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Modelling water availability and water allocation strategies in the Scheldt basin

Deelrapport 4-1
Analyses of hydrological models for climate change modelling – NAM

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Modelling water availability and water allocation strategies in the Scheldt basin

Sub report 4-1 –
Analyses of hydrological models for climate change modelling – NAM

Naranjo, P; Maroy, E.; Velez, C.; De Boeck K.; Pereira, F.; Nossent, J.; Mostaert, F.

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Abstract

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. Within the current subtask is investigated which is the most appropriate hydrological model for the sub catchments of the water balance model of the Scheldt basin in order to meet this prerequisite. This sub report describes the recalibration and evaluation of NAM models, which are part of the MIKE 11 software package (DHI, 2009).

The optimization during calibration is performed based on an automatic procedure, followed by a visual control. During the optimization routine the parameter sets are selected based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliffe efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows.

Overall, the performance of the updated NAM models, is substantially improved compared to the original NAM models. The summarized results for each of the gauged sub catchments within the study area, allow the user to get insight in the performance of the NAM model for each of the involved sub catchments. Based on this information and the evaluation of the PDM, VHM and WETSPA models, the user can make a well-grounded decision on which model to use for the considered objective.

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1 Introduction

1.1 Objectives

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. The goal of this subtask of the project 'Modelling water availability and water allocation strategies in the Scheldt basin', is to define the most appropriate hydrological models for the water balance model of the Scheldt basin in order to meet this prerequisite. Therefore, different hydrological models for each of the subcatchments in the study area are set up and evaluated on their appropriateness for low flow forecasting and climate change scenarios. The regarded models are NAM (©DHI), PDM (©Innovyze), VHM (©Willems, P.) and WETSPA (©VUB). Overall descriptions of these models can be found in Vansteenkiste et al. (2011). After evaluation of each of these hydrological models, the most appropriate model for each catchment can be used for the particular application.

This subreport covers the recalibration and evaluation of the NAM models, which are part of the MIKE 11 software package (DHI, 2009). In the previous project "Modelling of water availability and water allocation strategies for the Scheldt basin (project WL-09-46) the hydrological input of the water balance model was already generated by means of NAM models (De Boeck, K. et al, 2011). These NAM models were hitherto developed at Flanders Hydraulics within the scope of different projects, whereby the focus was mainly on flood forecasting and consequently on a good representation of high flows.

In the current project, hydrological NAM models for the gauged catchments (i.e. catchments upstream of a gauging station) are recalibrated whereby the focus is mainly on low flows. For each of the hydrological catchments, the NAM parameters will be updated.

The calibration is performed based on an automatic optimization procedure followed by a visual control. During the optimization routine the best parameters set is selected for each catchment based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliffe efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows.

Ungauged catchments inherit NAM parameters from similar neighboring catchments.

After validation and robustness checks, the newly calibrated NAM models will, if suitable, ready to be used for low flow forecasting and climate change scenario simulations.

1.2 Structure of the report

In a first section, the addressed catchments are defined and reliable gauging stations selected (Section 2). Second, rainfall and evapotranspiration are then interpolated for the selected catchments, according to the Thiessen polygon method (Section 3).

The general structure and parameters of the NAM model are outlined in Section 4 while the calibration strategy and basic logic behind the automated calibration algorithm are explained in Section 5.

Once all NAM models for the gauged catchments are calibrated, flow is simulated for 47 years (1967-2013). Ungauged catchments are simulated using parameters of a nearby catchment with similar characteristics. Results are synthesized in Section 6 and detailed in the appendices.

Section 7 presents conclusions of the calibration and some recommendations to consider when using the calibrated NAM models in the next steps of the project.

2 Catchment delineation

2.1 General

The inputs of the water allocation model are discharge time series at the upper boundaries and entries of tributaries in the modelled water network. This rainfall runoff discharge is simulated by means of one of the abovementioned hydrological models (NAM, PDM, VHM, WETSPA). Apart from the Scheldt catchment as such, the IJzer basin and the catchment of the Brugse Polders are also included in the water allocation model and therefore also included to this study. The map on Figure 1 shows the main river basins included in the water allocation model. In this report, results will be structured geographically per basin. The development of hydrological NAM models for the Meuse basin, which is also included in the water allocation model, is subject to a distinct report (Maroy et al., 2021).

Delineated hydrological subcatchments for the water allocation model were collected in 2010 based on past modelling studies (De Boeck et al. 2011) and updated within the framework of the present study. Figure 1 shows an overview of the delineated catchments in the water allocation model.

For the gauged catchments, where a time series of measured discharge is available, the NAM models are calibrated.

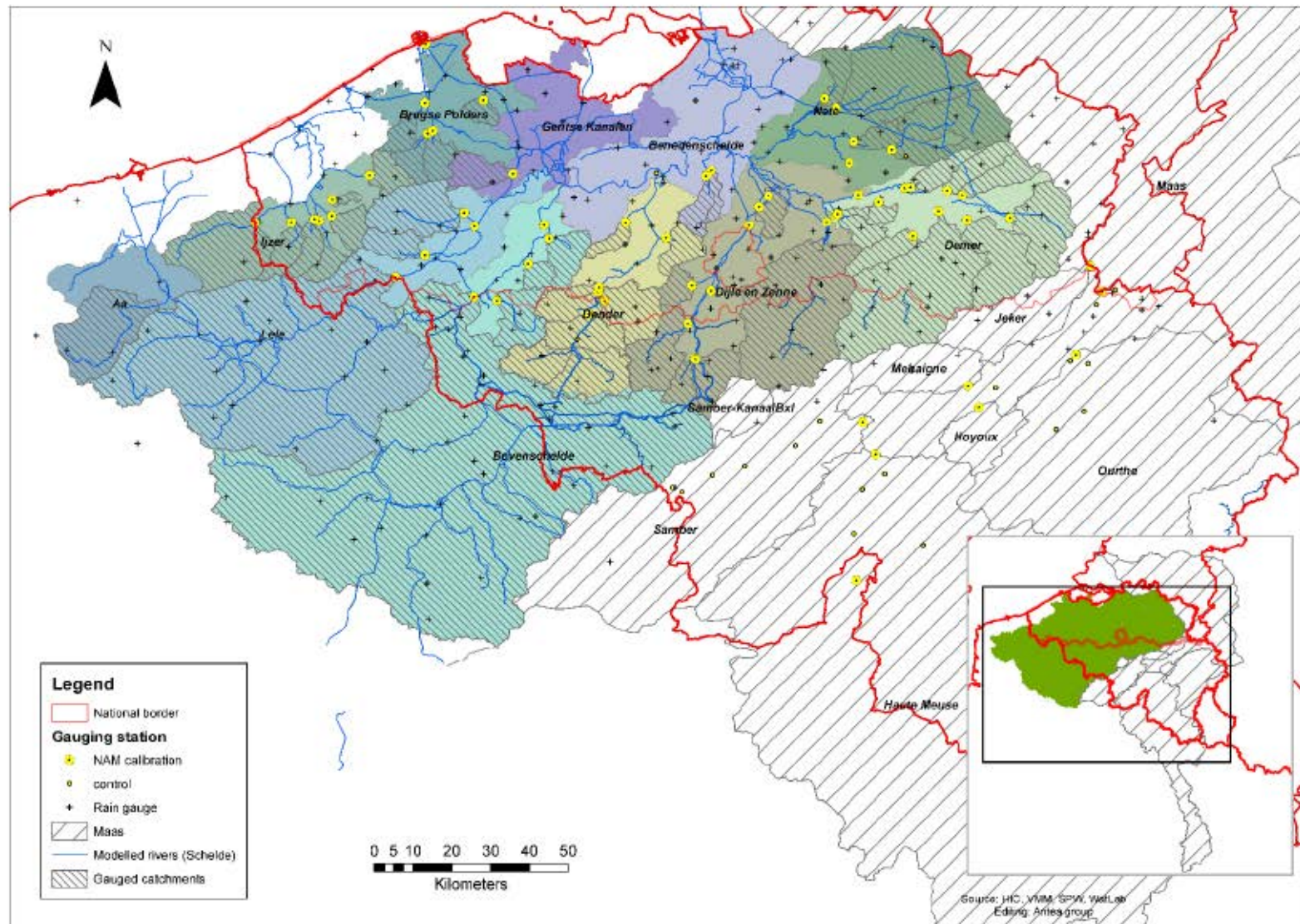
Some of the gauged catchments in the water allocation model are subdivided in different subcatchments to distribute the inflow over the modelled river stretches. Each of these subcatchments inherits the parameters of the main gauged catchment. An example of this is the Leie catchment upstream of the measuring station the Menen, which is subdivided into 27 subcatchments. The catchment itself is calibrated on the discharge timeseries of the gauging station the Menen. Within the water allocation model the rainfall runoff of each of these 27 subcatchments is calculated based on its particular interpolated rainfall- and evaporation series and linked individually to the appropriate modelled water course. For more detail about the choices and methodology of catchment delineation, please see De Boeck et al. (2011)¹. Ungauged models inherit NAM parameters from similar neighboring catchments.

All catchments of the water allocation model received a unique informative code, as defined in the previous phase of the project (De Boeck et al., 2011). Each code consists of 12 characters, relative to the catchment location, main water course and gauging station:

- **Character 1** : region where the catchment is located (V: Flanders; W: Wallonia; N: Netherlands; F: France)
- **Characters 2 and 3**: number of the Flemish hydrographic basin to which the catchment belongs.
- **Characters 4,5 and 6**: initials of the main water course
- **Characters 7, 8 and 9**: first three digits of the gauging station code (or 3 letter initials) for gauged catchments, and "000" for ungauged catchments.
- **Characters 10, 11 and 12**: three digit-suffix that ensure catchment code differentiation.

¹ WL2011R724_04c_rev2_1_DO3.doc

Figure 1 – Map of gauged and ungauged catchments of the Scheldt basin, Meuse, the Brugse polders and the IJzer



2.2 Gauged catchments

Table 1 lists the gauged stations used for calibration of the rainfall-runoff models. Catchments that were calibrated jointly are listed in Table 2.

Table 1 – List of gauging stations on the Scheldt and its tributaries for calibration of hydrological models

| Gauging station (code - water course; location) | Catchment ID | Area (km ²) | Gauged years |
|---|---------------------|-------------------------|--------------|
| 48810102 - Handzamevaart; Kortemark | V01HAN488180 | 78,6 | 1994-2016 |
| 46810102 - Ijzer; Roesbrugge Haringe | V01HEI468999 | 393,0 | 1986-2016 |
| 49510102 - Ieperlee; Zuidschote | V01IEP495080 | 63,4 | 1983-2014 |
| 49270102 - Kemmelbeek; Boezinge | V01KEM492060 | 73,9 | 1986-2015 |
| 49610102 - St. Jansbeek; Merkem | V01MAR496120 | 76,1 | 1986-2016 |
| 49110102 - Poperingevaart; Oostvleteren | V01POP491030 | 84,9 | 1984-2016 |
| 49910102 - Steenbeek; Merkem | V01SSV499140 | 16,1 | 1990-2009 |
| 44210102 – Ede; Maldegem | V02EDE442120 | 45,5 | 1983-2016 |
| 42610102 - Hertsbergebeek; Oostkamp | V02HER426010 | 77,3 | 1986-2016 |
| 4220102 – Kerkebeek; Sint-Michiels | V02KER422030 | 62,7 | 1983-2008 |
| 42510102 - Rivierbeek; Oostkamp | V02RIV425020 | 64,0 | 1983-2016 |
| 44656122 - Poekebeek; Nevele | V03POE446000 | 106,8 | 1983-2010 |
| 3610102 - Kleine Molenbeek; Liezele | V04MOL036110 | 32,6 | 1966-2016 |
| 3710102 - Grote Molenbeek; Malderen | V04MOM037100 | 67,3 | 1966-2016 |
| 38680122 – Leie; Menen | <u>F05LEI386999</u> | 2981,8 | 1998-2016 |
| 40310102 - Heulebeek; Heule | V05HEU403210 | 91,9 | 1972-2016 |
| 40110102 - Mandel; Oostrozebeke | V05MAN401230 | 258,4 | 1967-2013 |
| 32580122 - Bovenschelde; Bossuit | <u>F06BOS325999</u> | 5217,6 | 2001-2014 |
| 34710102 - Maarkebeek; Etikhove | V06MAA347160 | 48,7 | 1972-2016 |
| 34210102 - Zwalm; Nederzwalm | V06ZWA342190 | 112,1 | 1972-2016 |
| L5412 – Rhosnes; Amougies | W06RHOL54100 | 161,9 | 2012-2016 |
| 28510102 – Bellebeek; Essene | V07BEL285070 | 88,7 | |
| 28970102 – Mark; Viane | V07MAR289015 | 173,9 | 1976-2016 |
| 28210102 – Molenbeek; Erpe Mere | V07MOE282100 | 46,4 | 1986-2016 |
| 28810102 – Molenbeek; Geraardsbergen | V07MOG288020 | 23,1 | 1985-2014 |
| 2708-1050 Dendre; Lessines | W07DENLES999 | 511,8 | |
| 11110102-Barebeek; Elewijt | V08BAR111370 | 69,9 | 1997-2004 |
| 9310102 – Dijle; Wilsele | V08DIJ093400 | 886,9 | 1974-2014 |
| 23310102 – Zoonbeek; St Pietersleeuw | V08ZUU233100 | 64,8 | 1985-2016 |
| 2371-10050 Samme; Ronquieres | W08SAMRON000 | 133,6 | 1989-2016 |
| L5670 –Senette; Ronquieres | W08SENLS6010 | 70,4 | 1977-2016 |
| 1951-10050 Zenne; Tubize | W08SENTUB030 | 215,9 | 1975-2016 |
| 13610102 – Demer; Hasselt | V09DEM136000 | 255,1 | 1997-2016 |
| 15210102 - Gete; Halen | V09GET152080 | 800,4 | 1969-2013 |
| 16310102 – Herk; Kermt | V09HER163010 | 274,6 | 1977-2016 |
| 14710102 - De Hulpe; Molenstede | V09HUL147150 | 80,1 | 1986-2016 |
| 14310102 - Grote Losting; Wezemaal | V09LOS143300 | 15,2 | 1986-2016 |
| 16110102 - Mangelbeek; Lummen | V09MAN161040 | 102,9 | 1983-2011 |

| Gauging station (code - water course; location) | Catchment ID | Area (km ²) | Gauged years |
|---|--------------|-------------------------|--------------|
| 14410102 - Motte; Rillaar | V09MOT144270 | 33,6 | 1986-2010 |
| 14510102 - Velp; Ransberg | V09VEL145100 | 96,8 | 1969-2016 |
| 14110102 - Rotselaar; Winge | V09WIN141310 | 64,7 | 1986-2016 |
| 14810102 - Zwarte Beek; Lummen | V09ZWA148120 | 96,2 | 1983-2016 |
| 8610102 - Grote Laak; Vorst | V10GLA086020 | 62,6 | 1986-2014 |
| 7610102 - Grote Nete; Geel-Zammel | V10GNE076999 | 243,5 | 1985-2013 |
| 5210102 - Kleine Nete; Grobbendonk | V10KNE052000 | 584,7 | 1983-2016 |
| 6210102 – Molenbeek; Pulle | V10MOP062140 | 77,3 | 1986-2014 |
| 8210102 – Wimp; Wiekevorst | V10WIM082050 | 65,4 | 1989-2007 |

Table 2 – Catchments calibrated jointly based on one gauging station

| Station (code - water course; location) | Joint code | Catchments |
|---|----------------------|--|
| 46810102 - IJzer; Roesbrugge Haringe | F01IJZ468000 | V01HEI468010 F01YSE468000 |
| 38680122 – Leie, Menen | F05LEI386001 | F05BEC386023 F05DEU386090 V05LEI386180 F05BEC386025 F05DEU386110 F05LOI386035 F05BOU386005 F05DEU386120 F05LYS386000 F05CLA386017 F05DEU386130 F05LYS386010 F05CLA386020 F05DEU386140 F05LYS386015 F05DEU386040 F05DEU386150 F05LYS386115 F05DEU386050 F05DEU386160 F05MAR386070 F05DEU386060 F05LAW386018 F05MAR386100 F05DEU386080 F05LAW386030 W05LYS386170 |
| 32580122 - Bovenschelde; Bossuit | F06BOS325001: | F06BOS325000 F06ERC325030 W06BOS325095 F06BOS325015 F06HOG325070 W06BOS325105 F06BOS325016 F06RHO325060 W06BOS325115 F06BOS325017 F06SCA325020 W06HAI325080 F06BOS325018 F06SCA325025 W06HAI325085 F06BOS325019 F06SEL325040 W06HAI325090 F06ECA325050 F06SEN325010 |

2.3 Ungauged catchments

The NAM parameters for the ungauged catchments in the modelled area, are inherited from neighboring gauged catchments. The link between the ungauged and the corresponding gauged catchment is made based on the catchment characteristics (soil, slope, concentration time, land use).

3 Input data preprocessing

3.1 Thiessen polygon method

Interpolated precipitation was produced for each catchment according to the Thiessen polygon method, using Hydr@ (IMDC, 2010). Rainfall and evapotranspiration are interpolated using weights inversely proportional to the distance to the weather station, using measurements available for each time step. Because of the large scale and the long term nature of timeseries used in this study, a daily time step is used. For consistency reasons, calibration is also based on daily time series. Both meteorological and discharge time series are thus sampled at a daily time step.

3.2 Precipitation

Thiessen precipitation needed to be calculated for all delineated subcatchments (Section 2). Source data consists hereby of rainfall measurements from 1967 to 2013, spread over the entire model area and around. The Scheldt catchment extends over France, Flanders, Wallonia and the Netherlands. Precipitation data was thus gathered from instances in Belgium, Netherlands and France. For Belgium, precipitation data was gathered from KMI (The Royal Meteorological institute) and SPW (Public Services of Wallonia). For France, data was gathered from Météo France. Crosses on Figure 1 show used rainfall metering stations on and around the Scheldt basin (Météo France and KMI).

Since the previous NAM calibration study in Flanders (De Boeck et al. 2011), reliability of the rainfall interpolation was greatly increased for the French Leie and Bovenschelde (discussed in Michielsen et al., 2021). Due to additional data from the French weather stations, the amount of rain gauges for the the Bovenschelde and Leie (including the French part) increases to 46 rain gauges and 30 respectively (Table 3).

Table 3 – Number of rain gauges per hydrographic basin

| Hydrographic basin | Surface area (km ²) ² | Number of subcatchments (gauged and ungauged) | Number of rain gauges |
|--------------------|--|---|-----------------------|
| Benedenschelde | 1 704 | 24 | 21 |
| Bovenschelde | 5 947 | 33 | 46 |
| Brugse Polders | 1 046 | 24 | 13 |
| Demer | 2 334 | 36 | 29 |
| Dender | 1 384 | 17 | 17 |
| Dijle en Zenne | 2 450 | 49 | 37 |
| Gentse Kanalen | 917 | 29 | 11 |
| Ijzer | 1 046 | 18 | 9 |
| Leie | 3 886 | 39 | 30 |
| Nete | 1 673 | 20 | 24 |

² Bekkenbeheerplannen Vlaanderen (ANON., 2009)

3.3 Evapotranspiration

Whereas there is a lot of precipitation input data, it doesn't apply for evaporation data. Thiessen evaporation data is very scarce. As an example, for the entire period (from 1967-2013), there was only one active PE station in France, located in Langres, 10 km outside the southernmost part of the Scheldt basin. The evaporation per catchment was calculated based on interpolation of PE data which was already available from the Scheldt basin (a combination of Uccle and Herentals data). All interpolated evapotranspiration timeseries are practically identical because of their geographical proximity.

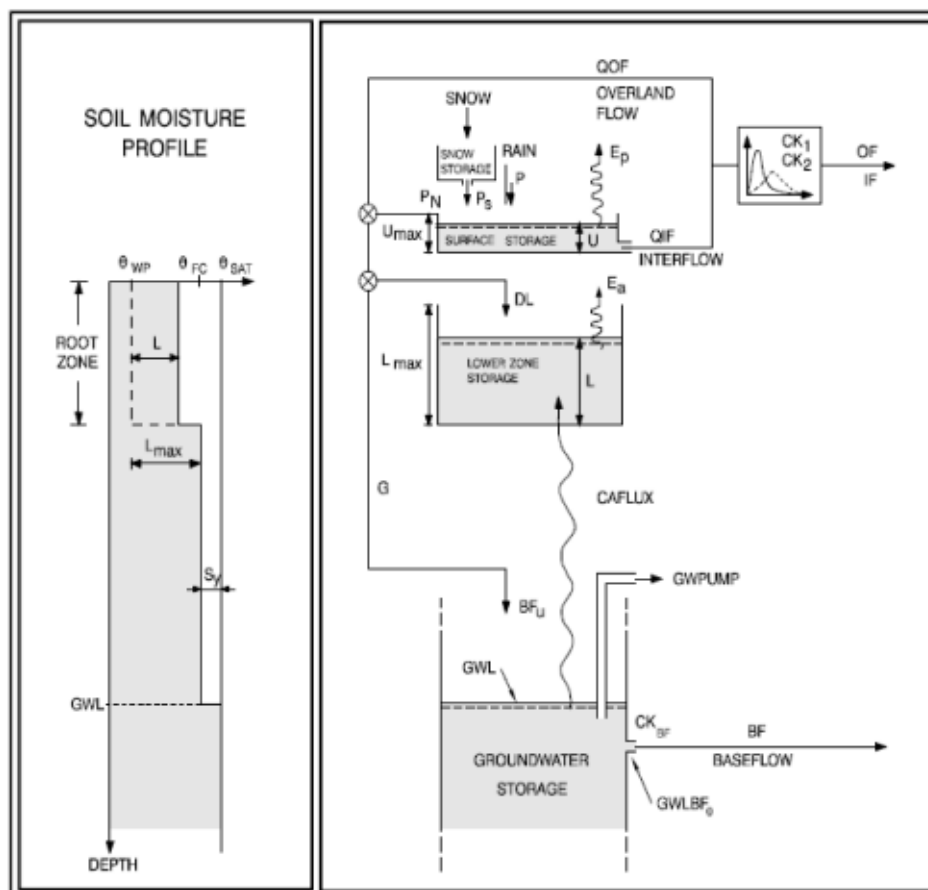
4 Rainfall-runoff modelling methodology

The hydrological model used which is investigated in this sub report is the conceptual rainfall-runoff NAM model. NAM is a rainfall-runoff lumped model structure developed by DHI as part of the MIKE 11 software package (DHI, 2009). For each catchment, discharge is simulated based on a unique set of parameters using interpolated rainfall and potential evapotranspiration timeseries as input. A description of NAM is outlined below.

4.1 Structure of the NAM hydrological model

The NAM model is a deterministic, lumped, conceptual rainfall-runoff model, simulating the overland-, inter and base-flow components as a function of the moisture contents in four storages. For this study, the snow module was not considered. NAM included three modelled storages: surface storage, lower storage or root zone, groundwater storage. Figure 4 below shows the general structure of the NAM model. The main components (reservoirs), state and flow variables, and parameters are represented. Being a lumped model, NAM treats each catchment as a single unit. The parameters and variables represent, therefore, average values for the entire catchment. For that reason, some of the parameters are related to physical processes but final values must be calibrated against hydrological time series. For more detail on the NAM model, please refer to DHI (2009).

Figure 2 – Structure of the NAM model (DHI, 2000)



4.2 NAM parameters description

Surface an root zone parameters

1. *Maximum water content in surface storage U_{max}*

U_{max} [mm] defines the maximum water content in the surface storage (interception, surface depression and uppermost soil). This maximum capacity has to be reached before any excess water occurs. The DHI manual indicate a typical range of 10-20 mm but some extend it to 5-35 (Madsen et al. 2000).

2. *Maximum water content in root zone storage L_{max}*

L_{max} [mm] defines the maximum water content in the lower or root zone storage. It can be interpreted as the maximum soil moisture content in the root zone available for the vegetative transpiration. Range is about 50-350 or even up to 500.

3. *Overland flow runoff coefficient CQOF*

CQOF [-] determines the extent to which excess rainfall runs off as overland flow and the magnitude of infiltration. It will be related to soil type and infiltration characteristics and also to some extent the recharge condition. Values of the range 0.01-0.90 have been experienced.

4. *Time constant for interflow CKIF*

CKIF [hours] determines, together with U_{max} , the amount of interflow. It is the dominant routing parameter of the interflow. Range is 500-1000 hours.

5. *Time constant for routing interflow and overland flow CK1 and CK2*

CK1,2 determines the shape of hydrograph peaks. Values depend on the size of the catchment and how fast it responds to rainfall. Typical values are in the range 3-48 hours but sometimes up to 72 (Madsen et al 2000).

6. *Root zone threshold value for overland flow TOF*

No overland flow is generated if the relative moisture content of the lower zone storage, L/L_{max} is less than TOF. For catchments with alternating dry and wet periods, the threshold values determine the onset of the flow components in the periods where the root zone is being filled up. Threshold values have no importance in wet periods. The significance of the threshold values vary from catchment to catchment. Values from 0 to 0.7 have been experienced.

7. *Root zone threshold value for interflow TIF*

TIF has the same function for interflow as TOF for overland flow. It is usually unimportant and can in most cases be set to zero.

Groundwater parameters

8. *Baseflow time constant CKBF*

CKBF [hours] determines the shape of the hydrograph in dry periods (exponential decay). It can be estimated from hydrograph recession analysis. CKBF values range from 500 to 5000 hours.

9. *Root zone threshold for groundwater recharge TG*

TG is similar to TOF for recharge. It is an important parameter for simulating the rise for the groundwater table in the beginning of a wet season.

5 Calibration strategy

5.1 Optimization algorithm

The algorithm used for optimization of NAM parameters is the Non-dominated Sorting Genetic Algorithm II or NSGA II³. This algorithm is suitable for optimization problems with multiple objective functions.

Variable values are generated in the first iteration. Each solution, that is to say an array of variable values, is called an *individual*. A *population* is a group of N solutions in each iteration. In the following iterations the created individuals are going to be “children” of the previous population, that is to say they are going to inherit “features” from couples of individuals chosen in the previous population according to specified selection and crossover techniques. The user can choose to randomly mutate the children features when an offspring is created.

The algorithm will then perform the *evaluation* of the solutions through the Pareto comparison, that is to say a solution dominates, or is better than, another solution if it is better than or equal to the other solution in all objectives and strictly better in at least one objective. A combined population R of parent and children population is formed; the individuals in it are sorted according to non-domination. Since all previous and current population members are included in R, the elitism is ensured. The best N solutions will be the population of the next iteration.

5.2 Objective function

Automatic calibration consists of optimizing (1) agreement between the average simulated and observed catchment runoff (overall volume error) and (2) overall agreement of the shape of the hydrograph. To assess these two aspects, evaluation is based on the following goodness-of-fit indexes:

1. Absolute error on cumulated total flow at each time step (to minimize), and
2. Logarithmic Nash-Sutcliffe efficiency (to maximize).

These two objectives are suited for NSGA-II optimization because they are contradictory for a number of model parameters. A reduced number of objectives (two) facilitates and fastens the algorithm convergence while ensuring good overall performance of the model. It is also important that these objectives be contradictory in order for the optimum to be well defined. There are generally trade-offs between performance for high and low flows. Therefore, final manual and visual checks will complete performance evaluation with possible focus on low or high flow.

The efficiency E proposed by Nash and Sutcliffe (1970) is defined as one minus the sum of the absolute squared differences between the predicted and observed values normalized by the variance of the observed values during the period under investigation. It is calculated as follows:

$$E = 1 - \frac{\sum_{i=1}^n (O_i - P_i)^2}{\sum_{i=1}^n (O_i - \bar{O})^2} \quad \text{Eq. 1}$$

with O observed and P predicted values.

³ Kalyanmoy Deb, Amrit Pratap, Sameer Agarwal, and T. Meyarivan. A Fast Elitist Multi-objective Genetic Algorithm: NSGA-II. IEEE Transactions on Evolutionary Computation, 6(2):182 - 197, April 2002.

To reduce the sensitivity to extreme values, the Nash-Sutcliffe efficiency E is also calculated with logarithmic values of O and P . Through logarithmic transformation of runoff values, the peaks are flattened and the low flows are kept more or less at the same level. As a result, the influence of low flow values is increased in comparison to the flood peaks, resulting in a higher sensitivity of log NSE to systematic model over- or underprediction (Krause et al. 2005).

The second objective of the algorithm is minimizing the absolute error on cumulated values at each time step (day). This ensures that the water balance remains satisfactory throughout the simulation (all years simulated).

The two goodness-of-fit statistics can be represented in 2 dimensions to represent the set of solutions evaluated by the algorithm. The best pairs constitute the Pareto front.

In order to select one single best solution, the two performance indexes were normalized (or rescaled) across the explored range (Eq. 2): with x_{min} set to zero for the absolute error, and x_{max} set to 1 for the logarithmic NSE.

$$x' = \frac{x - x_{min}}{x_{max} - x_{min}} \quad \text{Eq. 2}$$

This normalization resulted in values between 0 and 1 for the absolute error and between -1 and 1 for the NSE. The final solution was then selected among the final Pareto front, looking at the minimum Euclidian distance to theoretical optimum: log NSE = 1 and Absolute Error = 0 (Eq. 3).

$$d = \sqrt{(x_B - x_A)^2 + (y_B - y_A)^2} \quad \text{Eq. 3}$$

An example of Pareto front and final selection is shown in Figure 5 and Figure 6.

Figure 3 – All evaluated candidates (individuals) and final population of solutions (Pareto front)

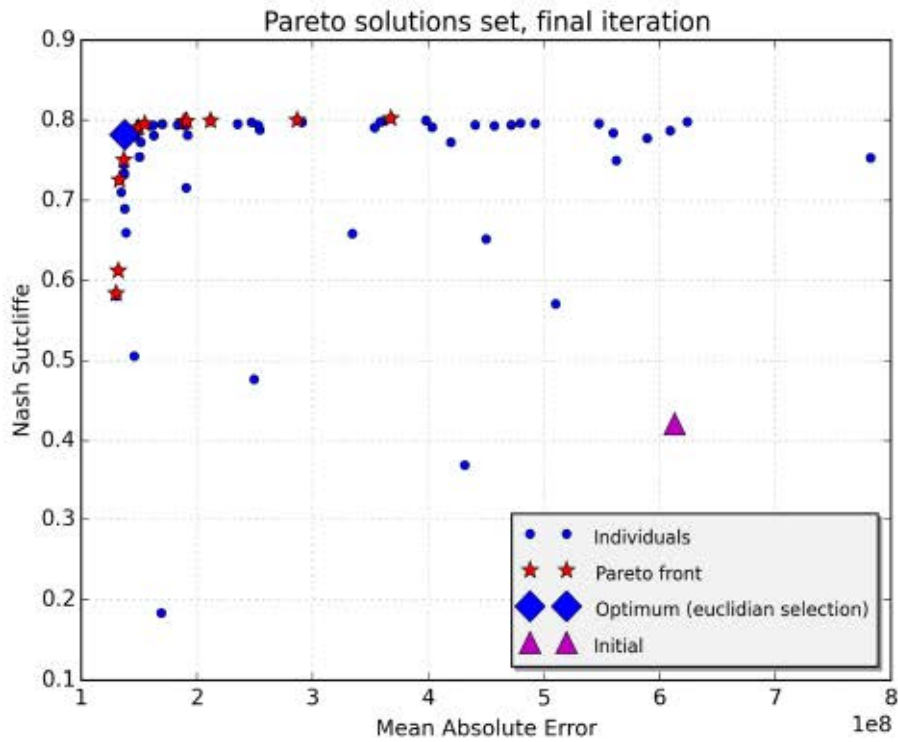
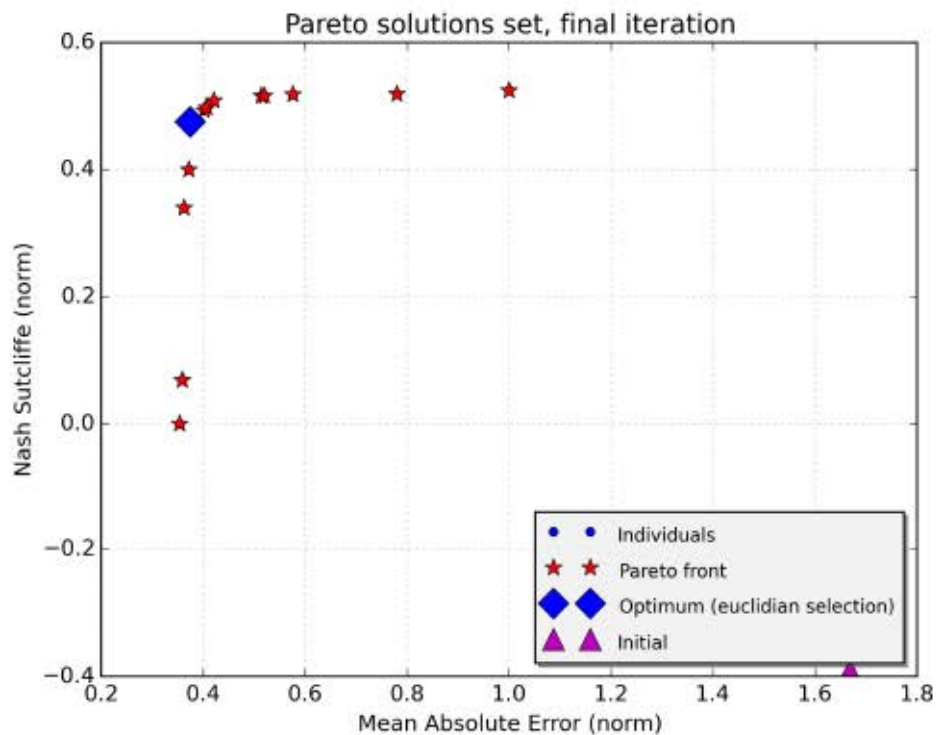


Figure 4 – Rescaled final population of solutions (Pareto front)



5.3 Implementation in Python

The Python version of the NSGA II algorithm was adapted for hydrological optimization purposes using a general framework supporting three rainfall-runoff models: NAM, PDM, VHM and WETSPA. Description of how the NAM model and the other lumped models are being implemented in Python can be found in Vansteenkiste et al. (2011) and Tran et al. (2014 a, b).

The calibration Python shell currently supports the following:

- Optimization of (one or all) model parameters for a given calibration period,
- Evaluation of model parameters for a given validation period,
- Plotting results of various alternative parameter sets on the same plot or separately (for example, the final population generated by the algorithm),
- Generating automatic reports of calibration and validation as Word document,
- Manual calibration for a given calibration period.

The first rainfall-runoff conceptual model used in this subtask is NAM. As a general rule, all ten parameters were optimized and explored parameter space was defined by boundaries in Table 4. These boundaries were assumed according to DHI recommendations and past experience with NAM (DHI, 2009; Madsen, 2000). In some particular cases, the optimum was not well defined or the algorithm could not converge in reasonable range and these boundaries were adjusted. Catchment surface area was considered reliable and was not optimized.

Whenever optimization was not delivering good results, boundaries were narrowed down using manual calibration.

Table 4 – NAM parameters and optimization boundaries

| Parameters | Umax | Lmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|----------------|------------|------|------|---------------|---------------|-----|-----|-----|-----|------|
| Lower boundary | 8 | 80 | 0,1 | 1000 (or 500) | 300 | 3 | 3 | 0,1 | 0,1 | 0,01 |
| Upper boundary | 35 (or 20) | 700 | 0,8 | 2000 | 800 (or 1000) | 72 | 72 | 0,9 | 0,9 | 0,9 |

6 NAM model calibration

6.1 Model configuration

In most cases and when data were available, a calibration period of 13 years was used, preferably from January 2001 to December 2013. Nevertheless, different time series were selected when available data were insufficient or unreliable, choosing 13 years of calibration if possible.

Four windows of typical events were selected for visual evaluation:

- 11/2002-04/2003 (high flow) – 6 months
- 06/2008-11/2008 (transition) – 6 months
- 02/2005-11/2005 (low flow) – 10 months
- 11/2010-04/2011 (recession) – 6 months

The calibrated parameters were validated for the entire time series of available data (also outside of the calibration period). Normally this period ranges from 1967 to 2013. Adjustments for a certain catchment are reported in the catchment-specific paragraphs below.

6.2 Model evaluation

While the optimization is limited to two objectives, logarithmic NSE and absolute error, it can be interesting to look at the other indexes listed when evaluating the final results. For example:

- Nash-Sutcliff efficiency
- Relative error (negative or positive) or bias
- Kling-Gupta efficiency (Gupta et al. 2009 and Kling et al. 2012)
- Relative Nash-Sutcliff efficiency

$$- E_{rel} = 1 - \frac{\sum_{i=1}^n \left(\frac{O_i - P_i}{O_i} \right)^2}{\sum_{i=1}^n \left(\frac{O_i - \hat{O}}{O_i} \right)^2} \quad \text{Eq. 4}$$

Since this work focuses on low flows, more importance is given to logarithmic NSE. However, high NSE values should also be sought in order to ensure good enough performance for higher flows as well, as much as possible.

An exact agreement between simulation and observations must not be expected because of different error sources (errors in meteorological input data, errors in measured discharge, errors inherent to the model structure). Calibration can only minimize those errors due to non-optimal parameter values.

NSE and logNSE values above 0.7 can be considered good. Values below zero mean that the predictive power of the model is worse than the measured average. Considering deviation of the measured discharge time series and errors in the meteorological inputs, NSE values are not expected to be above 0.8 (Willems, 2007).

Visual evaluation of the fit between simulated and observed total discharge is also taken into consideration to select the final solution, with a focus on good agreement of simulations for low flows. When useful, Nash-Sutcliffe efficiency (non-logarithmic) was also taken into account for evaluating the final set of candidates (when other fitness indexes were equivalent for example).

Apart from the calibration period, these goodness-of-fit statistics were calculated on the entire time series of available data (also outside of the calibration period) in order to validate calibrated parameters whenever more than 13 years of data was available.

The following section synthesizes the main results and conclusions of the NAM calibration in each river basin. Detailed graphs and calculated statistics, for calibration and validation periods, are given for each gauged catchments in Annex 3 to Annex 12.

The final sets of parameters for each calibrated NAM model and for each transposed NAM model are summarized in Annex 1.

6.3 IJzer basin

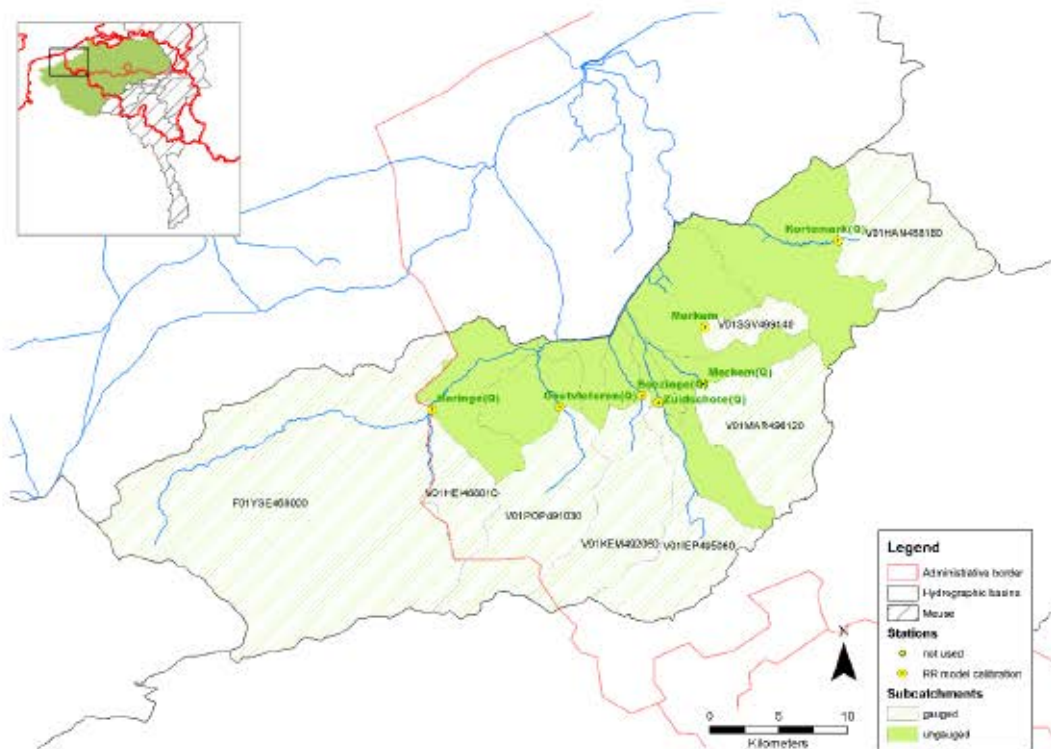
6.3.1 Context

Although there is no interaction between the Scheldt catchment and the IJzer catchment, the latter is included in the regional water allocation model for the sake of completeness.

The total surface area of the IJzer catchment is of 1 101 km² from which about one third is located in France (WL, 2006). This represents 1,6 % of the total study area (Scheldt basin + IJzer, excluding the Meuse). On the French side, the main tributaries are the Peene Becque, the Sale Becque and the Herzeele. In Flanders, the Poperingevaart, the Kemmelbeek, the Ieper-IJzer Canal with the Ieperlee and Martjensvaart, Stenensluisvaart, Houtensluisvaart and Handzamevaart are the main tributaries of the IJzer. Note that these tributaries are all discharging from the right bank of the IJzer River.

There are 8 gauged catchments in the IJzer catchment, covering 786 km² (70 % of the IJzer catchment area). Subcatchments V01HEI468010 and F01YSE468000 are located upstream of the gauging station in Roesbrugge. Figure 7 shows the catchments and corresponding measurement points.

Figure 5 – Catchments and flow metering station on the IJzer basin



6.3.2 Model performance

Table 5 and Table 6 present general performance statistics for the gauged subcatchments of the IJzer basin for the calibration and validation period. Graphs of simulations for the subcatchments V01HAN488180 (best model performance in this catchment) and V01IEP495080 (worst model performance in this catchment) are presented below (Figure 8 to Figure 15). For more detailed results on the remaining subcatchments is referred to Annex 3.

Values in Table 5 indicate a good agreement between the simulated and measured flow rates for the majority of the catchments, with overall NSE and LogNSE values higher than 0.6 and RelErr lower than ± 2 . Nevertheless, the results of the calibration and validation of subcatchment V01IEP495080 are not acceptable (Table 5 and Table 6). The low values of NSE and LogNSE are attributed to the complex hydrological situation of the catchment, which is influenced by the presence of structures and diversions. However visual inspection (Figure 11 to Figure 15) shows that the results are still acceptable. The catchment with code V01POP491030 presents an overestimation of discharge from 2009 (Figure 8 to Figure 11), although the general model performance for the entire validation period is adequate (Table 6).

Data remark: The period from 2001 to 2005 has been deleted from the calibration period for the catchment F01IJZ468000 due to unreliable high observed discharge values, resulting in a reduction of the calibration period to 9 years. The calibration period selected for the catchment with code V01IEP495080 is 1996-2008 since the discharge data from 2008 is not trustworthy. In the catchment V01SSV499140 there is not observe discharge from the beginning of the year 2009 and therefore the period 1996-2008 was taken as calibration period.

Table 5 – Overview of calibration results for gauged subcatchments in the IJzer basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|--|--|-------------------------|------|--------|------------|--------------------|
| 48810102 - Handzamevaart; Kortemark | V01HAN488180 | 78.6 | 0.79 | 0.78 | 0.3 | 2001-2013 |
| 46810102 - IJzer; Roesbrugge Haringe | F01IJZ468000 (V01HEI468010 and F01YSE468000) | 393.0 | 0.69 | 0.64 | -2.1 | 2005-2013 |
| 49510102 - Ieperlee; Zuidschote | V01IEP495080 | 63.4 | 0.50 | 0.44 | -0.6 | 1996-2008 |
| 49270102 - Kimmelbeek; Boezinge | V01KEM492060 | 73.9 | 0.63 | 0.52 | 1.2 | 2001-2013 |
| 49610102 - St. Jansbeek; Merkem | V01MAR496120 | 76.1 | 0.68 | 0.67 | 1.2 | 2001-2013 |
| 49110102- Poperingevaart; Oostvleteren | V01POP491030 | 84.9 | 0.65 | 0.42 | 5.8 | 2001-2013 |
| 49910102 - Steenbeek; Merkem | V01SSV499140 | 16.1 | 0.62 | 0.46 | 0.9 | 1996-2008 |

Table 6 – Overview of validation results for gauged subcatchments in the IJzer basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|---|--|-------------------------|------|--------|------------|-------------------|
| 48810102 - Handzamevaart; Kortemark | V01HAN488180 | 78.6 | 0.78 | 0.78 | -0.1 | 1994-2013 |
| 46810102 - IJzer; Roesbrugge Haringe | V01HEI468999 (V01HEI468010 and F01YSE468000) | 393.0 | 0.73 | 0.54 | 1.5 | 1987-2013 |
| 49510102 - Ieperlee; Zuidschote | V01IEP495080 | 63.4 | 0.47 | 0.48 | -11.1 | 1983-2013 |
| 49270102 - Kemmelbeek; Boezinge | V01KEM492060 | 73.9 | 0.64 | 0.57 | 9.3 | 1986-2013 |
| 49610102 - St. Jansbeek; Merkem | V01MAR496120 | 76.1 | 0.70 | 0.63 | 13.1 | 1986-2013 |
| 49110102 - Poperingevaart; Oostvleteren | V01POP491030 | 84.9 | 0.67 | 0.58 | -8.8 | 1984-2013 |
| 49910102 - Steenbeek; Merkem | V01SSV499140 | 16.1 | 0.62 | 0.40 | -16.8 | 1991-2008 |

48810102 - Handzamevaart; Kortemark (V01HAN488180)

Figure 6 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark (2001-2013)

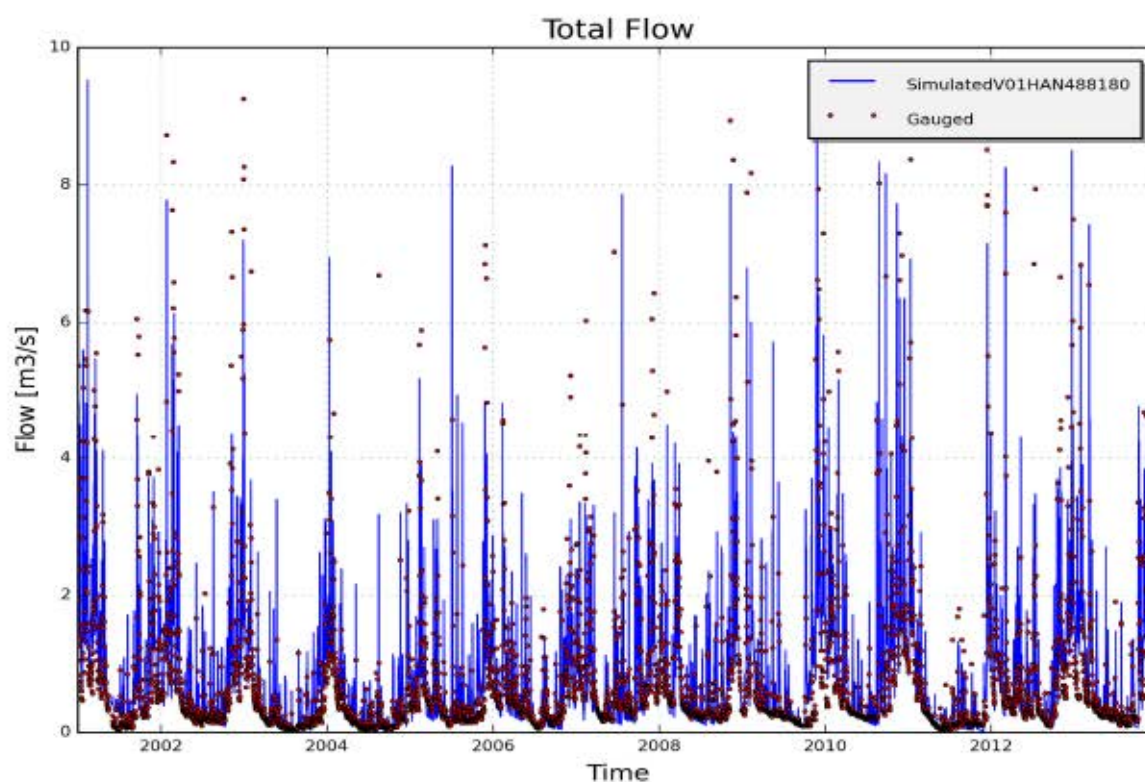


Figure 7 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark (2001-2013)

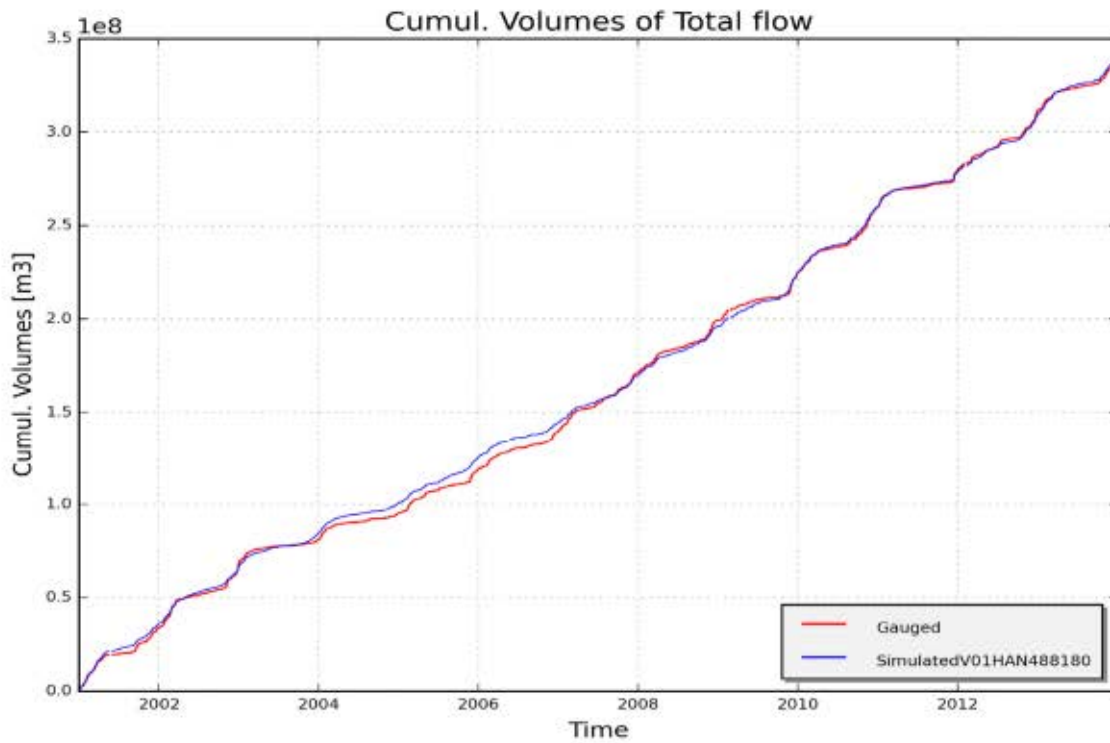
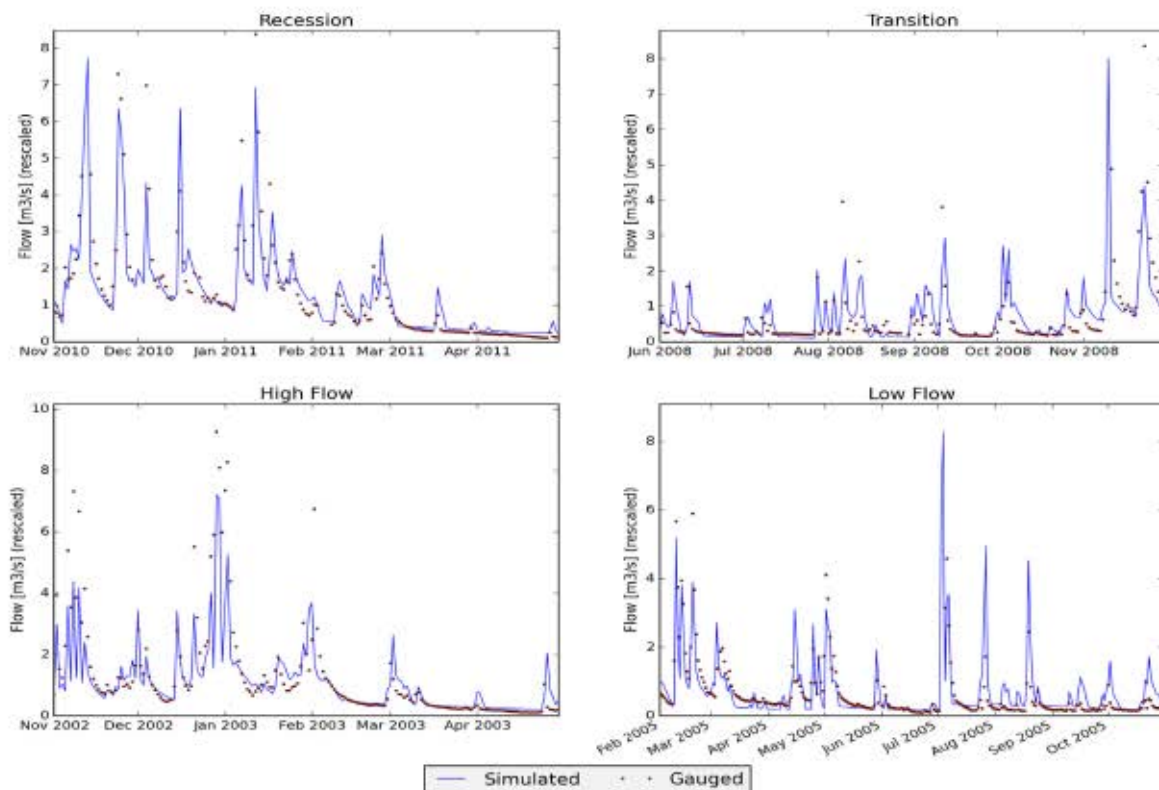


Figure 8 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Handzamevaart; Kortemark



49510102 - Ieperlee; Zuidschote (V01IEP495080)

Figure 9 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote(1996-2008)

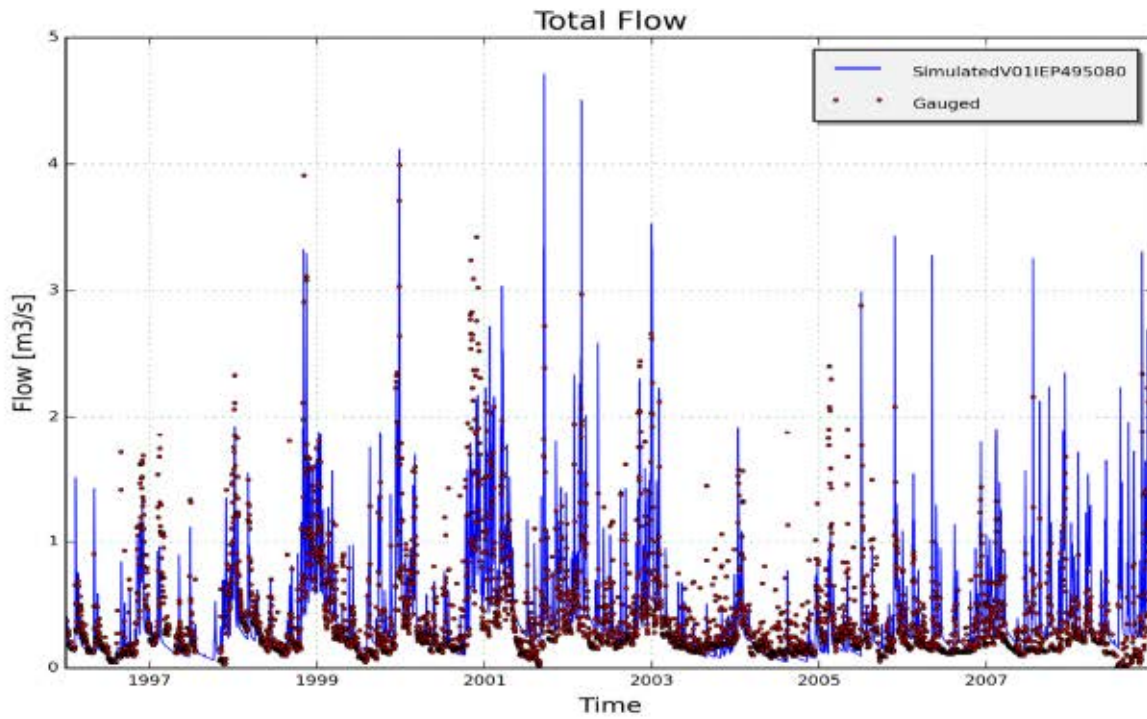


Figure 10 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

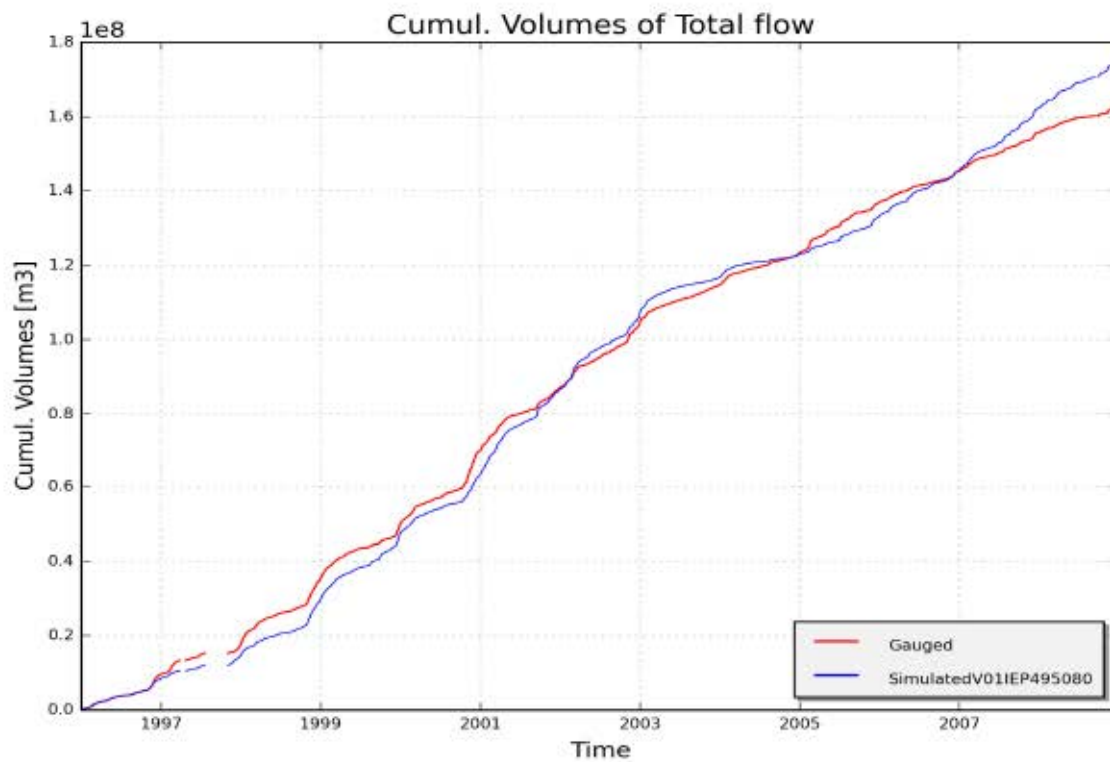


Figure 11 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee, Zuidschote

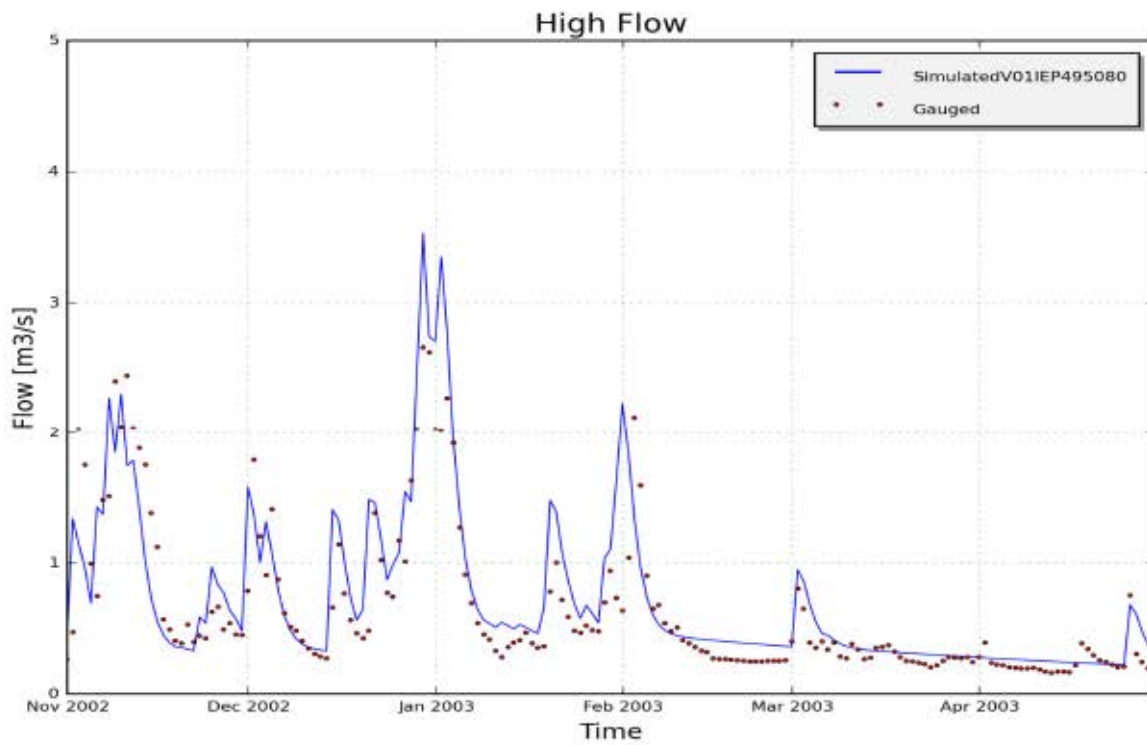


Figure 12 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee, Zuidschote

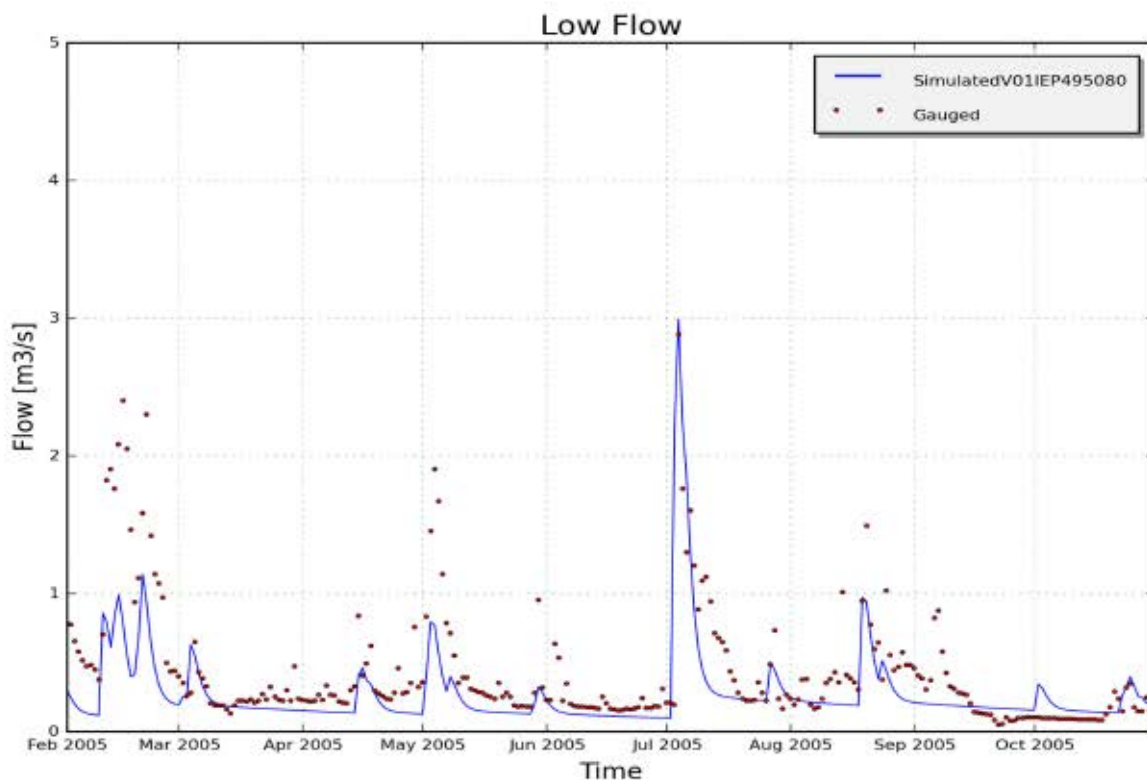
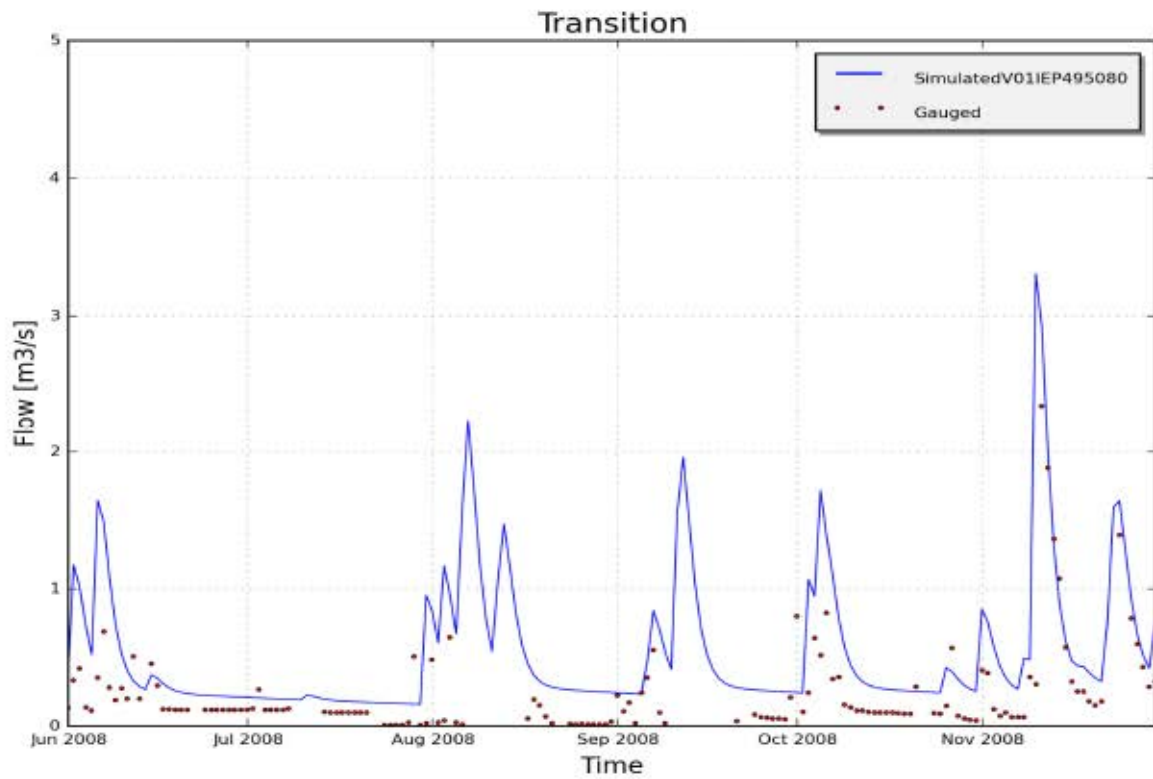


Figure 13 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V011EP495080, station 49510102 - Ieperlee, Zuidschote



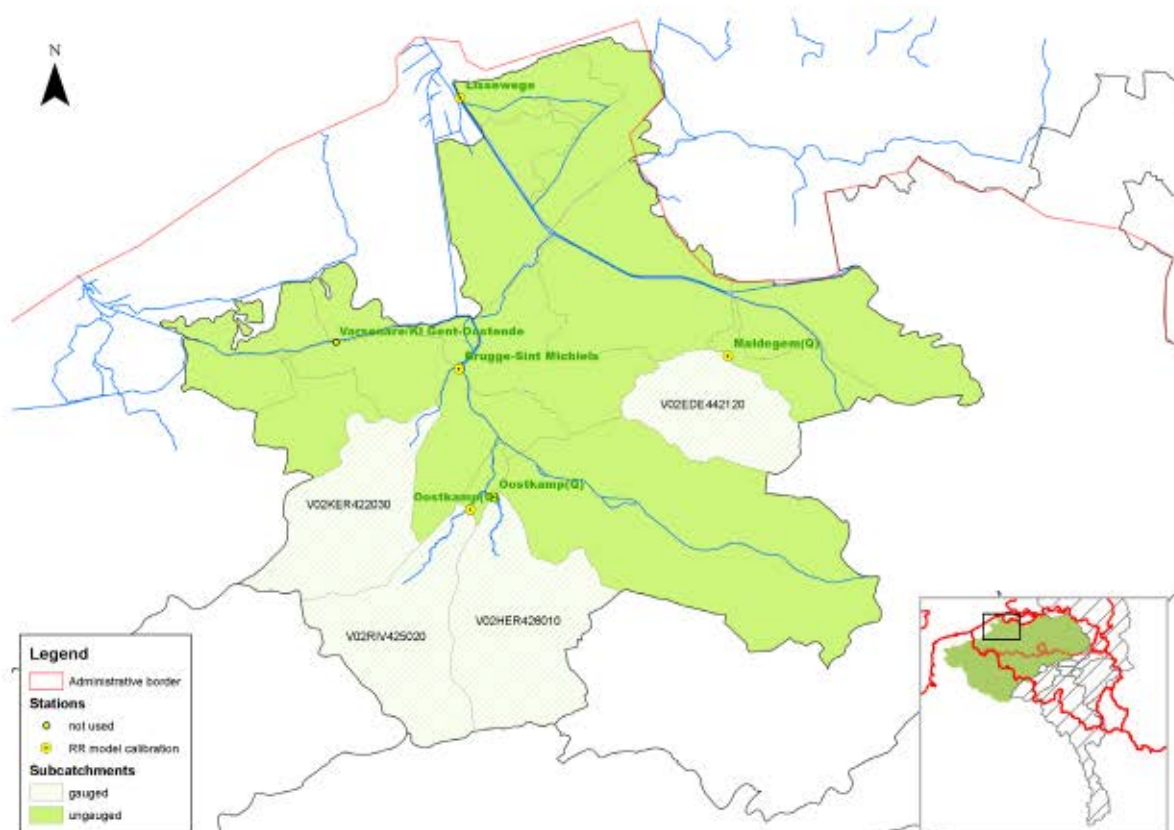
6.4 Brugse Polders

6.4.1 Context

The catchment of the Brugse Polders has an area of 1046 km², which is 4 % of the total area of subcatchments within the water allocation model. The Brugse Polders catchment is limited by the North Sea in the North and by the Dutch border in the Northeast. The main rivers of the basin are the canal connecting Gent and Oostende (Kanaal Gent-Oostende), the deviation canal (Afleidingskanaal) of the Leie and the Leopold canal. These artificial canals conduct water from the Leie catchment towards the sea. Additionally, several local polder water courses flow into these canals (De Boeck et al. 2011).

In the Brugse Polders, four gauged catchments account for 29 % of the total surface area (Figure 16).

Figure 14 – Subcatchments and measurement points in the catchment of the Brugse Polders



6.4.2 Model performance

Table 7 and Table 8 present general performance statistics for the gauged catchments of the Brugse Polders for the calibration and validation period. Graphs of simulations of the subcatchment V02EDE442120 (best performance) and V02RIV425020 (worst performance) are presented below (Figure 17 to Figure 22): Structure of the NAM model (DHI, 2000). For more detailed results on the other catchments, see Annex 4.

All the catchments show a sufficient model performance, although there is a general tendency to overestimation of the low flows. For instance, the flow is overestimated in the catchment V02HER426010 at the end of the year 2004 and at the end of 2007. V02KER422030 shows similar behavior.

Data remark: V02KER422030 does not have data after 2007, consequently the period 1995-2007 was selected for the calibration.

Table 7 – Overview of calibration results for gauged catchments on the Brugse Polders

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|-------------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 44210102 - Maldegem | V02EDE442120 | 45.5 | 0.81 | 0.55 | 1.4 | 2001-2013 |
| 42610102 - Hertsbergebeek; Oostkamp | V02HER426010 | 77.3 | 0.68 | 0.61 | 0.1 | 2001-2013 |
| 4220102 - Kerkebeek, Sint-Michiels | V02KER422030 | 62.7 | 0.61 | 0.66 | 0.7 | 1995-2007 |
| 42510102- Rivierbeek; Oostkamp | V02RIV425020 | 64.0 | 0.60 | 0.63 | -1.8 | 2001-2013 |

Table 8 – Overview of validation results for gauged catchments on the Brugse Polders

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|-------------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 44210102 - Maldegem | V02EDE442120 | 45.5 | 0.78 | 0.42 | -2.3 | 1984-2013 |
| 42610102 - Hertsbergebeek; Oostkamp | V02HER426010 | 77.3 | 0.71 | 0.56 | -5.3 | 1987-2013 |
| 4220102 - Kerkebeek, Sint-Michiels | V02KER422030 | 62.7 | 0.67 | 0.67 | -5.0 | 1984-2007 |
| 42510102- Rivierbeek; Oostkamp | V02RIV425020 | 64.0 | 0.60 | 0.58 | -7.0 | 1984-2013 |

44210102 – Maldegem (V02EDE442120)

Figure 15 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem(2001-2013)

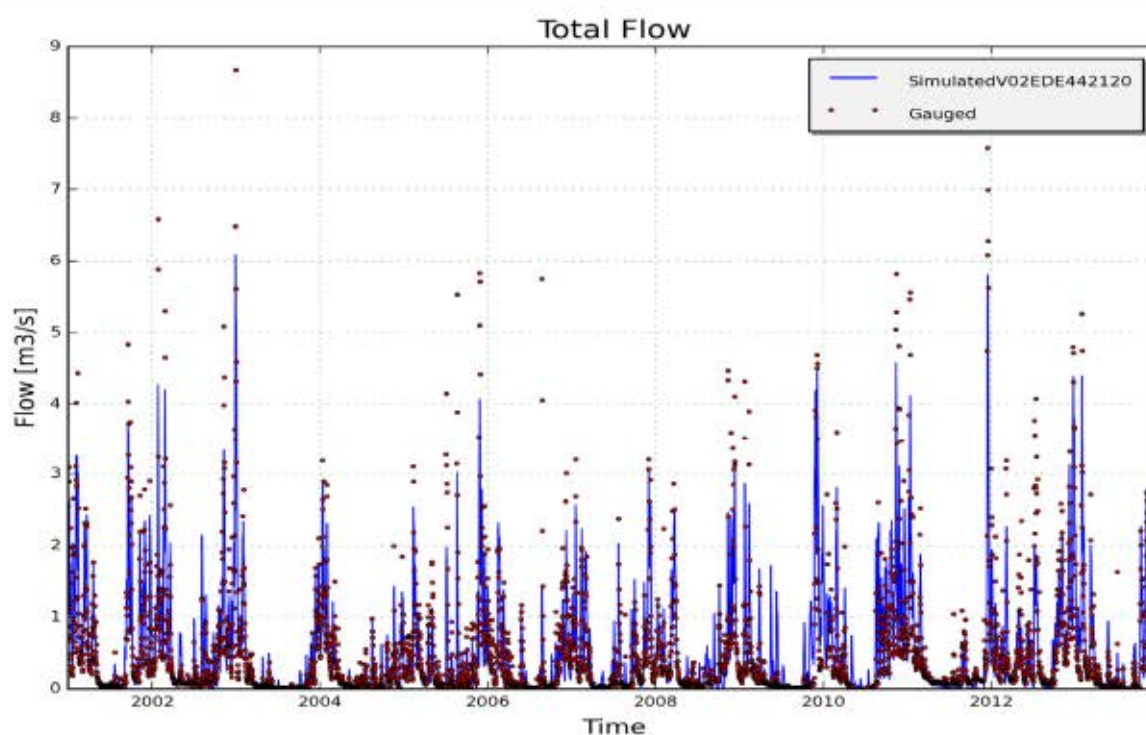


Figure 16 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02EDE442120, station 44210102 - Maldegem (2001-2013)

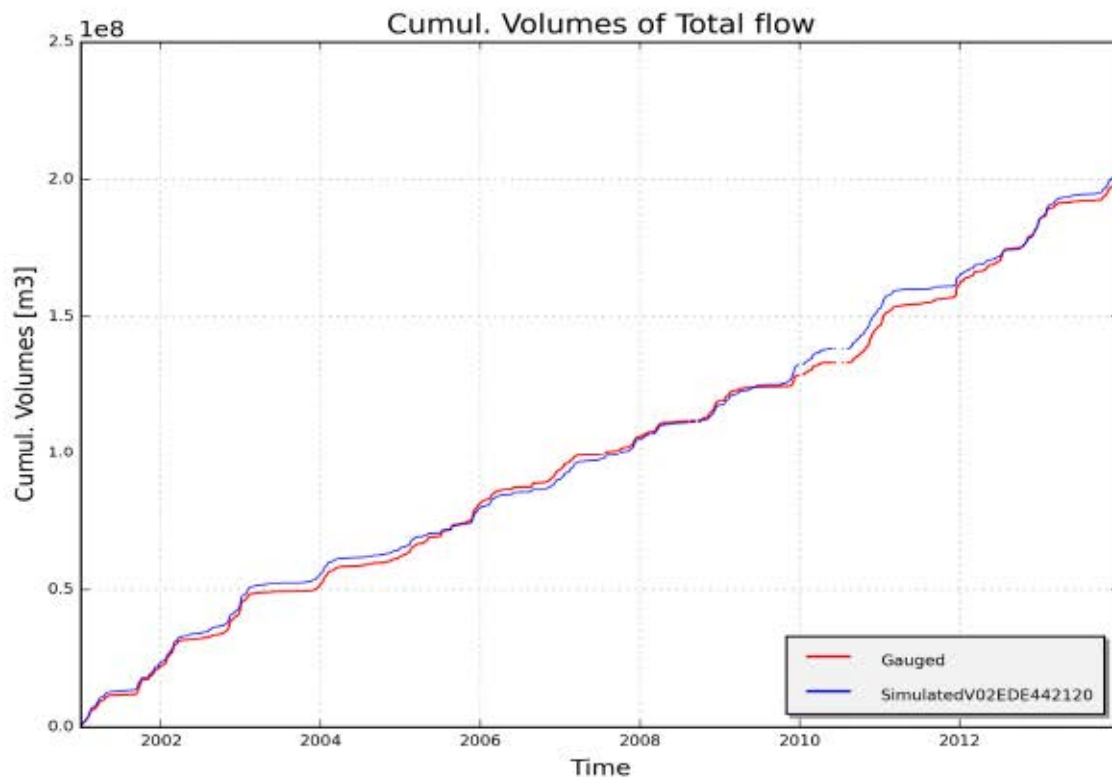
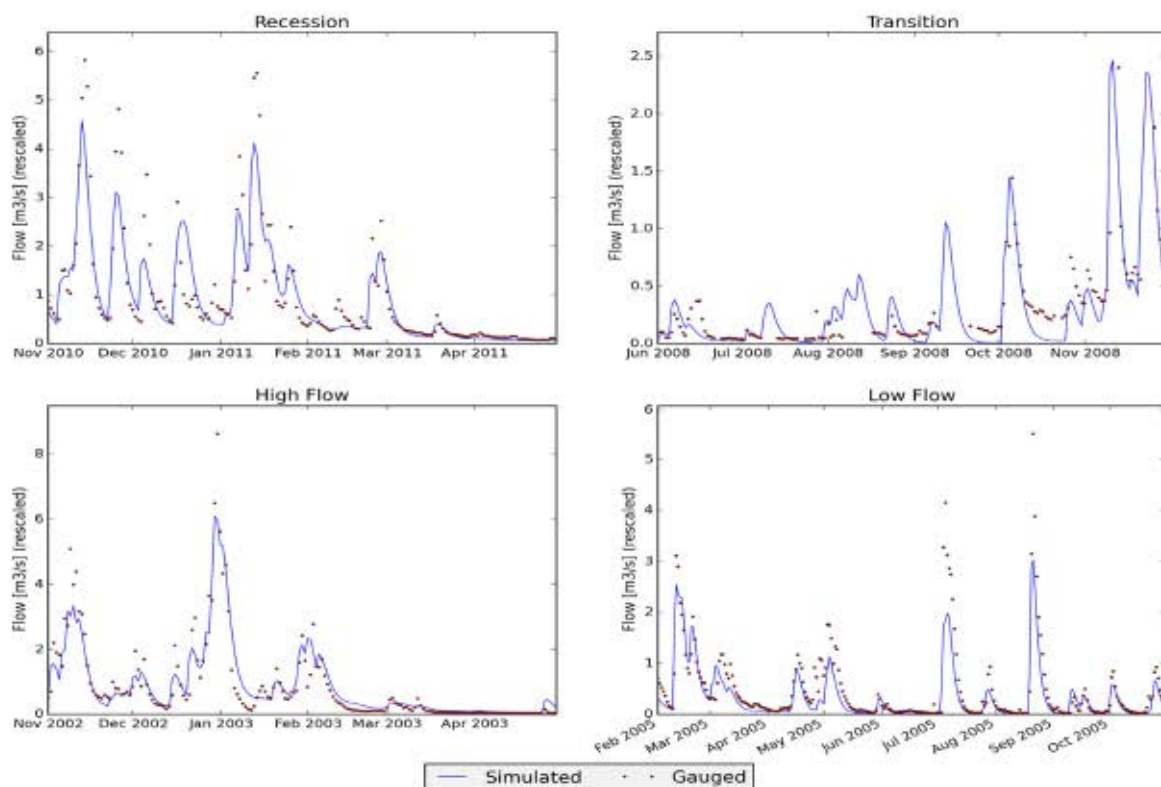


Figure 17 – Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 – Maldegem



6.4.2.1 42510102 - Rivierbeek; Oostkamp (V02RIV425020)

Figure 18 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (2001-2013)

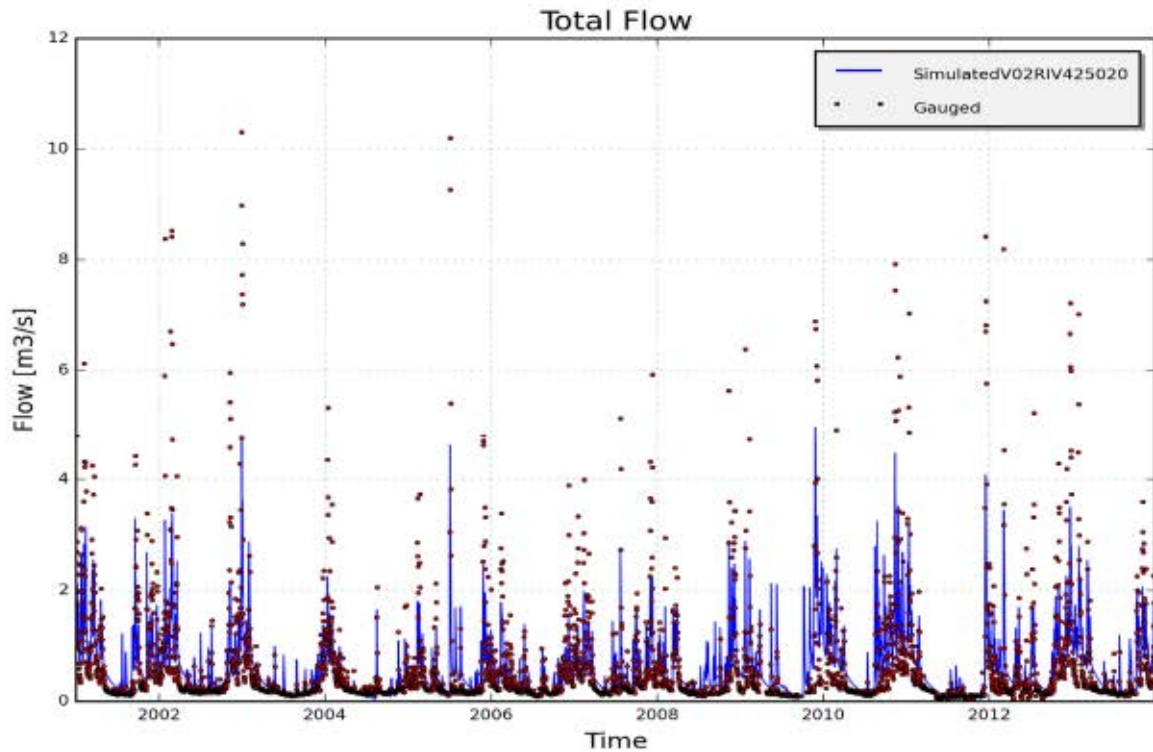


Figure 19 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (2001-2013)

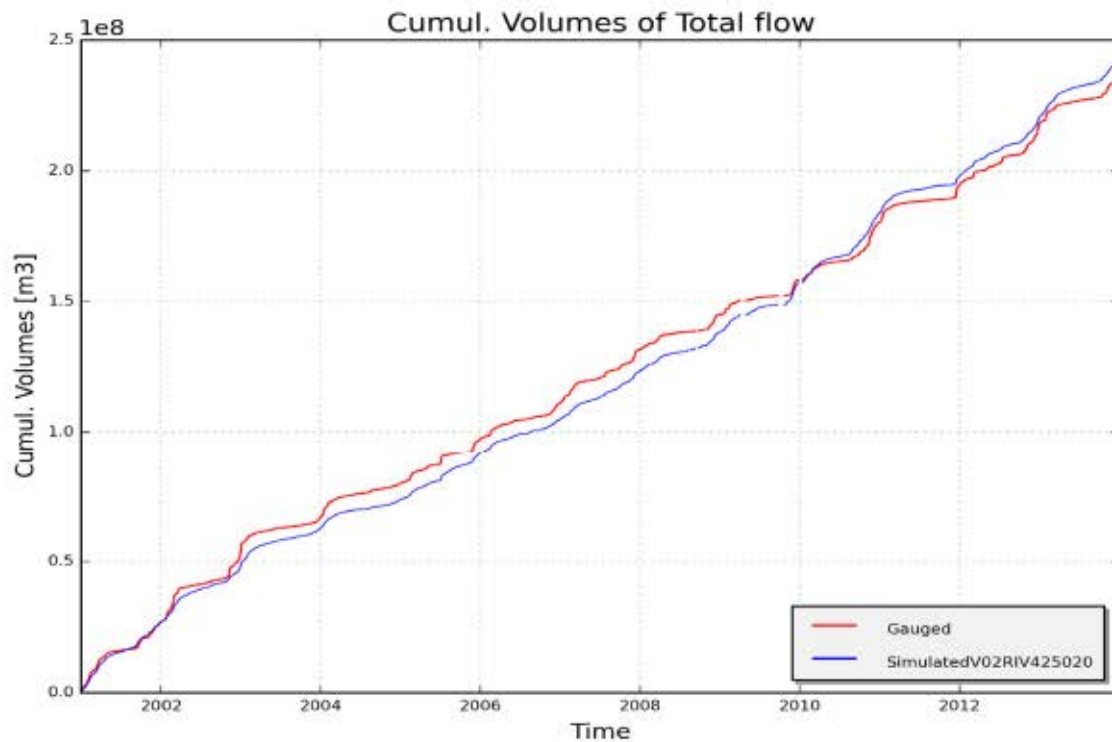
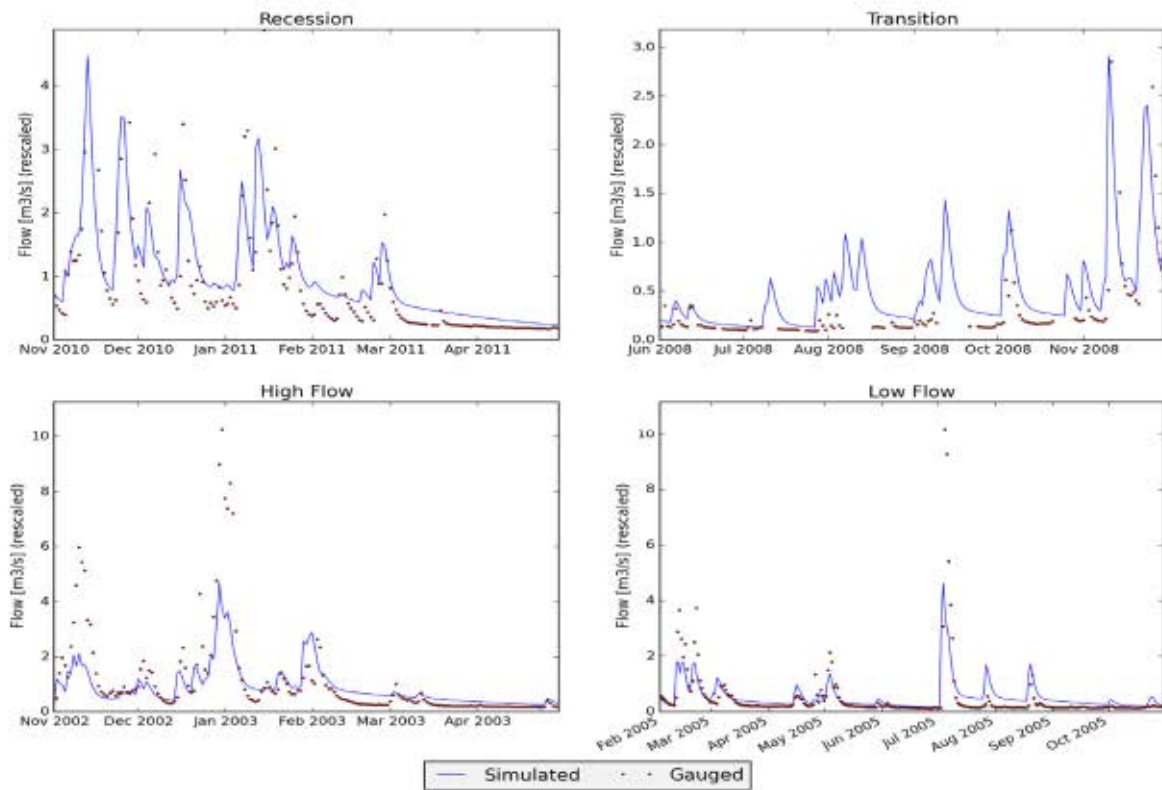


Figure 20 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp



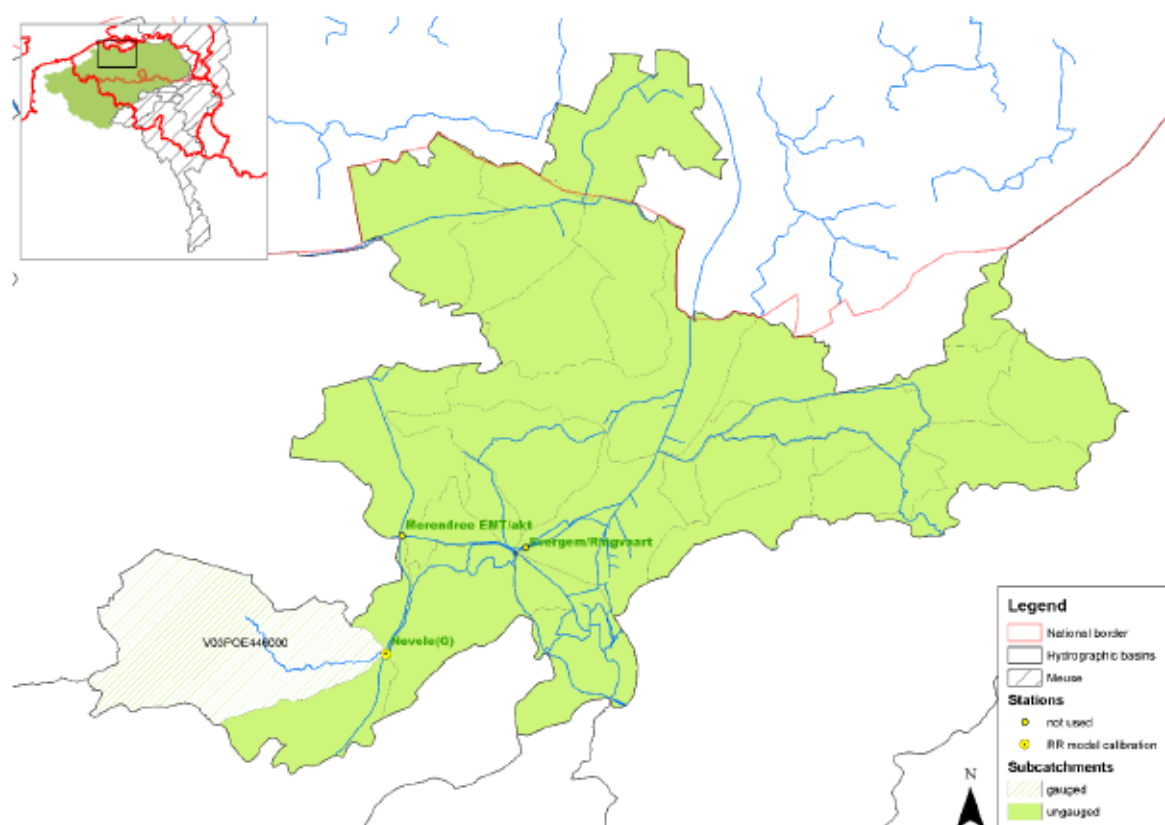
6.5 Gentse Kanalen

6.5.1 Context

The Gentse Kanalen catchment, covers a cluster of canals and their respective catchments and has a surface area of 917 km² (De Boeck 2011). The catchment represents 4 % of the total model area of the water allocation model. The Gentse Kanalen basin is limited West by the Brugse Polders, East by the Benedenschelde and South by the Leie catchment. The Dutch border stands in the North of the basin. Both the Leopold canal and the Gent-Terneuzen canal discharge into the Westerschelde (Western Scheldt) in the Netherlands.

There is only one gauged catchment within the basin of the Gentse Kanalen: 44656122 on the Poekebeek in Nevele. During the previous study the discharge at the Molenbeek in Puivelde was checked, based on project specific discharge data of the Sigmaplan update project (De Boeck et al., 2011). This station is not a permanent discharge station and consequently no new calibration is possible for this subcatchment. Catchments and measurement points are shown on the map in Figure 23. The gauged and recalibrated area of the basin amounts for 12 % of the total surface area of the basin.

Figure 21 – Subcatchments and measurement points on the Gentse Kanalen catchment



6.5.2 Model performance

Table 9 and Table 10 present general performance statistics for the gauged subcatchments of the Gentse Kanalen catchment for the validation and calibration period. The subcatchment shows a correct performance for the validation and calibration period with values of NSE and LogNSE above 0.7. Graphs of the simulation

of the subcatchment V03POE446000 are presented below (Figure 24 and Figure 25). For more detailed results on the other catchments is referred to Annex 5.

Data remark: the subcatchment V03POE446000 does not have data from 18/01/2001 to 29/11/2004 and after 2009. Longer calibration period was chosen in order to have 13 years of calibration.

Table 9 – Overview of calibration results for gauged catchments on the Gentse Kanalen

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 44656122 - Poekebeek; Nevele | V03POE446000 | 106.8 | 0.72 | 0.70 | -0.9 | 1993-2010 |

Table 10 – Overview of validation results for gauged catchments on the Gentse Kanalen

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Gauged years |
|------------------------------|----------------|-------------------------|------|--------|------------|--------------|
| 44656122 - Poekebeek; Nevele | V03POE446000 | 106.8 | 0.71 | 0.73 | 11.5 | 1983-2010 |

44656122 - Poekebeek; Nevele (V03POE446000)

Figure 22 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele(calibration period)

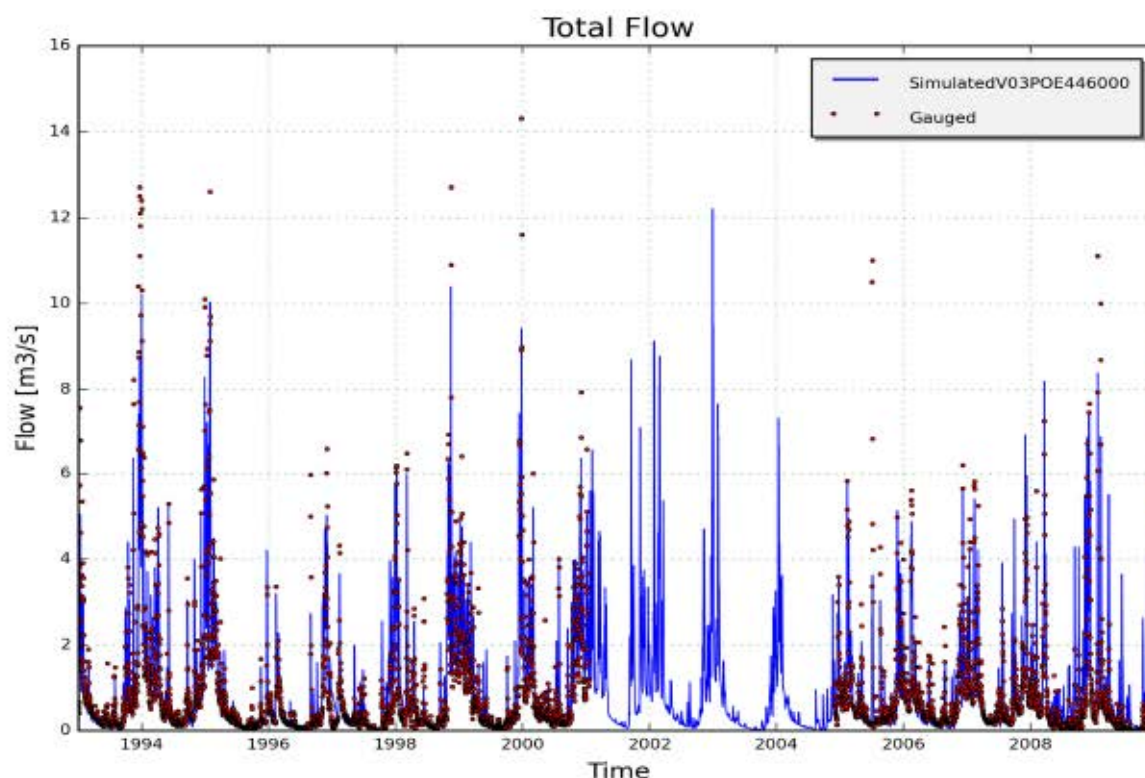
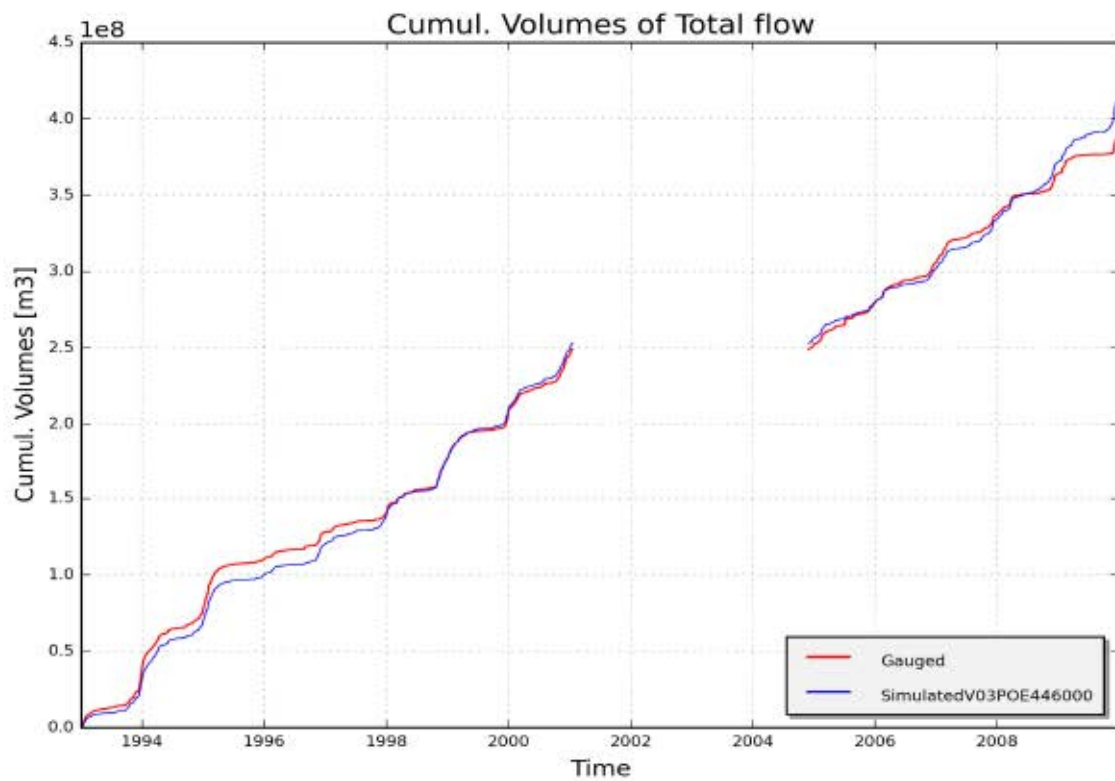


Figure 23 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (calibration period)



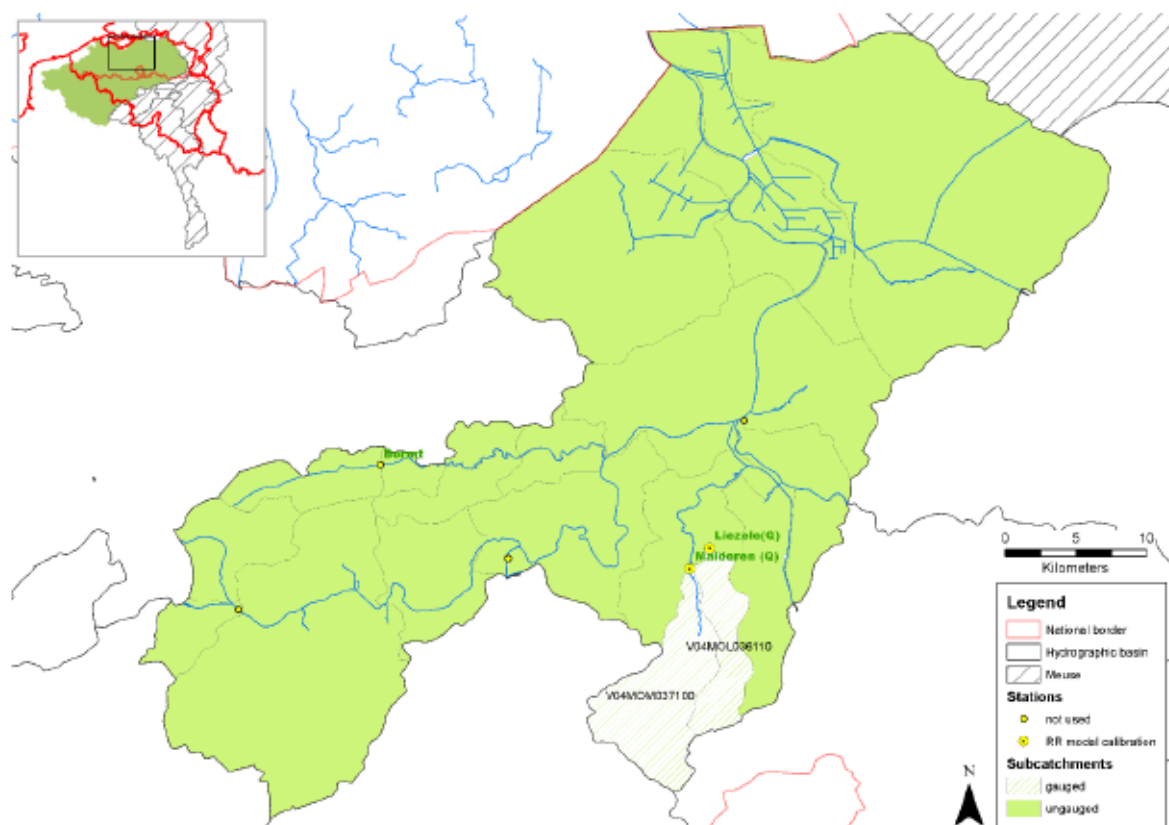
6.6 Benedenschelde

6.6.1 Context

The catchment of the Benedenschelde is 1 704 km² and belongs to the main Scheldt catchment. It covers the Flemish part of the tidal rivers in the Scheldt estuary, except the catchments corresponding to the main tributaries in this reach (Nete, Demer, Dijle, Zenne and Dender). The Benedenschelde catchment accounts for 8 % of the total catchment of the study area.

About 6 % of the surface area of the basin is gauged. During the previous study the discharge at the Ledebek in Borcht was checked, based on project specific discharge data of the Sigmaphan update project (De Boeck et al., 2011). This station is not a permanent discharge station and consequently no new calibration is possible for this subcatchment.

Figure 24 – Subcatchments and measurement points on the Benedenschelde catchment



6.6.2 Model performance

Table 11 and Table 12 present general performance statistics for the gauged catchments of the Benedenschelde basin for the calibration and validation period. Graphs of simulation of the catchments V04MOM037100 (best model performance) and V04MOL036110 (worst model performance) are presented below (Figure 27 to Figure 32). For more detailed results on the other catchments, see Annex 6.

The two catchments show a good model performance for the calibration and validation period, especially for low flows. NSE and LogNSE values are around 0.7, except the NSE in the catchment V04MOL036110, attributed to the underestimation of high peaks (Figure 30).

Table 11 – Overview of calibration results for gauged catchments on the Benedenscheide basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr(%) | Calibration period |
|-------------------------------------|----------------|-------------------------|------|--------|-----------|--------------------|
| 3610102 - Kleine Molenbeek, Liezele | V04MOL036110 | 32.6 | 0.58 | 0.67 | 1.3 | 2001-2013 |
| 3710102 - Grote Molenbeek, Malderen | V04MOM037100 | 67.3 | 0.76 | 0.73 | 1.3 | 2001-2013 |

Table 12 – Overview of validation results for gauged catchments on the Benedenscheide basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr(%) | Validation period |
|-------------------------------------|----------------|-------------------------|------|--------|-----------|-------------------|
| 3610102 - Kleine Molenbeek, Liezele | V04MOL036110 | 32.6 | 0.65 | 0.60 | 12.8 | 1967-2013 |
| 3710102 - Grote Molenbeek, Malderen | V04MOM037100 | 67.3 | 0.74 | 0.67 | 13.0 | 1967-2013 |

3710102 - Grote Molenbeek, Malderen (V04MOM037100)

Figure 25 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen(2001-2013)

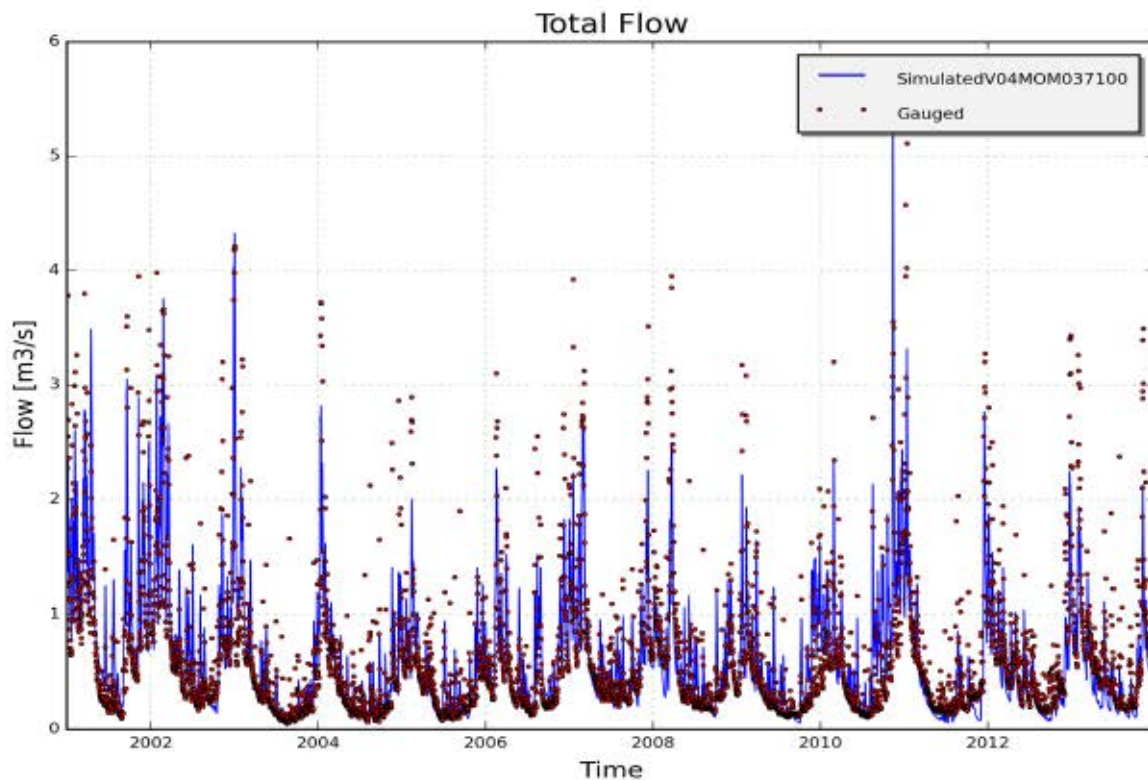


Figure 26 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (2001-2013)

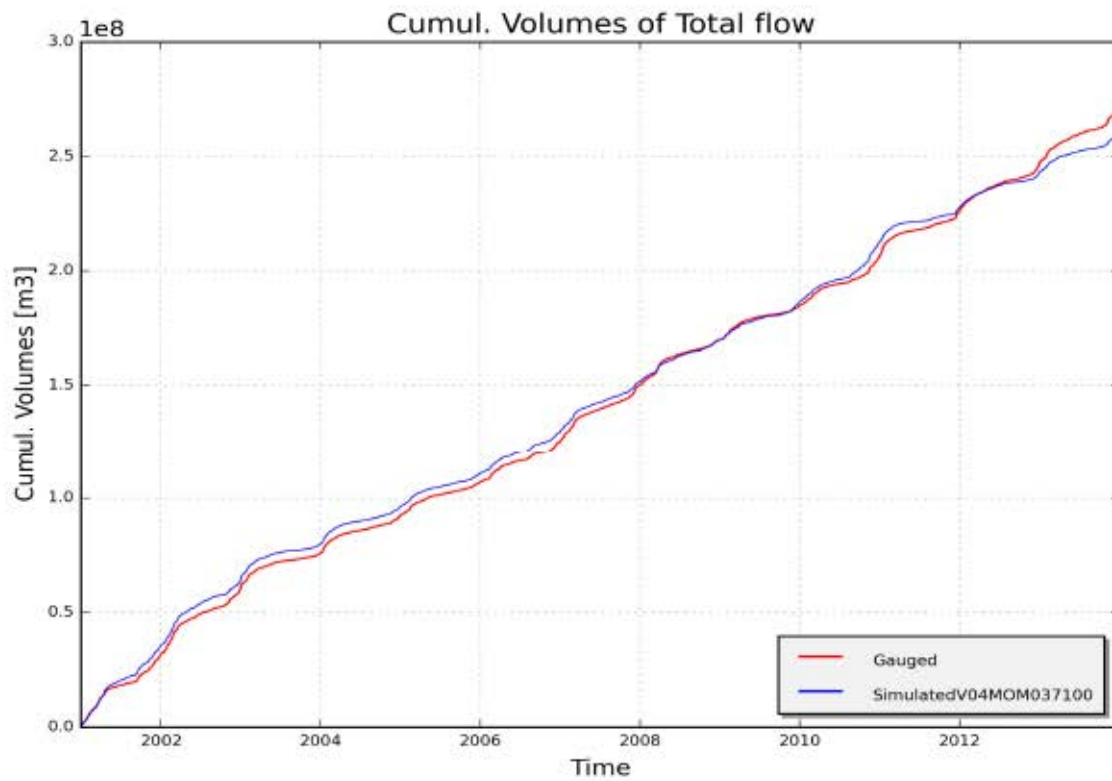
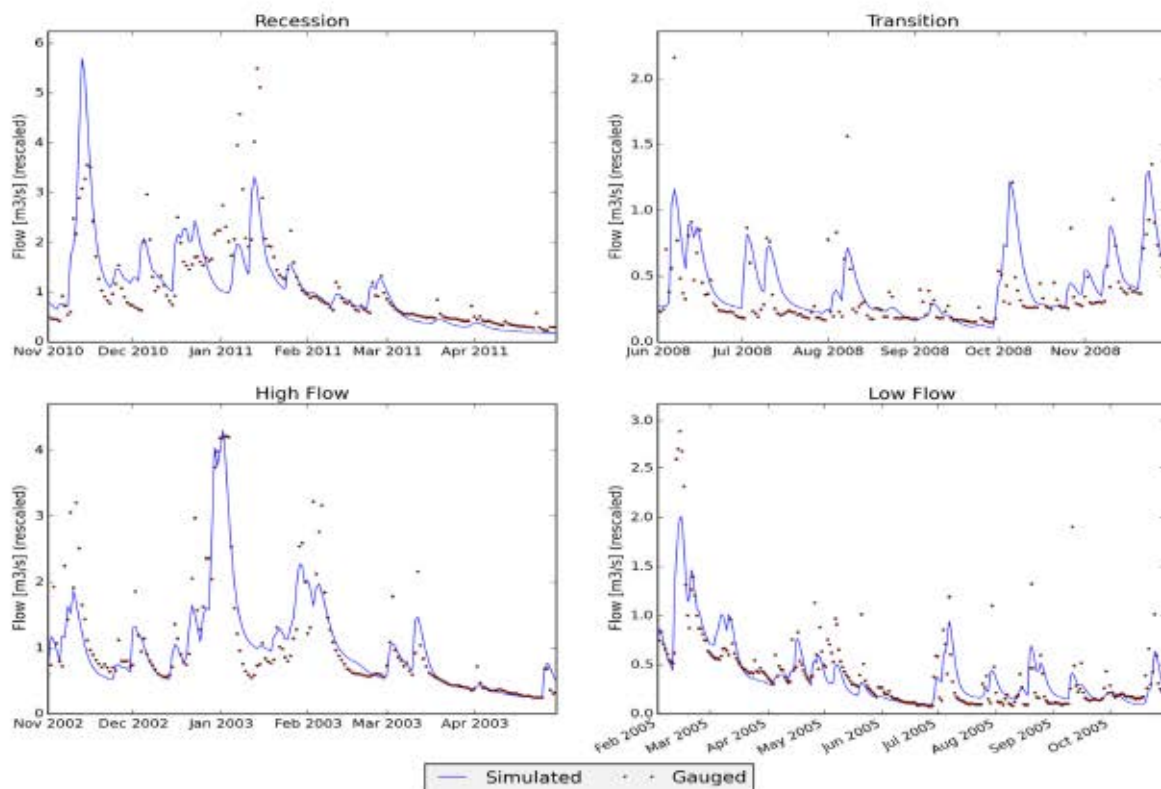


Figure 27 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen



3610102 - Kleine Molenbeek, Liezele (V04MOL036110)

Figure 28 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele(calibration period)

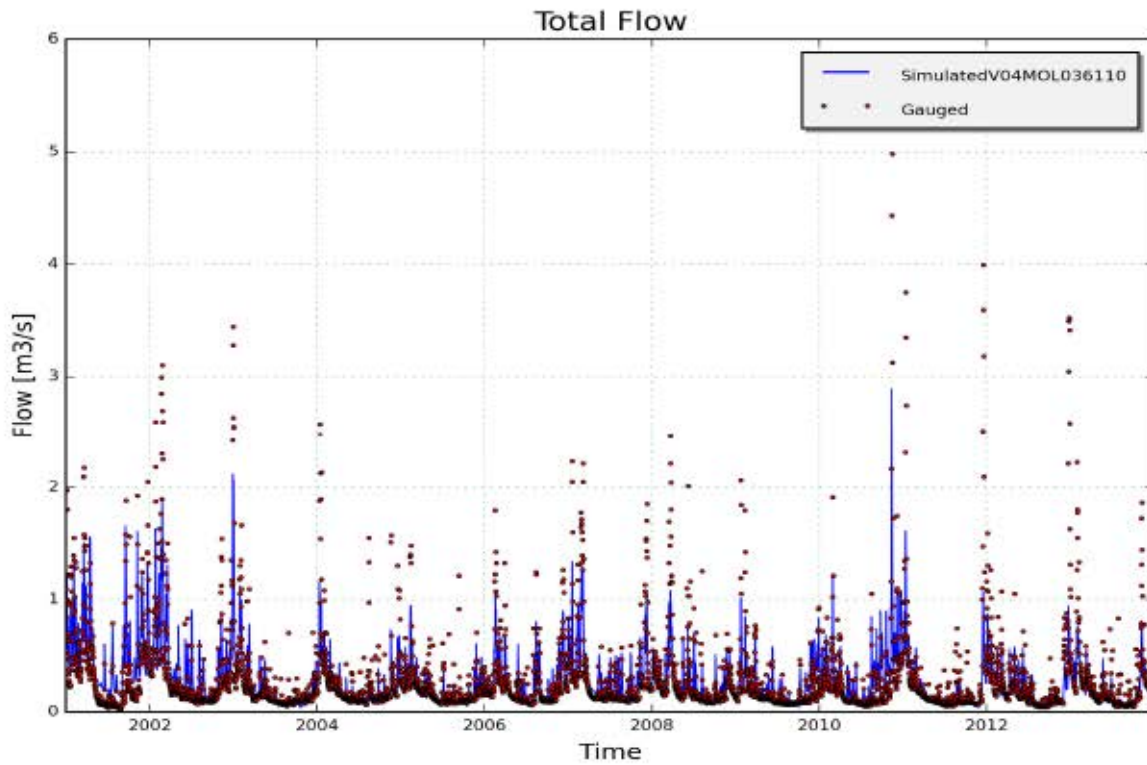


Figure 29 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (calibration period)

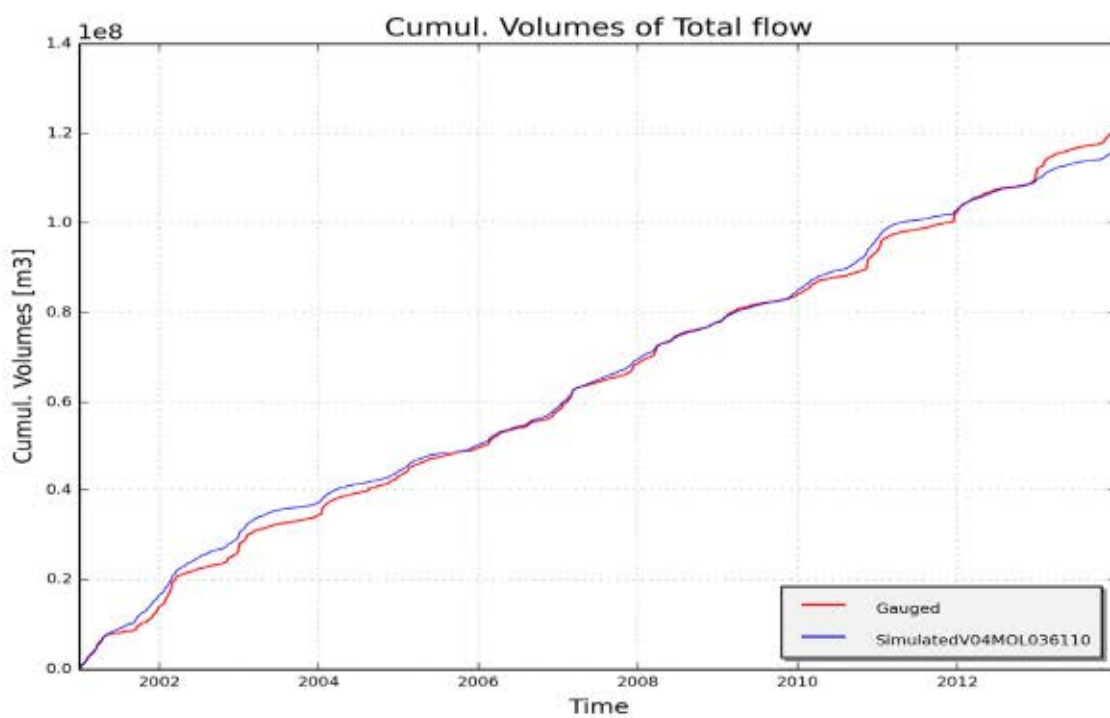
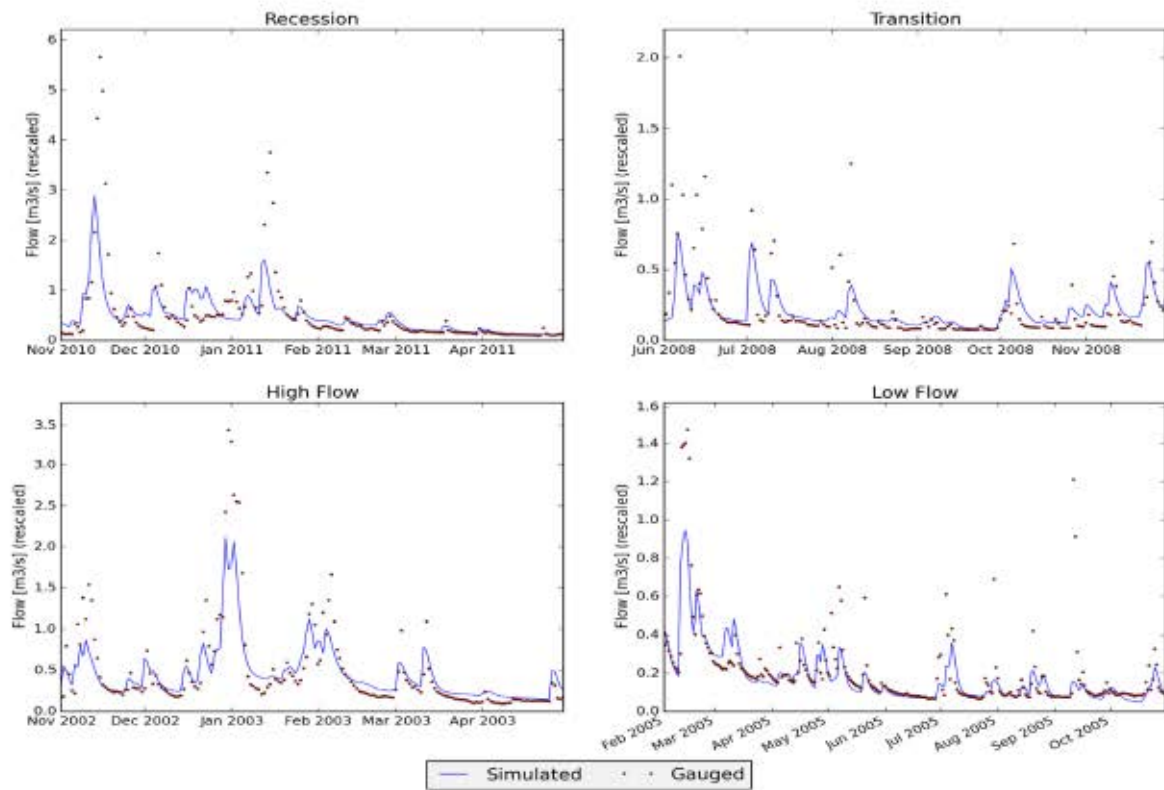


Figure 30 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele



6.7 Leie

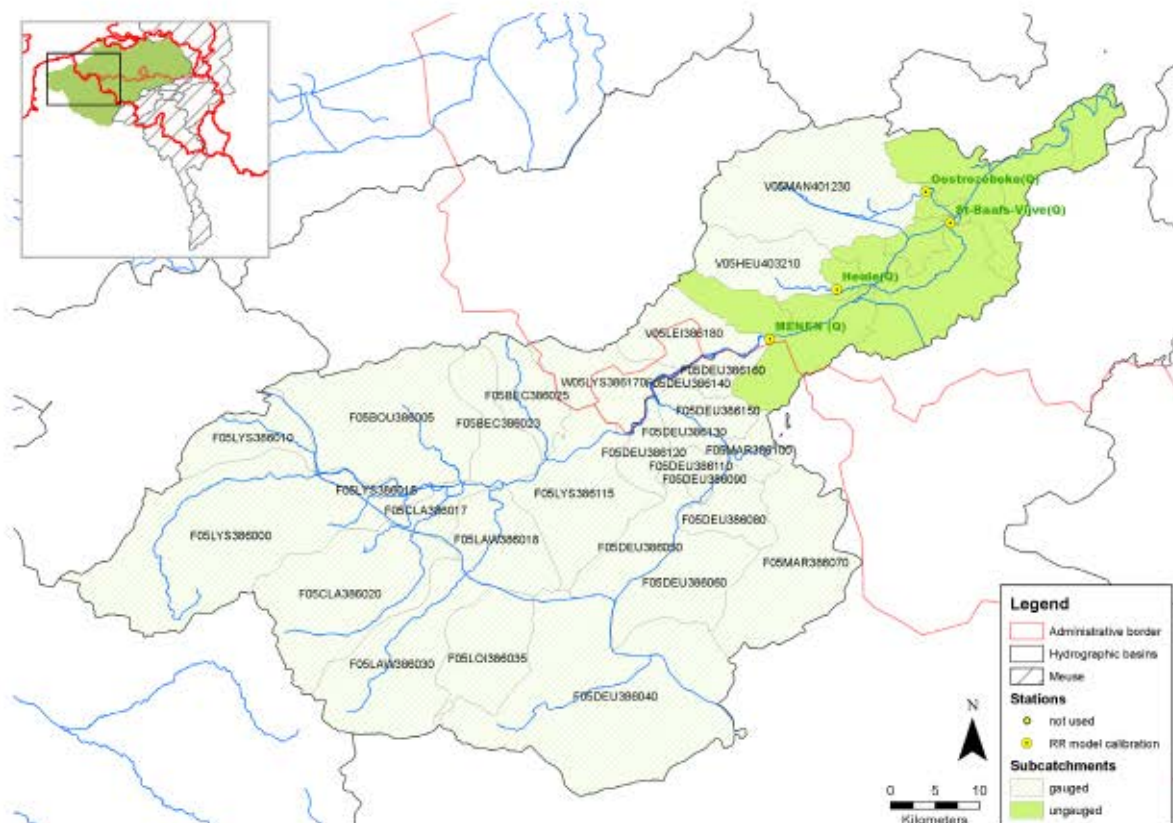
6.7.1 Context

The Leie catchment, being part of the international “Leie and Deûle” basin, has an area of 3 886 km² of which 982 km² is situated in Flanders. In Ghent, the Leie conflues with the Scheldt. The subcatchments of the Leie count for 18 % of the total study area.

In France, the Leie (or Lys in French) is connected to the Canal de Neufossé and the Canal d’Aire à la Bassée, both part of the canal system between Duinkerke and Denain. This canal constitutes the East-West link between the Scheldt, the Deûle, the Leie and the North Sea. The Dunkerque-Denain canal is supplied with water of the Schelde and its tributary, the Scarpe. Some of the water flowing from the Scheldt in the canal system, flows back to the Leie through the canalised Deûle. This interaction of rivers and canals leads to an enlarged complexity regarding the calibration of a hydrological model for this catchment.

Figure 33 shows the location of the flow gauges used for calibration of the NAM models on the Leie basin.

Figure 31 – Subcatchments and measurement points on the Leie catchment



The recalibration of the catchment upstream of the gauging station in Menen on the Leie (station 38680122), is done for this 1 big gauged subcatchment. However, the final runoff for the water allocation model is simulated separately for the 22 subcatchments separately, to be able to distribute the flow over the complex canal system described above.

With three gauging stations in Menen, Heule and Oostrozebeke, 85,6 % of the Leie basin is covered by discharge measurements.

6.7.2 Model performances

Table 13 and Table 14 present general performance statistics for the gauged catchments of the Leie basin for the calibration and validation period. Graphs of simulations for the catchments F05LEI386999 (best model performance) and V05MAN401230 (worst model performance) are presented below (Figure 34 to Figure 39). For more detailed results on the other catchments, see Annex 7. In paragraph 3.2 it was already mentioned that refinement of the precipitation data in the Leie catchment significantly improves the performance of the hydrological model for the catchment upstream Menen, compared to the first version of the water allocation model (see Michielsen et. al, 2021).

Adequate model performance was found for the catchments F05LEI386001 and V05HEU403210 for the calibration and validation period. The simulation of the catchment V05MAN401230 has a good correlation for the calibration period (2005-2008). However, according to the statistical (Table 14) and graphical results (Figure 37), the simulated values do not correctly match the observed data for the validation period. It might be attributed to a problem with the measures of the gauging station which are not constant or reliable. Figure 38 zooms in on the shift in the gauged discharges for the measurement station on the Mandel.

Data remark: The catchment V05MAN401230 has unreliable observed data for some periods. It is particularly remarkable for the period after 2009, so this period has not been included in the calibration.

Table 13 – Overview of calibration results for gauged catchments on the Leie basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|---------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 38680122, Leie te Menen | F05LEI386999 | 2981.8 | 0.78 | 0.73 | -1.0 | 2001-2013 |
| 40310102 - Heulebeek; Heule | V05HEU403210 | 91.9 | 0.76 | 0.67 | -3.6 | 2001-2013 |
| 40110102 - Mandel; Oostrozebeke | V05MAN401230 | 258.4 | 0.64 | 0.51 | 0.2 | 2005-2008 |

Table 14 – Overview of validation results for gauged catchments on the Leie basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|---------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 38680122, Leie te Menen | F05LEI386999 | 2981.8 | 0.79 | 0.75 | -0.6 | 1999-2013 |
| 40310102 - Heulebeek; Heule | V05HEU403210 | 91.9 | 0.81 | 0.69 | -5.8 | 1975-2013 |
| 40110102 - Mandel; Oostrozebeke | V05MAN401230 | 258.4 | 0.62 | -1.35 | -35.6 | 1967-2013 |

38680122, Leie te Menen (F05LEI386999)

Figure 32 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment F05LEI386999, station 38680122 – Leie, Menen(2001-2013)

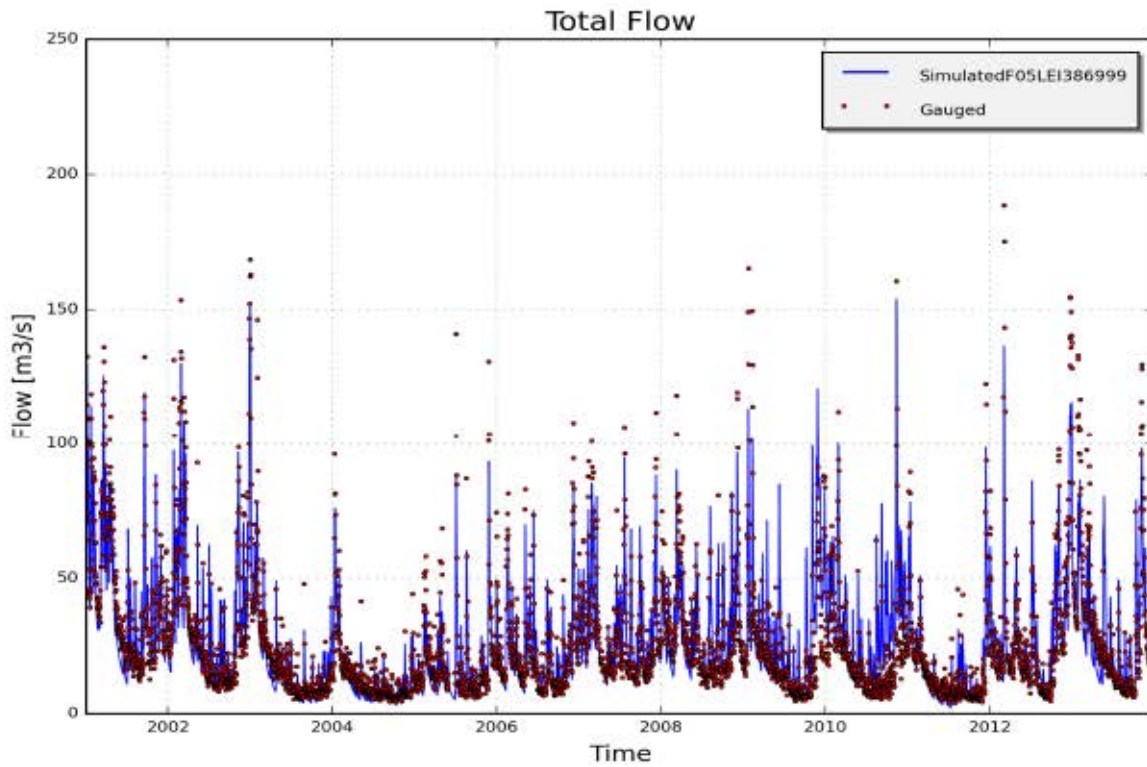


Figure 33 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment F05LEI386999, station 38680122 – Leie, Menen(2001-2013)

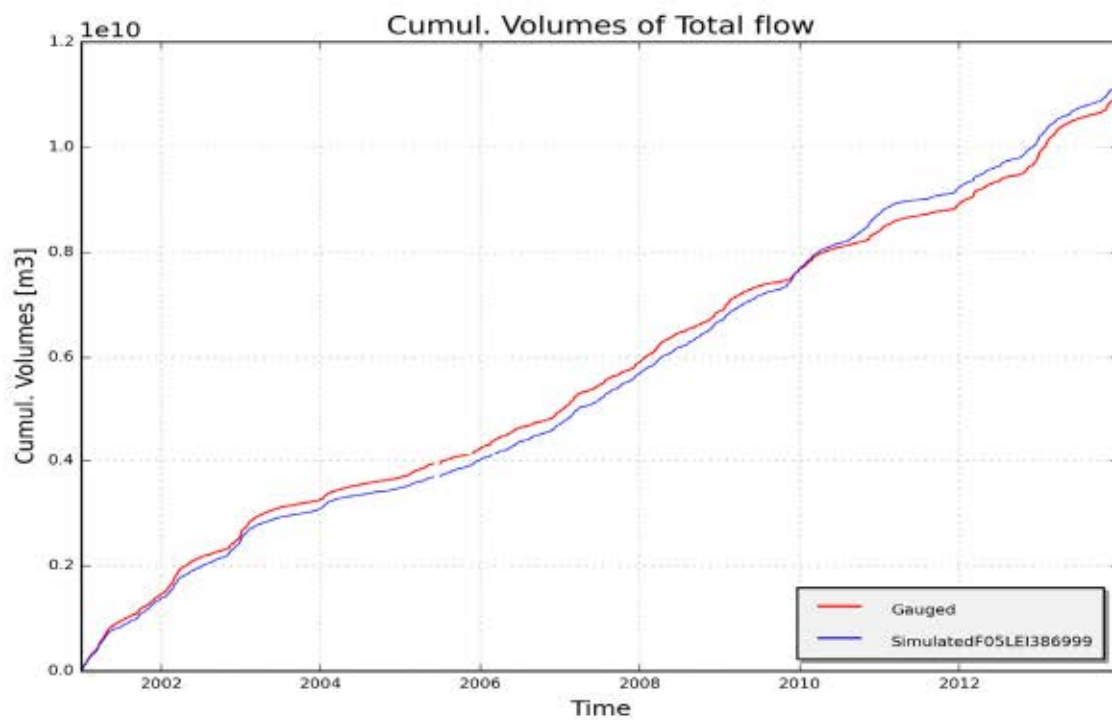
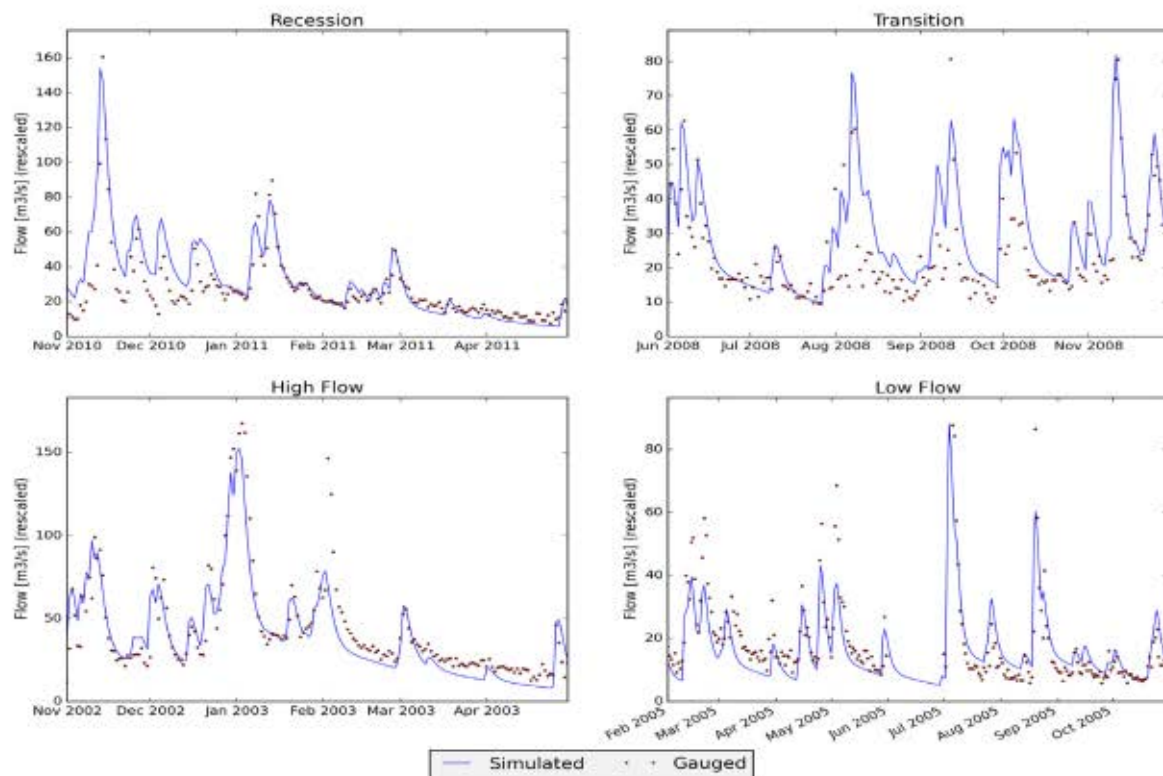


Figure 34 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment F05LEI386999, station 38680122 – Leie, Menen(2001-2013)



40110102 - Mandel; Oostrozebeke (V05MAN401230)

Figure 35 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period 1967-2013)

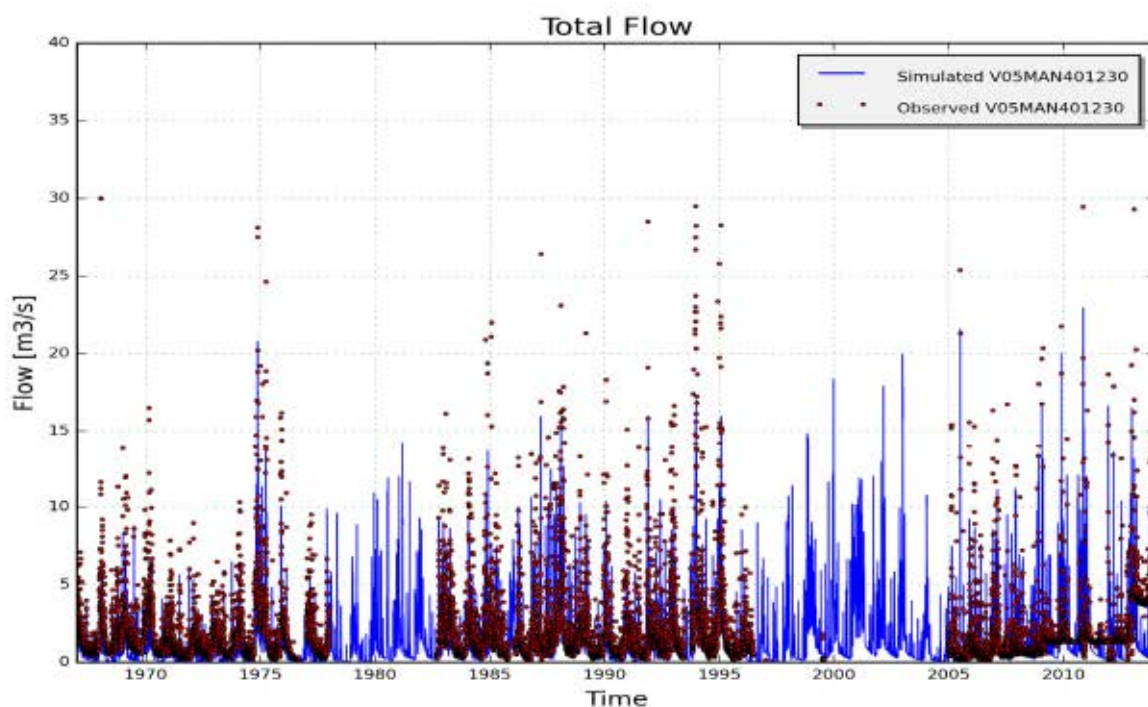


Figure 36 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke(calibration period)

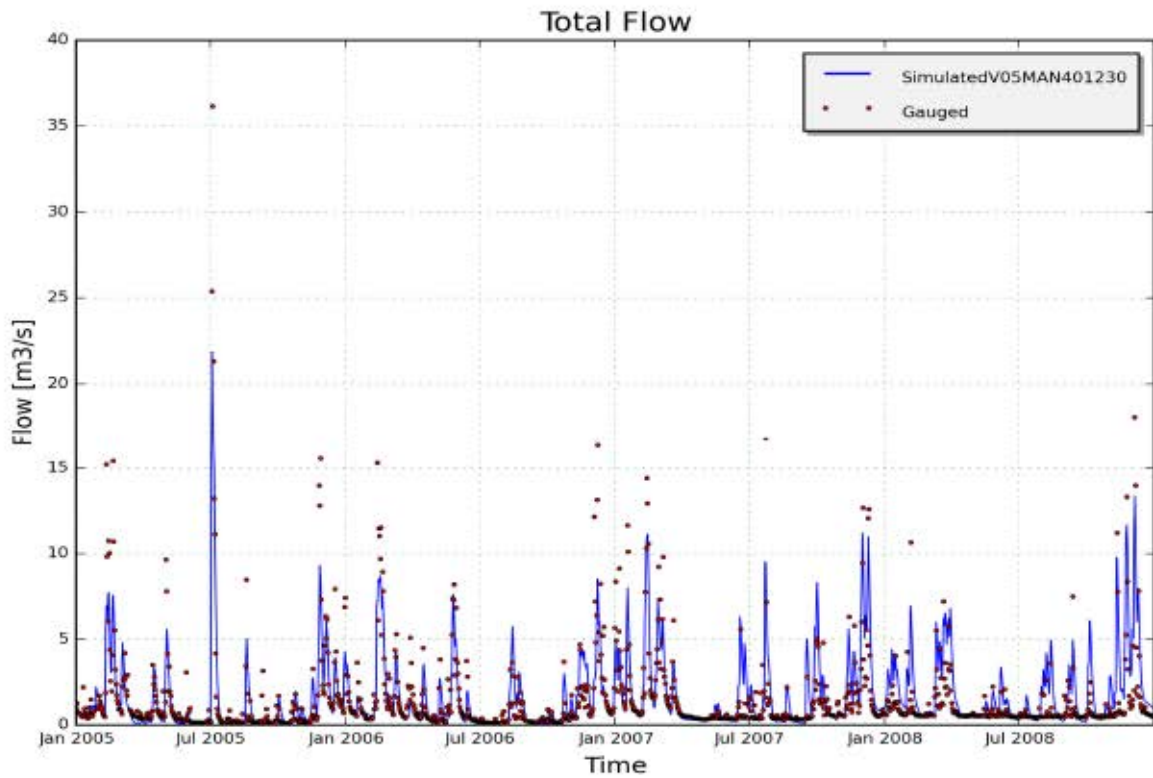


Figure 37 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (calibration period)

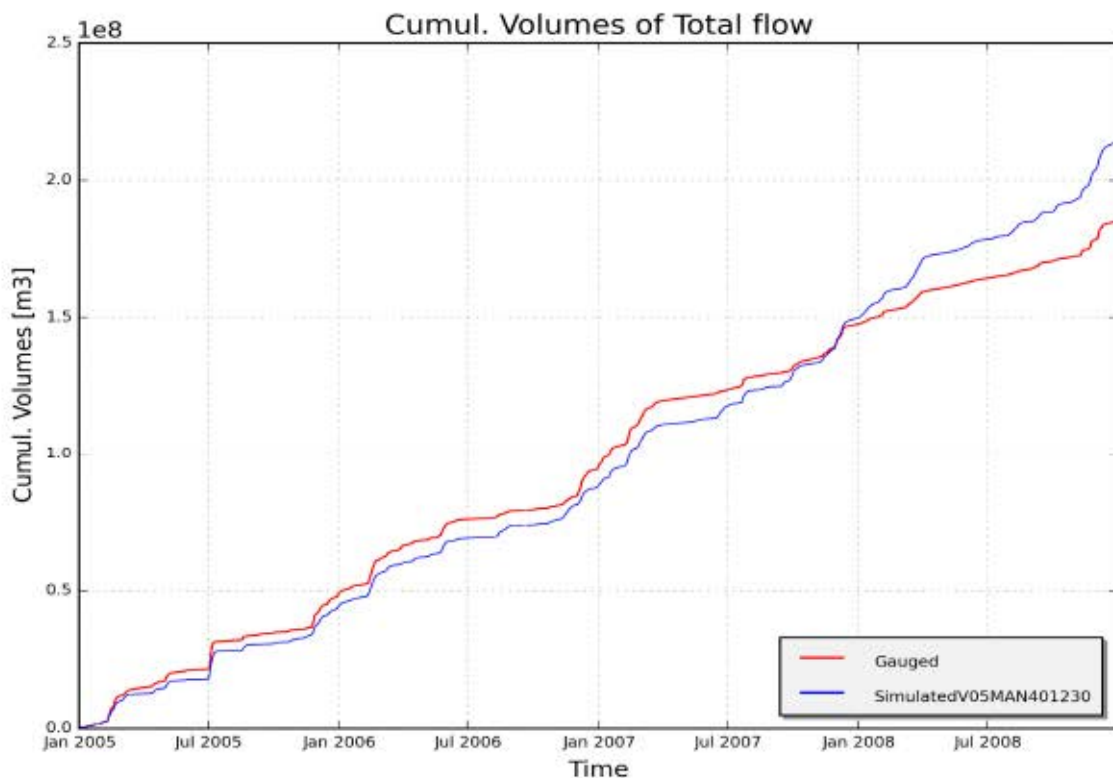
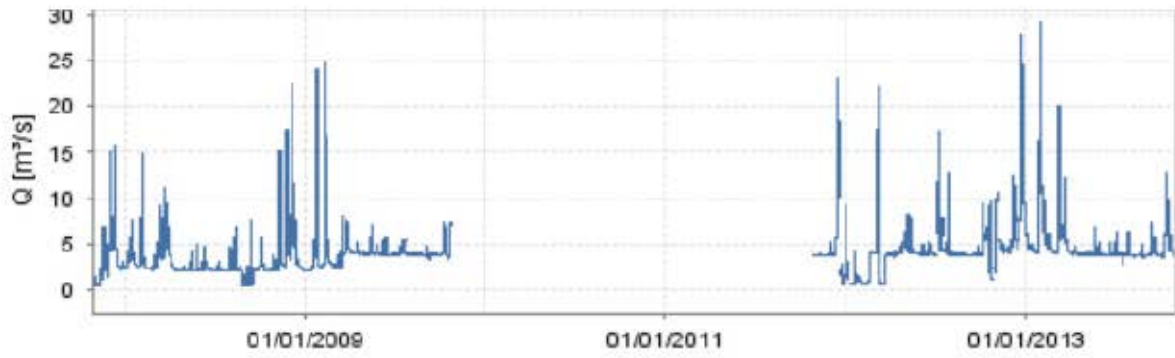


Figure 38 – Shift in measured discharge starting from april 2010 (source: www.waterinfo.be)



V06MAA347160 and W06RHOL54100. According to the catchment V06MAA347160, NSE and LogNSE values are below 0.50 for the calibration and even lower for the validation period. However, as shown in Figure 44 and Figure 46 low values are correctly represented. In W06RHOL54100, which is located in Amougies (Wallonia), the discrepancy of the hydrological model is due to the lack of available data within the calibration period (less than 2 years). The discharge of this subcatchment is especially during low flows negligible compared to the discharge of the Scheldt itself.

Data remark: The station 32580122 – Bovenschelde in Bossuit (F06BOS325999) has only measured discharge from 13/09/2001 onwards. The catchment W06RHOL54100 only has observed discharge data from February 2012 onwards so that the calibration and validation periods cover less than two years.

