SAS24 – Modeling for policy

Panel on AI & Society organized by Gesellschaft für Wissenschaftsforschung (GeWif)

Date: November 25th - 27th 2024

Location: High-Performance Computing Center Stuttgart, Nobelstraße 19, 70569 Stuttgart, Germany

Room: 0.439 Rühle Saal

Format of talks: 20 min presentation + 10 min discussion.

Format of keynotes: 40 min presentation + 20 min discussion.

	25.11. Monday	**26.11. Tuesday**	**27.11. Wednesday**
8:30	Reception	Reception	Reception
9:00	**Keynote Alyssa Bilinsky**	**Keynote Stephanie Harvard**	Modeling for Policy
10:00	Coffee Break	Coffee Break	Coffee Break
10:30	Values in Modeling	Values in Climate Modeling	Trusting Models
11:30	Coffee break	Coffee break	Coffee break
12:00	Transdisciplinary model building	Climate Modeling	Energy Models and policy
13:00	Lunch break	Lunch break	Lunch break
14:30	**GeWif Panel Keynote - Reinhard Kahle**	Uncertainty in Modeling	Values in Modeling 2
15:30	Coffee break	Coffee break	Coffee break
16:00	**GeWif Session 1**	Assumptions in Modeling	Modeling for Policy 2
17:00	Coffee break	End	Guided tours: CAVE and Computing Room
17:30	**GeWif Session 2**		End
18:30	Uni Thekle (self-pay, cash only!)		

Sessions and Abstracts

Keynotes

From Napkin Math to Test-Driven Development: Why Simple Models Matter (More) in an Era of High-Performance Computing

Alyssa Bilinski (Brown University)

Over the past few decades, researchers have seen rapid advancements in computational power, allowing for development and dissemination of complex statistical and mechanistic models. Amidst this backdrop, I will argue that simple models remain critical for policy – both on their own and as complements to more complicated "black boxes." I will begin by highlighting key features that differentiate policy modeling from other common prediction problems, including discrete (often binary) decisions; diverse, user-specific objectives; and asymmetric costs between false positives and false negatives. I will then illustrate, with examples from disease simulation modeling, several insights from simple models:

1) "Aiming off" -- Understanding what does (and does not) matter your decision
2) "It's all linear" – Knowing when complex models are simple models in disguise and why this helps us understand how (and whether) to use them
3) "Test-driven development" – Applying simple models to improve complex ones

Moral Models: Policy-making in the Age of Computer Simulation

Stephanie Harvard (University of British Columbia)

What does it mean to say that models are "value-laden" and why does it matter? In this presentation, we will address these questions, along with philosophical proposals for how to appropriately manage value-laden decisions in science, such as those that arise in policy-oriented modelling. Using a case study in health economics modelling in the context of climate change, we will identify philosophical and practical challenges that complicate the idea of 'values management' in policy-oriented modelling and consider to what extent those challenges can be overcome. Finally, we will consider the goal of achieving 'trustworthiness' in policy-oriented modelling, and reflect on what responsibilities modellers must uphold in order to warrant public trust.

GeWif Keynote: AI and Society

Reinhard Kahle (Uni Tübingen) / Chair and Introduction Harald Mieg (Humboldt Uni)

[Abstract tba]

Sessions Monday

Values in Modeling

Decision-Focused Learning and Values in Machine Learning

Sebastian Zezulka, Konstantin Genin (Uni Tübingen)

A prominent tradition in the philosophy of science, going back at least to Rudner (1953) and given canonical expression in Douglas (2000), argues that non-epistemic values have a central role to play in every stage of the scientific process. Defenders of the value-free ideal, such as Du Bois (1898, 1935) and Bright (2018), argue that allowing non-epistemic values to encroach on the scientific process undermines

trust in science, which should rather proceed on epistemic grounds alone. An analogous debate is currently animating machine learning. On the standard approach, many machine learning problems are factored into two independent stages: the prediction stage, in which purely epistemic values of predictive accuracy apply, and the optimization stage, in which predictions are used to guide socially-relevant distributive decisions. For example: in the prediction stage, an algorithm might estimate the probability with which a recently unemployed person will become long-term unemployed; in the optimization stage, positions in desirable training programs are allocated on the basis of predicted risk in order to minimize some social loss function (Zezulka and Genin, 2024). An emerging paradigm, called “decision-focused” learning, argues that factoring these kinds of problems into two independent stages sacrifices distributive optimality at the altar of predictive accuracy. They propose that prediction and optimization be integrated in an end-to-end system trained to optimize a loss function based on the resulting distributive decisions (Mandi et al, 2024). In other words, decision-focused learners argue that there is no independent predictive context in which only the value of predictive accuracy reigns. We argue that developments in decision-focused learning allow us to identify precisely those contexts in which it is possible to factor prediction and allocation and those in which such a factorization comes at the price of distributive optimality.

Bright, L. K. (2018). Du Bois’ democratic defence of the value free ideal. Synthese, 195(5), 2227-2245.
Douglas, H. (2000). Inductive risk and values in science. Philosophy of science, 67(4), 559-579.
Du Bois, W. E. B. (1898). The study of negro problems. The Annals of the American Academy of Political and Social Science, 11(1), 1–23.
Du Bois, W. E. B. (1935). Black reconstruction in America. New York: The Free Press.
Mandi, J., Kotary, J., Berden, S., Mulamba, M., Bucarey, V., Guns, T., & Fioretto, F. (2023). Decision-focused learning: Foundations, state of the art, benchmark and future opportunities. arXiv preprint arXiv:2307.13565.
Rudner, R. (1953). The scientist qua scientist makes value judgments. Philosophy of science, 20(1), 1-6.
Zezulka, S., & Genin, K. (2024, June). From the Fair Distribution of Predictions to the Fair Distribution of Social Goods: Evaluating the Impact of Fair Machine Learning on Long-Term Unemployment. In The 2024 ACM Conference on Fairness, Accountability, and Transparency (pp. 1984-2006).

