

Flow Regime from International Experimental and Network Data
6^{ème} conférence mondiale FRIEND

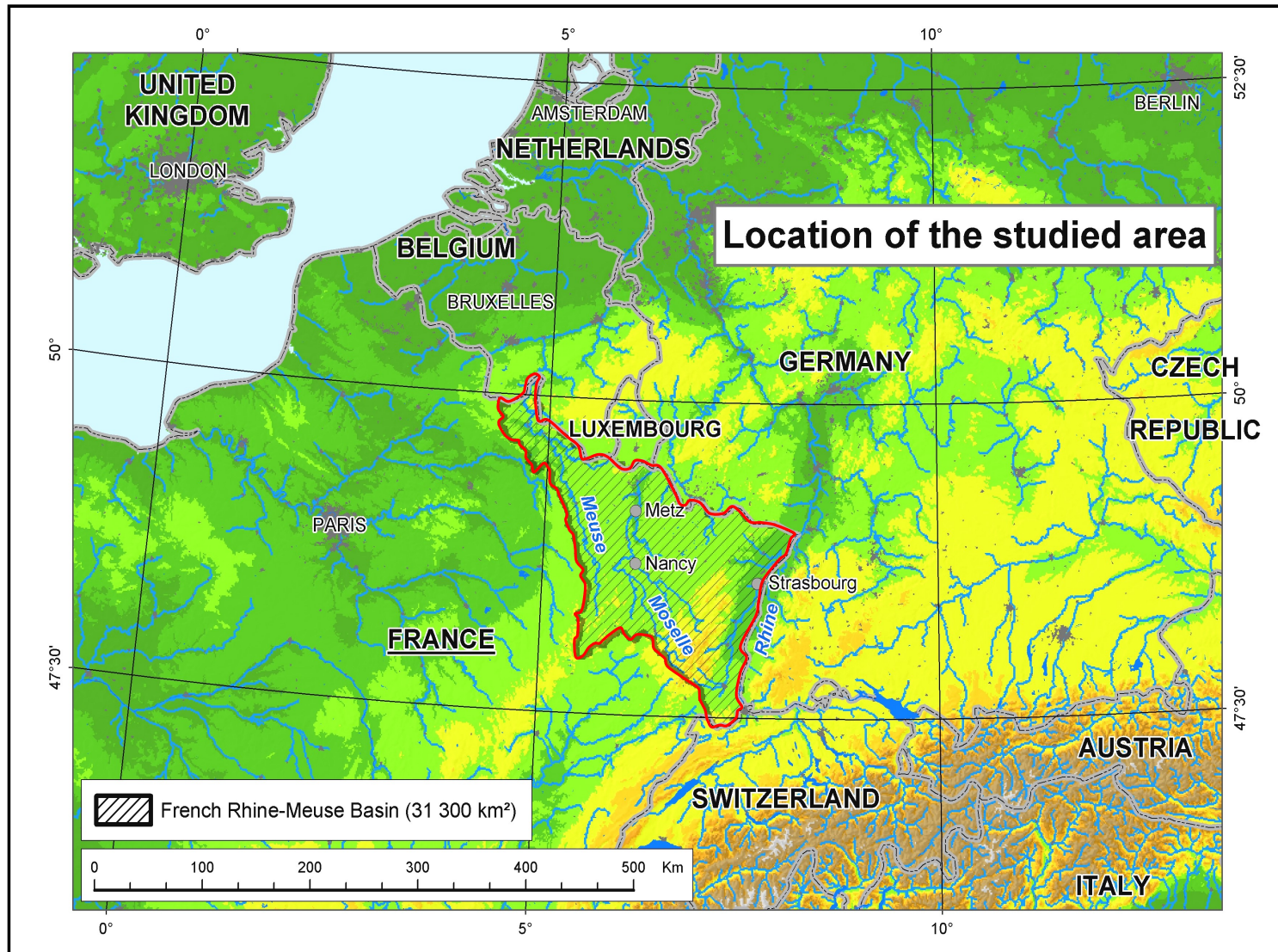
Changement global : Faire face aux risques et aux menaces sur les ressources en eau

**Estimating low flow discharges at ungauged sites by
relating model parameters to basins properties.**

CLAIRE LANG, EMMANUEL GILLE, DIDIER FRANÇOIS



- *The study area*



Context and methods

Methods for low flow estimation :

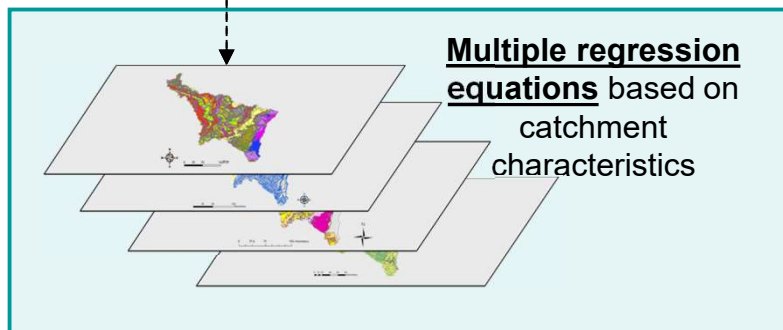
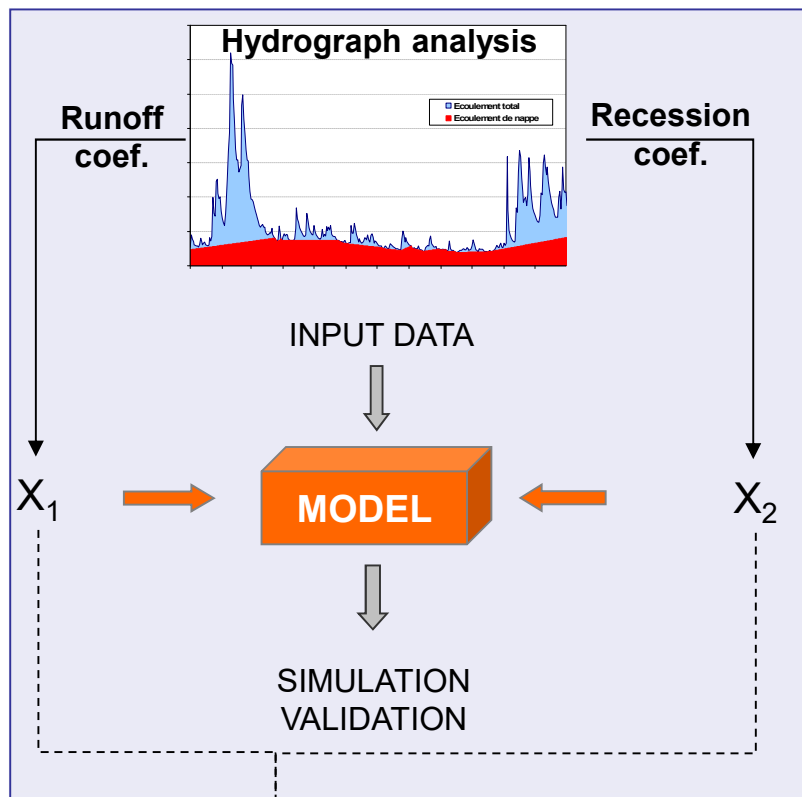
- *Statistical methods*
- *Rainfall-Runoff modeling*

Monthly lumped model
(simulation of the **MMAM** discharges)

