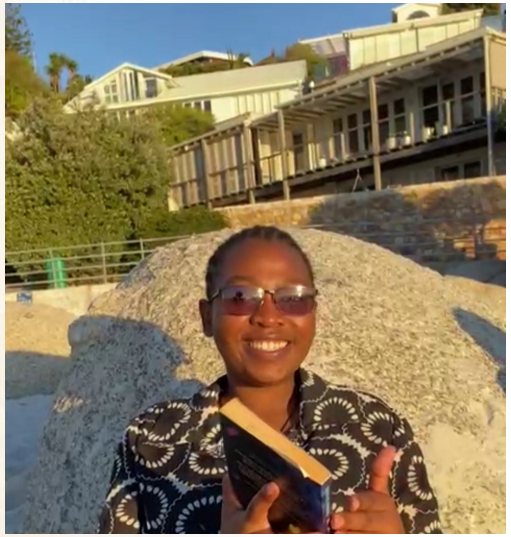
CHAC 2024
Climate and Health Africa Conference



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HABVIA

Assessing Indoor Thermal Comfort in Low-income Housing

A khayelitsha Case study

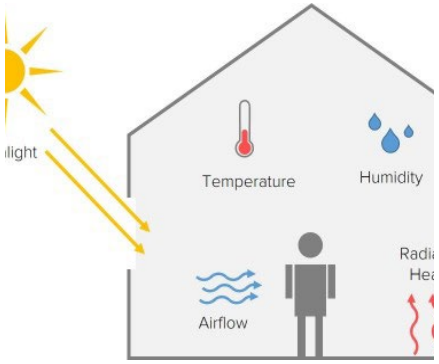
Background

Increasing extreme heat events due to global climate change (IPCC, 2023)

Indoor overheating as a major health and comfort issue (Synnefa *et al.*, 2020)

Thermal comfort and heat stress

Defined as perceived contentment with the thermal environment (ASHRAE)



Influenced by environmental factors such as temperature, humidity and wind velocity, personal factors such as clothing and metabolic rate. (Cheung et al, 2019)

Acceptable wet bulb temperature:

Critical: (20–32°C)
Fatal (24–37°C)

WHY WET BULB TEMPERATURE?

- The human body uses sweat evaporation to cool itself in high-temperature
- The wet bulb enables cooling via evaporation
- cooler wet bulb means that evaporative cooling is possible
- if wet bulb is the same as dry bulb it means no evaporation is happening, because air is saturated
- can be used as a proxy for body ability to cool via sweat evaporation as it reflects the combined effects of air temperature and humidity

- WBT remains a widely used measure
- Offers a solid starting point for understanding and quantifying heat stress.

Aims

To assess the relationship between housing type (formal vs informal) and indoor temperature variation.

To develop a predictive relationship between external weather data and internal thermal comfort.

To estimate trends in wet bulb temperature exceedances as a measure of thermal comfort in long term historical data (1940 -2024)

Methods

Data Collection

Outdoor Variables

Temp & Hum

(*SAWS, ERA5*)

Indoor Variables

Temp & Hum

(*HABVIA*)

Housing Characteristics

(*HABVIA, CORC*)

MEASUREMENT PERIOD

INDOOR DATA

- 60 Houses
- November 2023 – April2024
- Study still ongoing

OUTDOOR DATA

- South African Weather Service (cape town airport station) [2018 – 2024]
- ERA5 Reanalysis Database (1940 – 2024)

