Modelling nutrient fluxes using global datasets

-test on the Rhine Basin

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NAC 9

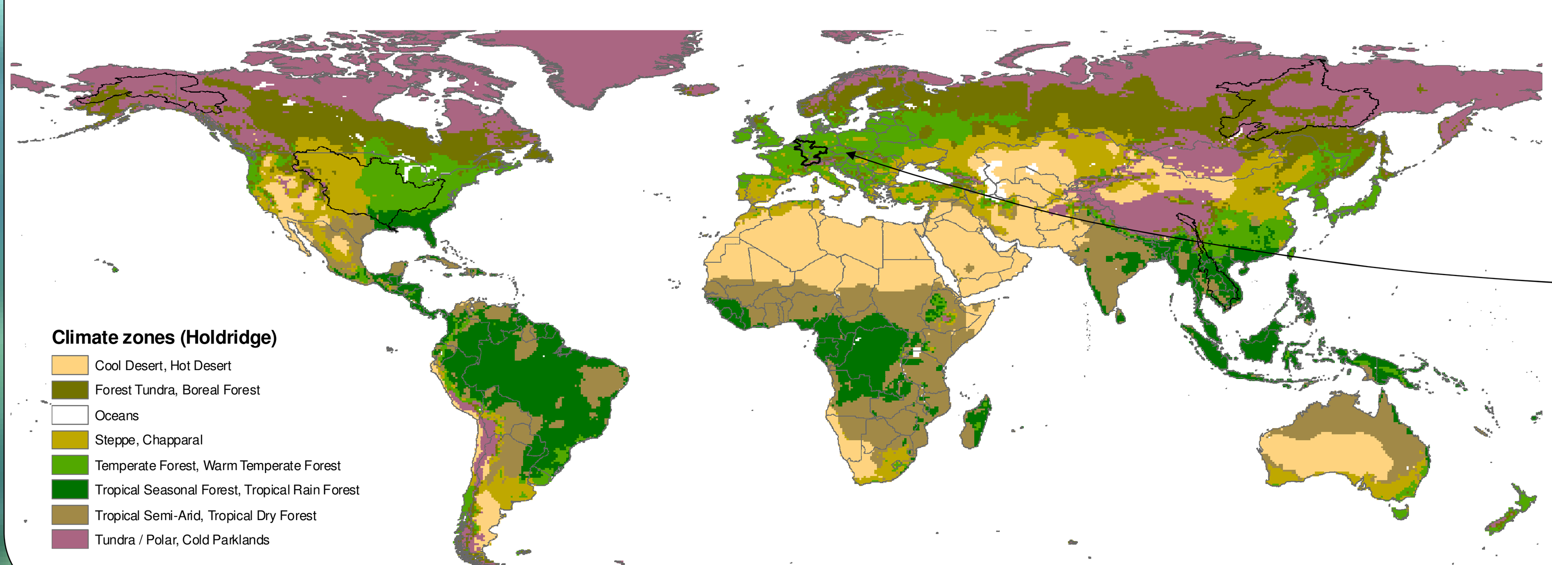
Aim

Develop a model for **estimating seasonal nutrient fluxes** (N & P) from **large river basins** to coastal seas **using global datasets**, that can provide a more accurate estimate of future nutrient loading in response to global change.

