«Beating the Heat 2024» Abstract Booklet

Talks

Mitigation & Impacts: Room 001 (Fab 2e)		
Time	**Author(s)**	**Topic**
11:30 – 12:00	Sujung Lee et al.	Individual vulnerability profiles to heat-related hospitalisations: A case time series analysis of older adults in Switzerland from 2019 to 2022
12:00 – 12:30	Cristian Martucci et al.	Heat-specific health literacy in the population aged 50+ in Switzerland
14:00 – 14:30	Sarah Koch et al.	Addressing Intersecting Crises: Climate, Housing, and Compounding Health Vulnerabilities for Senior Tenants
14:30 – 15:00	Stefan Stevanovic et al.	Sustainable Urban Development: The Roadway Enclosure and Its Contribution to the Urban Forestry
Monitoring & Measurements: Room 103 (Fab 2e)		
Time	**Author(s)**	**Topic**
11:30 – 12:00	Julie Fahy et al.	Beyond land surface temperature: identifying areas of thermal discomfort in cities by combining remote sensing and field measurements
12:00 – 12:30	Elisabeth Tadiri et al.	ACTUAL - Advancing research on extreme humid heat and health: An observational panel study of weather conditions on the physiology of the general adult population in Basse, The Gambia
Modelling & Simulations: Room 101 (Fab 2e)		
Time	**Author(s)**	**Topic**
11:30 – 12:00	Kutay Dönmez et al.	Enhanced Urban Climate Simulations in ICON TERRA_URB
12:00 – 12:30	Michael Schmutz et al.	Model based evaluation of architectural heat mitigation strategies
14:00 – 14:30	Franziska Stahl et al.	Simulation of cold air streams ventilating Winterthur - Neuhegi
14:30 – 15:00	Giacomo Falchetta et al.	Systemic Cooling Poverty: quantifying deprivation in the Global South

«Beating the Heat 2024» Abstract Booklet

Posters

Mitigation & Impacts: Foyer (Fab 2e)	
Author(s)	**Topic**
Gabriel Hannes Weber	Hydrogel in Substrate
Julian Raffetseder & Noa Levin	Governing Access to Sun and Shade: Urban Microclimates as Commons in Vienna and Berlin
Evan de Schrijver et al.	Heat- and Cold-related Mortality Impacts Under Future Scenarios of Climate Change and Urbanisation in Switzerland
Nils Tinner et al.	Bernometer - an interactive application to raise public awareness about urban heat stress
Daniela Friebel et al.	Perceived thermal comfort and subjective effects of climate-adapted urban design: a cognitive heat mapping approach in the city of Bern
Monitoring & Measurements: Foyer (Fab 2e)	
Author(s)	**Topic**
Lukas Meyer et al.	Combining topographic data and live station measurements for spatial interpolation of urban air temperatures
Setareh Amini & Stefan Brönnimann	Data Gathering and Quality Control of Urban Temperature Networks: a European Perspective
Nicolas Zurfluh et al.	Enhancing the accuracy of „low-cost“ urban air temperature sensor networks
Modelling & Simulations: Foyer (Fab 2e)	
Author(s)	**Topic**
Jixuan Chen et al.	Modelling pavement watering to support city-wide planning of heat mitigation measures
Meinolf Kossmann	Hectometre-scale urban climate projections of thermal indices for Cologne and Leverkusen using dynamical-statistical downscaling
Guo-Shiuan Lin & Gabriele Manoli	Daily and seasonal mobility modifies population heat exposure
Antonia Lina Burger & Nico Bader	Beating the rising energy consumption of buildings by adaptation strategies in a changing climate
Moritz Burger et al.	Spoilt for Choice - Intercomparison of Four Different Urban Climate Models
Alonso Bussalleu et al.	Modelling Europe-wide fine resolution daily ambient temperature for 2003-2020 using machine learning

Session «Mitigation and Impacts»: Talks

Individual vulnerability profiles to heat-related hospitalisations: A case time series analysis of older adults in Switzerland from 2019 to 2022

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Heat has been associated with increased hospitalisation risks in Switzerland, including cardiovascular diseases and mental disorders. Previous research indicates that older adults are more vulnerable to heat events, but understanding detailed information on individual risk factors is limited. To address this knowledge gap, in this ongoing project, we will assess the impact of heat on hospitalisation risks in the ageing population over 65 years old during the summer months from 2019 to 2022 in Switzerland. We already collected individual-level hospitalisation data linked to health data collected from homecare services (Spitex). Each record was linked to high-resolution temperature data (daily min, mean, and max) at 1 km resolution from MeteoSwiss. We will apply a case time series study design with a distributed lag non-linear model to estimate the short-term risk of hospitalisation among older adults and identify individual vulnerability profiles to heat. We will provide risk estimates at various geographical units (districts, cities, and cantons), for different heat indicators, and subgroup categories (e.g., sex, level of deprivation, and comorbidities). Our results will identify specific vulnerable subgroups within the older adults, such as those with dementia, diabetes, or those living alone. Assessing detailed individual risk factors is crucial for targeted prevention of heat-related hospitalisations for older adults.

