How-to EUROSEM - Part 1.1

INTRODUCTION TO EUROSEM: MODEL HYSTORY, USE AND …. MISUSE

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What is EUROSEM

The European Soil Erosion Model (EUROSEM) is a dynamic distributed model, able to **simulate sediment transport, erosion and deposition** by rill and interill processes in single storms for both individual fields and small catchments. Model **output includes total runoff, total soil loss, the storm hydrograph and storm sediment graph**.

EUROSEM describes the terrain using **cascading planes and channels**, is distributed and physically based. Its hydraulics, despite being **limited to hortonian overland flows**, is based on good mathematics and numerical approximations.

EROSEM has been developed starting from the model structure of KINEROS (Woolhiser et al. 1990), but **implementing new erosion routines and equations** mainly developed in european research in the 80's and 90's

EUROSEM has been developed with Financial support from Directorate General XII and VI of the Commission of the European Communities in the period 1986-2001)

Why EUROSEM ?

Following objectives were set as requirements for an European soil erosion model (Chisci and Morgan, 1988).

It should:

(1) enable the risk of erosion to be assessed;

(2) be applicable to fields and small catchments;

(3) operate on an event basis;

and

(4) be useful as a tool for selecting soil protection measures.

A short hystory of EUROSEM

KINEROS
Woolhiser et al. 1990

Transition to EUROSEM (1992-1993)

EUROSEM
First stable release
(Morgan et al 1998)

KINEROS Model was used as a basis to develop EUROSEM (Morgan et al., 1998).

In EUROSEM many erosion routines and equations substituted the original KINEROS. with other, giving preference to European scientific production.

EUROSEM continued to be developed until 2002 thanks to a series of European funded projects.

KINEROS2
Smith et al. 1999

Mwised project
(1998-2001)
EUROSEM 4.0 (beta)
EUROWISE
LISEM

A short hystory of EUROSEM

The European Soil Erosion Model (EUROSEM) is a joint effort of many European scientists:

J. Albaladejo Montoro, V. Andreu, K. Auerswald, P. Bazzoffi, W. Blum, Boiffin, H.R. Bork, P. J. Botterweg, V. Castillo, J.A. Catt, G. Chisci, B. Diekkrüger, W. Everaert, A. Folly, S. Giakoumakis, G. Govers, B. Hasholt, A.J. Johnston, E. Klaghofer, Y. Le Bissonnais, G. Monnier, R.P.C. Morgan, J. Nachtergaele, T. Panini, J.W.A. Poesen, J.N. Quinton, R.J. Rickson, J.L. Rubio, V. Sardo, , R.E. Smith, P. Strauss, M.E. Styczen, D. Torri, G. Tsakiris, R. Webster, M. Vauclin,. .. **And many others**.

Application of EUROSEM

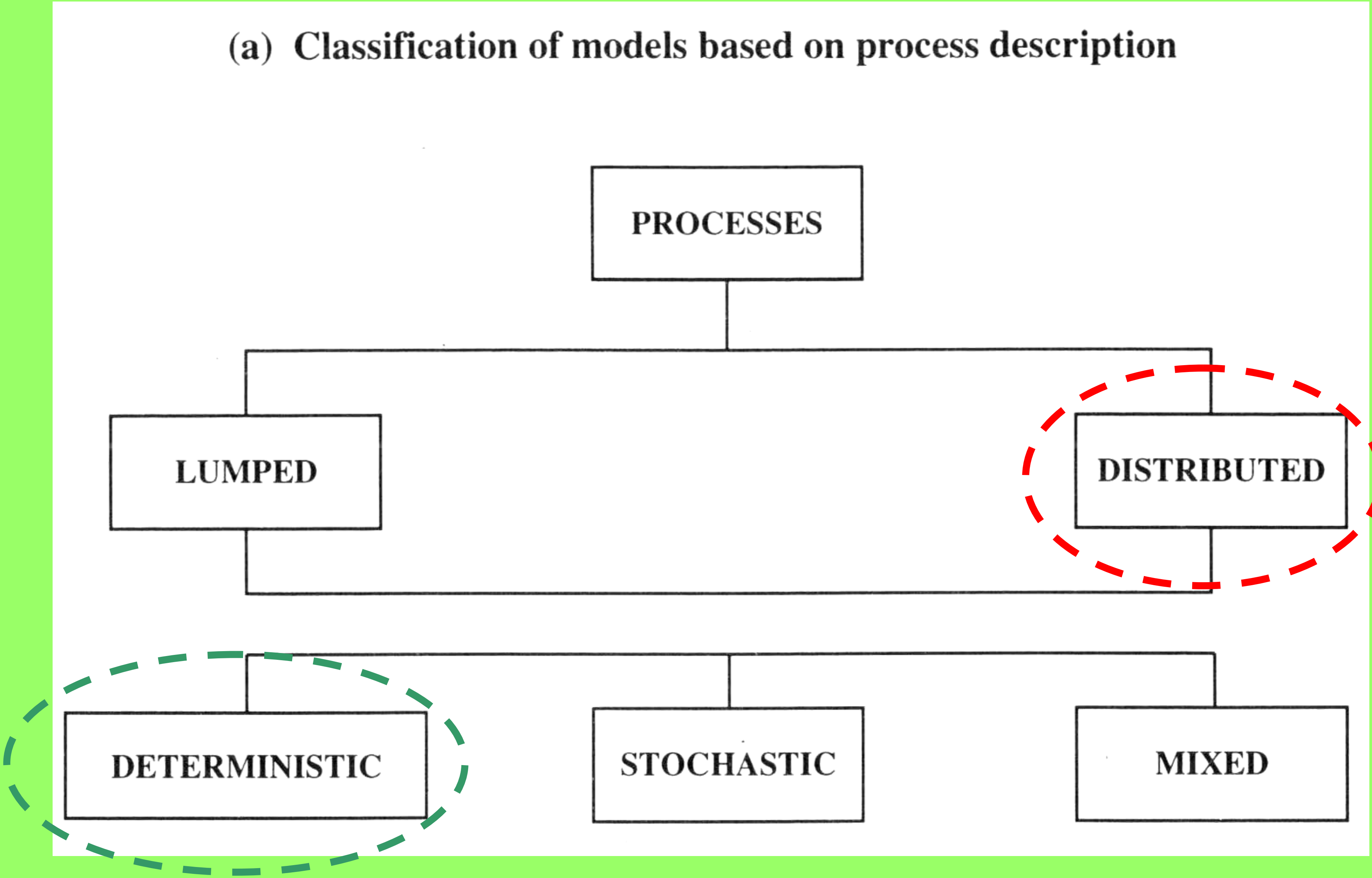
Assessment or erosion risk in plots, fields and small catchments (<100 ha);

Operate on an event basis: single storm or a succession of storm

(no evapotranspiration, hence no time continuity)

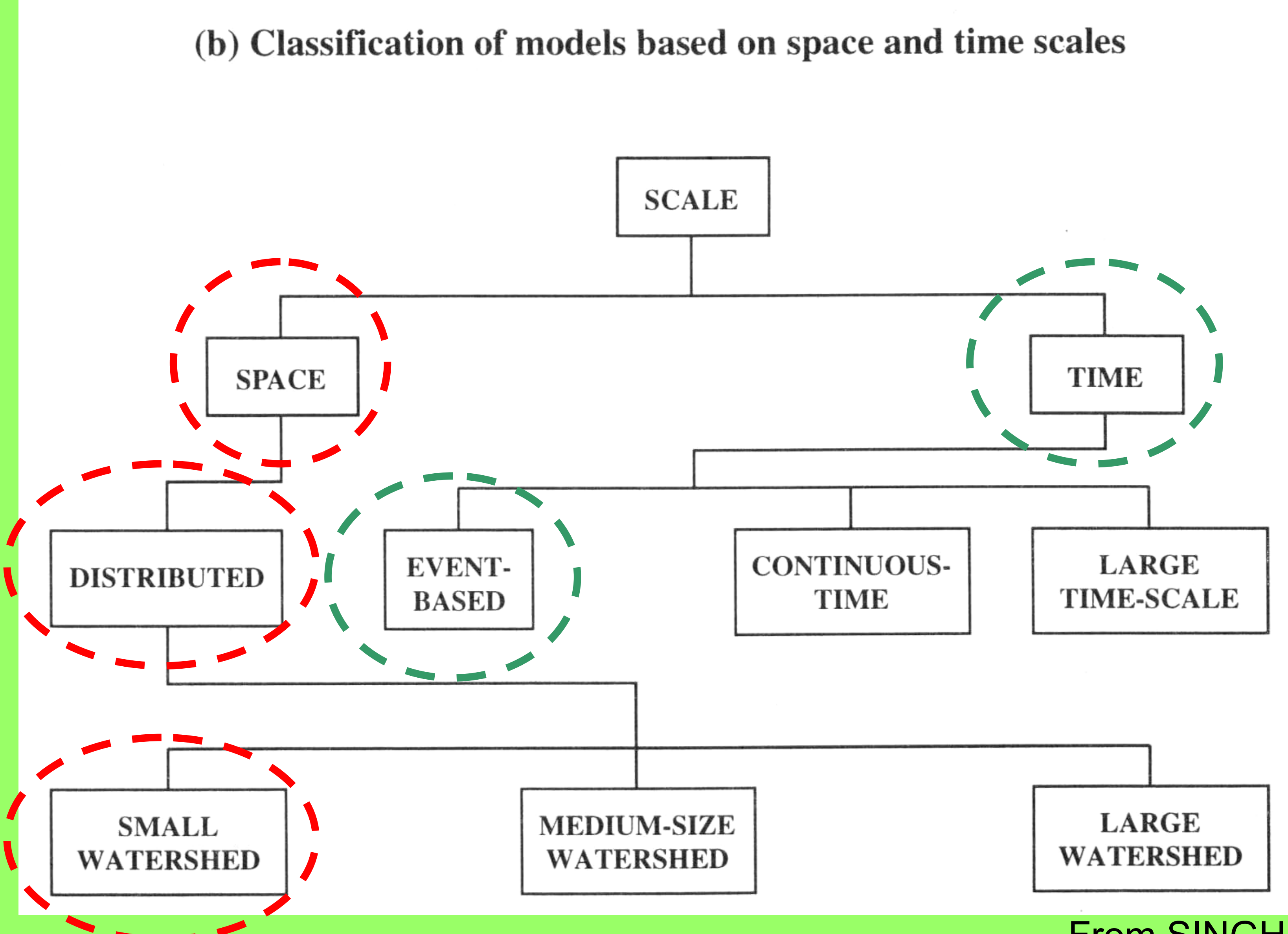
Tool for selecting soil protection measures via scenario analysis;

Eurosem an other soil erosion models



From SINGH (1995)

Eurosem an other soil erosion models



From SINGH (1995)

EUROSEM has a modular structure.

EUROSEM can be classified as a Distributed – Event based – Deterministic model

The model deals with:

· the interception of rainfall by the plant cover;
· the volume and kinetic energy of the rainfall reaching the ground surface as direct throughfall and leaf drainage;
· the volume of stemflow;
· the volume of surface depression storage;
· the detachment of soil particles by raindrop impact and by runoff;
· sediment deposition; and
· the transport capacity of the runoff.

Algorithms also deal with and stoniness. Attempts were also made for adding frozen soils

Main model structure

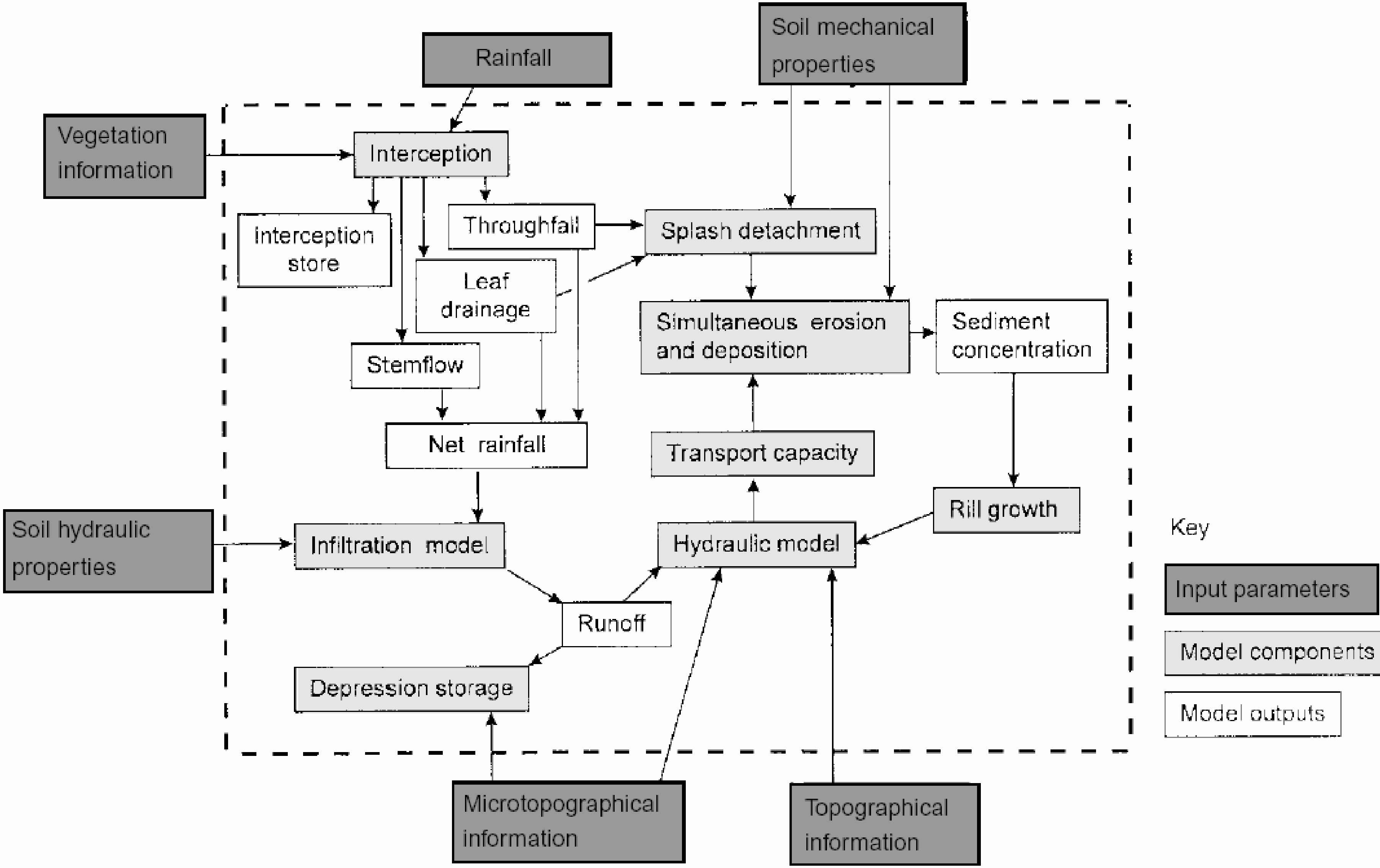
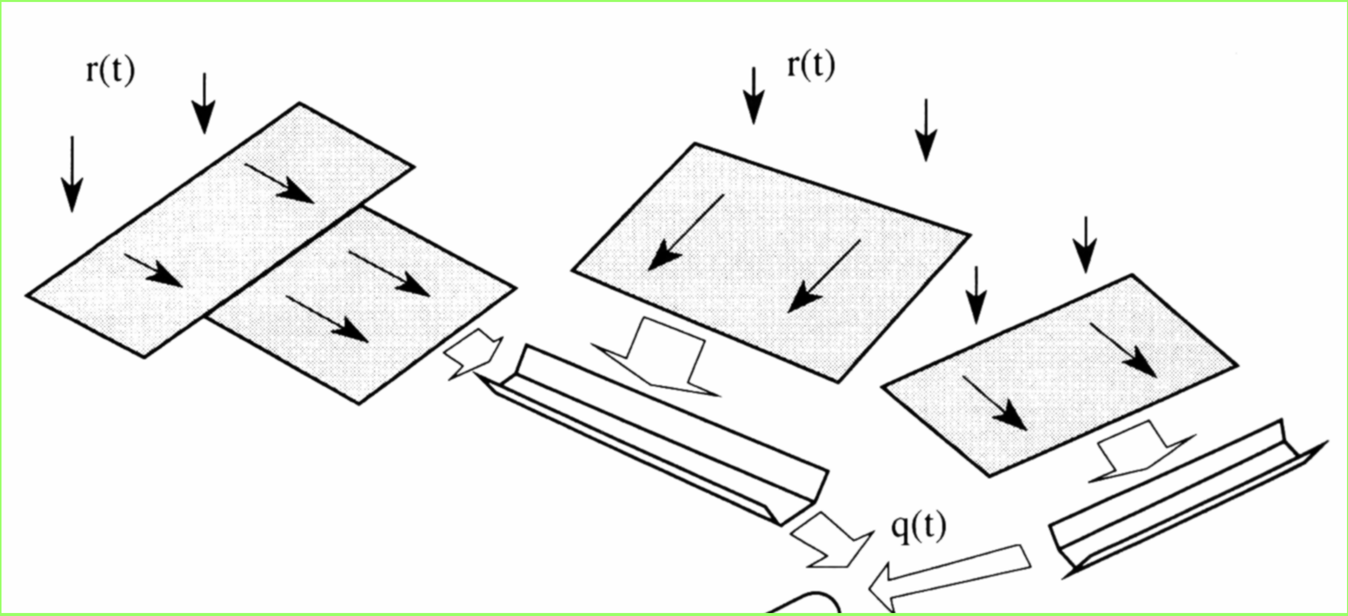


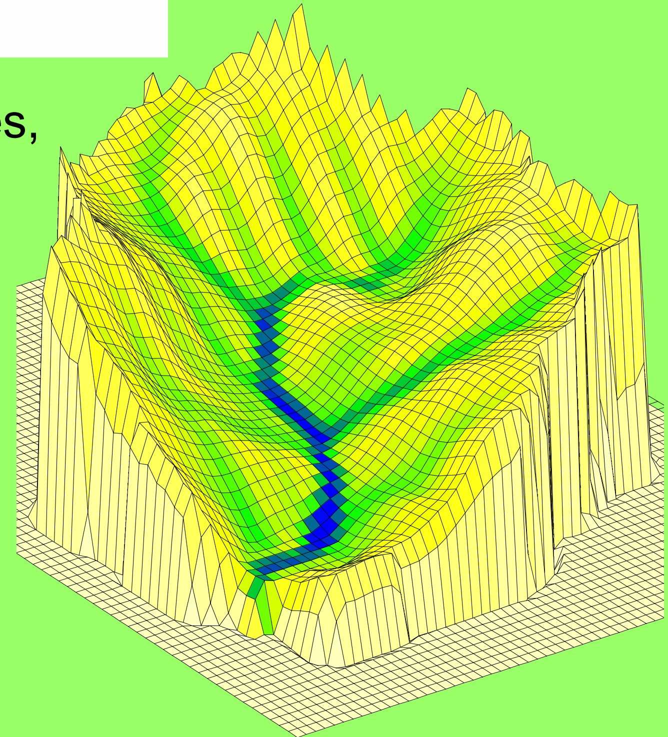
Figure 1. Flow chart of EUROSEM

From Morgan et al. 1998

Geometrical representation on terrain in EUROSEM



Conceptual representation - through a cascade of planes, and channels



DISTRIBUTED MODELS

Raster representation

Geometrical representation of terrain: planes and channels

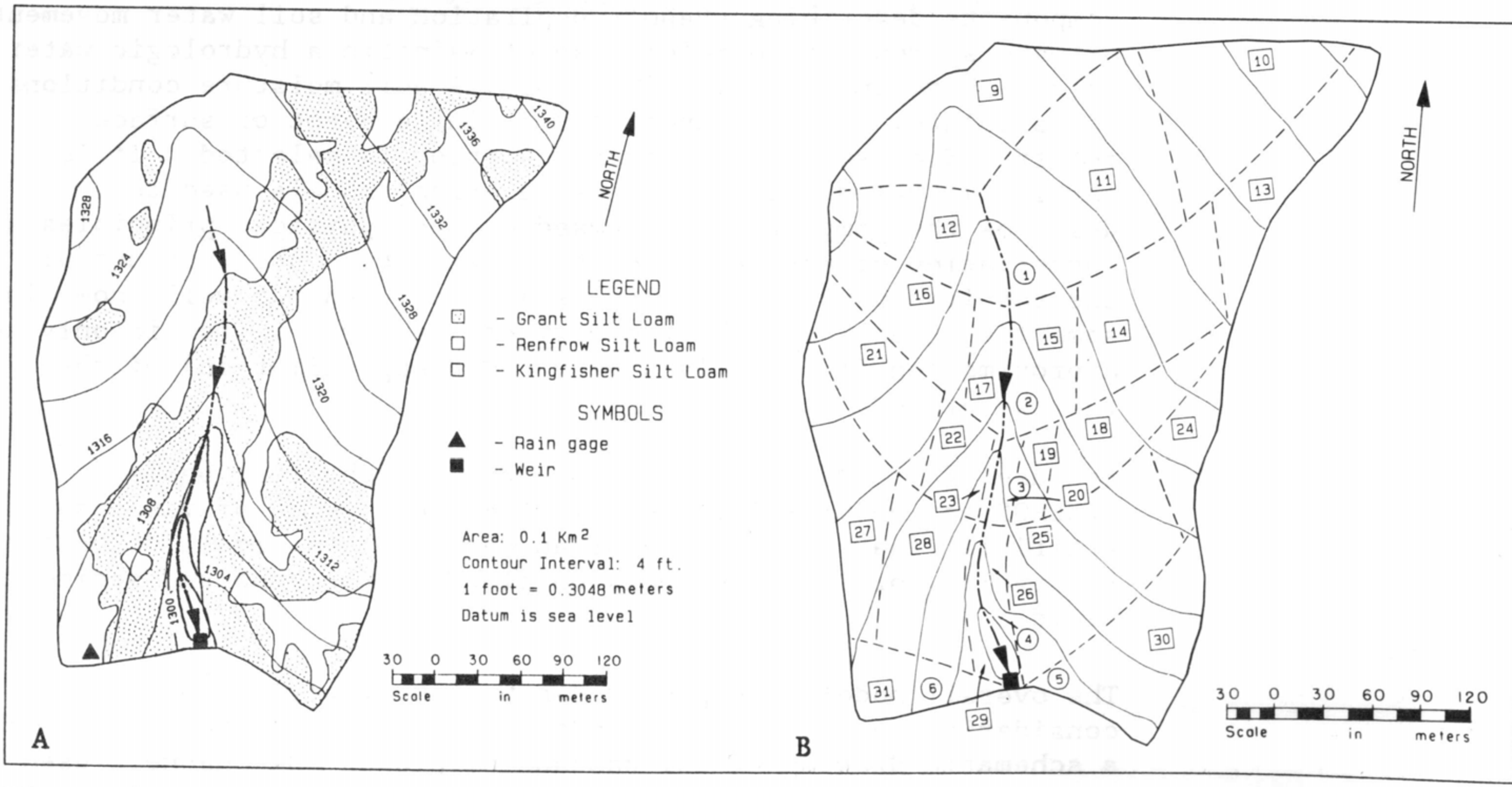


Figure 1.
R-5 catchment, Chickasha, OK: A, contour map; B, division into plane and channel elements.

From KINEROS manual (Woolhiser et al. 1990)

Geometrical representation on terrain in of EUROSEM planes and channels

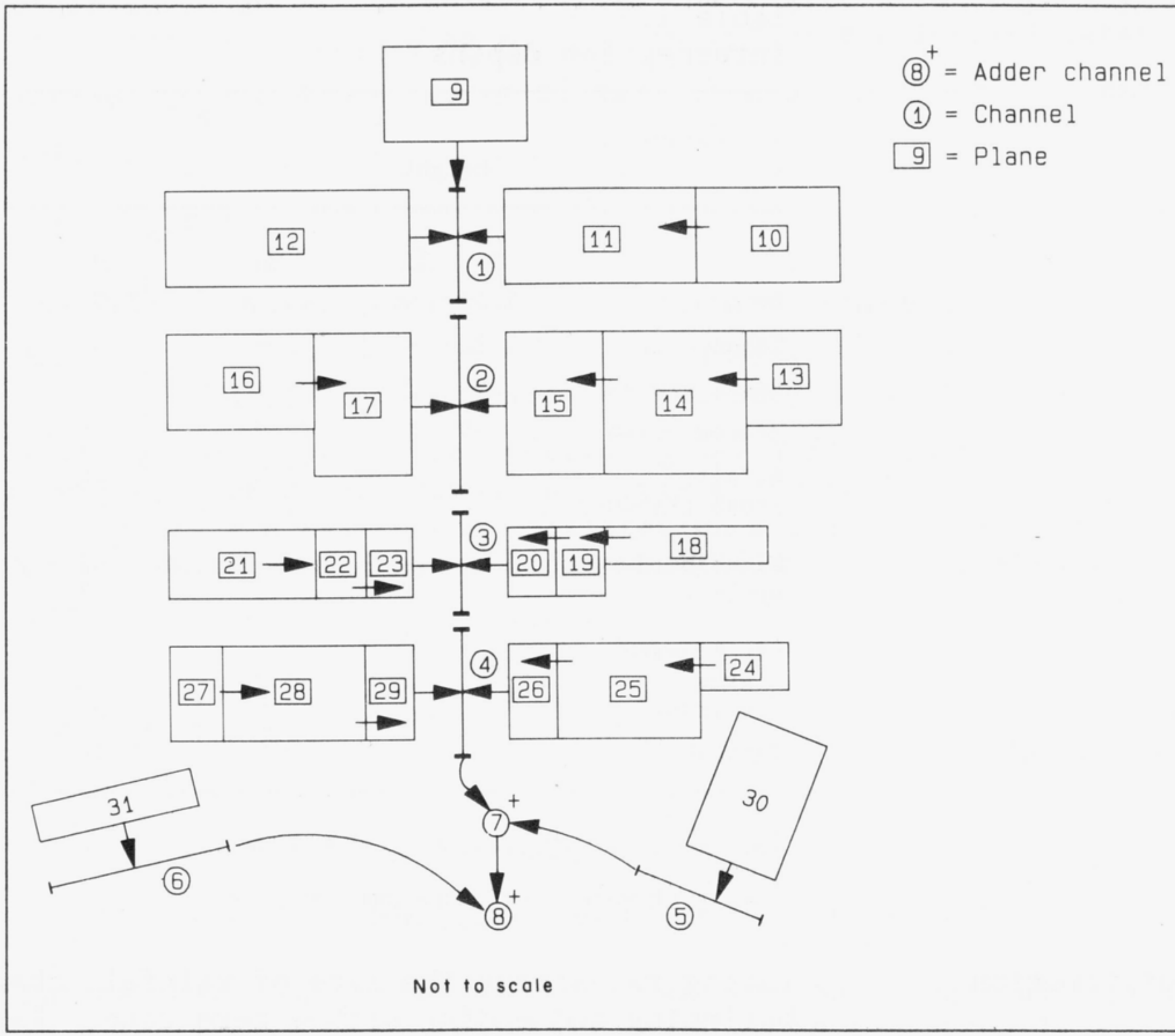
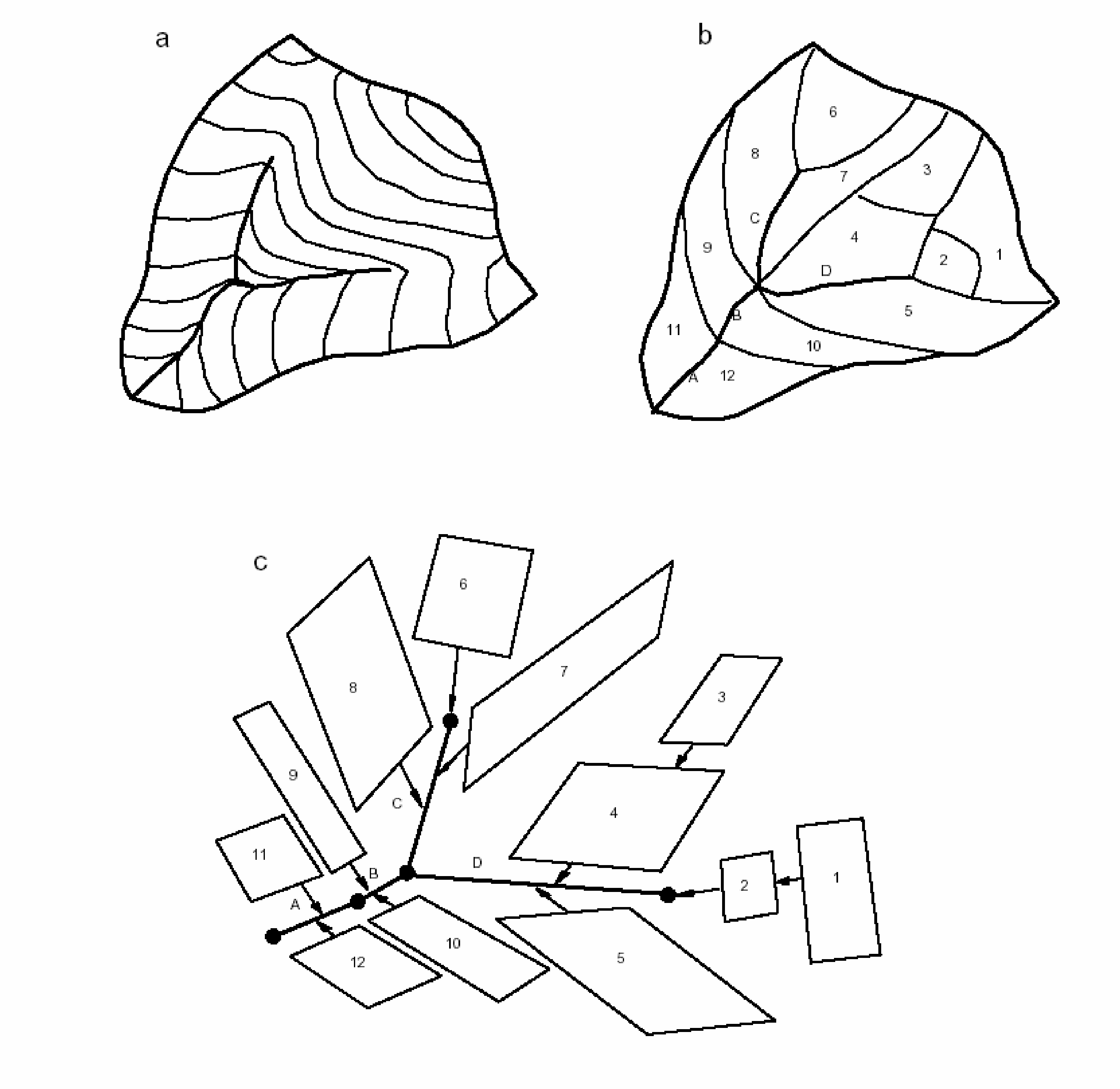


Figure 2.
Schematic of R-5 plane and channel configuration.

From KINEROS manual (Woolhiser et al. 1990)



Small wathersheed representation

Major known limits of application or EUROSEM (release 1998-99)

•Unable to generate rills/gully from a unrilled overland flow plane!
•Within storm soil surface dynamics is not considered !
(e.g. Soil crusting and sealing , Change of Ksat and porosity)
•One soil layer infiltration modelling!
•Only One infiltration model!
•Many other ….

Performance limits

•Long term simulation with Multiple storms are difficults
•Present stable version does not have a friendly User Interface

The last EUROSEM evolution: Mwised Project (1998-2001)

Achievements

Models:

•EUROSEM4win: erosion model (Delphi environment) Release 4.0 (beta)

•EUROWISE: erosion model (PCRaster environment – it is part of LISEM)

•RAINGEN 1: rainfall generator (C++, Fortran 90)

•SEI: pedofunctions-algorithms for estimating soil characteristics (JAVA applet)

New parts implemented in models

in erosion models:

•Ephemeral gully generation

•Ephemeral gully erosion

in RAINGEN 1

•scaling model with time dependent scaling factor

in Pedon-SEI

•water retention curves

•saturated hydraulic conductivity

•net capillary drive

Contribution to know-how: *ephemeral gully erosion – shaping new channel – alternative to Manning equation - dynamics of ponded areas in interrill – sealing thickness prediction and evolution – new algorithms for detachability-variable Ks and porosity etc.. (see –MWISED final report)*

Possible MISUSES of EUROSEM

- **Simulation on too large wathersheed >10-100 ha**
- **Simulation of too long storm when soil surface dynamics has a strong evidence**
- **Runoff and erosion controlled by tractor tracks or tillage direction non parallel to slope aspect direction**
- **Non-hortonian runoff (saturated runoff generation)**
- **Gully landscape (present version)**

EUROSEM SOFTWARE

Freeware and free use (no warranties – but see licence terms)

It can be downloaded, with documentation (PDF manual) and example files at no cost, at the following site:
http://www.silsoe.cranfield.ac.uk/nsri/research/erosion/download_dos.htm

Eurosem (EURO.EXE) operate with a very rough command line and text interface (DOS like console in all Windows OS - Win98/ME/NT/2000/XP)
Present officiale stable version has only text files as output.

