



On the complexity of model complexity: how geoscientists see it

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It is the core task of Earth scientists to gain insight into the complex systems of Nature. Yet, complexity may be perceived very differently across scientific disciplines and individual scientists. Understanding Nature often involves use of numerical models, ranging from simple linear equations to complicated frameworks of multiple models including feedbacks and emergent behaviour, crossing scales and disciplines. Given that all geoscientists study a complex system, the Earth, a plethora of models with different degrees of complexity is available. How do we, geoscientists, decide what model complexity is warranted or justified? Does this differ among disciplines? And, how do we even define model complexity?

We developed a short questionnaire to investigate the geoscientific community's views on complexity in models, which was distributed through social media and geoscientific mailing lists. The response was overwhelming, with 200 (!) responses on the first day and more than 600 fully completed after one month. The majority of the respondents work in research, either in academia (68%) or the public sector at a research institute (19%), most of the respondents were between 25 and 44 years old, with two-thirds (68%) being male versus 29% female. Most respondents use a model regularly (daily or weekly).

The results show that although a (formal) definition of model complexity exists, related to the degrees of freedom of the model, geoscientists generally have broader perceptions of model complexity. The number of processes explicitly included and the number of interactions / feedbacks incorporated were seen as important determinants of complexity.

In the view of respondents, models are not necessarily improved by making them more complex. Confidence is not per se higher in the simulations of a complex model compared to a simple one; and replies indicate that reduced complexity models are seen to be as useful as complex models for increasing our understanding of environmental processes. While increased computer power is not seen as a good justification for increasing model complexity, new observation techniques are seen as a good reason to consider greater complexity.

Interestingly, neither the discipline within the geosciences, nor career stage or work sector, explained the characterization of model complexity. The factor that mainly determined how respondents characterized model complexity was the way in which the respondents used models. For instance, programmers which technically implement and adapt model code, strongly relate model complexity to the required input variables, whereas model developers, defining the theoretical underpinnings of models, characterise model complexity mainly on the non-linearity of incorporated processes.

The results of the questionnaire demonstrate that there is no general consensus on how model complexity should be defined, and that formal definitions are not broadly or generally accepted. The way in which the model is used determine how people perceive model complexity, and also how they cope with this complexity. Surprisingly, no clear differences among different geoscientific disciplines were found. The insights of this questionnaire demonstrate the need to i) further formalize the definition of model complexity, and ii) to stimulate the dialogue among different model users.