23rd International Congress of Biometeorology

International Society of Biometeorology

May 14-17, 2023

Tempe, Arizona, USA

ABSTRACT BOOK – POSTERS

ASU

Thank you to sponsors and partners

GOLD LEVEL SPONSORS

Thank you to sponsors and partners

MAROON LEVEL SPONSORS

SPRINGER NATURE

HeatReady PHX
OFFICE OF HEAT RESPONSE AND MITIGATION

CoolSeal by GuardTop

COPPER LEVEL SPONSORS

Thermetrics

Life Is On Schneider Electric

PARTNERING SCIENTIFIC NETWORKS AND SOCIETIES

GLOBAL HEAT HEALTH INFORMATION NETWORK

EMS

Poster Abstracts

Numbering scheme:

Animal Biometeorology 101-105	Climate and Society 201-210	Human Health and Epidemiology 301-303
Human Biometeorology 401-415	Plant Biometeorology 501-509	Urban Biometeorology 601-612

Animal Biometeorology Posters

ID	Title	Presenting Author
101	WITHDRAWN	
102	Thermal comfort thresholds for broiler chickens based on performance and physiological responses Broiler chickens have undergone an intense process of genetic selection in recent decades, which implies that animals are more sensitive to microclimate changes. Therefore the exposure to inappropriate meteorological conditions can cause thermal stress and negatively impact performance. The aim of this work was to study the thermal comfort thresholds for broiler chicks in the first two weeks of the rearing period (between 1 and 14 days of age). Six hundred broiler chicks (Cobb strain) were divided in two groups: 300 were submitted to thermal comfort ranges recommended by the literature - 33ºC / 60% from one to seven days old, and 28ºC / 60% from eight to 14 days; and 300 were submitted to 30ºC / 60% from one to seven days old, and 26ºC / 60% from eight to 14 days. The experiment was carried out at the Poultry Production Sector of Iguatemi Experimental Farm of the State University of Maringá, Brazil. The dry-bulb, wet-bulb and black globe temperatures were collected for the micrometeorological characterization. The cloacal and body surface temperatures of chicks were collected twice a day at 8:00 am and 04:00 pm and their body weight was registered at seven and 14 days old. No differences were observed ($p > 0.05$) for the cloacal and body surface temperatures ($P>0.05$) of the chicks and the average were respectively 40.8ºC and 29.7ºC. The body weight of birds was not influenced ($P<0.05$) by the microclimatic conditions (0.155 and 0.371kg at 7 and 14 days old respectively). We concluded that chicks can be reared at lower thresholds compared to the literature once there is no negative impact on performance and physiology of the animals.	Nascimento, Sheila

103	Shape factor and body orientation to sun of Holstein cows raised in a tropical equatorial environment During hot-sunny days animals adjust their body orientation in order to reduce surface area intercepted by solar beam. This study proposes a software (Sketchup®) to calculate the shape factor of quadruped animals. Moreover, we evaluated the body orientation to sun and shade-use behavior of Holstein cows in an equatorial semi-arid region. The validation was determined observing if the values of the shape factor for a horizontal cylinder estimated by a mathematical equation are in agreement with those calculated under field conditions using a cylindrical model and values simulated with the software. The shade of the cylindrical model on a horizontal surface, positioned in an azimuthal angle (ω) equal to 90° was determined under field and also simulated in the software at regular one-hour intervals, between 10:00 and 16:00h. The results showed that the mathematical equation and simulation performed by Sketchup® well calculate the shape factor for horizontal cylinders. We also observed that horizontal cylinders positioned at azimuthal angle of 0° had the lower shape factor, which results less solar radiation being intercepted. Indeed, Holstein cows kept in an equatorial semi-arid region, when exposed to solar radiation orient body axis more parallel to the sun (ω = 0°), even when it is close to zenith. In conclusion, the Sketchup® can be used to calculate the shape factor of cylindrical models. Dairy cows kept in equatorial regions prefer orient body axis parallel to the sun.	Fonseca, Vinicius
104	Carbon footprint of Italian buffalo milk evaluated at farm gate This study estimated the cradle-to-farm gate carbon footprint (CF) of buffalo milk produced in central Italy. Farm data were collected from 10 dairy buffalo farms, and the analysis included input data processes from crop production to on-farm raw milk refrigeration. The functional unit adopted was 1 litre of Fat Protein Corrected Milk (FPCM) evaluated at the farm gate. The soil greenhouse gas (GHG) emissions from on-farm crop production were estimated using a biogeochemical process-based model (DNDC) that simulates soil nitrogen and carbon fluxes dynamics starting from site-specific data input involving soil management and climate data. A farm-model tool involving farm-specific input data regarding animals, production, and farm management was developed to estimate the CH4 and N2O emissions from animals and manure storage. Finally, the life cycle assessment (LCA) software SimaPro 9.1 was utilized to estimate the CF contribution	Lacetera, Nicola

	of all the other inputs considered in the buffalo milk production process, such as extra-farm feed production, energy consumption (i.e., fuel and electricity), transports of raw material inputs, etc. The CF of a litre of buffalo FPCM evaluated at the farm gate accounted for 3.52 kg CO2eq, a result slightly lower than the lower value of the range found in the literature (3.68-6.1 kg CO2eq/kg FPCM). Enteric fermentation, was the primary environmental hotspot (45%), followed by extra farm feed production (27%), manure management (10%), fuel consumption (7%), soil emissions (6%), with all the other inputs (transports, production of mineral fertilizers and herbicide, electricity consumption, and refrigerant gas leaks) accounting for the remaining 5%. The study provided helpful information on the GHG burdens of buffalo milk evaluated at the farm gate. Identifying life cycle hot spots may support improving environmental policies and farmers' decision-making that may mitigate the contribution of dairy buffalo farms to global warming.	
105	Occupy ToadStreet: Occupancy and Habitat Use of the Arizona Toad in Streams of Arizona Late-breaking submission; no abstract.	Montgomery, Brett

Climate and Society Posters

ID	Title	Presenting Author
201	Evaluation of heat wave Predictability skills of Numerical Weather Models. This study evaluates the skills of sub-seasonal to seasonal heat wave prediction skills of Numerical models over the northern Nigeria. The data used were Numerical model data (hindcast and forecast data) of three different models namely, NCEP's CFsv2, UMO's GloSea5-GC2-LI, ECMWF's SEAS5 and ERA 5 reanalysis datasets. The data output of both the NCEP's CFsv2 and UMO's GloSea5-GC2-LI initialized at 5, 7, 15 and 30-day lead between year 2000 and year 2020 (21years data) were used, while the ECMWF's SEAS5 data used are at 30-day lead time of the same year range, the ERA 5 reanalysis was used to compare the skills of the models. The heat index used in this study is the excessive heat index (EHI). The EHI was used to characterize the occurrence of heat wave. Grid point specific deep learning classification model was developed using the output of the numerical model and lead-time as input. The results reveal that heat wave predictability skills of the three numerical sub-seasonal to seasonal models are lower in the entire region. At all lead times, the models tend to overestimate heat wave frequency though it is more pronounced	Akinbobola, Ademola

	in the NCEP's CFsv2 model. The ECMWF's SEAS5 and UMO's GloSea5-GC2-LI models also overestimates the heat wave frequency, but at a reduced rate (up to 44% decrease) from the NCEP's CFsv2 model. From the extensive analysis above, the UMO's GloSea5-GC2-LI model performs best of the three numerical model at 5-day, 7-day and 15-day time lead. While the deep learning classification model performs better than all the model at 30-day time lead. Keyword: Heat wave, predictability, reanalysis data, Numerical models, heat index	
202	Heat related mortality and morbidity as public health issues: Understanding effectivity of existing Climate Action Plans in South Asia Climate change and rapid urbanization are posing complex challenges to the society and environment across the globe. Heat-related health risks are especially significant in various parts of South Asia, owing to extreme heat coupled with high population density and resource inequality during the past two decades. The 2022 heatwave in India and Pakistan witnessed significant human casualties in the form of hyperthermia and other morbidities. In this context, we investigate the effectiveness of the national climate action plans (CAP) of India and Pakistan in addressing heat-related public health issues towards ensuring climate and health justice. We first analyze various definitions and attributes of identified risks, hazards, and vulnerabilities mentioned in CAPs through the dual lens of heat risk and public health. Our critique involves the argument of whether the CAPs are based on tropical meteorology or socio-political factors that play a more important role in shaping the priorities. We next look into the highly successful example of the Ahmedabad Heat Action Plan from India. Lastly, we critically examine the gaps and future potentials. Our study aims to inform the existing state of the art towards providing recommendations and guidelines on extreme heat mitigation in high-density cities from an epidemiological perspective.	Banerjee, Shreya
203	Estimation of summer heat stress in Balkan's Urban Environments The observed planetary warming results in the increasingly frequent occurrence of heat extremes, very often heat waves, one of the biggest threats to human health in connection with the climate. Even the Balkan Peninsula is not spared from these increasingly frequent disasters that often cause heat stress in the human body. Particularly vulnerable to extreme heat are urban environments where heat stress is more pronounced. The study aims to present estimation of summer heat stress in 3 urban	Pecelj, Milica

