Editable Distributed Hydrological Model

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The Document and the EDHM Package

The Document

This document is the use guide for EDHM and some other concept about the hydrological models (**HM**) building. In Chapter 1 explain the basic concept of hydrological cycle and the important concept and idea of EDHM. In chapter 2 show the workflow of using a hydrological model with EDHM and the way to explain a new model. Chapter 3 and 4 show the basic information, e.g. input data, parameters and output data of every module or model.

EDHM

EDHM is a R package for hydrological models in order to simplify the models building, specially the distributed hydrological model. In the package contain many complete **MODEL** that can used directly, and many **MODULE** that can a new MODEL to building. All of the MODELs and MODULEs are build with matrix-arithmetic, that can good deal with the distributed situation. In the package there are many tools to calibrate the parameters or build a new MODEL or a new MODULE. The Package is only in GitHub published, for the first time use, please install the package EDHM and HMtools use the following code:

```
install.packages("devtools")
devtools::install_github("LuckyKanLei/HMtools")
devtools::install_github("LuckyKanLei/EDHM")
```

The summary of the Processes and Modules show in the following table:

PROCESS	MODULE
ReferenceET	[ReferenceET.Hargreaves](#ReferenceET.Hargreaves) | [ReferenceET.Linacre](#
ActualET	[ActualET.Gr4j](#ActualET.Gr4j) | [ActualET.Vic](#ActualET.Vic)
SNOW	[SNOW.17](#SNOW.17) | [SNOW.Ddf](#SNOW.Ddf)
BASEFLOW	[BASEFLOW.ARNO](#BASEFLOW.ARNO)
INTERCEPTION	[INTERCEPTION.Gash](#INTERCEPTION.Gash)
InfiltratRat	[InfiltratRat.GreenAmpt](#InfiltratRat.GreenAmpt)
Infiltration	[Infiltration.OIER](#Infiltration.OIER) | [Infiltration.SER](#Infiltration.SER)
RUNOFF	[RUNOFF.Gr4j](#RUNOFF.Gr4j) | [RUNOFF.OIER](#RUNOFF.OIER) | [RU
GROUNDWATER	[GROUNDWATER.Vic](#GROUNDWATER.Vic)
ROUTE	[ROUTE.G2RES](#ROUTE.G2RES) | [ROUTE.Gr4j](#ROUTE.Gr4j)

Chapter 1

Basic Concept

Before using of the EDHM it's very important to know the basic concept and primary idea about EDHM.

In EDHM the two mostly characters are **modularization** and **vectorization-arithmetic**, **modularization** focus on the coupling of the different *modules* of the hydrological *processes*, benefit by the modularization it's very convenience to change the method of process, what means the **editable** model; **vectorization-arithmetic** is very useful for the distributed hydrological model, it can greatly short the calculate time, especially when there are many grids (calculate units).

The water cycle of the Earth system and its variability at global, regional and local scales are influenced by a range of processes and mutual interactions, feedback mechanisms and as well as affected by anthropogenic processes.(**?**)

In EDHM a **PROCESS** is the mapping from those hydrological processes in a digital from, at the same time it's also the group (set) name of the some **MODULE**s those haven the same functions and same aims, and a **MODULE** is the definite method of a **PROCESS**, for example SNOW is PROCESS mapping the process that snow melting, accumulate and the state variety, SNOW.17 is then the true function that you can call in R, with the method by Andrson(**?**) forward.

Besides the PROCESS based on the hydrological processes, but sometimes a little different, due to the calculate factors in the lang time, some like *evapotranspiration* is a typical hydrological process, but in EDHM es is diveded into ReferenceET (reference evapotranspiration) and ActualET (actual evapotranspiration) two parts, because the most conceptual models calculate evapotranspiration in the two steps.

In the following section will show the meaning of hydrological processes and the mapped PROCESS.

MODEL is a coupled complete process with some subprocesses (also possible only one process), in EDHM is a true function to simulation the designed model with definite methods. It's also a set of **MODULE**s, those realize different process and correctly by the physical process.

The **VARIABLE** is the data those describe the state or character of the environment and the volume or character of water in different process. And in order to quickly find the VARIABLE and avoid the duplicate name of VARIABLE, the **GROUP** is like the folder of VARIABLE designed, for example in GROUP *Evatrans* (evapotranspiration) include the VARIABLEs *RET* (reference evapotranspiration), *AET* (actual evapotranspiration) and so on.