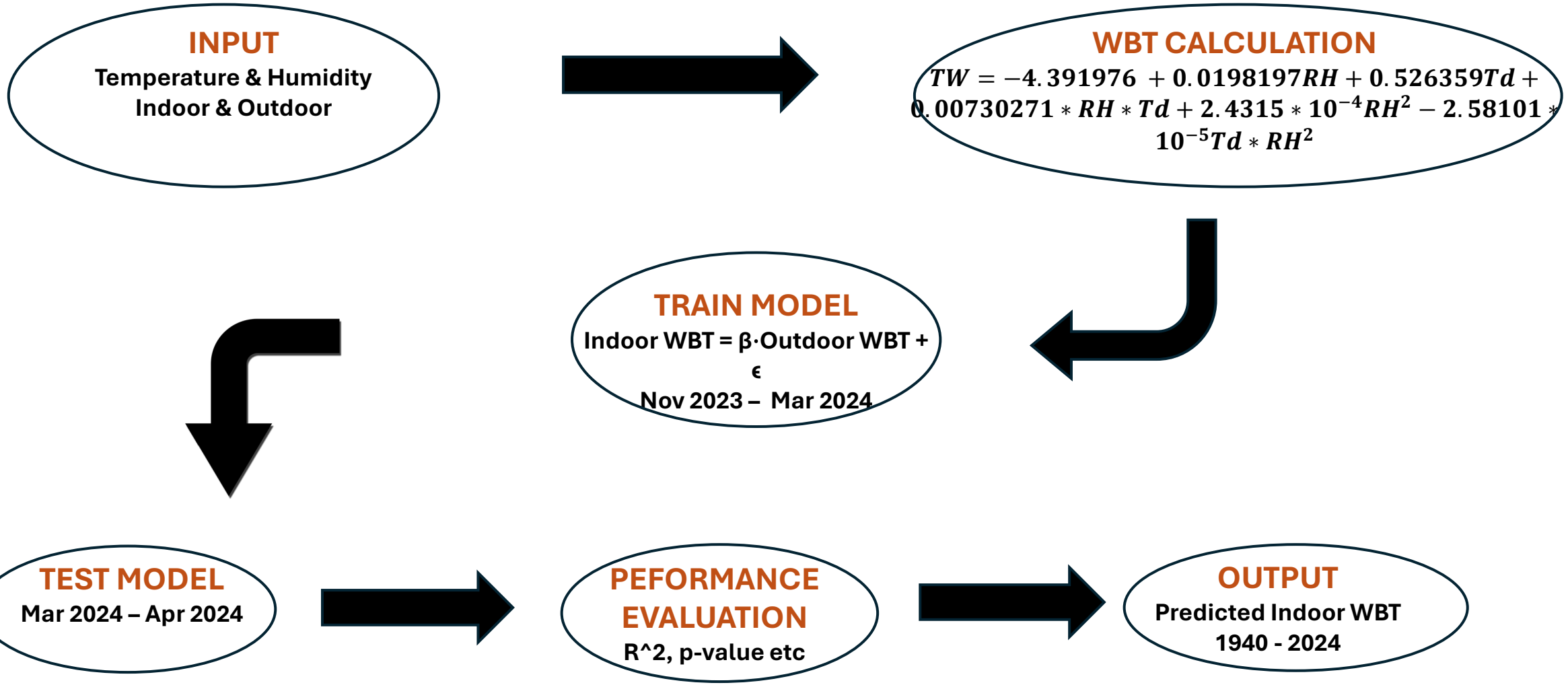
Data Analysis

Principal component analysis

Linear regression-predictive model

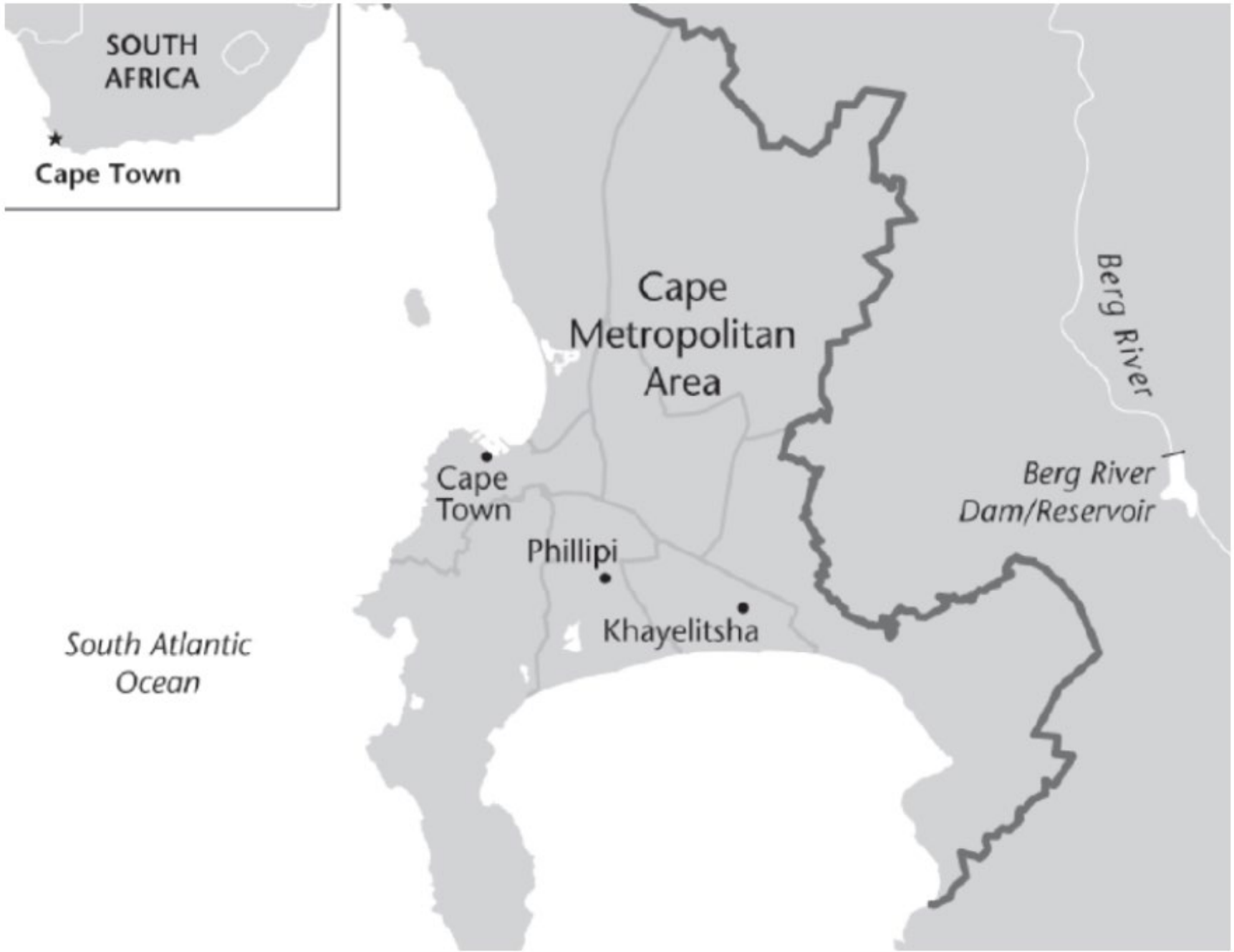
WBT trend analysis

Predictive model explained



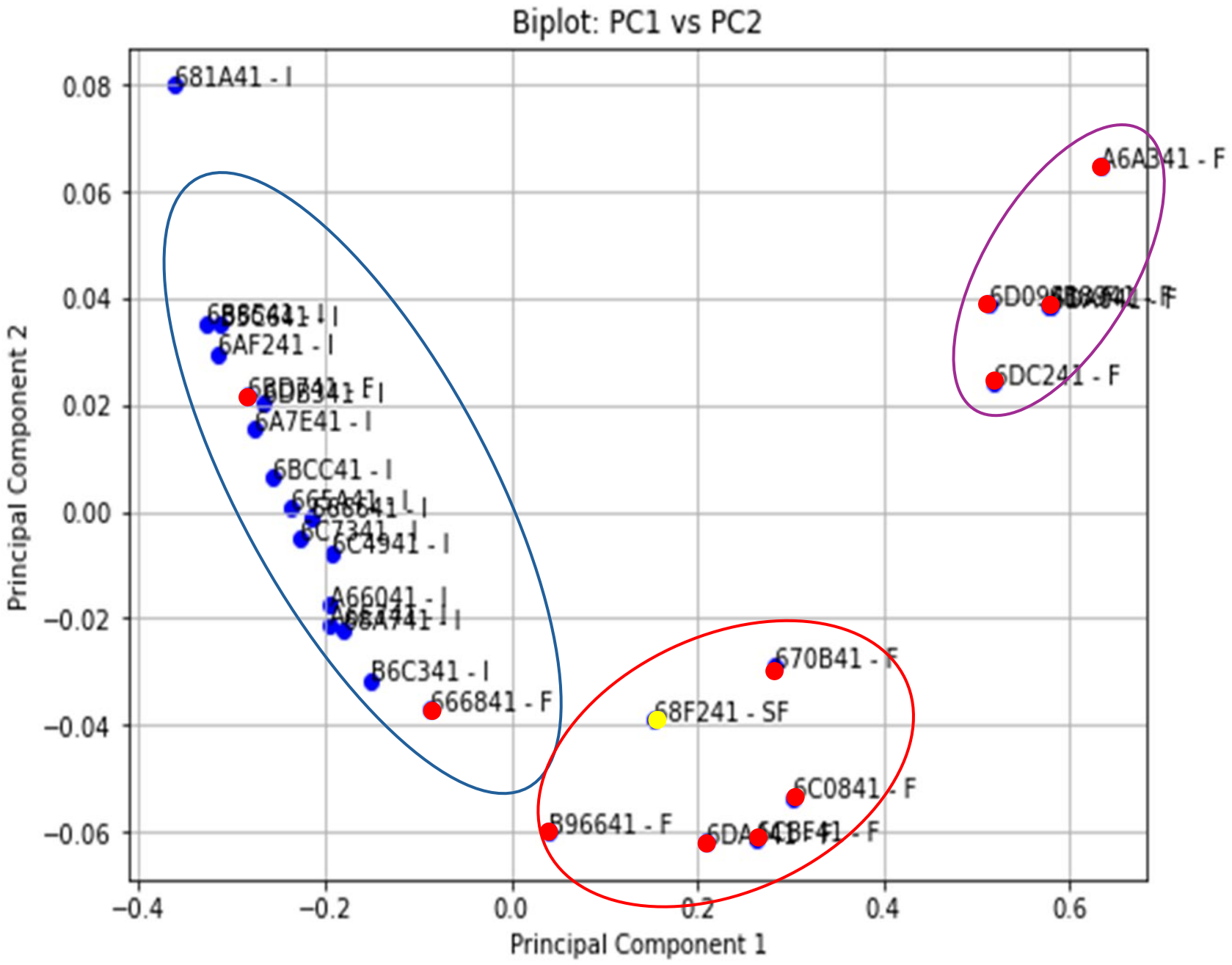
RESULTS

LOCATION

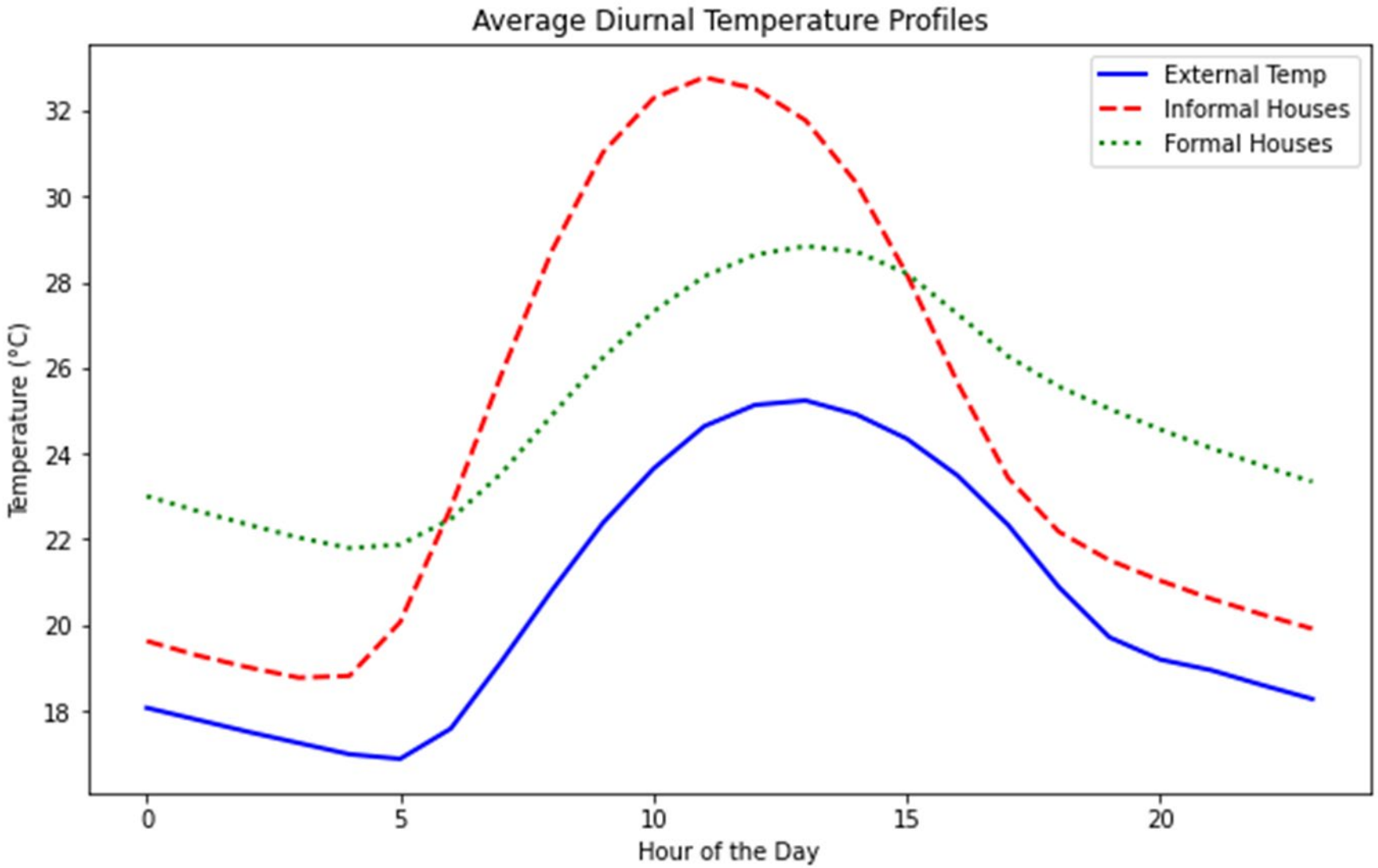

