HYDRONOMEAS: A WATER RESOURCES PLANNING AND MANAGEMENT SOFTWARE SYSTEM
European Geosciences Union (EGU) General Assembly,
Vienna, Austria, 25 - 29 April 2005
Session HS29: Hydrological modelling software demonstration
A. Efstratiadis, G. Karavokiros, and D. Koutsoyiannis
Department of Water Resources, National Technical University of Athens

What is HYDRONOMEAS?

HYDRONOMEAS is an operational tool for the management of complex water resource systems. It is suitable to a wide range of hydrosystems, incorporating numerous physical, operational, administrative and environmental aspects of integrated river basin management. The mathematical framework follows the parameterisation-simulation-optimisation scheme; simulation is applied to faithfully represent the system operation, expressed in the form of parametric rules, whereas optimisation is applied to derive the optimal management policy, which simultaneously minimises the risk and cost in decision-making.

Main modelling issues

- Employing stochastic simulation to handle the inherent uncertainty of future inflows and evaluate the system performance in reliability terms.
- Establishing a low-dimensional approach (by means of parametric operation rules), thus enabling an effective and efficient coupling of stochastic simulation within a water resource system optimisation framework.
- Handling all physical and operational constraints through a network linear optimisation model, ensuring a faithful representation of system operation and drastically reducing the computational effort of the simulation procedure.

Parametric rules for reservoir systems control

The rules, using two parameters per reservoir $i$, specify the corresponding target storage $s_i^*$ as a function of:
- the actual system storage $v$
- the total system capacity $k$
- the capacity of the specific reservoir $k_i$ (physical constraint)
- the desirable storage fluctuation limits $s_i^{\text{min}}$ and $s_i^{\text{max}}$ (operational constraint, user defined)

The parametric rules, introduced by Nalbantis & Koutsoyiannis (1997), have been generalised for the optimal control of both surface and groundwater resources.
Simulation through a network optimisation model

Assuming that inflows are projected through stochastic simulation, the target releases, as specified by the operation rules, may differ from the real ones, due to at least one of the following reasons:

- insufficient discharge capacity of the downstream aqueduct network;
- existence of alternative flow paths, with different costs (e.g., due to pumping);
- existence of multiple and contradictory water uses and operational constraints;
- insufficient inflows to fulfil demands or insufficient capacity to store flood runoff.

To evaluate the optimal fluxes, real components are transformed to digraph components, and virtual capacities and costs are assigned; the former represent target abstractions or flows, whereas the latter penalise undesirable fluxes (e.g., spill) and preserve priorities. At each time step a LP problem is formed, to achieve the following requirements:

1. strict satisfaction of all physical constraints (storage & flow capacity);
2. satisfaction of demand targets and operational constraints, preserving the user-defined priorities;
3. minimisation of departures between actual and target abstractions;
4. minimisation of transportation costs.

Digraph model representation; dotted lines represent virtual arcs, with capacity and unit cost in parenthesis.
The parameterisation - simulation - optimisation methodological framework

**Step 1: Hydrosystem data**
- System components and technical characteristics
- Water uses and priorities, operational constraints
- Inflow time series (historical, real time)
- Stochastic simulation of hydrological processes
- Synthetic inflows

**Step 2: Parameterisation**
Parametric expression of hydrosystem management policy (operation rules, for surface- and groundwater resource control systems)

**Step 3: Problem statement**
- Control variables (parameters)
- Constraints (in probabilistic terms)
- Performance measure (cost, reliability, safe yield)

**Step 4: Problem solution**
- Update of control variables
- Simulation procedure
- Digraph representation of real system components and targets
- LP model solution (simplex method)
- Step-by-step evaluation of optimal costs and fluxes, constraint handling
- Evaluation of system performance
- Global optimisation through the evolutionary annealing-simplex algorithm

**Step 5: Optimal solution**
- Operation rules
- System reliability
- Stochastic forecast of water availability and abstractions

**Step 6: Decision making**
Strategic planning and management
HYDRONOMEAS gives answers to questions such as:

- What is the **maximum total withdrawal** from the hydrosystem, for a given hydrologic regime and a given reliability level?
- What is the **minimum failure probability** in achieving a given set of operational goals, for a given hydrologic regime?
- What is the **minimum cost** to achieve a given set of operational goals, for a given hydrologic regime and a given reliability level?
- What is the **maximum benefit** from energy production?
- Which will be the **water availability** for a short-term time horizon?
- What are the impacts of different **management policies** or **hydroclimatic scenarios**?
- How could the system respond to **special occasions** such as channel damages or an intense increase of water demand for a specific period?
- What are the consequences of specific **modifications** in the hydrosystem (e.g., construction of new projects)?
Scenario data

- Network attributes
- Hydrological data
- Operational goals (targets)
- Simulation and optimisation options

Synthetic time series generated by CASTALIA are used by HYDRONOMEAS. The synthetic time series are statistically consistent with the historical ones.

A number of operational targets can be defined by the user from one of the following categories:
- water supply and irrigation targets
- energy production targets
- minimum flow preservation and maximum flow in selected aqueducts and time periods;
- minimum and maximum reservoir storage.

Simulation

Step by step visualisation of the simulation process

HYDRONOMEAS is developed within the project “ODYSSEUS: Integrated Management of Hydrosystems in Conjunction with an Advanced Information System”.

Project web page: http://www.odysseusproject.gr/
Research team web page: http://www.itia.ntua.gr/e/
E-mail contact: Hydronomeas@itia.ntua.gr