Table 15 – Overview of calibration results for gauged catchments on the Bovenschelde basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|----------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 32580122 - Bovenschelde; Bossuit | F06BOS325999 | 5217.6 | 0.68 | 0.62 | -2.9 | 2002-2013 |
| 34710102 - Maarkebeek; Etikhove | V06MAA347160 | 48.7 | 0.44 | 0.44 | -1.0 | 2001-2013 |
| 34210102 - Zwalm; Nederzwalm | V06ZWA342190 | 112.1 | 0.63 | 0.62 | -1.1 | 2000-2012 |
| L5412 Amougies - Rhosnes | W06RHOL54100 | 161.9 | 0.52 | 0.51 | 28.4 | 2012-2013 |

Table 16 – Overview of validation results for gauged catchments on the Bovenschelde basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|----------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 32580122 - Bovenschelde; Bossuit | F06BOS325999 | 5217.6 | 0.68 | 0.63 | -2.6 | 2002-2013 |
| 34710102 - Maarkebeek; Etikhove | V06MAA347160 | 48.7 | 0.44 | 0.32 | -27.4 | 1972-2013 |
| 34210102 - Zwalm; Nederzwalm | V06ZWA342190 | 112.1 | 0.59 | 0.54 | 4.7 | 1973-2013 |
| L5412 Amougies - Rhosnes | W06RHOL54100 | 161.9 | 0.50 | 0.47 | 49.6 | 2012-2013 |

34210102 - Zwalm; Nederzwalm (V06ZWA342190)

Figure 40 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (2001-2013)

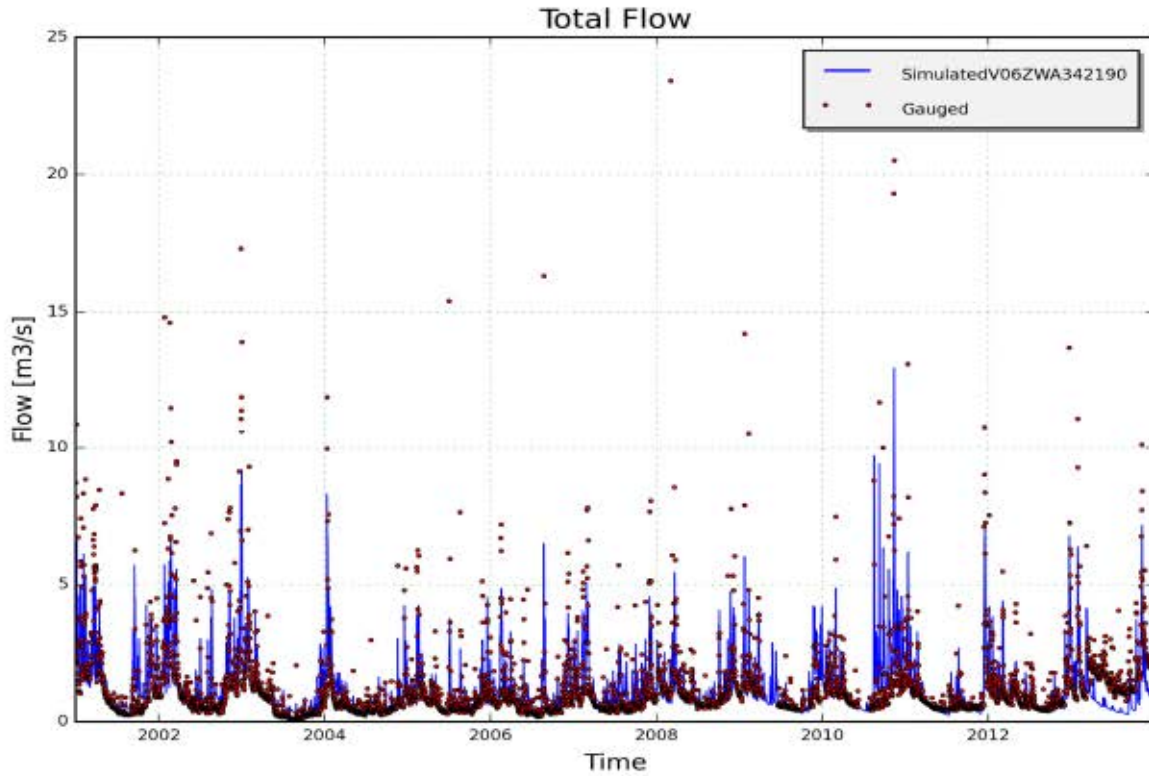


Figure 41 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (2001-2013)

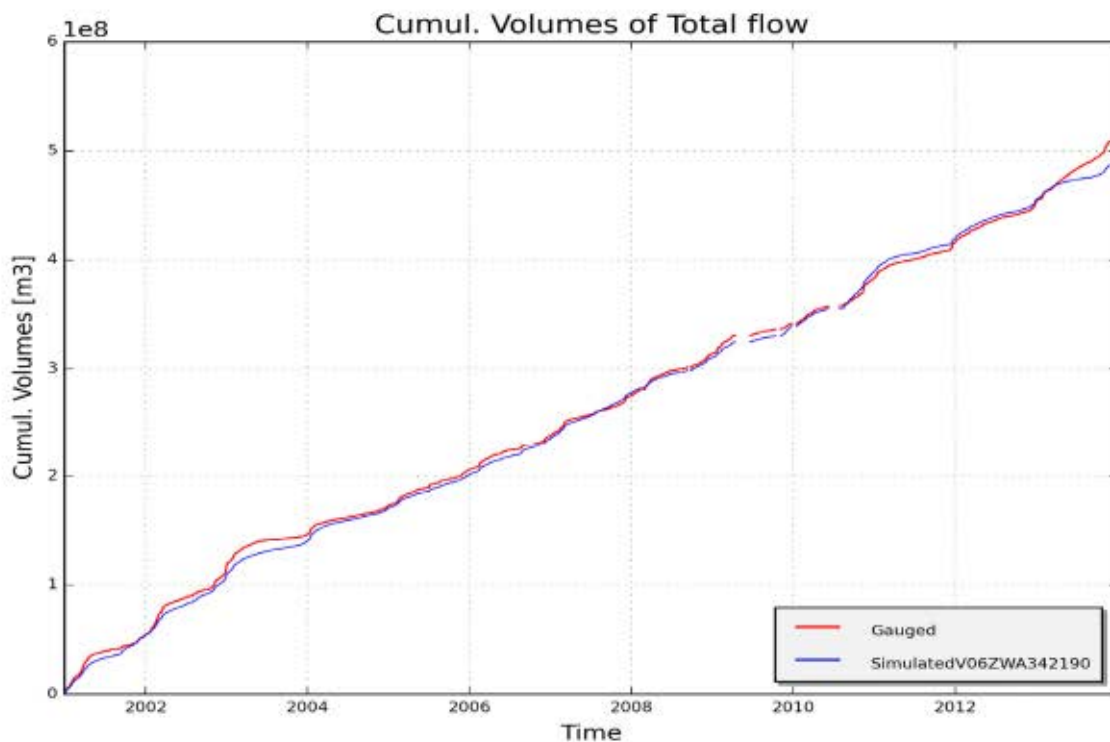
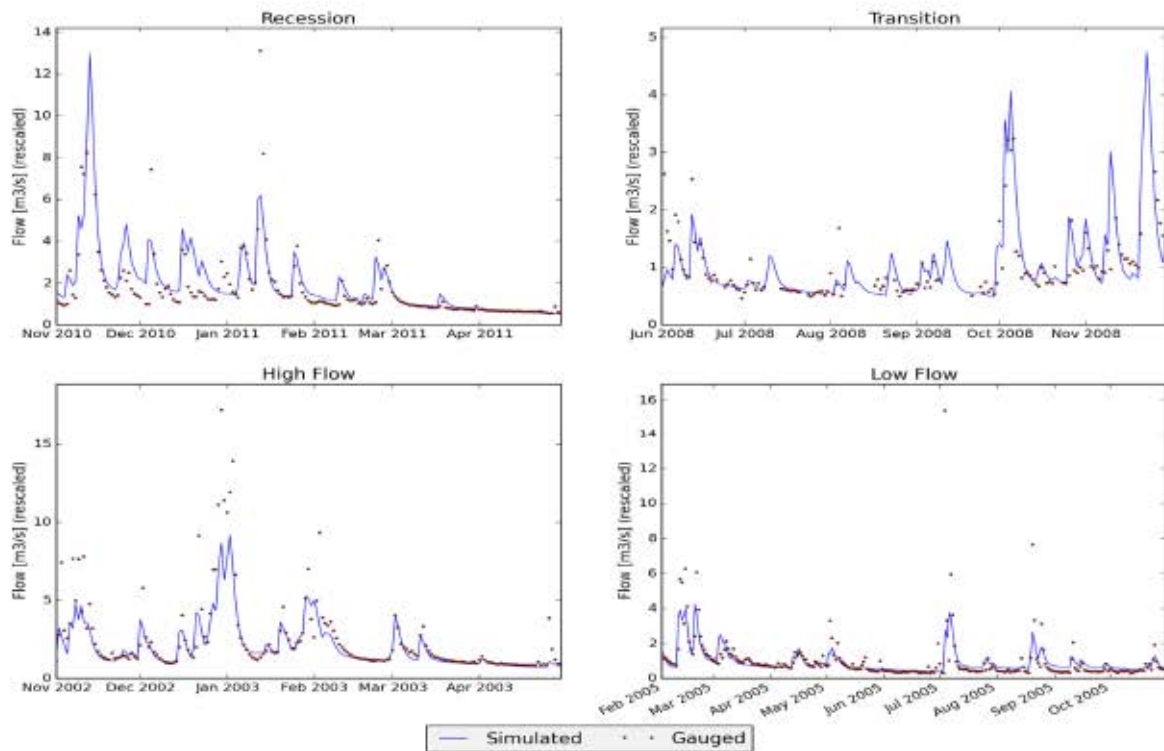


Figure 42 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)



34710102 - Maarkebeek; Etikhove (V06MAA347160)

Figure 43 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (2001-2013)

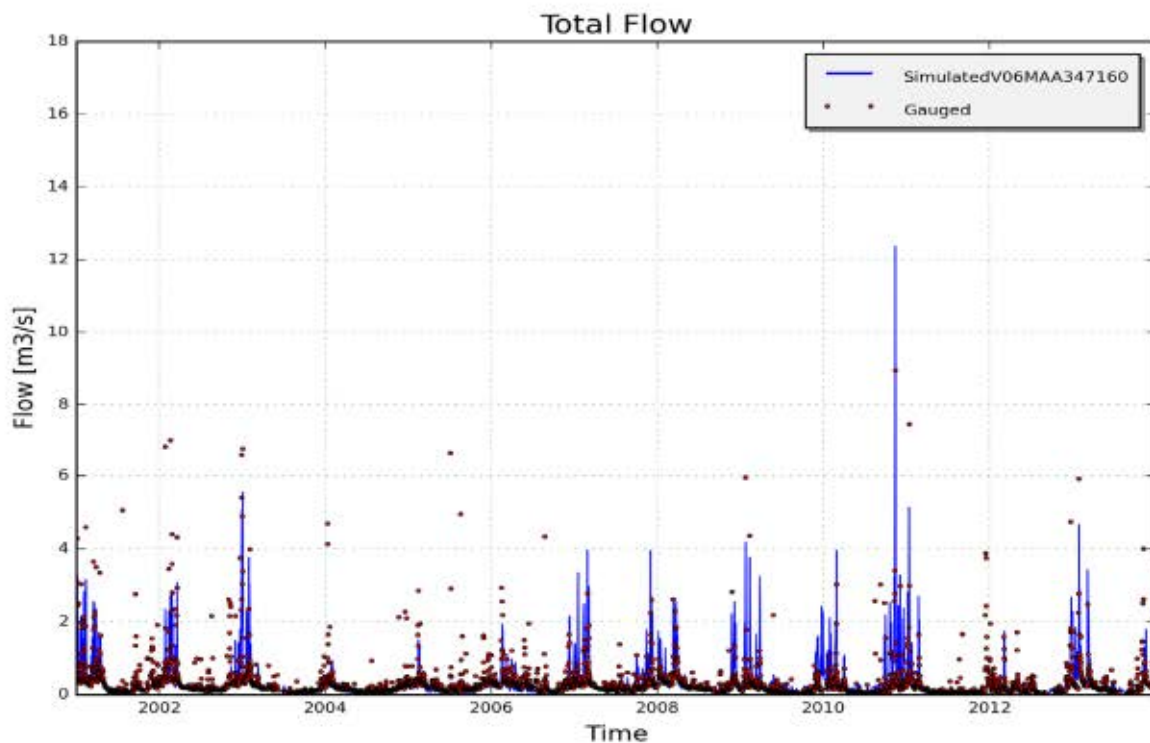


Figure 44 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V06MAA347160, station station 34710102 - Maarkebeek; Etikhove (2001-2013)

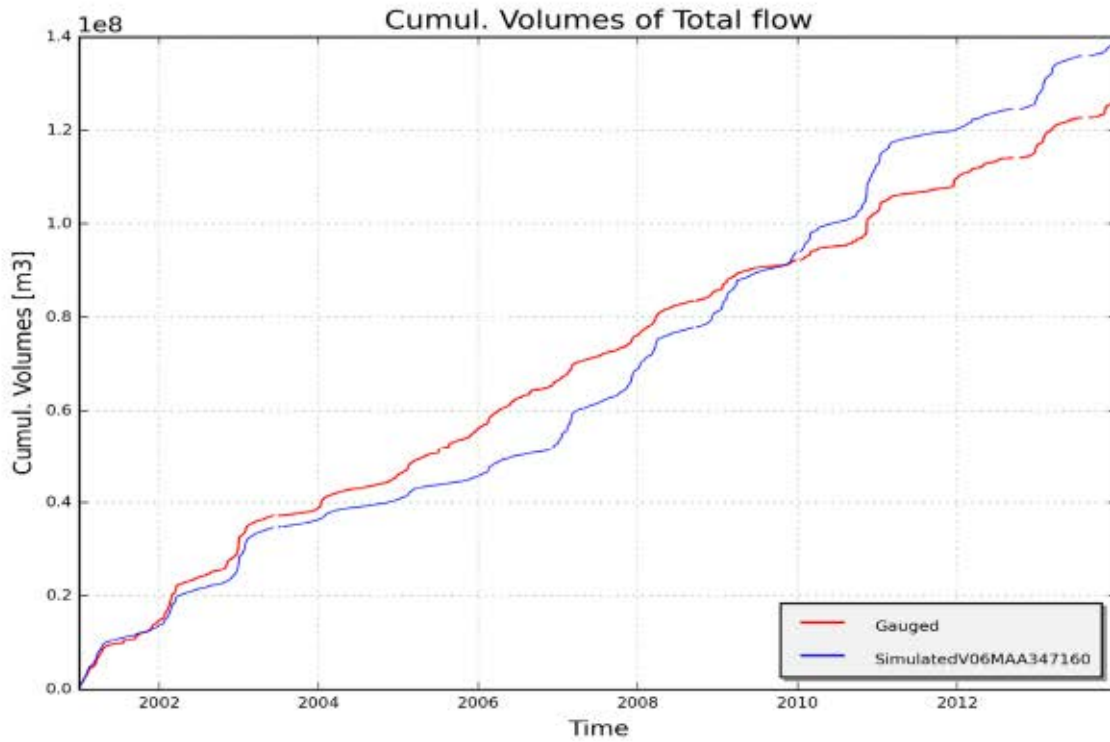
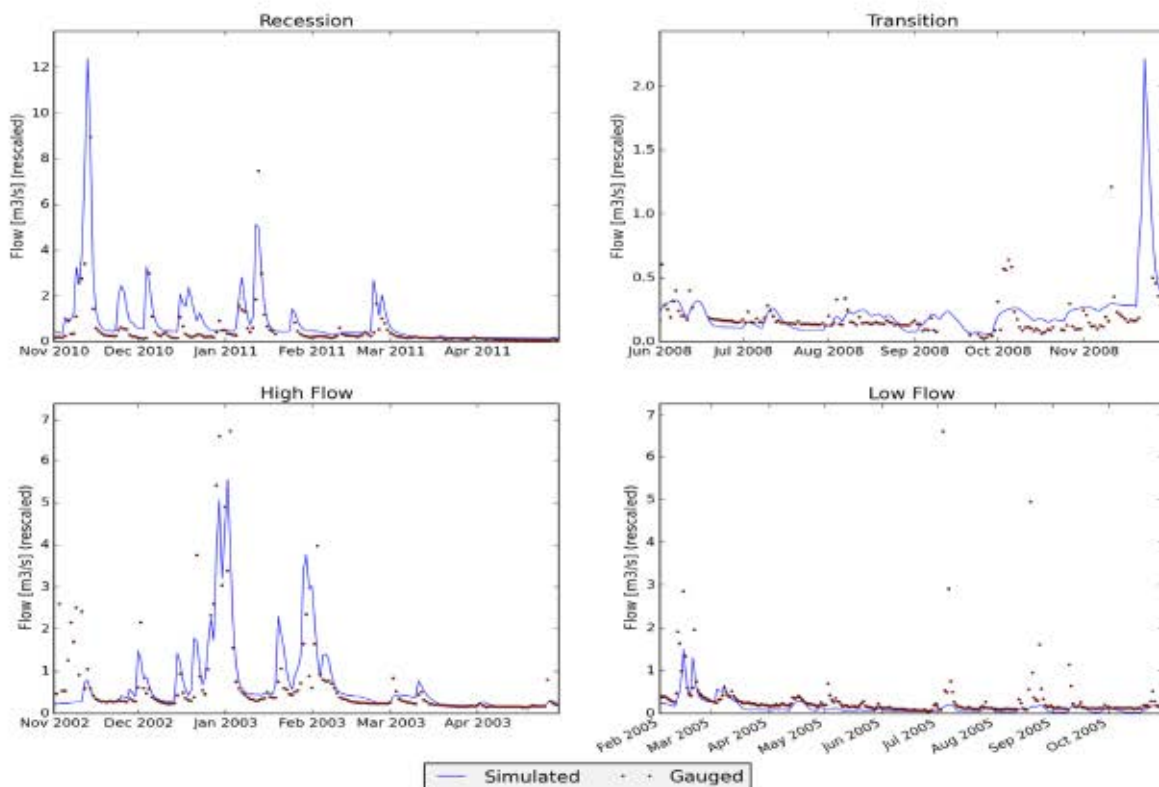


Figure 45 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove



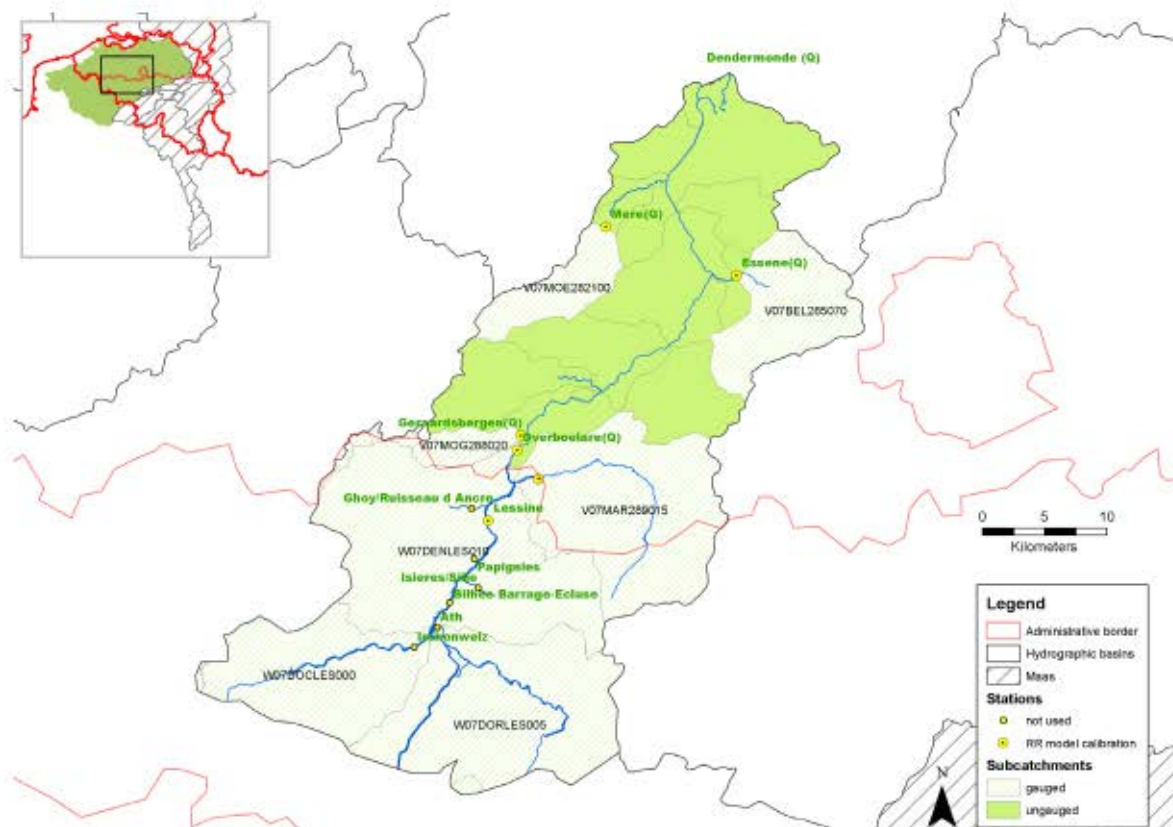
6.9 Denderbekken

6.9.1 Context

The Dender basin has an area of 1 384 km² and extends over Wallonia and Flanders. The upstream part (675 km²) is located in Wallonia and the lower part (709 km²) in Flanders. The Dender basin accounts for 6 % of the total catchment of the study area.

With 5 gauging stations used for model calibration, the portion of gauged catchments in this basin accounts for 61 % of total catchment area. The gauging station in Lessines is used to calibrate a hydrological model for the catchment upstream of this gauging station. In the water allocation model, this catchment is divided into 3 subcatchments.

Figure 46 – Subcatchments and measurement points in the Dender catchment



6.9.2 Model performance

Table 17 and Table 18 present the general performance statistics for the gauged catchments of the Dender catchment for the calibration and validation period. Graphs of simulations for the catchments V07MAR289015 (best model performance) and V07MOG288020 (worst model performance) are presented below (Figure 48 to Figure 52). For more detailed results on the other catchments is referred to Annex 9.

The simulated flow rates for most of the catchments are in agreement with the observed flow rates, with values of NSE and LogNSE higher than 0.60 for the calibration period.

Data remark: the gauging station 28210102 - Molenbeek, Erpe Mere (V07MOE282100) does not have discharge data during the years 2010 and 2011, so that the calibration period is until 2009. In the catchment

V07MOG288020, the years after 2009 have been deleted due to the existence of unreliable measured discharge data and therefore the calibration series starts in 2007. The catchment **W07DENLES999** does not have discharge data before 2008.

Table 17 – Overview of calibration results for gauged catchments on the Dender basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|--------------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 28510102 - Bellebeek, Essene | V07BEL285070 | 88,7 | 0.60 | 0.62 | 0.6 | 2001-2013 |
| 28970102 - Mark, Viane | V07MAR289015 | 173,9 | 0.75 | 0.62 | -0.3 | 2001-2013 |
| 28210102 - Molenbeek, Erpe Mere | V07MOE282100 | 46.4 | 0.53 | 0.74 | -2.5 | 1997-2009 |
| 28810102 - Molenbeek, Geraardsbergen | V07MOG288020 | 23.1 | 0.64 | 0.57 | 0.6 | 1997-2009 |
| Lessines | W07DENLES999 | 511.8 | 0.62 | 0.57 | -1.0 | 2008-2013 |

Table 18 – Overview of validation results for gauged catchments on the Dender basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|--------------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 28510102 - Bellebeek, Essene | V07BEL285070 | 88.7 | 0.53 | 0.53 | -7.1 | 1973-2013 |
| 28970102 - Mark, Viane | V07MAR289015 | 173.9 | 0.78 | 0.59 | -5.5 | 1977-2013 |
| 28210102 - Molenbeek, Erpe Mere | V07MOE282100 | 46.4 | 0.58 | 0.68 | 5.8 | 1986-2013 |
| 28810102 - Molenbeek, Geraardsbergen | V07MOG288020 | 23.1 | 0.62 | 0.48 | -6.4 | 1986-2013 |
| Lessines | W07DENLES999 | 511.8 | 0.62 | 0.57 | 0.3 | 2008-2013 |

28970102 - Mark, Viane (V07MAR289015)

Figure 47 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MAR289015, station 28970102 - Mark, Viane (2001-2013)

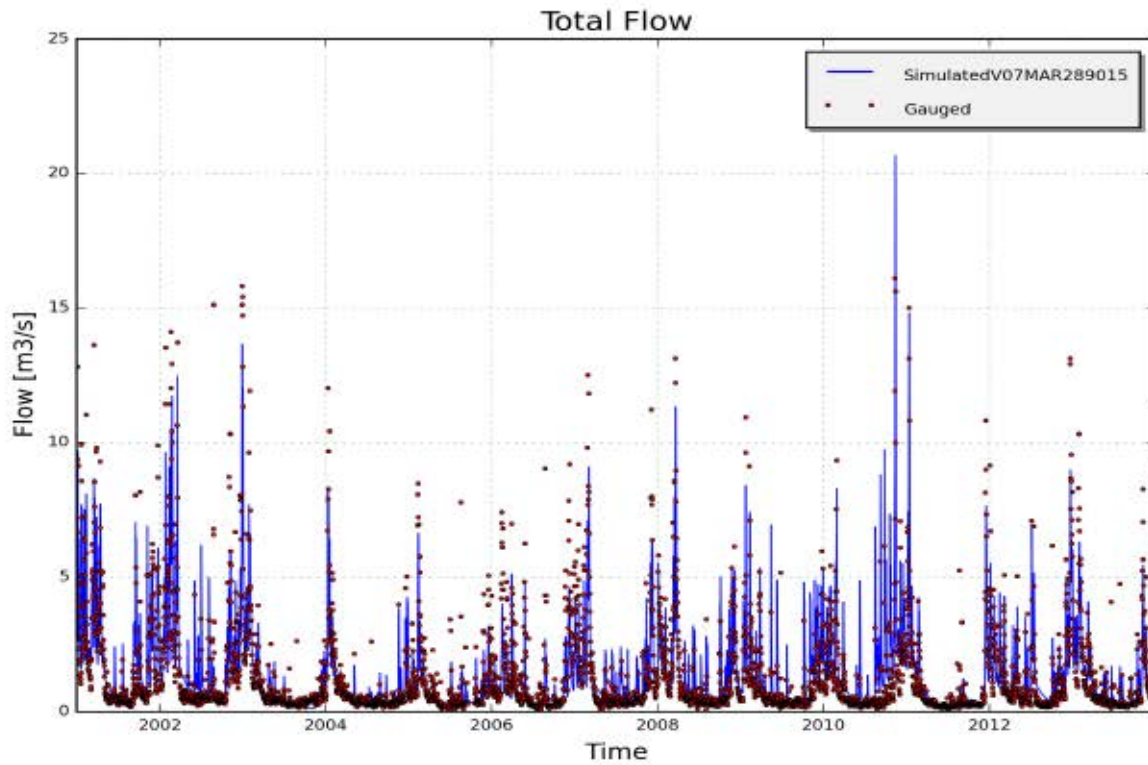


Figure 48 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MAR289015, station 28970102 - Mark, Viane (2001-2013)

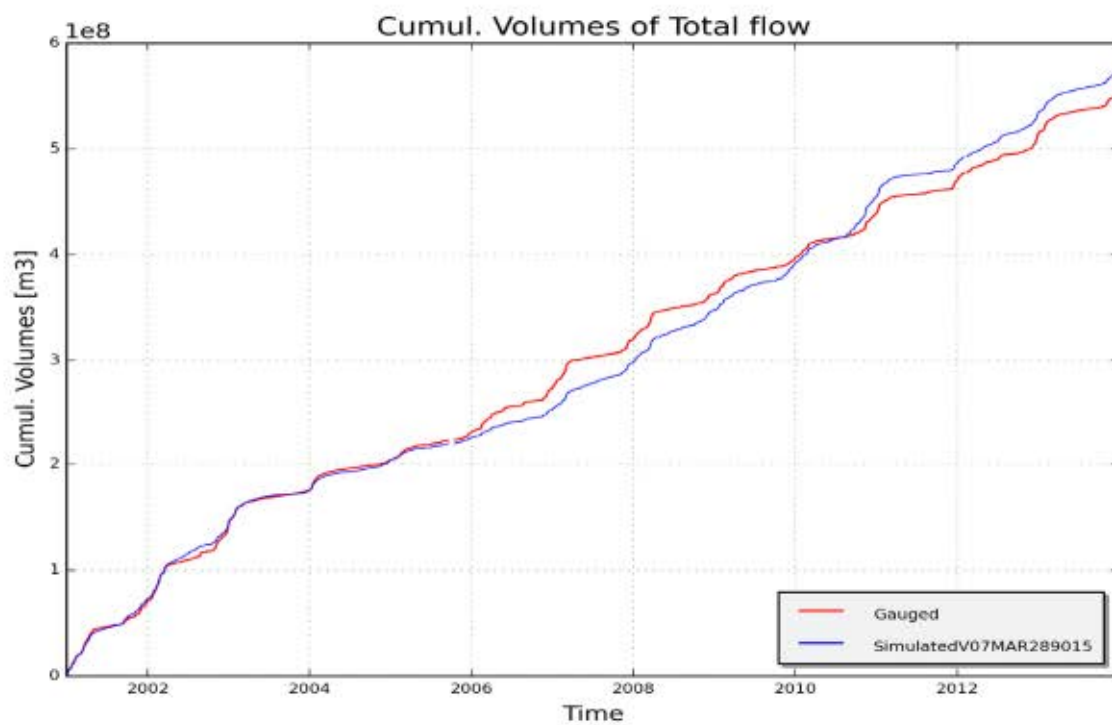
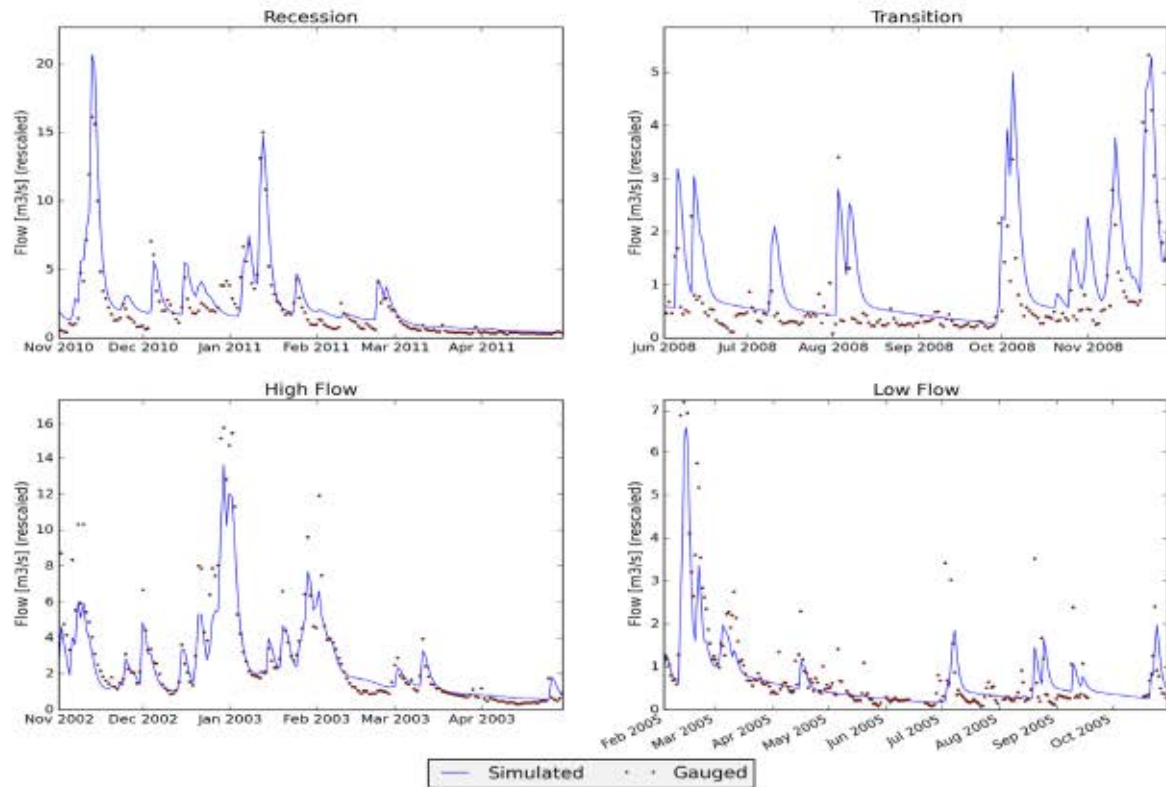


Figure 49 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Mark, Viane



28810102 - Molenbeek, Geraardsbergen (V07MOG288020)

Figure 50 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen(1997-2009)

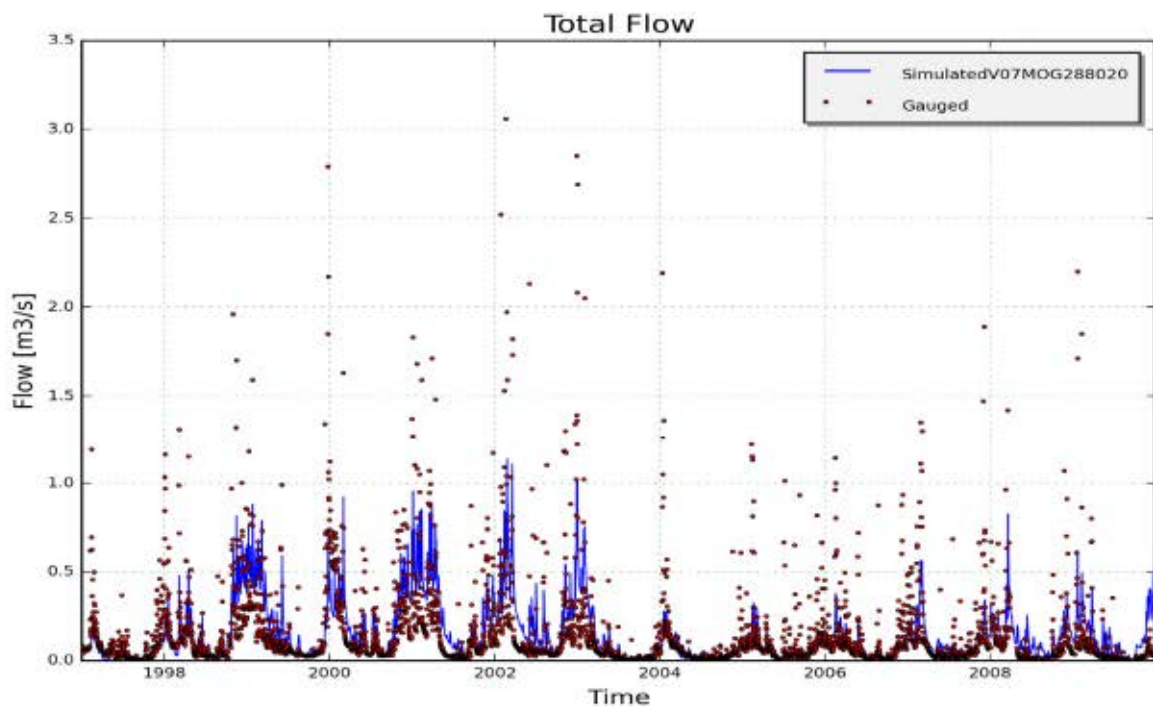


Figure 51 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (1997-2009)

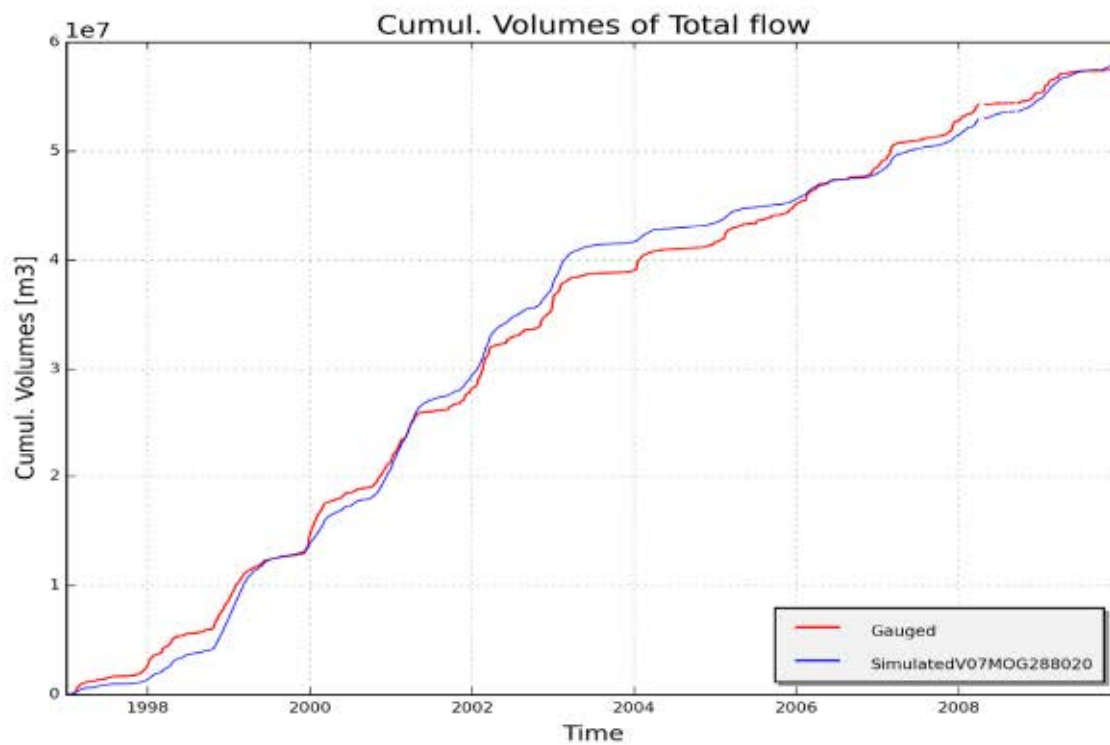
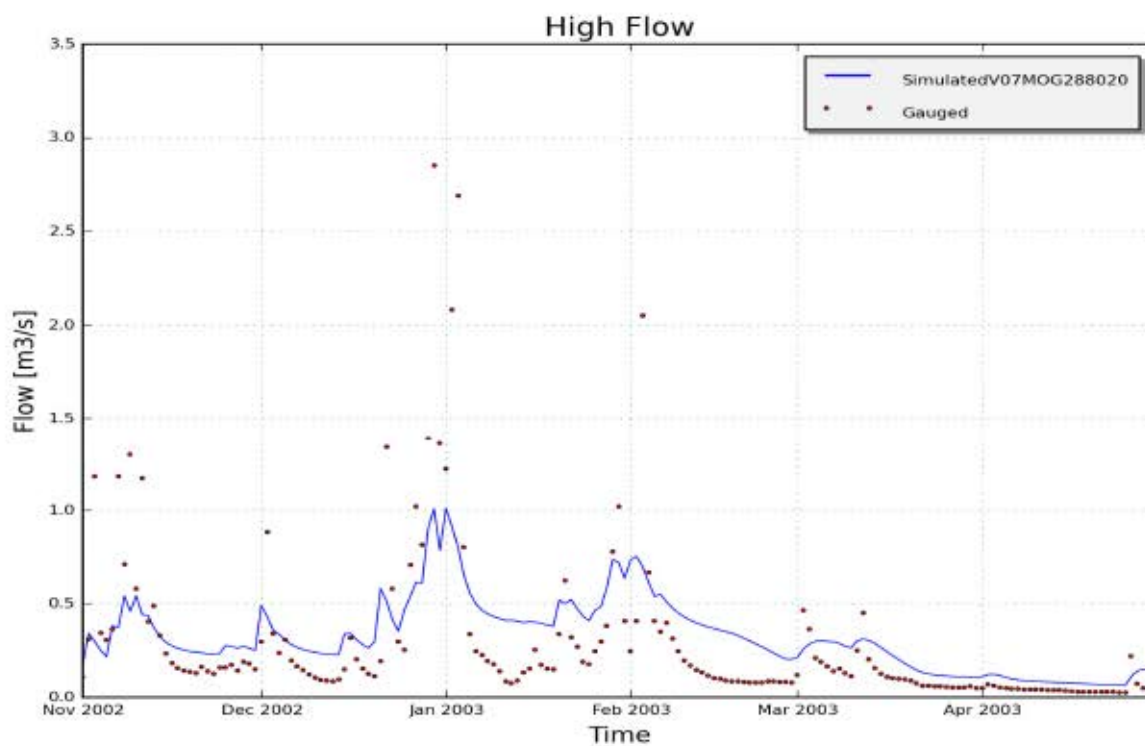
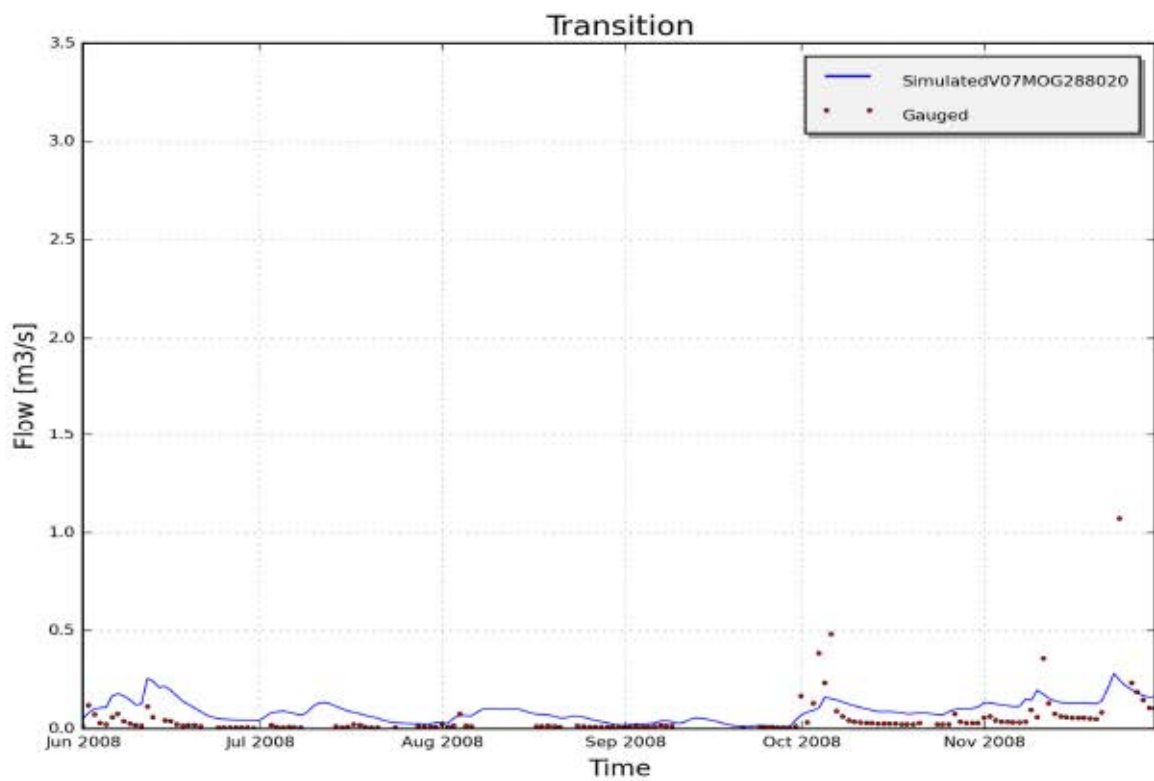
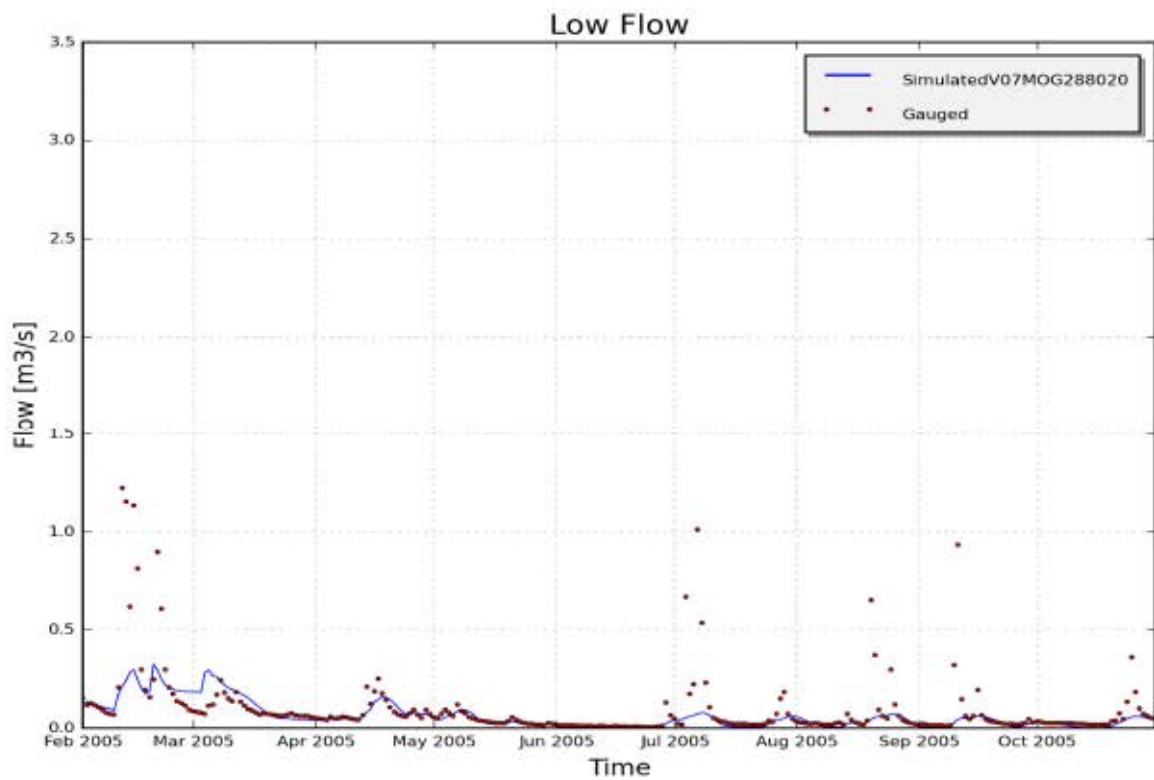


Figure 52 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen





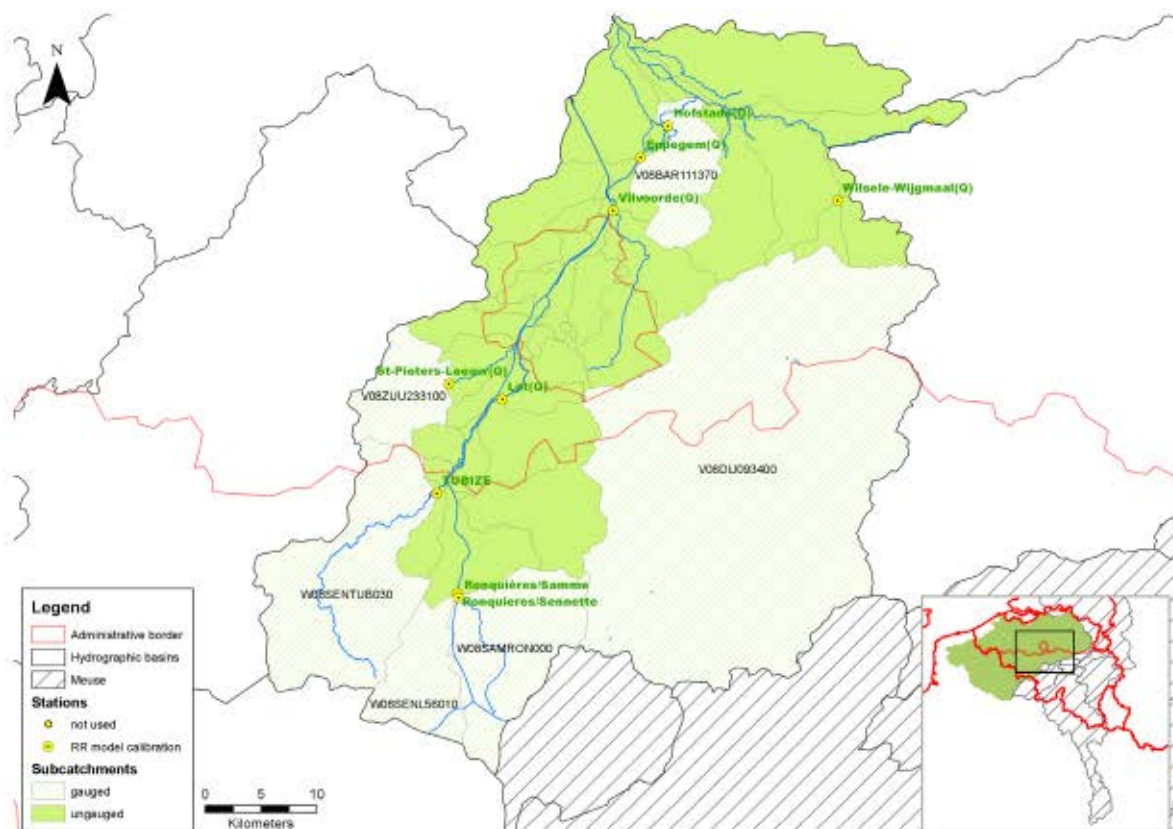
6.10 Dijle and Zenne

6.10.1 Context

The Dijle basin stretches over Flanders (55 %) and Wallonia (45 %) and has an area of about 1 290 km². The Zenne basin (ca. 1 160 km²) spreads across Wallonia (50 %), Brussels (14 %) and Flanders (36 %). In total, the Dijle and Zenne basin accounts for 11 % of the total area of the Scheldt basin.

Catchments and gauging stations are represented at Figure 54. Five stations are located on the Zenne on its tributaries before the confluence with the Dijle, measuring discharge for 43 % of the Zenne catchment. The discharge of the Dijle is measured by one station in Wilsele (67 % of the catchment surface area is gauged).

Figure 53 – Subcatchments and measurement points on the Dijle and Zenne catchment



6.10.2 Model performance

Table 19 and Table 20 present general performance statistics for the gauged catchments of the Dijle and the Zenne basins for the calibration and validation period. Graphs of simulations for the catchments **W08SENTUB030** (best model performance) and **V08DIJ093400** (worst model performance) are presented below (Figure 55 to Figure 60). For more detailed results on the other catchments, see Annex 10.

The catchments **V08BAR111370**, **V08ZUU233100**, **W08SAMRON000** and **W08SENTUB030** have adequate model performance with NSE and LogNSE values above 0.6. This with the exception of **V08ZUU233100**, but for the project purpose this hydrological model can even though be considered as adequate as low flows are correctly represented. Overall, all the catchments follow the same pattern as there is a general flow underestimation during the period comprised between 2004 and 2010 and flow overestimation afterwards (i.e. **V08ZUU233100** and **W08SENTUB030**). The worst model performance was found in **V08DIJ093400**. Some

explanations were already considered in a previous report to explain the mismatch between the observed and simulated discharge data (de Boeck et al., 2010). Firstly, the poor results were attributed to the effect of vegetation in the gauging station, which may influence the measurements and result in a bad q(h)-relationship. Another possible explanation is the fact of a dam construction in Rotselaar in 1994, which would make the relationship no longer valid and the influence of a large sewage plant whose effluent enters upstream the measurement station in the Dijle in Wilsele. Poor calibration results were also found in the catchment with code **W08SENL56010**, specially for low flows. For instance, discharge is underestimated from 2003 and overestimated from 2010.

Data remark: The catchment **V08BAR111370** only has measured discharge data from 02/01/1997 to 04/11/2004, so that this entire period was selected for the calibration. The catchment **W08SAMRON000** does not have data after 2010 and because of that years before 2001 have been included in order to have a longer calibration time period.

Table 19 – Overview of calibration results for gauged catchments on the Dijle and Zenne basins

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibration period |
|--------------------------------------|----------------|-------------------------|------|--------|------------|--------------------|
| 11110102-Barebeek, Hofstade | V08BAR111370 | 70,0 | 0.76 | 0.80 | 0.8 | 1997-2004 |
| 9310102 - Dijle, Wilsele | V08DIJ093400 | 861,4 | 0.39 | 0.29 | 3.1 | 2002-2013 |
| 23310102 - Zuunbeek, St Pietersleeuw | V08ZUU233100 | 64,8 | 0.58 | 0.51 | 0.1 | 2001-2013 |
| 2371-10050 Samme, Ronquieres | W08SAMRON000 | 134,0 | 0.67 | 0.68 | 1.3 | 1998-2010 |
| L5670 -Senette, Ronquieres | W08SENL56010 | 70,4 | 0.60 | 0.45 | -1.3 | 2001-2013 |
| 1951-10050 Zenne, Tubize | W08SENTUB030 | 215,9 | 0.65 | 0.69 | -0.3 | 2001-2013 |

Table 20 – Overview of validation results for gauged catchments on the Dijle and Zenne basins

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|--------------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 11110102-Barebeek, Hofstade | V08BAR111370 | 70,0 | 0.76 | 0.80 | 0.2 | 1997-2004 |
| 9310102 - Dijle, Wilsele | V08DIJ093400 | 861,4 | 0.18 | 0.10 | 25 | 1974-2013 |
| 23310102 - Zuunbeek, St Pietersleeuw | V08ZUU233100 | 64,8 | 0.61 | 0.48 | 22.4 | 1985-2013 |
| 2371-10050 Samme, Ronquieres | W08SAMRON000 | 134,0 | 0.68 | 0.54 | -11.5 | 1999-2010 |
| L5670 -Senette, Ronquieres | W08SENL56010 | 70,4 | 0.56 | 0.34 | -12.0 | 1977-2013 |
| 1951-10050 Zenne, Tubize | W08SENTUB030 | 215,9 | 0.66 | 0.64 | -5.6 | 1975-2013 |

1951-10050 Zenne, Tubize (W08SENTUB030)

Figure 54 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize(2001-2013)

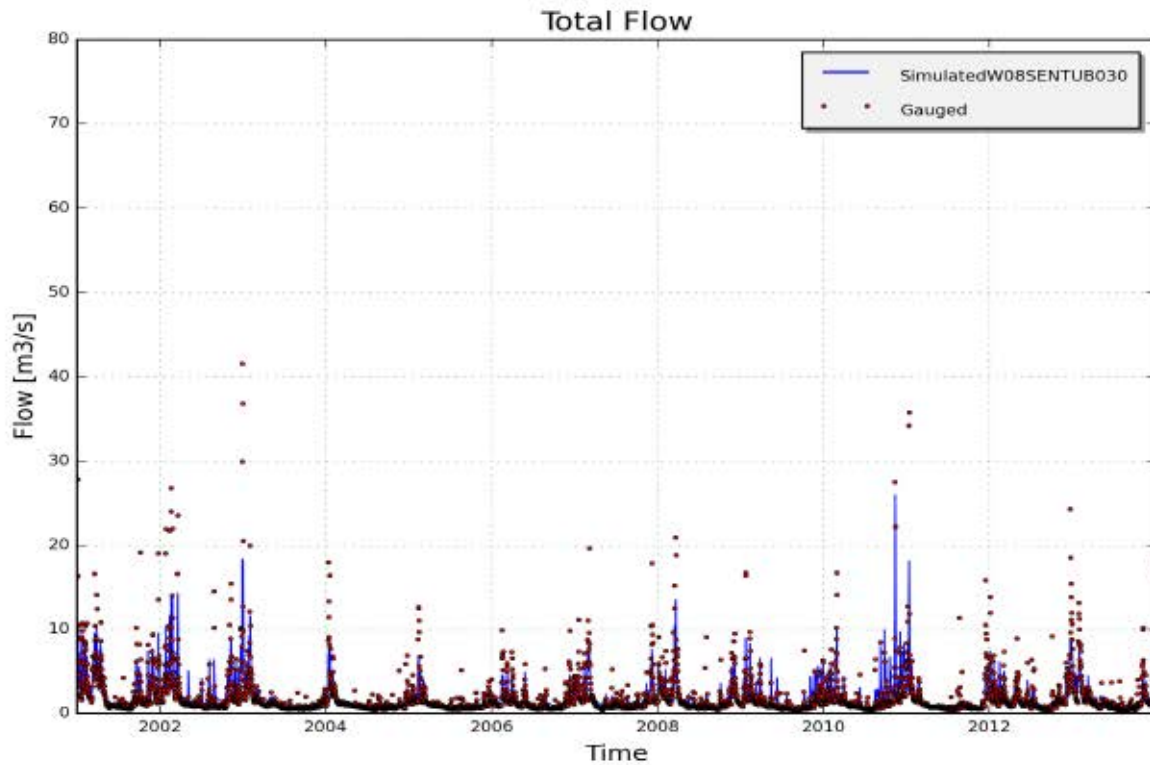


Figure 55 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (2001-2013)

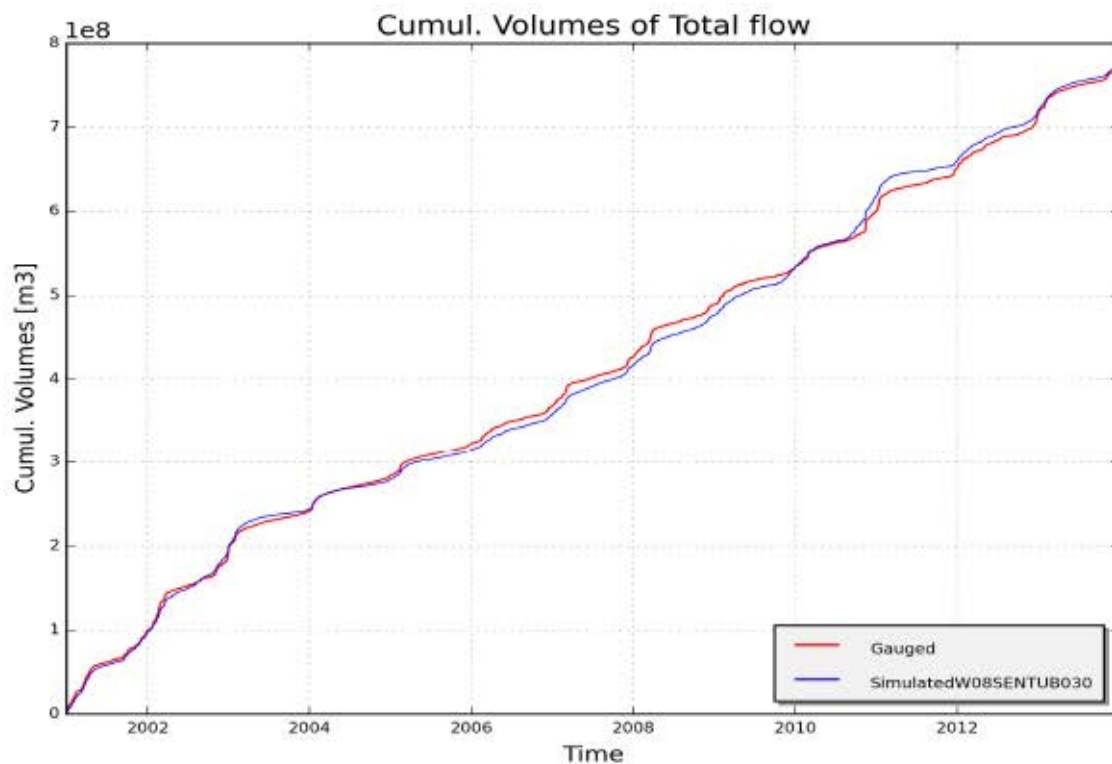
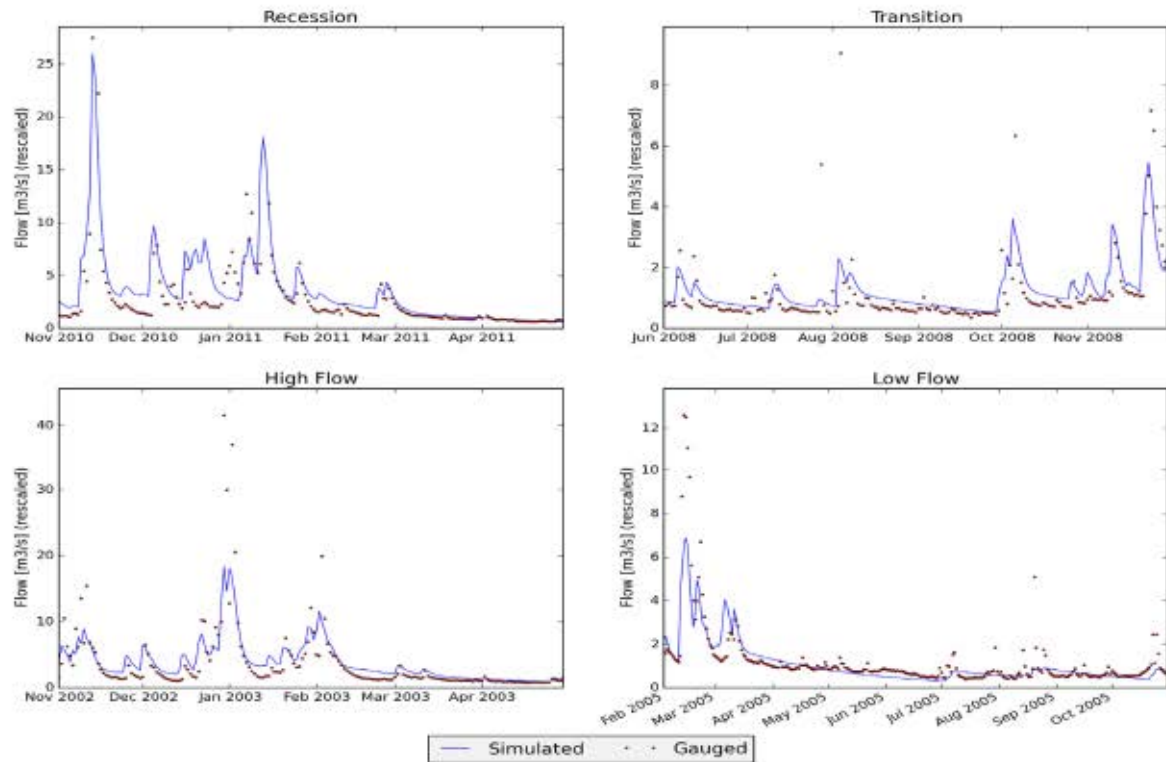


Figure 56 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize



9310102 - Dijle, Wilsle (V08DIJ093400)

Figure 57 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsle (2002-2013)

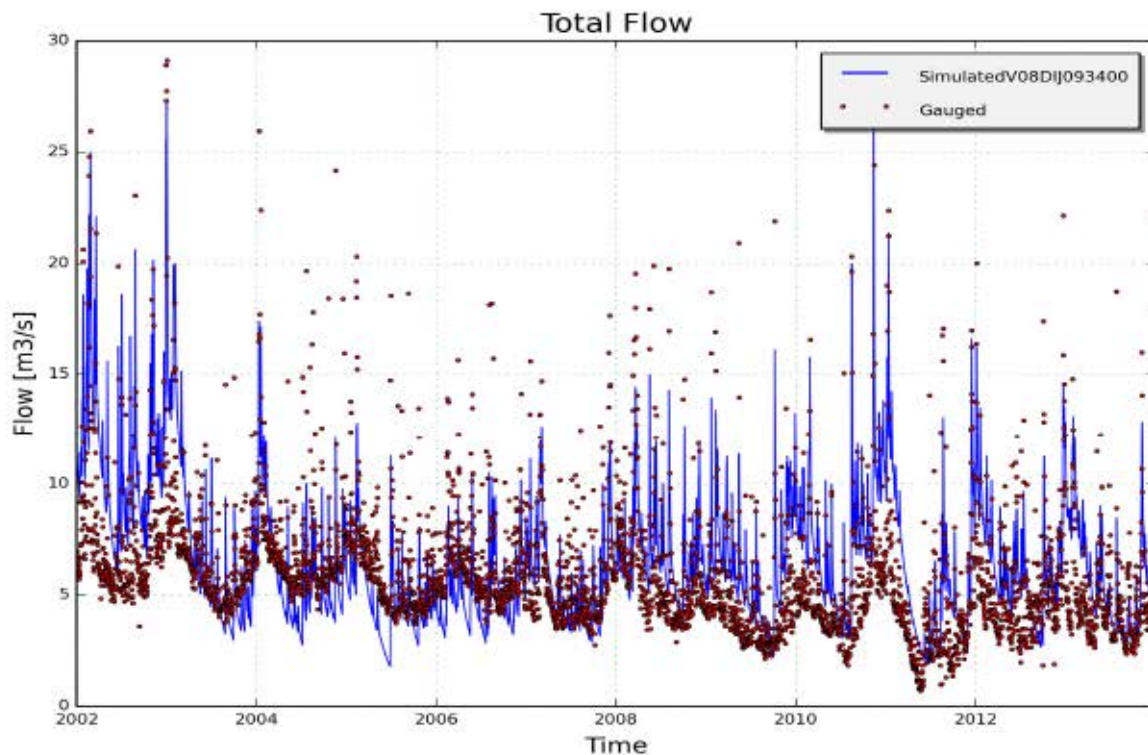


Figure 58 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (2002-2013)

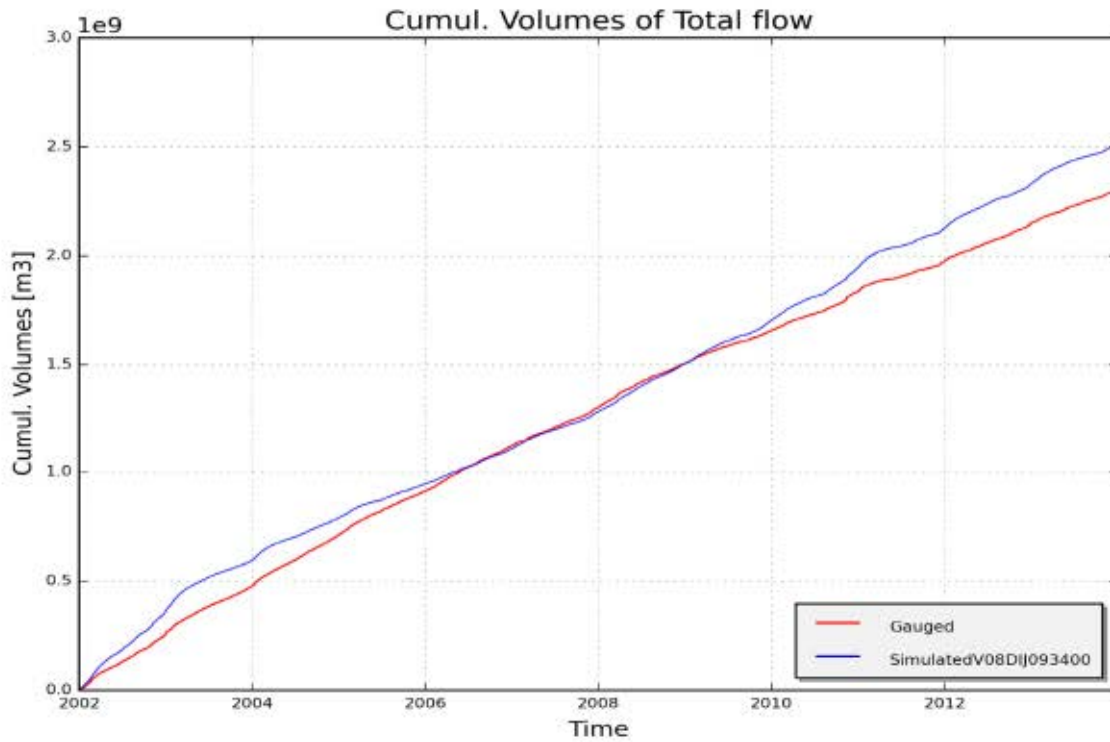
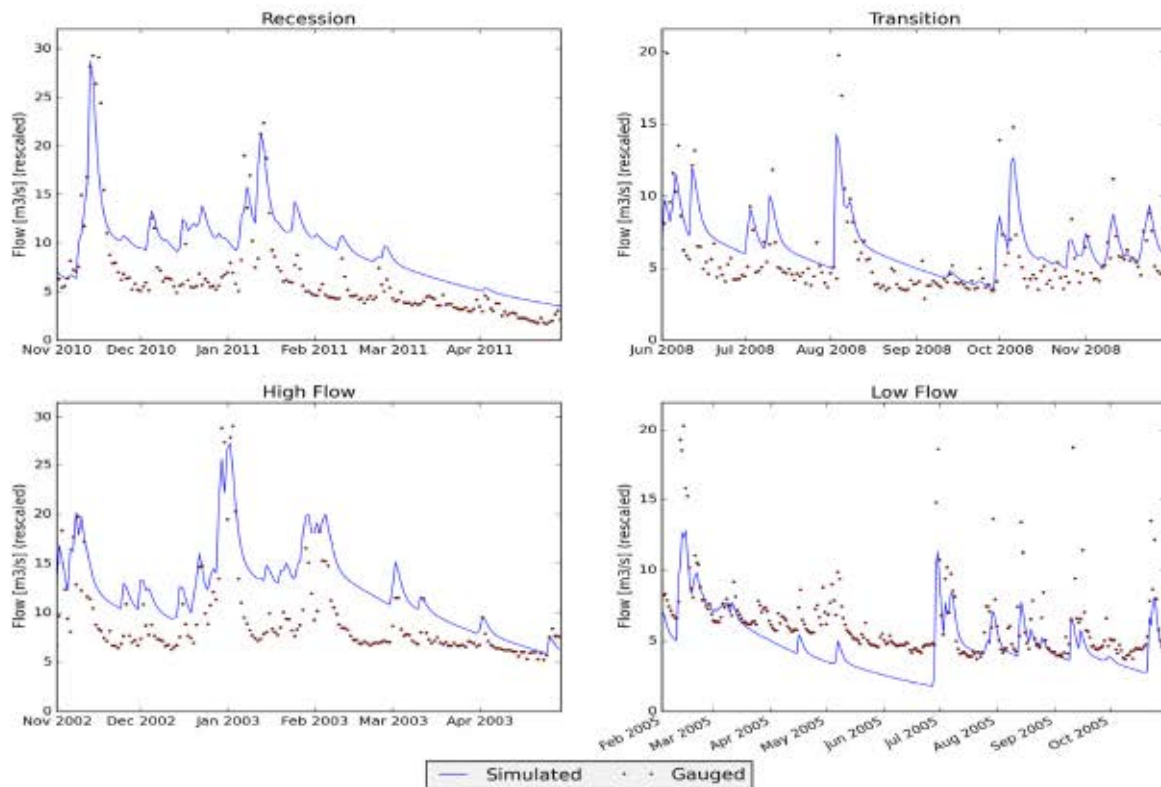


Figure 59 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele



discharge, especially after the year 2010. The results of the statistical parameters do not reach satisfactory values for the calibration period (2001-2013). Nevertheless, the results obtained for the validation period improve considerably, suggesting a deviation in more recent discharge measurements. Although V09LOS143300 has NSE values above 0.6, LogNSE value is 0.51 and low flows are generally underestimated (i.e. 2003, 2004, 2010 and 2011). The match between the observed and measured data for the validation period (1998-2013) is much worse, that might be attributed to an incorrect flow measurements before 2002.

According to the catchment with code V09MAN161040, the general behavior is adequate (NSE=0.63). However, the low flows are not accurately estimated, the LogNSE value is only 0.51 and there is an underestimation of low flows during the years 2005 and 2006, and a overestimation of flows in 2008 and 2010. The general behavior of the model during the calibration period for the catchment V09MOT144270 can be considered as adequate. However, low flows are not correctly represented as in some periods they are overestimated (i.e.1998,1999), while in others they are underestimated (i.e.1996) Furthermore, results are poorer in the validation (Table 22) and it can be suggested a problem with measured data (too low discharge). The statistical results of V09ZWA148120 for the calibration and validation period do not reach the acceptable threshold and the low flows are not correctly represented.

Data remarks: Some catchments are calibrated for different period as the normally used (2001-2013). Years 2011-2013 has been deleted from the simulation of the catchment V09DEM136000 due to a unreliability of the measured flow (too high). According to the catchment with code V09GET152080, there is no discharge data available for the year 2013, so that the period 2000-2012 has been selected. The catchment V09LOS143300 does not have data before 2002. The catchment V09MAN161040 does not have data available from the beginning of 2011 and between 11/05/2003-31/12/2004, so that the period 1998-2010 has been used. There is no observed discharge data in the catchment V09MOT144270 after 2010 and from 2008 the observed discharge data is not reliable, so that the period 1995-2007 was selected. In reference to the catchment V09ZWA148120, there is no data before 2001 and between beginning 2008 to 2010 and after 2010 the observed discharge data is not enough reliable.

Table 21 – Overview of calibration results for gauged catchments on the Demer basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Calibrationperiod |
|------------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 13610102 - Demer; Hasselt | V09DEM136000 | 255,8 | 0.69 | 0.66 | 5.0 | 1998-2010 |
| 15210102 - Gete; Halen | V09GET152080 | 800,4 | 0.62 | 0.58 | 0.7 | 2000-2012 |
| 16310102 - Herk, Kermt | V09HER163010 | 274,6 | 0.62 | 0.61 | 0.2 | 2001-2013 |
| 14710102 - De Hulpe; Molenstede | V09HUL147150 | 80,1 | 0.46 | 0.47 | -13 | 2001-2013 |
| 14310102 - Grote Losting; Wezemaal | V09LOS143300 | 15,2 | 0.66 | 0.52 | 2.4 | 2002-2013 |
| 16110102 - Mangelbeek; Lummen | V09MAN161040 | 103,1 | 0.63 | 0.51 | -0.2 | 1998-2010 |
| 14410102 - Motte; Rillaar | V09MOT144270 | 33,6 | 0.65 | 0.45 | -1.5 | 1995-2007 |
| 14510102 - Velp; Ransberg | V09VEL145100 | 96,8 | 0.67 | 0.70 | 2.2 | 2001-2013 |
| 141 - Rotselaar ; Winge | V09WIN141310 | 64,7 | 0.73 | 0.66 | 2.0 | 2001-2013 |
| 14810102 - Zwarte Beek; Lummen | V09ZWA148120 | 96,5 | 0.59 | 0.48 | 6.7 | 2001-2008 |

Table 22 – Overview of validation results for gauged catchments on the Demer basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr (%) | Validation period |
|------------------------------------|----------------|-------------------------|------|--------|------------|-------------------|
| 13610102 - Demer; Hasselt | V09DEM136000 | 255,8 | 0.60 | 0.39 | -0.7 | 1997-2013 |
| 15210102 - Gete; Halen | V09GET152080 | 800,4 | 0.60 | 0.67 | -0.7 | 1969-2012 |
| 16310102 - Herk, Kermt | V09HER163010 | 274,6 | 0.60 | 0.61 | -4.9 | 1977-2013 |
| 14710102 - De Hulpe; Molenstede | V09HUL147150 | 80,1 | 0.59 | 0.54 | -0.2 | 1987-2013 |
| 14310102 - Grote Losting; Wezemaal | V09LOS143300 | 15,2 | 0.32 | 0.30 | 37.9 | 1987-2012 |
| 16110102 - Mangelbeek; Lummen | V09MAN161040 | 103,1 | 0.66 | 0.51 | -0.8 | 1984-2009 |
| 14410102 - Motte; Rillaar | V09MOT144270 | 33,6 | 0.60 | 0.39 | -9.6 | 1997-2010 |
| 14510102 - Velp; Ransberg | V09VEL145100 | 96,8 | 0.67 | 0.67 | -1.3 | 1969-2013 |
| 141 - Rotselaar ; Winge | V09WIN141310 | 64,7 | 0.67 | 0.63 | 0.63 | 1987-2013 |
| 14810102 - Zwarte Beek; Lummen | V09ZWA148120 | 96,5 | 0.46 | 0.28 | -8.5 | 1983-2013 |

16310102 - Herk, Kermt (V09HER163010)

Figure 61 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (2001-2013)

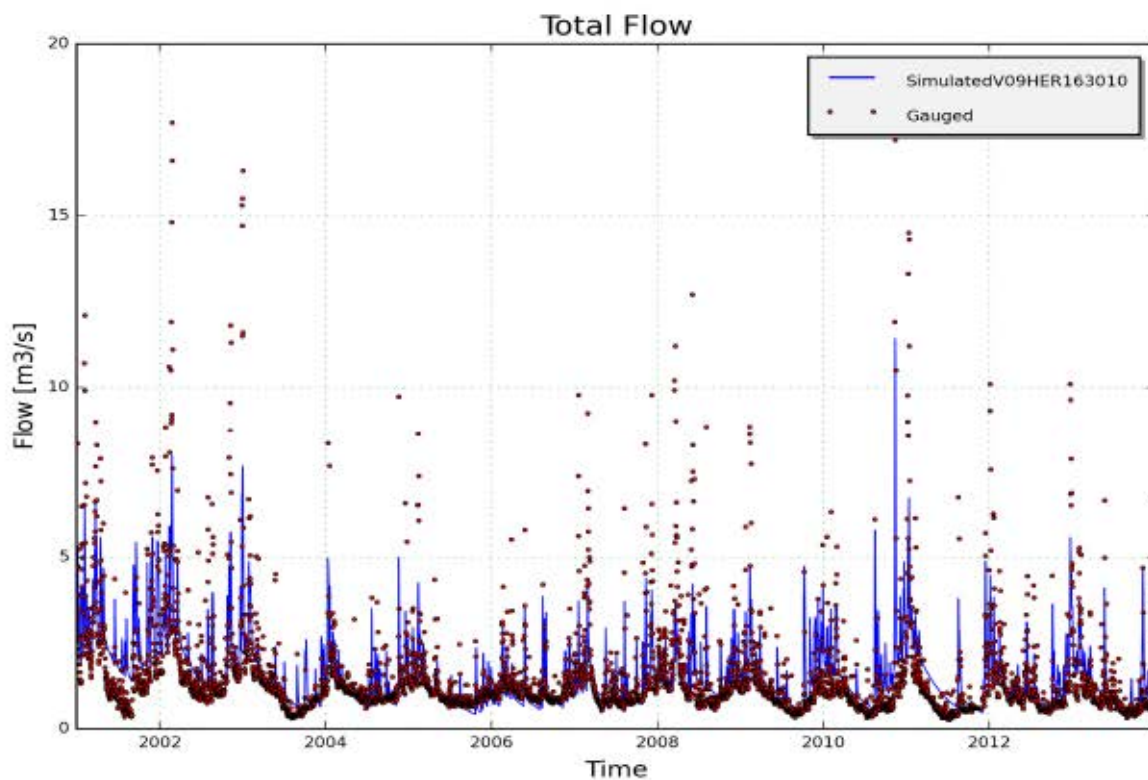


Figure 62 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V09HER163010, station 16310102 - Herk, Kermt (2001-2013)

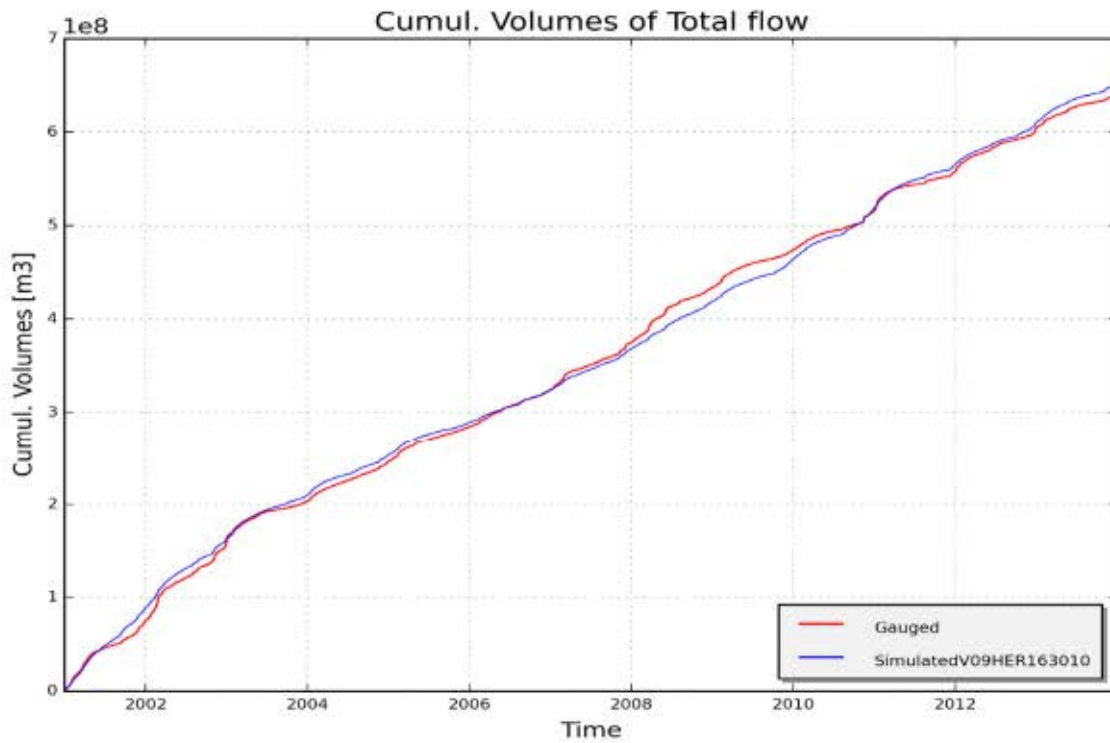
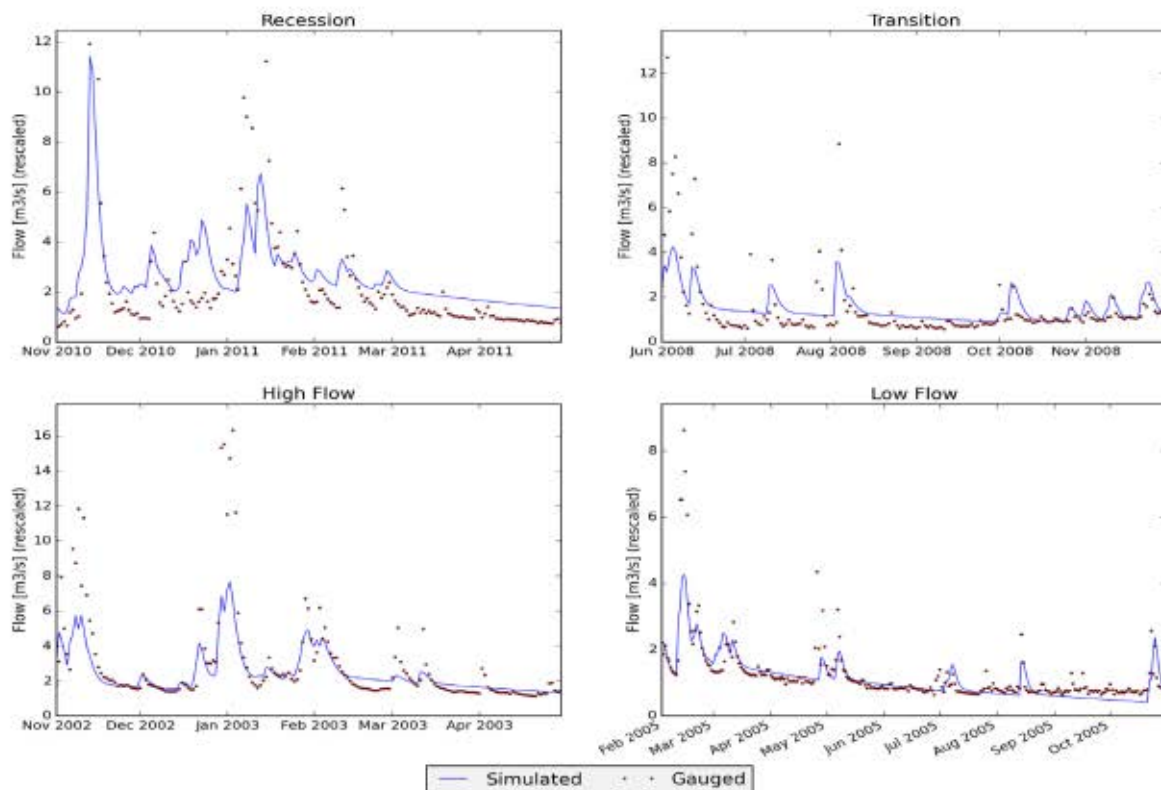


Figure 63 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt



14810102 - Zwarte Beek; Lummen (V09ZWA148120)

Figure 64 – Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (2001-2007)

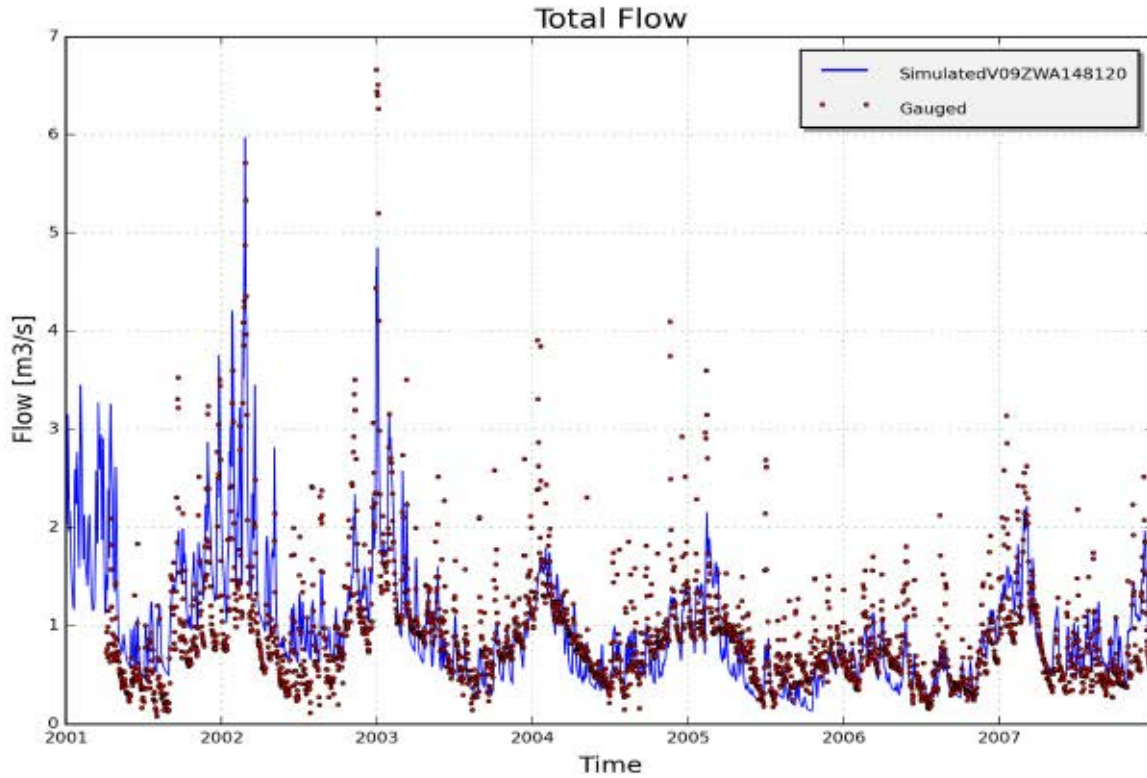


Figure 65 – Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (2001-2007)

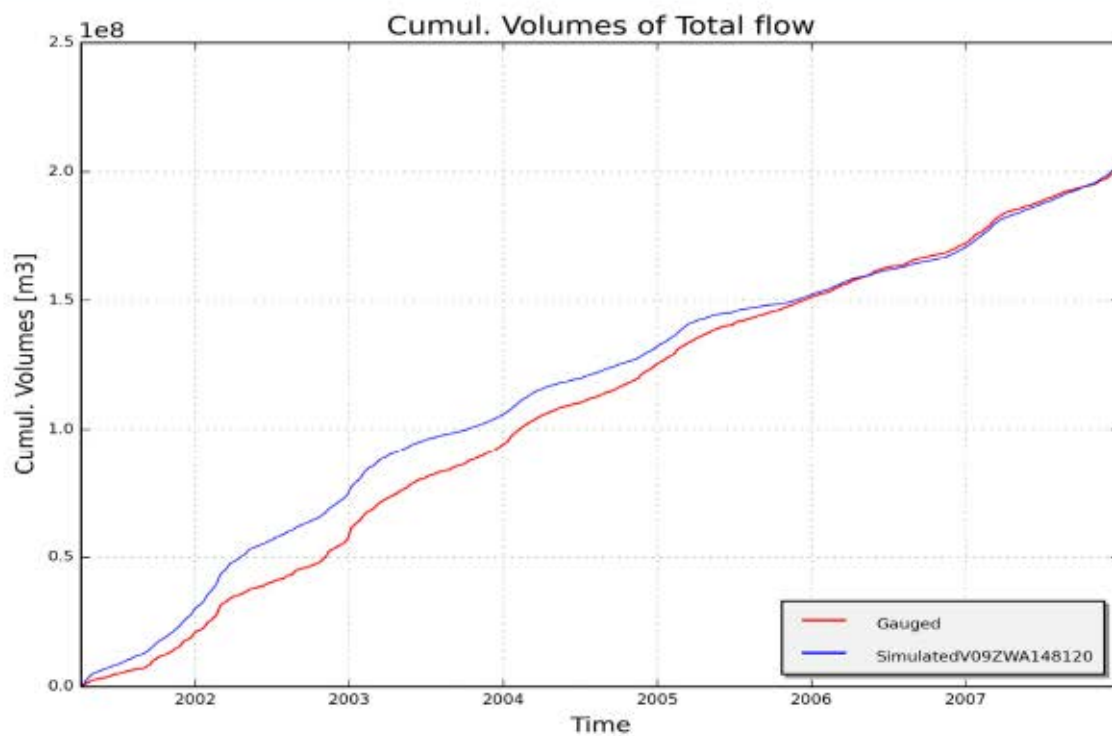


Figure 66 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

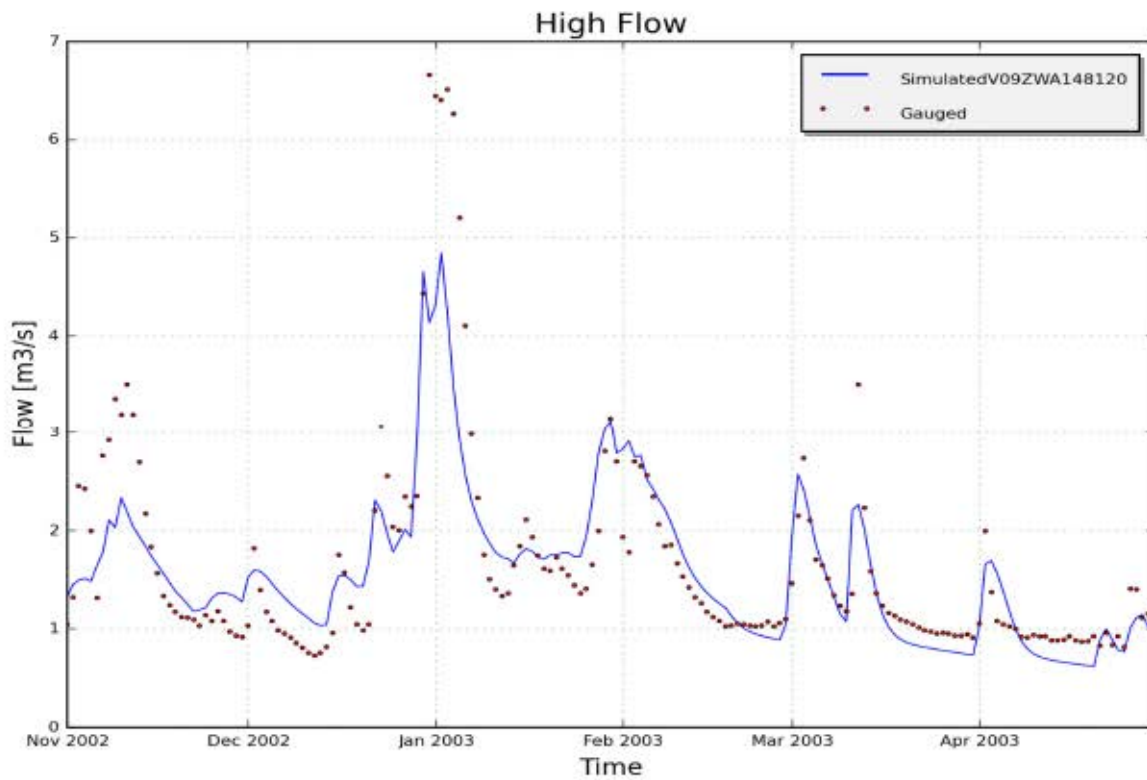
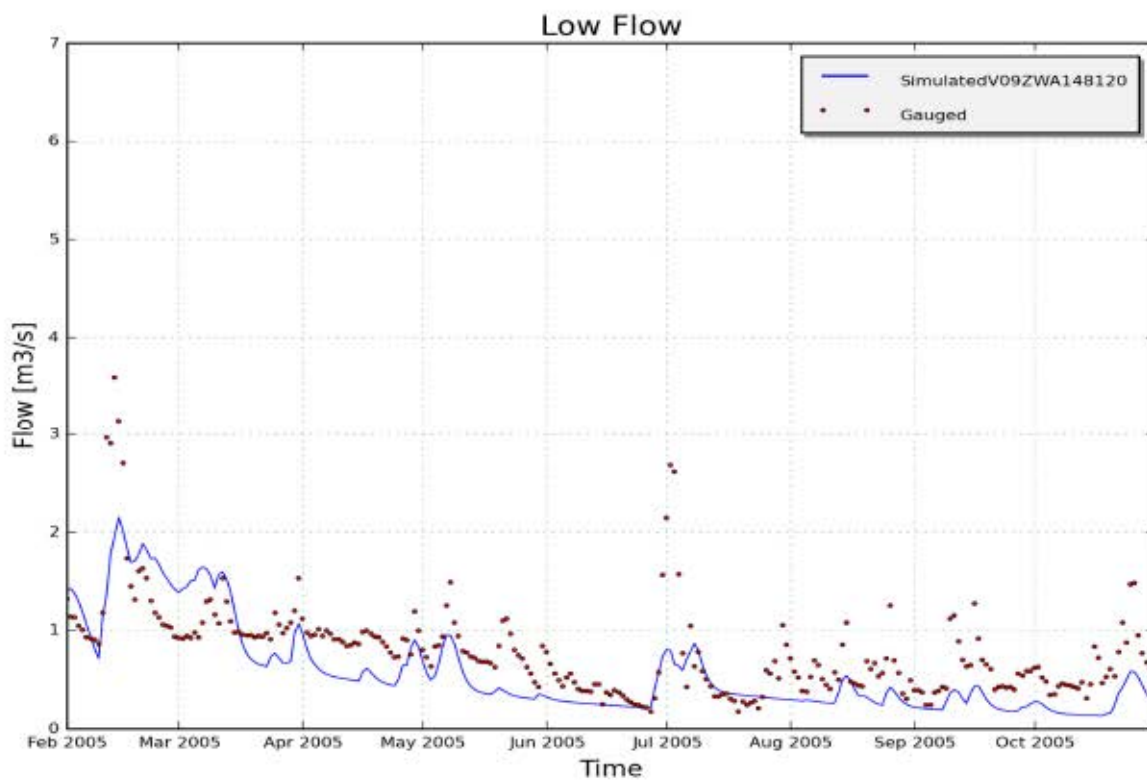


Figure 67 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen



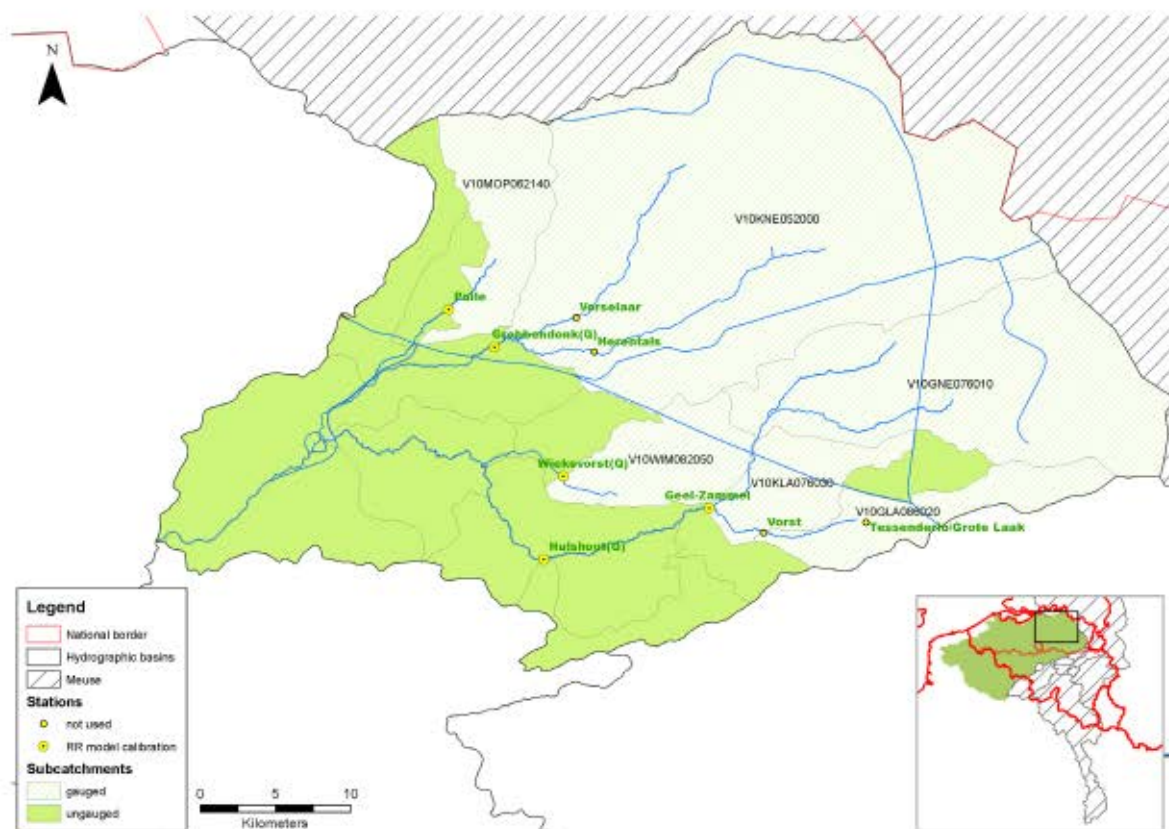
6.12 Netebekken

6.12.1 Context

The Nete catchment reaches over 1 673 km² and is located in North-East of Flanders. It can be divided into two catchments corresponding to the main rivers: Kleine Nete and Grote Nete. These two rivers flow together in Lier, where they coincide in the Beneden-Nete. This flows together with the Dijle to become the Rupel. The Nete basin accounts for 8 % of the total surface area of the Scheldt basin.

There are 5 gauging stations used for calibration of the rainfall-runoff models, covering 63 % of the Nete catchment surface area.

Figure 68 – Subcatchments and measure points for the Nete basin



6.12.2 Model performance

Table 23 and Table 24 present general performance statistics for the gauged catchments of the Nete basin. Graphs of simulations of the catchments with code **V10KNE052000** (best model performance) and **V10WIM082050** (worst model performance) are presented below (Figure 70 to Figure 76). For more detailed results on the other subcatchments is referred to Annex 12.

The model performance is satisfactory for most of the catchments in the Nete basin, with NSE and Log NSE values above 0.60 and Relative error values lower than ± 1 (i.e. **V10KNE052000**, **V10MOP062140**). However, it is necessary to highlight the difficulties found in some of the catchments. It is known that within this catchment several water courses are liable to abundant vegetation, which causes changes in the $q(h)$ relationships at the gauging station. This leads to more uncertainties in the gauged discharges. Although the catchment with code **V10GLA086020** presents good statistical results for the calibration period (Table 23),

there is a tendency to underestimate low flows. Furthermore, the statistical vales for the validation period point to a discrepancy between measurements and simulation results (NSE=0.456, LogNSE=0.284 and RelErr=-8.8%). The statistical results of the catchment with code **V10GNE076999** are acceptable, with NSE and LogNSE values above 0.60; however, there is a general tendency to underestimate low flows (i.e. 2003, 2005, 2006). According to the catchment with code **V10WIM082050**, the statistical values NSE and LogNSE are lower than 0.60 for the calibration and especially validation period (Table 23 and Table 24). However, except for some years where the low flow is overestimated (i.e. 1999, 2000, 2003), the general model performance for low flows can be considered as acceptable.

Data remarks: Some catchments are calibrated for different periods as the normally used (2001-2013). The gauging station **8610102 - Grote Laak in Vorst (V10GLA086020)** does not have discharge data from 2008 and during the years 1997 and 1998, so that the period selected for the calibration of this catchment is shorter (1999-2007). The calibration period of the catchment **V10GNE076999** is 2003-2013 since there is not data available in 2002. The catchment with code **V10MOP062140** does not have data from 23/04/2010 to 11/10/2011 and from 01/01/2004 to 31/12/2006, so that the calibration period has been selected from 1997 in order to have the same years of calibration than the other catchments. According to the gauging station **8210102 – Wiekevorst (V10WIM082050)**, the calibration period only lasts until the year 2007 due to unavailability of discharge data.

Table 23 – Overview of calibration results for gauged catchments on the Nete basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr | Calibration period |
|------------------------------------|----------------|-------------------------|------|--------|--------|--------------------|
| 8610102 - Grote Laak, Vorst | V10GLA086020 | 62,6 | 0.71 | 0.59 | -0.7 | 1999-2007 |
| 7610102 Grote Nete/Geel Zammel | V10GNE076999 | 243,5 | 0.71 | 0.65 | -2.9 | 2003-2013 |
| 5210102 - Kleine Nete; Grobbendonk | V10KNE052000 | 584,7 | 0.80 | 0.81 | -0.6 | 2001-2013 |
| 6210102 - Molenbeek, Pulle | V10MOP062140 | 77,3 | 0.60 | 0.66 | -0.5 | 1997-2013 |
| 8210102 - Wiekevorst | V10WIM082050 | 65,7 | 0.58 | 0.47 | -0.9 | 1995-2007 |

Table 24 – Overview of validation results for gauged catchments on the Nete basin

| Gauging station | Catchment code | Area (km ²) | NSE | logNSE | RelErr | Validation period |
|------------------------------------|----------------|-------------------------|------|--------|--------|-------------------|
| 8610102 - Grote Laak, Vorst | V10GLA086020 | 62,6 | 0.58 | 0.28 | -18.4 | 1986-2007 |
| 7610102 Grote Nete/Geel Zammel | V10GNE076999 | 243,5 | 0.70 | 0.57 | -7.4 | 1985-2013 |
| 5210102 - Kleine Nete; Grobbendonk | V10KNE052000 | 584,7 | 0.82 | 0.79 | -2.4 | 1983-2013 |
| 6210102 - Molenbeek, Pulle | V10MOP062140 | 77,3 | 0.64 | 0.63 | 12.2 | 1987-2013 |
| 8210102 - Wiekevorst | V10WIM082050 | 65,7 | 0.54 | 0.40 | 10.1 | 1990-2007 |

5210102 - Kleine Nete; Grobbendonk (V10KNE052000)

Figure 69 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (2001-2013)

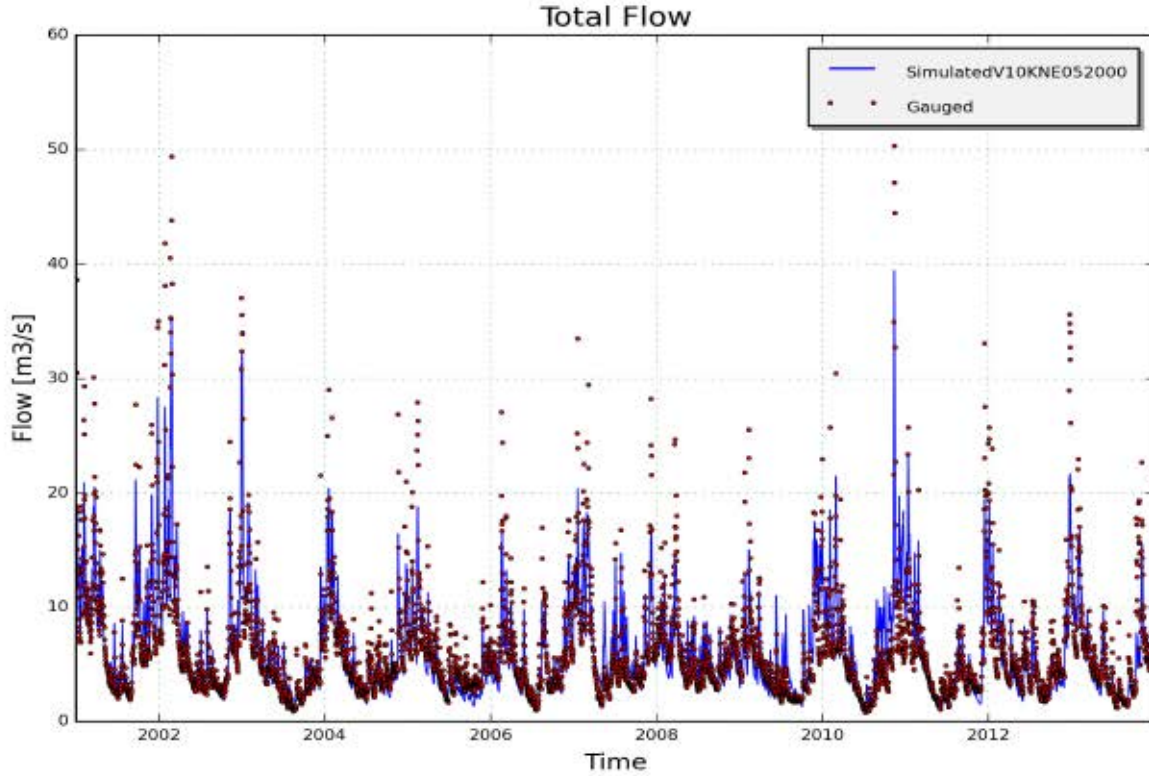


Figure 70 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (2001-2013)

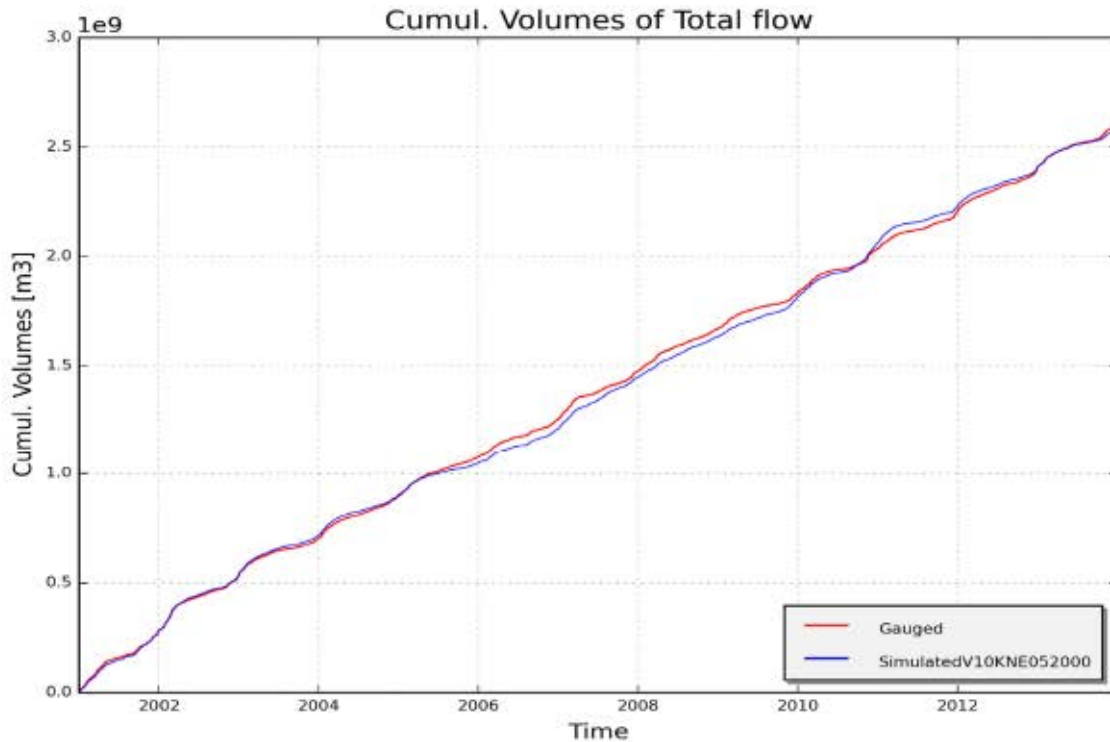
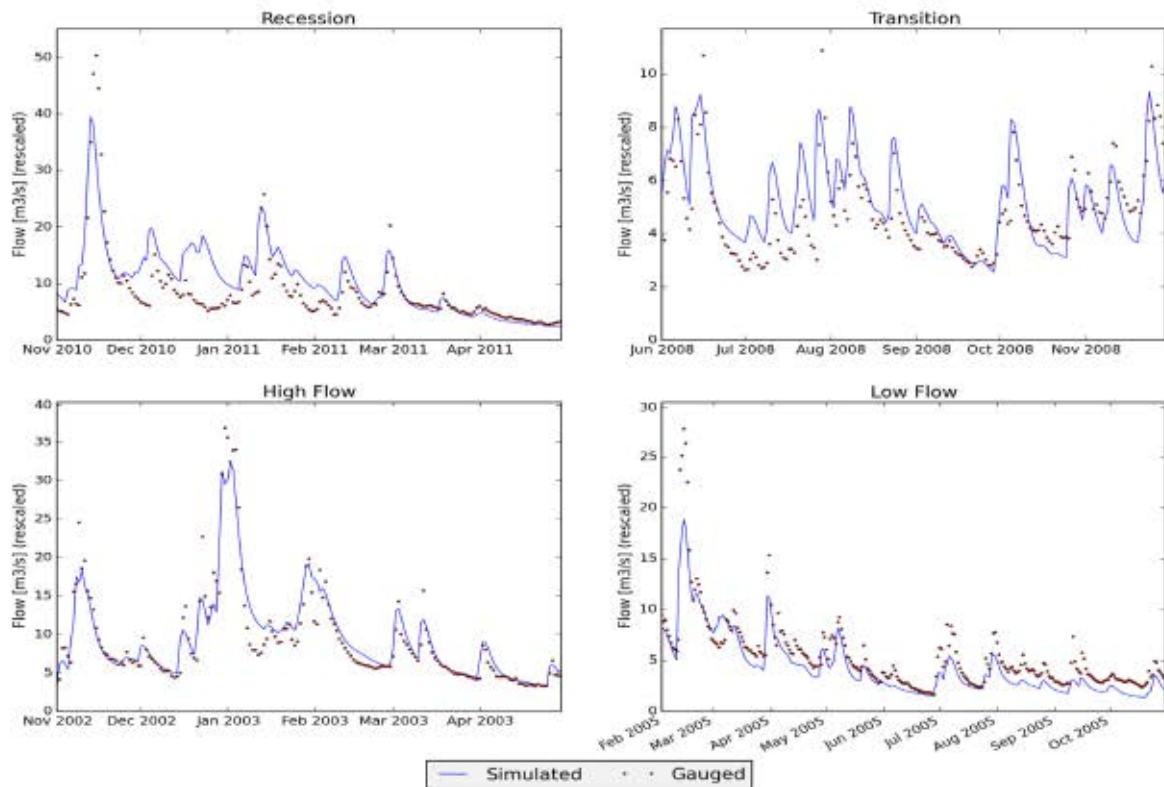


Figure 71 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events



8210102 – Wiekevorst (V10WIM082050)

Figure 72 – Measured (red) and simulated (blue) daily discharge [m^3/s] on catchment V10WIM082050, station 8210102 – Wiekevorst (1995-2007)

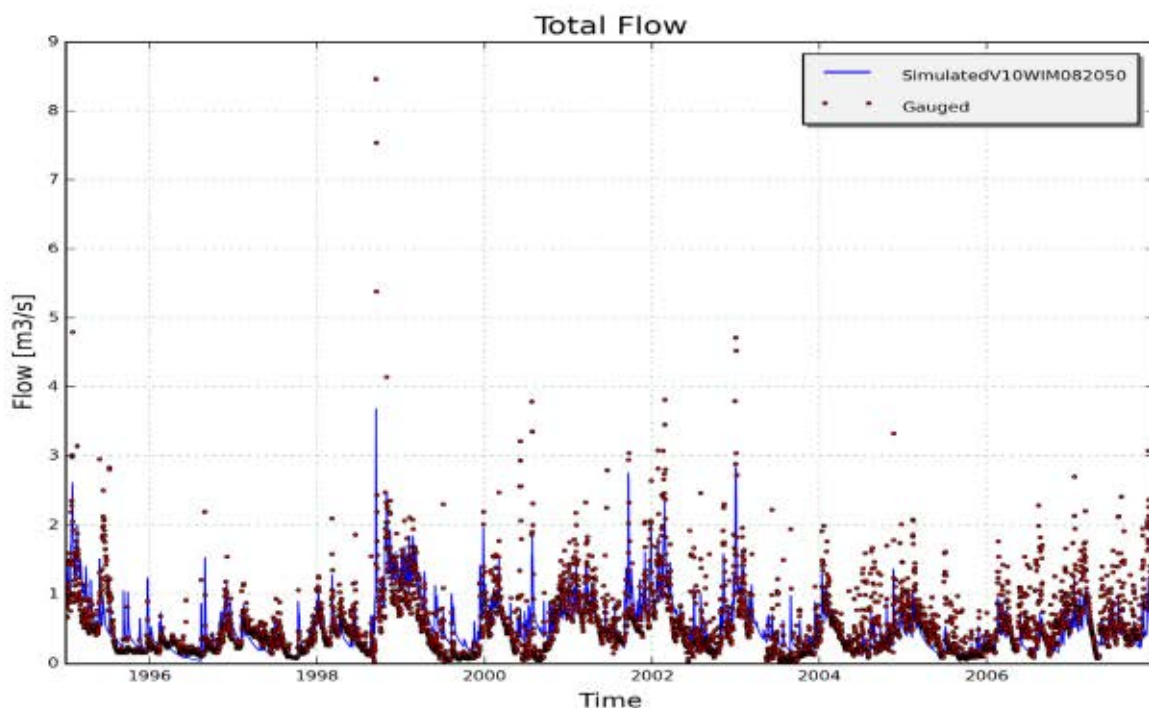


Figure 73 – Measured (red) and simulated (blue) cumulative discharge [m^3] on catchment V10WIM082050, station 8210102 – Wiekevorst (1995-2007)

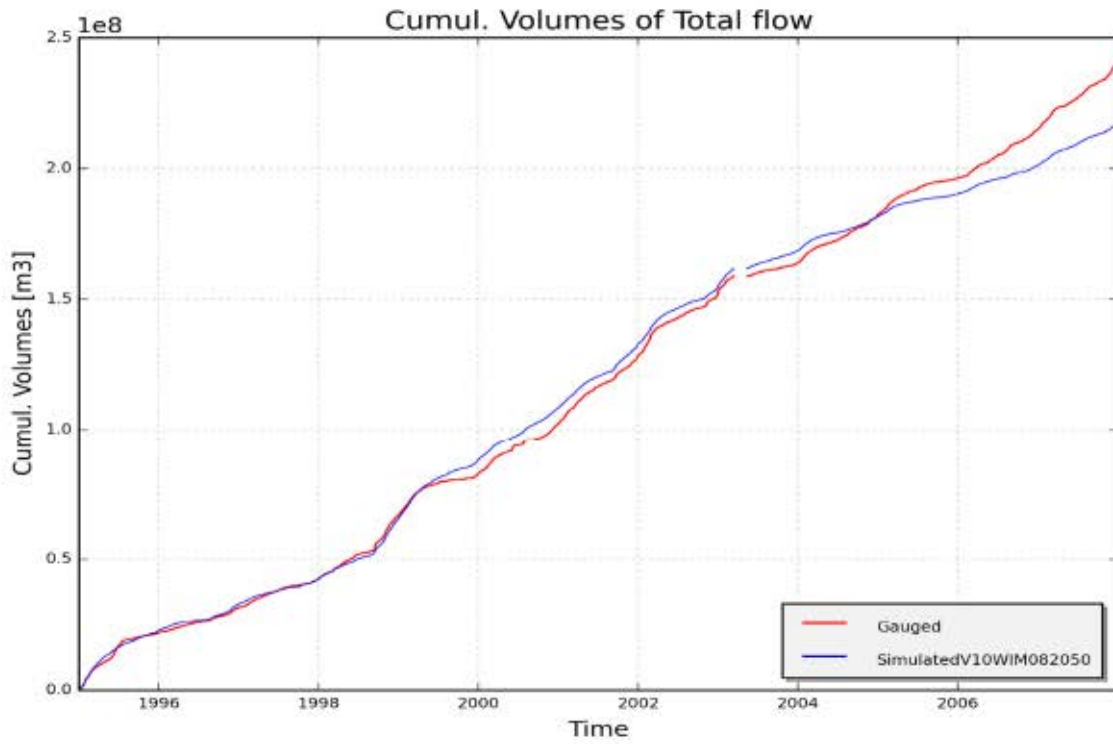


Figure 74 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

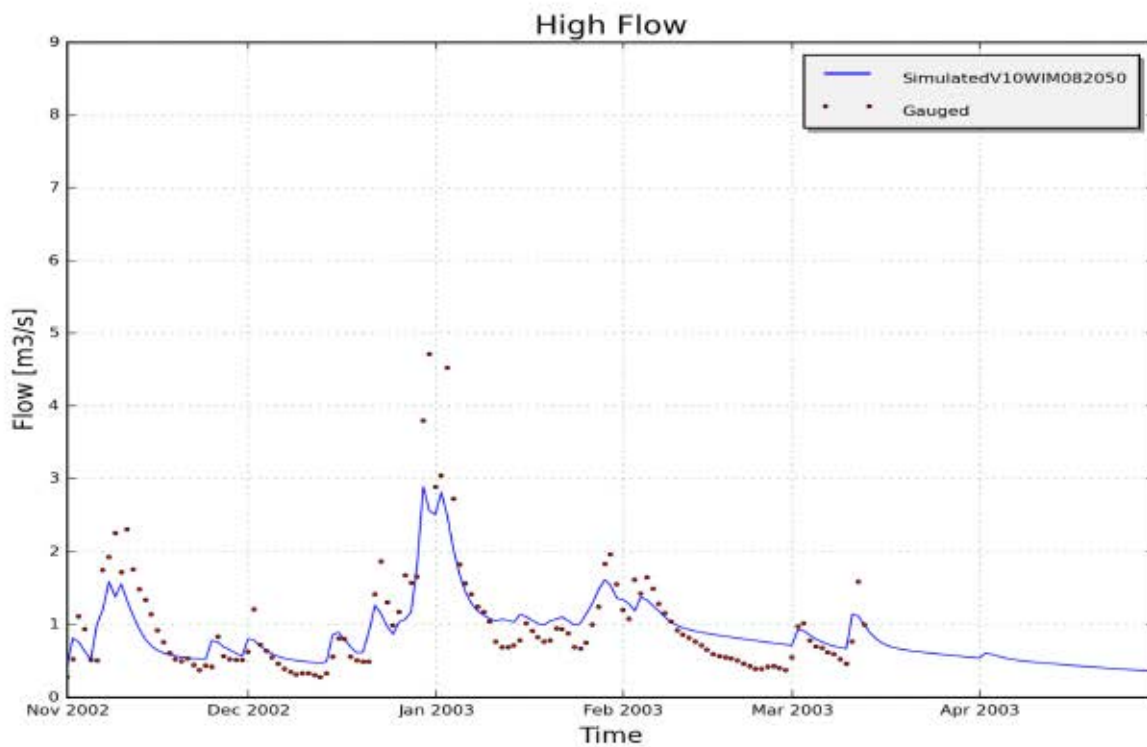
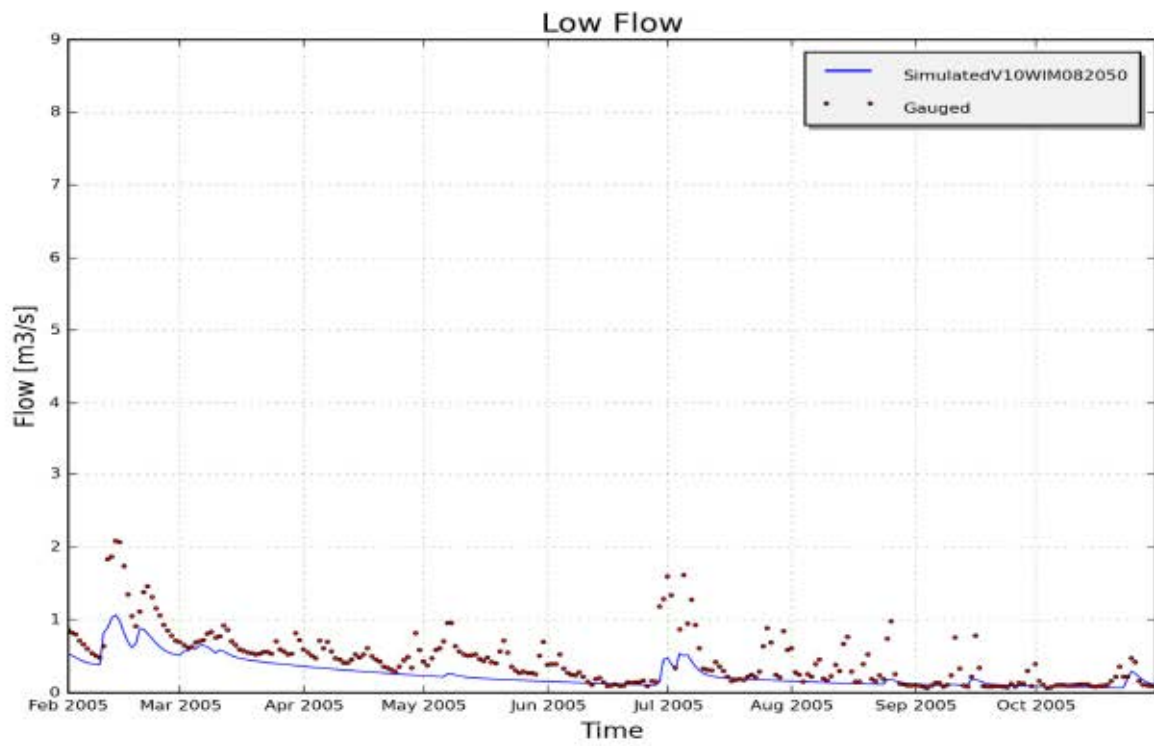


Figure 75 – Measured (red) and simulated (blue) daily discharge [m^3/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 – Wiekevorst



7 Summary

As stated before, the comprehensive results for each of the calibrated subcatchments, are attached from Annex 3 to Annex 12. In these Annexes the calibration summary, graphs and statistics are listed.

7.1 Comparison with original NAM models

In the project WL-09-46, the NAM models that were calibrated in previous studies were used as input in the water allocation model. As these NAM models were principally developed to be used in flood forecasting studies, these original hydrological models were calibrated focusing on high flows. By way of illustration, the simulated discharges of both the original model and the newly calibrated NAM model are displayed for each of the subcatchments in Annex 13. When evaluating these results, it is important to keep in mind that only a short (3 months) period is reported here. For some catchments the NSE values and/or the visual correspondence will therefore be deviant from the overall correspondence. For the majority of the catchments the simulated flows approach the gauged low flows best with the updated NAM model. Additionally the NSE of the updated catchment is generally better than the original NSE.

7.2 Graphical overview of the model performance

To give a quick overview of the overall result for the calibrated hydrological NAM models, a geographical summary is given in Annex 14 and Annex 15. Based on the statistics for each of the NAM models, a reclassification is performed to result in a quotation for the overall model performance. This quotation is then incorporated in a general map for the study area.

8 Conclusions and recommendations

The water balance model of the Scheldt basin will be used in order to perform low flow forecasts and calculate climate change scenarios. The goal of this subtask of the project 'Modelling water availability and water allocation strategies in the Scheldt basin', is to define the most appropriate hydrological models for the water balance model of the Scheldt basin in order to meet this prerequisite. Therefore, different hydrological models for each of the subcatchments in the study area are set up and evaluated on their appropriateness for low flow forecasting and climate change scenarios. The regarded models are NAM (©DHI), PDM (©Innovyze), VHM (©Willems, P.) and WETSPA (©VUB).

This subreport covers the recalibration and evaluation of the NAM models, which are part of the MIKE 11 software package (DHI, 2009). Hydrological NAM models for the gauged catchments (i.e. catchments upstream of a gauging station) were recalibrated whereby the focus is mainly on low flows. This calibration is done using an automatic optimization procedure followed by a visual control. During the optimization routine the best parameters set is selected for each catchment based on 2 criteria: (1) absolute error on cumulated total flow at each time step, and (2) logarithmic Nash-Sutcliffe efficiency. The first criterion aims to model the global flow pattern, the latter focuses mainly on the low flows. As a result, for each of the hydrological catchments, the NAM parameters are updated.

Overall, the performance of the updated NAM models, is substantially improved compared to the original NAM models.

As the final performance of the water balance model is directly dependent on its hydrological input, it is important to have insight in the performance of these hydrological input models. This is also the case when using the hydrological (e.g. NAM) models as input for simulations with the water balance model. The summarized results for each of the gauged subcatchments within the study area, allow the user to get insight in the performance of the NAM model for each of the involved subcatchments. Based on this information and the evaluation of the PDM, VHM and WETSPA models, the user will be able to make a well-grounded decision on which model to use for the considered objective. Therefore, this summarizing report should be consulted by any user applying the corresponding NAM models. In this way, the user gains insight in the uncertainties and performance of the hydrological models for each of the considered subcatchments.

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Appendix 1 List of optimized parameters for gauged catchments

| Catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|------------|-------|--------|------|----------|---------|-------|-------|------|------|------|
| V01HAN488180 | 78558940 | 7.92 | 265.39 | 0.90 | 1599.35 | 260.71 | 9.63 | 17.69 | 0.12 | 0.32 | 0.28 |
| V01HEI468999 | 393007000 | 15.01 | 113.10 | 0.90 | 3155.73 | 135.12 | 29.42 | 46.10 | 0.97 | 0.00 | 0.08 |
| V01IEP495080 | 63423128 | 13.58 | 586.71 | 0.81 | 2472.06 | 471.39 | 37.97 | 21.08 | 0.90 | 0.27 | 0.16 |
| V01KEM492060 | 73892930 | 4.62 | 132.47 | 0.79 | 1267.60 | 116.00 | 37.90 | 36.50 | 0.53 | 0.13 | 0.01 |
| V01MAR496120 | 76136621 | 9.08 | 103.97 | 0.80 | 1227.76 | 50.24 | 21.64 | 30.36 | 0.70 | 0.01 | 0.01 |
| V01POP491030 | 84868207 | 14.00 | 200.00 | 0.50 | 1000.00 | 393.60 | 30.00 | 28.80 | 0.90 | 0.01 | 0.22 |
| V01SSV499140 | 16095000 | 8.60 | 270.27 | 0.71 | 1579.45 | 344.62 | 29.27 | 28.57 | 0.53 | 0.16 | 0.61 |
| V02EDE442120 | 45489177 | 10.32 | 297.82 | 0.80 | 1036.24 | 540.27 | 39.67 | 42.18 | 0.68 | 0.39 | 0.80 |
| V02HER426010 | 77272201 | 15.00 | 489.24 | 0.73 | 1895.20 | 532.83 | 37.31 | 32.77 | 0.32 | 0.68 | 0.75 |
| V02KER422030 | 62718738 | 11.62 | 145.28 | 0.80 | 1570.54 | 214.48 | 29.61 | 23.79 | 0.60 | 0.20 | 0.11 |
| V02RIV425020 | 63980423 | 13.87 | 479.81 | 0.54 | 1530.32 | 291.54 | 40.53 | 19.96 | 0.84 | 0.20 | 0.13 |
| V03POE446000 | 106836849 | 13.84 | 189.96 | 0.79 | 1438.68 | 537.49 | 28.39 | 32.31 | 0.22 | 0.37 | 0.47 |
| V04MOL036110 | 32561957 | 8.32 | 538.34 | 0.57 | 1980.16 | 441.52 | 31.04 | 28.51 | 0.20 | 0.49 | 0.43 |
| V04MOM037100 | 67301328 | 8.97 | 436.18 | 0.50 | 1263.44 | 484.90 | 40.43 | 37.66 | 0.30 | 0.40 | 0.39 |
| F05LEI386999 | 2981779554 | 2.00 | 415.00 | 0.50 | 1100.00 | 270.00 | 44.00 | 32.00 | 0.60 | 0.10 | 0.10 |
| V05HEU403210 | 91912331 | 7.73 | 142.39 | 0.72 | 1021.65 | 148.29 | 34.08 | 29.70 | 0.70 | 0.01 | 0.13 |
| V05MAN401230 | 258441818 | 14.03 | 400.00 | 0.64 | 3500.00 | 750.00 | 44.10 | 28.97 | 0.48 | 0.20 | 0.70 |
| F06BOS325999 | 5217586196 | 5.83 | 466.26 | 0.20 | 1858.10 | 434.89 | 39.80 | 27.31 | 0.70 | 0.20 | 0.01 |
| V06MAA347160 | 48678191 | 15.71 | 471.22 | 0.86 | 33896.65 | 8000.98 | 21.42 | 20.78 | 0.23 | 0.90 | 0.85 |
| V06ZWA342190 | 112117540 | 2.33 | 95.71 | 0.51 | 1986.21 | 287.75 | 29.44 | 23.14 | 0.70 | 0.21 | 0.03 |
| W06RHOL54100 | 161928446 | 15.00 | 598.36 | 0.20 | 1457.68 | 749.84 | 29.25 | 17.37 | 0.70 | 0.01 | 0.98 |
| V07BEL285070 | 88641710 | 15.43 | 506.15 | 0.25 | 3562.63 | 545.63 | 31.54 | 30.64 | 0.20 | 0.20 | 0.50 |
| V07MAR289015 | 173908791 | 12.80 | 458.54 | 0.80 | 1506.59 | 424.26 | 25.70 | 29.54 | 0.70 | 0.41 | 0.31 |

| Catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------|-------|---------|------|---------|---------|-------|-------|------|------|------|
| V07MOE282100 | 46367171 | 4.89 | 77.01 | 0.52 | 1833.47 | 245.36 | 28.46 | 30.49 | 0.45 | 0.20 | 0.31 |
| V07MOG288020 | 23093628 | 24.90 | 700.00 | 0.56 | 2440.00 | 1900.00 | 30.00 | 30.00 | 0.59 | 0.64 | 0.80 |
| W07DENLES999 | 511840662 | 12.00 | 850.00 | 0.50 | 3300.00 | 550.00 | 39.91 | 38.15 | 0.59 | 0.66 | 0.72 |
| V08BAR111370 | 70079800 | 4.83 | 452.25 | 0.37 | 1138.99 | 369.59 | 36.58 | 30.89 | 0.20 | 0.21 | 0.12 |
| V08DUJ093400 | 861413000 | 4.79 | 2761.19 | 0.17 | 1744.70 | 462.70 | 21.83 | 38.10 | 0.90 | 0.44 | 0.41 |
| V08ZUU233100 | 64771005 | 18.96 | 587.13 | 0.48 | 1873.69 | 562.56 | 32.02 | 33.87 | 0.87 | 0.10 | 0.32 |
| W08SAMRON000 | 134097000 | 12.76 | 1528.91 | 0.32 | 1758.99 | 501.12 | 43.32 | 16.93 | 0.70 | 0.31 | 0.44 |
| W08SENL56010 | 70364773 | 19.54 | 965.60 | 0.31 | 1989.80 | 4506.17 | 30.95 | 18.15 | 0.78 | 0.20 | 0.41 |
| W08SENTUB030 | 215911078 | 13.35 | 325.56 | 0.83 | 1536.30 | 483.24 | 29.50 | 29.64 | 0.70 | 0.44 | 0.03 |
| V09DEM136000 | 255882000 | 9.58 | 751.12 | 0.35 | 2200.00 | 531.80 | 27.29 | 24.20 | 0.30 | 0.22 | 0.12 |
| V09GET152080 | 800395376 | 9.10 | 1814.65 | 0.09 | 1843.03 | 522.07 | 26.00 | 38.29 | 0.70 | 0.01 | 0.32 |
| V09HER163010 | 274602221 | 19.26 | 1675.52 | 0.27 | 3308.71 | 437.64 | 32.29 | 36.30 | 0.90 | 0.24 | 0.33 |
| V09HUL147150 | 80130245 | 0.40 | 35.00 | 0.27 | 8000.00 | 30.00 | 50.00 | 44.48 | 0.01 | 0.01 | 0.01 |
| V09LOS143300 | 15176294 | 11.29 | 1087.47 | 0.59 | 1234.35 | 485.29 | 25.27 | 16.43 | 0.53 | 0.70 | 0.66 |
| V09MAN161040 | 103081000 | 3.63 | 353.69 | 0.24 | 1596.55 | 483.93 | 35.11 | 31.33 | 0.25 | 0.06 | 0.01 |
| V09MOT144270 | 33590217 | 6.64 | 382.53 | 0.80 | 4808.55 | 480.53 | 33.48 | 33.11 | 0.01 | 0.33 | 0.00 |
| V09VEL145100 | 96801128 | 13.73 | 519.68 | 0.30 | 1744.68 | 635.00 | 24.57 | 26.15 | 0.20 | 0.32 | 0.36 |
| V09WIN141310 | 64739169 | 10.82 | 1491.15 | 0.35 | 1361.86 | 346.34 | 8.57 | 17.57 | 0.47 | 0.49 | 0.52 |
| V09ZWA148120 | 96514800 | 7.11 | 607.27 | 0.80 | 1934.50 | 136.41 | 25.94 | 34.83 | 0.10 | 0.57 | 0.08 |
| V10GLA086020 | 62621236 | 1.00 | 263.15 | 0.21 | 1694.68 | 201.28 | 32.07 | 28.13 | 0.01 | 0.00 | 0.01 |
| V10GNE076999 | 359885327 | 0.71 | 414.50 | 0.20 | 1525.84 | 232.16 | 42.37 | 38.80 | 0.70 | 0.08 | 0.00 |
| V10KNE052000 | 584669408 | 5.03 | 245.35 | 0.38 | 1321.53 | 271.71 | 40.25 | 40.69 | 0.20 | 0.24 | 0.01 |

Appendix 2 List of transferred parameters for ungauged catchments

| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|------|--------|-------|------|-------|------|------|-----|-----|-----|
| F01YSE468000 | F01IJZ468000 | 361120000 | 15 | 113.1 | 0.9 | 3156 | 135.1 | 29.4 | 46.1 | 1.0 | 0.0 | 0.1 |
| F05AAA000010 | F05LEI386999 | 248452728 | 2 | 415 | 0.5 | 1100 | 270.0 | 35.4 | 24.6 | 0.6 | 0.1 | 0.1 |
| F05AAA571000 | F05LEI386999 | 374113103 | 2 | 415 | 0.5 | 1100 | 270.0 | 36.2 | 23.8 | 0.6 | 0.1 | 0.1 |
| F05BEC386023 | F05LEI386999 | 80086039 | 2 | 415 | 0.5 | 1100 | 270.0 | 31.7 | 28.3 | 0.6 | 0.1 | 0.1 |
| F05BEC386025 | F05LEI386999 | 68930969 | 2 | 415 | 0.5 | 1100 | 270.0 | 31.5 | 28.5 | 0.6 | 0.1 | 0.1 |
| F05BOU386005 | F05LEI386999 | 255392628 | 2 | 415 | 0.5 | 1100 | 270.0 | 34.1 | 25.9 | 0.6 | 0.1 | 0.1 |
| F05CLA386017 | F05LEI386999 | 36547273 | 2 | 415 | 0.5 | 1100 | 270.0 | 30.1 | 29.9 | 0.6 | 0.1 | 0.1 |
| F05CLA386020 | F05LEI386999 | 226006473 | 2 | 415 | 0.5 | 1100 | 270.0 | 33.7 | 26.3 | 0.6 | 0.1 | 0.1 |
| F05DEU386040 | F05LEI386999 | 448818370 | 2 | 415 | 0.5 | 1100 | 270.0 | 37.1 | 22.9 | 0.6 | 0.1 | 0.1 |
| F05DEU386050 | F05LEI386999 | 74083951 | 2 | 415 | 0.5 | 1100 | 270.0 | 32.1 | 27.9 | 0.6 | 0.1 | 0.1 |
| F05DEU386060 | F05LEI386999 | 116669136 | 2 | 415 | 0.5 | 1100 | 270.0 | 33.6 | 26.4 | 0.6 | 0.1 | 0.1 |
| F05DEU386080 | F05LEI386999 | 57192180 | 2 | 415 | 0.5 | 1100 | 270.0 | 30.9 | 29.1 | 0.6 | 0.1 | 0.1 |
| F05DEU386090 | F05LEI386999 | 12829199 | 2 | 415 | 0.5 | 1100 | 270.0 | 28.8 | 31.2 | 0.6 | 0.1 | 0.1 |
| F05DEU386110 | F05LEI386999 | 16919150 | 2 | 415 | 0.5 | 1100 | 270.0 | 29.9 | 30.1 | 0.6 | 0.1 | 0.1 |
| F05DEU386120 | F05LEI386999 | 39450392 | 2 | 415 | 0.5 | 1100 | 270.0 | 30.2 | 29.8 | 0.6 | 0.1 | 0.1 |
| F05DEU386130 | F05LEI386999 | 21724484 | 2 | 415 | 0.5 | 1100 | 270.0 | 29.6 | 30.4 | 0.6 | 0.1 | 0.1 |
| F05DEU386140 | F05LEI386999 | 7480581 | 2 | 415 | 0.5 | 1100 | 270.0 | 28.5 | 31.5 | 0.6 | 0.1 | 0.1 |
| F05DEU386150 | F05LEI386999 | 39193251 | 2 | 415 | 0.5 | 1100 | 270.0 | 29.9 | 30.1 | 0.6 | 0.1 | 0.1 |
| F05DEU386160 | F05LEI386999 | 27005232 | 2 | 415 | 0.5 | 1100 | 270.0 | 29.7 | 30.3 | 0.6 | 0.1 | 0.1 |
| F05HEM000020 | F05LEI386999 | 134010959 | 2 | 415 | 0.5 | 1100 | 270.0 | 33.6 | 26.4 | 0.6 | 0.1 | 0.1 |
| F05LAW386018 | F05LEI386999 | 102249474 | 2 | 415 | 0.5 | 1100 | 270.0 | 31.0 | 29.0 | 0.6 | 0.1 | 0.1 |
| F05LAW386030 | F05LEI386999 | 188699853 | 2 | 415 | 0.5 | 1100 | 270.0 | 33.5 | 26.5 | 0.6 | 0.1 | 0.1 |
| F05LOI386035 | F05LEI386999 | 113093218 | 2 | 415 | 0.5 | 1100 | 270.0 | 32.1 | 27.9 | 0.6 | 0.1 | 0.1 |
| F05LYS386000 | F05LEI386999 | 375288119 | 2 | 415 | 0.5 | 1100 | 270.0 | 35.8 | 24.2 | 0.6 | 0.1 | 0.1 |
| F05LYS386010 | F05LEI386999 | 75860338 | 2 | 415 | 0.5 | 1100 | 270.0 | 31.9 | 28.1 | 0.6 | 0.1 | 0.1 |
| F05LYS386015 | F05LEI386999 | 28126242 | 2 | 415 | 0.5 | 1100 | 270.0 | 30.2 | 29.8 | 0.6 | 0.1 | 0.1 |
| F05LYS386115 | F05LEI386999 | 168458564 | 2 | 415 | 0.5 | 1100 | 270.0 | 33.5 | 26.5 | 0.6 | 0.1 | 0.1 |
| F05MAR386070 | F05LEI386999 | 200520118 | 2 | 415 | 0.5 | 1100 | 270.0 | 34.4 | 25.6 | 0.6 | 0.1 | 0.1 |
| F05MAR386100 | F05LEI386999 | 26635692 | 2 | 415 | 0.5 | 1100 | 270.0 | 29.6 | 30.4 | 0.6 | 0.1 | 0.1 |
| F06BOS325000 | F06BOS325001 | 775406341 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 42.4 | 17.6 | 0.7 | 0.2 | 0.0 |
| F06BOS325015 | F06BOS325001 | 107626587 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 31.9 | 28.1 | 0.7 | 0.2 | 0.0 |
| F06BOS325016 | F06BOS325001 | 142957003 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 33.1 | 26.9 | 0.7 | 0.2 | 0.0 |
| F06BOS325017 | F06BOS325001 | 33675779 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 30.2 | 29.8 | 0.7 | 0.2 | 0.0 |

| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-------------|-------|--------|-------|------|-------|------|------|-----|-----|-----|
| F06BOS325018 | F06BOS325001 | 16911203 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 28.6 | 31.4 | 0.7 | 0.2 | 0.0 |
| F06BOS325019 | F06BOS325001 | 36767530 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 29.7 | 30.3 | 0.7 | 0.2 | 0.0 |
| F06ECA325050 | F06BOS325001 | 191873673 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 33.8 | 26.2 | 0.7 | 0.2 | 0.0 |
| F06ERC325030 | F06BOS325001 | 167654904 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 33.8 | 26.2 | 0.7 | 0.2 | 0.0 |
| F06HOG325070 | F06BOS325001 | 208230656 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 34.0 | 26.0 | 0.7 | 0.2 | 0.0 |
| F06RHO325060 | F06BOS325001 | 80974476 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 32.1 | 27.9 | 0.7 | 0.2 | 0.0 |
| F06SCA325020 | F06BOS325001 | 464156652 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 37.2 | 22.8 | 0.7 | 0.2 | 0.0 |
| F06SCA325025 | F06BOS325001 | 805680274 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 43.5 | 16.5 | 0.7 | 0.2 | 0.0 |
| F06SEL325040 | F06BOS325001 | 201664095 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 35.6 | 24.4 | 0.7 | 0.2 | 0.0 |
| F06SEN325010 | F06BOS325001 | 599787214 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 39.4 | 20.6 | 0.7 | 0.2 | 0.0 |
| N03BRA000160 | W11BER551010 | 55104620 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 31.5 | 28.5 | 0.9 | 0.2 | 0.1 |
| N11MAA000060 | V09MOT144270 | 12970329080 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 77.9 | 3.0 | 0.0 | 0.3 | 0.0 |
| V01HAN000160 | V01MAR496120 | 92888613 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 33.2 | 26.8 | 0.7 | 0.0 | 0.0 |
| V01HEI468010 | F01IJZ468000 | 31890879 | 15.01 | 113.1 | 0.9 | 3156 | 135.1 | 30.1 | 29.9 | 1.0 | 0.0 | 0.1 |
| V01IEP000090 | V04MOL036110 | 3609701 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 28.2 | 31.8 | 0.2 | 0.5 | 0.4 |
| V01IEP000100 | V05HEU403210 | 24028123 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 29.8 | 30.2 | 0.7 | 0.0 | 0.1 |
| V01IEP000110 | V05HEU403210 | 6682382 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 29.1 | 30.9 | 0.7 | 0.0 | 0.1 |
| V01IJZ000020 | V01KEM492060 | 46105467 | 4.62 | 132.47 | 0.79 | 1268 | 116.0 | 31.7 | 28.3 | 0.5 | 0.1 | 0.0 |
| V01KEM000070 | V01KEM492060 | 12910514 | 4.62 | 132.47 | 0.79 | 1268 | 116.0 | 28.8 | 31.2 | 0.5 | 0.1 | 0.0 |
| V01MAR000130 | V01MAR496120 | 27537367 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 31.4 | 28.6 | 0.7 | 0.0 | 0.0 |
| V01POP000040 | V01MAR496120 | 34370958 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 30.0 | 30.0 | 0.7 | 0.0 | 0.0 |
| V01POP000050 | V04MOL036110 | 14704818 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 29.8 | 30.2 | 0.2 | 0.5 | 0.4 |
| V01SSV000150 | V01MAR496120 | 49650230 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 30.9 | 29.1 | 0.7 | 0.0 | 0.0 |
| V02AFL000140 | V02EDE442120 | 20916085 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 31.0 | 29.0 | 0.7 | 0.4 | 0.8 |
| V02BRU000110 | W11BER551010 | 5853310 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.9 | 32.1 | 0.9 | 0.2 | 0.1 |
| V02IVA000220 | W08SAMRON000 | 23089888 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.6 | 30.4 | 0.7 | 0.3 | 0.4 |
| V02JAB000040 | V02KER422030 | 24576621 | 11.62 | 145.28 | 0.8 | 1571 | 214.5 | 30.3 | 29.7 | 0.6 | 0.2 | 0.1 |
| V02KAT000100 | W08SAMRON000 | 11553682 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.0 | 31.0 | 0.7 | 0.3 | 0.4 |
| V02KGO000000 | V03POE446000 | 159793077 | 13.84 | 189.96 | 0.786 | 1439 | 537.5 | 33.9 | 26.1 | 0.2 | 0.4 | 0.5 |
| V02KGO000080 | V02EDE442120 | 11937762 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.0 | 31.0 | 0.7 | 0.4 | 0.8 |
| V02KWE000050 | W08SAMRON000 | 16546999 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.2 | 30.8 | 0.7 | 0.3 | 0.4 |
| V02LPK000170 | V02RIV425020 | 46643041 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 31.1 | 28.9 | 0.8 | 0.2 | 0.1 |
| V02LPK000180 | W08SAMRON000 | 31449434 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 30.4 | 29.6 | 0.7 | 0.3 | 0.4 |
| V02LPK000190 | W11BER551010 | 35092186 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 29.9 | 30.1 | 0.9 | 0.2 | 0.1 |
| V02MOE000160 | V02EDE442120 | 44401888 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 31.7 | 28.3 | 0.7 | 0.4 | 0.8 |
| V02NOO000150 | V02EDE442120 | 9234592 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.3 | 31.7 | 0.7 | 0.4 | 0.8 |
| V02NWG000210 | W08SAMRON000 | 12358385 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.3 | 30.7 | 0.7 | 0.3 | 0.4 |
| V02RIV000070 | V02EDE442120 | 5447570 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.1 | 31.9 | 0.7 | 0.4 | 0.8 |
| V02STE000090 | V02KER422030 | 27293881 | 11.62 | 145.28 | 0.8 | 1571 | 214.5 | 29.9 | 30.1 | 0.6 | 0.2 | 0.1 |

Modelling water availability and water allocation strategies in the Scheldt basin -
Sub report 4-1 – Analyses of hydrological models for climate change modelling – NAM

| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|--------|--------|-------|------|--------|------|------|-----|-----|-----|
| V02STE000115 | W11BER551010 | 17760000 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 29.9 | 30.1 | 0.9 | 0.2 | 0.1 |
| V02ZUI000060 | V02RIV425020 | 24223288 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 29.6 | 30.4 | 0.8 | 0.2 | 0.1 |
| V02ZUI000130 | V02RIV425020 | 45783008 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 31.9 | 28.1 | 0.8 | 0.2 | 0.1 |
| V02ZWI000200 | W08SAMRON000 | 34471720 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 31.7 | 28.3 | 0.7 | 0.3 | 0.4 |
| V03AFL000010 | V04MOL036110 | 41215066 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 32.4 | 27.6 | 0.2 | 0.5 | 0.4 |
| V03AFL000070 | V02EDE442120 | 56667175 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 31.7 | 28.3 | 0.7 | 0.4 | 0.8 |
| V03BOS000200 | V02EDE442120 | 26155768 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 30.9 | 29.1 | 0.7 | 0.4 | 0.8 |
| V03DUR000290 | V02EDE442120 | 6434651 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.6 | 31.4 | 0.7 | 0.4 | 0.8 |
| V03GEN000030 | W08SAMRON000 | 38982516 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 30.8 | 29.2 | 0.7 | 0.3 | 0.4 |
| V03HON000250 | V02EDE442120 | 20326328 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.9 | 30.1 | 0.7 | 0.4 | 0.8 |
| V03KAL000020 | V02RIV425020 | 43880593 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 30.9 | 29.1 | 0.8 | 0.2 | 0.1 |
| V03KAL000180 | V02EDE442120 | 32685177 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 30.5 | 29.5 | 0.7 | 0.4 | 0.8 |
| V03KEI000280 | V02EDE442120 | 28337740 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 30.0 | 30.0 | 0.7 | 0.4 | 0.8 |
| V03KGO000050 | V02EDE442120 | 12903199 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.3 | 30.7 | 0.7 | 0.4 | 0.8 |
| V03KGT000080 | W11BER551010 | 46966621 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 30.6 | 29.4 | 0.9 | 0.2 | 0.1 |
| V03KGT000100 | V05HEU403210 | 70017789 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 33.8 | 26.2 | 0.7 | 0.0 | 0.1 |
| V03KRU000120 | V02EDE442120 | 5007912 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.4 | 31.6 | 0.7 | 0.4 | 0.8 |
| V03LAN000190 | V02EDE442120 | 14793221 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.8 | 31.2 | 0.7 | 0.4 | 0.8 |
| V03LIE000060 | V02EDE442120 | 9399755 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.7 | 31.3 | 0.7 | 0.4 | 0.8 |
| V03LPK000130 | V02EDE442120 | 40778180 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 31.3 | 28.7 | 0.7 | 0.4 | 0.8 |
| V03LPK000140 | V04MOM037100 | 50278956 | 8.97 | 436.18 | 0.5 | 1263 | 484.9 | 31.7 | 28.3 | 0.3 | 0.4 | 0.4 |
| V03MOP000260 | V02EDE442120 | 31902535 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.9 | 30.1 | 0.7 | 0.4 | 0.8 |
| V03RIE000040 | V07MOG288020 | 6140607 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.0 | 32.0 | 0.6 | 0.6 | 0.8 |
| V03ROD000110 | V02EDE442120 | 6937269 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.2 | 31.8 | 0.7 | 0.4 | 0.8 |
| V03SLE000090 | V02RIV425020 | 44159840 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 31.1 | 28.9 | 0.8 | 0.2 | 0.1 |
| V03SPL000210 | V02EDE442120 | 5101420 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 27.9 | 32.1 | 0.7 | 0.4 | 0.8 |
| V03STE000240 | V02EDE442120 | 10519358 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.1 | 30.9 | 0.7 | 0.4 | 0.8 |
| V03VAL000220 | V02EDE442120 | 19542165 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.3 | 30.7 | 0.7 | 0.4 | 0.8 |
| V03WEE000230 | V02EDE442120 | 24038269 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 29.8 | 30.2 | 0.7 | 0.4 | 0.8 |
| V03ZSB000170 | V03POE446000 | 37827245 | 13.84 | 189.96 | 0.786 | 1439 | 537.5 | 30.6 | 29.4 | 0.2 | 0.4 | 0.5 |
| V03ZWS000150 | V02EDE442120 | 34937521 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 30.3 | 29.7 | 0.7 | 0.4 | 0.8 |
| V04BES000160 | V06ZWA342190 | 184850804 | 2.33 | 95.707 | 0.514 | 1986 | 287.7 | 34.3 | 25.7 | 0.7 | 0.2 | 0.0 |
| V04BES000170 | W11BER551010 | 18766706 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 28.9 | 31.1 | 0.9 | 0.2 | 0.1 |
| V04BES000180 | W08SAMRON000 | 67663418 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 32.8 | 27.2 | 0.7 | 0.3 | 0.4 |
| V04BES000185 | W11BER551010 | 28326405 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 29.5 | 30.5 | 0.9 | 0.2 | 0.1 |
| V04BES000190 | V09DEM136000 | 361066506 | 9.58 | 751.12 | 0.35 | 2200 | 531.8 | 36.4 | 23.6 | 0.3 | 0.2 | 0.1 |
| V04BES000200 | V07MAR289015 | 180989113 | 12.795 | 458.54 | 0.8 | 1507 | 424.3 | 33.1 | 26.9 | 0.7 | 0.4 | 0.3 |
| V04BES000210 | W11BER551010 | 37352188 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 30.4 | 29.6 | 0.9 | 0.2 | 0.1 |
| V04DUR000080 | V04MOL036110 | 13115959 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 29.2 | 30.8 | 0.2 | 0.5 | 0.4 |

| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|-------|--------|-------|------|--------|------|------|-----|-----|-----|
| V04DUR000090 | V09MOT144270 | 12911826 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.9 | 31.1 | 0.0 | 0.3 | 0.0 |
| V04LED000045 | V02EDE442120 | 10731840 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 28.6 | 31.4 | 0.7 | 0.4 | 0.8 |
| V04LEDBOR040 | V02EDE442120 | 33815271 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 30.6 | 29.4 | 0.7 | 0.4 | 0.8 |
| V04LOK000060 | V09MOT144270 | 12937291 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.0 | 31.0 | 0.0 | 0.3 | 0.0 |
| V04RUP000150 | W08SAMRON000 | 28627814 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.5 | 30.5 | 0.7 | 0.3 | 0.4 |
| V04SCH000000 | V09MOT144270 | 21348172 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.3 | 30.7 | 0.0 | 0.3 | 0.0 |
| V04SCH000010 | V09HER163010 | 232467654 | 19.26 | 1675.5 | 0.267 | 3309 | 437.6 | 34.3 | 25.7 | 0.9 | 0.2 | 0.3 |
| V04SCH000020 | V03POE446000 | 42342683 | 13.84 | 189.96 | 0.786 | 1439 | 537.5 | 30.3 | 29.7 | 0.2 | 0.4 | 0.5 |
| V04SCH000030 | V09WIN141310 | 55558393 | 10.82 | 1491.2 | 0.351 | 1362 | 346.3 | 31.5 | 28.5 | 0.5 | 0.5 | 0.5 |
| V04SCH000070 | V09HER163010 | 97843094 | 19.26 | 1675.5 | 0.267 | 3309 | 437.6 | 32.7 | 27.3 | 0.9 | 0.2 | 0.3 |
| V04VLI000140 | V09MAN161040 | 65737530 | 3.63 | 353.69 | 0.24 | 1597 | 483.9 | 32.7 | 27.3 | 0.3 | 0.1 | 0.0 |
| V04ZEL000050 | V04MOL036110 | 24207851 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 30.5 | 29.5 | 0.2 | 0.5 | 0.4 |
| V04ZIE000120 | V04MOL036110 | 52125854 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 31.9 | 28.1 | 0.2 | 0.5 | 0.4 |
| V04ZWA000130 | V08BAR111370 | 20223736 | 4.83 | 452.25 | 0.368 | 1139 | 369.6 | 29.4 | 30.6 | 0.2 | 0.2 | 0.1 |
| V05GAV000260 | V05HEU403210 | 137842273 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 33.7 | 26.3 | 0.7 | 0.0 | 0.1 |
| V05GEL000200 | V05HEU403210 | 47783349 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 31.0 | 29.0 | 0.7 | 0.0 | 0.1 |
| V05HEU000220 | V09MOT144270 | 16883706 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.2 | 30.8 | 0.0 | 0.3 | 0.0 |
| V05LEI000190 | V01KEM492060 | 108826195 | 4.62 | 132.47 | 0.79 | 1268 | 116.0 | 32.6 | 27.4 | 0.5 | 0.1 | 0.0 |
| V05LEI000240 | V09MOT144270 | 21304814 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.4 | 30.6 | 0.0 | 0.3 | 0.0 |
| V05LEI000250 | V09MOT144270 | 29836282 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.7 | 29.3 | 0.0 | 0.3 | 0.0 |
| V05LEI000280 | V03POE446000 | 97730942 | 13.84 | 189.96 | 0.786 | 1439 | 537.5 | 34.1 | 25.9 | 0.2 | 0.4 | 0.5 |
| V05LEI000290 | V02EDE442120 | 47172616 | 10.32 | 297.82 | 0.8 | 1036 | 540.3 | 31.2 | 28.8 | 0.7 | 0.4 | 0.8 |
| V05LEI000300 | V02RIV425020 | 39155357 | 13.87 | 479.81 | 0.54 | 1530 | 291.5 | 30.6 | 29.4 | 0.8 | 0.2 | 0.1 |
| V05LEI386180 | F05LEI386999 | 82706606 | 2 | 415 | 0.5 | 1100 | 270.0 | 31.6 | 28.4 | 0.6 | 0.1 | 0.1 |
| V05MAN000270 | V01SSV499140 | 13017615 | 8.6 | 270.27 | 0.71 | 1579 | 344.6 | 29.5 | 30.5 | 0.5 | 0.2 | 0.6 |
| V06BEI000150 | V07MOG288020 | 19134016 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.7 | 31.3 | 0.6 | 0.6 | 0.8 |
| V06KBK000130 | W08SAMRON000 | 8261974 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 28.3 | 31.7 | 0.7 | 0.3 | 0.4 |
| V06MAA000170 | V07MOG288020 | 4955439 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 27.6 | 32.4 | 0.6 | 0.6 | 0.8 |
| V06SCH000140 | V07BEL285070 | 56084506 | 15.43 | 506.15 | 0.247 | 3563 | 545.6 | 31.3 | 28.7 | 0.2 | 0.2 | 0.5 |
| V06SCH000180 | W08SAMRON000 | 87618176 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 31.8 | 28.2 | 0.7 | 0.3 | 0.4 |
| V06SCH000210 | V05HEU403210 | 81083174 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 32.6 | 27.4 | 0.7 | 0.0 | 0.1 |
| V06SCH000220 | V02HER426010 | 77342171 | 15 | 489.24 | 0.73 | 1895 | 532.8 | 32.6 | 27.4 | 0.3 | 0.7 | 0.8 |
| V06ZWA000200 | V09MOT144270 | 867129 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 26.9 | 33.1 | 0.0 | 0.3 | 0.0 |
| V07BEL000080 | V04MOL036110 | 11538072 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 29.1 | 30.9 | 0.2 | 0.5 | 0.4 |
| V07DEN000025 | V07MOG288020 | 27908996 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 29.7 | 30.3 | 0.6 | 0.6 | 0.8 |
| V07DEN000060 | V01MAR496120 | 73022161 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 31.2 | 28.8 | 0.7 | 0.0 | 0.0 |
| V07DEN000110 | V05HEU403210 | 97824902 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 34.7 | 25.3 | 0.7 | 0.0 | 0.1 |
| V07GRA000090 | V09MOT144270 | 28283573 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.6 | 30.4 | 0.0 | 0.3 | 0.0 |
| V07MOE000120 | V07MOG288020 | 8585990 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.6 | 31.4 | 0.6 | 0.6 | 0.8 |

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| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|-------|--------|-------|------|--------|------|------|-----|-----|-----|
| V07MOL000030 | V08BAR111370 | 53711139 | 4.83 | 452.25 | 0.368 | 1139 | 369.6 | 30.7 | 29.3 | 0.2 | 0.2 | 0.1 |
| V07MOL000050 | V07MOE282100 | 52610014 | 4.892 | 77.007 | 0.518 | 1833 | 245.4 | 30.5 | 29.5 | 0.5 | 0.2 | 0.3 |
| V07MOL000130 | V09MOT144270 | 22215247 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.6 | 30.4 | 0.0 | 0.3 | 0.0 |
| V07WOL000040 | V05HEU403210 | 49430997 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 30.1 | 29.9 | 0.7 | 0.0 | 0.1 |
| V08AAB000360 | V01MAR496120 | 60451204 | 9.083 | 103.97 | 0.8 | 1228 | 50.2 | 30.6 | 29.4 | 0.7 | 0.0 | 0.0 |
| V08BEY000240 | V09MOT144270 | 6114323 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.8 | 32.2 | 0.0 | 0.3 | 0.0 |
| V08BRO000175 | V07MOG288020 | 6262734 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.1 | 31.9 | 0.6 | 0.6 | 0.8 |
| V08BRU000180 | W11BER551010 | 16024099 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 31.2 | 28.8 | 0.9 | 0.2 | 0.1 |
| V08DIJ000430 | V04MOL036110 | 16839367 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 30.0 | 30.0 | 0.2 | 0.5 | 0.4 |
| V08DIJ000455 | V09MOT144270 | 9419886 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.0 | 31.0 | 0.0 | 0.3 | 0.0 |
| V08DRO000230 | V07MOG288020 | 1754271 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 27.5 | 32.5 | 0.6 | 0.6 | 0.8 |
| V08GLA000450 | V09MOT144270 | 29900000 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.7 | 29.3 | 0.0 | 0.3 | 0.0 |
| V08GRO000070 | W11BER551010 | 13748809 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 28.3 | 31.7 | 0.9 | 0.2 | 0.1 |
| V08HAL000080 | W11BER551010 | 10431011 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 28.7 | 31.3 | 0.9 | 0.2 | 0.1 |
| V08HAR000250 | W11BER551010 | 4183063 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.9 | 32.1 | 0.9 | 0.2 | 0.1 |
| V08HER000120 | V07MOG288020 | 15606705 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.7 | 31.3 | 0.6 | 0.6 | 0.8 |
| V08LEI000420 | V04MOL036110 | 61999329 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 31.8 | 28.2 | 0.2 | 0.5 | 0.4 |
| V08LOB000300 | W11BER551010 | 1727027 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.2 | 32.8 | 0.9 | 0.2 | 0.1 |
| V08LOT000110 | W08SAMRON000 | 16677869 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 29.6 | 30.4 | 0.7 | 0.3 | 0.4 |
| V08MAA000190 | W11BER551010 | 25513368 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 30.6 | 29.4 | 0.9 | 0.2 | 0.1 |
| V08MAA000320 | V07BEL285070 | 41562062 | 15.43 | 506.15 | 0.247 | 3563 | 545.6 | 29.9 | 30.1 | 0.2 | 0.2 | 0.5 |
| V08MAR000270 | W11BER551010 | 2655242 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.3 | 32.7 | 0.9 | 0.2 | 0.1 |
| V08MEC000390 | V04MOL036110 | 2184480 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 28.2 | 31.8 | 0.2 | 0.5 | 0.4 |
| V08MEC000440 | V04MOL036110 | 21167200 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 31.0 | 29.0 | 0.2 | 0.5 | 0.4 |
| V08MOB000090 | V08BAR111370 | 52906589 | 4.83 | 452.25 | 0.368 | 1139 | 369.6 | 29.8 | 30.2 | 0.2 | 0.2 | 0.1 |
| V08MOJ000220 | W11BER551010 | 24744883 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 29.4 | 30.6 | 0.9 | 0.2 | 0.1 |
| V08NEE000140 | V07MOG288020 | 24418401 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 29.6 | 30.4 | 0.6 | 0.6 | 0.8 |
| V08PAR000210 | V07MOG288020 | 10526023 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.6 | 31.4 | 0.6 | 0.6 | 0.8 |
| V08SAS000350 | V09MOT144270 | 11122038 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.8 | 31.2 | 0.0 | 0.3 | 0.0 |
| V08STA000060 | V07MOG288020 | 8939127 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.5 | 31.5 | 0.6 | 0.6 | 0.8 |
| V08TAN000290 | W11BER551010 | 8645642 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 28.1 | 31.9 | 0.9 | 0.2 | 0.1 |
| V08TAN000330 | W11BER551010 | 1728251 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.1 | 32.9 | 0.9 | 0.2 | 0.1 |
| V08TAN000340 | W11BER551010 | 4308051 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.7 | 32.3 | 0.9 | 0.2 | 0.1 |
| V08TRA000280 | W11BER551010 | 6403090 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.9 | 32.1 | 0.9 | 0.2 | 0.1 |
| V08UKK000160 | V09MOT144270 | 16556510 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.8 | 31.2 | 0.0 | 0.3 | 0.0 |
| V08VIL000310 | W11BER551010 | 2859650 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.3 | 32.7 | 0.9 | 0.2 | 0.1 |
| V08VLE000150 | W11BER551010 | 4942825 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 28.7 | 31.3 | 0.9 | 0.2 | 0.1 |
| V08VOR000170 | W11BER551010 | 4176350 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.6 | 32.4 | 0.9 | 0.2 | 0.1 |
| V08VRO000460 | V10MOP062140 | 125593344 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 33.6 | 26.4 | 0.6 | 0.5 | 0.6 |

| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|-------|--------|-------|------|--------|------|------|-----|-----|-----|
| V08VUN000435 | V09MOT144270 | 25988270 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.2 | 30.8 | 0.0 | 0.3 | 0.0 |
| V08WEE000410 | V09MOT144270 | 68292349 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 31.5 | 28.5 | 0.0 | 0.3 | 0.0 |
| V08WOL000260 | W11BER551010 | 46369269 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 30.4 | 29.6 | 0.9 | 0.2 | 0.1 |
| V08WOLBRU200 | V09WIN141310 | 49508996 | 10.82 | 1491.2 | 0.351 | 1362 | 346.3 | 29.9 | 30.1 | 0.5 | 0.5 | 0.5 |
| V08ZUU000130 | V07BEL285070 | 25927026 | 15.43 | 506.15 | 0.247 | 3563 | 545.6 | 29.2 | 30.8 | 0.2 | 0.2 | 0.5 |
| V09ALB000010 | V09MOT144270 | 9868911 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.1 | 30.9 | 0.0 | 0.3 | 0.0 |
| V09ALB000020 | V09MOT144270 | 678840 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.0 | 33.0 | 0.0 | 0.3 | 0.0 |
| V09BEG000160 | V09MOT144270 | 52288450 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.8 | 29.2 | 0.0 | 0.3 | 0.0 |
| V09DEM000030 | V09MAN161040 | 111804714 | 3.63 | 353.69 | 0.24 | 1597 | 483.9 | 34.0 | 26.0 | 0.3 | 0.1 | 0.0 |
| V09DEM000050 | W11OUR5805 | 17224252 | 6.1 | 125 | 0.411 | 1794 | 200.4 | 29.3 | 30.7 | 0.7 | 0.4 | 0.4 |
| V09DEM000070 | W11BER551010 | 15263780 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 29.7 | 30.3 | 0.9 | 0.2 | 0.1 |
| V09GLA000240 | V09MOT144270 | 13893219 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.7 | 30.3 | 0.0 | 0.3 | 0.0 |
| V09HEI000290 | V09MOT144270 | 11779955 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.8 | 31.2 | 0.0 | 0.3 | 0.0 |
| V09HER000060 | V09MOT144270 | 17904828 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.7 | 30.3 | 0.0 | 0.3 | 0.0 |
| V09HER000075 | V09MOT144270 | 4063569 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.6 | 32.4 | 0.0 | 0.3 | 0.0 |
| V09HUL000170 | V04MOL036110 | 10167667 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 28.7 | 31.3 | 0.2 | 0.5 | 0.4 |
| V09LAA000220 | V09MOT144270 | 4843899 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.3 | 31.7 | 0.0 | 0.3 | 0.0 |
| V09LEI000180 | V09MOT144270 | 2290158 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.1 | 32.9 | 0.0 | 0.3 | 0.0 |
| V09LEU000155 | V07MOG288020 | 8272837 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 28.0 | 32.0 | 0.6 | 0.6 | 0.8 |
| V09MAN000130 | V09MOT144270 | 2369062 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.1 | 32.9 | 0.0 | 0.3 | 0.0 |
| V09MOT000260 | V09MOT144270 | 8633853 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.2 | 31.8 | 0.0 | 0.3 | 0.0 |
| V09MOU000280 | W11BER551010 | 4720981 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 27.7 | 32.3 | 0.9 | 0.2 | 0.1 |
| V09OSS000230 | V09MOT144270 | 12017257 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.6 | 31.4 | 0.0 | 0.3 | 0.0 |
| V09VEL000110 | V09MOT144270 | 44224342 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.0 | 30.0 | 0.0 | 0.3 | 0.0 |
| V09VOO000090 | V09MOT144270 | 14913966 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.2 | 30.8 | 0.0 | 0.3 | 0.0 |
| V09VOS000200 | V09MOT144270 | 6343660 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.0 | 32.0 | 0.0 | 0.3 | 0.0 |
| V09WER000250 | V04MOL036110 | 3447994 | 8.316 | 538.34 | 0.573 | 1980 | 441.5 | 27.8 | 32.2 | 0.2 | 0.5 | 0.4 |
| V09WIJ000190 | V09MOT144270 | 6951100 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 27.9 | 32.1 | 0.0 | 0.3 | 0.0 |
| V09WIN000320 | V09MOT144270 | 17375263 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.0 | 30.0 | 0.0 | 0.3 | 0.0 |
| V09ZWA000140 | V09MOT144270 | 24807586 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 29.2 | 30.8 | 0.0 | 0.3 | 0.0 |
| V09ZWA000210 | V10MOP062140 | 19313232 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 29.3 | 30.7 | 0.6 | 0.5 | 0.6 |
| V10ALB076015 | V10GNE076999 | 24539871 | 0.713 | 414.5 | 0.2 | 1526 | 232.2 | 29.8 | 30.2 | 0.7 | 0.1 | 0.0 |
| V10BER000100 | V09MOT144270 | 28572454 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.0 | 30.0 | 0.0 | 0.3 | 0.0 |
| V10BEV000120 | V10MOP062140 | 26918434 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 30.9 | 29.1 | 0.6 | 0.5 | 0.6 |
| V10GES000130 | V09MOT144270 | 42189781 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 31.5 | 28.5 | 0.0 | 0.3 | 0.0 |
| V10GNE076010 | V10GNE076999 | 243532847 | 0.713 | 414.5 | 0.2 | 1526 | 232.2 | 35.3 | 24.7 | 0.7 | 0.1 | 0.0 |
| V10GOO000080 | V10MOP062140 | 44302117 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 31.8 | 28.2 | 0.6 | 0.5 | 0.6 |
| V10KLA076030 | V10GNE076999 | 54041574 | 0.713 | 414.5 | 0.2 | 1526 | 232.2 | 31.4 | 28.6 | 0.7 | 0.1 | 0.0 |
| V10KRE000110 | V09MAN161040 | 53928737 | 3.63 | 353.69 | 0.24 | 1597 | 483.9 | 31.5 | 28.5 | 0.3 | 0.1 | 0.0 |

