Technical Documentation GRADE part III

Models Meuse

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Summary
In this report a description is given of the models that are used in the FEWS-GRADE 2.0 system and more specific for the Meuse upstream of Borgharen. Three models are described, the daily HBV model covering the whole Meuse basin and the SOBEK-RE model for the reach from Chooz to Keijzersveer.

Version	Date	Author	Initials	Review	Initials	Approval	Initials
	dec. 2013	Mark Hegnauer		Frederiek Sperna Weiland		Gerard Blom	

State
final

Contents

1 Introduction

This document describes the hydrological and hydraulic models that are used in FEWS-GRADE 2.0 for the Meuse. The purpose of the document is to supply the reader with all necessary information about the models to understand and to work with the models.

2 HBV model

Within the GRADE project, 5 HBV models were derived for the Meuse basin upstream of Borgharen. The difference between the models is in the parameters that are used for each sub-basin. The structure of the 5 models is the same and is described in more detail in this report.

2.1 Software

The software used in FEWS-GRADE 2.0 is the original HBV96 version of the HBV model as it was developed by SMHI (Lindström 1997).

The HBV model consists of 6 modules:

- Precipitation routine; representing rainfall, snow accumulation and melt.
- Soil moisture routine; determining overland and subsurface flow and actual evapotranspiration.
- Fast runoff routine; representing storm flow.
- Base flow routine; representing base flow.
- Transformation routine; representing low flow delay and attenuation.
- Routing routine; flow through river reaches.

2.2 Model history

The HBV model for the Meuse was originally developed by Booij (2002 and 2005) and was re-calibrated by Van Deursen (2004). The re-calibration by Van Deursen was focussing on the complete flow regime. It was found that for extreme events, the HBV model as calibrated by Van Deursen, underestimated the high flows considerably (up to 300-400 m^3/s).
For the purpose of GRADE the model was recalibrated again. There were multiple reasons to do so:

1. The original calibration by Van Deursen underestimated the high flows considerably (up to 300-400 m^3/s).
2. For GRADE the uncertainty in the model parameters needed to be investigated.
3. New datasets for precipitation, temperature and discharge which were in line with the data used in GRADE became available for re-calibration.

2.3 General description of the model

The HBV model of the Meuse is a semi-distributed hydrological model that consists of 15 sub-basins. These sub-basins cover the whole Meuse basin up to Borgharen.
The HBV model runs on a daily time step. The model has been calibrated for the purpose of high flows.

The model was calibrated by performing a GLUE analysis. The setup and results of the calibration can be found in Kramer (2008). The 5 models are derived in such a way that each model represents a percentile of the high flows, i.e. 5%, 25, 50%, 75% and 95%. This means that from all parametersets that were accepted during the GLUE analysis, only 5 were selected in accordance with a percentile of the high flows corresponding to a return period of 100 years. The 5 parametersets span the uncertainty band of the HBV model. For more information see Kramer et al. (2008).

The values of the parameters that are used for each sub-basin for all GLUE parametersets are listed in Table B.1-B.5. The parameters that are used model wide are listed in Table A.1. The model input consists of daily averaged precipitation, temperature and evaporation for each sub-basin. The model is calibrated on the precipitation, evaporation and temperature data as it was used by Van Deursen (2004). For the synthetic evaporation series, a season dependent ETF[1] value (between 7 %/°C in summer and 13 %/°C in winter) is used to create the synthetic series.

