Geophysical Research Abstracts,
Vol. 11, EGU2009-5062, 2009
EGU General Assembly 2009

Short- and long-term impacts of wildfires on geomorphic processes in the Tyrolean Limestone Alps

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Slopes affected by forest fires are widespread in the northern parts of the Eastern Alps. On the prevailing limestone bedrock only thin soils have been developed which may be damaged or destroyed by fire; consequently, some of the observed historical fires resulted in severe degradation. We currently investigate a variety of affected slopes using an interdisciplinary approach (historical investigation, vegetation mapping, soil investigation, geomorphic measurements and modeling).

Erosional processes have been measured directly by means of erosion pins, sediment traps and mapping/weighting of avalanche debris. The results clearly show that mass wasting processes have increased by 1-3 orders of magnitude even several decades after the fires. Smaller fire slopes are characterized mainly by small-scale relocation processes while on larger slopes, significant avalanche erosion and linear fluvial erosion taking place. Furthermore, higher magnitudes in surface runoff enhance the probability of debris flows.

In addition to the mentioned measurements, fluvial erosion was modelled by a rulebased empirical model which has been developed for steep slopes in alpine catchments. The model was calibrated by measuring bedload output of channels on steep slopes using sediment traps. The analysis of the measured data showed, that the mean annual bedload discharge highly depends on the extent of the sediment contributing area, the steepness of slopes and the degree of vegetation cover. This model was used to derive the bedload output of the channels on the aforementioned slopes affected by the wildfires. The modelling result was validated with the measured bedload discharge data. This validation showed good agreement between modelled and measured bedload discharge. Due to the fact that the model uses the vegetation cover (covered or not covered) for deriving the sediment contributing area, changes (scenarios) in the bedload discharge after e.g. natural reforestation on the slopes can be estimated. The model runs show that sediment discharge markedly decreases with increasing vegetation coverage and vice versa. This result confirms the influence of wildfires on fluvial geomorphic activity.

Howwever, the geomorphic significance of the fires can only be fully understood in the context of the long-term fire history. Historical investigations suggest that the fire frequency has significantly increased due to anthropogenic activity. However, natural lightning fires also occurred, and they probably had a very large extent in the past when no fire fighting was taking place. Thus, fire-induced soil erosion is possibly a part of the natural process equilibrium. On the long term, forest fires probably prevent the development of a climax woodland vegetation and support the typical krummholz (shrub) formations of the sub-alpine belt.