Full implementation of a distributed hydrological model based on check dam trapped sediment volumes

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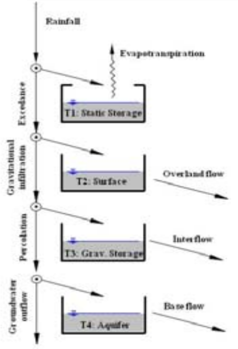
1 - INTRODUCTION

Aim of the study: calibrating a sediment model in an ungauged catchment (no water and sediment records).

Source of proxy data: sediment volumes trapped behind check dams.

Methodology:
1 – model conceptualization is **simplified** based on field observations;
2 – the model is calibrated based on the total **volume** trapped behind a **check dam**;
3 – a **spatial validation** is carried out by assessing model results at other 7 check dams;
4 – a **temporal validation** is carried out by comparing the model results with a stratigraphical description of a deposit.
5 – the model is further validated by comparing its results with a series of observed discharges

2 – TETIS MODEL



Hydrological sub-model (Francés et al., 2007):

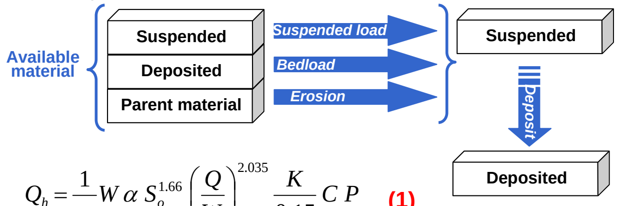
Distributed conceptual model with tank structure

Physically-based parameters

Distinction between slope, gully and channel cells

Propagation through the geomorphologic kinematic wave

Sediment sub-model (Bussi et al., 2013, 2014)**:** slope erosion processes (modified Kilinc – Richardson equation - 1) and gully and channel erosion processes (Engelund – Hansen equation - 2)



Available material

Suspended

Deposited

Parent material

Suspended load

Bedload

Erosion

Suspended

Deposit

Deposited

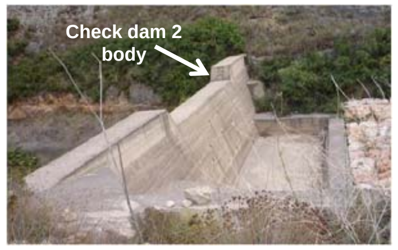
$$Q_h = \frac{1}{\gamma_s} W \alpha S_o^{1.66} \left(\frac{Q}{W}\right)^{2.035} \frac{K}{0.15} C P \qquad (1)$$

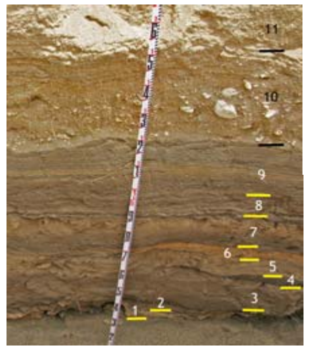
$$C_{w,i} = \beta \left(\frac{G}{G-1}\right) \frac{V S_f}{\sqrt{(G-1) g d_i}} \sqrt{\frac{R_h S_f}{(G-1) d_i}} \qquad (2)$$

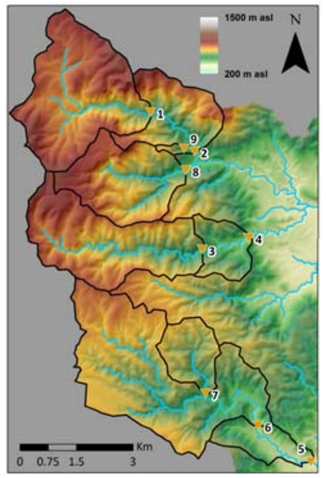
3 – CASE STUDY

Study area: Rambla del Poyo catchment, 30 km west of Valencia (Spain), 184 km^2, 1 raingauge, 1 streamgauge (Δt = daily), 8 check dams

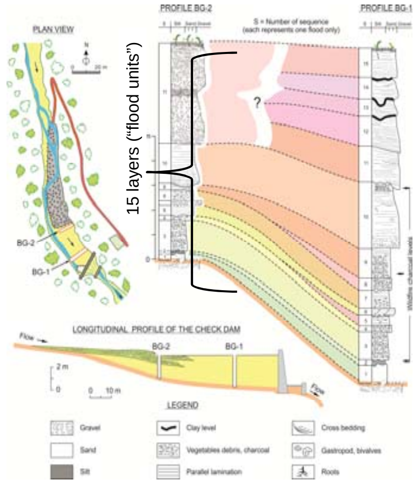
Dam	Sub-catchment	Maximum storage m^3	Sedimentation volume m^3	Sedimentation rate %	Dry bulk density $tons/m^3$	Drainage area km^2
1	B. Grande	1,200	1,100	91%	1.245	9.1
2	B. Grande	3,000	1,400	48%	1.195	12.9
3	B. de Ballesteros	1,800	600	36%	1.245	8.0
4	B. de Ballesteros	4,400	700	16%	1.197	10.1
5	B. del Gallo	10,800	190	2%	1.206	16.6
6	B. del Gallo	23,700	290	1%	1.190	15.0
7	B. del Gallo	1,600	120	7%	1.206	2.3
8	B. Grande	6,000	3,100	52%	1.251	5.4







Stratigraphical profile of check dam 2 deposit

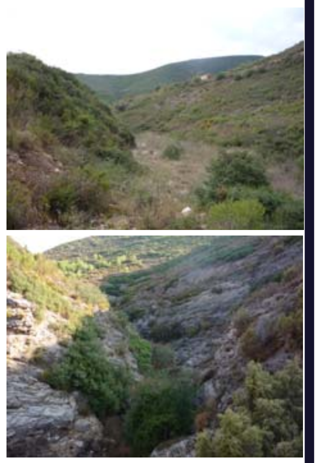


Stratigraphical description of a depositional sequence in a 3.5 m trench made across the **check dam 2 sediment deposit**, identifying all flood units; the separation between flood units is indicated by a break in deposition (Bussi et al., 2013).

