Global change impact on water resources at the regional scale - a reflection on participatory modeling

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Introduction

Here we present the use of Participatory Modeling (PM) to support the development of the integrated regional modeling system DANUBIA (Figure 2) as a scientific tool to evaluate the impact of global change on the Upper Danube Catchment (Germany - Figure 1). We use this case study to examine the specific conditions for **PM in the field of complex integrated models on a regional scale**. We focus on :

- The stakeholder dialogue's contribution in supporting the development of new, complex modeling systems, particularly on a regional scale,
- Conditions of stakeholder involvement in issues related to the distant future, such as climate change impacts on regional water availability, and
- Limitations of PM and scientists' motivation to carry out participatory research at all.

Or, in other words: Can participation at the same time help to improve the scientific quality of models AND to improve the applicability of such models, is that possible in case of a poorly understood problem and how motivated are scientists to really commit to such a process.

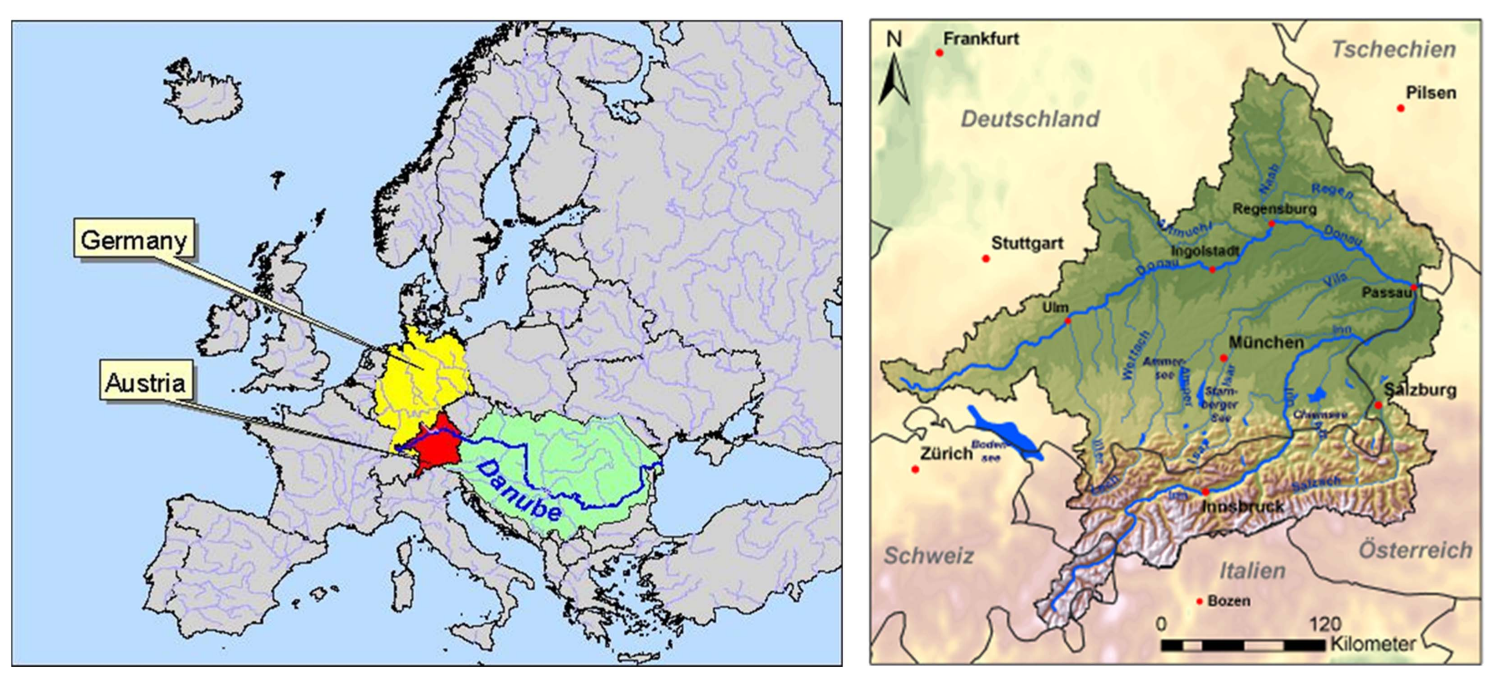

Figure 1: Upper Danube Catchment (UDC). Left (modified from Mauser et al. 2015 (in press): location of the UDC (red) as headwater catchment of the Danube basin (green). Right: relief and major geographic features of the UDC.

