

SIMGRO 4.1.2 User's guide

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ABSTRACT

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The regional hydrologic model SIMGRO is used for investigating various kinds of water management problems, specifically those where the interaction between groundwater and surface waters plays a crucial role. This manual contains comprehensive information regarding the way theoretical concepts relate to practical water management issues, technical features of the modules, installation, program use and error handling.

Keywords: finite element model, regional hydrology, simulation, water management.

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DWK-Programme 417

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1 Introduction

Integrated modelling has the attraction of including feedback mechanisms between the hydrological compartments. But covering a wide range of processes in a spatially distributed manner requires a large logistic effort, involving masses of data. Even the experienced modeller can easily make a fatal mistake. In the form of an ultimate safety net there is of course no substitute for constant awareness and thorough analysis of the simulation results. But avoiding mistakes in the first place is usually more efficient, and one of the prerequisites for doing that is to have a good overview of the model and its data. At a conceptual level that overview is provided by the theory description (Van Walsum et al., 2004). In the form of a reference guide the formats of input and output files are described in Dik (2004). The latter has the disadvantage that it is purely data-oriented, and not so much conceptually oriented. The aim of this guide is to document the functionalities at a technical level, following the thematic overview given in the theory description. It is hopefully of help in quickly making choices with respect to the modelling options and in maintaining an overview of a study.

Chapter 2 describes the functionalities and their definition in the the SIMGRO-input files. Per subsection we give:

- the organization of files involved in defining a certain functionality;
- a short description of the functionality;
- a specification of the input files.

The specifications are given as formatted tables of the involved parameters and the key variables (e.g. the node number) that are used for accessing them. Key variables – also called independent variables – are marked in bold. That helps to understand the structure of the input files.

In Chapter 3 we first describe the hard- and software that is needed for actually running the model, and then the actual running itself.

We wish you happy computing!

2 Input, programme use and output

2.1 General data flow

For each application, the model requires a set of input data files. The computer programme is then able to generate a set of output files during a 'model run' (Fig. 7).

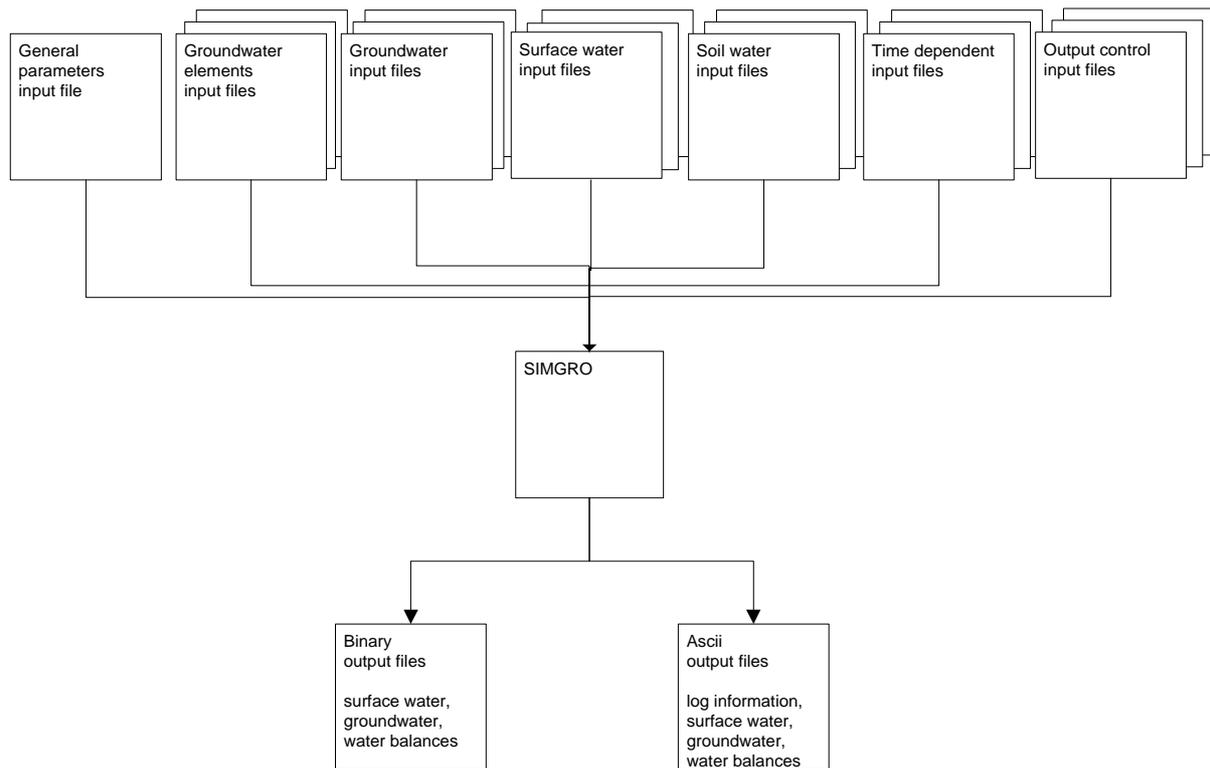


Figure 2.1 Dataflow in SIMGRO

2.2 Overview of input files

In Table 2.1 an overview of the input files is given. Various files are optional. The names of the files are abbreviated to four characters, followed by '_sim', '_nod', '_sub' or '_bin' and the extension '.inp' for input. A more extensive description of the input files is given in the document 'SIMGRO Description of input and output files' (Dik, 2004).

Table 2.1 Input files for SIMGRO

Input file	Required/optional	Module	Description
PARA_SIM.INP	req	parameter	general input file
NODE_SIM.INP	req	gr.w. elements	nodal coordinates
ELEM_SIM.INP	req	gr.w. elements	nodes per elements
NDSB_SIM.INP	req	surface water	nodes per subcatchments
MANA_SIM.INP	req	surface water	water management per subcatchment
GOTO_SIM.INP	req	surface water	drainage structure of subcatchments
DISH_SIM.INP	req	surface water	discharge capacity per subcatchment
URBN_SUB.INP	opt	surface water	urban sewerage structure
DRNG_NOD.INP	opt	surface water	drainage per nodal subdomain
RESV_SIM.INP	opt	surface water	supply per subcatchment
DISU_SIM.INP	opt	surface water	discharge capacity per subcatchment (summer)
TACL_SIM.INP	opt	surface water	target level lowering
INSW_SIM.INP	opt	surface water	initial conditions surface water system
INSW_BIN.INP	opt	surface water	initial conditions surface water system (binary file)
COND_NOD.INP	req	groundwater	conductivity per nodal subdomain
FAUL_SIM.INP	opt	groundwater	faults in the geology
INHH_SIM.INP	opt	groundwater	initial conditions hydraulic heads
INHH_BIN.INP	opt	groundwater	initial conditions hydraulic heads (binary file)
LUSE_SIM.INP	req	soil water	land use type data
UNSA_SIM.INP	req	soil water	soil phys. unit data
FILT_SIM.INP	req	soil water	infiltration capacity per soil phys. unit
ROOT_SIM.INP	req	soil water	land use specific data per soil phys. unit
FADE_SIM.INP	req	soil water	vegetation factor description
FACT_SIM.INP	req	soil water	vegetation factors
GIFT_NOD.INP	req	soil water	soil unit, sprinkling, meteo station per nodal subdomain
FRSW_NOD.INP	req	soil water	inundation curve per nodal subdomain
ROFF_SIM.INP	opt	soil water	runoff and infiltration data
AREA_NOD.INP	req	soil water	land use per nodal subdomain, thickness root zone
URBN_NOD.INP	opt	soil water	urban characteristics
INRZ_SIM.INP	opt	soil water	initial condition of root zone
INRZ_BIN.INP	opt	soil water	initial condition of root zone (binary file)
PLHH_NOD.INP	opt	output	hydraulic head per node
PLHH_LAY.INP	opt	output	hydraulic head per layer
PLHH_SUB.INP	opt	output	hydraulic head per subcatchment
PLWB_NOD.INP	opt	output	water balance per nodal subdomain
PLWB_LAY.INP	opt	output	water balance per layer
PLWB_SUB.INP	opt	output	water balance per subcatchment
NDBD_SIM.INP	opt	output	output as boundary nodes (levels)
NDLK_SIM.INP	opt	output	output as boundary nodes (fluxes)
NRBD_SIM.INP	opt	output	output as boundary subcatchments
METE_SIM.INP	req	meteo, time	precipitation and evapotranspiration
TIOP_SIM.INP	req	output, time	output options
TIBD_SIM.INP	opt	groundwater, time	boundary conditions
TIAB_SIM.INP	opt	groundwater, time	abstractions
TISW_SIM.INP	opt	surface water, time	water levels and discharges

2.3 Groundwater elements

Organization

Table 2.2 Related input files

Input file	Description
NODE_SIM.INP	Coordinates of nodes
ELEM_SIM.INP	Definition of elements

Description

The groundwater system is schematized into a number of layers, with horizontal flow in water-conveying layers (aquifers) and vertical flow in less permeable layers (aquitards).

For each layer the modelling domain is subdivided into triangular finite elements, enabling the use of relatively simple element shapes to describe complex geometrical configurations at the soil surface. For all layers the same network is used.

Several software programs can generate a finite element network (for example MicroFEM). There are nevertheless some requirements on the input files:

- the minimum distance between two nodes may not be smaller than 1 m;
- the number of contact points may not exceed the limit for which the code has been compiled and not be less than two. In the latter case a warning is given. We advise to not use more than twelve contact points;
- the nodes of the elements must be specified in counter-clockwise order.

The construction of the nodal subdomains (or so-called influence areas) is done by the model code itself. We recommend to not use too small node distances and to avoid extremely obtuse interior angles of elements. The stability of the calculations for a network with too small node distances (and therefore small nodal subdomains) can be low, depending also on the geohydrological situation. As a guideline a minimum nodal area of 2500 m² is given.

The finite-element network is the geometric basis of the model. All geographical information is linked to this network. That also goes for the watercourses, which are related to a node number via the file NDSB_SIM.INP and DRNG_NOD.INP.

Specification

Table 2.3 Input files and related variables

Input file	Parameter	Unit	Description
NODE_SIM.INP	<i>nnex</i>	-	external node number
	<i>xc</i>	-	x-coordinate
	<i>yc</i>	-	y-coordinate
ELEM_SIM.INP	<i>neex</i>	-	element number
	<i>ndel01</i>	-	node element 1
	<i>ndel02</i>	-	node element 2
	<i>ndel03</i>	-	node element 3

- The network itself is defined in the files NODE_SIM.INP (coordinates of the nodes) and ELEM_SIM.INP (definition of the elements).

2.4 Plant/Soil-Atmosphere interactions

Organization

Table 2.4 Related input files

Input file	Description
<i>General</i>	
METE_SIM.INP	meteo-data
PARA_SIM.INP	several general parameters
LUSE_SIM.INP	sprinkling data
	pointer to vegetation factors
FACT_SIM.INP	vegetation factors
ROOT_SIM.INP	start and stop values of the root zone content for sprinkling parameters for root water uptake function
<i>Node-specific</i>	
AREA_NOD.INP	land use type per nodal subdomain
GIFT_NOD.INP	sprinkling data
	meteorological region number
URBN_NOD.INP	impermeable fraction
	sewerage system
FRSW_NOD.INP	inundated areal fraction as a function of the mean groundwater depth

2.4.1 Precipitation

Description

For the simulation period, the time series information of the meteorological conditions should be available in the form of a step-function (usually per day, but preferably for shorter intervals), which should be specified in the file METE_SIM.INP. The data can for instance be assembled from standard meteorological data like precipitation (mm d^{-1}), average air temperature ($^{\circ}\text{C}$), global radiation (W/m^2) and relative humidity (-).

Measurements of precipitation usually contain small systematic errors due to wind-effects. To compensate for them a correction factor can be specified. The value is usually in the range of [1; 1.05].

The meteo data can be given for more than one gauging station in the region. In that case the relevant station should be specified for each of the nodal subdomains of the soil water /groundwater model (in GIFT_NOD.INP).

Specification

Table 2.5 Input files and related parameters for precipitation

Input file	Parameter	Unit	Description
METE_SIM.INP	<i>id</i>	-	day number
	<i>iy</i>	-	year number
	<i>pr</i>	mm	precipitation
PARA_SIM.INP	<i>nmme</i>	-	meteorological region number
	<i>fawa</i>	-	correction factor for precipitation
	<i>frpr</i>	-	fraction of time precipitation or sprinkling occurs
GIFT_NOD.INP	<i>nnex</i>	-	node number
	<i>nmme</i>	-	meteorological region number

- The meteorological data are specified in METE_SIM.INP. Meteorological data should be specified from the start to the end of the model run . The data in this file should be in chronological order.
The time step can be smaller than 1 day. When the user wants to use relatively short meteo time steps, the groundwater and surface water time steps should be chosen accordingly (see PARA_SIM.INP).
- The parameter *fawa*, the correction factor for precipitation, increases the precipitation rate with that factor (the real precipitation is usually greater than the measured precipitation), see PARA_SIM.INP.
- The parameter *frpr* in PARA_SIM.INP affects the precipitation and sprinkling *intensity*. For example a *frpr* of 0.1 concentrates the precipitation in ten percent of each time step. When the precipitation/sprinkling intensity exceeds the infiltration capacity, surface storage or runoff will occur (this parameter is independent of the groundwater time step). Care should be taken in choosing the value of *frpr* in accordance with the meteo data. Meteo data that are specified for short time steps (stemming from actual measurements for short intervals) require the setting of *frpr* to 1.0. And if a value of *frpr* has been calibrated for a certain historic series of meteorological data, the obtained value is not necessarily valid for a climate scenario.
- The meteorological region number specifies the meteorological station. See METE_SIM.INP and GIFT_NOD.INP.

2.4.2 Sprinkling

Description

The ‘natural’ precipitation can be augmented by sprinkling. During the growing season, precipitation deficits are likely to occur regularly. If, in severe cases, the water content in the root zone is lowered beyond the reduction point, crop growth will be reduced. To avoid this crops may be irrigated.

In SIMGRO, sprinkling is done from surface water and/or groundwater. If sprinkling from both groundwater and surface water is enabled, sprinkling from surface water has priority. Sprinkling requirements can be specified for each land use type or for each combination of land-use type and soil physical unit.

For determining the moment to start sprinkling (and to stop) use is made of the moisture content in the root zone. Sprinkling is triggered when the water content of the root zone has fallen below a crop-related ‘start’ value, and discontinued as soon it exceeds the ‘stop’ value. SIMGRO allows the user to specify a sprinkling gift which may be applied over the rotational period. For instance if a gift of 25 mm is specified to cover a period of ten days, the sprinkling demand equals 2.5 mm d⁻¹.

In terms of water use efficiency, the performance of sprinkling systems is comparatively poor. Water losses due to evaporation and percolation to the groundwater are accounted for. The gross amount of sprinkling applied to the soil surface is reduced with the factor $(1 - (1 - frirev) \cdot (1 - firrpe))$.

