

HISTORIC SNOW AVALANCHES IN THE PYRENEES: THE DESTRUCTION OF THE SMALL VILLAGE OF ÀRREU (PALLARS SOBIRÀ)

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ABSTRACT: Snow-avalanche events which cause destruction and loss of human lives stand out in the memory of people. In the Pyrenees several such avalanches are historically known which correspond to the more than 100-years return period category. In the present work we reconstruct one of these events. Our long-term objective is to reconstruct these historical major avalanches to improve the knowledge on major avalanche cycles, their frequency and intensity in this mountain range. On this occasion we reconstructed the event occurred in 1803 which devastated the small village of Àrreu (ten houses destroyed, and seventeen people killed) and caused its people to move location to a safer place. To the present day, after 215 years, there is no evidence of a similar phenomenon in the proximity of the ruins of the old village. The story of the catastrophe remains like something legendary in the valley's collective memory, as a circumstance belonging to the past, unlikely to occur nowadays. We combined several methodologies to reconstruct the event and the frequency of avalanches along the avalanche path. Search in historical documents rendered most of the information: when and where it occurred, and how many people were killed. Field inspection and dendrochronology allowed us to reconstruct several events of various sizes, and to obtain an estimate of the frequency at different elevations along the avalanche path, but due to the short age of the trees, we did not detect evidence of the most extreme event. Finally, with all the data we modeled the 1803 event and reproduced the most likely trajectory which destroyed the old village.

KEYWORDS: historical snow avalanches, Pyrenees, dendrogeomorphology, snow avalanche modeling

1. THE ANCIENT VILLAGE OF ÀRREU

Nowadays Àrreu is an abandoned village of Pallars-Sobirà district in the Pyrenees. Before 1803 the placement of this village was some 500 m to the west of the present location (now called Bordes d'Àrreu) (Figure 1).

The river which flows past both sites is Àrreu river, and to this main stream a lateral torrent coming from the west is Barranc de Monars. This mountain torrent has a broad watershed whose highest elevation is at 2453 m asl (Pic del Muntanyó), and a narrow gorge between 1650 and 1400 m asl when it discharges into Àrreu river (Figure 2).

In 1803 a snow avalanche destroyed the ancient village. Many people were killed, and most houses destroyed, and they decided to move to a safer location. This is the first time that a thorough study has been carried out to reconstruct the catastrophic event.

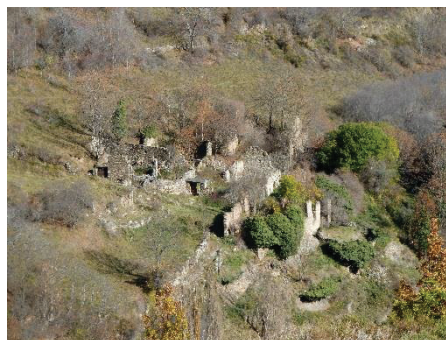
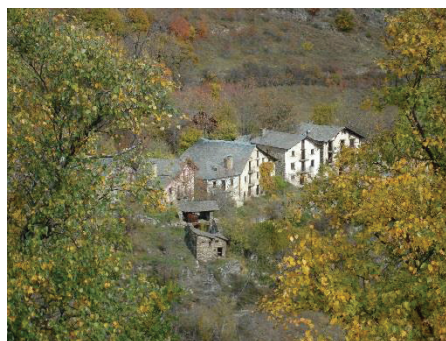


Figure 1: The small village of Àrreu in Pallars Sobirà (Pyrenees). Above: present location. Under: old village location (named Bordes d'Àrreu).

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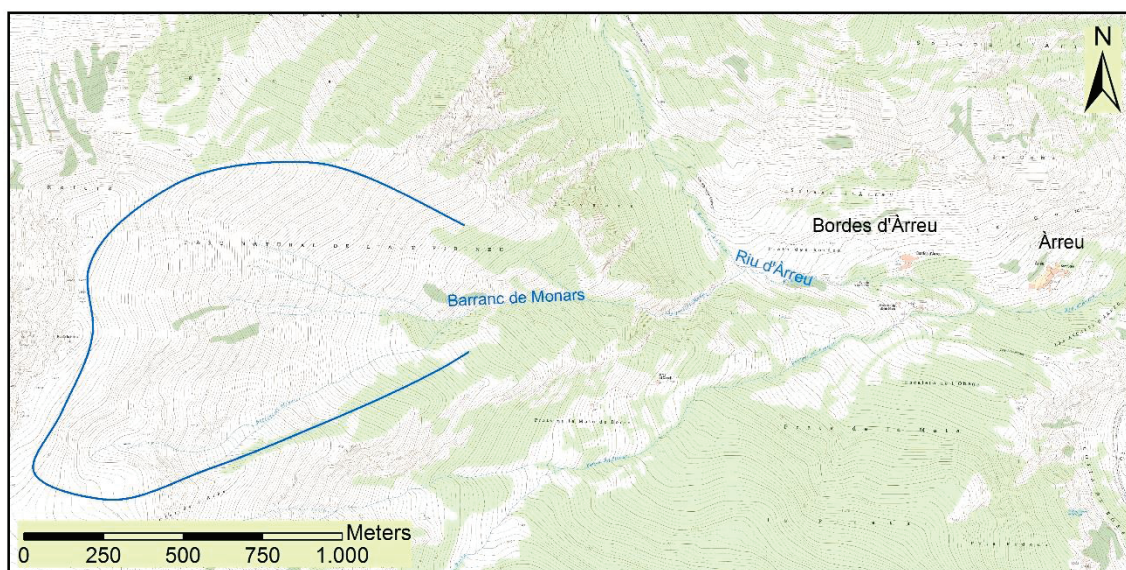


