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A Framework for the Simulation of Human Response to Global Change

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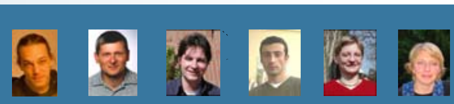

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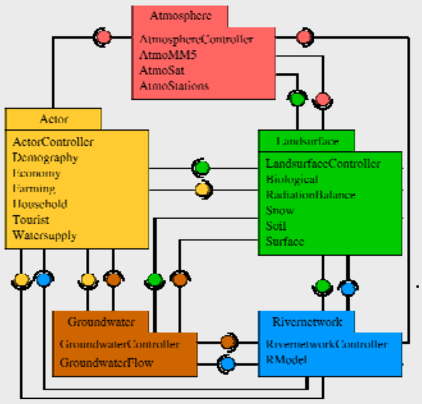


DANUBIA – A coupled simulation system

The research project GLOWA-Danube (www.glowa-danube.de) investigates Global Change effects on the water cycle of the Upper Danube river basin (Germany, ~80.0000 km²) involving 11 different disciplines from natural and social sciences. GLOWA-Danube attempts to develop integrated strategies and tools for water and land use management. Natural and social science simulation models are coupled in the simulation system DANUBIA. A primary scope of DANUBIA is to evaluate consequences of IPCC derived climate scenarios for the coming 50 to 100 years.

DANUBIA provides a Java developer framework for the implementation of simulation models and a runtime environment which coordinates implemented simulation models according to their local time step. Data exchange between the different simulation models is specified by interfaces. As a common notation for the specification of structural system properties we use the Unified Modelling Language (UML).

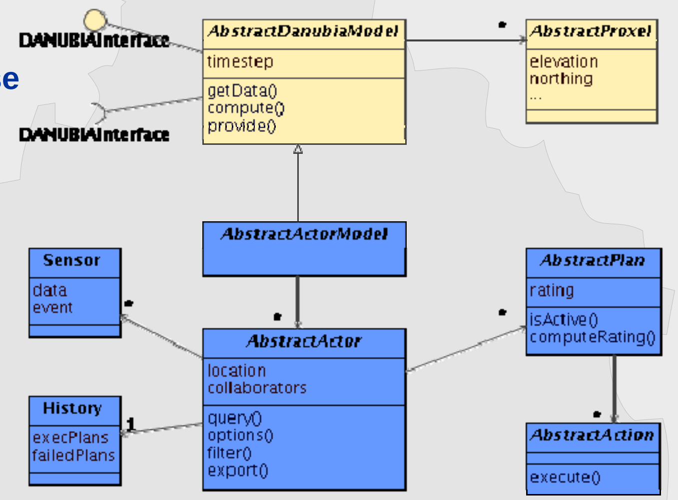
The socioeconomic models of DANUBIA, implemented within the main component 'Actor', are mainly responsible for calculating water demand, water extraction and water prices. Their implementation is based on the DeepActor framework.

DeepActor Framework – Simulating human response

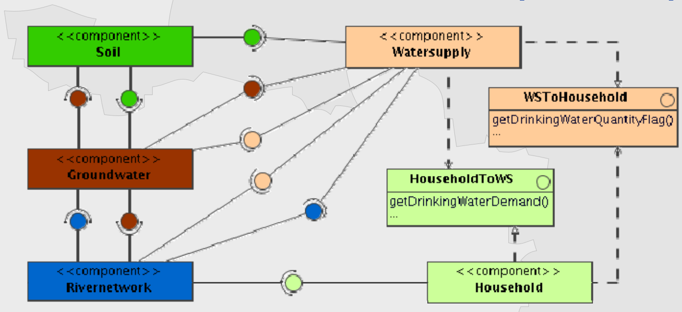
Socioeconomic response to Global Change is quite often based on a decision process, which includes the consideration of individual possibilities and preferences along with typical, type dependent 'thinking'. In order to simulate this type of behaviour, the 'Actors concept' was developed and implemented by the generic DeepActor framework as an extension of the DANUBIA developer framework.

An actor is any entity capable of making a decision. Within each time step of a simulation run, an actor observes its environment and activates plans as a reaction to its observations. Plan activation results in the execution of associated actions that model explicit state modifications of the simulation area. Different actors may have different course-of-actions as well as varying preferences, represented by their individual plans and their type-specific decision procedure.

The DeepActor framework applies object-oriented techniques to provide the basic building blocks of this concept in form of abstract base classes and predefined relationships among them. A concrete model may implement different actor, plan or action types by extending the respective base class.



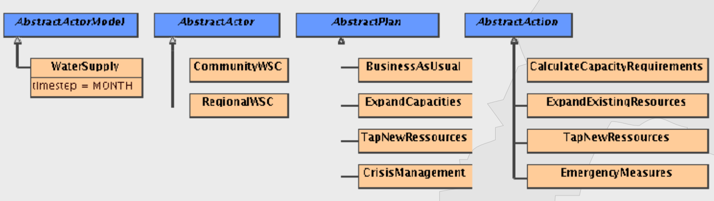
DeepWaterSupply and DeepHousehold

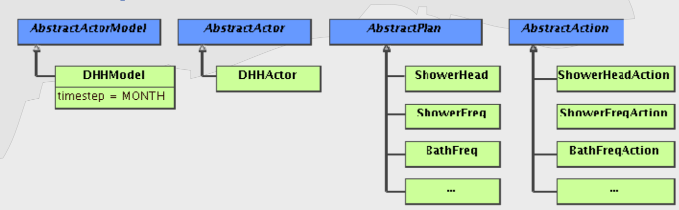


DeepWaterSupply is a model of the water supply sector comprising water extraction, treatment and distribution. It acts as a link between the natural 'supply side', simulated by a groundwater and a surface water model, and the socioeconomic 'demand side' simulated by a household, tourism, farming and an economy model of water consumption in the respective sectors. The main aim of DeepWaterSupply in the context of Global Change is to react reasonably to all possible changes on the supply and on the demand side.

The DeepHousehold model was designed to estimate the water use of households under changing surrounding conditions. The households get their water from the DeepWaterSupply model. They use it for showering, toilet flush, laundry etc. The wastewater is passed through virtual clarification plants to the model Rivernetwork.

Model implementation using the DeepActor Framework





Based on the framework the DeepWaterSupply model implements the actor type water supply company (WSC). A WSC compares the demands to the state of the resources on the supply side. Depending on the result a WSC chooses from different plans. For the water supply sector, the DeepActor-Approach has the advantage that it facilitates a flexible and realistic response to system changes. Scenarios can be easily defined by adjusting actor types and preferences and critical states can be identified without having to model the infrastructure of individual WSC explicitly.

The DeepHousehold model uses the DeepActor framework to implement different household lifestyles together with a common set of plans, modeling different kinds of water uses. A household actor decides upon different plans depending on its preferences (determined by the respective lifestyle) and the surrounding conditions. The decision process is based on Multi-Attribute Utility Theory. Among other things the air temperature, the modernity of the plan and the social desirability are used for a utility calculation. The DeepActor-Approach allows to unfold the reasons for these decisions.

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