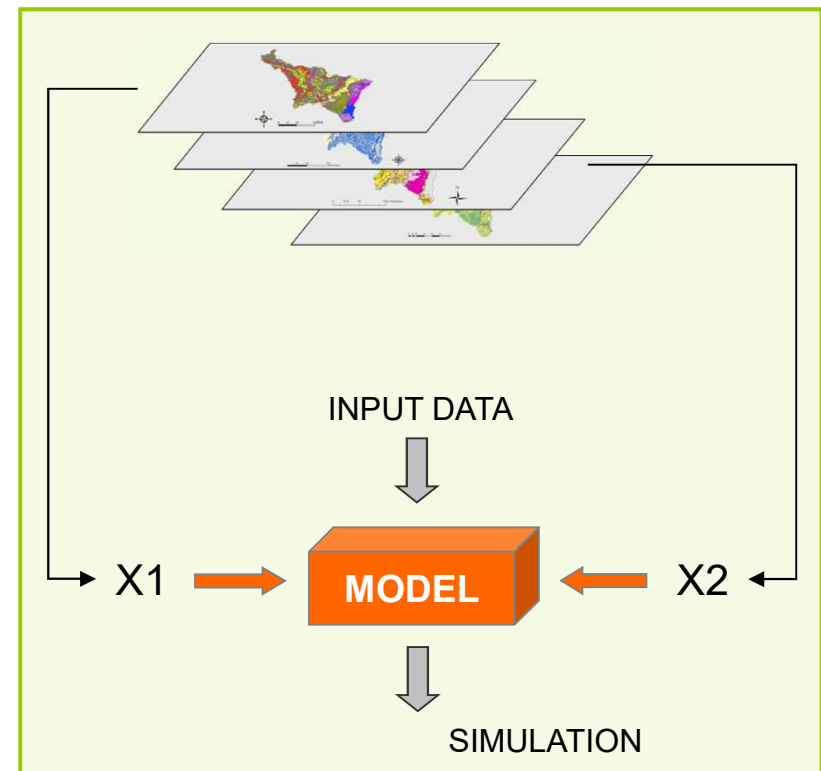
Semi-distributed model

Context and methods

MODELING → GAUGED BASINS



MODELING → UNGAUGED BASINS



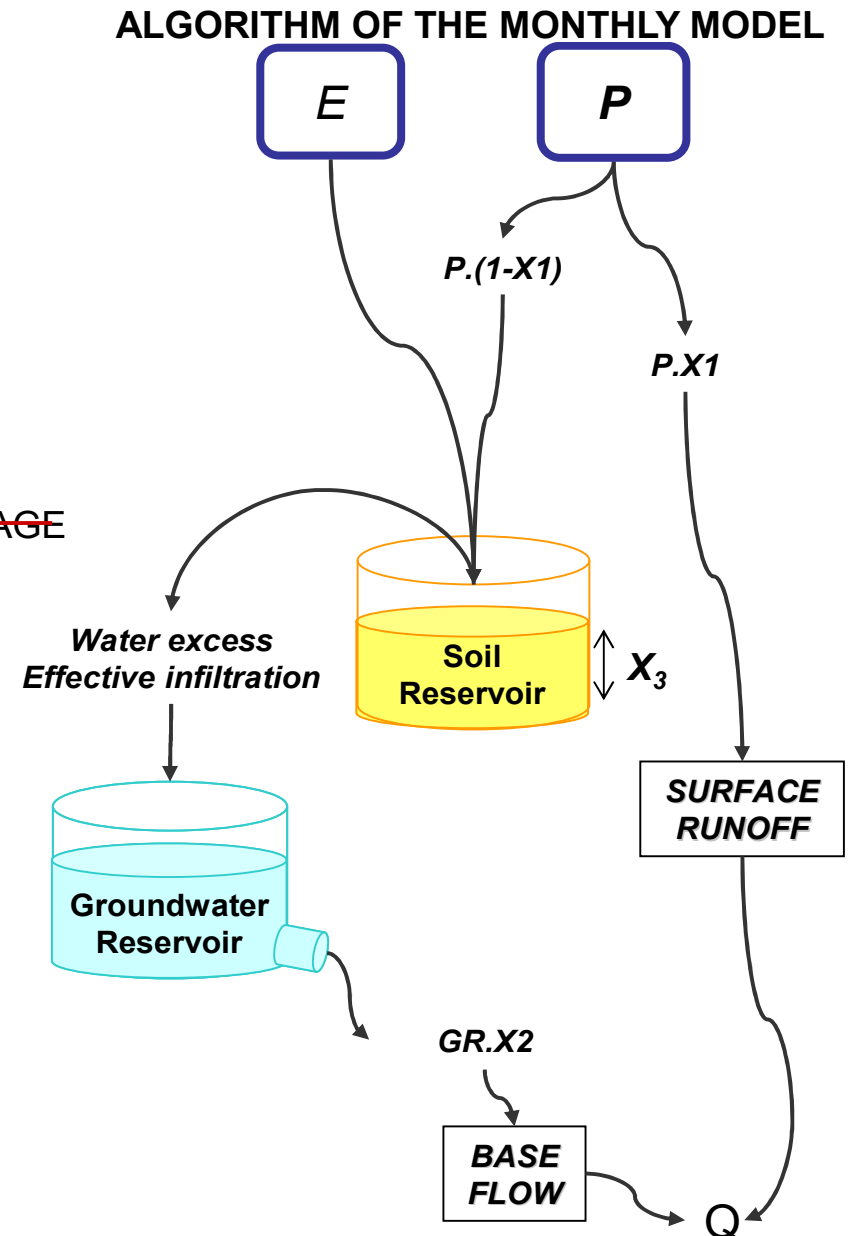
I. Validation of the monthly modeling at gauged sites

➤ The monthly model

3 PARAMETERS :

- X_1 : RUNOFF COEFFICIENT
- X_2 : RECESSION COEFFICIENT
- ~~X_3 : MAXIMUM CAPACITY OF THE SOIL STORAGE~~

Input data:
E: Potential evapotranspiration
P: Precipitations
Equations:
Surface runoff = $P \cdot X_1$
If $[P \cdot (1 - X_1)] \geq E$:
Soil Reservoir (SR) = $\text{Min} [PS + SR_{i-1} ; X_3]$
 $PS = [P \cdot (1 - X_1)] - E$
 $PR = \text{Max} [PS + SR_{i-1} - X_3 ; 0]$
If $[P \cdot (1 - X_1)] < E$:
 $PS = 0$
 $PR = 0$
 $SR = SR_{i-1} \cdot e^{(-E/A)}$
Groundwater Reservoir (GR) = $PR + GR_{i-1}$
Base flow = $GR \cdot X_2$
 $Q = \text{Surface runoff} + \text{Base flow}$

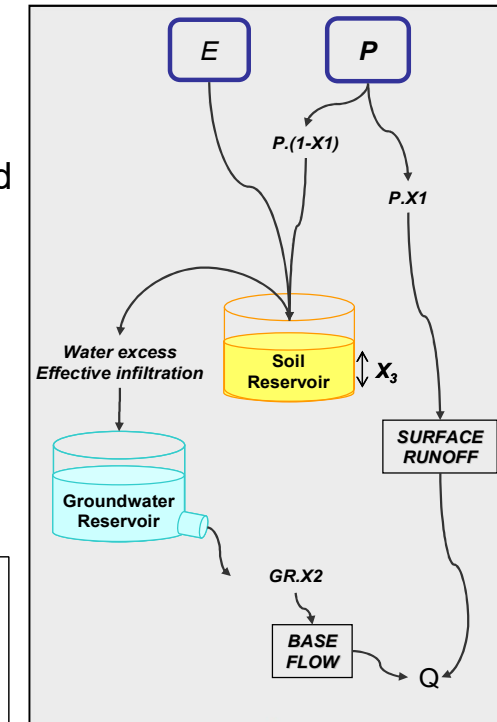
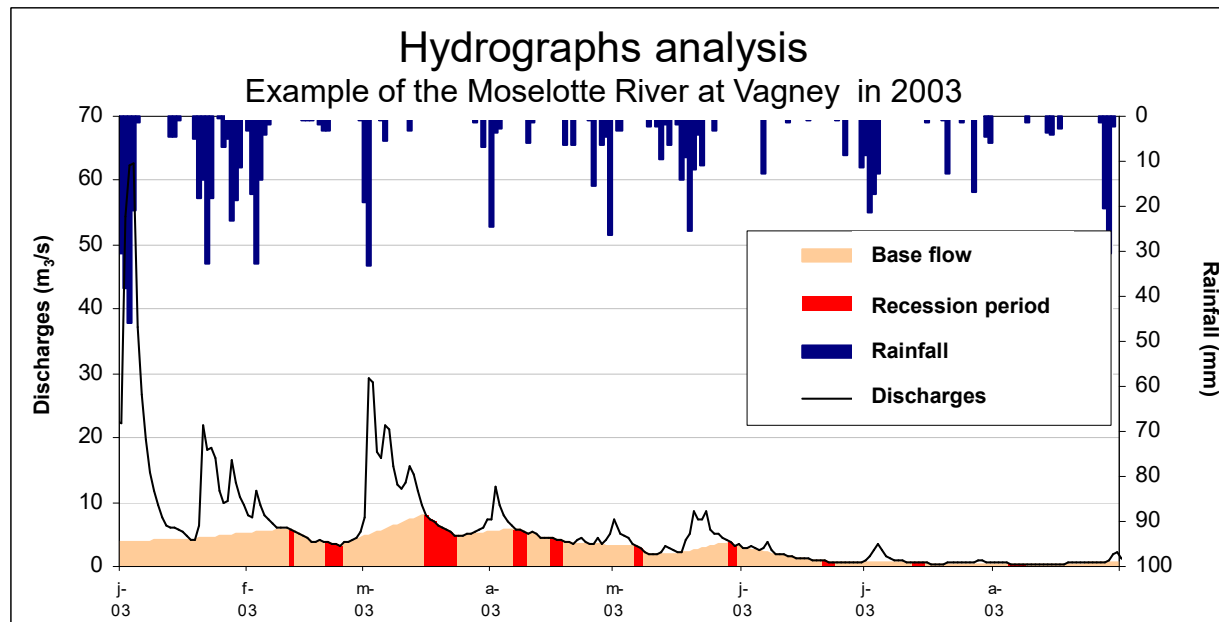


