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A checklist for model credibility, salience, and legitimacy to improve information transfer in environmental policy assessments

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ABSTRACT

Modelers involved in environmental policy assessments are commonly confronted with the lack of uptake of model output by policy actors. Actors have different expectations of models, condensed into three quality criteria: credibility, salience, and legitimacy. The fulfilment of quality criteria is also dynamic as expectations vary, change, and possibly counteract each other. We present a checklist for modelers involved in model-based assessments that is aimed at the identification and monitoring of issues, limitations and trade-offs regarding model quality criteria. It draws upon the literature of integrated assessments as well as case study analysis of environmental policy assessments for the Dutch government, based on expert interviews and embedded experience. The checklist is intended to be consulted during assessments; its application may result in greater awareness among modelers involved in assessments regarding model quality criteria, and may positively affect the uptake of model-based knowledge from environmental policy assessments by policy actors.

1. Introduction

Models[1] are simplified representations of real-life systems that allow for the combination of various and heterogeneous sources of knowledge, such as process knowledge, observational and experimental data, and expert judgment. Commonly models play an integral role in environmental policy assessments, in which they can fulfil various functions. For instance, models can have a heuristic, symbolic or relational role (Sterk et al., 2011); they can be tools to quantify the effects of alternative developments and policy scenarios (Schmolke et al., 2010), function as 'boundary objects' for participants and prospective users[2] of the environmental policy assessment to communicate and learn from each other (Borowski and Hare, 2007, and references therein; Jakeman et al., 2006), or serve to frame the assessment.

Over the years the role of models in assessments has also been criticized, showing structural differences in perspectives, interests and attitudes between different participants and users of the model-based assessments (Borowski and Hare, 2007, and

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[1] By 'models' we mean a whole range of conceptual models, mathematical models, simulation models, (spatial) databases, and indicators. In the context of environmental policy assessments the term 'model' often refers to a model chain, i.e. a set of models in which the output of one model is input to the next.

[2] We make a distinction between 'participants' and 'users' of environmental policy assessments. Participants are modellers and researchers, but also stakeholders who serve as experts. Users are primarily policy actors to whom results are delivered, but they can also be other stakeholders. The distinction is not necessarily very strict, but serves to indicate there are different groups around environmental policy assessments with different stakes, views, opinions, etc. towards the assessment goals as well as the models.

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references therein). This seems to correlate with the observation that there is a common lack of uptake and use of scientific information by policy actors and other non-scientists (Bauler, 2012; Lemos et al., 2012). In this respect, Kunseler et al. (2015) refer to the 'effectiveness' of an assessment, which is considered to be an emergent property based on the expectations that participants and users have regarding scientific assessment processes. The effectiveness is a proxy of the knowledge transfer between the various groups (participants and users) involved in the assessments. Although modelers and researchers may have the common perception that information is useful to users (e.g. Turnhout et al., 2013), the latter group may (and often does) think otherwise. In addition, it may not always be clear to the users how to use the results of the assessments. As a result the effectiveness of many environmental assessments is not as high as it could be due to (implicit) discrepancies among the various groups on how they judge the assessment processes and the usability of the provided results and insights (Kunseler et al., 2015).

For knowledge to be taken up by users it is essential to meet various expectations that are put forward by different participants and users (Liu et al., 2008; Meinke et al., 2006). As models are important carriers and production units of knowledge, these expectations also apply to models in particular. Expectations with regard to knowledge (and hence models) can be roughly aggregated into three quality criteria (Cash et al., 2002; Lusiana et al., 2011; McNie, 2007):

- ***Credibility*** concerns the scientific logic of the model and the soundness of the used knowledge. A model is deemed credible when concepts and processes in the model are considered acceptable as an approximation of the modelled system;
- ***Salience*** concerns the societal and political relevance of the use of the model in the assessment. A model is deemed salient when it plays a significant role in understanding and solving the policy issue at hand; its input is relevant to the issue, and its output can answer research questions that have been brought up in the context;
- ***Legitimacy*** concerns a fair representation of the views, values and concerns of involved stakeholders in the model used in the assessment. A model is deemed legitimate when these aspects are dealt with in the model and its inputs in an adequate way.

