



## Institute of Environmental Systems Research

Report

October 2007 – June 2011



Institute of  
Environmental  
Systems Research

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# Editorial

The report includes the period from October 1<sup>st</sup>, 2007 to June 30, 2011. It is the fifth one since the Institute of Environmental Systems Research has been established in 1994 to carry out interdisciplinary research of complex problems in the environmental field. The long report period of almost four years originates from several major developments and events, which are described in this report. This report also includes the experiences with the re-structured course program "Applied Systems Science", which is closely related to the Institute.

In a joint appointment with the Helmholtz Centre for Environmental Research (UFZ) in Leipzig/Halle the Institute established two new professorships in Ecological Modelling. Dr. Karin Frank and Dr. Andreas Huth from the Department of Ecological Modelling have been appointed in October 2010 and started teaching in the master course "Environmental Systems and Resource Management" in winter term 2010/11. These two professorships are the first joint appointments of the University of Osnabrück with a non-university research center. Dr. Jens Newig finished his habilitation in November 2009. He received the *venia legendi* in Systems Science as well as in Politics. He successfully applied for the professorship for Governance and Sustainability at the Leuphana University Lüneburg and was appointed in June 2010.

In winter term 2006/07 we started with the consecutive course programs on Applied Systems Science to meet the study requirements of the Bologna process. Successful students finish their course program after six semesters with the degree of a Bachelor of Science (B.Sc.) in Applied Systems Science and after four semesters a Master of Science in Environmental Systems and Resource Management (M.Sc.). In 2009 we decided to take part in the 2-Fächer Bachelor course program with the subdiscipline Environmental Systems Science. The Zentrale Evaluierungs- und Akkreditierungsagentur (ZEVA) has evaluated the programs and acknowledged them an outstanding educational course program, which is unique in Germany.

Research has been continued in the various research and development programs. A major part carried out at the Institute was supported by various international and national institutions, e.g. Deutsche Forschungsgemeinschaft (DFG), European Union (EU), Federal Environment Agency (UBA), German Environment Foundation (DBU), Federal Ministry of Education and Research (BMBF) as well as by industry and several foundations. Prof. Pahl-Wostl was successful to acquire the Integrated European Project AquaStress. She is the co-ordinator of 35 institutions working together on new approaches to integrating management, technical, economic and institutional instruments of water resources. Prof. Matthies is a partner in a DFG-Research Group on veterinary medicines in soil. A total amount of approximately 6 Million € was awarded in 2007 to 2011 for the various research projects. During this time 20 Ph.D., 31 Diplom, 12 B.Sc. and 1 M. Sc. have been finished of which the most were carried out at the institute. A large number of refereed papers, contributions to conferences, encyclopaedia as well as books, reports and other articles were published reflecting the remarkable activities of the institute members. I appreciate it very much to see how active all members contribute to the success and further development of the Institute. This is also demonstrated by the various awards for several diplom and Ph.D. theses.

This report is the last one for which I am responsible as the Chairman and Managing Director of the Institute. After 17 years of heading it I commit it to a new managing team. I wish my colleagues all the best for the future. Thanks to all who are supporting the Institute to develop it further to a national and international renowned research place. I would

especially like to thank my colleague Prof. Dr. Anselm Kratochwil, Chair of Ecology and member of the institute board since its establishment, for his cooperation and continuous support.

June 2011

Michael Matthies  
Director of the Institute

# 1 The Institute

One of the university's four interdisciplinary institutes, the *Institute of Environmental Systems Research (Institut für Umweltsystemforschung – IUSF)* was founded in 1994. It is a multi-departmental institution of the Departments of Mathematics/Computer Science, Biology/Chemistry, Physics, and Business Studies. The main research areas undertaken at the Institute include ecosystems analysis, biogeochemical modelling, theoretical biology and ecology incl. eco-epidemiological models, environmental exposure and risk analysis, eco-balances, environmental management systems, socio-economic issues, agent-based modelling, adaptive water management, and participatory environmental governance. Now accommodating some 40 faculty and 5 staff from the natural, social and environmental system sciences, the institute provides an inspiring, interdisciplinary intellectual environment.

In 1992, a C4 professorship in Applied Systems Science was filled with a focus on environmental systems research. A further C3 professorship with a main stress on mathematical modelling was filled in 1996. Thanks to the funding of the German Federal Environmental Foundation (DBU), another C4 professorship with a denomination of Substance Flow Management (Stoffstrommanagement) was filled in 2001 and later renamed Resource Management. On March 1<sup>st</sup>, 2007, the new Assistant Professor (Junior professor) for Applied Environmental Systems Analysis, Elke Fries, started her research and lecturing. Dr. Jens Newig finished his habilitation in 2009 and received the *venia legendi* for System Science and Political Science. He was appointed in 2010 University of Lüneburg. In a joint appointment with the Helmholtz Centre for Environmental Research in Leipzig/Halle the Institute established two new professorships in Ecological Modelling. Dr. Karin Frank and Dr. Andreas Huth from the Department of Ecological Modelling have been appointed in October 2010 and started teaching in the master course “Environmental Systems and Resource Management” in winter term 2010/11.

The study programme *Applied Systems Science*, which is also interdisciplinary and multi-departmental, was founded in 1989. In the following year, a complementary degree programme was also established. Starting with the winter semester 2006/07, both study programmes are being replaced by a Bachelor of Science and Master of Science in Applied Systems Science in accordance with the Bologna process. In 2008 the master programme was renamed in Environmental Systems and Resource Management, which describes more precisely the contents and teaching goals. In 2009 we decided to take part in the 2-Fächer Bachelor course program with the sub discipline Environmental Systems Science. In total, six departments are involved in the teaching of the three programmes in Applied Systems Science, with an emphasis on the Department of Mathematics and Computer Science, which is also responsible for managing the course.

Members of the board of the institute are during the report period:

- Prof. Dr. Michael Matthies (chairman of the institute board and managing director since 1994)
- Prof. Dr. Norbert deLange (Institute of Geoinformatics and Remote Sensing, member of the institute board since 2008)
- Prof. Dr. Anselm Kratochwil (Dept. of Biology/Chemistry, Chair Ecology, member of the institute board since 1994)
- Dr. Jens Newig (until 01/2010) and Christian Ehling (from 02/2010) (scientific staff of the Institute)
- Dr. Jürgen Berlekamp (scientific-technical staff of the Institute)

- Nils Kehrein (until 01/2010) and Stefanie Lutz (from 02/2010) (student of Applied Systems Science)

Research in environmental system science is carried out at the Institute in four working groups, which are briefly portrayed in the following paragraphs. This report does not include the research activities of the working groups of the other departments. The reader is referred to the reports of the respective departments or institutes.

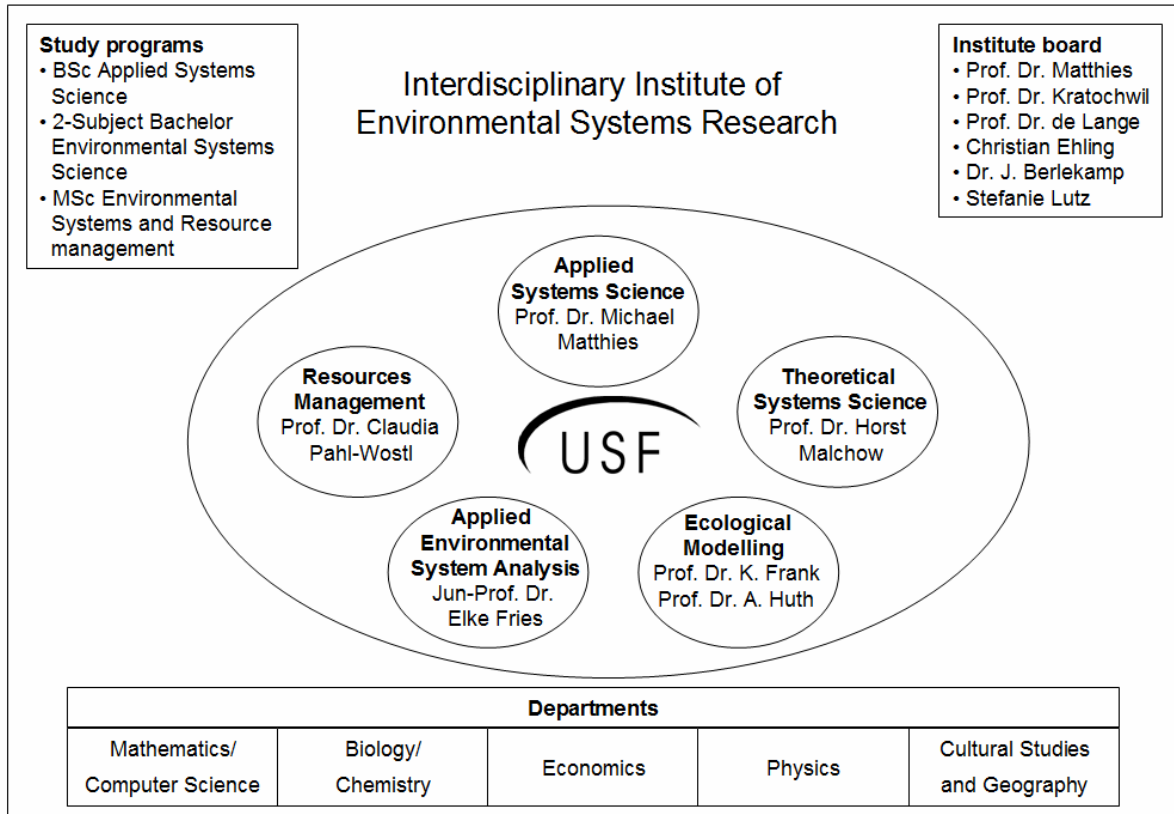


Figure 1 Organisation chart of the Institute of Environmental Systems Research

## Applied Systems Science



*Prof. Dr. Michael Matthies*

Our research activities comprise the analysis of the state of the environment and its compartments, the investigation of chemical fate and transport processes, and the development of methods for chemical and biological exposure and risk assessments. For these purposes, mathematical models are developed, which targets at quantifying environmental processes and at a better understanding of environmental systems. Furthermore, modelling allows for

predicting chemical exposure to humans and ecosystems on local, regional, and global scales.

A major emphasis of our scientific work lies on the development of fate and transport models of chemicals in the environment and their validation using monitoring data for comparison. Therefore, we use geo-referenced data, and perform sensitivity and uncertainty analyses, as well. Mass balances are calculated on regional and local scales, and GIS-supported environmental information and management systems are developed.

Main research topics are:

- Analysis, modelling and simulation of chemical pollution in water, soil, air, and plants
- Investigation and modelling of environmental fate and transport processes, e.g. volatilisation, sorption, uptake into microbial cells, biodegradation, long-range transport in air and water
- Modification of the geo-referenced aquatic exposure assessment GREAT-ER to metals, pharmaceuticals and other emerging micro-contaminants in rivers and its application to European river catchments
- Multi-medial modelling for the identification of chemicals with environmental persistence, long range transport potential, and bioaccumulation
- Calculation of mass and energy balances, GIS-supported environmental information and management systems
- Risk analysis of veterinary pharmaceuticals in soils

## Resources Management



*Prof. Dr. Claudia Pahl-Wostl*

The first Stiftungsprofessur of the University of Osnabrück, funded by the Deutsche Bundesstiftung Umwelt, was established by the Institute and filled in October 2001 with the denomination Stoffstrommanagement (Substance Flow Management). In 2010, the chair was renamed Ressourcenmanagement (Resources Management), which represents better its actual research field.

Innovative concepts for managing transformation processes towards sustainability are developed with an emphasis on an improved understanding of dynamics of actor networks and complex resource governance and management systems. We develop new concepts for participatory model development and management strategies. Activities proceed in close exchange with industry and public authorities and other stakeholder groups.

One focus is to improve the representation of the human dimension in integrated models and management processes. A promising method is agent based modelling. In this context, agents are autonomous software systems that describe the behaviour of social entities (individuals, organizations). A big advantage of this method is that it allows a more realistic representation of social and cognitive processes. In turn, this allows for exploring the complex spatio-temporal dynamics of human-technology-environment systems and thus the

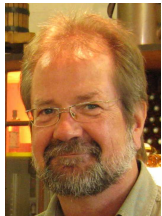
development of the basic foundations to manage transformation processes in such systems. In particular, agent based modelling is very well suited for participatory model development and application in processes of social learning with different stakeholder groups.

Over the past years a comprehensive conceptual and methodological framework has been developed to analyse the dynamics of resource governance and management systems and transition processes towards sustainability. The Management and Transition Framework (MTF) close a huge methodological gap and allow a consistent representation and comparative analyses of case studies. It has been applied to analyse which factors determine adaptive and transformative capacity of multi-level water governance and management systems. The goal is to combine empirical analyses guided by the MTF, tools from social network analysis and simulation models.

The main area of application is water resources management at different scales and the implications of the new European Water Framework Directive for river basin management in Europe. New integrated concepts for water resources management need to take into consideration the human dimension more explicitly. Adaptive integrated management concepts are more appropriate to deal with the complex resource management problems society faces nowadays.

Another important area of research is the development of general concepts for interdisciplinary work and integrative systems approaches. To strengthen innovative approaches in inter- and transdisciplinary research activities in international scientific networks is of paramount importance.

## Theoretical Systems Science



*Prof. Dr. Horst Malchow*

The studies deal with the mathematical analysis and modelling of growth, interactions and motion of biological populations. The main modelling tools are ordinary, partial and also stochastic differential equations with analytical and numerical analysis and simulations. Applications are thought in modelling bioinvasions including the spread of infectious diseases. The latter have strong ecological and economical impacts. The perception of their often harmful effects has been continuously growing both in sciences and in the public. Mathematical modelling is a suitable method to investigate the dynamics of invasions, both supplementary to and initiating field studies as well as control measures.

The non-linear effects that are possible in conceptual population-dynamical models need to be explained before they can be coupled as modules in more complex population-dynamical or even ecosystem models, whereby unpredictable (emergent) properties of the whole model can be generated. This is the only way in which the accuracy of management strategies or predictions can be increased.

## Environmental System Analysis



*Jun.-Prof. Dr. Elke Fries*

The research activities focus on the analysis of chemicals in natural and polluted ecosystems at different scales. Emission sources, transport and fate processes, exposure and risks are studied in different environmental compartments. The current focus is on organic emerging pollutants and marine plastic debris.

Sensitive analytical methods are developed and applied to measure organic trace contaminants in surface waters, ground water, waste water, air, soil, and polymers. Laboratory experiments (batch and leaching experiments) are performed for parameterisation of fate and exposure models to predict the transport and spatial distribution of pollutants at different scales as a basis for risk assessment. Monitoring concepts based on multivariate statistical approaches are developed and applied at a regional scale for model evaluation and to support uncertainty and sensitivity analysis. In addition external effects on the environment are analyzed economically.

Concepts for integrated risk managements are developed in cooperation with biologists and ecotoxicologists, geologists, marine scientists, social scientists and computer scientists. There is a close cooperation with the Chairs of Resource Management (Pahl-Wostl) and Ecology (Kratochwil, Eggers, Department of Biology/Chemistry).

## Ecological Modelling (since 10/2010)

The following two professorships in Ecological Modelling have been established in a joint appointment of the University of Osnbrück with the Helmholtz Centre of Environmental Research – UFZ, Leipzig to a build-up strategic partnership.



*Prof. Dr. Karin Frank*

Appropriate land use is seen as strategy to response to several challenges related to Global Change. It has to be ensured, however, that is realized in a sustainable way without adverse side-effects on the environment – especially the biosphere. Research therefore addresses:

Ecological risk analysis: Special focus is on model-based assessment of impacts of land use and climate change on stability properties (vulnerability, persistence, resilience, functional robustness) of ecological systems. Ecological risk analysis covers e.g. habitat loss and fragmentation, climate variability and extreme events, or increased production of bio-energy as strategy for climate protection. This is addressed: using spatial stochastic models

for biotic communities, by coupling statistical and dynamic models with (laboratory) experiments.

Management-support: Identification of critical trends, buffer mechanisms and indicators of sustainability; development of robust adaptation strategies in the context of: sustainable production of bioenergy, sustainable use of ecosystem services for livelihood security under climate change, maintenance of biodiversity and natural resources.