	environments in the Balkans, Ljubljana, Sarajevo and Niš. Research is focus on the occurrence of strong and very strong heat stress of the human organism. The research is conducted based on an hourly (14:00 CET) and "day by day" meteorological data set for 2012-2020 using UTCI index. The criterion of heat stress adopted in the study covered conditions in which the UTCI value was higher than 32°C.	
204	Serious games as a toolkit for understanding the need to adaptation to climate change in the neighborhoods. Strategy, serious games could be one of the most interesting and effective educational tools in climate change action methods. This is why interdisciplinary project Co-Adapt - Communities for Climate Change Action aims to develop an integration toolkit based on a computer game to support resiliency and citizen engagement in city-communities, empowering them in responding to new climate change challenges with bottom-up involvement. The game features simulations that allow local community to transform their neighborhoods into more resilient to the climate change. The game is adapted to local environmental and spatial conditions so people can play in a group on their real neighborhoods maps what stimulate higher motivation for participation in climate change transformation. They will explore various choices available for their neighborhoods (from wide, but limited and detailed range of solutions connected with green and blue infrastructure, renewable resources, climate-friendly changes of colors of facades and roofs etc.) and consequences (costs, savings, climatic benefits). The workshop toolkit integrates best practices collected from communities that are already involved in climate change actions in Norway, Denmark, Sweden, France or USA and which were visited by project' leaders. The pilot project will be carried out for six communities in Warsaw diversified in relation to exposure to urban heat island, flood risk etc., urban structure and socioeconomic factors. They were carefully chosen after consultations with Warsaw City Council out of the most active local communities and on city-owned land. City ownership is crucial because at the end of the game each of the community will gain some amount to implement some solutions from the game. Co-Adapt game is completely new idea of implementing science into the behavior of local communities to improve their living environment, to adapt to climate change and to mitigate this change.	Kuchcik, Magdalena

205	Development of a Spatial Synoptic Classification Scheme for East Africa with a Focus on Kenya Despite its wide array of applications, the utility of the Spatial Synoptic Classification (SSC) and proportional representation in the tropics remains limited. Much of the problem stems from the lack of available surface observation data and the initial development of the SSC in North American locations. There is an acute lack of SSC data across Central and East Africa. This research seeks to develop a Spatial Synoptic Classification using reanalysis data for East Africa with a focus on Kenya. Although some categories of the SSC may never be experienced in the tropical regions, the SSC is a useful tool to understand and predict weather-related effects on biometeorological variables related to health and ecology. Daily data (temperature, dew point, surface pressure, cloud cover, and wind speed/direction) at 6 hour intervals was analyzed in order to categorize Kenyan weather into types. Formal analysis is ongoing, but preliminary results show the expected dominant weather types of Dry Tropical and Moist Tropical with other weather types evolving.	Alaso, Daniella
206	CoSynHealth – Developing climate services for future urban health based on an urban system approach The health aspect is mostly overlooked in low-carbon or carbon-neutral scenarios for cities because they mainly focus on measures for reducing carbon emissions to mitigate climate change. However, urban planning as well as changes in lifestyles such as changes in the city structure to promote new mobility patterns, or the promotion of behavioral changes will likely affect health by changing the exposure to environmental stressors such as heat stress. At the same time, public health officials and city planners develop climate adaptation measures to reduce health risks and propose lifestyles to increase the health of urban dwellers in the future. However, a combination of climate mitigation and adaptation is required for a sustainable development of cities because Earth's climate will continue to change regardless of global efforts to reduce carbon emissions. The CoSynHealth project will close gaps between the climate mitigation research on the one hand and the climate adaptation research on the other hand by using the integrative urban system approach, which considers complex interactions between the urban environment, urban morphology, urban society, urban dwellers, and urban health. Based on this approach new climate services will be co-developed together with relevant stakeholders to fulfill the need for climate- and health-related information during the scenario	Hoffmann, Peter

	design process. In particular, high-resolution urban climate modelling and agent-based modelling will be integrated to determine the future exposure to heat stress and subsequently assess the impact of climate mitigation and climate adaptation measures on potential health outcomes at the neighborhood level.	
207	Climate information for Mostar travel destination (Bosnia and Herzegovina) - Bioclimatological postcard Weather and climate are of great importance for the vacation experience. It is recognized very often as the essential motivator for travel. From this perspective, the primary objective of the study is to present relevant climate and weather summer information about Mostar, the most popular tourist destination in Bosnia and Herzegovina. The study aims to present bioclimatic condition via bioclimatic postcard. The research is conducted into consideration of a twenty-one year daily set of meteorological data 2000-2020.	Pecelj, Milica
208	Exploring Air Quality in South Phoenix with Low-cost Sensors and Data Visualizations. Environmental change, urban land use, and industrial, agricultural, and transportation activities affect the quality of the air we breathe. Despite this, there has been a lack of research, and thus insufficient information, to understand the levels of air pollution experienced at finer scales within urban areas, making it difficult to address issues around pollution exposure and health. Those most vulnerable (e.g., children, those with respiratory illness, low-income) may be experiencing higher exposures. The aim of this research project is to monitor and analyze the air quality parameters of particulate matter <2.5 microns (PM2.5) and nitrogen dioxide (NO2), from real-time community-based sensors in the South Phoenix area. The sensors are largely deployed at elementary schools and community centers. Modular communication occurs through cellular data, and data is remotely accessed through a real-time API. Analyses take into consideration relevant factors such as weather, traffic data, and land use, which are key indicators of air pollution levels. Outputs include a community dashboard for schools, nurses, and teachers, leveraging statistical methods to analyze and compare the levels of PM2.5 and NO2 across time and space in relation to relevant predictors. A localized case study at school with seven on-campus sensors will be provided. The air quality network and case study provide comprehensive insight into the factors affecting air quality, children's exposure to pollution, and potential utility for health and learning in the region of South Phoenix. Data can also	Nair, Nethra Sunder

	be used for future research and policy development aimed at improving air quality.	
209	Spatiotemporal patterns of heat vulnerability in Reno city, Nevada, United States between 2000 and 2022 Reno city features the dry high desert biome of the Western Great Basin, which greatly influences its climate. It is denoted by low levels of precipitation to potential evapotranspiration. Since 1970, Reno has experienced a summer temperature increase of 10.9 degrees Fahrenheit, making it the fastest-warming city in the US. Despite Reno having the highest rate of Land Surface Temperature (LST) in the US, it is largely understudied. Little or no research exists to showcase and or map the effects of intense heat spatially and temporally. Therefore, this study assesses changes in heat patterns across 20 years. The resulting LST maps were utilized in the analysis of heat variation in the 20 years. Results indicated a rise in (LST) from 2000 to 2022 attributed to an increase in impervious surfaces and urban settlement as well as a loss in vegetation cover. An increase in impervious surfaces can be ascribed to a rise in urbanization. Sparse vegetation can be attributed to the replacement of vegetation cover by urban settlements and impervious surfaces. More so, increased impervious surfaces have more runoff water, which drains faster leading to less surface water for evapotranspiration. The replacement of vegetation with impervious surfaces if sustained would lead to the potential risk of frequent flooding and heat-related illnesses and deaths in Reno city. To address the problem of an increase in impervious surfaces, the study recommends the replacement of impervious surfaces with planted sections such as perennial beds to allow for storm water infiltration.	Macharia, Consolata
210	Heat response planning and strategies in Phoenix, Arizona This poster showcases new and ongoing efforts to protect the public from health dangerous associated with extreme heat in the hottest large city in the United States.	Litwin, Michelle