Epistemic Commitments Have No ‘Off’ Button: On the Embodiment of Commitments by Way of Model Formulation.

Zvi Hasnes-Beninson (Tel Aviv University)

Given the prominent role that models play in modern science, it is not surprising that philosophers of science have dedicated much effort to studying a broad range of model-related issues. One issue that exceeds the boundaries of philosophical discourse and has real-life implications is model-based public policy (MBPP). When discussing MBPP, it is important to note that models do not only inform public policies, but they are also informed by values and norms. My paper addresses this point and aims to show how models serve to introduce an agent’s epistemic commitments to the community to which that agent relates.

Epistemic commitments characterize individual agents. However, at the level of a community, it is more appropriate to discuss epistemic standards to which the community adheres. Addressing the issue of commitments that a model embodies requires several steps. The first step concentrates on the definition of epistemic commitments and my paper relies on the relevant literature that deals with that issue. However, I highlight some characteristics of commitments that are not handled by that literature, for example, epistemic commitments contain both evaluative and non-evaluative aspects, and are in this sense “thick”.

Once the main characteristics of commitments are defined, the second step is to demonstrate how commitments with those features are introduced to an epistemic community, such that the community adopts those commitments as standards. My paper focuses on model formulation as the mechanism through which such introduction takes place. An important distinction in my paper is between “model” as a complete artefact that can be used in various ways for various ends, and the process of formulating that artefact. Model formulation is a common practice, but it is the artefact, not the practice, that must meet epistemic standards so that the output of the model be rendered as “knowledge”. Put differently, a modeler could give her commitment a formal representation as a modeling assumption, thereby introducing that commitment to a given research community, while the practice that makes this introduction is not scrutinized.

Finally, since the discussion in the first two steps is abstract, the third step demonstrates the analytical framework with a case study. My paper focuses on Richard Levins’ approach to loop analysis, and especially the way it embedded his commitment to a dialectical view of nature, a methodological commitment that derived from his interpretation of the Hegelian-Marxist tradition. Two general

conclusions can be drawn for the case study: first, once a commitment is formalized, it can be rejected, but on grounds that differ from the motivations behind it. Second, the success of an agent to persuade her community to adopt her commitments as general standards could be measured in terms that differ from the agent's.

Boumans, M. (1999). Built-In Justification, in: Morgan M.S. & M. Morrison (eds.), *Models as mediators: Perspectives on Natural and Social Sciences* (pp. 66-96). Cambridge University Press.
Justus, J. (2006). Loop Analysis and Qualitative Modeling: Limitations and Merits. *Biology and Philosophy*, *21*(5), 647–666.
Levins, R. (1975). Evolution in Communities Near Equilibrium. In M. L. Cody & J. M. Diamond (Eds.), *Ecology and Evolution of Communities* (pp. 16–50). Harvard University Press.
Lynch, M. P. (2014). *In Praise of Reason: Why Rationality Matters for Democracy*. MIT Press.

Transdisciplinary model building

Fostering SSH integration into energy modeling: lessons learned from literature and Swiss energy research projects

Konstanty Ramotowski, Bianca Vienni-Baptista (ETH Zürich)

The integration of Humanities and Social Sciences into energy research and modeling has become a source of lively debate in the energy research field in recent years. It is seen as an opportunity for advancing models and improving their representation of reality, social relevance, and transparency. This paper presents the results of a literature review and a case study investigating the goals, challenges, and successful practices and methods of integrating Social Sciences and Humanities (SSH) into energy research, scenario building, and modeling. The scope of the paper includes: (i) a systematic review of the international literature on the integration of SSH in energy modeling; and (ii) a case study embedded in the literature derived from past collaborations in inter- and transdisciplinary research settings in Switzerland, that involved the integration of SSH in energy modeling.
Thanks to the more than a decade-lasting commitment to advance research on energy, Switzerland, similarly to the UK, has already established a community of energy researchers, including SSH researchers, and has a record of cooperation between modelers and social scientists on energy-related issues. Government agencies such as the Swiss Federal Office of Energy (SFOE) and the Swiss National Science Foundation (SNSF) recognize transdisciplinarity as a promising approach to improve the energy transition process. Cutting-edge projects such as Co-evolution and coordinated simulation of Swiss Energy System and Swiss Society (CoSi) aim to provide energy models that integrate insights from the social sciences and humanities with techno-economic research, fostering collaboration across disciplines to address the complexities of the energy transition.
This creates a unique environment to investigate the integration of SSH in energy research and modeling, to explore the social aspects of the energy transition, and the possibilities that the transdisciplinary approach creates for advancing cooperation in energy research field. Based on the examples of SSH integration aims, methods and challenges coming from the international literature, as well as on the recommendations for possible improvements of the SSH integration process, this paper reviews the developments within the inter- and transdisciplinary research projects carried out in Switzerland to date, in order to identify possible knowledge gaps and priority areas for research and integration activities. Applying the multidimensional understanding of integration embedded in transdisciplinary perspective, we found that much work needs to be done at the organizational, communicative, and cognitive-epistemic levels to foster the integration process in Swiss energy research. Advancing research on energy will also require openness to different epistemic cultures and acknowledging the importance of emotional, as well as social-interactive factors in facilitating an integration process. We see transdisciplinarity as an important way to achieve a better collaborative practice, to address the challenges of energy transition and support science-based decision making.

Achieving Situation Awareness: Modeling Collaboration in Safety-critical Environments

Stefka Schmid, Christian Reuter (TU Darmstadt)

Modeling and simulation of collaboration in safety-critical environments have a long history. In the context of warfare, wargaming and mission engineering have focused on the anticipation of consequences of interactive decision-making processes and battlefield developments. Today, defense policy relies on

agent-based models and the evaluation of different future scenarios. Safety-critical environments, in which decisions are high stake and time is essential, also comprise domestic issues of “civil security” such as computer-supported emergency response. In these contexts, situation awareness has been identified as highly important. Our research focuses on how socio-technical practices of modeling relate to situation awareness. Relying on both HCI approaches concepts and critical security studies allows us to gain insight into how collaboration in safety-critical environments is anticipated through modelling and becomes trustworthy and routinized.