Instrument design: The implementation of adaptation strategies requires the development of appropriate instruments. Thus, land use decisions are modeled in dependence of resource access, markets and policy instruments; identification of fail-incentives and demands on sustainable policy mixes. This is done using agent-based, ecological-economic modeling.

Sharpening of concepts and methodologies: Integral part of the research is the sharpening of concepts and methodologies of inter- and transdisciplinary research. This particularly concerns the coupling of models and the conduction of integrative system analyses across different levels of abstraction (concepts, models, case studies).

The research activities are part of the Helmholtz Research Programme „Terrestrial Environments: Strategies of Response to Global and Climate Change“.



*Prof. Dr. Andreas Huth*

The research group of Prof. Huth is working on models for ecological and biological systems and they are applying models for ecosystem management and nature conservation questions.

The group have developed a group of individual based vegetation models (forest, grassland). Vegetation and esp. forests provide important ecosystem services like resources (e.g. wood), climate regulation (carbon sequestration) or habitat for other species. Nevertheless climate change and land use are drivers which might modify the stability and dynamics of vegetation ecosystems strongly.

The forest models (FORMIND & FORMIX3) are used all over world mainly to analyse (a) the impacts of disturbance (e.g. fragmentation, drought), (b) the impacts of wood use, and (c) the role of the species composition on important ecosystem functions (e.g. productivity). Currently, new models modules are under development to calculate full carbon balances for forests under different management and climate scenarios.

The group is also working on new modelling and analysis techniques: individual based spatial explicit vegetation models, process based modelling, modelling with cellular automata and neural models, methods to analyze complex spatial structures (point pattern analysis, Ripley), methods for the estimation of model parameters (inverse modelling, Bayesian statistics), sensitivity analysis of models and model aggregation.

Main research fields are:

- dynamics of vegetation (temperate and tropical forests, grasslands)
- sustainable management of vegetation
- the role of forests in the global carbon cycle

- modelling the dynamics of biodiversity, key processes for the coexistence of species
- near-natural systems for bioenergy production
- physiological processes in ecosystems
- inverse modelling
- visualization of ecological models and their results
- remote sensing and ecological modelling

The research is embedded in the research program of the Helmholtz Association 'Terrestrial Environments: Strategies of Response to Global and Climate Change' and is supported by several external funded projects: two projects in research units of German Science Foundation (biodiversity research) and a large project funded by the European Research Council (Advanced Investigators Grant together with Thorsten Wiegand, 'Towards a unified theory of diversity').



## 2 Teaching

### 2.1 Courses

#### Winter term 2007 / 08

- *J. Berlekamp*, Geoinformationssysteme II, 4,5 ETCS
- *J. Klasmeier*, Environmental Systems Analysis, 3 ETCS
- *K. Frank*, Systemwissenschaftliche Exkursion “Institutionen und Projekte der aktuellen Umweltforschung“
- *E. Fries*, Environmental Chemistry and Analytical Methods, 3 ETCS
- *E. Fries, T. Eggers, J. Klasmeier, D. Remy*: Practical Course in Environmental Analysis, P, 6 ETCS
- *E. Fries, T. Eggers*: Phenols in Ecosystems - A Metaanalysis, 3 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *H. Malchow*, Gleichungsbasierte Modellierung II, 6 ETCS
- *M. Matthies*, Einführung in die Angewandte Systemwissenschaft, 6 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies*, Systemwissenschaftliches Kolloquium, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *J. Newig*, Actor and Stakeholder analysis, 3 ETCS
- *J. Newig*, Wasserpolitik. Ein Politikfeld im Umbruch, 3 ETCS
- *C. Pahl-Wostl*, Regelbasierte Modellierung, 6 ETCS

#### Summer term 2008

- *J. Berlekamp*, Geographische Informationssysteme, 6 ETCS
- *E. Fries*, Data and Models, 6 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *H. Malchow*, Gleichungsbasierte Modellierung I, 9 ETCS
- *M. Matthies*, Nachhaltigkeit – Konzepte, Methoden, Anwendungen, 6 ETCS
- *M. Matthies*, Hauptseminar Systemwissenschaft, 3 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *J. Newig*, Akteursanalyse, 3 ETCS
- *J. Newig*, Partizipative Governance, 3 ETCS
- *C. Pahl-Wostl*, Konzepte und Methoden der partizipativen Modellierung, 6 ETCS

#### Winter term 2008 / 09

- *J. Berlekamp*, Geoinformationssysteme II, 4,5 ETCS
- *E. Fries*, Environmental Chemistry and Analytical Methods, 3 ETCS

- *E. Fries, T. Eggers, J. Klasmeier, D. Remy*, Practical course in Environmental Analysis, P, 6 ETCS
- *E. Fries, T. Eggers*, Phenols in Ecosystems - A Metaanalysis, 3 ETCS
- *E. Fries*, Modelling and risk assessment (Proseminar), 3 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *J. Klasmeier*, Environmental Systems Analysis, 3 ETCS
- *M. Matthies*: Einführung in die Systemwissenschaft, 6 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies*, Systemwissenschaftliches Kolloquium, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *J. Newig, C. Pahl-Wostl*, Adaptive Governance und politische Steuerung, 3 ETCS
- *J. Newig*, Adaptive Governance, 3 ETCS
- *C. Pahl-Wostl*, Regelbasierte Modellierung, 6 ETCS
- *I. Siekmann*, Gleichungsbasierte Modellierung II, 6 ETCS

### Summer term 2009

- *J. Berlekamp*, Geoinformationssysteme I, 6 ETCS
- *E. Fries*, Data and Models, 6 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *H. Malchow*, Gleichungsbasierte Modelle I, 9 ETCS
- *M. Matthies*, Umweltrisikoplanung, 6 ETCS
- *M. Matthies*, Hauptseminar Systemwissenschaft, 3 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *J. Newig*, Implementation & Governance, 3 ETCS
- *C. Pahl-Wostl*, Adaptive Resource Management, 3 ETCS

### Winter term 2009 / 10

- *J. Berlekamp*, GIS-Modell-Integration
- *E. Fries*, Environmental Chemistry and Analytical Methods, 3 ETCS
- *E. Fries, T. Eggers, J. Klasmeier, D. Remy*, Practical course in Environmental Analysis, P, 6 ETCS
- *E. Fries, T. Eggers*, Phenols in Ecosystems - A Metaanalysis, 3 ETCS
- *E. Fries, A. Focks*, Modelling in Nature and Society (Proseminar), 3 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *J. Klasmeier*, Environmental Systems Analysis, 3 ETCS
- *H. Malchow*, Gleichungsbasierte Modellierung II, 6 ETCS
- *M. Matthies*, Einführung in die Systemwissenschaft, 6 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies*, Systemwissenschaftliches Kolloquium, 3 ETCS

- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *C. Pahl-Wostl*, Regelbasierte Modellierung, 6 ETCS
- *C. Pahl-Wostl*, Seminar Systemwissenschaft, 3 ETCS

### Summer term 2010

- *J. Berlekamp*, Geoinformationssysteme I, 6 ETCS
- *K. Frank*, Modellierung für ökologische Risikoanalyse (Kompaktkurs), 6 ETCS
- *E. Fries*, Data and Models, 6 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *H. Malchow*, Gleichungsbasierte Modelle I, 9 ETCS
- *M. Matthies*, Nachhaltigkeit – Konzepte, Methoden, Anwendungen, 6 ETCS
- *M. Matthies*, Hauptseminar Systemwissenschaft, 3 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *J. Newig*, Interdisziplinäres Seminar zur europäischen Wasserrahmenrichtlinie, 3 ETCS
- *C. Pahl-Wostl, E. Fries*, Adaptive Resource Management, 3 ETCS
- *C. Pahl-Wostl, J. Newig, K. Frank*, Systemwissenschaftliche Ansätze in verschiedenen Disziplinen, 3 ETCS
- *C. Pahl-Wostl*, Systemwissenschaftliches Seminar zur Präsentation von Bachelorarbeiten, 3 ETCS

### Winter term 2010 / 11

- *J. Berlekamp*, GIS-Modell-Integration, 4,5 ETCS
- *E. Fries*, Environmental Economics, 6 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *E. Fries, K. Frank*, Management of Climate Risks in Agriculture (Proseminar), 3 ETCS
- *A. Huth*, Populations- und individuenbasierte Modelle in der Ökologie (Kompaktkurs), 6 ETCS
- *J. Klasmeier*, Environmental Systems Analysis, 6 ETCS
- *H. Malchow*, Gleichungsbasierte Modellierung II, 6 ETCS
- *M. Matthies*, Einführung in die Systemwissenschaft, 6 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies*, Systemwissenschaftliches Kolloquium, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *C. Pahl-Wostl*, Regelbasierte Modellierung, 6 ETCS
- *C. Pahl-Wostl*, Seminar Systemwissenschaft, 3 ETCS

### Summer term 2011

- *J. Berlekamp*, Geographische Informationssysteme, 6 ETCS

- *K. Frank*, Modellierung für ökologische Risikoanalyse: Stochastische Ansätze (Kompaktkurs), 6 ETCS
- *E. Fries*, Data and Models, 6 ETCS
- *E. Fries*, Applied Environmental Systems Analysis (Project), 6 ETCS
- *G. Holtz*, Replikation agentenbasierter Modelle, 3 ETCS
- *G. Holtz*, Transitionen in Mensch-Technik-Umwelt-Systemen, 3 ETCS
- *A. Huth*, Populations- und individuenbasierte Modelle in der Ökologie, 3 ETCS
- *H. Malchow*, Gleichungsbasierte Modelle I, 9 ETCS
- *M. Matthies, C. Zarfl*, Umweltrisikoaanalyse, 6 ETCS
- *M. Matthies, C. Pahl-Wostl, H. Malchow, E. Fries*, Forschungsseminar, 3 ETCS
- *M. Matthies, J. Klasmeier, J. Berlekamp*, Umweltmodellierung (Projekt), 6 ETCS
- *C. Pahl-Wostl, G. Holtz*, Hauptseminar Systemwissenschaft, 3 ETCS
- *C. Pahl-Wostl*, Seminar Systemwissenschaft, 3 ETCS

## 2.2 Completed diplom, bachelor and master degrees

### Diplom theses 2007

Diplom theses marked with the letter [E] have been completed within the supplementary diplom course (Ergänzungsstudiengang). All the other diplom theses have been completed within the diplom course.

- *W. Avenhaus* [E], Implementation von GREAT-ER mit ArcGIS und Arc Hydro
- *A. Dietzel, Anne*, Modeling of contributing areas in small agricultural catchments
- *F. Lenz*, Data-based modelling of motorway traffic with time-dependent Fokker-Planck equations and their validation
- *T. Niemann*, Analyse, Konzeption und Umsetzung eines Projektmanagementsystems im EDV-Bereich eines internationalen Automobilzulieferers mit Hilfe von SAP PS

### Diplom theses 2008

- *O. Bahlmann*, Entwicklung eines einfachen Wasserbilanzmodells zur Ermittlung von Wasserstress
- *F. Böckmann*, Verfahren zur Vergabe von Kursplätzen
- *F. Bruns*, Optimierung der Zugbeladeplanung im kombinierten Verkehr
- *C. Ehling*, Abschätzung des Bioakkumulationspotentials organischer Verbindungen in der menschlichen Nahrungskette
- *S. Ernesti*, Simultane Expositionsabschätzung organischer Chemikalien und ihrer Abbauprodukte in Flusseinzugsgebieten
- *C. Fiedler*, Development of interface components for porting GREAT-ER functionalities to ArcGIS

- *S. Holzhauer*, Development of a Social Network Analysis and Visualization Module for Repast Models
- *M. Kalkuhl*, Modeling Climate Policy Instruments in a Stackelberg Game with Endogenous Technological Change and Market Imperfections
- *H. Nieße*, Modeling the Influence of Culture in River Basin Management
- *J. Schüngel* [E], Implementierung und Anwendung einer Methode zur Unsicherheits- und Sensitivitätsanalyse eines räumlich expliziten Landnutzungsmodells
- *M. Sieber*, A stochastic predator-prey plankton model with infected prey

### Diplom theses 2009

- *M. Beer*, Implementation einer magnetischen Wolke in ein numerisches Modell des interplanetaren Transports
- *R. Hagen*, Modellbasierte Analyse der Jagdstatistik von *Capreolus capreolus* (L. 1758) - Über die Bedeutung von Habitatstruktur, Klimabedingungen und Abschussvorgabe
- *N. Kehrein*, Entwicklung von GREAT-ER 3 unter ArcGIS mit Anwendung auf Benzotriazolen im Einzugsgebiet Hengstbach/Schwarzbach
- *A. Körner*, Risikobereitschaft bei erfahrungsbasierten und beschreibungsbasierten Entscheidungen
- *M. Lunzenauer*, Kontrastieren von zentralen, dezentralen und kooperativen Entscheidungen in einem agentenbasierten Modell zum Hochwasserschutz
- *D. Schittler*, Modeling populations with buffer mechanisms and age structure
- *G. Scholz*, CO<sub>2</sub>-Labelling
- *N. Schuhmacher*, Group Formation in Class and Peer Influences towards Risk Behavior - A Dynamic Systems Approach
- *J. Sprickerhof*, Effizientes Schleifenschließen mit sechs Freiheitsgraden in Lasercans von mobilen Robotern

### Diplom theses 2010

- *I. Hotopp*, Modellierung einer mikrobiellen Nahrungskette im Chemostaten
- *P. Kuper*, Entwicklung einer 4D Objekt-Verwaltung für die Geodatenbank DB4Ge0
- *S. Lutz*, Abschätzung der Relevanz verschiedener Eintragspfade in Oberflächengewässer für ausgewählte Arzneimittel
- *W. Steinmetz*, Einflussgrößen und deren Wechselwirkung auf die System- und Auftragsreihenfolgestabilität in einer Automobilfabrik

### Diplom theses 2011

- *C. Lintze*, Modellbasierte Analyse interagierender selbstoptimierender Systeme
- *M. Menninghaus*, Beziehungen zwischen Quell- und Zielregionen in der Nordsee - Probabilistische Charakterisierung und Vergleich von Ensemble-Driftsimulationen basierend auf verschiedenen Strömungsmodellen

- *I. Prinz-Tran*, Bodenwasserhaushalt unter Gras und Wald - Numerische Simulation der Wasserbewegung im Großlysimeter St. Arnold mittels Bromidtracer

### **Bachelor of Science 2009**

- *J. Krauss*, Optimierung des Osnabrücker Busnetzplans mit Hilfe eines Ameisenalgorithmus
- *J. Nehring*, Agent Based Predator Prey Simulation Controlled by Evolving Neural Networks
- *D. Neumann*, Variation of propagation conditions in interplanetary space: Influence on the particle distribution
- *T. Pollmeier*, Impact of in-stream removal processes on the fate of benzotriazoles in river water

### **Bachelor of Science 2010**

- *J. Bothe*, The Water Use of Cotton Cultivation in the Tarim River Basin in Northwest China
- *J. Zimmermann*, Automatisiertes Auffinden von Scanschatten in 3D-Laserscans

### **Bachelor of Science 2011**

- *T. Jensen*, Einfluss von Pendlerströmen auf die Emission von Arzneimittel in Fließgewässer
- *S. König*, Do additives in LDPE pellets influence the sorption of Polycyclic Aromatic Hydrocarbons (PAHs)?
- *O. La Cognata*, Sorption Behaviour of Polycyclic Aromatic Hydrocarbons (PAH) as a Function of Interlacing of Polyethylene Plastic Pellets
- *M. Nebel*, Implementation and analysis of 'satisficing' as a model for farmers' decision-making in an agent-based model of groundwater over-exploitation
- *H. Nolzen*, Indirect Land Use Change in the Context of Bioenergy Production - Conceptual Understanding through Agent-Based Modelling
- *S. Stehr*, Räumliche Analyse von PBDE-Kongenerenverhältnissen in Umweltkompartimenten

### **Master of Science 2008**

- *A. Bleier*, A Framework for Market-based Coordination in Multi-Agent Systems

## 2.3 System Science Colloquium

Each winter term a colloquium is held which is open to the public. Efforts are being made to win experts from the diverse sub-disciplines of system science. The date, the name of the lecturer and the title of each presentation are listed below:

