Human Outdoor Thermal Comfort Analysis for the 2 Australia and New Zealand 2023 Women's FIFA World cup

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ABSTRACT

Over the last century many indices have been developed and used to assess thermal comfort conditions for humans. Such indices are used sporadically for specific purposes; some are based on generalized results of measurements some on the empirically observed reactions of the human body to heat stress. Indices that are based on considerations of human heat balance are referred to as "rational indices". This paper presents a comparative analysis of the Thermal Comfort Index *via* Principal Components (PCTCI) and some of the most prevalent thermal comfort indices. So it is explored, in this work; some well-known classic methods to calculate thermal comfort, contrasting them with a method proposed here that is based on the Principal Components Analysis for some of the host cities of the 2023 FIFA Women's World Cup's in Australia (Asian Confederation) and in New Zealand (Oceania Confederation). The principal components analysis takes into account the natural outdoor urban space, which is influenced by the external atmosphere variables. The purpose of the comfort index is to measure the atmospheric variability and the result shows whether thermal comfort increases or decreases from one month to another or seasonally. Considering the predominant climate characteristics of Australia and New Zealand, it is possible to identify that among classical and canonical urban thermal comfort indices investigated. The Principal Component Thermal Comfort Index (PCTCI) provides convenient evidence to be also appropriate. The overall vision of the final results of the study is related to the equivalence between the classical climate-dependent thermal comfort indices and the proposal of a self-explanatory index by the linear combination of the atmospheric variables, which captures the greatest joint variability, without a pre-efined equation, but rather by the construction of an empirical equation, with regional coefficients. The observed climate variables determine, locally, the thermal comfort experienced by humans. Furthermore, similar to the human body, the PCTCI is very sensitive to changes in climate variables: temperature, solar radiation, wind, andhumidity. The PCTCI depicts the temporal variability of thermal conditions like the other indices, but in a more user-friendly way.

Keywords: Thermal Discomfort Index (TDI); Standard Temperature and Humidity Index (THI); Effective Temperature Index (ETI); Effective Temperature as a function of Wind Index (ETWI); Principal Component Thermal Comfort Index (PCTCI)

INTRODUCTION

As designed in and motivated by Lucio and Gomes for the 2022 FIFA Men's World Cup, in this paper is presented some information about human thermal comfort for the 2023 Women's FIFA World Cup. The competition will be jointly hosted by Australia and New Zealand, and is scheduled from July 20 to August 20, 2023. The human well-being can be directly

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affected by the urban weather and climate. The studies related to urban thermal comfort are important to help in the planning and management of urban space, contributing to the development of more thermally pleasant environments, especially in cities affected by a marked combination of air temperature, air relative humidity, wind speed and solar radiation. It is also worth ention that these indices express likely measures for the feeling of thermal comfort that tries to cover most of the human population, based on some atmospheric variables. One knows that human thermal comfort indices are vital tools for assessing outdoor thermal comfort in tropical and subtropical open space (outdoor) environments. There are several studies that introduce and evaluate thermal comfort indices. However, the selection of a thermal comfort index, which portrays the real human sensation, is a challenge, especially for the evaluation of outdoor thermal comfort. The urban open spaces provide a variety of activities such as sports, recreational activities, biking and outdoor walking for a variety of purposes. When using these spaces, people are exposed to atmospheric conditions that interfere with in their sensation of thermal comfort. In order to evaluate thermal comfort in these environments, indices are developed from the combination of influential variables, seeking to translate, through objective measurements, the feeling of comfort perceived by humans. Saud Ghani et al. provides a comprehensive and rich literature review on human thermal comfort indices, where they mention and works of reference widely cited in scientific papers, the most recently published-these studies assess the outdoor thermal comfort conditions using several classic thermal comfort indices. Besides, one knows that comfortable and healthy outdoor microclimates are beneficial to sustainable urban development [1].

Some elements of the atmosphere are directly related to thermal comfort and, consequently, to the quality of life of the human population. Outdoor thermal comfort is the thermal neutrality perceived by a person. Moreover the environmental aspects, thermal comfort are also influenced by behavioral and physiological characteristics. Empirical thermal comfort studies aim to analyze and establish the conditions necessary for human satisfaction, allowing them to feel thermally comfortable in order to increase their physical and/or intellectual performance. Experts define the importance of thermal comfort studies, since studies show a clear trend that discomfort caused by heat or cold, reduces human performance in intellectual, manual and perceptual activities. The Temperature and Humidity Index (THI) and the Thermal Discomfort Index (TDI) are based on the conditions of the atmospheric variables: Air temperature and relative humidity; and are easy to be evaluated, especially at a comparative level. The Effective Temperature as a Function of Wind (ETWI) were chosen according to. The ETWI has the same theoretical basis and application as the ETI, as can be seen in differing from it only by taking into account the action of the wind. HUMIDEX, suggested by also employs these variables for warm climates and to conclude, as alternative, one proposes similar to a parsimonious robust alternative: The determination of a climate-based composite index by means of Principal Components hereafter referred to as Principal Components Thermal Comfort Index (PCTCI). The key-question about this

study is the insertion of the idea based on the empirical construction of an outdoor human thermal comfort index by means a linear combination of meteorological variables (of one's own choice), whose coefficients are determined by a method that capture the maximum variability among them. One knows that the thermal comfort derives from the interaction between environmental and personal variables; one way to express this feeling is through calculations that aggregate meteorological variables and convert them into thermal comfort indices [2].

