Surface flow modelling on karst watersheds

– Case of the *Coulazou River* watershed within the Aumelas-Thau karst system, South of France –

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Scientific context

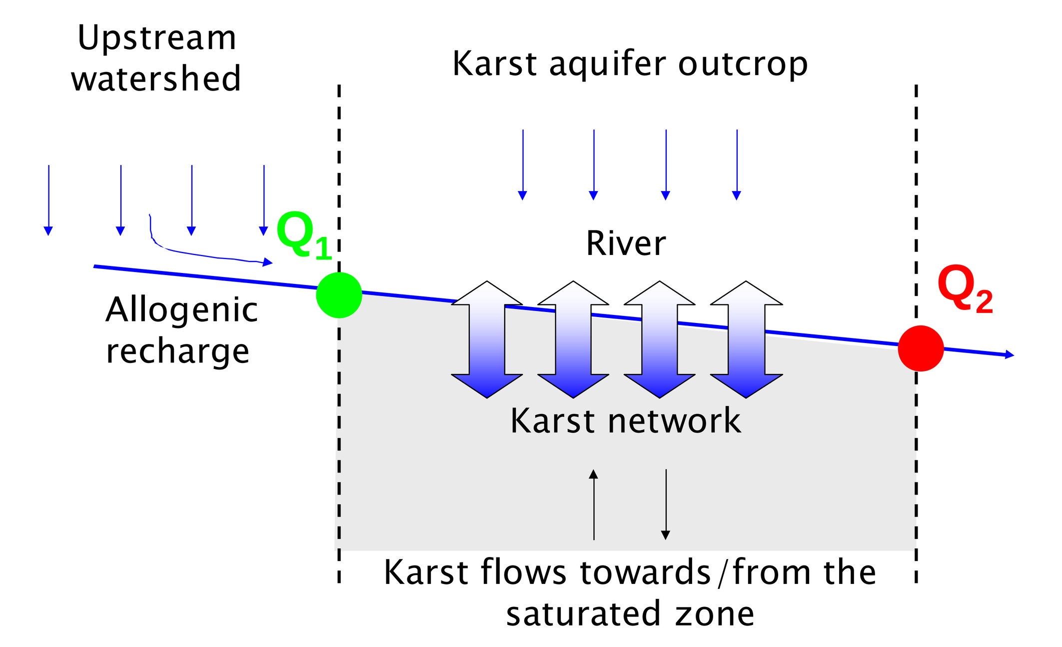

Fig. 1 : Schematic representation of a binary karst system

On karst watersheds, numerous karst features like swallow holes or temporary springs facilitate the exchange of water between the surface, the vadose zone and the saturated zone of the aquifer. Binary karst systems, i.e. karst systems partially fed by allogenic recharge (Fig. 1) are well appropriate to study the karst/river interactions since cave and karst network genesis is enhanced and surface flows which reach the karst aquifer are easily measurable. Such systems are furthermore representative of many rivers, especially near Montpellier (Cèze, Hérault, Vidourle etc.) where disastrous floods occur.

This poster deals with the modelling of the surface flood genesis and propagation in a river using a 5min semi-distributed conceptual model. Calibration results are interpreted according to hydrodynamic analyses.

Case study

The study area is located 20km West from Montpellier (Fig. 2).

