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Outstanding Student Poster Contest

Reconstruction of the sediment flow regime in a semi-arid Mediterranean catchment using check dam sediment information

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1 - INTRODUCTION

The problem: lack of historical sediment data for model calibration and validation.

Possible solution: check dam accumulated deposits are proxy data (a few millions all over the world, very valuable source of sediment data).

Objective: use this information for hydrological and sediment regime and for calibration and validation of sediment model.
Spatial validation: 8 check dam accumulated sediment volumes all over the studied catchment.
Temporal validation: stratigraphical description of a trench across one of the reservoirs.

Methodology:

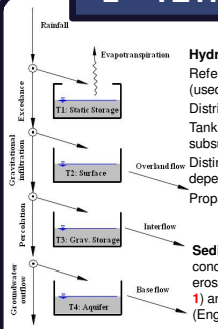
a – **estimation of solid volume trapped** in check dam reservoirs;

b – hydrological and **sediment modelling** with TETIS-SED model;

c - **stratigraphical description** of a depositional sequence in a 3.5 m trench across the deposit;

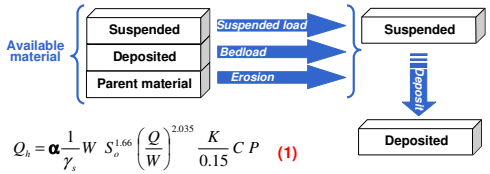
d – **flood dating** using model results and wildfire information related to charcoal content within the deposit.

2 – TETIS-SED



Hydrological sub-model
References: Francés et al., 2002, Francés et al., 2007 (used in over
Distributed conceptual model.
Tank structure: 4 tanks (static storage, surface, subsurface and aquifer).
Distinction between hillslope, gully and channel cells depending on the drainage area of each cell.
Propagation through the geomorphologic kinematic wave.

Sediment sub-model: based on CASC2D-SED conceptualization (Ogden and Heilig, 2001): slope erosion processes (modified Kilinc – Richardson, eq .- 1) and gully and channel erosion processes (Engelund – Hansen, eq. - 2)



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

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

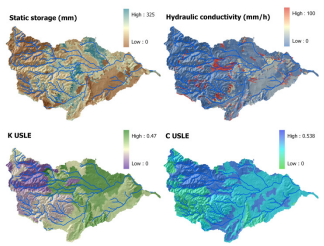
3 – CASE STUDY

Study area: Rambla del Poyo catchment, 30 km west of Valencia (Spain), 184 km², 1 raingauge, 1 streamgauge (Δt = 5 min)

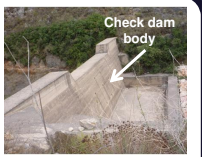
8 check dam (check dam 2 catchment in grey)

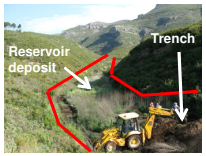
Dam	Sub-catchment	Maximum storage m^3	Sedimentation volume m^3	Sedimentation rate %	Dry bulk density $tons/m^3$	Drainage area km^2
1	B. Grande	1,200	1,100	91%	1.245	9.1
2	B. Grande	3,000	1,400	48%	1.195	12.9
3	B. de Ballesteros	1,800	600	36%	1.245	8.0
4	B. de Ballesteros	4,400	700	16%	1.197	10.1
5	B. 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

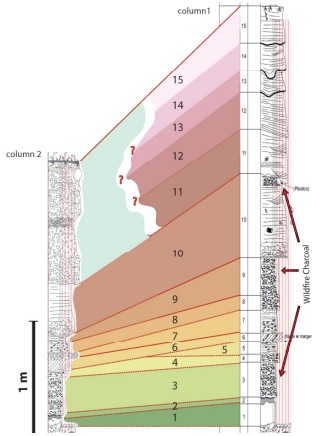
Some relevant model parameters:



Stratigraphical description of a depositional sequence in a 3.5 m trench made across the **reservoir 2 sediment deposit**, identifying all flood units; the separation between flood units is indicated by a break in deposition.







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

Not all events until the present are included; for the last ones, the stream velocity and energy conditions for generating slack-water deposits were not fulfilled due to the reservoir filling.

4 - RESULTS

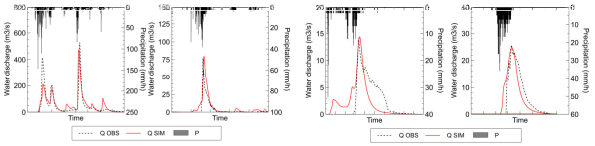
HYDROLOGICAL MODEL IMPLEMENTATION

Calibration at the Rambla del Poyo stream gauge (184 km²) with 5 minutes time resolution – October 2000 extreme flood (**streamgauge data**).

