PROCEEDINGS OF THE MEETING OF EXPERTS TO DEVELOP GUIDELINES ON HEAT/HEALTH WARNING SYSTEMS

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1. OPENING OF THE MEETING

The meeting was opened by Mr Wolfgang Kusch, Vice-President of the Deutscher Wetterdienst (DWD), on behalf of Mr Udo Gärtner, President of the DWD and Permanent Representative of Germany with WMO. Mr Kusch welcomed the participants to the meeting and to Freiburg, noted the importance of the issues associated with extreme heat events and human health, and wished the participants success with the important task to develop Guidelines for Heat/Health Warning Systems (HHWS). On behalf of Mr M. Jarraud, the Secretary-General of WMO, Dr. B. Nyenzi, Chief, World Climate Applications and CLIPS Division (WCAC) at WMO, welcomed the participants, and thanked the DWD, Mr Kusch, Professor Jendritzky and other colleagues for their excellent support in coordinating and hosting the meeting.

1.1 Background to the WMO Commission for Climatology (CCl) Activities Related to Heat/Health Warning Systems

Dr Nyenzi provided a brief overview of the WMO activities on Heat Health Warning Systems that have taken place over the last several years. At the Fourteenth WMO Congress (Geneva, May 2003), members noted that two Showcase Projects on Heat/Health Warning Systems had been successfully launched in Rome, Italy and Shanghai, China some years earlier. The WMO Member countries stressed the need for capacity building for National Meteorological and Hydrological Services (NMHSs) in such methodologies, and urged the Commission for Climatology (CCl) to continue to support these activities. Furthermore, Members had been urging the CCl to prepare Guidelines on HHWS for use by the NMHSs since the Fifty-third WMO Executive Council (EC) in June 2001. It was noted that although the two Showcase projects were launched in 1999 and 2000 respectively, WMO had not published any assessments of the operational phase of these initiatives.

1.2 WMO Perspectives on the Guidelines for Heat/Health Warning Systems

It was stressed that the Guidelines on Heat/Health Warning Systems are meant to serve the WMO Member countries, and therefore must be useful within a number of climate and socio-economic conditions. WMO Members face stressors such as population growth, intensification of Urban Heat Island effects and demographic shifts to cities that may make cities in some parts of the world particularly, and increasingly, vulnerable. Given the prevalence and serious impacts of heat waves around the world, and the IPCC projections that indicate such extreme events could increase in frequency or magnitude in a warmer global environment, development of the Guidelines must proceed as quickly as possible.

The Guidelines should include information on the nature of heat waves, options available for countries to assess their vulnerability to them, tools with which to predict dangerous episodes (with options ranging from simple to state-of-the-art) and on coordinated intervention strategies within communities, including advice on building effective partnerships with agencies that can implement health and social services for mitigation, within communities, of the negative public health impacts of heat waves. It should be noted that the purpose of the Guidelines is not to rank known HHWSs in any way, but to present information on a range of options that will allow any NMHS (whether large or small) to evaluate its needs in consideration of its capacity to implement and manage a HHWS. The WMO Guidelines will present these options in a fair and balanced way, with all due respect for, and balanced critique of, each method, for effective decision-making.

As the Guidelines are intended to help NMHSs develop HHWS programmes, a different strategy is recommended for sharing information on heat waves and their risks with a broader readership. Therefore the CCl is proposing a new booklet on heat waves, to be produced as a high priority by mid-year 2004. WMO recognized the complexity of these tasks, and the challenges inherent in operationally establishing and maintaining the full suite of activities needed to run effective Heat/Health Warning Systems.

1.3 Meeting Objectives

Dr Nyenzi urged the meeting to:

- provide all possible support to the President of the CCl in development of the booklet on heat waves;
- carefully review past and current developments in heat and human health research and applications;
- develop a comprehensive outline for the Guidelines on Heat/Health Warning Systems;
- establish a workplan for development of the document that would allow final publication well in advance of the Fourteenth session of the Commission for Climatology in November 2005; and
- review the Terms of Reference for both Expert Teams on climate and human health (ETs 3.7, 3.8) and discuss issues related to delivery of the assigned tasks.

2. ORGANIZATION OF THE MEETING

2.1 Approval of the Co-Chairs, the Meeting Agenda and Working Arrangements

The participants agreed that Professor Gerd Jendritzky and Dr Glenn McGregor would co-chair the meeting. The working arrangements were established (daily sessions from 9:00 AM to 5:30 PM, with brief coffee and lunch breaks). The hosts (DWD) offered to provide all meeting documents (those available electronically before the meeting, and those presented at or generated by the meeting) on CD for each participant at the end of the session. The provisional agenda was reviewed and approved with minor amendments (see **ANNEX I**).

2.2 Participants

Due to the cross-cutting nature of the issues involved in Heat/Health Warning Systems, participants at the meeting represented a range of disciplines. Attendees included representatives from each of the OPAG 3 Expert Teams (ETs) on Climate-Health issues, namely the ET on Operational Heat/Health Warning Systems (ET 3.7) and the ET on Health-related Climate Indices and their use in Early Warning Systems (ET 3.8). Key members of the CCl Core Management Team (President, CCl and Chair, CCl OPAG 3) and Public Weather Services (Chief, WMO PWS, and the VP, DWD) were present. Partnerships are critical to development of successful HHWS, and in that regard, representatives from the World Health Organization and the European Commission funded PHEWE Project (Assessment and **P**revention of Acute **H**ealth **E**ffects of **W**eather Conditions in **E**urope) also attended.

Dr L. Kalkstein (Lead for ET 3.7) was unable to be present, but provided extensive references as preparatory documents and was represented at the meeting by Ms Cegnar. Due to circumstances beyond their control, several other members of ET 3.7 (Ms Michelozzi and Mr Tan) also could not attend. The final List of Participants is attached as **ANNEX II**.

3. DEVELOPMENT OF THE PROPOSED CCl BROCHURE ON HEAT WAVES

The meeting clarified that the Guidelines on HHWS were those urged by WMO Decision bodies and Members, for the use of Members in evaluating needs for, and implementing HHWS in their NMHSs. The Guidelines will therefore be a technical document, including scientific details of the various options for HHWS. The CCl booklet on heat waves, on the other hand, will be written for a more general audience including WMO NMHSs, urban planners and other decision-makers, and the interested public (see item 3, below).

Decision 1: The meeting agreed that the first priority at the meeting and in the follow-on activities would be development of the detailed technical Guidelines on HHWS, as recommended by the Fourteenth WMO Congress in May 2003.

Decision 2: The CCl President will develop a booklet on heat waves, a key priority of the WMO (title of the booklet is yet to be determined). The approved outline for the booklet is presented in **ANNEX III**. The target deadline for delivery of the final text (including WMO approval process) is WMO EC-LVI, June 2004.

> ***Action:*** The Lead experts for the ETs 3.7 and 3.8 of OPAG 3 will support development of the CCl booklet on heat waves by helping to finalize the outline, proposing experts to complete the required content, assisting in the acquisition of graphics, photos and illustrations in publication quality and formats, and by acquiring the credit information and permissions for illustrations and photos (**Prof G. Jendritzky; Dr L. Kalkstein**).
>
> ***Action:*** The WMO Secretariat will be responsible for technical editing of the document, layout and printing. Due to the time required for these steps, these activities may be done in summer 2004 (after EC-LVI in June). (**C/WCAC**)
>
> ***Action:*** The Secretariat will review WMO Bulletins for applicable references that may support the text. ***Action completed***. (**L. Malone**, week of 19 April 2004).

4. REVIEW OF THE ACTIVITIES TO DEVELOP AND IMPLEMENT HHWS

4.1 Decisions of WMO EC, Congress and CCl, and Expert Team Actions on HHWS

An overview of WMO activities on HHWS was provided. The initiative began in January, 1997, within the mandate of a CCl Working Group on Climate and Health, at a meeting in the DWD, Freiburg. Two Showcase projects were conceived and implemented in Rome, Italy and Shanghai, China in 1999 and 2000, respectively. Following this, WMO Members stressed the need for capacity-building for NMHSs and urged that the experts proceed with Phase II to develop the Guidelines on HHWS, for the use of any WMO Members vulnerable to heat waves (as per the reports of WMO EC LIII, June 2001, section 4.1.37; CCl XIII, November 2001, section 7.1.7; WMO EC LIV, June 2002, section 4.1.4.6; WMO Congress XIV, May 2003, section 3.2.5.23). The activities on climate and health were redefined at the Thirteenth session of the CCl in November 2001, during which two new Expert Teams were established (ETs 3.7 and 3.8 as described above).

An important aspect of WMO Guidelines on HHWS is that they must transfer knowledge and build capacity to help and support any country whose citizens are vulnerable to dangerous heat waves. Comprehensive background information, details of the options for assessment of risks and prediction of extreme events and tools (from simple, to complex, state-of-the-art methods) must be made freely available for Members' use.

4.2 Review of the Rome and Shanghai HHWS Showcase Projects

An update on the Rome Showcase project was not provided since a member of the Rome project team was not able to attend the meeting.

In Shanghai the second Showcase HHWS project was developed under the umbrella of WMO, WHO and UNEP, using a synoptic meteorology/climatology approach developed at the University of Delaware, USA – the Spatial Synoptic Classification (SSC) (Kalkstein, 1996). Intense but infrequent heat waves occur in Shanghai and with 13 million inhabitants, the city meets the criteria set for Showcase projects (adequate sample size for application of the HHWS in question). Local health and meteorological authorities were willing to participate in development of the HHWS and to provide mortality and meteorological data (for the period 1989-1998) for development of the algorithms used in this approach. Algorithms specific to Shanghai were developed at University of Delaware in summer 2000. The University of Delaware HHWS model had been established on the basis of the identification of an offensive air mass that had been shown to be associated with elevated mortality rates in summer. Furthermore, an algorithm for excess deaths associated with offensive air masses had been created for further guidance. Using step-wise linear regression, meteorological and non-meteorological factors, the algorithm produced results that allow 4 categories of warning (0, or no warning, through to 4, or severe levels), based on the numbers of anomalous deaths expected (ranging from fewer than 39 to more than 80). The local health agencies had proposed a series of mitigation measures for saving lives and reducing burdens on society.

