Researchers suggest adding uncertainty to catastrophe models may help predictability

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Ruins from the 1906 San Francisco earthquake, remembered as one of the worst natural disasters in United States history. Credit: Public Domain

(Phys.org)—A small team of researchers with members from Universidad de Granada and Princeton University has found that adding some uncertainty to computer models meant to predict catastrophes such as stock market crashes, rapid desertification of a region, etc. can help make the models better. In their paper published in *Proceedings of the National Academy of Sciences,* the team describes how they employed mathematical models that allow for adding in randomness to catastrophe prediction models and what they found by doing so.

Catastrophes happen all the time, fires, earthquakes, hurricanes—and one thing they all have in common is that once key factors are in place, a tipping point is reached beyond which it is impossible to prevent them from occurring. As the researchers in this new study note, most computer models created for the purpose of predicting catastrophes are based on deterministic math—that is, they assume a perfect world where nothing is random. That approach cannot work in the real world of course, because real catastrophes quite often have several contributing factors that are random in nature. But programming in random factors has proven to be a challenge because of their very nature. In this new study, the researchers applied 1D and 2D spatially explicit models that are stochastic in nature and tested them on a real world scenario—where a tipping point is reached in an ecological area. In real life, such events exhibit another common trait of catastrophes, a group of rapid transitions that come about due to a small change in a system. A region lush with vegetation can fall into a transition to desert, for example, due to a rapid change in temperature or moisture levels.

By adding in randomness, the team found that they could reduce diffusion, and thus smooth out the factors that led to catastrophe—as an example, they noted that moving cattle around random pastures, rather than in a predictable way, tended to make the land more robust and less susceptible to catastrophe. Their hope is that more research on integrating randomness into forecasting models will lead to improvements in such systems thereby helping to save lives, money or perhaps the environment.

More information: Eluding catastrophic shifts Paula Villa Martín,

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Abstract
Transitions between regimes with radically different properties are ubiquitous in nature. Such transitions can occur either smoothly or in an abrupt and catastrophic fashion. Important examples of the latter can be found in ecology, climate sciences, and economics, to name a few, where regime shifts have catastrophic consequences that are mostly irreversible (e.g., desertification, coral reef collapses, and market crashes). Predicting and preventing these abrupt transitions remains a challenging and important task. Usually, simple deterministic equations are used to model and rationalize these complex situations. However, stochastic effects might have a profound effect. Here we use 1D and 2D spatially explicit models to show that intrinsic (demographic) stochasticity can alter deterministic predictions dramatically, especially in the presence of other realistic features such as limited mobility or spatial heterogeneity. In particular, these ingredients can alter the possibility of catastrophic shifts by giving rise to much smoother and easily reversible continuous ones. The ideas presented here can help further understand catastrophic shifts and contribute to the discussion about the possibility of preventing such shifts to minimize their disruptive ecological, economic, and societal consequences.