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Evaluating UKCP18-Based weather files for overheating assessment using building simulation: A case study for a flat in london

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Abstract
Global warming and net zero transition are the two biggest challenges currently faced by the building industry in the UK. While the net zero transition primarily focuses on the problems of energy efficiency and heat decarbonization, the rise of global temperature imposes a significant threat to the health and wellbeing of occupants and the industry is obliged to make buildings climate-resilient by testing their designs using future weather files. To improve the quality of the current weather files, a new project has been commissioned by CIBSE to revisit the data and the methodology employed for creating future weather files and produce new CIBSE weather files using the latest UK Climate Projections released in 2018 (UKCP18). In this study, we evaluate the newly produced weather files for overheating risk using building simulation. Two different batches of weather files were curated. The first batch was produced primarily using the existing methodology for creating the UKCP09 based weather files, with an adjustment to accommodate new features of the UKCP18 and an improved procedure for morphing the solar radiation data. The second batch was created through an improved morphing process to better emulate the characteristics of distributions of climatic variables. The differences between the existing UKCP09 and new UCKP18 based weather files are compared by evaluating overheating metrics. The new weather files enable robust building performance assessment against future climate conditions under different scenarios and will play an important role in designing climate-resilient buildings and delivering a net zero built environment.

Practical applications: As the extreme weather events resulting from climate change become more frequent and intense, they pose significant challenges to the resilience of the built environment and severe threats to the health and wellbeing of the occupants. Climate data, which serves as the foundation for climate risk assessment, plays a critical role in helping the building sector to achieve climate resilience through the means of performance assessment and the channel of regulatory compliance. In this study, the revised future

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weather files created using the latest UKCP18 climate projections are presented and evaluated using building simulation, as part of the weather file testing programme for quality assurance. The revision of the CIBSE weather files according to the latest climate science, i.e. UKCP18, will enable the building industry to quantify overheating risks with more accurate climate assumptions and better inform decision making about risk mitigation and climate adaptation.

Keywords

Overheating, weather file, morphing, climate change

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Introduction

The CIBSE weather datasets, including Design Summer Years (DSYs) and Test Reference Years (TRYs),[1] are used in the design of most building projects in the UK to assess energy demand and thermal comfort, and to meet national and local standards for energy efficiency and occupant health and wellbeing. The more robust the weather datasets, the more accurate the assessment of building design solutions. CIBSE future weather datasets were created using the UK Climate Projections in 2009 (UKCP09).[2] Since then, climate projections have evolved owing to the advancement of computing capability and improved understanding of the trajectory of climate change.

The UKCP18 is the latest generation of national climate projections for the UK.[3,4] The release of the UKCP18 and the subsequent release of high 2.2 km resolution hourly weather variables have provided a unique opportunity to reimagine CIBSE's future weather file datasets and expand them to multiple locations and design applications. Four types of projections with different spatial resolutions are available in the UKCP18, including probabilistic projections (25 km), global projections (60 km), regional projections (12 km), and local projections (2.2 km).[3] The UKCP18 not only provides a step change in the availability of climate change projections for the UK, but it also presents the great challenge of having to analyse large sets of data and to customise it for the various needs of the building industry. Therefore, CIBSE commissioned a Knowledge Transfer Project (KTP) to leverage the latest data made available by the UKCP18, to revise and further improve the current UKCP09 based weather files. As part of this project, two batches of weather files have been created using the probabilistic projections in the UKCP18, denoted as the UKCP18 v1 and v2. The UKCP18 v1 files were produced by largely following the same morphing practice as the existing UKCP09 based weather files with an adjustment to accommodate new features of the UKCP18 and an improved procedure for morphing the solar radiation data.[5] The UKCP18 v2 files were created using a modified morphing method, which exploits nonlinear transfer functions for variable transformation.

