Dear Referees,

thanks for your detailed evaluation of the manuscript. We appreciate your comments on our article and think that the revised version of the manuscript will reflect their influence.

There were some general comments and reservations included in both of your reviews, which can be summarized and condensed into the following issues:

1. Scarcity of information on the "traditional" evaluation of heat-related risks,
2. Appropriateness of the choice of only one single dwelling type,
3. Missing background information on the chosen representative building type,
4. Insufficient explanation of the detailed EnergyPlus building model including ventilation and occupant behaviour, and
5. Appropriateness of simplifications in the applied building modeles.

We understand your reservations and want to explain our view on the above points and document the changes in the manuscript:

1. We include more references and studies on the evaluation of heat-related risks with outdoor temperatures and include references to the most up-to-date publications. To allow for better classification of the indoor/outdoor concept in the field of probabilistic concepts to evaluate heat-related risks, an overview is included which summarizes the concepts to evaluate risk and hazard on different spatial scales (state level, city level, district level, individual level) . We think that this overview helps to better motivate the development of the pragmatic indoor/outdoor risk concept which can be applied with only little more information than an outdoor risk approach on a larger regional level. Furthermore, we also elaborate on the general probabibalistic evaluation of risk in the introduction and the definitions of risk, hazard, and vulnerability.

2. Considering that the majority of papers analyse risk data with outdoor climate data of one specific location (often air temperature data from nearby airport weather stations) any other model which is more suitable to represent the actual hazard of the persons at risks should be taken into consideration. Instead of one single time-series of air temperature of one outdoor location this paper evaluates the risk data with (modelled) time-series data of one single building zone. From a methodological point of view, the choice of any other proxy data, either measured or modelled is appropriate. Of course, the representativeness of the chosen building type can be questioned with the same justification as for the outdoor approach. We include this argumentation in the revised manuscript. Results of studies which use spatially resolved data to evaluate heat-related risk data are included in the argumentation.

3. The chosen building type reflects the most prevalent one, with the block-type building structure (promoterism and art nouveu block structure) having the largest share of the Berlin building stock (>28,3% of inhabitants). We include a reference to the Berlin building typology and the following table of the building structures in the revised manuscript.

Table: Building structures and construction periods of the Berlin building stock and number of inhabitants calculated with mean population density, data according to planning area typology

construction period	building structures	area (ha)	inhabitants	percentage
1870-1918	block-type structures, 4-6 storey	2888	965000	28,3%
1870-1918 + newer	block-type structures, 4-6 storey, space closure	1124	298000	8,7%
1920-1930	block-type structures with large courtyards	779	132000	3,9%
1920-1940	parallel, oriented line-type structures	853	221000	6,5%
1950-1980	line-type structures	2540	414000	12,1%
1960-1990	high-rise buildings and greater settlements	2283	632000	18,5%

1990-today	mixed types	515	107000	3,1%
all periods	detached houses	14702	643000	18,8%

4. The EnergyPlus building model includes seasonally adjusted infiltration rates and thus reflects increased window opening during the summer season. Such, natural ventilation is included in the model. We did not implemented the usage or control of outer shading elements (awnings or roller blinds) as the block-type buildings in most cases, especially in the upper storeys and on the front sides, do not feature such elements.
    The revised manuscript includes a more detailed description of the EnergyPlus building model and its parameterization. Furthermore we will provide the modelling file (Energy Plus IDF Format) as supplementary material. However, we try to keep the numerical model and its description as simple as possible. The simulation results serve as a regression basis for the simpler building models and the temporal resolution will be lost due to the integration on a daily time scale.
5. The simplified models are parameterized by regression with the simulation results of the EnergyPlus model and thus also include the relevant climate modifiers (including infiltration and user behaviour). These models are necessary to allow for a simplified transformation of the outdoor hazard into an indoor hazard and to foster understanding of the main influential effects. Furthermore, we used the operational room temperature from the EnergyPlus simulation for regression.
    Concerning the reservations towards the linear building model, we agree that this model is not sufficient to model indoor environments in an exact manner. In the paper it serves as a didactic bridge between outdoor and indoor approach and it is shown, that linear risk evaluation with outdoor weather data includes some building effects also. Additionally it can be seen that the linear model is missing the main non-linearities of the building envelope and thus only poorly explains the risk data.

