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Projection of groundwater nitrate evolution under different climate scenarios in NW Germany

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Ortmeyer, F.*, Mas-Pla, J., Banning, A.
*felix.ortmeyer@RUB.de

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Introduction

- Climate change effects must be taken into account in investigating future nitrate (NO_3^-) concentrations
- Climate projections forecasts for the different climate scenarios permit simulating the future water balances
- The evolution of NO_3^- concentration is simulated based on the expected climate scenarios, RCP 2.6, RCP 4.5, and RCP 8.5

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Methodology

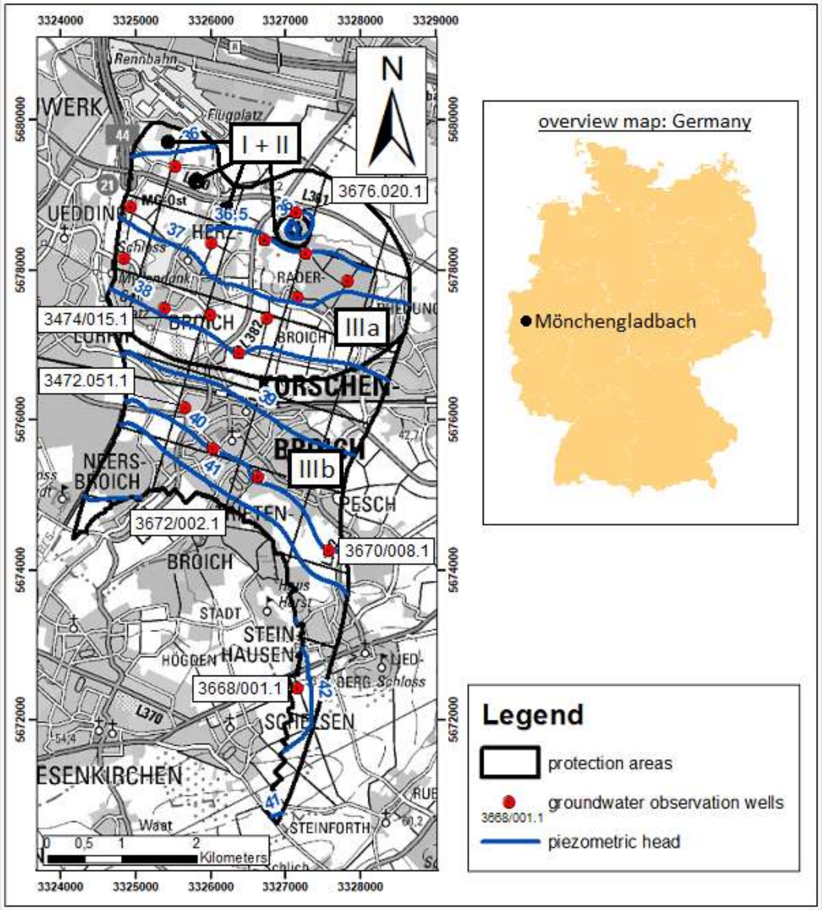

Fig. 1: Study area

- Study area is divided into 1000 x 1000 m cells
- Each cell is assigned a specific NO_3^- input and a NO_3^- degradation capacity
- Land use factors are determined according to the crop types (Allen et al., 1998), urbanized areas after Zhang et al. (2001)

