Instituto de Ingeniería del Agua y Medio Ambiente

UNIVERSIDAD POLITECNICA DE VALENCIA

Calibration of TETIS-SED model by using check dams sedimentation volumes with different temporal resolutions. Application to a Mediterranean medium size basin (Rambla del Poyo, Spain).

By:

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Introduction

- **The problem**
  - **Sediment modelling at the basin scale**
    - The aim of the work is to reproduce sediment cycle during the **last 20 years** in a Mediterranean catchment (Rambla del Poyo)
    - Lack of **data** for calibrating erosion and sediment yield models leads to incorrect and uncertain results
    - Solid volumes trapped in small mountain ponds (**check dams**) are an estimate of accumulated solid transport since construction date
    - Medium term simulation (20 years): **daily time-step or finer time-step**?

Introduction

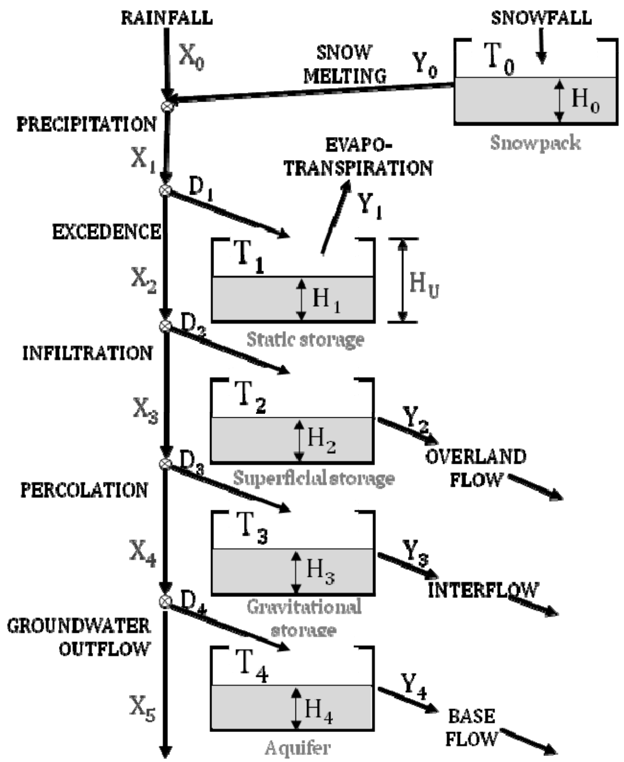
- **The study**

  - TETIS-SED model *(Bussi et al., J. Hydrol., submitted, Bussi et al., EGU11, Montoya et al., EGU09)* is applied to a Mediterranean catchment (Rambla del Poyo, Spain)

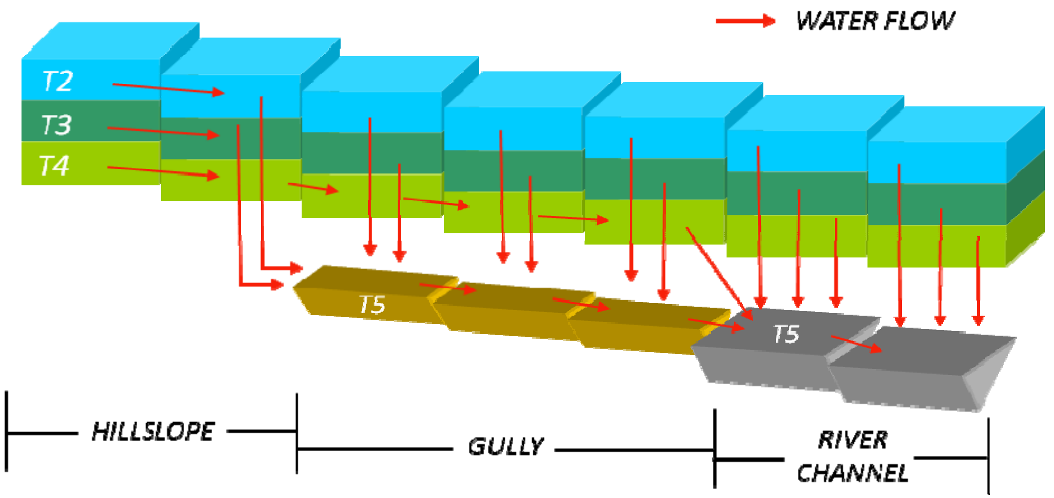
    - Model is calibrated with **solid volumes trapped** into check dams
    - **Dry Bulk Density** and **Trap Efficiency** are taken into account
    - Three **temporal resolutions** are used:
      - Δt = 5 minutes
      - Δt = 1 day
      - Variable Δt = 1 day during droughts, 5 minutes during flood events