Additionally to these general comments we adress your specific and technical comments below (in order of your specific comments in the manuscript) and document the changes in the manuscript. Please note that we only document on comments which need explanation. Comments which were directly implemented in the revised manuscript are not documented.

Kind Regards,

The Authors

BLACK: Referee comments,
BLUE Authors response,

Referee 1
General comments
This paper addresses an important topic – the role of indoor overheating on population mortality during hot weather, and addressed the issue in a novel way. This work is particularly relevant due to the predicted changes in climate, including an increase in extreme heat events, and the changes in the housing stock due to energy-efficient retrofit policies.

Due to the importance of the topic, I recommend publication, however I have a number of reservations. Firstly, the modelling work has examined only a single dwelling type, and has broadly generalised this across the entire housing stock, although I recognise that this is a

proof-of-concept study. We know that different dwelling types have varying overheating risks, and there is little background information provided to justify
the selection of the dwelling (some info on the prevalence of the building type would
be useful, for example). There seems to be little consideration for occupant behaviour
and ventilation during the modelling process, both of which can have significant influences on indoor temperature, and in the majority of cases building occupants can be
expected to take some action to counter high indoor temperatures such as opening
windows.
Authors response: See general responses 2, 3 and 4.

The development of models based on the EnergyPlus simulation – presumably to enable real-time risk estimation – ignores many modelling approaches that have been
shown to have a good correlation to EnergyPlus models, such as NeuralNetwork models. The assumption of linearity between indoor and outdoor temperatures is tenuous,
as buildings are transient, dynamic systems. Finally, a mention of the role of Urban
Heat Islands in potential risk would be beneficial, for example the paper by Gabriel
and Endlicher (Urban and rural mortality rates during heat waves in Berlin and Brandenburg, Germany, Environmental Pollution, 2011). The paper would also benefit from
more of a review of existing studies where heat-related mortality has been predicted
based on housing or urban characteristics.
Authors response: See general responses 1 and 5.
 This study does not intend to implement a real-time risk evaluation or real-time risk estimation (e.g. for a health warning system). Of course, artificial neural network (ANN) models could be used to have a more accurate reproduction of modelled or measured data. Nonetheless, we have some reservations towards the usage of these „black box" models as these incorporate much more parameters and the underlying physical processes can not be extracted and interpreted. Of course, all models with more parameters than the simplified 2- and 3-parameter models presented in the paper should explain the risk data with higher accuracy. If neural network models are applied these should directly correlate outdoor climate and risk data. The intention of the paper is to provide a robust model which allows for projections of risk development under changing climate and building conditions. Under these conditions, with longterm temporal extrapolation and new risk modifiers (e.g air-conditioning) the ANN models probably will fail.

Abstract Line 1. I would say they are generally based on outdoor climates. However,
some models (for example Wolf and MacGregor, as well as the ones referenced in the
paper) have developed risk indices which account for dwelling types.
Authors response: We modified the abstract accordingly and include your suggested reference and further references in the introduction. See also general response 1.

Pg 7622 line 20. Heat waves have definitions that vary according to different bodies.
Heat events which may not be categorised as heatwaves may also cause mortality risk
to increase. Please consider changing heat waves to 'heat events'.
Authors response: That is right and we do not want to argue on the definitions of heat waves. We follow your suggestion to more strictly differentiate between heat events and heat waves.

Pg 7624 line 24 Can you please reference PMV and UTCI
Authors response: A reference (Jendritzki et al., 2009) to these indices is included in the revised manuscript.