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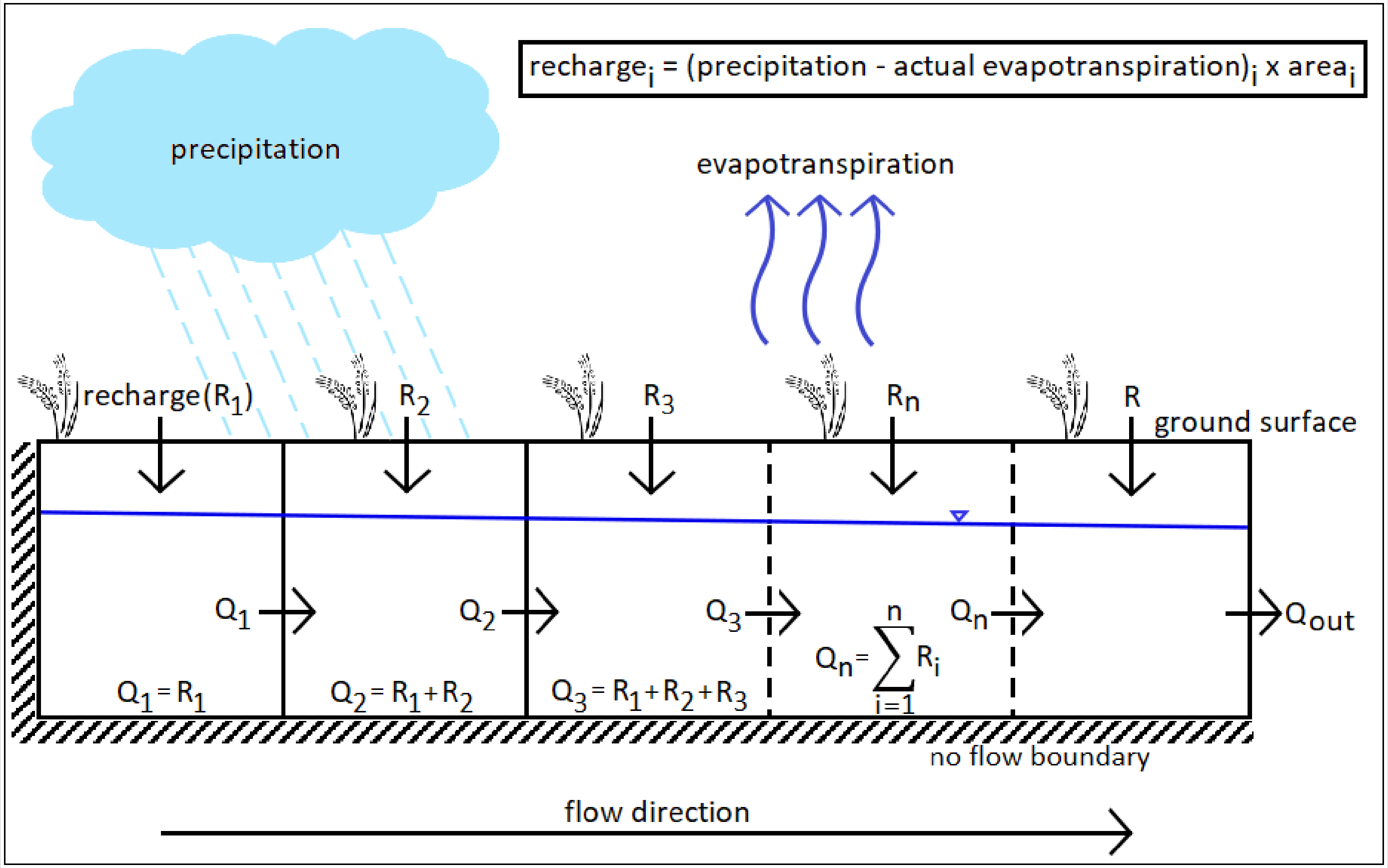

Fig. 2: One-dimensional scheme of the hydrological setup

- ET is calculated after Thornthwaite (1948)
- Nitrate concentration is calculated based on Thomann and Mueller (1987)

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Results

- RCP 4.5 presents a very positive scenario
- RCP 8.5 shows a strong decrease in groundwater recharge
- RCP 2.6 decreases similarly but increases in the last period