The TETIS-SED model

Hydrological sub-model: TETIS (Francés et al., 2007, *J. Hydrol*)



- Distributed and conceptual model
- Split structured parameters
- Threshold areas:



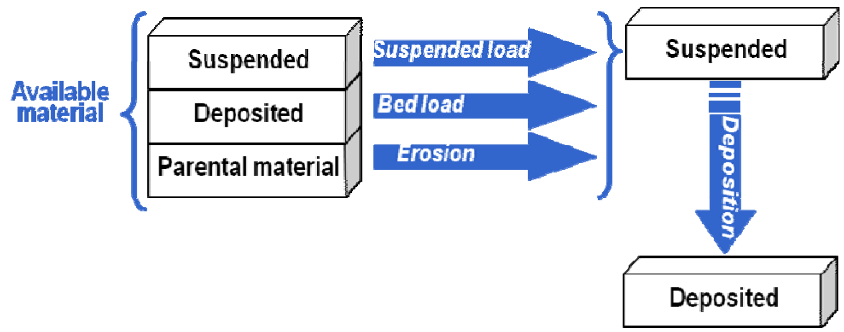
The TETIS-SED model

Sediment sub-model

- Integration of CASC2D-SED (Julien and Rojas, 2002) in TETIS
- Balance between water transport capacity and sediment availability
- Hillslope transport capacity: modified Kilinc – Richardson equation (1)
- Gully and channel erosion: Engelund – Hansen equation (2)

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

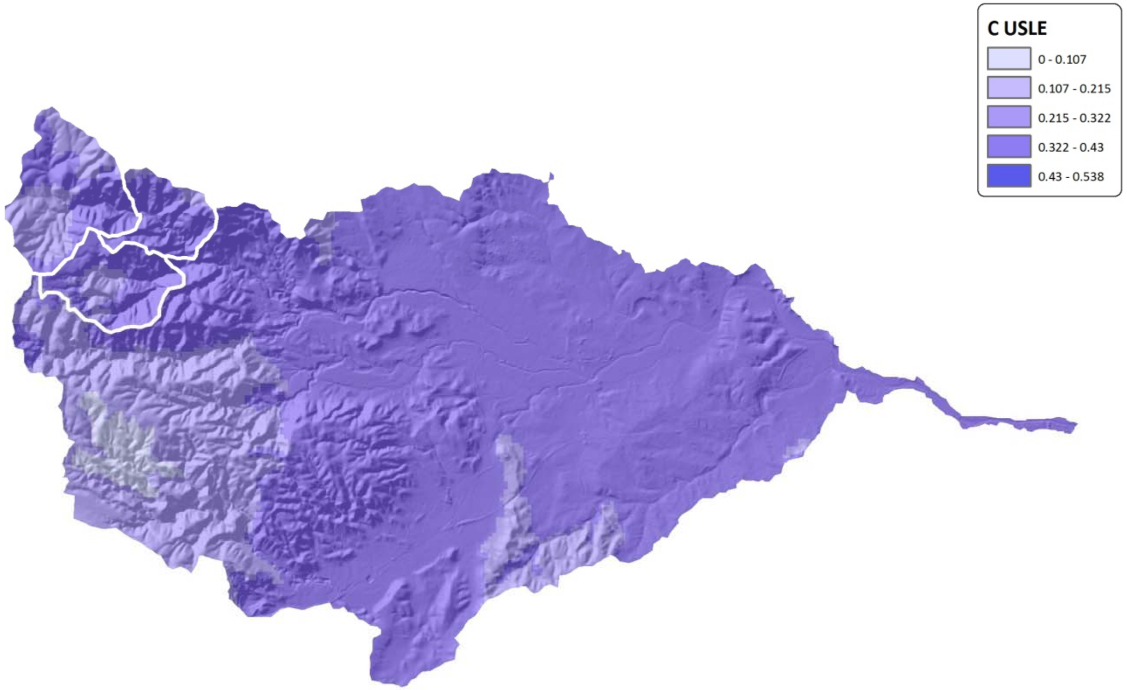
(2) $$C_{w,i} = \beta \left(\frac{G}{G-1}\right) \frac{V S_f}{\sqrt{(G-1) g d_i}} \sqrt{\frac{R_h S_f}{(G-1) d_i}}$$