SOUTH AFRICA
Cape Town
Cape Metropolitan Area
Berg River
Cape Town
Phillipi
Khayelitsha
Berg River Dam/Reservoir
South Atlantic Ocean

FORMAL HOUSING

INFORMAL HOUSING

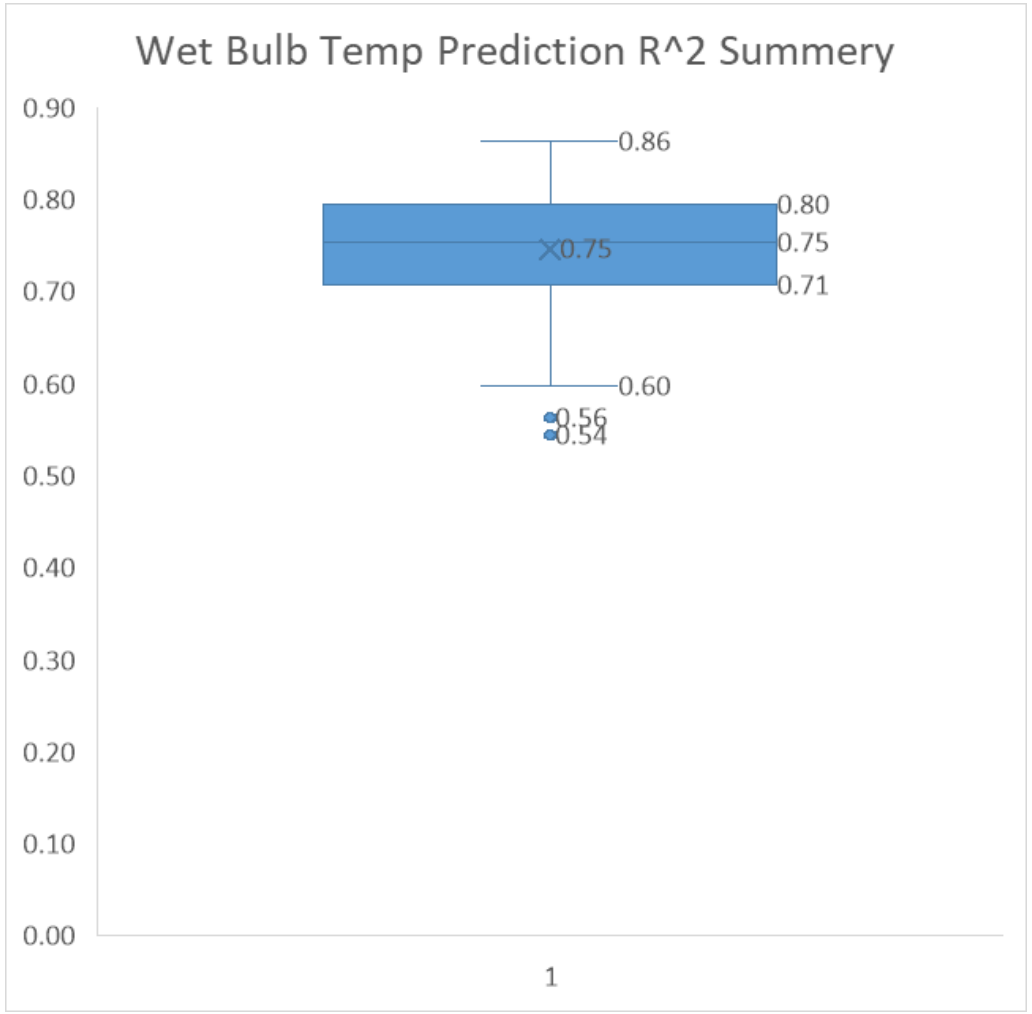


House Type	PC1 Loading	PC2 loading
Formal	0.55	0.77
Informal	0.92	0.35
Semi-Formal	0.65	0.69