Human Health and Epidemiology Posters

ID	Title	Presenting Author
301	The impact of weather types on elderly mortality during heat waves in Brazil Exposure to extreme heat can be harmful to human health, especially in the elderly people. The Synoptic Spatial Classification (SSC) is a useful tool to assess the impact of weather effects on human health. The aim of this study was to evaluate the impact of weather types based on the SSC (Dry Polar (DP), Dry Tropical (DT and DT+), Moist Polar (MP), Moist Tropical (MT and MT+), Dry Moderate (DM), Moist Moderate and Transition (TR) during heat waves on the elderly mortality from respiratory and cardiovascular diseases in the 26 State capitals of Brazil. Heat waves were identified as three consecutive days with maximum temperatures above the 90th percentile between the period 1996 to 2016. Poisson regression was used and an interaction between the weather types and heat waves was held. The relative risk of mortality was computed for each weather type during heat waves versus days without heat waves. The DT+ and TR weather types were more oppressive in increasing mortality (33.2%) during heat waves throughout Brazil. In the Midwest region, the DT+ weather type was the most oppressive during heat waves, showing a 62% increase in mortality from cardiovascular disease and 50% from respiratory disease compared to days without heat waves. The DT+ weather type also showed a high risk of mortality from cardiovascular disease during heat waves in the South region (75% increase). In the Northeast region, the TR weather type was oppressive for elderly mortality from respiratory disease (46% increase). In the North and Southeast regions, the TR and DT+ weather types were oppressive as well, but less than the other regions. These results are concerning, since the TR and DT+ weather types are showing an increase in frequency over the years during heat waves in Brazilian regions, in which the stakeholders must be alerted.	Teixeira Gonçalves, Fabio Luiz
302	The Human Costs of Extreme Heat Events: An Analysis Using Los Angeles County's Integrated Data Base Background: Local governments are at the frontline to ameliorate the human impact of climate change. Timely local information remains sparse, even Los Angeles County's recent Climate Vulnerability Assessment relied on public use data that were years old. LA County departments themselves were not able to quantify and often could not even identify the impact of extreme weather on their operations	Sturm, Roland

	or their clients. This project builds on a recent data integration effort through the county's Chief Information Office to provide timely local data. Methods: The ongoing analysis focuses on how recent heat events has impacted County services, breaking down effects for various outcome by geography and population characteristics. We consider county-provided services across multiple departments, including health care, emergency rooms, fire department, emergency calls, social services, and the coroner. Several heat definitions, including the National Weather Service heat alerts and competing measures, are compared regarding their predictive power. Results: The analysis is in process. Initial results demonstrate both very localized effects and sociodemographic differences. Deaths examined by the coroner differ substantially from county-level statistics during heat events, identifying particularly vulnerable groups. Conclusion: Despite all the interest in "Big Data", data on the human impact of heat waves remains sparse and published results are largely limited to mortality statistics and some health care use. LA County's data integration makes a broader range of outcomes available and with far more detail. Identifying localized impacts of extreme heat will improve developing tailored solutions that reduce the negative consequences. Solutions often lie beyond the purview of an individual department and will require cross-departmental collaboration.	
303	Disease Associations to Heat Mortality in Virginia, 2005–2020 Based on an extensive database of patient-specific mortalities in the Commonwealth of Virginia from 2005–2020 (985,072 cases), we examine the diseases associated with heat-related mortality in 12 climatically similar regions in the state. Each mortality is assigned to one of 25 Major Diagnostic Categories (MDCs) based on the primary cause of death. Climate-mortality relationships were established in each region using a generalized additive model approach to determine the overall relationship to maximum temperature over a 21-day lag. For locations where mortality increased at high temperatures, we identify the threshold temperature and compare the MDC distribution on days that exceed the threshold to all other days (based on a bootstrapped sample with 1000 replications) using a chi-square test ($p \leq 0.05$). We found that 10 of the 12 regions exhibited no statistically significant difference in the MDC counts between the no stress and heat stress profiles. After running chi-square post-hoc tests on the two stations that had differences (Winchester and Roanoke), none of the MDC groups were significantly different between the two profiles. This result implies that the impact of heat on mortality is not disease-specific.	Roney, Patrick

Human Biometeorology Posters

ID	Title	Presenting Author
401	Gravity, Gravitational Strain & the Geo-Magneto-Electric Field An Ever-Changing Field Gravitationally driven Earth-Tides result in depression and upheaval of local terrain, ranging from approximately 5.5 to 11 inches. This ongoing depression and upheaval results in structural changes to the geologic substrate. Local Earth-Tide measures of gravitational acceleration (g) and subcomponents of g, gSun and gMoon, will be used to introduce gravitational strain calculation formulae. Evidence of correlated gravitational field change indicators and geo-magneto-electric field behavior patterns will be presented. Gravitational strain profiles will be used to better understand the impact of gravitational field changes and their correlations with geomagnetic frequency behavior. As a demonstration of concept, a horseshoe magnet was used to create a directional, magnetic frequency generator. Experimental results reveal preliminary evidence of a disrupted geomagnetic field, including evidence suggesting water could impact magnetic frequency generator disruptive behavior. Observational results will be presented to explore correlations among (a) gravitational field change indicators, and (b) correlated discontinuities in stable geomagnetic field activity and (c) frequency-based changes to the geomagnetic field. It is hypothesized that: (1) gravitational fields cause Earth-Tide deformations which alter the shape of the planet and thereby cause geologic substrate strain, and (2) which impacts the geomagnetic strain profile, which alters stable and frequency-based components of geo-magneto-electric field behavior. Data to support this theoretical framework and ground this theory in preliminary empirical evidence of gravitationally driven geo-magneto-electric field effects, will be presented.	Parks, Peter
402	Gravity, Gravitational Acceleration & Geo-Magneto-Electric Field Behavior Reduced Signal Variability & Anomalous Air Gas Polarization Events Is it possible to identify a methodologically sound strategy to explore the interrelationship of gravity and electromagnetism? Empirical evidence of correlated gravitational field change indicators, geomagnetic behavior patterns, and air gas polarization events will be presented. Gravitationally driven Earth-Tides result in depression and upheaval of local terrain, ranging from approximately 5.5 to 11 inches. This upheaval results in structural changes to the geologic strain dynamics. Do these structural	Parks, Peter

	changes impact the geomagnetic field? This report presents descriptive analyses of six (6) 24-hour data segments revealing correlated measures of gravity (gravitational change indicators), electricity (polarized air gas surge events), and geomagnetic activity levels. Data segments were selected from a month-long dataset spanning noon, 1 August 2020 through noon, 1 September 2020 based on correlations (r) of cations (positively charged air gas) and anions (negatively charged air gas). Data from the six (6) highest correlation coefficients were selected for analysis. Observational results will be presented to explore correlated signal discontinuities among (a) gravitational field change indicators, (b) changes in stable geomagnetic field behavior, and (c) polarized air gas surge events. Data analyses reveal numerous 2-factor (magneto-electric, gravity-electric & gravity- magnetic) and 3-factor (gravity & magneto-electric) correlations as well as a consistent pattern of reduced magnetic signal variability (i.e. reduced signal amplitude) during time of anion surges. These findings invite further exploration of geo-magneto-electric field behavior, and the interrelatedness of gravity, magnetic field behavior, and air gas polarization processes. Based on findings presented herein, it is hypothesized that: (1) gravitational fields, resulting in localized deformations of the planet and variations in acceleration, (2) produce measurable alterations in the geomagnetic field, which (3) are causally related to air gas polarization processes and associated sub-atomic (i.e., quantum), molecular transformations.	
403	Gravity, Gravitational Strain & Geo-Magneto-Electric Correlates of Anomalous Air Gas Surge Events It has been long known that air gas ions play an important role in life on earth: plant, animal, and human. Polarized air gas molecules affect humans through serotonin pathways. Magnetic fields also impact all life on earth. Bees utilize electric field sensing in their pollen gathering quest. A theoretical framework, designed to extend Michael Faraday's vision of an experimental strategy to identify correlated gravitational and electromagnetic fields, will be introduced. Evidence of correlated gravitational field change indicators, geomagnetic field behavior patterns, and anomalous polarized air gas surges will be presented. Local Earth-Tide measures of gravitational acceleration (g), and subcomponents of g, gSun and gMoon, will be used to explore correlated geomagnetic behavior and polarized air gas surge events. Gravitationally driven Earth-Tides result in depression and upheaval of local terrain (~5.5 to 11 inches) resulting in structural changes to the geologic substrate. This appears to cause changes	Parks, Peter

	to frequency-based components of the geomagnetic field. A gravitational strain profile will be used to explore correlations among (a) gravitational field change indicators, (b) changes to the geomagnetic field, and (c) polarized air gas surges. It is hypothesized that (1) gravitational fields cause Earth-Tide deformations to the shape of the planet and thereby cause geologic substrate strain, and (2) these deformations result in changes to geomagnetic substrate strain profile which alters geomagnetic behavior and (3) Earth-Tides and associated geomagnetic field changes are causally related to changes in polarized air gas behavior. Data to support this theoretical framework will be presented to ground this theory in preliminary empirical evidence of gravitationally driven geo-magneto-electric field effects.	
404	Spatial and Empirical Evaluation of Human Thermal Comfort Index using three different Empirical Methods over Nigeria Different approaches have led to the formulation of several indices aimed to reach a balanced compromise among a reliable assessment, an easy calculation and a reduced number of measurements. The aim of this study is to evaluate the thermal comfort index of some selected stations in Nigeria using three different empirical indices. It is apparent that the higher temperatures in both regions were recorded in the dry season than the wet season with the northern part having its peak value in March/April with a value of 330C and another peak value of 29oC in October/November for Sokoto while the southern part had its peak value in February/March for Enugu with about 29.5oC and the second peak recorded at Warri in November with temperature of 28oC. In comparing the results from the three (3) indices, we can obviously identify the close similarities between Thermo-hygrometric index and ETI model, unlike Humidex that exhibits some features that are totally different from the other two (2) indices.	Akinbobola, Ademola
405	A Weather-Based estimation Model of Malaria Prevalence in Akure and Lagos South West, Nigeria This work assesses the recent impacts of weather parameters (rainfall, relative humidity and Maximum and Minimum Temperature) on malaria prevalence using statistical methods of analysis. Monthly records of reported cases of malaria occurrence (Private and Public) and weather variables were collected in Akure and Ikeja from the year 2012 to 2021. The analysis was based on generalized linear models. The preliminary results showed that	Akinbobola, Ademola

