Jul 1st, 12:00 AM

RIBASIM River Basin Planning and Management Simulation Program

Delft Hydraulics

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Delft Hydraulics
Delft, The Netherlands
www.wldelft.nl
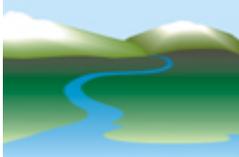
Introduction:

RIBASIM (River Basin Simulation Model) is a generic model package for analyzing the behaviour of river basins under various hydrological conditions. The model package is a comprehensive and flexible tool which links the hydrological water inputs at various locations with the specific water-users in the basin. RIBASIM is designed for river basin planning and management

RIBASIM follows a structured approach to river basin planning and management. RIBASIM enables the user to evaluate a variety of measures related to infrastructure, operational and demand management and the results in terms of water quantity and water quality. RIBASIM generates water distribution patterns and provides a basis for detailed water quality and sedimentation analyses in river reaches and reservoirs. It provides a source analysis, giving insight in the water's origin at any location of the basin.

RIBASIM has a set of features which make it a state of the art river basin simulation package. The model has been applied for more than 20 years in a large number of countries and in a wide variety of projects. Water management organizations world-wide use it to support their management and planning activities. Large and complex river basins have been modelled and simulated with RIBASIM. Separately modelled sub-basins can be combined into one main-basin.

RIBASIM has a link with the HYMOS hydrological database and modelling system. For detailed water quality process RIBASIM can be linked with the Delft Hydraulics DELWAQ water quality model.

Field of Application

RIBASIM is designed for any analysis which requires the water balance of a basin to be simulated. The resulting water balance provides the basic information on the available quantity of water as well as the composition of the flow at every location and any time in the river basin.

RIBASIM provides the means to prepare such balances in required detail, taking into account drainage from agriculture, discharges from industry and the downstream re-use of water. A number of basin performance parameters are generated for evaluation of the simulated situations.

A recent application of RIBASIM is the use of the model as flow routing component within a Flood Early Warning System (FEWS). Various hydrologic routing methods are available in RIBASIM e.g. Manning formula, Flow-level relation, 2-layered multi segmented Muskingum formula, Puls method and Laurenson non-linear "lag and route" method. The flow routing is executed on daily basis starting at any selected day for any number of days ahead.

User Interface

The structure of RIBASIM is based on an integrated framework with a user-friendly, graphically, GIS-oriented interface. Working with RIBASIM forces a structured approach to river basin planning and management.

This structured approach forms the basis for the working environment. The working environment provides

- guidance of the user at the design, calculation (simulation) and the analysis phase and a
- GIS environment for the interactive preparation of the basin schematization, the entry of object attribute data and the evaluation of simulation results.

Various tools from the Delft Tools library can be used:
- Case Management Tool (CMT) is an excellent tool to shape the structured approach. The working environment is a visualisation of the workflow diagram.

- Delft-GIS (Netter) software providing the user with essential features for a basin analysis which are not available in conventional GIS.
- Ods_View is a flexible tool for the presentation and export of time series results.
- The Case Analysis Tool (CAT) is a flexible tool to compare and evaluate the simulation cases.
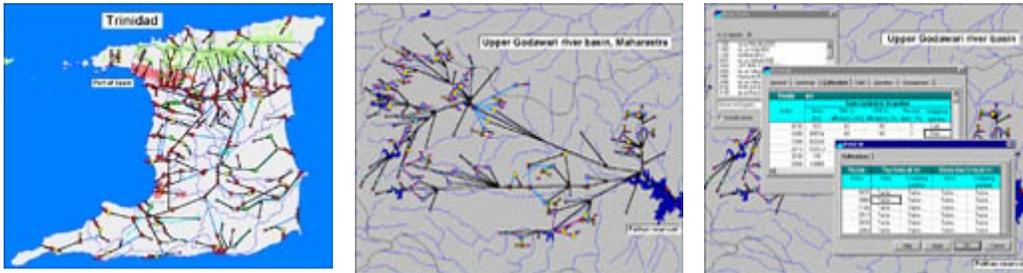
Delft GIS

RIBASIM is map oriented. A flexible modelling environment has been designed in which the modelling system is made independent of the user's choice of Geographic Information Systems (GIS).

It is centered on the network editor: Netter, the Delft-GIS tool. This tool provides the user with features which are not available under conventional GIS software and which are needed to carry out a basin analysis:

- map viewer
- interactive design of a river basin network schematization consisting of nodes and links
- editing of attribute data of each node and link
- fast visualisation of spatial and temporal data on maps
- presentation of data in form of various types of graphs
- animation of time series data
- optimised processing of very long time series with high speed

Water Users

Various water users (stakeholders) and water using activities are taken into account. These include (irrigated) agriculture , fresh and brackish water aquaculture, domestic supply, municipal supply, industrial water supply, wetlands, livestock, losses like evaporation and seepage, navigation, recreation, nature, ecology and environment, water rights, inter-basin transfers, groundwater recharge, river ice, and hydro-power generation.

