Optimising Weather Data Reference Periods

Enhancing Building Simulation Climate Data in a Changing Climate

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Presenter:
David Ferrari

Authors
Louise Patterson, David Ferrari, Huey Jean Tan and Trevor Lee

Introduction - Climate Change

- Long-term global warming trend
  - 2015 to 2022 are the eight warmest years on record
  - 2023 expected to be the warmest year yet
  - Shifts in temperature and precipitation, and greater incidence of extreme weather events
- To what extent can historical weather data represent future climate?

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Climate Files for Building Simulations

- Typical climate files consist of one year's worth (8,760 values) of various meteorological parameters, e.g. air temperature, humidity, solar radiation
- Climate files are derived using a reference period
  - Reference periods are typically at least 10 years
  - World Meteorological Organization uses a 30 year reference period[1]
  - CSIRO uses a 25 year reference period (1990 to 2015)
- Within the context of a warming climate, conventional reference periods might no longer accurately represent the future climate at a given location
  - We consider a shorter, more recent reference period constituting the past 15 full years (2008-2022)

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[1] Trewin, B, 2007, '*The Role of Climatological Normals in a Changing Climate*', World Meteorological Organization.

Sydney Temporal Analysis - Methodology

- Considered dry bulb temperature, dew point temperature, relative humidity, wind speed, GHI, and DNI
- Took monthly averages for each parameter using reference periods of 1990-2022 (33 years), 2008-2022 (15 years), 1990-2015 (CSIRO - 25 years)

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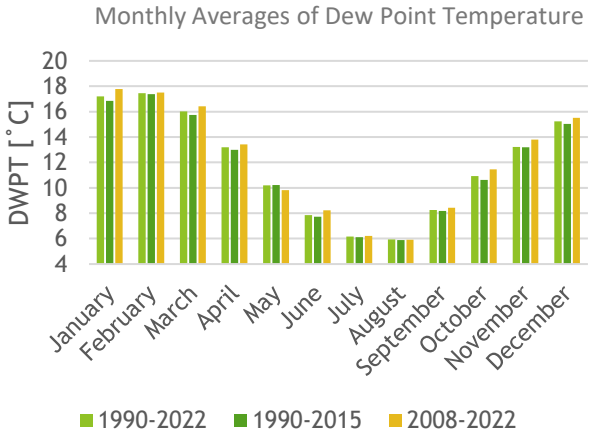
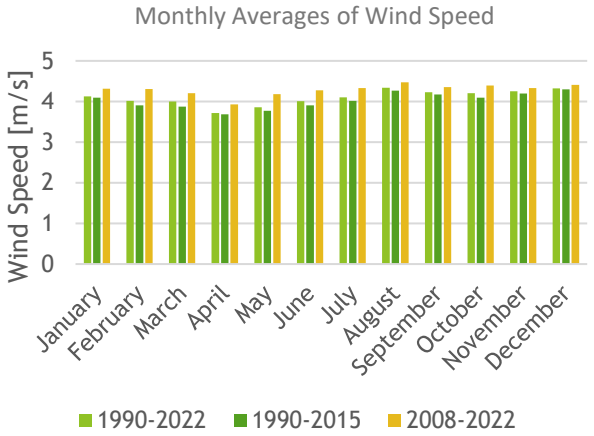
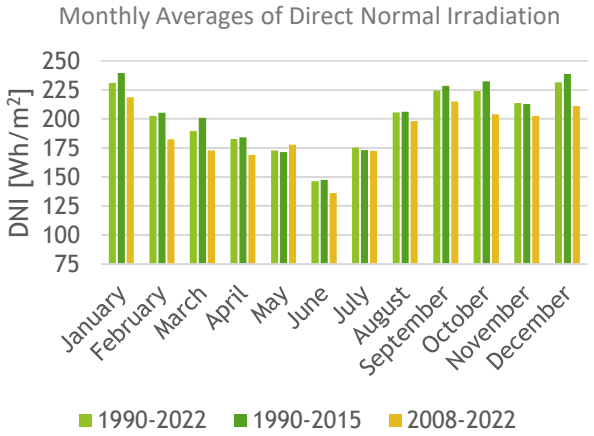
Sydney Temporal Analysis - Results

- Most notable differences observed for dew point temperature, wind speed, and DNI
  - 1990-2015 vs 2008-2022 annual averages: rise in dew point temperature of 0.38˚C, rise in wind speed of 6.64%, and decrease in DNI of 7.36%
  - 1990-2022 vs 2008-2022 annual averages: rise in dew point temperature of 0.24˚C, rise in wind speed of 5.77%, and decrease in DNI of 5.78%







Sydney Temporal Analysis - Results

- Differences in dew point temperature, wind speed, and DNI for 2008-2022 vs other reference periods were notable for most months
- Slight increases in 2008-2022 dry bulb temperature and relative humidity, and a decrease in GHI compared to other reference periods
  - Differences tended to be greater for Summer and Spring months

