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Assessment of the Hype Model for Simulation of Water and Nutrients

By Dr Jean Nepo Namugize
Lecturer at RP-IPRC Kigali
Representative of IAHS ECC on WQ
E-mail: jeannamugize@gmail.com

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Objective

To test HYPE in the upper reaches of the uMngeni Catchment, an area which is typical of rapidly developing conditions of southern Africa

- the simulation of streamflow and the concentration of dissolved inorganic nitrogen (DIN equates NH_4 + NO_3) and total phosphorus and
- provide insight into sources of the increased concentrations of DIN and TP and their spatial distribution in the catchment

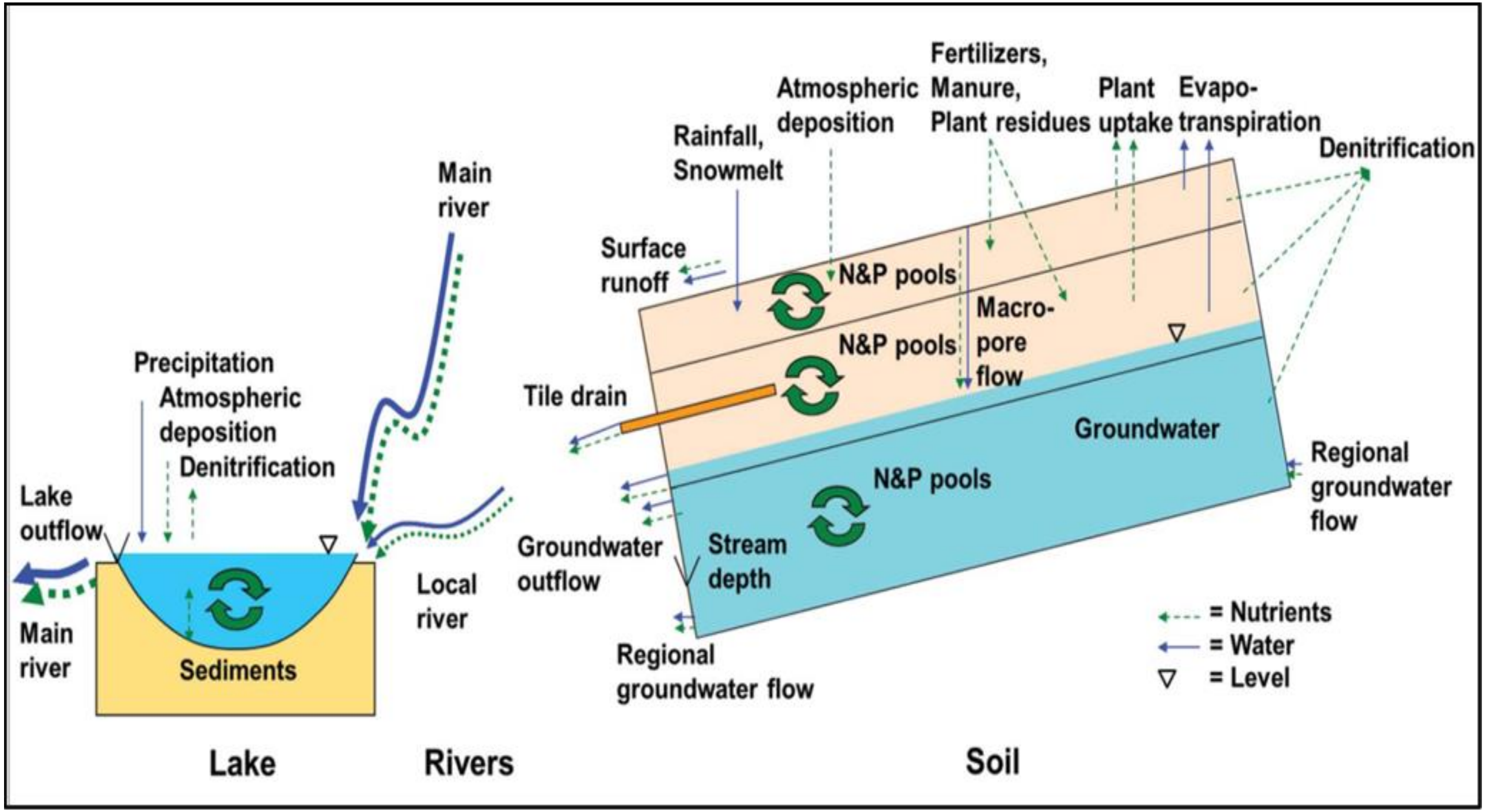
Why the HYPE Model?

- A (semi-)distributed hydrological model for water and water quality developed at SMHI (Norrkoping, Sweden) Daily time steps (experiments on hourly time step), temperature and precipition as forcing.
- Integrated modules for water quality (N,P,TOC) + tracers (^{18}O, conservative)
- Developed with focus on:
  - Prediction in Ungauged Basins (PUB)
  - Integration of water and water quality
  - Large model setups
  - Use in production system