15 flood units (layers) were identified. Each one corresponds to a flood event occurred between the dam construction (early '90) and nowadays.

4 - RESULTS

MODEL SIMPLIFICATION AND CALIBRATION



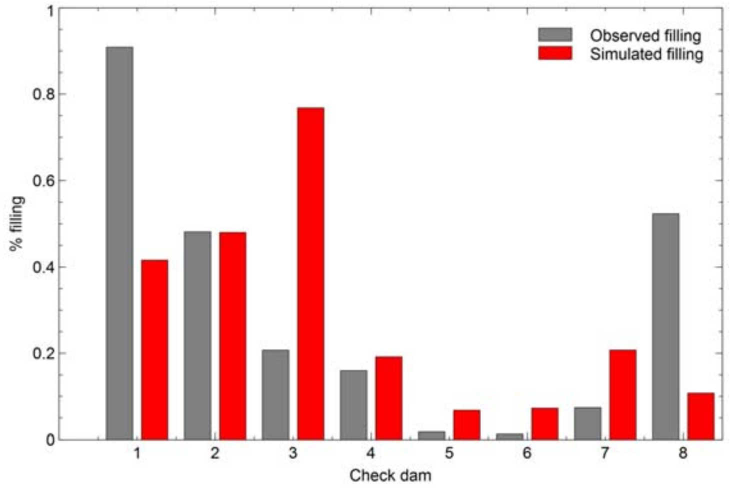
Some hypothesis (confirmed by **field observations**):
- Hortonian flow
- Very little interflow
- No base flow

Parameters to calibrate (**5 most influential parameters**):
- Maximum soil static storage
- Infiltration capacity at saturation
- Interflow velocity
- Channel flow velocity
- Maximum transport capacity for hillslopes

Calibration: reproduction of the total sediment volume accumulated behind check dam 2

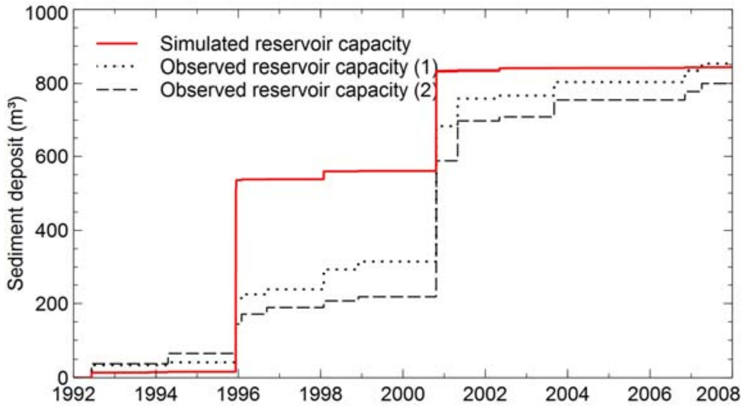
SEDIMENT SUB-MODEL SPATIAL VALIDATION

Observed vs Simulated filling of the remaining 7 check dams.



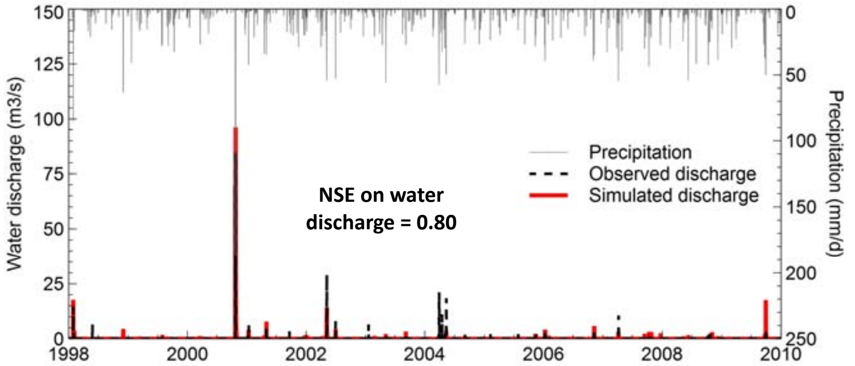
SEDIMENT SUB-MODEL TEMPORAL VALIDATION

Reservoir capacity evolution (1990-2012) of **check dam** 2 (the observed evolution was reconstructed through the stratigraphical analysis).



HYDROLOGICAL SUB-MODEL SPATIO-TEMPORAL VALIDATION

Daily water discharge at the Rambla del Poyo stream gauge (**catchment outlet**, 184 km^2).



5 - CONCLUSIONS

1 - Sediment proxy data help constrain water cycle model calibration (**transfer of information** from sediment cycle to water cycle);
2 - **Multidisciplinarity**: coupling hydrological modelling and palaeohydrological techniques for improving catchment knowledge;
3 - **Small data requirement**: rainfall and temperature, soil data, land use and partially filled check dams;
4 - **Generalization**: this technique can be used in almost all Mediterranean small and medium size catchments.

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