

Good modelling practice: expanding the ODD model description protocol for socio-environmental agent based models

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Abstract: We have found in a literature review of land use change models that the documentation of human decisions, adaptation and learning is quite often incomplete and incomprehensible and would greatly benefit from a standard protocol for model description. Grimm et al. [2006, 2010] introduced such a standard protocol (ODD – Overview, Design, Details) for describing individual-based (IBM) and agent-based models (ABM). However, the current version of ODD [Grimm et al. 2010] is mainly designed to describe ecological models and is limited when it comes to the description of socio-environmental models, where human decisions play a central role. Furthermore we think that the majority of published model descriptions presents the model rules rather as ad hoc rules than try to embed the model and assumptions in a theoretical framework. To put the model rules into theoretical context may not be technically necessary to reimplement the model, but it assists the reader to understand the model's functionality and its design and - maybe more important - it will facilitate the synthesis and comparison of specific case studies. Therefore we want to present an extension of the ODD protocol that explicitly addresses the needs to describe human decisions in agent-based models and to better link specific models to theory. This talk will be based on a working paper available in early 2012 that describes in detail our revised version of the ODD protocol. We have asked presenters in this session to base their model description on this revised ODD version and to discuss its applicability and usefulness.

Keywords: model comparison, theoretical background, human decisions

1 Introduction

Process-based models and in particular agent-based models (ABMs) play an important role to foster understanding of human-environmental interactions and feedbacks in natural resource use [Matthews et al. 2007, Schlüter et al. 2012]. In this regard the appropriate inclusion of human decision making in models has been proven to be of fundamental importance [Parker et al. 2003, Bousquet & Le Page 2004, An 2012]. However, two substantial shortcomings in the current modeling practice can be stated: (1) The reasoning for the choice of a certain human decision model is often not well documented, insufficient empirical or theoretical foundations are given or the decision model is only ad-hoc assumed [Feola and Binder 2010]. (2) It is often not described in a transparent manner (clear and complete) which would allow reproducibility of the model and facilitate

communication of the model and its results [Polhill et al. 2008]. Consequently, model comparison and advancement is hampered to a large extent. Standardized protocols for (agent-based) model description such as the ODD protocol (Overview-Design Concepts-Details) [Grimm et al. 2006, 2010] may help to overcome these obstacles. However, the original ODD-protocol [Grimm et al. 2010] focuses primarily on ecological dynamics and the development of protocols similar to ODD for socio-environmental models aimed at modeling human decisions needs to be put on the future research agenda [An 2012].

Therefore we present and discuss an extension of the ODD-protocol, termed ODD+D (ODD + Decision). This paper is based on a working paper that describes in detail the ODD+D protocol [Müller et al. 2012]. We have asked presenters in the session “Human decisions in agent-based models for natural resource use” at the annual iEMSs 2012 conference to base their model description on this revised ODD version and to discuss its applicability and usefulness. Furthermore the protocol will be discussed in a workshop “Human decisions in agent-based models (ABM) for natural resource use - need for protocols” during the same conference. Together with the position paper we have developed a template with questions that have to be answered in the process of modelling description. This template will also be discussed during the session and the workshop and it will be available on our homepage after the conference <http://www.ufz.de/index.php?de=10464>.

Structural changes between ODD and ODD+D

Structural changes between ODD and ODD+D have been performed, that have been motivated by two purposes: Firstly, to integrate aspects inherent to human decision-making into the ODD protocol and, secondly, to elaborate and add some categories in general, based on our experience in using ODD. However, the main idea is to preserve the basic structure of the ODD protocol, in order to foster the establishment of ODD as a standard. Additional design concepts of ODD+D are “Theoretical and empirical background”, “Individual decision making” and “Heterogeneity”. In ODD+D, the focus lies on the newly included encompassing category on “Individual decision making”. We deleted “Adaptation” as separate design concept, because we see adaptation as part of “Individual Decision Making”: When an agent adapts its behavior to changing socio-environmental conditions, the decision methods over time remain the same. In contrast to adaptation we consider learning as a process where the structure of the decision process changes substantially. For instance if the parameterization of a decision rule is updated due to changes in the environment we consider this as adaptation in contrast to a new equation including different variables which we would consider as learning. Furthermore the category “Implementation details” was added in the Details part. An overview of all changes is displayed in **Table 1**, and a detailed explanation is given in the following paragraphs.