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| Catchment | Associated gauged catchment | Area | Umax | SMmax | CQOF | CKBF | CKIF | CK1 | CK2 | TIF | TOF | TG |
|--------------|-----------------------------|-----------|--------|--------|-------|------|--------|------|------|-----|-----|-----|
| V10MOL000060 | V09ZWA148120 | 40694619 | 7.112 | 607.27 | 0.8 | 1934 | 136.4 | 33.1 | 26.9 | 0.1 | 0.6 | 0.1 |
| V10MOP000150 | V10MOP062140 | 32418924 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 31.4 | 28.6 | 0.6 | 0.5 | 0.6 |
| V10NET000170 | V10MOP062140 | 66664720 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 32.3 | 27.7 | 0.6 | 0.5 | 0.6 |
| V10NET000180 | V09MAN161040 | 80302347 | 3.63 | 353.69 | 0.24 | 1597 | 483.9 | 32.0 | 28.0 | 0.3 | 0.1 | 0.0 |
| V10ROL000040 | V09ZWA148120 | 23571007 | 7.112 | 607.27 | 0.8 | 1934 | 136.4 | 30.0 | 30.0 | 0.1 | 0.6 | 0.1 |
| V10STE000070 | V09ZWA148120 | 42571635 | 7.112 | 607.27 | 0.8 | 1934 | 136.4 | 30.8 | 29.2 | 0.1 | 0.6 | 0.1 |
| V10TAP000160 | V10MOP062140 | 46191820 | 13.7 | 872.81 | 0.209 | 1149 | 471.8 | 32.7 | 27.3 | 0.6 | 0.5 | 0.6 |
| V10WIM000090 | V09MOT144270 | 29330881 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 30.2 | 29.8 | 0.0 | 0.3 | 0.0 |
| V11ALB000045 | W11BER551010 | 44990800 | 2.25 | 193 | 0.754 | 1606 | 460.0 | 30.1 | 29.9 | 0.9 | 0.2 | 0.1 |
| V11MAA508050 | V10KNE052000 | 837912122 | 5.025 | 245.35 | 0.376 | 1322 | 271.7 | 41.5 | 18.5 | 0.2 | 0.2 | 0.0 |
| V11VOE000010 | V09VEL145100 | 59555900 | 13.728 | 519.68 | 0.296 | 1745 | 635.0 | 30.1 | 29.9 | 0.2 | 0.3 | 0.4 |
| V11WIL508055 | V09DEM136000 | 21849142 | 9.58 | 751.12 | 0.35 | 2200 | 531.8 | 29.3 | 30.7 | 0.3 | 0.2 | 0.1 |
| W05LYS386170 | F05LEI386999 | 91812026 | 2 | 415 | 0.5 | 1100 | 270.0 | 32.2 | 27.8 | 0.6 | 0.1 | 0.1 |
| W06BOS325095 | F06BOS325001 | 256772308 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 36.0 | 24.0 | 0.7 | 0.2 | 0.0 |
| W06BOS325105 | F06BOS325001 | 226789872 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 34.5 | 25.5 | 0.7 | 0.2 | 0.0 |
| W06BOS325115 | F06BOS325001 | 111071545 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 32.1 | 27.9 | 0.7 | 0.2 | 0.0 |
| W06HAI325080 | F06BOS325001 | 275201697 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 35.5 | 24.5 | 0.7 | 0.2 | 0.0 |
| W06HAI325085 | F06BOS325001 | 241293103 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 33.7 | 26.3 | 0.7 | 0.2 | 0.0 |
| W06HAI325090 | F06BOS325001 | 273091288 | 5.83 | 466.26 | 0.203 | 1858 | 434.9 | 35.0 | 25.0 | 0.7 | 0.2 | 0.0 |
| W06HAY000110 | V05HEU403210 | 64102892 | 7.732 | 142.39 | 0.719 | 1022 | 148.3 | 31.4 | 28.6 | 0.7 | 0.0 | 0.1 |
| W06RHO000120 | V09MOT144270 | 7595336 | 6.636 | 382.53 | 0.8 | 4809 | 480.5 | 28.1 | 31.9 | 0.0 | 0.3 | 0.0 |
| W07DENLES010 | W07DENOVB005 | 271049169 | 12 | 850 | 0.5 | 3300 | 550.0 | 35.7 | 24.3 | 0.6 | 0.7 | 0.7 |
| W07DOCLES000 | W07DENOVB005 | 127972527 | 12 | 850 | 0.5 | 3300 | 550.0 | 32.5 | 27.5 | 0.6 | 0.7 | 0.7 |
| W07DORLES005 | W07DENOVB005 | 196976608 | 12 | 850 | 0.5 | 3300 | 550.0 | 34.1 | 25.9 | 0.6 | 0.7 | 0.7 |
| W08HAI000050 | V07BEL285070 | 80826978 | 15.43 | 506.15 | 0.247 | 3563 | 545.6 | 31.2 | 28.8 | 0.2 | 0.2 | 0.5 |
| W08SEN000020 | W08SAMRON000 | 53081078 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 30.4 | 29.6 | 0.7 | 0.3 | 0.4 |
| W08ZEN000040 | V07MOG288020 | 19240238 | 24.9 | 700 | 0.56 | 2440 | 1900.0 | 29.1 | 30.9 | 0.6 | 0.6 | 0.8 |
| W11JEK553010 | W11MEH5820 | 463411008 | 12.9 | 804.5 | 0.254 | 2009 | 655.0 | 37.7 | 22.3 | 0.7 | 0.3 | 0.4 |
| W11MAA0030 | W11MEH5820 | 503217000 | 12.9 | 804.5 | 0.254 | 2009 | 655.0 | 32.0 | 31.0 | 0.7 | 0.3 | 0.4 |
| W11MAA0040 | W11MEH5820 | 370820000 | 12.9 | 804.5 | 0.254 | 2009 | 655.0 | 32.0 | 31.0 | 0.7 | 0.3 | 0.4 |
| W11SAM0000 | W08SAMRON000 | 178620000 | 12.76 | 1528.9 | 0.315 | 1759 | 501.1 | 33.8 | 26.2 | 0.7 | 0.3 | 0.4 |

Appendix 3

Results of calibration and validation of NAM parameters for catchment "V01HEI468999" (IJZER)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01HEI468999" (IJZER)

1.1 Input data

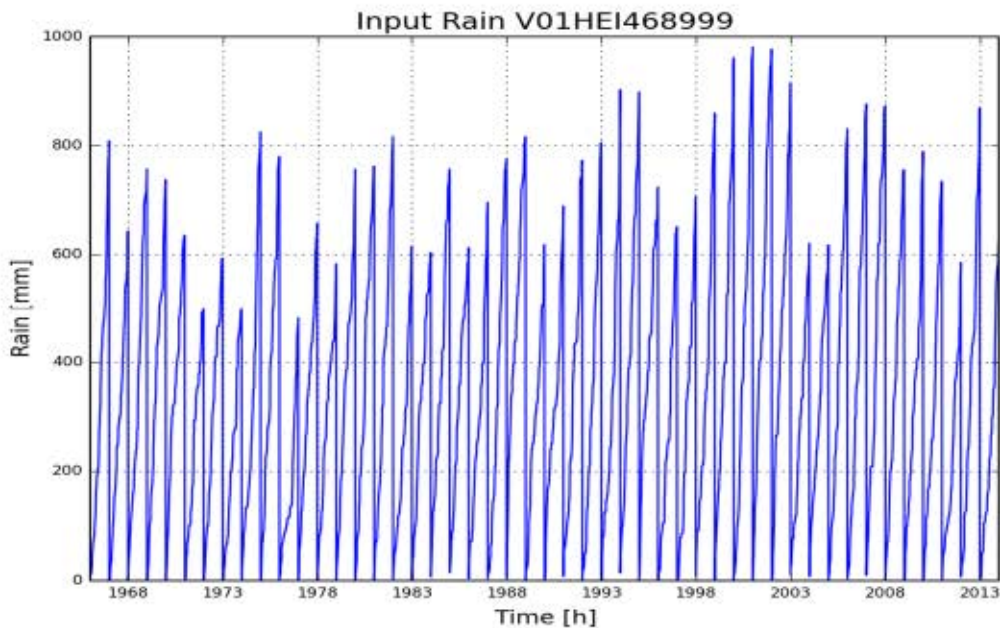


Figure 1: Cumulative precipitation on catchment V01HEI468999 (IJzer)

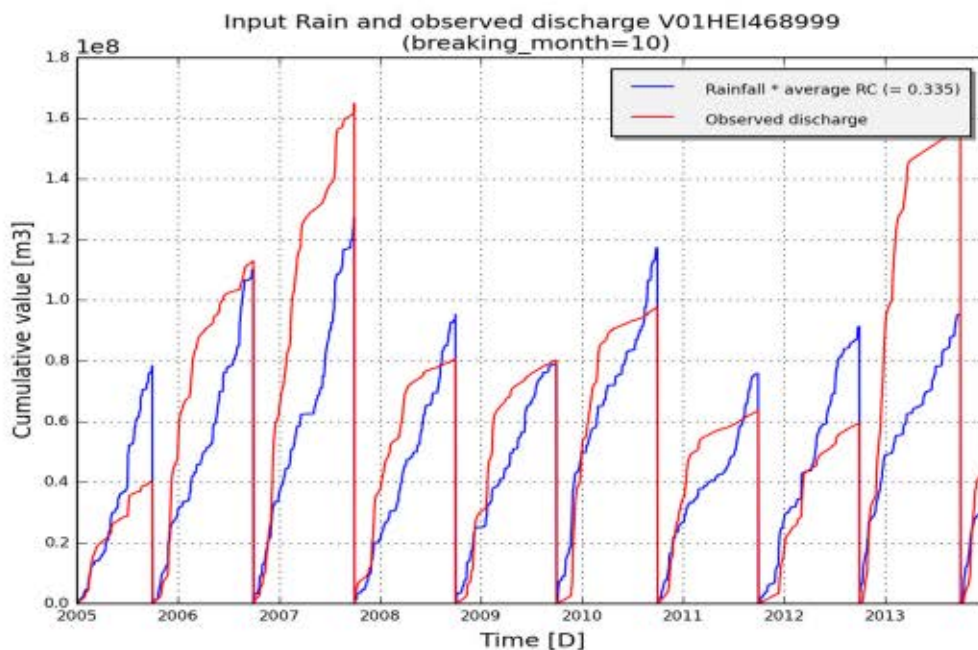


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01HEI468999 (IJzer)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01HEI468999 |
| subcatchment_area [m2] | 393007000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 15.01), (‘SMmax.C’, 113.1), (‘CQOF.C’, 0.9), (‘CKBF.C’, 3155.73), (‘CKIF.C’, 135.12), (‘CK1.C’, 29.42), (‘CK2.C’, 46.1), (‘TIF.C’, 0.97), (‘TOF.C’, 0.0), (‘NAM.TG.C’, 0.08)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 27859304.25 | 51328195.366 |
| RelErr | -2.1 % | 1.5 % |
| RMSE | 31998679.179 | 61267749.642 |
| NS | 0.689 | 0.73 |
| NS_log | 0.641 | 0.539 |
| NS_rel | 0.085 | -0.162 |

1.3 Observed and simulated timeseries for optimum parameters

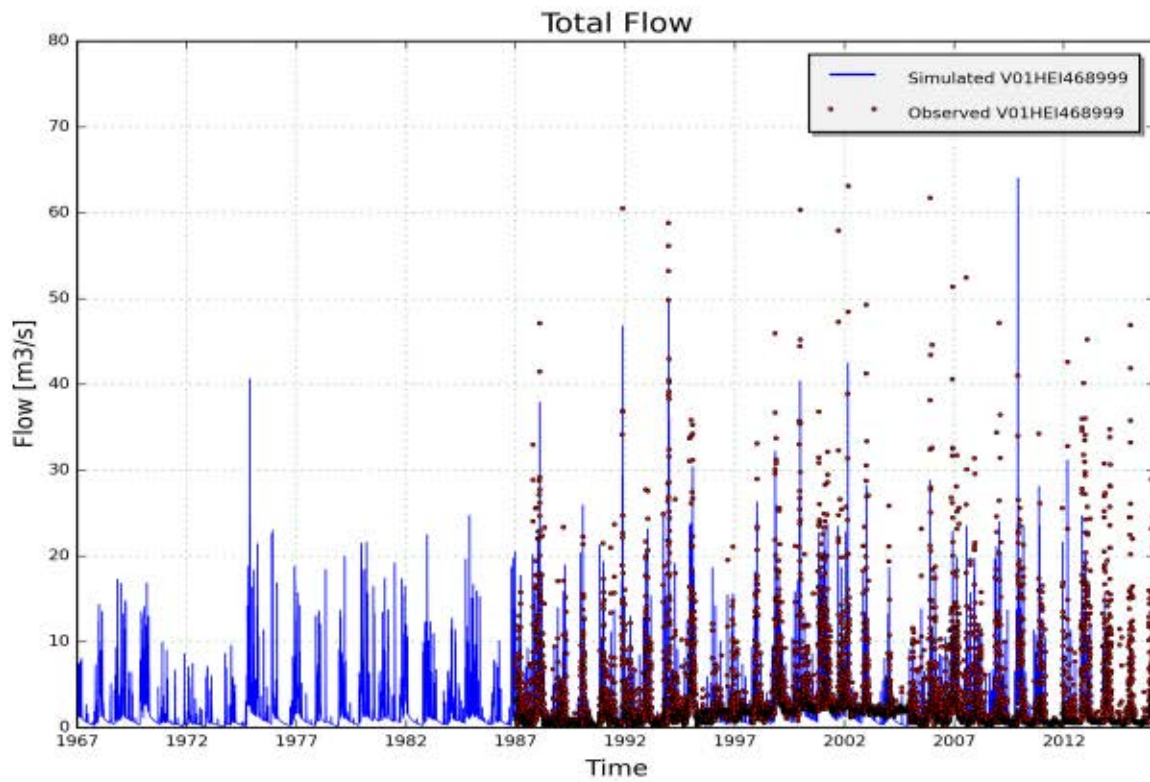


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (validation period 1967-2013)

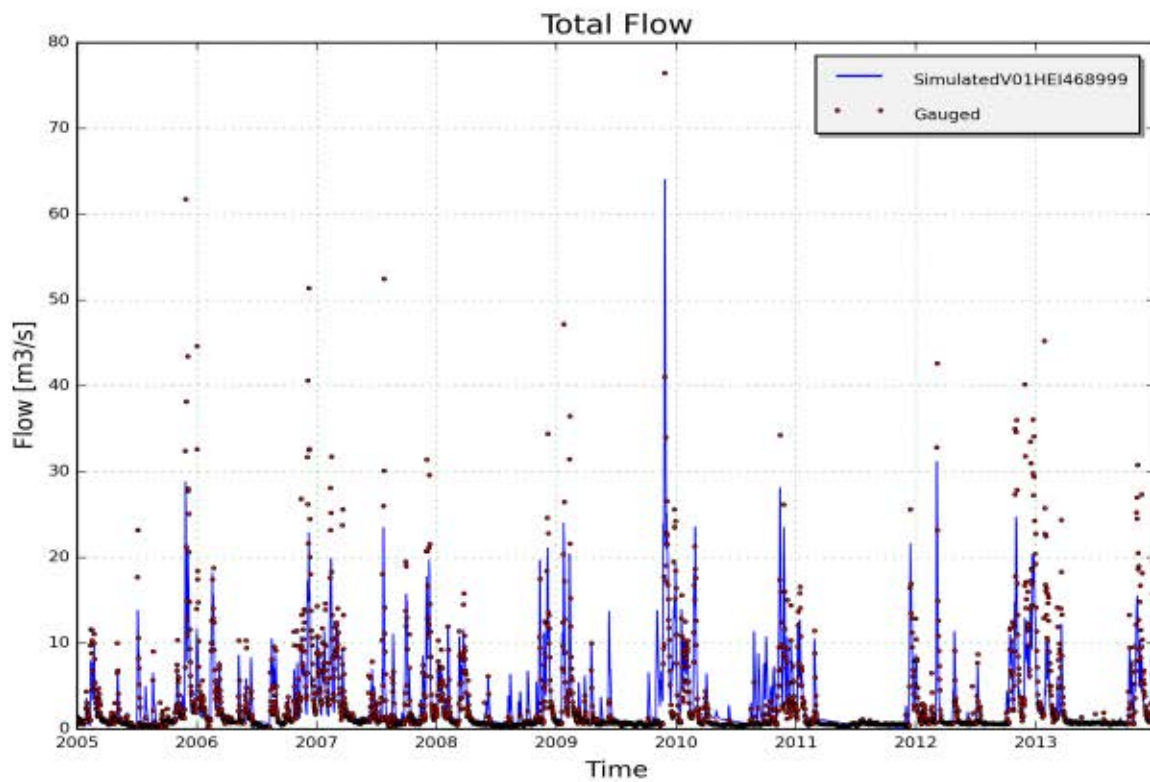


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (calibration period)

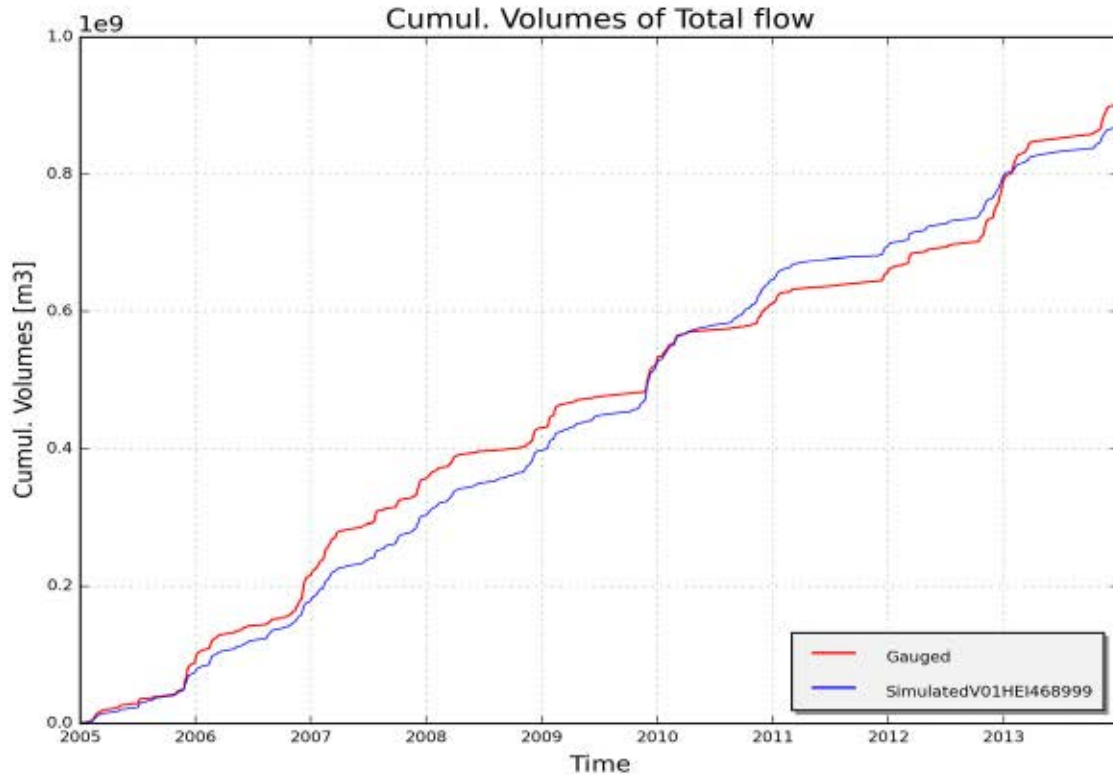


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01HEI468999, station 46810102 - Ijzer; Haringe (calibration period)

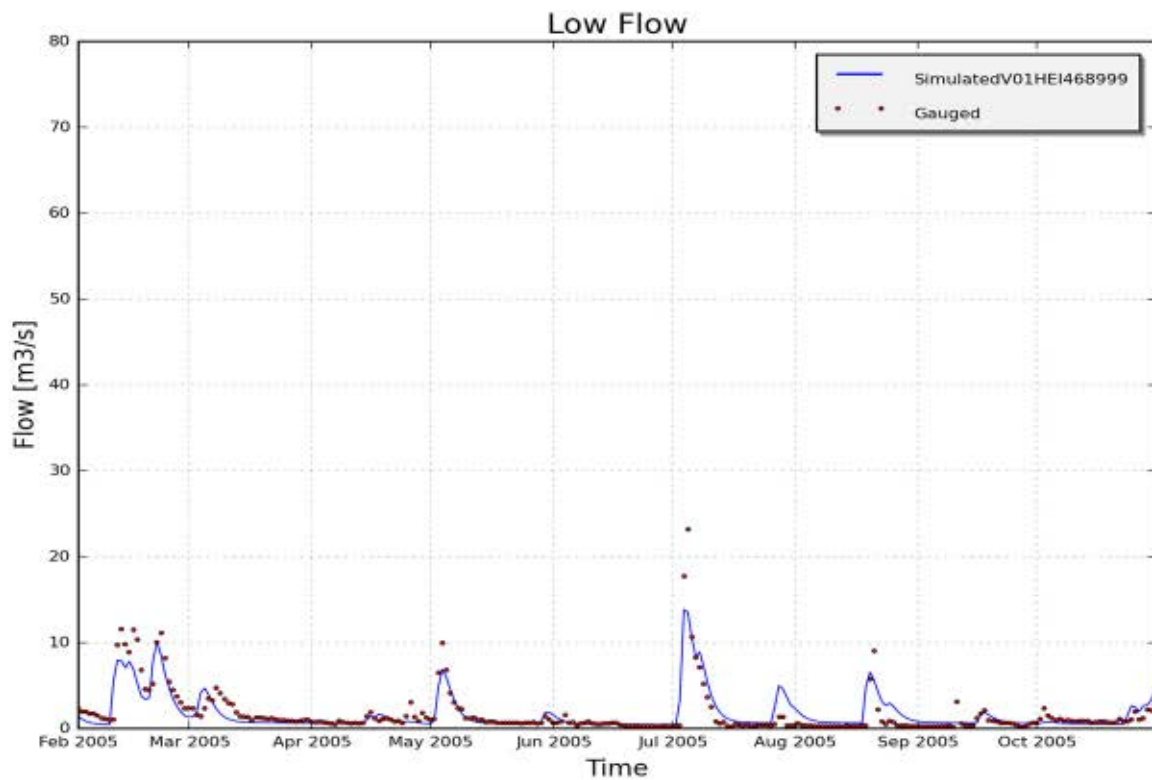


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01HEI468999, station 46810102 - Ijzer; Haringe

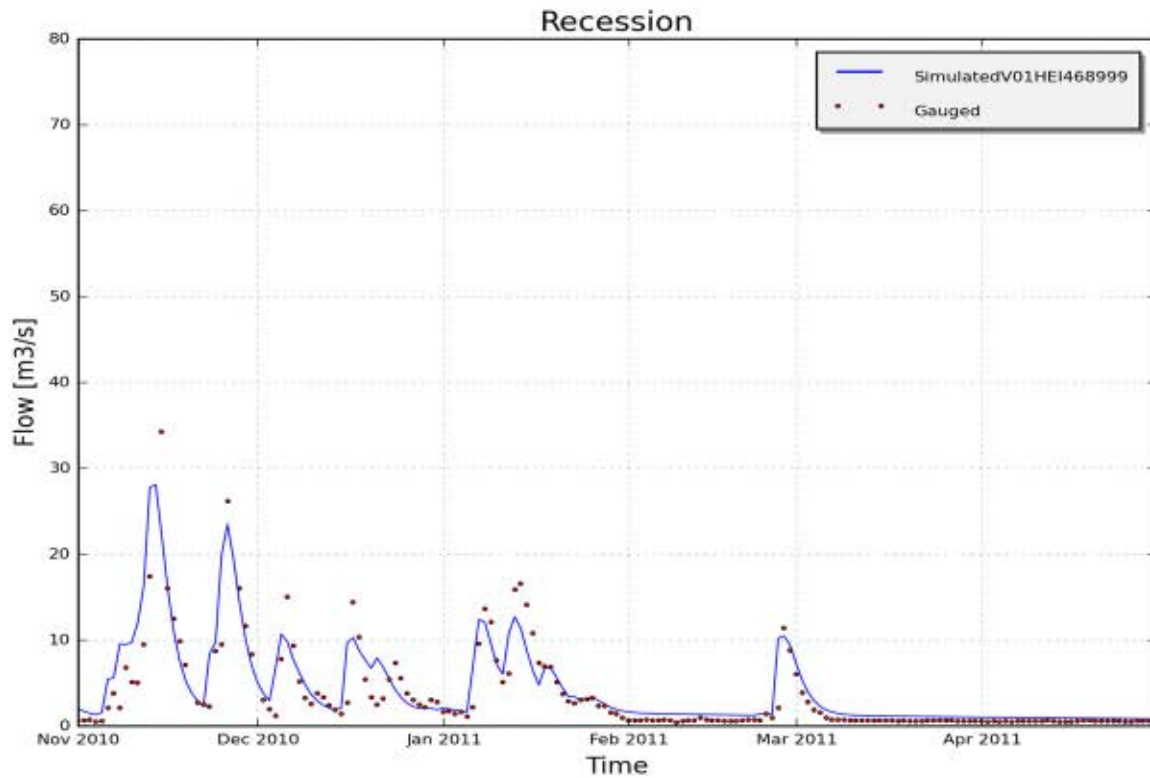


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HEI468999, station 46810102 - Ijzer; Haringe

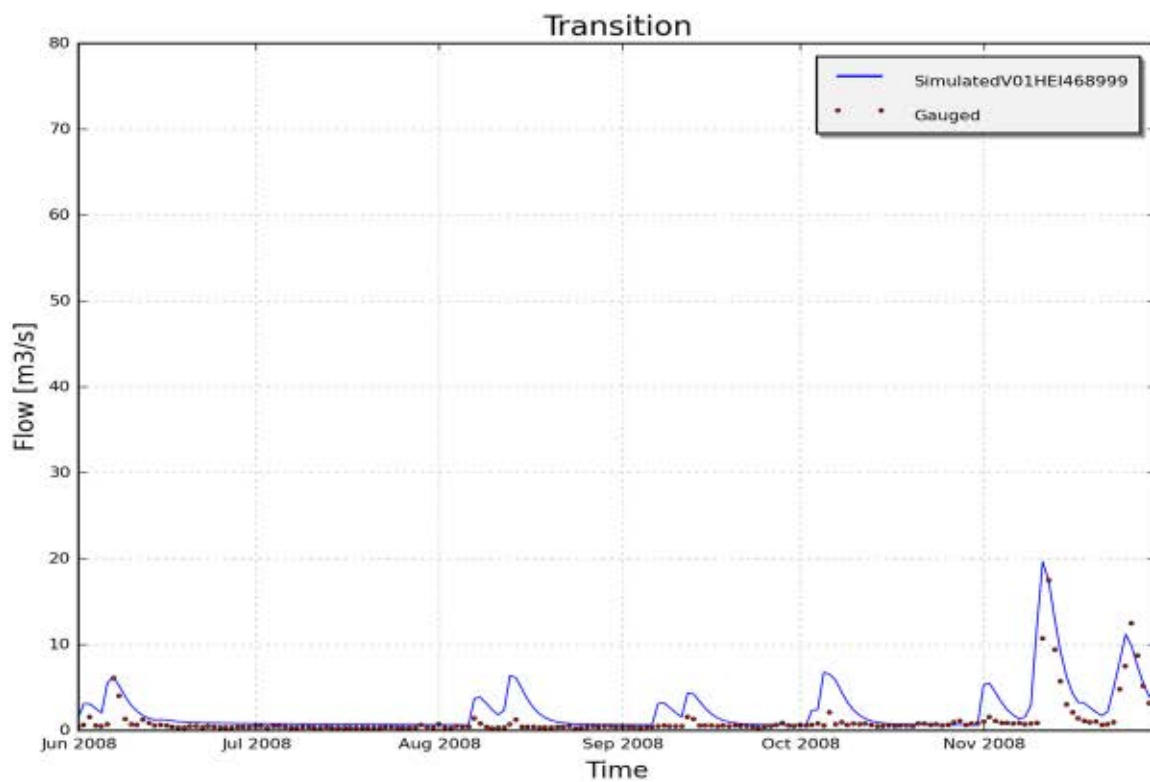


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HEI468999, station 46810102 - Ijzer; Haringe

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01IEP495080" (IJZER)

2.1 Input data

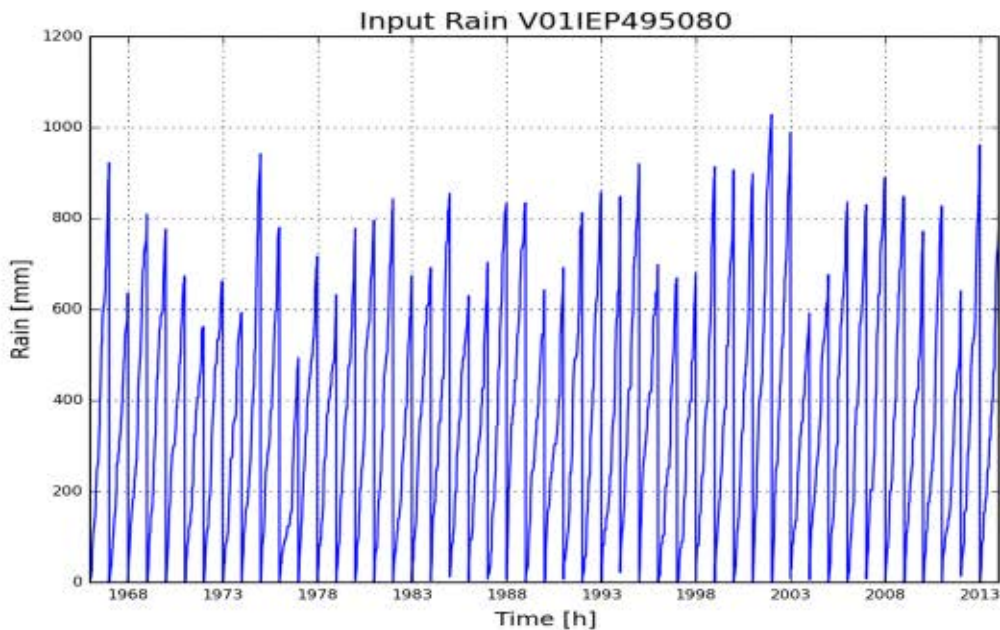


Figure 1: Cumulative precipitation on catchment V01IEP495080 (IJzer)

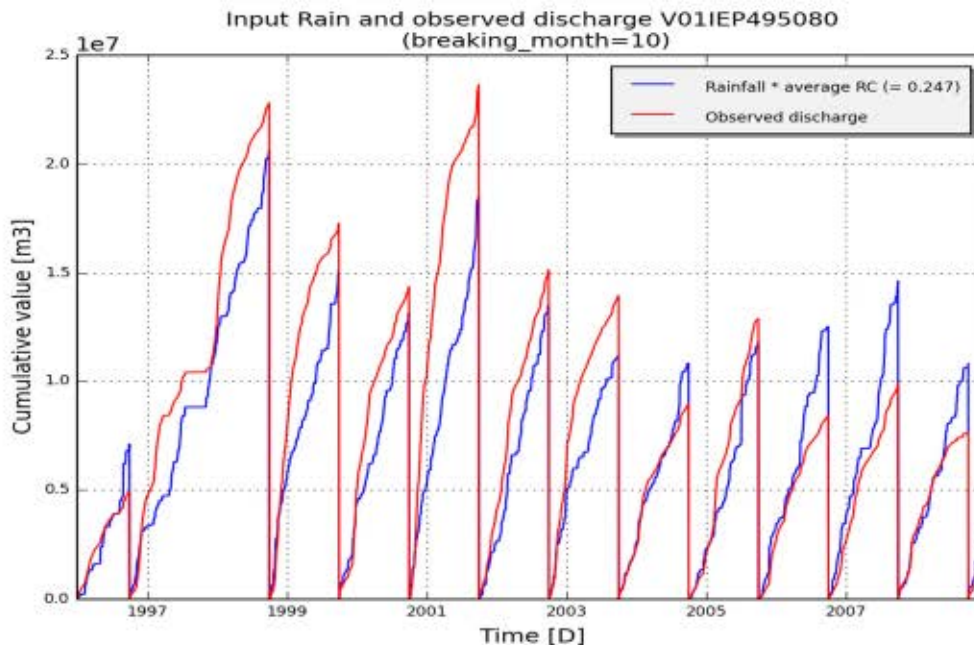


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01IEP495080 (IJzer)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01IEP495080 |
| subcatchment_area [m2] | 63423128 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.58), (‘SMmax.C’, 586.71), (‘CQOF.C’, 0.81), (‘CKBF.C’, 2472.06), (‘CKIF.C’, 471.39), (‘CK1.C’, 37.97), (‘CK2.C’, 21.08), (‘TIF.C’, 0.9), (‘TOF.C’, 0.27), (‘NAM.TG.C’, 0.16)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3229681.539 | 24679754.671 |
| RelErr | -0.6 % | -11.1 % |
| RMSE | 4041317.074 | 27258865.951 |
| NS | 0.501 | 0.465 |
| NS_log | 0.441 | 0.476 |
| NS_rel | -10.373 | -5.109 |

2.3 Observed and simulated timeseries for optimum parameters

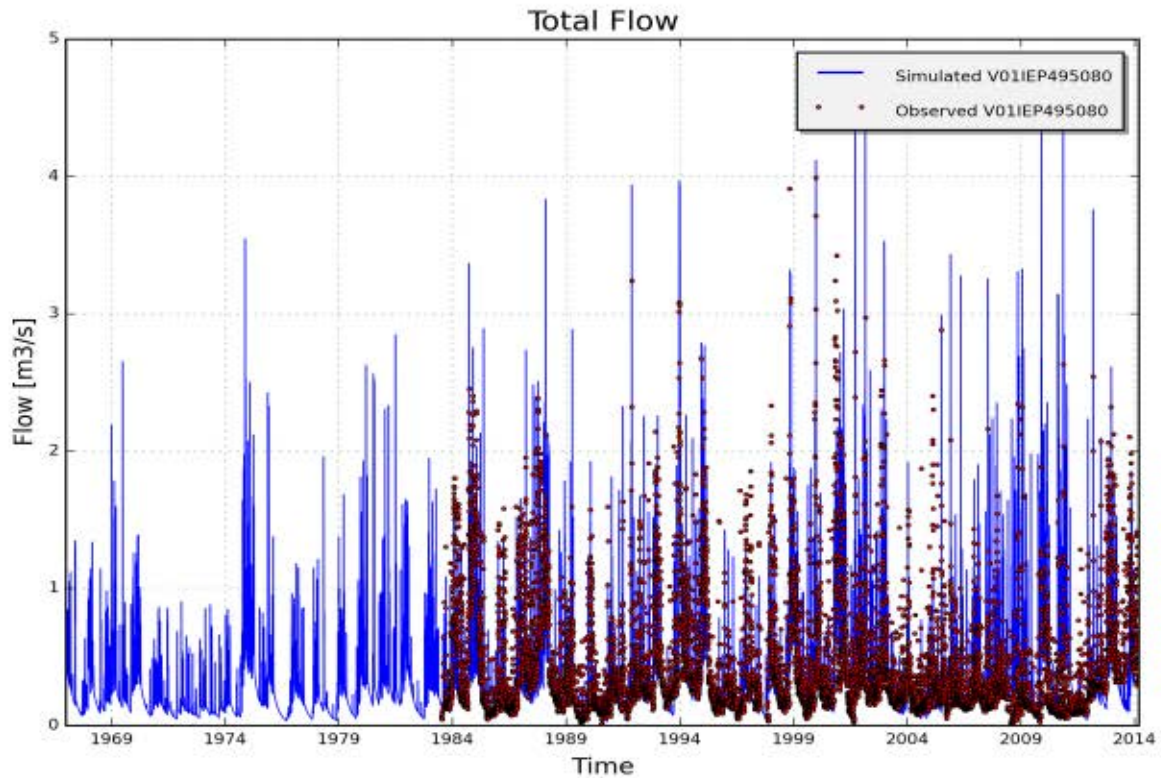


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01IEP495080, station 49510102 - leperlee; Zuidschote (validation period 1967-2013)

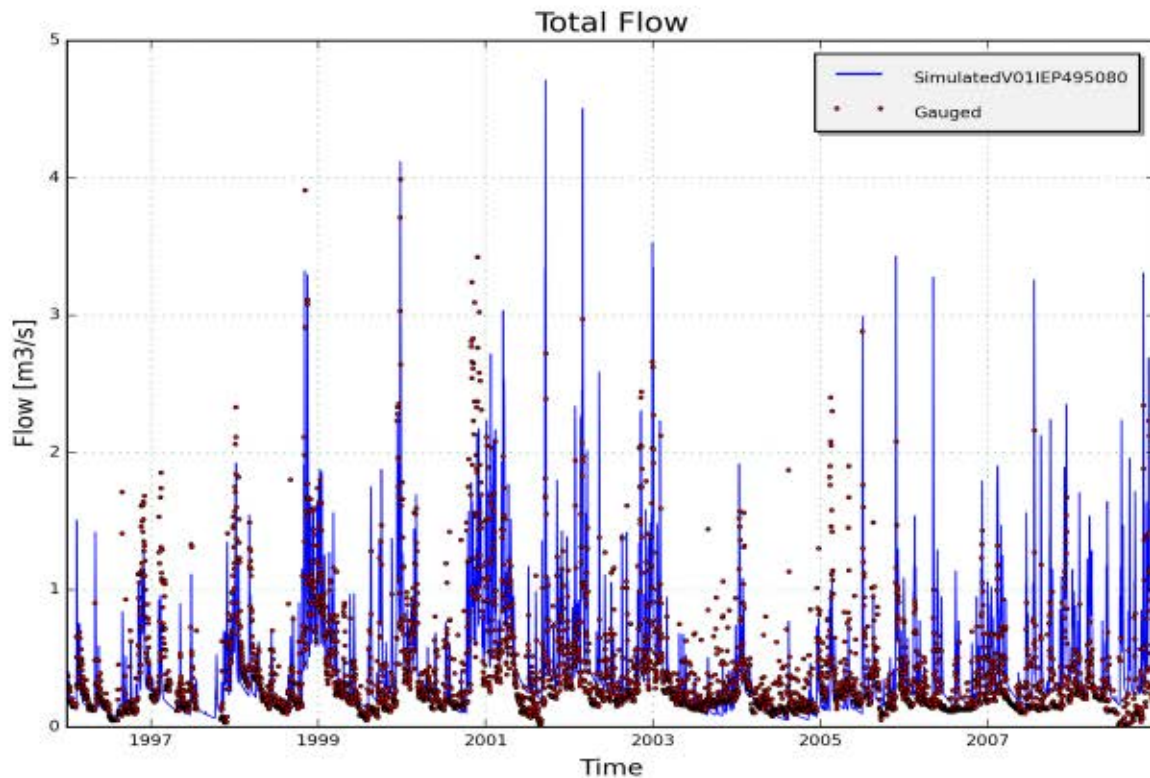


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01IEP495080, station 49510102 - leperlee; Zuidschote (calibration period)

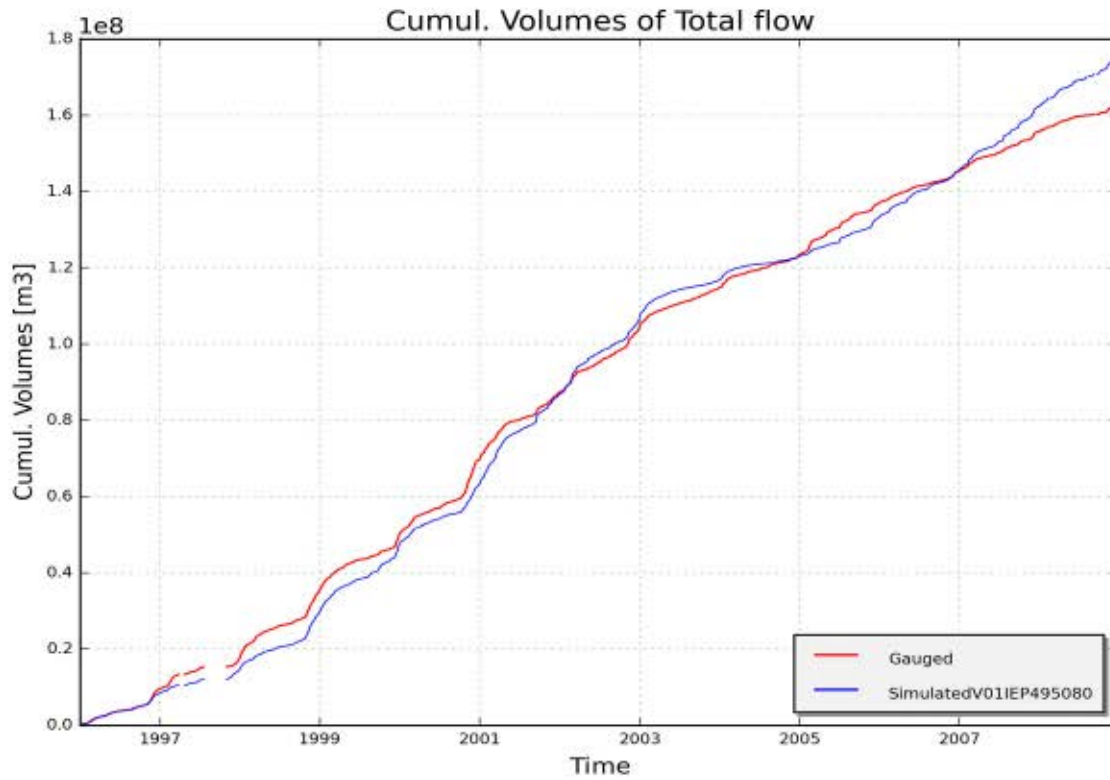


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote (calibration period)

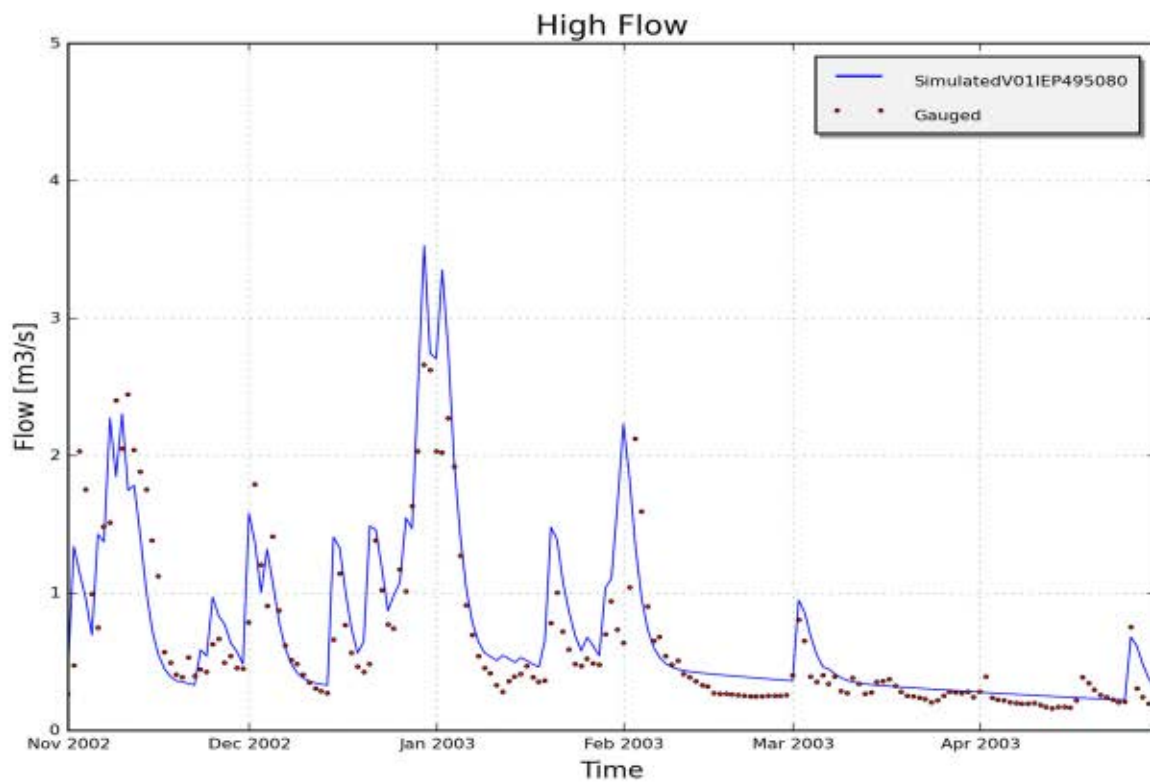


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - Ieperlee; Zuidschote

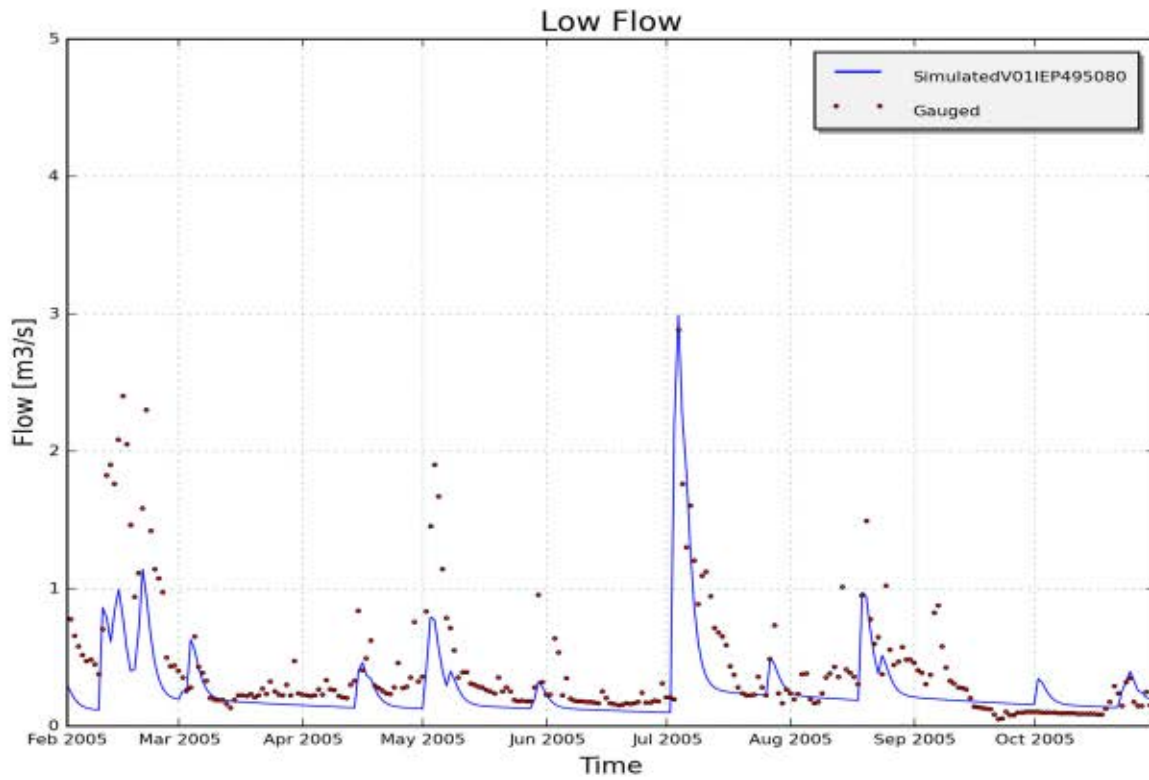


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - leperlee; Zuidschote

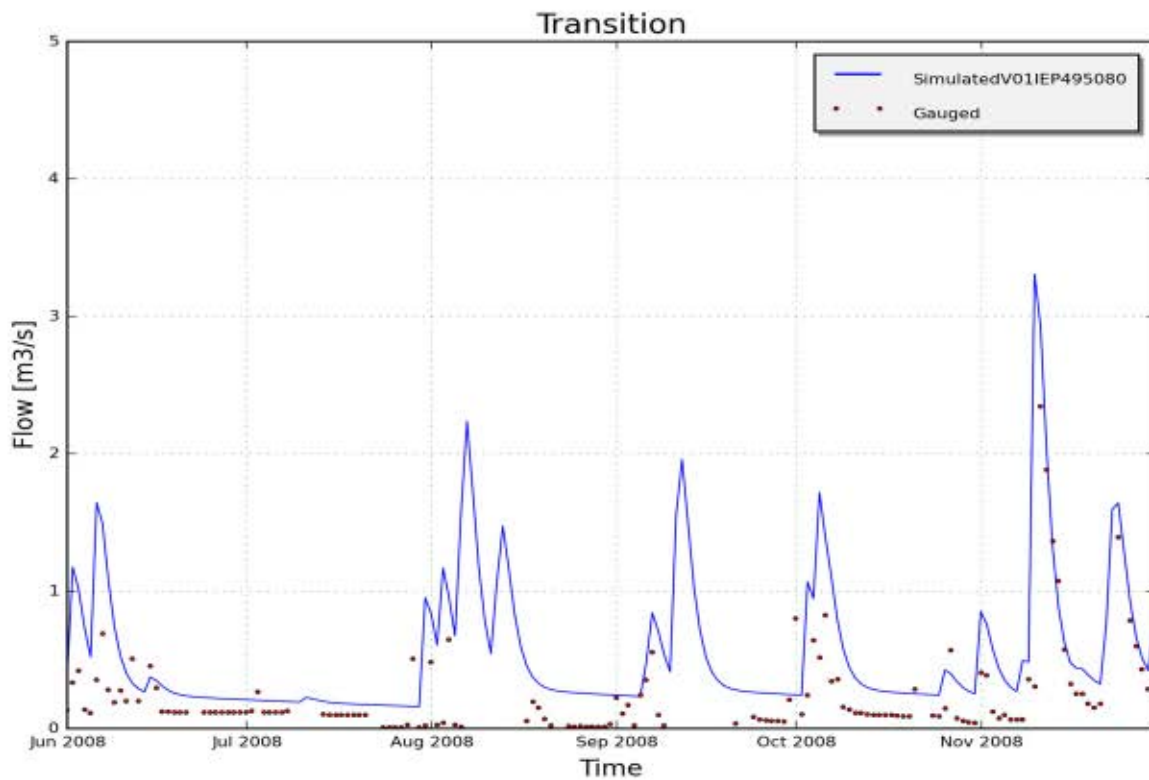


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01IEP495080, station 49510102 - leperlee; Zuidschote

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01KEM492060" (IJZER)

3.1 Input data

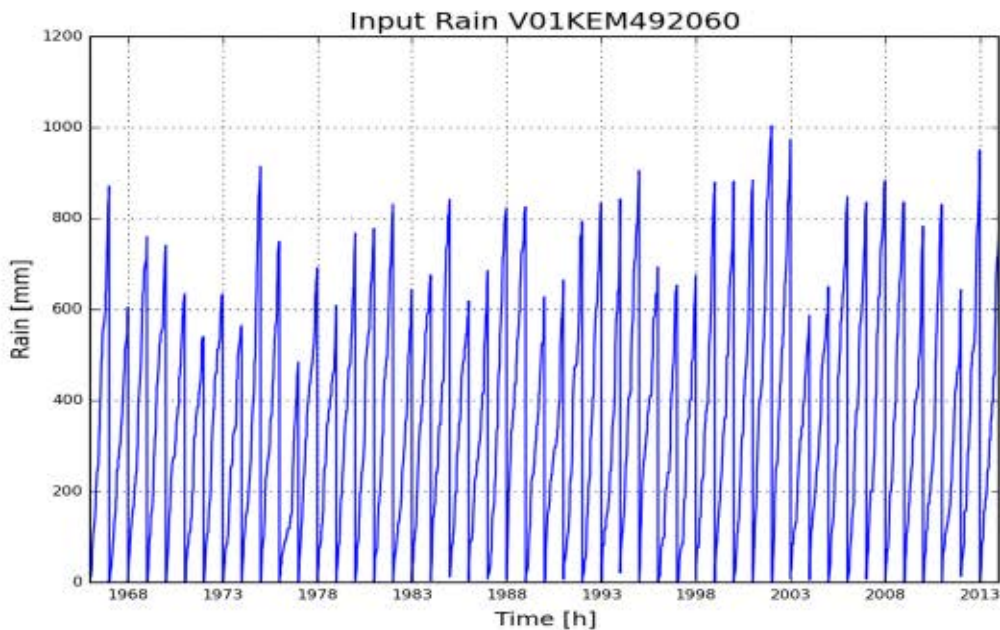


Figure 1: Cumulative precipitation on catchment V01KEM492060 (Ijzer)

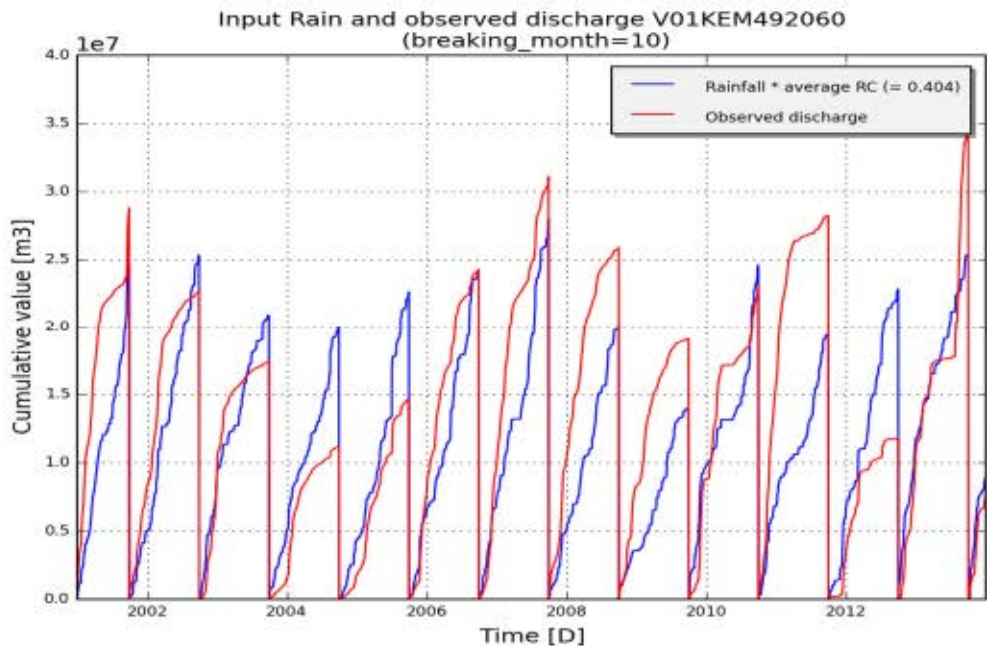


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01KEM492060 (Ijzer)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01KEM492060 |
| subcatchment_area [m2] | 73892930 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 4.62), (‘SMmax.C’, 132.47), (‘CQOF.C’, 0.79), (‘CKBF.C’, 1267.6), (‘CKIF.C’, 116.0), (‘CK1.C’, 37.9), (‘CK2.C’, 36.5), (‘TIF.C’, 0.53), (‘TOF.C’, 0.13), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 4764669.888 | 25427800.686 |
| RelErr | 1.1 % | 9.3 % |
| RMSE | 5538150.951 | 26996815.778 |
| NS | 0.628 | 0.636 |
| NS_log | 0.524 | 0.57 |
| NS_rel | -21.958 | -10.262 |

3.3 Observed and simulated timeseries for optimum parameters

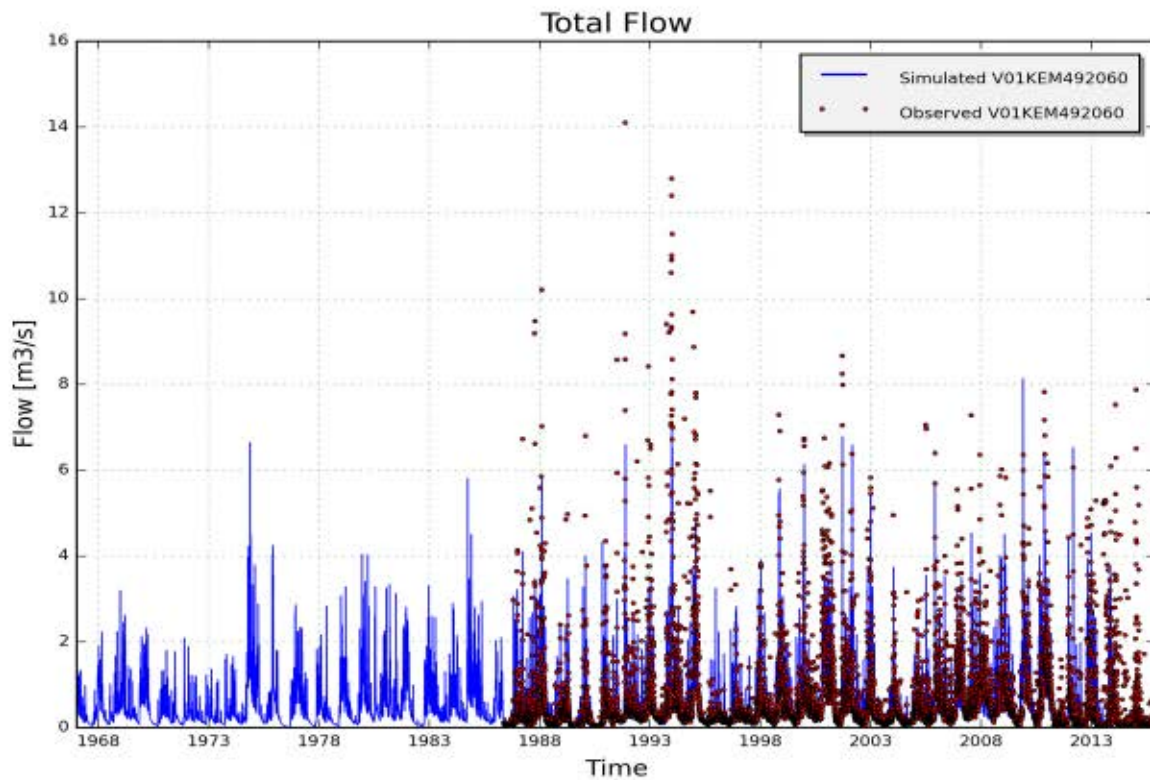


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (validation period 1967-2013)

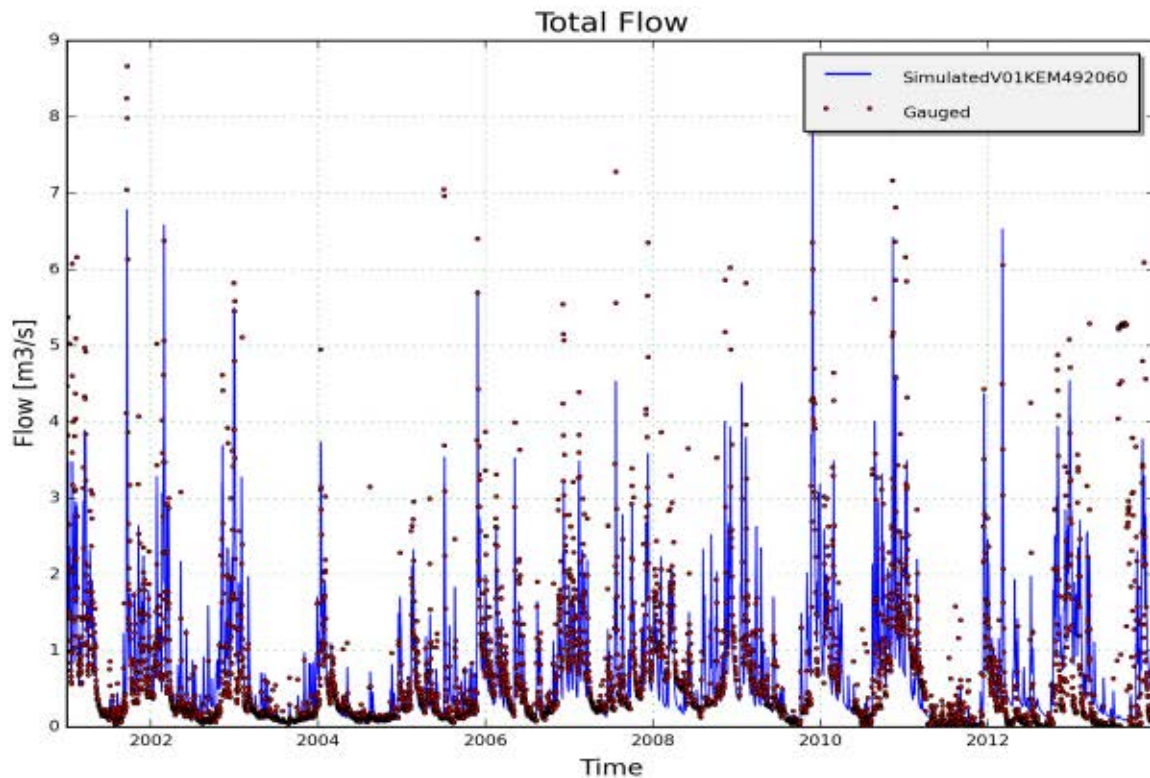


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (calibration period)

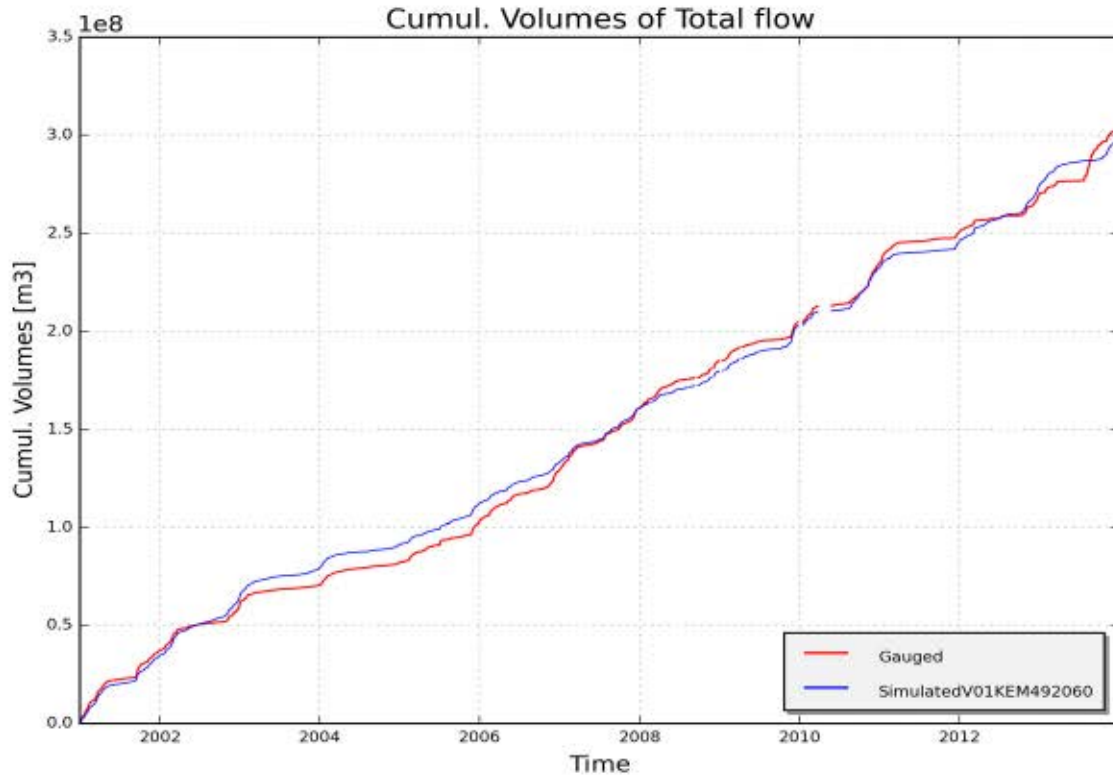


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge (calibration period)

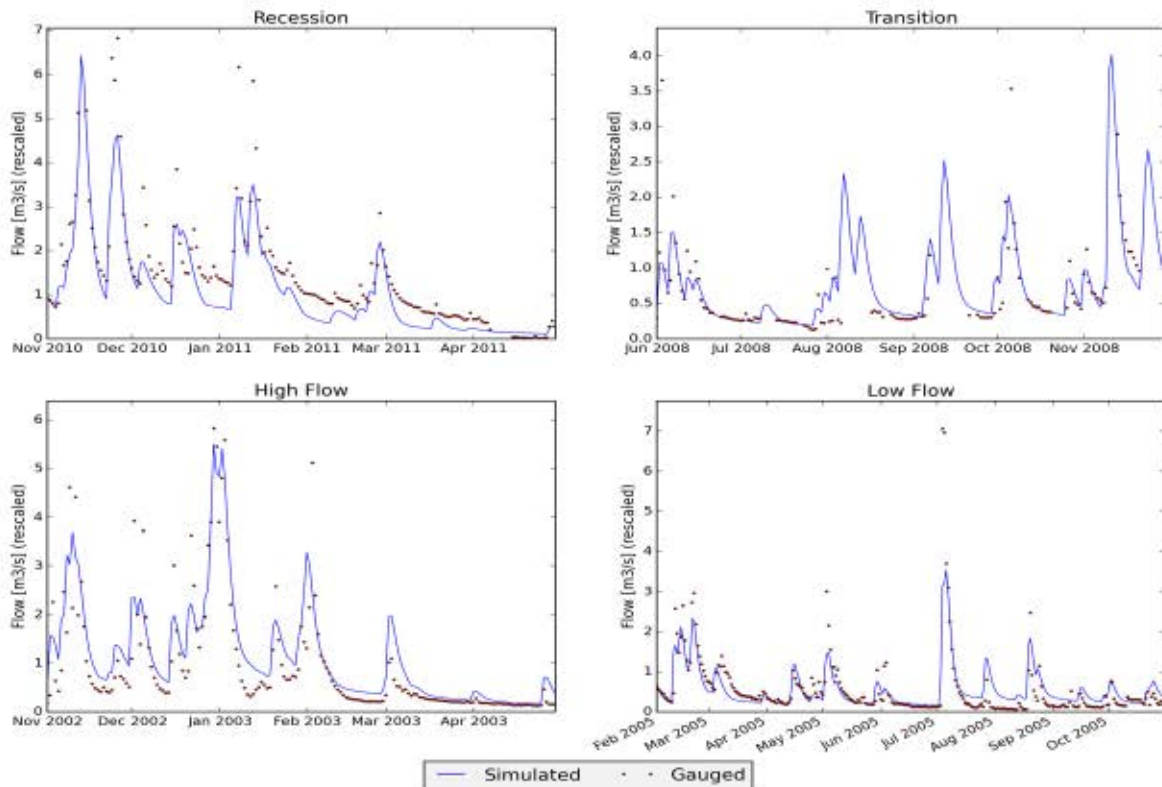


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01KEM492060, station 49270102 -Kemmelbeek; Boezinge

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01MAR496120" (IJZER)

4.1 Input data

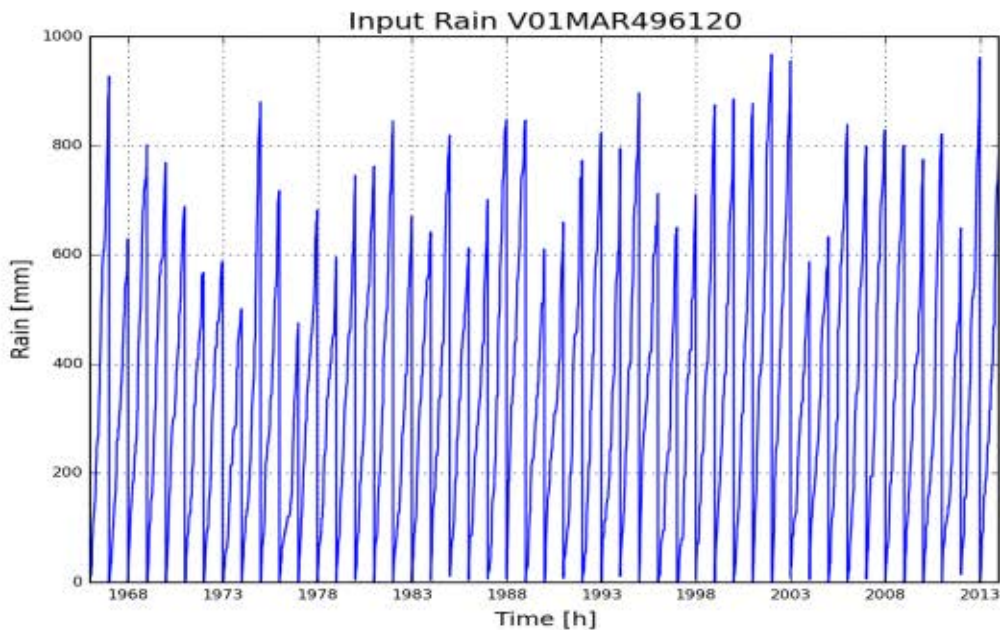


Figure 1: Cumulative precipitation on catchment V01MAR496120 (IJzer)

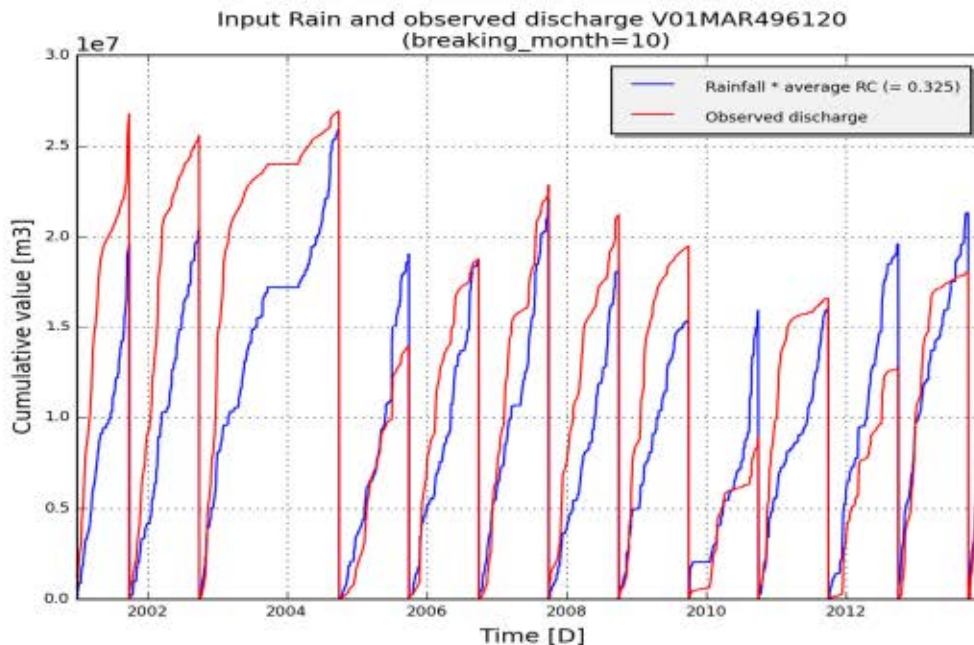


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01MAR496120 (IJzer)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01MAR496120 |
| subcatchment_area [m2] | 76136621 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 9.08), (‘SMmax.C’, 103.97), (‘CQOF.C’, 0.8), (‘CKBF.C’, 1227.76), (‘CKIF.C’, 50.24), (‘CK1.C’, 21.64), (‘CK2.C’, 30.36), (‘TIF.C’, 0.7), (‘TOF.C’, 0.01), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 7188652.019 | 32882262.345 |
| RelErr | 1.2 % | 13.1 % |
| RMSE | 9892545.691 | 38012301.793 |
| NS | 0.676 | 0.696 |
| NS_log | 0.672 | 0.626 |
| NS_rel | -0.719 | -5.751 |

4.3 Observed and simulated timeseries for optimum parameters

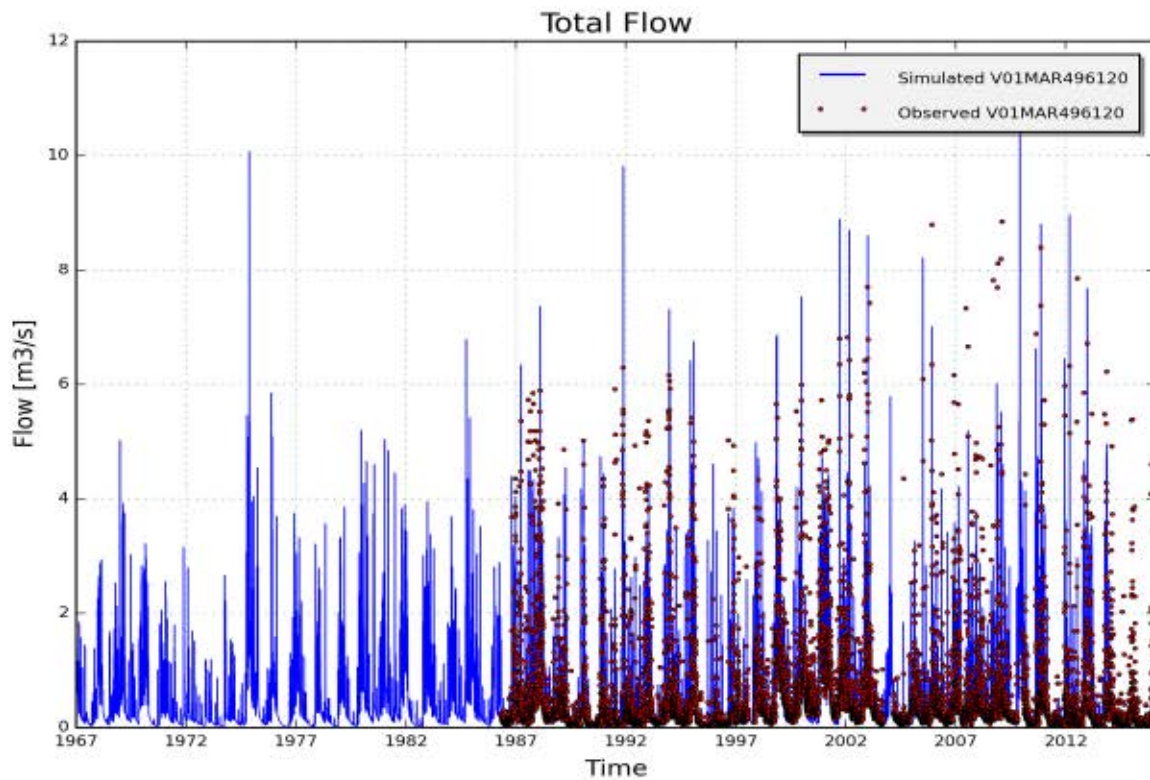


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (validation period 1967-2013)

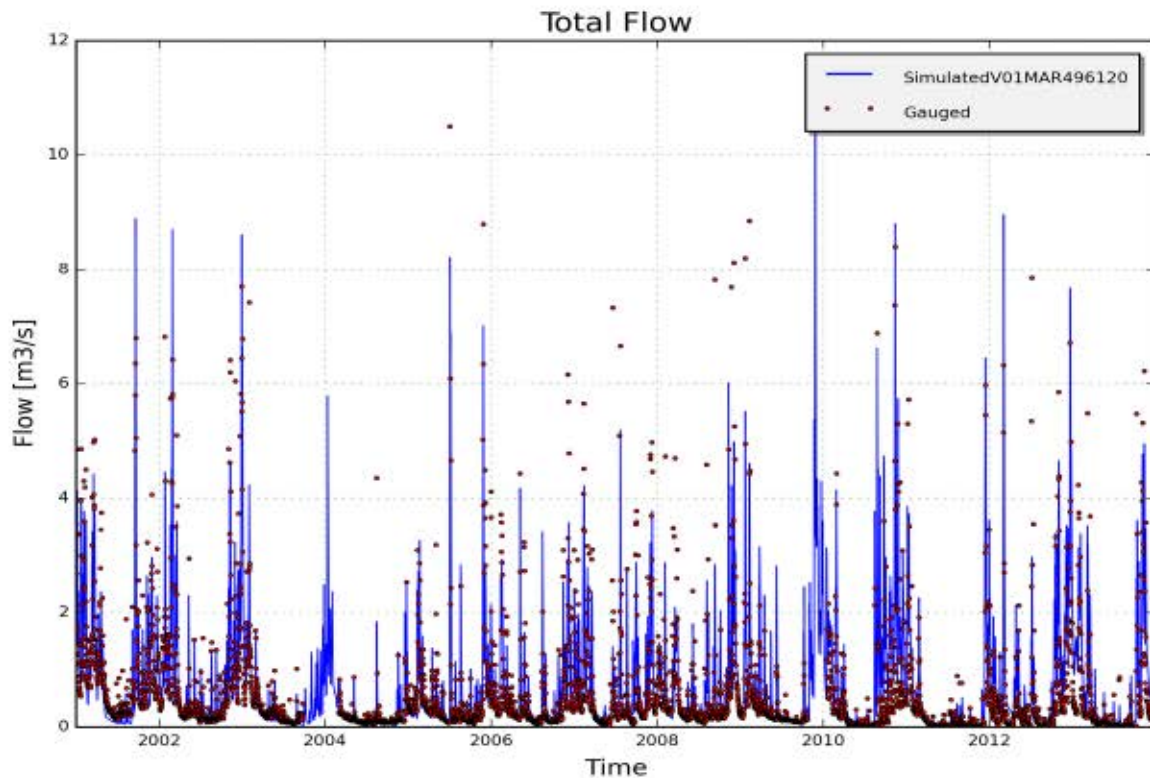


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (calibration period)

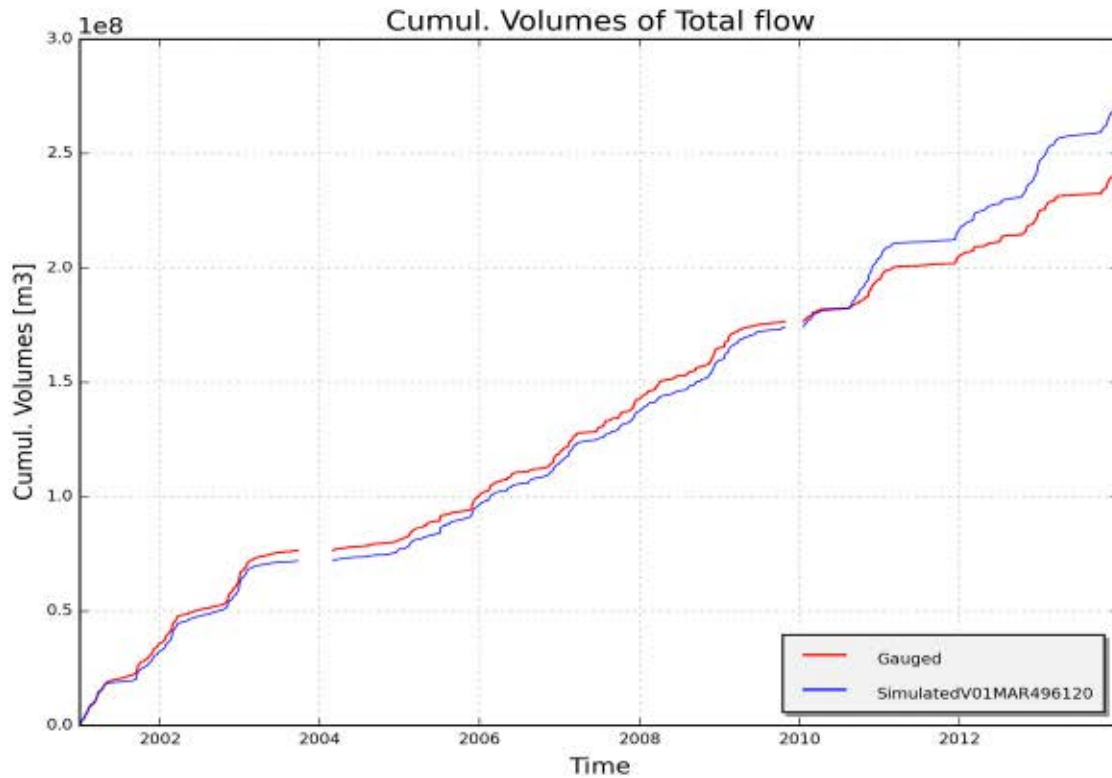


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem (calibration period)

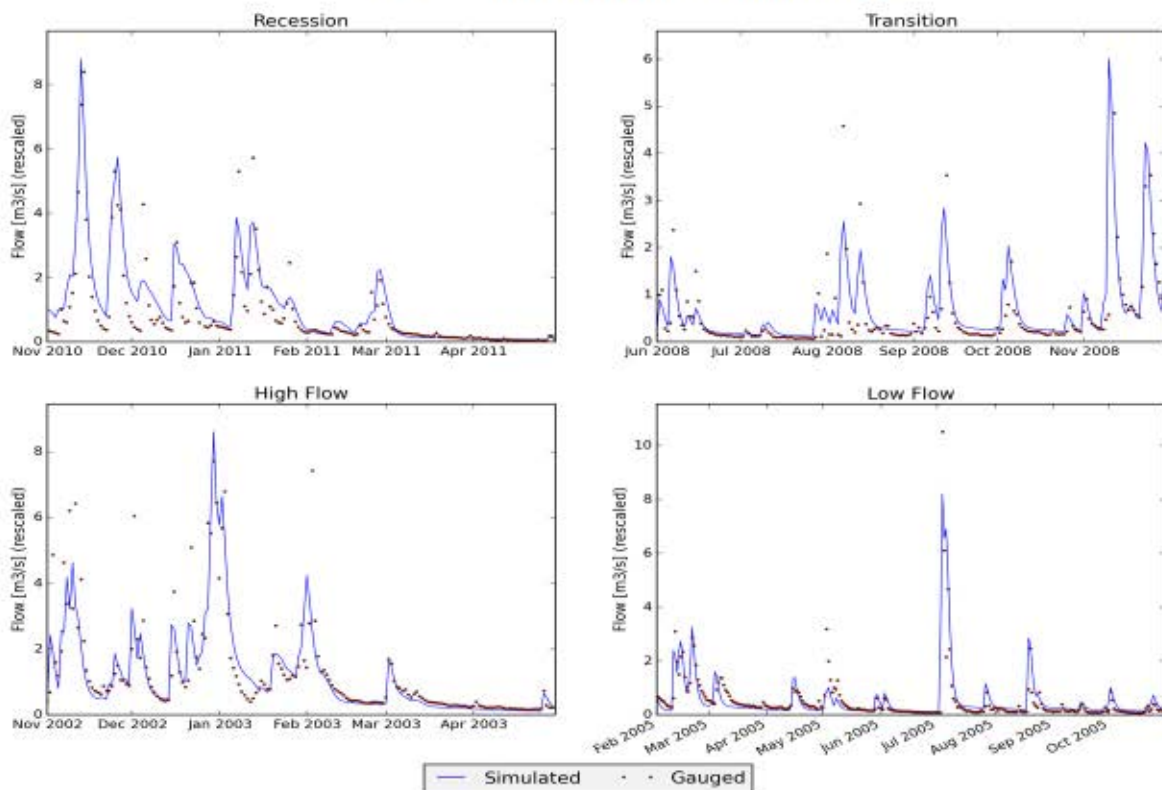


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01MAR496120, station 49610102 - St. Jansbeek; Merkem

5 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01POP491030" (IJZER)

5.1 Input data

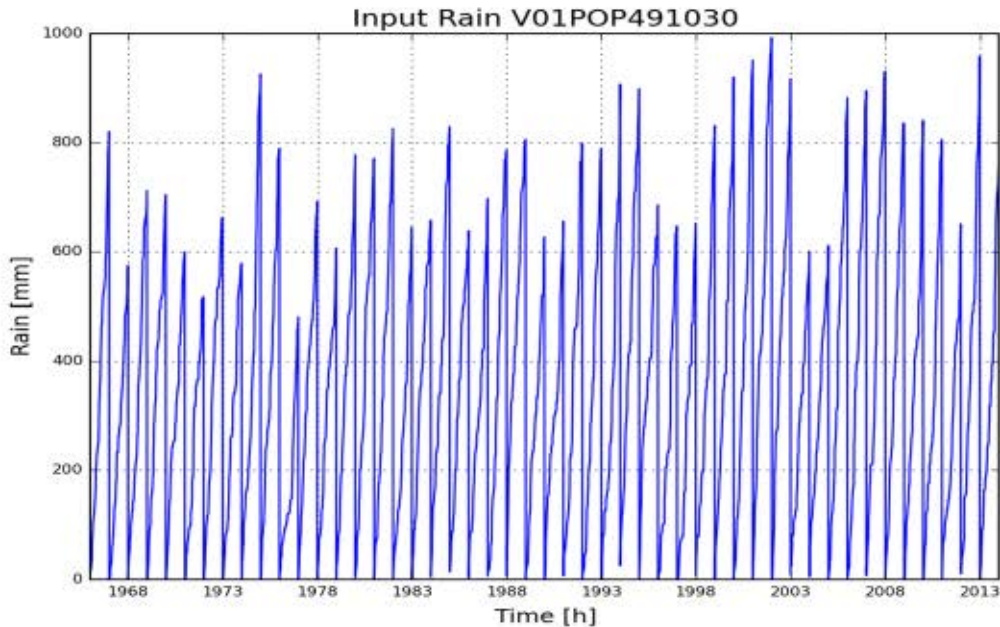


Figure 1: Cumulative precipitation on catchment V01POP491030 (Ijzer)

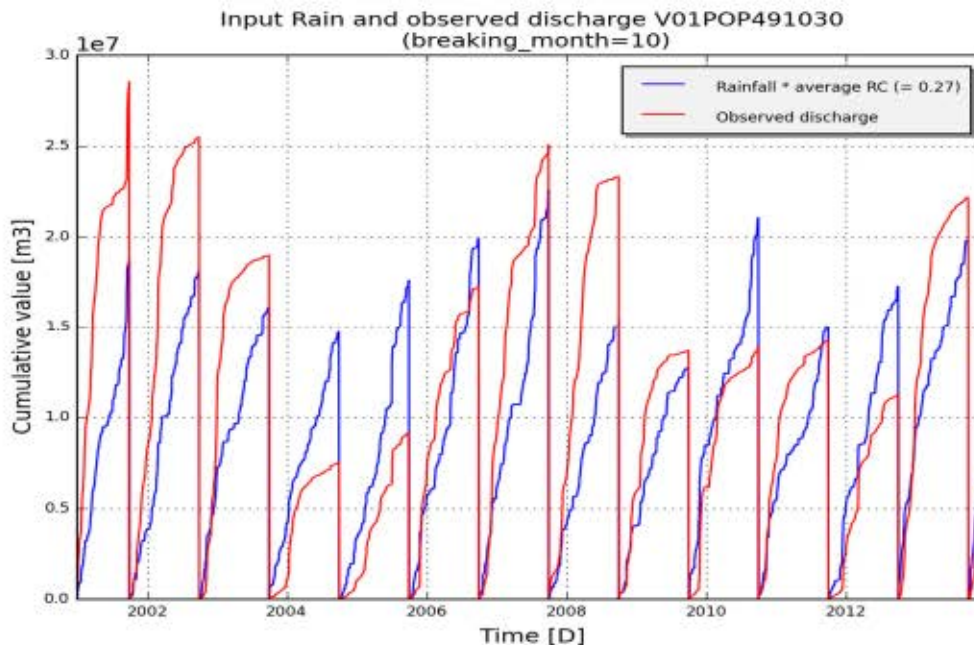


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01POP491030 (Ijzer)

5.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01POP491030 |
| subcatchment_area [m2] | 84868207 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 14.0), (‘SMmax.C’, 200.0), (‘CQOF.C’, 0.5), (‘CKBF.C’, 1000.0), (‘CKIF.C’, 393.6), (‘CK1.C’, 30.0), (‘CK2.C’, 28.8), (‘TIF.C’, 0.9), (‘TOF.C’, 0.01), (‘NAM.TG.C’, 0.22)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 10444511.299 | 25853220.967 |
| RelErr | 5.8 % | -8.8 % |
| RMSE | 16049778.286 | 29581201.593 |
| NS | 0.645 | 0.669 |
| NS_log | 0.423 | 0.58 |
| NS_rel | -1.253 | -0.432 |

5.3 Observed and simulated timeseries for optimum parameters

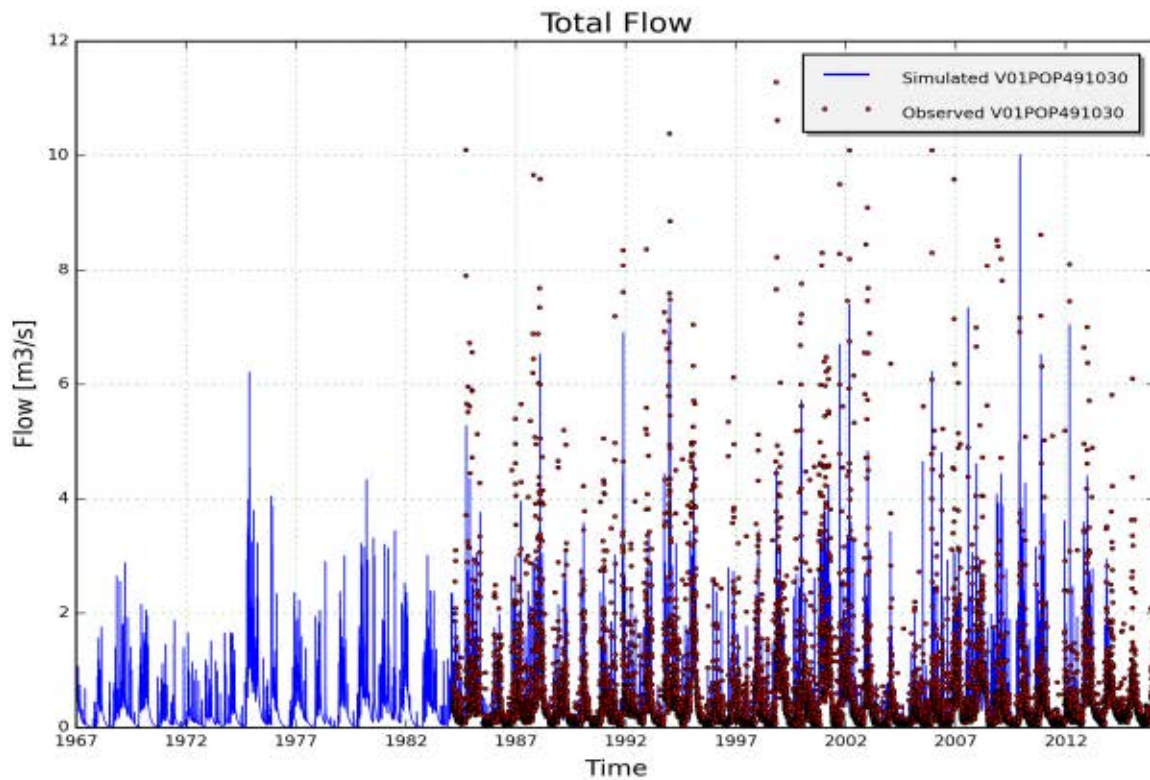


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (validation period 1967-2013)

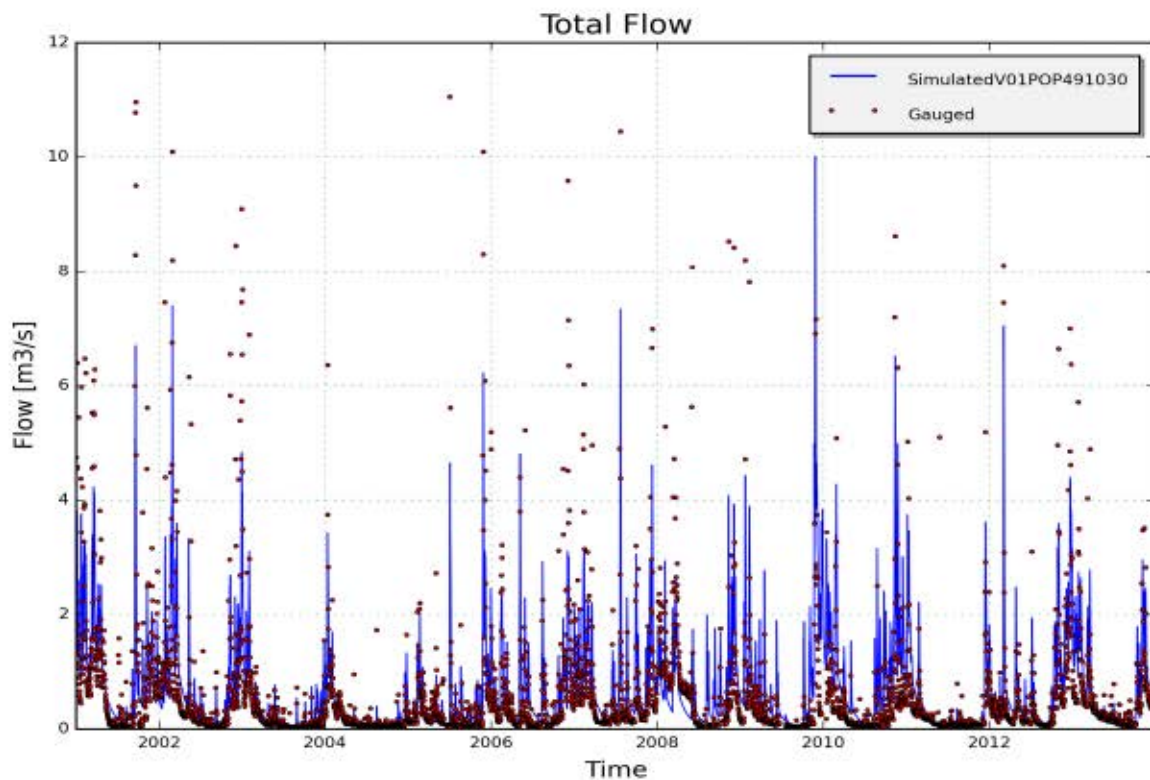


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (calibration period)

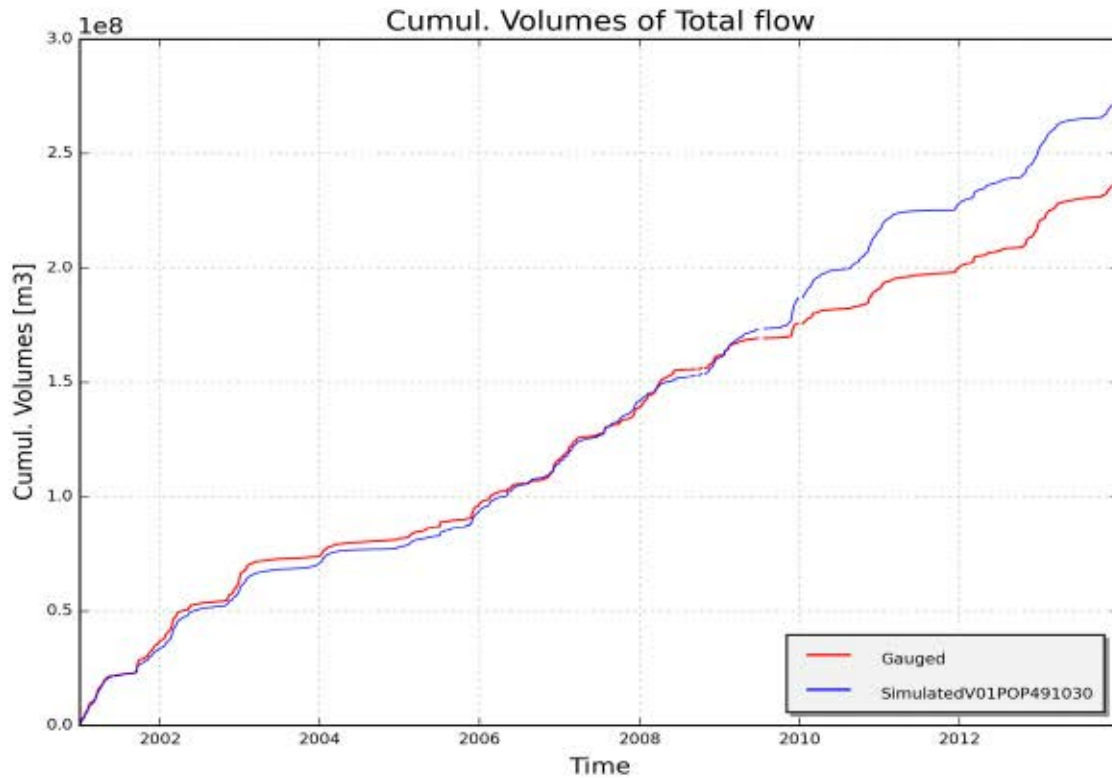


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren (calibration period)

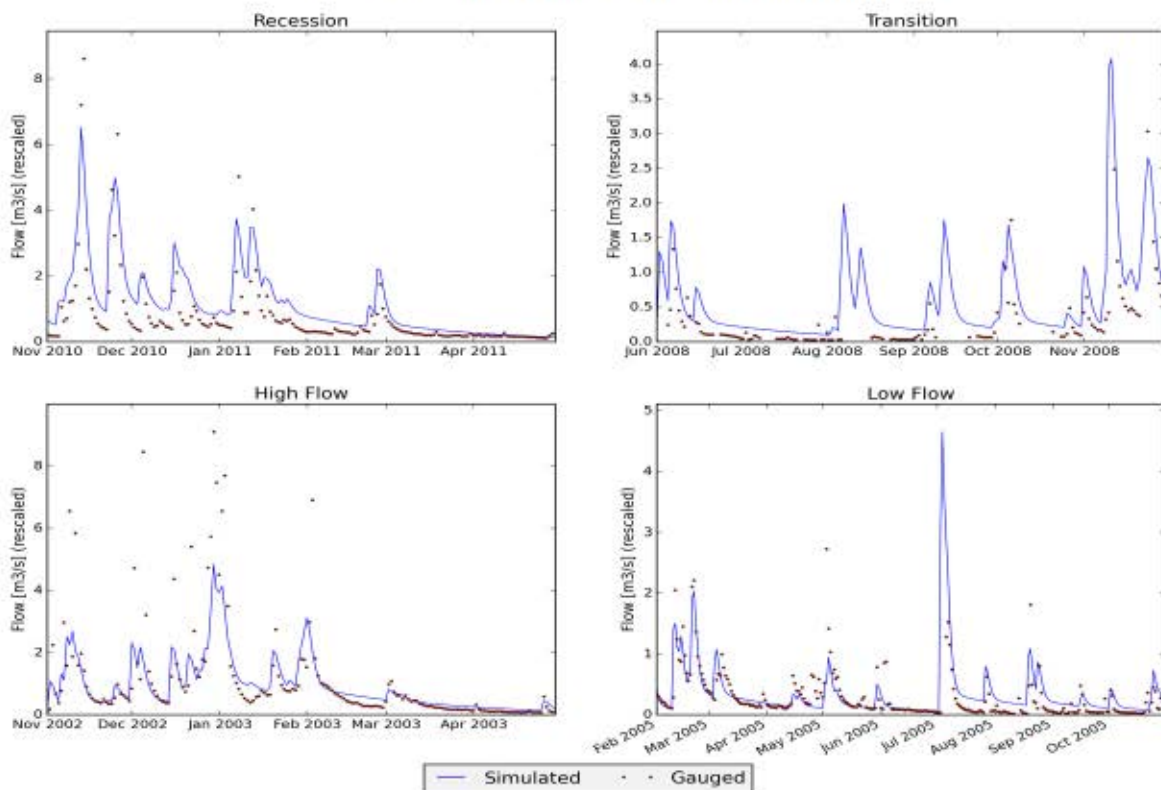


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01POP491030, station 49110102-Poperingevaart; Oostvleteren

6 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01SSV499140" (IJZER)

6.1 Input data

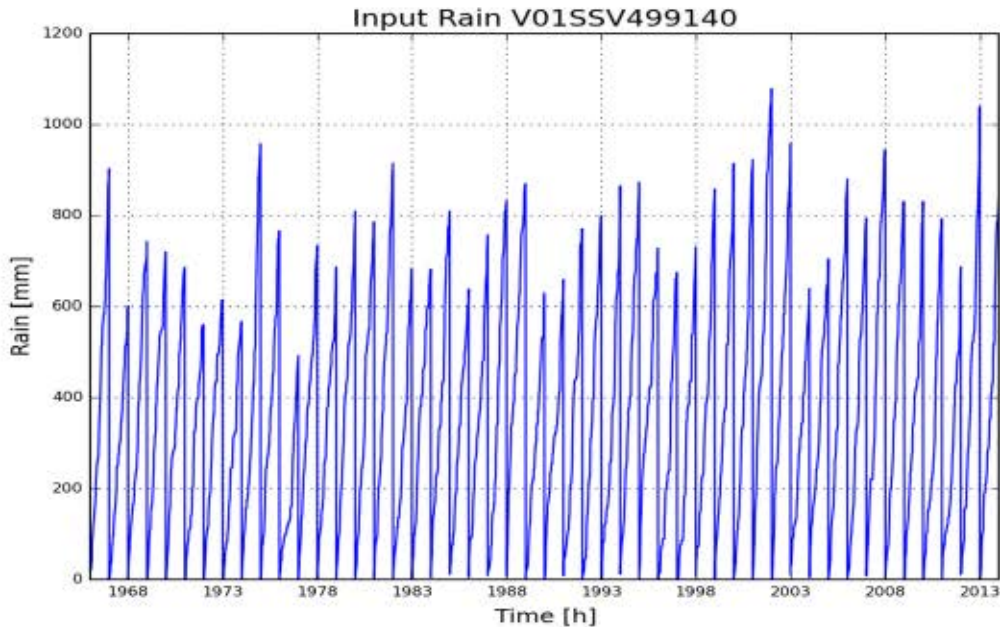


Figure 1: Cumulative precipitation on catchment V01SSV499140 (Ijzer)

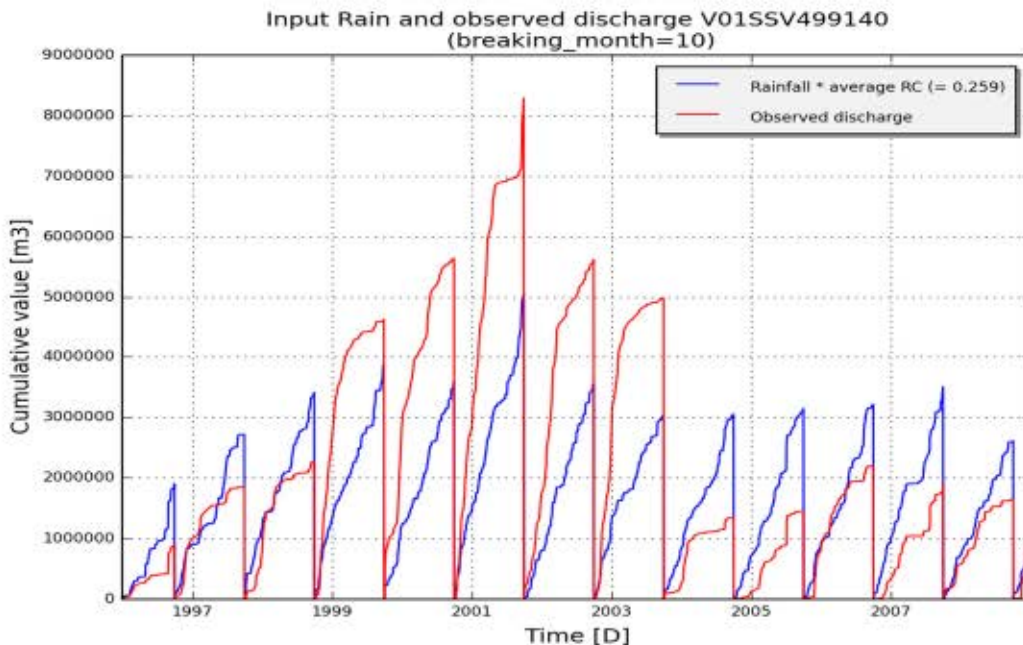


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01SSV499140 (Ijzer)

6.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01SSV499140 |
| subcatchment_area [m2] | 16095000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 8.6), (‘SMmax.C’, 270.27), (‘CQOF.C’, 0.71), (‘CKBF.C’, 1579.45), (‘CKIF.C’, 344.62), (‘CK1.C’, 29.27), (‘CK2.C’, 28.57), (‘TIF.C’, 0.53), (‘TOF.C’, 0.16), (‘NAM.TG.C’, 0.61)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 1144989.242 | 6483838.307 |
| RelErr | 0.9 % | -16.9 % |
| RMSE | 1560267.092 | 6854360.121 |
| NS | 0.615 | 0.615 |
| NS_log | 0.463 | 0.399 |
| NS_rel | -71.382 | -60.388 |

6.3 Observed and simulated timeseries for optimum parameters

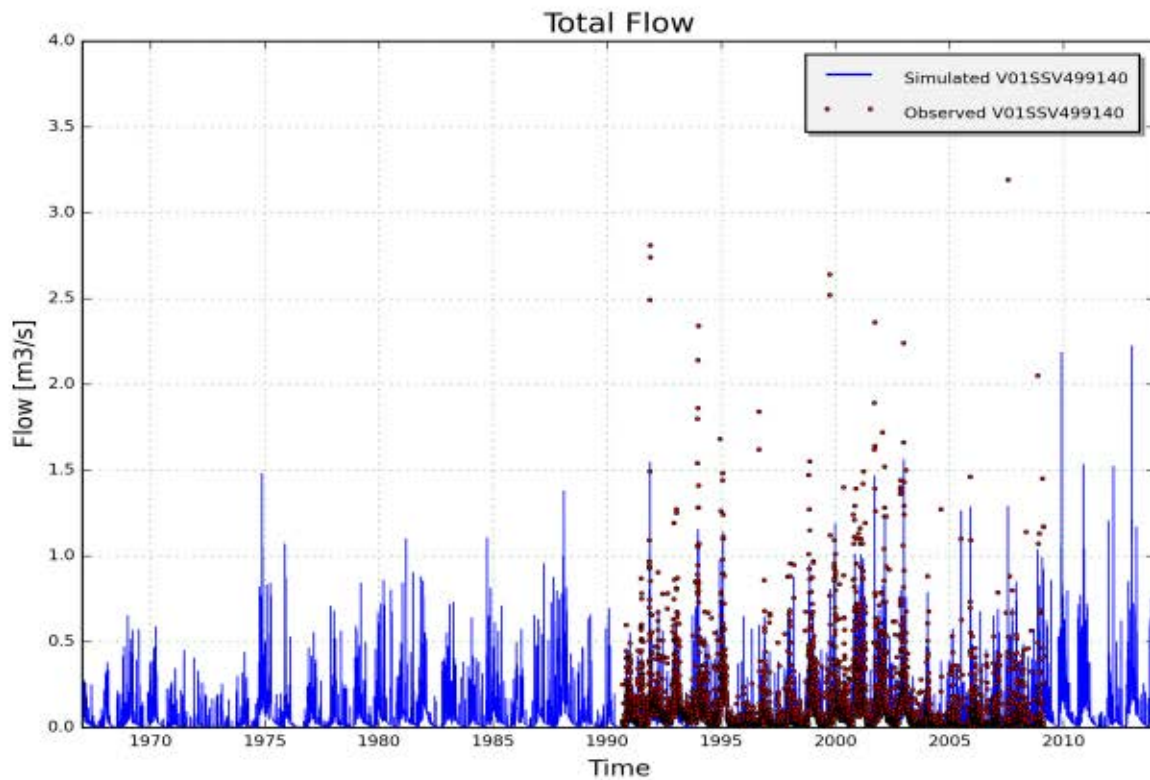


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (validation period 1967-2013)

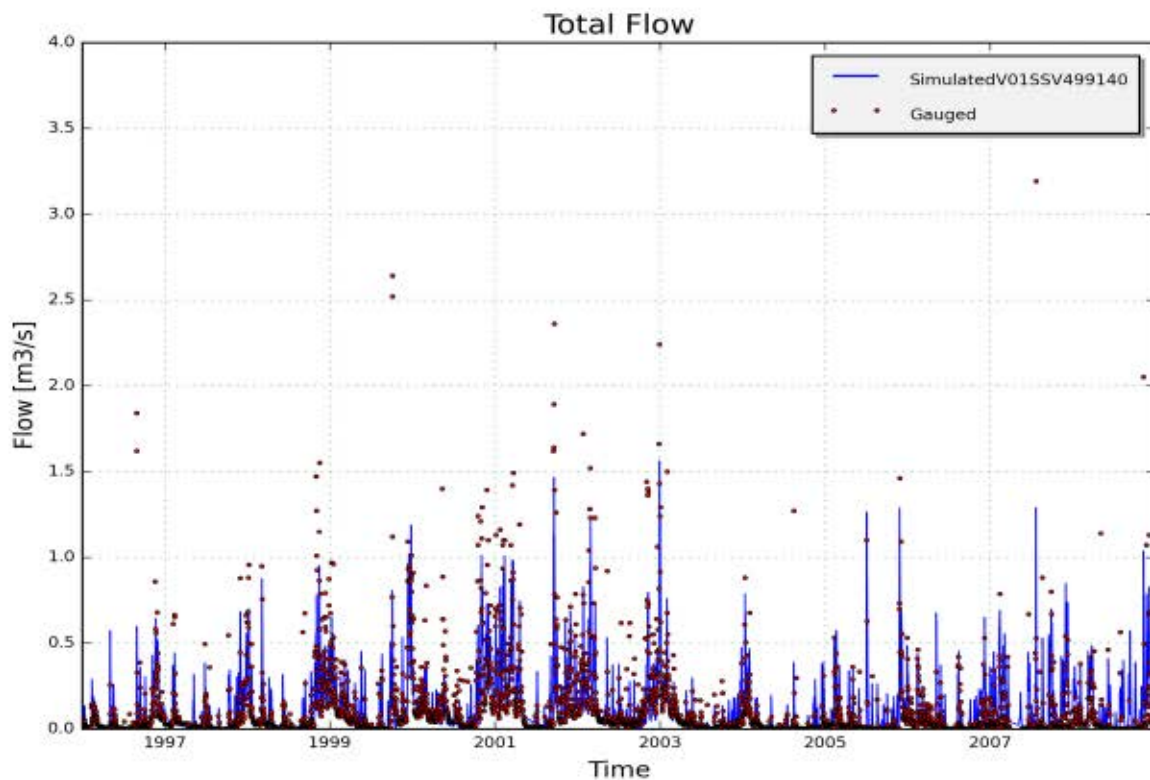


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (calibration period)

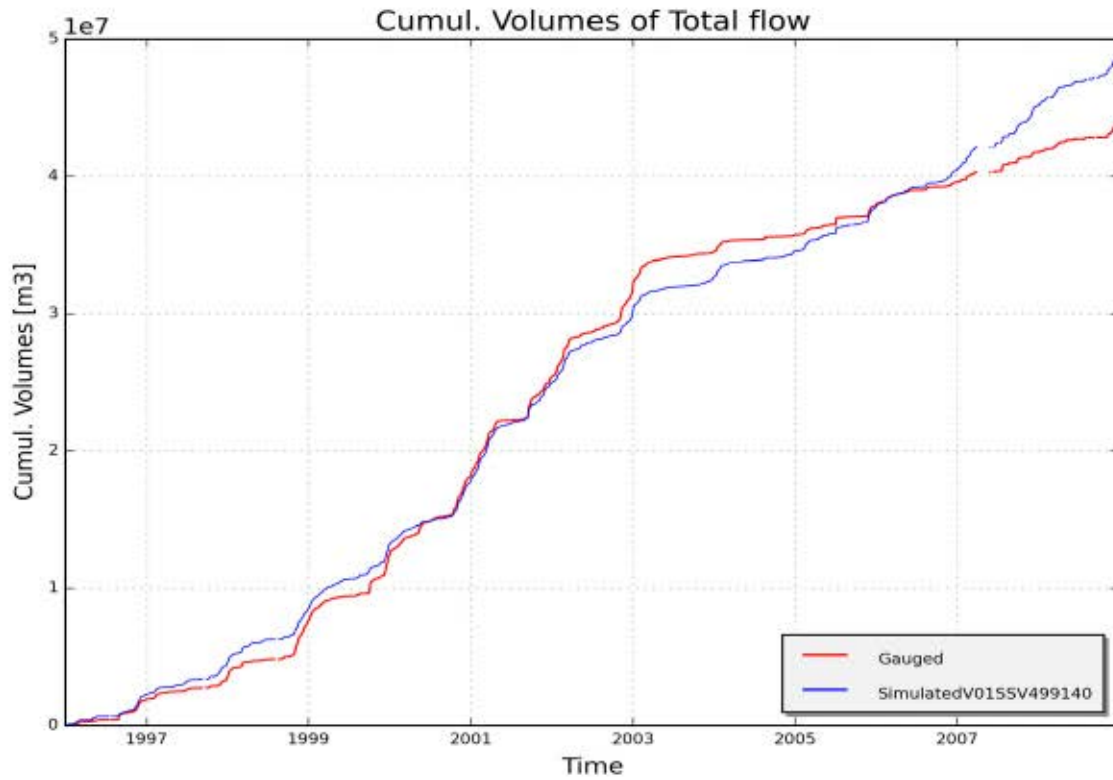


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem (calibration period)

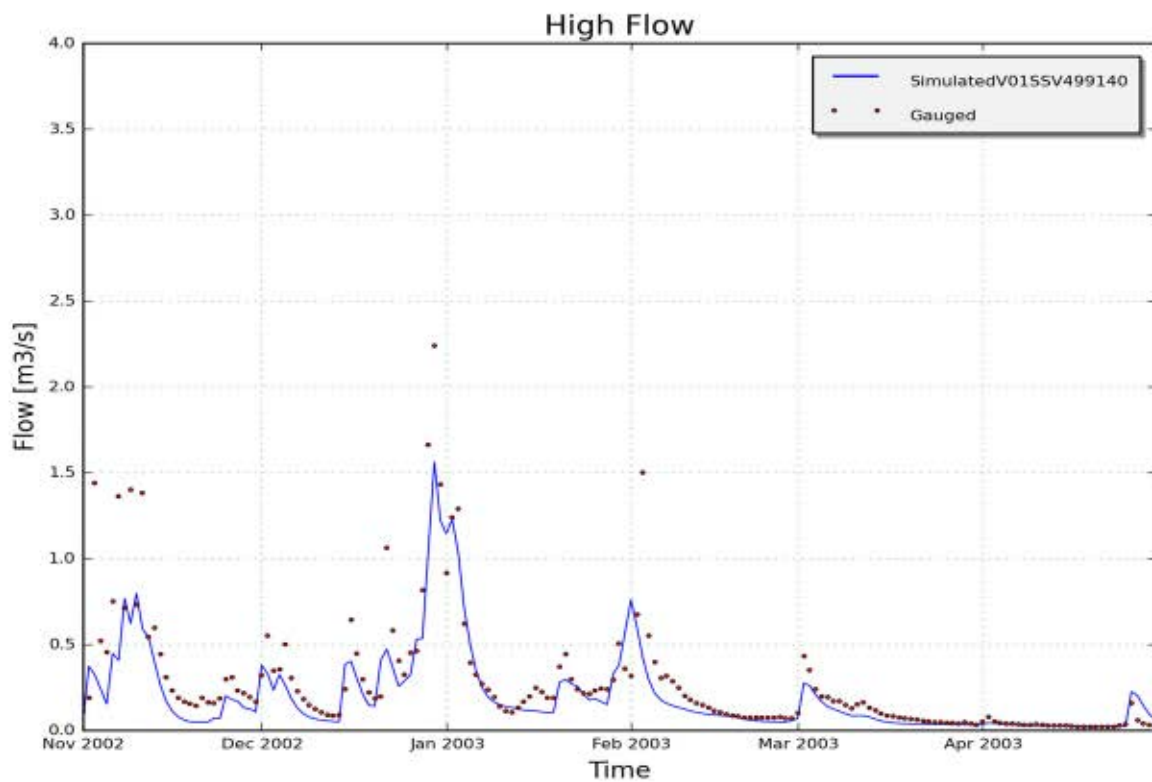


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem

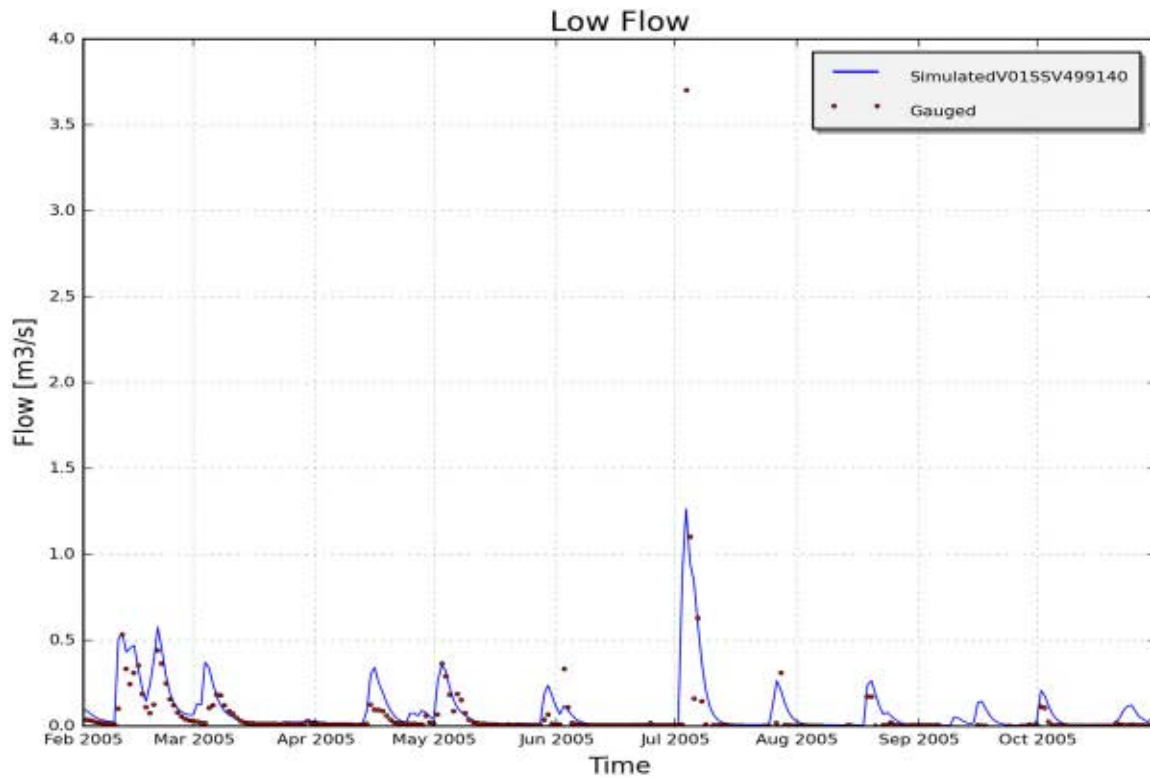


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem

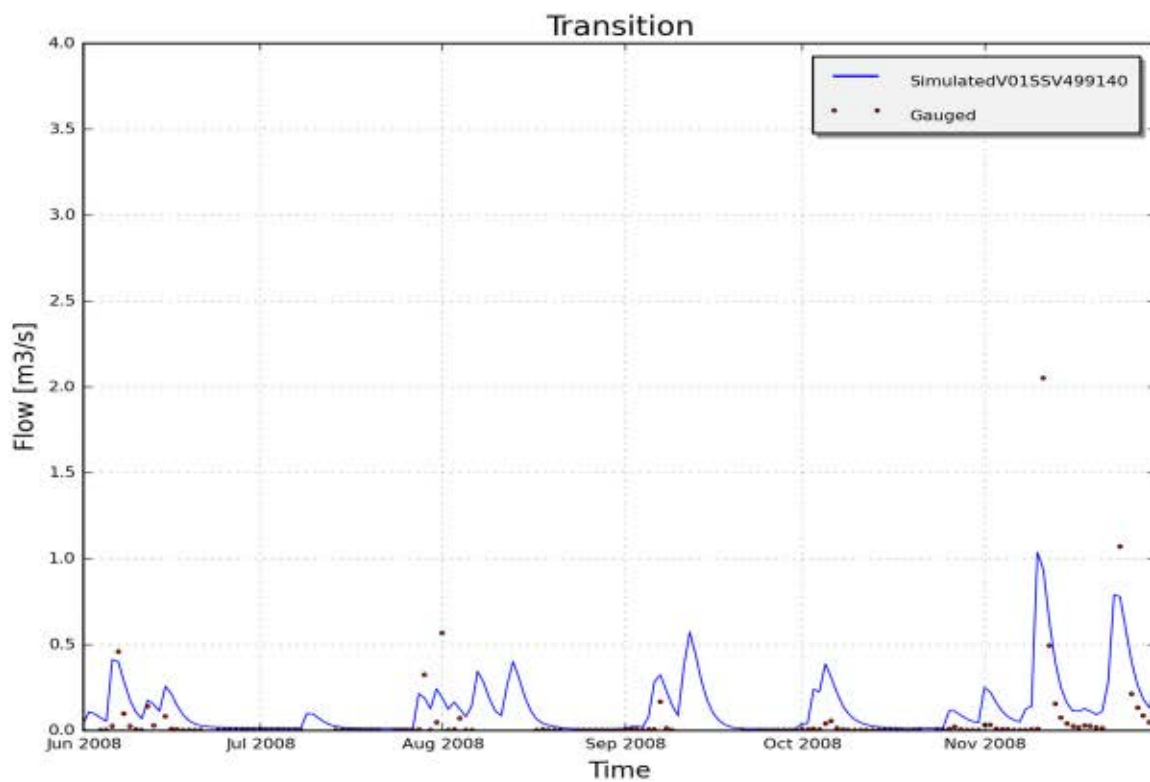


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01SSV499140, station 49910102 - Steenbeek; Merkem

7 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V01HAN488180" (IJZER)

7.1 Input data

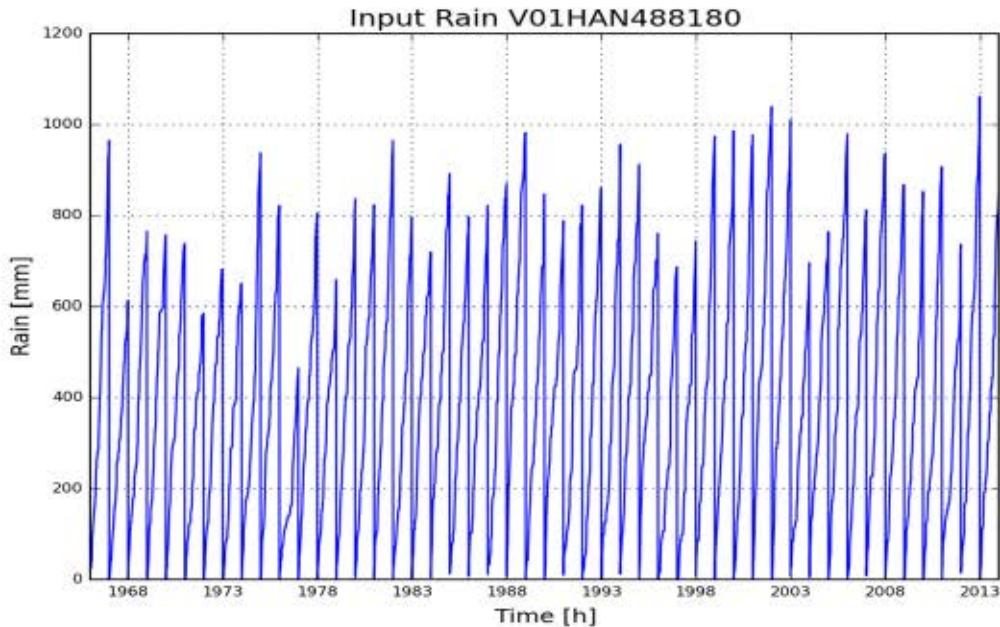


Figure 1: Cumulative precipitation on catchment V01HAN488180 (IJzer)

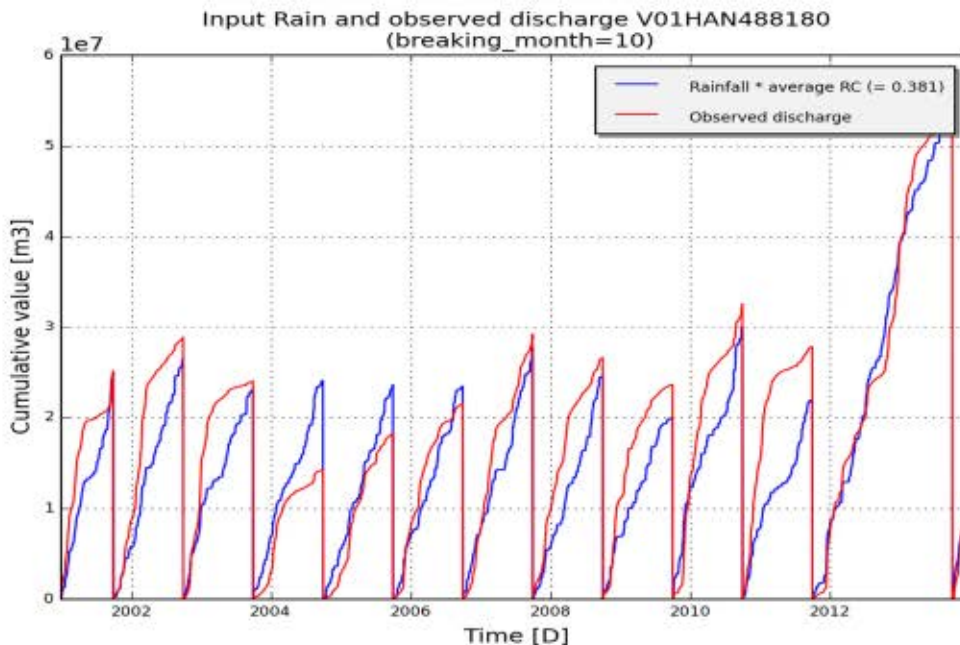


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V01HAN488180 (IJzer)

7.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V01HAN488180 |
| subcatchment_area [m2] | 78558940 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 7.92), ('SMmax.C', 265.39), ('CQOF.C', 0.9), ('CKBF.C', 1599.35), ('CKIF.C', 260.71), ('CK1.C', 9.63), ('CK2.C', 17.69), ('TIF.C', 0.12), ('TOF.C', 0.32), ('NAM.TG.C', 0.28)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 1976388.383 | 2782771.854 |
| RelErr | 0.3 % | -0.1 % |
| RMSE | 2449762.832 | 3425779.947 |
| NS | 0.789 | 0.78 |
| NS_log | 0.777 | 0.777 |
| NS_rel | 0.725 | 0.661 |

7.3 Observed and simulated timeseries for optimum parameters

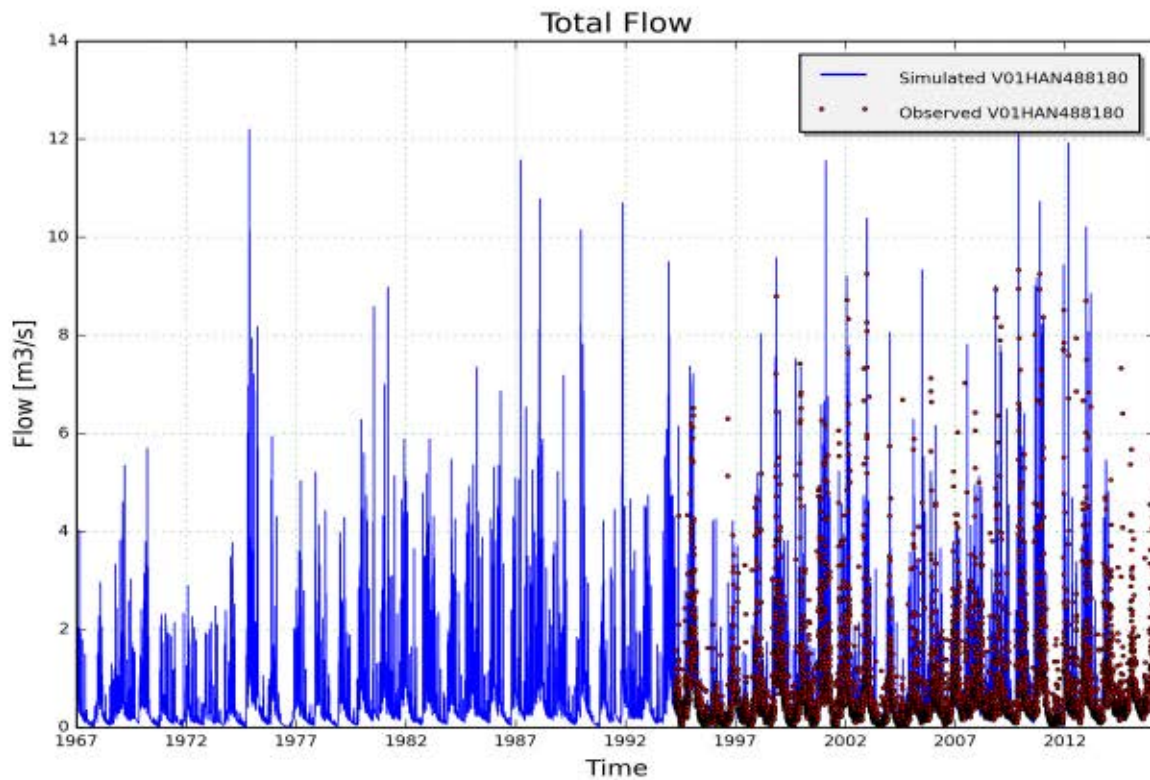


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (validation period 1967-2013)

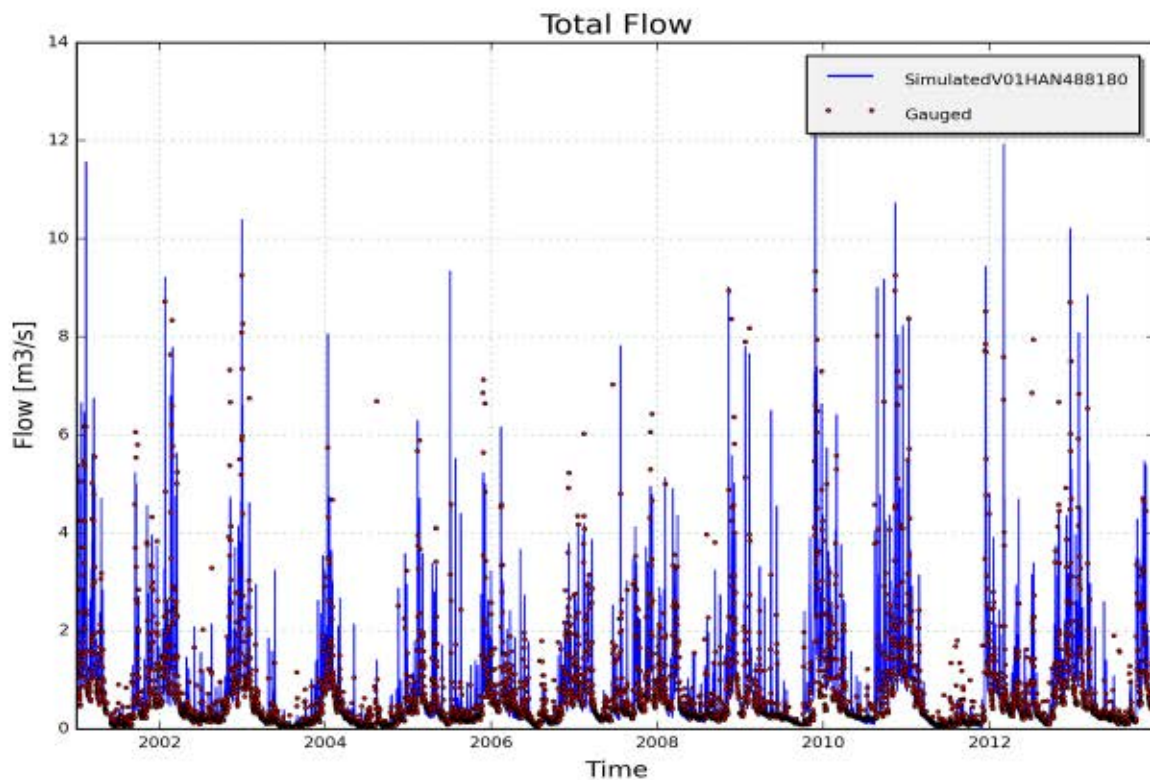


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (calibration period)

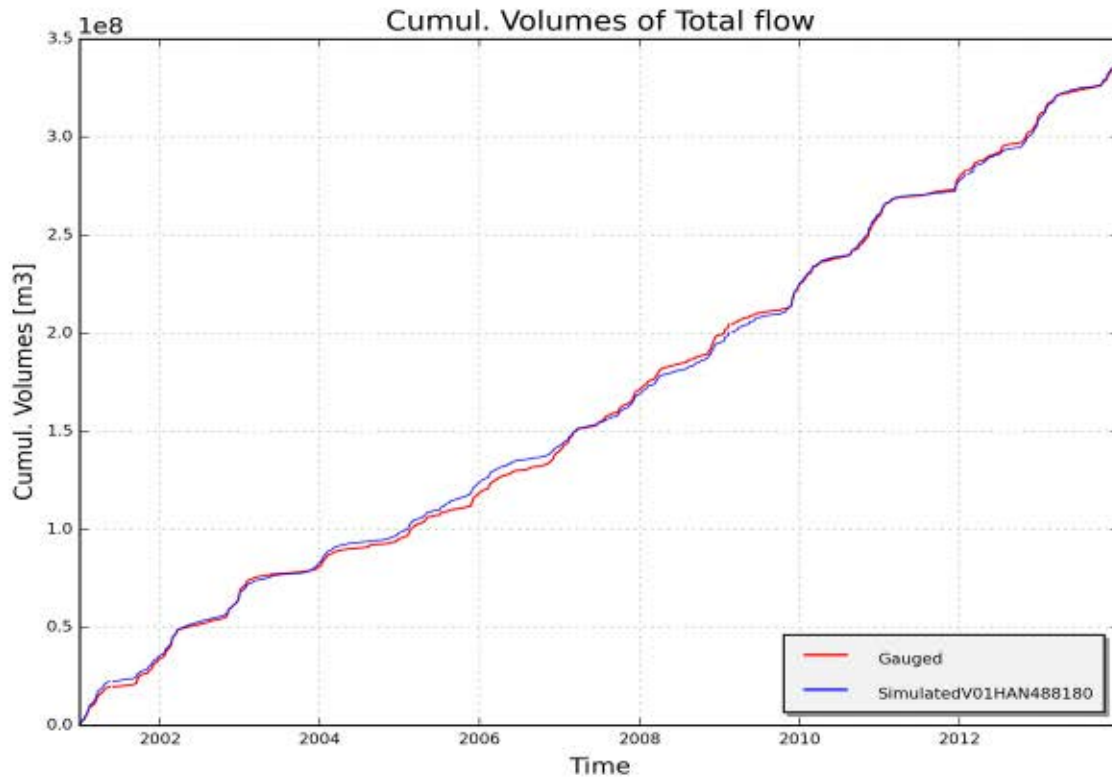


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark (calibration period)

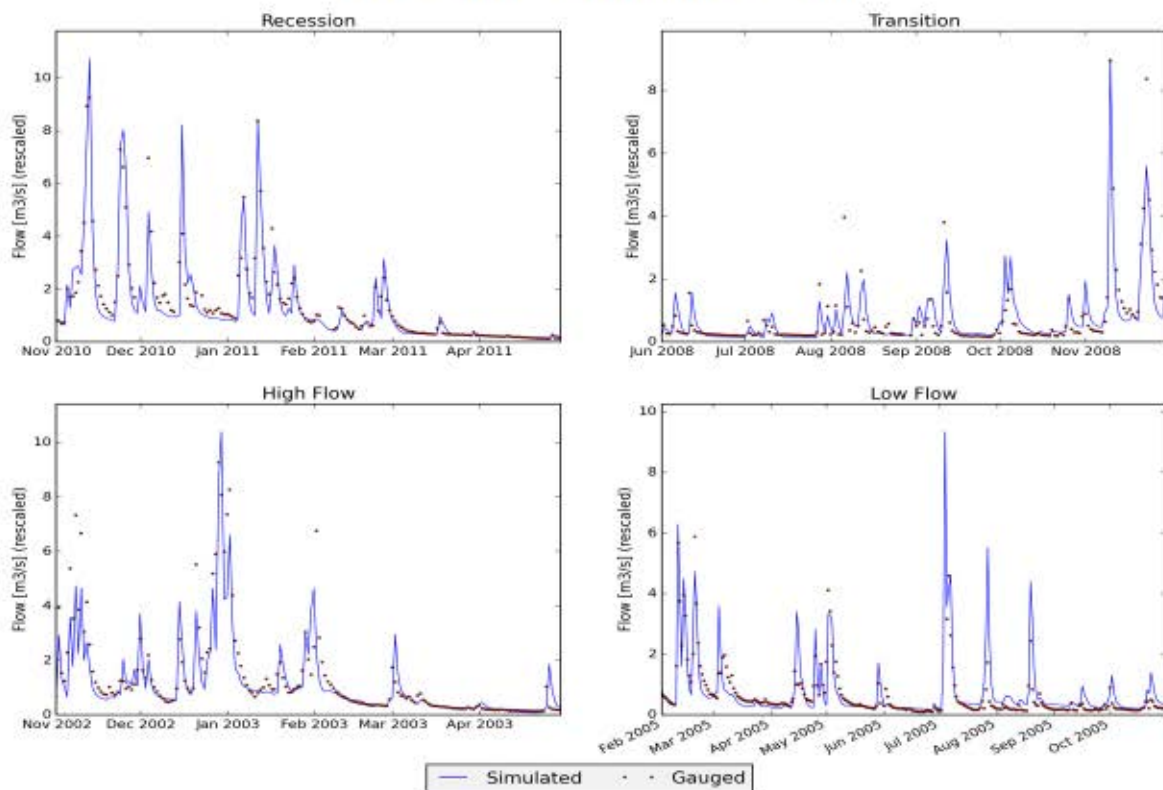


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V01HAN488180, station 48810102 - Krekelbeek; Kortemark

Appendix 4

Results of calibration and validation of NAM parameters for catchment "V02HER426010" (BRUGSE POLDERS)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V02HER426010" (BRUGSE POLDERS)

1.1 Input data

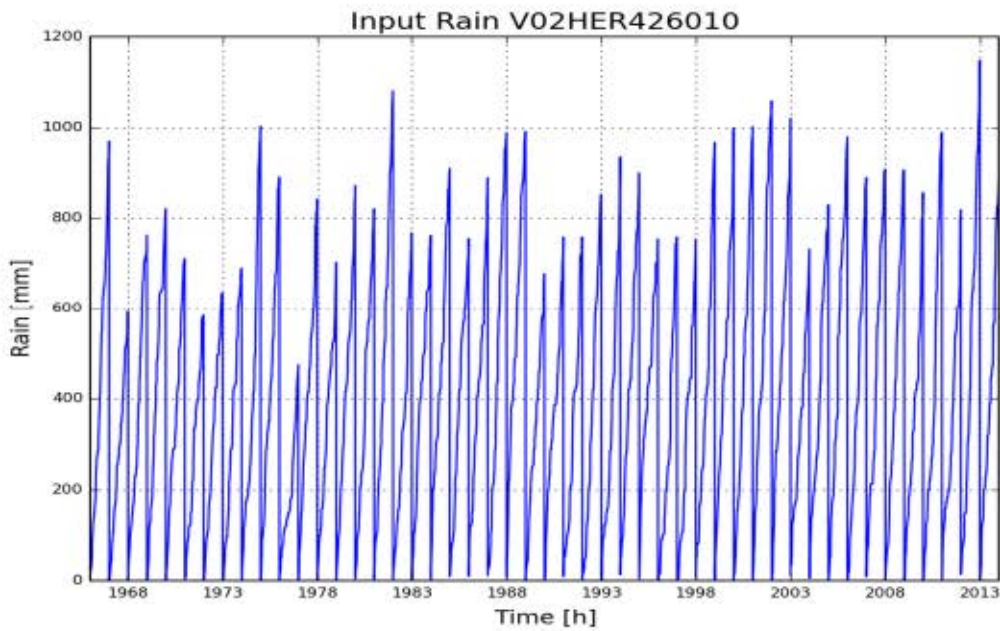


Figure 1: Cumulative precipitation on catchment V02HER426010 (Brugse Polders)

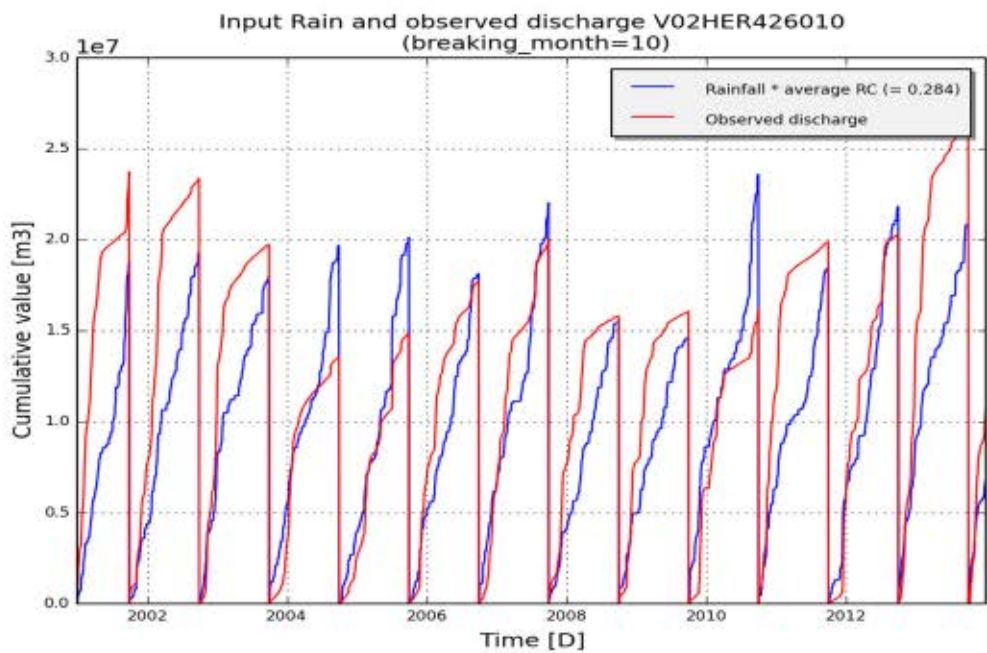


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V02HER426010 (Brugse Polders)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V02HER426010 |
| subcatchment_area [m2] | 77272201 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 15.0), (‘SMmax.C’, 489.24), (‘CQOF.C’, 0.73), (‘CKBF.C’, 1895.2), (‘CKIF.C’, 532.83), (‘CK1.C’, 37.31), (‘CK2.C’, 32.77), (‘TIF.C’, 0.32), (‘TOF.C’, 0.68), (‘NAM.TG.C’, 0.75)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 7167909.359 | 17286632.103 |
| RelErr | -0.0 % | -5.3 % |
| RMSE | 8869428.107 | 20289225.135 |
| NS | 0.684 | 0.713 |
| NS_log | 0.613 | 0.559 |
| NS_rel | 0.182 | -0.035 |

1.3 Observed and simulated timeseries for optimum parameters

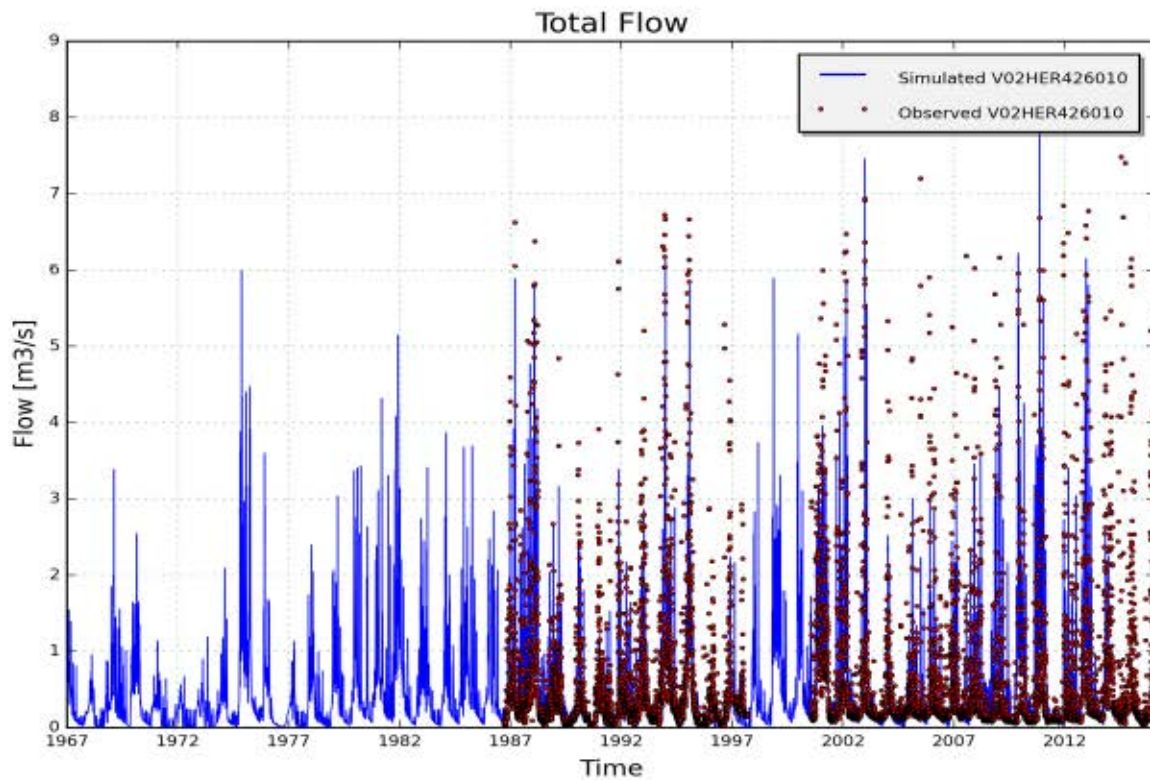


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (validation period 1967-2013)

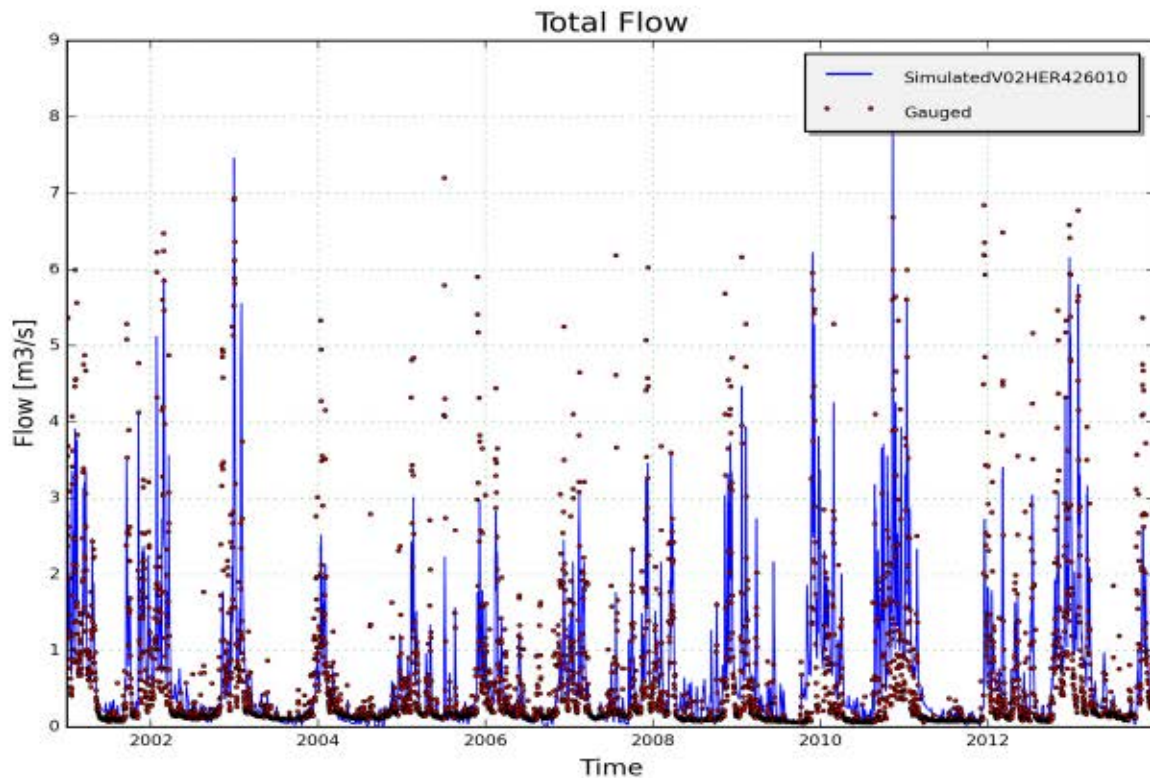


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp(calibration period)

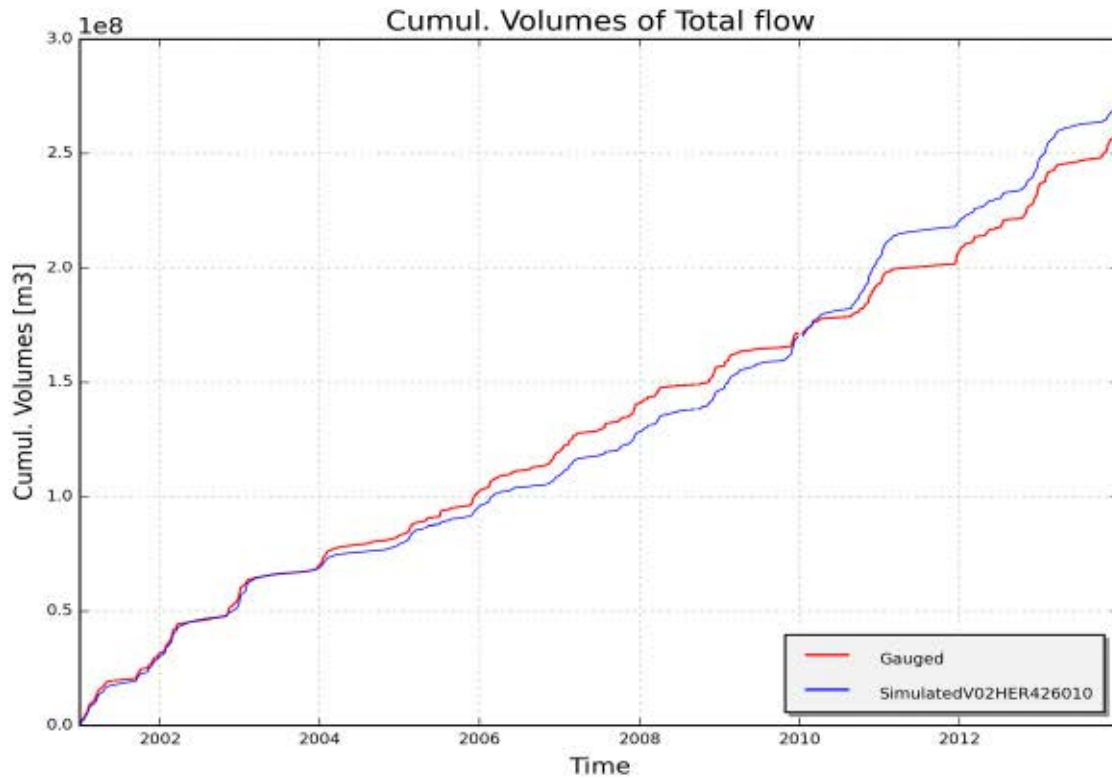


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp (calibration period)

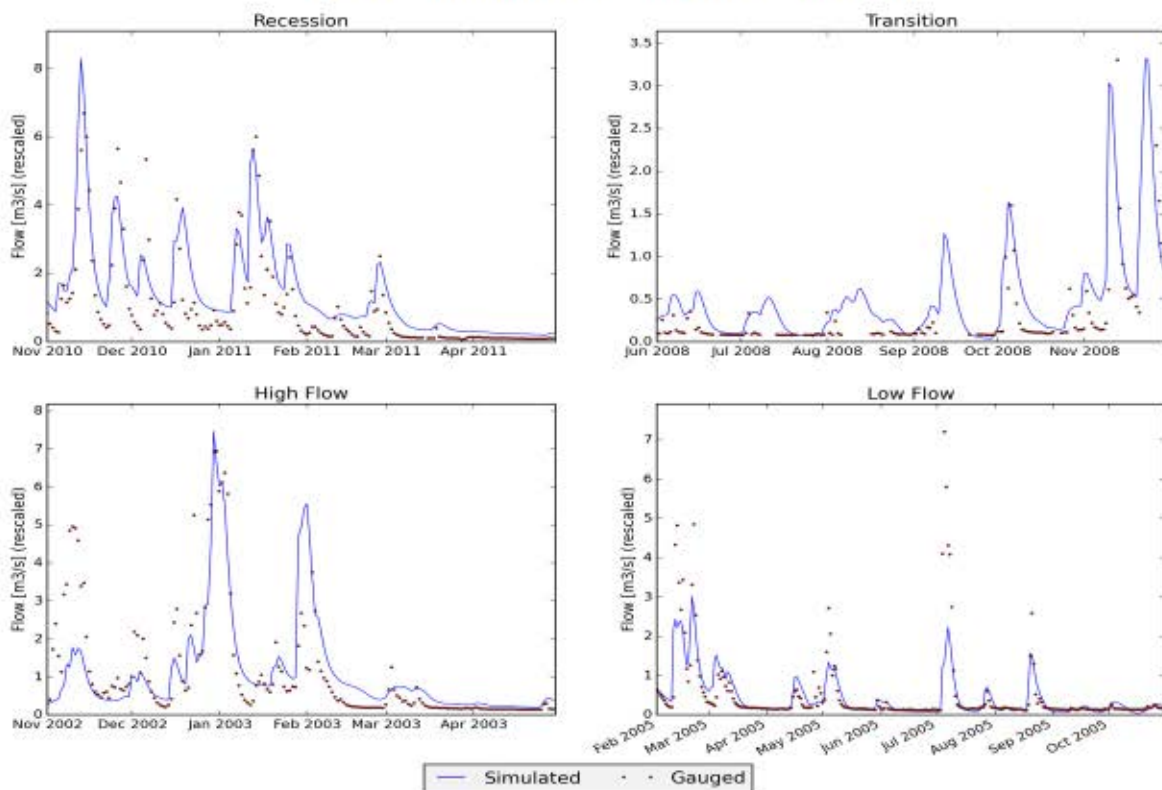


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02HER426010, station 42610102 - Hertsbergebeek; Oostkamp

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V02KER422030" (BRUGSE POLDERS)