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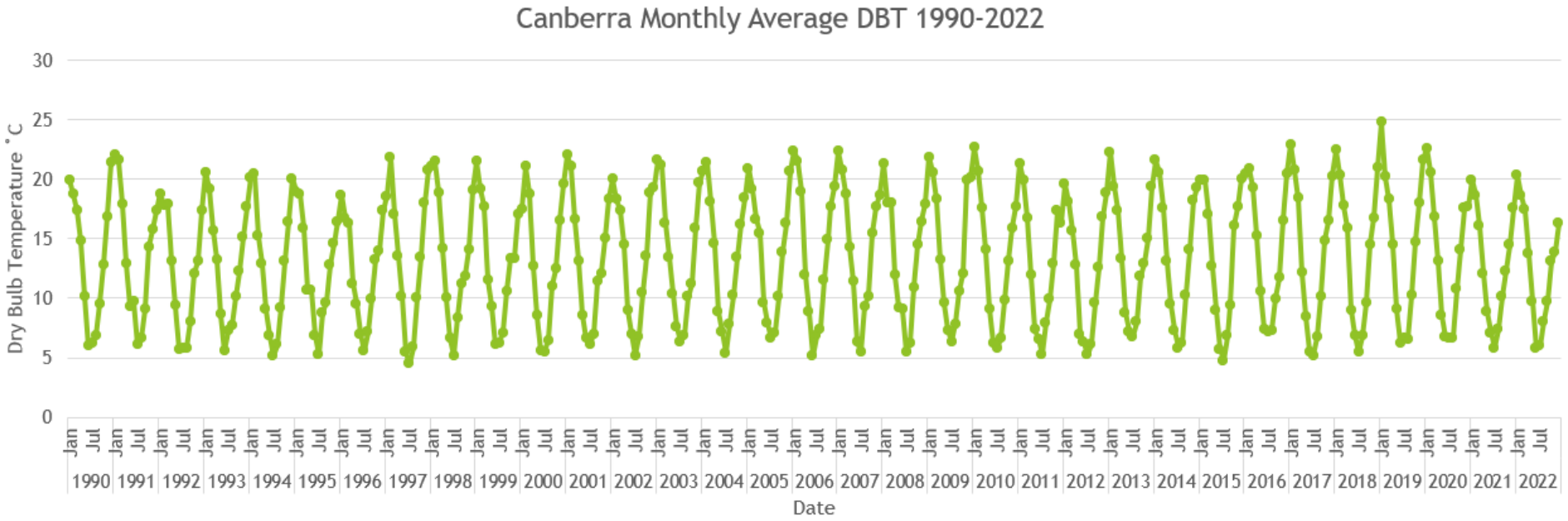
Canberra Monthly Average DBT 1990-2022
Dry Bulb Temperature °C
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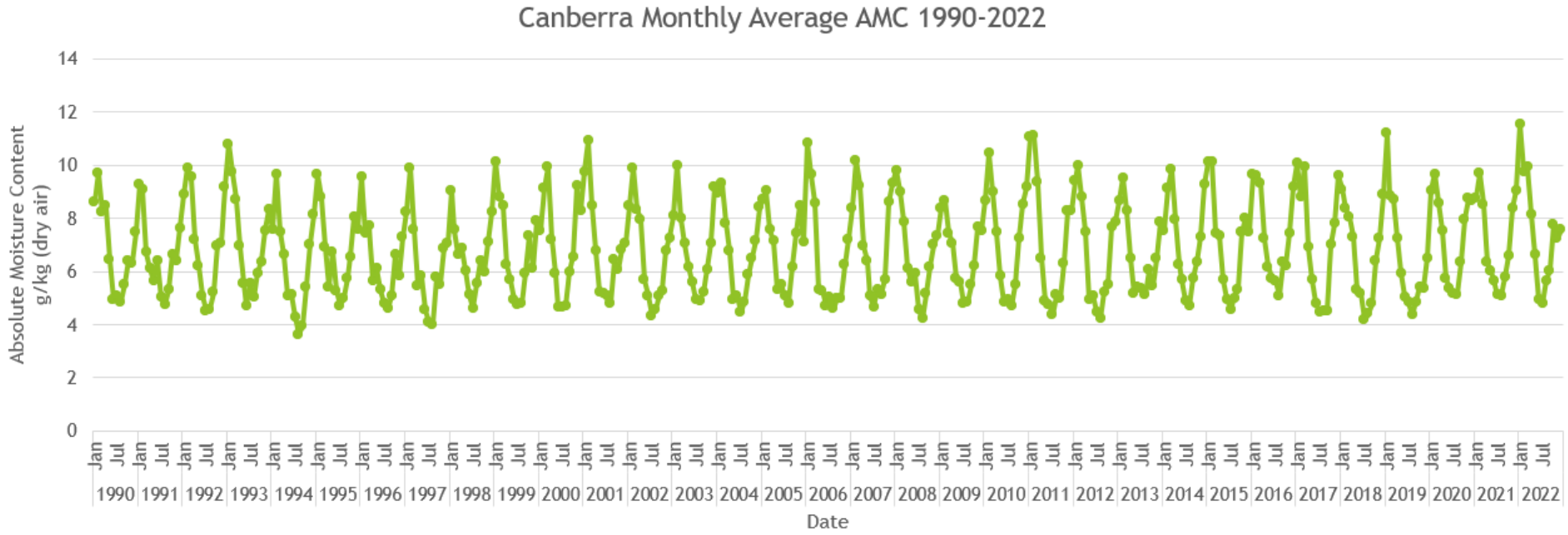
Canberra Monthly Average AMC 1990-2022
Absolute Moisture Content g/kg (dry air)
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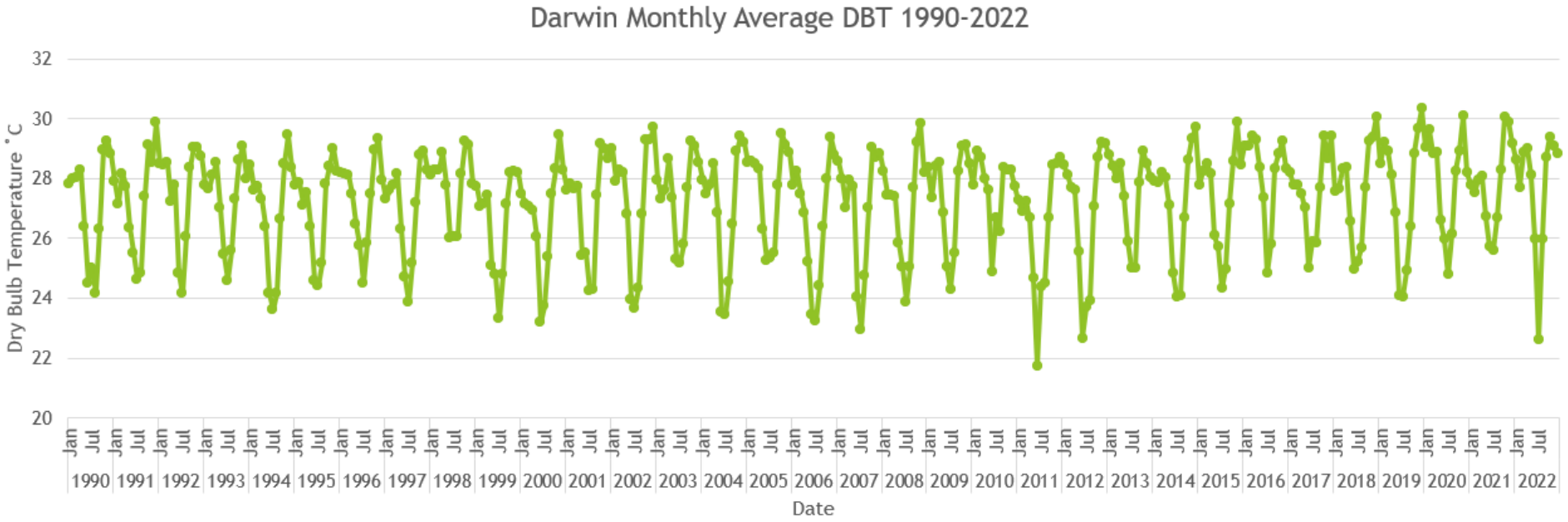
