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BRIEF REPORT

REVISED Heatwave 1987: the Piraeus *versus* Athens case [version 2; peer review: 2 approved]

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Abstract

Background

Heatwaves represent the main indices of climate change, while mortality is one of the established markers of their human effects. For unknown reasons populations adapt to temperature variations/challenges differently. Thus, to allow better precision and prediction, heatwave evaluations should be enriched by historical context and local data.

Methods

The mortality data for 1987 were collected from the Piraeus municipality registry, whereas data for Athens were obtained from literature retrieved from PUBMED. Ambient characteristics were extracted from the Geronikolou's 1991 BSc thesis and the reports of national organizations. From the death events, the odds ratio and relative risk in Piraeus compared to the Athens were calculated. Finally, a simple neural network proposed the dominant ambient parameter of the heatwave effects in the city residents of each location.

Results

The 1987 heatwave was more lethal (seven-fold) in Athens than in

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Approval Status ✔ ✔

	1	2
version 2 (revision) 29 Feb 2024		✔ view
version 1 31 Jan 2023	✔ view	? view

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Any reports and responses or comments on the article can be found at the end of the article.

Piraeus and dependent on atmospheric nitric oxide (NO) concentration (with probability 0.999). In the case of Piraeus in 1987, ozone characterized the phenomenon (with probability 0.993).

Conclusions

The odds of dying due to a heatwave are highly dependent on lifestyle, population sensitivity to preventive measures and public health policy, while the phenomenon was mainly moderated by ozone in Piraeus in 1987, and NO in Athens irrespective of year.

Keywords
heatwaves; Eastern Mediterranean Sea; mortality; heatwave 1987; Athens 1988; Athens 1992; odds ratio; relative risk; mortality; neural networks; ozone; NO

This article is included in the HEAL1000 gateway.

This article is included in the Climate gateway.

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Author roles: Geronikolou S: Conceptualization, Data Curation, Formal Analysis, Investigation, Methodology, Project Administration, Resources, Software, Supervision, Validation, Visualization, Writing – Original Draft Preparation, Writing – Review & Editing; **Zimeras S**: Software, Validation, Visualization, Writing – Review & Editing; **Tsitomeneas S**: Visualization, Writing – Review & Editing; **Chrousos GP**: Funding Acquisition, Project Administration, Supervision, Validation, Visualization, Writing – Review & Editing

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REVISED **Amendments from Version 1**

This version includes details on the calculation of probabilities, a new Figure (3) where the jet streams blowing those days in the area are illustrated (source Greek National Meteorological Organization (EMY)). We, further, edited the text and added more references.

Any further responses from the reviewers can be found at the end of the article

Introduction

Excessive ambient temperatures represent the main indices of climate change, while mortality is one of the most established markers of its human effects. In the last few decades, the annual incidence of extreme weather event disasters has tended to rise[1]. Thus, in the last 50 years, 22,173 all-cause disasters (conflicts, biological, natural, technological) have taken place, causing 6.2 million deaths globally[2]. The same report also suggests that 8% of the 89% of the observed total all-cause mortalities that were registered in the Emergency Events Database (EM-DAT) of the Center for Research on the Epidemiology of Disasters (CRED)[1,2] were attributed to heatwaves[1].

High ambient temperatures are closely related to mortality increases in most countries[3], and this risk is expected to rise in the near future, as they are closely related to climate change[4–7]. Daily deaths and high ambient summer temperatures have been correlated irrespective of city heterogeneity, as shown in the Assessment and Prevention of Acute Health Effects and Weather Conditions in Europe (PHEWE) project[8,9]. Daily mortality and weather and air quality data for 15 European cities were analyzed over 11 years, and it was concluded that the warm season heat-mortality curve was J-shaped, with Mediterranean cities having higher temperature thresholds and steeper slopes than Central and Northern European cities.

Heatwaves are rather common in the Southeastern Mediterannean climate. Yet, there are few studies reporting heatwave mortalities in this area: Vassalo *et al.* reported a gender specific risk ratio in Malta before 1995[10], whilst the Pyrgou *et al.*[11] and Heaviside studies evaluated the heatwave related mortality in Cyprus between 2003–2005 (11 events)[12]. Meehl and Tebaldi in 2004 suggested that in the 21st century, the heatwaves will be more frequent, longer-lasting and heavier even in countries not previously associated with high temperatures[13].