2.1 Input data

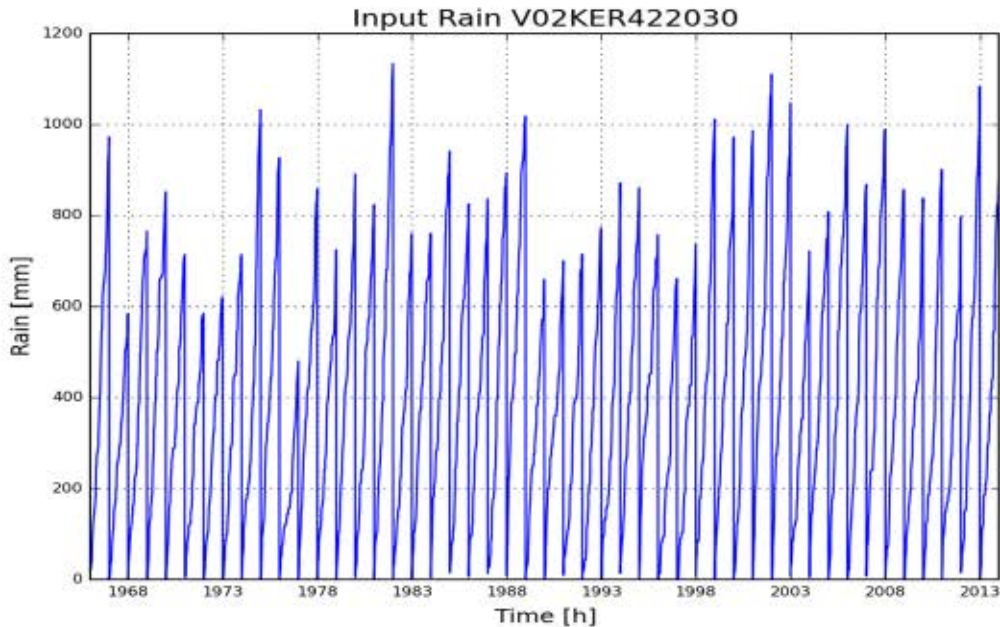


Figure 1: Cumulative precipitation on catchment V02KER422030 (Brugse Polders)

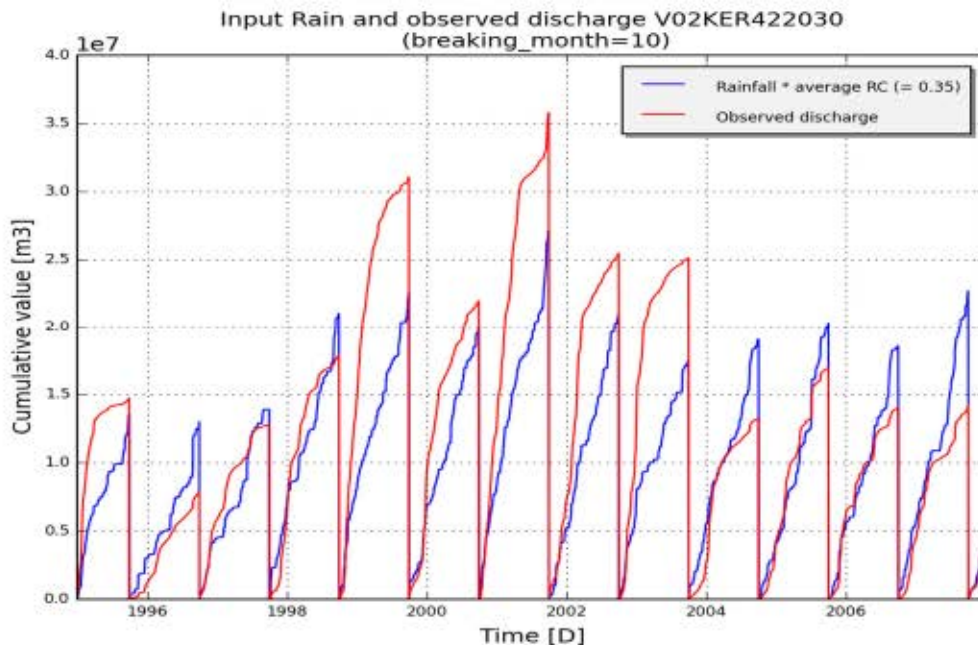


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V02KER422030 (Brugse Polders)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V02KER422030 |
| subcatchment_area [m2] | 62718738 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 11.62), (‘SMmax.C’, 145.28), (‘CQOF.C’, 0.8), (‘CKBF.C’, 1570.54), (‘CKIF.C’, 214.48), (‘CK1.C’, 29.61), (‘CK2.C’, 23.79), (‘TIF.C’, 0.6), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.11)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 2274945.854 | 12345193.459 |
| RelErr | 0.7 % | -5.0 % |
| RMSE | 3914353.068 | 13094210.777 |
| NS | 0.605 | 0.665 |
| NS_log | 0.664 | 0.667 |
| NS_rel | -2.252 | -1.012 |

2.3 Observed and simulated timeseries for optimum parameters

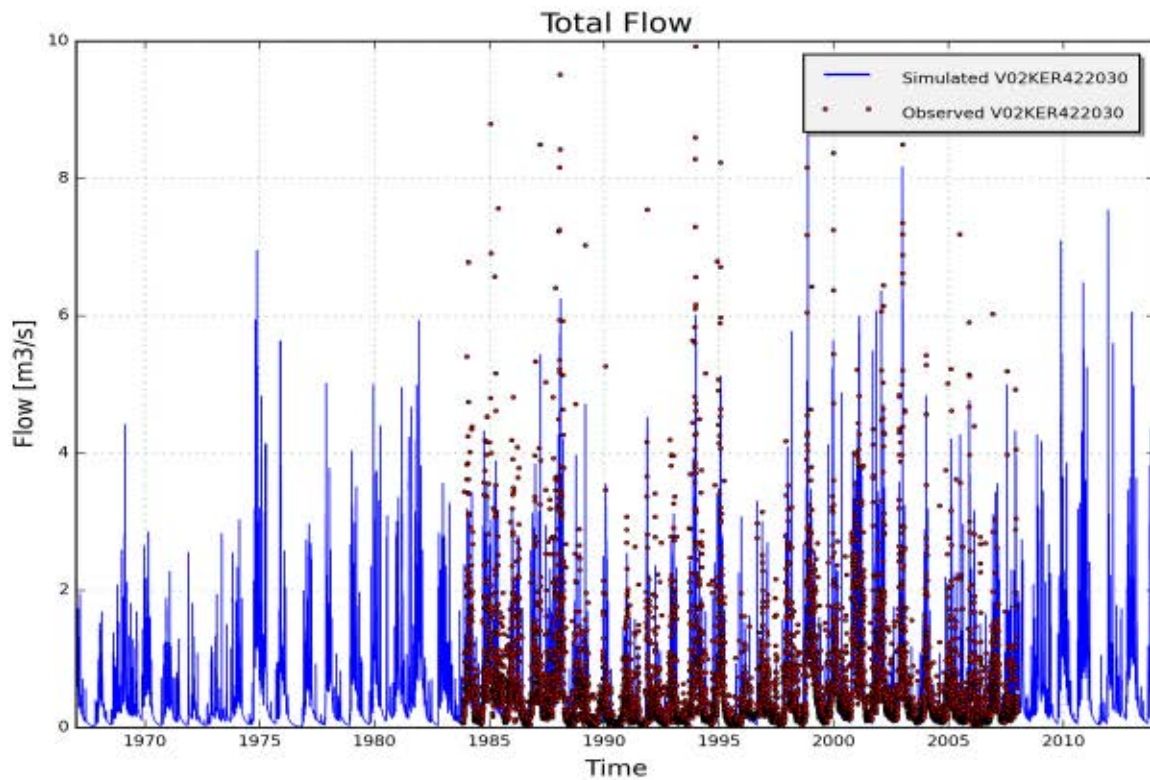


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (validation period 1967-2013)

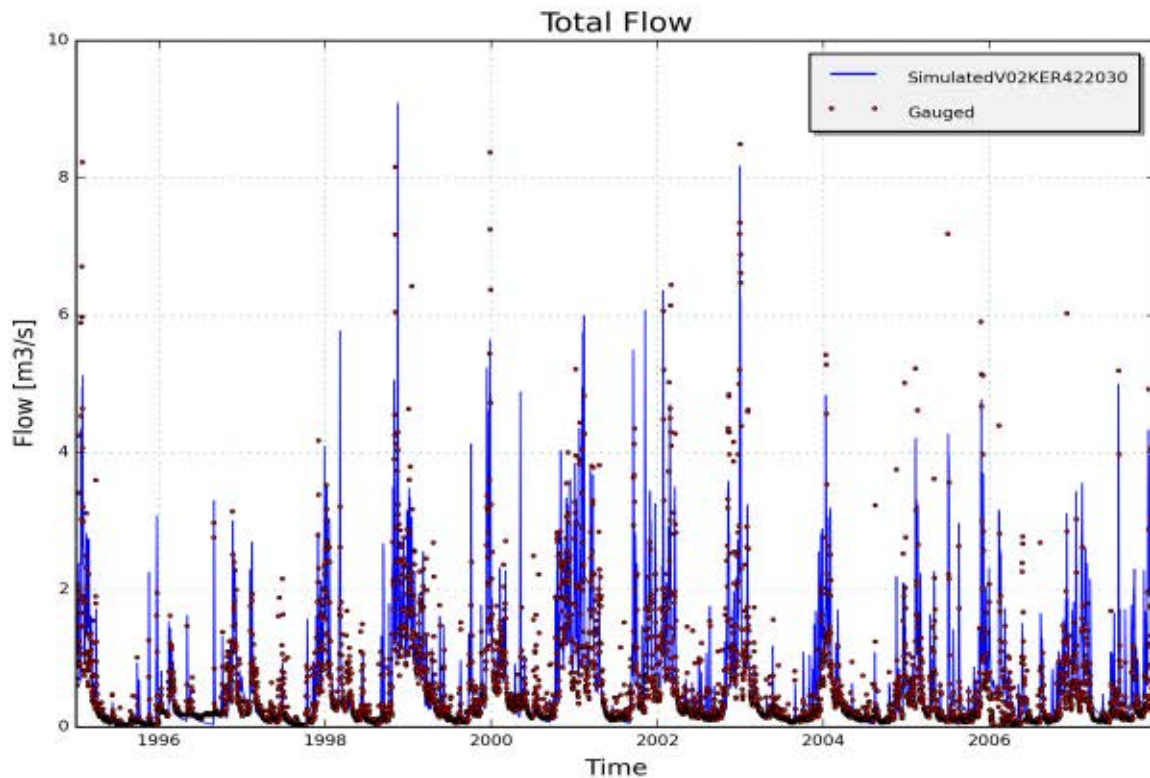


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (calibration period)

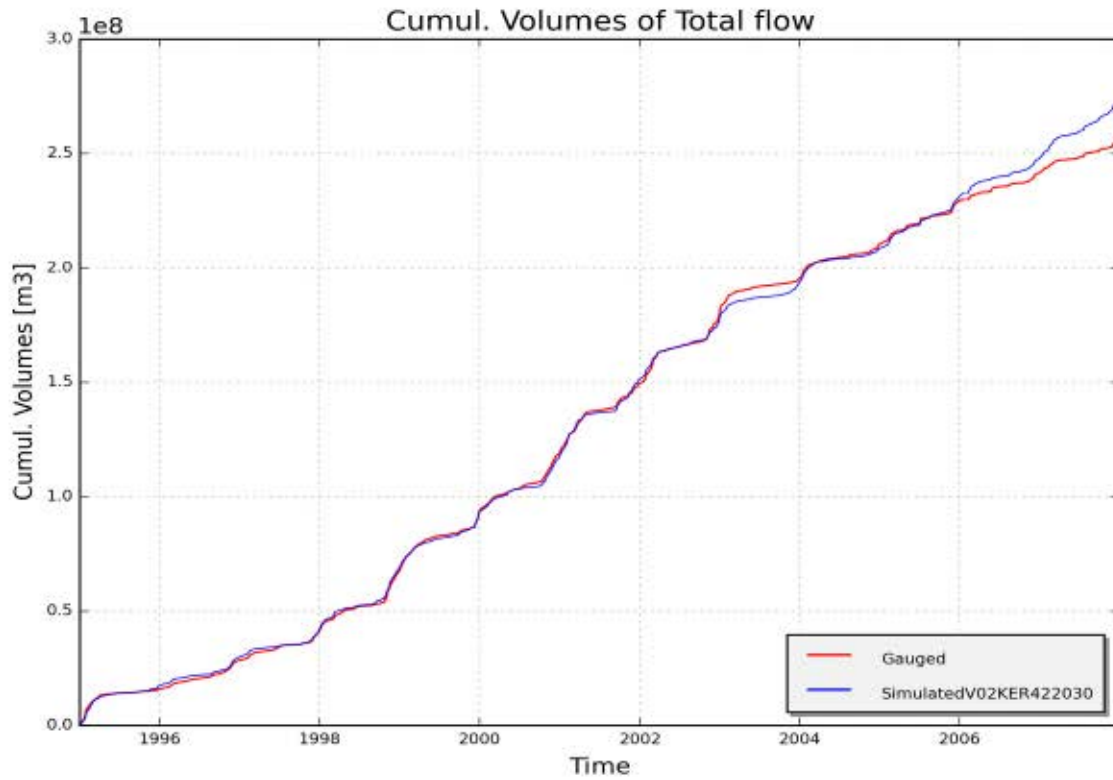


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels (calibration period)

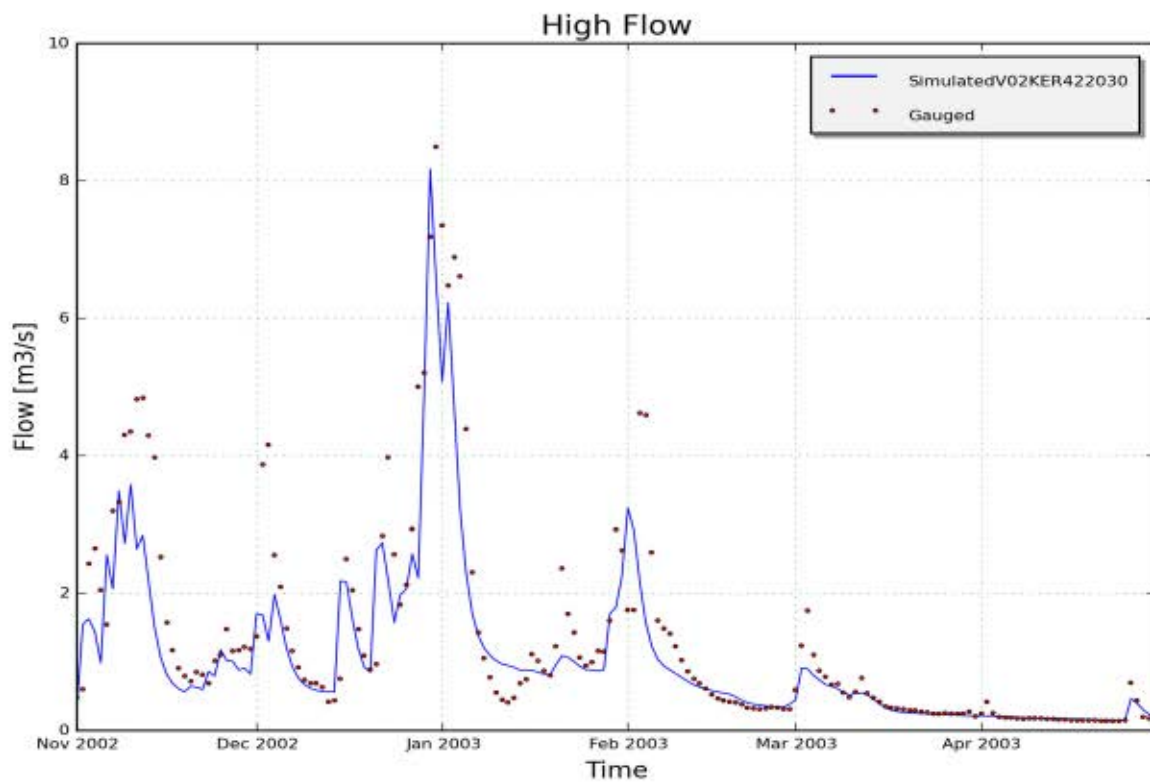


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

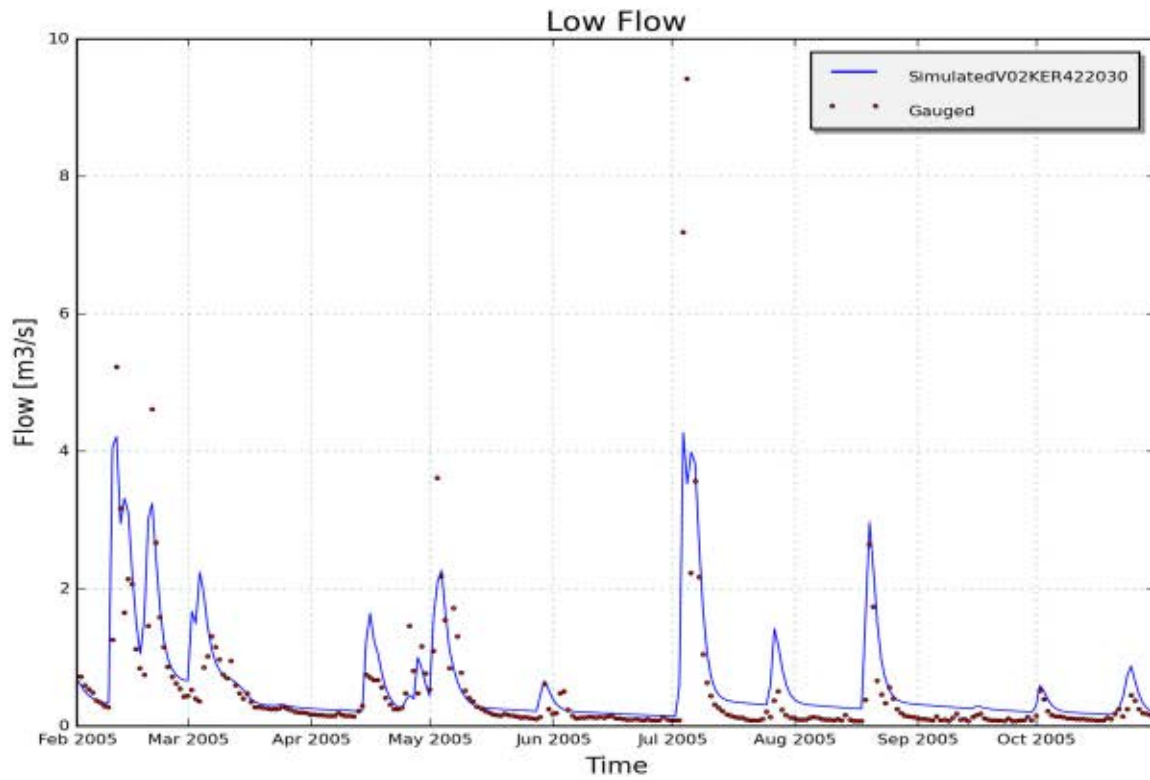


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V02KER422030, station 4220102 - Kerkebeek, Sint-Michiels

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V02RIV425020" (BRUGSE POLDERS)

3.1 Input data

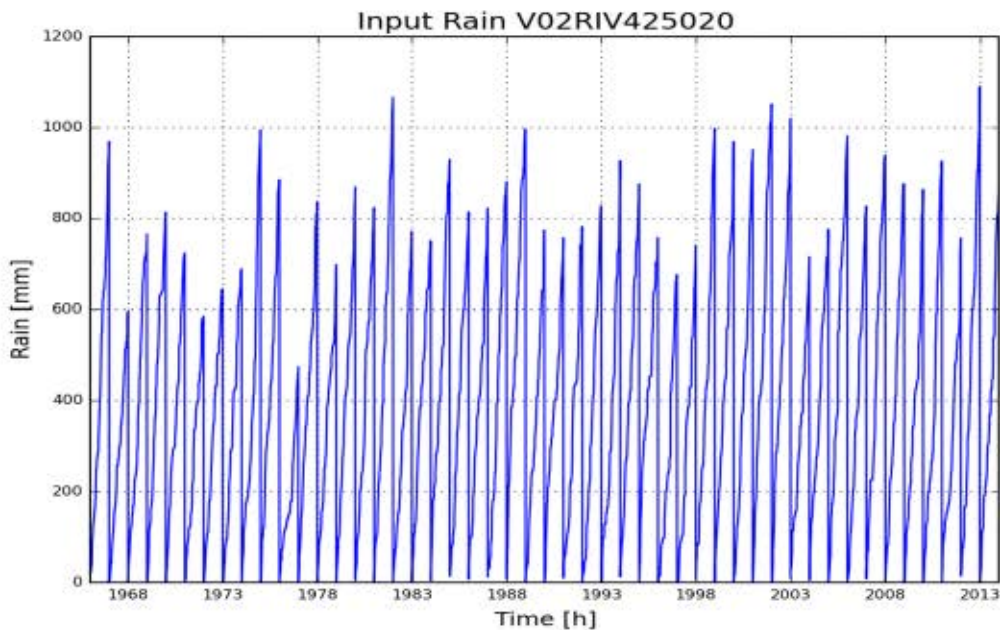


Figure 1: Cumulative precipitation on catchment V02RIV425020 (Brugse Polders)

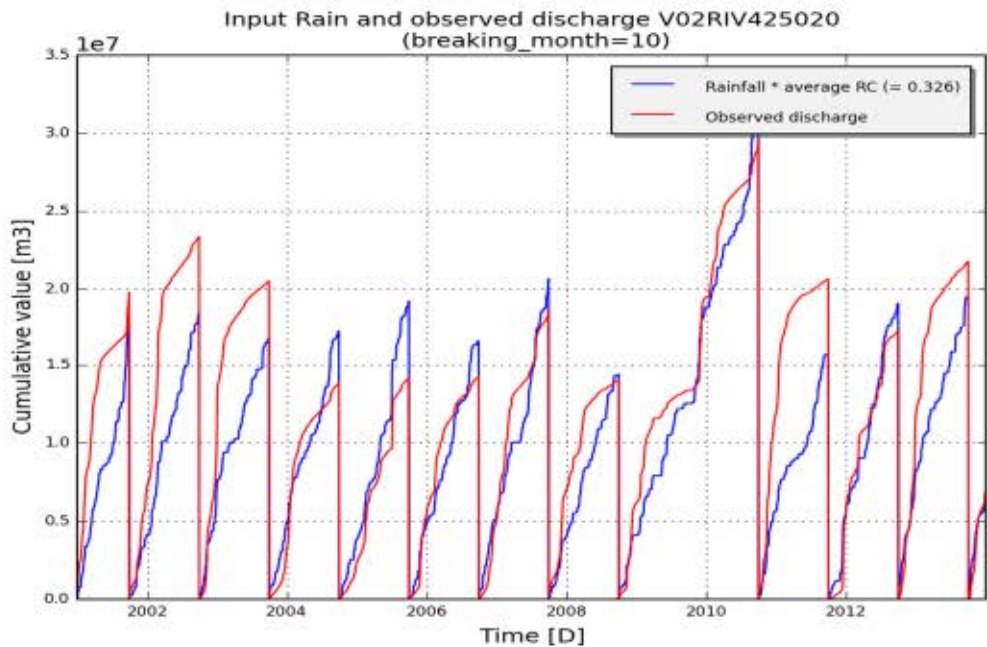


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V02RIV425020 (Brugse Polders)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V02RIV425020 |
| subcatchment_area [m2] | 63980423 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.87), (‘SMmax.C’, 479.81), (‘CQOF.C’, 0.54), (‘CKBF.C’, 1530.32), (‘CKIF.C’, 291.54), (‘CK1.C’, 40.53), (‘CK2.C’, 19.96), (‘TIF.C’, 0.84), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.13)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 4649428.997 | 25089015.972 |
| RelErr | -1.8 % | -7.0 % |
| RMSE | 5104784.85 | 28824429.812 |
| NS | 0.589 | 0.604 |
| NS_log | 0.624 | 0.58 |
| NS_rel | -1.074 | -1.799 |

3.3 Observed and simulated timeseries for optimum parameters

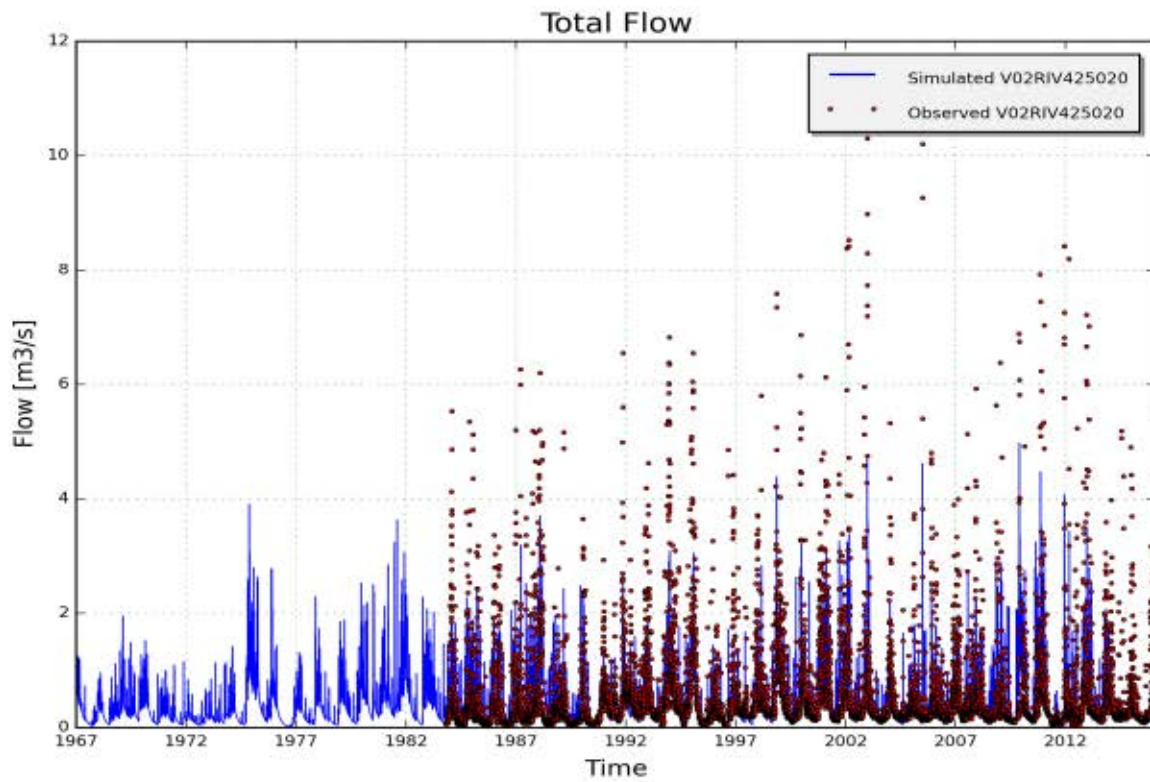


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (validation period 1967-2013)

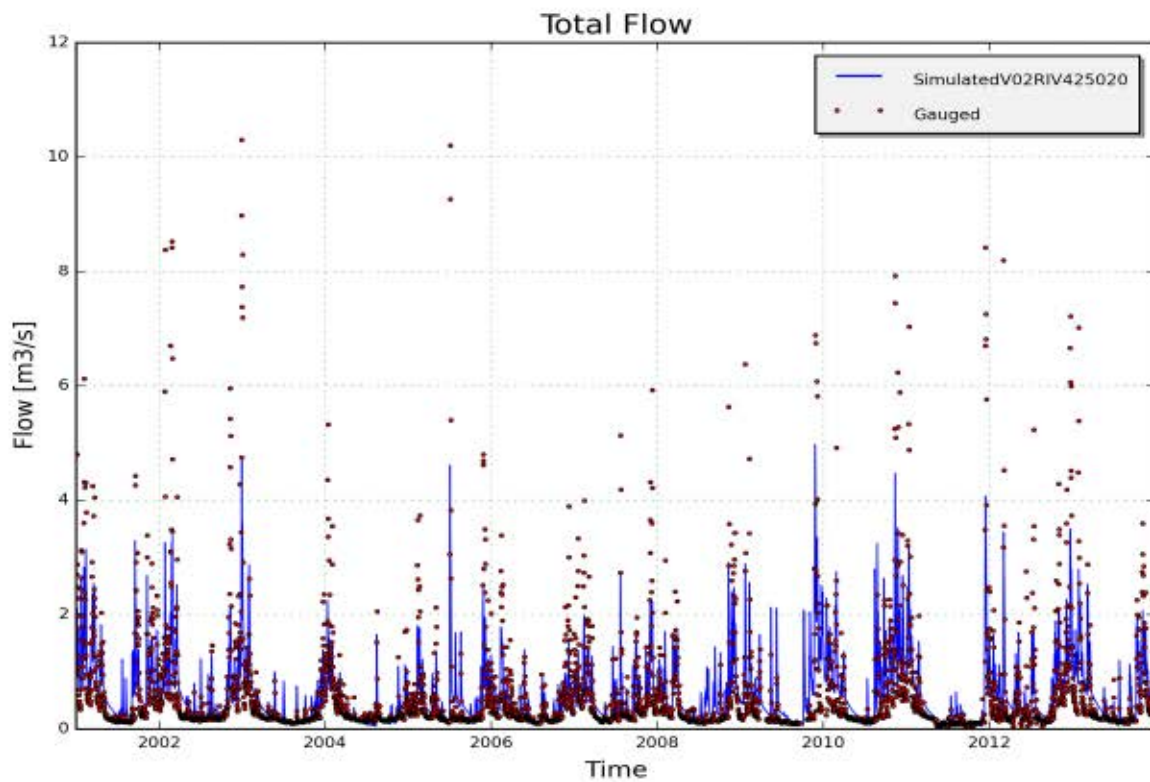


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp(calibration period)

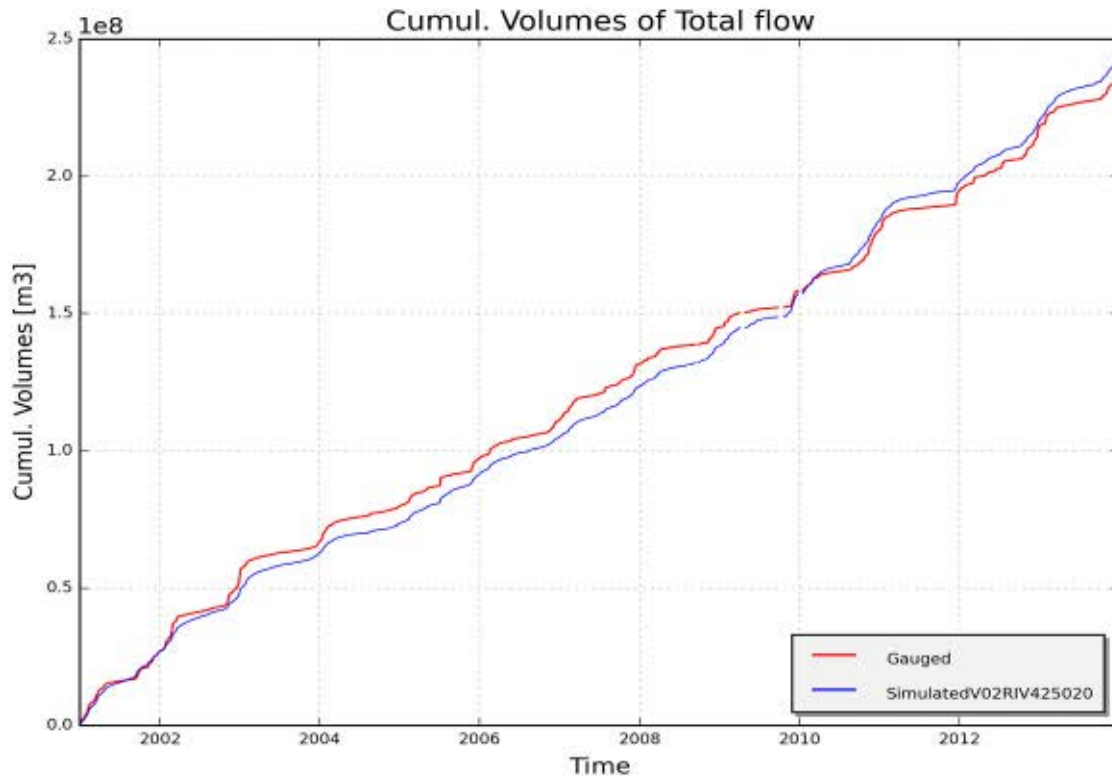


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp (calibration period)

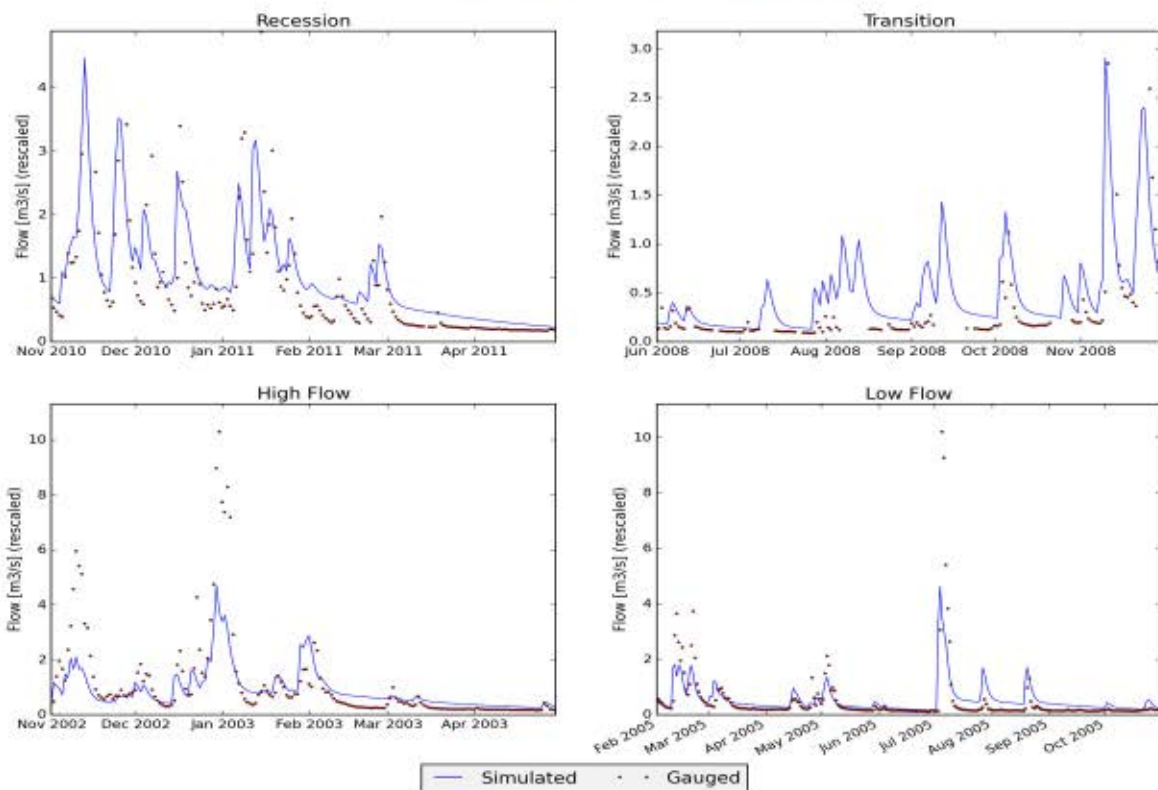


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02RIV425020, station 42510102- Rivierbeek; Oostkamp

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V02EDE442120" (BRUGSE POLDERS)

4.1 Input data

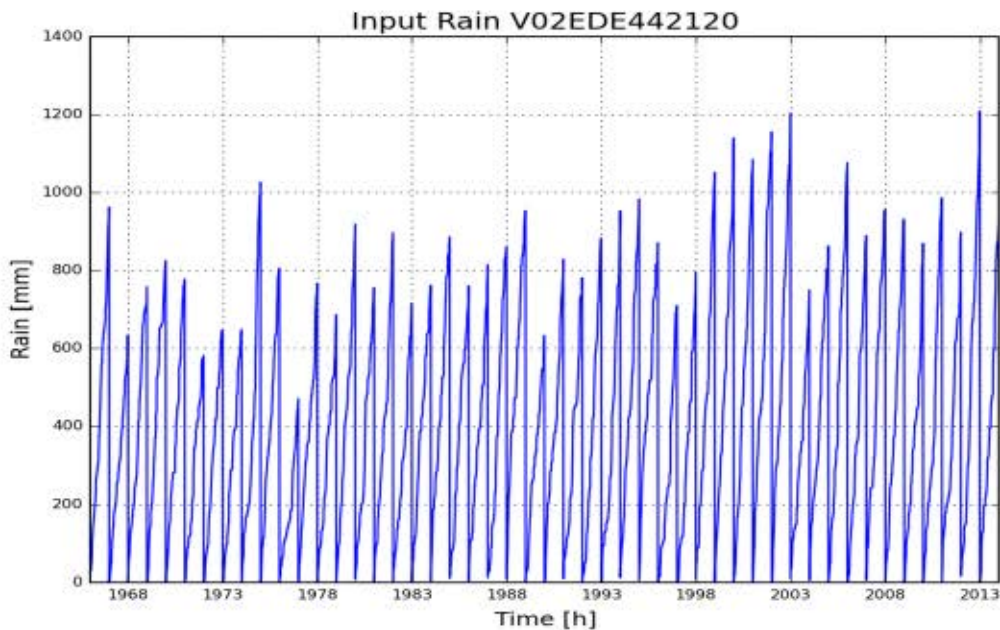


Figure 1: Cumulative precipitation on catchment V02EDE442120 (Brugse Polders)

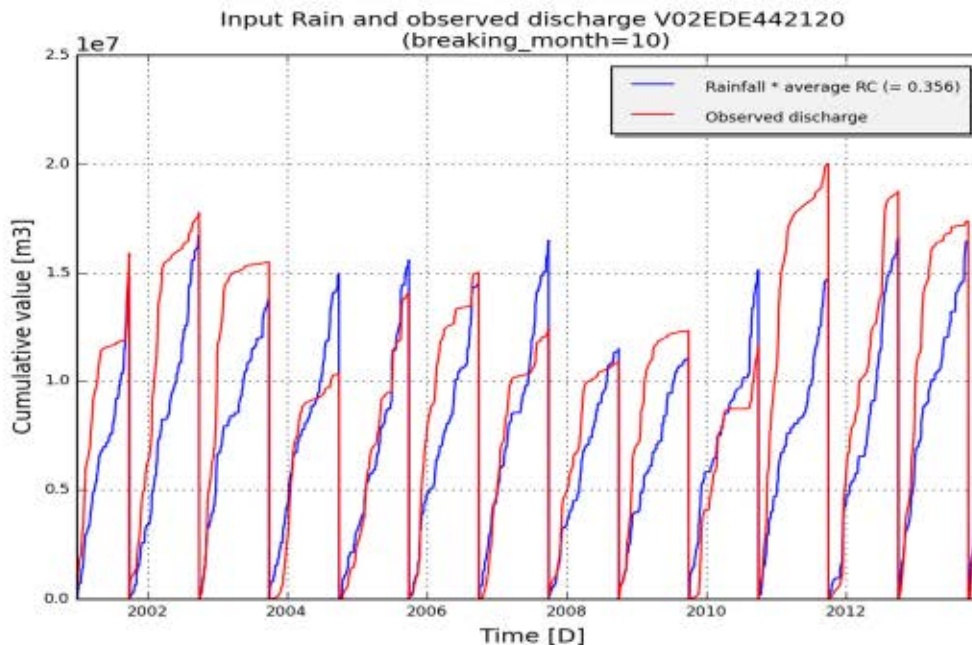


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V02EDE442120 (Brugse Polders)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V02EDE442120 |
| subcatchment_area [m2] | 45489177 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 10.32), (‘SMmax.C’, 297.82), (‘CQOF.C’, 0.8), (‘CKBF.C’, 1036.24), (‘CKIF.C’, 540.27), (‘CK1.C’, 39.67), (‘CK2.C’, 42.18), (‘TIF.C’, 0.68), (‘TOF.C’, 0.39), (‘NAM.TG.C’, 0.8)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 2318177.682 | 5590925.169 |
| RelErr | 1.4 % | -2.3 % |
| RMSE | 2762293.593 | 7807190.351 |
| NS | 0.809 | 0.779 |
| NS_log | 0.549 | 0.423 |
| NS_rel | -6.353 | -4.771 |

4.3 Observed and simulated timeseries for optimum parameters

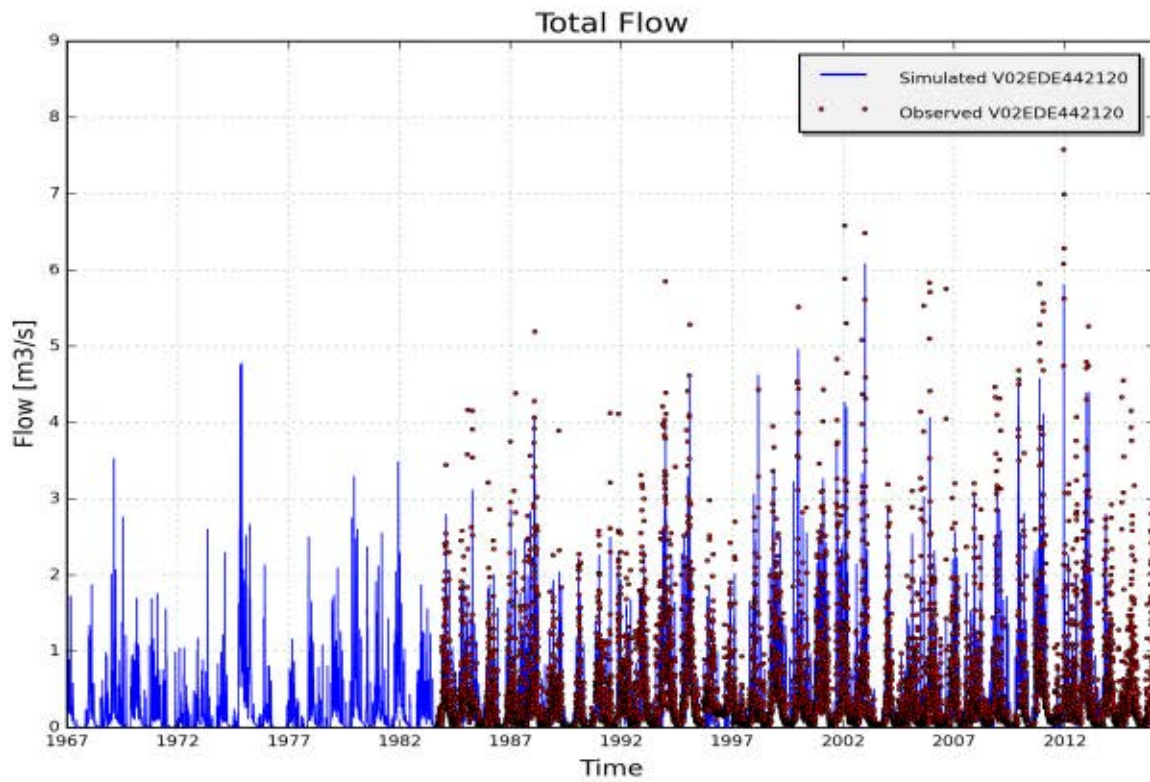


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem (validation period 1967-2013)

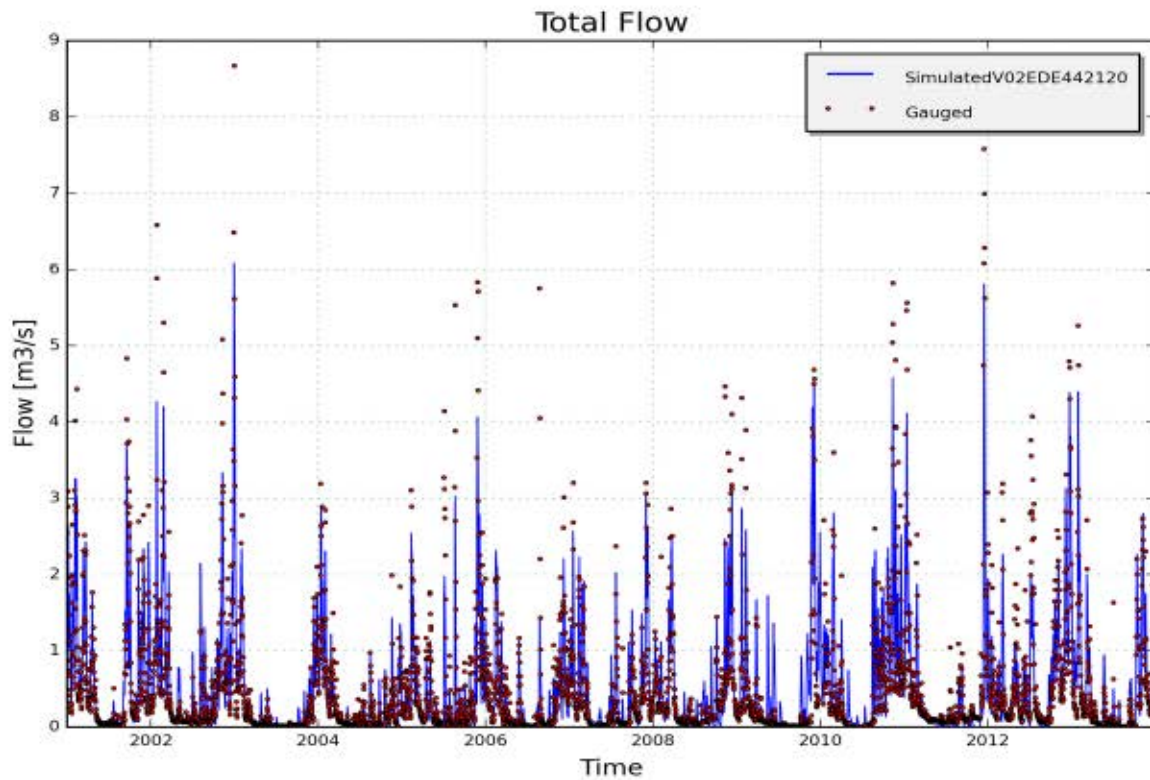


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V02EDE442120, station 44210102 - Maldegem (calibration period)

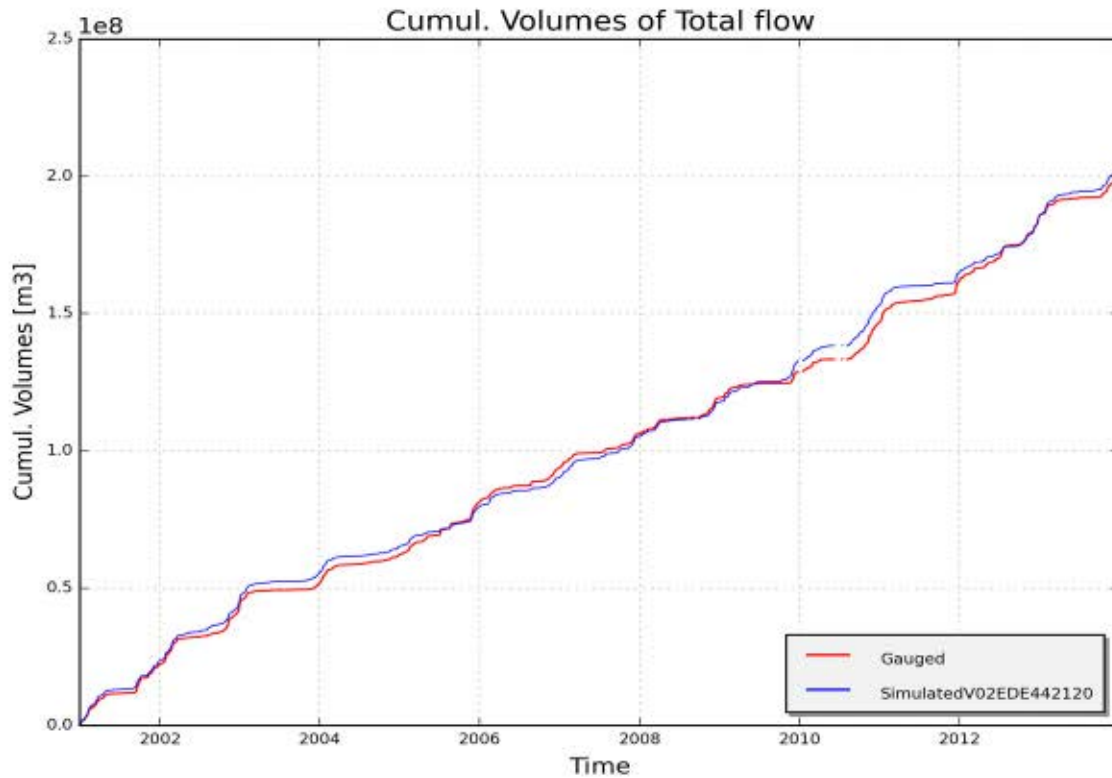


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V02EDE442120, station 44210102 - Maldegem (calibration period)

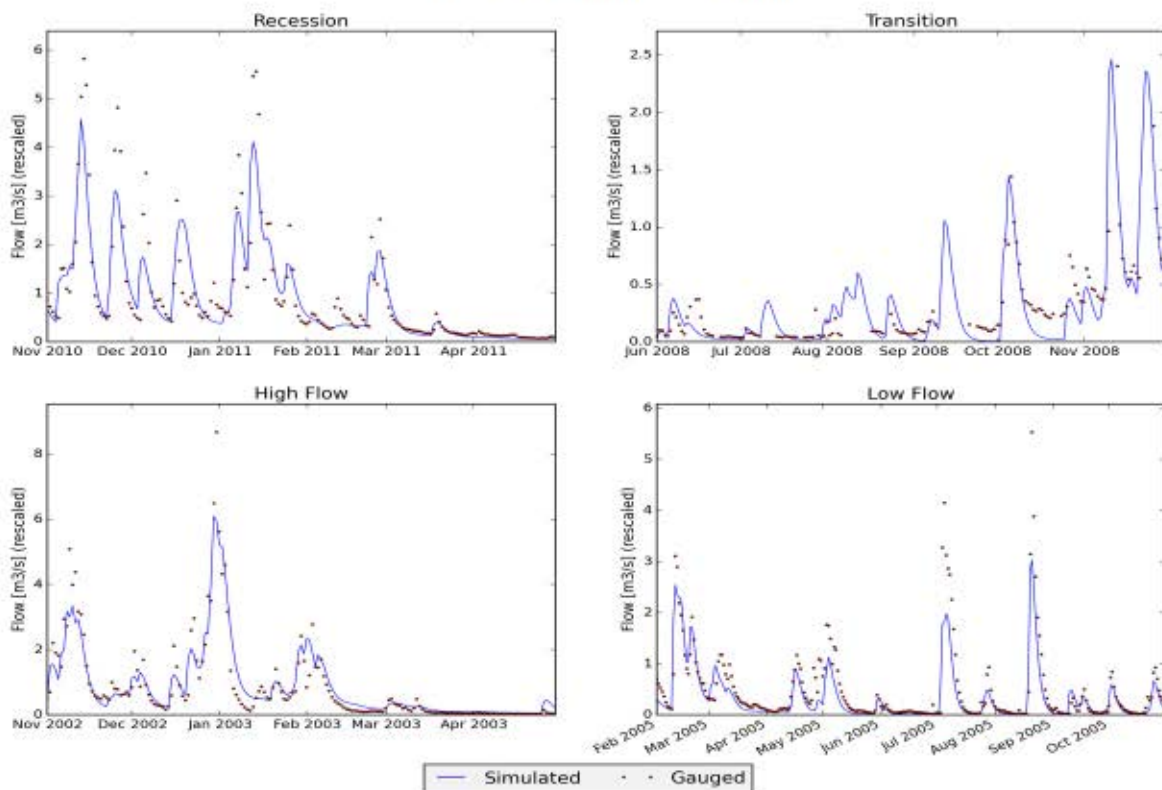


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V02EDE442120, station 44210102 - Maldegem

Appendix 5

Results of calibration and validation of NAM parameters for catchment "V03POE446000" (GENTSE KANALEN)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V03POE446000" (GENTSE KANALEN)

1.1 Input data

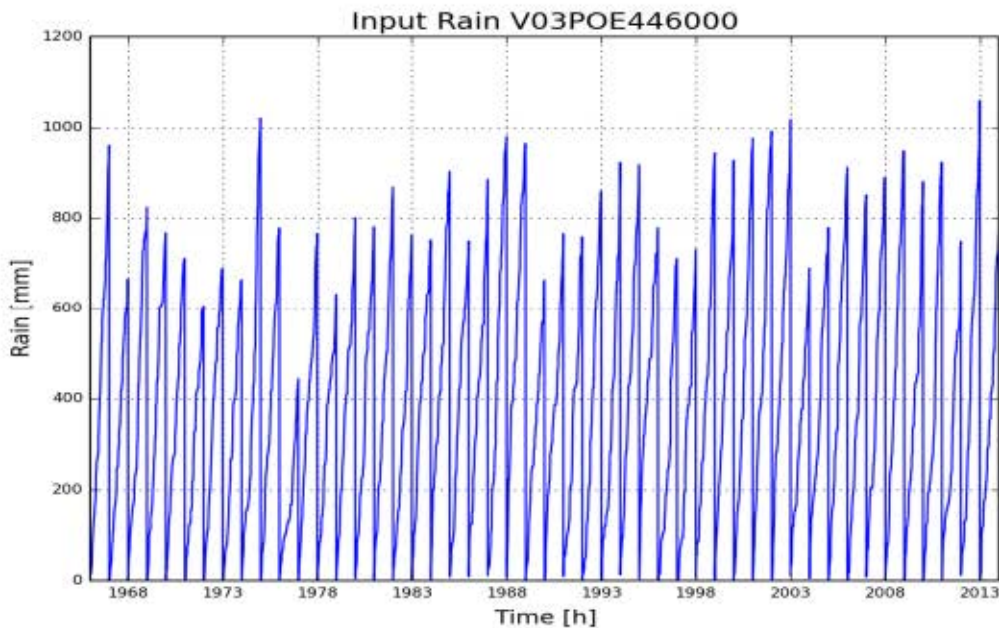


Figure 1: Cumulative precipitation on catchment V03POE446000 (Gentse Kanalen)

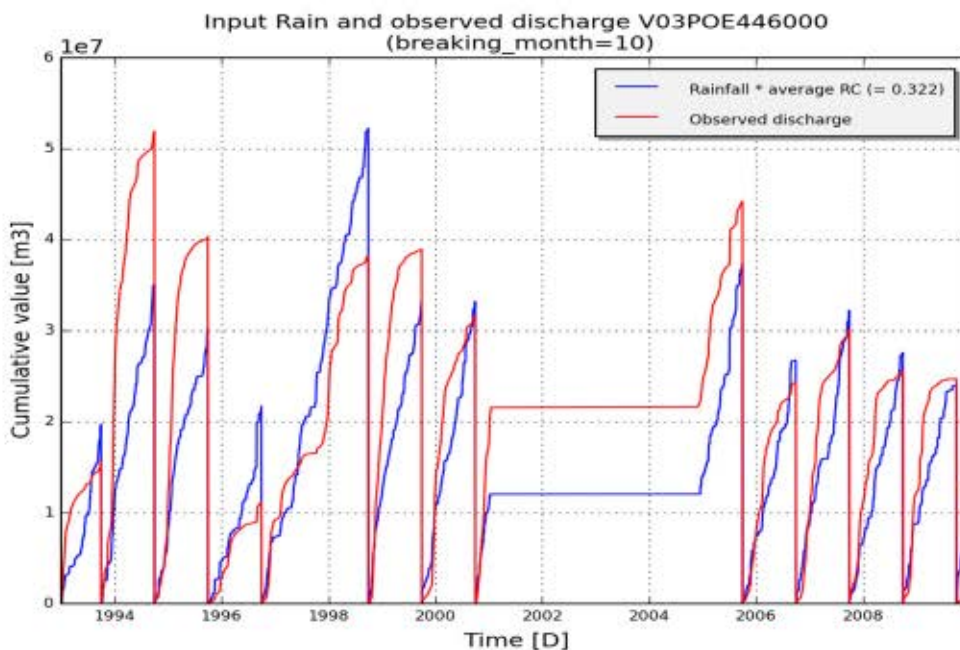


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V03POE446000 (Gentse Kanalen)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V03POE446000 |
| subcatchment_area [m2] | 106836849 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.84), (‘SMmax.C’, 189.96), (‘CQOF.C’, 0.79), (‘CKBF.C’, 1438.68), (‘CKIF.C’, 537.49), (‘CK1.C’, 28.39), (‘CK2.C’, 32.31), (‘TIF.C’, 0.22), (‘TOF.C’, 0.37), (‘NAM.TG.C’, 0.47)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 5223417.108 | 36235456.959 |
| RelErr | -0.9 % | 11.5 % |
| RMSE | 6664908.05 | 39076848.073 |
| NS | 0.723 | 0.705 |
| NS_log | 0.696 | 0.725 |
| NS_rel | -2.85 | -1.548 |

1.3 Observed and simulated timeseries for optimum parameters

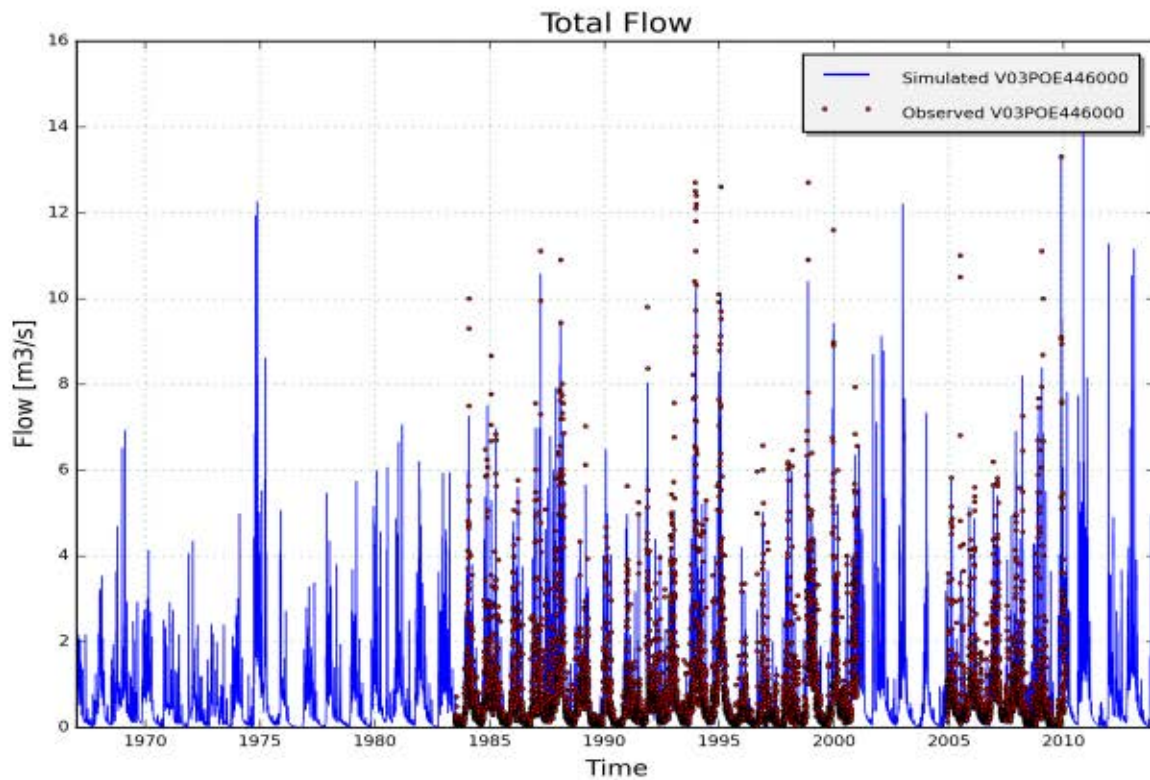


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (validation period 1967-2013)

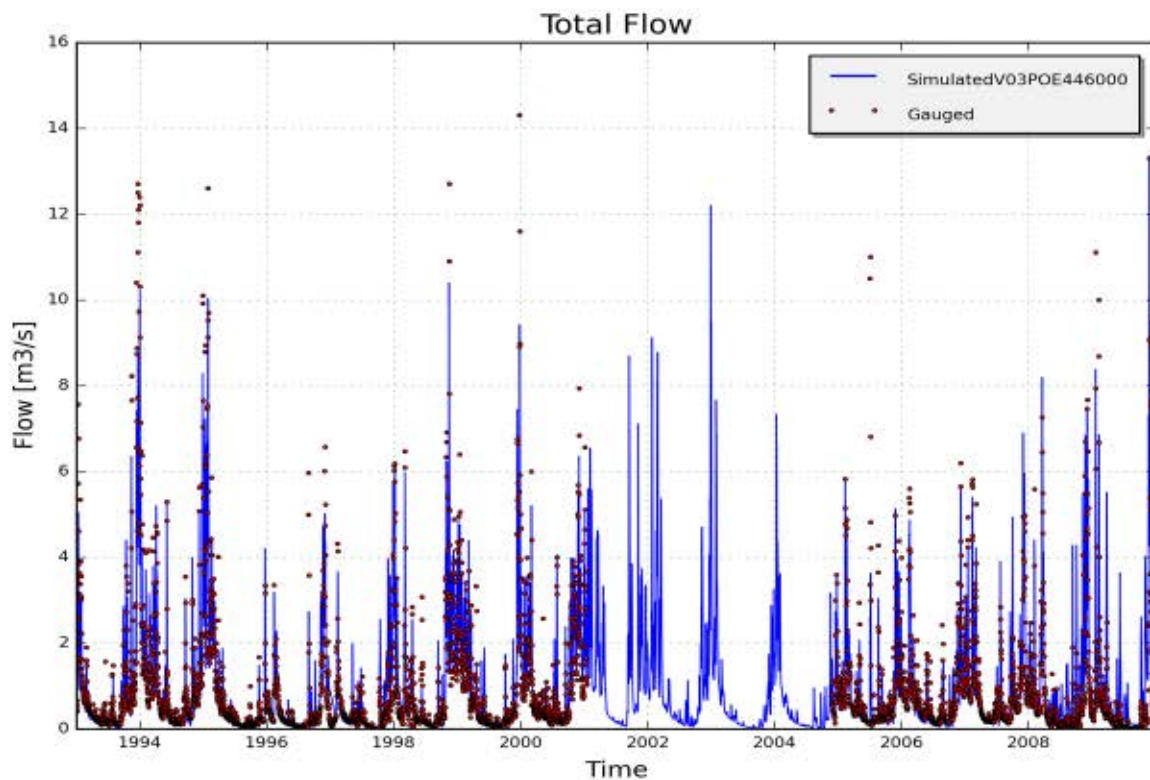


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele(calibration period)

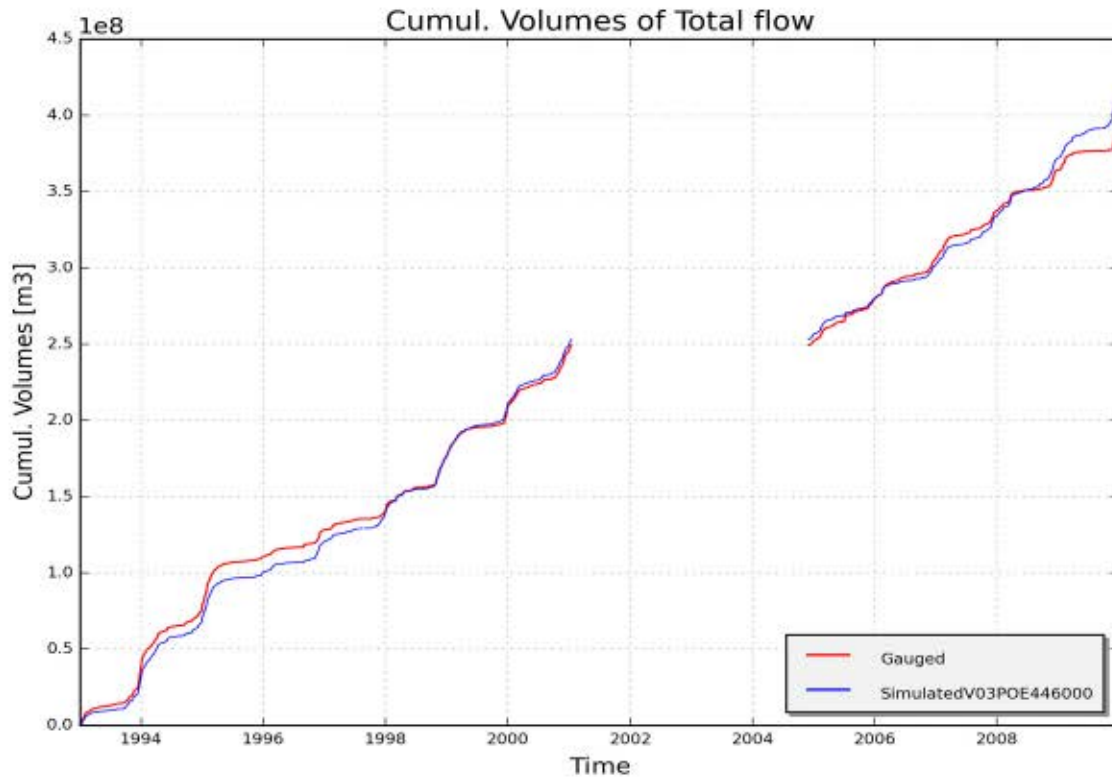


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V03POE446000, station 44656122 - Poekebeek; Nevele (calibration period)

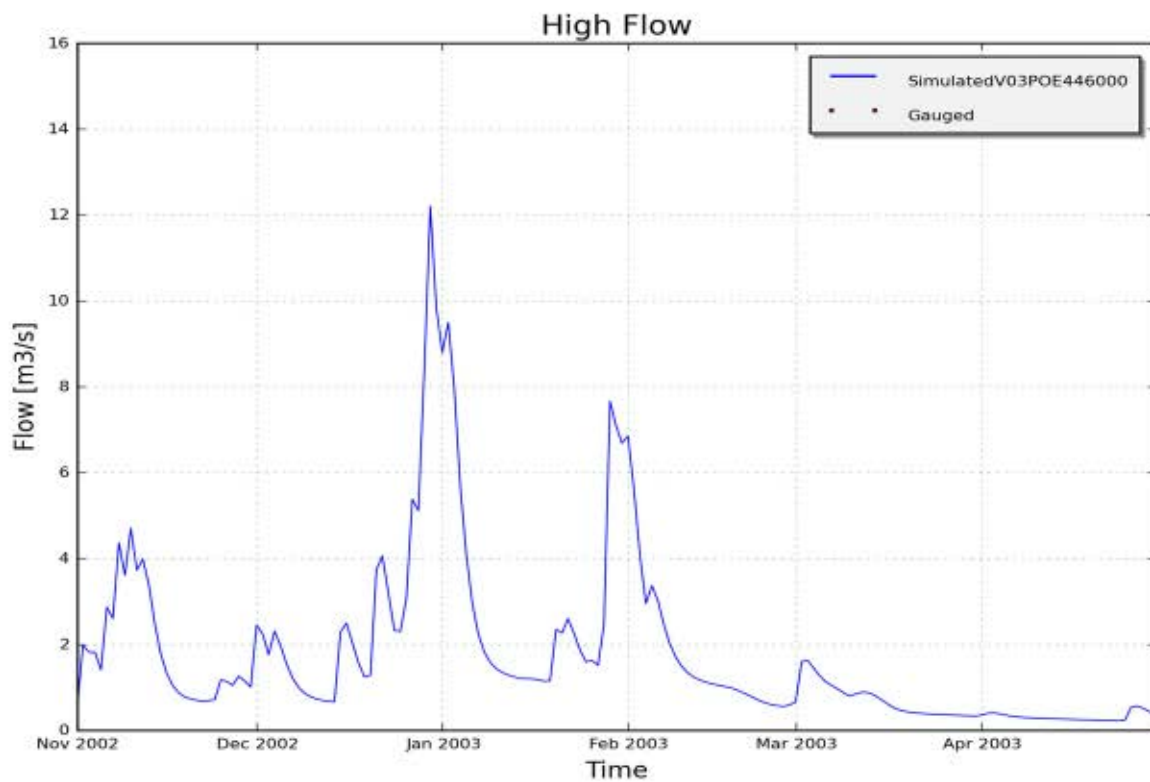


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

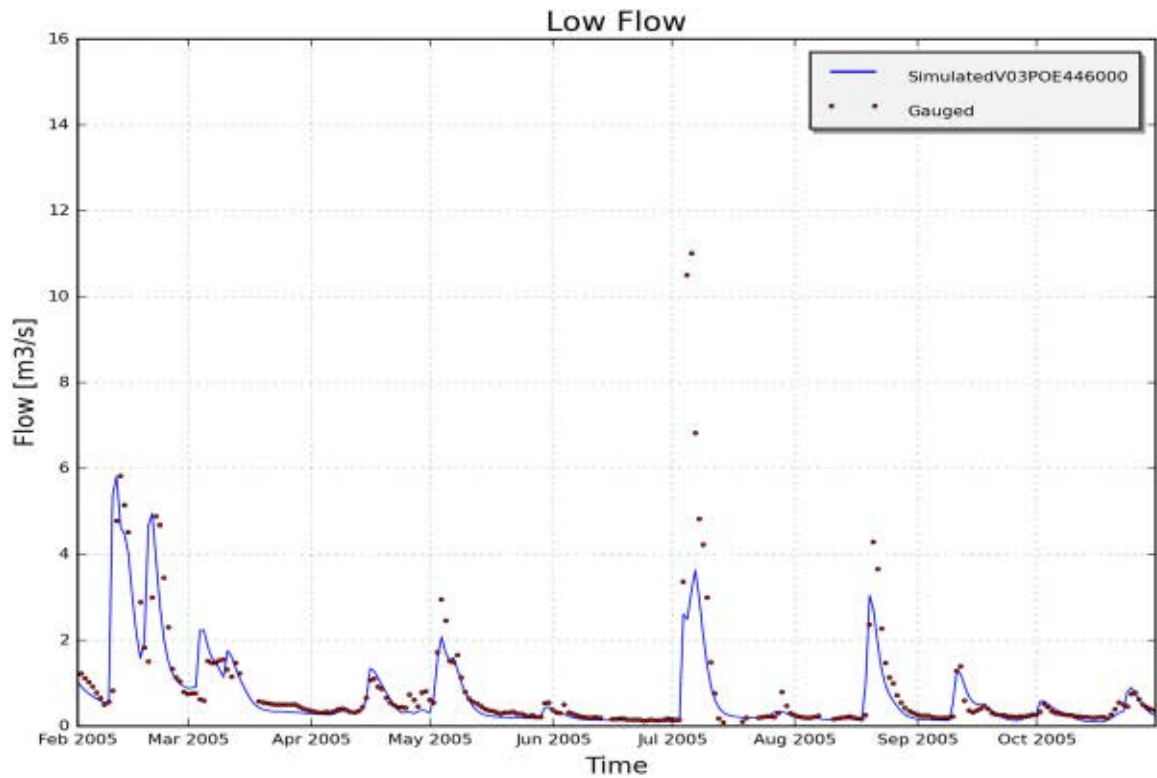


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

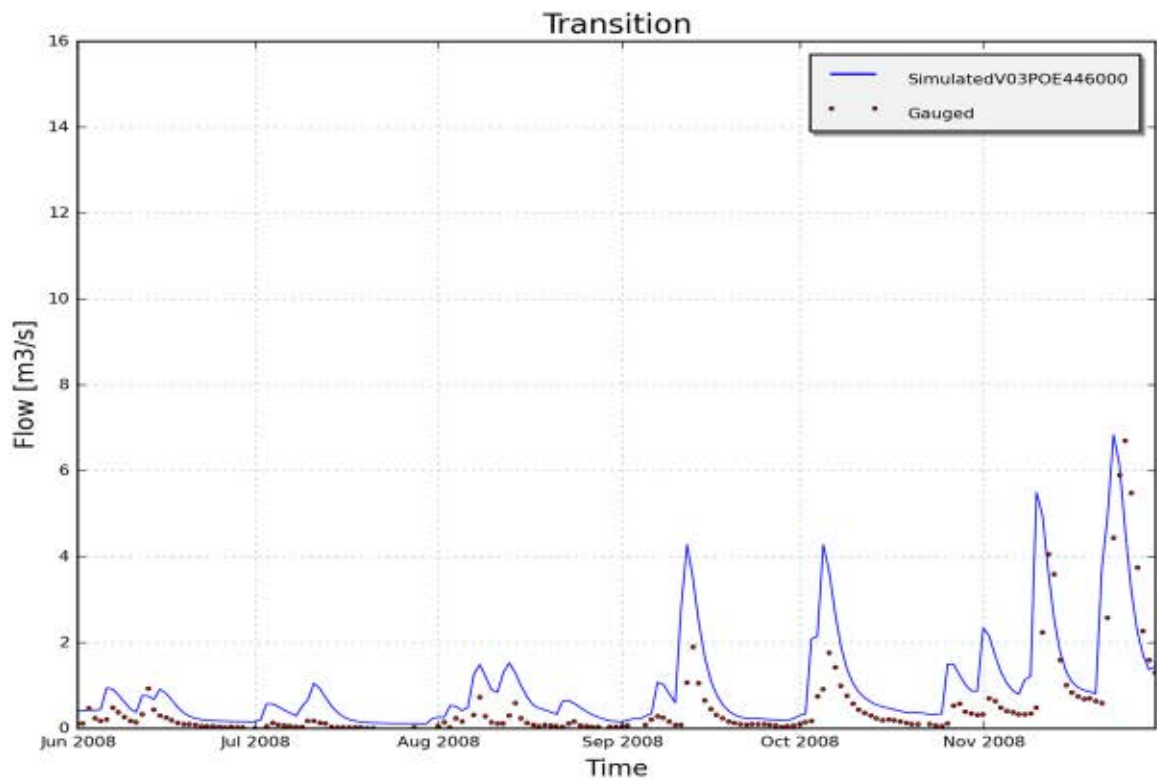


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V03POE446000, station 44656122 - Poekebeek; Nevele

Appendix 6

Results of calibration and validation of NAM parameters for catchment "V04MOM037100" (BENEDENSCHELDE)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V04MOM037100" (BENEDENSCHELDE)

1.1 Input data

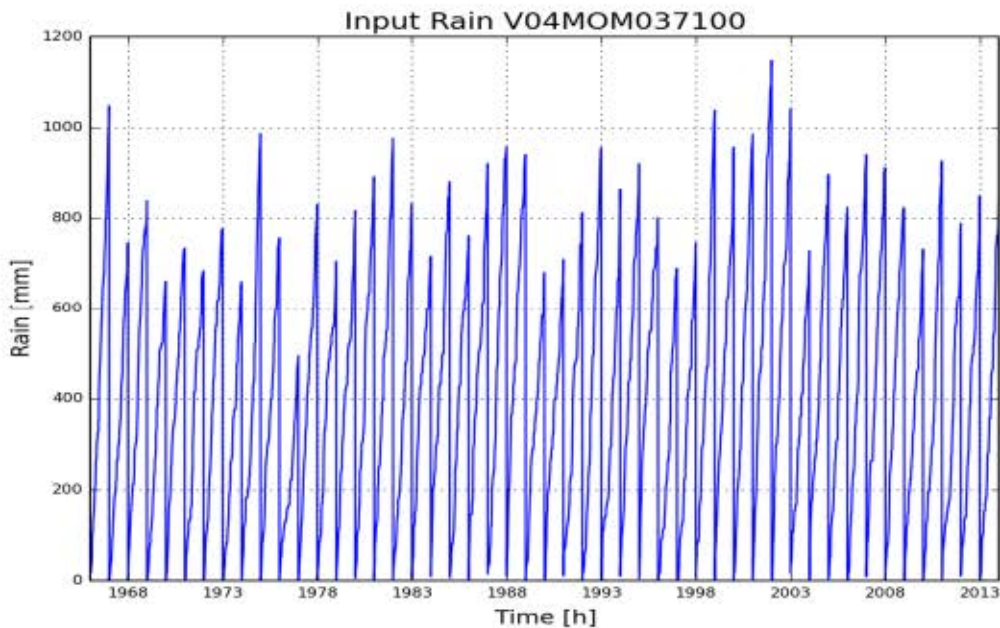


Figure 1: Cumulative precipitation on catchment V04MOM037100 (Benedenschelde)

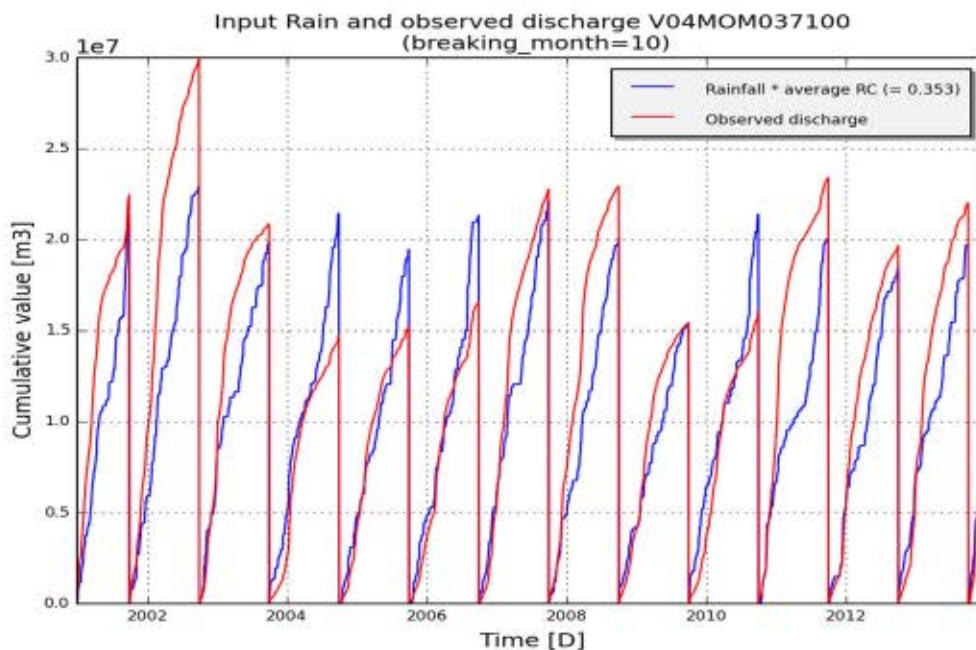


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V04MOM037100 (Benedenschelde)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V04MOM037100 |
| subcatchment_area [m2] | 67301328 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 8.97), ('SMmax.C', 436.18), ('CQOF.C', 0.5), ('CKBF.C', 1263.44), ('CKIF.C', 484.9), ('CK1.C', 40.43), ('CK2.C', 37.66), ('TIF.C', 0.3), ('TOF.C', 0.4), ('NAM.TG.C', 0.39)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3154999.648 | 49373688.226 |
| RelErr | 1.3 % | 13.0 % |
| RMSE | 3700677.288 | 56525331.165 |
| NS | 0.761 | 0.741 |
| NS_log | 0.73 | 0.666 |
| NS_rel | 0.715 | 0.433 |

1.3 Observed and simulated timeseries for optimum parameters

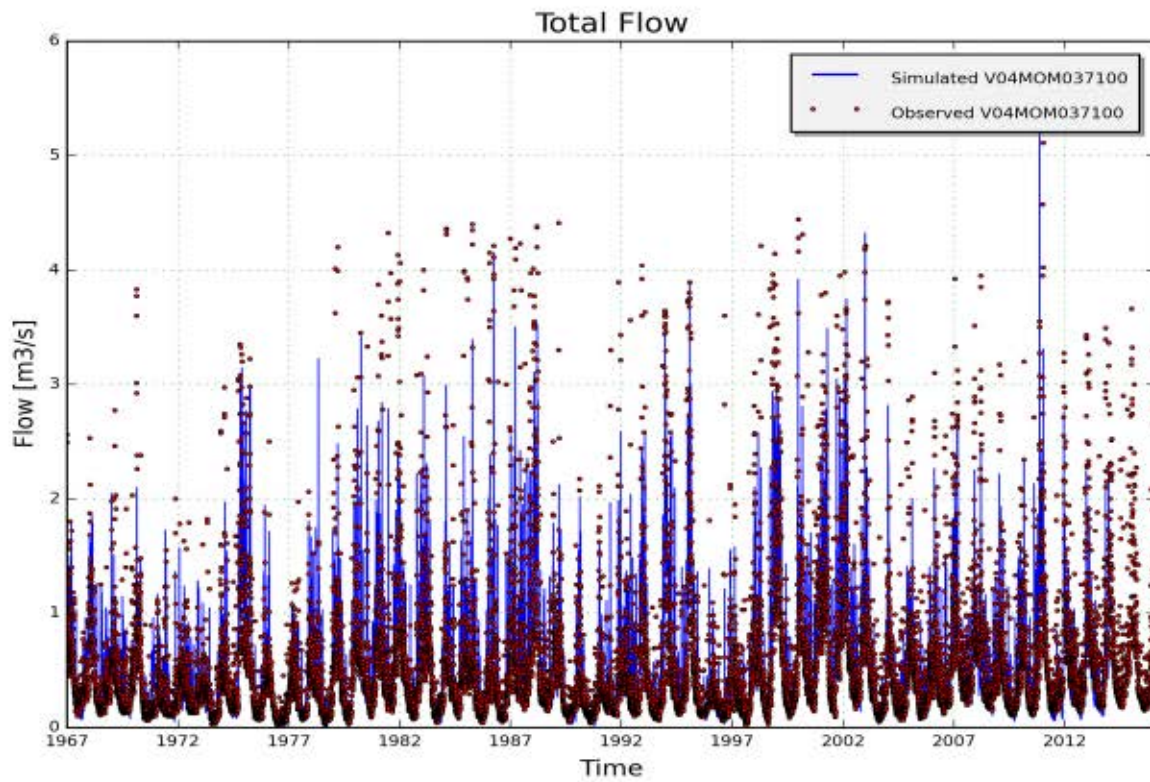


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (validation period 1967-2013)

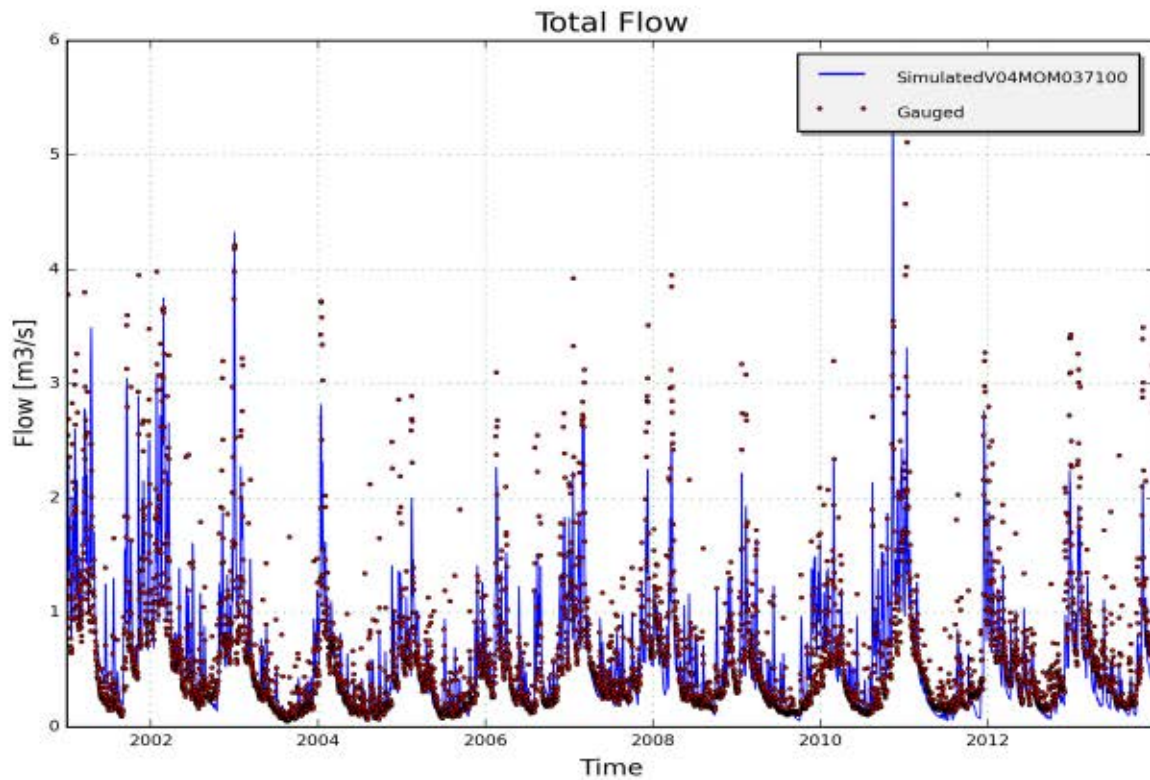


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (calibration period)

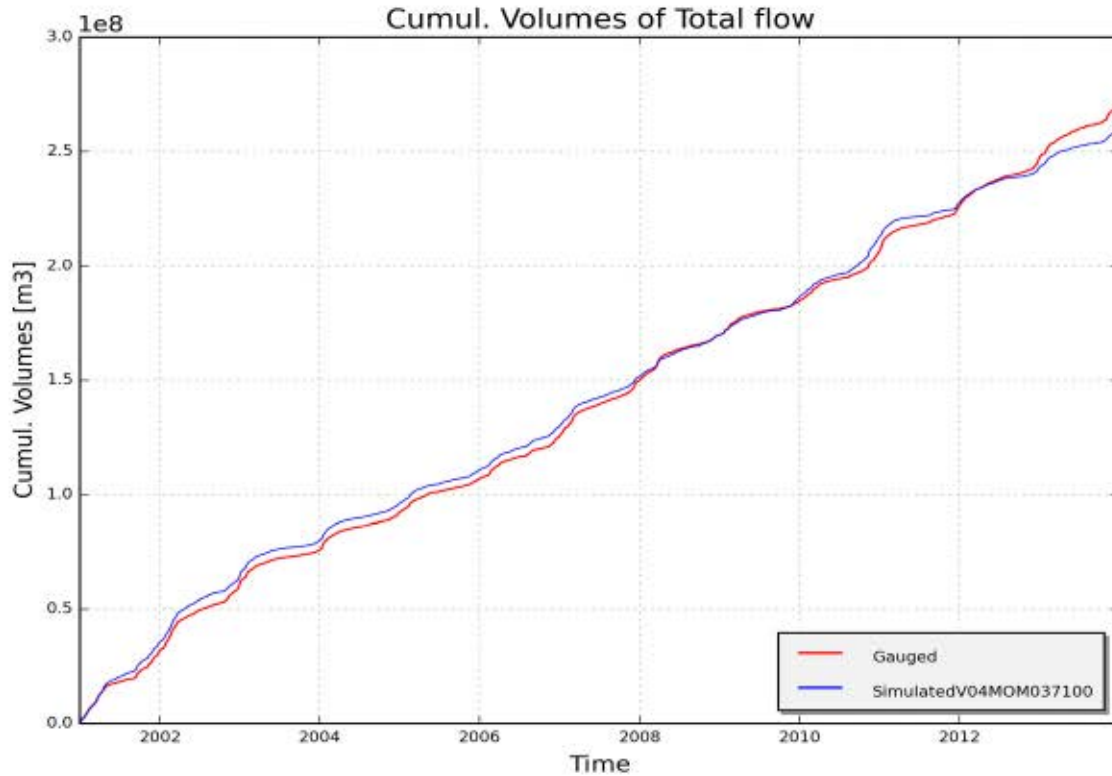


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen (calibration period)

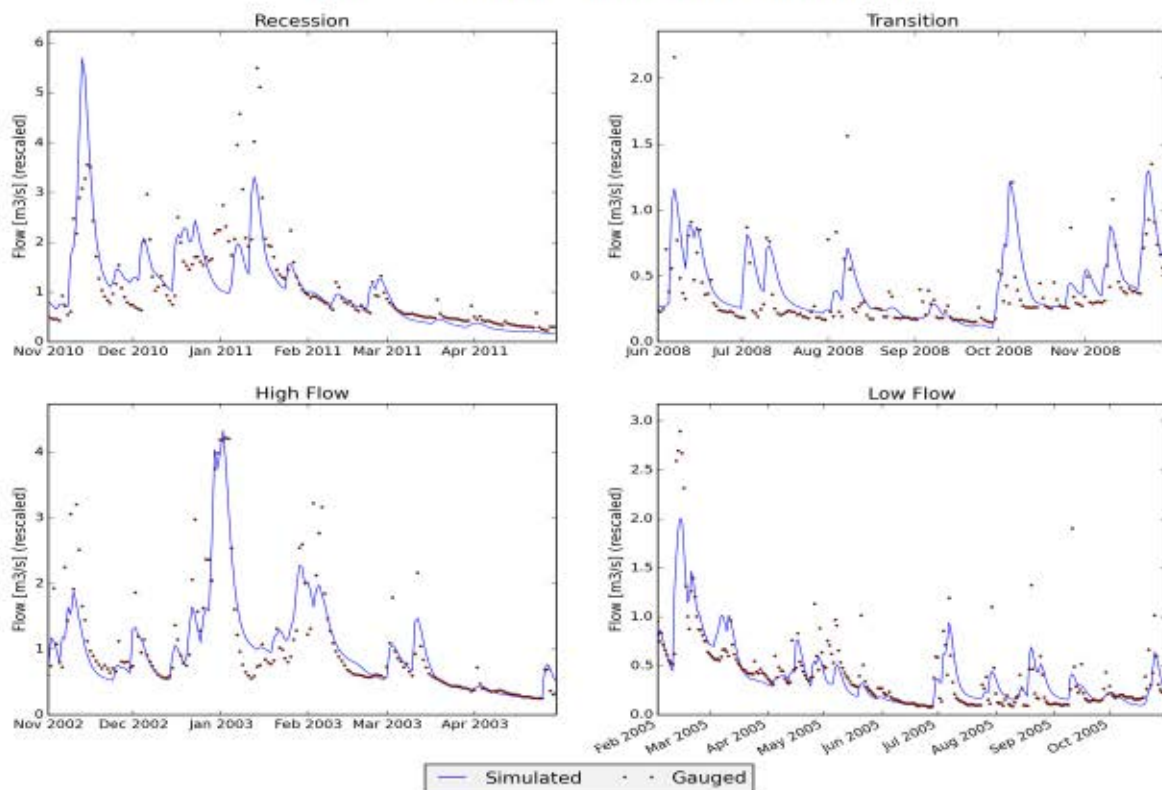


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V04MOM037100, station 3710102 - Grote Molenbeek, Malderen

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V04MOL036110" (BENEDENSCHELDE)

2.1 Input data

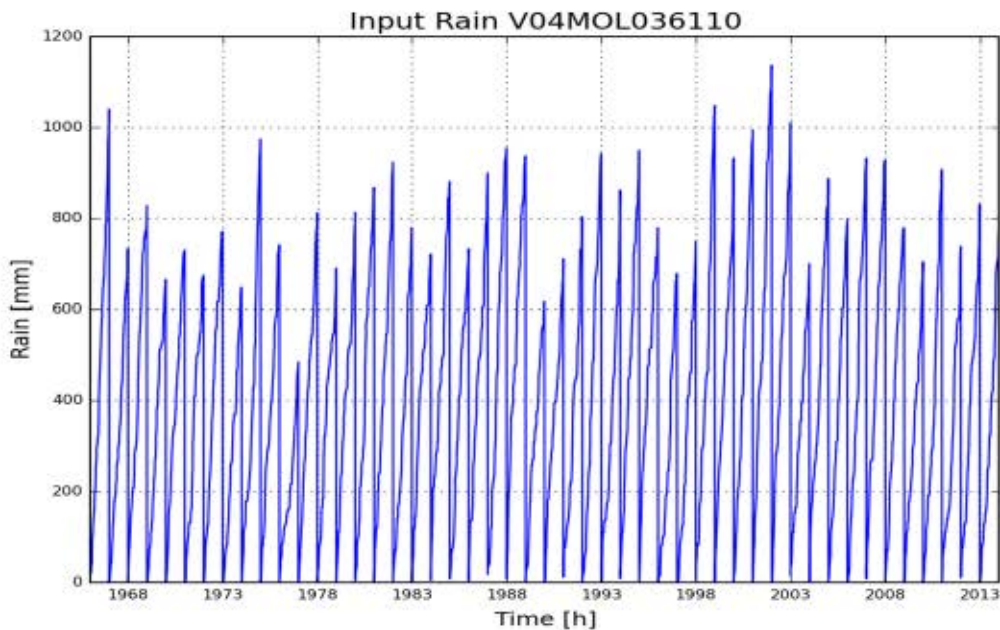


Figure 1: Cumulative precipitation on catchment V04MOL036110 (Benedenschelde)

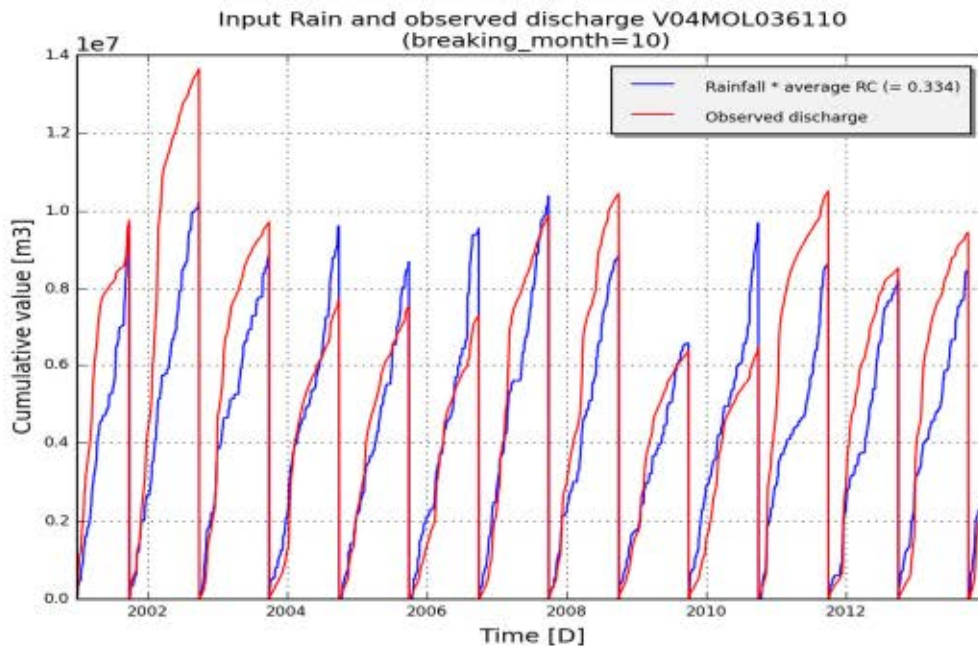


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V04MOL036110 (Benedenschelde)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V04MOL036110 |
| subcatchment_area [m2] | 32561957 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 8.32), (‘SMmax.C’, 538.34), (‘CQOF.C’, 0.57), (‘CKBF.C’, 1980.16), (‘CKIF.C’, 441.52), (‘CK1.C’, 31.04), (‘CK2.C’, 28.51), (‘TIF.C’, 0.2), (‘TOF.C’, 0.49), (‘NAM.TG.C’, 0.43)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 1392724.35 | 22149324.693 |
| RelErr | 1.3 % | 12.8 % |
| RMSE | 1787347.909 | 26086769.867 |
| NS | 0.579 | 0.647 |
| NS_log | 0.673 | 0.595 |
| NS_rel | 0.68 | -0.783 |

2.3 Observed and simulated timeseries for optimum parameters

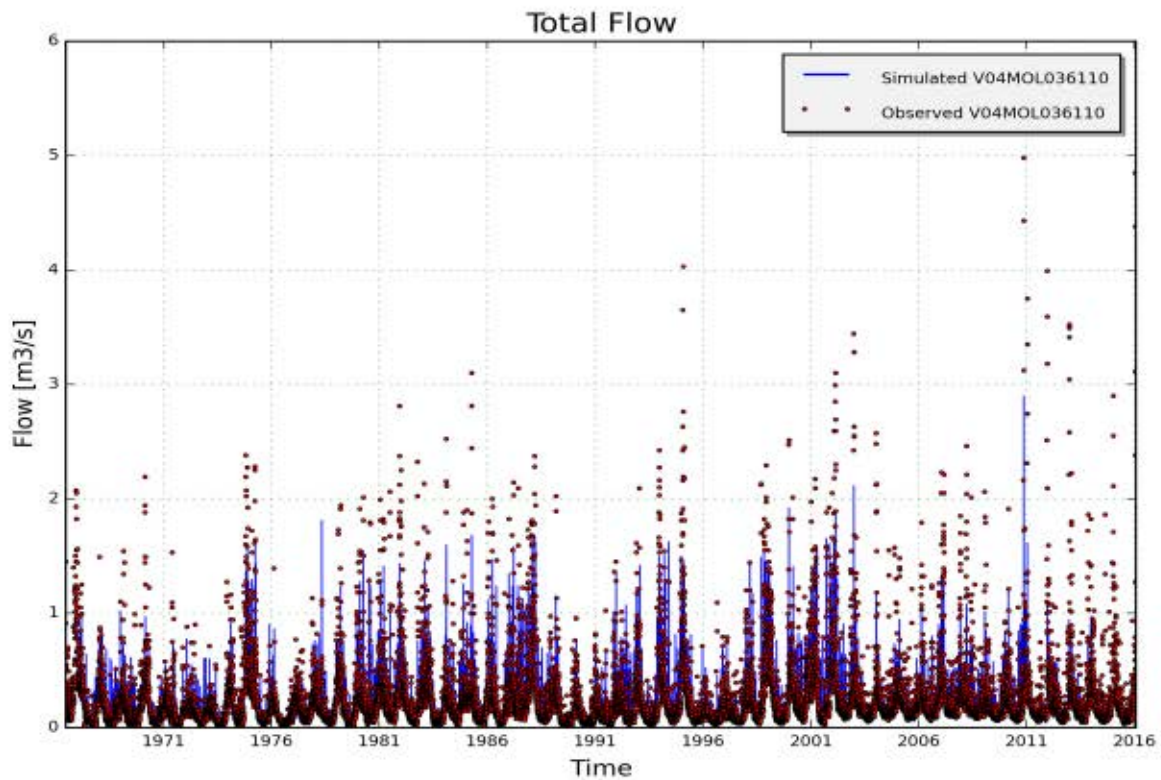


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (validation period 1967-2013)

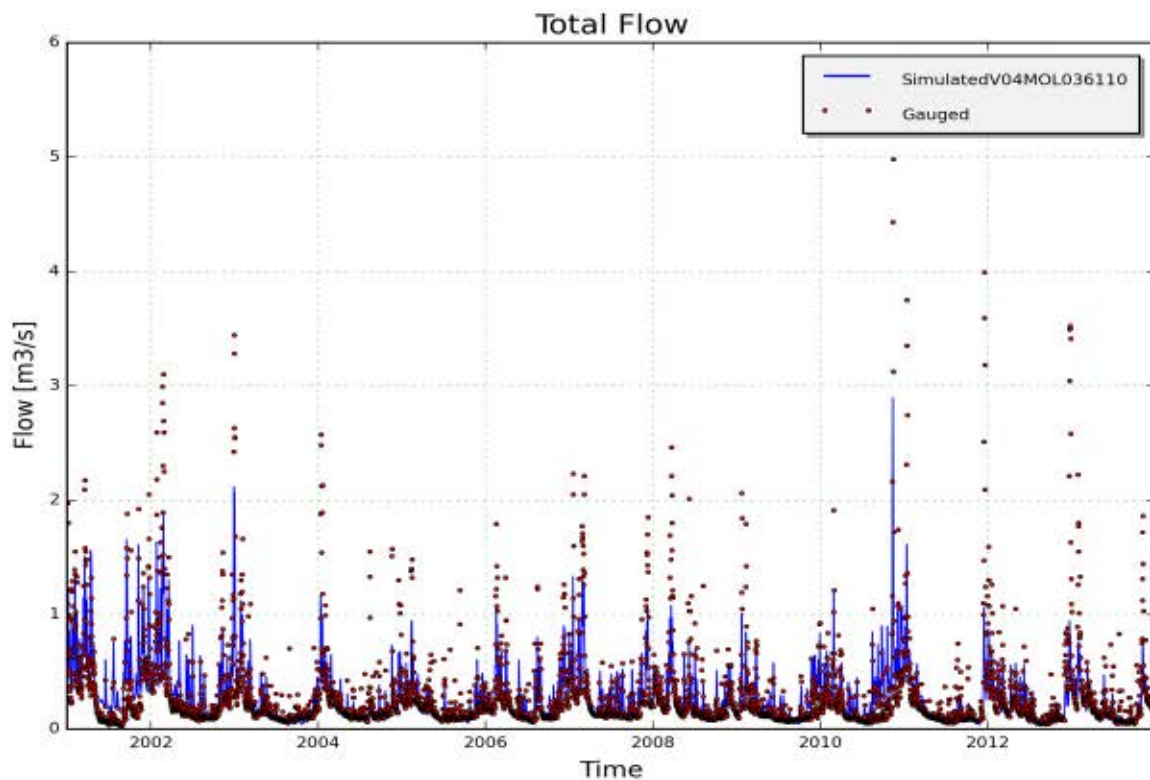


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (calibration period)

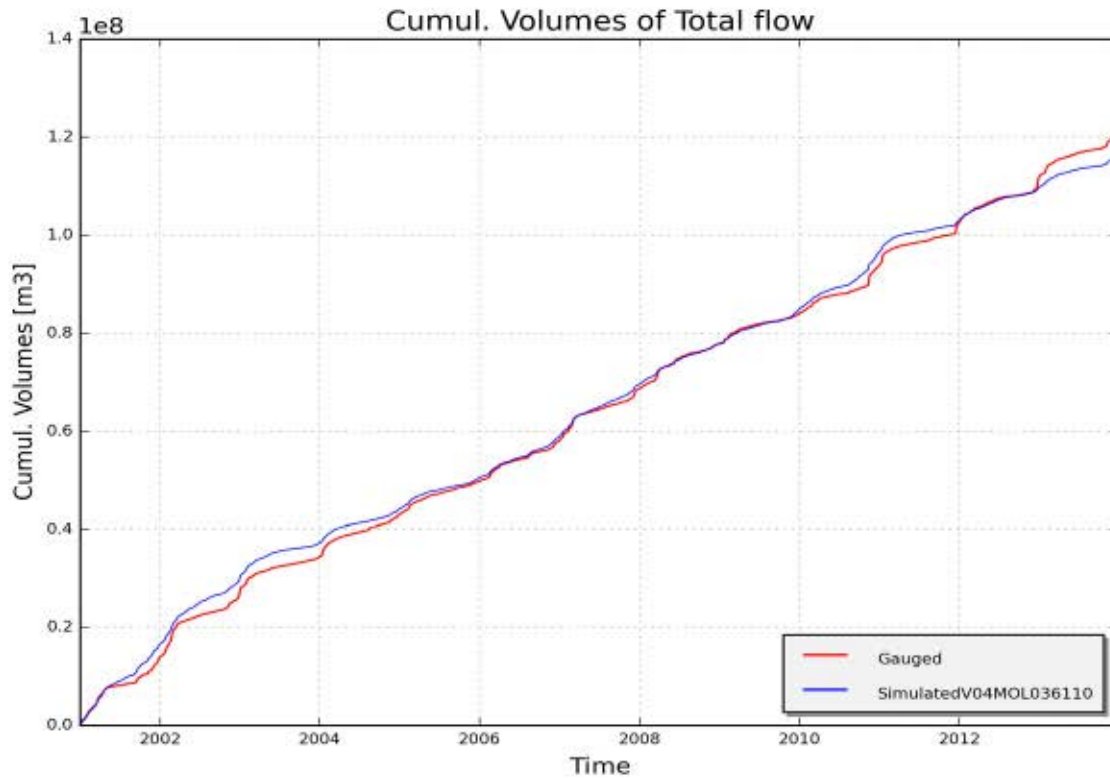


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele (calibration period)

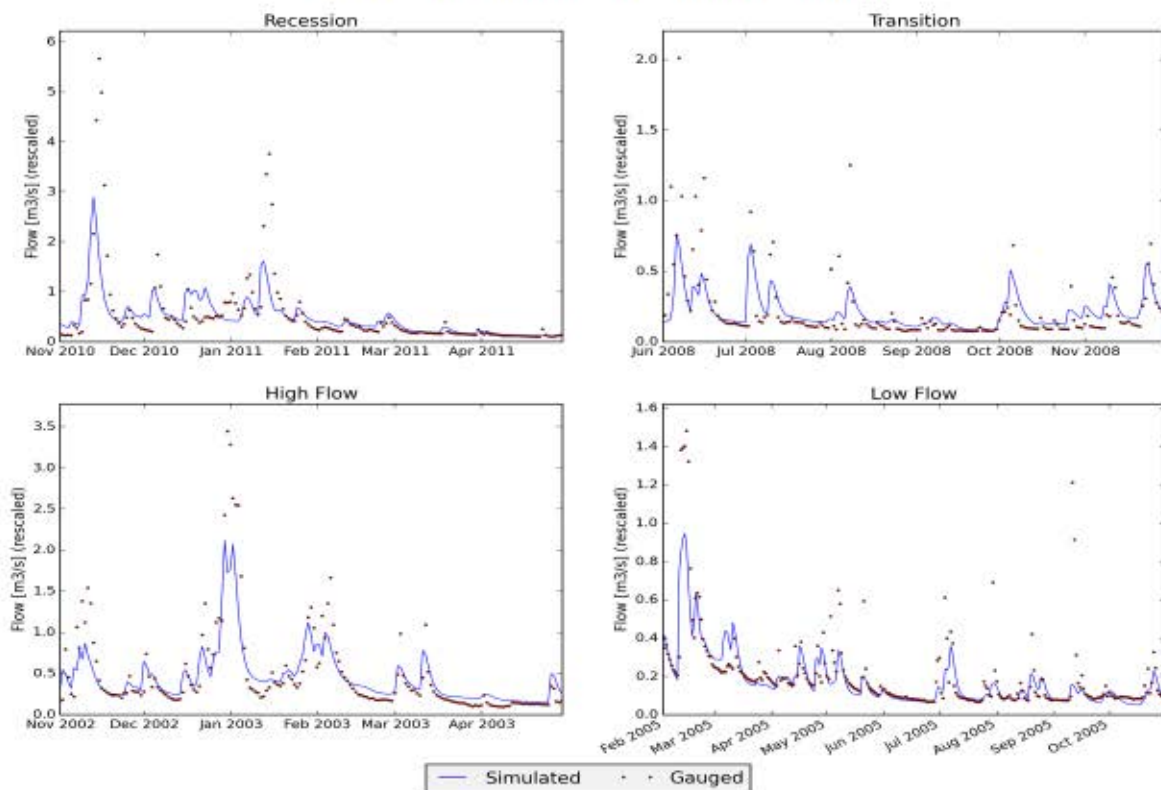


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V04MOL036110, station 3610102 - Kleine Molenbeek, Liezele

Appendix 7

Results of calibration and validation of NAM parameters for catchment "V05HEU403210" (LEIEBEKKEN)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V05HEU403210" (LEIEBEKKEN)

1.1 Input data

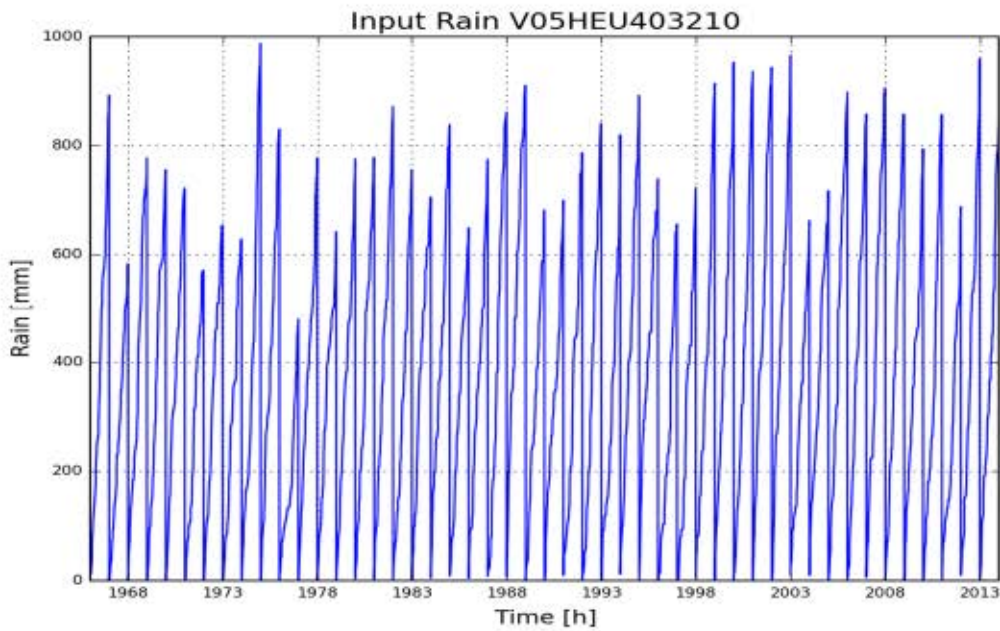


Figure 1: Cumulative precipitation on catchment V05HEU403210 (Leiebekken)

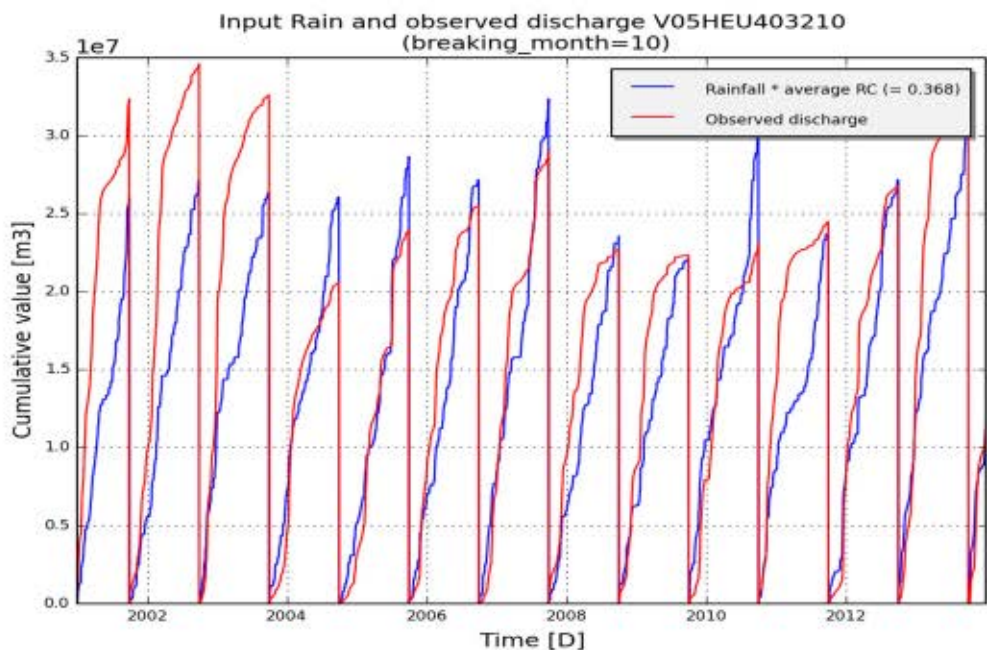


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V05HEU403210 (Leiebekken)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V05HEU403210 |
| subcatchment_area [m2] | 91912331 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 7.73), (‘SMmax.C’, 142.39), (‘CQOF.C’, 0.72), (‘CKBF.C’, 1021.65), (‘CKIF.C’, 148.29), (‘CK1.C’, 34.08), (‘CK2.C’, 29.7), (‘TIF.C’, 0.7), (‘TOF.C’, 0.01), (‘NAM.TG.C’, 0.13)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 9896506.101 | 30217032.529 |
| RelErr | -3.6 % | -5.8 % |
| RMSE | 11181745.344 | 37444446.588 |
| NS | 0.764 | 0.805 |
| NS_log | 0.673 | 0.692 |
| NS_rel | -17.886 | -5.759 |

1.3 Observed and simulated timeseries for optimum parameters

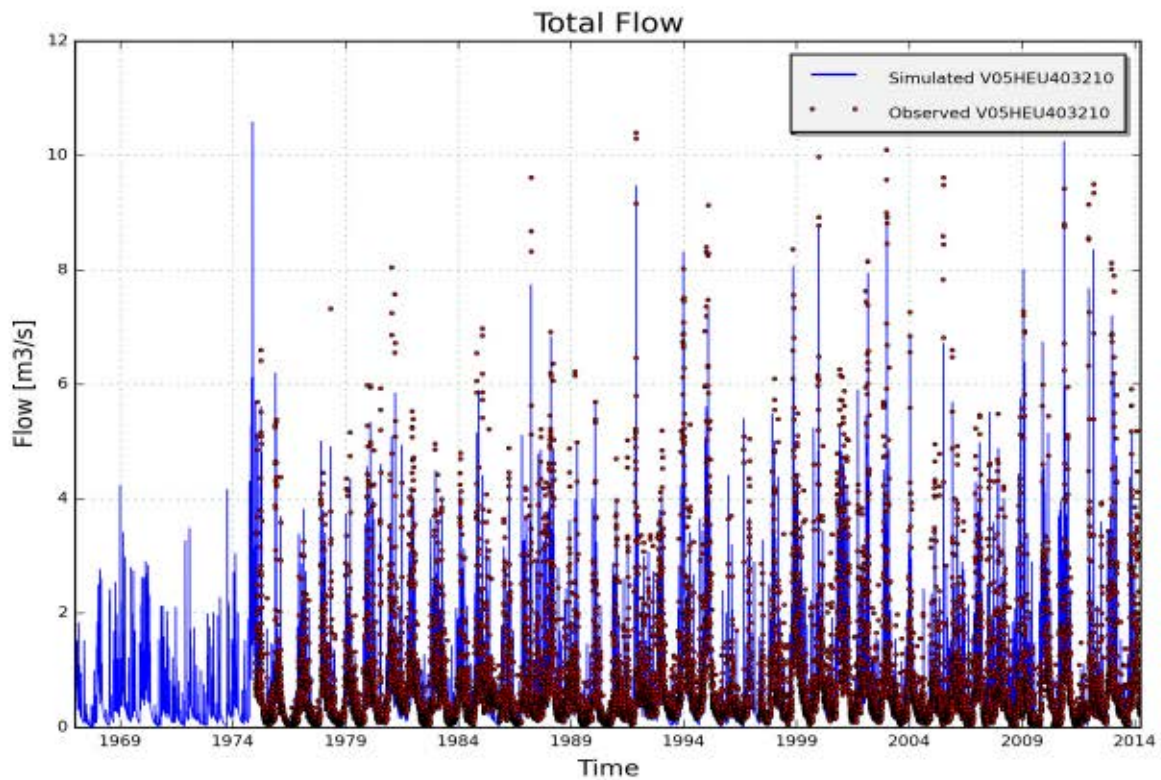


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (validation period 1967-2013)

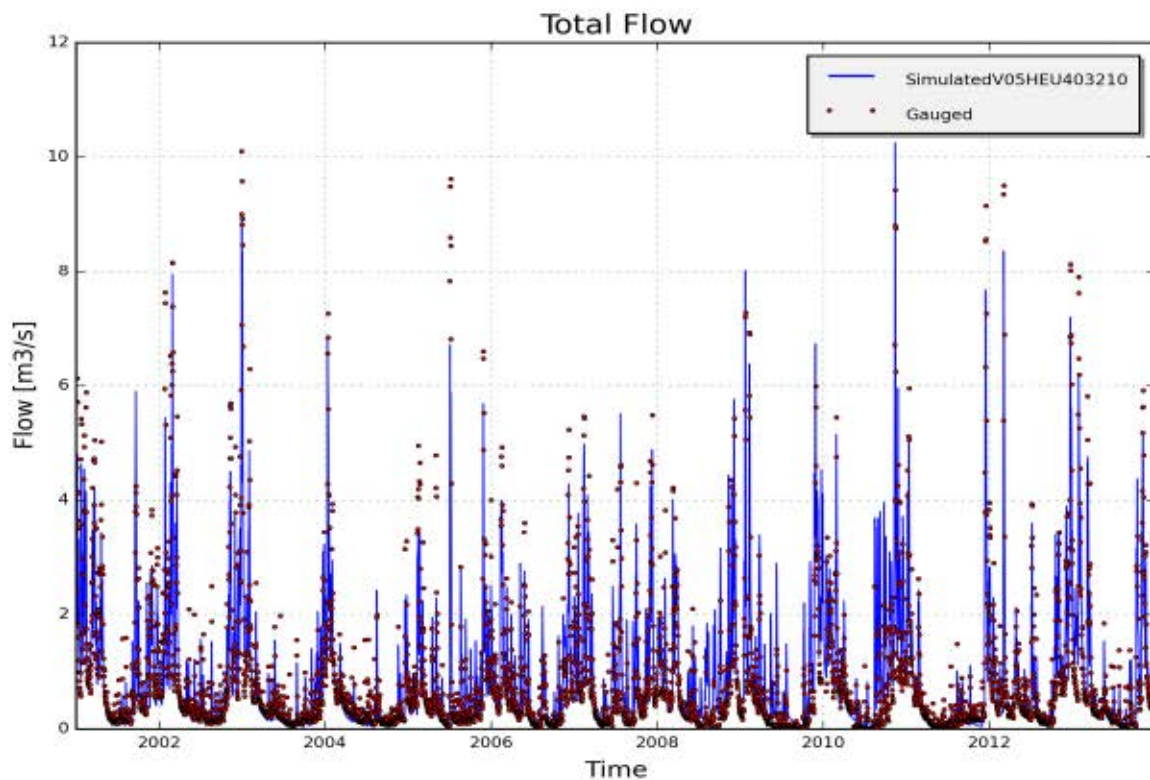


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (calibration period)

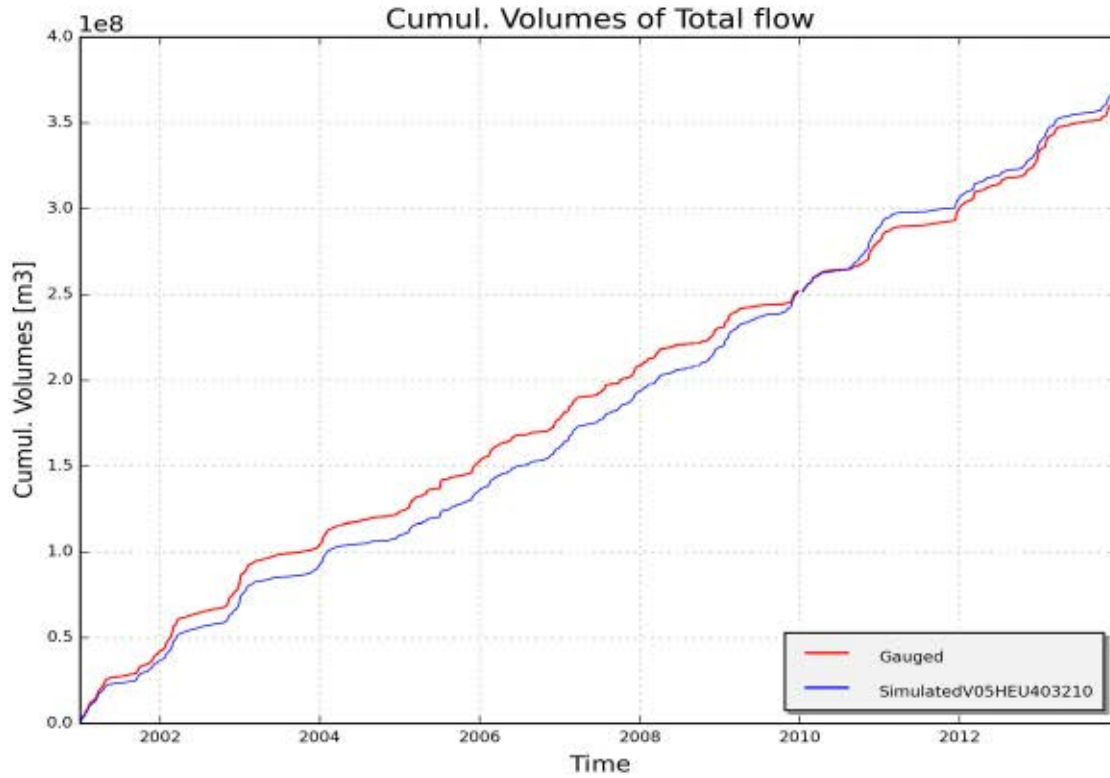


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05HEU403210, station 40310102 - Heulebeek; Heule (calibration period)

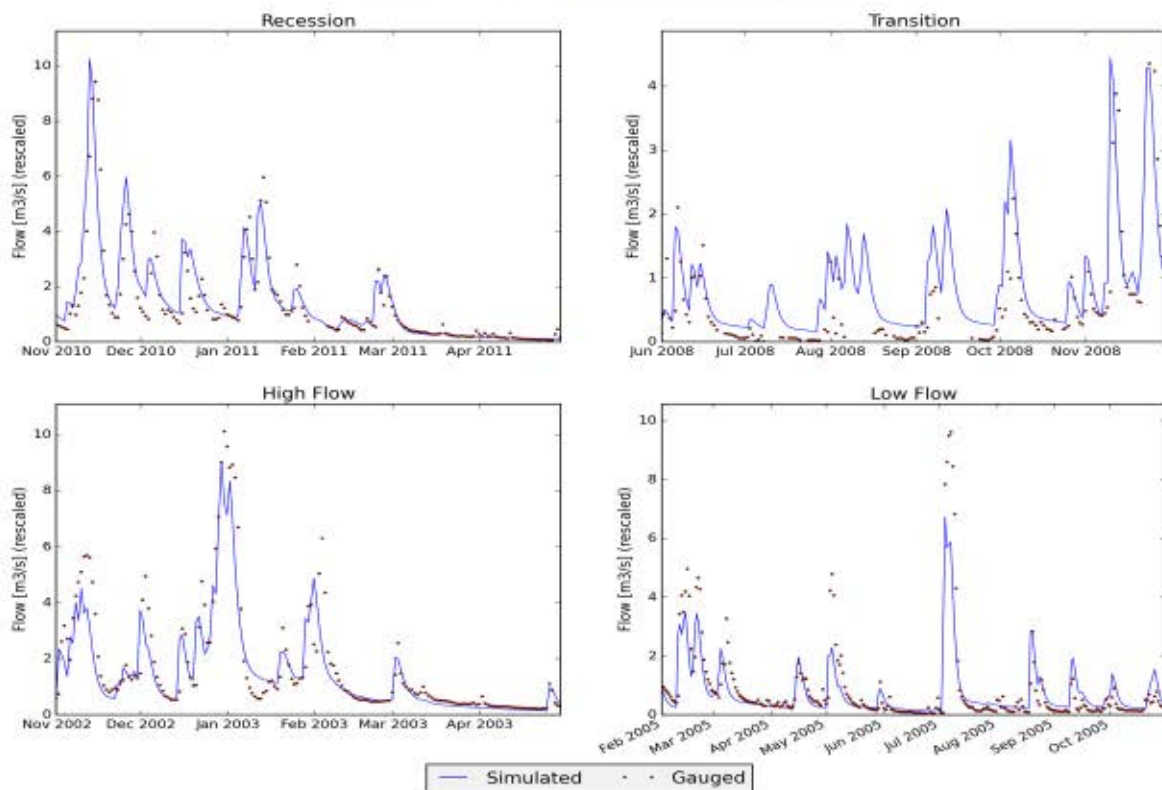


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V05HEU403210, station 40310102 - Heulebeek; Heule

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V05MAN401230" (LEIEBEKKEN)

2.1 Input data

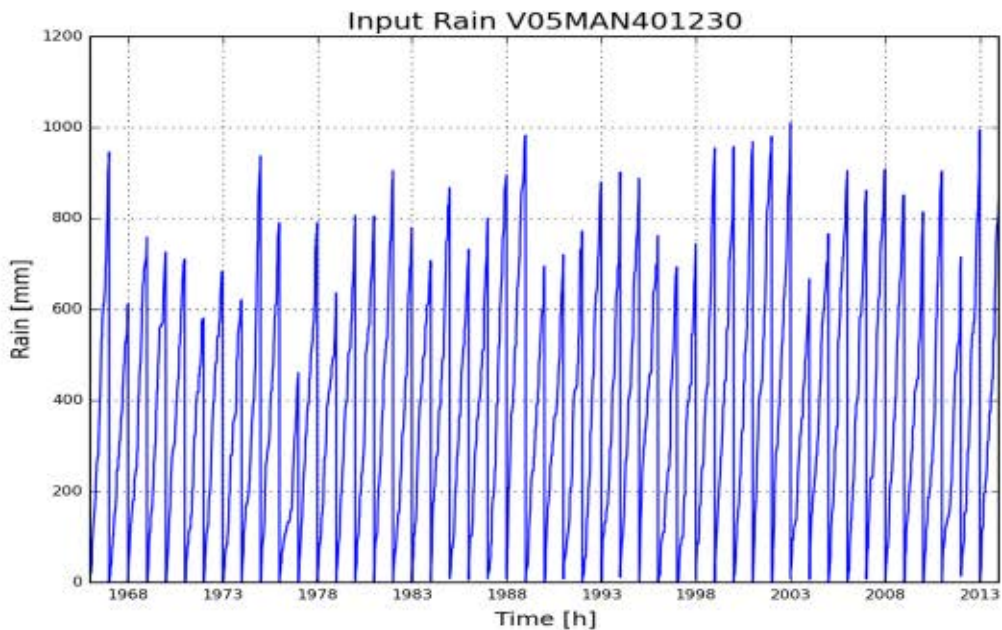


Figure 1: Cumulative precipitation on catchment V05MAN401230 (Leiebekken)

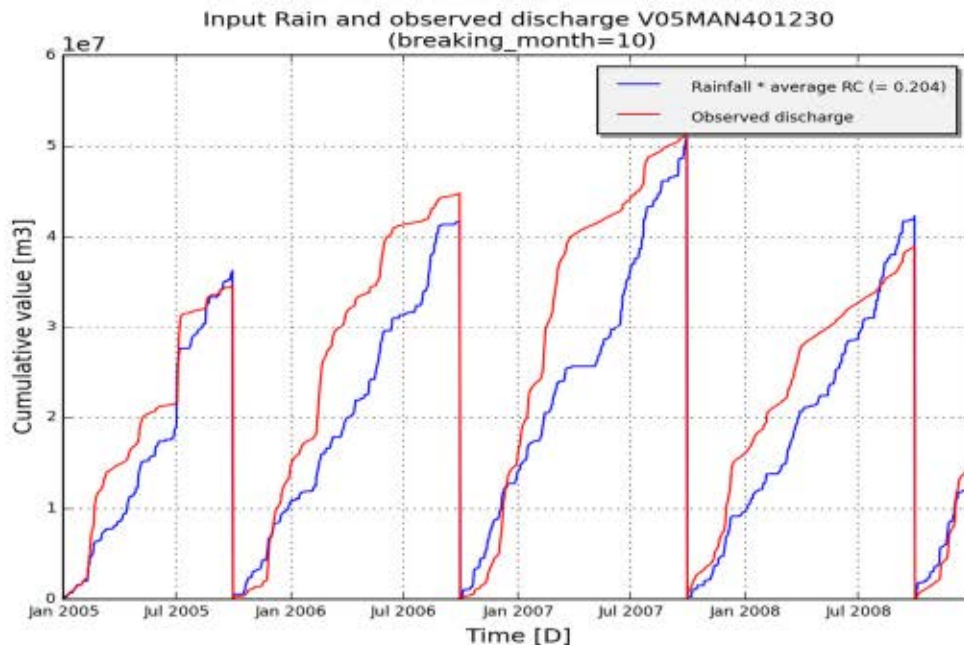


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V05MAN401230 (Leiebekken)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V05MAN401230 |
| subcatchment_area [m2] | 258441818 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 14.03), (‘SMmax.C’, 400.0), (‘CQOF.C’, 0.64), (‘CKBF.C’, 3500.0), (‘CKIF.C’, 750.0), (‘CK1.C’, 44.1), (‘CK2.C’, 28.97), (‘TIF.C’, 0.48), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.7)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 7343714.383 | 377523469.473 |
| RelErr | 0.2 % | -35.6 % |
| RMSE | 9359204.166 | 418853167.743 |
| NS | 0.644 | 0.615 |
| NS_log | 0.504 | -1.349 |
| NS_rel | -1.501 | -2.014 |

2.3 Observed and simulated timeseries for optimum parameters

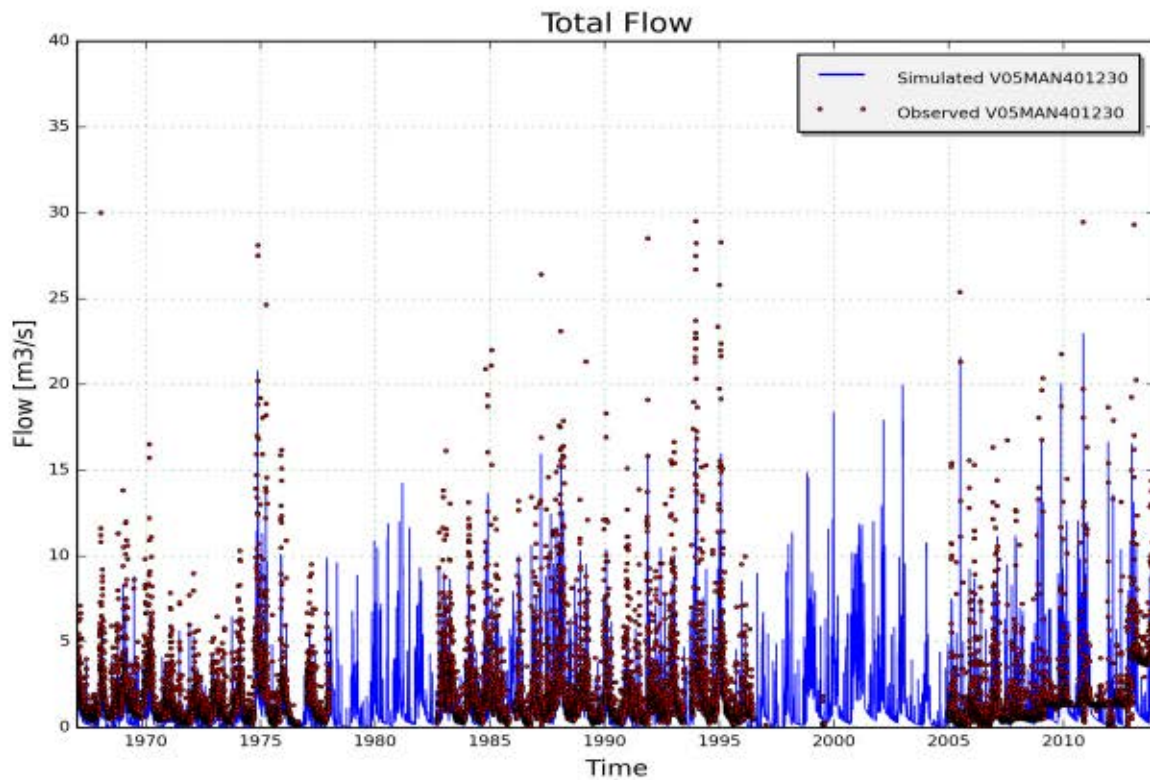


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (validation period 1967-2013)

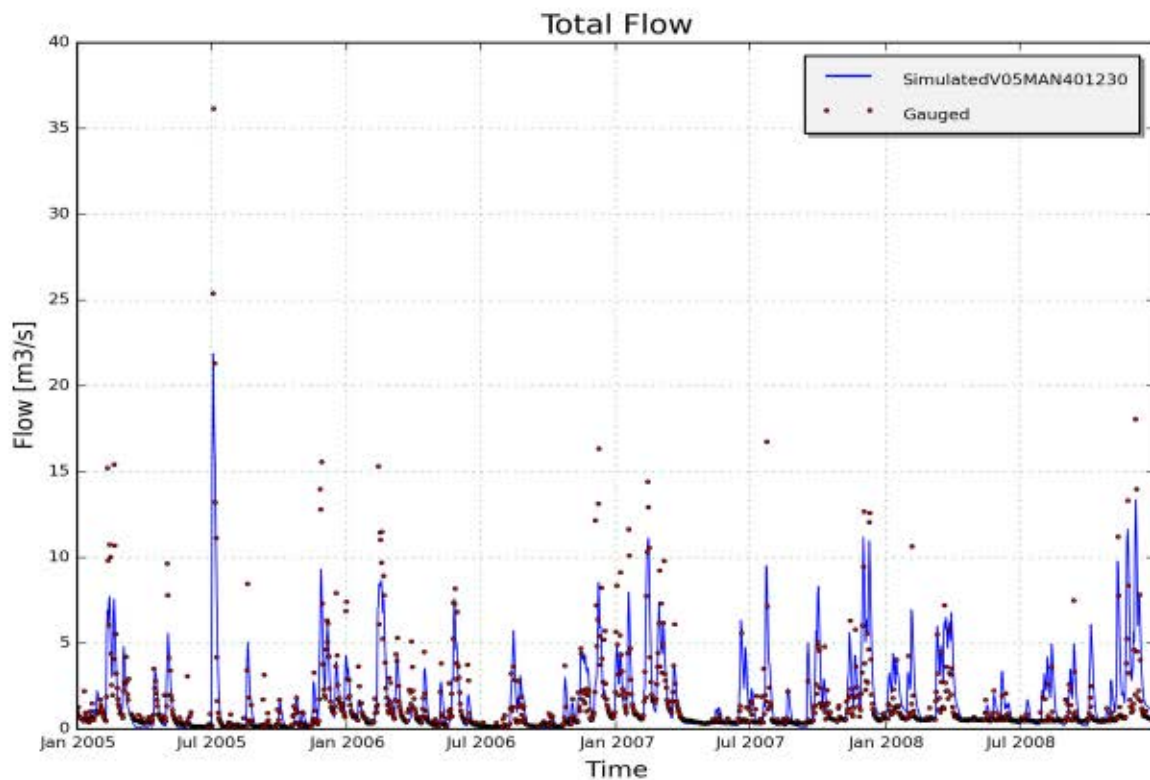


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (calibration period)

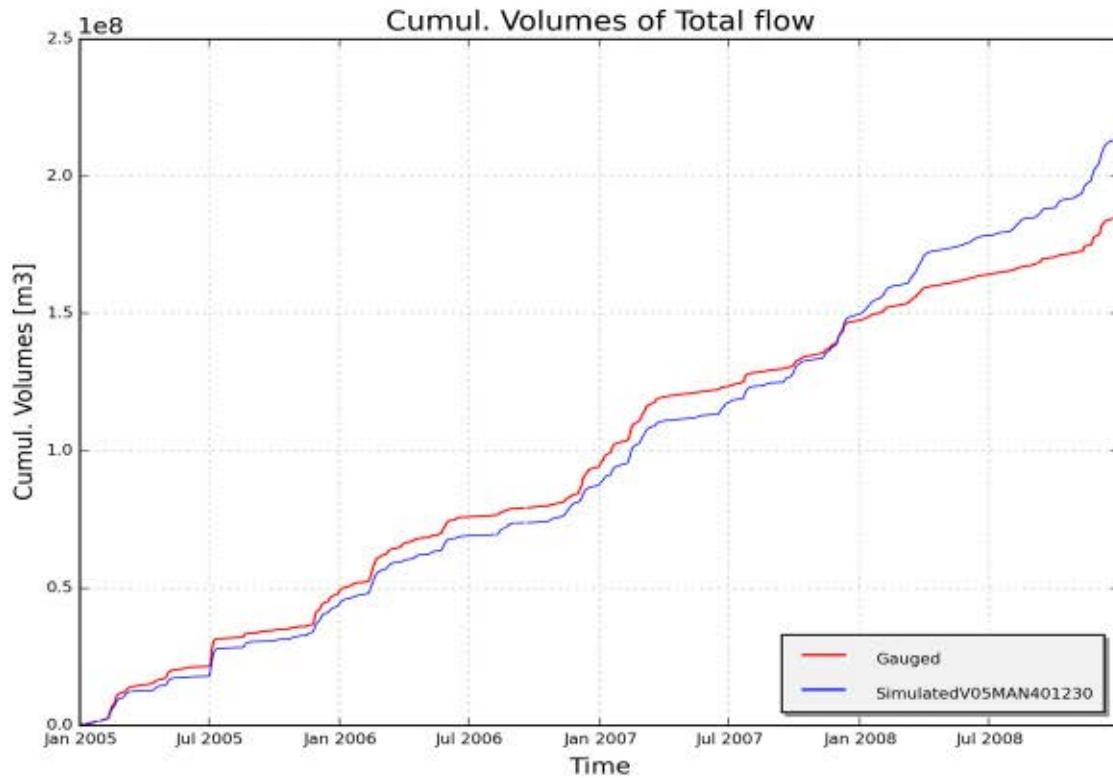


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke (calibration period)

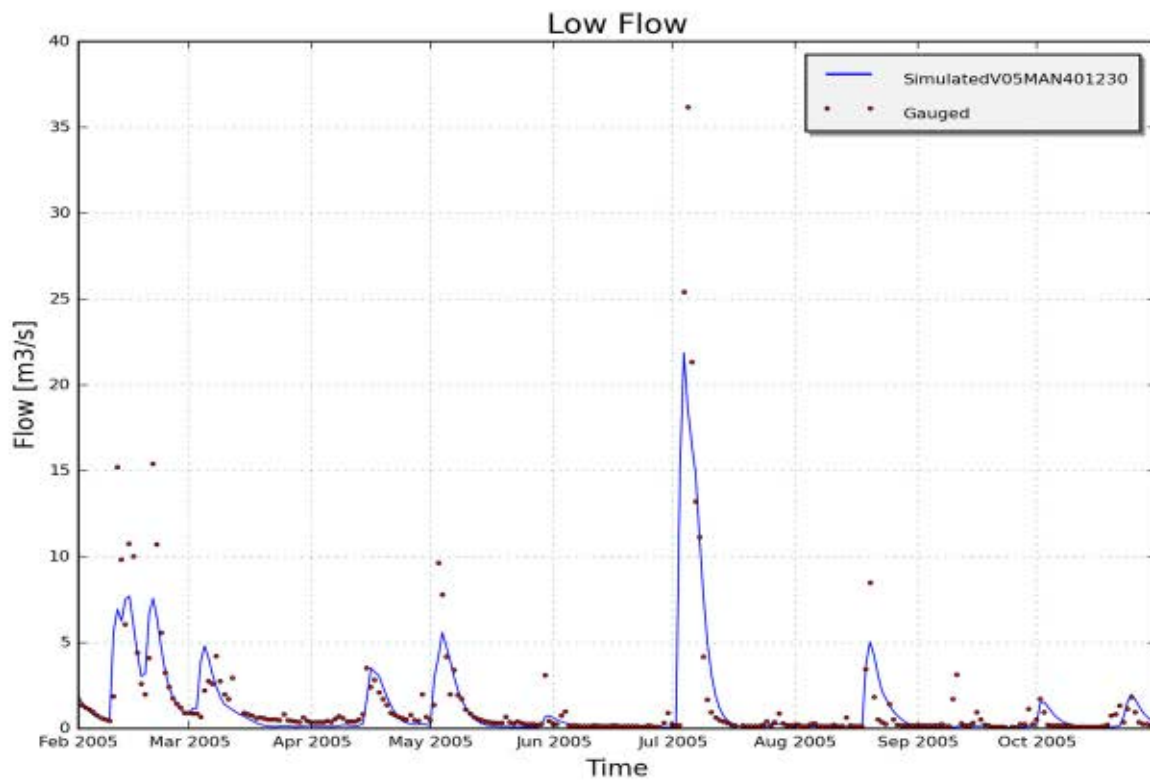


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke

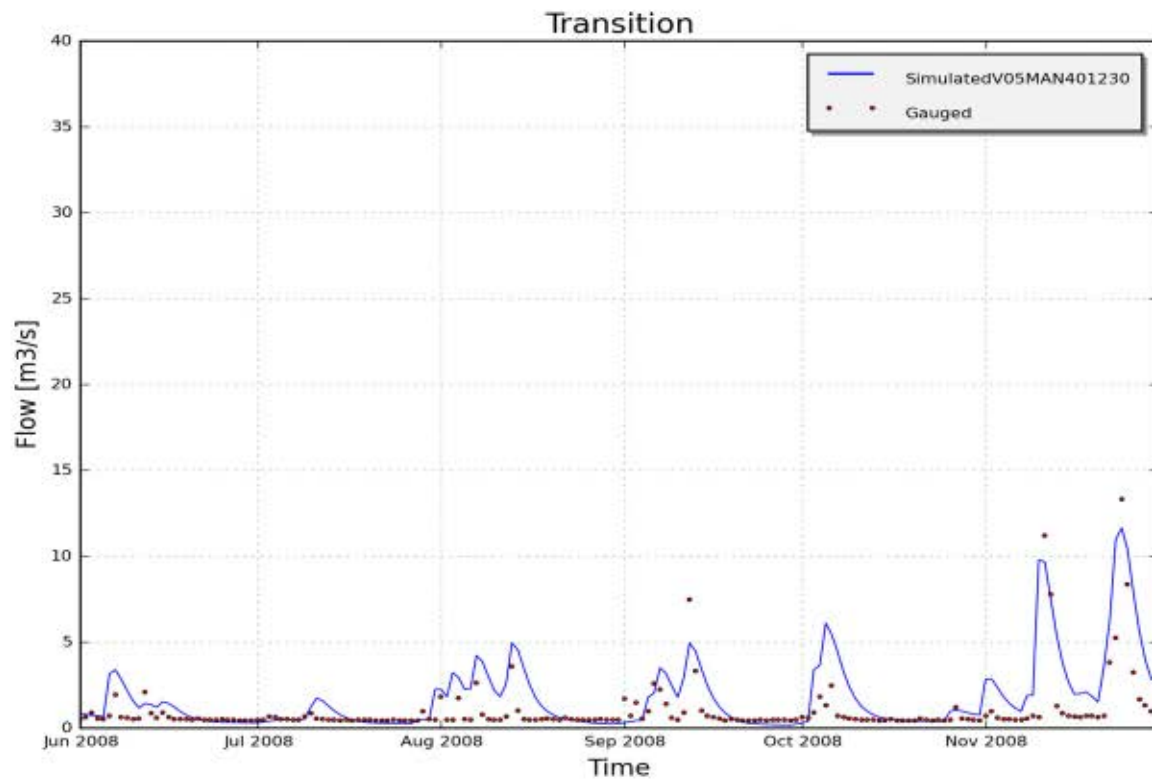


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V05MAN401230, station 40110102 - Mandel; Oostrozebeke

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "F05LEI386999" (LEIEBEKKEN)

3.1 Input data

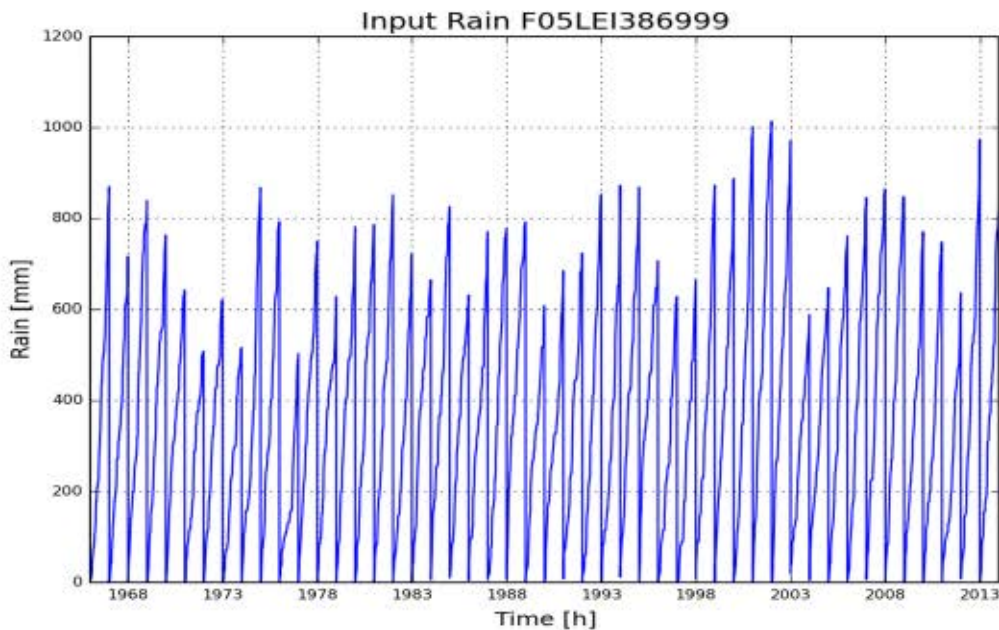


Figure 1: Cumulative precipitation on catchment F05LEI386999 (Leiebekken)

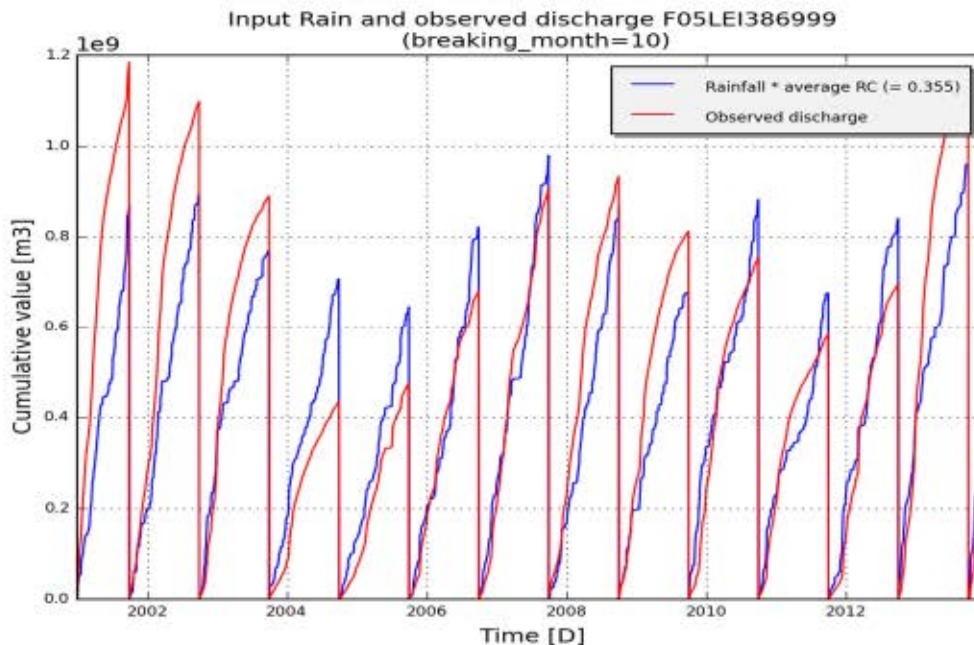


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment F05LEI386999 (Leiebekken)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | F05LEI386999 |
| subcatchment_area [m2] | 2981779554 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:(['Umax.C', 2.0), ('SMmax.C', 415.0), ('CQOF.C', 0.5), ('CKBF.C', 1100.0), ('CKIF.C', 270.0), ('CK1.C', 44.0), ('CK2.C', 32.0), ('TIF.C', 0.6), ('TOF.C', 0.1), ('NAM.TG.C', 0.1)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 205289659.012 | 177059872.217 |
| RelErr | -1.0 % | -0.6 % |
| RMSE | 220343618.327 | 202049766.193 |
| NS | 0.779 | 0.792 |
| NS_log | 0.731 | 0.747 |
| NS_rel | 0.663 | 0.677 |

3.3 Observed and simulated timeseries for optimum parameters

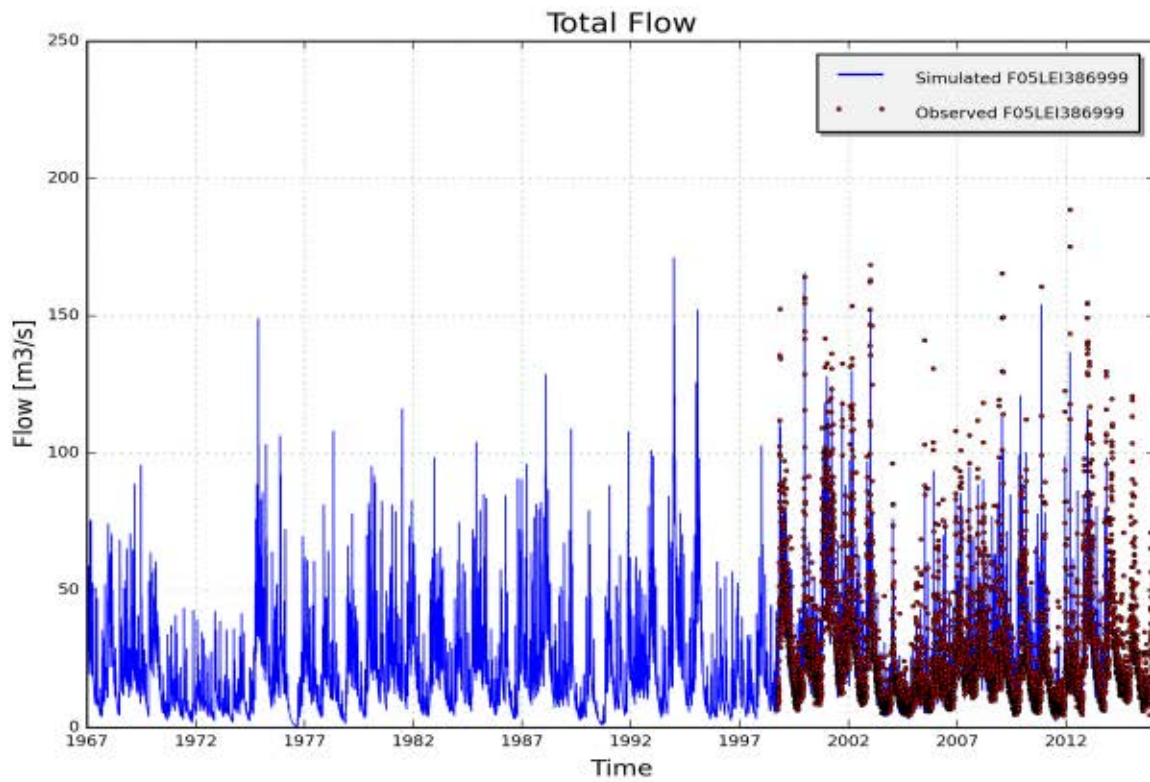


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F05LEI386999, station unknown (validation period 1967-2013)

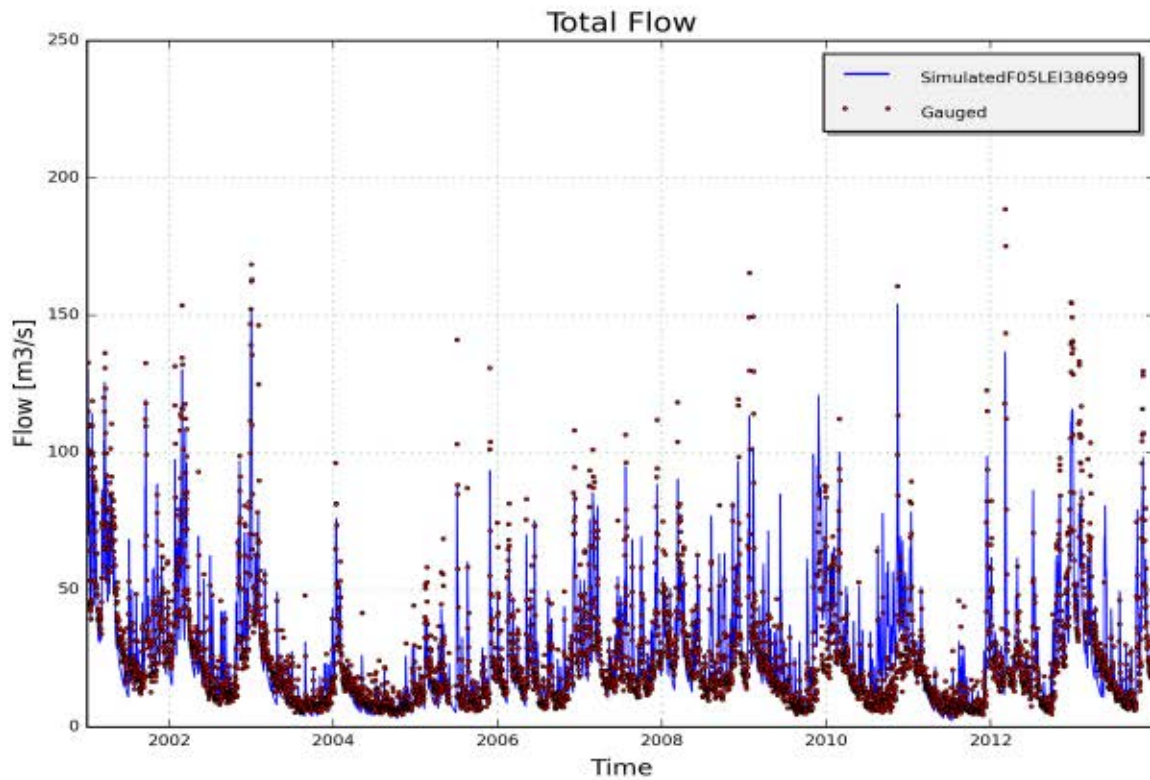


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F05LEI386999, station unknown (calibration period)

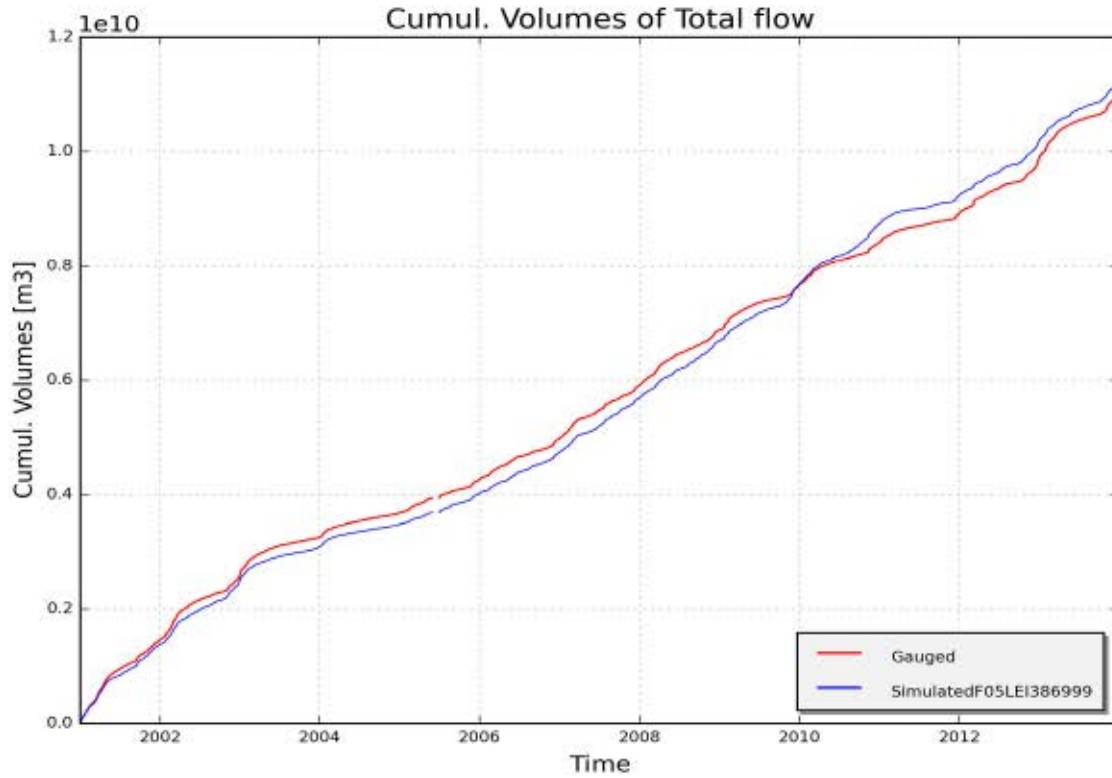


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment F05LEI386999, station unknown (calibration period)

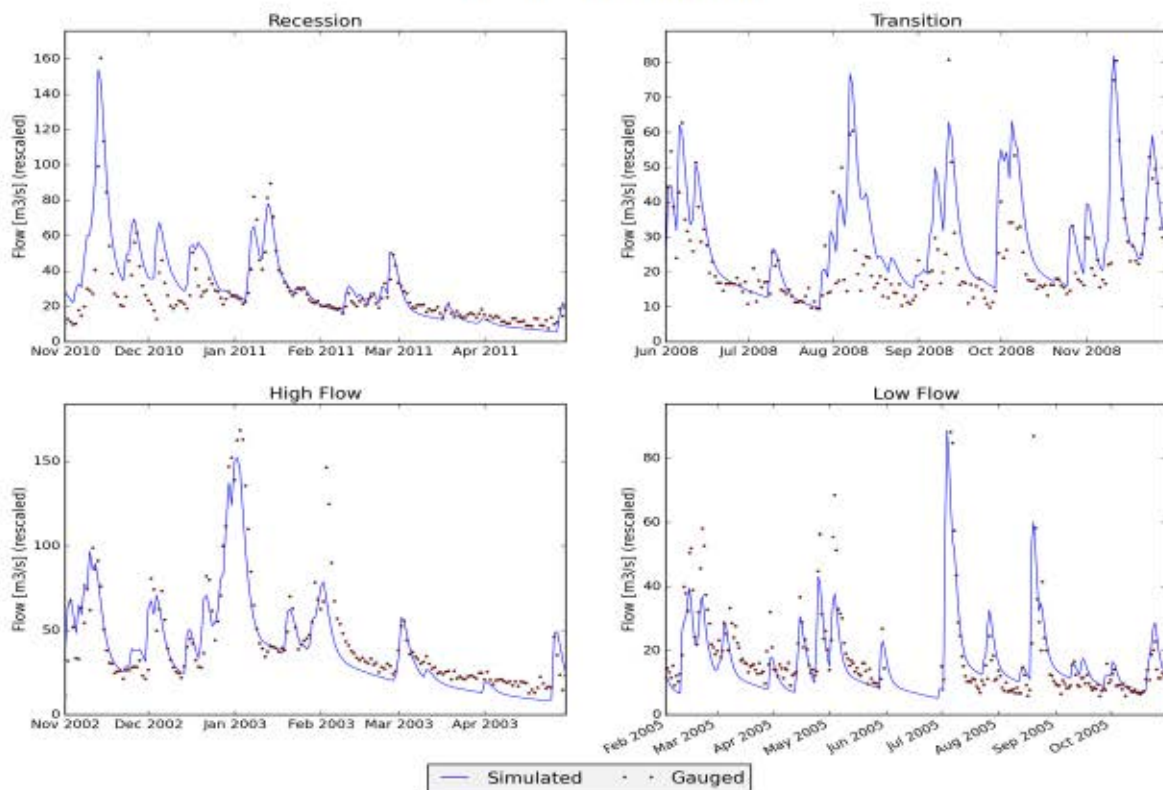


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment F05LEI386999, station unknown

