Distributed model of radionuclide wash-off from the Pripyat river watershed of Chernobyl Exclusion Zone: testing and simulation of accidental deposition on snow cover

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The models of radionuclide wash-off from watershed were tested mainly for the experimental plots or for the small river watersheds. The development of the model of radionuclide wash-off due to snow melting within EC OPERRA-HARMONE project and the data collection within Japanese JICA-JST funded "Chernobyl project" of the program SATREPS provided an opportunity to simulate the radionuclide wash-off from the watershed of the Pripyat River in the Chernobyl Exclusion Zone (ChEZ).

The model of radionuclide wash-off during the snow melting RETRACE -RS was developed as the extension of the model RETRACE –R (Zheleznyak et al, 2010), which code is integrated into the Hydrological Dispersion Module of the Decision Support System RODOS. RETRACE -R is based on such assumptions:

(A) the rate of the radionuclide wash-off formed by each elementary grid cell of the watershed is calculated from precipitation rate and density of deposition in this cell through the "wash-off" coefficient (Monte et al., 2004; Smith et al, 2004; Garcia-Sanchez and Konoplev, 2009).

(B) radionuclides washed out from the cell are transported without time delay to the nearest river channel cell - to the 1-D grid element of the river model RIVTOX.

The model RETRACE –RS describes the water flux on the watershed as the sum of the precipitations and water yield from the snow melting. It is assumed that radionuclides deposited on snow cover are evenly distributed (diluted) in the water column of melted snow. The vertical water flux described by the model can be considered as "snowmelt for a certain time period" of the widely used "temperature index approach" for snow melting modelling.

The digital maps of ^{137}Cs and ^{90}Sr depositions in the ChEZ were constructed on the basis of the database collected by (Kaspharov et al, 2001). The maps of the snow cover height and density during the winters 1985-1986 and 1986 -1987 were obtained from the Ukrainian Hydrometeorological Center. The one-dimensional river hydrodynamic and radionuclide transport model RIVTOX is implemented for Pripyat River, Kiev reservoir and Dnieper river downstream to Kiev. RIVTOX receives the lateral inflow along the river channel simulated by RETRACE-RS on the grid covering ChEZ. The model testing for the spring flood 1987 shows a reasonable comparison of the simulated and measured dynamics of the concentrations of ^{90}Sr and ^{137}Cs in river water near Chernobyl and Kiev.

The model was implemented for the scenario of the "Alternative History" of the Chernobyl accident that in this scenario happens 1.01.1987 producing the same deposition as after the real Chernobyl accident 26.04.1986 however on snow cover. The modelled huge water contamination in this scenario provides an upper estimate of the consequences of a "winter Chernobyl accident".

The way of further watershed model extension by the introducing the "coefficient of washing-out of particulate radionuclide" is discussed.