Researchers make major step in improving forecasts of weather extremes such as floods, droughts

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(PhysOrg.com) -- Moisture and heat fluctuations from the land surface to the atmosphere form a critical nexus between surface hydrology and atmospheric processes, especially those relevant to rainfall. While current theory has suggested that soil moisture has had a positive impact on precipitation, there have been very few large-scale observations of this. A team of researchers from Columbia Engineering, Geophysical Fluid Dynamics Laboratory, and Rutgers University has now demonstrated that evaporation from the land surface is able to modify summertime rainfall east of the Mississippi and in the monsoonal region in the southern U.S. and Mexico. One of their main findings is that evaporation from the land is, however, only able to modify the frequency of summertime rainfall, not its quantity.

"This is a major shift in our understanding of the coupling between the land surface and the atmosphere, and fundamental for our understanding of the prolongation of hydrological extremes like floods and droughts," said Pierre Gentine, Assistant Professor of Applied Mathematics at The Fu Foundation School for Engineering and Applied Science at Columbia University, and co-author of the paper "Probability of Afternoon Precipitation in eastern United States and Mexico Enhanced by High Evaporation," published in the June 5th online edition of *Nature Geoscience*. The other co-authors are Kirsten Findell (Geophysical Fluid Dynamics Laboratory), Benjamin Lintner (Rutgers University), and Christopher Kerr (Geophysical Fluid Dynamics Laboratory).

The researchers used data from the National Centers for Environmental Prediction (NCEP) to quantify the impacts of continental evaporation on the frequency and intensity of summertime rainfall over North America. They discovered that higher evaporation increases the probability of afternoon rainfall east of the Mississippi and in Mexico, while it has no influence on rainfall over the Western U.S. The difference is due to the humidity present in the atmosphere. The atmosphere over the western regions is so dry that no matter what the input of moisture via evaporation is from the surface, an added source of moisture will not trigger any rain since it will instantaneously dissipate into the atmosphere. The atmosphere over the eastern regions is sufficiently wet so that the added moisture from the surface evaporation will make it rain.

"If it starts getting really wet in the east," noted Gentine, "then the surface will trigger more rain so it becomes even moister, and this sets up a vicious cycle for floods and droughts. Nature - i.e. the land surface and the vegetation - cannot control the rainfall process in the west but it can in the east and in the south. This is really important in our understanding of the persistence of floods and droughts."

Consequently, once a flood or a drought is triggered by large-scale processes, such as sea surface temperature anomalies, the flood/drought conditions are most likely to persist in the eastern and southern U.S. But in the West, the duration and frequency of floods/droughts are controlled only by oceanic processes: the surface cannot modify the rainfall process. Whether the soil is dry or wet doesn't change subsequent rainfalls: consequently the surface will not help hydrological extremes persist (e.g. floods/droughts).

Gentine is developing a theoretical framework to understand the precipitation and cloud formation over land and says this should be an important breakthrough in our understanding of how soil moisture and vegetation controls cloud formation and the precipitation process. "I find this work fascinating because it's a great blend of theoretical research - understanding how nature works - and practical applications that affect our world -like flood/drought/water management. My lab is right outside: observing clouds and precipitation!"

Provided by Columbia University

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