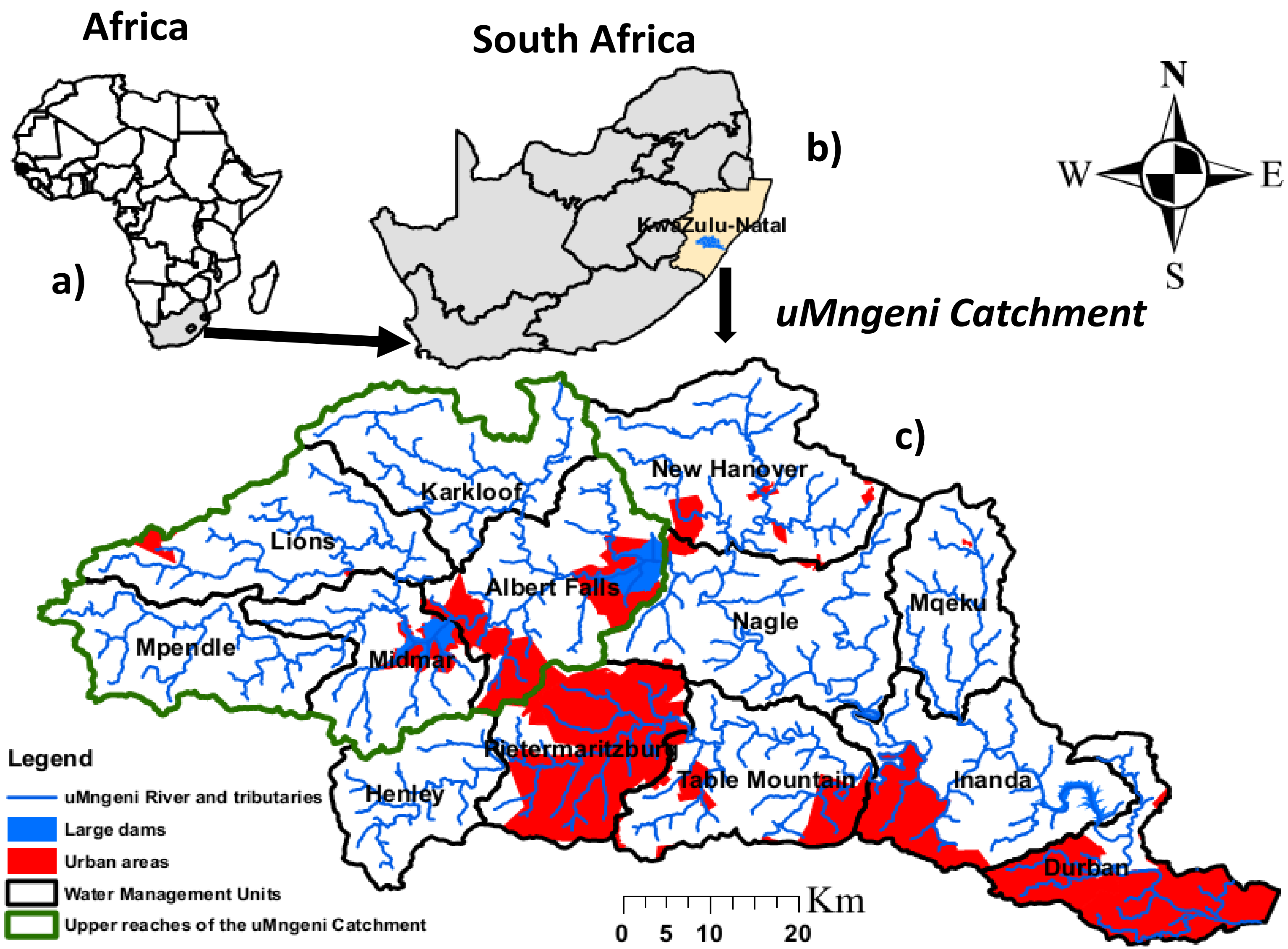
More details on the model: http://hypeweb.smhi.se/model-water/

Schematic illustration illustration of nutrient transport and turnover of nutrients within a sub-basin in the HYPE model

(Strömqvist et al., 2012)

