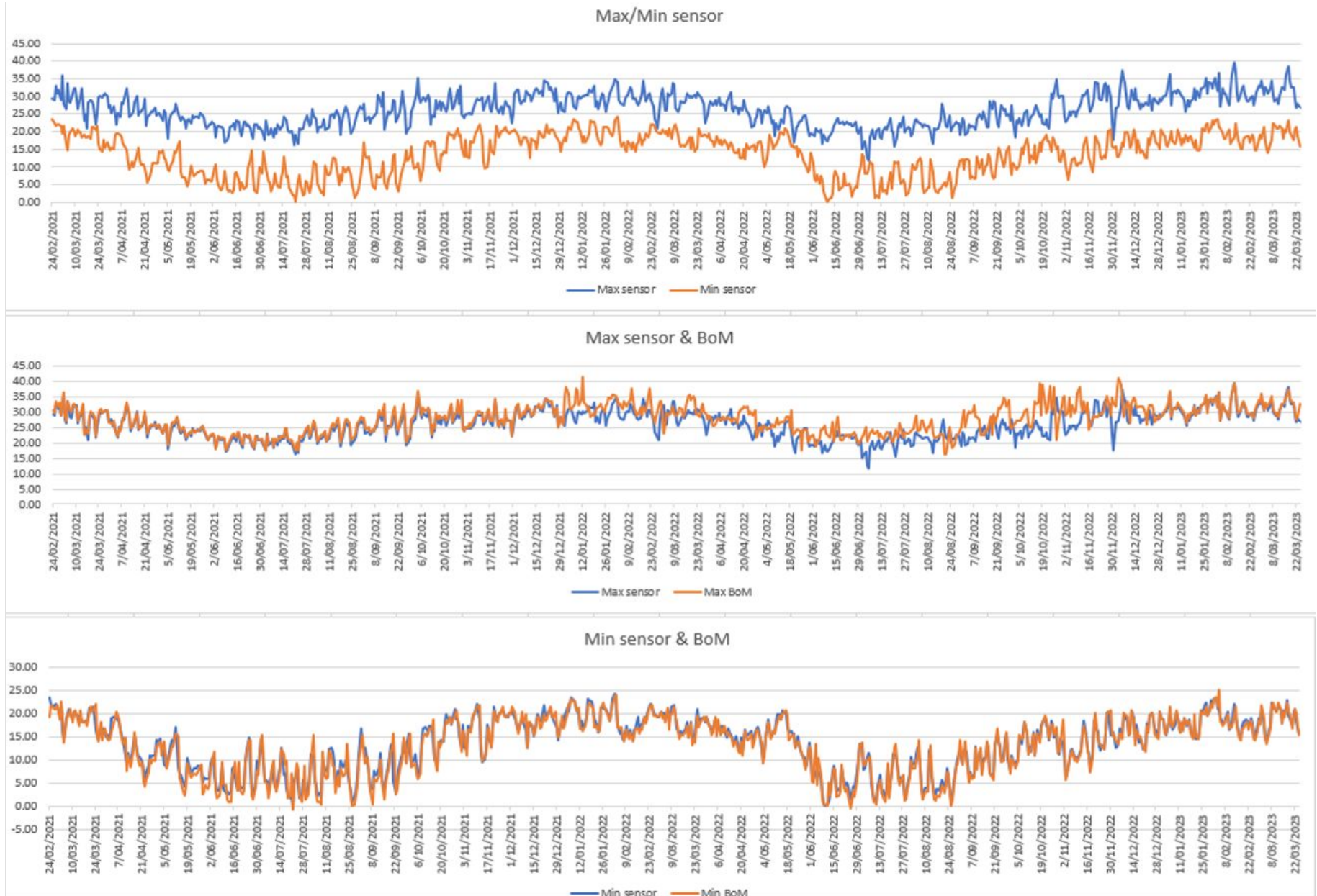
Ripley #573

- Data collection period: 24 February 2021 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered for the sensor for a period of time
- Minimum temperature (during the night) are consistent between the sensor and BoM



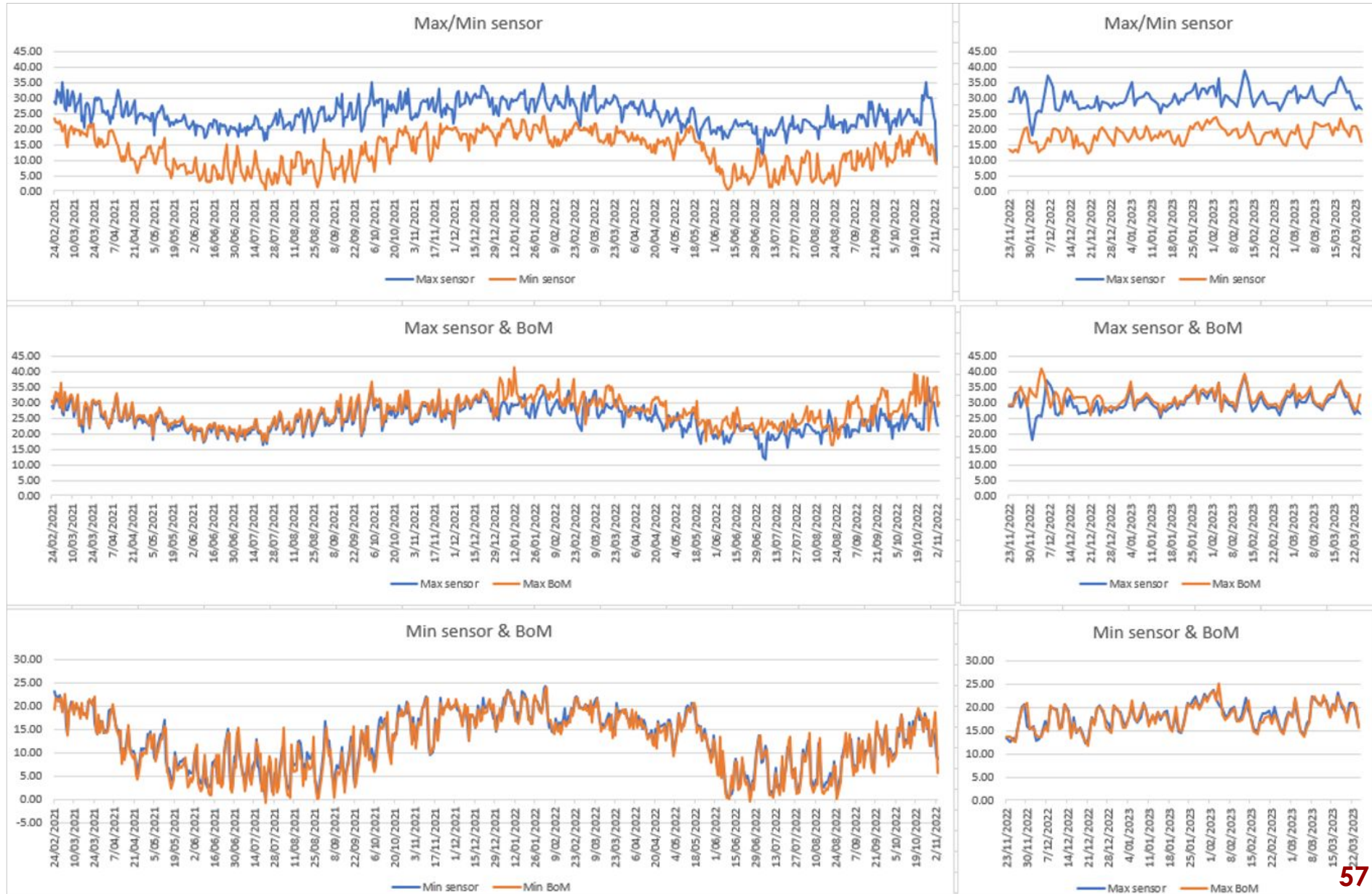
Ripley #578

- Data collection period: 24 February 2021 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered for the sensor for a period of time
- Minimum temperature (during the night) are consistent between the sensor and BoM



Ripley #579

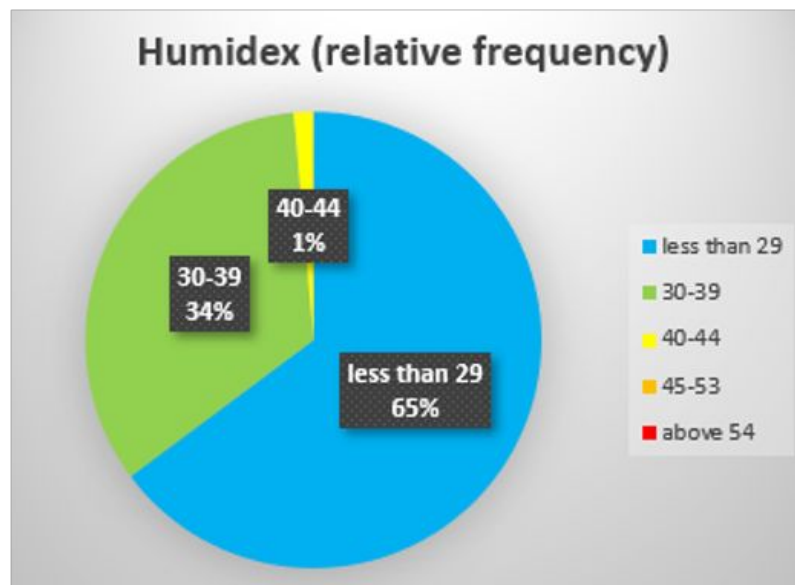
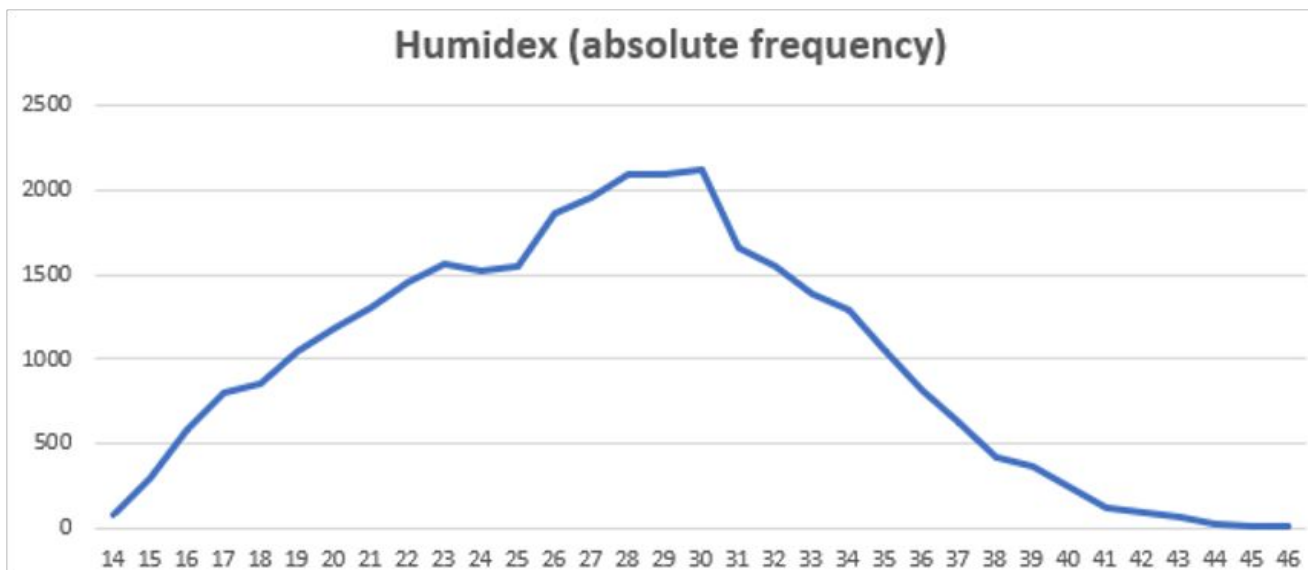
- Data collection period: 24 February 2021 to 3 November 2022 and 23 November 2022 to 24 March 2023
- Maximum temperature (during the day) sensor and BoM are similar, with lower temperatures registered for the sensor for a period of time
- Minimum temperature (during the night) are consistent between the sensor and BoM



