

Suburban catchment modelling

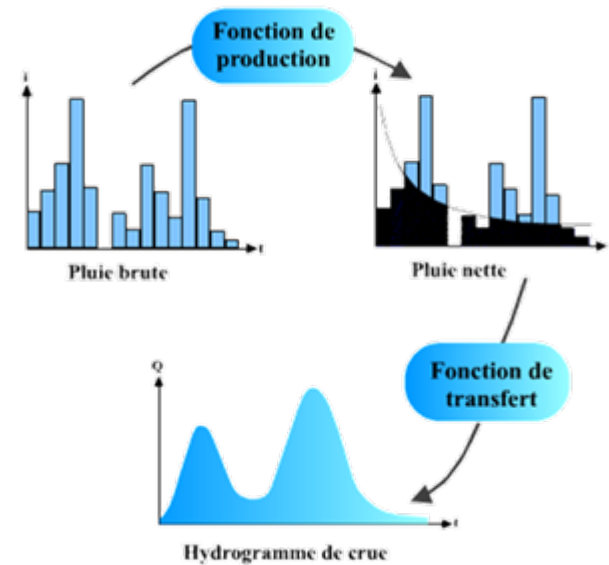
Database analysis and system coupling

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Overview

- Purpose and Context
- Production
- Transfer Function
- Future Work



Unplanned urban development



*São Paulo, Brazil
27 /12/ 2009*

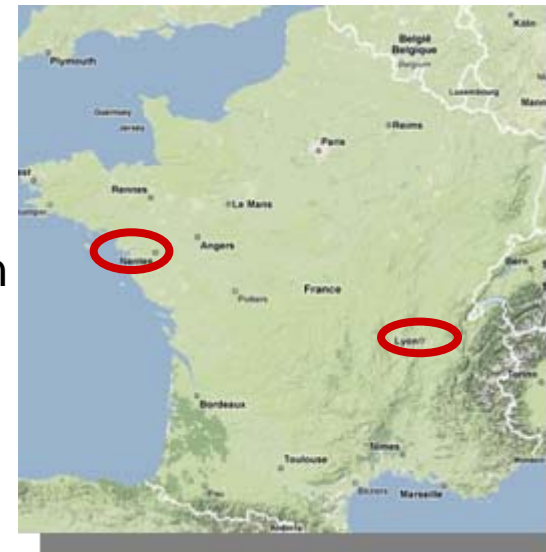


Project Assessing the Vulnerability of Peri-Urban Rivers ANR- AVuPUR 2008-2010

- 1) Database creation
- 2) Water cycle detailed description
- 3) Hydrological modelling, adapted to suburban areas
- 4) Evaluation of the impacts generated by land cover evolution and climate changes

- **2 sites:**



- L'Yzeron (Lyon)
- La Chézine (Nantes)

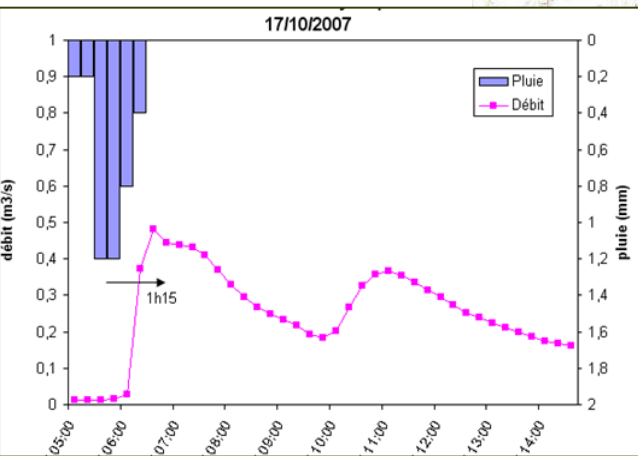
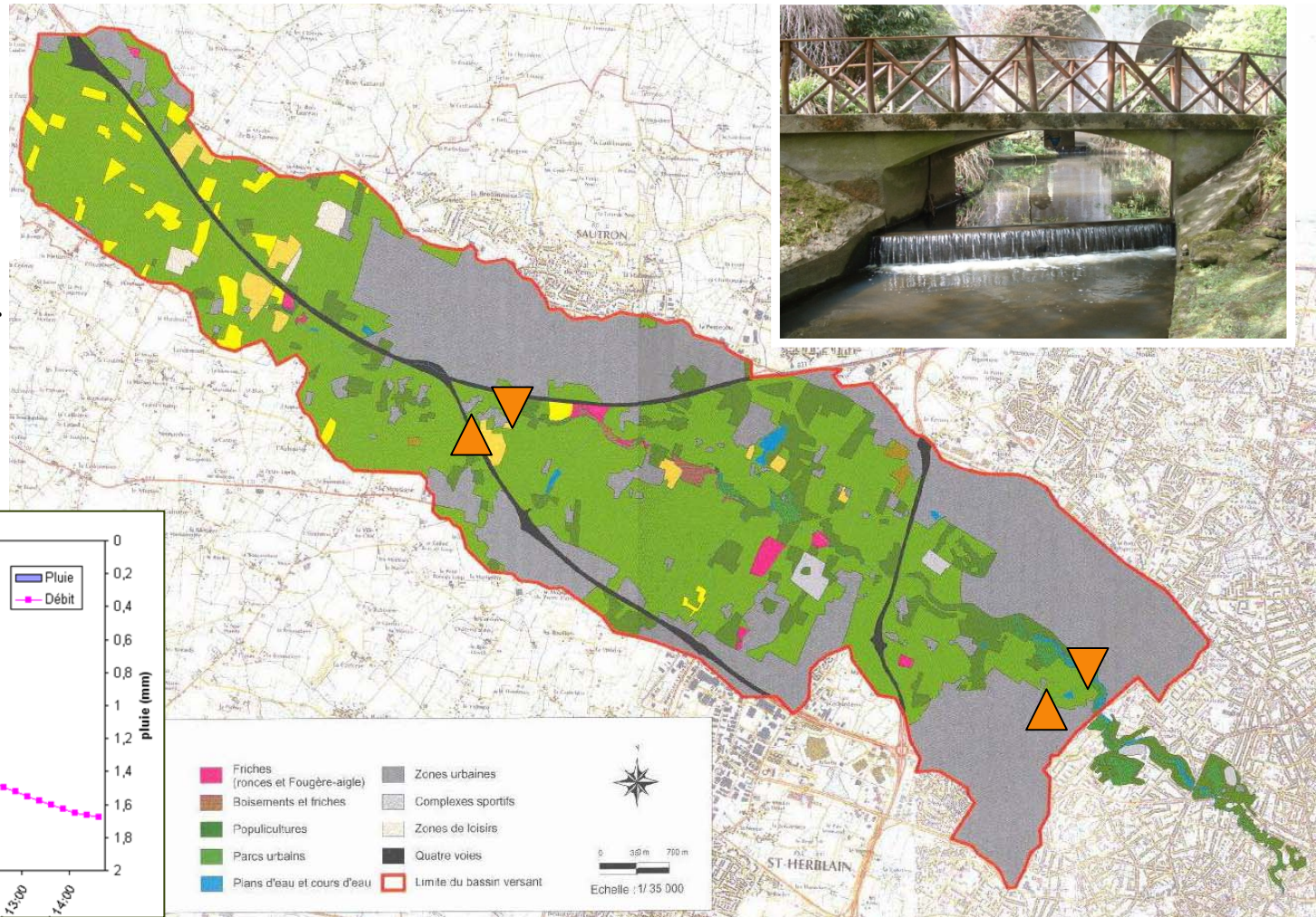


