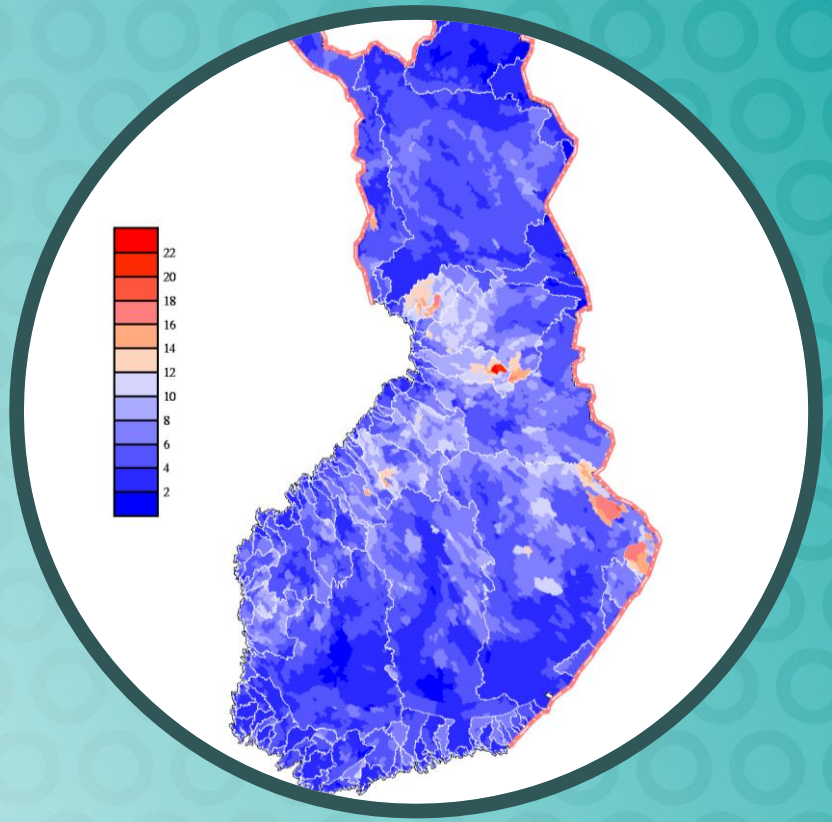
VEMALA TOC: towards better national scale carbon leaching estimates



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MAANKÄYTTÖSEKTORIN ILMASTORATKAISUT

SYKE

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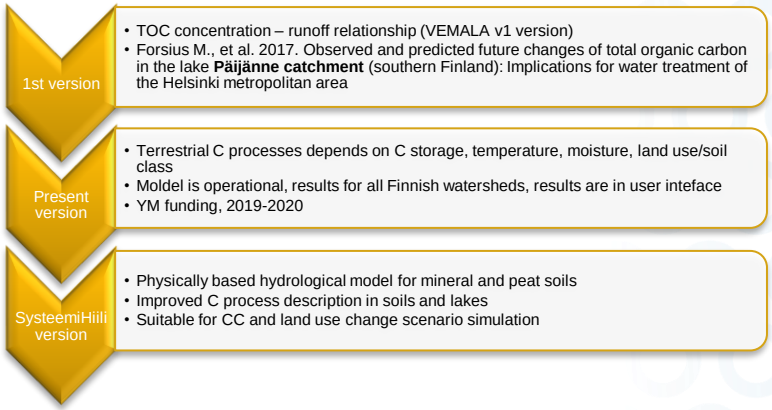
Background

- VEMALA modelling system:
  - national scale nutrient loading tool used in WFD implementation and international reporting (e.g. HELCOM)
  - VEMALA model is simulating TN, TP (and their fractions), SS, TOC loading for all Finnish watersheds,
  - Consists of several submodels – hydrological model, terrestrial models, river transport model, lake biogeochemical model
  - Catchment scale model, spatial unit: 3th level sub-catchment (60 km^2) and 4th level sub-catchment (around 2 km^2), Time step – one day
- Aim of the SysteemiHiili project is to further develop and apply the VEMALA modelling tool for TOC loading and CO_2 emissions from inland waters simulation in present conditions, climate change and land use scenarios at catchment scale