The data reported in these studies were the mean daily death events or effect size (risk ratio for each gender).

Meehl and Tebaldi's projections have been verified already and the need for new public health policies preventing high mortality risk depending on locality (geography, climate, culture) have to be designed and applied. For unknown reasons, populations adapt to temperature variations or challenges differently[10]. Location, lifestyle, genetic predisposition, environmental pollution are ongoing research targets in our attempts to calculate their impact on individuals and populations. Such data are important for authorities to make correct decisions regarding public health and city planning. Public health measures should adapt to these considerations to mitigate heatwave effects. The evaluation of heatwaves should be enriched by historical context and local events to allow better precision in data analysis and more accurate predictions of future crises. This study aims to contribute with a heatwave report for Piraeus in 1987 published as part of a dissertation in the Public Hygiene Department[11], as this is a representative urban population (ranked third in growth) and the largest port in the Mediterranean Sea. The Piraeus 1987 case will be examined it in the light of the mortality odds, and more importantly, will be compared with other heatwaves in the same geographical area at the same and different times.

Methods

A retrospective study was designed comprising of the daily all cause deaths in Piraeus during the summer of 1987[11]. The above heatwave was compared to diverse heatwaves in the Attica area: Athens in 1987[12–14], Athens in 1988[12–14], and Athens in 1992[15].

The data extracted by these studies were processed to calculate:

- the odds ratio as follows: OR=π/(1-π), where π: incidence (risk)[16].
- the relative risk of dying in each heatwave (v) compared to the Piraeus 1987 heat wave mortality risk:

$RR= \pi_V/\pi_{Piraeus}$ [16]

Discomfort index (DI) is an index of the discomfort felt in warm weather as a result of the combined effects of the temperature and air humidity. It was calculated using Thom's formula[17] as follows:

DI=T- 54*(0.55-0.0055*RH)*(T-14.5),

where T: temperature; RH: relative humidity.

Ozone and nitric oxide (NO) measurements were extracted either from the included publications, and/or the Geronikolou 1991 thesis.

We also present pollution and solar activity data (sunspot numbers) for each month that the heatwave under investigation had been observed. The sunspot numbers are related to cosmic rays and are investigated for their influence on the climate and for their impact on human health[18]. As for the network, the values were normalized by being divided by the sum of exponential values and then converted into probabilities. According to the previous analysis, a softmax function was adopted, translating the resulting numbers into a probability distribution. Thus, the output of the function can be interpreted by a percentage number representing the possibility of an event to occur.

Results

Daily mortality events were based on the Geronikolou's (1991) BSc thesis that included a study of all death events archived in the city of Piraeus between June 1st 1987 and August 31st 1987. In these 92 days, 263 death events were archived, with 62 of them occurring during the heatwave[11]. Concerning the Athens data, they were extracted by existing publications[12–15].

In Table 1 the registered population in each municipality census (for both Piraeus and Athens) are listed

In Table 2 the geography and pollution characteristics and the calculated DI are depicted.

In Table 2, to overcome the problem with the missing values (noted as n/a), two interpolation methods were used considering:

1. Lagrange interpolation polynomial[19–21] and

2. Cubic spline interpolation[21,22].

Due to the uncertainty in the form (direction) of the data, computation of the average between the two interpolation methods was opted. Results are shown inside the bracket of the data.

In Table 3 the calculated probabilities of heat-related mortality are presented.

Usually, neural networks are applied to big data analysis cases, but in this case, their use is as a pilot for data processing. Regarding the effect of the factors influencing the occurrence of heatwaves, a simple neural network-developed taking into consideration the proposing parameters from Table 2: NO, ozone, temperature, discomfort index and sunspot. The idea behind this model is to predict the importance of the parameters affecting the heatwaves. The model x_i i=1,..,n consists of the proposed parameters and w_i i=1,..,n represents the corresponding weights. In our case all the parameters had the same weight (w_i =1);

Σ is denoted as the summation of the multiplication between parameters and weights (w_i x_i); f(x) is the activation function.

The activation function is an integral part of a neural network. Without an activation function, a neural network is a simple linear regression model. This means that the activation function gives non-linearity to the neural network. The proposed formula for the function is the softmax with [33–36]

$$Soft\max(x_i) = \frac{e^{x_i}}{\sum_{i=1}^{k} e^{x_i}}, j = 1, 2, \ldots, k$$

The values were divided by the sum of exponential values to normalize and then converted them into probabilities.