Darwin Monthly Average DBT 1990-2022
Dry Bulb Temperature °C
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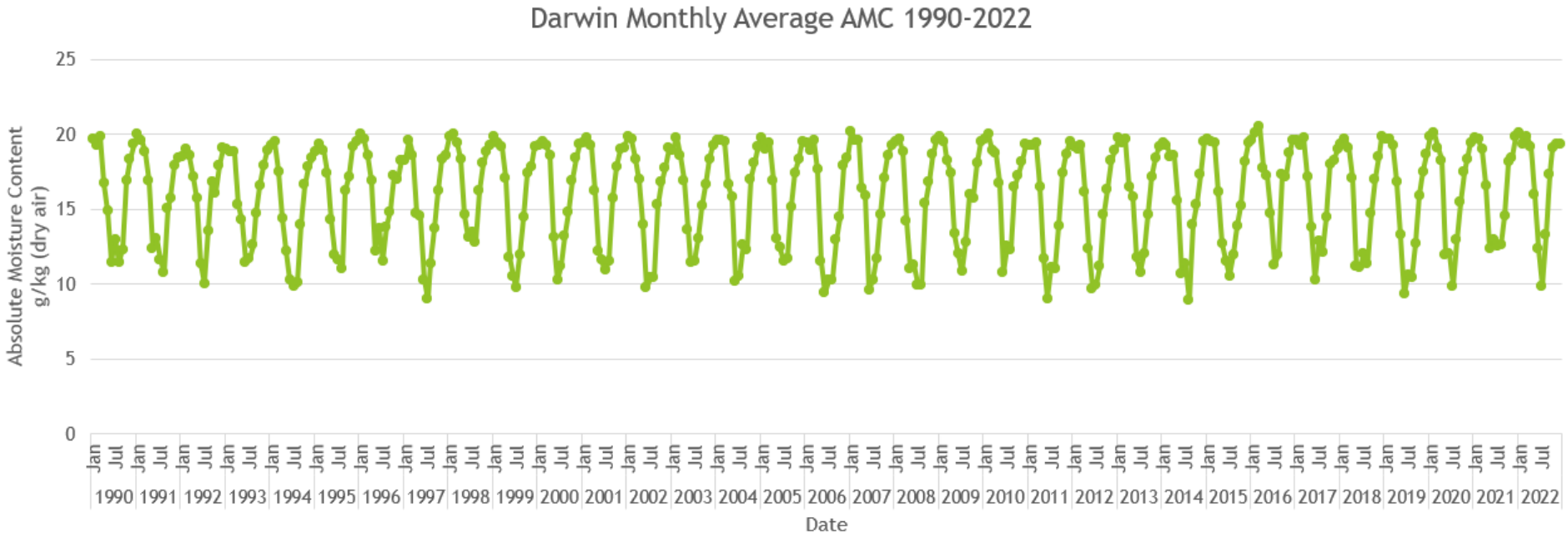
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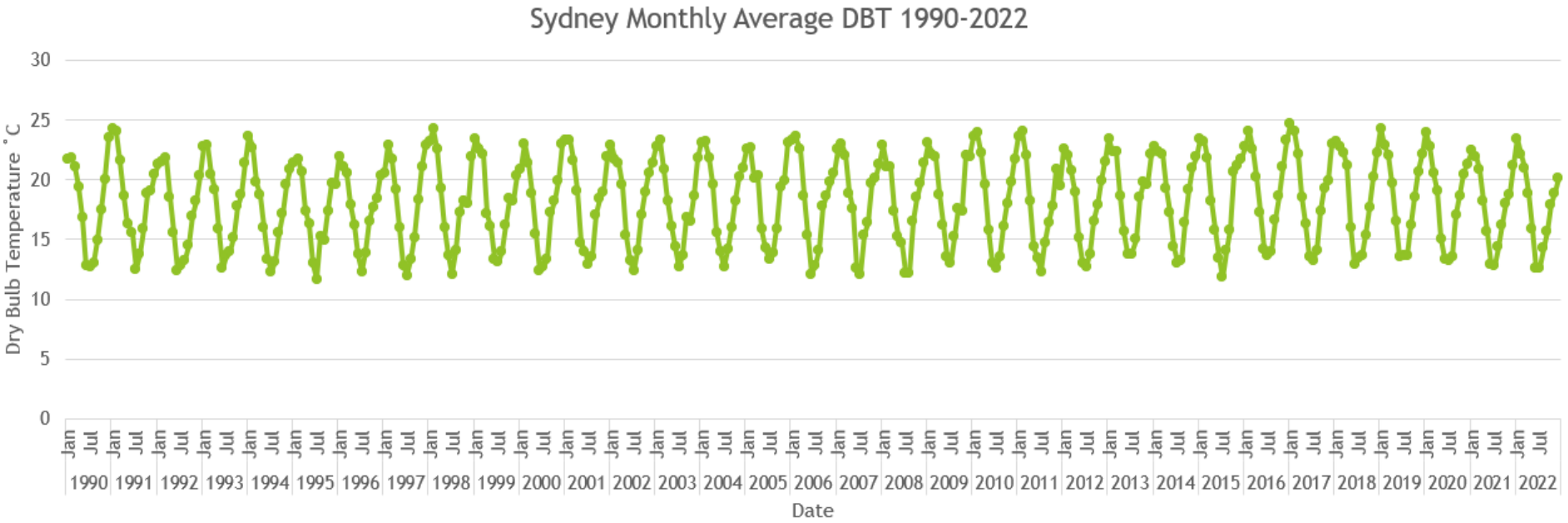
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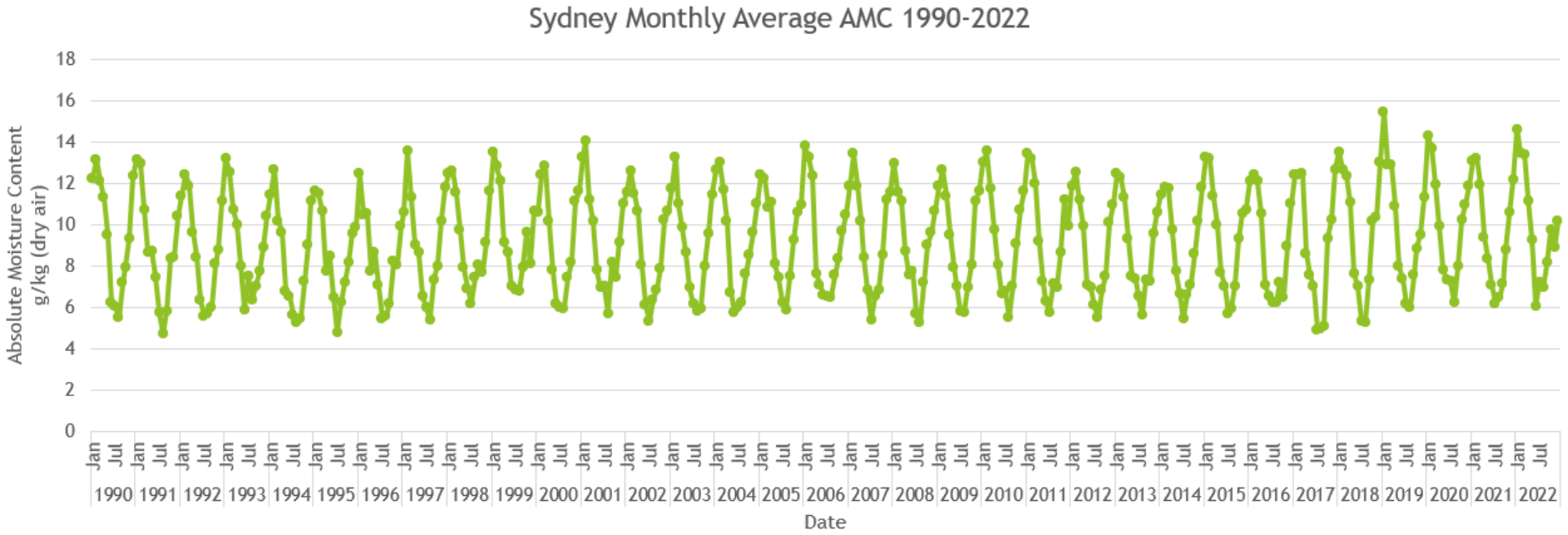
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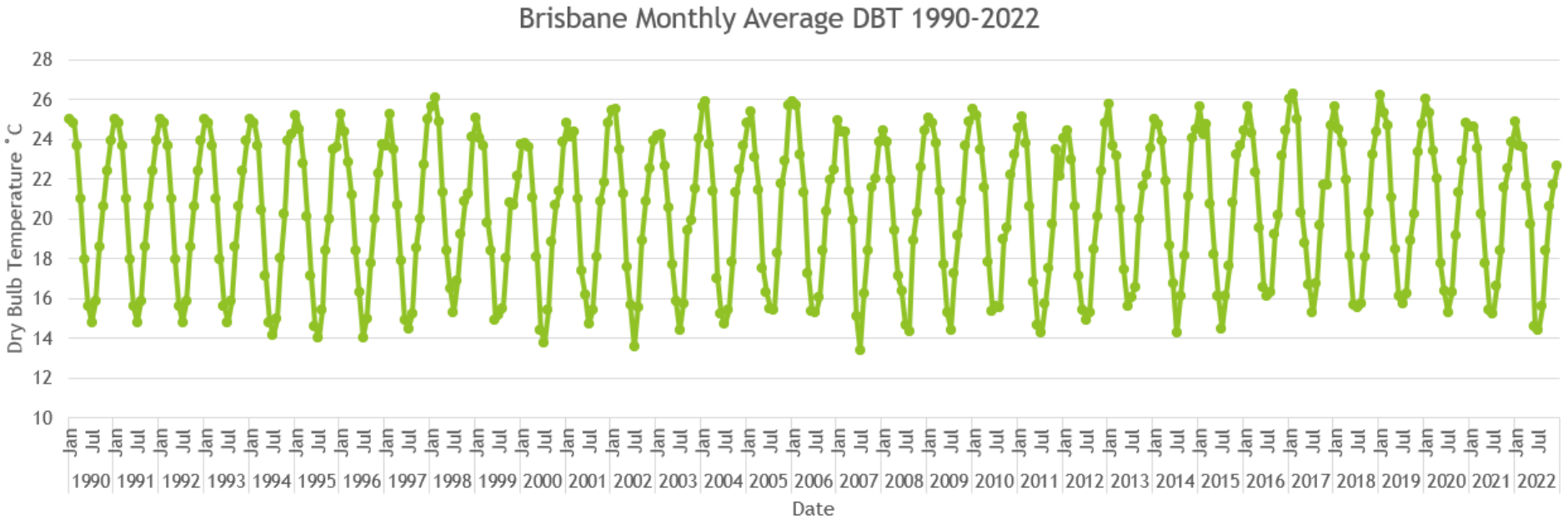
