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Are our dynamic water quality models too complex? A comparison of a new parsimonious phosphorus model, SimplyP, and INCA-P

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Catchment-scale water quality models are used for exploring the potential effects of land management, land use change and climate change on water quality. However, the dynamic, catchment-scale nutrient models in common usage are complex, with many uncertain parameters requiring calibration, limiting their usability and robustness. A key question is whether this complexity can be justified. To explore this, a parsimonious phosphorus model, SimplyP, has been developed incorporating a coupled rainfall-runoff model and a biogeochemical model able to simulate daily streamflow, suspended sediment, particulate and dissolved phosphorus dynamics. The model's complexity was compared to one popular nutrient model, INCA-P, in terms of number of equations and parameters, and the performance of the two models was compared in a small (51 km2) rural catchment in northeast Scotland. For three land use classes, less than six SimplyP model parameters must be determined through calibration, the rest may be based on measurements, whilst INCA-P has around 40 unmeasurable parameters. Despite substantially simpler process-representation, SimplyP performed comparably to INCA-P in both calibration and validation, and produced similar long-term projections in response to changes in land management. Results support the hypothesis that INCA-P is overly complex for the study catchment. We hope our findings will help prompt a wider model comparison exercises, as well as debate amongst the water quality modelling community as to whether today's models are fit for purpose. Simpler models such as SimplyP have the potential to be useful water management and research tools, building blocks for future model development, or performance benchmarks against which more complex models could be evaluated.