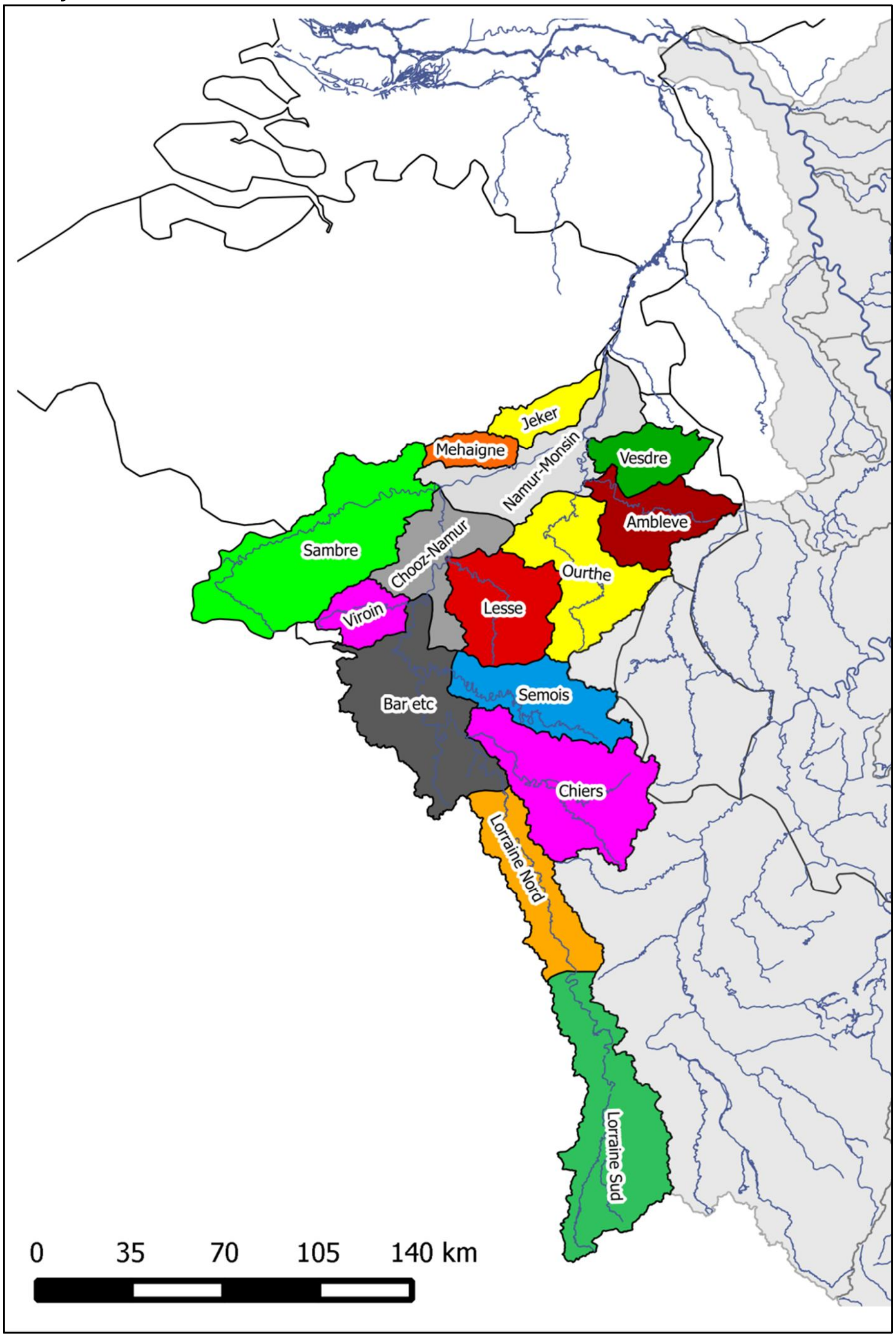

Figure 2.1 Overview of the HBV sub-basins in the Meuse basin upstream of Borgharen

[1] *ETF is the parameter that determines the evaporation difference from the reference evaporation of that month, based on the temperature difference on the specific day of the year. It has unit %/°C.*

2.4 Model structure

The water that is generated in the HBV model is routed trough the main channel. HBV uses a type of Muskingum routing. In HBV, the main stem of the Meuse is modelled within the sub-basins mentioned as “main channel” in Table 2.1.

The link between HBV model structure and HBV sub-basin names in Figure 2.1 is listed in Table 2.2. In the HBV model, there are two dummy-basins which are used to model the confluences between the Ambleve and the Vesdre (Conf001) and the Meuse and Jeker (Conf002). These basins are listed in Table 2.3.

Table 2.1 List of sub-basins of the main channel in HBV along which the water is routed. The basin Conf001 receives water from upstream (Subbas11 and Subbas12)

Flow direction	Main channel	Lateral 1	Lateral 2	Lateral 3	Lateral 4
↓	Subbas1				
	Subbas3				
	Subbas4	*Subbas2*	*Subbas5*	*Subbas6*	
	Subbas7	*Subbas8*			
	Subbas14	*Subbas9*	*Subbas10*	*Subbas13*	*Conf001* *
	Conf002	*Subbas15*			

Table 2.2 Link between HBV model structure and names in Figure 2.1

HBV model structure	Name
Subbas1	Lorraine Sud
Subbas2	Chiers
Subbas3	Lorraine Nord
Subbas4	Bar etc
Subbas5	Semois
Subbas6	Viroin
Subbas7	Chooz-Namur
Subbas8	Lesse
Subbas9	Sambre
Subbas10	Ourthe
Subbas11	Ambleve
Subbas12	Vesdre
Subbas13	Mehaigne
Subbas14	Namur-Monsin
Subbas15	Jeker

Table 2.3 Dummy basins which are not in Figure 2.1

HBV model structure	Name
Conf001	Confluence Ambleve/Vesdre
Conf002	Maas Monsin-Borgharen

3 SOBEK-RE model

3.1 Software

Use is made of the SOBEK-RE software. GRADE only uses the “sobeksim.exe” version 2.0.

