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# Development of a regional model for integrated management of water resources at the basin scale

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**Abstract**

Integrated modeling is a novel approach to couple knowledge and models from different disciplines and research fields and to use their potential in the strategic planning of water management at the river basin scale. The MOSDEW integrated regional model has been developed in the Neckar basin, a 14,000 km$^2$ river catchment in South–West Germany as a model cascade of nine submodels covering large scale hydrology, groundwater flow, water demand, agricultural production, point and non-point pollution and chemical as well as biological water quality. The models are being tested and validated in the Neckar basin as well as in additional river basins in West Africa (Ouémé basin) and Central Asia (Chirchik–Ahangaran–Keles basin, CHAB) with contrasting ecological, hydrological and socio-economic boundary conditions. The transfer to the CHAB basin required changes in the submodel selection and integration structure due to the strong anthropogenic modifications of the flow regime in the downstream area. There, water is conveyed from the Chirchik river to other catchments and distributed in a complex channel system to satisfy the demand of competing water users (irrigation, urban water supply, energy production). In the Ouémé basin, the ecohydraulic model was not integrated due to lack of input data for ecological requirements of fish species whereas the groundwater flow model was not applicable to the predominant presence of aquifers in fractured rock. The model results obtained so far are promising with respect to their accuracy to be used in scenario simulations for the strategic basin wide planning of water management.


*Keywords:* Integrated water resources management; Model coupling; Neckar basin; Ouémé basin; Chirchik–Ahangaran–Keles basin

## 1. Introduction

Water resources in the European Community, as well as in developing countries, are under increasing pressure from the continuous growing demand for sufficient quantities of good quality water for all purposes. Consequently, in 2003 the European Commission launched the "EU Global Water Initiative", which proposes to apply the principles of the European Water Framework Directive (WFD) to other continents. The central feature of the WFD is the use of river basins as the basic unit for all planning and management actions. Within the RIVERTWIN project (<www.rivertwin.org>) the integrated regional model MOSDEW is being adjusted and tested for the strategic planning of water resources management in three river basins in Europe, Central Asia and West Africa.

Integrated modeling is a novel approach to couple knowledge and models from different disciplines and research fields. The coupling may be soft (data coupling) or rigid (dynamic model coupling). At the global scale,

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research activities in integrated regional modeling have led to the development of prototypes of so-called Earth System Models like the IMAGE model (Alcamo, 1994; Leemans et al., 1998), which are now being improved and upgraded to be used in forecasting of global climate change effects on ecosystems and society. The MERGE model (Model for Evaluating Regional and Global Effects; Manne et al., 1995) which was developed in the United States, may be viewed as a contribution of academic economists to provide a framework for thinking about the management of climate change.

At the regional scale, most of the integrating modeling approaches in the last decade have focused on the description of the interaction between atmospheric and hydrological processes integrating disciplines from natural sciences (Rode et al., 2002; Horák and Owsinski, 2004; STREAMES, 2000; IWRMS, 2001; TISZA RIVER PROJECT, 2004). Scenario studies combining socio-economic and biophysical models have been successfully carried out for East Anglia (Loveland, 2001), North–East of Brazil (Printz and Lang, 2003), the Aral Sea Basin (De Groen et al., 2002; Dukhovny, 2002) and at local scale (Dabbert et al., 1999). However, most of these studies are lacking features of water quality modeling that are important for implementation of the WFD, in particular biological water quality, or do not consider the impact of economic and social drivers on water quality.

Hence, the regional model MOSDEW has been developed in the Neckar basin (SW Germany) to assist planning authorities and decision makers in assessing the impacts of economic and demographic development, and the effects of global climate and land use changes on the long-term availability and quality of water bodies. The model approach is being transferred and adapted to the two contrasting river catchments in West Africa (Ouémé river) and Central Asia (Chirchik–Ahangaran–Keles basin). Besides the assessment of the effects of future climate change on water availability and water quality, the integration approach has been designed to address the following needs in the three river basins: (1) quantifying the impact of land use changes caused by the reform of the European common agricultural policy on water quality as well as income generation in the agricultural sector in the Neckar basin, (2) describing the interactions between land use effects on biological quality in the Neckar basin, (3) estimating the changes in agricultural productivity, water quality, water supply and demand on the background of two different official development scenarios in the Oueme basin, and (4) allocating water resources between sectors (including environmental requirements) without compromising land resources, water quality and agricultural development in the CHAB basin.

## 2. Model structure

In the Neckar basin, the regional model MOSDEW (Model for Sustainable Development of Water Resources) integrates a model cascade of nine submodels that are "loose-coupled" through the MOSDEW interface (Fig. 1). A statistical model for downscaling of climate scenario outputs from GCM runs starts the model cascade (Bárdossy and Plate, 1992; Stehlík and Bárdossy, 2002). In parallel, the agroeconomic sector model ACRE (Henseler et al., 2005) is calculating the distribution of agricultural land use types and crops. ACRE responds to developments on the agricultural market, political interventions (like the EU Common Agricultural Policy) and

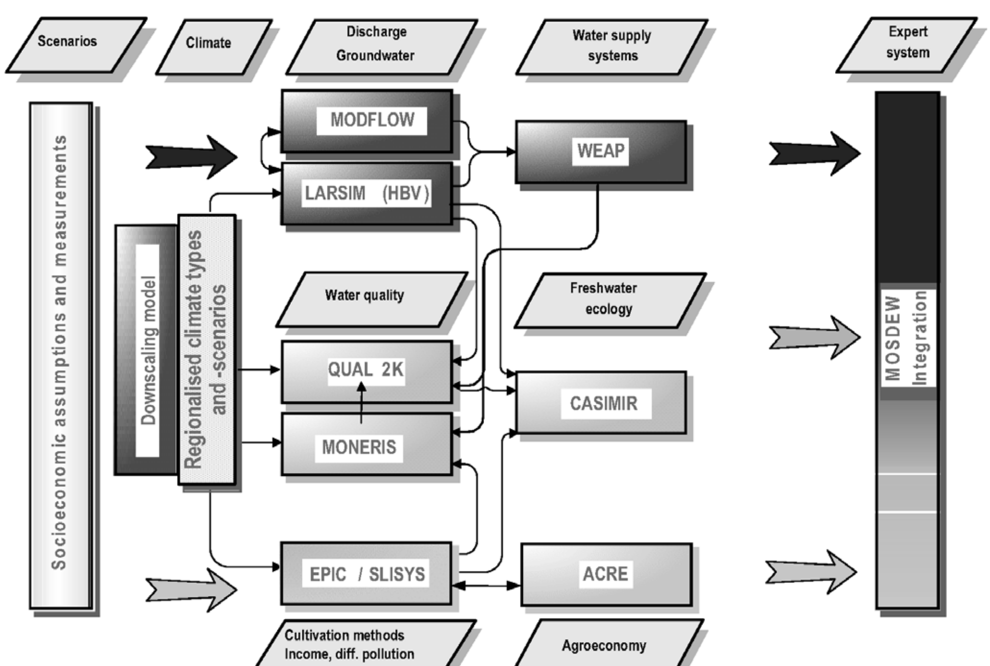


Fig. 1. Integration structure of the submodels in the Neckar basin.