	malaria positively related to rainfall and relative humidity with very strong value during the rainy season (May-October). Also, a temperature range was observed to enhance the prevalence of malaria revealing that at some temperature ranges, few cases were reported. In predicting the malaria occurrence, the forecast model showed that different meteorological factors have varying degree of contribution while minimum temperature is not a limiting factor in the prediction especially in Lagos. The weather-based malaria prediction model developed could be applicable in practice together with skillful seasonal climate forecasts and existing malaria surveillance data.	
406	Development and validation of an integrated thermal sensation scale for the assessment of thermal state during whole-body water immersion: A pilot study Introduction: So far there is not a widely acceptable definition of cold and hot water. This problem is multidimensional, since it arises from the difficulty in understanding the meaning of sensation, the variety of thermal scales and the difficulty in finding objective criteria that could separate physiological responses from deep internal interpretation. Aim of the study: The purpose of this study was to develop and validate an integrated thermal sensation scale for estimation of thermal load in water that relies on environmental physiology. Methodology: This research was based on a mixed methods approach. We identified domains and items for measuring thermal load and examined their content validity. Thereafter, we formed the integrated scale based on the ISO 10551 standard, and finally, conducted a pilot study for the scale validation utilizing a 30 min head-out water immersion at 26oC in healthy females (n=4) and males (n=4) (age: 22.6 ± 8.0 years, body mass: 67.7 ± 9.5 kg, height: 169.0 ±5.6 cm). Results: We identified 3 aspects (environment, physiological and behavioral thermoregulation) and a total of 18 items, of whom 8 items (water temperature, water immersion duration, core temperature, skin temperature, body heat storage, shivering, thermal sensation, thermal comfort), that were valid in terms of scale-level content validity index (S-CVI = 92%), were incorporated in our scale: icy <12oC, cold 12-24oC, cool 24-29oC, neutral 29-38oC, warm 38-43oC, hot >43oC. Facet validity was excellent as proved by a homogenous cool feeling. Construct validity (Confirmatory Factor Analysis = 0.64), and test-retest reliability (weighted kappa coefficient = 0.65) were satisfactory. Conclusion: Our validation study revealed that our model could characterize aquatic thermal load though whole-body thermal sensation based on well-established thermoregulatory mechanisms. Further research is	Ntoumani, Maria

	needed to validate the accuracy of our behavioral model in a variety of water temperatures and in larger sample size. Keywords: whole-body water immersion, behavioral thermoregulation, thermal sensation, validation	
407	Outdoor thermal comfort in urban green space during summer in humid subtropical climate: Chandigarh, India. Green spaces are a quintessential part of cities. They essay an array of ecosystem services including the fulfilment of passive and active recreational needs of the populace. This study examines the micrometeorological conditions prevalent in green spaces and the associated thermal perception through concurrent field surveys. The study was conducted in Asia's largest Rose garden - Zakir Hussain Rose Garden located in Chandigarh (30°44′ 11″ N, 76°47′ 18″ E), India. 277 respondents were surveyed regarding their thermal perception during summer in 2018. The outdoor thermal comfort conditions associated with different landscape configurations were evaluated based on the Physiological Equivalent Temperature (PET). Obtained results indicate that the landscape configurations and shade attributes of the sampled locations play a crucial role in influencing respondent thermal perception. Further, the study highlights the distinct thermal sensitivities among respondents based on their residence time in the city. The finding thus underscores thermal adaptation among residents.	Suneja, Manavvi
408	A comprehensive clothing model to simulate the heat transfer in skin-clothing-environment system Introduction: The human thermoregulation system continuously interacts with the surrounding thermal environment to maintain normothermia. The thermal interaction between the human body and environment is affected by the clothing layer and resultant air layers (boundary and enclosed air layers) since most skin-surface area is typically covered by clothing. Therefore, the function of clothing is not limited to appearance or social aspects, but it also affects the thermal balance and has major role in maintaining thermal comfort and protection. To-date clothing models provide oversimplified consideration of enclosed air layers that may lead to up to 30% underestimation of heat exchange through clothing. In this study, we will present a comprehensive clothing model including effect of spatial heterogeneity of air layers and human movement on heat transfer with great focus on thorough systematic validation. Method: The developed model considers	Joshi, Ankit

	the spatial heterogeneity of air layers and their effect on free/forced convection, radiation, conduction, moisture diffusion/evaporation, and condensation in a multi-layered clothing ensembles. In addition, the model is able to simulate the effect of human movement (e.g., walking) on convection and ventilation, which significantly affects heat transfer. The presented model is systematically validated based on thermal manikin and thermal cylinder data for various ambient conditions, clothing types, and static (seating/standing) and dynamic (walking) conditions. Results: The model enabled to gain further insights about the effect of the clothing fit, design, and fabric properties on local heat transfer and thermal comfort for real-life situations. The model showed good agreement with measured data with an average relative error of 12%. Conclusion: The findings of this study can serve as a research and design tool for many research fields, e.g., thermoregulation models, thermal comfort studies, and clothing research, where analysis of the interaction between thermal environment and human body is in focus.	
409	Cell phone based application for exploring thermal perception in urban areas: case of Prague-Holešovice district Manifestation of climate change together with increasing urbanization call for more efficient solutions in urban planning. Most of the studies regarding thermal comfort research are based mainly on thermal conditions. Nevertheless, according to the human-oriented paradigm it becomes apparent that thermal comfort is largely affected by mental component which is usually neglected. In this contribution, we introduce a simple cell phone (based) application, which provides reporting of actual thermal sensation vote of a control group of respondents and presents first results for Prague-Holešovice district (Czech Republic) which can be further analyzed statistically in context of several other recorded and simulated environmental as well as mental factors. First results revealed arterial roads and exposed concrete areas as mental hotspots. Results also suggest that particular areas including a peninsula with a river port, a waterfront or one of the parks were perceived differently then we could expect. Eventual findings of this study ought to be taken into account, together with the thermal exposure, in planning effective heat stress reduction measures in urban areas.	Lehnert, Michal

410	Seasonality related differences in cognitive responses of patients with coronary artery disease Background. Seasonal fluctuations in human cognitive function have been suggested (Brennen T., 2021) and environmental factors might explain such variations. The study aimed to evaluate seasonality-related differences in cognitive responses of individuals with coronary artery disease (CAD) during cardiac rehabilitation (CR). Subjects and methods: This cross-sectional study included 1241 individuals with CAD (mean age 57±9 years, 288 women, 23.2%) attending CR within two weeks of receiving treatment for the acute coronary syndrome. Cognitive functioning testing included the Digit Span Test (DST) to measure patients' auditory attention and mental flexibility; Digit Symbol Substitution Test (DSST) to measure psychomotor ability, speed and visual-motor coordination; and Trail Making Test Part A (TMT-A) to measure perceptual speed, and Part B (TMT-B) to measure cognitive flexibility. Mini-Mental State Examination (MMSE) was used to screen the global cognitive functioning (25-30 score: normal cognition). New York Heart Association (NYHA) functional class, age, and education were included in a linear regression analysis to identify independent predictors of each test score. Results. Aggregating the data by two seasons we found a subtle seasonal variation in cognitive functioning with better performances in summer/fall compared to winter/spring. Individuals with CAD and cognitive impairment (as defined by the MMSE score < 25) scored significantly worse on cognitive flexibility (TMT-B) tasks in winter/spring versus summer/fall (β=-0.219, p=0.035) seasons. Individuals with CAD patients with MMSE scores ≥ 25 performed significantly better on auditory working memory (DST): Backward span (β=0.064, p=0.034) task in summer/fall compared to winter/spring. Conclusion. Seasonality slightly affects individuals with CAD cognitive functioning. If performance tests are not to be repeated in different seasons, attention needs to be given to the most appropriate season to test.	Martinaitiene, Dalia
411	Simple and cost-effective setup for quantifying convective correction for mean radiant temperature measurements using cylindrical radiation thermometers Cylindrical radiation thermometers (CRTs) are cost-effective devices for measuring the mean radiant temperature (MRT) in outdoor settings. The devices consist of a small metal pipe with a centrally placed thermocouple measuring the CRT temperature (Tcrt) that is secured using epoxy. MRT is calculated from	Rykaczewski, Konrad

