EGU22-13053
https://doi.org/10.5194/egusphere-egu22-13053
EGU General Assembly 2022

Causal Diagnostics for Observations - Experiments with the L63 system

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Study of cause and effect relationships – causality - is central to identifying mechanisms that cause the phenomena we observe. And in non-linear, dynamical systems, we wish to understand these mechanisms unfolding over time. In areas within physical sciences like geosciences, astrophysics, etc. there are numerous competing causes that drive the system in complicated ways that are hard to disentangle. Hence, it is important to demonstrate how causal attribution works with relatively simpler systems where we have a physical intuition. Furthermore, in earth and atmospheric sciences or meteorology, we have a plethora of observations that are used in both understanding the underlying science beneath the phenomena as well as forecasting. However in order to do this, optimally combining the models (theoretical/numerical) with the observations through data assimilation is a challenging, computationally intensive task. Therefore, understanding the impact of observations and the required cadence is very useful. Here, we present experiments in causal inference and attribution with the Lorenz 63 system – a system studied for a long time. We first test the causal relations between the variables characterising the model. And then we simulate observations using perturbed versions of the model to test the impact of the cadence of observations of each combination of the 3 variables.