Name of Model, Date, Version Number:
CEQUEAU v 4.1.20.07 , 12/2009

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Brief Description:
The CEQUEAU hydrological model is a user friendly distributed deterministic model that takes into account the physical characteristics of a watershed as well as their space domain variations. This operation is made possible through a subdivision of the watershed into two discretisations. Subdivising catchment area into elements facilitates the use of remote sensing for the determination of physiographic characteristics and the estimation of variables such as precipitation and snowcover.
The model consists of two main functions. The first function, called production function, is aimed at the vertical water flow production in the soil and is schematized by different intercommunicating reservoirs. The second one, called transfer function, is aimed at the channel routing and uses determined draining factors using physiographic data.
Basic computation time interval: 1, 2, 3, 4, 6, 8, 12 or 24 hours. Choice of language for windows and printed graphs, the languages presently available are: English, Spanish, French, Polish and Portuguese. The CEQUEAU model version 4.0 allows short and mid-term forecasting with various updating options.

Model Type:
Distributed deterministic
Continuous precipitation and snowmelt runoff.

Model Objective(s):
Stream flow simulation; Short and mid-tern forecasting with various updating options

Model Structure or Mathematical Basis:
Water balance with interconnected reservoirs

Spatial Scale Employed in the Model:
The model was used for watershed of 1 km^2 to 100,000 km^2 with square of 0.1 km To 30 km.

Temporal Scale Employed in the Model:
1, 2, 3, 4, 6, 8, 12 hours steps or daily

Input Data Requirement:

The meteorological data required at each temporal step are:
Maximum and minimum air temperature
Liquid and solid (optional) precipitation
Hydrometric data at each temporal step are:
Stream flows for natural watershed and
Water levels and dam evacuation for artificial watershed

Model Output:
Steam flows at any points of the watershed and many estimate temporal and spatial data on the watershed.

Input Data Format:
All data files present in the project window may be created and edited with the help of the CEQUEAU editor. The CEQUEAU editor defines the fields and explains all the variables used by the model CEQUEAU. Presently, this editor is available in French only

Output Data Format:
Several files are created in order to receive the results of the quantity simulations. They take the name of the first part of quantity parameter file (*.PAH) in order to identify adequately what simulation they belong to. Every file created has an extension that identifies the file content. For the quantity simulation we have the following files:

- .SIM File of general results
- .DJO File of streamflows or levels observed and calculated from the real stations
- . .DSP File of spatial data
- .DFI File of streamflows or levels calculated from fictional stations
- .TPF File of temperatures, rain and snowmelt on the watershed.
- .ERS File of errors
- .HSN File of water levels in the reservoirs
- .ETA File of state variable for manual updating (optional)
- .MAJ File of manual updates (optional)
- .PRE File of short term forecast streamflows (optional)
- .PMT File of mid-term forecast streamflows (optional).

Parameter Estimation/Model Calibration:
The adjustment of the parameters of the model is done by trials and errors and/or by optimization

Model Testing and Verification:
The verification of the adjustment of the model is done by analysis of numerical criteria and the analysis of the results presented on graphs with the CEQUEAU interface. The model computes some numerical criteria and can produce several types of graph showing the observed and calculated stream flows. Three types of graphs are available: graphs of spatial data, graphs of temporal data, and graphs of forecast data.

Model Sensitivity:
The accuracy of CEQUEAU model was tested in comparison with other well known

hydrological models in the world in the framework of two (2) inter-comparisons of hydrological models fostered by the World Meteorological Organisation (WMO). At the occasion of the first inter-comparison [1] dealing with the simulation of flow rates including snow melt, CEQUEAU model was one of the eleven (11) models originating from eight (8) countries which was tested on six (6) rivers from six (6) different countries.
[1] World Meteorological Organization (1986). Intercomparison of models of snowmelt runoff. Geneva Switzerland Operational Hydrology WMO, no.646.

More recently, at the occasion of a second inter-comparison fostered by the World Meteorological Organisation [2] related to forecasting of flow rate in real time, CEQUEAU was one of the fourteen (14) models coming from eleven (11) countries and tested on three (3) rivers from three (3) different countries.
[2] World Meteorological Organization (1992). Simulated real-time intercomparison of hydrological models. Geneva Switzerland Operational Hydrology WMO no.779.

Model Reliability:
The verification of the adjustment of the model is done by analysis of numerical criteria and the analysis of the results presented on graphs.

Model Application/Case Studies:
In the last decades, CEQUEAU model was used for many watersheds in the Province of Quebec, in Canada and elsewhere in North and South America. It is also used in Europe and Africa. In the Province of Quebec, it was applied in some sixty (60) rivers/watersheds and used to determine probable maximal floods (PMF) in many watersheds of northern Quebec.
CEQUEAU model is presently used on a regular basis by some institutions in the Province of Quebec to forecast flow rates in real time.

Platform/Operating System:
Windows 95 and up.

Programming language and software:
The programming language are FORTRAN and C.

Web-based or desk-top application?

Is the application flexible to couple with external programs and user created executables?
Every file created can be used by external programs.

Are system and user documentation available? (Web site)
Chapter 13 of Mathematical Models of Large Watetrshed
Singh, V. P. and D. K. Frevert (Ed.), 2002.Mathematical Models of Large Watershed Hydrology, Water Resources Publications, Highlands Ranch, CO, 80163_0026 USA, (2002) Chapter 13 p 507_ 576.
Abstract in English (95 pages) CEQO-RA.PDF
Abstract in French (89 pages) CEQO-RF.PDF

Manual in French (458 pages) MANUEL-CEQUEAU.PDF

Are example applications available? (Web site)
To illustrate some of the possible options with the quantity simulation module, the program include the data of 3 watersheds, EATON river (629 $km^{2)}$, the Mistassibi river (9 320 $km^{2)}$ and the Chicoutimi and Aux Sables river (3 500 km^{2}). The Eaton river watershed is used to illustrate the spatial and temporal graphs. The Mistassibi river watershed is used to illustrate the temporal graphs and the forecasts in real time. The watershed of Chicoutimi and Aux Sables rivers is used to illustrate, with a one hour time-step, a simulation of a very important flood that occurred in 1996.

Is there a user group or hotline-type support? (Website)

Other Comments:
Choice of language for windows and printed graphs. The languages presently available are: English, Spanish, French, Polish and Portuguese.

More information available on the web site of CEQUEAU model
http://www.ete.inrs.ca/activites/modeles/cequeau/aindex.html

Abstract in English
http://www.ete.inrs.ca/activites/modeles/cequeau/ceqo-ra.pdf

Abstract in French
http://www.ete.inrs.ca/activites/modeles/cequeau/ceqo-rf.pdf