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Model assessment of additional contamination of water bodies as a result of wildfires in the Chernobyl exclusion zone

Yu. I. Bondar [a], A.D. Navumau [b], A.N. Nikitin [b], J. Brown [c, d], M. Dowdall [c, *]

[a] Polessie State Radiation-Ecological Reserve, Khoiniki, Belarus
[b] Institute of the Radiobiology of the National Academy of Sciences of Belarus, Gomel, Belarus
[c] Norwegian Radiation Protection Authority, Østerås, Norway
[d] Centre for Environmental Radioactivity, Ås, Norway

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ABSTRACT

Forest fires and wild fires are recognized as a possible cause of resuspension and redistribution of radioactive substances when occurring on lands contaminated with such materials, and as such are a matter of concern within the regions of Belarus and the Ukraine which were contaminated by the Chernobyl accident in 1986. Modelling the effects of such fires on radioactive contaminants is a complex matter given the number of variables involved. In this paper, a probabilistic model was developed using empirical data drawn from the Polessie State Radiation-Ecological Reserve (PSRER), Belarus, and the Maximum Entropy Method. Using the model, it was possible to derive estimates of the contribution of fire events to overall variability in the levels of ^{137}Cs and ^{239,240}Pu in ground air as well as estimates of the deposition of these radionuclides to specific water bodies within the contaminated areas of Belarus. Results indicate that fire events are potentially significant redistributors of radioactive contaminants within the study area and may result in additional contamination being introduced to water bodies.

1. Introduction

Forest and wildfires are one of the major contributors of gaseous and particulate pollutants to the atmosphere (Lazaridis et al., 2008) and can play a significant role in terms of their influence on atmospheric chemistry and levels of airborne radioactivity (Luterbacher et al., 2004; Carvalho et al., 2012). As a result of the nuclear accident at the Chernobyl nuclear power plant in 1986, approximately 6 million hectares of mixed forest were contaminated by radionuclides, the most heavily contaminated area of forest covering over 2 million hectares of the territories of Belarus and Ukraine (see Fig. 1). Wildfires occurring on such contaminated territories pose a high risk for firefighters due to the local dispersal of radioactive materials and resuspension to air. Additionally, populations may be affected by radioactive smoke particles that can be transported over long distances (Dusha-Gudym, 1996, 2005; Hao et al., 2009). However the results of controlled burning of experimental plots of forest or grassland in the Chernobyl exclusion zone has indicated that the transport and deposition of radioactive particles during forest and grassland fires cannot be considered as being extensive (Yoschenko et al., 2006a,b). Differences in opinion on this issue arise from the extreme complexity regarding the direct measurement of radionuclides released into the atmosphere from wildfires, their transfer over long distances and their residence times in the atmosphere. The work reported upon here with respect to model evaluation is directed towards attempting to address this problem.

Modelling changes in the airborne concentration of radionuclides in the atmosphere after fire events facilitates elucidation of the scale of their spatial distribution, as well as allowing estimation of changes in the radiation exposure of living organisms and people at different distances from the fire. It should be noted that features of forest and wildfires put significant limitations on using most popular types of models: the source of radionuclides is a wide area (frequently fluctuating in both size and location) with an uneven distribution of emissions with respect to time and area, a degree of inherent spontaneity is present as well as differences in the properties of the combustible materials involved and variability in the burn height (from subsurface to 10–20 m and higher). Strong wildfires can cause alterations in tropospheric properties that exert an influence on radionuclides transfer in the atmosphere (Goldammer et al., 2008) and, in some contrast to other anthropogenic sources of radionuclides, forest and agricultural biomass fires are poorly described in the literature due to the inherent

* Corresponding author.
E-mail address: mark.dowdall@nrpa.no (M. Dowdall).

