How can man-made climate change be proven?

November 9 2017, by Lukas Gudmundsson

Credit: AI-generated image (disclaimer)

If observed climate variables such as temperature or precipitation change over time, it raises the question as to whether human influence plays a role. To investigate this, scientists are applying a method for estimating causal relationships.

The fact that greenhouse gases emitted by humans are changing the global climate system is scientifically undisputed. Climate researchers often look to the future with their models and try to calculate how the increasing concentration of CO2 in the atmosphere will affect various climate variables such as temperature or precipitation.

However, we also experience weather and climate in the present day: for example, Switzerland has grown increasingly warm over the last century. If exceptionally warm summers become ever more frequent, it soon raises the question of how human actions influence the current and past climate. But how can we investigate whether an observed change in the climate is caused by man-made climate change or is simply due to naturally occurring fluctuations?

We only have one world

Unfortunately, we cannot test this question experimentally as scientists. The reason is as banal as is it serious: we only have one world. We cannot conduct classical experiments in which we contrast a climate with human influence to a climate without human influence.

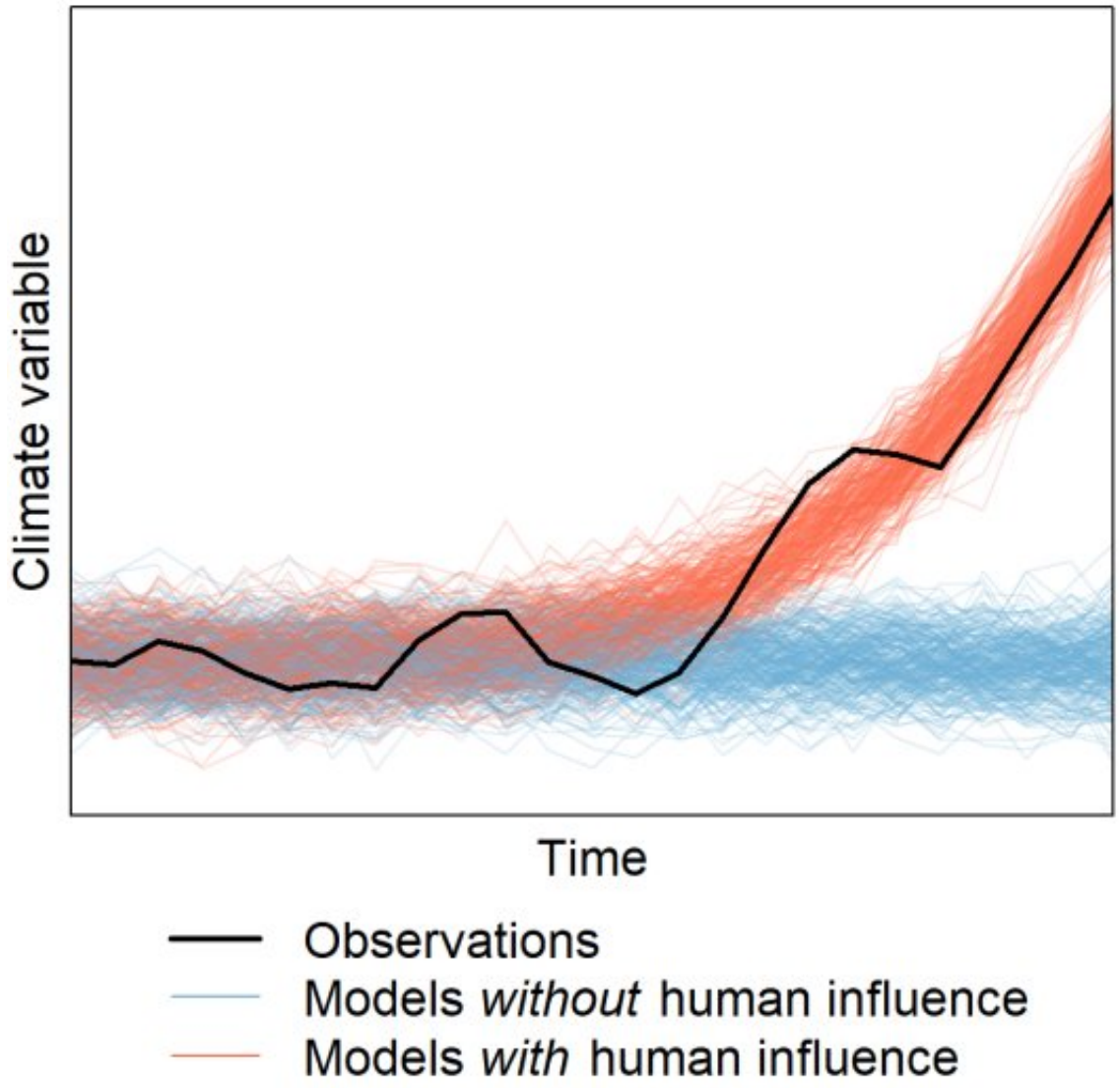


Illustration of the detection and attribution method. Only in the second half of the analysed period does the observed change stand out strongly enough from the model simulations without human influence and is comparable to the simulations with human influence. Credit: ETH Zurich

What is available to us, however, are long observation series for precipitation, water level, temperature, number of storms and many other measured parameters. To test whether these climate variables are

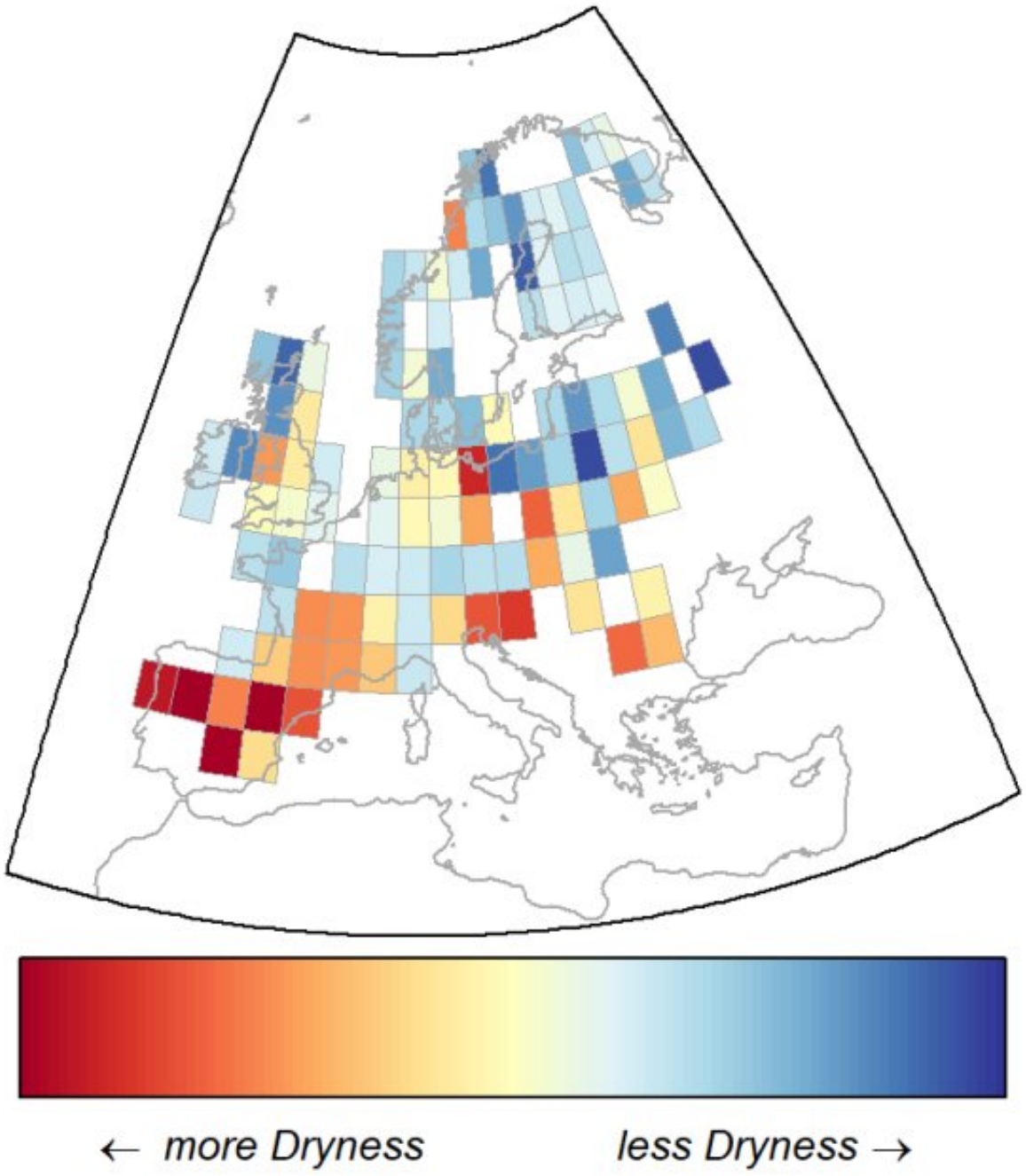
influenced by rising greenhouse gas emissions from human activities, scientists have developed the detection and attribution method.

