Podcast Interview: Jingfang Fan

PNAS: Welcome to Science Sessions. I'm Paul Gabrielsen. The study of earth's changing climate can be approached in several ways. Some scientists focus on the physical mechanisms of how climatic processes interact with each other, and input their understanding of these processes into ever more sophisticated models for predicting future climate conditions. But there's another way. Other researchers study the climate in terms of changes that have already occurred, and use that information to infer how the climate system operates and how it might continue to change in the future. Jingfang Fan, of Bar-Ilan University, has taken the latter approach. In a recent PNAS paper, Fan and his colleagues constructed a model of the global climate system using a network approach. By designating geographic points as nodes and identifying which nodes experiences similar climate variations, the authors hoped to study how climate has changed in the past few decades and how it might change under several possible climate scenarios. Fan recently spoke with PNAS about the work. He explains the network model approach.

Fan: The climate system is a complex and a non-linear system. So, we study it with a network approach. In climate networks, the geographic locations are regarded as network nodes, and the level of similarity between the climate records of different grid points represent the network links and we find an abrupt or first-order percolation transition during the evolution of the climate networks.

PNAS: The authors also utilized a statistical approach called percolation theory. This approach tests how interconnected different nodes in the model are, and gets its name from the interconnectedness of pores in a solid that allow a liquid to percolate through it. In this application, the researchers ran the percolation model to see how clusters of similar climate nodes grew and joined like regions, like small raindrops coalescing into larger drops on a window. There was a point in the percolation, though, when the system abruptly changed. Fan describes this point, which he calls the "percolation threshold."

Fan: The percolation threshold describes the point at which the climate system switched from several big clusters to a very fewer clusters. Each cluster had similar climate phenomenon. This finding allows us to relate changes in the clusters of the climate system to a more specific phenomenon.

PNAS: The percolation threshold led the researchers to look for a physical mechanism that could underlie the phenomenon. By comparing successive time series of five years each, from 1979 to 2016, the authors noticed that, over time, the climate network around the tropics appeared to be expanding. The mechanism behind the expansion, Fan says, may be expansion of the atmospheric feature known as the Hadley cell.

Fan: The Hadley cell is atmospheric circulation. It's present as the rising air at the equatorial region and the subsidence at low latitudes. The equatorial rising air is associated with convection and precipitation while the subsidence of air is associated with very dry air in the deserts. That is the reason for the desert belt region. So changes in the extension and the intensity of the Hadley cell reflect the extension of this region and the heat transport to the high latitudes. The association of our climate network to the Hadley cell measure provided more physical meaning to our findings.

PNAS: Climate models that project future climate scenarios support the researchers' findings, showing a weakening and expansion of the Hadley cell and the tropical climate region.

Fan: Most surprising to us is we find very clear trends over climate change as it is reflected in the joining clusters. It means that the network percolation analysis we proposed here may have identified the regions that are more probable to experience decline in precipitation.

PNAS: The results, Fan says, provide an additional perspective on the effects of climate change on global atmospheric circulation patterns.

Fan: We provide an additional way to look and understand the effects of climate change. The usually Hadley cell analysis is average along in temporal direction, and thus it does not record the changes in the zonal direction. So our methods provided both that zonal direction and meridional regions. Thus, it can be useful for forecasting the extent of the tropical cluster to detect its influence on different areas in response to global warming or in the future.

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