I. Validation of the monthly modeling at gauged sites

➤ The model parameters are extracted from the hydrographs

The model parameters are calculated from an hydrograph analysis

- X_1 : Runoff coefficient calculated from a base flow separation method
- X_2 : Recession coefficient calculated from a recession analysis

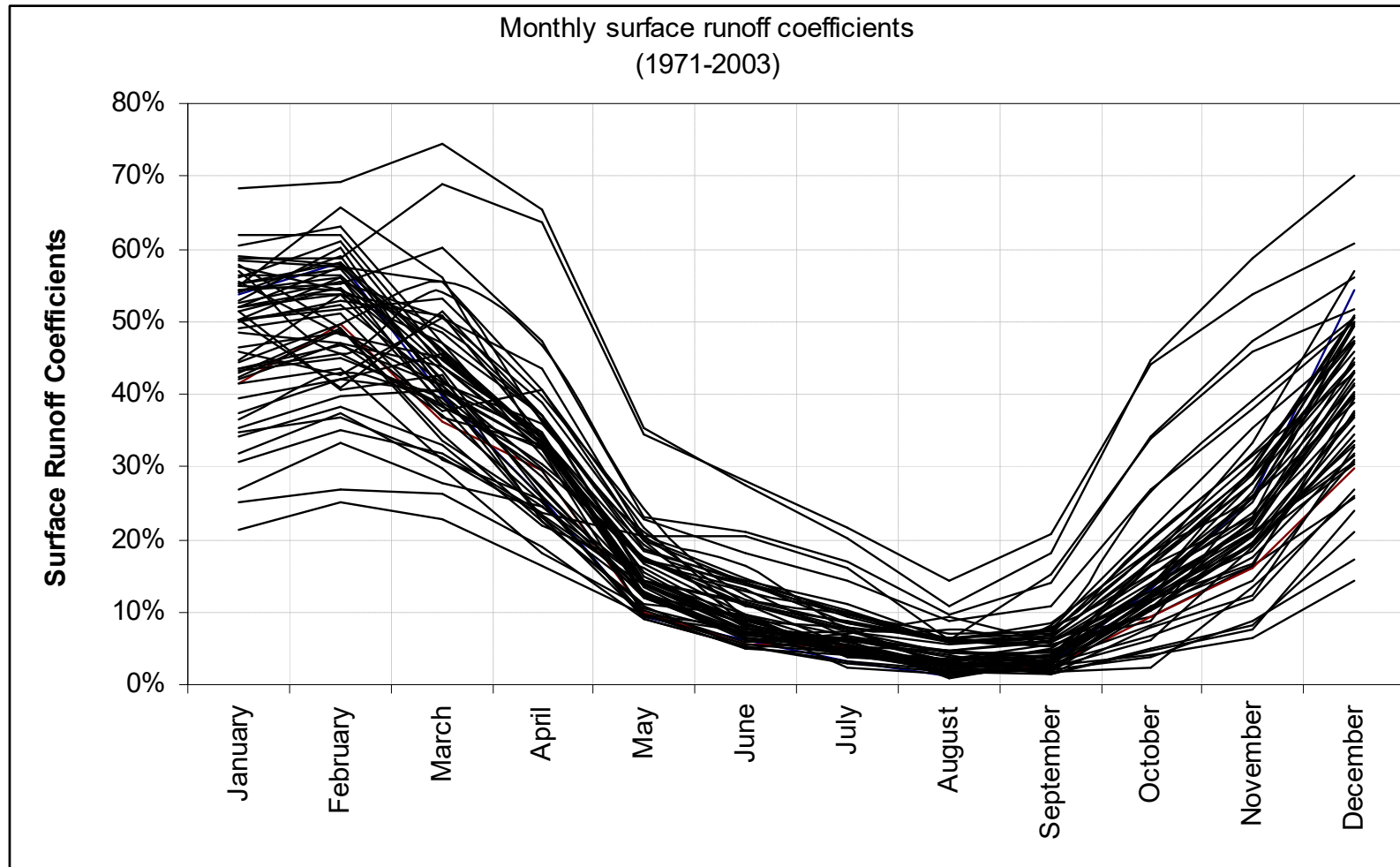


I. Validation of the monthly modeling at gauged sites