It can be summarized as:

MODULE = **PROCESS** × **Method**

MODEL = $\sum$ **MODULE**$_i$

VARIABLE are putted in the **GROUP**

1.1 Basic Concept of Hydrological Cycle

The hydrological cycle is composed of different components, which include evaporation from water surfaces and bare soil, evapotranspiration from vegetated land, transport of water vapour in the atmosphere, cloud droplet formation and cloud dynamics, the mechanisms leading to liquid and solid precipitation, the movement of water and change in soil moisture in the unsaturated soil, including root dynamics, surface and river run-off, and groundwater flow.(**?**)

Also from (**?**): A convenient term to denote the circulation of water from the sea, through the atmos- phere, to the land; and thence, with many delays, back to the sea by overland and subterranean routes, and in part by way of the atmosphere; also the many short circuits of the water that is re- turned to the atmosphere without reaching the see.

The whole cycle will spilt by the vertical layer in six layers which are Atmosphe, Snow, Canopy, Surface, Subsurface and Ground. There indeed are not the complete hydrological cycle components, limited by the first stage, in the first stage will focus on the conceptual models.

1.1.1 Atmosphere (Atmos)

In the Atmosphere major occur the process precipitation and part of the evapotranspiration, the concept of the evapotranspiration will show in section 1.1.3 in Canopy group.

Precipitation: As used in hydrology, precipitation is the discharge of water, in liquid or solid state, out of the atmosphere, generally upon a land or water surface. It is the common process by which atmospheric water becomes surface or subsurface water * * *. The term “precipitation” is also commonly used to designate the quantity of water that is precipitated. (Meinzer, 1923, p. 15.) Precipitation includes rainfall, snow, hail, and sleet, and is therefore a more general terr than rainfall.

Effective precipitation: 1. That part of the precipitation that produces runoff. 2. A weighted average of current and antecedent precipitation that is “effective” in correlating with runoff.(**?**)

The two most important forms of precipitation are rainfall and snowfall, the other form will not considered in general situation or simulation.

Rainfall: The quantity of water that falls as rain only. Not synonymous with precipitation.

Snowfall: A form of precipitation composed of ice crystals.

In this layer PROCESS PRECDicid and GROUP ***Prec*** show in the following Table:

Variable	Unit	Description
Precipitation	mm	Precipitation, summe of rain and snow
SnowFall	mm	Snow
RainFall	mm	Rain

And the typical meteorological data set ***MetData***

1.1.2 Snow

waterequivalent of snow: Amount of water that would be obtained if the snow should be completely melted. Water content may be merely the amount of liquid water in the snow at the time of observation. (Wilson, 1942a, p. 153-154.)

In this layer PROCESS SNOW and GROUP ***Snow*** show in the following Table:

Variable	Unit	Description
TAir	Cel	Average Air temperature in Timestep
TMax	Cel	Maximal Air temperature in one day
TMin	Cel	Minimul Air temperature in one day
Actual_vapor_press	mPa	Actual vapor press
RelativeHumidity	%	Relative Humidity, not greater than 100
WindSpeed	m/s	Average Wind Speed
WindH	m	The hight to mess the WindSpeed
SunHour	h	Sunshine duration in one day

Variable	Unit	Description
Ice_Volume	mm	Soild Ice Volume, not depth
Liquid_Volume	mm	Liquid Volume
SN17_ATI	–	–
SN17_HD	mm	–
Volume	mm	Summe Volume of Ice and liquid water, not depth

1.1.3 Canopy

Condensation: The process by which water changes from the vapor state into the liquid or solid state. It is the reverse of evaporation.(**?**)

Evaporation:The process by which water is changed from the liquid or the solid state into the vapor state. In hydrology, evaporation is vaporization that takes place at a temperature below the boiling point.(**?**)

Transpritation: The quantity of water absorbed and transpired and used directly in the bulling of plant tissue, in a specified time. It does not include soil evaporation. (After Blaney, I951a, p. 4.) The process by which water vapor escapes from the living plant, principally the leaves, and enters the atmosphere. As considered practically, transpiration also includes *guttation*. (Lee, 1949, p. 260.)

Evapotranspiration: Water withdrawn from a land area by evaporation from water surfaces and moist, soil and plant transpiration.(**?**)

Relative evaporation: The ratio of the rate of evaporation from a land or water surface in contact with the atmosphere, to the evaporativity under existing atmospheric conditions. It is the ratio of actual to potential rate of evaporation, generally stated as a percentage. (Derived from Meinzer, 1923, p. 14.) The opportunity for a given rate of evaporation to continue is determined by the available moisture supply. (Meyer, 1928, p. 244.)

Potential evaporation: Water loss that will occur if at no time there is a deficiency of water in the soil for use of vegetation. (Thornthwaite, 1944, p. 687.)

Interception: The process and the amount of rain or snow stored on leaves and branches and eventually evaporated back to the air. Interception equals the precipitation on the vegetation minus stem flow and throughfall (after Hoover, 1953, p. 1.)