Figure 2: Location map of Àrreu and Barranc de Monars. Bordes d'Àrreu is the actual name of the old village of Àrreu that was destroyed by a major avalanche in 1803.

2. METHODOLOGY

To gather information about the avalanche activity in the surroundings of Àrreu we combined several sources:

1. Search in historical documents
2. Field inspection
3. Dendrogeomorphological analysis
4. Snow avalanche modeling

Dendrochronological samples from selected trees were gathered and analysed to date disturbance events recorded in their tree rings. The method is described in Muntán et al. (2004) and Stoffel et al. (2010).

To simulate the major avalanche occurred in 1803 the procedure consisted of the following sequential steps:

- Statistical modeling (using the α - β regression model (Lied and Bakkehoi, 1980) with the Furdada and Vilaplana (1998) general equation for the Pyrenees.
- Dense part physical modeling with RAMMS (Christen et al. 2010).
- Powder part physical modeling with SL1D (AVAL-1D from SLF).

3. RESULTS

Three historical documents were most determining in finding out from where the destructive avalanche had descended and an approximation to the destructive effect in buildings and lives lost.

From the prayer *Goigs de la Mare de Déu de la Neu d'Àrreu* (Urgell Diocese) we found out that the avalanche had occurred in Barranc de Monars. The other two documents (Madoz 1845-1850; Zamora 1790) let us quantify the losses: 10 houses and 17 people killed. Avalanche release date was Christmas.

The field survey showed that trees are, in general, young, although the watershed is nowadays forested. Most trees are less than 60 years old. No tree was found to reach more than 200 years. Therefore, the possibility of detecting any dendrochronological evidence of the event in 1803 was soon discarded.

We sampled trees along the track and runout of the avalanche path as shown in Figure 3.

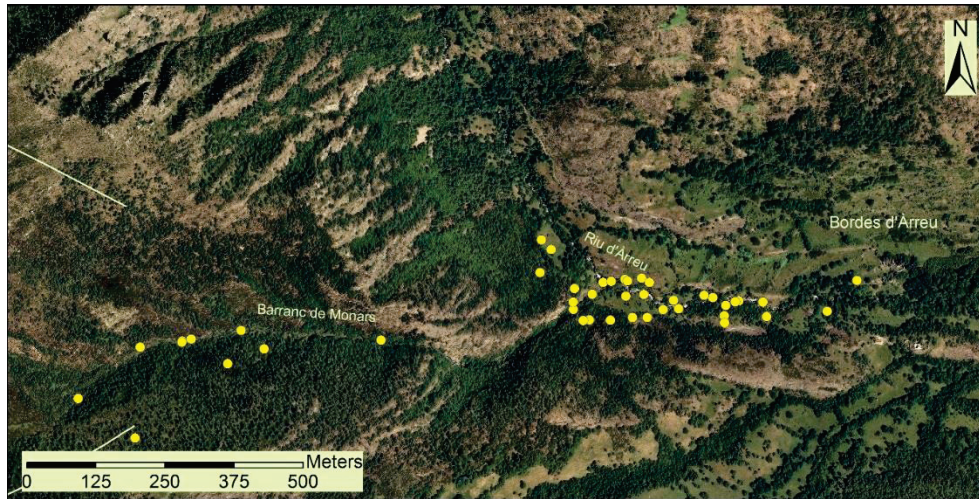


Figure 3: Trees sampled for dendrogeomorphological analysis along the avalanche track at Barranc de Monars and at the runout at the main stream of Àrreu.