The case-study

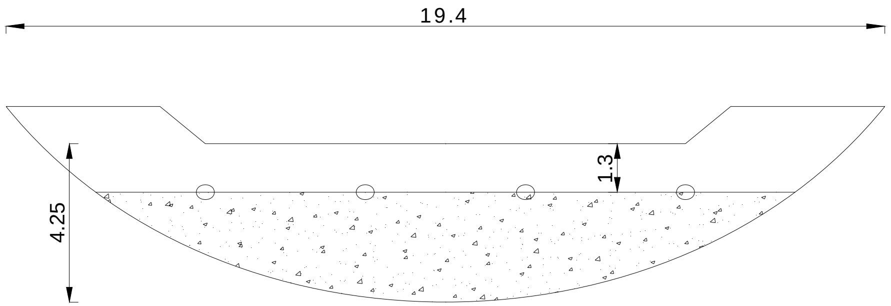
■ The Rambla del Poyo catchment

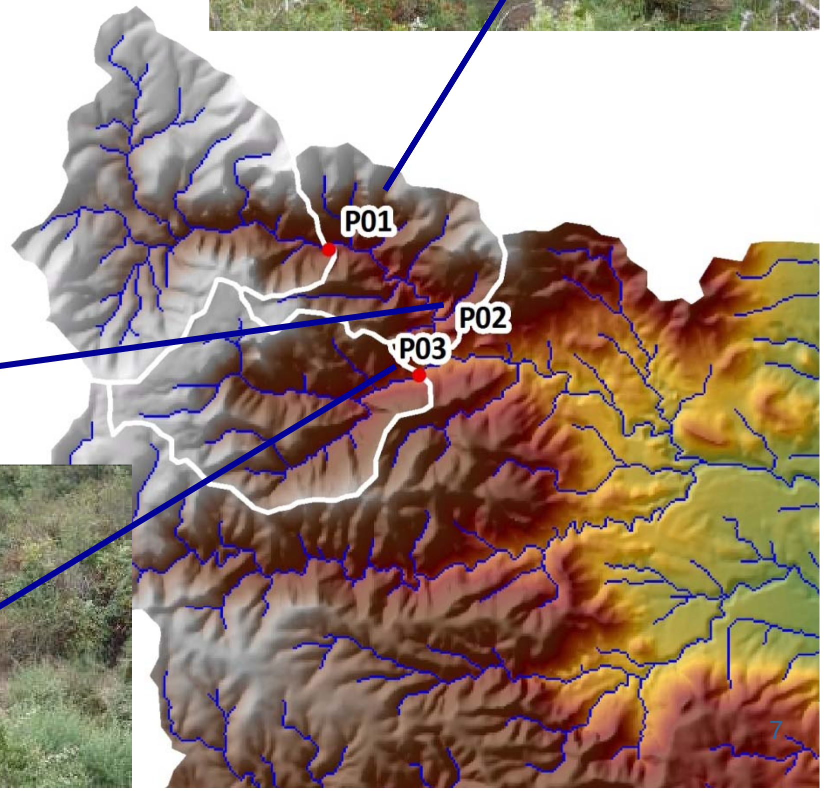
- Mediterranean catchment draining to Albufera Lagoon (Valencia, Spain)
- 185 km^2 to streamgauge
- 3 check dams built in '90s (9, 13 and 6 km^2)