Heat-specific health literacy in the population aged 50+ in Switzerland

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Increasing heat stress poses a risk to human health. In summer 2023, we conducted a telephone survey among a representative sample of the population aged 50 years and older (n=1800) on individual heat-specific health literacy in Switzerland. Heat-specific health literacy encompasses the knowledge about health risks and behavioural measures, the perception of concern due the heat and the implementation of heat protection measures.

The population aged 50+ considered themselves to be well informed about behavioural recommendations to protect their health in hot weather. However, many effective behavioural measures were either unknown or not actively implemented. On average, the population was aware of three out of eight categories of behavioural measures. Men over the age of 75, people with no post-compulsory education and those in financial difficulties were less aware of behavioural recommendations and implemented them less frequently than the other respondents. Half of the surveyed population considered high temperatures to be a risk to their own health. This number was significantly lower in German-speaking Switzerland (46%) than in French-speaking Switzerland (76%) and Ticino (66%). Moreover, for a third of the important target group for prevention measures, namely with a chronic illness and people aged 75 and older, did not consider heat to be a risk to their health. Around 8% stated that they had spoken to a healthcare professional about the heat in summer 2023. Extrapolated to the population 50+, an estimated 300,000 people spoke to a healthcare professional about heat and around 6,000 people consulted a healthcare service due to heat-related medical emergencies.

This study is the first nationally representative survey on the topic of heat and health in Switzerland. It serves as a basis for monitoring the heat-specific health literacy and provides information on the effectiveness of public health measures to inform the population on heat-related health risks.

Addressing Intersecting Crises: Climate, Housing, and Compounding Health Vulnerabilities for Senior Tenants

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Uneven impacts of climate change-induced heatwaves and wildfires are acutely felt indoors. Research on indoor environmental quality is emerging but often overlooks the social, political, and legal determinants of the built environment and health. An important co-determinant of health is housing. In many cities, housing is increasingly unaffordable and unfit for a changing climate. Tenants are left sacrificing safety for affordability because the buildings least prepared for climate change are often the most affordable. Tenants have little control over their units and cannot easily access adaptation measures. Senior tenants who are low-income, disabled, and/or racialized are particularly vulnerable. Governments have introduced programs to increase access to cooling (e.g., retrofits, free air conditioners). But if not accompanied by proper tenant protections, these initiatives could lead to displacement or rent hikes, meaning that adaptation and mitigation efforts could create unintended negative, inequitable outcomes for health.

We combine insights of environmental health and climate justice to study the indoor environments of senior tenants' homes and foster equitable climate action. This requires interdisciplinary and trans-sectoral research to measure and create livable thresholds, prototype justice-based interventions, monitor implications of new climate policies on housing, and support community-based climate resilience measures. In Barcelona, New York City, and Vancouver – three cities facing the intersecting crises of climate and housing – we will pursue four initiatives:

a) measure indoor environmental quality and its impact on health;

b) implement and evaluate in-building communal 'climate safe' rooms;

c) monitor the unintended outcomes of climate adaptation and mitigation policies on tenancy;

d) identify mechanisms that may lead to climate-related rent increases or displacement.

Together, these initiatives provide environmental, health, and social data to inform public discourse that propels adaptation and mitigation efforts without displacing or disempowering seniors, and safeguard the right to secure, high-quality housing as climate change progresses.

Sustainable Urban Development: The Roadway Enclosure and Its Contribution to the Urban Forestry

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One of Switzerland's most heavily traversed roadways, accommodating 120,000 vehicles, extends through the residential district of Zurich. The roadway enclosure, an integral element of a construction project, seeks to minimize the adverse effects caused by the motorway, focusing particularly on noise and exhaust fumes. It encases the motorway, acting as a protective barrier to shield the neighborhood from negative repercussions. The resultant green and open space on the roof, serves the dual purpose of bringing together two sections of the neighborhood and establishing a continuous green area on the roof for the local population.

The Zurich University of Applied Sciences (ZHAW) conducted outdoor tests to explore the impact on the urban forest and the incorporation of green elements within the structure, intending to transform the enclosure into a thriving green oasis. Three prospective tree species (Ulmus 'New Horizon', Salix alba 'Liempde', Quercus frainetto 'trump') underwent analysis in three structurally stable substrates (FLL standard, adapted Stockholm and Zurich substrate). Soil samples, sap flow measurements, and root analyses were conducted after a 4-year period.

