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Neural network simulation of soil NO_3 dynamic under potato crop system

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Nitrate leaching is a major issue in sandy soils intensively cropped to potato. Modelling could test and improve management practices, particularly as regard to the optimal N application rates. Lack of input data is an important barrier for the application of classical process-based models to predict soil NO_3 content (SNOC) and NO_3 leaching (NOL). Alternatively, data driven models such as neural networks (NN) could better take into account indicators of spatial soil heterogeneity and plant growth pattern such as the leaf area index (LAI), hence reducing the amount of soil information required. The first objective of this study was to evaluate NN and hybrid models to simulate SNOC in the 0-40 cm soil layer considering inter-annual variations, spatial soil heterogeneity and differential N application rates. The second objective was to evaluate the same methodology to simulate seasonal NOL dynamic at 1 m deep. To this aim, multilayer perceptrons with different combinations of driving meteorological variables, functions of the LAI and state variables of external deterministic models have been trained and evaluated. The state variables from external models were: drainage estimated by the CLASS model and the soil temperature estimated by an ICBM subroutine. Results of SNOC simulations were compared to field data collected between 2004 and 2011 at several experimental plots under potato cropping systems in Québec, Eastern Canada. Results of NOL simulation were compared to data obtained in 2012 from 11 suction lysimeters installed in 2 experimental plots under potato cropping systems in the same region. The most performing model for SNOC simulation was obtained using a 4-input hybrid model composed of 1) cumulative LAI, 2) cumulative drainage, 3) soil temperature and 4) day of year. The most performing model for NOL simulation was obtained using a 5-input NN model composed of 1) N fertilization rate at spring, 2) LAI, 3) cumulative rainfall, 4) the day of year and 5) the percentage of clay content. The MAE was 22% for SNOC simulation and 23% for NOL simulation. High sensitivity to LAI suggests that the model may take into account field and sub-field spatial variability and support N management. Further studies are needed to fully validate the method, particularly in the case of NOL simulation.