Model:HBV

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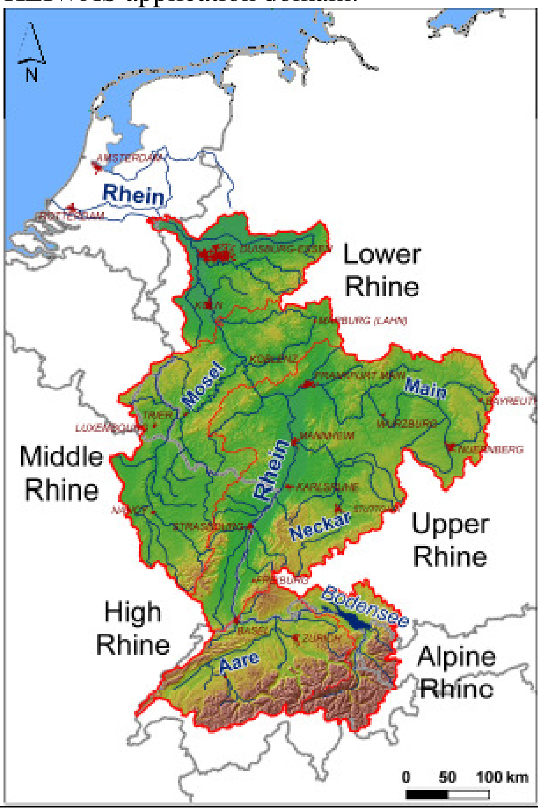
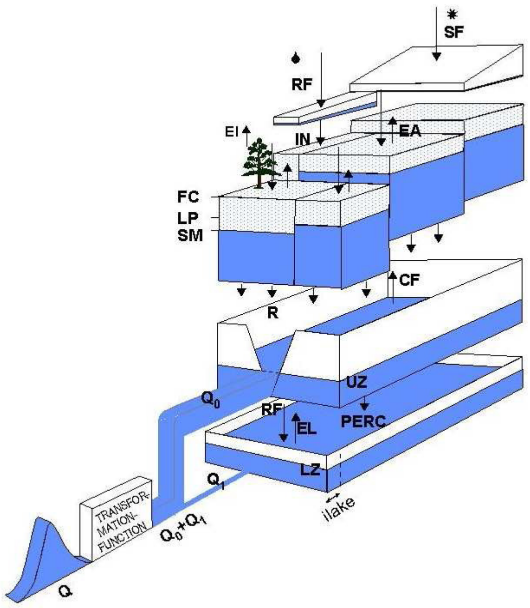
1. General Information	
Model name	HBV (Hydrologiska Byråns Vattenbalans-avdelning)
Version	HBV-96
Author(s) / First publication	Bergström and Forsman (1973), Bergström (1976), Lindström et al. (1997)
Contact person (name, email)	kundtjanst@smhi.se
Institute	SMHI
Web site	www.smhi.se
General modelling objectives	Calculation and forecasting of flows in rivers
Domain of applicability	- operational or scientific applications in more than 50 countries (e.g. Sweden, Zimbabwe, India and Columbia) with different climate conditions - existing applications for micro-, meso- and macroscale areas - largely applied in Sweden KLIWAS application domain:



KLIWAS contact (authority, name, email)	BfG, Maria Carambia, carambia@bafg.de
Model adaption in KLIWAS	-
Model coupling in KLIWAS	Input data from input data from regional climate models (REMO, RACMO, HadRM etc.) Output data for SOBEK, QSIM, SSIM3D
2. Model description	

Model type	Conceptual model
Temporal discretization	Continuous
Temporal resolution	1h, 2h, 3h, 4h, 6h, 8h, 12h, 1d
Spatial discretization	semi-distributed
Spatial resolution	variable (HBV134 applied in KLIWAS for hydrological modelling of the Rhine River catchment: ~ 1200 km²)
Dimension	none
Short description of model structure detailing main function	The main components of the model are routines for snow accumulation and melt, a soil moisture accounting procedure, routines for runoff generation and a simple routing procedure. Spatial units of the model are sub basins representing real river catchments. Sub basins of considerable elevation range can also be divided into zones of different elevation and land cover (forest, non forest, lake, glacier). This subdivision is only considered in the snow and soil moisture routines. <u>Snow Routine:</u> Precipitation is divided into rainfall (RF) and snowfall (SF) using a threshold temperature. On days with temperatures below the threshold, precipitation is supposed to be snow. The consideration of a transition from rain to snow over a temperature interval is possible. Based on a degree-day approach snow melt is computed. Snow distribution is calculated separately for different zones in the sub basins. <u>Soil Routine:</u> The routine mainly controls runoff formation. The part of excess water (R), the portion of water evaporating (EA) as well as the water amount stored in the soil (SM) is determined. Depending on the ratio of the actual soil moisture, the maximum water storage capacity (FC) and an exponent representing drainage dynamics the runoff coefficient is calculated. The parameter LP is a soil moisture value above which evapotranspiration equals potential evapotranspiration. In addition, the interception in forest and non forest areas an be simulated. <u>Runoff Generation Routine:</u> This routine transforms excess water from the soil routine to runoff. It consists of one upper , non-linear (UZ), and one lower, linear (LZ), reservoir. The former represents direct runoff, the latter base flow which is fed by groundwater. As long as there is water in UZ, water will percolate to LZ, the amount is determined by the parameter PERC. By means of a transformation function timing and distribution of the resulting runoff (Q_0+Q_1) is further modified. <u>Routing Procedure:</u> The routing is performed using a modified version of Muskingum's equations.
Scheme of model structure	The scheme shows the main model components.

	 Source: SMHI (2008)
Procedure of model parameter estimation	- Calibration for each sub basin possible - An automatic calibration routine does not belong to the model itself.
3. Model inputs / Model outputs	
List and characteristics of input variables	Normally, daily station values of rainfall and air temperature, and daily or monthly estimates of potential evaporation are used as input data.
List and characteristics of output variables	total computed outflow [m³/s], actual evaporation [mm] Numerous possible output variables (cf. SMHI (2008)) Output is available for each simulation time step and for 3 spatial levels (zone values, values valid for the sub basin, values valid for the sub basin and all upstream sub basins)
4. Examples of model applications	
Catchments, objectives etc.	A number of evaluations and applications are documented at the website of SMHI
Results of existing comparisons with other models	Different comparison studies exist (cf. website of SMHI or e.g. Te Linde et al.(2008))
Application in the framework of KLIWAS	Ensemble simulations targeting on the assessment of climate change impacts on the discharges in the Rhine River Basin. Evaluation with respect to high, mean, and low flow indicators (MHQ, MoMQ, MQ, FDC_Q10, FDC_Q90, NM7Q etc.).
5. List of 5 selected references	

Bergström, S., and Forsman, A. (1973) Development of a conceptual deterministic rainfall-runoff model. Nordic Hydrology, Vol. 4, No. 3.

Bergström, S. (1976) Development and application of a conceptual runoff model for Scandinavian catchments. SMHI Reports RHO, No. 7, Norrköping.

Lindström, G., Johansson, B., Persson, M., Gardelin, M., and Bergström, S., (1997) Development and test of the distributed HBV-96 hydrological model, J. Hydrol., Vol. 201, pp. 272-288.

SMHI (2008) Integrated Hydrological Modelling System, Manual, Version 6.0., Norrköping

Te Linde A. H., Aerts, J. C. J. H, Hurkmans, R. T. W. L., Eberle, M.(2008): Comparing model performance of two rainfall-runoff models in the Rhine basin using different atmospheric forcing data sets, Hydrol. Earth Syst. Sci., 12, 943–957.