The findings revealed qualitative distinctions among the adapted substrates and others. Nevertheless, the adapted substrates exhibited a slightly higher increase in growth. Elms and willows demonstrated optimal conditions for the enclosure, as confirmed by measurements. Excavations uncovered that roots were able to proliferate beneath the covering despite the substantial load. This enabled the first planting concepts for the trees, perennials and climbing plants.

The results of this construction project offer innovative solutions for the ecological and sustainable enhancement of busy roads. This not only contributes to an improvement in the quality of life but also facilitates the expansion of urban forests in other cities.

Session «Mitigation and Impacts»: Posters

Hydrogel in Substrate

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The present study investigates how the use of hydrogel in the substrate affects the plant and the soil. Through literature review and an own experiment, it is assessed whether it makes sense to use hydrogel as an additive for tree substrates.

Given the limited acceptance of synthetic hydrogels due to microplastic concerns, a 100% biodegradable product«Agrobiogel» was tested in an own field experiment. The effects of Agrobiogel on 60 Solanum lycopersicum and soil were evaluated over a 40-day period. One group was continuously irrigated, while a second group received water only until day 23. The results indicate that hydrogel significantly increases water retention capacity of soil. Not only does it enhance water content at field capacity, but it also elevates water content at the permanent wilting point. The experiment suggests that water stored by hydrogel is largely available to plants. Additionally, hydrogel reduces soil water evaporation rate, resulting in taller plants, reduced symptoms of drought stress, and higher fresh weight in the group with discontinued irrigation. The group with discontinued irrigation achieved the best results, with 30 grams of hydrogel per liter of substrate. Among the continuously irrigated groups, the group with 20 grams of hydrogel per liter performed the best. This group produced the highest fresh weights, indicating improved water use efficiency compared to the other groups.

Agrobiogel has great potential to reduce damage caused by drought stress and improve biomass production. This hydrogel appears suitable to be used as a new water-retaining component in tree substrates. However, before the hydrogel can be widely applied, further research on its long-term effects, economic viability, and use with various tree species and substrates is necessary. Thus, it could be evaluated whether the addition of Agrobiogel to tree substrates can actually achieve improved plant growth while saving personnel resources, water, and costs.

Governing Access to Sun and Shade: Urban Microclimates as Commons in Vienna and Berlin

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In our presentation, we argue that urban microclimates and their constitutive components should be considered as urban commons. By documenting the availability and absence of solar radiation, we reflect on the equitable distribution of sun and shade within the built environment. Recent studies suggest that viewing microclimates and their control as a collective rather than individual matter is necessary for climate adaptation (Roesler 2022, Roesler, Kobi, Stieger 2022). Therefore, thermal governance on an urban level becomes urgent.

We will outline methodologies for conceiving a new type of thermal governance by exploring passive “solar access” and “shade equity”, as well as active cooling and heating infrastructures, as components of the urban microclimate. This will be done by comparing between two case studies of consolidated urban districts in two Central European cities projected to shift towards the subtropical climate that has until now been typical of the Southern European region (Rohat et al. 2017, Bastin et al 2019): Berlin and Vienna. Since urban density is a constitutive quality of cities, the challenge must be to adapt them in a way that will ensure densification *and* equitable solar and shade access at the same time. To this aim, we will document the solar access implications of current urban building regulations and juxtapose them with an ethnographic study of thermal practices in both case study sites. How can future cities be planned and designed in a way that takes microclimatic components under consideration and what could constitute an equitable governance of microclimates as commons?

Heat- and Cold-related Mortality Impacts Under Future Scenarios of Climate Change and Urbanisation in Switzerland

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Within epidemiology, the urban heat island phenomena, i.e., the differential heating of urban areas compared to rural areas, has extensively been linked to increased mortality risk. Yet, epidemiological studies rarely account for progressive urbanisation when projecting future heat- and cold-related mortality impacts for populations. In this study, we aim to disentangle the urbanisation-specific contribution to the overall heat- and cold-related mortality in Switzerland for multiple warming targets.

Through a two-stage time-series analysis, we derived age-specific (below 75 and above 75 years) temperature-mortality associations for each Swiss district between 1990–2010. In the second stage, we estimated the exposure-response function for each district and age category, considering both the factual and counterfactual scenarios, while accounting for the urban/rural status of each district. Subsequently, leveraging on 2-km downscaled temperature projections (CMIP5), population projections (SSP5), and progressive urbanisation projections for Switzerland, we estimated the heat- and cold-related mortality impacts for different warming targets (1.5°C, 2.0°C and 3.0°C). We then disentangled the contribution of urbanisation on the overall projected heat- and cold-related mortality impacts for Switzerland, at the national level as well as for each district.

