HEATWAVE FORECASTING WITH A COUPLED AIR-BUILDING MODEL

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Abstract

An effective heatwave forecasting scheme is necessary to warn the health services and public as early as possible to take appropriate measures. A simple building box model was set up to simulate the temperature of a model building during a heat wave in different regions. This simple model can explain the heat related death much better than the outside temperature (minimum or maximum). We found a very good correlation between the inner-box-temperature and the heat related death.

Key words: heatwave, mortality rate, building-air model

1. INTRODUCTION

Summer 2003 in Germany will be remembered for extreme high temperatures and for a strong impact on health especially on the elder. In western parts of Germany heat related death rose about 25% (LOEGD 2004). The number of emergency calls rose significant (PFAFF 2003). An effective heatwave forecasting scheme is necessary to warn the health services and public as early as possible to take appropriate measures.
Different authors found that heat related death in heatwaves do not correlate very well with daily maximum temperatures. Daily minimum temperatures and the duration of the heatwave are important factors, too (JENDRITZKY, TINZ 1999).
The reason for this could be that it takes a while until the outside heat will warm up the interior of buildings without air conditioning. Our idea to offer a new and better forecasting system was to build up a building box model to simulate the interior temperature of a model building and relate it to the death rate.

2. METHODS

The diversity of building types in Germany don't allow to choose an average building type for the model. Only the average size of the building box conforms to the average in Germany.
A building box model was set up to simulate the temperature of this model building during a heatwave in different regions. The parameters of the building box, like the conductivity of the walls, are taken from the building standards of 1984 in Germany (RWE 1991), which represents the majority of buildings. The following tables (Tab. 1, Tab. 2) show the parameters of the model house (RWE 2004).

parameters of the model house	U-value	unit	area	unit
walls overall (without floor, with roof)	1	$W * m^{-2} * K$	197,5	m^2
windows overall	2	$W * m^{-2} * K$	22,5	m^2
roof overall	1	$W * m^{-2} * K$		
floor overall	1	$W * m^{-2} * K$		
air quantity in the building	300	m^3		
air change	0,2	$\% * 100^{-1}$ per hour		
overall-mass in the building	102500	kg		
specific heat	1	$kJ * kg^{-1} * K$		
indoor start temperature	20	°C		

Tab. 1: parameters of the model house

areas of the model house	length in m	height in m	window ratio in $\% * 100^{-1}$
southern area wall	10	3	0,25
eastern area wall	10	3	0,2
northern area wall	10	3	0,1
western area wall	10	3	0,2
roof area (plane bungalow)	10	10	0
floor overall	10	10	0

Tab. 2: areas of the model house

To simulate the interior heat load we choose the typical energy consumption and inner heat production of a family. The temperature variation inside the building is simulated with weather data from the nearest weather station.

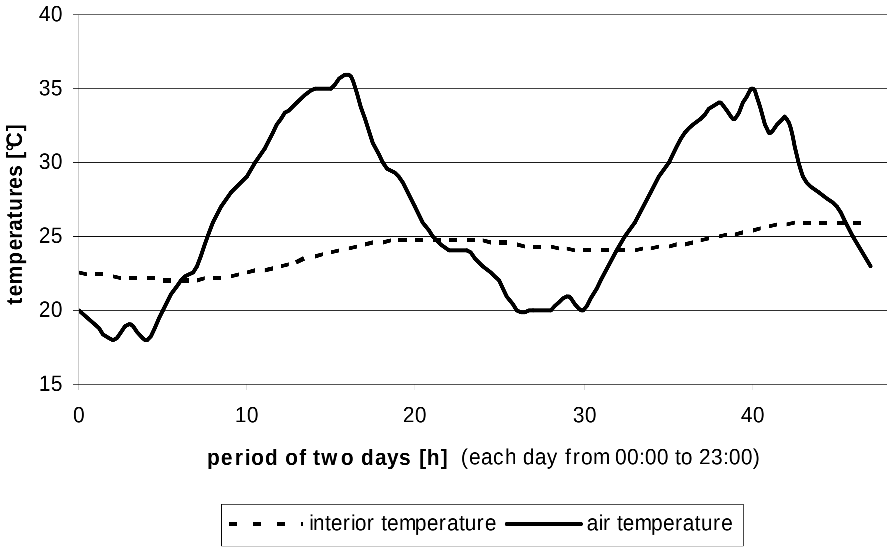

Figure 1: example of air and interior temperature variation on two sunny days

3. RESULTS

Figure 2 shows the relation between the maximum air temperature during summer 2003 (from 1st of June to 31st of August) in Frankfurt (DWD 2003) and the daily mortality rate in Frankfurt. The correlation between the air temperature and the mortality rate is moderate (r = 0.57).

