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The spatial distribution of caesium-137 over Northern Ireland from fallout from the Chernobyl nuclear accident

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The spatial distribution of caesium-137 (^{137}Cs) across the land is of much interest because it can tell us about the redistribution of the radionuclide as a result of soil erosion, differential migration through the soil—or its complement, differential retention in the soil. Any such inferences from survey measurements depend on the assumption of a broadly even distribution from weapons testing fallout, and the substantial deposition of ^{137}Cs in rain following the Chernobyl accident on 26 April 1986. Deposition from the latter was not uniform over large areas, of course, and measurements across northern England showed that the magnitude of ^{137}Cs deposition depended largely on the distribution of convective rainfall in the days immediately after the accident. There were too few measurements of ^{137}Cs deposition at close spacings to estimate local variation.

Twenty years after the deposition from Chernobyl a detailed airborne radiometric survey of the whole of Northern Ireland was flown. Flights were made along transects 200 m apart with recordings at 80 m intervals along the flight lines to give more than one million data in total. We have used the data to investigate the spatial distribution of ^{137}Cs. Our initial geostatistical analyses suggested substantial short-range variation in the distribution of ^{137}Cs. We wished to determine whether soil erosion or soil type could account for this. We made further detailed analyses using the terrain parameter compound topographic index as an index of soil erosion and deposition and soil maps to account for the migration or retention of ^{137}Cs.

The concentration of ^{137}Cs in the soil is greatest where most rain fell in the few days after the accident. However, the local variances are of similar magnitudes across the the majority of the province. The global variogram of the radionuclide shows a large proportion of the spatially correlated variance occurring within 700 m and a longer-range structure extending to 15 km. Local variograms where most rain fell have the largest proportions of correlated variance. Soil type in these regions accounts for 18% of the spatially correlated variance, which suggests that soil controls the migration of ^{137}Cs to some extent. This inference accords with our independent measurements of ^{137}Cs down through the soil. By contrast, the terrain index accounted for very little of the variance, which suggests that soil erosion across the largely vegetated landscape has been a much smaller contributor to redistribution of the radionuclide. The largest short-range variation in ^{137}Cs concentrations occurs in the Mourne Mountains (in the south east of the province), probably because of the numerous small patches of organic-rich soil interspersed between shallow, raw soil over granite. This observation suggests that differences in the capacity of the soil to trap and retain the radionuclide is the dominant factor accounting for the observed short-range variation. We cannot determine the relative importance of deposition in accounting for the observed short-range variation because we do not have measurements at a sufficiently fine resolution.

We discuss the implications of our findings for the use of ^{137}Cs as a tracer where the radionuclide was deposited after the Chernobyl accident. We are continuing to process the airborne radiometric data to remove potential interferences caused by radon.