SENSITIVITY ANALYSIS FOR COMPLEX DYNAMIC MODELS: A GLOBAL SENSITIVITY INDEX PER FACTOR

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The development of dynamic models describing complex ecological or soil-crop systems continues to grow in popularity, for both academic research and project management [1]. Sensitivity Analysis (SA) is a prerequisite tool for model building and for model-based applications [2]. It can be used to identify the model components which may need a more thorough modeling effort and those which could be simplified [3]. Sensitivity analysis is often used to select the model parameters that should be estimated with the best possible accuracy [4].

For a dynamic model, sensitivity analysis may be separately applied on each daily output, but there is a high level of redundancy between dates that are close in time, and this may also lead to miss out interesting features of the dynamics [5]. As an alternative, Campbell and McKay [6] proposed to decompose time series upon a complete orthogonal basis and to compute sensitivity indices on each component of the decomposition.

In this paper, we follow on this proposal and present the multivariate sensitivity analysis under a global framework coherent with classical multivariate methods. A global index is deduced which synthesizes the decomposition of the total output inertia between parameter main effects and interactions. It may be used to select a subset of parameters to be estimated. In addition, a quality criterion based on a dynamic coefficient of determination is proposed for any approximation associated with the decomposition.

Our approach was applied to a dynamic model simulating nitrous oxide (N_2O) emissions from agricultural fields with a daily time step [7]. N_2O is a potent greenhouse gas, involved in ongoing climate change. Generalized sensitivity indices were computed to identify which among the 15 model parameters had the strongest effects on the model time series outputs. Three parameters had a total generalized sensitivity index higher than 15%: (i) the N_2O:N_2 denitrification ratio (r) (ii) the potential denitrification rate (PDR) (iii) the half-saturation constant of the denitrification process (km). The quality of our sensitivity indices was assessed by computing a dynamic coefficient of determination.

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