Pg 7625 Line 6 It is not immediately clear what is meant by retardation effects in this
context. Does this refer to prior weather conditions? Or prior indoor temperatures?
Authors response: Actually, it is generally written and refers to indoor or outdoor hazards. We want to provide a general framework to work with heat related risks. We use the termisnus lag in the revised manuscript to be more consistent with the literature on risk assessment with outdoor hazards.

Pg 7625 Line 20. Indoor contributions to temperature due to internal gains (from, for

example, occupant metabolism, hot water supply, and electrical equipment) may also contribute to indoor overheating, independent of weather conditions.

Authors response: The internal gains can be considered to be constant for each day and independent of the weather. The EnergyPlus simulation includes mean internal loads. We agree that the loads can contribute to overheating, however, for simplification in the proof-of-concept calculation, we do not extract these internal gains in the simplified models as further parameters would be necessary to cover their contribution. Considering the derivation of the physical building model these constant gains would only generate a general offset on the temperature level.

Pg 7625 Line 21 Please clarify what is meant by night recreation

Authors response: We use another formulation (nightly physiological regeneration) in the revised manuscript.

Pg 7626 Line 6 Please clarify what is meant by 'exposition parameter'. Is this a parameter to describe exposure?

Authors response: We changed the terminus exposition to exposure throughout the whole manuscript and give a more detailed explanation of our understanding of exposure in section 2.1.

Pg 7626. Equation 6. While it can be inferred from the following paragraph, it would be helpful if you could explain the variables Nout and N. If one were to define Nout and N, would it account for the lag-behaviour of a population spending time in both outdoor and indoor locations, or is it largely nominal? Is there an argument for having exposure inside non-domestic buildings accounted for?

Authors response: The concept does not intend to model the temporal paths of one individual in different thermal environments. Following the methodology of the risk concept the main influential climatic surrounding has to be identified (outdoor, indoor unconditioned, or indoor conditioned). If a system sub-group spends its predominant time in non-domestic buildings, e.g. shift worker in office like environment, this can be implemented. However, in scope of the example of heat-related mortality of the retired population aged >65 we restrict the conceptual description to the domestic indoor environment.

Pg 7627 line 10. Occupant behaviour in response to high internal temperatures (for example the opening of windows) and preceding weather conditions (alongside varying thermal mass within the building fabric storing heat energy from previous hot or cold days) will also lead to non-linear relationships between indoor and outdoor temperature. The assumption of linearity is tenuous.

Authors response: Linearity, of course, does not represent the thermal behaviour of the building. However, it is included for didactic reasoning on a theoretical level. This argumentation should foster the understanding that linear regression approaches (e.g. ANOVA, PCA) used in other studies miss the main non-linearities of the underlying building physics. This section and the following linear model show the results of a common regression analysis. From a didactic point of view it is not only important to show that detailed models perform better, but also to understand why and to what extend these are better than more simple models.

Pg 7628 EN 15251 refers to comfort thresholds, and has a linear relationship to running mean temperature. Comfort thresholds do not easily transfer to mortality risk, as defined by increased risk above temperature thresholds, as it accounts for occupant adaptation over a period of hot outdoor weather, and it is generally presented as a number of percentage of hours exceeding comfort thresholds (which will be highly non-linear with outdoor temperatures – please see Mavrogianni et al, 2014, The impact of occupancy patterns, occupant-controlled ventilation and shading on indoor overheating risk in domestic environments, Building and Environment). It is not clear how the linear relationship between comfort temperature thresholds and outdoor temperatures, as detailed in EN 15251, supports a linear relationship between outdoor and indoor absolute temperature.

Authors response: You are certainly right. We just wanted to provide an example with a linear relation between an outdoor hazard value and an indoor hazard value. We corrected the

argumentation in the revised manuscript.