### Winter Term 2007/ 2008: 14<sup>th</sup> Colloquium

- 01.11.2007 *Dr. Marc Strickert*, Leibniz-Institut, Gatersleben: Was tun mit hochdimensionalen biomedizinischen Daten?
- 08.11.2007 *Prof. Dipl. Ing. Gerhard Weil*, Fachhochschule Osnabrück: Beispiele neuer Verfahren in der Wasseraufbereitung
- 15.11.2007 *Prof. Dr. Helge Bormann*, Carl von Ossietzki Universität Oldenburg: Abschätzung der Auswirkungen von Landnutzungsänderungen auf den Wasserhaushalt von Einzugsgebieten mithilfe von Multi-Modell-Ensembles
- 22.11.2007 *Dr. Katrin Kayser*, Universität Hannover: Einsatz einer Bodenfilteranlage zur Behandlung der mit Enteisungsmitteln belasteten Oberflächenabflüsse am Flughafen Hannover-Langenhagen - Konzeption und erste Betriebserfahrungen
- 29.11.2007 *Dr. Martin Jenssen*, Waldkunde-Institut-Eberswalde : Biologische Vielfalt, Stabilität und Naturnähe - falsche Paradigmen und neue Konzepte
- 06.12.2007 *Prof. Dr. Roland Czada*, Universität Osnabrück: Das politische System als Beteiligungs- und Problemlösungszusammenhang
- 13.12.2007 *Dr. Bertram Ostendorf*, Universität Adelaide, Australien: Management von regionalen Umweltproblemen mit geographischen Informationssystemen – Beispiele aus Südastralien
- 17.01.2008 *Dipl. Ing. Burkhard Golla*, Biologische Bundesanstalt, Kleinmachnow: Vorgehensweise für eine probabilistische georeferenzierte Analyse der Exposition von PSM
- 24.01.2008 *Prof. Dr. Andrea Lenschow*, Universität Osnabrück: Lernen in Netzwerken - kritische Bemerkungen
- 31.01.2008 *Prof. Dr. Michael Hauhs*, Universität Bayreuth: Komplex oder Interaktiv? Verschiedene Rollen von Computermodellen in den Umweltwissenschaften

### Winter Term 2008/ 2009: 15<sup>th</sup> Colloquium

- 30.10.2008 *PD Dr. Indra Spiecker gen. Döhmman*, Institut für Informationsrecht, Universität Karlsruhe & MPI zur Erforschung von Gemeinschaftsgütern, Bonn: Neue Wege des Risikomanagements im gesetzlichen Versicherungswesen.
- 06.11.2008 *Dr. Andreas Beyer*, BIOTEC TU-Dresden: Proteine und ihre Freunde - Modellieren auf zellulärer Ebene
- 20.11.2008 *Prof. Dr. Pascale Cancik*, Universität Osnabrück: Aktionspläne zur Minderung von Luftverunreinigungen und Lärm - neue Instrumente zur Bekämpfung von Umweltproblemen.
- 27.11.2008 *Prof. Dr. Andreas Ernst*, Universität Kassel: Von der sozialen Modellierung zur Stakeholder-Schnittstelle.

- 04.12.2008 *Prof. Dr. Alexander Krämer*, Universität Bielefeld, Fakultät für Gesundheitswissenschaften: Health in Megacities.
- 11.12.2008 *Prof. Dr. Alfons Balmann*, Potsdam Leibniz Institut für Agrarentwicklung in Mittel- und Osteuropa: Agentenbasierte Politikanalysen: Stand, Herausforderungen und Perspektiven dargestellt am Beispiel des Agrarsektors.
- 08.01.2009 *Dr. Jochen Hinkel*, Potsdam Institut für Klimafolgenforschung: Transdisciplinary Knowledge Integration - Cases from Integrated Assessment and Vulnerability Assessment.
- 15.01.2009 *Dr. Pieter Bots*, Cemagref Montpellier, Frankreich: Inside our outside the box? Different approaches to multi-actor systems.
- 22.01.2009 *Dr. Bernhard Truffer*, Cirus - Sozialwissenschaftliche Innovationsforschung, Eawag Dübendorf, Schweiz Innovationssysteme - Ein integratives Konzept sozialwissenschaftlicher Innovationsforschung.
- 29.01.2009 *Dr. Peter Viebahn*, Wuppertal-Institut: Systemanalyse zukünftiger Energie- und Mobilitätsstrukturen - Ökobilanzen, Kosten und Szenarien am Beispiel von "clean-coal", Wasserstoff und erneuerbaren Energien.

#### **Winter Term 2009/ 2010: 16<sup>th</sup> Colloquium**

- 21.10.2009 *Prof. Dr. Johannes Barth*, GeoZentrum Nordbayern, Friedrich-Alexander-Universität Erlangen-Nürnberg: Tips and tricks of stable isotope investigations in environmental sciences: some case studies
- 28.10.2009 *Prof. Dr. Thomas Bousonville*, Hochschule für Technik und Wirtschaft des Saarlandes: Ameisenkolonien und evolutionäre Algorithmen zur Lösung logistischer Probleme.
- 04.11.2009 *Prof. Dr. Jan P. Sendzimir*, International Institute for Applied Systems Analysis (IIASA), Laxenburg, Austria: Support for Learning and Transition Processes in Sustainable Resources Management
- 11.11.2009 *Prof. Dr. Felix Müller*, Christian-Albrechts-Universität zu Kiel, Ökologie Zentrum: Ökosystemare Ansätze und Indikatoren für ein integratives Umweltmanagement
- 25.11.2009 *Prof. Dr. Gunnar Lischeid*, Institut für Landschaftswasserhaushalt, Leibniz-Zentrum für Agrarlandschaftsforschung e.V.: Von der Prozessstudie zum systemischen Ansatz: Beispiele aus der Landschaftshydrologie
- 02.12.2009 *Dr. Bernhard Aue*, Niedersächsisches Landesamt für Verbraucherschutz und Lebensmittelsicherheit, Oldenburg: DL-PCB in Futtermitteln - Kontaminanten aus der Umwelt
- 09.12.2009 *Dr. Christoph Külls*, Universität Freiburg, Institut für Hydrologie: Adaptive Management von Grundwasserressourcen – von Agenten-basierten Modellen zur impliziten Nachhaltigkeit
- 13.01.2010 *Dr. Manuel Gottschick*, Universität Hamburg, FSP BIOGUM: Climate Adaption Governance: Entwicklung von Strategien zur Anpassung an den Klimawandel der Metropolregion Hamburg (Klimzug Nord)
- 20.01.2010 *Prof. Dr. Thorsten C. Schmidt*, Universität Duisburg-Essen, FB Chemie: Prediction of soil sorption of non-ionic organic compounds: power and limitations of polyparamer linear free energy relationships

27.01.2010 *Prof. Dr. Ralf Ebinghaus*, GKSS Forschungszentrum Geesthacht: Umweltmonitoring von neuartigen Problemstoffen am Beispiel der Polyfluorierten Organischen Verbindungen (PFCs)

### **Winter Term 2010/ 2011: 17<sup>th</sup> Colloquium**

03.11.2010 *Dr. Ulrich Callies*, GKSS Forschungszentrum: Driftsimulationen zur Unterstützung der Interpretation von Messdaten in der südlichen Nordsee

10.11.2010 *Prof. Dr. Uwe Schneidewind*, Wuppertal Institut für Klima, Umwelt, Energie: Sustainable Transition Research - Forschungsperspektiven am Wuppertal Institut für Umwelt, Klima und Energie

17.11.2010 *Prof. Dr. John Grin*, Universität Amsterdam: Transitions to a sustainable society: a governance perspective

24.11.2010 *Dr. Thomas Preuß*, RWTH Aachen: Der Einsatz von mechanistischen Modellen zur Beschreibung, Analyse und Vorhersage der Wirkung von Stressoren auf biologische Systeme

01.12.2010 *Dr. Heike Schmitt*, Universität Utrecht: Antibiotikaresistenz in der Umwelt

08.12.2010 Antrittsvorlesungen

*Prof. Dr. Karin Frank*, Helmholtz Zentrum für Umweltforschung – UFZ: Modellierung für ökologische Risikoanalyse und Nachhaltigkeit

*Prof. Dr. Andreas Huth*, Helmholtz Zentrum für Umweltforschung - UFZ : Die Natur im Computer – Was können wir über Ökologie mit Modellen lernen?

12.01.2011 *Prof. Dr. Michael Pregernig*, Albert-Ludwigs-Universität Freiburg: Wissenschaft im Kräftefeld der Politik: Theoretische Ansätze und empirische Befunde zu wissenschaftlicher Politikberatung in der Umwelt- und Ressourcenpolitik

19.01.2011 *Prof. Dr. Klaus Kümmerer*, Leuphana Universität Lüneburg: Nachhaltige chemische Stoffe der Zukunft – vom bloßen Kochen zum intelligenten Menue

26.01.2011 *Dr. Matthias Lüdeke*, Potsdam Institut für Klimafolgenforschung: Globale Archetypen der Vulnerabilität gegenüber Klima- und Globalem Wandel

02.02.2011 *David A. Vasseur, Ph.D.*, Department of Ecology and Evolutionary Biology, Yale University, New Haven: A Tale of Two Synchronies: Intraspecific and interspecific dynamics in space and time.

## **2.4 Other Teaching**

### **Summer Schools**

- 10. UFZ-Winterschule “Ökologische Modellierung”, 25.02.-07.03.2010, Leipzig & Kohren-Sahlis
- 11. UFZ-Winterschule “Ökologische Modellierung”, 03.-13.03.2011, Leipzig & Kohren-Sahlis

### **Training Courses**

- 4th and 5th International Summer School on Environmental Chemistry and Ecotoxicology of persistent toxic substances: “Monitoring and exposure modeling of

emerging con-taminants in river water”. Research Centre for Environmental Chemistry and Ecotoxicology (RECETOX). Masaryk University, Brno, Czech Republic. 06.-13.07.2008 and 05.-12.07.2009.

- PhD course: Xenobiotics in the urban water cycle. Monitoring and modeling of ben-zotriazoles in river water in the catchment area of Hengstbach/Schwarzbach - A case study. Department of Environmental Engineering. Technical University of Denmark. 08.-18.06.2009
- International Graduate Training Course in “Ecological Modelling” as part of the EU Marie Curie Series of Events METIER (METHods of Interdisciplinary Environmental Research), 22 May to 2 June 2008, Bad Schandau

## 3 Research

Research has been continued in the various research and development programs. A major part carried out at the institute was supported by various international and national institutions, e.g. Deutsche Forschungsgemeinschaft (DFG), European Union (EU), Federal Environment Agency (UBA), German Environment Foundation (DBU), Federal Ministry of Education and Research (BMBF) as well as by industry and several foundations. Funding of more than 1 Million EURO has been raised per year of the report period (Table 1).

Year	Budget €
2007	1.492.669,-
2008	1.256.509,-
2009	1.113.690,-
2010	1.344.212,-
2011	841.461,-
Total	6.048.549,-

Table 1: External funding in the years 2007 to 2011 (without the newly established professorships Ecological Modelling)

### 3.1 Research projects

#### 3.1.1 Applied Systems Science

##### **Development of a screening tool for identification of PBT / vPvB substances under REACH**

*Christian Ehling, Prof. Dr. Michael Matthies*

According to the European Union chemicals regulation REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) chemicals have to be evaluated on their persistence, bioaccumulation and toxicity potential (PBT assessment). Long-range transport potential (LRTP) is included in the Stockholm Convention on Persistent Organic Pollutants (POPs) as an additional criterion and is considered to be of equivalent concern to classify a chemical as PBT compound.

We developed the model ETAPOS (Environmental Transport and Accumulation of Persistent Organic Substances) to evaluate organic chemicals simultaneously according to their persistence, long-range transport potential and bioaccumulation potential. ETAPOS combines a level III multimedia model with a dynamic bioaccumulation model that considers accumulation along the aquatic as well as the terrestrial food chain leading to man. The multimedia part of ETAPOS is based on ELPOS (Environmental Long-Range Transport Potential of Organic Substances). To account for bioaccumulation the intake fraction (IF) has been implemented as screening indicator. Further screening criteria are the overall persistence (Pov) and the characteristic travel distance (CTD) for LRTP. ETAPOS calculates all indicators within the same generic multimedia environment.

The model ETAPOS enables a multi-criteria evaluation of organic chemicals with respect to their POP and PBT properties.

Funding: German Federal Environment Agency (UBA)

Term: 01.05.2009 – 30.04.2010

## **Advancements of Concepts for Identification of Substances of Very High Concern (SVHC) in Terms of the REACH Regulation**

*Dr. Chistiane Zarfl, Prof. Dr. Michael Matthies, Ines Hotopp; cooperation with Dr. Martin Scheringer and Dr. Matthew MacLeod, ETH Zurich*

The European chemicals legislation REACH (Registration, Evaluation, Authorisation and Restriction of Chemicals) focuses on the “registration, evaluation, authorization and restriction of chemicals”. For substances with properties of very high concern (SVHC) an authorization is required for production and use. These SVHC include chemicals which are carcinogenic, mutagenic, or toxic to reproduction (CMR), persistent, bioaccumulative and toxic (PBT) or very persistent and very bioaccumulative (vPvB) or substances of “equivalent concern” as identified from scientific evidence, such as endocrine disruptors.

However, a substance’s long range transport potential (LRTP) and the subsequent hazard to remote regions are not included in the current REACH legislation. LRTP in air, with ocean currents and in migrating animals is though considered a critical substance property according to the Stockholm Convention on Persistent Organic Pollutants (POPs) in addition to persistence, bioaccumulation and adverse effects. Besides measurements in remote regions, e.g. the Arctic, substance properties describing environmental fate and modelling results are considered as indicators for LRTP under the Stockholm Convention. LRTP in air is explicitly mentioned in terms of a degradation half-life in air of more than 2 days. Substances with LRTP cross international boundaries and may be transported to particularly sensitive ecosystems like the Arctic. Therefore, the objective of this research project is to develop a strategy, based on the example of chosen substances, to evaluate whether long-range transport potential as critical substance property should be integrated into identification of substances of very high concern according to REACH.

The state-of-the-art of long-range transport of organic substances in the atmosphere, with ocean currents, migrating animals and sorbed to water-borne plastic particles has been compiled. Monitoring data of legacy POPs were used to investigate critical pathways by tracing back transport from remote areas to source regions. Our investigations showed that plastic particles have no significant influence on LRTP in water. Moreover, boundaries derived from benchmark chemicals are also valid for the classification of substances with LRTP in water.

Funding: German Federal Environment Agency (UBA)

Term: 01.10.2009 – 30.09.2011

## **Veterinary Medicines in Soils: Basic Research for Risk Analysis (Subproject C of DFG-Research Group FOR566)**

*Prof. Dr. Michael Matthies, Dr. Jörg Klasmeier, Dr. Andreas Focks, Tanja Müller; cooperation with partners of FOR566*

Manure from animal husbandry often contains residues of antibiotics and microbes, which incorporate antibiotic resistance genes. Huge amounts of this manure are applied as fertilizer to agricultural soils. Recently, ecologically active concentrations of antibacterial veterinary medicines are detected in soils. However, in order to make a comprehensive risk analysis basic modelling approaches are missing. In February 2005, the DFG (German Research Foundation) research group FOR566 “Veterinary Medicines in Soils: Basic Research for Risk Analysis” was established to investigate the fate of veterinary antibiotics in soil and their effects and risks on the soil ecosystem. After a successful evaluation of the first three years in 2008 the second three years phase of FOR66 started on 1. July 2008.

The activities of the research group are characterized by an intensive cooperation between the single subprojects, which are assigned to soil science, environmental chemistry, microbiology and modelling. Experimental investigations are carried out within the context of a central experiment, i.e. they are based on samples of a central experimental setup. Our subproject deals with the mathematical modelling of the investigated processes and with the integration of the results of the single subprojects into a consistent modelling framework for risk assessment.

