How to predict the sedimentological impacts of reservoir operations?

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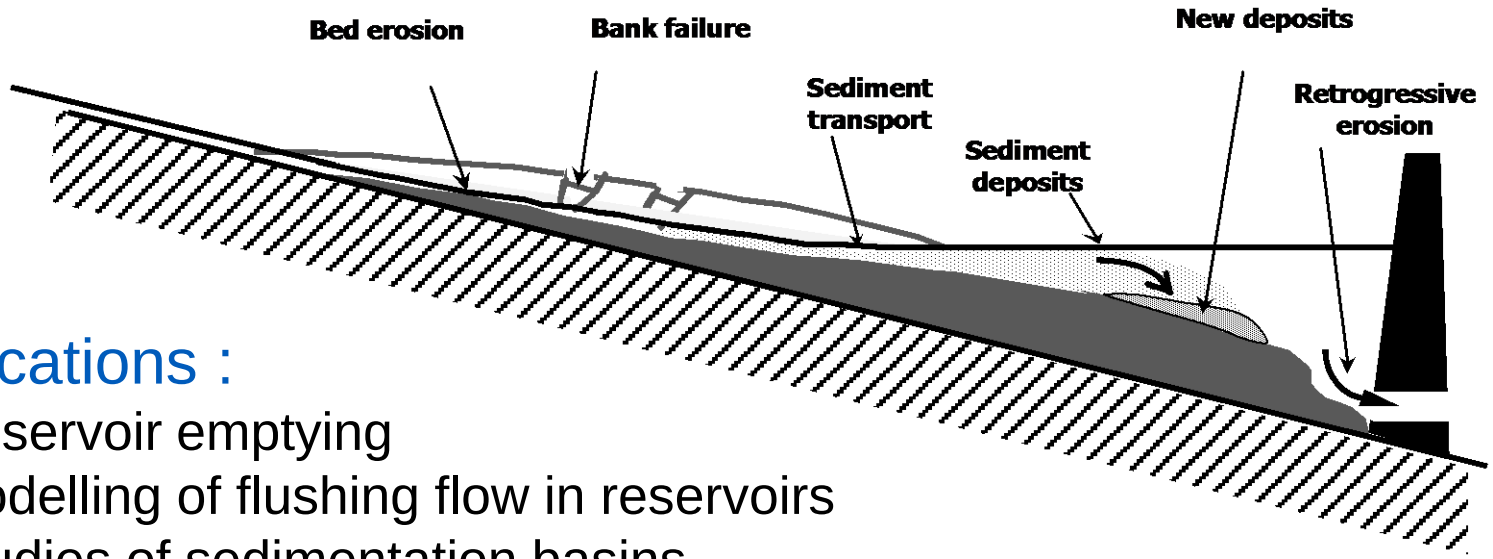
- ➔ **Presentation of the numerical code Courlis**
- ➔ **The emptying of Tolla Reservoir**
- ➔ **The flushing of St Egrève reservoir during floods**
- ➔ **Conclusions**

Presentation of the numerical code Courlis

One-dimensional numerical model that can simulate cohesive sediment transport in open channels under unsteady flow conditions

- Sediment concentrations throughout a waterway
- Changes in riverbed bathymetry caused by sediment transport