In this layer PROCESS ReferenceET, ActualET, INTERCEPTION and GROUP ***Evatrans*** show in the following table:

Variable	Unit	Description
RET	mm	Reference evapotranspiration
EvaporationCanopy	mm	Evaporation from Canopy
AET	mm	Actual evapotranspiration
Transpiration	mm	Transpiration (water from Root layer of vegetation)
EvaporationLand	mm	Evaporation from Landsurface (sometimes cotain the Evaporation from Watersurfac

Intercept show in the following table:

Variable	Unit	Description
Interception	mm	Interception in Canopy

Canopy show in the following table:

Variable	Unit	Description
StorageCapacity	mm	Canopy Storage Capacity for Intercept and Evaporation from Canopy

And ***Aerodyna*** show in the following table:

Variable	Unit	Description
AerodynaResist	s/m	Aerodyna Resist
ArchitecturalResist	s/m	Architectural Resist
StomatalResist	s/m	Stomatal Resist

1.1.4 Surface (Runoff, Route)

Runoff: That part of the precipitation that appears in surface streams. It is the same as streamflow unaffected by artificial diversions, storage, or other works of man in or on the stream channels. Runoff may be classified as follows: Classification as to speed of appearance after rain- fall or snow melting: Direct runoff Base runoff Classification as to source: Surface runoff Storm seepage Groundwater runoff.

Surface runoff: That part of the runoff which travels over the soil surface to the nearest stream channel. It is also defined as that part of the runoff of a drainage basin that has not passed beneath the surface since precipitation. The term is misused when applied in the sense of direct runoff. See also, Runoff, Overland flow, Direct runoff, Groundwater runoff, and Surface water.

Direct runoff: The runoff entering stream channels promptly after rainfall or snowmelt. Superposed on base runoff, it forms the folk of the hydrograph of a flood. See also surface runoff. The terms base runoff and direct runoff are time classifications of runoff. The terms ground-water runoff and surface runoff are classifications according to source.(**?**)

Infiltration capacity: The maximum rate at which the soil, when in a given condition, can absorb falling rain or melting snow.(**?**)

Infiltration: The flow of a fluid into a substance through pores or small openings. It connotes flow into a substance in cont distinction to the word percolation, which connotes flow through a porous sub- stance.(**?**)

Overland flow: The flow of rainwater or snowmelt over the land surface toward stream channels. After it enters a stream, it becomes runoff.(**?**)

Streamflow: The discharge that occurs in a natural channel. Although the term discharge can be applied to the flow of a canal, the word streamflow uniquely describes the discharge in a surface stream course. The term "streamflow" is more general than runoff, as streamflow may be applied to dis- charge whether or not it is affected by diversion or regulation.(**?**)

Unit hydrograph The hydrograph of direct runoff from a storm uni- formly distributed ever the drain- age basin during a specified unit of time; the hydrograph is reduced in vertical scale to correspond to a volume of runoff o* 1 inch from the drainage basin. (After Am. Soc. Civil Engineers 1949, p. 105.)

In this layer PROCESS RUNOFF, ROUTE and GROUP ***Route*** show in the following table:

Variable	Unit	Description
WaterSource	mm	Water Source for Routing, sometimes the same Data with the Runoff
UHAll	–	All the UH data for all of the Grids for Routr with IUH
TypeGridID	–	The grids type for Routr with IUH
TransAll	–	All of the transform Matrix for all of the Grids for Routr with IUH
Store	mm	Store in the Route (for some Module)
Gr4j_UH1	–	UH form 1 only for Module ROUTE.Gr4j, made by the function
Gr4j_UH2	–	UH form 1 only for Module ROUTE.Gr4j
StaFlow	m3/s	Station Flow in the seted grid

And ***GeoData*** show in the following table:

Variable	Unit	Description
Latitude	deg	Latitude
Elevation	m	Elevation

1.1.5 Subsurface (Subsur)

Field-moisture capacity: The quantity of water which can be permarently retained in the soil in opposition to the downward pull of gnvity.(?)

Field-moisture deficiency: The quantity of water, which would be required to restore the soil moisture to field-moisture capacity.(?)

Field-moisture: Water diffused in the soil, the upper part of the zone of aeration from which water is discharged by the trans- piration of plants or by soil evap- oration. See Field-moisture ca- pacity and Field-moisture defi- ciency.