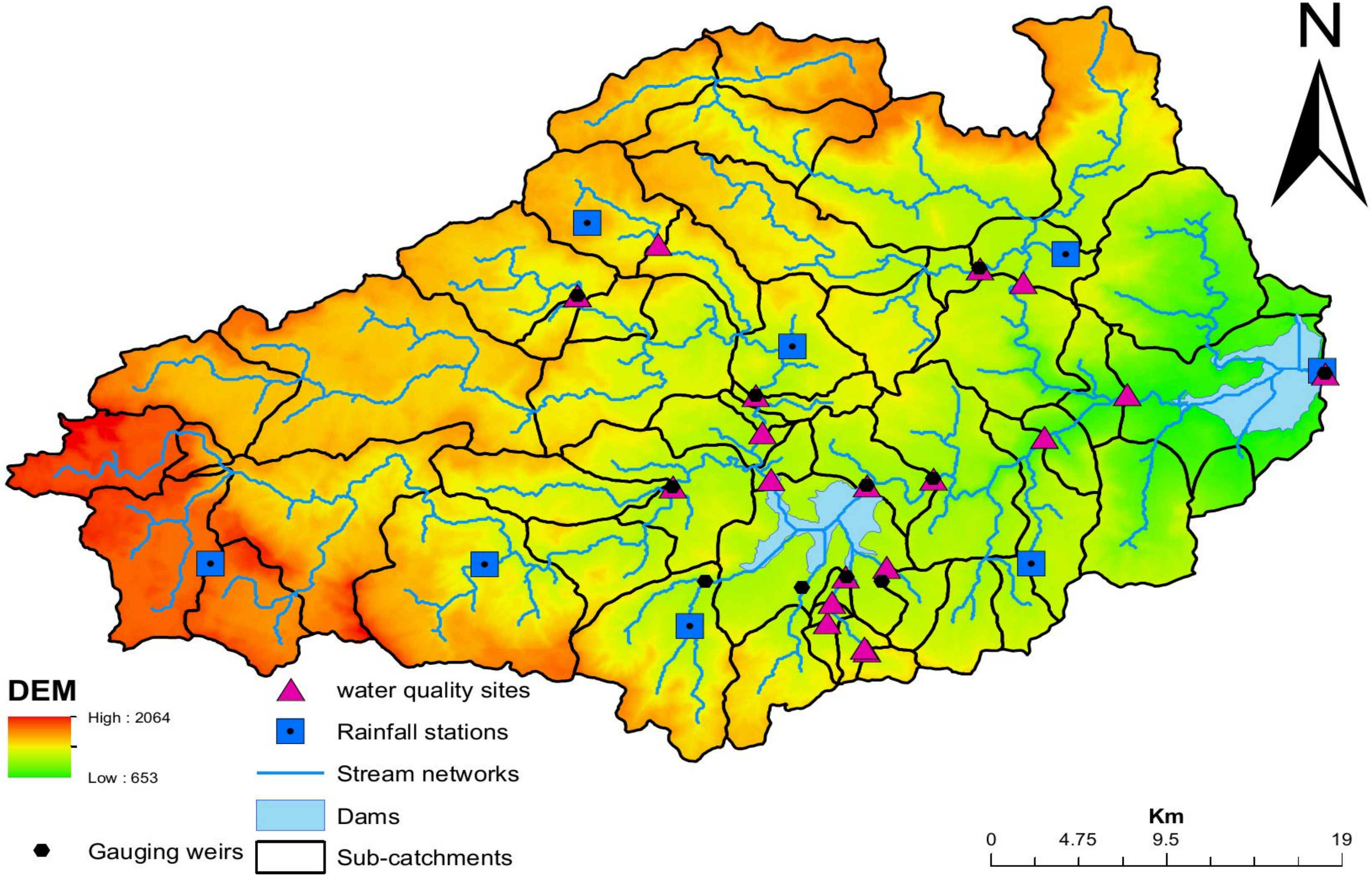


Study area

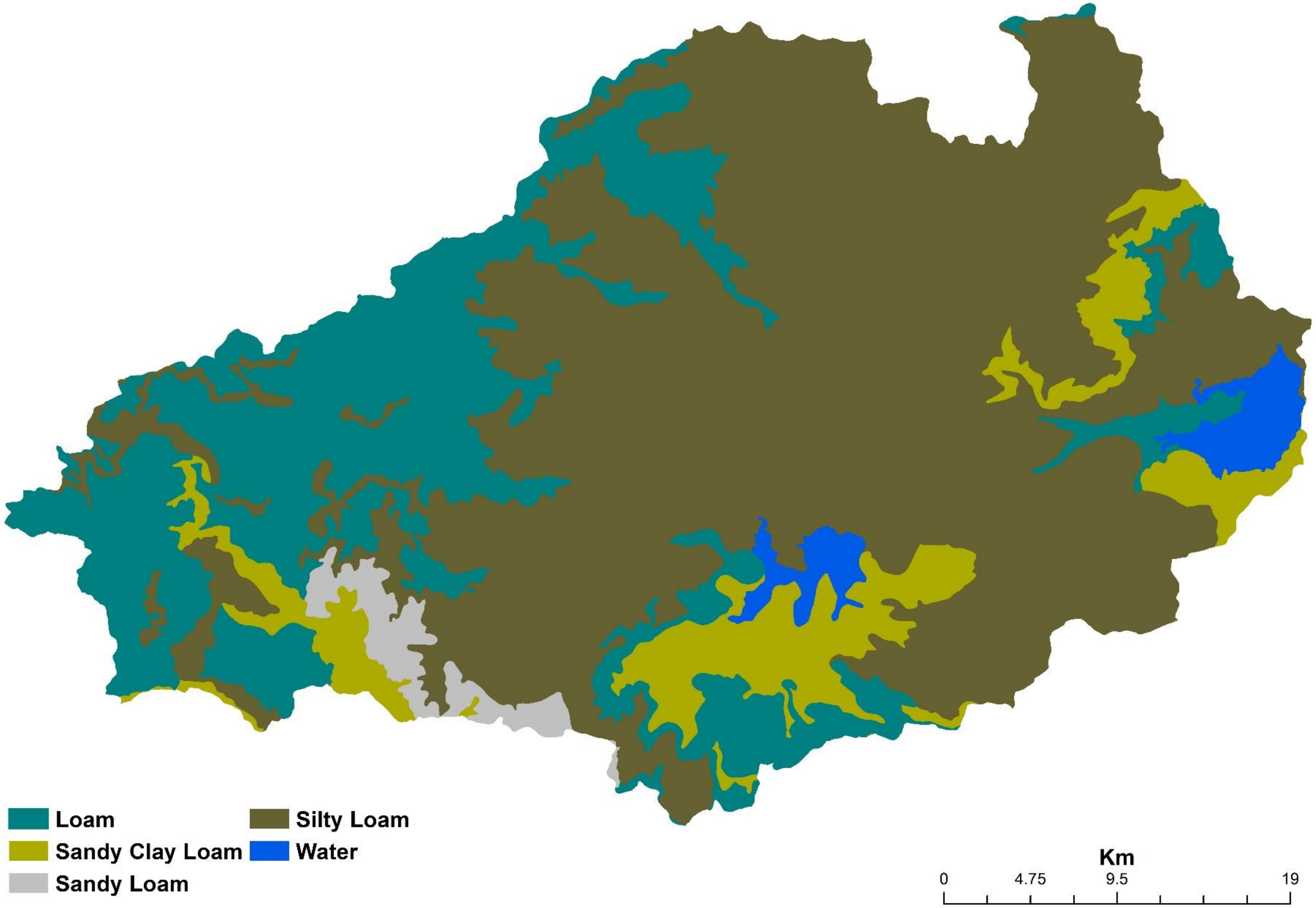


Africa
South Africa
a)
b)
c)
KwaZulu-Natal
uMngeni Catchment
N
W
E
S
Karkloof
New Hanover
Lions
Albert Falls
Nagle
Mqeku
Mpendle
Midmar
Pietermaritzburg
Table Mountain
Inanda
Henley
Durban
Legend
uMngeni River and tributaries
Large dams
Urban areas
Water Management Units
Upper reaches of the uMngeni Catchment
0 5 10 20
Km

