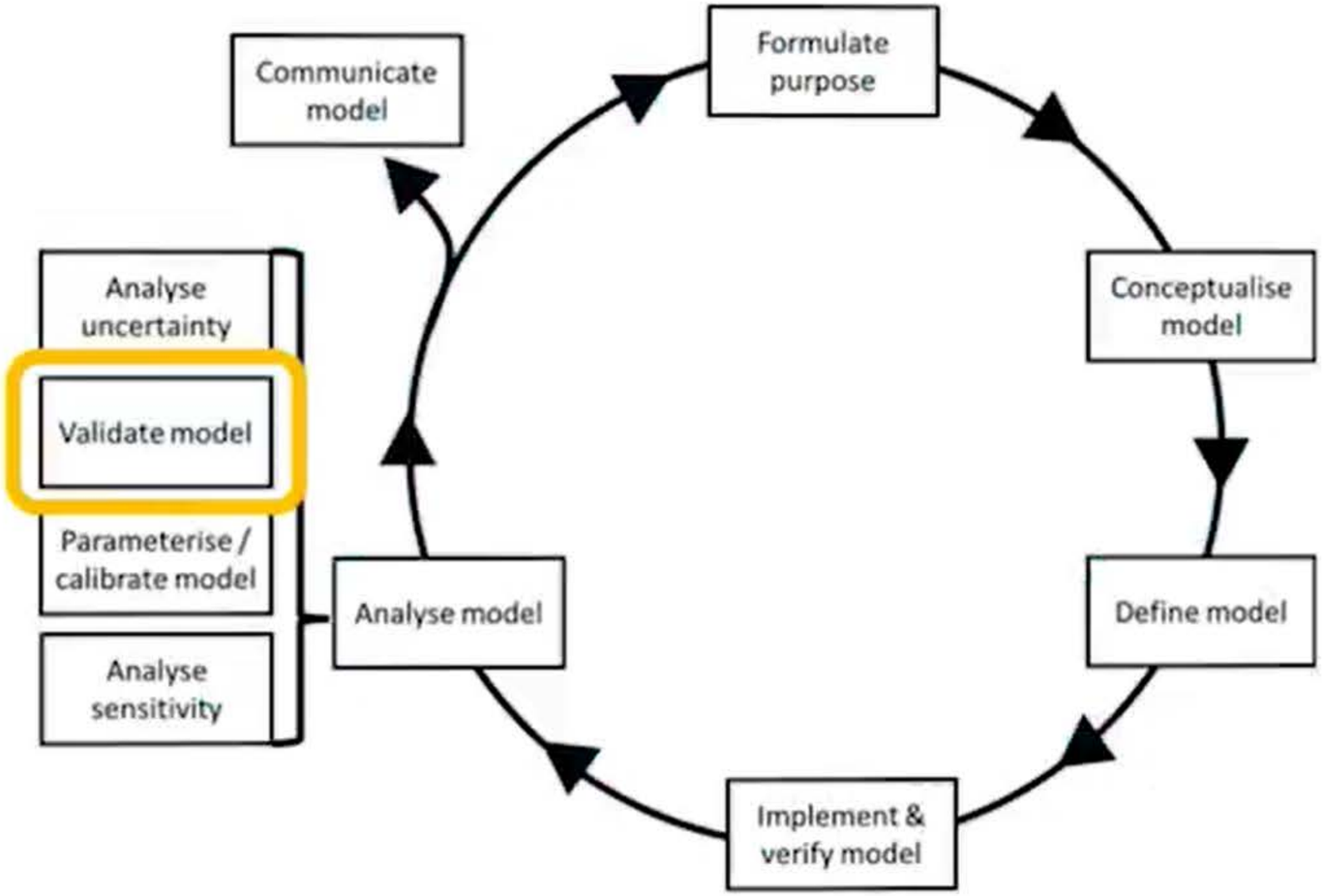
VALIDATION



Source: Own elaboration based on Grimm & Railsback (2005) and de By et al. (2013)

MODEL VALIDITY = ADEQUATE FOR ITS PURPOSE

An et al. (2021)

CHOOSING THE VALUE

- Input validation
- Process validation
- Descriptive output validation
- Predictive output validation

An et al. (2021)

TRACE PROTOCOL

TRAnsparent and
Comprehensive
Ecological
modelling
documentation

Grimm et al. (2014)