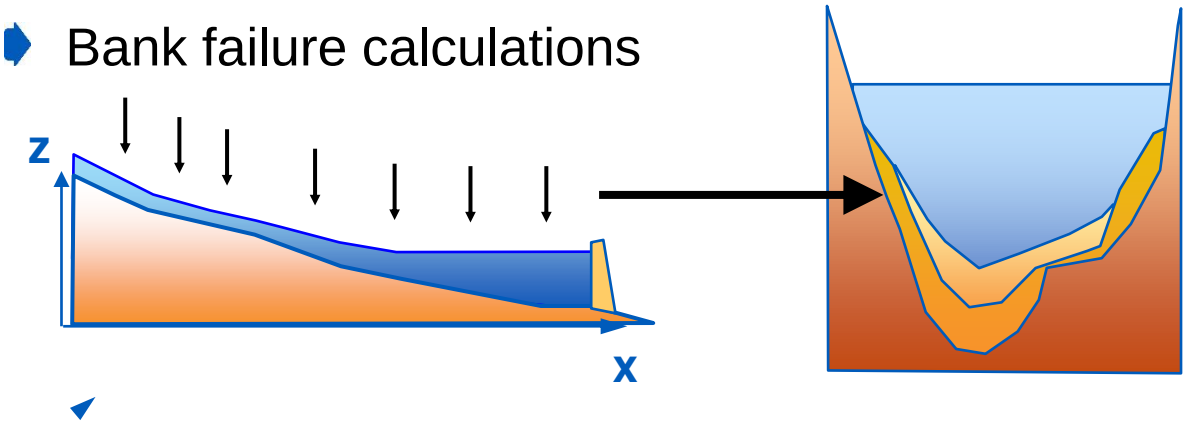
Applications :

- Reservoir emptying
- Modelling of flushing flow in reservoirs
- Studies of sedimentation basins

Presentation of the numerical code Courlis

Calculation principles:

- 1D modeling of hydraulics and sediment transport
- 2 separate calculation modules : 1 for hydraulics (MASCARET), 1 for sediment transport
- Sub and super critical regimes, permanent and transient states
- 2D calculation of erosion and deposition in cross-sections
- Krone & Partheniades Formula for deposition and erosion of cohesive sediment; For sand, the transport capacity is calculated with the Engelund Hansen formula
- Description of several layers of sediments
- Bank failure calculations



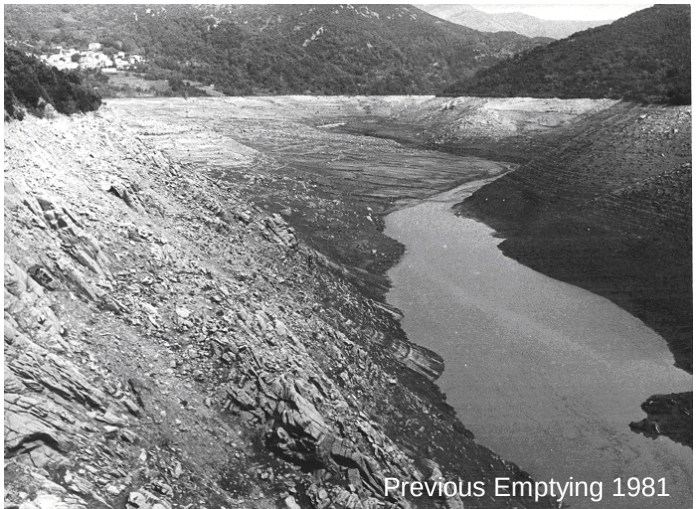
The emptying of Tolla Reservoir

Tolla Reservoir (South Corsica) :

- emptying in order to perform works on the dam
- downstream water intake for drinking water of Ajaccio city (53 000 inhabitants) => mitigate water quality degradation downstream during the operation
- not so many option : dilution using tributaries, settling tank, time during the year, speed of lowering and minimal elevation

Use of numerical modeling

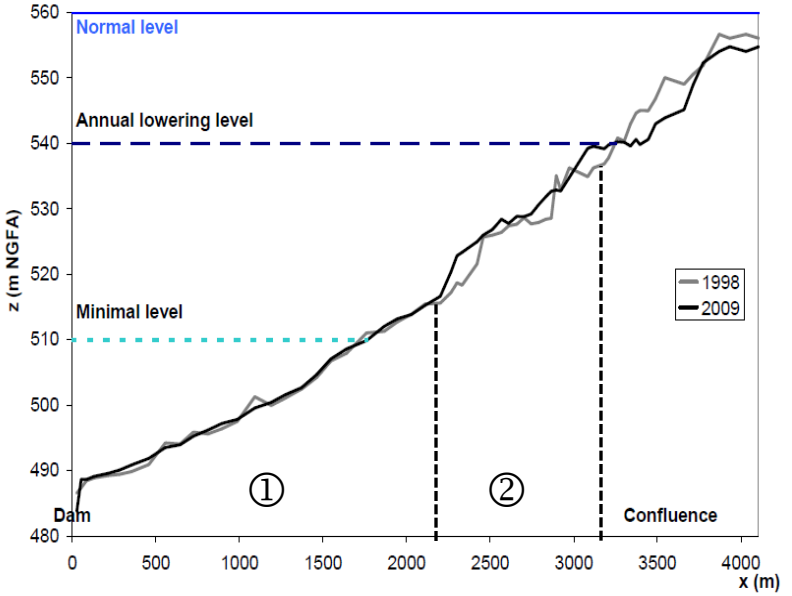
- to estimate the quantities of eroded sediments
- to test different scenarii of emptying