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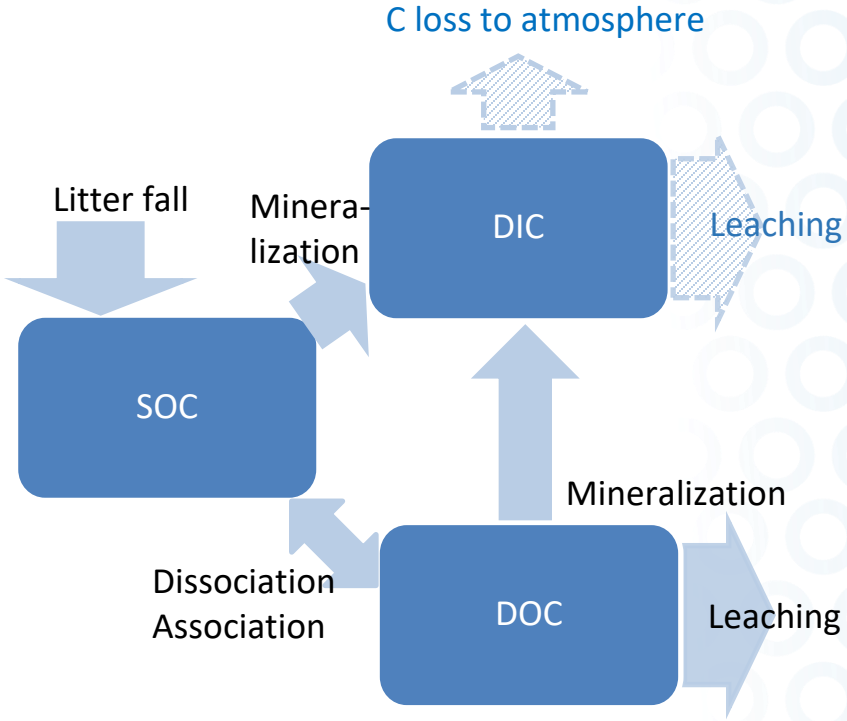
VEMALA TOC processes in the soil

- Based on INCA-C model (Futter et al., 2007)
- 3 C storages in the soil – solid organic carbon (SOC), dissolved organic carbon (DOC), dissolved inorganic carbon (DIC)
- Processes described in the model:
  - Mineralization of SOC and DOC (depends on T and soil moisture (SM))
  - Dissociation of SOC, Association of DOC
  - Leaching, Transport of DOC with subsurface runoff and baseflow
- 6 land use classes – agriculture on clay, coarse and peat soils, forest on mineral soils, forest on undrained peat soils, forest on drained peatlands