But…

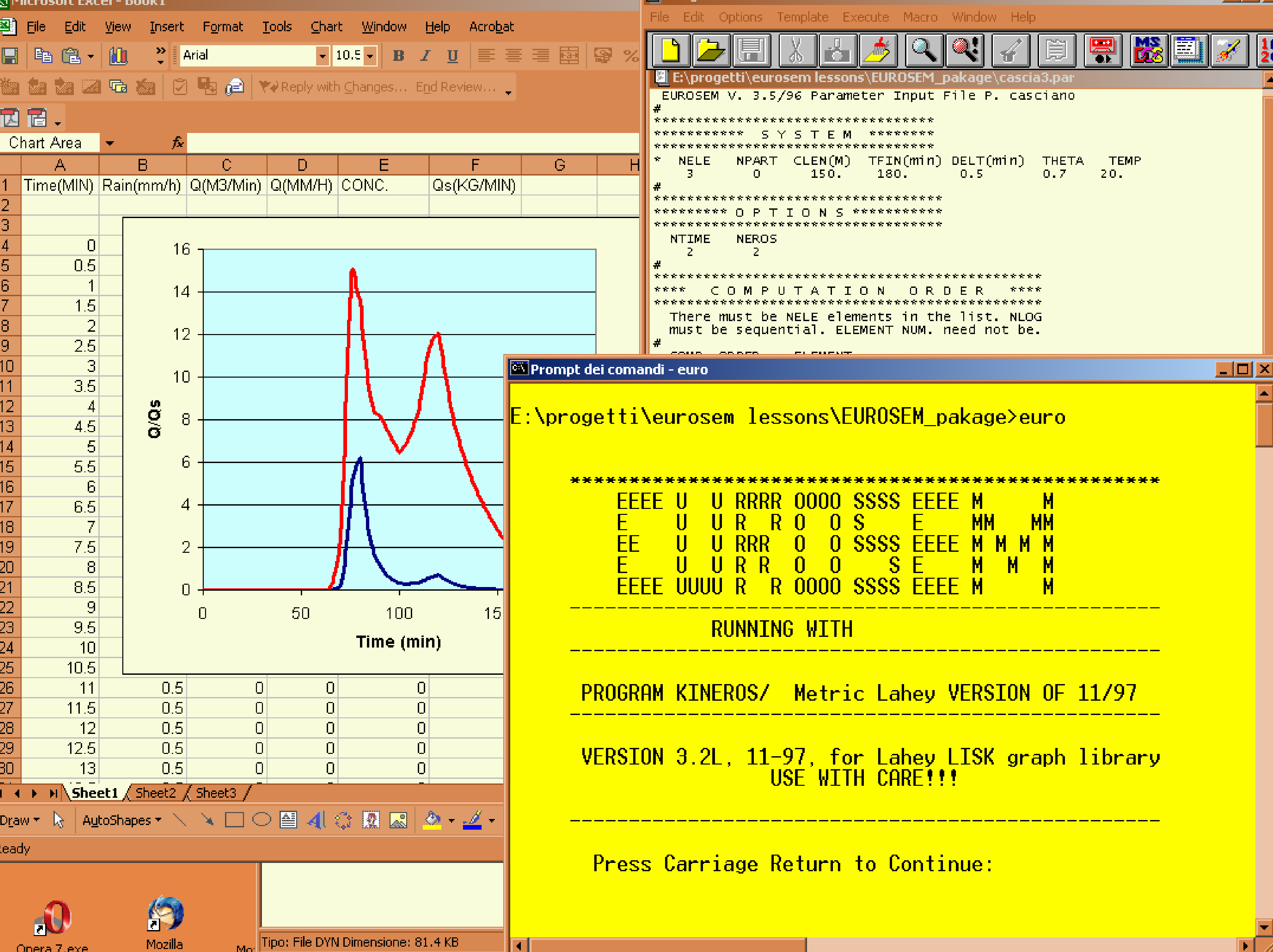

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Chart Area
Time(MIN) Rain(mm/h) Q(M3/Min) Q(MM/H) CONC. Qs(KG/MIN)
Q/Qs
Time (min)
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EUROSEM
RUNNING WITH
PROGRAM KINEROS/ Metric Lahey VERSION OF 11/97
VERSION 3.2L, 11-97, for Lahey LISK graph library
USE WITH CARE!!!
Press Carriage Return to Continue:

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EUROSEM HYDROLOGIC COMPONENT

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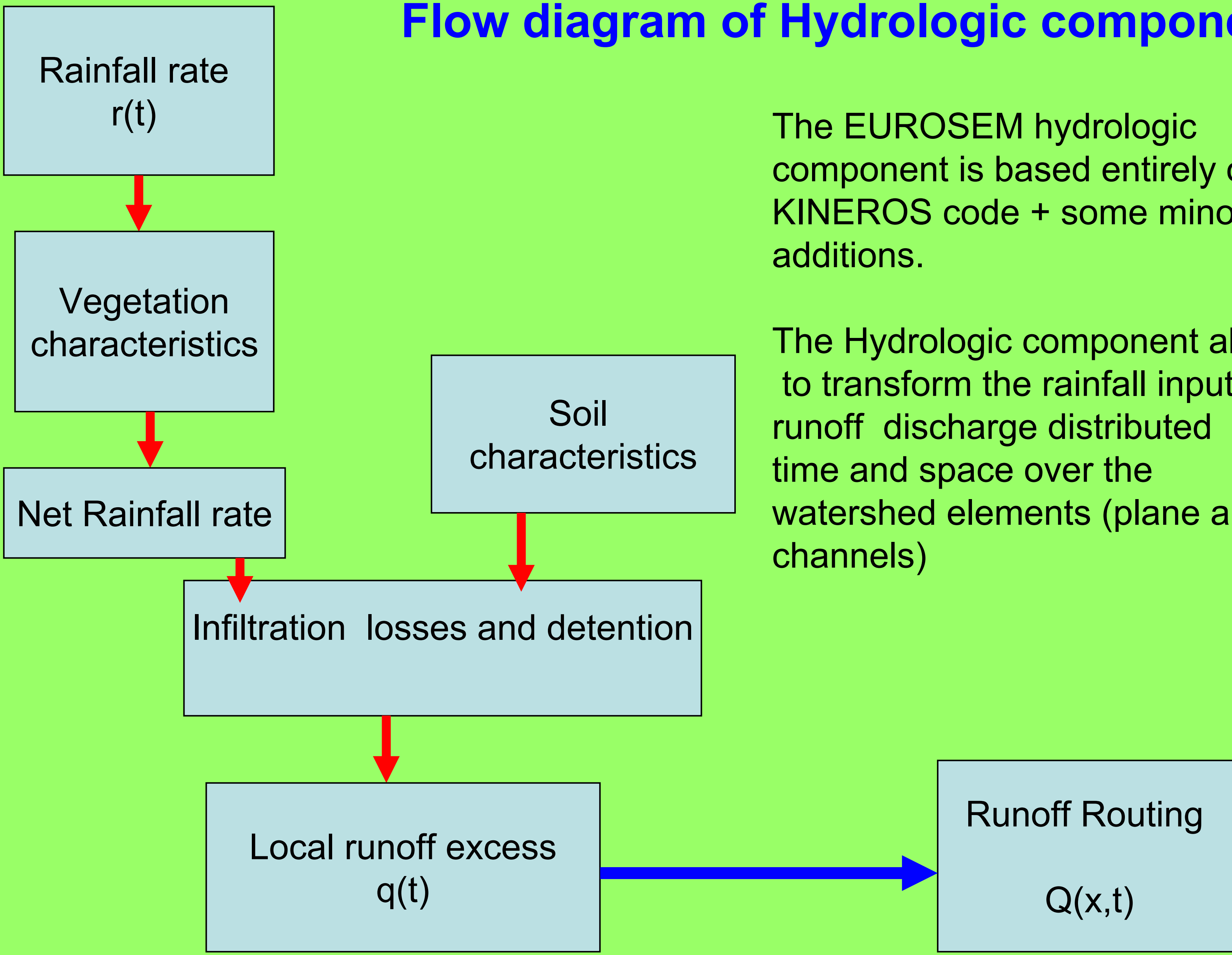
Flow diagram of Hydrologic component



The EUROSEM hydrologic component is based entirely on KINEROS code + some minor additions.

The Hydrologic component allows to transform the rainfall input in runoff discharge distributed in time and space over the watershed elements (plane and channels)

Rainfall input

t (h)	P(mm)	dt (h)	i(mm/h)	Pcum(mm)
10.00	0.00	0.00	0.00	0.00
10.66	2.60	0.66	3.94	2.60
12.00	3.00	1.34	2.24	5.60
12.33	2.00	0.33	6.06	7.60
13.00	0.20	0.67	0.30	7.80
13.33	0.80	0.33	2.42	8.60
14.00	0.00	0.67	0.00	8.60
14.66	0.80	0.66	1.21	9.40
15.40	3.00	0.74	4.05	12.40
16.00	5.60	0.60	9.33	18.00
16.33	7.00	0.33	21.21	25.00
17.66	1.80	1.33	1.35	26.80
18.00	0.00	0.34	0.00	26.80
18.40	0.40	0.40	1.00	27.20
19.00	4.40	0.60	7.33	31.60
19.33	12.20	0.33	36.97	43.80
20.00	3.40	0.67	5.07	47.20
21.00	0.00	1.00	0.00	47.20

Informatio used by EUROSEM

Old type of rain gauge with graphical recorder

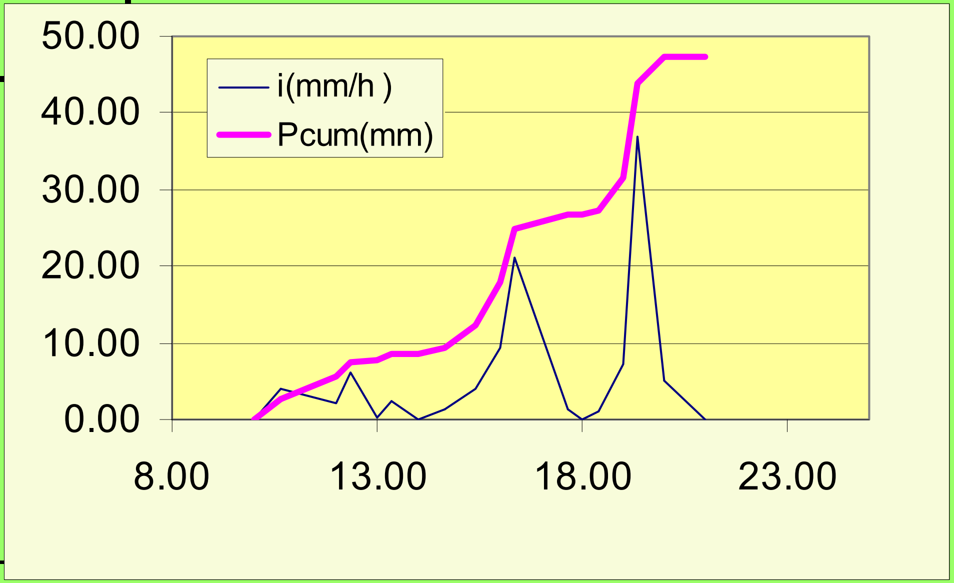
t=time (h)

dt= time step (h)

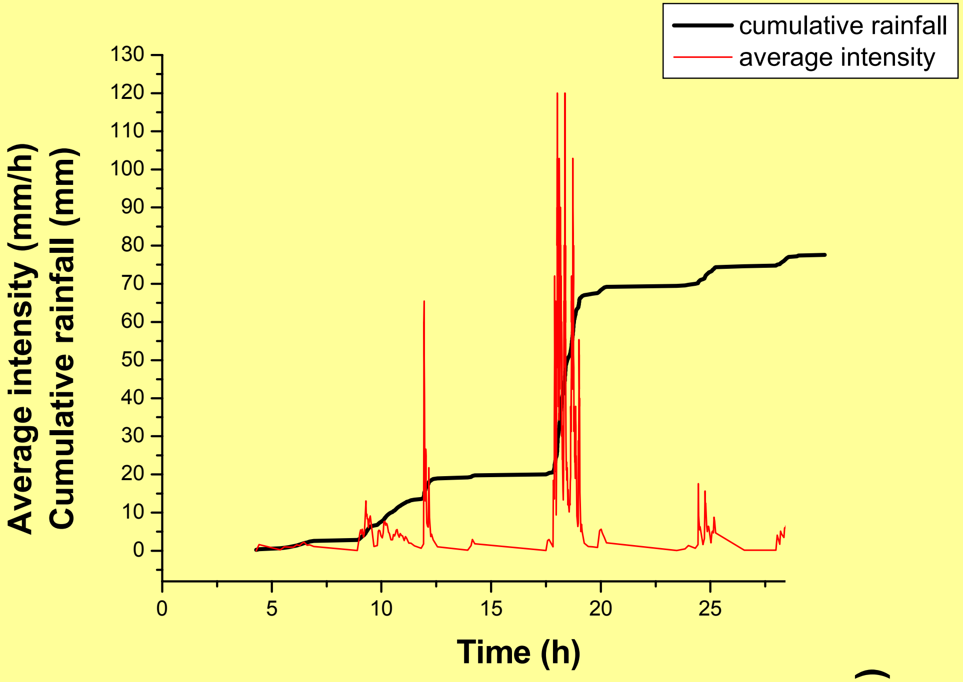
P= amount of rainfall in time step (mm)

i=average intensity in time step(mm/h)

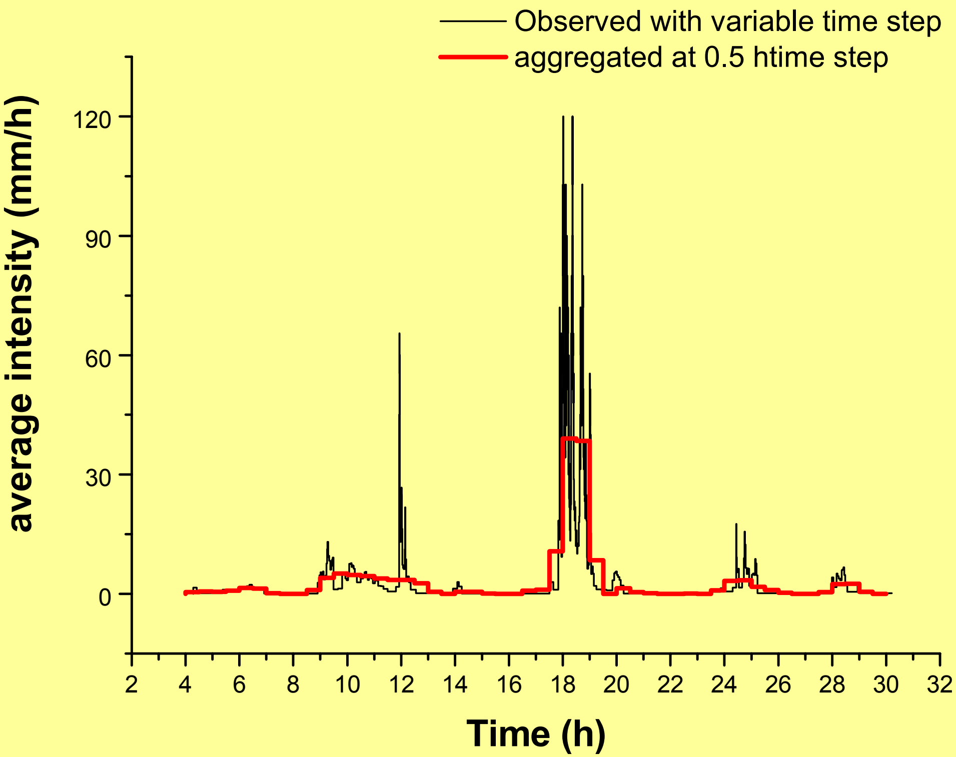
Pcum= cumulayive rainfall (mm)



Rainfall input



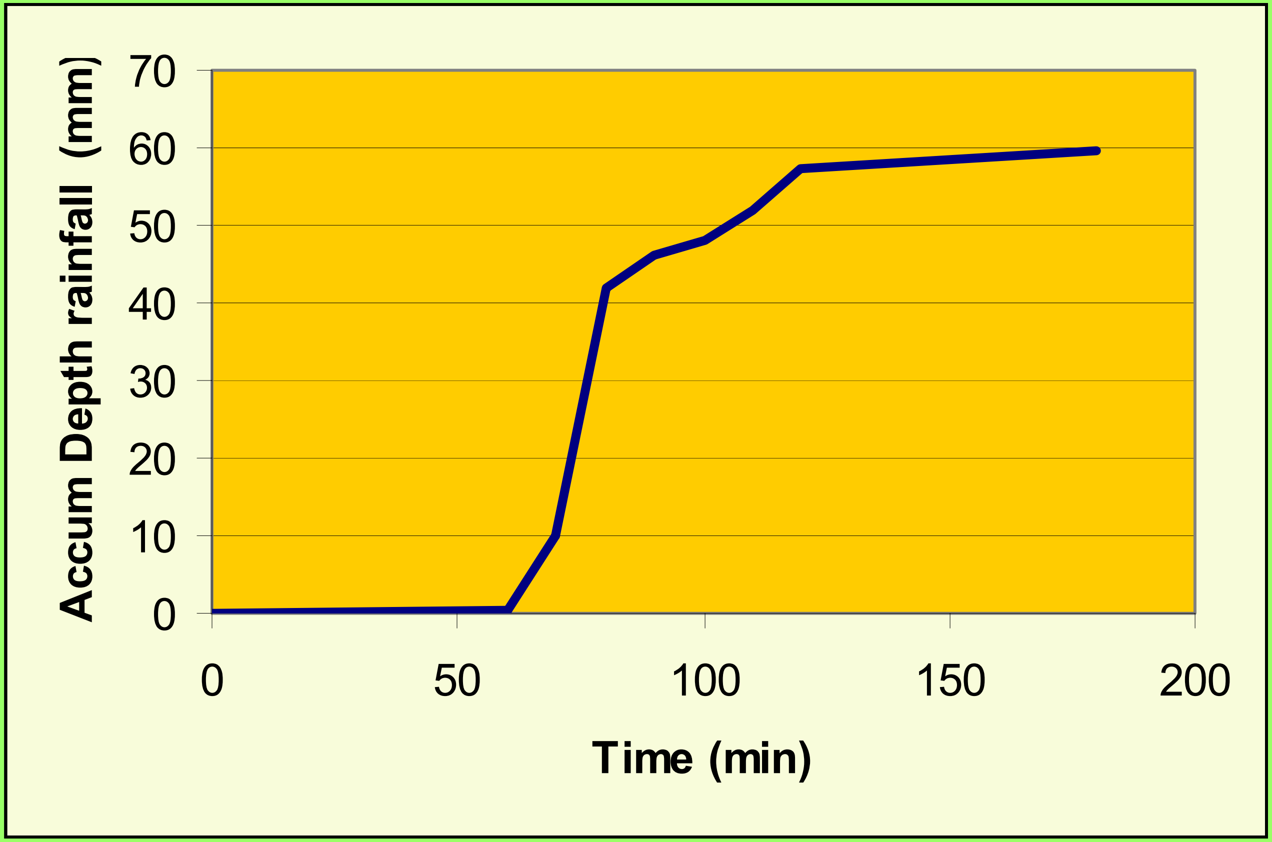
Rain gauge with high resolution digital recording



Effect of time step aggregation on the computation of rainfall intensity

Rainfall input …
As read by EUROSEM

TIME (min)	ACCUM. DEPTH (mm)
------	------------
0.0	0.0
60.0	0.5
70.0	10.0
80.0	42.0
90.0	46.0
100.0	48.0
10.0	52.0
120.0	57.5
180.0	59.5
200.0	59.5



Basic storm informations are defined for (each raingauge) as:
Accumulated depth (mm) over time (min).
The time step may be variable but it has a strong influence on average rainfall intensity computation r(t)

From Rainfall

the rainfall amount that is intercepted by canopy is subtracted to rain and distributed between plant storage and stem flow.
Plant storage is dynamic because it re-drip drops while it is refilled by rainfall.

The net rainfall at the ground surface, which is therefore available for infiltration, is the summation of the direct throughfall (DT), stemflow (SF) and leaf drainage(LD) minus interception (IC).

$$LD = TIF - SF$$

$$NR = DT + LD + SF = R - Ic_{stor}$$

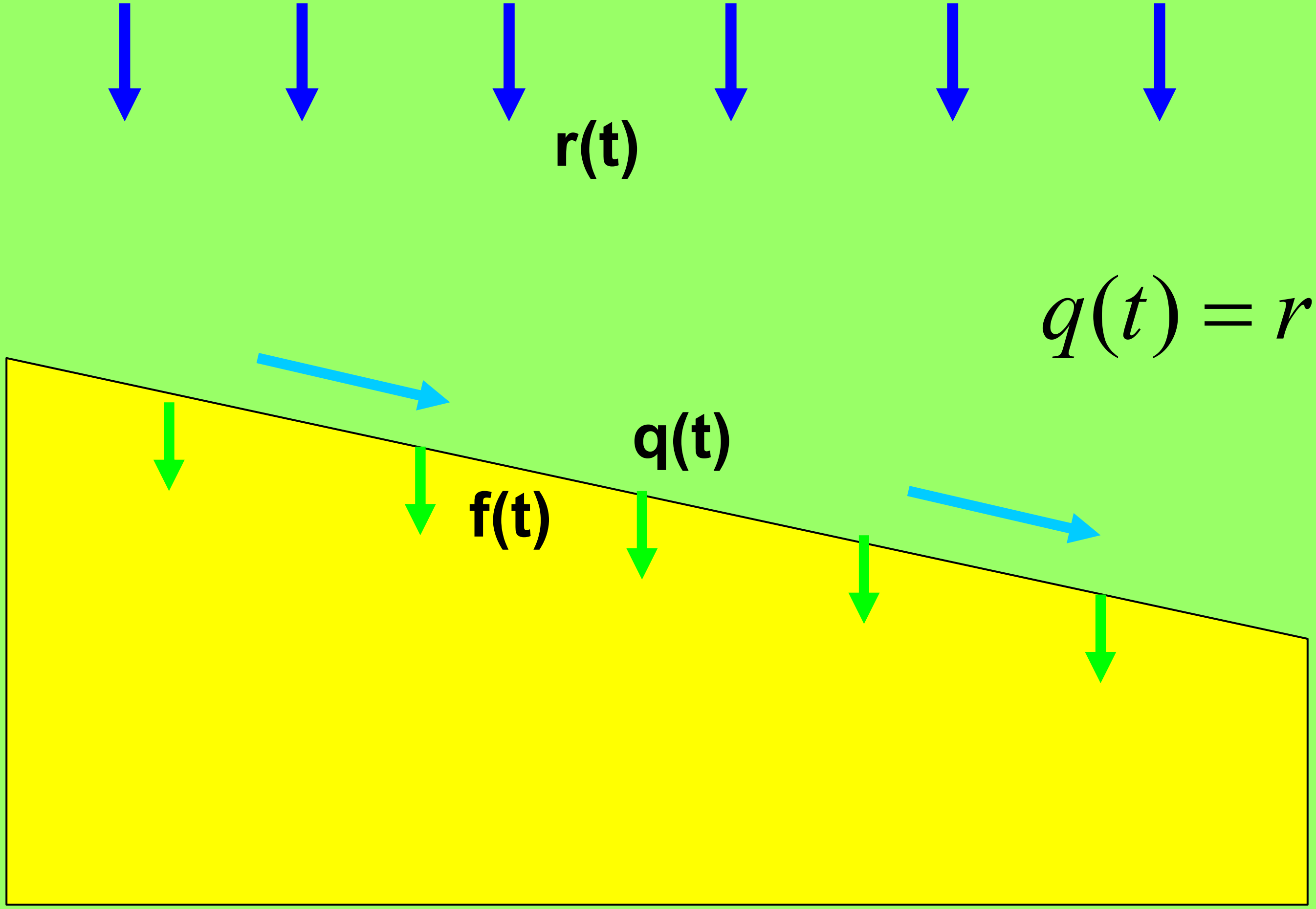
EUROSEM adopts a dynamic approach which allows rainfall to pass from the canopy to the ground at the same time as the interception store (IC max) is being filled.

$$IC_{store} = IC_{max}[1 - \exp(R_{cum} / IC_{max})]$$

To Net Rainfall

Infiltration losses - 1

Net rainfall rate r(t) is transformed in rainfall excess q(t) by subtraction of the infiltration rate f(t). EUROSEM as KINEROS use the Smith & Parlange (1978) model.



$$q(t) = r(t) - f(t)$$

Infiltration losses - 2

The Smith & Parlange (1978) model.

$$f = k_s \frac{e^{F/B}}{e^{F/B} - 1}$$

$$B = G(\theta_s - \theta_i)$$

$$G = \frac{1}{k_s} \int_{-\infty}^{0} k(\Psi) d\Psi$$

Where:

Ks = the **saturated hydraulic conductivity** of the soil (cm min-1),

F = the **amount of rain already absorbed** by the soil (cm), and

B = an **integral capillary and water deficit parameter** of the soil (cm).

G = the **effective net capillary drive** (cm)

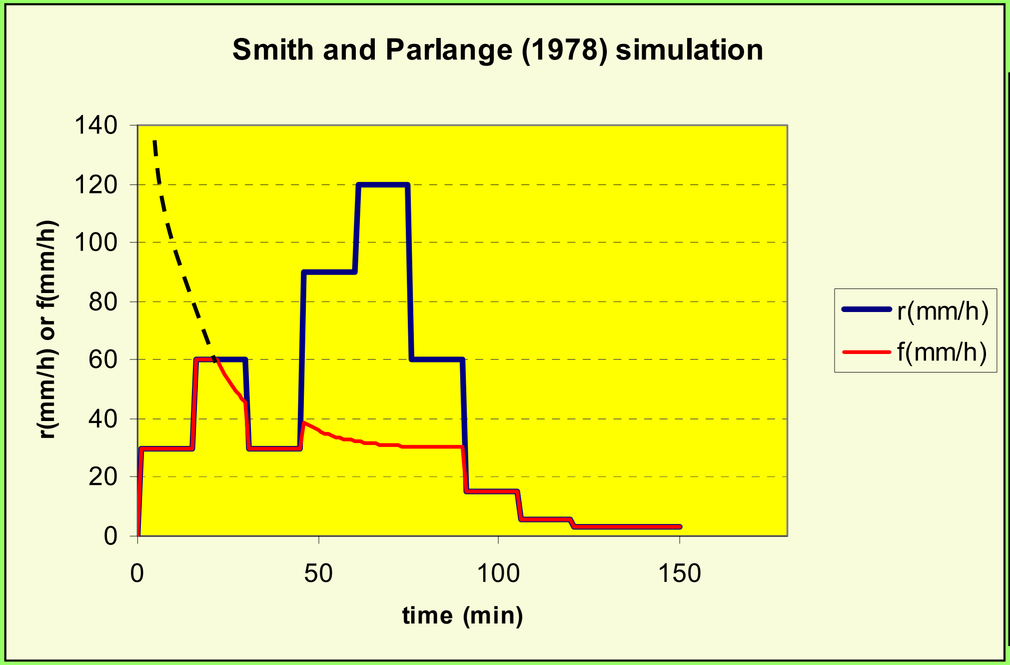
θs = the maximum value of water content of the soil (cm3 cm-3).

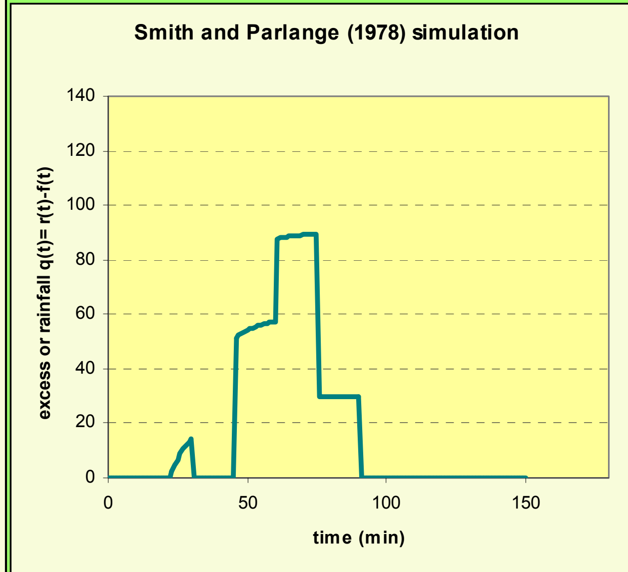
θi = the initial value of soil water content (cm3 cm-3).

ψ = the soil matric potential (-), and

K(ψ) = a hydraulic conductivity function.

Infiltration losses - 3

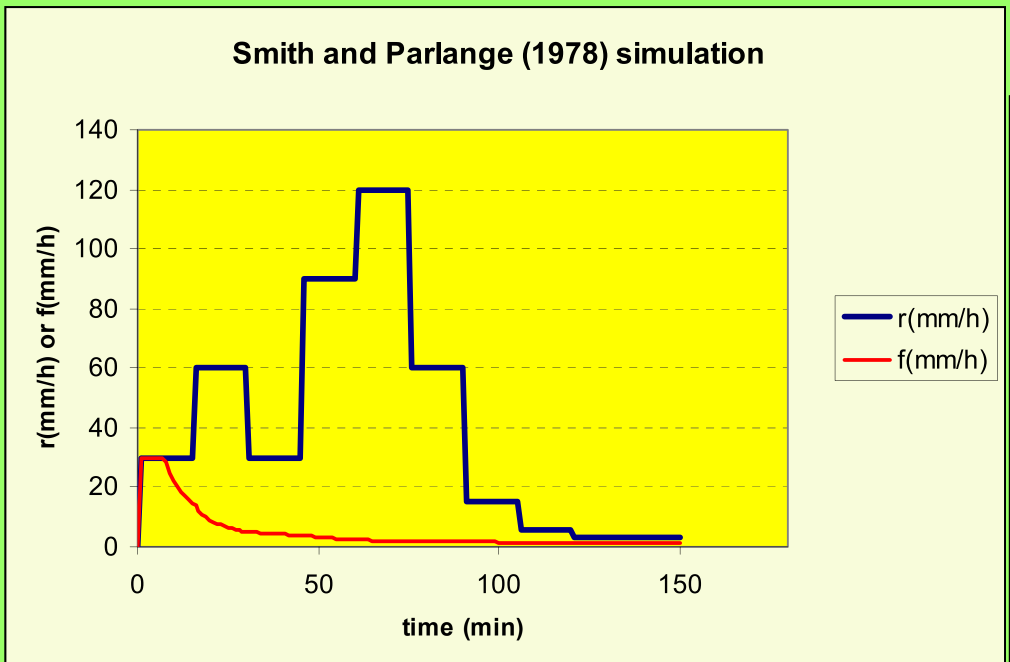


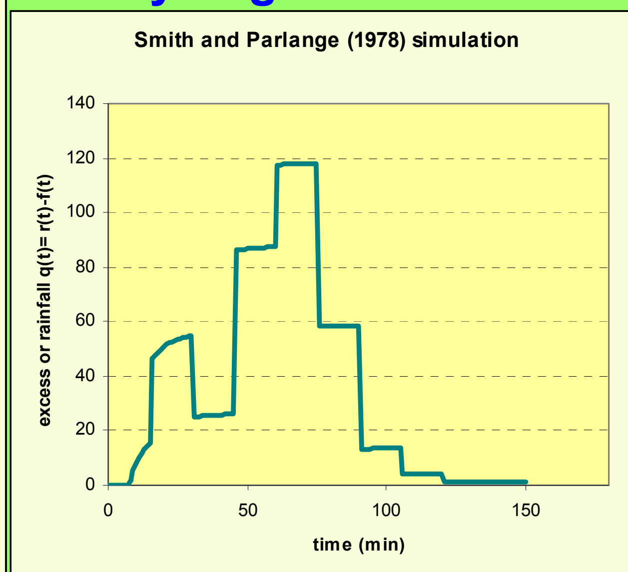


sandy loam

Ks (mm/h)	30
G(mm)	100
dteta	0.2

f(t) : numerical computation with real hyetogram



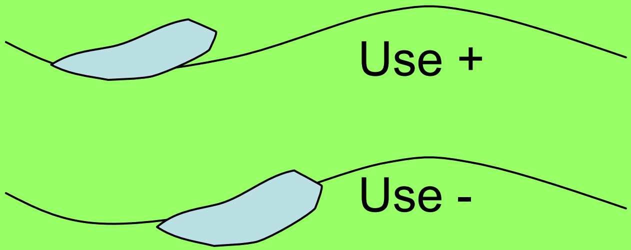


silty - clay

Ks (mm/h)	1
G(mm)	500
dteta	0.2

Infiltration losses - 4

$$k_{sroc} = k_s(1 \pm PAVE)$$



Ksroc = a modified value of saturated hydraulic conductivity (cm/min)
PAVE = aerial rock fragment cover.

Use + if rock fragmemnt sits on the surface
Use – if Rock fragment is embedded
(Poesen *et al.*, 1994).

$$B_{roc} = B(1 - ROC)$$

Broc = the parameter B modified for rock fragments, ROC = the fraction of the soil composed of rock fragments, expressed as a volume ,between 0 and 1

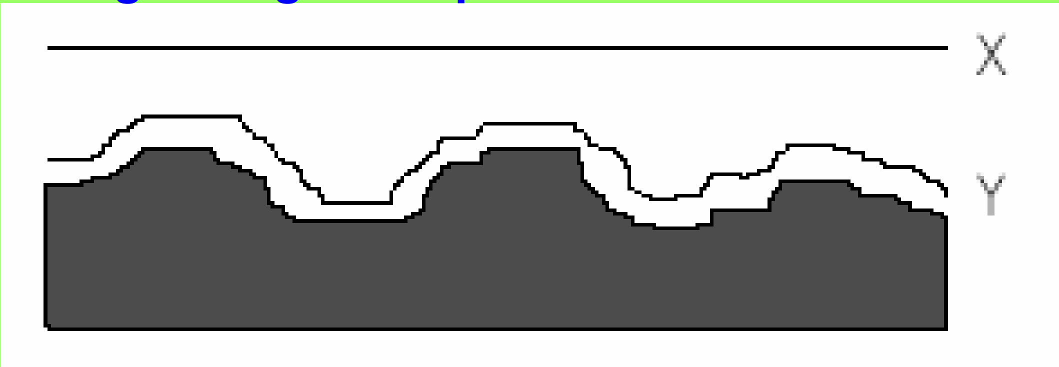
$$k_{sveg} = \frac{k_s}{1 - PBASE}$$

Ksveg is the saturated hydraulic conductivity of the soil with the vegetation;
PBASE is the total area of the base of the plant stems expressed as a proportion (between 0 and 1) of the total area of the plane.