According to the previous analysis, the opted softmax function translated the resulting numbers into a probability distribution. Thus, the output of the function can be interpreted by a percentage number representing the probability of an event to occur.

Based on the proposed neural network (Figure 1) the important parameters for different years are:

Piraeus 1987 - ozone probability 0.993

Athens 1987 - NO probability 0.999

Athens 1988 - NO probability 0.999

Athens 1992 - NO probability 0.999

Table 1. Cities of Piraeus and Athens demographics.

Year	Piraeus	Piraeus greater area	Athens
1951	186,088	n/a	n/a
1961	183,957	n/a	n/a
1971	187,458	439,138	867,023
1981	196,389	476,304	885,737
1991	182,671	456,865	772,072
2001	175,697	466,065	745,514
2011	163,688	448,997	664,046

n/a: not available; Source: Hellenic National Statistic Authority

Discussion

The Eastern Mediterranean Sea is surrounded by highly diverse regions such as North Africa, the Middle East and Asia Minor. Socioeconomic, environmental and population inequities have been associated with anthropogenic climate dryness and change. For millennia, ambient temperature exposure has influenced the human body leading to physiologic responses that sometimes may be morbid or lethal (Figure 2). The ancient Greek physician Hippocrates, known as the father of Western medicine, in his work *"On airs, waters and places"*, documented the human physiology and variations of clinical manifestation in populations living under different environmental conditions (wind flow, density and direction, soil type, temperature, humidity, local water bodies, etc.). On the other hand, Roman mythology, by attributing the heat phenomena to the rise of the "dog star" (Sirius) defined the time periods of heatwaves between 3rd of July and 11th of August each year[12]. Coincidentally, the heat events studied herein took place during July. Currently, we have real-time and historical records to evaluate the heatwave effects that will lead to planning future mitigations via public health measures.

In this study, we focused on the largest port city of Southeast Europe and the Eastern Mediterranean Sea, Piraeus. According to the National Oceanic and Atmospheric Administration (NOAA), the location's latitude is 37.873° and longitude

Table 2. **Ambient characteristics in Piraeus and Athens due to heatwaves.**

Characteristics	Piraeus 1987	Athens 1987	Athens 1988	Athens 1992
Latitude	37.873°	37.984	37.984	37.984
Longitude	23.675°	23.7275	23.7275	23.7275
NO (μg/m³)	88	162	182	n/a (157)
Ozon (μg/m³)	93	87	86	84
Temperature (OC)	42	43.6	42	41.6
Humidity (%)	57.33	60	n/a	n/a
Discomfort index	37.077	37.2	n/a (37.33)	n/a (37.46)
Duration (days)	10	10	7	n/a
Sunspot numbers	33	33	39	64.4

n/a: not available

Table 3. **Calculated probabilities of mortality-risk in Piraeus and Athens due to heatwaves.**

Mortality/heatwave	Piraeus 1987	Athens 1987	Athens 1988	Athens 1992
Deaths (absolute)	67	2000	28	359
Odds Ratio (OR)#	0.0003157	0.002258007	0.00000316121	0.000464983
Relative risk (RR)#	1	7.152382	0.100133	1.472862