Results from the first phase indicate that the bioavailable sulfadiazine (SDZ) fraction decreases very fast after manure application. However, effects on the functional diversity of the soil microbes and on the abundance of sulfadiazine resistant bacteria may still occur. Some important results achieved in the second phase are summarized:

- Batch experiments give evidence that directly after mixing of soil with SDZ a considerable part of SDZ is not extractable even with harsh methods such as microwave extraction; this was observed independently from soil moisture and manure amendment.
- The structure of the kinetic fate model was evaluated by simulations of fate dynamics of SDZ and metabolites in soil under special consideration of the reversibility of the non-extractable residues (NER) after sequential  $\text{CaCl}_2$  and MeOH extractions. The simulations gave strong indication that a considerable part of the NER must be present in reversible form to explain the time course of the easily extractable fraction.
- Parameter rate constants from micro- and mesocosm experiments have been quantified from different data sets. De-acetylation of Ac-SDZ to SDZ is a fast process that affects the abundance of SDZ in the EAS fraction and prevents sequestration of Ac-SDZ. Hydroxylation of SDZ to 4-OH-SDZ has been confirmed by various consistent observations as a slow process in soil.
- Field experiments were preliminarily simulated under consideration of field temperature and moisture conditions. The results indicate that a large part of the variability observed under field conditions can be explained by temperature and instantaneously moisture effects. However, the release of SDZ and 4-OH-SDZ from the RES fraction seems to be influenced by the moisture conditions in soil in a not yet well understood manner.
- The bacteriostatic effect of the 4-OH-SDZ metabolite on *E. coli* has been investigated with an *in-vitro* microtiter test system. No antibiotic effect of 4-OH-SDZ was observed which we explain by the tautomeric structure of the pyrimidine moiety. Thus, 4-OH-SDZ has not to be considered in risk assessment for soil bacteria communities. Instead, hydroxylation of SDZ to 4-OH-SDZ has a detoxification effect.
- The effect of the repeated application of SDZ-containing manure on dynamics and function of bacterial and archaeal ammonium oxidizers has been analysed with the established model. Effect constants for AOB as derived from phase I experiments could be confirmed in their order of magnitude. However, in one of the two soils an adaptation was observed, leading to increased inhibition constants. On the level of *in situ* nitrification, an accumulation of SDZ effects through repeated application was not visible.

Funding: German Research Foundation (DFG)

Term: 01.05.2005 to 30.04.2012

**Influence of different land use intensities on abundance, diversity and activity of nitrogen fixing microbes as well as ammonia oxidizing bacteria and archaea in grassland ecosystems (InDiLaNi) (DFG-Priority Program "Biodiversity Exploratories")**

*Ines Hotopp, Dr. Andreas Focks, Prof. Dr. Michael Matthies; cooperation with Prof. Michael Schloter, Helmholtz-Center Munich*

One of the central goals of the Exploratories is the development of mechanistic knowledge about the links between land use intensities and biodiversity patterns in and above soil. As a first approximation to these links, a conceptual model has been developed in a joint approach of the synthesis group of soil biology projects in the frame of the biodiversity Exploratories. The innovative about this conceptual approach is that the whole complex set of land use intensities, microbial diversity, soil nutrient turnover processes and abiotic conditions is structured and entities from those different organizational levels are connected with each other. This conceptual model forms the basis for an integrative, mechanistic modeling approach, where in a stepwise approach specific nitrogen and carbon transformation processes in soil should be analyzed and transferred into small mathematical process models.

Funding: German Research Foundation (DFG)

Term: 01.04.2011 – 31.03.2014

**ESR investigations of the interaction of xenobiotica with soil organic radicals**

*Dr. Olga Alexandrova, Dr. Jörg Klasmeier, Prof. Dr. Michael Matthies; cooperation with Prof. Dr. Hans-Jürgen Steinhoff (Dept. Physics)*

In this work, we show that electron spin resonance (ESR) is a powerful tool to investigate the molecular mechanism of binding of organic chemicals to soils. We develop the method of paramagnetic spin probes and applied it to soils. It allows not only for observing the reaction of soils with the free radicals but also for observing some peculiarities of this interaction. Introducing of paramagnetic substances with different substitutes, i.e. spin labels (SL) to soils, we tried to notice the special features of common molecular mechanism of binding of organic chemicals to soils.

Funding: Own budget

Term: 01.01.2011 - ongoing

**Natural remediation of surface water systems used as deposits of nuclear industry waste by humic substances**

*Dr. Olga Alexandrova, Prof. Dr. Michael Matthies,*

Radionuclides are found in all parts of the environment, including the atmosphere, aquatic and terrestrial systems, and throughout the biosphere. As with other chemicals, the fate and transport of radionuclides in the environment results from the interaction of physical, chemical, and biological processes. Radionuclide transport from highly contaminated water reservoirs is of great importance for human exposure. In turn, radionuclide dispersal is connected with the problem of radioactive waste disposal. Spatially extended dispersal of radionuclides can lead to severe contamination of human water resources and to contamination of biota, which again are part of ecological food chains with humans as end members. Different natural processes exert high influence on contamination patterns, which partly exhibit elevated radionuclide concentrations in areas remote to the primary radionuclide sources.

After World War II, nuclear production industry of the Sowjet Union was established in South Ural which is still in operation. A large number of water reservoirs have been con-

taminated as a result of this industrial activity. These reservoirs are diverse in morphology and function. Several reservoirs have been used as a depository of radioactive waste. Another group of reservoirs were significantly contaminated only once during the Kyshtym accident in 1957. The third group of reservoirs that are relatively pure have been unaffected by nuclear industry and subsequent dispersal in the environment in the region of South Ural.

In all reservoirs, the long-lived radionuclides  $^{137}\text{Cs}$  and  $^{90}\text{Sr}$  occur in measurable concentrations. Moreover, industrial reservoirs keep a high radioactivity of  $\alpha$ -emitting radionuclides, such as  $^{235}\text{U}$ ,  $^{238}\text{U}$ ,  $^{239}\text{Pu}$ ,  $^{240}\text{Pu}$ . In order to understand and estimate how these radionuclides migrate from nuclear waste and influences the contamination of the environment, and what mechanisms exist decreasing or retarding the radionuclide migration, we examined the sorption behaviour of radionuclides in water bodies of differently contaminated water reservoirs, each of them typical of one of the types mentioned above.

Based on the originating experimental data, the sorption of radionuclides was investigated and the relevant processes and significant parameters were found. Among different processes, the interaction of radionuclides with humic substances appreciably influences on binding of radionuclides to mineral solids in water solution that promote their immobilization in nuclear waste. The accumulation of radionuclides by solid phase was mathematically expressed in a form of modified Henry's law that was calculated for the first time: the local increase in the concentration of humics results proportional increasing of local content of adsorbed radionuclides. The influence of humic substances on radionuclide sorption is provided by their special properties of a reversible transform into micelles. Multipole molecules and associates of humic substances form a single ensemble with humic substances micelles. An increase of local humic substance concentration causes microphase conversion of some portion of multi-pole molecules into micelles with additional capture of radionuclides in micelle granule. The theoretical approach based on consideration of protons ( $\text{H}^+$ ) as fermion gas in water solution was assumed and applied to this phenomenon, being due to the dual nature of humic substances molecules. Combining of all assumed models allows for understanding observed phenomenon of remediation effect of humic substances in the radioactively contaminated reservoirs. Investigation of changing of electrostatical status of micelles leads to modelling of remediation effect of humic substances in respect to influence on fish in contaminated waters. This effect was interpreted and quantified, based on properties of proteins of gill's cell membranes to lose  $\text{H}^+$  under certain conditions in water solution

Thus, natural attenuation of radioactive contamination of fresh water was considered as an alternative to manage radioactive materials released into the environment. A management alternative takes advantage of natural remediation processes, especially the binding of radionuclides and their compounds to water body solids via humic substances. The formation of radionuclide complexes with humic acids removes and converts radionuclides to a less hazardous form, and is followed by a decrease in radionuclide bioavailability to fresh water biota, especially fish and benthos.

The quantification of natural remediation of highly contaminated surface water systems located in South Ural via humic substances is the first step for sustainable developing of nuclear industry. In the surface water systems, humic acids are shown to promote the immobilization of radionuclides and, thus, decrease the bioavailability for fish contamination in the investigated water bodies. Humic substances appreciably influence on the chemical and biological interactions between radionuclides and the environment that has experienced increasing interest concerning the remedial uses of humic materials.

Funding: Deutscher Akademischer Auslandsdienst (DAAD)

Term: 01.04.2006 – 30.09.2009

## **GREAT-ER (Geography-referenced Regional Exposure Assessment Tool for European Rivers)**

*Prof. D. Michael Matthies, Dr. Jörg Klasmeier, Dr. Jürgen Berlekamp*

GREAT-ER is a powerful software tool for modelling the fate and behaviour of chemical substances in surface waters. It combines a geographic information system (GIS) with chemical models for calculating and modelling spatially explicit substance concentrations.

Substance concentrations calculated by GREAT-ER are displayed in color-coded maps. Input data for calculation are physical-chemical and biochemical substance parameters as well as geo-referenced production and consumption patterns. It allows for calculating spatially explicit substance concentrations resulting from wastewater emissions (sewage treatment plants and industrial emitters) as well as surface runoff. GREAT-ER creates a direct link between emissions and concentrations and provides the possibility to analyse potential hot spots within a catchment as well as to identify the most important emission sources and pathways on a regional scale.

A number of different GREAT-ER projects have been conducted in the reporting period. Short descriptions of the individual projects are given below.

Funding: See below

Term: See below

### **Geo-referenced simulation of concentrations of two household insecticides in the Ruhr river basin**

*Dr. Jörg Klasmeier*

Existing information from the official emission scenario documents of two insecticides were translated into estimates for compound loads in treated wastewater effluent. Simulations with the geo-referenced model GREAT-ER delivered local concentrations in the Ruhr river basin for different emission scenarios that were compared to target values (PNEC). Suggestions were made for suitable monitoring to further evaluate how realistic the emission assumptions are.

Funding: Bayer Environmental Science, Lyon

Term: 01.04.2008 – 30.06.2008

### **Geo-referenced simulation of copper concentrations in the Ruhr river basin for an evaluation of local and regional effects of emissions on surface water concentrations**

*Nina Hüffmeyer, Dr. Jörg Klasmeier*

The geo-referenced model GREAT-ER was used to simulate copper concentrations in the Ruhr river basin taking into account local emission estimations from different sources such as household, traffic, industry, roof runoff or agricultural runoff (fertilizer). Simulated concentrations agreed well with available monitoring data. The local concentration at the mouth of the Ruhr into the Rhine proved to be comparable to the predicted environmental concentration (PEC) calculated with the EU standard modeling tool (EUSES) and laid down in the EU risk assessment report for copper.

Funding: European Copper Institute (ECI), Brussels

Term: 16.12.2007 – 31.03.2009

## **Identification of important zinc contributions to the overall zinc load in River Rhine by geo-referenced evaluation of observed zinc concentrations**

*Dr. Jörg Klasmeier, Dr. Jürgen Berlekamp, Nina Hüffmeyer, Jutta Wissing*

### Tier 2: Detailed model analysis of Sieg and Main catchment

A detailed geo-referenced analysis of zinc concentrations in the *Main* River catchment and the *Sieg* River catchment has been performed using the model GREAT-ER. By establishing the link between point source and non-point source emissions and local concentrations the effect of different zinc sources on the concentrations on a local and regional scale could be evaluated. This analysis is extremely helpful in defining promising reduction measures for river reaches that exceed existing water quality target values. In the Sieg River catchment former mining activities mainly contribute to observed high zinc loads, whereas in the Main River catchment the high population density and the domestic zinc consumption are responsible for the observed zinc concentrations.

### Tier 3: Evaluation of model results by systematic monitoring in the Main river basin

GREAT-ER model results achieved in tier 2 of the project were confirmed by comparison with monitoring data in the Main catchment. Results were used for detailed investigation and evaluation of the impact of urban sources on zinc concentrations in surface water under varying environmental conditions. A targeted monitoring campaign has been set up in the Main river basin with special focus on the North-Bavarian parts. Samples regularly collected at water quality monitoring sites by Bavarian water authorities as well as samples from own campaigns in the sub-catchments *Tauber*, *Upper and Middle Main* were analyzed for total zinc and compared to simulation results to enhance the acceptability of model simulations amongst regulators and authorities.

Funding: International Zinc Association (IZA), Brussels

Term: 01.04.2007 – 31.12.2009

## **Micropollutants in Bavarian surface waters**

*Stefanie Lutz, Nils Kehrein, Dr. Jörg Klasmeier, Dr. Jürgen Berlekamp, Prof. Dr. Michael Matthies*

A desktop version of the GREAT-ER model was implemented including the whole Bavarian river network (mainly large parts of the river basins Main and Danube). Model simulations for eleven pharmaceuticals and two flame retardants were compared to monitoring data specifically collected for the project by the contractor. Two data series representing different discharge situations (low to medium and high) had been compiled. Model simulations were performed assuming average discharge. In the Danube river basin, actual discharge data were available that sufficiently explained observed deviations between the simulations and monitoring data. This supports the appropriateness of the simulations as means for a general assessment of the average exposure situation in a catchment. The model is additionally designed to easily simulate the effect of reduction measures (e.g. enhanced removal efficiency of selected sewage treatment plants) and compare the scenario outcome to the reference scenario (*status quo*). This allows for an a priori assessment of different measures and strongly supports the search for the most promising reduction strategy.

Funding: Bayerisches Landesamt für Umwelt, Augsburg

Term: 01.11.2009 – 31.03.2011

## **Field experiments in artificial streams to develop and evaluate a model approach for volatilization of hydrocarbons and other organic pollutants from natural rivers**

*Jan Priegnitz, Dr. Jörg Klasmeier, Dr. Marcus Schulz, Prof. Dr. Michael Matthies*

The effect of different environmental parameters and substance properties on the volatilization of organic pollutants from surface water bodies to the atmosphere were investigated in systematic mesocosm experiments at the artificial stream and pond system (FSA) of the German Federal Environmental Agency (UBA). To collect information on how the different influence parameters affect volatilization, experiments were designed to allow for separate evaluation of the effect of individual parameters and transfer of results from experimental to real field conditions.

Suitable reference compounds were selected and five different experimental setups were run to investigate the effect of flow velocity, wind speed, water temperature, stream bed roughness and channel geometry on volatilization. The experimental data were thoroughly evaluated in the light of existing theory. An improved semi-empirical volatilization model that allows for estimation of volatilization rates under given environmental conditions was developed.

Funding: Kompetenzzentrum Wasser, Berlin

Term: 01.10.2007 – 31.03.2009

## **Feasibility study “Forum Water Westerberg“**

*Anne-Christin Meyer zu Holte, Dr. Jürgen Berlekamp, Prof. Dr. Michael Matthies; cooperation with Prof. Dierk Meyer-Pries, Prof. Dr. Sabine Zachgo, Ulrich Rösemann, Clemens Hölscher*

Two water towers in direct neighborhood of the Botanical Garden of the University of Osnabrück are out of action since 2007. According to their fascinating architecture and the very attractive location, these buildings could be reused as an inspiring interactive discovery center on the subject water and plants. Since these water towers, which comprise about 1800 square meters, were provided by the ‘Stadtwerke Osnabrück’ in October 2010 the USF started the project ‘Forum Water Westerberg’ in cooperation with the Friends of the Botanical Garden. The aim of this project is to create an integrated and sustainable concept for an interactive information center on water and plants.

Water is an essential resource in the world and the media as well as several educational institutions address this issue. Although basic knowledge about water is widely spread within Germany, it is difficult to impart complex interrelations in ecosystems. A research result within this project consents that there are only rare offers about water in educational sites surrounding Osnabrück, which mostly concentrate on the ecology of water bodies.

To achieve the project’s goal of elaborating a coherent overall concept, many museums, exhibitions and Science Centers which deal with the subject of water had been recorded in the first couple months. The data relating to the exhibitions was summarized in reviews and used as a basis for a priority list. To learn more about establishing and successfully running an information center, museums and exhibitions with high priority were visited. Directors and employees were interviewed for additional information about the content and concept of their exhibition, about practical experiences they have made, their funding body and financing the museum.

Certainly, instead of just giving facts and information as many museums and information centers still do, the ‘Forum Water Westerberg’ wants to make the interrelations a real and sensuous experience especially concerning hydrosphere and biosphere.

At the end of this project, local and regional actors as well as museum experts will discuss the concept in a workshop. The future realization phase will be based on the revised concept.

