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Natural Hazards and Earth System Sciences
Discussions

Interactive comment on "The role of building models in the evaluation of heat-related risks" *by* O. Buchin et al.

Anonymous Referee #2

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General comments

Despite the wealth of evidence on the impact of outdoor climate on heat-related morbidity and mortality, the relationship between indoor thermal conditions and adverse health effects is poorly understood to date. Building envelopes are significant modifiers of temperature exposure and associated health risks. This is particularly important for vulnerable individuals, such as the elderly, the very young, the chronically ill, or people with mobility problems, who are likely to spend a large proportion of their time indoors. For a given outdoor temperature, there will be a wide range of indoor temperatures as a function of building fabric characteristics and occupant behaviour. Given the scarcity of monitored indoor environmental quality data across large, nationally representative building stocks in Europe, building thermal performance modelling can be a valuable

tool in this investigation. The research topic is, thus, important and timely. However, this manuscript would benefit from a major revision before it can be accepted for publication.

As a general comment, I found certain parts of the paper that refer to the terms 'risk', 'hazard', 'vulnerability' and 'exposure' difficult to follow. I would recommend that the authors provide clear definitions of what constitutes risk, hazard, vulnerability and exposure early on in the paper. If we refer to an individual, then their vulnerability to a heat-related hazard depends on their sociodemographic characteristics (age, health status etc.) and not the characteristics of the building they occupy. Building characteristics will modify their *exposure* to said hazard and, thus, the overall risk. I think that this needs to be made clearer in the text.

As this is a proof of concept study that has only modelled a single dwelling type and no information is offered on its frequency of occurrence, caution is advised when its findings are generalised to the entire housing stock.

In addition to the above, the model assumes a linear relationship between indoor and outdoor heat hazards. This assumption is highly questionable given the dynamic nature of building systems (building physics, inhabitant behaviour, ventilation, internal heat gains etc.). Further assumptions are made according to which the impact of ventilation and internal heat gains on indoor overheating is negligible, despite the fact that there is a wealth of evidence in the existing literature that has shown the opposite. Such assumptions, thus, limit the generalisability of the model findings further.

With regard to presentation, a large number of equations are used throughout the text but quite often the various equation terms are not fully defined and their physical units are not provided. Last, the manuscript would benefit from thorough proofreading from a native English speaker.

Specific comments

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Page 2, Abstract: The Abstract could provide a) some additional description of the three simplified building models used in this study, b) a brief description of the single dwelling type modelled, and c) a summary of key findings and their implications for future research and public health policy.

Page 2, lines 20-24: It would be useful to add an indication of the magnitude of projected increases and a comment on whether urban heat island intensities will be affected by background climate change.

Page 2, line 25: 'The living conditions, especially building structure and air conditioning' > I would suggest rephrasing this as: 'Building-related factors that are likely to affect indoor thermal conditions, e.g. building structure and air conditioning'

Page 2, lines 25-26 and page 3, lines 1-11: A table that provides a summary (and potentially a ranking?) of building characteristics likely to influence indoor overheating and associated heat-related health effects would be welcome here.

Page 3, line 5: The following paper may also be a relevant reference: Salagnac, J.-L. (2007). Lessons from the 2003 heat wave: A French perspective. Building Research and Information, 35(4), 450–457.

Page 3, lines 12-15: This is the only mention of similar studies / methodological approaches in the paper. Are the authors aware of any additional studies in this area, perhaps developed for other climatic contexts? For example, relevant work has been carried out by research teams that have developed heat vulnerability indices for London. I would suggest presenting the Brandt (2006) and Pfafferott and Becker (2008) studies in more detail, together with any additional relevant studies in a separate paragraph.

Page 3, line 20: Some indication of the % time people spend at home / indoors, in Germany or other Northern European climates, would be useful and help highlight the importance of this investigation.

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Page 4, equation (1): Could the authors provide simple definitions of the equation terms 'risk', 'hazard' and 'vulnerability'? Furthermore, shouldn't *exposure* to a given hazard also form part of this equation? By way of illustration, the heat-related mortality risk of a 65+ year old individual in Berlin due to heat stress during a heat wave will be higher if they spend time in a dwelling that exacerbates overheating problems compared to an air-conditioned dwelling that reduces their exposure to the hazard.

Page 4, lines 6-7: It would be useful if the authors explain this further.

Page 4, lines 18-19: Could the authors explain what constitutes a hazard definition function (HDF)?

Page 5, equation (3): "In this case the hazard signal is directly proportional to the hazard intensity h." > How do we know this? How is hazard intensity defined?

Page 5, line 8: A definition of 'retardation effects' in this specific context would be useful. For example, does is it refer to time lags due to thermal mass effects?

Page 5, lines 13-16: I find this part a little difficult to follow. See general comment above.

Page 5, lines 20-21: 'can also be independent from the outdoor conditions by means of air conditioning' > What about individuals in low income settings that cannot afford to purchase an air-conditioning system, or even if they have one installed, do not switch it on as frequently as they would like due to concerns about electricity costs? Would this be accounted for in the model as increased hazard, vulnerability or exposure factor? What about individuals who tend to use or not use air conditioning based on existing and evolving social norms?

Page 5, lines 21-23: Is it only the night time thermal conditions that are important for health?

Page 6, line 6: If I understand this correctly, variable e would be affected by variable a, thus resulting in the influence of air conditioning being double counted?

