internal climate variability because of its chaotic behaviour. Averaging many such unconstrained simulations, initialized with slightly different conditions, filters out internal variability and isolates the externally forced response. All climate models project warming in the equatorial Pacific as a forced response, many with equatorial maxima, and a consensus is emerging that forced global warming weakens trade winds. These findings suggest that the recent negative PDO trend is of internal, natural origin rather than the result of a forced response. Yet, an ensemble of model simulations should encompass all possible realizations of internal variability in its spread. However, the observed magnitude of trade-wind strengthening between 1992 and 2011 is far outside the ensemble spread of the 48 simulations examined[2]. Consequently, the observed global-mean surface temperature trends for the past two decades is lower than all but a few of 117 simulations, which means a very low chance of the current hiatus[4]. It is inferred that the models underestimate PDO magnitude, or overestimate the trade-wind weakening and equatorial Pacific warming as the forced response. The latter affects estimates of climate sensitivity — the magnitude of global surface warming against a given CO_2 increase.

Even if the transition to the negative PDO is natural, the question of causation is not addressed by England *et al.*, but is worth examining for decadal climate predictions. Some recently suggested possibilities include the remote influence from Indian Ocean warming[5], a phase transition in the Atlantic Multidecadal Oscillation[6] and stochastic year-to-year variability of El Niño/La Niña[1].

The idea of the PDO influence on hiatus periods is not new. Studies have shown that hiatus events are also found in unconstrained model integrations — but not at the observed timings — and are statistically associated with the negative PDO (and other natural variability modes) and enhanced ocean heat uptake[7,8]. The contribution of England *et al.* is to attribute the current hiatus event to the PDO. But models have limitations. How can we observationally confirm that the Earth is still gaining extra heat and that the heat is stored in the ocean? Satellite measurements do not provide the global net radiative imbalance with high accuracy because there is a small difference between the large incoming and outgoing radiation. Instead, we can use observations of ocean heat content because the ocean absorbs more than 90% of the extra heat. Studies show that the heat content has kept increasing during the current hiatus[9,10]. However, the result of England *et al.* favours a higher-order discrimination: the increase of heat content must be accelerated during the hiatus[10], whereas a slowdown in radiative forcing would lead to deceleration. Such a perturbation in heat-content increase should manifest itself in the rate of sea-level rise due to thermal expansion. The quantification of ocean heat uptake by England *et al.* provides a basis for such attempts to attribute decadal climate change. ❐

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HUMAN IMPACTS

Winter weather and health

There has been much debate about whether winter warming due to climate change will substantially decrease mortality in that season. Research now finds that cold severity no longer predicts the number of excess winter deaths in England and Wales.

Cunrui Huang and Adrian Barnett

For centuries, the seasons and weather have been considered fundamental determinants of human health. In temperate climates, there is a distinctive seasonal pattern of mortality — with a significant number of additional deaths in winter — known as excess winter deaths (EWDs). Assessments of the health impacts of climate change have often concluded that a reduction in the severity and length of cold weather because of global warming would substantially reduce EWDs[1,2]. However, the accuracy of these predictions depends on how much of this winter mortality is directly dependent on cold outdoor temperatures, as opposed to other factors. Writing in *Nature Climate Change*, Staddon and colleagues[3] suggest that the association of annual variation in EWDs with the number of cold days that was observed until the mid-1970s has now disappeared, leaving only the incidence of influenza-like illnesses to explain any of the yearly variation in EWDs during the past decade. By looking at data for England and Wales, they conclude it is unlikely that EWDs will decrease in the region if winters warm with climate change.

It has long been recognized that in England and Wales mortality is much higher in the winter than the rest of the year[4]. This seasonal pattern is consistent across much of the world, and most countries suffer 10% to 30% EWDs[5]. A complex range of specific causes explains seasonal mortality, including the high incidence of cardio-respiratory and infectious diseases in the winter and the direct impact of cold weather. Understanding the causes of EWDs will help with disease prevention and save lives.