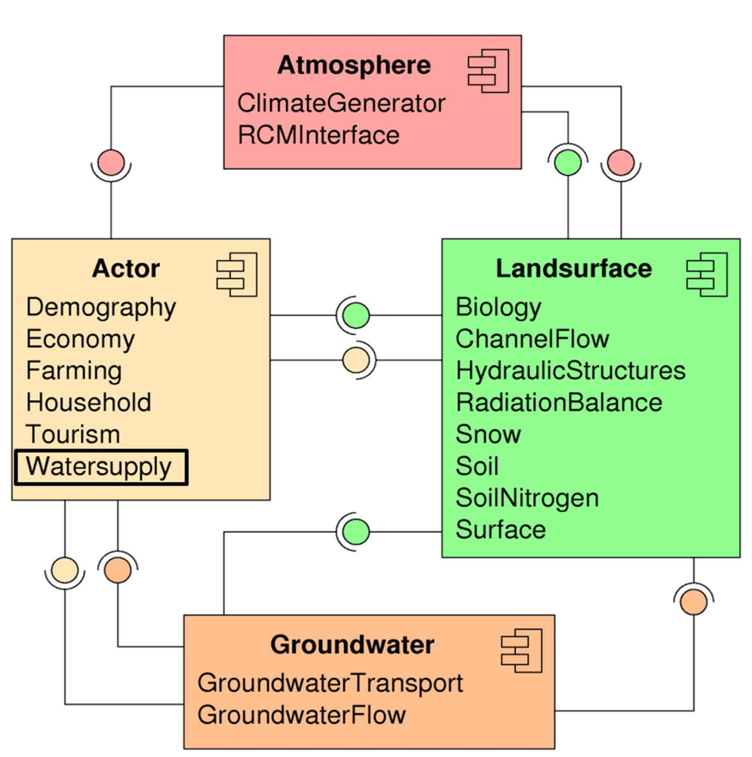

Figure 2: Main components and models of the DANUBIA system. (modified from Mauser et al. 2015 (in press)

DANUBIA is a fully coupled modeling system developed to study important processes and feedback related to water resources from both the natural and social science perspectives (Ludwig et al. 2003). It consists of 17 separate model components and a central framework that controls data exchange and temporal sequences (Barth et al. 2004, Hennicker et al. 2010). One model component of particular interest in the context of this article is the WaterSupply model (Barthel et al. 2010). WaterSupply's role in the DANUBIA modeling system is to simulate the behavior of water supply companies (WSCs) in the event of changing boundary conditions (i.e. changes on the demand or supply side). Table 1 describes the progress of the development of DANUBIA as a whole and WaterSupply in relation to the stakeholder dialogue.

