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Dynamic and Distributed Hydrologic Models of the Balsas River Basin for Decision Support in IWRM

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The Balsas River Basin

The Balsas River Basin in Mexico extends over 111,600 km^2, ranging in altitude from 5,300 m to sea level. It includes part of ten States with a population of some 10.1 million. The important hydroelectric generation compromises allocation of water to other growing uses. Two coordinated simulation models were developed to support the integrated water resources management.

Dynamic water resources management model

The dynamic simulation model of the Balsas river basin is aimed at supporting the consensus building in the River Basin Council. It allows determining the surface and groundwater balance, with a daily time step and multiyear simulation horizon.

Through a friendly interface different water management scenarios are defined and compared, such as: change in long term trends of water demand for various uses, inter-basin water transfers, water losses control in distribution networks and improvement of efficiency in irrigation systems. These scenarios will be considered in the definition of allocation rules in a region characterized by complex problems.

The input data are detailed at a municipal or irrigation district level. The output results are aggregated in time by month, year and simulation horizon; as well as spatially by watershed, hydrologic region, aquifer, state and administrative region. This model was developed in IMTA using *Powersim* linked with *Excel*.

Physiography

The physiographic characteristics of the watershed were derived with *Physitel*, from DEM, land use, soil type, river and reservoirs network data in vector and raster formats. These include altitude, slope, orientation, drainage network (arcs, nodes and points) and UH polygons. The percentage of land use classes and predominant soil texture were attributed to each HU.

A selected threshold drainage area resulted in the delineation of 2,348 relatively homogeneous hydrologic units (HU) averaging 47.5 km^2, each one associated with river segments or reservoirs. The resulting geodatabase was exported to be used by *Hydrotel*.

Distributed hydrologic model

Hydrotel generates multiyear mean daily runoff series in every HU, along with other useful variables. The simulated runoff series are fed into the surface water module of the dynamic water resources model of the river basin.

The model simulates direct, subsurface and base flows through six processes. The first four of them relate to vertical processes: interpolation of daily precipitation, minimum and maximum temperatures, snow accumulation and snowmelt, potential and actual evapotranspiration, and vertical water balance in three soil layers. The remaining two relate to horizontal processes: overland runoff, and river network and reservoir routing.

For some of the processes there are two or more alternative algorithms to choose from depending on the available datasets. *Physitel and Hydrotel* were developed in the INRS-ETE of Quebec, Canada.

Hydrologic Model Calibration

The parameters of the processes of *Hydrotel* were calibrated for watersheds defined by groups of HU using an optimization scheme. The reference period of runoff records includes humid and dry years at selected stations. The criteria included dry season, humid season and annual volumes, daily average flow, synchronization of events, and peak flows.

Conclusions

The application of a distributed hydrologic model coordinated with a dynamic simulation water management model has proven feasible and useful in the Balsas river basin. Its great advantage is the gain in confidence among the stakeholders for the highly detailed representation and good adjustment between simulation and reality.

This methodology is applicable to many other national and international transboundary watersheds, even in developing countries, where consensus building through the

analysis of scenarios based on objective grounds is both challenging and crucial.