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A distributed multi-compartment hydrological model with dynamic vegetation and nutrient turnover

Jens-Olaf Delfs (1,2), Sebastian Gayler (1), Thilo Streck (3), Benny Selle (1), Christian Klein (4), Eckart Priesack (4), Ashok Singh (2), Thomas Kalbacher (2), Wenqing Wang (2), Olaf Kolditz (2,5)

(1) Water-Earth System Science (WESS) Tübingen, Tübingen, Germany, (2) Department Environmental Informatics, Helmholtz Centre for Environmental Research - UFZ Leipzig, Leipzig, Germany, (3) Institute of Soil Science and Land Evaluation, University of Hohenheim, Stuttgart, Germany, (4) Institute of Soil Ecology, German Research Centre for Environmental Health, Helmholtz Centre Munich, Neuherberg, Germany, (5) Applied Environmental System Analysis, Technical University of Dresden, Dresden, Germany

Agricultural practices impact soils and the wider environment (groundwater, receiving water courses and ponds, etc.) with various feedback loops. For instance, groundwater extraction may increase infiltration rates and nitrate leaching from the plant root zone. To assess such inter-compartment feedbacks with a numerical model, the object-oriented modeling platform OpenGeoSys (OGS), which is designed for Thermo-Hydro-Mechanical-Chemical processes in porous and fractured media (open to the public via www.opengeosys.org), is coupled with the soil-plant-atmosphere model system Expert-N. Latter consists of interchangeable sub-modules for thermo-hydro-chemical processes at land surfaces subject to agricultural production and forestry. In the resulting model, OGS solves partial differential equations through a Galerkin finite element approach to transfer water, air, heat and nitrogen compounds in the overland, soil and aquifer compartments, while Expert-N provides source / sink terms for evapotranspiration, plant growth, and nutrient turnover (mineralization, denitrification, etc.). General criteria are determined to guarantee stability when coupling hydrological compartments by iterating and to ensure that inter-compartment water and solute fluxes are insensitive to variations in leakage. Test cases include a synthetic surface-subsurface flow benchmark with evapotranspiration (Panday & Huyakorn problem) and a cross section of the Ammer catchment in South-West Germany, where precipitation water flows to groundwater wells, which are used for the supply of potable water.