The focus of this paper is to compare different versions of DSY weather files using overheating assessment. Specifically, two comparisons are conducted to evaluate the impacts of the different climate projections (i.e., UKCP09 and UKCP18), and the different morphing methods (i.e., the bounded weighted stretch morphing algorithm and the revised nonlinear transformation morphing algorithm) through overheating assessment. A single-aspect flat is modelled as the case study building and London Weather Centre is employed as the case study location. The overheating risks are investigated in three time horizons, i.e. 2020s, 2050s, and 2080s. According to the simulation results, the risk of overheating for the case-study flat in London could increase significantly in the future owing to climate change. The hours of exceedance produced by using the UKCP09 files are more adverse than those of the UKCP18 files in London. Please note the UKCP18 based weather files employed in this study will be further improved and may not represent the final version released by CIBSE.[6] Nevertheless, this study plays an important role in enhancing the transparency of the UKCP18 based weather files by having a direct comparison against the previous UKCP09 based files. The key implications on the overheating risks that the UK is facing as a result of climate change remains the same.

UKCP18 based weather files

Creation of UKCP18 based weather files

The process of creating climate projections entails many layers of uncertainties, such as the uncertainty in future carbon emissions, the modelling uncertainty, which indicates the uncertainty caused by an imperfect knowledge of the climate system, as well as the uncertainty from the measurement errors in the baseline observations. It is difficult to fully comprehend these uncertainties and generate a perfect projection of future climate using a single deterministic model, due to the complexity of the climate system.[4,6] One example of such complexity is the level of carbon emission. More specifically, to model and predict future climate it is necessary to make assumptions about the economic, social and physical changes to our environment that will influence climate change. Representative Concentration Pathways (RCPs) are a method for capturing those assumptions within a set of scenarios. RCPs specify concentrations of greenhouse gases that will result in total radiative forcing increasing by a target amount by 2100, relative to pre-industrial levels. Radiative forcing targets for 2100 have been set at 2.6, 4.5, 6.0 and 8.5 watts per square metre (W/m^2) to span a wide range of plausible future emissions scenarios and these targets are incorporated into the names of the RCPs, i.e., RCP2.6, RCP4.5, RCP6.0 and RCP8.5.[7] Therefore, the creation of future weather files considers various scenarios and parameter settings to account for the uncertainty of climate change and enables assessments associated with different levels of climate related extreme events, e.g., emission scenarios, time horizons, percentile settings.

Following the format of the existing UKCP09 weather files, the UKCP18 based DSY files are created for four emission scenarios, i.e. RCP8.5, RCP6.0, RCP4.5, and RCP2.6, three time horizons, i.e. 2020s (2009-2029), 2050s (2039-2059), and 2080s (2069-2089), three percentile settings, i.e. 10th, 50th, and 90th, three types of heat events with different intensities and durations, i.e. DSY1, DSY2, and DSY3, as well as 16 locations across the UK, i.e. Belfast, Birmingham, Cardiff, Edinburgh, Glasgow, Leeds, London Gatwick, London Heathrow, London Weather Centre, Manchester, Newcastle, Norwich, Nottingham, Plymouth, Southampton, and Swindon.

The technique used for creating future weather files is morphing, which applies the climate change projections to the existing weather files.[5] The future weather data yielded by morphing not only incorporates the climate change signal, but also retains the hour-to-hour variability of the observed weather timeseries. In this study, two versions of the UKCP18 based weather files are presented, denoted as the UKCP18 v1 and v2. The UKCP18 v1 files are produced by following the existing bounded weighted stretch morphing algorithm, which was applied previously to create the UKCP09 files.[5] The existing morphing method produces data distributions which tends to underestimate tail events, e.g., extreme heat events. Therefore, an improved nonlinear morphing process is proposed to overcome this limitation. The proposed method employs nonlinear transfer functions, including trigonometric functions, inverse trigonometric functions, as well as exponential functions, which are composed to produce data distributions with heavy tails and better encapsulate extreme events with high impacts but low probabilities. The proposed nonlinear morphing method was validated using the latest observation data from 2010 to 2020 and further employed to create the UKCP18 v2 files.