Chézine River Basin

Water level monitoring station at the outlet

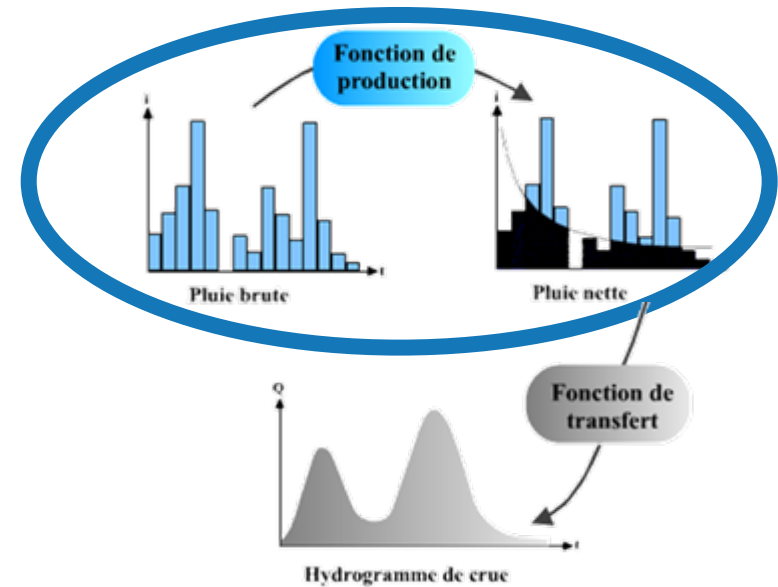
Length: 15 km
Surface: 29 km²

-  = *Pluviometer*
-  = *Hydrometric Station*



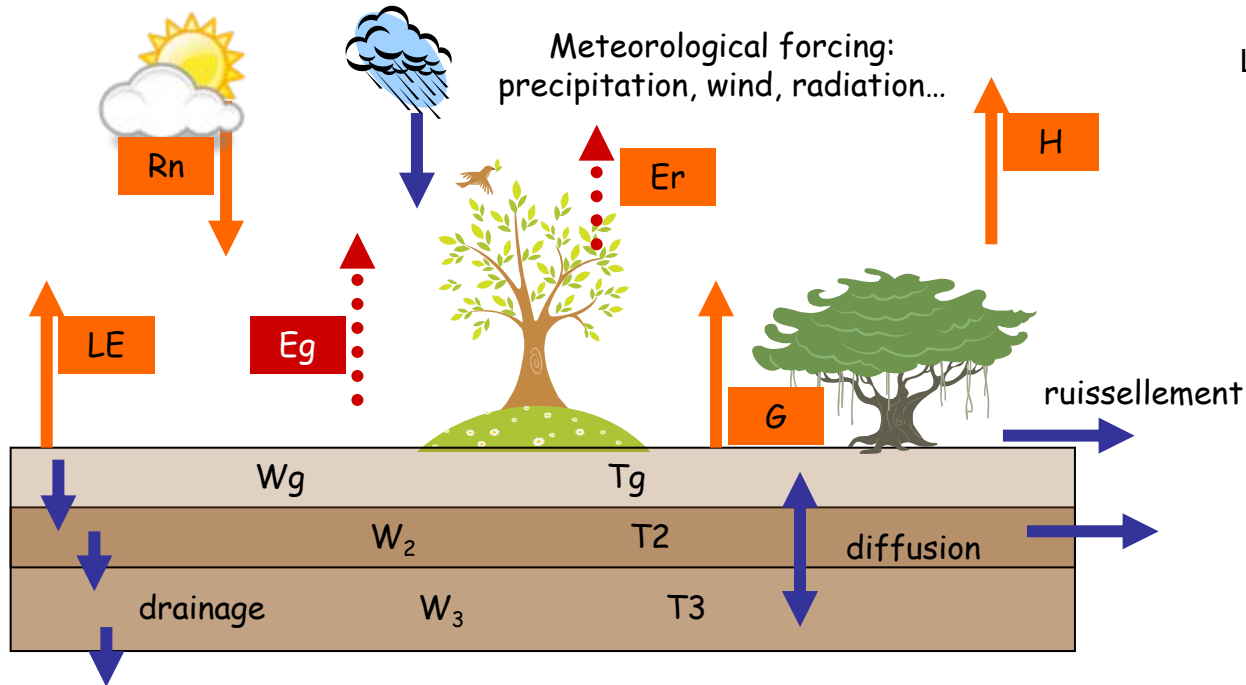
Production

Base models



ISBA- 3L: Noilhan et Planton, 1989; Boone, 2000

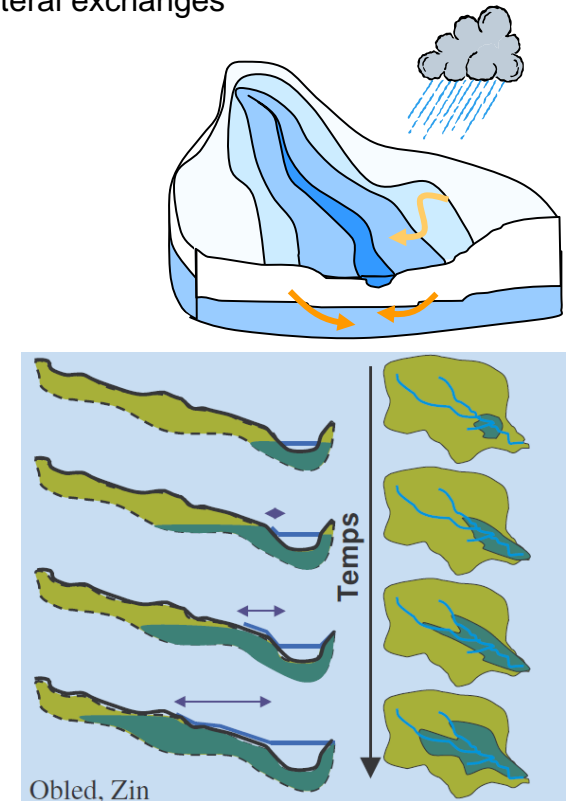
Vertical exchanges



Topmodel

Beven et Kirkby, 1979; Datin, 2000

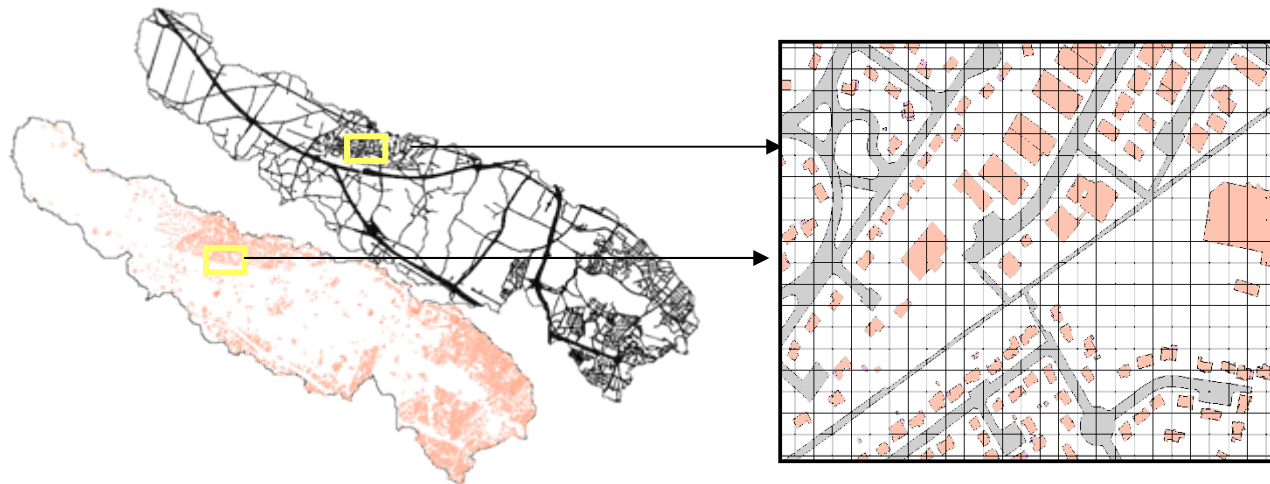
Lateral exchanges



Introduction of urban areas into the model

Impervious surfaces

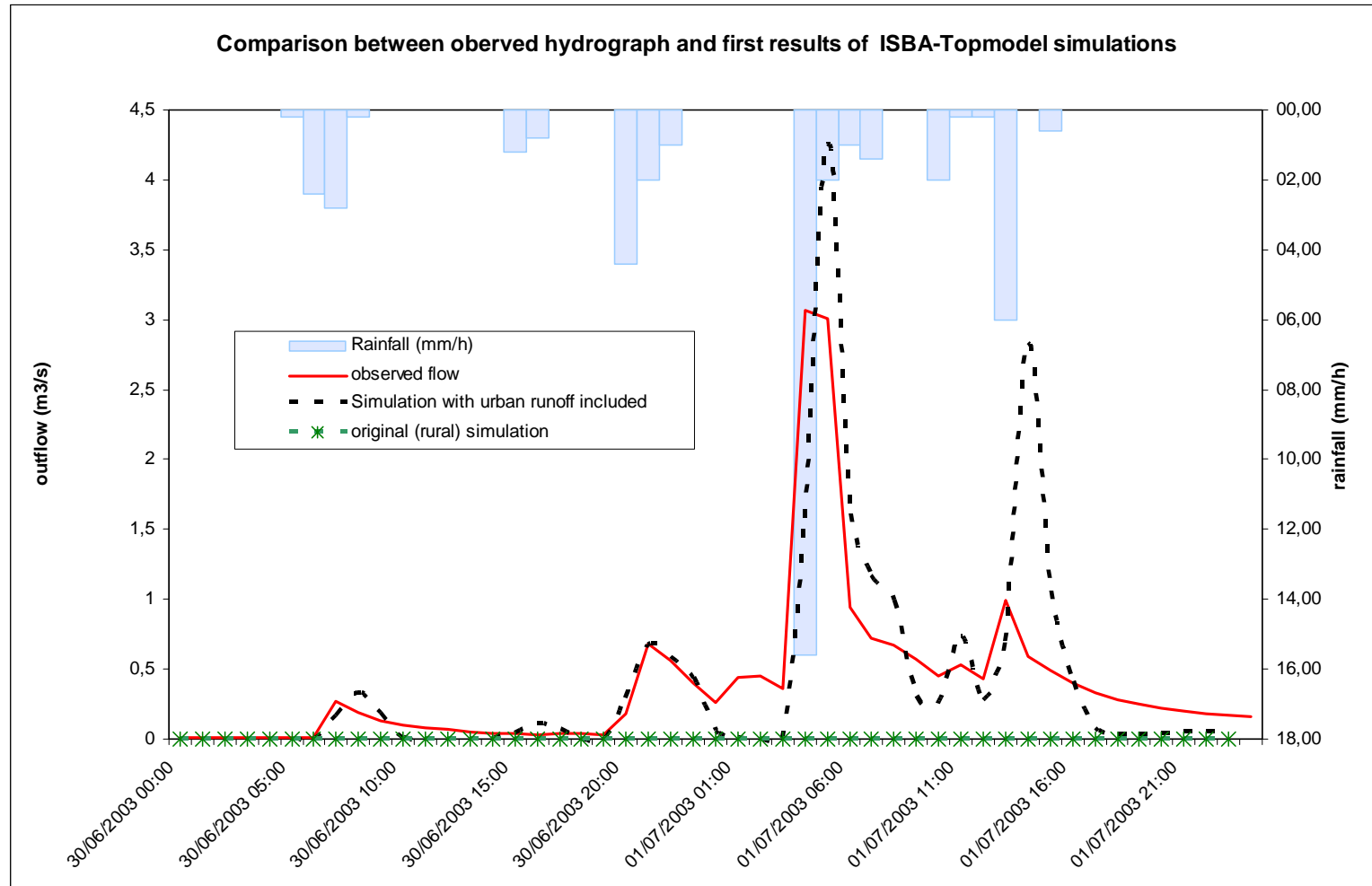
- Reduced infiltration, runoff increase

