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# UTCI as a prediction tool for heatwave-induced health hazards in Europe

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## Introduction

**1** Heatwaves are a dangerous meteorological hazard to human health. Heat-related disorders such as heat exhaustion and sunstroke are responsible for excess morbidity and mortality in affected areas.

**2** With the likely increase in number, intensity and duration of heat waves over most land areas in the 21st century, it becomes mandatory to develop a system that is able to deliver timely, accurate and useful early notices of health hazards to health-related decision-makers, professionals and institutions.

**3** A heatwave-associated Heat Health Warning System (HHWS) is being developed as part of the pan-European multi-hazard early warning system constructed within the ANYWHERE project
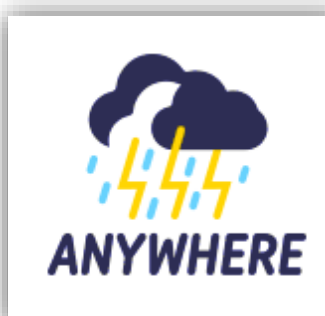
## Thermal comfort assessment

The ANYWHERE HHWS is based on the operational computation of the UTCI-Fiala model to predict the Universal Thermal Climate Index (UTCI), an equivalent temperature representing the thermal stress induced by the atmospheric environment on the human body

### UTCI-Fiala model

- A dynamic multi-node model of body thermoregulation coupled with a clothing model[1,2]
- Predicts human body's temperatures and its regulatory responses in different outdoor climate conditions

### Universal Thermal Climate Index (UTCI)

- Summarises human body's temperature and regulatory responses via principal component analysis
- Equal to the air temperature ($Ta$) of a reference environment plus an offset depending on the values of air and mean radiant temperature ($Tmrt$), wind speed ($va$) and humidity (water vapour pressure $vp$ or relative humidity $RH$) from the real environment[3]

$$UTCI = f(Ta; Tmrt; va; vp) = Ta + \text{offset}(Ta; Tmrt; va; vp)$$

Reference environment    An *ideal* condition of: calm air (wind speed equal to 0.5 m/s at 10 m above the ground), no additional thermal irradiation (mean radiant temperature equal to air temperature), 50% relative humidity, and vapour pressure constant to 20 hPa for air temperatures above 29°C, a person walking at 4km/hr (metabolic heat production equal to 2.3 MET ≈ 135W/m²)

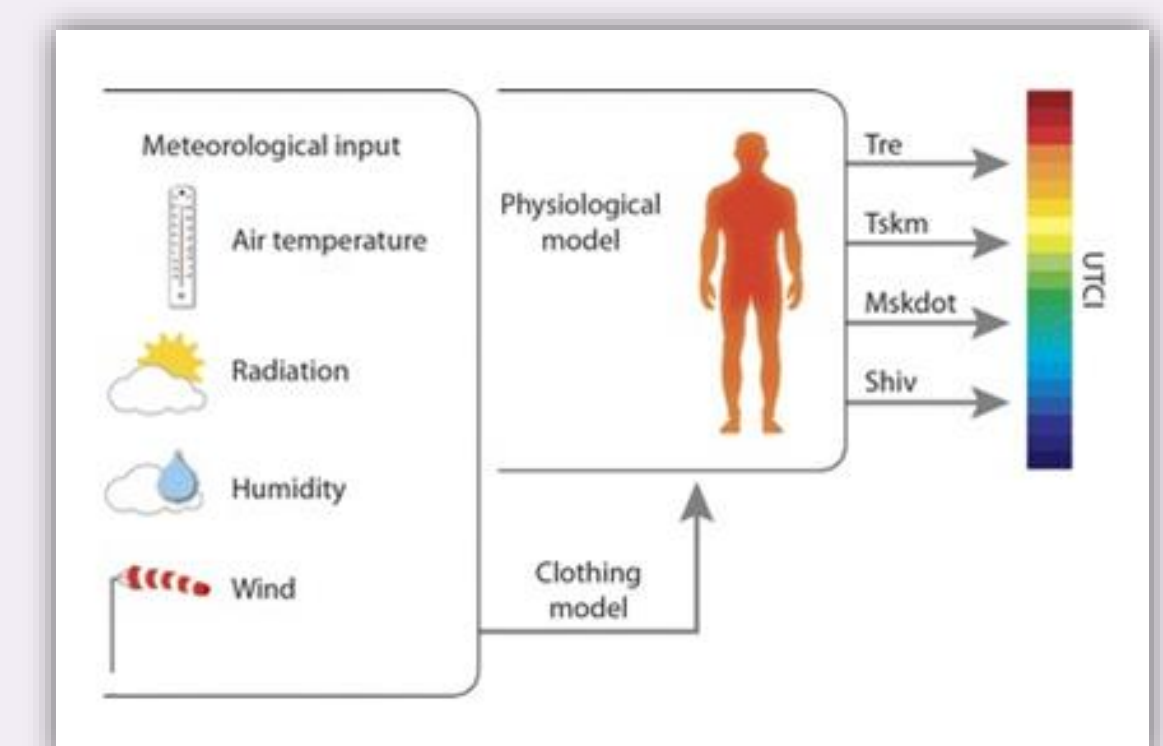Real environment    The *actual* environmental factors inducing thermal stress » input to the UTCI-Fiala model