We found that the projected heat-related mortality at national level in Switzerland, under progressive urbanisation assumption, is expected to be 7% higher than the projected heat-related mortality assuming constant urbanisation levels, for 3.0°C warming. However, the rural regions exhibit substantial increases in heat-related mortality for certain districts, potentially increasing heat-related mortality up to 4-fold compared to a scenario of non-urbanisation, which may directly be attributed to the effects of urbanisation. The urbanisation-specific contribution to overall cold-related mortality projections was found to be negligible under all warming scenarios.

Our findings suggest that current trends in urbanisation may amplify the future heat-related mortality in Switzerland, mainly affecting rural areas, emphasizing the need for adaptation measures in view of progressive urbanisation.

Bernometer - an interactive application to raise public awareness about urban heat stress

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Air temperatures within the city can be markedly higher than in the rural surroundings, which is known as the “urban heat island” (UHI) effect and especially relevant for health. Weather forecasts hardly take the UHI effect into account and are therefore often too cool for the city, especially at night. The interactive app “Bernometer” is designed to provide an interactive map of Bern's urban heat island showing the past, present, and future intra-urban air temperature variability at a high spatial resolution (https://bernometer.unibe.ch). This allows the urban population not only to depict the urban heat stress at specific locations within the city, but also to receive heat alerts and recommendations about how to reduce individual heat stress through adaptive behaviour. The temperature data used for the temperature maps is based on an extensive monitoring network consisting of 65 to 90 low-cost measurement devices, which has been in operation since 2018. Data from Openmeteo is used for the forecasts and the temperature maps are created using a machine learning algorithm ($R^2 \approx 0.7$, RMSE ≈ 0.7 K).

Perceived thermal comfort and subjective effects of climate-adapted urban design: a cognitive heat mapping approach in the city of Bern

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Due to their spatial characteristics, cities experience increased heat stress, which adversely affects the urban population and infrastructure. To ensure that cities remain liveable in the face of climate change, heat stress must be minimised through climate-adapted urban design. A survey along with a cognitive mapping approach was used to analyse how urban structures, microclimatic adaptation measures and their thermal properties affect urban citizens' subjective perception of public spaces on hot summer days in the city of Bern. The results emphasise the importance of green spaces, trees, shade, and water elements for thermal comfort and well-being. Streets with high traffic load and heavily sealed areas without green infrastructure impose high to extreme heat stress and are perceived as unpleasant. This work provides important insights into how thermal factors and other environmental conditions impact human well-being in urban public spaces. These findings can contribute to the development of targeted measures to improve a city's liveability. The methodology of subjective heat perception and cognitive mapping can serve as an alternative or complementary approach to microclimatic measurements, simulations, and modelling to identify areas with a need for action. Moreover, the outcomes emphasise that psychological and social aspects of thermal perception must be considered in urban planning processes for climate change adaptation.

Session «Monitoring and Measurements»: Talks

Beyond land surface temperature: identifying areas of thermal discomfort in cities by combining remote sensing and field measurements

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Urban areas are heating up much faster than their surroundings, creating a heat island that critically affects the thermal comfort of their inhabitants. Satellite images of land surface temperatures (LST) are commonly used to identify areas within cities that generate thermal discomfort. However, measurements of LST provide temperatures of the highest surface layer (tree canopy, rooftop, etc.), and do not represent the micro-environment of pedestrians, which also depends on factors such as solar irradiance and relative humidity.

Here, we developed predictive models for Physiological Equivalent Temperature (PET), an indicator of thermal discomfort. For this, we measured PET (n = 4472) along eight transects (range: 700-5000 meters) using a multi-sensor instrument in the urban fabric of Geneva, Switzerland during periods of summer heat. We parametrised generalised additive models (GAM) and linear mixed models (LLM) with six commonly available predictor variables *irradiance in July, Local Climate Zone (LCZ), albedo, LST, Normalised Difference Moisture Index (NDMI)* and *canopy cover*.

We found that LST alone explained < 2% of the observed variation in PET, whereas the GAM with all the 6 predictor variables had R^2 = 0.43. The LCZ explained the largest proportion of variance in PET (7.3 %). The GAM predicted lower thermal discomfort in the densely built city center than in the peri-urban environment, which is in stark contrast to geographical patterns of LST.

