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Towards a flexible statistical modelling by latent factors for evaluation of simulated responses to climate forcings: Part I

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Abstract

Evaluation of climate model simulations is a crucial task in climate research. In a work consisting of three parts, we propose a new statistical framework for evaluation of simulated responses to climate forcings, based on the concept of latent (unobservable) factors. Here, in Part I, we suggest several latent factor models of different complexity that can be used for evaluation of temperature data from climate model simulations against climate proxy data from the last millennium. Each factor model is developed for use with data from a single region, which can be of any size. To be able to test the hypotheses of interest, we have applied the technique of *confirmatory factor analysis*. We also elucidate the link between our factor models and the statistical methods used in Detection and Attribution (D&A) studies. In particular, we demonstrate that our factor models can be used as an alternative approach to the methods used in D&A studies. An additional advantage of their use is that they, in contrast to the commonly used D&A methods, make it, in principle, possible to investigate whether the forcings of interest act additively or if any interaction effects exist. In Part II we investigate and illustrate the expansion of factor models to structural equation models, which permits the statistical modelling of more complicated climatological relationships. The performance of some of our statistical models suggested in Part I and Part II is evaluated and compared in a numerical experiment, whose results are presented in Part III.

Keywords: Confirmatory Factor Analysis, Structural Equation models, Measurement Error models, Climate model simulations, Climate forcings, Climate proxy data, Detection and Attribution

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