6.2. Humidex data

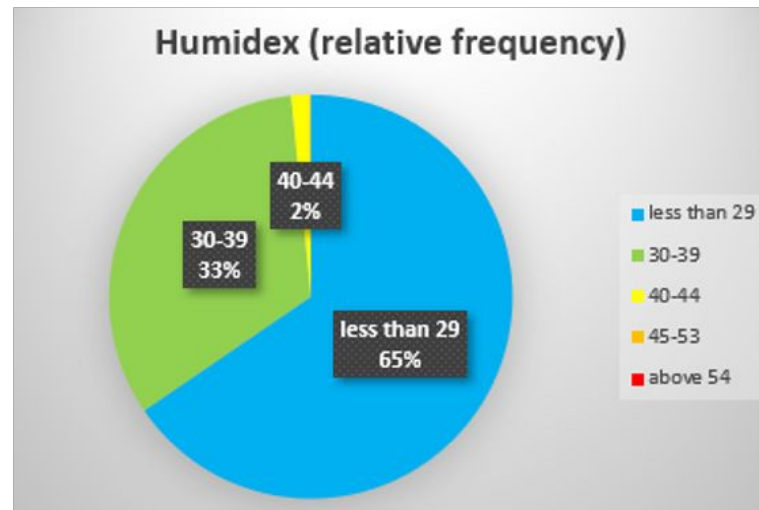
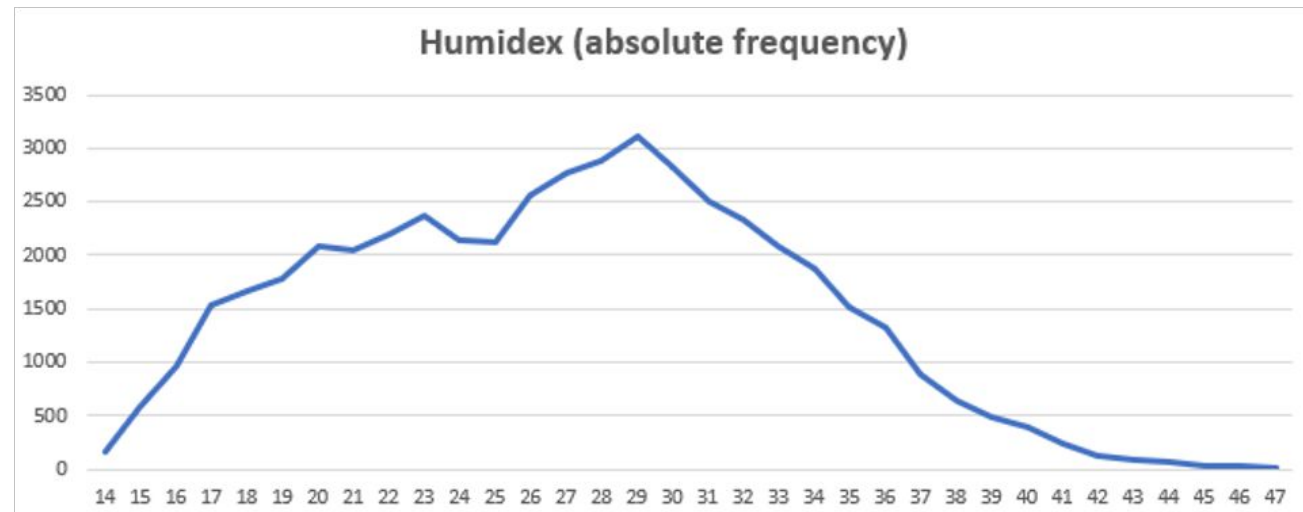
Bell St #569

Humidex	Frequency		
14	86		
15	296		
16	590		
17	800		
18	862		
19	1041		
20	1178		
21	1301		
22	1450		
23	1563		
24	1516		
25	1553		
26	1860		
27	1953		
28	2093		
29	2097	Total	20239
30	2118		
31	1660		
32	1542		
33	1385		
34	1288		
35	1052		
36	818		
37	629		
38	421		
39	371	Total	11284
40	237		
41	127		
42	89		
43	63		
44	26	Total	542
45	16		
46	7	Total	23



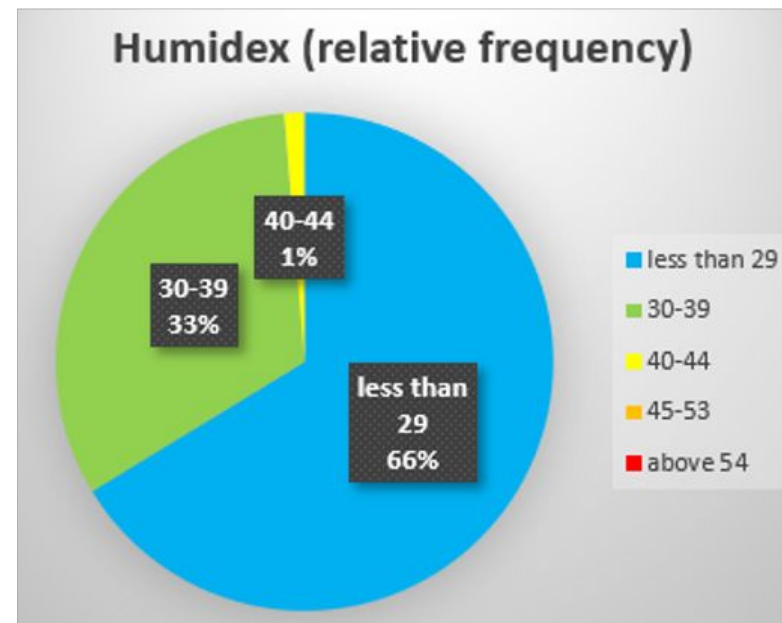
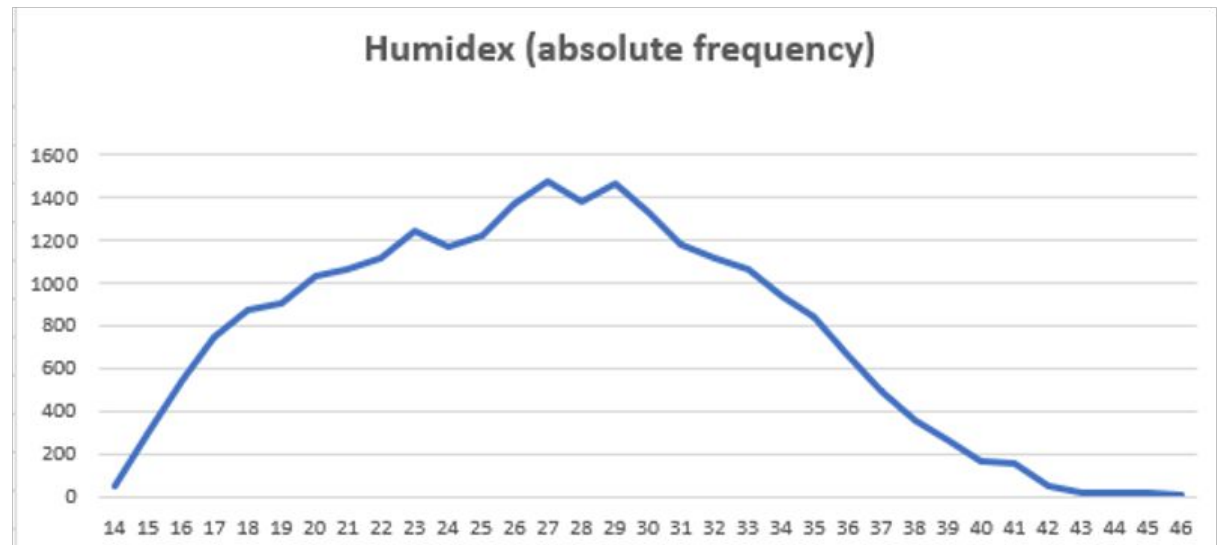
Bell St #574

Humidex	Frequency		
14	166		
15	584		
16	965		
17	1534		
18	1665		
19	1773		
20	2082		
21	2050		
22	2194		
23	2365		
24	2135		
25	2129		
26	2565		
27	2770		
28	2880		
29	3110	Total	30967
30	2823		
31	2496		
32	2333		
33	2084		
34	1881		
35	1511		
36	1321		
37	890		
38	642		
39	494	Total	16475
40	395		
41	244		
42	116		
43	95		
44	59	Total	909
45	30		
46	20		
47	8	Total	58