- Use of monthly runoff coefficients instead of an annual value

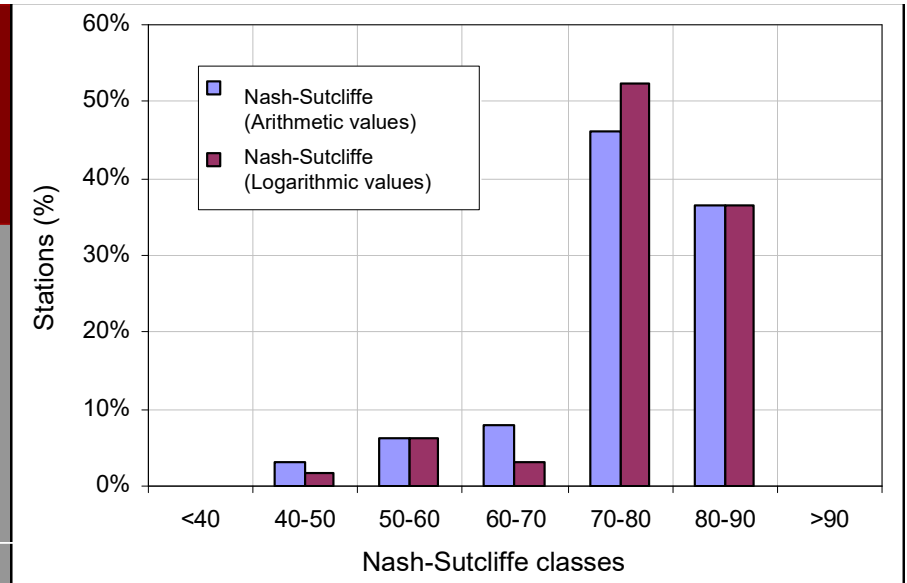
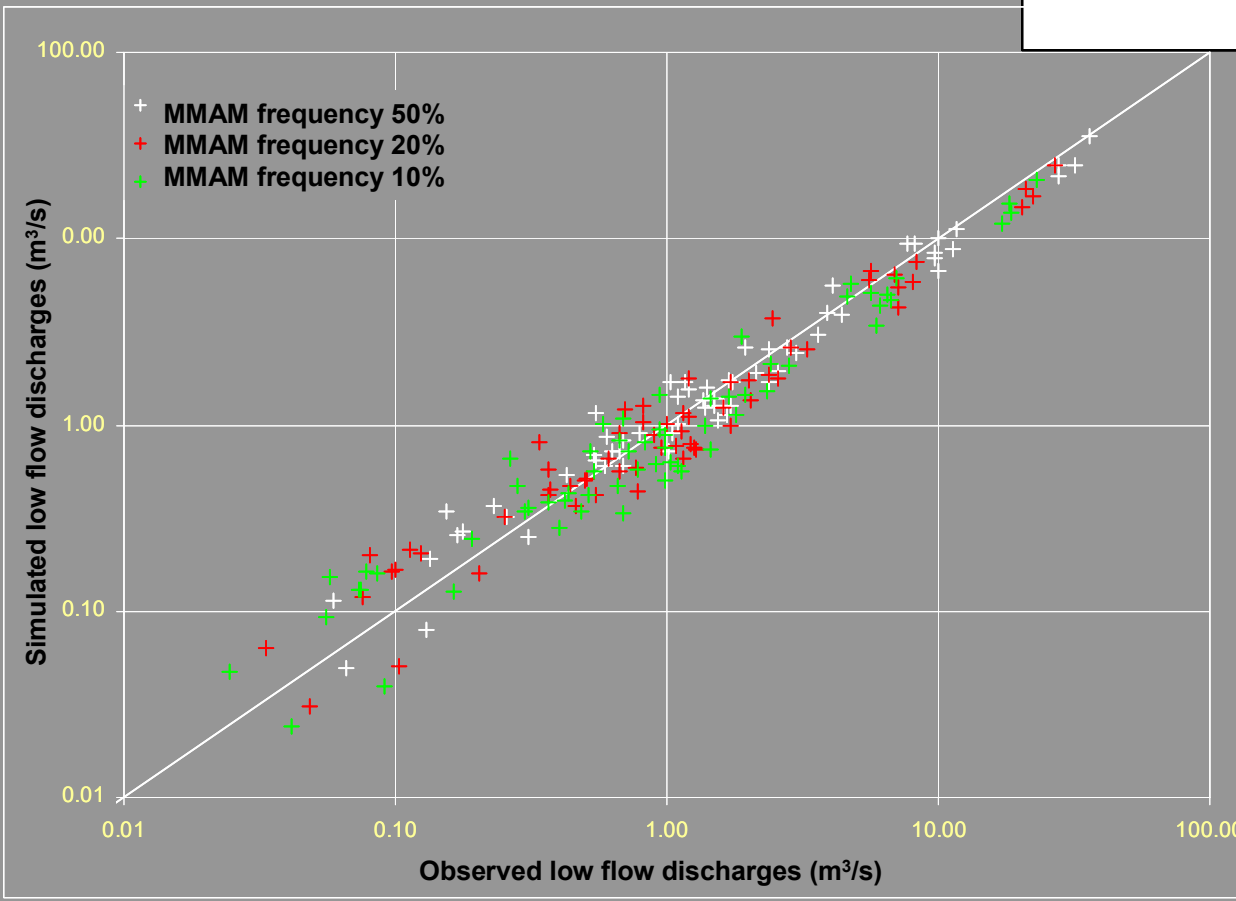
Seasonality of the Surface Runoff Coefficient

Results from about 60 catchments located in the studied area for the period 1971-2003.



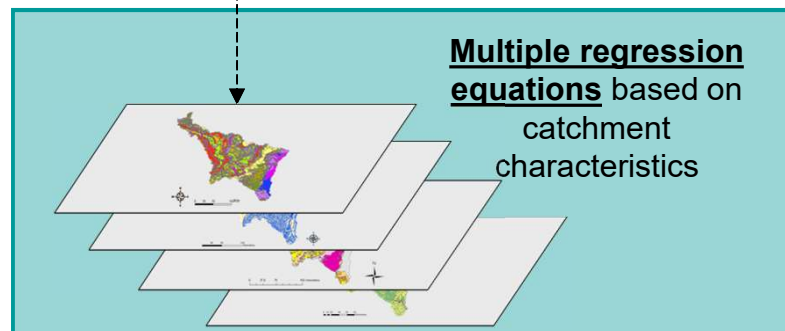
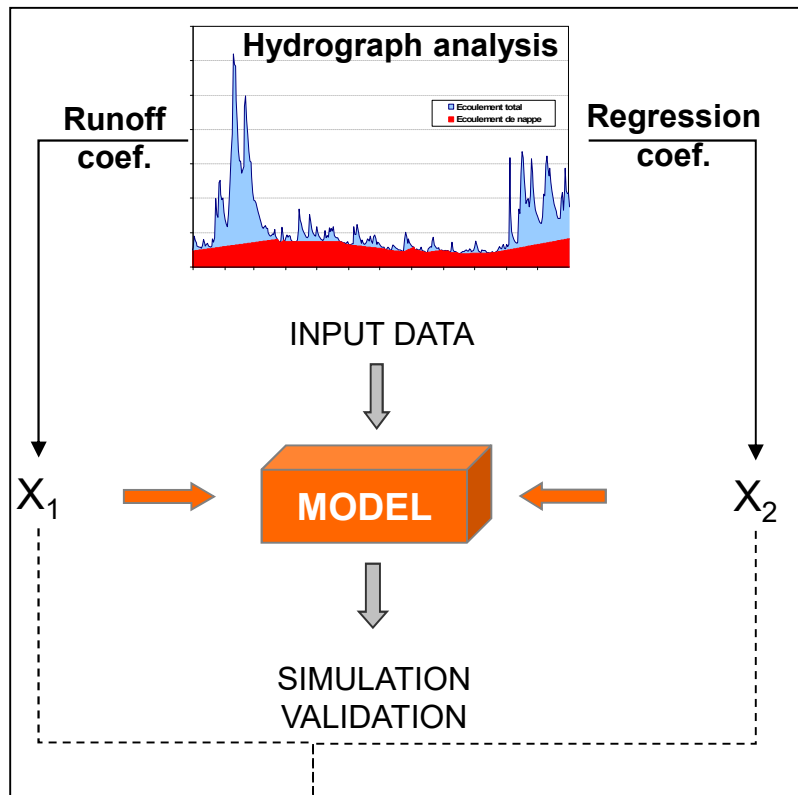
I. Validation of the monthly modeling