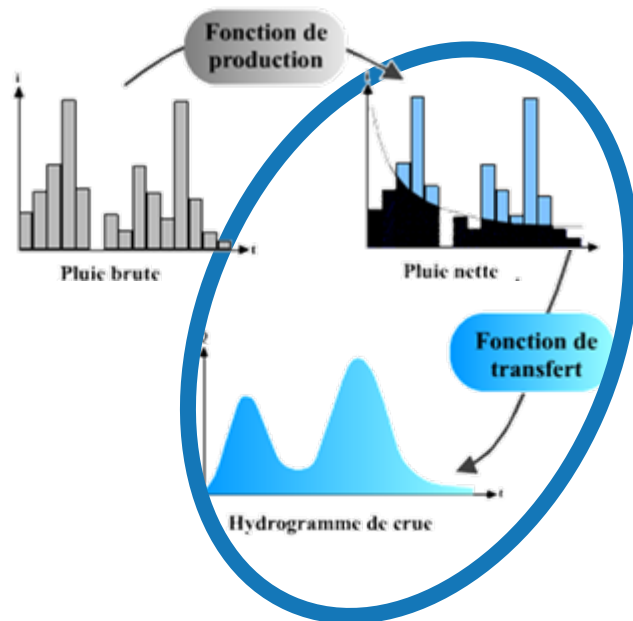


Impermeable area: 18%

Simulation of an event over the Chezine Basin

- Rainfall
- Outlet flow
- Result obtained with the original model
- Simulation using the modified model



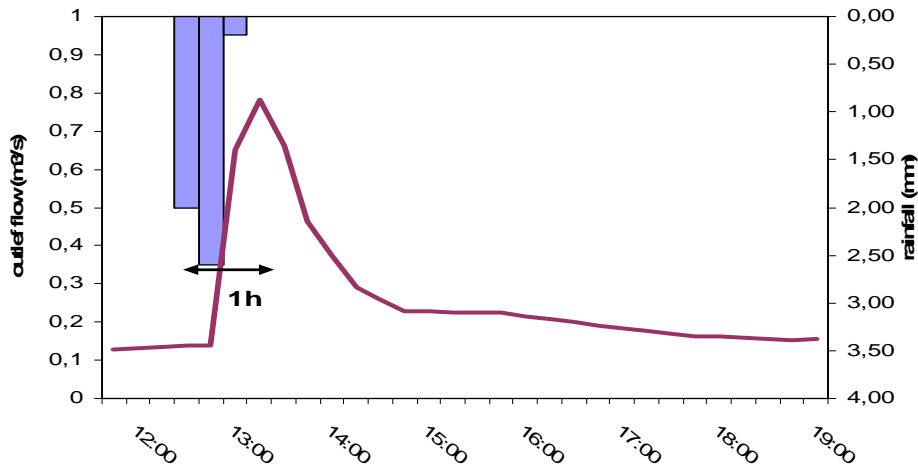


Transfer function

- Database analysis
- Unit hydrograph extraction by FDTF
- Geomorphological transfer function

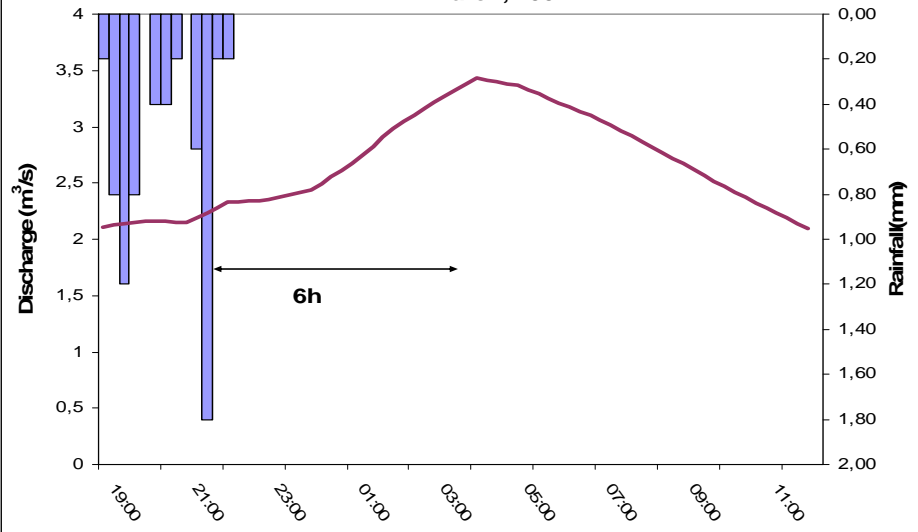
Database analysis

Chezine 15/05/2001

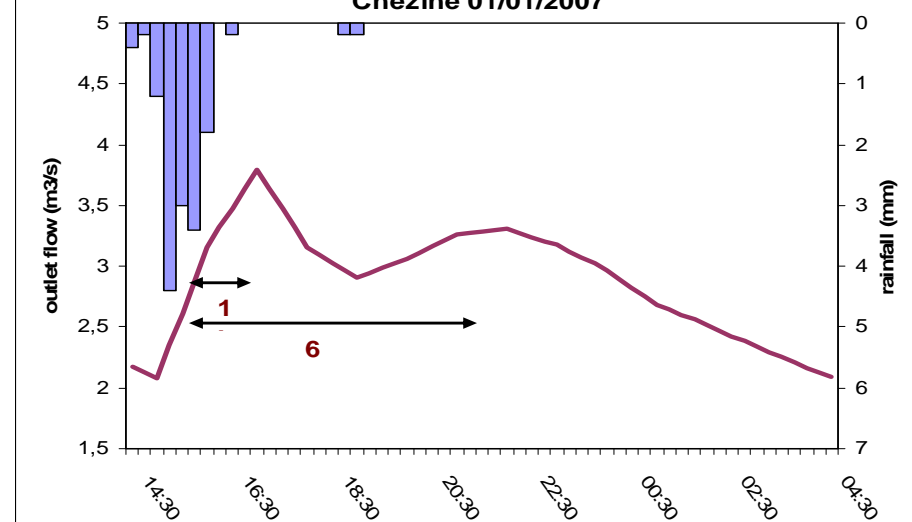


- A single peak rainfall is often followed by 2 outflow peaks ...
- The Lag-time is usually close to 1h, but in some events it is more than 6h...