Comparison of key weather variables

Due to the large quantity of future weather files, it is challenging to evaluate all of them in this study. Therefore, we employ DSY1 files morphed using the change factors at 50th percentile under the high emission scenario, i.e. RCP8.5, as an exemplar for demonstration. The above settings are recommended in TM59 for overheating assessment.[8] Owing to the critical role played by temperature and solar radiation in resulting overheating, the characteristics of temperature and global horizontal solar radiation data are compared among different versions of weather files, namely UKCP09 weather files, UKCP18 v1 files, as well as UKCP18 v2 files. Despite the importance of wind speed in overheating assessment, it is not included for comparison in this study since the wind speed is not morphed due to the absence of relevant change factors from UKCP18. Furthermore, to ensure a fair comparison, the UKCP18 v1 files are compared with UKCP09 files to investigate the influences of different climate projections on weather file generation. The two versions of UKCP18 based weather files, i.e. v1 and v2, are compared to study the impacts of the different morphing processes on weather file creation.

Temperature. The annual maximum (Max), minimum (Min), and mean temperature (Mean) data are extracted from the three versions of DSY1 weather files in 2020s, as shown in Table 1. In general, the annual maximum, minimum, and mean temperatures in the UKCP09 files are higher than those in UKCP18 v1 files across all locations. The only two exceptions are Nottingham and Swindon, where, despite lower mean temperatures, the annual peak temperatures in the UKCP18 v1 files are slightly higher than those in the UKCP09 files. Through a further investigation this pattern, i.e. a higher warming level in the UKCP09 files, can also be observed in 2050s and 2080s.

This phenomenon of a warmer climate in the UKCP09 files can be attributed to two reasons. Firstly, within each of the three time horizons adopted for weather file creation, i.e. 2020s, 2050s, 2080s, the time horizon in the UKCP09 represents a further projection into the future than the UKCP18. The UKCP18 uses a 20-years baseline period of 1981-2000, whereas the UKCP09 employs a 30-years baseline period of 1961-1990. As a result, the 2020s in the morphed UKCP18 files represents the period of 2009-2029, as opposed to 2011-2040 in UKCP09 files. Hence, the 2020s in the UKCP09 files indicates a projection further into the future, compared to UKCP18 files. This observation aligns with other research literature that also demonstrate that the

Table 1. Comparison of temperature data among three versions of DSY1s in 2020s at 50th percentile (°C).

Temperature	Files	Belfast	Birmingham	Cardiff	Edinburgh	Glasgow	Leeds	LondonGTW	LondonLHR	LondonLWC	Manchester	Newcastle	Norwich	Nottingham	Plymouth	Southampton	Swindon
Max	18_v1	27.1	31.7	29.3	27.7	28.7	31.2	34.2	34.2	33.2	29.9	29.5	31.6	32.9	28.1	30.8	31.6
	18_v2	29.1	34.0	31.5	31.0	30.7	33.6	36.8	36.6	35.3	32.4	31.8	33.5	35.9	30.5	33.4	33.9
	09_v	27.3	31.8	29.5	27.9	28.6	31.3	34.6	34.6	33.6	30	29.7	31.6	32.8	28.2	31	31.5
Min	18_v1	−5.4	−4.3	−2.4	−6.0	−6.6	−1.5	−7.4	−4.3	0.3	−4.2	−2.8	−10.2	−3.9	−1.5	−6.5	−3.4
	18_v2	−5.4	−4.3	−2.4	−6.0	−6.6	−1.5	−7.4	−4.3	0.3	−4.2	−2.8	−10.2	−3.9	−1.5	−6.5	−3.4
	09_v	−5.1	−3.9	−2.4	−5.7	−6.3	−1.1	−6.8	−3.7	0.9	−3.9	−2.4	−9.9	−3.7	−1.2	−5.9	−3.1
Mean	18_v1	10.2	11.0	11.0	9.7	9.7	11.3	11.8	12.6	13.3	11.0	9.5	10.9	9.4	11.6	11.8	10.5
	18_v2	10.2	11.0	11.0	9.7	9.7	11.2	11.8	12.6	13.3	11.0	9.5	10.9	9.4	11.6	11.8	10.5
	09_v	10.5	11.2	11.3	10.0	10.0	11.5	12.2	13.0	13.7	11.3	9.8	11.1	9.6	11.9	12.1	10.8

climate projections in 2009 exhibit a higher warming level than the projections in 2018 across the UK.[9,10] Therefore, the temperature anomalies extracted from the UKCP09 probabilistic projections are larger than those from the UKCP18, which lead to higher temperatures after applying the morphing algorithm.

