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Natural Hazards and Earth System Sciences

Preface

"Tree-ring reconstructions in natural hazards research"

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Time series of tree rings have considerably contributed to the endeavors of earth-system, earth-surface processes and natural hazards in the past. The potential of dendrogeomorphology (Stoffel et al., 2010) lies in the capacity of trees growing in climates with distinct seasons to both preserve evidence of past disasters and to provide critical information on their dating with annual and sometimes monthly resolution (Stoffel and Beniston, 2006; Kaczka et al., 2010). As a result, tree-ring records may represent one of the most valuable and precise natural archives for the reconstruction and therefore for the understanding of past events.

The initial employment of tree rings in earth-surface process studies was simply as a dating tool (Alestalo, 1971; Shroder, 1980): it rarely exploited other environmental information that could be derived from studies of ring-width variations and records of damage contained within the tree itself. However, these unique, annually resolved, tree-ring records usually preserve potentially valuable archives of past geomorphic events on timescales of a few decades to several centuries. The documentation of time series of events as well as the understanding their areal extent and controls provides valuable information that can assist in the prediction, mitigation and defense against these hazards and their effects on society. This special issue contains a selection of presentations given to session NH10.02 "Tree-ring reconstructions in natural hazards research", organized within the General Assembly of the EGU in Vienna on 20 April 2007. The session was convened by Markus Stoffel and Michelle Bollschweiler. A total of 18 oral communications and poster were presented, from which eight are included in this special volume.

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The different contributions illustrate how tree-ring analysis can be used to reconstruct natural hazards and provide information that may be used to understand the future occurrence of events. The papers also illustrate the breadth and diverse applications of contemporary dendrogeomorphology and underline the growing potential to expand these studies, possibly leading to the establishment of a range of techniques and approaches that may become standard practice in the analysis of specific hazards. In addition, data on process dynamics and triggers are of great value for the overall understanding of mass movements and the way they are influenced by changing climatic conditions. Such data represent compulsory prerequisites for realistic estimates of the current and for potential future evolution of earth-surface processes in space and time and a basis for future research in an even larger variety of geographic environments.

In the introductory paper, Stoffel and Bollschweiler (2008) provide a broad overview on current approaches used in tree-ring reconstructions of natural disasters resulting from earth-surface processes and outline the impact that mass movements have on tree morphology, tree growth and wood anatomy.

The second paper by Schneuwly and Stoffel (2008) reconstructs rockfall activity on a slope in the Swiss Alps using 154 wounds from 32 European larch (*Larix decidua* Mill.), Norway spruce (*Picea abies* (L.) Karst.) and Swiss stone pine (*Pinus cembran* L.) trees. The intra-annual position of wounds points to strong intra- and inter-annual variations of rockfall activity, with a clear peak (76%) in winter. Findings suggest that rockfall activity at the study site is driven by annual thawing processes and the circulation of melt water in preexisting fissures. Data also indicate that 43% of all rockfall events occurred in 1995, when two major precipitation events are recorded in nearby meteorological stations.

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Two contributions of the special issue deal with erosion and landscape evolution. Rubiales et al. (2008) used anatomical changes in exposed roots of Scots pine (*Pinus sylvestris* L.) to date denudation along a trail located in the Sierra de Guadarrama (Spain). The moment of root exposure was reconstructed via changes in ring width, tracheid number per ring, percentage of latewood and earlywood lumina. Results indicate that *P. sylvestris* show a statistically significant anatomical response to exposure by sheet erosion. Increased ring widths are accompanied by a slight reduction of earlywood tracheid lumina and several rows of thick-walled latewood tracheids. Scuderi et al. (2008) use a combination of dendroclimatic and dendrogeomorphic approaches to study relationships between climatic variability and hillslope and valley floor dynamics in a small drainage basin in the Colorado Plateau (USA). Root exposure, tree tilting, change in plant cover as well as the burial or exhumation of valley bottom trees and shrubs suggest that the currently observed process of root colonization and rapid breakdown of the weakly cemented bedrock by subaerial weathering has lead to a discontinuous, climate-controlled production of sediment from these slopes. High-amplitude precipitation shifts over the last 2000 years may exert the largest control on landscape processes and may be as, or more, important than other hypothesized causal mechanisms (e.g. ENSO frequency and intensity, flood frequency) in eroding slopes and producing sediments.

The application of dendrogeomorphology for the dating of snow avalanches is well established in the natural hazards literature and a variety of methodologies are employed by different authors. However, no standard currently exists for appropriate sample sizes, the "weighting" of tree-ring responses, or the minimum number of responding trees required to infer an avalanche event. Butler and Sawyer (2008) review the literature of dendrogeomorphology as it applies to snow avalanches, and examine the questions of sample size, type of ring reactions dated and weighted, and minimum responses. Tree-ring data are presented from two avalanche paths in the Rocky Mountains (Montana, USA), from trees uprooted by high-magnitude snow avalanches in the winter of 2002. These data provide distinct chronologies of past avalanche events, and also illustrate how the critical choice of a minimum index number can affect the number of avalanche events in a final chronology based on tree-ring analysis. The second paper dealing with snow avalanches is by Muntan et al. (2009) and reports a regional study of large-scale snow avalanche events in the SE Pyrenees in the last four decades. Results show that dendrogeomorphology may complement written records even for relatively recent events and that results can be of great value for the assessment of runout distances or lateral spread as well as for the realization of hazard maps. Casteller et al. (2008) coupled tree-ring data from Southern Hemisphere beech (*Nothofagus pumilio*) with a two-dimensional snow avalanche model to reconstruct a deadly avalanche which occurred in the Patagonian Andes (Argentina) in winter 2002. Using information released by local governmental authorities and compiled in the field, the avalanche event was numerically simulated using AVAL-1D and RAMMS. Model simulation results were compared with documentary and tree-ring evidence and show a good agreement between the modeled and reconstructed extent. Differences between observation and simulation are mostly stemming from the low resolution of the digital elevation model used to represent topography.

Solomina et al. (2008) used tree rings to data volcanic eruptions at Shiveluch, one of the most active volcanoes in Kamchatka. The authors report tree-ring dates for a recent pyroclastic flow in the Baidarnaia valley to shortly after AD 1756, but not later than AD 1758. This date coincides with the decrease of ring-width in trees growing near Shiveluch volcano in 1758–1763. The deposits of the pyroclastic flow in the Kamenskaia valley probably date back to $\sim$AD 1649. This date is in close agreement with previously obtained radiocarbon dates of these sediments and with tephrochronological data and show that tree-ring records can be very valuable to constrain the chronology of volcanic events in remote areas.

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