Previous Emptying 1981

The emptying of Tolla Reservoir

Data available :

- two bathymetries : 1998 and 2009
- sediments samples
- No calibration data

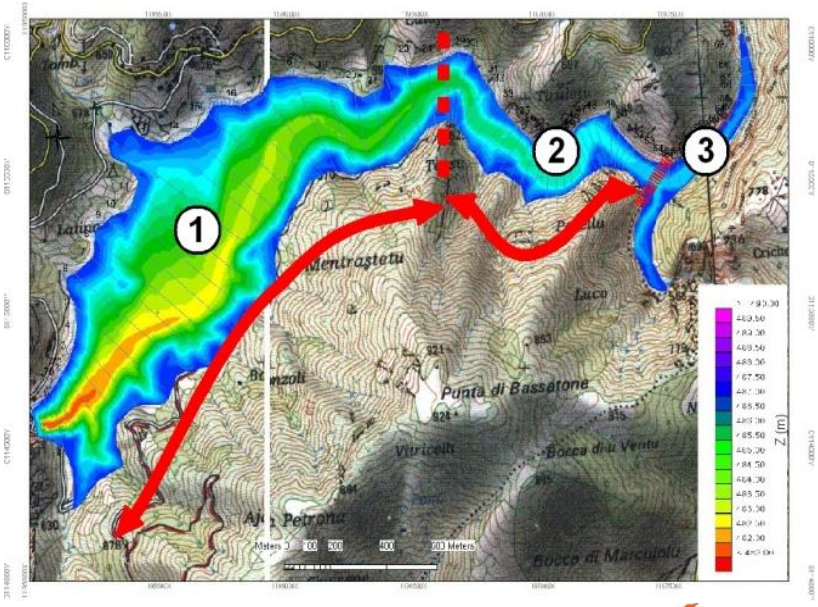


Schematic description for modeling

- ①Downstream area : silt
- ②Middle area : sand + thin layer of silt
- ③Upstream area : not modeled

	C (g/l)	sand (%)	Silt parameters τ_{ce} (Pa)	M ($kgs^{-1}m^{-2}$)	w_s (m/s)	τ_{cd} (Pa)
1	280	0	0.1 – 1	0.01 – 0.02	$2.10^{-3} - 10^{-2}$	0.01 – 0.1
2	370	19	0.5 – 2	0.01 – 0.02	$2.10^{-3} - 10^{-2}$	0.01 – 0.1

	C (g/l)	Sand parameters sand (%)	d_{50} (μm)	w_s (m/s)	K_p ($m^{1/3}s^{-1}$)
sand	1400	90	90	7.10^{-3}	75 – 95