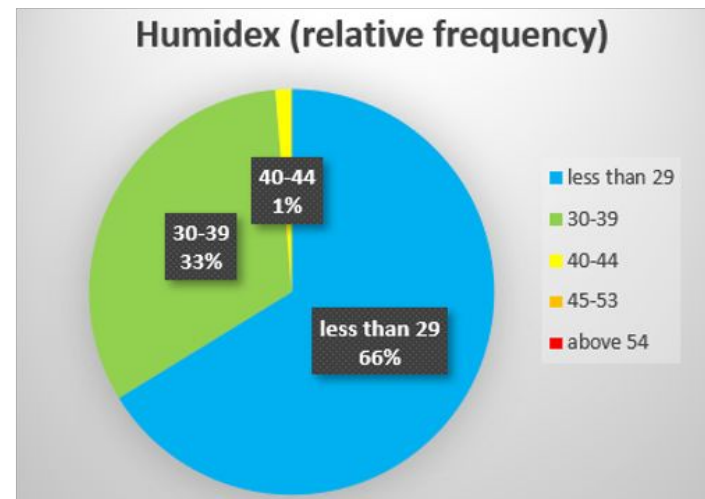
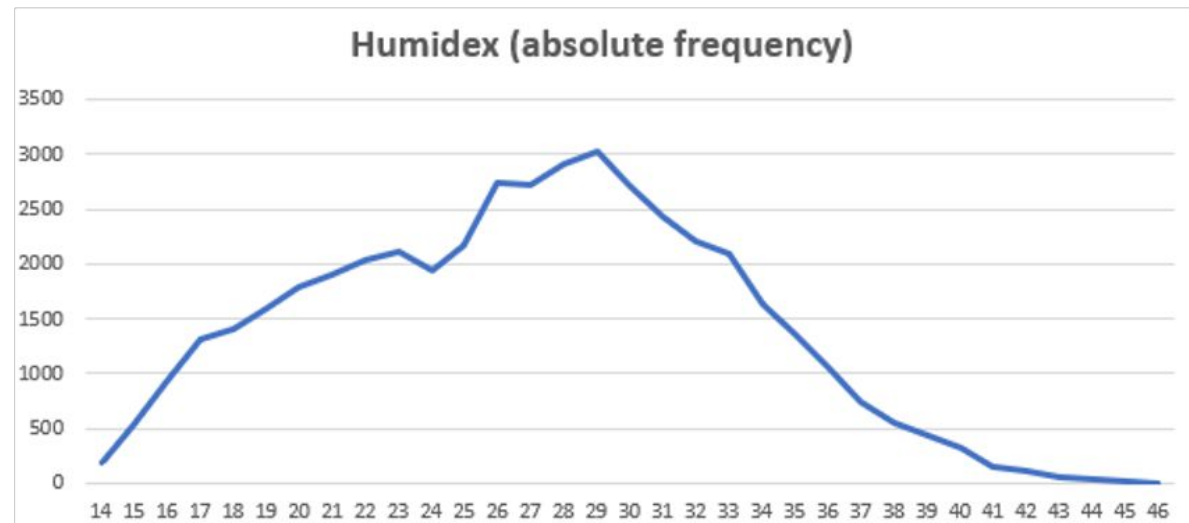
Bell St #577

Humidex	Frequency		
14	51		
15	300		
16	546		
17	745		
18	874		
19	899		
20	1031		
21	1058		
22	1117		
23	1236		
24	1166		
25	1222		
26	1366		
27	1473		
28	1379		
29	1458	Total	15921
30	1328		
31	1179		
32	1114		
33	1060		
34	939		
35	836		
36	658		
37	493		
38	352		
39	256	Total	8215
40	160		
41	154		
42	45		
43	12		
44	13	Total	384
45	11		
46	4		
47	0	Total	15



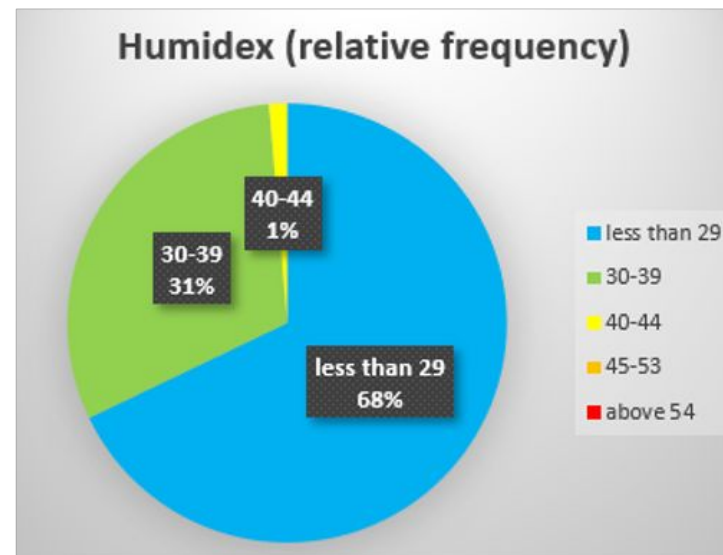
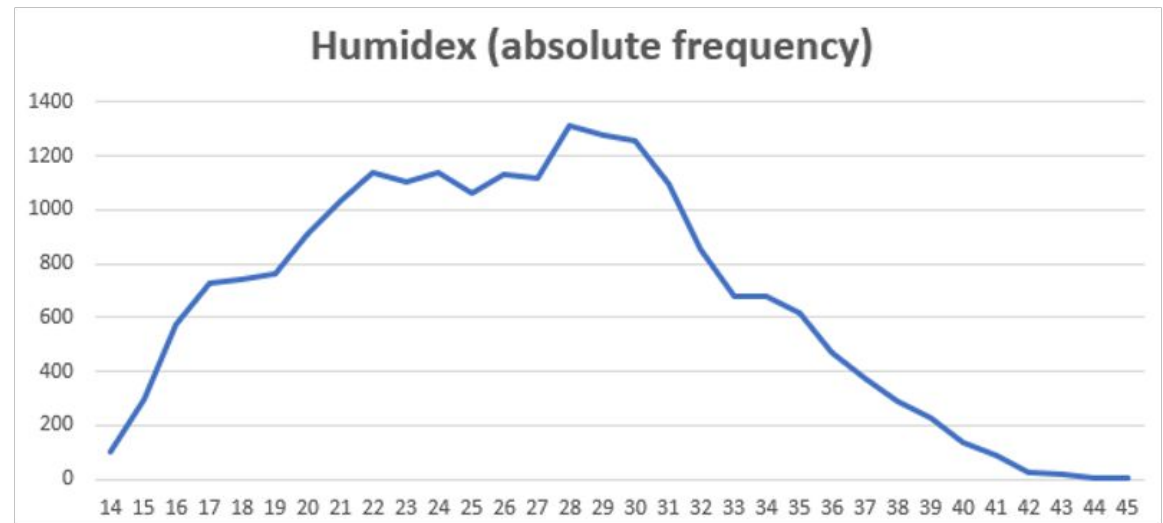
Bell St #580

Humidex	Frequency		
14	189		
15	532		
16	936		
17	1313		
18	1406		
19	1592		
20	1785		
21	1908		
22	2032		
23	2120		
24	1934		
25	2179		
26	2735		
27	2723		
28	2908		
29	3032	Total	29324
30	2728		
31	2429		
32	2199		
33	2086		
34	1630		
35	1348		
36	1064		
37	751		
38	554		
39	435	Total	15224
40	332		
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42	116		
43	65		
44	46		
45	27	Total	738
46	7	Total	7



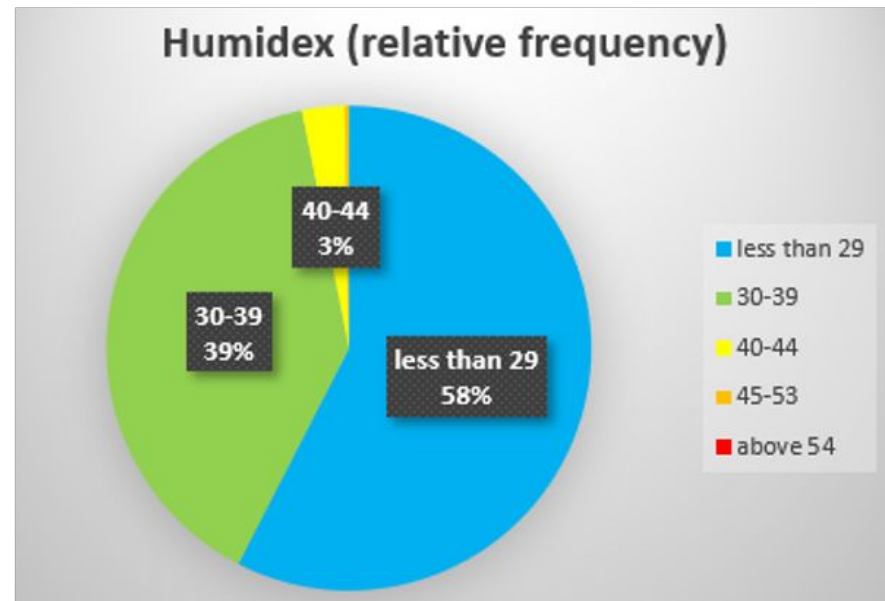
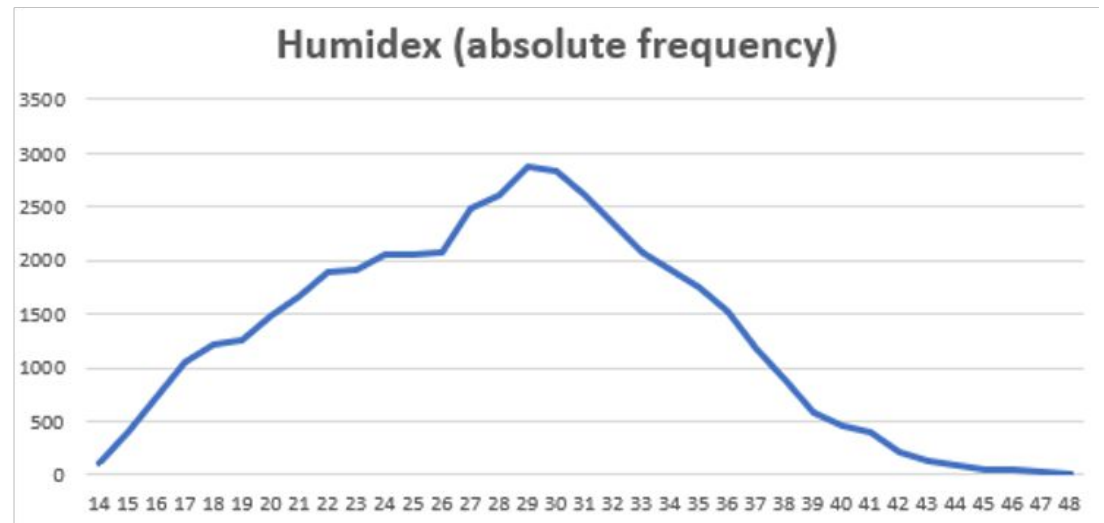
Brisbane St #571