Specification

Table 2.6 Input files and related parameters for sprinkling

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>frrpe</i>	-	fraction of sprinkling water that percolates directly
	<i>frirev</i>	-	fraction of sprinkling water that evaporates directly
	<i>frpr</i>	-	fraction of time precipitation or sprinkling occurs
	<i>dhtasp</i>	m	water level below target before sprinkling is prohibited
	<i>cmspro</i>	mm	total sprinkling gift over rotational period
LUSE_SIM.INP	nmteex	-	number of land use type
	<i>durospte</i>	d	duration of rotational period for sprinkling
	<i>idsphgte</i>	-	day number to start sprinkling
	<i>idspedte</i>	-	day number to end sprinkling
	<i>frspte</i>	-	threshold for sprinkling, rel. root zone water content
ROOT_SIM.INP	spunex	-	soil physical unit number
	nmteex	-	land use type number
	<i>frrbg</i>	-	relative root zone storage start sprinkling
GIFT_NOD.INP	<i>frrnd</i>	-	relative root zone storage end sprinkling
	nnex	-	node number
	<i>nlab</i>	-	layer number for abstraction
	<i>fmmxabsw</i>	mm d ⁻¹	maximum abstraction from surface water
	<i>fmmxabgw</i>	mm d ⁻¹	maximum abstraction from groundwater
	<i>flmxabsw</i>	m ³ d ⁻¹	maximum abstraction from surface water
	<i>flmxabgw</i>	m ³ d ⁻¹	maximum abstraction from groundwater
<i>nnab</i>	-	node from which groundwater is abstracted	
<i>nrab</i>	-	subcatchment from which surface water is abstracted	

- The trigger for sprinkling is the moisture deficit fraction *frspte* in LUSE_SIM.INP and can be specified per combination of land use type and soil physical unit in ROOT_SIM.INP. These last values overrule the values in LUSE_SIM.INP.

- The total sprinkling gift *cmspro* in PARA_SIM.INP defines the total gift during the specified rotational period (in LUSE_SIM.INP). The duration of the rotational period can also be specified per land use type in LUSE_SIM.INP.
- The fraction that evaporates and the fraction of time sprinkling occurs are defined in PARA_SIM.INP (see the parameters *frirpe*, *frirev*, *frpr*).
- The parameter *dbtasp* defines the water level below the target level (see PARA_SIM.INP) before sprinkling is prohibited and therefore prevents the surface water from running dry.
- The parameter *frpr* in PARA_SIM.INP affects the precipitation and sprinkling intensity. When the precipitation/sprinkling intensity exceeds the infiltration capacity, surface storage or runoff will occur (this parameter is independent of the groundwater time step). For example, when *frpr* equals 0.1 the precipitation is concentrated in ten percent of each time step.
- In GIFT_NOD.INP several characteristics are defined: the layer for groundwater sprinkling, the abstraction node, the surface watercourse, the fraction from groundwater or surface water and the maximum capacities from groundwater and surface water.

2.4.3 Interception

Description

Incoming precipitation can fall directly on the ground surface as free throughfall or can be intercepted by the vegetation canopy. Due to interception the evaporation can be enhanced. For land use types other than pine and deciduous forest, interception is assumed a constant fraction of the precipitation volume during the summer season. The interception is limited by an upper bound. The interception of forest land-use types must be accounted for in METE_SIM.INP.

Specification

Table 2.7 Input files and related parameters for interception

Input file	Parameter	Unit	Description
<i>General</i>			
LUSE_SIM.INP	<i>nmteex</i>	-	number of land use type
	<i>frpric</i>	-	interception fraction

- The maximum interception (per day) is specified in FACT_SIM.INP.

2.4.4 Evapotranspiration

Description

Four main types of land use are distinguished: bare soil, vegetated area, inundated area/surface water and urban area. The characteristics for the evaporation/transpiration differ for each of these types and are therefore described separately.

If no vegetation factor is specified, bare soil evaporation is assumed. The evaporation for fallow soil is separately specified in METE_SIM.INP.

The evapotranspiration of vegetated soil is computed in three steps by:

- computing the reference crop evapotranspiration;
- applying a vegetation factor to obtain the potential evapotranspiration;
- reducing the potential evapotranspiration to the actual evapotranspiration based on the soil moisture content.

The evaporation of intercepted rainfall should be accounted for in the forest evaporation in the file METE_SIM.INP.

For inundated area and surface waters specified in the file AREA_NOD.INP precipitation and evaporation is calculated.

Urban areas are considered to be partly vegetated and partly paved. The paved parts of urban areas are considered to have a zero evapotranspiration. The model assumes that for 'Urban area connected to the sewerage system' (see LUSE_SIM.INP: *ipagte* = 5) the precipitation fallen on impermeable area, flows out of the model, unless a sewerage system is specified in URBN_NOD.INP/URBN_SUB.INP.

Specification

Table 2.8 Input files and related parameters for evaporation

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>faevsw</i>	-	evaporation factor for surface water
	<i>frimub</i>	-	impermeable fraction of urban area
	<i>frimse</i>	-	sewered fraction of impermeable area
METE_SIM.INP	<i>id</i>	-	day number
	<i>iy</i>	-	year number
	<i>evgr</i>	mm	potential reference evapotranspiration
	<i>evpf</i>	mm	potential evapotranspiration of pine forest
	<i>evdf</i>	mm	potential evapotranspiration of deciduous forest
	<i>faevba</i>	mm	evaporation factor of bare soil
LUSE_SIM.INP	<i>nmteex</i>	-	meteorological region number
	<i>nmteex</i>	-	number of land use type
	<i>tena</i>	-	name of land use type
	<i>ipfa</i>	-	pointer for evaporation factor
FACT_SIM.INP	<i>id</i>	-	day number
	<i>nmfaex</i>	-	crop factor number
	<i>faev</i>	-	crop factor
	<i>lain</i>	-	Leaf Area Index LAI
	<i>vxin</i>	mm	maximum interception of one day
	ROOT_SIM.INP	<i>spunex</i>	-
<i>nmteex</i>		-	land use type number
<i>dprz</i>		m	root zone thickness
<i>frev01</i>		-	relative root zone storage for h1
<i>frev02</i>		-	relative root zone storage for h2
<i>frev03</i>		-	relative root zone storage for h3l
<i>frev04</i>		-	relative root zone storage for h3h
<i>frev05</i>		-	relative root zone storage for h4
AREA_NOD.INP	<i>nnex</i>	-	node number
	<i>nmteex</i>	-	number of land use type
	<i>frarte</i>	-	areal fraction
GIFT_NOD.INP	<i>nnex</i>	-	node number
	<i>nmteex</i>	-	meteorological region number
URBN_NOD.INP	<i>nnex</i>	-	node number
	<i>nrse01</i>	-	sewerage or surface water system number
	<i>frimub</i>	-	impermeable fraction
	<i>frimse</i>	-	fraction impermeable surface that is sewered
	<i>nrse02</i>	-	number second sewerage system
	<i>fxse02</i>	m ³ d ⁻¹	maximum discharge to second sewerage system
FRSW_NOD.INP	<i>nnex</i>	-	node number
	<i>dpfrsw</i>	m	groundwater depth below soil surface
	<i>frsw</i>	-	areal fraction surface water

– Meteo-data

For the simulation period, the time series information of the meteorological conditions should be available in the form of a step-function (usually per day, but

preferably for shorter time intervals), which should be assembled in the file METE_SIM.INP:

- reference crop evapotranspiration;
 - evaporation for pine forest;
 - evaporation for deciduous forest;
 - evaporation of bare soil.
- Evapotranspiration
The crop factor numbers are referred to in LUSE_SIM.INP by the pointer to the evaporation factors (*ipfa*). See FACT_SIM.INP.
 - The model assumes that for ‘Urban area connected to the sewerage system’ (*ipagte* = 5) the precipitation that falls on impermeable area flows out of the model, unless a sewerage system is specified in URBN_NOD.INP.
 - Root water uptake function
Per combination of soil physical unit and land-use type the characteristic storages are given of the root water uptake function. See ROOT_SIM.INP
 - Characteristics for urban area
See PARA_SIM.INP for the impermeable fraction and sewered fraction
 - Evaporation of surface water
If no crop factor for the surface water is defined in FACT_SIM.INP, the surface water evaporation rate is assessed using the factor *faevsw* from PARA_SIM.INP
 - Land-use types
Several types of land use can be specified per nodal subdomain.
See AREA_NOD.INP and URBN_NOD.INP
 - Inundated fraction as a function of the ground water depth
The inundated fraction must be consistent with the groundwater depth: it may not decrease with shallower groundwater tables.
In order to prevent the combined storage coefficient of groundwater and surface waters to exceed 1.0, the areal fraction of the surface water system must be compensated for in the *frsm*-records. The programme does not do that automatically.
See FRSW_NOD.INP

2.5 Soil water

Organization

Table 2.9 Related input files

Input file	Description
<i>General information</i>	
PARA_SIM.INP	several general parameters
UNSA_SIM.INP	several soil physical characteristics
ROOT_SIM.INP	several parameters of root water uptake function; start/stop criteria for sprinkling
FILT_SIM.INP	infiltration capacity per soil physical unit
<i>Node-specific information</i>	
GIFT_NOD.INP	soil physical unit
AREA_NOD.INP	thickness of root zone
FRSW_NOD.INP	inundated areal fraction as a function of groundwater depth
ROFF_SIM.INP	storage, infiltration and percolation for simulating runoff
INRZ_SIM.INP	initial condition root zone
INRZ_BIN.INP	initial condition root zone (binary file)

2.5.1 Surface runoff

Description

Surface runoff occurs when the precipitation cannot infiltrate quickly enough into the soil, or even cannot infiltrate at all (urban areas or fully saturated soil profiles). In these extreme cases all of the rainfall remains on the soil surface, where it gathers in pools that can start to overflow if the rain persists for a long enough time. Only when it finds its way to the surface water system does it actually become runoff.

In the conceptualization of the runoff process a distinction is made between:

- runoff that is generated due to a limiting infiltration capacity of the soil surface itself (i.e. the soil physical properties and conditions);
- runoff that is generated due to the full saturation of the soil column.

Runoff parameters are defined in the input file ROFF_SIM.INP. It includes the depression storage, the minimum and maximum infiltration capacity and the maximum percolation flux from the root zone to the deep groundwater.

If the optional file ROFF_SIM.INP is missing, the runoff is simulated using a simpler concept. In this concept there is only one maximum infiltration capacity, which is defined per soil physical unit (see FILT_SIM.INP).

Specification

Table 2.10 Input files and related parameters for runoff

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>fpr</i>	-	fraction of time precipitation or sprinkling occurs
FILT_SIM.INP	<i>spunex</i>	-	soil physical unit number
	<i>fmmxif</i>	mm d ⁻¹	infiltration capacity
GIFT_NOD.INP	<i>nnex</i>	-	node number
	<i>spunex</i>	-	soil physical unit number
ROFF_SIM.INP	<i>nnex</i>	-	node number
	<i>sxsund</i>	m	maximum storage on surface
	<i>fxifnd</i>	m d ⁻¹	maximum infiltration capacity
	<i>fnifnd</i>	m d ⁻¹	minimum infiltration capacity
	<i>frifmxnd</i>	-	storage fraction for <i>fxifnd</i>
	<i>frifmnd</i>	-	storage fraction for <i>fnifnd</i>
	<i>fxpend</i>	m d ⁻¹	maximum percolation from root zone

- The infiltration capacity per soil physical unit number is defined in FILT_SIM.INP. These numbers are assigned to the nodes in GIFT_NOD.INP.
- Runoff parameters are defined in the input file ROFF_SIM.INP. It includes:
 - o the depression storage;
 - o the minimum infiltration capacity and the storage fraction in the root zone for this infiltration capacity;
 - o the maximum infiltration capacity and the storage fraction in the root zone for this infiltration capacity;
 - o the maximum percolation flux from the root zone to the deep groundwater.
- Runoff depends on the infiltration capacity and the depression storage. When the infiltration capacity is assigned per node (in ROFF_SIM.INP), this value overrules the specified infiltration capacity per soil physical unit (in FILT_SIM.INP).
- The parameter *fpr* in PARA_SIM.INP affects the precipitation and sprinkling intensity. When this intensity exceeds the infiltration capacity, surface storage or runoff occurs (this parameter is independent of the groundwater time step). For example, when *fpr* equals 0.1 the precipitation is concentrated in ten percent of each time step.

2.5.2 Unsaturated flow

Description

The unsaturated zone is modelled at the nodal subdomain level. For each nodal subdomain the dominant soil physical unit should be determined (see GIFT_NOD.INP). This soil physical unit is a standard soil type with specific characteristics (see UNSA_SIM.INP). In fact, the data used in SIMGRO can be considered as a meta-model. The data for these standard types are assembled using the model CAPSEV (Wesseling, 1991). A ready-to-use database is available.

Root zone depths are assumed to not vary in time. The depth can be specified for each combination of land use and soil physical unit (ROOT_SIM.INP and AREA_NOD.INP). Various types of land use and root zone depths may exist within a single subdomain. Their exact locations are not included in the SIMGRO database: only the relative surface

areas that they occupy are known. However, in the current modelling practice the nodal subdomains are at field scale, so usually only one type of land use is specified.

In order to prevent the combined storage coefficient of groundwater and surface waters exceeding 1.0, the areal fraction of the surface water system must be compensated for in the *frsw*-records. The programme does not do that automatically.

