Temperature-related human mortality (TRM) in European regions

End-User Requirements Specification Report

Blue-Action Case Study Nr. 2

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About this document

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Summary for publication

We used our networks of contacts to explore a wide range of institutions, sectors and experts. We considered key policy-makers from institutions at different levels, including authorities from international organizations and national agencies in Europe and the United States, as well as local stakeholders from regional governments, metropolitan areas and city councils. The objective of the deliverable was to provide an exhaustive overview about the best way to design and implement a heat health early warning system that maximizes its impact and goes beyond what is currently available.

A set of interviews and meetings were organized to achieve three main objectives:

a) To provide a general overview of the objectives and methodologies of the project to scientists from outside the climate community.
b) To compile information from previous and ongoing initiatives in the domain of heat stress and human health.
c) To discuss possible ways of collaboration in order to coordinate current initiatives and explore potential synergies.

The interaction with the end-users and stakeholders helped us to fully understand the current situation of operational heat health early warning systems in Europe and globally, together with their limitations and potential needs and opportunities. As a result of the interaction with the different institutions, sectors and experts, we found several areas that were key for the improvement of heat health early warning systems:

- Need for a unified pan-European service.
- Need for a service that can be adapted to all European societies.
- Need for the use of non-climate data, mainly mortality numbers.
- Need for a service that can be adapted to urban environments.
- Need for predictions and warnings beyond a few days.
- Need for the long-term engagement of end-users.
- Need for support and funding beyond the end of projects.

Taking into account the current limitations in climate and mortality data availability, as well as in seasonal forecasting skill, the deliverable proposes a prototype of pan-European heat health early warning system that addresses most of these needs.

Work carried out

Identification logic

We used our networks of contacts to explore a wide range of institutions, sectors and experts. We considered key policy-makers from institutions at different levels, including authorities from international organizations and national agencies in Europe and the United States, as well as local stakeholders from regional governments, metropolitan areas and city councils.

We covered a wide range of public and private sectors, including public health agencies, universities, climate change impact offices, institutes on working security and health, and public and private hospitals and clinics. These stakeholders represented many areas of expertise and backgrounds within the domain of human health, such as psychiatry, epidemiology, pharmacy, legal and preventive medicine, public and environmental health or obstetrics. We have additionally been in contact with experts in the domain of animal health, in order to explore the potential generalization and application of the research to the interaction between animals and humans through the food chain.

Apart from stakeholders, decision-makers and scientists within the domain of human health, we also contacted meteorologists, climatologists and geographers from meteorological agencies and climate research centres to better understand the dependencies between climate, the environment and associated impacts on human health. This approach was complemented with the expertise of demographers and experts in socioeconomic inequality, especially at the urban scale, in order to understand the impact of non-climate variables on climate-related impacts on health.

Process for obtaining information

In total, around 50 people were contacted, and different communication channels were used for the interaction. For international stakeholders from world leading international institutions, the interaction was done mainly through online meetings and international conferences. For example, the temperature-related mortality case study was exposed in the *Fifth International Conference on Climate Services* (ICCS5), held in Cape Town, South Africa (February 28th - March 3rd 2017, http://www.climate-services.org/iccs/iccs5/). The event included sessions on ongoing health action plans at the international and national levels, and was the perfect environment for the discussion of end-user needs and learning from previous similar initiatives.

Instead, for local authorities, the interaction was done through phone calls and group meetings. For example, we were invited to give a lecture about current ongoing initiatives on global heat health action plans in the event "*Action Plan to Avoid the Effects of Heat Waves on Health in Catalonia*", which was organized by the Catalonia Government on June 27th 2017. The event was an excellent opportunity to learn from local authorities about the current needs in heat health action plans in regions, metropolitan areas and cities.

Objectives addressed during the process

The interviews and meetings were designed in order to achieve three main objectives:

a) *To provide a general overview of the objectives and methodologies of the project* to scientists from outside the climate community, and *to explain the main characteristics of the heat early warning system* that is going to be created within the temperature-related mortality case study.

b) *To compile information from previous and ongoing initiatives in the domain of heat stress and human health*. This point was oriented towards three main areas: i) which are the main requirements in terms of climate observations and simulations for the development of a heat action plan?, ii) which are the best statistical or epidemiological methods to fit the climate and mortality data?, and iii) which is the best way to depict the information derived from the product so that it is easily understood by decision-makers and the general public?
c) *To discuss possible ways of collaboration in order to coordinate current initiatives and explore potential synergies*.

