Selecting extreme weather file to assess overheating in residential building

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Abstract. Climate change is great challenge for current and newly built buildings. Nowadays, TMY weather file can be easily generated following the IPCC scenarios. Nevertheless, since these data are extrapolated with stochastic model from monthly mean values, they do not show a real pattern and do not include extreme events like heatwaves. In order to get more representative data, we propose in this work a methodology to select real measured files from a large database in light of heatwaves and climate change. This methodology is applied to the city of Lyon, for which 26 years of weather data are available. Three measured weather files projected for the time periods 2020, 2050 and 2080 are selected. These files are used in building thermal simulation of residential building with low or high thermal inertia. Summer overheating is analysed through two different comfort indicators: adaptative comfort and Givoni chart. Results indicates that summer overheating risk is obviously increased with future weather files. When compared to usual TMY files, this risk is also enhanced by using weather file including extreme events like heatwaves. Last, we note that discomfort is mainly encountered during this extreme events.

1. Selecting extreme weather files

A weather file is an input of high importance when simulating building energy performance and thermal comfort. Currently, typical weather files created statistically from historic data are mainly used in Building Energy Modeling (BEM) to design building envelop and HVAC systems. Besides, evaluating their resilience to climate short-term and long-term change is becoming more relevant. On the one side, typical future weather files can be created through downscaling approaches combining climate projections with a weather generator. On the other side, extreme weather files can be created by analyzing differently historic data. Increased frequency and intensity of extreme weather events is expected in the future. Therefore, their representation in future weather files is necessary, but remains challenging [1].

In this work, a methodology is proposed for selecting measured weather data including summer extreme temperature events to represent the climate change projections for different periods. This methodology is applied to the city of Lyon (France). Open-source weather data measured between 1994 and 2018 in the frame of International Daylight Measurement Programm [2] are compared to typical weather files generated with Meteonorm for the current (2020) and future periods (2050 and 2080 under the A2 emission scenario). The selection is carried out through two stages (see figure 1) on dry bulb temperature since this data is the mostly affected by climate change [3]. First, evaluating the
number of hours above 28 °C allows to shortlist measured weather years: 6 years for 2020, 7 years for 2050 and 1 year for 2080. Then, final years are chosen by analyzing maximal temperature, duration, and global intensity of heatwaves (as defined in [4]) through bubble chart representation. It comes that measured years 2004, 2006 and 2003 are the most representative of current, 2050 and 2080 periods respectively. Their relevance is checked against other weather data and regional future weather projections.

![Weather data collection and comparison](image)

**Figure 1.** Methodology applied to the city of Lyon (France) for selecting measured weather files including extreme temperature events regarding the climate change projections for different periods.

2. **Consequences on summer thermal comfort**

The selected measured and generated weather files are used for simulating the thermal response of a 5-storey residential building with Design Builder (v. 6.1). This building comprises 42 flats. Total floor area is 3920 m², window cover is 15% and compactness index is 1.12. Two types of exterior wall are considered: high thermal inertia wall made of concrete and external thermal insulation, and low thermal inertia wall made of wood-based materials. Occupancy schedule can be found in [5]. Particularly, mechanical ventilation of 0.5 Vol.h⁻¹ and nocturnal over-ventilation of 3.5 Vol.h⁻¹ are set.

Thermal comfort is investigated in the living room of an east-west oriented flat located in top floor. Three indicators are evaluated: the number of hours exceeding 28 °C (a maximum of 50 h is usually considered in construction programs), the number of hours out of the comfort zones defined in Givoni chart (assuming indoor air velocity of 1 m.s⁻¹) and in the standard EN 15251 for building of the category II. The two last methods allow considering relative humidity and adaption strategies in comfort evaluation. The analysis is performed during occupation periods (5h / d) from May to September (765 h occupation). Results are shown in figure 2. The criterion “T > 28 °C” is always higher than the two other criteria. The threshold of 50 h is respected for current weather files and high inertia building, but largely exceeded for other cases. The suitability of this criteria currently used in construction programs can be questioned. For Givoni and adaptive criteria (EN 15251), three trends are observed:

- The low thermal inertial building is less comfortable than high thermal inertia building, as obtained in [6]. Indeed, it is more sensitive to exterior loads like temperature or solar radiation. The operative temperature varies to large extend in the living room, leading to discomfort at midday and in the evening. Thermal comfort could be improved by adding thermal inertia in interior wall.
- Building will be less comfortable in the future. For instance, a few hours of discomfort are predicted with current weather files, while it may reach 270 h for the 2080 period. This is due to an increase of mean external temperature by 1.5 to 3 °C during summer.
- Using measured weather files lead to more discomfort than using generated weather files, due to more heatwaves. Indeed, because of high exterior temperature, night ventilation is not
sufficient to cool the building and decrease the interior operative temperature. On the other hand, the influence of relative humidity is limited, particularly on Givoni chart.

To evaluate the significance of heatwaves on discomfort periods, the ratio between discomfort observed during heatwave periods over total discomfort is evaluated in figure 3 for future weather files (2080 period). This ratio varies between 25 and 75%. It is higher when measured weather files are used. Due to more frequent, longer and more intense heatwaves, the building cannot cool down. Particularly, high thermal inertia building seems to be more sensitive to heatwaves. On the contrary, the low thermal inertia building is also sensitive other high temperature events that are not considered as heatwaves. The ratio predicted with EN 15251 comfort criterion is generally lower in agreement with previous findings [6]. Indeed, this criterion is based on weighted running mean of daily mean outdoor temperature which can mitigate mathematically the effect of heatwaves.

Figure 2. Number of hours of thermal discomfort in low and high thermal inertia buildings for various current and future weather files (measured or generated).

Figure 3. Discomfort ratio due to heatwave predicted for future measured or generated weather files (2080 period).

3. Summary
This study proposed a methodology to select measured weather files from a large data regarding the climate change and the occurrence of extreme temperature events. When used in thermal simulations of a building located in Lyon (France), these files lead to more discomfort (whatever the comfort criterion) in low and high thermal inertia buildings compared to simulations performed with usual TMY files. Particularly, discomfort will mainly occur in the future during extreme events like heatwaves. Therefore, a special attention should be paid to heatwaves when designing future new buildings and especially when testing new design solution and/or adaption solution to limit summer overheating and improve thermal comfort.

References
[1] Herrera M, Natarajan S, Coley DA, Kershaw T, Ramallo-González AP, Eames M, Fosas D and Wood M 2017 Building Services Engineering Research and Technology 38 602-627.
[2] http://idmp.entpe.fr/stafr.htm
[3] Nik V 2016 Applied Energy 177 204-226.
[4] Ouzou G, Soubeyroux JM, Schneider M, Vautard R and Planton S 2016 Climate Services 4 1-12.
[5] Lauzet N 2019 PhD. Thesis Université Bretagne Sud Lorient France.
[6] Adekunle TO and Nikolopoulou M 2016 Building and Environment 103 21-35.