Funding: Deutsche Bundesstiftung Umwelt (DBU)

Term: 01.10.2010 - 30.04.2012

### **Development of fish farming in the Aral Sea basin**

*Prof. Dr. Bakhtiyor Karimov (Tashkent, Uzbekistan), Prof. Dr. Michael Matthies*

Water is a very important natural resource and therefore should be used very effectively and rationally. Technologies utilizing water should be intensive and up-to-date allowing to produce maximum product per unit of water. The cooperation with the Institute of Water Problems, Tashkent (Uzbekistan) has been continued with a three months' research stay of Prof. Karimov. Within this cooperation new sustainable fish farming concepts in Uzbekistan are being developed. The goal of this study is to determine well-adjusted aquaculture concepts for Uzbekistan with special focus on the catchment area of the Aral Sea. A multidisciplinary approach was chosen to consider the biological, ecological, technological and economical criteria for a future development of aquaculture. On a basis of this study ideas for future business and research projects are recommended.

Funding: Alexander von Humboldt Foundation

Term: 01.08.2010 – 31.12.2010.

### **Emission, transport and fate of marine litter in the North Sea**

*Dr. Christiane Zarfl, Mathias Menninghaus, Sebastian Lotter, Prof. Dr. Michael Matthies; cooperation with Dr. Ulrich Callies (Helmholtz Center Geesthacht)*

The problem of marine litter, particularly plastics, has been recognized in all marine ecosystems. Monitoring programs of plastic pollution have long been implemented, and impacts on fish and seabirds have been reported. However, systematic knowledge on emission pathways and transport processes is scarce. The North Sea is a vulnerable ecosystem with input of anthropogenic debris from shipping, riverine transport, fisheries and tourism. In cooperation with the Helmholtz Center Geesthacht (Dr. Callies) the relation between source and receptor regions in the North Sea has been investigated by using numerical long-term simulation of particle transport and drift. At present, monitoring data of floating objects are used to elucidate the transport pathways of different seaweed species.

Funding: Own budget

Term: 01.08.2010 – ongoing.

## **3.1.2 Resources Management**

### **NeWater (New Approaches to Adaptive Water Management under Uncertainty)**

*Prof. Dr. Claudia Pahl-Wostl, Dr. Sabine Möllenkamp, Dr. Britta Kastens, Dr. Marcela Brugnach, Jörn Möltgen, Nicola Isendahl, Christian Knieper, Patrick Huntjens, Kathrin Knüppe*

NeWater (New Approaches to Adaptive Water Management under Uncertainty) was a research project supported by the European Commission under the sixth framework program,

PRIORITY 6.3 “Global Change and Ecosystems” (contract No 511179 (GOCE)), running from 2005 to 2009.

NEWATER project identified key elements of current water management regimes and investigated their interdependence. Research was focused on transformation processes of these elements in their transition to adaptive integrated water resources management. The project had case studies in Europe, Africa and Central Asia, where new methods were developed and tested in participatory settings. The project involved forty partner organizations. Key IWRM areas where NeWater delivered major insights included:

- governance in water management (methods to arrive at polycentric, horizontal broad stakeholder participation in IWRM)
- sectoral integration (integration of IWRM and spatial planning; integration with climate change adaptation strategies, cross-sectoral optimisation and cost-benefit analysis)
- scales of analysis in IWRM (methods to resolve water resource use conflicts; trans-boundary issues)
- information management (multi-stakeholder dialogue, multi-agent systems modelling; novel monitoring systems for decision systems in water management)
- infrastructure (innovative methods for river basin buffering capacities; role of storage in adaptation to climate variability and climate extremes)
- finances and risk mitigation strategies in water management (new instruments, role of public-private arrangements in risk-sharing)
- stakeholder participation (promoting new ways of bridging science, policy, and implementation)

The USF was responsible for the overall co-ordination of the project and had a leading role in Work Block 1 “Transition to adaptive management of river basins” and Work Block 6 “Management and Project Internal Coordination Platform”, as well as in several Work packages.

The project produces numerous deliverables. The key findings are summarized in a number of synthesis products all products are available for download: <http://www.newater.uos.de/>

Funding: European Commission under the sixth framework program, PRIORITY 6.3 “Global Change and Ecosystems” (contract No 511179 (GOCE))

Term: 01.01.2005 – 28.02.2009

## **AquaStress**

*Dr. María Máñez, Dr. Sonja Schmidt, Silke Panebianco, Ole Benjamin Schröder*

Mitigation of Water Stress through new Approaches to Integrating Management, Technical, Economic and Institutional Instruments

AquaStress was an EU funded integrated project (IP) contract n°511231-2 - 6th EC Framework Programme for RTD (<http://www.cordis.lu>), delivering interdisciplinary methodologies, which in turn enable actors at different levels of involvement and at different stages of the planning process to mitigate water stress problems. The project drew on both, academic and practitioner, skills to generate knowledge in technological, operational management, policy, socio-economic, and environmental domains. Contributions come from 35 renowned organizations from 17 countries. Aquastress adopted a case study – stakeholder - driven approach and is organised in three phases; (i) characterisation of selected

reference sites and relative water stress problems, (ii) collaborative identification of preferred solution options, (iii) testing of solutions according to stakeholder interests and expectations.

AquaStress generated scientific innovations to improve the understanding of water stress from an integrated multi-sectoral perspective to support:

- diagnosis and characterisation of sources and causes of water stress;
- assessment of the effectiveness of water stress management measures and development of new tailored options;
- development of supporting methods and tools to evaluate different mitigation options and their potential interactions;
- development and dissemination of guidelines, protocols, and policies;
- development of a participatory process to implement solutions tailored to environmental, cultural, economic and institutional settings;
- identification of barriers to policy mechanism implementation;
- continuous involvement of citizens and institutions within a social learning process that promotes new forms of water culture and nurtures long-term change and social adaptivity.

The USF was responsible for the coordination of Work Block 2 and contributes to Work Blocks 3, 4, 5 and 6. Project webpage: [www.aquastress.net](http://www.aquastress.net)

Funding: European Union integrated project (IP) contract n°511231-2 - 6th EC Framework Programme for RTD (<http://www.cordis.lu>)

Term: 01.02.2005 - 28.02.2009

### **Policy Science Interactions - Connecting Science and Policy through Innovative Knowledge Brokering in the field of Water Management and Climate Change (PSI-Connect)**

*Prof. C. Pahl-Wostl, Dr. Carolin Butler Manning, Björn Fokken*

PSI-connect is a three-year collaborative project (2009 - 2012) funded under the 7th framework programme of the European Commission. The project aims to improve the quality and value of interactions between policy and science in the field of climate change impacts on river systems. PSI-connect is:

- developing and testing different types of knowledge brokering instruments
- evaluating the usefulness of these knowledge brokering instruments
- disseminating the project findings to the relevant policy and science communities, as well as to practitioners

The different knowledge brokering instruments will be applied and tested in case studies at EU, national and regional level. Main actors will be policy makers, scientist and water managers jointly dealing with issues of high relevance to the participants that are related to climate change impacts on water resource management. The project partners design collaborative learning processes tailored to the specific situations and needs of participants. The practicability and effectiveness of the knowledge brokering instruments applied will be evaluated. The learning process will foster a dialogue between actors bridging the gap between policy and science.

For further information: <http://www.psiconnect.eu/>

Funding: European Commission under the 7th framework programme

Term: 01.05.2009 – 30.04.2012

### **Coordinating Twinning partnerships towards more adaptive Governance in river basins (Twin2Go)**

*Prof. Dr. Claudia Pahl-Wostl, Dr. Britta Kastens, Christian Knieper, Kathrin Knüppe, Björn Fokken, Georg Holtz*

Twin2Go (Coordinating twinning partnerships towards more adaptive governance in river basins) is a research project supported as a coordination action by the European Commission under the 7th Framework Programme (Contract No. 226571). Duration: June 2009 - September 2011.

The overall objective of the Twin2Go project is to increase the impact and benefit of past and ongoing research with regard to adaptive water governance in the context of climate change. To this end, Twin2Go aims to compare, synthesise and consolidate the outcomes of several EU-funded projects that undertook research on the management of water resources in river basins around the world. The project aspires to draw context-sensitive but transferable approaches for improving adaptive water governance, with a special focus on governance structures that allow an effective response to climate change. Moreover, the project strives to formulate policy-relevant best practices and tools for implementing adaptive water governance and for improving the uptake of research results. Finally, Twin2Go aims to disseminate the outcomes of the project effectively to relevant policy makers.

The USF is responsible for the overall co-ordination of the project and has a leading role in Work Package 1 “Elaboration of framework for diagnostic approach for scaling-up project results”. Furthermore, the USF is strongly involved in Work Package 2 “Extract context-specific approaches from project results”.

For further information: <http://www.twin2go.uos.de/>

Funding: European Commission under the 7th Framework Programme (Contract No. 226571)

Term: 01.06.2009 – 30.09.2011

### **GTZChinyanja**

*Dr. J. Krywkow, Prof. Dr. Claudia Pahl-Wostl*

For almost two decades the research and aid organisation WorldFish endeavours to support smallholders in Malawi and Zambia to introduce the Integration of Aquaculture into Diversified Food production Systems (IADFS). However, implication of an increased application of this production system, especially, on the water balance of a wider catchment area are unknown. For this reason the international research project GTZChinyanja was launched. The central approach of this project is to employ a multi-agent system (MAS) representing the interplay between various types of farming activities with the water balance of the farmland region.

The research team assumes adaption strategies to climate change impact such as increasingly irregular rainfall pattern. On the other hand a cumulative application of IADFS may have impact on the water balance of the respective sub catchments on the long run, and occasionally entailing local conflicts over water resources. Respective observation have been made in a number of sample sites during field visits.

Data have been collected from various sources including satellite imagery, census data, questionnaires, interviews, workshops and field measurements. The multi-disciplinary team operates on four sub topics: farming system, socio-economic research, GIS and

agent-based modeling (ABM). The ABM will have a central function, however, GIS serves as a preprocessor and structuring data for modelling with agents. Spatially explicit agent-based simulation will be conducted in order to examine the impact of farmers' activities on the sub watersheds.

Along with the development of the MAS a participatory process with farmers and involved organisations such as fish farming clubs was initiated. A role playing game (RPG) was developed and tested by stakeholders from NG and NGO during a workshop. Moreover, a series of 250 interviews will gain more detailed insights of farming practise, adaption strategies and assumptions for the transition from purely rain-fed farm types to irrigation and fish-farming types. Based upon recently gained empirical data and the Artificial Chingale MAS simulation may be run to test scenarios both of climate change impact as well as altering farming practise schemes. One of the aspired outputs will be a spatially-explicit representation of diversified water use including downstream effects and possible sources of water conflicts, that may help organisations such as water managers, fishery and agraric organisations to plan a well-managed and balanced support for coping with the effects of climate impacts and the diversified development of farming systems.

USF is responsible for designing the MAS, and together with Seeconsult preparing, conducting and analysing the participatory process with representatives of relevant organisations and farmers. Moreover, USF is responsible for capacity building in terms of teaching agent-based methodology to end users of the system and representatives of universities and colleges.

Partners: WorldFish Centre, IWMI, University of Osnabrück, seeconsult

Funding: Bundesministerium für wirtschaftliche Zusammenarbeit und Entwicklung (BMZ)

Term: 01.04.2010 – 31.03.2013

### **Analysis of potentially new themes in water management - future trends and research needs**

*Dr. Britta Kastens, Nina Wernsing, Dr. Carolin Rettig, Johannes Halbe, Prof. Dr. Claudia Pahl-Wostl*

Water resources management has become an important theme on the scientific and political agendas. The importance of the international dimension and impacts of global change have moved in the centre of attention. Numerous national and international programs have addressed water related themes.

The German Ministry of Education and Research (BMBF) has funded several major research programs on Integrated Water Resources Management and Global Change. The goal of this study is to make recommendations for promising future research themes by analysing the international water research and policy landscape and by taking stock of recent achievements. The study has thus the following objectives:

- Provide an overview of recent and emerging developments in topical research areas in the field of water resources of high scientific and political relevance.
- Evaluate research themes with respect to their potential for scientific breakthroughs, political impact and suitability for the German water community.
- Develop recommendations for a future research programme of the BMBF.

The project is divided into two research phases. Result of the first research phase is a weighted list based on a detailed review of the most important future issues in water research. In the second stage of research the in-depth analysis of the core issues occurs. As a result of this analysis four thematic clusters were identified and further specified in each case:

1. Water for Food in the 21st century
2. Water related risks, vulnerability, adaptive capacities
3. Governance of transformation
4. Manipulating flow and water bodies for managing ecosystem services

Based on a preliminary assessment the following themes of high political relevance and major research needs and potential have been identified and build the basis. On the basis of these tasks final recommendations were developed for a future research programme of the BMBF.

Funding: BMBF

Term: 01.07.2009 – 30.06.2010

### 3.1.3 Theoretical Systems Science

#### **Study of pattern formation in plankton populations under the effects of toxin producing phytoplankton, infection and environmental factors**

*Prof. Dr. Horst Malchow, Dr. Ram Rup Sarkar*

The aim of this research project is to develop mathematical and stochastic models of the phytoplankton-zooplankton system to understand the mechanisms of planktonic blooms, pulses and succession in the presence of toxic and/or infected phytoplankton and to suggest some control measure of harmful phytoplankton blooming. (Cooperation with Moscow, Bordeaux).

Funding: Alexander von Humboldt Foundation (Alexander von Humboldt Stiftung)

Term: 01.05.2004 - 30.04.2005

#### **Patterns in the Spatiotemporal Spread of Infectious Diseases and Biological Invasions**

*Ivo Siekmann, Michael Sieber, Prof. Dr. Horst Malchow*

Infectious diseases have ever been one of the greatest threat of man, animal as well as plant populations and the functioning of ecosystems. Mathematical epidemiology has identified several mechanisms (e.g. spatial seasonal forcing, heterogeneity, or stochasticity) which are responsible for specific patterns in the spatiotemporal dynamics. Fatal diseases may dramatically regulate the host population density. Hence, the vital dynamics become important. This research mainly investigates reaction-diffusion models with an Allee effect in vital dynamics. Moreover, the impact of pathogens on the fate of biological invasions is investigated. Infectious diseases are often suggested as explanation for a spontaneous collapse of a successfully established alien species, but detailed data and studies are lacking. Model results predict that pathogens can slow-down, stop or reverse invasion fronts of their host population, provided that the latter is subjected to an Allee effect. (Cooperation with Bath, Bordeaux, Marseille, Hiroshima, Christchurch, Auckland).

Funding and Term: Erskine Foundation New Zealand 2008, Japan Society for the Promotion of Science 2009, Deutsche Forschungsgemeinschaft 2005-2009, Deutscher Akademischer Austauschdienst 2009-2010, LLP Erasmus Program since 2001

### 3.1.4 Applied Environmental Systems Analysis

#### Toxicity of sediments at the Mediterranean Sea coast

*Prof. Dr. Elke Fries, Melanie Wissing, Dr. Francois Galgani, Chantal Goreux*

In preliminary studies some indications were found that the toxicity of beach sand is caused by organic contaminants like polycyclic aromatic hydrocarbons (PAHs). The objective of this project is to monitor and evaluate the chemical contamination and toxicity of beach sands at the Mediterranean Sea coast at a regional scale. A dataset will be provided as a basis for risk assessment of beach sands in this area for the first time. During August/September 2011 a monitoring campaign will be performed in the study area. A combination of biotests and chemical analyses will be applied to allow the determination of the bioavailable fractions of PAHs sorbed on the sediments that are causing the toxicological effects. Multivariate statistical methods will be applied to identify the sources of PAHs. In addition the presence of microplastics will be assessed in the sediments.

