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Millennial scale variability of denudation rates for the last 15 kyrs inferred from the detrital ^{10}Be record of lake Stappitz in the Nationalpark Hohe Tauern, Austrian Alps

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Keywords

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Summary

Reconstructing paleo-denudation rates over Holocene time-scales in an Alpine catchment provides an excellent opportunity to isolate and test the climatic forcing of denudation, disentangling its effects from tectonics or anthropogenic effects. We measured cosmogenic ^{10}Be on two sediment cores from Lake Stappitz (FRITZ & UCIK, 2001) in the Nationalpark Hohe Tauern (Austrian Alps) to derive a 15-kyr long record of the upstream Seebach Valley (Fig. 1).

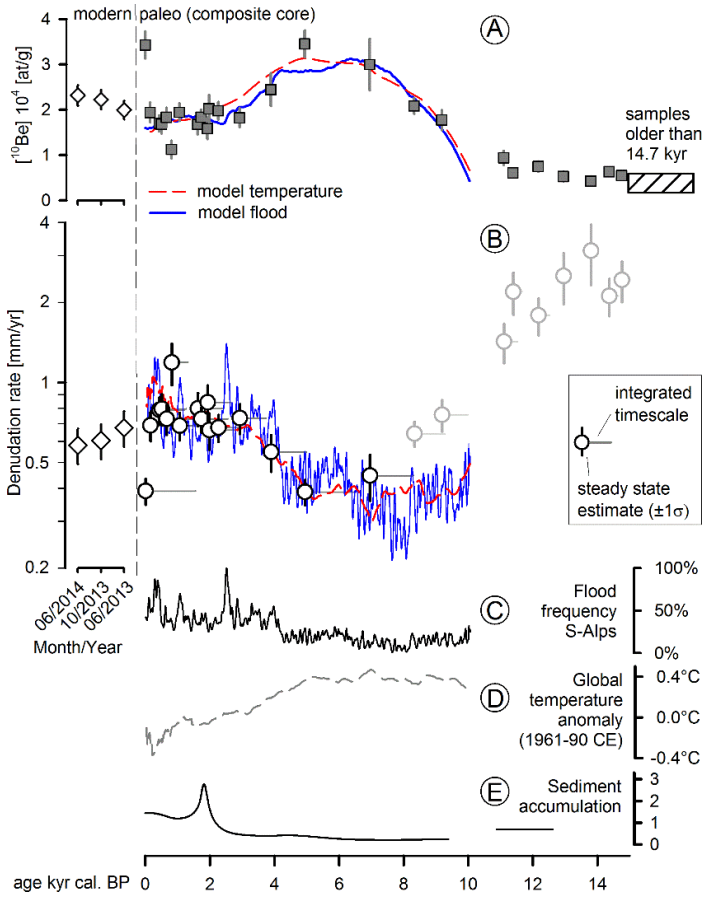

Figure 1: (A) 10Be concentrations from the core (gray squares) and the active stream (diamond shape) with the transient model output data using the climate records of (C) flood frequency (WIRTH et al. 2013) and (D) temperature (MARCOTT et al. 2013) as input denudation history (blue solid line and red dotted line, respectively. (B) steady-state denudation rates (white circles, shaded where they are not meaningful, see text). (E) Sediment accumulation rates derived from the age-depth model of the composite core.

Our study provides quantitative estimates of catchment denudation for the Holocene in an unprecedented temporal resolution (GRISCHOTT et al., in press). Due to the existence of the lake over the Holocene, the upstream Seebach Valley was isolated from baselevel (tectonic) changes and the high elevation minimizes anthropogenic impacts. The ^{10}Be record indicates significant, but temporally decreasing, mixing with low-dosed paraglacial sediments from 15 to 7 kyr cal BP. In the absence of perturbing glacial sediments after 7 kyr cal BP, the ^{10}Be concentrations can be converted to catchment-wide denudation rates (GRANGER et al., 1996).

Denudation rates significantly fluctuated over this time period and are related to the hillslope response of climate forcing. Lower hillslope erosion rates of ca. 0.4 mm/yr found between 5 to 7 kyr cal BP correlate with a stable climate, infrequent flood events (WIRTH et al., 2013) and higher temperatures (MARCOTT et al., 2013) that favoured the widespread growth of stabilizing soils and vegetation (NICOLUSSI et al., 2005). Higher hillslope erosion rates of ca. 0.8 mm/yr for the last ~4 kyr correlate with a variable, cooler climate where frequent flood events increase denudation of the less protected hillslopes. Overall our results suggest a tight coupling of climate and hillslope erosion in alpine landscapes as it has been observed in other parts of the Alps (ARNAUD et al., 2016).

