

OVERVIEW

on the most important research achievements and on method development in GLOWA-Elbe

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The research work in GLOWA-Elbe aims both to develop methods (application orientated) and to influence policy, but the development of methods represents an essential preliminary task on which the policy-orientated investigations and further work can be based.

Among the methodological preliminary results and products are:

- production of consistent databases,
- extension of many models from their original area of application and extension of the corresponding validation,
- co-ordinated combination of different models to investigate complex research questions, and
- general procedures in determining the extent and direction of global change, its impacts and suitable adaptation strategies.

For the methodological work there are four focus points:

1. Modelling of the Elbe as a whole
2. Large-scale water management modelling with integrated socio-economic analysis in the Spree/Havel region
3. Analysis of and model adaptation to specific research questions in sub-regions
4. Integrated strategies for the sustainable settlement of water use conflicts.

1. Modelling the whole Elbe

Climate

A consistent climate data set for the German part of the Elbe river basin was produced. It includes daily values of the most important climatic variables for 369 climate stations and is available both on a station-by-station basis and as an interpolated data set. A climate scenario for a transient climate change for the period 2001-2055 was produced at the same resolution using the model system STAR. (http://www.glowa-elbe.de/status_praes/gersteng/gesamt.html) The STAR climate scenario covers 100 statistical possibilities. It realizes a predetermined rise in temperature with a mean of +1.4°C. The development of precipitation is determined by the model and varies with different realizations.

To test the quality of the regional climate model REMO, the observed daily precipitation values for the German part of the Elbe river basin were compared with the calculated values (http://www.glowa-elbe.de/status_praes/mpi/gesamt.html). The agreement being up to requirement, REMO was then used with the SRES-B2 emission scenario to generate a climate data set for Central Europe. It has a spatio-temporal resolution of 6 hours and roughly 16 km. The periods 1990-99 (reference) and 2020-50 (scenario) were simulated.

For the period 1979 to 1999, analysis series were determined for general weather situations, with particular emphasis on ground temperatures and precipitation. A new circulation index was produced for the 1990s and using NOAA and Meteosat satellite data, and daily registers of the cloud cover amount and cloud type were analysed for the whole area. On the basis of climate calculations with the models ECHAM and REMO for the SRES-B2 emission scenario, local neuro-fuzzy models were developed taking a classification of general weather situations and climate data series as a basis, and were used to generate climate series for the period 2003 to 2052. By varying the parameters within the area of statistical uncertainty, 100 realizations of these climate series were produced, analogous to the STAR scenario. The plausibility of these climate series is currently being tested. (http://www.glowa-elbe.de/status_praes/fub/gesamt.html)

For the simulation of spatially and temporally highly resolved climate fields, the DWD set up a local model.

Water availability

The development of water availability for the Elbe as a whole was simulated – considering several climate scenarios – using the model system WaterGAP. Scenarios for population development and on the development of water requirements for primary energy production were produced and included in the calculations.

(http://www.glowa-elbe.de/status_praes/doell/gesamt.html)

Water budget and ecosystem interactions

The ecohydrological model system SWIM was validated for parts of the region and for the whole region using gauge data for runoff, maps of groundwater isoline and regional yield statistics. It was used for the area-differentiated simulation of the impacts of climate and land-use change on evapotranspiration, flow and groundwater recharge and on yields of important agricultural crops (http://www.glowa-elbe.de/status_praes/valen/gesamt.html).

Catchment-related nutrient budget and water quality

The model system MONERIS was used to determine the effects of climate scenarios on the nitrogen and phosphorous load/content of the whole Elbe. A new data base with comprehensive information on land use and land-use intensity was constructed (http://www.glowa-elbe.de/status_praes/behrendt/gesamt.html).

Agriculture

On the basis of the current framework for agricultural policy (Agenda 2000), a projection was made using the model system RAUMIS for the development of agriculture and land use (reference situation) up to 2010 and 2020. In comparison to the reference situation scenario, analyses were firstly carried out on the consequences of a high degree of liberalization of the EU agricultural market for agricultural land use and farm cropping structures without climate change. In addition, agricultural-environmental policy measures such as the introduction of a tax on mineral nitrogen or a limitation on stock-keeping density were examined as regards their potential to reduce nitrogen surplus in agriculture (http://www.glowa-elbe.de/status_praes/goem/gesamt.html). We are currently looking at what consequences the climate-induced yield changes given by SWIM would have on the simulated agricultural land use. Further, the model system MONERIS is being used to test what consequences changes of land use and nutrient surpluses in combination with differing scenarios on climate change have for nutrient loads.

