# The Heat Health Warning System of DWD—Concept and Lessons Learned

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# The Heat Health Warning System of DWD—Concept and Lessons Learned

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**Abstract** The Heat Health Warning System (HHWS) is a way to provide information for the general public and the public health authorities in order to be prepared for heat waves and to minimize their negative health impacts. The combination of weather forecast, thermal indices (Perceived Temperature) and their specific thresholds, short time acclimatization of people during summer conditions, nocturnal minimum temperature and indoor conditions are used to predict specific conditions such as heat episodes, which are associated with consequences like an increased mortality and morbidity among human population. In addition information about the expected duration of these conditions is important. These specific thresholds and approaches have thermo-physiological bases and are used to assess the levels of heat stress to which humans are exposed. Warnings are generated from the numerical daily weather forecast and then confirmed or adjusted by the biometeorology forecaster. The HHWS can lead to a reduction of the heat related mortality and in general to protection of human life. The HHWS is in operation since 2005 and preliminary studies indicate a reduction in the heat related mortality ever since.

## 1 Introduction

There is evidence that heat has a big influence on human health especially on mortality and morbidity. The 2003 heat waves led to a significant increase in the number of fatal casualties (IPCC 2007; Matzarakis et al. 2011; Larsen 2006). Due to the climate change in the future both the frequency and intensity of heat waves is expected to increase, which will lead to a rise in heat-related mortality (Matzarakis et al. 2011; Muthers et al. 2010), with the main risk for the elderly, chronically ill, very young children and socially isolated people (Koppe 2009).

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In Germany the HHWS is based on a thermal index (Perceived Temperature) and the impact analysis is based on the quantification how the different thermal stress categories impact on human health, and when it is necessary to issue a warning, and analysis of mortality data from various European regions (Koppe 2005). As the morbidity data available are often inadequate, unfortunately, total mortality can be selected as the indicator of health impacts. It was found that in all the regions investigated, heat loads classified as "heavy" and "extreme" were associated with a clear deviation of actual mortality from the expectation value (Koppe 2005). On average days with a heavy heat load result in a mortality rate that is about 13 % higher than the expected (Koppe 2005, 2009). Even a moderate heat load is linked to a significant increased mortality.

As a consequence of the 2003 heat waves, many European weather services have set up HHWS. The HHWS can utilize weather forecast to predict specific periods of heat, which can have negative implications and impacts on human health (Koppe 2009). For protection of population appropriate communication strategies and a well-structured preparedness plan to trigger intervention measures need to be provided and established (Koppe 2009).

# 2 Methodology

The HHWS of the German Meteorological Service consists of several components and includes both automatically generated information from the numerical weather forecasts and human consideration and decisions by biometeorologists. The HHWS includes also ways of communication and preventive actions to be taken. In the following, the warning process is explained.

## *2.1 Perceived Temperature*

There is knowledge and evidence that a single meteorological factor like air temperature is not appropriate to describe the entire effect extraordinary heat might have on the human body. Therefore the energy exchange between the human body and its environment, which takes place via short- and long wave radiation, the turbulent flows of sensible and latent heat including breathing, sweating and other energy fluxes, is applied. For the calculations of the energy balance of the human body, there are four basic meteorological variables: air temperature, mean radiant temperature (which considers short- and long wave radiation fluxes), air humidity, and wind speed at a human related height (Matzarakis 2007; Parsons 2003). Together with thermo-physiological factors like the metabolic rate and the clothing, these meteorological elements provide the six fundamental factors which define the conditions for energy/heat exchange between the human body and its environment (Matzarakis 2007; VDI 1998).