Upstream watershed : 21km²

Karst aquifer outcrop : 34km²

Non karst watershed : 6km²

Total watershed : 61km²

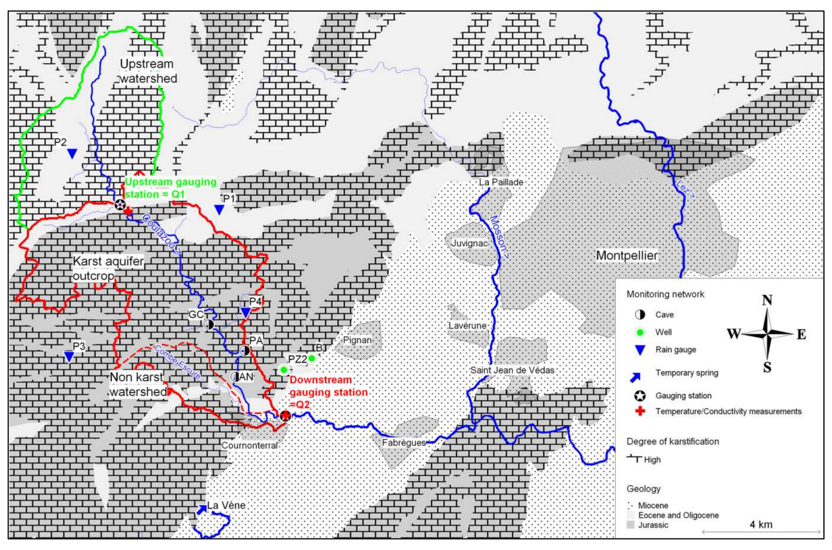

Fig. 2 : Study area

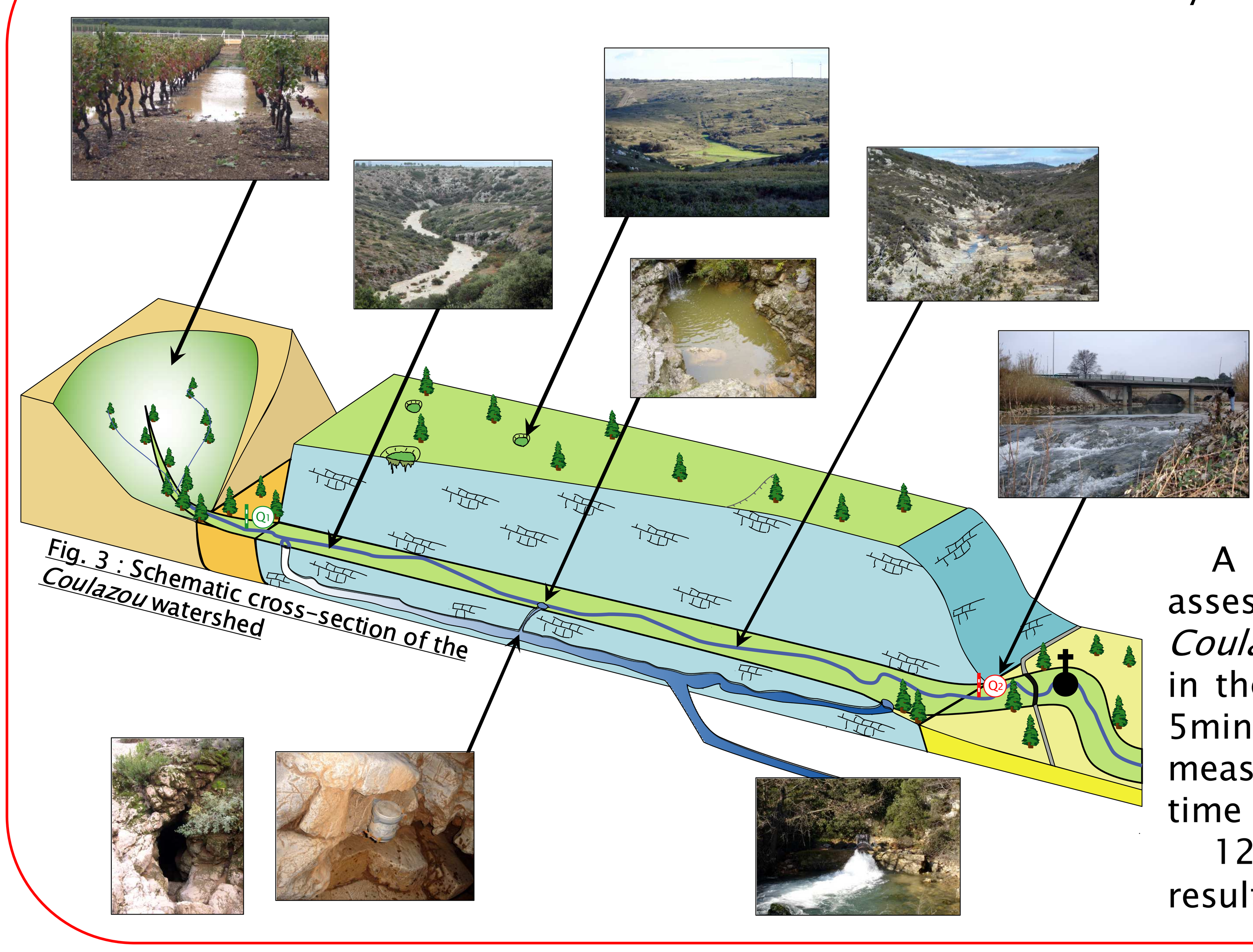

Fig. 3 : Schematic cross-section of the *Coulazou* watershed

Rapid and intense floods occur in the upstream watershed of the *Coulazou* River. Then, the river reaches the karst aquifer where caves act as swallow holes or springs (Fig. 3).

A monitoring network has been settled for the karst/river interactions assessment (Fig. 2), including (i) 4 rain gauges distributed over the 61km² *Coulazou* watershed at a 5min time step, (ii) surface flows measurements in the river upstream (Q_1) and downstream (Q_2) of the karst aquifer at a 5min time step, (iii) water-level, temperature and electrical conductivity measurements in caves in the riverbed and wells near the river at a 10min time step.

12 flood events have been used to calibrate the model and to compare results with fields measurements.