GeWif Session 1

Generation of Information - a Caveat for Creative Scientific Work? Learner Support in Times of Large Language Model Tools

Christian Stary (Johannes Kepler Universität Linz), Klaus Fuchs-Kittowski (Berlin)

In this contribution the process of knowledge generation is examined critically in the context of creative scientific work in academic education. We review insights into human and artificial knowledge generation and derive some guidelines based on classroom experiences with ChatGPT. It turns out hat each phase in developing creative scientific work skills requires specific consideration with respect to Large Language Model support. Large Language Model tools can be used in the course of capacity building based on generated information when being prompted in a context-sensitive way. However, a clear distinction must be made between generating and creating, between the algorithmic processing of information and genuinely creative human activity.

The Challenge for AI in Education: Ensuring Fair and Secure Learning Environments

Vlasta Sikimić (Eindhoven University)

The use of AI in education can improve the learning process and contribute to lifelong learning. AI helps create personalized study programs and supports students' needs. However, to ensure epistemic justice and general justice in education, we need to take care of the adequate representation of knowledge in the data. Moreover, we need to provide fair access to technology and learning for all students, especially those from underprivileged parts of the world. If the general goal of education is to help students become informed and responsible citizens of the world, this request becomes even more prominent. I will discuss the ways of using AI in education that promote equity, fairness, and inclusion and ensure that every student has the opportunity to succeed epistemically.

GeWif Session 2

Wissen in Zeiten von Künstlicher Intelligenz (in German)

Ralph-Miklas Dobler (Hochschule für angewandte Wissenschaften München)

Die Verbreitung von Künstlicher Intelligenz, insbesondere von Generativer Künstlicher Intelligenz innerhalb der Gesellschaft wächst. Die Produkte sowie die Nutzung finden bewusst oder unbewusst einen hohen Grad an Akzeptanz. Hauptsächlich Texte und Bilder vermitteln und bedingen das gesellschaftliche Wissen zunehmend. Dieser Wissenswandel wird zu einer Herausforderung für Bildung und Wissenschaft. Der Beitrag versucht die Entwicklung und ihre Folgen zu erfassen und in den größeren Horizont der Wissensgeschichte einzubetten.

Sessions Tuesday

Values in Climate Modeling

Assessing Feasibility with Value-laden Models

Simon Hollnaicher (Otto-von-Guericke-Universität Magdeburg)

Integrated Assessment Models, or IAMs, play a vital role in the science-policy interface and feature prominently in the Assessment Reports of the IPCC. IAM are computer models that combine (or “integrate”) a representation of the climate and earth system with socio-economic and technological modules to gain insights into climate mitigation. IAMs model pathways for different human- and climate-future, which are valuable in informing policymakers on climate solutions, and which are relied upon up by different research communities in the climate discourse.

The wider impact of the work of the IAM community is astonishing. IAMs have become one of the central tools in creating knowledge on climate solutions. For instance, a fifth of the publications in the IPCC AR5 came from the IAM discourse (van Beek u. a. 2022, 2), even though it represents only a small fraction of all publications on climate mitigation. Or, a recent framework on assessing scenario feasibility of different climate strategies, emerging in the IAM community (cf. Brutschin u. a. 2021), received its own section in the recent AR6. IAMs have a place in the sun when it comes to scientific assessments on climate change. However, this influence is far from uncontroversial. This talk investigates on one aspects of integrated modeling and its role in the science-policy-interface. It describes how Process-based-IAMs emerged as tools for providing scenario evidence on the feasibility of climate goals and mitigation strategies. This mode of modeling, which I refer to as "assessing feasibility," gained prominence with the adoption of the Paris Goals, which' feasibility was in question from the moment of their adoption. IAMs provide a valuable contribution in showing how these goals are attainable. The application of IAMs to the feasibility issue is, however, far from unproblematic. Based on philosophical literature, the talk will show that the concept of feasibility has a special normative role and is often used to demarcate descriptive aspects of a decision situation from the value questions that are relevant for it.
PB-IAMs, however, feature a range of value judgments, many of which lack sufficient value transparency and plurality in scientific assessments. Relying on modeled pathways to indicate the feasibility and infeasibility of different options, goals, or strategies raises therefore the question how modelers should deal with the value judgments in the models. If value judgments stay implicit in scientific assessments, they can have an undue influence on policy decisions and, thus, undermine the legitimacy of scientific advice to policymakers. The talk argues that it is important to increase value transparency and value plurality in regard to IAMs and gives a short outlook how this could be achieved in practice. As normative uncertainty is among the most significant kinds of uncertainty in modeling climate futures, there is a vital need for a research agenda that engages directly with the value dimension of IAMs.

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Brutschin, Elina, Silvia Pianta, Massimo Tavoni, Keywan Riahi, Valentina Bosetti, Giacomo Marangoni, und Bas van Ruijven. 2021. „A multidimensional feasibility evaluation of low-carbon scenarios". Environmental Research Letters 16 (6): 064069. https://doi.org/10.1088/1748-9326/abf0ce.