	absorbed radiation, Ra, which is equal to the sum of the radiation emitted, Rem, and the convective heat transfer of the surrounding, Qcon. If the exterior of the CRT is at a uniform temperature, Ts, that is equal to the internally measured Tcrt, we can then calculate: Ra= Rem+ Qcon= els(Tcrt+273.15)4+h(Tcrt-Ta) Where Ta is the air temperature and h is the average heat transfer coefficient for the cylinder surface. The latter value is calculated using correlations based on average air speed velocity. However, such correlations fail to account for turbulence of the incoming air, which can at times be double the h value. While the turbulence intensity and length scales can be quantified, expensive high-speed anemometers are required for the task. To avoid turbulence related errors in MRT measurements and the need to acquire expensive anemometers, this study introduces cost-effective heated cylinders that can be used to directly measure h. The devices consist of a polished aluminium thin-walled pipe with the same external dimensions as the CRT. A constant power flux Q" is provided to the inside wall using two thin-film heaters while a micro-thermocouple measures the wall temperature, Ts. Accordingly, we can quantify h as Q"/(Ts-Ta). We describe the calibration of these devices in wind tunnels with low and medium turbulence intensity and application in field conditions along with CRTs, benchmarking against integral radiation measurements using MaRTy. These cost-effective devices will facilitate quantification of the entire heat load on a human in multiple urban locations rather than temperature and humidity alone.	
412	Outdoor Mister Systems' Water Usage and Cooling Effectiveness With the increase in the severity of drought conditions in the Southwest region of the U.S. paired with rising temperatures, it is becoming increasingly important to look at the systems used to keep people cool in large cities, such as in Phoenix, Arizona. One method employed by businesses is the use of outdoor misting systems, which rely on the evaporative cooling effect of water. This study examines the relationship between misting droplet size, water usage, and thermal comfort using these low-pressure misting systems, tested within hot and dry conditions representative of the arid U.S. southwest. A model misting system using three nozzle sizes was set up in a controlled heat chamber environment (starting baseline conditions of 40°C air temperature and 15 % relative humidity were used). Droplet size was measured using water-reactive paper, while water use was determined based on weight-change measurements. These measurements were paired with temperature and humidity measurements	Johnson, Trevor

	observed in several locations around the chamber to allow for a spatial analysis. Thermal comfort is determined based on psychrometric changes within the room that include both temperature and humidity changes. On average, air temperatures decreased between 2 to 4°C depending on droplet size and sensor location. These data allow for recommendations to be made to businesses and people in the community to select misting systems that save water while providing thermal relief.	
413	Sensitivity Analyses of Instruments for Microclimatic Measurements to Observe Park Cool Island in Tropical Climates: A Case Study in Singapore Many modern cities around the world today are experiencing urban overheating due to a combination of anthropogenic climate change and the urban heat island (UHI) phenomenon. This has resulted in urban areas experiencing higher ambient temperatures, which has extensive implications on energy demand, human-health and well-being in cities. Nature-based solutions (NBS) have been proposed to improve urban resilience, such as setting aside areas of green parks within a city. These parks provide a cooling effect known as the 'Park Cool Island' (PCI). This study deployed 18 MX2301A Honest Observer by Onset (HOBO) Temperature/RH Data Loggers around Bishan-Ang Mo Kio Park in the hot humid tropical city of Singapore to 1) measure the extent of PCI and 2) observe the differences in responses with and without a RS1 Solar Radiation Shield setup. We conducted the experiment during September 2021 to December 2021 without radiation shields, and January 2022 to November 2022 with radiation shields. Ten MX2301A sensors were set up inside a public park, and eight in the surrounding urban high-rise area. Further, we spatiotemporally analysed the study area using ArcGIS Pro, and observed lower air temperature (Ta) observed within the park compared to the surrounding urban areas. The dataset with the radiation shields recorded lower ranges of Ta and relative humidity (lower maximums and higher minimums). These results aim to reveal the extent of the PCI in tropical cities, and how effective parks and greenspaces are in reducing urban temperature. The study is further capable of informing the effectiveness of using these measurement apparatus to observe micro-climatic variables, while also complimenting the lacking literature on UHI and heat mitigation in tropical environments. Inferences obtained from this case study could also be useful in improving outdoor thermal environment in cities using NBS.	Yik, Sin Kang

414	Performance evaluation of ENVI-met for seasonality in a tropical urban medium-sized park Rapid urban development and climate change has resulted in urban overheating in many cities across the world. Singapore, a tropical city-state in Southeast Asia, is no exception to this phenomena. Nature-based solutions (NBS) through the provision of publicly accessible urban green parks is increasingly a popular measure to improve urban resilience and mitigation against heat within cities, given its space constraints. The 2030 Singapore Green Plan aims to expand green spaces by up to 1000 hectares as a continual effort to pursue its “City in a Garden'' vision. To assist in the effective execution of such ambitious plans, the relevant agencies have explored various models that can help optimise the deployment of green spaces. ENVI-met (version 5.0.3) is a robust microclimate model that can be used for planning and estimating the cooling benefits from implementing park expansion in dense cities. We evaluate the model performance by simulating Bishan-Ang Mo Kio (BAMK) Park, a medium-sized 62 hectare linear park situated in a densely populated residential area. In other studies, simulations have input boundary conditions for specific days which may not be representative of the seasonality of the area. In this study, our simulation was forced using seven weather types that are representative of the meteorological conditions of Singapore’s tropical hot-humid climate. This allows us to investigate the extent of park cool island for a tropical urban medium-sized park, accounting sufficiently for typical days in the Southwest (SW), Northeast (NE) monsoon and intermonsoon periods. The model is validated using field measurements collected between January 2022 to December 2022. These results show that while ENVI-met is a useful model to project air temperature outputs for urban planning considerations, it is important to input representative boundary conditions and validate the model to account for the seasonality in the respective study areas.	Ching, Graces
415	Residents’ summertime thermal perception in diverse urban parks in Warsaw, Poland Urban green spaces are well known to improve thermal comfort under hot weather conditions. However, the magnitude of the cooling effect of different types of urban parks in Poland has not been fully understood yet. In this study we aim to determine how thermal perception of Warsaw residents varies depending on the type and size of urban park. More than 1200 visitors were surveyed in August 2022 in the 6 selected urban greenery complexes, differing from each other in the covered area, land use	Lindner-Cendrowska, Katarzyna

	type, presence of the water body, as well as the age and tree species composition. In every location, thermal perception researches were carried out at two sites - in full sun and in the shade of trees. Individuals' thermal comfort assessment and preferences towards particular weather elements were compared with measured meteorological parameters and UTCI values. The possible impact of actual physical activity and clothing habits of interviewees on their thermal sensations were controlled as well. Our study provides empirical evidence to what extent shading by trees can be efficient strategy in thermal stress reduction during summer in moderate climatic zone. What is more, better understanding how various park arrangements may affect residents' thermal perception can assist the city authorities in designing and revitalizing green areas to better adapt to climate change.	

Plant Biometeorology Posters

ID	Title	Presenting Author
501	Detecting changes in aspen phenology due to variations in environmental conditions in SE Wyoming Aspen, like most deciduous trees growing in Wyoming, shed their leaves in autumn to conserve resources. This is in response to lower sunlight and dropping temperatures and is termed as leaf drop. When the duration of sunlight and temperature increase in spring, new leaves start growing which is termed as budburst. The timing of the appearance of new leaves in spring and their drop in fall is important because many wildlife depend on aspen. The phenology of aspen trees is linked to physical parameters such as sunlight, temperature, precipitation, wind, and others. Within and between year changes in climatic conditions can alter the phenology of aspen trees, which can impact other wildlife and the environment in which they grow. This study analyzed the effect of duration of sunlight, temperature, precipitation, elevation, slope, and aspect on the budburst and leaf drop in aspen trees in Medicine Bow-Routt National Forests, Wyoming. The ground locations of aspen trees were obtained from US Geological Survey's National GAP maps. Normalized Difference and Enhanced vegetation indices derived from Moderate Imaging Spectrometer (MODIS) imagery data were used for estimating budburst and leaf drop data of the trees. The twenty years of satellite and environmental observations were analyzed using data science methods to determine changes in budburst and leaf drop times in aspen trees.	Sivanpillai, Ramesh