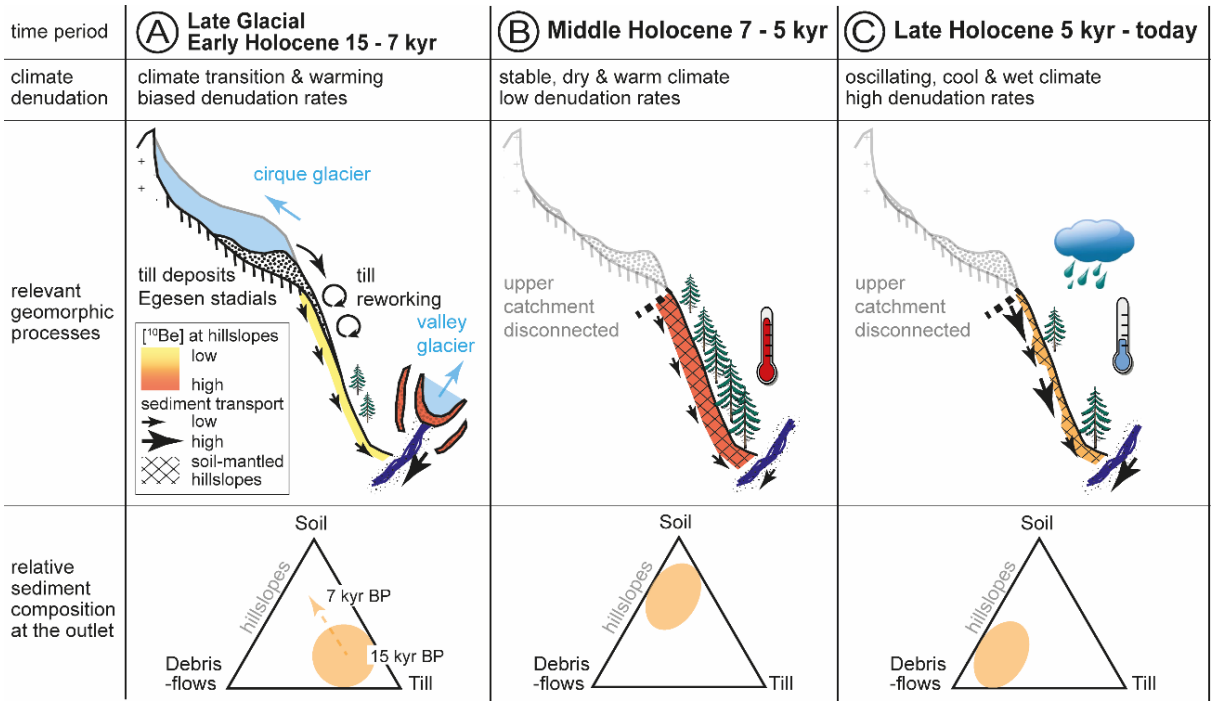

Figure 2: The environmental history of the Seebach Valley schematically explained in three distinct time periods between 15-7 kyr, 7-5 kyr and 5 kyr to present subdivided in climate and observed denudation rates, relevant geomorphic processes in the catchment visualized along a valley transect and the relative sediment composition at the outlet with the three major sediment sources 'soil', 'till', and 'debris-flows'. During the Late Glacial and Early Holocene (A), reworking of the glacial sediments and previously zeroed hillslopes leads to low 10Be concentrations of exported sediments. The Mid-Holocene (B) is characterized by rare flood events and warm temperatures leading to soil development and stabilization of hillslopes. Note, the upper half of the catchment is disconnected in terms of sediment transport. Later increase of the flood frequency and colder temperatures during the Late Holocene (C) leads to higher hillslope erosion and sediment flux.

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References

ARNAUD, F., POULENARD, J., GIGUET-COVEX, C., WILHELM, B., RÉVILLON, S., JENNY, J.-P., REVEL, M., ENTERS, D., BAJARD, M., FOUINAT, L., DOYEN, E., SIMONNEAU, A., PIGNOL, C., CHAPRON, E., VANNIÈRE, B., AND SABATIER, P., 2016, Erosion under climate and human pressures: An alpine lake sediment perspective: Quaternary Science Reviews, v. 152, p. 1-18.

FRITZ, A., AND UCIK, F. H., 2001, Vegetationsgeschichte des Seebachtals. Beitrag zur Klima- und Vegetationsgeschichte des Seebachtales bei Mallnitz, Hohe Tauern, während der letzten 17000 bis 18000 Jahre., Naturwissenschaftlicher Verein für Kärnten: Klagenfurt, p. 393-402.

GRANGER, D. E., KIRCHNER, J. W., AND FINKEL, R., 1996, Spatially averaged long-term erosion rates measured from in situ-produced cosmogenic nuclides in alluvial sediment: Journal of Geology, v. 104, no. 3, p. 249-257.

GRISCHOTT, R., KOBER, F., LUPKER, M., REITNER, J. M., DRESCHER-SCHNEIDER, R., HAJDAS, I., CHRISTL, M., AND WILLETT, S. D., in press, Millennial scale variability of denudation rates for the last 15 kyr inferred from the detrital 10Be record of Lake Stappitz in the Hohe Tauern massif, Austrian Alps: The Holocene, v. 0, no. 0, p.

MARCOTT, S. A., SHAKUN, J. D., CLARK, P. U., AND MIX, A. C., 2013, A Reconstruction of Regional and Global Temperature for the Past 11,300 Years: Science, v. 339, no. 6124, p. 1198-1201.

NICOLUSSI, K., KAUFMANN, M., PATZELT, G., VAN DER PLICHT, J., AND THURNER, A., 2005, Holocene tree-line variability in the Kauner Valley, Central Eastern Alps, indicated by dendrochronological analysis of living trees and subfossil logs: Vegetation History and Archaeobotany, v. 14, no. 3, p. 221-234.

WIRTH, S. B., GLUR, L., GILLI, A., AND ANSELMETTI, F. S., 2013, Holocene flood frequency across the Central Alps - solar forcing and evidence for variations in North Atlantic atmospheric circulation: Quaternary Science Reviews, v. 80, p. 112-128.

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