MATERIALS AND METHODS

The climate of Australia and New Zealand are strongly influenced by general circulation patterns prevalent in the SW Pacific. Critical to the strength of this circulation is the temperature gradient between Antarctica and the SE Asian tropics, and between Antarctica and the Australian continent. The ocean plays a key role, since there are no major land masses between the South island of New Zealand and Antarctica. More regional circulations, such as El Niño Southern Oscillation, affect the climate patterns in this region.

New Zealand's climate is complex and varies from warm subtropical in the far north to cool temperate climates in the far south, with severe alpine conditions in the mountainous areas. Australia's climate is the driest of all inhabited continents, with considerable rainfall and temperature variability both across the country and from year to year.

In this paper one analysis the thermal comfort characteristic, based on the Climate Normal of some FIFA Women's World Cup 2023 host cities (Figure 1) [3].

Figure 1: Venues where the matches will be held for the 2023 FIFA Women's World Cup.

Auckland; Perth; Sydney; and Wellington metropolitan regions. Besides the conventional atmospheric variables: air temperature, air relative humidity and wind speed one also considerate the outdoor thermal radiation (W/m^2. μm) that is defined as the rate at which radiation of wavelength λ is incident on a surface, per unit surface area and per unit wavelength interval dλ around λ-also named thermal irradiation that is the term used to say that somebody is being exposed to thermal radiation. The dataset are presented at a resolution of 0.5° × 0.5° (50 km × 50 km 50 km grid), for the most recent climatology, 1991-2020, the dataset is from the high resolution grid datasets. The typical climate of

each one metropolitan region is illustrated as the climatology calculated from the 1991-2020 climatological normal, according to the International Standard Atmosphere model and the Climatic Research Unit (CRU) dataset of the University of East AngliaIn the graphs presented hereafter, as figure, the center line is the ensemble mean, also called climatological normal, and the dashed lines form the standard deviation intervals (mean centered interval-upper level plus (0.33, 0.66, 0.99) times the standard deviation and lower level minus (0.33, 0.66, 0.99) times the standard deviation).

In Perth, summer is warm and dry and winter is mild with precipitation, the weather is windy with almost cloudless skies-summer in Australia falls between the months of December and February. In Sydney, summer is warm and partly cloudy and winter is short and mild with almost cloudless skies. The average hourly wind speed in Perth undergoes small seasonal variations throughout the year. The air relative humidity in Perth does not vary significantly throughout the year. However, one should also mention the capital's climate; the average wind speed in Sydney does not vary significantly throughout the year. Sydney has significant seasonal variation in the air relative humidity [4].

New Zealand's summer season runs from December to February. In Auckland, summer is pleasant; winter is cool and rainy, the

weather is windy and partly cloudy. In Wellington, summer is pleasant; winter is cool, with precipitation and strong winds. The average hourly wind speed in Auckland undergoes significant seasonal variations throughout the year. Auckland has moderate seasonal variation in relative air humidity. The average hourly wind speed in Wellington has small seasonal variations throughout the year. The relative humidity in Wellington does not vary significantly throughout the year.

More recently, the interest in thermal control of outdoor environments had increased. The indices investigated, in this study for outdoor thermal comfort assessments, include various parameters, which are either directly measured or given by worldwide standards [5].

Temperature and Humidity Thermal Comfort Index (THTCI)

The classic THTCI establishes, basically, three levels of comfort for the external environment. The THTCI is an index that combines air temperature and relative humidity. The classic THTCI establishes, basically, three levels of comfort for the external environment. The THTCI is an index that combines air temperature and relative humidity (Table 1).

Table 1: THTCI classical thresholds.

21 ≤ THTCI (°C) <24	Comfortable
24 ≤ THTCI (°C) <26	Slightly uncomfortable
THTCI (°C) ≥ 26	Extremely uncomfortable

The Humidity Index (HUMIDEX)

The HUMIDEX is an index to describe how hot or warm the weather feels to the average person, by combining the effect of heat and humidity. HUMIDEX differs from the THTCI used in the United States in being derived from the dew point rather than the relative humidity, though both dew point and relative

humidity (when used in conjunction with air temperature) are directly related to atmospheric moisture. The calibration equation or transformation is applied in order to determine the relationship between the dew point temperature and the minimum temperature (Table 2).

