

Hypothesizing and testing causal relationships in correlated time-series observations

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Abstract

Traces of past earth system states are preserved in an array of biogeochemical archives. Extracting information from these archives produces valuable data that reveal time progression of environmental conditions. Covarying measurements entice cause-effect explanations, but establishing causal relationships from observational studies requires a rigorous epistemology. Correlation is necessary for hypothesizing a causal relationship, but insufficient for forming conclusions. Common-cause explanations, such as independent orbital forcing of correlated measurements, must be rejected based on characteristics of the data. Determining amplitude and phase response over a range of frequencies provides a test of cause-effect scenarios: measured cause must precede proportionate effect in a manner consistent with direct forcing theory. Amplitude and phase persistence (coherence) through time provides a method for quantifying probabilistic confidence in a cause-effect conclusion. In this presentation, methods are described, and then applied to ice core proxies for air temperature and atmospheric carbon dioxide concentration.

Biography

Gary B. Hughes is currently Assistant Professor in the Statistics Department at California Polytechnic State University in San Luis Obispo, CA. Dr. Hughes has worked in the infrared imaging industry since 1990, performing various functions in mechanical, software, manufacturing, reliability and systems engineering. Since 1993, he has also taught and performed research at several academic institutions, including Cal Poly San Luis Obispo, UC Santa Barbara and Cal State Channel Islands. He completed a Ph.D. in Earth & Environmental Science at the University of Pennsylvania; a M.A. in Applied Mathematics at UC Santa Barbara; and a B.A. in Mathematics at Northwestern University.