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Page 6, line 6: Is variable e of the same value when used for hin and hout? How would the model account for reductions in heat exposure indoors (use of shading systems) vs. outdoors (wearing sunscreen or a hat)? Also, does time spend indoors include time spent in non-domestic buildings or transport?

Page 6, lines 8-10: What about dwellings that are only partly air conditioned (e.g. have only one room air conditioned, or are cooled only for a limited amount of time due to concerns about cost, carbon emissions, indoor air quality etc.)?

Page 6, lines 17-19: This needs to be explained further.

Page 6, equations (4), (5) and (6): I was wondering whether equations (4), (5) and (6) could be merged into a single simpler equation.

Page 7, lines 3-5: "[. . .] it is useful to assume a linear correlation between indoor and outdoor hazard, hin = chout." To what extent is this a valid assumption (see general comment above)? Are there data to support this assumption for the German housing stock? Also, assuming a linear relationship with a slope c, how do we know there is no constant term b, i.e. hin = chout + b? Furthermore, hout was defined earlier as a function of outdoor temperature thresholds that are location-specific and were defined based on epidemiological evidence. How is hin defined in this context?

Page 8, lines 8-10: The standards cited (EN 15251:2012, ANSI/ASHRAE Standard 55-2013) assume a linear relationship between the desired 'comfort temperature' and the running mean of outdoor temperature, to factor in acclimatisation effects for the population, based on extensive field data collected during large scale thermal comfort surveys. Comfort temperature is, however, different to the actual indoor temperature of a building. As explained above, the latter is likely to be influenced by building fabric characteristics, occupant behaviour etc.

Page 8, line 18: Omitting the impact of natural ventilation is another major assumption. Taking into account that a very small number of dwellings will have windows closed

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during a period of hot weather, the output of the model will be rather limited as it will only apply to a very small fraction of the housing stock. In addition to this, what about the influence of uncontrolled ventilation, i.e. building fabric air permeability?

Page 9, line 4: "[. . .] we assume that internal heat sources are negligible [. . .]" > This is another major assumption than needs justification. Existing monitoring and modelling work has demonstrated that internal heat sources can, in fact, be significant modifiers of indoor overheating risk and, thus, not including them would significantly limit the applicability of the model.

Page 9, line 10: The Wright et al. (2005) relationship was developed based on data collected from British dwellings, of which the fabric and occupancy characteristics are likely to be different to other housing stocks. To what degree would it apply to the German housing stock, for example?

Page 10, lines 1-4: How typical is this building type for Berlin / Germany? An indication of its % prevalence across the stock would be useful.

Page 10, lines 9-10: Why was this value specified? Is it based on available monitoring data?

Page 10, lines 12-21: The time periods of climate data used for building modelling and the hazard calculation do not match. Is this likely to affect the accuracy of the results?

Page 11, lines 1-2: "The system group is assumed to be fully exposed to the indoor climate (e = 0) without air conditioning (a = 0)." > This is another major assumption that limits the generalisability of the study findings to only certain parts of the population.

Page 12, lines 1-2: What is the main criterion of a model's success?

Page 12, lines 24-26: "Note that elevated mortality rates occur 25 at 19C as the winter season data with elevated mortality rates is influencing this mean value." > This is slightly unclear.

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Page 13, line 12: How were these threshold ranges defined?

Page 15, lines 21-23: Building characteristics possibly explain part of the geographical variation in outdoor temperature thresholds for temperature-related mortality. Other factors include population acclimatisation levels, social norms, the effectiveness of public health infrastructure etc.

Page 16, lines 2-6: Local microclimate effects are also likely to be important.

Page 16, lines 7-14: A brief comment of how such time lag effects vary across housing stocks with different thermal mass / inertia characteristics would be welcome.

Page 18, line 4: 'recalculation also of historic indoor conditions' > It is unclear what is meant by this term.

Page 18, lines 20-22: "It was shown that the definition of vulnerability in a traditional risk approach based on the outdoor hazard does not contradict exposition towards the indoor hazard." As per my earlier comment, I believe that the vulnerability levels of an individual / population remain unchanged; it is their exposure to a hazard that varies between indoors and outdoors.

Technical corrections

Page 2, line 2: 'groups are most' > 'groups spend most'

Page 2, line 2: 'can easily discussed' > 'can be assessed'

Page 2, line 12: 'Exemplary, . . .' > 'As an example in this study, . . .'

Page 2, line 14: 'parametrized' > 'parameterized'

Page 3, line 4: 'peoples' > 'people'

Page 4, equation (1): The equation nomenclature (e.g. e, p, s) needs to be defined right below the equation.

Page 4, lines 6-7: It would be useful if the authors explain this further.

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Page 4, lines 6-7: 'differentiated' > 'differentiates'

Page 5, equation (3): All equation terms need to be defined right below the equation.

Page 5, line 21: 'nightly recreation' > Does this refer to night time sleep and rest?

Page 6, line 1: 'additive' > 'formulated'?

Page 6, line 6: 'exposition' > 'exposure'?

Page 6, equation (6): The equation term Nout is not defined.

Page 8, equation (8): The equation terms need to be defined.

Page 9: equation (13): The equation term Thist is not defined.

Page 10, line 12: 'of the the indoor climate' > 'of the indoor climate'

Note My main area of expertise is building physics. I would, therefore, suggest obtaining at least one additional review from a colleague with expertise in the area of epidemiology that could comment on the linkages of model outputs with mortality data.

Interactive comment on Nat. Hazards Earth Syst. Sci. Discuss., 2, 7621, 2014.

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Interactive Discussion

Discussion Paper