The case-study

- **The Rambla del Poyo catchment**

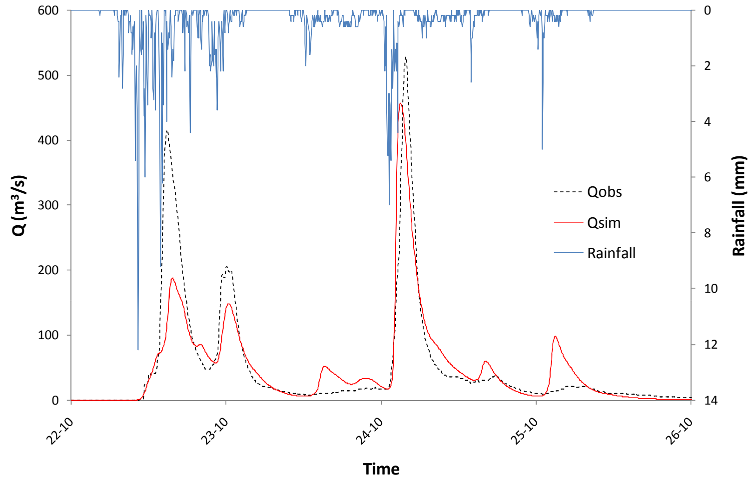




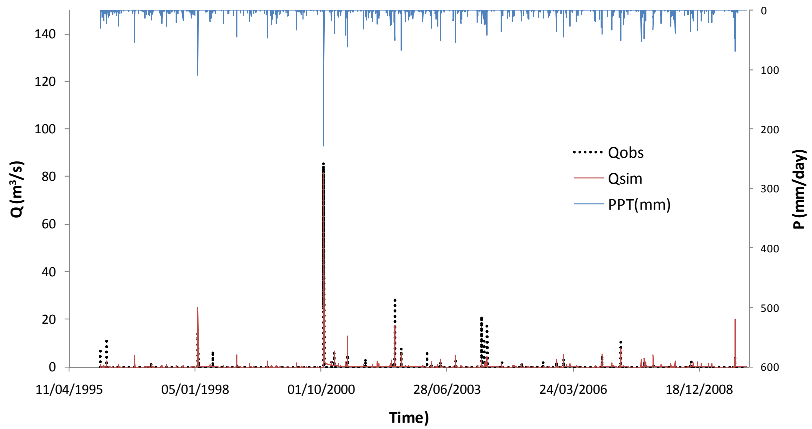
Results - hydrology

Hydrological calibration and validation

- 5 mins time-scale:
  - More than 20 events for calibration and validation
  - **Automatic calibration**: October 2000 (NSE=0.8)



- Daily time-scale:
  - 1990 – 2010 discharge and precipitation records
  - **Automatic calibration**: 1998 – 2002 (NSE=0.85)



Results – retained sediments

Dry bulk density (dBD)

- Lane and Koeltzer (1943) and Lara and Pemberton (1963):

$$dBD = dBD_i + 0 \cdot 434K\left[\left(\frac{T}{T-1}\ln T\right) - 1\right]$$

$$dBD_i = \frac{dBD_{i(\mathrm{sand})}\mathrm{Sand\%} + dBD_{i(\mathrm{silt})}\mathrm{Silt\%} + dBD_{i(\mathrm{clay})}\mathrm{Clay\%}}{100}$$

$$K = \frac{K_{(\mathrm{sand})}\mathrm{Sand\%} + K_{(\mathrm{silt})}\mathrm{Silt\%} + K_{(\mathrm{clay})}\mathrm{Clay\%}}{100}$$