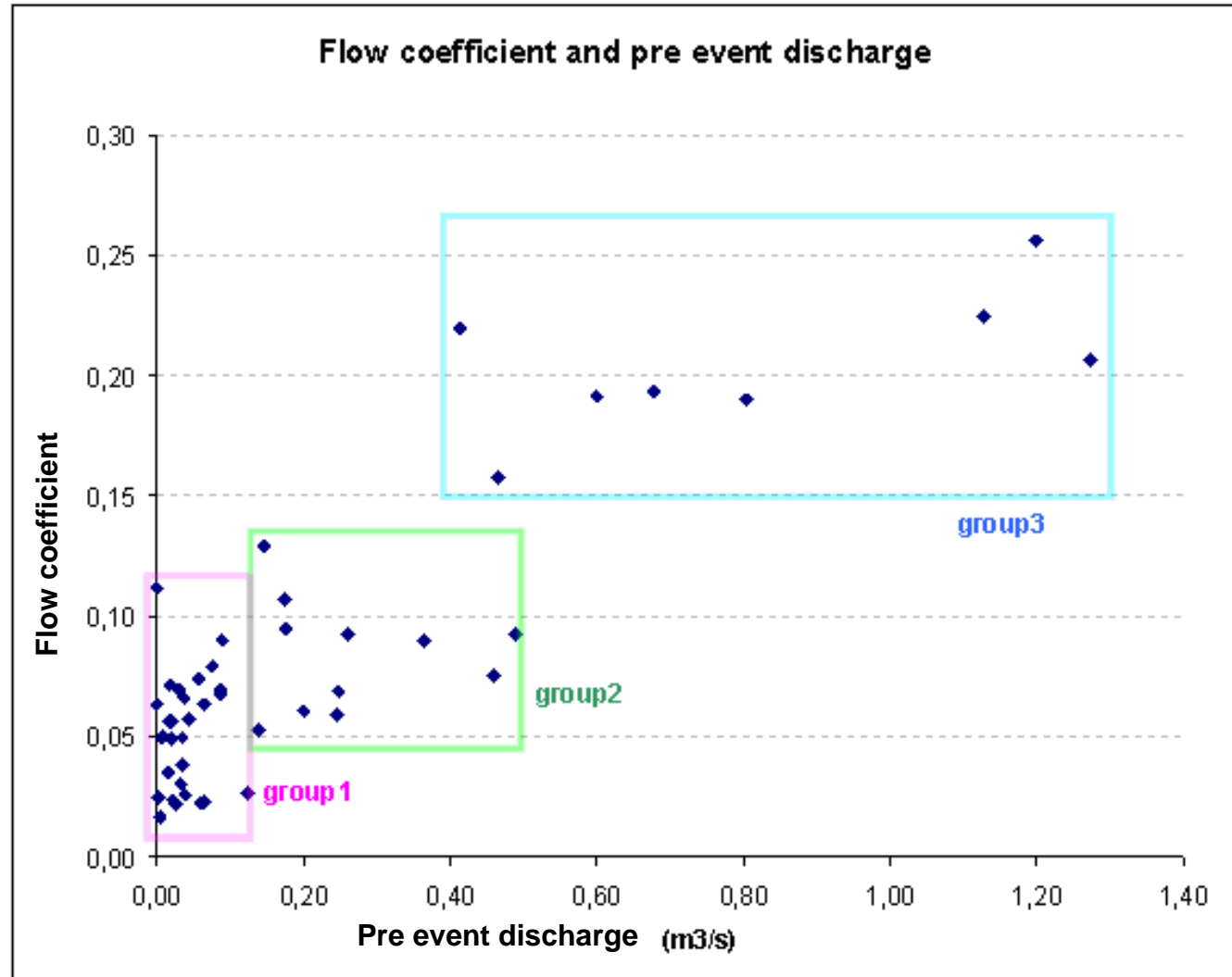
21-22 March, 2001



Chezine 01/01/2007

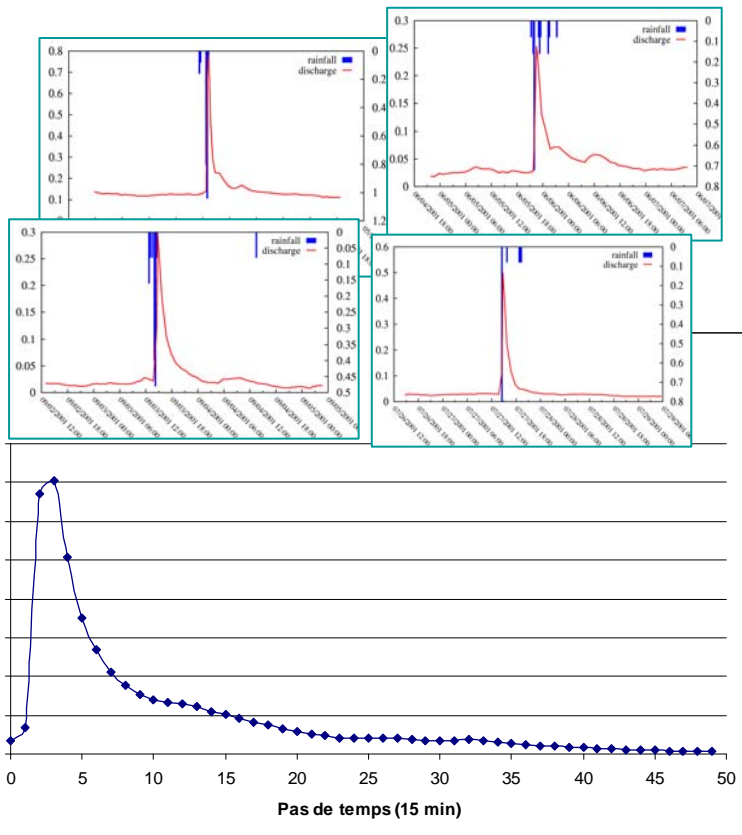


Hydrological response and initial soil moisture state

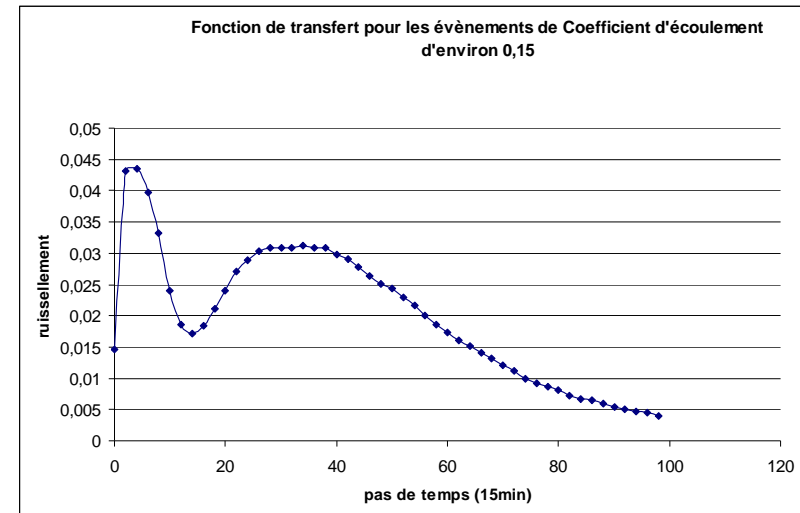
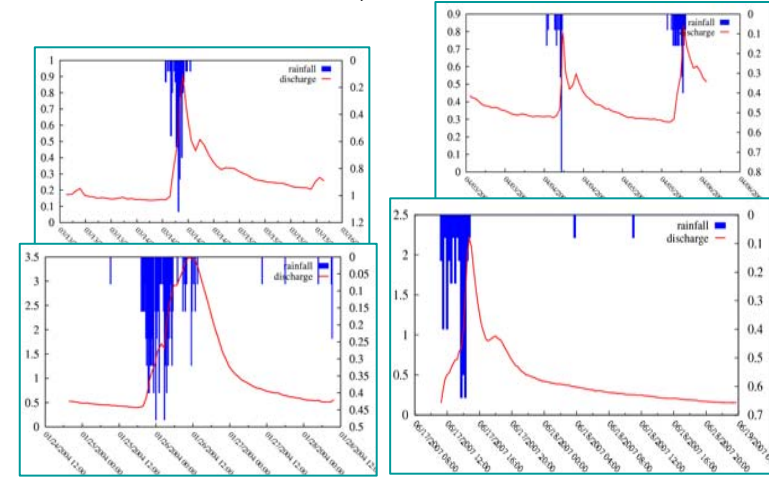


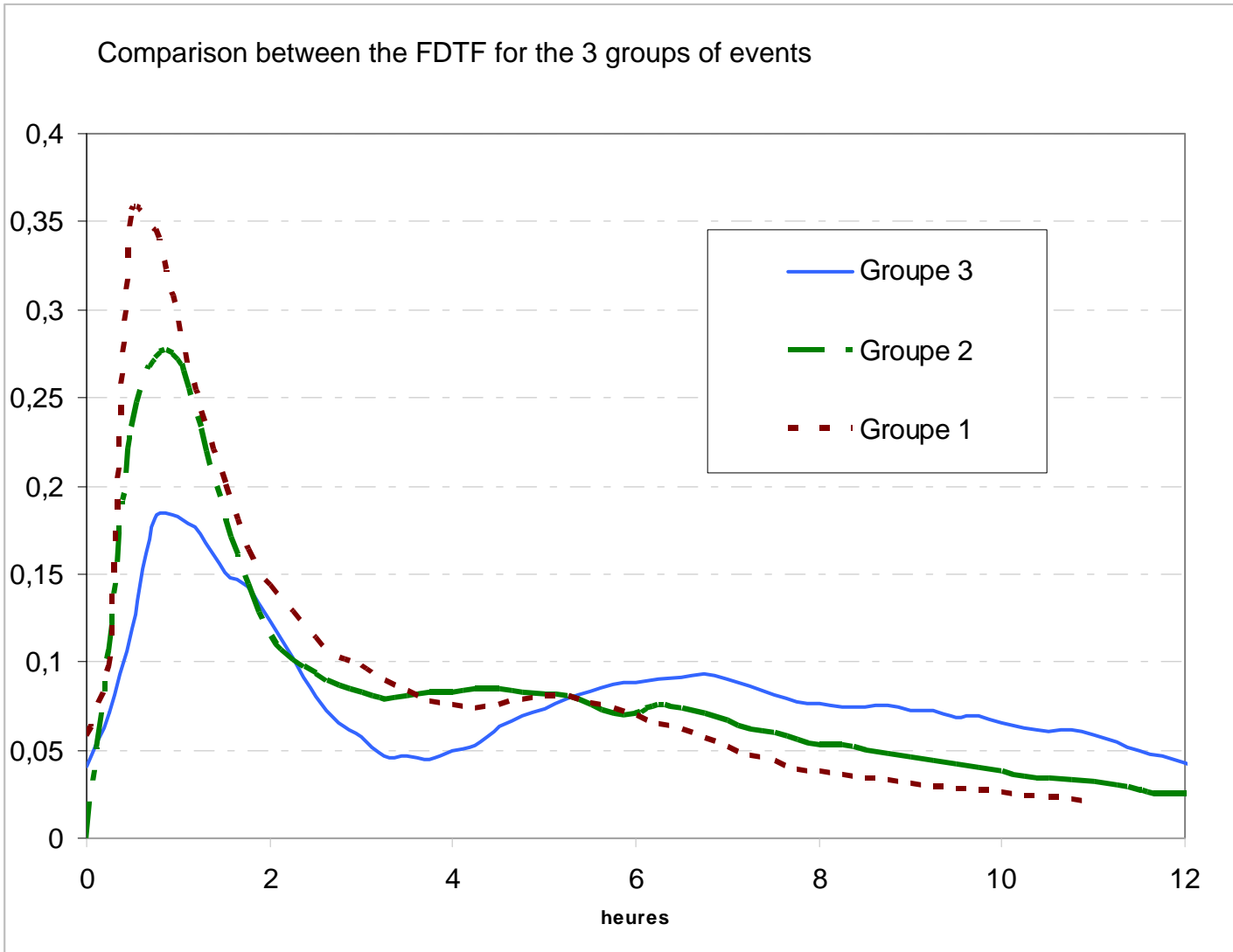
FDTF: First Differenced Transfer Function