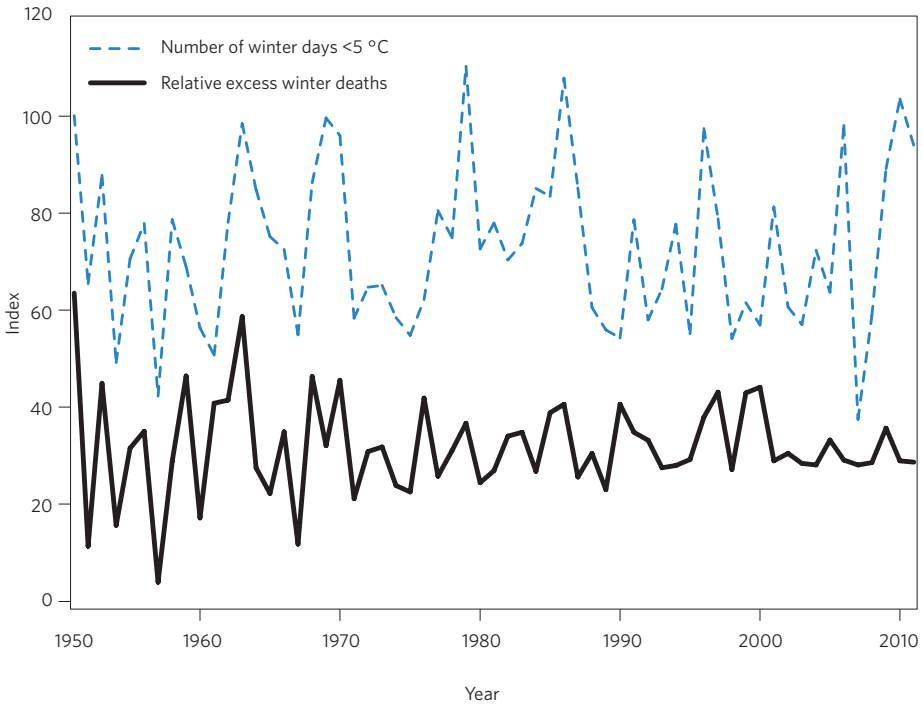

Figure 1 | Detrended data showing the year-to-year variation in excess winter deaths compared with the number of winter days below 5 °C. Data were detrended by removing the time component. Excess winter deaths are expressed relative to the size of the population over 65 years old. An index is used to allow for the easy comparison of peaks. Figure reproduced from ref. 3.

Although much of the evidence points to the fact that cold weather is somehow responsible for EWDs, it is surprising that the level of EWDs is higher in warmer localities[5]. In recent years the strength of observed associations between cold temperature and winter mortality also seems to have weakened in some places[6]. This calls into question the assumption that outdoor temperature is the reason for the strong seasonal dependence of mortality. In fact, the complex and changing patterns of seasonal variations in mortality are likely to be related to a combination of socioeconomic, cultural and physiological adaptations to cold temperatures. Modern heating technology, along with better winter clothing, improved health care and increased prosperity and social welfare, may have reduced the harmful effects of cold weather[7].

The short-term effects of temperature on mortality have been widely studied in various climates, with most previous studies finding that cold temperatures increase it[8]. These studies usually use a time-series design to compare daily mortality counts with daily ambient temperatures. Time-series analysis has the advantage of accounting for multiple confounding factors because the same population is examined repeatedly under varying exposure conditions, such as daily temperatures, but constant (or slowly varying) covariate patterns, such as diet or smoking[9]. However, it is still difficult to completely separate the effects of cold temperatures, which are often measured with long lag times, from seasonality.

Staddon and colleagues examine yearly data on EWDs in England and Wales through an interesting approach. The team used data over the past 60 years to identify factors associated with the decreasing trend in EWDs and its annual variation. With a detailed analysis, they show that cold outdoor temperatures now contribute little to EWDs (Fig. 1) so that milder winters resulting from climate change are unlikely to offer a public health benefit.

By analysing deaths for the whole of England and Wales, Staddon and colleagues report on the key drivers that underlie the annual variations in EWDs. However, using yearly data means their sample size is quite small. Moreover, as a crude measure of the extent of winter severity, they record the number of days below 5 °C. This threshold model assumes that a daily temperature of –10 °C is the same as one of 4 °C. It also ignores the fact that less severe cold days have lower relative risks, but are also far more common and so have a larger overall impact on the number of EWDs. Therefore, more convincing evidence would come from a study that used continuous temperature data. In addition, Staddon and colleagues have expressed EWDs relative to the size of the population over the age of 65 , but the study did not account for an increasingly ageing population, and the concern is whether this could influence the declining trend of EWDs. For all these reasons, more evidence is needed before any changes to public health policy are made. In particular, at this stage, we would not advise to scale down the current cold-weather plans enacted in the UK at local and national levels.

The effects of weather on health have attracted renewed interest because of the observed and projected climate change. Under the assumption that most EWDs are attributable to cold temperatures, many previous studies have concluded that a warming climate will considerably decrease winter mortality. However, to answer the question of how climate change will influence EWDs requires an understanding of complex and intertwined relationships[2,10]. The paper by Staddon and colleagues sheds some light on the issue, suggesting that cold outdoor temperatures are unlikely to continue to have the same significant effect on excess deaths in winter as they have had in the past. ❐

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