Going Beyond the Epistemic Limits of Climate Models

Futura Venuto (Uni Bern)

Climate models are proven to be inaccurate: not only are the variables involved usually non-linearly interdependent, but also many processes and factors are underdetermined or even unknown. Such limits lead to an epistemic discrepancy between the model output and the real-world observation. My interest lies in the tension between the accuracy and the usability of a climate model, aiming to answer the question of their value for policy.
There is common agreement on tackling such a problem by shifting from an epistemic perspective to an instrumental one, overcoming the inaccuracy problem by setting practical standards for usability (Jebeile and Roussos, 2023). Indeed, a model's predictive scope is not directly proportional to its ability to perfectly replicate the target system; as the 'adequacy-for-purpose' view suggests, climate models can be considered representational tools that serve specific representational goals (Parker, 2020). I consider it more useful to focus on how the climate system might be, assuming that hypotheses and results describe real possibilities since this perspective implicitly involves a further assessment of the outcome likelihood (Katzav, 2014).
Such a perspectivist approach becomes relevant when accounting for how models can inform policymaking. Indeed policymakers are epistemically dependent on the claims of the scientific community, and therefore scientific interpretation of the model is crucial since it leads to significantly different courses of political action. Any consideration of how probable it is for a particular outcome to occur within the actual climate system involves assessing, evaluating, and ranking scenarios according to their likelihood or remoteness. For instance, a climate model meta-analysis suggests that for many species, a higher extinction risk is a real possibility influenced by anthropogenic climate change, making it less remote than it would be without human influence (Urban, 2015). This implies that climate models, considering all their limits, do require heavy interpretation on the scientist's side, thus inevitably involving both epistemic and non-epistemic judgments.
My aim is to offer an account of how scientists can inform policymakers based on their models. First of all, I assume that a perspectivist attitude is the right approach to understanding how models can provide relevant information for policy. Such a perspective implies that scientists evaluate scenarios according to their potentiality, and for this, they need to rely on non-epistemic judgments. I ultimately want to argue

that climate scientists are justified in exercising their non-epistemic judgments without undermining the scientific value of their claims, and therefore, their relationship with policymakers. Inspired by the traditional challenge to the fact-value dichotomy, my argument relies on the definition of expertise (Majszak and Jebeile, 2023). Indeed, professional experience involves not only theoretical knowledge but also practical skills, intuition, and shared values, a skill set that as a whole allows scientists to overcome any epistemic gap intrinsic in their research field.
Therefore, experts' assessments of climate models constitute a robust epistemic foundation for policymaking. Even if relying on non-epistemic judgments goes against the traditional objective ideal in science, such judgments possess a crucial value in terms of their practical usefulness, representing the best available tool for informed decision-making in the face of climate research uncertainty. By going beyond the inherent limits of climate models, experts are able to build up incomplete and imperfect data, ensuring that policy decisions are supported by the most valuable information available.

Majszak, M. and Jebeile, J. (2023), "Expert judgment in climate science: How it is used and how it can be justified", Studies in History and Philosophy of Science. Part a/Studies in History and Philosophy of Science, 100, 32–38.
Jebeile, J. and Roussos, J. (2023), "Usability of climate information: toward a new scientific framework", WIREs Climate Change, 14:5, e833
Katzav, J. (2014), "The epistemology of climate models and some of its implications for climate science and the philosophy of science", Studies in History and Philosophy of Science Part B: Studies in History and Philosophy of Modern Physics, 46, pp. 228-238.
Parker, W. S. (2020), "Model Evaluation: An Adequacy-for-Purpose View", Philosophy of Science, 87, (3):457-477.
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Climate Modeling

Alternative Ways of Deciding Under Uncertainty in View of Global Warming

Hermann Held (Uni Hamburg)

Over the past decades, climate economics developed two main schools of thought on how to take decisions under uncertainty about the impacts of global warming. Hereby, 'uncertainty' denotes any lack of knowledge, in line with the IPCC's definition and contrary to the tradition of insurance economics. Until 2019, the cost benefit tradition predominantly led to emission reduction recommendations violating the 2°C target, while the precaution-oriented one made the 2°C target its cornerstone. Although we observe convergence of policy recommendations from both schools since then, it is currently unclear, how robust these approaches really are, from a fundamental perspective.
We highlight that both schools of thought, in view of the present knowledge structure on the climate problem, display fundamental conceptual difficulties. Hence, we developed a hybrid out of both schools of thought that solves any of the above problems and should also be applicable for most management settings of complex systems. In particular it might serve as an assessment scheme for new technologies to be employed for tackling the climate problem.
This ongoing research could benefit from targeted exchange with philosophers and social scientists to better understand the normative implications of our alternative assumptions system as well as the acceptance levels for various ambiguity attitudes.

Distributive Epistemic Injustice in Climate Modeling

Maria Sojka (Heinrich Heine Universität Düsseldorf)

The role of values in science has traditionally often been discussed as a primarily epistemic problem, with the potential for some entailing ethically concerning consequences (Douglas 2009, Ch. 3). A central question of philosophical debates about the adequacy of non-epistemic values in science has been the extent to which these values lead scientists to draw epistemically problematic conclusions. This has also been a particular focus of discussions about the significance of non-epistemic values in climate modeling (e.g., Winsberg 2012, Betz 2013, Parker 2014, Intemann 2015, Schmidt & Sherwood 2015, Parker & Winsberg 2018). However, as research on the role of non-epistemic values in climate modeling further has shown, there are instances where non-epistemic value judgments in intra-scientific processes can be, at the same time, unavoidable, epistemically harmless and ethically problematic (Parker & Winsberg 2018). That is, they do not lead to the endorsement of 'false facts' but have nevertheless undesirable consequences. This is due to the complexity of the climate system, which requires scientists to make decisions regarding which parts of the climate system are modeled with more accuracy than others. Thus, these models echo specific "predictive preferences" (Winsberg 2012). Value judgments about the extent

to which particular processes and variables are included in the models have to be made. Climate modeling is a protracted and expensive undertaking, and modeling centers are predominantly located in the Northern Hemisphere, particularly in Europe and North America (Chen et al. 2021. p. 218). Therefore, there is a risk that models disproportionately reflect the epistemic interests of those who created and paid for the models (Parker & Winsberg 2018, Harvard & Winsberg 2022). More generally speaking, there is a risk that the epistemic needs of particular marginalized communities for specific kinds of information are overlooked, impacting their ability to make policy decisions. This issue has also been noted in the latest IPCC report (Chen et al. 2021, p. 172). In this paper, I argue that when these communities are not in a position to generate this knowledge on their own, it can lead to distributive epistemic injustice (Irzik & Kurtulmuş 2024). Further, I will reason that models as complex as climate models are prone to distributive epistemic injustice, as they are so expensive that certain groups must rely on others to consider their predictive needs. Jebeile and Crucifix (2021) argue that applying a concept of scientific objectivity that takes into account the standpoints of underrepresented groups can guard against overlooking predictive needs of particular
marginalized communities. However, I argue, that the unique epistemic challenges of complex computer simulations, especially their “analytical impenetrability” (Lenhard & Winsberg 2010), make value management a difficult, if not unattainable task, in the context of climate modeling. I conclude that, due to the epistemic opacity of the models, it is often not possible to trace how particular modeling decisions will affect the epistemic needs of specific communities. This makes it particularly difficult to determine the extent to which distributive epistemic injustice is actually an unintended feature of particular models.

