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Be2D: A model to understand the distribution of meteoric ^{10}Be in soilscapes

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Cosmogenic nuclides have revolutionised our understanding of earth surface process rates. They have become one of the standard tools to quantify soil production by weathering, soil redistribution and erosion. Especially Beryllium-10 has gained much attention due to its long half-live and propensity to be relatively conservative in the landscape. The latter makes ^{10}Be an excellent tool to assess denudation rates over the last 1000 to 100 $\times$ 10^3 years, bridging the anthropogenic and geological time scale. Nevertheless, the mobility of meteoric ^{10}Be in soil systems makes translation of meteoric ^{10}Be inventories into erosion and deposition rates difficult. Here we present a coupled soil hillslope model, Be2D, that is applied to synthetic and real topography to address the following three research questions. (i) What is the influence of vertical meteoric Be^{10} mobility, caused by chemical mobility, clay translocation and bioturbation, on its lateral redistribution over the soilscape, (ii) How does vertical mobility influence erosion rates and soil residence times inferred from meteoric ^{10}Be inventories and (iii) To what extent can a tracer with a half-life of 1.36 Myr be used to distinguish between natural and human-disturbed soil redistribution rates? The model architecture of Be2D is designed to answer these research questions. Be2D is a dynamic model including physical processes such as soil formation, physical weathering, clay migration, bioturbation, creep, overland flow and tillage erosion. Pathways of meteoric ^{10}Be mobility are simulated using a two step approach which is updated each timestep. First, advective and diffusive mobility of meteoric ^{10}Be is simulated within the soil profile and second, lateral redistribution because of lateral soil fluxes is calculated. The performance and functionality of the model is demonstrated through a number of synthetic and real model runs using existing datasets of meteoric ^{10}Be from case-studies in southeastern US. Brute force optimisation allows reliably parameter constraining, resulting in a good agreement between simulated and observed meteoric ^{10}Be concentrations and inventories. Our simulations suggest that meteoric ^{10}Be can be used as a tracer to unravel human impact on soil fluxes when soils have a high affinity to sorb meteoric ^{10}Be.