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EXPLORING CLIMATE VARIABILITY OF MARINE WEST COAST CLIMATE

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ABSTRACT

Global warming reflected by the variation of climate trend over years is one of major concerns all over the world. The increase in temperature will certainly affect human well-being, health, agriculture and other sectors. This paper investigated the climate trend in four locations namely Melbourne, Oxford, Liverpool and Aberdeen Gardens. Those are categorized under Marine West Coast Climate according to Koppen-Geiger world map. These locations were purposely selected for a research study concerned with thermal comfort. It was observed that the variation in terms of temperature and precipitation over years depends on several factors such geographic location, altitude, latitude and other factors.

Keywords: climate classification, koppen-geiger, marine west-coast, climate, temperature, precipitation.

INTRODUCTION

Climate is widely accepted as a description of weather over a long period of time, commonly 30 years period (Trewartha, 1937; Esfandeh and Sedighizadeh, 2011; Chen and Chen, 2013). It shows how the atmosphere behaves in a specific area within a period of time (Blair, 1942; Petersen, Sack *et al.* 2010). Climate elements include averages of precipitation, temperature, humidity, sunshine and wind velocity (Bautu and Bautu, 2006). Understanding these trends is important in predicting the immediate future weather (Pidwirny, 2014).

Koppen Geiger climate classification is the most frequently used and accepted system in understanding climate patterns. It is relatively simple and having easy classification (da Cunha and Schoffel, 2011; Mishra and Ramgopal, 2013), thereby this research chooses Koppen-Geiger climate classification system to understand some of the charecterisitics of Marine West Coast Climate.

The Koppen Geiger classification consists of five primary types designated as A, B, C, D, and E. These five primary types are namely, tropical moist climates (Type A), dry climates (Type B), moist subtropical mid-latitude climates (Type C), moist continental mid-latitude climates (Type D), and polar climates (Type E) (Kottek, Grieser *et al*. 2006; Rubel and Kottek, 2010; Farmer and Cook, 2013; Mishra and Ramgopal, 2013). Those primary classifications are further divided into secondary and tertiary categorization (Stem, De Hoedt *et al*. 2000; Kottek, Grieser *et al.* 2006). The secondary ccategorization is differentiated by precipitation value, while the tertiary categorization is controlled by the temperature value.

This paper is about investigating the moist subtropical mid-latitude climates (Type C). This climate generally has warm and humid summers with mild winters. This climate mainly occurs on the eastern and western borders of most continents which are from 30° to 50° of latitude. The winter weather of climate type C is described by the mid-latitude cyclone; whereas, in summer, it is characterized by the precipitations caused by convective thunderstorms (Rao, 2008; Pidwirny, 2014).

The climate type C has several dominant minor types. Those include Humid Subtropical (Cfa), Marine-Mild winter (Cfb), Marine-Cool Winter (Cfc), Dry Winter, Wet Summer (Cwa/Cwb/Cwc), Interior Mediterranean (Csa), Coastal Mediterranean (Csb). This paper will investigate and discuss the Marine-Mild winter type or Marine West Coast Climate type (Cfb).

Cfb is widely known by marine climate. It is subjected to short dry summers and humid climate (Chen and Chen, 2013). This climatic type has warmest months with an average temperature above 10 ℃. The average temperature during the coldest month is between -3 ℃ and 18 ℃ (Kottek, Grieser *et al.* 2006). Some of the locations subjected to such climate are Coastal Oregon, Washington, west coast of Canada and southern west coast of Alaska, central and northwest Europe, southern Chile, southern coast of South Africa, southeast Australia and New Zealand (Pidwirny, 2011).

METHODOLOGY

Firstly, the locations for this investigation are collected from the RP-884 database. The raw data RP-884 are available in the website of Faculty of Architecture, Design and Planning in the University of Sydney. Then, all the survey locations were classified by using the World Map of Koppen-Geiger Climate Classification updated with CRU TS 2.1 temperature and VASClimO v1.1 precipitation data 1951 to 2000 (Kottek, Grieser *et al.* 2006). After that, the locations under C climatic type were selected for more detailed sub-climatic classifications.

This paper only focus on the locations under Cfb for naturally ventilated buildings. Historical temperature and precipitation data from year 1980 to year 2009 were collected from each country's meteorological stations for further analysis. Thereby, the variations of temperatures and precipitations for the selected thirty years period were analysed and discussed.

RESULTS AND DISCUSSIONS

In this section, firstly discussed the selected survey locations in Cfb climatic type. Then, the

temperature and precipitation variation for Cfb survey locations over 30 year's period are observed and discussed.

