TREX – AP2: Geophysics and water dynamics

Status and review of the modeling work

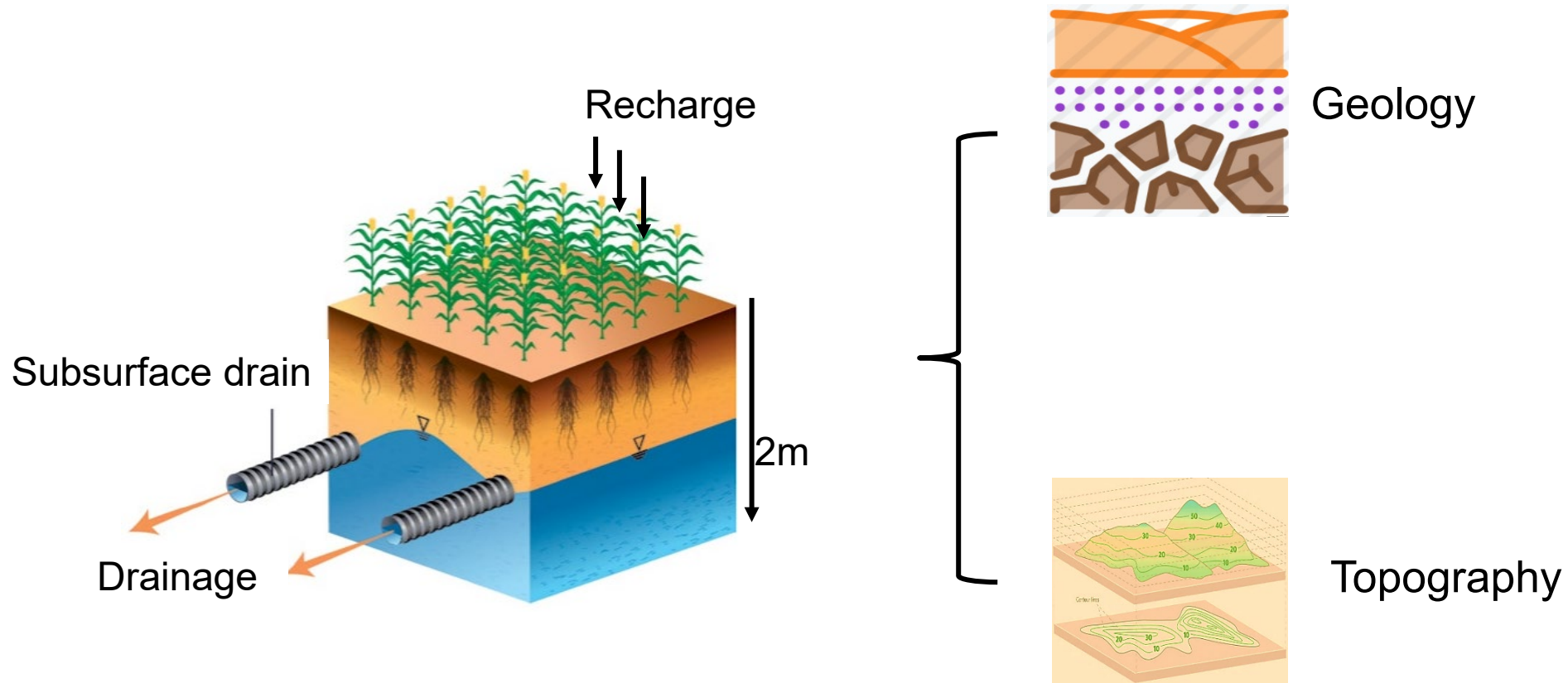**Hafsa Mahmood**

Hydro Geophysics Group, Department of Geoscience, Aarhus University
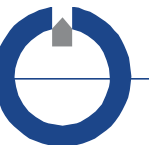
Rasmus R. Frederiksen