Other Losses : Depression Storage

Other important losses that reduce the net rainfall is the amount of water that can be stored temporarily in depressions at the soil surface.
Depression storage D is computed using a roughness parameter RFR

$$RFR = \frac{Y - X}{Y} * 100.$$

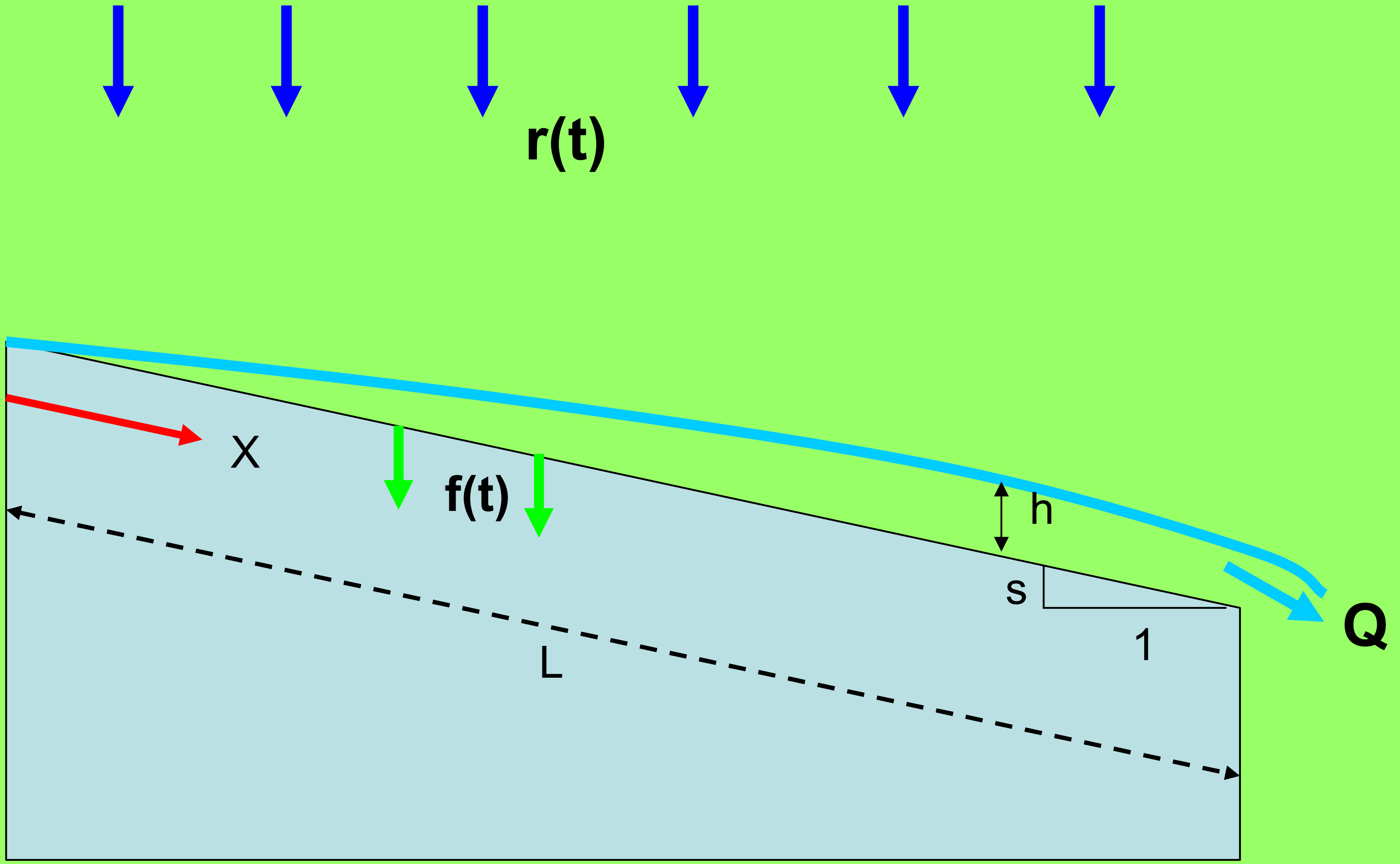


The roughness of the soil surface is expressed in EUROSEM by a roughness measure (RFR) defined as the ratio between the straight line distance between two points on the ground (X) and the actual distance measured over all the microtopographic irregularities (Y)

$$D = \exp(-6.66 + 0.27 * RFR)$$

RFR is converted into a surface storage depth, D (cm), using a regression equation from Auerswald (1992):

From Net Rainfall to overland flow



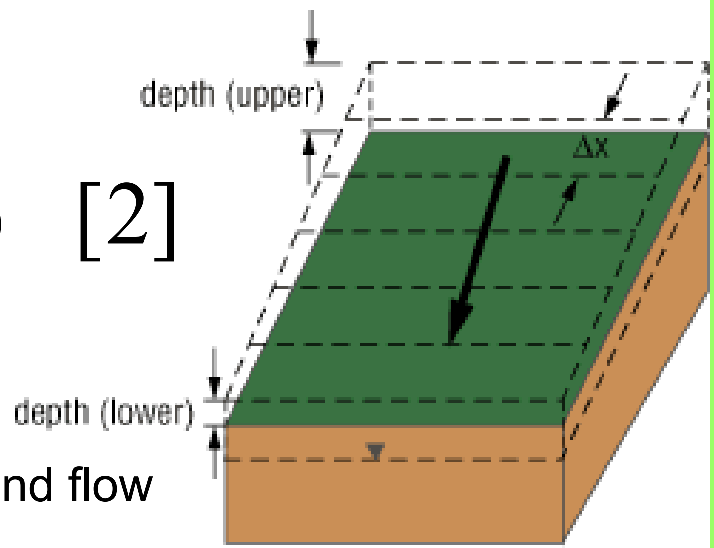
Runoff routing: Basic equations and algorithms

For each plane and channel the flow is viewed as <u>one-dimensional process</u>. Here flux *Q* (unit discharge per unit width) is power function of mean depth of flow *h* [eq.1]. α and *m* are parameter related to slope, roughness and flow conditions.

Kinematic Wave Methods for Overland Flow

$$Q = \alpha h^m \qquad [1]$$

$$\frac{\partial h}{\partial t} + \frac{\partial Q}{\partial x} = q(x,t) \qquad [2]$$



[eq.1] and [eq. 2] give [eq. 3], which is valid for diffuse overland flow

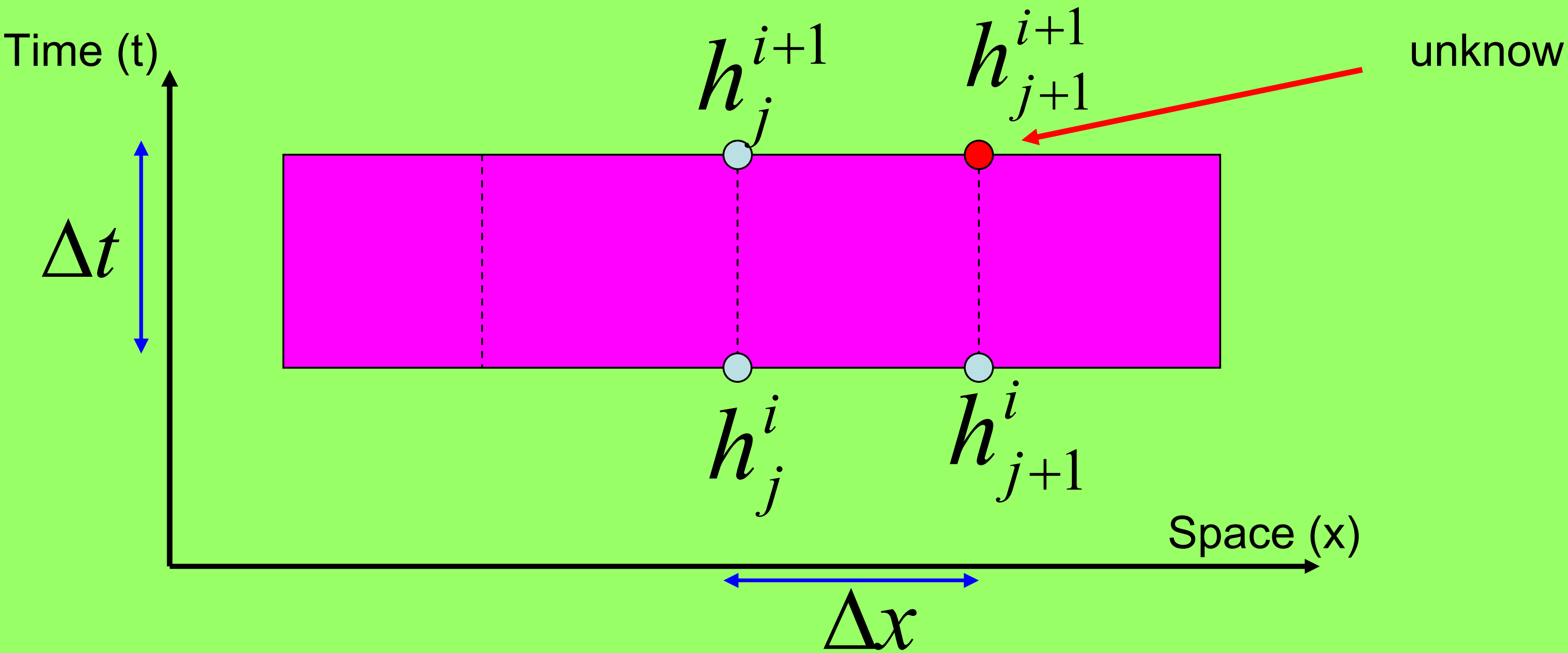
$$\frac{\partial h}{\partial t} + \alpha m h^{m-1} \frac{\partial h}{\partial x} = q(x,t) \qquad [3]$$

[eq.2] ensures mass conservation and continuity:
***t* is time; *x* is space and m is usually set to 1.66 (Manning's equation)**

[eq.2] is a simpified form of Saint Venant equation

q(x,t) is the rate of local input (net rainfall) or lateral inflow

Kinematic wave numerical solution scheme



Four point implicit method. Finite difference equation is non-linear so is solved for the unknown using Newton-Raphson method

$$
\begin{aligned}
&h_{j+1}^{i+1} - h_{j+1}^{i} + h_j^{i+1} - h_j^{i} + \\
&+\frac{2\Delta t}{\Delta x}\left\{\theta_w\left[\alpha_{j+1}^{i+1}\left(h^m\right)_{j+1}^{i+1} - \alpha_j^{i+1}\left(h^m\right)_j^{i+1}\right] + \left(1-\theta_w\right)\left[\alpha_{j+1}^{i}\left(h^m\right)_{j+1}^{i} - \alpha_j^{i}\left(h^m\right)_j^{i}\right]\right\} \\
&\qquad - \Delta t\left(\bar{q}_{j+1} + \bar{q}_j\right) = 0
\end{aligned}
$$

THETA factor used to improve convergence

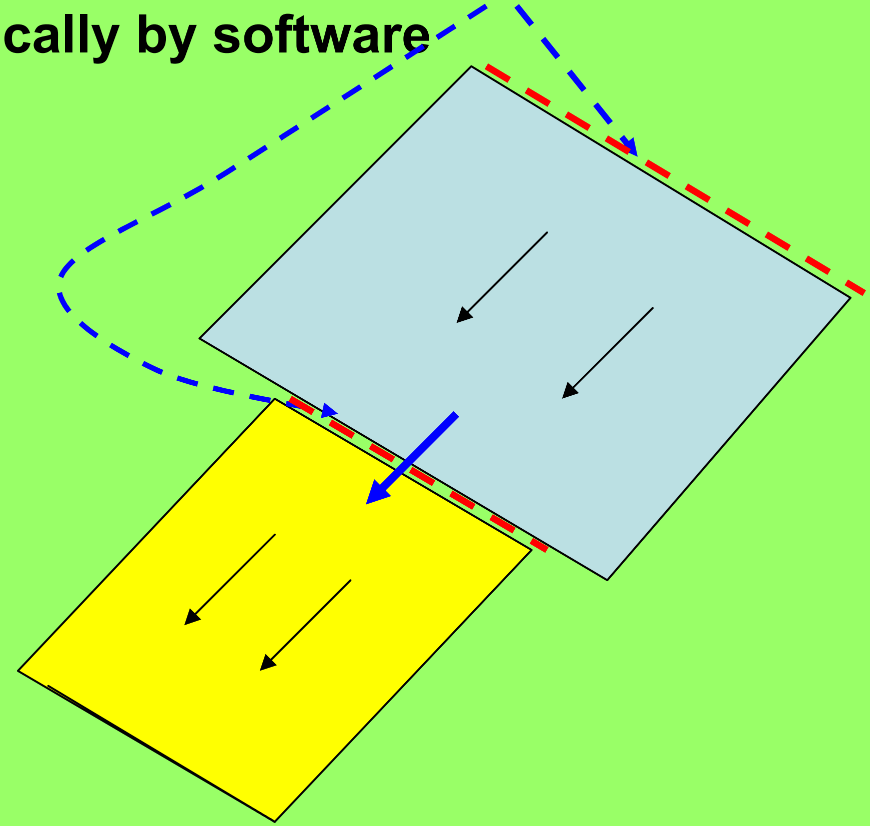
Numerical stability of solution

The convergence is strongly dependent from:

Δx and Δt adopted

THETA parameter (usually in the range 0.6-08)

The boundary conditions h(0,t) are defined automatically by software



KINEROS and EUROSEM manuals give additional informations on numerical methods adopted

Roughness, Channels and final Runoff output

$$\alpha = \frac{s^{0.5}}{n}$$

α depends from slope and roughness (Manning coefficient n)

$$m = \frac{5}{3}$$

m value depend from type of flow (assumed turbolent)

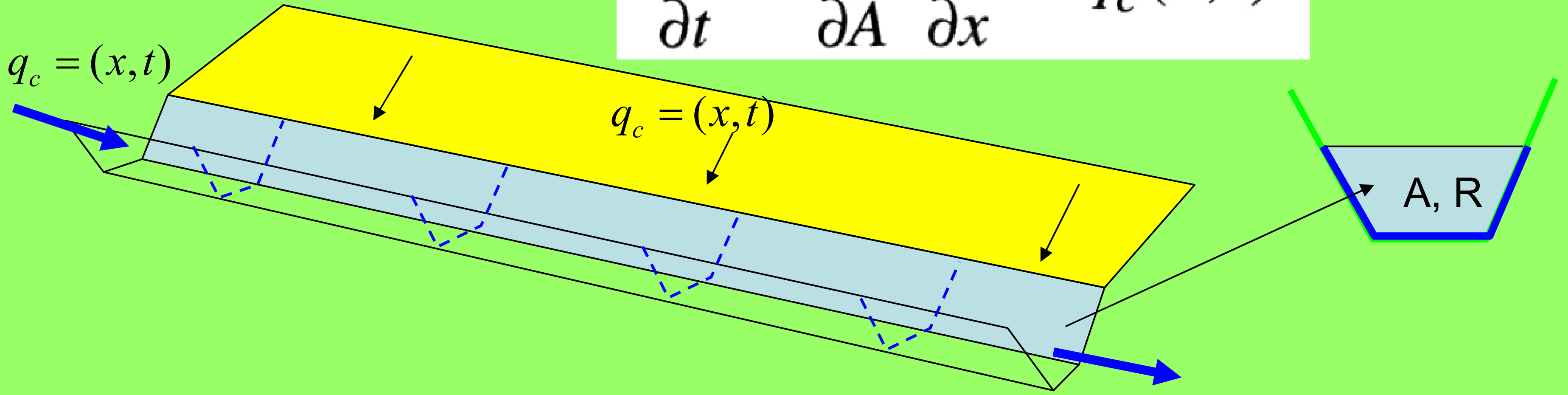
Channel flow
Continuity equation

$$Q = \alpha R^{m-1} A$$

R = hydraulic radius

A = wet cross section of flow in channel

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial A}\frac{\partial A}{\partial x} = q_c(x,t)$$

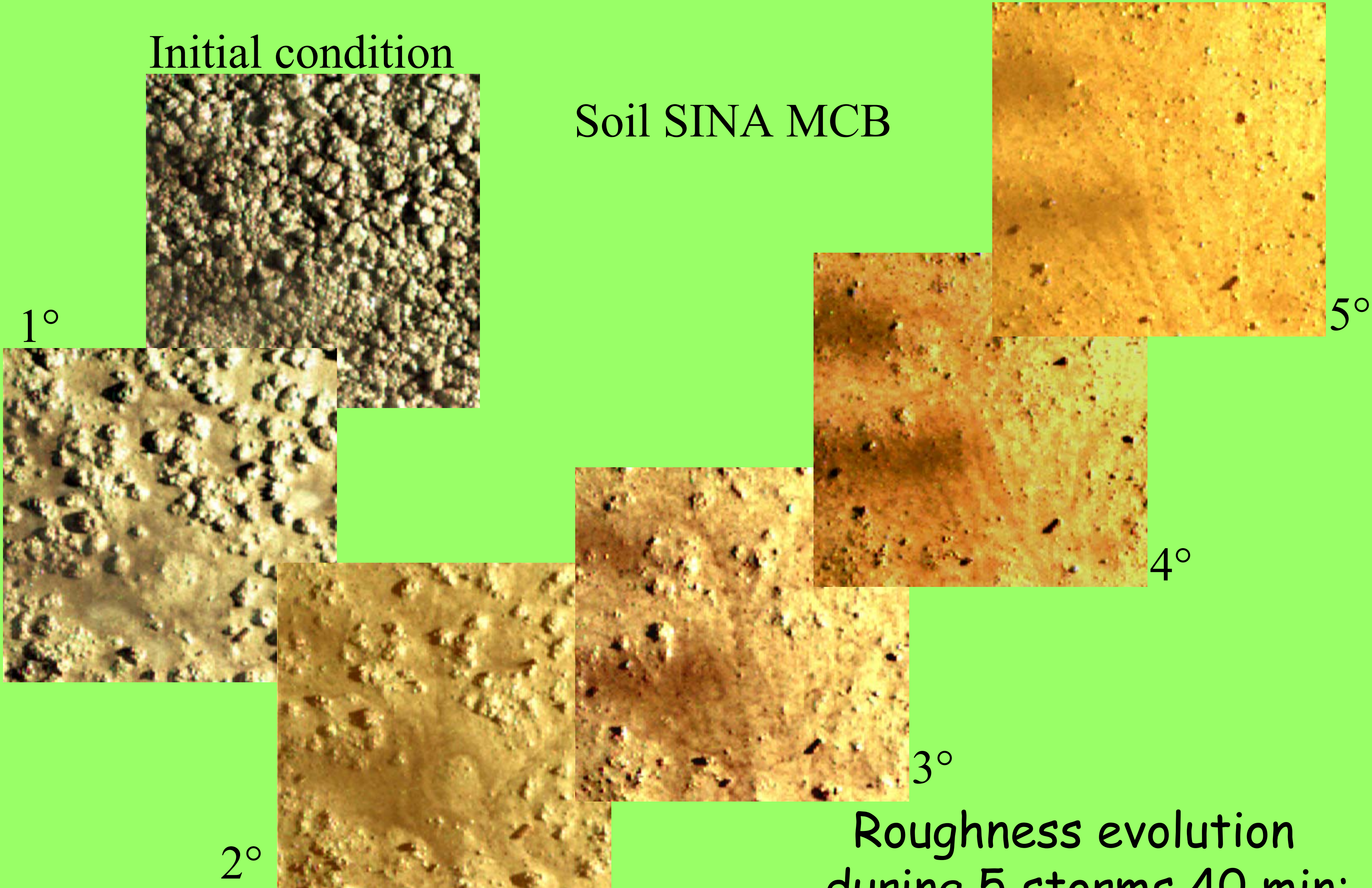


Q = flow rate in channel

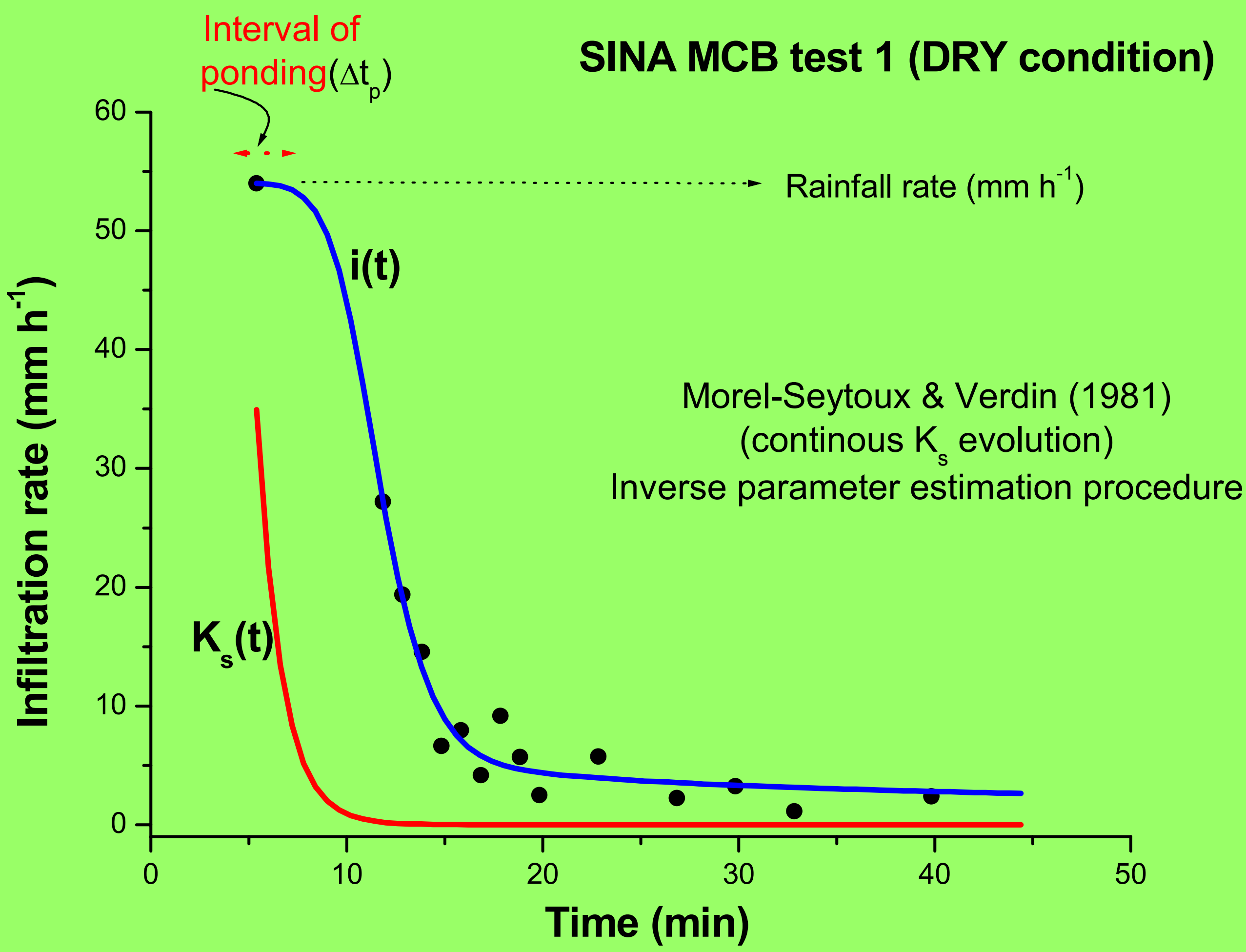
Some evident weaknesses in EUROSEM hydrologic components!

- Soil surface dynamic within storm
- Deposition/re-entrainment and sealing formation
- Ks changes during the storm
- Roughness changes during the storm
- A ROUGH roughness parameter and algorithm for depression storage computation.
- Infiltration eq. of Smith and Parlange has severe problems with low structural stability soils (see KINEROS2 and MWISED Report). Better performances with other model !

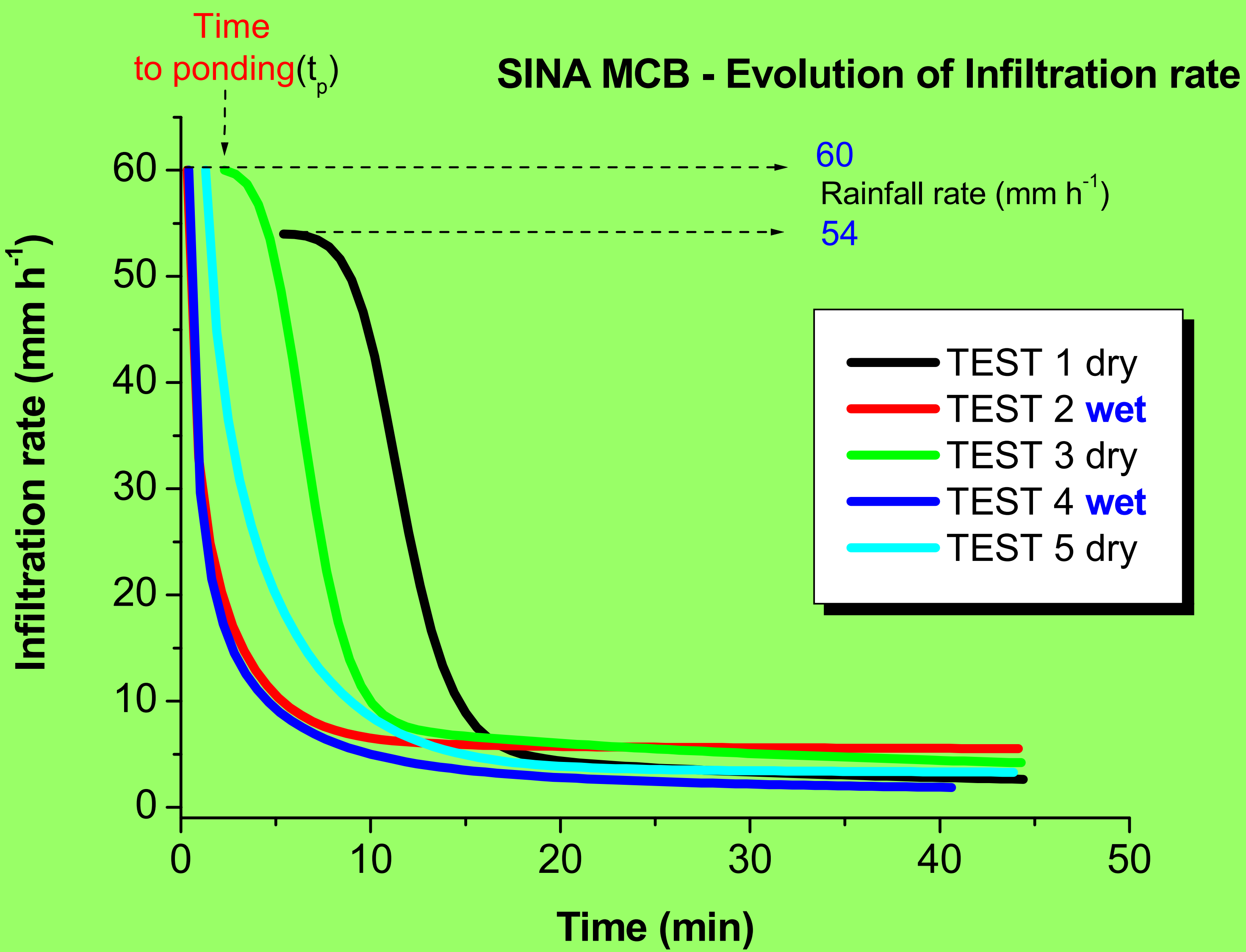
Infiltration – and soil surface dynamics

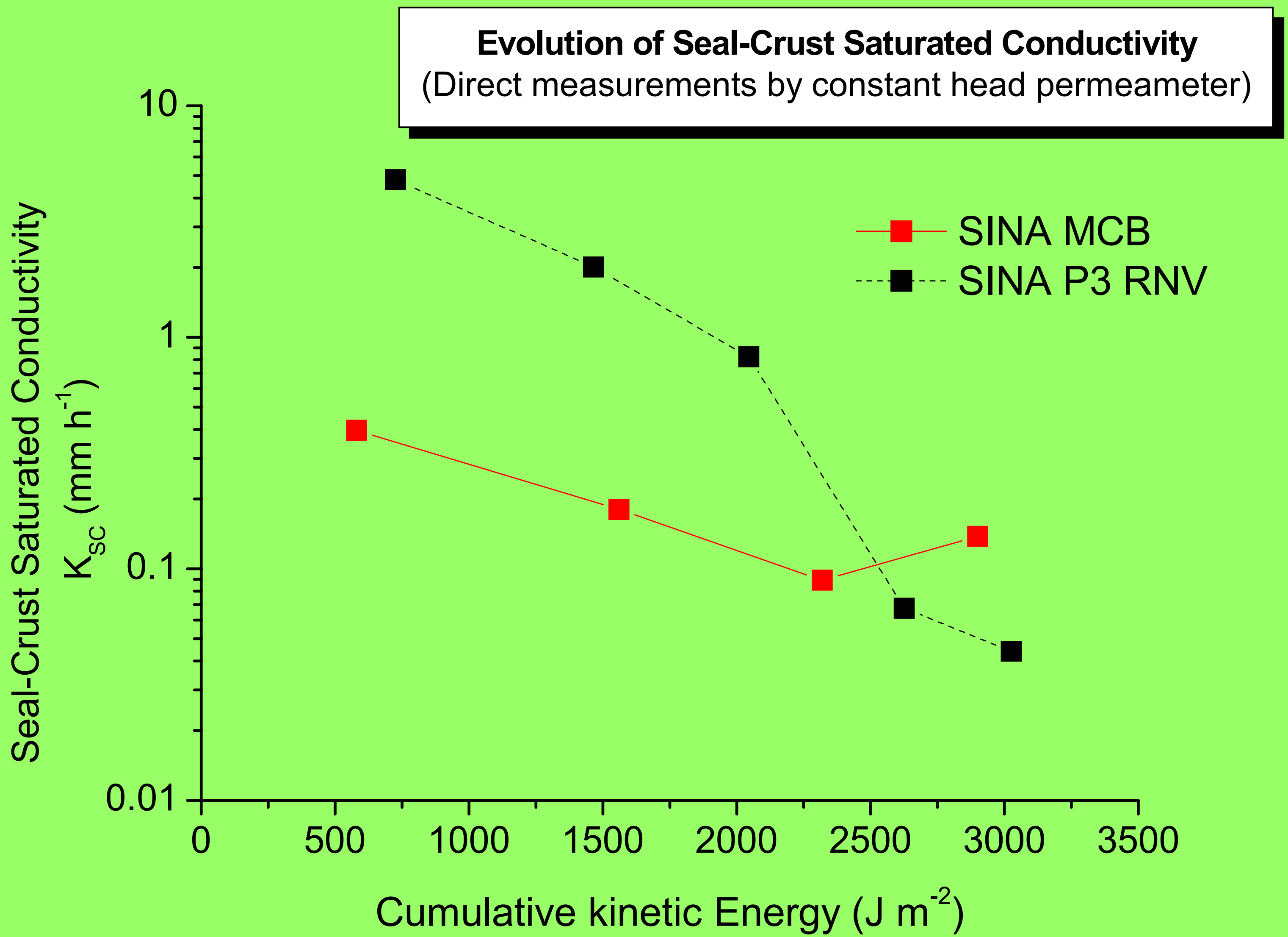


Roughness evolution during 5 storms 40 min; $r=55\text{-}60\ (mm\ h^{-1})$



SINA MCB test 1 (DRY condition)
Interval of ponding(Δt_p)
Rainfall rate (mm h^{-1})
i(t)
K_s(t)
Morel-Seytoux & Verdin (1981)
(continous K_s evolution)
Inverse parameter estimation procedure
Infiltration rate (mm h^{-1})
Time (min)
0
10
20
30
40
50
60


Time
to ponding(t_p)
SINA MCB - Evolution of Infiltration rate
60
Rainfall rate (mm h^{-1})
54
TEST 1 dry
TEST 2 wet
TEST 3 dry
TEST 4 wet
TEST 5 dry
Infiltration rate (mm h^{-1})
0
10
20
30
40
50
60
Time (min)


Evolution of Seal-Crust Saturated Conductivity
(Direct measurements by constant head permeameter)
SINA MCB
SINA P3 RNV
Seal-Crust Saturated Conductivity
K_{SC} (mm h^{-1})
10
1
0.1
0.01
0
500
1000
1500
2000
2500
3000
3500
Cumulative kinetic Energy (J m^{-2})

Key points of the hydrologic component

- Ranfall interception and transformation in net rainfall rate
- Correction of hydraulic parameters for soil surface characteristics (e.g. stoniness)
- Infiltration capacity computed numerically – Smith and parlange model
- Runoff routing with simplified Saint Venant equation and numerical procedure to solve it.
- Dynamic simulation is strongly influcenced by adopted TIME STEP and THETA values, and initial values of some soil hydraulic parameters.
- Hydrological algorithms do not consider some components that have a low influence on single storm simulation (e.g. evotranspiration)
- Hydrological component output is applied to simulate EROSION on the virtual watershed or plot

How-to EUROSEM - Part 1.3

SOIL EROSION PROCESSES IN EUROSEM

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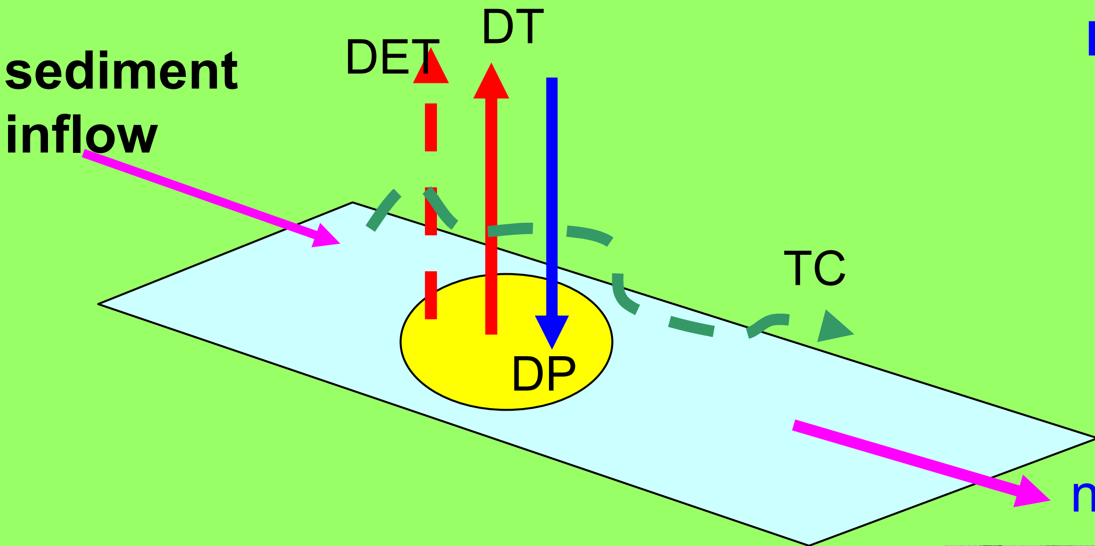
SOIL EROSION PROCESSES BY WATER :
As simulated by EUROSEM

Basic processes:

- Splash detachment of soil particles
- Sheet erosion by overlan flow – interrill erosion
- Rill erosion (side walls collapse not included)
- Erosion in channels (side walls collapse not included)

Note: concurrent processes of detachment, transport an deposition are modelled in such a way that at the end of simulation the amount of erosion or deposition may be evaluated for each element of the watersheed.



DETACHMENT – TRANSPORT – DEPOSITION - (REDETACHMENT)

DT = Flow Detachment rate
TC = flow transport capacity
DP = deposition rate in flow
DET = rainsplash detchment rate

In EUROSEM the net erosion rate is obtained by a continuos balance bethween concurrent processes: ***detachment, transport capacity, and deposition***

The net flow detachment rate

DF=f(TC, flow, soil par..)

Net erosion rate

e=DET +DF

RANDROP SPLASH AND DETACHMENT

Total kinetic energy of rainfall
KE=KE(DT)+KE(LD) (J m-2 mm-1)

$$KE(DT) = 8.95 + (8.44 \log r)$$

KE(DT) It is estimated as a function of direct trhoughfall rainfall intensity r (mm hr-1)

$$KE(LD) = (15.8 \,.\, PH^{0.5}) - 5.87$$

PH = the effective height of the plant canopy (m).
If PH<0.14 m KE(LD)=0.0

Finally Soil detachment by raindrop impact (DET; g m-2) is calculated.

$$DET = k\,(KE)\,e^{-bh}$$

k = an index of the detachability of the soil (g J-1),
KE = the total kinetic energy of the rain (J m-2),
b = an exponent,
h = the depth of the surface water layer (mm).