When comparing the two versions of UKCP18 files, although they demonstrate the same mean temperature for each location assessed, the peak temperatures in v2 files are higher than those in v1 files across all locations. This difference is attributed to the revised morphing method which aims to produce more extreme heat events in the v2 files to align them with the warming trend observed in recent years. The improved morphing method is validated using the observation data between 2010 and 2020. Since the focus of this study is to present the new weather files and their implications on overheating assessment, the details of the proposed improved morphing method will be further explained in future studies.

Solar radiation. The annual peak and mean global horizontal irradiance (GHI) data of the three versions of weather files across all locations are demonstrated in Table 2. Overall, the annual mean GHI data in the UKCP18 based files are marginally higher than those in the UKCP09 files for most of the locations, except Edinburgh and Newcastle. However, the UKCP09 files exhibit higher peak GHI values in several locations, i.e. Leeds, Manchester, as well as the three locations around London. The differences between the UKCP18 v1 and v2 files are very minor on GHI data.

Despite employing a similar morphing procedure when creating the UKCP09 and the UKCP18 v1 files, there is a major difference in the processing of solar radiation data. The GHI data in the UKCP09 files were estimated using a simplified clear sky model and were not morphed due to the absence of change factors for solar radiation in the probabilistic projections in UKCP09. In contrast, the GHI data were obtained through morphing in the UKCP18 based files. Overall, the positive change factors result in higher GHI values in the UKCP18 based weather files.

Table 2. Comparison of global horizontal irradiance among three versions of DSYs in 2020s at 50th percentile (Wh/m^2).

GHI	Files	Belfast	Birmingham	Cardiff	Edinburgh	Glasgow	Leeds	LondonGTW	LondonLHR	LondonLWC	Manchester	Newcastle	Norwich	Nottingham	Plymouth	Southampton	Swindon
Max	18_v1	747.0	763.0	773.0	736.0	736.0	752.0	907.0	907.0	907.0	748.0	741.0	754.0	754.0	780.0	776.0	762.0
	18_v2	747.0	763.0	773.0	736.0	736.0	752.0	907.0	907.0	907.0	748.0	741.0	754.0	754.0	780.0	776.0	762.0
	09_v	747	763	773	736	736	753	915	919	918	749	741	754	754	780	776	762
Mean	18_v1	100.9	112.9	114.9	100.7	98.2	111.3	125.1	124.6	125.3	104.6	97.9	111.7	109.6	120.8	125.0	113.6
	18_v2	100.9	112.9	114.8	100.7	98.2	111.2	125.0	124.6	125.3	104.5	97.9	111.7	109.5	120.7	124.9	113.5
	09_v	100.5	111.8	113.3	100.9	97.9	110.5	123.9	124.1	123.9	104.3	98.2	110.2	108.5	120.0	124.1	112.6

Variable distributions in the UKCP18 v2 files

To gain a detailed understanding of the newly produced UKCP18 v2 weather files, using temperature data as an example, the monthly average values and cumulative probability distributions across eight exemplar locations are presented in Figures 1 and 2. In Figure 1, the three London sites have the highest temperature during summertime, whereas Plymouth and London Weather Centre have the highest temperature during wintertime. The urban heat island effect can also be observed, as evidenced by the larger temperature gaps between London Weather Centre and Heathrow, especially in winter.

Figure 2 displays a density map (top) and a cumulative distribution plot (bottom). The density map reflects the number of samples across the spectrum of temperature for different locations. The more solid the horizontal line the more data points were found within that temperature range. The cumulative distribution plot demonstrates the probability of temperatures not exceeding certain thresholds, highlighting the variability and extremes across the different locations.

The hot weather events are more likely to happen in the three London locations as indicated by their long right tails, and less likely to happen in Plymouth and Belfast, as indicated by the density map in Figure 2. While Gatwick has the widest temperature range, London Weather Centre demonstrates the highest annual mean temperature (i.e. 13.3°C), and a warmer winter compared to the rest of locations.