Brisbane Monthly Average DBT 1990-2022
Dry Bulb Temperature °C
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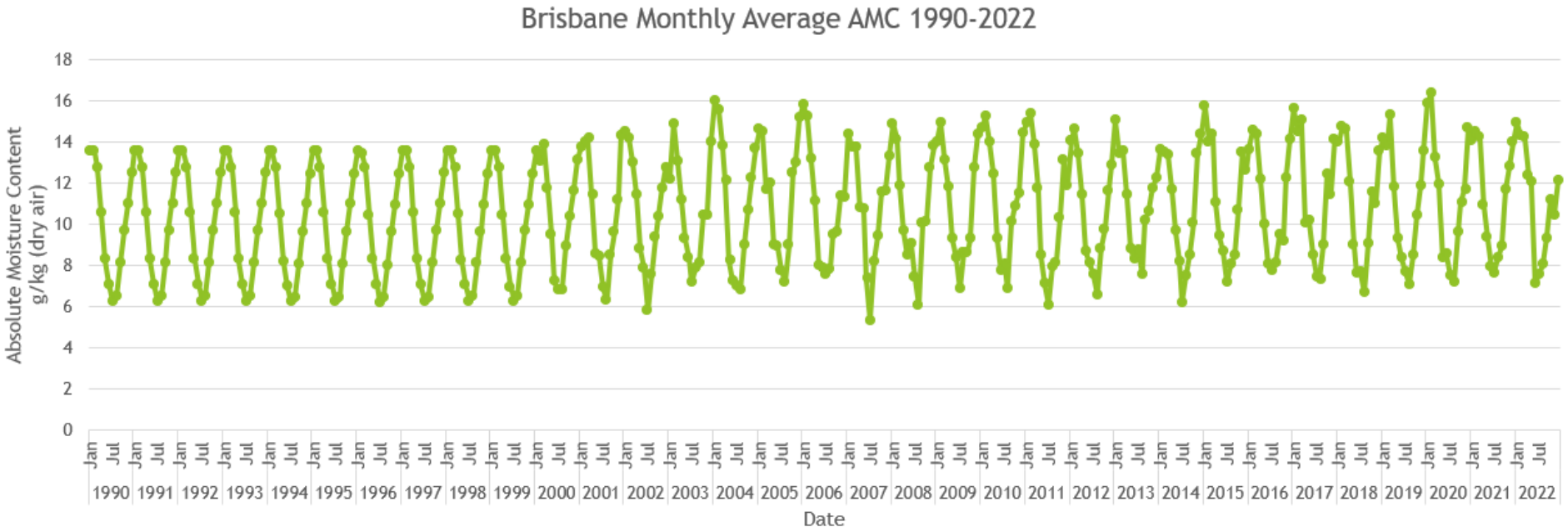
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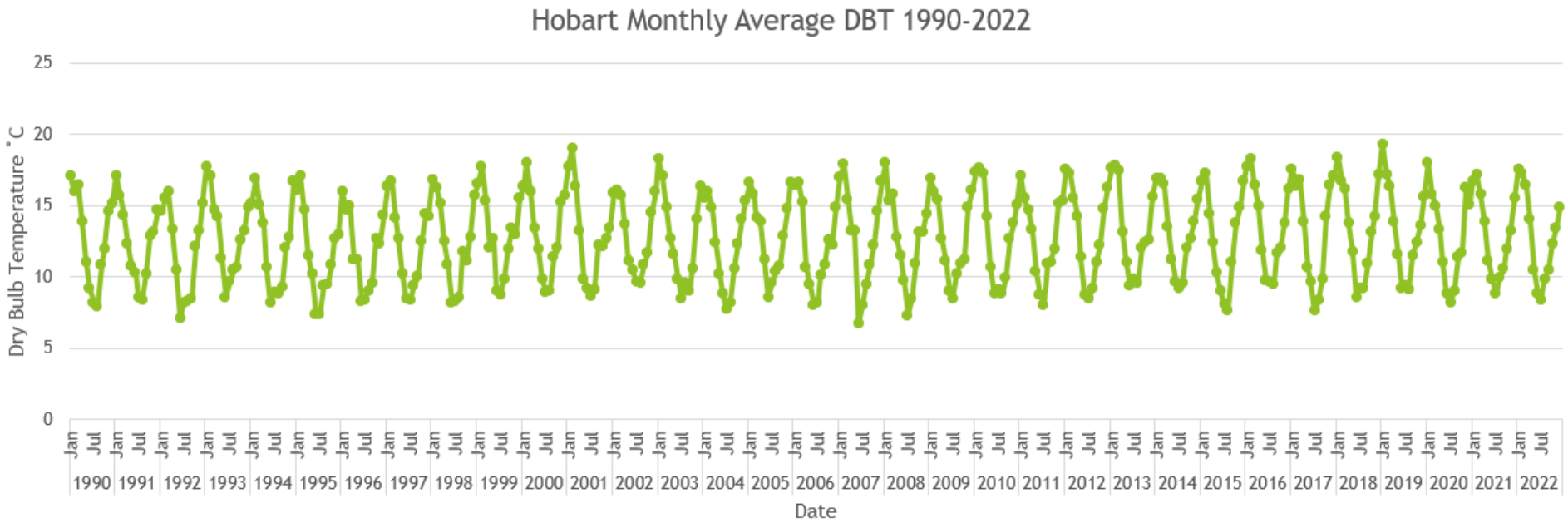
Hobart Monthly Average DBT 1990-2022
Dry Bulb Temperature °C
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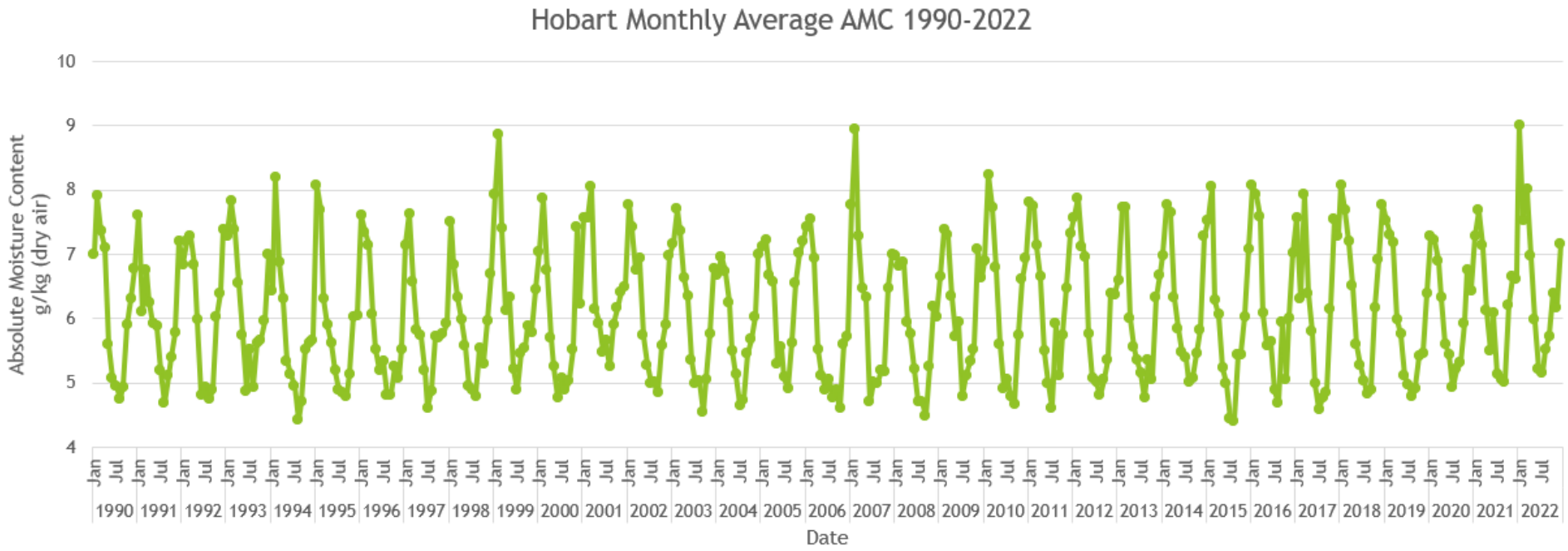
