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Fallout radionuclides indicate a 10% loss of European topsoil in 50 years

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Quantifying soil erosion is a major research challenge due to erosion's episodic character and spatial variation. Fallout radionuclides as $^{239+240}$Pu and ^{137}Cs are powerful tools to assess net soil losses integrated over long periods applicable to most regions of the world. The traditional approach of the FRN method is based on the comparison between an inventory (total radionuclide activity per unit area) at a given sampling site and that of an undisturbed reference site (e.g., located in a flat and well-vegetated area). Compared to reference, a decrease in the FRN inventory indicates erosion and an increase indicating deposition of sediments and associated FRN. So far, FRN based assessment was restricted to a regional/catchment scale as spatially distributed data of reference inventories was missing.

In this study, we aim at upscaling the FRN approach to a central area of Europe covering France, North Italy, South Germany, and Belgium using the Land Use/Cover Area frame Survey – LUCAS soil sample bank. Both fallout sources left a specific radionuclide imprint in European soils. First, plutonium was used to quantify global versus Chernobyl fallout contributions to ^{137}Cs found in European soils. Subsequently, spatial prediction models (general additive models) allowed reconstructing the global versus Chernobyl ^{137}Cs fallout pattern across national boundaries. The definition of these ^{137}Cs and the Pu baseline maps allows assessing soil redistribution rates at n=137 cropland sites with both FRNs across the study area. We selected barley, wheat, maize, and vineyard plots covering different slope angles as cropland sites. For both FRNs, differences between the reference and site-specific FRN inventory show an inventory and associated topsoil (0-20cm) loss of approximately 10% since 1963. Converting these inventory changes with a simple mass balance model to soil redistribution rates results in average soil erosion rates of 8.8 ± 6.3 t/

ha yr, assuming a tillage depth of 20 cm. Although the involved uncertainties are large, these net erosion rates exceed the expected magnitude.