Table 2: HUMIDEX classical thresholds.

HUMIDEX (°C) ≤ 20	Dangerous hypothermia
20 < HUMIDEX (°C) ≤ 29	Modest discomfort
30 < HUMIDEX (°C) ≤ 39	Discomfort
40 < HUMIDEX (°C) ≤ 45	Huge discomfort
HUMIDEX ≥ 45 (°C)	Dangerous hyperthermia

Thermal Discomfort Index (TDI)

The TDI also establishes a relationship between average temperature and humidity relative air humidity; however it has different comfort levels. The TDI does not consider discomfort

caused by cold. Distribution of TDI classes according to (Table 3). TDI is a physiological thermal stress indicator for people based on dry-bulb and wet-bulb temperature [6].

Table 3: TDI classical thresholds.

TDI (°C) ≤ 21	Comfortable

21< TDI (°C) ≤ 24	Mild comfortable (or mild discomfortable)
24< TDI (°C) ≤ 26	Partly uncomfortable
26< TDI (°C) ≤ 28	Uncomfortable (significant deterioration of the psychophysical condition)
28< TDI (°C) ≤ 32	Very strong discomfort
TDI (°C) ≥ 32	Severe discomfort

The Standard Effective Temperature Thermal Comfort Index (SETTCI)

The temperature calculated as a function of the dry bulb temperature and the wet bulb temperature. The SETTCI is defined as the temperature of a stable, saturated atmosphere that, in the absence of radiation, would produce the same effect as the conditions of the regular exposure to atmosphere conditions.

It indicates the combined effects of relative humidity, air speed, air temperature, and clothing. This is a modified method for assessing the impact of air humidity on air temperature conditions acceptable to and by humans. The SETTCI range, established empirically in the literature by experts (Table 4) [7].

Table 4: SETTCI classical thresholds.

SETTCI (°C) ≤ 20	Partly comforted
20< SETTCI (°C) ≤ 24	Comforted
24< SETTCI (°C) ≤ 28	Uncomforted
28< SETTCI (°C) ≤ 32	Discomforted
SETTCI (°C) ≥ 32	Strong discomfort

The Effective Temperature as a function of Wind Thermal Comfort Index (ETWTCI)

Effective Temperature as a function of wind is the temperature calculated as a function of dry bulb temperature, wet bulb temperature (relative humidity) and air speed. ETWTCI, besides also establishing a relationship between average temperature and relative air humidity, considers wind speed data, presenting eleven distinct ranges of thermal comfort levels. The first six ranges establish thermal sensations that go from very cold, with values lower than 5°C, to slightly cool, between 19°C and 22°C.

The seventh range presents itself as a transition between the conditions of discomfort by cold and discomfort by heat, evaluating the environment as comfortable when the sensations of comfort are between 22°C and 2°C. In sequence, it indicates the thermal sensations as being slightly hot, means warm, when temperatures range between 25 and 28, moderate hot for values between 28°C and 31°C, hot (warm) for values between 31 and 34 and very hot for values greater than 34°C. The range of ETWTCI, empirically established in the literature (Table 5).

Table 5: ETWTCI classical thresholds.

ETWTCI (°C) ≤ 5	Very cold (extreme cold physiological health stress)
5< ETWTCI (°C) ≤ 10	Cold (high cold physiological health stress)
10< ETWTCI (°C) ≤ 13	Reasonable cold (cold physiological health stress)
13< ETWTCI (°C) ≤ 16	Slightly cold (cooling of the body)
16< ETWTCI (°C) ≤ 19	Slightly cold (slight cooling of the body)
19< ETWTCI (°C) ≤ 22	Slightly cool (vasoconstriction)
22< ETWTCI (°C) ≤ 25	Comfortable (thermal neutrality)
25< ETWTCI (°C) ≤ 28	Slightly warm (little sweat, vasodilatation)

28< ETWTCI (ºC) ≤ 31	Moderate warm (sweating)
31< ETWTCI (ºC) ≤ 34	Hot (profuse sweating)
ETWTCI (ºC) ≥ 34	Very hot (thermoregulatory failure)

Motivated by the recently released UTCI project derived from the COST European Cooperation in Scientific and Technical Research which is a temperature equivalent (°C), based on the measure of the human physiological response to the thermal environment; the authors has introduced thermal radiation in the open environment as an input atmosphere variable, with the proposal to apply the optimal interpolation properties provided by the Principal Component Analysis methodology [8].