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Absolute Moisture Content g/kg (dry air)
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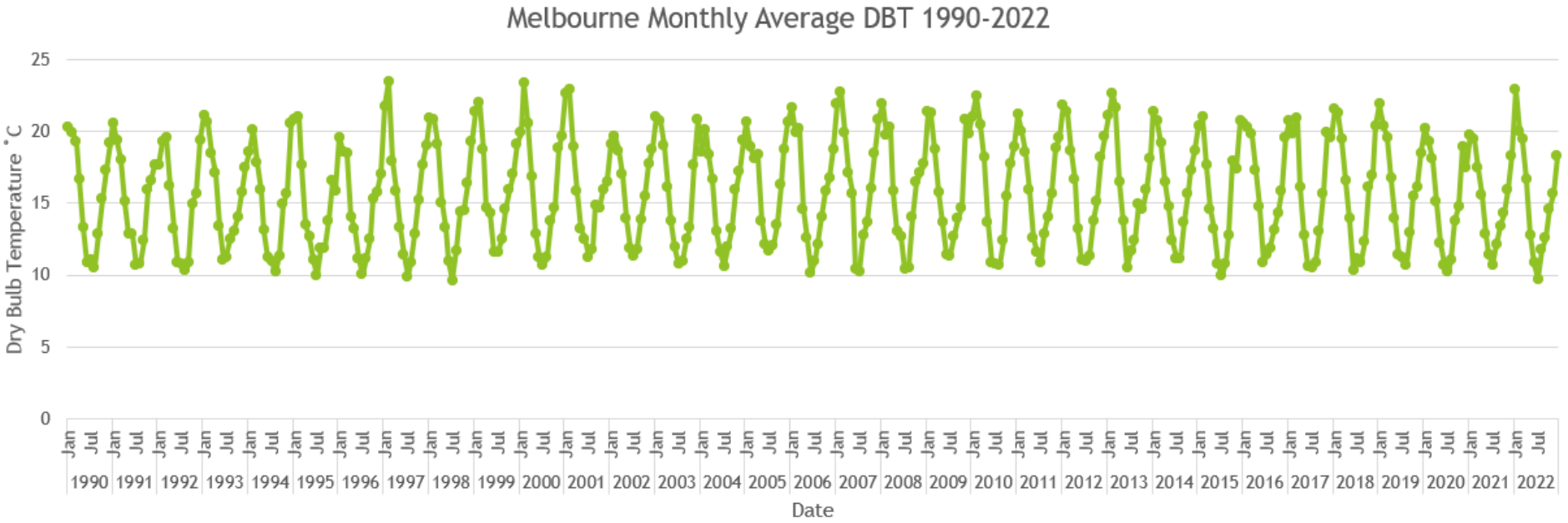
Melbourne Monthly Average DBT 1990-2022
Dry Bulb Temperature °C
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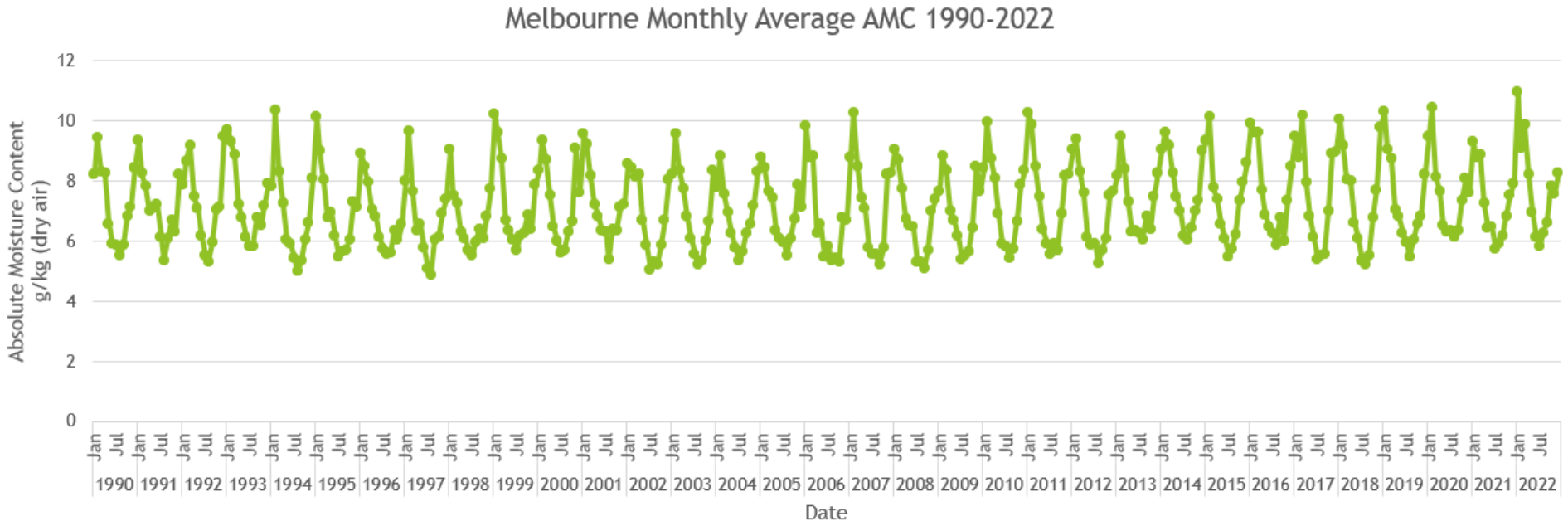