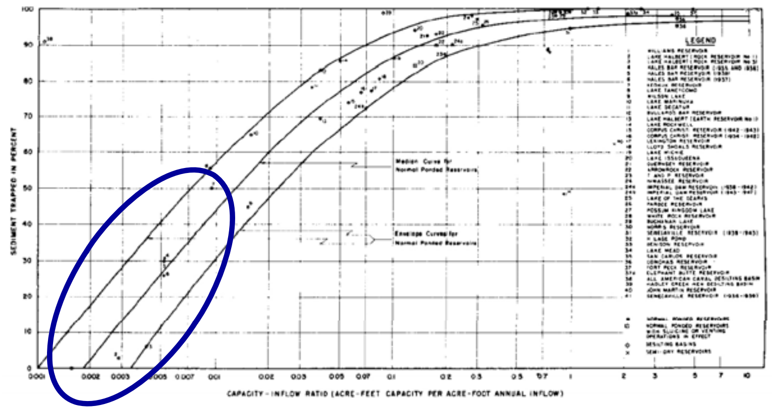
- Coefficients (*dBDi* and *K*) for reservoirs normally empty

tons/m^3	P1	P2	P3
Lane and Koeltzer	1.34	1.34	1.37
Lara and Pemberton	1.15	1.05	1.13
Average value	**1.25**	**1.19**	**1.25**

Results – trap efficiency

Trap efficiency (TE)

- Brune (1953) curves: high uncertainty and doubtful applicability



- The TE may vary depending on: maximum discharge, dam volume, shape, ...

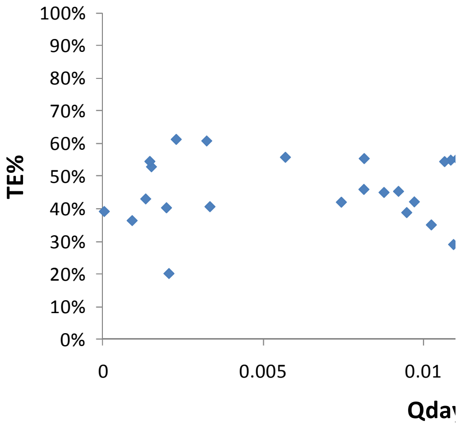
An existing model for TE is used to infer a relation between **TE and Discharge / Reservoir volume**

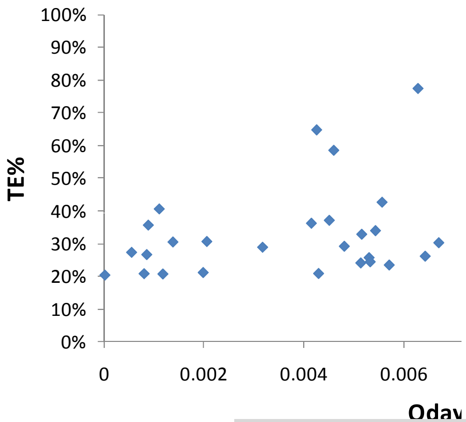
- Sediment Trap Efficiency for Small Ponds (**STEP**, Verstraeten and Poesen, 2001)
  - Simple algorithm
  - Suitable for large time periods
  - Developed for small ponds