3.2 Model history

For building of the Sobek-RE model of the Meuse from Chooz to Keizersveer, use was made of two SOBEK-RE models (zie Van der Veen (2006)):

- Model Chooz – Borgharen is made by WL|Delft Hydraulics, based on the ZWENDL forecasting system as it was build up by H. Berger in 1991.
- Model of the Dutch Meuse (version J04_4-1).

In Kramer (2009) a study was done on the structures that were used in de SOBEK model upstream of Borgharen. The conclusion was that the effect of the weirs during high discharges was very limited.

3.3 General description of the model

The SOBEK-RE Meuse model used in GRADE comprises the Meuse from Chooz (Belgium) to Keizersveer (Netherlands)

The model describes the situation of 1997 for Belgian part of the Meuse (from Chooz to Borgharen) and the situation of 2006/2007 for the Dutch part of the Meuse (Borgharen to Keijzersveer). The model contains retention areas and groundwater interaction along the Dutch part of the Meuse. There is no groundwater interaction and there are no retention areas along the Belgian part of the Meuse.

There are several lateral inflows defined, both for the Dutch and the Belgian part of the Meuse. The model runs with a time step of 1 hour.

More information about the model and the model coupling procedure can be found in Van der Veen (2007).

3.4 Model boundaries

Table 3.1 gives an overview of the boundaries of the Sobek model of the Meuse. All upstream boundaries are discharge boundaries, whereas the downstream boundary consists of the rating-curve (or Q-h relation).

Table 3.1 Overview of the boundaries of the Sobek models for the Meuse

Place	Name in SOBEK-RE	Boundary type	Data
Belgian Meuse (upstream of Borgharen)			
Chooz	BM1_Chooz	Upstream	Q
Dutch Meuse (downstream of Borgharen)			
	MS3_A2_oospl	upstream	Q
	MS3_P10_domme	upstream	Q
	MS3__beg_zytak	upstream	Q
	MS3_boscbroek	upstream	Q
	MS3_PlakraMoo	upstream	Q
	MS3_SluiAndel	upstream	Q
	MS3_SluiWeurt	upstream	Q
Keizersveer	MS3_KeizerMSW	Downstream	Qh-rel.

3.5 Lateral inflows

Table 3.2 shows the lateral inflows that are related to the inflow of small rivers into the Meuse

Table 3.2 Overview of the tributaries that are schematized as lateral inflows

	River	Name in SOBEK-model	Point or Diffuse
Belgian Meuse (upstream of Borgharen)			
Meuse (BE)	Lesse	BM1_HBV08_Lesse	Point
	Sambre	BM1_HBV09_Sambre	Point
	Ourthe	BM1_HBV10_Ourthe	Point
	Ambleve	BM1_HBV11_Ambleve	Point
	Vesdre	BM1_HBV12_Vesdre	Point
	Mehaigne	BM1_HBV13_Mehaigne	Point
	Meuse Chooz-Namur	BM1_HBV07_1_50	Point
		BM1_HBV07_2_50	Point
	Meuse Namur-Monsin	BM1_HBV14_1_50	Point
		BM1_HBV14_2_50	Point
	Albertkanaal	BM1_Albertkanaal	Point
Dutch Meuse (downstream of Borgharen)			
Meuse (NL)	Jeker	MS3_HBV15_Jeker	Point
	Geul	MS3_grensmas3	Point
	Belgian Limburg	MS3_grensmas4	Point
	Geleenbeek	MS3_grensmas5	Point
	Uffeltse/Thornerbeek	MS3_grensmas6	Point
	Vlootbeek	MS3_zandmas1	Point
	Linked to MS3_SlsLinne	MS3_zandmas2	Internal link
	Roer	MS3_zandmas3	Point
	Swalm + 25% Reuver-Gennep	MS3_zandmas4	Point

	Neerbeek	MS3_zandmas5	Point
	Peel	MS3_zandmas6	Point
	NO Brabant + 50% Reuver-Gennep	MS3_zandmas7	Point
	Niers, NO Brabant + 25% Reuver-Gennep	MS3_zandmas8	Point
	Pumping station Bloemers	MS3_zandmas9	Point
	Pumping station Quarles v. Ufford	MS3_getymas1	Point
	Hertogswetering	MS3_getymas2	Point
	Drinkwater abstraction DZH	MS3_Andelms1	Internal link
	Pumping stations "Afgedamde Maas"	MS3_Andelms2	Point
	Zandleij	MS3_Zandleij	Point
	Julianakanaal	MS3_Julianakanaal	Point
	8/16 Julianakanaal	MS3_lateralkan	Point
	Sluis Linne (3/16 Julianakanaal)	MS3_SlsLinne	Point
	Link to MS3_Julianakanaal	MS3_julkan1	Internal link
	Link to MS3_Lateralkan	MS3_lateral1	Internal link
	Ternaaien	MS3_Ternaaien	Point
	Zuid Willemsvaart	MS3_Zuidwillemsv	Point

3.6 Retention areas

The Sobek-RE model for the Meuse only contains retention areas downstream of the Dutch border. The retention areas are listed in table Table 3.3. In Table 3.4 the internal abstraction are listed. For these location there is no connection with the HBV-model.

