SEDIMENT TRANSPORT DURING THE SNOWMELT PERIOD IN A MEDITERRANEAN HIGH MOUNTAIN CATCHMENT

7th International Conference on Geomorphology

Melbourne
6-11 Jul 2009

Noemí Lana-Renault[1,2*], Bernardo Alvera[2], José M. García-Ruiz[2]

1) Physical Geography Research Institute, Utrecht University, The Netherlands; 2) Instituto Pirenaico de Ecología, CSIC, Spain

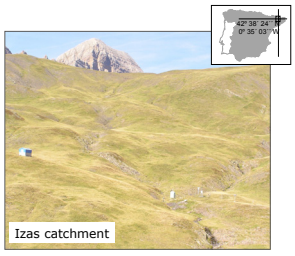
* lana-renault@geo.uu.nl

INTRODUCTION

Snow accumulation and **melting** play **key hydrological and geomorphological roles in high mountain catchments**. Monitoring of the Izas catchment (in the sub-Alpine belt of the Central Spanish Pyrenees) since 1987 has provided information on various hydrological and sediment transport processes (Martínez-Castroviejo et al. 1991; Del Barrio et al., 1997; Alvera & García-Ruiz, 2000; Anderton et al., 2002). In this study **sediment transport was assessed during the snowmelt period** in order to analyze **the effect of both daily and seasonal hydrological contrasts on sediment mobilization and export.**

THE CATCHMENT

The Izas catchment (0.33 km²) is located in the Central Spanish Pyrenees, between 2060 and 2280 m a.s.l. The bedrock is composed of carboniferous slates. **Solifluction** is very active in deep soils, while **terracettes** develop on degraded soils of south facing slopes. A dense and steep **gully system** occurs on slates close to the divide. This small area is the most important sediment source for the main channel (Díez et al., 1988).



Mean annual temperature is around **3°C** and total annual rainfall is **1900 mm**, with most precipitation occurring between **October and May**. During the cold season, precipitation falls as **snow**, which covers the catchment until June.

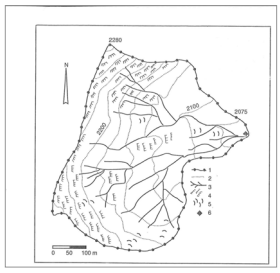


Fig 1. The Izas catchment. 1: Main divide. 2:Contour levels. 3:Fluvial network. 4:Terracettes. 5: Solifluxion lobes. 6: Location of the measurement site.

THE EQUIMENT

The Izas catchment is equipped with a automatic **weather station** and **gauging station** (V-notch weir) where the height and temperature of runoff water are recorded. Sediment transport was monitored using a **slot-trap** for bedload, an **automatic water sampler** for suspended and dissolved solid concentrations, a **conductivimeter**, and a **turbidimeter** that enabled evaluation of the suspended sediment. Information on snowpack corresponds to a **snow pillow** located close to the flume, where snowmelt ends rapidly compared to the rest of the catchment.

ANNUAL DYNAMICS

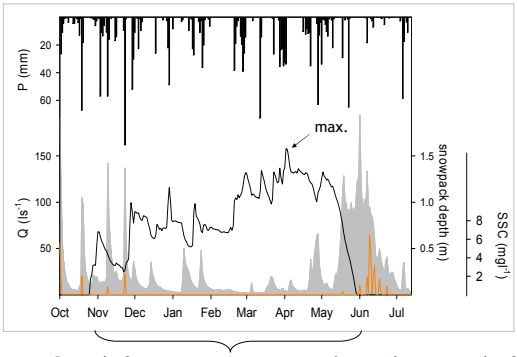


Fig 2. Daily precipitation (P), average daily discharge (Q), suspended sediment concentration (SSC) and snowpack depth for the period 1 October 2003 to 12 July 2004

Period of increasing snow accumulation (however, the falling section of the curve is not representative of the whole catchment)

Discharge

- Autumn: large fluctuations due to rainfall events accompanied by short snowmelt periods
- Winter: long period of low flows, with almost constant discharges in February and March
- End of April to end of June: period of high flows, coinciding with snow depletion in the catchment

Suspended sediment concentration showed small peaks in **autumn** and during the **snowmelt period**, when the catchment starts to be free of snow

SEDIMENT OUTPUT

	Water year 2003/04	Snowmelt period	% snowmelt period
Precipitation (mm)	2155	228	10.6
Runoff (mm	1983	955	48.1
Susp. Sedim. (Mg)	**11.9**	**7.3**	**61.1**
Solutes (Mg)	**54.6**	**22.5**	**41.2**
Bedload (Mg)	**3.1**	-	-