Humidex	Frequency		
14	102		
15	297		
16	572		
17	731		
18	744		
19	764		
20	908		
21	1037		
22	1139		
23	1107		
24	1138		
25	1065		
26	1129		
27	1115		
28	1315		
29	1275	Total	14438
30	1258		
31	1098		
32	856		
33	680		
34	678		
35	620		
36	468		
37	372		
38	292		
39	228	Total	6550
40	139		
41	90		
42	26		
43	18		
44	6	Total	279
45	2	Total	2



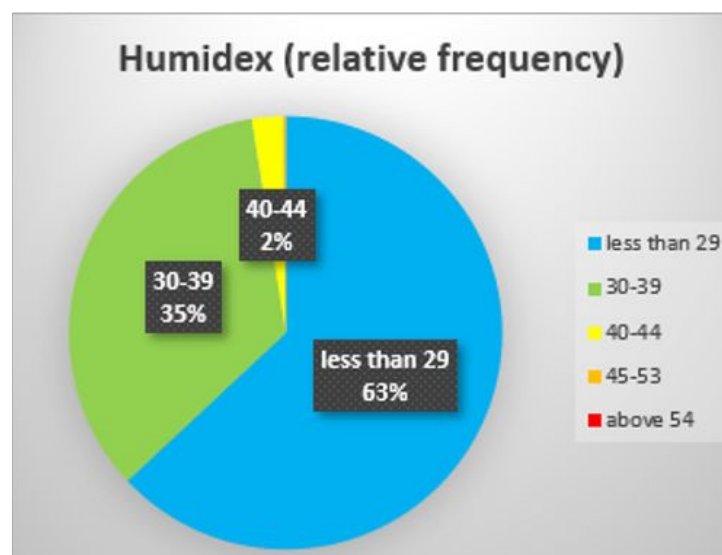
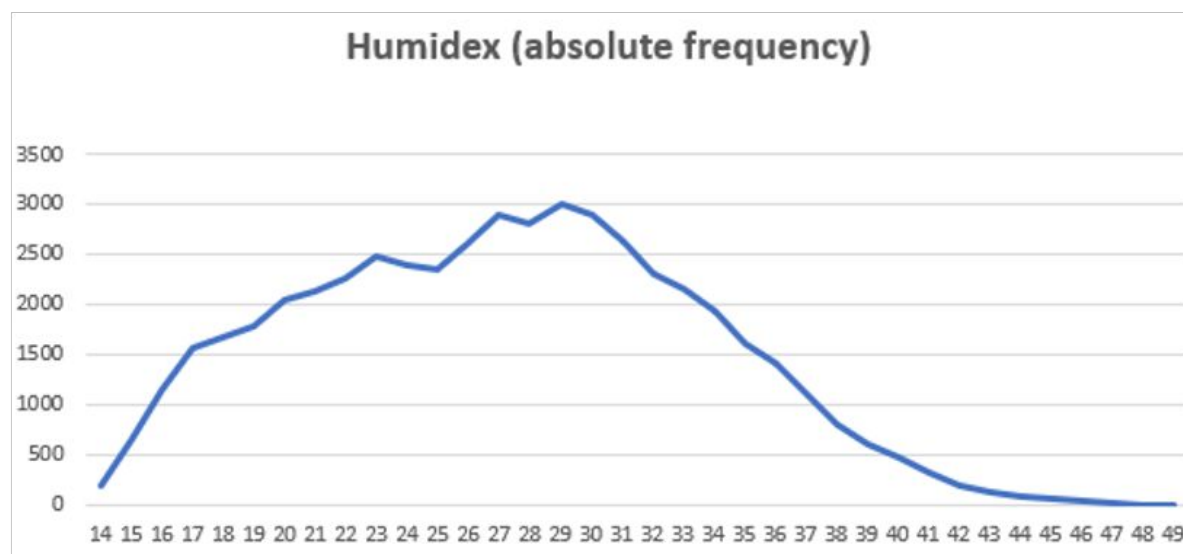
Brisbane St #575

Humidex	Frequency		
14	106		
15	405		
16	716		
17	1047		
18	1216		
19	1246		
20	1482		
21	1659		
22	1898		
23	1906		
24	2054		
25	2054		
26	2068		
27	2482		
28	2616		
29	2880	Total	25729
30	2824		
31	2607		
32	2339		
33	2071		
34	1917		
35	1741		
36	1523		
37	1168		
38	884		
39	584	Total	17658
40	462		
41	397		
42	213		
43	123		
44	79		
45	54	Total	1328
46	42		
47	21		
48	7	Total	70



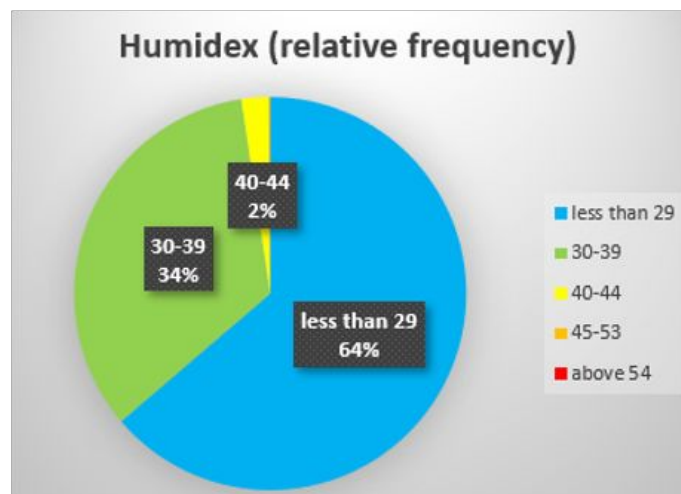
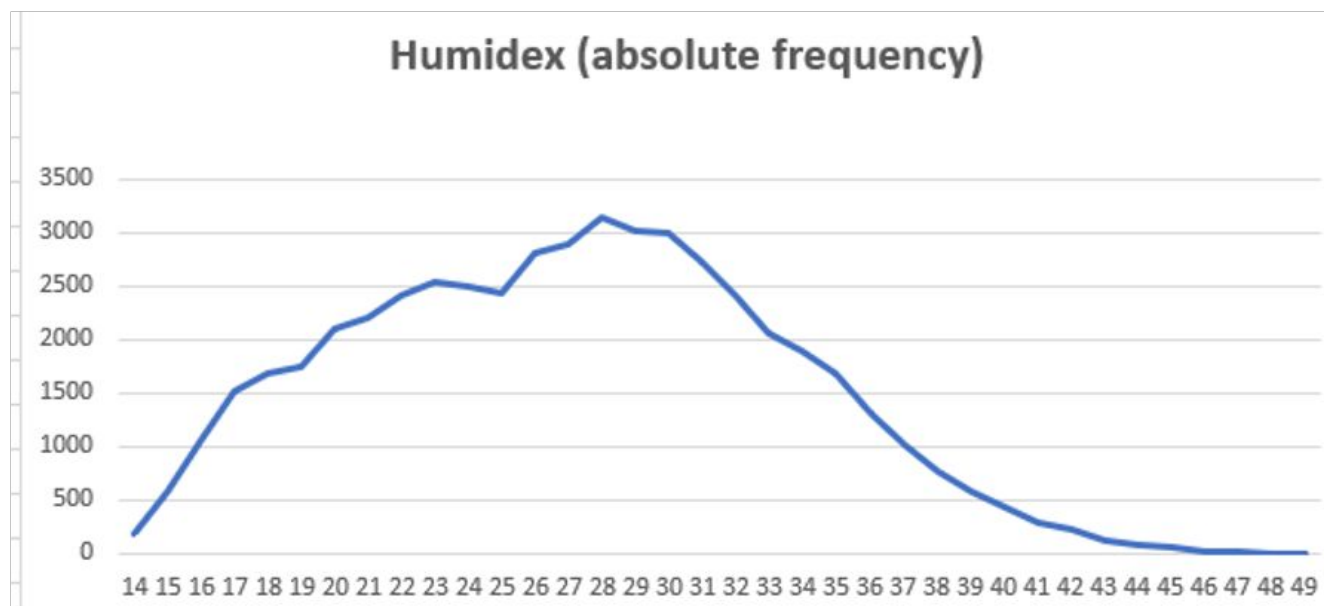
Limestone St #570

Humidex	Frequency		
14	194		
15	649		
16	1143		
17	1563		
18	1676		
19	1783		
20	2035		
21	2121		
22	2259		
23	2473		
24	2398		
25	2349		
26	2606		
27	2886		
28	2809		
29	3008	Total	31952
30	2901		
31	2639		
32	2299		
33	2161		
34	1927		
35	1611		
36	1404		
37	1112		
38	796		
39	610	Total	17460
40	474		
41	315		
42	192		
43	123		
44	79		
45	55	Total	1238
46	27		
47	8		
48	1		
49	1	Total	37