In this layer PROCESS InfiltratRat, Infiltration and GROUP ***Infilt*** show in the following table:

Variable	Unit	Description
Infiltration	mm	Infiltration
InfiltrationRat	mm	Infiltration Rate (for some INFITRATION Module)
InfiltrationRateMax	mm	Maximal Infiltration Rate (for some INFITRATION Module)

And ***SoilData*** show in the following table:

Variable	Unit	Description
Porosity	100%	Soil Porosity, not greater than 1
SaturatedConductivity	m/s	Soil Saturated Conductivity
Conductivity	m/s	Soil actual Conductivity
WettingFrontSuction	m/s	Wetting Front Suction

1.1.6 Ground

Base flow / runoff: Sustained or fair weather runoff. In most streams, base base flow is composed largely of ground water effluent. (Langbein and others, 1947, p. 6.) The term base flow is often used in the same sense as base runoff. However, the distinction is the same as that between stream flow and runoff. When the concept in the terms base flow and base runoff is that of the natural flow in a stream, base runoff is the logical term.

Groundwater: Water in the ground that is in the zone of saturation, from which wells, springs, and ground-water runoff are supplied. (After Meinzer, 1949, p. 38r,)

In this layer PROCESS GROUNDWATER and GROUP ***Ground*** show in the following table:

Except the above data GROUP, the ***TimeData*** describe the time information:

Variable	Unit	Description
MoistureVolume	mm	Moisture volume
MoistureCapacityMax	mm	Maximal Moisture Capacity
ZoneMoistureVolume	mm	Moisture volume, when the Ground is in more than one Layer divided
ZoneDepth	mm	Ground Depth, , when the Ground is in more than one Layer divided
BaseFlow	mm	Base Flow
MoistureCapacity	mm	Moisture Capacity
Depth	mm	Ground Depth
Overflow	mm	Overflow, when the caculated water volume greater than Capacity
Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divi

Variable	Unit	Description
NDay	–	Day nummer in one year

1.2 Important ELements of EDHM

In addition to the PROCESS, MODULE, MODEL there are also some other concept oabout EDHM, some like:

The arguments of a MODULE of include: **InData** and **Param**

InData is a list of all VARIABLE the MODULE needed, like previous section explained the VARIABLEs must putted in the GROUP.

Pram is the parameter list of all the empirical parameters (different as function arguments) of the MODULE.

You can check the MODULE needed VARIABLE (InData) and parameters (Param) with "Data_" + MODULE name in R, some like `Data_ReferenceET.Linacre` and the same time every Param give the suggested maximal and minimal value of the parameter in this MODULE.

You can also check the same content in the R Help windows with the MODULE name.

The output of the MODELUE have the similar structure like InData, the VARIABLE of **OutData** is also include in the “**Data_**” dataset.

The **Data_XXX** is a list that had added in EDHM package, the using about it will show in the next chapter.

Different from MODULE the input variable of MODEL will divided in to **TimeVariData** and **TimeInvariData**:

TimeVariData is the dataset of all VARIBLE those are variable in the time serie, e.g. *TAir*, *Precipitation* and other meteorological data.

TimeInvariData is the dataset of all VARIBLE those are invariable in the time serie, e.g. *Latitude*, *Elevation* and other geological and topography data.

The aim to the division is in order to convenient get the data of one time step. Actuly the most MODULE can only deal with on time step data, because the state is associated to the last time step, in the MODULE there are no timely loop, only in MODEL there is a loop.

But for some MODULE, those not contact with last time (e.g. all MODULE in PROCESS ReferenceET) or the full time data are known (e.g. ROUTE.G2RES), you can calculate the whole time series without loop.

Step is special unit in EDHM, in EDHM the time serise is divided into many equal time interval, one time interval is a *Step*, the other units are given by UCUM. The most VAERIABLE like a rate, tempo those unit should be in [mm/Step], will simplify as [mm].

Chapter 2

Model Use and Develop

2.1 MODEL / MODULE Structure or Concept

Essentially a MODULE or a MODEL is a function in R, so in R a function make up of **name**, **arguments** and **body**, except the output **return** is also very important.

The **name** of a MODULE composed of a PROCESS and Method, lik `ReferenceET.Hargreaves`; the **name** of a MODEL composed of "MODEL" and a model method, like `MODEL.CVIC`.

The **arguments** of MODULE and MODEL are fest in the form "InData, Param, …" for MODULE and "TimeVariData, TimeInvariData, Param, …" for MODEL, so for the data transfer it's very important to set the same structure as "Data_" dataset.

The **body** is the most important part of a function (MODULE or MODEL), generally it depended on the method.

The **OutData** (output) is also so important that not ignore, it must use the GROUP-VARIBLE type as InData.

Excepted, the reference and a data set, that make up of InData, Param and OutData can't be omitted, especially when the MODULE or MODEL are also for the other aviable.