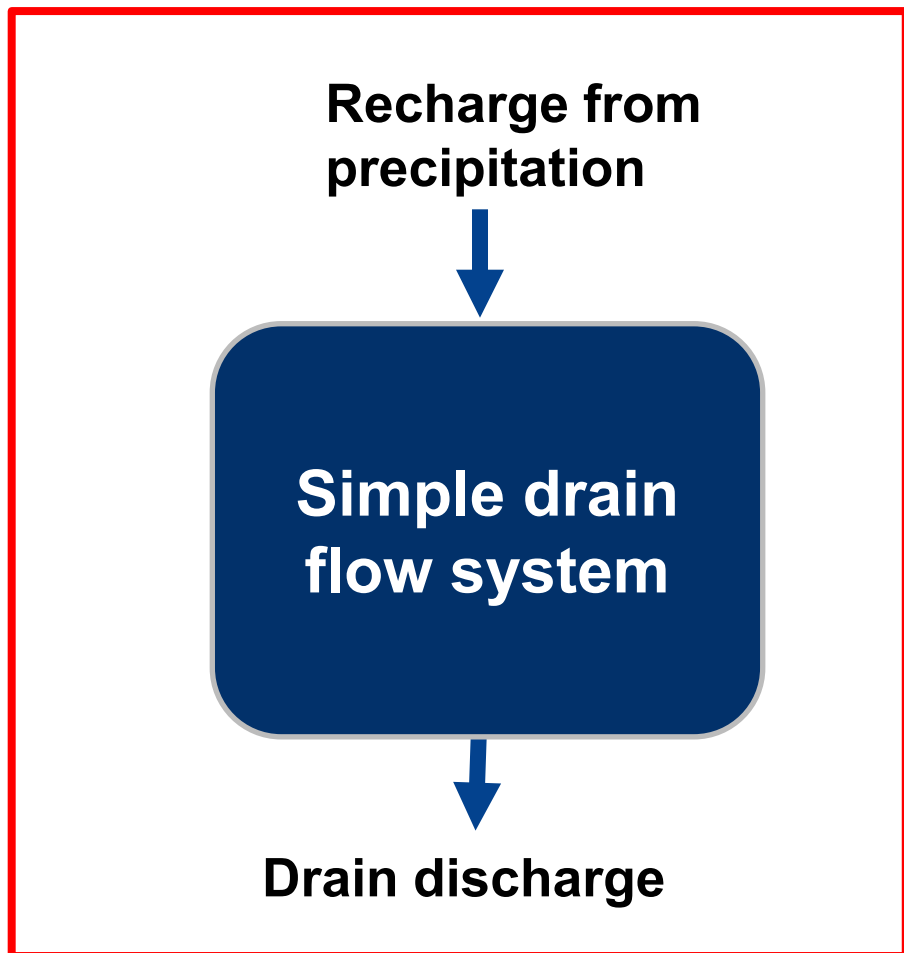**Institute of Bioscience, Aarhus University**

Dated: 24.11.2021

STØTTET AF

Promilleafgiftsfonden for landbrug

WATEC
AARHUS UNIVERSITY CENTRE FOR WATER TECHNOLOGY

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Drain flow dynamics

Recharge

Subsurface drain

Drainage

2m

Geology

Topography

Who controls the drain flow dynamics ?

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Simple and complex drain flow systems

