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Geomorphic modulation of climate impacts on soil-sediment temperature distributions in Alpine mountain basins

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Understanding the possible evolution of sediment transfer processes under past and future climate change is a critical challenge. This evolution is the product of two primary processes: (1) sediment production by soil and rock weathering and (2) process that control the erodability of weathered material. Alpine mountain basins are generally out of equilibrium with current climate such that there is commonly a prior accumulation of weathered material. What is of more importance is the extent to which this material is erodible in the face of climate change. Critical here are the effects of temperature change upon the distribution in space and time of the frozen surface layer, which will control both the thickness of potentially active sediment and the presence/absence of impeded drainage. Quantifying these processes and their changing spatial distribution in response to climate change will allow a better understanding of where and to what extent future climate change might impact upon sediment flux in these basins. However, this quantification requires consideration of a number of factors including: (1) the distribution of basin elevation with altitude (i.e. basin hypsometry), due to the effects of temperature lapse rates; (2) the distribution of basin aspect with altitude, due to the effects of aspect upon local temperature distribution; and (3) the combined effects of (1) and (2) upon the spatial patterns of snowfall which may exert a critical influence upon the onset of surface layer melt during the spring-summer period. We know that basin hypsometry varies as a function of geology, history of tectonic forcing and glacial erosion, producing basins that have the potential to module climate impacts upon soil-sediment erodability in very different ways. This poster aims to assess this modulation.

We reconstruct space-time patterns of soil-sediment temperature distribution for a number of Swiss mountain basins, with contrasting geology, tectonic history and glacial erosion. We drive a model of incoming solar radiation using high resolution DEM data and combine this with lapse rates to produce spatial distributions of mean annual temperature and typical annual temperature range for each basin. For each year, the surface temperature variation is considered to be sinusoidal and an analytical solution for 1-D heat conduction in the surface layer is used. The proposed model is simple, does not require heavy calibration and requires little field data for calibration. Meteorological and borehole monitoring network measurements are used as validation data to assess model outputs performances. We have integrated the frozen soil thickness over time to construct a thermal index to illustrate thechanging space-time patterns in active layer thickness over the last century and to construct possible future patterns. This reveals very strong geomorphic modulation of possible climate change effects due to the combined impacts of differences in basin hypsometry and basin aspect.