

A first dendrogeomorphologic approach of snow avalanche magnitude–frequency in Northern Iceland

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ABSTRACT

The paper examines the potential of dendrogeomorphic analyses to deliver a one-year resolution chronology of snow-avalanche winters in Northern Iceland, at the scale of a colluvial cone covered with European White Birch trees and shrubs (*Betula pubescens* Ehrh.). Reconstruction of the avalanche history is performed using tree-ring analyses. Determination of the most reliable growth disturbance (class 1 of growth eccentricity) and applying a tempering index value with threshold 10% of trees responding in the same year and at least two trees affected, avalanche-activity years are highlighted, resulting in 52 avalanche winters. Amongst those, 5 winters have activity index over 40%, indicating major years. Calculation of frequency of similar growth disturbances at each tree provides a return period ranging from 4.2 to 19 years. Inferred spatial extent of snow-avalanche events induces flow-like snow avalanches with limited extent around the tree-less parts of the cone with a return period under 6 years; the cone is totally covered and the distal tree-limit over-passed with a return period of 15–20 years.

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1. Introduction

Annual increment rings in tree growth reflect and record local environmental conditions (Wiles et al., 1996). Therefore, all changes in climate, weather and other external factors are manifested in the wood reaction occurring in trunk morphologies and tree-ring sequences (Shroder, 1980; Shroder and Butler, 1987; Schweingruber, 1996; Strunk, 1997; Stoffel, 2005). Dendrogeomorphology has been used effectively in snow-avalanche research (i.e. Ives et al., 1976; Carrara, 1979; Butler and Malanson, 1985a, 1985b; Jenkins and Hebertson, 1994; Patten and Knight, 1994; Rayback, 1998; Larocque et al., 2001; Hebertson and Jenkins, 2003; Dubé et al., 2004), mostly with the aim of dating events, using softwood from diverse conifer species. Few studies have investigated hardwood species (Bryant et al., 1989; Mundo et al., 2007; Casteller et al., 2008; Szymczak et al., 2010) with similar efficiency.

Recently, tree-ring analyses have been conducted to reconstruct the frequency and extent of snow avalanches in several places, e.g.

in the Spanish Pyrenees (Muntán et al., 2004, 2009), the Swiss (Stoffel et al., 2006; Casteller et al., 2007) and French Alps (Corona et al., 2010). To date, snow-avalanche chronologies based on proxy data with a one-year resolution do not exist for Iceland. In this country, during the 20th century alone, 166 lives were lost due to snow avalanches (Sæmundsson et al., 2003), and economic losses were worsening in the country (Jóhannesson and Arnalds, 2001). The devastating year 1995 (Decaulne, 2007) reinforced the need to gather critical information on historical events, such as extent and occurrence, to further develop mitigative measures. Therefore recent snow-avalanche documentation mainly concentrates on areas where population density and the number of transportation corridors have increased over the past decades (Decaulne, 2007). Historical records are scarce or lacking in newly occupied areas, and do not cover the return period of major events, i.e. +/– 200 years (McClung and Schaerer, 1993). During recent years, studies based on geomorphological evidence of snow-avalanche activity have been conducted in remote areas (Decaulne and Sæmundsson, 2006, 2007), determining runout distances for major avalanches in selected paths and transferring results to paths located above fjord communities (Decaulne et al., 2008). However, occurrence of snow-avalanche deposits far downslope was determined only by the mean of relative dating (Decaulne and Sæmundsson, 2010).

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The purpose of this study is to supplement previous researches on snow-avalanche occurrence, based on a geomorphologic approach, with a high resolution chronology of snow-avalanche winter events at cone scale using dendrogeomorphic methods on European White Birches (*Betula pubescens* Ehrh.), inferring snow-avalanche frequency, return period and spreading.

2. Geographic setting

The study was conducted in Northern Iceland, in the southern Fnjóskadalur valley, on one of the large colluvial cones on the eastern side of the valley (65°35'30"N, 17°44'17"W). The topography is characterized by steep slopes ranging from 200 m a.s.l. to 820 m a.s.l., talus and colluvial cones form below 350–300 m a.s.l. The cone itself,

exposed south-westwards, exhibits a tree and shrub European White Birch cover (*Betula pubescens* Ehrh.), as previously described in Decaulne and Sæmundsson (2008) (Fig. 1), while the valley bottom is covered with an arctic heath heavily grazed, mainly by sheep. The valley, quite remote from human activities, is known to encounter major snow-avalanche activity during the winter. Despite the lack of written sources, this fact is attested by numerous couloirs on the headwall and lower talus, and by well individualised accumulations of scattered boulders far from the toe of the slope (Decaulne and Sæmundsson, 2005). The cone investigated here has a concave profile, clearly marked by snow-avalanche activity (Decaulne and Sæmundsson, 2010): debris distribution reveals longitudinal sorting with coarser material located mainly at the most distal part of the profile and the orientation of boulders attests a strong correlation