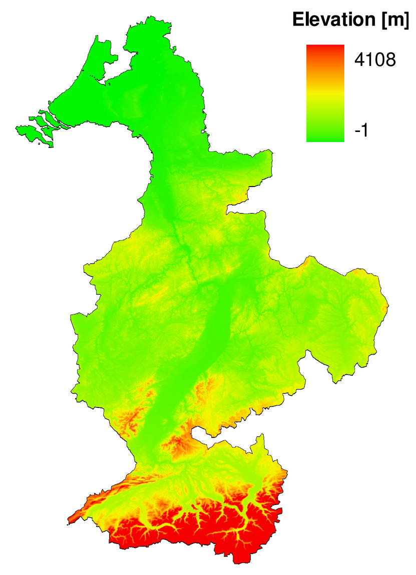
Abstract

Nutrient discharge to coastal waters from rivers draining populated areas is often the direct cause of large algal blooms. Changing conditions in the drainage basin, like land use or climate change, can alter current riverine N and P fluxes and further increase the pressure on coastal water quality. Several small and large scale models have been employed to quantify riverine nutrient fluxes on a yearly to decadal timescale. These models are either too detailed for global application or too coarse in temporal resolution for incorporation of seasonal dynamics. A new model, RiNUX, has been developed to adequately simulate present nutrient loads and capture the intra-annual variation at the basin scale using globally available distributed datasets. The model shows that groundwater and point sources are the largest suppliers of N measured at the river outlet. Preliminary results show a Nash-Sutcliffe efficiency of 0.67 for modelled monthly TN loads over the period 1990-2000.

Major River Basins in various climate zones



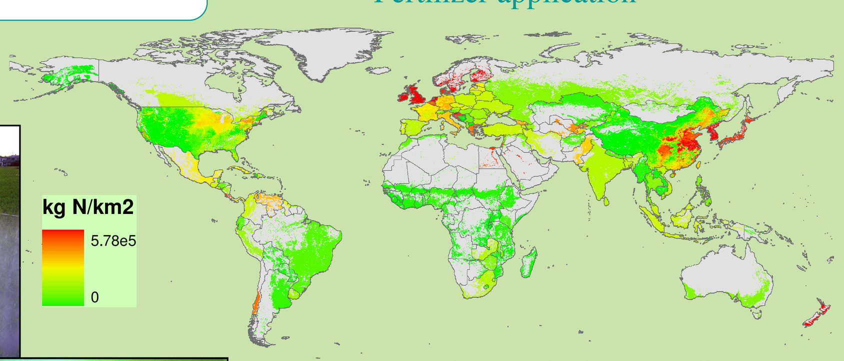
test basin: Rhine

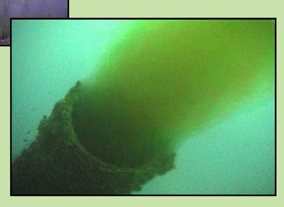


MODEL INPUT

Nutrient Emission

Fertilizer application



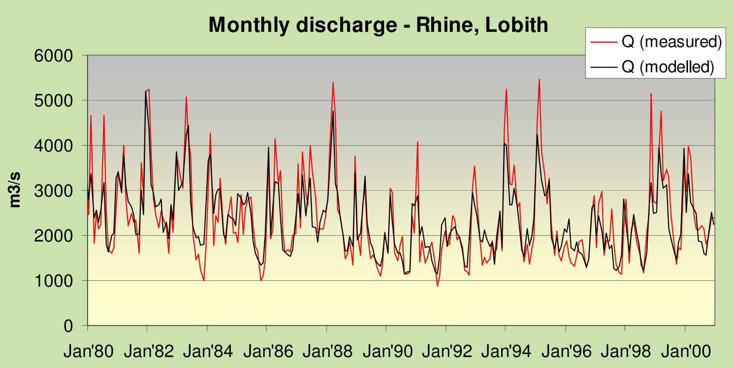


Agricultural emission ↑

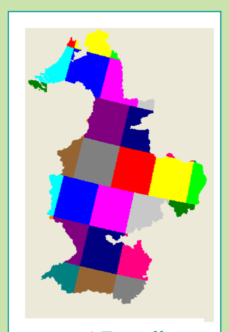
Point source emission →

Nutrients enter the river basin via application of fertilizers and manure, through atmospheric deposition, biological fixation, weathering or sewage and are transfered to the river outlet by water and sediments.

