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Application of bomb- and Chernobyl-derived radiocaesium for reconstructing changes in erosion rates and sediment fluxes from croplands in areas of European Russia with different levels of Chernobyl fallout

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1. Introduction

It is now generally accepted that global warming and land use change have caused significant changes of sediment redistribution rates within the different parts of the fluvial system during recent decades (Walling and Fang, 2003; Walling, 2009; Syvitski and Kettner, 2011; Vanmaercke et al., 2012, 2016). Obtaining reliable assessments of the magnitude of such changes can, however, encounter problems due to the lack, or limited availability, of long-term monitoring data. This is particularly the case for rates of sediment mobilization and transfer within catchments, since there are fewer long-term records of these components of sediment budgets than for the sediment loads of rivers and therefore catchment sediment yields (Nearing et al., 2005; Jetten and Favis-Mortlock, 2006; Wilkinson et al., 2009; Cerdan et al., 2010). In the absence of long-term monitoring data for erosion rates, models can be used to reconstruct changes in rates of sediment mobilization and transfer, but the reliability of the results will depend heavily on the nature of the model used and its ability to deal with a non-stationary conditions. Major changes in land use and changes in hydrometeorological conditions, such as a reduction in snow accumulation during winter and in the incidence of frozen conditions, resulting in the reduced importance of the spring melt in causing soil erosion, can introduce problems for model calibration. The inherent inter-annual variability of erosion rates and the occurrence of extreme events introduces additional problems in attempting to identify and quantify such changes and trends (García-Ruiz et al., 2015). Existing analysis of available datasets suggests that a record of anual erosion rates spanning ca. 20–25 years is required to derive a reliable estimate of the mean annual erosion rate. Such data are frequently seen as an important requirement for characterizing the spatial variability of sediment transport dynamics at the regional scale (Walling, 1991; Golosov et al., 2013; García-Ruiz et al., 2015). However, the limited availability of long-term monitoring data again limits the scope for assembling reliable information on longer-term mean annual erosion rates.

Against this background, there is a need to explore other approaches to quantifying medium-term erosion rates and, more particularly, changes in erosion rates through time in response to land use and climate change. The use of fallout radionuclides, including caesium-137 (^{137}Cs) and unsupported or excess lead-210 (^{210}Pb$_{ex}$), has provided a timely and valuable basis for obtaining time-integrated estimates of mean anual erosion rates over a period of ca. 50–60 years with ^{137}Cs or ca. 100 years with ^{210}Pb$_{ex}$ (Walling and He, 1992; Zapata, 2002; Mabit et al., 2008; Benmansour et al., 2013; Olson et al., 2013). Where Chernobyl fallout occurred in 1986 and it dominates the ^{137}Cs inventory, the time window involved may be reduced to ca. 30 years (see Golosov, 2002). However, this general approach is of limited value for assessing changing erosion rates and the trends involved. Recent studies by Porto et al. (2014, 2016a) have demonstrated the potential for using repeat measurements or resampling procedures involving ^{137}Cs and ^{210}Pb$_{ex}$ to estimate medium-term erosion rates for different time windows and to therefore quantify changes in erosion rates between those time windows. However, although valuable, this approach can face problems in defining the precise

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