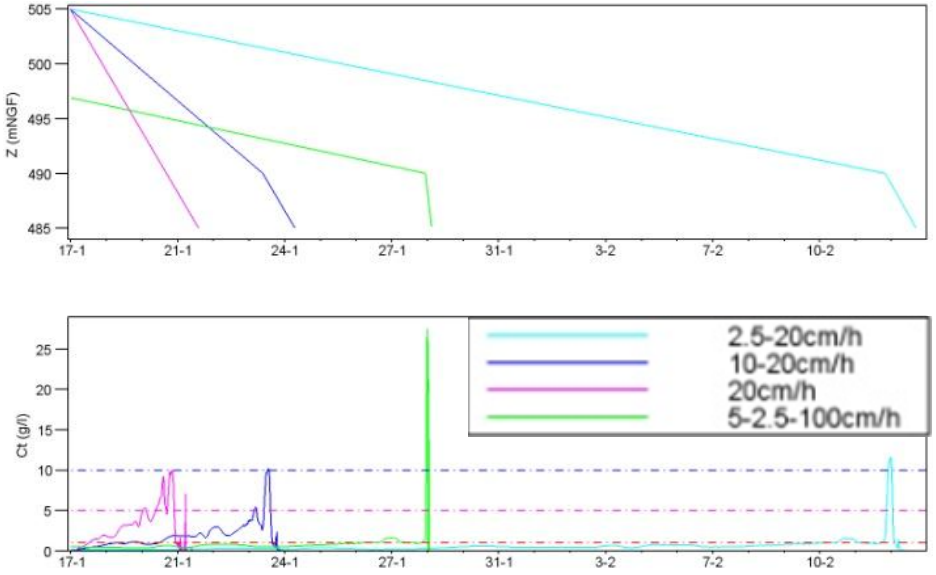
Parametric analysis

- Identify the set of realistic parameters that gives max. masse and concentration

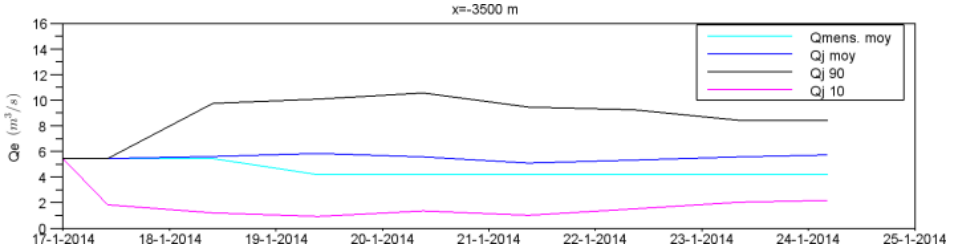
The emptying of Tolla Reservoir

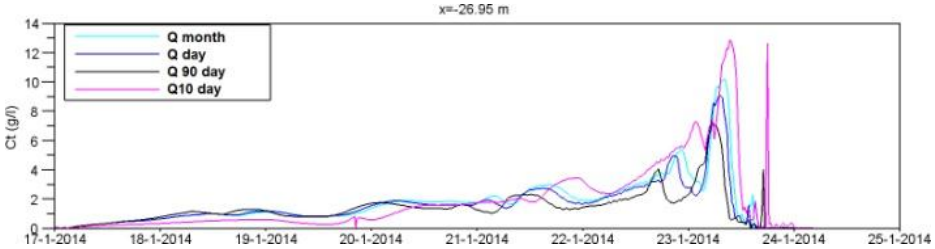
emptying scenario

Level variations and output concentrations for different lowering speeds



Emptying calculations (10cm/h) for different upstream discharges.

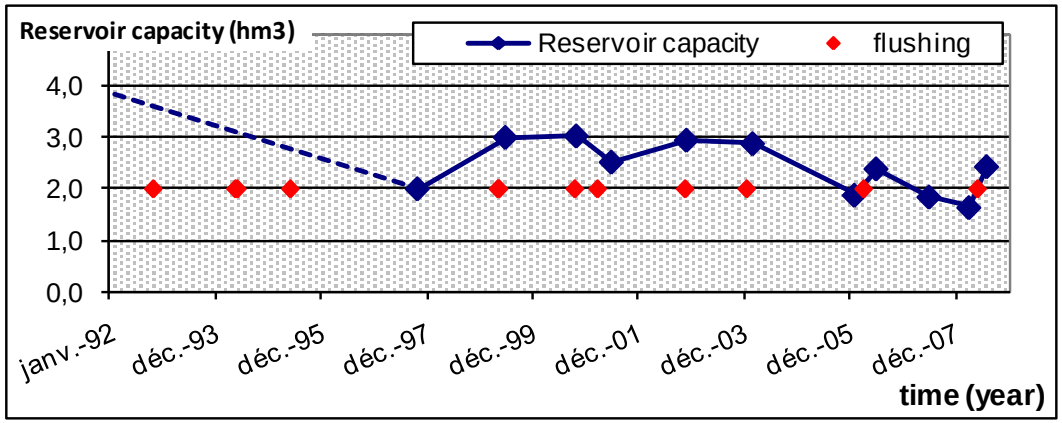




The flushing of St Egrève reservoir

(St-Egrève Reservoir French Alps) :