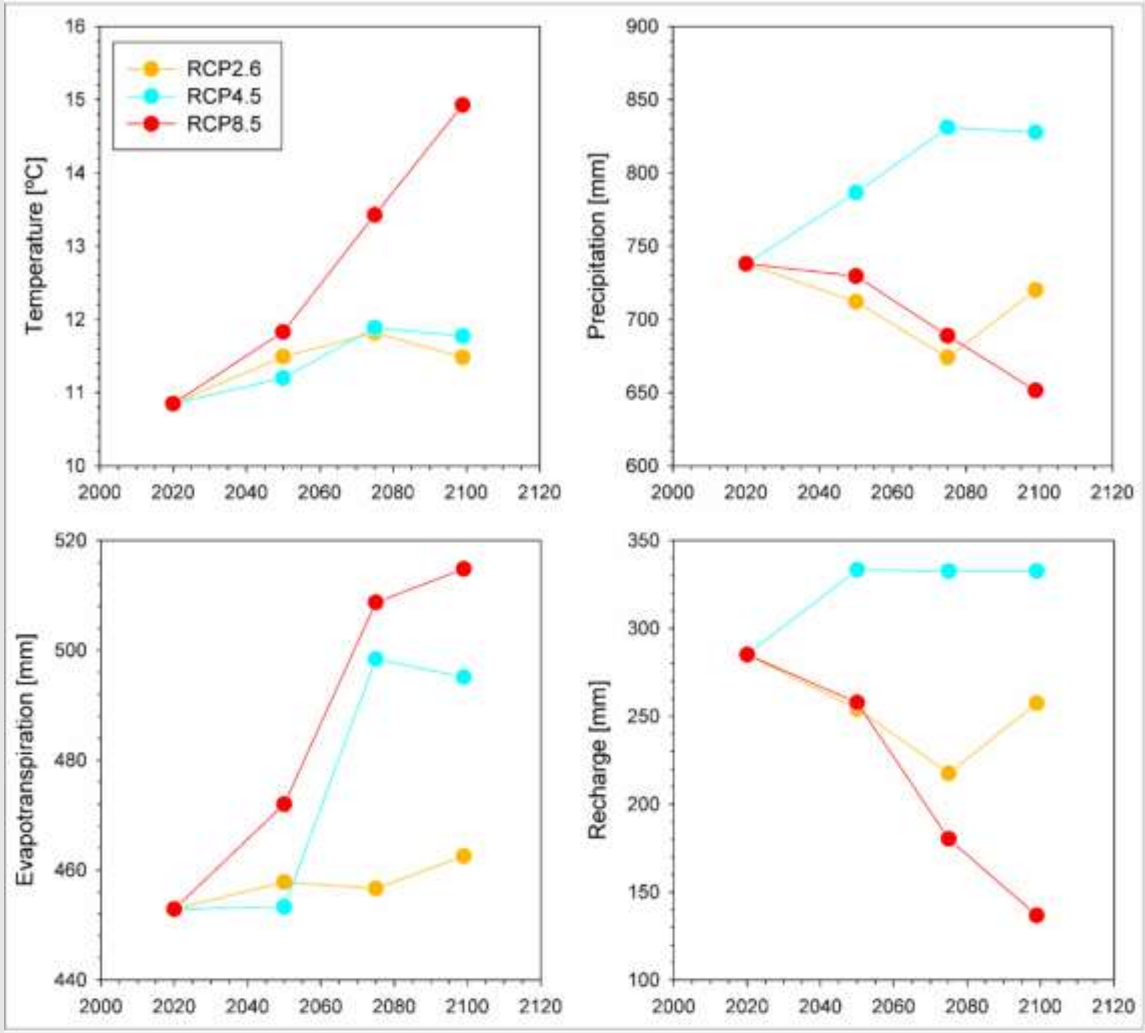

Fig. 3: Evolution of the water balance components for the distinct climatic RCP scenarios

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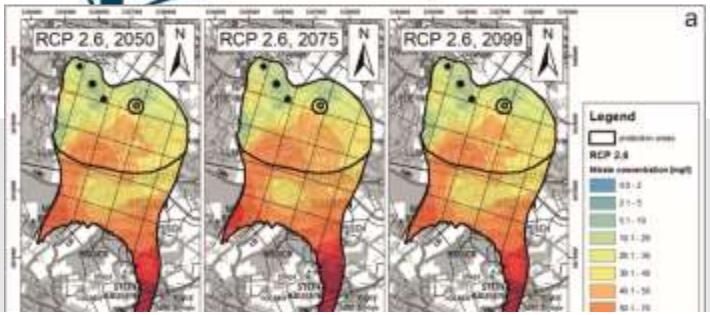