This study provides an improved model for identifying urban streets and neighbourhoods where thermal stress is likely to occur during the day. LST is poorly correlated with air temperature and PET, and thus should not be used alone to predict outdoor thermal discomfort.

ACTUAL - Advancing research on extreme humid heat and health: An observational panel study of weather conditions on the physiology of the general adult population in Basse, The Gambia

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Extreme weather events are considered among the most hazardous environmental factors for human health. However, the role of humidity on heat-related health impacts remains undetermined. Within the ACTUAL project, this study aims to assess comprehensively the impact of humid heat and further environmental conditions on health in a representative population in Basse Santa Su, a region at high-risk of extreme heat strain and humid heat exposure.

We will use the Health and Demographic Surveillance Study to recruit 60 healthy adults residing in Basse to conduct a panel study, where each participant will be monitored for 4 non-consecutive weeks scattered across the study year covering both the dry (November-May) and rainy (June-October) seasons. Questionnaires on daily activity, thermal sensation and comfort, climate adaptation, air quality, symptoms of physiological heat strain, mood, and subjective sleep quality will be administered. Time-resolved environmental heat stress and physiological heat strain will be measured using environmental monitors collecting indoor and outdoor temperature, humidity, air quality, and environmental noise exposure, and wearable devices collecting step count, heart rate, sleep, and skin temperature.

We will perform descriptive analysis to assess baseline characteristics, level of heat stress (i.e., individual measurement), heat strain, and further environmental covariates. We will then apply the case-time series design and perform linear, non-linear, and logistic mixed models to assess the association between individual time-resolved exposure to humid heat and physiological heat strain.

We expect that populations exposed to extreme humid heat experience higher levels of physiological heat strain when compared to dry heat conditions, and that impacts will differ across gender, age, socio-economic resources, housing, and occupation. We hypothesize that current study settings in climate epidemiology (i.e. ecological designs with outcome averaged across a population) may not be suitable for assessing the health impact of humid heat and can be improved using individual-level assessments.

Session «Monitoring and Measurements»: Posters

Combining topographic data and live station measurements for spatial interpolation of urban air temperatures

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We use spatial data in combination with live station measurements at about 120 locations around the city of Bern to statistically model the spatial distribution of urban air temperatures in real-time. Maps are displayed live to the public on a website [1] and data is made available via an API [2].

A statistical model is built, which uses spatial variables to predict the air temperature measured by the sensors by assuming that the urban air temperature at a given location is influenced by its surrounding within a given distance (e.g. the average Sky View Factor within 25 m or 50 m) [3]. The spatial data consists of land use data, topographical information, and further data such as the Sky View Factor [4].

Different statistical methods, such as linear Regression, or nonlinear models like Random Forest Regression are examined and validated using historical data from 2023. The prediction of the statistical model is corrected to fit the measurements using inverse distance weighting interpolation, providing a balance between statistically predicted and measured air temperatures. The derived output grid of air temperature has a spatial resolution of 10 m covering a 14.6 km by 12.4 km box around Bern. This allows to capture micro-scale features of the urban climate. Owing to the low calculation time of the statistical model, the air temperature map can be calculated and displayed in near real-time.

The live map provides a valuable tool for communication, education, and awareness building. Furthermore, it provides information to citizens and authorities about hot spots on heat days and on the potential cooling effects of locations such as local parks, the surrounding hills, or the Aare river.

Data Gathering and Quality Control of Urban Temperature Networks: a European Perspective

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European cities are facing severe climate change impacts, intensified by urban heat islands (UHIs). These increased urban temperatures affect public health, energy consumption, and overall livability. To tackle these issues, it is crucial to understand urban temperature variations. Traditional weather stations are often scarce due to high costs, but new low-cost devices(LCDs) provide valuable data despite some accuracy challenges. On the other hand, accurate UHI mapping is vital for effective climate adaptation and sustainable urban planning.

So, in our recent research, which is part of the European COST-Action FAIRNESS (https://www.fairness-ca20108.eu/). We have collected the recorded temperature values by LCDs from 12 European networks and applied uniform quality control to ensure a reliable database for further studies and evidence-based urban planning and climate adaptation strategies.

The cities included in this study are Amsterdam, Basel, Bern, Biel, Birmingham, Freiburg, Ghent, Novi Sad, Rennes, Turku, Sofia, and Zurich. The data have been archived in the Station Exchange Format (SEF), a machine-readable format containing both metadata and air temperature data. To enhance the reliability and precision of the datasets, we developed a seven-step automatic quality control procedure applicable to all stations, ensuring consistency in temperature data assessment. Looking ahead, these datasets will be published, providing accessibility to researchers, urban planners, and other stakeholders. The outcomes of this preliminary phase contribute to advancing space-time analysis in temperature assessment and establish a robust foundation for subsequent research stages.