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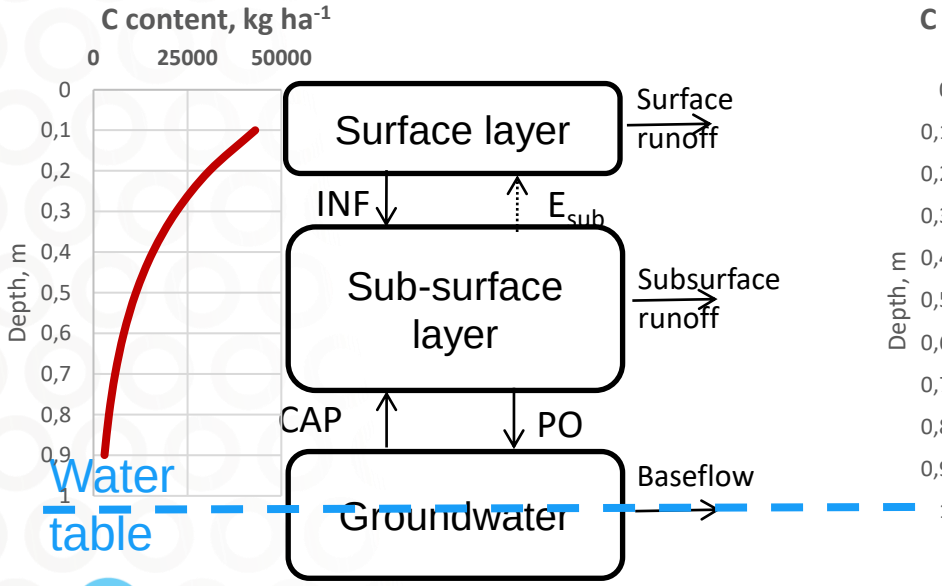
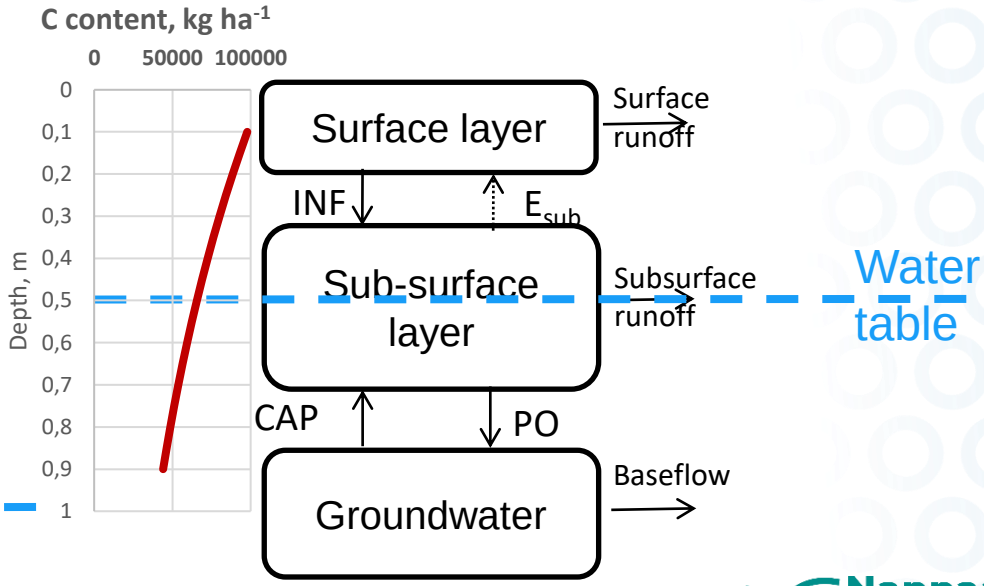
Physically based hydrological model in TOC modelling

- **Mineral soil**, C is stored in the surface layer of the soil, then exponentially decreasing
- **Peat soil**, much higher C content, evenly distributed within the depth





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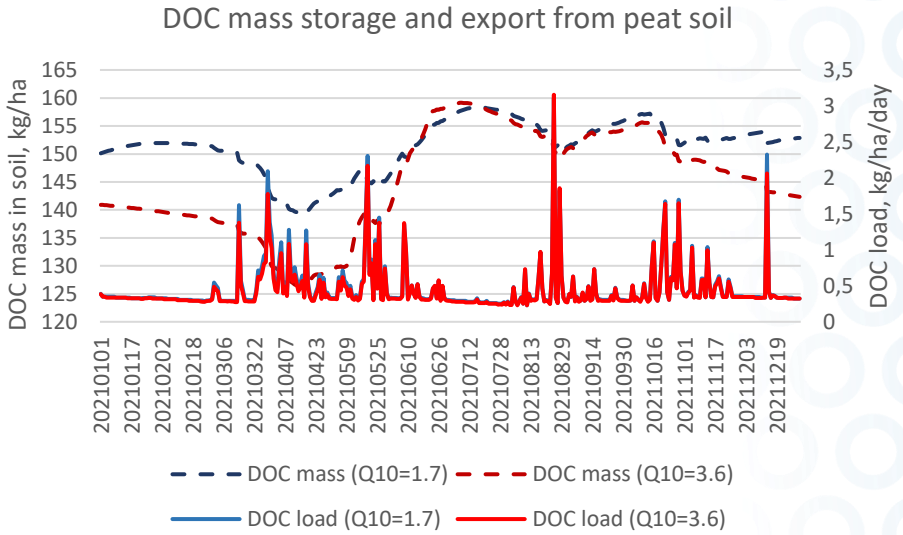
DOC dynamics in the soil