2.2 Use Model with a MODEL or Run_MODEL

2.2.1 Check the InData list

2.2.2 Data Preparation

2.2.3 Evaluate

2.2.4 Calibrate

2.3 Copuling a new Model with MODULE

2.3.1 Choose MODULE

2.3.2 Set the Data-FLow

2.3.3 Build the MODEL and Run_MODEL

2.4 Design a new MODULE

2.4.1 Method and Formula

2.4.2 Coding the Inhalt

2.4.3 Set In/OutData and Parameter

Chapter 3

Basic Information of MODULEs

Overview of **MODULEs**

PROCESS	MODULE
ReferenceET	[ReferenceET.Hargreaves](#ReferenceET.Hargreaves) | [ReferenceET.Linacre](#ReferenceET
ActualET	[ActualET.Gr4j](#ActualET.Gr4j) | [ActualET.Vic](#ActualET.Vic)
SNOW	[SNOW.17](#SNOW.17) | [SNOW.Ddf](#SNOW.Ddf)
BASEFLOW	[BASEFLOW.ARNO](#BASEFLOW.ARNO)
INTERCEPTION	[INTERCEPTION.Gash](#INTERCEPTION.Gash)
InfiltratRat	[InfiltratRat.GreenAmpt](#InfiltratRat.GreenAmpt)
Infiltration	[Infiltration.OIER](#Infiltration.OIER) | [Infiltration.SER](#Infiltration.SER)
RUNOFF	[RUNOFF.Gr4j](#RUNOFF.Gr4j) | [RUNOFF.OIER](#RUNOFF.OIER) | [RUNOFF.SER]
GROUNDWATER	[GROUNDWATER.Vic](#GROUNDWATER.Vic)
ROUTE	[ROUTE.G2RES](#ROUTE.G2RES) | [ROUTE.Gr4j](#ROUTE.Gr4j)

3.1 ReferenceET

3.1.1 ReferenceET.Hargreaves

This MODULE reference to the Literature: Reference Crop Evapotranspiration from Temperature (**?**).

InData

Param

OutData

Return to the Overview of MODULEs.

Group	Variable	Unit	Description
MetData	TAir	Cel	Average Air temperature in Timestep
	TMax	Cel	Maximal Air temperature in one day
	TMin	Cel	Minimul Air temperature in one day
GeoData	Latitude	deg	Latitude
TimeData	NDay	–	Day nummer in one year

Paramter	Min	Max	Unit	Description
PeriodN	1	9999	–	The number of Step
GridN	1	9999	–	The nummber of effektive Grids

Group	Variable	Unit	Description
Evatrans	RET	mm	Reference evapotranspiration

3.1.2 ReferenceET.Linacre

This MODULE reference to the Literature: A simple formula for estimating evaporation rates in various climates, using temperature data alone (**?**).

InData

Group	Variable	Unit	Description
MetData	TAir	Cel	Average Air temperature in Timestep
	Actual_vapor_press	mPa	Actual vapor press
GeoData	Latitude	deg	Latitude
	Elevation	m	Elevation
TimeData	NDay	–	Day nummer in one year

Param

Paramter	Min	Max	Unit	Description
PeriodN	1	9999	–	The number of Step
GridN	1	9999	–	The nummber of effektive Grids

OutData

Group	Variable	Unit	Description
Evatrans	RET	mm	Reference evapotranspiration

Return to the Overview of MODULEs.

3.1.3 ReferenceET.PenMon

This MODULE reference to the Literature: Step by Step Calculation of the Penman-Monteith Evapotranspiration (FAO-56) (**?**).

InData

Group	Variable	Unit	Description
MetData	TAir	Cel	Average Air temperature in Timestep
	TMax	Cel	Maximal Air temperature in one day
	TMin	Cel	Minimul Air temperature in one day
	RelativeHumidity	%	Relative Humidity, not greater than 100
	WindSpeed	m/s	Average Wind Speed
	WindH	m	The hight to mess the WindSpeed
	SunHour	h	Sunshine duration in one day
GeoData	Latitude	deg	Latitude
	Elevation	m	Elevation
TimeData	NDay	–	Day nummer in one year

Param

Paramter	Min	Max	Unit	Description
PeriodN	1	9999	–	The number of Step
GridN	1	9999	–	The nummber of effektive Grids

OutData

Group	Variable	Unit	Description
Evatrans	RET	mm	Reference evapotranspiration

Return to the Overview of MODULEs.

3.2 ActualET

3.2.1 ActualET.Gr4j

This MODULE reference to the Literature: Improvement of a parsimonious model for streamflow simulation (**?**).

InData

Group	Variable	Unit	Description
Evatrans	RET	mm	Reference evapotranspiration
Ground	MoistureVolume	mm	Moisture volume
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

OutData

Return to the Overview of MODULEs.

Paramter	Min	Max	Unit	Description
Gr4j_X1	0.1	9.99	mm	NA

Group	Variable	Unit	Description
Evatrans	AET	mm	Actual evapotranspiration
Prec	Precipitation	mm	Precipitation, summe of rain and snow

3.2.2 ActualET.Vic

This MODULE reference to the Literature: none (**?**).