Pg 7628 Line 13 Representing a building as a box model leads to the assumption that the sources of heat gains are located in the same zone as the occupant exposed, or that the heat will be evenly transferred throughout the dwelling. Please justify this.
Authors response: We'd like to point out that our requirement on the models is not to perfectly match the interior temperatures and their distribution but to represent a mean indoor temperature in the built environment as a reliable value for the risk evaluation. According to the model assumptions there is only one temperature in the zone and the heat is evenly transferred.

Pg 7628 line 18. Ventilation is very important for reducing overheating risk. I understand if this was ignored in the physical building model, but it is important to know whether it was included in the EnergyPlus model.
Authors response: See authors general response 4. Natural ventilation/infiltration is included in the EnergyPlus model and we have included more information in the respective section. As the simplified models are parameterized with the results of the EnergyPlus simulations, they also include infiltration (and occupant behaviour and internal heat sources), however in an indirect way.

Pg 7629 – Parameterization data. Was ventilation included in the EP model? Without even a nominal air change rate, the overheating risk is likely to be very high indeed. What was the reason for the choice of storey of the dwelling, given that a number of studies have shown top-floor flats have amongst the greatest overheating risk of all dwelling types? This model is representative of a single dwelling type, yet is applied using population mortality data.
Authors response: See general response 2. We understand that the spatial resolution of indoor temperatures in one region would be more accurate. However, even "normal" risk evaluation is often based on only one (not even representative) climate. The spatial distribution is resolved in some studies for the outdoors, however, there is no general trend to include the indoors. We have choosen an intermediate storey of the dwelling, as this can be associated to be a good representation of all other storeys. We think, that the climate in the top-floor flats does not represent the climate of the whole group. However, there will always remain some arbitrariness in the choice of one representative point for a spatially distributed system which can not be resolved in this paper.

7633 Line 13 – please define/clarify SD
Authors response: SD=Standard deviation

Pg7633 Line 21 – Do you mean example rather than exemplary?
Authors response: Yes.

Pg7633 Line 22 – it is unclear until you look at the figure that the calculation has been done for individuals over 65 – this should be mentioned in the text, ideally in the methodology. Where did the mortality data come from? It is possible you would see a stronger association with an older age group
Authors response: As the old are known to be highly at risk, we used this age group. The association between heat and mortality is stronger for the older as preexisting medical conditions are known to be exarcerbated by the heat. We describe the source of the data in section 2.5 and motivate the specific age group in the revised manuscript.

Pg 7634 Line 9 – Is this the mean number across the population aged over 65?
Authors response: Yes. We included further reference to the age group in the revised manuscript.

Pg 7636 Line 2 – there is more recent data for London, and other locations. Please see, e.g.: Armstrong et al, Association of mortality with high temperatures in a temperature climate: England and Wales, 2010, JECH Gasparrini et al, The effect of high temperatures on cause-specific mortality in England and Wales, Occ and Env Med, 2012

Referee 2

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.
Authors response: See general response 1.

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.
Authors response: See general responses 4 and 5. Linearity, of course, does not represent the thermal behaviour of the building. However, it is included for didactic reasoning on a theoretical level. This argumentation should foster the understanding that linear regression approaches (e.g. ANOVA) used in other studies miss the general contribution and non-linearities of the underlying building physics. This section and the following linear model show the results of a common regression analysis. From a didactic point of view it is not only important to show that detailed models perform better, but also to understand why and to what extend these are better than more simple models.

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

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.
Authors response: We would like to implement your suggestions, however, the abstract is restricted to a maximum of 200 words and we prioritised to strengthen c) in the revised abstract.

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.
Authors response: We included further references in the revised manuscript.

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'
Authors response: We have included your suggestion into the revised manuscript.

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.
Authors response: We appreciate your idea, however the scope of the paper is not to rank specific building characteristics. However, we included further characteristics in the text and separate between the most influential characteristics and minor modifiers.