The Principal Component Thermal Comfort Index (PCTCI)

The Principal Component Analysis (PCA) is a multivariate technique that can be used to analyze interrelationships among variables and capture variability in terms of variance and its inherent dimensions, called components or factors. Principal components are empirical indices based on the construction of weighted linear combinations of the original variables, in the case of this study, climate based on atmosphere characteristics or measurements. In practice, they describe the variance and covariance structure of correlated variables in terms of a set of new uncorrelated variables. PCA purposes:

Transform the variables into new uncorrelated latent factors also called Empirical Orthogonal Empirical (EOF); extract the signal contained in the data (eliminate or reduce the noise present in the data and; construction of indexes, as latent variables. The goal is to find a way to synthesize the information contained in several original variables into a smaller set of synthetic variables (components) with minimal loss of information. The number of possible principal components becomes the number of variables considered in the analysis, but generally the first components are the most important since they capture most of the total variance [9].

Principal components, in general, are extracted *via* covariance matrix, but also can be extracted via correlation matrix, as in this study, due to the fact that the climate variables are different in nature or genesis (measurement unit). Once the components are characterized, they can then be used as latent variables to create an information score. Basic ideas in principal components analysis using the matrix spectral decomposition theorem, in terms of eigenvalues and related eigenvectors matrix decomposition. First, one determines the number of principal components that account for most of the variation in your data, using the proportion of variance that the components capture (get almost hold explain). Use the cumulative proportion to determine how much variance the principal components get it. Retain the principal components that capture an acceptable level of variance.

The intrinsic nature of the variables considered, together in a linear combination, based on the temporal support, will define the probabilistic thresholds of thermal comfort. PCTCI are empirical indices, which consider standard sources of variability, seasonal or intra-annual, related to local meteorological attributes behavior. The standard deviation range is important to indicate the margin of uncertainty (or inaccuracy) regarding a calculation that has been made. However, in this study, the standard deviation dispersion range is used to determine the thermal comfort threshold values. The standard deviation (stdev) measures the amount of variability, or dispersion, from the individual data values to the arithmetic average (mean). Besides the correct interpretation of the confidence interval is probably the most challenging aspect of this statistical concept. The proposed range of the PCTCI (Table 6) is based on the standard deviation (stdev) range, as an associated threshold, and assessed with reference to the traditional and classical indices previously presented [10].

Table 6: PCTCI cognitive thresholds.

PCTCI (ºC) ≤ (mean (PC1)–0.99*stdev (PC1))	Very uncomfortable (cold sensation)
(mean (PC1)–0.99*SD (PC1))<PCTCI (ºC) ≤ (mean (PC1)–0.33*SD(PC1))	Slightly comfortable
(mean (PC1)-0.33*stdev (PC1))<PCTCI (ºC) ≤ ((mean (PC1)+0.33*stdev (PC1))	Comfortable (thermal neutrality)
(mean (PC1)+0.33*stdev (PC1))<PCTCI (ºC) ≤ (mean (PC1)+0.99*stdev (PC1))	Uncomfortable with slightly warm (little sweat and vasodilatation)
PCTCI (ºC) ≥ (mean (PC1)+0.99*stdev (PC1))	Uncomfortable with moderate warm (sweating and heat sensation)

As already bring up, as very well established method by data science methods, the PCA is used in exploratory data analysis and for decision making in predictive models. PCA is typically used for dimensionality reduction, using each data point only in

the first principal components (in most cases first and second dimensions) to obtain lower dimensional data while maintaining as much of the variance of the data as possible. The first principal component can be equivalently as a direction that maximizes the variance of the projected data. Eigen decomposing the correlation matrix of the variables often analyzes principal components.

Principal component analysis, or PCA, is a dimensionality-reduction method that is often used to reduce the dimensionality of large data sets, by transforming a large set of variables into a smaller one that still contains most of the information in the large set. The goal of this paper is to provide logical explanations of what PCA is and to simplify mathematical concepts such as standardization, covariance, correlation, eigenvectors and eigenvalues, neither of the Spectral Decomposition Theorem, without focusing on how to compute them. But everything is computed using R software. Without further argument, it is the eigenvectors and eigenvalues that are behind all the magic explained above, because the eigenvectors of the Covariance matrix are actually the directions of the axes where there is more variance (more information) and which one calls Principal Components. The eigenvalues are simply the coefficients attached to the eigenvectors, which give the amount of variance carried in each Principal Component. In summary: Principal Component Analysis, or PCA, is a statistical procedure that allows you to summarize the information content of large data tables into a smaller set of "summary indices" that can be more easily analyzed [11].

RESULTS AND DISCUSSION

Concerning the confirmatory analysis of the AUS and NZEAL metropolitan regions, Thermal Comfort Indices, taking into account each index previously presented.