InData

Group	Variable	Unit	Description
Aerodyna	AerodynaResist	s/m	Aerodyna Resist
	ArchitecturalResist	s/m	Architectural Resist
	StomatalResist	s/m	Stomatal Resist
Canopy	StorageCapacity	mm	Canopy Storage Capacity for Intercept and Evaporation f
Evatrans	RET	mm	Reference evapotranspiration
Ground	MoistureVolume	mm	Moisture volume
	MoistureCapacityMax	mm	Maximal Moisture Capacity
Intercept	Interception	mm	Interception in Canopy
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
SoilMoistureCapacityB	0	0	–	–

OutData

Group	Variable	Unit	Description
Evatrans	EvaporationCanopy	mm	Evaporation from Canopy
	Transpiration	mm	Transpiration (water from Root layer of vegetation)
	EvaporationLand	mm	Evaporation from Landsurface (sometimes cotain the Evapo

Return to the Overview of MODULEs.

3.3 SNOW

3.3.1 SNOW.17

This MODULE reference to the Literature: National Weather Service river forecast system: snow accumulation and ablation model (**?**).

InData

Group	Variable	Unit	Description
MetData	TAir	Cel	Average Air temperature in Timestep
Snow	Ice__Volume	mm	Soild Ice Volume, not depth
	Liquid__Volume	mm	Liquid Volume
	SN17__ATI	–	–
	SN17__HD	mm	–
Prec	SnowFall	mm	Snow
	RainFall	mm	Rain
GeoData	Elevation	m	Elevation
TimeData	NDay	–	Day nummer in one year

Param

Paramter	Min	Max	Unit	Description
SN17__SCF	0.70	1.40	–	Snowfall correction factor
SN17__MFMAX	0.50	2.00	mm/6hCel	Maximum melt factor considered to occur on June 21
SN17__MFMIN	0.05	0.49	mm/6hCel	Minimum melt factor considered to occur on December 21
SN17__UADJ	0.03	0.19	mm/6hCel	The average wind function during rain-on-snow periods
SN17__NMF	0.05	0.50	mm/6hCel	Maximum negative melt factor
SN17__TIPM	0.10	1.00	–	Antecedent snow temperature index
SN17__PXTEMP	-2.00	2.00	Cel	Temperature that separates rain from snow
SN17__MBASE	0.00	1.00	Cel	Base temperature for non-rain melt factor
SN17__PLWHC	0.02	0.30	–	Percent of liquid–water capacity
SN17__DAYGM	0.00	0.30	mm/d	Daily melt at snow–soil interface
TimeStepSec	1.00	9999.00	s	Second pro Step

OutData

Group	Variable	Unit	Description
Snow	Ice__Volume	mm	Soild Ice Volume, not depth
	Liquid__Volume	mm	Liquid Volume
	SN17__ATI	–	–
	SN17__HD	mm	–
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Return to the Overview of MODULEs.

3.3.2 SNOW.Ddf

This MODULE reference to the Literature: none (**?**).

InData

Param

Group	Variable	Unit	Description
Ground	MoistureVolume	mm	Moisture volume
Snow	Volume	mm	Summe Volume of Ice and liquid water, not depth
Prec	SnowFall	mm	Snow
	RainFall	mm	Rain

Paramter	Min	Max	Unit	Description
Factor_Day_degree	0	0	–	–

OutData

Group	Variable	Unit	Description
Snow	Volume	mm	Summe Volume of Ice and liquid water, not depth
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Return to the Overview of MODULEs.

3.4 BASEFLOW

3.4.1 BASEFLOW.ARNO

This MODULE reference to the Literature: LARGE AREA HYDROLOGIC MODELING AND ASSESSMENT PART I: MODEL DEVELOPMENT (?).

InData

Group	Variable	Unit	Description
Ground	MoistureVolume	mm	Moisture volume
	MoistureCapacityMax	mm	Maximal Moisture Capacity

Param

Paramter	Min	Max	Unit	Description
ExponentARNOBase	0	0	–	–
ARNOBaseThresholdRadio	0	0	–	–
DrainageLossMax	0	0	–	–
DrainageLossMin	0	0	–	–

OutData

Group	Variable	Unit	Description
Ground	BaseFlow	mm	Base Flow

Return to the Overview of MODULEs.

3.5 INTERCEPTION

3.5.1 INTERCEPTION.Gash

This MODULE reference to the Literature: An analytical model of rainfall interception by forests (?).

InData

Group	Variable	Unit	Description
Canopy	StorageCapacity	mm	Canopy Storage Capacity for Intercept and Evaporation from Canopy
Evatrans	EvaporationCanopy	mm	Evaporation from Canopy
Intercept	Interception	mm	Interception in Canopy
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
CoefficientFreeThroughfall	0	0	–	–

OutData

Group	Variable	Unit	Description
Intercept	Interception	mm	Interception in Canopy
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Return to the Overview of MODULEs.