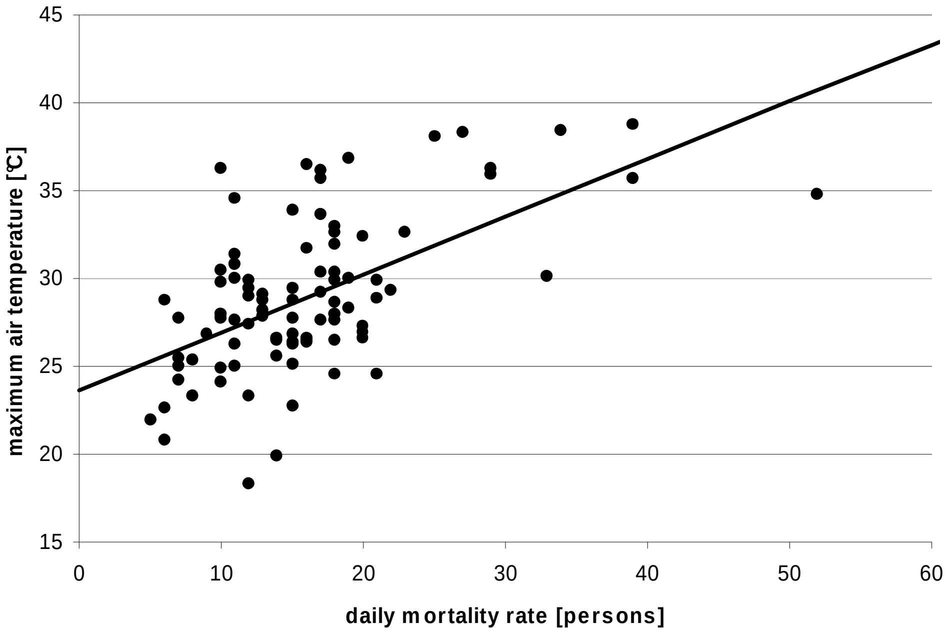

Figure 2: correlation between the maximum air temperature and the daily mortality rate in Frankfurt (summer 2003 from 1st of June to 31st of August)

This weak correlation is not a surprise because the risk of heat related death is only a problem for people at an age of over 65 which have already health related problems (HEUDORF, STARK 2004). This group of people do not spend time in the hot outside air.

Figure 3 shows the daily maximum temperature in August 2003 and the calculated model interior temperature for Frankfurt. Figure 4 demonstrates the correlation of these two parameters.

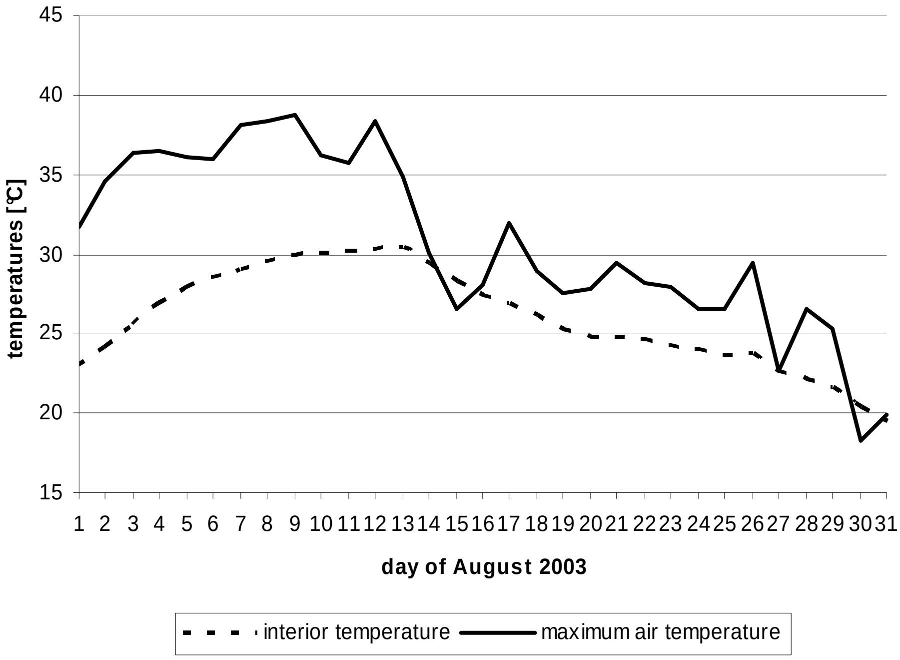

Figure 3: daily maximum temperature and calculated model interior temperature in Frankfurt, August 2003