Table 3.3 Retention areas in the Dutch part of the Meuse (bron Van der Veen (2007)

	Retention area	Name in SOBEK-model	Type
Meuse (NL)	Ret-114_Latkw2__in	Ret-114_Latkw2__in	Two sided retention
	Ret-114_Latkw2_uit	Ret-114_Latkw2_uit	Two sided retention
	Ret-116_Blitte__in	Ret-116_Blitte__in	Two sided retention
	Ret-116_Blitte_uit	Ret-116_Blitte_uit	Two sided retention
	Ret-118_BerAye__in	Ret-118_BerAye__in	Two sided retention
	Ret-118_BerAye_uit	Ret-118_BerAye_uit	Two sided retention
	MS3_Thorn___Ret	MS3_Thorn___Ret	Retention
	MS3_Latkw1__Ret	MS3_Latkw1__Ret	Retention
	MS3_Maastri_Ret	MS3_Maastri_Ret	Retention

	MS3_MeeMaa__Ret	MS3_MeeMaa__Ret	Retention
	MS3_MkpMid__Ret	MS3_MkpMid__Ret	Retention
	MS3_NAplas1	MS3_NAplas1	Retention uncoupled ponds
	MS3_NAplas2	MS3_NAplas2	Retention uncoupled ponds
	MS3_NAplas3	MS3_NAplas3	Retention uncoupled ponds
	MS3_NAplas4	MS3_NAplas4	Retention uncoupled ponds
	MS3_NAplas5	MS3_NAplas5	Retention uncoupled ponds
	MS3_NAplas6	MS3_NAplas6	Retention uncoupled ponds
	MS3_NAplas7	MS3_NAplas7	Retention uncoupled ponds
	MS3_NAplas8	MS3_NAplas8	Retention uncoupled ponds
	MS3_Negeno__Ret	MS3_Negeno__Ret	Retention
	MS3_Otters__Ret	MS3_Otters__Ret	Retention
	MS3_Ittere__Ret	MS3_Ittere__Ret	Retention
	MS3_Heelpl__Ret	MS3_Heelpl__Ret	Retention
	MS3_Borgha__Ret	MS3_Borgha__Ret	Retention
	MS3_adMaas__Ret	MS3_adMaas__Ret	Retention

Table 3.4 Internal abstraction in the Dutch part of the Meuse (bron Van der Veen (2007)

	Name in SOBEK	Description	Type
Meuse (NL)	'MS3_kortsl_Mstr1'	H-dependent abstraction	Constant
	'MS3_kortsl_Mstr2'	Linked to 'MS3_kortsl_Mstr1'	Constant
	'MS3_kortsl_Borg1'	H-dependent abstraction	Constant
	'MS3_kortsl_Borg2'	Linked to 'MS3_kortsl_Borg1'	Constant
	'MS3_kortsl_Itte1'	H-dependent abstraction	Constant
	'MS3_kortsl_Itte2'	Linked to 'MS3_kortsl_Itte1'	Constant
	'MS3_kortsl_adMa1'	H-dependent abstraction	Constant
	'MS3_kortsl_adMa2'	Linked to 'MS3_kortsl_adMa1'	Constant
	'MS3_kortsl_MeMa1'	H-dependent abstraction	Constant
	'MS3_kortsl_MeMa2'	Linked to 'MS3_kortsl_MeMa1'	Constant
	'MS3_kortsl_Nege1'	H-dependent abstraction	Constant
	'MS3_kortsl_Nege2'	Linked to 'MS3_kortsl_Nege1'	Constant
	'MS3_kortsl_Latk1'	H-dependent abstraction	Constant
	'MS3_kortsl_Latk2'	Linked to 'MS3_kortsl_Latk1'	Constant
	'MS3_kortsl_Grev1'	H-dependent abstraction	Constant
	'MS3_kortsl_Grev2'	Linked to 'MS3_kortsl_Grev1'	Constant
	'MS3_kortsl_Linn1'	H-dependent abstraction	Constant
	'MS3_kortsl_Linn2'	Linked to 'MS3_kortsl_Linn1'	Constant
	'MS3_kortsl_Roer1'	H-dependent abstraction	Constant
	'MS3_kortsl_Roer2'	Linked to 'MS3_kortsl_Roer1'	Constant
	'MS3_kortsl_Roer3'	H-dependent abstraction	Constant
	'MS3_kortsl_Roer4'	Linked to 'MS3_kortsl_Roer3'	Constant