Appendix 8

Results of calibration and validation of NAM parameters for catchment "W06RHOL54100" (BOVENSCHELDE)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "W06RHOL54100" (BOVENSCHELDE)

1.1 Input data

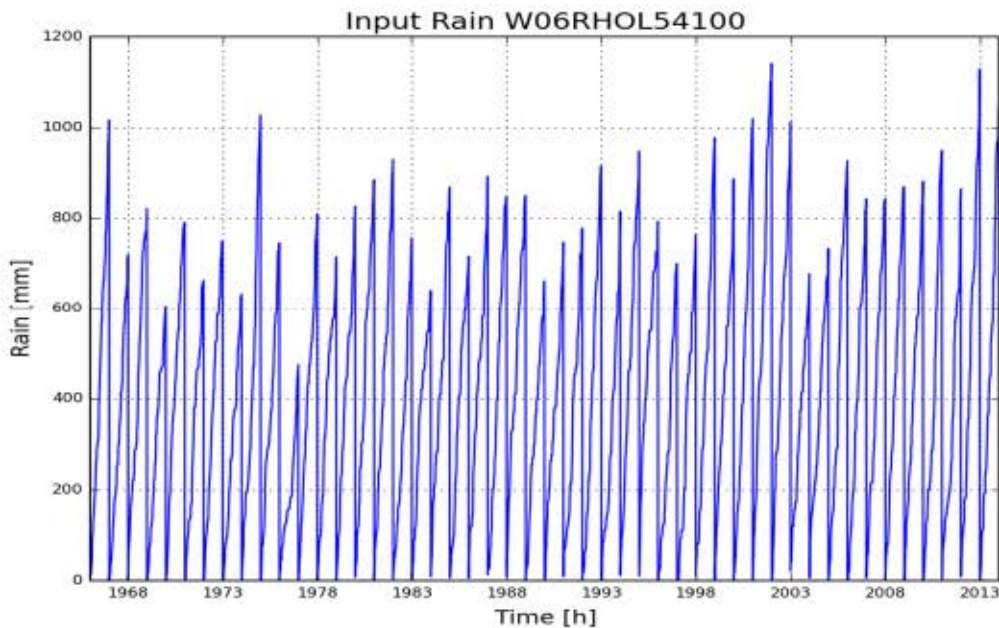


Figure 1: Cumulative precipitation on catchment W06RHOL54100 (Bovenshelde)

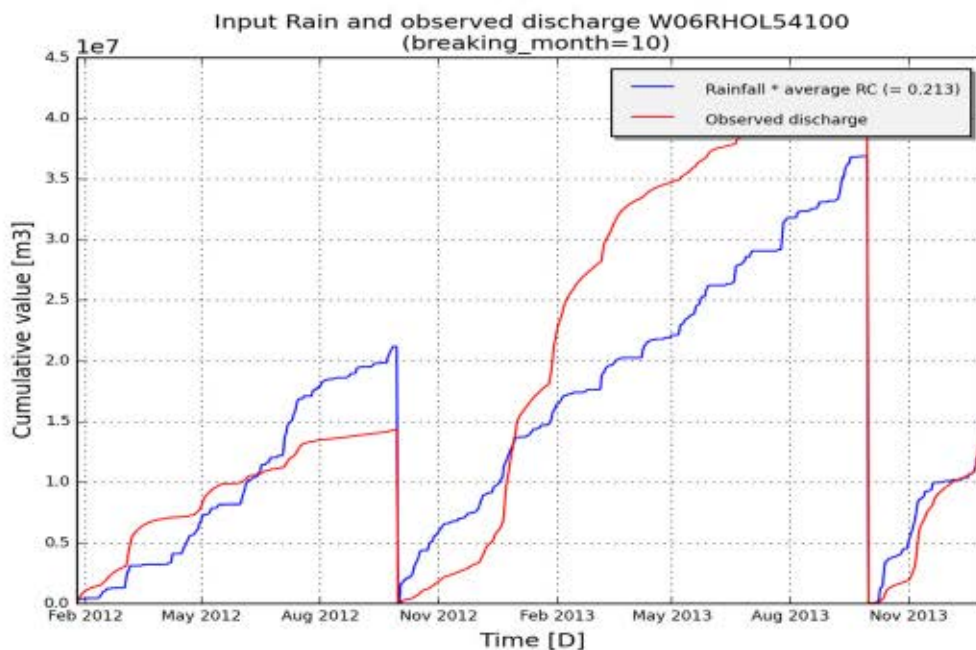


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment W06RHOL54100 (Bovenshelde)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | W06RHOL54100 |
| subcatchment_area [m2] | 161928446 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 15.0), ('SMmax.C', 598.36), ('CQOF.C', 0.2), ('CKBF.C', 1457.68), ('CKIF.C', 749.84), ('CK1.C', 29.25), ('CK2.C', 17.37), ('TIF.C', 0.7), ('TOF.C', 0.01), ('NAM.TG.C', 0.98)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 9619348.405 | 16353000.422 |
| RelErr | 28.4 % | 49.6 % |
| RMSE | 12896681.07 | 19045051.018 |
| NS | 0.522 | 0.505 |
| NS_log | 0.511 | 0.469 |
| NS_rel | -0.095 | -0.743 |

1.3 Observed and simulated timeseries for optimum parameters

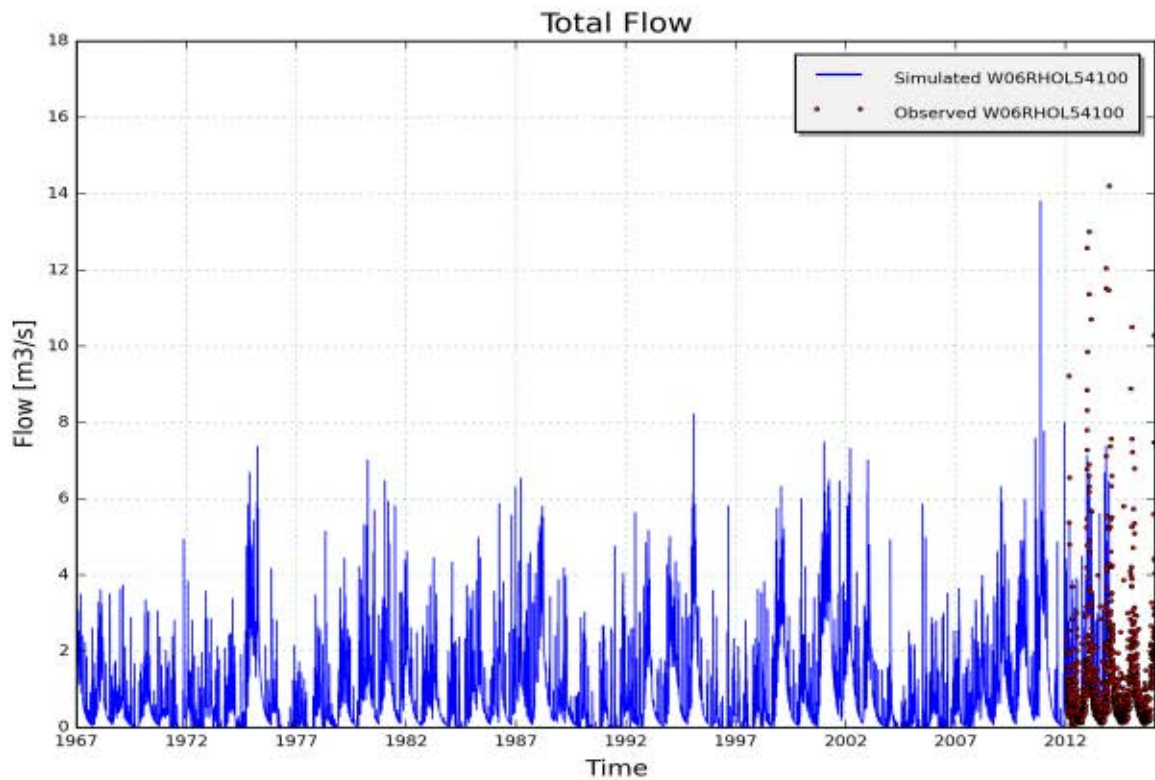


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (validation period 1967-2013)

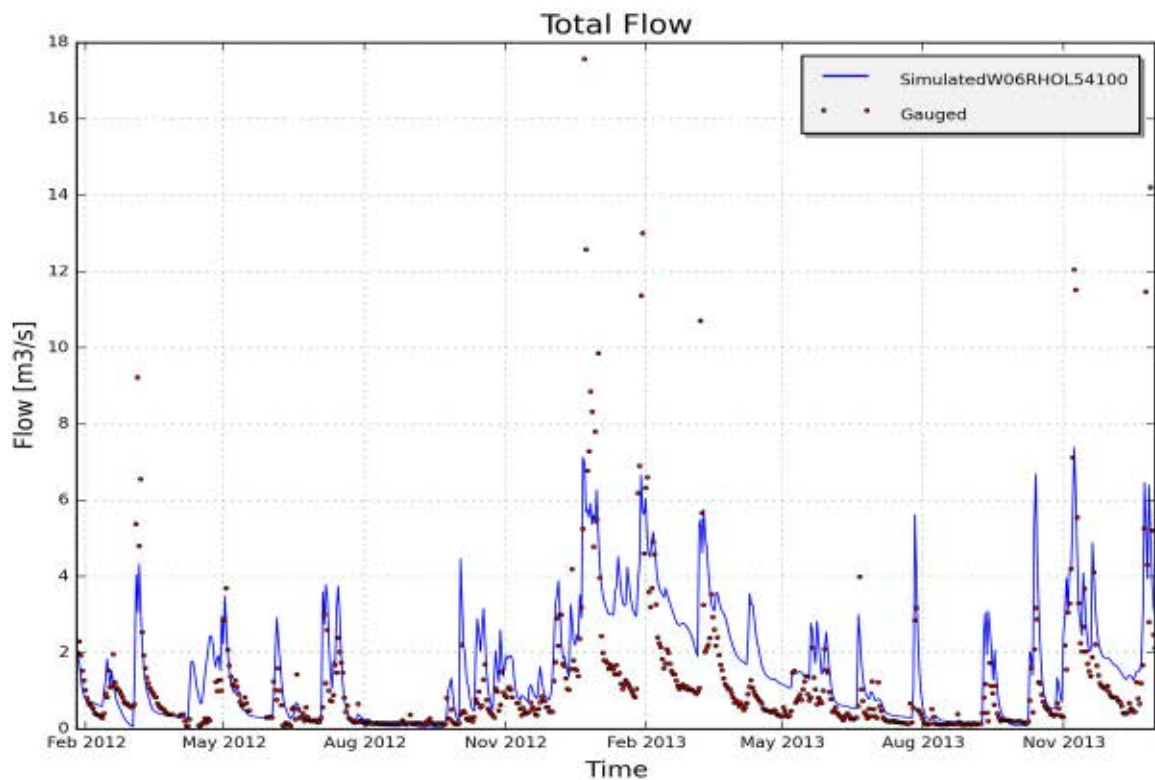


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (calibration period)

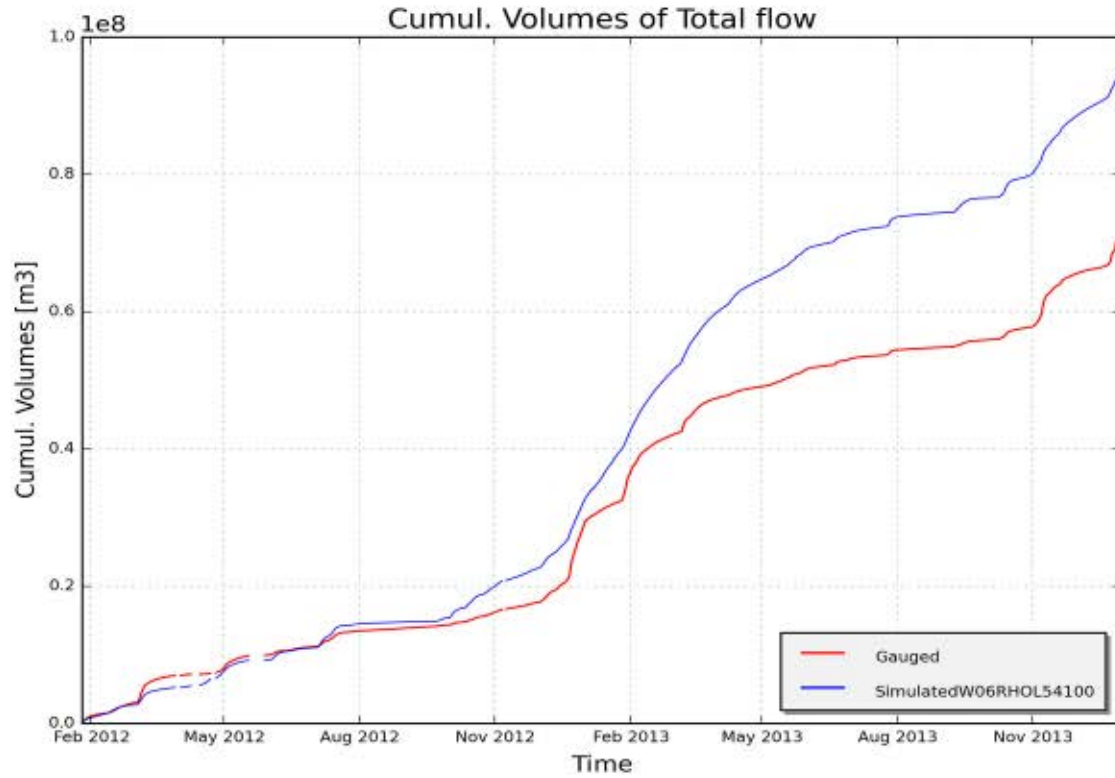


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment W06RHOL54100, station L5412 Amougies - Rhosnes (calibration period)

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V06MAA347160" (BOVENSCHELDE)

2.1 Input data

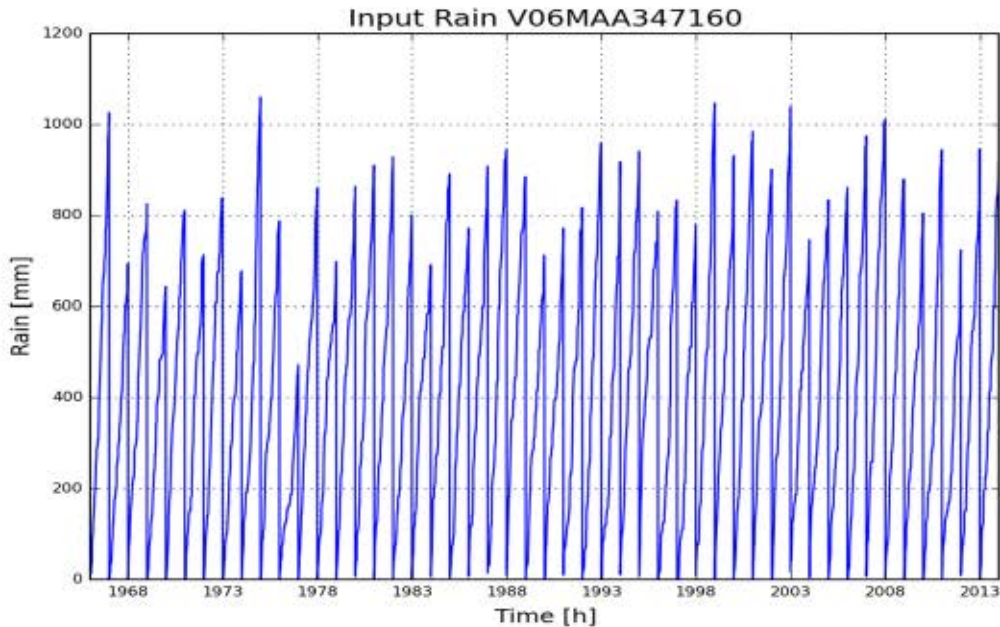


Figure 1: Cumulative precipitation on catchment V06MAA347160 (Bovenshelde)

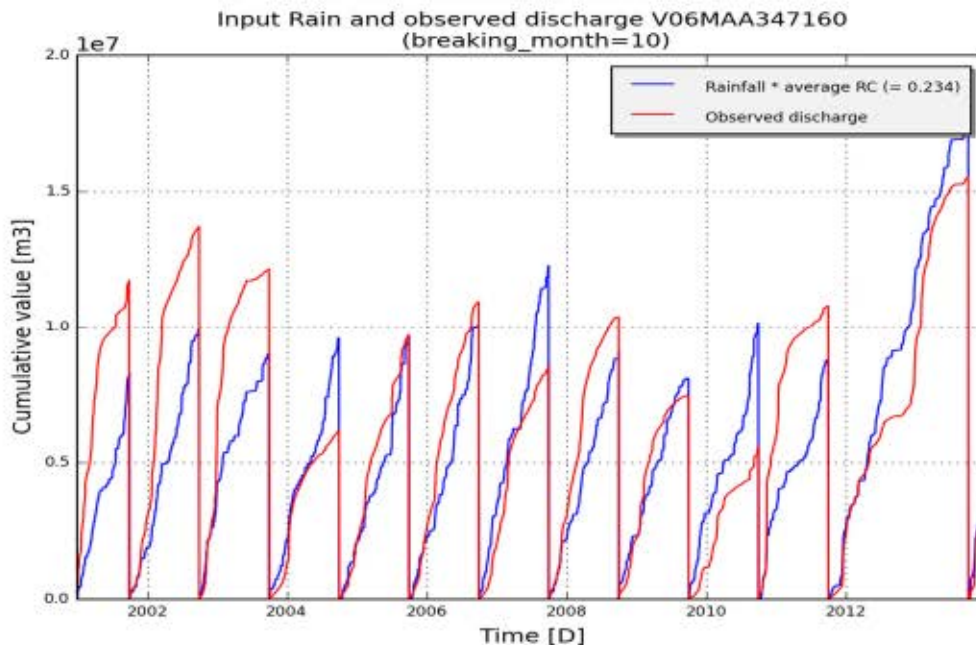


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V06MAA347160 (Bovenshelde)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V06MAA347160 |
| subcatchment_area [m2] | 48678191 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 15.71), (‘SMmax.C’, 471.22), (‘CQOF.C’, 0.86), (‘CKBF.C’, 3386.65), (‘CKIF.C’, 800.98), (‘CK1.C’, 21.42), (‘CK2.C’, 20.78), (‘TIF.C’, 0.23), (‘TOF.C’, 0.9), (‘NAM.TG.C’, 0.85)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 6666493.724 | 76619587.428 |
| RelErr | -1.0 % | -27.4 % |
| RMSE | 7930810.044 | 91217607.481 |
| NS | 0.443 | 0.444 |
| NS_log | 0.436 | 0.322 |
| NS_rel | 0.53 | 0.539 |

2.3 Observed and simulated timeseries for optimum parameters

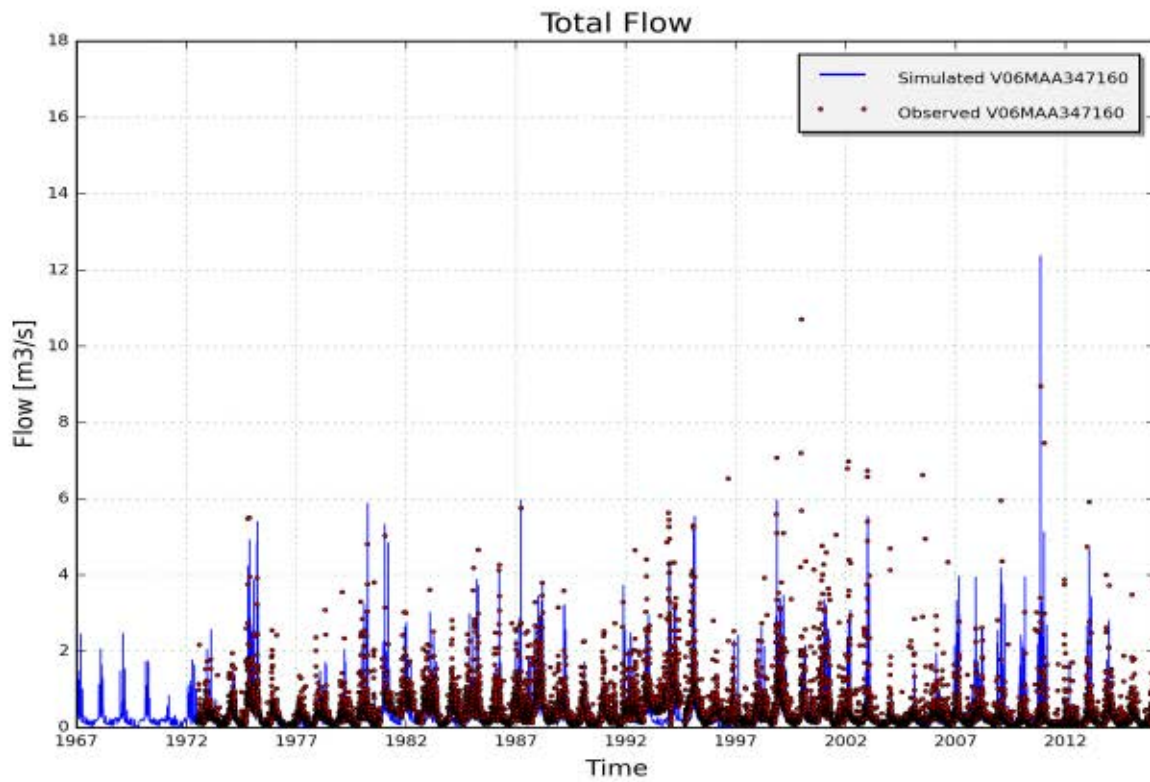


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (validation period 1967-2013)

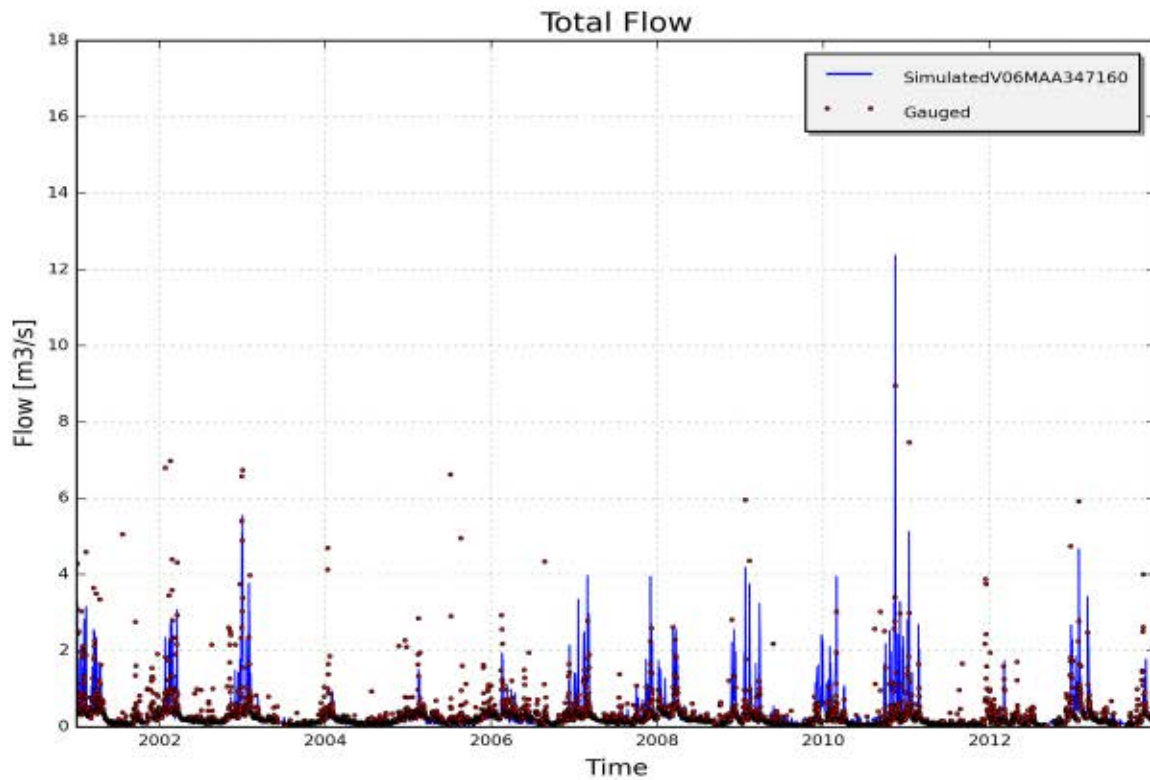


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (calibration period)

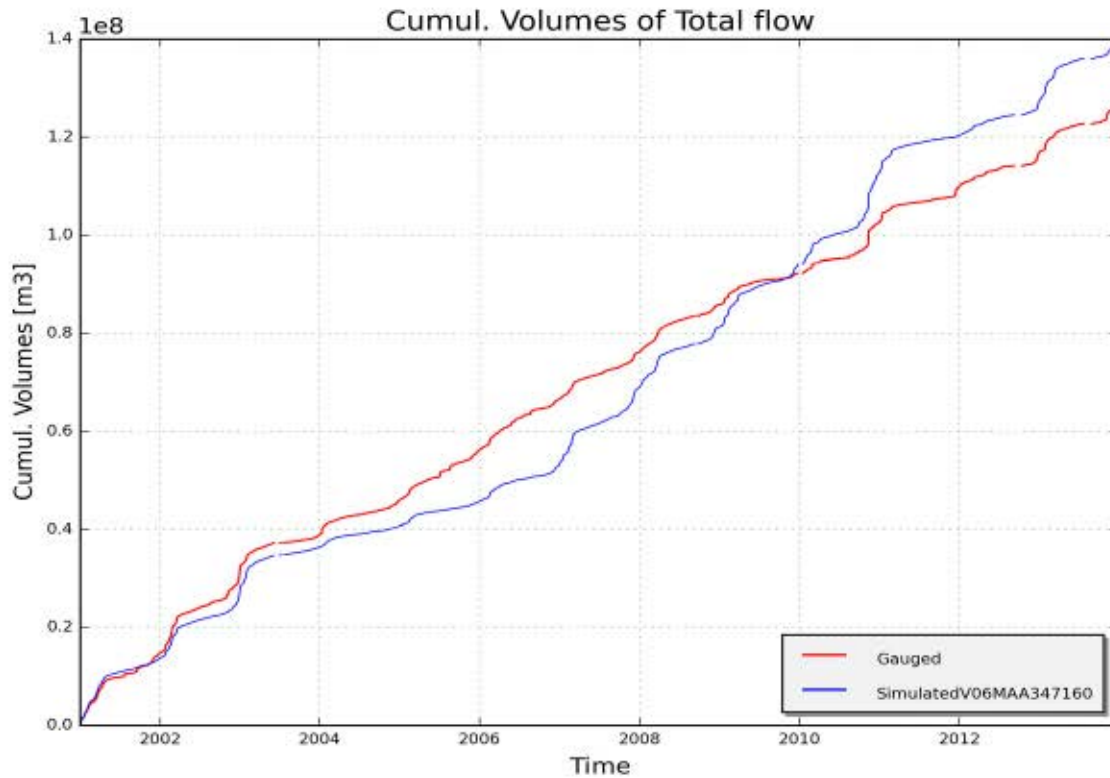


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove (calibration period)

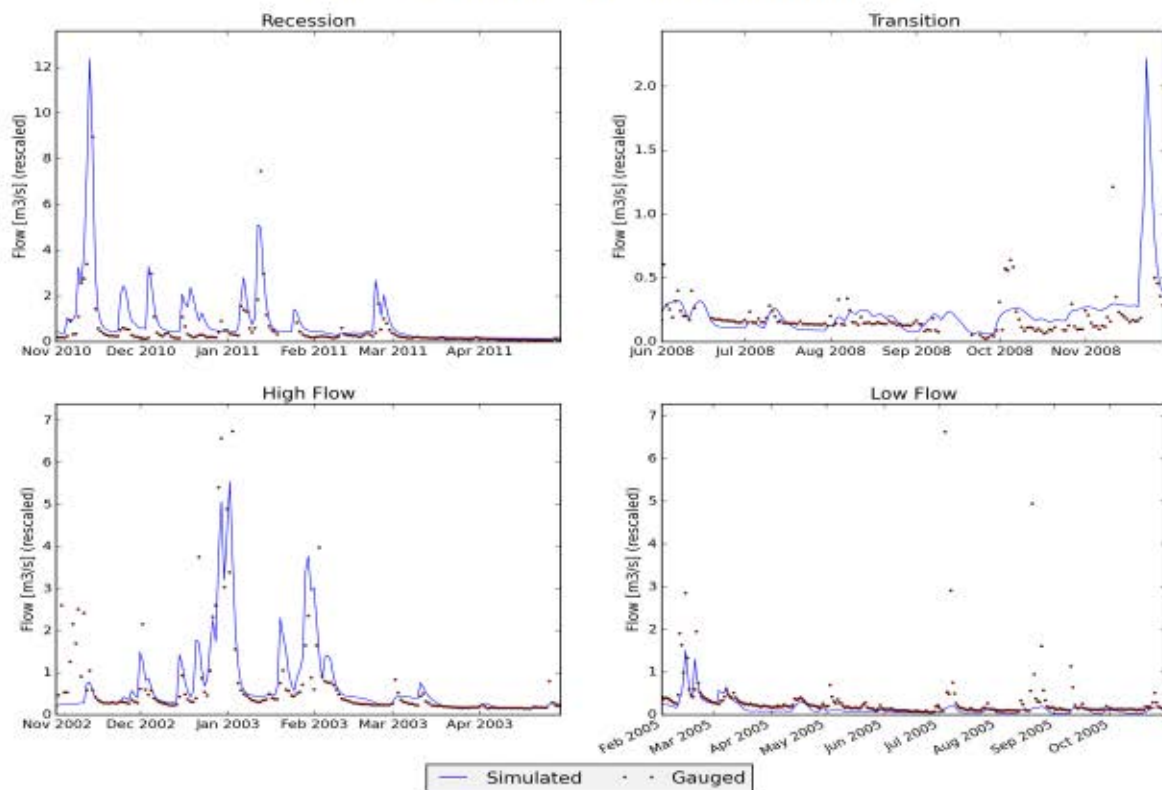


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06MAA347160, station 34710102 - Maarkebeek; Etikhove

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V06ZWA342190" (BOVENSCHELDE)

3.1 Input data

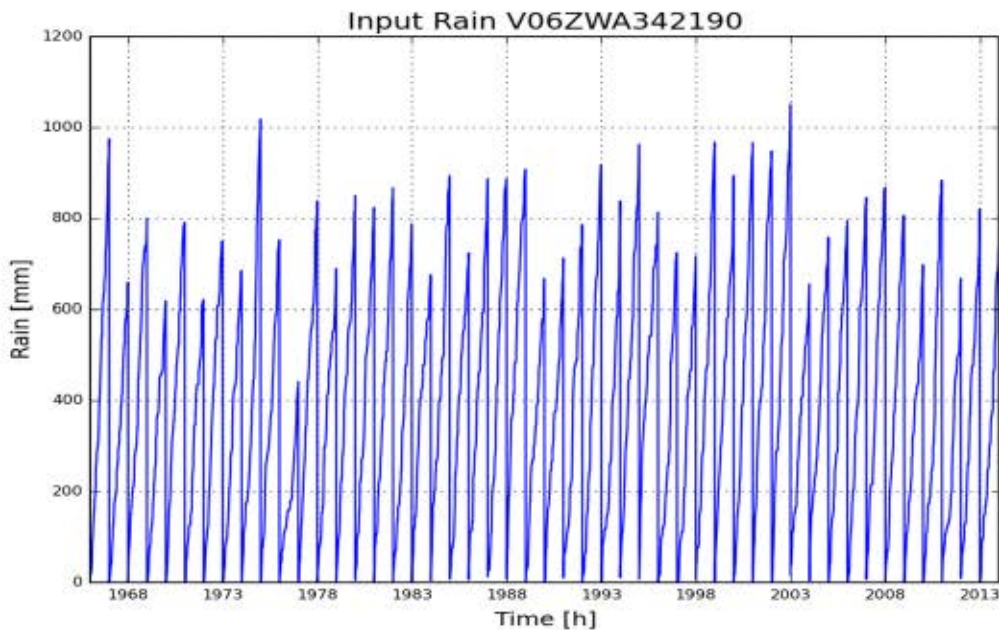


Figure 1: Cumulative precipitation on catchment V06ZWA342190 (Bovenshelde)

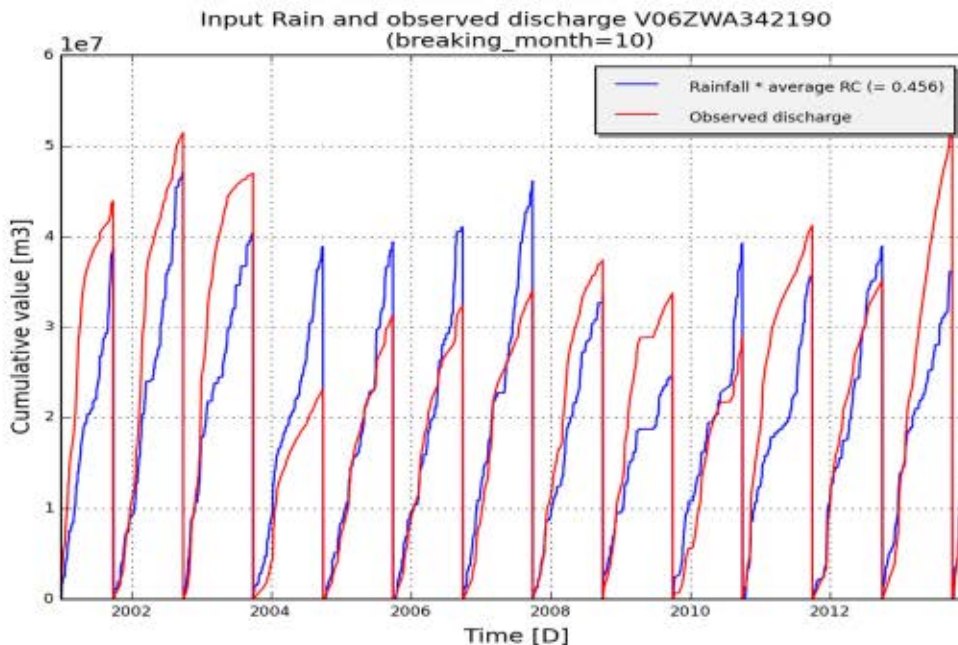


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V06ZWA342190 (Bovenshelde)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V06ZWA342190 |
| subcatchment_area [m2] | 112117540 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 2.33), (‘SMmax.C’, 95.71), (‘CQOF.C’, 0.51), (‘CKBF.C’, 1986.21), (‘CKIF.C’, 287.75), (‘CK1.C’, 29.44), (‘CK2.C’, 23.14), (‘TIF.C’, 0.7), (‘TOF.C’, 0.21), (‘NAM.TG.C’, 0.03)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 4670355.414 | 36313450.897 |
| RelErr | -1.1 % | 4.7 % |
| RMSE | 5766917.749 | 40255322.276 |
| NS | 0.63 | 0.591 |
| NS_log | 0.62 | 0.538 |
| NS_rel | 0.661 | -24.954 |

3.3 Observed and simulated timeseries for optimum parameters

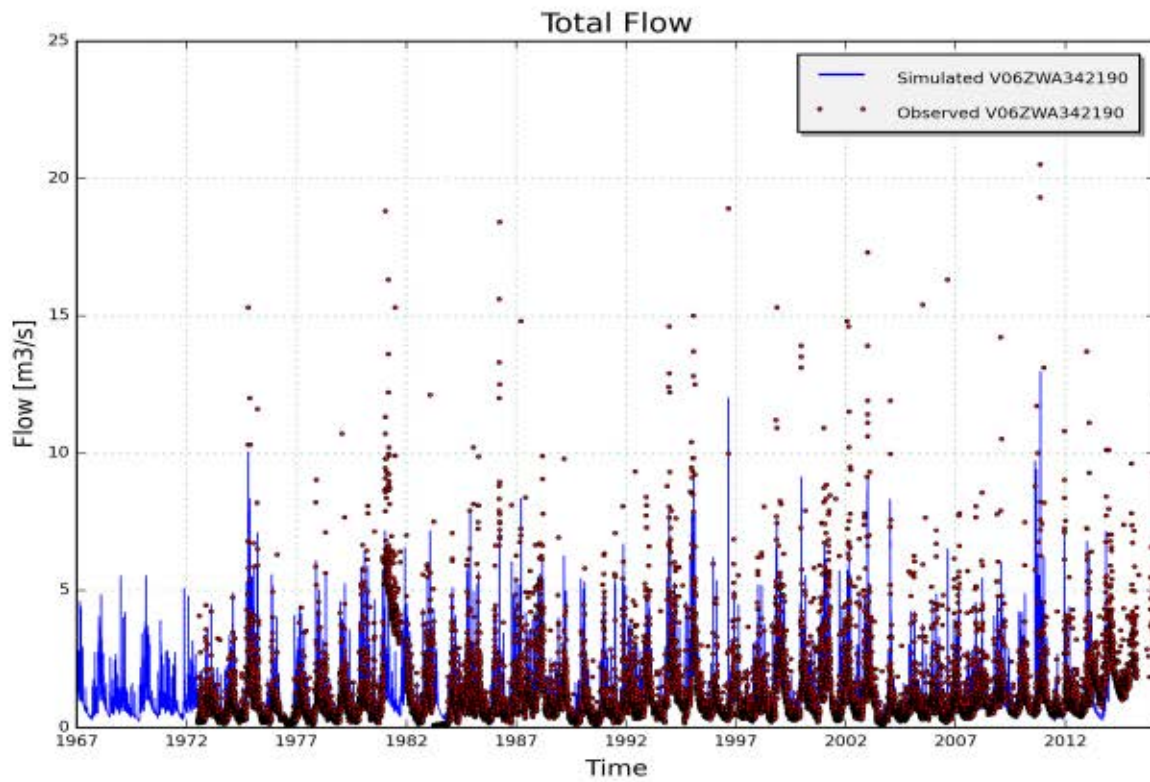


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (validation period 1967-2013)

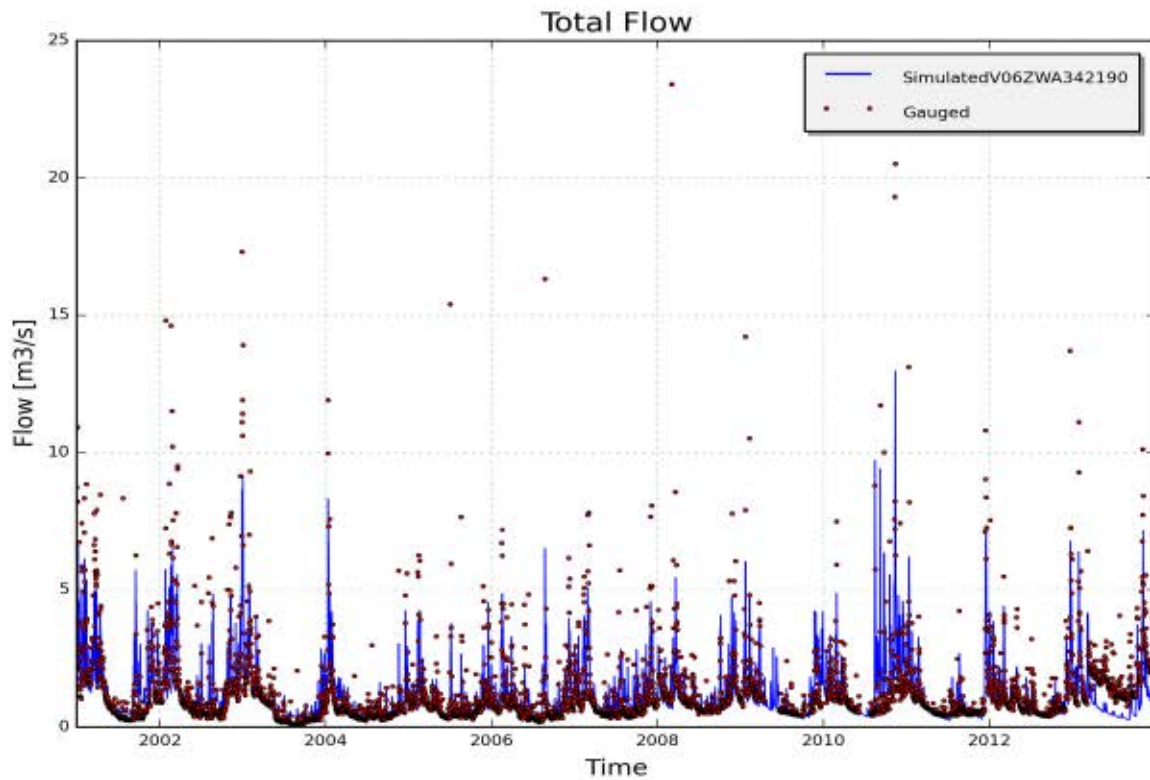


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)

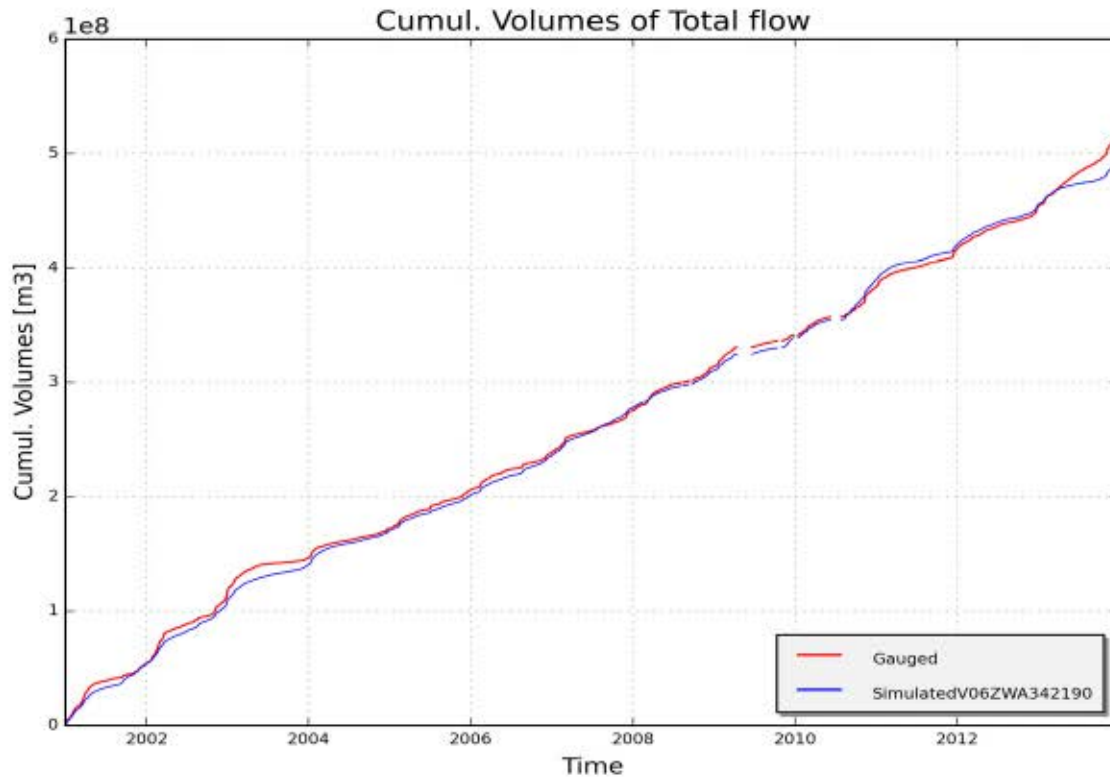


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm (calibration period)

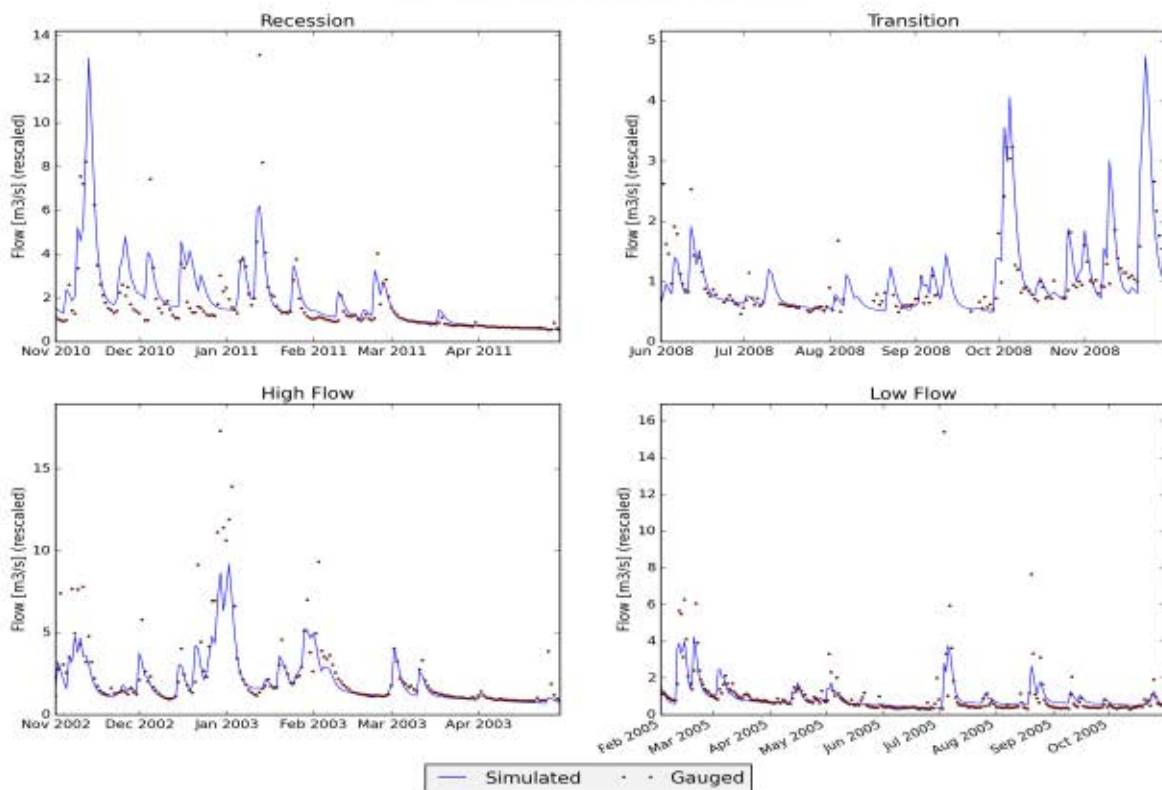


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V06ZWA342190, station 34210102 - Zwalm; Nederzwalm

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "F06BOS325999" (BOVENSCHELDE)

4.1 Input data

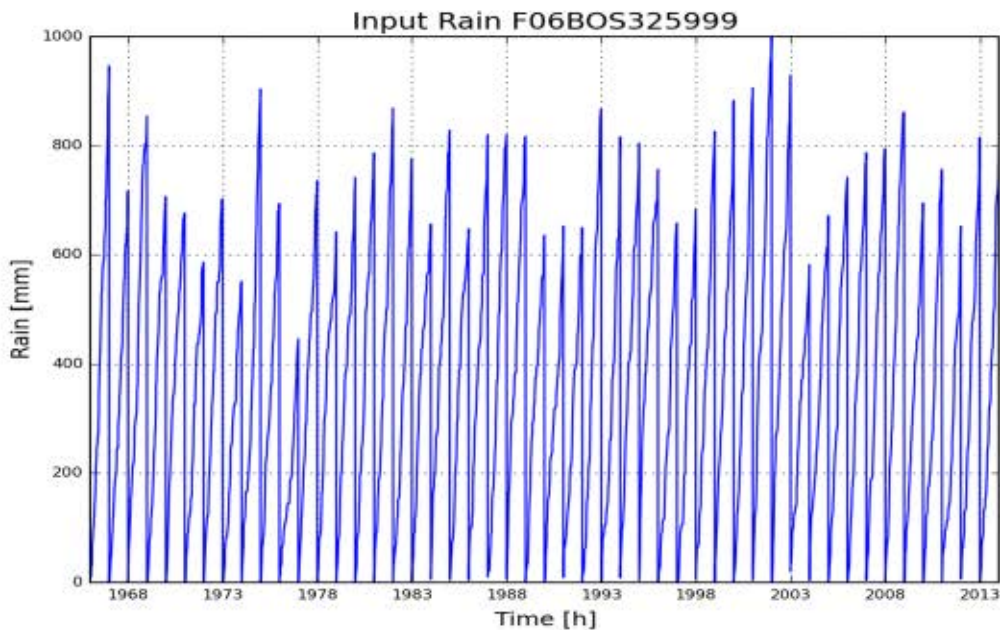


Figure 1: Cumulative precipitation on catchment F06BOS325999 (Bovenshelde)

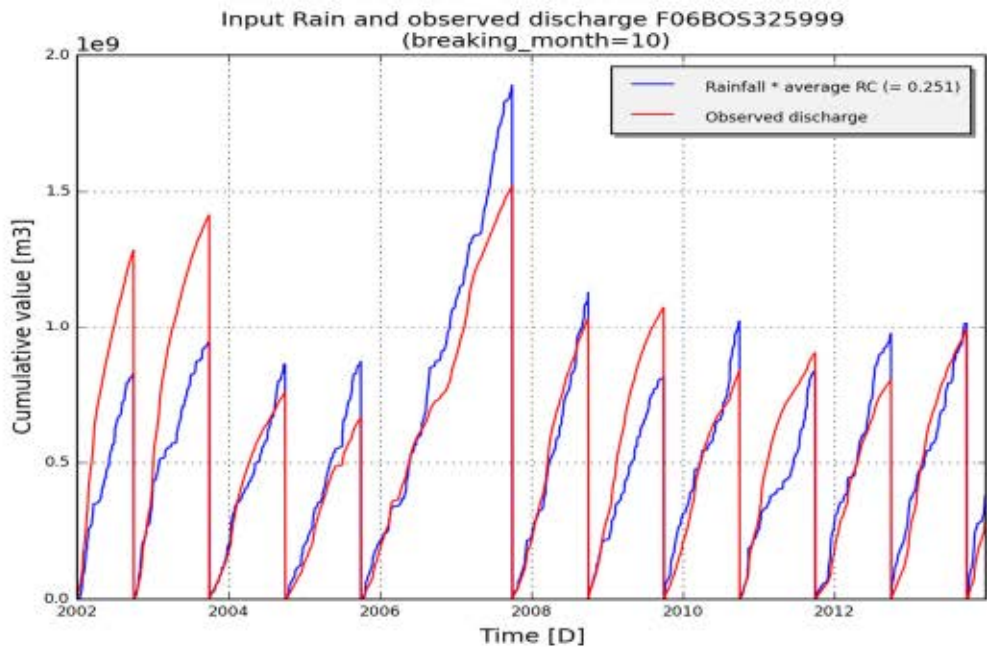


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment F06BOS325999 (Bovenshelde)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | F06BOS325999 |
| subcatchment_area [m2] | 5217586196 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 5.83), (‘SMmax.C’, 466.26), (‘CQOF.C’, 0.2), (‘CKBF.C’, 1858.1), (‘CKIF.C’, 434.89), (‘CK1.C’, 39.8), (‘CK2.C’, 27.31), (‘TIF.C’, 0.7), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 390321953.048 | 379112601.72 |
| RelErr | -2.9 % | -2.6 % |
| RMSE | 434390348.204 | 426808439.572 |
| NS | 0.675 | 0.68 |
| NS_log | 0.617 | 0.628 |
| NS_rel | 0.663 | 0.665 |

4.3 Observed and simulated timeseries for optimum parameters

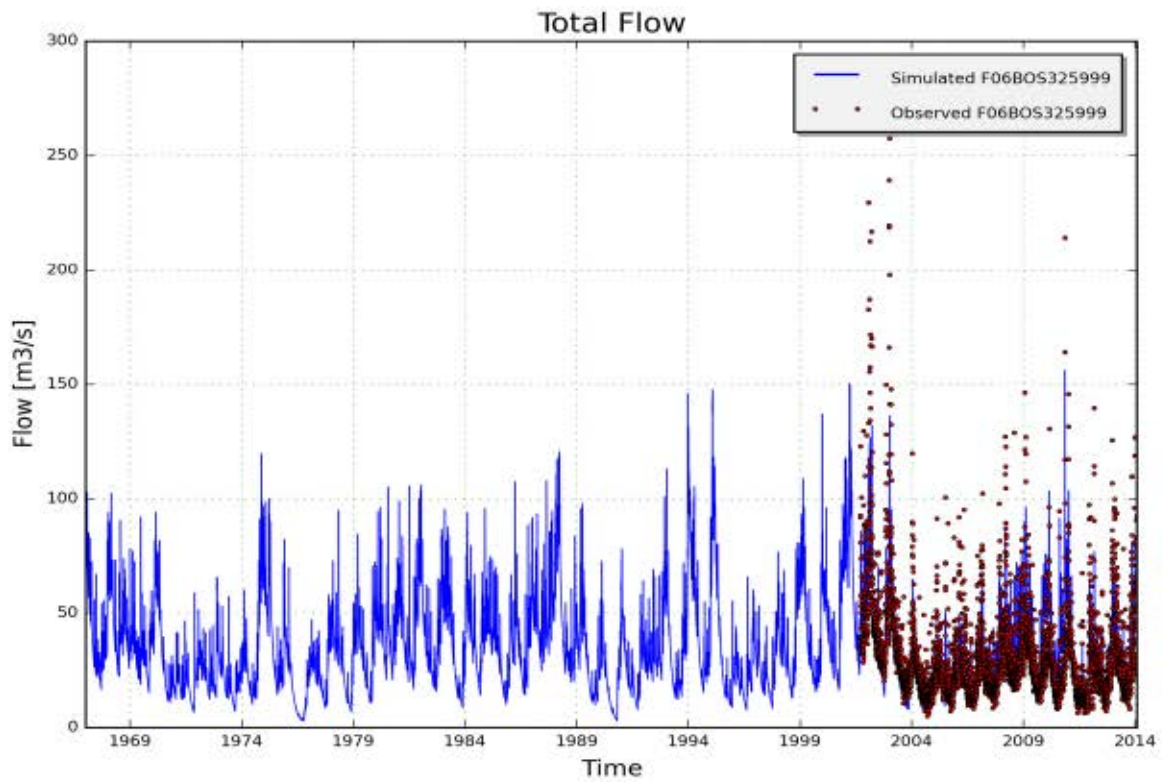


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F06BOS325999, station unknown (validation period 1967-2013)

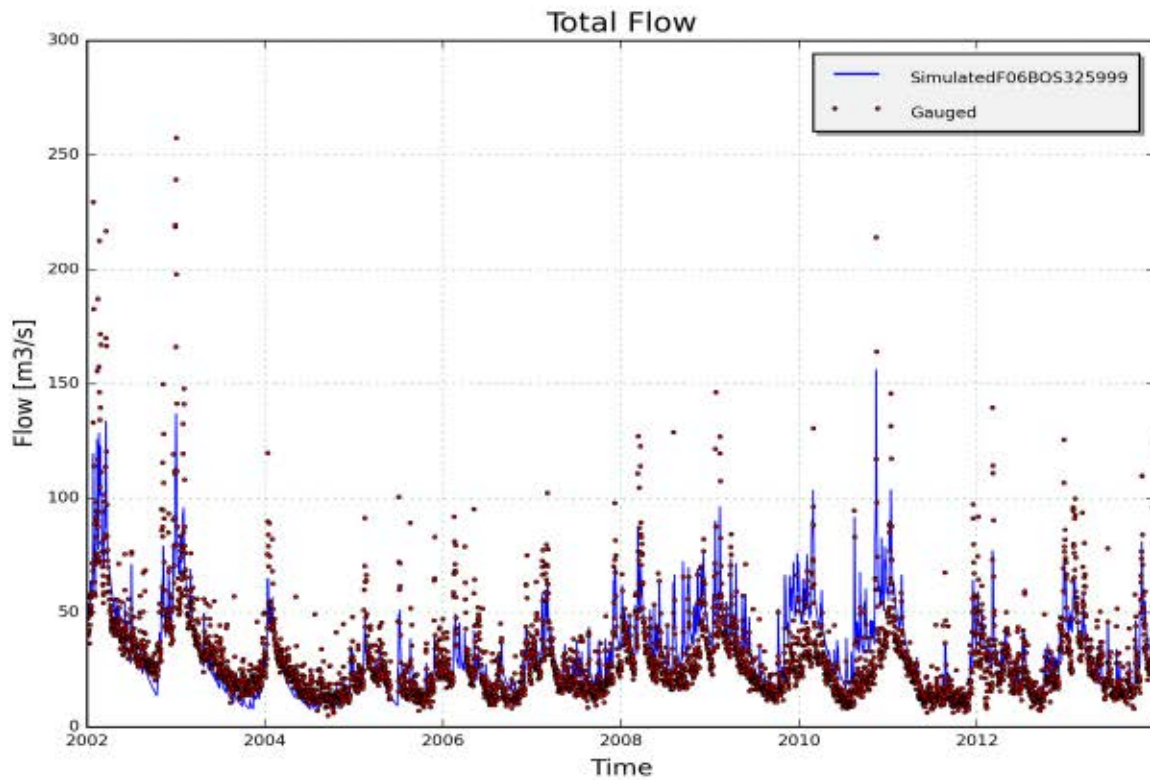


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment F06BOS325999, station unknown (calibration period)

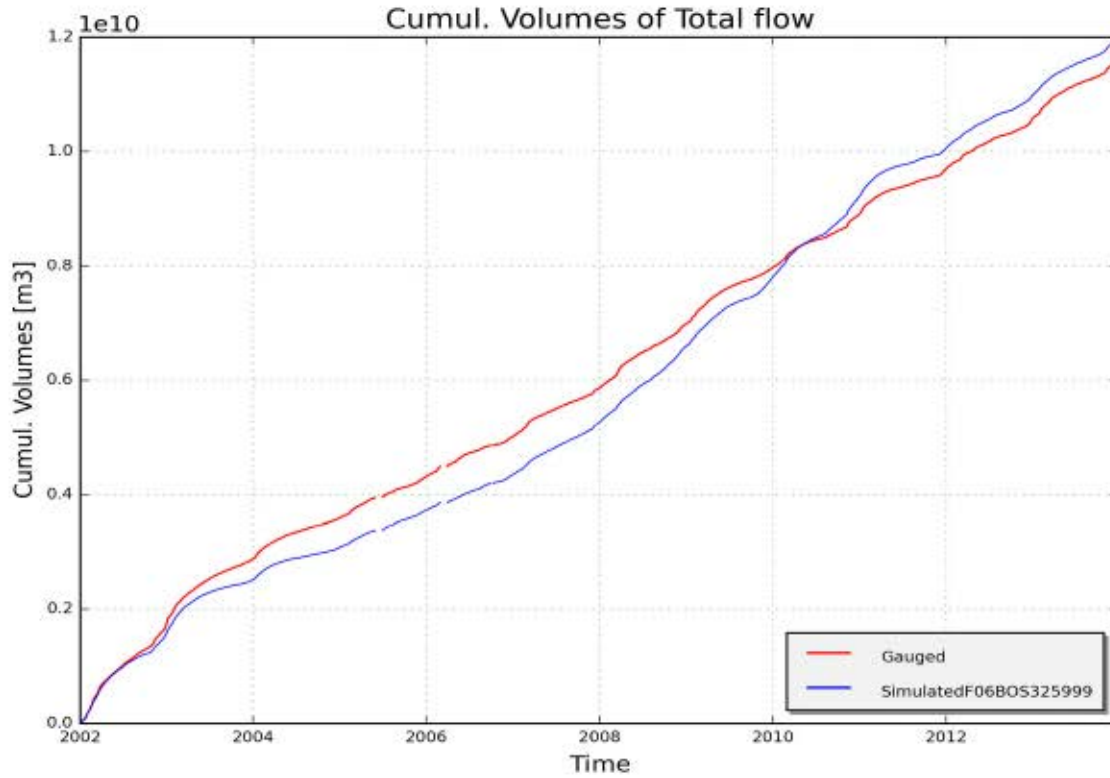


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment F06BOS325999, station unknown (calibration period)

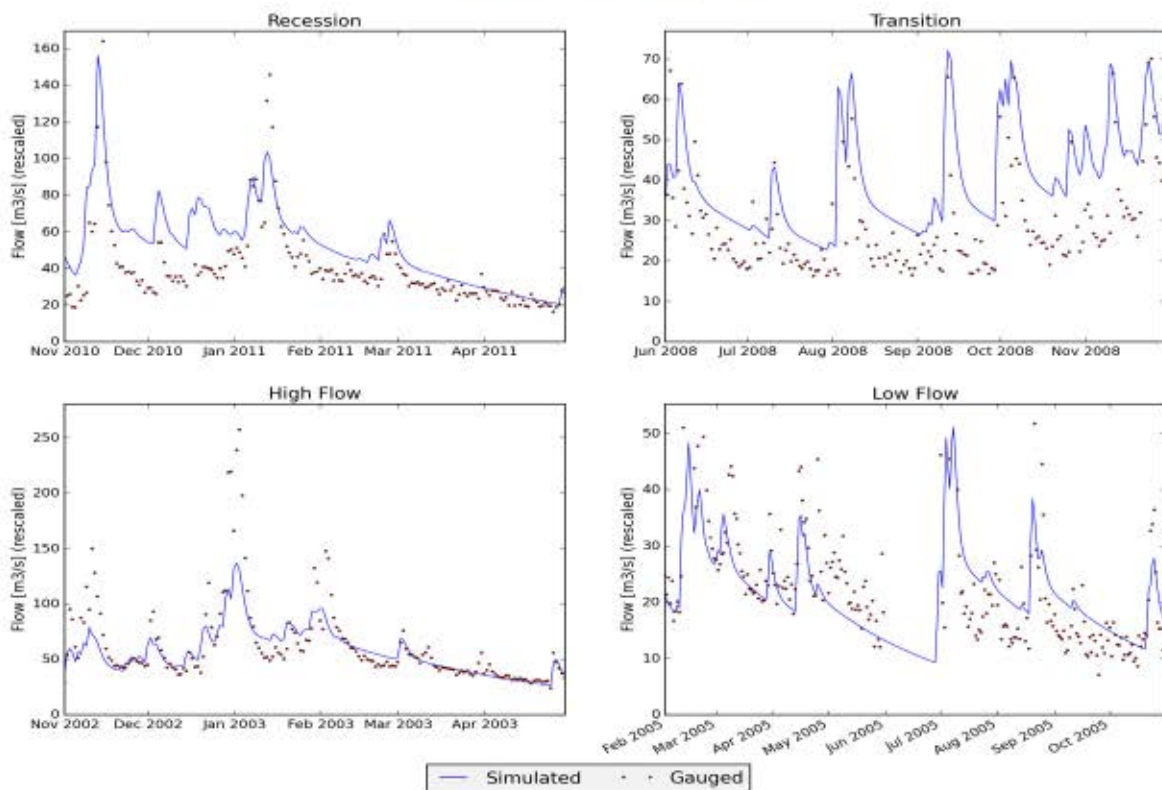


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment F06BOS325999, station unknown

Appendix 9

Results of calibration and validation of NAM parameters for catchment "V07MAR289015" (DENDERBEKKEN)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V07MAR289015" (DENDERBEKKEN)

1.1 Input data

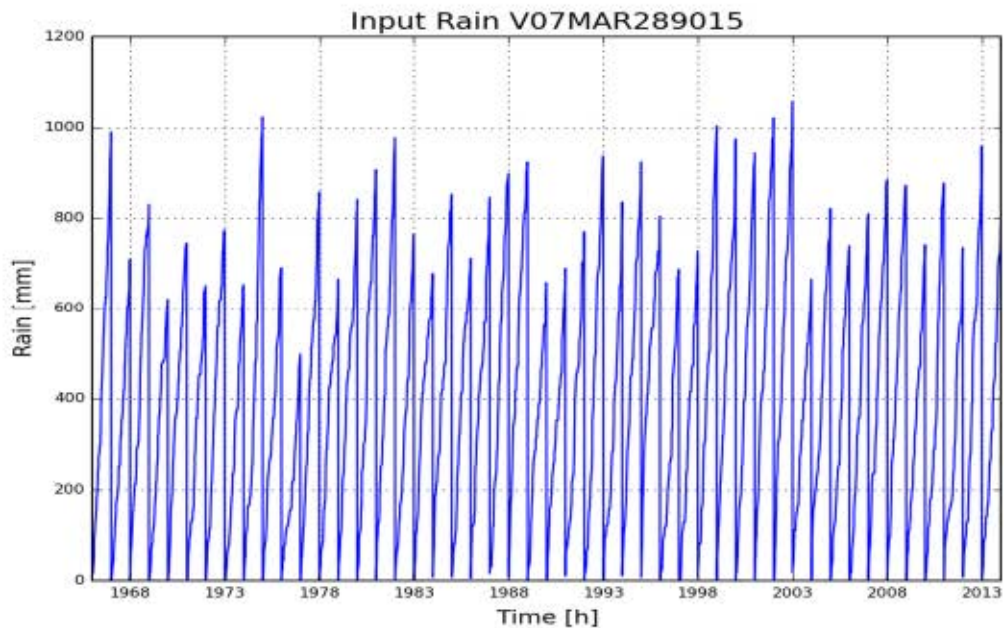


Figure 1: Cumulative precipitation on catchment V07MAR289015 (Denderbekken)

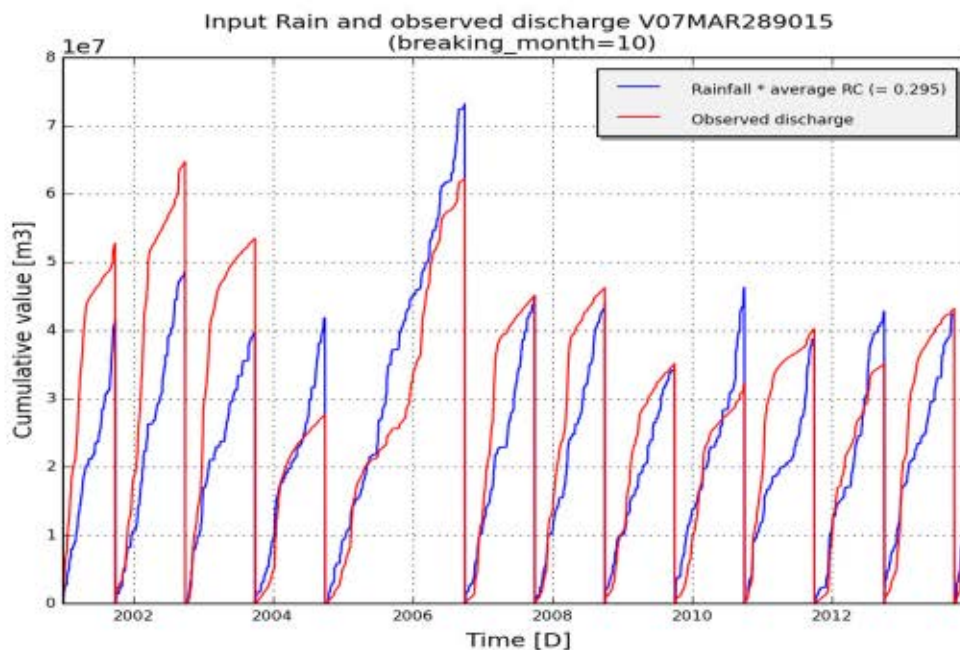


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V07MAR289015 (Denderbekken)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V07MAR289015 |
| subcatchment_area [m2] | 173908791 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 12.8), ('SMmax.C', 458.54), ('CQOF.C', 0.8), ('CKBF.C', 1506.59), ('CKIF.C', 424.26), ('CK1.C', 25.7), ('CK2.C', 29.54), ('TIF.C', 0.7), ('TOF.C', 0.41), ('NAM.TG.C', 0.31)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 11038413.187 | 41768395.854 |
| RelErr | -0.3 % | 5.5 % |
| RMSE | 13948068.316 | 48935195.71 |
| NS | 0.752 | 0.775 |
| NS_log | 0.62 | 0.585 |
| NS_rel | 0.111 | -11.33 |

1.3 Observed and simulated timeseries for optimum parameters

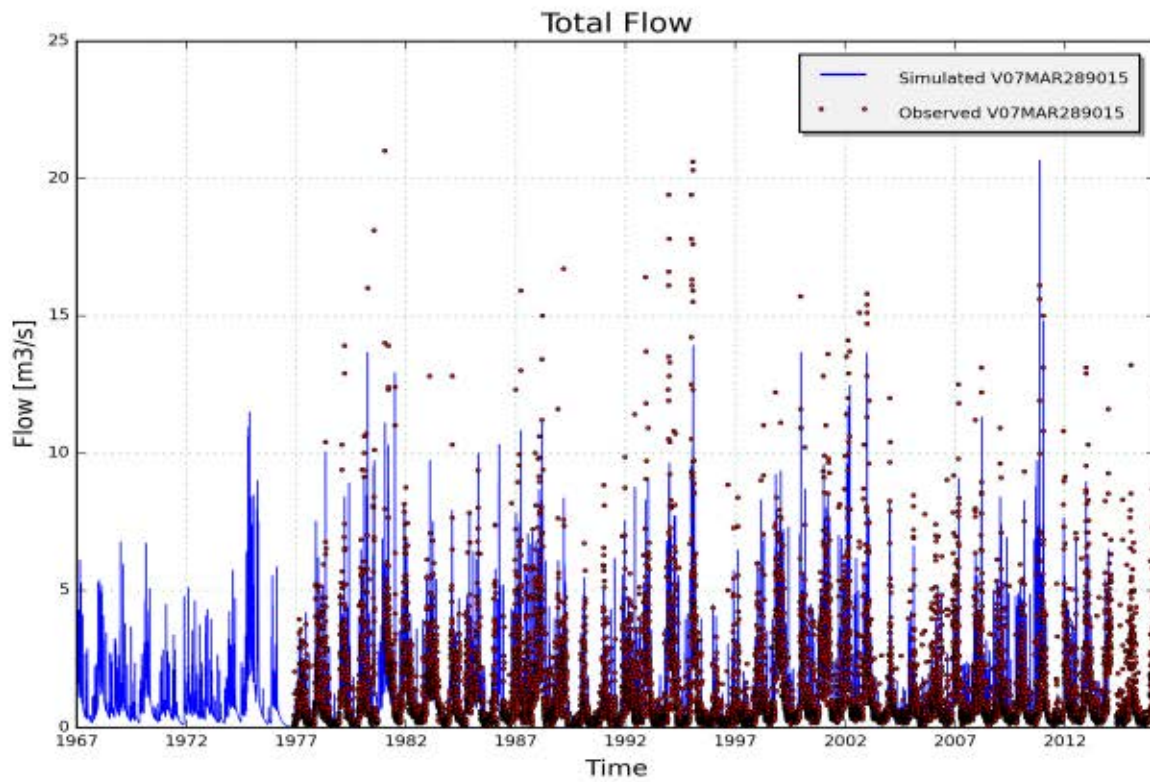


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MAR289015, station 28970102 - Marke, Viane (validation period 1967-2013)

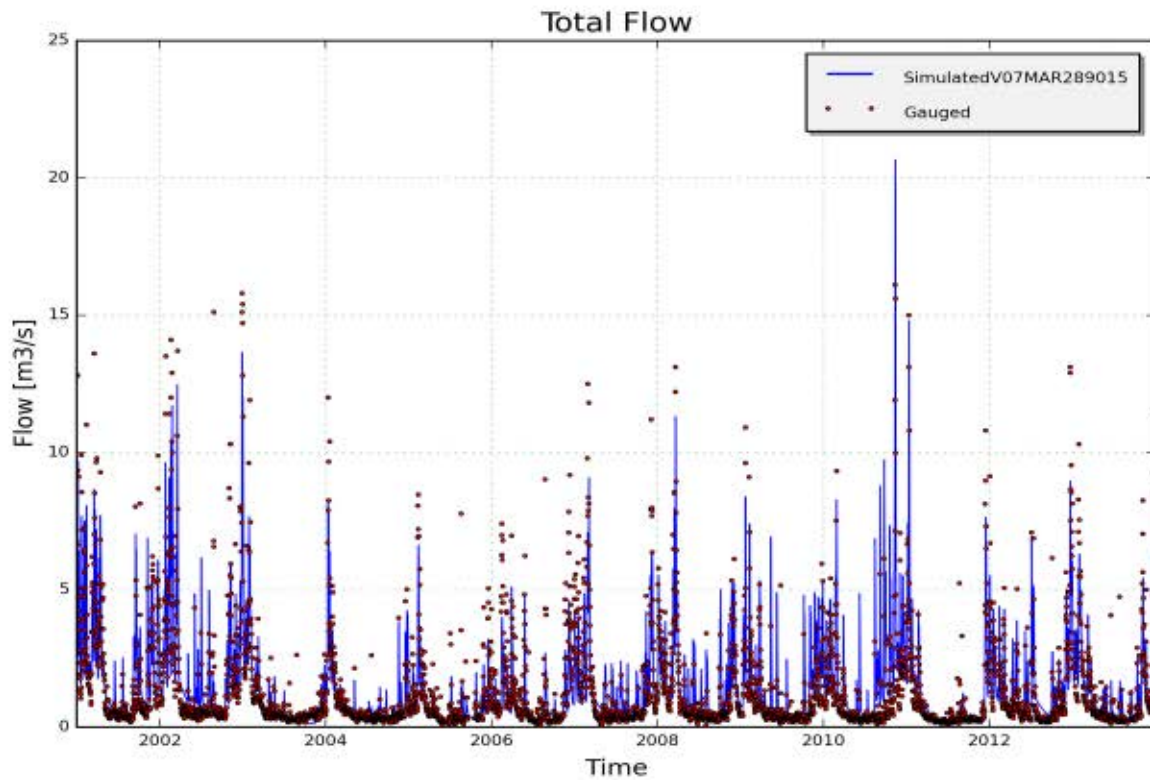


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MAR289015, station 28970102 - Marke, Viane (calibration period)

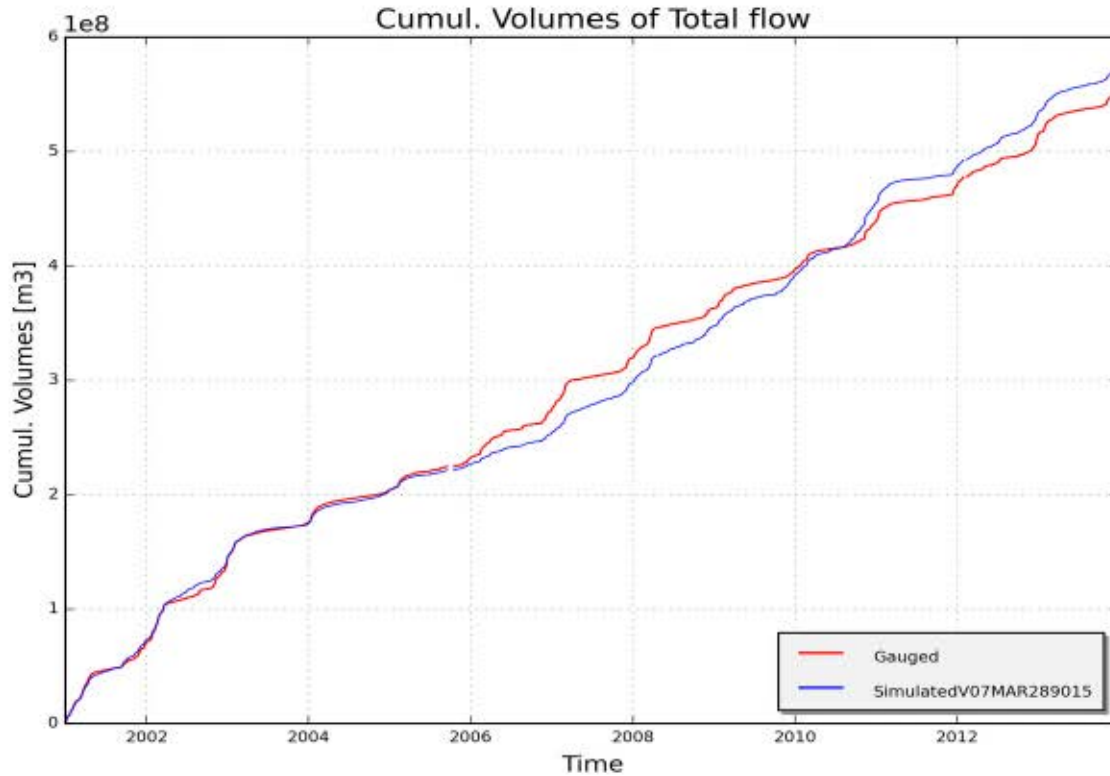


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MAR289015, station 28970102 - Marke, Viane (calibration period)

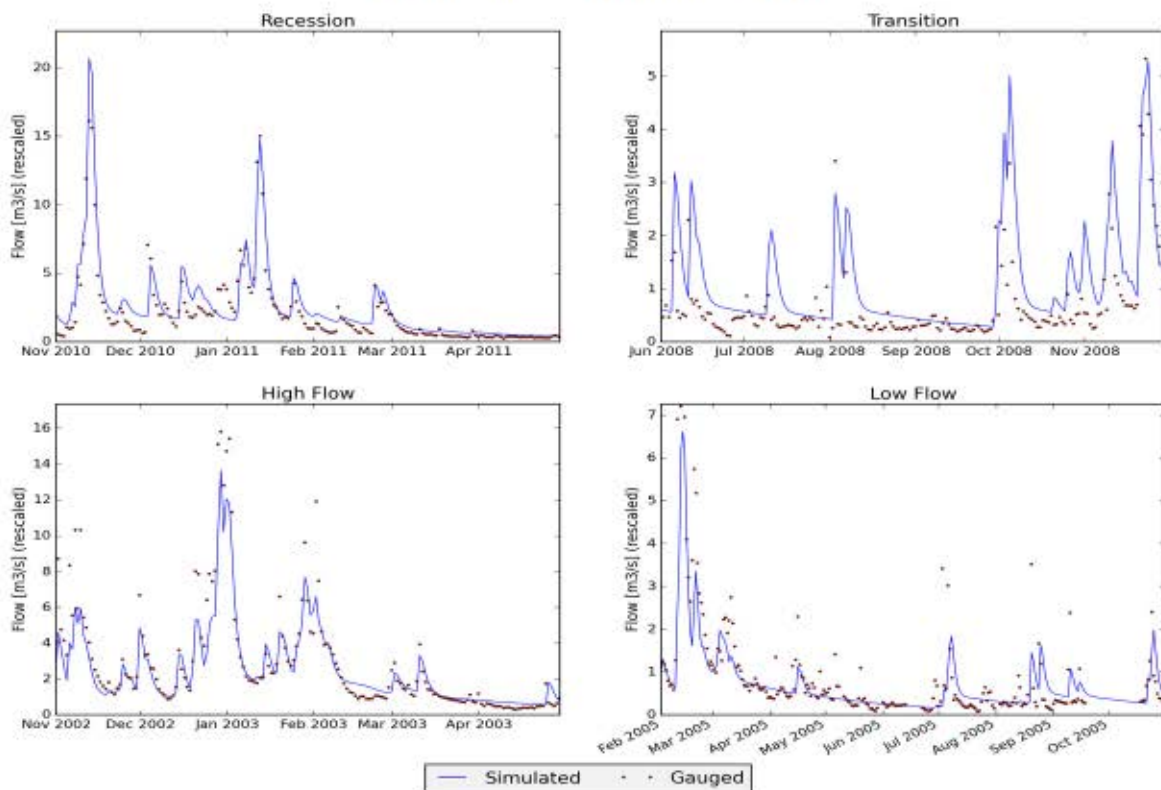


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MAR289015, station 28970102 - Marke, Viane

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V07MOE282100" (DENDERBEKKEN)

2.1 Input data

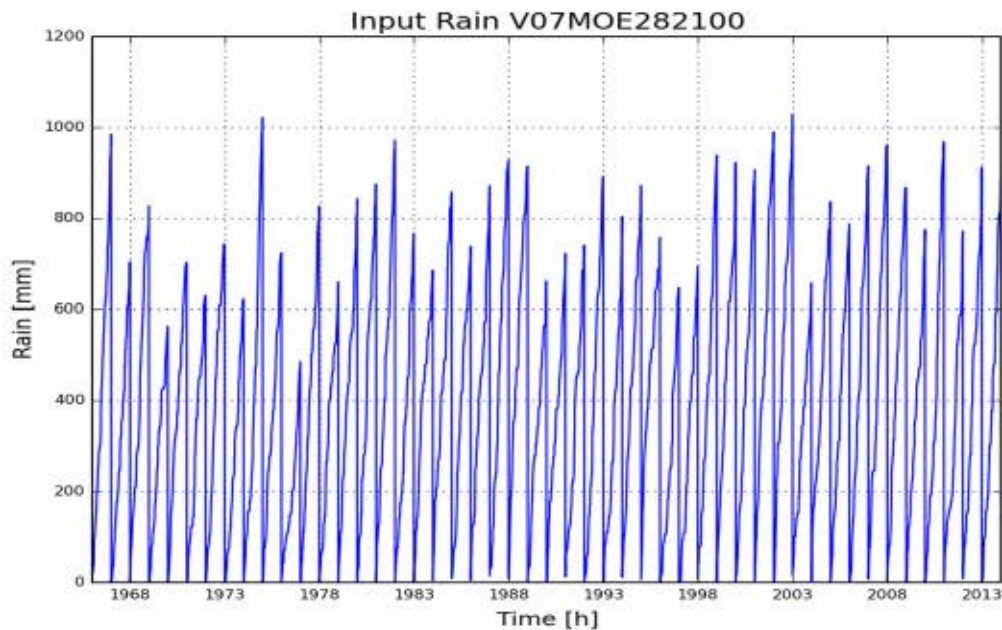


Figure 1: Cumulative precipitation on catchment V07MOE282100 (Denderbekken)

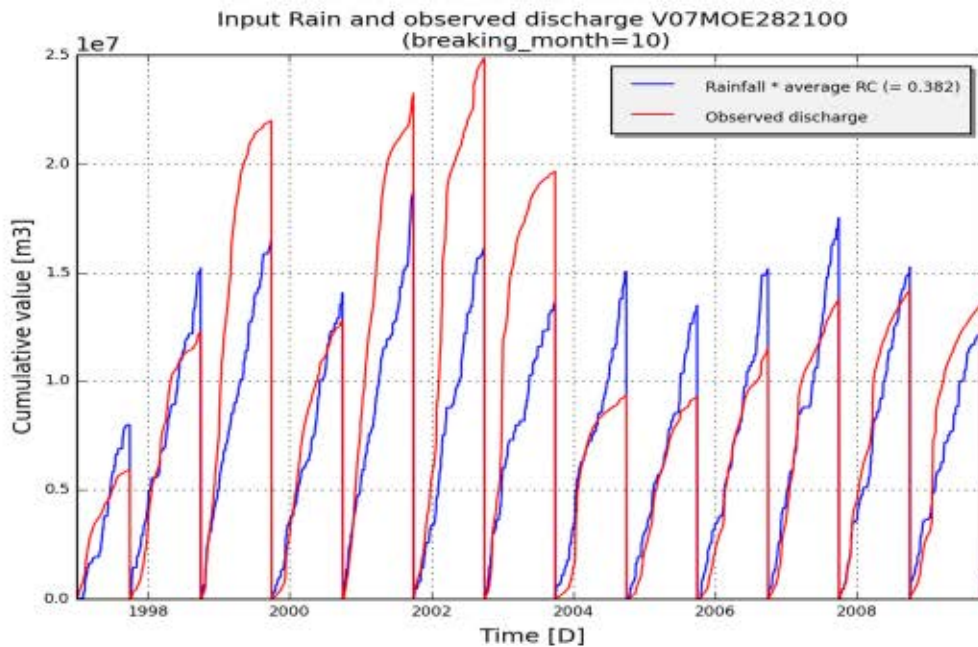


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V07MOE282100 (Denderbekken)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V07MOE282100 |
| subcatchment_area [m2] | 46367171 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 4.89), (‘SMmax.C’, 77.01), (‘CQOF.C’, 0.52), (‘CKBF.C’, 1833.47), (‘CKIF.C’, 245.36), (‘CK1.C’, 28.46), (‘CK2.C’, 30.49), (‘TIF.C’, 0.45), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.31)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3993807.81 | 10788669.004 |
| RelErr | -2.5 % | 5.8 % |
| RMSE | 5134549.393 | 11638065.484 |
| NS | 0.532 | 0.584 |
| NS_log | 0.737 | 0.667 |
| NS_rel | 0.735 | 0.706 |

2.3 Observed and simulated timeseries for optimum parameters

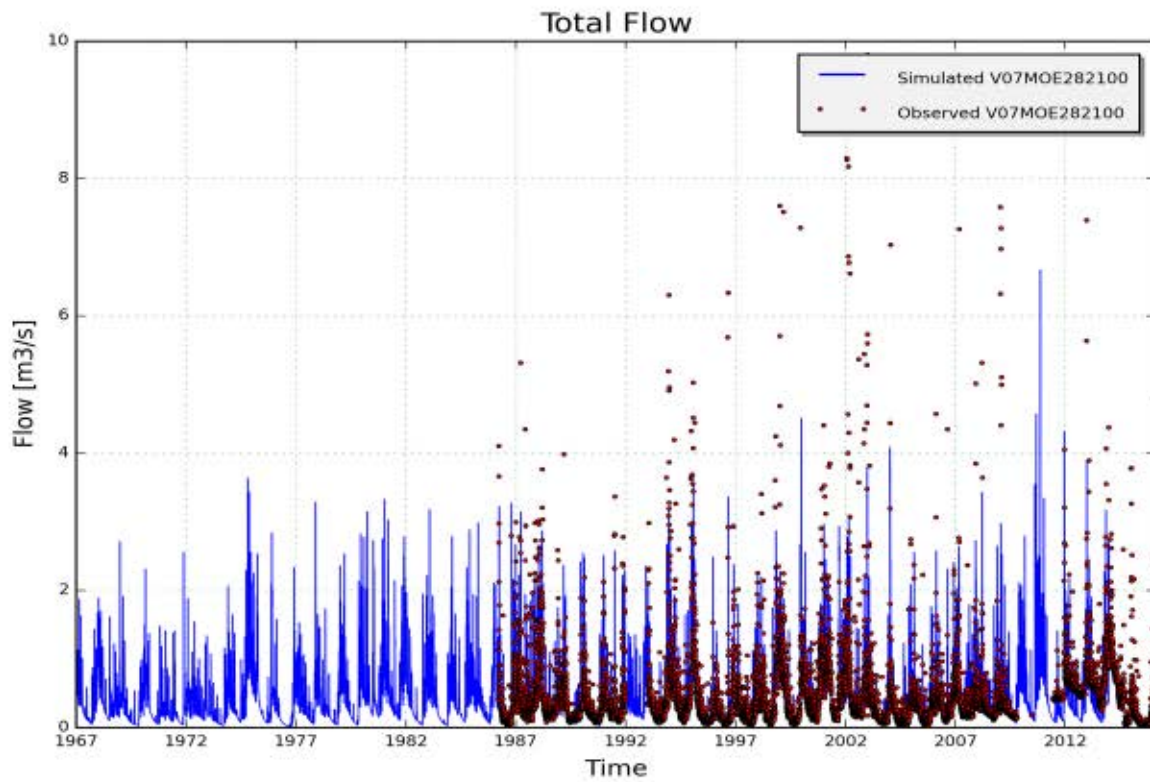


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (validation period 1967-2013)

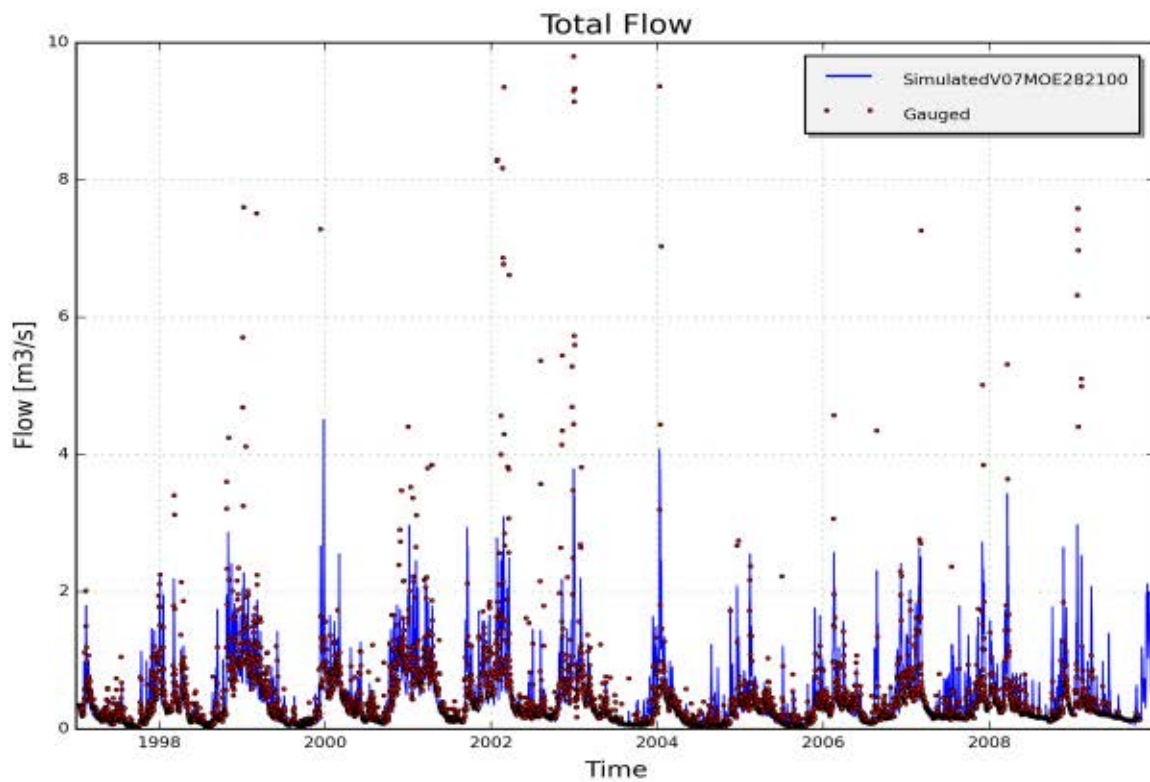


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (calibration period)

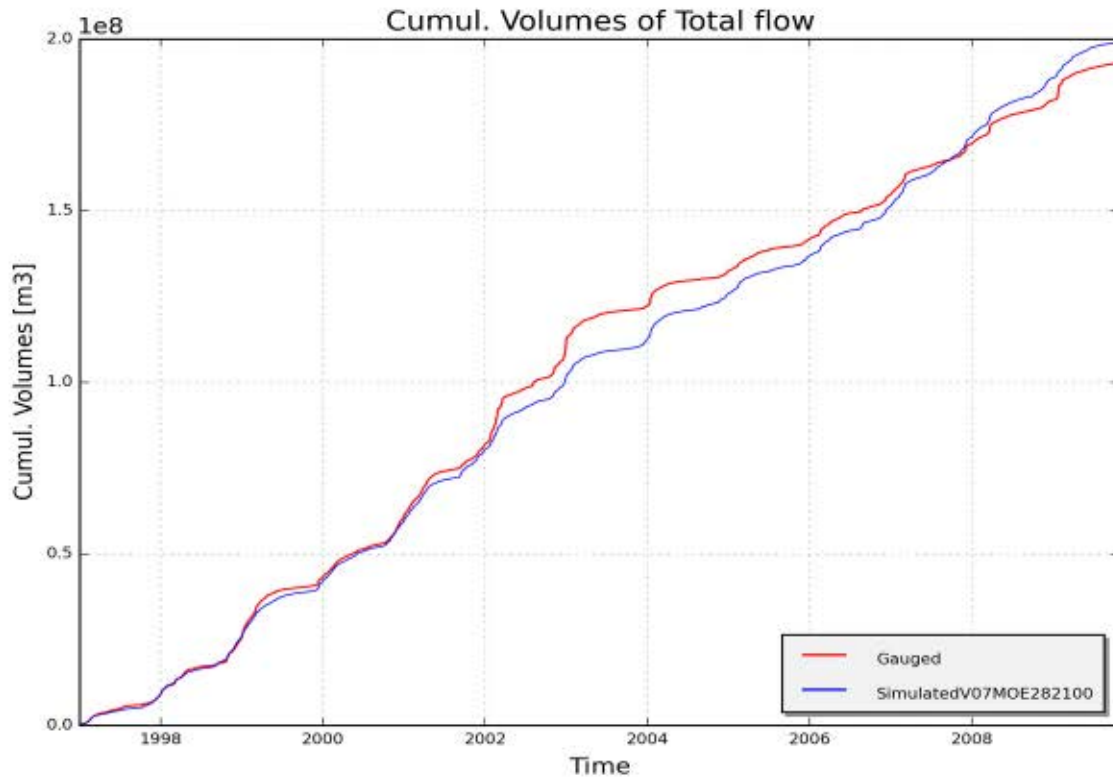


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere (calibration period)

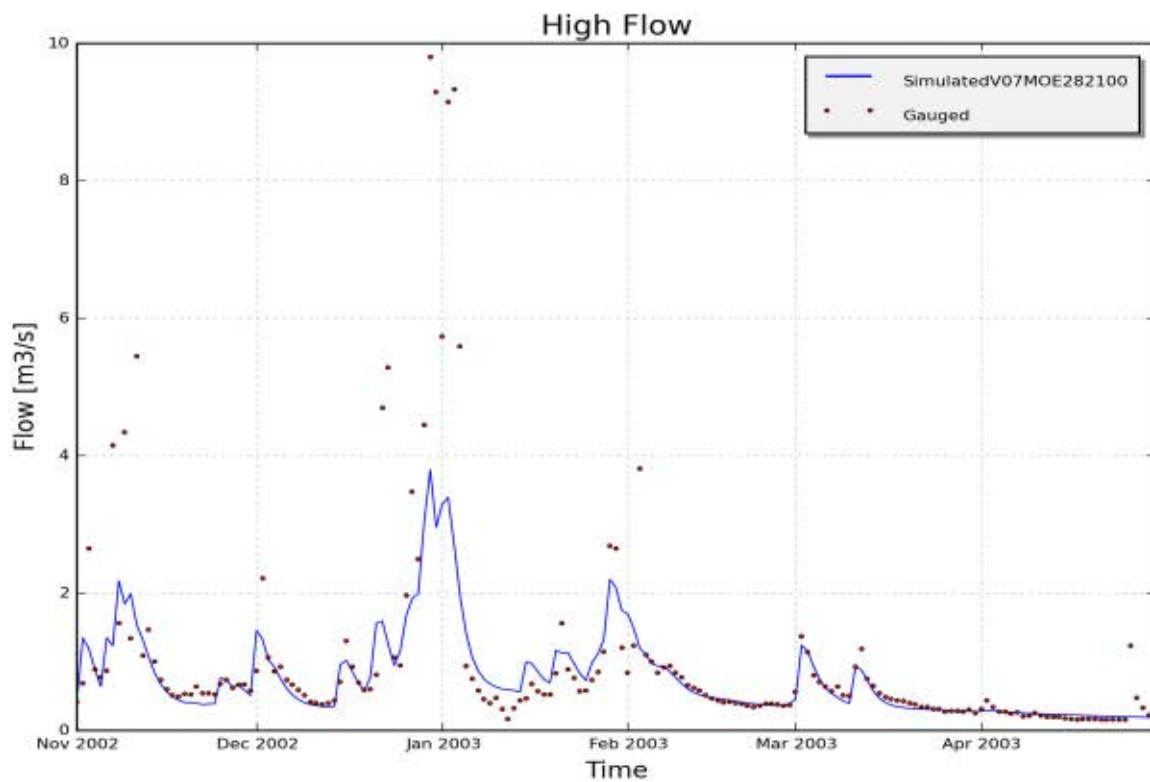


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

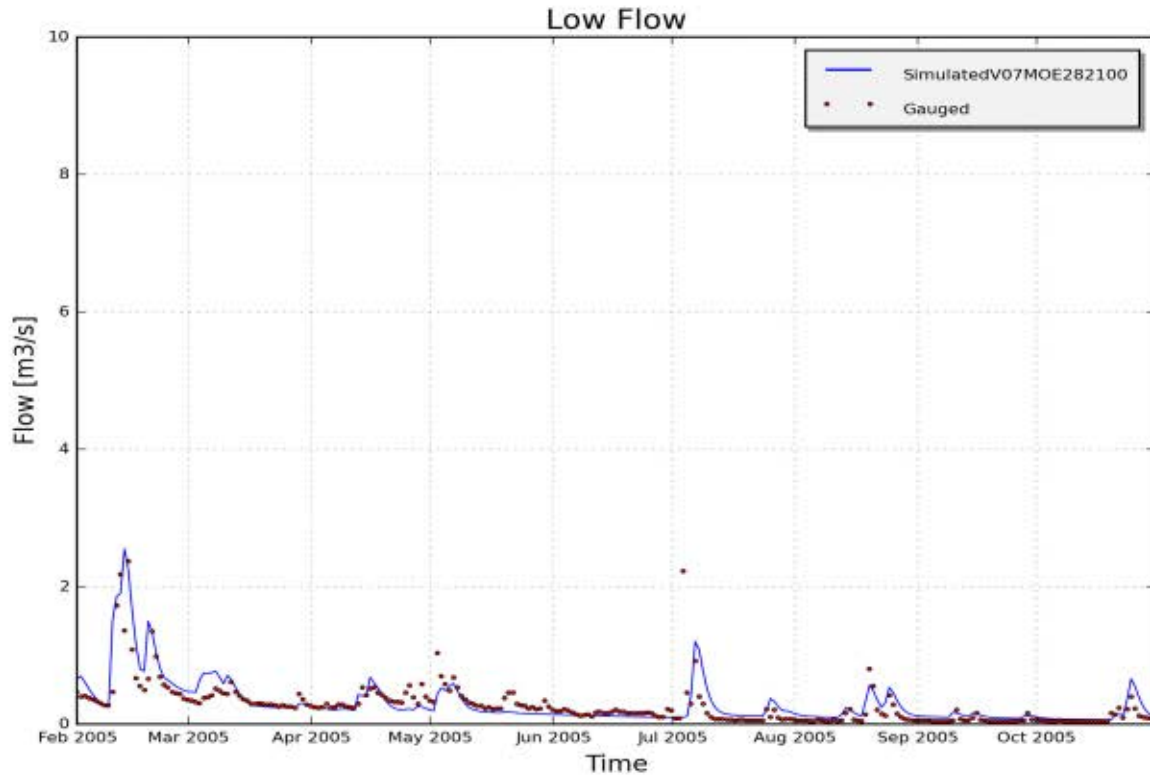


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

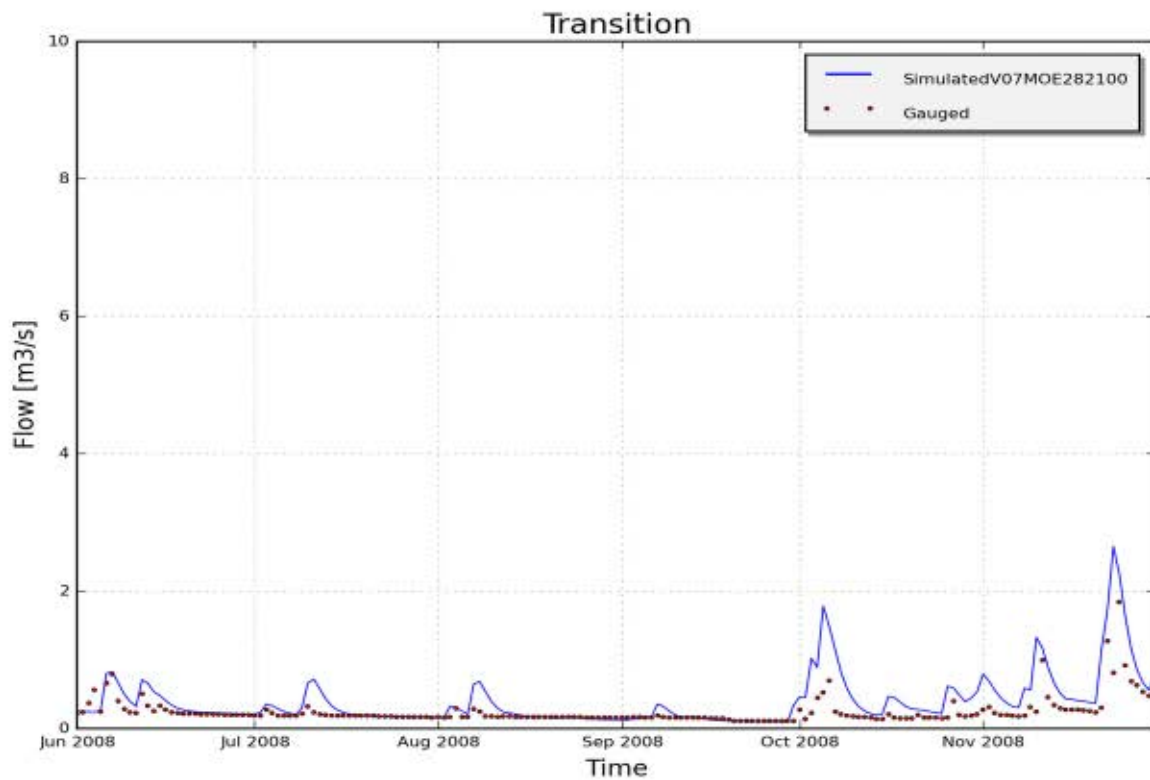


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOE282100, station 28210102 - Molenbeek, Erpe Mere

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V07MOG288020" (DENDERBEKKEN)

3.1 Input data

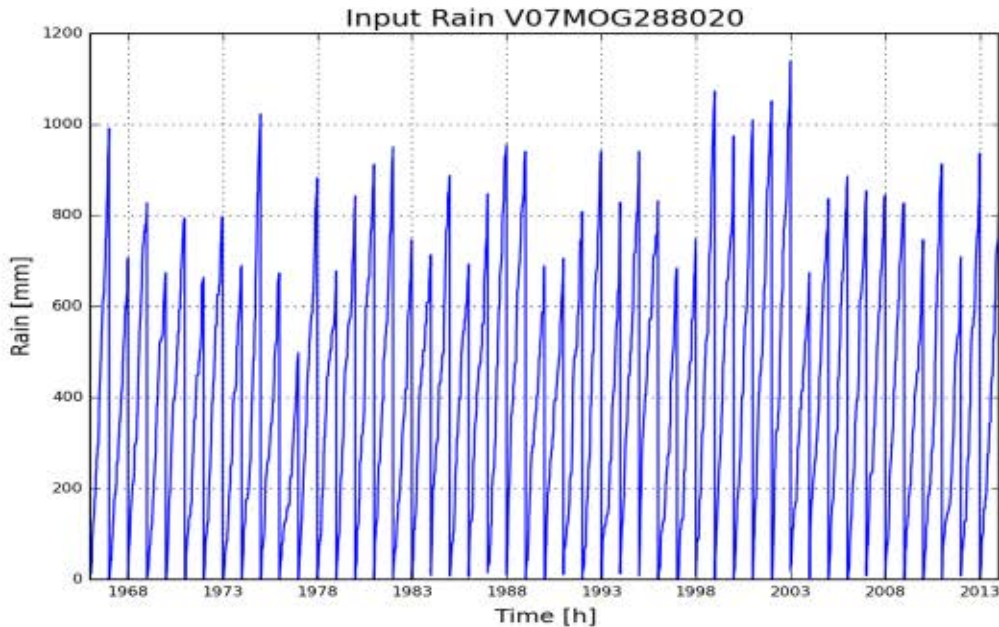


Figure 1: Cumulative precipitation on catchment V07MOG288020 (Denderbekken)

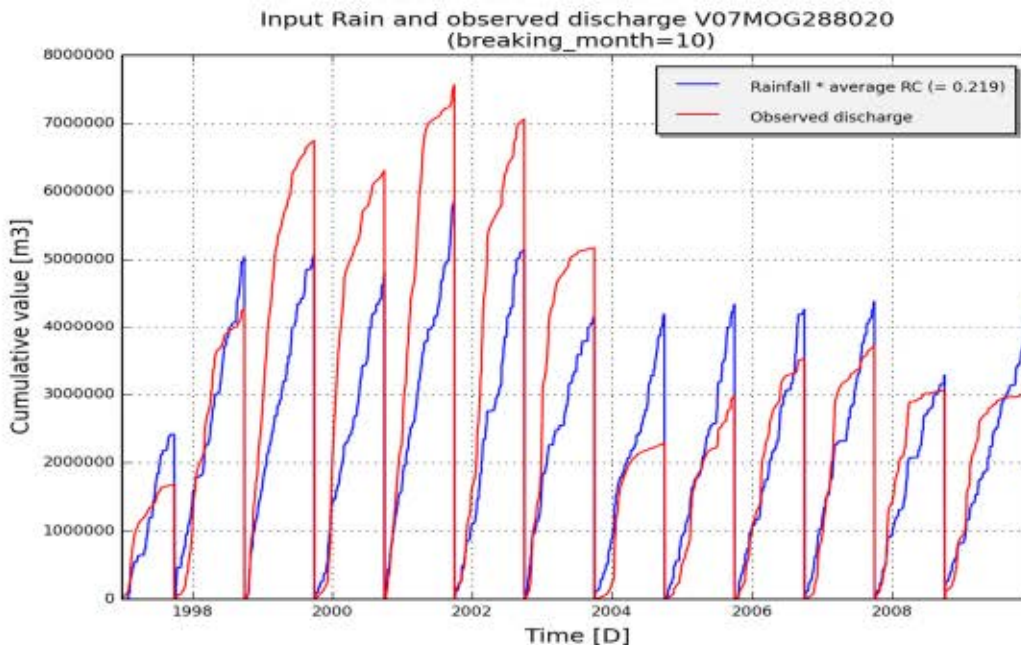


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V07MOG288020 (Denderbekken)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V07MOG288020 |
| subcatchment_area [m2] | 23093628 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 24.9), (‘SMmax.C’, 700.0), (‘CQOF.C’, 0.56), (‘CKBF.C’, 2440.0), (‘CKIF.C’, 1900.0), (‘CK1.C’, 30.0), (‘CK2.C’, 30.0), (‘TIF.C’, 0.59), (‘TOF.C’, 0.64), (‘NAM.TG.C’, 0.8)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 1142288.158 | 4478024.373 |
| RelErr | 0.6 % | -6.4 % |
| RMSE | 1359504.146 | 5202754.77 |
| NS | 0.643 | 0.617 |
| NS_log | 0.569 | 0.484 |
| NS_rel | -0.444 | -0.76 |

3.3 Observed and simulated timeseries for optimum parameters

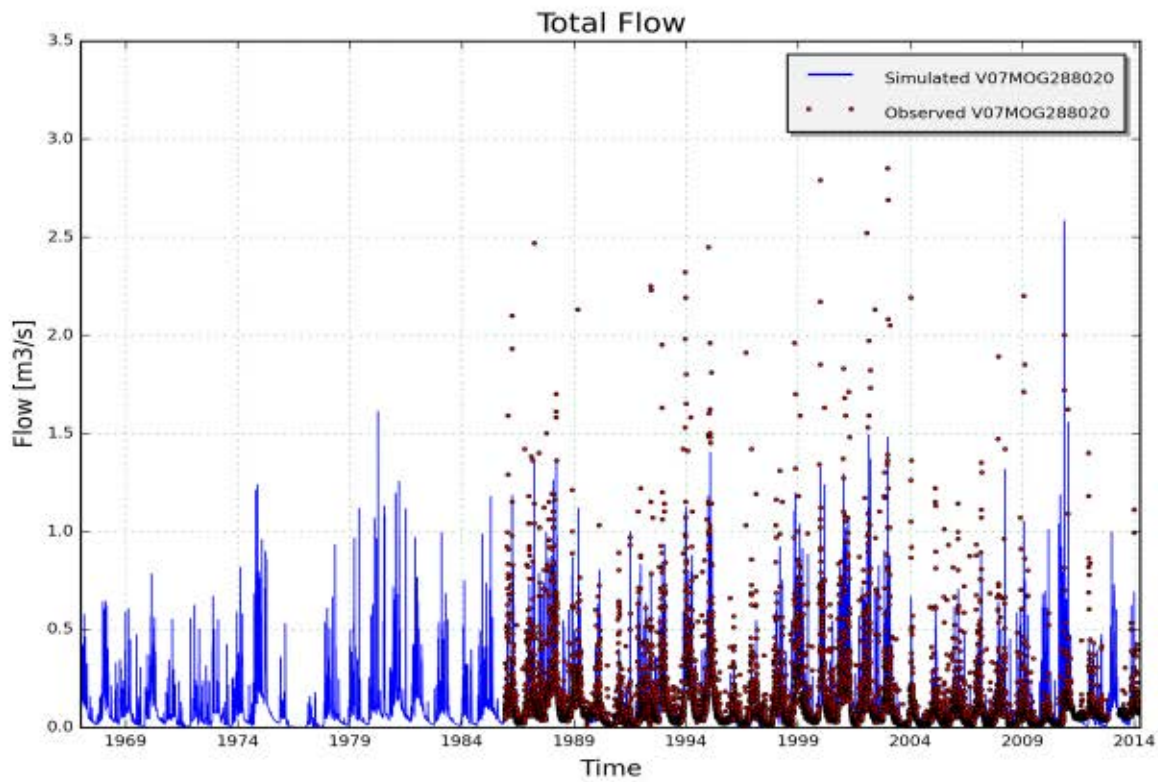


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (validation period 1967-2013)

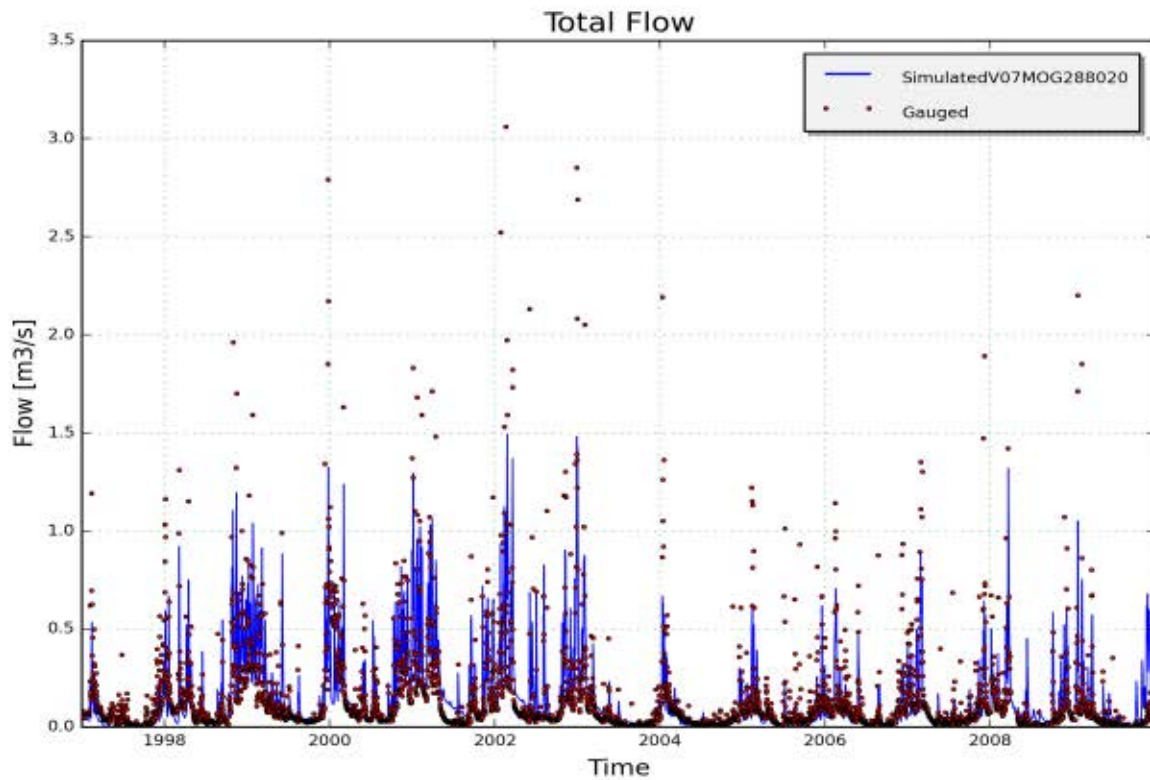


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (calibration period)

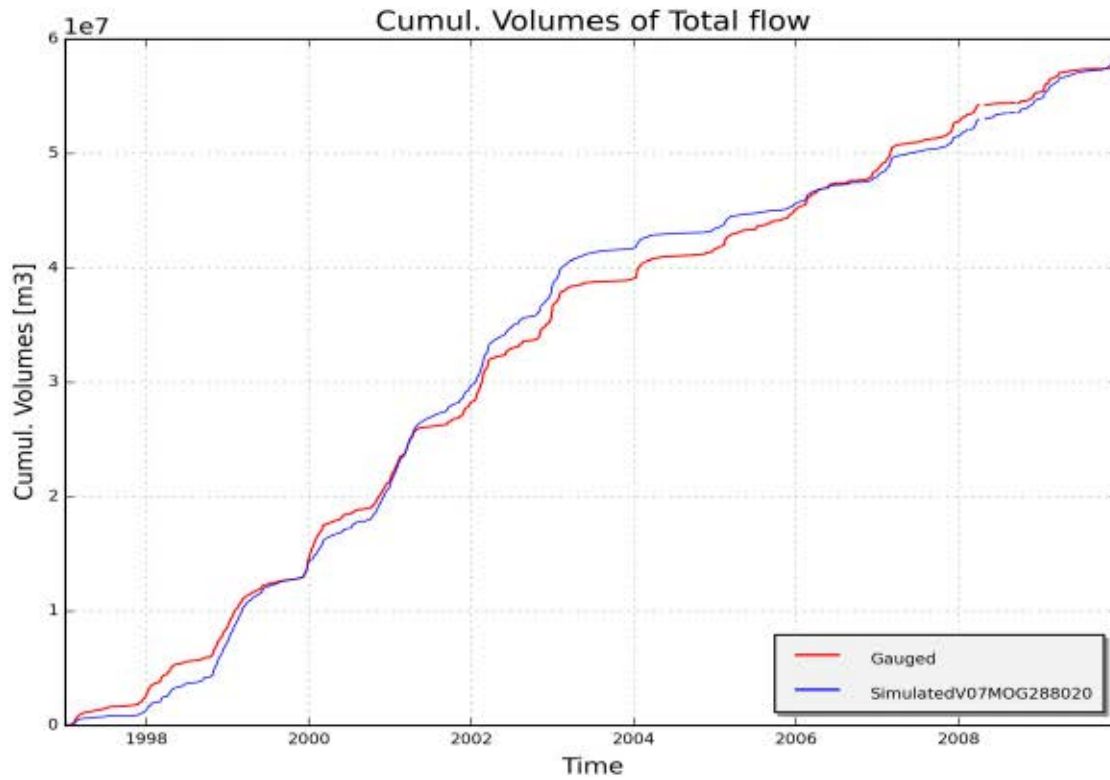


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen (calibration period)

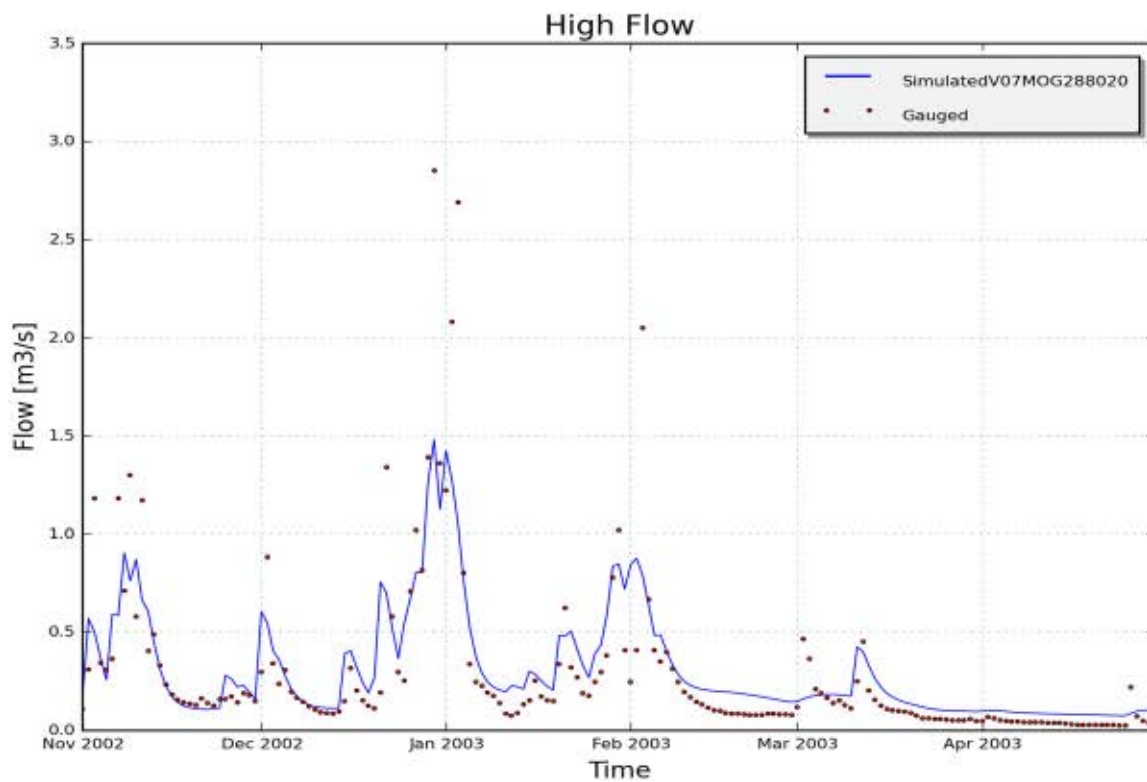


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

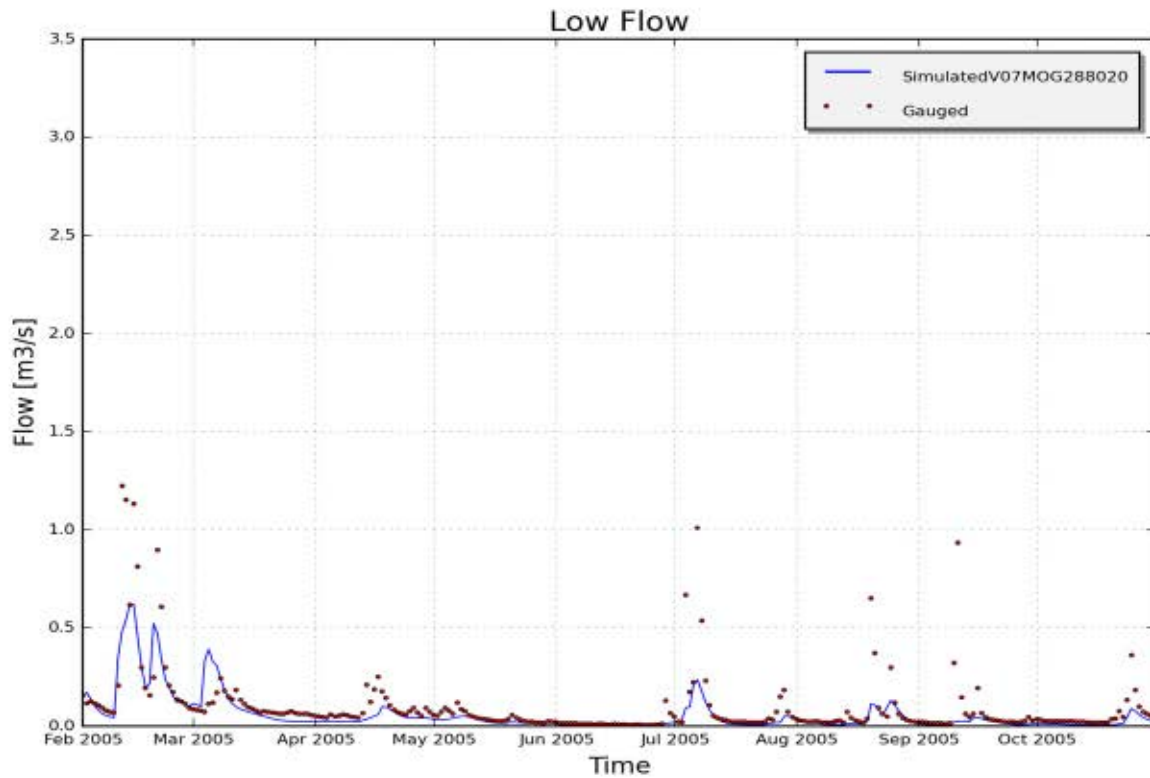


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

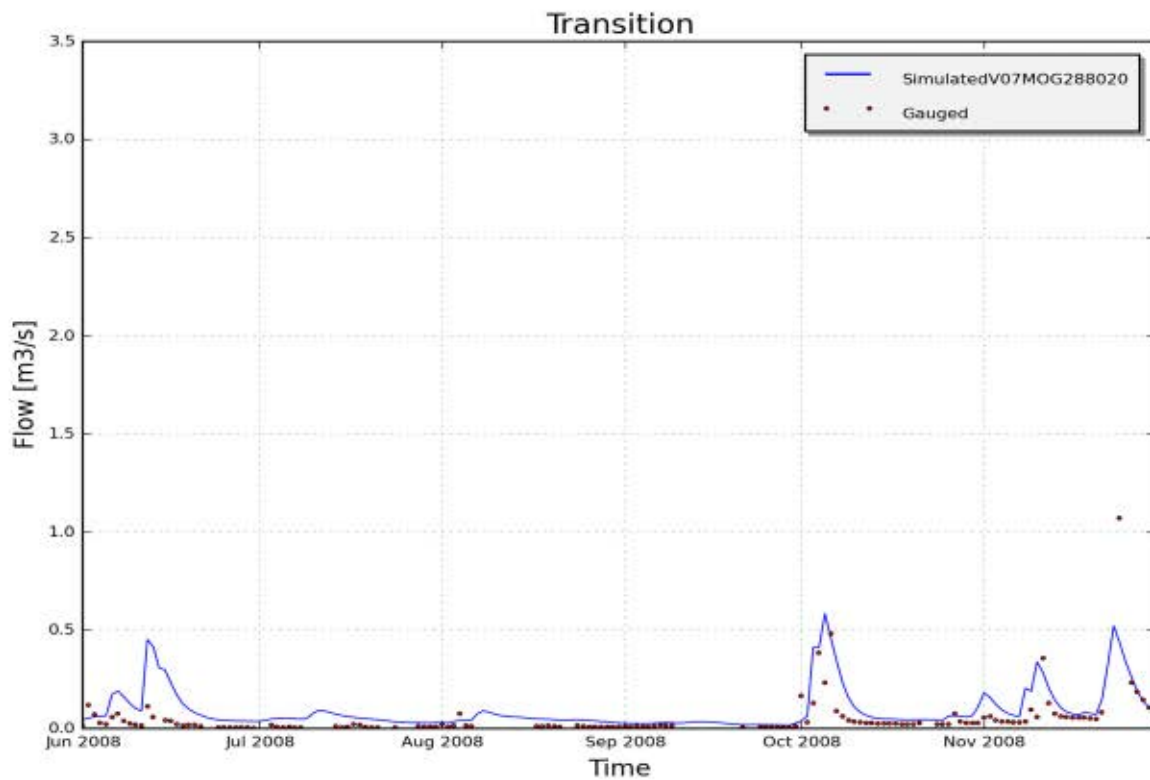


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V07MOG288020, station 28810102 - Molenbeek, Geraardsbergen

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "W07DENLES999" (DENDERBEKKEN)

4.1 Input data

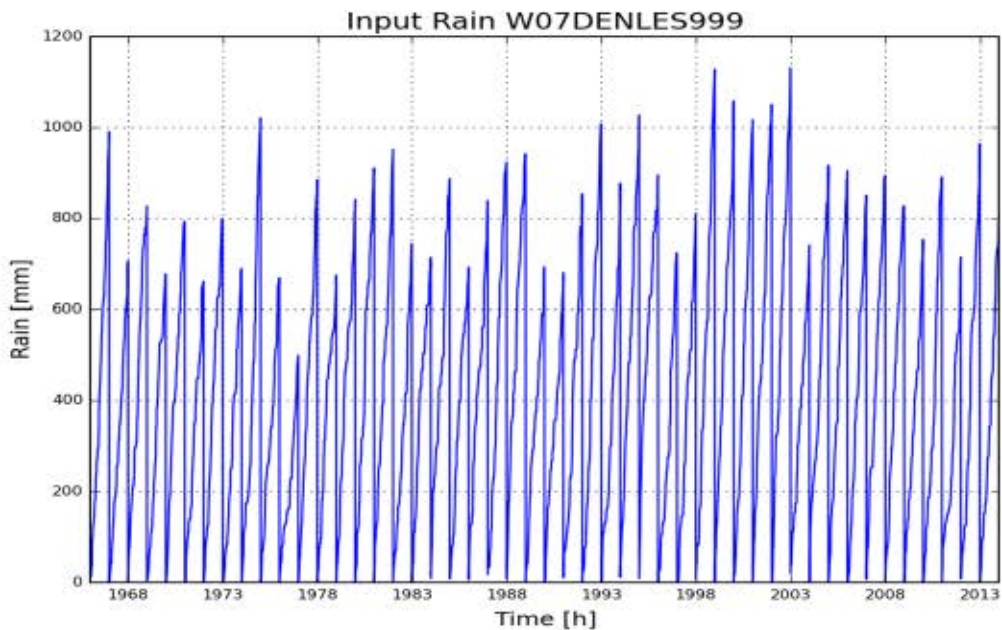


Figure 1: Cumulative precipitation on catchment W07DENLES999 (Denderbekken)

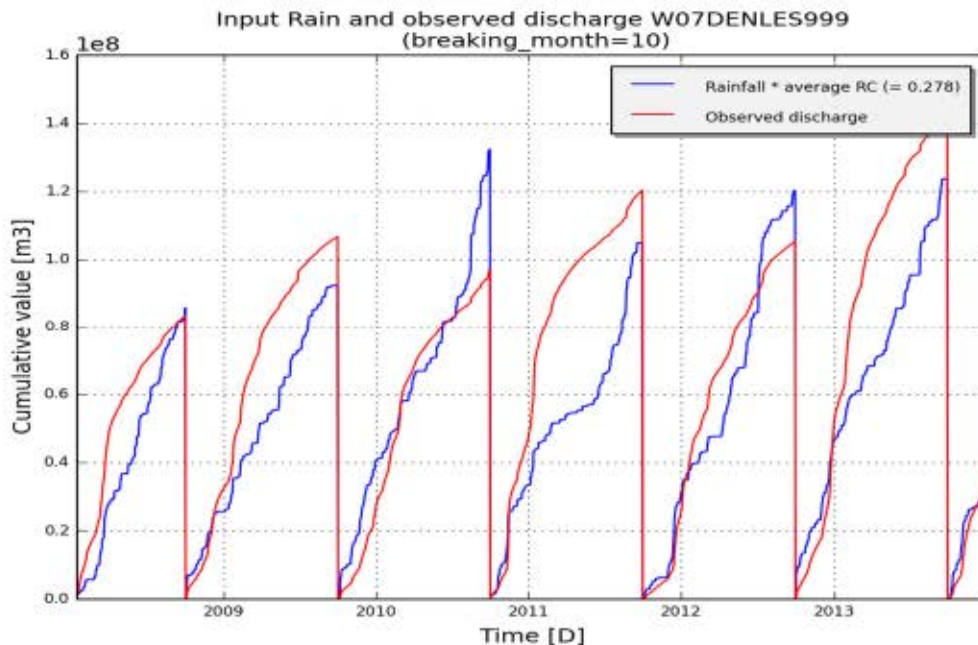


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment W07DENLES999 (Denderbekken)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | W07DENLES999 |
| subcatchment_area [m2] | 511840662 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 12.0), (‘SMmax.C’, 850.0), (‘CQOF.C’, 0.5), (‘CKBF.C’, 3300.0), (‘CKIF.C’, 550.0), (‘CK1.C’, 39.91), (‘CK2.C’, 38.15), (‘TIF.C’, 0.59), (‘TOF.C’, 0.66), (‘NAM.TG.C’, 0.72)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 17889702.205 | 17138306.155 |
| RelErr | -1.0 % | 0.3 % |
| RMSE | 21954444.878 | 21867177.478 |
| NS | 0.619 | 0.62 |
| NS_log | 0.565 | 0.568 |
| NS_rel | 0.748 | 0.746 |

4.3 Observed and simulated timeseries for optimum parameters

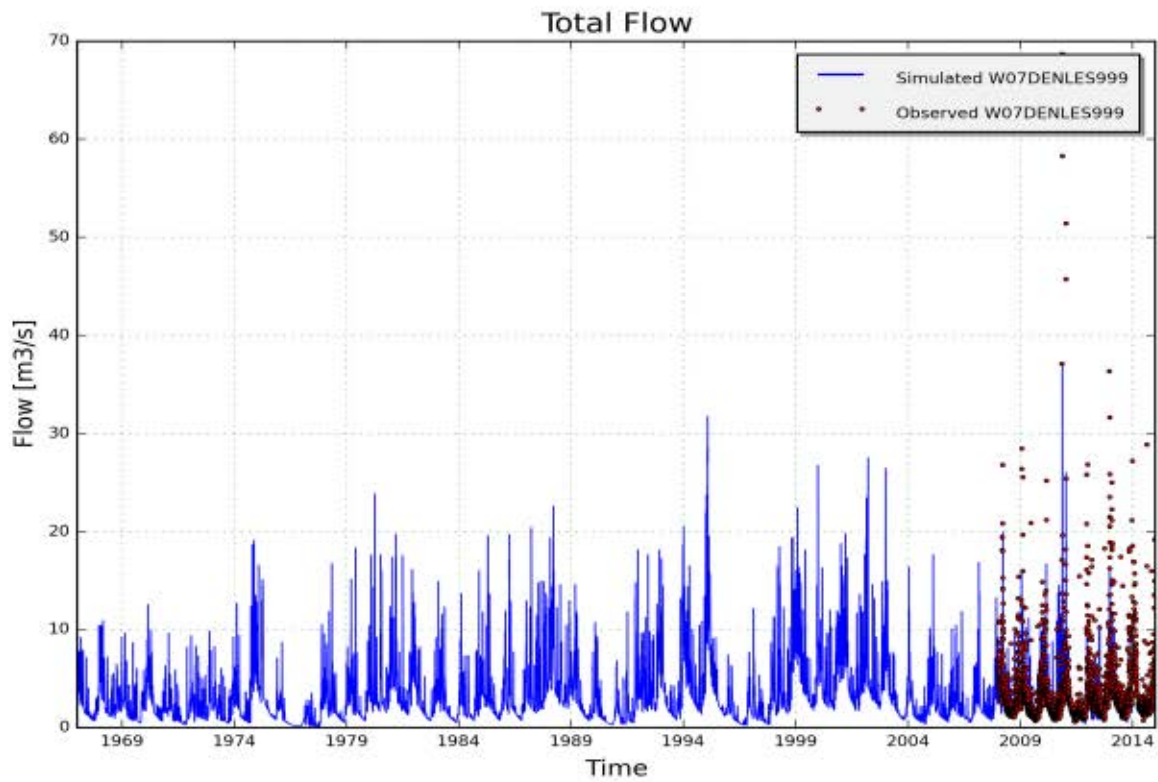


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W07DENLES999, station Lessines (validation period 1967-2013)

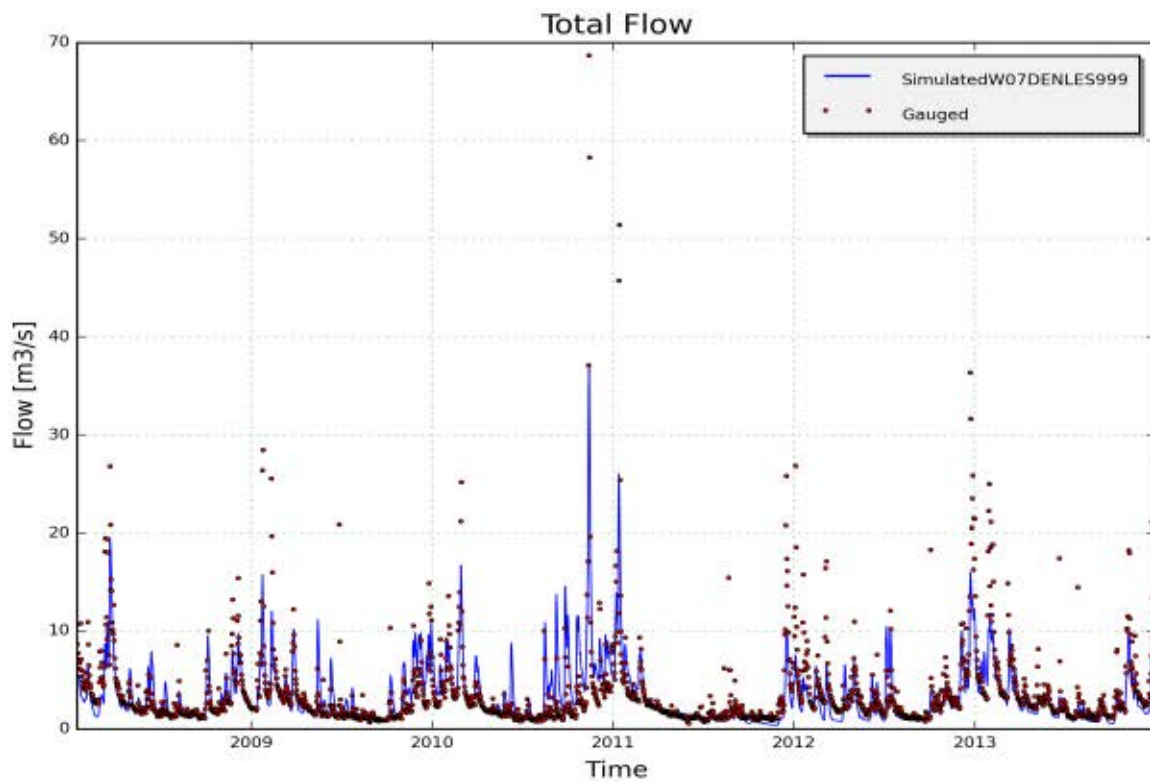


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W07DENLES999, station Lessines (calibration period)

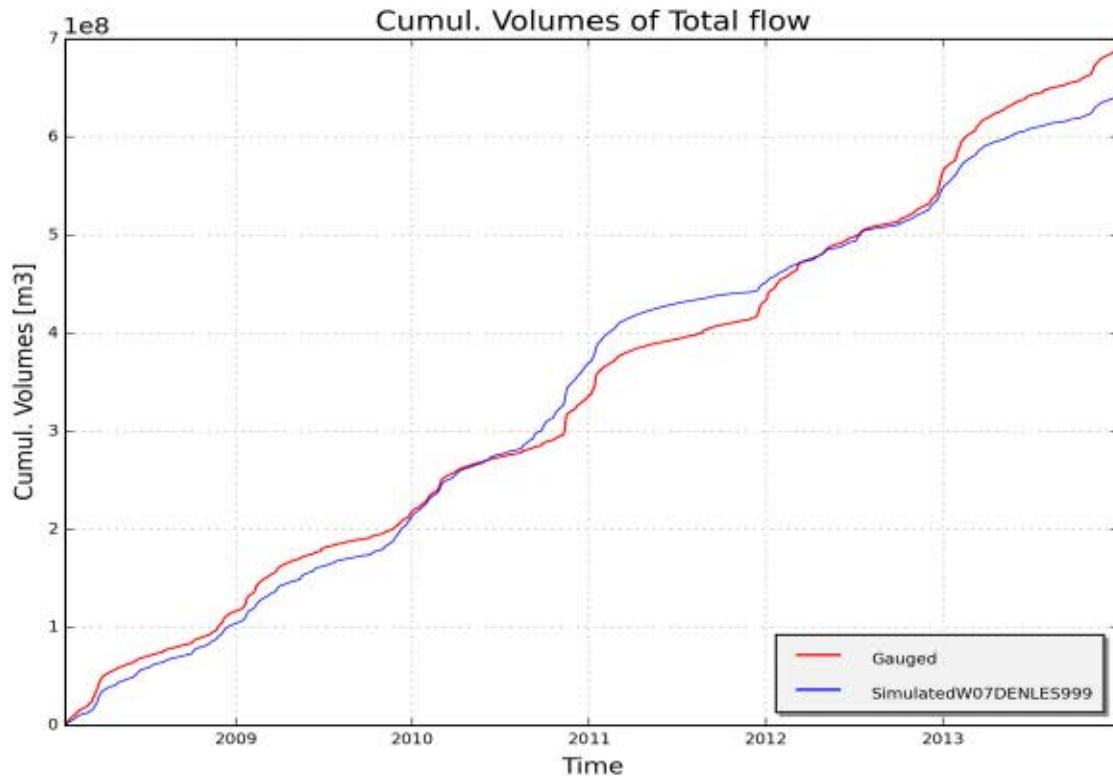


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W07DENLES999, station Lessines (calibration period)

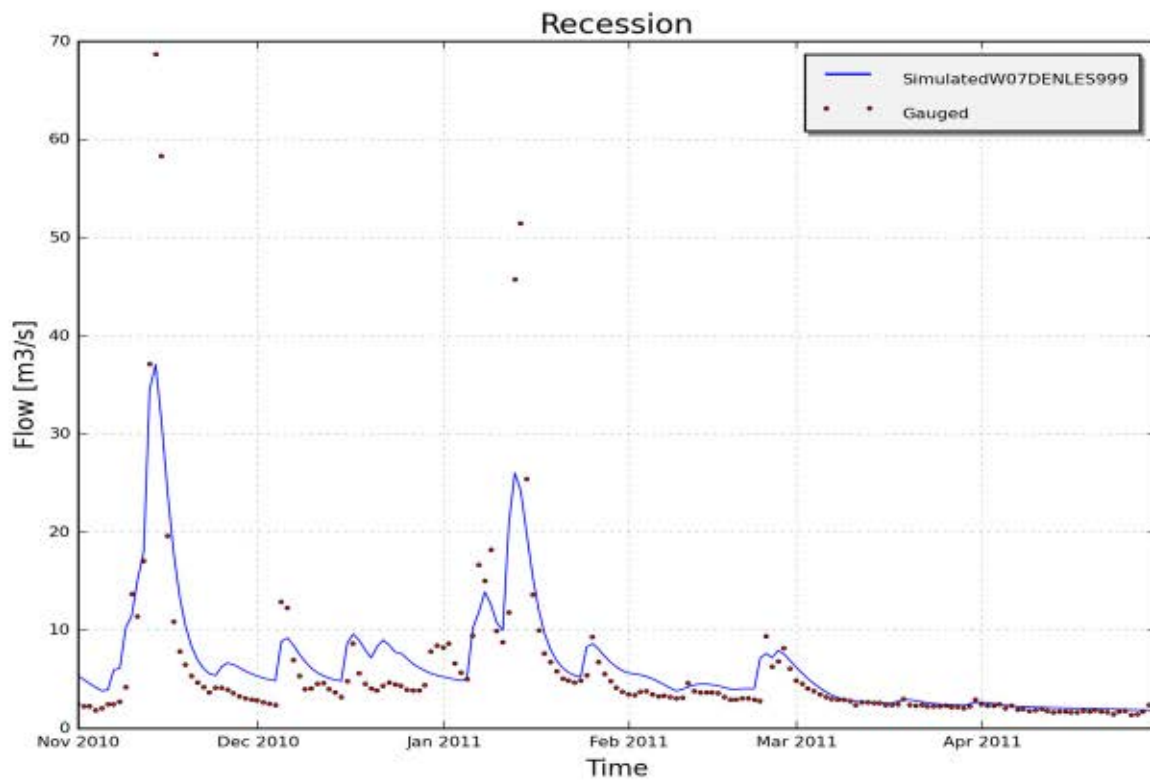


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W07DENLES999, station Lessines

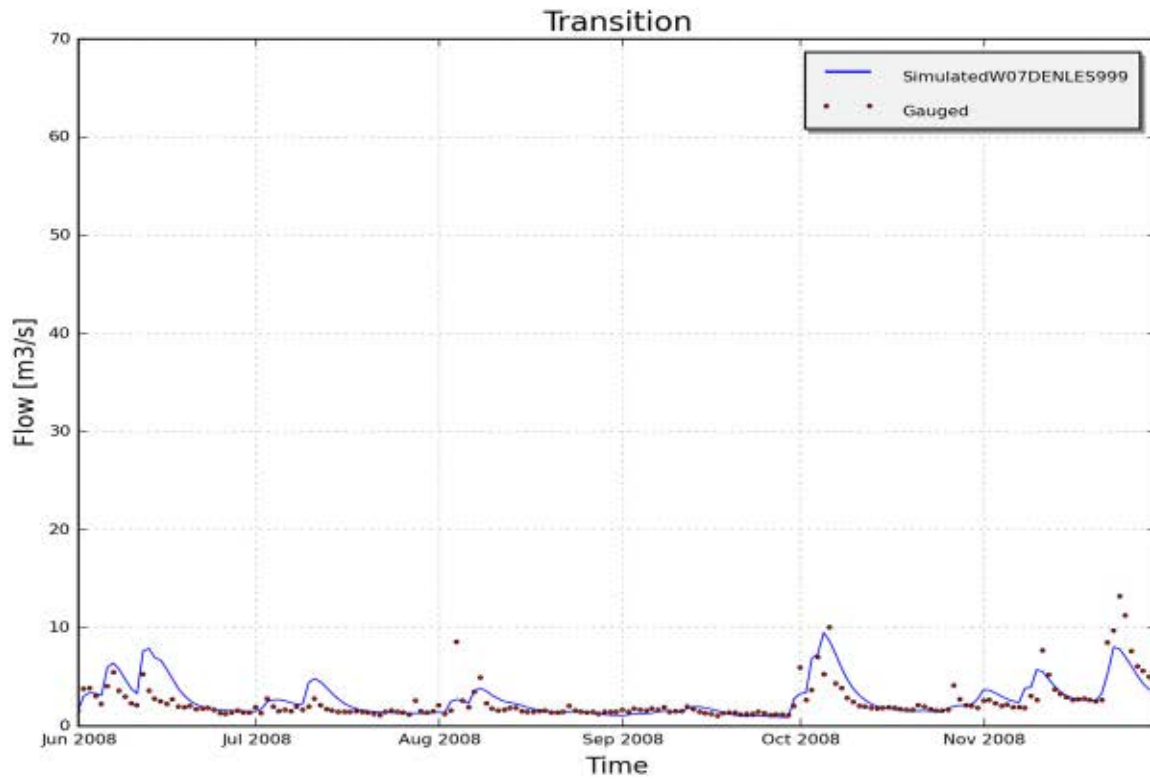


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W07DENLES999, station Lessines

5 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V07BEL285070" (DENDERBEKKEN)

5.1 Input data

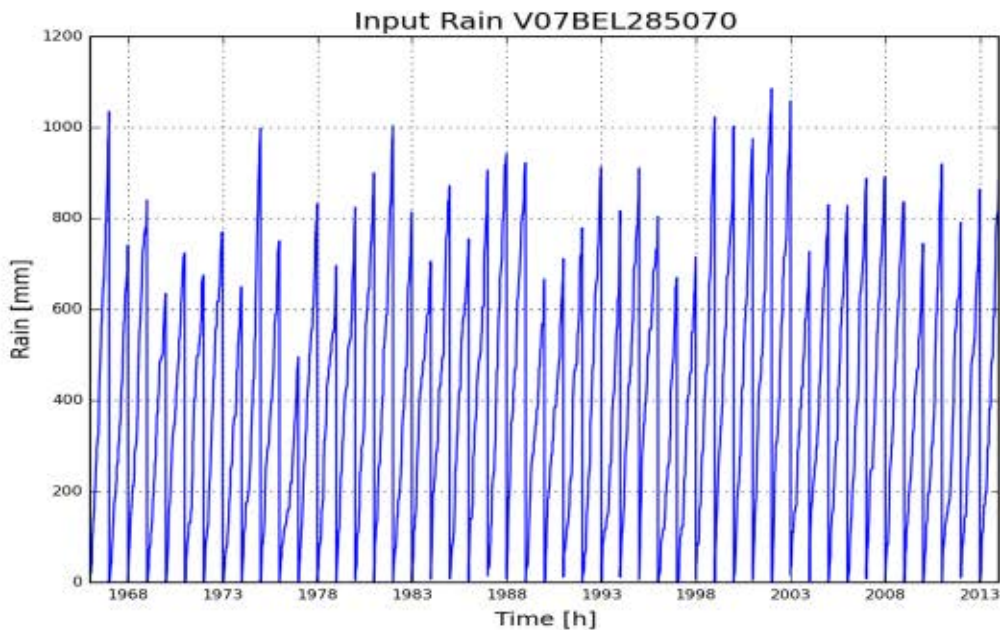


Figure 1: Cumulative precipitation on catchment V07BEL285070 (Denderbekken)

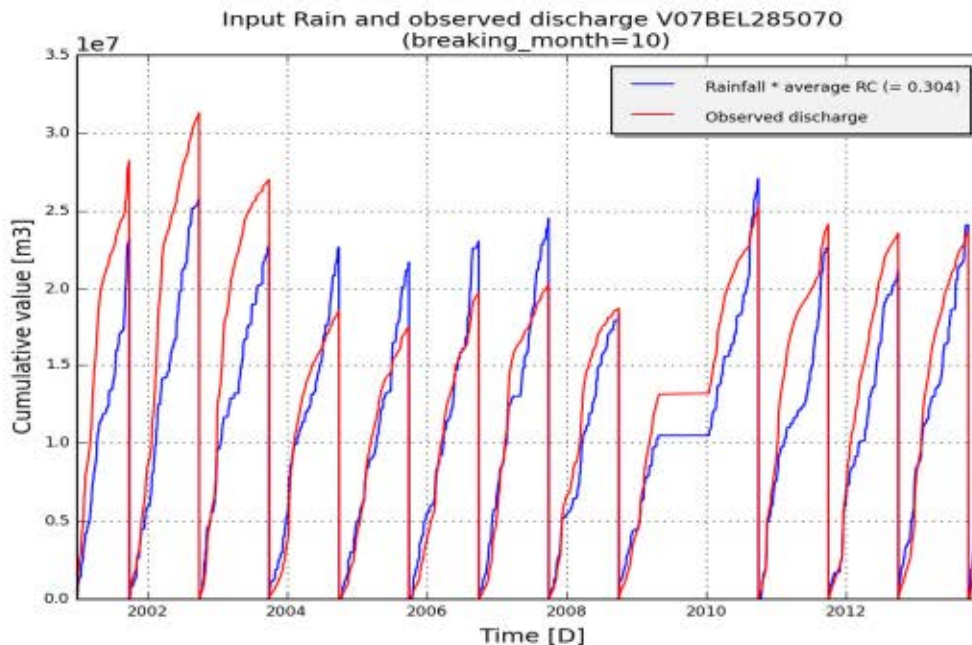


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V07BEL285070 (Denderbekken)

5.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V07BEL285070 |
| subcatchment_area [m2] | 88641710 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 15.43), (‘SMmax.C’, 506.15), (‘CQOF.C’, 0.25), (‘CKBF.C’, 3562.63), (‘CKIF.C’, 545.63), (‘CK1.C’, 31.54), (‘CK2.C’, 30.64), (‘TIF.C’, 0.2), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.5)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 2572440.441 | 32045719.311 |
| RelErr | 0.6 % | -7.1 % |
| RMSE | 3165255.935 | 34720018.281 |
| NS | 0.603 | 0.527 |
| NS_log | 0.625 | 0.533 |
| NS_rel | 0.616 | -23.12 |

5.3 Observed and simulated timeseries for optimum parameters

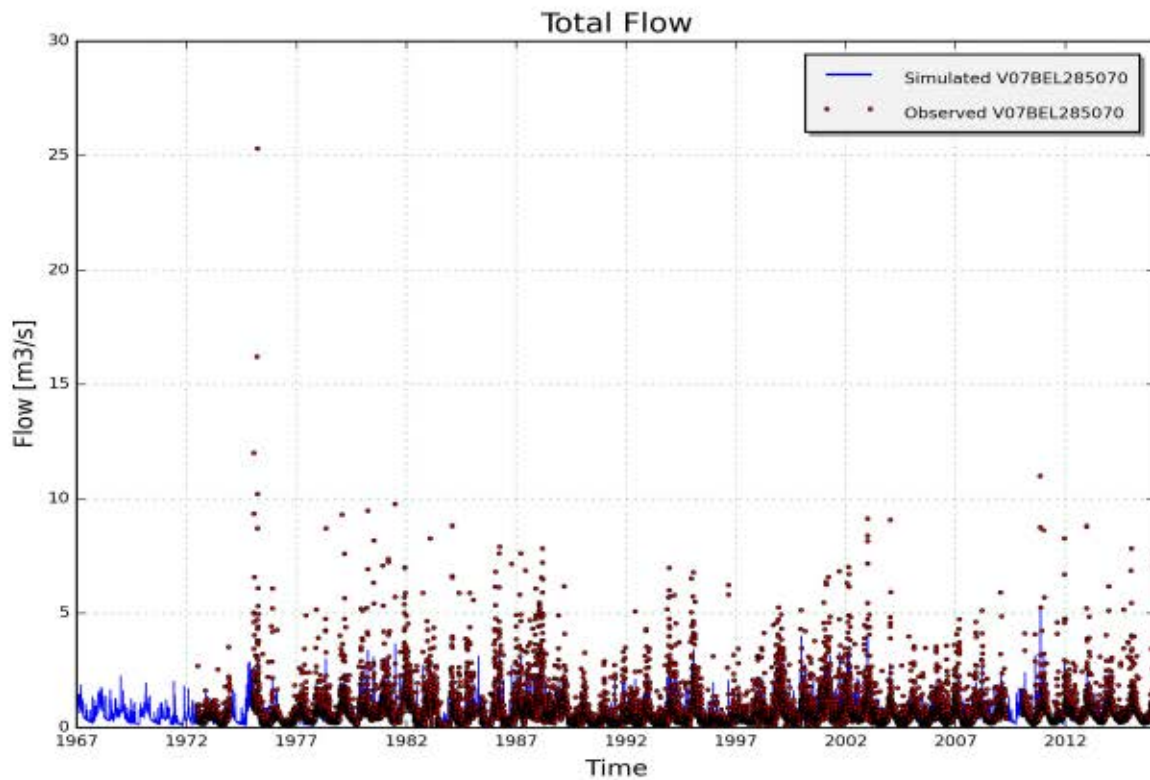


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (validation period 1967-2013)

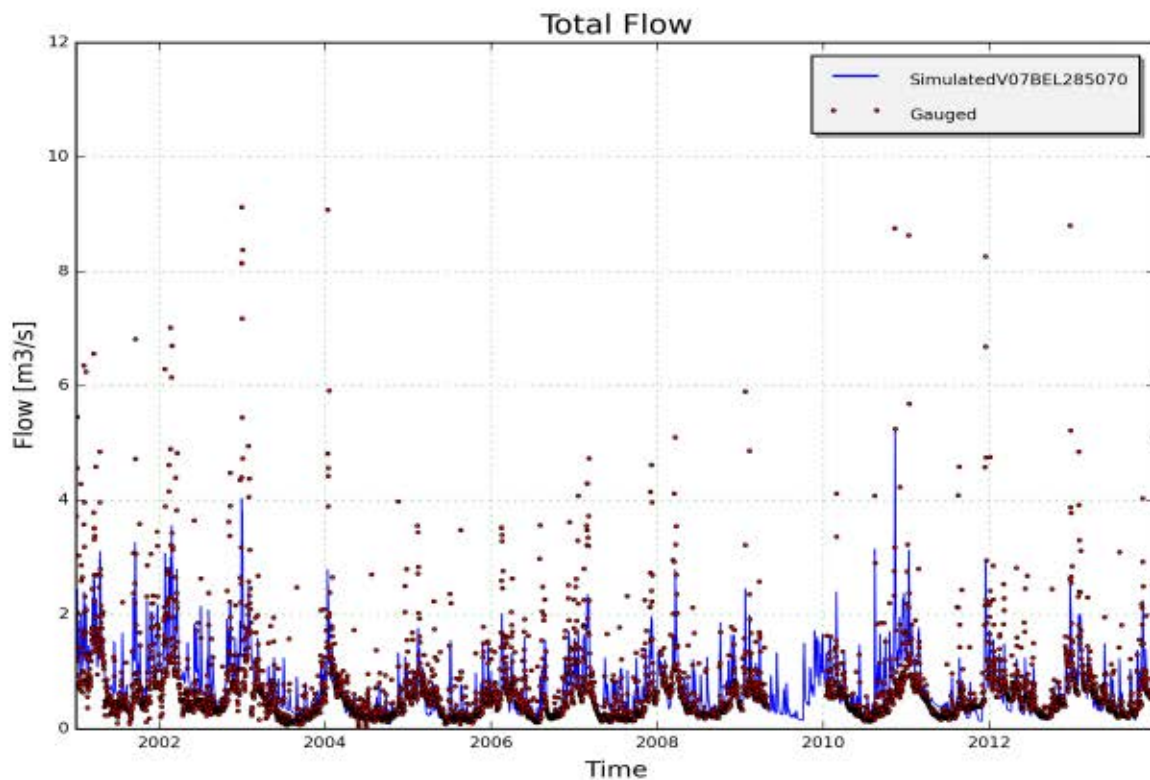


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (calibration period)

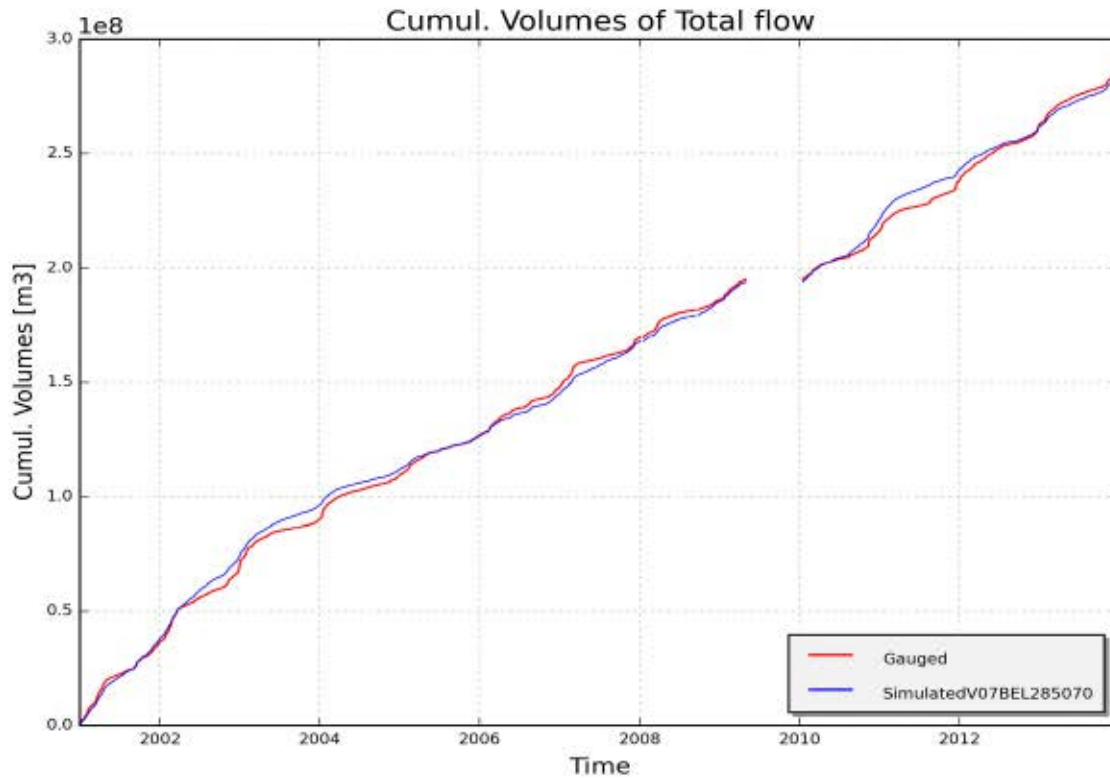


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V07BEL285070, station 28510102 - Bellebeek, Essene (calibration period)