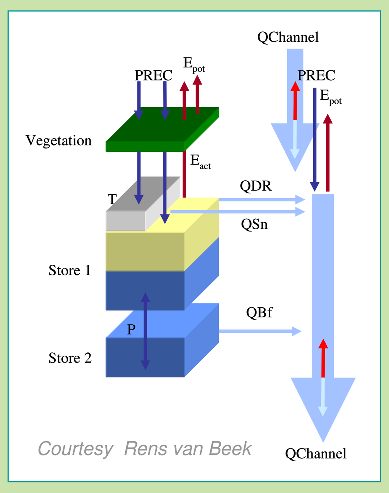
Water fluxes



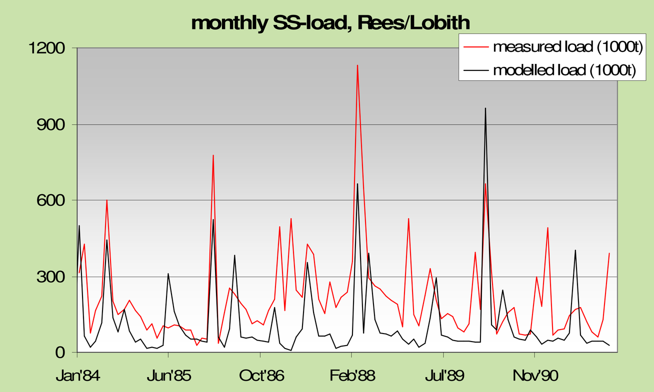
ERA40 climate input



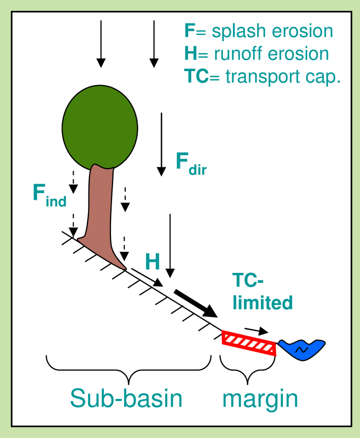
... ±15 cells

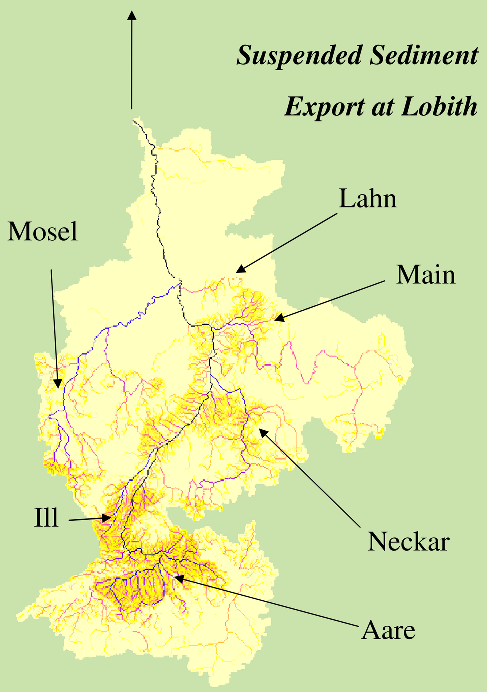


Sediment fluxes



Adapted from RMMF model (MORGAN, 2001)