Results of the Shanghai studies showed that more women tend to die in heat waves than men (partly because there were more women in the age group most vulnerable to heat waves), and that factors such as the social structure of the city and building styles played a significant role in mortality related to heat events. The hot, humid Maritime Tropical (MT+) airmass was seen to be most associated with anomalous death. It was also learned that mortality data is tricky to deal with, as there was little consistency in classification of heat-related deaths. However, many heat-related deaths are due to circulatory or respiratory failure.

The Shanghai authorities noted that there was a need to develop further intervention plans, including some long-term actions, such as:

- suggestion to municipal government to implement long-term heat/health related prevention and intervention activities;
- better city planning and increase of green areas to reduce the "heat island" effect;
- recommending development and implementation of occupational health regulations of some protective provisions concerning work time, environment and compensation during a heat wave;
- sufficient resources to support the health education for residents and target groups, concrete intervention measures at the time of a heat wave, and research in weather and human health;
- education and intervention can be also done targeting those with sustainable treatment of some drugs, etc.

China was considering developing HHWS for other vulnerable cities including Wuhan (capital of Hubei Province), Nanchang (capital of Jiangxi Province), Nanjing (capital of Jiangsu Province) and Hangzhou (capital of Zhejiang Province). Several systems were being discussed by the Department of Forecasting Service and Disaster Mitigation, China Meteorological Administration, but had not yet been funded. The CMA was also conducting additional research into the impacts of heat on human health, the distribution of excessive deaths and the urban heat island effect, and other heat indices for use in Heat/Health Warnings.

In discussion it was noted that there had been various levels of success with the intervention strategies developed in some cities with installed HHWS. It was also noted that many attempts (by the President of the CCl, by the WMO Secretariat (through C/WCAC and C/PWS), by the Lead for ET 3.7 and by the DWD) had been made to try to provide Heat/Health information to the Hellenic National Meteorological Service in time for the Athens Olympics of August 2004, with effectively no success.

4.3 Overview of Past OPAG 3 Expert Team Activities and Actions Related to HHWS

It was noted that the initial discussion on the Showcase HHWS Projects took place in the 1997 Freiburg Meeting of Experts on Climate and Human Health including WHO (WCASP-42). This meeting also led to the idea to link the CHH activities to the (informal) WMO/WHO/UNEP Interagency Network on Climate and Human Health. The development and installation of HHWSs (the U. Delaware model) have been completed for Rome and Shanghai. It was further noted that development of an appropriate intervention strategy that took into consideration local needs, such as political and urban infrastructure, is the most difficult step in the development of HHWSs.

The ET on Operational Heat/Health Warning Systems (ET 3.7, OPAG 3) reported that the Terms of Reference for the work of the ET had been revised (see **ANNEX IV**). The meeting noted that, to come into effect, these ToRs would have to be presented to and approved by the CCl management team.

Progress in the work related to the ToRs of ET 3.7 included development of HHWS (the U. Delaware model) in three additional cities in Italy, several US cities, and in Toronto, Canada. A number of papers on the established systems and their effectiveness were published or ‘in press’. ET members have participated in conferences, such as the International Congress of Biometeorology, Kansas City, USA, 2002. Several ET members participated in the EU PHEWE project, and worked in close partnership with partners (particularly within Europe), such as WHO.

NMHSs played a major role in issuing of Heat/Health Warnings, by contributing weather and climate data, short-term forecasts, extreme event indices, knowledge of climate, including urban and microclimates, and they have proven links to the media. As well, in future, NMHSs will link monthly to seasonal forecasts into the programme, where skill allows.

4.4 The European Union PHEWE Project

4.4.1 Overview

The general aim of the Assessment and **P**revention of Acute **H**ealth **E**ffects of **W**eather Conditions in **E**urope (PHEWE) project is to assess the association between weather and acute health effects (daily mortality and hospital admissions) during the warm season in Europe and to provide information for public health policy on preventive and adaptive actions. PHEWE objectives include development of a European database of meteorological variables and health indicators, recorded on a daily basis, and analyses of the effects of weather on daily mortality and hospital admissions and on the confounding and synergy between weather and air pollution, as well as public health guidance and an estimation of the burden of disease. As well, PHEWE will develop a Heat/Health Watch Warning System (WWS) for 5 pilot cities (London, Paris, Barcelona, Rome, Budapest), along with proposals for public health actions.

4.4.2 The PHEWE Heat/Health Watch Warning System (Workpackage 'F')

The overall aim of the WWS work package is to develop Heat/Health Watch Warning Systems (WWS) for five European cities that can be applied in the mitigation of heat related death and illness. The protocols associated with system development, evaluation of predictability, operation and testing may be applied to warning system development in other European cities through technology transfer. Specific details of the objectives, methodologies, deliverables, expected results and milestones are attached as **ANNEX V**.

The Heat/Health WWS, based on a synoptic approach and on forecast meteorological variables, is a model to predict in advance and to alert city's residents of potentially oppressive weather conditions that could negatively affect health. This represents a unique innovation in the field of climate and health research in Europe because a co-ordinated effort to develop a Heat/Health WWS based on actual climate and health relationships and the application of a common set of development protocols, has not yet been attempted at the Pan European scale. Moreover, there are also a number of specific innovative aspects that relate to basic science and public health policy, namely:

- Warning systems developed will take into account the climate and population characteristics of each of the target cities;
- Warning system advisories will be related to tangible health outcomes;
- The WWS is specifically designed to prevent adverse health effects and therefore a unique system and service for citizens of the targeted cities will be provided;
- A landmark set of intervention plans will be designed for the mitigation of heat related death and illness in the target cities;
- A virtual real time test of the system will be undertaken;
- System development will promote interdisciplinary collaboration and engender a collegiate approach to climate and health research.

It was noted that algorithms have been developed for the city of London, and those for Budapest are in progress. The Budapest 'Roadshow' has been completed, and the London event is scheduled for 7 May 2004. The algorithms for the other cities are to be developed by the end of May 2004. A protected web site will be developed to hold the prediction results. In September 2004, the system effectiveness will be evaluated. The DWD will provide the required forecast and meteorological input. The HHWS team leads for the PHEWE project will inform WMO/CCl of their experiences in data handling, analysis protocols, and barriers to implementation and intervention strategies. Four CCl ET members are also PHEWE participants, so both projects will benefit from close collaboration.

Early results from the HHWWS workpackage of the PHEWE project indicate that increased mortality is associated with a DT+ (Dry Tropical) airmass. The difference between the PHEWE airmass-based approach and that of the U. Delaware system is that for the case of PHEWE prediction algorithms are run everyday, whereas the other only proceeds to predict excess deaths when one of the pre-defined airmasses is forecast. For the PHEWE approach, other methods, in addition to the airmass approach, are used, and it does not depend on a fixed definition of 'summer'. The PHEWE approach is similar to the U. Delaware one in that it produces single-station results and validation lags operations by about 2 years, while waiting for the official mortality data. It is uncertain that airmass identification is a vital part of the forecast system as other approaches, such as a simple model based on the Apparent Temperature may yield superior predictability of excess mortality. . Unlike some HHWWS elsewhere the PHEWE system will take meteorological forecast information directly into the predication algorithms. Another aspect of the airmass approach PHEWE is evaluating is that some airmass-based systems assume that people do not die of heat in non-MT+ or DT+ airmasses, but, of course, deaths do occur from hot weather on non-MT+ and DT+ days.

4.5 Overview of HHWS Activities in Toronto, Canada

A Heat/Health Alert System has been developed for Toronto, Canada by Dr S. Sheridan (Kent State U.) and Dr L. Kalkstein (U. of Delaware). The system development was funded by the Toronto Atmospheric Fund and the Toronto Department of Public Health. Two "offensive" weather types were identified: Dry Tropical (DT) and Moist Tropical Plus (MT+). Both types are associated with approximately 4 deaths greater than the mean, and both are the least common weather types (together 7% of all summer days). The system became operational in summer of 2001 as a pilot project, in collaboration with Toronto Weather Office (Environment Canada).

The system utilizes daily weather predictions to assign each day one of three system levels: routine monitoring, heat alert, or heat emergency. When a heat alert or emergency is forecast, Toronto Public Health issues a press release, and mobilizes its various services, along with numerous other city agencies, in an effort to minimize potential adverse impacts of hot weather. These services include contacting vulnerable people, setting up 'hotline' information service, providing hot-weather tips, distributing bottled water, directing residents to cooling centres, etc. In the hot summer of 2002, 15 Alerts and 2 Emergencies were issued, and the costs of mitigation activities to Toronto Public Health were estimated to be $100 000 (CDN); excluding in-kind and indirect expenses. Costs to numerous other partners are largely unknown. Mortality statistics for 2002 are not yet available.

After three summers in operation, preliminary feedback from Toronto Public Health and Toronto Weather Office suggests that this system has certain merits and some drawbacks. The merits include greater partnership between several agencies at different government and community levels. The heat alert system is based on a better scientific approach (as compared to Humidex), and it provides a better tool for decision making. On the negative side, the system remains largely a "black box" to Toronto weather forecasters since it runs on a computer at U. of Delaware. The system would benefit from giving Toronto forecasters a greater understanding and control. The system is highly sensitive to dewpoint temperature (DP) and would be difficult to automate since NWP models have weakness with DP and cloud cover prediction. The system does not adequately account for microclimatic conditions. For example, system development required weather data that are available only at a suburban site (Toronto Int'l Airport), which does not adequately describe lake breezes and the urban heat island effect. The system does not address air quality and morbidity issues. It is a site-specific alert system (for Toronto), and the surrounding nearby cities and towns can potentially be confused or misled, when they hear a heat alert issued for Toronto.

A research project is currently underway and led by the City of Toronto and the Ontario Region of Environment Canada to assess the possible impacts of climate change on human mortality in south-central Canada. This project (to be completed in March 2005) also examines human stresses due to the present climate, including the synergistic effects of heat and air quality. It applies a more holistic weather classification approach; it employs longer weather, mortality and air pollution records in several cities (Windsor, Toronto, Ottawa and London), and it examines the stresses on human mortality year-round (due to heat, cold and/or air pollution).