'MS3_aanvoe_ouma1'	H-dependent relation with oude Maas	Constant
'MS3_aanvoe_ouma2'	Linked to 'MS3_aanvoe_ouma1'	Constant
'MS3_kortsl_Mook1'	H-dependent abstraction	Constant
'MS3_kortsl_Mook2'	Linked to 'MS3_kortsl_Mook1'	Constant

3.7 Groundwater interaction

Groundwater interaction is only taken into account for some locations in the Dutch part of the Meuse river. The locations for which groundwater interaction is schematized are listed in Table 3.5. The groundwater interaction is modelled using the retention option in Sobek-RE.

Table 3.5 List of locations where there is groundwater interaction

Part	Name in SOBEK-model	Type
Meuse (NL)	MS3_GRW1	Groundwater retention
	MS3_GRW2	Groundwater retention
	MS3_GRW3	Groundwater retention
	MS3_GRW4	Groundwater retention
	MS3_GRW5	Groundwater retention

3.8 Structures

In the SOBEK model of the Meuse structures are defined to regulate the water levels. The structures that are implemented are listed in Table 3.6. The maximum and minimum threshold values are the values between which the gate level can change. In Van der Veen (2007) more information about the weirs can be found (e.g. timing of the weir opening and closing).

Table 3.6 List of all structures in the SOBEK model of the Meuse, from Chooz until Borgharen

Discharge Location	Weir	Weir closed Maximum threshold (m +NAP)	Weir open Minimum threshold (m +NAP)
Chooz (boarder between France and Belgium)	Quarte Cheminee	99.21	96.99
	Hastiere	96.01	91.06
	Waulsort	93.22	88.71
	Anseremme	90.79	85.56
Dinant (downstream of the Lesse)	Dinant	88.56	83.83
	Houx	86.59	82.06
	Hun	84.59	79.56
	Riviere	81.80	77.66
	Talifer	79.72	75.56
	La Plante	77.72	73.56
Namen (downstream of the Sambre)	Grands Malade	75.65	70.76
	Andenne Seilles	71.76	65.06
	Ampsin Neuville	66.37	60.41
	Ivoz-Ramet	61.54	56.28
Luik (downstream of the Ourthe, Ambleve and Vesdre	Monsin	57.42	52.66
	Lixhe	50.84	45.50
Eijsden	Borgharen	43.83	

4 Coupling of HBV and SOBEK-RE model

The HBV model and the SOBEK models are coupled within the GRADE project, to allow the water coming from the HBV model to be routed along the main river. The SOBEK model includes more of the physics than the routing model that is present in the HBV model.

In Table 4.1 the coupling of the SOBEK boundaries with HBV sub-basins is shown upstream of Borgharen. In Table 4.2 the conditions for the boundaries along the Dutch part of the Meuse, downstream of Borgharen, are shown.

Table 4.3 shows the coupling of the lateral flows that flow into the SOBEK model upstream of Borgharen. For the laterals along the Dutch part of the Meuse, downstream of Borgharen, the conditions are listed in Table 4.4.

The HBV model of the Meuse does not provide enough information to the SOBEK model, because the HBV model only models the flow until Borgharen. For all Dutch laterals, information is provided by transforming the flow at Borgharen to a corresponding flow at the Dutch laterals, or by using a constant value. In Table 4.2 and Table 4.4 an overview is given of the transformation that is done for each Dutch boundary or lateral. Here the “Value below threshold” means the value that is used for the lateral when the flow at Borgharen is below the threshold and the “Value above threshold” means the value that is used for the lateral when the flow at Borgharen is above the threshold.

Table 4.1 Coupling of HBV units to SOBEK boundaries upstream of Borgharen

Place	**Name in SOBEK-RE**	**HBV unit / HBV station**	**HBV Name**	**Factor**
Belgian Meuse (upstream of Borgharen)				
Chooz	BM1_Chooz	H-MS-0011	Bar etc (Chooz)	1.00

Table 4.2 Boundary conditions for Dutch boundaries downstream of Borgharen

Name in SOBEK-model	**FEWS ID**	**Threshold**	**Value below threshold**	**Value above threshold**
Dutch Meuse (downstream of Borgharen)				
MS3_A2_oostpl	I-MS-DOMA	56.4	0.0266 * QB[1]	1.5
MS3_P10_domme	I-MS-DOMP	45.5	0.033 * QB[1]	1.5
MS3__beg_zytak	*dummy*	Constant		0.0
MS3_boscbroek	*dummy*	Constant		0.0
MS3_PlakraMoo	*dummy*	Constant		0.0
MS3_SluiAndel	*dummy*	Constant		0.0
MS3_SluiWeurt	*dummy*	Constant		0.0