: Calculations are based on dead/survived+dead

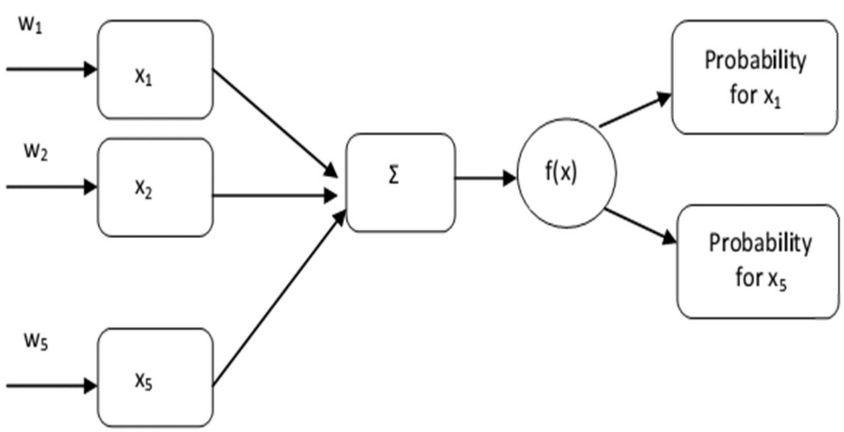

Figure 1. **Neural network.**

is 23.675, while its coordinates are 37°56′34.8″N 23°38′49″E. It is a rather flat (highest elevation/hill) 87 m (285 ft) coastal urban city covering 50.417 km² (19.466 sq mi). Piraeus's seaport is only 7 km from the Athens city center. It usually has temperature which is 3 °C lower than Athens, with blowing sea winds and a higher humidity[12,13]. Piraeus is flat, including only one hill of 87 m height, while the mountains are in the far distance. Athens, on the contrary, includes hills and mountains, and is characterized by vast urban density and numerous heat-islands due to stone pedestrian areas, narrow roads and high buildings. In Piraeus the urban density is clearly lower and the roads are wider, allowing the sea winds to cool the city. In Figure 3, the jet streams flowing above Athens and Piraeus during the heatwave 25-29/7/1987 are illustrated. In addition,

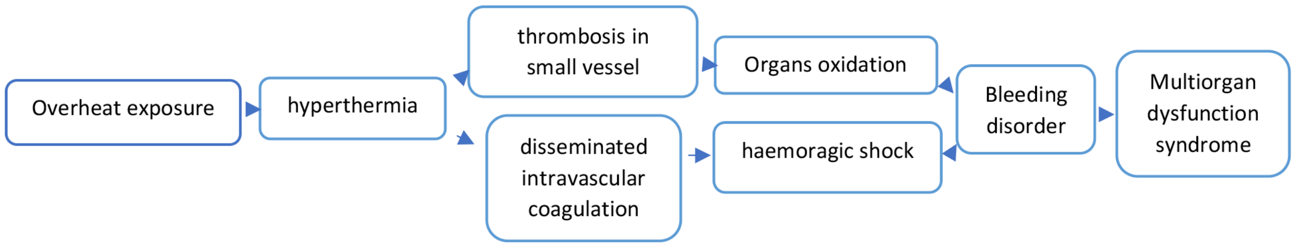

Figure 2. Physiologic mechanisms explaining heat-related morbidity and mortality.

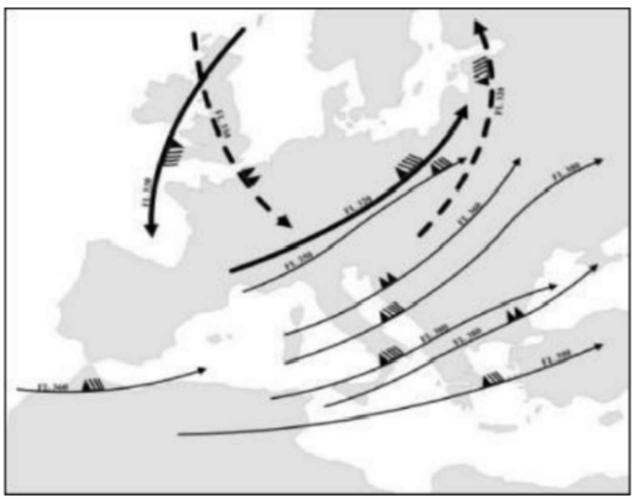

Figure 3. Map of the jet streams flowing above Athens and Piraeus during the heatwave 25-29/7/1987. Source: Hellenic National Meteorological Service archive.

the sea water vapor, enhanced by extreme heat, contributes to the deleterious effects of carbon dioxide while that is being transported inland by the blowing western winds[23]. It should be noted herein that this water vapor percipitates by 0.04 p/million annually[23].

The seven-fold relative risk in mortality of Athens compared to Piraeus in 1987 may be explained by the geography (Athens city basin is surrounded by four mountains and includes four hills), by the high urban density, and by the microclimatic characteristics (sea jets, mostly plain ground, etc.). The photochemistry pollution emitted by the industries located in the greater Piraeus area (beyond the Piraeus municipality borders) is transported to Athens city center by the western wind and/or jets, possibly influencing the population, but not the surface ozon concentration, as established by Varotsos *et al.*[24] This latter study -same as that of Kiraly *et al.*[25], this latter study suggested that temperature, wind flows and humidity may be responsible for the local variations of pollution and related episodes. Although the calculated discomfort index was at medical emergency levels (> 32) and more or less equivalent in Piraeus and Athens, the deaths observed were clearly fewer in Piraeus, than those that occurred in the Athens municipality (Table 2).