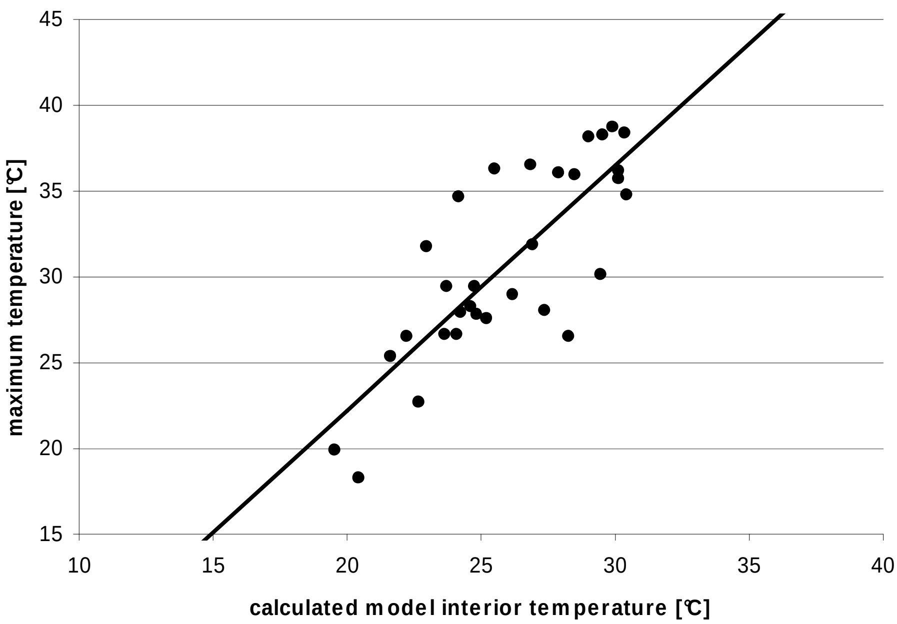

Figure 4: correlation of daily maximum temperature and calculated model interior temperature in Frankfurt, August 2003

The interior temperature muffles the temperature variations of the outside air. The maximum interior temperature during a heatwave can be expected 1-3 days after the maximum of the air temperature.

Figure 5 shows the interior temperature and the mortality rate on a daily basis for the summer 2003 in Frankfurt (1st June - 31st of August). The correlation between the interior temperature and the mortality rate is 0.8.

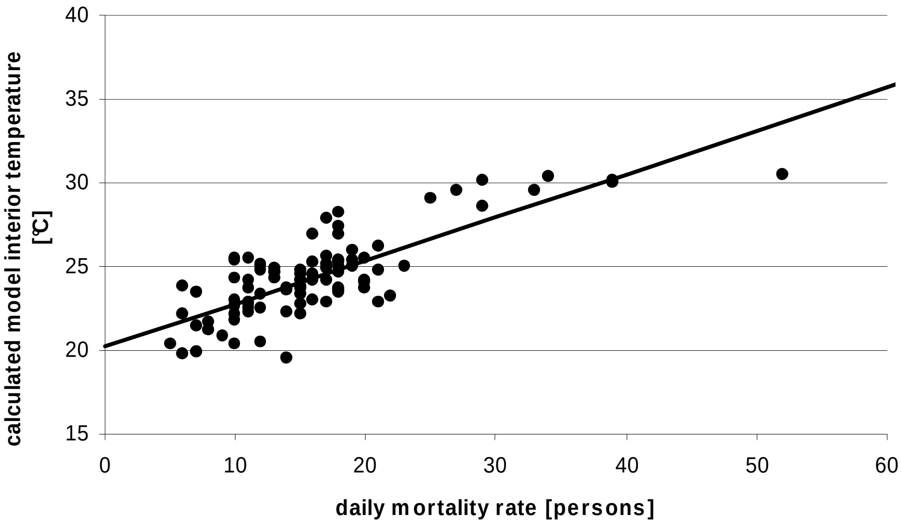

Figure 5: correlation of interior temperature and the mortality rate on a daily basis in Frankfurt (summer 2003 from 1st of June to 31st of August)

The temperature in the model building rose in Frankfurt from 23.0 °C at the beginning of the heatwave (1st of August 2003) to 30.5 °C at the end of the heatwave (13th of August 2003).

This coupled-air building model can explain the heat related death in Germany much better than all air temperature (minimum or maximum) indicators. We found a correlation between the inner-box-temperature and the heat related death between 0.80 and 0.89 during different heatwaves in Germany.

4. CONCLUSION

We believe that the reason for this good correlation is that elder people avoid the outside heat and stay indoors. Without air conditioning and proper ventilation the outside heat comes into the building with a time lag during a heat wave. Health problems because of the thermoregulation occur because of the high temperatures indoors.
The model is used since April 2006 on the weather emergency website **www.unwetter.de/innenraum/** in Germany. A nationwide forecast enables a precise heatwave forecast.

The next step is to use the model on a worldwide scale.

5. REFERENCES

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