Geophysical Research Abstracts
Vol. 16, EGU2014-1940-1, 2014
EGU General Assembly 2014

An attempt to estimate tolerable soil erosion rates by matching soil formation with denudation in Alpine grasslands

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Thresholds for soil erosion rates in alpine grasslands do not exist so far, partly due to the lack of soil formation rates, as an indicator for sustainable tolerable soil loss. We aimed at (i) defining soil formation rates for alpine grasslands on siliceous lithology and compare them to measured and modelled soil erosion rates with special focus on the Urseren Valley (Central Swiss Alps) and (ii) discuss possible future development under global change perspectives.
Ranges of soil formation rates were determined using published newly computed data for Alpine grasslands soils. Existing definitions of soil production and soil formation were combined into two new concepts to derive tolerable erosion rates: one is based on the actual soil production (as a function of time) and the other one on erosion rates linked to resulting soil depths. Soil erosion rates were taken from published studies in the European Alps in general with a special focus on the case study Urseren Valley.
Soil production is a strong function of time and ranges approximately from 50 – 100 t km-2 yr-1 in relatively old soils (10 – 18 kyr) to 100 – 900 t.km 2.yr 1 in young shallow soils (1-10 kyr). Erosion threshold values can be computed to ensure a specific soil depth. If a soil thickness of 20 cm is aimed at then erosion should not exceed 45 – 105 t km 2 yr 1. Measured recent soil erosion rates in alpine areas range from 600 to 3000 t.km-2.yr-1 in intensively used slopes. Average catchment values for the Urseren Valley using the model USLE were 180 t.km 2.yr 1, which already considerably exceeds soil formation rates leading in the long-term to a soil thickness of about 6 – 12 cm (fine earth considered only).
The current balance between soil formation and soil erosion rates indicates unsustainable management of grassland soils in the Urseren Valley. Other Alpine regions report similar or even higher erosion rates. Consequently, attention is needed in Alpine grasslands which are used for agricultural purposes because today's soil erosion rates might exceed soil formation considerably resulting in shallow soils. Development under future global change scenarios is likely to increase soil erosion rates even further.