

THE SHOWCASE PROJECTS ON HEAT/HEALTH WARNING SYSTEMS:
INTERNATIONAL COLLABORATION WITHIN THE CLIMATE AGENDA

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1. INTRODUCTION

The World Meteorological Organization (WMO), together with a number of major partner organizations in the Climate Agenda and national and municipal agencies, is collaborating in a series of Showcase Projects begun in 1999 to demonstrate the application of climate information and weather forecasts to the reduction of human deaths related to extreme heat waves. Although the Rome and Shanghai projects are drawing heavily from the successful experiences of similar climate applications that were instituted in the United States, they are also incorporating knowledge gained throughout the network of climate and health applications that are overseen by the WMO's Commission for Climatology.

Identifying features of the projects are that they involve a multidisciplinary team from the outset, they depend on proven climate applications that correlate historical climate and health information with dangerous air masses, they result in an integrated warning system that gives city dwellers concrete information to mitigate the life-threatening effects of extreme heat waves, and the ongoing responsibility for the resulting system lies wholly within the local organizations.

2. WMO FOCUS ON HUMAN HEALTH

The WMO contributes to the studies that underpin the World Climate Applications and Services Programme through the scientific activities of the Commission for Climatology (CCI), implemented by the Secretariat through the World Climate Programme Department. Through its Climate Information and Prediction Services (CLIPS) Project, WMO helps its 185 Member countries and territories put new knowledge into practice by incorporating techniques and services such as heat/health warning systems into their operational national climate services.

Collaboration in climate applications among the major international partners is fostered through the Inter-Agency Committee on the Climate Agenda (IACCA). The Showcase Projects team includes the United Nations Environment Programme (UNEP) and the World Health Organization (WHO)—renewing their commitment to the multiagency collaboration that co-produced the book, Climate Change and Human Health. The timeliness of the choice of "Weather, climate and health" as the theme for the 1999 World Meteorological Day was underscored with the participation of WHO's Director-General in the activities.

The WMO's participation in the Showcase Projects is a product of the CCI's priority on "Development of climate services in support of human health." The projects follow guidelines that were proposed by a group of experts convened by the WMO, which met in Freiburg, Germany in 1997. The group included health and meteorology specialists, from WMO, UNEP, and WHO. The WMO activities are cross-coordinated through its CCI, Commission for Basic Systems, and Commission for Atmospheric Sciences.

3. HEAT/HEALTH WARNING SYSTEM

The Heat/Health Warning Systems are based on the knowledge of how human beings respond physiologically to a number of atmospheric conditions, including temperature, humidity, wind, and solar radiation. Although humans have a great capacity to adapt to varied climates and environments, they are still vulnerable when surrounding meteorological conditions change considerably, especially if that change is sudden. For example, exposure to extreme temperatures may lead to heat stroke or hypothermia. In most countries, people can live comfortably in the temperature range of 17°C–31°C. However, when the temperature of the surrounding air raises the body's core temperature to above 40.6°C, death from heat stroke can result.

During unusually hot episodes, mortality rates from all causes can more than double the normal rates, especially when episodes are prolonged. Persons either below 3 years old or over age 65 are more vulnerable. Urban populations are typically more vulnerable to heatwaves than their rural

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counterparts, and those in cities in temperate zones show the strongest negative response. In addition, the urban heat-island effect may exacerbate the effects.

The impact of heat has been studied primarily in relation to mortality (death) rather than morbidity, primarily because mortality data are generally available. The assumption is made that heat-related deaths can be represented by the number of deaths that occur in a period that are above what would have occurred without the heatwave (known as the "baseline level"). In the development of a Heat/Health Warning System, synoptic methodologies are evaluated for modelling the dangerous air masses, daily comparisons of various weather elements to corresponding mortality rates are used to establish associations between them, and a warning system is developed that is based on short term weather forecasts of those elements. Finally, a decision tree is developed to link the heat warning information to mitigative steps.

4. THE SHOWCASE PROJECT IN ROME

The Rome Showcase Project is being conducted under the World Climate Applications and Services Programme, and is funded completely by the United Nations Environment Programme. The project team is headed by Dr L. Kalkstein, the Director of the Center for Climatic Research of the University of Delaware (USA), and includes representatives of the Lazio Health Authority, the Italian Meteorological Service, the Slovenian Hydrometeorological Institute, and the WMO. The World Health Organization and its European Centre for Environment and Health are also maintaining an interest.