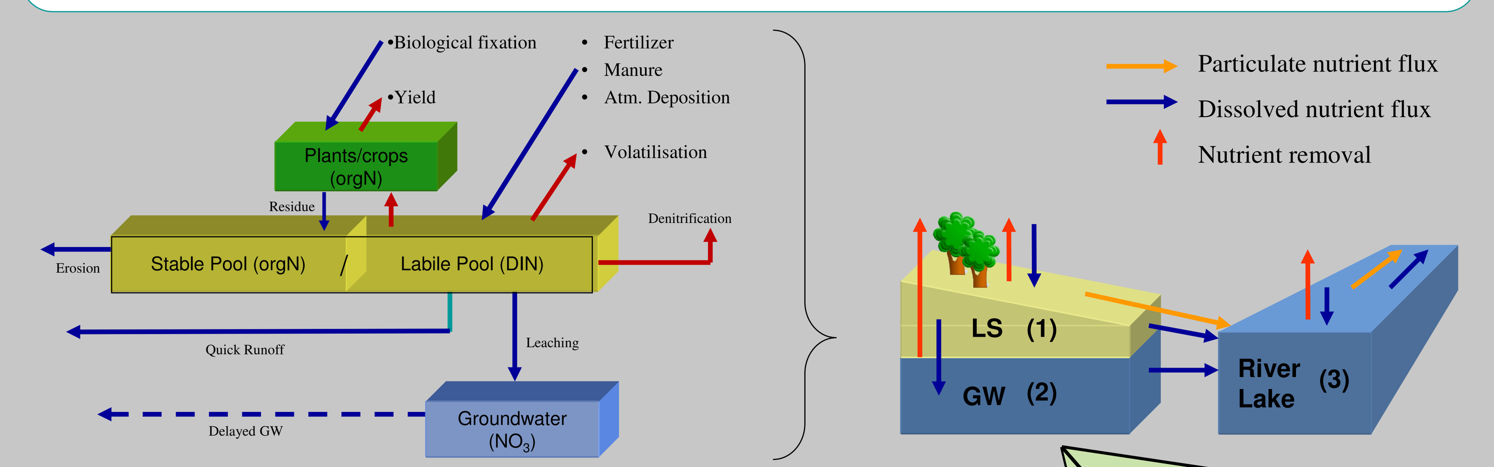


Main tributaries contributing sediment and associated nutrients.

SOIL NUTRIENT TRANSFER:
Surface runoff, groundwater buffer or soil storage

MODEL SCHEME

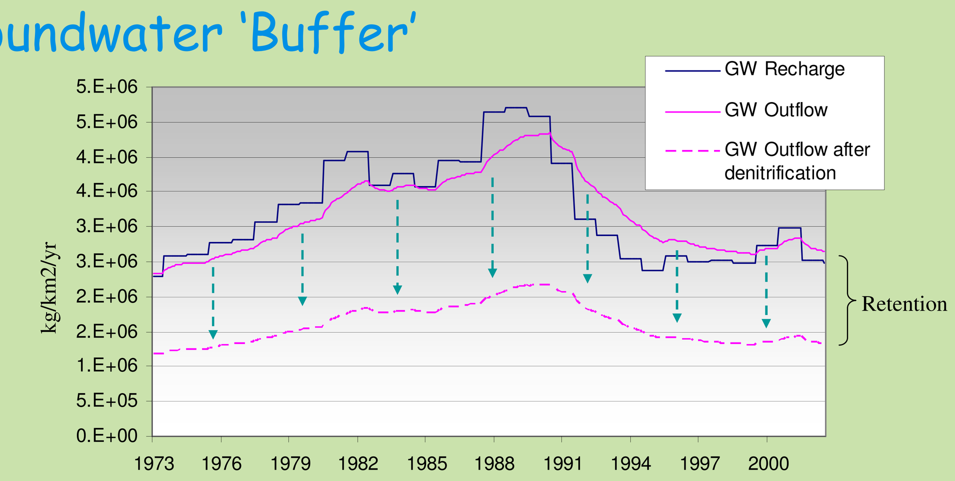
The transfer of dissolved (in the labile pool) and particulate (in the stable pool) nutrients from the soil to either the surface water or groundwater is dependent on the nutrient content, moisture, temperature and other properties (e.g. texture) of the soil.