Simple drain flow system

Complex drain flow system

Recharge from precipitation

Simple drain flow system

Drain discharge

Recharge from precipitation

Complex drain flow system

Lateral fluxes

Drain discharge

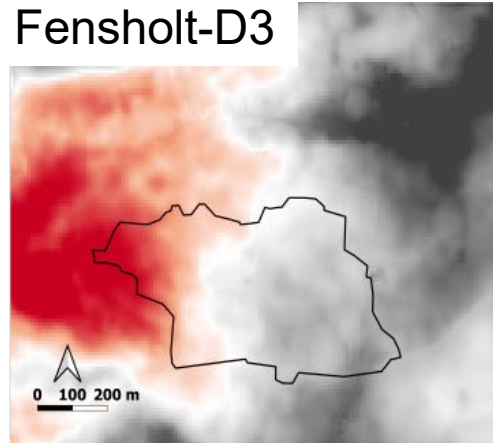**Vertical fluxes**
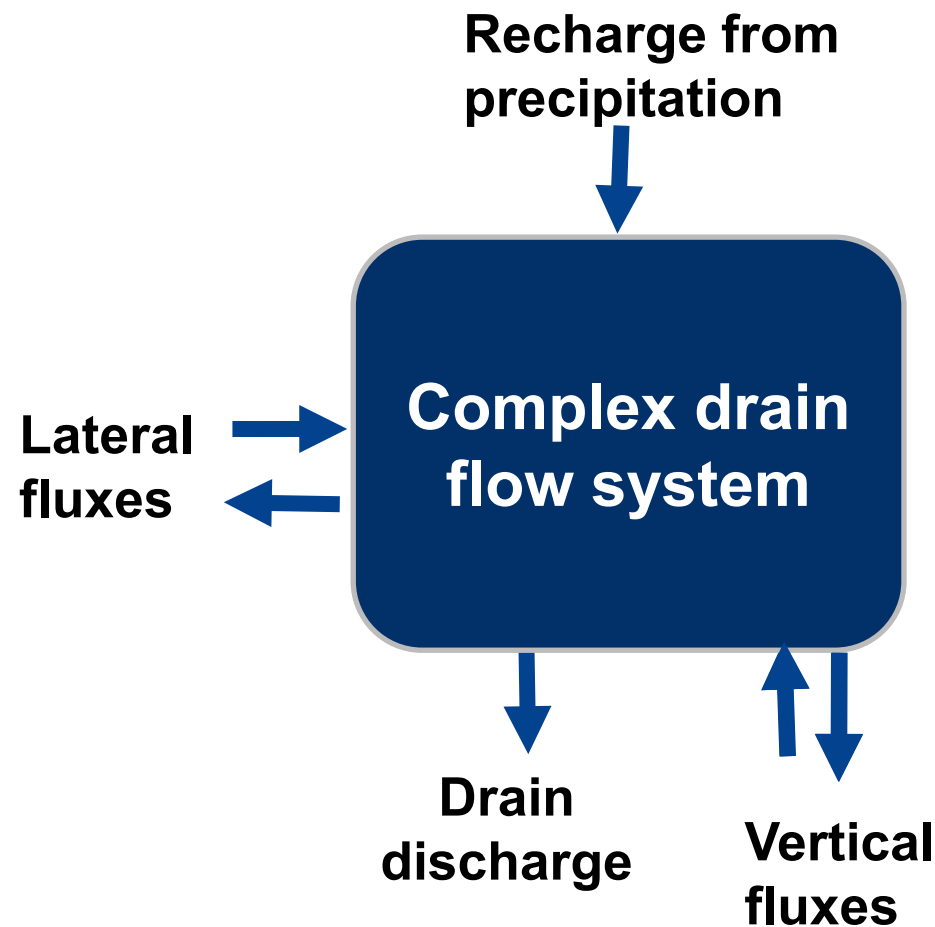
Drain flow fraction = Volume of discharge / Volume of recharge
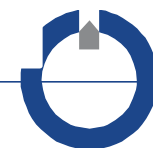
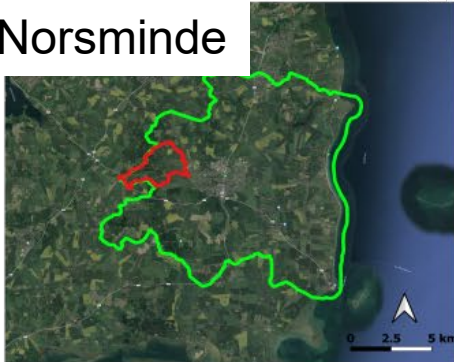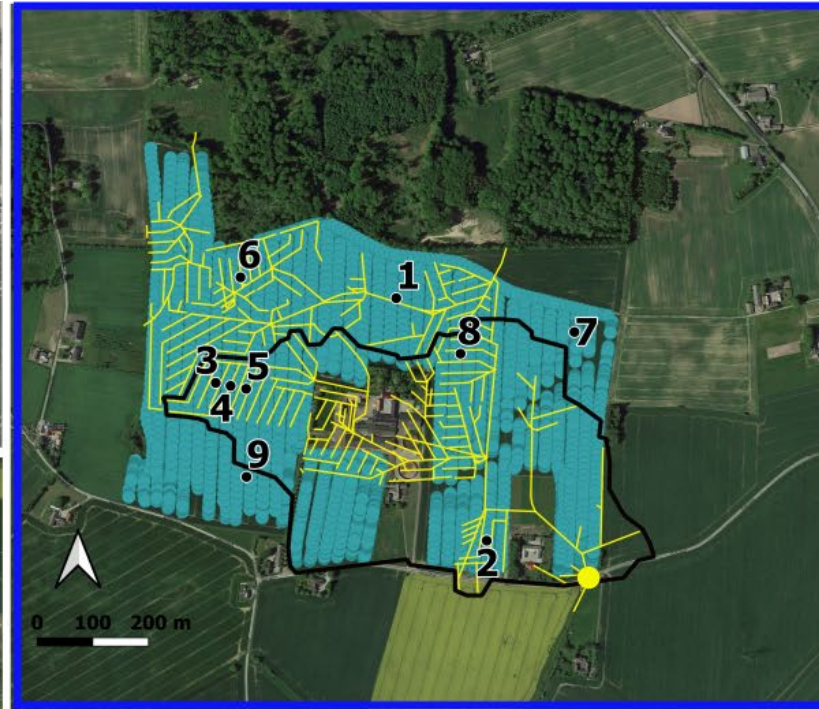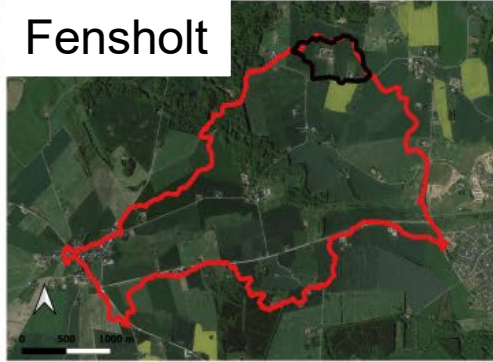# Study area: Fensholt-D3

