



^{137}Cs re-sampling as a method for soil erosion assessment in Alpine grasslands

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Over the past decades, radioactive fallout ^{137}Cs has been used as a tracer to provide information on soil erosion and sedimentation rates. However, the method may produce relatively large uncertainties in Alpine grasslands. The latter difficulties are caused by a combination of (i) the heterogeneous distribution of atmospheric ^{137}Cs Chernobyl fallout, (ii) the partly snow covered ground in Alpine areas during the fallout event in April 1986, which results in inhomogeneous ^{137}Cs distribution during snow melt and (iii) uncertainties in finding undisturbed references sites in the geomorphological and anthropogenic highly active slopes of the Alps.

To overcome these difficulties, our aim is to replace the classical ^{137}Cs approach, where an undisturbed reference site is compared to erosional sites, with a re-sampling approach, where we re-sample sites which have already been measured for ^{137}Cs inventories in the past. Thus, we use temporal instead of spatial reference.

The study area is located in the Central Swiss Alps in the Urseren Valley. Potential erosional sites have been sampled in 2007 and re-sampled in 2012. Two different grassland types were investigated: hayfield (2 sites) and pasture without dwarf shrubs (3 sites). For each site, 4 to 9 sampling points have been defined, and at each point two soil samples have been collected. To reduce the random error, the two soil samples were bulked prior to gamma-analysis. ^{137}Cs inventories of the two sampling years were calculated and used to assess recent soil erosion in the experimental sites.

Our results show that within the 5 years measurable soil erosion and deposition processes have occurred within the sites, as indicated by the relevant difference between the ^{137}Cs inventories of 2007 and 2012. 64% of the sites exhibit a decrease in ^{137}Cs inventories, 20% of the sites an increase, and the remaining 16% no significant difference. In particular, hayfield sites have been affected by erosion processes, mostly due to high snow glide and avalanche dynamic, whereas pasture inventories indicate both deposition and erosion. Resulting re-sampling erosion rates for the period of 2007-2012 indicate high erosion rates of $>20 \text{ t ha}^{-1} \text{ yr}^{-1}$, which confirm previous studies.

The ^{137}Cs re-sampling method has also been successfully tested to verify the appropriateness of reference sites. Reference sites in the study area, defined and sampled in 2010, have been re-sampled in 2013. Sites which did not show a considerable difference in ^{137}Cs inventories, may subsequently be used to apply the classical ^{137}Cs approach.

The ^{137}Cs re-sampling approach represents an effective and reliable method to assess short term erosion in Alpine grasslands, and a useful addition for the ^{137}Cs classical approach, in validating the suitability of reference sites.