Specification

Table 2.11 Input files and related parameters for unsaturated flow

Input file	Parameter	Unit	Description
UNSA_SIM.INP	<i>spunex</i>	-	soil physical unit number
	<i>dprzun</i>	cm	thickness of root zone
	<i>dpgwun</i>	m	depth of groundwater below soil surface
	<i>srrzdc</i>	mm	storage of root zone for drying conditions
	<i>srrzwc</i>	mm	storage of root zone for wetting conditions
	<i>fmca</i>	mm d ⁻¹	capillary rise flux
	<i>scca</i>	-	storage coefficient
FILT_SIM.INP	<i>spunex</i>	-	soil physical unit number
	<i>fmmxif</i>	mm d ⁻¹	infiltration capacity
ROOT_SIM.INP	<i>spunex</i>	-	soil physical unit number
	<i>nmteex</i>	-	land use type number
	<i>dprz</i>	m	root zone thickness
	<i>frev01</i>	-	relative root zone storage for h1
	<i>frev02</i>	-	relative root zone storage for h2
	<i>frev03</i>	-	relative root zone storage for h3l
GIFT_NOD.INP	<i>nnex</i>	-	node number
	<i>spunex</i>	-	soil physical unit number
AREA_NOD.INP	<i>nnex</i>	-	node number
	<i>dprz</i>	m	thickness of root zone
FRSW_NOD.INP	<i>nnex</i>	-	node number
	<i>dpfrsw</i>	m	groundwater depth below soil surface
	<i>frsw</i>	-	areal fraction surface water
ROFF_SIM.INP	<i>nnex</i>	-	node number
	<i>fxpend</i>	m d ⁻¹	maximum percolation from root zone
INRZ_SIM.INP	<i>nnex</i>	-	node number
	<i>nmteex</i>	-	land use type number
	<i>vmrzdcte</i>	m	initial moisture content of root zone
INRZ_BIN.INP	<i>nnex</i>	-	node number
	<i>nmteex</i>	-	land use type number
	<i>vmrzdcte</i>	m	initial moisture content of root zone
	<i>cuevac</i>	m	sum of actual soil evaporation
	<i>cuevpt</i>	m	sum of potential soil evaporation
	<i>vmsute</i>	m	volume per unit area stored on surface

- Characteristics per soil physical number
This lookup table relates the capillary flux and several storage coefficients to the soil physical unit number, root zone depth and groundwater level. See UNSA_SIM.INP

- The infiltration capacity is specified in a separate file, i.e. `FILT_SIM.INP`
- Root zone characteristics (see `ROOT_SIM.INP`)
Per combination of soil physical unit and land-use type there is a specification of :
 - thickness of root zone;
 - the characteristic storages of the root water uptake function.
- Initial root zone conditions
The initial conditions can be defined in `INRZ_SIM.INP` and `INRZ_BIN.INP`. When both files `INRZ_SIM.INP` and `INRZ_BIN.INP` are available, the file `INRZ_BIN.INP` is used as input file. The binary input file has some extra arguments.
The file `INRZ_BIN.INP` is a binary file. At the end of SIMGRO-run a file `inrz_bin.out` is generated, which can be used as an input file for the next run.
- Soil physical unit
The characteristics of the soil physical units are defined in the file `UNSA_SIM.INP`. These standards are assigned to the nodes in `GIFT_NOD.INP`.
- Thickness of the root zone
The thickness of the root zone can optionally be defined per node in `AREA_NOD.INP`. Definition in this file has priority over the (general) specification in `ROOT_SIM.INP`.
- Percolation from root zone
The maximum percolation rate is defined in `ROFF_SIM.INP`.

2.6 Groundwater

Organization

Table 2.12 Related input files for groundwater

Input file	Description
<i>General information</i>	
<code>PARA_SIM.INP</code>	several general parameters
<i>Node specific information</i>	
<code>COND_NOD.INP</code>	geohydrological parameters
<code>FAUL_SIM.INP</code>	faults
<code>INHH_SIM.INP</code>	initial heads
<code>INHH_BIN.INP</code>	initial heads (binary file)
<code>TIBD_SIM.INP</code>	time dependent boundary conditions for boundary nodes
<code>TIAB_SIM.INP</code>	time dependent conditions for internal nodes

2.6.1 Regional flow

Description

In paragraph 2.5 the unsaturated flow is described. This paragraph concerns the deep groundwater. Of course there is an interaction between these two compartments that cannot be distinguished sharply from each other. In this paragraph the geohydrological schematization and parameterization is paid attention to.

We assume that the subsoil can be schematized to alternating layers of:

- aquifers, with essentially horizontal flow;
- aquitards, with essentially vertical flow.

In the schematization the top layer can either be an aquitard or an aquifer. The bottom layer of the (modelled) system is always an aquifer. It is possible to define faults which hamper the flow in aquifers, see FAUL_SIM.INP. The fault is simulated by assigning an effective fraction of the transmissivity to a couple of nodes.

Several types of boundary conditions can be used. Boundary conditions can be supplied in the form of heads or net fluxes within all nodes of the domain. The flow to wells can either involve head or flux boundary conditions. In the latter case we assume that it is always possible to extract the desired amount.

Specification

Table 2.13 Input files and related variables for groundwater

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>dtgw</i>	d	time step for groundwater module
	<i>dhm<x>nd</i>	m	maximum tolerance in head per node for stopping iteration
	<i>wpit</i>	-	weighting parameter of previous time step
	<i>nxit</i>	-	maximum number of iterations
	<i>fam<x>cv</i>	-	threshold convergence factor
	<i>far<x>cv</i>	-	overrelaxation factor for convergence
	<i>far<x>dv</i>	-	overrelaxation factor for divergence
	<i>far<x>in</i>	-	initial overrelaxation factor
COND_NOD.INP	nnex	-	node number
	nl	-	layer number
	<i>thly</i>	m	layer thickness
	<i>posf</i>	m ⁻¹	specific storativity per meter layer thickness
	<i>cd01</i>	m d ⁻¹	hydraulic conductivity in the <i>x'</i> -direction of the principal conductivity axes
	<i>cd02</i>	m d ⁻¹	hydr. conductivity in the <i>y'</i> -direction (aquifers) hydr. conductivity in the <i>z'</i> -direction (aquitards)
	<i>anxd</i>	deg	angle between <i>x</i> -axis and principal direction of conductivity in the <i>x'</i> -direction, taken clockwise from the <i>x'</i> -axis to the <i>x</i> -axis (aquifers)
	FAUL_SIM.INP	nd01	-
nd02		-	node number 2
nl		-	layer number
<i>frcd</i>		-	effective fraction transmissivity fault
INHH_SIM.INP	nnex	-	node number
	nl	-	layer number
	<i>dpin</i>	m	initial groundwater depth below soil surface
INHH_BIN.INP	<i>hbin</i>	m+msl	initial hydraulic head above mean sea level
	nnex	-	node number
	nl	-	number of layer
	<i>hbin</i>	m+msl	initial hydraulic head above mean sea level
	<i>cupvdt</i>	m ³	summation of fluxes over previous time step
TIBD_SIM.INP	<i>dbdt</i>	m	change hydraulic head over previous time step
	id	-	day number
	iy	-	year number
	nnex	-	node number
	nl	-	layer number
	<i>iolv</i>	-	option code for level reference
	<i>bhgwmm</i>	see <i>iolv</i>	new groundwater level
TIAB_SIM.INP	<i>flgwmm</i>	m ³ d ⁻¹	boundary flux
	id	-	day number
	iy	-	year number
	nnex	-	node number
	nl	-	layer number
	<i>iolv</i>	-	option code for level reference
	<i>bhgwmm</i>	see <i>iolv</i>	new groundwater level

<i>flgnw</i>	$\text{m}^3 \text{d}^{-1}$	new abstraction flux
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- Time step for the groundwater module
In PARA_SIM.INP the time step for the groundwater module, *dtgw*, is specified. The time steps for the groundwater and surface water calculations usually have a value of 0.25 and 0.05 days. Of course, this depends on the goal of a study and the type of system modelled. In highly dynamic systems, it is advisable to reduce the time step for surface water to for instance 0.01 day and for groundwater to 0.10 day. Runoff is modelled at the time step of the meteorological data.
- Parameters for numerical solution scheme.
The control parameters of the numerical scheme are specified in PARA_SIM.INP. Usually standard values are used. The convergence of the iteration procedure depends on overrelaxation. It is possible to influence the number of iterations through changing the parameters. But speeding up the computational procedure may introduce water balance errors. In Table 2.14 the standard values are given.

Table 2.14 Standard values control parameters of solution scheme

name	General value	unit	Description
<i>dbmxnd</i>	0.003	m	maximum tolerance in head per node for iteration
<i>npit</i>	1.00	-	weighting parameter of previous time step
<i>nxit</i>	500	-	maximum number of iterations
<i>famxcv</i>	1.00	-	threshold convergence factor
<i>farxcv</i>	1.10	-	overrelaxation factor for convergence
<i>farxdv</i>	0.80	-	overrelaxation factor for divergence
<i>farxin</i>	1.38	-	initial overrelaxation factor
<i>farxmn</i>	0.20	-	minimum overrelaxation factor

- Ill-defined initial conditions may cause the model to be unstable during first time steps. In order to reduce the risk of instability, the user is recommended to specify relatively tolerant (i.e. high) values of *dbmxnd* and *nxit* for the first model run.
- Initial groundwater levels and flows
The initial conditions can be defined in INHH_SIM.INP and INHH_BIN.INP. When both files INHH_SIM.INP and INHH_BIN.INP are available, the file INHH_BIN.INP is used as input file. The binary file has some extra arguments.
The file INHH_BIN.INP is a binary file. At the end of SIMGRO-run a file *inbh_bin.out* is generated, which can be used as an input file for the next run (after renaming).
- The layer thickness, conductivity in x' -direction, conductivity in z -direction, specific storativity and the angle of the x -axis with respect to the principal conductivity direction of the x' -axis (only relevant for anisotropy in the xy -plane) are defined in COND_NOD.INP;
- Faults are (optionally) defined in FAUL_SIM.INP.
- Boundary conditions
Time dependent flux and level boundaries can be chosen.
See file TIBD_SIM.INP
- Groundwater abstractions or groundwater level control
Time dependent flux and level boundaries can be chosen.
See file TIAB_SIM.INP

2.7 Surface water

Organization

Table 2.15 Related input files for surface water

Input file	Description
<i>General information</i>	
PARA_SIM.INP	several general parameters
<i>Node or surface water specific information</i>	
DRNG_NOD.INP	dimensions of watercourses and drains drainage resistances connection to watercourse
GOTO_SIM.INP	surface water weir levels weir control options backflow option
URBN_SUB.INP	urban sewerage system
MANA_SIM.INP	option for target or weir level control target levels target level control options
DISH_SIM.INP	Q(h)-relationships
DISU_SIM.INP	Q(h)-relationships during the summer period
TACL_SIM.INP	control specifications
RESV_SIM.INP	surface water supply definition
INSW_SIM.INP	initial surface water levels
INSW_BIN.INP	initial surface water levels (binary)
TISW_SIM.INP	time dependent boundary conditions

2.7.1 Watercourses of the regional system

Description

For practical purposes the following classification into classes of watercourses is used:

0. watercourses that do not have any interaction with the groundwater system, but only serve as a conduit for surface water;
1. primary watercourses, involving canals that traverse the region, but the level is determined at a supra-regional scale;
2. secondary watercourses, forming the main arteries of the regional system;
3. tertiary watercourses, usually the ditches;
4. field drains;
5. furrows/gulleys.

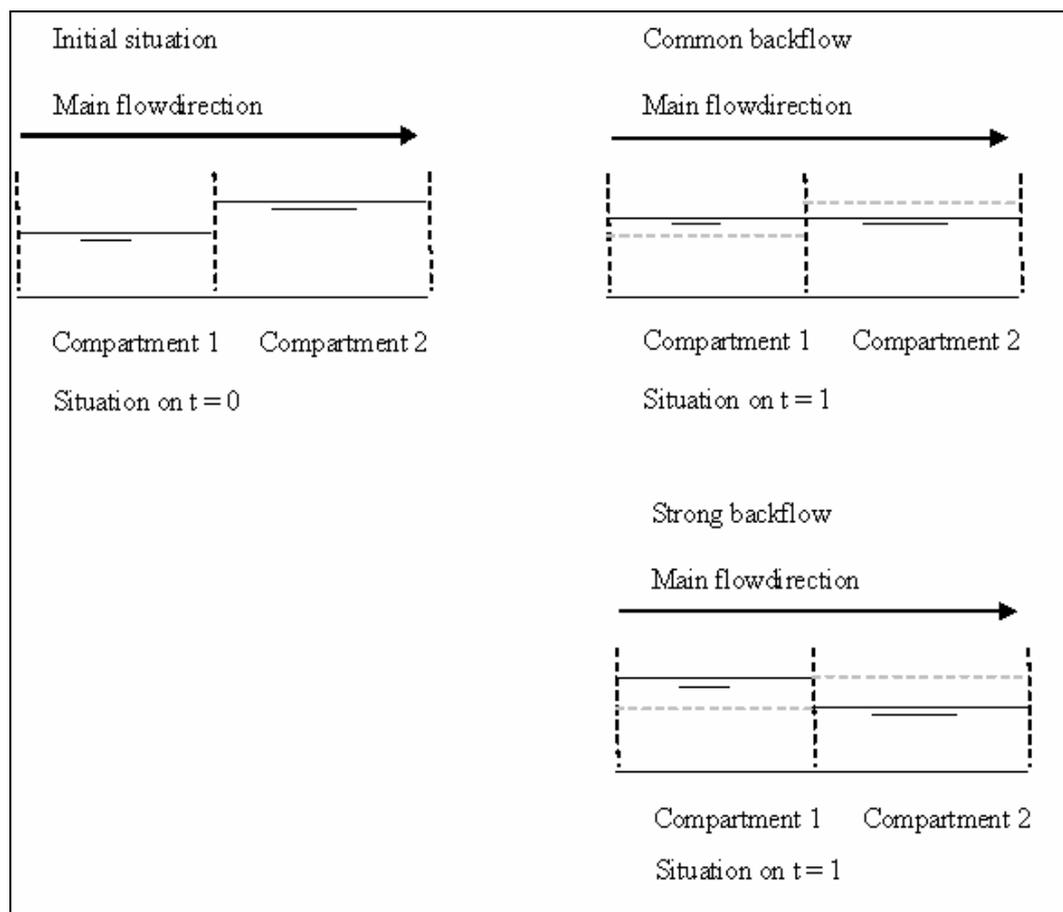
The first system usually represents the boundary conditions for the second system. The second system is usually modelled in detail: in each trajectory flow and water level are simulated. For the smaller watercourses (system 3/4/5), a connection to a secondary watercourse is defined, and the water level in that secondary watercourse is used for the drainage calculations (par. 2.7.4). The main watercourses are described by:

1. Definition of the connections between the trajectories (GOTO_SIM.INP);
2. The discharge as a function of the water level is defined for each of the trajectories (DISH_SIM.INP and DISU_SIM.INP);
3. The dimensions of the subtrajectories through nodal subdomains (DRNG_NOD.INP).

When doing the schematization of the watercourses into trajectories, it is recommended to make them neither too long nor too short. Too long trajectories may cause too much levelling out of surface water levels and too short trajectories may cause numerical problems. As a guideline a minimum length of 25 m is recommended and a maximum of 500 m, but this also depends on the discharges per trajectory and the cross-sectional dimensions. High discharges require greater lengths or smaller time steps.

The general flow direction in the SIMGRO concept for the surface water is downstream. For the calculation of flow in the reverse direction (e.g. during summer when the conduits are used for water supply) a number of so-called ‘backflow’ options are available. The default backflow option is set in PARA_SIM.INP. The backflow option can be specified per watercourse in the file GOTO_SIM.INP. The latter will overwrite the default value.

In Figure 2. the ‘common’ backflow option ($iofwbk=1$) and the strong backflow option ($iofwbk=2$) are visualized. In case of mega backflow ($iofwbk=3$) also the water level in the second downstream compartment will be checked. It should be realized that in the case of backflow option 2 and 3 weirs are backward permeable, so both backflow options should not be used for weirs and pumps!



Figuur 2.2 Backflow and strong backflow

For most problems the use of the strong backflow option $iofwbk = 2$ is advised for trajectories without structures. One should use $iofwbk = -1$ for weirs, $iofwbk = 0$ for pumps. It is recommended to use $iofwbk = 3$ for bifurcations.