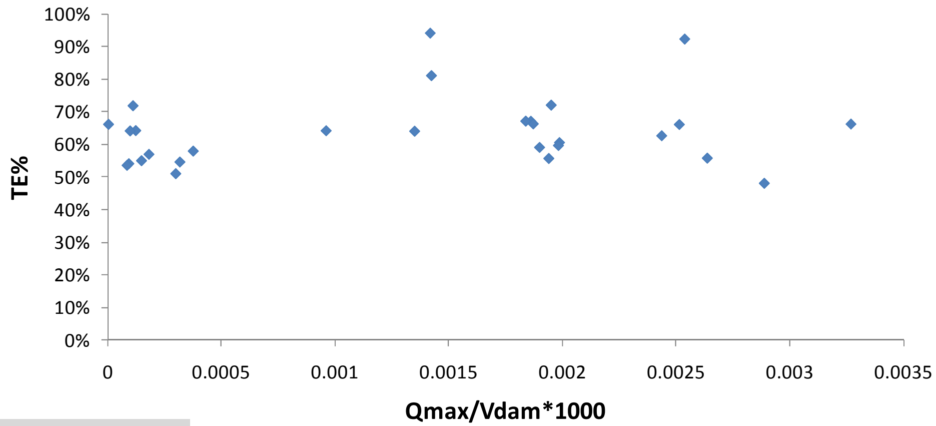
Results – trap efficiency

■ Trap efficiency (TE) – daily time-step

- 31 events are simulated with TETIS-SED
- STEP model is used to compute TE
- The TE provided by STEP is plotted vs Q day / V dam * 1000







Dam	TE(%)
P01	50%
P02	35%
P03	65%

Results – daily model

Daily time-step calibration

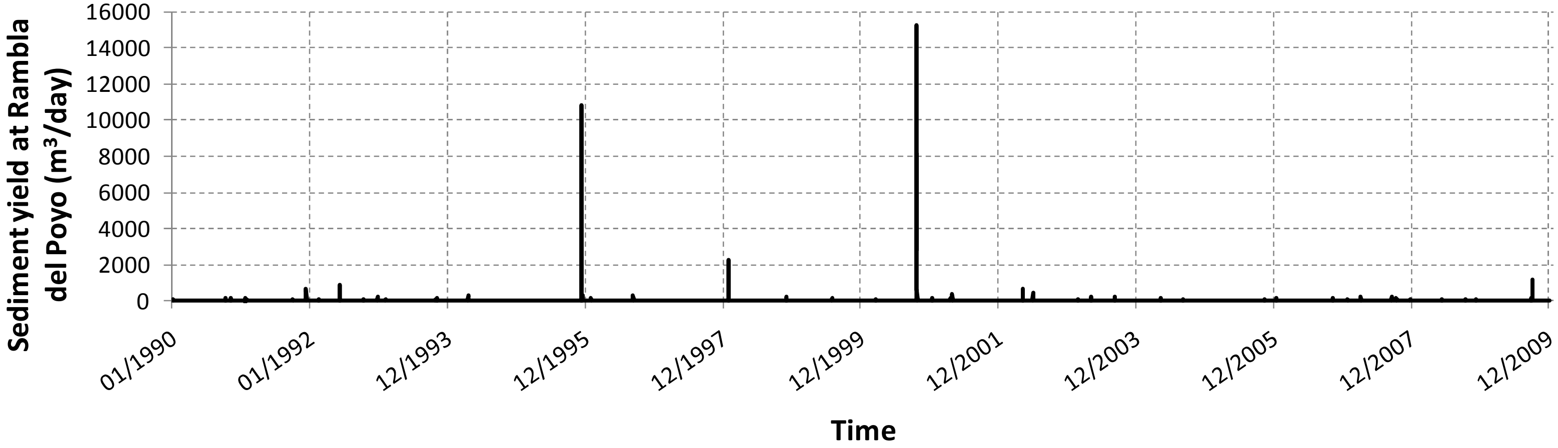
- TE: fixed (no relationship between daily discharge and TE)
- "Expert trial and error" calibration in P02 (Objective Function: Volume Error)