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.
Authors response: Thanks for this information. We include the information from the reference in the introduction part of the revised manuscript.

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.
Authors response: We do not have found further studies which relate time series of indoor conditions to risk data. The vulnerability indices for London (Wolf and McGregor, 2013) include building type and air-conditioning as principal components in a vulnerability analysis for London, however, without fostering the understanding for the underlying building physics and without analysing actual risk data. We included a more detailed survey on further approaches to handle buildings in risk analysis.

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.
Authors response: We include study results of Krause and Schulz (1998) for Germany and Jenkins et al. (1992) for California, US, both showing that time spend indoors exceeds 80%.

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.
Authors response: We have revised this section, especially we implement a more detailed

paragraph on the general understanding of exposure in risk analysis and our understanding of exposure as modifier between indoor and outdoor hazard. See also general response 1.

Page 4, lines 6-7: It would be useful if the authors explain this further.
Authors response: We have revised this section and include the general description of risk, hazard, vulnerability, and exposure in the introduction.

Page 4, lines 18-19: Could the authors explain what constitutes a hazard definition function (HDF)?
Authors response: We intended to name the process of getting a hazard intensity from any hazard signal as this is done in many analyses e.g. by filtering, or transformation to running mean. To point out, that these processes also refer to the hazard definition, we included the term "HDF" into the original manuscript. In the revised manuscript we do not use the terminus hazard definition function and more accurately describe the functional relations.

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?
Authors response: We revised the description of this section.

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?
Authors response: In the revised manuscript we use lag instead of retardation. The effects refer to building thermal mass and human physiology. If the effects can be separated we use ther termini thermal lag and physiological lag in the revised manuscript.

Page 5, lines 13-16: I find this part a little difficult to follow. See general comment above.
Authors response: We revise the description of this section.

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?
Authors response: This is really an important question. Unfortunately, we do not have any data to evaluate the impact of individuals with low income in areas with large proportion of air-conditioned buildings. However, the risk concept is able to allow for such a differntiation, which does not hold true for other concepts. If the number of these people can be estimated these can be included in the group of people without air conditioning and such are exposed to the unconditioned indoor climate, otherwise, in the analysis the increase in risk at constantly low hazard will increase the vulnerability of the whole group under consideration and can be attributed to the low income in a separate vulnerability analysis.

Page 5, lines 21-23: Is it only the night time thermal conditions that are important for health?
Authors response: No, we use daily mean data to describe the hazard, either indoor or outdoors. However, the argumention fosters the necessity for the evaluation of the indoor environment as only few people spend the night outdoors.

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?
Authors response: Having air conditioning does not necessarily mean that people are predominantly exposed to the air conditioned climate. Example: If the risk of heat stroke in a group of construction workers is evaluated it is necessary to know the percentage of workers predominantly working outdoors (e.g. 30%) and the fraction of air-conditioned environments (e.g

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.)?
Authors response: The concept does not intend to model the temporal paths of one individual in different thermal environments. Following the methodology of the risk concept the main influential climatic surrounding has to be identified (outdoor, indoor unconditioned, indoor conditioned). If a system sub-group its predominant time in non-domestic buildings, e.g. shift worker in office like environment, this can be implemented. However, in scope of the example of mortality of the retired population aged >65 we restrict the conceptual description to the domestic indoor environment.

Page 6, lines 17-19: This needs to be explained further.
Authors response: We include an explanation in the beginning of the section in the revised manuscript.

Page 6, equations (4), (5) and (6): I was wondering whether equations (4), (5) and (6) could be merged into a single simpler equation.
Authors response: We changed the order of the equations to (5),(6), and (4) to improve readability. However, from a didactic point of view, we do not want to merge them into one single 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?
Authors response: Linearity, of course, does not represent the thermal behaviour of the building and in this section we do not want to make an assumption which represents the German building stock. However, it is included for didactic reasoning on a theoretical level. This argumentation should foster our understanding that linear regression approaches (e.g. ANOVA, PCA) miss the general contribution and non-linearities of the underlying building physics. This section and the following linear model show the results of common regression analysis. From a scientific point of view it is not only important to show that other, detailed models perform better, but also to understand why these are better than other models.

