Predicting abrupt transitions and extreme events in the Earth system

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In view of ongoing climate change, two key challenges of Earth system science are to predict (i) changes in extreme weather events, and (ii) abrupt state transitions of unstable subsystems of the Earth system. In current Earth system models (ESMs), many processes are not resolved explicitly, but approximated by empirical equations with free parameters, leading to structural model errors. These errors are sufficiently small that ESMs can be tuned to reproduce climatic averages of the last 150 years, for which instrumental observations are available. However, the same models perform poorly in simulating extremes, and in reproducing abrupt transitions evidenced in paleoclimatic records. The confidence that ESMs can reliably predict changing extremes and future abrupt transitions is therefore low. To account for structural ESM errors, I propose to further advance techniques from Machine Learning - in particular systematic Bayesian inference and Artificial Neural Networks (ANNs) - to develop hybrid models that combine ANNs with physics-based ESMs. It has recently been shown that ANNs can approximate simple, yet chaotic model systems, but their potential to extenuate structural errors in ESMs on the basis of past observations remains unexplored. A successful implementation of the project would increase the reliability of predictions of changing extremes and future abrupt transitions.

Projektbeteiligte

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