The differences in death events between the Athenian heatwaves are attributed to preventive measures and daily practice followed by the population. Most, if not all, houses took sun shading and air conditioning provisions immediately following the 1987 heat. Greek authorities imposed restrictions on outdoor working hours (for blue collar workers, construction workers, farmers, etc.) and advised the population to stay at home or under shade during the most dangerous hours of 11am–4pm. In 1987 heatwave, everybody was outdoors, including housewives that used to buy groceries and bread for the dialy meal, between 11–2 pm.

Pollution parameters are directly and indirectly affected by solar activity[26]. The latter contributes to stroke-related mortality (thrombotic events), as demonstrated by previous studies[27], although it has been established that it is not associated with climate change[26]. Thus, we added the relevant data, herein, for future consideration in future heatwave events. Finally, the 1987 heatwave results were of great importance because confounding factors, such as lifestyle, dietary preference variations, high pollution exposure, and genetic heterogeneity were absent at the time[27]. Our study was limited to death events reported by the municipality and not the greater area of Piraeus or Athens. The health impacts of exposure to overheating include hyperthermia, triggering bleeding disorder either through thrombosis in small vessels or disseminated intra-vascular coagulation. The resultant bleeding disorder may lead to multi-organ dysfunction syndrome and/or death (Figure 2).

The 1987 heatwave in Greece had been a real milestone in public health policy and citizens' daily practice. Until this heatwave, construction practices followed certain standards, which neglected measures to protect subjects from prolonged extreme weather events used in the past. More specifically, citizens took no provision for sun shading or air conditioning. After the 1987 heatwave, the Greek authorities and the population took effective measures to better prepare against such events in the future. This was mirrored in the lower mortality rates due to extreme heat events in 1988 and 1992. Some of the excess mortality risk (about 47%) observed in 1992 is probably explained by a significant change in population consistency as a result of a vast immigration flow from the northern borders of the country, that was in progress at the time and had not been registered in the 1991 census.

Finally, these results confirmed the findings of Dimitriadou *et al.*, Ebi *et al.* and Mazaraki *et al.*, indicating that public health warning systems need to be created, taking into account locality, including geography, microclimatic parameters, population consistency and behavior[28–30].

The probability of NO affecting each heatwave was found to be higher in Athens irrespective of the year/event measured. The lack of significant fluctuations of NO in time has been noted by Varotsos[24]. In 1987, Piraeus ozone probability (certainty) to regulate the heatwave effect on strokes was higher. In addition, it has been established that ozone levels show a positive linear correlation with ambient temperature[31], man-made pollution and moisture[32]. Thus, we suggest that, during the 1987 Piraeus heatwave, seawater evaporated incorporating industrial pollution and, thus, increased tropospheric ozone through photochemical reactions.

Conclusions

The 1987 heatwave had a decisive role in understanding Greek reality. From the same heat-stress event, Piraeus, a coastal city, experienced much less mortality than the neighboring continental Athens. The heatwaves were affected by NO in Athens every year and ozone in Piraeus in 1987, as observed using probabilities extracted via neural network evaluations, proving that, local geography and climate characteristics moderate human mortality. The heatwave events that followed had milder effects because of the newly established public health prevention policy and citizen compliance and adaptation to the new measures.

Data availability

Source data

Piraeus Mortality data may be found in Geronikoulou *et al.*[27]. The rest of the mortality data is derived from the included publications. All pollution measurements (ozone and nitric oxide) were calculated from the measurements included in the Hellenic Ministry of Environment and Energy reports, whereas humidity and temperature measurements were derived from literature as well as the Hellenic National Meteorological Service archives (printed)

Figure 1 Our created network

Figure 2 Our created summary of heat-related physiology mechanisms for non-health educated readers convenience

Figure 3 Map of the jet streams flowing above Athens and Piraeus during the heatwave 25-29/7/1987. Source: Hellenic National Meteorological Service archive

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Open Peer Review

Current Peer Review Status: ✓ ✓

Version 2

Reviewer Report 01 March 2024

https://doi.org/10.5256/f1000research.157393.r251741

✓

Themis P. Exarchos
Bioinformatics and Human Electrophysiology Laboratory, Department of Informatics, Ionon University, Corfu, Greece

Authors have addressed all my concerns.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Data mining, decision support systems

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 08 September 2023

https://doi.org/10.5256/f1000research.137258.r161963

?