FLOW DETACHMENT AND DEPOSITION - 1

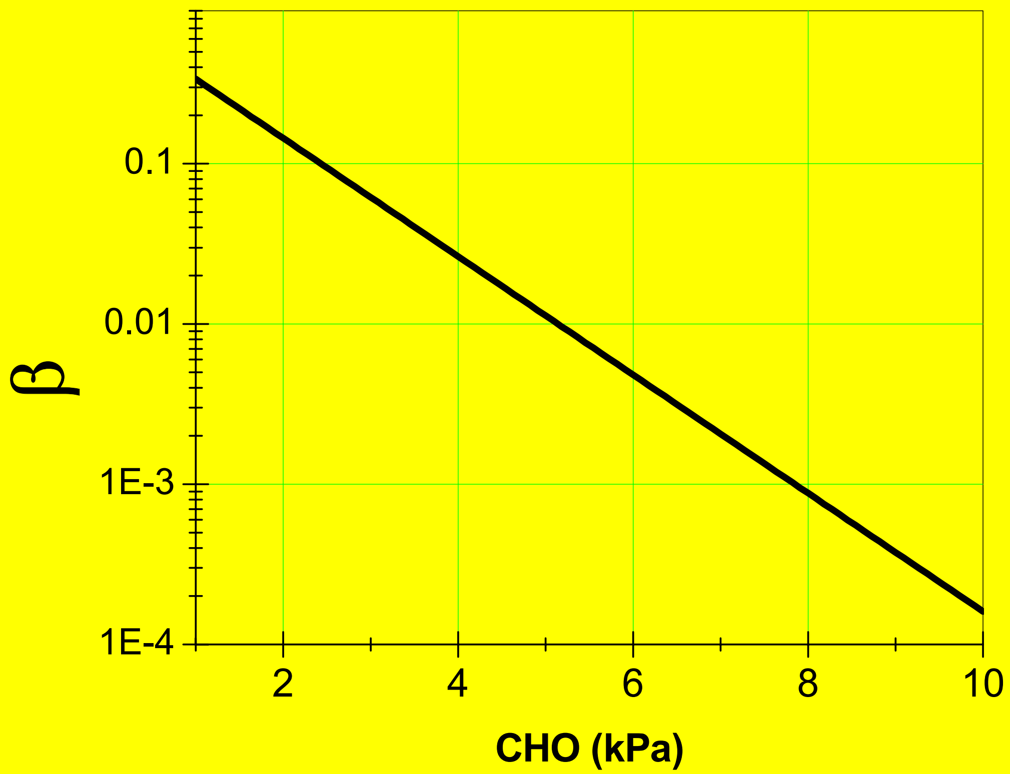
The theory assumes that the transport capacity of runoff (TC) reflects a balance between the two continuous counteracting processes of erosion and deposition. It implies that the ability of flowing water to erode its bed is independent of the amount of material it carries and is only a function of the energy expended by the flow, particularly the shear between the water and the bed, and the turbulent energy in the water.

$$DF = \beta\, w\, v_s\, (TC - C)$$

C = sediment concentration ($m^3\ m^{-3}$)
TC = flow transport capacity ($m^3\ m^{-3}$)
Vs = settling velocity ($m\ s^{-1}$)
W= width of flow (m)
β = flow detachment efficiency coefficient.

FLOW DETACHMENT AND DEPOSITION : efficiency function β

$$\beta = 0.75e^{-0.85CHO}$$



CHO means cohesion.

This equation was not experimentally derived.
It was deduced from the fact that various studies had shown that rill erosion starts after that flow shear stress has overcame a threshold proportonal to cohesion

FLOW DETACHMENT AND DEPOSITION - 2

The Transport capacity is mostly based on UNIT STREAM POWER defined as:

$$\omega = u\,S$$

S = slope (cm cm-1)
u = mean flow velocity (cm/s),

Interrill Transport Capacity

$$TC = \frac{b}{\rho_s q}\left(\left(\Omega - \Omega_c\right)^{0.7/n} - 1\right)^n$$

$$\Omega = \omega^{1.5}/h^{2/3}$$

Ω,Ωcr = Bagnold unit stream power and critical unit stream power
Bagnold (1966), Everaert (1991)

Rill Transport Capacity

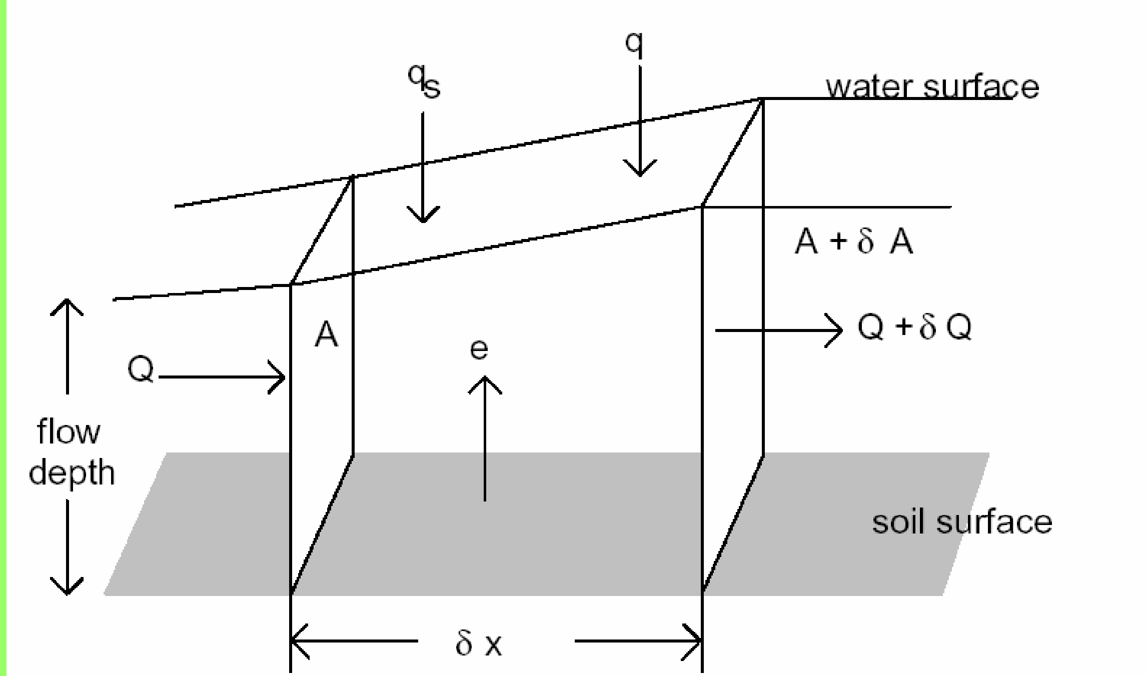
$$TC = c\,(\omega - \omega_{cr})^{\eta}$$

ωcr = critical value of unit stream power (= 0.4 cm/s),

c,η = experimentally-derived coefficients depending on particle size.

BASIC EQUATION FOR SEDIMENT ROUTING IN (x,t)

The mass balance, continuity, equation is solved for C, at [*j+1*,*i+1*], position using the same solution scheme for runoff routing in plane and channels

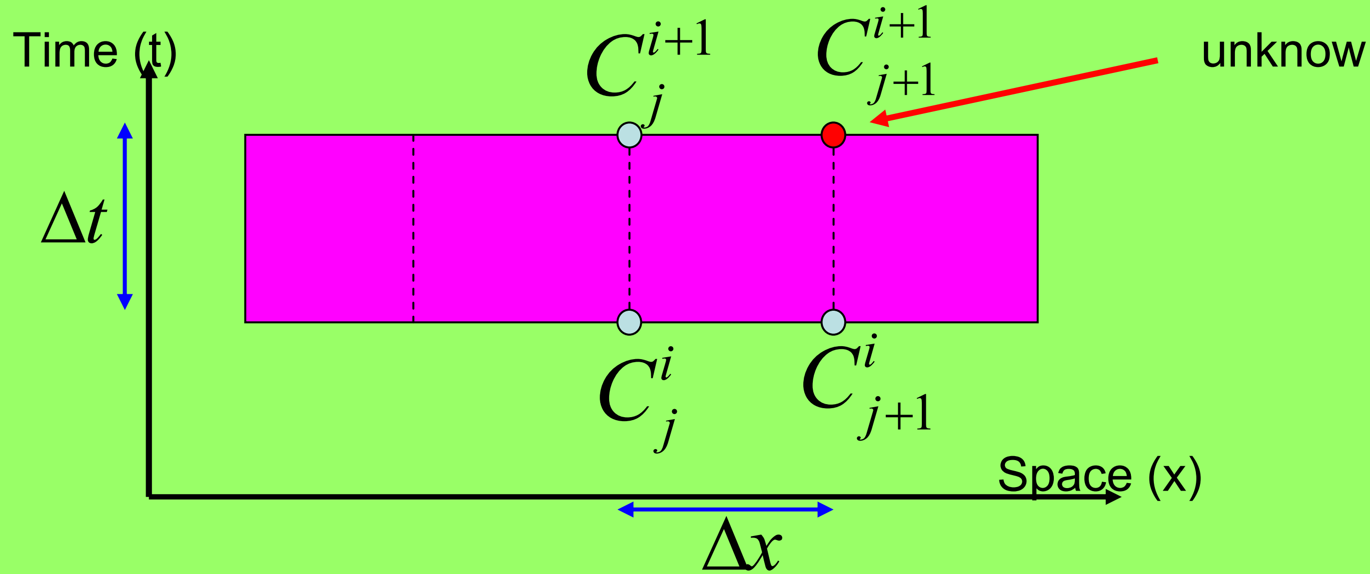


$$\frac{\partial (AC)}{\partial t} + \frac{\partial (QC)}{\partial x} - e(x,t) = q_s(x,t)$$

from Morgan et al. (1998)

C = sediment concentration ($m^3\ m^{-3}$); A = cross sectional area of the flow (m^2);
Q = discharge ($m^3\ s^{-1}$);
q_s = external input or extraction of sediment per unit length of flow ($m^3\ s^{-1}\ cm^{-1}$);
e = net detachment rate or rate of erosion of the bed per unit length of flow;
($m^3\ s^{-1}\ cm^{-1}$) ; x = horizontal distance; t = time.

FINAL EROSION/DEPOSITION RATE OUTPUT



For each time step and each node along the slope plane, the net rate of erosion (e) and the sediment discharge (product QC) are calculated. Finally *e* is obtained as:

$$e_{j+1}^{i+1} = DET^{i+1} + \beta w v_s \left(TC_{j+1}^{i+1} - C_{j+1}^{i+1}\right)$$

KNOWLEDGE BASE IN EUROSEM (1998) AND ITS LIMITATION

At present part of the knowledge base implemented in EUROSEM 3.5 is outdated. This knowledge base phothographs the state of the art at 1998. (a state of the art filtered from the scientists that worked at EUROSEM projects ….).
Some developement during MWISED project were implemented into EUROSEM 4 (beta), which is not distributed due to bugs in the User Interface and no funds to keep correcting them.

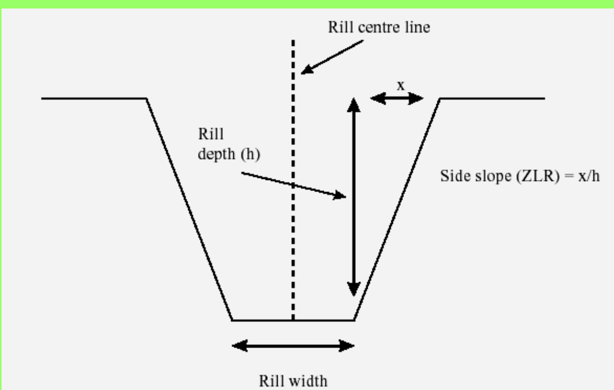
Many new erosion algorithms and procedures has been developed since 1998.
New results of basic research in erosion and detachmet has to be reviewed for possible inclusion in new EUROSEM (e.g. detachment of choesive sediments, and probabilistic entrainment).
More efficent numerical solution scheme are possible.

.. And much more.

How-to EUROSEM - Part 2.1

INPUT PARAMETERS IN EUROSEM: MEANING AND GUIDE TO ASSESSMENT

Lorenzo Borselli*



Texture (*)	Detachability (EROD; g/J)		
	low	mean	high
clay	1.7	2.0	2.4
clay loam	1.4	1.7	1.9
silt	0.8	1.2	1.6
silt loam	0.8	1.5	2.3
loam	1.0	2.0	2.7
sandy loam	1.7	2.6	3.1
loamy sand	1.9	3.0	4.0
fine sand	2.0	3.5	6.0
sand	1.0	1.9	3.0

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TYPE OF INPUT PARAMETERS IN EUROSEM

- **Measured in field (RILL DENSITY, SOIL HYDRAULIC PARAMETERS, ROUGHNESS, RAINFALL..)**

- **Indirect estimation from other parameters (VEGETATION COVER)**

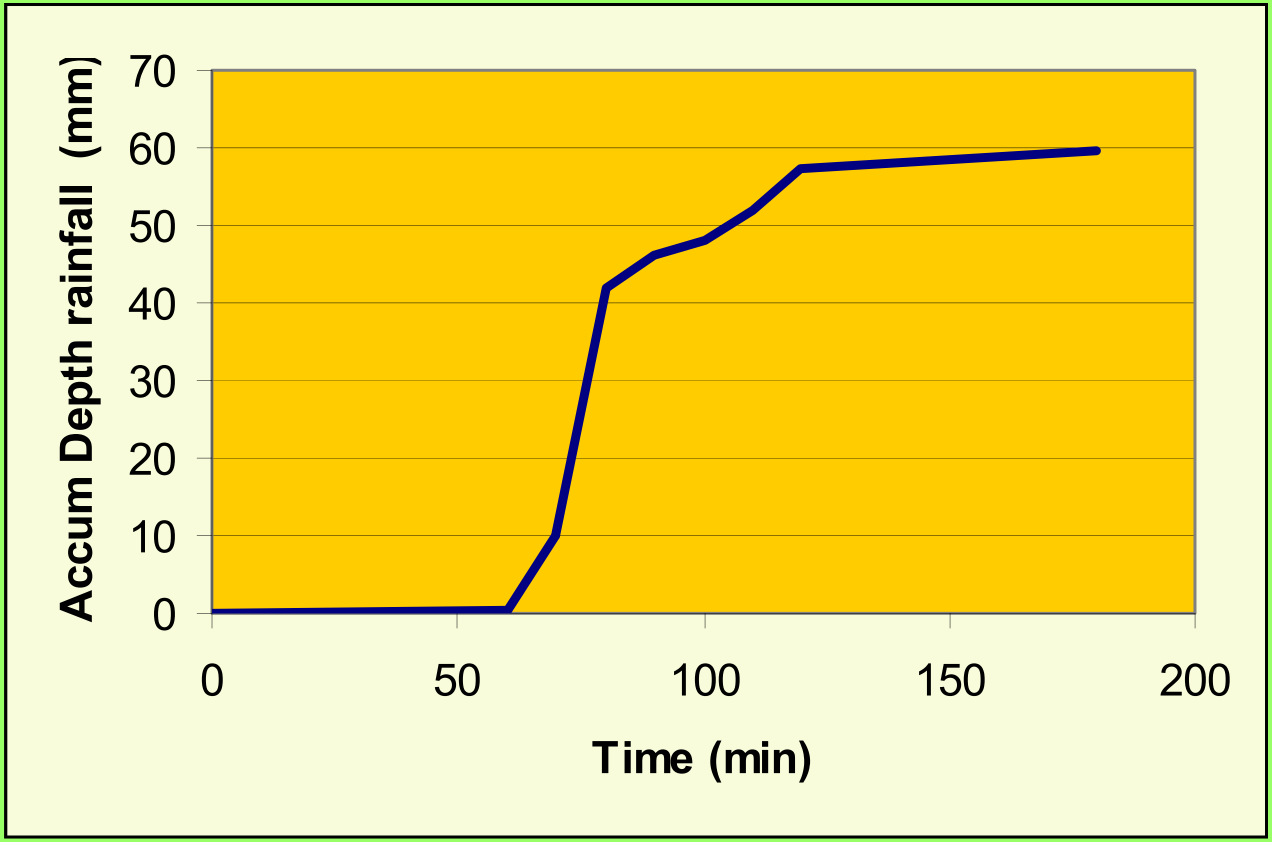
- **Estimation from reference tables, or algoritms (pedofunctions) (e.g. SOIL HYDRAULIC PARAMETRS)**

- **As output from other models (VEGETATION PARAMETER)**

- **Obtained after a preliminary estimation and calibration or tuning procedure (e.g. Manning's n)**

Rainfall input …as used by EUROSEM

TIME (min)	ACCUM. DEPTH (mm)
------	------------
0.0	0.0
60.0	0.5
70.0	10.0
80.0	42.0
90.0	46.0
100.0	48.0
10.0	52.0
120.0	57.5
180.0	59.5
200.0	59.5



Basic storm informations are defined for (each raingauge) as:
Accumulated depth (mm) over time (min).
The time step may be variable but it has a strong influence on average rainfall intensity computation r(t)

SOIL HYDRAULIC PARAMETERS - 1

FMIN - The saturated hydraulic conductivity of the soil. The value entered should be that for the soil itself (usually ignoring stones and vegetation) and need not be adjusted for plant cover or rock fragments. Adjustments are made within EUROSEM for taking into consideration soils with a vegetation or rock fragment cover (permeameters, tension infiltrometers, pedofunctions). FMIN = Ks (*mm/h*)

G - Effective net capillary drive of the soil (mm) (Tension infiltrometer, pedofunctions)

$$G = \frac{1}{k_{sat}} \int k(\psi)\, d(\psi)$$

Effective net capillary drive can be derived from the following equation relating unsaturated hydraulic conductivity to the matric potential of the soil:

Where
G = effective net capillary drive (mm)
Ksat = the saturated hydraulic conductivity (mm/h),
K = the unsaturated hydraulic conductivity at matric potential (ψ).

SOIL HYDRAULIC PARAMETERS - 2

POR - The porosity of the soil.

$$POR = 1 - \rho_b / \rho_s$$

where:
ρ_b = the bulk density of the soil (Mg/m^3),
ρ_s = the particle density of the soil (usually assumed = 2.65 Mg/m^3).

THI - The initial volumetric moisture content of the soil, i.e. at the start of the storm (corrected by gravimetric method, or measured by TDR)

THMAX - The maximum moisture content of the soil (at field capacity matric potentials -1 m respectively.)

$$\theta_v = \theta_m \rho_b / \rho_w$$

where:
θv = the volumetric moisture content (m^3/m^3),
θm = the gravimetric moisture content,
ρb = the dry bulk density of the soil (Mg/m^3), and
ρw = the density of water (= 1.0 Mg/m^3).

ROC - The fraction of the soil, expressed between 0 and 1 occupied by rock fragments. (fraction by mass → fraction by volume correction Torri et al. 1994 and EUROSEM manual)

SOIL HYDRAULIC PARAMETERS - 3

FMIN=Ks an example of reference table

Texture (*) (USDA classification)	Saturated hydraulic conductivity (mm/h) low	mean	high
Sand	170	210	600
Loamy sand	18	61	800
Sandy loam	7	26	190
Loam	2	13	65
Silt loam	3	7	25
Sandy clay loam	1	4	50
Clay loam	0.4	2	38
Silty clay loam	0.6	1.5	12
Sandy clay	0.6	1.2	25
Silty clay	0.5	0.9	5
Clay	0.1	0.6	12

After EUROSEM MANUAL – Morgan et. Al. 1998

SOIL HYDRAULIC PARAMETERS - 4

Others hydraulic parameters.
Example of reference table

Direct measurements are always preferable to assessement by reference table, or other methods, because the calibration and tuning procedure can be concentrated only on the <u>unmeasurable (or unmeasured)</u> variables.

Texture (*)	Porosity (POR) (v/v)			Residual saturation (THR) (v/v)	Maximum saturation (THR) (v/v)	Net capillary drive (G) (mm)		
	low	mean	high	mean	mean	low	mean	high
Sand	0.37	0.44	0.50	0.020	0.42	22	101	207
Loamy sand	0.37	0.44	0.51	0.035	0.41	41	147	323
Sandy loam	0.35	0.45	0.56	0.040	0.41	98	248	526
Loam	0.38	0.46	0.55	0.030	0.43	185	375	937
Silt loam	0.42	0.50	0.58	0.015	0.47	220	485	1043
Sandy clay loam	0.33	0.40	0.46	0.070	0.33	220	617	1070
Clay loam	0.41	0.46	0.52	0.070	0.39	250	533	1174
Silty clay loam	0.42	0.47	0.52	0.380	0.43	370	720	1470
Sandy clay	0.37	0.43	0.49	0.110	0.32	373	768	1730
Silty clay	0.43	0.48	0.53	0.060	0.42	430	812	1700
Clay	0.43	0.48	0.53	0.090	0.39	460	890	1830

(*) Texture classes according to USDA classification

Values are those recommended by Woolhiser et al (1990) for use as inputs to KINEROS.

Data for THR and THMAX are taken from the SR and SMAX values respectively in Woolhiser et al (1990) after dividing by soil porosity.

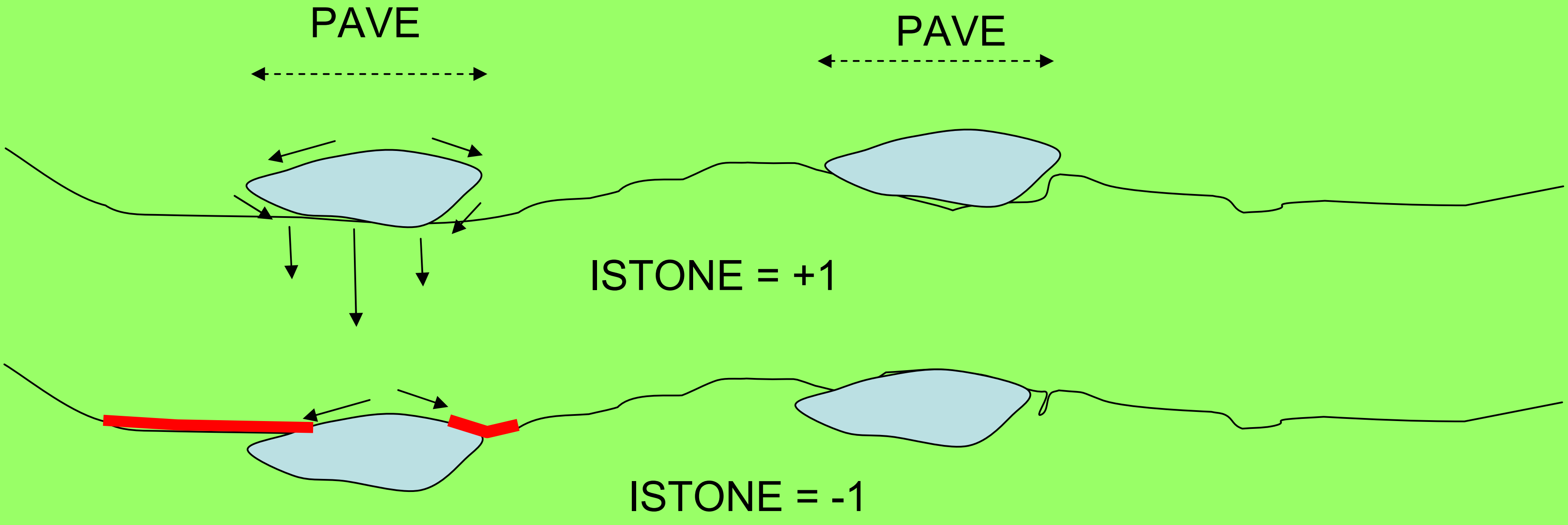
EUROSEM MANUAL – Morgan et. Al. 1998

ROCK FRAGMENTS

EUROSEM simulates the following effects of rock fragments:
(1) a reduction in the relative volume of the soil not acting as a porous medium;
(2) a reduction in the area of fine earth exposed to raindrop impact;
(3) a change in the effective saturated hydraulic conductivity of the soil.

These effects are expressed through the parameters :
ROC, PAVE and ISTONE respectively.

ROC - The fraction of the soil, expressed between 0 and 1 occupied by rock Fragments. (fraction by mass → fraction by volume correction Torri et al. 1994 and EUROSEM manual)



PAVE

The parameter, PAVE, describes the <u>fraction of the soil surface covered by non-erodible material</u>. It can be masured using vertical photograph on gridded square surfaces. Normal image processing software o grid counting method gives the fraction

ISTONE

The parameter, ISTONE, determines whether the effect of PAVE is to decrease or Increase the saturated hydraulic conductivity of the soil (The nature of the effect is dependent upon the size of the element and the position of the rock fragments on the surface of the soil (Poesen and Ingelmo-Sanchez, 1992; Poesen et al, 1994).

SOIL SURFACE 3

Soil erodibility is described in EUROSEM using two parameters: one is a measure of the detachability of the soil by raindrop impact (EROD) and the other, used to express the detachability of the soil by flow, is soil cohesion (COH).

EROD table

Table A9.1. Guide values for soil detachability (EROD)

Texture (*)	Detachability (EROD; g/J)		
	low	mean	high
clay	1.7	2.0	2.4
clay loam	1.4	1.7	1.9
silt	0.8	1.2	1.6
silt loam	0.8	1.5	2.3
loam	1.0	2.0	2.7
sandy loam	1.7	2.6	3.1
loamy sand	1.9	3.0	4.0
fine sand	2.0	3.5	6.0
sand	1.0	1.9	3.0

(*) Soil texture classes according to the USDA system.

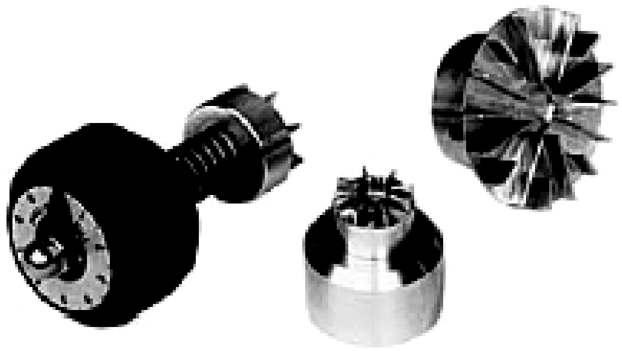
Minimum values should be used when the soil is in a loose and dry initial state. Maximum values should be used when the soil is loose and moist. Mean values are for sealed or compacted top soil.

After Poesen (1985), Poesen and Torri (1988), Govers (1991) and Everaert (1992).

SOIL SURFACE 4

COH

Soil cohesion (COH; kPa) should be measured with a **torvane** in the field after the surface has been saturated. <u>At least six replications should be made on a single element; if the variability is greater than 15 per cent, the number of replicates should be increased to 10.</u>



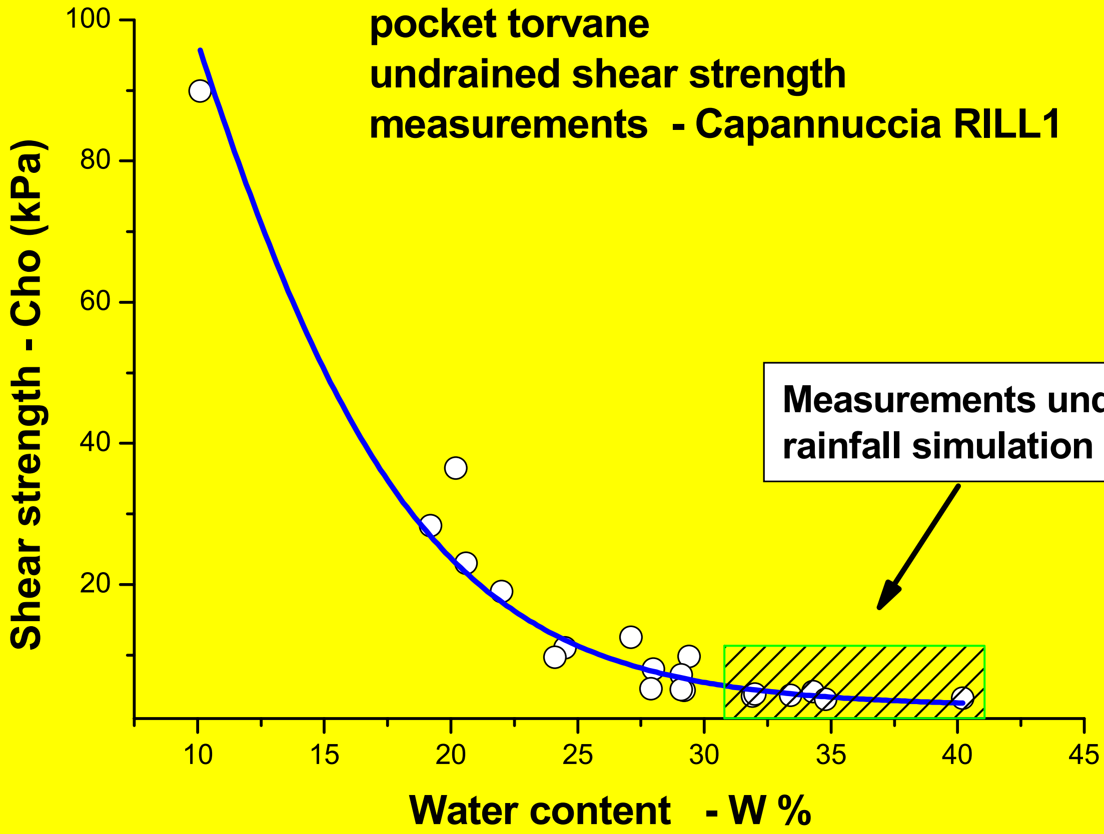
The Torvane is a hand-held vane shear device for rapid determination of shear strength in cohesive soils either in the laboratory or in the field

Texture (*)	uncompacted			compacted		
	low	mean	high	low	mean	high
clay	10	12	14	29	33	44
clay loam	9	10	14			
silty clay	9	15	11			
silty clay loam	10	9	26			
sandy clay loam	8	3	10			
silt loam	2	3	5	6	9	17
loam	2	3	4	7	7	8
fine sandy loam	2	3	3	5	6	8
sandy loam	2	2	4	4	7	10
loamy sand	2	2	3	6	8	9
sand	2	2	3	8	8	9

(*) Soil texture classes according to the USDA system

After Vickers (1993)

SOIL SURFACE 5



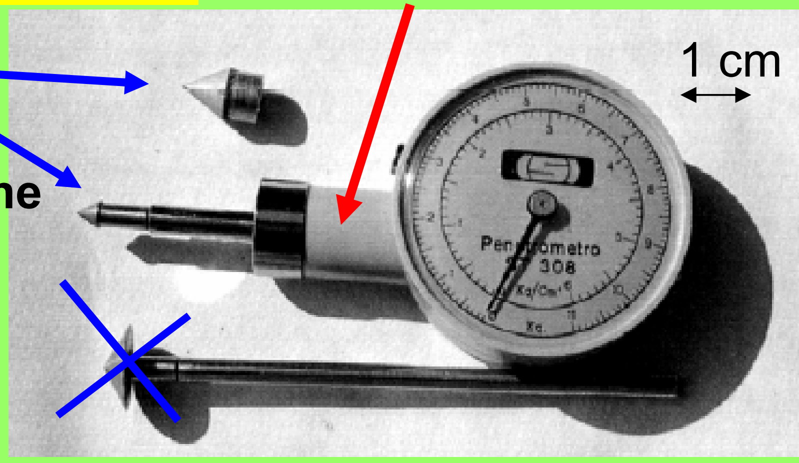
Measurements with torvane are affected by:
water content
irregular soil surface,
insufficient maintainance

Pocket Penetrometer as modified to measure crust strength and undrained Shear strenght (CHO): Borselli (1995), Borselli(1996)

Comparison between torvane and <u>Non Modified</u> pocket are available from Zimbone et al (1996)

Modified tips

Modified spring



EFFECT OF ROOT REINFORCEMENT

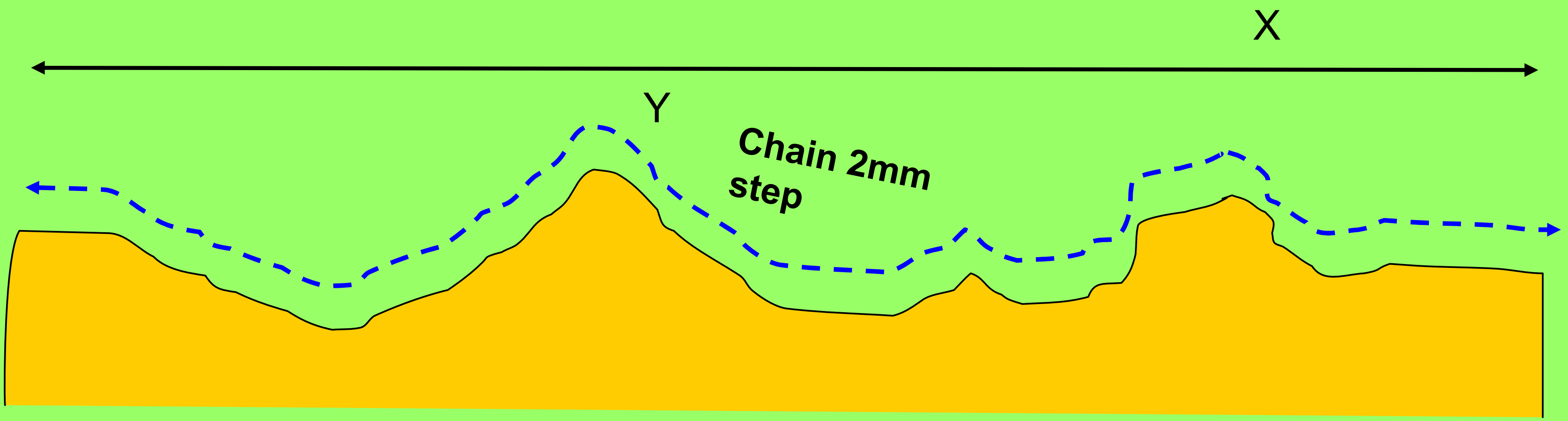
Table A9.3. Guide values for increases in soil cohesion (COH) brought about by root reinforcement

Vegetation type	Increase in soil cohesion (COH; kPa)
barley	0.2-0.6
grass	1-8
marram grass	1.5-15
chaparral, matorral	0.3-3
alfalfa	10
Alder	2-12
Sitka spruce	4-12
Hemlock	1-8
Willow	6
Poplar	2
Maple	4-6
Pines	4-10
Coniferous forest	1-17.5
Candlenut	15-35
Acacia	1-5

After Gray and Leiser (1982), Greenway (1987) and Wu (1995)

SURFACE ROUGHNESS-1

$$RFR = 100\frac{Y - X}{Y}$$



RFR

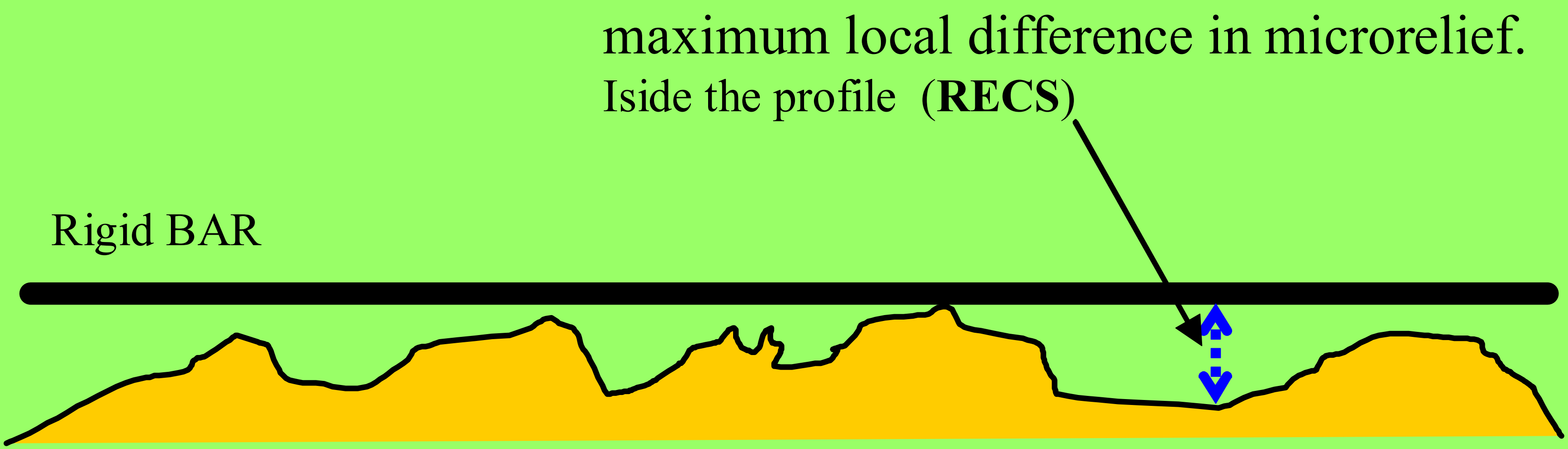
The parameter, RFR, expresses the roughness of the soil surface as <u>measured in the downslope direction</u> (i.e. the direction of surface water flow). It is used in EUROSEM to estimate the surface depression storage. The parameter is related to the ratio of the straight-line distance between two points on the ground (X) to the actual distance measured over all the microtopographic irregularities (Y). Tape metre and steel chain (each chain ring being about 2-3 mm along its longest axis) is used for the measurements.