Betz, G. (2013). In defense of the value-free ideal. European Journal for Philosophy of Science, 3(2), 207–220.
Chen, D., Rojas, M., Samset, B., Cobb, K., Diongue-Niang, A., Edwards, P., Emori, S., Faria, S. H., Hawkins, E., Hope, P., Huybrechts, P., Meinshausen, M., Mustafa, S. K. E. A. R., Plattner, G. & Treguier, A. M. (2021). Framing, Context, and Methods. In Masson-Delmotte, V., Zhai, P., Pirani, A., Connors, S.L., Péan, C., Berger, S., Caud, N., Chen, Y., Goldfarb, L., Gomis, M.I., Huang, M., Leitzell, K., Lonnoy, E., Matthews, J.B.R., Maycock, T.K., Waterfield, T., Yelekçi, O., Yu, R. & B. Zhou (Eds.), Climate Change 2021: The Physical Science Basis. Contribution of Working Group I to the Sixth Assessment Report of the Intergovernmental Panel on Climate Change (pp. 147– 286). Cambridge, United Kingdom and New York: Cambridge University Press.
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Harvard, S. & Winsberg, E. (2022). The Epistemic Risk in Representation. Kennedy Institute of Ethics Journal, 32(1), 1-31.
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Uncertainty in Modeling

Value Chain Models, Accountability and Epistemic Risks

Clément Lasselin (Sorbonne Université)

This paper analyzes the uncertainties associated with value chain models that are utilized as the basis for policy and legal decisions. I propose an analysis that is situated at the intersection of philosophy of science, political science, and law (Jasanoff, 1990; Frischmann, Marciano, and Ramello, 2019). Value chains encompass technical activities carried out by different actors to produce final goods and services (e.g., food value chains, electricity value chains, automobile value chains) (Gereffi, Humphrey, and Sturgeon, 2005). The actors involved in value chains may have varying degrees of knowledge about and influence over the activities of other actors involved in the same value chain (Kaplinsky and Morris, 2001).

Value chains vary in complexity, involving a greater or lesser number of elements in different interactions (Cattaneo, Gereffi, and Staritz, 2010).

Many policymakers and courts seek to regulate the activities that take place within value chains, especially within global value chains operating in multiple territories (Mayer and Gereffi, 2010). In doing so, they try to identify the actors involved in these value chains, their activities, the impacts of these activities, and their influence on the organization of value chains, in order to make informed decisions regarding them. At the European Union level, for instance, policymakers have published several norms aligned with this goal to improve the sustainability of value chains (e.g., the Due Diligence Directive).

Researchers have developed value chain models that represent the complex causal relationships between value chain elements (Trienekens, 2011; Ponte and Sturgeon, 2014). These models can be utilized by decision-makers to obtain accurate information about the interrelationships in value chains and to adjust their decisions accordingly. Through such models, they can more easily identify which actors are organizing value chain activities and can be subsequently held accountable for their impacts. This can improve the efficiency of decision-making processes (Kaplinsky, 2000).

However, value-chain models—like all models—are based on various methodological assumptions regarding how they represent their object (Winsberg, 2010). Therefore, these models can be subject to numerous uncertainties. If modelers fail to adequately address these uncertainties when communicating their models, there is a risk of providing misleading information that might lead decision-makers to make unjustified and counterproductive decisions (Cartwright, 1999). Drawing on other work in the philosophy of science on models and on examples provided from my thesis work, I will demonstrate these limitations and argue for more prudent ways to consider value-chain models when addressing the accountability of actors involved in them.

The hunt for assumptions and epistemic uncertainties in global irrigation models

Seth Nathaniel Linga (University of Birmingham), Joshua Larsen (University of Birmingham), Michela Massimi (University of Edinburgh), Nanxin Wei (University of Birmingham), Arnald Puy (University of Birmingham)

Many global water models (GWMs) include an irrigation module designed to simulate water use in agriculture. These computational tools integrate biophysical, management, and socioeconomic data streams to estimate irrigation water withdrawal (IWW). However, the complexity of reality forces analysts to employ assumptions, simplifying the modelling chain or filling gaps in their knowledge. Uncertainties in the representation of the phenomenon of interest are part and parcel of any model-based exercise. Yet, traditional uncertainty and sensitivity analyses often overlook epistemic uncertainties stemming from modelling assumptions, leaving significant portions of the uncertainty space unexplored. We do not know the extent to which irrigation models are grounded on scientifically substantiated claims versus premises that are based more on practicality – pragmatic assumptions. This knowledge is important to define the robustness of irrigation models and their epistemic reach. Using sensitivity auditing, we will expose potentially relevant assumptions embedded in the modelling of IWW by eight GWMs (CLM4.5, H08, LPJmL, MATSIRO, MPI-HM, PCR-GLOBWB, VIC,Water-GAP) that likely have non-negligible influence in the final estimation. Our goals are to delineate: 1) the empirically grounded domain of these models, and 2) the space formed by uncertain, potentially changeable decisions. First, we evaluate the epistemological consistency of these assumptions, differentiating between pragmatic and non-pragmatic from the lens of philosophy of science. Non-pragmatic assumptions are grounded in empirical evidence or scientific principles and, thus, can be more rigid and less amenable to exploratory approaches. In contrast, pragmatics are flexible and more dependent on the interpretation of the model. We focus on pragmatic assumptions and unveil the uncertainty space of framing qualitative assumptions. By juxtaposing these claims against scientific knowledge and field data, we reveal nuances that challenge the reliability of GWMs in informing irrigation policies and managing water resources. This study advocates for actions on two fronts: (a) model developers should strive for transparency, laying bare their assumptions, and (b) decision-makers and stake-holders should critically appraise the underlying assumptions when applying these models in real-world scenarios.

