

A tiered guide to communicate modelling, not models



<https://www.istockphoto.com/de/fotos/pesticide-application>

Volker Grimm

Context and content

- Not mathematics per se, but models (mathematical and simulation)
- Not public per se, but regulatory authorities (regulators)
- Risk assessment of pesticides
- Ecological models (cream-itn.eu)
- TRACE documents
- Three screening questions (general)
- Tiered approach to communication

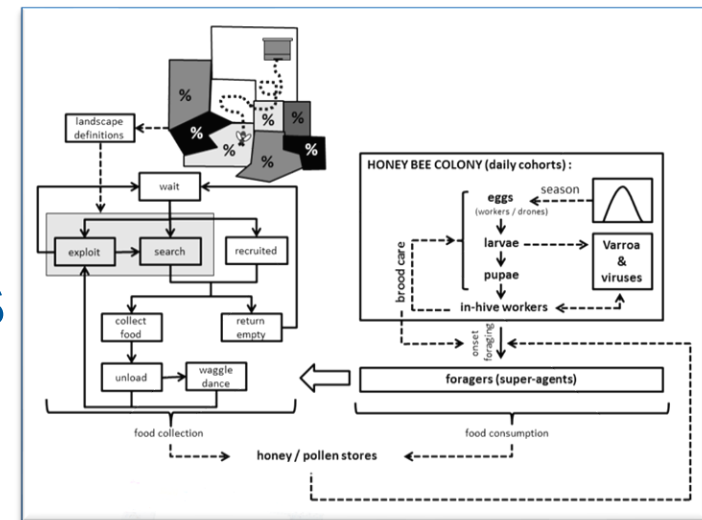
Ecological risk assessment of pesticides

- For pesticide registration, elaborate tests according to guidance documents have to be performed
- European Food Safety Authority (EFSA), UK: Health and Safety Executive (HSE)
- **Risk quotient = Exposure / Toxicity [e.g. LD50]**
- Below threshold: risk acceptable
- Uncertainty: safety factor (10, 100, 1000)
- Tiered approach: from lab to field experiments

Increasing ecological realism

Uncertainty: safety factors (10, 100, 1000) are fully arbitrary

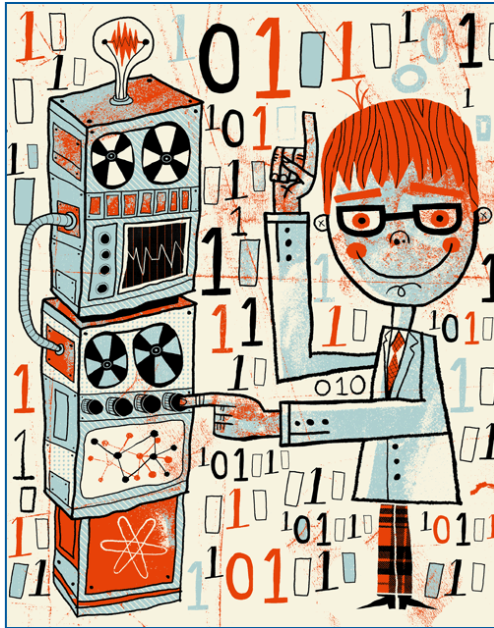
Ecological models: translate lab effects on individuals to realistic effects on populations



www.beehave-model.net

The problem

Modeller



Decision maker



Decision making – risk assessment

- Models are simplified representations to answer specific questions
- Models leave out many factors, and represent others in a much simplified way

Why should I base any decision affecting the real world on the output of a simplified, and possibly inappropriate representation?

What do we need to base decisions on models?

- What IS the model? Conceptually and formally
- Why has it been designed this way?
- Has it been correctly implemented?
- Has it been thoroughly analyzed?
- Are the main effects well understood?
- How sensitive is model output to changes in parameters and model structure? How uncertain is model output?
- **What are the indicators that the model is a sufficiently good representation of its real counterpart?**