Project phase / Scope of description	First phase, 2001–2004: Data acquisition and unstructured stakeholder activities	Second phase, 2004–2007: Model consolidation and first approach to a structured stakeholder dialogue	Third phase, 2007–-2010: Model finalization and structured, externally moderated stakeholder dialogue
GLOWA-Danube Project			
Progress of the development of all model components and the DANUBIA framework			
Overall goals	Implementation of all model components, interfaces, and basic concepts Proof of concept	Full implementation of models and framework Provision of first, coupled-scenario results	Provision of final results based on complex scenarios Conclusions about global change impacts on the UDC Handing over DANUBIA to practice
Status of the DANUBIA framework	Development of basic architecture of fundamental concepts (space, time, and interfaces)	Fully developed common framework Definition and handling of complex scenarios and provision of results Addition of the DeepActor sub-framework to model human decisions (Barthel et al. 2008)	Refinement and adjustment Tools to analyze and visualize results Enhance user friendliness and performance
Status of model components	Adaptation of preexisting models to the framework, development of new model components—very heterogeneous status Data acquisition for model parameterization and calibration/verification	Co-existence of fully developed components and components in various stages of development Growing awareness of limitations, particularly with respect to model integration	Almost all model components fully developed Model integration not fully accomplished—"weak links" substituted by work around
Results	Simple, mainly to prove technical capacities of models and framework, simplistic scenarios. Validation of most components and framework impossible.	Individual components provide meaningful results. All integrative results strongly influenced by "weak components"	Results from different complex scenarios yet not including all model components Results are published in the Global Change Atlas of the UDC (Mauser and Prasch 2015 (in press))
Challenges	Different state of model components leads to reduced interaction between models. Data acquisition more difficult than expected Reluctance of data owners to provide sensitive data	Fully developed, complex model components reduce model performance. Integrated simulations extremely slow. Scenario definition proves to be more difficult than expected. Increasing links	Constant adjustment and refinement of model components lead to problems with dependent components: the integrated model is never "ready." Uncertainty and probability of results cannot be quantified. Due to low model performance, only few, integrated scenario simulations are possible.
Progress of the project-wide, stakeholder dialogue			
Organization	Stakeholder process not explicitly mentioned in the project plan No centrally organized stakeholder dialogue Heterogeneous stakeholder activities carried out by single groups of the consortium	Stakeholder process part of project plan A group of scientists from the consortium responsible for the implementation of the process Main activity: Thematic stakeholder workshops with stakeholders from different subthemes (agriculture, water supply, etc.)	Stakeholder process becomes central to the project plan. External company specializing in stakeholder activities hired Various, clearly structured activities (see text).
Goals	Data acquisition Making the project known Include stakeholder and user perspectives in model conceptualization.	Include stakeholder perspectives in model and scenario development Discussion of results Create acceptance for the approach	Improve models and scenarios. Increase quality and relevance of results. Make DANUBIA usable and useful (see text).
Challenges	Unclear to what degree global change would present a problem to the UDC Dialogue with stakeholders based on vague and sometimes over-confident promises made by the modelers and also vague (and unrealistic) expectations by the stakeholders	Low interest from stakeholders, no clear stakeholder identification strategy Stakeholder dialogue not recognized as a central part of the project by scientists	Model component and framework development advanced limited possibilities (flexibility) to respond to stakeholder suggestions. Regional model unable to provide the local results of high temporal resolution in which most stakeholders are interested
Results	Unclear Identification of groups of potentially interested stakeholders Improved access to data	Decision to approach the stakeholder dialog in a more professional in the third phase Decision to include the main state agency as a project partner	Difficult to evaluate. Many lessons were learned yet the ultimate goals were not reached (Maschke et al. 2013). The project was terminated, and the consortium split up and moved without performing a concluding evaluation.
WaterSupply model			
Progress of the development of the WaterSupply model component			
Implementation	Development of a completely new model component	Fully functional model, yet without "decision-making" capability (see) Parallel development of a DeepActor WaterSupply model	Fully implemented, including decision-making component
Results	None	Validation for past periods partly successful Development of a concept to directly transform abstract model results into simple categories of good/bad (Barthel et al. 2008)	Results for various complex scenarios (e.g., Reiter et al. 2012) with relatively low spatial and temporal resolution
Difficulties	Restricted access to data about water supply companies (WSCs), partly because of an ongoing discussion on liberalization/privatization of the water supply sector	Model results acceptable at a regional level but not at the level of individual WSCs No access to data/information needed to carry out realistic decision making	The decision-making component of the model could not be validated against observed data.
Progress of the stakeholder process arranged specifically by the WaterSupply developer group			
Organization	Meetings with individual stakeholders and agencies Network meetings: Workshops with participants, mainly from ministries and agencies, to discuss model concepts and goals	Contacts in various forms with WSCs and other stakeholders to ask for data and advice Two large surveys (questionnaires) with 1,800 WSCs about technical and economic questions	Meetings with supra-regional agencies Otherwise, only through the common, project-wide, moderated stakeholder process
Materials presented to stakeholders	Problem descriptions, first ideas about model concepts, results from individual tests and basic simulations	First results from coupled simulations (validation with observed data) Concepts of the decision-making component	Results from the complex scenario simulations Presentation of model concepts
Challenges	Many data owners are reluctant to provide sensitive data in view of unclear results, Stakeholders want to see results first, before they commit to being involved.	Low return from questionnaires Loss of interest from main stakeholders as no "convincing" results can be provided Global change is not considered a main problem.	Results too regional and general for local stakeholders, too little detail of results. Model too complex and slow for regional stakeholders Large WSCs and agencies conduct their own global change research.
Stakeholder impact on model development	Low, through direct input Indirectly high, through clarification of data availability	Very limited Stakeholders point out deficiencies that can partly be removed.	See section 4.3

Table 1: Details of the Stakeholder process in GLOWA-Danube for the project as a whole and the WaterSupply model component specifically