502	Effects of urbanisation, temperature and air pollutants on pollen production of three allergenic species Climate change is believed to alter pollen production of many woody and herbaceous plant species. In this study, we investigated pollen production of three anemophilous species, i.e., Betula pendula, Plantago lanceolata and Dactylis glomerata. We sampled plant material along an urbanization gradient in Ingolstadt, Germany, and analyzed pollen production estimates with regard to the potential influencing factors urbanization, air temperature and the air pollutants nitrogen dioxide (NO2) and ozone (O3). In order to obtain NO2 and O3 concentrations, we established a land use regression model. Pollen production of B. pendula and P. lanceolata was significantly higher at rural locations and we found negative correlations with temperature (B. pendula, P. lanceolata) and urbanization (P. lanceolata). This indicates that higher temperatures are linked to lower pollen production. In addition, our results from regression analyses indicate the positive influence of NO2 and O3 on pollen production of D. glomerata. In conclusion, we have found species-specific variations of pollen production due to environmental influences and a high variability under similar environmental conditions. Future studies should combine experiments in a controlled environment with field research to further assess the possible effects of climate change on medically relevant plant characteristics such as pollen production.	Jetschni, Johanna
503	Effects of water and energy balance on net ecosystem exchange of sweet cherry orchard It is axiomatic that the water balance and energy balance of an ecosystem influence the NPP of an ecosystem. This paper aimed to determine the influence of light energy and water utilisation by sweet cherry trees on the NPP. The water balance of an ecosystem is determined by rainfall- as the system is rainfed, Evapotranspiration and Soil water balance. Evapotranspiration was measured with the eddy covariance system. In contrast, the energy balance was measured with extended components of the eddy covariance system. The study was conducted for three years, from 2017 to 2019. SWC increased from 0.15 to 0.20 cm3 cm-3 when more than 20 mm of rainfall was received in the area. The ET during the fruit growth stages of the dry 2019 season was lower than the 2017 and 2018 seasons, which were wet. A positive relationship between available surface energy flux (Rn – G) and convective energy fluxes partitioned (LE + H) was obtained for 2017 (R2 = 0.83), 2018 (R2 = 0.66) and 2019 (R2 = 0.63). The highest available energy flux reached was 66% during the wet 2017 season, and the lowest was in the dry 2019 season with 59%. The mean evaporative fraction reached for the wet season in 2017 was more than 37% and only 31.7% for the dry 2019 season during the flowering up to the harvesting stage for sweet cherries. The GPP ranged from -9.45 to -2.23 and from -11.92 to -4.04 µmol m-2 s-1 during the 2018 and 2019 measurement periods. During the entire season, the study area's NEE was 4.76 g CO2 kg-1 H2O. There was high and enhanced net ecosystem exchange a few days after	Tharaga, Phumudzo Charles

	rainfall and during high incoming solar radiation days. The rate of NEE is driven by high energy and more available water in the soil, and the vegetative status of the orchard.	
504	Studying the reproductive phenology of two sympatric Eucalyptus species to support the conservation of the endangered Red-tailed Black Cockatoo of Southeastern Australia. The Red-tailed Black-Cockatoo of southeastern Australia (Calyptorhynchus banksii graptogyne) is an endangered subspecies occupying a small range overlapping the Victorian and South-Australian border. They feed almost exclusively from the seeds of Eucalyptus baxteri and E. arenacea. Like other eucalypts, their reproductive phenology is characterized by long and overlapping reproductive cycles, and long flowering periods, that do not necessarily occur on an annual cycle, with flowering events being highly variable in intensity. These patterns result in “fruitless” years, presumably causing the cockatoo to be unsuccessful in reproduction. Few studies, none of which are definitive, have attempted to characterize the phenology of E. baxteri or E. arenacea. While there are multiple datasets of current and historical flowering and seed crop production, herbarium records, and single phenological observations, these have not been combined to quantify the phenological patterns of the species. The known distribution of the two study species complicates this characterization; they are morphologically identical and intermingle, so it is unclear which data correspond to which species. Understanding the species-specific phenological cycles and their spatiotemporal patterns in response to environmental and genetic variability should enable the prediction of the impacts of climate variability and change on the food resources of the cockatoos. This project aims to resolve the distribution of the two eucalypts through genomics and spatial modeling to harmonize and assemble the existing phenological data for each species. These resultant datasets will be used to develop a phenological model that integrates genetic and environmental variability. The model will be used to test if spatial and temporal patterns in the cockatoo's occurrence are influenced by the flowering and seed crop phenology of the two eucalypts.	Giraldo-Escobar, Claudia-Helena
505	WITHDRAWN	
506	Phenological shifts across the seasons in South Africa: records from traditional and social media Phenological shifts have been widely documented across the northern Hemisphere. In the southern Hemisphere, phenological records are more sparse. In South Africa, there are no phenology gardens, farm records are usually only stored for the 5-year period required for tax auditing, and historical documents such as diaries and log books seldom consistently report on phenological events. However, a couple of phenological events are so spectacular, that they capture the attention of the public each year. These	Fitchett, Jennifer

	events have been well documented in the print media over the past century, and social media over the past decade. This provides some of the first records of phenological shifts for Southern Africa. Here we synthesise these phenological records, and the phenological shifts that they reveal, for the Jacaranda blossoms, Namaqualand daisy bloom, and the brown-veined white butterfly migration over the past century.	
507	PEP725, the European phenological database "Phenology – the timing of seasonal activities of animals and plants – is perhaps the simplest process in which to track changes in the ecology of species in response to climate change" (IPCC 2007). PEP725, the Pan-European Phenological Database, is thought as a European research infrastructure to promote and facilitate phenological research. Its main objective is to build up and maintain a European-wide phenological database with an open, unrestricted data access for science, research and education. So far, 20 European meteorological services and 6 partners from different phenological network operators have joined PEP725. The PEP725 phenological data base (www.pep725.eu) now offers close to 13 million phenological observations, essentially starting with 1951, comprising more than 200 species and 69 growing stages based on the BBCH scale. The data base grows with about 100000 additional observations per year. Having accepted the PEP725 data policy and finished the registration, the data can be downloaded according to various criteria, e.g. by a specific plant or all data from one country. To date (January 2023) we could count at least 115 peer - reviewed publications based on the PEP725, 17 of them published in Nature and one in Science. A small but very active community continues to produce high quality research on plant physiological mechanisms and their relation with the atmospheric environment. Download statistics and the rapidly growing number of PEP725 based publications demonstrate the great demand and potential of the PEP725 phenological data set, which urgently needs development including a facilitated access, gridded versions and near real time products to attract a greater range of users. Finally, we would invite all, who have already used PEP725, to give us feedback!!! (markus.ungersboeck@geosphere.at; helfried.scheifinger@geosphere.at)	Hans, Ressl
508	Towards a Phenological Index for Australia Australia seemingly lacks extensive phenological data, however, more data are being uncovered. These are at single locations which can be used to assess impacts of climate on plant and animal communities at a local scale, however, such data are inadequate to inform regional, state, and national assessments. Methods exist to combine such 'messy' data - a phenological index, which combine phenophases records of interest, into an integrated time series (e.g. eastern China, England and the United States). An index should enable state and national assessments and inform international comparisons. First flowering dates (FFD) in the State of Victoria were collected from different sources:	Keatley, Marie

	newspapers, government records, diaries, citizen scientists and the ClimateWatch database. To date these cover the period 1906 to 2022. The average FFD of overlapping records (2000 -2014) of two citizen scientists were compared via correlation: all FFD records, spring FFD records, and FFD of shared species. The records were collected in urban (dates weren't recorded in 2008 and 2011) and peri-urban environments. Gridded climate data were downloaded from https://www.longpaddock.qld.gov.au/silo/ to determine via linear regression the influence of climate on FFD. There was no significant correlation between all FFD or spring FFD records (P=0.785 and P=0.899, respectively). There was a significant correlation between the shared 16 species (r=0.688, P=0.007, n=14). For the shared species, linear regression found that maximum temperatures and rainfall influenced flowering: positively for April maximum temperature (urban: r2=0.276, P=0.050, peri-urban: r2=0.378, P=0.011), July rain (urban: r2=0.283, P=0.050), spring rain (peri-urban: r2 =0.258, P=0.038), and negatively for maximum spring temperature (peri-urban: r2=0.359, P=0.014). Although a very small dataset the results are encouraging that in the Australian context different sites can be integrated. This work is contributing to the development of a Phenological Index for Australia.	
509	Heliocaminiform structures: Plant organs that function as microgreenhouses Plant structures that enclose trapped air are morphologically and taxonomically diverse. They range from pubescence (trichomes) on various parts of plants to flowers, inflorescences, stems, culms, fruits, bracts, leaves, galls, algal pneumatocysts, to non-plants such as lichen podetia, and fungal fruiting bodies. Despite being familiar, such structures have not been studied systematically until recently when their complex thermodynamic functionality as microgreenhouses has been recognized. We propose the term "heliocaminiform" (Greco-Latin origin for 'sun-room') provides an umbrella term that describes form and function. Almost all the hollow structures we have examined have internal temperatures of several degrees C warmer than ambient temperature in sunshine, but those differences are abolished under cloud or at night. The potential importance for the additional heat is presumed to be in growth, maturation, reproduction, sexual function, and overall fitness and phenology of the plants. There seem to be no experimental studies on those effects even though they may help explain aspects of plants' responses to climate change and to phenological mismatches with symbionts (mutualists and herbivores) as ecologically co-dependent partners. Our review and observations open a remarkably new and hitherto surprisingly neglected avenue in botany which we hope others will explore.	Coates, Charlotte

