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

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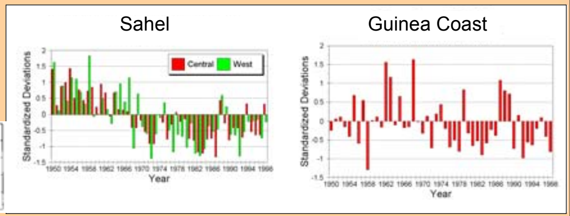
Objectives:
- Representation of actual hydrological processes in Benin (West Africa) on the regional scale
- Quantification of the regional water fluxes and the available water resources (concerning water use)
- Development of (modelling) tools for scenario analyses and management applications

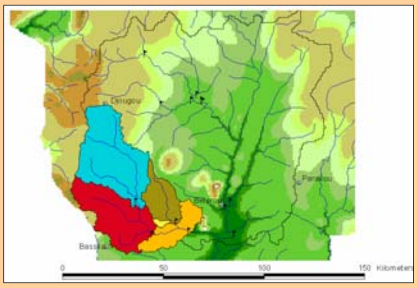


Background:
- Observation of dry periods over more than 20 years in the 70ies and 80ies (see right)
- Increasing degradation of the „natural“ savannah in central Benin in the last 20 years
- Undamped population growth in Benin (+3%), partly > 5% caused by migration processes
- Consequence: actual and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

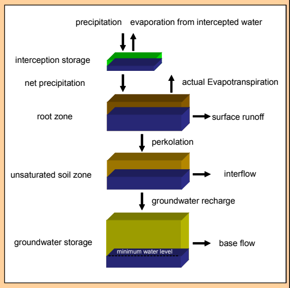
Target catchment of IMPETUS in Benin
- Target catchment: upper Ouémé catchment (right), catchment area of about 15,000 km²
- Focus of hydrological modelling preliminarily set on the Térou catchment (3,133 km², colours)



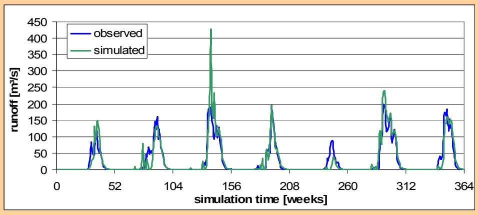
Catchment characteristics:
- About 1100mm/a rainfall and 150mm/a runoff
- Savannah landscape, degraded in the north
- Agricultural areas (yam, manioc, cotton, maize) are integrated into the savannah as a mosaic
- Undulating, moderate topography and mostly crusted, lateritic soils

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

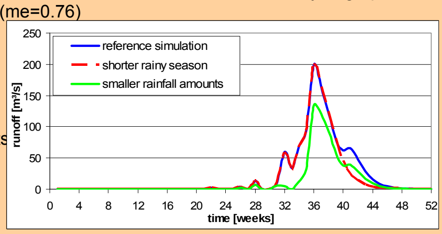


Model application for the Térou river
- Model calibration for the years 1993-1999 (criterion: maximisation of model efficiency, Nash & Sutcliffe, 1970)
- Model efficiency (=me) between observation and simulation (fig. right) of 0.76, coefficient of determination of 0.81
- Almost exact simulation of the long term total discharge (water balance) over the whole simulation period (25.1 by 25.2 m³/s)
- Acceptable simulation of the hydrological saisonality (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 (Resfgaard, 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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