Figure 2 illustrates the Temperature and Humidity Thermal Comfort Index (THTCI) for the AUS and NZEAL metropolitan regions, throughout the year. Above the highest value for this index indicates a condition of extreme discomfort condition. The most comfortable months are from June to September (Figure 3).
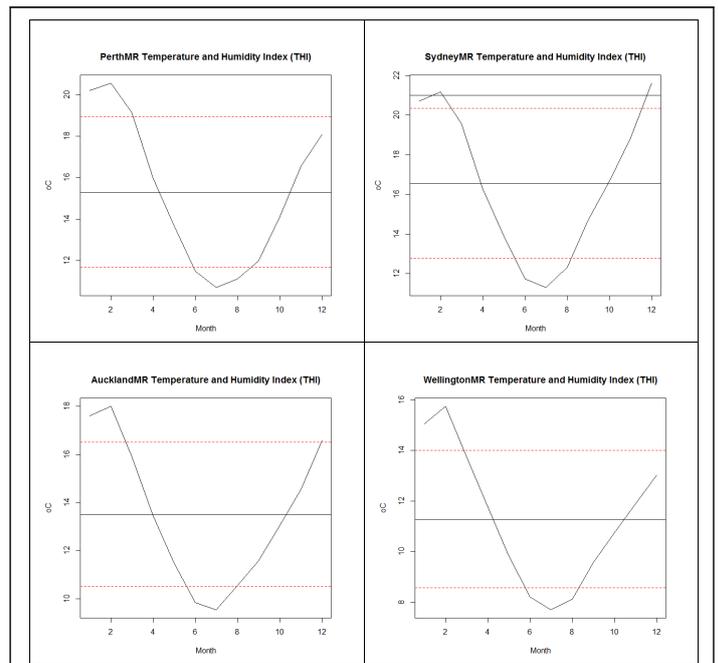

Figure 2: Temperature and Humidity Index (THTCI) based on the Climate Normal for some FIFA Women's World Cup 2023 host cities: Perth; Sydney; Auckland; and Wellington metropolitan regions.

Figure 3 illustrates the HUMIDEX for the AUS and NZEAL metropolitan regions, throughout the year. Above the highest value for this index indicates a condition of extreme discomfort condition. It corroborates that the most comfortable months are from June to September.
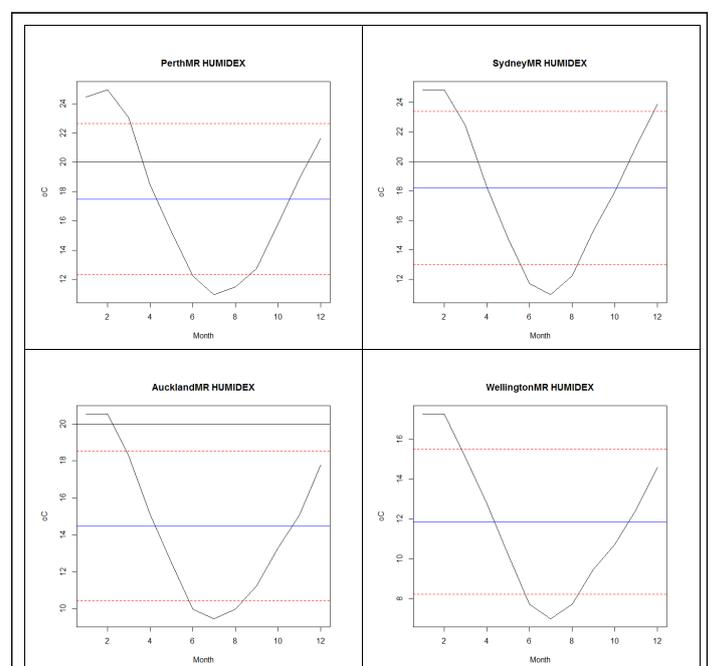

Figure 3: HUMIDEX based on the climate normal for some FIFA Women's World Cup 2023 host cities: Perth; Sydney; Auckland; and Wellington metropolitan regions.

Figure 4 evidences the Thermal Discomfort Index (TDI) for AUS and NZEAL metropolitan areas from November to March. Unlike the HUMIDEX index, it ignores the discomfort caused