Themis P. Exarchos
Bioinformatics and Human Electrophysiology Laboratory, Department of Informatics, Ionon University, Corfu, Greece

This article presents an analysis and comparison of the heatwaves of Piraeus and Athens in 1987. Mortality data were collected from registries and literature, whereas ambient characteristics were

collected by previous research and open national reports.
The odds ratio of death events of the two cities were calculated and compared.
The major outcome found was that the heatwave was seven-fold more lethal in Athens than in Piraeus, dependent on nitric oxide (NO) concentration.

The article is well written and results are presented in an easy to understand way for the readers.

Comments to the authors:
Please extend the introduction section with additional references and state of the arts in similar works (other heatwaves, other parameters taken into account, comparison models etc).

In addition, please add some more details on the identification of the following probabilities:
Piraeus 1987 - ozone probability 0.993
Athens 1987 - NO probability 0.999
Athens 1988 - NO probability 0.999
Athens 1992 - NO probability 0.999

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Data mining, decision support systems

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 25 Oct 2023
Stella Geronikolou

This article presents an analysis and comparison of the heatwaves of Piraeus and Athens in 1987. Mortality data were collected from registries and literature, whereas ambient characteristics were collected by previous research and open national reports.
The odds ratio of death events of the two cities were calculated and compared.
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Comments to the authors:
Please extend the introduction section with additional references and state of the arts in similar works (other heatwaves, other parameters taken into account, comparison models etc).
We have added 3 more references (11-13) targeting to the same nearer-geographical area, as well as one (10) that establishes the need for studies like ours.

In addition, please add some more details on the identification of the following probabilities:
Piraeus 1987 - ozone probability 0.993
Athens 1987 - NO probability 0.999
Athens 1988 - NO probability 0.999
Athens 1992 - NO probability 0.999
We added the following text:
The values were divided by the sum of exponential values and then converted into probabilities. According to previous analyses, the opted softmax function translated the resultant numbers into a probability distribution. Thus, the output of the function can be interpreted by a percentage number representing the probability of an event to occur.

Competing Interests: No competing interests were disclosed.

Reviewer Report 28 July 2023

https://doi.org/10.5256/f1000research.137258.r185613

Alexandros G. Georgakilas
DNA Damage Laboratory, Physics Department, School of Applied Mathematical and Physical Sciences, National Technical University of Athens (NTUA), Athens, Greece

In this study, the authors have studied the important role of heatwaves due to climate change. Heatwave associated mortality is one of the established markers of their human effects.

Populations adapt to temperature variations/challenges differently for unknown reasons. Thus, heatwave evaluations should be enriched by historical context and local data, to allow better precision and prediction. The authors, present mortality data for 1987 collected from the Piraeus municipality registry, whereas data for Athens were obtained from literature retrieved from PUBMED. Ambient characteristics were derived from a thesis and the reports of national organizations. From the death events, the odds ratio and relative risk in Athens compared to the Piraeus 1987 event were calculated. Finally, a simple neural network proposed the dominant ambient parameter of the heatwave phenomenon in each place.

The study is well-thought and organized but the authors need to consider the following :

Comments:

1. Language in general must be more carefully looked at and read for more proper English.

2. Please rephrase the sentence "The same study and Kiraly".

3. If there is a detailed chart/map (from National Metereological Agency in Greece: EMY) of the winds blowing in the area during the heat wave of 1987 which is maybe not available on the internet, this reviewer thinks it's worth to provide these data since it will support the claims of the work.

4. Please explain why the sunspots were included and if there is any correlating data or literature that mention in 1987 in Athens and Piraeus areas morbidity rates for elderly people due to possible exposure to the high temperatures during not recommended hours like between 12-5.

5. The PubMed database - does it contain any relative biological data for such conditions?

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Yes

Are the conclusions drawn adequately supported by the results?
Yes

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Applied Physics and Biological effects of radiations from UV to ionizing.