During discussion, it was pointed out that it would be difficult to assess the impacts of trends in health-care, socio-economic conditions, intervention strategies, etc. on mortality trends in climate change scenarios.

4.6 DWD Experience with the KLIMA-Michel-Model in the Heat Waves of 2003

Although heat waves are rare events, they are associated with significant mortality impacts (Basu and Samet, 2002). In August 2003 a major heat wave killed about 25 000 people all over Europe, about half of them in France (Larson, 2003). In the federal state of Baden-Württemberg in south-west Germany 970 to 1490 deaths have been attributed to the heat wave. Many such heat-related deaths may be preventable with adequate warning and an appropriate response to heat emergency measures (Basu and Samet, 2002). The meteorological component of a HHWS is based on a heat stress indicator. Indicators based on air temperatures, simple thermal indices, or weather classifications (holistic approaches) give no insight into cause/effect relationships. Fundamentally, the mechanism of heat exchange between the human body and its thermal environment is defined by air temperature, water vapour pressure, wind velocity, and mean radiant temperature (note that the mean radiant temperature (°C) is defined as that uniform temperature of a black enclosure which would result in the same heat loss by radiation from a person as from the actual enclosure under study) (Fanger, 1970). Thermophysiologically relevant assessment procedures that combine the above-listed meteorological variables with metabolic rate and with due consideration of the insulation effect of clothing, require the application of complete heat budget models.

Apart from the holistic approaches, heat load warning procedures are based on an absolute or a relative threshold. An absolute threshold implies that there will be rare heat load in colder regions and frequent heat load in warmer regions. Relative thresholds (e.g. the 97 % percentile), on the other hand, are based on the assumption that the probability of heat load is in the same order of magnitude everywhere.

At present there is no official (globally accepted) definition of the term ‘heat wave’ – there are a number of definitions in place around the world, but with different thresholds for different regions or seasons. An impact-related definition of a “heat wave” must meet the criteria that society is susceptible to or unable to cope with these events.

A fundamental issue associated with heat impacts on human health is that people adapt to the local climate, and to changing conditions quite well, but usually not completely, and frequently only after a number of days or weeks of exposure. Thresholds can be either absolute (e.g. heat stress and health impacts are rare in ‘colder climates’ and frequent in ‘warmer climates’) or relative (e.g. same heat stress probability in all climates). The approach followed in the DWD uses both. The absolute threshold component accounts for two thirds of the result, and is based on Perceived Temperature (PT) thresholds (to be replaced in 2005 by the UTCI). The relative threshold component accounts for one third of the result, and takes acclimatization factors into account (there is a gain over the short-term, a few days to weeks, but a loss after a month).

The DWD has criteria for issuing heat warnings – strong to extreme heat load is required, and there must be 3 or more days forecast of moderate or higher heat load. Details of the Klima-Michel-Model (Jendritzky et al., 1979) used by the DWD to assess the environment in a thermophysiologically relevant way, details of the DWD analysis of the heat wave of 2003 and all references quoted are provided in **ANNEX VI**.

A second area of interest is the expected mortality of heat load. The expected value of a time series is needed to calculate excess mortality during heat waves, and there are two ways to estimate this. The first is to use the experience of previous years. This approach is not influenced by short-term ‘disturbances’, and provides stable estimates, but long time series are needed (and not always available), and care has to be taken to account for population changes over time. The second method is to use the experience of the current period. This approach is more flexible, there is no need to adjust for population trends and it can be applied to even short time series. However, this technique is prone to underestimation of mortality during extreme heat events.

In discussion, it was noted that the good results using PT should be similar to results expected once the shift is made to the UTCI (spring 2005). These techniques have been applied outside Germany – in Lisbon and Madrid, and will be applied in the studies of the 5 PHEWE cities.

4.7 Bioclimatological Aspects of Summer 2003 over France

The extreme heat wave of the first two weeks of August 2003 occurred during the hottest summer period (June to August) of the last fifty years and followed a six-month period of drought. Moreover, this heat wave was outstanding in duration (lasting for two weeks) and in geographic extension (over all parts of the country, including mountains and coastal regions) with absolute temperature records in 70 out of 180 stations. Its tragic health impacts, with 15 000 excess deaths, were probably strongly intensified by the persistently high nighttime temperatures on the one hand, by high levels of pollution on the other hand: in Paris, with serial data files since 1873, morning temperatures on the 11th and 12th August were the highest ever registered, with 25.5°C (previous record: 24 °C in 1976). Ozone ($O3$) peaks were strong and frequent, accompanied with some $NO2$ unusual peaks, probably due to the absence of bracing wind.

Nevertheless this unique heat wave is consistent with climate change projections and more heat waves can be expected in the next few years or decades.

This heat wave affected most parts of Europe, yet France was the most strongly affected with Andalusia and Portugal, due to unusually hot air masses coming from North Africa and settling over Western Europe.

Météo-France issued a press release on 1st August announcing a progressive climb in temperatures for the following days over the whole country. On 4th August Metéo-France offered on its website simple health advice and a review of historical deadly heat waves. A further press release on 7th August included a health warning, especially directed towards elderly and sick persons. The progressive ending of the heat wave was announced on 13th August.

Although messages were updated daily on www.meteo.fr and were well broadcasted by the media toward the general public, however, the messages did not hit the important target, i.e. the health sector and the health managers. There was no pre-existing procedure within the health sector for coping with heat waves, which contributed to the 15 000 additional deaths suffered by France.

In response to that heavy toll, an early Heat Health Warning System is being established with French public survey agencies along with a common scheme for Cold Spells Warnings (previously running). This response includes a first announcement forecast for Health and Social Services professionals 4 to 7 days before the event, a warning forecast 1 to 3 days before the event for the media and general public, and an enhanced warning (so-called 'Vigilance') on a four colours warning scale (green, yellow, orange and red) in case of predicted Tmin and Tmax exceeding some identified thresholds. Tentative criteria for 'Orange Vigilance', for example, are Tmax > 35°C for tomorrow with Tmax > 35°C today. Criteria for 'Red Vigilance' are Tmax > 42°C for tomorrow or Tmax > 40°C and Tmin > 22°C for tomorrow or Tmax > 35°C and Tmin > 22°C for tomorrow with Tmax > 35°C yesterday and today. These criteria will be refined by health services before the procedure becomes operational beginning of June 2004, and may evolve later once the procedure is in place, considering potentially better approaches.

The inclusion of other biometeorological warnings (such as UV index, pollen and pollution concentrations) is also being considered.

In discussion, it was noted that there were advantages for an NMHS in focusing on only meteorological parameters in predicting dangerous heat waves (lack of access to the mortality data, for example, is not an issue). As well, the Vigilance maps are products previously agreed with the participation of French civilian defence groups, and therefore are 'familiar' products, which are well received by the public. A further advantage of this system over city-specific airmass classification techniques is that all of France is covered in the warning maps, and therefore the spatial extent of dangerous situations can clearly be seen.

4.8 The Universal Thermal Climate Index (UTCI)

4.8.1 Background

The assessment of the thermophysiological effects of the atmospheric environment is one of the key issues in human biometeorology. In the past, more than 100 different procedures of various degrees of sophistication have been developed. However, only in the last 30 years significant progress has been made with the development of comprehensive heat budget models that take all significant heat exchange mechanisms into account. Based on current advances in science and easy access to information, there is a need for global harmonisation of the development and dissemination of a universally valid climate index. Example is the successful international introduction of the UV-Index with the help WMO and WHO.

4.8.2 Objectives and benefits

The main objective is to develop a Universal Thermal Climate Index UTCI (working title) for thermophysiologically relevant assessments of the atmospheric environment for human health and well-being, as well as related human biometeorological applications such as daily forecasts, warnings (wind chill, HHWS), bioclimate mapping, urban and regional planning, environmental epidemiology, and climate impact research.

In principle, relatively simple though complete heat budget models (i.e. such that can be applied on a routine basis) are available. The reliability of such models must be tested by comparison with the few most advanced multi-node models of human thermoregulation and of existing knowledge in thermophysiology, partially described in ISO- or ASHRAE-Standards. This requires simulations of more than 104 combinations of the meteorological input-parameters: air temperature, mean radiant temperature, water vapour pressure, wind velocity, and a range of clothing values (behavioural adaptation). The operational UTCI model finally to be defined must represent the state-of-knowledge, however, must not be more complex as existing two node-models. UTCI will be thermophysiologically significant in the whole continuum of heat exchange, valid in all climates and scales, and will provide total body as well as in the cold skin freezing information. UTCI will be a temperature index as Perceived Temperature PT with the following reference conditions: Metabolic rate 135 W/m² (walking 4 km/h), calm wind, mean radiant temperature equals air temperature, relative humidity 50 %, adapted clothing between 0.5 and 2.0 clo.

4.8.3 Dissemination

The target audiences are national weather services; environment protection agencies; public health agencies; researchers, working in the field; regional and urban planners; the general public. Besides the standard means as website, reports, workshops, scientific publications the basic intention is to provide a WMO-CCl guideline on the "Assessment of the Thermal Environment" that covers also the complete software necessary to run the procedure.

4.8.4 Additional information

Due to the fact that the thermophysiological assessment of the atmospheric environment plays a key role in human biometeorology the International Society of Biometeorology decided in 2000 to establish a Commission 6 on the development of UTCI (chair: G. Jendritzky) http://arbmed.klinikum.uni-muenchen.de/biomet/Commission6.htm .
Coming up soon: http://www.dwd.de/UTCI

In general discussion on indices, it was recommended that the CCl health experts contact Tom Peterson, NCDC, to discuss the various indices his ET (OPAG 2) have been working on, particularly those related to climate-health studies. Additional information about climate indices is available on the CLIVAR web site: http://www.clivar.org/.