SURFACE ROUGHNESS-2

RECS (cm)

The term, RECS, defines the average value of the maximum local difference in microrelief. It is used to drive the infiltration process within the KINEROS model when, after the cessation of rainfall, infiltration is controlled by the depth of water lying on the surface.

<u>The value of RECS can be obtained by measuring the absolute difference in height between the highest and lowest point in each of the transects used to determine RFR, and taking the average of, at least, 10 measurements.</u>



SURFACE ROUGHNESS-3

REFERENCE VALUES FOR RFR

Tillage implement	Roughness ratio (RFR; cm/m)
Mouldboard plough	30-33
Chisel plough	24-27
Cultivator	15-23
Tandem disc	25-28
Offset disc	32-35
Paraplow	32-35
Spike-tooth harrow	17-23
Spring-tooth harrow	25
Rotary hoe	21-22
Rototiller	23
Drill	20-21
Row planter	13-22

Data assembled by K.Auerswald from studies by Alberts et al (1989), Williams et al (1990) and Yoder et al (1991).

SURFACE ROUGHNESS-4

Mannig's '*n*' for fields and cultivated areas

Manning's *n* is used in EUROSEM to describe the roughness imparted to flow.

Manning's *n* value has key importance for runoff routing in plane and channels

Since Manning's *n* cannot be measured directly, its value needs to be estimated.

Rock fragment fraction correction:

$$n_{roc} = n \cdot e^{0.018\,ROC}$$

Land use or cover		low	mean	high
Bare soil: roughness depth	< 25 mm	0.010	0.020	0.030
	25-50 mm	0.014	0.025	0.033
	50-100 mm	0.023	0.030	0.038
	> 100 mm	0.045	0.047	0.049
Bermuda grass: sparse to good cover				
very short grass	> 50 mm	0.015	0.023	0.040
short grass	50-100 mm	0.030	0.046	0.060
medium grass	150-200 mm	0.030	0.074	0.085
long grass	250-600 mm	0.040	0.100	0.150
very long grass	> 600 mm	0.060	0.150	0.200
Bermuda grass: dense cover		0.300	0.410	0.480
Other dense sod forming grasses		0.390	0.450	0.630
Dense bunch grasses			0.150	
Annual grasses (e.g. Sudan grass)			0.200	
Kudzu		0.070	0.150	0.230
Lespedeza (legumes)			0.100	
Natural rangeland		0.100	0.130	0.320
Clipped range		0.020	0.150	0.240
Wheat straw mulch	2.5 t/ha	0.050	0.055	0.080
	5.0 t/ha	0.075	0.100	0.150
	7.5 t/ha	0.100	0.150	0.200
	10.0 t/ha	0.130	0.180	0.250
Chopped maize stalks	2.5 t/ha	0.012	0.020	0.050
	5.0 t/ha	0.020	0.040	0.075
	10.0 t/ha	0.023	0.070	0.130
Cotton		0.070	0.080	0.090
Wheat		0.100	0.125	0.300
Sorghum		0.040	0.090	0.110
Mouldboard plough		0.020	0.060	0.100
Chisel plough; residue rate	< 0.6 t/ha	0.010	0.070	0.170
	0.6-2.5 t/ha	0.070	0.180	0.340
	2.5-7.5 t/ha	0.190	0.300	0.470
	> 7.5 t/ha	0.340	0.400	0.460
	< 0.6 t/ha	0.010	0.080	0.410
Disc/harrow residue rate	0.6-2.5 t/ha	0.100	0.160	0.250
	2.5-7.5 t/ha	0.140	0.250	0.530
	> 7.5 t/ha		0.300	
No tillage: residue rate	< 0.6 t/ha	0.030	0.040	0.070
	0.6-2.5 t/ha	0.010	0.070	0.130
	2.5-7.5 t/ha	0.160	0.300	0.470
Coulter		0.050	0.100	0.130

After Petryk and Bosmajian (1975), Temple (1982) and Engman (1986)

SURFACE ROUGHNESS- 5

Assessment of Mannig 'n' for rill and small channels

Cowan's summation method

$$n = (n_0 + n_1 + n_2 + n_3 + n_4)m_5 \, .$$

Material, n_0

earth	0.020
rock	0.025
fine gravel	0.024
coarse gravel	0.028

Degree of surface irregularity, n_1

smooth	0.000
minor (e.g. only minor slumping)	0.005
moderate (e.g. moderate slumping)	0.010
severe (e.g. badly slumped, or irregular rock surfaces)	0.020

Variation of channel cross section, n_2

gradual	0.000
alternating occasionally	0.005
alternating frequently	0.010–0.015

Relative effect of obstructions (*e.g. debris, roots, boulders*), n_3

neglible	0.000
minor	0.010–0.015
appreciable	0.020–0.030
severe	0.040–0.060

Vegetation, n_4

none	0.000
low	0.005–0.010
medium	0.010–0.025
high	0.025–0.050
very high	0.050–0.100

Degree of meandering, m_5 (*multiplier*)

minor (sinuosity < 1.2)	1.00
appreciable (sinuosity 1.2–1.5)	1.15
severe (sinuosity > 1.5)	1.30

After Cowan (1956)

VEGETATION PARAMETERS

COVER

The percentage canopy cover (COVER:proportion between 0 and 1) of the ground surface obscured by vegetation when viewed vertically from above

PLANTH

The average height of the canopy (PLANTH; cm)

SHAPE

plant shape factor (SHAPE) between thin bladed vegetation such as grasses, cereals and needle-leaved trees (SHAPE =1) and broad-leaved vegetation (SHAPE = 2).

PBASE

Percentage basal area of the vegetation (PBASE). PBASE is the total area of the plant stems expressed as a proportion (between 0 and 1) of the square metre.

DINTR

The maximum interception storage (DINTR; mm) of a vegetation cover.

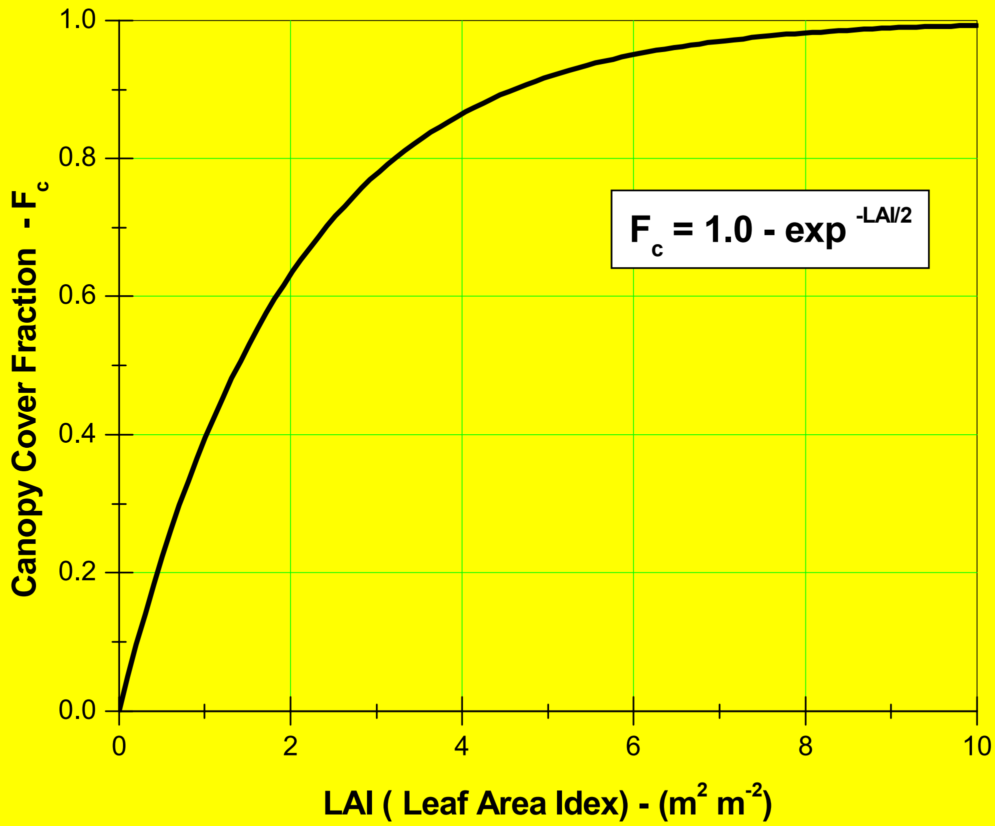
PLANGLE

The average angle of the stems (PLANGLE; degrees) of the vegetation cover.

COVER

The percentage canopy cover (COVER:proportion between 0 and 1) of the ground surface obscured by vegetation when viewed vertically from above.

Ground cover can also be calculated from LAI (leaf area index) which is given by crop-grow models



after Choudhury(1989)

VEGETATION - 2

DINTR
The maximum interception storage (DINTR; mm) of a vegetation cover depends upon its canopy cover and the size, shape and roughness of its leaves.

EUROSEM MANUAL
Morgan et al. 1998

Table A7.1. Guide values of maximum interception storage for mature plants

Vegetation/Crop type	DINTR (mm)
Fescue grass	1.2
Molinia	0.2
Rye grass	2.5
Meadow grass, clover	2.3
Blue stem grass	2.3
Heather	1.5
Bracken	1.3
Tropical rain forest	2.5
Temperate deciduous woodland: winter	1
Temperate deciduous woodland: summer	2.5
Needleleaf forest: pines	1
Needleleaf forest: spruce, firs	1.5
Evergreen hardwood forest	0.8
Apple	0.5
Soya beans	0.7
Potatoes	0.9
Cabbage	0.5
Brussels sprouts	1
Sugar beet	0.6
Millet	0.3
Spring wheat	1.8
Winter wheat	3
Barley, rye, oats	1.2
Maize	0.8
Tobacco	1.8
Alfalfa	2.8

After Horton (1919), Zinke (1967), Rutter and Morton (1977) and Herwitz (1985)

VEGETATION - 3

parameters

PLANT
PANGLE
SHAPE

Plant type	Height (m)	Stem angle (°)	Shape factor
Maize	2-3	50-80	2
Millet, sorghum	1-2	50-80	2
Oilseed rape	1-1.4	25-60	2
Linseed	0.8-1.6	60-90	2
Pineapple	0.5-1	70-90	2
Potato	0.6-1	30-50	2
Cassava	2.5-3	70-90	2
Rice	0.5-1	70-80	1
Sugar beet	0.8-1	70-80	2
Sugar cane	3-6	70-90	2
Tobacco	1.5-2	10-60	2
Wheat, barley, oats	0.5-1.5	80-90	1
Rye	1-2	80-90	1
Rubber	18-30	20-80	2
Oil palm	9-10	0-90	2
Coffee	4-4.5	40-80	2
Tea	1-1.5	60-80	2
Cocoa	4.5-7	60-80	2
Coconut	18-30	0-90	2

Extracted from EUROSEM MANUAL – Morgan et. Al. 1998

After Cobley (1956), Bogdan (1977), Tindall (1983), Doorenbos and Kassam (1986), De Rougemont (1989) and Langer and Hill (1991). These references should also be consulted for crops not listed.

VEGETATION 3

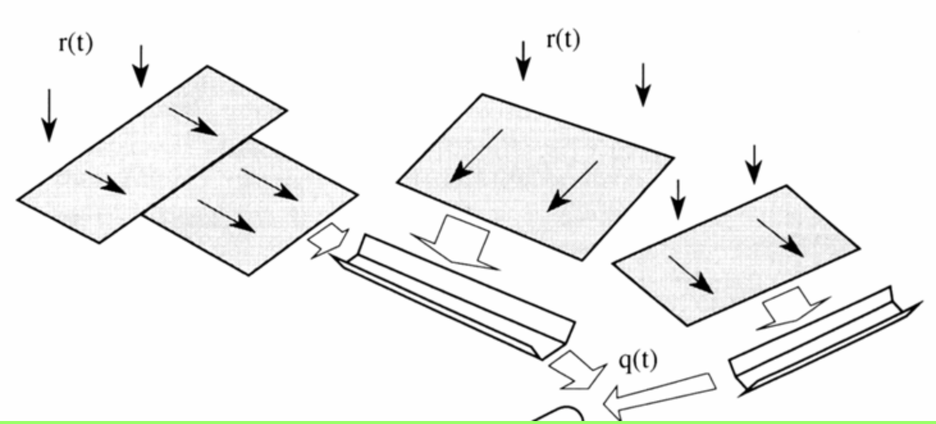
PBASE

PBASE is the total area of the plant stems expressed as a proportion (between 0 and 1) of the square metre.

Land use or cover	Cover condition	Proportional basal area (PBASE)
Fallow: after row crops		0.1
Fallow: after sod		0.3
Row crops	poor	0.1
	good	0.2
Small grain	poor	0.2
	good	0.3
Hay - legume	poor	0.2
	good	0.4
Hay - sod	poor	0.4
	good	0.6
	excellent	0.8
Pasture or range (bunch grass)	poor	0.2
	fair	0.3
	good	0.4
Temporary pasture - sod	poor	0.4
	fair	0.5
	good	0.6
Permanent pasture or meadow	poor	0.8
	good	1.0
Woods and forest		1.0

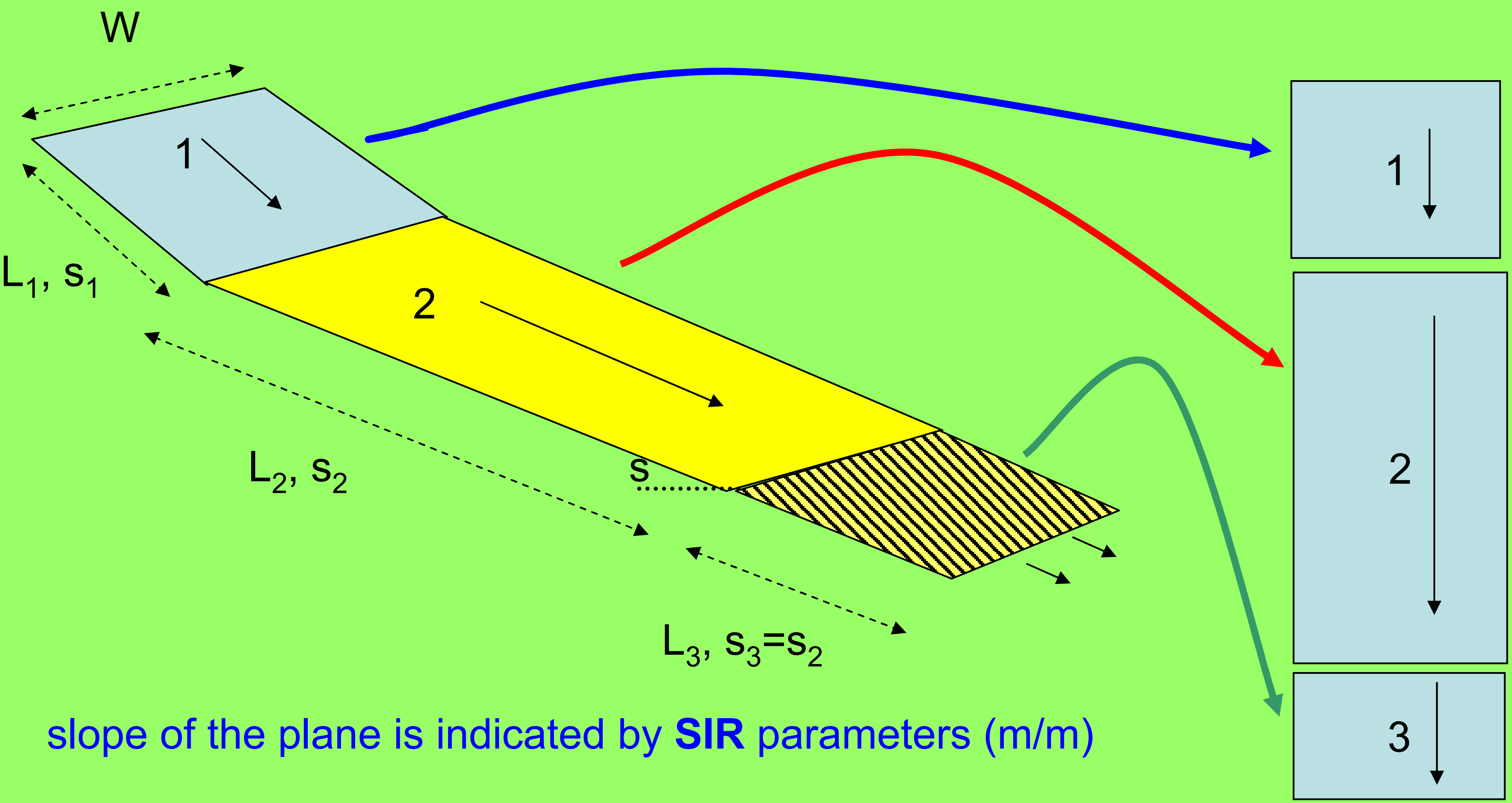
After Holtan (1961)

VIRTUAL WHATERSHED AND FIELD REPRESENTATION

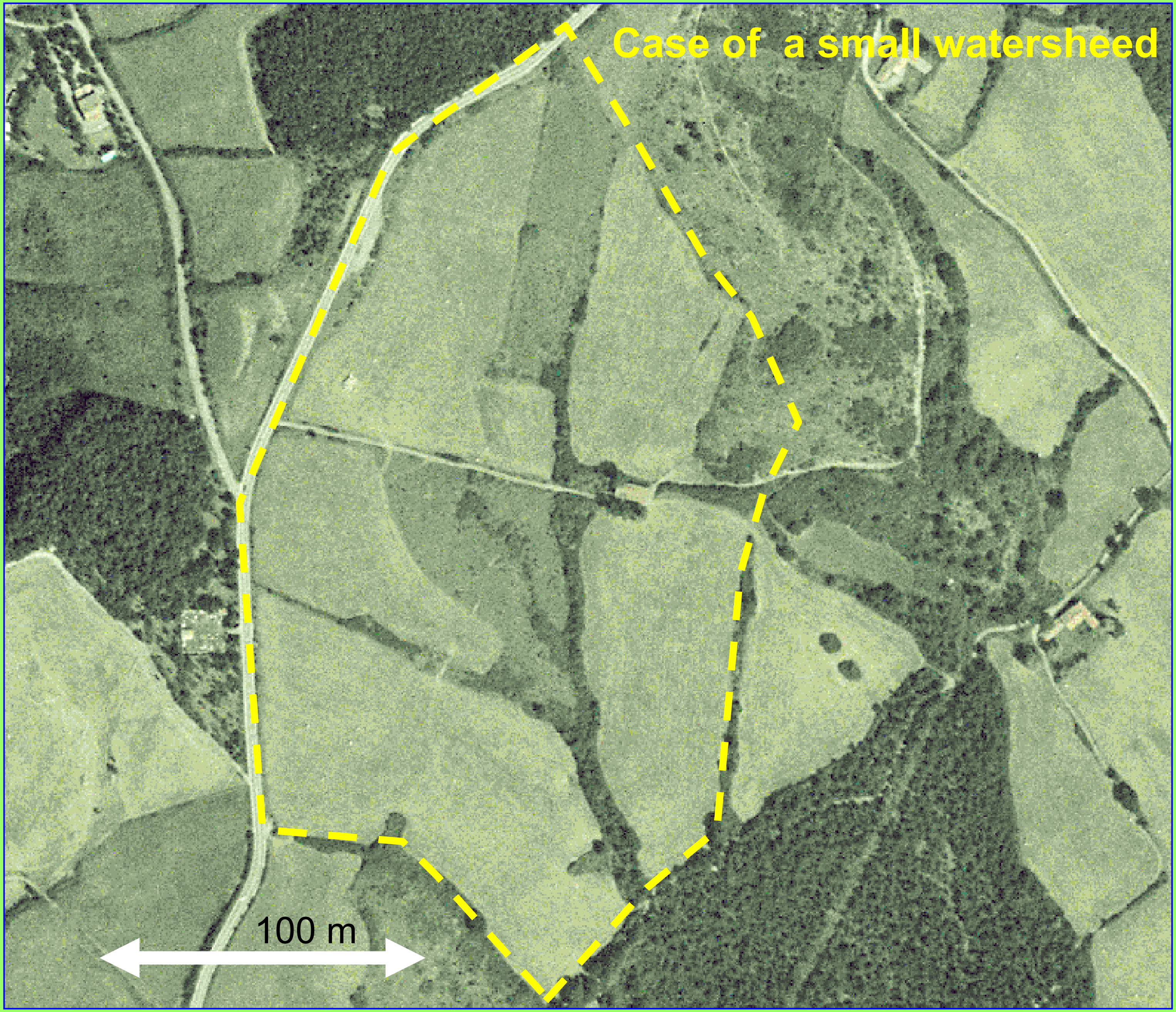


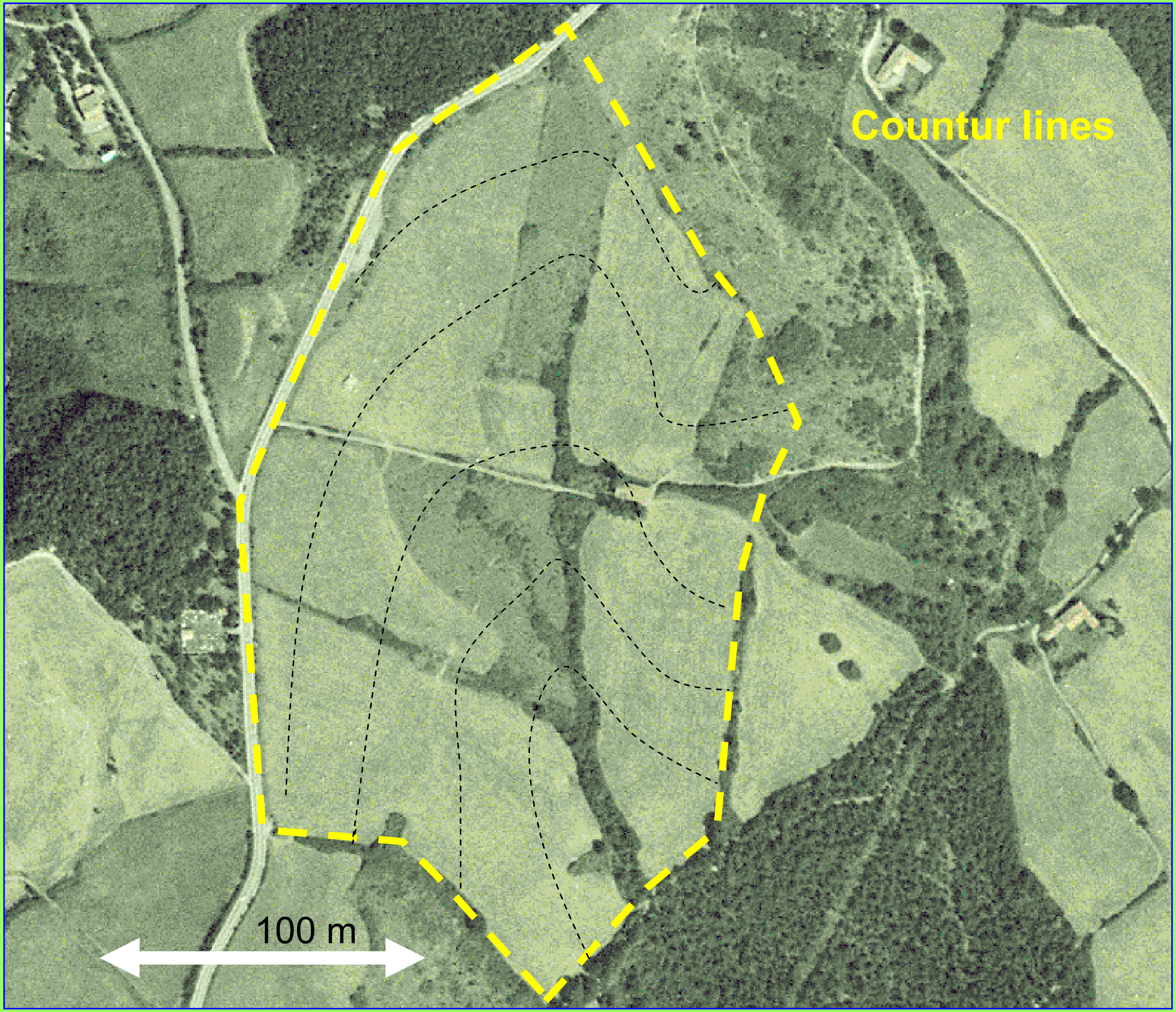
Regular Field Plot

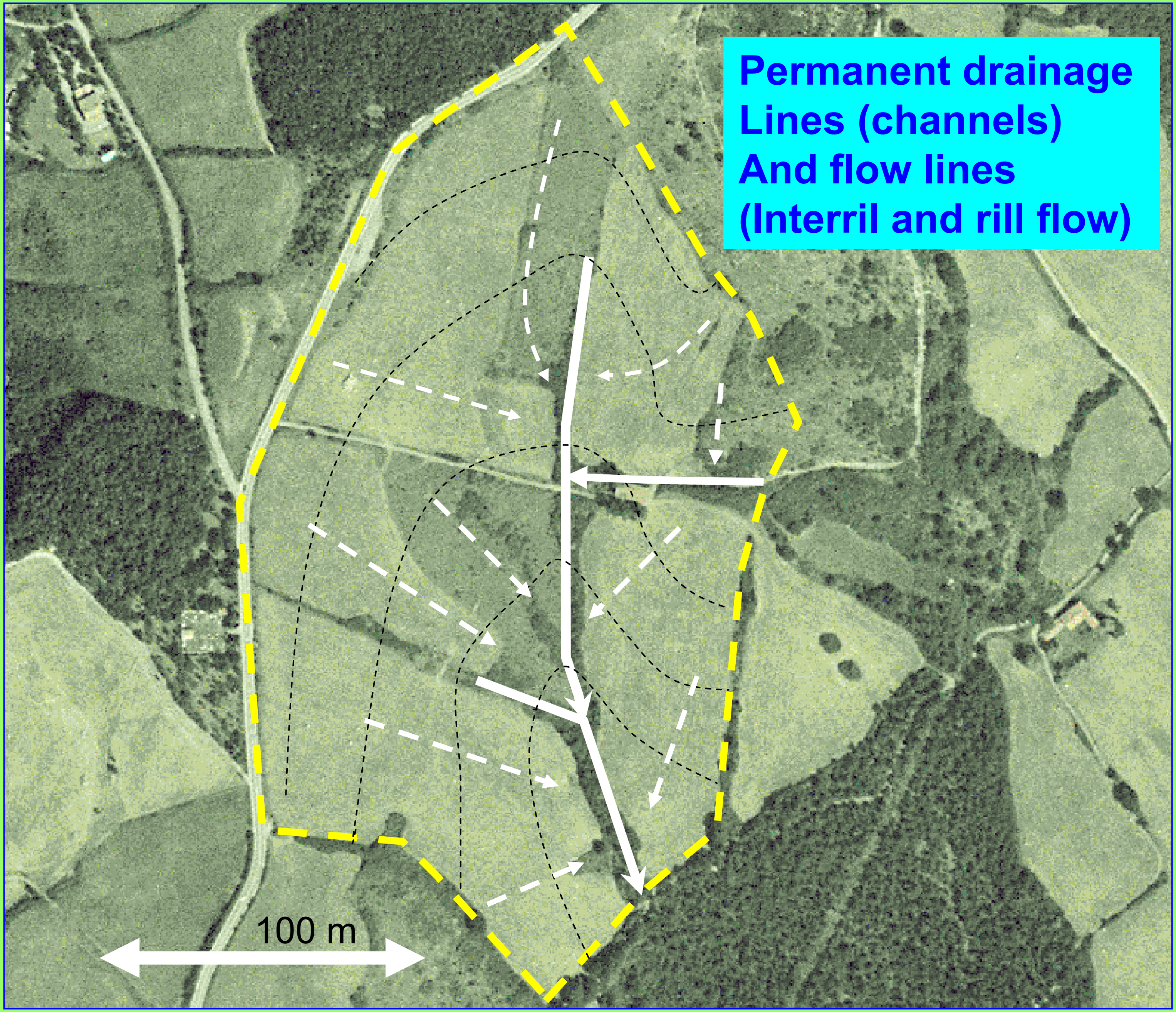
Modelled with cascading planes



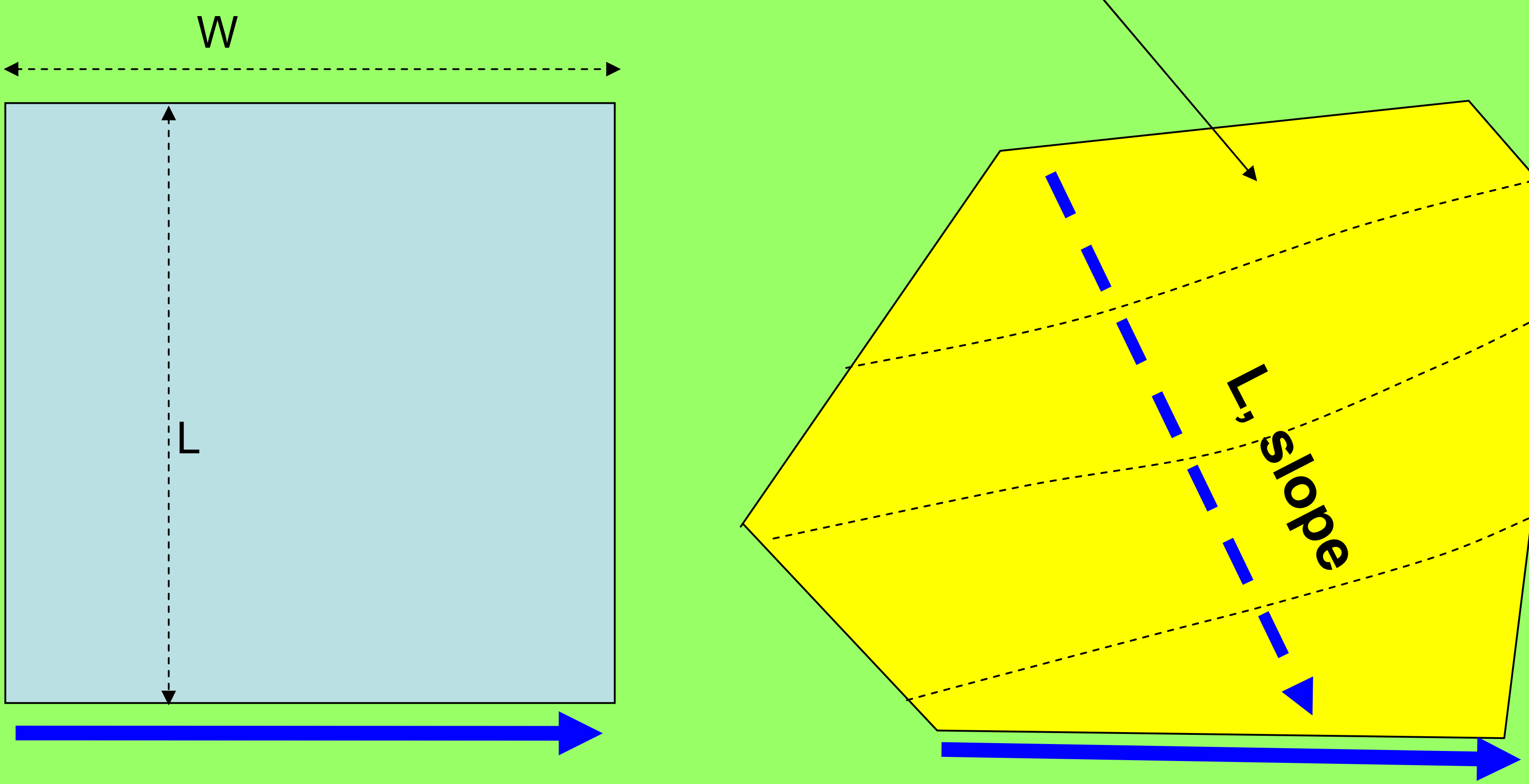
slope of the plane is indicated by **SIR** parameters (m/m)


