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Comparison of SWAT and a deep learning model in nitrate load simulation at the Tuckahoe creek watershed in the United States

Jiye Lee[1], Dongho Kim[2], Seokmin Hong[3], Daeun Yun[3], Dohyuck Kwon[3], Robert Hill[1], Yakov Pachepsky[4], Feng Gao[4], Xuesong Zhang[4], Sangchul Lee[2], and KyungHwa Cho[5]

[1]University of Maryland, College Park, United States of America (jiyelee@umd.edu, rlb@umd.edu)
[2]University of Seoul, Seoul, Republic of Korea (hoya@uos.ac.kr, slee2020@uos.ac.kr)
[3]Ulsan National Institute of Science and Technology, Ulsan, Republic of Korea (hge7524@unist.ac.kr, allsilveryun@unist.ac.kr, kwon3969@unist.ac.kr)
[4]US Department of Agriculture-Agricultural Research Service, Beltsville, United States of America (yakov.pachepsky@usda.gov, Feng.Gao@usda.gov, Xuesong.Zhang@usda.gov)
[5]Korea University, Seoul, Republic of Korea (khcho80@korea.ac.kr)

Simulating nitrate fate and transport in freshwater is an essential part in water quality management. Numerical and data-driven models have been used for it. The numerical model SWAT simulates daily nitrate loads using simulated flow rate. Data-driven models are more flexible compared to SWAT as they can simulate nitrate load and flow rate independently. The objective of this work was evaluating the performance of SWAT and a deep learning model in terms of nutrient loads in cases when deep learning model is used in (a) simulating flow rate and nitrate concentration independently and (b) simulating both flow rate and nitrate concentration. The deep learning model was built using long-short-term-memory and three-dimensional convolutional networks. The input data, weather data and image data including leaf area index and land use, were acquired at the Tuckahoe Creek watershed in Maryland, United States. The SWAT model was calibrated with data over the training period (2014-2017) and validated with data over the testing period (2019) to simulate flow rate and nitrate load. The Nash-Sutcliffe efficiency was 0.31 and 0.40 for flow rate and -0.26 and -0.18 for the nitrate load over training and testing periods, respectively. Three data-driven modeling scenarios were generated for nitrate load. Scenario 1 included the flow rate observation and nitrate concentration simulation, scenario 2 included the flow rate simulation and nitrate concentration observation, and scenario 3 included the flow rate and nitrate concentration simulations. The deep learning model outperformed SWAT in all three scenarios with NSE from 0.49 to 0.58 over the training period and from 0.28 to 0.80 over the testing period. Scenario 1 showed the best results for nitrate load. The performance difference between SWAT and the deep learning model was most noticeable in fall and winter seasons. The deep learning modeling can be an efficient alternative to numerical watershed-scale models when the regular high frequency data collection is provided.