The negative backflow options can be used when the calculations in a certain compartment are not stable. The minus-sign causes the algorithm to ‘wait one time step’ before rising from below the threshold of the $Q(b)$ -relationship (in the case of a weir that is the crest) to above it. This option was devised for suppressing the premature spilling of water over a weir crest just downstream of a bifurcation.

There are several other ways of stabilizing the surface water model. The first is to reduce the time step. A second option is to change the parameter $dhmxsw$. This parameter defines the maximum change in surface water level over $dtsw$. Using the recommended values of 0.03 m for $dhmxsw$ and 0.01 d for $dtsw$, the maximum surface water change equals 3 m per day.

Specification

Table 2.16 Input files and related variables for regional watercourses

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>idbgnlcl</i>	-	day number to start water level control
	<i>idednlcl</i>	-	day number to stop water level control
	<i>dtsw</i>	d	time step for surface water module
	<i>dbmxxsw</i>	-	maximum change in surface water level over dtsw
	<i>iofwbk</i>	-	calculate back flow (default setting)
DRNG_NOD.INP	<i>nnex</i>	-	node number
	<i>nmsy</i>	-	system index
	<i>dpsw</i>	m	drain depth
	<i>wisw</i>	m	drain width at bottom
	<i>adsw</i>	-	cotangent of slope
	<i>ddsw</i>	m	drain spacing
	<i>lesw</i>	m	length of drainage system
	<i>nrex</i>	-	subcatchment drainage record connects to
GOTO_SIM.INP	<i>nrex</i>	-	number water course
	<i>nrgo</i>	-	watercourse water is conducted to
	<i>hwrsml</i>	m+msl	summer weir level (<i>ioma</i> = 2 or 4)
	<i>hwrrwt</i>	m+msl	winter weir level (<i>ioma</i> = 1 or 2)
	<i>hwrlw</i>	m+msl	lowest possible weir level
	<i>iofwbk</i>	-	option for backflow
URBN_SUB.INP	<i>nrex</i>	-	subcatchment number of sewerage reservoir
	<i>nr01</i>	-	goto waste treatment reservoir (<i>rwzi</i>)
	<i>nr02</i>	-	goto spillage reservoir
	<i>srse</i>	m ³	storage capacity of sewerage reservoir
	<i>flpocp</i>	m ³ d ⁻¹	pump over capacity
	<i>fldw</i>	m ³ d ⁻¹	dry weather discharge
MANA_SIM.INP	<i>nrex</i>	-	subcatchment number
	<i>ioma</i>	-	option for weir/target in summer/winter
	<i>lwasm</i>	m+msl	summer target level (<i>ioma</i> = 1 or 3)
	<i>lwant</i>	m+msl	winter target level (<i>ioma</i> = 3 or 4)
	<i>lwfsb</i>	m+msl	reference level of subcatchment
DISH_SIM.INP or DISU_SIM.INP	<i>nrex</i>	-	subcatchment number
	<i>dhwr</i>	m	energy head above weir crest
	<i>fmnr</i>	l/s/ha	discharge capacity of weir
	<i>fswr</i>	m ³ /s	discharge capacity of weir
	<i>nrgo</i>	-	“goto” subcatchment
TISW_SIM.INP	<i>id</i>	-	day number
	<i>iy</i>	-	year number
	<i>nrex</i>	-	subcatchment number
	<i>iolv</i>	-	option code for level reference
	<i>bhswnw</i>	see <i>iolv</i>	new surface water level
	<i>bhwrrnw</i>	see <i>iolv</i>	new weir/target level
	<i>flswnw</i>	m ³ d ⁻¹	new surface water inflow rate
INSW_SIM.INP	<i>nrex</i>	-	subcatchment number
	<i>dnsw</i>	m	initial surface water level below reference level
	<i>bhsw</i>	m	initial surface water level above mean sea level
INSW_BIN.INP	<i>nrex</i>	-	subcatchment number
	<i>dnsw</i>	m	initial surface water level below reference level
	<i>flin</i>	m ³	surface water inflow over surface water time step
	<i>flow</i>	m ³	surface water outflow over surface water time step
	<i>vmpa</i>	m ³	parked volume

- Period for water level control
This period is specified in PARA_SIM.INP. The period between *idbgwlcl* and *idedwlcl* is the summer period, which has the following characteristics:
 - the summer weir or target levels are valid;
 - the dynamic water level control for the summer is active (when specified), see GOTO_SIM.INP and MANA_SIM.INP;
- The winter period has the following characteristics:
 - the winter weir or target levels are valid;
 - the dynamic water level control for the winter is active (when specified), see GOTO_SIM.INP and MANA_SIM.INP
- Time step for surface water module.
In PARA_SIM.INP the time step for the surface water module, *dtsw*, is specified. The time steps for groundwater and surface water calculations usually have a value of respectively 0.25 and 0.05 days. Of course, this depends on the goal of the study and the system modelled. In highly dynamic systems, it is advisable to reduce the time step for surface water to for instance 0.01 day and for groundwater to 0.10 days;
- Parameters for numerical approximation
The parameter *dbmxsw* has to be specified in PARA_SIM.INP. Usually standard values are used. In Table 2.17 the general value for *dbmxsw* is given.

Table 2.17 General values for numerical approximation

Name	General value	Unit	Description
<i>dbmxsw</i>	0.030	m	Maximum change in surface water level per <i>dtsw</i>

- Surface water structure
The surface water structure is defined in GOTO_SIM.INP. There is a maximum to the number of connections (5 branches are allowed).
In the surface water structure, no closed loops are allowed.
- Target levels and weir levels (summer and winter)
Both target and weir levels can be specified. MANA_SIM.INP specifies the target levels and GOTO_SIM.INP the weir levels. The parameter *ioma* in MANA_SIM.INP determines the use of target or weir level in the model.
Weir and target levels can be specified as time dependent levels, see TISW_SIM.INP.
- Reference level
The soil surface reference level, *hrfsb*, is used for transferring water levels ‘with respect to soil surface’.
- Q(h)-relationships
See DISH_SIM.INP and DISU_SIM.INP.
It is not allowed to decrease the discharge capacity of a weir with increasing energy head above the weir crest.
DISU_SIM.INP specifies the Q(h)-relationship for summer situations.
- Calculation of upstream flow
The default backflow option is set in PARA_SIM.INP. The backflow option can be specified per watercourse in the file GOTO_SIM.INP. The latter will overrule the default value. For most problems the use of the strong backflow option *iofwbk* = 2 is advised (see GOTO_SIM.INP). One should use *iofwbk* = -1 for weirs, *iofwbk* = 0 for pumps. It is advised to use *iofwbk* = 3 for bifurcations.

- Urban sewerage system
See URBN_SUB.INP.
- Initial surface water conditions
The initial conditions can be defined in INSW_SIM.INP and INSW_BIN.INP. When both files are available, the file INSW_BIN.INP is used as input file. This binary file has some extra arguments.
At the end of a SIMGRO-run a file *insw_bin.out* is generated, which can be used as an input file for the next run (after renaming).
- Boundary conditions
Time dependent weir levels and inflow fluxes can be chosen as a boundary condition (TISW_SIM.INP). At the moment the definition of fixed surface water levels is not functional¹.
- Dimensions of the watercourses
See DRNG_NOD.INP.

2.7.2 Weirs and pumps

Description

When weirs are implemented in the model, not only the weir levels or target level should be assigned (GOTO_SIM.INP and MANA_SIM.INP), but also the relationship between water level and discharge should be specified (DISH_SIM.INP and DISU_SIM.INP).

Water level control with a weir can either be done *indirectly* by manipulating the weir crest or *directly* by manipulating the target water level.

When in the model definition the target level is activated, the model itself will calculate the optimal weir crest. The weir crest will in that case be adjusted in such a way that the water level upstream equals the target level (if there is enough water for that). The weir crest cannot, however, become lower than the lowest possible weir level (as defined in GOTO_SIM.INP)!

The SIMGRO-code also has the possibility of letting the weir/target levels be determined by groundwater level (or surface water level or soil water content). In that case a water level control scheme must be specified in the form of a table, with per record:

- a groundwater level in the monitoring node *i*;
- a lowering of the target/weir level in trajectory *n*.

The records must form a consistent set, with decreasing groundwater level (starting from 0 at the soil surface) and decreasing lowering of the target/weir level. The principle being ‘the higher the groundwater level, the lower the weir/target level should be’, in order to counteract the negative effects of too wet conditions. The model interpolates to get the corresponding lowering of the weir or target level. If the current groundwater level is deeper than the deepest groundwater level in the table, the lowering for the deepest groundwater level is taken.

¹ Depending on the goal, there is a workaround using fixed inflow fluxes and special Qh-relations.

Specification

Table 2.18 Input files and related variables for weirs and pumps

Input file	Parameter	Unit	Description	
PARA_SIM.INP	<i>idbgwlc</i>	-	day number to start water level control	
	<i>idedwlc</i>	-	day number to stop water level control	
GOTO_SIM.INP	<i>nrex</i>	-	number water course	
	<i>nrgo</i>	-	watercourse water is conducted to	
	<i>lwvms</i>	m+msl	summer weir level (<i>ioma</i> = 2 or 4)	
	<i>lwvwt</i>	m+msl	winter weir level (<i>ioma</i> = 1 or 2)	
	<i>lwvhw</i>	m+msl	lowest possible weir level	
	<i>ndwr</i>	-	node for weir level control on ground water level (<i>ioma</i> = 1, 2 or 4)	
	<i>iowvmsnd</i>	-	index weir level control on summer ground water level (<i>ioma</i> = 2 or 4)	
	<i>iowvwtnd</i>	-	index weir level control on winter ground water level (<i>ioma</i> = 1 or 2)	
	<i>nrwr</i>	-	water course for weir level control on surface water level (<i>ioma</i> = 1, 2 or 4)	
	<i>iowvmsb</i>	-	index weir level control on summer surface water level (<i>ioma</i> = 2 or 4)	
	<i>iowvwtb</i>	-	index weir level control on winter surface water level (<i>ioma</i> = 1 or 2)	
	<i>ndfrwr</i>	-	node for weir level control using root zone saturation (<i>ioma</i> = 1, 2 or 4)	
	<i>iowvmsfr</i>	-	index weir level control on summer saturation (<i>ioma</i> = 2 or 4)	
	<i>iowvwtfr</i>	-	index weir level control on winter saturation (<i>ioma</i> = 1 or 2)	
	MANA_SIM.INP	<i>nrex</i>	-	subcatchment number
		<i>ioma</i>	-	option for weir/target in summer/winter
		<i>lvtasm</i>	m+msl	summer target level (<i>ioma</i> = 1 or 3)
<i>lvtawt</i>		m+msl	winter target level (<i>ioma</i> = 3 or 4)	
<i>lvrfsb</i>		m+msl	reference level of subcatchment	
<i>ndta</i>		-	node for target level control on ground water level (<i>ioma</i> = 1, 3 or 4)	
<i>iotasmnd</i>		-	index target level control on summer ground water level (<i>ioma</i> = 1 or 3)	
<i>iotawtnd</i>		-	index target level control on winter ground water level (<i>ioma</i> = 3 or 4)	
<i>nrta</i>		-	subcatchment for target level control on surface water level (<i>ioma</i> = 1, 3 or 4)	
<i>iotasmsb</i>		-	index target level control on summer surface water level (<i>ioma</i> = 1 or 3)	
<i>iotawtsb</i>		-	index target level control on winter surface water level (<i>ioma</i> = 3 or 4)	
<i>ndfrta</i>		-	node for target level control using the root zone saturation (<i>ioma</i> = 1, 3 or 4)	
<i>iotasmfr</i>		-	index target level control on summer saturation (<i>ioma</i> = 1 or 3)	

	<i>iota</i>	-	index target level control on winter saturation (<i>ioma</i> = 3 or 4)
TACL_SIM.INP	<i>iota</i>	-	index for level control
	<i>dpgwlv</i>	m	groundwater depth below soil surface or surface water level below reference level or saturation level of the root zone
	<i>lwt</i>	m	lowering target/weir level
DISH_SIM.INP or	<i>nrex</i>	-	subcatchment number
	<i>dhwr</i>	m	energy head above weir crest
DISU_SIM.INP	<i>fmwr</i>	l/s/ha	discharge capacity of weir
	<i>fswr</i>	m ³ /s	discharge capacity of weir
	<i>nrgo</i>	-	“goto” subcatchment
TISW_SIM.INP	<i>id</i>	-	day number
	<i>iy</i>	-	year number
	<i>nrex</i>	-	subcatchment number
	<i>iolv</i>	-	option code for level reference
	<i>hwrnw</i>	see <i>iolv</i>	new weir/target level

- Period for water level control
This period is specified in PARA_SIM.INP. The period between *idbgwlvcl* and *idedwlvcl* is the summer period, which has the following characteristics:
 - o The summer weir or target levels are valid;
 - o The dynamic water level control for the summer is active (when specified), see GOTO_SIM.INP and MANA_SIM.INP;
- The winter period has the following characteristics:
 - o The winter weir or target levels are valid;
 - o The dynamic water level control for the winter is active (when specified), see GOTO_SIM.INP and MANA_SIM.INP
- Target levels and weir levels (summer and winter)
Both target and weir levels can be specified. MANA_SIM.INP specifies the target levels and GOTO_SIM.INP the weir levels. The parameter *ioma* in MANA_SIM.INP determines the use of target or weir level in the model.
Weir and target levels can be specified as time dependent levels, see TISW_SIM.INP.
- Q(h)-relationships
See DISH_SIM.INP and DISU_SIM.INP.
It is not allowed to decrease the discharge capacity of a weir with increasing energy head above the weir crest.
DISU_SIM.INP specifies the Q(h)-relationship for summer situations.
- Dynamic target or weir level control on surface water levels, groundwater levels or root zone saturation.
See MANA_SIM.INP and GOTO_SIM.INP in combination with TACL_SIM.INP
The indexes *iowrsmnd*, *iowrwtnd*, *iowrsmnb*, *iowrwtb*, *iowrsmfr*, *iowrwtfr* refer to the indexes in the file TACL_SIM.INP.
When because of the implementation of more control levels several target levels are calculated, the lowest target level will be used.

2.7.3 Surface water supply

Description

During summer, many regions receive surface water supply from outside the region. The reason for supplying the water can be diverse. In the higher parts of the Netherlands, the reason is usually to supply water for sprinkling and sub-irrigation. In the lower parts (which are below sea level), the supply is mainly used for maintaining water quality at an acceptable level. The origin of the water is either a storage reservoir, an other watercourse or one of the large rivers that flow all year round.

In SIMGRO, there are two ways of implementing water supply:

1. 'out of nowhere', from outside the model region;
2. through special links that involve the transfer from one watercourse to the next.

Per watercourse trajectory only one type of supply can be used.

