The ODD protocol: an update with guidance to support wider and more consistent use

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The ODD (Overview, Design concepts, Details) protocol is a standard format for describing agent-based models (ABMs, also known as individual-based models). It was introduced in *Ecological Modelling* in 2006 (Grimm et al. 2006) and updated in 2010 (Grimm et al. 2010). Accordingly, ODD has been most widely used in articles on ABMs published in *Ecological Modelling*, and its use in other disciplines and journals is also increasing (Vincenot 2018). An extension of ODD for describing in more detail ABMs that include human decision making (ODD+D; Müller et al. 2013) is also widely used. Still, despite its many benefits both for readers and writers, ODD use has not increased much since 2011, indicated by the annual proportion of articles using the term "agent/individual-based model" that also cite one or both of the ODD articles (Grimm et al. 2020, Fig. 2). Moreover, it is clear that many authors of ODD model descriptions still struggle with understanding and following the standard.

In a new update of ODD, Grimm et al. (2020) discuss a range of reasons why ODD is not used more widely and more consistently. While acknowledging that there can be reasons for not using ODD, the authors believe that wider use of ODD would be good for advancing agent-based modelling and related research, and also the impact and usefulness of each model. They discuss a range of reasons limiting the use of ODD: a lack of guidance on how to use ODD; the length of ODD documents; the complexity of ODDs for highly complex models; many ODDs lacking detail sufficient to enable reimplementation; and the lack of ODD sections covering a model's design rationale, its underlying narrative, and the criteria by which the model's fitness for its purpose is evaluated.

The authors, a team of 19 modellers from ecology and the social sciences, discuss how these limitations can be overcome and provide possible solutions. They suggest only one change to the protocol itself: changing the first ODD element, "1. Purpose", to "1. Purpose and Patterns" and using this element to identify observed patterns that will be used to evaluate whether the model is realistic enough for its purpose (e.g., Edmonds et al. 2019). These patterns should be identified at the start because they strongly affect the design of models. This new ODD format is already used in a recent textbook on agent-based modelling (Railsback and Grimm 2019).

In addition, Grimm et al. (2020) provide extensive material in the supplements S1-S7. S1 is a detailed guide on how to use ODD. For each ODD element there is a summary of its rationale, a list of typical misinterpretations, a checklist of questions, and a number of examples from existing publications. Hyperlinks facilitate navigating in this guidance document. S1 should help ODD beginners write complete and consistent ODDs and help reviewers check for ODD consistency.

Supplement S2 provides guidance on how to write summary ODDs, i.e., summary model descriptions that are short enough to be included in the main text of an article. S3 provides guidance and an example of "nested ODDs": for very complex models, it can be helpful to use elements of ODD to describe particularly large and complex submodels. Using ODD at the submodel level helps readers get a sufficient overview of the submodels despite their size and complexity, while still providing full detail. S4 provides examples of "delta ODDs", i.e., descriptions of different versions of an existing ABM or new models substantially based on previous ones already described in ODD. To support "delta ODDs", S5 addresses licence agreements through which ODD authors can permit others to use and modify existing ODDs, much like open-source software. S6 reminds readers of TRACE documents, which have a broader scope than ODD and are meant to provide a documentation not only of the model itself, but also of the other elements of iterative model development, including testing, analysis, and applications. Finally, S7 provides suggestions for standardizing description of the simulation experiments carried out with a model.

These supplements, and the article itself, are meant to facilitate and harmonize the use of ODD. The protocol not only provides a format for describing existing models, but it also helps in formulating and designing a model by providing a checklist of key questions to ask. ODD also facilitates communication across different disciplines, and has already created a link between the literature in ecology, where ABMs are most often referred to as "individual-based models", and the social and other sciences, where the term ABM is used (Vincenot

2018). Finally, the authors suggest that ODD is not only useful for ABMs, but for all kinds of simulation models; the only ODD elements specific to ABMs are in some of its Design concepts.

I hope that the writers, readers, reviewers and editors dealing with *Ecological Modelling* will make use of the open-access update and the supplements provided by Grimm et al. (2020). ODD was from the start designed as a "living standard" to be improved with use. Citing the 2006 and the new 2020 article whenever ODD is used helps us track, review, and improve the use of ODD; likewise, comments and questions, for example in the user forum of COMSES Net (Network for Computational Modeling in Social and Ecological Sciences; https://forum.comses.net/) are highly welcome.

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