Urban Biometeorology Posters

ID	Title	Presenting Author
601	Tree Canopy Change Detection in Phoenix, Arizona (2014-2020) The City of Phoenix, Arizona, United States, is one of many cities across the globe that have made major investments in increasing tree canopy for pedestrian thermal comfort, urban heat reduction, and aesthetic rejuvenation of the City. Urban tree lifespans are typically shorter due to the often hostile conditions of the urban built environment. Trees are also frequently removed from properties due to concerns about crime or nuisance animals. To understand the return on investment of past and future tree planting across the city and identify areas where trees have been removed, it is vital to have a comprehensive picture of tree canopy coverage at a high spatial resolution. To this end, we used freely available remote sensing data collected by United States federal agencies including the United States Geological Survey (USGS) and the United States Department of Agriculture (USDA) to detect changes in tree canopy coverage from 2014 to 2020 in the City of Phoenix. We used three dimensional lidar point cloud data from the USGS, supplemented with the Normalized Difference Vegetation Index (NDVI) derived from 0.6 m resolution National Agriculture Imagery Program (NAIP) imagery to detect tree canopy for 2014 and 2020. After significant investments in tree planting that are currently ongoing in the City of Phoenix, the process we used will allow us to compare tree canopy in the future using an identical methodology that allows for direct comparison.	Wright, Mary
602	Urban Adaptation Index of Brazilian Capitals The adaptation potential of cities can be verified by the dimensions of urban public policies, such as: Housing, Urban Mobility, Sustainable Agriculture, Environmental Management and Response to climate impacts. The Urban Adaptation Index (UAI) relates these dimensions to Brazil's National Adaptation Plan for Climate Change (NAPCC). Information on the dimensions of urban public policies was obtained from the profile of Brazilian municipalities from the Brazilian Institute of Geography and Statistics. Indicators were created relating the NAPCC with each of the dimensions of urban public policies in the 26 Brazilian capitals. All affirmative responses to the indicators received the value 1 (one) and all negative responses or no information received the value 0 (zero). The UAI was obtained as the arithmetic mean of the results of the five urban dimensions analyzed on a scale ranging from zero (non-ideal adaptive potential) to one (ideal adaptive potential). Among all the urban dimensions of the UAI, Urban Mobility had the highest scores. The dimensions Sustainable Agriculture, Environmental Management and Responses to Climate Impacts had the lowest scores in all Brazilian capitals, causing the adaptive potential of each of the capitals to decrease. Only the city of São	Teixeira Gonçalves, Fabio Luiz

	Paulo presented a UAI close to the ideal (0.9), the other capitals presented deficits in their dimensions of urban public policies, which contributed to the decrease of Brazil's adaptive potential. Porto Velho, Aracaju and Boa Vista are capitals that deserve special attention from public policies to improve/implement projects and plans aimed mainly at Housing, Environmental Management and Responses to Climate Impacts. Our results showed that Brazilian capitals are still not sufficiently prepared to adapt to climate change, which could endanger the health and quality of life of the Brazilian population in the coming years, if Brazilian public policies do not take immediate action.	
603	Contributions of Roads to Surface Temperature: Evidence from Southern California Planners often regard streets as targets for mitigating urban heat across cities by virtue of being abundant, publicly-owned, low-albedo, low-vegetation surfaces. Few studies, however, have assessed the role streets play in contributing to urban heat, and the scale of their effect relative to the built environment around them. We examine the relationship between road area and land surface temperature across a variety of biophysical regions through the urban areas of Los Angeles and San Bernardino Counties in Southern California. Our results show that wide streets have no consistent, detectable effect on urban heat. Rather, vegetation is the primary cooling mechanism for urban areas. In the absence of trees, concrete highways are the coolest surfaces, though particular hot or cool pockets (e.g., airports, industrial centers, parks) can dominate neighborhood temperature signatures. In considering LST mitigation strategies, these hotspots might outweigh the cumulative effects of road surface changes.	Engel, Ruth
604	The effects of 2-D and 3-D urban landscape metrics on mean radiant temperature in hot-arid Tempe, Arizona, USA The composition and configuration of the two-dimensional (2-D) and 3-dimensional (3-D) built environment impact the urban thermal environment, affecting the energy use of buildings, urban ecosystem services, and human heat exposure. We investigated how 2-D and 3-D building and vegetation patterns affect the mean radiant temperature (MRT) distribution in Tempe, Arizona to determine which landscape metrics are most important to minimize human thermal exposure in hot-arid conditions. 1-m resolution MRT data and seventeen 2-D and 3-D landscape metrics were analyzed at census block scale (micro) and urban scale (macro) for the hottest summer period in Tempe, AZ. The landscape metrics were calculated from a Digital Surface Model, a 3D vegetation and building point cloud obtained from high resolution (0.5-m) USGS LiDAR data, and a 1-m resolution land use/land cover map classified from 2015 National Agriculture Imagery Program (NAIP) data. The metrics were calculated with FragStat and include class area (CA), percentage of landscape (PLAND), largest patch index (LPI), number of patches (NP), patch density (PD),	Cilek, Ahmet

	above-ground biomass (AGB), building height (BH), height variance of building (HV), building density (BD), average volume (AV), and vegetation height (VH). Hourly MRT was simulated using the SOlar LongWave Environmental Irradiance Geometry (SOLWEIG) model. The relationship between landscape metrics and MRT outcomes was analyzed using correlation coefficients and multiple linear regression, specifically focusing on the impact of building height and vegetation on surface temperatures and MRT. Results will help understand which landscape compositions and configurations increase outdoor human thermal comfort and inform passive cooling strategies in urban planning and design.	
605	Modeling the extent of park cool island on park size influence using ENVI-met: A Case Study of Singapore Cities around the world are experiencing urban warming as a result of climate change and the Urban Heat Island effect. To alleviate these effects, parks are well-known as green-blue infrastructure that is able to provide multiple benefits such as recreational spaces, ecosystem services and a cooling effect known as the "Park Cool Island" (PCI). As urban planners and policymakers seek to incorporate urban parks into city plans, it is useful to understand the impact of park size on PCI to maximise its benefits. Current understanding of park characteristics and its effect on urban areas is limited, and most studies have been carried out in sub-tropical or temperate contexts. Our study investigates how nature park size affects micrometeorological parameters in tropical rainforest climate (Köppen Classification: Af). To achieve this, several hypothetical scenarios are modelled and simulated on ENVI-met (version 5.0.3). Three nature park sizes of increasing size (5, 7, and 10 hectares) with standardised vegetation coverage are modelled and compared against a concrete jungle scenario without any green spaces. The domain is built considering building regulations and guidelines from Singapore. The boundary conditions forced in the model include weather types that are representative of Singapore's climate throughout the year. The results show that larger park sizes result in cooler temperatures than surrounding urban areas. The study further reports that park sizes do not correlate linearly with cooling effects. These findings may assist urban planners and government agencies in Singapore to determine the ideal park size for neighbourhoods. This can further mainstream planning and designing urban parks in cities in tropical climates for environmental benefits.	Ho, Xiang Tian
606	Urban Bioclimatic Conditions and Potential Health Risks: a report from a Hot-Humid Tropical City Impact of weather extremes on human health has become an issue of increased significance in recent times, considering the increasing rate of urbanization and the much-associated heat island phenomenon. This study examines human bioclimatic conditions in a medium sized hot- humid tropical city in Nigeria, utilizing data from 34 sampling points that adequately represents the different land use types within the study area. In	Balogun, Ifeoluwa