3.6 InfiltratRat

3.6.1 InfiltratRat.GreenAmpt

This MODULE reference to the Literature: Drainage to a water table analysed by the Green-Ampt approach (?).

InData

Group	Variable	Unit	Description
Ground	MoistureVolume	mm	Moisture volume
	Depth	mm	Ground Depth
SoilData	Conductivity	m/s	Soil actual Conductivity
	WettingFrontSuction	m/s	Wetting Front Suction
	Porosity	100%	Soil Porosity, not greater than 1

Param

Paramter	Min	Max	Unit	Description
GridN	1	9999	–	NA

OutData

Group	Variable	Unit	Description
Infilt	InfiltrationRat	mm	Infiltration Rate (for some INFITRATION Module)

Return to the Overview of MODULEs.

3.7 Infiltration

3.7.1 Infiltration.OIER

This MODULE reference to the Literature: none (**?**).

InData

Group	Variable	Unit	Description
Infilt	InfiltrationRat	mm	Infiltration Rate (for some INFITRATION Module)
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
InfiltrationRateB	0	0	–	–

OutData

Group	Variable	Unit	Description
Infilt	Infiltration	mm	Infiltration

Return to the Overview of MODULEs.

3.7.2 Infiltration.SER

This MODULE reference to the Literature: none (**?**).

InData

Param

OutData

Return to the Overview of MODULEs.

Group	Variable	Unit	Description
Ground	MoistureCapacityMax	mm	Maximal Moisture Capacity
	MoistureCapacity	mm	Moisture Capacity
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Paramter	Min	Max	Unit	Description
SoilMoistureCapacityB	0	0	–	–

Group	Variable	Unit	Description
Infilt	Infiltration	mm	Infiltration

3.8 RUNOFF

3.8.1 RUNOFF.Gr4j

This MODULE reference to the Literature: Improvement of a parsimonious model for streamflow simulation (**?**).

InData

Group	Variable	Unit	Description
Ground	MoistureVolume	mm	Moisture volume
Evatrans	AET	mm	Actual evapotranspiration
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
Gr4j_X1	0.1	9.99	mm	NA

OutData

Group	Variable	Unit	Description
Ground	Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divided
	MoistureVolume	mm	Moisture volume

Return to the Overview of MODULEs.

3.8.2 RUNOFF.OIER

This MODULE reference to the Literature: none (**?**).

InData

Param

Group	Variable	Unit	Description
Infilt	InfiltrationRateMax	mm	Maximal Infiltration Rate (for some INFITRATION Module)
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Paramter	Min	Max	Unit	Description
InfiltrationRateB	0	0	–	–

Group	Variable	Unit	Description
Ground	Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divid
Infilt	Infiltration	mm	Infiltration

OutData

Return to the Overview of MODULEs.

3.8.3 RUNOFF.SER

This MODULE reference to the Literature: none (**?**).

InData

Group	Variable	Unit	Description
Ground	MoistureCapacityMax	mm	Maximal Moisture Capacity
	MoistureVolume	mm	Moisture volume
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
SoilMoistureCapacityB	0	0	–	–

OutData

Group	Variable	Unit	Description
Ground	Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divid
Infilt	Infiltration	mm	Infiltration

Return to the Overview of MODULEs.

3.8.4 RUNOFF.Vic

This MODULE reference to the Literature: A new surface runoff parameterization with subgrid-scale soil heterogeneity for land surface models (**?**).

InData

Group	Variable	Unit	Description
Ground	MoistureCapacityMax	mm	Maximal Moisture Capacity
	MoistureVolume	mm	Moisture volume
Infilt	InfiltrationRat	mm	Infiltration Rate (for some INFITRATION Module)
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
SoilMoistureCapacityB	0	0	–	–
InfiltrationRateB	0	0	–	–

OutData

Group	Variable	Unit	Description
Ground	Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divided
Infilt	Infiltration	mm	Infiltration

Return to the Overview of MODULEs.

3.8.5 RUNOFF.VM

This MODULE reference to the Literature: none (**?**).

InData

Group	Variable	Unit	Description
Ground	MoistureCapacity	mm	Moisture Capacity
	MoistureCapacityMax	mm	Maximal Moisture Capacity
Infilt	InfiltrationRateMax	mm	Maximal Infiltration Rate (for some INFITRATION Module)
Prec	Precipitation	mm	Precipitation, summe of rain and snow

Param

Paramter	Min	Max	Unit	Description
SoilMoistureCapacityB	0	0	–	–
InfiltrationRateB	0	0	–	–

OutData

Group	Variable	Unit	Description
Ground	Runoff	mm	Runoff, it will be more wert, when the Runoff is in different form divided
Infilt	Infiltration	mm	Infiltration

Return to the Overview of MODULEs.

