



IMPETUS WEST AFRICA

Regional hydrological modelling in Benin (IMPETUS project) and its potential benefit for the local population

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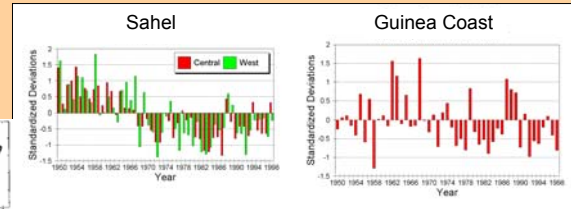
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Objectives:

- Representation of **actual hydrological processes** in Benin (West Africa) on the regional scale
- Quantification of the **regional water fluxes** and the **available water resources** (concerning water use)
- Development of (modelling) tools for **scenario analyses** and management applications

Background:

- Observation of **dry periods over more than 20 years** in the 70ies and 80ies (see right)
- Increasing **degradation of the „natural“ savannah** in central Benin in the last 20 years
- Undamped **population growth** in Benin (+3%), partly > 5% caused by migration processes
- Consequence: actual and future **shortage of water resources** in West Africa



IMPETUS project:

- Integrative management project for the efficient and sustainable use of freshwater in West Africa (Morocco & Benin, see left)
- Project is funded in the framework of the **GLOWA** programme of the **BMBF**: global change of the water cycle
- Focus is set on the interfaces and feed back mechanisms between **natural** and **social sciences and processes** respectively
- Estimation of the influence of **environmental change processes** on regional water cycle, water availability and food production within regional scale river catchments (15,000-30,000 km²)
- Investigation of the effects of **human activities** on natural cycles (water, carbon)

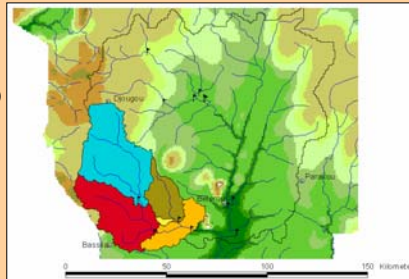
Main focus of the 3 project phases:

1. phase: **analyse** of actual and past processes 2000-2003
2. phase: **scenario studies** – what happens if...? 2003-2006
3. phase: implementation of a **management/decision support system** 2006-2008



Target catchment of IMPETUS in Benin

- Target catchment: **upper Ouémé catchment** (right), catchment area of about 15,000 km²
- Focus of hydrological modelling preliminarily set on the **Térou catchment** (3,133 km², colours)



Catchment characteristics:

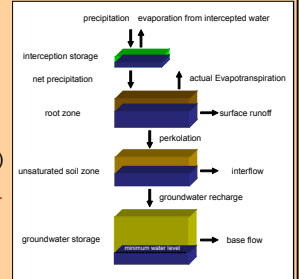
- About 1100mm/a **rainfall** and 150mm/a **runoff**
- **Savannah landscape**, degraded in the north
- Agricultural areas (yam, manioc, cotton, maize) are integrated into the savannah as a mosaic
- **Undulating, moderate topography** and mostly crusted, **lateritic soils**

Data base

- Soil map, DEM, geology, land use
- Weather data, runoff data (daily resolution)
- **But: information content and resolution is not sufficient for process based modelling of the water fluxes**

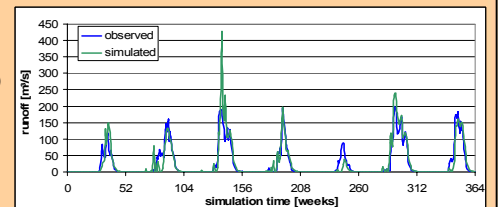
Conceptual model approach (UHP, see right)

- **Reservoir approach**: 4 storages (3 lin. stor.)
- ETP: calculation according to **Priestley-Taylor**
- ETA: reduction of ETP using soil storage
- Runoff generation using the **SCS-CN** method
- **Lumped** approach



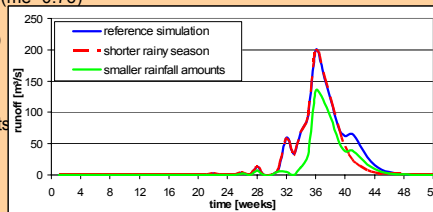
Model application for the Térou river

- **Model calibration** for the years 1993-1999 (criterion: **maximisation of model efficiency**, Nash & Sutcliffe, 1970)
- Model efficiency (=me) between observation and simulation (fig. right) of 0.76, coefficient of determination of 0.81
- Almost exact simulation of the long term total discharge (**water balance**) over the whole simulation period (25.1 by 25.2 m³/s)
- Acceptable simulation of the hydrological **seasonality** (dry and wet season) and of the **base flow** (recession behaviour)
- But: partly significant errors of simulated peak flow (error analysis required – errors caused by the model or by input data?)



Validation

- **Uncertainty analysis** (rainfall data, model parameters, ...) to calculate confidential intervals of the simulated hydrographs
- Validation by split sampling test (Resgaard, 1996) for the year 2000 (me=0.76)
- Validation by model application of other, similar catchments (Donga, upper Ouémé) for the period 1997-2000 (me between 0.72 and 0.84)



First exemplary scenario (decrease of precipitation)

- **Decrease of precipitation by 10%**
- Scenario 1: Shortening of the rainy season by 10% of rainfall amounts
- Scenario 2: Reduction of all rainfall events by 10%
- Effects of the scenarios on hydrograph are totally different (fig. right)
- **Necessity of exact scenario definition** based on knowledge on the properties and processes; scenario definition based on expertise

Application oriented indicators:

- Duration of the **vegetation period** (respectively the period showing a soil water storage status > x%)
- Quantification of the amount of **water available for plants**
- Quantification of the **groundwater storage status** in the end of the rainy season / in the end of the year
- Estimation of the **water required for irrigation** purposes to compensate decreasing precipitation amounts



Outlook – forthcoming work:

- Core activities of IMPETUS during the forthcoming project period are scenarios and scenario analyses (**What happens if?**)
- Starting point: **SRES scenarios** (IPCC, 2001)
- Modification of global SRES scenarios using **local / regional knowledge** about processes, properties and observed changes
- Development of scenarios concerning climate (precipitation, temperature), population (growth, migration), land use and land degradation, global economy and local markets, socio-economic and socio-cultural boundary conditions
- Use of the **scenario inventory** for an assessment of expected environmental changes and consequences on the regional scale

Which benefit has the local population by IMPETUS?

- IMPETUS is a scientific project and not a development project – for this reason the **direct benefit is limited** (education and training, work, tools, data, etc.)
- **Relevant indirect benefits:**
 - Development of the **awareness** that water resources are valuable, and that water resources can become short in the future (soil fertility, value of natural ecosystems); basic information can be delivered by scenario studies
 - Implementation of **decision support systems** based on the **scenario inventory** developed during the second project phase; furthermore representation of the essential processes and feedback mechanisms of the process structure within the models and **model components** (concerning the water cycle and the food production)
 - Formulation of **management plans** and **strategies** how in an **efficient** way to use **scarce resources** (water, soil) in cooperation with regional and local authorities as well as stakeholders
- Therefore **relevant response indicators** such as groundwater storage status in the end of the rainy season, duration of the vegetation period or potential demand for irrigation purposes are required (see above) to assess **consequences of potential system changes**. Based on the presented scenarios, tools and indicators a **decision support** can be achieved.



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