Group 1
FDTF: $R^2=0,94$

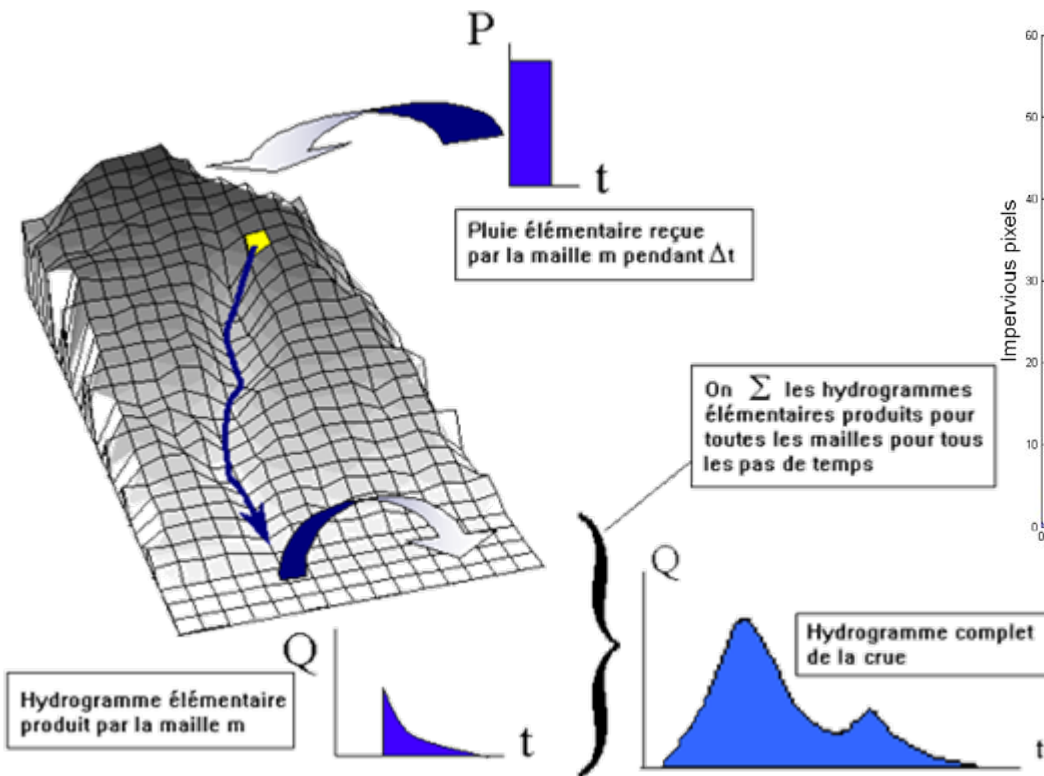


Group 3
FDTF: $R^2=0,82$

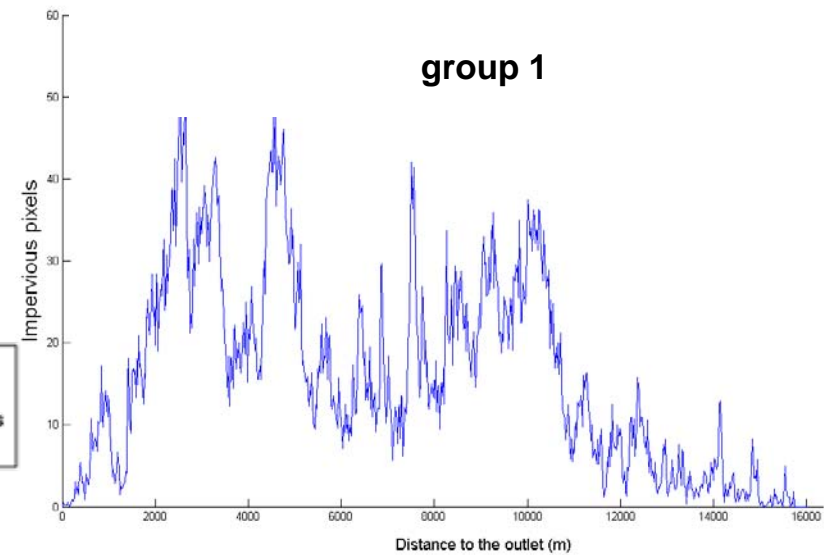




Geomorphological transfer function

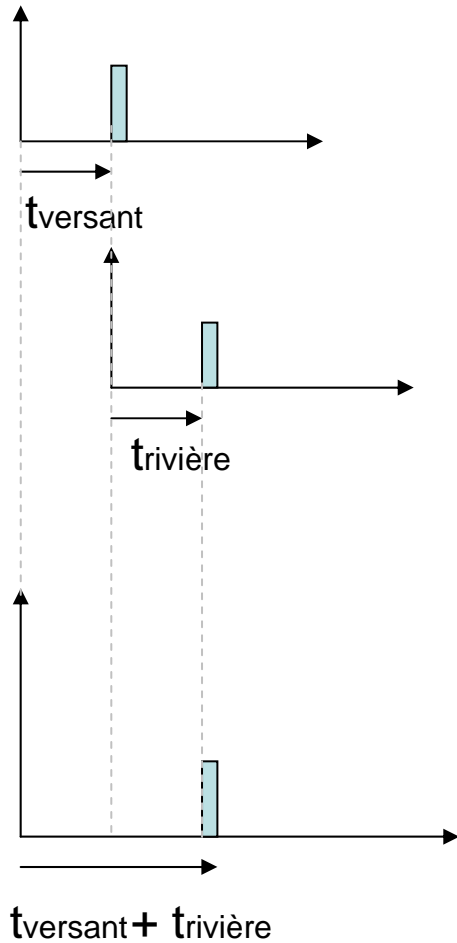


Impervious pixels distance distribution

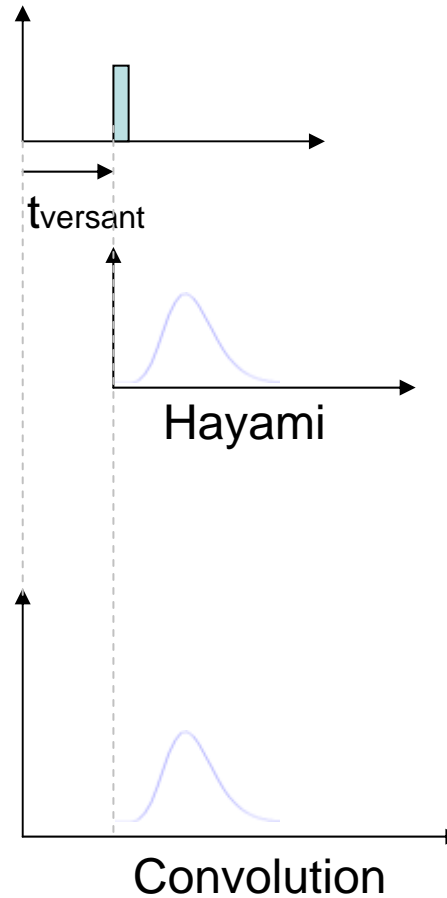


Unit
Hydrograph
for group 1

Simple transfer



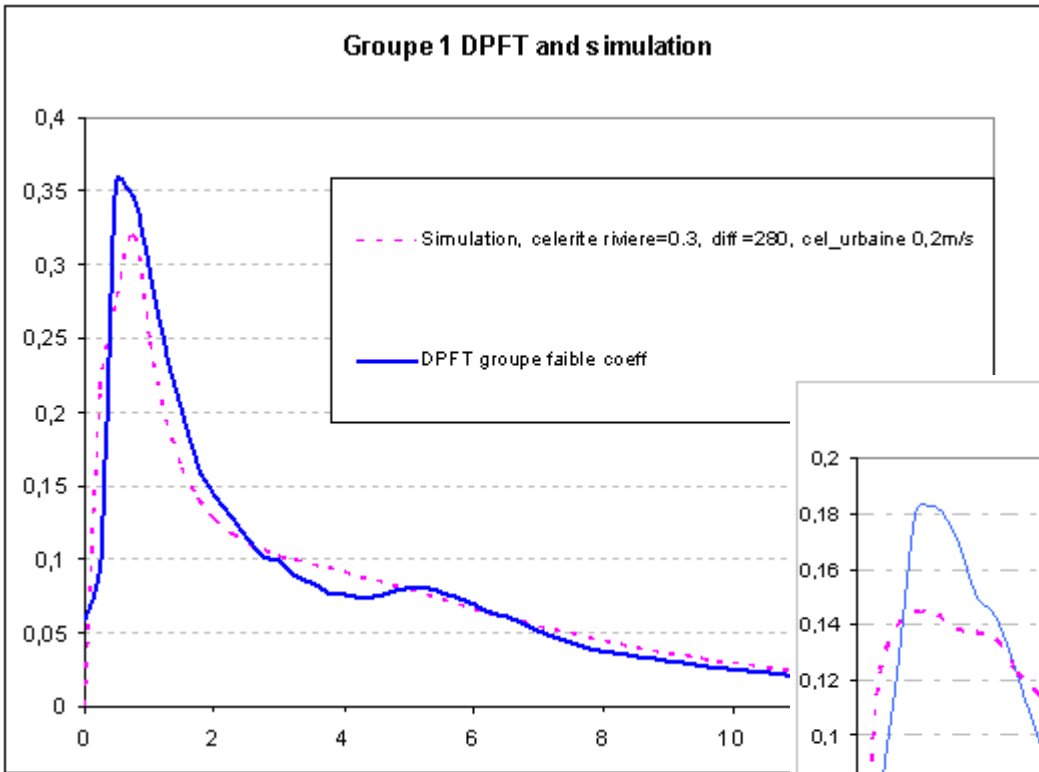
Modified routing, by the introduction of diffusion effects