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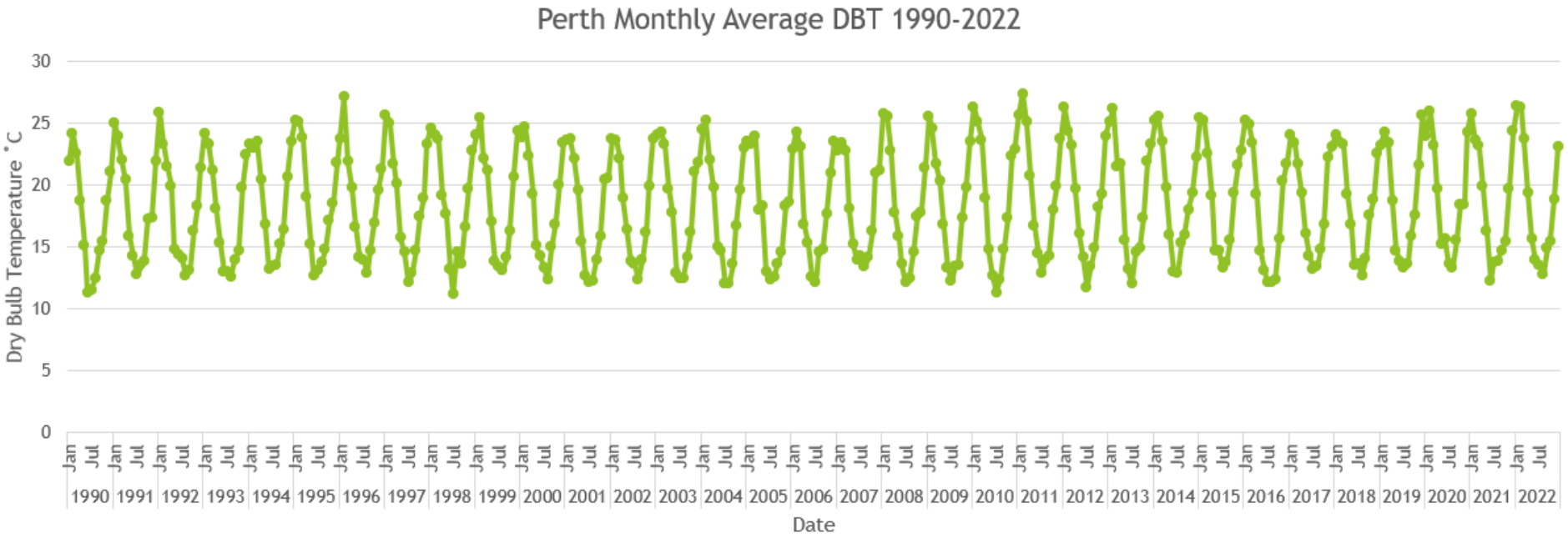
Perth Monthly Average DBT 1990-2022
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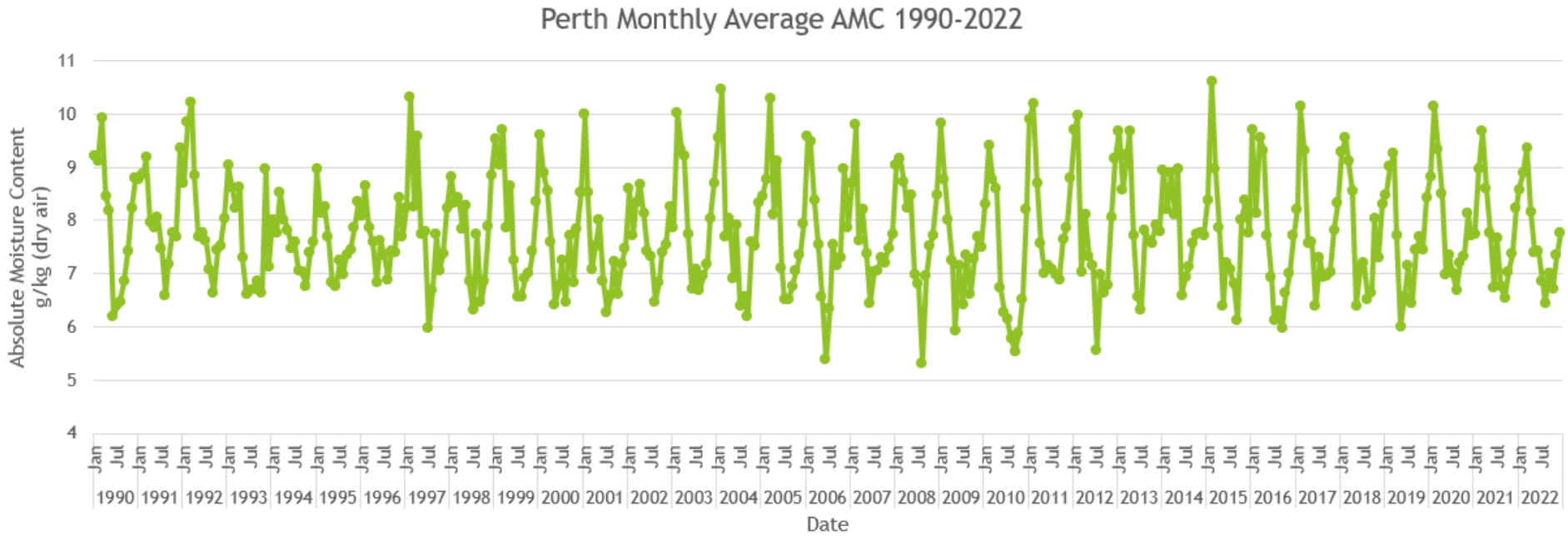
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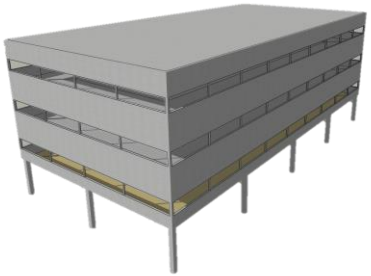
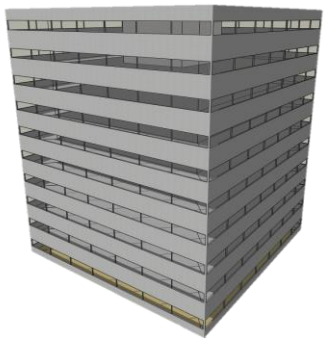
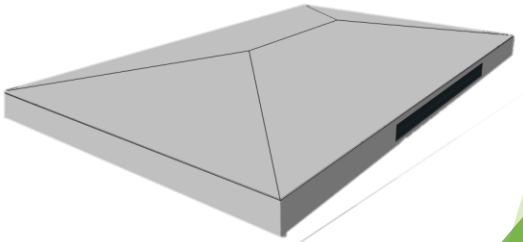
Examining HVAC Energy Consumption - Methodology