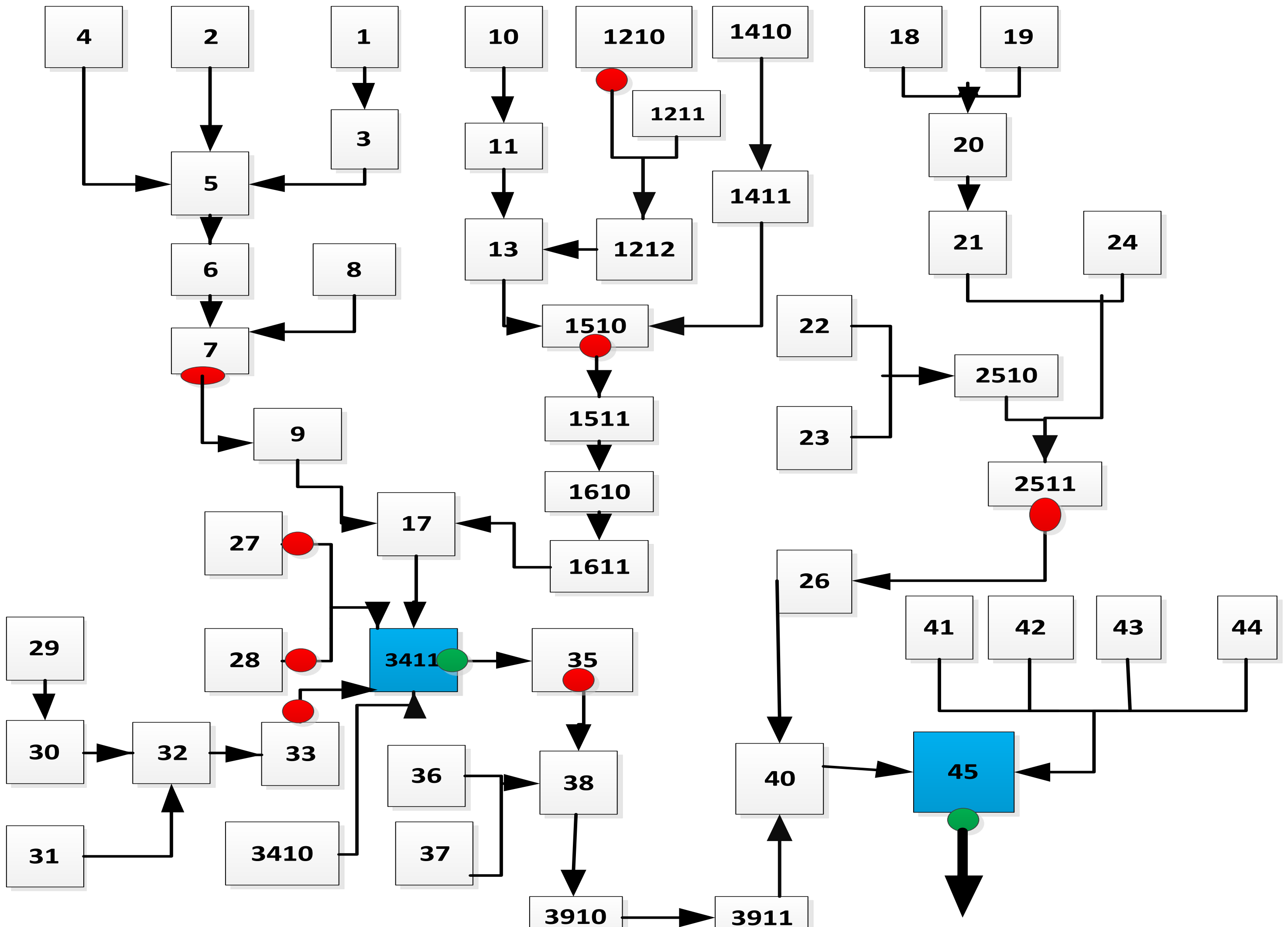
Water resources management in the area



Land use and land cover and soil types



Flow direction in the catchment

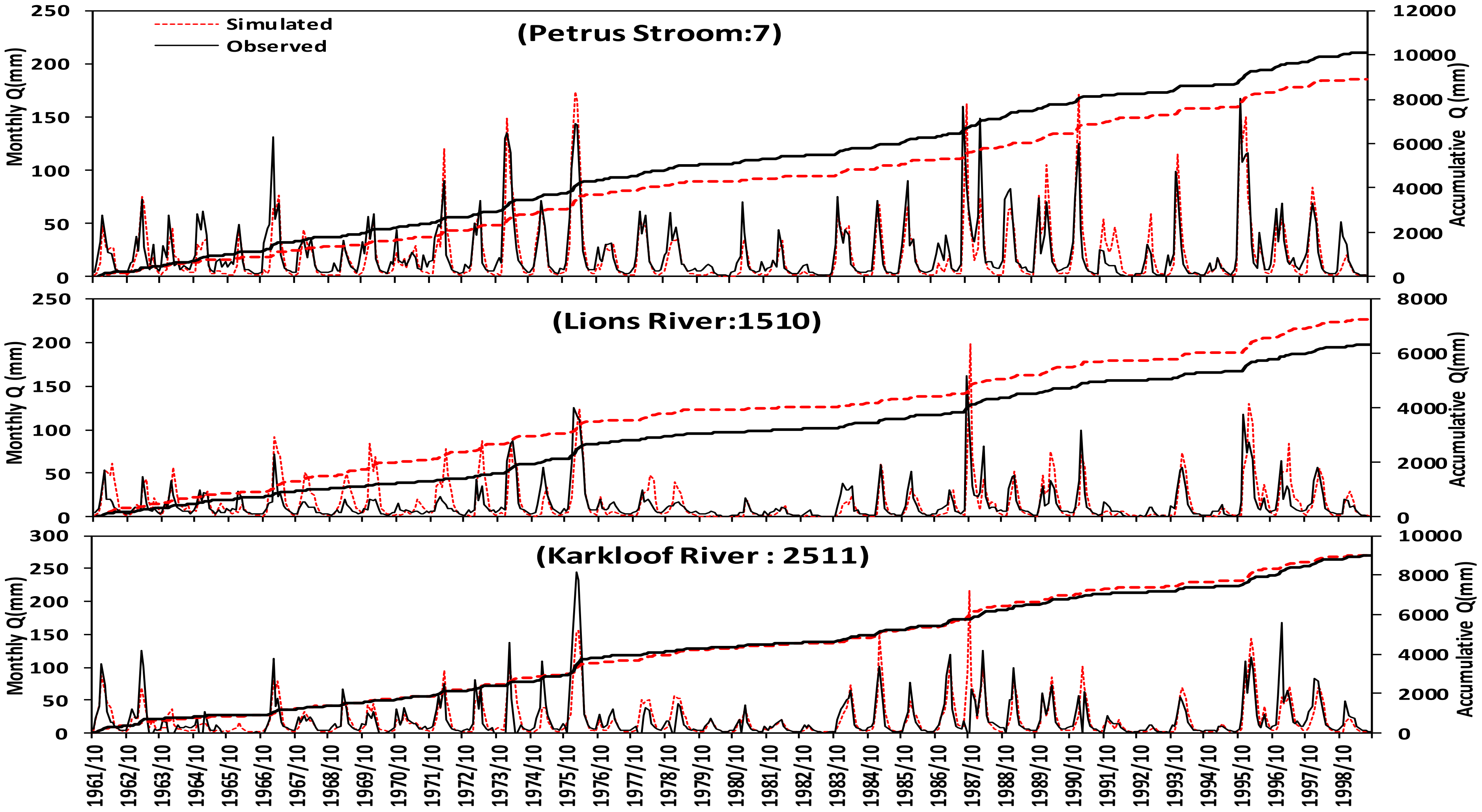


HYPE Model input data for the catchment

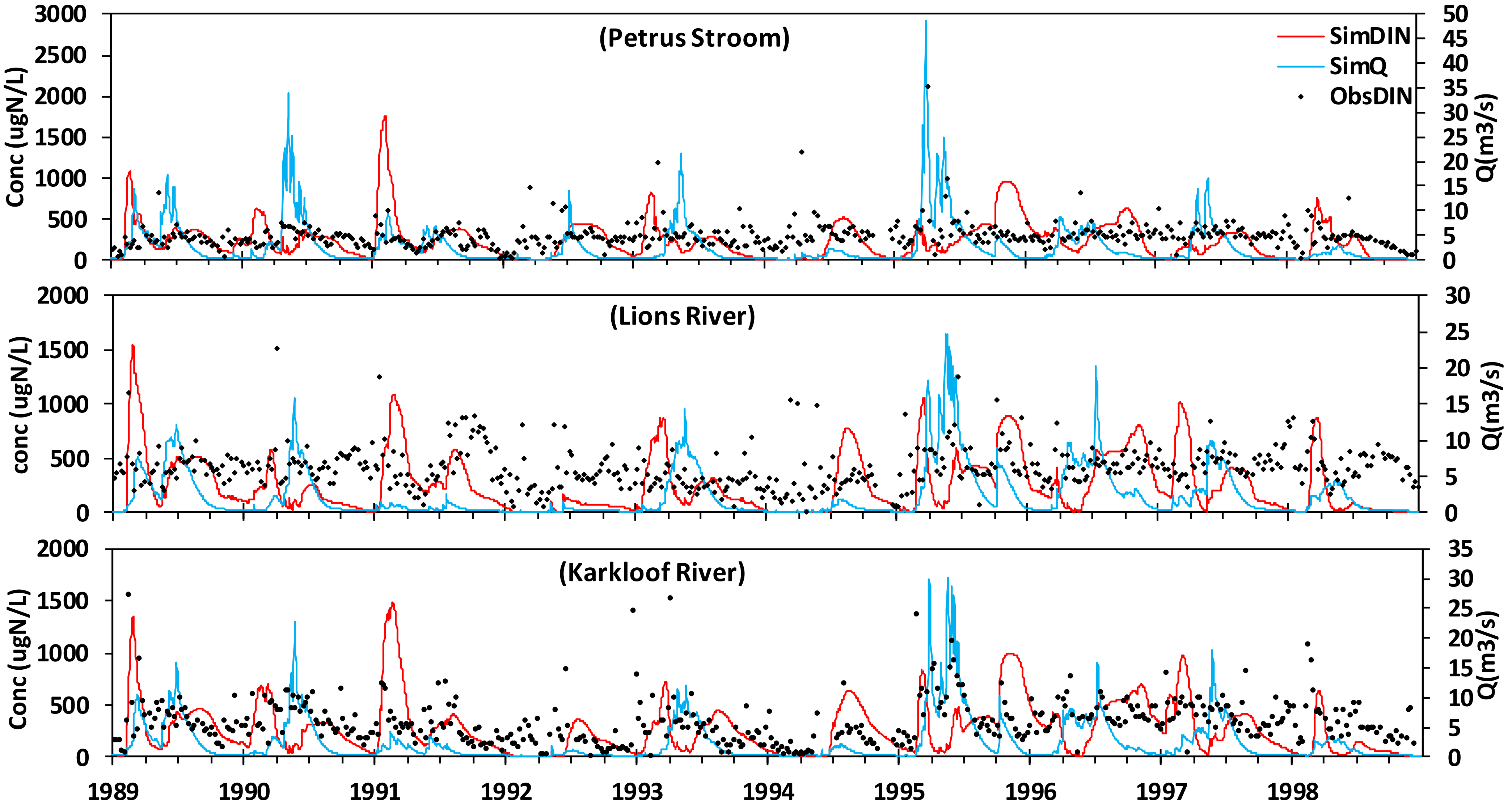
	Data	Data type
1	Climatological data	Daily precipitation
		Daily air temperature
2	Geographic data	Sub-basin area
		Land use types
		Elevation/slope means
		Hydrographical network, stream drainage depth, main river length
3	Dam information	Depth, regulation rules, rating curve
4	Soil data	Soil layer depth and number of horizons, soil layer thickness, soil water holding capacity
		soil nutrient content (initial nutrient storage)
		Soil texture
5	Water quality	Measured daily streamflow
		weekly/monthly nutrient concentrations (dissolved inorganic nitrogen (DIN), soluble reactive phosphorus (SRP) and total phosphorus (TP))
6	Agricultural practices	Manure and inorganic fertilizer application, crop husbandry, timing and amount of fertilization, sowing and harvesting for the area
7	Water management	Sub-catchment fraction of irrigation Water withdrawn from the groundwater
8	Other source of nutrients	Flow from rural household not connected to the municipal wastewater works
		Discharge and concentration of DIN, SRP and TP
		Atmospheric deposition