Supply from outside the model region

The supply is specified in the file MANA_SIM.INP using the parameters *dbtasu* and *fxsuswsb*. When the waterlevel in a trajectory drops below the specified level, supply is triggered. Supply to a watercourse is triggered by *dbtasu*. The maximum water supply is specified by *fxsuswsb*.

Supply from one watercourse to another

It is possible to use one trajectory as a supply source for multiple inflow trajectories. But the model can not handle supply to one target trajectory from different sources. Supply from another watercourse is defined in MANA_SIM.INP in combination with RESV_SIM.INP.

The supply will be regulated by (see also Figure 2.3):

1. the water level in the target watercourse. *Dbtasu* triggers the supply to a watercourse (see MANA_SIM.INP). If the water level in the target watercourse *m* is lower than the supply water level the supply will be increased;
2. the maximum water supply to a watercourse from another watercourse is defined in RESV_SIM.INP;
3. the water level in the extraction watercourse. If the level in the extraction trajectory *n* has become lower than the minimum level, the supply will be decreased (see RESV_SIM.INP);
4. the flow in the flow control trajectory. If the flow in the trajectory *k* is greater than the desired flow, the supply will be decreased (see RESV_SIM.INP).

By specifying subcatchment number 0 for the extraction watercourse in RESV_SIM.INP water supply from outside the model area can be simulated, while using the control facilities of RESV_SIM.INP!

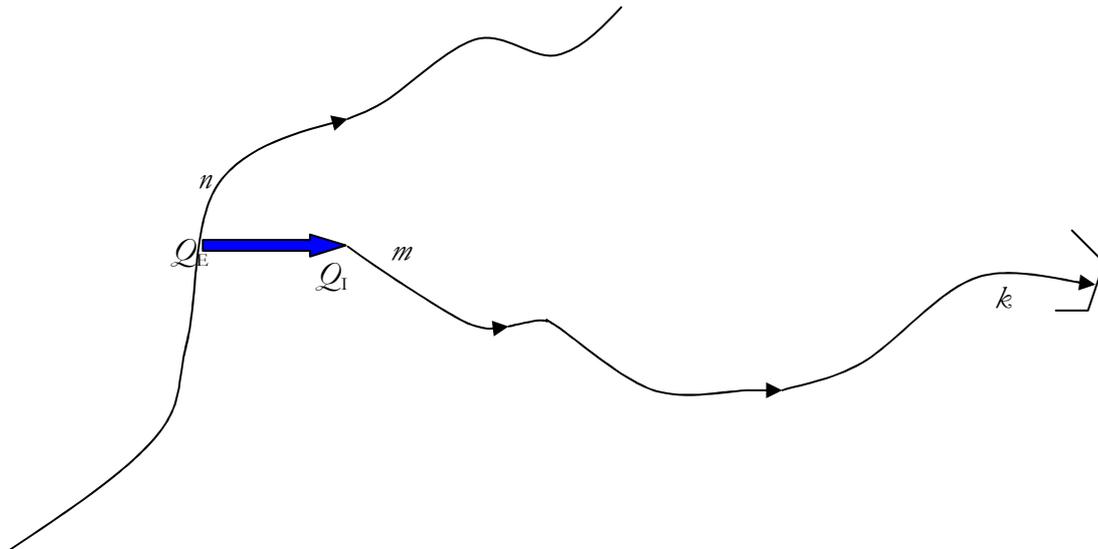


Figure 2.3 Surface water supply link. Water is transferred from trajectory n to m . Supply control is based on the water levels in n and m , and the flow in the trajectory at k .

Specification

Table 2.19 Input files and related variables for surface water supply

Input file	Parameter	Unit	Description
MANA_SIM.INP	nrex	-	subcatchment number
	<i>dbtasu</i>	m	depth below target level for supply
RESV_SIM.INP	<i>fxsusmsb</i>	$\text{m}^3 \text{d}^{-1}$	maximum supply surface water
	nrrviw	-	subcatchment number of reservoir for which water is supplied (in)
	<i>nrrvow</i>	-	subcatchment number of supply reservoir (out)
	<i>dbtarv</i>	m	maximum depth below weir level in supply reservoir
	<i>flmrv</i>	$\text{m}^3 \text{d}^{-1}$	maximum flow at subcatchment nrsbow for supply
	<i>flmxrv</i>	$\text{m}^3 \text{d}^{-1}$	maximum supply
	<i>nrsbow</i>	-	subcatchment for control

2.7.4 Drainage and subcatchments

Description

In NDSB_SIM.INP all nodal subdomains are assigned to the watercourses that collect the surface runoff of the respective subcatchments. The assignment of the other drainage fluxes is done in the file DRNG_SIM.INP. Note that *not* all of the drainage fluxes from a certain node have to be assigned to the same watercourse (and its accompanying subcatchment) that is specified in NDSB_SIM.INP: in DRNG_SIM.INP the assignment of a nodal drainage record to a watercourse is specified *explicitly*, and can thus deviate from that in NDSB_SIM.INP. The assignment to a watercourse not only determines where the water goes to, but also the water level that is used in the drainage flux calculation itself. Watercourse number 0 is used for boundary nodes (see NDSB_SIM.INP).

With the parameter *iodrly* (PARA_SIM.INP) several methods can be selected for the determination of the drainage and infiltration resistances:

- option -1: the resistances are recalculated but only for layer 1;
- option 0: the resistances from DRNG_NOD.INP are used;
- option 1: the drainage resistances are recalculated for the intersecting layers;
- option 2: it is assumed that only entry and exit resistances are of importance (for the layers intersected by the watercourses).

It is recommended to use drainage option *iodrly* = 1. The programme itself will calculate the drainage resistances based on the geohydrological situation and the dimensions of the watercourse. The model also calculates which geohydrological layers are intersected and will be drained by the watercourse.

Specification

Table 2.20 Input files and related variables for regional watercourses

Input file	Parameter	Unit	Description
PARA_SIM.INP	<i>iodrly</i>	-	calculate drainage for multiple layers
DRNG_NOD.INP	<i>nnex</i>	-	node number
	<i>nmsy</i>	-	system index
	<i>dpsw</i>	m	drain depth
	<i>wisw</i>	m	drain width at bottom
	<i>adsw</i>	-	cotangent of slope
	<i>ddsw</i>	m	drain spacing
	<i>lesw</i>	m	length of drainage system
	<i>redr</i>	d	drainage resistance
	<i>reen</i>	d	entry resistance
	<i>rein</i>	d	infiltration resistance
	<i>reex</i>	d	exit resistance
		<i>nrex</i>	-
NDSB_SIM.INP	<i>nnex</i>	-	node number
	<i>nrex</i>	-	subcatchment this drainage record connects to

- The method for drainage and infiltration calculations is selected by parameter *iodrly* (PARA_SIM.INP).
- Dimensions of the watercourses and drainage systems
See DRNG_NOD.INP;
- Drainage characteristics
Several resistances, see DRNG_NOD.INP;
- Connection to the surface water system, see DRNG_NOD.INP.

2.8 Time dependency

Organization

Table 2.21 Related input files for groundwater

Input file	Description
<i>General information</i>	
PARA_SIM.INP	several general parameters
METE_SIM.INP	meteo-data
<i>Node or surface water specific information</i>	
TIBD_SIM.INP	time dependent boundary conditions for boundary nodes
TIAB_SIM.INP	time dependent boundary conditions for internal nodes
TISW_SIM.INP	time dependent boundary conditions for surface water
TIOP_SIM.INP	specification periods for output

Description

The most important driving force for a hydrologic model is the meteorologic time series, which is specified in the file METE_SIM.INP.

The boundary conditions for the groundwater and surface water system have to be specified in the files:

- TIBD_SIM.INP for the boundary nodes of the groundwater system;
- TIAB_SIM.INP for the internal nodes of the groundwater system;
- TISW_SIM.INP for the surface water system.

The most important feature of the file TIOP_SIM.INP is the specification of the periods for periodical water balance output.

These four *ti**_sim.inp* files are **not** the input files for the executable *simgro4.exe*. Before running *simgro4.exe* these files have to be converted to one file TIME_SIM.INP. This conversion is done by the programme *simtime.exe*.

Specification

Table 2.22 Input files and related variables for time dependent variables

Input file	Parameter	Unit	Description
METE_SIM.INP	id	-	day number
	iy	-	year number
	<i>pr</i>	mm	precipitation
	<i>evgr</i>	mm	potential reference evapotranspiration
	<i>evpf</i>	mm	potential evapotranspiration of pine forest
	<i>evdf</i>	mm	Potential evapotranspiration of deciduous forest
	<i>faevba</i>	mm	evaporation factor of bare soil
TIBD_SIM.INP	nmme	-	meteorological region number
	id	-	day number
	iy	-	year number
	nnex	-	node number
	nl	-	layer number
	<i>iolv</i>	-	option code for level reference
	<i>hbgwnw</i>	see <i>iolv</i>	new groundwater level
TIAB_SIM.INP	<i>flgwnw</i>	m ³ d ⁻¹	boundary flux
	id	-	day number
	iy	-	year number
	nnex	-	node number
	nl	-	layer number
	<i>iolv</i>	-	option code for level reference
	<i>hbgwnw</i>	see <i>iolv</i>	new groundwater level
TISW_SIM.INP	<i>flgwnw</i>	m ³ d ⁻¹	new abstraction flux
	id	-	day number
	iy	-	year number
	nrex	-	subcatchment number
	<i>iolv</i>	-	option code for level reference
	<i>hbswnw</i>	see <i>iolv</i>	new surface water level
	<i>hbwrnw</i>	see <i>iolv</i>	new weir/target level
TIOP_SIM.INP	<i>flswnw</i>	m ³ d ⁻¹	new surface water inflow rate
	id	-	day number
	iy	-	year number
	nl	-	layer number
	<i>io</i>	-	option number
	<i>dtgwnw</i>	d	groundwater time step

- Meteo-data

The meteorologic data are specified in METE_SIM.INP. Meteorologic data should be specified from the time to start the model run till the time to stop. The data in this file should be in chronological order.

The time step can also be smaller than 1 day. When the user wants to use relatively short meteo time steps, the appropriate groundwater and surface water time step (see PARA_SIM.INP) should be used

- Boundary conditions

Time dependent flux and level boundaries can be chosen.

See file TIBD_SIM.INP

- Groundwater abstractions or groundwater level control
Time dependent flux and level boundaries can be chosen.
See file TIAB_SIM.INP
- Surface water levels, weir levels, inflow flux
Time dependent water levels, weir levels and inflow flux boundaries can be chosen.
See file TISW_SIM.INP
- Periods for output
The most important feature is the specification of the periods for periodical water balance output.
See file TIOP_SIM.INP

2.9 Output

2.9.1 ASCII-output files

The advantage of ASCII-output-files is the direct readability of these files. A disadvantage is the inefficient way the data is stored. In SIMGRO, there is a big choice in generating these ASCII-files. Water levels as well as water balances can be written to ASCII-files. In the following table an enumeration of the different output-files is given. In addition, the options necessary to generate these outputfiles are given.

Table 2.23 Input files, description and options

file	output if	module	description
INPT_SIM.OUT	<i>ioptin</i> = 1	-	input data
INFO_SIM.OUT	always	-	errors, warnings and information
ITER_SIM.OUT	<i>ioptit</i> = 1	-	iteration results
HHGW_NOD.OUT	PLHH_NOD.INP	groundwater	heads per node
HHGW_SUB.OUT	PLHH_SUB.INP	groundwater	heads per subcatchment
HHGW_LAY.OUT	PLHH_LAY.INP	groundwater	heads per layer
HHSW_NOD.OUT	PLHH_NOD.INP	surface water	surface water levels per nodal subdomain
HHSW_SUB.OUT	PLHH_SUB.INP	surface water	surface water levels per subcatchment
HHSW_LAY.OUT	PLHH_LAY.INP	surface water	surface water levels per layer
HHGW_TNO.OUT	<i>iopttn</i> = 1	groundwater	groundwater levels per node (bimonthly)
WBALDNOD.OUT	<i>ioptwbal</i> = 1, PLWB_NOD.INP	all	water balance of top layer per nodal subdomain per groundwater time step
WBALDSUB.OUT	<i>ioptwbal</i> = 1, PLWB_SUB.INP	all	water balance of top layer per subcatchment per groundwater time step
WBALDLAY.OUT	<i>ioptwbal</i> = 1, PLWB_LAY.INP	all	water balance of top layer
WBSADNOD.OUT	<i>ioptwbsa</i> = 1, PLWB_NOD.INP	groundwater	saturated water balance of top layer per nodal subdomain
WBSADSUB.OUT	<i>ioptwbsa</i> = 1, PLWB_SUB.INP	groundwater	saturated water balance per subcatchment
WBSADLAY.OUT	<i>ioptwbsa</i> = 1, PLWB_LAY.INP	groundwater	saturated water balance
WBSWDSUB.OUT	<i>ioptwbsw</i> = 1, PLWB_SUB.INP	surface water	surface water balance per subcatchment
WBSWDLAY.OUT	<i>ioptwbsw</i> = 1, PLWB_LAY.INP	surface water	surface water balance
WBUNDNOD.OUT	<i>ioptwbun</i> = 1, PLWB_NOD.INP	soil water	unsaturated water balance per nodal subdomain
WBUNDSUB.OUT	<i>ioptwbun</i> = 1, PLWB_SUB.INP	soil water	unsaturated water balance per subcatchment
WBUNDLAY.OUT	<i>ioptwbun</i> = 1, PLWB_LAY.INP	soil water	unsaturated water balance
WBALPNOD.OUT	<i>ioptwbal</i> = 1	all	water balance of top layer per nodal subdomain per period
WBALPSUB.OUT	<i>ioptwbal</i> = 1	all	water balance of top layer per subcatchment per period
WBALPLAY.OUT	<i>ioptwbal</i> = 1	all	water balance of top layer
WBSAPNOD.OUT	<i>ioptwbsa</i> = 1	groundwater	saturated water balance of all layers per nodal subdomain
WBSAPSUB.OUT	<i>ioptwbsa</i> = 1	groundwater	saturated water balance per subcatchment
WBSAPLAY.OUT	<i>ioptwbsa</i> = 1	groundwater	saturated water balance
WBSWPSUB.OUT	<i>ioptwbsw</i> = 1	surface water	surface water balance per subcatchment
WBSWPLAY.OUT	<i>ioptwbsw</i> = 1	surface water	surface water balance
WBUNPNOD.OUT	<i>ioptwbun</i> = 1	soil water	unsaturated water balance per nodal subdomain
WBUNPSUB.OUT	<i>ioptwbun</i> = 1	soil water	unsaturated water balance per subcatchment
WBUNPLAY.OUT	<i>ioptwbun</i> = 1	soil water	unsaturated water balance

The formats of these files are described in the Input/Output description of SIMGRO (Dik, 2004).

2.9.2 Binary output files

Description

Writing to a binary file is an efficient way to store data. By specifying the output options (in `PARA_SIM.INP`) the desired output can be get.