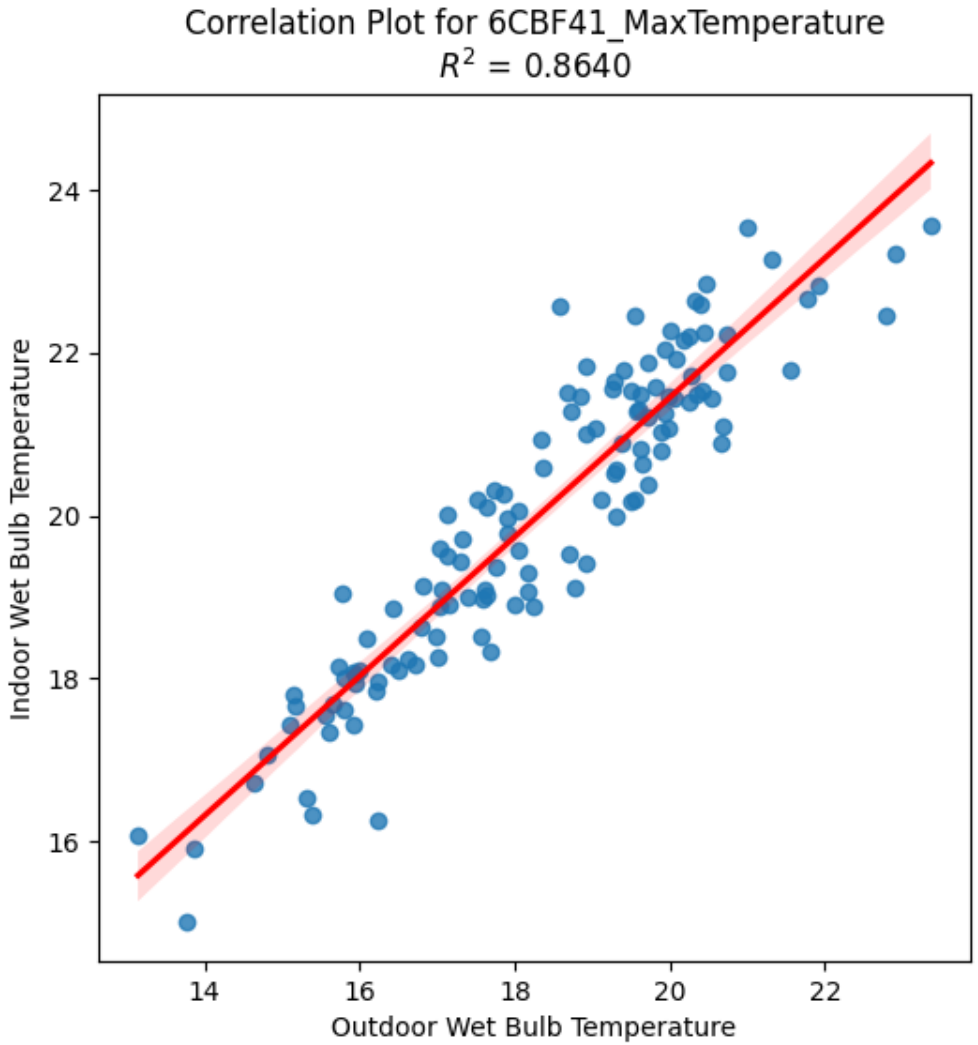

Average Diurnal Temperature Profiles
External Temp
Informal Houses
Formal Houses
Temperature (°C)
32
30
28
26
24
22
20
18
0
5
10
15
20
Hour of the Day

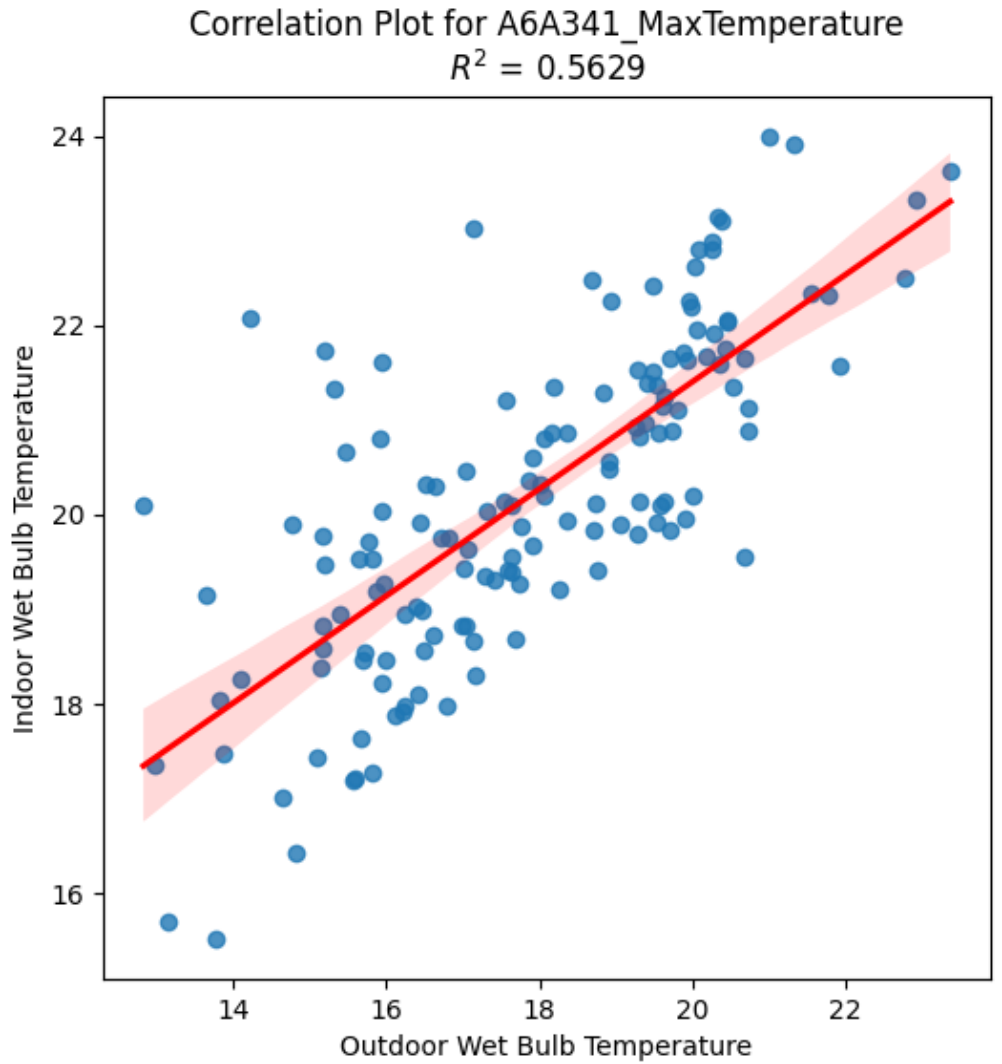
Predictive model- Simple linear regression