Simulation results

Experiment settings

The newly created weather files are tested for overheating assessment using DesignBuilder. A two-bedroom flat in London is employed as the case study building. The total building area is 94 m^2 and the total glazing area is 30.24 m^2. The triple glazed low-emissivity glass was modelled for windows, with a U-value of 1.058 W/m^2K and a SHGC (solar heat gain coefficient) of 0.579. The external walls comprise four layers with a U-value of 0.254 W/m^2K.The building layout is presented in Figure 3. All parameter settings follow the CIBSE TM59 guidance.[8] The simulations are run for the current DSYs and three versions of future DSYs under different time horizons, i.e. 2020s, 2050s, and 2080s, generated for London Weather Centre to investigate the incremental impact of climate change on building performance. Two overheating criteria defined in TM59 are reported in Tables 3 and 4.

Simulation results of the current DSYs

The simulation results of the three current DSYs, i.e., DSY1, DSY2, DSY3, are employed as the baseline to investigate the resilience of the flat under different types of hot weather events in London. The results fail to pass the two overheating criterions defined in TM59. These are:

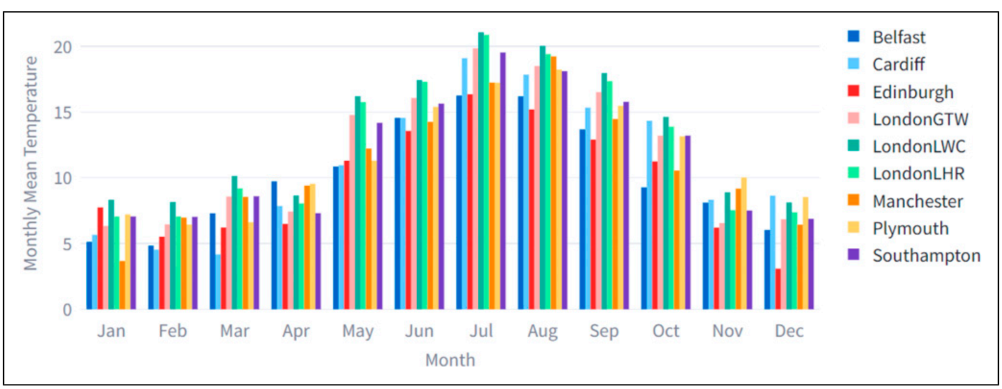

Figure 1. Monthly average temperatures in the UKCP18 v2 DSY1 files in 2020s at 50th percentile.

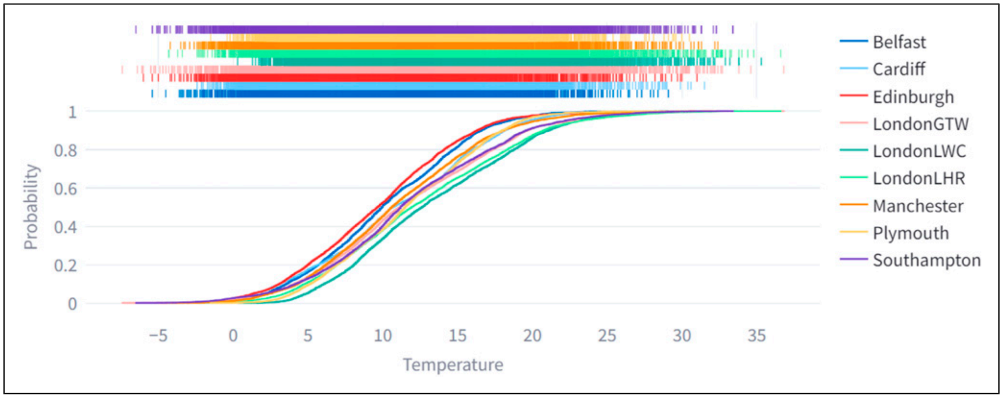

Figure 2. Cumulative distributions of temperature in the UKCP18 v2 DSY1 files in 2020s at 50th percentile.