Assumptions in Modeling

Transparency and persuasion: Chances and risks of XAI applications in modeling for policy

Martina Philippi (Uni Paderborn)

In addition to many other areas of application, AI also promises benefits in the field of policymaking: large amounts of data can be analysed efficiently, information on correlations can be provided in a short space of time and patterns can be recognised that would not be accessible to the human eye. In accordance with the approach of evidence-based policy making (De Cavalho & da Silva 2021), regulations can be assessed and justified for relevance and effectiveness in this way. As in other areas, the opacity of AI applications here is widely seen as a problem. An approach that works on the basis of socio-technical interconnections promises a remedy here: explainable AI, which provides customised, comprehensible explanations of AI-generated assessments not only for AI experts, but also for other target groups such as domain experts or affected parties. Due to this objective, XAI is not only about transparency - i.e. the traceability of how a system arrives at its results - but also about addressing different perspectives, expertise and roles (Gerlings et al. 2022).
It should be noted that the potential of XAI promises two benefits at the same time: Firstly, it enables a gain in information. This applies not only to cases in which AI experts encounter the black box problem, but also to those in which domain experts or affected parties are dependent on a kind of translation of the technical details. In this way, it is ideally possible to clarify which categories have been used to model reality, which prioritisations and which assumptions are being used. On the other hand, this new technology also has a persuasive dimension. Here, human-machine interaction is mimicking interpersonal communication, which can increase acceptance of AI systems (and this is in many cases desired and desirable). At the same time that means that it also adopts some of the fundamental characteristics of interpersonal communication: although explanations can identify and name the presuppositions of an AI system and thus, for example, uncover biases, the communicative nature of explanations means that they are themselves based on fundamental assumptions that cannot be addressed in their enactment.
The demand for transparency must therefore be shifted from AI to XAI applications. Besides responsible development, critical use is essential here, which means that the various stakeholders must train their eyes to recognise unobtrusive assumptions, perceptual habits and practices. Just as forecasts of developments must be understood and handled in a proper manner (and not like a weather forecast, Kaminski et al 2023), both AI assessments and their justifications must be critically scrutinised. This is anything but trivial when embedding an informative system in a practical context. In my contribution, I would like to show to what extent XAI for use in scientific policy advice and policymaking is an excellent use case for examining this problem: it is less about decisions in individual cases, such as in medical applications, but about the holistic assessment of situations, phenomena or contexts; and awareness-raising requirements for a responsible use of this novel approach concern different stakeholder groups such as regulators and the public, which makes it necessary to address different perspectives and levels of knowledge.

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Sessions Wednesday

Modeling for Policy

[Title tba]

Ralf Schneider (HLRS)

Abstract tba

Modeling the development of transport related preferences and choices in Germany using dynamic microsimulation

Petra Stein and Anthony Daykin (Universität Duisburg-Essen)

Predicting future transport demand requires the inclusion of a wide range of complex influences. Individual, family and regional factors shape people's mobility decisions as well as their transport preferences. Existing simulations of transport behavior are often limited to specific regions and focus on short-term details, such as time of day network performance. By including the transport related preferences of individuals, we aim to introduce new research questions into the field of transport research. Dynamic microsimulation enables us to project the development of these preferences and mobility related choices in the German population over decades, whilst accounting for demographic changes in the underlying population and regional variations. Hypothetical future scenarios and policy interventions can be incorporated into the simulation, so that their complex impacts on a heterogenous population can be better understood.

Trusting Models

Three Stories about trust and medical models

Andreas Kaminski, Andreas Brenneis (TU Darmstadt)

Trust in medicine has often been primarily understood as the trust patients have in doctors. What has been overlooked, however, is the trust that doctors have in patients—or the lack thereof. And finally, there is the trust doctors have in their own abilities. In the case of medical models, these three relationships come to the forefront. In this talk, we will attempt to show how values and successful actions are negotiated in this context.

Validity Without Data – a Tour de Force For Building Trust

Johannes Lenhard (RPTU Kaiserslautern)

The contribution examines the Club of Rome's famous "Limits to Growth" report (Meadows et al. 1972). This study presents an early and most influential exemplar of modeling for policy. A number of traits make it remarkable. One is its ambition. The report presented a prototype for world modeling and put scientific-model-based prediction in a policy context. Another is the instrumental basis for modeling. The report built on a computer-based approach to modeling, namely on Forrester's system dynamics. Jay Forrester (1918–2016), engineer at MIT, had led the development of Whirlwind, the first high-speed supercomputer, in the 1940s and 1950s. From the 1960s onwards, he had tailored system dynamics to the capabilities of digital computers and went on to model systems from the company, to urban areas, and to the global level. Although Forrester is not one of the authors of the Club of Rome study, this study relies on Forrester's work as the modeling backbone (Forrester 1971). The contribution will focus on the issue of validity. This question presented a multi-faceted challenge for "Limits to Growth". One issue was the unprecedented scope of modeling: the future of the entire world system. Another issue was that systematic data were almost completely lacking. Thus, arguing for the validity of the study required addressing both issues at the same time. This was the challenge that Forrester took on. My thesis is that Forrester followed a strategy for building trust into the model's forecast, i.e. the "Limits to Growth" report, by arguing that missing data were not a major issue exactly because the purpose is modeling for policy.
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Energy Models and policy