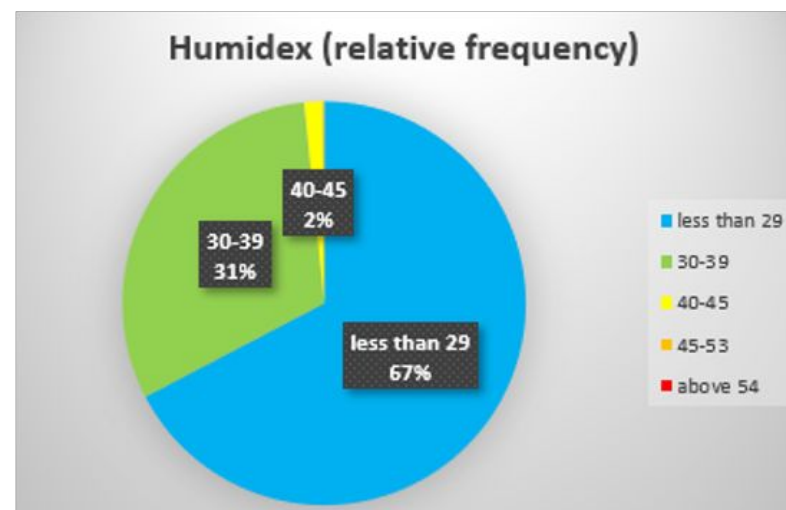
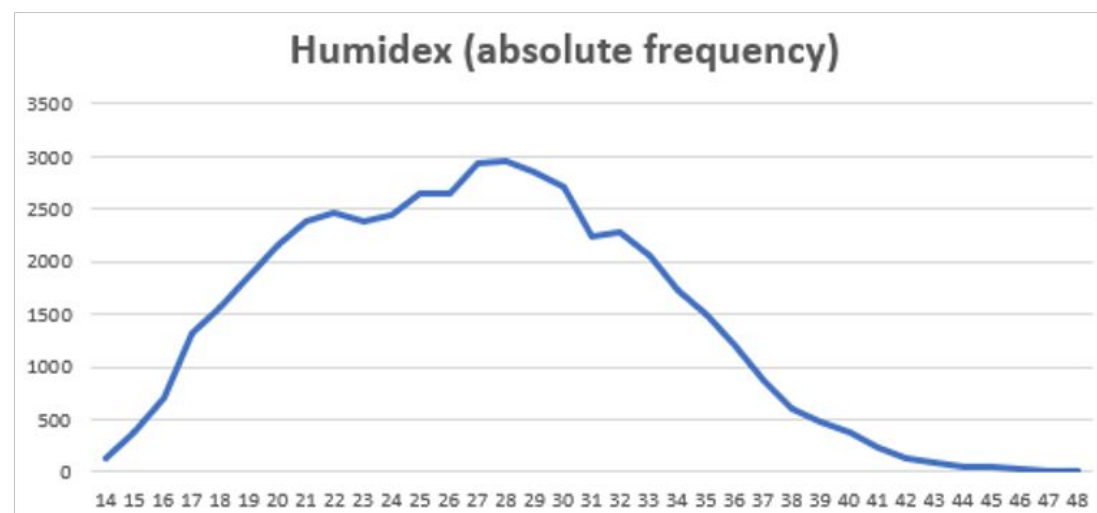
Limestone St #576

Humidex	Frequency		
14	179		
15	573		
16	1061		
17	1512		
18	1673		
19	1733		
20	2096		
21	2201		
22	2401		
23	2536		
24	2488		
25	2427		
26	2801		
27	2880		
28	3131		
29	3022	Total	32714
30	2997		
31	2714		
32	2403		
33	2046		
34	1880		
35	1690		
36	1315		
37	1009		
38	766		
39	579	Total	17399
40	424		
41	282		
42	221		
43	124		
44	80		
45	44	Total	1175
46	21		
47	10		
48	1		
49	1	Total	33



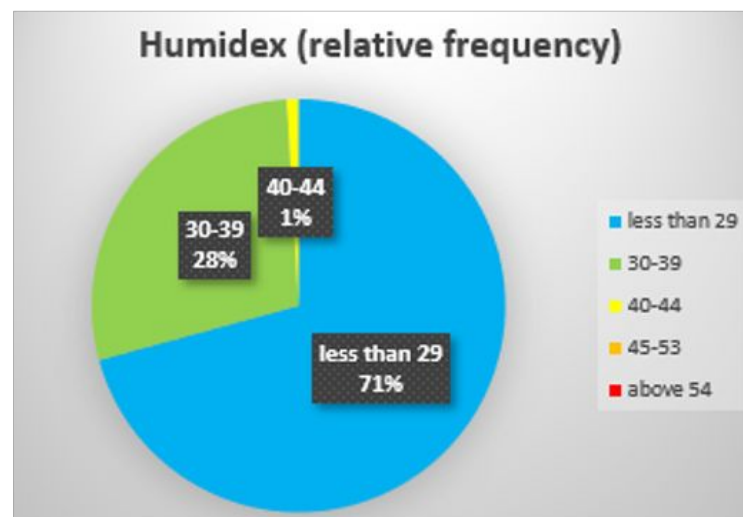
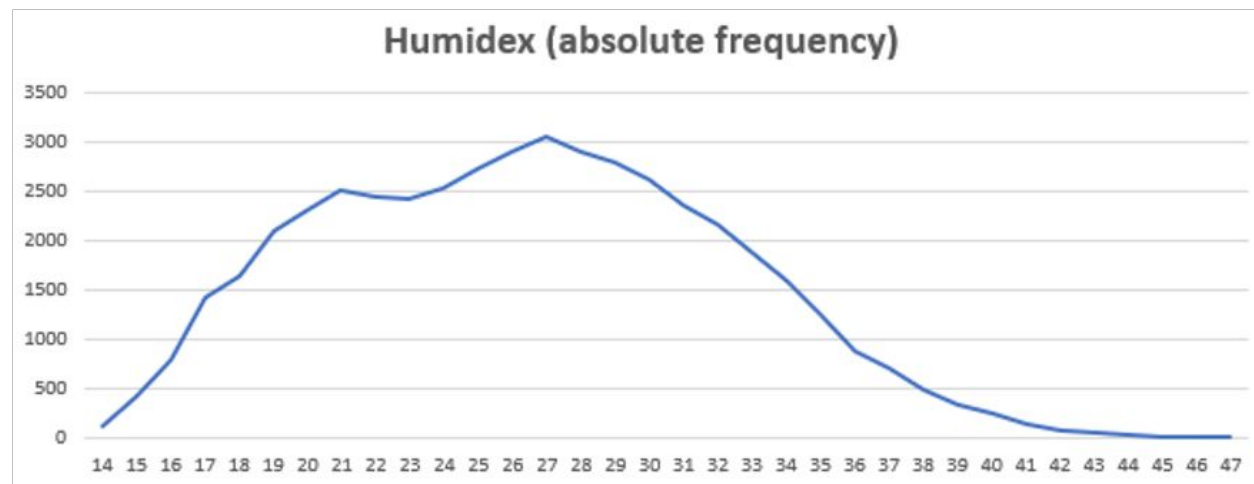
Ripley #142

Humidex	Frequency		
14	122		
15	371		
16	697		
17	1308		
18	1556		
19	1842		
20	2160		
21	2383		
22	2459		
23	2375		
24	2446		
25	2645		
26	2655		
27	2932		
28	2949		
29	2847	Total	31747
30	2703		
31	2245		
32	2278		
33	2047		
34	1719		
35	1497		
36	1215		
37	865		
38	607		
39	479	Total	15655
40	366		
41	237		
42	134		
43	93		
44	54	Total	884
45	40		
46	20		
47	8		
48	1	Total	69



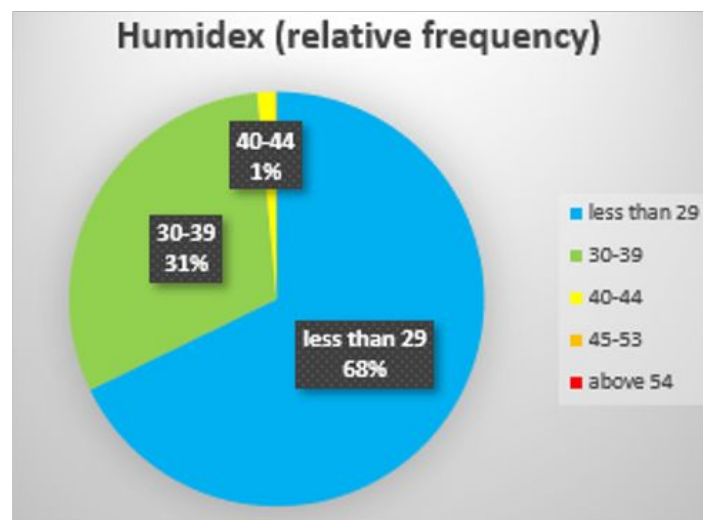
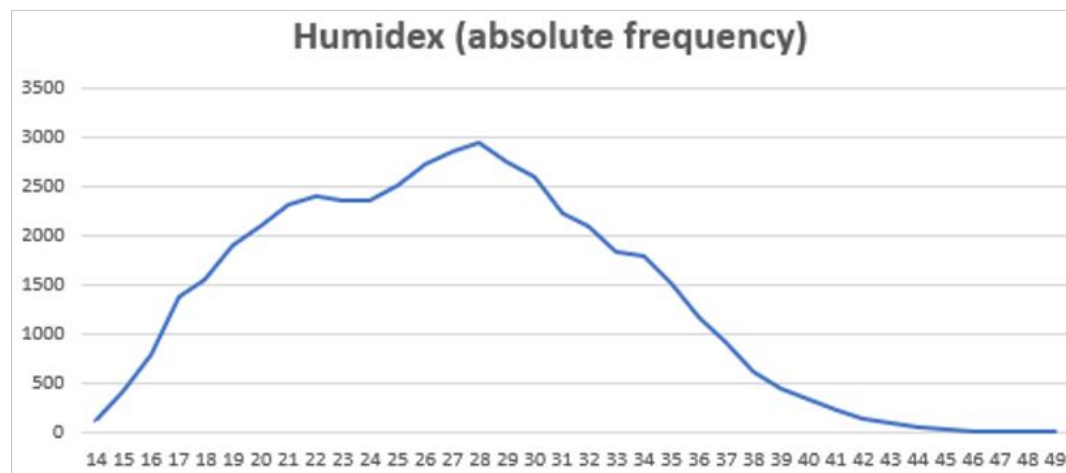
Ripley #572

Humidex	Frequency		
14	117		
15	434		
16	795		
17	1429		
18	1646		
19	2095		
20	2327		
21	2515		
22	2448		
23	2426		
24	2543		
25	2720		
26	2905		
27	3064		
28	2912		
29	2796	Total	33172
30	2615		
31	2349		
32	2169		
33	1872		
34	1599		
35	1242		
36	881		
37	696		
38	492		
39	331	Total	14246
40	241		
41	134		
42	81		
43	48		
44	33	Total	537
45	8		
46	3		
47	1	Total	12