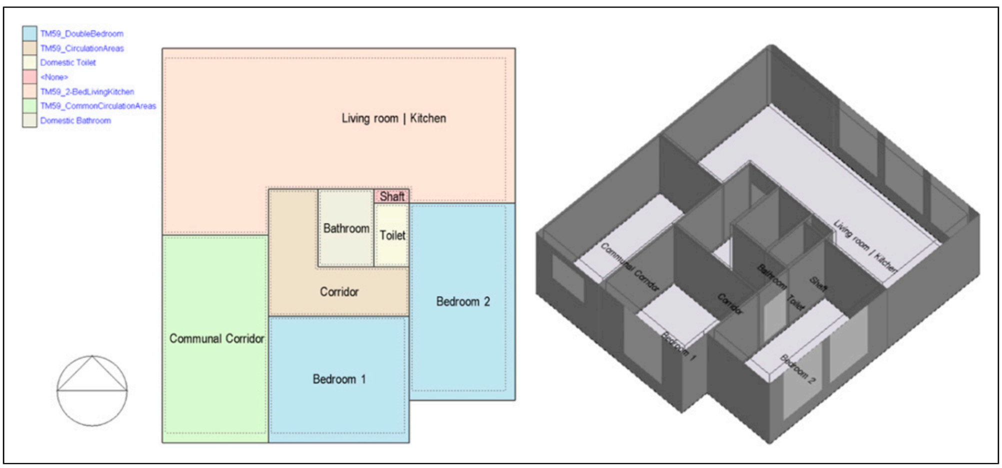

Figure 3. Layout of the flat for case study.

Table 3. Simulation results of the current DSYs

Baseline current DSYs	Zone	London_LWC_DSY1		London_LWC_DSY2		London_LWC_DSY3	
		Criterion A (%)	Criterion B (hr)	Criterion A (%)	Criterion B (hr)	Criterion A (%)	Criterion B (hr)
	Bedroom1	0.38	24	1.11	61	1.49	74
	Bedroom2	0.61	23	1.58	50	2.44	64
	LivingRoomXKitchen	0.37	N/A	1.86	N/A	2.04	N/A

Table 4. Simulation results of future DSY1s.

Weather file	Zone	2020s		2050s		2080s	
		Criterion A (%)	Criterion B (hr)	Criterion A (%)	Criterion B (hr)	Criterion A (%)	Criterion B (hr)
UKCP09_DSY1	Bedroom1	0.79	49	1.68	127	4.57	299
	Bedroom2	0.95	48	2.97	137	7.87	328
	LivingRoom kitchen	0.91	N/A	2.2	N/A	7.14	N/A
UKCP18 v1_DSY1	Bedroom1	0.67	39	1.22	86	4	257
	Bedroom2	0.86	45	2.24	99	7.81	298
	LivingRoom kitchen	0.87	N/A	1.42	N/A	6.9	N/A
UKCP18 v2_DSY1	Bedroom1	0.64	31	1.04	70	3.32	258
	Bedroom2	1.05	31	1.97	78	5.95	305
	LivingRoom kitchen	0.56	N/A	1.19	N/A	4.83	N/A

1) 3% of occupied hours for living rooms, kitchens, and bedrooms should not exceed 26°C.
2) No more than 33 h should exceed 26°C for bedrooms only.

As shown in Table 3, the flat passed both criteria under DSY1 (highlighted in green) but failed under DSY2 and DSY3 (highlighted in red). The hours failing to meet the overheating criteria are more than doubled when replacing DSY1 with DSY2 or DSY3, owing to the more intense hot weather events represented by DSY2 and DSY3.

Simulation results of the future DSYs of London Weather centre

Since DSY1 in 2020s is recommended for overheating assessment in TM59, we further tested the flat using different versions of DSY1 generated for London Weather Centre (i.e. the UKCP09, UKCP18 v1, and UKCP18 v2 files). To investigate the long-term impacts of climate change, the DSY1s under different time horizons are also employed for simulation (i.e. 2020s, 2050s, and 2080s). The results are presented in Table 4. Overall, the case study flat failed to pass the overheating assessment for all the employed future DSY1 files except one, i.e. the UKCP18 v2 DSY1 in 2020s. Despite passing the test using the above weather file, the hours of exceedance are only 1 hour less than the prescribed overheating criterion for bedrooms. Among the three versions of weather files for London Weather Centre, the UKCP09 files are most challenging to pass, followed by the UKCP18 v1 and v2 files, successively. The simulation results broadly align with the temperature data analysed in Section 2.0. Moreover, the bedroom nighttime criterion is more challenging to pass than the criterion for living rooms and kitchens in our case study. By 2080s, neither of the criteria can be met for the case study flat, and the hours of exceedance for the bedroom nighttime criterion can be up to 300 due to the sustained hot weather events in future. This indicates the scale of the challenge faced by the building sector to achieve climate-resilient building design.