- Sydney weather data (1990-2022) from BOM processed in in-house software *ClimateCypher*
- Considered 3 archetypical buildings, compliant with the current NCC: a 3-storey office building, a 10-storey office building, and a ground-level supermarket
- Analysed HVAC heating, cooling, and total energy consumption by simulating the processed data and building models in EnergyPlus







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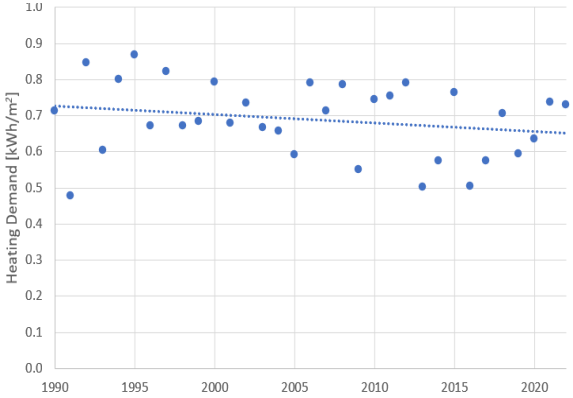
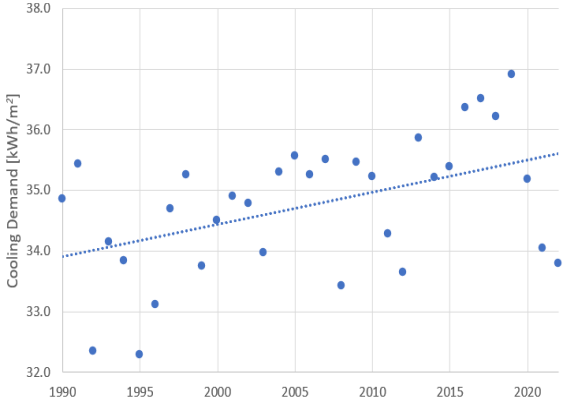
Examining HVAC Energy Consumption - Results