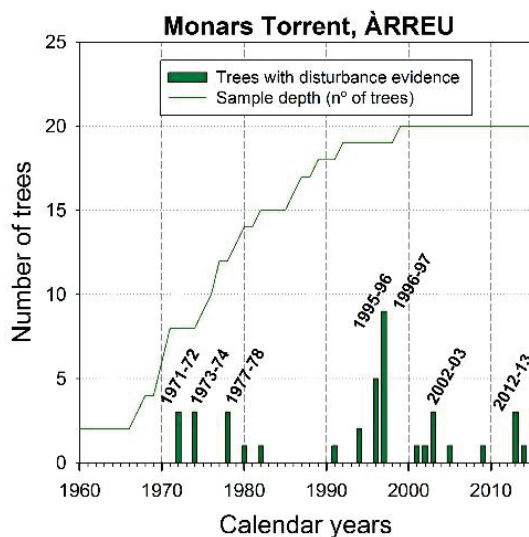


Figure 4: Years with a high probability of snow-avalanche events, from dendrogeomorphological analysis of tree samples.

Dendrochronological analysis of tree samples gathered at different elevations, pointed out several years with growth disturbances in their tree rings, corresponding most likely to avalanche events in the seasons shown in Figure 4.

Only the avalanche event in 1995-96 had been recorded as a major event. All other events had been of a lower magnitude. And, according to dendrogeomorphological analysis, most of them did not surpass Barranc de Monars narrow gorge.

3.1 Simulation of the snow avalanche which destroyed the old village of Àrreu

The α - β model was used to obtain a first approximation of the runout distance (Figure 5). For a T100 or higher the resultant avalanche would reach the old village of Àrreu. The profile is not parabolic, there is a flat area at 1600 m asl which makes this calculation not so liable.

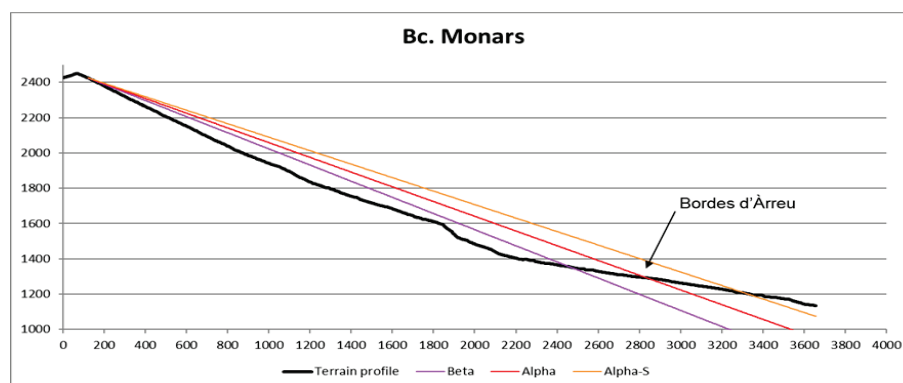


Figure 5: Estimation of the runout distance by applying the α - β model using Pyrenees data.

RAMMS was used to modelise the dense part with the following premises:

A T300 major scenario was considered owing to the season (December) and to the climatic context (LIA transition).

A broad start zone based on the evidence from 1995-96 known avalanche.

Snow depth of 144 cm is calculated as for the close Bonaigua nivometeorological station (3-days precipitation, T300). Wind accumulation is also considered.

RAMMS results are not enough to explain the extent of the 1803 avalanche event (Figure 6).

