Climanosco Research Articles

Collection 1, Launch challenge

Are humans to blame for the heat experienced in Geneva in the summer of 2015?

By Oliver Angelil, 24 August 2016

RESEARCH ARTICLE

Since the dawn of the Industrial Revolution, humans have been changing the chemical composition of the atmosphere by burning fuels such as coal, oil, and natural gas. These gases are known to scientists as “greenhouse-gases”. Greenhouse-gases are vital to sustain life on Earth, but rapidly increasing concentrations of them can have catastrophic consequences. The word ‘catastrophic’ is perfectly fitting here, because, as will be demonstrated in this article, it is now believed our greenhouse-gas emissions play a large role in the occurrence of extreme weather events that cause billions of dollars worth of damage to infrastructure, and bring about tens of thousands of human deaths every year. We additionally explain how extremes occurring over spatial scales smaller than what climate models can resolve, such as a heatwave over the city of Geneva in Switzerland, can be attributed to human activity – the first study of its kind to use such an approach.

An Analogy

A heatwave was responsible for killing 70,000 people in Europe in 2003, and there is strong evidence suggesting human activity was responsible for significantly increasing the chance of

that heatwave [C. Schaer et al., 2004]. Before we jump ahead, let's take a step back and use an analogy to help our readers understand why scientists in this field often use probabilistic language, i.e., "the burning of fossil fuels increased the odds/chance/frequency/probability of this extreme event", and not "this extreme event was (or was not) caused by the burning of fossil fuels". Picture a scenario in which you are commuting on the highway. Driving faster can increase the odds of an accident, but is does not imply that when an accident does occur, a high rate of speed was the cause. This is because a number of other factors could have caused the accident: for example a wet road or a driver in a nearby vehicle who had too much alcohol at dinner. A statement like "the chance of an accident was increased by X percent because of the increased speed" may be technical, but is a rigorous way to answer the question. A controlled experiment would need to be performed to be able to attribute a certain increase in speed to the chance of an accident – for example suppose we create two hypothetical scenarios/cities in which all factors (except speed) that could potentially cause an accident are kept constant: same alcohol consumption, same number of slippery roads, same number of people texting while they drive, etc. If the only difference is the average speed of vehicles (say 60 km/h vs 100 km/h), and we count the number of accidents that occur in each scenario: say 10 vs. 20 respectively, we can conclude that increasing your speed from 60 km/h to 100 km/h increases your chance of having an accident by 100%.

Transforming the Analogy to the Climate System

The 'speed' in our analogy represents the concentration of greenhouse-gases in the atmosphere; the 'intoxicated/texting drivers' and 'wet roads' represent natural variability in the climate system – those aspects within the system which can still cause the damaging/harmful event we are studying; and lastly an accident represents an extreme weather event. Extreme weather events that we are typically interested in are events unusual enough to cause harm to human health or infrastructure. In this study it is defined as the highest 5-day average temperature in a 10 year period. So how do we attribute the chance of an extreme event to human activity then? We generate the two 'scenarios' as would equally be required in the above analogy. Because we do not know what the current world would look like had humans never existed, one popular way to answer the question is with complex climate models describing (as best we can) the physics and dynamics of the climate system. When models are extremely complex as in the case of climate models, they are run by super-computers that can make calculations and process information at rates much faster than any desktop computer could.

The Experiment

One advantage of climate models is that one can alter aspects of them to see how they would behave under certain 'different' situations. We run a climate model under two different scenarios and then count the number of extreme weather events ('accidents' in the analogy)

that occur in each scenario. One scenario is the world as it is now with greenhouse-gas concentrations and sea surface temperatures set to current values. The second scenario is a world without human industrialisation: we reduce carbon dioxide and methane concentrations in the atmosphere and we cool the ocean appropriately. We run the model under each scenario many times so that enough extreme events are simulated such that we can get statistically significant samples of extremes in both cases [P. Pall et al., 2011].

So Did Humans Actually Increase the Probability of the Heatwave Over Geneva?

When it comes to heatwaves, all the models currently used by scientists agree that the chance of these events occurring over almost all parts of the Earth have increased as a consequence of human activity through our greenhouse-gas emissions. In our study we found that attribution statements (e.g., “driving at 100 km/h increases your chance of an accident by 100%”) for heatwaves hardly change between heatwaves occurring over a spatial domain the size of the canton of Geneva, and heatwaves occurring over larger spatial domains, i.e. over Switzerland and over Europe. Correlations between attribution statements for heatwaves occurring over large spatial scales versus ones for events occurring over small spatial scales show an extremely high correlation (~0.97). In other words, results show that human greenhouse-gas emissions have similarly altered the probability of the occurrence of these events over both spatial scales. Such a result suggests the chance of heatwaves occurring beyond the smallest scale at which weather is computed in the models (e.g. over spatial scales the size of Geneva), have also almost certainly increased as a consequence of the greenhouse-gases we as humans have emitted [O. Angelil et al., 2014]. Final results suggest our emissions since the Industrial Revolution may have increased the likelihood the Genevan heatwave by a factor of 2-8 times depending on the model used.

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