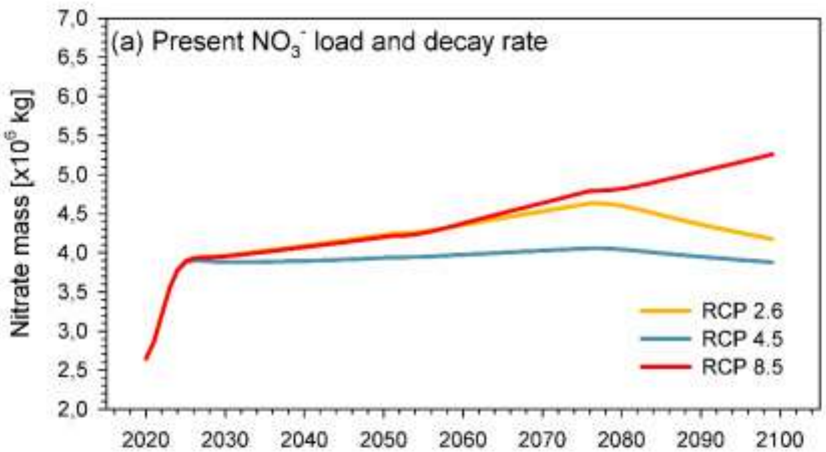
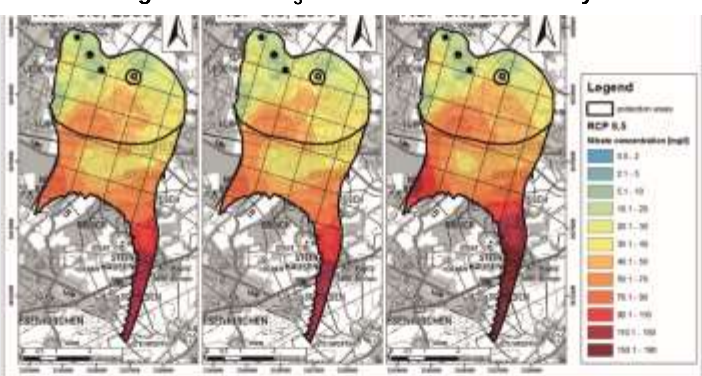


Fig. 6: Total NO_3^- mass of the whole study area



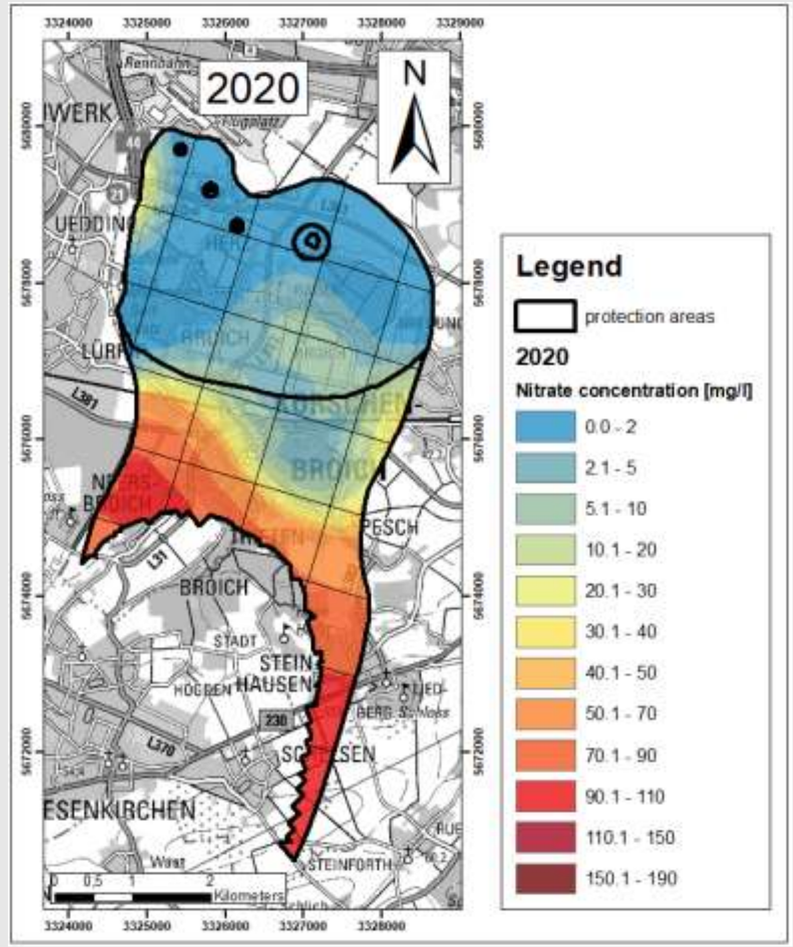


Fig. 4: Present groundwater NO_3^- concentration

Fig. 5: Groundwater NO_3^- concentration projections for the years 2050, 2075 and 2099 for the three climate scenarios