➤ *Observed Mean Monthly Annual Minimum (MMAM) discharges vs. simulated MMAM*



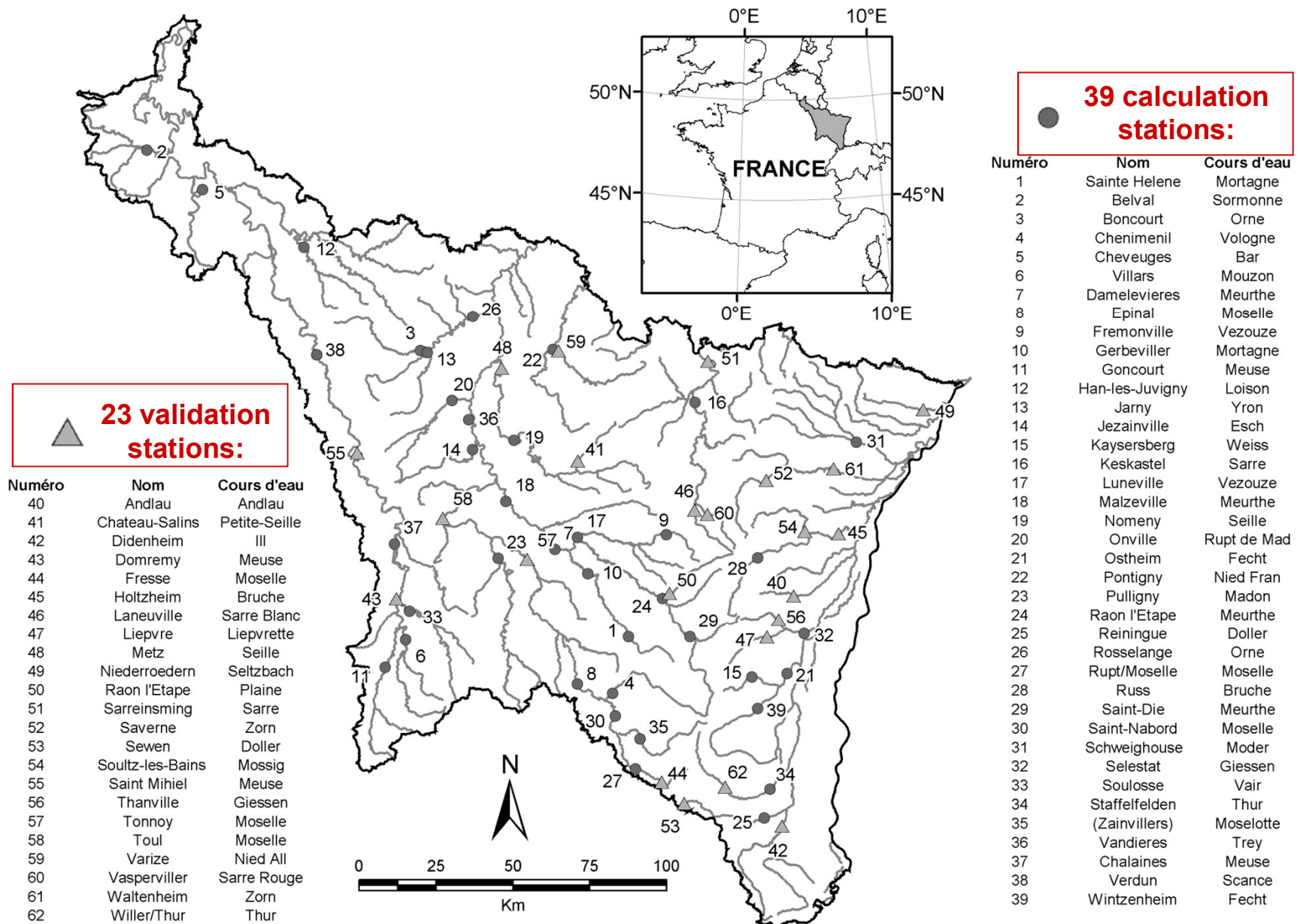
➤ *Nash-Sutcliffe criterion (period 1971-2000 – statistics from 60 basins)*

II. Relations between the model parameters and basins properties



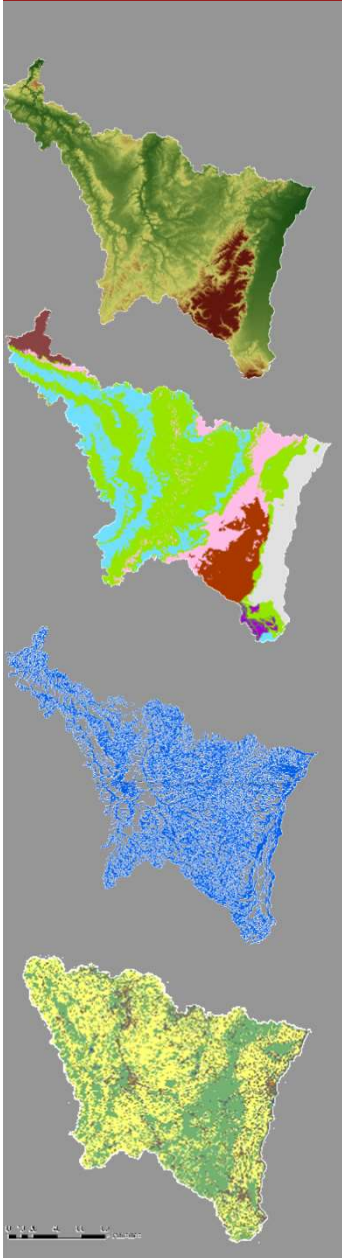
II. Relations between the model parameters and basins properties

➤ Stations that were selected



II. Relations between the model parameters and basins properties

➤ Extraction of catchment properties



About fifty characteristics were extracted:

- **Topography** (elevation, slope)
 - **Morphometrical characteristics** (perimeter, area, Gravelius)
 - **Geology**
 - **Hydrographical network** (drainage density, drainage length)
 - **Soil cover**
 - **Rainfall**
- *These physical properties are used to estimate the parameters of the model.*

II. Relations between the model parameters and catchment properties

➤ Multiple regression equations

- **Multiple regression equations for the estimation of parameters of the model:**
- **The runoff coefficient X_1 & the recession coefficient X_2**

	J	F	M	A	M	J	J	A	S	O	N	D		RC
R²	0.720	0.670	0.833	0.815	0.735	0.812	0.719	0.669	0.833	0.853	0.837	0.684	R²	0.659
C	0.159	0.199	0.172	-0.011	0.032	-0.122	-0.088	-0.064	-0.102	-0.151	-0.148	-0.104	C	0.49
P	0.46	0.232	0.576	0.83	0.919	0.943	0.884	0.857	0.876	0.728	0.927	0.615	Sand.	0.78
IG	*	*	*	-0.08	-0.137	*	*	*	*	*	*	*	DD	-0.417
DD	0.34	0.348	0.211	*	*	0.098	*	*	*	0.169	0.114	0.234	Lime.	0.277
Lime.	0.205	0.43	*	0.491	0.251	0.148	0.065	0.073	-0.081	-0.119	-0.115	0.175	MAR	0.856
Sand.	-0.49	-0.467	-0.477	*	-0.262	-0.207	-0.246	-0.078	-0.063	-0.335	-0.207	*	Granite	1.336
Granite	*	0.331	0.099	0.672	*	*	*	*	*	*	*	0.63	Agri	-1.009
MAR	0.512	0.437	*	0.576	*	*	*	*	*	*	0.302	0.926	Slope	-0.914

R² : R-squared value
R² aj. : Adjusted R-squared value
C : Constant
P : Total rainfall month and month₁
IG : Gravélius index
DD : Drainage density
Lime. : Percentage of limestone
Sand. : Percentage of sandstone
Granite : Percentage of granite
MAR : Percentage of marl and clay
Agri : Percentage of agricultural area
PMoy : Mean slope of the basin

