学位論文内容の要旨

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学位論文題名

Modelling hydrological processes and ^{137}Cs load responses to climate and land use changes in Hiso River watershed, Fukushima, Japan

（福島県比曽川流域における気候と土地利用の変化に対する水文過程と^{137}Cs負荷応答のモデル化）

Hiso River watershed (HRW) is within the radiocesium contaminated area caused by the disaster in Fukushima Daiichi nuclear power plant (FDNPP). Lots of Cesium-137 (^{137}Cs) released from the FDNPP were discharged from the terrestrial environments through the river system and considered as most risk contributor for human health and ecosystems. The subsequent decontamination work after the FDNPP accident resulted in enormous land use change in HRW. With the uncertain tandem roles of expected changes played in hydrological processes, there is an urgent need to evaluate the impacts of climate and land-use changes on hydrological processes and estimate the ^{137}Cs discharge. The key objectives of this study are: (1) to downscale future climatic variables using the statistical method (SD) from three General circulation models (GCMs) and evaluate the effect of temperature and precipitation on hydrological processes. (2) to evaluate streamflow, sediment and ^{137}Cs load using the SWAT model in HRW. (3) to evaluate components of water cycle in different scenarios based on changes of future climate and land use in HRW.

1. Temperature and precipitation projection from multi-GCMs

This study strives to construct future daily rainfall and maximum and minimum temperature (Tmax and Tmin) from three GCMs (CanESM2: Representative Concentration Pathway (RCP) 2.6, 4.5 and 8.5; HadCM3: A2 and B2; MIROC5: RCP2.6, 4.5 and 8.5) in HRW by SD. Projections in three future periods (2030s: 2010-2039, 2060s: 2040-2069, and 2090s: 2070-2099) are compared to observations in the baseline (1980-2009). Tmax and Tmin are predicted to increase by -0.6 – 4.2 °C and -0.1 – 3.9 °C under all climate scenarios. Conversely, there are several discrepancies in the projections of precipitation under different GCMs scenarios. MIROC5 is projected a range of 11.6 – 13.3 % increasing in rainfall, but CanESM2 and HadCM3 with the decline trends by 17.4 % and 0.2 %, respectively. The generated outcomes from three GCMs exhibit an increase (4.5%) in temperature while a decrease (-2.0%) in precipitation, which is expected that there will be a warmer and dryer weather in HRW.

2. Hydrological processes responses to land use change and ^{137}Cs load modelling

This study applied the Soil and Water Assessment Tool (SWAT) to assess the dynamics of streamflow and sediment yields during 2013-2017 at daily scale in HRW. Then ^{137}Cs load in the river was evaluated and simulated using the well-calibrated SWAT model and the equation between turbidity and dissolved and suspended ^{137}Cs. SWAT model successfully simulated streamflow and sediment yield. Steep areas were identified as the critical source area of soil erosion and deposition dominated channel sediment routing during 2013-2017. After excluding extreme peak values caused by heavy rainfall weather, the monthly total ^{137}Cs load in the stream was basically well simulated ($R^2 > 0.52$ and $Ens > 0.47$). The simulated total ^{137}Cs load of 3263.02 MBq/yr was close to the observed of 3573.36 MBq/yr. Besides, three land use scenarios were assumed under climate conditions of 2011-2017 in SWAT model. Scenario 1 assumed no agriculture abandon, scenario 2 assumed agricultural land changed to be wild grass, and scenario 3 assumed agricultural/wild grass land changed to be bare land. Results showed that conversion from agricultural lands to wild grass showed a relative small decrease of streamflow (-0.8%) while a more evident decrease of sediment yield (-21%). In addition, streamflow and sediment yield obviously increased 3.8-4.6% and 28-63%, respectively, when the land with plant cover was changed to the bare land.

3. Impacts of climate and land use changes on hydrological processes

Three land-use change scenarios under future climate scenarios from three GCMs were established and input into SWAT model during 2010-2099, compared to baseline of 1980-2009. Smallest increased temperature and greatest decreased rainfall derived from CanESM2 led to the greatest decreased (4.8–94.0%) in all water balance components. Highest temperatures and more rainfall from MIROC5 resulted that water yield (WY), surface runoff (SURQ), groundwater flow (GWQ) and lateral flow (LATQ) increased 19.1%, 29.8%, 18.0%, and 17.3%, respectively. While decreased in evapotranspiration (ET) by 2.4–9.5%. MIROC5-RCP8.5 scenario always generated larger magnitudes for climatic variables and water balance components compared with other climate scenarios. Land use changes will bring a minor influence on simulated mean annual WY, LATQ and ET in the future. However, it will strongly impact on SURQ and GWQ when agricultural/wild grass land changed to bare land, which obviously increases SURQ.