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**Table 1** Perceived temperature, thermal perception and physiological stress (after VDI 1998)

| Perceived temperature (°C) | Thermal perception | Thermo-physiological strain |
|---|---|---|
| <− 39 | Very cold | −4: extreme cold stress |
| −39 to −26 | Cold | −3: heavy cold stress |
| −26 to −13 | Cool | −2: moderate cold stress |
| −13 to 0 | Slightly cool | −1: less cold stress |
| 0–20 | Comfortable | 0: no thermal stress |
| 20–26 | Slightly warm | 1: less heat load |
| 26–32 | Warm | 2: moderate heat load |
| 32–38 | Hot | 3: heavy heat load |
| ≥38 | Very hot | 4: extreme heat load |

The method used by the German Meteorological Service for the health-relevant assessment of the thermal environment is Perceived Temperature (PT) (Jendritzky 1990; VDI 1998; Staiger et al. 2012). This is based on a complete energy budget model of the human body and takes into account all relevant mechanisms of heat exchange with the atmospheric environment. The computation of Perceived Temperature is based on a standard male, known as "Klima-Michel". This standard male chooses his clothing in order to remain in thermal comfort as far as possible, with a clothing value (clo) from 0.5 to 1.75. The Perceived Temperature (PT) is given in the dimension °C and can be summarized in terms of a scale of physiological stress or strain (Table 1) Staiger et al. 2012.

The calculation of Perceived Temperature is performed based on hourly data of the weather forecast of the German Meteorological Service and for heat warning the value of PT at 12 UTC is used with the warning criteria of classes of the heavy heat load (3) and extreme heat load (4) (Table 1). However, because days with at least a moderate heat load occur relatively frequently—between 30 and 40 times a year—"moderate heat load" is not suitable for use as a warning criterion; excessively frequent warnings may result in "warning fatigue", with people failing to take them seriously (Koppe 2009).

## 2.2 *Short Time Acclimatization and Nocturnal Conditions*

During summer, humans gradually become more acclimatized to high temperature conditions. Heat loss becomes more efficient, e.g. through an increase in the sweating rate. In order to account for this acclimatization, a procedure has been developed which allows the threshold value of the comfort range (Table 1) to be adjusted according to the thermal conditions of the last 30 days (Koppe 2005). The classification bands are maintained, however, and the threshold values for moderate, heavy and extreme stress shift accordingly (Koppe 2009). The thresholds for individual stress categories vary, in addition, from region to region: for example,

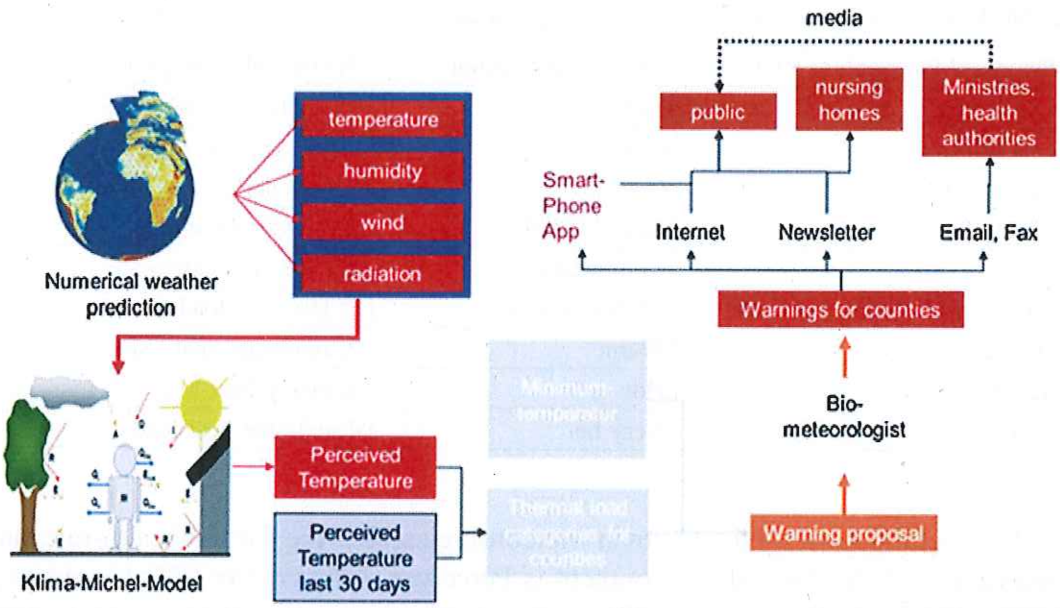


**Fig. 1** Workflow of HHWS and ways of communication

they are generally higher in southwestern than in northern Germany in summer (Koppe 2009) (Fig. 1).