Case of a small watersheed
100 m

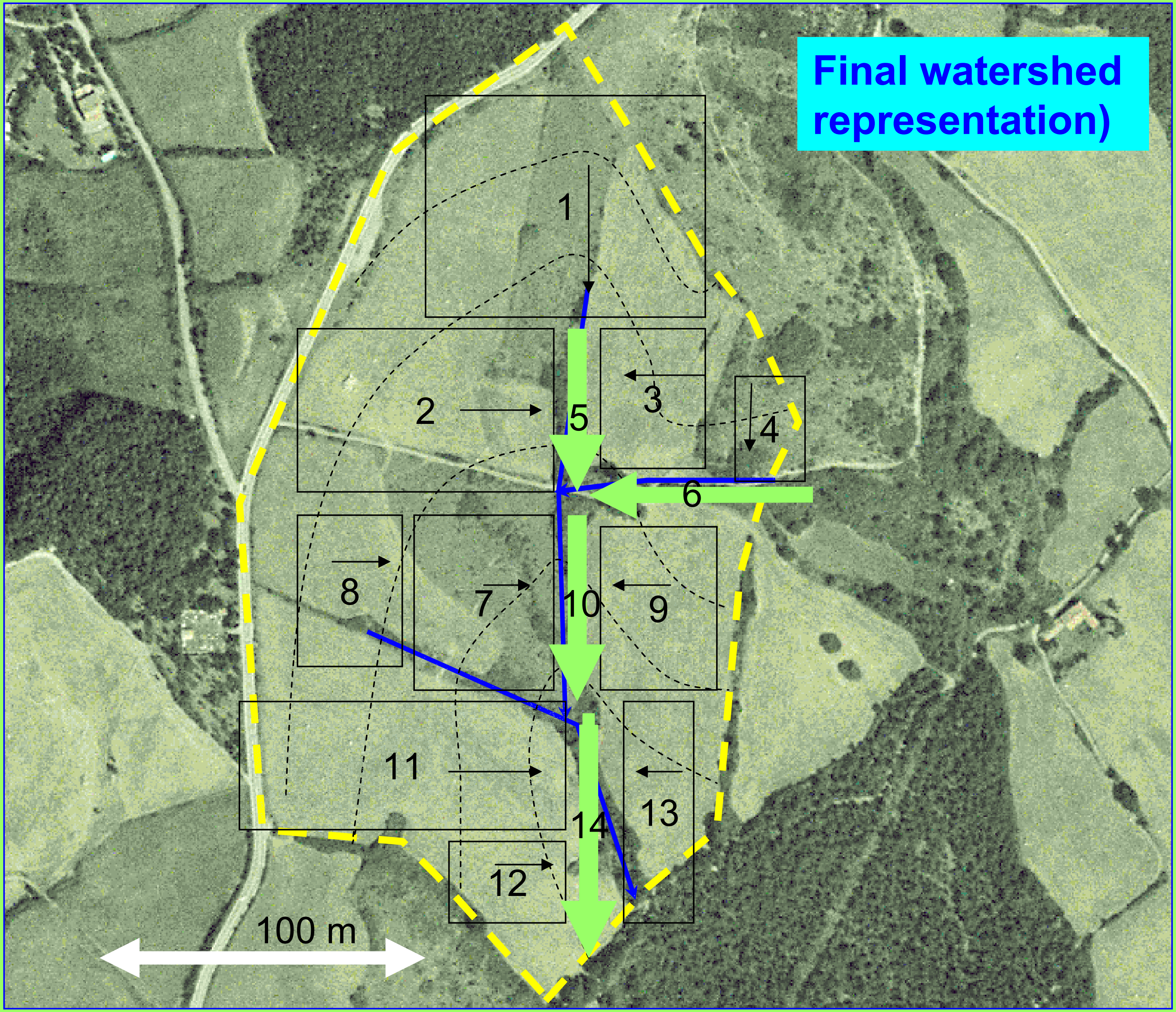

Countur lines
100 m


Permanent drainage
Lines (channels)
And flow lines
(Interril and rill flow)
100 m

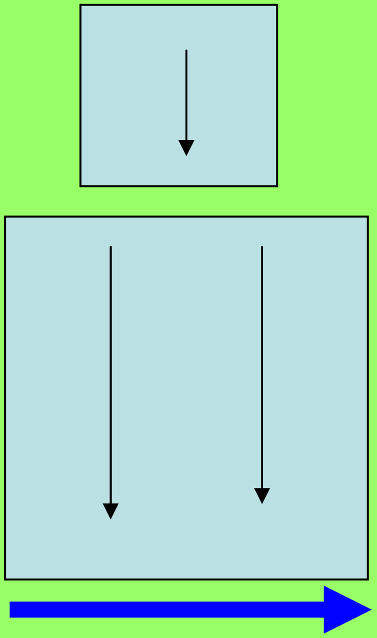
Irregular field plot



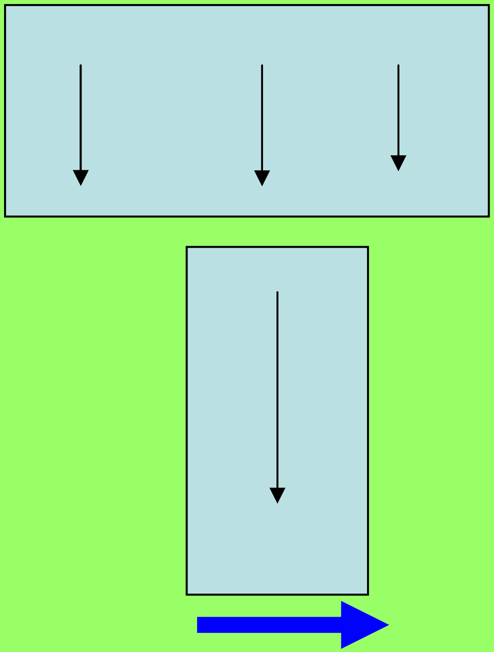
W=A/L


Final watershed representation)
1
2
3
4
5
6
7
8
9
10
11
12
13
14
100 m

FLOW DIVERGENCE AND CONVERGENCE

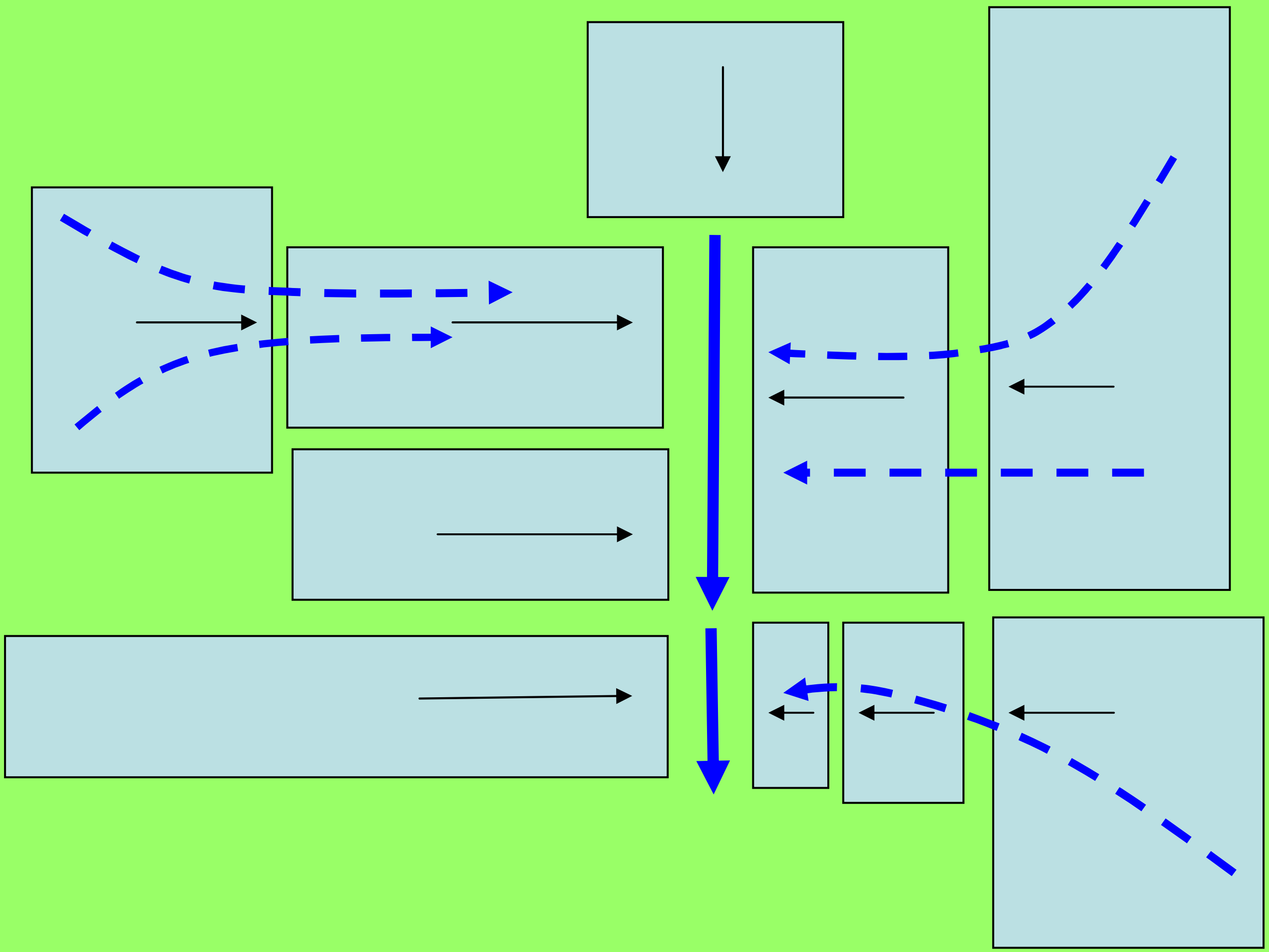


Cascade of planes with
<u>Flow divergence</u>



Cascade of planes with
<u>Flow convergence</u>

Plane and channel arrangement

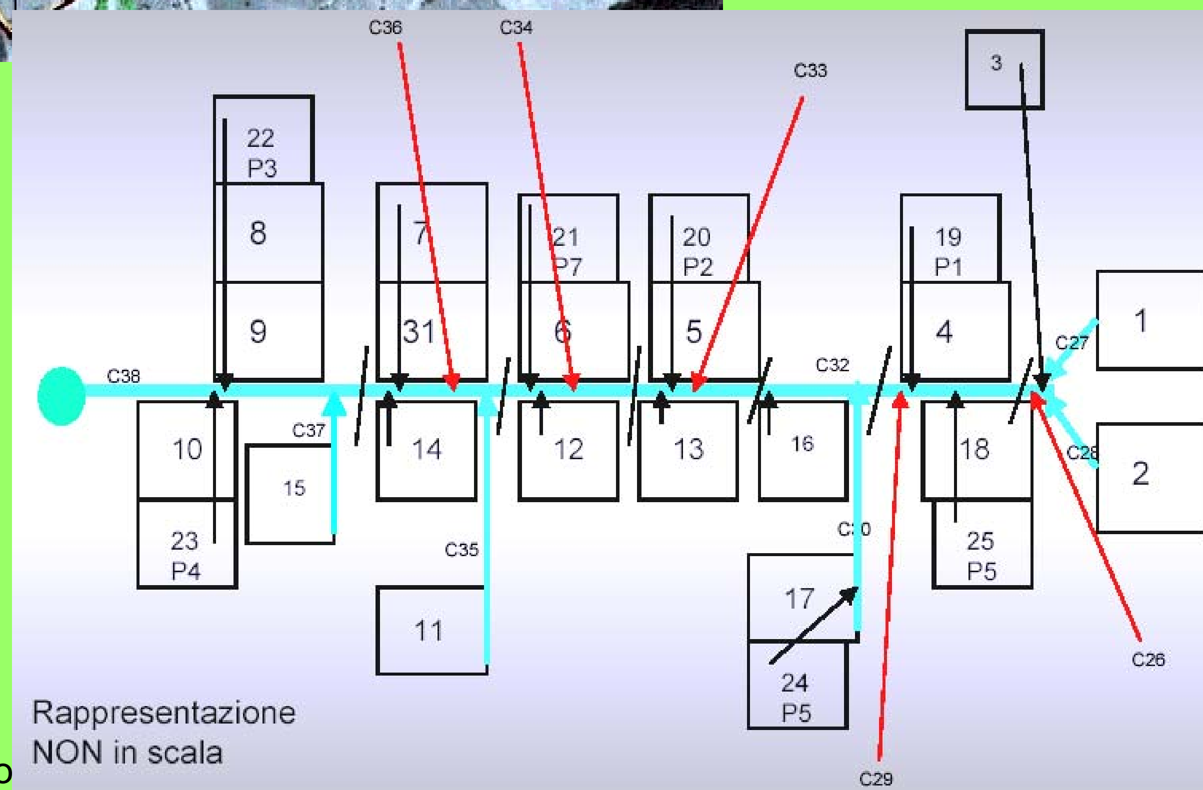


WATERSHED AND PLOTS REPRESENTATION TIPS AND SUGGESTIONS

For field plots:
- **Graphical shetch in scale with relevant informations as:**
- **flow direction,**
- **slopes in flow direction,**
- **connections and changes of land use**
- **Presence and geometry of rill or furrows**
- **All the information associated at each homogeneous portion of it.**

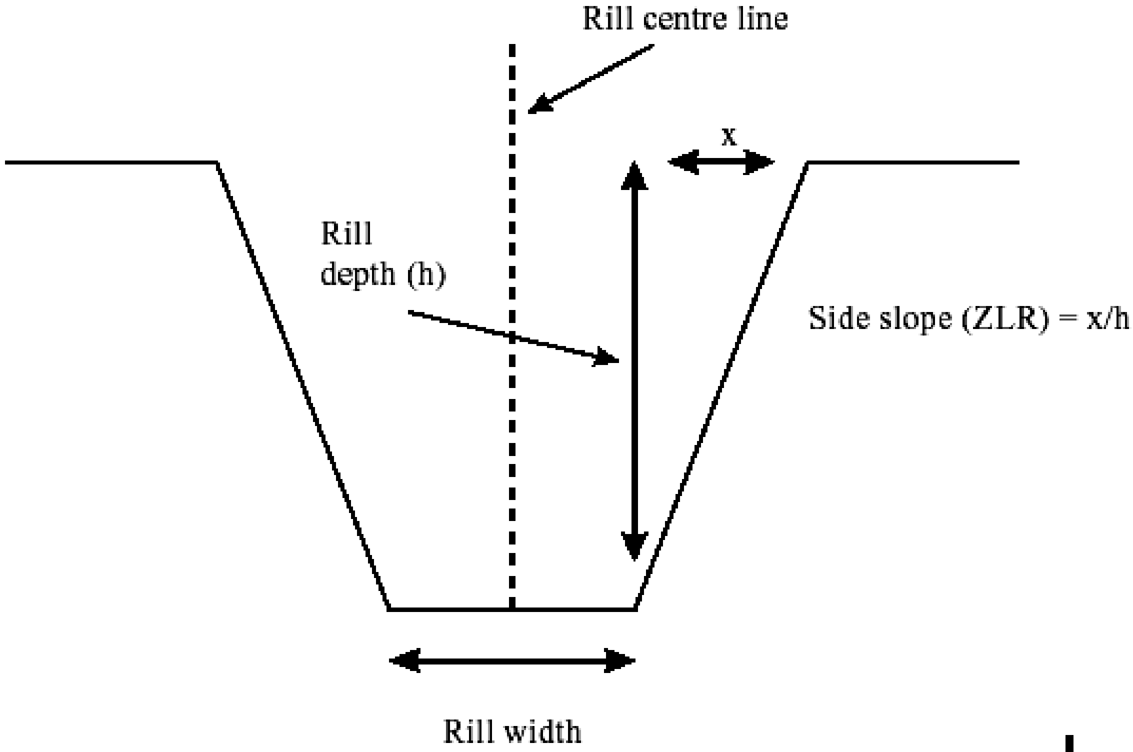
For small wathershed
- **A good DEM with contour levels,**
- **mainstream channel,**
- **Slopes ,**
- **land uses**
- **flow direction,**
- **and connectivity hillslope channels**
- **In case of irregular plots take the maximum flow length L and compute width W dividing A by L**

And ... GOOD luck



A compex example
After Acutis (2001)

Rills and channels - 1



EUROSEM rill geometry

Plane with rill and interrill

RILL GEOMETRY

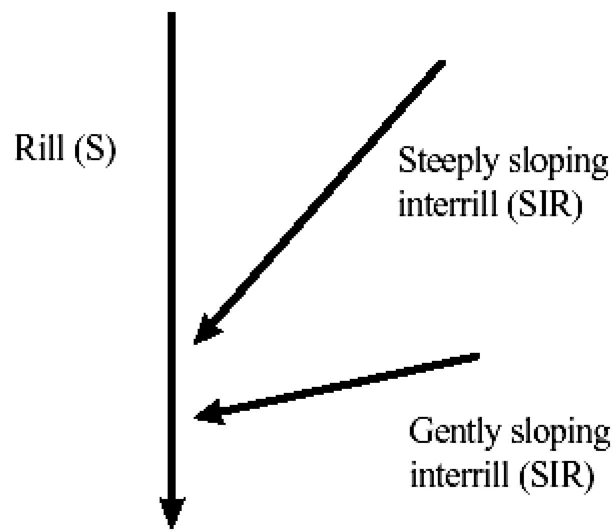
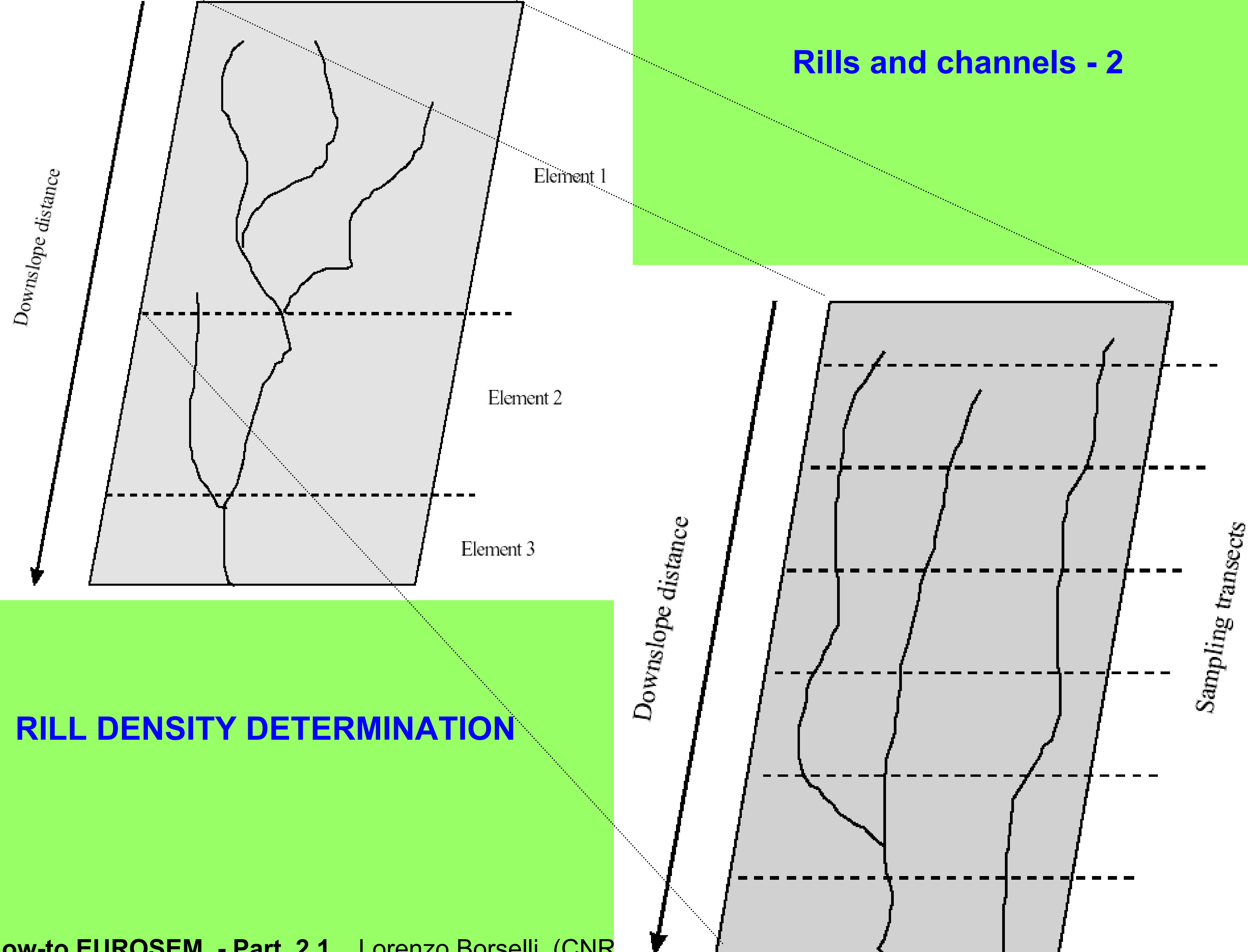


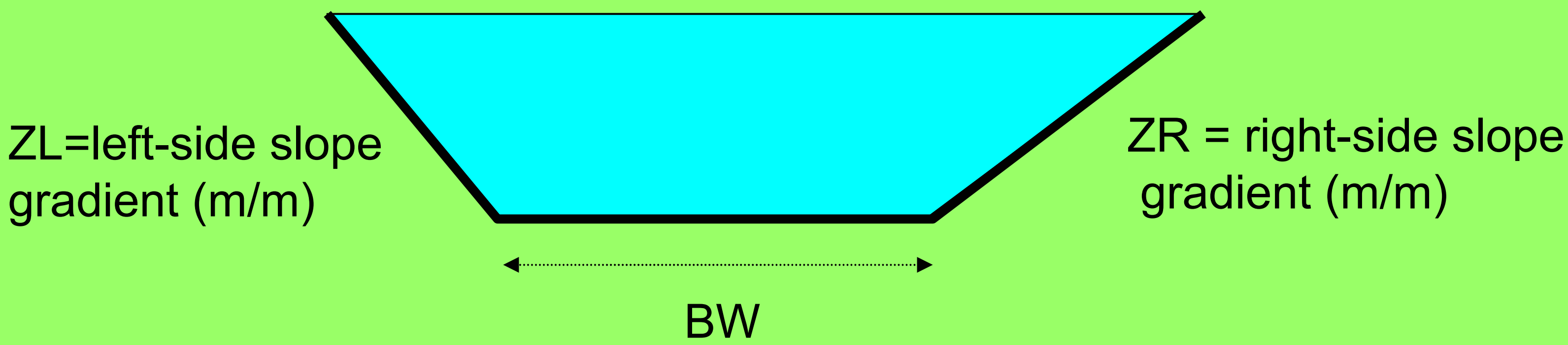
Figure A2.1. Rill (S) and interrill (SIR) slope paths on a plane (hillslope) element

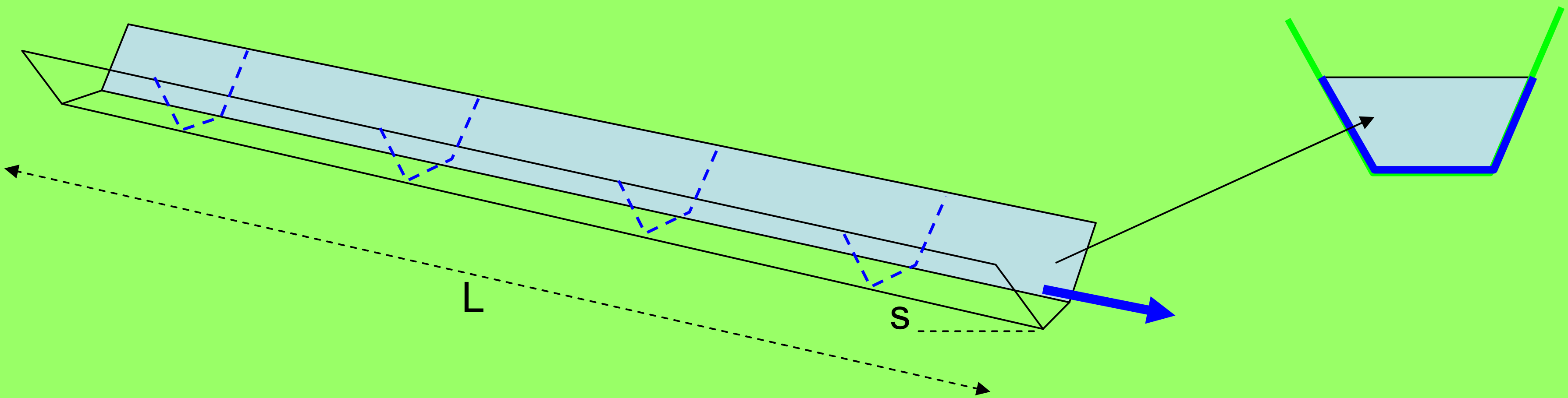
Rills and channels - 2



RILL DENSITY DETERMINATION

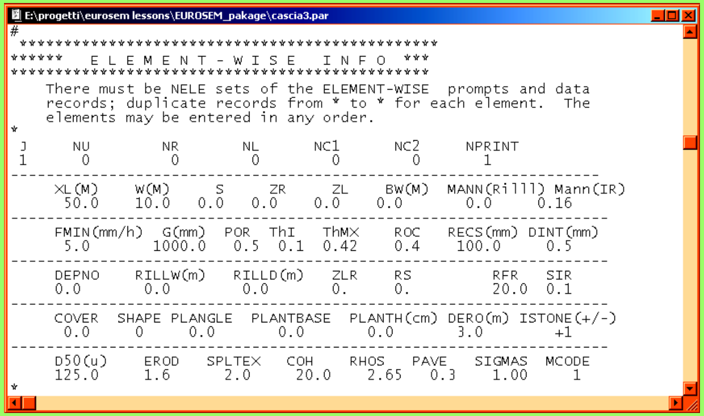
CHANNEL’S GEOMETRY





INPUT FILES IN EUROSEM: STRUCTURE AND GUIDE TO CREATION

Lorenzo Borselli*



E:\progetti\eurosem lessons\EUROSEM_pakage\cascia3.par

```
#
 ************************************************
******   E L E M E N T - W I S E   I N F O  ***
************************************************
    There must be NELE sets of the ELEMENT-WISE  prompts and data
    records; duplicate records from * to * for each element.  The
    elements may be entered in any order.
*
 J      NU          NR        NL        NC1       NC2      NPRINT
 1       0           0         0          0         0         1
-------------------------------------------------------------------
     XL(M)     W(M)      S      ZR      ZL     BW(M)   MANN(Rilll) Mann(IR)
      50.0     10.0    0.0     0.0     0.0     0.0       0.0       0.16
--------------------------------------------------------------------
     FMIN(mm/h)   G(mm)   POR   ThI    ThMX     ROC    RECS(mm) DINT(mm)
      5.0        1000.0   0.5   0.1   0.42      0.4    100.0       0.5
--------------------------------------------------------------------
     DEPNO      RILLW(m)    RILLD(m)    ZLR      RS           RFR    SIR
     0.0         0.0         0.0        0.       0.           20.0   0.1
--------------------------------------------------------------------
     COVER   SHAPE  PLANGLE   PLANTBASE   PLANTH(cm)  DERO(m)  ISTONE(+/-)
      0.0      0      0.0        0.0        0.0        3.0        +1
--------------------------------------------------------------------
     D50(u)     EROD    SPLTEX    COH      RHOS    PAVE    SIGMAS   MCODE
     125.0      1.6      2.0      20.0     2.65    0.3      1.00      1
*
```

Consiglio Nazionale delle Ricerche

Istituto di Ricerca per la Protezione Idrogeologica (CNR-IRPI),

Piazzale delle Cascine 15, 50144, Firenze, Italy

borselli@irpi.cnr.it

http://www.fi.cnr.it/irpi

TYPES OF INPUT FILES

- **Rainfall input file (usual extension: .PCP)**

It contains:

The data wich represents the hyetogram in cumulated form : time (min) versus cumulated depth of rainfall (mm)

The data are given for each raingauge

The table associating raingauge number to plane number must be correctly compiled

- **Parameters input file (usual extension: .PAR)**

It contains:

The information of watersheed structure and links between elements

The ELEMENT WISE INFORMATIONS for each elements (plane or channel) of the virtual watersheed.

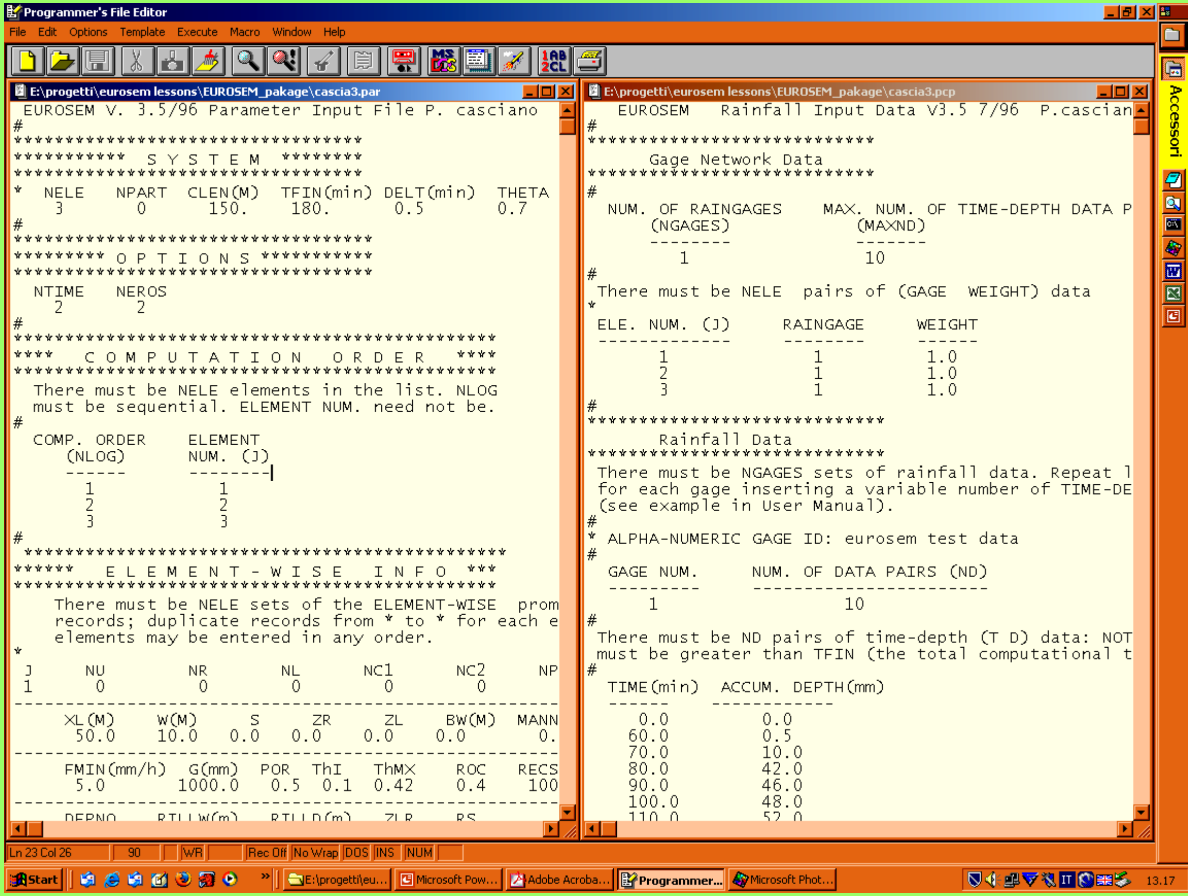
The constants assumed for the dynamic simulation (time step, Theta, ...)

STRUCTURE OF INPUT FILES

All the input files are ASCII text files.

They can be edited using a normal TEXT EDITOR program:

- Commercial programs
- Programs present in the Window OS (e.g. notepad.exe, write.exe)
- Freeware text editors (e.g. ConText, PFE …….)