Main results achieved

The interaction with the end-users and stakeholders helped us to fully understand the current situation of operational heat early warning systems in Europe and globally, together with their limitations and potential needs and opportunities.

State-of-the-art: previous and existing initiatives

The record-breaking summer 2003 heat wave, which caused more than 70,000 excess deaths in western Europe, represented a stepping point in the awareness of public authorities, health agencies and decision-makers regarding the risks associated with extreme (and non-extreme) temperatures. Very few early warning systems were available in Europe until 2002, while after the event many European countries implemented operational plans, often integrated within broader public response actions addressing other derived health problems (i.e. they are often referred to as heat health action plans).

Nevertheless, protocols, methodologies and warning issuing criteria largely vary from one country to another. We here describe two of the most advanced operational systems available to date in Europe, which illustrate the large heterogeneity among countries: Germany and England. Most of the systems that are currently used in Europe are entirely based on regional thresholds of temperature, and in some cases, other climate variables or derived indices. This is the type of system that is for example used in England, in which regional warnings are issued when a regional temperature threshold is exceeded.

At the other end, the system in Germany is by far more complex and sophisticated, given that it is based on an energy balance model of an idealised human body that is used to compute a measure of perceived temperature. The system uses several meteorological variables and thermo-physiological factors over a period of a month to issue health warnings, e.g. metabolic rate, clothing, air temperature, mean radiant temperature, short- and long-wave radiation fluxes, air humidity or wind speed, among many others. The system is available at different levels, including regions, counties and large cities, as well as for vulnerable population groups (e.g. the elderly).

Current limitations

A major limitation is the lack of a harmonized operational system available for all European countries and cities that is not only based on climate information and heat stress indicators. The few initiatives that have partially addressed this strategic gap so far have been developed within the framework of multi-country European projects. For example, the PHEWE, EUROHEAT http://www.euroheat-project.org/dwd/index.php and CIRCE projects explored the effects of air pollutants and meteorological variables on mortality, but analyses including mortality data were either restricted to a limited number of representative cities, or early warnings were issued at the continental scale only based on climate heat stress indices and not on impact mortality data.

Another major limiting factor is associated with the forecast skill of the climate variables that are used in current heat health early warning systems. In general, European heat action plans do not use forecasts with lead times beyond 1 to 2 days, essentially due to two main factors. On the one hand, the costs of systematic false alarms are enormous in terms of losing the trust of public authorities and users of health information. On the other hand, public health systems are only prepared to transform weather- and climate-related early warning information at very short lead times into effective action measures saving costs and health risks. In both cases, the limited predictability skill of operational weather and climate forecasts at lead times beyond 3-to-5 days in Europe is a major limiting factor.

Public health authorities and relevant end-users have warned us about the potential counter-productive effect of using seasonal climate forecasts to drive an early warning system of temperature-related mortality. They have shown serious concerns about the development of a tool within the sensitive domain of human health that is not based on demonstrated skilful forecasts of atmospheric variables. They stressed the fact that unskilful forecasts of health risks could have a very negative impact on public health management, and therefore they encouraged us that the operational early warning system is only developed for those lead times with demonstrated forecast skill. In addition, they highlighted that no early warning system of health risk is current available at the European scale, and therefore, it would be a huge advance that this was developed for lead times of a few days.