Funding: Institut français de recherche pour l'exploitation de la mer (Ifremer), Laboratoire LER/PAC, Bastia, Corsica and University of Osnabrueck

Term : 15.08.2011 - 14.08.2012

#### Emissions, transport and fate of organic plastic additives (OPAs) and engineered titanium dioxide (TiO<sub>2</sub>) nanoparticles in plastics in the marine environment

*Prof. Dr. Elke Fries, Dr. Martin Ebert, Prof. Dr. Henner Hollert, Katrin Ellerbrake, Sven Ernesti*

This project investigates the chemical composition of marine plastic debris with a focus on organic plastic additives (OPAs) and engineered titanium dioxide (TiO<sub>2</sub>) nanoparticles in plastics to assess the chemical impact of such polymer additives on marine organisms. Information will be provided on the release and distribution of OPAs in the marine environment. Leaching experiments with ethylene vinyl acetate (E.V.A.) and polyethylene were performed to study leaching kinetics of benzophenone and polycyclic aromatic hydrocarbons (PAHs). The migrating chemicals were determined in the aqueous phase using Solid Phase Microextraction (SPME) and Gas Chromatography-Mass Spectrometry (GC-MS). Different factors that control leaching behaviour were studied such as polymer type, additive polarity and environmental conditions like pH, temperature and ionic strength. In addition more than 100 microplastics were separated from natural beach sediments collected at the Island Norderney in the German Bight by floatation. In these microplastics, TiO<sub>2</sub>-nanoparticles were identified using an Environmental Scanning Electron Microscope (ESEM). OPAs will be identified and quantified in these microplastics using Pyrolysis-GasChromatography-Mass spectrometry (PyGC-MS). In addition biotests will be performed to assess the toxicity of OPAs leaching from these microplastics found in the environment. Exposure concentrations of OPAs and TiO<sub>2</sub>-nanoparticles in sea water will be estimated by considering quantities of marine plastic debris and experimentally determined fate parameters. The results of this project will be incorporated as preliminary studies to an Collaborative Project under the 7th Framework Programme of the EC, called ENV 2012 – 6.2.4 "Management and potential impacts of litter in the marine and coastal environment " coordinated by Ifremer, Bastia, Corsica.

Funding: Research Pool of the University of Osnabrueck

Term: 01.02.2011 – 31.07.2011

## **Behaviour and fate of organoclay from cosmetics and personal care products in municipal waste water treatment plants**

*Prof. Dr. Elke Fries, Melanie Wissing*

Organoclay is a modified bentonite, in which the cations of clay minerals were replaced by quaternary alkylammonium compounds in an industrial process. Organoclay particles are added mainly to personal care products such as deodorants, shampoos, lotions, creams and sun creams and cosmetics such as mascara, liquid makeup, and lipsticks used to improve the fluid properties of these products. Worldwide approximately 1000 tons/yr of the organoclay powder are used in the personal care and cosmetics industry. Due to its application spectrum organoclay enters municipal waste water treatments plants and may be discharged into rivers by effluents. The aim of this project is to study the behaviour and fate of organoclay during the waste water treatment process. First the influence of natural organic matter (NOM) on the stabilization of organoclay in aqueous suspensions was studied in laboratory experiments. A second series of experiments will be established at the waste water treatment plant of Frankfurt Niederrad in August 2011 to investigate the influence of sewage sludge and aluminum based coagulants on the organoclay stabilization in aqueous suspensions.

Funding: University of Osnabrueck

Term: 15.08.2010 – 30.09.2011

## **1H-benzotriazole and tolyltriazoles in the aquatic environment: sources, transport and risk assessment**

*Aliz Kiss, Prof. Dr. Elke Fries*

Benzotriazoles (BT) as 1H-benzotriazole (1H-BT), 5-methyl-1H-benzotriazole (5Me-BT), and 4-methyl-1H-benzotriazole (4Me-BT) are frequently used as corrosion inhibitors in dish washer detergents and aircraft de-icing/anti-icing fluids (ADAFs). Discharge of treated municipal waste water and controlled over-runs of combined waste water sewers are potential point sources for BT in rivers.

This project was established to achieve the following aims: (i) the development of an analytical method based on Solid Phase Extraction (SPE) and Gas Chromatography-Mass Spectrometry (GC-MS) for the detection of BT in river water, waste water and products. This method should be relatively simple, cheap and quick because of numerous samples, and both tolyltriazoles-isomers (4Me-BT and 5Me-BT) should be quantified separately, (ii) the evaluation of contribution of BT-input originating from ADAFs used at Frankfurt Airport and dishwasher detergents into Hengstbach/Schwarzbach River and its tributaries, (iii) the determination of spatial and temporal variability of concentrations and mass flows in the Hengstbach/Schwarzbach River and its tributaries, (iv) the assessment of persistence and eco-toxicological risk potential of BT in the aquatic environment, and (v) validation of the exposure concentrations of all three substances predicted by the GREAT-ER model for the selected catchment.

Funding and Term: German Environmental Foundation (DBU), May 2007 - July 2008, Research Pool of the University of Osnabrück, August 2008 - February 2009, German Environmental Foundation (DBU), March 2009 - February 2011.

## **Spatial and temporal distribution of organophosphate esters in soil**

*Ivana Mihajlović, Prof. Dr. Elke Fries*

Due to their technical and physico-chemical characteristics, OPEs are widely utilized as flame retardants and plasticizers in rubbers, textiles, upholstered furniture, lacquers, plastics, building materials and electronic equipment. The global consumption of OPEs estimated to 186 000 tons in 2001, increased by almost 10% for five years and it is still growing in the last years, due to the ban of brominated diphenyl ethers (BDE) - penta-BDE and octa-BDE in the EU and the entry into force of the RoHS (Restriction of Certain Hazardous Substances). This gives cause for concern, because some of these substances are persistent and have negative effects on human health. Individual data on the occurrence of several OPEs in water and air has increased continuously over the last decade. Data on the occurrence of OPEs in soils, however, are rather limited. The first aim of this project was to develop an analytical method for analyzing OPEs in soil using a combination of Soxhlet Extraction, Solid Phase Microextraction (SPME) and Gas Chromatography-Mass Spectrometry (GC-MS). This method was applied to determine concentrations of OPEs in soil samples collected from different sites in Germany to study OPE-pollution of soils from diffuse atmospheric sources and to identify the main deposition processes.

Funding: German Environmental Foundation (DBU)

Term: 01.04.2010 – 31.03.2011

## **Sorption of ortho-phenylphenol to soil**

*Dr. Chunli Zheng, Prof. Dr. Elke Fries,*

Conflicting sorption coefficients for ortho-phenylphenol (OPP) have been reported in the literatures, which resulted in the conflicting assessments on OPP mobility in soil. To ascertain the sorption coefficient of OPP, batch experiments were performed based on OECD guideline 106, using three types of soils. Headspace Solid Phase Microextraction (HS-SPME) and Gas Chromatography-Mass Spectrometry (GC-MS) were applied to the determination of OPP concentration in the liquid phase. The sorption isotherms obtained for all three soils under equilibrium conditions were described well, assuming linear sorption. The organic carbon normalized distribution coefficients ( $K_{oc}$ ) ranged from 894 to 1703 L/kg, which suggested that OPP is moderately mobile in soil. The results also showed that the  $K_{oc}$  value of OPP can be predicted precisely from the octanol-water partitioning coefficient ( $K_{ow}$ ), whereas it was underestimated by one order of magnitude when water solubility is used.

Funding: German Academic Exchange Service, Research Pool of the University

Term: 01.04.2009 – 31.03.2010

## **Analysis of PAH in soil by thermal desorption and GC/MS**

*Michael Oravec, Prof. Dr. Elke Fries*

The analysis of organic compounds in high matrix samples such as soils is a common analytical problem. Classic extraction of soils with solvents for the analysis of polycyclic aromatic hydrocarbons (PAHs) is time and cost consuming according to the use of high volumes of solvents and several sample preparation and extract cleanup steps. The Thermal Desorption (TD) technique permits direct analysis of organic compounds in solid matrices without any prior solvent extraction or other sample preparation. The aim of this project was to develop an analytical method for the analysis of PAHs in soil using TD and Gas

Chromatography-Mass Spectrometry (GC-MS). The focus was put on parameter optimization during desorption and conditions of cool inject systems.

Funding: European Commission Erasmus exchange program

Term: 01.09.2008 – 31.03.2009

### **Organic pollutants in snow and ice from Antarctica: long range transport and deposition processes**

*Petr Kukučka, Prof. Dr. E. Fries, Prof. Dr. Jana Klanova, Alice Dvorská, Prof. Dr. Gerhard Lammel*

Long range transport (LRT) of organic pollutants (OP) from temperate zones to the polar region is an important phenomenon demonstrating the persistence of organic chemicals in the environment. To evaluate the fate of OP in the environment interactions of chemicals with ice and snow play an important role especially in areas characterized by low temperatures. In the last decade, the focus of research has been put on the occurrence of semi-volatile organic compounds (SVOC) in snow and air in the Arctic. The aim of this project is to analyze snow and ice samples for the occurrence of SVOC (hexachlorohexanes, the more volatile polycyclic aromatic hydrocarbons and polychlorinated biphenyls) and volatile organic compounds (VOC) (alkanes, alkylbenzenes). A special focus was put on the appropriate design of the analytical methods to distinguish between deposition processes of OP on snow and ice surfaces. Firn samples attributed to the period between 2002 and 2005 were collected from a snow pit on the Ekstrom Shelf Ice in the Weddell Sea (70843.80S, 8825.10W). Low-volume meltwater samples (5 mL) were extracted by solid-phase micro-extraction (SPME) and analysed for polycyclic aromatic hydrocarbons (PAHs) by gas chromatography-mass spectrometry. The recovery of the analytical method for the 4–6 ring PAHs was low. PAH concentrations in snow were found within the range of 26–197 ng/L. The most prevailing substances were determined to be naphthalene, 1- and 2- methyl-naphthalene, acenaphthylene, acenaphthene and phenanthrene, with naphthalene accounting for an overall mean of 82% of total PAH. Potential emission sources of PAHs in snow were studied using back-trajectory statistics and available emission data of combustion sources in and around Antarctica. The distance to the sources (ships and research stations) in this region was found to control the snow PAH concentrations. There was no indication for intercontinental transport or marine sources.

Funding: Ministry of Education, Youth and Sports of the Czech Republic, the Ministry of Environment of the Czech Republic and by the European Commission Erasmus exchange program

Term: 01.03.2007 – 31.08.2008

### **Occurrence and distribution of benzothiazole (BTZ) in river water and wastewater**

*Prof. Dr. Elke Fries, Dr. Jörg Klasmeier, Tillmann Gocht*

In this project the regional distribution of the micropollutant benzothiazole (BTZ) in river water by sampling 15 river sites in the Schwarzbach watershed (about 400 km<sup>2</sup>) from November 2008 to February 2010 was investigated. Additionally, wastewater samples from three municipal wastewater treatment plants (WWTPs) in Germany were analyzed. The applied analytical method was based on Solid Phase Extraction (SPE) followed by Gas Chromatography-Mass Spectrometry (GC-MS). BTZ was detected in all wastewater influent and effluent samples as well as in all river water samples collected downstream of the wastewater discharge. This corroborates the ubiquitous occurrence of BT in the aqueous environment. Concentrations were between 50 and 856 ng/L in the river water. With only a

few exceptions, temporal and spatial variations of BT concentrations in river water were low. Rather continuous BT concentrations over a wide range of discharge indicate that dilution along the mainstream is negligible and, thus, supporting the hypothesis that paved surface runoff during rain events is an important BT source not only for wastewater influent but also for river water. This was supported by detecting the highest BTZ concentrations at sampling locations close to the dense highway network around the city of Frankfurt. Since BTZ was also detected in river water collected from locations that were clearly unaffected by wastewater effluent discharge, surface runoff must be considered as a diffuse source of BTZ in river water. In addition a new analytical method was developed to analyze BTZ in high matrix samples such as untreated wastewater. The method was based on Stir Bar Sorptive Extraction (SBSE) using a novel polyacrylate (PA)-coated stir bar (PA Twister®). After extraction, BT was desorbed in a thermal desorption system (TDS) and analysed by GC-MS (gas chromatography-mass spectrometry). Since no filtering or clean-up steps or solvents were necessary SBSE clearly performs better than all previously used extractions techniques for analysing BT in untreated wastewater in terms of easy use, sample throughput and analytical costs. In addition, matrix effects were small. A low limit of detection (LOD) of 0.256 µg/L was achieved using only a small sample volume of 18 mL. Small sample volumes significantly reduce sample transport costs.

Funding: Universtiy of Osnabrueck

Term: 01.04.2007 – 28.02.2009

### 3.1.5 Ecological Modelling

#### Towards a Unified Spatial Theory of Biodiversity

*Dr. T. Wiegand, Prof. Dr. A. Huth*

One of the biggest and most persistent challenges in contemporary ecology is to explain the high diversity in ecological communities such as tropical forests, grasslands, coral reefs, or plankton ecosystems. The broad objective of our project is to understand the relative importance of processes and factors that govern the composition and dynamics of species-rich communities. Advances in this issue have important implications for efforts to protect terrestrial biodiversity from climate and land use change. Surprisingly, although most processes which are thought to contribute to species coexistence have a strong spatial component, the rich source of information on spatial patterns has not been used. To accomplish our goal, we take a radically different approach than previous attempts and adopt a spatially explicit perspective that will allow us to take significant steps towards a *Unified Spatial Theory of Biodiversity*. We use the best data sets available, i.e., 25-50 ha megaplots of tropical forests each comprising several hundred of species and >100000 trees that are monitored and censused every 5 years. We proceed in three steps. (1) We quantify the highly complex spatial structures found in these forests using state-of-the-art techniques in spatial pattern analysis. (2) We build a range of individual-based spatially-explicit simulation models ranging from “pure” neutral models to detailed process-based models of tropical forest, such as FORMIND. (3) We use pattern-oriented modelling to confront these simulation models with the set of patterns identified in (1) to identify the most parsimonious models that account simultaneously for all (spatial) patterns. The challenges of our ambitious project, i.e., describing the highly complex spatial structures in species-rich communities and the complexity of ecological interactions among hundreds of species, and the resulting high demand of computer power can only be tackled within the framework of a large project. We anticipate that the new spatial perspective and innovative computer modelling techniques will allow for a major break through in this important challenge at

the frontier of ecological research, and open up new horizons for understanding and conservation of biodiversity.

Funding: European Science Foundation

Term: 01.01.2009 – 31.12.2015

### **Forest dynamics, landslide dynamics, and their interactions – a process-based landscape modelling approach for a mountain rain forest in South Ecuador**

*Prof. Dr. A. Huth, Prof. Dr. B. Schröder (Univ. Potsdam)*

It has been hypothesized that natural disturbances such as landslides have an important effect on biodiversity in the tropical mountain forests of Southern Ecuador. Thus, understanding landslides in the context of forest dynamics is a precondition for understanding this megadiverse ecosystem. Our project aims at analysing and predicting the spatiotemporal dynamics of forest landscapes including landslides and their abiotic and biotic controls.

Therefore, we develop process-based forest models and couple them with landslide models of different complexity based on regionalized terrain attributes, soil properties and hydrological factors. The resulting spatially explicit, dynamic integrated landscape model allows us to understand the interplay of the main drivers of landslides and landscape dynamics, and to predict the spatiotemporal development of forests along with their implications on habitat dynamics, biodiversity, risk assessment and forest management.

We will be able to estimate carbon balances for the different forest types and the whole research area. The carbon fluxes will strongly depend on the successional state of forests and their disturbance history.

Funding: German Science Foundation (research group "Biodiversity and Sustainable Management of a Megadiverse Mountain Ecosystem in South Ecuador ")

Term: 01.01.2010 – 31.12.2013

### **Plant functional traits translated into vegetation dynamics - Responses to environmental factors and effects on ecosystem functions of the Kilimanjaro region**

*Prof. Dr. A. Huth, Prof. M. Kleyer (Univ. Oldenburg)*

This project assumes that responses of plants to changes of climate and land use depend on their functional traits rather than on their taxonomic affiliation. Through shifts in plant functional trait composition, changes in the biodiversity component of ecosystems also affect nutrient and water cycling and the capacity of the ecosystem to adapt to changes of climate and land use. Here, we combine an empirical and a modelling approach to better understand the relationships between the composition of plant functional traits, environment, and ecosystem functioning in the Kilimanjaro region.

Our first objective is to understand the response of ecophysiological and regenerative traits of plant species and communities to changes in soil resources, land use and fire as well as effects of plant traits on ecosystem functions such as nutrient and water cycling or plant – animal interactions, including seed dispersal. Plant traits will be assessed by sampling approx. 120 species for morphological traits and approx. 60 species for traits requiring laboratory analysis in 60 plots. The trait composition of the communities of these selected species will be related to environmental and ecosystem parameters (recorded by subprojects 2, 3, 4, 6, 7, 8) using statistical approaches. Traits will be classified into response and effect traits depending on whether they respond to the environment and/or affect ecosystem properties.