**Figure 1** | Concept of the UTCI-Fiala model. Outputs are rectal temperature *Tre*, mean skin temperature *Tskm*, sweat production *Mskdot*, and heat *Shiv* generated by shivering.[4]

**Figure 2** | UTCI assessment scale of thermal stress categories.[3]

| UTCI range [°C] | Stress Category |
|---|---|
| above +46 | extreme heat stress |
| +38 to +46 | very strong stress |
| +32 to +38 | strong heat stress |
| +26 to +32 | moderate heat stress |
| +9 to +26 | no thermal stress |
| +9 to 0 | slight cold stress |
| 0 to -13 | moderate cold stress |
| -13 to -27 | strong cold stress |
| -27 to -40 | very strong cold stress |
| below -40 | extreme cold stress |

## UTCI and European heatwaves

UTCI as computed from the ECMWF ERA-Interim database is used to explore UTCI's potential as a tool in the ANYWHERE HHWS to evaluate the thermal stress induced by heatwave conditions on human health

### 1 Climatology

UTCI was calculated for the summer season (1st June to 31st August) using the ECMWF global atmospheric reanalysis system (ERA-Interim dataset, 1979-2016 period) as input to the UTCI-Fiala model.

➤ In the summer months Europe is affected by different levels of heat-associated stress
- Heat stress has a time dependency: UTCI achieves higher values in central day times
- Heat stress has a space dependency: UTCI achieves higher values in Southern Europe

➤ Recent summer seasons have been characterized by higher UTCI values than past ones
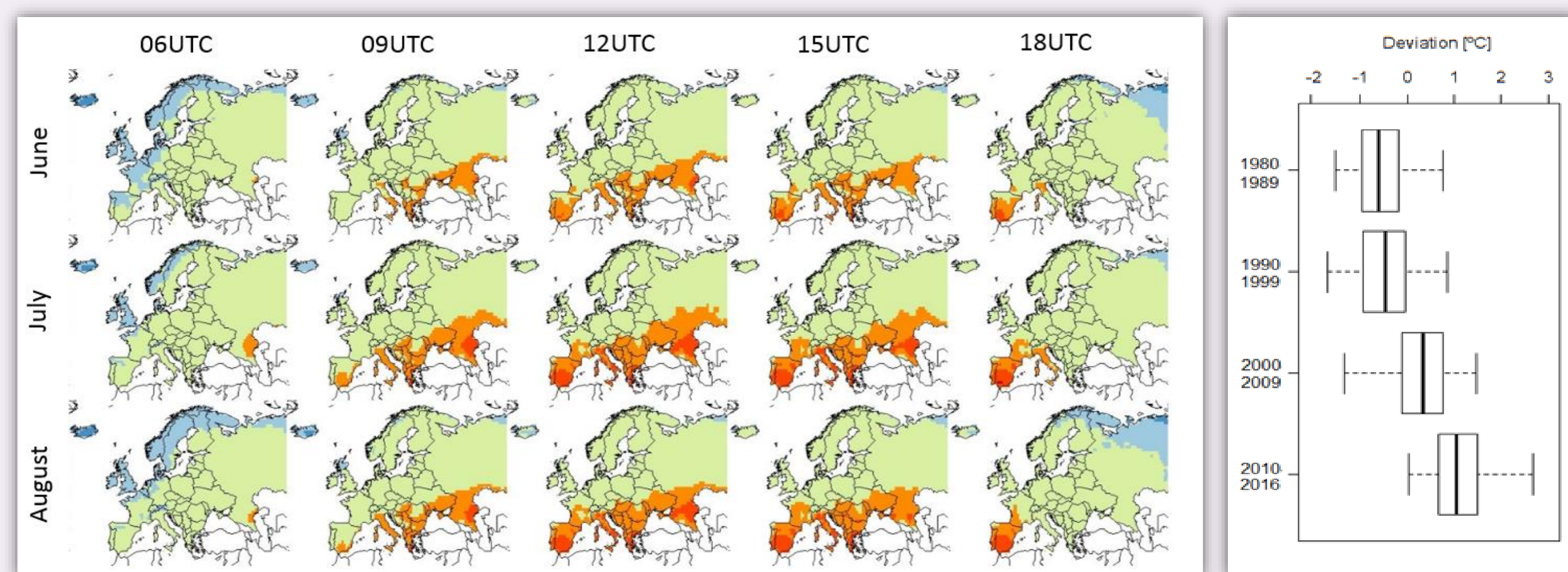