Table 4.3 Coupling of HBV units to SOBEK lateral flows upstream of Borgharen

Name in SOBEK-RE	HBV unit / HBV station	HBV Name	Factor
Belgian Meuse (upstream of Borgharen)			
BM1_HBV08_Lesse	H-MS-0013	Lesse	1.00
BM1_HBV09_Sambre	H-MS-0019	Sambre	1.00
BM1_HBV10_Ourthe	H-MS-0020	Ourthe	1.00
BM1_HBV11_Ambleve	H-MS-0017	Ambleve	1.00
BM1_HBV12_Vesdre	H-MS-0010	Vesdre	1.00
BM1_HBV13_Vesdre	I-MS-0013	Mehaigne	1.00
BM1_HBV7_1_50	I-MS-0007	Meuse Chooz-Namur	0.50
BM1_HBV7_2_50	I-MS-0007	Meuse Chooz-Namur	0.50
BM1_HBV14_1_50	I-MS-0014	Meuse Namur-Monsin	0.50
BM1_HBV14_2_50	I-MS-0014	Meuse Namur-Monsin	0.50
BM1_Albertkanaal	-	-	Weekly pattern[3]

Table 4.4 Boundary conditions for Dutch laterals, downstream of Borgharen

Name in SOBEK-model	FEWS ID	Threshold	Value below threshold	Value above threshold	
Dutch Meuse (downstream of Borgharen)					
MS3_HBV15_Jeker	I-MS-0015	-	-	-	Jeker
MS3_grensmas3	I-MS-GMS3	76.95	0.013 * QB[2]	0.00	Geul
MS3_grensmas4	I-MS-GMS4	80.85	0.0062 * QB[1]	0.50	Belgian Limburg
MS3_grensmas5	I-MS-GMS5	419.36	0.0124 * QB[1] - 4.2	0.00	Geleenbeek
MS3_grensmas6	I-MS-GMS6	80.85	0.0062 * QB[1]	0.50	Uffeltse/Thorner beek
MS3_zandmas1	I-MS-ZMS1	419.36	0.0124 * QB[1] - 4.2	0.00	Vlootbeek
MS3_zandmas2	Internal release			-	Linked to MS3_SlsLinne
MS3_zandmas3	I-MS-ZMS3	0.01	-	0.00	Roer
MS3_zandmas4	I-MS-ZMS4	-	0.46	0.46	Swalm + 25% Reuver-Gennep
MS3_zandmas5	I-MS-ZMS5	80.85	0.0062 * QB[1]	0.50	Neerbeek
MS3_zandmas6	I-MS-ZMS6	80.85	0.0062 * QB[1]	0.50	Peel
MS3_zandmas7	I-MS-ZMS7	-	0.70	0.70	NO Brabant + 50% Reuver-Gennep
MS3_zandmas8	I-MS-ZMS8	1500	-	3.31	Niers, NO Brabant + 25% Reuver-Gennep
		2500	-0.001 * QB[1] + 3.31	2.50	
MS3_zandmas9	I-MS-ZMS9	-	0.23	0.23	Pumping station Bloemers
MS3_getijmas1	I-MS-GTM1	-	0.22	0.22	Pumping station Quarles v. Ufford
MS3_getijmas2	I-MS-GTM2	1500	-	4.05	Hertogswetering
		2500	(-0.001 * QB[1] + 2.5) * 4.05 + 0.1	1.32	
MS3_Andelms1	Constant				Drinkwater

[2] *Discharge at Borgharen*

				-2.50	abstraction DZH
MS3_andelms2	I-MS-AMS2	-	0.20	0.20	Pumping stations Afgedamde Maas
MS3_Zandleij	I-MS-DOMZ	-	0.16	0.16	Zandleij
MS3_Julianakanaal	-	Weekly pattern[3]		-	Julianakanaal
MS3_lateralkan	Weekly pattern[4]			-	8/16 Julianakanaal
MS3_SlsLinne	Weekly pattern[4]			-	3/16 Julianakanaal
MS3_julkan1	Internal release			-	Linked to MS3_Julianakanaal
MS3_lateral1	Internal release			-	Linked to MS3_Lateralkan
MS3_Ternaaien	Weekly pattern[4]			-	Ternaaien
MS3_ZuidWillemsv	Weekly pattern[4]			-	Zuid Willemsvaart