Results and discussions
Streamflow simulation during the calibration period (1989-1995)

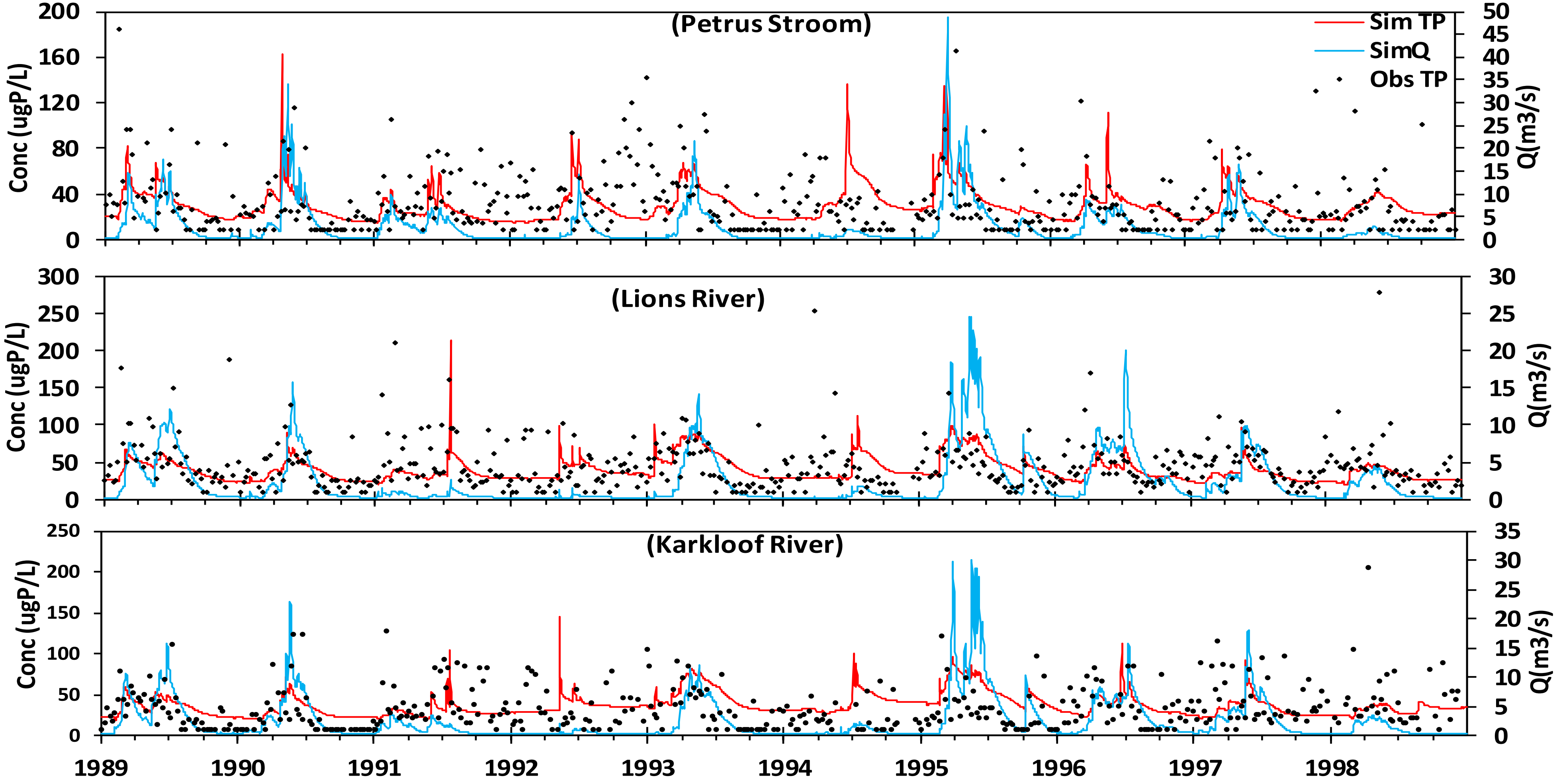
Results and discussions
Simulation of streamflow (1961-1999)