For the night situation, the minimum temperature is considered, if it falls below a specific threshold (16–18 °C, depending on the region), as night-time cooling guarantees a recovery period (Koppe 2009). During long-lasting heat waves, acclimatization adjustment of the threshold values to weather conditions over recent weeks could well produce too high threshold value for "heavy heat load". Therefore, in order to ensure that warnings continue to be issued during this type of scenario, the warning threshold value is fixed at a maximum of 34 °C Perceived Temperature. In addition, for a more appropriate description of the conditions indoors, information from a building simulation model that provides data about thermal conditions in the indoor environment is considered in issuing of the heat warning (Pfafferott and Becker 2008).

## 2.3 *Warning Criteria*

Based on the above automated factors, the biometeorologist considers the preliminary warning proposal, adjusts and modifies it, if needed, and—most importantly—decides about issuing the warning. On each day that the Perceived Temperature at 12.00 Universal Time Coordinated (UTC) exceeds the warning threshold, a warning is issued by the DWD at around 10 a.m. The warning covers a two day period. The information pathways are followed when the "heavy heat load" threshold is exceeded. Based on numerical weather prediction for the next 48 h, the model calculates whether the "heavy heat load" warning threshold will be exceeded in the individual counties across Germany, and up to which altitudes. This generates a warning recommendation which is then reviewed by biometeorologists. They have the option to accept the recommendation to issue a warning, and they can also add warnings of their own if, in their view, a critical situation could arise (Koppe 2009). The warning is valid on county level including several elevation classes.

## 3 Communication and Application of Warnings

The warnings generated in this way are published on the DWD website (http://www.dwd.de/gesundheit). The heat warning is available as maps and registered users can receive information by daily newsletter. A specific smartphone application is also available for general use. The main target groups are the public, nursing homes and ministries of the federal states and other authorities. The relevant health and supervisory authorities are also notified; they are responsible for drawing up a list of intervention measures and monitoring their implementation. There is also the option of broadcasting the warning more widely to the public on radio and television. In addition to the heat warning for the next 48 h, the DWD provides heat load information for the next 2–7 days. In addition the warning includes information about the number of days with heat warning.

## 4 Discussion and Conclusions

Nowadays it is important, to, not only issue warnings about high air temperatures but also to consider other meteorological parameters that influence the heat balance of the human body (Matzarakis 2007; Koppe 2009). The DWD applies the Perceived Temperature for this purpose. When issuing heat warnings, the threshold values that must be exceeded in order to trigger a warning are adjusted to local weather conditions over the past 30 days. This adjustment is necessary to take account of the fact that the human body adapts to its thermal environment (acclimatisation). For a southern European, for example, a Perceived Temperature of 30 °C is a common condition, whereas for people in northern Germany, such temperatures may result in considerable physical stress.

Evaluations of the HHWS in the Federal State of Hessen show that the system is working effectively, especially in the area of residential elderly care. There is a clear signal that the number of admissions has fallen significantly (Koppe 2009). This shows that the measures taken in Hessen in response to heat warnings have successfully reduced the number of heat-related health complaints. Additionally a high awareness and acceptance of the HHWS has been lately confirmed by a project of the Federal Environmental Agency, where the current warning systems in Germany were assessed (Capellaro and Sturm 2015).

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In view of the climate change and the prospect of more frequent and intensive heat waves, it is important to develop such intervention measures further and extend them to other areas outside residential care. Although the elderly are classed as particularly vulnerable, other groups of person can suffer during heat waves, as well.

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