211 Mg km⁻² yr⁻¹

90 Mg km⁻² yr⁻¹

43% annual sediment yield

During snow melt period:

Suspended sediment: **24.4**%
Solutes: **75.6** %
No bedload

DISCHARGE AND SEDIMENT DURING THE SNOWMELT PERIOD

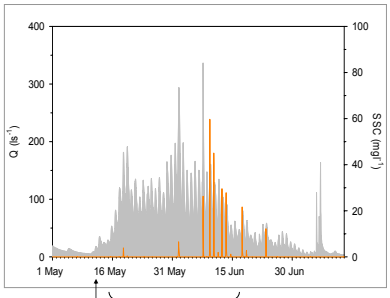


Fig 3. Hourly discharge (Q) and suspended sediment concentration (SSC) during the snowmelt period

A sustained period of continuous high flows

A marked discharge increase

Daily hydrographs showed a characteristic **wave pattern** reflecting the effect of daily temperature oscillations

The suspended sediment concentration did not follow this daily pattern, with the exception of some days in mid June that coincided with some **high discharges**

Q-SSC histeretic loops

Hysteretic loops show that suspended sediment concentration behaves in a very different manner according to the type of flood (rainfall or melting-related events), most probably in relation to the location and area occupied by sediment sources

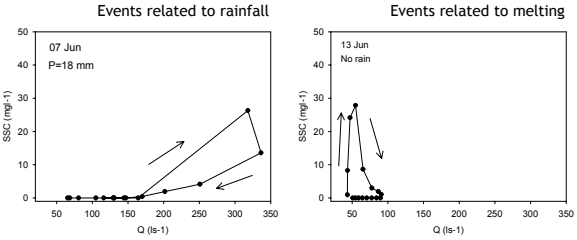


Fig 4. Relationships between hourly suspended sediment concentrations (SSC) and discharge (Q) for two events of the snow melting period

CONCLUSIONS

The results indicate the hydrological and geomorphological importance of the -brief- snowmelt period during the water year. For 2003/04,

- The two-month snowmelt period discharge represented almost **50% of the total annual runoff** and **42.8% of sediment transport**
- During this period, most sediment was exported in the form of **solutes** (75.6%) and not suspended sediment (24.4%)
- Most of the suspended sediment was carried in the **second part of the snowmelt period**, when an expanding area of the catchment was free of snow, reflecting the importance of sediment mobilization from the **ravine banks** and **saturated areas close to the snowmelt front**
- Hysteretic loops suggest **different Q-SSC behaviors** according to the type of flood (rainfall or melting-related events),

⇒ Further research is necessary, with more water years and a detailed analysis of prevailing geomorphic processes and sediment accessibility from the hillslopes

REFERENCES

Alvera, B. & García-Ruiz, J. M. 2000. Variability of sediment yield from a high mountain catchment, Central Spanish Pyrenees. Arctic, Antarctic, and Alpine Research, 32 (4), 478-484.

Anderton, S.P., White, S.M. & Alvera, B. 2002. Micro-scale spatial variability and the timing of snow melt runoff in a high mountain catchment. Journal of Hydrology, 268, 158-176.

Del Barrio, G., Alvera, B., Puigdefábregas, J. & Díez, J. C. 1997. Response of high mountain landscape to topographic variables: Central Pyrenees. Landscape Ecology, 12, 95-115.

Díez, J. C., Alvera, B., Puigdefábregas, J. & Gallart, F. 1988. Assessing sediment sources in a small drainage basin above timberline in the Pyrenees. IAHS Publ., 174, 197-205.

Martínez-Castroviejo, R., García-Ruiz, J. M., Díez, J. C. & Alvera, B. 1991. Coarse sediment transport in an experimental high mountain catchment of Central Pyrenees, Spain. Zeitschrift für Geomorphologie Suppl Bd, 83, 105-114

ACKNOWLEDGEMENTS

This research has been financially supported by the following projects: "Processes and sediment balances at different spatial scales in Mediterranean environments: Effects of climate fluctuations and land use changes" (PROBASE, CGL2006-11619/HID). Monitoring of the catchment has been supported by the agreement between CSIC and the Spanish Ministry of Environment (RESEL). N. Lana-Renault has benefited from a research contract (I-D+I 2008-2011 National Program), funded by the Spanish Ministry of Education and Science.