Number of houses = 53



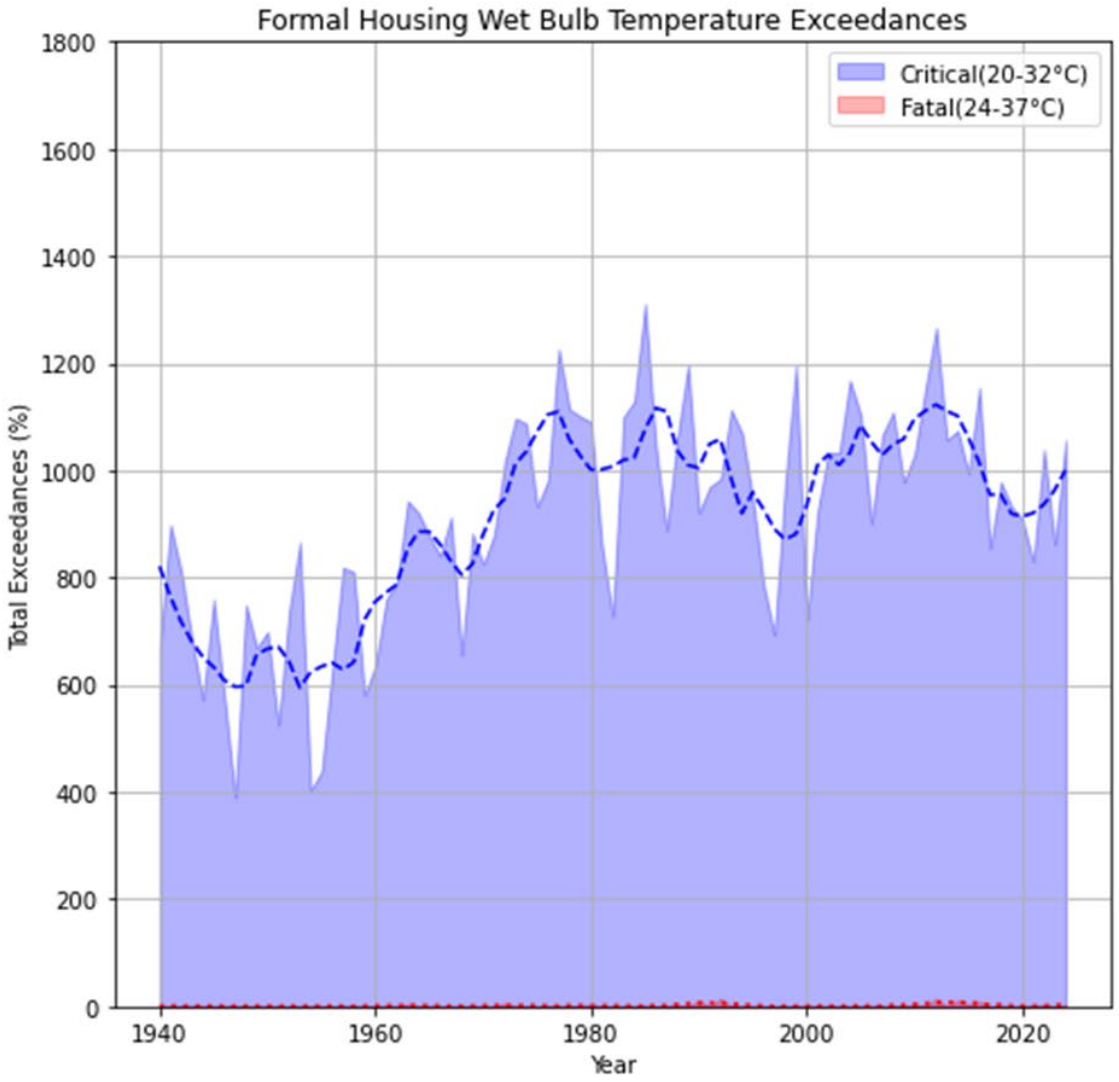
Slope Summery Statistics	
mean	0.81
max	1.1
Q1	0.74
median	0.79
Q3	0.87
min	0.57

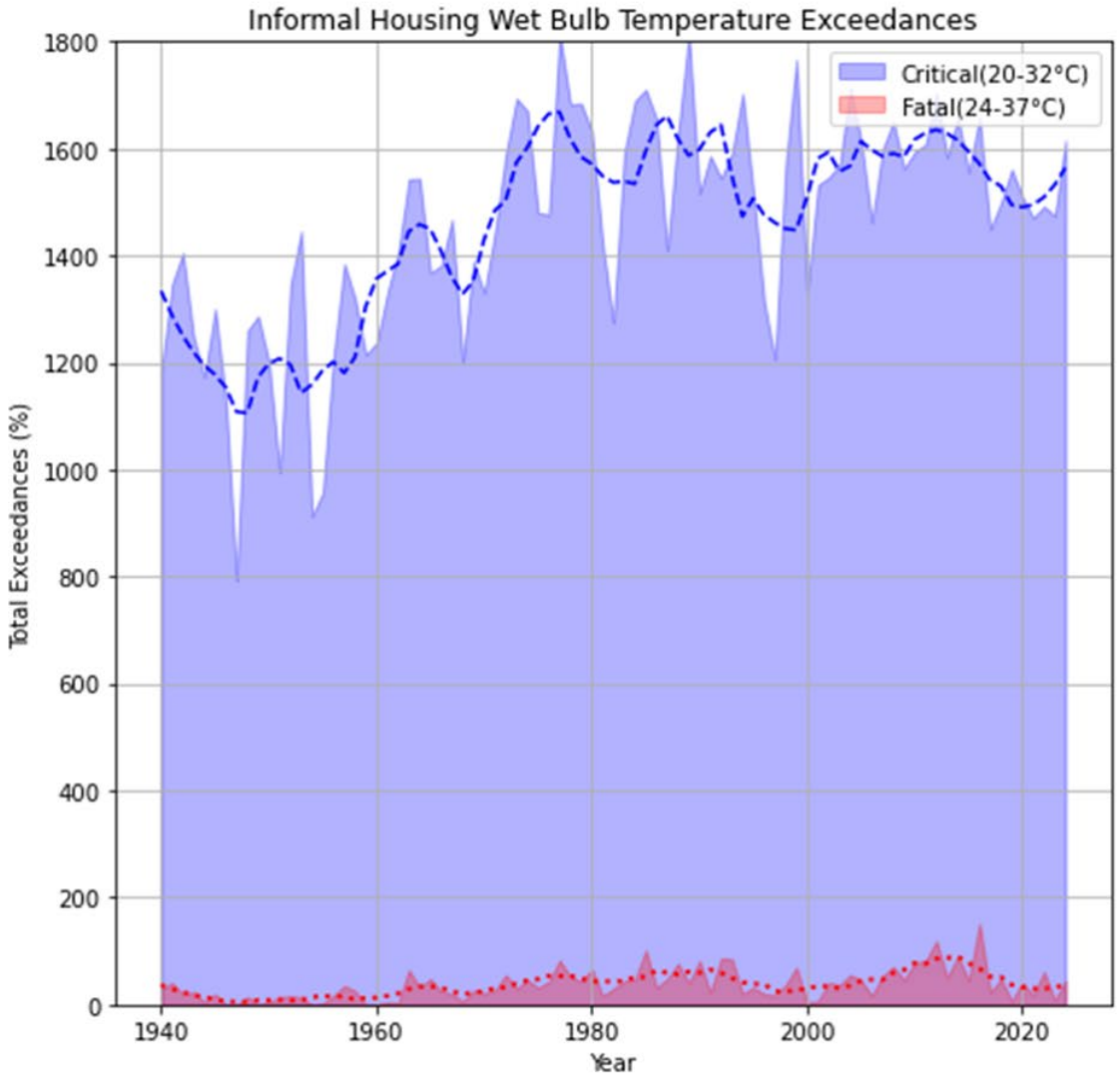

Correlation Plot for 6CBF41_MaxTemperature
R^2 = 0.8640
Indoor Wet Bulb Temperature
Outdoor Wet Bulb Temperature
16
18
20
22
24
14
16
18
20
22