To extract information from the binary output files two help files have to be used. So each binary output consists of three files:

- the key information is written to `.key`-files,
- the timer information to `.tim`-files (both in `ascii`);
- the actual output is written to `.out`-files, using a binary ‘format’.

In general, the output can be divided into:

- Files with the groundwater heads:
 - `HH.KEY/.TIM/.OUT`;
 - `GT.KEY/.TIM/.OUT`;
 - `GW.KEY/.TIM/.OUT`;
- Files with the surface water discharges and optionally surface water discharges:
 - `SW.KEY/.TIM/.OUT`;
- Files with waterbalance terms and additional information:
 - `DBNDPSIM` or `DBNDDSIM.KEY/.TIM/.OUT`: water balance for the unsaturated zone (per period or per day);
 - `DBSBPSIM` or `DBSBDSIM.KEY/.TIM/.OUT`: water balance for the subcatchments (per period or per day);
 - `DBLYPSIM` or `DBLYDSIM.KEY/.TIM/.OUT`: water balance for the saturated zone (per period or per day).

Quite often, the `SIMGRO`-results will be used as input for other programs. The binary output files contain all the information, i.e. water levels, water balances and additional information. There are several programs available to extract the desired information from the binary files, see Appendix 2.

The time step for the standard output is defined by $dtpt$ (in `PARA_SIM.INP`) and for the output per period as specified in `TIOP_SIM.INP`. For example, for each $dtpt$ groundwater levels are written to the file `HH.OUT`. Usually a value of 1 day is used.

The output files are listed below in Table 2.24. In addition, the options necessary to generate these output files are given.

The formats of these files are described in the the Input/Output description of `SIMGRO` (Dik, 2004).

Table 2.24 Output files, description and options

File	Output if	Module	Description
HH.OUT	PLHH_NOD.INP, PLHH_LAY.INP ²	groundwater	hydraulic heads for each ombination of nodes and layers (per <i>dtpt</i>)
GT.OUT	iopttn = 1	groundwater	freatic groundwater levels of layer 1 for each node (bimonthly)
GW.OUT	ioptgw = 1, 2, 3	surface water /groundwater	groundwater depth and/or surface water depth (per <i>dtpt</i>)
SW.OUT	ioptsw = 1, 2	surface water	surface water outflow and opt. surface water level (per <i>dtpt</i>)
DBNDPSIM.OUT	ioptdb = 1	soil water	water balance terms for the nodes for the root zone (per period)
DBSBPSIM.OUT	ioptdb = 1	surface water	water balance terms for the subcatchments (per period)
DBLYPSIM.OUT	ioptdb = 1	groundwater	water balance terms for all the layers (per period)
DBNDDSIM.OUT	PLWB_NOD.INP	soil water	water balance terms for the nodes for the root zone (per <i>dtpt</i>)
DBSBDSIM.OUT	PLWB_SUB.INP	surface water	water balance terms for the subcatchments (per <i>dtpt</i>)
DBLYDSIM.OUT	PLWB_NOD.INP	groundwater	water balance terms for all the layers (per <i>dtpt</i>)

² For each combination of a node from PLHH_NOD.INP and a layer from PLHH_LAY.INP the heads are written to the file *hh.out*.

3 Programme execution

3.1 Hardware requirements

To run SIMGRO you are advised to use at least the following system configuration:

- IBM compatible PC with a pentium processor (≥ 2 GHz);
- 512 Mb RAM;
- CD drive for installation of SIMGRO;
- hard disk with at least 2 Gb free;
- WindowsNT or Windows XP.

3.2 Executables

Two executables have to be run:

- *Simtime.exe*: Prior to running the actual SIMGRO model, the programme SIMTIME is run. This programme generates the file TIME_SIM.INP and contains all the time dependent input. For instance, the data for output, the boundary conditions for the border nodes, the discharges, the boundary conditions for the surface water;
- *Simgro4.exe*: the main program.

3.3 Runtime

The runtime on a computer with the specifications from paragraph 3.1 for a model with the following characteristics:

- 35 000 nodes;
- 70 000 elements;
- 7 layers;
- 2 500 subcatchments;
- a time step of 0.25 d for the groundwater and 0.05 d for the surface water requires about 50 minutes per run year for this model

3.4 Programme evaluation and restrictions

For quality reasons a procedure for changing the code of SIMGRO has been put in place. Part of this procedure is testing the changes. Two types of test are performed during the development of SIMGRO 4.1:

- an implementation test;
- a functional test.

Implementation tests are performed during programme development. For this purpose the static analyser FORCHECK (Leiden University, 1994) is helpful. The purpose of the

implementation test is to check whether the syntax of the SIMGRO code is indeed free from apparent errors and warnings.

A functional test is performed after each change in the programme code. Differences with older versions are only accepted when they can be explained.

Testing however will never be a guarantee for the absence of errors. Therefore, a user should always interpret the results of the model and should always be able to understand them.

3.5 Problems during execution

A user may encounter problems during execution of the model. To determine the cause of these problems the following steps should be taken:

- check the amount of free memory (RAM) on your PC;
- check the size of the paging file. It should be at least 1500 MB;
- check the amount of free hard disk space;
- inspect the reported errors in the files INFO_TIM.OUT and INFO_SIM.OUT. Open these files, read the (last) lines in the file and try to determine if there is a mistake in the input file.

The log-files are:

- INFO_TIM.OUT: This file contains the log of running *Simtime.exe*. It is recommended to consult this file, especially when the programme has crashed;
 - INFO_SIM.OUT: This file contains the log of running *Simgro4.exe*. It is recommended to always consult this file. Several checks will be done while reading the input-files. Warnings and errors are written to the log-file. These warnings will not cause the programme to stop, but can be of help in preventing wrong input.
All messages are listed in Appendix 1.
Informative messages and warnings can be suppressed (see parameter *ioptms* in PARA_SIM.INP).
 - ITER_SIM.OUT. Iteration results are written to this file. At the end of each groundwater time step, the flow balance error per layer is printed as well as the maximum change in head of a node. This file can be used when encountering problems with the groundwater solution scheme;
- check whether the dimensions of the model are bigger than the dimensions of the executable. If that is the case, you should reduce the model dimensions or use an executable with greater dimensions;
 - check if there are tabs in the input files or check the positions in the input file. Check if there are empty lines at the end of your input file.

Literature

Van Walsum, P.E.V., A.A. Veldhuizen, P.J.T. van Bakel, F.J.E. van der Bolt, P.E. Dik, P. Groenendijk, E.P. Querner, 2004. *SIMGRO 5.0; Description of theory and model implementation*. Wageningen, Alterra, Alterra-rapport 913.1.

Dik, P.E., 2004. *SIMGRO Description of input and output files*. Wageningen, Alterra, Alterra-rapport 913.2.

Appendix 1 Programme messages

Programme messages are written to file INFO_SIM.OUT. They include error messages, warnings and informative messages. Output to this file may be regulated – to a certain extent – with the option parameter *ioptms*.

Error messages

Error messages are intended to inform the user about unexpected situations, causing a model run to be discontinued. It is wise to not only take notice of the reported errors. You should also carefully study all warnings and informative messages, as these may indicate the real cause of your problem. Error messages cannot be suppressed.

In the following, a list of error messages is given, including suggested actions.

**** E01 arsubr ** Closed loop in surface water system**

There appears to be an inconsistency in the drainage structure. Water from a downstream subcatchment is being transported to an upstream one. This can e.g. have been caused by faulty digitization of the watercourses, by forgetting to ‘lift’ the digitization tool at the end of a main stream before continuing in another subcatchment. Check GOTO_SIM.INP.

**** E02 open_out ** Could not open file for read or write - iostat = [io]**

Either input files are missing or blocked, or output files could not be opened. Make sure you are not editing or viewing one of the input files. Check whether METE_SIM.INP and TIME_SIM.INP exist. Check free disk space.

**** E03 SIMGRO ** No convergence in iteration scheme**

A serious problem has occurred: SIMGRO is forced to stop its execution because of a convergence problem in the iteration scheme. Check INFO_SIM.OUT for warnings. In addition check your iteration results in ITER_SIM.OUT.

**** E04 SIMGRO ** Maximum number of iterations ([nxit]) passed**

Your model does not meet the iteration criteria *dbmxit* (see PARA_SIM.INP) within the maximum number of iterations *nxit*. Increase the maximum number of iterations, loosen the *dbmxit*. In addition check your iteration results in ITER_SIM.OUT.

**** E05 contp ** Node [nd]**

Band width of : [n1] is greater maximum (= [n2])

Node [nd] has too many contact points. Your network is not suitable for SIMGRO. Redesign your finite element network.

**** E06 matrix ** Node : [nd]**

The area is : [ar] (not acceptable)

The subdomain of node [nd] is calculated negative, implying a network error. Your network is not suitable for SIMGRO. Redesign your finite element network.

**** E07 qunsat ** [dy] [yr] node [nd] land use [nt]**

Moisture content of root zone less than 0.0 mm

The moisture content of the root zone is completely dried out, causing a water balance error. Check your root zone characteristics.

**** E08 matrix ** [dy] [yr] element no [el]**

Water bearing part top layer less than 0 cm (= [d1] cm)

The groundwater depth falls below the depth of the first layer. For calculation purposes a minimum water bearing thickness is assumed (see W58). The SIMGRO continues. Check your vertical schematization.

**** E09 readt ** Type of data record incorrect, is : *[txt1]**

It requires to be : *[txt2] record

An error has occurred in TIME_SIM.INP. This file is originally generated by *readtime.exe*. Do not manually change it.

**** E10 convt ** Day number 366.00 of year [yr] does not exist**

An error has occurred in METE_SIM.INP or TIME_SIM.INP. These file is originally generated by *readtime.exe*. Do not manually change them.

**** E11 ctrl_rea ** Line [line] of file [name file].inp**

Variable [name var] [desc var]

is [v1]

and exceeds maximum value [v2]

Run will stop due to error condition

Error in tabular input, value too high. Check input file.

**** E12 ctrl_rea ** parameter file**

Variable [name var] [desc var]

is [v1]

and exceeds maximum value [v2]

Run will stop due to error condition

Error in parameter input, value too high. Check PARA_SIM.INP.

**** E13 ctrl_rea ** Line [line] of file [name file].inp**

Variable [name var] [desc var]

is [v1]

and is less than minimum value [v2]

Run will stop due to error condition

Error in tabular input, value too low. Check input file.

**** E14 ctrl_rea ** Parameter file**

Variable [name var] [desc var]

is [v1]

and is less than minimum value [v2]

Run will stop due to error condition

Error in parameter input, value too low. Check PARA_SIM.INP.

**** E15 ctrl_val ** Variable [name var] [desc var]**

Number [n1] does not exist

Check input on line [line] of file [name file].inp

Input error on (foreign) key variable, te key variable does not exist. Check your input.

**** E16 freeunit ** No free unit number available for opening file**

Too many files are opened. Contact your SIMGRO supplier.

**** E17 rd_int ** Unexpected character "X" found in parameter [var name]**

Error in parameter input, variable cannot be read. Check PARA_SIM.INP.

**** E18 rd_int ** Character "0" not found in ASCII-set 1-256**

ASCII table does not seem to be correct. Contact your SIMGRO supplier.

**** E19 readpar ** Cannot open parameter file PARA_SIM.INP.inp for read**

Parameter file PARA_SIM.INP is either missing or currently locked. Make sure you are not editing or viewing it. Check it existence.

**** E20 readt ** Dimension of nxpsfl = [nx] too small**

Too many prescribed fluxes specified

You have specified too many time dependent data. Reduce this amount or contact your SIMGRO supplier for a higher value of *nxpsfl*.

**** E21 readvar ** Cannot initialize SDAS**

The Standard Data Exchange Software (SDAS) is not linked. Contact your SIMGRO supplier.

**** E22 readvar ** Cannot open dataset SIMGRO.ddf for read**

File *SIMGRO.ddf* is either missing or currently locked. Make sure you are not editing or viewing it. Check it existence.

**** E23 readvar ** Cannot open table [file_name] for read**

Input file [file_name] is either missing or currently locked. Make sure you are not editing or viewing it. Check it existence.

**** E24 readvar ** Error on line [line] of file [file_name]; variable [var]**

An error occurred on line [line] of file [file_name]. Variable [var] cannot be read. Check your input file.

**** E25 readvar ** Cannot close file [file_name]**

Close error on file [file_name]. File is probably not opened. Contact your SIMGRO supplier.

**** E26 readvar ** Table [file_name]; Missing variable [var] with position:**

nd = [nd]

Missing input specification for [nd]. Check input file.

**** E27 readvar ** Incorrect number of [var] in table [file_name]**

[n1] found in table; [n2] according to input parameter

Inconsistency in input of [var] in table [file_name]. According to the parameter file you should have specified [n2] instead of [n1]. Check input file.

**** E28 readvar ** Maximum number of [var] exceeded in table [file_name]**

According to input parameter maximum is: [n1]

Inconsistency in input of [var] in table [file_name]. [n1] exceeds the maximum number of [var]. Check input file or contact your SIMGRO supplier.

**** E29 readvar ** GOTO_SIM.INP, subcatchment: [nr]**

Outflow fraction is not 1.000, but [v1]

The fraction of surface water outflow from subcatchment [nr] is not exactly 1.000. Check GOTO_SIM.INP.

**** E30 readvar ** node [nd]**

Total areal fraction of land use = [fr]

It should be 1.000

Check your area-records.

**** E31 readvar ** Line number [line] table DISH_SIM.INP**

Too many input data for subcatchment [nr]

Specify no more than *nxdhwr* weir levels per subcatchment. Check DISH_SIM.INP.

**** E32 readvar ** Line number 127 table DISH_SIM.INP**

Too many input data for default

Specify no more than *nxdhwr* weir levels for default. Check DISH_SIM.INP.

**** E33 readvar ** DISH_SIM.INP, subcatchment 45**

Flux over weir crest inconsistent with differential head:

dh = [h1] flux = [f1]

dh = [h2] flux = [f2]

Make sure the flux over the weir crest increases with an increasing differential head. Check DISH_SIM.INP.

**** E34 readvar ** frsw_sim.inp, node [nd] subcatchment [nr]**

Inundation inconsistent with depth:

depth = [d1] inun. fr. = [f1]

depth = [d2] inun. fr. = [f2]

Make sure the inundation fraction decreases with increasing depth. Check *frsw_sub.inp* or FRSW_NOD.INP.

**** E35 readvar ** No level control specified for level control number [n1]**

Check TACL_SIM.INP.

**** E36 readvar ** TACL_SIM.INP, level control number [n1]**

Lowering target level inconsistent with groundwater depth:

depth = [d1] low. = [l1]

depth = [d2] low. = [l2]

Make sure the target level lowering decreases with increasing depth. Check TACL_SIM.INP.

**** E37 readvar ** UNSA_SIM.INP; missing input**

soil physical unit [u1] and root zone depth [r1]

Check UNSA_SIM.INP.