Meetings were held in Rome on 1-2 February to initiate work on the heat/health watch-warning system. The meetings explored the relationship between climatological elements and air masses associated with extreme heat waves and the increase in deaths within city populations in the United States and in Italy, and of the value of steps that can be taken to mitigate the likely effects of heatwaves that will be identified through the project. They also resulted in agreement on the implementation steps, individual responsibilities and schedule to implement a Heatwave Watch/Warning System in Rome in 2000.

The Italian participants agreed that the system will be operated by the Lazio Health Authority. This differs from the practice in the U.S., where the Heat/Health Warning is provided by the National Weather Service. The Philadelphia Department of Public Health will assist the Lazio Health Authority in defining intervention actions.

The system is being developed at the University of Delaware and will be transferred to the Lazio Health Authority. The mortality data necessary to develop the system was provided to the University of Delaware from the Lazio Health Authority, and was correlated with the historical meteorological data that was provided by the Italian Meteorological Service. There will be a retrospective evaluation of the developed system, to make certain that it is identifying dangerous weather with relative accuracy. And, there will be a plan to check the effectiveness of the system once it is operational to make certain that the system is saving lives and serving a useful purpose.

The schedule for 1999 called for assembly of mortality and historical meteorological data; system development; retrospective evaluation of the system to demonstrate predictive ability of the system; commencement of software development; and determination of the nomenclature for the system (e.g. watch/warning terminology, etc.). The project steps in 2000 will begin with completion of intervention (mitigation) plans and initial personnel training at the Lazio Health Authority; proceed to software installation on Lazio Health Authority computers and completion of training; and system operation in test and adjust mode will commence in late spring, continuing for 45 days. Initial operation will commence on 1 July 2000, at which time an evaluation of system effectiveness will also begin.

5. INITIAL RESULTS OF THE ROME PROJECT

Testing of three different synoptic methodologies for their usefulness in addressing the problem resulted in selection of the Spatial Synoptic Classification (SSC) as the best model in terms of identifying high-mortality days. The SSC classifies each day into one of eight air masses:

- Dry Polar (DP),
- Dry Moderate (DM),
- Dry Tropical (DT),
- Moist Polar (MP),
- Moist Moderate (MM),
- Moist Tropical (MT),
- Moist Tropical Plus (MT+), the warmest and most humid subset of MT, and
- Transition (TR).

The system accounts for numerous meteorological parameters, as well as their variation throughout the day. It is believed the evaluation of all these parameters simultaneously is the reason for the SSC's superior results, as simpler models, such as an apparent temperature algorithm, are not capable of incorporating the entire umbrella of weather conditions present on any given day.

Figure 1 depicts the total mortality by air mass for Rome for the summertime, defined as 15 May to 30 September, over the period 1987-1998. It is clear that two air masses in particular, MT+ and DT, have a mean mortality which is statistically significantly higher than the other 6 air masses, with an additional 5 to 8 deaths per day.

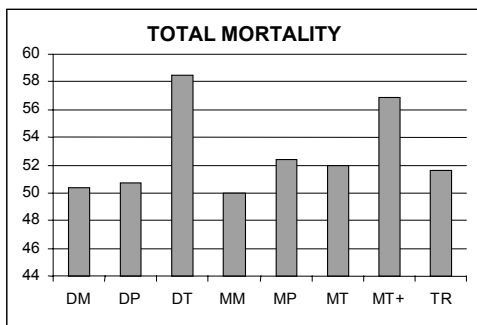


Figure 1. Mean total mortality by air mass for Rome

One interesting feature noted is the disproportionate number of females that died on the most extreme DT days. As can be seen in Table 1, over 57 percent of those who died on the 10 DT days with the highest mortality were female. In comparison, on all other DT days the total is 50.4 percent, and on all summer days, 49 percent female. Interestingly, this result did not occur on the most excessive MT+ days, where the total was roughly equal to the average for all MT+ days. The cause of this phenomenon is uncertain.

