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Distributed modeling of radionuclide washing out from the watersheds in solute and with suspended sediments: case studies Abukuma River, Fukushima Prefecture and Pripyat – Dnieper river system, Ukraine

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The measurements of ^{137}Cs concentration in the rivers of Fukushima prefecture demonstrate the more significant role of the fluxes of ^{137}Cs adherent to the suspended sediments in comparison with the rivers contaminated after the Chernobyl accident. Therefore the forecasting of ^{137}Cs concentration during the floods requires to use the models of radionuclide wash-off from the watersheds with sediments.

Comprehensive modeling of radionuclide transport processes could be provided on the basis of the physically-based distributed models of hydrological and sediments transport processes. Such distributed models can describe soil erosion and sedimentation processes, as also exchange of the radionuclides between solute, suspended sediment and upper soil level. We developed such type .model DSHVM-R based on the distributed hydrological- sediment transport model DHSVM of Washington University. The model implementation for the experimental plots in Fukushima prefecture demonstrated a good possibility of the model for the analyses on the influence of the steepness of the watershed slopes and the intensity of the rainfall in the increased role of particulate ^{137}Cs transport. From another side, the implementation of such a model for large river watershed required too large computational time and significant efforts for processing of the large sets of the distributed data still not available for all watersheds.

We developed model RETRACE _RS that combines the simplicity of the watershed empirical models based on the washing -out coefficient approach with the possibility to use geographically distributed data of the radioactive fallout and GIS layers for rivernets. The model RETRACE_RS is an 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 the assumptions that the rate of the radionuclide wash- off from each elementary grid cell of the watershed can be calculated from precipitation rate and density of deposition in this cell through the “wash-off” coefficient Kw; and that the radionuclides washed out from the cell are transported without time delay to the nearest river channel cell - to the grid element of the 1-D river model

RIVTOX as lateral inflow. In RETRACE _RS the possibility of RETRACE_R to simulate washing -out of the radionuclides from watershed to river in solute was extended by the fluxes of the particulate radionuclide transport calculated via the " washing out coefficient for particulate radionuclide transport " -Kss. The formula to calculate Kss values is based on the empirical relations for the particulate ^{137}Cs transport in the rivers of Fukushima prefecture (Sakuma et al, 2019). The model was tested on the basis of the measurements of ^{137}Cs concentration in Abukuma river during the high floods in 2018-2019. The modeling system RETRACE_RS - RIVTOX was validated also on the basis of the data sets of radionuclide transport in the Pripyat and Dnieper rivers. The system is testing for the prediction of aquatic radionuclide transport from the Chernobyl NPP area to the Kyiv region during the extreme floods.