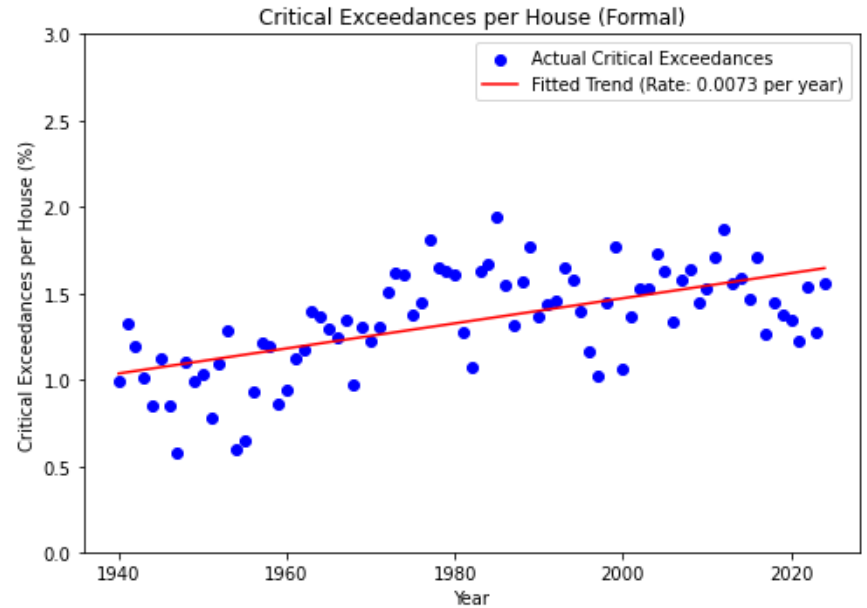

Correlation Plot for A6A341_MaxTemperature
R^2 = 0.5629
Indoor Wet Bulb Temperature
Outdoor Wet Bulb Temperature
16
18
20
22
24
14
16
18
20
22