Ground Water
Surface Water

MODEL OUTPUT

Groundwater 'Buffer'

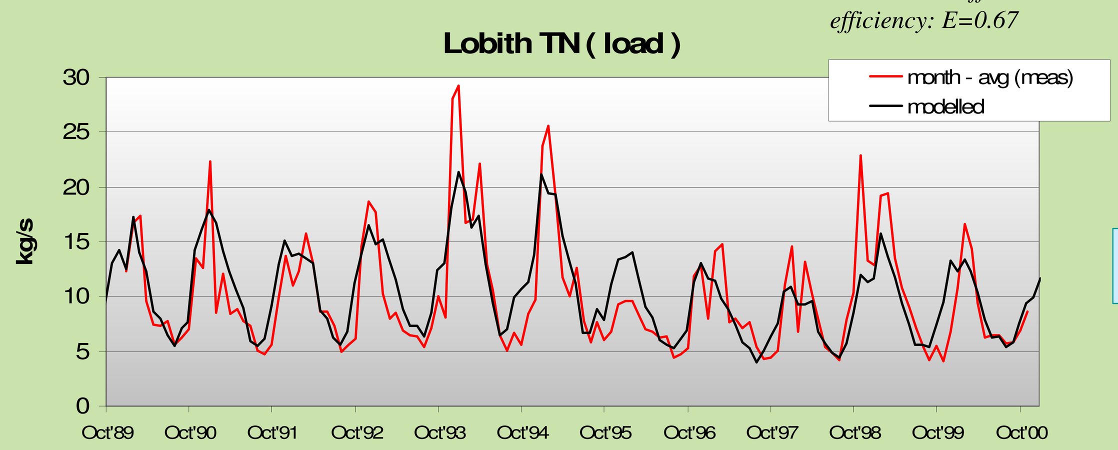


Nutrients leaching to the groundwater store are retained based on the residence time before entering surface water. Part is denitrified during transport.

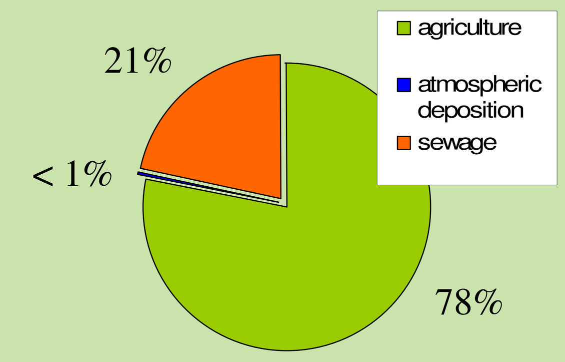
RETENTION IN CHANNEL:
f(Temp,Floodplain,Discharge)

RIVERINE NUTRIENT LOAD

Nash & Sutcliffe efficiency: E=0.67



SOURCE APPORTIONMENT



Agricultural land:
2·10³ kg N/km²/yr reaches the river in dissolved form; while only 6 kg N/km²/yr as particulate N.

Retention:
The summed retention in the groundwater and in the channel amounts to 73% of the nutrients that are mobilized in the soil.

Conclusions

Distributed modelling in large basins enables nutrient apportionment, and helps to allocate areas that attenuate or contribute to the delivery of emitted nutrients.

Nutrient dynamics are closely related to variation in soil water change and temperature variations. Therefore inclusion of seasonality may improve the prediction of future nutrient loads following Global Change (e.g. climate, landuse).

The RiNUX model, designed for intermediate scale, is able to predict present nutrient dynamics for a temperate, human-dominated river under seasonally variable conditions using globally available datasets and may contribute to predict nutrient delivery to coastal seas.

The incorporation of seasonally variable nutrient fluxes may enhance the modelling of river basins located in other climate regions.

References

Bergström, S. (1995). The HBV Model. Computer models of watershed hydrology. V. P. Singh. Colorado, Water Resources Publications: 443-476.
De Wit, M.J.M. (2001). Nutrient fluxes at the river basin scale. I: the PolFlow model. Hydrological Processes 15(5): 743-759.
Data Source: IKSR - Internationale Kommission zum Schutz des Rheins, Bundesanstalt für Gewässerkunde, www.iksr.org.
Morgan, R.P.C. (2001). A simple approach to soil loss prediction: a revised Morgan-Morgan-Finney model, Catena 44: 305-322.