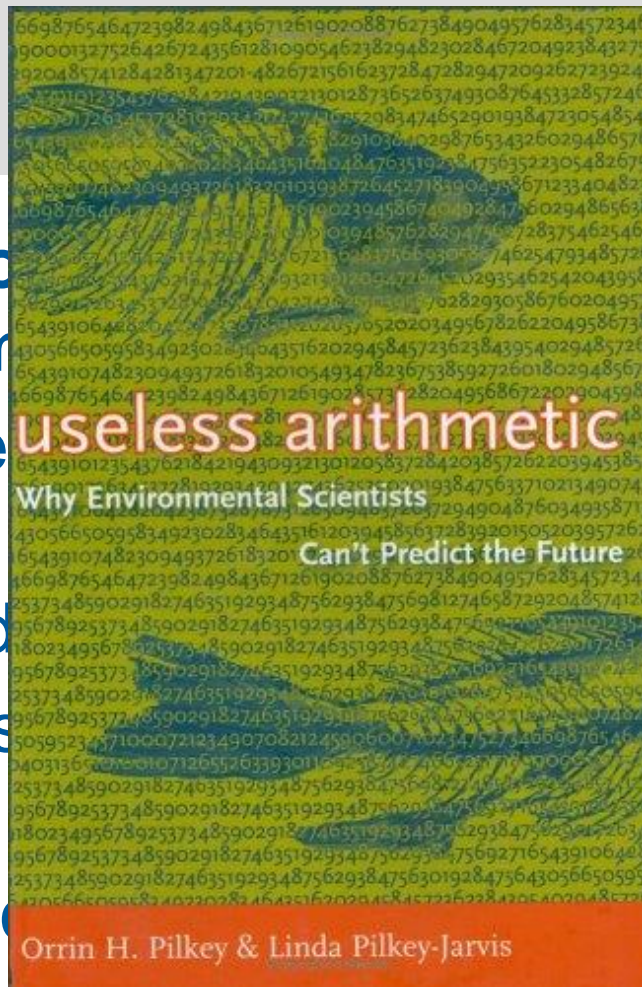


Decision makers – risk

How can they answer all the questions about a model used in a dossier (and its predictions)?

- No training in ecological/mechanistic modelling
- No time to check every model
- No clear idea how to assess model quality, and its predictions

- Just reject model-based risk assessments?
- Just accept model-based risk assessments, if others did it before, or if it looks OK?



How to solve the communication problem

- Models are presented as static entities
- >95% of what modellers do remains undocumented
- We need a **standard** way of documenting (and planning) model development and testing

- What IS the model? Conceptually and formally
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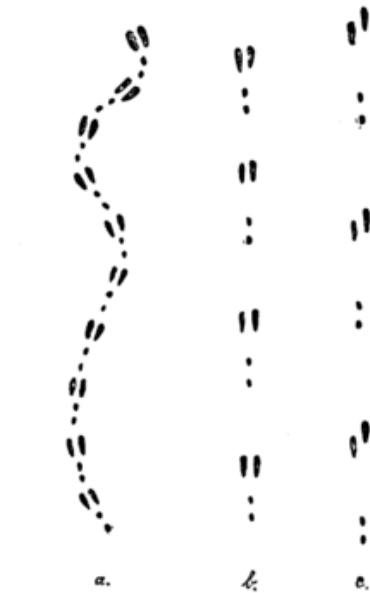
LINKING TRACE AND EVALUATION

TRACE documents:

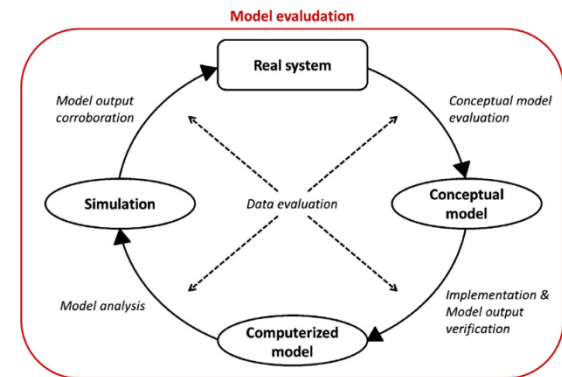
- A standard format for organizing and documenting the elements of model evaluation
- A means to an end: documenting to what degree and how **good modelling practice** was followed

EVALUATION:

‘The entire **process** of establishing model quality and **credibility** throughout all stages of model development and application’ (Augusiak et al. 2014)



J. Augusiak et al. / Ecological Modelling 280 (2014) 117–128





ELSEVIER

Contents lists available at [ScienceDirect](#)

Ecological Modelling

journal homepage: www.elsevier.com/locate/ecolmodel

Towards better modelling and decision support: Documenting model development, testing, and analysis using TRACE

Volker Grimm^{a,b,c,*}, Jacqueline Augusiak^d, Andreas Focks^d, Béatrice M. Frank^e,
Faten Gabsi^f, Alice S.A. Johnston^g, Chun Liu^{g,h}, Benjamin T. Martin^{a,i}, Mattia Meli^j,
Viktoriia Radchuk^{c,e}, Pernille Thorbek^h, Steven F. Railsback^k

TRACE TEMPLATE

In your paper/report/dossier you refer to the TRACE document:

“In the Supplementary Material, we provide a TRACE document (“TRANSPARENT and Comprehensive model Evaluation”; Schmolke et al. 2010; Grimm et al. 2014; Augusiak et al. 2014) containing evidence that **our model was thoughtfully designed, correctly implemented, thoroughly tested, well understood, and appropriately used for its intended purpose. A summary of the TRACE document is given in Table <..>.”/**