Selected Survey Locations for Investigation

There are 25 survey locations in the ASHRAE database RP-884. Table-1 depicts the climatic type of each survey locations according to the World Map of Koppen-Geiger Climate Classification.

Table-1. Koppen-Geiger climatic type of survey locations in database ASHRAE RP-884.

Koppen-Geiger Climatic Types	Survey Locations based on the ASHRAE RP-884 Database
Type A	Bangkok, Jakarta, Darwin, Townsville, Singapore, Honolulu.
Type B	Karachi, Multan, Peshawar, Quetta, Kalgoorlie.
Type C	Liverpool, Antioch, Brisbane, Melbourne, Saidu Sharif, Athens, Oxford, Sydney, San Francisco Bay Area, San Ramon, Auburn.
Type D	Montreal, Ottawa, Grand Rapid.

After the determination of the locations subjected to the main climate type C, the survey location for natural ventilated buildings were extracted and identified according to their own secondary and tertiary classification by using the World Map of Koppen-Geiger Climate Classification. This is shown in Table-2.

Table-2. Climatic type's survey locations with NV type survey buildings.

Type C Koppen-Geiger Climate Classification with NV Building Types	Survey Locations based on the ASHRAE RP-884 Database
Cfa	Brisbane, Saidu Sharif
Cfb	Melbourne, Oxford, Liverpool
Csb	San Francisco Bay Area
Csa	Athens

Since the latitude between Oxford and Liverpool is too close, another location namely Aberdeen Gardens, Washington was included in this study. It is subjected to Cfb type. This is for better understanding of the climate patterns. Figure-1 shows the exact locations selected for further analysis.

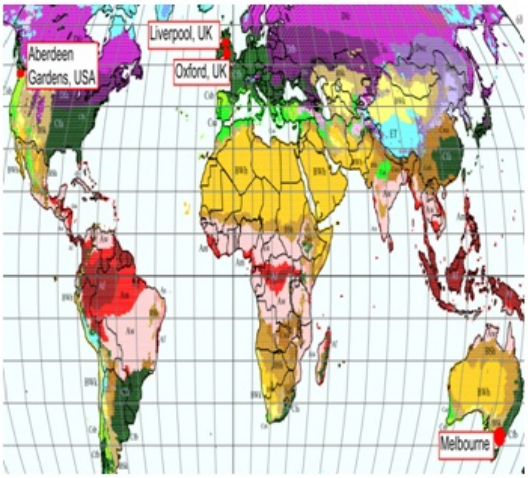

Figure-1. Survey locations under investigated in this paper.

Comparison of Temperature and Precipitation Variation for Cfb Survey Locations Over 30 Years Period (1980 – 2009)

In this section, the temperature and precipitation variations of Melbourne, Oxford, and Liverpool over 30 years period were analysed from the year 1980 until year 2009.

For the Melbourne location shown in Table-3, it is apparent that there was a drop in temperature of almost 0.6 °C from year duration 1990 – 1994 to year duration 1995–1999. This was followed by an average yearly increase of temperature by nearly 0.07 °C. For the precipitation, it was apparent that there was a drop of about 1mm from year 1995 until year 2009.

Table-3. Mean precipitation and mean temperature in Melbourne from year 1980 to year 2009.

Year Duration	5 years duration Mean Precipitation (mm)	5 years duration Mean Temperature (°C)
1980 - 1984	49.04	15.01
1985 - 1989	58.89	14.76
1990 - 1994	60.46	14.87
1995 - 1999	56.60	14.29
2000 - 2004	50.71	14.82
2005 - 2009	44.54	15.43

The observed patterns of Oxford climate over 30 years is listed in Table-4. It was observed that from 1985 to 2004, there was a slightly raise in average temperature of 0.05 °C, Furthermore, the yearly precipitation slightly increased by 0.37mm. This was from 1985 until 2004, and then the observed yearly average dropped by 0.4mm starting from 2005 until 2009.

Table-4. Mean precipitation and mean temperature in Oxford from year 1980 to year 2009.

Year Duration	5 years duration Mean Precipitation (mm)	5 years duration Mean Temperature (°C)
1980 - 1984	52.64	10.34
1985 - 1989	52.19	10.03
1990 - 1994	53.71	10.60
1995 - 1999	55.50	10.98
2000 - 2004	59.59	11.14
2005 - 2009	57.75	11.29

For the Liverpool case study, the analysis is summarized in Table-5. There was a slightly yearly average raise in temperature by 0.04 °C from 1985 to 2009, whereas the precipitation slightly decreased by 0.3mm per year starting from 1980 until 1999, and then climbed up averagely by 0.9mm per year from 1995 until 2004. This was followed by a slight precipitation drop starting from year 2005.

