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A comparison of two causal methods in the context of climate analyses

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Correlation does not necessarily imply causation, and this is why causal methods have been developed to try to disentangle true causal links from spurious relationships. In our study, we use two causal methods, namely the Liang-Kleeman information flow (LKIF) and the Peter and Clark momentary conditional independence (PCMCI) algorithm, and apply them to four different artificial models of increasing complexity and one real-case study based on climate indices in the North Atlantic and North Pacific. We show that both methods are superior to the classical correlation analysis, especially in removing spurious links. LKIF and PCMCI display some strengths and weaknesses for the three simplest models, with LKIF performing better with a smaller number of variables, and PCMCI being best with a larger number of variables. Detecting causal links from the fourth model is more challenging as the system is nonlinear and chaotic. For the real-case study with climate indices, both methods present some similarities and differences at monthly time scale. One of the key differences is that LKIF identifies the Arctic Oscillation (AO) as the largest driver, while El Niño-Southern Oscillation (ENSO) is the main influencing variable for PCMCI. More research is needed to confirm these links, in particular including nonlinear causal methods.