- For safety reasons, a freeboard of 1m with respect to the crests of the reservoir embankment must be guaranteed for a flood of 3000 m3/s
- The Isère River's waters are highly loaded with fine sediment
- The St Egrève reservoir has
  - a bed on the left bank that continues to silt up
  - a channel with a variable section. It is deepened during floods



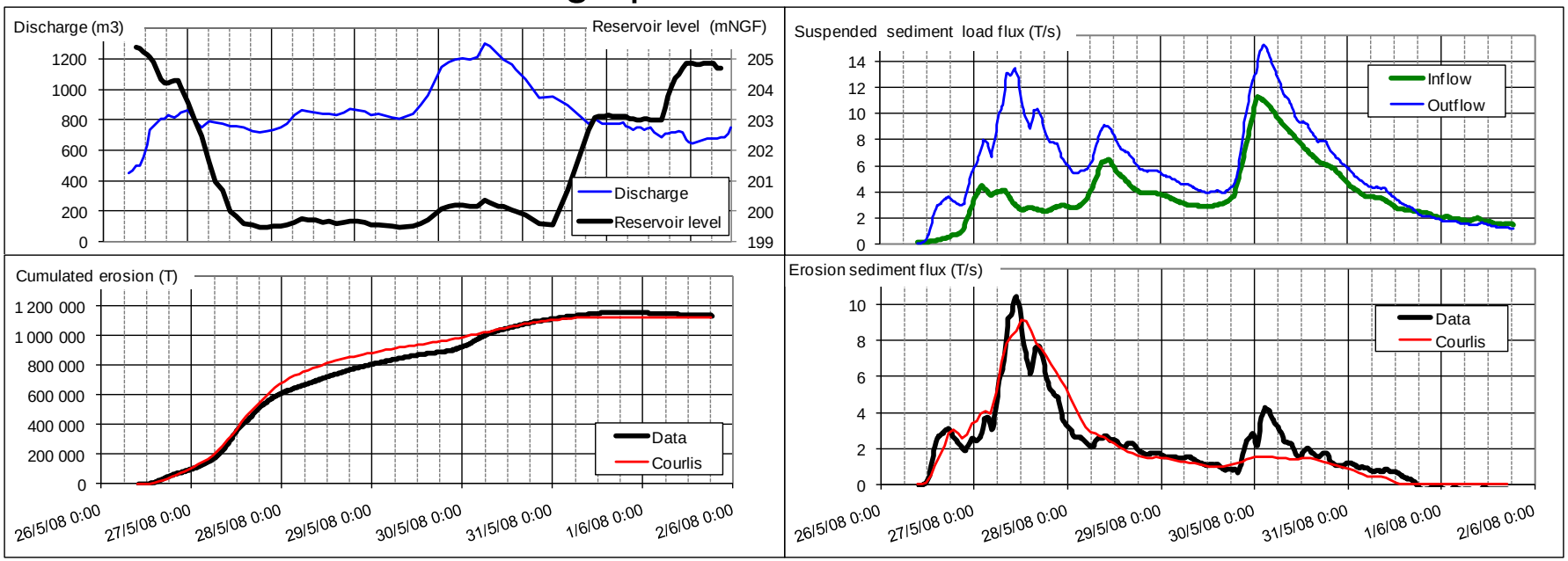
Use of numerical modelling

- to determine the bottom evolution kinetics during floods (evaluate the bottom level at the flood peak)