by cold sensation. However, just like the other indices so far, it has confirmed lower values between the months from June to September. As well can be seen an extreme with the highest values of the respective index between the months December and March. This can lead to a risk of severe discomfort. Moreover, The Discomfort Index (TDI) indicates that it is increasing from February to June [12].
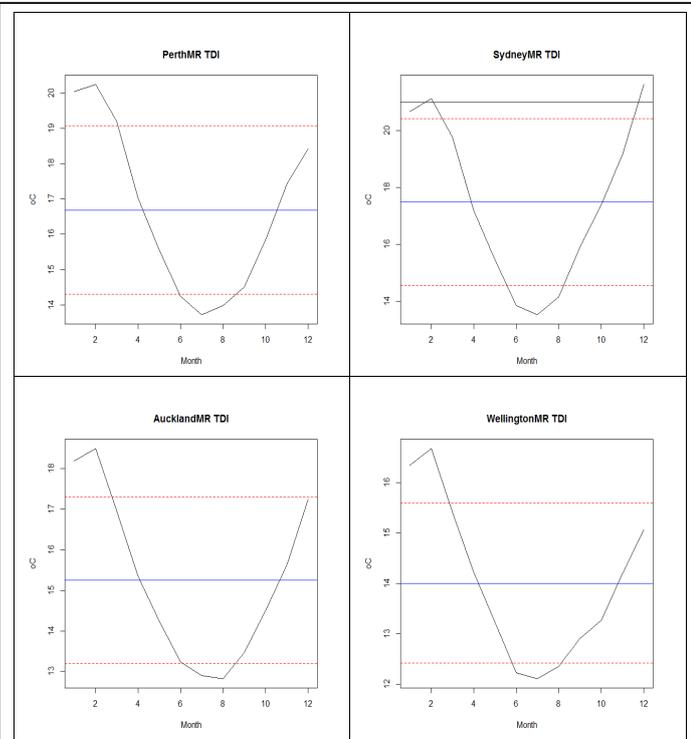

Figure 4: Thermal Discomfort Index (TDI) also knows as Thom Discomfort Index based on the climate normal for some FIFA Women's World Cup 2023 host cities: Perth; Sydney; Auckland; and Wellington metropolitan regions.

Figure 5 illustrates the Standard Effective Temperature (ETI) index for the AUS and NZEAL metropolitan regions, throughout the year. It indicates a peak for the month of February, in which temperature values are also higher. This indicates a behavior of the index similar to the others. Additionally, the ETI has a continuous growth until the month of August, with linearity in some months it reaches its highest value in February and after that a considerable decrease. It has regular discomfort values between January and March and inferior comfort values in the interval June to September. The climatology via ETI is similar to that found by TDI, with respect to the months with statistical significance and the fact that the mean values are also higher than the average, although it presents higher maximum amplitude than the TDI.
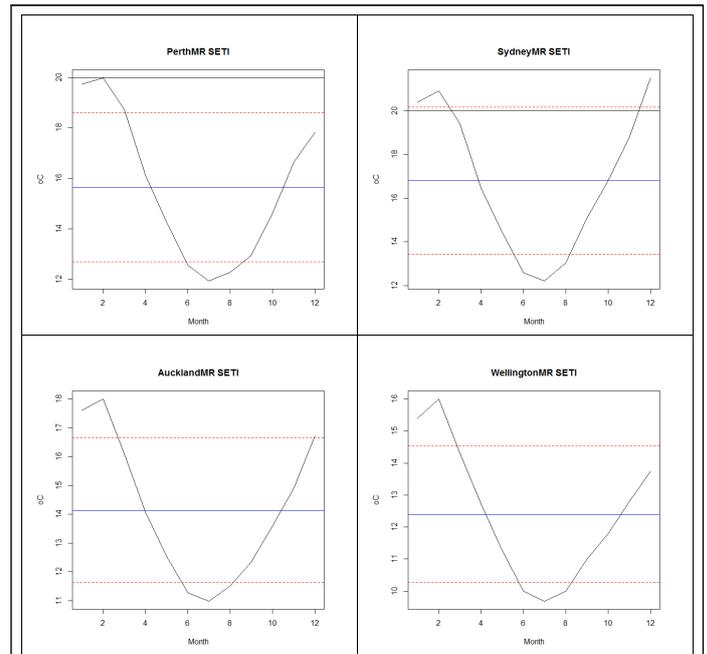

Figure 5: Standard Effective Temperature Thermal Comfort Index (SETTCI) based on the climate normal for some FIFA Women's World Cup 2023 host cities: Perth; Sydney; Auckland; and Wellington metropolitan regions.

Figure 6 give us an idea about the Effective Temperature as a function of Wind Index (ETWI) throughout the year. This index has values that start to increase from February to July and decreases from October to February. And so, like the other indices, the behavior of the curve follows a seasonal pattern, in which the higher temperatures are directly related to the highest values for this index. The climatology *via* ETWI is similar to that found by HUMIDEX, regarding the months with statistical significance, however it presents smaller maximum amplitude and the median values are higher than the mean, indicating a major asymmetry.
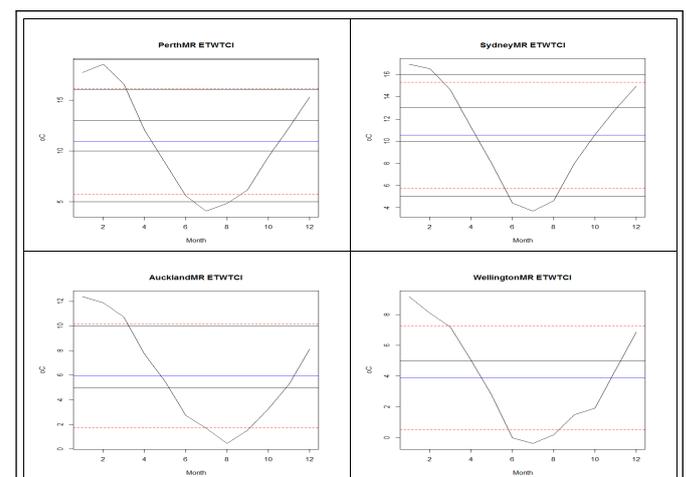