Date	Total Deaths	Percent Female	Percent Male
11-Aug-94	103	53.4	46.6
01-Aug-92	101	66.3	33.7
03-Aug-92	91	67.0	33.0
07-Aug-94	88	55.7	44.3
09-Aug-94	87	65.5	34.5
10-Aug-94	87	50.6	49.4
24-Jul-88	86	46.5	53.5
29-Jul-92	83	54.2	45.8
23-Jul-87	82	58.5	41.5
02-Aug-92	81	53.1	46.9
TOP 10 DT	889	57.3	42.7
All other DT	4723	50.4	49.6

Table 1. Total mortality, and percent by gender, for the ten DT days with the highest mortality

DT and MT+ comprise only approximately 11 percent of all summer days (Table 2). DT contains the highest temperatures of any air mass, and the lowest cloud cover. MT+, while lower in afternoon temperature, has the highest dew point of any air mass. Both of these air masses typically have very high overnight temperatures.

Air Mass	Frequency (percent)	Temperature Dew Point			Cloud Cover (tenths)
		15 h (°C)	03 h (°C)	15 h (°C)	
DM	45	28	17	14	2
DP	7	22	12	10	3
DT	7	33	21	15	1
MM	16	23	17	16	6
MP	2	18	13	12	7
MT	10	28	20	18	4
MT+	4	31	22	20	4
TR	8	27	19	14	4

Table 2. Mean frequency and character of the air masses in Rome in summer

Typically, the air masses which contain the highest mortality also contain the highest standard deviation of mortality as well. Hence following the initial identification of "offensive" air masses, tests are done to discern which within-air mass parameters on offensive air mass days are most closely linked to mortality. These parameters include:

- maximum, minimum, and mean apparent temperature values (of 3 h, 9 h, 15 h, and 21 h LST) for both the day and the day prior,
- 15 h temperature and dew point,
- 3 h temperature,
- mean daily cloud cover,
- cooling degree hours for the day and the day prior,
- time of season, and
- day in sequence of an oppressive air mass.

Algorithms were developed separately for DT and MT+ using several different death totals (note that all *exclude* violent deaths):

- all,
- those under 65,
- those 65 and over,
- those 75 and over,
- only females, and
- only males.

The parameters which show a statistically significant relationship with mortality variability within the offensive air mass were identified using stepwise linear regression, and the developed algorithm can be used to estimate excess mortality on days when weather emergencies are declared.

A very weak correlation is noted in those under 65, with approximately 12 deaths per day regardless of air mass or meteorological conditions. As previously mentioned, women appear to be more susceptible than men on excessive DT days, but not on MT+ days. All other categories provided similar results; the two best categories are all deaths, and deaths of those over 65, which removes the apparent white noise of death totals for those under 65.

On DT days, several parameters are important. Time of season is a negative factor, as mortality is higher earlier in the season before people are acclimated to the summer weather. Day in sequence is a positive factor, as persistent oppressive air mass conditions obviously would exacerbate any health problem. In terms of meteorological conditions, the morning's minimum (3 h) apparent temperature and yesterday's average apparent temperature are both contributing, positive factors.

MT+ days have a different set of important criteria. Perhaps because this air mass is always warm overnight, minimum temperatures are not important. Rather, a total heat load factor of cooling degree hours is important. For over 65 mortality, the day's cooling hours are important, while for total deaths, yesterday's cooling hours are important. It is unclear why there is a distinction although the two are highly correlated. The only other factor accounted for within the MT+ data is time of season, again a negative factor.

6. THE SHANGHAI SHOWCASE PROJECT

A meeting was held in Shanghai in October 1999 to initiate the second Showcase Project—Heat/Health Warning System. The Rome project team (external members) was augmented with representatives from WHO and its Regional Office in Manila, and joined by representatives of the Chinese Meteorological Administration, the Shanghai Meteorological Bureau, the Shanghai Health Administration, and other Chinese experts.

The Shanghai Showcase Project is being funded jointly by the WMO and the WHO, with contributions by the U.S. National Oceanic and Atmospheric Administration and Environmental Protection Agency. The Chinese Government is funding internal activities within the project. Additionally, interest has been shown by UNEP in joining the project in the near future.

7. WMO PLANS FOR ADDITIONAL SHOWCASE PROJECTS

A number of requests have been received from other locales interested in participating in Showcase Projects in Climate and Health in their cities-- a strong testament to the need and to the efficacy of the heat/health warning system concept.

Plans are under development for the best approach to assist in building the capacity for local systems worldwide. The WMO will continue to participate in multiagency projects, to the extent that extra-budgetary funding permits. The primary aspect of the next generation of Showcase Projects will be the development and provision of guidance materials and a programme for transferring techniques and technology worldwide. At the same time, consideration is being given to extending the concept to cover other sectors, such as energy.