Enhancing the accuracy of „low-cost“ urban air temperature sensor networks

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The urban heat island is a widely studied phenomenon which describes the temperature differences between the warmer urban areas and their cooler rural surroundings. With rising temperatures and more frequent heatwaves due to climate change, the health risk factor for urban populations is increasing. Therefore, accurate and detailed monitoring of air temperatures in urban areas is becoming highly relevant.

Urban climate models are constantly improving while still being heavily reliant on ground-truth data. Measurement networks for collecting the data can be quality optimized with recent technology and quantity optimized by using “low-cost” sensors. Measuring air temperature with low-cost sensors in cities however involves some sources of errors due to the sensor design (e.g. heat accumulation) and induced errors from the sensor location, such as too high temperatures due to radiation reflected or emitted by nearby buildings or sealed surfaces.

This study aims to develop a method for the correction of the low-cost sensor measurements towards a common standard. Data from 290 sensors of the meteoblue city climate networks in Basel and Zurich, with detailed metadata is analysed. This allows detecting and analysing location-induced sources of error like sensor orientation, distance to buildings, shading effects, differences in the surface characteristics and other physical factors possibly affecting the micro-scale air temperature measurements.

Based on the measurements data from 2020 to 2024, ensemble learning methods, such as random forest, or more simple methods, such as multiple linear regressions, are trained. A correction algorithm based on the error sources (predictors) attempts to minimize the local errors in the urban measurement networks. Enhancing the precision of the urban measurement network data improves the information basis for city planners and decision makers. It helps to create more trustworthy quantity optimized sensor networks and gives insights for additional sensor errors that can be minimized by data post-processing.

Session «Modelling and Simulations»: Talks

Enhanced Urban Climate Simulations in ICON TERRA_URB

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TERRA_URB is a bulk urban canopy parameterization initially developed for the COSMO atmospheric model and recently integrated into the icosahedral non-hydrostatic weather and climate model ICON. In its current form, ICON TERRA_URB relies on spatially uniform urban canopy parameters (UCPs), which do not adequately represent the typically large variability of building heights, density, and other properties across a city. Therefore, as a first step, we implemented spatially varying UCPs derived from the globally available Ecoclimap Second Generation dataset's local climate zone information and evaluated the impact of this new data set on ICON TERRA_URB simulations for the cities of Zurich and Basel, Switzerland. In a second step, we further enhanced the spatial representation of UCPs by incorporating detailed city-specific local data on building geometries and on radiative and thermal properties. Finally, we evaluated the performance of the model and the impact of the increasingly detailed representation of UCPs by simulating a hot period in the summer of 2022 and comparing the simulations against each other and a suite of observational data.

Model based evaluation of architectural heat mitigation strategies

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When it comes to heat mitigation, planers and architects can already rely on a wide range of actions where the efficacy has been proved scientifically and in practice. Whilst knowledge about the effect of individual mitigation strategies might be derived from precursor studies the transfer of this information to new projects is not straight forward and the resulting benefit for the local micro-bioclimate cannot easily be quantified.

We developed a model based approach which allows covering urban heat analysis from mesoscale down to micro scale based on the large eddy simulation model system PALM-4U. Within the model it is possible to define complex 3D building structures as well as 3D vegetation elements and the landscape architecture with a variety of land use classes and high spatial resolution (1m). Physical properties of different surface types or buildings can be defined individually. The static input data of the model, i.e the topography and the surface properties can be included from national surveys (e.g. swissALTI3D, swissBUILDINGS3D, swissTLM3D in Switzerland). By coupling the model to the output of weather forecasting systems it is possible to test the performance of projects in terms of heat mitigation under real conditions.

The current study covers a project in the city of Bern where a central square is transformed by adding new elements like mobile shading cubes or large shading sails as well as different pavement types in order to create a better bioclimate. We present the process of selecting effective mitigation strategies based on the results from the modelling as well as the collaboration with local authorities, planners and architects.

Simulation of cold air streams ventilating Winterthur - Neuhegi

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Due to its proximity to the forested areas on the Hegiberg, the region Neuhegi can likely profit from nocturnal cold air drainage flows, ventilating the built-up and densely populated area. In summer during calm synoptic conditions, these nocturnal cold air flows from elevated forested areas are important to locally reduce the heat build-up. According to the current Planhinweis- und Klimaanalysekarten a main channel for the cold air flows is from the elevated forested slopes of the Hegiberg, through an empty field next to the train station Hegi to the residential area.