Potential needs and opportunities

As a result of the interaction with the different institutions, sectors and experts, we concluded that there is room for improvement in heat health early warning systems in seven essential areas:

a) ***Unified pan-European service***: the next generation of heat health early warning system in Europe should expand across borders and implement a service with a unified and coherent methodology that provides relevant and comparable information to local end-users in different countries. The lesson from the unprecedented summer 2003 heat wave is that climatic phenomena define continental-scale impacts, but unfortunately the awareness and preparedness nowadays varies among countries, regions and cities.

b) ***Flexibility of the pan-European service***: the heat health early warning system should however adapt to the specific needs and the different climatic regimes existing in Europe. More importantly, the socio-demographic structure and associated vulnerabilities of European societies represent a major factor to be taken into account for the definition of the warning issuing criteria. This heterogeneity therefore requires from a flexible methodology that is suited to the different requirements among and within societies.

c) ***Use of climate and mortality data***: the use of mortality information is an essential requirement for the creation of a unified and flexible heat health early warning system. Nowadays, actions plans are essentially based on climate data, and in very few cases they truly model the real impact of the climate phenomena. A coherent and unified mortality database is therefore an essential need for the development of a pan-European heat health early warning system describing the regional heterogeneity of temperature extreme impacts.

d) ***Continental service for cities***: a major but still not addressed challenge for early warning systems is the assessment of impact information for urban environments, which are characterized by the urban heat island effect and the anthropogenic sources of atmospheric pollution. The next generation of heat action plans should include high-resolution climate and mortality information to derive early warning systems for European cities, which should include the exacerbation effect of the urban heat island within the context of global warming and increasing urban populations. The system might however be largely constrained by downscaling uncertainties in forecasting and epidemiological modelling of the climate-mortality relationship.

e) ***Warnings for multiple lead times***: in general, existing heat health early warning systems do not use weather and climate forecasts for lead times beyond a few days, essentially because the public health community generally believes that there is limited skill, which would systematically undermine the reliability of health warnings from public authorities. A new generation of early warning systems for longer lead times would however provide a window of opportunity for the generation of new products and services if the skill of climate forecasts significantly improved, for example by targeting vulnerable population groups and reducing exposure to climatic hazards. Recommendations from public health authorities however point to a more conservative target based on the demonstrated skilful predictions of weather forecasts at short lead times.

f) ***Long-term engagement of end-users***: the long-term engagement of relevant end-users is a essential step for the development of early warning systems. This engagement plan should include, but is not restricted to, the identification of decision-makers, the understanding of their specific needs and problems to be modelled, and the identification of the vulnerable population groups or economic activities that largely depend on atmospheric variability, together with a priority list of the associated costs.

g) ***Structural support beyond projects***: previous initiatives developing pan-European heat health early warning systems have been traditionally linked to European projects, which represent a major source of funding supporting research for limited periods of time. The resulting outcomes are discontinued systems that in rare occasions evolve after the end of the project. A potential way to circumvent this limitation might be that measures also target the private sector, which could eventually be a source of long-term support. Even in a special sector such as health, which is largely based on initiatives from the public sector, early warning systems might derive into significant contributions for a range of private activities, such as in the areas of occupational health or health insurance.

Progress beyond the state of the art

The work that has been done so far is strictly limited to the analysis of previous and existing initiatives in the area of heat health early warning systems in Europe, together with a description of current limitations and potential needs and opportunities for the next generation of climate services within the health sector. As such, it provides an exhaustive overview about the best way to design and implement an early warning system that maximizes its impact and goes beyond what is currently available.

Taking into account the current limitations in climate and mortality data availability, as well as in seasonal forecasting skill, we here propose the development of a prototype of pan-European heat health early warning system for more than 160 NUTS2 regions in 16 European countries representing more than 400 million people (addressing **point a)** above). These countries would be Austria, Belgium, Croatia, the Czech Republic, Denmark, France, Germany, Italy, Luxembourg, Netherlands, Poland, Portugal, Slovenia, Spain, Switzerland and the United Kingdom (England and Wales only).

For the development of the early warning system, we will use daily counts of deaths and population size by date and region, so that the prototype can be flexible and adapt to the different climate regimes, sociodemographic profiles and vulnerability levels of European societies (**points b) and c)).** We might consider to explore the possibility of using mortality data for cities for a multi-level service, but this will be largely constrained by mortality data availability and the forecast skill and associated uncertainties at small scales **(point d)**. We will mainly use the demonstrated skill from weather forecasts in order to address the current gap in existing systems, but the climate impact model will be designed in a way that can be later generalized to subseasonal and seasonal climate forecasts when they effectively generate skillful predictions at a level that matches the requirements from public health authorities **(point e)**. Finally, we will take into account the lessons learnt from the interaction with a range of end-users **(point f)**, both from the public and private sectors **(point g)**.