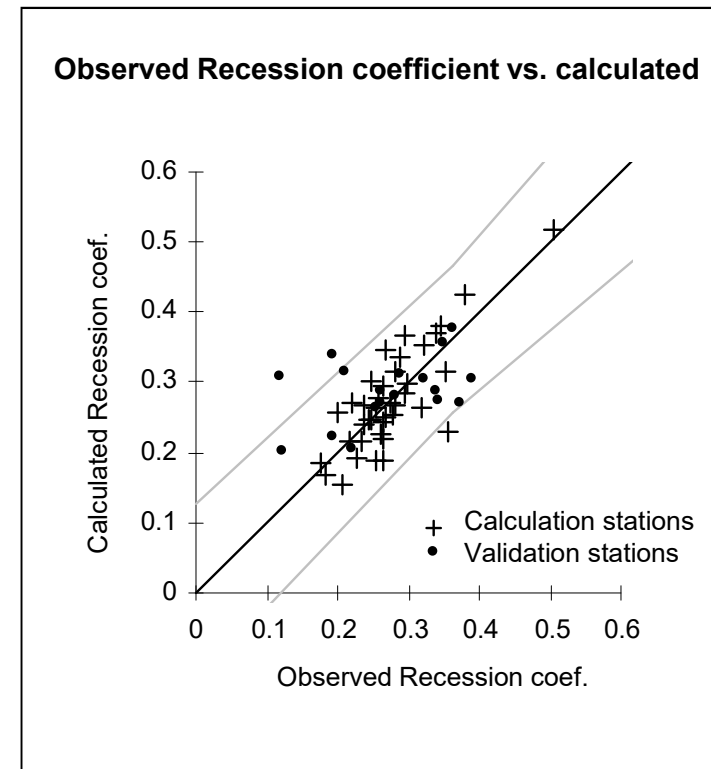
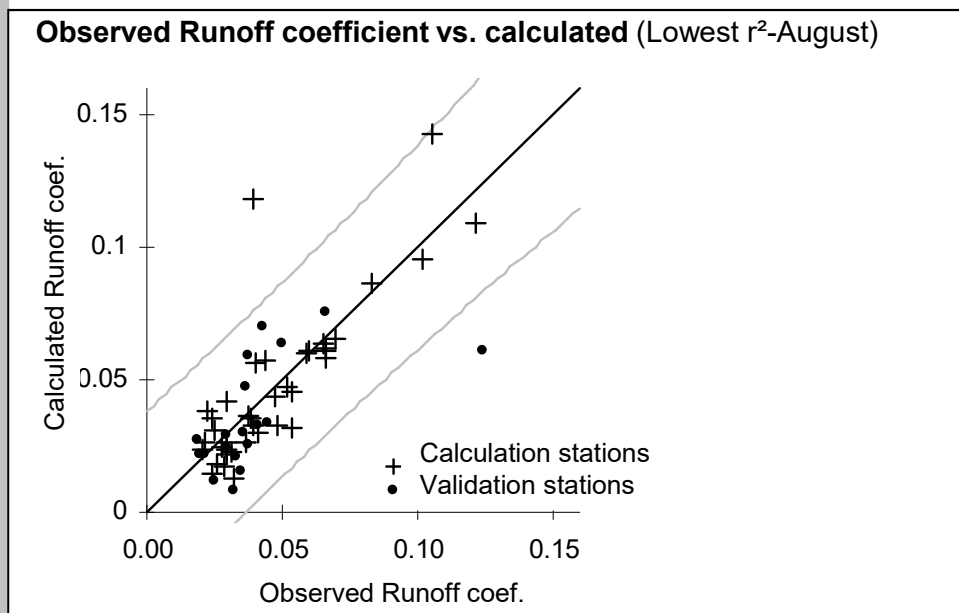
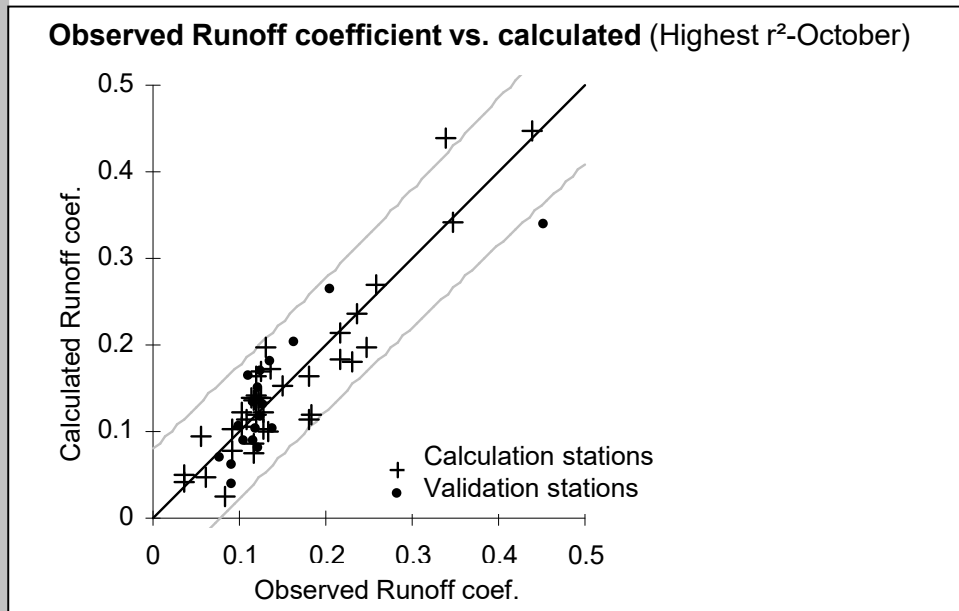
Coefficients of determination

Constants of the regressions

Coefficients of the regressions

II. Relations between the model parameters and basins properties

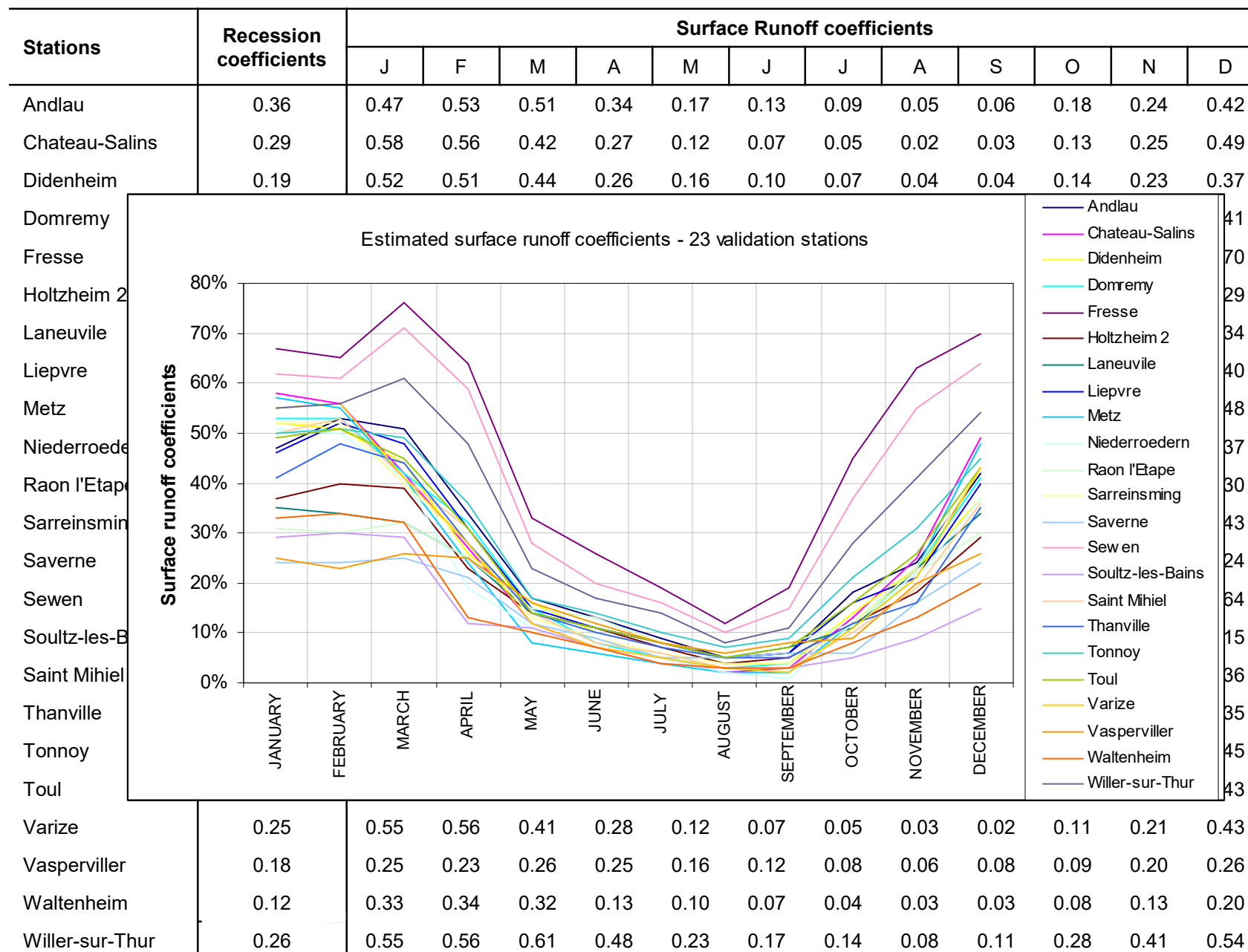
➤ Observed parameters (hydrographs) vs. Calculated parameters (multiple regressions)