TRACE TEMPLATE

Contents

1	PROBLEM FORMULATION	2
2	MODEL DESCRIPTION.....	2
3	DATA EVALUATION	3
4	CONCEPTUAL MODEL EVALUATION.....	3
5	IMPLEMENTATION VERIFICATION.....	3
6	MODEL OUTPUT VERIFICATION.....	4
7	MODEL ANALYSIS.....	4
8	MODEL OUTPUT CORROBORATION	4

Template: 1. Problem formulation

1 Problem formulation

This TRACE element provides supporting information on: The decision-making context in which the model will be used; the types of model clients or stakeholders addressed; a precise specification of the question(s) that should be answered with the model, including a specification of necessary model outputs; and a statement of the domain of applicability of the model, including the extent of acceptable extrapolations.

Summary:

<Provide here a concise summary of this element, e.g. brief text and/or a bullet point list. If you use lists, make sure that elements in the list match exactly the headings of the corresponding part in the text. If this TRACE element is long, the summary list should include page numbers/hyperlinks, or subheadings and a corresponding TOC with page numbers and hyperlinks. Use your word processing software to create hyperlinks and page numbers which are automatically updated. Please keep bold font and indentation for the summary.>

<Table of contents – optional>

<Your text>

Good examples of trace documents exist

- The template works quite well
- Typically 20-30 pages
- Can also be much longer (Daniel Ayllón: 110 pages)
- TRACE: “TRANSPARENT and Comprehensive model Evaluation”

Readers know where to find what kind of information. TRACE provides supporting evidence and thereby increases a model's credibility

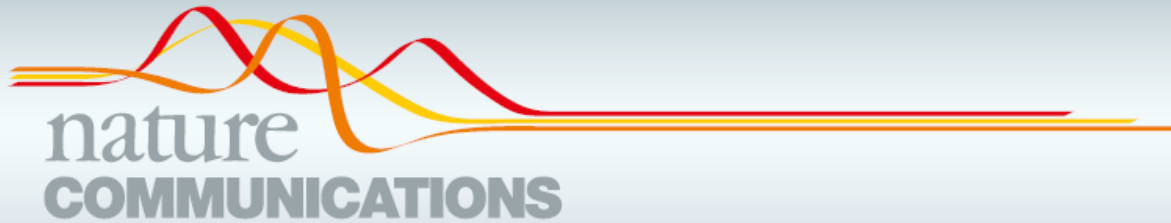
But ..

- **TRACE is for those who, in principle, have to evaluate models**
- **What about those who have to make decisions but who are not expected to go into details (media, politicians, managers, “the public”)?**

Recent example: Covid-19 pandemic, which lead to a flood, if not tsunami, of models

➤ Our approach: TRACE includes the answers, but what are the right questions to ask?

Three questions to ask







COMMENT

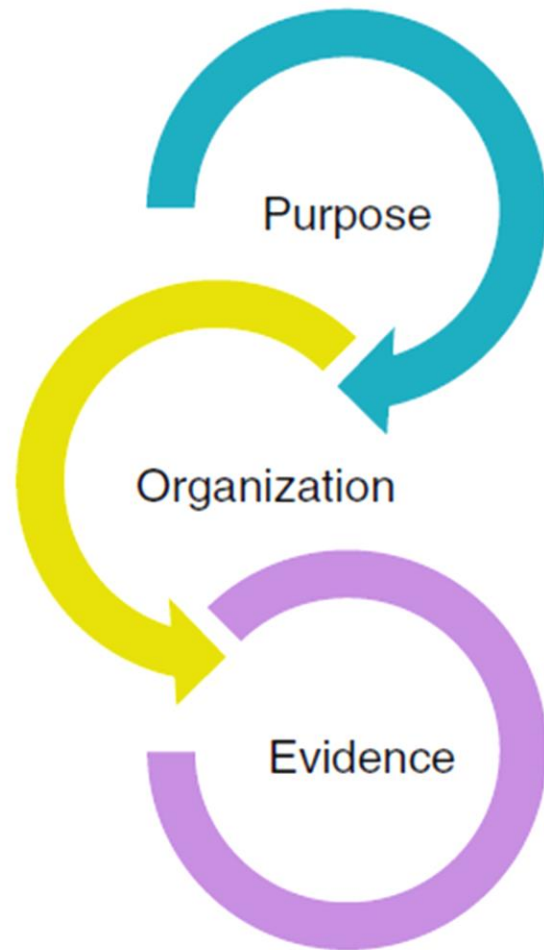
<https://doi.org/10.1038/s41467-020-17785-2>

OPEN

Three questions to ask before using model outputs for decision support

Volker Grimm ^{1,2}✉, Alice S. A. Johnston ³, H.-H. Thulke ¹,
V. E. Forbes ⁴ & P. Thorbek⁵

Screening questions



The model should be transparently and comprehensively documented and communicated (e.g. TRACE, ODD).