Table-5. Mean precipitation and mean temperature in Liverpool from year 1980 to year 2009.

Year Duration	5 years duration Mean Precipitation (mm)	5 years duration Mean Temperature (°C)
1980 – 1984	72.38	10.25
1985 – 1989	70.37	9.86
1990 – 1994	66.46	10.39
1995 – 1999	65.77	10.64
2000 – 2004	74.84	10.64
2005 – 2009	73.58	10.88

For the case of Aberdeen Gardens, the analysis is summarized in Table-6. It can be observed that averagely the temperature in Aberdeen Gardens kept decreasing from year 1980 until year 1999 with a rate of 0.06 °C per year, but there was also a slight increase of temperature starting from year 2000 to year 2004. For the precipitation, it was observed that a slight increase was found within year 1980 to year 1999, but it dropped slightly since year 2000 and raised up again from year 2005.

Table-6. Mean precipitation and mean temperature in Aberdeen Gardens from year 1980 to year 2009.

Year Duration	5 years duration Mean Precipitation (mm)	5 years duration Mean Temperature (°C)
1980 – 1984	1.32	7.21
1985 – 1989	1.33	6.74
1990 – 1994	1.55	6.73
1995 – 1999	1.71	6.05
2000 – 2004	1.51	6.43
2005 – 2009	1.55	6.33

Figure-2 and Figure-3 show the temperatures and precipitations variation for Melbourne, Oxford, Liverpool and Aberdeen Gardens over year 1980 to year 2009. The observed temperature range was within 4 °C to 16 °C. Whereas, the precipitation range varied from 0mm to 80mm. However there was an obvious difference in temperature patterns between those locations. This was due to the latitude of Melbourne which is situated below the equator, whereas Oxford and Liverpool are not only neighborhood but further located above the equator. Oxford and Liverpool seems to have almost similar temperature and precipitation patterns. The difference between the latitude of those two places is only 1.7°.

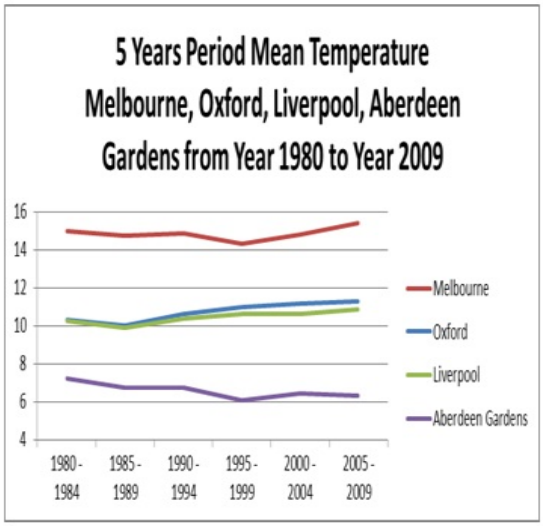

Figure-2. Temperature variation for Melbourne, Oxford and Liverpool over year 1980 to year 2009.

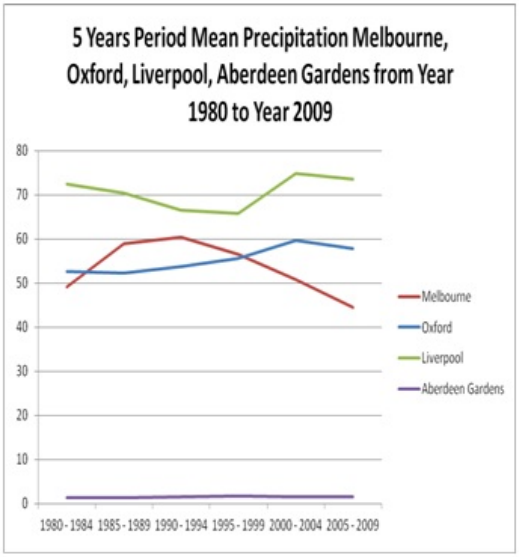

Figure-3. Precipitation variation for Melbourne, Oxford and Liverpool over year 1980 to year 2009.

CONCLUSIONS

This study is about understanding climate type Cfb within the years 1980 to 2009. Four locations were investigated, namely, Melbourne, Oxford, Liverpool and Aberdeen Gardens.

As a conclusion, it was observed that the variation in terms of temperature and precipitation projected over years for climate type Cfb depends on the geographic location such altitude, latitude and other factors. Further investigations are needed to understand the wind, and humidity patterns of those locations.

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