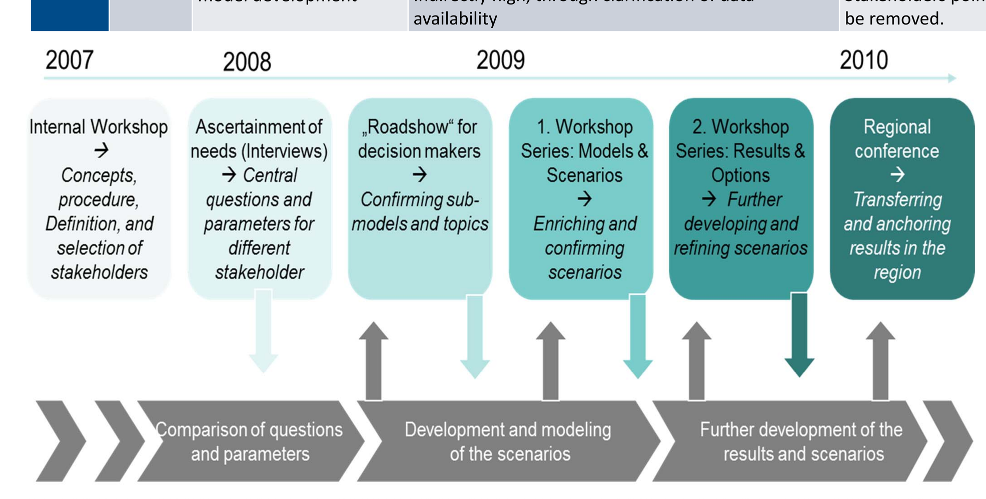

Figure 3 : Main elements of the stakeholder dialogue in the third phase of the project. In the third phase, IFOK was employed to coordinate and evaluate the stakeholder dialogue.

Results

According to the modelers expectations the stakeholder dialoge should have resulted in the following:

1. Establishment of a regional network of global change in relation to water management.
2. Acceptance of the developed modeling concepts.
3. Improvement of model concepts, model parameterization, and scenarios..

The results with respect to these objectives can be summarized as follows

- The GD project was successful in engaging stakeholders in an informative discussion about global change impacts, scenarios, and models
- However, the developed integrated modeling system has not been adopted and used by any of the participating stakeholders to date.
- The PM process had only minor impact on the model conceptualization, parameterization, and validation.
- There was a large discrepancy between what the stakeholders wanted and what the model could actually provide.
- The enormous complexity and unquantifiable but obviously huge uncertainties presented a main obstacle to stakeholder adoption.
- Most scientists were either disappointed or annoyed (or both) by the tedious and unproductive dialogue

Lessons learned:

- It is difficult to achieve highest scientific standards in model development (acceptance by the scientific community) and applicable, user-friendly, context-specific models (acceptance by stakeholders / end-users) at the same time
- In global change research addressing a regional scale with vast uncertainties, fuzzy problem definitions, manifold feedback between nature and humans, and large scales of time and space, PM requires a TD approach, that is, finding a common understanding of problems, integrating knowledge and values, defining roles and responsibilities within the process, and clearly committing to the task.
- The collaboration of scientists/modelers and stakeholders in an early phase, an open discussion of their respective goals, and a mutual understanding of rationales may prevent disappointment due to unfulfilled expectations.
- It is dangerous to think that scientists, particularly from the field of natural sciences, can be genuinely interested in deep involvement in PM (and transdisciplinary science). There are minimal incentives to commit to such tedious processes, specifically for scientists in their early career stages without tenure.
- To use PM in the field of regional modelling in global change research major incentives have to be created for scientists that require a new definition of "scientific quality"

References

Barth M, Hennicker R, Kraus A et al (2004) DANUBIA: An integrative simulation system for global change research in the Upper Danube Basin. Cybernetics and Systems 35: 639-666

Barthel R, Janisch S, Nickel D et al (2010) Using the Multiactor-Approach in Glowa-Danube to Simulate Decisions for the Water Supply Sector Under Conditions of Global Climate Change. Water Resour Manage 24: 239-275

Barthel R, Janisch S, Schwarz N et al (2008) An integrated modelling framework for simulating regional-scale actor responses to global change in the water domain. Environ Model Software 23: 1095-1121 Maschke P, Petschow U, Hirschfeld J (2013) Wissenstransfer in der sozio-ökonomischen Wasserforschung : an der Schnittstelle zwischen Forschung und Praxis. Ökologisches Wirtschaften 4: 12-13

Hennicker R, Bauer SS, Janisch S et al (2010) A generic framework for multi-disciplinary environmental modelling, Ottawa, ON, pp. 980-994.

Ludwig R, Mauser W, Niemeyer S et al (2003) Web-based modelling of energy, water and matter fluxes to support decision making in mesoscale catchments - the integrative perspective of GLOWA-Danube. Phys Chem Earth 28: 621-634

Mauser W, Prasch M (2015 (in press)) Regional Assessment of Global Change Impacts Springer

Reiter A, Weidinger R, Mauser W (2012) Recent Climate Change at the Upper Danube-A temporal and spatial analysis of temperature and precipitation time series. Clim Change 111: 665-696

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