### 2 The 2003 heatwave

From June through July until mid-August an area of high pressure, firmly anchored over most of Western Europe, conveyed very hot dry air mass up from south of the Mediterranean thus rising temperatures to 20-30% higher values than the seasonal average. Extreme maximum temperatures repeatedly recorded in most of the southern and central countries.

➤ In August western and central areas of Europe were characterized by
- UTCI values up to 10°C higher than seasonal average
- Heat stress up to 2 levels higher than seasonal average

➤ The number of days with higher heat stress increased in all European capitals
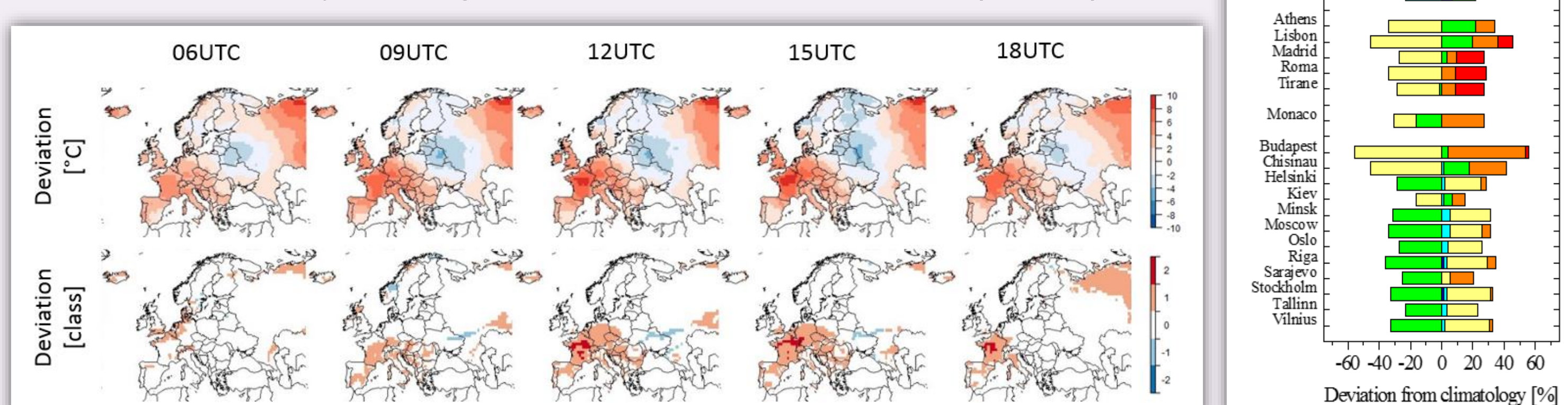


### 3 UTCI-mortality relationship

August mortality data (EUROSTAT and National Statistical Offices databases, 1979-2015 period) were retrieved, and their correlation with UTCI average values at 12 UTC for the same month analysed.

