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Implementing soil erosion process into the land surface model ORCHIDEE

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Erosion and transport of sediments and soil organic carbon (SOC) by running water play an important role in global biogeochemical cycles. Nevertheless, these processes are still ignored in land surface models which are used to project the future land-atmosphere C fluxes in response to anthropogenic CO_2 emissions, climate and land use change. By implementing the soil erosion model MUSLE (the Modified Universal Soil Loss Equation) into the land surface scheme ORCHIDEE (the ORganizing Carbon and Hydrology in Dynamic Ecosystems), we developed the new model ORCHIDEE-MUSLE that simulates the erosion-induced loss of sediment and SOC from land to inland waters, as well as the impacts of soil erosion on vertical SOC profiles at daily time step. Evaluation of ORCHIDEE-MUSLE for the Rhine Watershed in Europe shows that our model reasonably reproduces the magnitude and spatial pattern of soil erosion rates, as well as the seasonal patterns of sediment discharge rates at different locations of the Rhine Watershed. From 1901 to 2014, the average sediment loss rate from slope-land to river networks in Rhine Watershed is about 53.02 ($\pm$21.90) g m^{-2} yr^{-1}, and the SOC loss rate is 0.42 ($\pm$0.19) g C m^{-2} yr^{-1}. Soil erosion during the whole simulated 114 year has averagely induced a reduction of 0.45% of the total SOC stock in the top 2 m soil layer of the Rhine Watershed. We conclude that the coupling of MUSLE and ORCHIDEE should be a feasible and reliable way to implement soil erosion and deposition processes into land surface model.