Predicting Tile Drainage Discharge

UID: 102265

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Introduction

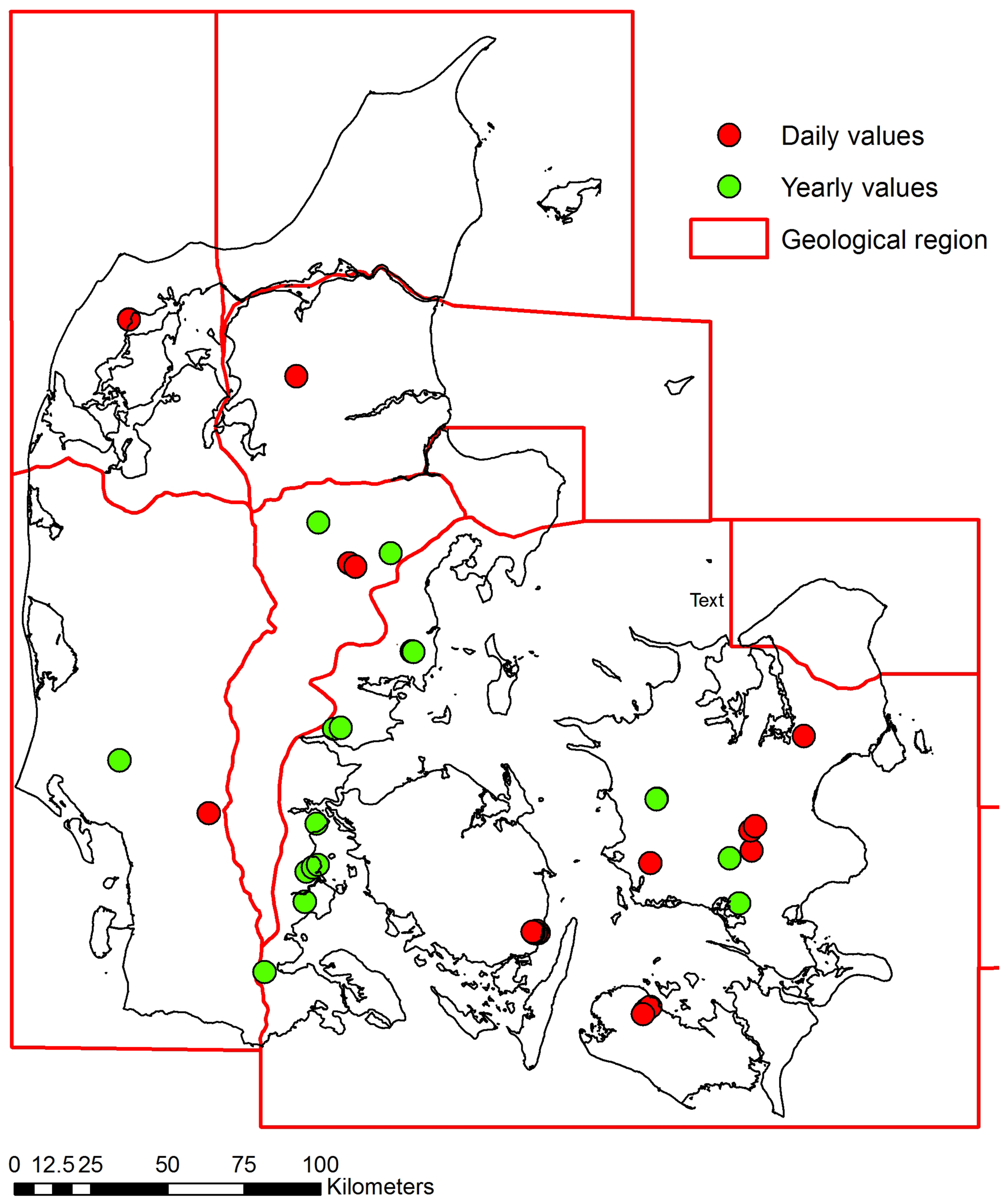
- More than 50% of Danish agricultural areas are expected to be artificial tile drained.
- Transport of water and nutrients through the tile drain system to the aquatic environment is expected to be significant.
- For different mitigation strategies such as constructed wetlands an exact knowledge of the water load coming from the tile drainage system is essential.