➤ The correlation between UTCI and mortality (Pearson correlation coefficient) is:
- positive for most of Europe, i.e. as UTCI increases the number of deaths increases with it
- negative for some countries, i.e. as UTCI increases the number of deaths decreases with it

**The 2003 heatwave case study**

With a death toll estimated to exceed 30,000 the heatwave of 2003 is the deadliest natural disaster in Europe in the last 50 years.

➤ Higher-than-average UTCI values are mostly associated to higher-than-average mortality, made exception for Ireland

Elderly people were the most affected. Italy counted more than 4,000 casualties during the month of August only. Genoa, one of ANYWHERE test-bed cities experienced the second highest temperature ever recorded (+36°C on August 7th) and high mortality among the elderlies (+22.2% with respect to 2002).[5]

➤ UTCI values were mostly associated to moderate-to-very strong heat stress

➤ UTCI's correlation with mortality is time-dependent
- Day time: strongest correlation at 12UTC
- Lag time (time between exposure to heat stress and death): highest correlation at 4 days

➤ 2m temperature's correlation with mortality better at specific times
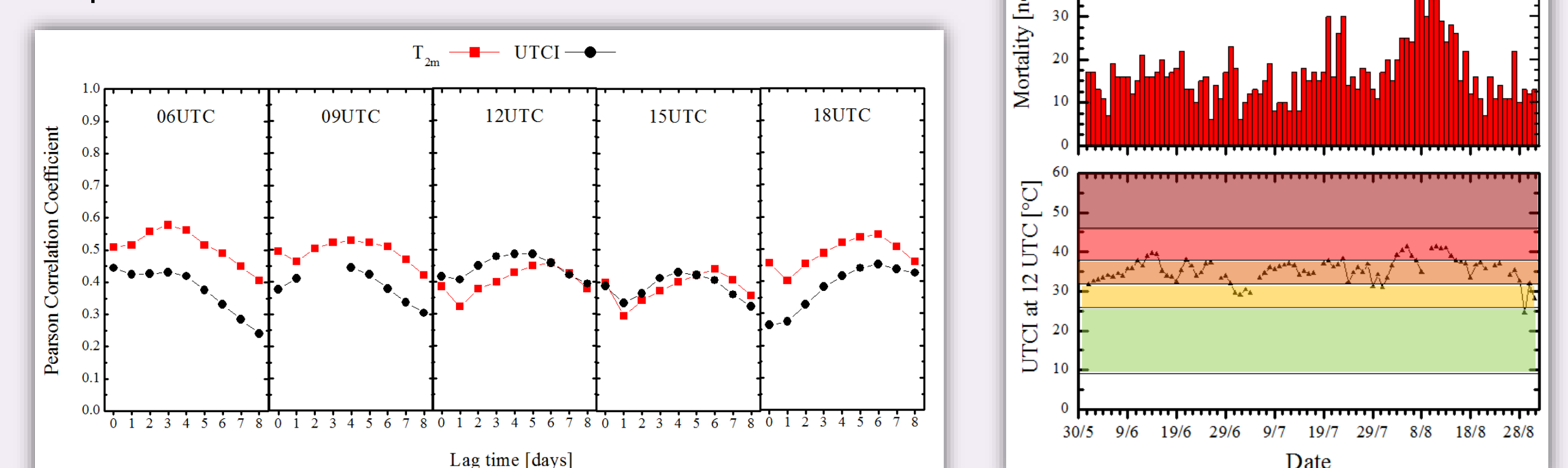


## Conclusions

The potential of UTCI as a tool for forecasting hazardous-to-health heat stress has been investigated for Europe

✓ UTCI values are highest at central day times and in Southern Europe
✓ UTCI values in the 2003 heatwave saw heat stress increasing by up to 2 levels with respect to seasonal average
✓ UTCI values correlate with mortality differently according to time and geographical area

**References**
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**[5]** Conti *et al.*, Env. Research 98:390, 2005