[3] The weekly pattern is described in more detail in appendix E of Van der Veen (2007)
[4] The weekly pattern is described in more detail in appendix E of Van der Veen (2007)

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A List of parameters in rmod.par

Table A.1 List of parameters in rmod.par file. These values are overruled if given in bmod.par (see Table B.1)

Parameter	Value	Description	Unit
pcalt	0.100	Altitude correction factor for precipitation	-
tcalt	0.600	Altitude correction factor for temperature	
rfcf	0.99714		
sfcf	1.01758		
cfmax	3.75653	Snowmelt rate	Mm/day
tt	-1.41934	Temperature threshold above which snowmelt occurs	°C
dttm	0.54391		
tti	1.000		
cfr	0.050		
whc	0.100		
fosfcf	0.800		
focfmax	0.600		
fc	180.00	Maximum storage capacity in soil moisture	Mm
lp	0.66	Limit of potential evaporation	-
beta	1.79743	Control of the increase in soil moisture per mm rainfall	-
cflux	1.37990		
cevpfo	1.150		
ecorr	1.000	Evaporation correction factor	
ecalt	0.100	Altitude correction factor for evaporation	-
sfdistfo	0.200		
sclass	1.000		
sfdistfi	0.500		
k4	0.02307		
perc	0.400	Percolation	
khq	0.120	Recession parameter at HQ (high flow parameter)	1/day
hq	3.400		
alfa	0.700	Measure of non-linearity	-
maxbas	1.000	Delay	Day
recstep	999.000		
cevpl	1.000		
critstep	1.000		
pcorr	1.000	Precipitation correction factor	-

B List of all HBV sub-basins

Table B.1 List of parameters in bmod.par files for the 5% GLUE parameterset

Basin	alfa	beta	lp	fc	khq	HQ	maxbas	perc
SUBBAS1	1,10	2,74	0,62	428,06	0,08	1,49	3,93	-
SUBBAS10	0,93	1,75	0,23	189,32	0,13	2,63	2,20	-
SUBBAS11	1,04	2,65	0,62	187,46	0,12	4,10	1,40	0,60
SUBBAS12	1,44	1,23	0,46	249,17	0,20	3,85	1,10	1,20
SUBBAS13	0,60	1,90	0,24	488,07	0,14	4,11	1,10	1,10
SUBBAS14	0,82	2,37	0,29	467,93	0,19	3,02	-	-
SUBBAS15	0,15	1,97	0,40	273,00	0,08	-	-	-
SUBBAS2	0,38	1,07	0,41	367,46	0,04	3,69	-	-
SUBBAS3	1,21	3,11	0,99	225,18	0,08	2,85	-	-
SUBBAS4	0,55	1,08	0,69	206,07	0,10	3,91	1,20	-
SUBBAS5	1,12	2,80	0,36	117,30	0,05	1,29	2,50	-
SUBBAS6	1,54	2,85	0,28	263,16	0,08	1,32	-	-
SUBBAS7	0,49	1,57	0,62	112,22	0,30	4,09	-	-
SUBBAS8	1,05	2,84	0,66	364,96	0,13	1,53	2,00	-
SUBBAS9	0,43	2,30	0,80	497,36	0,09	1,96	-	-

Table B.2 List of parameters in bmod.par files for the 25% GLUE parameterset

Basin	alfa	beta	lp	fc	khq	HQ	maxbas	perc
SUBBAS1	1,10	2,74	0,62	428,06	0,08	1,49	3,93	-
SUBBAS10	0,93	1,75	0,23	189,32	0,13	2,63	2,20	-
SUBBAS11	1,04	2,65	0,62	187,46	0,12	4,10	1,40	0,60
SUBBAS12	1,44	1,23	0,46	249,17	0,20	3,85	1,10	1,20
SUBBAS13	0,60	1,90	0,24	488,07	0,14	4,11	1,10	1,10
SUBBAS14	0,82	2,37	0,29	467,93	0,19	3,02	-	-
SUBBAS15	0,15	1,97	0,40	273,00	0,08	-	-	-
SUBBAS2	0,38	1,07	0,41	367,46	0,04	3,69	-	-
SUBBAS3	1,21	3,11	0,99	225,18	0,08	2,85	-	-
SUBBAS4	0,55	1,08	0,69	206,07	0,10	3,91	1,20	-
SUBBAS5	1,12	2,80	0,36	117,30	0,05	1,29	2,50	-
SUBBAS6	1,54	2,85	0,28	263,16	0,08	1,32	-	-
SUBBAS7	0,49	1,57	0,62	112,22	0,30	4,09	-	-
SUBBAS8	1,05	2,84	0,66	364,96	0,13	1,53	2,00	-
SUBBAS9	0,43	2,30	0,80	497,36	0,09	1,96	-	-