Objectives

- To predict and describe temporal as well as spatial tile drainage discharge patterns using different model approaches:
  - Dynamic models
  - Statistical models

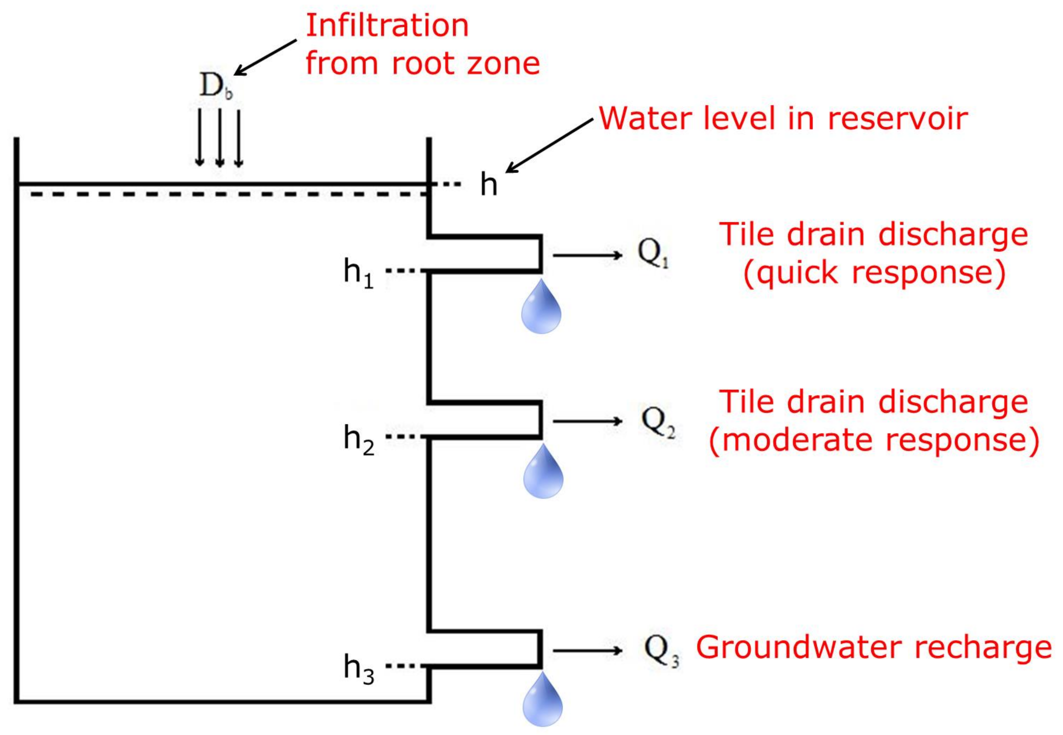
Materials

- Measurements from 35 Danish drain catchments stations (1 to 24 hectares):



Methods

- **Dynamic model (linear reservoir model)**
  - Data from 11 stations with long time series (8 to 20 years) with daily discharge values.
  - Simple root zone model as input (EVACROP, Olesen and Heidmann, 1990) based on climatic data.



  - First-order non-homogeneous differential equation:

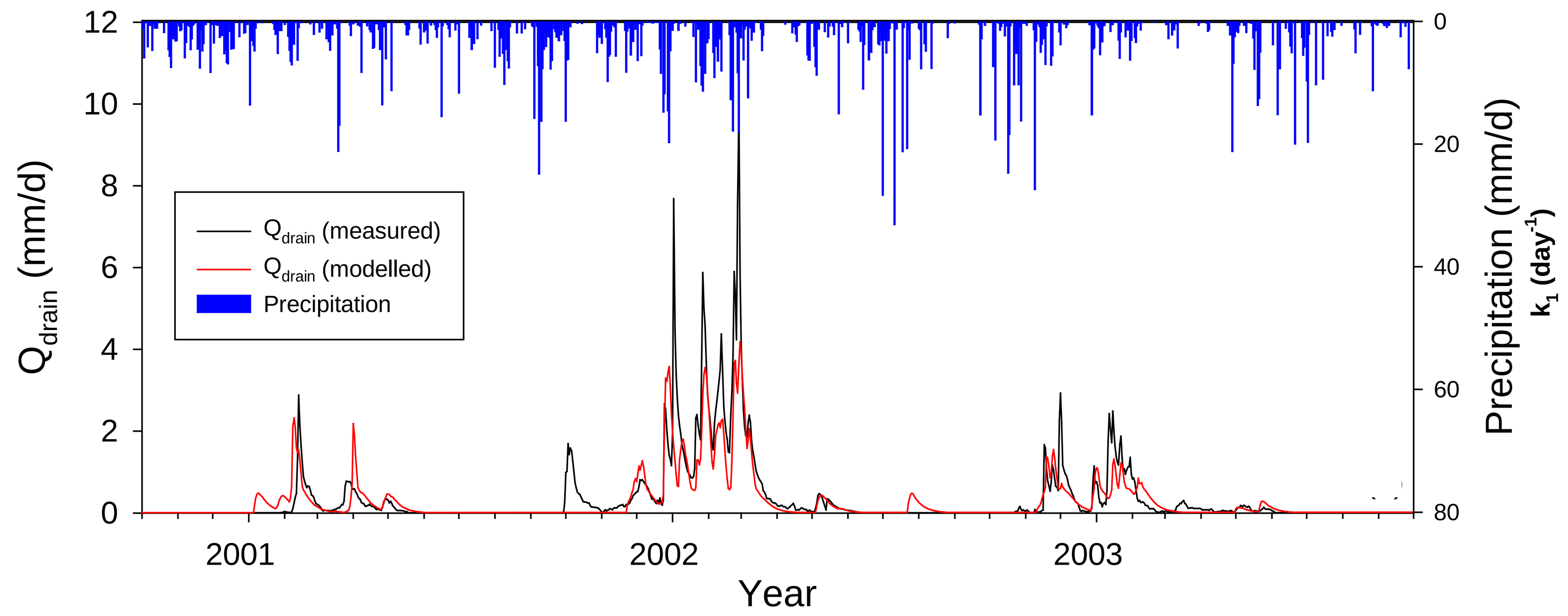
$$D_b = \Sigma k_i (h - h_i) + \frac{dh}{dt}$$

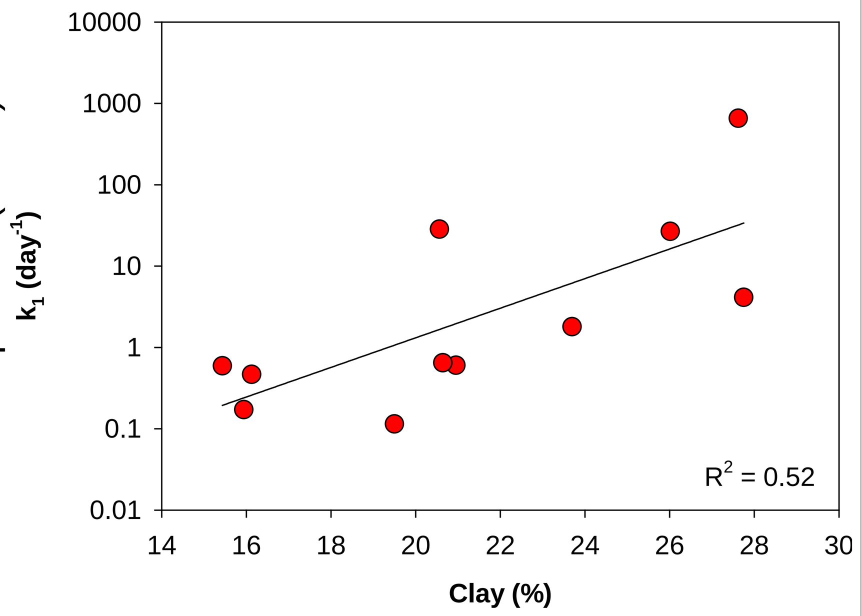
Where i = 1-3, k_i is the respons coefficient [1/T], and t is time.