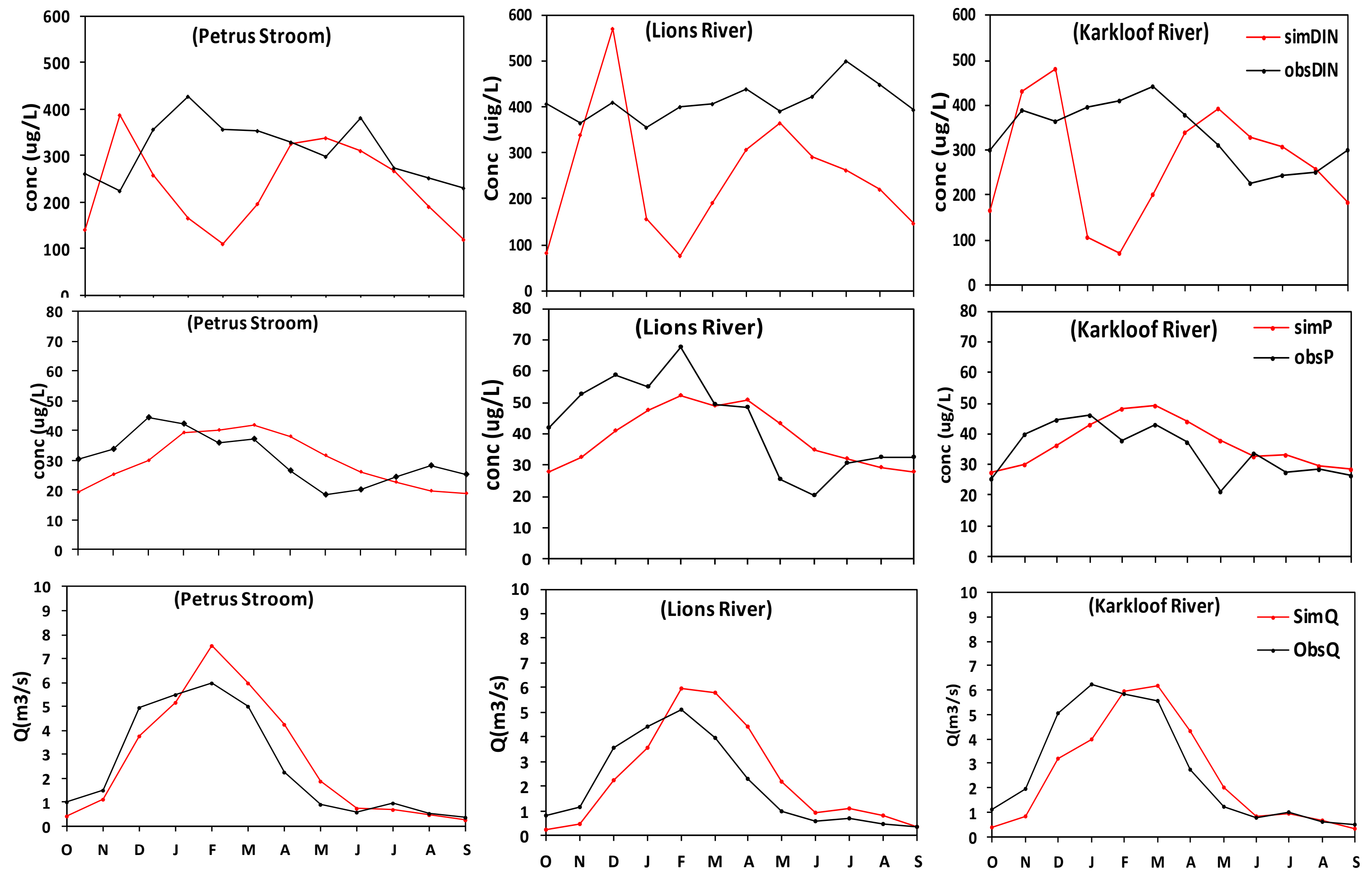
Results and discussions
Water quality: DIN (1989-1999)



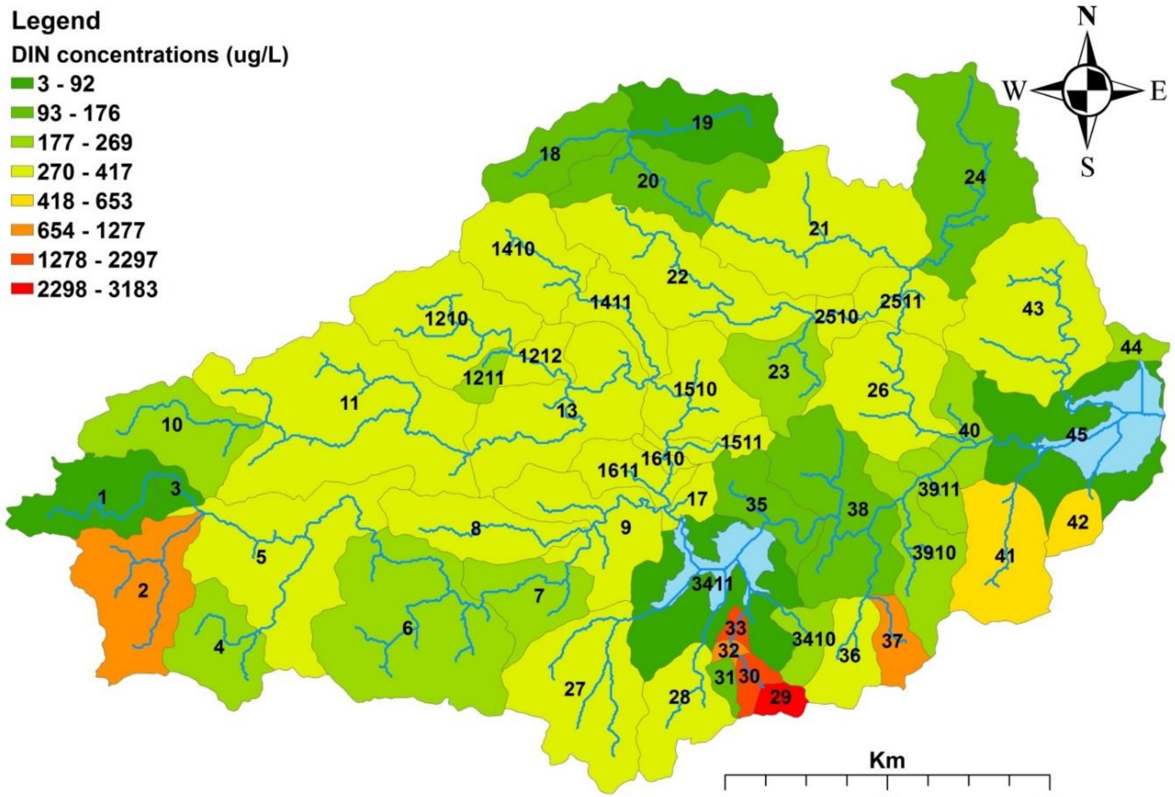
Results and discussions
Water quality: TP (1989-1999)