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Author Response 25 Oct 2023

Stella Geronikolou

In this study, the authors have studied the important role of heatwaves due to climate change. Heatwave associated mortality is one of the established markers of their human effects. Populations adapt to temperature variations/challenges differently for unknown reasons. Thus, heatwave evaluations should be enriched by historical context and local data, to allow better precision and prediction. The authors, present mortality data for 1987 collected from the Piraeus municipality registry, whereas data for Athens were obtained from literature retrieved from PUBMED. Ambient characteristics were derived from a thesis and the reports of national organizations. From the death events, the odds ratio and relative risk in Athens compared to the Piraeus 1987 event were calculated. Finally, a simple neural network proposed the dominant ambient parameter of the heatwave phenomenon in each place.

The study is well-thought and organized but the authors need to consider the following:

Comments:

1. Language in general must be more carefully looked at and read for more proper English.
   We have appropriately edited the MS.

1. Please rephrase the sentence "The same study and Kiraly".
   We rephrased as follows: "This study same as that of Kitaly et al ..."
2. If there is a detailed chart/map (from National Metereological Agency in Greece: EMY) of the winds blowing in the area during the heat wave of 1987 which is maybe not available on the internet, this reviewer thinks it's worth to provide these data since it will support the claims of the work.

Actually, there is such a map in the National Metereological Agency in Greece (EMY) in printed but not digital archives. We have added it as Figure 3.tiff

1. Please explain why the sunspots were included and if there is any correlating data or literature that mention in 1987 in Athens and Piraeus areas morbidity rates for elderly people due to possible exposure to the high temperatures during not recommended hours like between 12-5.T*he underlying mechanism linking solar cycle length and earth surface temperature is poorly understood. Total solar irradiance as a valid marker of solar energy increases in solar activity maxima (sunspots increase) and decreases in solar minima accordingly. Lane et al suggested that the sensitivity of the climate to the solar irradiance is 27% higher than its sensitivity to greenhouse warming effec*ts.

http://www-das.uwyo.edu/~geerts/cwx/notes/chap02/sunspots.html

*Lane, L.J., M.H. Nichols, and H.B. Osborn 1994: Time series analyses of global change data. Environ. Pollut., **83**, 63-68.*

Aquila, V., Swartz, W. H., Waugh, D. W., Colarco, P. R., Pawson, S., Polvani, L. M., & Stolarski, R. S. (2016). Isolating the roles of different forcing agents in global stratospheric temperature changes using model integrations with incrementally added single forcings. Journal of Geophysical Research: Atmospheres, 121(13), 8067–8082. https://doi.org/10.1002/2015JD023841
Kopp, G., Krivova, N., Wu, C.J. et al. The Impact of the Revised Sunspot Record on Solar Irradiance Reconstructions. Sol Phys ***291****, 2951–2965 (2016). https://doi.org/10.1007/s11207-016-0853-x*
Geronikolou S, Leontitsis A, Petropoulos V, Davos C, Cokkinos D, Chrousos G. Cyclic stroke mortality variations follow sunspot patterns. F1000Res. 2020 Sep 3;9:1088. doi: 10.12688/f1000research.24794.2. PMID: 33224479; PMCID: PMC7667520.

1. 1. The highest temperature is observed between the hours 12.00-17.00. *No death event was observed in ages 0-50 y in Piraeus. Most deaths occurred in the age groups over 65 in Piraeus during this heatwave. Greek women usually buy bread before lunchtime (from 12.00-15.00), thus the idea of the Reviewer seems real.*

The PubMed database - does it contain any relative biological data for such conditions?
Many heatwaves have been reported in the PubMed database. No other publication refers to Southeastern Mediterranean cities before 1992.
We added a new citation, that of *Geronikolou S, Leontitsis A, Petropoulos V, Davos C, Cokkinos D, Chrousos G. Cyclic stroke mortality variations follow sunspot patterns. F1000Res. 2020 Sep 3;9:1088. doi: 10.12688/f1000research.24794.2. PMID: 33224479; PMCID: PMC7667520.*
where we explain how electromagnetic perturbations affect human physiology: by a preserved physiology mechanism in ages and species (R1).

Competing Interests: We have no competing interests to disclose