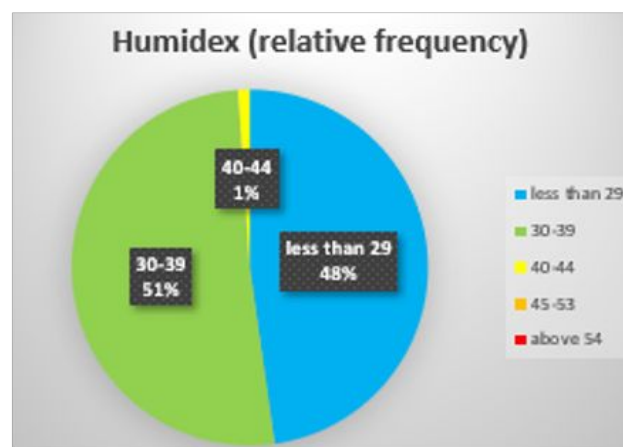
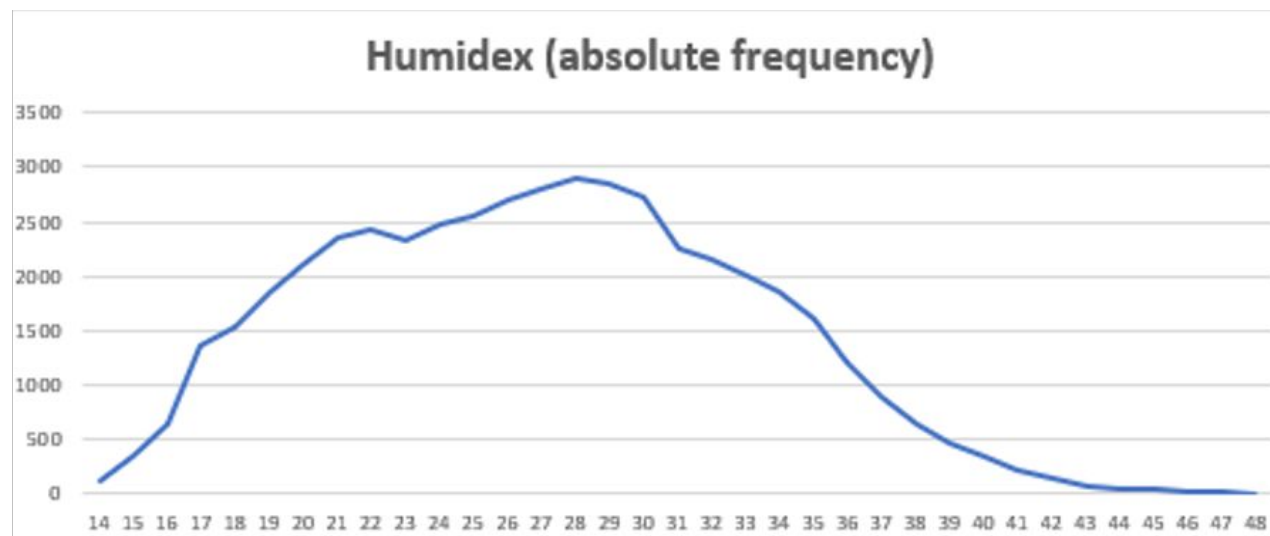
Ripley #573

Humidex	Frequency		
14	122		
15	424		
16	784		
17	1386		
18	1555		
19	1905		
20	2091		
21	2312		
22	2396		
23	2353		
24	2361		
25	2522		
26	2731		
27	2850		
28	2945		
29	2746	Total	31483
30	2594		
31	2219		
32	2109		
33	1840		
34	1800		
35	1509		
36	1174		
37	929		
38	626		
39	440	Total	15240
40	331		
41	228		
42	131		
43	88		
44	55	Total	833
45	22		
46	18		
47	7		
48	1		
49	2	Total	50



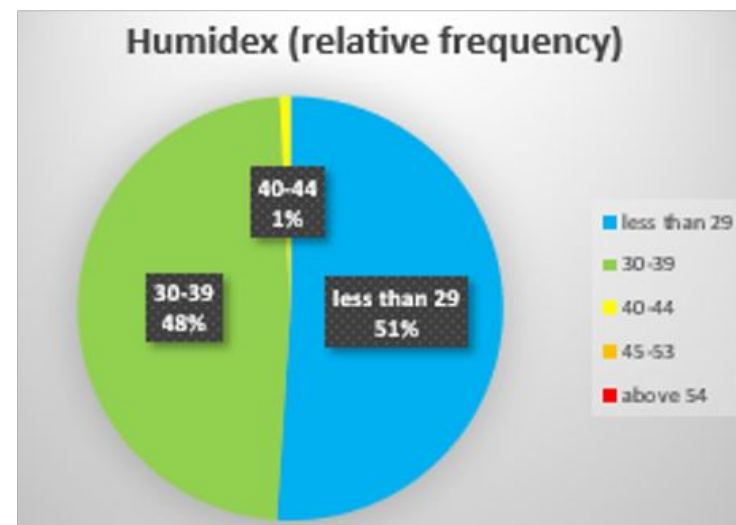
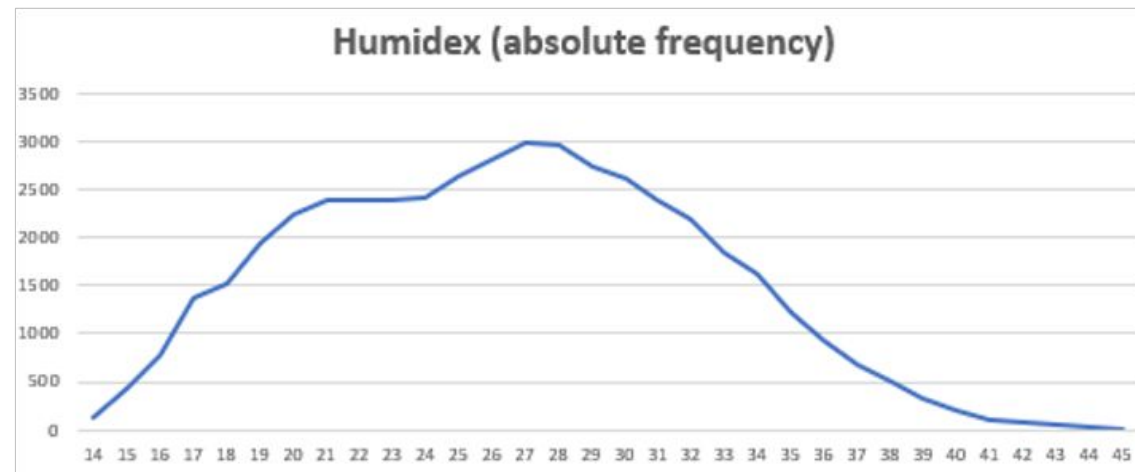
Ripley #578