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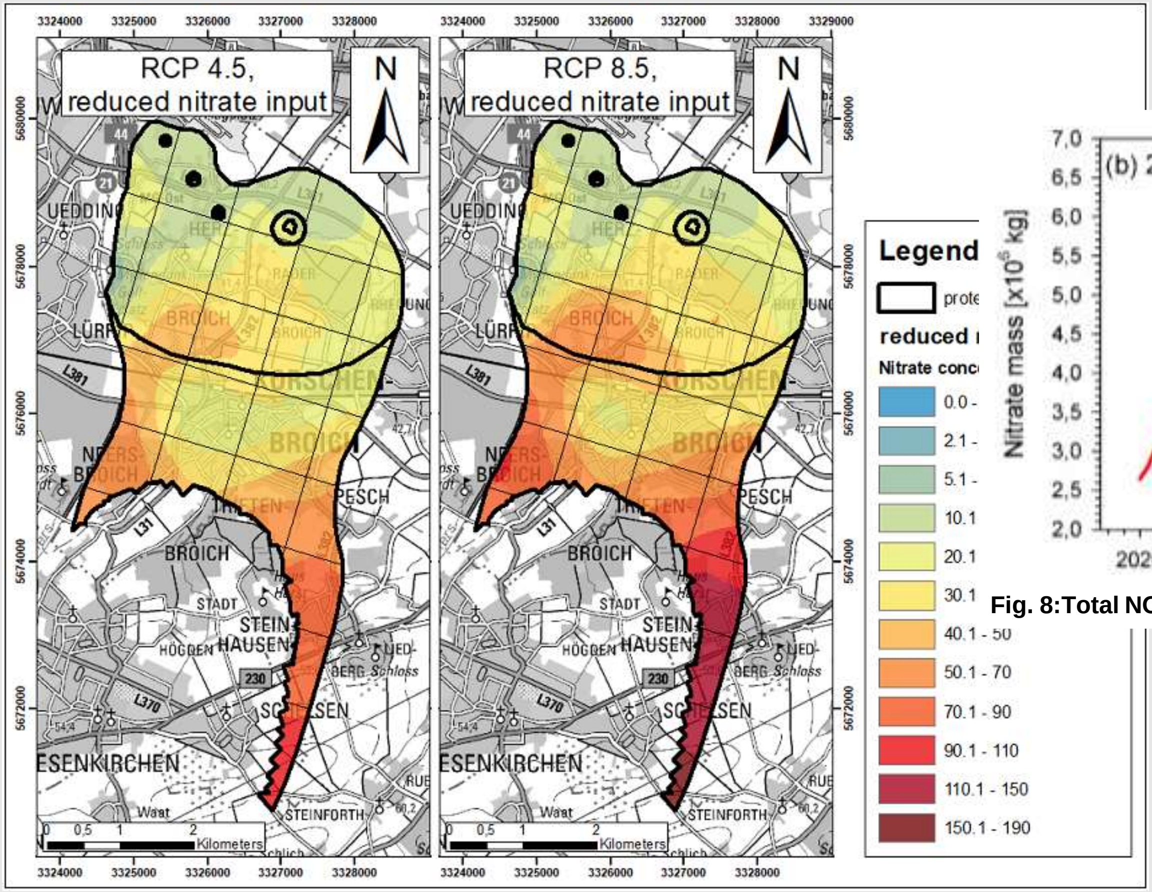

Fig. 7: Groundwater NO_3^- concentration projections with 20% reduced NO_3^- input