**** E38 readvar ** UNSA_SIM.INP; unit [u1] rzd [r1] drying conditions**

Storage in root zone inconsistent with groundwater depth:

depth = [d1] storage = [s1]

depth = [d2] storage = [s2]

Make sure the root zone storage decreases with an increasing depth. Check UNSA_SIM.INP.

**** E39 readvar ** UNSA_SIM.INP; unit [u1] rzd [r1] wetting conditions**

Storage in root zone inconsistent with groundwater depth:

depth = [d1] storage = [s1]

depth = [d2] storage = [s2]

Make sure the root zone storage decreases with an increasing depth. Check UNSA_SIM.INP.

**** E40 readvar ** UNSA_SIM.INP; unit [u1] rzd [r1]**

Capillary rise flux inconsistent with groundwater depth:

depth = [d1] cap. rise = [c1]

depth = [d2] cap. rise = [c2]

Make sure the capillary rise decreases with an increasing depth. Check UNSA_SIM.INP.

**** E41 readvar ** Maximum number of drainage data, [nx] exceeded**

You have specified too many drainage data. Reduce this amount or contact your SIMGRO supplier.

**** E42 readvar ** Node number [nd] found twice in NDSB_SIM.INP:
on lines [line1] and [line2]**

You may only specify the key variable node once in NDSB_SIM.INP. Check NDSB_SIM.INP.

**** E44 readvar ** RESV_SIM.INP**

Supply to subcatchment [nr] from at least 2 reservoirs

You may only specify water to be supplied from one internal subcatchment (reservoir). Check RESV_SIM.INP.

**** E45 readvar ** node_sim.inp**

Distance between node [nd1] and [nd2] less than 1.00 m

The coordinates of two nodes are too close, which may cause erroneous modelling results. Redesign your network.

**** E46 readvar ** UNSA_SIM.INP; unit [u1] rzd [r1]**

No storage coefficient specified for gr.depth [d1]

Missing input value. Check UNSA_SIM.INP.

**** E47 readvar ** GOTO_SIM.INP; subcatchment [nr1] discharges to [nr2]
for which no surface water is specified**

Apparently you have not specified drainage records in subcatchment [n2], implying the absence of surface water. There can be no discharge to a subcatchment which has no surface water. Check either the drainage records or GOTO_SIM.INP.

**** E48 readvar ** Parameter file. Pointer for land use [nt] does not exist**

You have specified one of the pointers to be [nt]. This pointer does not exist in LUSE_SIM.INP. Check PARA_SIM.INP.

- ** E49 readvar ** Parameter file. Pointer [nt] used more than once**
 You have specified two or more of the pointers to be [nt]. You may only use a pointer once. Check PARA_SIM.INP.
- ** E50 readvar ** Line number [line] table frsw
 Too many input data for node [nd]**
 You have specified more than *nxfsw* records nor node [nd]. Check FRSW_NOD.INP or *frsw_sub.inp*.
- ** E52 matrix ** Transmissivity (neg) [kD] for node [nd]**
 SIMGRO has calculated the transmissivity of node [nd] to be negative. This is probably caused by the shape of your triangular network. Redesign your network and check your conductivity records.
- ** E53 pre_spr ** Sprinkling dates do not exist
 The dates read are : [dy] [yr]**
 An error has occurred in *irri_sim.inp*. This file is originally generated by SIMGRO. Do not manually change it.
- ** E54 pre_spr ** [dy] [yr] node number: [nd] not found**
 An error has occurred in *irri_sim.inp*. This file is originally generated by SIMGRO. Do not manually change it.
- ** E55 qunsat ** Error reading METE_SIM.INP**
 An error has occurred in METE_SIM.INP. This file is originally generated by *readtim.exe*. Do not manually change it.
- ** E56 qunsat ** Reading end of file METE_SIM.INP**
 You have probably change the calculation times in PARA_SIM.INP without re-running *readtim.exe*. Run *readtim.exe*.
- ** E57 qunsat ** Error in rainfall and evapotranspiration data
 day no and year of this data is : [dy1] [yr1]
 day no and year of calculations is : [dy2] [yr2]**
 An error has occurred in METE_SIM.INP. This file is originally generated by *readtim.exe*. Do not manually change it.
- ** E58 readvar ** Inconsistency in ROOT_SIM.INP
 in evpotranspiration or irrigation fractions
 for soil physical unit [ns] and land use [nt]**
 Check ROOT_SIM.INP.
- ** E59 wtable ** node : [nd] land use : [nt]
 First time calculation of perched water table not possible**
 Check input data and results.
- ** E60 contp ** Boundary node erroneously defined as internal node
 node = [nd] subcatchment = [nr]**
 Check NDSB_SIM.INP.
- ** E61 contp ** Internal node erroneously defined as boundary node**

node = [nd] subcatchment = [nr]

Check NDSB_SIM.INP.

**** E62 readvar ** Element number [el] found more than once in elem_sim**

You may only specify the key variable element number once in ELEM_SIM.INP. Check ELEM_SIM.INP.

**** E63 readvar ** Element number [el] is not a triangle**

Check ELEM_SIM.INP.

**** E64 prndwbnd ** Write error in file [file_name]**

Either [file_name] is missing or blocked. Make sure you are not editing or viewing one of the input files. Do not delete any file during a SIMGRO-run.

**** E65 readvar ** Incorrect number of transportation subcatchments**

According to parameter nutr : [n1]

According to management table: [n2]

You have not specified the correct number of transportation subcatchments. Check PARA_SIM.INP or MANA_SIM.INP.

**** E66 readvar ** Error in transportation subcatchment [nr]**

Weir level reference cannot be relative (iorfwr = 0)

if no reference is specified

Make sure you specify a reference level for a transportation subcatchment if *iorfwr* is 0. Check MANA_SIM.INP.

Warnings

Warnings are intended to inform the user about unexpected features, without the run having to be discontinued. It is wise to at least take notice of them after each model run. The warnings can be suppressed by specifying *ioptms* = 2 in *PARA_SIM.INP*.

**** W01 flowdir ** [dy] [yr] layer : [ly]**

Cannot plot flow direction for an aquitard

You have specified to plot the lateral flow for an aquitard for which there is only vertical flow. Check *TIOP_SIM.INP*.

**** W02 qleak ** [dy] [yr] node [nd]**

Water bearing part of top layer becomes less than 1.00 m

Programme assumes 1.00 m and continues

For calculation purposes a layer cannot fall dry. Therefore a minimum water bearing part is assumed. Check your conductivity records.

**** W03 chkele ** Angle of element [el] greater than [deg] deg.**

The configuration of your finite element network determines the reliability of your results. This element may cause numerical deviations. Redesign your network.

**** W04 chkele ** Direction of element [el] switched**

The direction of element must be counter-clockwise. Check your network.

**** W05 chkele ** Node [nd] lies within the inner circle of element [el]**

The configuration of your finite element network determines the reliability of your results. This element may cause numerical deviations. Redesign your network.

**** W06 readt ** Cannot write output results for other models if ioptom = 0**

Warning not active.

**** W07 wbal_sub ** Error in perched water balance for subcatchment: [nr]**

of [v1] mm

pe, pepl, drpl, srpl = [v2] [v3] [v4] [v5]

Check *prch_nod.inp* or *prch_sub.inp*.

**** W08 ctrl_rea ** Line 112 of file [name file].inp**

Variable [name var] [desc var]

is [v1]

and exceeds maximum value [v2]

Therefore the variable is set to maximum

Make sure you have specified your input in the requested unit.

**** W09 ctrl_rea ** Line 112 of file [name file].inp**

Variable [name var] [desc var]

is [v1]

and exceeds maximum value [v2]

Check your input, run will continue with old value

Make sure you have specified your input in the requested unit.

**** W10 ctrl_rea ** Line 112 of file [name file].inp**

Variable [name var] [desc var]
is 10.00
and is less than minimum value 15.00
Therefore the variable is set to minimum

Make sure you have specified your input in the requested unit.

**** W11 ctrl_rea **** Line 112 of file [name file].inp
Variable [name var] [desc var]
is 10.00
and is less than minimum value 15.00
Check your input, run will continue with old value

Make sure you have specified your input in the requested unit.

**** W12 rd_int **** Empty string found for parameter [var name]
set to default value = [def]

Check whether the default value is okay.

**** W13 readt **** Time of time dependent data does not fit time interval
Time was :[dy1] [yr1]
It becomes :[dy2] [yr2]

A discrepancy has occurred between the time management of SIMGRO and file TIME_SIM.INP. This file is originally generated by readtim.exe. Do not manually change it.

**** W14 readt **** New prescribed head for node : [nd] layer : [ly]
New head is : [h1] m
Present value is : [h2] m
Difference more than [h3] m

You have specified a new boundary condition, which deviates from the present one more than [h3]. Check TIBD_SIM.INP.

**** W15 readt **** node [nd]
Prescribed head internal node allowed for top layer only

You may only use a prescribed head for the top layer for nodes other than boundary nodes. Check TIAB_SIM.INP.

**** W16 readt **** New water level surface water in subcatchment: [nr]
New depth is = [d1] m
Present depth = [d2] m
Change is more than [d3] m

You have specified a new fixed surface water level, which deviates from the present one more than [d3]. Check TISW_SIM.INP.

**** W17 readt **** Cancel prescribed water level in subcatchment: [nr]
No prescribed water level present

You can only cancel a prescribed water level if one is present. Check TISW_SIM.INP.

**** W18 readt **** Reading end of file : TIME_SIM.INP
Calculation continues for maximum 50 days

The end of file TIME_SIM.INP is found. This file is originally generated by *readtim.exe*. Do not manually change it.

**** W19 readvar ** No Q-h relation specified for subcatchment [nr]**
Make sure you have not erroneously forgotten to specify a Q-h relation for subcatchment [nr] in file DISH_SIM.INP.

**** W20 readvar ** MANA_SIM.INP**
Winter weir level of subcatchment [nr] too low.
Specified by user to be 1.70
According to drainage records set to 1.30

A weir crest level may not be specified below the deepest drain within a subcatchment. SIMGRO automatically shifts the weir crest. Check MANA_SIM.INP and your drainage records.

**** W21 readvar ** MANA_SIM.INP**
Summer weir level of subcatchment [nr] too low.
Specified by user to be 1.50
According to drainage records set to 1.30

A weir crest level may not be specified below the deepest drain within a subcatchment. SIMGRO automatically shifts the weir crest. Check MANA_SIM.INP and your drainage records.

**** W22 readvar ** MANA_SIM.INP**
IORFWR for subcatchment [nr] specified to be 1; set to 2
iorfwr is either 0 for weir levels relative to soil surface or 2 for weir levels relative to MSL. *iorfwr* = 1 is treated like 2. Check MANA_SIM.INP.

**** W23 readvar ** MANA_SIM.INP**
Node number [nd] used as reference node
for weir level not found within subcatchment [nr]

It is likely for reference nodes to be located within its own subcatchment. Check MANA_SIM.INP.

**** W24 SIMGRO ** node : [nd] with vertical resistance of : [r1]**
Set to minimum value (= 10.0) for top layer

For computational stability a minimum vertical resistance of 10 days is assumed. Check your conductivity records.

**** W25 SIMGRO ** Layer above and below [ly] are not both aquifers**
Warning is not active anymore.

**** W26 SIMGRO ** [dy] [yr] node [nd]**
Water level is more than 100 cm above soil surface
Severe inundation may be caused by unreliable input.

**** W27 readvar ** Inconsistency in surface water data of subcatchment [nr]**
Weir/target level summer = [lvsm] lower than
weir/target level winter = [lvwt]
Check MANA_SIM.INP.

**** W28 matrix ** Water bearing part (top layer) for element no : [el]**
becomes less than 0.1 m
Programme assumes minimum of 0.1 m

See error message E08.

**** W29 surfw ** [dy] [yr] Subcatchment : [nr] with fixed water level
Supply exceeds maximum**

required supply : [s1] maximum : [s2]

You have specified a fixed water level in subcatchment [nr]. To maintain the prescribed level too much water supply is required. Check your drainage records, manament records and your time dependent input.

**** W30 surfw ** [dy] [yr] Maximum supply capacity exceeded**

max= [s1] m3/s actual supply= [v2] m3/s factor= [f1]

The supply to the entire modelling region exceeds the maximum supply specified in PARA_SIM.INP. During the next surface water time step the supply to all subcatchments is therefore reduced by a factor [f1].

**** W31 surfw ** [dy] [yr] Discharge data of subcatchment [nr]**

Calculated discharge [f1] m3/d > maximum [f2] m3/d

The discharge from subcatchment [nr] exceeds the highest input discharge in DISH_SIM.INP. The dish table is extrapolated.

**** W32 surfw ** [dy] [yr] Subcatchment : [nr]**

Oscillation problem in surface water

Oscillation = [h1] m

The surface water level in subcatchment [nr] shows a problematic oscillation, indicating instability of your surface water system. This may be caused by low drainage resistances in combination with deep drainage. It may also be caused by ill defined initial conditions.

**** W33 surfw ** [dy] [yr] Subcatchment : [nr]**

Water level below invert level of surface water system

Water balance error = [f1] mm

Surface water problem in subcatchment [nr]. Water balance error, indicating instability of your surface water system. This may be caused by low drainage resistances in combination with deep drainage.

**** W34 surfw ** [dy] [yr] Subcatchment : [nr]**

Not in enough capacity in reservoir for supply demand

Supply from reservoir [nr] is reduced due to a water shortage. If possible water is supplied from outside the modelling region (see RESV_SIM.INP and MANA_SIM.INP).

**** W35 pre_spr ** [dy] [yr] Node: [nd]**

Reduction factor [f1] for sprinkling

due to exceeded abstraction during previous time step

Not enough capacity available for sprinkling demand. Check *irri_sim.inp*.

**** W36 pre_spr ** [dy] [yr] Node: [nd]**

Reduction factor [f1] for sprinkling from surface water

due to exceeded abstraction during previous time step

Not enough surface water available for sprinkling demand. Check *irri_sim.inp*.

**** W37 pre_spr ** [dy] [yr] node: [nd]**

Reduction factor [f1] for sprinkling from groundwater

due to exceeded abstraction during previous time step

Not enough groundwater available for sprinkling demand. Check *irri_sim.inp*.

**** W38 pre_spr ** [dy] [yr] node number: [nd] land use: [nt]**

No such land use type

File *irri_sim.inp* is generated by SIMGRO. Do not manually change this file.

**** W39 pre_spr ** [dy] [yr] node : [nd] act = [s1] max = [s2]**

More surface water abstracted for sprinkling than maximum

Too much surface water abstracted. Check your water balance.

**** W40 pre_spr ** [dy] [yr] node = [nd] girr = [s1] gmax = [s2]**

More groundwater abstracted for sprinkling than maximum

Too much groundwater abstracted.

**** W41 sprink ** [dy] [yr] node : [nd] girr = [s1] gmax = [s2]**

More groundwater abstracted for sprinkling than maximum

Check GIFT_NOD.INP or *gift_sub.inp*.