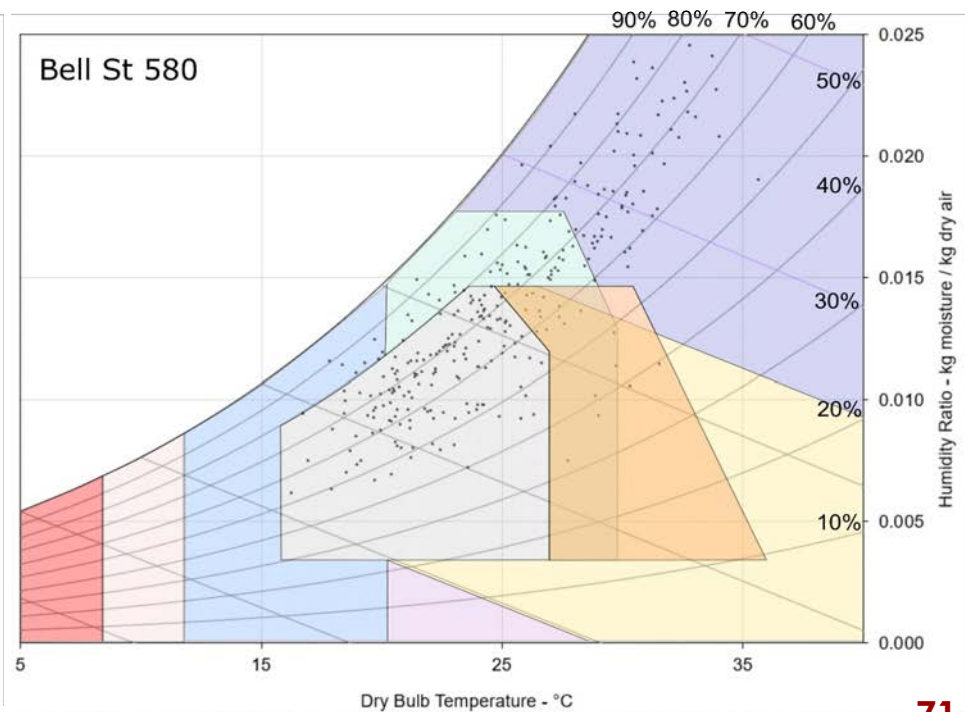
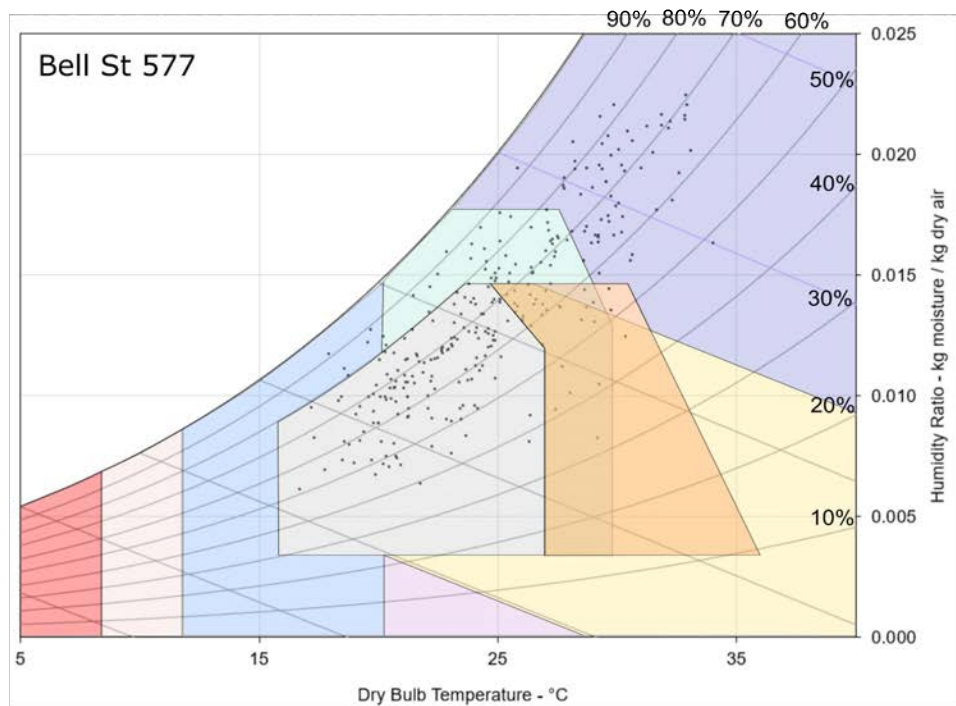
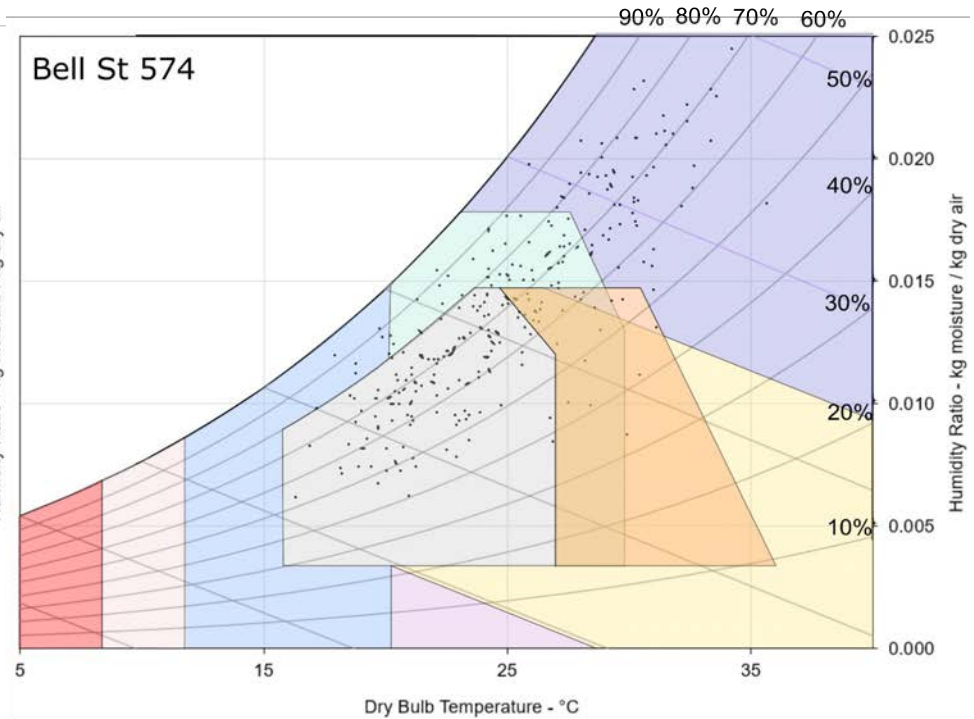
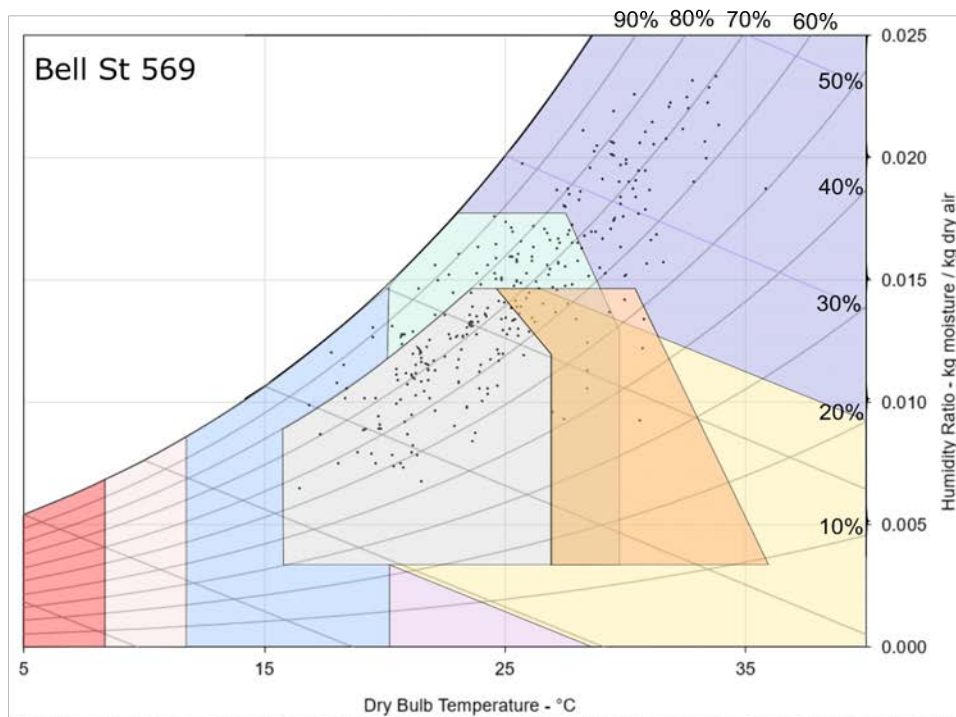
Humidex	Frequency		
14	106		
15	346		
16	627		
17	1352		
18	1535		
19	1864		
20	2103		
21	2341		
22	2440		
23	2340		
24	2472		
25	2549		
26	2693		
27	2811		
28	2905		
29	2840	Total	31324
30	2728		
31	2250		
32	2156		
33	2004		
34	1861		
35	1599		
36	1198		
37	896		
38	630		
39	457	Total	15779
40	342		
41	217		
42	138		
43	69		
44	51	Total	817
45	35		
46	10		
47	10		
48	1	Total	56

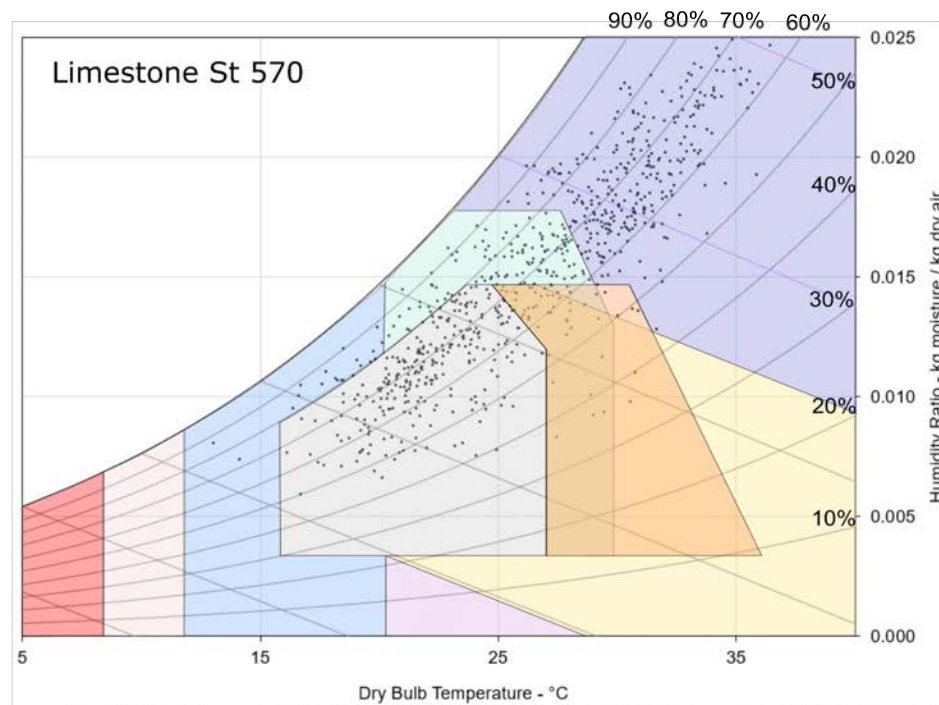
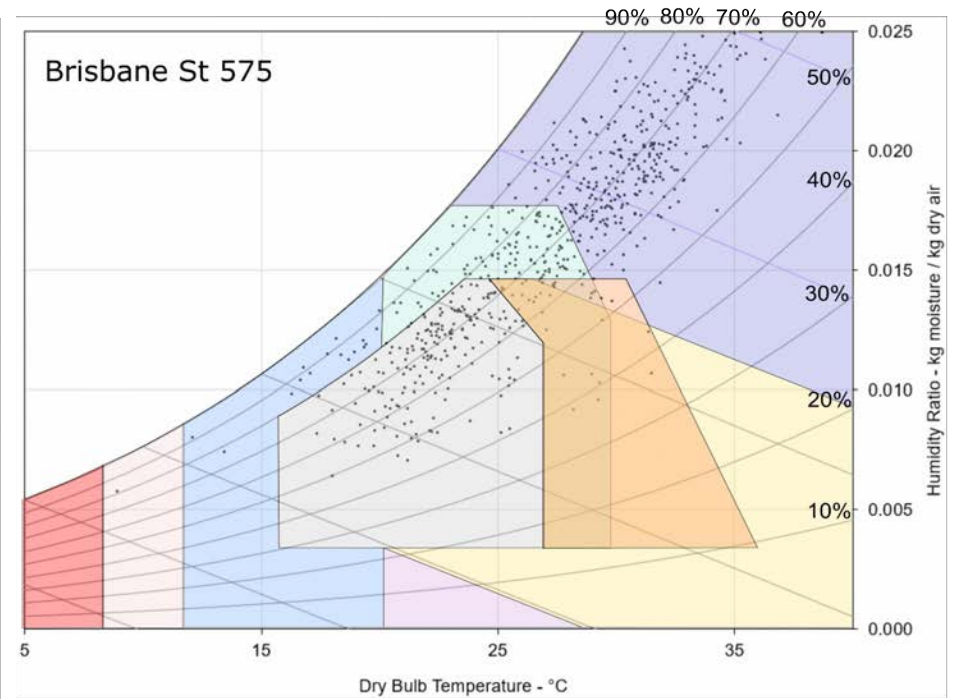
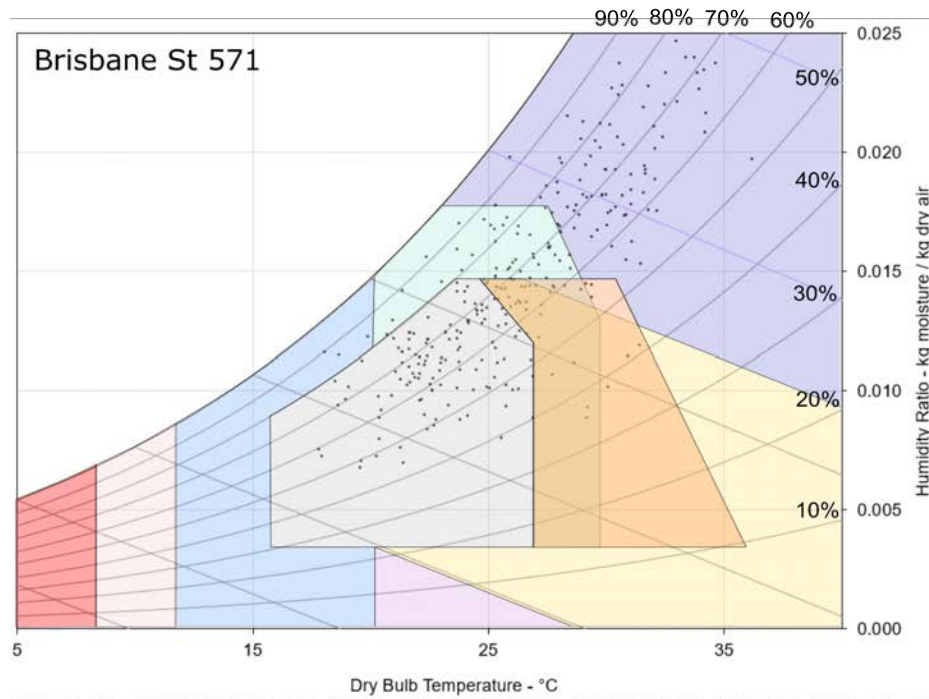