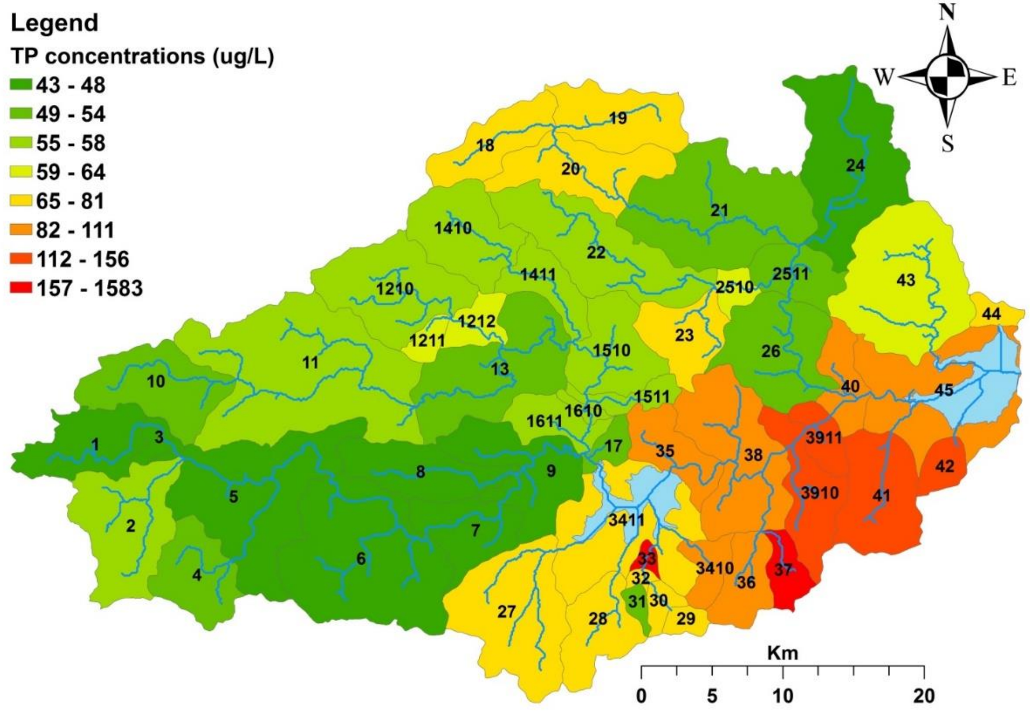


Seasonal variation of streamflow and nutrients in the catchment



Distribution maps of nutrient in sub-catchments





Conclusion

- The HYPE model was successfully tested in the catchment.
- The most important factors affecting the predictions of runoff in the model were crop coefficient (Kc), the recession coefficients of the two upper soil layers (rrcs1 and rrcs 2) and the variables related with the water storage of the soil (field capacity, wilting point and effective porosity).
- The most sensitive parameters in the simulation of DIN and TP were denitrification, the initial pools of nutrients , crop uptake and the mineralisation of decay of fastN and fastP.

Conclusion (ct’d)

- The model represented the water balance well.
- High flow events were captured well, with a general over-simulation of base flow events.
- An under-estimation of streamflow was identified in the outlet sub-catchments, due to a simplified spatial variation of evapotranspiration processes in the model.
- The model has provided acceptable simulations of streamflows, and the good fits between modelled and measured values, especially at the monthly time-step, where NSE values of ~ 0.7 were noted in four out of the nine sub-catchments.
- Across the catchment, TP concentrations and loads are released from sub-catchments that have the major point-sources of pollution
- The model has represented the streamflow and its seasonal variation in the area well.
- The model outputs of average concentrations of DIN and TP and their spatial distribution reflects the reality in the catchment

Model caveats

- Simplification of the processes driving evapotranspiration in the model is a key challenge which affects the simulations of runoff in the catchment.
- The simplification of inter-catchment transfer, water abstraction and release in the model

Way forward: Application of HYPE to simulate streamflow in Nyabugogo catchment

- Collection of data has started in 2017
- Climate data, LULC and initial setup of the model in September 2017 was done at SMHI
- Still working on model input data.

Acknowledgements

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WATER • AMANZI

water & sanitation
Department:
Water and Sanitation
REPUBLIC OF SOUTH AFRICA

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YAKWAZULU-NATALI

SMHI

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Hydrology and Earth System Sciences
Discussions
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Assessment of the Hype Model for Simulation of Water and Nutrients in the Upper uMngeni River Catchment in South Africa

Jean N. Namugize[1], Graham P.W. Jewitt[1,2], David Clark[1] and Johan Strömqvist[3]

[1] Centre for Water Resources Research, School of Agriculture, Earth and Environmental Sciences, University of KwaZulu-Natal, Scottsville, 3209, South Africa

[2] Umgeni Water Chair of Water Resources Management, School of Engineering, University of KwaZulu-Natal, Scottsville, 3209, South Africa

[3] Swedish Meteorological and Hydrological Institute (SMHI), SE-60176, Norrköping, Sweden