	addition, a survey of human thermal perception records on micro-climatic parameters of immediate surroundings of the respondents was obtained through questionnaires. Differences in the diurnal, monthly and seasonal variation of human bioclimatic characteristics between classified urban and rural environments were evaluated and tested for statistical significance. The study also integrates geographic information system to examine day-to-day time variation of physiologic comfort of the people living in the urban environment using Physiological Equivalent Temperature (PET) at strategic points across different land use types. Results showed that thermal stresses are found spatially and temporally across different land uses within the study area. Higher frequencies of high temperatures observed in the city centre suggest significant heat stress and health risk in this hot humid city. Analysis of the responses from sampled population across different land use depicts that many of the respondents have low understanding of climate change and thermal stress. The study calls for improved urban planning with adequate heat island mitigation measures, effective policies that supports sustainable urban development and enhanced awareness of climate induced problems in the study area.	
607	Reflective Pavements as an Urban Heat Mitigation Strategy: What is still to be understood? Reflective pavements (sometimes referred to as "cool pavements") are a heat mitigation strategy of growing interest in urban centers across the globe. These novel asphalt sealants lighten the color of traditionally-black asphalts, reflecting more sunlight and allowing less energy to penetrate the roadway's surface during the day. This alteration in energy absorption can lead to reduced surface temperatures and, ultimately, a reduction in the overlying air temperature. All of this is aimed to improve human thermal comfort in urban centers plagued by the notorious "urban heat island" effect. The addition of reflective pavements to municipalities' heat-fighting arsenals has prompted competition across the market space and curated an array of technological improvements. Despite growth in popularity and innovation, the American southwest remains on the vanguard of reflective pavement research. In particular, Arizona State University has partnered with the City of Phoenix Streets Department to monitor the performance of reflective pavements in multiple neighborhoods across the city. Studies have provided an abundance of knowledge about the way reflective pavements interact with the microclimate to alter microscale meteorological conditions—indicating the importance of local influences on reflective pavement's effectiveness. Modeling mean radiant temperature has provided insights into the human health costs and benefits associated with reflective sealants. In addition, temperature measurements allow us to monitor what is happening below the surface up to human height. Despite this, findings prompt a multitude of questions for exploration. How does the underlying surface material impact the efficiency of reflective coatings?	Van Tol, Zachary

	And, what is the role of shade and other local features in deciding whether or not to install reflective pavements?	
608	Meet Singapore MaRTy (SMaRTy): Biometeorological measurements in a tropical rainforest climate Mean radiant temperature (TMRT) greatly influences outdoor thermal comfort (OTC) in tropical hot-humid climates. However, the dynamics of TMRT at pedestrian level has been hard to quantify with fixed weather stations. Thus, we assembled and deployed the first mobile biometeorological cart in Singapore. SMaRTy is an ensemble of sensors that records air temperature, humidity, wind speed, and six-directional shortwave and longwave radiation. The shortwave and longwave radiation are used to calculate TMRT. We walked SMaRTy along a pre-planned urban route from 0900-1000, 1230-1330, and 1600-1700 on days that were sunny and had relatively low cloud cover. These time slots represent transitional periods from cool (warm) to warm (cool), and include solar noon where there is maximum radiation from the Sun. Our preliminary results revealed a larger increase in TMRT when transitioning from shaded to unshaded areas compared to air temperature (Ta). Initially designed to measure urban micrometeorological parameters in hot and arid Arizona climate (Middel and Krayenhoff, 2019), our study demonstrates SMaRTy's effectiveness in obtaining granular data for OTC evaluation in tropical rainforest climates such as Singapore. High cloud cover and unpredictable wet weather conditions are challenges to data collection. To overcome this, we conducted year-long fieldwork across different seasonalities to acquire datasets representative of Singapore's hot-humid climate. Extending this study further, future research may provide insight on microclimatic variability of different urban morphologies within a city.	Pek, Rachel
609	Analysing impacts of urban morphological variables and density on outdoor microclimate for tropical cities: A review and a framework proposal for future research directions Modifying urban morphology, defined as mass, density, and orientation of building stock in cities, are well-known heat mitigation strategies addressing urban heat islands (UHI) at various scales and consequent thermal discomfort. However, varying morphological aspects may have divergent effects on Outdoor Thermal Comfort (OTC) in cities. Unlike UHI, which is derived from urban-rural temperature differences, OTC can be quantified by thermal comfort indices considering the objective assessment of microclimatic variables including air temperature (Ta), relative humidity (RH), mean radiant temperature (TMRT), and wind speed (Va), as well as a subjective assessment of individual perception. In tropical cities, thermally uncomfortable conditions prevail year-round due to higher Ta and RH coupled with high solar irradiance from its equatorial location. To better understand the relationship between density related morphological	Ho, Beatrice

	variables, microclimate conditions and OTC, we first conduct a systematic literature review to identify existing research gaps and uncertainties. Then, propose a methodological framework on how to address the gaps and uncertainties in mainstream urban design and urban planning process keeping into consideration microclimatic, comfort and socio-economic variables.	
610	Human thermal sensation by local climate zones Urban areas have more vulnerable thermal environments than their surrounding areas. Recently, many urban studies have been trying to analyze human thermal environments using the local climate zone (LCZ) concept. However, all required microclimatic data for outdoor human thermal sensation (HTS) in various LCZs are rarely collected for effective comparisons. This study investigated HTS classes based on LCZs for urban and landscape planning in the city of Suwon, Republic of Korea. Suwon was classified in LCZs, and climatic data (air temperature, relative humidity, wind speed and direction, and shortwave and longwave radiation) were collected at various LCZs during clear summer daytime from 2017 to 2021. These climatic data were used for estimating HTS, physiological equivalent temperature (PET) and universal thermal climate index (UTCI). The results showed: (1) LCZs near the city center had much higher HTS than those of the same LCZs away from the center; (2) the coefficient of determination (r2) between sky view factor and HTS of all LCZs was not great, with r2=0.66 for PET and r2=0.71 for UTCI; (3) the r2 between aspect ratio and HTS in the commercial areas was great for PET, r2=0.94, and not as high for UTCI, r2=0.61; (4) the r2 between sky view factors and HTS in the high-rise apartment areas was great for PET, r2=0.99, and not as high for UTCI, r2=0.78; (5) in the commercial areas, PET works better for air temperature changes than UTCI, as r2=0.86 for PET and r2=0.08 for UTCI; and, (6) HTS classes can be divided 6 scales in PET and 4 scales in UTCI for summer daytimes. The same LCZ will have a different HTS depending on the location within the city, aspect ratio, sky view factor and other effects.	Park, Sookuk
611	The influence of the type of green spaces in urban parks on soil temperature Climate change, as well as population growth in cities, and thus the density of buildings, strengthen the urban heat island effect, which is well documented in the scientific literature. Urban green spaces (UGSs), including parks, have a very important cooling function, and vegetation management can enhance or weaken their cooling capacity. Thermal and humidity conditions of the air layer near the ground are largely dependent on surface and soil conditions. Therefore, in the CLIMPARK project, launched in 2022, we study soil temperature variability at a depth of 5 cm in six selected parks in Warsaw. For this purpose, we installed HOBO Pendant MX2201 and TMS-4, TOMST data loggers at 55 measurement points in the	Słowińska, Sandra

	parks and 8 outside them in the reference areas. Preliminary results of soil temperature measurements from the summer of 2022 showed that places, where the average daily soil temperature was buffered to the greatest extent, had the highest tree cover density, in contrast to open spaces with low greenery, e.g. lawns, exposed to direct sunlight and not irrigated. The difference in the daily average soil temperature between those places was 4.4ºC for the summer period however, on the hottest summer day, the difference in maximum soil temperature reached almost 19ºC. The collected soil temperature data, together with data on the physical characteristics of the soil, vegetation, sky view factor, and meteorological conditions will be used to model microclimatic conditions and to study their relationship with land surface and air temperature. The research has been carried out in the project No. 2021/41/B/ST10/01997 ("The role of urban parks in modifying city climate and bioclimate today and in the future - CLIMPARK") financed by the National Science Center, Poland.	
612	Using microclimate sensations and PET to assess outdoor thermal comfort ranges: A case study of Singapore's urban green space The 2030 Singapore Green Plan aims to expand, intensify and restore green spaces in the urban landscape to transform Singapore into a City in Nature. While urban green spaces offer vital ecosystem services such as regulating elevated temperatures in cities, less information exists on how urban green spaces influence outdoor thermal comfort (OTC) and thus the utility of the space. OTC, which is dependent on people's perceptions of the complex interactions amongst ambient humidity, wind and both air and radiant temperatures, can be better understood by comparing microclimate/thermal comfort index against qualitative measurements of comfort perceptions. In this study, we analysed a dataset from an ongoing OTC campaign in Bishan-Ang Mo Kio Park, an urban park situated within a Singapore residential neighbourhood. We calibrated OTC thresholds for physiological equivalent temperatures (PET) by analysing PET against thermal perception survey responses. We examined OTC according to neutral and acceptable temperatures (NT and AT), where respondents perceive 'comfortable' outdoors in the outdoor green spaces. A preliminary analysis reveals that the estimated NT of 25.8ºC, when respondents experience neither heat or cold stress, is closely aligned to Singapore's mean temperatures (26.0 – 27.0ºC). AT ranged from 22.6 to 29.4 ºC. NT for this study is lower compared to the NT of 27.2ºC (for acclimatised respondents) that Heng and Chow derived in their 2019 paper.	Heng, Su Li