As part of the Rahmenplan Stadtklima the city of Winterthur is intending to conserve cold air channels. Part of the measurement network in Winterthur is a cluster of eight temperature sensors in the region around the train station Hegi. Based on the sensors' temperature data, and the larger scale meteorological situation a simulation day is chosen, on which the cold airflows are likely important. Subsequently, the airflows and micro-climate are simulated with the large eddy simulation model PALM for the current building situation.

The simulation is repeated with a virtual obstacle on the field next to the train station, blocking the cold air channel. This allows us to investigate the current cold air ventilation and the influence of a potential future development on the field on the airflow and temperature evolution in the residential area. By using the in-situ measurements to validate the initial simulation, we can then analyse the status quo and quantify the temperature change in the area if the airflow is disrupted.

Systemic Cooling Poverty: quantifying deprivation in the Global South

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Humanity is already facing growing risks associated with the increasing frequency and intensity of extreme heat events. While air conditioning, cooling centers, green and blue spaces provide protection, they are not available to all. People living in areas characterized by spatial, infrastructural (including physical, social and intangible infrastructures) and material deficiencies are more exposed to the negative consequences of excessive heat, with significant inequality implications.

This paper provides a first quantitative assessment of systemic cooling poverty (SCP) in the Global South. SCP, introduced in Mazzone et al. (2023, Nat. Sust., DOI: 10.1038/s41893-023-01221-6) is defined as a situation of multidimensional deprivation that prevents an individual from achieving thermal comfort and adapting to hot temperatures. Deprivation can arise from exposure to specific climatic conditions, lack of infrastructure and assets, the existence of social and thermal inequalities, health conditions, education and work standards.

We assemble a wide range of data sources from household surveys, historical climate records, large geospatial datasets, and satellite data to represent the five core dimensions of SCP: (i) climate, (ii) infrastructure and assets, (iii) social and thermal inequalities, (iv) health, and (v) education and labor standards. We cover 29 countries in the Global South and quantify heterogeneities in SCP both between and within countries. We are able to identify areas with high concentrations of households facing severe SCP, identify the main drivers of observed SCP, and highlight key interventions to reduce deprivation and increase adaptive capacity. The joint representation of the different dimensions of heat adaptation deprivation allows to significantly advance the understanding of existing and growing heat-related risks due to climate change.

Session «Modelling and Simulations»: Posters

Modelling pavement watering to support city-wide planning of heat mitigation measures

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Pavement watering is considered as a promising solution to mitigate urban heat and adapt urban environments to climate change, yet there are few modelling tools to support the planning of such practices, especially at larger scales. This study presents the new development in the TARGET model that incorporated the simulation of the cooling impact of pavement watering. This improved model was evaluated against measurements as well as modelling data, which showed a good agreement. The model was then tested with different input information to ensure the robustness and reliability of its results, showing a reduction of 15 °C in surface temperature and up to 2 °C in air temperature induced by wetting the pavement, as expected. The testing results also provide some first insights into the best practices for pavement watering. Finally, a city-scale demonstration proves the viability of the model for its stated purpose. The improved model opens up opportunities for further understanding of the cooling impact and water demand of the pavement watering practices, paving the way towards smart planning of heat mitigation measures and urban water management for more liveable cities.

Hectometre-scale urban climate projections of thermal indices for Cologne and Leverkusen using dynamical-statistical downscaling

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Rasterdata of the mean annual numbers of summer days (Tmax ≥ 25°), hot days (Tmax ≥ 30°), and tropical nights (Tmin ≥ 20°) with grid spacing of 100 m are calculated for the German cities of Cologne and Leverkusen. The calculation is based on dynamical-statistical downscaling of regional climate observations (period 1971-2000) and of a 21-member multi-model ensemble of regional climate projections (periods 2031-2060 and 2071-2100) for the scenario RCP8.5. The cuboid method (Früh et al. 2011, https://doi.org/10.1175/2010JAMC2377.1) and a total of 16 MUKLIMO_3 urban climate simulations are used to calculate the thermal climate indices for the 30-year periods. The presented results show a strong increase of all thermal indices until the end of this century, highlighting the need to mitigate climate change and to adapt to a much hotter summer climate in the two cities. The study also addresses combined thermal impacts of possible urban development and regional climate change.