The second objective is to develop an individual and process-based vegetation model to study the transient dynamics of vegetation types in response to environmental factors and human disturbances. The plant trait data sampled in the field will be used to parameterise main parts of the vegetation model. The model will be based on the FORMIND approach. Inventory data and empirical trait-environment relationships will be important to calibrate and validate model formulations. With the help of the vegetation model we will study successional dynamics and the impact of disturbances on tree communities, focusing on the role of plant traits.

Funding: German Science Foundation (research unit "Kilimanjaro ecosystems under global change: Linking biodiversity, biotic interactions and biogeochemical ecosystem processes")

Term: 01.01.2010 – 31.12.2013

### **METHODS of Interdisciplinary Environmental Research (METIER)**

*Prof. Dr. Karin Frank (Scientific co-ordinator)*

The EU Marie Curie Series of Events METIER ([www.peer.eu/projects/metier\\_training\\_courses](http://www.peer.eu/projects/metier_training_courses)) was organized by the PEER-network of seven large European centres for environmental research (JRC-IES, Cemagref, CEH, NERI, SYKE, Alterra, and UFZ). It consisted of seven graduate training courses and one final conference on cutting-edge methods of modern interdisciplinary environmental research from data collection over data analysis and modelling to policy design in challenging field such as climate adaptation, biodiversity conservation, water resource management, or sustainable land use. Accordingly, the courses addressed topics such as: remote sensing of the atmosphere, land surface and hydrosphere; environmental and particularly ecological modelling; data management; environmental visualisation; scenario development and analysis. While the courses primarily aimed to provide methodological knowledge, the final conference held directly in the venue of the European Commission was dedicated to demonstrating the potential of the different methods for solving complex environmental problems, providing experience with the interaction between science and policy, and bringing together early stage researchers with internationally renown experts in their field, but also with environmental managers and policy makers. In total, around 270 early stage researchers from all over the world have been directly trained in the frame of METIER and even more people have been reached indirectly as the entire educational material has been published in the internet and is online for download.

Funding: European Commission; Marie Curie Programme

Term: 01.02.2006 – 31.01.2010

### **Ecological Economics: Modelling and conceptual foundation with an example of grazing in semi-arid landscapes (Eco-Eco)**

*Prof. Dr. Stefan Baumgärtner (at that time, Univ. Heidelberg) and Prof. Dr. Karin Frank*

This project was part of the special program of the Volkswagen Foundation on the „Promotion of Young Scientists in Interdisciplinary Environmental Research“. In its frame, a joint Junior Research Group (Eco-Eco) of economists from the University of Heidelberg and ecological modelers from the UFZ in Leipzig has been build-up. Aim of the project was the development of a framework for analyzing the interplay of ecological and economic dynamics of complex environmental problems at the edge of natural and social systems across different levels of abstraction: concepts, models, and case studies. This enables that studies are both conceptually sound and anchored in reality that is the precondition for

providing both understanding of the environmental problem and a sustainable solution to these problems. Core of the developed framework was an ecological-economic model system that mediates between abstract concepts and concrete case studies. To demonstrate applicability and potential of the framework, it was applied to the problem of grazing in semi-arid regions causing the problem of degradation with two case studies in Namibia. In this system, fluctuations in precipitation drive the entire dynamics of semi-arid rangeland systems (biomass, livestock, farmers' income) and produce spatiotemporal variability. Therefore, the interplay of ecological and economic buffer mechanisms was part of the research in the project. It also was shown that risk aversion can make a short-term optimizing farmer sustainable (usually, it is supposed that short-term orientation causes unsustainability). The suggested integrated methodology also enables us to derive pitfalls and chances of newly introduced institutions of risk management (e.g. rain-index insurance).

Funding: Volkswagen Stiftung (Programme "Young Scientists in Interdisciplinary Environmental Research")

Term: 01.04.2004 – 30.06.2008

### **Sustainability of (post-)nomadic resource utilization under Global Change – Conceptual understanding through ecological-economic modelling**

*Prof. Dr. K. Frank and Dr. B. Müller*

This research is part of the DFG Collaborative Research Centre 586 "Difference and Integration" of the Universities Leipzig and Halle ([www.nomadsed.de/en\\_index.html](http://www.nomadsed.de/en_index.html); Subproject E10). Aim of the project is the analysis of the sustainability of (post-)nomadic resource utilization systems that are exposed to various processes of global change such as climate change, liberalization, social and institutional change. Questions of particular interest are the capability and adaptation strategies of (post-)nomadic households for coping with impacts of global change. This requires sound understanding of the complex interplay of ecological (productivity and regeneration ability of pastures and livestock, climate conditions) and socio-economic factors (resource portfolio of the individual households, resource access regimes, institutions of risk management, preferences, local knowledge) on the pasture and their long-term development. Particular interest is in the consequences of resource utilization for sustainability, measured in terms of both livelihood security of households (socioeconomic criterion) and regeneration ability of the pasture (ecological criterion). In order to analyse the dynamics of such socio-ecological systems, appropriate agent-based, ecological-economic models are developed in the project with the aim to foster conceptual understanding of (post-)nomadic systems under Global Change and to support the synthesis work in the Collaborative Research Centre that is crucial in its third phase. The modelling work in Subproject E10 is in close cooperation with social geographers from another subproject (A4) who are working empirically and have an excellent data base on the household scale for linking the models to data. Research in the project is anchored in three case studies in different (post-)nomadic regions: East Moroccan High Plateau (Oriental), High Atlas Mountains, Tibetan Highlands. In all cases, there is cooperation with local partners.

Funding: German Science Foundation (Collaborative Research Centre 586 "Difference and Integration" of the Universities of Leipzig and Halle; Subproject E10)

Term: 01.07.2008 – 30.06.2012

### **Sustainability standards for biomass production**

*Prof. Dr. Rainer Luick (Forsthochschule Rottenburg) and Prof. Dr. Karin Frank*

Aim of this project was the analysis of ecological impacts of an increasing production of biomass for energy at a regional scale, the derivation of sustainability standards and the systematization of implications for the evaluation and design of policy instruments from agriculture and nature conservation with relevance in the bioenergy context. The ecological impact assessment was done using spatially explicit ecological models with ground-breeding field birds as important indicator of biodiversity in agrarian landscapes. The modeling work was complemented by a policy analysis. Both have been anchored in reality using surveys in four sample bioenergy regions in Germany where the farmers were asked for their behavior in making land-use decisions in dependence on the market and the accessibility of (economic or legal) incentives of different types.

Funding: Federal Agency of Nature Conservation (BfN)

Term: 2008-2009

### **Sustainable Bioenergy Systems**

*Dr. Daniela Thrän, Prof. Dr. Andreas Huth, Prof. Dr. Karin Frank et al.*

This project was initiated to foster a comprehensive system analysis of bioenergy systems that adequately accounts for the interplay between ecological, socioeconomic and technological aspects relevant for bioenergy issues. This interplay is usually ignored. Aspects of particular interest in this context are the environmental impacts of the land use change driven by an increasing demand for biomass for energy beyond emissions (that are usually taken into account in standard life cycle assessments) such as: impacts on biodiversity and ecosystem services, on soil functions, or on the chemical and ecological state of running water systems. The project intends to foster the establishment of a strategic partnership of the UFZ with the German Biomass Research Centre (DBFZ Leipzig), to bundle their complementary competences (DBFZ: technological and economic, UFZ: environmental and political science), to establish a new UFZ Department “Bioenergy Systems (BEN)” and to foster the bioenergy research currently running in a network within the UFZ (BEN and other UFZ-departments such as the Department of Ecological Modelling AH and KF belong to. Special interest is in the development of a methodology for spatially differentiated life cycle assessment, innovative biomass production through location-dependent production systems and the choice of species-mixtures as strategies for reconciling bioenergy with biodiversity.

Funding: Helmholtz-Association (Impulse and Connection Funds)

Term: 01.07.2010 – 30.06.2015

## **3.2 Research cooperations**

### **Cooperations within the University of Osnabrück**

- Ecology: Biogeochemical fate processes (Prof. A. Kratochwil, Prof. T. Eggers)
- Economics: Controlling chaotic population dynamics (Dr. F. Westerhoff)
- Physics: ESR studies on stable organic radicals in soil (Prof. Steinhoff)

## Cooperations on a national basis

- Naturschutzbund Deutschland (NABU): Vorkommen von Mikroplastikpartikeln und Kunststoffadditiven in Strandsedimenten in ausgewählten Naturschutzgebieten auf Fehmarn, Ostsee (Dr. Kim Detloff)
- Environmental Mineralogy, Institute for Applied Geosciences, Technical University of Darmstadt: Engineered titanium dioxide (TiO<sub>2</sub>) nanoparticles in marine plastic debris (Dr. Martin Ebert).
- Max Planck Institute for Chemistry, Mainz: Organic pollutants in snow and ice from Antarctica: Long range transport and deposition processes (Prof. Dr. Gerhard Lammel)
- Department of Ecosystem Analysis, Institute for Environmental Research (Biology V), RWTH Aachen University: Occurrence and toxicity of organic plastic additives in sediments (Prof. Dr. Henner Hollert)
- Department Aquatic Ecotoxicology, Institute for Ecology, Evolution and Diversity, Johann Wolfgang Goethe University Frankfurt: Acute and chronic toxicity of benzotriazoles to aquatic primary producers and two Daphnia species (Prof. Dr. Jörg Oehlmann, Dr. Matthias Oetken)
- Center for Applied Geoscience, University of Tuebingen: Occurrence and distribution of benzothiazole (BTZ) in wastewater (Dr. Tillmann Gocht)
- Stadtentwässerung Frankfurt am Main: Verhalten von organoclay im Abwasser, Benzotriazole und Benzothiazol im Abwasser (Dr. Rolf Götz)
- Centre of Agricultural and Landscape Research (ZALF), Müncheberg: Polare organische Spurenstoffe im Grundwasserleiter des Oderbruchs (Dr. Cristoph Merz), Measuring and modelling volatilization of organic pollutants from flowing waters (Dr. Balla)
- AquaEcology, Oldenburg: Assessment of the water quality of the German Bight using long-term data of marine phytoplankton (Dr. Claus Dürselen)
- Ecological Field Station, University of Würzburg: Modelling metapopulation dynamics (Prof. Dr. H.J. Poethke)
- University of Applied Sciences (Fachhochschule) Osnabrück, Soil Ecotoxicology: Copper in the Hase catchment (Prof. Dr. Hans-Christian Fründ)
- Federal Agency of Environment (UBA), Berlin: Measuring and modelling volatilization of organic pollutants from flowing waters (Dr. Stefan Meinicke)
- Helmholtz Centre for Environmental Research (UFZ), Social Science Division: Multi-level governance and scale-issues (Prof. Dr. B. Hansjürgens, Dr. I. Dombrowsky)
- Helmholtz Centre for Materials and Coastal Research, Geesthacht: Modelling of floating objects in the North Sea (Dr. Callies)
- Institute for Environmental and Sustainability Communication, University of Lüneburg: The role of media in participatory governance for sustainability (Prof. Dr. H. Heinrichs)
- Institute for Regional Development and Structural Planning (IRS), Erkner: Multi-level governance and scale-issues (Dr. T. Moss; Dr. M. Wissen)
- Leibniz-Institute of Freshwater Ecology and Inland Fisheries: Assessing the origin of river bed substances in the lower River Elbe near Magdeburg (Dr. Martin Pusch)
- Oeko-Institut, Berlin: Governance for Sustainable Development (J.-P. Voß)

- Research Centre on Biotechnology, Society and the Environment at the University of Hamburg, Junior Research Group AgChange: Public Participation, Sustainability and Political Economy (Dr. P. H. Feindt)
- Wuppertal Institut für Klima, Umwelt, Energie GmbH, FG1 – Zukünftige Energie- und Mobilitätsstrukturen (Prof. Dr.-Ing. Manfred Fishedick, Dr. Peter Viehbahn, Dr. Stefan Lechtenböhmer, Georg Wilke)

### Cooperation on an international Basis

- Ifremer, Laboratoire LER/PAC, Bastia, Corsica: Toxicity of sediments at the Mediterranean Sea coast (Dr. Francois Galgani)
- Ifremer-Centre de Brest, Département DEEP/LEP, Plouzané, France: Occurrence of microplastics in marine snow (Dr. Alexis Khripounoff)
- Department of Environmental Engineering and Occupational Safety and Health, Faculty of Technical Sciences, University of Novi Sad, Serbia: Flame retardants in soils and atmospheric deposition processes (Prof. Dr. Mirjana Vojinovic Miloradov)
- Xi'an Jiaotong University, Xi'an, China: Orthophenylphenol in soils (Dr. Chunli Zheng)
- Total Petrochemicals Research Feluy, Feluy, Belgium: Microplastic related toxicity of sediments at the Mediterranean Sea coast (Chantal Goreux)
- Beijing Normal University (Beijing, China), EAWAG (Dübendorf, Switzerland): Water, Environment and Food Security: Integrating Economic and Environmental Objectives - A case study of the Haihe Basin in China (Liu Changming, Beijing Normal University; Hong Yang, EAWAG)
- Doshisha University, Kyoto (Japan): Biological invasions (Prof. N. Shigesada)
- ETH Zürich, Safety and Environmental Technology Group, Institute for Chemical and Bioengineering (PD Dr. Martin Scheringer, Dr. Matthew MacLeod)
- Hiroshima University (Japan): Analytical treatment of reaction-diffusion problems (Prof. H. Seno)
- International Institute for Sustainable Development, Winnipeg (Canada): Participatory Modelling and Scenario Building (Dr. D. S. Rothman)
- Institute of Experimental and Theoretical Biophysics Pushchino (Russia): Modelling marine plankton dynamics (Prof. A.B. Medvinskii, M.M. Gonik)
- Institute of Social Ecology, IFF - Faculty for Interdisciplinary Studies, Vienna (Austria): Participatory Modelling, Agent-based modelling in agrarian regions (Prof. Dr. M. Fischer-Kowalski, Prof. Dr. H. Haberl)
- Instituto Venezolano de Investigaciones Cientificas (IVIC), Caracas, Venezuela (Dr. J. Paolini) Shirshov Institute of Oceanology Moscow (Russia): Pattern Formation in Reaction-Diffusion Systems (Dr. A.Y. Morozov)
- Institute of Water Problems, Uzbek Academy of Sciences, Tashkent, Uzbekistan (Prof. Makhudov, Prof. Karimov)
- Masaryk University Brno (Czech Republic), Centre for Environmental Chemistry and Ecotoxicology (RECETOX): Organic pollutants in snow and ice from Antarctica: Long range transport and deposition processes (Prof. Dr. J. Klanova)
- Trinity College, Dublin (Ireland), Institute of Zoology: The influence of benthic structures on nutrient retention in Irish headstreams (Dr. Kenneth Irvine)

- University of Aarhus (Denmark), National Environmental Research Institute: Comparative analysis of case studies on participatory and collaborative environmental governance (Oliver Fritsch)
- University of Bath (Great Britain): Modelling biological invasions (Dr. F.M. Hilker)
- University of Leicester (Great Britain): Pattern Formation in Reaction-Diffusion Systems (Dr. S.V. Petrovskii)
- University of Marseille (France): Biological-physical interactions in aquatic systems (Prof. J.-C. Poggiale)
- University of Torino (Italy): Numerical analysis (Prof. Dr. E. Venturino)
- University Victor Segalen Bordeaux 2 (France): Mathematical epidemics (Prof. M. Langlais)
- University of Canterbury, Christchurch (New Zealand): Plant invasions (Dr. A. James, Dr. R. Brown)

### Visiting scientists

- Dr. Chunli Zheng, April 2009-March 2010, School of Environmental and Biological Science and Technology Dalian University of Technology, China.
- Prof. Dr. Lei, Yan, October 2010. Beijing Key Lab. Of Spatial Information Integration & Its Applications, Peking University, China.
- Taixia Wu, September 2010. Institute of Remote Sensing Application, China Academy of Science.
- Prof. Dr. Bakhtiyor Karimov, September – December 2010, Institute of Water Problems, Tashkent, Uzbekistan.

