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National level water quality simulation and climate change scenarios in Finland with WSFS-Vemala model

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WSFS-Vemala model have been developed for water quality simulation and scenarios for Finland. The model consists of sub-models for hydrological cycle, nutrient leaching and transport in rivers and lakes. Simulation of total phosphorus, total nitrogen, suspended solids and total organic carbon is included.

Hydrological simulation is based on WSFS system, which simulates the hydrological cycle by one day time step using standard meteorological data. The system covers the whole land area of Finland, including cross-border watersheds, total of 390 000 km2. The meteorological inputs of the model are daily precipitation and temperature and the simulated components are snow accumulation and melt, soil moisture, evaporation, ground water, runoff and discharges and water levels of rivers and lakes. The remote sensing data used in the model includes satellite data of snow coverage and snow water equivalent and precipitation from weather radars. In the hydrological simulation Finland is divided into 6200 50-100 km2 sub-basin. All lakes larger than one hectar are simulated, which is about 58 000 lakes. The large number of lakes is characteristics for Finland and especially for water quality simulation the lake processes are important and therefore all lakes are included.

Since agriculture is the main source of nutrient loading, fields are described in detail. Slope profile, crop and soil type data for each 1 100 000 fields in Finland are described, which covers 2 450 000 hectares of fields. For phosphorus leaching and erosion simulation the field level Icecream model is applied. In the Icecream model farming practicies, fertilization, crop growth, phosphorus cycle in the soil and finally leaching and erosion are simulated on daily timestep. For nitrogen simulation in fields a similar process based model is applied on sub-basin level and field scale nitrogen simulation with Icecream model is under development. Point loads, atmospheric deposition and load from settlements are included in the model. For natural background leaching and loading from forestry are used estimated values, process based description is under development. Sedimentation, erosion and denitrification are modelled for rivers. In lakes sedimentation, resuspension, release from sediments and denitrification are modelled.

The WSFS-Vemala model is applied for load reduction and country wide climate change scenarios. In load reduction scenarios farming practices and fertilization of each field can be adjusted separately by the characteristics of the field. In climate change scenarios water quality until year 2060 is simulated. For the effects of climate change on agriculture we are using DREMFIA sector model scenarios from MTT Agrifood Research Finland. DREMFIA model gives scenarios as hectars of different crops, fertilization levels and number of cattle in four regions in Finland. Scenarios for point loading, scattered settlements, forestry and background leaching are based on expert estimates. WSFS-Vemala model is then simulated with modified weather, loading and farming input and results include concentrations in rivers and lakes and finally loading into the Baltic Sea. Preliminary scenario results show a slight increase in annual loading and remarkable shift in seasonal loading, with increased loading in winter.

WSFS-Vemala model is also applied for real time simulation and forecasting of water quality, including forecasts for chlorophyll-a concentration. Forecasts are provided for the public by www pages at www.environment.fi/waterforecast.