Daily and seasonal mobility modifies population heat exposure

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Human health is closely linked to air temperature, with evidence indicating a J- or U-shaped relationship between temperature exposure and mortality risk. In urban areas, the urban heat island effect typically results in higher temperatures, and daily commuting can significantly increase daytime populations—for instance, by approximately 95% in New York County. Most prior studies have estimated exposure based on residential populations without accounting for mobility, even though 80% of the employed population in Europe commutes between residence and workplace, and 62% of Europeans take at least one tourism trip annually. This study integrates mobility data, air temperature simulations, and temperature exposure-response curves for 80 European cities to assess the impact of seasonal and daily mobility on heat exposure. Our findings reveal that daily commuting increases the population and heat exposure in urban areas, particularly towards the city centers, during the summer. Conversely, commuting to warmer city centers (from colder rural areas) may provide benefits in winter. Seasonally, populations exposure decreases in most cities during summer as residents travel outward for holidays, but risk significantly rises in popular tourist destinations, such as Mediterranean coastal cities, where population peaks from June to August. On average, daily mobility increases heat exposure by 9%, while seasonal mobility reduces it by 0.6% across the 80 European cities. These results highlight the critical role of mobility in reshaping the spatial and temporal distribution of heat exposure in cities, providing valuable insights for mitigating temperature-related health risks in various urban and climatic settings.

Beating the rising energy consumption of buildings by adaptation strategies in a changing climate

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People in urban areas experience health issues due to high thermal stress caused by the urban heat island effect. The number of people at risk will increase in the future because of the anthropogenic climate change. Buildings are changing the energy budget, resulting in strong heat emissions and higher temperatures in their surroundings. In order to ensure a healthy environment, many buildings will require air conditioning to maintain a safe indoor temperature, leading to increased energy consumption in the future.

This study focuses on the development of a new model framework, which estimates the building-specific energy consumption in urban areas in a changing climate. Known building-based climate change adaptation measures are integrated to show the impact of different strategies on energy consumption.

The framework is based on the meteoblue City Climate Model (mCCM) to incorporate the urban heat island effect and the small-scale air temperature variability in urban areas. By linking this model with various climate signals from Representative Concentration Pathways (RCPs), it is possible to estimate the future impact of climate change. To assess the effect of different climate change adaptation measures on buildings, such as white roofs or facade greening, the Surface Urban Energy and Water Balance Scheme (SUEWS) is applied. This allows us to evaluate future energy consumption for heating and cooling of buildings and how different adaptation measures could reduce this consumption.

This tool can aid city planners and architects in designing and modifying existing buildings to mitigate the effects of climate change and reducing the energy consumption of buildings. It is crucial to maintain livable indoor temperatures to save lives, especially in buildings where vulnerable people reside, such as nursing homes, hospitals, and schools, as well as simple residential buildings.

Spoilt for Choice - Intercomparison of Four Different Urban Climate Models

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In recent years, different models to simulate urban climate variables have been applied to various cities. As the model outputs are usually validated individually, this raises the question about which urban climate model to choose for what specific purpose. The present study aims to find answers to this by intercomparing air temperature outputs of four different urban climate models that have been applied in the city of Bern, Switzerland. This includes a geostatistical land use regression model and the numerical models MUKLIMO_3, PALM, and FITNAH 3D. Using data from 70 stations of an urban air temperature measurement network, we intercompare the four models by focusing on the modeled urban air temperature variability. MUKLIMO_3 outputs show a weak urban air temperature variability, while strong small-scale temperature gradients are modeled by FITNAH 3D. PALM outputs are the only ones that reproduce the impact of a large-scale ventilation pattern, but have a large positive bias. The most accurate estimates of the urban air temperature variability are obtained from the land use regression model. For future applications of urban climate models, we reinforce the need of validation with in-situ measurements, since the outputs (and subsequent policies) depend substantially on the selection of the model.

Modelling Europe-wide fine resolution daily ambient temperature for 2003-2020 using machine learning

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To improve our understanding of the health impacts of high and low temperatures, epidemiological studies require spatiotemporally resolved ambient temperature (Ta) surfaces. Exposure assessment over various European cities for multi-cohort studies requires high resolution and harmonized exposures over larger spatiotemporal extents. Our aim was to develop daily mean, minimum and maximum ambient temperature surfaces with a 1 × 1 km resolution for Europe for the 2003–2020 period. We used a two-stage random forest modelling approach. Random forest was used to (1) impute missing satellite derived Land Surface Temperature (LST) using vegetation and weather variables and to (2) use the gap-filled LST together with land use and meteorological variables to model spatial and temporal variation in Ta measured at weather stations. To assess performance, we validated these models using random and block validation. In addition to global performance, and to assess model stability, we reported model performance at a higher granularity (local). Globally, our models explained on average more than 81 % and 93 % of the variability in the block validation sets for LST and Ta respectively.

Furthermore, we quantify the spatial and temporal variability and compare agreement between the presented Tmean models, the gap filled LST surfaces, the state of the art ERA5-land 2mt temperature estimates and the weather station data for 800 cities across Europe.