The flushing of St Egrève reservoir

Calibration and validation

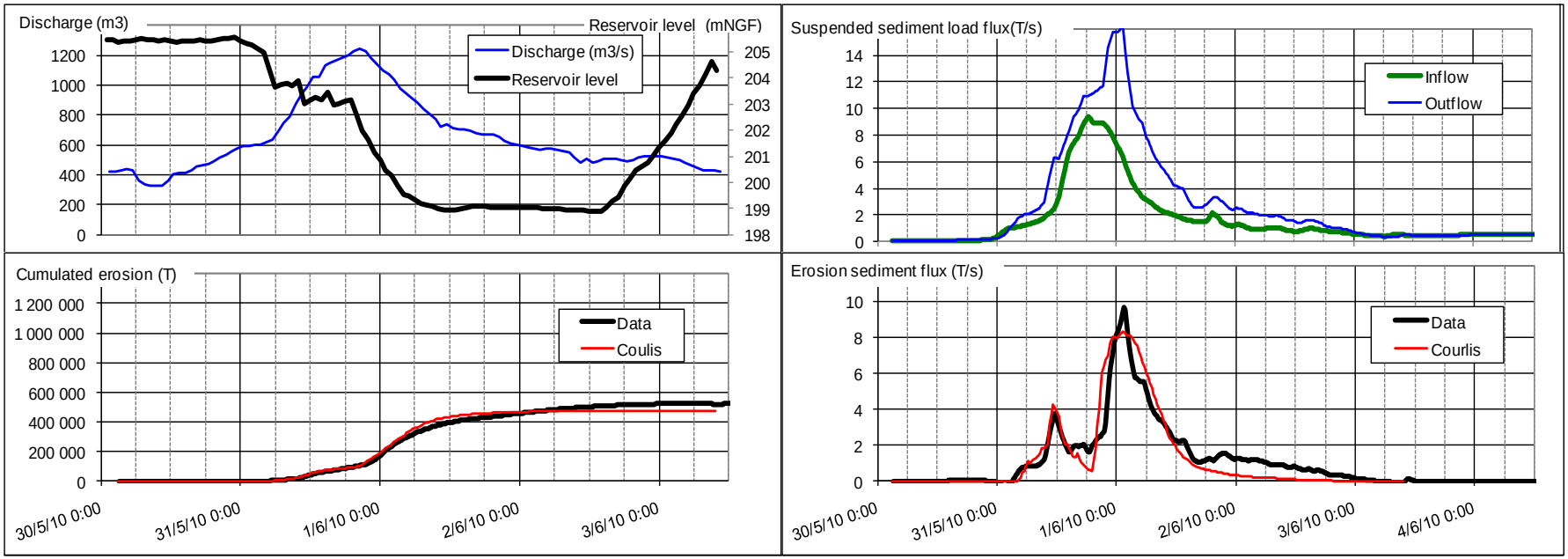
- A lot of measurements for calibration :
  - Discharges, suspended sediment concentrations, water levels
  - several bathymetries before / after floods,
  - sediment samples …
- Calibration : 2008 flushing operation



The flushing of St Egrève reservoir

Calibration and validation

- A lot of measurements for calibration :
  - Discharges, suspended sediment concentrations, water levels
  - several bathymetries before / after floods,
  - sediment samples …
- Validation : 2010 flushing operation