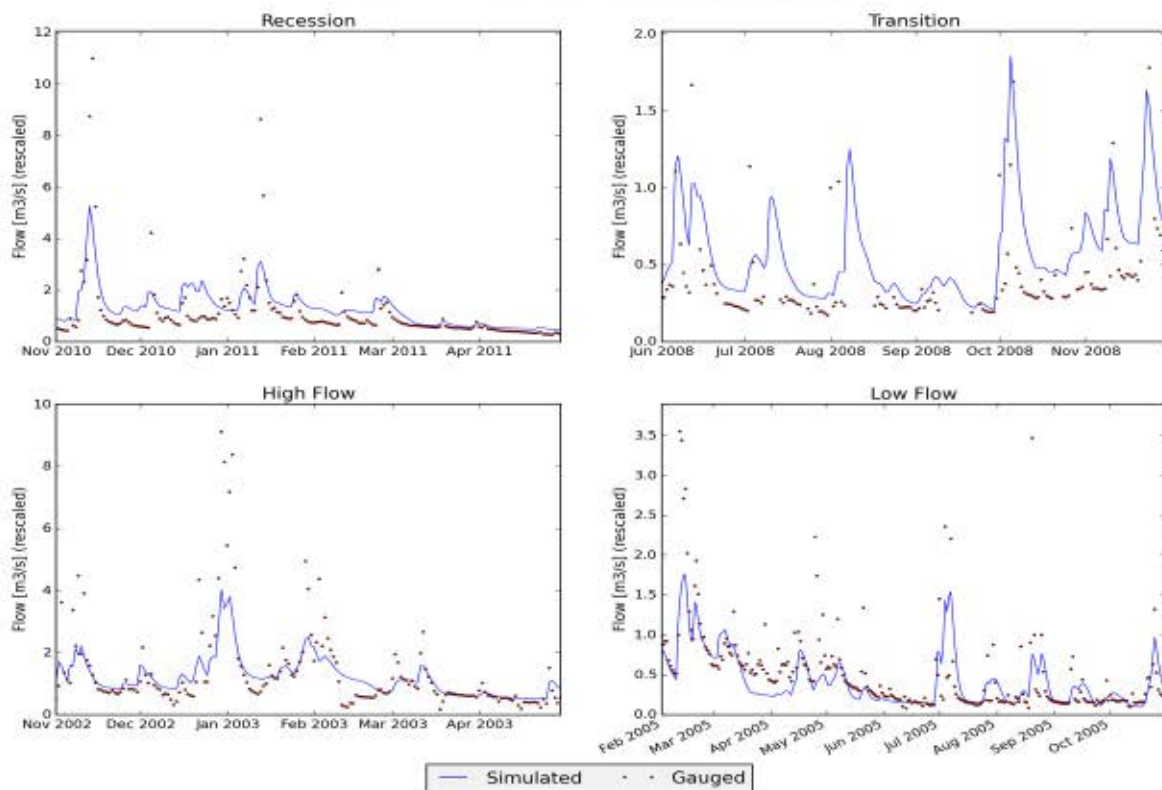


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V07BEL285070, station 28510102 - Bellebeek, Essene

Appendix 10

Results of calibration and validation of NAM parameters for catchment "V08DIJ093400" (DIJLE/ZENNEBEKKEN)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V08DIJ093400" (DIJLE/ZENNEBEKKEN)

1.1 Input data

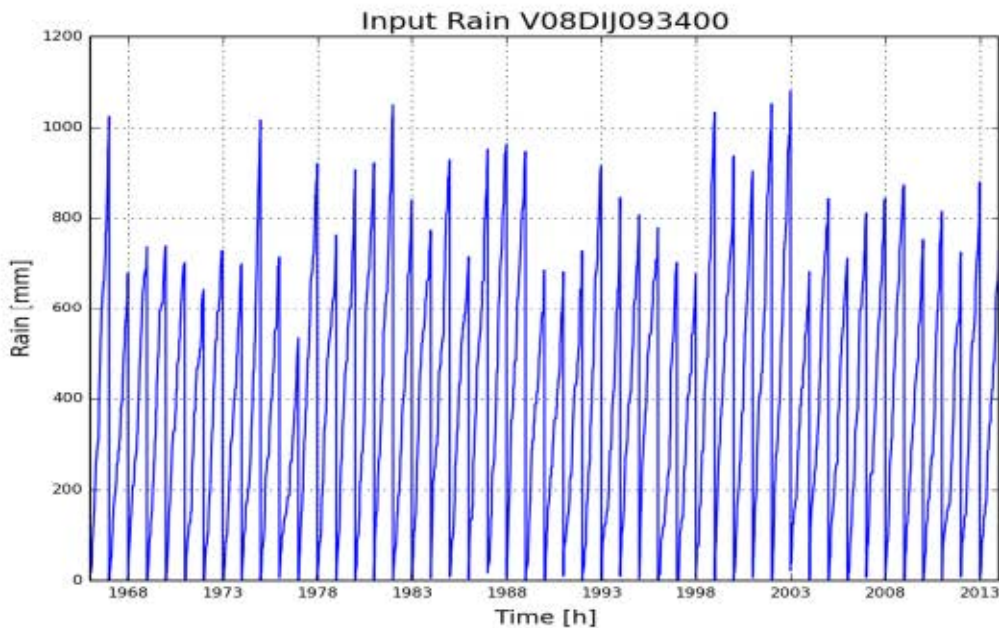


Figure 1: Cumulative precipitation on catchment V08DIJ093400 (Dijle/Zennebekken)

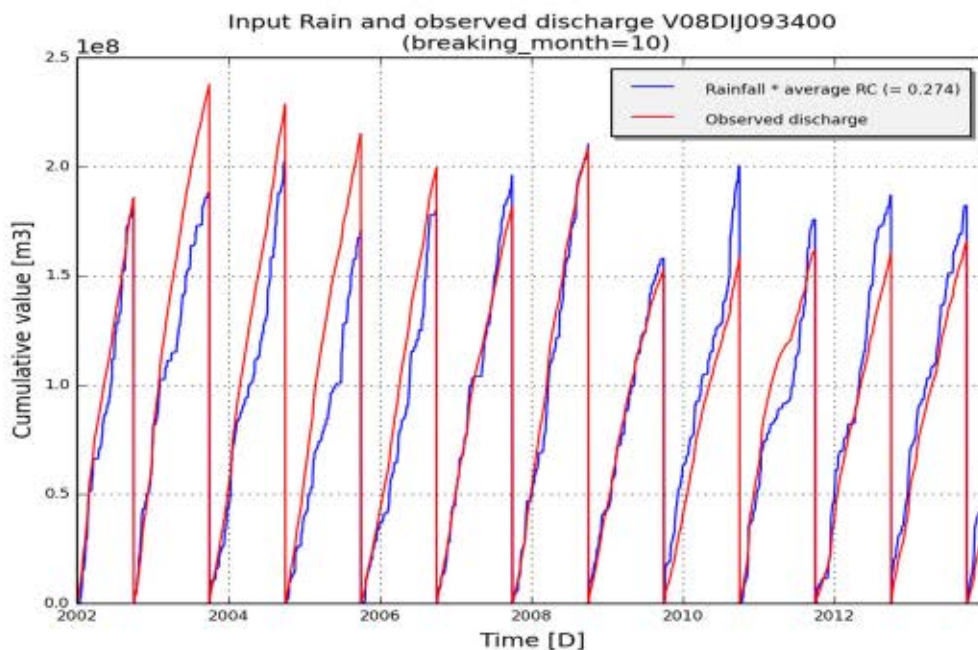


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V08DIJ093400 (Dijle/Zennebekken)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V08DIJ093400 |
| subcatchment_area [m2] | 861413000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 4.79), ('SMmax.C', 2761.19), ('CQOF.C', 0.17), ('CKBF.C', 1744.7), ('CKIF.C', 462.7), ('CK1.C', 21.83), ('CK2.C', 38.1), ('TIF.C', 0.9), ('TOF.C', 0.44), ('NAM.TG.C', 0.41)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 64882503.564 | 881623327.231 |
| RelErr | 3.1 % | 25.0 % |
| RMSE | 75742571.238 | 969056138.8 |
| NS | 0.389 | 0.178 |
| NS_log | 0.286 | 0.102 |
| NS_rel | 0.201 | -0.09 |

1.3 Observed and simulated timeseries for optimum parameters

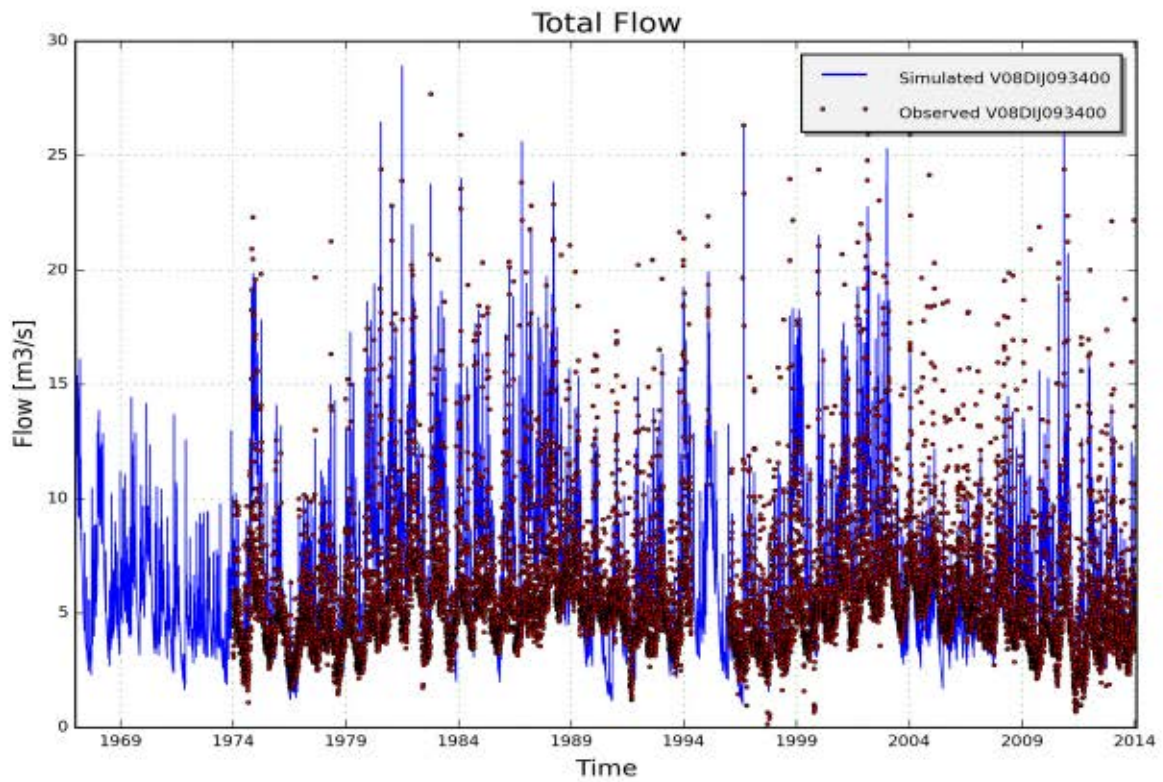


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (validation period 1967-2013)

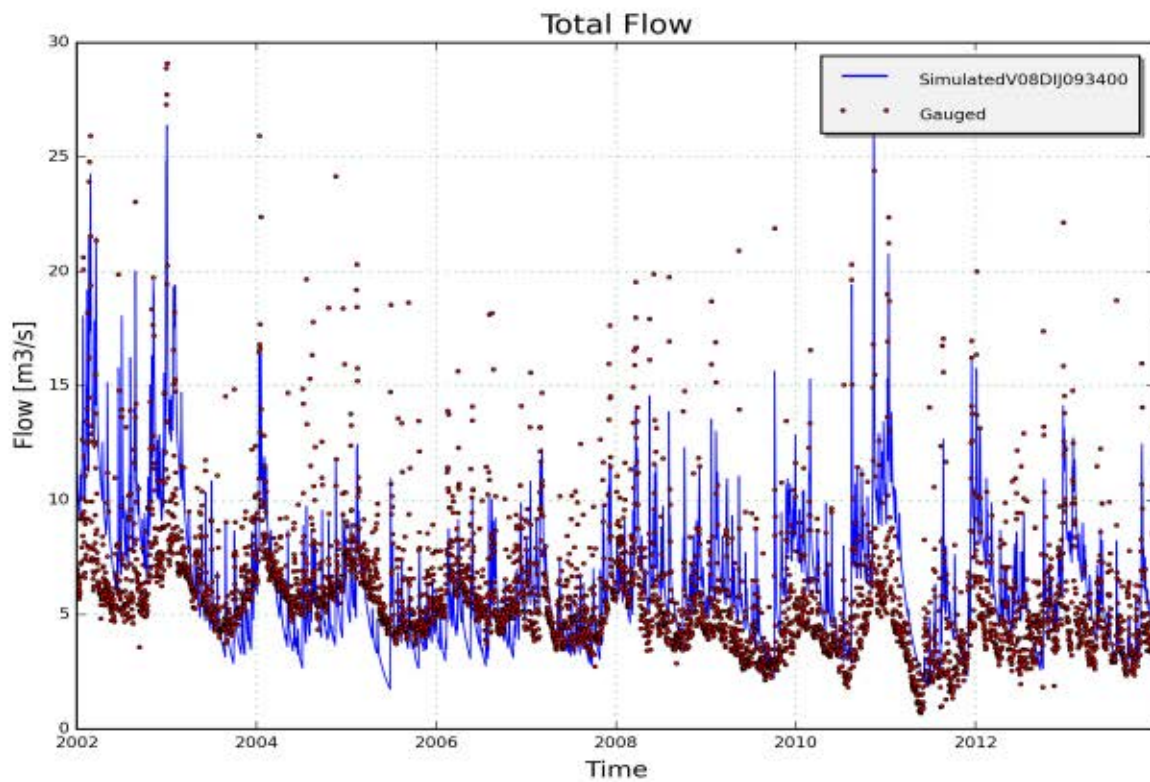


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V08DIJ093400, station 9310102 - Dijle, Wilsele (calibration period)

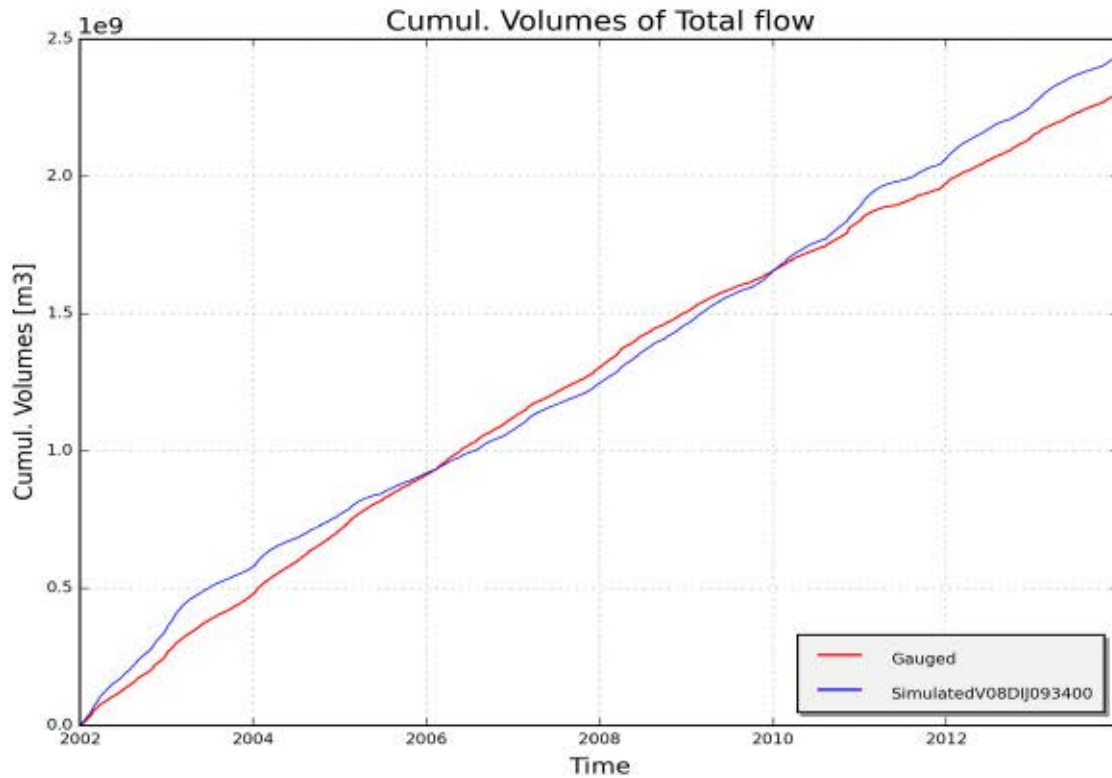


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08DIJ093400, station 9310102 - Dijke, Wilsele (calibration period)

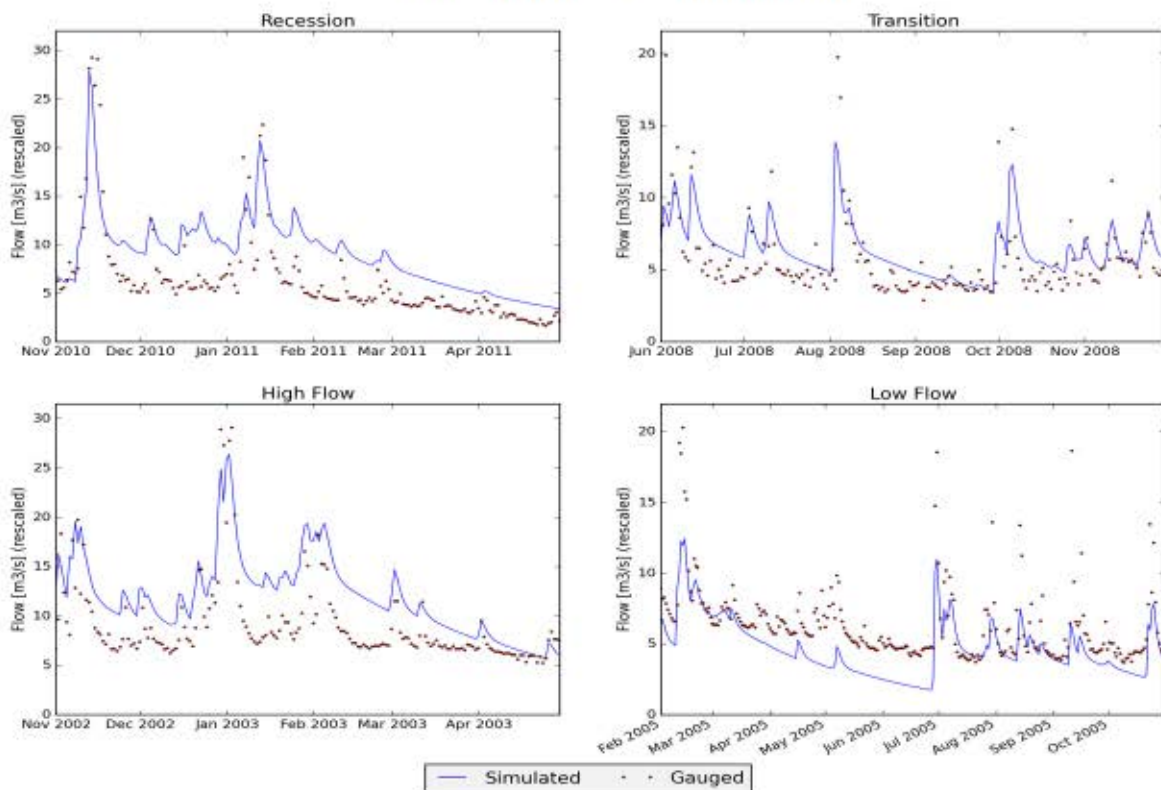


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V08DIJ093400, station 9310102 - Dijke, Wilsele

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V08ZUU233100" (DIJLE/ZENNEBEKKEN)

2.1 Input data

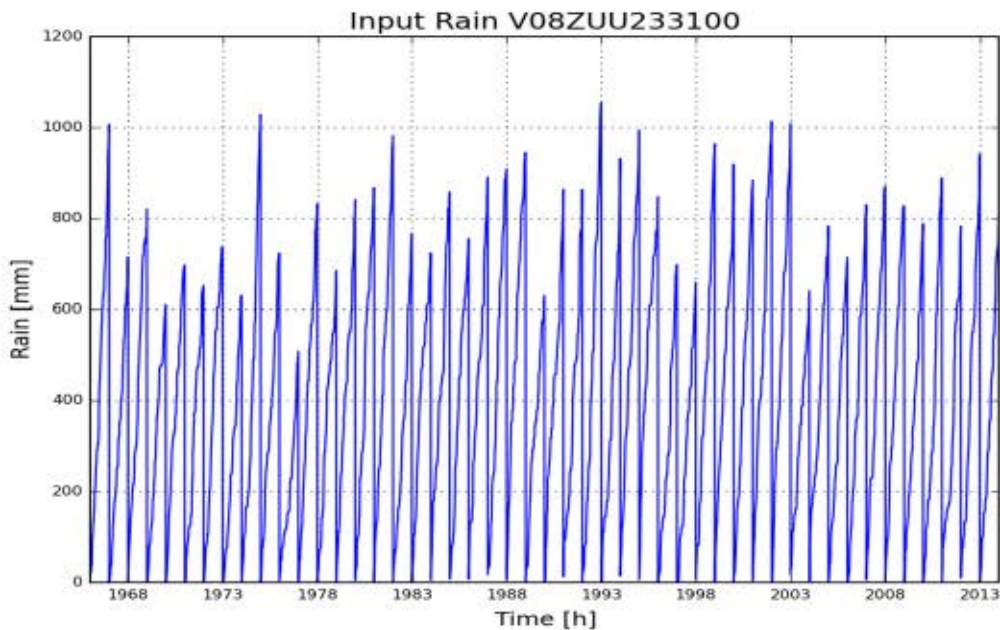


Figure 1: Cumulative precipitation on catchment V08ZUU233100 (Dijle/Zennebekken)

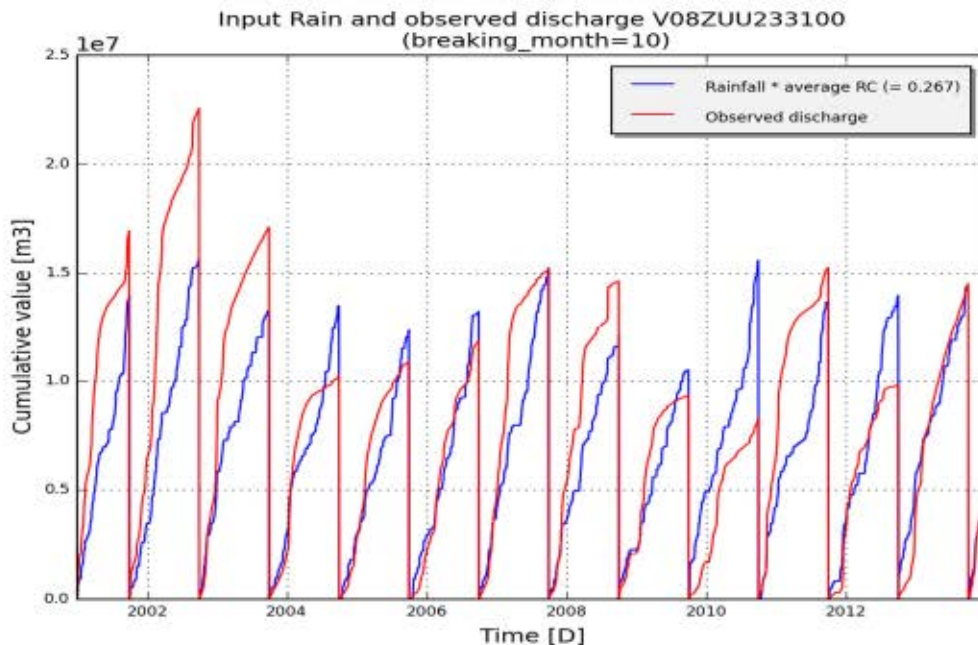


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V08ZUU233100 (Dijle/Zennebekken)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V08ZUU233100 |
| subcatchment_area [m2] | 64771005 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 18.96), (‘SMmax.C’, 587.13), (‘CQOF.C’, 0.48), (‘CKBF.C’, 1873.69), (‘CKIF.C’, 562.56), (‘CK1.C’, 32.02), (‘CK2.C’, 33.87), (‘TIF.C’, 0.87), (‘TOF.C’, 0.1), (‘NAM.TG.C’, 0.32)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 5186269.689 | 46093534.106 |
| RelErr | -0.0 % | 22.4 % |
| RMSE | 6430324.047 | 50534122.73 |
| NS | 0.579 | 0.606 |
| NS_log | 0.51 | 0.483 |
| NS_rel | -0.205 | -2.392 |

2.3 Observed and simulated timeseries for optimum parameters

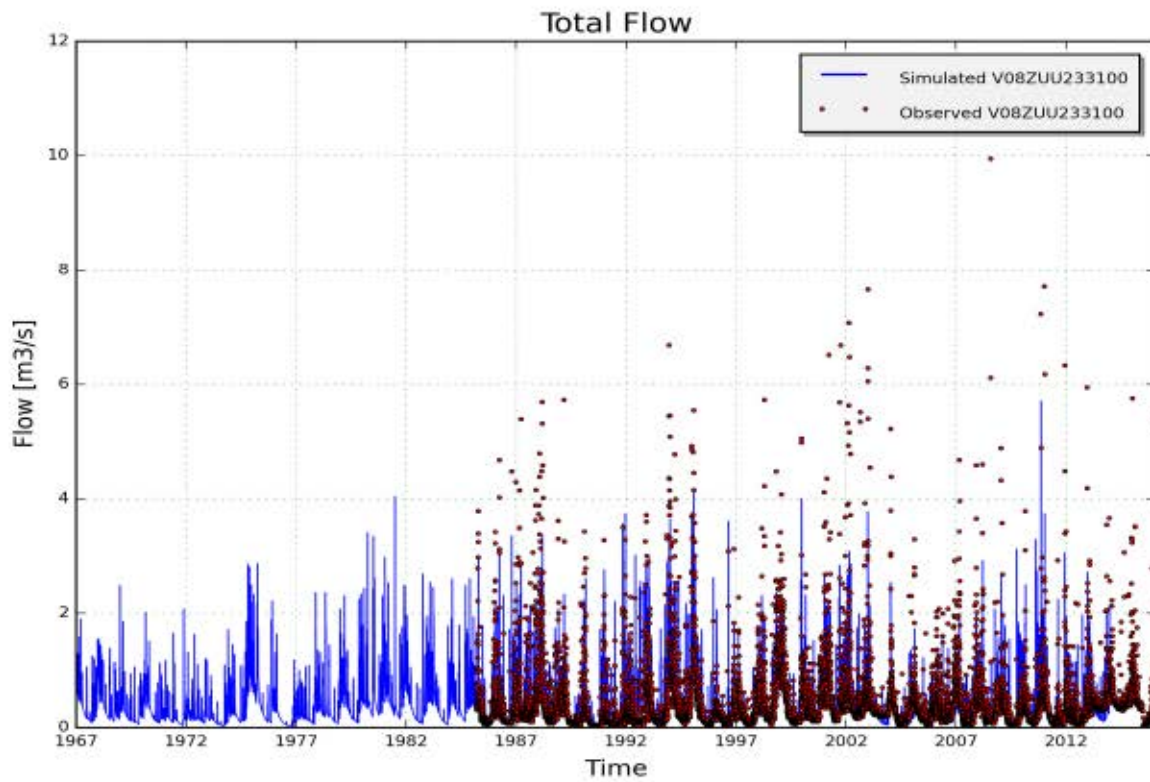


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (validation period 1967-2013)

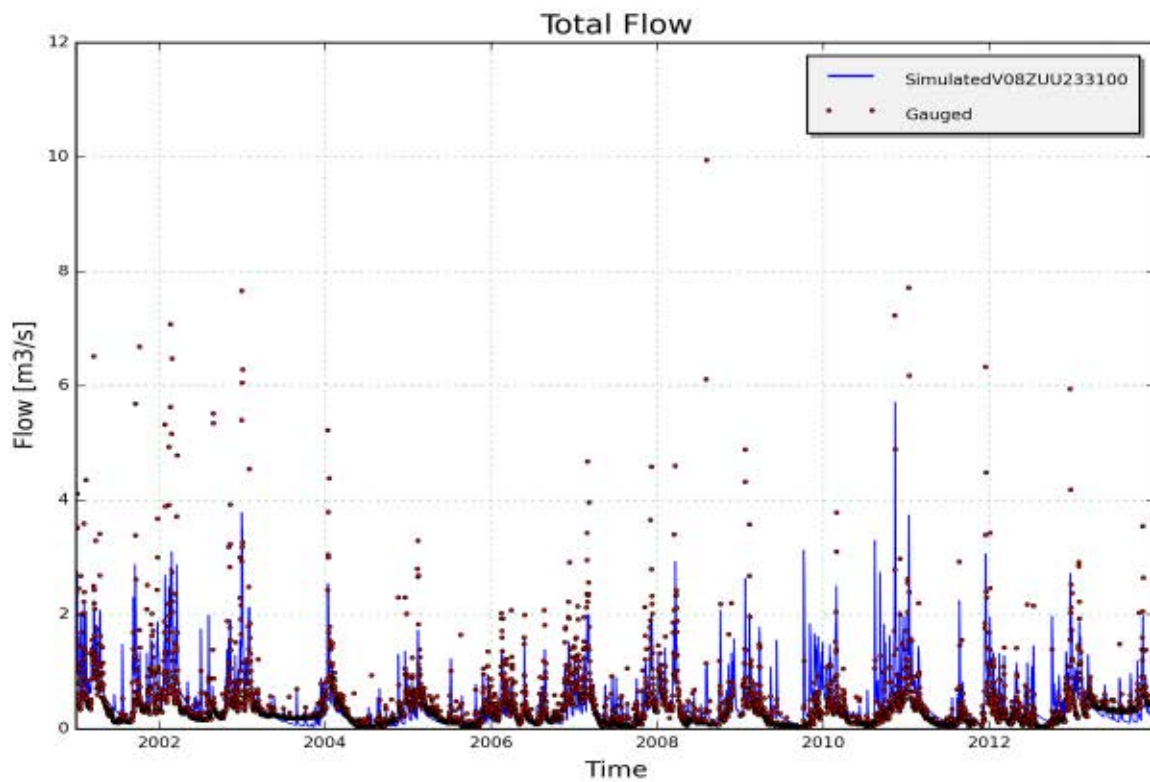


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (calibration period)

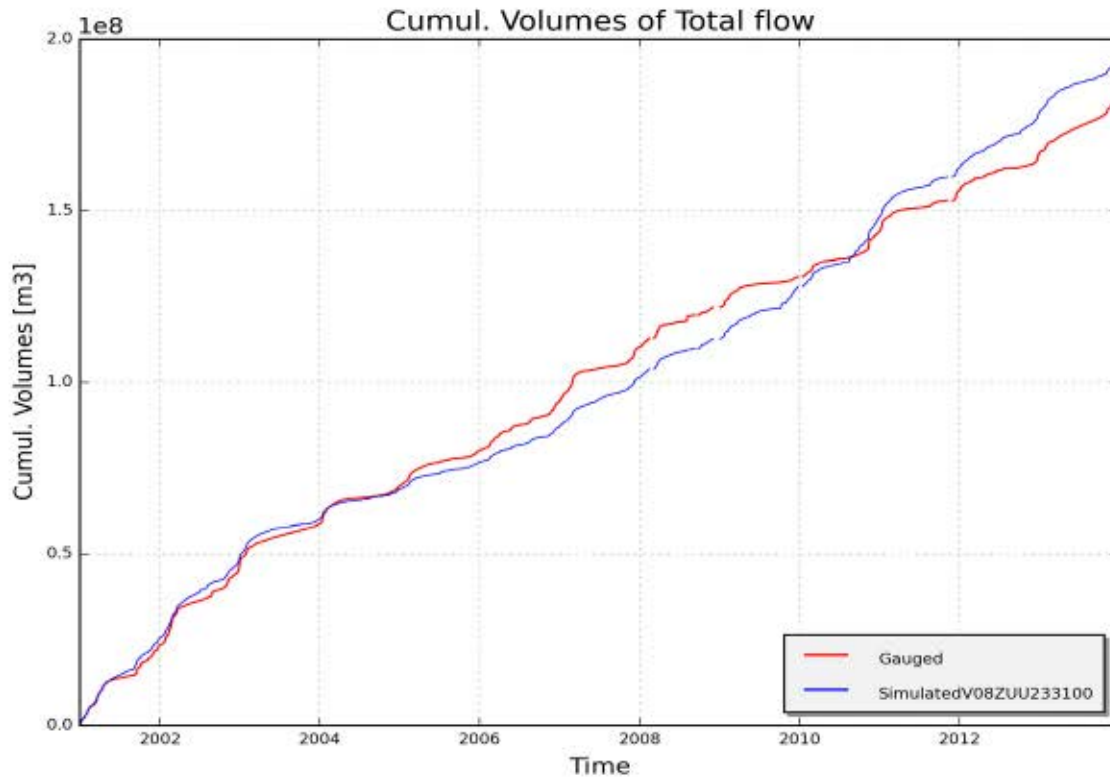


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw (calibration period)

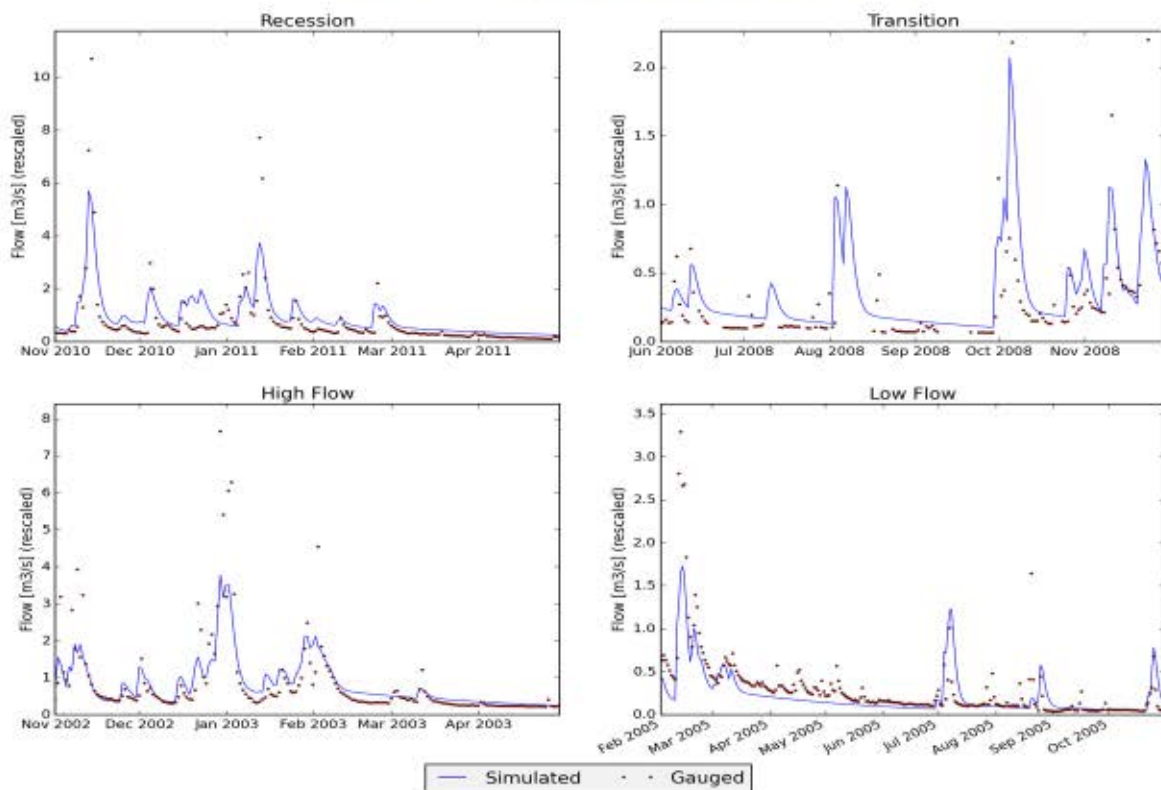


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V08ZUU233100, station 23310102 - Zuunbeek, St Pietersleeuw

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "W08SAMRON000" (DIJLE/ZENNEBEKKEN)

3.1 Input data

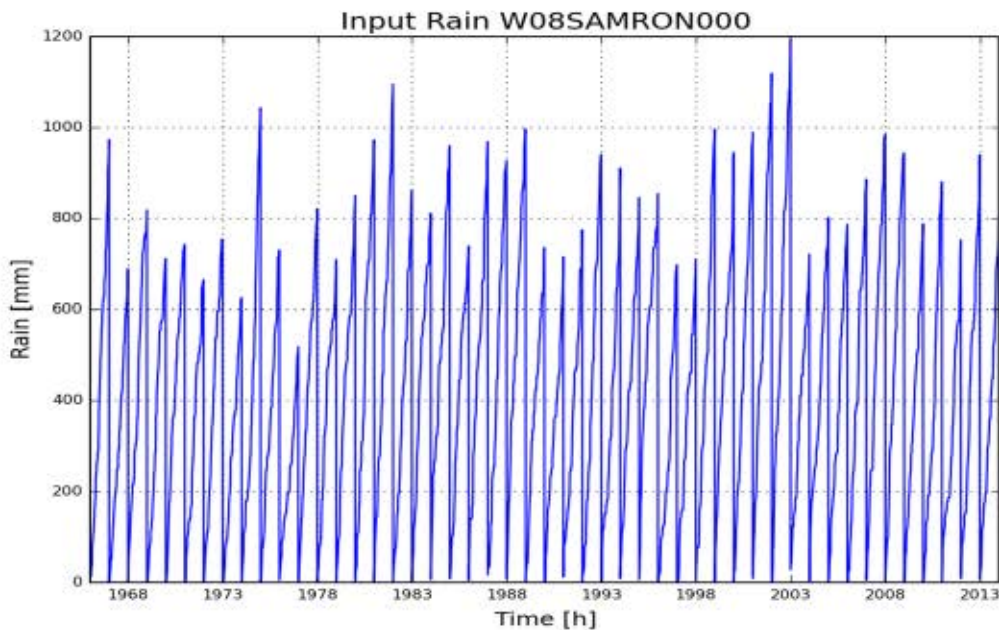


Figure 1: Cumulative precipitation on catchment W08SAMRON000 (Dijle/Zennebekken)

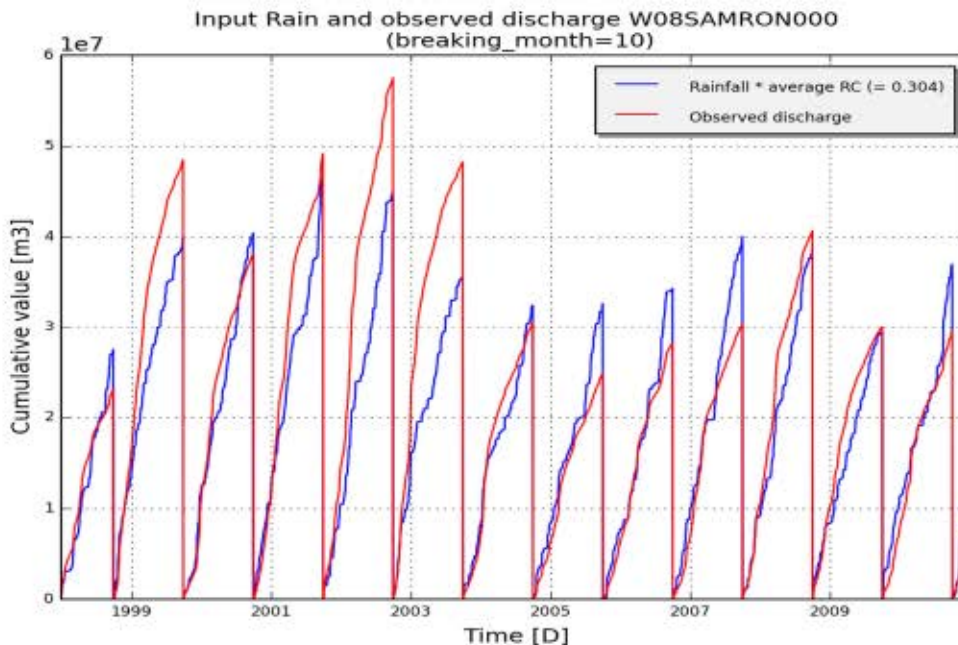


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment W08SAMRON000 (Dijle/Zennebekken)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | W08SAMRON000 |
| subcatchment_area [m2] | 134097000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 12.76), (‘SMmax.C’, 1528.91), (‘CQOF.C’, 0.32), (‘CKBF.C’, 1758.99), (‘CKIF.C’, 501.12), (‘CK1.C’, 43.32), (‘CK2.C’, 16.93), (‘TIF.C’, 0.7), (‘TOF.C’, 0.31), (‘NAM.TG.C’, 0.44)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3895626.23 | 48045047.572 |
| RelErr | 1.3 % | -11.5 % |
| RMSE | 5479838.243 | 50696766.192 |
| NS | 0.666 | 0.68 |
| NS_log | 0.676 | 0.537 |
| NS_rel | 0.785 | 0.805 |

3.3 Observed and simulated timeseries for optimum parameters

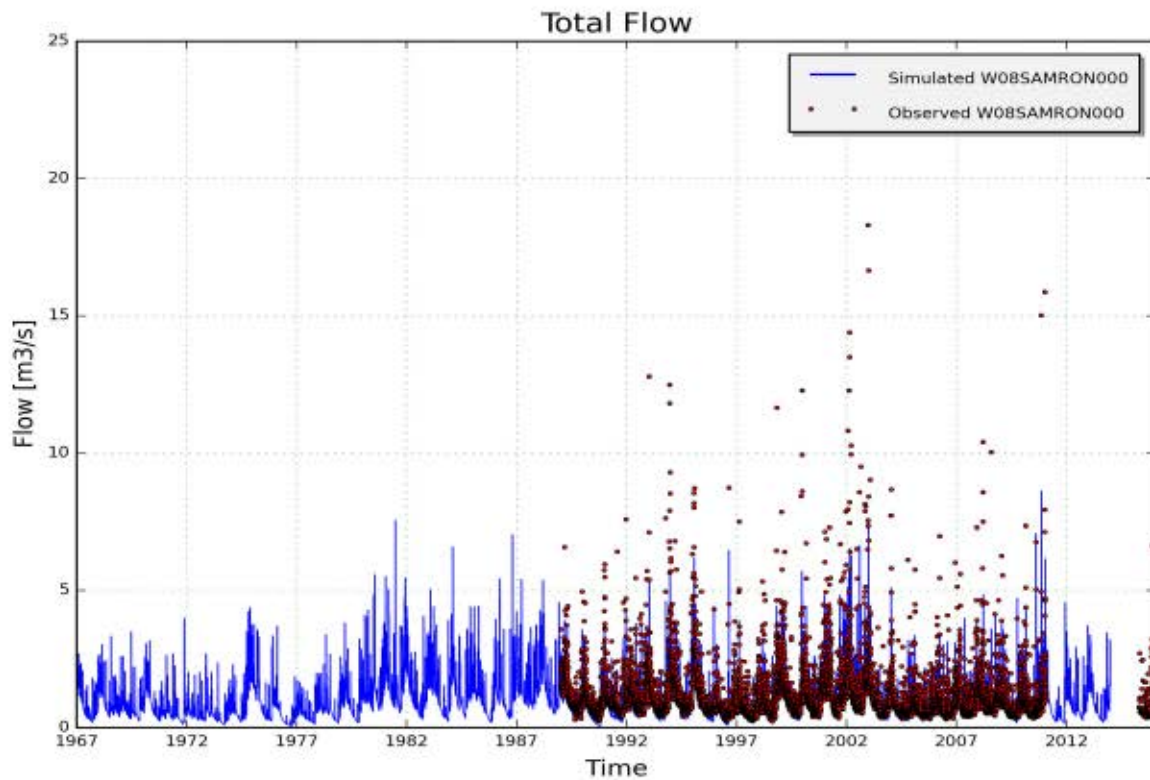


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (validation period 1967-2013)

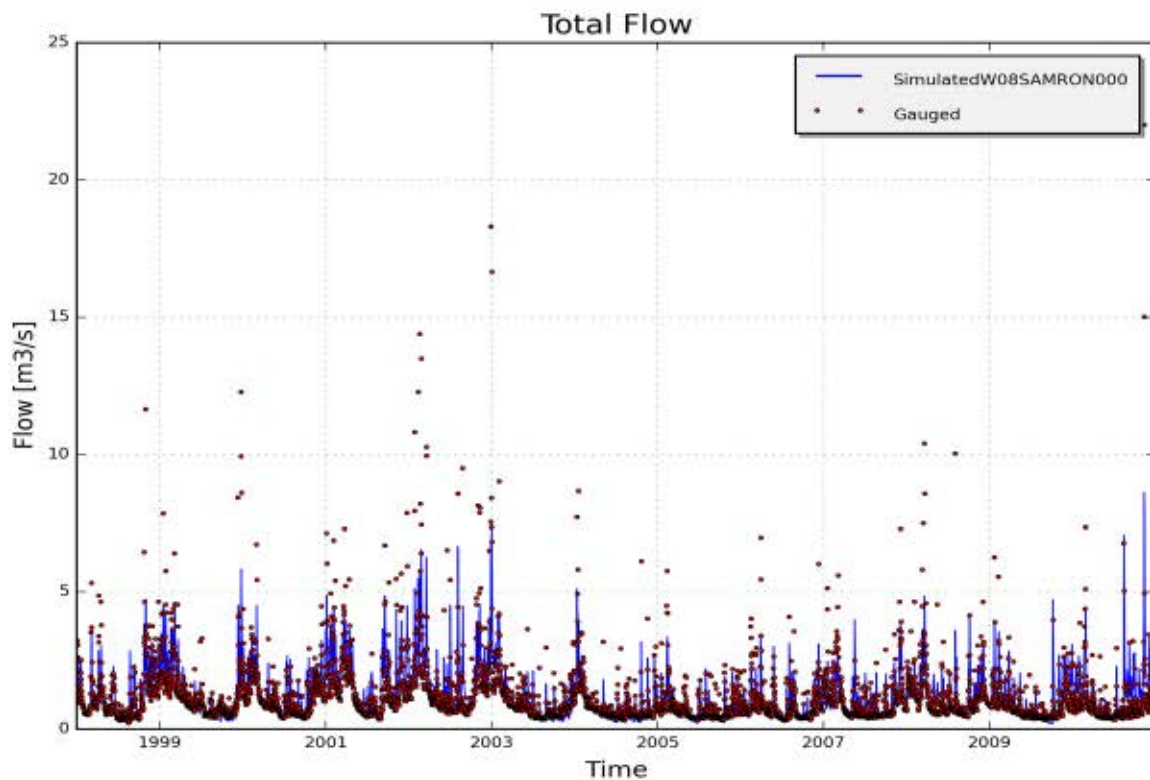


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (calibration period)

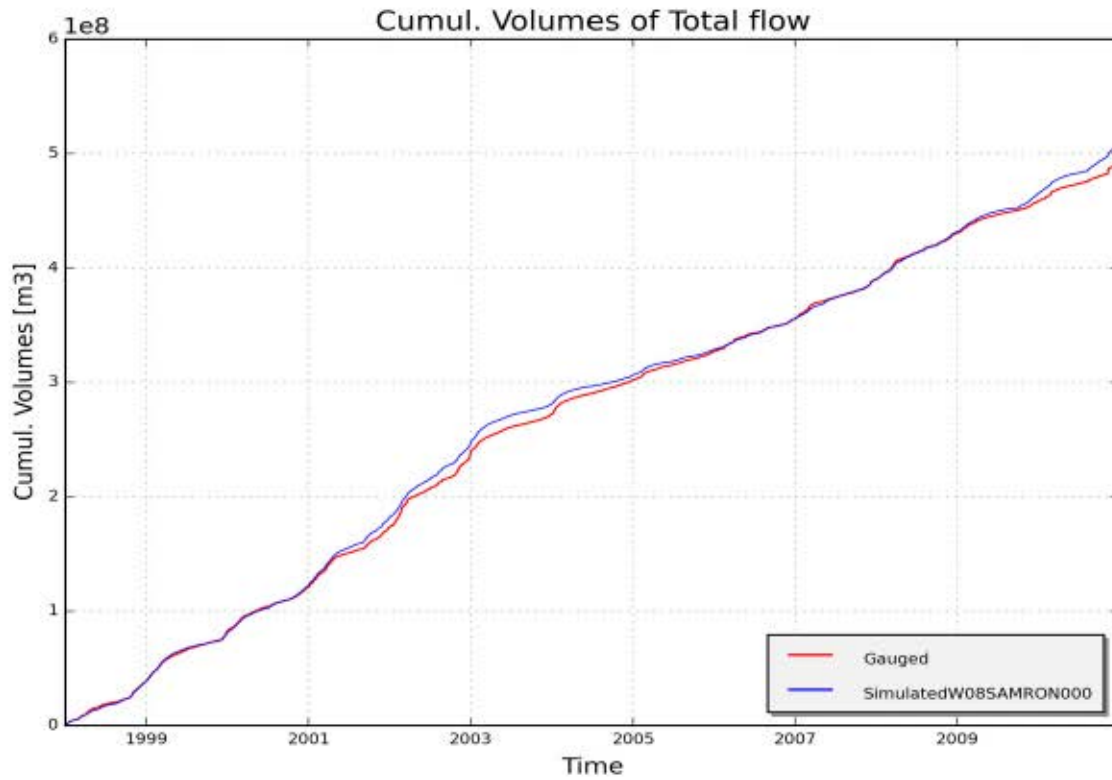


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres (calibration period)

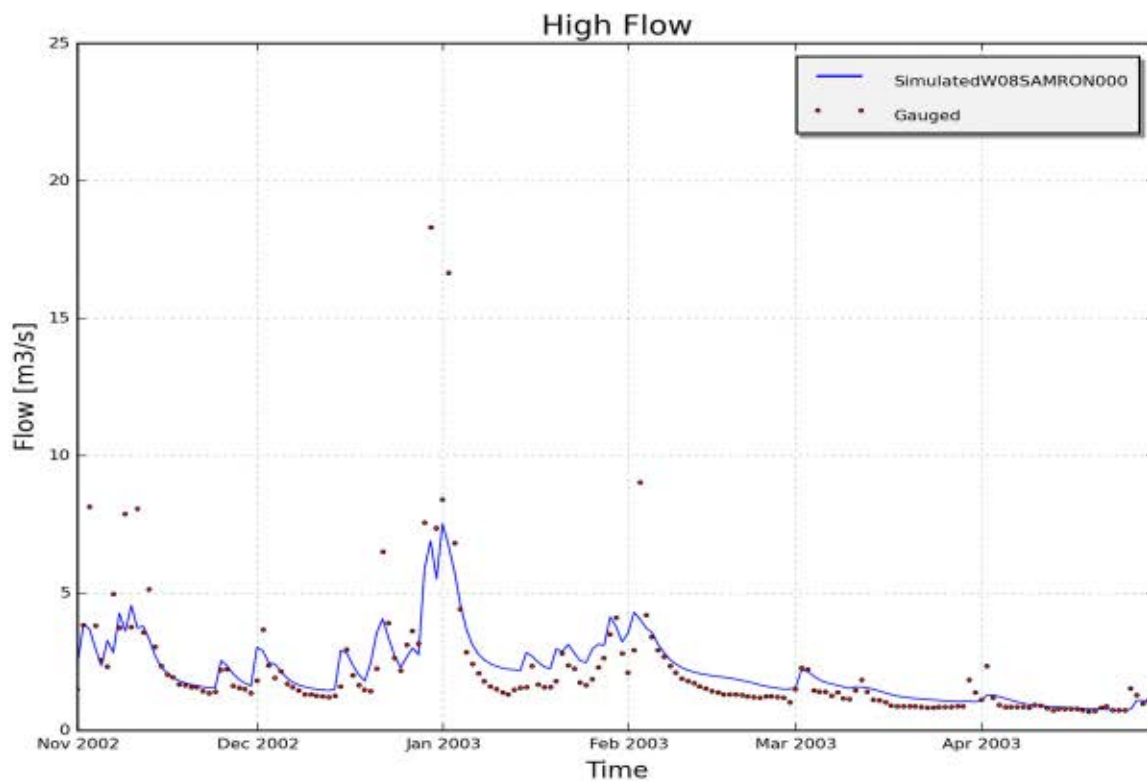


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

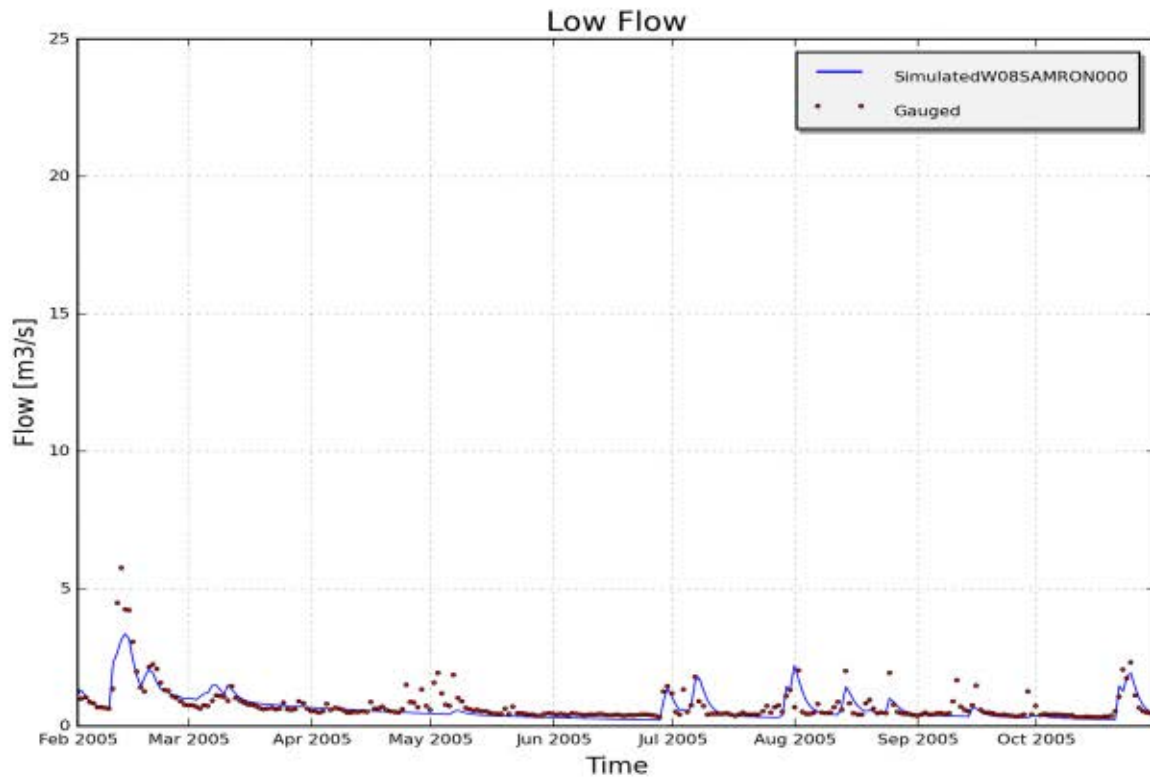


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

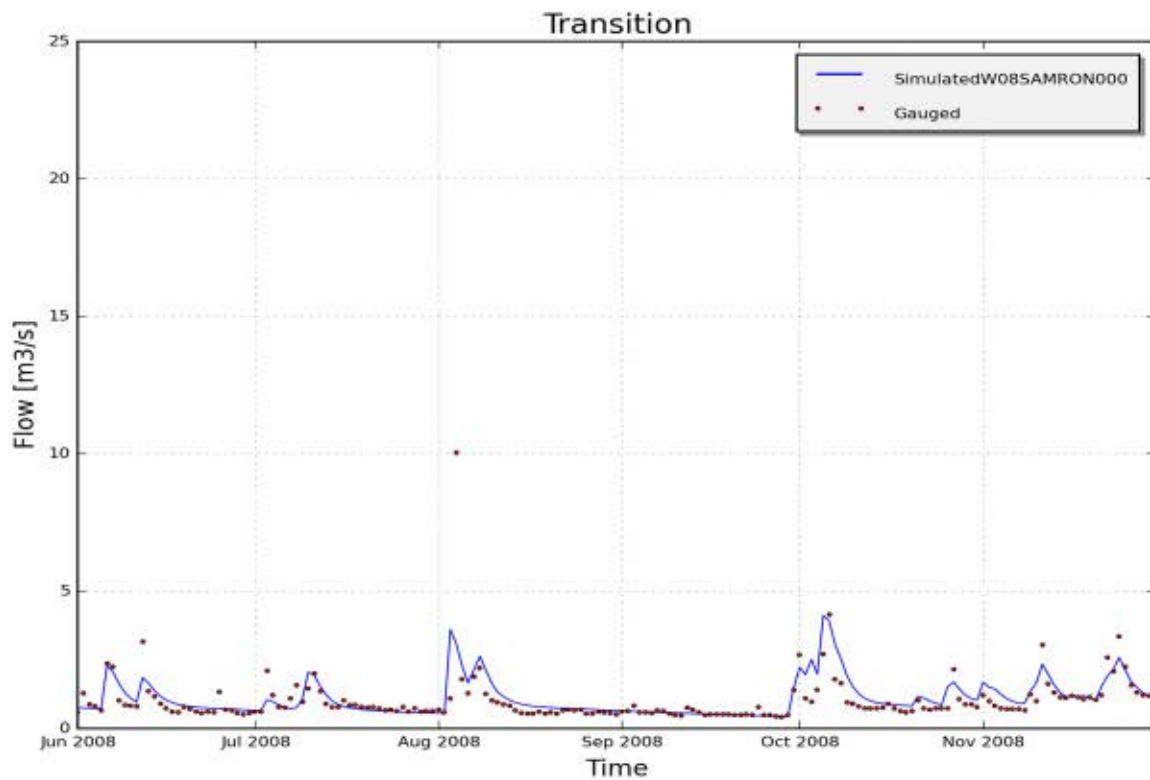


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment W08SAMRON000, station 2371-10050 Samme, Ronquieres

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "W08SENL56010" (DIJLE/ZENNEBEKKEN)

4.1 Input data

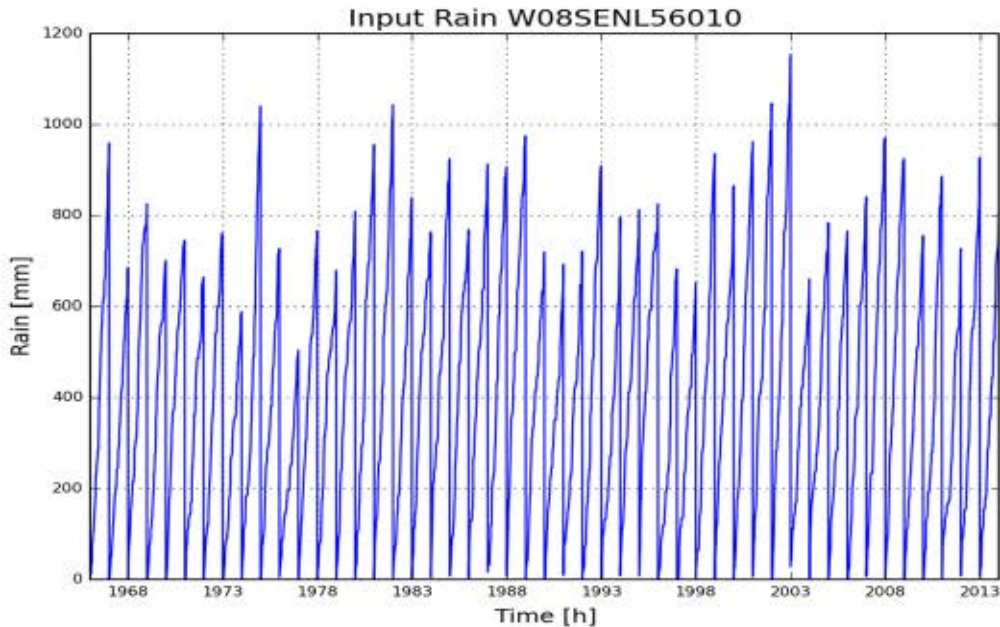


Figure 1: Cumulative precipitation on catchment W08SENL56010 (Dijle/Zennebekken)

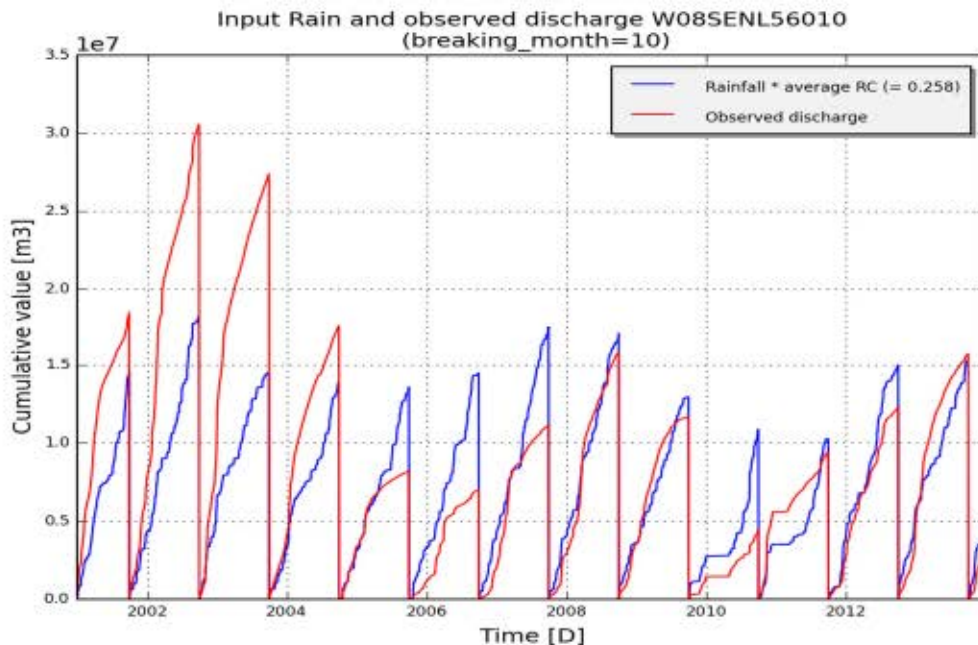


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment W08SENL56010 (Dijle/Zennebekken)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | W08SENL56010 |
| subcatchment_area [m2] | 70364773 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 19.54), (‘SMmax.C’, 965.6), (‘CQOF.C’, 0.31), (‘CKBF.C’, 1989.8), (‘CKIF.C’, 4506.17), (‘CK1.C’, 30.95), (‘CK2.C’, 18.15), (‘TIF.C’, 0.78), (‘TOF.C’, 0.2), (‘NAM.TG.C’, 0.41)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 6723991.548 | 38200000.062 |
| RelErr | -1.3 % | -12.0 % |
| RMSE | 8033472.712 | 45129104.534 |
| NS | 0.6 | 0.558 |
| NS_log | 0.451 | 0.335 |
| NS_rel | 0.076 | 0.346 |

4.3 Observed and simulated timeseries for optimum parameters

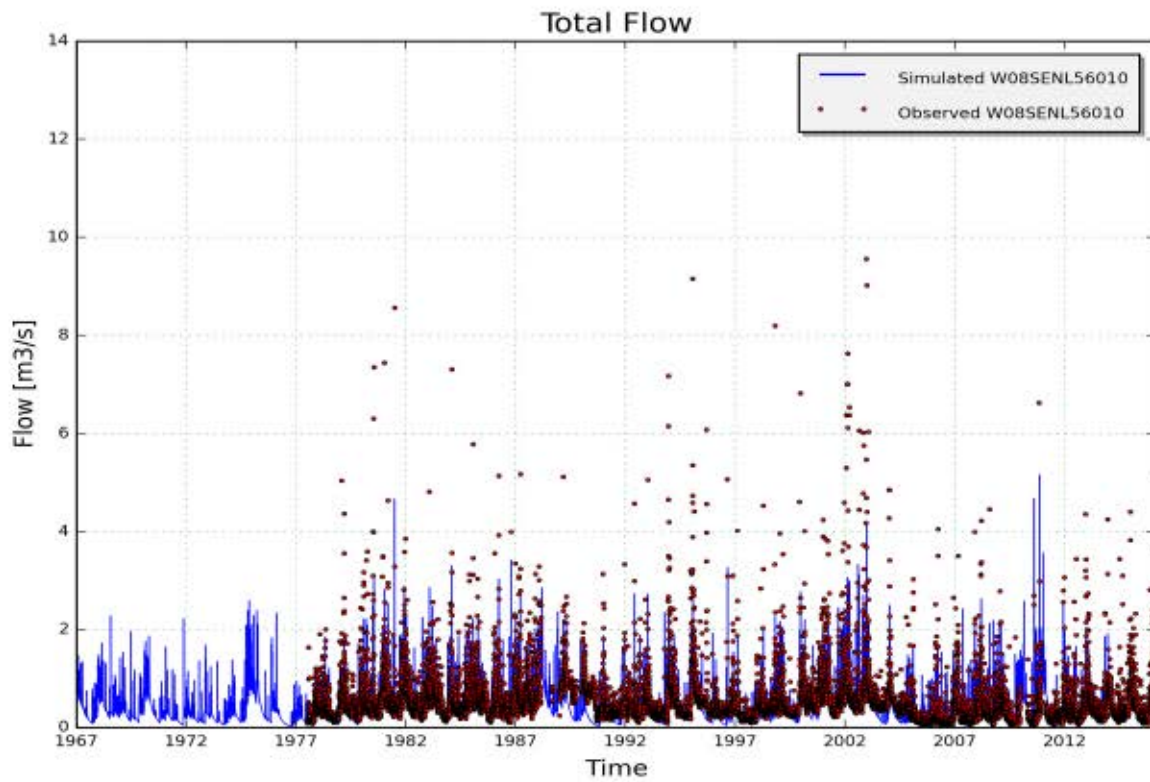


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENL56010, station L5670 -Senette, Ronquieres (validation period 1967-2013)

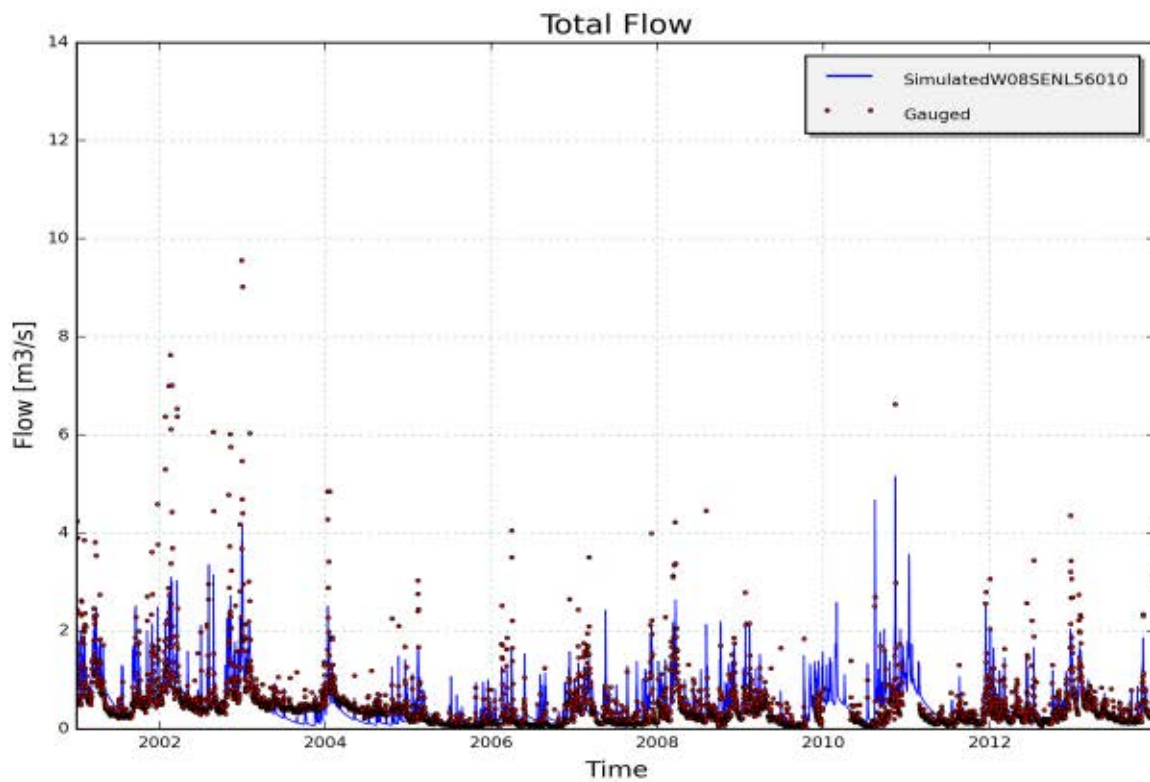


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment W08SENL56010, station L5670 -Senette, Ronquieres(calibration period)

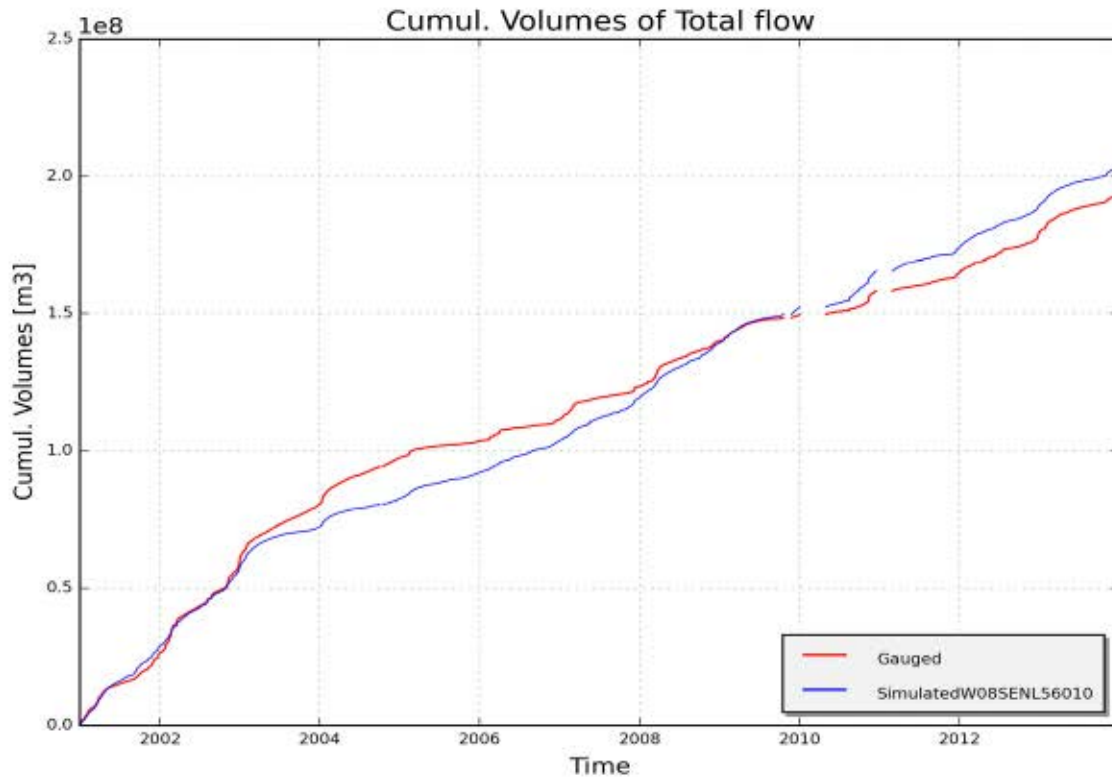


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENL56010, station L5670 -Senette, Ronquieres (calibration period)

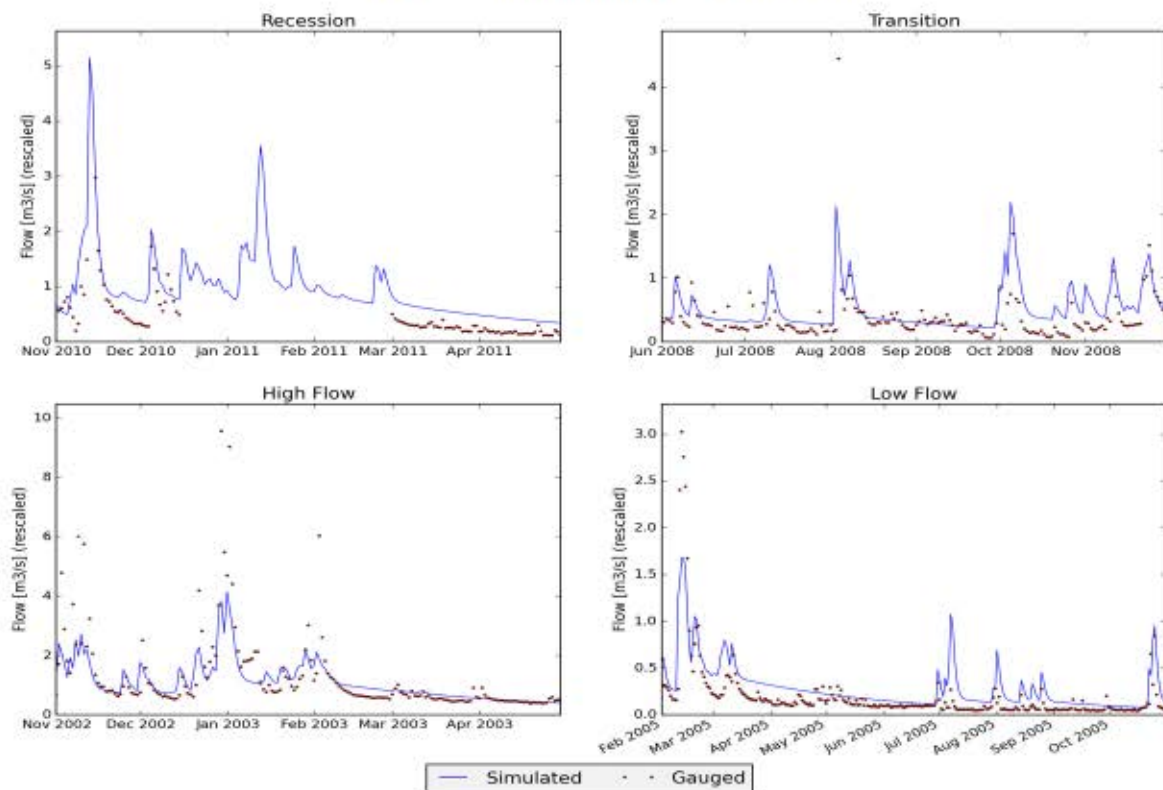


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SENL56010, station L5670 -Senette, Ronquieres

5 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "W08SENTUB030" (DIJLE/ZENNEBEKKEN)

5.1 Input data

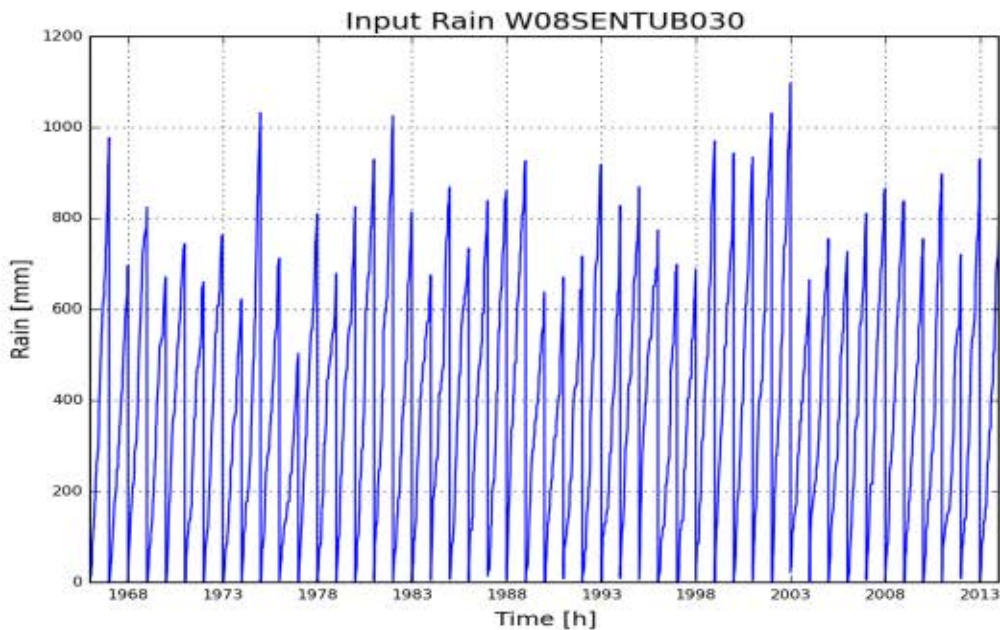


Figure 1: Cumulative precipitation on catchment W08SENTUB030 (Dijle/Zennebekken)

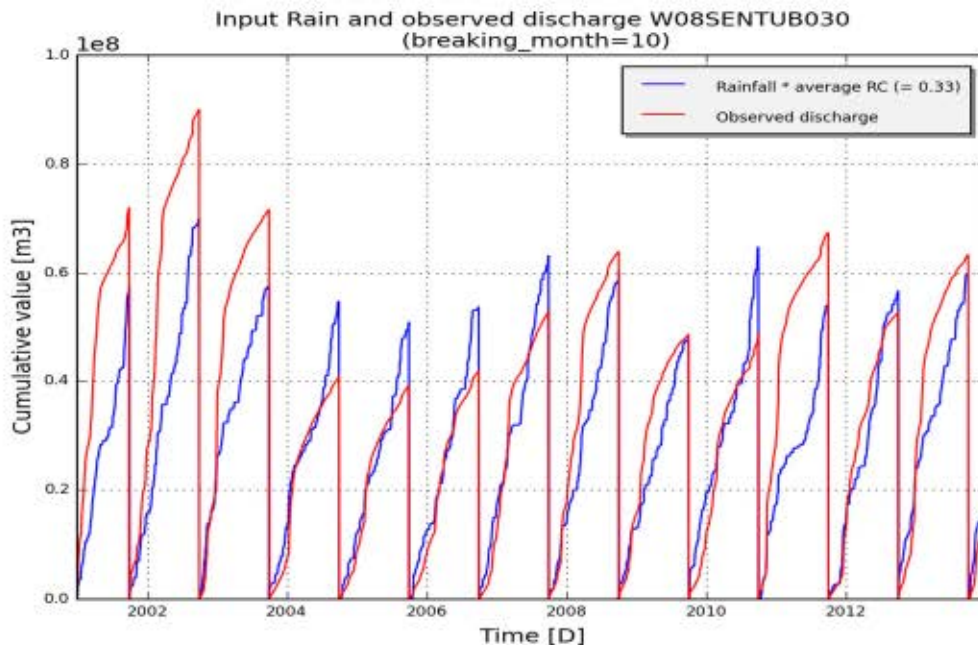


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment W08SENTUB030 (Dijle/Zennebekken)

5.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | W08SENTUB030 |
| subcatchment_area [m2] | 215911078 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.35), (‘SMmax.C’, 325.56), (‘CQOF.C’, 0.83), (‘CKBF.C’, 1536.3), (‘CKIF.C’, 483.24), (‘CK1.C’, 29.5), (‘CK2.C’, 29.64), (‘TIF.C’, 0.7), (‘TOF.C’, 0.44), (‘NAM.TG.C’, 0.03)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 7256139.144 | 67316956.35 |
| RelErr | -0.3 % | -5.6 % |
| RMSE | 8540470.243 | 77019510.405 |
| NS | 0.653 | 0.656 |
| NS_log | 0.685 | 0.642 |
| NS_rel | 0.839 | 0.826 |

5.3 Observed and simulated timeseries for optimum parameters

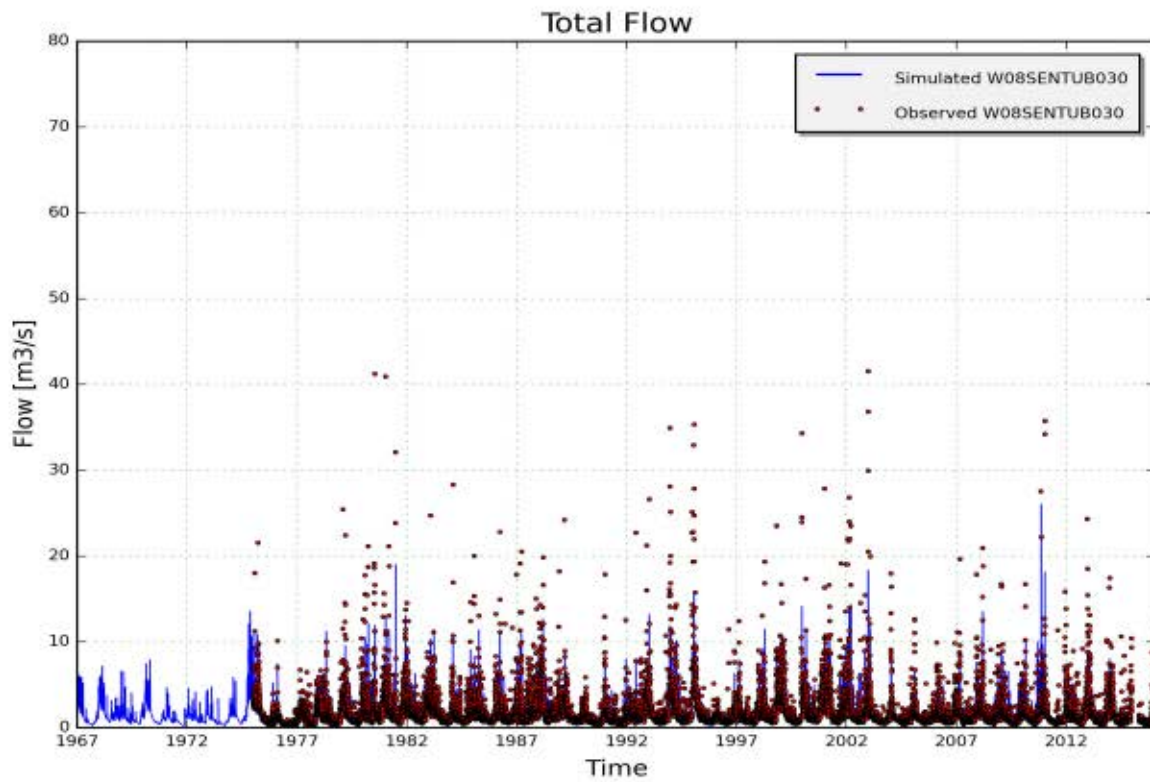


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (validation period 1967-2013)

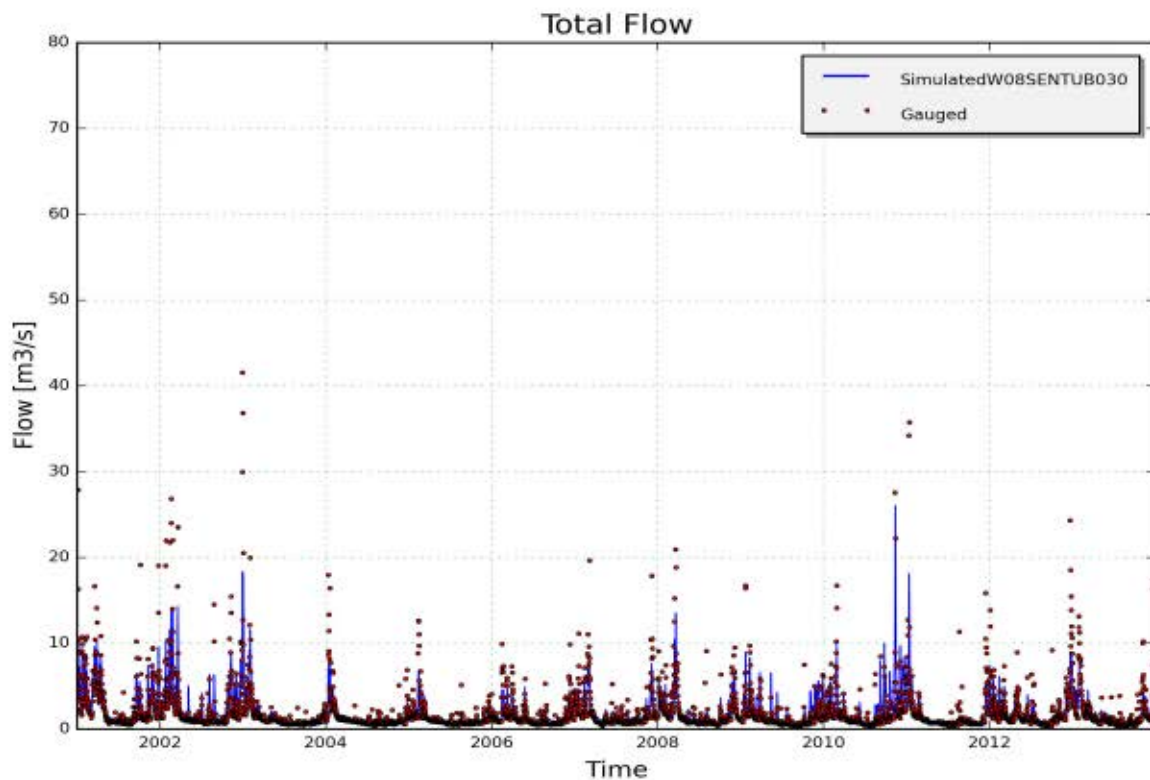


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (calibration period)

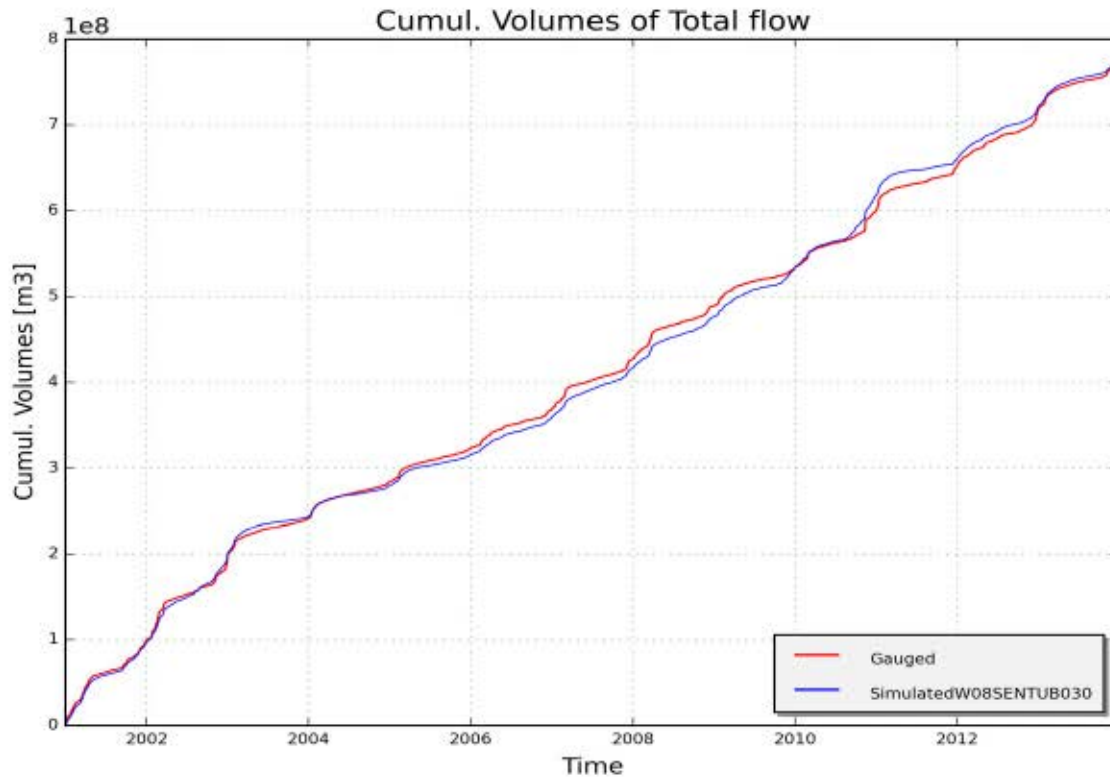


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize (calibration period)

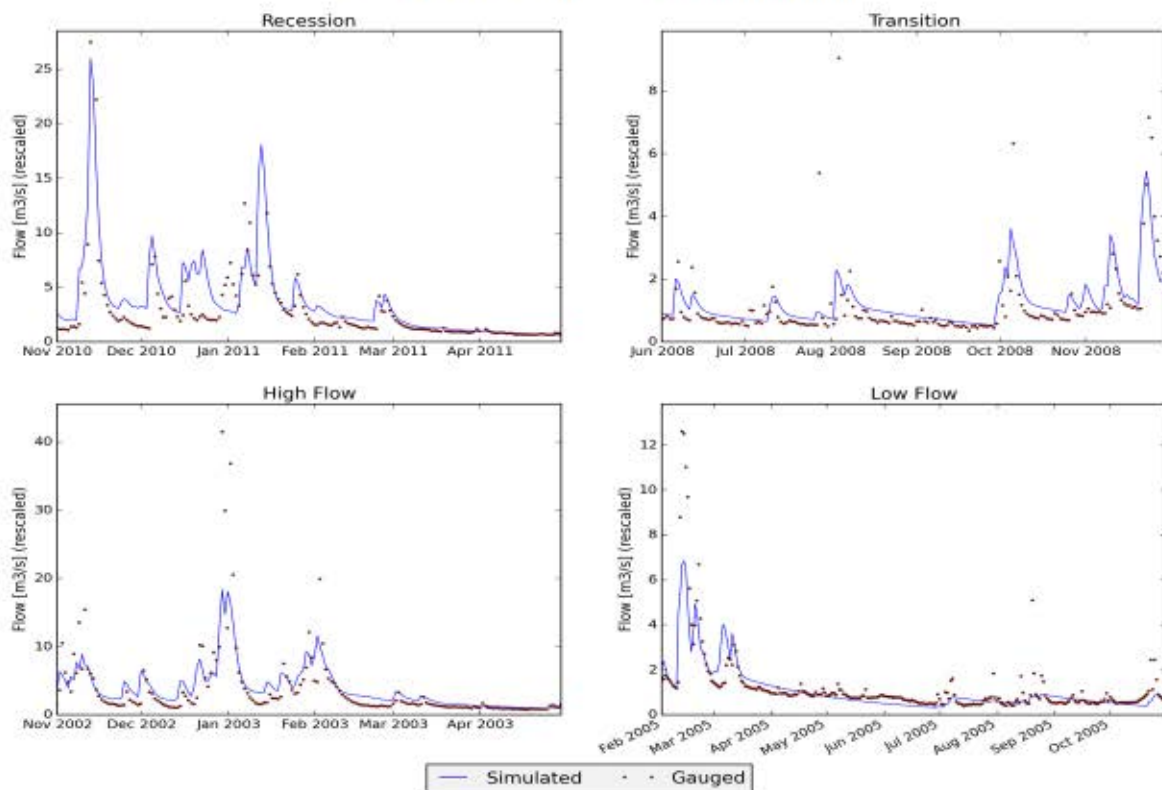


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment W08SENTUB030, station 1951-10050 Zenne, Tubize

6 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V08BAR111370" (DIJLE/ZENNEBEKKEN)

6.1 Input data

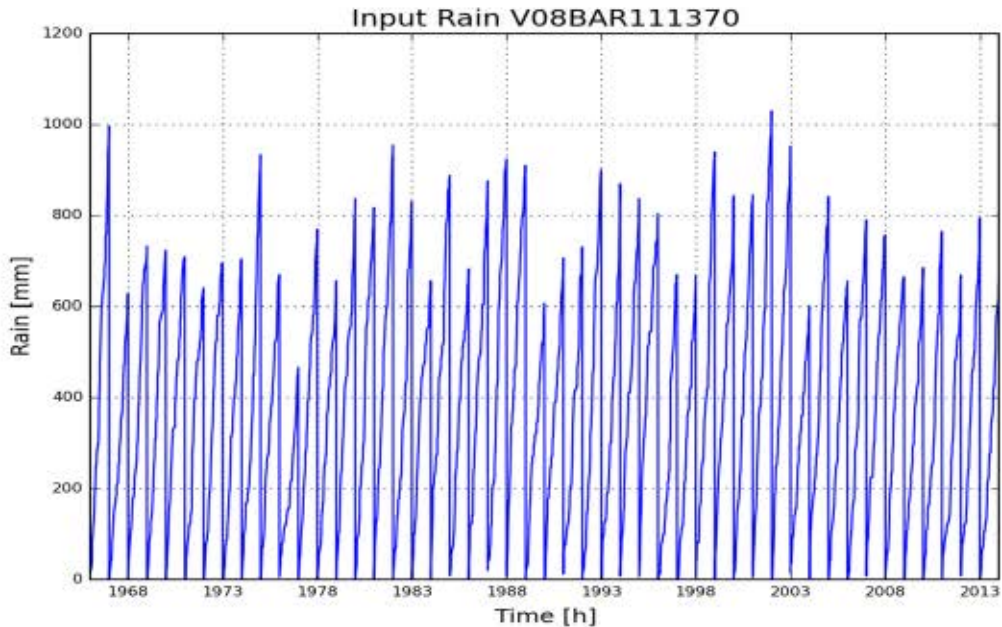


Figure 1: Cumulative precipitation on catchment V08BAR111370 (Dijle/Zennebekken)

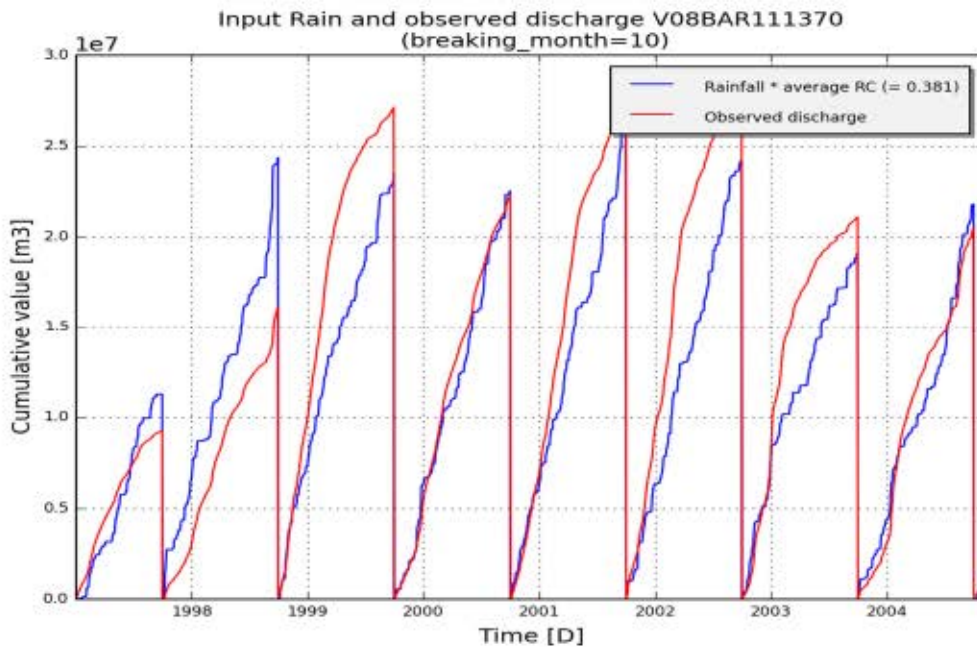


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V08BAR111370 (Dijle/Zennebekken)

6.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V08BAR111370 |
| subcatchment_area [m2] | 70079800 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 4.83), (‘SMmax.C’, 452.25), (‘CQOF.C’, 0.37), (‘CKBF.C’, 1138.99), (‘CKIF.C’, 369.59), (‘CK1.C’, 36.58), (‘CK2.C’, 30.89), (‘TIF.C’, 0.2), (‘TOF.C’, 0.21), (‘NAM.TG.C’, 0.12)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 1945008.825 | 1826432.625 |
| RelErr | 0.8 % | 0.2 % |
| RMSE | 2563133.234 | 2474846.775 |
| NS | 0.76 | 0.761 |
| NS_log | 0.802 | 0.802 |
| NS_rel | 0.797 | 0.799 |

6.3 Observed and simulated timeseries for optimum parameters

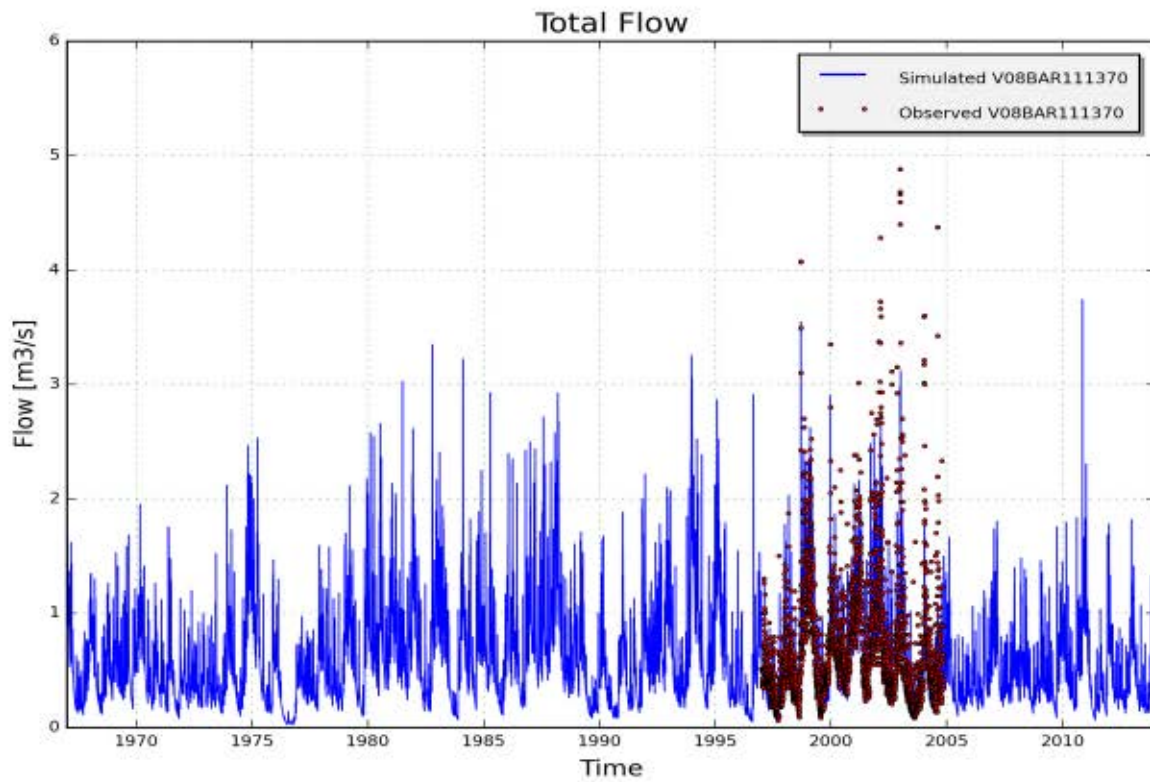


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08BAR111370, station 11110102-Barebeek (validation period 1967-2013)

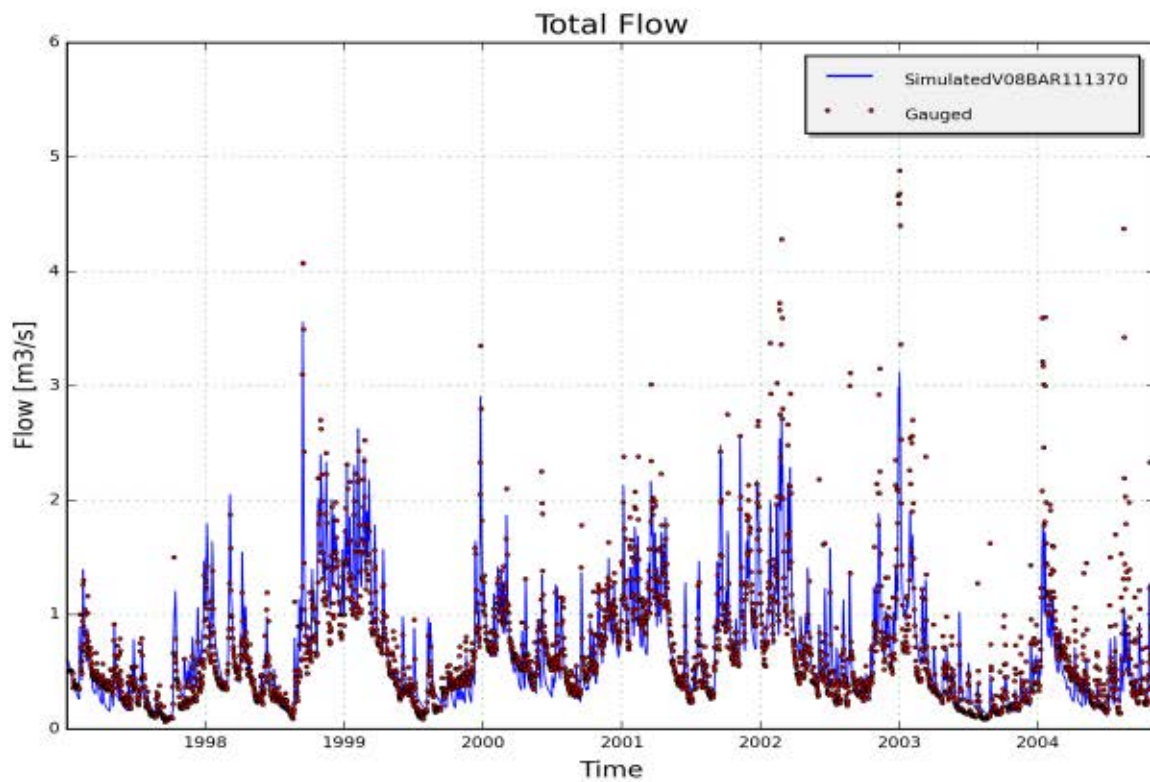


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V08BAR111370, station 11110102-Barebeek (calibration period)

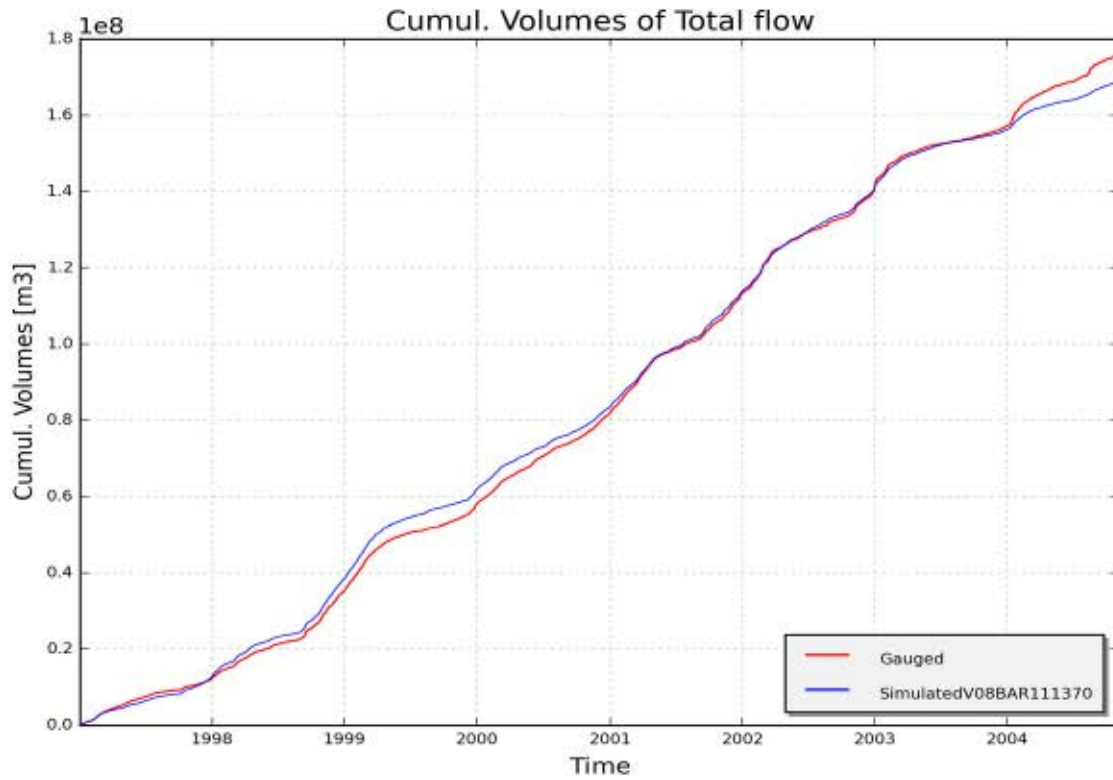


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V08BAR111370, station 11110102-Barebeek (calibration period)

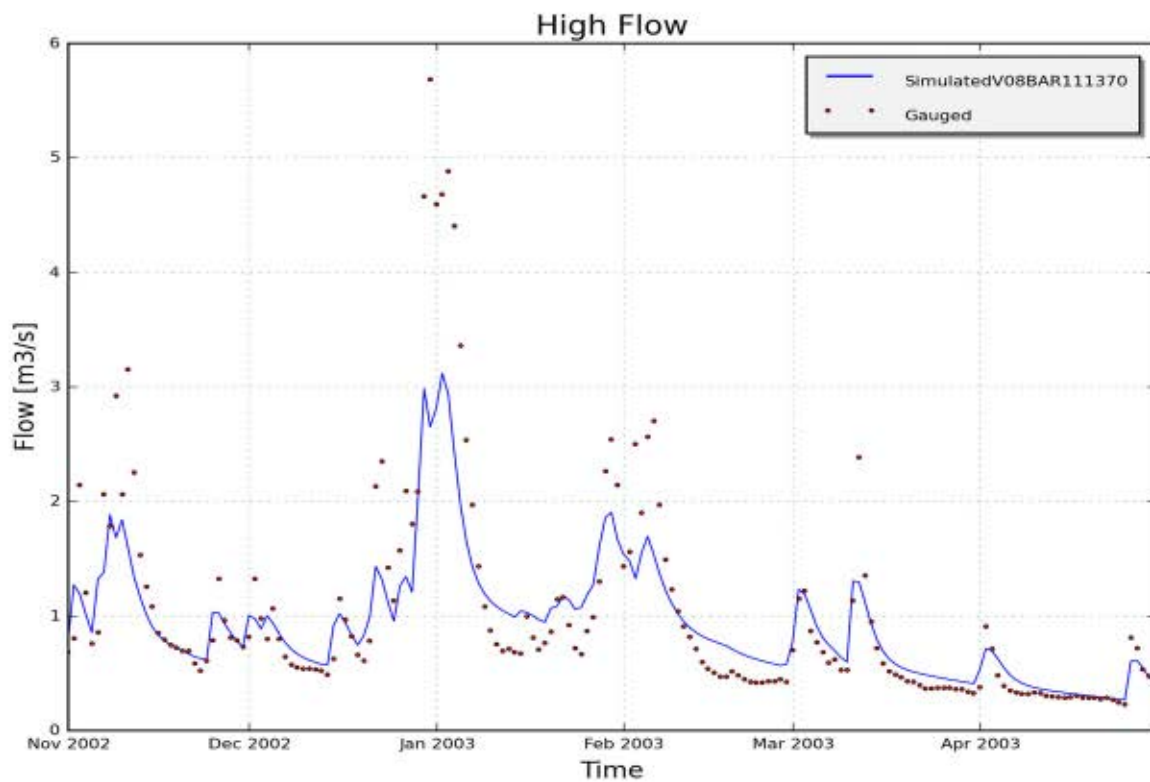


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V08BAR111370, station 11110102-Barebeek

Appendix 11

Results of calibration and validation of NAM parameters for catchment "V09HER163010" (DEMERBEKKEN)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09HER163010" (DEMERBEKKEN)

1.1 Input data

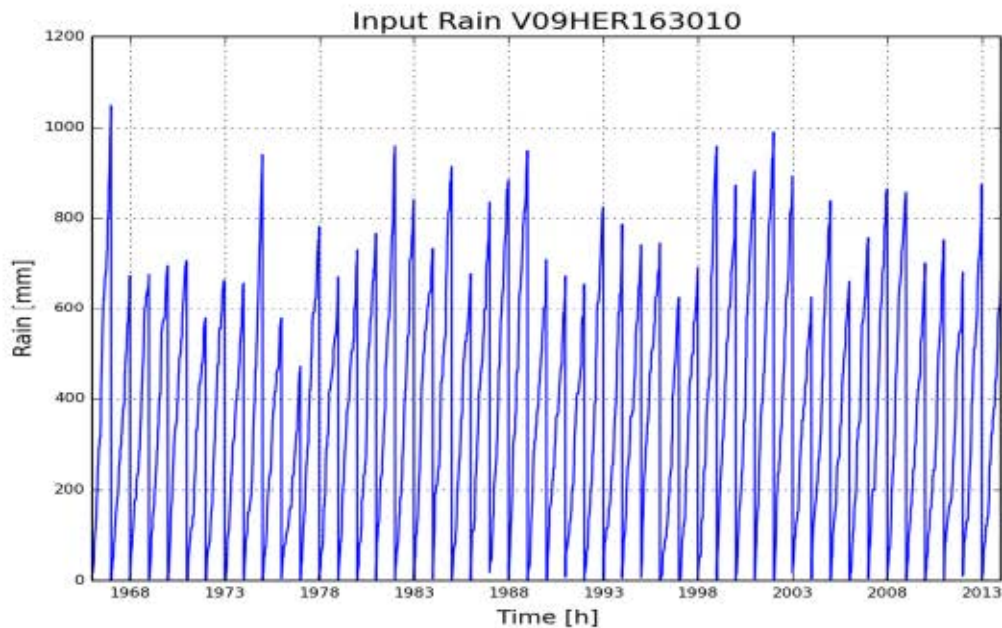


Figure 1: Cumulative precipitation on catchment V09HER163010 (Demerbekken)

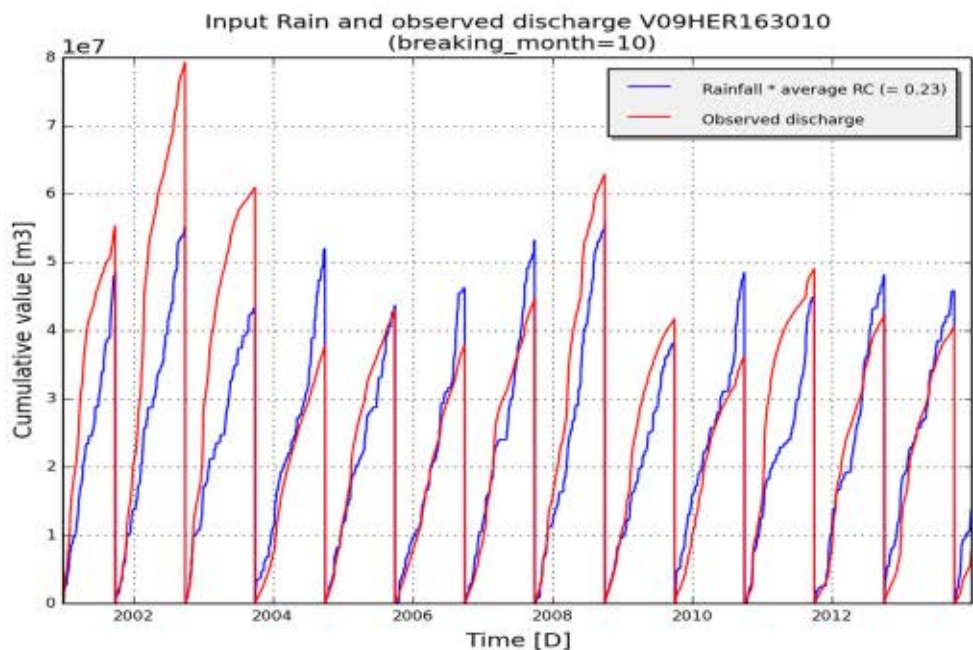


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09HER163010 (Demerbekken)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09HER163010 |
| subcatchment_area [m2] | 274602221 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 19.26), (‘SMmax.C’, 1675.52), (‘CQOF.C’, 0.27), (‘CKBF.C’, 3308.71), (‘CKIF.C’, 437.64), (‘CK1.C’, 32.29), (‘CK2.C’, 36.3), (‘TIF.C’, 0.9), (‘TOF.C’, 0.24), (‘NAM.TG.C’, 0.33)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 6920562.004 | 47420626.386 |
| RelErr | 0.2 % | -4.9 % |
| RMSE | 8364282.876 | 51143396.617 |
| NS | 0.623 | 0.602 |
| NS_log | 0.607 | 0.609 |
| NS_rel | 0.687 | 0.518 |

1.3 Observed and simulated timeseries for optimum parameters

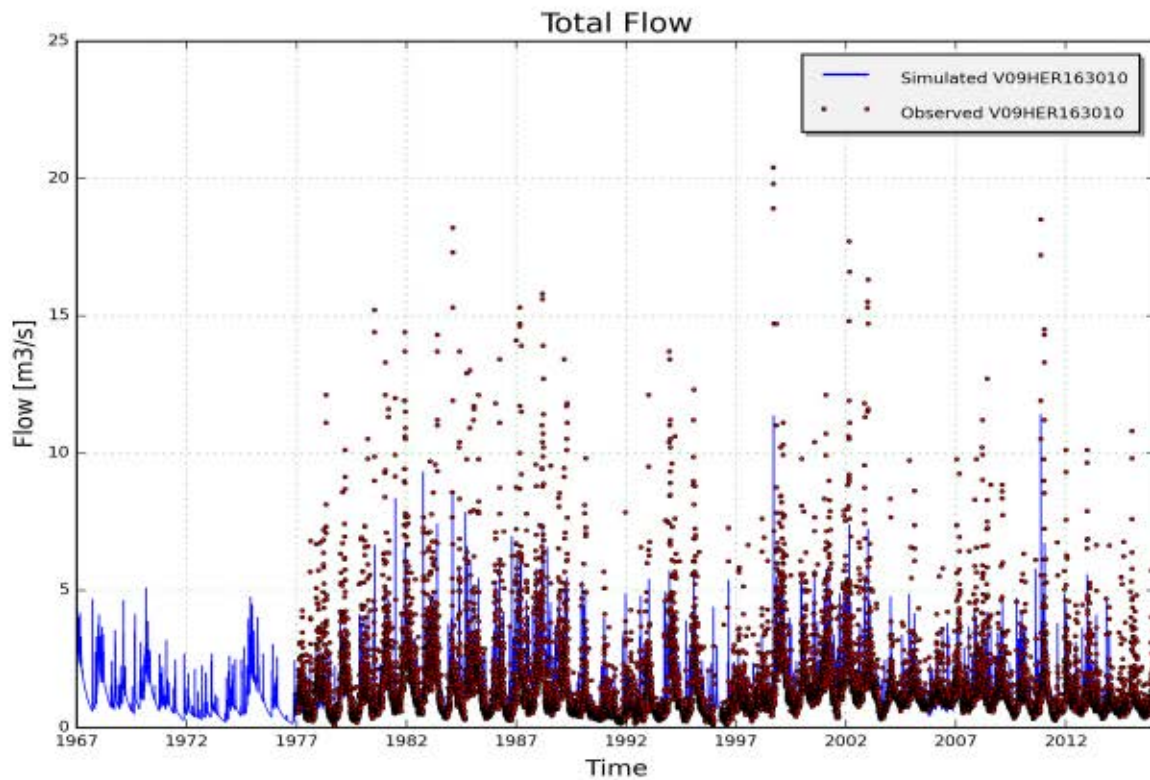


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (validation period 1967-2013)

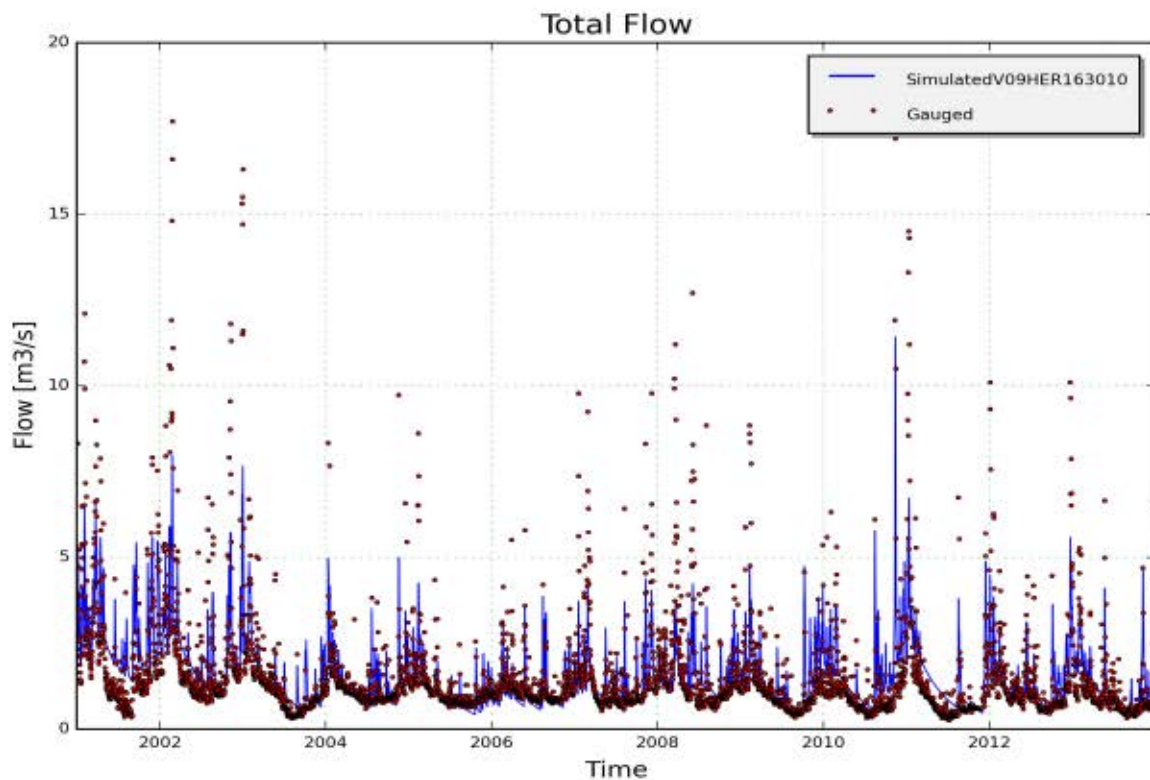


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09HER163010, station 16310102 - Herk, Kermt (calibration period)

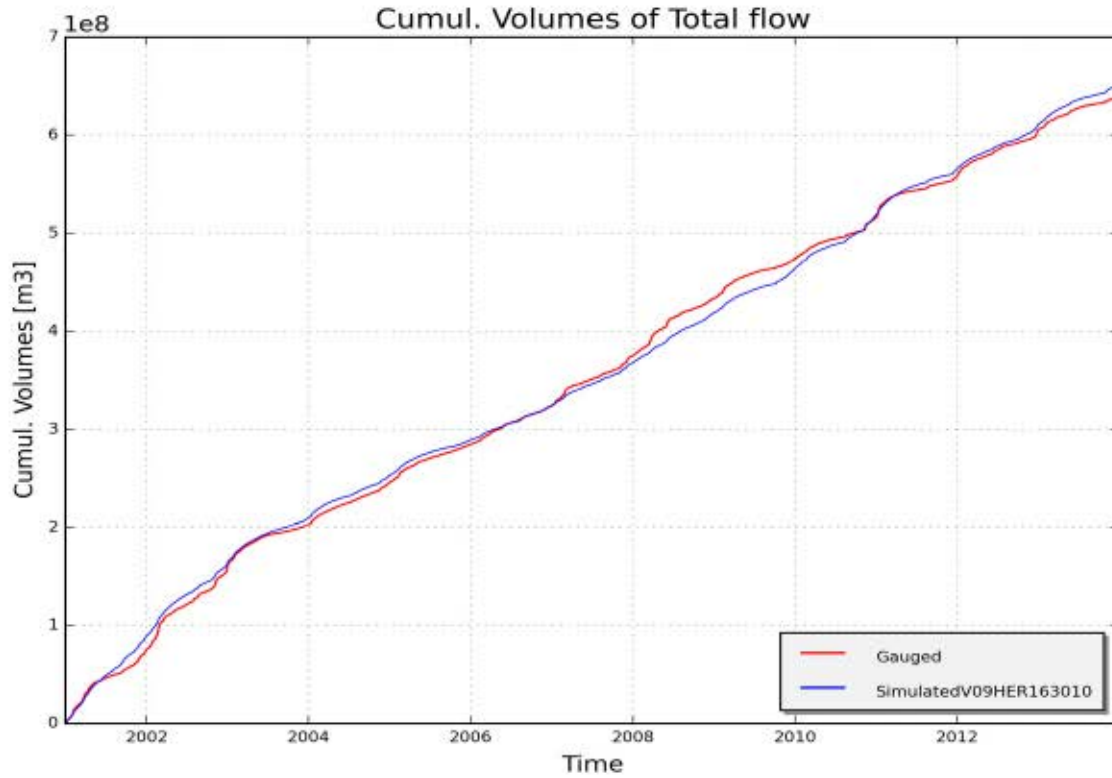


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09HER163010, station 16310102 - Herk, Kermt (calibration period)

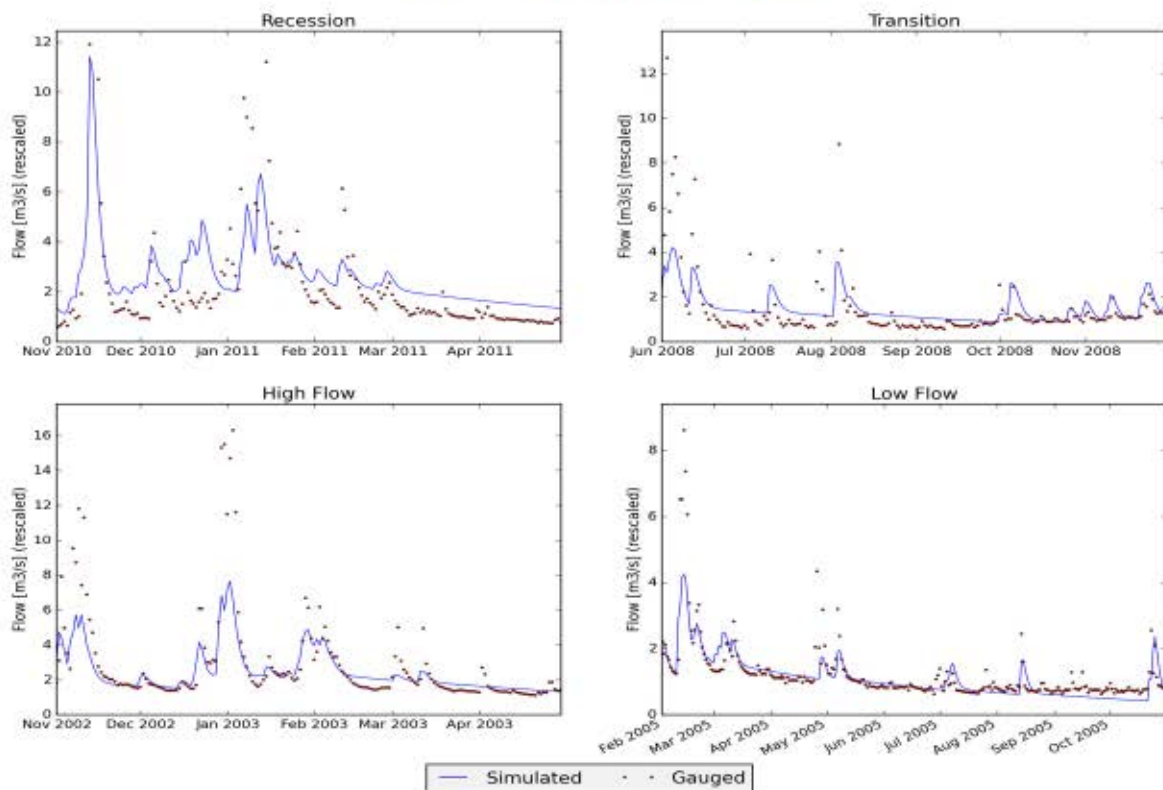


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09HER163010, station 16310102 - Herk, Kermt

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09HUL147150" (DEMERBEKKEN)

2.1 Input data

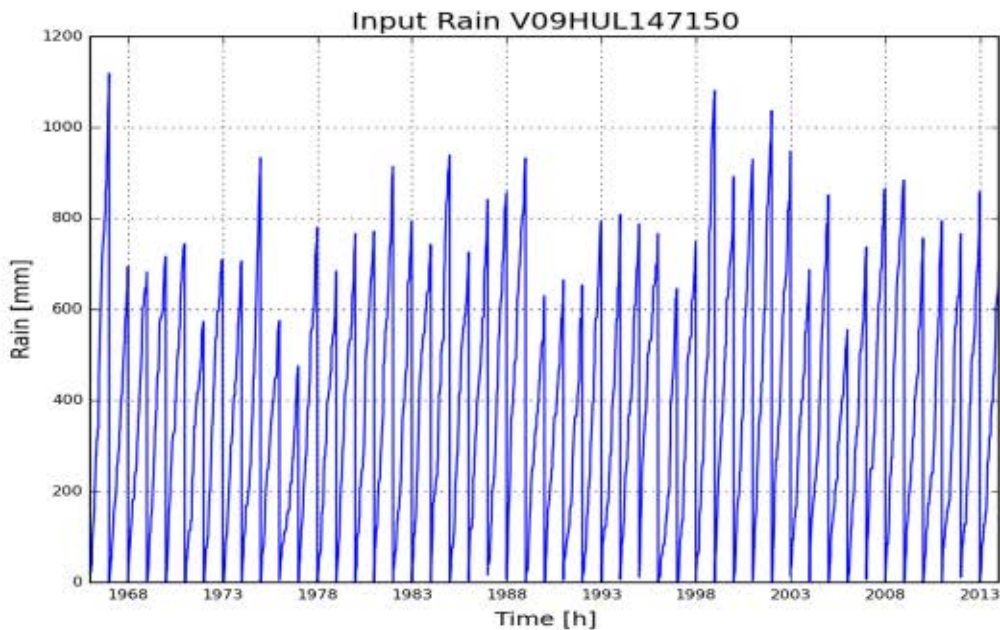


Figure 1: Cumulative precipitation on catchment V09HUL147150 (Demerbekken)

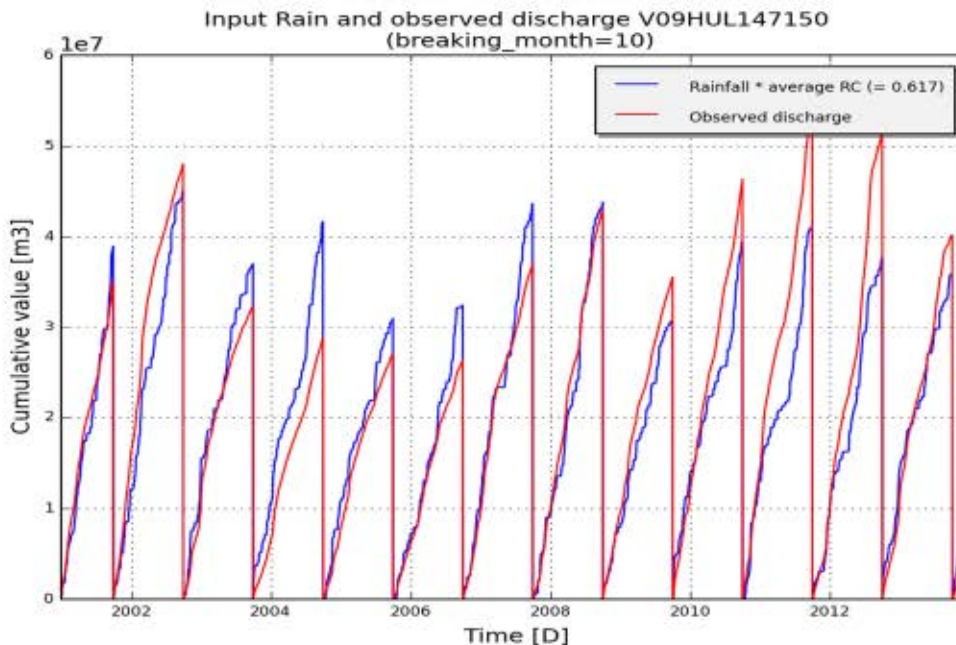


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09HUL147150 (Demerbekken)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09HUL147150 |
| subcatchment_area [m2] | 80130245 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:['Umax.C', 0.4), ('SMmax.C', 35.0), ('CQOF.C', 0.27), ('CKBF.C', 8000.0), ('CKIF.C', 30.0), ('CK1.C', 50.0), ('CK2.C', 44.48), ('TIF.C', 0.01), ('TOF.C', 0.01), ('NAM.TG.C', 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 31980096.038 | 13277784.343 |
| RelErr | -13.0 % | -0.2 % |
| RMSE | 40632489.161 | 20120179.173 |
| NS | 0.464 | 0.586 |
| NS_log | 0.474 | 0.541 |
| NS_rel | 0.746 | 0.648 |

2.3 Observed and simulated timeseries for optimum parameters

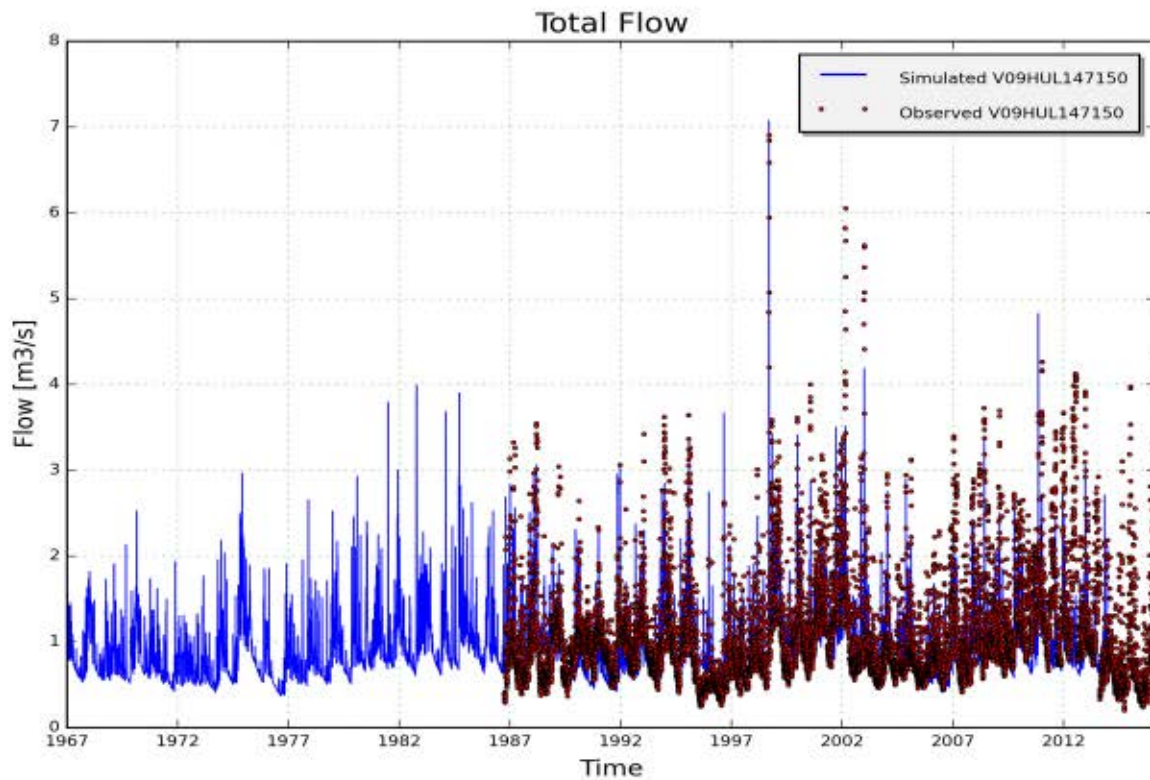


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (validation period 1967-2013)

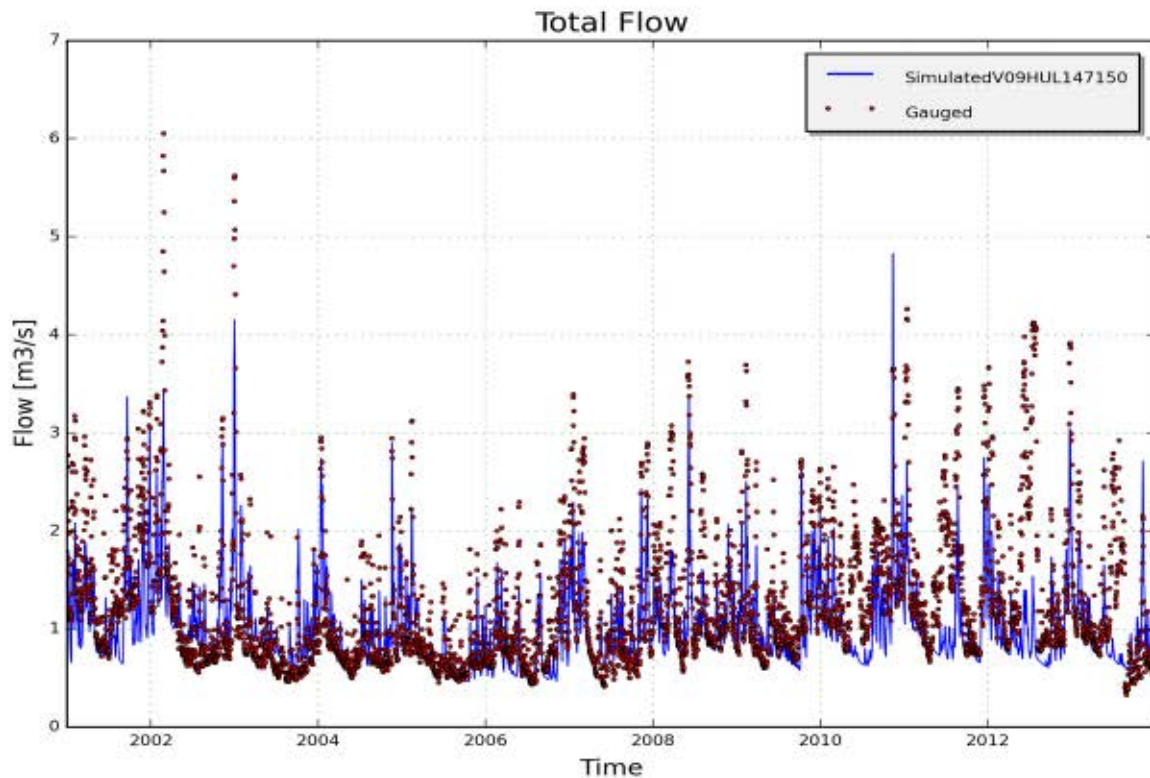


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (calibration period)

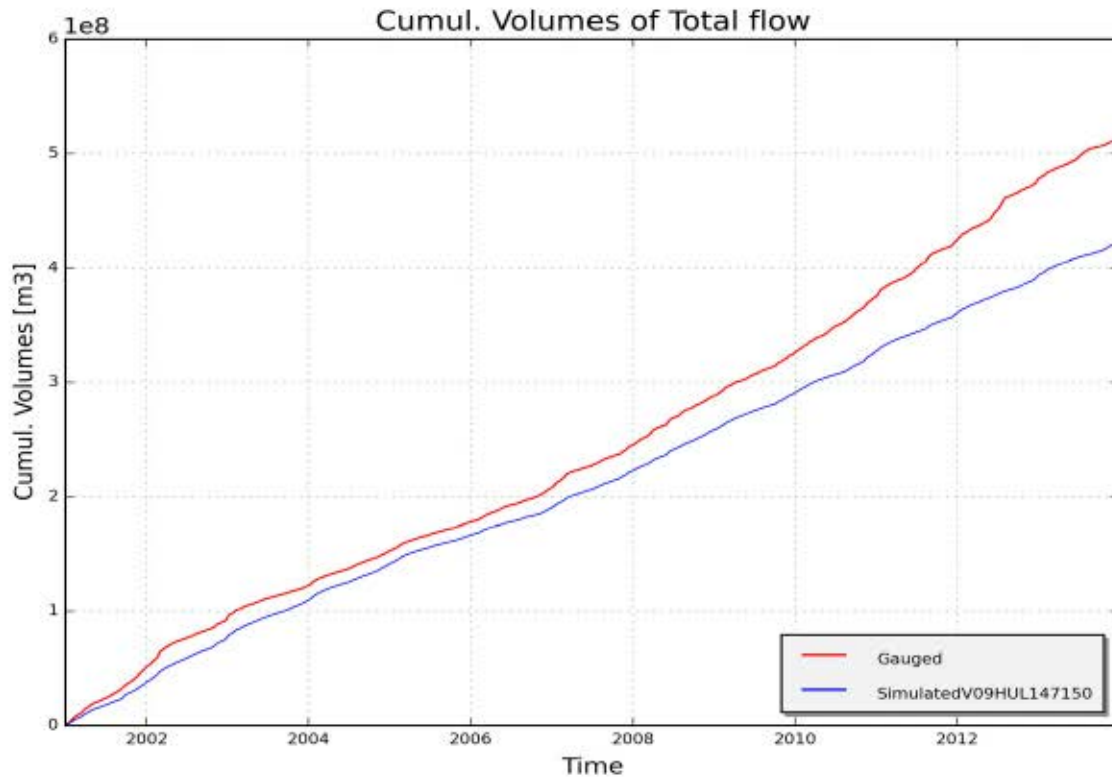


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede (calibration period)

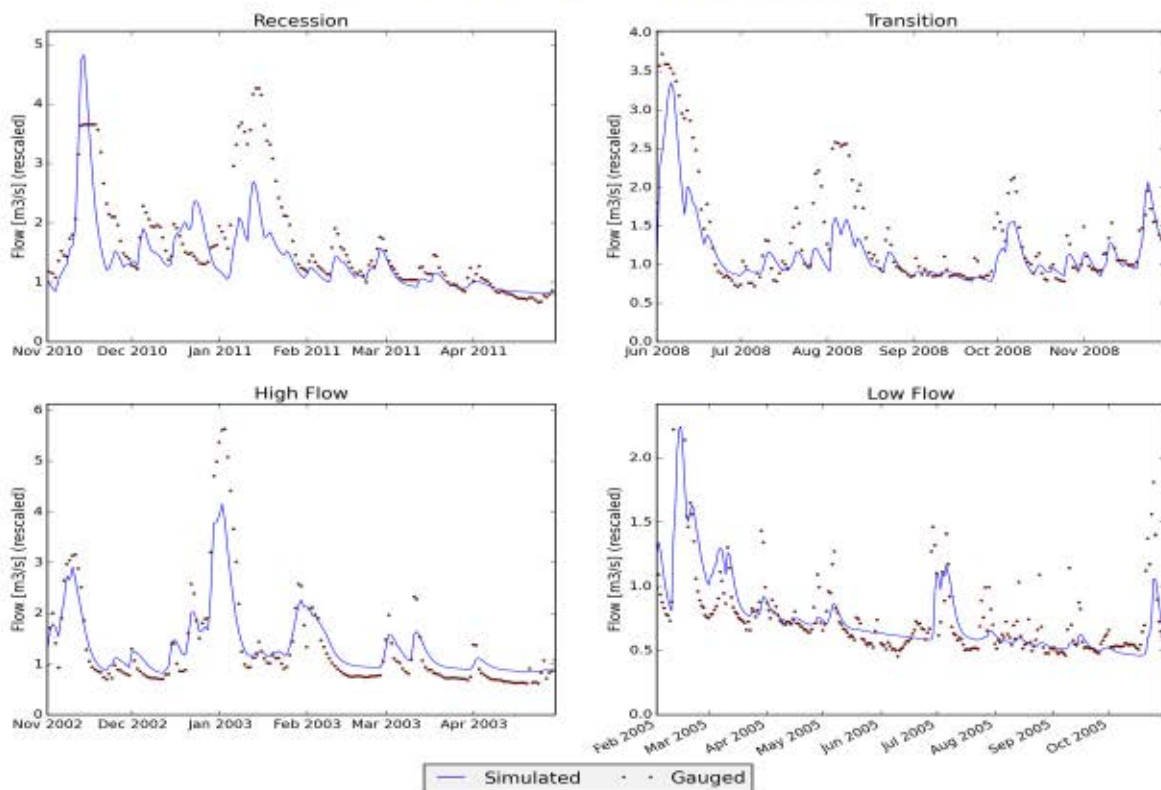


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09HUL147150, station 14710102 - De Hulpe; Molenstede

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09LOS143300" (DEMERBEKKEN)

3.1 Input data

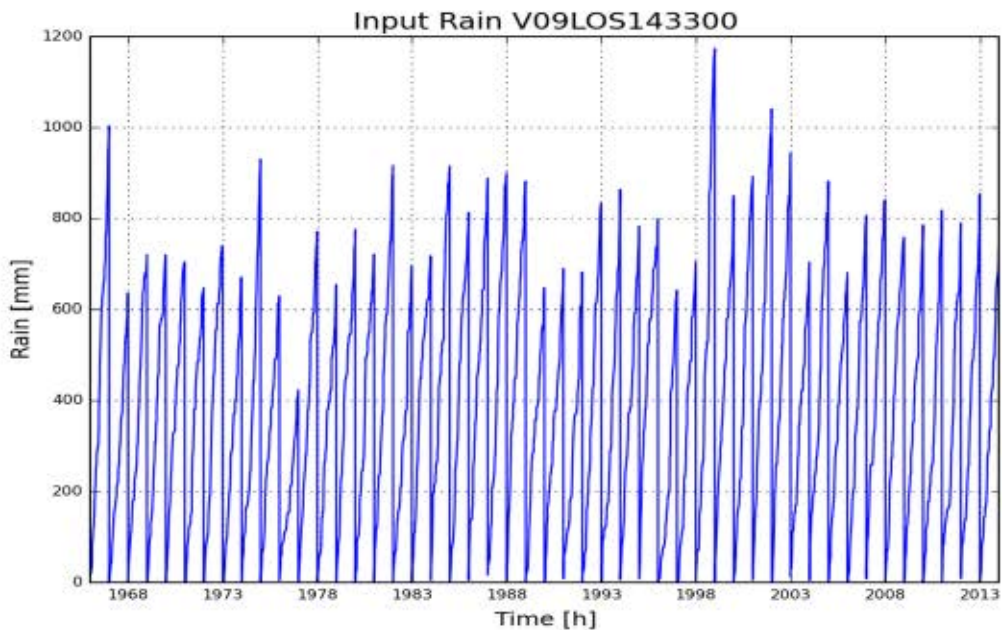


Figure 1: Cumulative precipitation on catchment V09LOS143300 (Demerbekken)

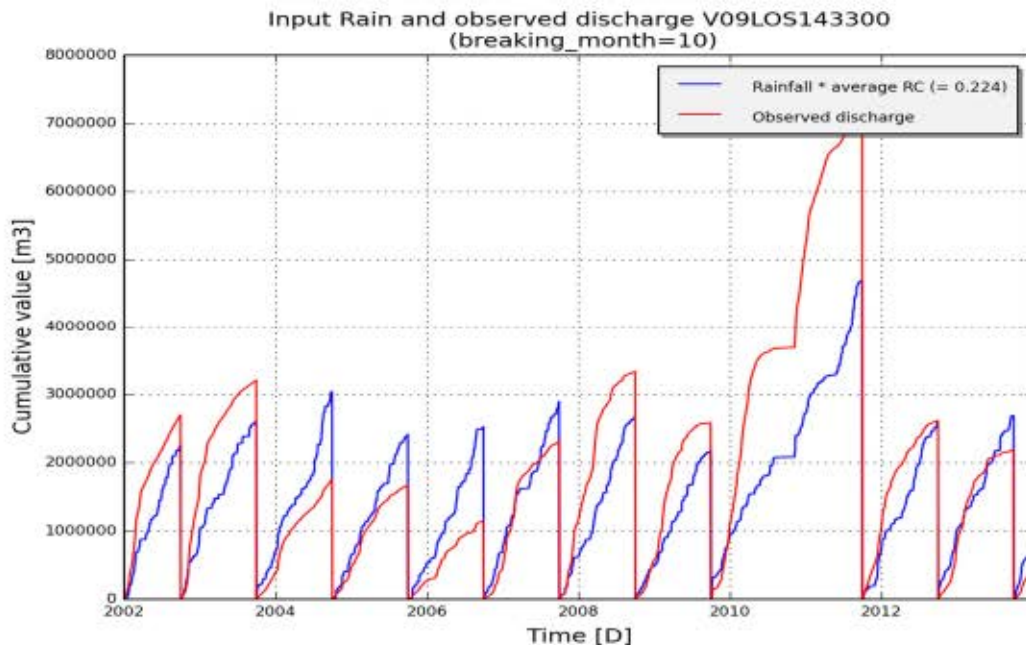


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09LOS143300 (Demerbekken)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09LOS143300 |
| subcatchment_area [m2] | 15176294 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 11.29), (‘SMmax.C’, 1087.47), (‘CQOF.C’, 0.59), (‘CKBF.C’, 1234.35), (‘CKIF.C’, 485.29), (‘CK1.C’, 25.27), (‘CK2.C’, 16.43), (‘TIF.C’, 0.53), (‘TOF.C’, 0.7), (‘NAM.TG.C’, 0.66)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 647896.733 | 11424059.66 |
| RelErr | 2.4 % | 37.9 % |
| RMSE | 730353.39 | 12943115.878 |
| NS | 0.662 | 0.319 |
| NS_log | 0.515 | 0.295 |
| NS_rel | -1.225 | -13.562 |

3.3 Observed and simulated timeseries for optimum parameters

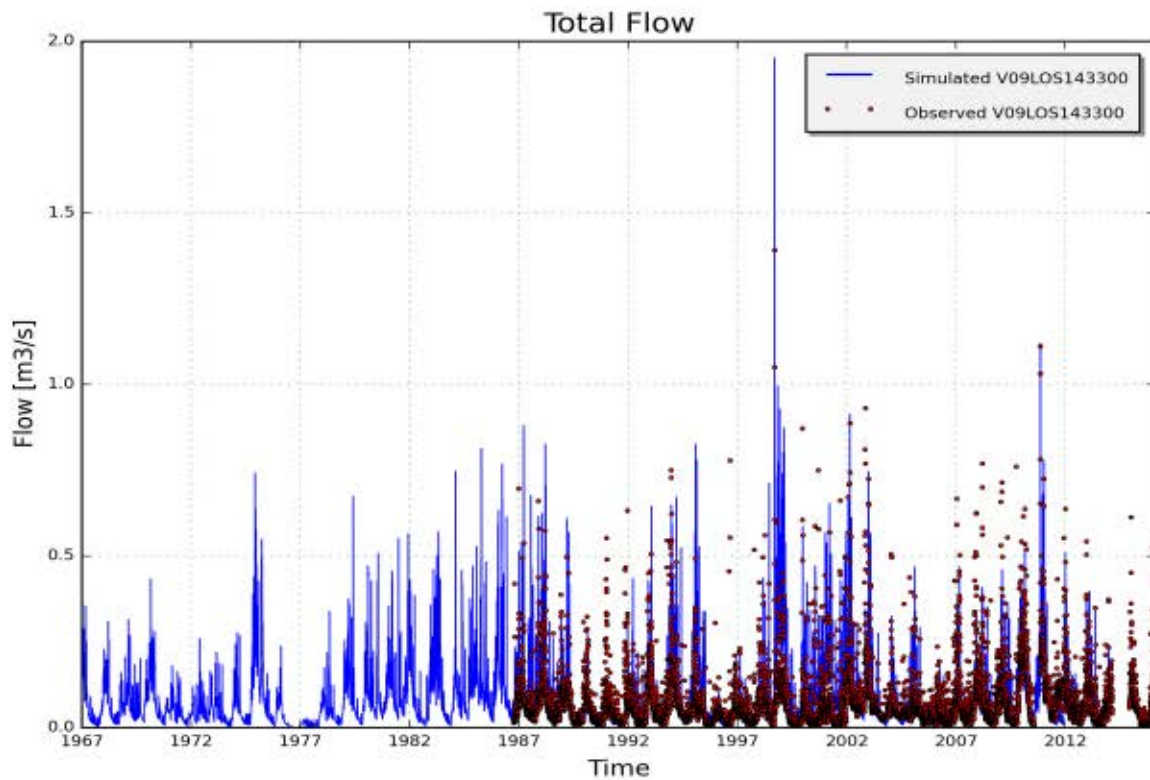


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal (validation period 1967-2013)

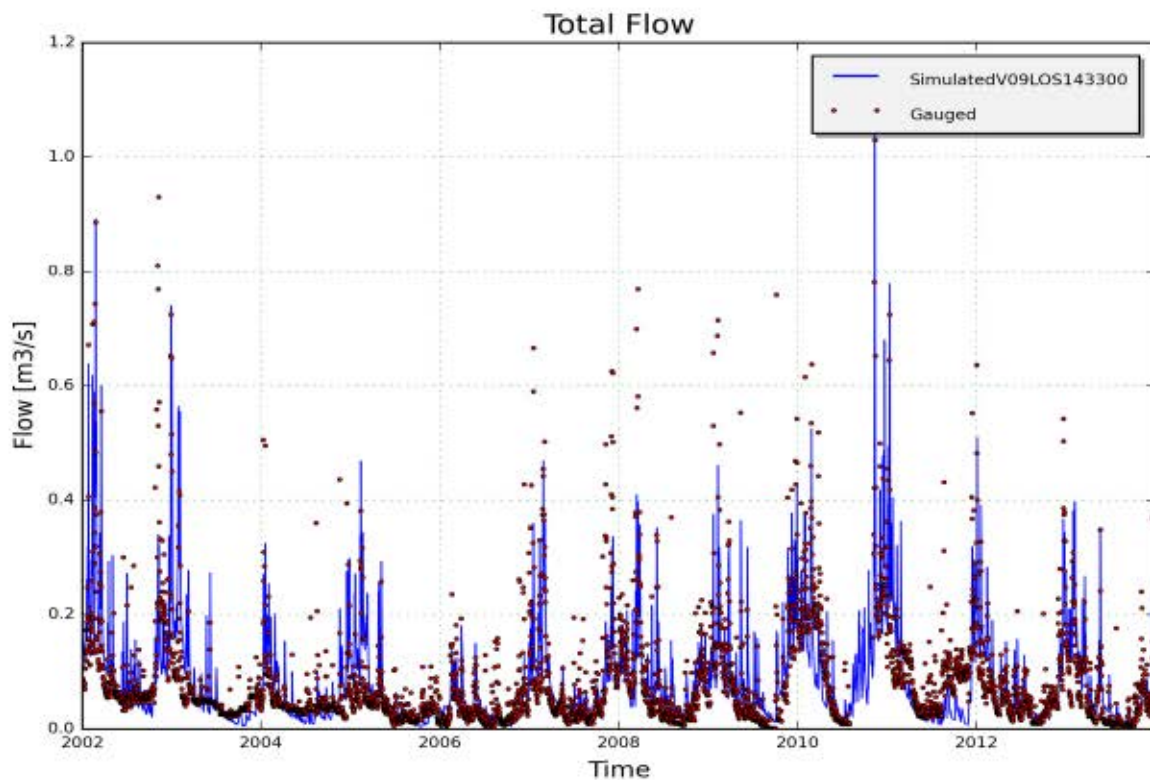


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09LOS143300, station 14310102 - Grote Losting; Wezemaal(calibration period)

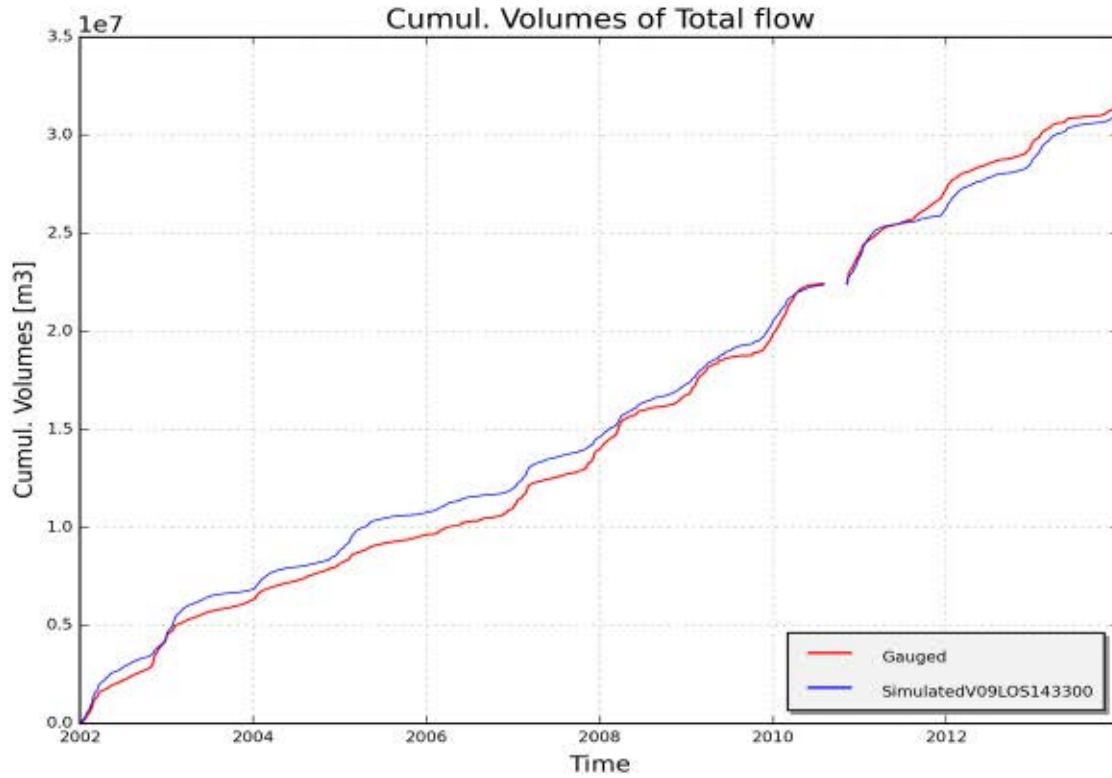


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09LOS143300, station 14310102 - Grote Losing; Wezemaal (calibration period)

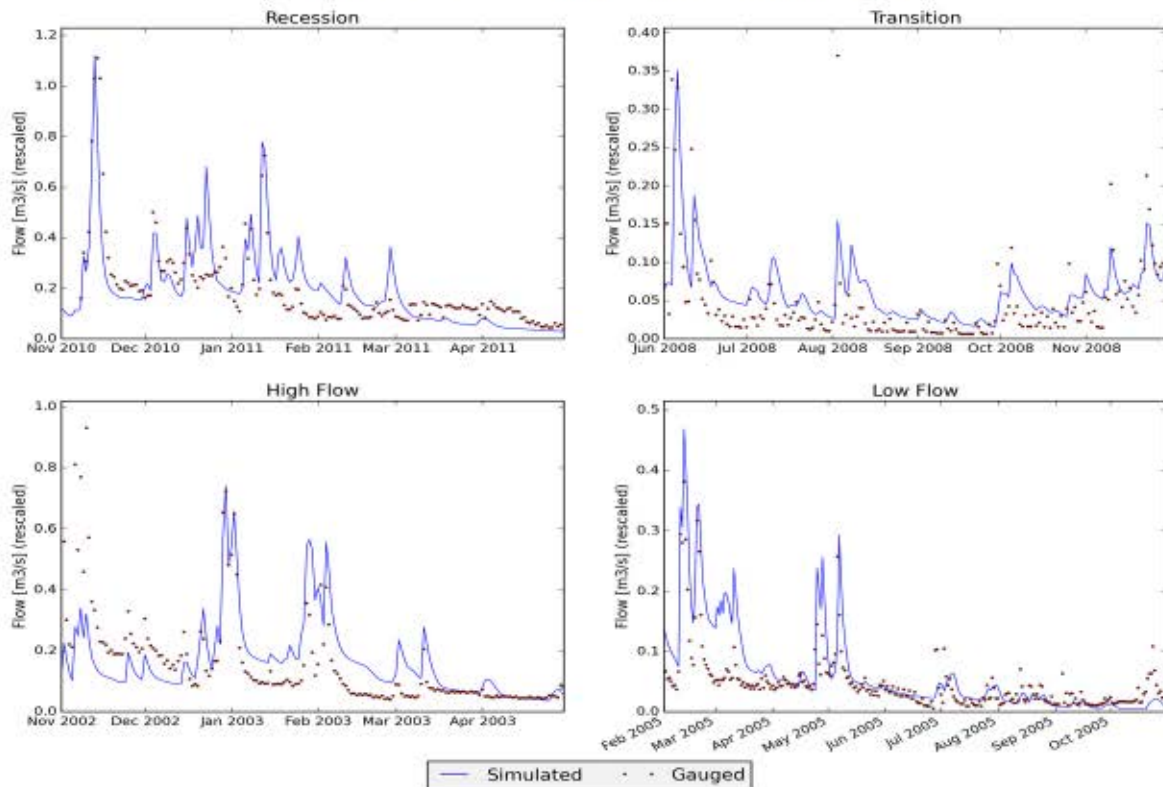


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09LOS143300, station 14310102 - Grote Losing; Wezemaal

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09MAN161040" (DEMERBEKKEN)

4.1 Input data

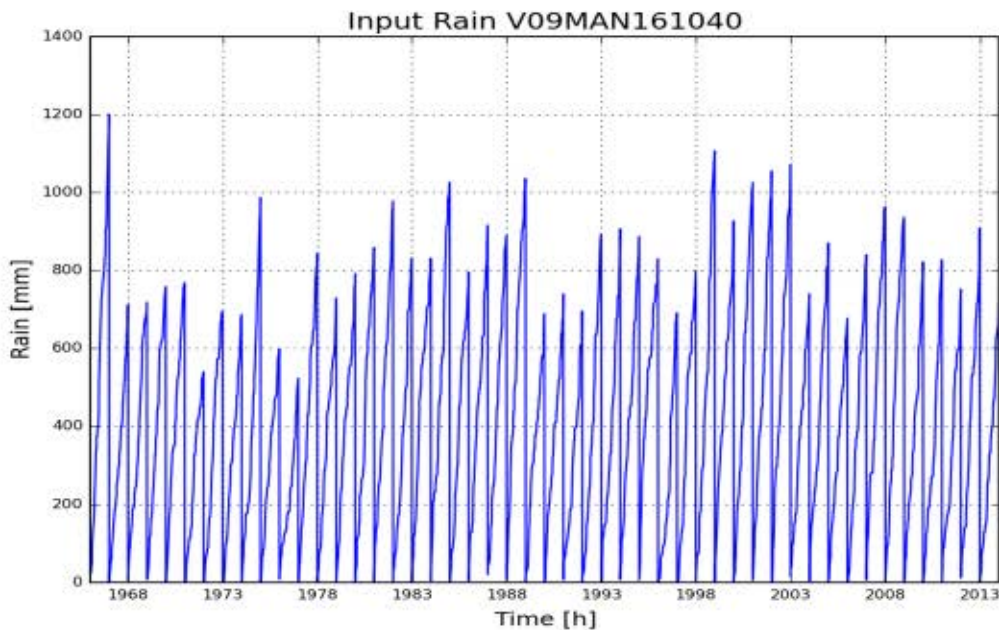


Figure 1: Cumulative precipitation on catchment V09MAN161040 (Demerbekken)