Model structure using HEC-HMS

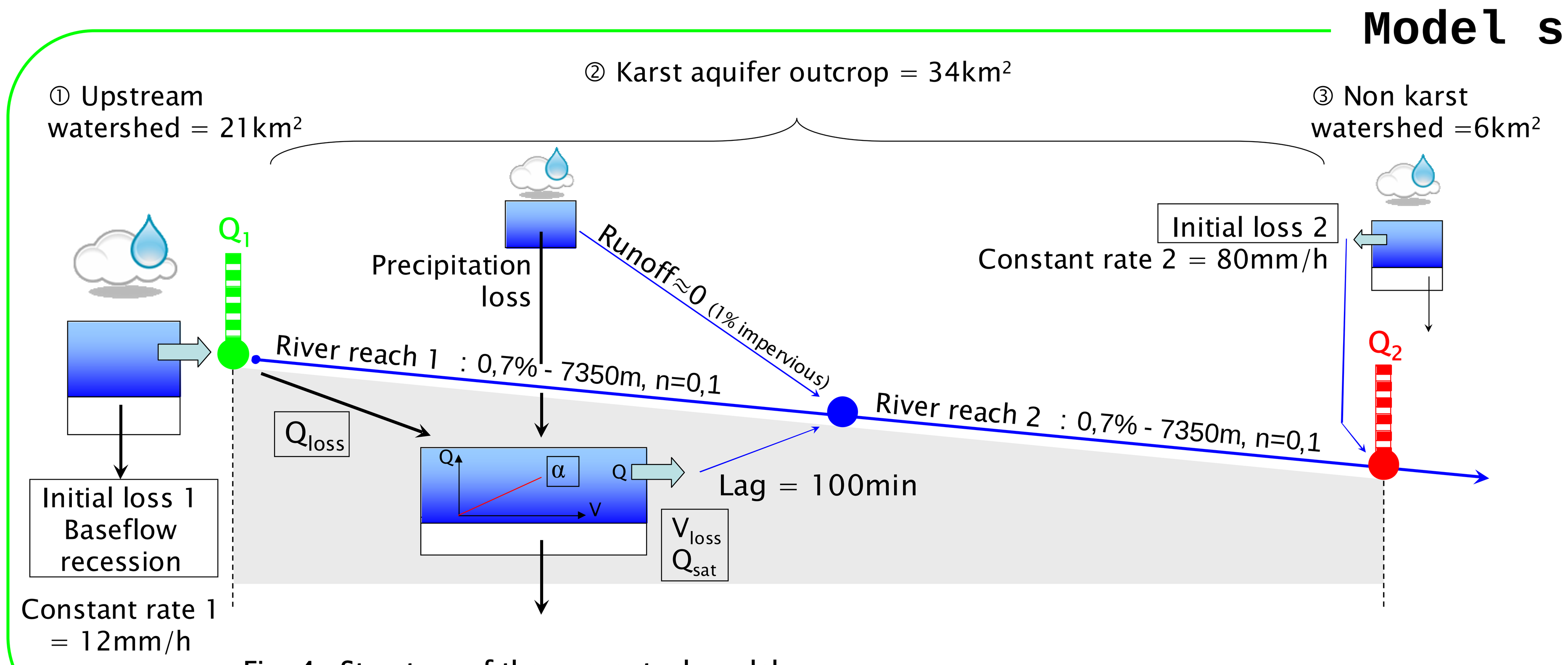

Fig. 4 : Structure of the conceptual model

The kinematic wave routing approximation is used for the 3 subbasins and the 2 river reaches. Rainfall is estimated by the Thiessen polygon method. Baseflow is computed for Q_1 by the exponential recession method. On the karst area, Q_{loss} accounts for the swallow capacity of caves in the riverbed while Q_{sat} represents the saturation of the drainage network. Captured surface waters are routed to a reservoir which is also fed by rapid infiltration through the karst. A linear relationship between the volume in the reservoir and the karst discharge in the river is assumed (α). Finally, a constant lag for the groundwater transfer is used.

The 7 (2 for Q_1 and 5 for Q_2) framed parameters are fitted for each flood at a 5min time step.