- DOC storage is increasing during low flow periods, and then flushed out with runoff events
- Baseflow is forming a steady DOC flow also during low flow periods
- Two soil temperature sensitivity paremeter values were tested Q_{10} (1.7 and 3.6)
- With higher Q_{10} there is higher DOC production in summer periods, higher leaching in autumn
- Soil moisture decrease is also elevating simulated DOC concentration in the soil



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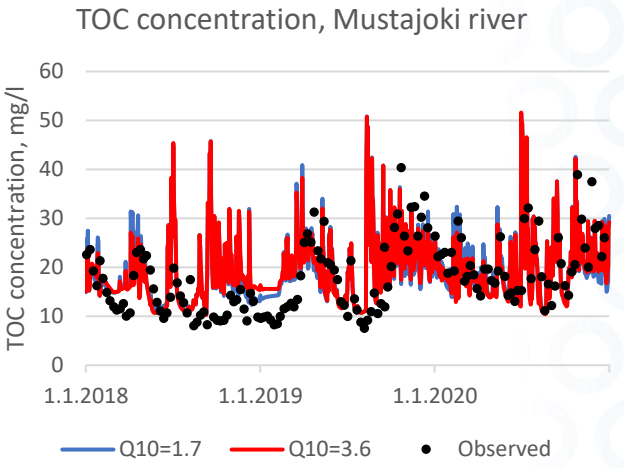
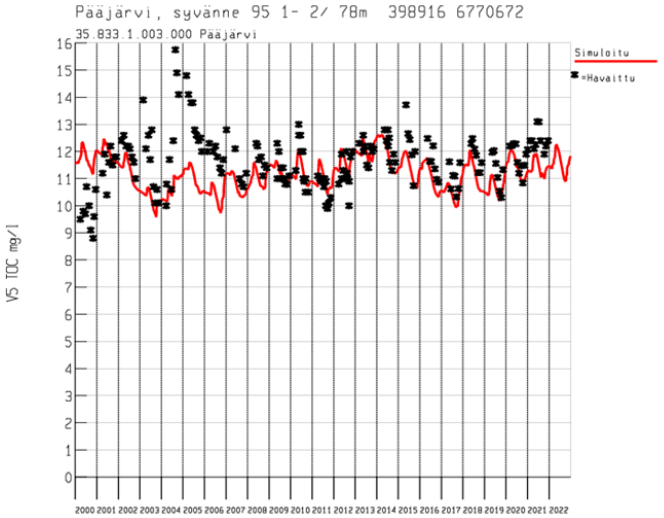
TOC concentration simulation in Pääjärvi catchment

- New model has been calibrated by using intensive and excellent Pääjärvi catchment observation data, 6 river points and a lake point (Lammi Biological station)
- Calibration of the model:
  - Annual TOC loading from land use/soil classes compared to values in literature (Metsävesi project, etc.)
  - Daily TOC concentrations calibrated against daily observed in streams, lake
- Model simulates lake TOC balance: inflow loading, outflow loading and retention (42% in Pääjärvi, long residence time)