Dam	VolErr%
P02	0%

Daily time-step validation

- Spatial validation in P01 and P03

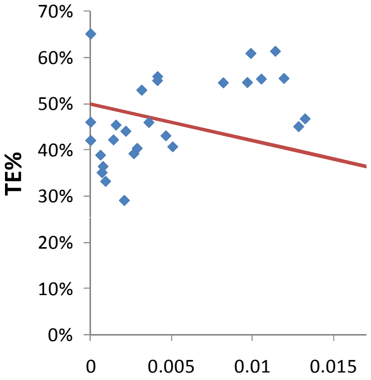
Dam	VolErr%
P01	10%
P03	-51%



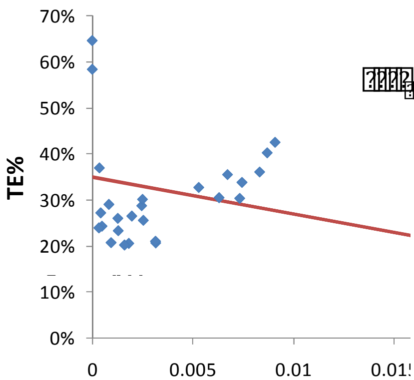
Results – trap efficiency

Trap efficiency (TE) – 5 minutes time-step

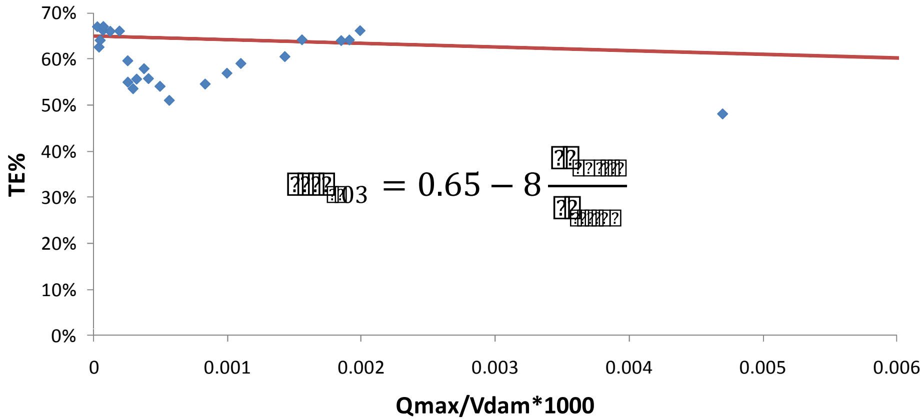
- Simulation of 31 real events at Δt = 5 mins
- STEP model is used to compute TE
- The TE provided by STEP is plotted vs Q max / V dam



$$TE_{01} = 0.5 - 8\frac{Q_{max}}{V_{dam}}$$



$$TE_{02} = 0.35 - 8\frac{Q_{max}}{V_{dam}}$$



$$TE_{03} = 0.65 - 8\frac{Q_{max}}{V_{dam}}$$

Results – 5 mins model

5 minutes Δt calibration

- The calibration was not possible due to the high computing cost (20 year of data at 5 minutes time resolution = more then 2 millions data records!)
- 84% of total sediment volume in 20 years corresponds to 31 relevant flood events, following daily model

➡ It is not necessary to simulate 20 years with fine time resolution

➡ However, continuous simulation can provide initial soil moisture and initial deposited sediment conditions

⬇

CONTINUOUS SIMULATION WITH VARIABLE TIME-STEP

Results – variable Δt model

Variable Δt calibration

- The 31 flood events were simulated with fine time-step (5 minutes)
- The drought periods were simulated with coarse time step (1 day)
- Every simulation provides a **hydrological final state** and a **sedimentological final state** which are used **as initial state** of the following simulation
- Different parameters sets were used for daily and 5 mins models
- “Expert trial and error” calibration in P02 (Objective Function: Volume Error)