The category “Basic Principles” was renamed to “Theoretical and Empirical Background” and expanded in order to emphasize the importance of information about the sources of the assumptions and data used in a model. The ODD category “Objectives” has been merged into the newly created category “Individual decision making”. The categories “Sensing” and “Prediction” have been expanded and their order reversed, to reflect the characteristics and timeline of human decision-making. For the same reason, the category “Interaction” was expanded. The category “Heterogeneity” was introduced, as it is a property which often distinguishes ABMs from other models, and can, therefore, provide a good impression of their characteristics. The category “Stochasticity” was moved before “Observation”. The category “Emergence” was moved into the category “Observation”, to lower the risk that users might mistake it for a feature to be constructed, rather than an outcome of the model. Finally, the category “Implementation Details” was included in the Details part, since we believe that this information will improve comparability and reproducibility.

Table 1: Structural changes between ODD and ODD+D. New categories are bold.

| | ODD | ODD+D |
|-----------------|--------------------------------------|---|
| Overview | Purpose | Purpose |
| | Entities, state variables and scales | Entities, state variables, scales and exogenous |
| | Process overview and scheduling | Process overview and scheduling |
| Design Concepts | Basic Principles | Theoretical and Empirical Background |
| | <i>Emergence</i> | |
| | | Individual Decision Making (incl. Objectives and Adaptation) |
| | Adaptation | |
| | <i>Objectives</i> | |
| | Learning | Learning |
| | | Individual Sensing |
| | Prediction | Individual Prediction |
| | Sensing | |
| | Interaction | Interaction |
| | Stochasticity | |
| | Collectives | Collectives |
| | | Heterogeneity |
| | Stochasticity | |
| Observation | Observation (incl. Emergence) | |
| Details | | Implementation Details |
| | Initialization | Initialization |
| | Input Data | Input Data |
| | Submodels | Submodels |

Discussion

Using standardized protocols for describing simulation models generally provides a lot of advantages [Grimm et al. 2010]: The experienced scientific audience can understand models described with a standardized protocol more easily; and meta-analysis on existing models is facilitated. Referees of scientific articles may find it easier reviewing a manuscript that draws upon such a protocol. Modelers do not have to care about the structure of their model description, as the structure is already given by the protocol. And finally, modelers-to-be might seek guidance on what aspects of a model have to be conceptualized and thought about before implementing it. Thus, communication about ABMs including human-decision making might similarly benefit from the ODD+D protocol.

In the ODD+D protocol, questions on the theoretical background of the model are raised. Without explicitly stating the theoretical or conceptual background, the audience might interpret the model in a wrong way. Metaphorical and theoretical plasticity is also an issue for modeling human decision-making, as different scientific disciplines use a variety of approaches for conceptualizing decision-making. Even in a single discipline, different schools of thought have specific, often implicit assumptions about human decision-making. Without knowing the exact theoretical or conceptual background, scholars from different disciplines or schools might interpret the same model description in a totally different way and come to different conclusions. To facilitate communication about human decision-making

implemented in ABMs, it is thus extremely important to describe both theory or concepts and the implementation of the models.

In sum, the ODD+D protocol shall foster the explicit description of the theoretical background of ABMs incorporating human decisions and important details of the model implementation. This enables the scientific community to reproduce simulation results and to further develop already existing models. Finally, a widespread usage of a protocol such as ODD+D would clearly facilitate model comparisons focused on human decisions and thus answer the “particular need for research that compares these decision-making models to extant theory, practice, and observation of the real world” [Parker et al. 2003]. However, such a standardized protocol must evolve from a debate of the modeling community and therefore we hope that the session and the workshop on the biannual meeting of the iEMSs in Leipzig will bring us one step closer to an accepted standardized model description protocol.

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