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.
Authors response: You are certainly right. We just wanted to provide an example with a linear relation between an outdoor hazard value and an indoor hazard value. We corrected the argumentation in the revised manuscript.

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 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?

Authors response: see general response 4.

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.
Authors response: Of course, the effect of internal sources can be significant modifiers and their impact can be handled in an improved model. Nonetheless, the simplified model does not (explicitly) include internal sources.

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?
Authors response: We just use the underlying modelling framework, which is based on a physical modelling approach. We do not use the parameterization of the British housing stock but use a parameterization with the representative building described above.

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.
Authors response: see general response 2.

Page 10, lines 9-10: Why was this value specified? Is it based on available monitoring data?
Authors response: We use normative values. We modified this to 20°C in the revised manuscript in accordance to DIN EN 12831 (calculation of heating loads) for indoor air temperatures in living and sleeping rooms.

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?
Authors response: We use different time periods for building parameterization and for hazard calculation as the data are only available for the different time periods. Furthermore, this approach should represent the possible process of risk analysis (Building parameterization with short-term measurements or numerical simulation --> risk analysis with longer time-series and simplified model). We only expect differences if the climate data in the longer period is leading to extrapolation of the indoor climate.

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.
Authors response: As there is nearly no air conditioning in German/Berlin dwellings this assumption is generalisable (however, this assumption can not be backed by statistics). Of course, it has to be modified if applied to other cities with a significant share of air-conditioning.

Page 12, lines 1-2: What is the main criterion of a model's success?
Authors response: The models performance is determined (and rated) by high predictibility at low root mean square deviation (RMSD). Further criteria can be a low number of descriptive parameters. We include a definition of successful model-perfomance in the revised manuscript.

Page 12, lines 24-26: "Note that elevated mortality rates occur at 19C as the winter season data with elevated mortality rates is influencing this mean value." > This is slightly unclear.
Authors response: For heat-related mortality, direct effects on the respiratory system are probably more important, while for cold-related mortality, analysis yielded evidence of an important indirect effect involving increased incidence of influenza and other respiratory infections (Kunst et al. 1993).

Page 13, line 12: How were these threshold ranges defined?
Authors response: The considered threshold range starts at the lower end 1K above the minumum air temperatures (15°C outdoors, 19°C indoors) and ends at the maximum temperature.

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.
Authors response: We agree that all these factors might influence outdoor temperature thresholds, however, if these effects have to be quantified the building characteristic has to be extracted from the data. Thats what the concept can be applied for and we expect that the remaining variation is in a narrower temperature range.

Page 16, lines 2-6: Local microclimate effects are also likely to be important.
Authors response: Of course, some studies evaluate the spatial distribution of risk and outdoor (micro)climate. Such a study is out of scope of the given data.

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.
Authors response: The representative building can be considered as a building with high thermal mass, however, the building-related lag-parameter (t=100h =4d) of the physical building model can not be directly compared to the lag days of 1-2 days (see Gosling et al., 2009) calculated from the risk and climate data by cross-correlation. We include this point in the revised manuscript.

Page 18, line 4: 'recalculation also of historic indoor conditions' > It is unclear what is meant by this term.
Authors response: We changed the sentence to: "Building models are essential in the understanding and evaluation of the indoor climate and allow for a~calculation of a time-series of indoor climate conditions from a time-series of outdoor climate conditions. In this way, a~risk analysis based on outdoor climate data can be also interpreted from the indoor context."

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.
Authors response: We agree that vulnerability should not be influenced by the building characteristics. However, this holds true for the 'traditional' risk approaches.

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.