Denmark
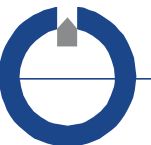
Fensholt-D3

Norsminde

Fensholt

Digital elevation model (m)

82

98

- Resistivity data points
- Fensholt-D3 Catchment (Study area)
- Piezometers
- Outer domain
- Norsminde Catchment
- Fensholt Catchment
- Drainage system
- Drain Station

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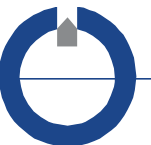# Methodology

- **Hydrogeological model**
  - Estimating hydraulic conductivity (K) from slug test
  - Mapping and modelling electrical resistivity (Ωm)
  - Translation of Ωm to K
  - Delineation of high and low K zones

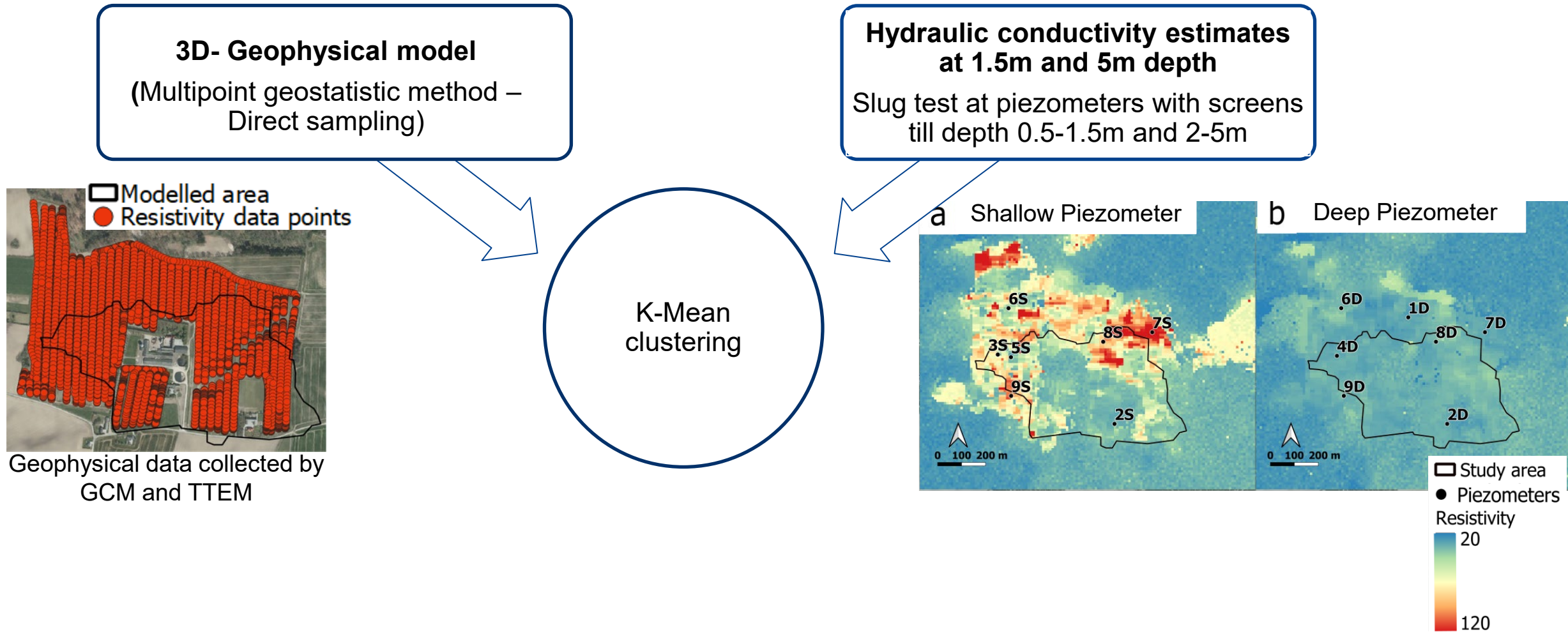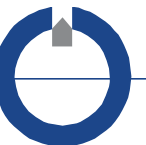- **Groundwater flow model**
  - Uniform K baseline scenario
  - Individual K values scenarios
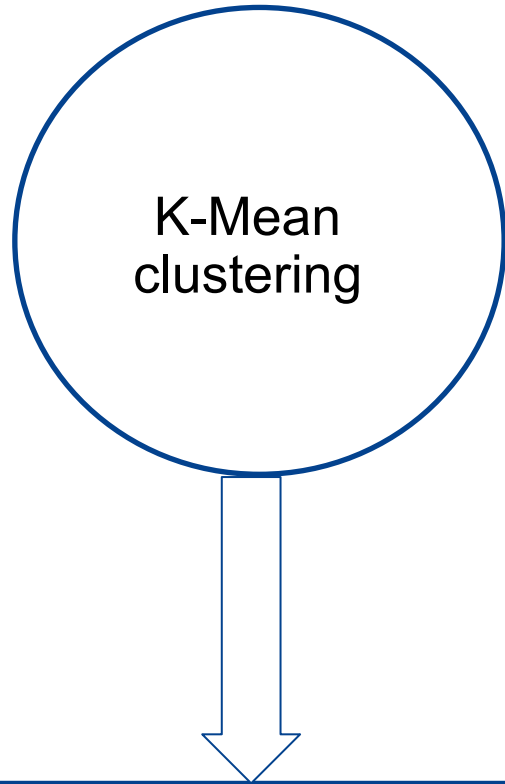 - K-zonation scenarios