4.9 Linkages between Public Weather Services and HHWS

By way of introduction, background information was provided on the WMO Public Weather Services Programme: its objectives and purpose, the guiding principles of the programme and the various components that would be of special interest to the work of the CCl Expert Teams developing the Guidelines on HHWS. The primary goals of Public Weather Services are to strengthen Members' capability to meet the needs of the community through the provision of comprehensive weather and related services with particular emphasis on public safety and welfare, and to foster a better understanding by the public of the capabilities of NMHSs and how best to use their services. Areas of focus for PWS include development of effective warnings, and delivery of products and services that meet the needs of the various user-groups, including the public. PWS experts are generally highly skilled in dealing with the media and in presentation of information, and strive to deliver forecasts, and especially warnings, in time (to allow adequate time for preventative actions) and in clear, unambiguous language.

In particular, the meeting was informed of the guidelines under preparation by the WMO PWS Division and the Commission for Basic Systems (CBS) on biometeorology and air pollution forecasting (see item 3.11 below for more detail). The Expert Team expressed interest in several areas of the PWS programme that had features of mutual interest and common objectives with its own activities. The meeting also was informed of the upcoming session of the Commission for Basic Systems, in the Russian Federation (November 2004) and expressed interest in continuing the close collaboration between CCl and CBS through participating in the technical conference prior to the CBS itself (the theme will be applications of new technologies). If necessary, a proposal to establish a new Regional Specialized Meteorological Centre (RSMC) could be made at CBS (it was suggested that possibly Regional Climate Centres (not yet implemented in any WMO Region) could be involved in developing Heat/Health Warnings, but the consensus in the meeting was that HHW are, at present, more closely aligned with PWS and RSMCs temporal mandates).

4.10 WMO-PWS Guidelines on Air Quality Forecasts and Biometeorology

These guidelines are intended to provide useful advice to National Meteorological and Hydrological Services (NMHSs) on methods of incorporating air quality forecasts and biometeorological information into the suite of products and services offered to the public. The guidelines are being developed by the Public Weather Services (PWS) Expert Team on Product Development and Service Assessment at the request of the Commission on Basic Systems (CBS). It is acknowledged that several NMHSs already provide this type of information and some others are on the verge of developing an air quality programme. However, all NMHSs should find this document useful, especially those in developing countries that would be seeking to develop or improve their national public weather services delivery while, at the same time, attempting to come to terms with some aspects of the widening array of environmental issues.

There is a growing awareness of the linkages between human health and the weather and climate that should be incorporated into the content of national public weather services programmes. An increasing number of NMHSs include specific environmental information into their public bulletins with the goal of improving public understanding of relevant environmental issues and to enable people to take actions to minimize adverse environmental effects or stress.

Timely air quality information can assist the public in coping with problems caused in urban and in some rural areas by ground-level ozone, sulphur dioxide, nitrous oxide and particulate matter. Air quality advisories issued when predetermined pollutant thresholds are exceeded should result in actions to reduce pollution levels and encourage people to avoid polluted areas thereby alleviating adverse effects on health. Examples of actions that people can take in response to NMS air quality advisories include using public transportation, staggering of work hours or even staying indoors. Industry and regulatory agencies may decide on temporary shutdown of polluting factories, thermal power plants, banning some categories of vehicles from urban centres and closing government offices.

The pollen season is reasonably well known by many people but allergy sufferers benefit most from information on the exact time of ripening and release of pollen, so they can take action to minimize the adverse effects on their health. The presence of pollen, its density and trajectory, as well as the possibility of being removed from the atmosphere by showers, all depend on the day-to-day weather.

Increased UV radiation has been shown to increase the incidence of skin cancers and eye cataracts in humans, and may also affect plants, aquatic organisms and other natural systems. The monitoring of UV values and incorporation of the measurements into a simplified UV-index can alert people to protect themselves during critical periods of elevated UV intensity by avoiding outdoor activities, wearing protective clothing and using chemical sunblocks or sunscreens (skin lotions).

Chapter 1 of this document introduces the importance of, and rationale for, air quality forecasts and biometeorology. Chapter 2 covers human biometeorology (in a narrower sense) and concentrates on aspects of the atmospheric environment relevant for human health questions arising from heat exchange, solar radiation and air pollution. Chapter 3 deals with air quality forecasts, pollution measuring and monitoring, atmospheric transport modelling and cooperation on environmental issues at the national, regional and international levels. Evidently, the services required for the good health, safety and well-being of national communities can be significantly improved if NMHSs are ready to tap into the existing body of knowledge, practices, research and technology to design and deliver appropriate biometeorological information and advisories to the public.

It was noted that WMO plays an essential role in transfer of knowledge to NMHSs, particularly those in Developing Countries. WMO Products such as the various Guidelines under development are important tools, and should be made available to Members with full information, all required technical details and, if applicable, such things as software. The PWS team developing the Guidelines on Air Quality Forecasts and Biometeorology will work with the CCl experts developing the Guidelines on HHWS, to harmonize text and any common aspects of the two products.

4.11 Basic Considerations on Necessary Features of Operational HHWS

4.11.1 Background

There is strong evidence that heat does kill people. In the USA heat waves are considered as the most detrimental atmospheric extreme events. More than 25 000 excess deaths occurred in west- and south-west Europe during the August 2003 heat wave. Heat/Health Warning Systems such as those in use in Rome and Shanghai (the WMO/WHO/UNEP-Showcase projects) and in North America demonstrate that lives can be saved (as per the report by Teisburg et al: 'Heat Watch/Warning Systems Save Lives: Estimates Costs and Benefits for Philadelphia 1995-1998'.

4.11.2 Key heat-health issues

Procedures in existing HHWSs in Rome, Shanghai, Toronto, etc. (all based on the Philadelphia example) can be described in categories related to the public health, meteorological, biometeorological, and epidemiological factors related to heat and human health:

4.11.2.1 The Public Health Issue

Development of a locally-adjusted disaster preparedness (emergency response) plan is probably the most difficult, but most important part of an effective HHWS. This plan becomes active whenever a significant heat load event is predicted. Multiple agencies will likely be involved. It is necessary to define such things as intervention measures for various scales of events, vulnerable sectors of society, and to identify the relevant people and groups (agencies, decision-makers, stakeholders, etc.) and their areas of responsibility.

4.11.2.2 Heat Load – Human response to heat, and assessment of dangerous conditions

Hampering heat exchange from the human body to the atmosphere produces strain for the organism. People with limited adaptation capacity, i.e. people who are not fit, die from different causes but thermoregulation is always concerned. There is a need for a health-related definition of thermal environmental stress (i.e. to identify what is "thermophysiologically significant").

There are four primary methods for determination of a heat event likely to significantly affect human health. They range from simple meteorological approaches to highly sophisticated systems that rely on a host of health and epidemiological input and multi-agency collaboration. Each method has its 'pros and cons', and varying levels of success. Forecasts of dangerous heat conditions can be based on:

(a) **Single meteorological variables** such as air temperature or relative humidity. Relative humidity is often not used effectively, but temperature does contain information about the thermal environment;
(b) **Simple thermal indices** (historic) as e.g. the Heat Index. These are believed to have limited relevance and limited reliability;
(c) **Weather classifications** (holistic approach). This approach has been shown to be successful in heat/health studies. The technique requires the development of a synoptic or weather type classification that can, depending on the level of sophistication, be data and analysis intensive. Furthermore, synoptic or weather types, as is the case for human energy-based biometeorological indices, can never be verified, as they are statistical or numerical constructs. This contrasts with conventional meteorological variables, as forecast values of these can be compared with actual observed values;

(d) **Heat budget models**, as e.g. UTCI. These are thermophysiologically relevant, consider the complete heat exchange conditions, and are valid for all thermal environments (both heat and cold). Only such procedures are able to fulfil the precondition that the same value of an index means always the same for the human body, independently from the combination of the single values of the meteorological input parameters.

Note that when applying a thermal assessment approach in order to detect an extreme event, additional effects (such as intensity, duration, time lag) have to be considered.

4.11.2.3 Heat Load Forecasts

These must be based on routine services of NMHSs. The Public Health group defines the kind of emergency information they want, e.g. heat load intensity or mortality increase information. Acclimatization should be taken into account.

4.11.2.4 Epidemiology

Correlation studies between the biometeorological assessment procedure and health data (mortality/morbidity) are reasonable for calibrations, i.e. to define specific thresholds. From a scientific point of view it is useful to have epidemiological results. Frequently, however, the availability of health data, lack of expertise and resources are unsolvable problems. Additionally this “fine tuning” would be only valid for the specific area of investigation. From a practical point of view, for regions vulnerable to heat waves but without the mortality data and other such resources, it is important to have options for acceptable HHWSs that do not depend on epidemiological input.

4.11.3 Conclusion

A WMO Guideline must provide a simple, generalized, though specific description of all aspects of HHWS (public health, meteorological, biometeorological and epidemiological issues), applicable to NMHSs in both developed and developing countries, and to services that may not have biometeorological skills or access to epidemiological data. Free access to all procedures and information must be warranted. If necessary, the support of RSMCs (e.g. on UTCI), under the umbrella of WMO, can easily be implemented.

4.12 WHO Activities Related to Heat and Human Health Including cCASHh

4.12.1 Background

The three key areas of WHO’s global efforts in climate and human health are in development of partnerships, knowledge, and policy. These lead to coordination of related research and sharing of information and results, support to policymakers (the Health Evidence Network has developed 10 common questions for policymakers), and projects such as cCASHh (Climate Change and Adaptation Strategies for Human Health).

The goal of the cCASHh project is to enhance the adaptation possibilities of communities to climate-related impacts on human health. Areas of interest include the health impacts of temperature extremes and extreme weather events and the effects of climate change on Vector and Food borne diseases. Methods used include vulnerability assessment, economic valuation, policy analysis and integrated assessment modelling. The project is in effect in EU and accession countries in Europe.

cCASHh research covers thermal stresses (such as heat waves); extreme weather events; flood-borne diseases; and vector- and rodent-borne diseases. Given the IPCC projections for likely increases in extreme weather and climate events in a warmer global environment, the health community needs to take preventative measures to effectively plan for the future. This was recently taken up for the 4th Ministerial Conference on Environment and Health in Budapest, June 2004.