RIBASIM includes special features such as

- water demand and allocation computation for the irrigated agriculture and the brackish water aquaculture in separate model components and
- wetland modelling can be fine-tuned by specific network schematization options

Reservoir Operation

RIBASIM contains a reservoir operation simulation component used to model single and multi-purpose reservoirs, lakes and storage basins. The following aspects are taken into account:

- various outlets: main gate, turbine gate, spillway and any number of head sluices
- hydraulic characteristics of the reservoir and gates
- operation rule curves for flood control, maximum energy production, firm storage, zoning of the reservoir storage and hedging (water rationing) of target releases
- hedging based on the target release (demand oriented) or based on the actual storage (supply oriented)
- specific operation based on level control
- operation of groups of reservoirs in series and/or parallel
- operation based on expected reservoir inflow
- hydrological aspects: evaporation losses and rainfall input based on reservoir surface area, seepage losses
- hydro-power station characteristics: head - power capacity relation, head - power efficiency relation, discharge – tail level relation, discharge - head loss relation
- firm energy demand per time step with a water allocation priority fully taken into account in the water allocation procedure on basin level

Groundwater

RIBASIM contains a groundwater simulation component, which computes the aquifer water balance taking into account the aquifer characteristics, the external inflows, groundwater recharge, groundwater abstractions and lateral flows. Further;

- groundwater management options are available to simulate various measures and
- conjunctive use of surface (river and reservoir) and groundwater can be modelled.

For irrigated agriculture the irrigation efficiency is differentiated based on the sources: surface water (river, reservoir) and groundwater pumping capacities are taken into account.

Water Management

RIBASIM has a general setup. A variety of water management and water allocation procedures can be modelled.

- The following features are available: water allocation priority per individual user
- source priority per individual user
- operation rules of individual reservoirs and groups of reservoirs
- groundwater management rules
- operation rules of the diversion structures (weirs, gates)
- water allocation based the online computed target demands and target releases
- proportional water allocation
- re-use of drainage water by downstream users

Hydropower

Hydro power production can be modelled at reservoirs and run-of-river hydro power stations. The produced energy is computed based on the hydro-power station characteristics and the actual water levels upstream (reservoir water level) and downstream (tail water level).

Firm energy production forms one of the water using activities in the basin and is fully taken into account in the water management options.

Routing

RIBASIM accepts basically any time step size. However, most basin simulations are executed on a monthly, half-monthly, 10-day, weekly or daily basis. In most situations the selected simulation time is such that mass equations are used for the simulations. In situations that this is not valid RIBASIM offers various hydrologic channel and reservoir routing procedure.

Source Analyses

RIBASIM computes the flow composition at any location in the basin. Sources like runoff from a sub-catchment, agriculture drainage, domestic and industrial sewage, reservoir water, groundwater, etc. are shown as components of the flow. This flow composition can be used as a basis for the analysis of the sources of water for the various users and thus as a first water quality assessment.

Water Quality

RIBASIM computes the concentration of substances in each river reach and water body, and the substance balance of each water user. Any number of substances can be defined by the user like salt, Biological Oxygen Demand, Nitrogen, Phosphorus, Bacteria, Toxic substances,

etc. Natural as well as artificial purification of the water is taken into account by modelling the natural retention in river reaches and water bodies, and waste water treatment plants. The computation is based on the computed flow and water allocation pattern. The waste generation (polluting substances concentration) at the system boundaries is specified as a relation between the substance concentration of the abstracted water and the drainage flow e.g. from irrigation areas.

The Delft water quality model DELWAQ in its full version is not part of the standard RIBASIM software. If an advanced in-depth modelling of chemical and biological processes is required a full link with DELWAQ can be developed.

Performance

Using a set of simulations, usually made for a range of alternative development or management strategies, the performance of the basin is evaluated in terms of water allocation, water shortages, firm and secondary hydropower production, overall river basin water balance (water accounting), flow composition, crop production, flood control, water supply reliability, groundwater use, and others, or combinations of these.

The user can select the format in which the results will be shown or exported, including graphs, thematic maps, animation, tables, and transferred to spreadsheets.
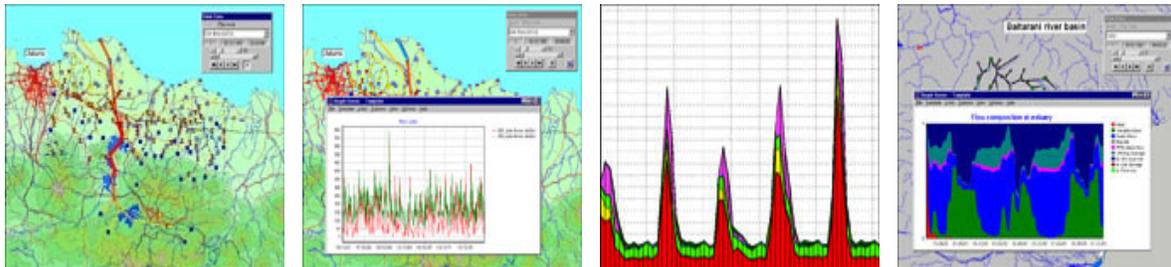
Applications

RIBASIM can be used for basin planning and management:

- long-term basin planning: the preparation of long and mid-term basin plans e.g. with a time horizon of 10 to 25 years. All kind of measures (technical, operational and institutional) can be analyzed with RIBASIM. Questions to be answered are for example: to what extent is development possible? What potential conflicts among users may arise and what are the impacts of various development alternatives?
- short term (half or one year) water allocation scheduling: preparation of a seasonal operation plan for the basin. RIBASIM can be used to determine e.g. a crop plan based on reservoir storage and expected inflows.

- in-season operation scheduling: during the season based on the actual situation in the field, the actual rainfall and the updated forecasts an updated water allocation schedule can be determined for the coming weeks or months. Questions that can be answered are for example: what is the water allocation to users in case of water scarcity? What is the impact of specific management options?
- Flow forecasting systems. At any time the flow at various locations along the river is predicted based on forecasts of the catchment runoff and hydrologic routing of river flow. Questions which are relevant here is e.g. what flow can we expect the coming few weeks or months at the intake of our drinking water reservoirs or irrigation scheme, or at the country border?