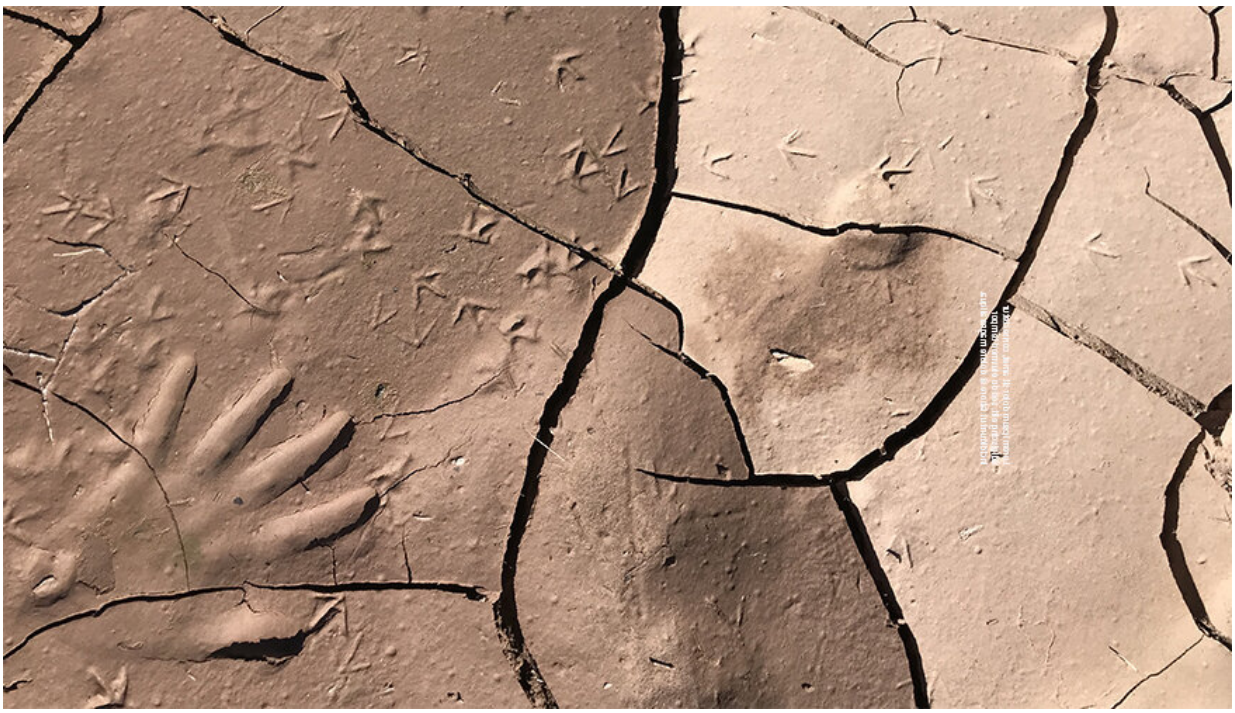
Increases in greenhouse gas, particulate pollution emissions drive regional drying around the globe

July 7 2020, by Anne M Stark



LLNL scientists and collaborators used fingerprinting — the process of separating the relative roles of natural and human influences on global climate — to identify how greenhouse gas and particulate pollution emissions drive regional drying around the globe. Credit: Lawrence Livermore National Laboratory

Despite devastating impacts of drought on human and natural systems,

the reasons why long-term regional drying occurs remain poorly understood.

Research led by Lawrence Livermore National Laboratory (LLNL) scientists has identified two signatures or "fingerprints" that explain why arid conditions are spreading worldwide, and why the Western United States has tended toward drought conditions since the 1980s while the African Sahel has recovered from its prolonged drought. The research appears in the July 6 edition of *Nature Climate Change*.

The team of U.S. and Canadian scientists found that since 1950, human-generated greenhouse gasses and particulate atmospheric pollution have influenced global changes in temperature, precipitation and aridity in two distinct ways, each yielding a different fingerprint pattern.

The fundamental goal of fingerprinting is to separate the relative roles of natural and human influences on global climate. While it has helped to identify a discernible human influence in observational records of temperature, water vapor, rainfall and snowpack, this approach based on fingerprinting has not been used very often in aridity research.

Using a novel fingerprinting analysis focusing on the joint fluctuations in temperature, rainfall and aridity in climate model simulations and observations, the team identified two large-scale mechanisms that have been driving global aridity change.

"The climate we are experiencing is influenced by many factors," said LLNL climate scientist Celine Bonfils, lead author of the paper. "In nature, the atmosphere is very noisy but it also responds to external factors that act at different paces and places, a bit like how different musical instruments contribute to a song, each with their own tonal signatures, rhythms and placements within the song."

These external factors include the well-known 11-year fluctuation in the sun's energy; the episodic drumming of volcanic eruptions that shade the Earth from the sun for one to three years; the accompanying choir of particulate aerosols emitted from Europe, North America, China and India that shade the Earth and alter its cloud properties; and the resounding crescendo of the gradual accumulation of greenhouse gasses. Because each of these external factors has a characteristic timbre, like that of each of the musical instruments, this team of scientists has been able detect their distinct individual resonances in climate observations.

In this study, the team found two major forced changes in the climate system that emerge from the "background noise" produced by random internal climate processes. "It is a bit like capturing two different songs playing simultaneously out of a noisy background," Bonfils said.

One song is louder and clearer: The dominant fingerprint is characterized by global warming, intensified wet-dry patterns of precipitation, and progressive large-scale continental aridity—all largely driven by a slowly evolving increase in greenhouse gas emissions.

The second and more subtle fingerprint captures a temperature contrast between the Northern and Southern Hemispheres, controlled by the cooling influence of particulate pollution emitted from Europe and North America up until the 1980s. This temperature contrast moved the tropical rain belt southward, away from the cooler Northern Hemisphere, causing more rainfall over the Western U.S. and less over the Sahel and India. After pollution regulations were put in place in following the Clean Air Act, the tropical rain belt shifted back northward, bringing less rainfall to the Western U.S. and more to the Sahel.

"The major contributing instruments of this intertwined mashup are the steady increase in greenhouse gasses, the temporal evolution of

particulate pollution and the episodic occurrence of volcanic eruptions, which all contributed in singular ways," Bonfils said.

"Understanding how greenhouse gas-induced widespread aridity will be modulated regionally by future sulfate aerosol emissions is an essential requirement for making reliable predictions of 21st century hydroclimate changes," said John Fyfe, a co-author from the Canadian Center for Climate Modeling and Analysis. "These predictions will help inform critical decisions on water, food and energy security—not only for the U.S. and Canada, but also for other regions around the world."

More information: Céline J. W. Bonfils et al. Human influence on joint changes in temperature, rainfall and continental aridity, *Nature Climate Change* (2020). DOI: 10.1038/s41558-020-0821-1

Provided by Lawrence Livermore National Laboratory