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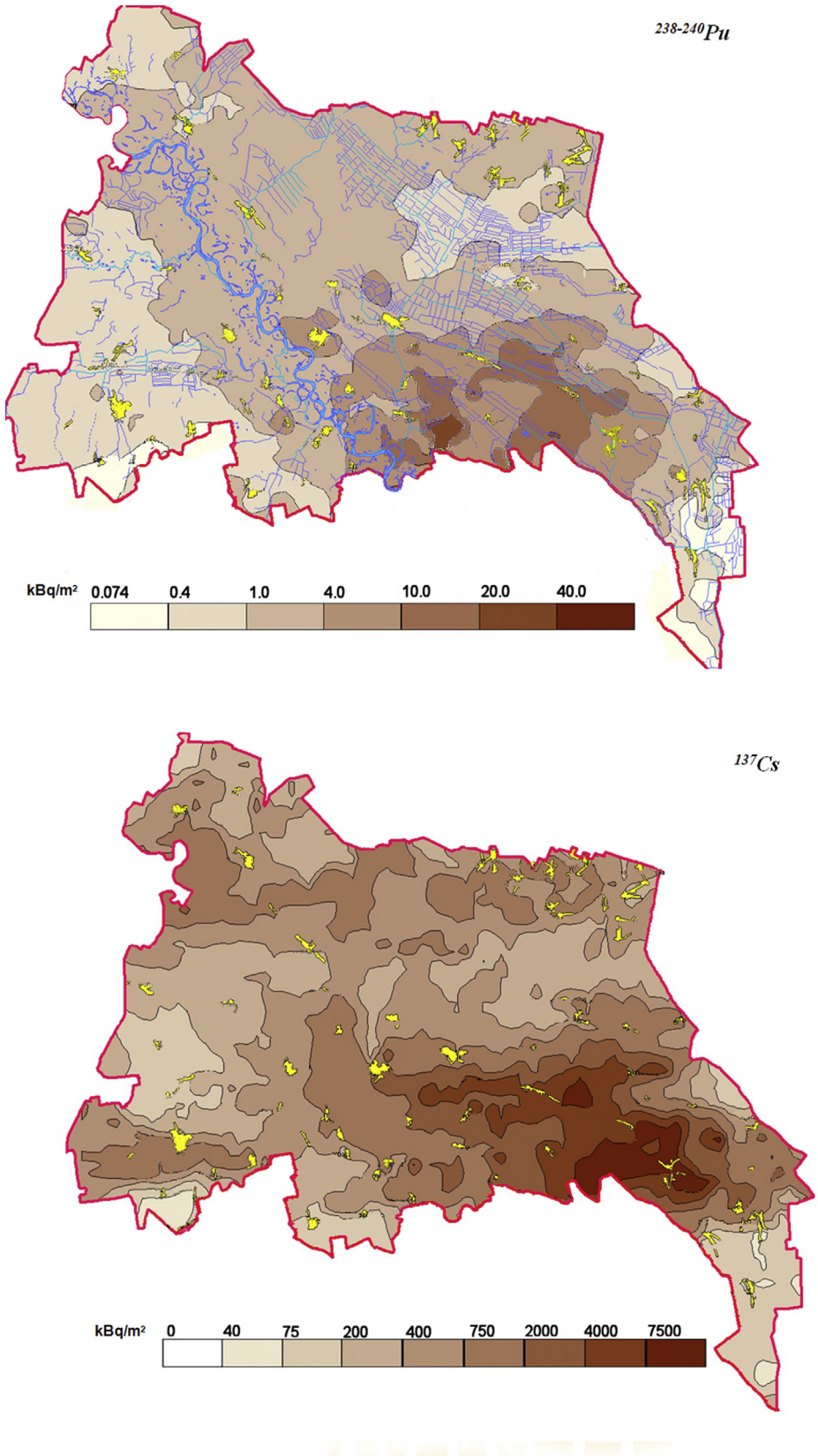

Fig. 1. Contamination densities of ^{137}Cs and $^{238-240}Pu$ in soils of the Polessie State Radiation-Ecological Reserve (PSRER).