Impact

How has this work contributed to the expected impacts of Blue-Action?

The information contained in this deliverable will contribute to the design and development of the prototype of heat health early warning system, which will address the following project's impacts:

a) Delivery of new downstream products and services by interacting with business stakeholders.
b) b) Improvement of the capacity to respond to the impact of climatic change on the environment and human activities in Europe.
c) c) Enhancement of the response capacity of specific stakeholders in the Northern Hemisphere by delivering in an open dialogue with specific end-users the results of the research activities to the society and testing the value of the climate services through joint activities with societal players.
d) d) Contribution to better servicing the economic sectors that rely on improved forecasting capacity through the collaboration between selected stakeholders and scientists.

Impact on the business sector

We interacted with a wide range of public and private sectors, including public health agencies, universities, climate change impact offices, institutes on working security and health, and public and private hospitals and clinics.

In particular, the interaction with stakeholders of the **private sector** might be relevant for designing the prototype of early warning system in a way that it has large applications for a range of private activities, such as in the areas of occupational health or health insurance.

Lessons learned and Links built

There are two essential positive outcomes from this deliverable. On the one hand, we have expanded our network of contacts in the area of health and heat stress by contacting scientists that are responsible for similar initiatives, both in Europe and elsewhere, and by interacting with decision-makers, stakeholders and non-scientists. On the other hand, this interaction has provided us a broader view of the real needs of final end-users beyond the scientific community, which will be crucial for a better design of the heat health early warning system by maximizing its impact to a broader range of sectors.

As a result of our participation in the *Fifth International Conference on Climate Services* (ICCS5), held in Cape Town, South Africa (February 28th - March 3rd 2017, http://www.climate-services.org/iccs/iccs5/), we have started to tentatively interact with other initiatives, such as the H2020 projects PRIMAVERA and CLIMAEUROPE. In addition, we also belong to the consortium of the PUCS project (*Pan-European Urban Climate Service, another H2020 project*), which might provide us the perfect environment for extending the early warning system down to the urban scale.

As a result of the interaction with public health authorities and relevant end-users, who strongly encouraged us to use only demonstrated skilful forecasts, we have decided to constrain the range of lead times of the early warning system to a few days, and thus, to use weather forecasts for the prediction of health risks.

This will require the redefinition of Deliverables D5.8 and D5.9:

- D5.8 *A report describing the methodology underlying the product*, whose delivery is foreseen in project month 36. The climate impact model is now expected to use weather forecasts, and not the "state-of-the-art" (or control) climate forecasts described in the original proposal. The report to be delivered will remain essentially unchanged, describing the methodology used and including the deviations from the original plan.
- D5.9 *Evaluation of the early warning system*, whose delivery is foreseen in project month 48.The In this case, we will not be able to perform a comparison between "state-of-the-art" and "beyond-state-of-the-art" climate forecasts. Instead, we plan to use weather forecasts, which do not need to be validated because they have been largely tested by research teams in the area of numerical weather forecasting. As an alternative proposal to the original plan, we will deliver a report describing how well the climate impact model reproduces mortality numbers and health risks when it is driven by climate observations. This report will provide useful information on the potential skill under a scenario of perfect weather or climate forecasts, which will define an upper bound in the prediction skill of the early warning system.

Contribution to the top level objectives of Blue-Action

This deliverable contributes to the achievement of the following objectives and specific goals indicated in the Description of the Action[1]:

- **Objective 7 Fostering the capacity of key stakeholders to adapt and respond to climate change and boosting their economic growth** by collecting their needs for the development of a heat health early warning system.
- **Objective 8 Transferring knowledge to a wide range of interested key stakeholders** by designing the heat health early warning system in a way that takes into account the needs of the stakeholders.

[1] part B, Section 1.1: http://blue-action.eu/index.php?id=4019

References (Bibliography)

These are the papers or publications consulted during the researches:

1. D'Ippoliti et al. (2010) The impact of heat waves on mortality in 9 European cities: results from the EuroHEAT project. Environmental Health 9, 37.