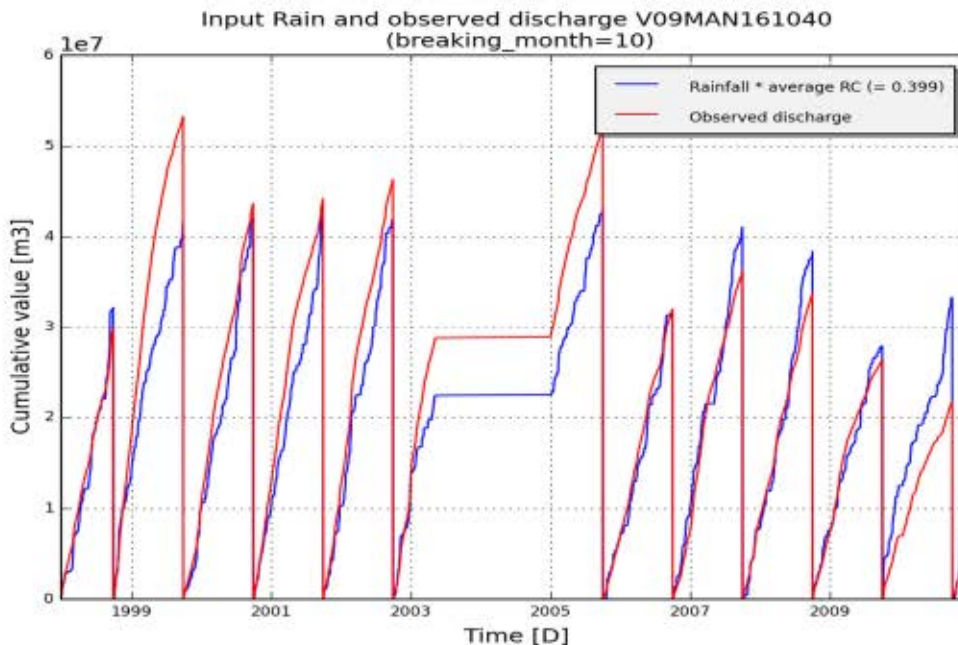


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09MAN161040 (Demerbekken)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09MAN161040 |
| subcatchment_area [m2] | 103081000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 3.63), (‘SMmax.C’, 353.69), (‘CQOF.C’, 0.24), (‘CKBF.C’, 1596.55), (‘CKIF.C’, 483.93), (‘CK1.C’, 35.11), (‘CK2.C’, 31.33), (‘TIF.C’, 0.25), (‘TOF.C’, 0.06), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 5112321.349 | 7061789.336 |
| RelErr | -0.2 % | -0.8 % |
| RMSE | 6856983.927 | 8076691.957 |
| NS | 0.628 | 0.659 |
| NS_log | 0.507 | 0.51 |
| NS_rel | 0.496 | 0.522 |

4.3 Observed and simulated timeseries for optimum parameters

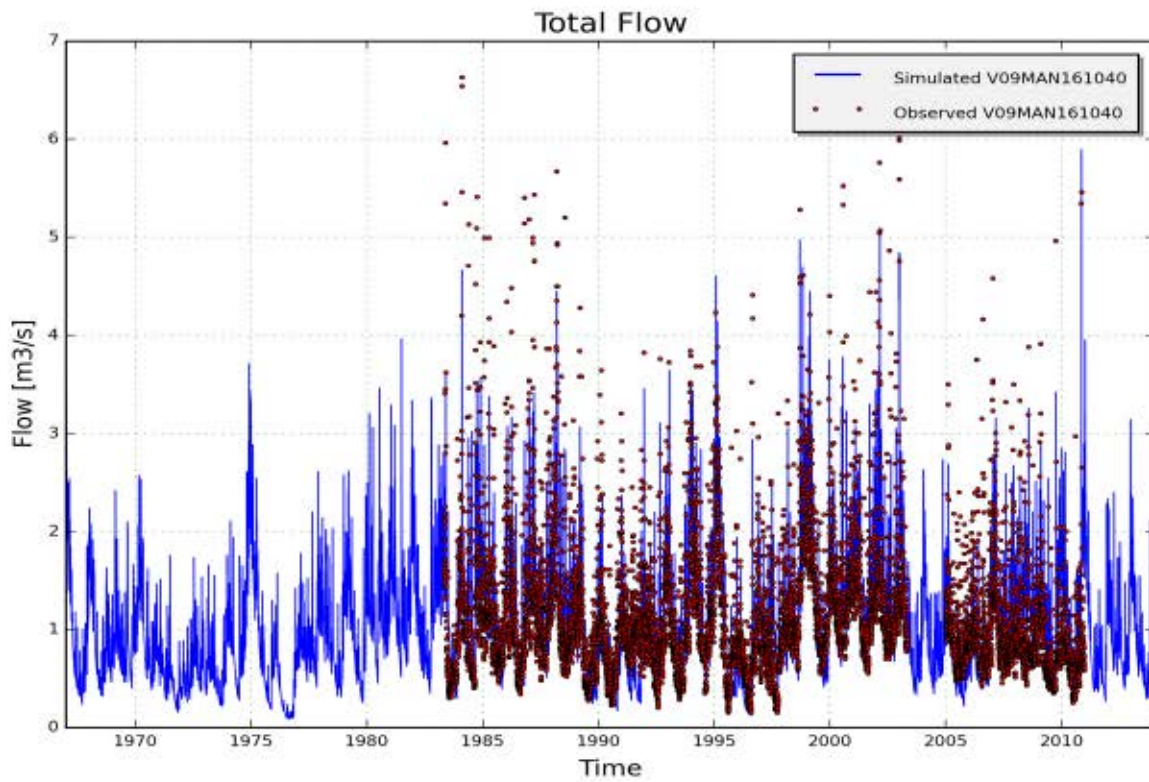


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (validation period 1967-2013)

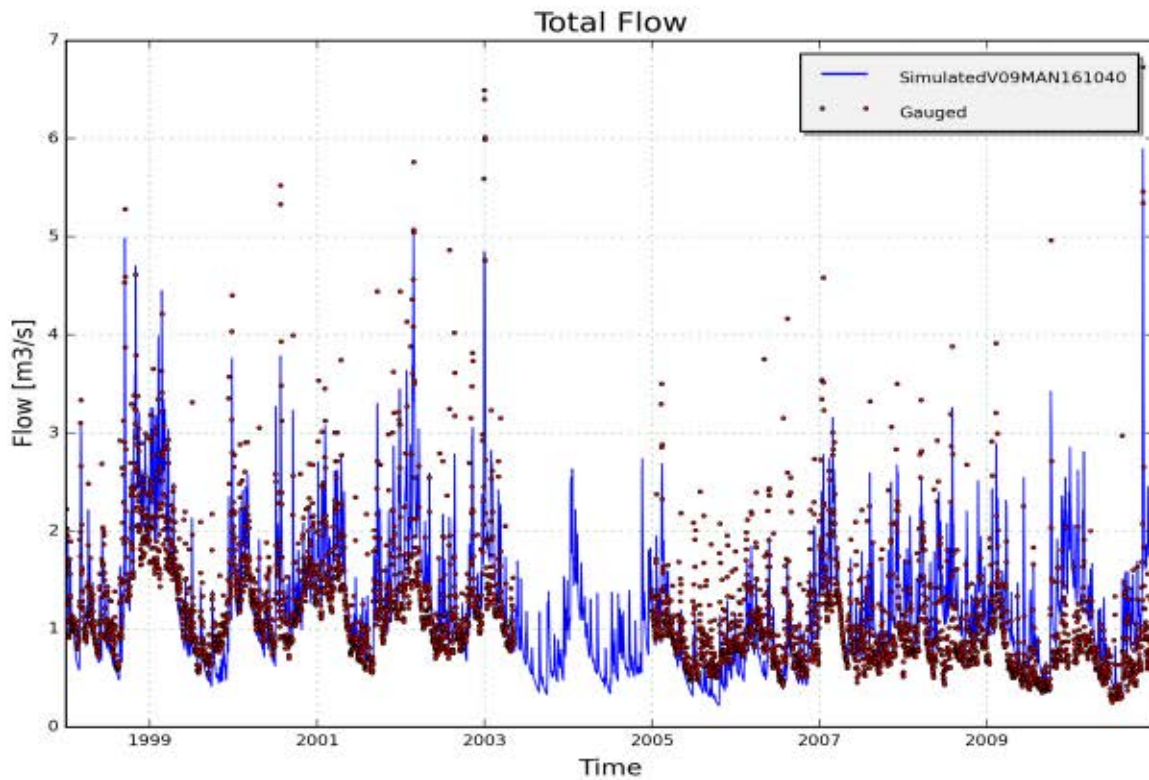


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (calibration period)

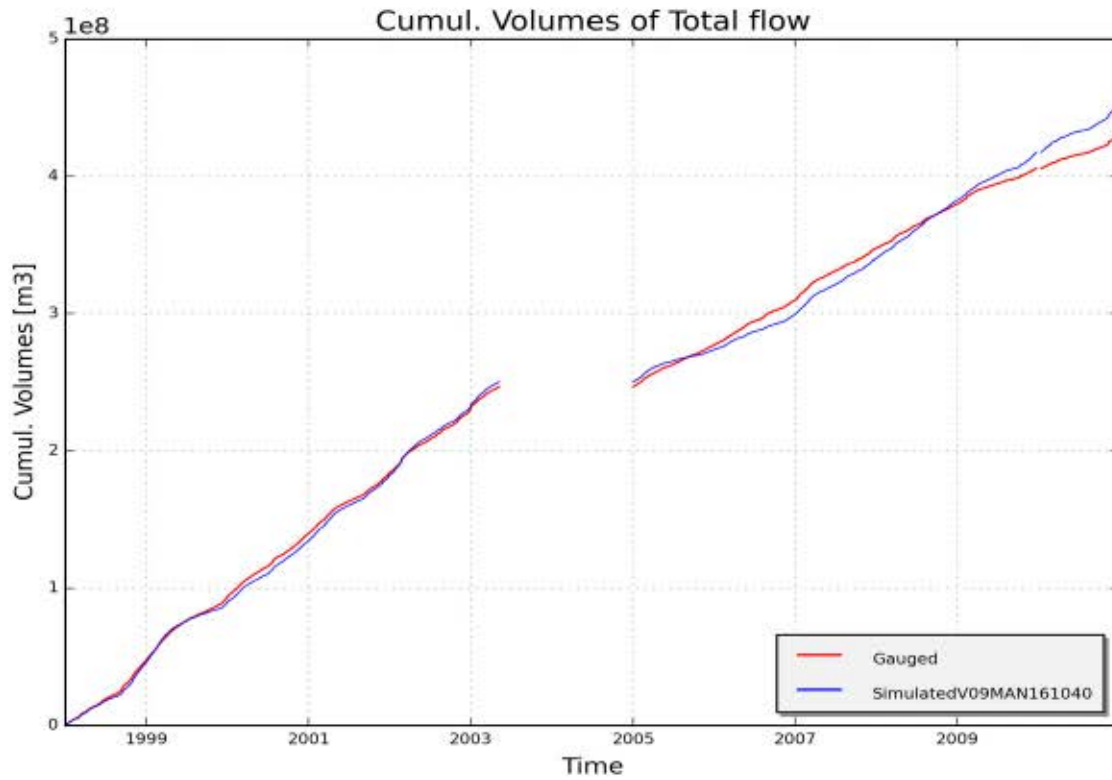


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen (calibration period)

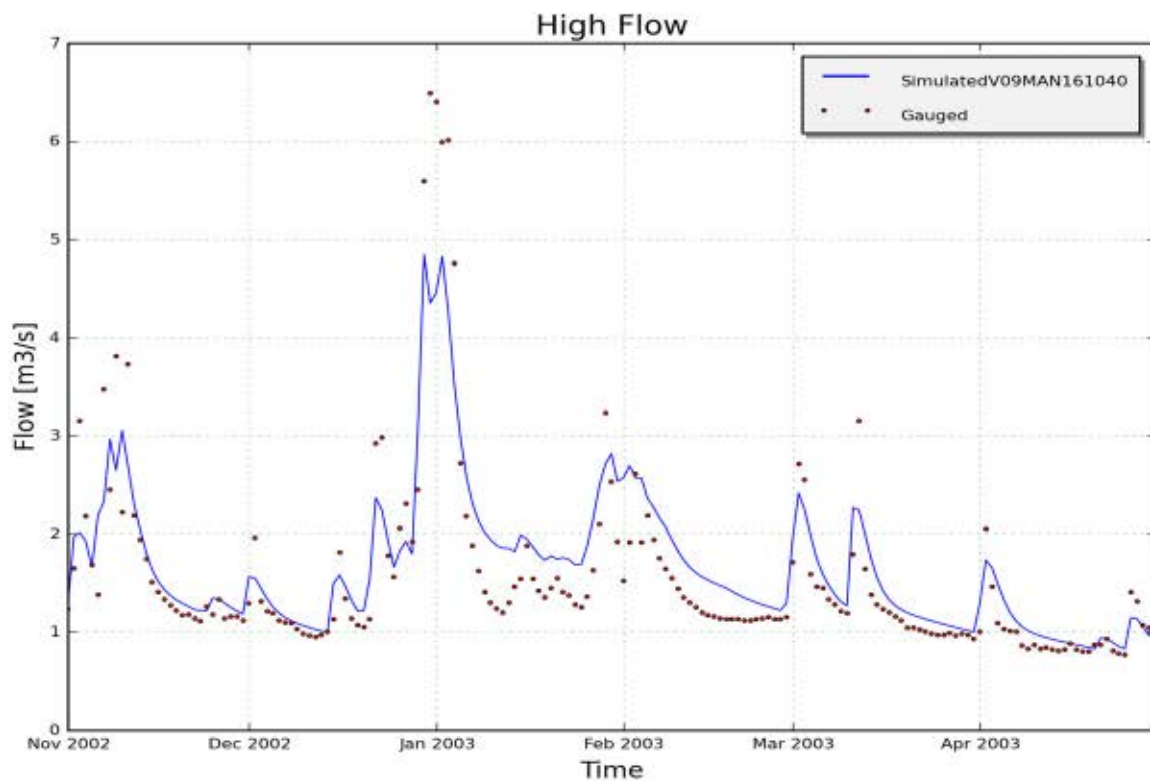


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

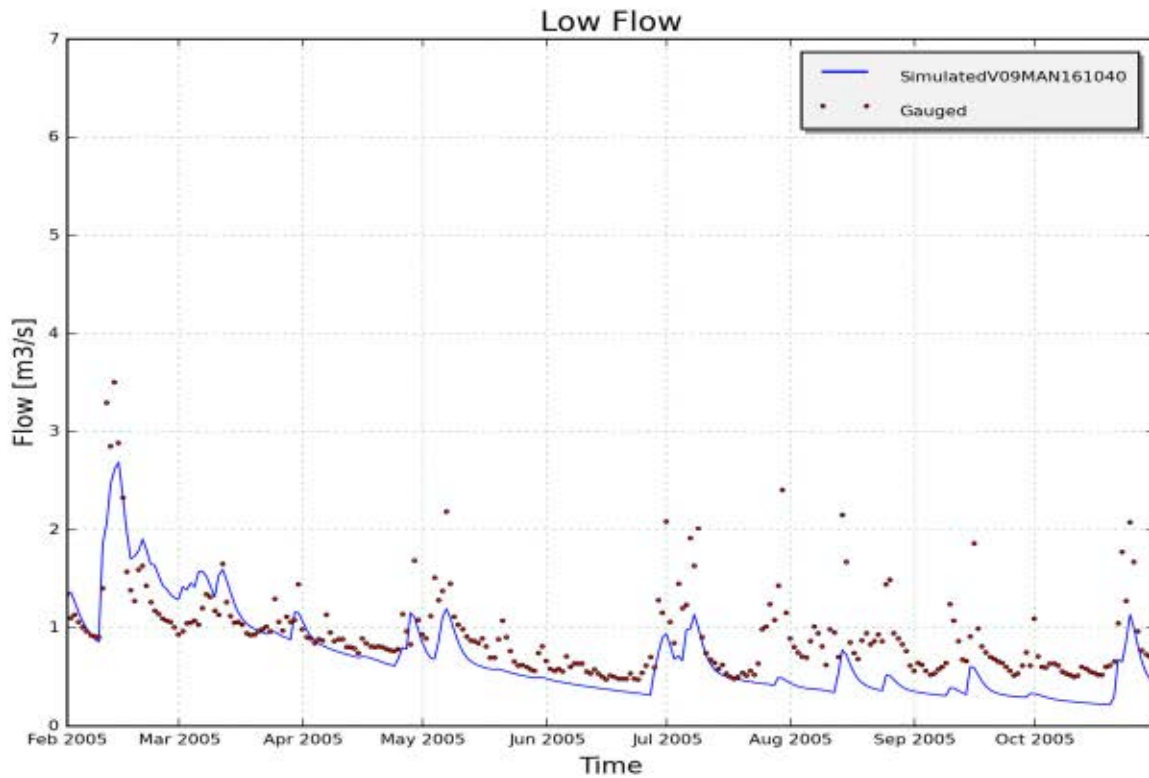


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

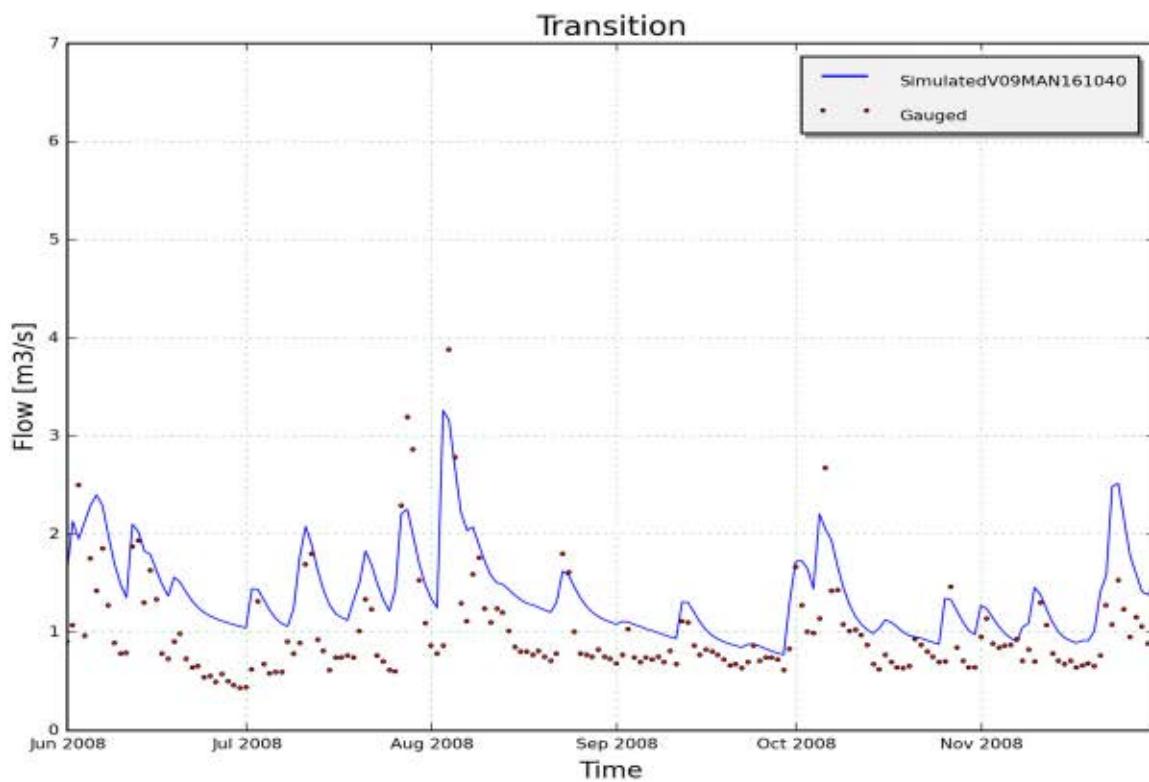


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MAN161040, station 16110102 - Mangelbeek; Lummen

5 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09MOT144270" (DEMERBEKKEN)

5.1 Input data

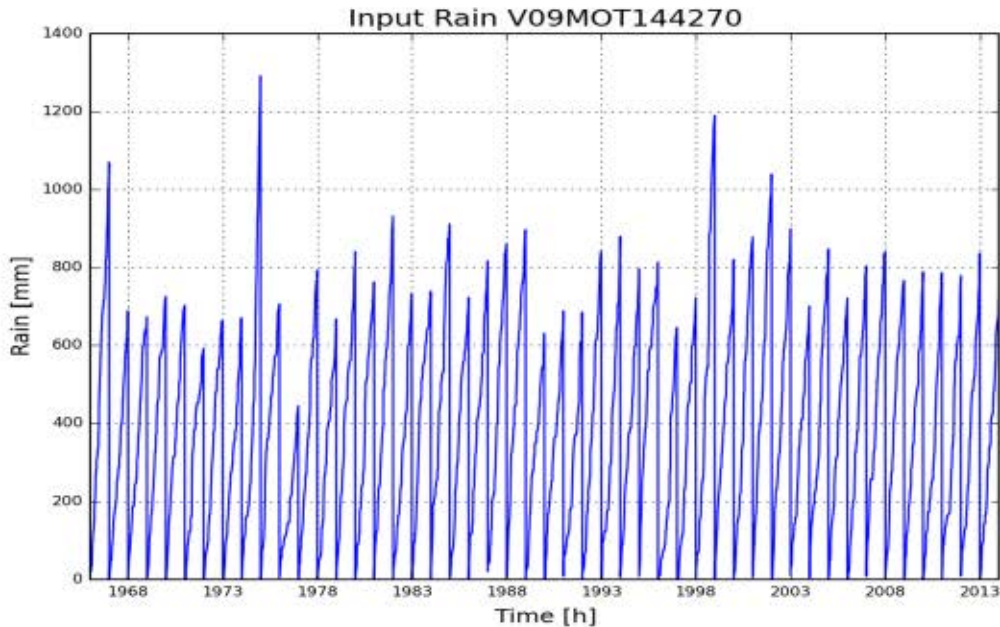


Figure 1: Cumulative precipitation on catchment V09MOT144270 (Demerbekken)

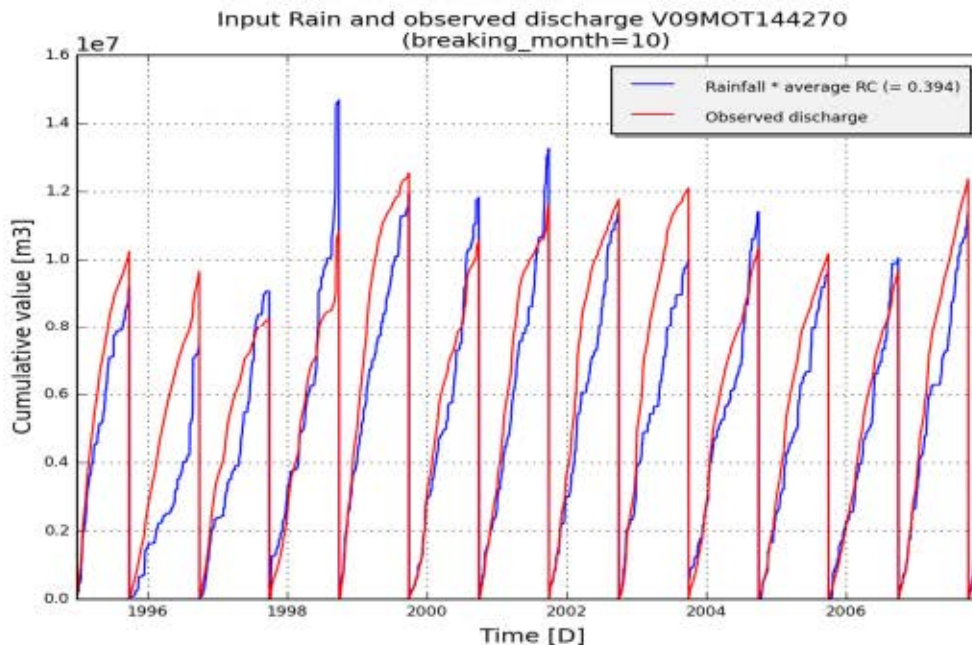


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09MOT144270 (Demerbekken)

5.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09MOT144270 |
| subcatchment_area [m2] | 33590217 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 6.64), (‘SMmax.C’, 382.53), (‘CQOF.C’, 0.8), (‘CKBF.C’, 4808.55), (‘CKIF.C’, 480.53), (‘CK1.C’, 33.48), (‘CK2.C’, 33.11), (‘TIF.C’, 0.01), (‘TOF.C’, 0.33), (‘NAM.TG.C’, 0.0)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 2587351.886 | 13050703.513 |
| RelErr | -1.5 % | -9.6 % |
| RMSE | 3297476.338 | 15064338.082 |
| NS | 0.651 | 0.595 |
| NS_log | 0.452 | 0.389 |
| NS_rel | -2.216 | -1.146 |

5.3 Observed and simulated timeseries for optimum parameters

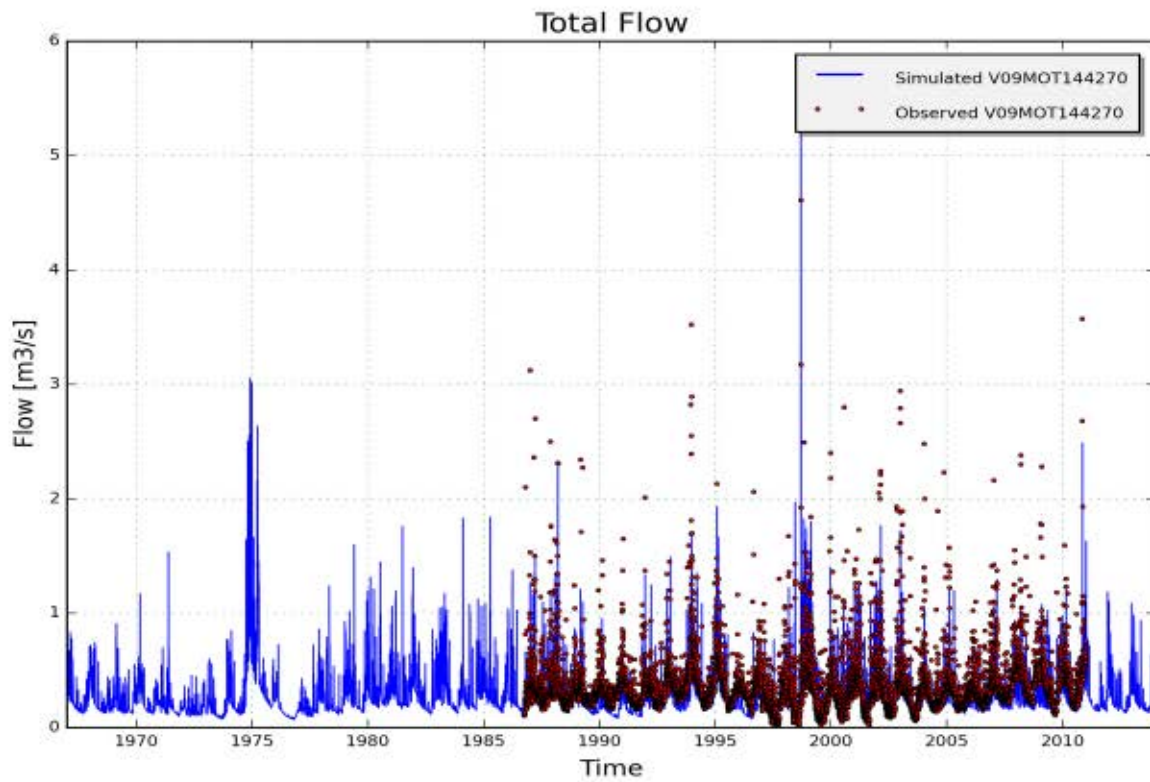


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (validation period 1967-2013)

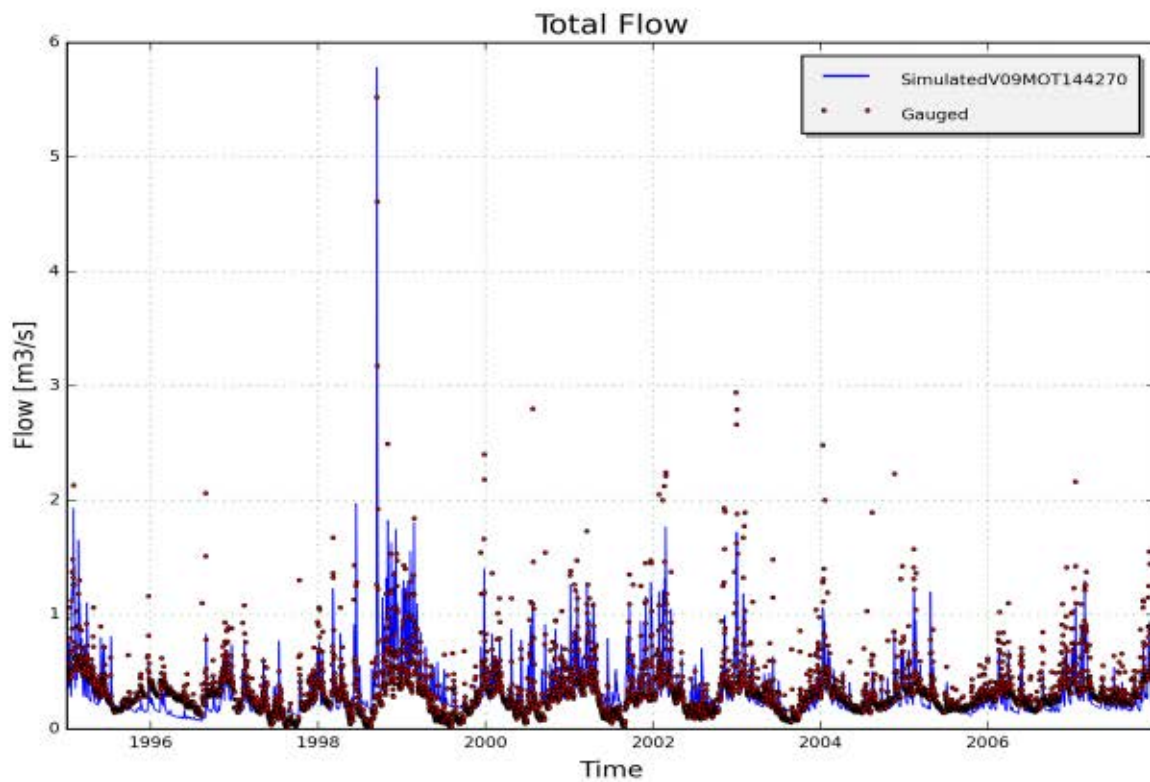


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09MOT144270, station 14410102 - Motte; Rillaar(calibration period)

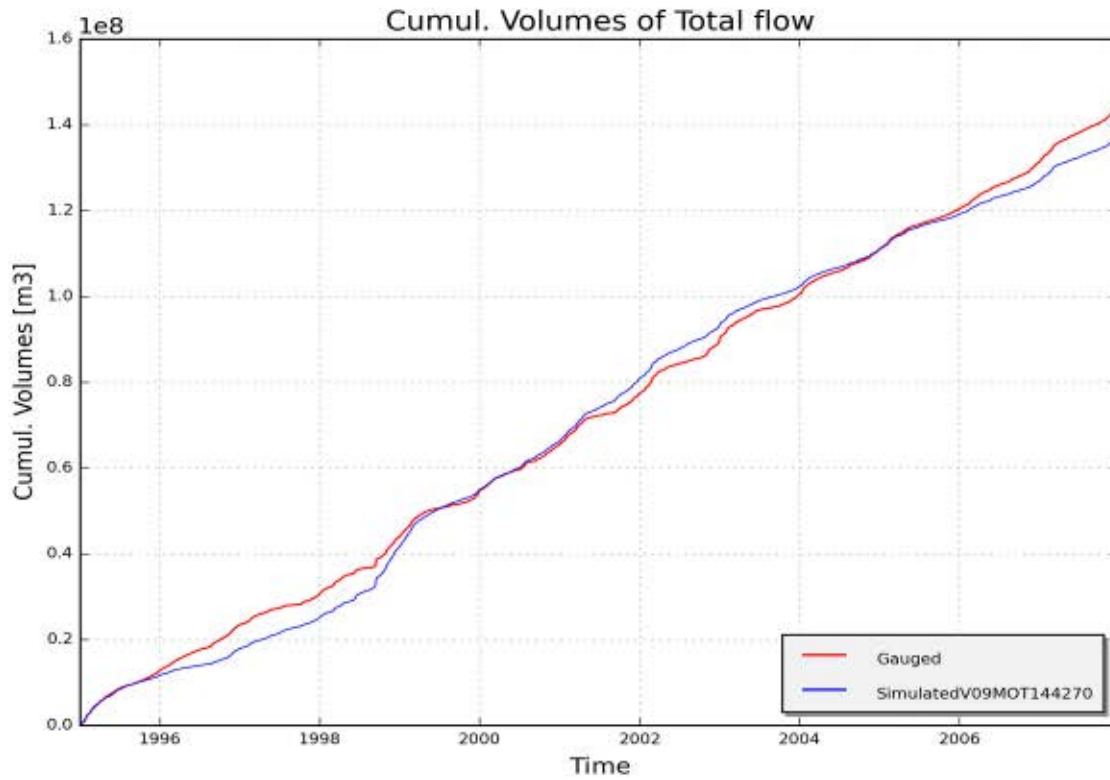


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09MOT144270, station 14410102 - Motte; Rillaar (calibration period)

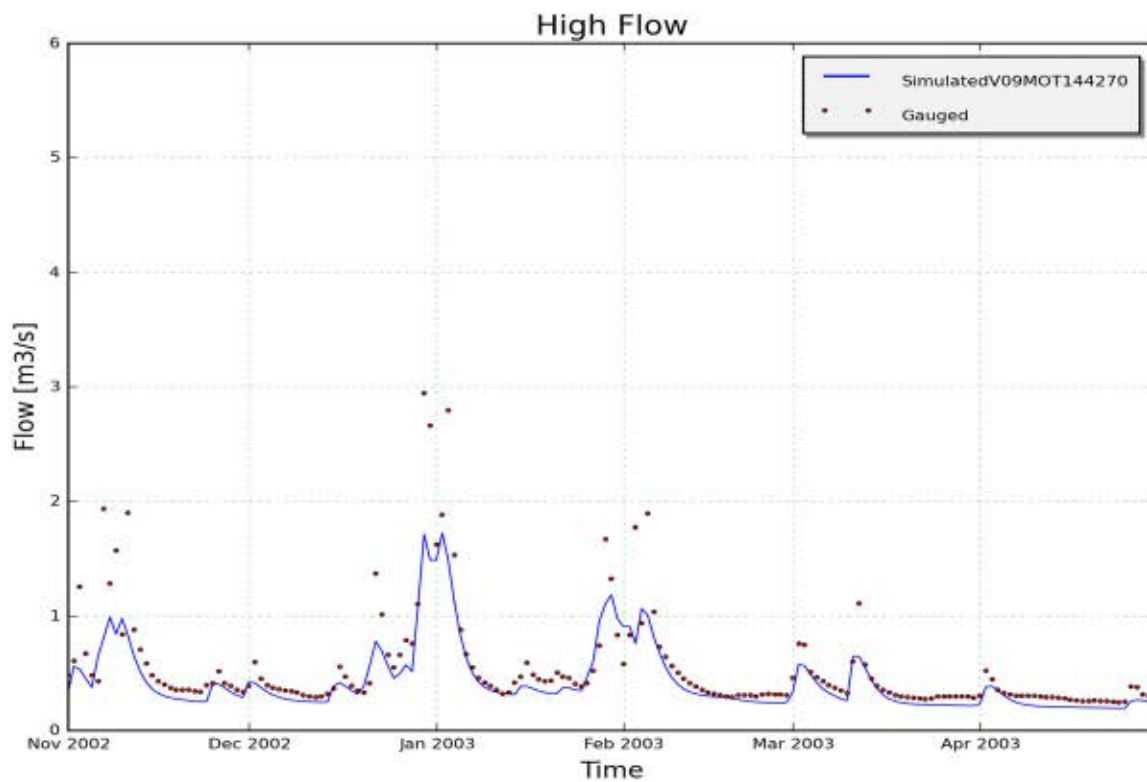


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar

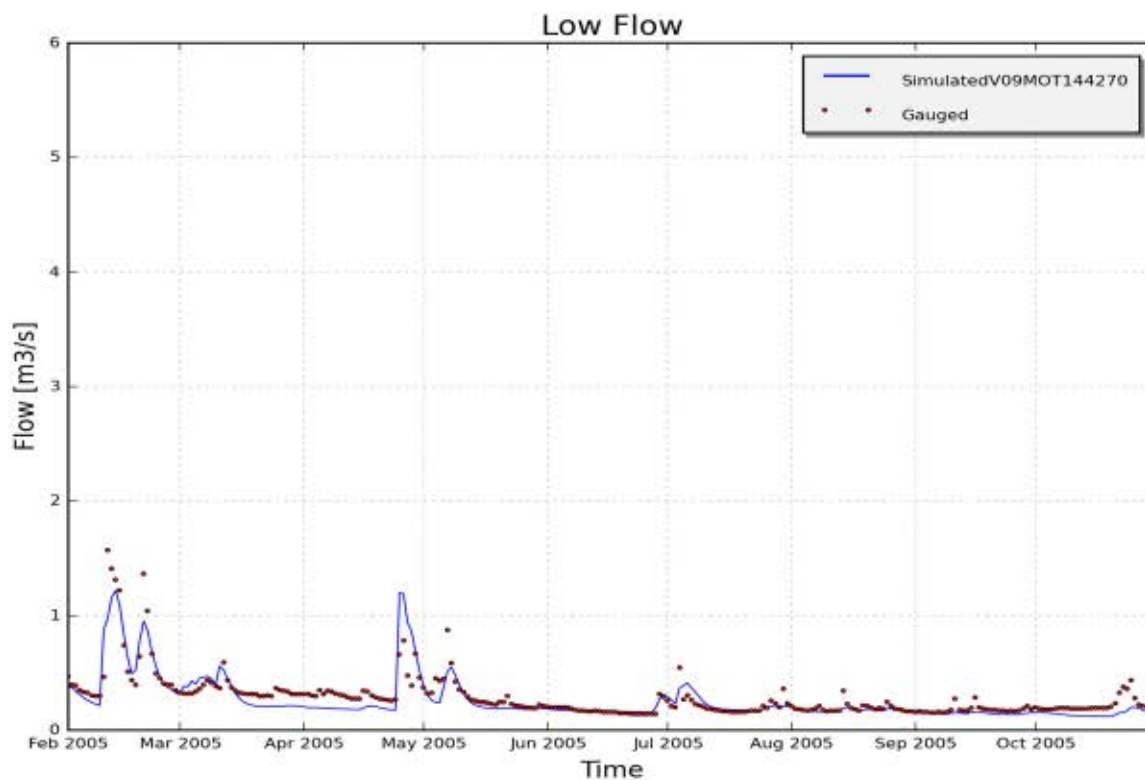


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09MOT144270, station 14410102 - Motte; Rillaar

6 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09VEL145100" (DEMERBEKKEN)

6.1 Input data

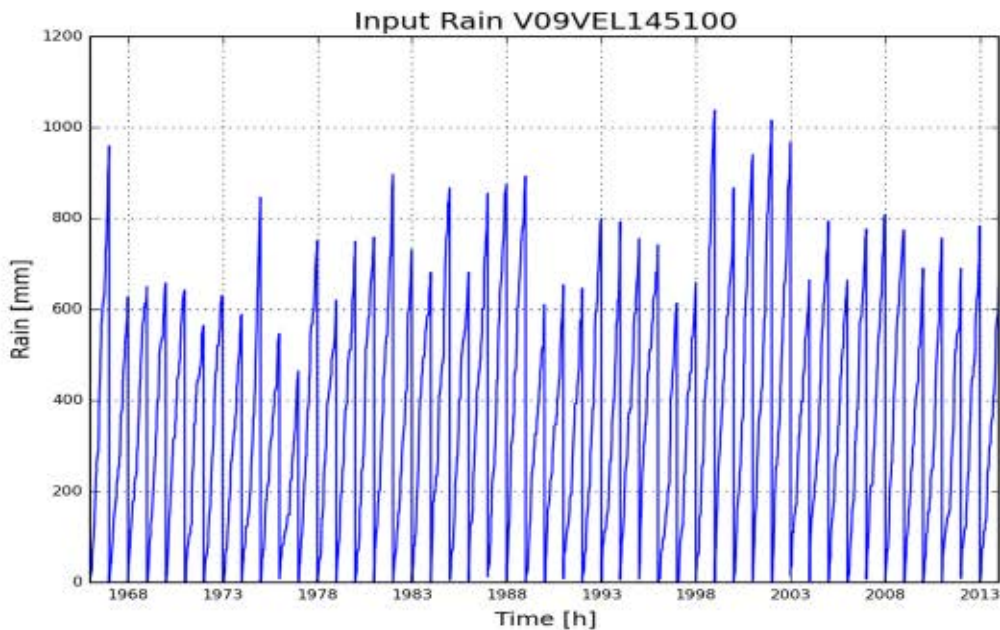


Figure 1: Cumulative precipitation on catchment V09VEL145100 (Demerbekken)

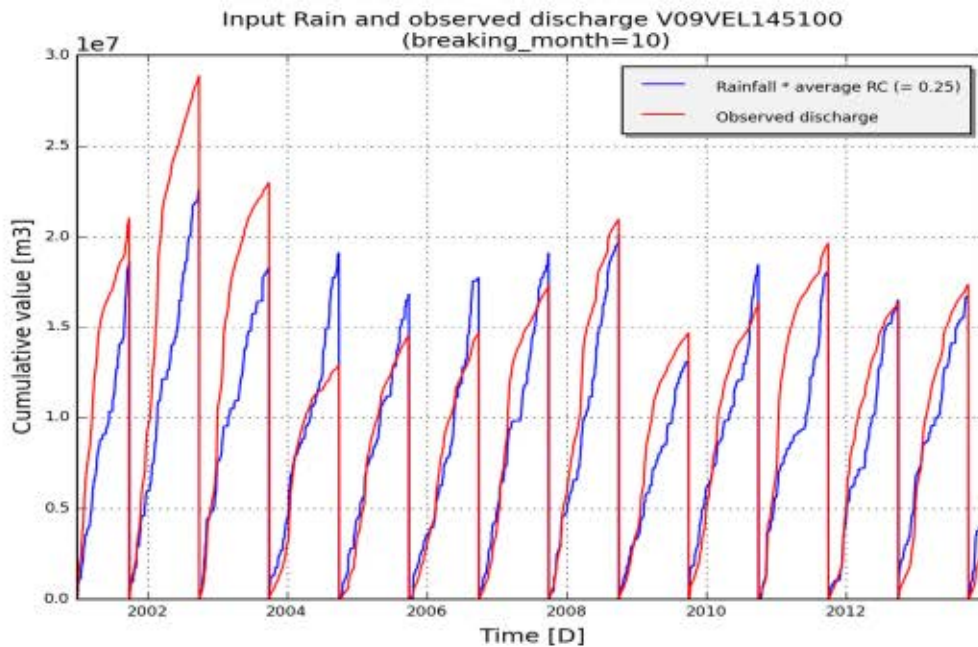


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09VEL145100 (Demerbekken)

6.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09VEL145100 |
| subcatchment_area [m2] | 96801128 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.73), (‘SMmax.C’, 519.68), (‘CQOF.C’, 0.3), (‘CKBF.C’, 1744.68), (‘CKIF.C’, 635.0), (‘CK1.C’, 24.57), (‘CK2.C’, 26.15), (‘TIF.C’, 0.2), (‘TOF.C’, 0.32), (‘NAM.TG.C’, 0.36)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3237242.479 | 11377855.919 |
| RelErr | 2.2 % | -1.3 % |
| RMSE | 3861596.448 | 12455865.551 |
| NS | 0.674 | 0.667 |
| NS_log | 0.703 | 0.669 |
| NS_rel | 0.77 | -0.238 |

6.3 Observed and simulated timeseries for optimum parameters

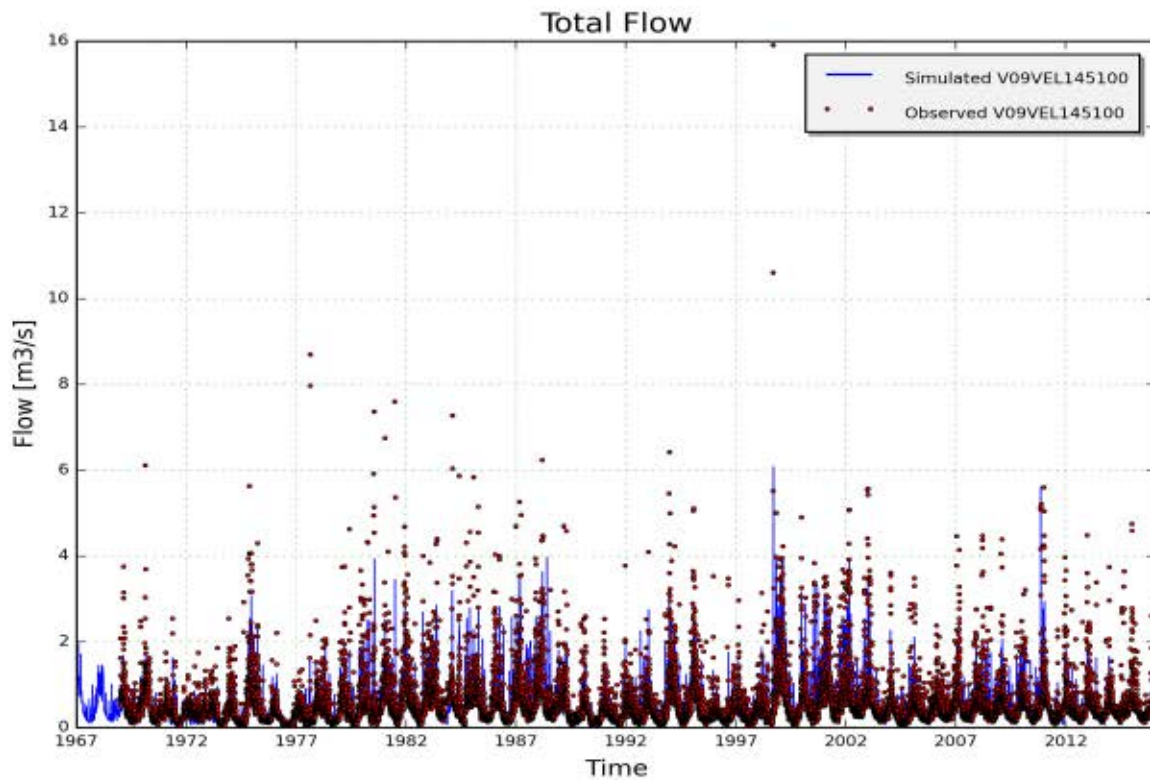


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (validation period 1967-2013)

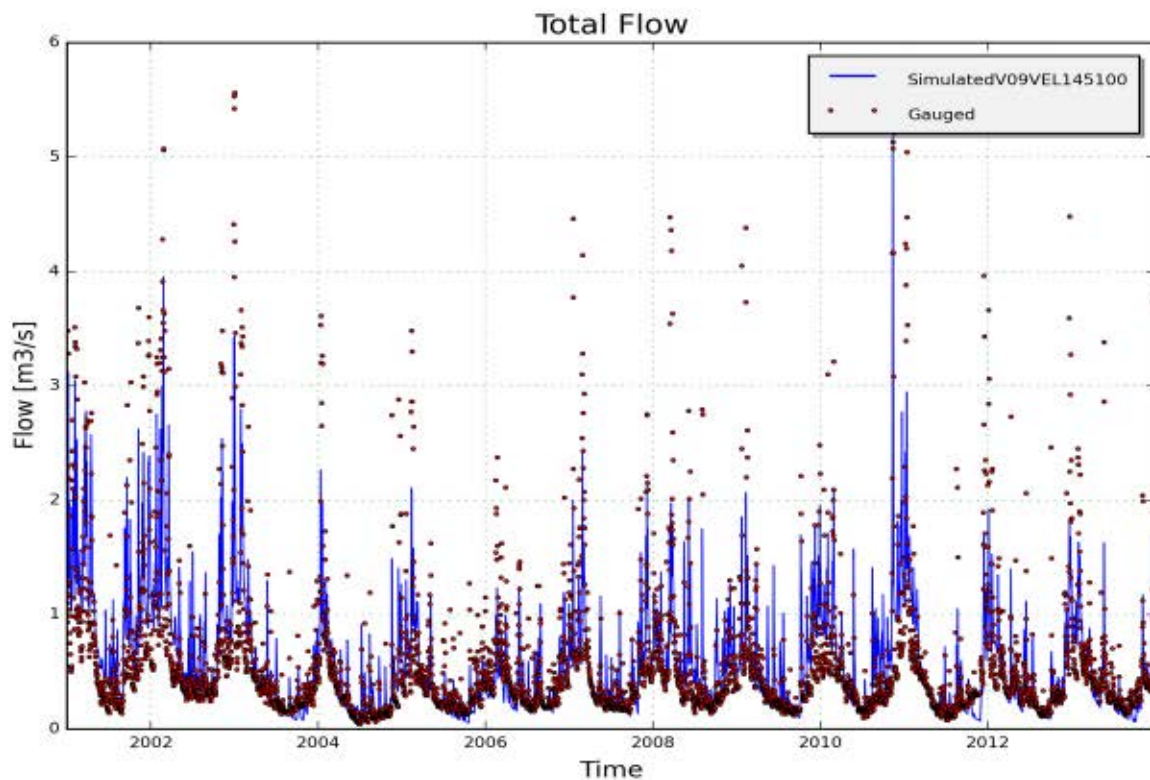


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (calibration period)

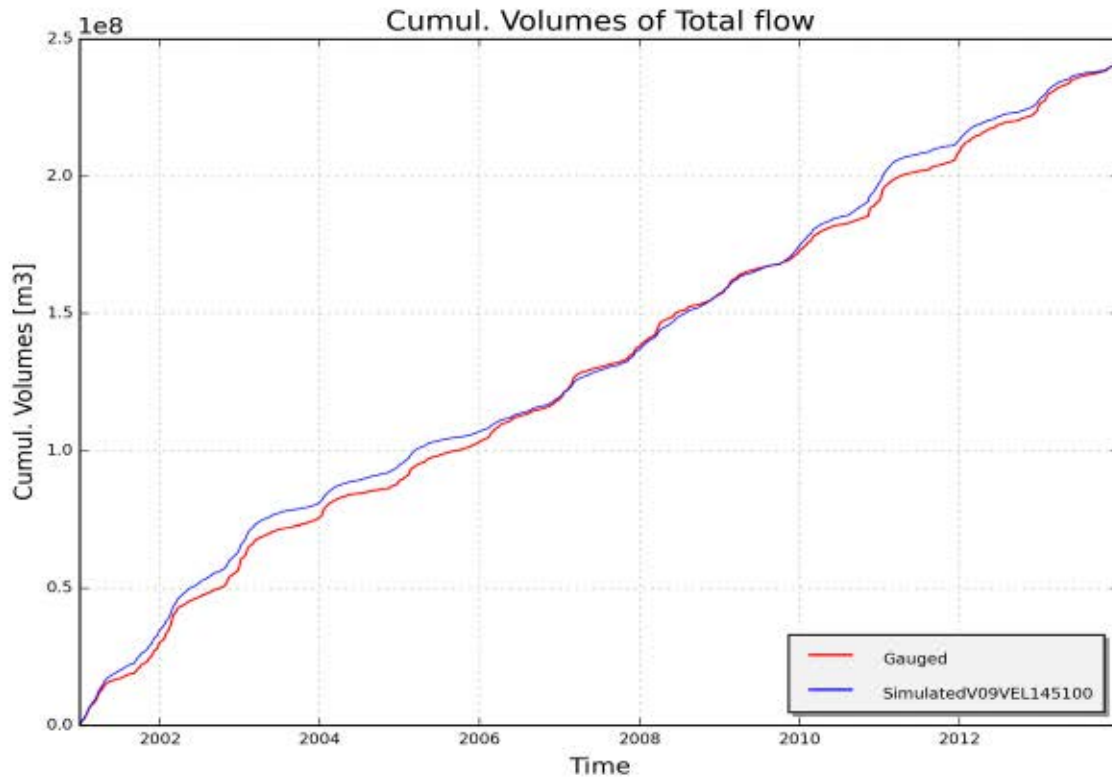


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09VEL145100, station 14510102 - Velp; Ransberg (calibration period)

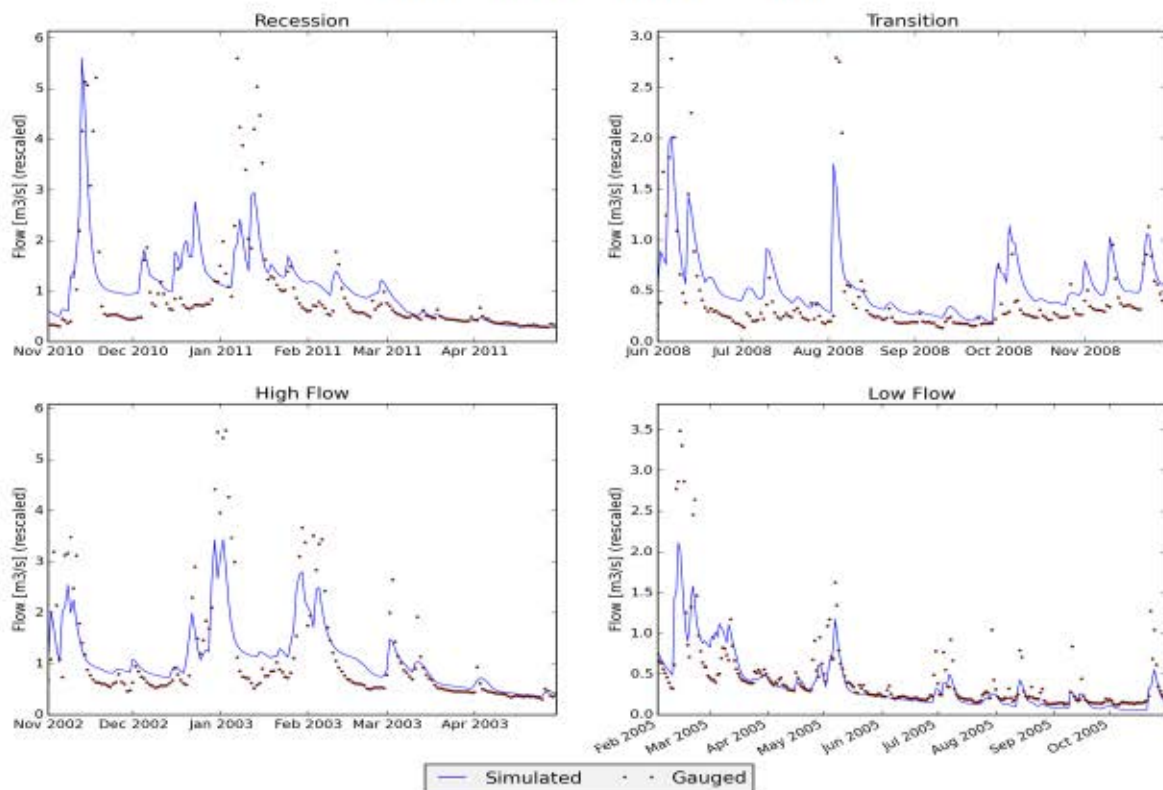


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09VEL145100, station 14510102 - Velp; Ransberg

7 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09WIN141310" (DEMERBEKKEN)

7.1 Input data

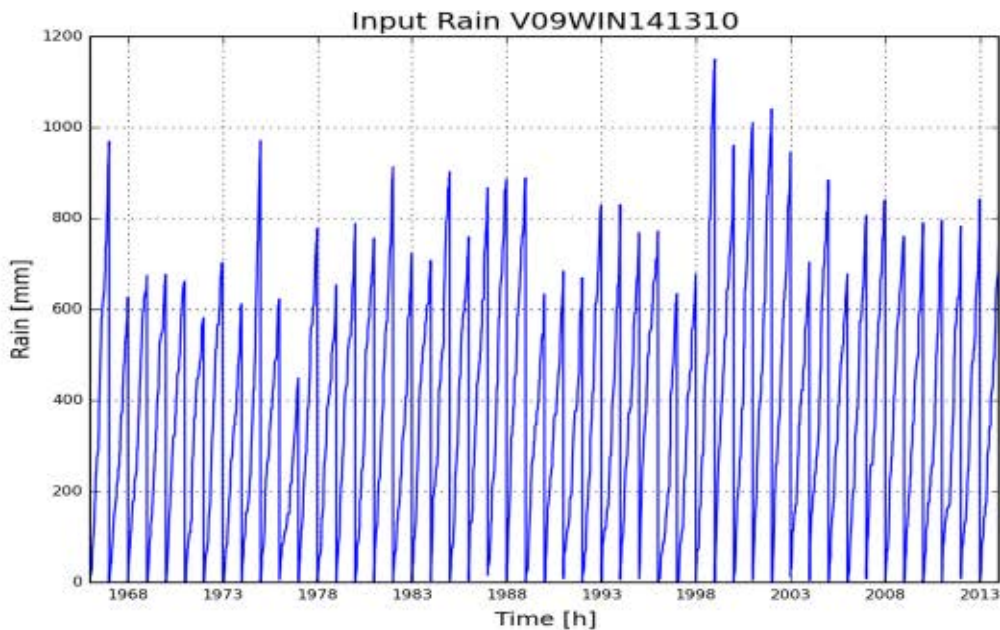


Figure 1: Cumulative precipitation on catchment V09WIN141310 (Demerbekken)

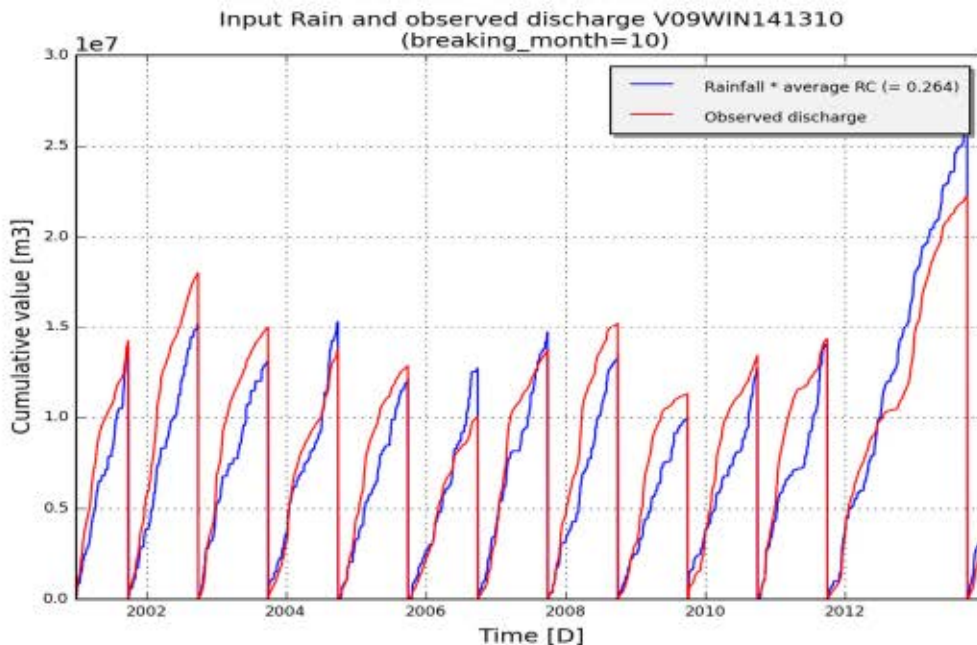


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09WIN141310 (Demerbekken)

7.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09WIN141310 |
| subcatchment_area [m2] | 64739169 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 10.82), (‘SMmax.C’, 1491.15), (‘CQOF.C’, 0.35), (‘CKBF.C’, 1361.86), (‘CKIF.C’, 346.34), (‘CK1.C’, 8.57), (‘CK2.C’, 17.57), (‘TIF.C’, 0.47), (‘TOF.C’, 0.49), (‘NAM.TG.C’, 0.52)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3503420.484 | 6558085.14 |
| RelErr | 2.0 % | 0.4 % |
| RMSE | 4405426.501 | 7798755.684 |
| NS | 0.725 | 0.674 |
| NS_log | 0.66 | 0.633 |
| NS_rel | -12.069 | -6.28 |

7.3 Observed and simulated timeseries for optimum parameters

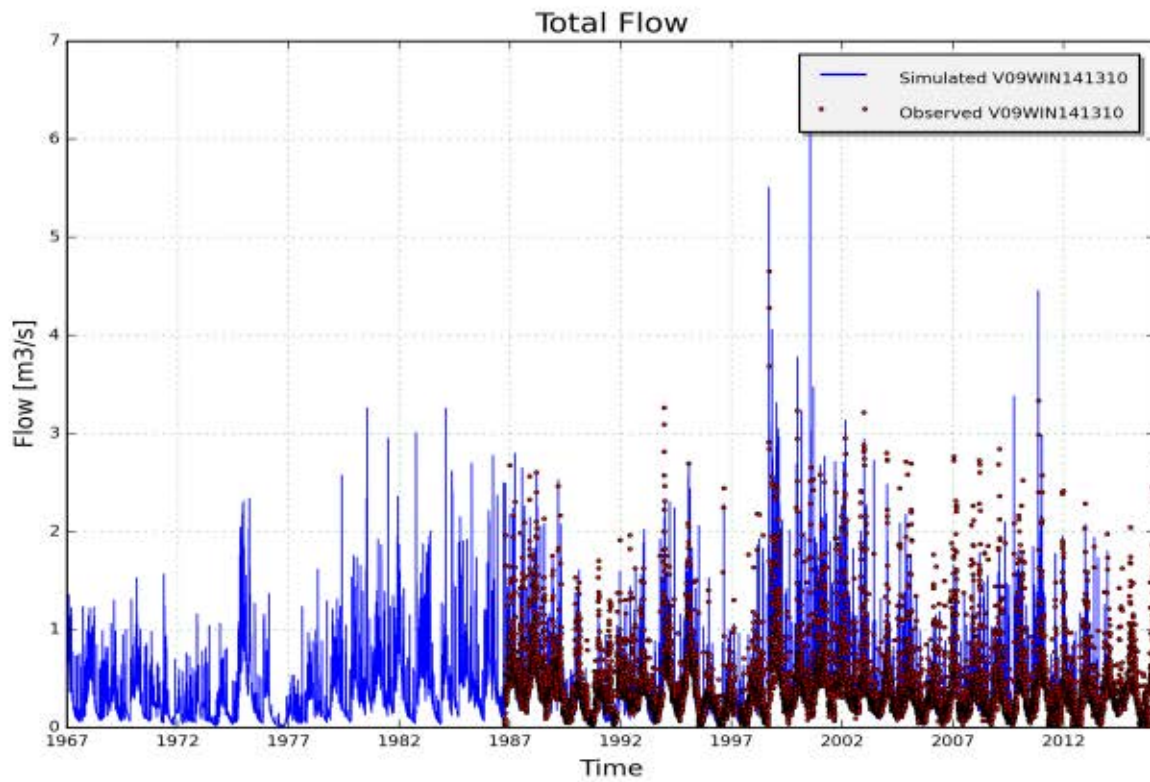


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (validation period 1967-2013)

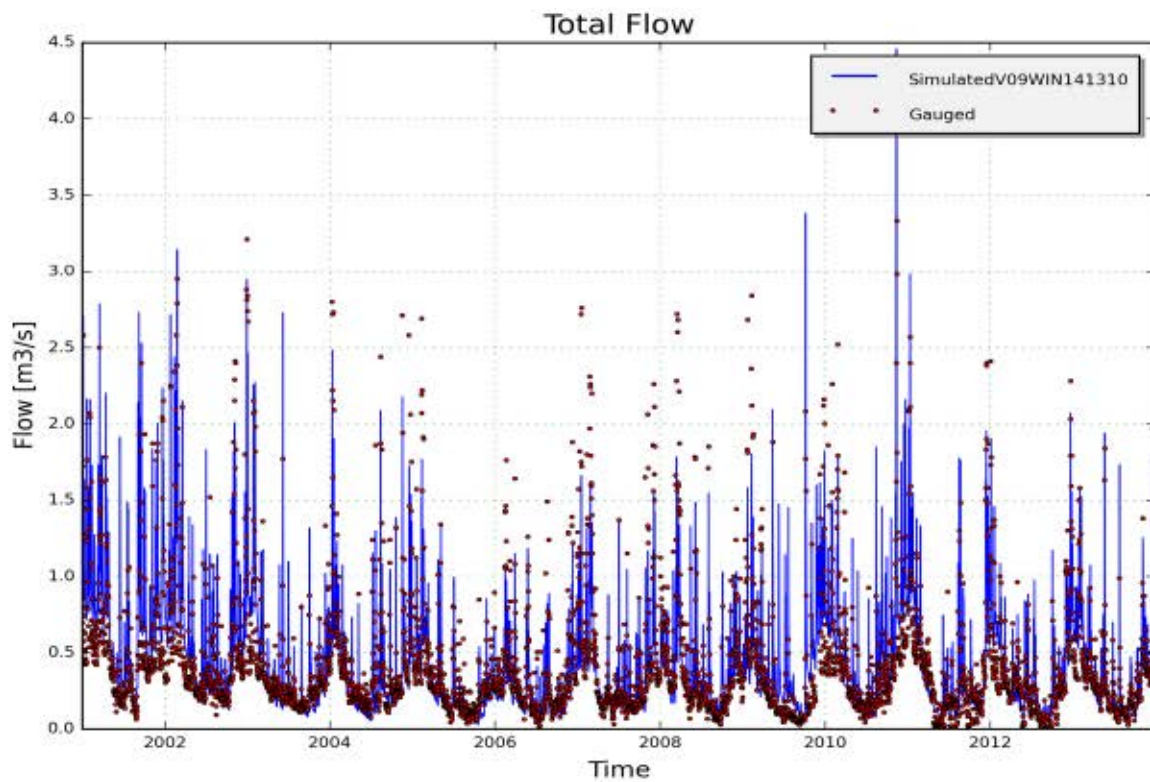


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (calibration period)

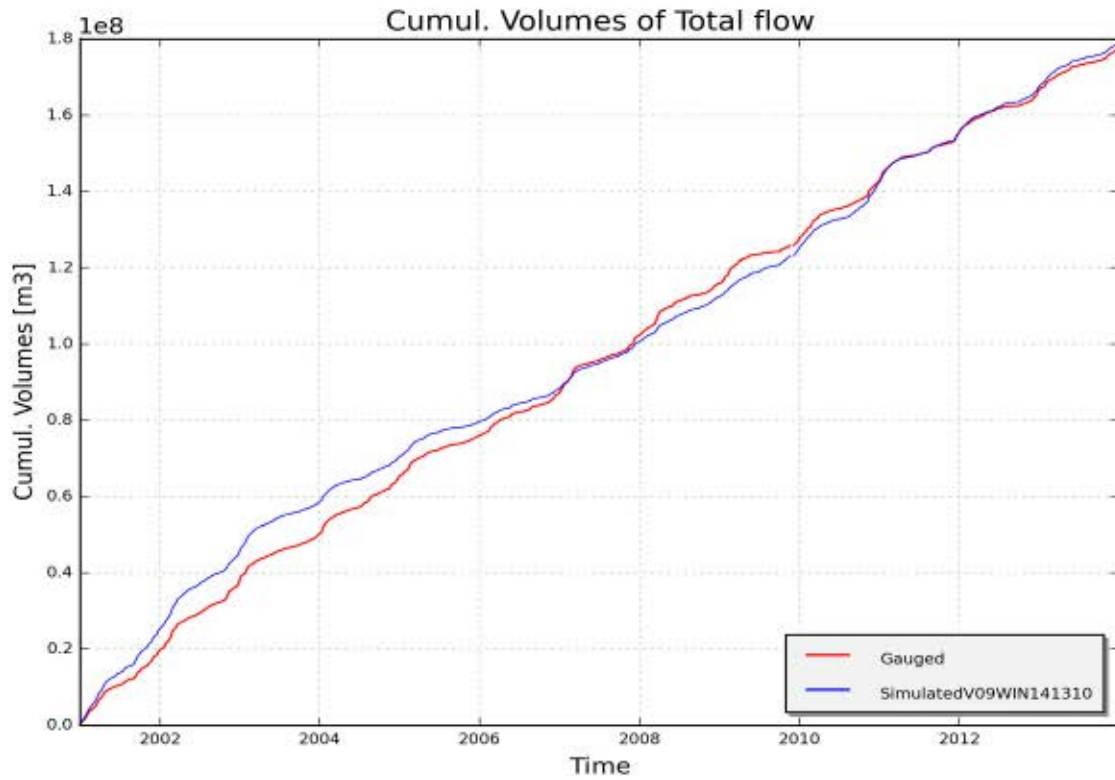


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V09WIN141310, station 141 - Rotselaar ; Winge (calibration period)

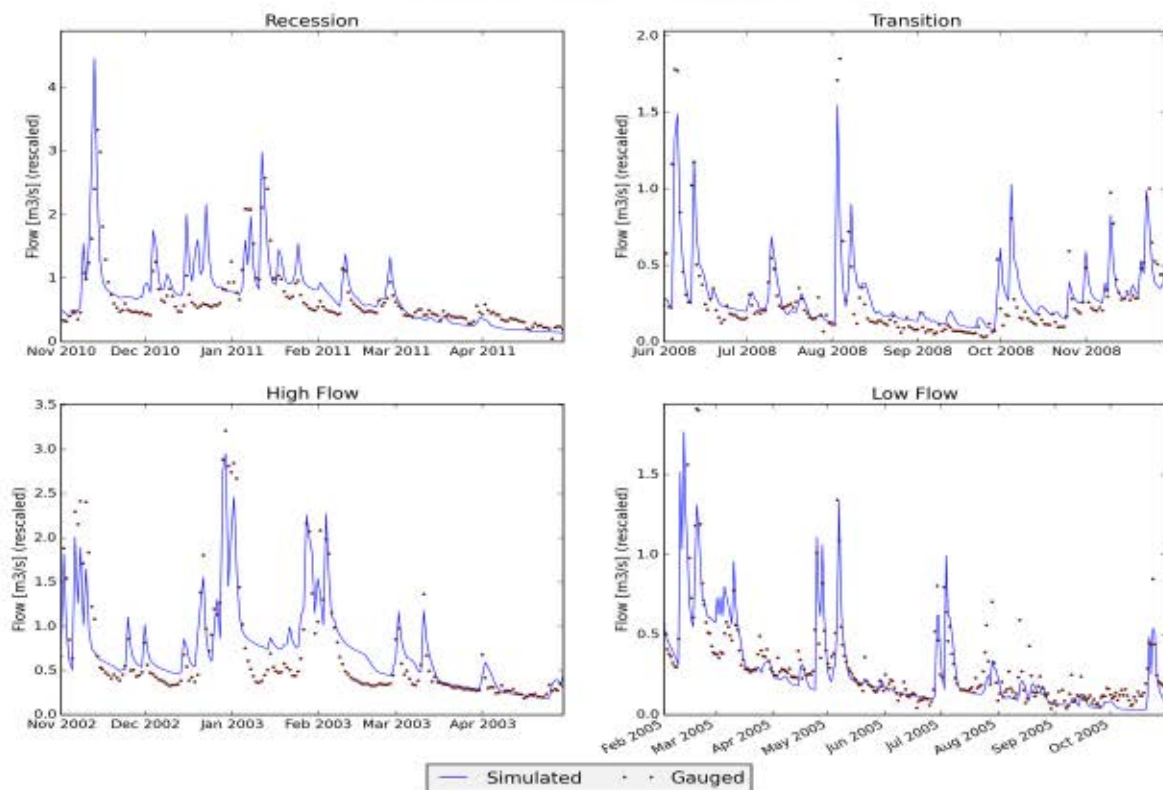


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09WIN141310, station 141 - Rotselaar ; Winge

8 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09ZWA148120" (DEMERBEKKEN)

8.1 Input data

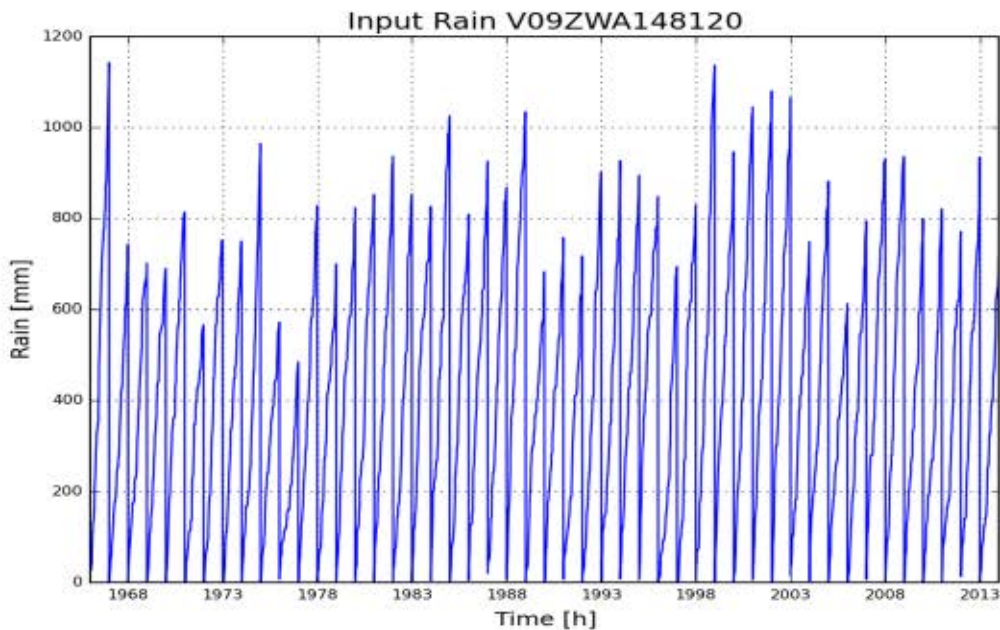


Figure 1: Cumulative precipitation on catchment V09ZWA148120 (Demerbekken)

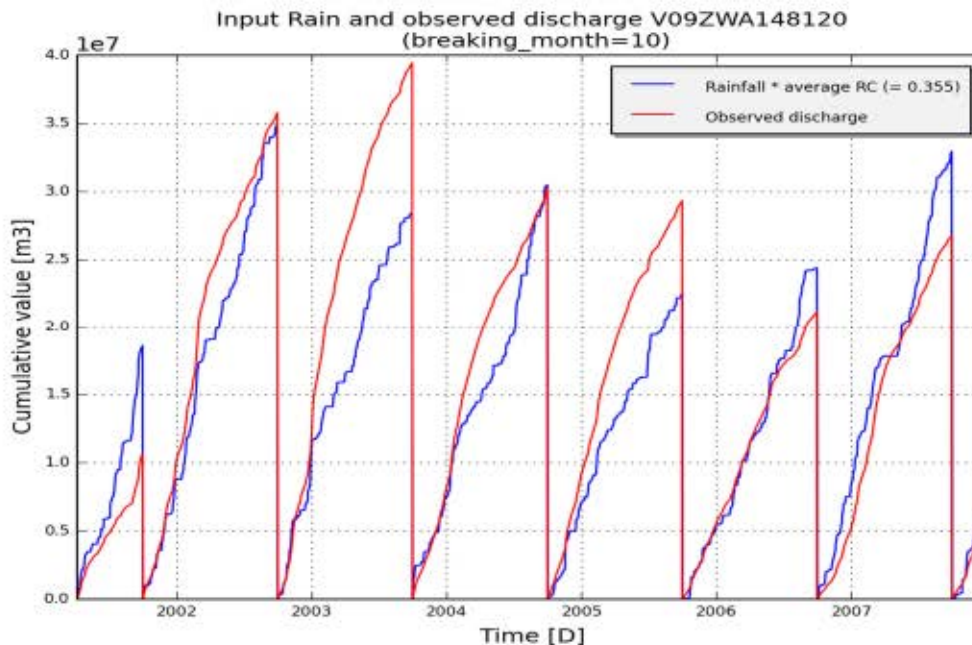


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09ZWA148120 (Demerbekken)

8.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09ZWA148120 |
| subcatchment_area [m2] | 96514800 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[('Umax.C', 7.11), ('SMmax.C', 607.27), ('CQOF.C', 0.8), ('CKBF.C', 1934.5), ('CKIF.C', 136.41), ('CK1.C', 25.94), ('CK2.C', 34.83), ('TIF.C', 0.1), ('TOF.C', 0.57), ('NAM.TG.C', 0.08)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 7522179.941 | 35701523.45 |
| RelErr | 6.7 % | -8.5 % |
| RMSE | 9592710.144 | 40571371.63 |
| NS | 0.594 | 0.457 |
| NS_log | 0.478 | 0.286 |
| NS_rel | 0.4 | -1.985 |

8.3 Observed and simulated timeseries for optimum parameters

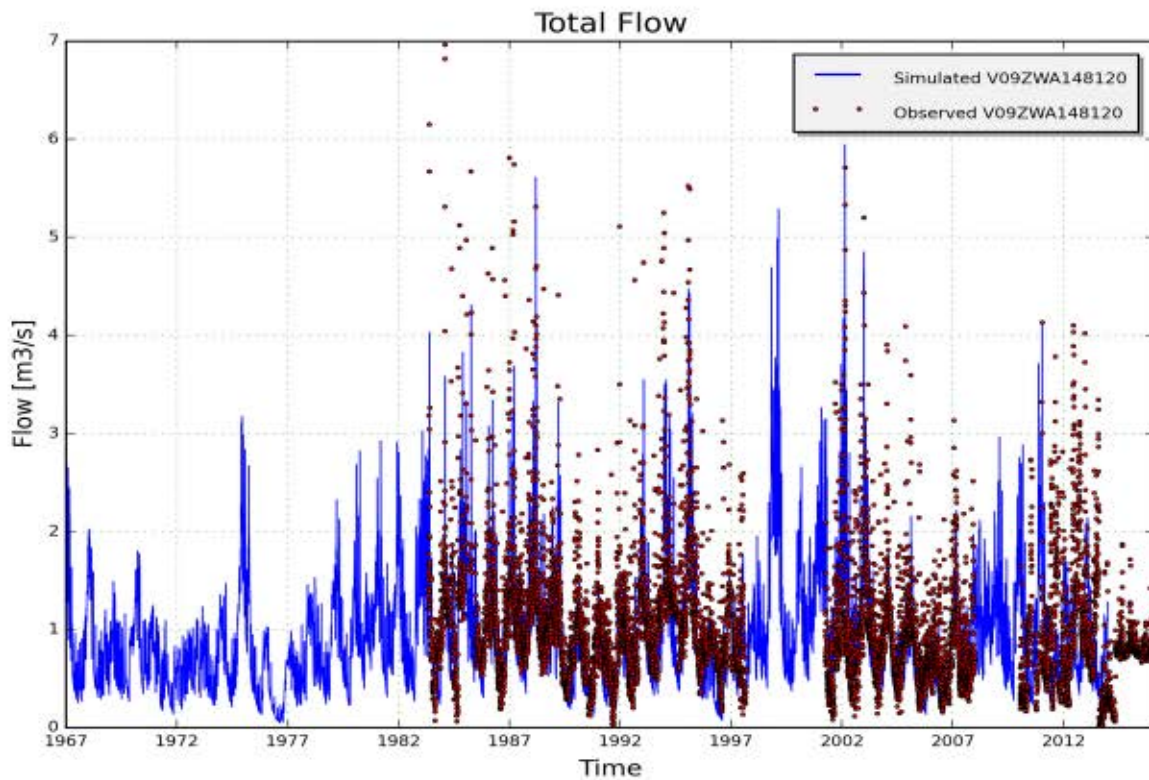


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (validation period 1967-2013)

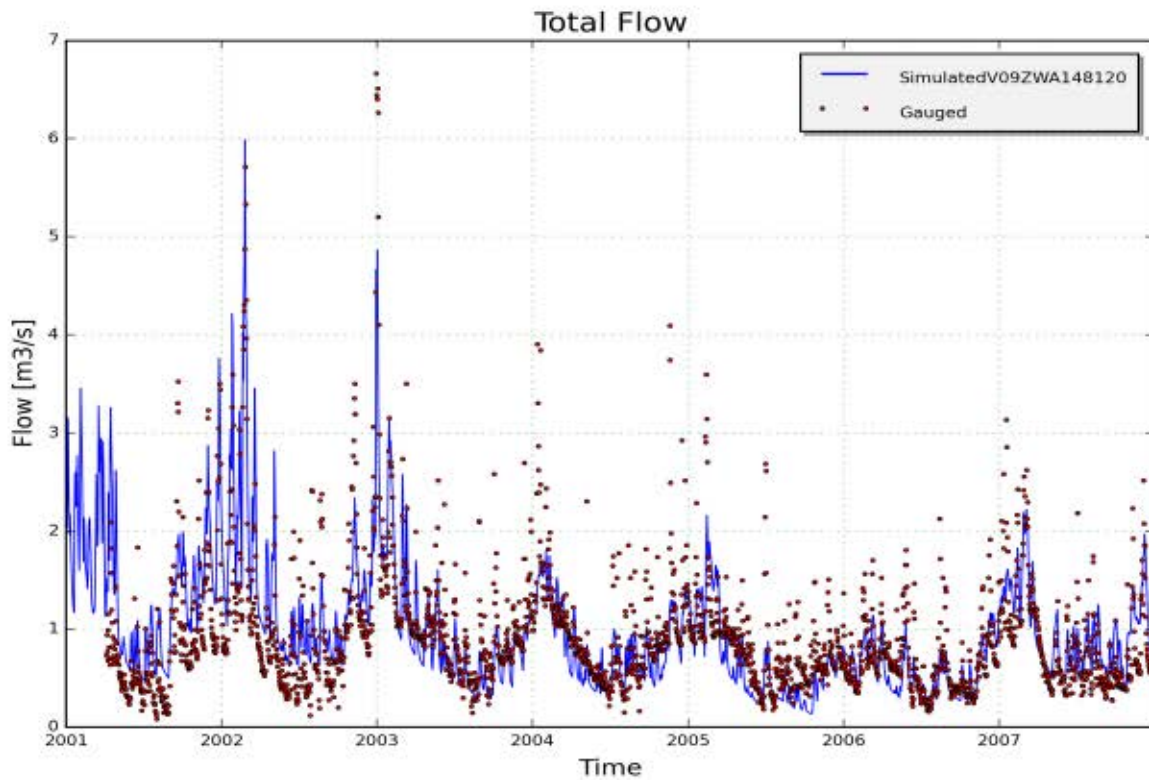


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (calibration period)

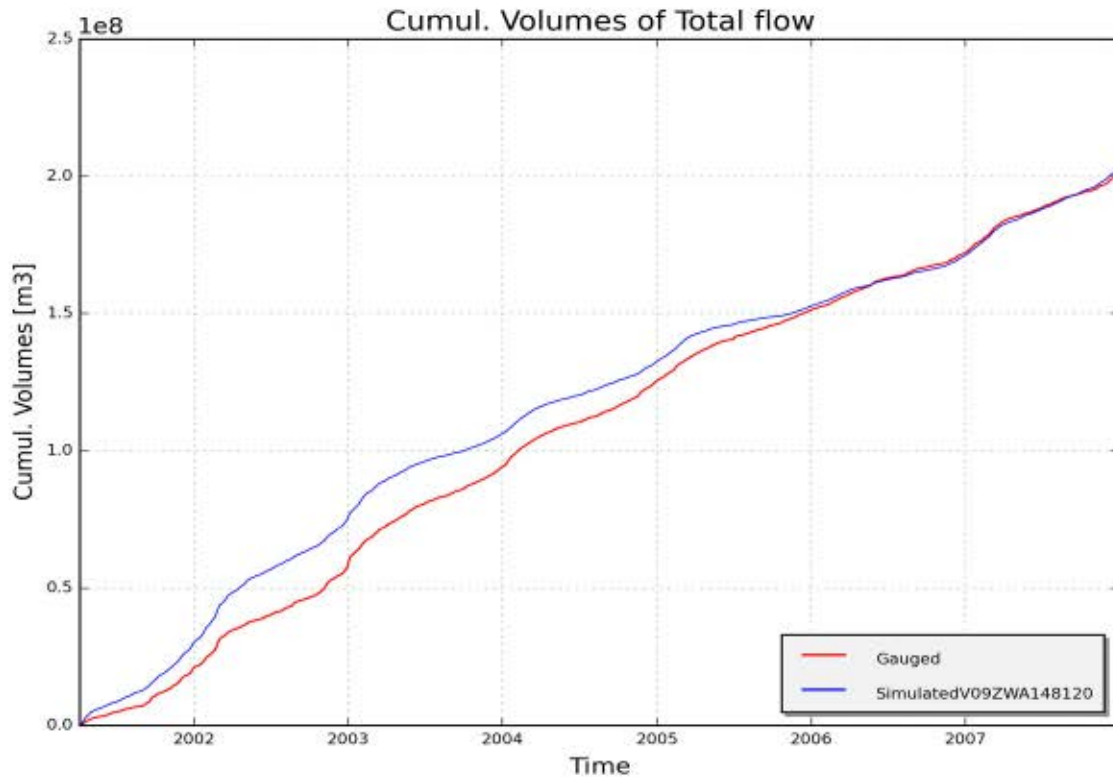


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen (calibration period)

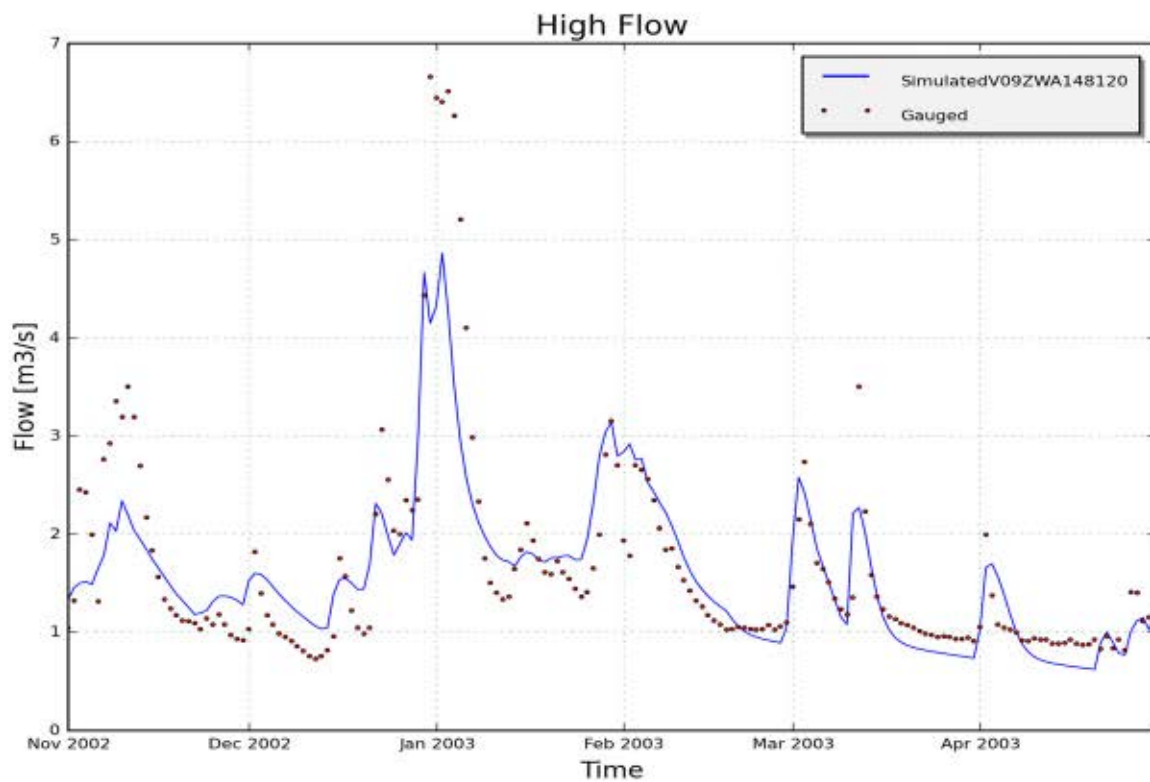


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

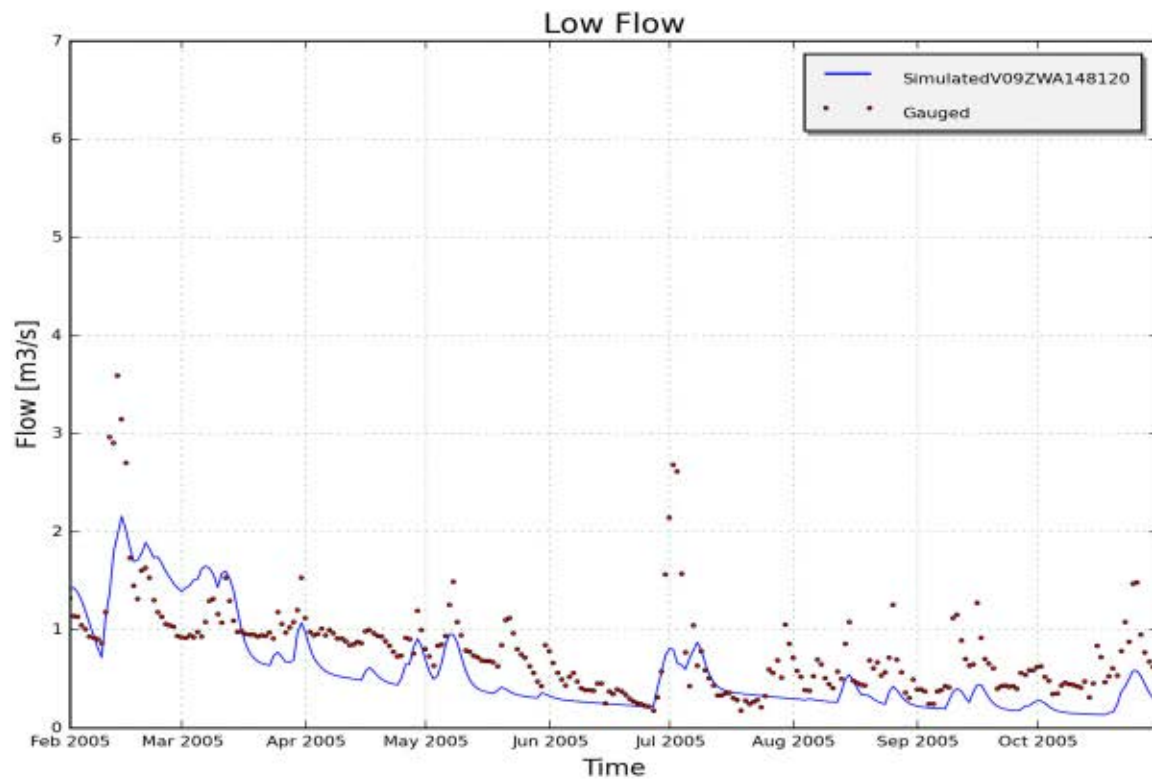


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09ZWA148120, station 14810102 - Zwarte Beek; Lummen

9 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V09DEM136000" (DEMERBEKKEN)

9.1 Input data

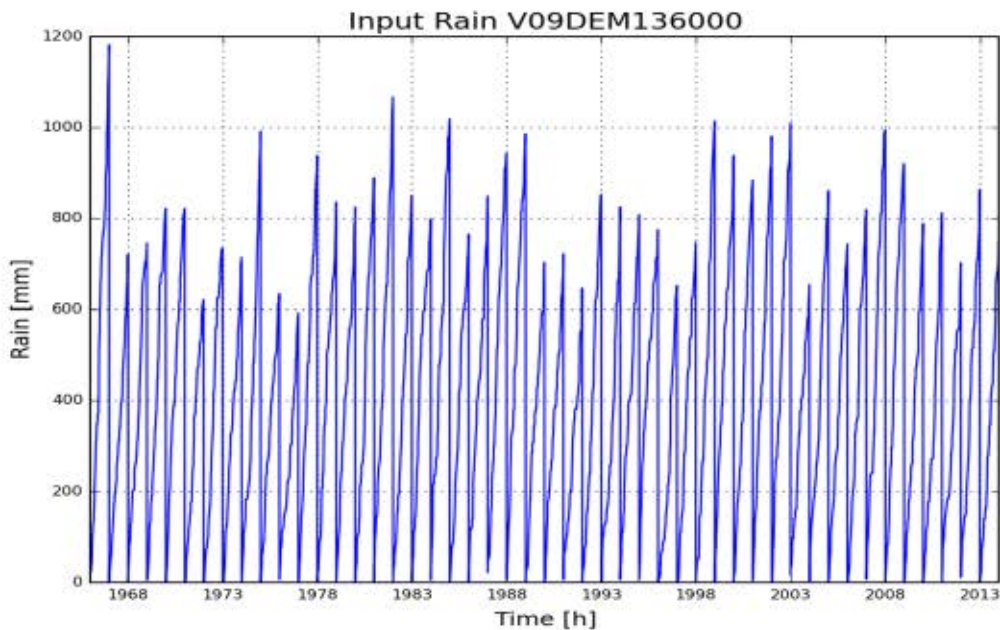


Figure 1: Cumulative precipitation on catchment V09DEM136000 (Demerbekken)

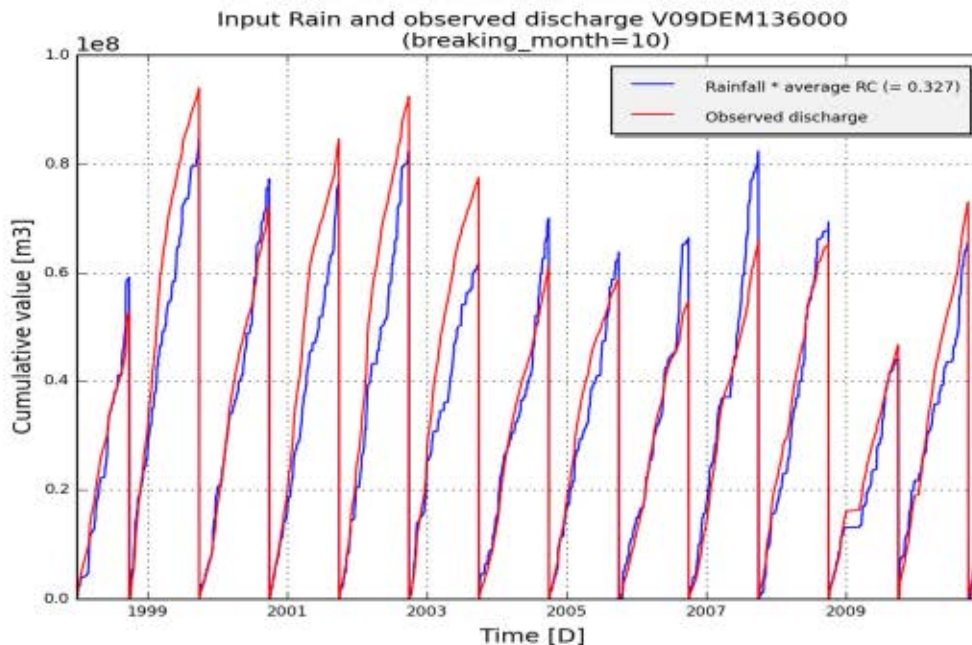


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V09DEM136000 (Demerbekken)

9.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V09DEM136000 |
| subcatchment_area [m2] | 255882000 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 9.58), (‘SMmax.C’, 751.12), (‘CQOF.C’, 0.35), (‘CKBF.C’, 2200.0), (‘CKIF.C’, 531.8), (‘CK1.C’, 27.29), (‘CK2.C’, 24.2), (‘TIF.C’, 0.3), (‘TOF.C’, 0.22), (‘NAM.TG.C’, 0.12)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 24289653.115 | 11914227.843 |
| RelErr | 5.0 % | -0.7 % |
| RMSE | 26742487.047 | 17289403.205 |
| NS | 0.687 | 0.6 |
| NS_log | 0.655 | 0.389 |
| NS_rel | 0.756 | 0.732 |

9.3 Observed and simulated timeseries for optimum parameters

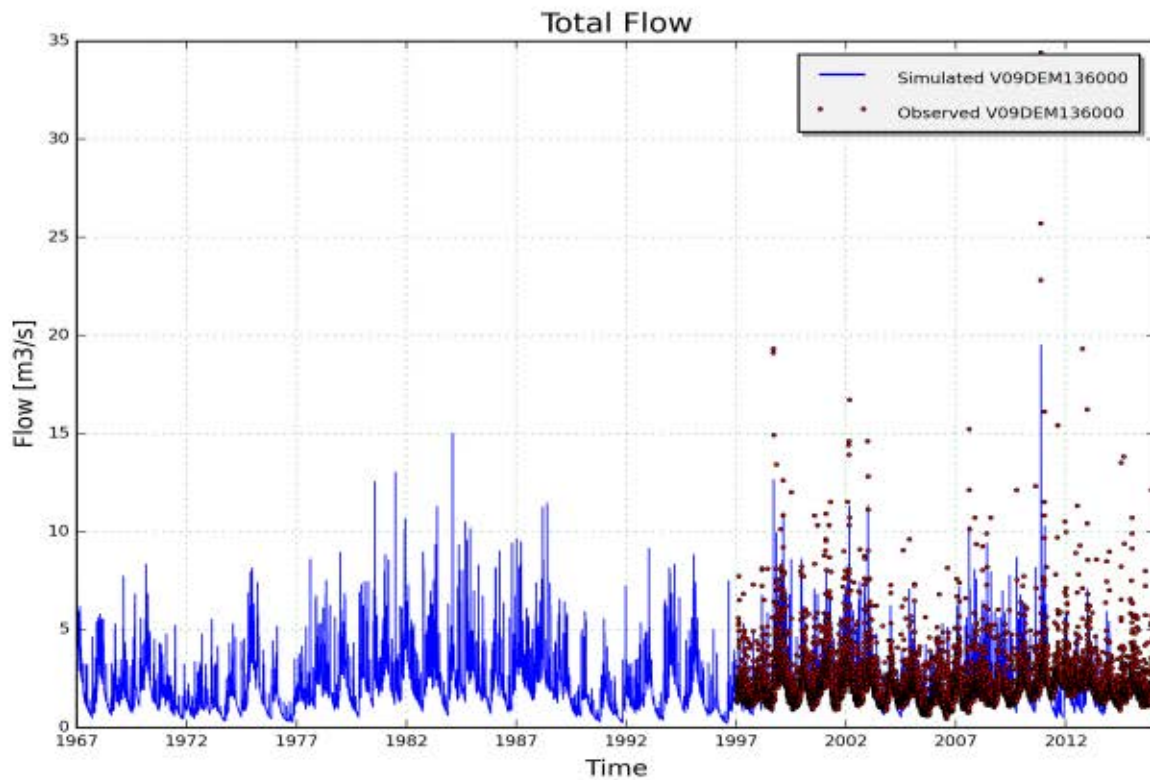


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (validation period 1967-2013)

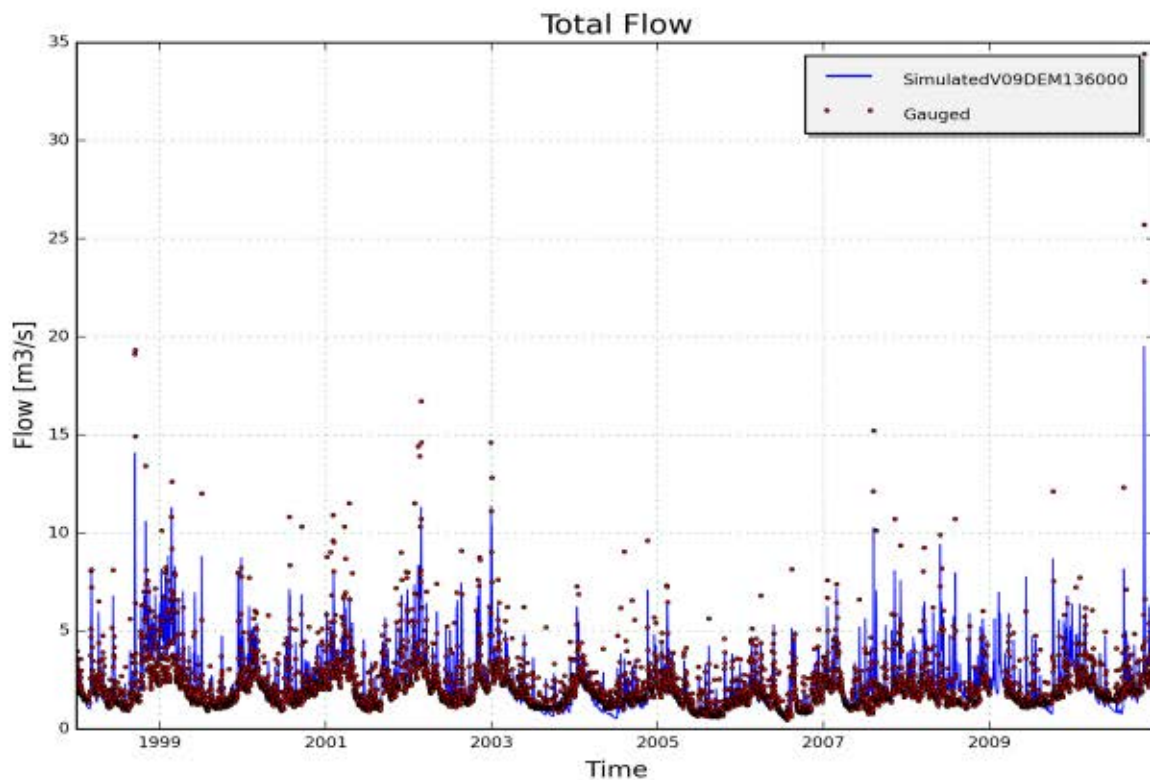


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V09DEM136000, station 13610102 - Demer; Hasselt(calibration period)

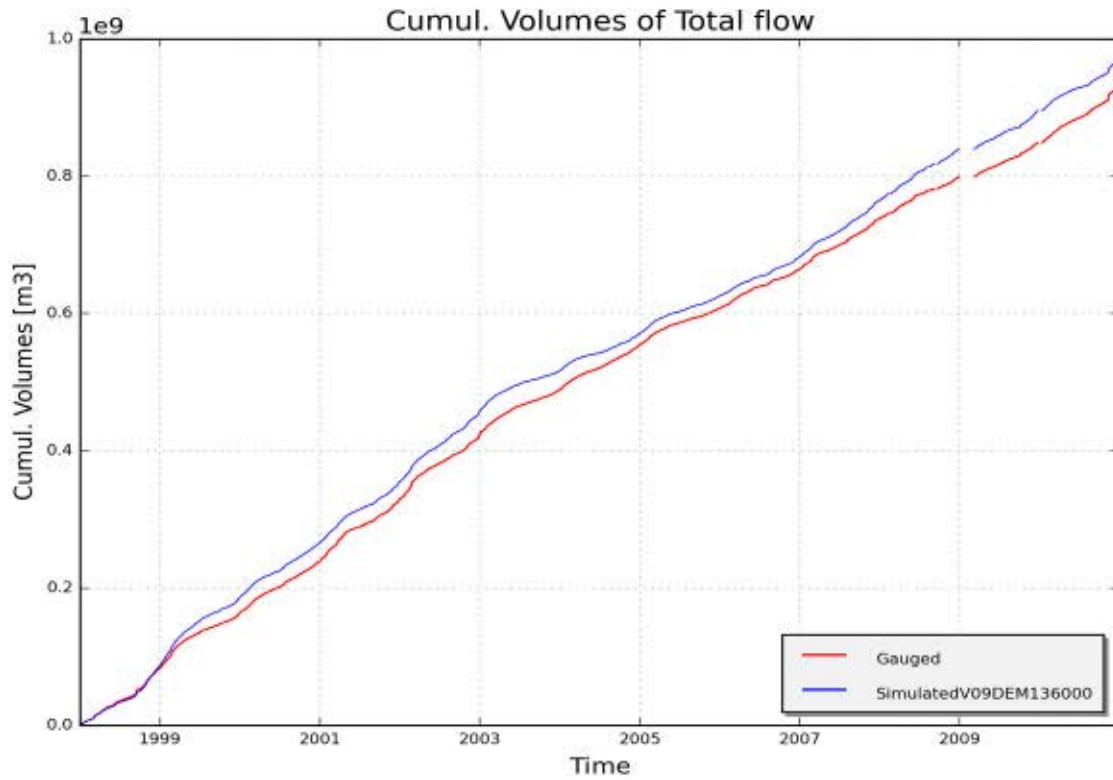


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V09DEM136000, station 13610102 - Demer; Hasselt (calibration period)

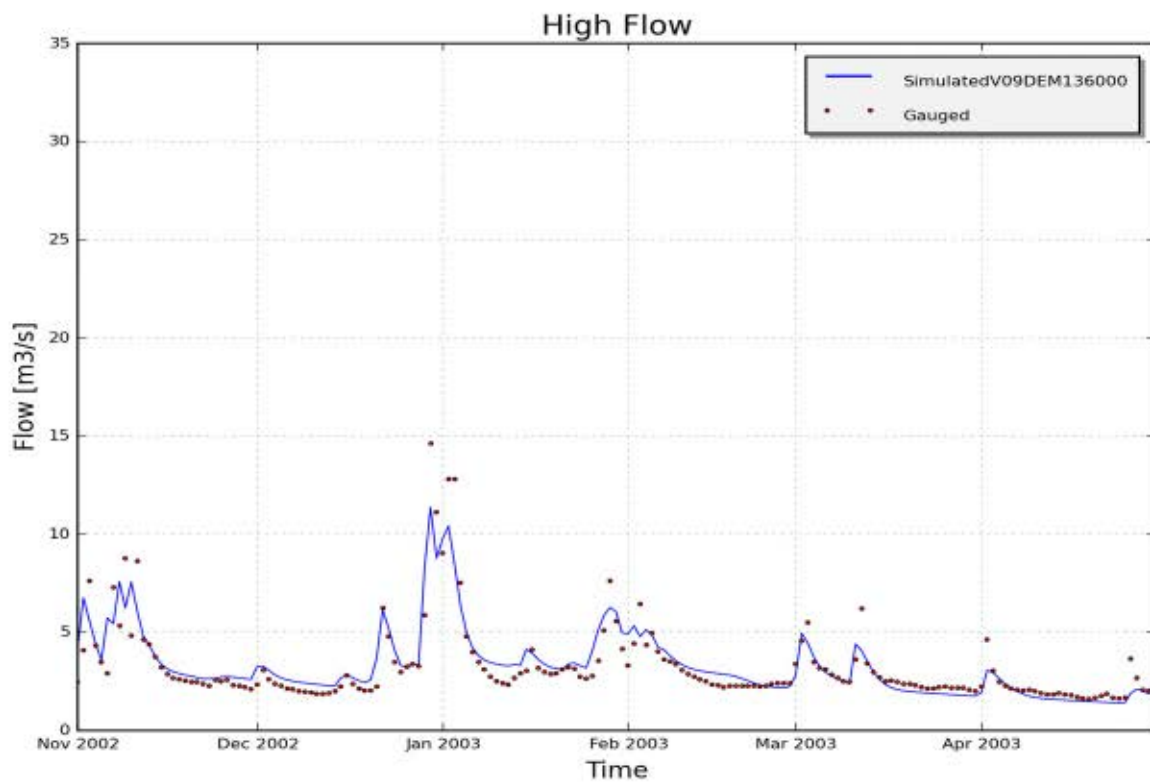


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

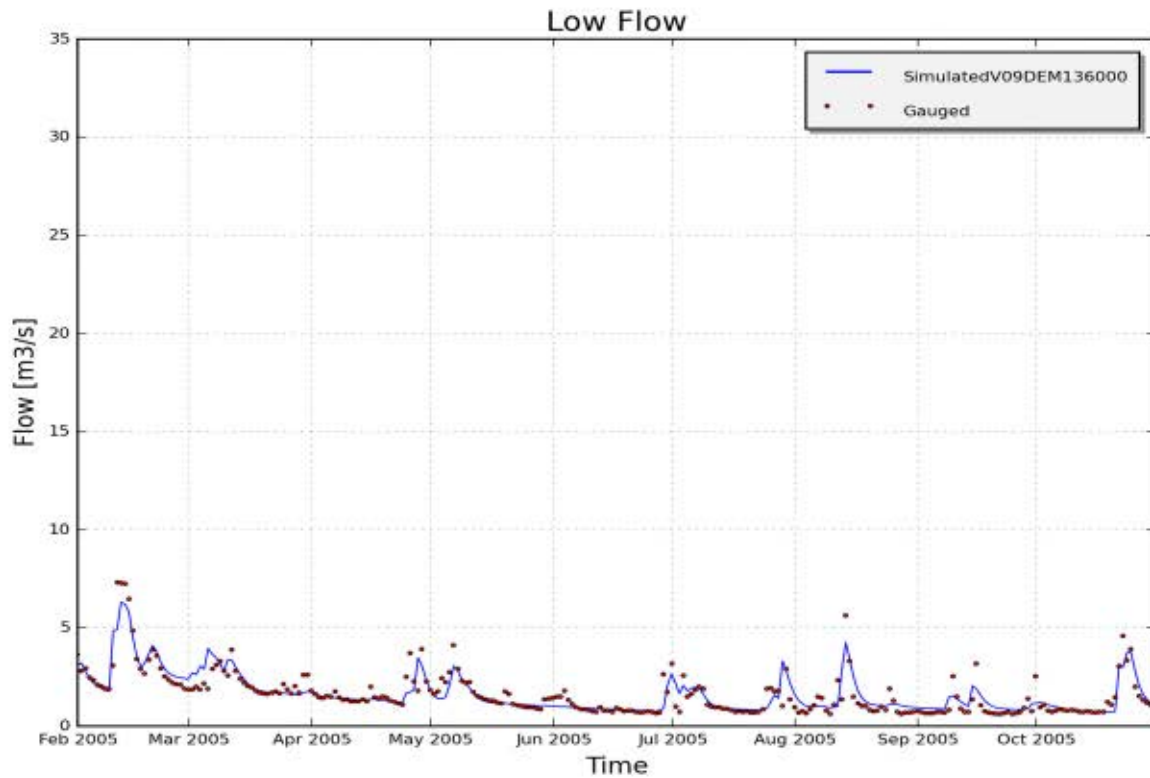


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

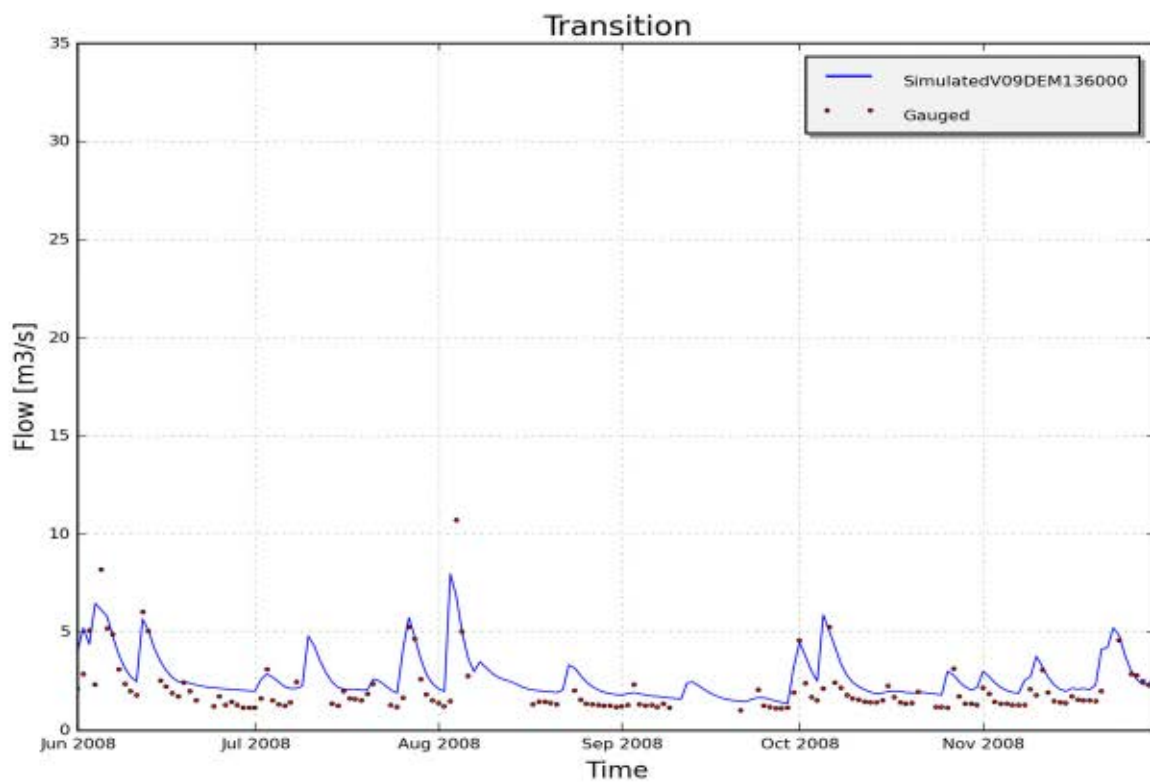


Figure 8: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V09DEM136000, station 13610102 - Demer; Hasselt

Appendix 12

Results of calibration and validation of NAM parameters for catchment "V10GNE076999" (NETE)

1 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V10GNE076999" (NETE)

1.1 Input data

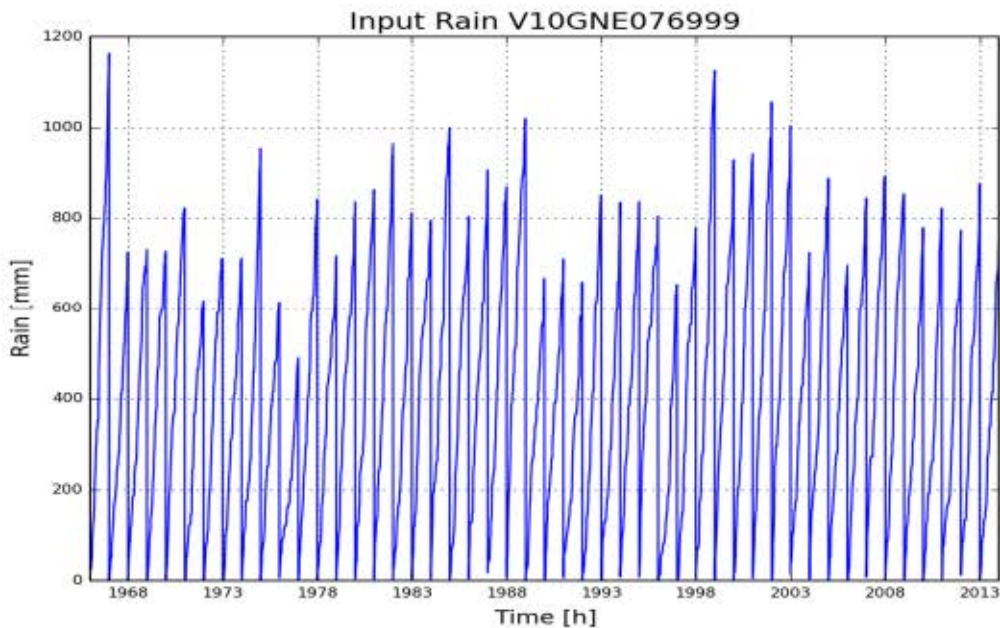


Figure 1: Cumulative precipitation on catchment V10GNE076999 (Nete)

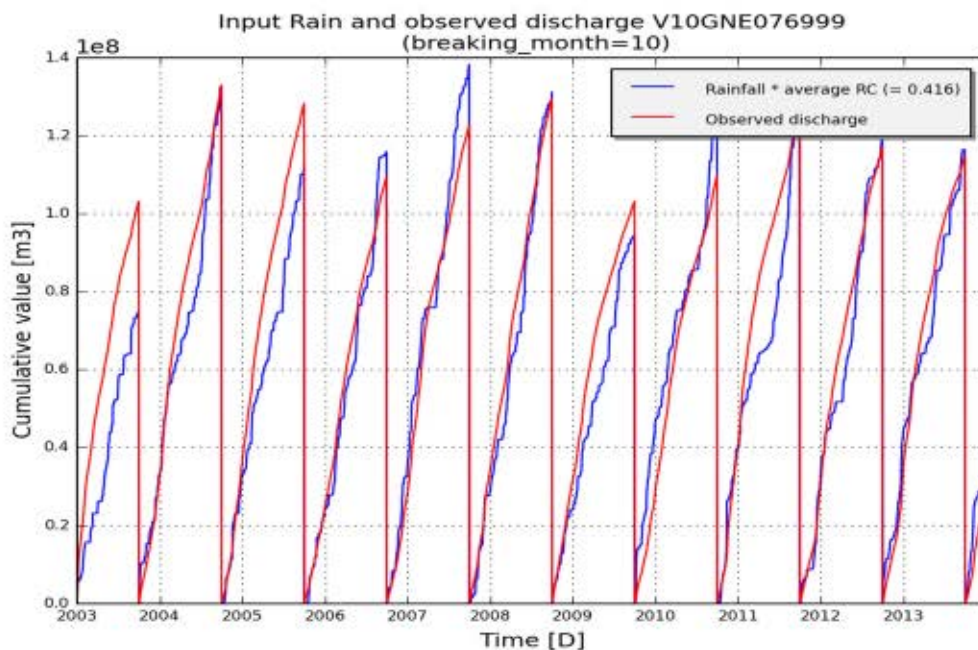


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V10GNE076999 (Nete)

1.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V10GNE076999 |
| subcatchment_area [m2] | 359885327 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:['Umax.C', 0.71), ('SMmax.C', 414.5), ('CQOF.C', 0.2), ('CKBF.C', 1525.84), ('CKIF.C', 232.16), ('CK1.C', 42.37), ('CK2.C', 38.8), ('TIF.C', 0.7), ('TOF.C', 0.08), ('NAM.TG.C', 0.0)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 24815894.109 | 138454474.942 |
| RelErr | -2.9 % | -7.4 % |
| RMSE | 31134402.617 | 150595370.336 |
| NS | 0.709 | 0.701 |
| NS_log | 0.652 | 0.574 |
| NS_rel | 0.728 | 0.651 |

1.3 Observed and simulated timeseries for optimum parameters

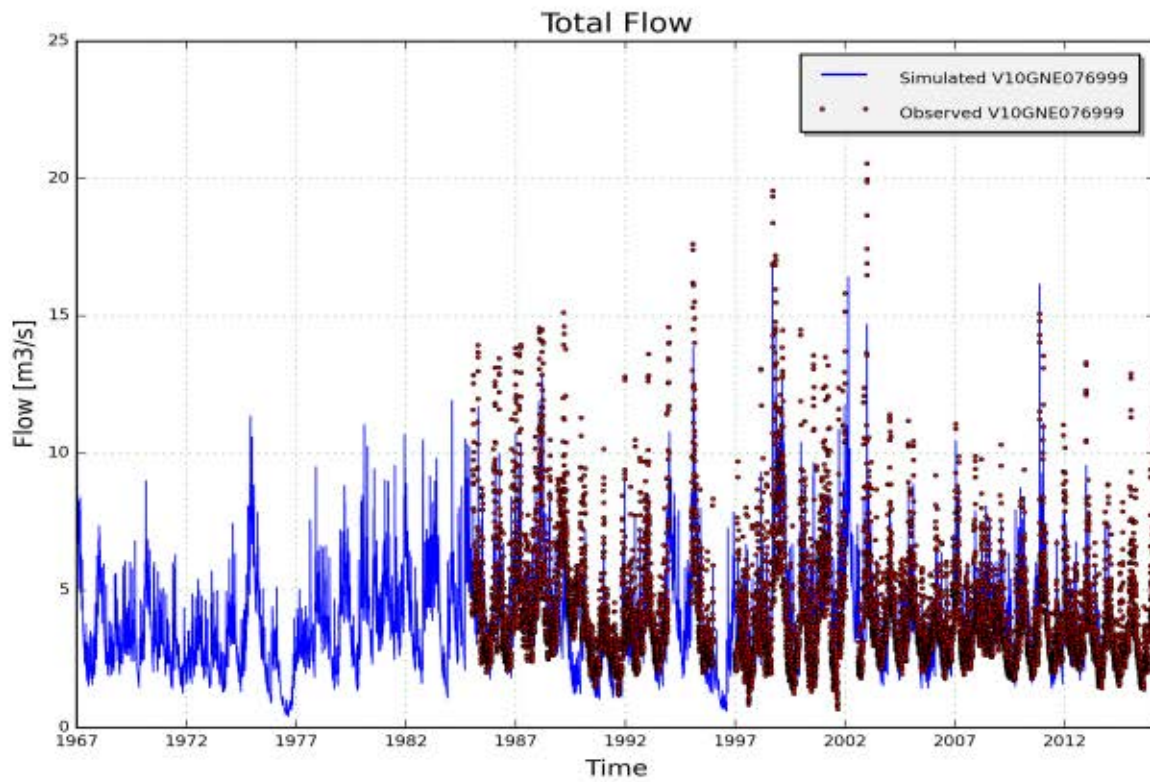


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (validation period 1967-2013)

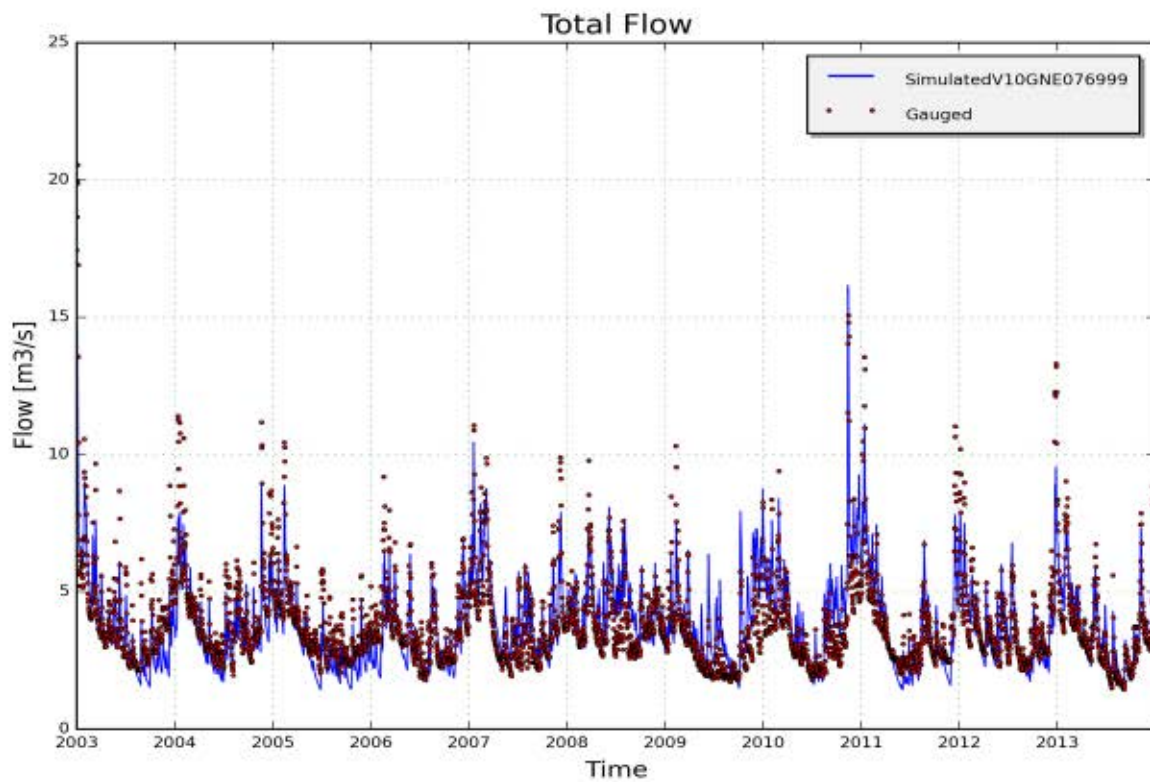


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel(calibration period)

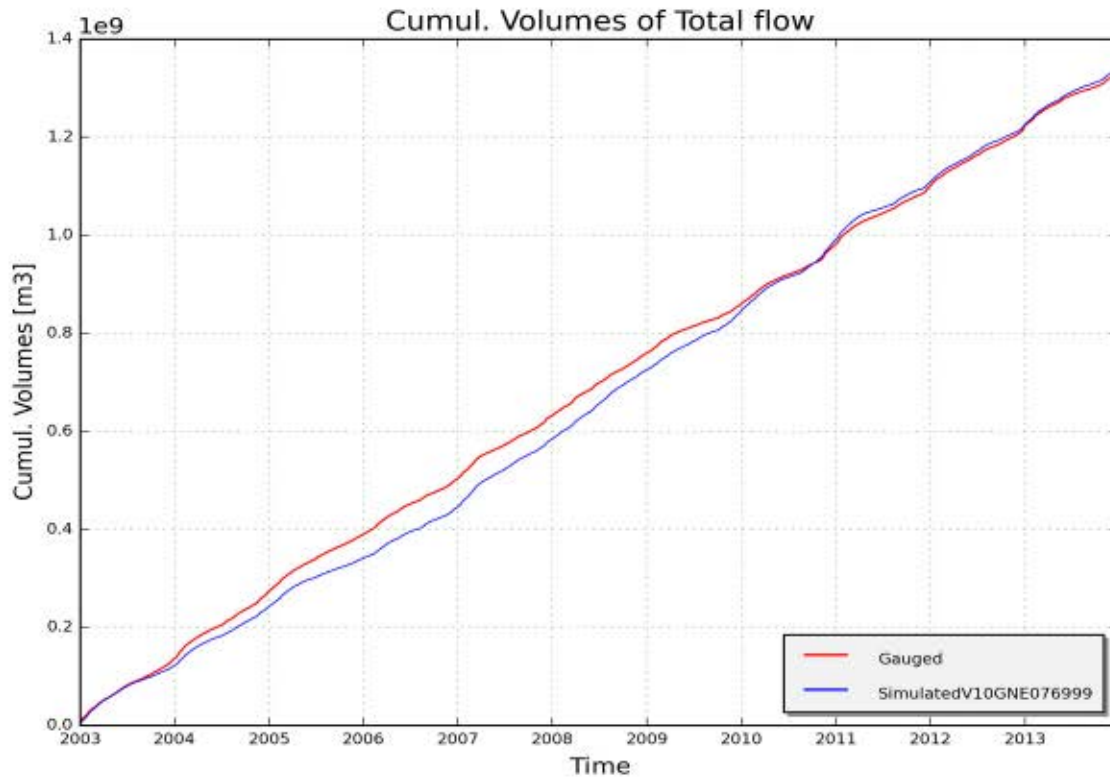


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel (calibration period)

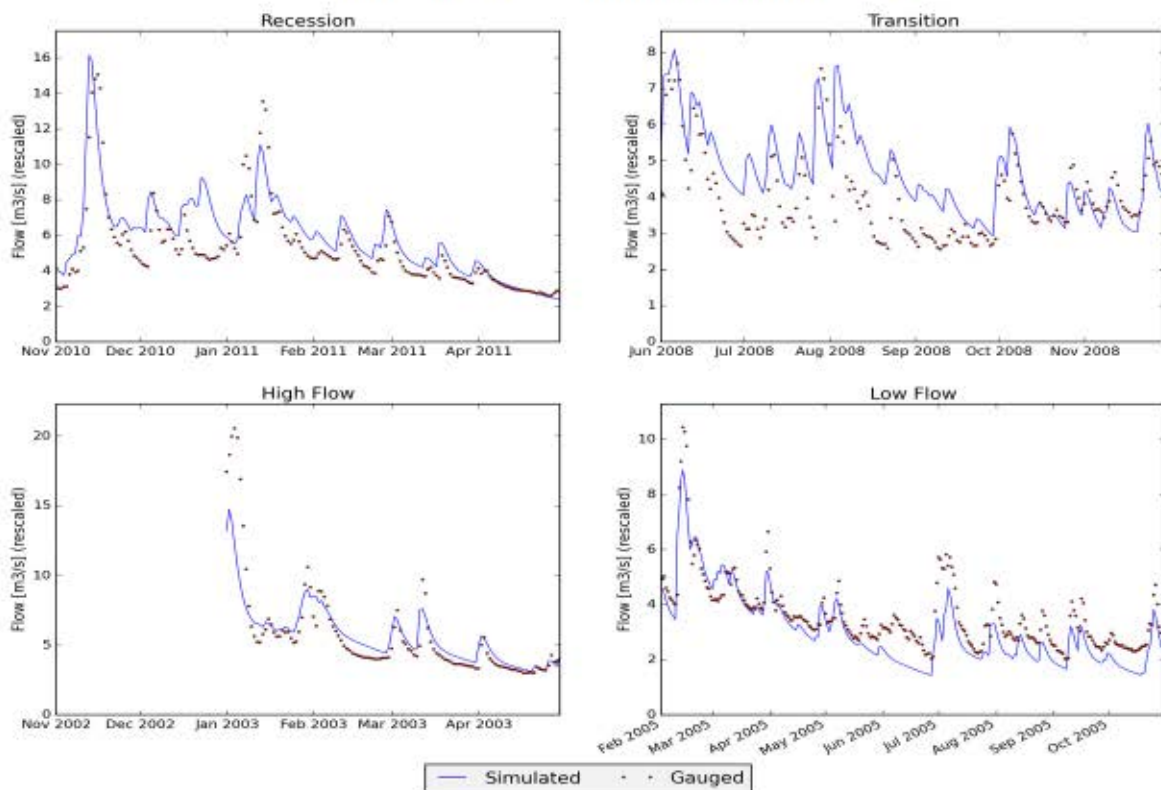


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10GNE076999, station 7610102 Grote Nete/Geel Zammel

2 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V10KNE052000" (NETE)

2.1 Input data

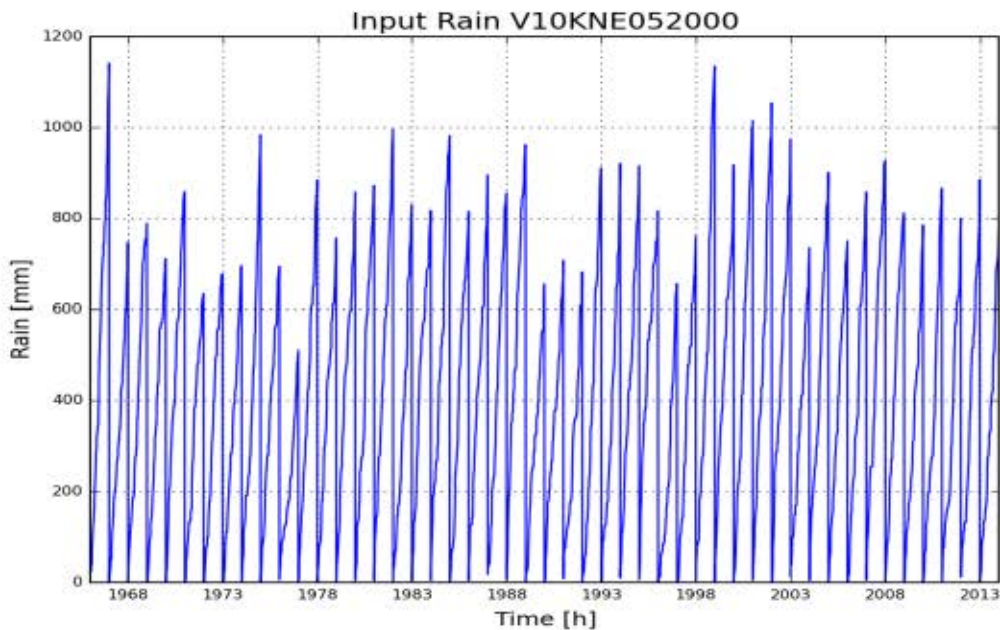


Figure 1: Cumulative precipitation on catchment V10KNE052000 (Nete)

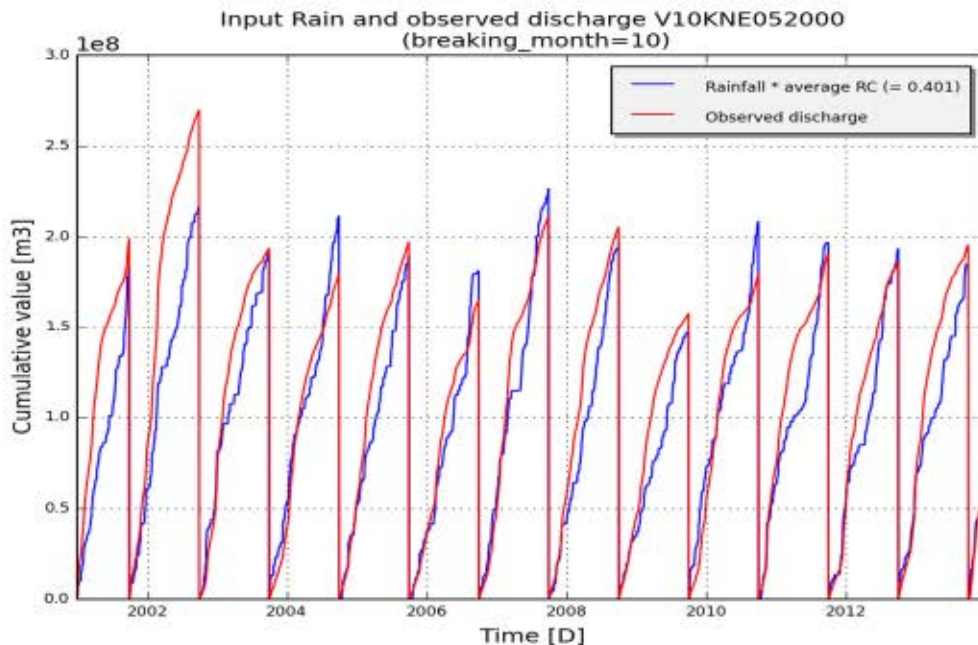


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V10KNE052000 (Nete)

2.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V10KNE052000 |
| subcatchment_area [m2] | 584669408 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 5.03), (‘SMmax.C’, 245.35), (‘CQOF.C’, 0.38), (‘CKBF.C’, 1321.53), (‘CKIF.C’, 271.71), (‘CK1.C’, 40.25), (‘CK2.C’, 40.69), (‘TIF.C’, 0.2), (‘TOF.C’, 0.24), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 20828972.549 | 77280031.587 |
| RelErr | -0.6 % | -2.4 % |
| RMSE | 25606190.457 | 83388548.709 |
| NS | 0.799 | 0.821 |
| NS_log | 0.808 | 0.792 |
| NS_rel | 0.824 | 0.838 |

2.3 Observed and simulated timeseries for optimum parameters

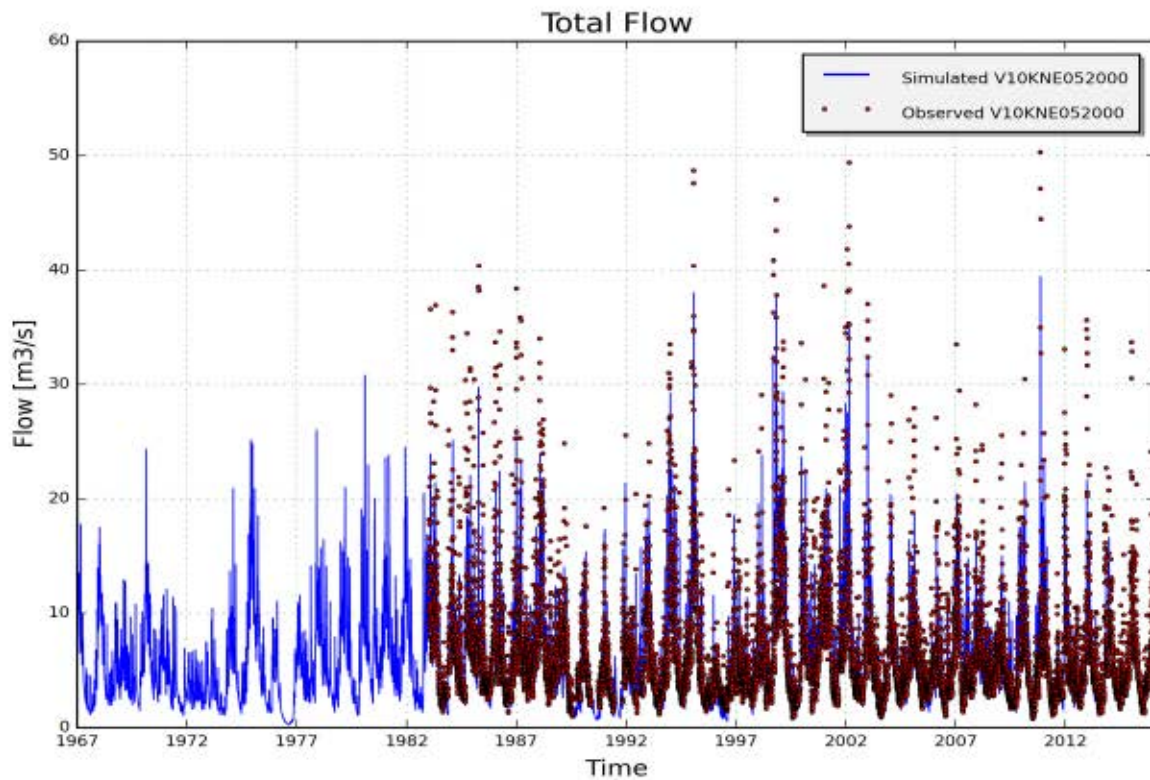


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (validation period 1967-2013)

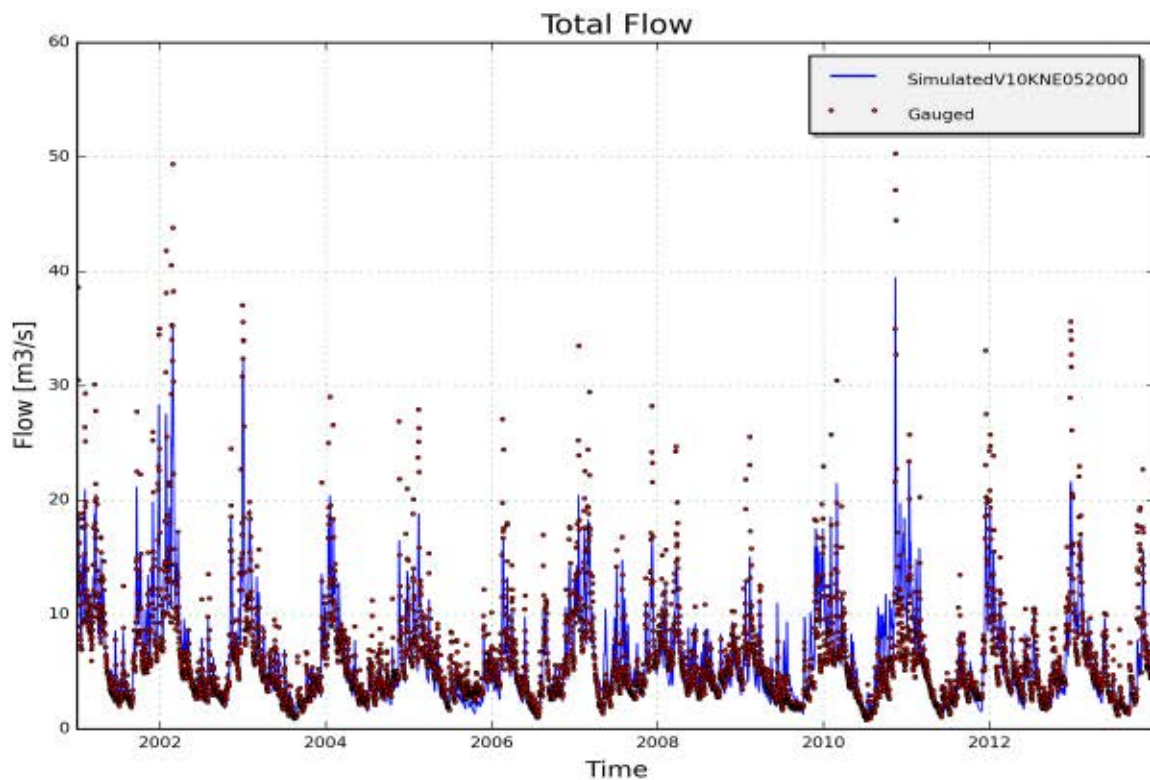


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (calibration period)

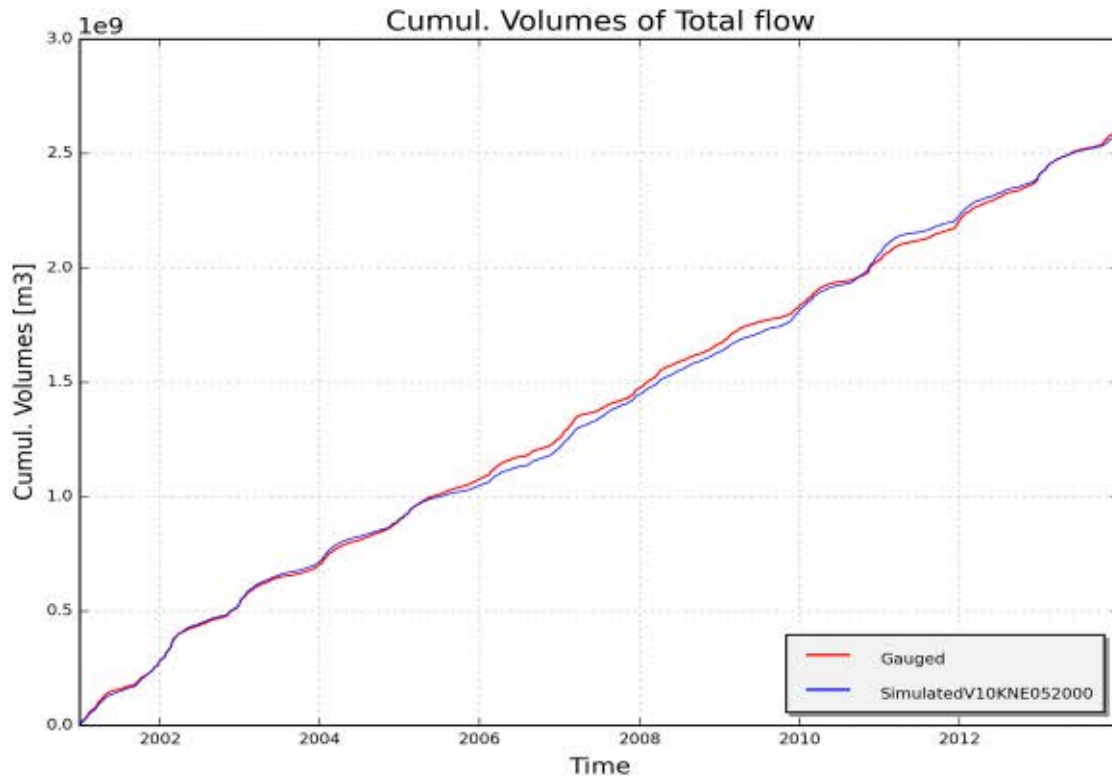


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk (calibration period)

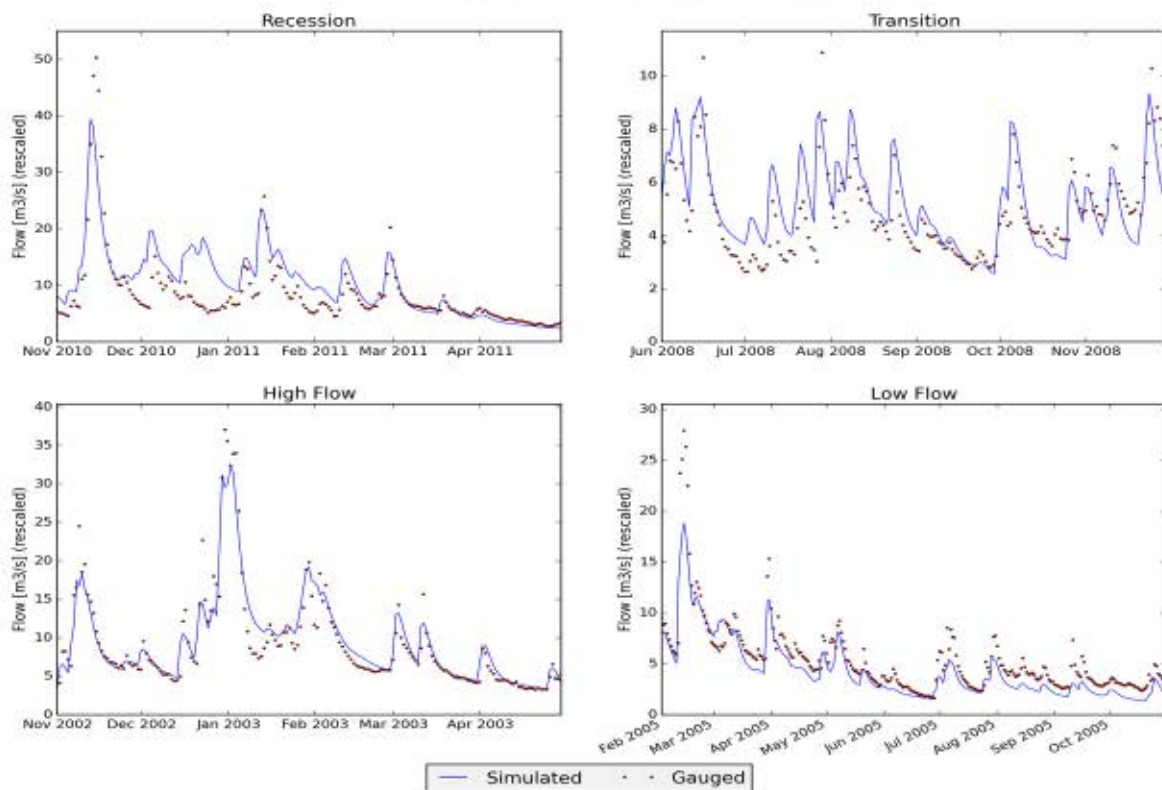


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10KNE052000, station 5210102 - Kleine Nete; Grobbendonk

3 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V10MOP062140" (NETE)

3.1 Input data

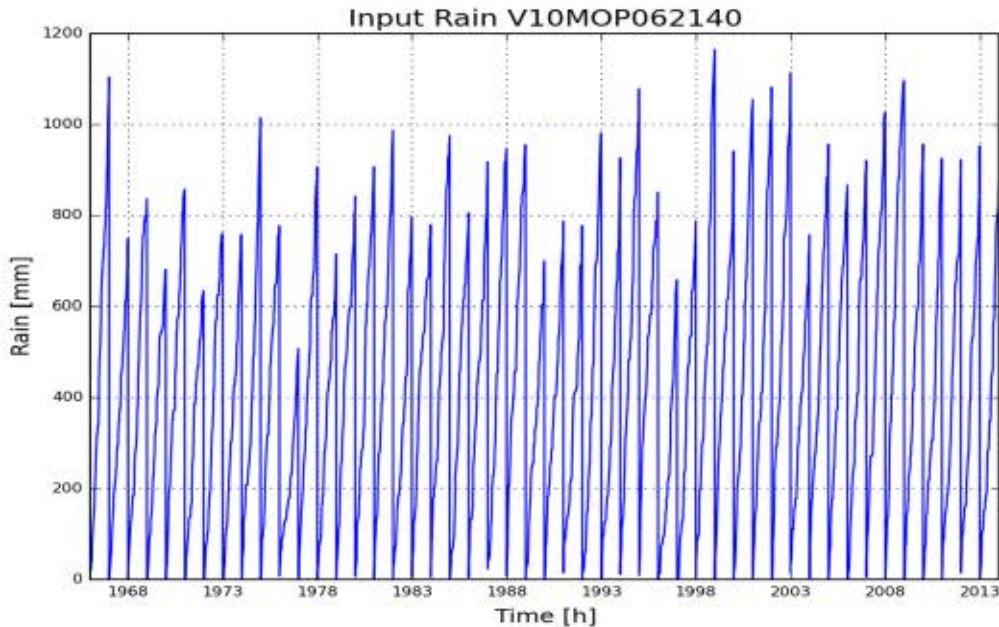


Figure 1: Cumulative precipitation on catchment V10MOP062140 (Nete)

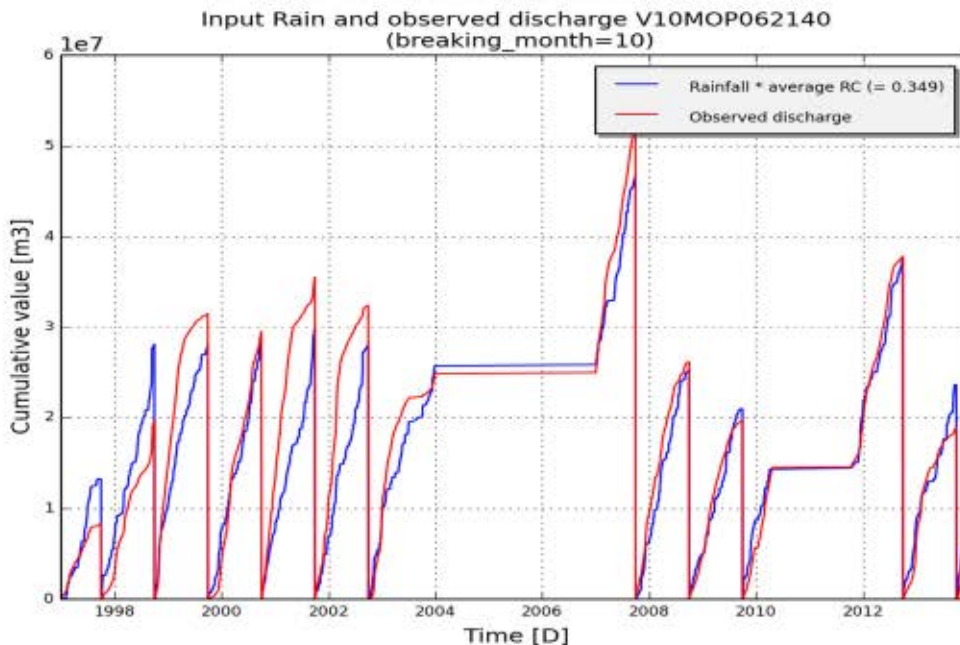


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V10MOP062140 (Nete)

3.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V10MOP062140 |
| subcatchment_area [m2] | 77319091 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 13.7), (‘SMmax.C’, 872.81), (‘CQOF.C’, 0.21), (‘CKBF.C’, 1149.22), (‘CKIF.C’, 471.76), (‘CK1.C’, 23.07), (‘CK2.C’, 32.59), (‘TIF.C’, 0.61), (‘TOF.C’, 0.53), (‘NAM.TG.C’, 0.55)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 3293178.779 | 27527028.359 |
| RelErr | -0.5 % | 12.2 % |
| RMSE | 4326797.677 | 28613155.965 |
| NS | 0.599 | 0.64 |
| NS_log | 0.658 | 0.629 |
| NS_rel | -0.274 | -0.669 |

3.3 Observed and simulated timeseries for optimum parameters

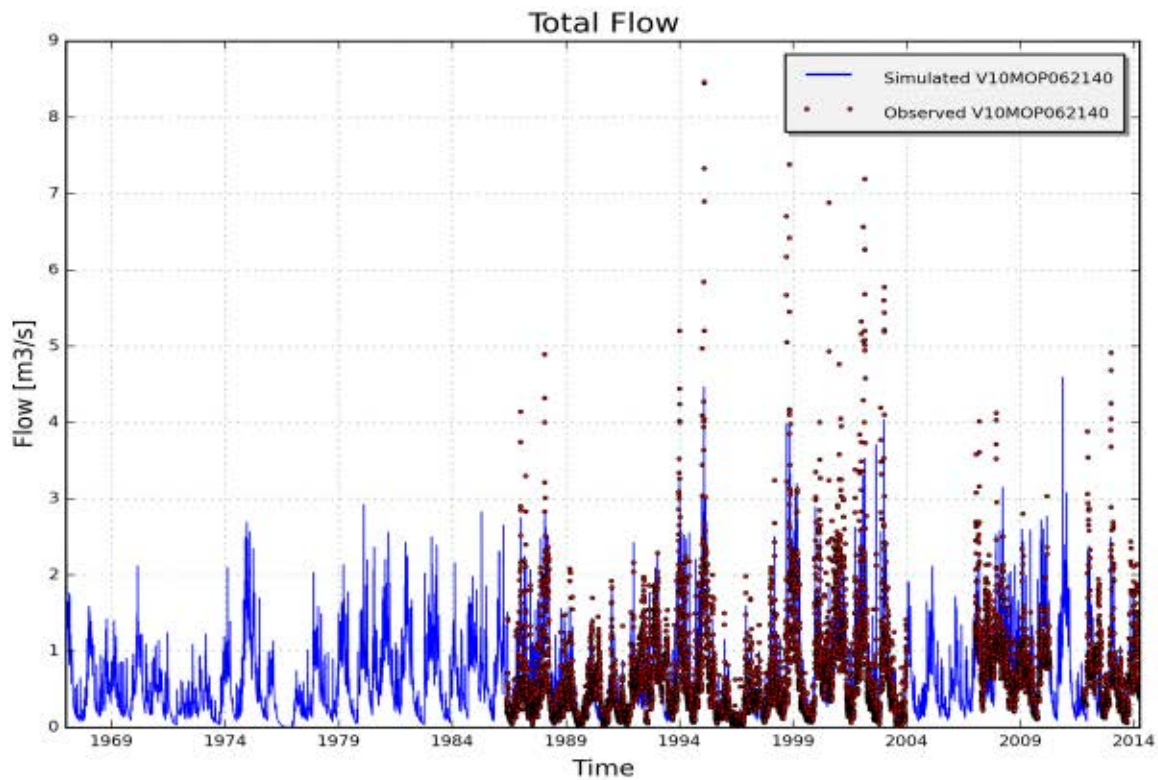


Figure 3: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (validation period 1967-2013)

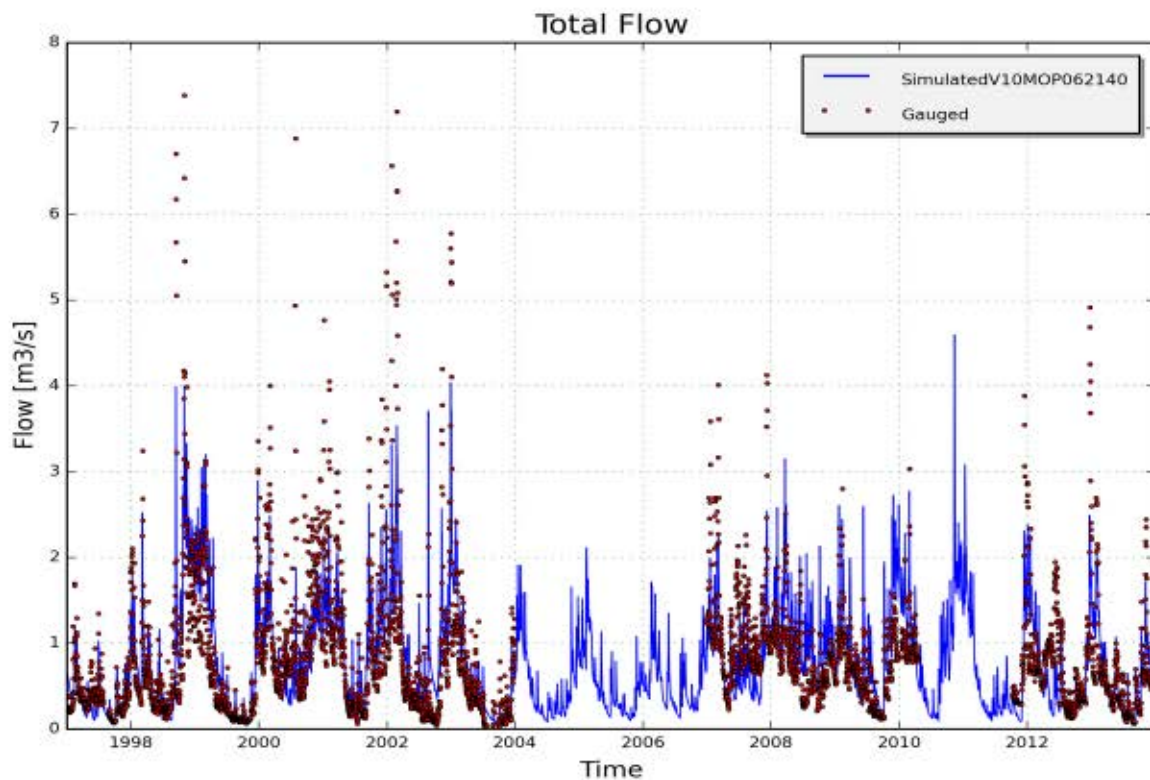


Figure 4: Measured (red) and simulated (blue) daily discharge [m3/s] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (calibration period)