The heat wave in France of 2003 resulted in significant lessons for the health and social sectors. First, the health crisis in France caused by the heat wave in 2003 was unforeseen and was only detected belatedly. Health authorities were overwhelmed by the influx of patients; crematoria and cemeteries were unable to deal with the influx of bodies; and retirement homes were under-equipped with air-conditioning or space cooling environments and manpower. The crisis was compounded by the fact that many elderly people were living alone without a support system and without proper guidelines on how to protect themselves from the heat. The heat wave highlighted several problems in public health systems, including the limited number of experts working in the area of environment and health and the need for a significant improvement in the exchange of information between several public organizations and agencies, as well as a clear definition of responsibilities in these areas (WHO, 2004: Public health responses to extreme weather and climate events. EUR/04/5046269/15)

The WHO, in consultation with other agencies and Health ministries, agreed that the health sector needs to be informed by systems that predict heat waves (e.g. seasonal forecasting and Heat/Health Warning Systems). The health sector itself needs systems for early detection of the health impacts of heat waves (e.g. mortality surveillance and disease outbreak rapid information systems); and the capability to prevent the health impacts of extreme weather and climate extremes, both by short- and long-term measures.

4.12.2 WHO perspectives on requirements for HHWS

The requirements for an effective Heat/Health Warning System have been described by Auger and Kosatsky (2002) and by Koppe et al (2004) in Heat-waves: risks and responses (World Health Organization, Regional Office for Europe, Health and global environmental change, series, No2). The requirements include:

1. Sufficiently reliable heat wave forecasts for the population of interest (the meteorological component); there might be problems with the accuracy, sensitivity (number of false alarms and events missed) and timeliness of the existing systems;

2. Robust understanding of the cause-and-effect relationships between the thermal environment and health (epidemiological, statistical and biometeorological components);

3. Effective response measures to implement within the window of lead-time provided by the warning (public health component); and

4. A community that is able to provide the needed infrastructure (public health component).

4.12.3 cCASHh perspectives on evaluation criteria for HHWS

Within the cCAShh project, a consultative workshop organized by the DWD in Freiburg, 2003, evaluation criteria for the development of HHWS were discussed (Koppe et al, 2004):

1. Describe the public health importance of “heat”.
2. Describe the system to be evaluated:
    - objectives of the system
    - administrative structure of the system and agencies
    - scientific basis for the system

- components and operation of the system
- a flow chart of the system.

3. Public health usefulness of the system:
   - what actions are initiated in response to the warning(s) and who is responsible for these
   - if actions are not implemented, give the reason(s)
   - list other anticipated responses to be linked to the warning.
4. Describe the resources used to operate the system:
   - the costs of setting up the system (initial costs)
   - the annual cost of maintaining the system, including indirect costs
   - the estimated direct cost per warning or level of warning.
5. Evaluate the system for each of the following attributes:
   - transparency
   - integrity
   - acceptability
   - communication
   - effectiveness
   - sensitivity and specificity
   - timeliness
   - sufficiency of the system.
6. Evaluate the specific measures for each of the following attributes:
   - acceptability or credibility
   - timeliness
   - effectiveness.

4.12.4 Conclusions and discussions

It was noted that France and Portugal do not use a synoptic airmass HHWS (the reasons for which are not known). The health sector is interested to know whether the alternate systems have been tested for accuracy, predictability, public acceptability, etc.

In the review of lessons learned from the European heat wave of 2003 and existing warning systems, an important finding was that the key for success is the collaboration and communication between the several institutions and agencies at all levels (WHO, 2004). Another important factor is that within Nations there are different responsibilities, competences and financial availabilities. In Italy, for example, the delivery and development of HHWS was given to the health authorities. However, this varies between countries and the above-mentioned criteria play an important role. A cost-benefit analysis related to use of the U. Delaware system in the city of Philadelphia is available in the report by Teisberg et al: ‘Heat Watch/Warning Systems Save Lives: Estimates Costs and Benefits for Philadelphia 1995-1998. This was published in Epidemiology 14 (5): S35-S35 Suppl. 1 by Ebi et al. (2003).

In discussion, it was noted that the health community is interested in warnings not just of those heat conditions in which significant excess death might be likely, but also in events during which the population would feel the impacts of exceptional heat, such as discomfort, heatstroke, dehydration, etc. The meeting agreed that the health and social sectors should be offered any information that would help prevent illness and heat stress, not just ‘excess’ mortality. As well, the meeting discussed the matter of the threshold (for the decision whether or not to issue a warning), and noted that the stakeholders were concerned at any threshold that did not reflect that saving even one life is important. Further, it was noted that while prediction of numbers of excess deaths is useful for establishment of thresholds for issuing warnings and for eventual evaluation of the warning system, such information should not be issued in forecasts to the public.

5. DEVELOPMENT OF THE OUTLINE AND WORKPLAN FOR THE GUIDELINES FOR HEAT/HEALTH WARNING SYSTEMS

5.1 Review of Issues Associated with Development of HHWS

The key issue of whether the meteorological community should issue forecasts of the impacts of extreme heat events (i.e. excess mortality) was discussed in detail, as it is fundamental in determining the content and direction of the Guidelines on HHWS. There was consensus amongst the participants that the expertise within the meteorological community is in predicting the weather conditions that are dangerous to health, and their spatial and temporal characteristics. Utility of seasonal predictions in HHWS was raised, and the meeting was informed that in some regions of the world, particularly in regions with a strong ENSO signal, seasonal forecasts are already being applied to health issues (particularly for diseases like malaria). In the UK, research is underway assessing the feasibility of winter seasonal health forecasts for assisting the health sector in planning for winter emergency services. Seasonal predictability may not yet be reliable enough in Europe, however, although the DEMETER project has shown interesting potential.

The issues of responsibility and liability were raised, for issuance of Heat/Health Warnings. If the warnings were simply of hazardous weather conditions, the warnings would be solely the responsibility of NMHSs. However, Heat/Health Warnings require collaboration by more than one agency. Because of the multiple agency aspects, and the possibility of commercial forecast systems being involved, it is unclear who would be liable in the event of forecast failure.

On several occasions (most recently at the Fourteenth Congress in 2003), WMO Members have stressed the need for capacity building for NMHSs for HHWS methodologies, and urged development of Guidelines on HHWS for the use of NMHSs. With respect to the HHWS described in the Guidelines, it is WMO's expectation that methodology and related tools (software, code, etc.) needed for implementation and operation of HHWS will be made freely available to NMHSs. There was a global agreement in session in this regard.

Decision 3: In an effective HHWS, the meteorological/climate community should focus on predicting and advising on periods of anomalous heat load, or heat stress, based on upcoming weather/climate conditions as well as an understanding of human physiological responses to such conditions, and should not forecast specific health impacts (e.g. mortality) of heat stress. There is also a need for the health community to determine an estimate of the likely health outcomes of this heat stress (e.g. possible dehydration, heatstroke, even mortality), to facilitate decisions related to planning, and to intervention activities. Strong collaboration between meteorological/climate, health and social communities and development of effective intervention strategies will be vital for protection of the end-users, the vulnerable public, from the harmful impacts of heat waves.

5.2 Identify the Target Group(s) for the Guidelines

The Guidelines will be for the use of National Meteorological and Hydrological Services for use in evaluating and implementing a HHWS. As well, the Guidelines will be of importance to the health and social sectors that will predict impacts on the public of predicted extreme conditions, and arrange for any necessary actions and interventions for protection of the well being of citizens. The stakeholders will need detailed information and guidance. The meteorological community will need sufficient information in the Guidelines on the various indices and warning systems for decision-making, information and tools (e.g. software or code) for implementation, advice on building effective interfaces with other stakeholders. The health and social sectors will need to understand the meteorological contributions, their relevance to their decision-making. They would need clear guidance as to criteria for various levels of the events forecasted and advice for the development of the interfaces. Given the various target groups, care must be taken with level of language and detail in the Guidelines.

Given that the warnings will be related to both heat and health, it would be preferable to set up an institutional framework between WMO and WHO for issuing the warnings. This would be in keeping with the informal Interagency Network on Climate and Human Health, and would build on the positive collaborations between WMO and WHO on global and regional levels in recent years. In this regard, WHO offered to collaborate with WMO on development of the Guidelines, particularly in development of the text related to the health impacts of heat. WHO will also collaborate with all pertinent agencies on intervention activities.

Decision 4: The WHO offer to collaborate with WMO on development of the Guidelines on HHWS was strongly supported by the meeting. The Director of the World Climate Programme, Mr Ken Davidson, when consulted, agreed completely with the proposal from WHO, and further suggested that WMO and WHO jointly seek external funding to expand the effort through supporting relevant workshops around the world (in the most susceptible areas, and especially in developing regions), and to eventually produce a comprehensive report on the effects of heat waves on the public. A regional workshop series would be a useful vehicle for transfer of technology, training and capacity building in use of the more sophisticated (state of the art) HHW systems. Dr Bettina Menne briefed WHO management on the tentative agreement.

Action: WMO will issue a letter to WHO to formalize this agreement on the Guidelines and related activities (**C/WCAC**).

5.3 Establish the Outline for the Guidelines

The meeting discussed and agreed on the breakdown of responsibilities for development of the Guidelines on HHWS.

Decision 5: The process will be coordinated by the Chair of CCl OPAG 3; the development of content, and the review/editing phases will be supervised by the leads for the Expert Teams on Operational HHWS (ET 3.7) and Health-related Climate Indices and their use in Early Warning Systems (ET 3.8); writing for each chapter of the Guidelines will be coordinated by various experts (details noted in the following outline); the WMO Secretariat will coordinate publication of the Guidelines (technical editing, layout, etc.); and the Preface will be written by the Secretary-General, WMO. It was agreed that the guidelines must be ready for EC 2005.

Action: The WMO Secretariat will locate the UK paper on evaluation of the impacts of the hot summer of 1995 on various economic sectors in the UK, and distribute it to members of the meeting and ETs 3.7 and 3.8 of OPAG3. This will be particularly relevant to development of Section 10 of the Guidelines on Policy and Resource Implications for HHWS as it will provide cost-benefit examples. ***Action completed.*** The references are:

Palutikof, J.P., Subak, S. and Agnew, M.D. (Eds.), 1997: "Economic Impacts of the Hot Summer and Unusually Warm Year of 1995." University of East Anglia, Norwich (for the Dept. of the Environment), 196pp. Can be obtained from the Global Atmosphere Division, UK Department of the Environment, Romney House, Marsham Street, London. ISBN 0-902170-05-8.