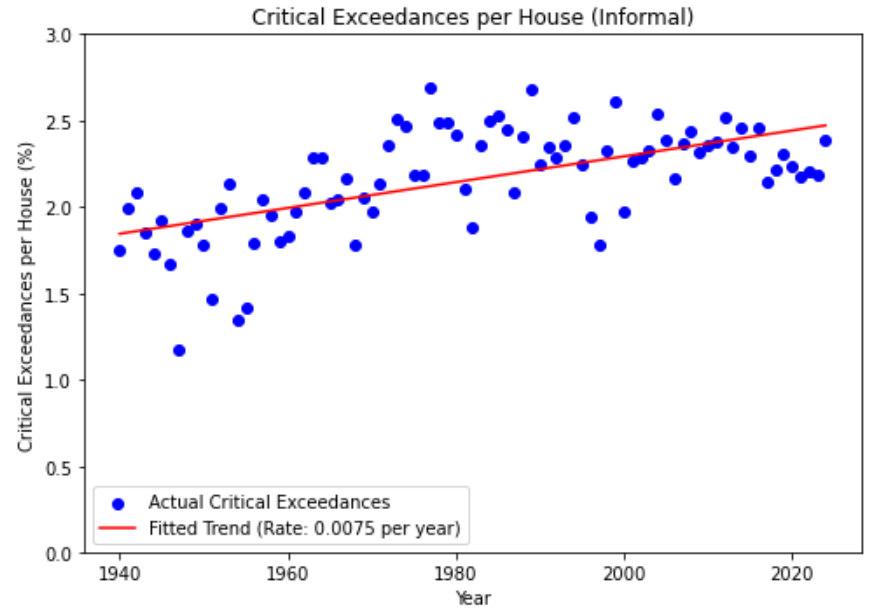
WBT Trends

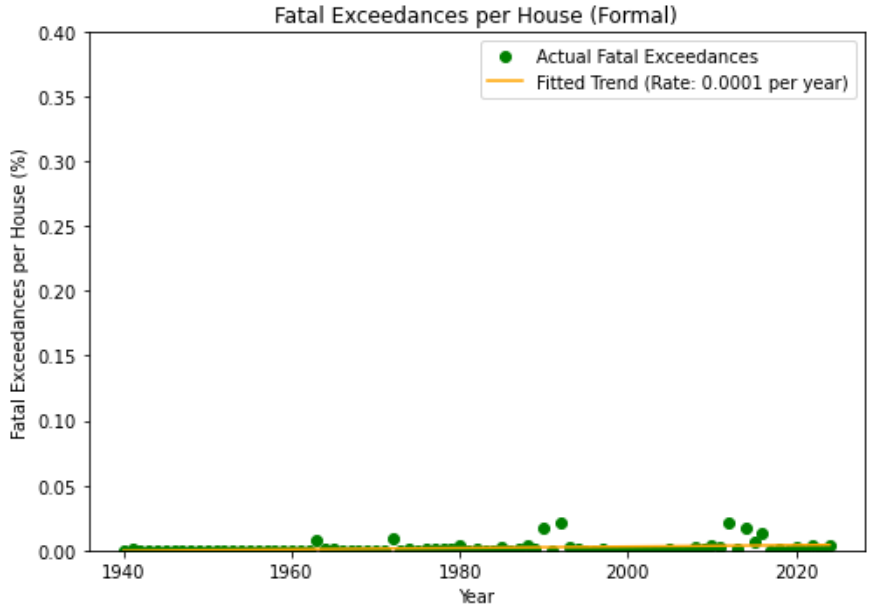
26 Formal
26 Informal

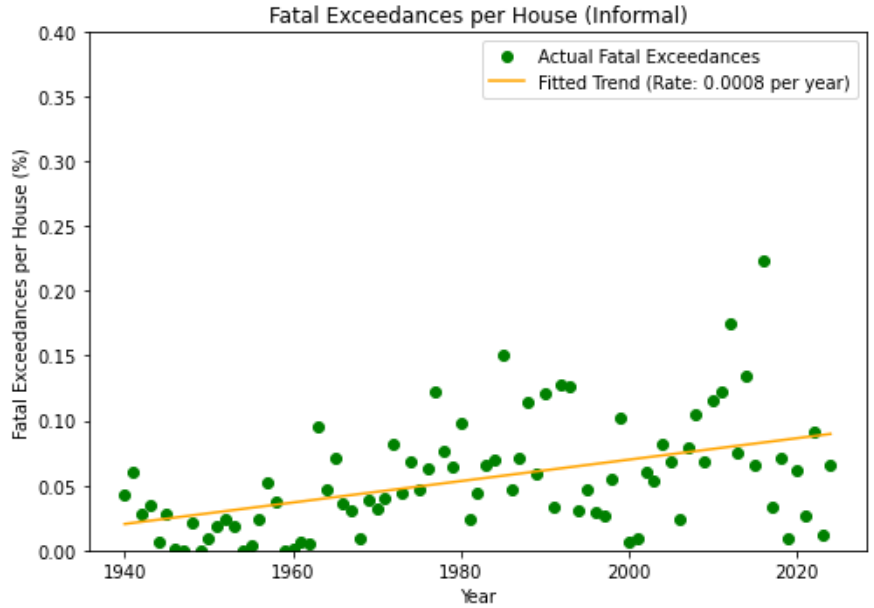


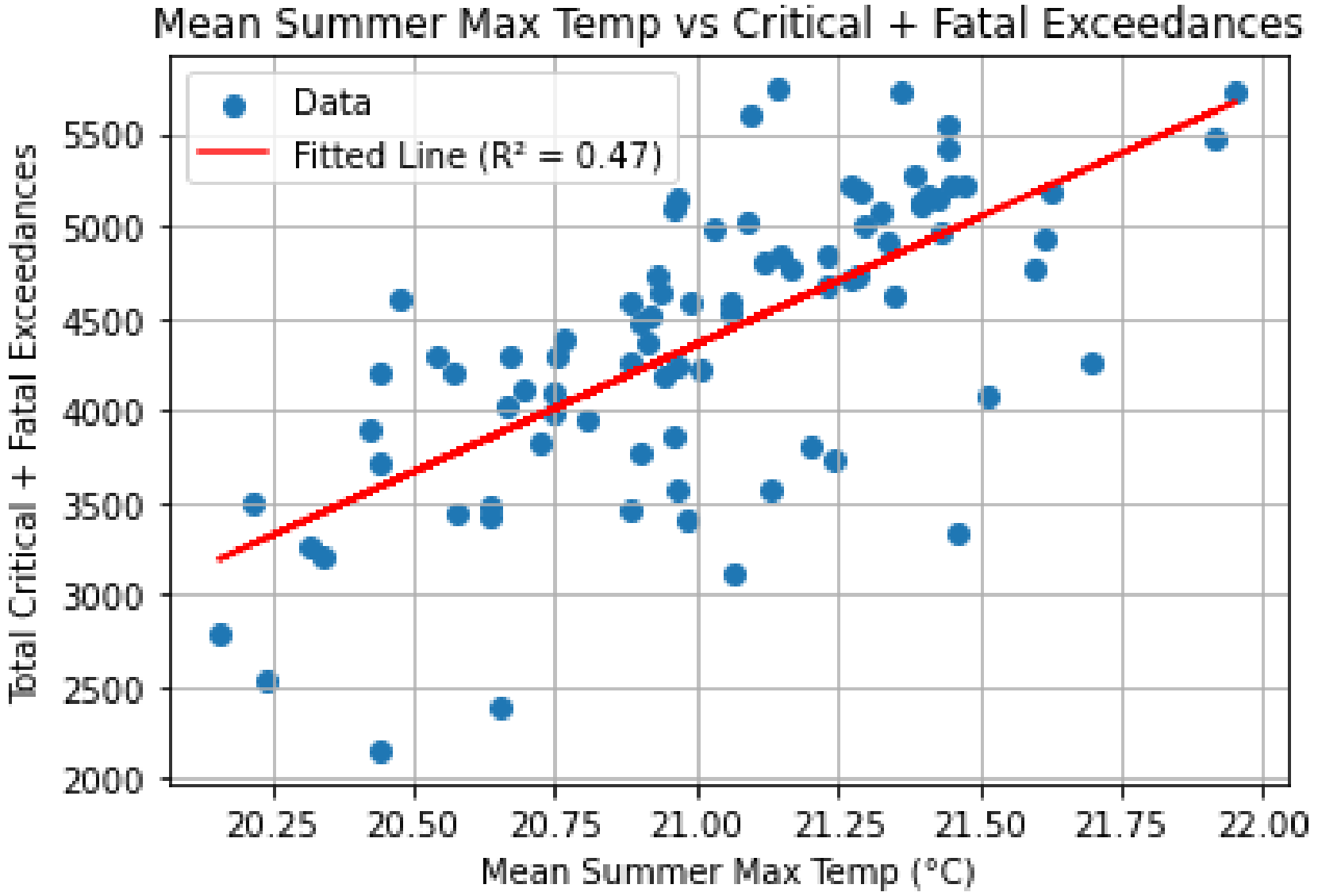



Critical Exceedances per House (Formal)
Actual Critical Exceedances
Fitted Trend (Rate: 0.0073 per year)
Critical Exceedances per House (%)
Year


Critical Exceedances per House (Informal)
Actual Critical Exceedances
Fitted Trend (Rate: 0.0075 per year)
Critical Exceedances per House (%)
Year


Fatal Exceedances per House (Formal)
Actual Fatal Exceedances
Fitted Trend (Rate: 0.0001 per year)
Fatal Exceedances per House (%)
Year


Fatal Exceedances per House (Informal)
Actual Fatal Exceedances
Fitted Trend (Rate: 0.0008 per year)
Fatal Exceedances per House (%)
Year


Mean Summer Max Temp vs Critical + Fatal Exceedances
Data
Fitted Line (R² = 0.47)
Total Critical + Fatal Exceedances
5500
5000
4500
4000
3500
3000
2500
2000
20.25
20.50
20.75
21.00
21.25
21.50
21.75
22.00
Mean Summer Max Temp (°C)

Discussion

- Low-income housing occupants are vulnerable to indoor overheating with average daily temperatures being higher than external temperature.
- Informal houses* are even more vulnerable, with less ability to buffer extreme outdoor temperatures.
- The persistent critical exceedances over time highlight that indoor thermal comfort is compromised and
- There is increasing vulnerability to heat related health issues in vulnerable locations.

WBT as a heat stress Index

What's missing?

- Physiological data
- Socio-cultural data variables
- Demographic variables
- Qualitative data – what are people saying
  (thermal comfort is largely perceived)

Other model variables:

- Solar Radiation
- Housing and community characteristics (wall type, vegetation, pavements, number of people, activities etc)

