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Spatial heterogeneity of Cs-137 soil contamination at the landscape scale of the Bryansk Region (Russia)

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The passage of the Chernobyl plume over the Bryansk region (Russia) in the end of April 1986 led to the deposition of radionuclides on the ground by wet and dry deposition processes. According to the results of the Cs-137 air gamma survey (AGS, grid size: 100 m x100 m), which was conducted in summer 1993, it was shown that the processes of Cs-137 lateral migration took place due to nearly a fourfold increase of Cs-137 in the lower slope as compared to the upper part of the slope during a seven-year period after the Chernobyl accident. The variability patterns of Cs-137 could be described by a stochastic or a deterministic function of the measurement location. The patterns variations could be associated with the nonlinear response of many interacting variables within the landscape system.

In the test area located at a distance of about 280 km from the Chernobyl Nuclear Power Plant Cs-137 surface activity typically ranges from below 7 kBq/m2 to approximately 50–60 kBq/m2 re[U+FB02]ecting the combination of deposition due to global fallout from the atmospheric testing of nuclear weapons, and the relatively low levels of Chernobyl deposition to the area.

To model the Cs-137 distribution depending on complex landscape attributes the following information layers were used: 1) the soil map at the scale of 1:50,000; 2) SRTM elevation data acquired from the Global Land Cover Facility at a 3 arc second resolution. Fundamental difficulties in distributed erosion modelling arise from the natural complexity of landscape systems and Cs-137 spatial heterogeneity.

The SRTM DEM of the test site has a grid size about 90 m, which is not sufficient for distributed hydrological modelling at the landscape scale. The scaling problem arises because of the mismatch between SRTM DEM pixel dimensions and the size of erosion network (width about 10-50 m) that concentrates Cs-137 run-off from the overlying slopes and watershed areas. To build a hydrologically correct local drain direction (LDD) with a 12.5, 25 and 50 m grid a downscaling procedure was applied.

The downscaling procedure is based on an original data approximation method - Simplicity versus Fitting (SvF). The method is to find a compromise between the simplicity of a model and the precision of experimental data replication.

Using the downscaling method in a similar way, maps of cesium distribution with different levels of mesh – 12.5, 25 and 50 m were built. The study of scaling relationships for map resolution (pixel sizes) between cesium heterogeneity and DEM derivatives was conducted.