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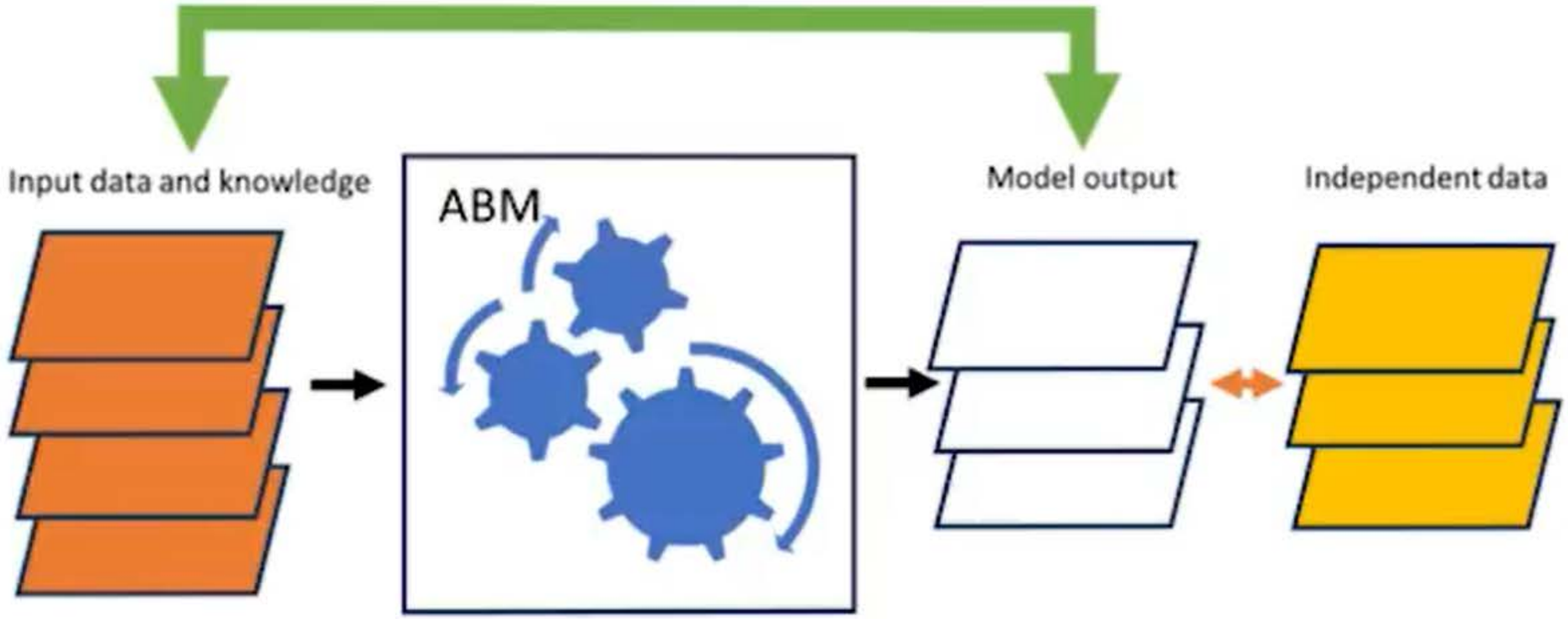
PREDICTIVE OUTPUT VALIDATION



- Input validation
- Process validation
- Descriptive output validation
- Predictive output validation

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How to keep it adequate: A protocol for ensuring validity in agent-based simulation

Christian Troost [a,*], Robert Huber [b], Andrew R. Bell [c], Hedwig van Delden [d], Tatiana Filatova [e], Quang Bao Le [f], Melvin Lippe [g], Leila Niamir [h], J. Gareth Polhill [i], Zhanli Sun [j], Thomas Berger [a,k]

[a] Hans-Ruthenberg-Institute, Universität Hohenheim, Wollgrasweg 43, 70597, Stuttgart, Germany
[b] Agricultural Economics and Policy Group ETH Zürich, Switzerland
[c] Earth & Environment Department, Boston University, Boston, MA, USA
[d] Research Institute for Knowledge Systems (RIKS), Maastricht, the Netherlands
[e] Multi Actor Systems Department, Faculty of Technology Policy and Management, TU Delft, the Netherlands
[f] International Center for Agricultural Research in the Dry Areas (ICARDA), Cairo, Egypt

Troost et al. (2023)

How To Validate Agent-Based Model – Summary of Video

- In this lecture, we will discuss how to check whether your model is adequate for its intended purpose. The technical term for this is validation.

- Scientific journals, but also stakeholders, will ask you for model validation. Luckily, there is a whole protocol developed that can help you document your model evaluation efforts.

