As world warms, vegetation changes may influence extreme weather

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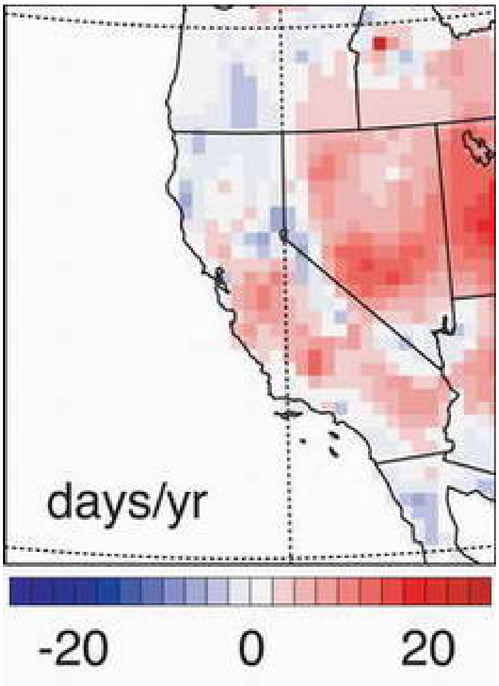

A Purdue University climatologist has found that vegetation can significantly affect extreme weather, a discovery that could add a new piece to the global warming puzzle.

This figure of the western United States shows the impact vegetation changes resulting from global warming have on extreme climate events when compared with the effect of global warming alone. As vegetation responds to the greenhouse effect, the number of extremely hot days could double in frequency in semi-arid areas, such as the Great Basin and the California coast. (Diffenbaugh lab)

Noah S. Diffenbaugh has found that extreme weather events, such as storms and heat waves, can vary substantially in frequency and severity in a region depending on how vegetation responds to global warming. This is believed to be the first study to indicate that as vegetation responds to climate change, those changes in ground cover may affect where and how often extreme weather events occur. While climate scientists have theorized that this relationship exists, Diffenbaugh said, this study gives further credence to the idea that interactions among land, air and sunlight are more complex than we might imagine.

"Earth's climate is all about relationships, and this study shows that ground cover plays a significant part in determining changes in climate extremes," said Diffenbaugh, who is an assistant professor of earth and atmospheric sciences in Purdue's College of Science. "We are accustomed to hearing that greenhouse gases affect climate, but they are not the only factor we should consider. Our climate models also must incorporate the effect of vegetation if they are to capture the full scope of reality."

Diffenbaugh said he conducted the research, which appears in this week's issue of the journal Geophysical Research Letters, because extreme climate events are one of the most important variables in human interaction with the environment.

"People have suspected for some time that the greenhouse effect can change how often extreme events occur and how severe they are," he said. "We also know that climate change will affect what vegetation grows where and that those vegetation changes can feed back to further change the mean climate state. But this is the first insight we've had into whether those vegetation changes will also change the frequency and magnitude of extreme temperature and precipitation events, such as droughts and severe storms."

Using a climate model at the University of California-Santa Cruz, where he was previously a postdoctoral researcher working with Lisa C. Sloan, Diffenbaugh conducted a study on an area of the western United States, primarily examining

California, Oregon, Nevada and parts of the surrounding region. The work grew from a previous study in which Sloan and graduate students Mark Snyder and Jason Bell took the quantity of carbon dioxide present in the atmosphere in the mid-1700s before the Industrial Revolution – 280 parts per million, compared with today's 380 – and doubled it to obtain an idea of what the region's weather could do if CO2 levels continue to rise. Diffenbaugh took the same hypothetical high-CO2 atmosphere and factored in the effect of vegetation on the region's weather in order to compare the amount of impact vegetation would have.

"What the comparison suggests is that in some places, such as coastal Oregon, greenhouse gases would be responsible for nearly all of the changes," Diffenbaugh said. "But in central California or the Great Basin, vegetation would be a far more significant factor in regulating the changes."

Diffenbaugh said that whether vegetation feedbacks make for more or fewer extreme events depends on the region.

"Changes in vegetation cover can push the region toward more or fewer extreme events – it depends on where you look," he said. "In the high Sierra Nevada, for example, people have often theorized that as the globe warms, evergreen forests will migrate to higher altitudes and be lost as they hit the mountaintops. We certainly see this warming and the predicted forest loss. But we also see that as the forests disappear, the higher elevations may not experience as much extreme warmth as expected because environmental feedbacks the new vegetation generates may mitigate this net warming."

In other more populous places, however, the effect could be the exact opposite.

"In central California, vegetation changes could even further increase the maximum temperatures over and above what the carbon dioxide will do on its own," Diffenbaugh said. "The model suggests that as the vegetation there responds to the greenhouse effect, heat waves will be longer, more frequent and more intense."

Diffenbaugh said that while the experiment was valuable for establishing the relationship between vegetation and climate, further refinement of the methodology would be necessary.

"This is the first time anyone has tried to understand these particular relationships, and though we can see they exist, our vision is still blurry," he said. "I put together the experiment in order to better understand how the Earth works, and it has been successful on that level. But the results should not be taken as a prediction of the future. I would characterize them as a first approximation of how two important components of the climate system can interact."

One of the improvements he would like to make, he said, involves incorporating more realistic conditions into the model.

"Interpretations of this research could be challenged because it is an initial idealized experiment, not a forecast," Diffenbaugh said. "For example, I used an idealized vegetation cover for the region, and I have left out several important processes, such as the role of human land use and the role of changes in the way nutrients cycle from the earth into living things and back again."

Land use change is a critical factor, Diffenbaugh said, considering the changes that agriculture and city expansion have had on the western United States and on the planet as a whole.

"We'd like to understand how important human land use changes, such as deforestation, urbanization, et cetera, may be to extreme climate in the future," he said. "Human land use has changed over time, and these changes might be influencing our instrumental records of extreme temperature and precipitation. As urban areas expand, as they are expected to do dramatically over the next century, it will become important to know how these changes might affect how often extreme temperature and precipitation events occur and how severe those events could be."

Time also is a variable Diffenbaugh said needs to be addressed.

"Next time around, I would also like to increase the length of the simulations," he said. "What we'd really like is a model that can show us how extreme climate events respond to vegetation changes on the scale of decades or even centuries. At this point, it's a matter of devoting enough computer time to achieving that goal."

Source: Purdue University

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