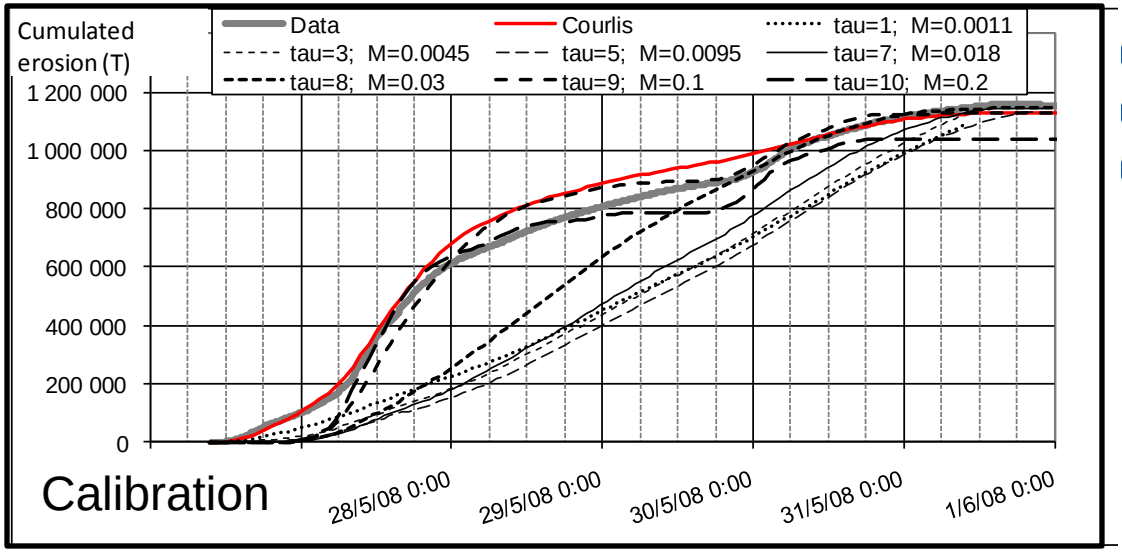


Study of a flood event with a peak discharge of 3000 m3/s

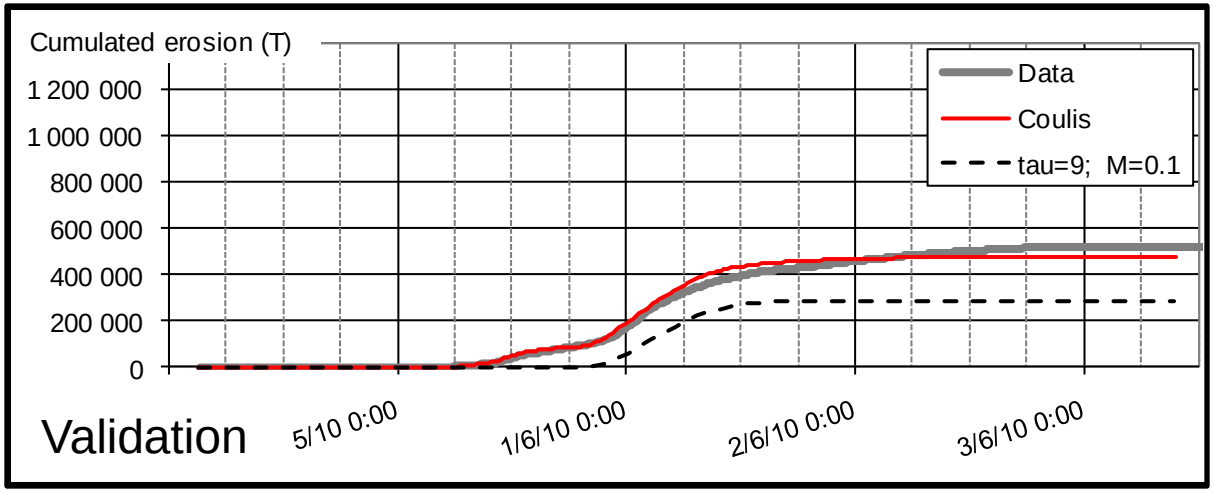
The flushing of St Egrève reservoir

Calibration and validation

- Example : attempt to calibrate/validate with a single layer of sediment



- **Red : calibrate modele with 3 layers**
- **Black : tests with one layer**
- **Grey : Data**



The use of a single critical shear stress of 9 Pa, acceptable for the 2008 flood, gives an excessively low value for the 2010 flood.

Conclusions

- Courlis is successfully used to model reservoir emptying and flushing :
  - Confirms the necessity of a significant upstream discharge, and the importance of the lowering speed at the end of the emptying
  - Good agreement between model and data in the case of flushing

- A special attention must be given to the choice of physical parameters : sediments measurements + calibration data

- Code still under development at EDF/R&D part of the system TELEMAC MASCARET http://www.opentelemac.org/

thanks for your attention