Assessing cause and effect in the model

The method involves a combined analysis of long observation series and simulation experiments in which climate models are calculated both with and without human influence in order to compare them with the actual observations. If the latter are only reproduced by the simulations with emissions, it can be concluded that man-made climate change is demonstrable in the observations.

However, the possibility of natural fluctuations underlying an observed change must also be considered: not every summer is equally warm and not every winter is snowy. This can be ruled out by using climate models repeatedly to simulate the range of these fluctuations. The more the observation differs from the range of natural climate fluctuations, the more reliable the conclusion that man-made climate change influences the observation.

The detection and attribution method is an important instrument for climate research and was used in the last UN climate report in the chapter on the evidence of man-made climate change. However, the method does have weaknesses. It is not always clear if climate models correctly estimate the range of natural fluctuations, and the possibility that an observed change was caused by a process that is not included in the climate models can never be entirely excluded. Despite these problems, the method can provide convincing evidence in a line of reasoning.



Observed change in Europe's freshwater resources. Credit: L. Gudmundsson

Climate change leaves its mark on water resources

An example: in a recent study published in the journal *Nature Climate Change*, we were able to use the detection and attribution method to show that the observed decline in freshwater resources in southern Europe is very likely to be related to increasing greenhouse gas emissions.

We analysed observation series on the runoff of several hundred small rivers from 1956 to 2005 and compared them with climate models. The observations show that there has been a tendency towards dryer conditions in southern Europe in recent decades, while the north has tended to become wetter. Climate models only reflect this pattern when human greenhouse gas emissions are taken into account.

Although factors such as natural climate variability and human water use (e.g. irrigation) also play a role, overall, the results clearly show that climate change is already affecting Europe's water resources today, and that increasing water shortages in southern Europe are a likely consequence in the future.

More information: IPCC, Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, in Summary for Policymakers., T.F. Stocker, et al., Editors. 2013. p. 1535.

Bindoff, N.L., et al., Detection and Attribution of Climate Change: from Global to Regional, in Climate Change 2013: The Physical Science Basis. Contribution of Working Group I to the Fifth Assessment Report of the Intergovernmental Panel on Climate Change, T.F. Stocker, et al., Editors. 2013, Cambridge University Press. p. 867-952.

Gudmundsson, L., S.I. Seneviratne, and X. Zhang, Anthropogenic climate change detected in European renewable freshwater resources. *Nature Clim. Change*, 2017.

Provided by ETH Zurich