**** W42 wtable ** Iteration limit of perched groundwater table reached**

day year node l.use

[dy] [yr] [nd] [nt]

Water balance errors may occur. Check *prch_nod.inp* or *prch_sub.inp*.

**** W43 wtable ** [dy] [yr] node : [nd]**

Perched water table disappeared

Remaining water in storage is : [v1] mm

Storage set to 0.0 mm

A water balance error of [v1] is accepted. Check *prch_nod.inp* or *prch_sub.inp*.

**** W44 wtable ** [dy] [yr] node : [nd]**

Perched water table present, but no storage left over

water depth is : [d1] m storage is : [s1] mm

A small water balance error is accepted. Check *prch_nod.inp* or *prch_sub.inp*.

**** W45 readt ** layer [ly] node [nd]**

Boundary flux for aquitard cannot be defined

An inconsistency is found in TIME_SIM.INP. This file is originally generated by *readtim.exe*.

Do not manually change it.

**** W46 readvar ** RESV_SIM.INP**

Subcatchment [nr] both inflow-subcatchment and outflow-reservoir

Record skipped

A subcatchment cannot supply water to itself. Check RESV_SIM.INP.

**** W47 flowb ** [dy] [yr] Water balance error in layer [ly] of [p1] %**

A water balance error may be caused by too low accuracy. Reduce *dbmxit* in PARA_SIM.INP. It may also be caused by temporary instabilities or instabilities in the surface water system.

**** W48 flowb ** [dy] [yr] node [nd] change in head [d1]**

Change in phreatic level is more than : [d2]

Phreatic levels are relatively stable. High precipitation may cause this level to change rapidly. Surface water instability may cause rapid changes as well.

**** W49 contp ** Number of contact points is 2 for node [nd]**

All contact point are boundary nodes

The results for node [nd] are determined by boundary conditions. Be aware of this when interpreting your results. It is best to redesign your network.

**** W50 readvar ** No surface water system specified in drainage tables**

Your SIMGRO model does not include a surface water system. Make sure this is your wish. Check DRNG_NOD.INP and *drng_sub.inp*.

**** W51 readt ** No surface water system present in subcatchment [nr]**

Changes in surface water data not relevant

You have not specified a surface water system in subcatchment [nr]. This makes changing surface water data in TIME_SIM.INP irrelevant. Check your drainage records.

**** W52 readvar ** Inconsistency in conductivity data**

Conductivity of aquifer layer [ly1] = [k1] m/d

Conductivity of aquitard layer [ly2] = [k2] m/d

The average conductivity of aquitard [ly2] is greater than average conductivity of aquifer [ly1]. Check your conductivity records. Make sure the deepest layer is an aquifer.

**** W53 readvar ** FACT_SIM.INP; missing evaporation factor**

Crop [crop] : factor number = [nf] day = [dy]

An evaporation factor is missing in the series. Check FACT_SIM.INP.

**** W54 readvar ** FACT_SIM.INP; unexpected evaporation factor**

Crop [crop] : factor number = [nf] day = [dy]

You have specified a single evaporation factor, no series. Check FACT_SIM.INP.

**** W55 readvar ** RESV_SIM.INP; No surface water system defined
in inflow subcatchment [nr1] or outflow subcatchment [nr2]**

Record is skipped. Check RESV_SIM.INP or your drainage records.

**** W56 readvar ** Inconsistency in irrigation data for node [nd] subr [nr]**

Sprinkling capacity from surface water is [c1] m³/d

No surface water defined in subcatchment; capacity set to 0.0

Check GIFT_NOD.INP or *gift_sub.inp*.

**** W57 readvar ** Inconsistency in irrigation data**

Sprinkling from aquitard (ly = [ly1]) for node [nd]

Set to aquifer below (ly = [ly2])

Abstraction of groundwater can only take place from an aquifer. Check GIFT_NOD.INP or *gift_sub.inp*.

**** W58 netanal ** Inconsistency in drainage structure**

**Upstream subcatchment [nr1] and downstream subcatchment [nr2]
are not neighbouring subcatchments**

Check GOTO_SIM.INP.

**** W59 netanal ** Inconsistency in drainage structure**

Upstream subcatchment [nr1] Surface water system = [sy1]

Downstream subcatchment [nr2] Surface water system = [sy2]

Check GOTO_SIM.INP and drainage records in belonging DRNG_NOD.INP.

A watercourse with a lower systemnumber cannot flow into a watercourse with a higher systemnumber

**** W60 netanal ** Inconsistency in drainage structure**

Subcatchment [nr] consists of more than one polygon

Check NDSB_SIM.INP. This is no problem for the model.

**** W61 netanal ** Inconsistency in drainage structure of subcatchment [nr]**

Depth of surface water system [sy1] = [dp1] m

Depth of surface water system [sy2] = [dp2] m

Check your drainage records.

Informative messages

Informative messages are intended to give information on the status of the program. It is wise to at least take notice after the first model run. The informative messages can be suppressed by specifying *ioptms* > 0 in PARA_SIM.INP, except for messages I28 to I31.

**** I01 contp ** The band width is [nc] for node [nd]**

The maximum number of contact points found is [nc] for node [nd].

**** I02 printe ** Total number of iterations = [it]**

Printed only at the end of a (succesfull) SIMGRO run.

**** I03 readpar ** Ready reading parameter file PARA_SIM.INP.inp**

**** I04 readt ** New input data at day = [dy] year = [yr]**

**** I05 readt ** New prescribed head (internal node)**
Layer = [ly] node = [nd] head = [h1] m

**** I06 readt ** New prescribed head (boundary)**
Layer = [ly] node = [nd] head = [h1] m

**** I07 readt ** Cancel prescribed head; layer = [ly] node = [nd]**

**** I08 readt ** New prescribed flux**
Layer = [ly] node = [nd] flux = [fl] m³/d

**** I09 readt ** Cancel prescribed flux; layer = [ly] node = [nd]**

**** I10 readt ** New discharge in subcatchment [nr] flux = [fl] m³/d**

**** I11 readt ** New water level surface water in subcatchment: [nr]**
Water level below soil surface = [d1] m

**** I12 readt ** Cancel prescribed water level in subcatchment = [nr]**

**** I13 readt ** New ground water time step= [dt] d**

**** I14 readt ** Plot of heads; layer = [ly]**

**** I15 readt ** New summer/winter weir level for subcatchment [nr]**
Old summer level [d1] old winter level [d2]
New summer level [d3] new winter level [d3]

**** I16 readvar ** Optional table [file name] not found**

**** I17 readvar ** Succesfully read non-time-dependent input for SIMGRO**

**** I18 readvar ** Line [line] of table [file name] default values:**
[var1] = [v1]
[var2] = [v2]

**** I21 readvar ** No inundation curve specified for node [nd]**

**** I22 readvar ** GOTO_SIM.INP not found**

```

All subcatchments discharge to boundary region
** I23 readvar ** GOTO_SIM.INP not specified for subcatchment [nr]
Subcatchment discharges to boundary subcatchment
** I24 SIMGRO ** Reading input data for SIMGRO

** I25 SIMGRO ** Reading input data for SIMGRO completed

** I26 SIMGRO ** Calculation at day : [dy] year : [yr]

** I27 SIMGRO ** Window in aquitard; layer number : [ly]

** I28 SIMGRO ** E N D O F S I M G R O
-----
** I29 SIMGRO ** Number of informative messages = [ni]
      Number of warnings      = [nw]
      Number of errors        = [ne]
** I30 SIMGRO ** List of informative messages, warnings and errors
      Code #
      [code1] [n1]
      [code2] [n2]
** I31 readvar ** [ne] errors found in non-time-dependent SIMGRO input
      Programme is discontinued

** I32 readvar ** [n1] errors found while reading NDSB_SIM.INP
[n1] errors are found in table NDSB_SIM.INP, forcing SIMGRO to discontinue the
execution immediately. Check all error messages.

```

Appendix 2 Reading binary output files

Several programs have been developed to read the binary output and to convert it to the desired format. The programs are described in the remainder of this paragraph. The programme has to be run with several arguments. The arguments are:

<dir> : directory
<key> : name of the key-file (plus extension)
<item> : name of the item as used in the key-file
<node/sub> : node number or sub-catchment number (depending on the binary file)
<layer> : layer number
<day> : day number (1..366)
<year> : year number (1900..2100)

binbda.exe

Programme for the conversion of the standard SIMGRO binary file to a direct access binary file.

The programme has to be executed with two arguments:

- binbda.exe <dir> <key>

For example a time series of the groundwaterlevels for node 30433 and layer 1:

```
binbda.exe d:\schieland\out\mis\basis\01\ hh.key
```

The programme reads the *.out-file and generates the file *.bda (**b**inary **d**irect **a**ccess).

read_bin.exe

The executable can only read a direct access databases. Standard the output of SIMGRO is **not** in direct access format. Therefore, a conversion has to be made. This can be done by using the conversion programme binbda.exe.

This programme can be used in two ways:

- To generate a time series;
- To generate a data series for the whole model area, for the specified item and specified time(s).

The following key-files can be read with read_bin.exe:

- hh.key
- gt.key
- sw.key
- dbndpsim.key/dbn DDSIM.key
- dbsbpsim.key/dbsb DSIM.key
- dblypsim.key/dbly DSIM.key

Time series

The programme has to be called with five arguments:

- `read_bin.exe <dir> <key> <item> <layer> <node/sub>`

For example a time series of the groundwaterlevels for node 30433 and layer 1:

```
read_bin.exe d:\schieland\out\mis\basis\01\ hh.key hh 1 30433
```

The generated text-file is written to the directory <dir> and the name of the text file is composed as follows:

- `<item>_<node/sub>_<layer>.txt`

The unit of the item as described in the key-file will be converted in the following case:

- reading the item **flowsw** from **sw.key** the unit will be converted from m^3/d to **m^3/s** .

The columns of the text file represent:

- `dd/mm/yyyy`
- value of item

Model area series

The programme has to be called with at least four arguments (when no period is specified all the periods of the tim-file are selected):

- `read_bin.exe <dir> <key> <item> <layer> (<day> <year>)^n`

Several day-year combinations can be specified.

For example for every node the mean leakage to root zone for day 273 and 274 of 1996:

```
read_bin.exe d:\schieland\out\mis\basis\01\ dbndpsim.key fliwlkrz 1 273.0 1996 274.0
1996
```

This programme generates a text file with the item information for the specified layer and the specified periods.

The generated text-file is written to the directory <dir> and the name of the text file is composed as follows:

- `<item>_<layer>.txt`

The columns of the text file represent:

- `dd/mm/yyyy`
- value of item

The units of the items as described in the key-file will be converted in the following case:

- from m^3/d to **mm/d** ;
- from m^3 to **mm** ;

The average for the item over the period(s) is presented in case of flux and storage terms. In case of levels, the values **at the end** of the specified periods are averaged.

read_gt.exe

This programme generates a text file with the mean lowest, the mean highest, the spring and the mean groundwater level (in Dutch abbreviated to GLG, GHG, GVG and GG). The characteristics for the freatic groundwater levels are calculated for all the nodes.

The programme has to be called with at least four arguments (when no period is specified all the periods of the tim-file are selected):

- read_gt.exe <dir> gt.key hhti(nd,1)

The groundwater heads should be available for a period of at least two years.

The generated text-file is written to the directory <dir> and the name of the text file is:

- gxg.txt

The columns of the text file represent:

- node number
- glg, the mean lowest groundwater level
- ghg, the mean highest groundwater level
- gvg, the spring groundwater level
- gt-group1 (new group)
- gt-group2
- gt-group3

The units are transformed from m+MSL to centimetres below soil surface.

read_balans.exe

This programme generates a text file with the (water balance) items out of the binary files. The programme calculates an average for the specified periods, the specified subareas and the specified layer.

The programme has to be called with five arguments:

- readbalans.exe <dir> <key> <file_nd_sb> <file_per> <file_lay>

For example the balances for the saturated zone:

```
readbalans.exe d:\schieland\out\mis\basis\01\ dblypsim.key wbn_d_gb.in wb_per.in  
wb_ly.in
```

The key-files that can be used are:

- dblypsim.key: water balance items for the saturated zone;
- wbn_dsim.key: water balance items for the root zone
- wbn_ssim.key: water balance items for the surface water

<file_nd_sb> : name of the file with the node or sub-catchment numbers and the balance areas (node_subcatchment nr, nr water balance area). Several water balance areas

can be specified. These areas may overlap (for instance one water balance area may be the total model area another one may be a part of the model area). Sub-catchments should be specified when using the file dbbpsim.key, nodes should be specified when using one of the files dblypsim.key or dbndpsim.key.

The format of this file is as follows (1 line comment, lines with the format 2I10);

```
**nodesub  area
   1      1
   2      1
   etc    etc
```

<file_per> : name of the file with the periods

Used are the **line numbers** of the periods in the tim-file, with the first period as line number 0.

The format of this file is as follows (1 line comment, lines with format I10);

```
**period (line numbers, period 1 is line number 0)
   0
   1
   2
   etc
```

<file_lay> : name of the file with the layer number. This file is only used when reading the keyfile dblypsim.key (water balances for the saturated zone).

The format of the file is as follows (1 line comment, lines with format I10);

```
**      layer
   1
```

The groundwater heads should be available for a period of at least two years.

The generated text-file is written to the directory <dir> and the name of the textile is:

- balansgb.txt

The output file for every specified water balance area looks like:

```
Nr wat. bal.area :      1
Number of nodes :    3950
Number of periods :     39
Number of layer :      1
Waterbalance area : 4210.5298 ha
Item      Dimension  Value  Description of variabel
-         -          -      -
-         -          -      -
etc       etc        etc    etc
```

The file with the water balances for the saturated zone, dblypsim, contains information for all of the nodes. The binary file for the root zone does not contain the water balance items for the border nodes.

The units of the water balance items are transformed to mm or mm d⁻¹. The (ground)water levels are averaged over the nodes without any weighting for the area of the nodes.

freq_hib.exe

This programme has been developed for the implementation of the stochast method. It generates a text file with the item information for the specified layer and the specified periods. The base information for the calculations are:

- a file with the probabilities of an event (combination of the initial situation, the amount of precipitation and the pattern of the precipitation)
- a table with the inundated area per event.

On base of this information a cumulative frequentional distribution is calculated for events with a certain reoccurrence time.

The programme has to be called with at least four arguments (when no period is specified all the periods of the tim-file are selected):

- freq_hib.exe < file_inun> <file_stoch > <file_reocc > <dir>

<file_inun> : filename table with the inundation area per stochast
<file_stoch> : filename table with the reoccurrence times per stochast
<file_reocc> : filename table with the reoccurrence times to calculate the inundated areas

The generated text-files are written to the directory <dir> and the names of the text files are:

- cumfr.txt : cumulative frequentional distribution (fitted)
- events.txt : selected events
- freq.txt : reoccurrence times per event