Results and discussion

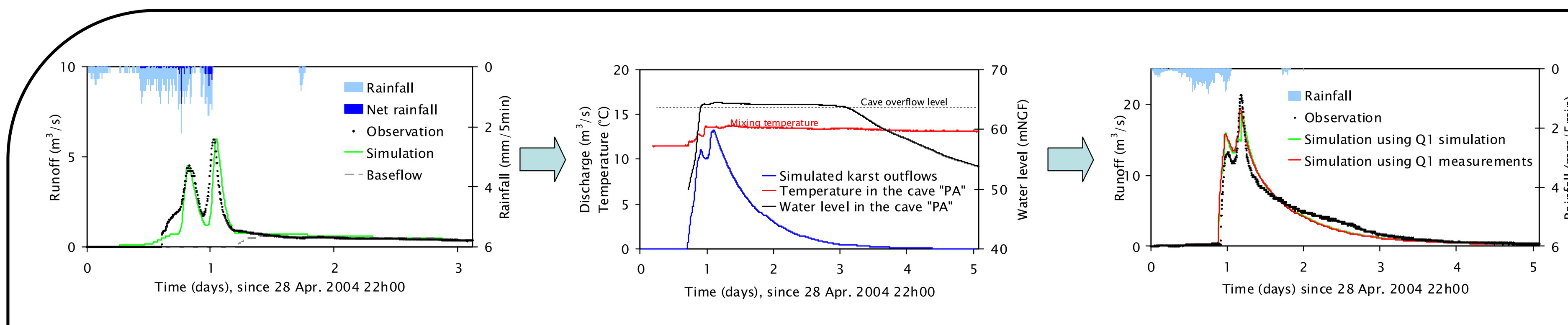

Fig. 5 : Case of a gaining stream : Flood 1

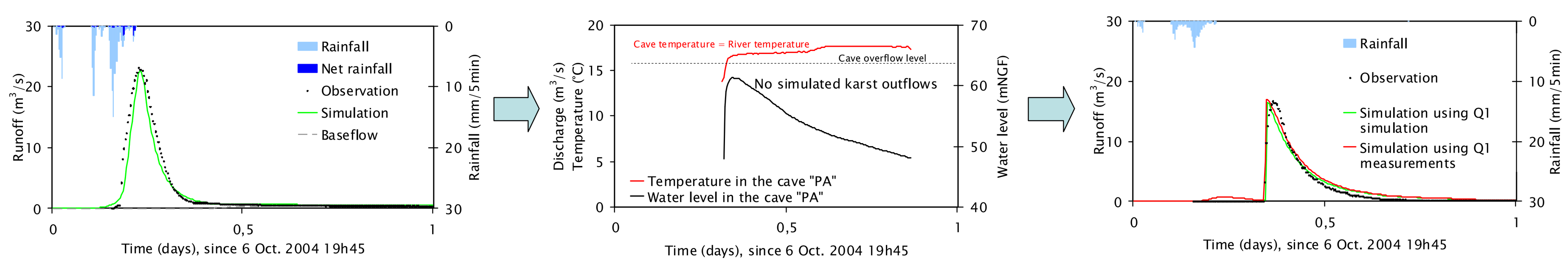

Fig. 6 : Case of a loosing stream : Flood 2

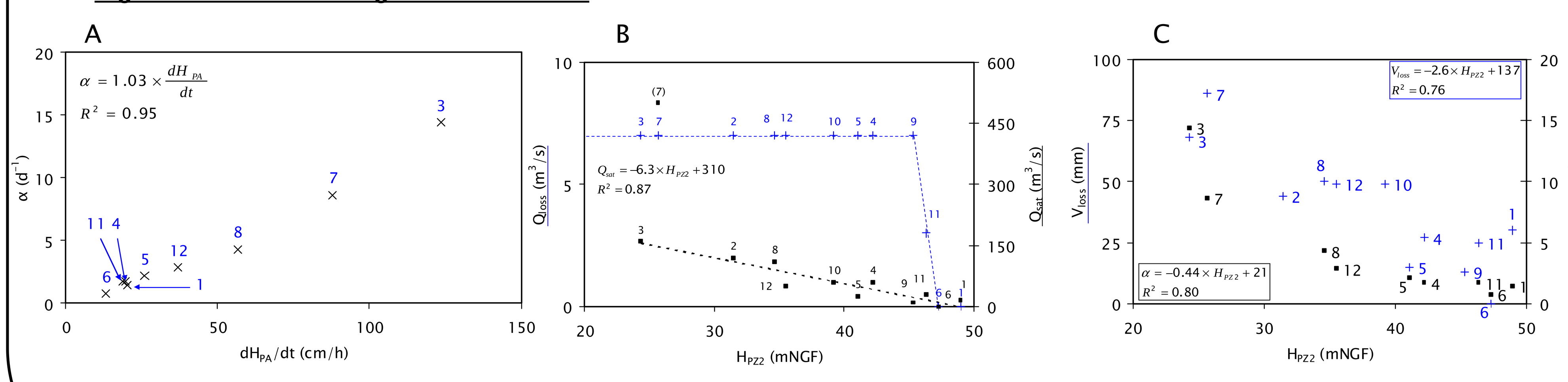

Fig. 7 : Calibration results versus fields measurements

The structure of the conceptual model is suitable to reproduce various hydrodynamic interactions : gaining stream (Fig. 5), loosing stream (Fig. 6), alternatively gaining and loosing stream, connected/perched river, perched epikarst aquifer or karst aquifer overflows.

Simulated karst outflows are correlated to cave measurements (Fig. 5 and 6), and α is related to the water level decrease in cave (Fig. 7A), which verifies the linear reservoir assumption.

Fitted parameters may also be related to initial water level in well P_{Z2} (Fig. 7): Q_{loss} shows a simple relationship, which means that negligible infiltration occurs in high water condition. It is noticeable that the break point around 48mNGF corresponds to the level of the upper karst network development. Fig. 7C shows a quite good relationship between α and the initial water level in well P_{Z2}, which verifies that the higher the water fluctuation in the vadose zone is and the higher the head losses are and thus the lower α is.

All these relationship have now to be used for a validation process which could lead to an original flood warning model using rainfall and water level measurements in well as input.