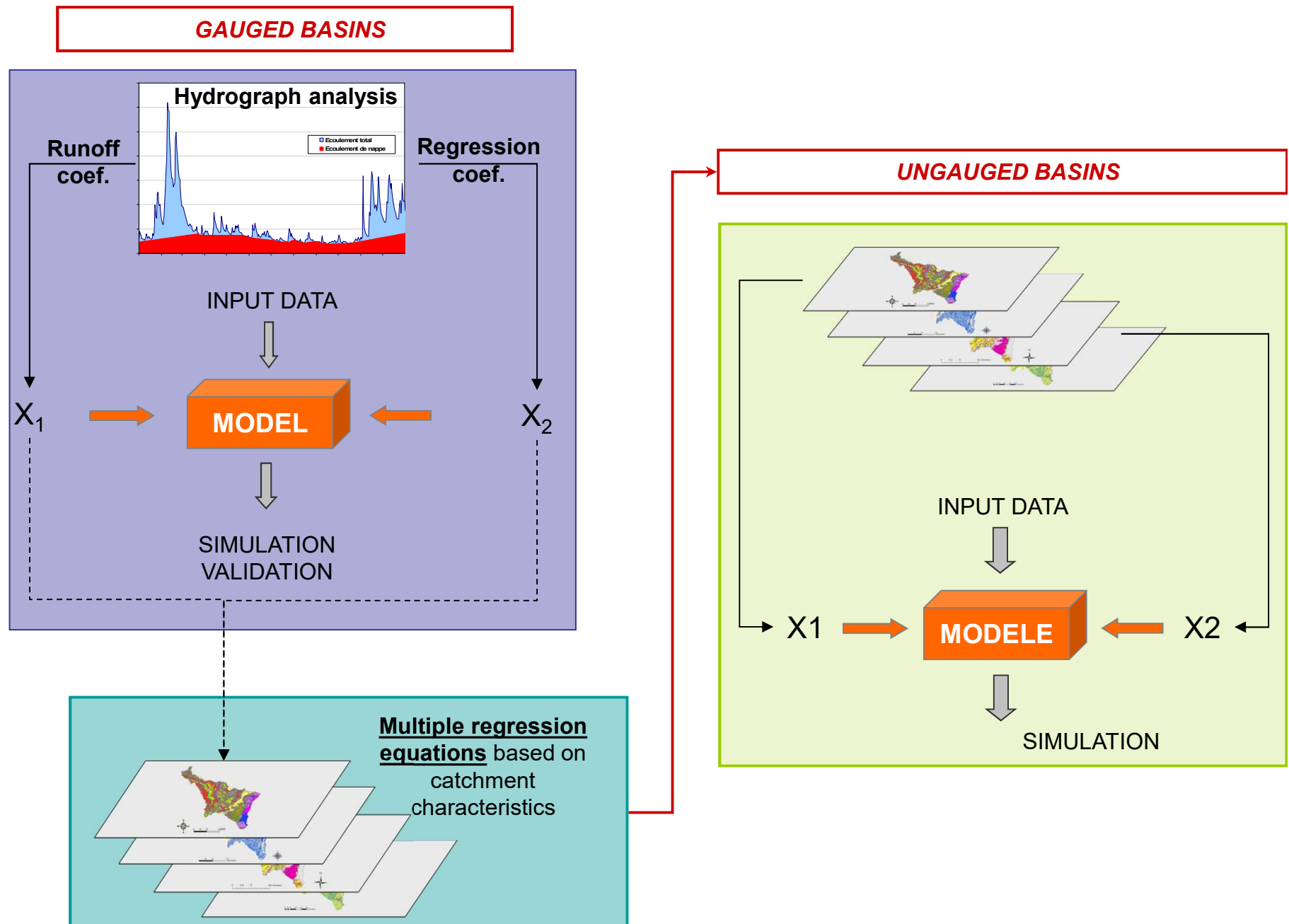
Confidence interval: 95 %

II. Relations between the model parameters and basins properties

➤ The model parameters for the validation package: parameters from regression equations



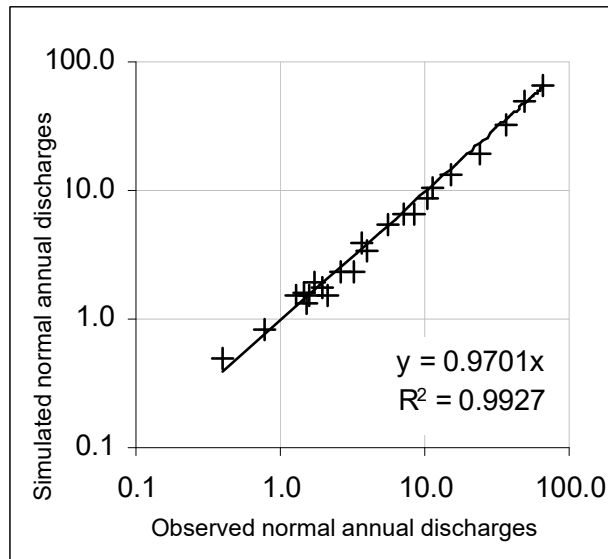
III. Validation of the monthly modeling at ungauged sites



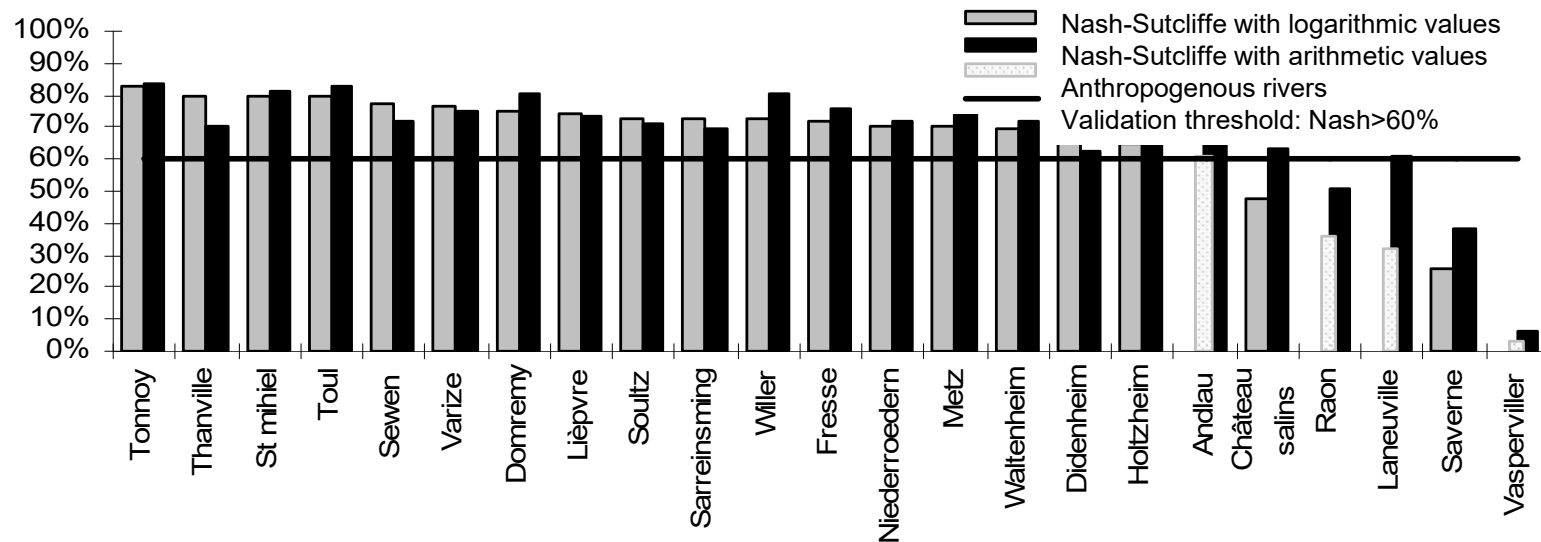
III. Validation of the monthly modeling at ungauged sites

➤ The model efficiency

Scatterplot between observed normal annual discharges and simulated (1971-2000)