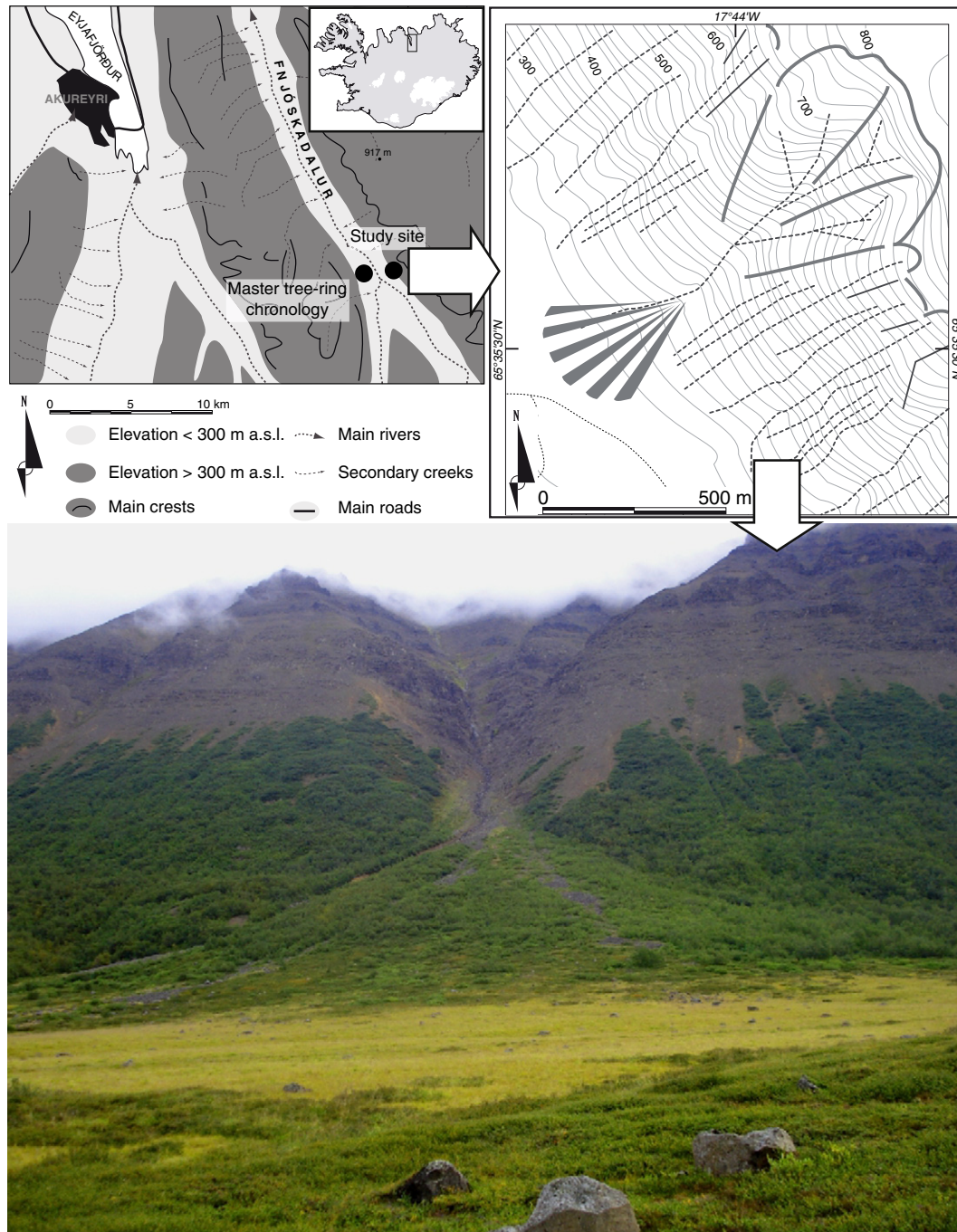


Fig. 1. Location and view of the study area (Photo: A. Decaulne).

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