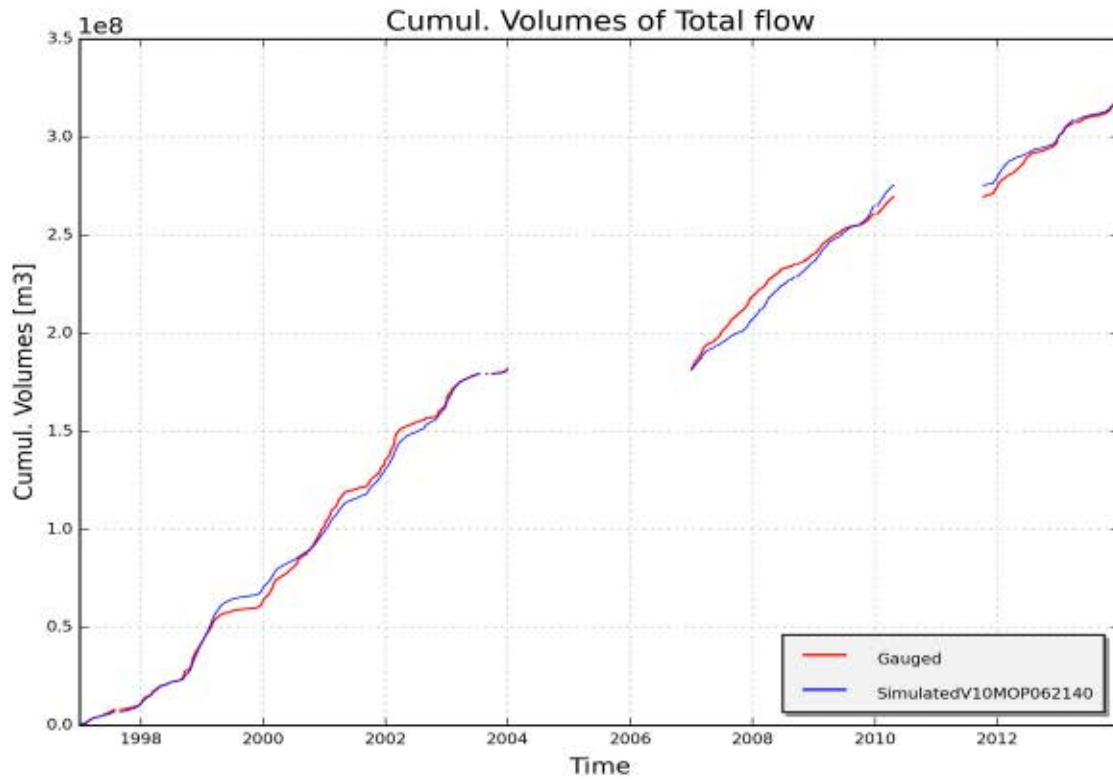


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m3] on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle (calibration period)

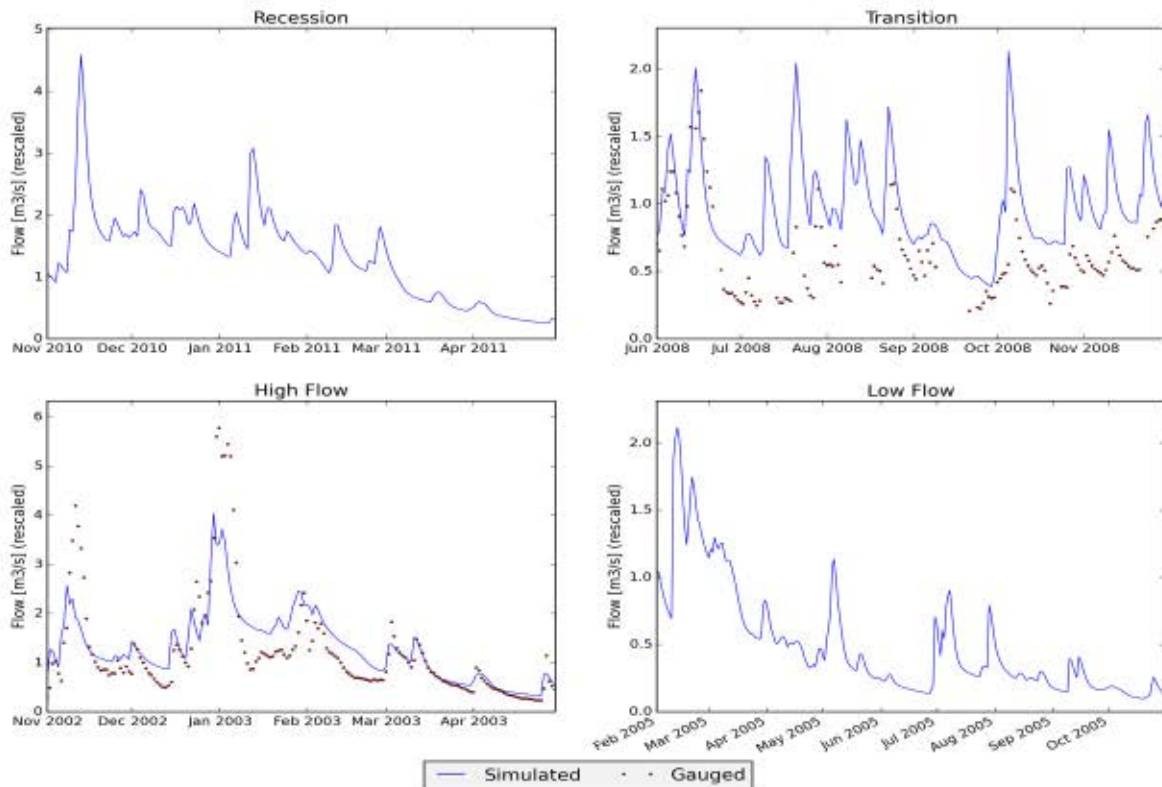


Figure 6: Measured (red) and simulated (blue) daily discharge [m3/s] during specific low and high flow events on catchment V10MOP062140, station 6210102 - Molenbeek, Pulle

4 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V10WIM082050" (NETE)

4.1 Input data

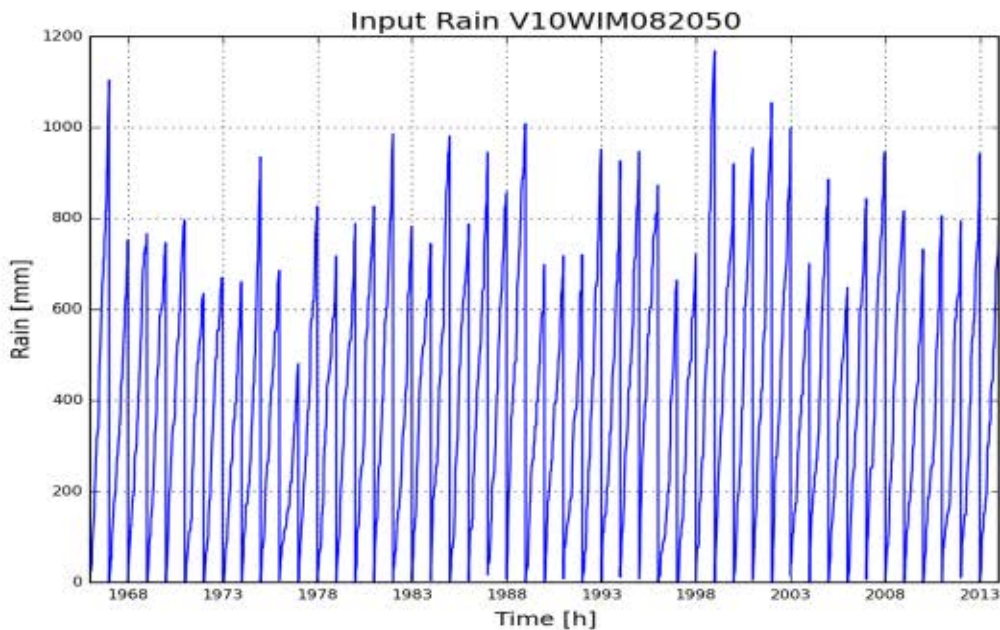


Figure 1: Cumulative precipitation on catchment V10WIM082050 (Nete)

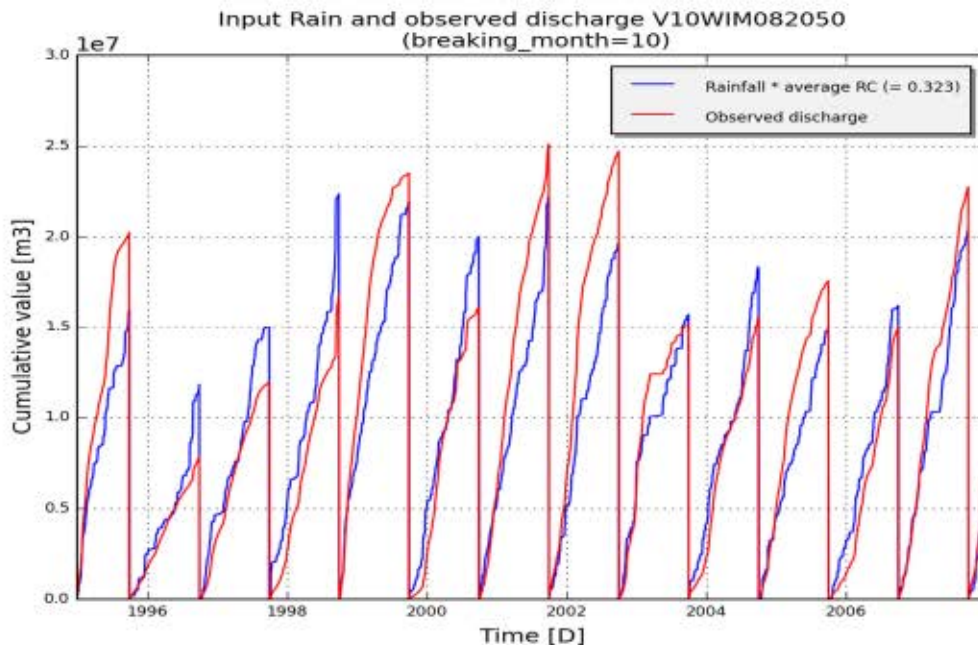


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V10WIM082050 (Nete)

4.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V10WIM082050 |
| subcatchment_area [m2] | 65701200 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 10.17), (‘SMmax.C’, 1903.02), (‘CQOF.C’, 0.25), (‘CKBF.C’, 1622.51), (‘CKIF.C’, 367.89), (‘CK1.C’, 24.32), (‘CK2.C’, 27.14), (‘TIF.C’, 0.79), (‘TOF.C’, 0.46), (‘NAM.TG.C’, 0.43)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 4285455.207 | 13789151.051 |
| RelErr | -0.9 % | 10.1 % |
| RMSE | 6458763.829 | 15418482.746 |
| NS | 0.575 | 0.544 |
| NS_log | 0.47 | 0.404 |
| NS_rel | -11.32 | -7.278 |

4.3 Observed and simulated timeseries for optimum parameters

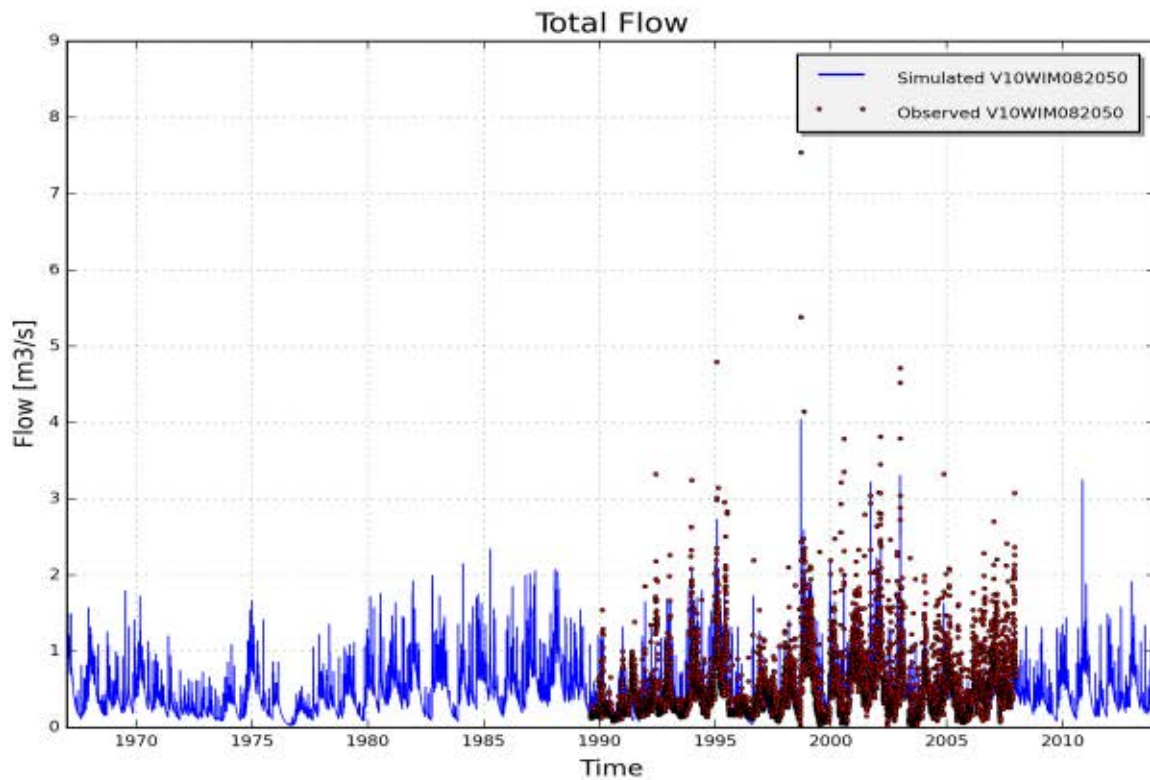


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10WIM082050, station 8210102 - Wiekevorst (validation period 1967-2013)

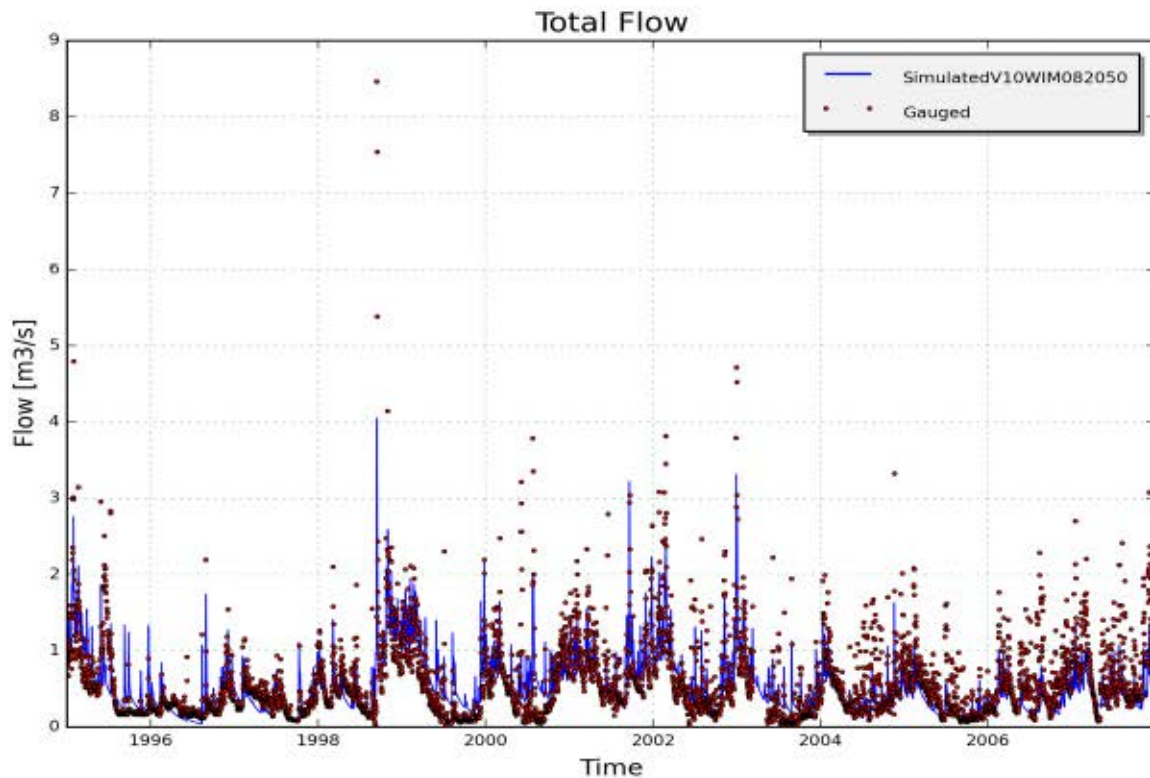


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10WIM082050, station 8210102 - Wiekevorst (calibration period)

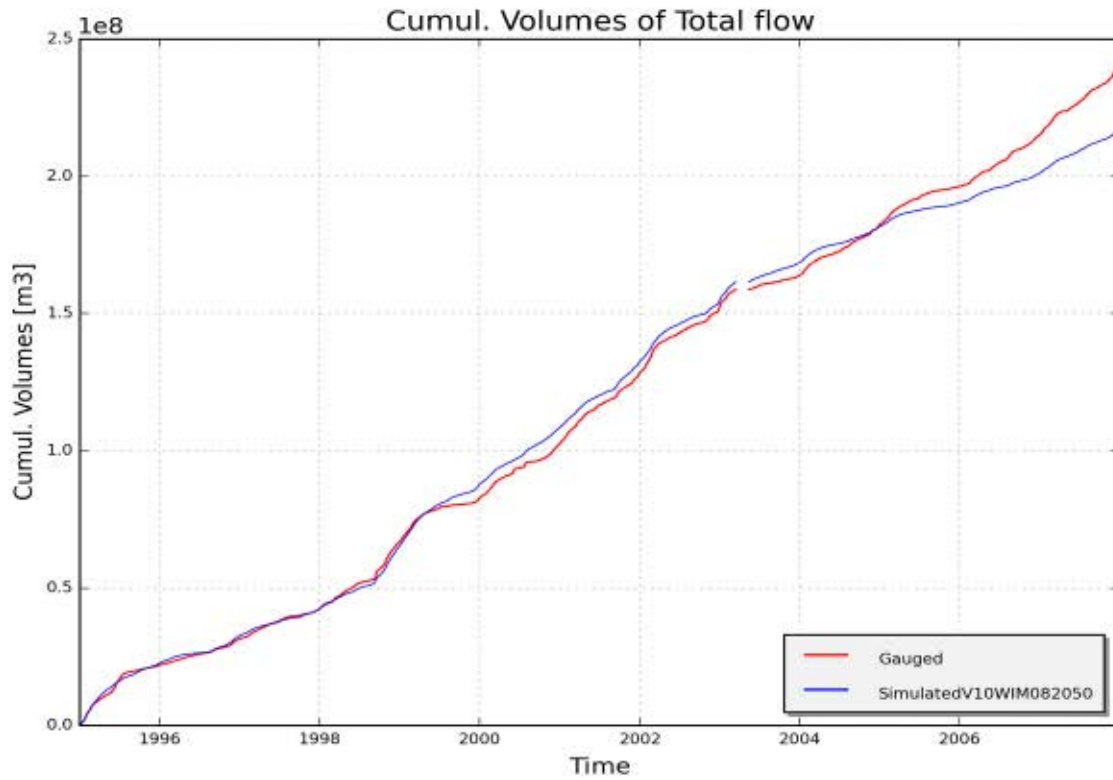


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10WIM082050, station 8210102 - Wiekevorst (calibration period)

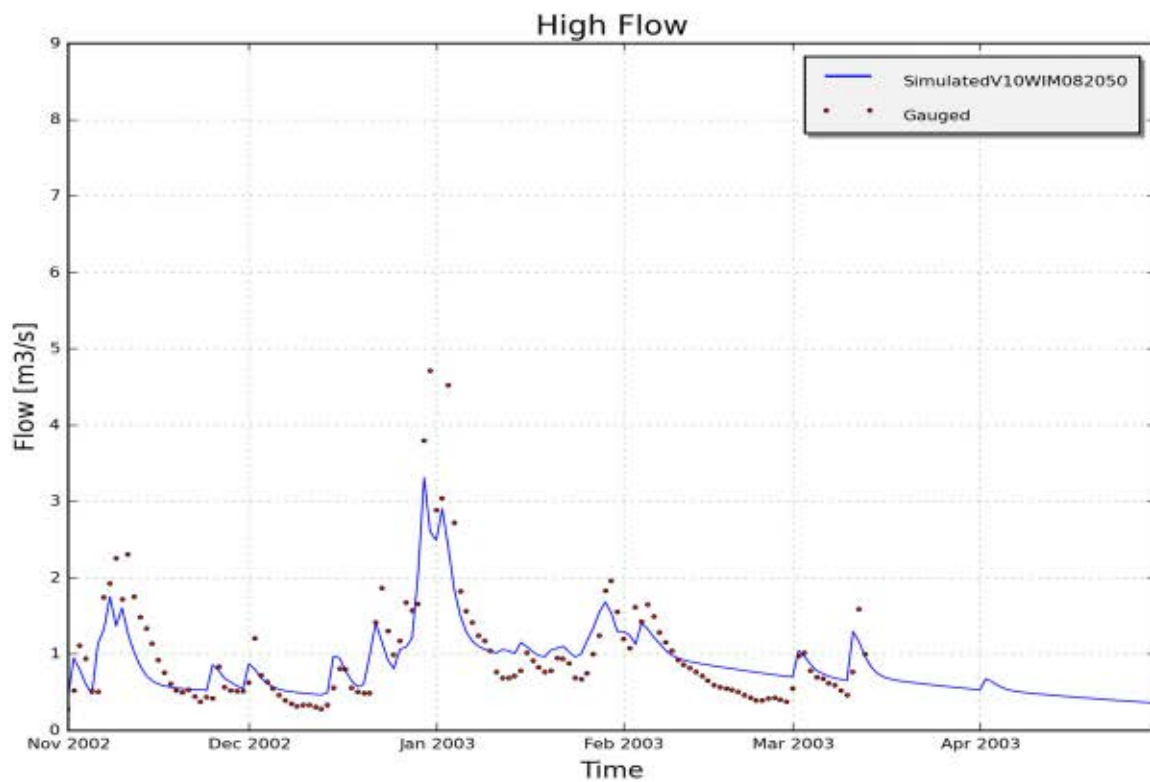


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

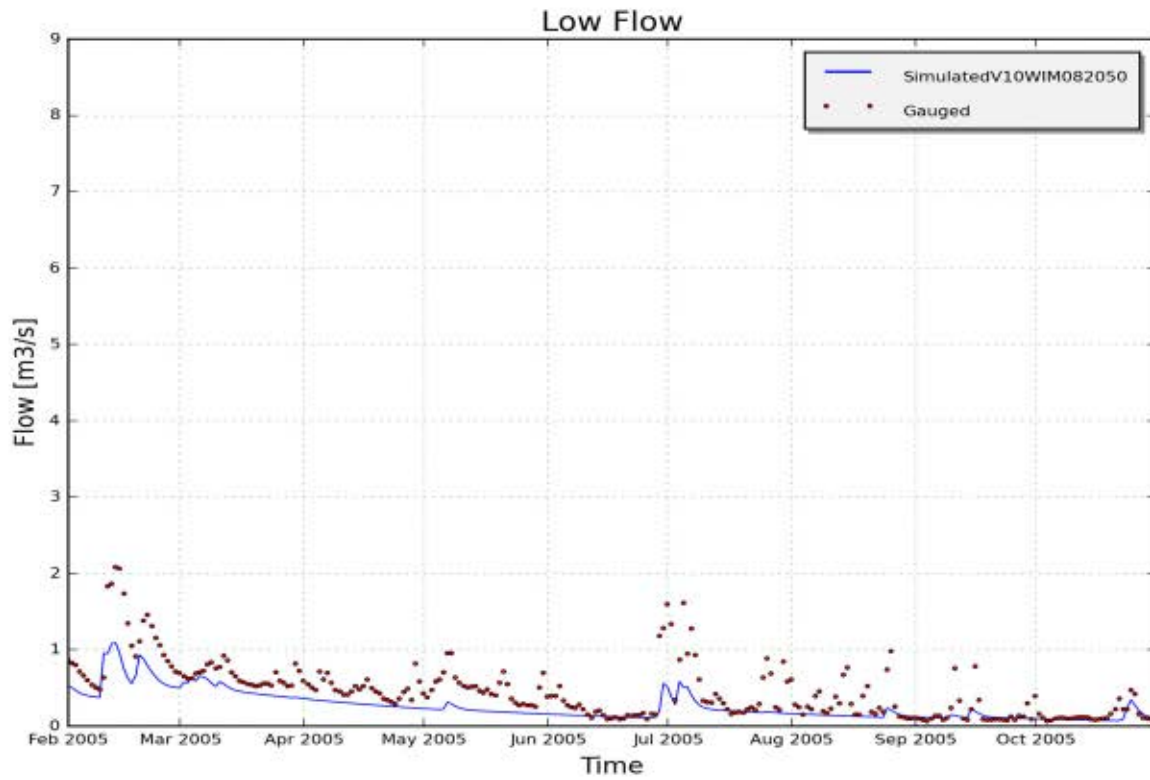


Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10WIM082050, station 8210102 - Wiekevorst

5 RESULTS OF CALIBRATION AND VALIDATION OF NAM PARAMETERS FOR CATCHMENT "V10GLA086020" (NETE)

5.1 Input data

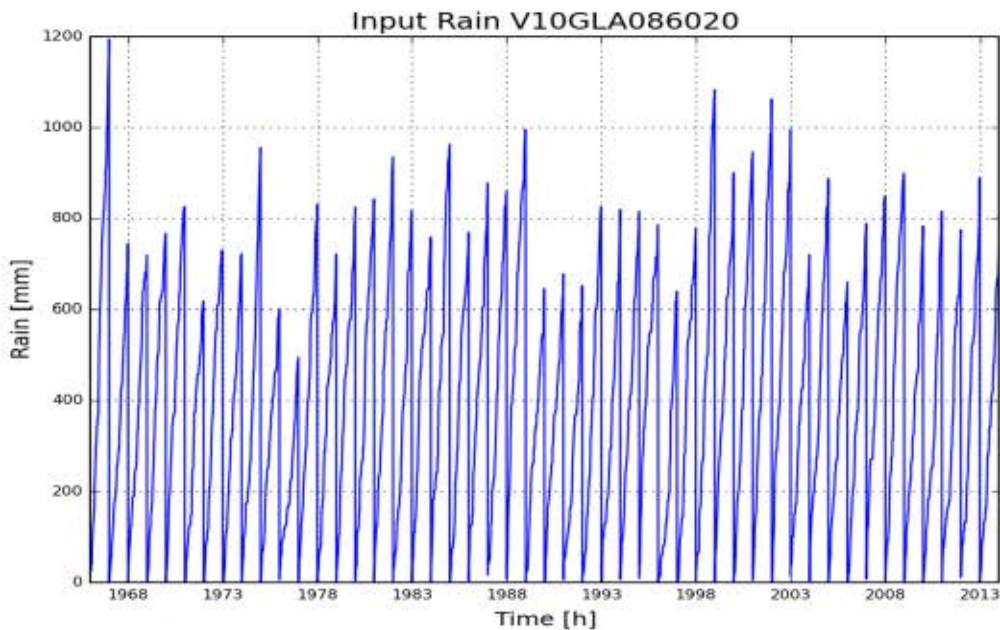


Figure 1: Cumulative precipitation on catchment V10GLA086020 (Nete)

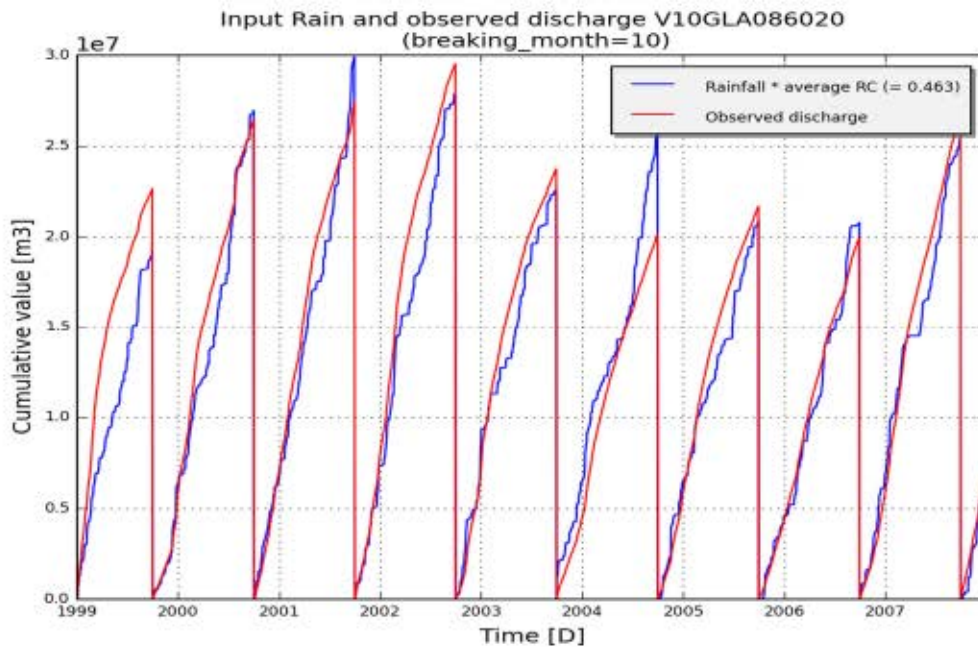


Figure 2: Annual cumulated discharge (red) and scaled precipitation (blue) according to average runoff coefficient (total Q/total P) on catchment V10GLA086020 (Nete)

5.2 Summary calibration

| | |
|------------------------|-------------------|
| model_structure | NAMclassic.Lumped |
| subcatchment_name | V10GLA086020 |
| subcatchment_area [m2] | 62621236 |
| start_date | 01-01-1967 |
| end_date | 31-12-2013 |
| frequency | daily |

Optimal parameter set:[(‘Umax.C’, 1.0), (‘SMmax.C’, 263.15), (‘CQOF.C’, 0.21), (‘CKBF.C’, 1694.68), (‘CKIF.C’, 201.28), (‘CK1.C’, 32.07), (‘CK2.C’, 28.13), (‘TIF.C’, 0.01), (‘TOF.C’, 0.0), (‘NAM.TG.C’, 0.01)]

| | Fitness calibration | Fitness for all available period |
|---------------|---------------------|----------------------------------|
| AbsErr | 2737338.532 | 50504100.8 |
| RelErr | -0.7 % | -18.4 % |
| RMSE | 3834051.28 | 53338388.863 |
| NS | 0.709 | 0.575 |
| NS_log | 0.586 | 0.278 |
| NS_rel | 0.756 | -3.711 |

5.3 Observed and simulated timeseries for optimum parameters

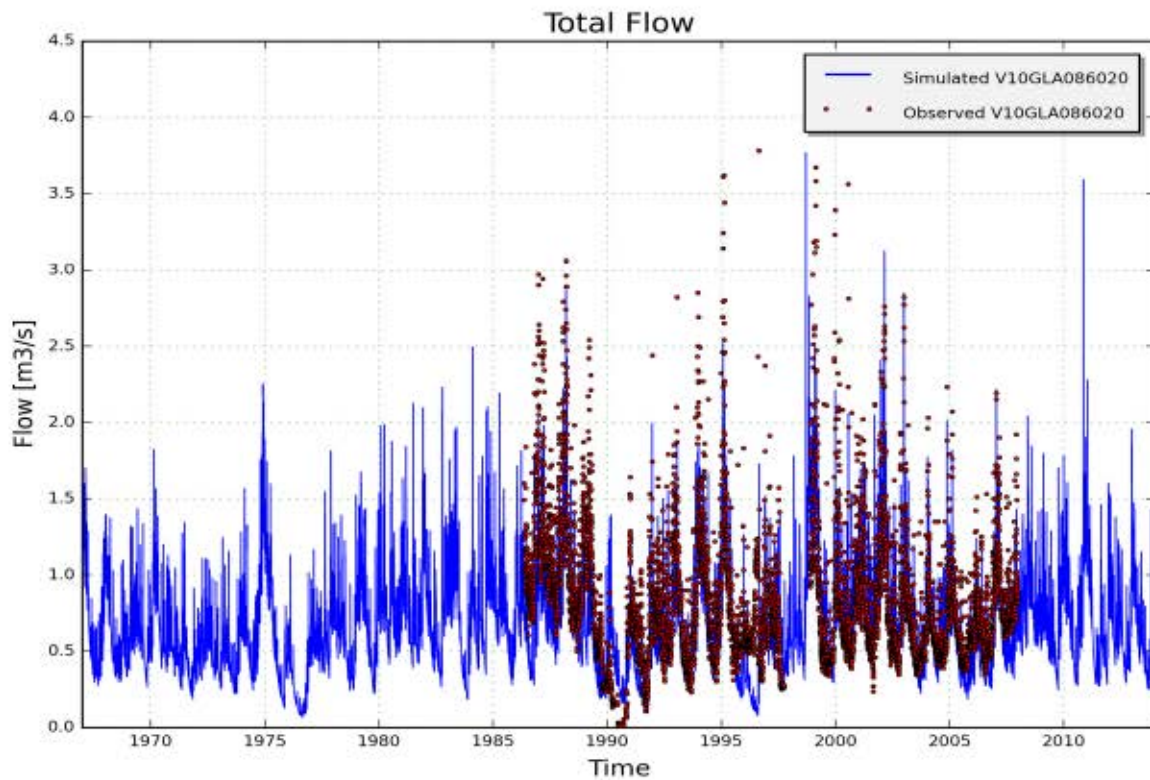


Figure 3: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (validation period 1967-2013)

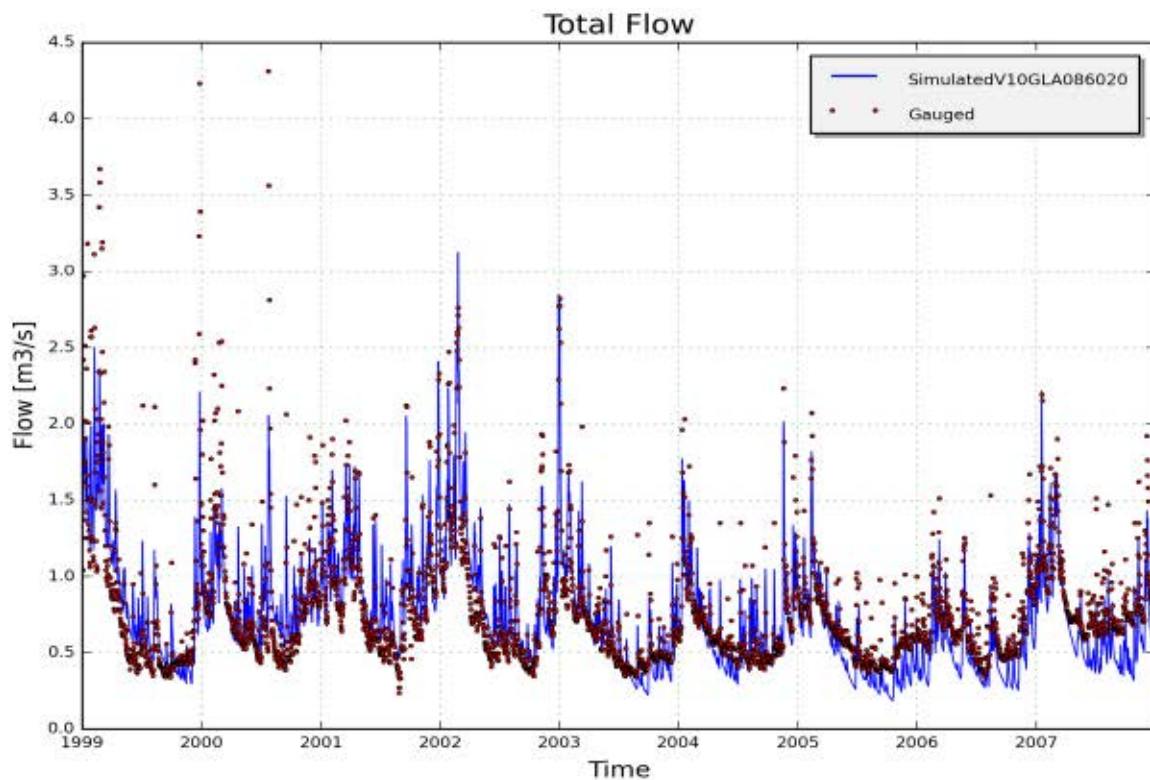


Figure 4: Measured (red) and simulated (blue) daily discharge [m³/s] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (calibration period)

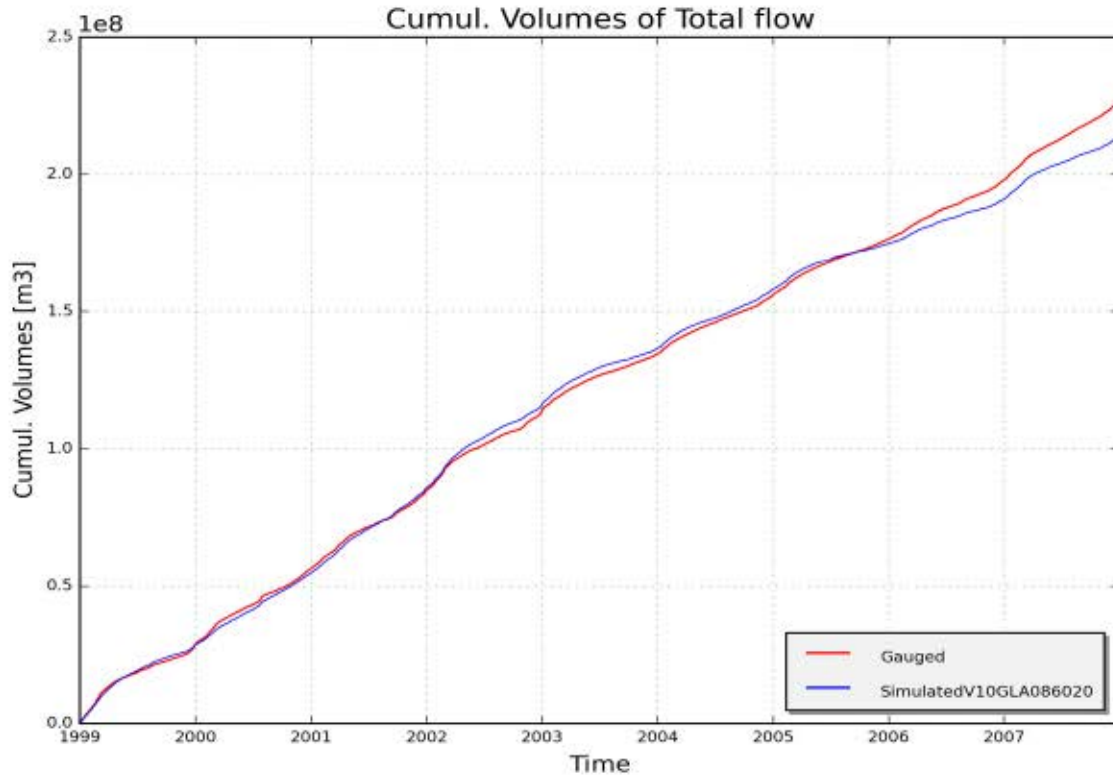


Figure 5: Measured (red) and simulated (blue) cumulative discharge [m³] on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst (calibration period)

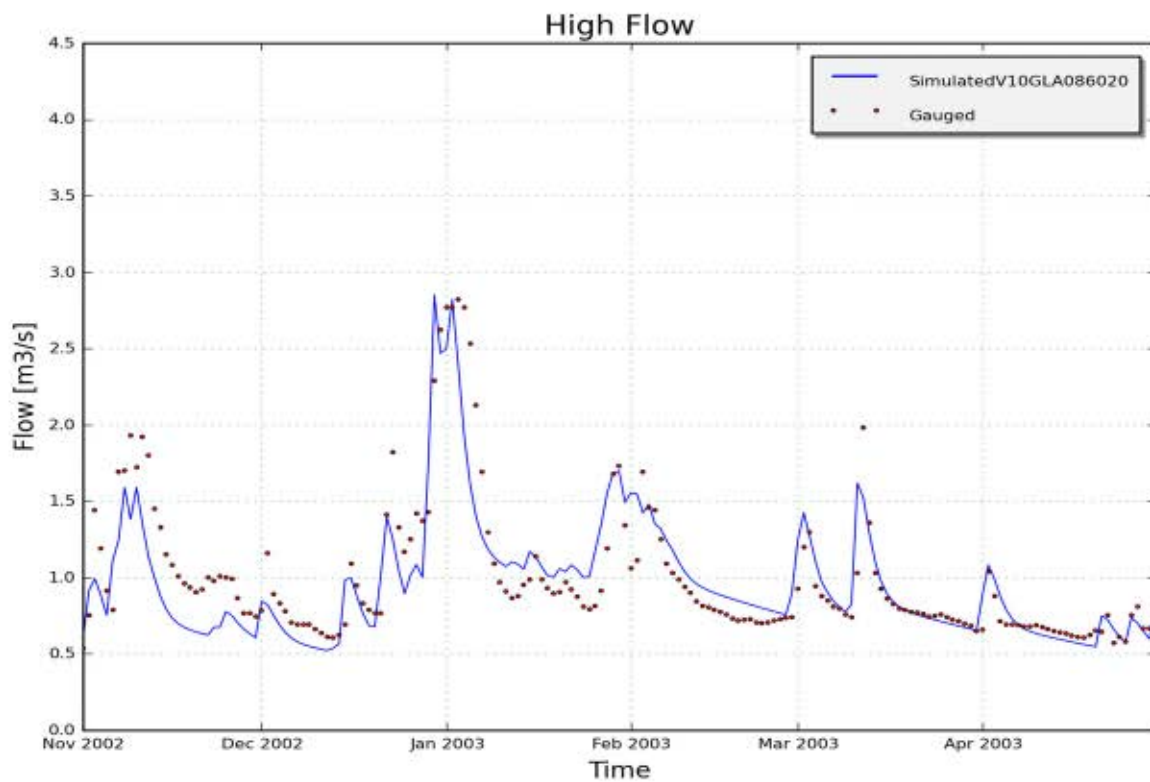


Figure 6: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst

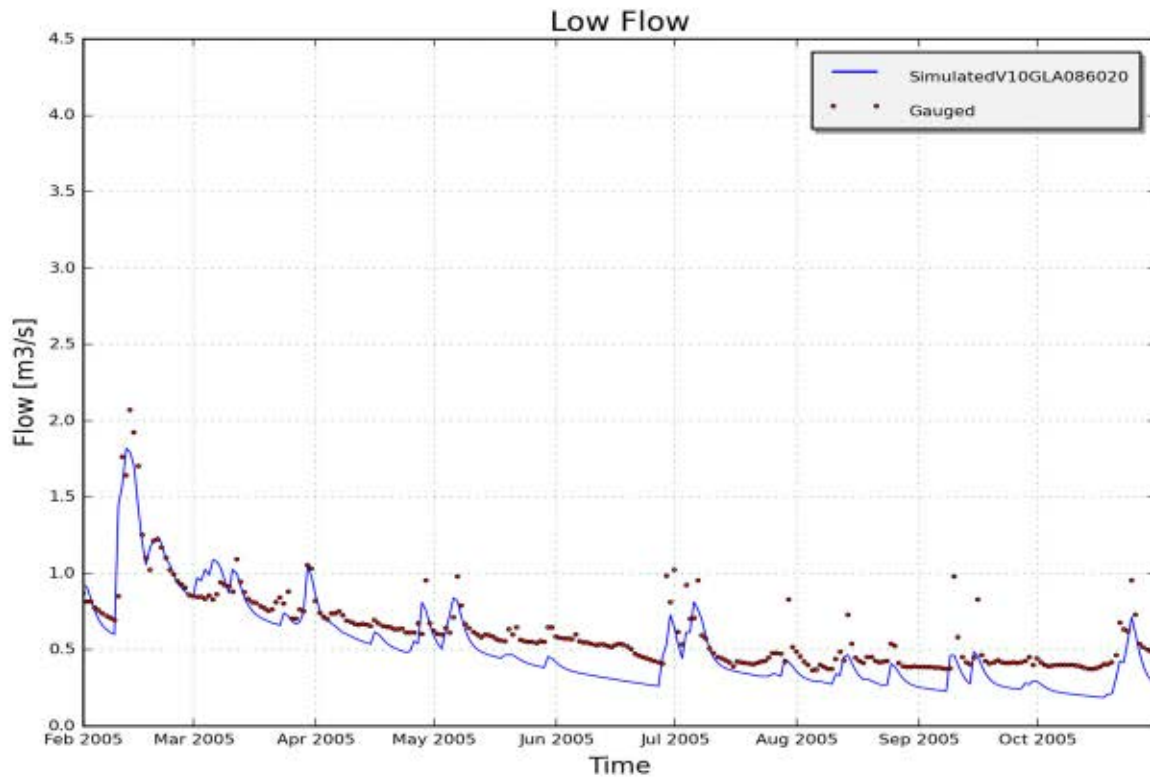
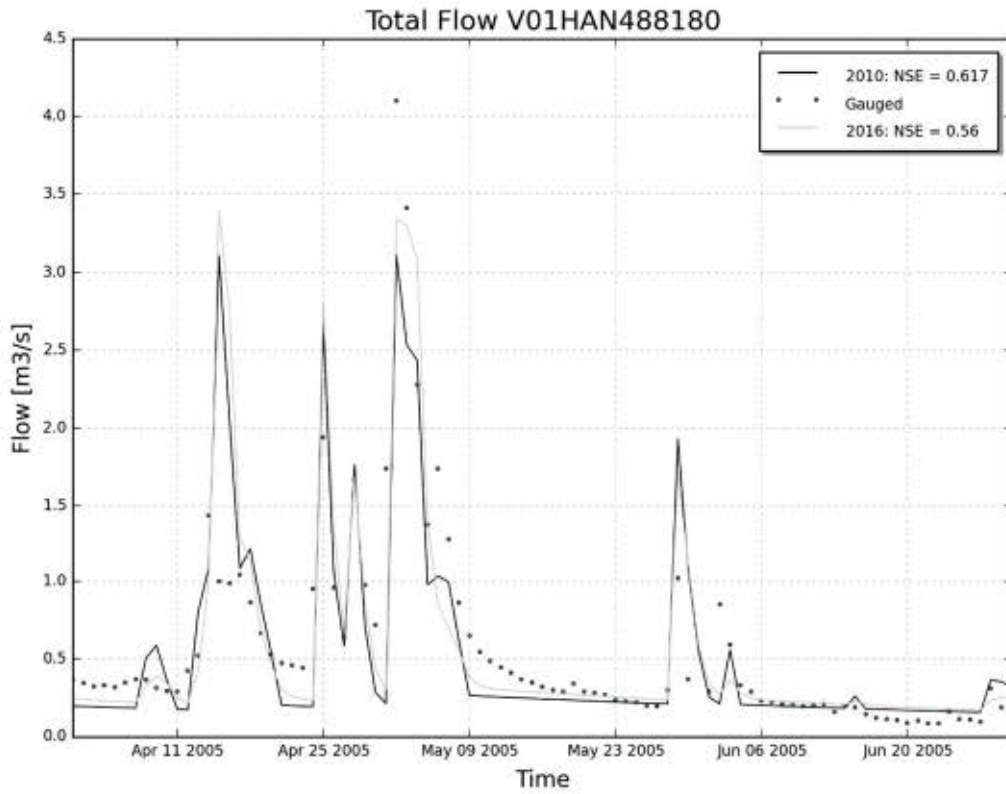


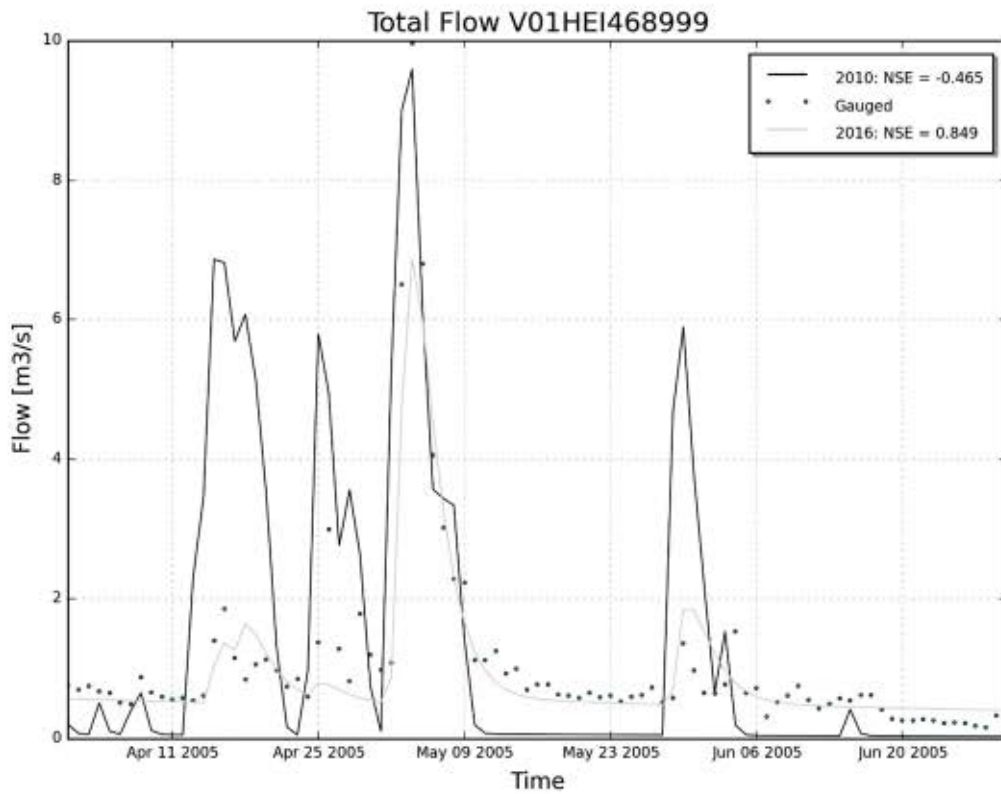
Figure 7: Measured (red) and simulated (blue) daily discharge [m³/s] during specific low and high flow events on catchment V10GLA086020, station 8610102 - Grote Laak, Vorst

Appendix 13 Comparison NAM 2010-2016

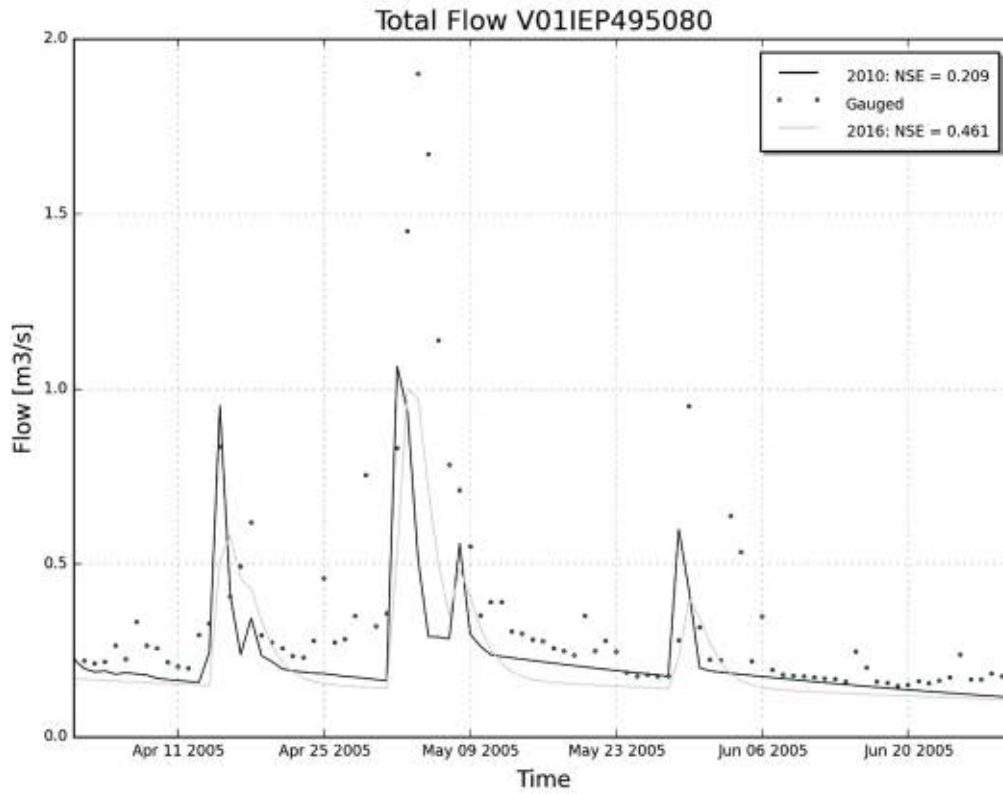
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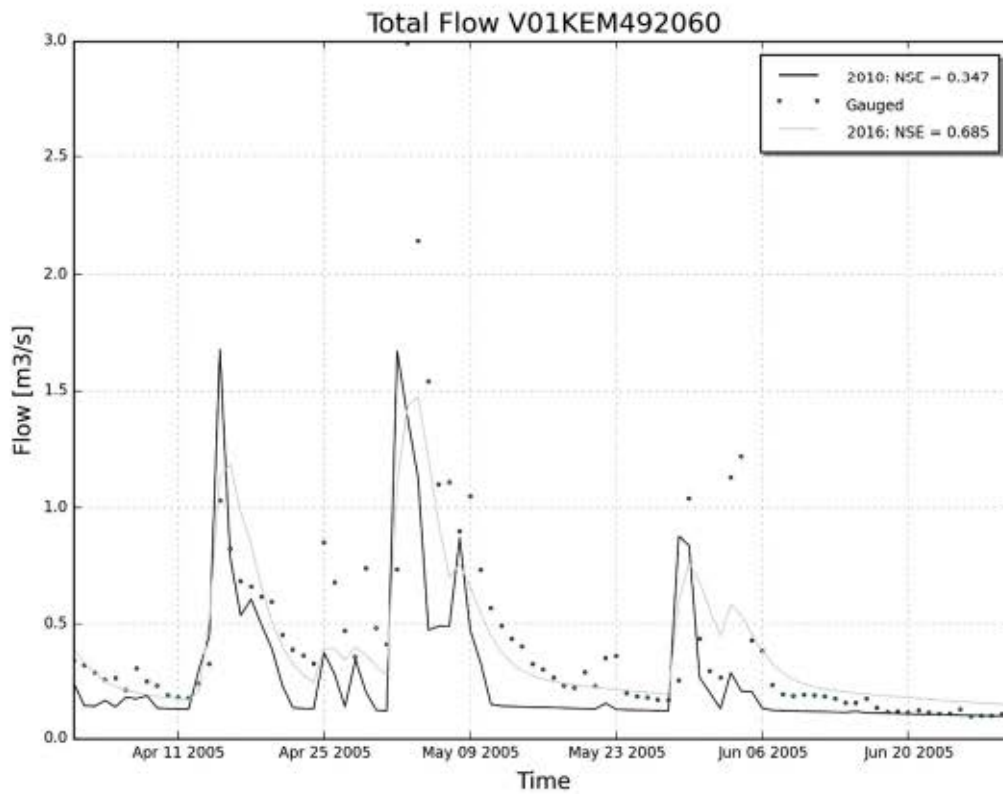
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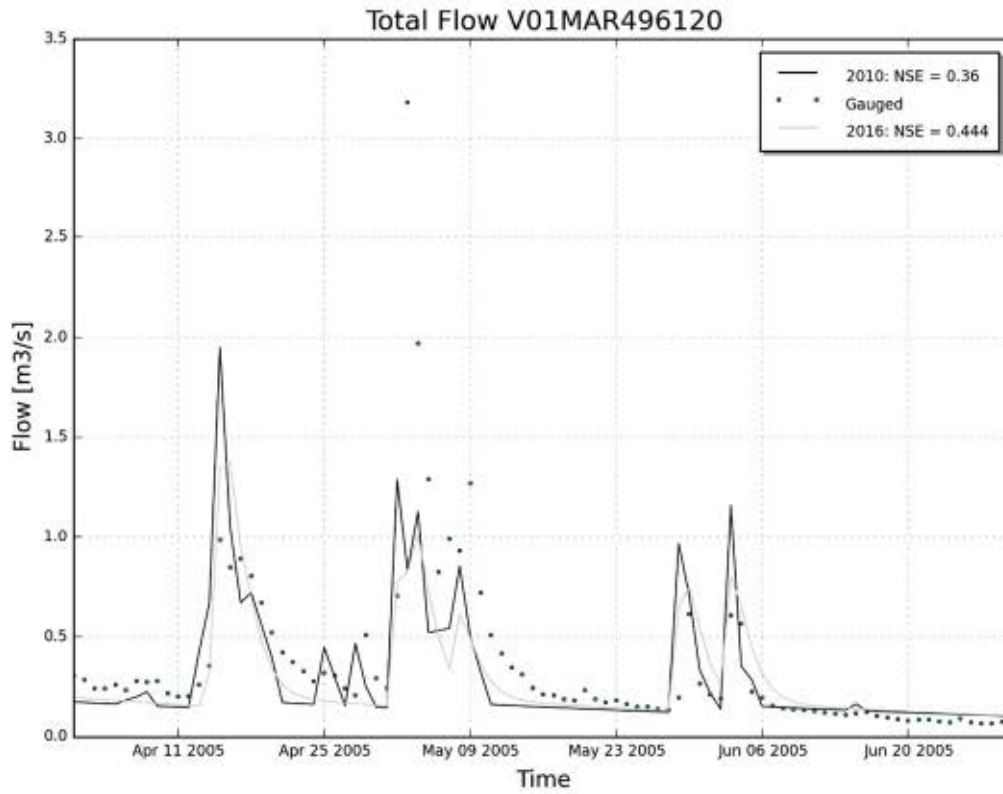
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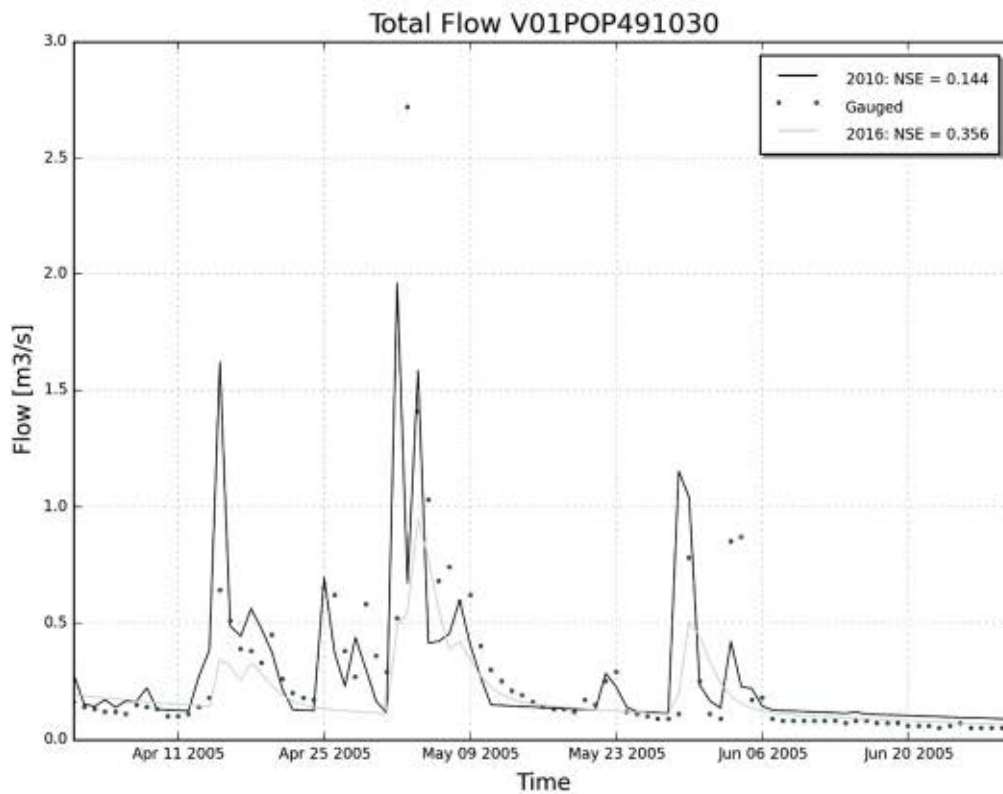
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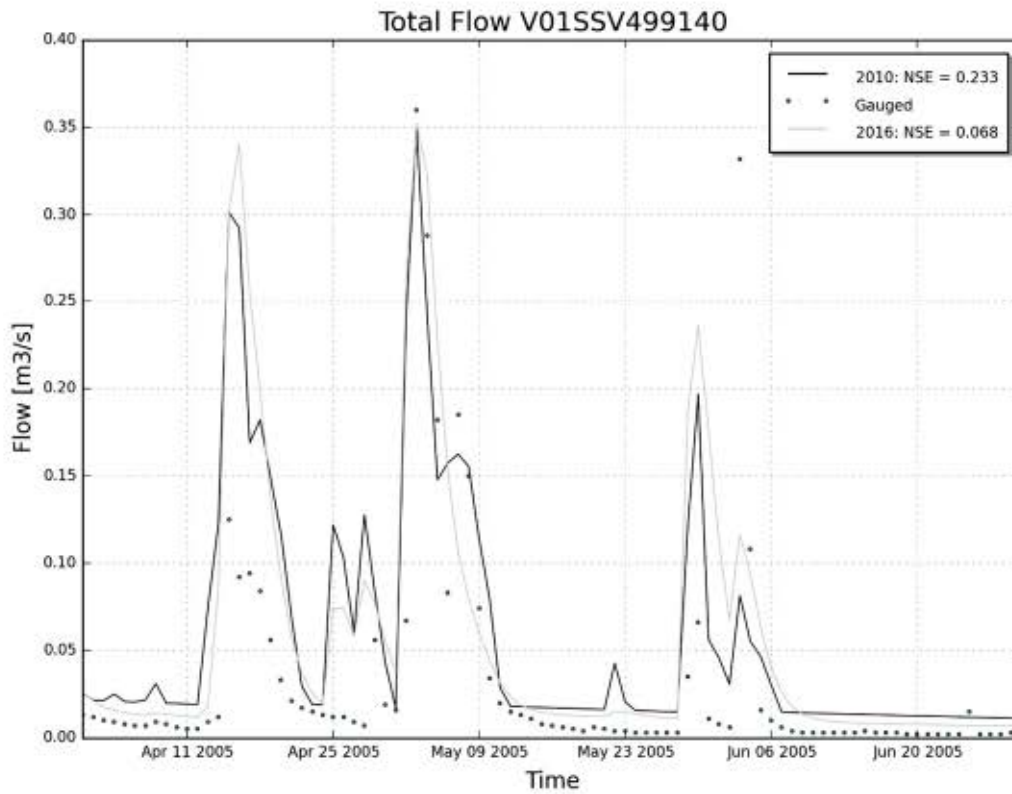
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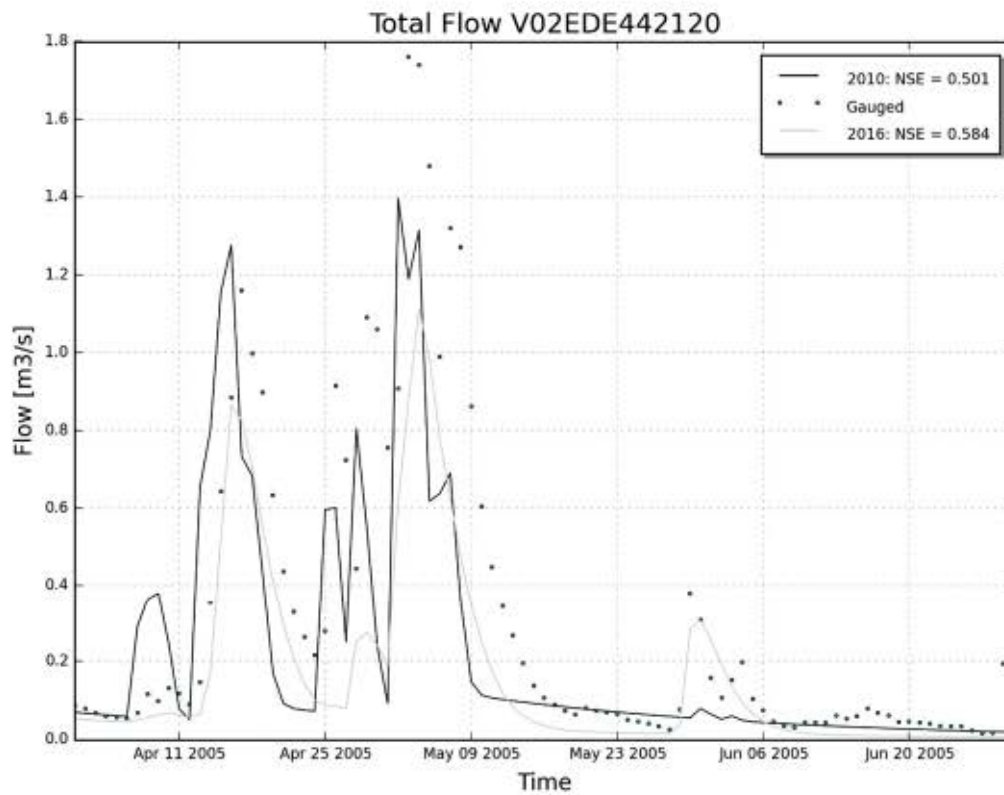
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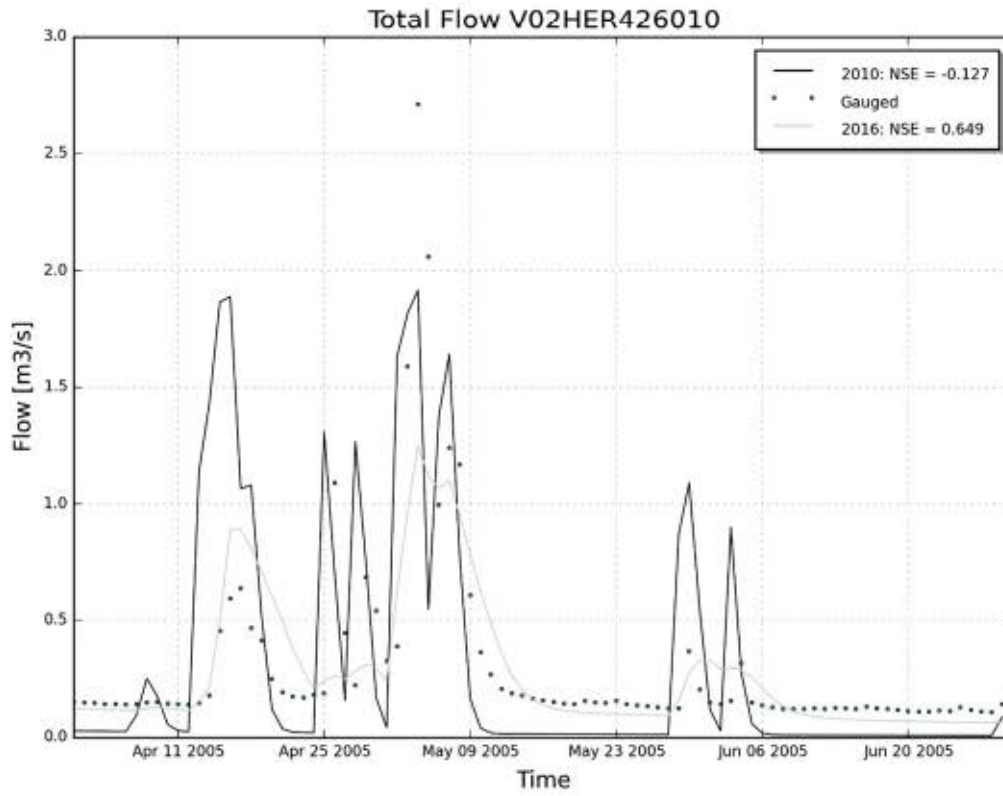
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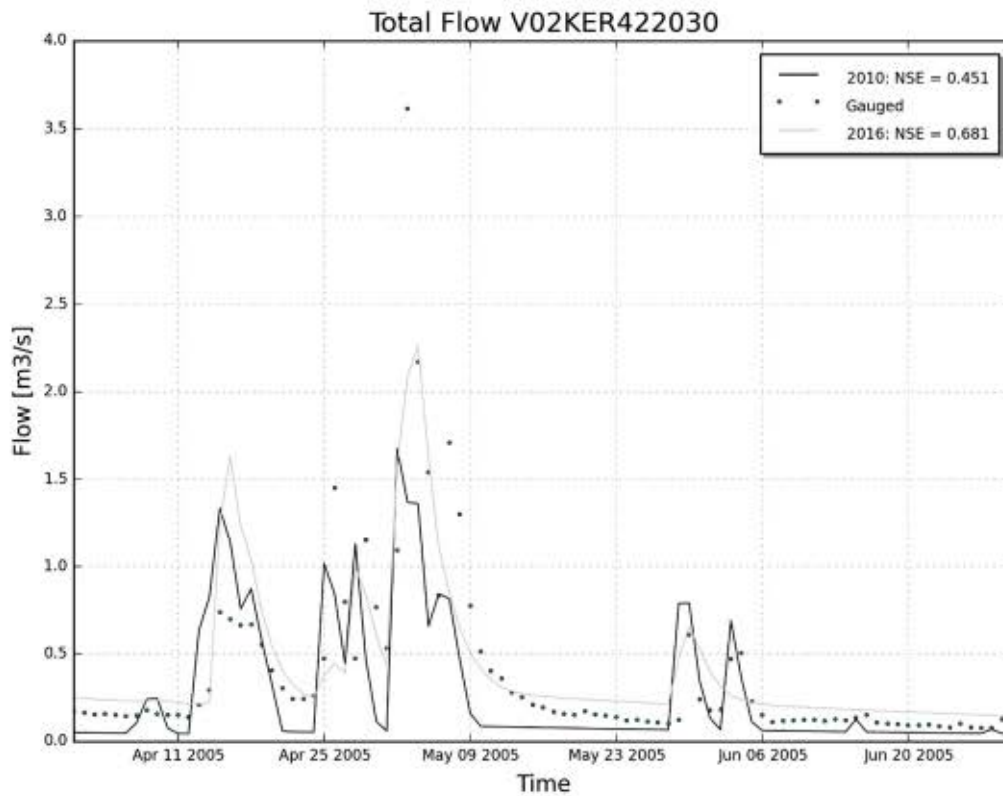
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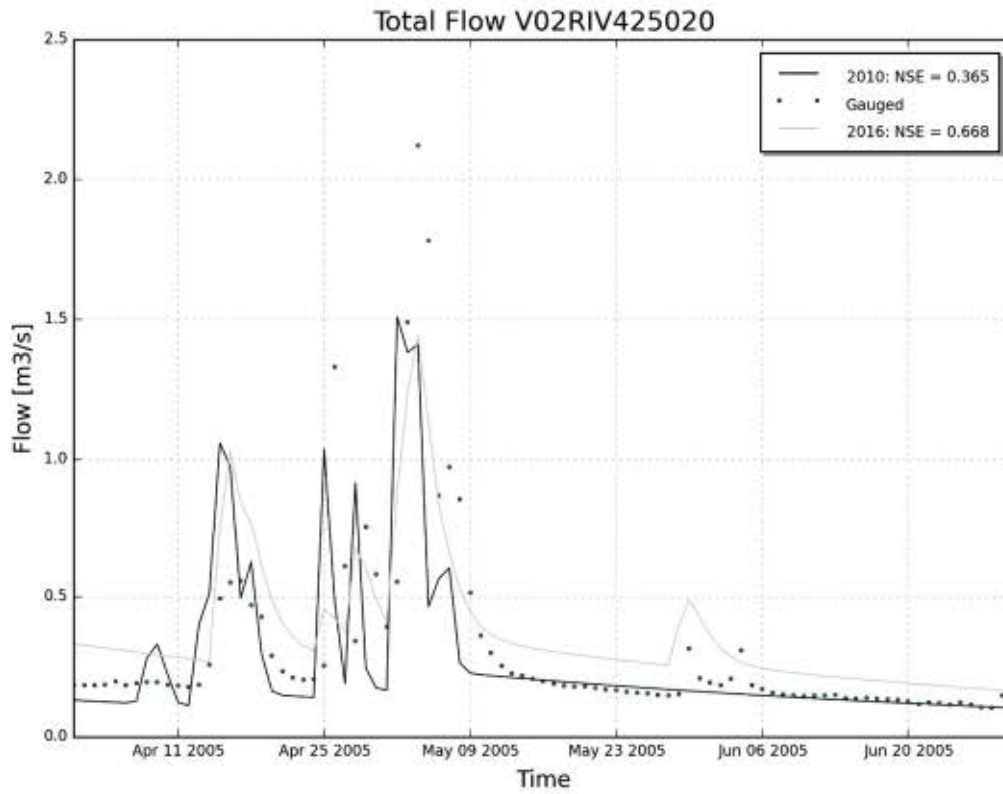
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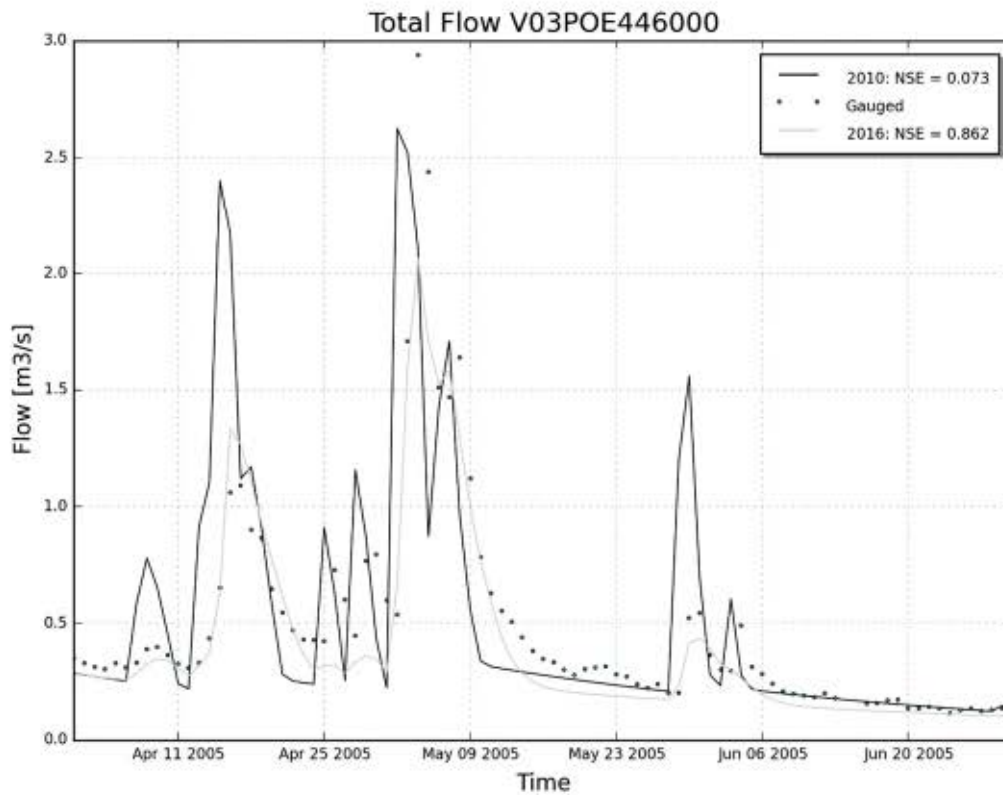
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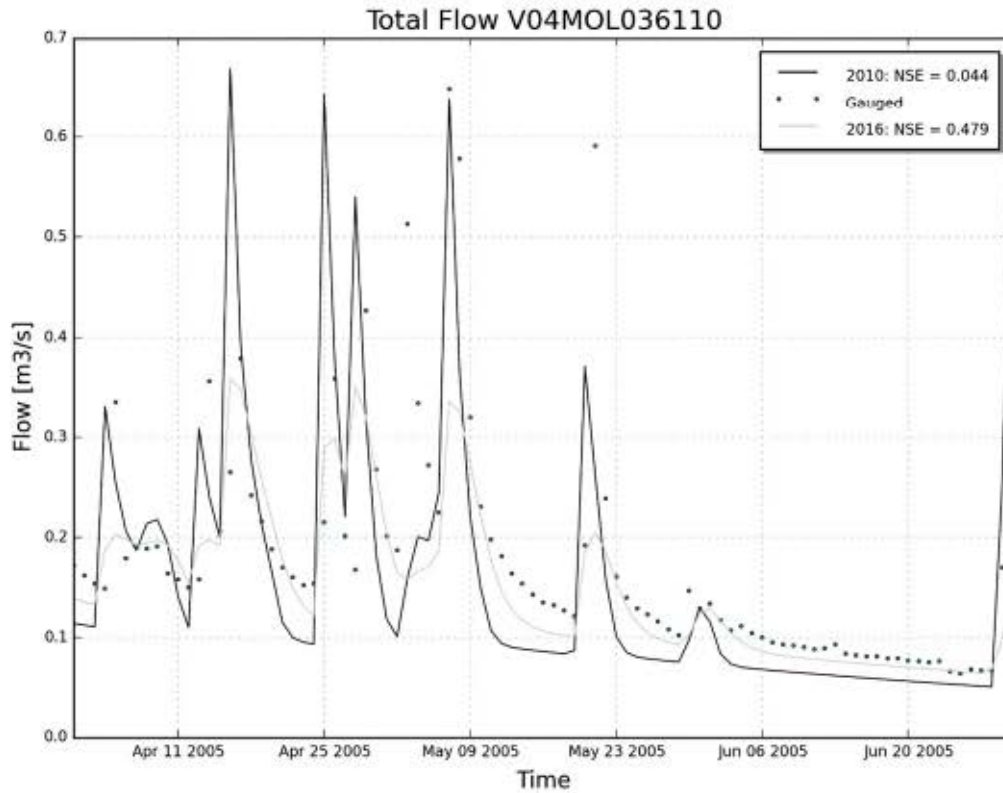
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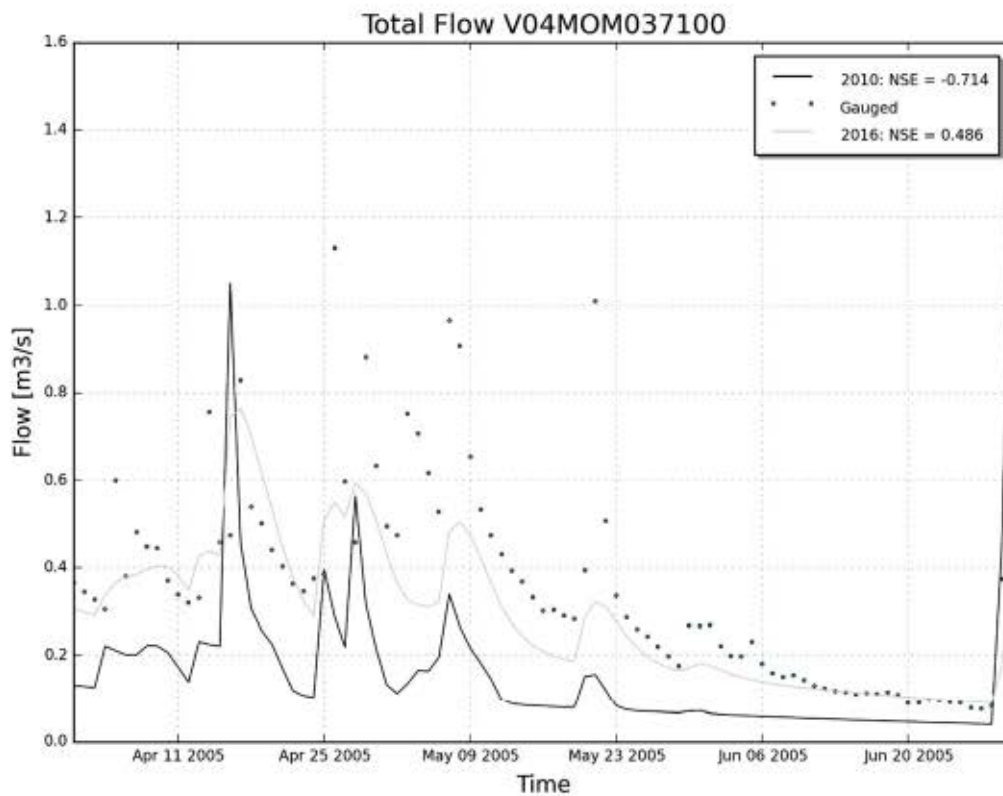
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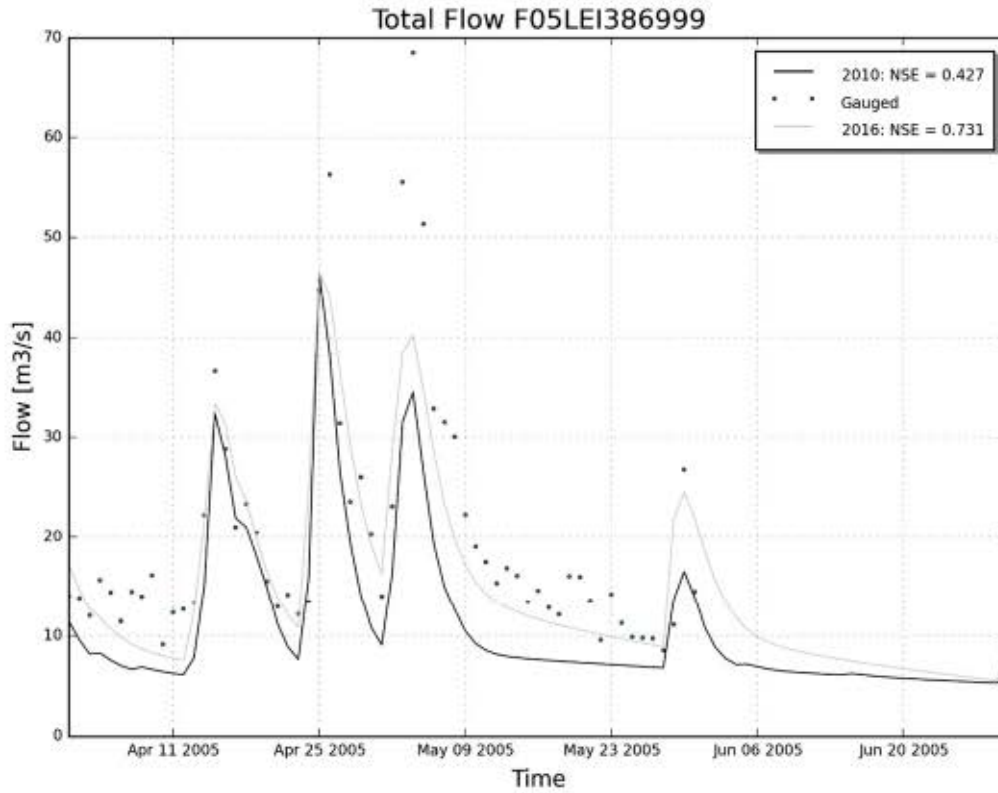
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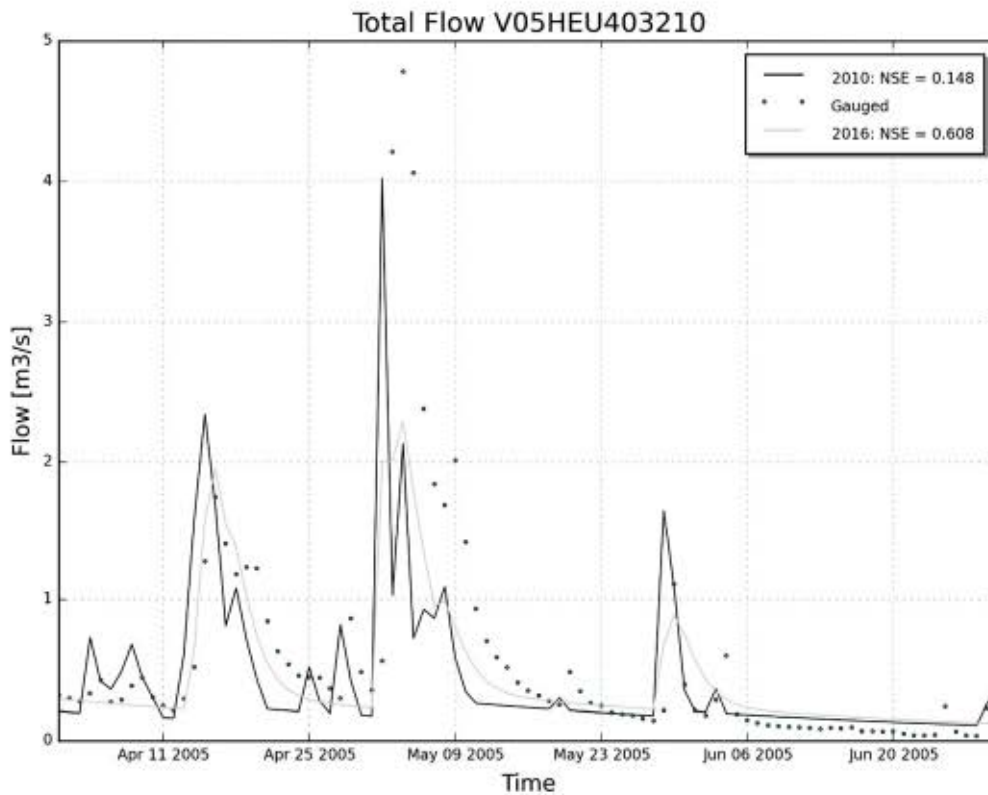
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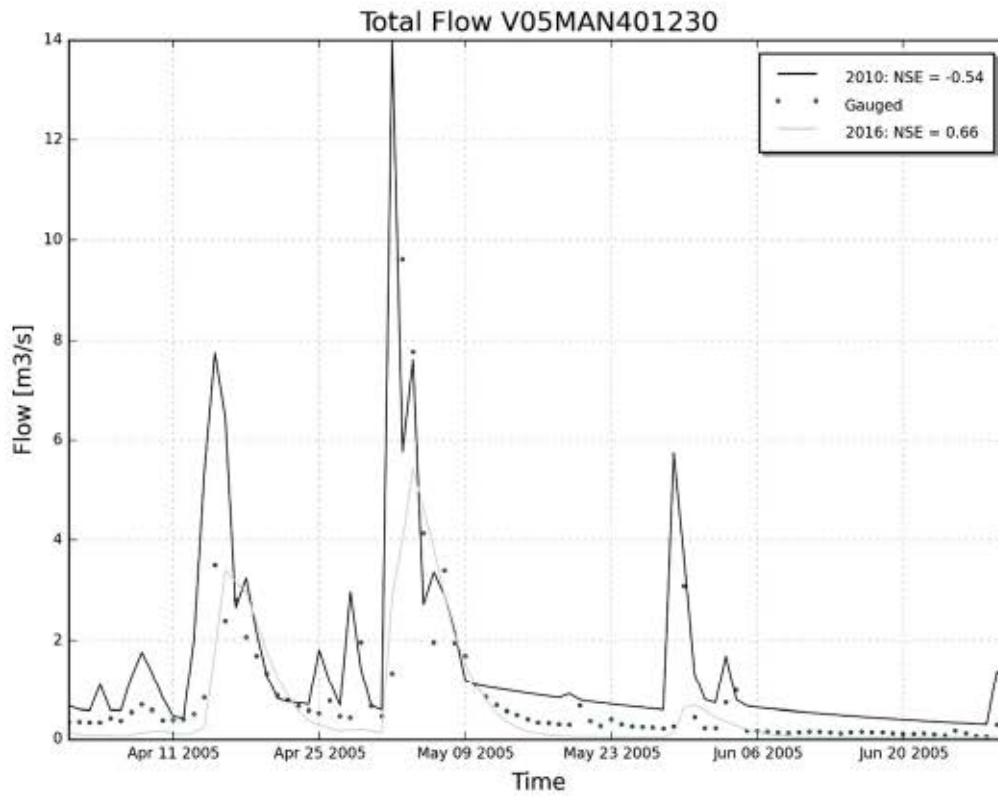
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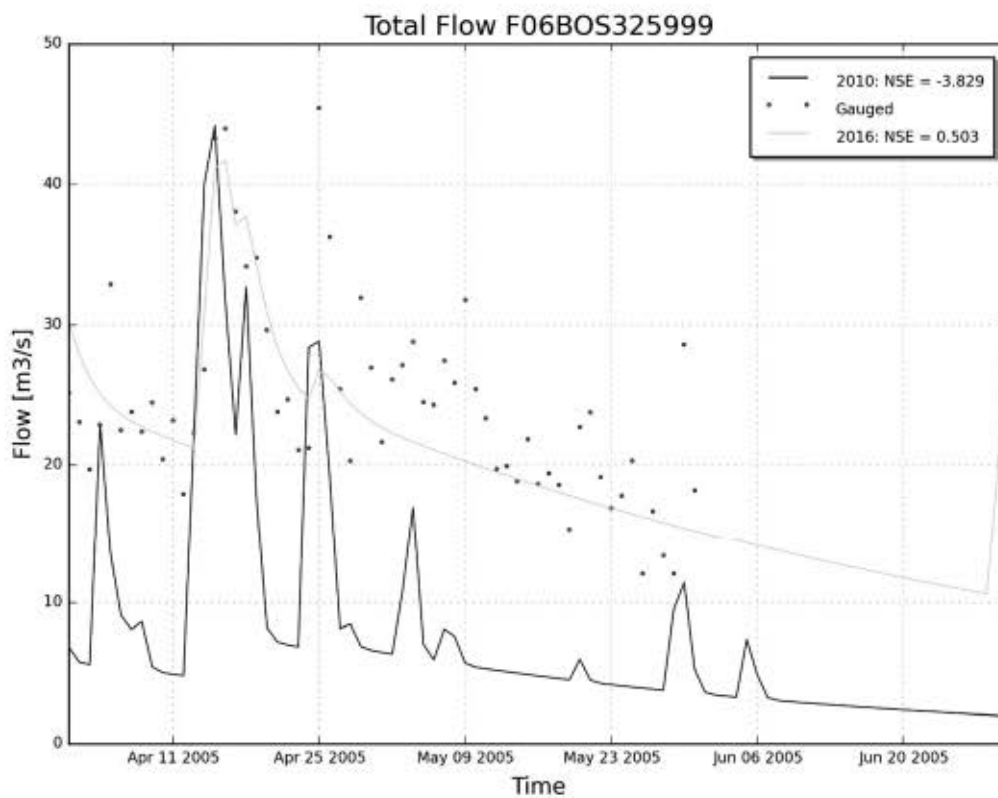
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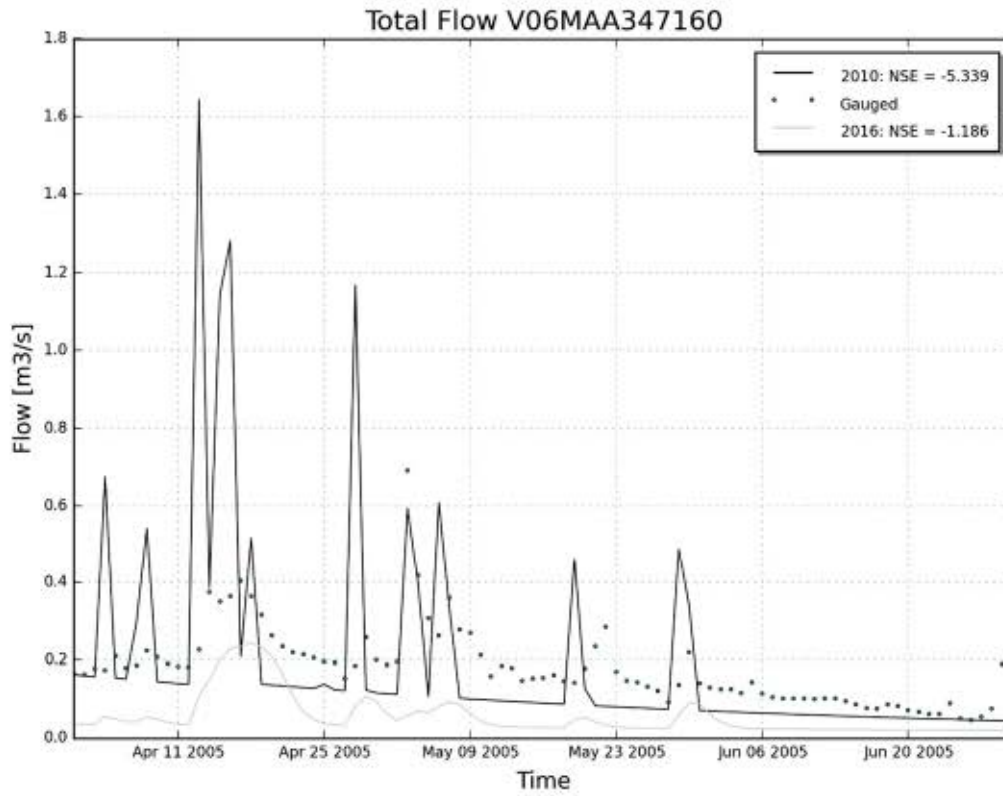
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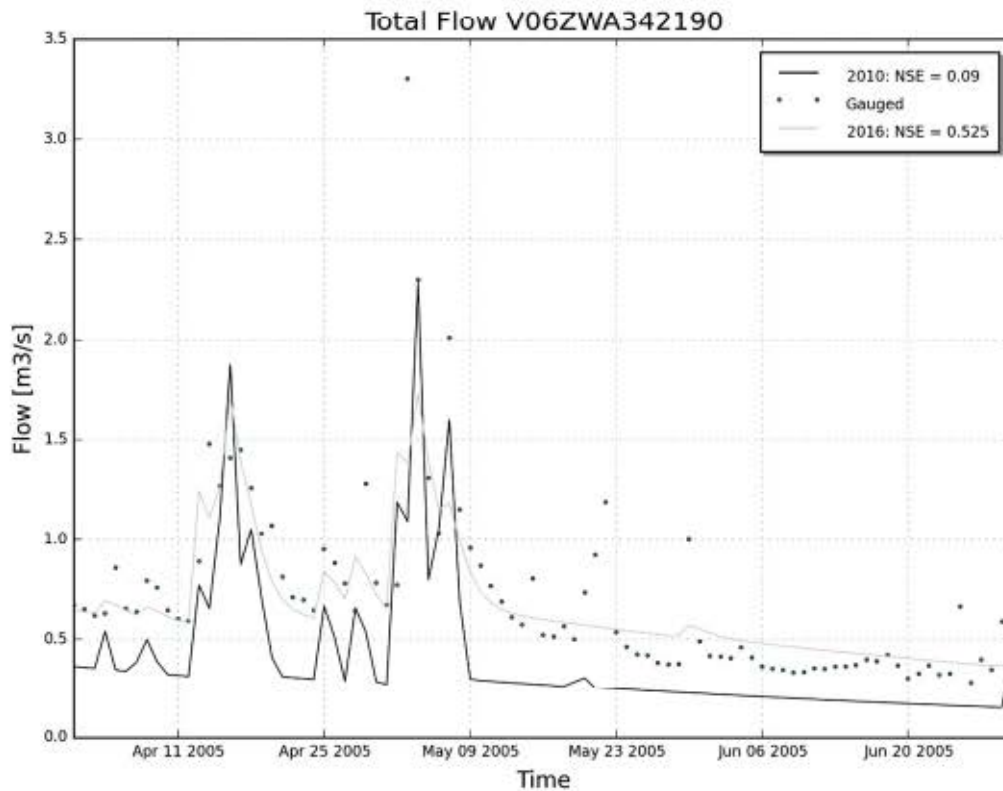
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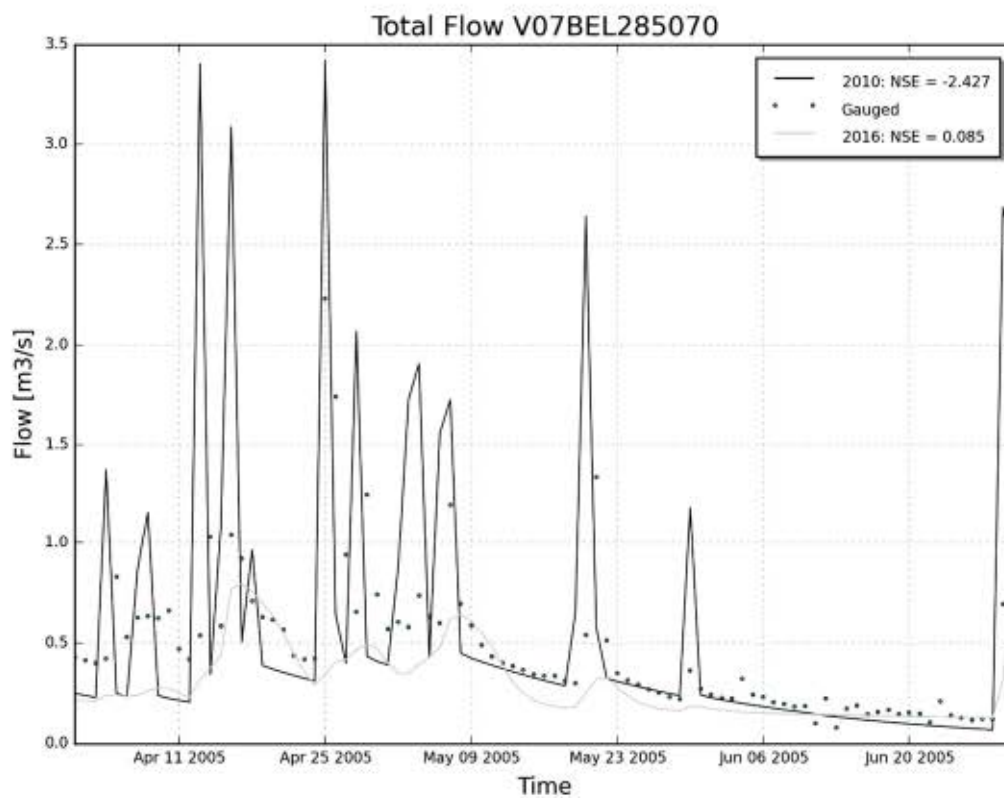


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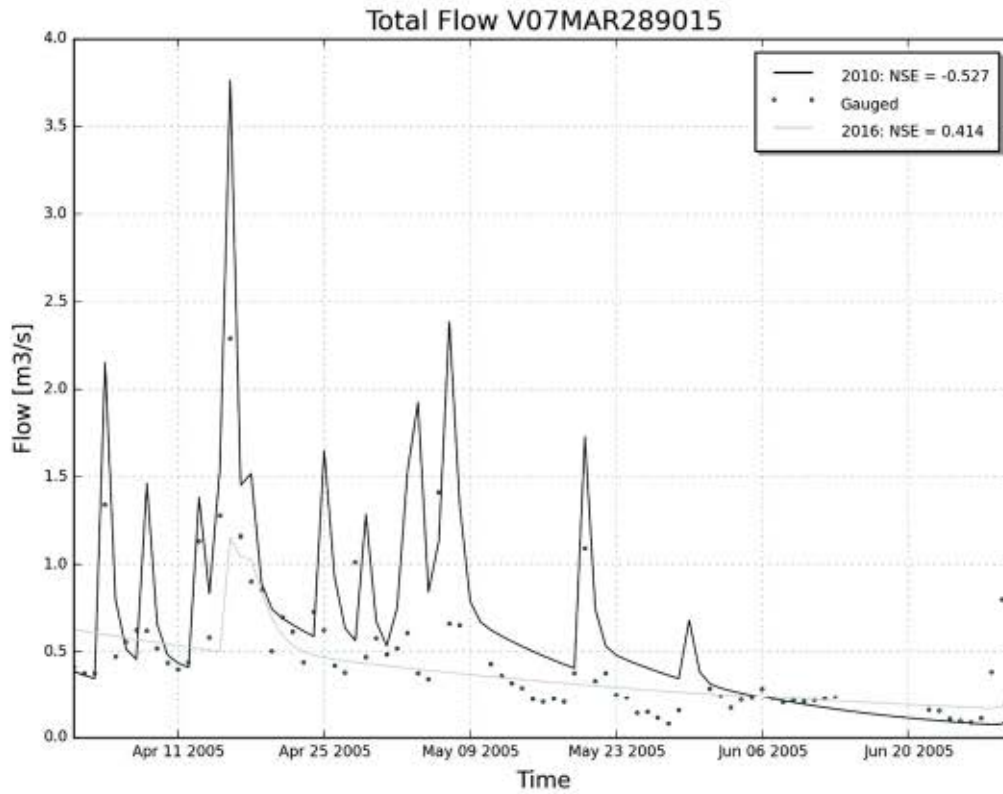


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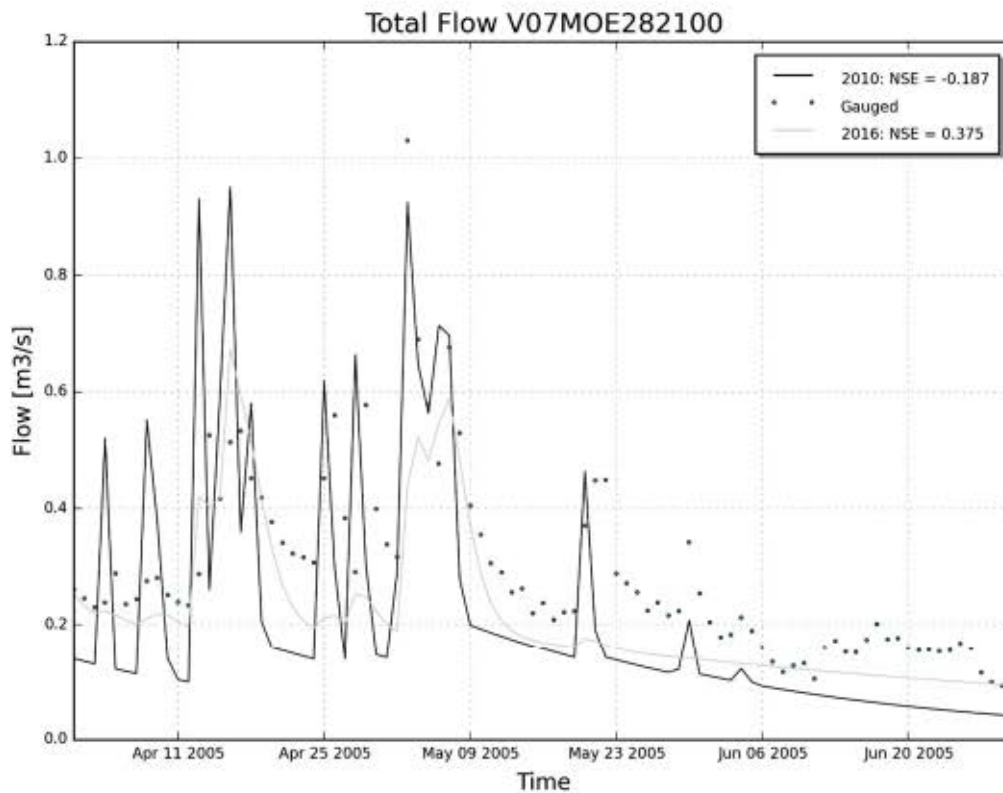
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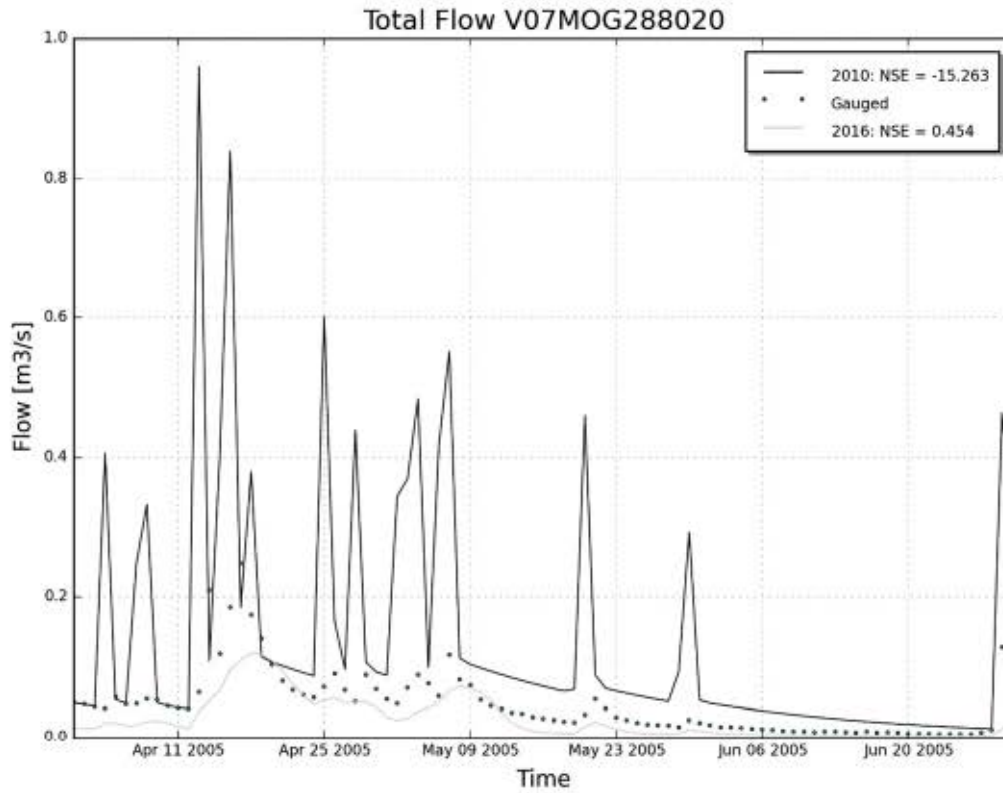
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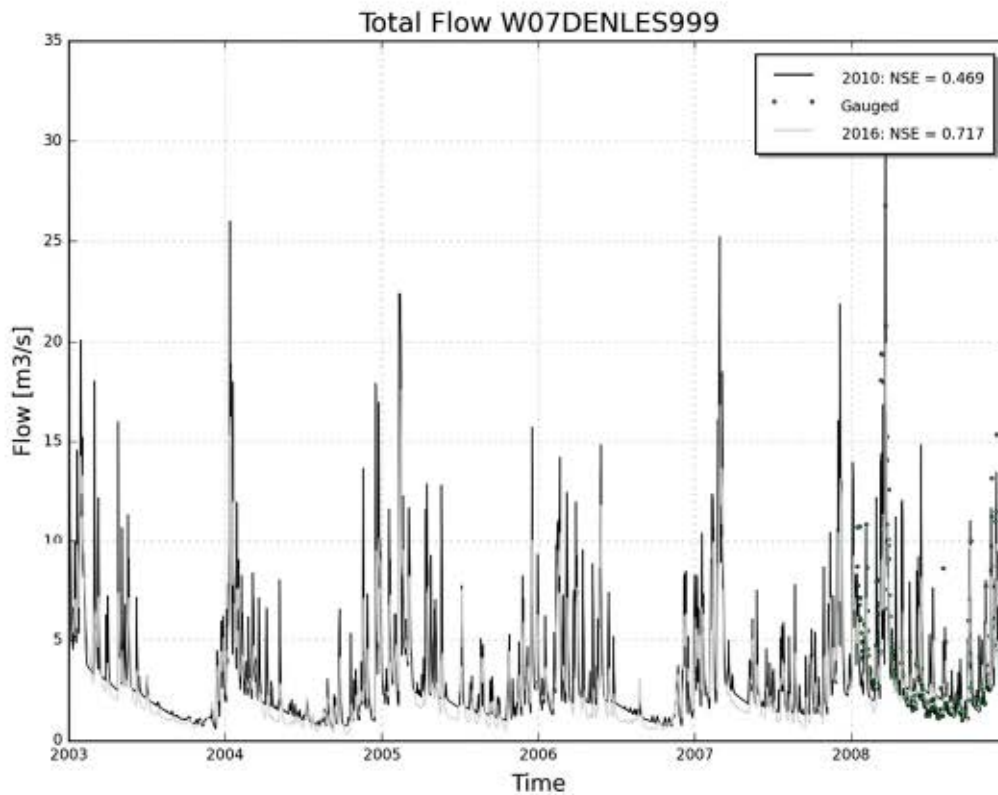
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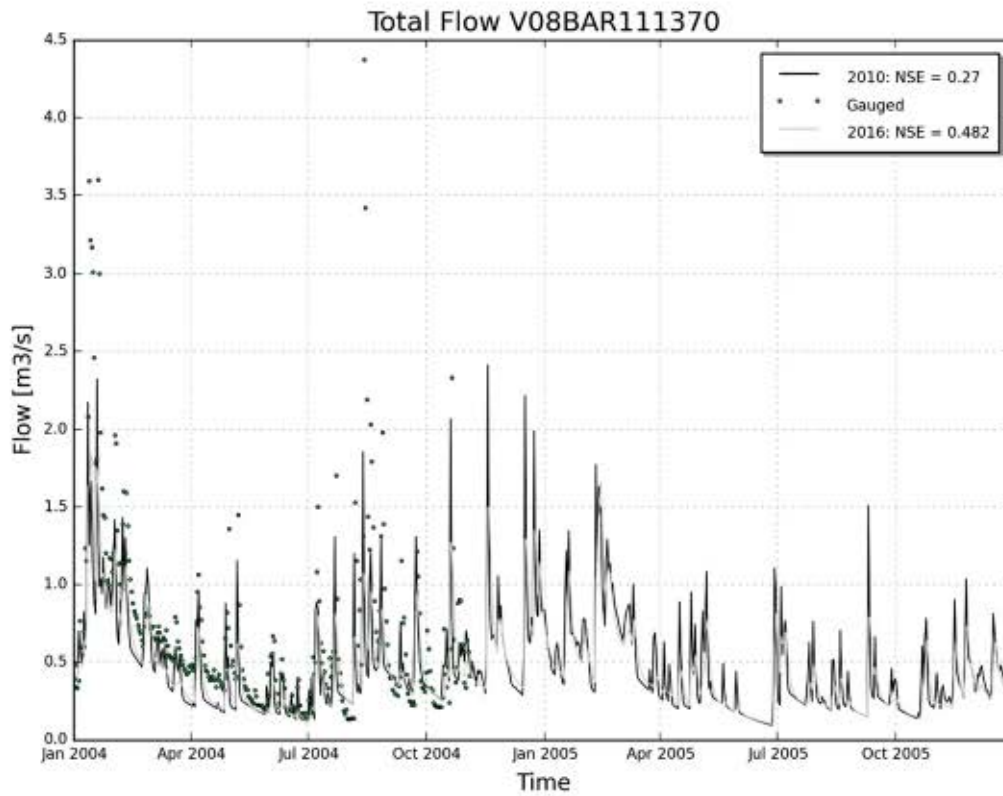
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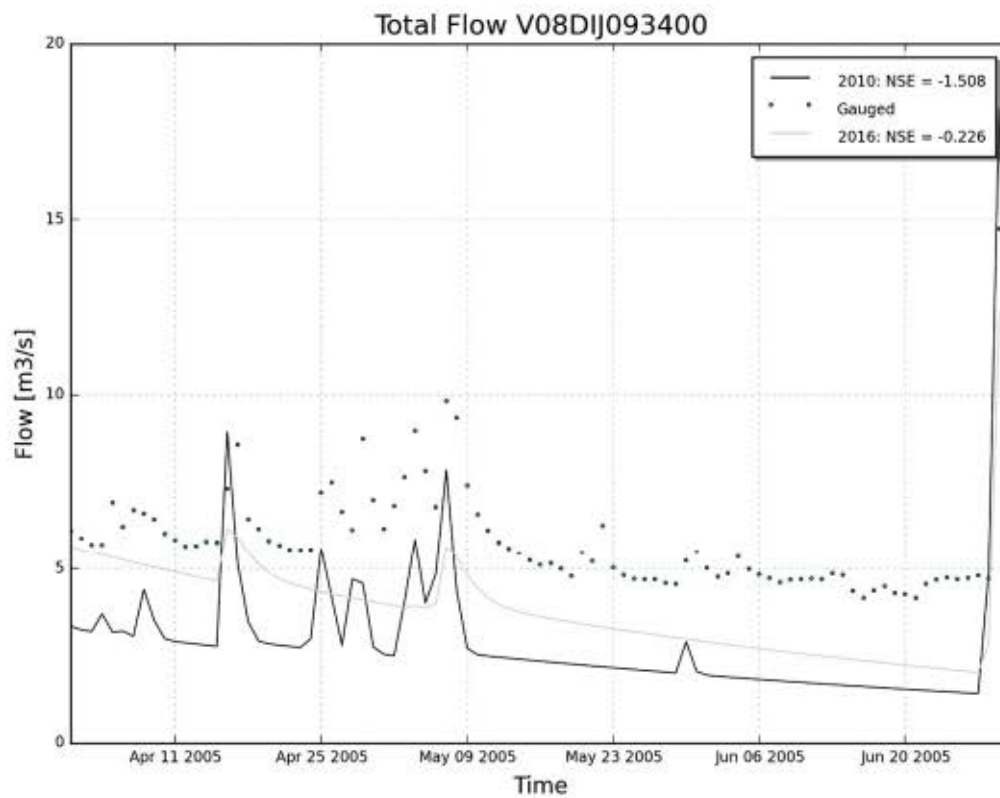
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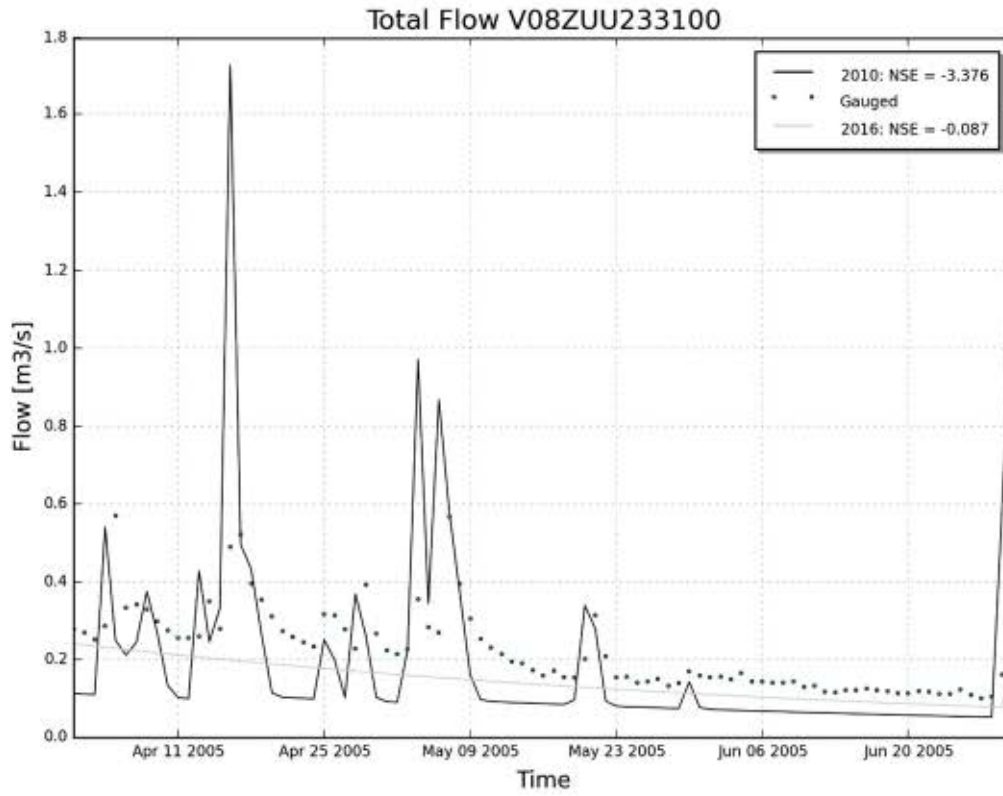
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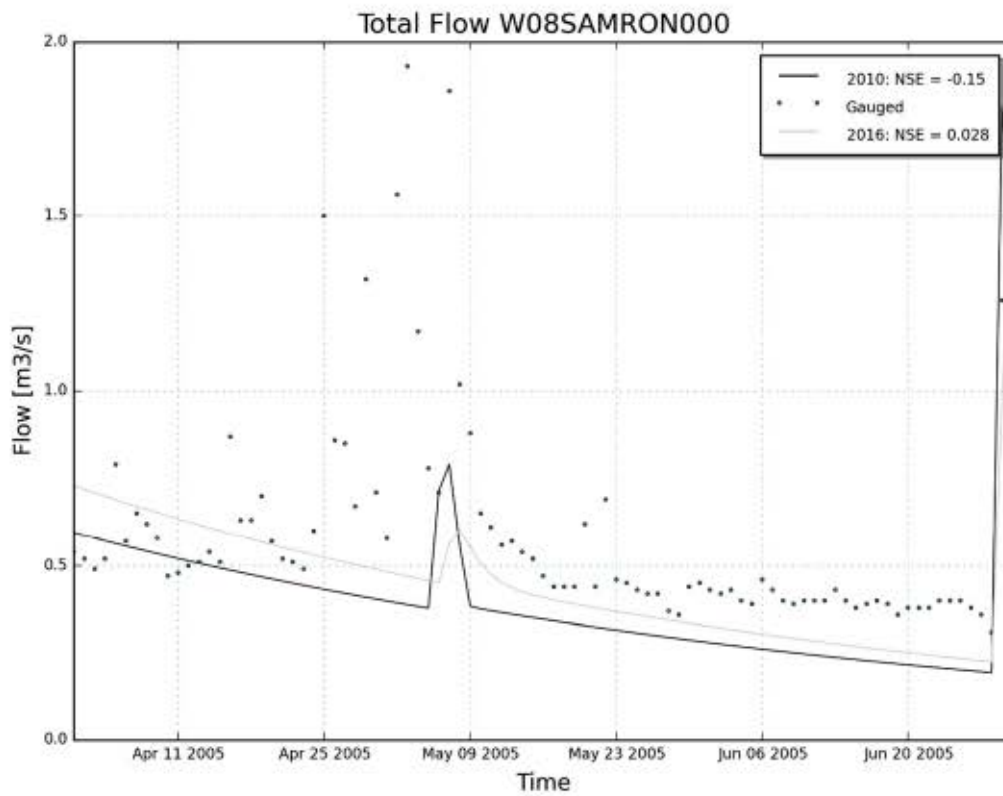
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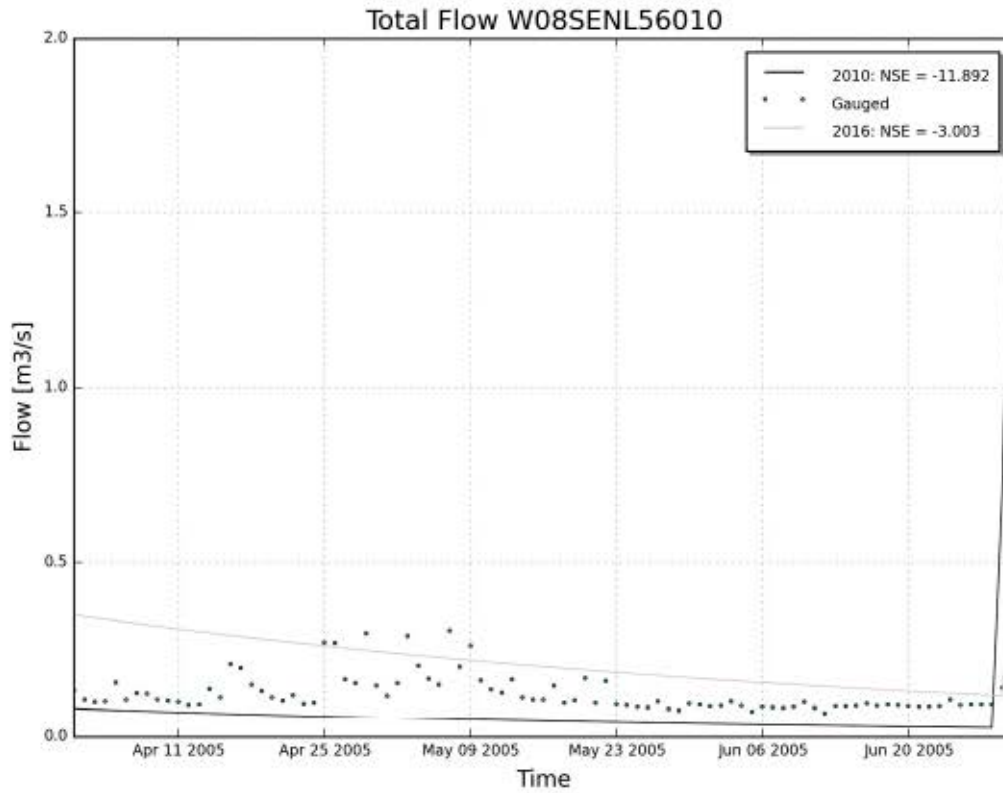
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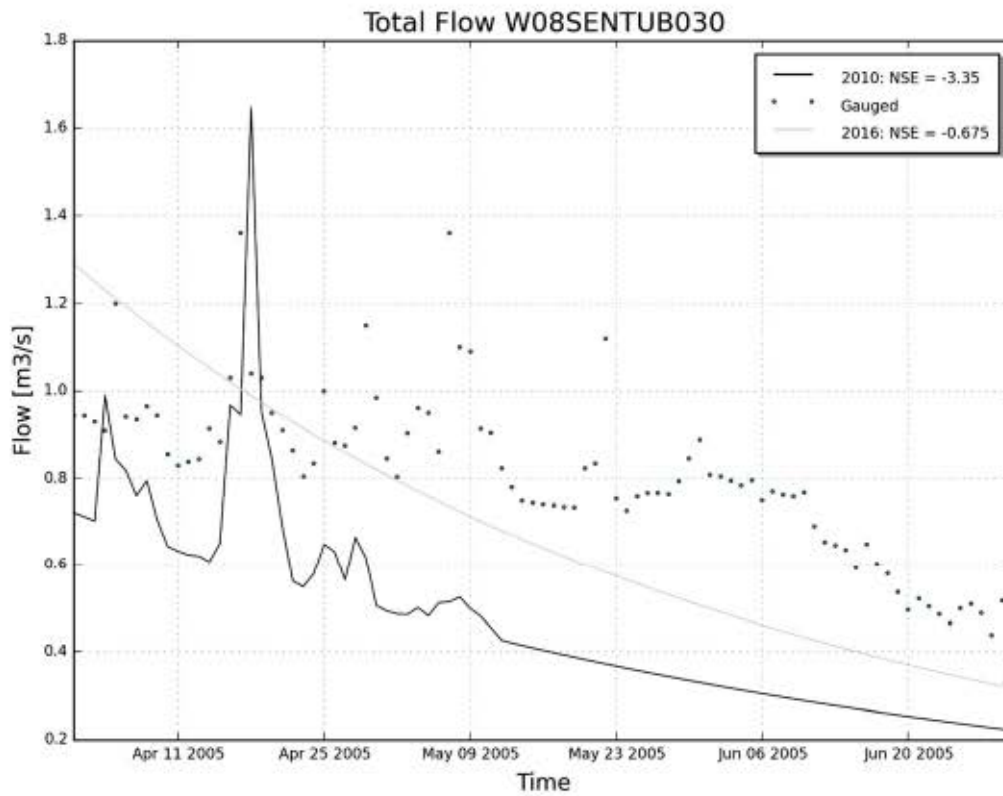
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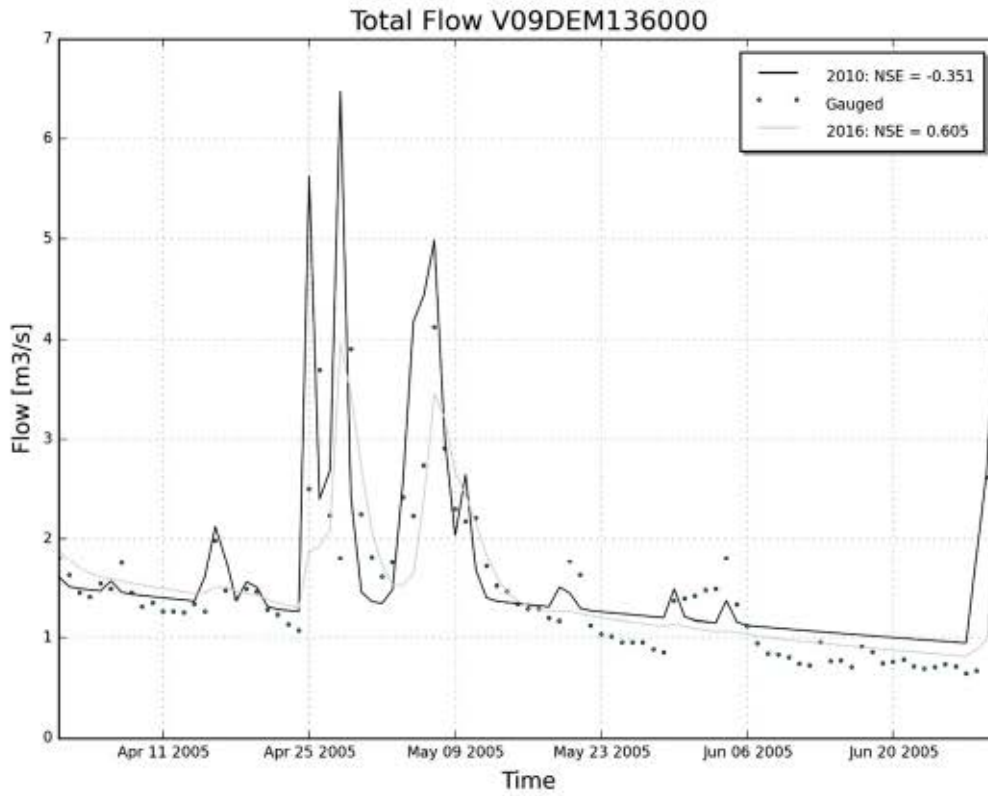
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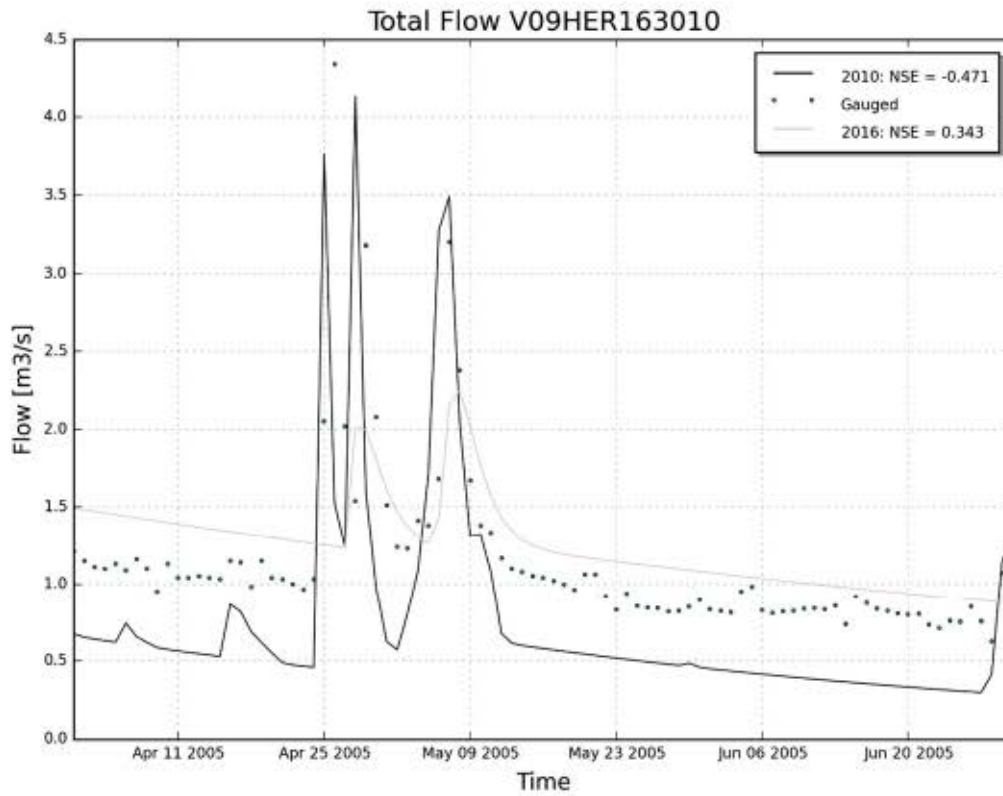


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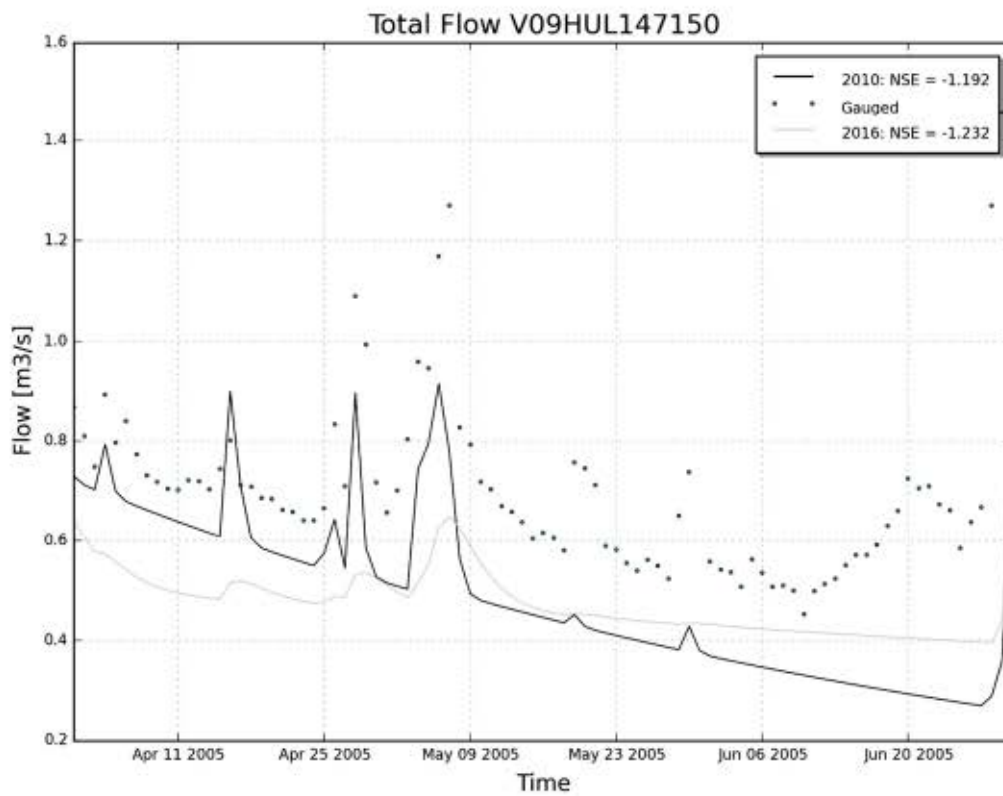


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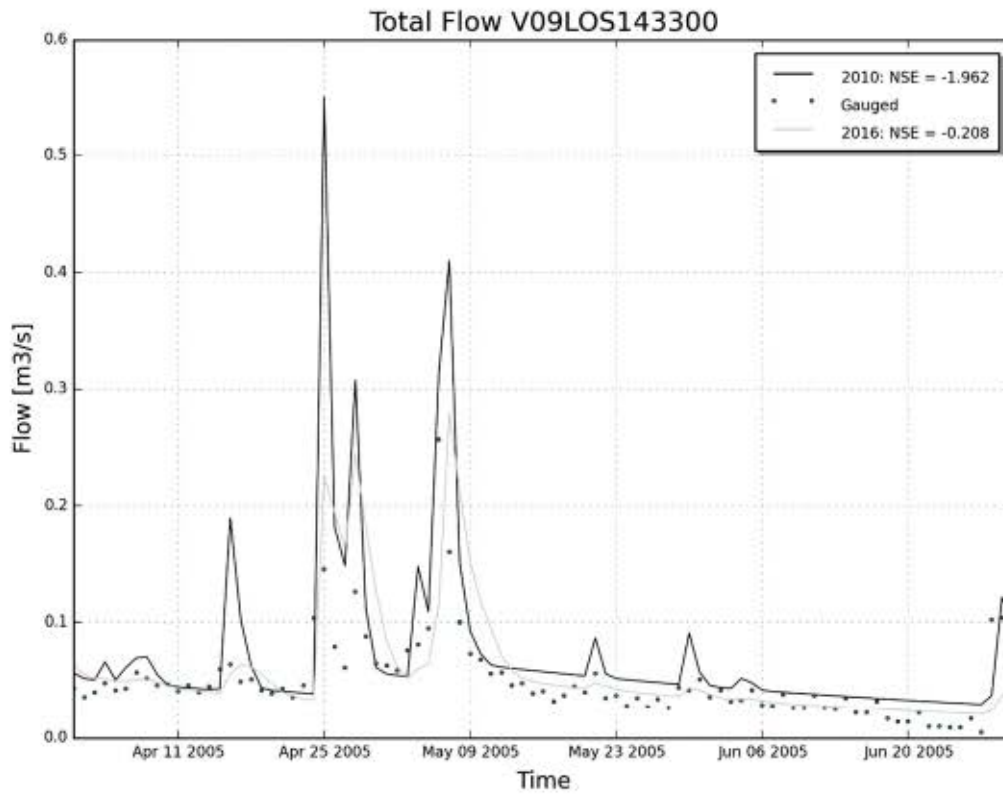
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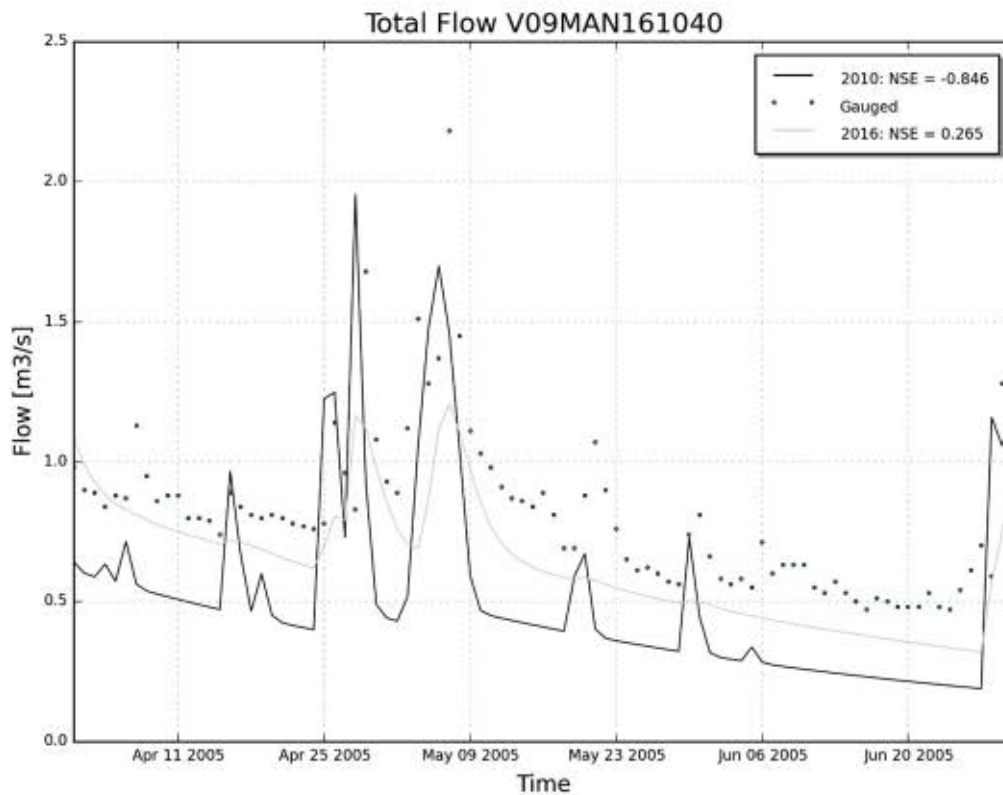
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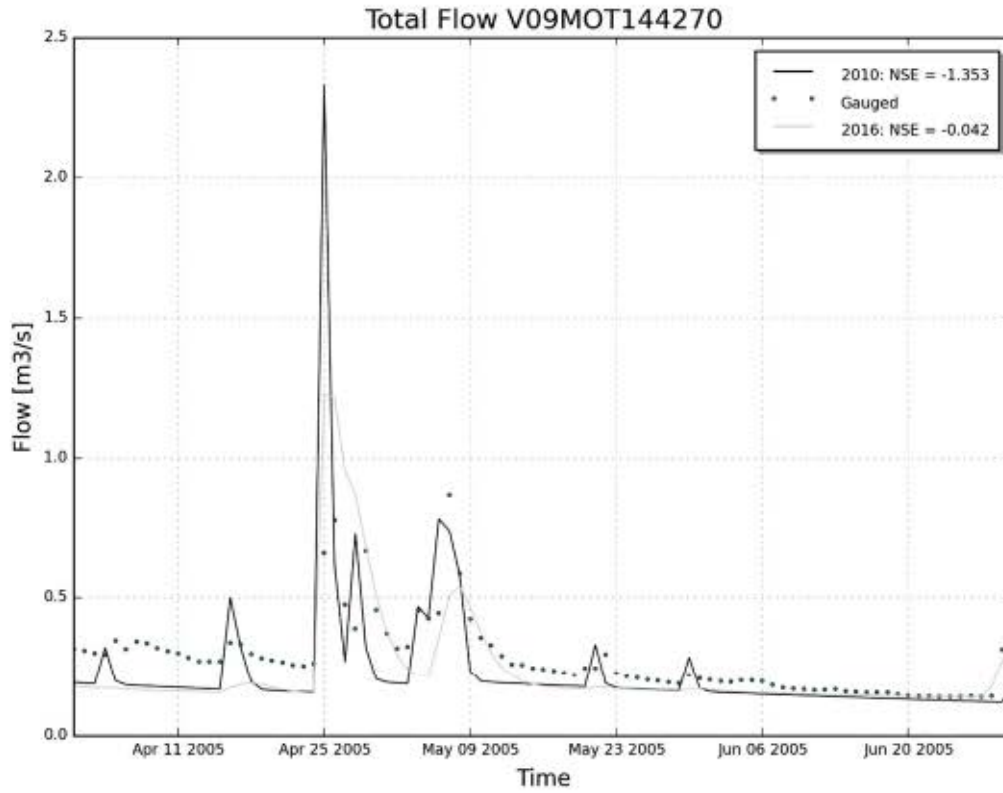
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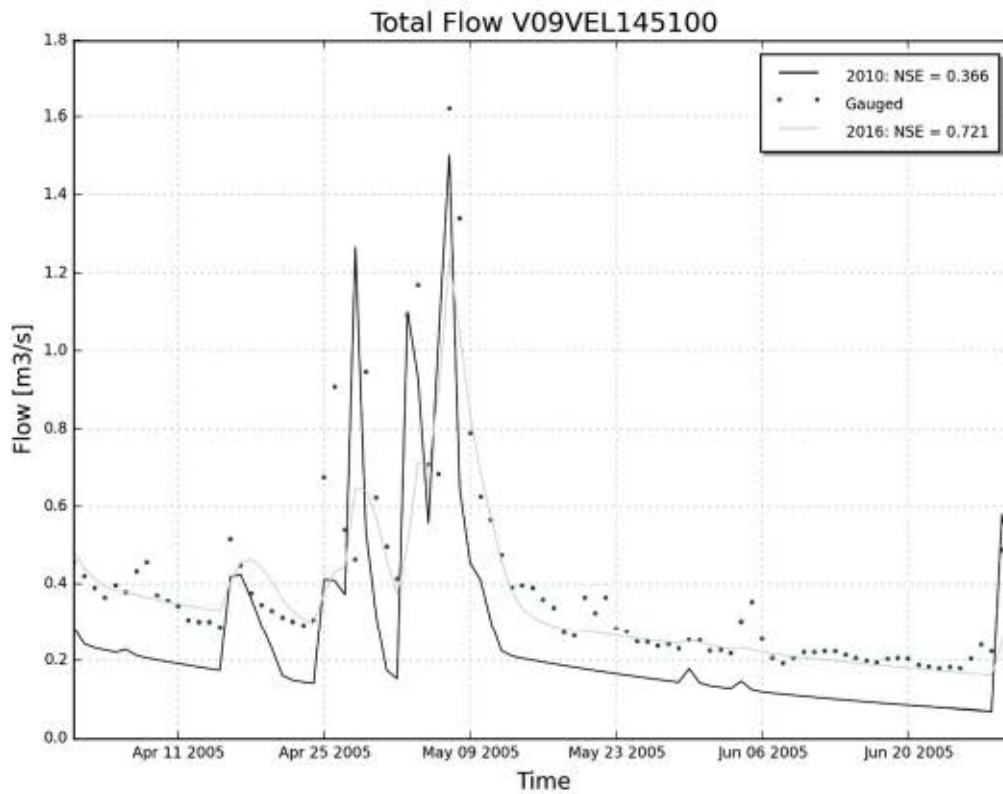
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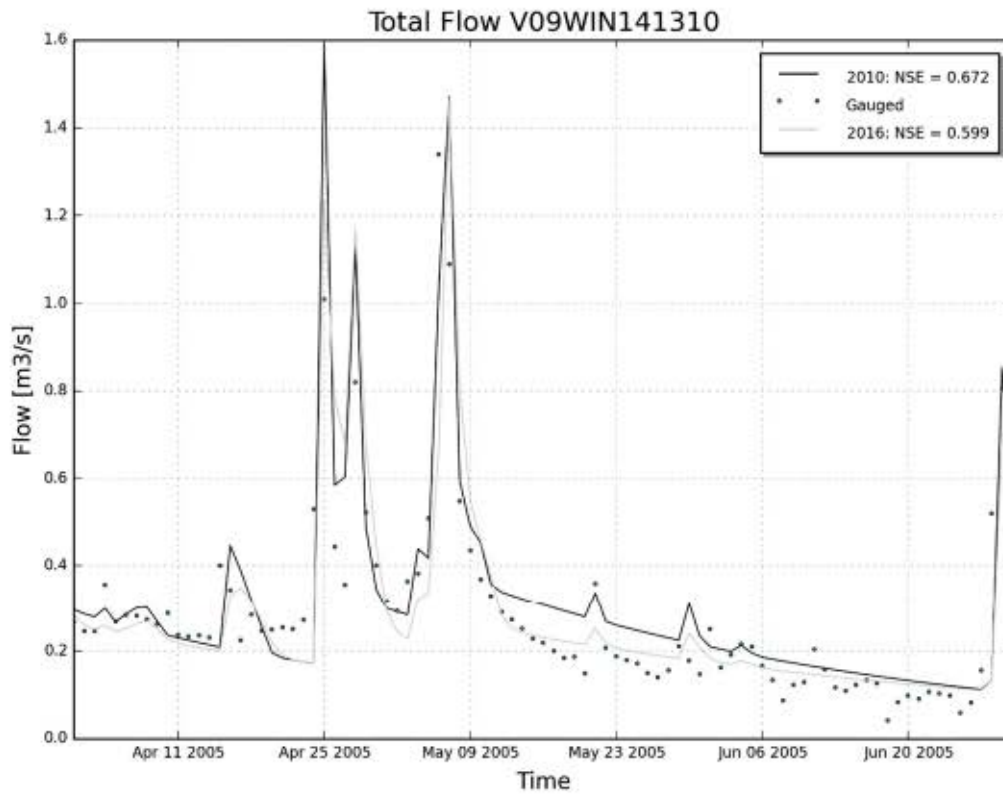
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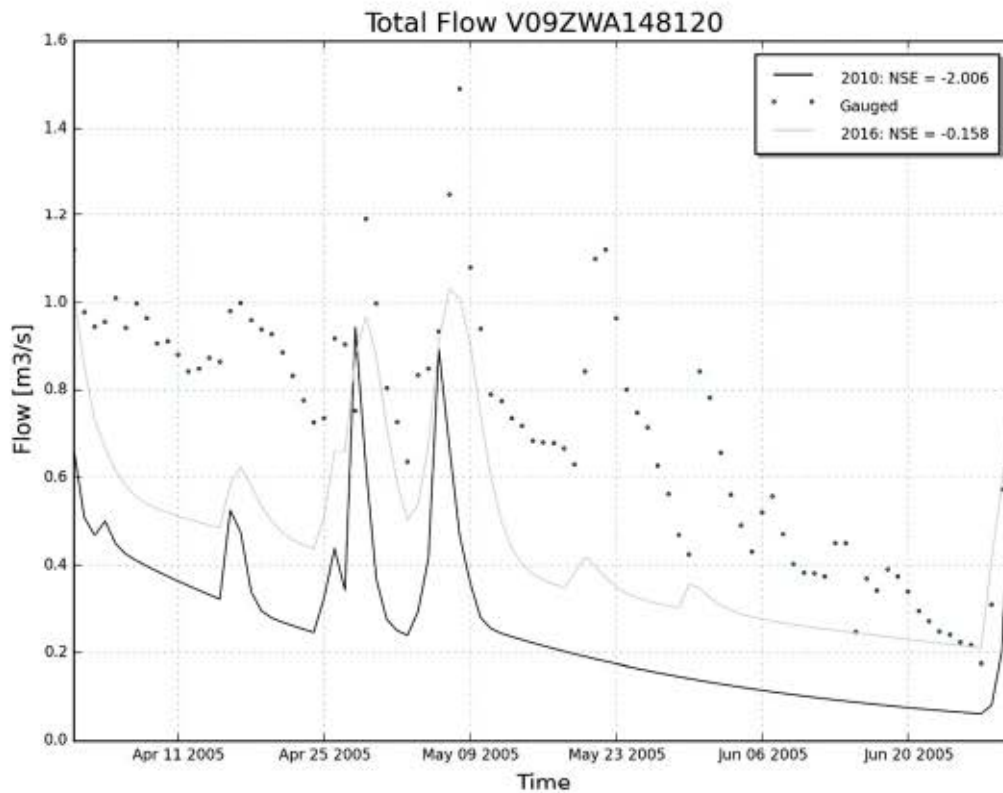
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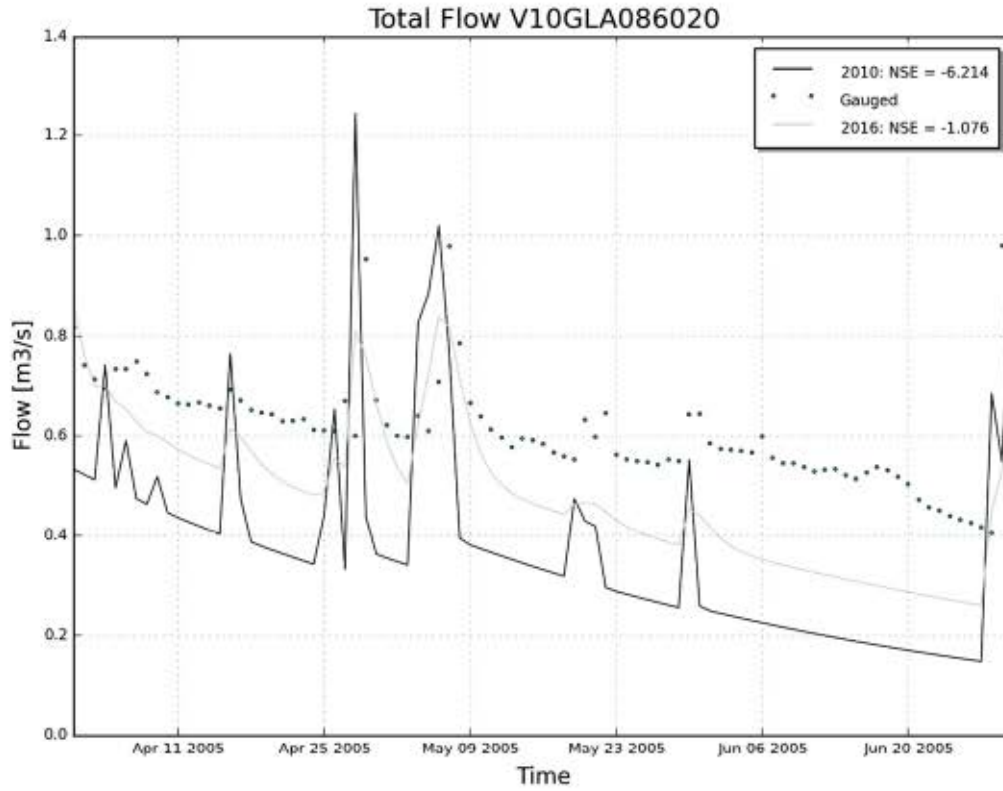
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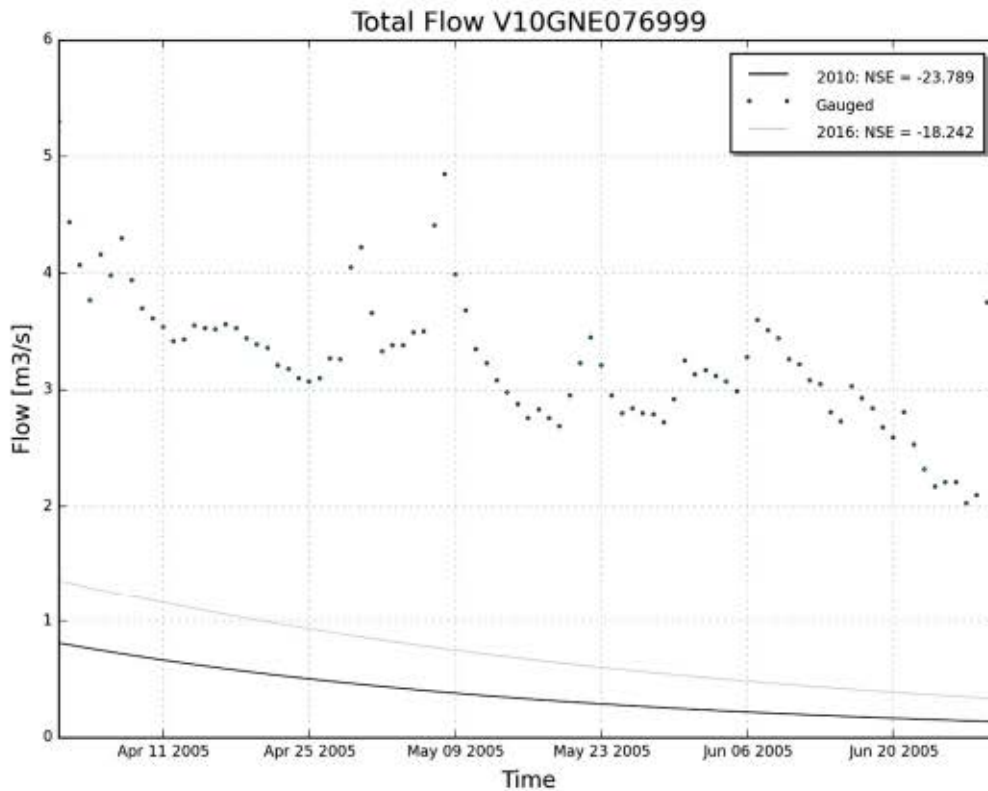
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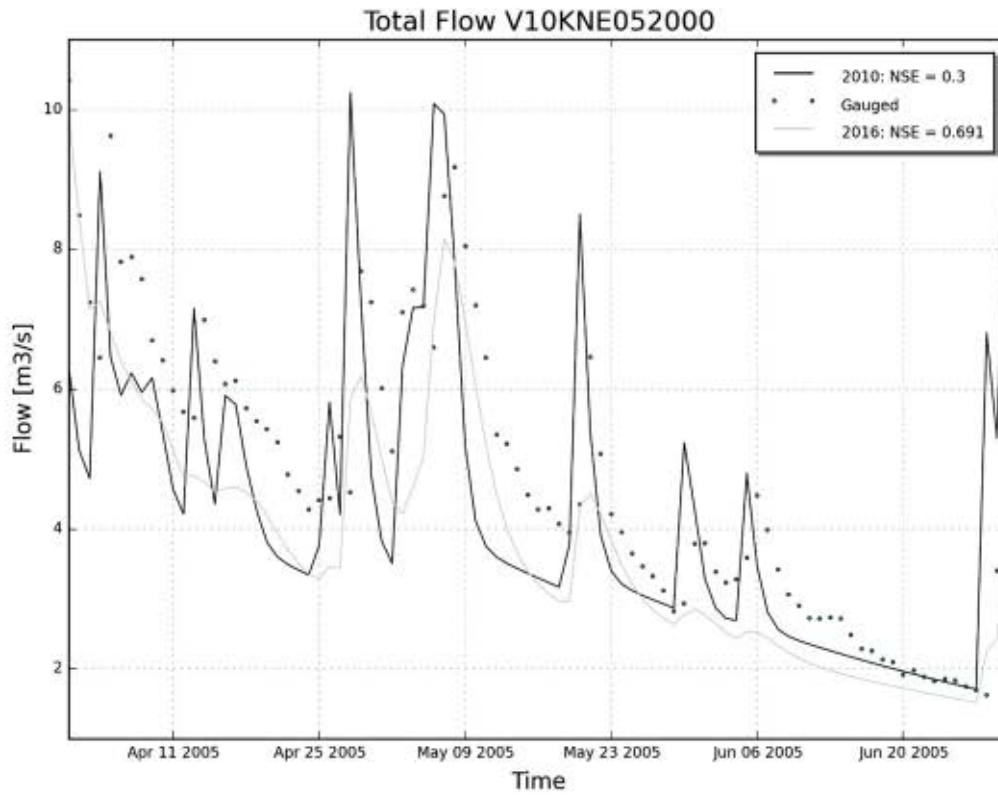
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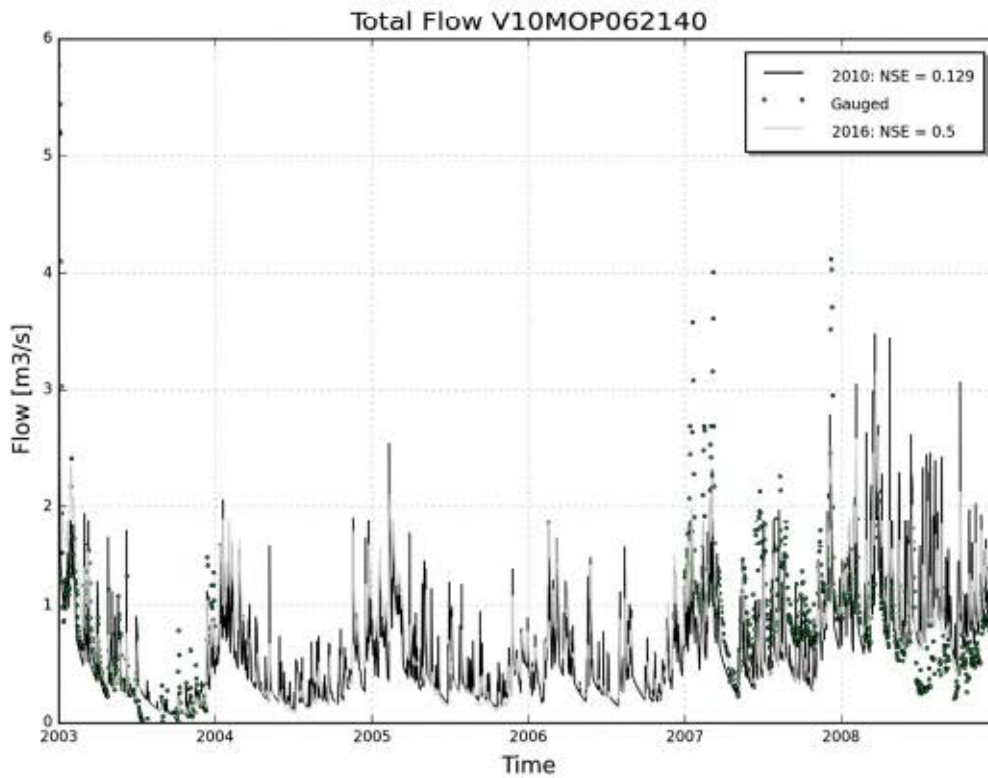
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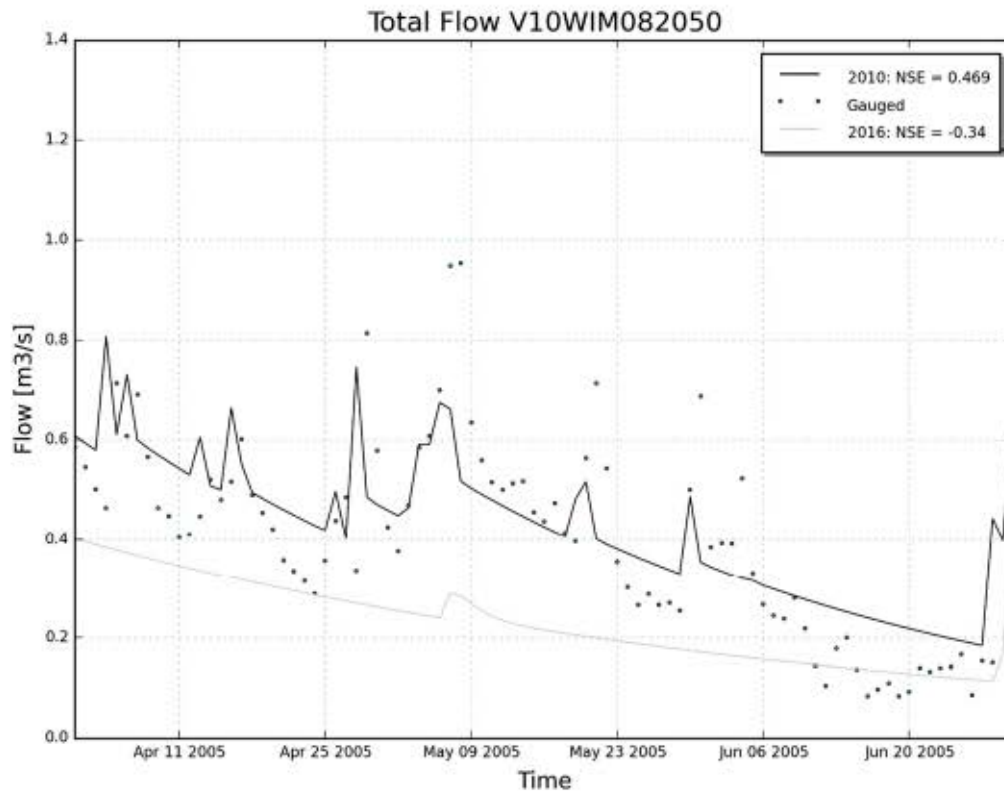
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V10MOP062140



V10WIM082050



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