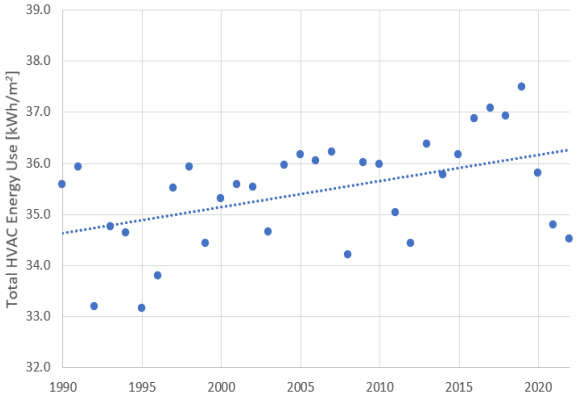
Annual Energy Consumption for Heating of Three Building Archetypes in Sydney (1990-2022)



Annual Energy Consumption for Cooling of Three Building Archetypes in Sydney (1990-2022)



Annual Total HVAC Energy Consumption of Three Building Archetypes in Sydney (1990-2022)



- Trend of decreasing heating demand
- Trend of rising annual average cooling demand and total HVAC energy usage
- Cooling demand from 2015-2019 was relatively high, but there is a notable 8.79% reduction from 2019-2022

Examining HVAC Energy Consumption - Results

Average Consumption		
1990-2022	**1990-2008**	**2008-2022**
398,400 kWh	396,400 kWh	400,400 kWh

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Conclusions

- Notable differences in critical meteorological elements used in building simulations within the recent 2008-2022 period compared to the older 1990-2022 and 1990-2015 reference periods
- Shifts in building cooling and heating demand observed over the past decades
- Traditional reference periods may fail to adequately represent the changing climate
- Need for reliable weather data that more accurately characterises the climate in which buildings will operate
  - Achievable through frequent updates and/or a shorter measurement period.

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Proposed Next Steps

- Continued monitoring of climate trends
- Investigation of the annual variations and timing of peak cooling loads, and how these may vary with climate change
- eXtreme Meteorological Year (XMY) climate files
  - P01, P10, P90, and P99 data → weather that would be expected 1%, 10%, 90% and 99% of the time in a given period
  - Understanding building energy performance in an extreme year

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Thank You!

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