2. European Environment Agency (2012) Climate Change, Impacts and Vulnerability in Europe 2012. EEA, Copenhagen, Denmark.

3. IPCC (2014) Climate Change 2014: Synthesis Report. IPCC, Geneva, Switzerland, 151 pp.

4. Matzarakis (2017) The Heat Health Warning System of DWD—Concept and Lessons Learned. Springer Atmospheric Sciences.

5. Robine et al. (2008) Death toll exceeded 70,000 in Europe during the summer of 2003. C. R. Biol. 331, 171–178.

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7. Available at http://www.euro.who.int/__data/assets/pdf_file/0018/112473/E91350.pdf

8. Vardoulakis (2012) Health Effects of Climate Change in the UK 2012 – Current evidence, public health recommendations and research gaps. Health Protection Agency, UK.

Dissemination and exploitation of Blue-Action results

Dissemination activities

Type of dissemination activity	Title	Date and Place	Estimated buget	Type of Audience	Estimated number of persons reached
Participation to a conference	Fifth International Conference on Climate Services (ICCS5). Participant: Joan Ballester (ISGlobal)	Cape Town (South Africa), February 28th - March 3rd 2017	0€ (paid by other project)	Scientific Community, policy makers	>500
Participation to a conference	Action Plan to Avoid the Effects of Heat Waves on Health in Catalonia. Participant: Joan Ballester (ISGlobal)	June 27th 2017	0€ (local event)	Scientific Community, policy makers	30-50
Participation to a conference	H2020 Climate Services projects workshop organised by EASME. Participants: Joan Ballester (ISGlobal) and Steffen Olsen (DMI)	Brussels (Belgium), November 29-30 2017	See form C of ISGlobal and DMI	Scientific Community, policy makers	50
Participation to a conference	Blue-Action's WP5 Meeting with GERICS Participant: Joan Ballester (ISGlobal)	Hamburg (Germany), July 10-12, 2017	See form C of ISGlobal	Scientific Community	20
Participation to a conference	2017 Community Earth System Model (CESM) Tutorial. Participant: Joan Ballester (ISGlobal)	Boulder (USA), June 14-18 2017	0€ (paid by other project)	Scientific Community	50-100
Participation to a conference	Kick-off Meeting of the Blue-Action Project. Participant: Joan Ballester (ISGlobal)	Berlin (Germany), January 18-20 2017	See form C of ISGlobal	Scientific Community	50-100
Participation in activities organised jointly with other H2020 project(s)	Kick-off Meeting of the PUCS Project. Participant: Joan Ballester (ISGlobal)	Antwerp (Belgium), June 14-16, 2017	0€ (paid by other project)	Scientific Community	20
Poster	H2020 Climate Services projects workshop organised by EASME. Poster on the TRM case study: Joan Ballester (ISGlobal)	Brussels (Belgium), November 29-30 2017	See form C of ISGlobal	Scientific Community, policy makers	50
Poster	H2020 Climate Services projects workshop organised by EASME. Poster on Blue-Action case studies: Steffen Olsen (DMI)	Brussels (Belgium), November 29-30 2017	See form C of ISGlobal and DMI	Scientific Community, policy makers	50

Peer reviewed articles

Publications in open access are accessible via OpenAIRE.

Title	Authors	Publication	DOI (if available)	Publication Status (in preparation, under review, accepted)	Open Access
European seasonal mortality and influenza incidence due to winter temperature variability	Joan Ballester, Xavier Rodó, Jean-Marie Robine, François Richard Herrmann	Nature Climate Change 6, 927-930 (2016)	10.1038/nclimate3070	Published	Paid by other project

Other publications

No other publication related to the topic of the project.

Uptake by the targeted audiences

As indicated in the Description of the Action, the audience for this deliverable is the general public (PU).

This is how we are going to ensure the uptake of the deliverables by the targeted audiences:

- Social media used by the project.
- Zenodo repository.
- Direct dissemination to other H2020 projects related to Climate Services.

Intellectual property rights resulting from this deliverable

There are no intellectual property rights resulting from this deliverable at the time being.