Palutikof, J.P., Subak, S. and Agnew, M.D., 1998: "Impacts of the Exceptionally Hot Weather of 1995 in the UK." In: Proc. 10th Conference on Applied Climatology, American Meteorological Conference, Reno, Nevada, October 1997, pp.232-235 (keywords: impacts, climate change, UK, economic)

Action: Copies of the WMO Guidelines for Public Weather Services will be acquired from the WMO Public Weather Services Division. One copy will be provided to each of the chapter lead authors of the HHWS Guidelines **(C/WCAC)**.

The meeting developed and approved the following outline for the Guidelines on HHWS (agreements on assignments/responsibilities for development of the Guidelines and deadlines for the work are embedded). The meeting further noted that section 5 'Approaches to and data requirements for HHWS' is the key one for the Guidelines. All approaches must be discussed in reasonable detail. The simple techniques included should have enough information for full implementation. The more complex/sophisticated systems described could be elaborated on (and technology shared) through capacity-building training workshops.

It was further noted by the meeting that WMO guidance must be useful to all Members, regardless of the socio-economic status of the country. Intervention strategies must therefore cover a range of options for both developed and developing nations.

Guidelines for Heat/Health Warning Systems - Outline

1. **Introduction**
   (Abdel Maarouf → max. 1500 words)

   - Global issue, spatial and temporal distribution of heat waves all over the world; India, South America etc.; WMO Bulletin?
   - Refer to climate change as a risk factor, however, these guidelines are not about climate change but "normal" climate variability
     → it's important now, and will be even more important in the future
   - Introduction of the guidelines
   - Introduction about CCL and Expert Team (reference to PWS guidelines Chapter about heat waves; Background to guidelines (how we got here?)
   - Seamless Service (all time scales; etc.); cross-cutting activity; emphasise the fact that heat and health is a cross cutting issue; cutting also across major agencies (WMO; WHO)
   - Raising awareness of health problems during heat waves
   - Tasks of National Meteorological and Hydrological Services (NMHSs) → single voice principle (NB: only NMHSs can issue weather/climate warnings)
   - Interagency benefits; collaboration with other sectors (e.g. WHO) and programmes
   - Focus: guide the Public Weather Service up to the interface to the public health part; then facilitate the interface
   - How to use these guidelines
   - Benefits to the users and end-users
   - HHWS is part of the service (value added)

2. **Heat as a health problem: impact of heat on human health, thermophysiology (WHO/WMO; Bettina Menne → 4000 - 5000 words)**

   - Direct and indirect heat-related deaths → risk factors of heat-related mortality/morbidity/well-being
   - Vulnerability, sensitivity (socio economic factors, demographics (health status), other confounding factors)
   - Symptoms of heat illness
   - Centre for Disease Control guidelines; International Federation of Red Cross and Red Crescent Society (etc.) homepage(s) (McGeehin et al. (B. Menne to add names)
   - Other impacts of heat waves

3. **What is a HHWS?**
(Suresh Boodhoo → 1500 - 2000 words)

- Parts of a warning system:
  - o Detection of warning; Communication; Response
- Kind of events (Refer to section 5.4 of PWS doc)
  - o Fast moving, slow onset
- Where HHWS are in place now
- Purpose of HHWS
- Definitions
- Benefits of HHWSs (refer to section 2.3 of PWS doc)

4. **Potential users or stakeholders**
(Jianguo Tan → 1000 words)

→ Refer to chapter 4 and 9 of PWS document
- Engaging users and stakeholders (WHO to help to identify users; stakeholders)
- Communication
- Identification of users and end-users and their needs
- System should not be developed in isolation
- Timeliness of the warning

5. **Approaches to and data requirements for HHWS; Development of HHWS (Gerd Jendritzky; Glenn McGregor; Larry Kalkstein**
→ min. 10 000 words)

→ broad overview; general principles behind the approaches; main pros and cons of each approach; description in general terms
→ decision which approach to be taken by the NMHSs
→ criteria for issuing warnings; offer options (based on approach selected)
→ technology transfer (workshops)

- Simple met. indices (e.g. Ta, rh)
- Simple human biometeorological indices (AT)
- Human energy balance based indices; heat budget models (Gerd)
- Synoptic approaches, air mass based approaches (Larry)

6. **Implementation and dissemination of Heat/Health Warnings**
(Tanja Cegnar → 5000 words)

- What to do with the information after the computer has produced the numbers
- Relates also to the criteria of issuing a warning
- How to implement a warning; contact stakeholders
- Include different lead times (general public; stakeholders)
- Interface definition
- Operational questions

→ refer to chapter 7 of PWS document

7. **Intervention strategies**
(WHO → relevance; applicability and effectiveness;
Larry Kalkstein → max. 5000 words (1. Draft))

→ address the issues so that people start to think about it
→ case studies in boxes
- Making a HHWS work
- Mention explicitly long-term intervention measures (climate-related design)
- Locally adjusted interventions
- What is possible; interventions

8. **Risk communication; Awareness**
   (Tanja Cegnar → 3000 words)

→ Refer to chapter 9 of PWS doc
- Perception of people what would be a credible source of information
- How to get a message across
- Language to be used in the message creation
- Lead time of the warning
- Start of the heat wave season
- Raising public awareness (e.g. a WMO world heat wave day)

9. **Evaluation; Effectiveness**
   (Paola Michelozzi → 3000 words

→ Refer to Chapter 10, PWS doc
→ Evaluation of the public response necessary;
no detailed advice
by an independent "group"
- Feedback loops
- Evaluation of the performance of the system
- Evaluation of the "effectiveness"

10. **Policy and resource implications of HHWSs**
    (Wolfgang Kusch; Tom Kosatsky (WHO regional Office for Europe, Rome) → 2000 - 3000 words)

- Technical resources; human power resources; financial resources; needed infrastructure

→ for both meteorological and health questions and others (fire, social, emergency...)

11. **Future trends / outlook**
    (Glenn McGregor, Gerd Jendritzky → 1000 words)

→ Refer to Chapter 11 PWS doc
- Seasonal, medium to long-range forecasting
- Heat wave climatology
- Distribute information by special centres
- Health surveillance systems

BIBLIOGRAPHY

APPENDIX

- Examples of HHWS (Showcase; ICARO)

→ Please ensure political and institutional correctness (if possible show regional balance/coverage in the examples used).

5.4 Establish a Process and Schedule for Review and Approval of the Guidelines

The meeting agreed upon the following process and schedule for development, approval and publication of the Guidelines on HHWS:

First Draft	30 August 2004
Second Draft	29 October 2004
Final Draft	15 December 2004
Broad Review	January 2005
Final Revisions	February 2005
Approval, Technical Editing, Layout	March, April 2005
Printed Version	April, May 2005
Final Product	EC June 2005
Distribution	After EC, July 2005

6. OTHER BUSINESS

The Expert Team on Health-related Climate Indices and their use in Early Warning Systems (ET 3.8) reviewed the Terms of Reference developed by the CCl (November 2001) to guide their work. The workload involved in completing all the tasks would not be an easy burden. It was noted that it is the first item on the list that is the key priority for the ET. As well, some of the tasks may reflect work that was underway in the former CCl structure, and the proponents may by now no longer be active in the field.

Decision 6: Leaders of the Expert Teams have the flexibility to redefine the Terms of Reference for their ETs, as long as they do this in consultation with the CCl management chain of command. The revisions must be approved and take into consideration the time remaining to CCl - XIV when the Expert Teams are required to submit a report.

Action: ET 3.8 will review the ToRs originally developed at CCl-XIII (November 2001) (see **ANNEX VII)**, seek approval from CCl, and work/report on the new set of agreed deliverables **(Prof. Jendritzky)**.

In this regard, it was noted that:

- Item (a) is the key deliverable for ET 3.8;
- ToRs for ET 3.8 section (b) need to be reworded. Several issues are important and could be pursued, such as impacts on health of ozone (often a developed country issue) and of vector and water-borne disease (developing country issue, more acutely). It was agreed to review and continue development of understanding on the key issues of climate and health, and to, at least, develop a bibliography for topics that have not been actively pursued by members of the expert team;
- Items (c) and (d) are acceptable as written.

Action: Indices related to climate and human health will be discussed with Tom Peterson, Chair of OPAG 2 (Monitoring and Analysis of climate Variability and Change) **(Prof. Jendritzky)**.

7. MEETING REPORT

The WMO Secretariat agreed to draft the report on the proceedings of the meeting, issue it for review by 23 April 2004, and publish the final report by the end of May 2004. The consensus and decisions achieved during the meeting, as approved by WMO and the CCl in this report, will guide the subsequent work of the Expert Teams involved in this meeting (ET 3.7 and ET 3.8).

8. CLOSURE OF THE MEETING

On behalf of the WMO, Dr Nyenzi thanked the DWD and colleagues, Professor Jendritzky, Ms Koppe and Mr Kusch for the excellent hospitality and support for the meeting. He thanked the participants for the enthusiastic and generous support that made the meeting a great success, and that will lead to the successful development of the Guidelines on HHWS, in time for WMO Executive Council in June 2005. Mr Boodhoo, President of the Commission for Climatology, extended his gratitude as well for the satisfactory conclusion to the meeting. All participants joined Mr Boodhoo and Dr Nyenzi in thanking the co-chairs for their excellent leadership throughout the meeting.

The meeting was closed at 3:00 PM on 16 April 2004.