These three quality criteria serve to discuss the effectiveness of assessments in general (Kunseler et al., 2015; Meinke et al., 2006; Schut et al., 2013), but are equally applicable to models in particular (White et al., 2010).

Examples in the literature seem to suggest that the effectiveness of models in environmental policy assessments may be higher when expectations by stakeholders on model credibility, salience and legitimacy are properly addressed by modelers. In case the model does not meet the expectations of different participants and users there is an increased risk that the model and its output – and perhaps the conclusions or recommendations of the whole assessment in which the model is used – will be subject to criticism or may not be accepted by some or all of the users. One example of this concerns the efforts in the Global Biodiversity Assessment (Cash et al., 2002). In that particular case, the limited attention to salience issues caused the primary intended audience (parties to the Convention on Biological diversity) to have little interest in the kind of questions that were being asked by the scientific assessors. Information relevant to their decision making was not produced, and the assessment was largely ignored by the intended audience (Cash et al., 2002, and references therein).

In this paper we build upon the assumption that by taking the various expectations of participants and users into account the credibility, salience and legitimacy of models used in assessments will increase. It is further assumed that a proper reflection upon the perceptions on model quality among the various modelers, users and stakeholders participating in the assessment process is a necessary condition to increase the 'effectiveness' of information. This is not likely to be a trivial matter. There are at least four points that modelers have to be aware of.

The first point is that the three quality criteria do not necessarily have to be equally satisfied but should be balanced in the context in which models are produced and used. For instance, Lusiana et al. (2011) interviewed 122 potential users of a resource management model of various backgrounds and found that salience (i.e. the relevance of the model) was considered to be more important than credibility. At the same time legitimacy is considered to be an essential requirement for scientific knowledge to be transferred to non-scientific actors and to be translated into 'actionable knowledge', i.e. the science-policy interface (Meinke et al., 2006).

The second point is that the three quality criteria can also be counteracting. Trade-offs can result, especially under restrictions such as resource limitations (Cash et al., 2002). For instance, Ginger (2014) explored two different dimensions of legitimacy in model-based environmental planning cases (legitimacy based on procedure, and legitimacy based on scientific expertise), and found the two to be counteracting each other. It is therefore important to be explicit on the various aspects of the quality criteria and to address potential trade-offs between them.

The third point is the variability between modelers, users and participants in their perception of model credibility. Established scientific practice is aimed at the publication of models in peer-reviewed journals that first and foremost assess the scientific originality of the models (Schmolke et al., 2010). Furthermore, there are sets of standards for 'quality', such as the use of SI (International System of Units) units and following good modelling practices (STOWA/RIZA, 1999), which is coupled to the well-known model development cycle (Jakeman et al., 2006; see section 5 of this paper). Even if modelers have a shared view on credibility this does not exclude the possibility that non-modelers have different views.

The fourth point is that perceptions of the three quality criteria seem to be dynamic in nature (Sarkki et al., 2015) and may even be path-dependent. For example, Schut et al. (2013) discuss a case study in which at some point the credibility and legitimacy of specific research, which was earlier judged to be credible, salient, and legitimate, was openly questioned and contested by stakeholders as a result of interactions with partners that were not trusted. The dynamic nature of the quality criteria is also demonstrated by the case study we present in section 3 in this paper. It is conceivable that similar shifts can occur in the credibility, salience and legitimacy of models over the course of an assessment. This suggests that a monitoring of the quality criteria should occur at regular intervals.

This paper aims to develop a practical tool with suggestions for good practice for model developers to identify, avoid and help deal with issues regarding credibility, salience and legitimacy. It could also help in creating awareness among modelers involved in assessments, in particular concerning the four above-mentioned points. The selected format is a checklist with items for modelers to go through at a regular interval during model development and application. The evaluation of a model regarding the quality criteria cannot be seen separately from the policy issue context in which the model is developed, analyzed and applied. While not specifically aimed at models, trans-disciplinary approaches (implicitly) cover many aspects of model credibility, salience and legitimacy in suggesting ways for dealing with unstructured problems, i.e. problems in which there is great diversity and lack of knowledge