Causal Explanation For Climate Impact Advice

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ABSTRACT

Climatic warming, known as the "greenhouse effect", is one of the major concerns since the 1980's. Political decisions are needed to combat human-induced greenhouse warming of the Earth, and an expert adviser is required because of the complexity of the problems. The development of methodologies for climate impact advice require a large amount of knowledge from diverse sources, such as, observed data, research reports and mathematical models. The work described in this paper concentrates on the acquisition of knowledge from equations in a mathematical model.

Even a simple mathematical model can have extraordinary dynamic behaviour. However, one of the limits of the mathematical models is that they provide no explicit knowledge of how to perform analysis or to interpret results. When domain experts are asked to explain a result from numerical simulation, they often describe behaviour as a set of numerical values along some successive time points, but are often unable to give a causal explanation of why things behave as they do.

Our intention is to use the existing mathematical model itself to assist the system in explaining and justifying its advice for decision making. To understand better the various climate-related processes is to improve our predictive capability and to facilitate decision making. Users are not trying to make new scientific interpretations, rather the intent is to permit decision makers to make decisions on a good qualitative understanding of complex mathematical systems. The need to produce a meaningful causal explanation for justifying an hypothesis is often stated as a fundamental part of an intelligent decision support system.

We propose to use information from the user about aspects of the models, which are interactive with the outside world where these are obvious to the user, and secondly heuristics to reduce equations to a suitable form to produce a reasonable causal explanation. We recognise that the use of information from the user can support the identification of dependencies among variables. We then use the dependency characteristic of variables to reconstruct equations to be asymmetric causal equations. An asymmetric equation is one where the variables on the right hand side (RHS) and left hand side (LHS) cannot be exchanged. In this form the LHS of an equation is the dependent variable. Causality is then explicitly represented in the asymmetric causal equations.

Researchers have worked on constructing causal explanation from equations, such as Iwasaki and Simon's *causal ordering*, and de Kleer and Brown's *mythical causality*. However, none of them have applied and used input, output and other causal information, as well as heuristics to produce "normal" structural equations and "reasonable" causality. As well, the heuristics we propose appear to overcome the practical deficiencies of causal ordering in handling feedback.