ANNEX I

AGENDA

1. OPENING OF THE MEETING

   1.1 Background to the WMO Commission for Climatology (CCl) Activities Related to Heat/Health Warning Systems
   1.2 WMO Perspectives on the Guidelines for Heat/Health Warning Systems
   1.3 Meeting Objectives

2. ORGANIZATION OF THE MEETING

   1.4 Approval of the Co-Chairs, the Meeting Agenda and Working Arrangements
   2.2 Participants

3. DEVELOPMENT OF THE PROPOSED CCl BROCHURE ON HEAT WAVES

4. REVIEW OF THE ACTIVITIES TO DEVELOP AND IMPLEMENT HHWS

   4.1 Decisions of WMO EC, Congress and CCl, and Expert Team Actions on HHWS (Dr Nyenzi)
   4.2 Review of the Rome and Shanghai HHWS Showcase Projects (Ms Cegnar)
   4.3 Overview of Past OPAG 3 Expert Team Activities and Actions Related to HHWS (Ms Cegnar)
   4.4 The European Union PHEWE Project (Dr McGregor)
   4.5 Overview of HHWS Activities in Toronto, Canada (Mr Maarouf)
   4.6 DWD Experience with the KLIMA-Michel-Model in the Heat Waves of 2003 (Ms Koppe)
   4.7 Bioclimatological Aspects of Summer 2003 over France (Mr Bessemoulin)
   4.8 The Universal Thermal Climate Index (UTCI) (Prof. Jendritzky)
   4.9 Linkages between Public Weather Services and HHWS (Ms Kootval)
   4.10 WMO-PWS Guidelines on Air Quality Forecasts and Biometeorology (Mr Kusch)
   4.11 Basic Considerations on Necessary Features of Operational HHWS (Prof. Jendritzky)
   4.12 WHO Activities Related to Heat and Human Health Including cCASHh (Dr Menne)

5. DEVELOPMENT OF THE OUTLINE AND WORKPLAN FOR THE GUIDELINES FOR HEAT/HEALTH WARNING SYSTEMS

   5.1 Review of Issues Associated with Development of HHWS
   5.2 Identify the Target Group(s) for the Guidelines
   5.3 Establish the Outline for the Guidelines
   5.4 Establish a Process and Schedule for Review and Approval of the Guidelines

6. OTHER BUSINESS

7. MEETING REPORT

8. CLOSURE OF THE MEETING

ANNEX II

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ANNEX III

WMO/CCl Booklet on Heat waves
Outline accepted at the Meeting of Experts on HHWS, Freiburg, 14 - 16 April 2004

Target audience is the WMO NMHSs, and the interested public
(Note that the title of the booklet is still to be determined.)

1 Introduction – Meteorological Concept of heat wave
2 Criteria for distinguishing heat wave from local temperature
3 Terminologies/definitions
4 Occurrence **-** Where is it most common? (noting that a global heat wave climatology may not yet exist)
5 Importance of good climate data (requirement from NMHSs)
6 Socio economic impacts of heat waves
Do heat waves affect only human beings?
(Impact on agriculture (Shiv), corals, livestock (Shiv), water sector (Pierre to provide photo of dry Garonne during summer of 2003), forest (fires), recreation and tourism, energy, etc. Other photos of the 2003 heat wave can be found at: ("06.08.03 – Hitzewelle in Deutschland" http://www.badische-zeitung.de/aktionen/2003/fotos/&p%5Bnavpage%5D=4)
7 Factors leading to the occurrence of heat waves - (Summer months (not welcome), Climatic fluctuation, urban configuration, change in land use and living conditions etc. Global causes (Reference to IPCC reports), regional, local and micro-scale causes.
8 Biometeorology (Gerd)
9 Is it possible to predict occurrence of heat waves? (short- medium- and long-term) Roles of mathematical modeling of climate (Climate indices, El Niño, La Niña etc.)
10 How hard have heat waves hit? Factual information on impact of heat waves (Statistics from different WMO Members and Leslie –Climate into the 21st Century)
11 WMO Initiatives (past actions initiated by WMO and CCl)
12 Who are the actors? (media, health, fire services, social security and others)
13 Actions necessary to mitigate impacts of heat waves. - Roles of Meteorological Services and coordination with other stakeholders such as health authorities.
14 Conclusion

Foreword (by the Secretary-General of WMO)

General: WMO has in the past produced a number of booklets related to issues of climate and human well being such as urban climate, human health among others. In recent years the issue of climate, heat stress and human well-being has come to the forefront for several member countries. New dimensions have been added to the issue as occurrences of heat waves claimed lives in the thousands.

It is expected that the severity of heat waves may gain yet other dimensions with the expected increases in the global temperature projected by the IPCC.

All these have warranted a revisit to the issue of heat waves.

ANNEX IV

Proposed Terms of Reference for the Work of ET 3.7 (Operational HHWS)

ToR I

To develop at least two more actual heat/health systems for vulnerable cities that have good meteorological and mortality databases. Both Casablanca and Delhi represent good choices, but we've had requests from other developing world locales, including South Africa. In addition, there has been possible mention of system development for Athens considering the upcoming Olympic Games. All of these suggestions are unofficial, and we have not yet approached the proper authorities nor gained funding to begin this work. These cities, along with a number of others for which we have developed operational website-based heat/health systems (Rome, Shanghai, Toronto, and a number of US cities), would form the basis for all future watch/warning system work. By developing these new systems, ET members will actually participate in system development and procedures. In addition, we can use individuals whom we have previously worked with to help in the development of the guidance materials mentioned later in this ToR (at least three of these people, Ms Cegnar, Ms Michelozzi, and Mr Tan, are members of the ET). We need to define somewhat standardized plans to develop such systems down the road (e.g. all systems should be based on real weather-health relationships in the specific urban area; each system is tailored for the locale's individuality in demographics, etc.).

ToR II

Guidance material development. A key goal is to develop guidance material that will permit technology transfer to all potential locales with interest in this problem, and will allow cities to independently develop their own watch/warning systems. The guidance material will include:

1- data necessary to develop a system
2- actual system development
3- software installation
4- operation and collaboration among local agencies who are significant stakeholders
5- mitigation/intervention plans that have proven successful at other locals
6- checks of system effectiveness (this is an essential part of system development as it is important to determine if, in fact, the system is saving lives).

ToR III

Possible expansion of system to seasonal forecasts. The original systems are designed for 48-60 hours advance notice. Many countries are now developing longer-range forecasts for a season, and it is possible that we can develop the means to estimate heat-related problems a month or two in advance, giving proper authorities more time to take action. With the addition of Mr. O'Lenic on our team, we have access to longer-term forecast expertise.

ToR IV

Interaction with other ETs, most significantly the ET on health-related climate indices. We will develop a plan to compare such indices based on their ability to evaluate weather/health outcomes retrospectively.

ToR V

Recommend further actions to make heat/health warning systems a fully integrated part of CLIPS operations. This will require collaboration with WMO personnel and other individuals involved with CLIPS activities.

ANNEX V

PHEWE Workpackage 'F' on Heat/Health Watch Warning Systems

Aim/Objectives

The overall aim of the WWS work package is to develop heat /health watch warning systems (WWS) for 5 European cities that can be applied in the mitigation of heat related death and illness. Related objectives are:

1. To construct statistical algorithms that will form the scientific basis of the WWS for the prediction of heat related death and illness in the target cities (Rome, Paris, Barcelona, London, and Budapest). These will describe the relationship between stratified/unstratified daily mortality (morbidity) and a range of standard and derived (rate of change and antecedent) daily meteorological and human energy balance-based heat stress index variables.

2. To design a set of generic and city specific mitigation measures for the reduction of heat stress related mortality and morbidity as an integral part of a WWS for each city.

3. To formulate protocols for implementing a WWS

4. To install and undertake a ghost trial of the WWS for each target city and thus an evaluation of the potential effectiveness of the WWS and associated mitigation measures.

Methodology/Work Description

1. **Statistical algorithm development**: Analyses leading to algorithm development will be based on stratified and unstratified daily mortality (morbidity) data. Stratification, according to population characteristics and air mass types, represents an innovative aspect of the methodology as it is believed that vulnerability to heat stress related death and illness is dependent on the interaction between population characteristics and "offensive" air mass types. Initially, algorithm development will use standard linear regression; from a logistical WWS operational point of view, such algorithms are probably the most "user-friendly". However, advanced statistical techniques will also be explored.

2. **Algorithm Predictability:** algorithm predictability and final model choice(s) will be established using a range of quantitative forecast skill scores and cross-validation.

3. **System operation protocols and mitigation measures**: A "WWS Road Shows" will be organized for WWS stakeholders to: (a) assess the candidature of potential WWS operators in the target cities, (b) develop a set of generic and city specific guidelines for WWS operation (c) identify WWS operator training needs and (d) design operationalisable generic and city specific intervention plans for the mitigation of heat related mortality and morbidity. Guidelines will also be settled on for WWS installation and testing. Workshop attendees are expected to be from stakeholder institutions such as health authorities, meteorological and emergency services in the target cities.

4. **System Installation and Testing:** WWS will be installed on a central server for all 5 cities in order to undertake a single summer ghost trial of the WWS (summer 2004). Predictions of health outcomes will be made and virtual warnings issued by the WWS. Stakeholder agencies will evaluate their ability to respond to the warning and to implement the intervention plans by undertaking a self-assessment of their degree of preparedness. Estimates of the potential number of deaths or hospitalisations prevented will also be made along with a diagnosis of WWS failures.

Deliverables

D13: Validated algorithms for the prediction of heat stress related mortality and morbidity for 5 European cities
D14: A set of protocols for the operation of WWS in 5 European cities
D15: A set of generic and unique mitigation measures in the form of intervention plans for the reduction of heat related death and illness in European cities
D16: A report on the WWS effectiveness for 5 European cities

Expected Results

1. The mortality/morbidity prediction algorithms will be city specific due to location-unique climate and health relationships.

2. There will be inter-city variation in the statistical nature of the prediction algorithms.

3. That the candidate organisations for WWS operation and the WWS mitigation measures for each of the cities are likely to vary due to inter-city socio-economic and political contrasts.

4. WWS can be implemented and operated effectively for each of the target cities assuming political will at the local level exist.