  - Model calibration using the Gauss-Marquardt-Levenberg method.
  - Calibration of response coefficients ($k_{1\text{-}3}$).
  - $h_{1\text{-}3}$ and baseflow are fixed.
- **Statistical model (Polynomial regression)**
  - Data from 35 stations used (yearly values).
  - Predictors:
    - Clay-% (A, B, and C horizon)
    - Soil class (Danish soil classification)
    - Geological region
    - Geology
    - Topographical wetness index
    - Depth to groundwater
    - Precipitation

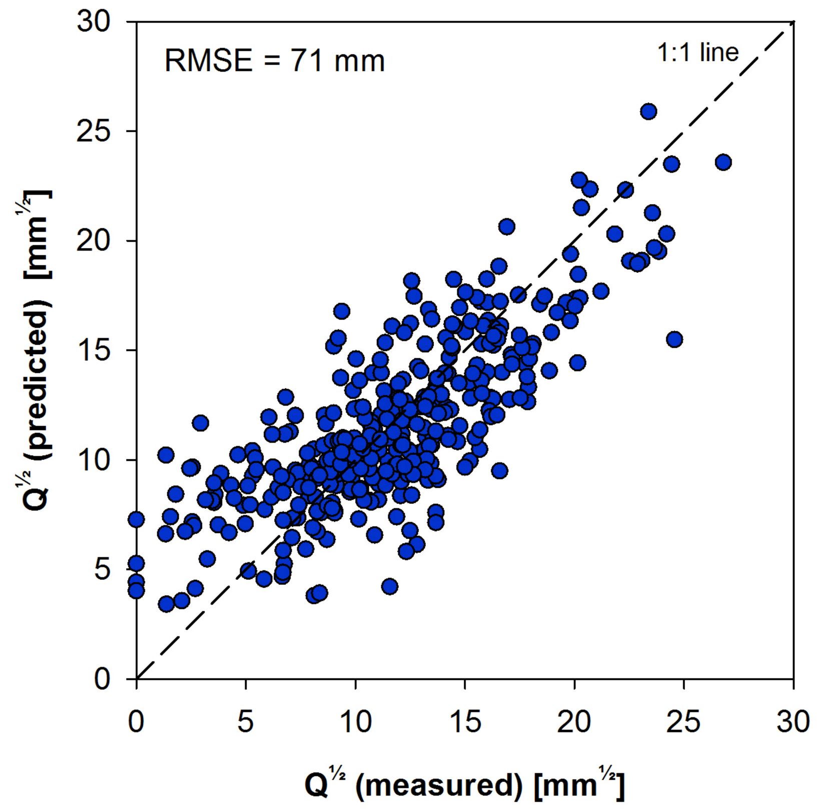
Results

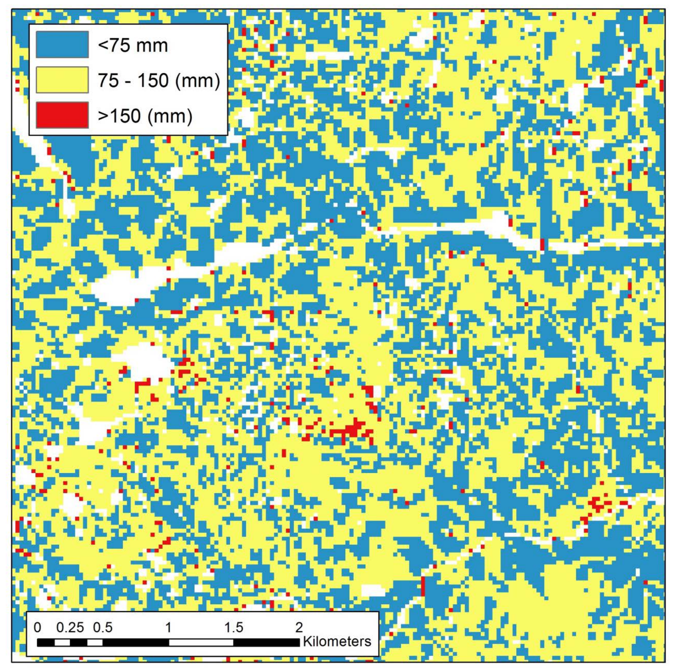
- Dynamic model (daily discharge)

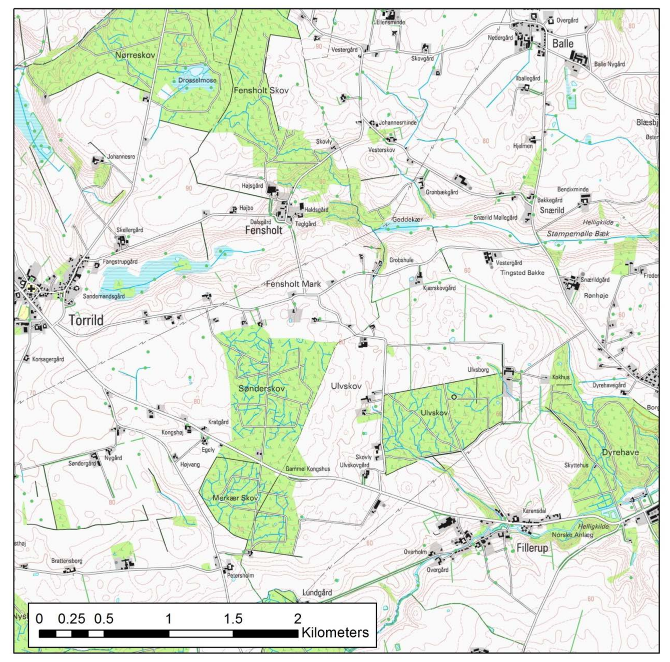




  - Example of output from the model plotted against measured daily discharge values (left).
  - Calibrated and site specific parameters showed a fairly good correlation between the clay-% in the C horizon and the response factor k_1 (right) representing the quick response from the tile drain discharge. For all other parameter combinations, no or only weak correlations were found.
- Statistical model (yearly discharge)







  - Based on a second order polynomial, a relation was found predicting the yearly drain discharge (left). Significant predictors were **yearly precipitation**, **clay-% in the C-horizon**, and **topographical wetness index**. The map in the middle shows an example of the yearly drain discharge (in mm) at a yearly precipitation of 600 mm in a typical Danish moraine landscape (right).

Conclusions

- A simple linear reservoir model performed well modeling the daily discharge from the tile drainage system. A fairly good correlation was found between the clay-% in the C horizon and the response coefficient controlling the discharge peaks from the tile drain system.
- Yearly tile drain discharge could be reasonably predicted by a statistical regression model with yearly precipitation, clay-% in the C-horizon, and topographical wetness index as predictors.
- There is a need to further develop and test the models on a broader dataset taking the geological variability of Denmark more into account.

Acknowledgments

This work was supported by the GUDP project "Drain Filter Technologies for Optimized Nutrient Reduction" (iDRÆN) financed by The Danish AgriFish Agency, Ministry of Food, Agriculture and Fisheries of Denmark (www.idraen.dk)

References

Olesen, J.E., and T. Heidmann 1990. EVACROP. Et program til beregning af aktuel fordampning og afstrømning fra rodzonen, version 1.00 (in Danish). Arbejdsnotat nr. 9. Dep. of Agrometeorology, Danish Inst. of Plant and Soil Science, Tjele, Denmark.

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