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Multivariate geostatistical analysis of fallout radionuclides activity measured by in-situ gamma-ray spectrometry
Case study: Loessial paired sub-catchments in northeast Iran

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ABSTRACT

Cs-137 and other fallout radionuclides (FRNs) have been used worldwide for more than four decades as powerful techniques to assess the magnitude and spatial pattern of soil redistribution. Cs-137, $^{210}Pb_{ex}$, and ^{7}Be have successfully been used as tracers of soil redistribution. Their coincident use can frequently provide worthwhile information for different time scales of soil redistribution. These radionuclides can either be measured in the laboratory or in-situ. In the present study in-situ measurements using a portable HPGe detector were carried out in two loessial paired sub-catchments with fairly similar characteristics in northeast Iran. Spatial sampling design based on a minimax approach was used to determine that 60 sites were sufficient for both areas of interest. Geostatistical analysis and the linear model of co-regionalization (LMC) were applied in this study for radionuclides. The spherical model for Sample and Testifier sub-catchments with ranges of 750 m and 500 m respectively was selected as the most suitable model. The highest and the lowest non-captured variability belonged to $^{210}Pb_{ex}$ and ^{7}Be for both studied areas. The patterns of spatial variation of ^{7}Be and Cs-137 for Sample and the patterns of spatial variation of ^{7}Be and $^{210}Pb_{ex}$ for Testifier sub-catchment were very similar. For Cs-137, global uncertainty for both sub-catchments was nearly the same, but different for other radionuclides. The distribution of local uncertainty for all radionuclides in the Testifier sub-catchment was the same. The means of spatial distance between the grid cells with the highest and the lowest uncertainty for ^{7}Be, Cs-137, and $^{210}Pb_{ex}$, are 0.4, 1, and 7 km, respectively.

1. Introduction

Cs-137, excess or unsupported lead-210 ($^{210}Pb_{ex}$), and beryllium-7 (^{7}Be) are non-exchangeable radionuclides. They have been used world-widely for more than four decades, and their use has proved to be a powerful technique to assess the magnitude and spatial pattern of soil erosion and sedimentation (Ritchie and Ritchie, 2008). They are rapidly and strongly fixed by the surface soil or small sediment particles. For these reasons, they have successfully been used as tracers of soil redistribution (Wallbrink and Murray, 1993; Walling and He, 1999; Matisoff et al., 2002; Zapata, 2002; Walling et al., 2003; Zhang et al., 2003; Mabit et al., 2008; An et al., 2014).

Due to different history and half-life of these radionuclides (Zapata, 2002), their simultaneous use can frequently provide worthwhile information for different temporal scales of soil erosion and sedimentation (Mabit et al., 2008).

Not only soil redistribution data over different temporal scales can be obtained using a single soil sampling, thereby avoiding time consuming and costly installations (Mabit et al., 2008), but

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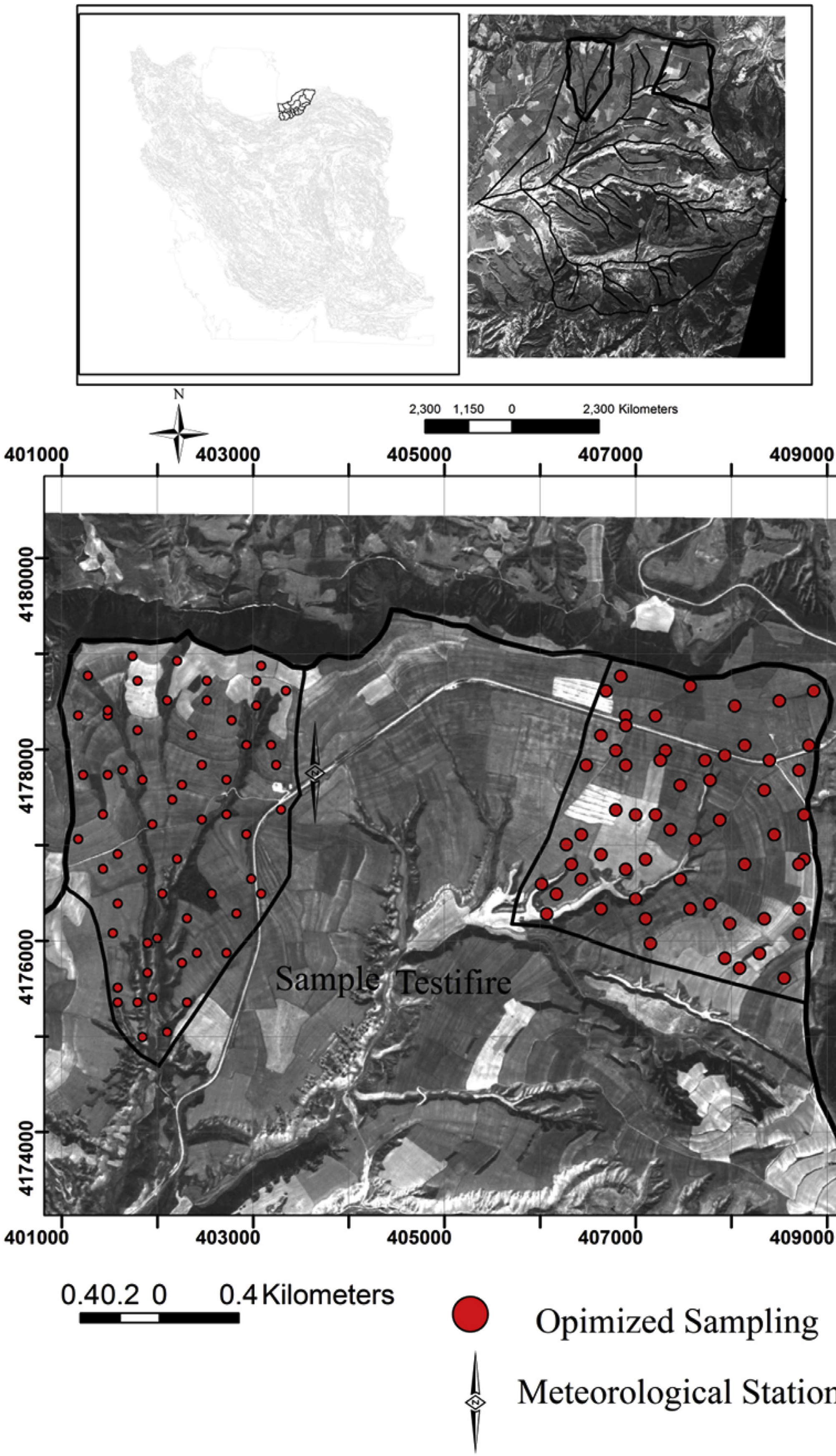

Fig. 1. Location of study area (paired sub-catchments) in northeast of Golestan Province, Iran.

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