Analytical Solution of
the diffusion wave
equation
Noyau de Hayami

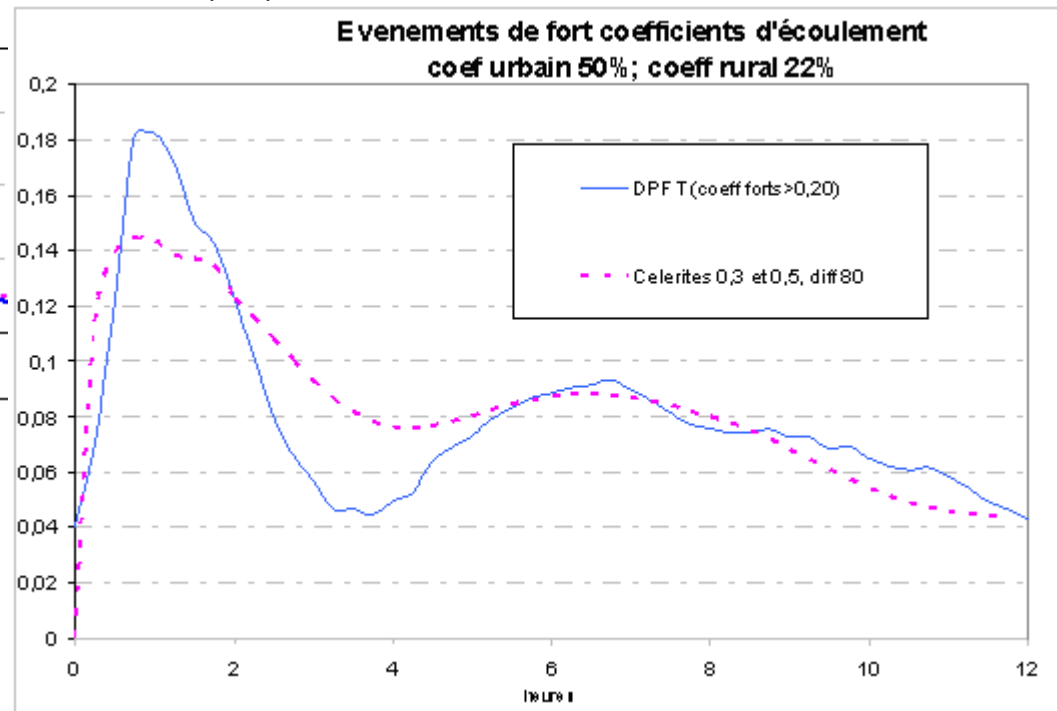
$$K(t) = \frac{L}{2\sqrt{(\pi D)}} e^{\left[\frac{CL}{4D} \left(2 - \frac{L}{Ct} - \frac{Ct}{L} \right) \right]} t^{\frac{3}{2}}$$

Groupe 1 DPFT and simulation



Comparison between FDTF and simulation with the modified transfer function

Evenements de fort coefficients d'écoulement
coef urbain 50% ; coeff rural 22%





Future Work

Integrate the transfer function presented into the coupled system

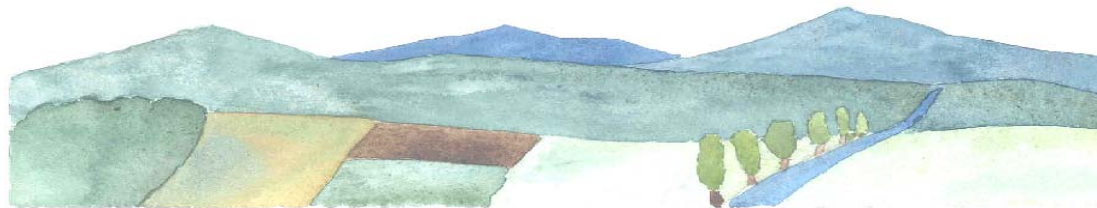
Introduce drainage network effects

Verify model transposability by testing it in other river basins

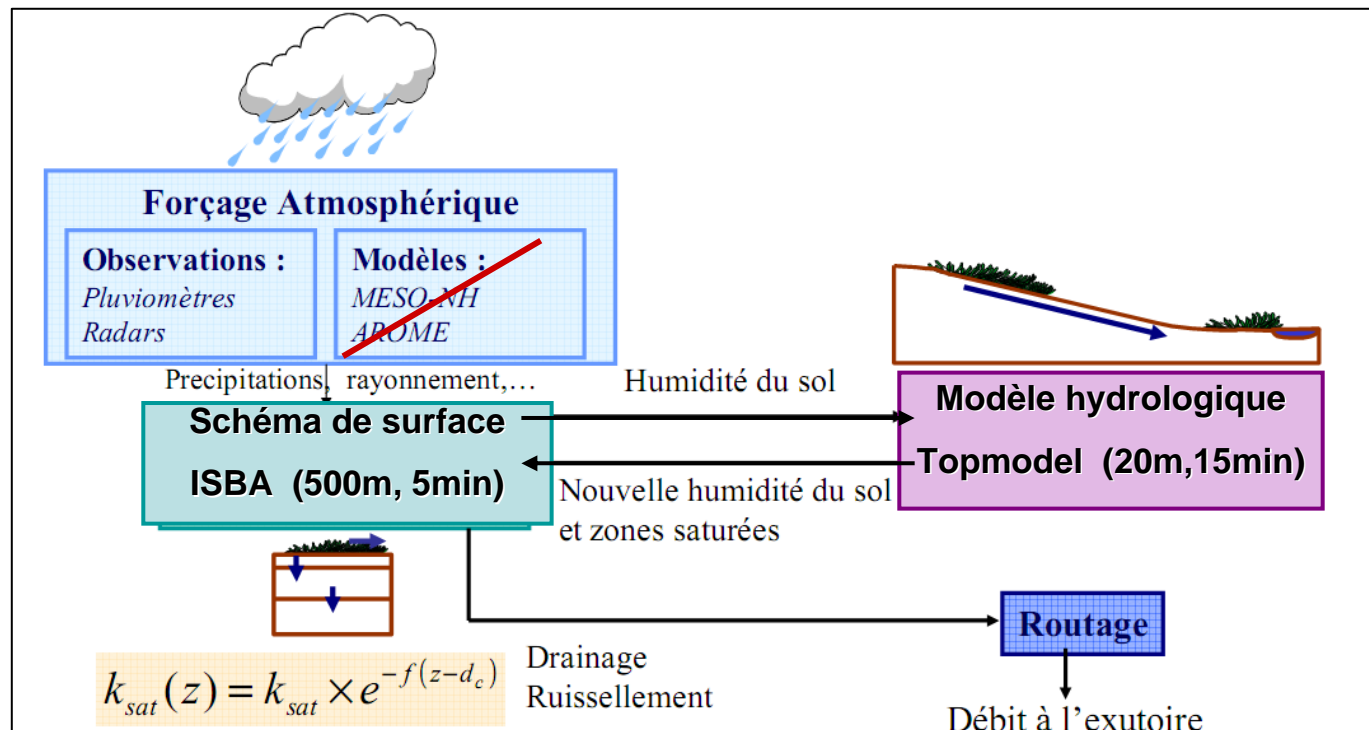
Simulate the hydrological impact under the predicted scenarios:
land use evolution and new climate conditions

Acknowledgements

**ANR- funding the project AVuPUR
Katia Chancibault and Hervé Andrieu (LCPC)
Isabelle Braud (Cemagref Lyon)**



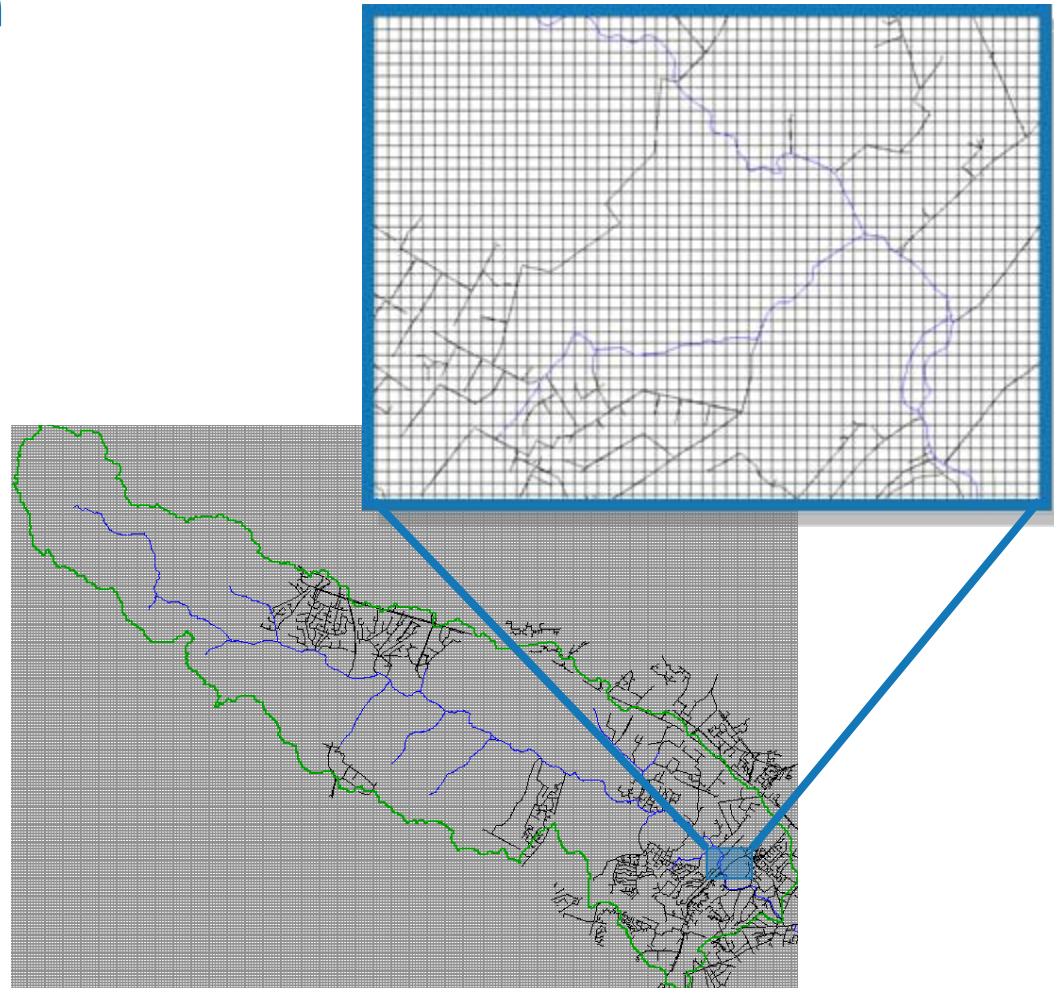
Couplage ISBA-Topodyn , Bouilloud et al 2009