2. Large-scale water management modelling with integrated socio-economic analysis in the Spree/Havel region

A long-term water management model ("ArcGRM Spree/Schwarze Elster") was available for the Spree and Schwarze Elster basins, which was developed and used on behalf of the federal states of Saxony, Saxony-Anhalt, Brandenburg and Berlin and the mining rehabilitation agency LMBV. Because of its suitability as an integration instrument, this model and also parts of the software it was based on (http://www.glowa-elbe.de/status_praes/wasy/gesamt.html) were developed further in GLOWA-Elbe. This resulted in the production of ArcGRM GLOWA for the scenario period 2003-2052 (extended by 20 years), with which important innovations in catchment-related research on global change and its impacts were achieved. For the first time stochastic model input values of ArcGRM were produced on the basis of a multitude of realizations (100 in this case) of a climate scenario (STAR). The water inflow, (spatially and temporally differentiated), from the various sub-regions were calculated with the N/A models ARCEGMO and EGMOD for each scenario realization. The climate impacts for the Spree/Havel region according to balance point (?) and realization were summarized as statistical distribution functions. The diversity and scope for variation of possible changes in climate is thus more comprehensively taken into account than was previously internationally usual.

The model values for the development of water management had a socio-economic foundation and were derived on the basis of a given framework for global development. The future water requirements of the energy sector and the expected water flood needed to the former open-cast pits were calculated with aid of the model and using the IKARUS-database. Using specially developed, sector-specific economic transfer functions, the water management model results were translated into benefits and costs for the economic sectors concerned. By this means, for each regional balance point, not only a water management assessment but also a socio-economic assessment of climate change can be made for each scenario realization, and can be summarized as statistical distribution functions.

The probable changes in flow up to 2052 produced by ArcGRM GLOWA simulations, together with the socio-economic impacts on benefits, costs and employment derived from these results, formed an important basis for the multi-criteria analysis of alternative policy actions.

3. Analysis, model adaptation to address specific regional problems

Landscape conferences

A method was developed to record the expectations ("visions") of citizens on the future development of "their" landscape or region, its main component being (in addition to analysis) interviews, workshops and landscape conferences held with affected members of the public. The general aim was given as the "sustainable development of the landscape", which plays a particular role in people's consciousness. From the starting point of a large-scale typology, the investigations were concentrated on two areas: the "Niederlausitzer Boden" (former industrial landscape type) and the Spandau region ("urban area"). In a representative survey 400 people from each area were asked for their opinions. The workshops and landscape conferences were attended by 20 to 40 participants, made up of representatives of citizens' action groups, members of nature protection or sports associations, town and parish councillors, interested senior employees of firms or institutions, and politically, culturally or socially active individuals (http://www.glowa-elbe.de/status_praes/ipsen/gesamt.html).

Upper Spree

With involvement from stakeholders and other people affected, the development frameworks and fields for action relevant to water availability were identified and 20 alternatives for action formulated. These action alternatives were assessed using the (water management and socio-economic) results of ArcGRM GLOWA in the framework of multi-criteria analysis.

Because of the substantial involvement of the policy-making body in the research process, it can be assumed that the results of the scenario calculations will influence the shape of future water management policy in the Spree/Havel region significantly (http://www.glowa-elbe.de/status_praes/kalt/gesamt.html).

Spreewald

A water management model, ArcGRM Spreewald, was constructed for the Spreewald wetlands on the basis of the model system ArcGRM and the water balance model WABI, and was validated using data on regional runoff (http://www.glowa-elbe.de/status_praes/dietrich/gesamt.html). In order to be able to depict the heterogeneity and complexity of the Spreewald successfully, the underlying models - and thus also the area in which they can be applied in the future - were considerably extended. The ArcGRM Spreewald model was firstly used to investigate the effects of global change on the water budget components evaporation, additional water needs, additional water deficit and total runoff of the lowland area, together with groundwater levels of sub-areas in the Spreewald. The inclusion of the nested detail model "Spreewald" in ArcGRM GLOWA led to a multitude of solutions on the principles of nesting detailed sub-models; these can be used again in the planned extension of ArcGRM GLOWA to create a large-scale ArcGRM GLOWA-Elbe model.