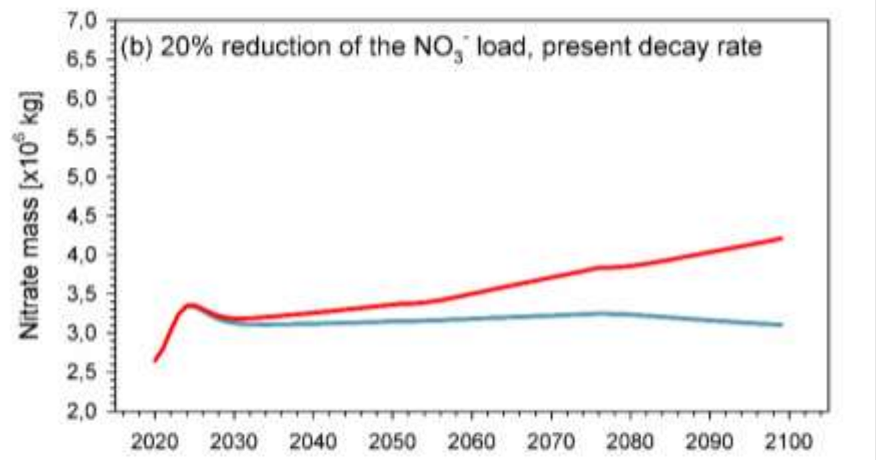

Fig. 8: Total NO_3^- mass of the whole study area with 20% reduced NO_3^- input

Conclusions

- Analysis of the downscaled climate projections shows a large variability of potential effects on the future water balance
- A rising NO_3^- mass in the water catchment Lodshof by a factor between1.50 to 1.89 is expected as a result of climate change
- It is not expected that a 20% reduction in NO_3^- input will ensure that the limit value of 50 mg/l is not exceeded
- Uniform measures for entire regions or countries are not the strategy to solve the NO_3^- problem, aquifer-/site-specific solutions are required

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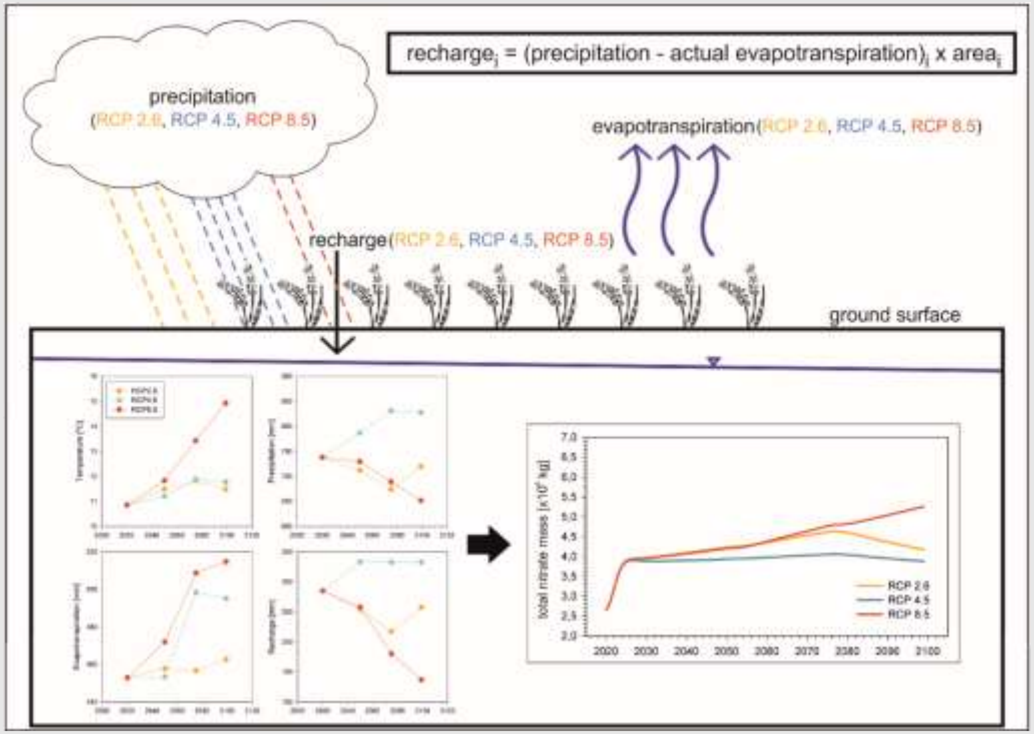

Thank you for your attention

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Thornthwaite (1948):

$$\frac{ET}{P} = \frac{1 + w\,\frac{ET_o}{P}}{1 + w\,\frac{ET_o}{P} + \left(\frac{ET_o}{P}\right)^{-1}}$$

ET = Actual evapotranspiration
P = Precipitation
ETo = Potential evapotranspiration
w = Land use factors

Thomann and Mueller (1987):

$$V\frac{dc}{dt} = W(t) - Q(t)c - KVc$$

V = Water volume
W = Nitrogen inputs
c = Concentration
t = Time
Q = Water flow
K = First-order decay factor