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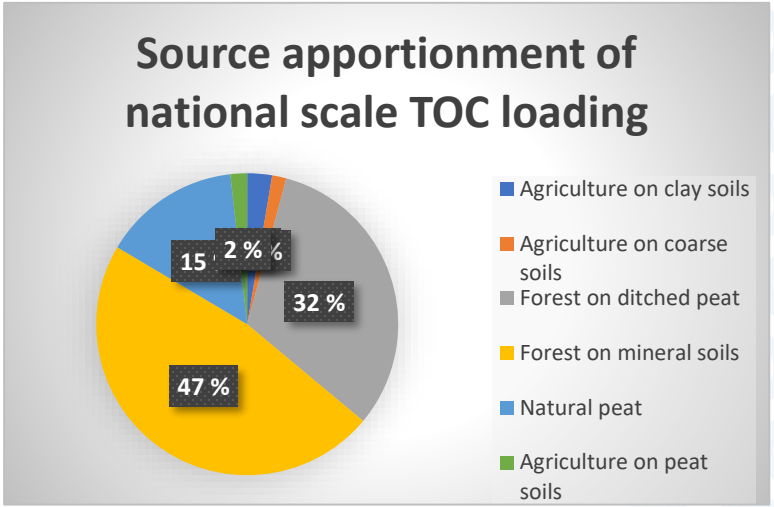
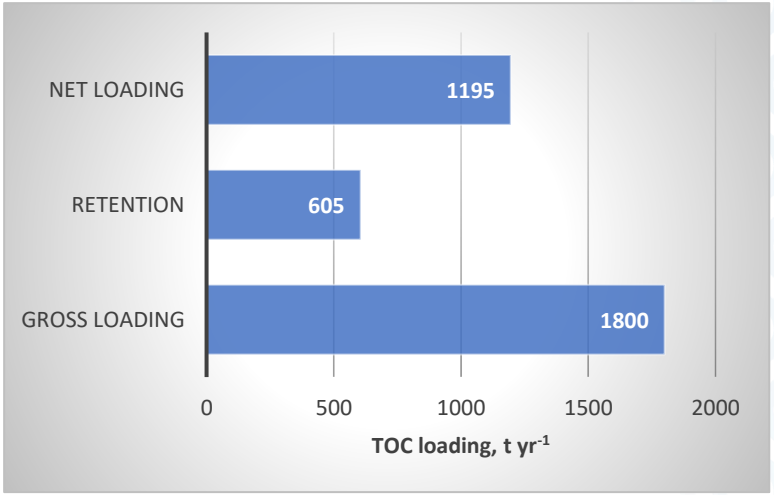
Summary of TOC loading from Finnish watersheds (results from previous version)

- The biggest source of TOC loading is forest on mineral soils (47%),
- Next source is forests on ditched peat soils (32%),
- Specific TOC loading from peat soils is around 2.5 to 3 times higher than from mineral soils.
- Mean simulated TOC specific loading for test basins is from forest on ditched peat soils 120 kg ha^{-1} a^{-1},
- Mean from natural peat soils 80 kg ha^{-1} a^{-1}
- Mean from forest on mineral soils 39 kg ha^{-1} a^{-1},
- Mean from agriculture on mineral soils 22-47 kg ha^{-1} a^{-1}
- One cause of brownification of waters is elevated TOC loading from drained peat soils, models could be used to simulate the way to mitigate loading from drained peat soils





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Summary

Usage of VEMALA model:

- VEMALA model provides TOC loading, concentration for all lakes, rivers, also input for biogeochemical lake model
- TOC concentration could be added as one of the criteria in ecological classification of the water bodies for WFD implementation work
- CO_2 loss from water bodies could be used for IPCC estimates of national GHG budgets
- VEMALA is used to study TOC and nutrient loading changes and mitigation in climate change scenarios in Systeemihiili, Blueadapt and other projects

Challenges:

- Modelling the catchment scale with different land use/soil classes is challenging
- Hydrology is controling the TOC transport out of the soil, hydrological model for different soil textures is a key for TOC loading simulation
- Change in C stocks in soil for climate change effect simulation on TOC loading

BlueAdapt

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Thank you!

More info about VEMALA:

https://www.syke.fi/en-US/Research__Development/Water/Models_and_tools/Models_for_river_basin_management_planning/A_water_quality_and_nutrient_load_model_system_for_Finnish_watersheds_VEMALA