Urban zones incorporation

2) Urban Drainage

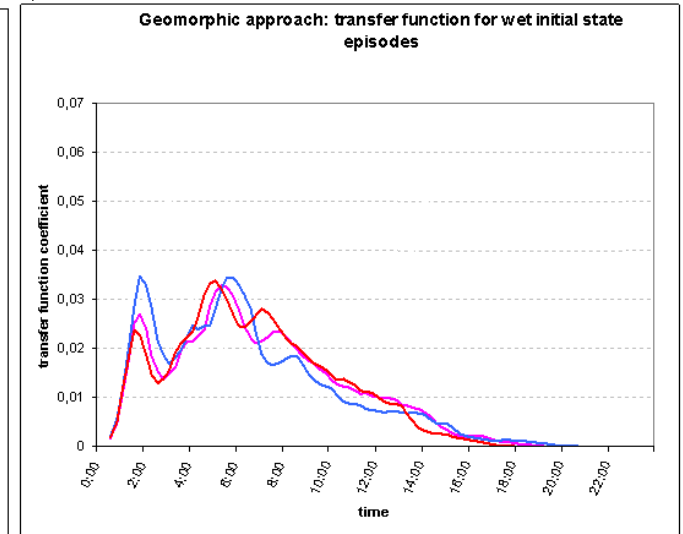
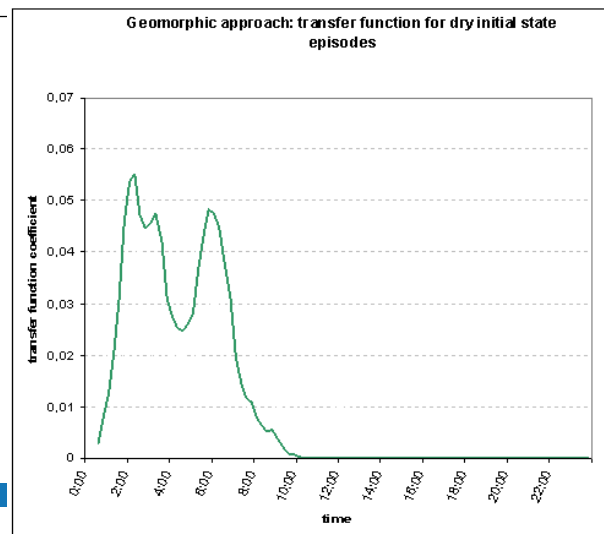
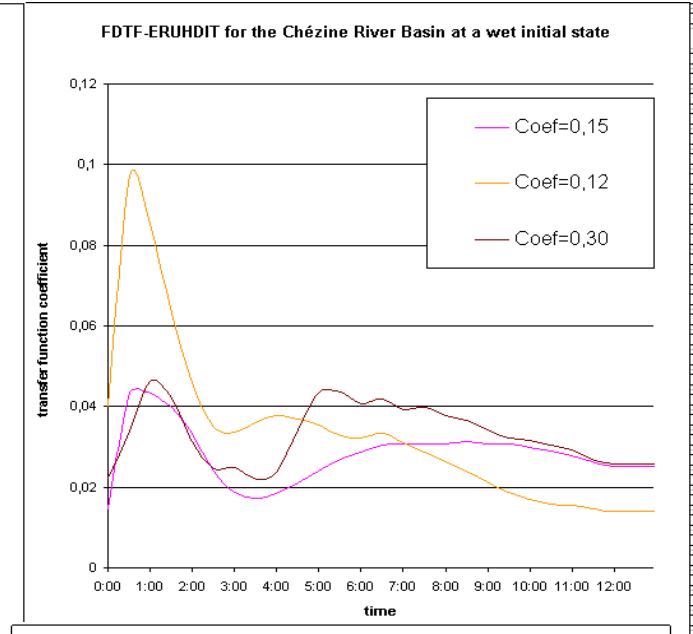
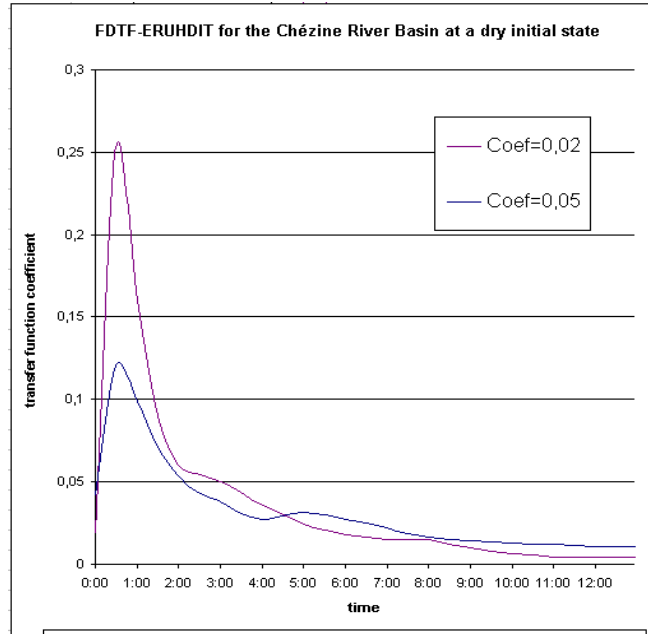
- Artificial pathways
 - Gironàs, 2007
- Topurban
 - Valeo, 1998;
 - Priou, 2005
- Urban hydrology
 - Morena, 2004;
 - Rodriguez, 1999
- Interactions between ground water and sewer network
 - Le Delliou, 2009

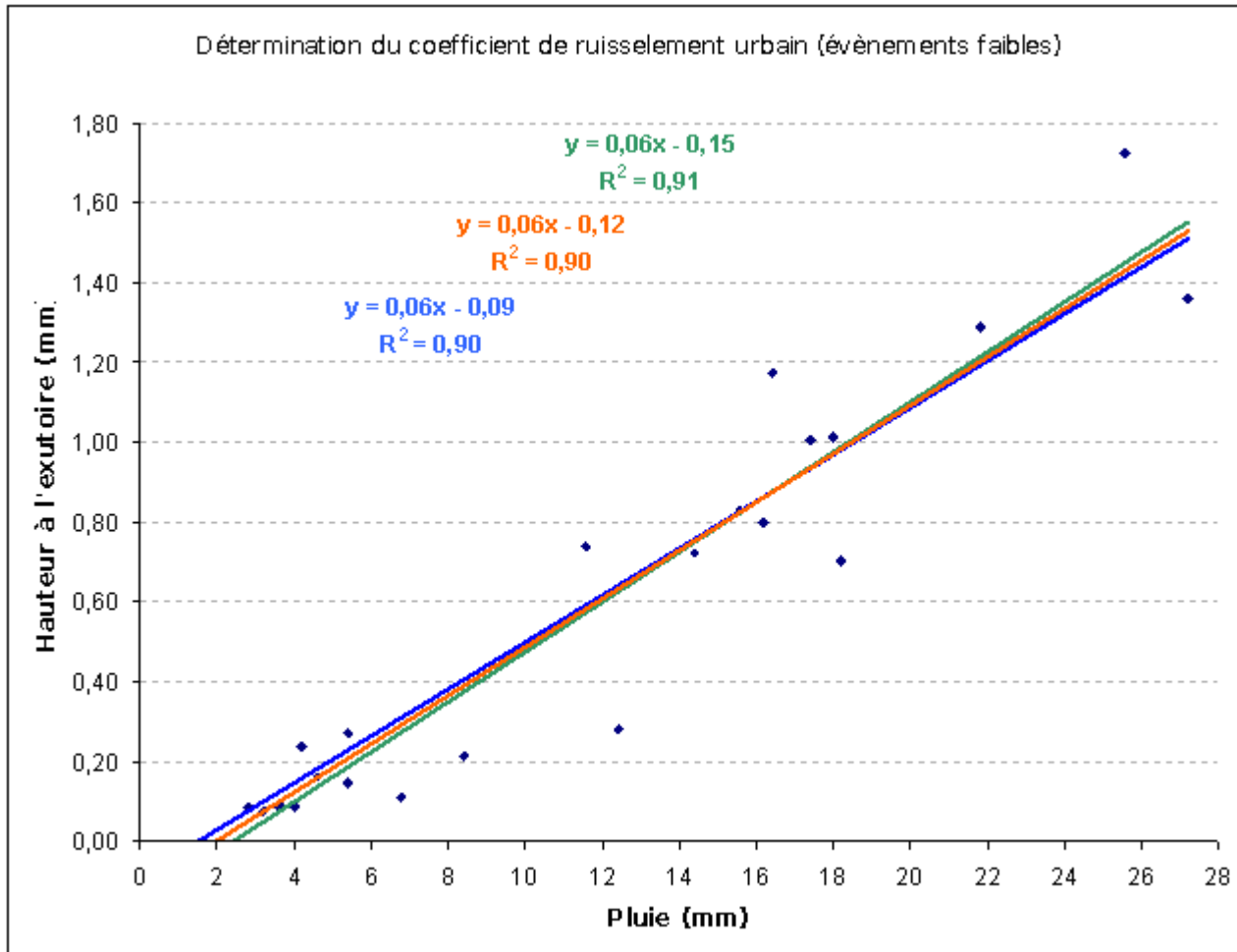


Routage

DPFT

Fonction de transfert géo-morphologique





Pertes sur surfaces urbaines:
1.5, 2 et 2.5mm.