Relevant Corresponding Milestones

1. A landmark set of city specific, validated statistical algorithms for heat related mortality/morbidity prediction.

2. Organisation of a “WWS Operation Protocols and Mitigation Measures” workshop.

3. The installation and ghost trialling of a WWS for each of the target cities.

4. A final report detailing WWS strengths, weaknesses, opportunities and targets for each of the target cities.

The heat-wave 2003
- the DWD experience -

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Although heat waves are rare events, they are associated with significant mortality impacts (e.g. BASU and SAMET, 2002). In August 2003 a major heat wave killed about 25 000 people all over Europe, about half of them in France (LARSON, 2003). In the federal state of Baden-Württemberg in south-west Germany 970 to 1490 deaths can be attributed to the heat wave. Many of the heat-related deaths may be preventable with adequate warning and an appropriate response to heat emergency measures (BASU and SAMET, 2002). The meteorological component of a HHWS is based on a heat stress indicator. Indicators based on air temperatures, simple thermal indices, or weather classifications (holistic approaches) give no insight into cause / effect relationships. Fundamentally, we know the mechanism of heat exchange between the human body and its thermal environment that is defined by air temperature, water vapour pressure, wind velocity, and mean radiant temperature[1] (FANGER, 1970). Thermophysiologically relevant assessment procedures that combine the above-listed meteorological variables with metabolic rate and with due consideration of the insulation effect of clothing, require the application of complete heat budget models.

Apart from the holistic approaches, heat load warning procedures are based on an absolute or a relative threshold. An absolute threshold implies that there will be rare heat load in colder regions and frequent heat load in warmer regions. Relative thresholds (e.g. the 97 % percentile), on the other hand, are based on the assumption that the probability of heat load is in the same order of magnitude everywhere. Up until today the term “heat wave” has not been defined officially. Heat waves as extremes are rare events. And an impact-related definition of a “heat wave” must also meet the criteria that society is susceptible to or unable to cope with these events.

Humans are adapted and acclimatized to a certain extent to their local climate. Therefore there is a spatial and temporal variability within the thresholds upon which health effects can be found (e.g. KALKSTEIN and GREENE, 1997). Because of short-term acclimatisation the threshold, above which an increase in mortality can be found, varies within the year.

The Klima-Michel-Model has been applied to assess the environment in a thermophysiologically relevant way (JENDRITZKY ET AL., 1979). The parameter used is the Perceived Temperature PT, which takes all relevant mechanisms of heat exchange into account with due consideration given to well-adapted clothing. The meteorological input variables are air temperature, water vapour pressure, wind velocity and short-wave as well as long-wave radiant fluxes. PT [°C] is defined as the air temperature of a reference environment in which the perception of heat and / or cold would be the same as under the actual conditions. In the reference environment the wind velocity is reduced to a slight breeze, the mean radiant temperature is equal to air temperature and relative humidity is 50%. The model is originally based on the predicted mean vote (PMV) equation of FANGER (1970) and uses the PMV* correction of GAGGE ET AL. (1986) to account more accurately for latent heat fluxes (evaporation). The thermophysiological assessment is made for a standardized person called “Klima Michel”, who adapts his clothing between 0.5 clo[2] (summer clothes) and 1.75 clo (winter clothes). This standardized person is

[1] The mean radiant temperature (°C) is defined as that uniform temperature of a black enclosure which would result in the same heat loss by radiation from a person as from the actual enclosure under study (FANGER, 1970).

[2] Clo: clothing insulation value. 1 clo is equal to 0.155 m² K / W

35 years old, 1.75 m in height and weighs 75 kg. His work performance is 175.5 W, which corresponds to walking at approximately 4 km / h. The assessment procedure is designed as being representative for people staying outdoors.

In order to eliminate trends and seasonal fluctuations, the Gaussian smoothing was applied to the PT data. For the smoothing of the PT data a backward filter was applied (half Gaussian filter), which includes the 30 days before. The reason for using the half filter and the shorter filter length is that the filter is considered to display the short-term acclimatisation processes. The conceptual model behind this assumption is that most of the physiological changes of short-term acclimatisation take place within one or two weeks and are lost within a month. Also short-term behavioural adaptation is included in the model, e.g. the amount of clothing worn, as this cannot be distinguished from acclimatisation (physiological adaptation) at the population level. Hence, the relative weight of the first one or two weeks should be higher than that of the end of the period. Therefore filter weights based on a normal distribution seem to be an appropriate approach.

In order to overcome the shortcomings of the already existing heat indicators, the DWD method includes short-term adaptation in a thermophysiologically relevant assessment procedure by using the Perceived Temperature. It combines an absolute with a relative threshold. The absolute part is based on the thresholds for heat load and cold stress shown in table 1 based on the PMV values of FANGER (1970). The relative part is introduced by using the Gaussian smoothed values of PT. These represent the temperature to which a human being can adapt by short-term adaptation.

The upper value for the adapted comfort range (UACR) which is 20°C by using the absolute threshold only (UCC), is calculated as follows:
UACR = UCC + (F12 – UCC)*0,33 [°C].

The lower value for the adapted comfort range (LACR) is 0°C by using the absolute threshold only (LCC) and is modified accordingly for the new approach:
LACR = LCC + (F00 – LCC)*0,33 [°C].

Table 1: Perceived Temperature (PT), thermal sensation and thermal stress (based on FANGER, 1970)

PT in °C	Thermal sensation	Thermal stress level	Name
	Very hot	Extreme	
38	Hot	Strong	
32	Warm	Moderate	
26	Slightly warm	Slight	
20	Comfortable	None	UCC*
0	Slightly cool	Slight	LCC**
-13	Cool	Moderate	
-26	Cold	Strong	
-39	Very cold	Extreme	

*UCC: Upper constant comfort range

**LCC: Lower constant comfort range

F12 is the smoothed value of PT at 12:00 and F00 is the smoothed value for PT at 00:00, respectively. The absolute part is weighted with 2/3 and the relative part with 1/3. The weight for the relative part refers to the experience that populations do not adapt completely to the weather conditions of the past few weeks. For example, within a population there are unfit individuals who acclimatize to a lesser extent than the fit persons. Therefore, the weighting factor has to account for such intra-individual differences within a population.

For the assessment of the heat load the PTs at 12:00 UTC are used here because they are available for many weather stations and are normally close to the maximum value. In order to calculate the different heat load and cold stress levels the differences between the absolute levels are added to UACR and LACR. For conditions above the comfort range the increment is 6 K and for conditions below the comfort range the increment is -13 K (table 1). By including the relative part, the thresholds listed in table 1 are modified.

Among others, the inclusion of short-term adaptation has the advantage that the index can be used without modification in different climate regions and during different times of the year. The DWD procedure accounts for short-term adaptation by including the last 30 days. Therefore it is not necessary to define artificially a summer season or to include the day of the year (season) in the model. In addition, there is probably no need to calibrate the method for each city or region for which a warning is given, as it has to be done for the synoptic systems. However, it should be borne in mind that the DWD heat load model does not include the level of long-term adaptation to a certain climate. Possible long-term adaptation measures include appropriate building and urban design, other behavioural factors (such as the siesta in southern Europe), etc. In addition, heat-related mortality depends on societal factors such as the age structure and the health status of the population. If the adaptation level and societal factors are set as constant over time, differences between populations in mortality increase must be expected for the different heat load categories. These differences indicate the sensitivity of a society and provide a possibility of comparing the vulnerability of different populations.

The described procedure shows significant differences in the effect of the diverse thermal stress categories on the mortality rate. Therefore, these categories can be used as heat load indicators and as basis for a general definition of the term “heat wave”. The “strong heat load” category satisfies both requirements for an extreme event. Within 30 years (1968-1997) only 97 days have been classified as days with a strong heat load. At the same time these days show on average an elevated mortality, indicating the susceptibility of the society.

It is important to include a time factor in the assessment of thermal stress. Mortality increases with the persistence (days in a row) of a moderate and strong heat load because of the assumed dose response relationship. Another reason might be that with prolonged periods of heat indoor environments also become hotter and the net heat load increases.

An important problem to be solved when analysing the effects of heat waves or other “events” on mortality is the determination of the “expected mortality”. Different philosophies can be applied to determine the expected value. One philosophy is, that we expect what we are used to. In other words the basis for the expected value is the long-term mean. As mortality-rates changes within a year, the long-term mean of the course of the year of daily mortality data must be calculated. This only works if long time series are available and if the data can be controlled for trends in mortality rate and in population size.

A second philosophy is to base the expectation on the experience of the current period. In this case the expected value is calculated by a low-pass filter. This filter accounts for trends and a changing population size, so that this kind of information is not necessary. However it is not possible to construct a perfect filter, selecting only the wanted frequencies, because single values always influence the value of the filter function. Therefore there is the possibility that the

"expected value" calculated for an event is influenced by the event itself. There are possibilities to minimize this influence. However it is not possible to eliminate it totally.
Analysing the impact of the 2003 heat wave in SW Germany the effect of the chosen method for estimating the expected value ranges from a calculated excess in mortality for the period 31.07 – 18.09.2003 from 1001 heat related deaths using a low pass filter to 1372 heat related deaths using a 36 year mean course of the year.

Another important factor that influences the estimate of excess mortality is the length of the analysed period because of harvesting and other effects. For the 2003 heat wave and the low-pass filter method an analysed period from 31.07. – 23.08. lead to 1287 excess death and an analysed period from 31.07. – 30.09. to 970, respectively.
These considerations on the expected values show that comparisons between the different studies looking at the impacts of heat waves should be carefully examined and should only be compared if the basis and methods for the estimation of the expected mortality are the same.

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ANNEX VII

Terms of Reference for ET 3.8 on Health-related Climate Indices and their Use in Early Warning Systems, as established at CCl, November 2001

(a) To review critically and make recommendations on the efficacy and validity of universal thermal climate indices;

(b) To review and make arrangements for the continued quantification of the relationship between health stressors such as ozone, other environmental pollutants, vector and water-borne diseases, adverse radiative impacts, heat and cold stress on the one hand, and meteorological factors, including climate indices;

(*c*) To identify or develop custom-built climate indices for vulnerability assessments, preparedness planning and alerts on particular health outcomes of climate variations;

(*d*) To identify requirements for, and make recommendations on, the coordination of further research in the area of climate and human health;

(*e*) To submit reports in accordance with timetables established by the C-OPAG and/or Management Group.