Figure 6: Effective Temperature as a function of Wind Thermal Comfort Index (ETWTCI) based on the climate normal for some FIFA Women's World Cup 2023 host cities: Perth; Sydney; Auckland; and Wellington metropolitan regions.

Regarding the Principal Components construction, the factor loadings schemeshows the results of the first two components. Figure 7 illustrates the Principal Component Thermal Comfort Index (PCTCI) throughout the year, based on the first Principal Component. This index has values that start to increase in October and decreases in January. And so, like the other indices, the behavior of the curve follows a seasonal pattern, in which the higher temperatures are directly related to the highest values for this index. The climatology *via* PCTCI is similar to that found by the others classic indices, regarding the months with statistical significance. The viability and suitability of the index proposed in this study, the PCTCI, was checked by contrasting it with the classic indices and considering a correlation coefficient greater than 95% [13].
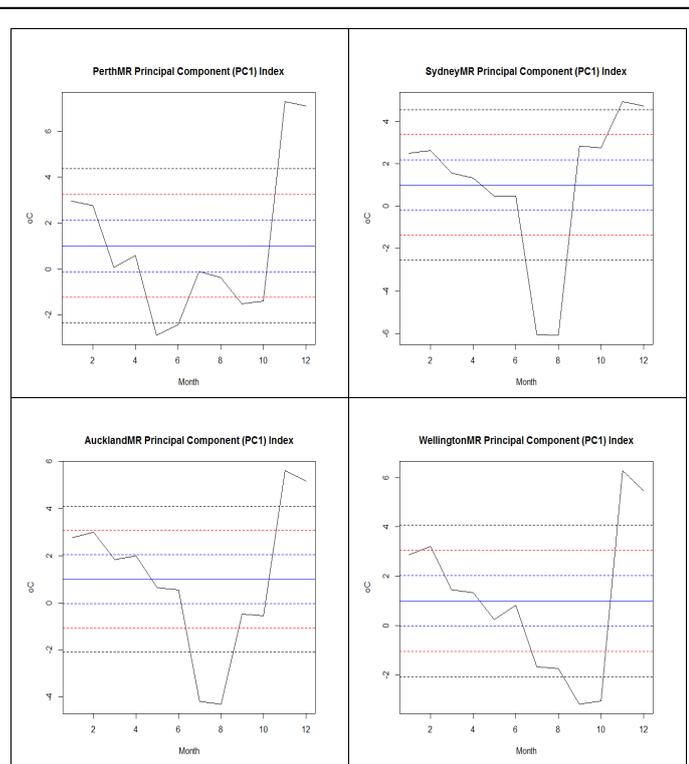

Figure 7: PCTCI based on the climate normal for some FIFA Women's World Cup 2023 host cities (from top to bottom and left to right): Perth; Sydney; Auckland; and Wellington metropolitan regions. The blue line is the ensemble average and the red dashed line is the standard deviation-based interval, and the solid lines are the thresholds established in the literature.

In multivariate statistics the "scree plot" is a graphic tool widely used to determine the number of factors to retain in an exploratory factor analysis or principal components to keep in a Principal Component Analysis (PCA), shows that the eigenvalues start to form a straight line after and in the third one principal component. If 95% (80% with respect to PC1 and 15% regarding to PC2) is an appropriate amount of the variation explained in the data, one should use the first two principal components. To interpret each principal component, examine the magnitude and direction of the coefficients on the original variables. The larger the absolute value of the

coefficient, the more important the corresponding variable will be when calculating the component. How large the absolute value of a coefficient needs to be in order for its importance to be considered subjective. Use the specialist expertise to determine at what level the value of the correlation is important. Concerning to the interpretation of the main results of Principal Component Analysis, the first two principal components have eigenvalues greater than 1. These two components have explained about 95% of the total variability [14].