ACKNOWLEDGEMENTS

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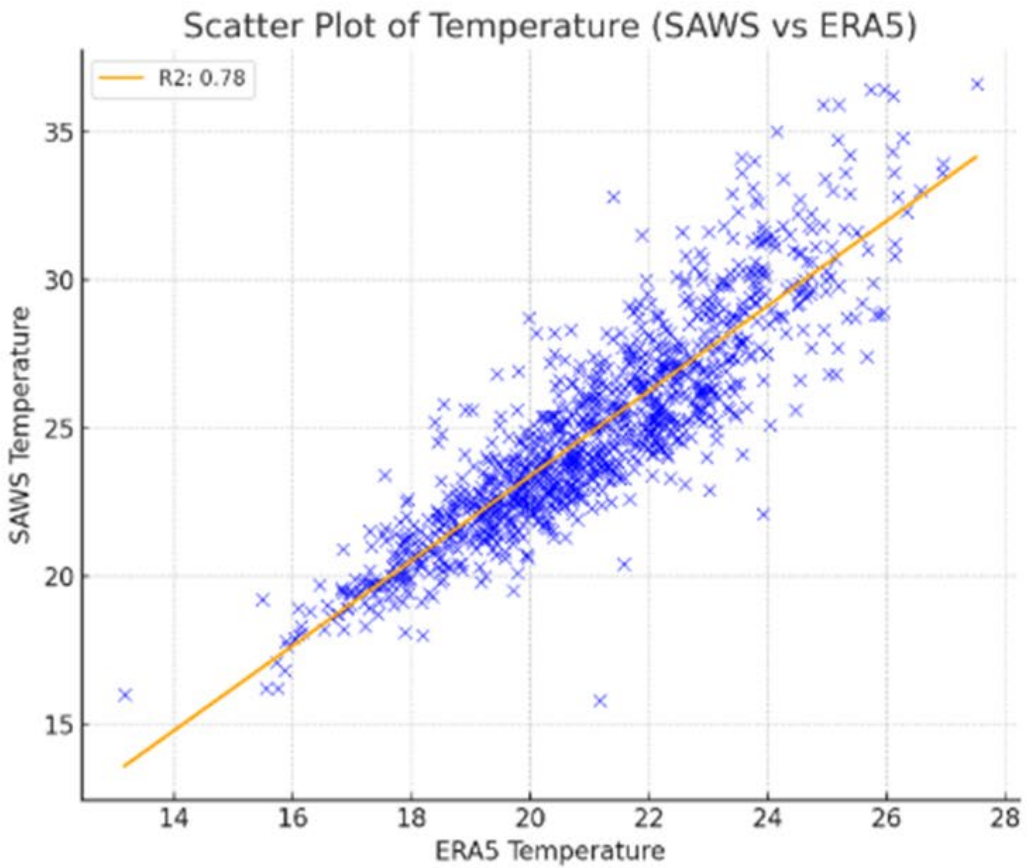
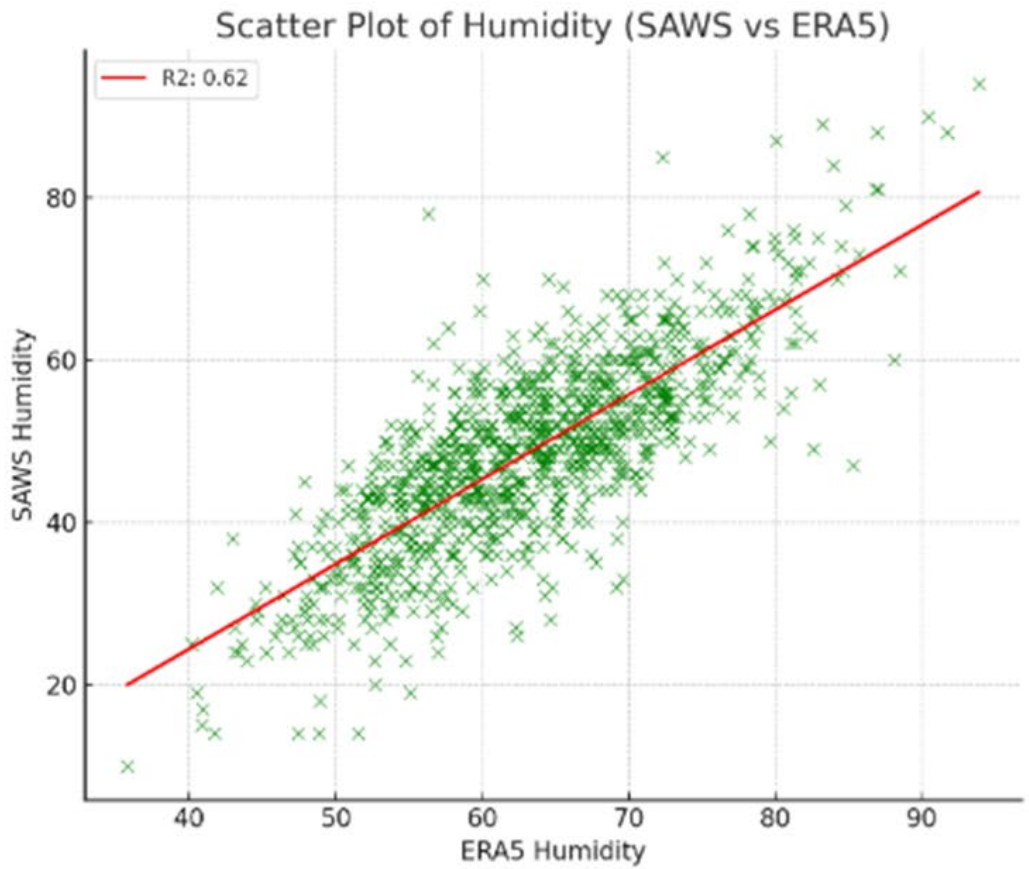
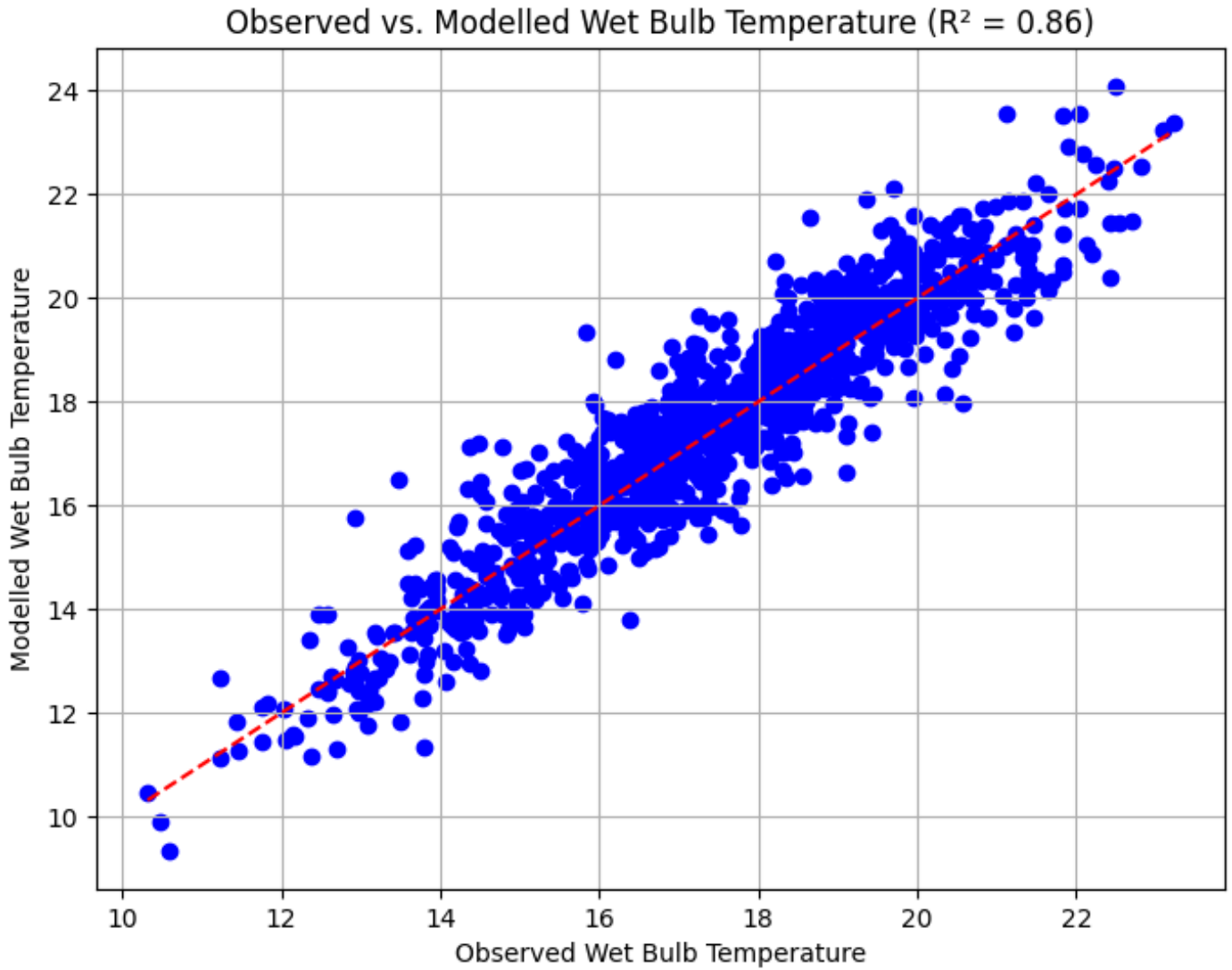
SPES BONA
HABVIA
wellcome
South African Weather Service
NRF


Scatter Plot of Temperature (SAWS vs ERA5)
R2: 0.78
SAWS Temperature
ERA5 Temperature
15
20
25
30
35
14
16
18
20
22
24
26
28


Scatter Plot of Humidity (SAWS vs ERA5)
R2: 0.62
SAWS Humidity
ERA5 Humidity
20
40
60
80
40
50
60
70
80
90


Observed vs. Modelled Wet Bulb Temperature (R² = 0.86)
Modelled Wet Bulb Temperature
Observed Wet Bulb Temperature
10
12
14
16
18
20
22
24