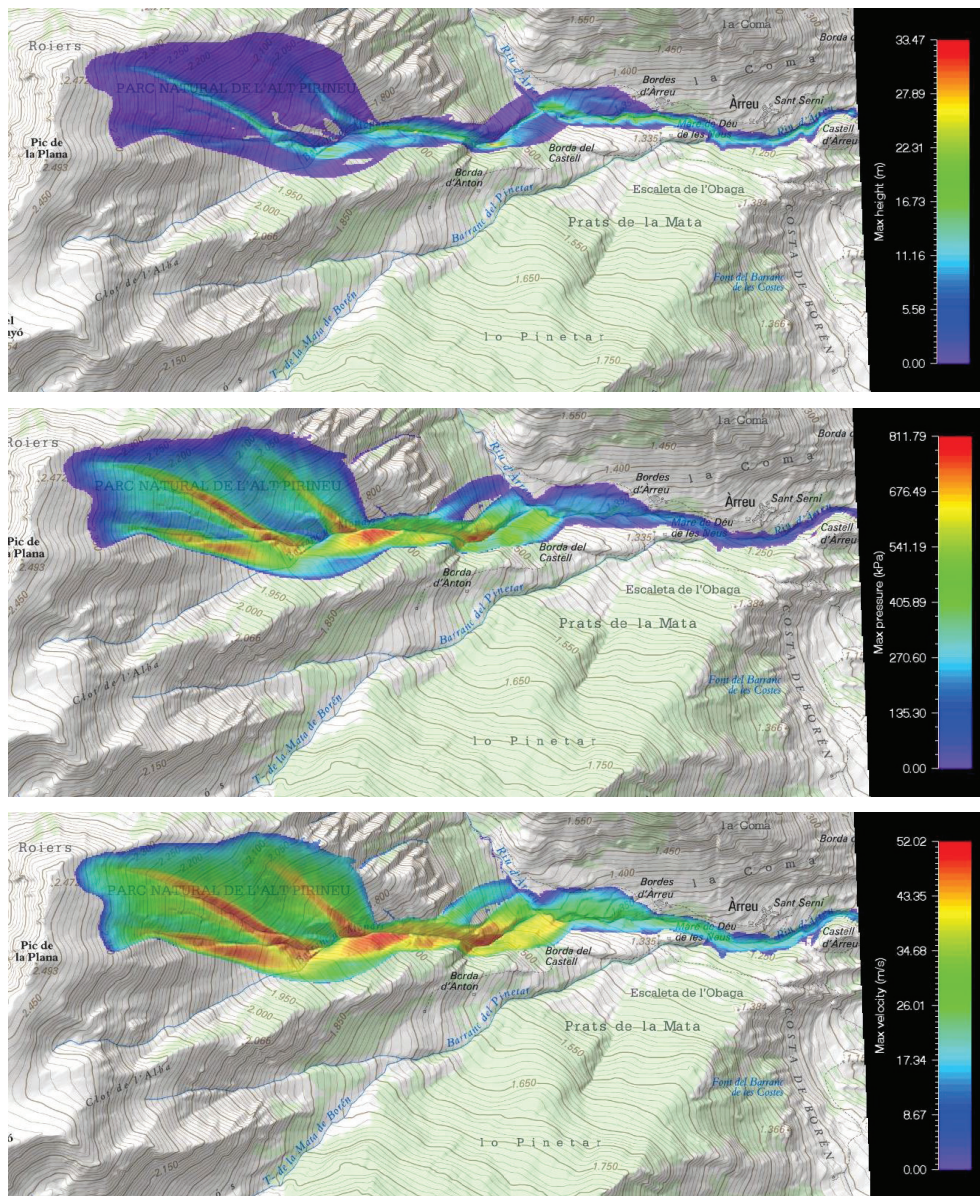


Figure 6: RAMMS results are not enough to explain the extent of the 1803 avalanche event.

For this reason, SL1D was used to modelise the powder part. Results are shown in Figure 7.

At the site where the houses were the initial pressure would have been 2 kPa up to 10m height.

Walls would not have been destroyed, but windows and doors would.

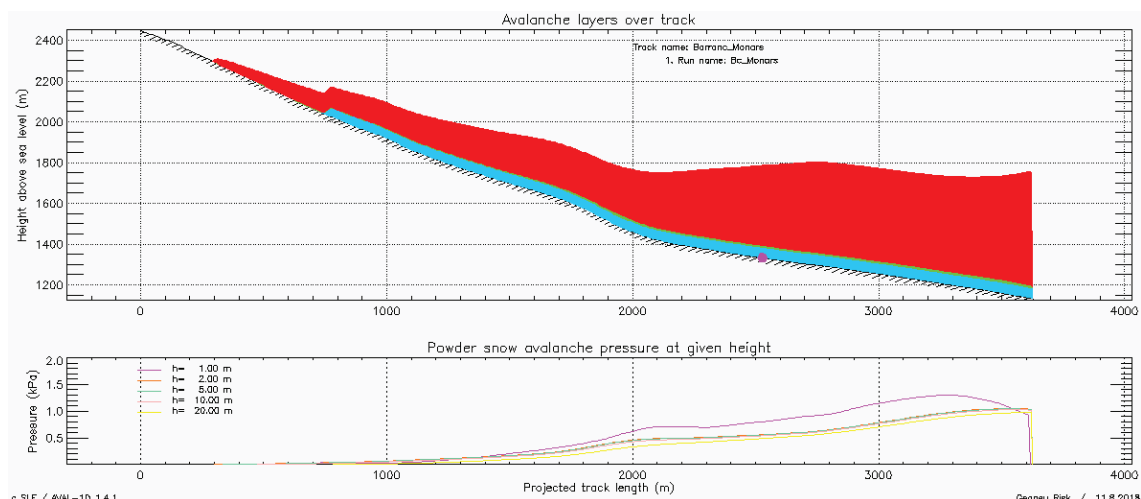


Figure 7: SL1D results. The pink dot corresponds to the old village site.

4. CONCLUSIONS

The snow avalanche that destroyed the old village of Àrreu was a first magnitude event, belonging to the 300 years return period category. No other similar avalanche has been registered in the past 215 years in Barranc de Monars.

By combining a range of sources and methods (historical documentation, field survey, dendrochronology, and modeling) we were able to reconstruct the major event, being the historical documents the key to unravel the occurrence and the computer models the necessary tools to understand the event.

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