Effect of important air pollutants may be absent from key precipitation observations

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Credit: NASA

Pioneering new research from the University of Exeter could have a major impact on climate and environmental science by drastically transforming the perceived reliability of key observations of precipitation, which includes rain, sleet and snow.

The ground breaking study examines the effect that increased aerosol concentrations in the atmosphere, emitted as a result of burning fossil fuels, had on regional temperature and precipitation levels.

Scientists from Exeter's Mathematics department compared observed regional temperature and precipitation changes throughout the 20th century with results produced by the latest complex climate models over the same period.

The study showed that the observed regional temperature changes, as well as observed precipitation levels in the tropics, were in agreement with the range of the modelled responses given current best estimates of the influence of aerosols on the Earth's energy budget.

However, when looking at geographical areas within the Northern Hemisphere mid-latitudes – which includes Europe, much of North Asia and North America – the study showed a significant discrepancy between observed precipitation levels and those predicted from the models.

This new analysis could transform our understanding of observed changes in the local hydrological cycle and offer a unique opportunity to correct for potential biases in measurements.

The new study, published in leading scientific journal *Nature Climate Change*, was produced by Joe Osborne and Dr Hugo Lambert, from Exeter's College of Engineering, Mathematics and Physical Sciences.

Dr Lambert explained: "Scientists have known that observed mid-latitude precipitation trends may be in error for many years. Our new physical framework fits together temperature changes, aerosol changes and other precipitation changes to show by how much. We now have the opportunity to correct 20th century precipitation trends."

The concentration of human-made aerosols in the atmosphere increased rapidly in the decades following the Second World War. Although aerosols interact with clouds and precipitation in complex ways, the

primary effect is to reflect sunlight and cool the planet's surface. Hence, physical theory and modelling suggest there are robust expectations for regional temperature and precipitation change.

The study showed that climate models replicate the mid-twentieth-century fall in temperature linked to increased aerosol concentrations that is seen in observations.

It also showed that models and observations were in agreement over a reduction in rainfall in the Northern Hemisphere tropics around the same time, which is associated with the severe Sahel drought of the 1970s.

However, there was a dramatic discrepancy between the expected change in precipitation across the Northern Hemisphere mid-latitudes – where industrialisation occurred most heavily in the 20th century – and observations. While the modelling and physical theory suggested precipitation should fall, observations suggest that it increased.

Joe, a PhD student and lead author, explained the significance of the study. He said: "The study shows that precipitation in two key regions alters in line with mid-20th Century changes in aerosol across a number of the latest climate models. This can be understood in terms of the aerosol influence on the amount of energy received at the Earth's surface and consequent changes in atmospheric circulation.

"However, we also show that the response of precipitation observations in the mid-latitudes is not as we might have expected, given the models and our understanding."

More information: 'The missing aerosol response in twentieth-century mid-latitude precipitation observations' by Joe Osborne and Dr Hugo Lambert is published in *Nature Climate Change*: dx.doi.org/10.1038/nclimate2173