- **Data analysis**
  - Model output: drain discharge at outlet and drain flow fraction
 - Topographical indices
  - Regression analysis

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Hydrogeological model: K and Ωm

3D- Geophysical model

(Multipoint geostatistic method – Direct sampling)

Hydraulic conductivity estimates at 1.5m and 5m depth

Slug test at piezometers with screens till depth 0.5-1.5m and 2-5m

Modelled area
Resistivity data points

Geophysical data collected by GCM and TTEM

K-Mean clustering

a Shallow Piezometer

b Deep Piezometer

6S
7S
8S
3S 5S
9S
2S

6D
1D
8D 7D
4D
9D
2D

0 100 200 m

0 100 200 m

Study area
Piezometers
Resistivity
20
120

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# Hydrogeological model: translation of Ωm to K

K-Mean clustering

Delineation of hydraulic conductivity zones (K)
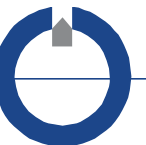(using geophysical threshold found between clusters)
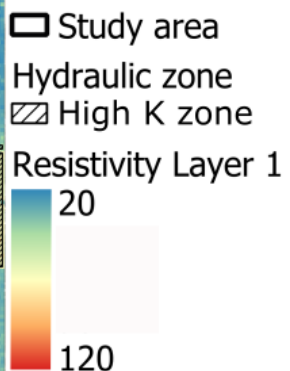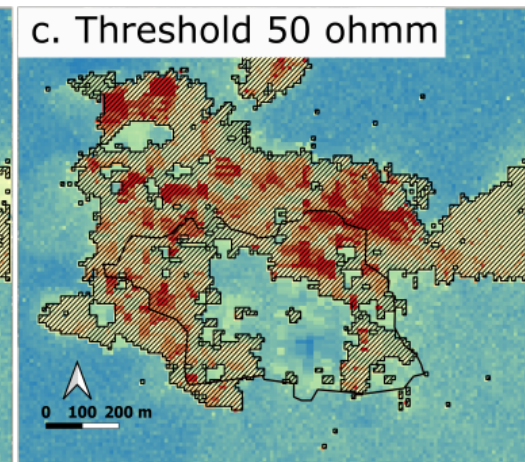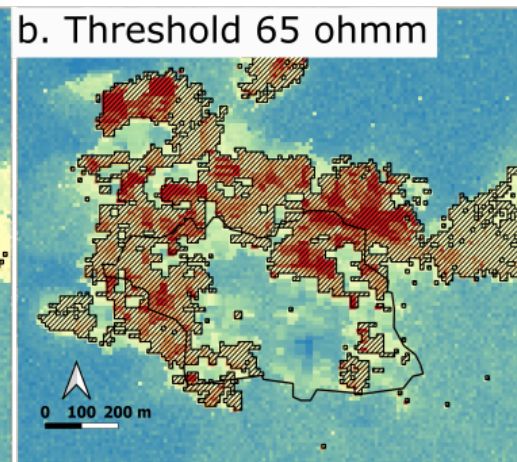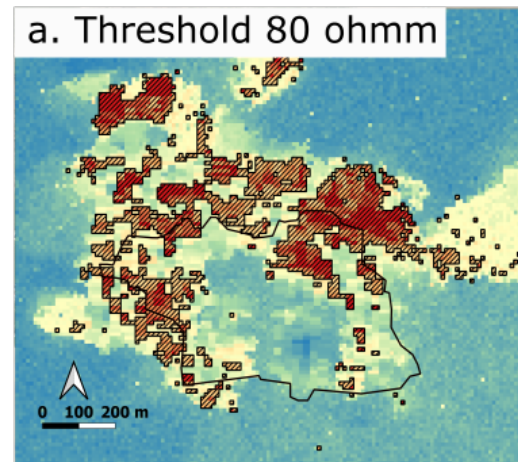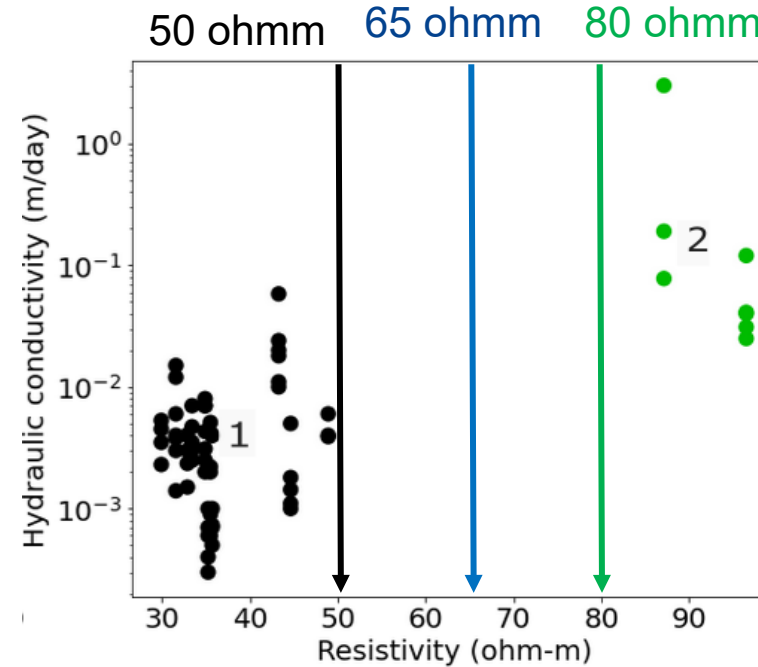
Groundwater flow model