Thinking Open Modeling Politically: The Case of Energy Models

Anja Bauer (Uni Klagenfurt)

Computational models are key techniques for informing and supporting energy policies and planning at various levels. Given their importance for high-stakes decisions, the opacity and incomprehensibility of

models has long been addressed. Models have been criticized as black boxes that obscure the assumptions, theories, interests, and data that drive results. As a result, transparency and accessibility have long been key issues in modeling for policy. The energy modeling community has been at the forefront of open modeling with a variety of initiatives to increase transparency, provide access to data, and open access to modeling tools.
Bottom-up initiatives by researchers, such as openmod (https://openmod-initiative.org/), provide a variety of open-source modeling tools for use and adaptation and regular workshops and networking events to build an open-source community. Influential institutions such as the International Energy Agency (IEA) have also taken steps towards greater transparency by releasing parts of the underlying scenario data following criticism of their projections. In the context of regional energy planning, regulators in several U.S. states (e.g., Hawaii and Arizona) have required utilities to provide free access to the underlying commercial modeling tools to stakeholders such as environmental groups or local governments. Non-profit organizations are also driving the development of open access tools. Prominently, the World Resources Institute (WRI) has developed the Energy Access Explorer, an "open-source, online and interactive platform designed to visualize energy access in unserved and underserved areas and support locally led, data-driven solutions to achieving universal energy access" (https://www.wri.org/initiatives/energy-access-explorer).
As diverse as these initiatives are, they all point to the high political salience of open energy modeling. Drawing on recent examples, my presentation offers an exploratory discussion of the politics of open energy modeling and aims to outline a corresponding research agenda. First, the discursive embedding of open modeling is of great analytical interest. Demands and efforts for open modeling are frequently accompanied by hopes for better quality and validity of models, more transparency, credibility, and ultimately trust and political legitimacy. At times, open modelling is even associated with the democratization of science and politics. A second dimension of inquiry concerns the role of models as boundary objects between scientists, policymakers and stakeholders and the related question of whether and how science-policy-society interactions change with open modeling. What new forms of collaboration are possible; can open modeling create a common understanding? Third, open access to data and tools implies a shift in resources, knowledge and, potentially, political power. By gaining access, actors traditionally outside of energy planning, such as environmental NGOs, may be empowered to challenge energy planning and policy. This leads to the question of whether and how open modeling changes not only the configurations of energy politics, but also the directions of energy policy. Potential shifts in political power also draw attention to resistance and counter-trends to open modeling.

Modeling Renewable Energy Trading Networks: A Multicriteria Optimization Approach

Michèle Knodt, Mile Misic (TU Darmstadt)

Decarbonizing economies and energy systems is urgently needed to meet current climate change mitigation targets. However, many countries, particularly in Europe, will not be able to meet their rapidly growing demand for renewable energy by expanding domestic production in the near future. As a result, these countries are planning to import additional renewable energy using chemical carriers such as hydrogen and metals. These plans raise the question of which countries to partner with for renewable energy trade. However, selecting the appropriate trading partners is a complex task that requires navigating between several potentially conflicting objectives, including cost efficiency, sustainability, governance, and security of supply. In this article, we develop a new formalized optimization method including both empirical indicators and abstract selection rules, that can help select partner countries in the presence of such trade-offs. We illustrate our method by examining the case of Germany as an importer of renewable energy using iron as an energy carrier. Our method identifies an optimal set of potential trading partners and their shares of supplied renewable energy by minimizing costs while meeting the chosen constraints. For example, under the most stringent sustainability and security constraints, the model identifies Australia, the United States, Brazil, Spain, Canada and Chile as potential trading partners for Germany, while relaxing these constraints adds more countries such as Morocco and Oman to the selection. Our method is the first to identify trade networks, i.e. concrete sets of partner countries, that can bridge (expected) gaps in the importing country's renewable energy supply. It can therefore provide valuable guidance and justification for the development of renewable energy trading partnerships.

Values in Modeling 2

Reflections on developing ‘value-explicit’ positive targeted scenarios for biodiversity modelling

Elliot Woodhouse (International Institute for Applied Systems Analysis)

Models, and targeted scenarios have been argued to be essential for achieving the required ‘transformative change’ (IPBES 2019) needed to meet the goals of the Kunming-Montreal Global Biodiversity Framework KMGBF (CBD 2022). This transformative change needed for the preservation and restoration of biodiversity raises no small number of ethics and justice challenges. As Plutynski & Fujita-Lagerqvist state, “Biodiversity is at the intersection of a host of political and economic conflicts over land, resources, and power (2016, p.282).” Moreover, it is increasingly understood that perceptions of injustice present a powerful impediment to successful policy making (Martin et al., 2020; Thaller et al., 2023). Within this context, it is imperative that modelers identify methods for incorporating and making explicit considerations of justice within biodiversity targeted scenarios.

A central factor driving these justice challenges is the diverse ways that different groups and individuals have for valuing the non-human natural world (IPBES 2022). IPBES has therefore recommended that scenario’s are developed which reflect a multiplicity of ways of valuing nature, as well as diverse perspectives on what principles of justice are employed. Doing so could allow modelers to depict how varying perspectives on justice result in changed modelling outcomes in key policy areas. For instance, central to the justice of conservation efforts is how the burden of setting aside land for biodiversity preservation is shared (Armstrong 2024); and our answer to how this burden is distributed, and the ultimate spatial pattern of preserves will be determined by which principle of distributive justice is employed in our scenario building. Where scenario development fails to recognize a multiplicity of accounts of justice or explicitly identify their normative presumptions, they not only obscure the role that justice plays in shaping modelling outcomes, but run the risk of being procedurally or recognitionally unjust if they impose their normative values on others when those models are used to inform policy.