Hicks (1944)*	0.25 à 2.50
Brombach (1984)	0.31 à 0.72
Maniak (1972)*	0.40 à 1.20
Desbordes (1974)	0.50 à 1.00
Watt et Kidd (1975)	0.51
Pecher (1969)*	0.70 à 1.20
Krauth (1972)*	0.85
Annen et Schoss (1972)*	1.00
Neumann (1976)	1.00 à 3.00
Langford et Turner (1973)*	1.10
Horner et Jens (1942)*	1.25 à 2.50
valeurs USA*	1.60
Terstriep et Stall (1969)*	2.20

Pertes sur surfaces urbaines: 1.5, 2 et 2.5mm.

groupe 2 Détermination du coefficient de ruissellement en zone rurale

Pertes urbaines:1,5mm; Pertes rurales:3mm

Coef urbain=33%; Coef rural = 4%

Coef urbain=40%; Coef rural = 2%

Pertes Urbaines 2mm; Pertes Rurales: 4 mm

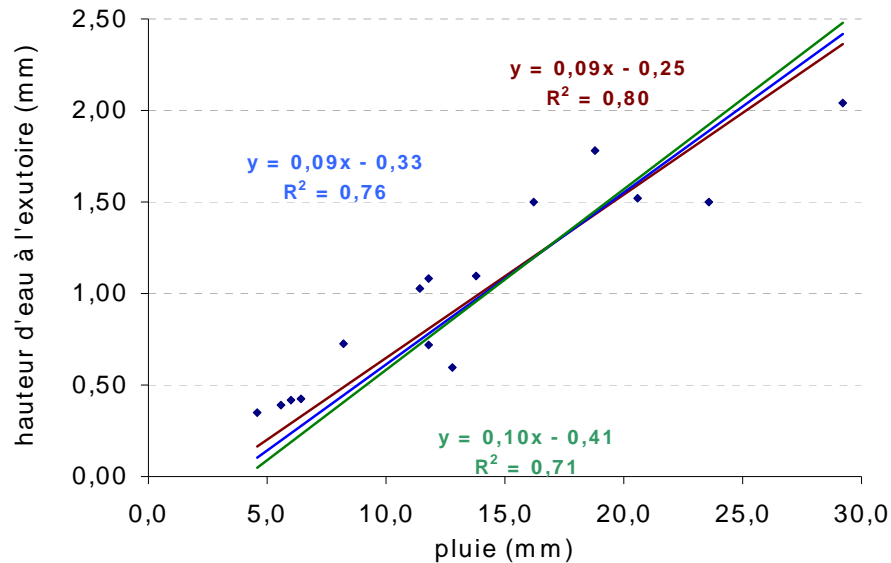
Coef urbain=33%; Coef rural = 5%

Coef urbain=40%; Coef rural = 3%

Pertes Urbaines 2,5mm; Pertes Rurales: 5 mm

Coef urbain=33%; Coef rural = 5%

Coef urbain=40%; Coef rural = 3%



Groupe 3 Détermination du coefficient de ruissellement de forts évènements pluvieux

Pertes urbaines:1,5mm; Pertes rurales:3mm

Pertes Urbaines 2mm; Pertes Rurales: 4 mm

Coef urbain=33%; Coef rural = 23%

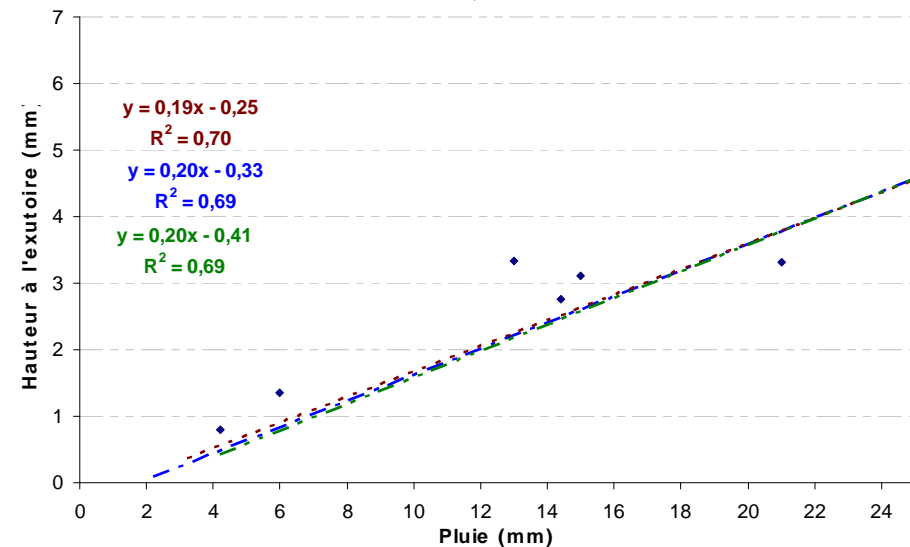
Coef urbain=40%; Coef rural = 22%

Coef urbain=50%; Coef rural = 19%

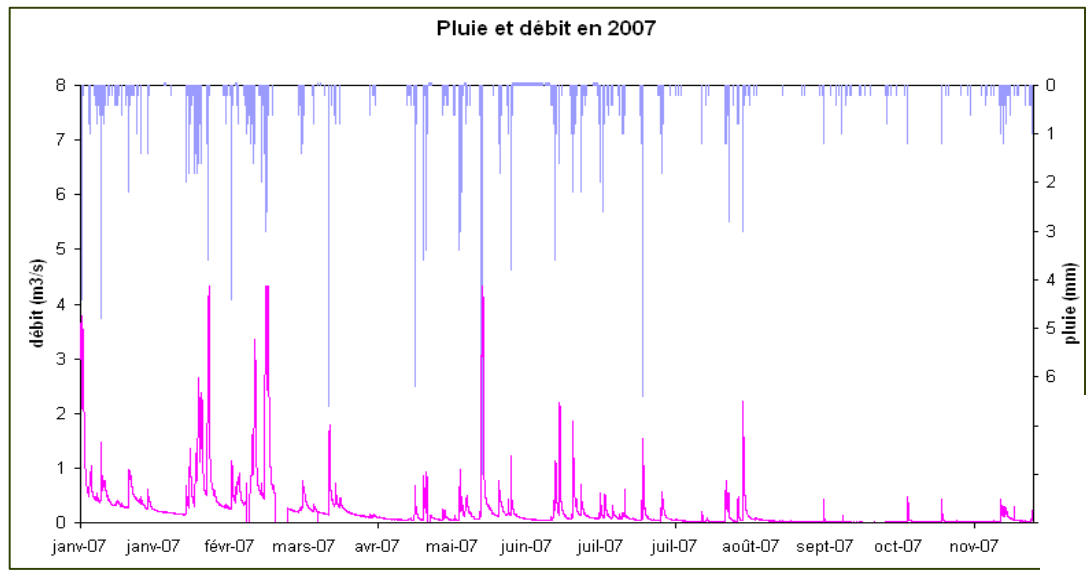
Pertes Urbaines 2,5mm; Pertes Rurales: 5 mm

Coef urbain=40%; Coef rural = 23%

Coef urbain=50%; Coef rural = 21%

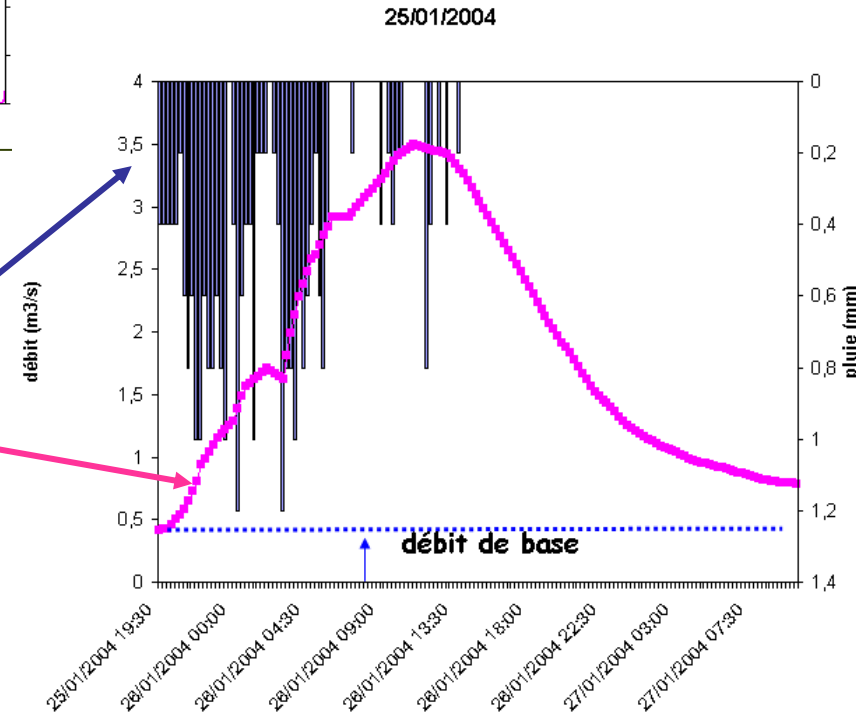


◆ Traitement des données pluie et débit



Coefficient d'écoulement

$$Coeff = \frac{Volume\ d'\ eau\ ruisselé}{Volume\ d'\ eau\ précipité}$$



Localisation des pixels ruraux contributifs

Indice topographique

- Quels sont les pixels qui sont saturés ?

L'indice topographique classifie les pixels entre eux par rapport à leur propension de se saturer

$$\lambda_i = \ln\left(\frac{a_i}{\tan \beta_i}\right)$$

(Beven & Kirkby, 1979)

a_i = surface spécifique

(l'aire contributive / côté
d'un pixel)

β_i = pente locale