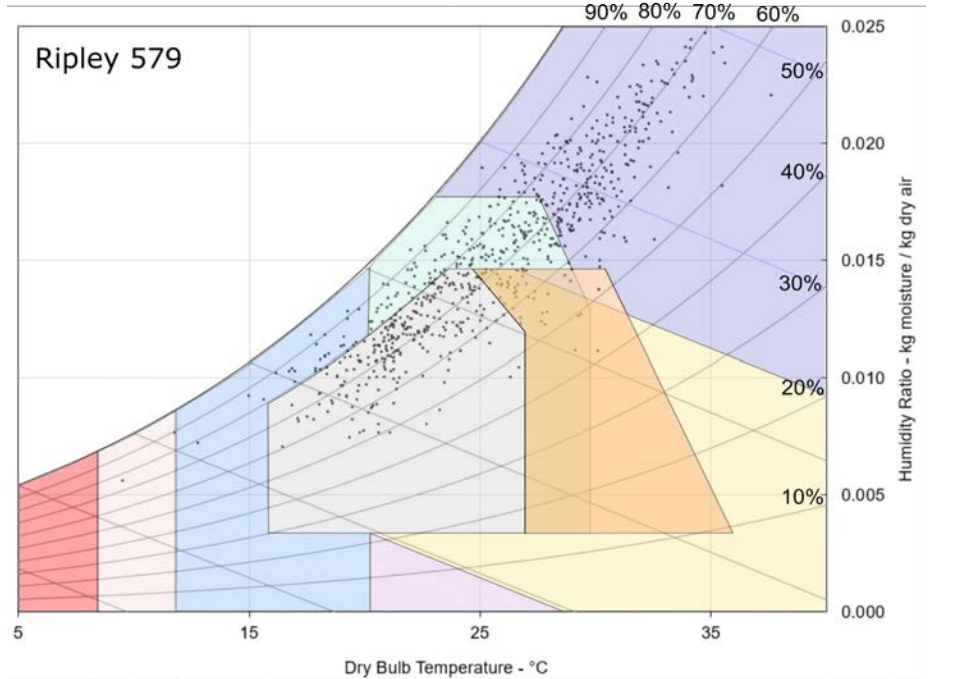
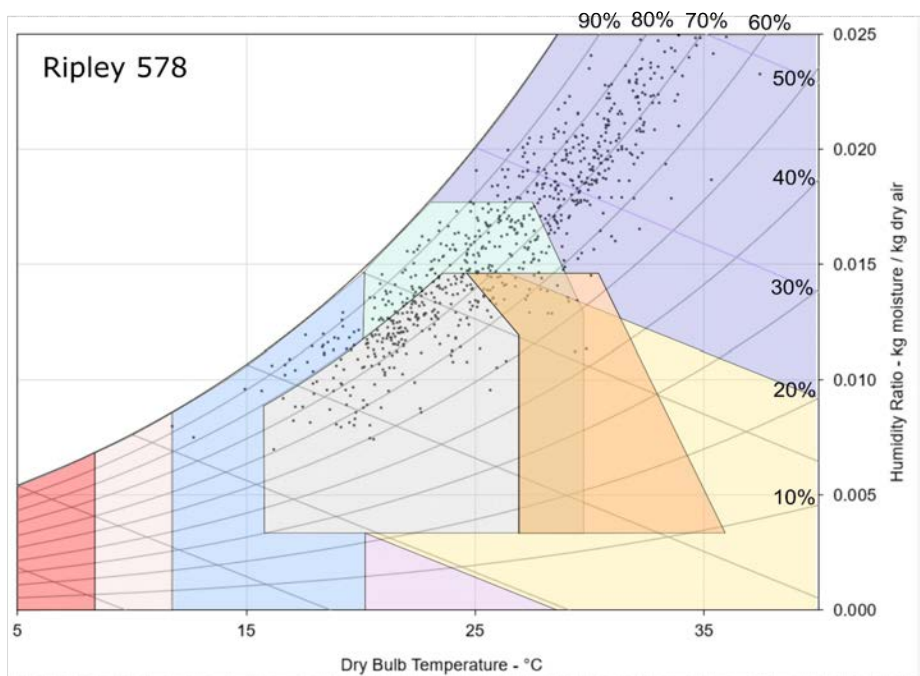
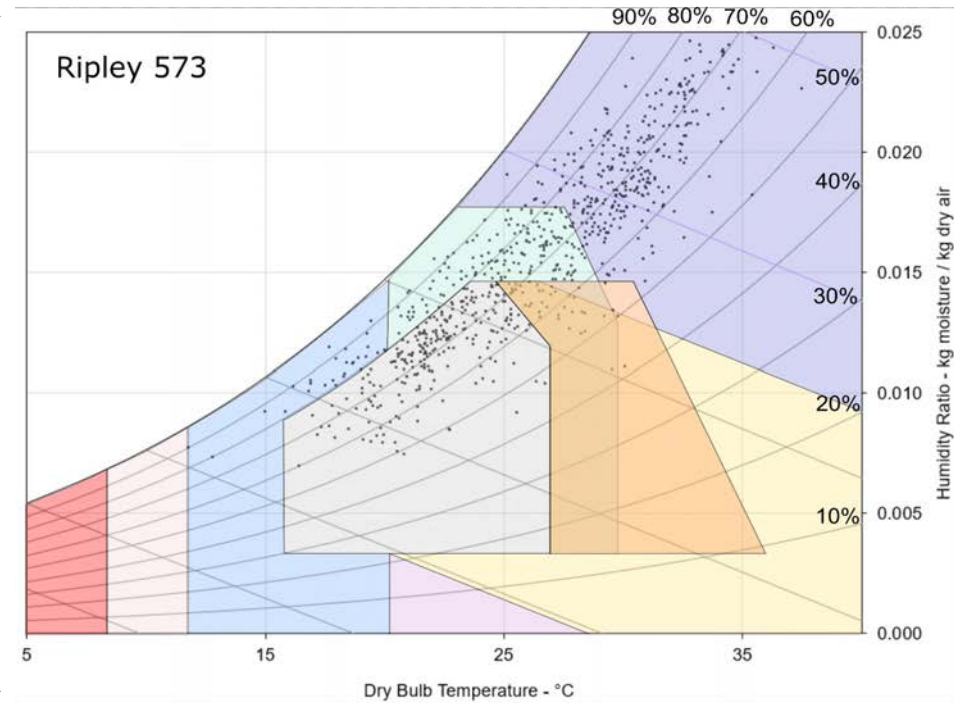
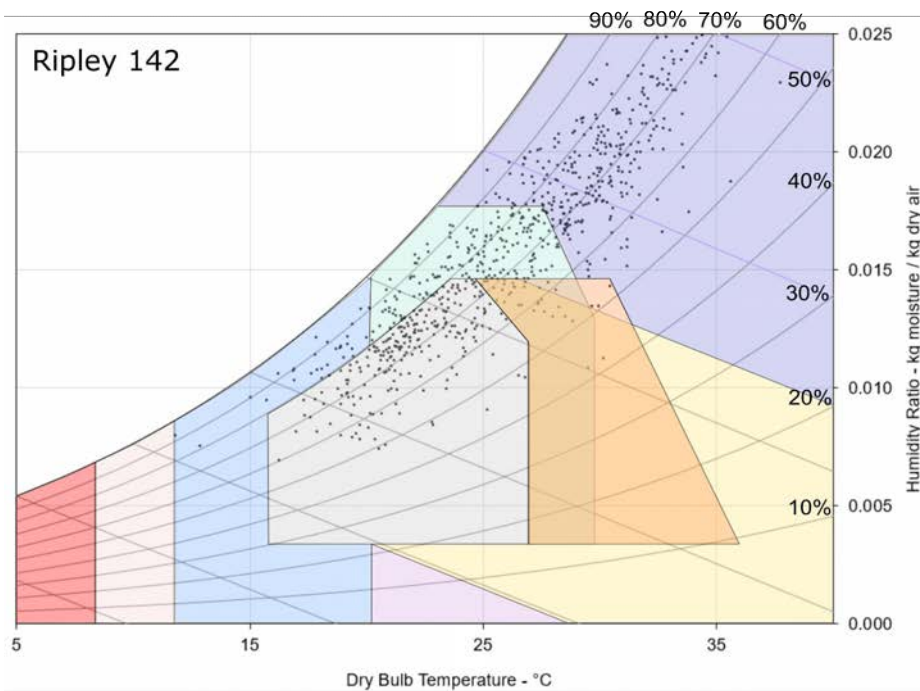
Ripley #579

Humidex	Frequency		
14	128		
15	415		
16	766		
17	1380		
18	1516		
19	1947		
20	2237		
21	2390		
22	2403		
23	2380		
24	2408		
25	2637		
26	2815		
27	2994		
28	2956		
29	2730	Total	32102
30	2614		
31	2397		
32	2181		
33	1845		
34	1616		
35	1229		
36	933		
37	668		
38	498		
39	323	Total	14304
40	215		
41	110		
42	90		
43	45		
44	22	Total	482
45	9	Total	9









THANK YOU

The involvement of key stakeholders is crucial during the development of the project to ensure its relevance and to make sure that the expected outcomes are achieved.

We would like to thank warmly all the persons who welcomed us very openly in Ipswich, residents and staff who answered our questions, and the Ipswich City Council for its appetite for knowledge and new ideas.

Prepared and written by
Prof Karine Dupre & Dr Silvia Tavares
May 2023