The RAINFOREST project attempts to address this challenge through the development of new *value-explicit* positive pathways for biodiversity, which can be used as target scenarios for modelers. Our work builds on previous work in this area in the Sustainable Development Pathways (Kriegler et al., 2022), and the Nature Futures Framework (Durán et al., 2023; L. M. Pereira, Davies, Belder, et al., 2020; I. M. D. Rosa et al., 2017). However, the RAINFOREST pathways go further by deepening the account of justice in the pathways through the incorporation of a new non-normative framework for environmental justice (Hanger-Kopp et al., 2024; Zimm et al, 2023). The four resulting pathways were developed broadly through a ‘story-and-simulation’ approach (Alcamo, 2021) through a combination of expert-led qualitative storyline development as well as through participatory expert-led stakeholder exercises.

This paper critically reflects upon both the motivations and methods used in the development of the RAINFOREST pathways and the supporting non-normative ‘Justice Framework’. We consider the challenges that incorporating non-epistemic scenarios into models raises and consider the trade-offs between normative and normatively agnostic approaches to including justice in scenario development.

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The Intertwining of Modeling and Policy: Roles, Expectations and Normative Aspects

Andreas Brenneis (TU Darmstadt)

Models in science serve various purposes, including scientific proofs, predictions, and explanations. The predictive and explanatory functions, in particular, can be crucial for various political decision-making processes. These models focus on a specific aspect of reality (the target domain) to model and predict it using various parameters. The selection of the target domain, parameters, and other decisions in the modeling process can be influenced by both epistemic and political factors.
This presentation aims to descriptively analyze the intertwining of politics and modeling while identifying normative aspects. The focus will be on the political decision-making side and the various demands placed on models:
Models developed with purely epistemic intentions (e.g., attempting to validly describe and explain the climate) and then incorporated into the political decision-making process.
Models developed or commissioned with a political agenda, establishing a close connection between modeling and political decision-making from the outset.
Models developed and provided without consideration by political decision-makers.
I will explore additional options for the relationship between scientific modeling and political decision-making. My starting point is the typology of four different actor types in science often used in Science & Society discussions: Pure Scientist, Science Arbiter, Issue Advocate, and Honest Broker of policy alternatives (Pielke 2007). I propose that these roles and associated role expectations can be located not only on the modeling side but also effect the side of those who initiate political decision-making processes or finally make use of models to make political decisions.
I will discuss whether the self-perception of actors on the policy side can also be assigned to one of these four roles. An important step in clarifying the relationships between modeling and policy is to elucidate the possible roles (and role expectations) that both sides bring to the process of modeling for policy.
Conflicting role expectations may be one main reason why models fail to optimally inform decision-making processes. From the foundation of role expectations and expectations of expectations, normative aspects of modeling for policy can get addressed, such as transparency, trust, and the ethical use of scientific information in governance.
This presentation contributes to the conference themes by exploring the following aspects:
The relationship between modelers and decision-makers: What are the (mutual) role expectations, and how might they conflict?
Non-epistemic model functions in policy contexts: Can specific model functions be linked to certain (combinations of) actor types?
Power relations between models, policymakers, and the public: Are there optimal ways to align actor types on both the modeling and policy-making sides?
By examining these aspects, I aim to provide insights into the complex interplay between scientific modeling and policymaking, contributing to the discourse on Modeling for Policy.

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Modeling for policy 2

Urban Digital Twins to Foster Collaborative Planning Processes and Improve Policy and Decision Making

Uwe Wössner (HLRS), Fabian Dembski (Tallinn University of Technology)

Digital twins have been used for more than a decade in the engineering sector, particularly in mechanical engineering. They have only been used for cities and regions for a few years. An essential component of digital twins are models, but also (big) urban data, processes and simulations, for example. By their very nature, cities are not machines - they are complex systems linked to economic, ecological, social and demographic conditions and changes. This makes it important but also difficult to model them. The choice of different levels is usually determined by specific interests and thus also the abstraction of the data and the level of detail. By modelling the (urban) stock, scenarios and visions and testing them by means of simulation before implementation in the real world, they have the potential to support planning, policy and decision-making processes. Human-digital twin interfaces play a key role here, together with immersive visualisation. Based on examples from Germany and Estonia, this article will focus specifically on the topic of democratic access to planning processes and policy-making and present examples of already implemented interfaces and future potential for immersive interaction between humans and digital twins.

A reflection on computational modeling from the viewpoint of the physics of complex systems

Miriam Klopotek (Uni Stuttgart)

Computational modeling is a science whose historical roots are, in part, in the modeling of diverse physical phenomena, where the latter are inherently ‘too complex’ for our innate intuitions about the world to explain. In most of these cases, we do not have analytical descriptions–solved in explicit form–able to describe the phenomena. This is particularly the case within physics, where analytical theory development goes hand-in-hand with simulations. In statistical physics, simulated model systems show various forms of emergent phenomena, which are at the heart of theoretical study on complex systems. Through simulations, we gain ‘in-silico laboratories,’ which has accelerated the pace of theoretical development while, at the same time, unveiling just how truly ‘complex’ the grounds are for using any particular model: implicit presumptions made in the design have far-reaching consequences for a model’s robustness, generalizability and validity. This is particularly the case for dynamical phenomena, which, in physical terms, means physics under nonequilibrium conditions. Even when trying to incorporate ‘unknowns’ into a highly flexible model, we need to make presumptions on the ‘shape’ of their distribution, their origin, and how they interact with the relevant variables of a system. Precisely, this and other aspects are shared with modern machine-learning approaches to modeling. For this reason, I believe statistical physics can provide basic insight and anecdotal understanding of impertinent issues like scientific explainability, insight extraction, knowledge gain, estimating uncertainties, etc. They are all innately related through the elusive idea of complexity, which is relational and for which there is currently no single definition rooted in physical theory under general (time-dependent) conditions. Although all physical computational models have basic underpinnings about ‘real’ systems in the outside world, a number of interesting philosophical debates can emerge about what we are actually seeing in a model’s output. I think this provides an important basis for discussion when asking what we want, need, and expect in computational models from the factual side, which becomes an especially delicate issue in the context of policy-making.