3.9 GROUNDWATER

3.9.1 GROUNDWATER.Vic

This MODULE reference to the Literature: none (?).

InData

Group	Variable	Unit	Description
Ground	ZoneMoistureVolume	mm	Moisture volume, when the Ground is in more than one
	ZoneDepth	mm	Ground Depth, , when the Ground is in more than one I
	BaseFlow	mm	Base Flow
Infilt	Infiltration	mm	Infiltration
Intercept	Interception	mm	Interception in Canopy
SoilData	Porosity	100%	Soil Porosity, not greater than 1
	SaturatedConductivity	m/s	Soil Saturated Conductivity

Param

Paramter	Min	Max	Unit	Description
GridN	1	9999	–	The nummber of effektive Grids

OutData

Group	Variable	Unit	Description
Ground	Overflow	mm	Overflow, when the caculated water volume greater than Ca
	ZoneMoistureVolume	mm	Moisture volume, when the Ground is in more than one Lay

Return to the Overview of MODULEs.

3.10 ROUTE

3.10.1 ROUTE.G2RES

This MODULE reference to the Literature: none (?).

InData

Group	Variable	Unit	Description
Route	WaterSource	mm	Water Source for Routing, sometimes the same Data with the Runoff
	UHAll	–	All the UH data for all of the Grids for Routr with IUH
	TypeGridID	–	The grids type for Routr with IUH
	TransAll	–	All of the transform Matrix for all of the Grids for Routr with IUH

Param

Paramter	Min	Max	Unit	Description
PeriodN	1	9999	–	The number of Step
GridN	1	9999	–	The nummber of effektive Grids

OutData

Group	Variable	Unit	Description
Route	StaFlow	m3/s	Station Flow in the seted grid

Return to the Overview of MODULEs.

3.10.2 ROUTE.Gr4j

This MODULE reference to the Literature: Improvement of a parsimonious model for streamflow simulation (**?**).

InData

Group	Variable	Unit	Description
Route	WaterSource	mm	Water Source for Routing, sometimes the same Data with the Runoff
	Store	mm	Store in the Route (for some Module)
	Gr4j_UH1	–	UH form 1 only for Module ROUTE.Gr4j, made by the function
	Gr4j_UH2	–	UH form 1 only for Module ROUTE.Gr4j

Param

Paramter	Min	Max	Unit	Description
Gr4j_X2	0.1	9.99	mm/Step	The catchment water exchange coe icient
Gr4j_X3	0.1	9.99	mm	The one-day maximal capacity of the routing reservoir
Gr4j_X4	1.0	9.99	mm/Step	The HU1 unit hydrograph time base
time_step_i	1.0	9999.00	–	The time Step index

OutData

Group	Variable	Unit	Description
Route	StaFlow	m3/s	Station Flow in the seted grid
	Store	mm	Store in the Route (for some Module)

Return to the Overview of MODULEs.

Chapter 4

Model

4.1 Report 16.4

PROCESS	MODULE
ReferenceET	[ReferenceET.Hargreaves](#ReferenceET.Hargreaves) | [ReferenceET.Linacre](#ReferenceET.Lina
ActualET	[ActualET.Gr4j](#ActualET.Gr4j) | [ActualET.Vic](#ActualET.Vic)
SNOW	[SNOW.17](#SNOW.17) | [SNOW.Ddf](#SNOW.Ddf)
RUNOFF	[RUNOFF.Gr4j](#RUNOFF.Gr4j) | [RUNOFF.OIER](#RUNOFF.OIER) | [RUNOFF.SER](#RU
ROUTE	[ROUTE.G2RES](#ROUTE.G2RES) | [ROUTE.Gr4j](#ROUTE.Gr4j)

4.1.1 Snowmelt

Type 1 **Temperature**

$$SM = (T - T_s) \times c_f$$

where SM is the snowmelt [mm] (of water), cf is the factor of melt [mm/Cel d], T is the mean air temperature [Cel], and T_s is a threshold temperature value [Cel].

Type 2 **Energy (radition)**

$$SM = \frac{ISR \times (1 - \alpha) + C_0 + C_1 \times T}{\rho \times L_f}$$

where α is the snow albedo, ISR is the incoming shortwave radiation [W/m2], C_0 and C_1 are factors accounting for the temperature-dependent energy fluxes ([W/m2] and [W/m2Cel], respectively), ρ is the density of snow [kg/m3], and L_f is the fusion latent heat [J/kg].

More information see the literarure (**?**)

4.2 Classical VIC

Chapter 3.1

Section

4.3 GR4J

Chapter 5

Final Words

We have finished a book.

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