Temporal validation at the Rambla del Poyo stream gauge (184 km²) using 38 rainfall events between 1990 and 2009 (**streamgauge data**).

Initial soil moisture state estimation by continuous simulation of the antecedent time series (from the previous event to the actual rainfall event) at a daily time scale, in order to reduce computational time.

Some results:



Calibration: October '00 Validation: January 98 Validation: January'06 Validation: June '02

SEDIMENT MODEL IMPLEMENTATION

Dry bulk density estimated by Lane and Koeltzer (1943) formulae and **Trap Efficiency** estimated by coupling the Sediment Trap Efficiency for small Ponds (STEP) model (Verstraeten and Poesen, 2001) and TETIS-SED.

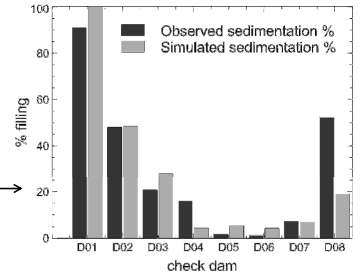
Parameters to be calibrated: transport capacity in hillslopes (α coefficient in eq. 1) and channels (β coefficient in eq. 2).

Calibration at the check dam 02 sub-catchment using the sediment volume accumulated in the reservoir

Spatial validation using the other 8 check dam total volume deposits.

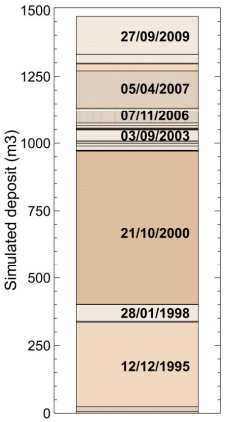
Results:

α coefficient = **350**
β Coefficient = **0.05**



HYDROLOGICAL AND SEDIMENT REGIME RECONSTRUCTION

Flood units volume estimation
by making the hypothesis that layers have a simple pyramidal shape (or wedge); every volume represents an observation of the sediments trapped in the reservoir corresponding to each flood event.



Simulation:

The sediment modelling provided a series of deposited sediment in the reservoir 2.

The 100% of the sediment volume corresponded to 38 rainfall events; 5 rainfall events account for the 80% of the total deposit.

Reconstruction:

- In summer 1994 a strong wildfire took place, and the flood unit 3 is the first one which contains charcoal: for this reason it is related to 12/12/1995 event.

-The 21/10/2000, the biggest event, is related to the sum of flood units 8, 9 and 10, since the rainfall event has 3 peaks (see hydrological calibration at left) and has probably generated 3 depositional layers.

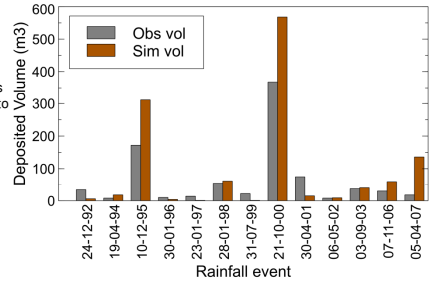
-The rest of the flood units are related to the remaining events, following the time sequence and discarding rainfall which produced very small deposits (<1 m³).

Temporal validation:
The reconstructed series was used to validate the model event by event (temporal validation).

There are 13 observed events (15 layers, 3 of which belong to the same flood event).

The volume error for the 4 biggest observed events ranges between **-80 and +80%**.

The results are satisfactory although the model tends to overestimate the greatest events.



5 - CONCLUSIONS

1 - Check dam deposits provided very useful **information for sediment model calibration and validation** in space and time.

2 - The stratigraphical description was also very valuable for model validation and for the **reconstruction** of the sediment regime.

3 - The **model results are satisfactory** and give a good estimation of sediment yield.

4 - The **ephemeral behavior** of the catchment is confirmed: intermittent discharge, the highest 13 flood events account for 97% of total sediment yield in 20 year.

5 -The model tends to **overestimate sediment yield for high magnitude rainfall events** (or maybe their observed volume is underestimated): further research is needed.

Acknowledgements

This study was funded by the **Spanish Ministry of Economy and Competitiveness** through the projects:
- CSD2009-00065 (SCARCE-CONSOLIDER: Assessing and Predicting Effects on Water Quantity and Quality in Iberian Rivers caused by Global Change)
- CGL2008-06474-C02-01/02 (FLOOD-MED: Flood Hazards in Mediterranean Rivers in the Context of Climate Variability and Environmental Change)

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