Table B.3 List of parameters in bmod.par files for the 50% GLUE parameterset

Basin	alfa	beta	lp	fc	khq	HQ	maxbas	perc
SUBBAS1	1,10	2,74	0,62	428,06	0,08	1,49	3,93	-
SUBBAS10	0,93	1,75	0,23	189,32	0,13	2,63	2,20	-
SUBBAS11	1,04	2,65	0,62	187,46	0,12	4,10	1,40	0,60
SUBBAS12	1,44	1,23	0,46	249,17	0,20	3,85	1,10	1,20
SUBBAS13	0,60	1,90	0,24	488,07	0,14	4,11	1,10	1,10
SUBBAS14	0,82	2,37	0,29	467,93	0,19	3,02	-	-
SUBBAS15	0,15	1,97	0,40	273,00	0,08	-	-	-
SUBBAS2	0,38	1,07	0,41	367,46	0,04	3,69	-	-
SUBBAS3	1,21	3,11	0,99	225,18	0,08	2,85	-	-
SUBBAS4	0,55	1,08	0,69	206,07	0,10	3,91	1,20	-
SUBBAS5	1,12	2,80	0,36	117,30	0,05	1,29	2,50	-
SUBBAS6	1,54	2,85	0,28	263,16	0,08	1,32	-	-
SUBBAS7	0,49	1,57	0,62	112,22	0,30	4,09	-	-
SUBBAS8	1,05	2,84	0,66	364,96	0,13	1,53	2,00	-
SUBBAS9	0,43	2,30	0,80	497,36	0,09	1,96	-	-

Table B.4 List of parameters in bmod.par files for the7 5% GLUE parameterset

Basin	alfa	beta	lp	fc	khq	HQ	maxbas	perc
SUBBAS1	1,10	2,74	0,62	428,06	0,08	1,49	3,93	-
SUBBAS10	0,93	1,75	0,23	189,32	0,13	2,63	2,20	-
SUBBAS11	1,04	2,65	0,62	187,46	0,12	4,10	1,40	0,60
SUBBAS12	1,44	1,23	0,46	249,17	0,20	3,85	1,10	1,20
SUBBAS13	0,60	1,90	0,24	488,07	0,14	4,11	1,10	1,10
SUBBAS14	0,82	2,37	0,29	467,93	0,19	3,02	-	-
SUBBAS15	0,15	1,97	0,40	273,00	0,08	-	-	-
SUBBAS2	0,38	1,07	0,41	367,46	0,04	3,69	-	-
SUBBAS3	1,21	3,11	0,99	225,18	0,08	2,85	-	-
SUBBAS4	0,55	1,08	0,69	206,07	0,10	3,91	1,20	-
SUBBAS5	1,12	2,80	0,36	117,30	0,05	1,29	2,50	-
SUBBAS6	1,54	2,85	0,28	263,16	0,08	1,32	-	-
SUBBAS7	0,49	1,57	0,62	112,22	0,30	4,09	-	-
SUBBAS8	1,05	2,84	0,66	364,96	0,13	1,53	2,00	-
SUBBAS9	0,43	2,30	0,80	497,36	0,09	1,96	-	-

Table B.5 List of parameters in bmod.par files for the9 5% GLUE parameterset

Basin	alfa	beta	lp	fc	khq	HQ	maxbas	perc
SUBBAS1	1,10	2,74	0,62	428,06	0,08	1,49	3,93	-
SUBBAS10	0,93	1,75	0,23	189,32	0,13	2,63	2,20	-
SUBBAS11	1,04	2,65	0,62	187,46	0,12	4,10	1,40	0,60
SUBBAS12	1,44	1,23	0,46	249,17	0,20	3,85	1,10	1,20
SUBBAS13	0,60	1,90	0,24	488,07	0,14	4,11	1,10	1,10
SUBBAS14	0,82	2,37	0,29	467,93	0,19	3,02	-	-
SUBBAS15	0,15	1,97	0,40	273,00	0,08	-	-	-
SUBBAS2	0,38	1,07	0,41	367,46	0,04	3,69	-	-
SUBBAS3	1,21	3,11	0,99	225,18	0,08	2,85	-	-
SUBBAS4	0,55	1,08	0,69	206,07	0,10	3,91	1,20	-
SUBBAS5	1,12	2,80	0,36	117,30	0,05	1,29	2,50	-
SUBBAS6	1,54	2,85	0,28	263,16	0,08	1,32	-	-
SUBBAS7	0,49	1,57	0,62	112,22	0,30	4,09	-	-
SUBBAS8	1,05	2,84	0,66	364,96	0,13	1,53	2,00	-
SUBBAS9	0,43	2,30	0,80	497,36	0,09	1,96	-	-