- Let's look at our workflow of working with an agent-based model.

- Validating your model is part of the model analysis. So, most steps already need to be covered, including a sensitivity analysis and the parameterization. Without this validation step, you don't know whether you can trust your model.

- Therefore, I also validate my own models, and I'm glad to share some lessons learned with you.

- Unfortunately, there's no consensus in the modelling community regarding what exactly validation is and which aspects it covers. If you search for the term, for example, you might come across a very narrow definition.

- A model is validated if you can make predictions about independent data that were not used for setting up the model. However, this definition is clearly way too narrow for agent-based models, and you will see why in a moment.

- Here, we rather say a model is validated if it is adequate for its intended purpose. Therefore, it is important to be clear about the model purpose, and we even have a separate lecture on model purposes.

- **So, what does adequate for its intended purpose mean? How can we check that?**
    - Ahn and colleagues **distinguish 4 different aspects of empirical validation.**
        1. **Input validation:**
            - Are the inputs to the model meaningful?

        2. **Process validation**:
            - How well do the processes represented in the model reflect the real world for the model purpose?

        3. **Descriptive output validation:**
            - How well can the model output capture the features of the data used to build the model?

        4. **Predictive output validation:**
            - Is the model able to forecast for sample data not used for model building or data only acquired later or for another case study?
- **Only this last aspect is what the narrow definition of validation, which I mentioned earlier, refers to. But model validation should be much larger than that.**

- **Let's look at each of these four aspects of validation in more detail.**

- From now on, I will often refer to the so-called **TRACE protocol.**

- **TRACE** stands for **Tra**nsparent **and C**omprehensive **E**cological **Modeling Documentation** and has useful tips how to conduct the validation and how to transparently share the information.

- **Let's imagine we have an AVM with some processes, input data, and knowledge going into the model and some model output.**

    1. **Input validation is then the orange part in this figure.**
        - **Are the inputs to the model meaningful?**
            a. This question refers to the quantitative and qualitative data you use to design and parameterize and or calibrate your model.

            b. Critically reflect on these inputs and their sources.

        - **How could you document the input validation?**
            a. You can document the input validation by listing all data sources that you use for designing and parameterizing the model.

            b. References, data sources, or information about the data collection process.

    2. **Process validation is highlighted in blue.**
        - **How well do the processes represented in the model reflect the real world for the model purpose?**
            a. In this step, you are asked to assess the simplifying assumptions inherent to your model design.

        - **Which spatial and temporal scales did you choose and why not others?**

        - **Which entities did you select and which ones not?**

        - **Which processes are included and what is covered with stochastic elements?**

        - **How did you incorporate interactions?**

        - **This is the moment to also reflect on which theories or concepts have influenced your choices and how and whether other models played a role in your design.**

3. **Descriptive output validation in green.**
    - **How well can the model output capture the features of the data used to build the model to make this more tangible?**
        a. Models are supposed to reproduce some real-world patterns.

        b. Your knowledge about those real-world patterns enabled you to build your model in the 1st place.

        c. For the descriptive output validation, you list these real-world features and which criteria you used to say yes, this model indeed can simulate them.

4. **Predictive output validation in yellow.**
    - **Is the model able to forecast for sample data not used for model building? Or data only acquired later or for another case study.**

    - **If this is not possible because no independent data is available, you should still discuss why the model should be trusted.**

5. **The very narrow definition of validation that I mentioned earlier is only about this. Last step, and now it is clear why this is too narrow for us.**
    - **For example, if you focus on predictive output validation only, you might still have the wrong processes included that happen to produce the required output patterns.**

    - **If your model purpose is to explain something, the model would then still not be adequate for its purpose.**

6. **This example also makes clear that for all of these reflections on model validity, it is important to consider the intended purpose of the model.**

7. **There are many different methods available to assess to what extended simulation model relates to empirical data.**

8. **Deciding which method or combination of methods is needed is complex because the type of research question and the data and knowledge availability and uncertainty also influence what can be done.**

9. **A lot more details on this are given in the protocol for ensuring validity in agent-based models by Trost and colleagues.**

For today, we will leave it here by distinguishing input validation, process validation, descriptive output validation, and predictive output validation.

Validation entails a lot of steps and therefore time and effort. However, it is worth investing that time since you want to trust in your own model.

Interesting model outcomes should indeed be the result of relevant model processes and input data, not some error in your code or a process not well represented in the model. This is even

more important if your model will inform stakeholders and policy making. This is the reason why not only scientific journals but also stakeholders will ask you for model validation.