What is the model's purpose? Was the model designed to demonstrate, understand, or predict real-world system dynamics? Is the model's domain of applicability suitable to address the proposed questions?

How is the model organized? What are the entities and their state variables? What processes are modeled, and how do these processes link entities to system dynamics? What is the temporal and spatial resolution?

Is there evidence the model works? What patterns can the model reproduce? Can the model make independent predictions, and under what conditions?

The three screening questions support decision makers to assess whether a model is suitable for addressing real-world decisions and provide a common language for communication.

Time for a new standard quote

**“All models are wrong, but some are useful”
(George Box, 1978)**

- **Right, but this misses a key point for model communication**

**“All models look right, but how do we know?”
(Volker Grimm, 2023)**

- **Create a culture of asking the right questions about models!**
- **Communicate the answers before these question are asked!!!**

Summary: Tiered approach

- **Start from screening questions**
Create sensitivity towards purpose, model assumptions/structure, and evidence for realism
- **Make sure the answers can easily be found (TRACE or similar)**
- **Compare and assess different models addressing the same question/system in a more systematic way**

Thank you for your attention!

Models for application: a challenge

How to make socio-environmental modelling more useful to support policy and management?

Meike Will¹  | Gunnar Dressler¹  | David Kreuer¹  | Hans-Hermann Thulke¹ 
Adrienne Grêt-Regamey²  | Birgit Müller¹ 

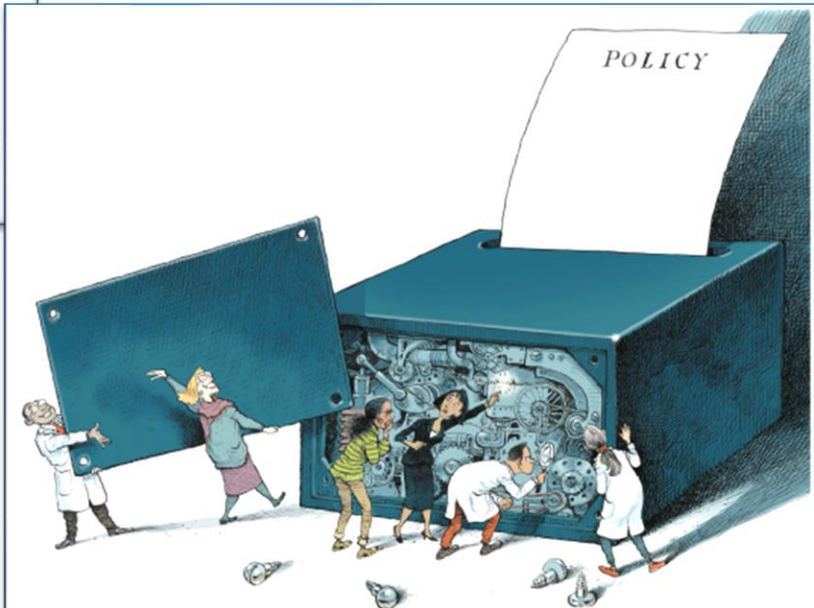
Three questions to ask before using model outputs for decision support

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Review

Communicating complex ecological models to non-scientist end users

Samantha J. Cartwright^{a,*}, Katharine M. Bowgen^b, Catherine Collop^c, Kieran Hyder^d,
Jacob Nabe-Nielsen^e, Richard Stafford^f, Richard A. Stillman^g, Robert B. Thorpe^h,
Richard M. Siblyⁱ



Five ways to ensure that models serve society: a manifesto

Andrea Saltelli, Gabriele Bammer, Isabelle Bruno, Erica Charters, Monica Di Fiore, Emmanuel Didier, Wendy Nelson Espeland, John Kay, Samuele Lo Piano, Deborah Mayo, Roger Pielke Jr, Tommaso Portaluri, Theodore M. Porter, Arnaud Puy, Ismael Rafols, Jerome R. Ravetz, Erik Reinert, Daniel Sarewitz, Philip B. Stark, Andrew Stirling, Jeroen van der Sluijs & Paolo Vineis

Template: 2. Model output corroboration

This TRACE element provides supporting information on:

- **How model predictions compare to independent data and patterns that were not used, and preferably not even known, while the model was developed, parameterized, and verified.**

By documenting model output corroboration, model users learn about evidence which, in addition to model output verification, indicates that the model is structurally realistic so that its predictions can be trusted to some degree.