Debate heating up over changes in climate variability

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Debate heating up over changes in climate variability

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Abstract
Heatwaves have profound socio-economic impacts. Increases in temperature variability would exacerbate these impacts but debate rages in the literature about whether the climate has or will become more variable. There is currently no firm evidence that temperature variability has or will increase because questions have been raised about the methods used to reach this conclusion. However, irrespective of changing temperature variability, the impact from increases in the frequency and intensity of heatwaves will be a major problem for the future.

Heatwaves kill people and cause enormous economic and environmental damage [1, 2]. In 2012, the Intergovernmental Panel on Climate Change (IPCC) Special Report on Managing the Risks of Extreme Events and Disasters to Advance Climate Change Adaptation (SREX) concluded that there was medium confidence that the length and/or number of heatwaves had increased since the middle of the 20th century and that it was very likely that the length, frequency, and/or intensity of these events would increase over most land areas by the end of the 21st century [3]. These conclusions were reiterated and strengthened by the IPCC Fifth Assessment Report (AR5) [4], released last month. However the IPCC has so far been unable to draw firm conclusions about whether temperature variability is increasing. Indeed SREX even contained the question ‘is the climate becoming more extreme?’. To paraphrase the answer, ‘we don’t know’. If it is, then the impacts from changes in extreme heat could be far greater than if only mean temperatures were increasing.

In recent years several studies have tried to address this question directly. Some have analysed daily observational data [5, 6] but these data are not available across the whole globe. Methodological differences between these studies mean that the results are hard to compare. Most studies, including Coumou and Robinson [7], who investigated both past and future temperature variability, have used monthly or seasonal temperature data as a proxy for severe heatwaves [8–10]. This allows a more global assessment. However, although a relationship exists between extreme monthly mean temperatures and the presence of heatwaves [8, 9], monthly temperatures do not reflect the intensity and duration of heatwaves—the aspects that are likely to have the most severe impact on people and the environment. In contrast to the studies based on daily observations, the studies using monthly or seasonal data [8–11] can be compared but disagree on temperature variability.

There are two camps: one that says that temperature variability is increasing globally [9] and one that says that it isn’t [10, 11] (or at least that the jury is still out [6]). The validity of the method used by the first camp [9] and also incorporated into the Coumou and Robinson study, has been questioned by studies in the second camp [10–12]. The main issue relates to the normalization of temperature anomalies, creating the impression that overall variability has increased [10]. Other problems relate to the existence of trends in time series and the changing number of observing stations over time [11]. Once issues such as
these have been accounted for, there appears to be little overall change in global temperature variability. In addition, Huntingford et al [10] indicate that many climate models predict decreases in variability in the future, while [7] essentially points to no change. However there does seem to be some consistency between the studies in both camps that variability has increased in some regions e.g. western Europe.

There are a number of other issues that have led to the disparity of conclusions amongst studies of extreme events. Given that extremes are rare by definition, the statistical characterization of historical and future heatwave changes is challenging due to small sample sizes and the fact that extremes are not normally distributed [13]. While some studies have chosen to address this by employing specialized statistics, including extreme value theory [12], others have inferred the behaviour of extremes by applying more standard statistical methods to extreme indices [14] or monthly means [7–9]. The applicability of methods using monthly means may be limited by the physical climate itself, such as in tropical regions where, due to a small annual temperature range, a change in the mean temperature greatly exacerbates changes in the frequency of extreme events [15]. Thus local normalization may be required to combine distributions from different regions [10].

Remaining issues regarding the assessment of extreme heat include, but are not limited to, the fact that the definitions of heatwaves vary, and are designed with different impact groups in mind. This subjectivity of definition has made it impossible to implement a universal metric for comparative assessment across regions and sectors. In addition, temperature alone may not be a sufficient indicator of human comfort, for example, which is greatly compromised by the coupled increase of temperature and humidity [16].

Despite these obstacles, robust conclusions can still be made about changes in heatwaves over the observational record. Most regions, with a few exceptions (e.g. the USA and southern South America), show an increase in frequency, duration and/or intensity of heatwaves [14]. This is consistent with our understanding of how heatwaves should be affected under anthropogenic climate change. Indeed, studies of recent extreme heat events such as those in Europe in 2003 [17], Russia in 2010 [18] and Australia in 2013 [19] indicate anthropogenic influences increased the risk of those events occurring. In addition, in spite of the difficulties that climate models have in simulating some important heatwave processes, many recent studies are now indicating that models where soil–moisture and land–atmosphere feedbacks have been properly accounted for give a more realistic representation of the intensity of individual heatwave events [3]. This, combined with the enormous amount of evidence supporting a human influence on the warming of the climate [4], would suggest that we have seen, and should continue to see, increases in many heatwave characteristics.

Irrespective of methodological concerns, the Coumou and Robinson study provides insight into the heat extremes of the future. There is little challenge to their conclusions that regional increases in the frequency of heatwaves have and will occur or that these are likely to scale with our future global emissions of greenhouse gases [20]. That is, the more we emit, the more severe heatwaves will be. While we may want to sort out the ‘variability issue’ for scientific reasons, it does not alter the fact that the future will be bleak with regard to heat extremes, especially in the most vulnerable communities, unless substantial mitigation policies and adaptation strategies are put in place.

References