The groundwater levels calculated in ArcGRM Spreewald were used as initial information by the vegetation development model VEGMOS (http://www.glowa-elbe.de/status_praes/wessol/gesamt.html). For VEGMOS, the hydro-ecological amplitudes for the development of the biotope and corresponding development of vegetation types for the Spreewald were determined, and then both the threat to vegetation and the potential development of vegetation under changing water budget conditions were quantified and localized.

As the basis for an assessment in monetary terms of the leisure value of the Spreewald, a survey was carried out of 720 holidaymakers participating in punting trips there. Using count-data models, the results were used to quantify the effects of the changing navigability of rivers in the Spreewald and the leisure value of the Spreewald as such.

Berlin

For the basically urban area formed by the Berlin conurbation and its suburbs in the catchments of the lower Spree and lower Havel, the Berlin component of ArcGRM GLOWA was used to perform detailed nested investigations on changes in water availability (especially in the summer months) and the possibility of achieving water quality II, and effects of climate change and management alternatives were simulated (http://www.glowa-elbe.de/status_praes/opperm/gesamt.html). Here, the ArcEGMO model was used to simulate the actual water availability and inflow for nine areas in the north, where the development of population and associated changes in built-up area and rainfall drainage, as well as changed climatic conditions, were taken into consideration. Geographic trends regarding sealing or unsealing were provided by the newly developed model LUSIM.

To investigate the effects of changed sewage treatment capacity on water quality in zones of flow (prognoses of nitrogen and nutrient budgets and the plankton biocenose) the water quality model for flowing water QSIM, which was further developed as part of the project, was used. The water quality reaction of shallow lakes (frequency of the layers) to an increase in temperature was simulated using the ecological lake model EMMO, which was also further developed.

Unstrut

Ecosystem impact analyses on the effects of development scenarios on the water and nutrient budgets of this region were carried out in a nested form for the catchments of the Unstrut gauges Oldisleben (4,175 km², area 1) and Nängelstedt (716 km², area 2). A focus of the detailed investigations in area 2 was the retention capacity of the river flood plains and its influence on water and nutrient budgets. In addition, a coupled groundwater-precipitation-flow model was constructed, which was realized through coupling the groundwater model MODFLOW with the ArcEGMO model, and is accompanied by a comprehensive measurement programme.

A variety of methods are used to validate the model, e.g. lysimeter experiments run since 1997 on riverside sites in area 2, investigations on groundwater dynamics and groundwater properties, tracer experiments and isotope analyses for percolation water, groundwater and eluvial soils.

For the districts of Eichsfeld, Sömmerda with Erfurt, Nordhausen, Unstrut-Hainich and the Kyffhäuser area, a selection of typical farms was made using a classification and weighting method. The consequences for the farms of the liberalization of the EU agricultural market and a more regional or ecological type of farming were investigated using a farm management planning programme in accordance with the RAUMIS analysis for the Elbe as a whole.

4. Integrated strategies on sustainable handling of water use conflicts

The Integrated Method Approach (IMA) was further developed as a methodological platform for the action-orientated research in GLOWA Elbe (http://www.glowa-elbe.de/status_praes/wechs/gesamt.html). It consists of categories describing water use conflicts under the conditions of global change and logical schemes describing the course of events leading to identification of preferred variants for solution of conflicts.

The IMA was used both in the sub-projects dealing with the Elbe as a whole and for the Spree/Havel and Unstrut regions, in order to produce a consistent scenario reference. For this, a unified framework of conditions for global change was modelled and assessed for the entire Elbe region; these were laid down as "external driving forces" in the form of so-called development frameworks, and were used as identical input into all impact analyses and application calculations. The scenario analyses in the Spree/Havel region, too, were carried out on the basis of these underlying conditions, and the consequences for regional and sectoral water users were investigated and assessed. A key role here is played by management alternatives for reservoirs, dams and streamlets, the impacts of which on water availability for various sectors and ecosystems along the Spree were investigated with the model system ArcGRM GLOWA. The integrated consideration of the problem of water distribution under differing overlying global change conditions means embracing all sectors in individual sub-regions (Upper Spree, Spreewald, Berlin), and also the inclusion of all sectors and sub-regions for the area of the Elbe as a whole. In the scenario analysis, results of simulations with ArcGRM GLOWA and nested ecological simulations (Spreewald vegetation; Berlin water quality) together with results of sectoral cost-benefit analyses and opinions of interest groups / affected persons are taken into account.

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