The ratios of the hours for the bedrooms to be overheated at night between the current and future DSY1 are calculated to enable a direct comparison with the status quo. As shown in Table 5, the ratios calculated using the simulation results in 2020s are 2.0, 1.7 and 1.3, for the UKCP09, UKCP18 v1, and UKCP18 v2 files, respectively. This trend gradually worsens in future timelines, with the hours of exceedance regarding the nighttime criterion increasing more than ten times in 2080s.

Table 5. Ratio of the simulation results between the future DSY1s and current DSY1.

Weather file	Zone	2020s Criterion A (%)	2020s Criterion B (hr)	2050s Criterion A (%)	2050s Criterion B (hr)	2080s Criterion A (%)	2080s Criterion B (hr)
UKCP09_ DSY1	Bedroom1	2.08	2.08	4.42	5.38	12.03	12.62
	Bedroom2	1.56	2.09	4.87	5.98	12.90	14.36
	LivingRoom kitchen	2.46	N/A	5.95	N/A	19.30	N/A
UKCP18 v1_DSY1	Bedroom1	1.76	1.63	3.21	3.63	10.53	10.85
	Bedroom2	1.41	1.95	3.67	4.35	12.80	13.05
	LivingRoom kitchen	2.35	N/A	3.84	N/A	18.65	N/A
UKCP18 v2_DSY1	Bedroom1	1.68	1.31	2.74	2.94	8.74	10.90
	Bedroom2	1.72	1.37	3.23	3.42	9.75	13.37
	LivingRoom kitchen	1.51	N/A	3.22	N/A	13.05	N/A

Discussion

In this section, we further explore the factors which could attribute to the variance of the results of overheating when using different versions of weather files.

Difference between UKCP09 and UKCP18 v1

As demonstrated in the previous section, the overheating results produced by the UKCP09 files are more adverse than the UKCP18 files in London. This can be caused by two factors. Firstly, the climate model in the UKCP09 could produce a higher warming level than the UKCP18. As evidenced by the existing studies,[9,10] the higher warming level can be observed from the UKCP09 regional projections across all three warming scenarios in the UK, i.e. 2°C, 3°C, and 4°C, compared to the UKCP18 probabilistic and regional projections as shown in Figure 4. As a result, the change factors extracted from the UKCP09 are much higher than those from the UKCP18, therefore leading to higher future temperatures after applying the morphing process.

In addition, the different definitions of time horizons between the UKCP09 and UKCP18 files can also attribute to such differences. More specifically, 2020s, 2050s, 2080s represent the periods of 2011-2040, 2041-2070, 2071-2100 in the UKCP09, and 2009-2029, 2039-2059, 2069-2089 in the UKCP18. Therefore, the change factors were extracted from the populations of climate ensembles at different time horizons. This leads to larger change factors being applied in morphing when creating the UKCP09 weather files due to the longer horizon into future.

Overall, it is more challenging to pass the overheating test using UKCP09 files in London. Using the outdated climate projections for overheating risk assessment could result in overdesign, or even possibly the mandatory requirement of installing mechanical cooling. With the update of the UKCP18 based weather files, the state-of-the-art future climate projections can be employed to inform design choices and more passive measures can be promoted in making buildings future-proof and energy-efficient. However, limited literature can be found on the direct comparison between the UKCP09 and UKCP18 projections at high spatial and temporal resolutions. More investigations are still needed to better understand the attributing factors and explain the differences between UKCP09 and UKCP18 based weather files and overheating results.

