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Distributed modeling of radiocesium washoff from the experimental watershed plots of the Fukushima fallout zone

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The distributed hydrological "rainfall- runoff" models provide possibilities of the physically based simulation of surface and subsurface flow on watersheds based on the GIS processed data. The success of such modeling approaches for the predictions of the runoff and soil erosion provides a basis for the implementation of the distributed models of the radionuclide washoff from the watersheds. The field studies provided on the Chernobyl and Fukushima catchments provides a unique data sets for the comparative testing and improvements of the modeling tools for the watersheds located in the areas of the very different geographical and hydro-meteorological condition The set of USLE experimental plots has been established by CRIED, University of Tsukuba after the Fukushima accident to study soil erosion and 137Cs wash off from the watersheds (Onda et al, 2014).
The distributed watershed models of surface and subsurface flow, sediment and radionuclide transport has been used to simulate the radionuclide transport in the basin Dnieper River, Ukraine and the watersheds of Prefecture Fuksuhima. DHSVM-R is extension of the distributed hydrological model DHSVM (Lettenmayer, Wigmosta et al, 1996-2014) by the including into it the module of the watershed radionuclide transport. DHSVM is a physically based, distributed hydrology-vegetation model for complex terrain based on the numerical solution of the network of one-dimensional equations. The surface flow submodel of DHSMV has been modified: four-directions schematization for the model's cells has been replaced by the eight-directions scheme, more numerically efficient finite -differences scheme was implemented. The new module of radionuclide wash-off from catchment and transport via stream network in soluble phase and on suspended sediments including bottom-water exchange processes was developed for DHSMV-R.
DHSVM-R was implemented recently within Swedish- Ukrainian ENSURE project for the modeling of 234U wash-off from the watershed of Konoplyanka river, tributary of Dnieper Rivet at the territory of the Pridneprovsky Chemical) Plant and neighboring tailings dumps. The modeling results has been used for the assessment of the watershed's "hot spots" and analyses of the ways of the diminishing of the uranium wash off from the watersheds
The testing of DHSMV-R has started in 2014 for Fukushima watershed experimental plots. The major amount of 137Cs is washed out from watershed on sediments and only small fraction in solute. The reason for such phenomenon that was not observed at Chernobyl can be - steeper slopes, more intensive rains (daily maximum in Fukushima city at 160 mm, hourly maximum 69mm) and higher Kd values due to the volcanic kind of soils. The virtual rain of the daily amount 200 mm (as in mountains around Fukushima city) was applied for Farmland A1-slope 7.36% and imaginary watershed (case B) the same as A1 however slope as in Chernobyl plots (Konoplev, 1996) 4%.
Due to the high nonlinearity in erosion equations for the such heavy precipitations the total amount of washed out 137Cs with sediments for the steep watershed A due to the simulated rainstorm (11530 Bq) is at 20 times higher, than such amount for mild slope watershed B (690 Bq) when the watershed A is only twice steeper than B.
The modeling results demonstrate that the higher intensity of the extreme rainstorm in Fukushima area than in Chernobyl area initiated even on slightly steeper slopes the much higher amount of 137Cs washed out with sediments in Fukushima than in Chernobyl area. The successful testing of the distributed model provides the background for the simulation of the watersheds of the larger scales for small, medium and large rivers. The implementation of such models is important as for the forecasting of 137Cs wash out from the watersheds and following transport in rivers for the highest extreme floods that still did not happen in Fukushima area after the accident, as also for the long term forecasting of 137Cs in watershed-river systems at Fukushima.