Dam	VolErr%
P02	1%

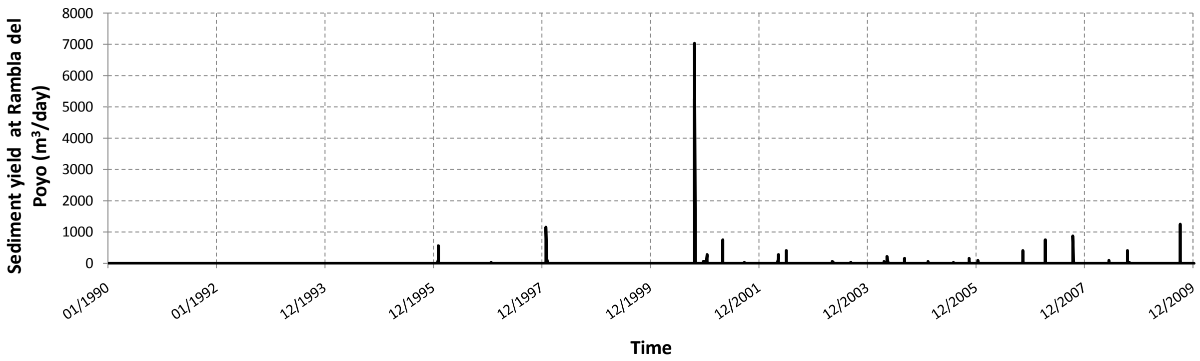
Variable Δt validation

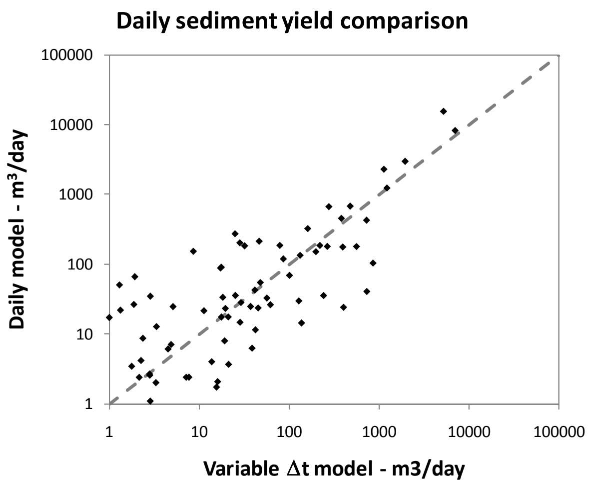
- Spatial validation in P01 and P03

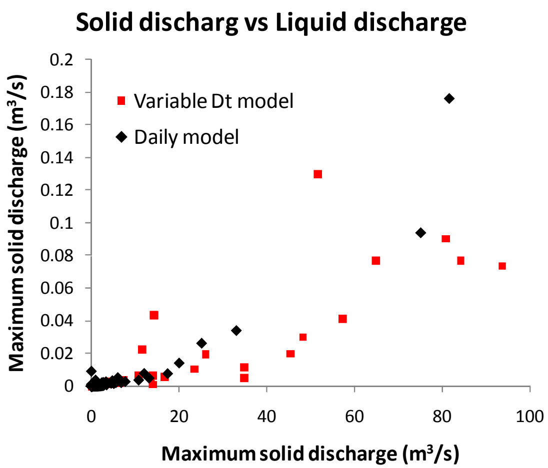
Dam	VolErr%
P01	-4%
P03	5%

Results – variable Δt model

Variable Δt model







Conclusions

- **Satisfactory performance of TETIS-SED model**
- **Sediments trapped into check dams may be very useful for calibrating a sediment model**
- **Daily time-scale is not correct:**
  - Time-scale effect
  - TE errors
- **Finer time scale better describes erosion and transport processes**
- **Variable Δt is a good compromise between computing requirements and precision**
- **Ongoing research**
  - Apply the model to other case-studies (larger reservoirs with less TE error)
  - Dating sediment layers deposited by different flood events using palaeofloods techniques

Acknowledgments

FloodMed Project

Scarce – Consolider Project

Thank you for your attention!