Performance of the modeling for the validation package

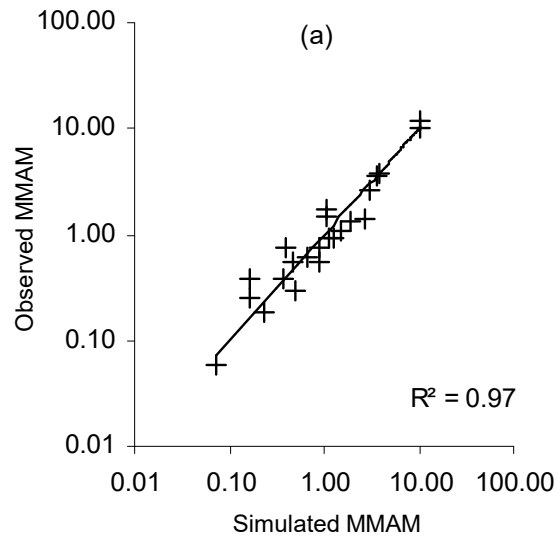


III. Validation of the monthly modeling at ungauged sites

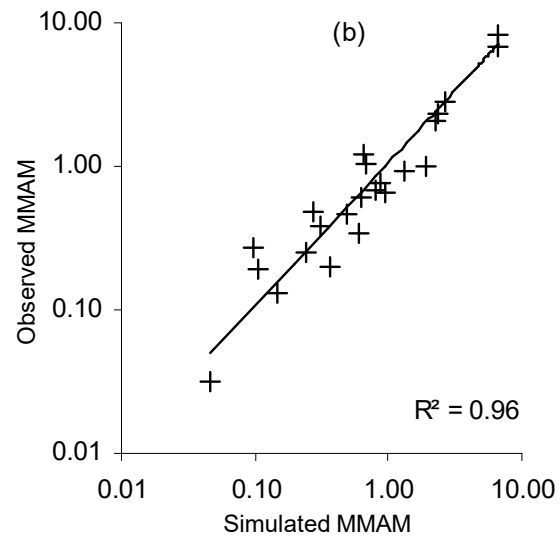
➤ The model efficiency for characteristics low flow estimation

Correlation between observed characteristics low flow and simulated characteristics low flow discharges

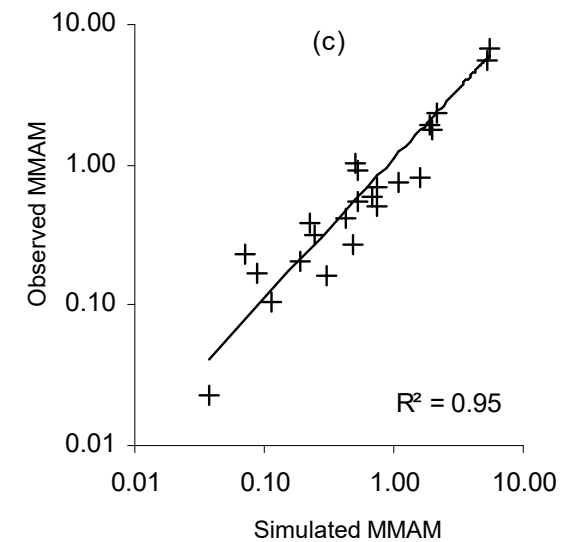
(a) MMAM frequency 50%



(b) MMAM frequency 20%

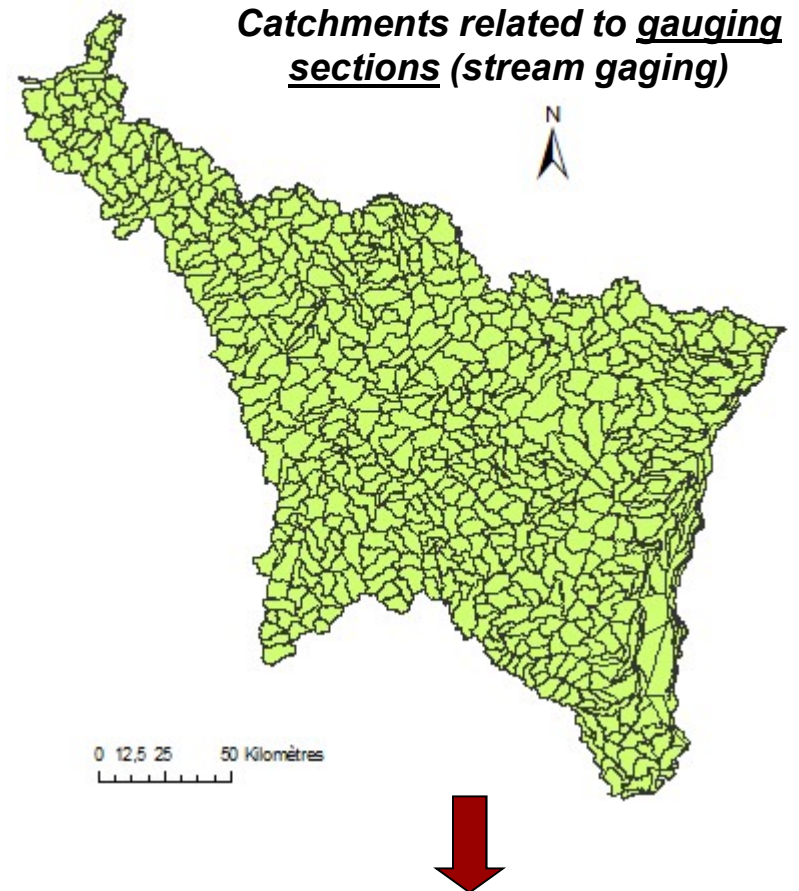
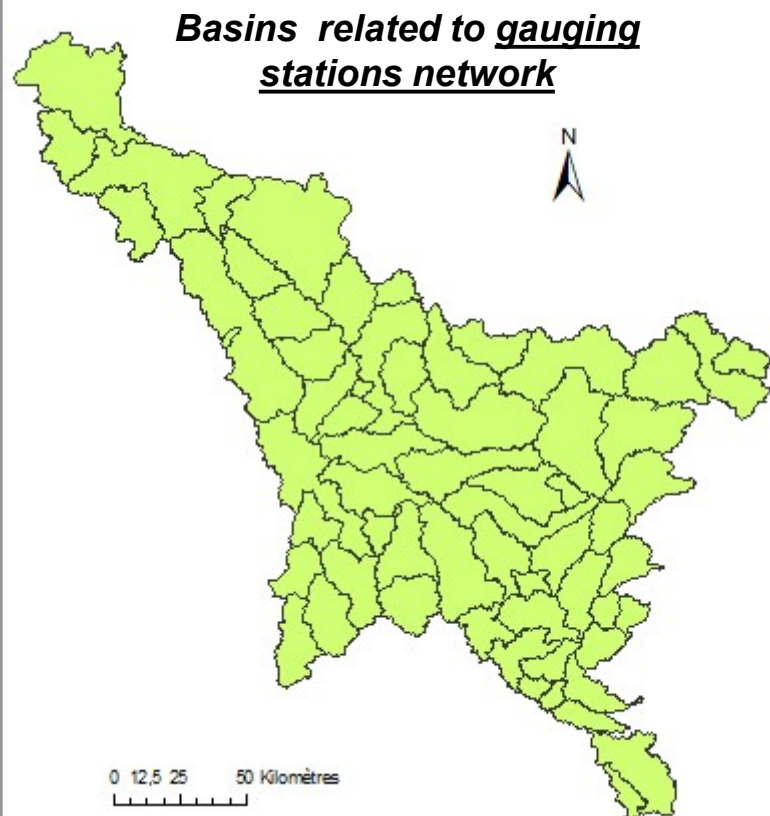
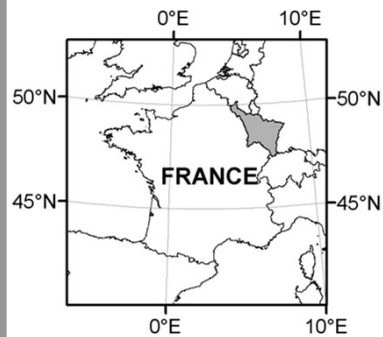


(c) MMAM frequency 10%



IV. Development of a semi-distributed model

http://www.lorraine.ecologie.gouv.fr/cataloguedebits/catalogue_debits.htm



Data base of low flow characteristics discharges:

- MMAM frequency 50%
- MMAM frequency 20%
- MMAM frequency 10%

Perspectives

- The current target is to develop a semi-distributed modeling based on the same methodology.
- The database of characteristics low flow discharges will be used to improve the semi-distributed modeling and to evaluate the errors of the model.
- Statistical methods will also be applied to compare the efficiency of each approach and to reduce the uncertainty of the estimations.



Thanks for your attention