

# Causes for the recent changes in cold- and heat-related mortality in England and Wales

Nikolaos Christidis · Gavin C. Donaldson ·  
Peter A. Stott

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**Abstract** Cold related mortality among people aged over 50 in England and Wales has decreased at a rate of 85 deaths per million population per year over the period 1976–2005. This trend is two orders of magnitude higher than the increase in heat-related mortality observed after 1976. Long term changes in temperature-related mortality may be linked to human activity, natural climatic forcings, or to adaptation of the population to a wider range of temperatures. Here we employ optimal detection, a formal statistical methodology, to carry out an end to end attribution analysis. We find that adaptation is a major influence on changing mortality rates. We also find that adaptation has prevented a significant increase in heat-related mortality and considerably enhanced a significant decrease in cold-related mortality. Our analysis suggests that in the absence of adaptation, the human influence on climate would have been the main contributor to increases in heat-related mortality and decreases in cold-related mortality.

## 1 Introduction

Human health is affected in an array of ways by climatic variability and change. Changes in mortality from cardiovascular and respiratory illnesses in hot or cold weather are among the direct physiological impacts (Basu and Samet 2002; Diaz et al.

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N. Christidis (✉) · P. A. Stott  
Met Office Hadley Centre, FitzRoy Road, Exeter, EX1 3PB, UK  
e-mail: nikos.christidis@metoffice.gov.uk

P. A. Stott  
e-mail: peter.stott@metoffice.gov.uk

G. C. Donaldson  
Academic Unit of Respiratory Medicine, University College London,  
Royal Free and University College Medical School,  
Rowland Hill Street, London, NW3 2PF, UK  
e-mail: g.donaldson@medsch.ucl.ac.uk

2002; Donaldson and Keatinge 1997; Hajat et al. 2004; Huynen et al. 2001; Keatinge et al. 2000a). The transmission of infectious diseases is also known to accelerate with warming and to be sensitive to rainfall changes (Curriero et al. 2001; Rose et al. 2001; Singh et al. 2001). This relationship is manifest during El Niño events (Hales et al. 1996; Malezer et al. 1999). In addition to natural variability, climate change due to human activity poses a major concern (McMichael et al. 2006; Patz et al. 2005). The Department of Health in the UK recently published a report on the health effects of climate change in the country (Kovats 2008). Apart from rising temperatures, various other aspects of climate change affect human health. Changes in droughts, floods, storms and land use affect regional food yields which could be a precursor of malnutrition or hunger (Hari Kumar et al. 2005; McMichael 2001). Together with sea level rise these factors are also linked to exposure to storm surges (Guha-Sapir et al. 2004), degradation of water availability and quality (Schwartz and Levin 1999), population displacement (Nicholls and Tol 2006) and poor sanitation (Sur et al. 2000). Air quality, as a final example, is degraded by emissions of air pollutants like ozone associated with a range of respiratory diseases (Ito et al. 2005). A comprehensive overview of the impacts of climate change on health is given in Confalonieri et al. (2007) in the fourth assessment report (AR4) of the Intergovernmental Panel on Climate Change (IPCC). The interplay between health and climate change, including both its direct effects (i.e. rising temperatures), as well as the resulting socio-economic, political and demographic disruptions, is multifaceted and complex. In order to be better understood, a multidisciplinary approach is required that facilitates collaboration between experts in a range of fields. This paper provides such an example that reports results from a joint medicine and climate science project.

There is a wealth of evidence for changes in cold- and heat-related mortality during the past few decades for cities or small sub-continental regions mainly in Europe, Australia and the United States (Davis et al. 2004; Donaldson et al. 2003; Guest et al. 1999; Keatinge et al. 2000b; Medina-Ramón and Schwartz 2007). In response to anthropogenic climate change, one would expect that warmer summers lead to increases in mortality, while milder winters to decreases. The overall effect, however, is also influenced by better adaptation of the population to extreme temperatures. In the UK, for example, heat-related mortality showed no such trend during 1971–2003, which could be indicative of adaptation, while cold-related mortality decreased by more than 33% (Kovats 2008). Although the overall effect appears to be beneficial, the numerous other impacts of climate change on human health, like those already mentioned earlier, are almost invariably detrimental. Moreover, even if the synergy between adaptation and milder winters decreases the total mortality related to cold and heat, extreme events like heatwaves may still exert a stress beyond the adaptation limits on the population. Such events are accompanied by sharp increases in daily mortality which cause public concern and attract ample media attention. A well studied example is the 2003 European heatwave which cost the lives of more than 30,000 people (Conti et al. 2005) with almost half the deaths in France (Vandentorren and Empereur-Bissonnet 2005). Even in the less affected area of England and Wales, there was a 16% increase in mortality during August 2003 (Health Statistics 2006). Stott et al. (2004) estimated that climate change has at least doubled the risk of an event like the 2003 European heatwave. Climate model projections show that in the coming decades heatwaves will increase both in