THE RAINFALL DATA FILE - 1

Max number of time - depth data pairs

The number of raingages

Correspondence table between raingages and element number

If you change the number of elements (plane+ channels)

You must update the correspondence table

E:\progetti\eurosem lessons\EUROSEM_pakage\cascia3.pcp

```
   EUROSEM    Rainfall Input Data V3.5 7/96  P.casciano  28/08/98
#
****************************
      Gage Network Data
****************************
#
  NUM. OF RAINGAGES    MAX. NUM. OF TIME-DEPTH DATA PAIRS FOR ALL GAGES
      (NGAGES)               (MAXND)
      --------               --------
         1                     10
#
 There must be NELE  pairs of (GAGE  WEIGHT) data
*
 ELE. NUM. (J)      RAINGAGE      WEIGHT
 -------------      --------      ------
       1                1          1.0
       2                1          1.0
       3                1          1.0
#
*****************************
        Rainfall Data
*****************************
 There must be NGAGES sets of rainfall data. Repeat lines from * to *
 for each gage inserting a variable number of TIME-DEPTH data pairs
 (see example in User Manual).
#
* ALPHA-NUMERIC GAGE ID: eurosem test data
#
  GAGE NUM.     NUM. OF DATA PAIRS (ND)
  ---------     -----------------------
      1                   10
#
```

THE RAINFALL DATA FILE - 2

Raingage identification number and no. of data pairs

Time – depth data pairs

data must be entered for each rain gauge

E:\progetti\eurosem lessons\EUROSEM_pakage\cascia3.pcp

```
#
*****************************
       Rainfall Data
*****************************
 There must be NGAGES sets of rainfall data. Repeat lines from * to *
 for each gage inserting a variable number of TIME-DEPTH data pairs
 (see example in User Manual).
#
* ALPHA-NUMERIC GAGE ID: eurosem test data
#
  GAGE NUM.     NUM. OF DATA PAIRS (ND)
  ---------     -----------------------
      1                   10
#
 There must be ND pairs of time-depth (T D) data: NOTE: The last time
 must be greater than TFIN (the total computational time).
#
  TIME(min)  ACCUM. DEPTH(mm)
  ------     ------------
    0.0          0.0
   60.0          0.5
   70.0         10.0
   80.0         42.0
   90.0         46.0
  100.0         48.0
  110.0         52.0
  120.0         57.5
  180.0         59.5
  200.0         59.5
*
```

PARAMETERS FILE - 1

No. Of elements

Simulation end after …

Time step for simulation

Theta parameter For numerical solution

Computation order for elements

Maximum cumulate length on connected elements

The parameters indicated with this symbol should never be changed

E:\progetti\eurosem lessons\EUROSEM_pakage\cascia3.par

```
 EUROSEM V. 3.5/96 Parameter Input File P. casciano
#
**********************************
***********  S Y S T E M  ********
**********************************
*  NELE    NPART    CLEN(M)   TFIN(min)  DELT(min)  THETA   TEMP
    3        0       150.      180.       0.5        0.7    20.
#
***********************************
*********  O P T I O N S  *********
***********************************
  NTIME    NEROS
    2        2
#
*********************************************
****   C O M P U T A T I O N   O R D E R   ****
*********************************************
  There must be NELE elements in the list. NLOG
  must be sequential. ELEMENT NUM. need not be.
#
  COMP. ORDER     ELEMENT
     (NLOG)       NUM. (J)
     ------       ---------
       1             1
       2             2
       3             3
#
```

PARAMETERS FILE - 2

The parameters indicated with this symbol should never be changed

Element identification

W and L of element (plane)

Splash erodibility

Cohesion

Total impervious fraction

Manning's n (interrill)

E:\progetti\eurosem lessons\EUROSEM_pakage\cascia3.par

```
 *********************************************
******   E L E M E N T - W I S E   I N F O  ***
**********************************************
    There must be NELE sets of the ELEMENT-WISE  prompts and data
    records; duplicate records from * to * for each element.  The
    elements may be entered in any order.
*
  J       NU         NR        NL        NC1       NC2       NPRINT
  1        0          0         0          0         0          1
-------------------------------------------------------------------
      XL(M)     W(M)      S       ZR       ZL      BW(M)   MANN(Rill)  Mann(IR)
       50.0     10.0     0.0     0.0      0.0      0.0       0.0       0.16
--------------------------------------------------------------------
      FMIN(mm/h)   G(mm)   POR   ThI    ThMX     ROC     RECS(mm)  DINT(mm)
       5.0          1000.0  0.5   0.1   0.42     0.4      100.0      0.5
--------------------------------------------------------------------
      DEPNO     RILLW(m)    RILLD(m)    ZLR      RS           RFR    SIR
      0.0        0.0         0.0        0.       0.           20.0   0.1
--------------------------------------------------------------------
      COVER   SHAPE  PLANGLE   PLANTBASE   PLANTH(cm)  DERO(m)  ISTONE(+/-)
       0.0     0      0.0       0.0         0.0         3.0        +1
--------------------------------------------------------------------
      D50(u)      EROD    SPLTEX    COH     RHOS     PAVE    SIGMAS   MCODE
      125.0       1.6      2.0      20.0    2.65     0.3      1.00      1
*
*
```

Hydraulic, Vegetation, And surface parameters

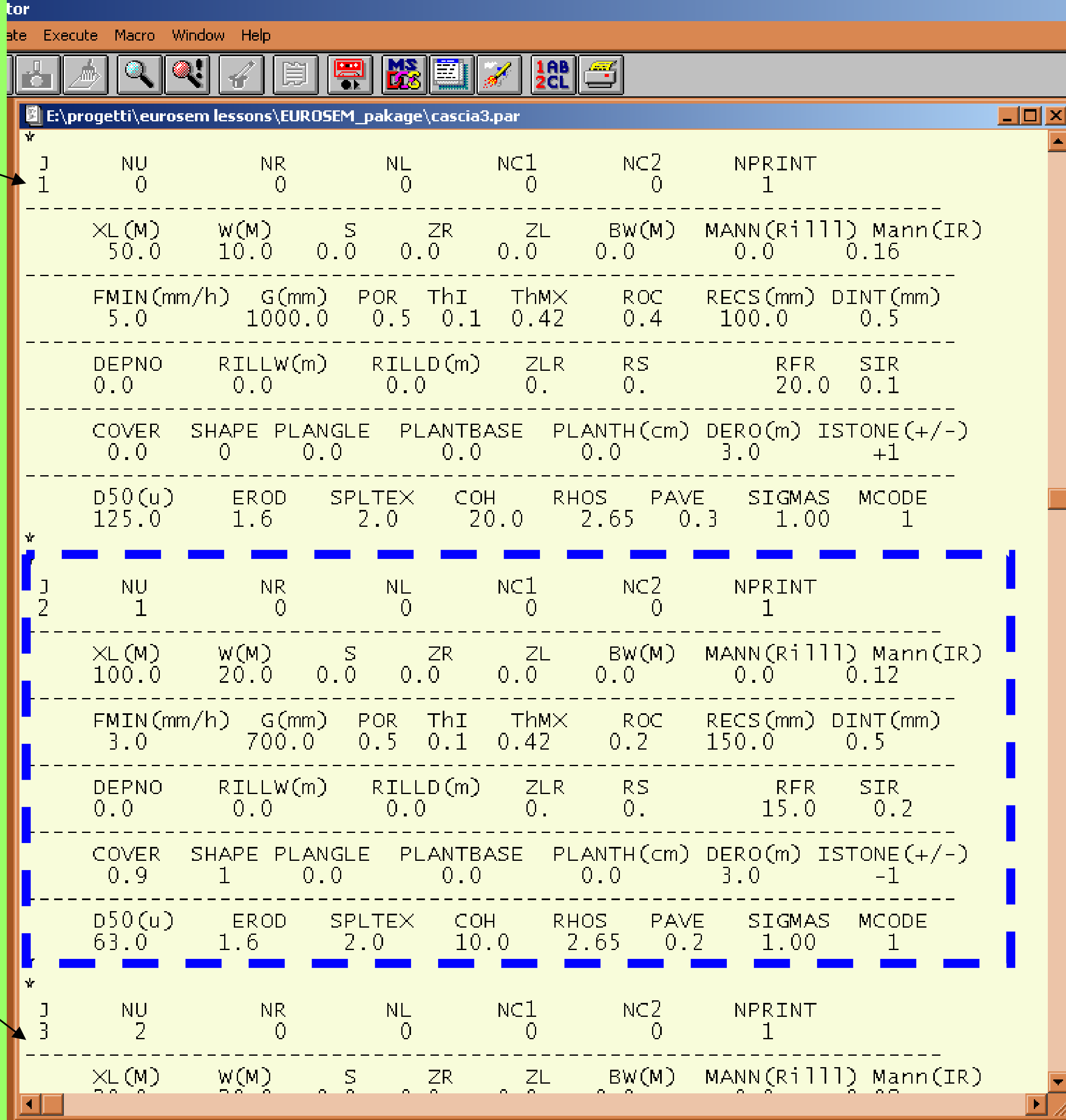
PARAMETERS FILE - 3

Element 1

The table of the parameters must be repeated for each element (plane or channel)

Element 2

Element 3




```
*
 J       NU        NR        NL        NC1       NC2       NPRINT
 1       0         0         0         0         0         1
-----------------------------------------------------------------
   XL(M)    W(M)     S      ZR      ZL      BW(M)   MANN(Rill)  Mann(IR)
   50.0     10.0    0.0    0.0     0.0     0.0      0.0        0.16
-----------------------------------------------------------------
   FMIN(mm/h)   G(mm)   POR   ThI   ThMX   ROC   RECS(mm)  DINT(mm)
   5.0          1000.0  0.5   0.1   0.42   0.4   100.0     0.5
-----------------------------------------------------------------
   DEPNO    RILLW(m)    RILLD(m)    ZLR    RS        RFR    SIR
   0.0      0.0         0.0         0.     0.        20.0   0.1
-----------------------------------------------------------------
   COVER  SHAPE  PLANGLE  PLANTBASE  PLANTH(cm)  DERO(m)  ISTONE(+/-)
   0.0    0      0.0      0.0        0.0         3.0      +1
-----------------------------------------------------------------
   D50(u)   EROD   SPLTEX   COH    RHOS   PAVE   SIGMAS   MCODE
   125.0    1.6    2.0      20.0   2.65   0.3    1.00     1
*
 J       NU        NR        NL        NC1       NC2       NPRINT
 2       1         0         0         0         0         1
-----------------------------------------------------------------
   XL(M)    W(M)     S      ZR      ZL      BW(M)   MANN(Rill)  Mann(IR)
   100.0    20.0    0.0    0.0     0.0     0.0      0.0        0.12
-----------------------------------------------------------------
   FMIN(mm/h)   G(mm)   POR   ThI   ThMX   ROC   RECS(mm)  DINT(mm)
   3.0          700.0   0.5   0.1   0.42   0.2   150.0     0.5
-----------------------------------------------------------------
   DEPNO    RILLW(m)    RILLD(m)    ZLR    RS        RFR    SIR
   0.0      0.0         0.0         0.     0.        15.0   0.2
-----------------------------------------------------------------
   COVER  SHAPE  PLANGLE  PLANTBASE  PLANTH(cm)  DERO(m)  ISTONE(+/-)
   0.9    1      0.0      0.0        0.0         3.0      -1
-----------------------------------------------------------------
   D50(u)   EROD   SPLTEX   COH    RHOS   PAVE   SIGMAS   MCODE
   63.0     1.6    2.0      10.0   2.65   0.2    1.00     1
*
 J       NU        NR        NL        NC1       NC2       NPRINT
 3       2         0         0         0         0         1
-----------------------------------------------------------------
   XL(M)    W(M)     S      ZR      ZL      BW(M)   MANN(Rill)  Mann(IR)
```

LIST OF INPUT PARAMETERS -1

Variable	Symbol	Definition	Units
ACCUM.DEPTH		Accumulated depth of rain	mm
BW		Width of channel bottom	m
CLEN		Characteristic length of catchment. Use maximum lengths of cascading planes or longest channel	m
COH	J	Cohesion of the soil or soil-root matrix as measured at saturation using a torvane	kPa
COVER	COV	Percentage canopy cover	%
D50	d_{50}	Median particle diameter of the soil	µm
DELT		Time increment number used in calculations, usually 1 minute	min
DEPNO		Average number of concentrated flow paths (rills) across the width of the plane	
DERO		Maximum depth to which erosion can occur because of a non-erodible layer in the soil	m
DINT	IC_{max}	Maximum interception storage of the vegetation cover	mm
ELE.NUM.(J)		Element number	
EROD		Detachability of the soil particles by raindrop impact	g/J
FMIN	k_{sat}	Saturated hydraulic conductivity of the soil	mm/h
G	G	Effective net capillary drive of the soil	mm
GAGE.NUM		Rain gauge number	
ISTONE		Governs effect of rock fragments on saturated hydraulic conductivity (+1 = increase in hydraulic conductivity; -1 = decrease in hydraulic conductivity)	
J		Element number	
MANN(IR)	n	Value of Manning's n for the interrill area, allowing for roughness effects of soil particles, rock fragments, surface microtopography and vegetation cover (also used for non-rilled elements and channel elements)	$m^{1/6}$
MANN(RL)		Value of Manning's n for the rills, allowing for roughness effects of soil particles, rock fragments, surface microtopography and vegetation cover	$m^{1/6}$
MAXND		Maximum number of time-depth pairs for all rain gauges	
MCODE		Governs selection of sediment transport equations for interrill flow (0 = Govers; 1 = Everaert)	

Variable	Symbol	Definition	Units
NC1		Element number of first channel contributing at upstream boundary of a channel element	
NC2		Element number of second channel contributing at upstream boundary of a channel element	
NELE		Total number of plane and channel elements	
NEROS		Allows user to call or reject erosion option within KINEROS. Set = 2 for EUROSEM	
NGAGES		Number of rain gauges (1-20)	
NL		Element number contributing flow to left-hand side of channel (when facing downstream)	
NLOG		Governs computation order	
NPRINT		Controls amount of information provided in the auxiliary output file. Normally set at 1 (other options are 2 and 7).	
NR		Element number contributing flow to right-hand side of channel (when facing downstream)	
NU		Element number of plane contributing to upslope boundary	
NUM.OF DATA PAIRS (ND)		Number of time-depth pairs for rainfall data	
NUM.(J)		Number of element corresponding to NLOG. Governs order in which elements are treated in computation.	
PAVE	PAVE	Fraction of surface covered by non-erodible material, e.g. rock fragments, concrete, tarmac	
PBASE	PBASE	Percentage of basal area of vegetation expressed as a proportion between 0 and 1	
PLANGLE	PA	Average acute angle of the plant stems to the soil surface	degrees
PLANTH		Effective canopy height	m
POR		Soil porosity	% v/v
RAINGAGE		Identification number assigned to the rain gauge	
RECS	RECS	Infiltration recession factor	mm
RFR	RFR	Downslope roughness	
RHOS		Specific gravity of the sediment particles	mg/m^3
RILLD		Average depth of concentrated flow paths (rills)	m
RILLW		Average width of concentrated flow paths (rills)	m
ROC	ROC	Proportion of rock fragments in the soil by volume	

LIST OF INPUT PARAMETERS -2

Variable	Symbol	Definition	Units
RS		Governs the option of whether the width and depth of rills are uniform over the length of the element or whether they increase downslope	
S	s	Average slope of the rills or concentrated flow paths on a plane element	m/m
SHAPE		Plant leaf shape factor, 1 = bladed leaves; 2 = broad leaves. A value of 0 = no vegetation and sets stemflow to zero	
SIGMAS		Standard deviation of sediment diameter (not used in present version of EUROSEM)	
SIR	s	Interrill slope (also used for slope of plane elements without rills and for channel elements)	m/m
SPLTEX	b	Water depth exponent affecting soil detachment by raindrop impact (set to 2.0 in present version of EUROSEM)	
TEMP		Air temperature at time of rainfall	° C
TFIN		Duration of model simulation. Value must be less than the end-time of the last time-depth pair of the rainfall data	min
THETA		Weighting factor in finite difference equations, usually set between 0.5 and 1.0	
THI	θ_I	Initial volumetric moisture content of the soil	% v/v
THMAX	θ_s	Maximum volumetric moisture content of the soil	% v/v
TIME		Accumulated time from start of storm	min
W		Width of plane element (set to 0.0 for channels)	m
WEIGHT		Multiplication factor for weighting of RAINGAGE	
XL		Length of plane or channel element	m
ZL		Side slope of left side of trapezoidal channel	1:x
ZLR		Side slope of concentrated flow paths (rills)	1:x
ZR		Side slope of right side of trapezoidal channel	1:x

TIPS TO CREATE AND MANAGE INPUT FILES

A sketch of the watersheed or field plot, with all the relevant parameters must be available

It is useful to have, as reference, the example input data files given with The EURO.EXE program

They can be edited and modified easily with a text editor before running each simulation, if required.

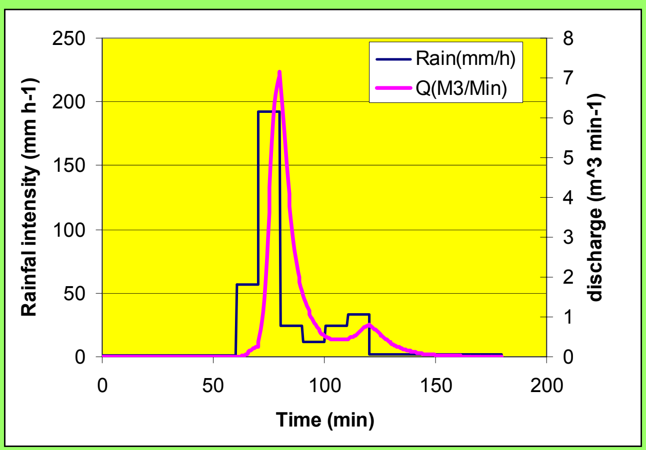
If some error message appears instead of the NORMAL COMPLETION message the program should give indications of possible errors due to mistakes in the input files.

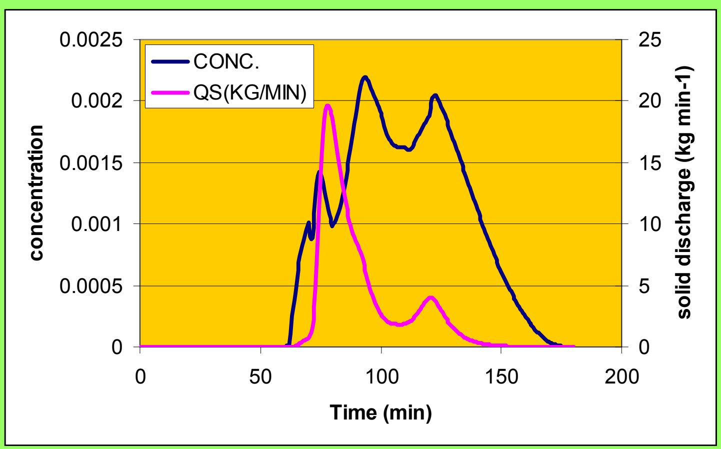
Other tips are indicate in USER manuale of EUROSEM.

How-to EUROSEM - Part 2.3

OUTPUT FILES IN EUROSEM: STRUCTURE AND INTERPRETATION

Lorenzo Borselli*





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TYPES OF OUTPUT FILES -1

THREE OUTPUT FILES ARE PROVIDED AUTOMATICALLY:

Static output file (extension .STA)

The file gives information identifying the study area and a list of the input data used in the simulation. The file follows with a summary of the total erosion or deposition simulated for the storm with separate accounting for the rill and interrill areas.

[syntetic informations on simulation results]

Dynamic output file (extension. DYN)

The file contains:

data on each element;

the total sediment removed from each element,

data on runoff volume, runoff depth,

sediment concentration and total sediment removed from the element for each time step in the simulation,

time to peak flow rate and the rate of flow at the peak,

water balance calculation for the storm.

[Detailed informations on simulation results]

TYPES OF OUTPUT FILES -2

Auxiliary Output File(estension .Aux)

The file gives auxiliary information on :

Local water balance, inteception, vegetation interaction.

Separatedly for the interrill and rill areas it provides:

- **A sediment budget comprising the volume of material eroded on the element (eros),**
- **the input of sediment from the element above, if any (susp),**
- **the volume of sediment removed from the element (sedout)**
- **the overall sediment balance.**

Final spacings and dimensions of the rills or concentrated flow paths;

The total surface erosion or deposition within the storm for each node on the element for which simulations were made.

[**Auxiliary information to inspect, in each element, the quality of the simulation**]

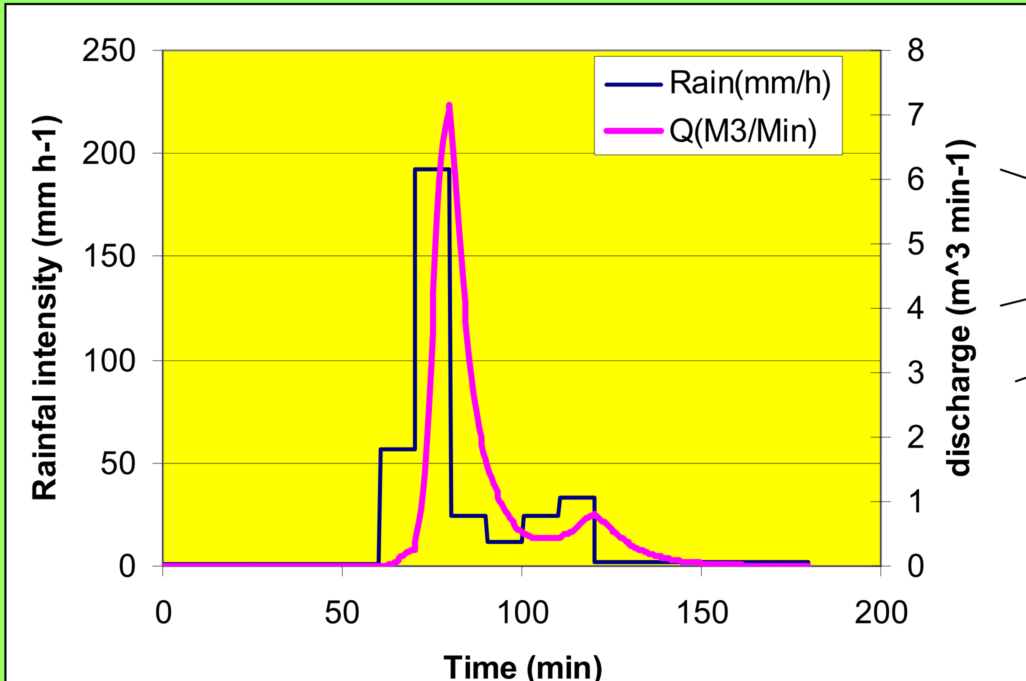
STRUCTURE STATIC OUTPUT FILES

Summary of input data
For the element

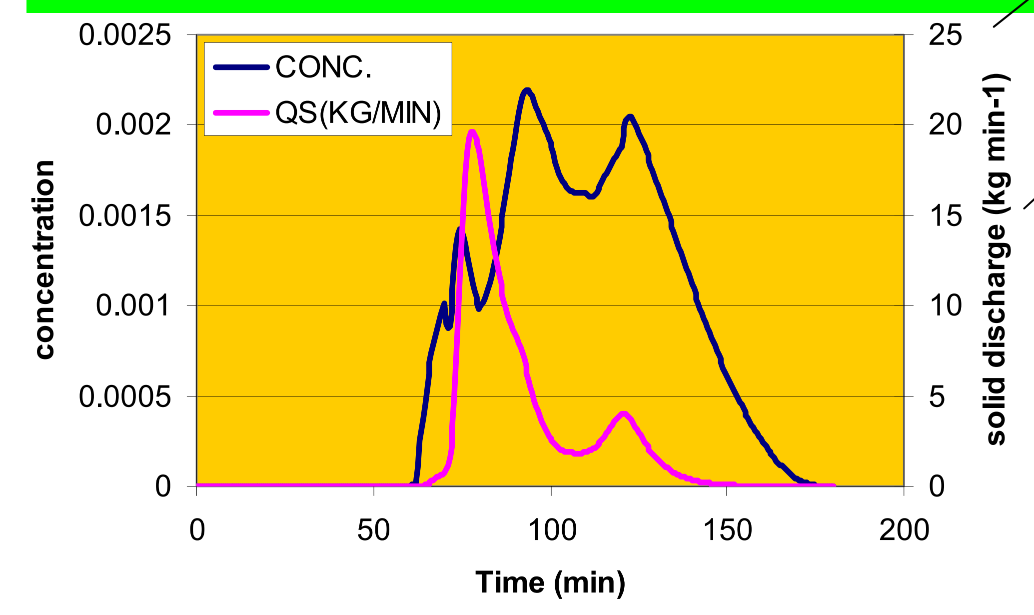
Erosion summary

Hydrological data sumamry

```
INPUT DATA FOR ELEMENT      2
=========================
NU:       1
   W:        20.00 M       XL:        100.00 M        S:       .00
MANN:         .000       FMIN:          2.40 MM/HR    G:    700.00 MM
 POR:          .50        THI:           .10        THMX:       .42
 ROC:          .20       RECS:        150.00 MM    DINTR:       .50 MM
DEPNO:         .00         RS:            .0         RFR:    15.000 %
 ZLR:          .00      RILLW:           .00 M     RILLD:       .00 M
COVER:         .90      SHAPE:          1           PANG:       .00 o
PBASE:         .00      PHEIG:           .00 M       D50:     63.00 um
 EROD:        1.60 G/J SPLTX:          2.00          COH:     10.00 KPA
 RHOS:        2.65kgm3  PAVE:           .20        SIGMA:      1.00
  SIR:        .200      DERO:          3.00 m
Derived parameters:    MN(IR):          .139  SurfStor:     .000074 mm


EROSION SUMMARY
---------------
GROSS INTERRILL EROSION        691.741 kg      3.459 t/ha

NET EROSION/DEPOSITION         678.233 kg      3.391 t/ha
(a minus denotes deposition)


HYDROLOGY SUMMARY, ELEMENT    2
==============================

NET RAINFALL                               =   59.050      (MM)
PEAK RAINFALL RATE                         =   192.00      (MM/H)

TIME TO RUNOFF                             =   64.000      (MIN)
DURATION OF RUNOFF                         =   116.00      (MIN)
TIME TO PEAK FLOW RATE                     =   80.000      (MIN)
PEAK FLOW RATE                             =   149.27     (MM/H)

TIME TO PEAK SEDIMENT DISCHARGE            =   76.000     (MIN)
PEAK SEDIMENT DISCHARGE                    =   15.045     (kg/MIN)
```



DYNAMIC OUTPUT FILE DATA PLOTTING



ELE #	TYPE	VOL. BAL. ERROR %	SED. TOTAL (KGS.)
2	PLANE	.146E-01	692.988

.0735 mm Inactive Storage Capacity on plane

HYDROGRAPH FOR ELEMENT 2
CONTRIBUTING AREA = 2500.00 SQ. METER OR .2500 HECTARES

Time(MIN)	Rain(mm/h)	Q(M3/Min)	Q(MM/H)	CONC.	QS(KG/MIN)
.00	.50	.00000	.000	.00000000	.0000
.50	.50	.00000	.000	.00000000	.0000
1.00	.50	.00000	.000	.00000000	.0000
1.50	.50	.00000	.000	.00000000	.0000
2.00	.50	.00000	.000	.00000000	.0000
//	//	//	//	//	//
66.00	57.00	.01829	.439	.00858816	.4162
66.50	57.00	.02863	.687	.00742054	.5629
67.00	57.00	.04157	.998	.00668683	.7366
67.50	57.00	.05719	1.373	.00618703	.9376
68.00	57.00	.07555	1.813	.00582528	1.166
68.50	57.00	.09662	2.319	.00555319	1.422
69.00	57.00	.12088	2.901	.00532733	1.706
69.50	57.00	.14721	3.533	.00516252	2.014
70.00	57.00	.17647	4.235	.00502351	2.349
70.50	192.00	.37381	8.971	.00346113	3.429
71.00	192.00	.62421	14.981	.00273960	4.532
71.50	192.00	.92395	22.175	.00232089	5.683
72.00	192.00	1.27289	30.549	.00204259	6.890
72.50	192.00	1.66776	40.026	.00184245	8.143
73.00	192.00	2.09636	50.313	.00169617	9.423
73.50	192.00	2.57420	61.781	.00157444	10.74
74.00	192.00	3.09402	74.256	.00146754	12.03
74.50	192.00	3.63656	87.277	.00137042	13.21
75.00	192.00	4.17330	100.159	.00127986	14.15
75.50	192.00	4.65525	111.726	.00119767	14.77
76.00	192.00	5.03967	120.952	.00112651	15.04
76.50	192.00	5.31857	127.646	.00106656	15.03
77.00	192.00	5.51367	132.328	.00101615	14.85
77.50	192.00	5.65564	135.735	.00097332	14.59
78.00	192.00	5.77087	138.501	.00093640	14.32
78.50	192.00	5.87661	141.039	.00090422	14.08
79.00	192.00	5.98172	143.561	.00087615	13.89
79.50	192.00	6.09361	146.247	.00085148	13.75
80.00	192.00	6.21946	149.267	.00082913	13.67
80.50	24.00	5.69781	136.747	.00086444	13.05
81.00	24.00	5.22476	125.394	.00090327	12.51
81.50	24.00	4.78803	114.913	.00094586	12.00
82.00	24.00	4.37928	105.103	.00099288	11.52
//	//	//	//	//	//
174.50	2.00	.00421	.101	.03317351	.3701
175.00	2.00	.00406	.097	.03269653	.3514
175.50	2.00	.00391	.094	.03223731	.3341
176.00	2.00	.00378	.091	.03179568	.3183
176.50	2.00	.00366	.088	.03137076	.3039
177.00	2.00	.00354	.085	.03096148	.2906
177.50	2.00	.00344	.083	.03056634	.2785
178.00	2.00	.00334	.080	.03018365	.2674
178.50	2.00	.00326	.078	.02981162	.2572
179.00	2.00	.00318	.076	.02944834	.2478
179.50	2.00	.00310	.074	.02909195	.2391
180.00	2.00	.00303	.073	.02874054	.2309

TIME TO PEAK FLOW RATE = 80.000 (MIN)
PEAK FLOW RATE = 149.27 (MM/H)

AUXILIARY OUTPUT FILE

Number of nodes for numerical Solution.

Real time vegetation effects

Relevant data about hyetograph (e.g. kinetic energy)

Erosion or accumulation depths aat each node!!

```
        *** PLANE NO.      2 DIAGNOSTIC INFORMATION ***
stocap(m):     .000074

Downslope flow distance divided into 10 nodes11.11 m apart.


                        INTERCEPTION DATA FOR ELEMENT     2

                   ALL DATA EXPRESSED AS MM PER TIME DEPTH PAIR

TIME      RAIN      TFALL      DRIP       STEM      VEGSTORE      ERROR
MIN        MM        MM         MM         MM         MM           %
 60.       .500      .050       .273       .000      .17706       .00000
 70.      9.500      .950      8.277       .000      .27292       .00000
 80.     32.000     3.200     28.800       .000      .00002       .00000
 90.      4.000      .400      3.600       .000      .00000       .00000
100.      2.000      .200      1.800       .000      .00000       .00000
110.      4.000      .400      3.600       .000      .00000       .00000
120.      5.500      .550      4.950       .000      .00000       .00000
180.      2.000      .200      1.800       .000      .00000       .00000
200.       .000      .000       .000       .000      .00000       .00000
  0.       .000      .000       .000       .000      .00000       .00000


                     RAINFALL HYETOGRAPH FOR PLANE NO.    2
          (AFTER INTERCEPTION REMOVED)               Kinetic Energy (J/m2/mm)
        TIME (MIN)      INTENSITY(MM/HR)        Rain                Leaf Drip
             .0                     .32                .310                 .000
           60.0                   55.36               4.307                 .000
           70.0                  192.00               5.332                 .000
           80.0                   24.00               3.577                 .000
           90.0                   12.00               2.992                 .000
          100.0                   24.00               3.577                 .000
          110.0                   33.00               3.846                 .000
          120.0                    2.00               1.480                 .000
          180.0                     .00                .000                 .000
          200.0                     .00                .000                 .000

          THE RAIN GAGE FOR PLANE     2 IS GAGE NO.   1
       PPCT. WEIGHT IS 1.00    INTERCEPTION IS  .45   (MM)

Surface contains no explicit rills

 INtRill eros, susp, sedout, and Bal. (m*3):
   -.26103     .00472     .00000     -.25631
 Rill eros, susp, sedout, and Bal. (m*3):
    .00000     .00000     .26150      .25594

     GEOM. PARAMETERS ARE  L=  100.0   W=   20.0   S=  .2000
     ROUGHNESS: MANNINGS N= .139
     INFILT. PARAMETERS ARE FMIN=   2.40000 mm/h;  G= 700.000 mm
    POR=  .1000  SMAX=  .5000   SI=  .4200   ROC=  .200  RECS=    .15 mm
     EROSION PARAMETERS ARE ---
       D50= 63.0        RHOS=  2.65 POR=    .50 PAVE.FAC.=  .200
     ACCUMUL. SURFACE DEPOSIT. OR EROSION (NEG.)         AT EACH NODE (m.)
 -.11083      -.48068E-02  -.49208E-02  -.49538E-02  -.50301E-02  -.51456E-02
-.53092E-02  -.54909E-02  -.56612E-02  -.56680E-02

               **** WATER BALANCE AT END OF PLANE ****
           <INFLOW BASED ON (PPT*GAGE WT) - INTER. + RUNON>
  INFLOW=  .130E+03 OUTFLOW=  .129E+03 STOR.=  .220E+00 ERROR=  .146E-01 %

-------------------------------------------------------------------------------
```

KEY POINTS for OUTPUT INTEPRETATION

A valid guide on output intepretation is given by EUROSEM reference manual.

The output data are given for each element (plane or channel)

Erosion data related to the last element in the cascade are the net erosion simulated for the watershed or cascading planes

Mass balance error is given in the output files (.sta, .dyn) of each element
The mass balance error should be less than 0.5-1.0% to be accepted.
If the mass balance is higher reduce the time step or change the THETA value

Data in static output file may be plotted using a spreadsheet by COPY and PASTE data columns from a TEXT editor program

Output interpretation, and evaluation, is the most important part of our job… !!

COMPARISONS WITH MEASURED DATA: MODEL EVALUATION, SENSITIVITY ANALYSIS AD TUNING

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SOURCES OF UNCERTAINTY RUNNING EUROSEM -1

Some papers dealing with source of uncertainty in eurosem model running (Quinton, 1997; Folly et al. 1999; Veihe and Quinton (2000); Veihe et al. 2000; Veihe al. ,2001).

These studies indicate the inherent difficulties for reducing the uncertainty and improving model performances.