### 3.3 Conferences and workshops hosted by the institute

- Workshop on „GIS for desertification and soil degradation management“, Instituto Venezolano de Investigaciones Cientificas (IVIC), Caracas, Venezuela, Oct 30th - Nov 7th 2006 (J. Berlekamp, S. Lautenbach)
- WADEMED Synthesis Workshop. USF in cooperation with CIRAD and Cemagref 11.-15. Dez. 2006 (Bettina Blümling und Prof. Dr. Claudia Pahl-Wostl).
- Joint workshop on Global Assessments: Bridging Gaps and Linking to Policy, Washington, DC. May 9-11, 2007. Co-hosted by the Institute of Environmental Systems Research, The Integrated Assessment Society (TIAS) and the Global Water System Project (GWSP). Additional support from the Harmoni-CA project and the United Nations Environment Programme.
- Annual Conference “Environmental Chemistry and Ecotoxicology - From Chemo-dynamics to Risk Assessment” of the German Chemical Society (GDCh), September 26–28, 2007, Institute of Environmental Systems Research, Osnabrück

## 3.4 Publications

### 3.4.1 Applied Systems Science

#### Journal articles with peer review

- Alder A.C., Schaffner C., Majewsky M., Klasmeier J., Fenner K.* (2010): Fate of b-blocker human pharmaceuticals in surface water: Comparison of measured and simulated concentrations in the Glatt Valley Watershed, Switzerland. *Water Res.* 44, 936-948.
- Alexandrova O., Schulz M., Matthies M.* (2008): Estimation of the influence of humic substances on radionuclide binding to solids in deposits of radioactive waste. *Water, Air, and Soil Pollution*, 194: 287-299.
- Aleksandrova O. N., Schulz M., Matthies M.* (2010). Natural remediation of surface water systems contaminated with nuclear waste via humic substances in South Ural. *Water Air Soil Pollut.* 206, 203-214.
- Bach M., Letzel M., Kaul U., Forstner S., Metzner G., Klasmeier J., Reichenberger S., Frede H.-G.* (2010). Measurement and modeling of bentazone concentration in the river Main (Germany) originating from point and non-point sources. *Water Res.* 44, 3725-3733.
- Berlekamp J., Graf N., Hess O., Lautenbach S., Reimer S., Matthies M.* (2007): Integration of MONERIS and GREAT-ER in the Decision Support System for the German Elbe River Basin. *Environmental Modelling & Software* 22(2), 239-247.
- Bester K., Hüffmeyer N., Schaub E., Klasmeier J.* (2008): Surface water concentrations of the fragrance compound OTNE in Germany - A comparison between data from measurements and models. *Chemosphere*, 73 (8): 1366-1372.
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- Focks, A., Klasmeier J., Matthies M.* (2010). Mechanistic link between uptake of sulfonamides and bacteriostatic effect: Model development and application to experimental data from two soil microorganisms. *Environ. Toxicol. Chem.* 29(7), 1445-1452.
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- Fries, E., Klasmeier, J., Gocht, T.* (2011) Occurrence and distribution of benzothiazole in the Schwarzbach watershed (Germany). *Journal of Environmental Monitoring.* DOI:10.1039/C1EM10474H.
- Heuer H., Focks A., Lamshöft M., Smalla K., Matthies M., Spiteller M.* (2008): Fate of sulfadiazine administered to pigs and its quantitative effect on the dynamics of bacterial resistance genes in manure and manured soil. *Soil Biology & Biochemistry* 40, 1892-1900.
- Heuer, H., Solehati, Q., Zimmerling, U., Kleineidam, K., Schloter, M., Müller, T., Focks, A., Thiele-Bruhn, S., Smalla, K.* (2011): Accumulation of sulfonamide resistance genes in arable soils due to repeated application of manure containing sulfadiazine. *Appl. Environ. Microb.* 77(7), 2527-2530.
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- Lautenbach S., Berlekamp J., Graf N., Seppelt R., Matthies M.* (2009): Application of the Elbe-DSS: Scenario Analysis and Management Options. *Environmental Modelling & Software* 24, 26-43.
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- Matthies M., Klasmeier J., Beyer A., Ehling, C.* (2009): Assessing persistence and long-range transport potential of current-use pesticides. *Environ. Sci. Technol.* 43, 9223–9229.
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### 3.4.6 Scientific Contribution Series

Editor: Prof. Dr. Michael Matthies; ISSN 1433-3805.

The Contributions no. 1 and nos. 3-21 are only available in printed form and can be ordered at cost of 10 EUR per issue from the Institute of Environmental Systems Research, University of Osnabrück, Barbarastr. 12, D-49069 Osnabrück, Germany. Since no. 22 these Contributions are no longer available in printed form, but may be downloaded from the internet via <http://www.usf.uni-osnabrueck.de/usf/beitraege/>.

Contributions subsequently listed have been issued during the report period:

- No. 41 *Michael Matthies* (Ed.): [Klimawandel](#). October 2007. (4.8M)
- No. 42 *Nina Hüffmeyer* (Diploma Thesis): [Modellierung von Zink in der Ruhr - Emissionspfade und Belastungsanalyse](#). August 2006. (1,3M)
- No. 43 *Jutta Wissing* (Diploma Thesis): [Georeferenzierte hydromorphologische Charakterisierung von Flussgebieten](#). November 2006.
- No. 44 *Jan Priegnitz* (Diploma Thesis): [Analyse von Koffein als Abwassermarker in Fließgewässern](#). April 2007.
- No. 45 *Johannes Witt* (Diploma Thesis): [Pharmacokinetics of sulfadiazine in pigs](#). May 2006.
- No. 46 *Wibke Avenhaus* (Diploma Thesis): [Implementation von GREAT-ER mit ArcGIS und Arc Hydro](#). August 2007.
- No. 47 *Horst Malchow* (Ed.): [Komplexe Systeme und nichtlineare Dynamik in Natur und Gesellschaft](#). July 2008.
- No. 48 *Christian Ehling* (Diploma Thesis): [Abschätzung des Bioakkumulationspotentials organischer Verbindungen in der menschlichen Nahrungskette](#). August 2008.
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## 3.5 PhD dissertations and Habilitationen

### 3.5.1 PhD dissertations

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- Berkhoff, Karin* (2007): GIS-basierte Modellierung der Grundwasserempfindlichkeit in einer agrarischen Intensivregion. Referees: Prof. Dr. C. Pahl-Wostl, PD Dr. Sylvia Herrmann (Uni Hannover)
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- Borowski, Ikle* (2008): How can social learning be supported during the implementation of the European Water Framework Directive. Referees: Prof. Dr. C. Pahl-Wostl, Dr. Bert Enserink (TU Delft)
- Panbianco, Silke* (2008): Simulation sozio-technischer Abhängigkeiten bei der Verbreitung dezentraler Anlagen der Abwasserbeseitigung im ländlichen Raum der neuen Bundesländer. Referees: Prof. Dr. C. Pahl-Wostl, Prof. Dr. Sabine Kunst (Uni Potsdam)
- Siekman, Ivo* (2009): Mathematical modelling of pathogen-prey-predator interactions, Referees: Prof. Dr. H. Malchow, Dr. S.V. Petrovskii.
- Focks, Andreas* (2009): Effect of Sulfadiazne in Soil: Integrative Modelling Approaches as a Basis for Environmental Risk Assessment, Referees: Prof. Michael Matthies, Prof. Michael Schloter (TU München).
- Fellermann, Harold* (2009): Physically Embedded Minimal Self-Replicating Systems - Studies by Simulation. Referees: Prof. Dr. H. Malchow, Prof. Dr. S. Rasmussen (University of Southern Denmark)
- Blümling, Bettina* (2009): Mitigating agricultural groundwater over-extraction in the Hai River Basin of the North China Plain – a comparison of three social science research approaches. Referees: Prof. Dr. C. Pahl-Wostl, Dr. Hong Yang (ETH Zürich and EA-WAG)
- Alexandrova, Olga* (2009): Natural remediation of surface water systems used as deposits of nuclear industry waste by humic substances, Referees: Prof. Dr. Michael Matthies, Prof. Dr. Kirchner (Uni Bremen).
- Zeibig, Sten* (2009): The Regulation of Populations Featuring Non-Breeder Pools. . Referees: Prof. Dr. K. Frank, Prof. Dr. B. Blasius (Uni Oldenburg)
- Hartig, Florian* (2009): Metapopulations, Markets and the Individual: Refining Incentive-Based Approaches for Biodiversity Conservation on Private Lands. Referees: Prof. Dr. H. Malchow, Prof. Dr. U. Berger (TU Dresden), Dr. B. Whittan (University of Queensland, Brisbane, Australia)
- Holtz, Georg* (2010): Modelling system innovations in coupled human-technology-environment systems. Referees: Prof. Dr. C. Pahl-Wostl, PD Dr. Bernhard Truffer (Uni Bern and EAWAG)
- Hüffmeier, Nina* (2010): Exposure Assessment of Metals in Aquatic Environments: A Geo-reference Model Approach for Surface Waters. Referee: Prof. Dr. Michael Matthies, PD Dr. Kai Bester (Uni Duisburg-Essen).

- Isendahl, Nicola* (2010): (Re-) framing Uncertainties in Water Management Practice. Referees: Prof. Dr. C. Pahl-Wostl, Dr. Art Dewulf (Wageningen UR)
- Wissing, Jutta* (2010): A Hydrological Framework for Geo-referenced Steady-state Exposure Assessment in Surface Water on the Catchment Scale, Referees: Prof. Dr. Michael Matthies, Prof. Dr. Rode (Helmholtz Zentrum, Magdeburg).
- Herrfahrdt, Elke* (2010): The transformation towards adaptive water governance regimes in the context of climate change. Referees: Prof. Dr. C. Pahl-Wostl, Prof. Dr. Carl Folke (Uni Stockholm)
- Huntjens, Patrick* (2010): Water Management and Water Governance in a Changing Climate: Experiences and Insights on Climate Change Adaptation in Europe, Africa, Asia and Australia. Referees: Prof. Dr. C. Pahl-Wostl, Prof. Dr. John Grin (VU Amsterdam)
- Banitz, Thomas* (2011): Modelling Bacterial Growth, Dispersal and Biodegradation. Prof. Dr. K. Frank, Prof. Dr. C. Picioreanu (TU Delft, NL)
- Priegnitz, Jan* (2011): Untersuchung der Ausgasung organischer Chemikalien in einer Fließgewässersimulationsanlage. Referees: Prof. Dr. Michael Matthies, Prof. Dr. Christine Achten (Uni Münster).

### 3.5.2 Habilitationen

- Dr. Jens Newig* (2009): Environmental Governance im Lichte von Partizipation und Effektivität (gemeinsames Verfahren unter Federführung des FB Sozialwissenschaften). Referees: Prof. Dr. C. Pahl-Wostl, Prof. Dr. R. Czada (Department Social and Political Sciences, University Osnabrück).

### 3.6 Awards

- Sten Zeibig* (2008): Nachwuchswettbewerb „Wissenschaft verstehen“ des Helmholtz-Zentrum Umweltforschung UFZ Leipzig
- Jochen Sprickerhoff* (2009): Innovationspreis der Intevation GmbH.
- Sven Lautenbach* (2009): Environmental Modelling & Software Best Paper Award 2009: Decision Support.



## 4 Faculty and staff

### 4.1 Faculty: Applied Systems Science

- Michael Matthies, Dr. rer. nat., Professor of Applied Systems Science, Founding and Managing Director of the Institute
- Jörg Klasmeier, Dr. rer. nat., Dipl.-Chem., Senior researcher
- Jürgen Berlekamp, Dr. rer. nat, Dipl.-Biol., appointed lecturer
- Klaus Brauer, Dipl.-Math., Akad. Director (until 06/2005), appointed lecturer
- Christiane Zarfl, Dr. rer.nat., Dipl.-Systemwiss. Research assistant (until 05/2011)
- Andreas Focks, Dr. rer. nat., Dipl.-Systemwiss., Postdoc (until 02/2011)
- Marcus Schulz, Dr. rer.nat., Dipl.-Geol., senior researcher (until 03/2011)
- Nina Hüffmeyer, Dr. rer. Nat., Dipl.-Systemwiss., Ph.D. student (until 12/2009)
- Jutta Wissing, Dr. rer. nat., Dipl.-Systemwiss , Ph.D. student (until 12/2009)
- Olga Alexandrova, Dr. rer. nat., Dipl.-Phys.
- Christian Ehling, Dipl.-Systemwiss., Ph. D. student
- Tanja Müller, Dipl.-Geoökol., Ph. D. student
- Nils Kehrein, Dipl.-Systemwiss., Ph. D. student
- Ines Hotopp, Dipl.-Systemwiss., Ph. D. student
- Anne-Christin Meyer zu Holte, Dipl. Geogr., Research assistant

### 4.2 Faculty: Resources Management

- Claudia Pahl-Wostl, Dr. rer. nat. habil., Prof. of Resources Management
- Bettina Blümling, Dipl.-Ing., doctoral candidate
- Ilke Borowski, Dipl.-Ing., doctoral candidate
- Marcela Brugnach, Dr. phil., Dipl.-Ing., senior researcher, project manager
- Dirk Günther, Dipl. Soz-Wiss., doctoral candidate
- Georg Holtz, Dipl.-Systemwiss., doctoral candidate
- Patrick Huntjens, researcher, doctoral candidate
- Nicola Isendahl, Dipl.-Ing., doctoral candidate
- Kai Kaldrack, Dipl.-Systemwiss., doctoral candidate
- Britta Kastens, Dipl.Geogr., Dr. rer. nat., senior researcher
- Christian Knieper, Dipl.-Geogr., researcher (since 09/2007)
- Maria Manez, Dr., senior researcher
- Möllenkamp, Sabine, Dr., Dipl.-Geogr., DEA; Politikwiss., M.A.; senior researcher
- Jörn Möltgen, Dipl.-Geogr., project manager and researcher
- Jens Newig, Dipl.Geo-Ökol., Dr. iur, Assistant Professor
- Silke Panebianco, Dipl.-Ing., doctoral candidate
- Sonja Schmidt, Dipl.-Ing., Dr. rer.nat., senior researcher
- Ole Schroeder, Dipl.-Systemwiss., doctoral candidate
- Caroline van Bers, researcher
- Chun Xia, researcher, doctoral candidate

### **4.3 Faculty: Theoretical Systems Science**

- Horst Malchow, Professor of Applied Systems Science, Dr.rer.nat., Dr.sc.nat., Dipl.-Phys.
- Ivo Siekmann, Dr.rer.nat., Dipl.-Systemwiss., Dipl.-Math. (until 04/2009)
- Michael Sieber., Dipl.-Systemwiss., doctoral candidate

### **4.4 Faculty: Applied Environmental Systems Research**

- Elke Fries, Dr., Juniorprofessorin for Applied Environmental Analysis
- Chunli Zheng, Dr., research assistant (until March 2010)
- Aliz Kiss Dipl.-Umweltwiss., doctoral candidate (since March 2009)
- Ivana Mihajlović (Msc), doctoral candidate (since March 2010)

### **4.5 Faculty: Ecological Modelling**

- Karin Frank, Prof. Dr., Professorin for Ecological Modelling, Department of Ecological Modelling, Helmholtz-Center for Environmental Research (UFZ), Leipzig-Halle
- Andreas Huth, Prof. Dr., Professor for Ecological Modelling, Department of Ecological Modelling, Helmholtz-Center for Environmental Research (UFZ), Leipzig-Halle
- Claudia Dislich, Dipl.-Math., doctoral candidate
- Franziska Taubert, Msc. Math., doctoral candidate
- Florian Hartig, Dr. rer. nat., Dipl.-Phys., postdoc
- Friedrich Angermüller, Dipl. Biogeos., doctoral candidate
- Rico Fischer, Msc. Math., doctoral candidate
- Martin Kazmierczak, Dipl.-Biol., doctoral candidate
- Eduardo Velazquez, Dr., Dipl.-Biol., postdoc
- Jeroen Everaars, Dipl.-Biol., scientist
- Anne Püschel, Dipl. Geoökol., doctoral candidate (until 2010)
- Alvaro Gutierrez, Msc. Forest Science Ph.D. (until 2010)

### **4.6 Technical and administrative staff**

- Elke Altekruise, Institute administration
- Jürgen Berlekamp, Dr.rer.nat., System administrator
- Irene Brink, Secretary
- Johannes Wösten, Dipl.-Math., System administrator
- Melanie Wissing, Technical Assistant