Figure 8 illustrates the Orthogonal Principal Component Thermal Comfort Index (OPCTCI) throughout the year, based on the PC2. This index is orthogonal, by construction. And so, like the other indices, the behavior of the curve follows a seasonal pattern, in which the higher temperatures are directly related to the highest values for this index. Besides, the PC2 is time-lagged information for the beginning of the season of worst thermal comfort as an early warning for action [15].
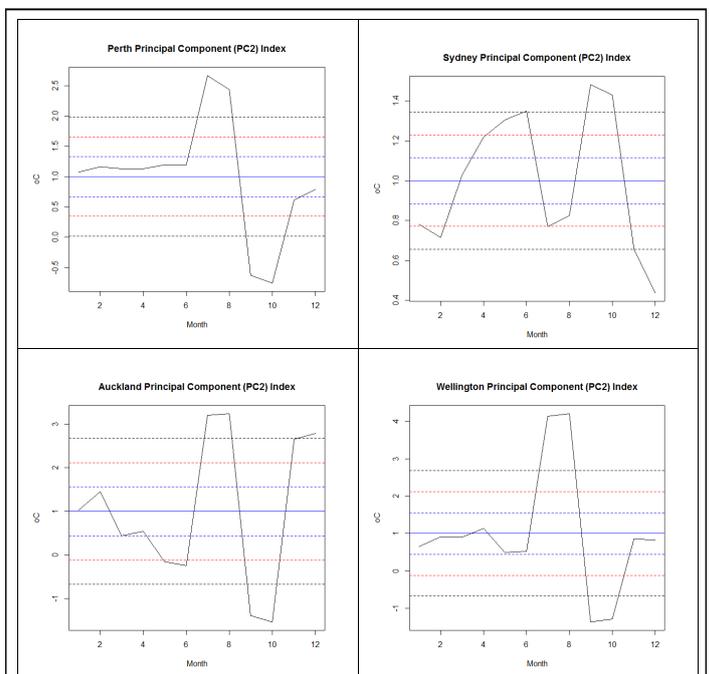

Figure 8: Orthogonal PCTCI based on the climate normal for some FIFA Women's World Cup 2023 host cities (from top to bottom and left to right): Perth; Sydney; Auckland; and Wellington metropolitan regions. The blue line is the ensemble average and the red dashed line is the standard deviation-based interval, and the solid lines are the thresholds established in the literature.

As point out, this work was motivated by the discussion in using the R language with the intention to support. As already bring up, as very well established method by data science methods, the PCA is used in exploratory data analysis and for decision making in predictive models. PCA is typically used for dimensionality reduction, using each data point only in the first principal components (in most cases first and second dimensions) to obtain lower dimensional data while maintaining as much of the variance of the data as possible. The first principal component can be equivalently as a direction that maximizes the variance of the projected data. Principal

components are often analyzed by eigen decomposing the correlation matrix of the variables.

CONCLUSION

In this work one has considered to investigate the objective thermal comfort indexes, which only consider environmental factors related to atmospheric variables. That is, the climate state of the atmosphere from the 1991-2220 climatological normal. Further studies should be done with the objective of assess the PCIDEX for other temporal support, period, location and climate. In addition, other atmospheric attributes not mentioned in this report may also be considered.

Principal Components are latent variables that are constructed as linear combinations of the initial variables. These combinations are constructed such that the new variables are uncorrelated and most of the information within the initial variables set is compressed into the first component. PCA tries to put as much information as possible into the first component, then as much remaining information into the second, and so on. One important thing to realize here is that Principal Components are hard to be interpreted and have the possibility of no real meaning, since they are constructed as linear combinations of the initial variables. Since there are as many principal components as there are variables in the data, the principal components are constructed such that the first principal (PC1) component represents the greatest possible variance in the data set, and in this and in this work the second component (PC2) was also considered, since given the time lag, this can be interpreted as an early warning to the period of the year of best thermal comfort sensation. As proposed in the justification and motivation of the research undertaken, in this paper one compares the applications of different indices of thermal comfort, considering data of temperature humidity and wind speed data. The results show that there was no difference in classification, regarding the region under study. This fact portrays the low climatic variability observed in the region. The 2023 FIFA Women World Cup will be held in the best time of year to visit the host cities, characterizing how pleasant the weather is in Australia and New Zealand throughout the year, based on the computed thermal comfort indices scores. The results highlight that, even in a very subtle way, distinct classifications of thermal comfort were obtained according to each index of thermal comfort, according to each index. It was possible to observe that the THI and TDI provided classifications closer to each other, and predominantly more extreme than the indexes ETI and ETWI. It is interesting to note that for the ETI and ETWI indices, in general, it was possible to perceive a change in the classification of measurements taken in the sun and shade, in the same periods, revealing their greater sensitivity to variations in the parameters. Furthermore, the index obtained by means of Principal Component Analysis (PCTCI) showed the same temporal

pattern as the TEWI, but with a better refinement of classification. This fact makes this index a viable alternative to the classic indices of thermal comfort. There is no difference that can be considered, of results between the indices! What one wants to emphasize is the concordance, which implies the co-existence of the indices! What one must pay attention to is the use of the index that is most appropriate for the study or investigation being carried out! At any moment of this work it was intended to critically comment on the indices, only in the simplest way, considering the Principle of Parsimony.

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