The reason are:

- **Model uncertainty (EUROSEM unable to simulate some processes (e.g. soil crusting).**
- **Watershed representation**
- **Spatial temporal variability of some parameters (e.g. hydraulic variables)**
- **Presence of some unmeasurable parameter that has high sensitivity (e.g. n Manning)**

SOURCES OF UNCERTAINTY RUNNING EUROSEM - 2

To resolve part of the problems some indications are given:

- **Measure what can be measured**
- **Multiple simulation to verify parametres sensitivity**
- **Parallel calibration and validation test**
- **Stategies for calibrating some parameters**
- **Possibility to force some parameters outside**
- **Parameter normal reference range of variability**

Comparison techniques

- **Visual graphical comparison between time series(observed/simulated)**
- **Statistical parameters (e.g. MF – modelling efficiency)**

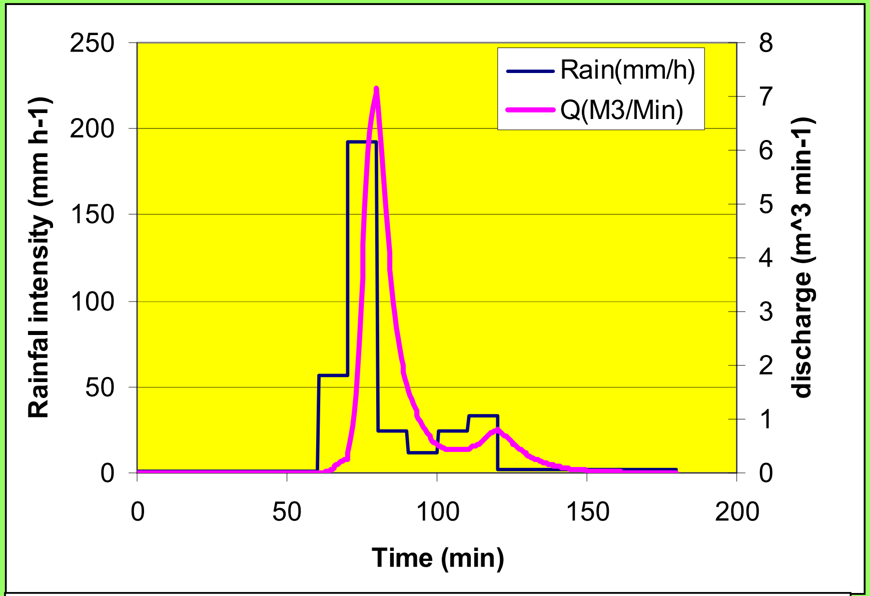
General steps for comparisons:

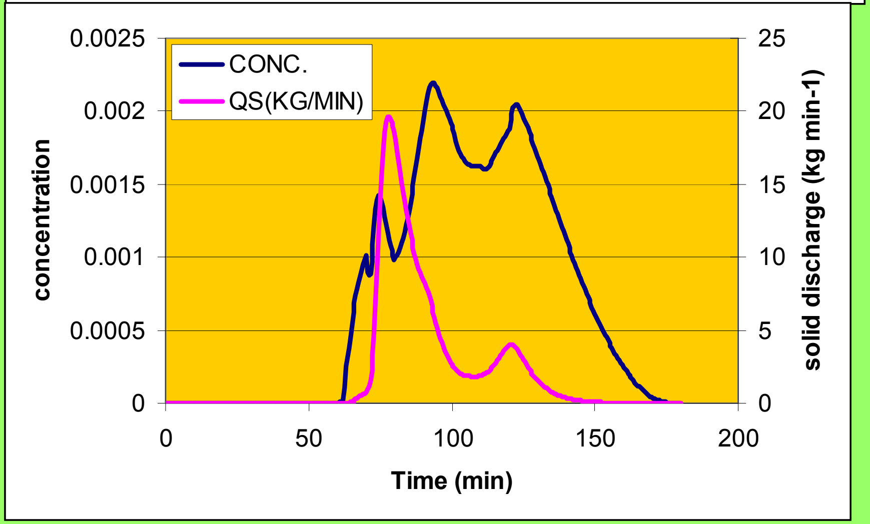
1) **First compare the Hydrograms**
2) **Then compare the sedigraphs**
3) **Compare the total amount (runoff and erosion)**

MEASURED DATA

TIME SERIES:

•RUNOFF RATE (mm/h)
•LIQUID DISCHARGE (m^3/min)
•SEDIMENT DISCHARGE (kg/min)
•CONCENTRATION



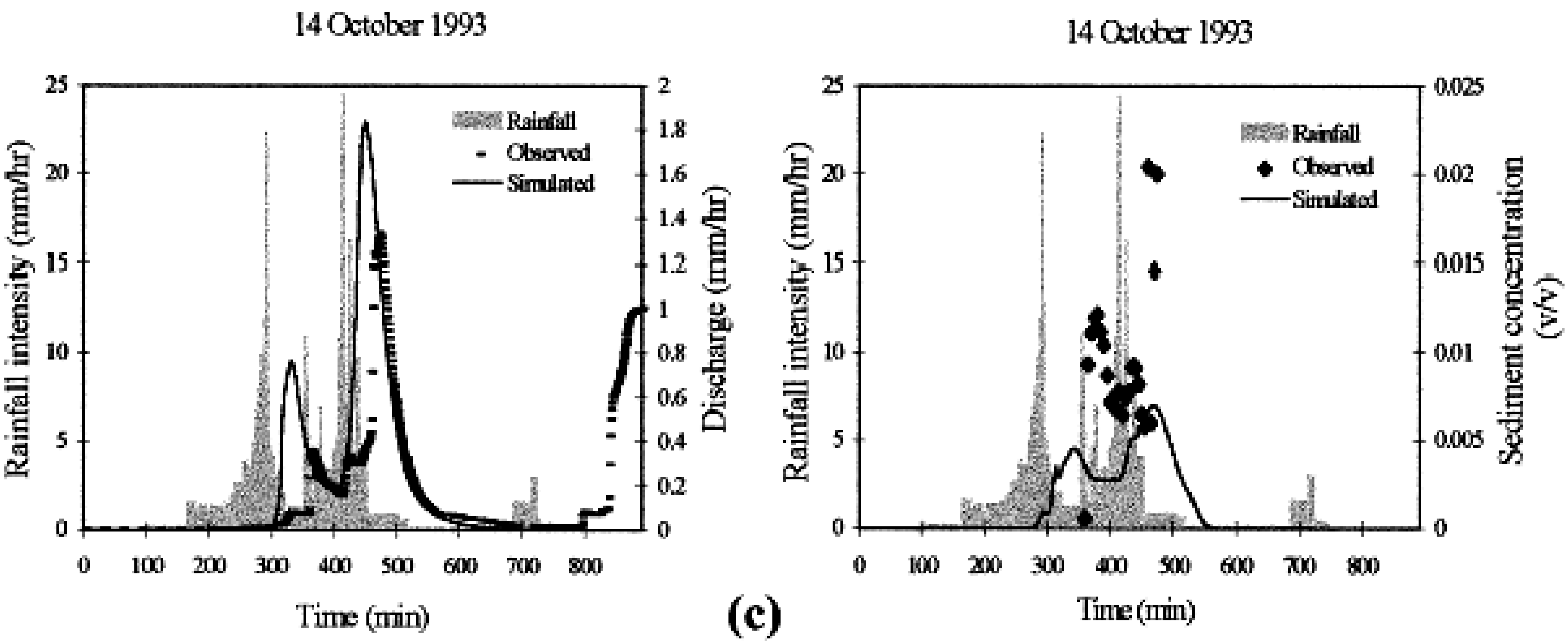


TOTAL AMOUNTS:

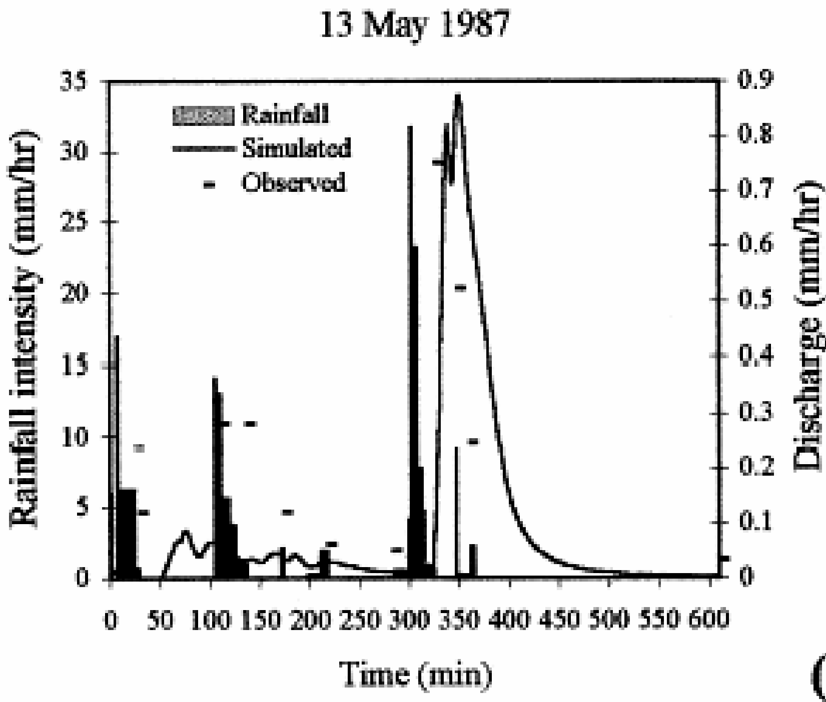
•INFILTRATION (mm)
•RUNOFF (mm)
•EROSION/DEPOSITION AMOUNT AND RATE (kg, kg/ha)

EURISTIC COMPARISON TECHNIQUES WITH OUTPUT TIME SERIES

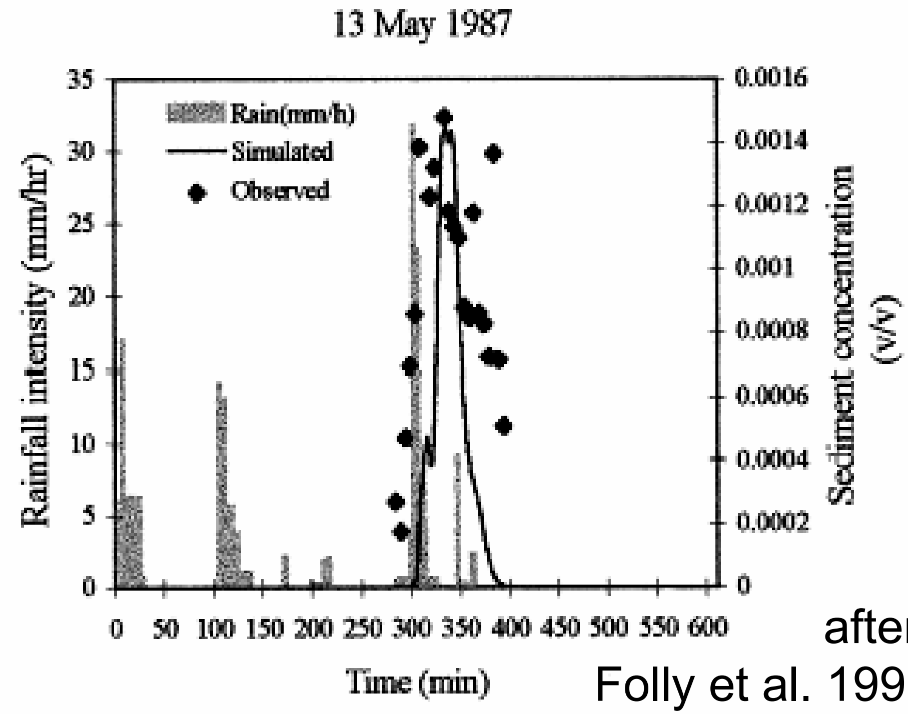
Visual correspondace of peaks
Visual corespondance of runoff start time
Visual correspondance of steady state values
Visual correspondance of raising and decreasing limb



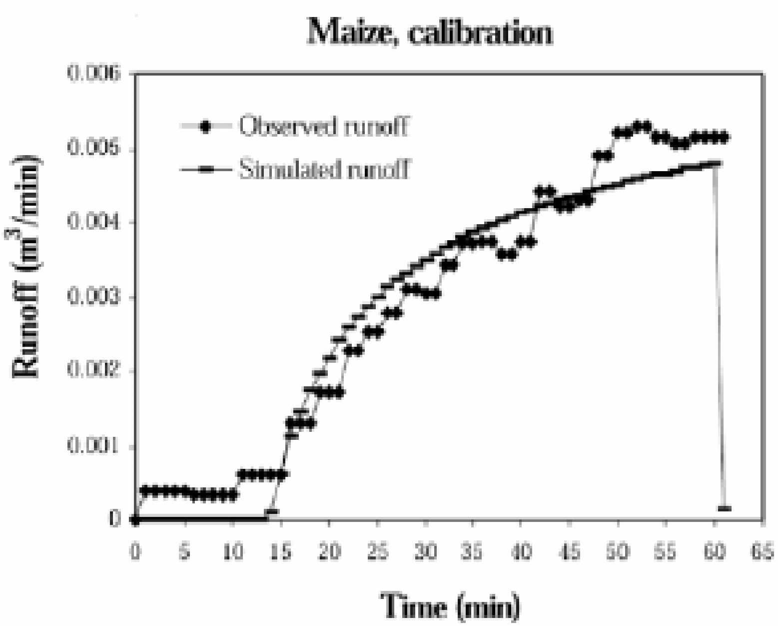
after Folly et al. 1999

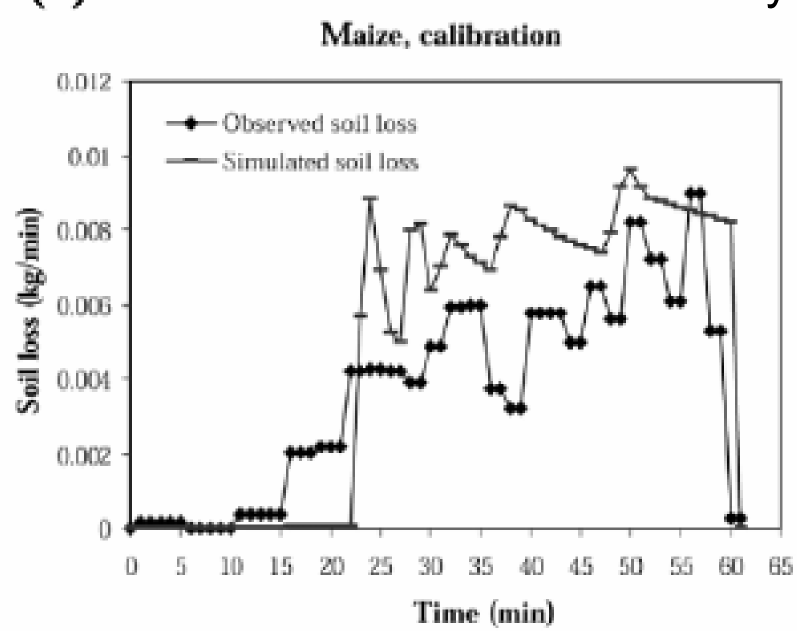


(a)



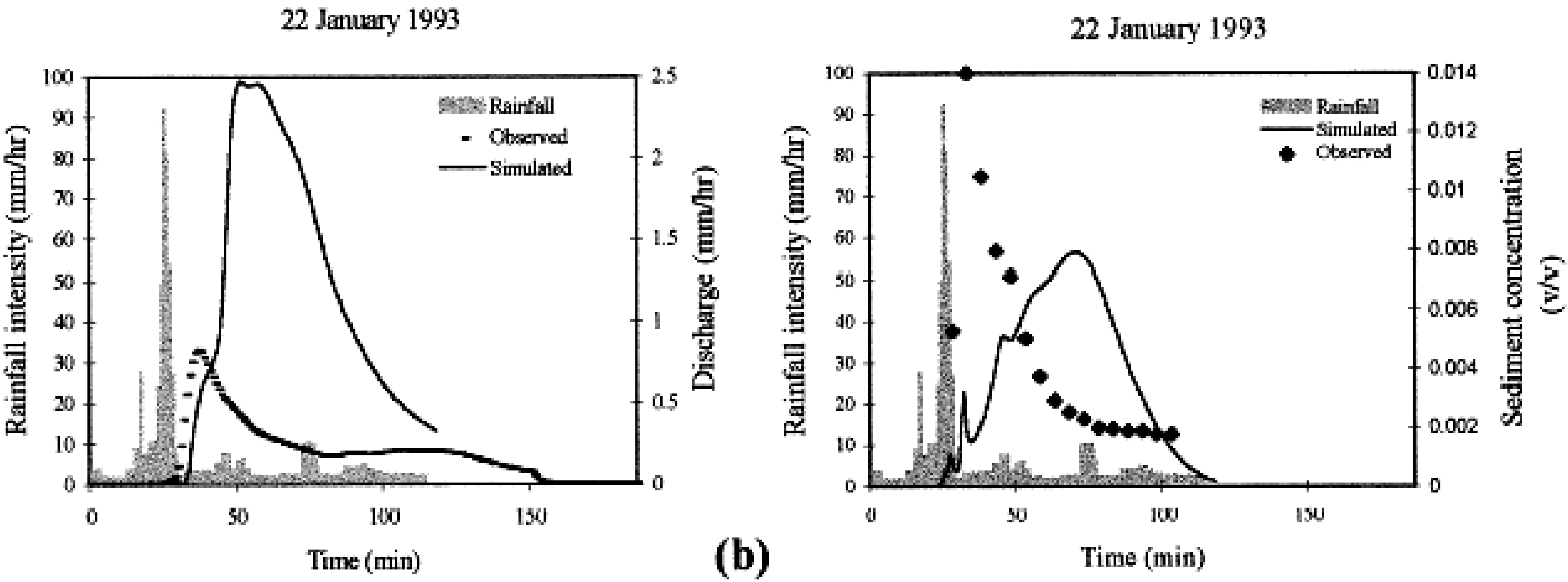
after
Folly et al. 1999



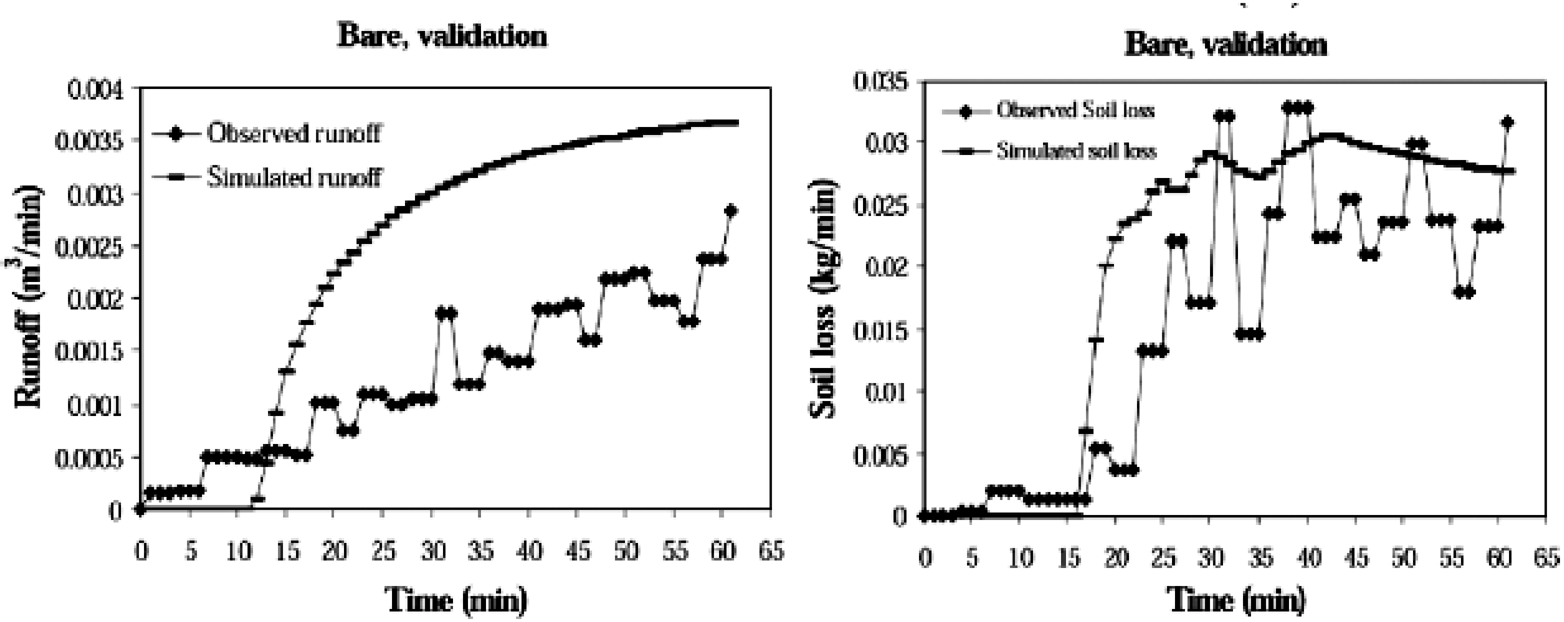


after
Veihe et al. 2000

Examples of non correspondance



after Folly et al. 1999



after Veihe et al. 2000

TOTAL AMOUNT COMPARISONS

Model results for the validation storms with respect to discharge, soil loss, peak discharge and peak sediment discharge (N/A = not available)

Location and storms	Discharge (m^3/ha)		Soil loss (t/ha)		Peak run-off (l/min)		Peak soil loss (g/min)	
	Simulated	Observed	Simulated	Observed	Simulated	Observed	Simulated	Observed
Costa Rica								
Bare1	478.8	266.1	3.9	3.1	3.7	2.8	30.6	32.8
Bare2	154.2	51.0	0.1	0.1	2.3	1.7	8.5	4.0
Maize	443.5	914.7	0.0	1.3	4.8	7.8	0.0	12.9
Grass	140.0	1043.7	0.2	0.2	2.5	7.7	14.5	3.4
Nicaragua								
1994	1446.9	892.9	56.9	55.5	N/A	N/A	N/A	N/A
1995	689.0	727.1	28.3	29.7	N/A	N/A	N/A	N/A
Mexico								
Plot 10c	115.1	100.7	2.7	3.9	0.6	0.8	14.3	21.5
Plot 24a	165.8	91.7	0.1	1.7	0.6	0.5	0.5	4.3
Plot 45a	135.8	91.7	0.2	0.1	0.6	0.3	1.0	0.8
Plot 45b	353.9	101.9	0.3	0.4	0.8	0.3	0.7	1.4

after Veihe et al. 2001

MODELLING EFFICIENCY CRITERIA

$$\mathrm{ME} = 1 - \frac{\sum (Y_{\mathrm{obs}} - Y_{\mathrm{pred}})^2}{\sum (Y_{\mathrm{obs}} - Y_{\mathrm{mean}})^2}$$

ME (model efficiency) , proposed by Nash and Sutcliffe (1970) was used as a measure of likelihood:

Where:

Y_{obs} is the observed value,

Y_{pred} is the predicted value,

Y_{mean} is the mean observed value.

Values for ME range from +1 to -∞.

The closer ME approximates 1, the better the model will predict individual values.

For time series and comparisons for non linear model ME is generally superior to RMSE as evaluation criterion.

But … Beware to use only ME !

SENSITIVITY ANALYSIS - 1

Usual range of variability of some common parameters

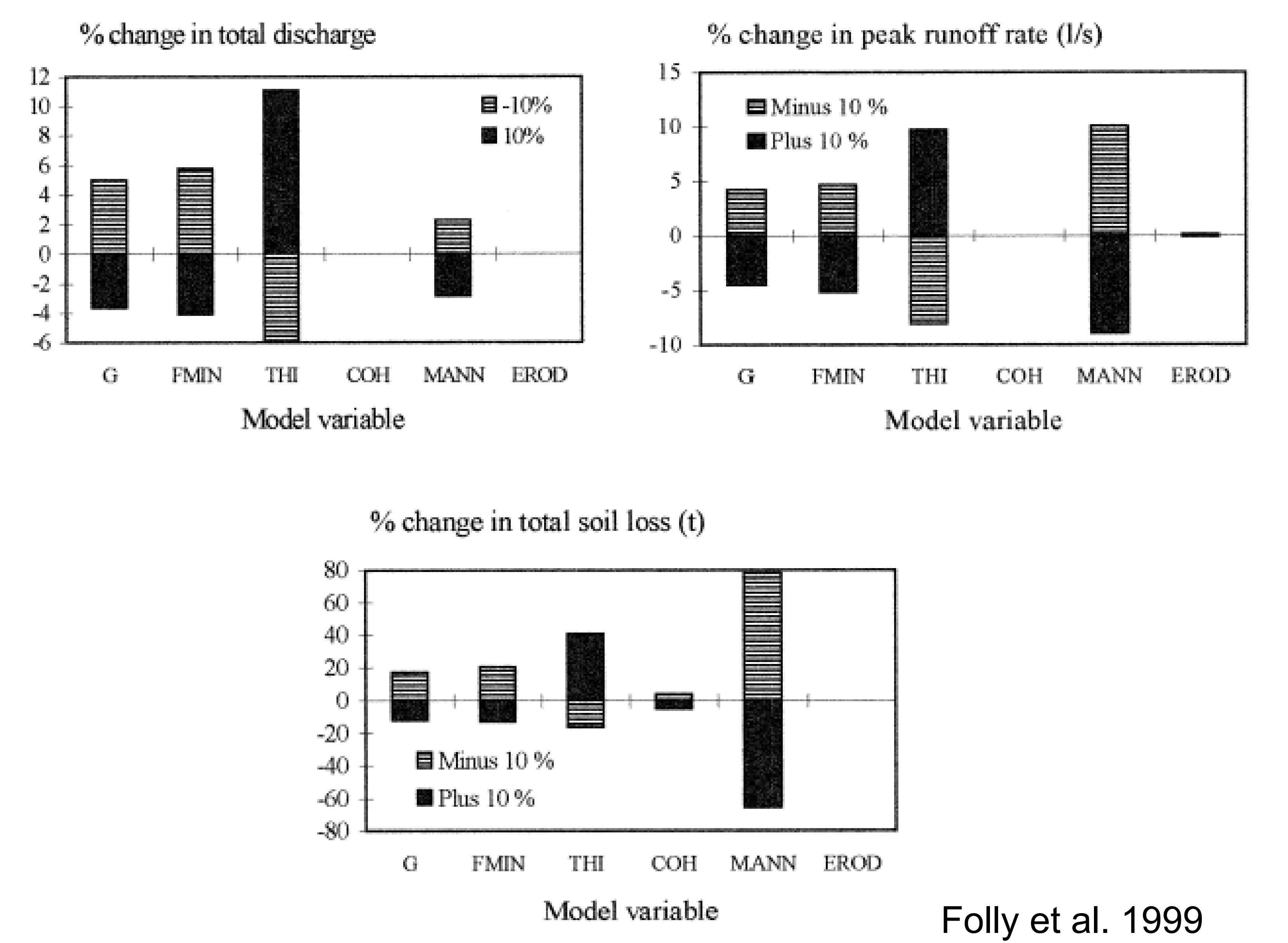
Table I. Soil and vegetation characteristics

Category	Parameter	Mean	Range	SD	CV (%)	Units	Source
Soil hydrology	Saturated hydraulic conductivity	29	0·0–75	22	0·86	mm/h	*4*
	Maximum volume moisture content	0·40	0·25–0·45	0·14	0·35	v/v	*2*
	Initial volume moisture content	0·35	0·05–0·40	0·12	0·35	v/v	*2*
	Effective net capillary drive	400	10–1000	240	0·60	mm	
	Soil porosity	0·45	0·35–0·60	0·04	0·09	v/v	*5*
Soil erodibility	Cohesion	5	0·5–35	1·25	0·25	kPa	*6*
	Median particle size	100	25–250	8	0·08	µm	*3*
	Detachability of soil particles	5	1–10	1·25	0·25	g/J	*1*
Vegetation	Maximum interception storage	1·5	0·1–5	0·50	0·33	mm	
	Percentage basal area	0·2	0·01–0·75	0·10	0·50		
	Percentage canopy cover	0·5	0·01–1·0	0·20	0·40		
	Angle of plant stems	45	10–90	10	0·22	Degrees	
	Effective canopy height	45·9	0–150	34·6	0·75	cm	*7*

1. Poesen (1986), *2*. Bhatti *et al.* (1991), *3*. Healy and Mills (1991), *4*. Tiscareno-Lopez *et al.* (1993), *5*. Persicani (1995), *6*. Folly (1997), *7*. Fog and Krogh (Personal communication).

after Veihe and Quinton 2000

SENSITIVITY ANALYSIS STUDIES -3

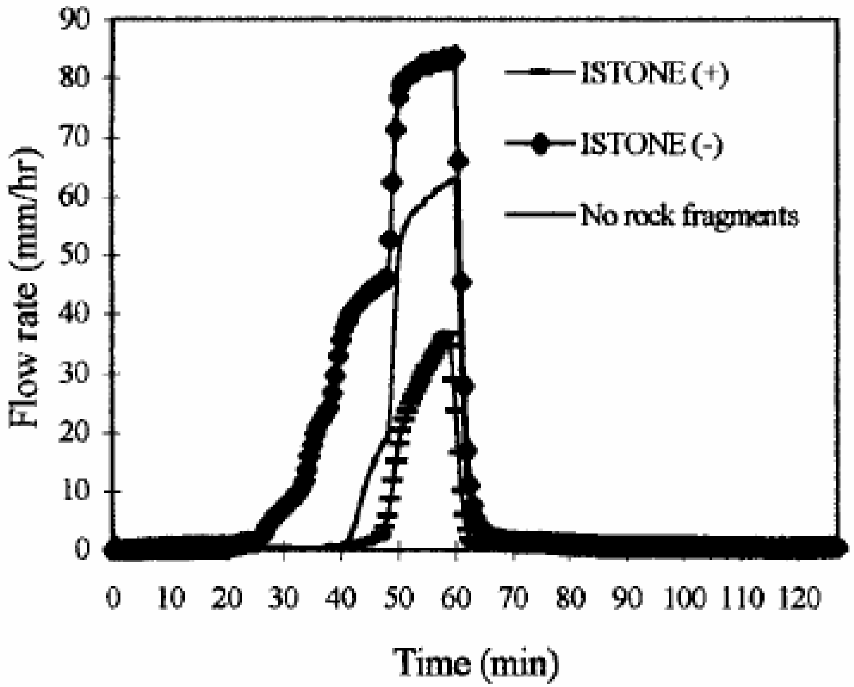


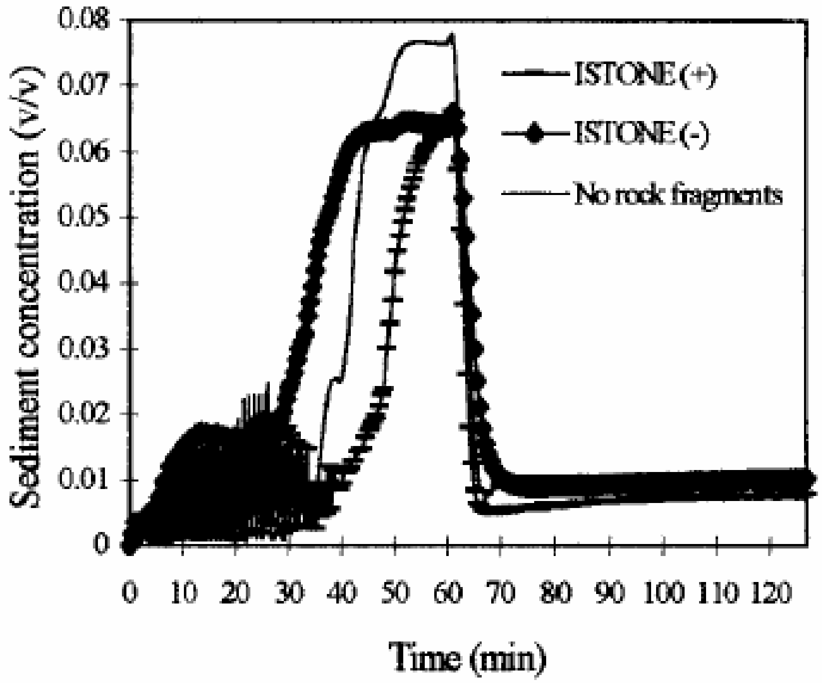
Folly et al. 1999

SENSITIVITY ANALYSIS STUDIES – 4

$$K_{sroc} = K_s(1 - PAVE)$$

$$K_{sroc} = K_s(1 + PAVE)$$





Sensitivity analysis studies

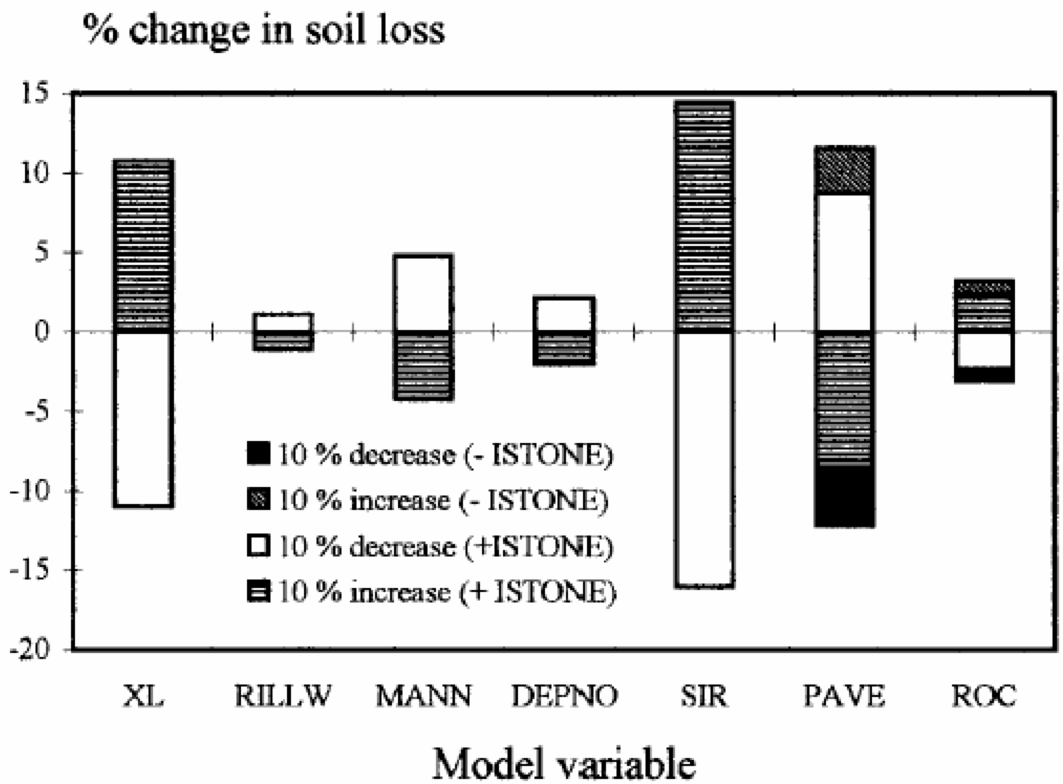


Figure 5. Sensitivity of the model output of total soil loss to changes in the slope length (XL), rill width (RILLW), Manning's n (MANN), the number of rills (DEPNO), interrill slope (SIR), the fraction covered by non-erodible material (PAVE) and the fraction of rock fragments (ROC)

Veihe et al 2000

Measure how many parameters as possible!

Ks
G
porosity
CHO
…
vegetation parameters
…

Use other as tuning tools

Tuning and Forcing

Tuning should be concentrated on a selected group of parameters because it gets more reliable results

Forcing can be admitted but be careful to use values which keep The parameter's physical meaning (e. g. sat. conductivity):

Calibration required (percentage wise increase or decrease in parameter values) in order to fit EUROSEM to observed data

Calibration parameter	Costa Rica		Nicaragua	Mexico	
	Maize	Grass		Plots 24b+27	Plot 10b
Hydrologic parameters					
Saturated hydraulic conductivity		−100	+185	+200	
Porosity			+11		
Maximum initial moisture content			+11		
Net capillary drive	+40			+50	+50
Soil detachability					TV
Manning's *n*	Set to 0.18	0.5			
Soil parameters					
Soil cohesion	+100	Max. TV	−20	TV	TV
Other parameters					
Rill depth and width			+100		
Total area of plant stems (%)		+20			

TV = Table values and refers to the EUROSEM User manual (Morgan et al., 1998b).

SOME KEY POINTS IN EUROSEM

Validation may be developped in a series of rules to define reliable applications under specific conditions.
In this case we should maintain the coherence with the objective and structure of the model (model limitations).
Application rules can extend the model documentation itself.

The Application of Eurosem is not simple becuse it has inherent complexities.
Actual runoff generation and erosion processes are much more complex than those described in the EUROSEM code (e.g.: only hortonian runoff)

Present version of EUROSEM collect reduced set of erosion/runoff algorithm and knowledge (until 1998-1999)

The model needs updating and its range of validity must be enlarge to include in it new knowledge and algorithms (e.g. saturated overland flow).