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Recent progress and new methods for detecting causal relations in large nonlinear time series datasets

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Detecting causal relationships from observational time series datasets is a key problem in better understanding the complex dynamical system Earth. Recent methodological advances have addressed major challenges such as high-dimensionality and nonlinearity, e.g., PCMCI (Runge et al. *Sci. Adv.* 2019), but many more remain. In this talk I will give an overview of challenges and methods and present a novel algorithm to identify causal directions among contemporaneous (or instantaneous) relationships. Such contemporaneous relations frequently appear when time series are aggregated (e.g., at a monthly resolution). Then approaches such as Granger Causality and PCMCI fail because they currently only address time-lagged causal relations.

We present extensive numerical examples and results on the causal relations among major climate modes of variability. The work overcomes a major drawback of current causal discovery methods and opens up entirely new possibilities to discover causal relations from time series in climate research and other fields in geosciences.

Runge et al., Detecting and quantifying causal associations in large nonlinear time series datasets, *Science Advances* eeaau4996 (2019).