Difference between UKCP18 v1 and v2

The major difference between UKCP18 v1 and v2 files lies in the morphing process. In the

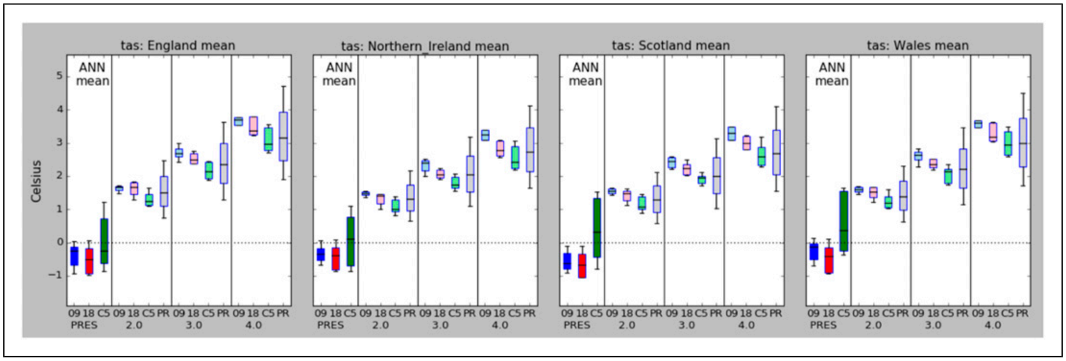

Figure 4. Comparison of annual mean surface temperature anomalies relative to 1981-2000 for the UKCP09 Regional Model Ensemble ("09": blue), UKCP18 Regional Model Ensemble ("18": pink) CMIP5 global ensemble ("C5": green) and UKCP18 probabilistic projections ("PR": purple)[10].

production of the UKCP18 v1 files, the original morphing method is employed, whereas in the UKCP18 v2 files, an improved morphing procedure was used which can better emulate the hot weather events and match with temperature record in observations. While the original morphing method assigns the change factors in a proportional manner across the whole spectrum of data distributions, the improved morphing method prioritises the extremes, i.e. the tails of data distributions. Since the overheating assessment adopts the hours of exceedance as the criteria, and the magnitude of exceeding the prescribed temperature threshold is not considered, the improved morphing method could produce more favourable assessment results due to less hours of exceedance.

Overall, morphing has inherent limitations and as such it is unlikely to identify a single perfect solution. The limitations are amplified by the method used for overheating assessment, where the dynamic variation between the day and nighttime temperature profiles are taken under consideration and can subsequently affect the assessment results significantly. The observation data indicate that the improved morphing method can produce more realistic temperature distributions (with longer tails) to capture events with low probabilities but high impacts (i.e., heatwave events). Nevertheless, further research is required to uncover the relationship between the morphing process and the overheating criteria, as well as its implications on building design.

Conclusion

In this research, the newly produced UKCP18 based future DSYs were tested for overheating assessment in London using building simulation. A total of four different versions of weather files were tested, including the current DSYs, the UKCP09 based DSYs, the UKCP18 based DSYs produced using the original morphing method (v1), as well as the UKCP18 based DSYs produced using an improved morphing method (v2). The simulation outcome indicates the risk of overheating for the case-study flat in London could increase significantly in future owing to climate change. According to the simulation results, the UKCP09 based files are most challenging to pass the TM59 overheating criteria, compared to all different versions of the weather files. This is due to the higher warming level embedded in the UKCP09 projections and the different time horizons employed for extracting change factors. Among the two versions of UKCP18 based weather files, the UKCP18 v2 files produce more favourable results than the UKCP18 v1 files, owing to the relatively smaller hours of exceedance above the threshold prescribed for overheating assessment.

To the best of our knowledge, this study is the first to evaluate the latest UKCP18 based weather files on overheating assessment, and conduct a direct comparison with the current DSYs, the UKCP09 and UKCP18 based DSYs. The insights generated from this study enhance our understanding about the new weather files and lay a good foundation for the future improvement of weather files used in building simulation to enable a climate-resilient built environment. However, there are also limitations with this research. Firstly, there is a lack of holistic consideration of creating bespoke weather files which are representative of urban climate characterised by the urban heat island effects. Besides, the findings of this research are based on a single case study building in London, therefore might not apply to other locations or other types of buildings. The potential of utilising effective passive design practice and nature-based solutions in mitigating overheating risks is not yet investigated in this study. We will address the above limitations by exploring the opportunities of creating granular weather files using the high-resolution projections in the UKCP18, extending the current simulation study to more locations under various scenarios of climate change, as well as investigating effective pathways to achieve climate adaptation for the building sector in future studies.

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