- **Groundwater model - MODFLOW 6**

- **Simulation period 01-Jan-2013 to 31-Dec-2014**

- **10 x 10 m Resolution (120 *140)**

- **6 model layers**
  - 1 m thickness for layer 1-5
  - 15 m thickness for layer 6
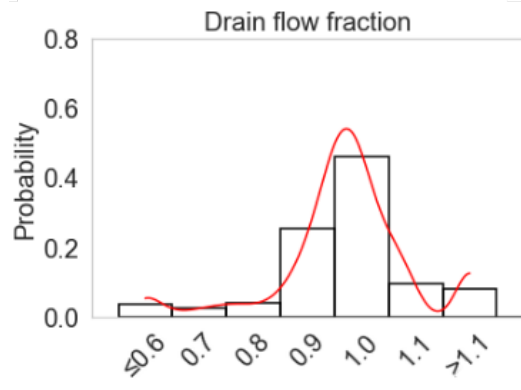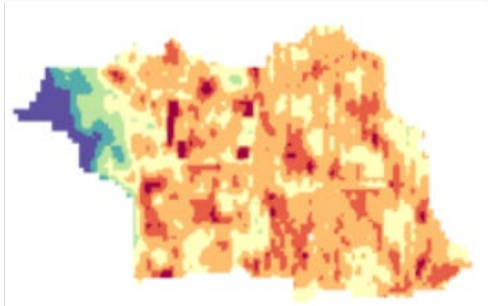
- **No-flow boundaries**

- **Subsurface drainage where needed**
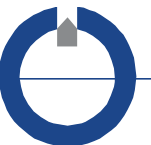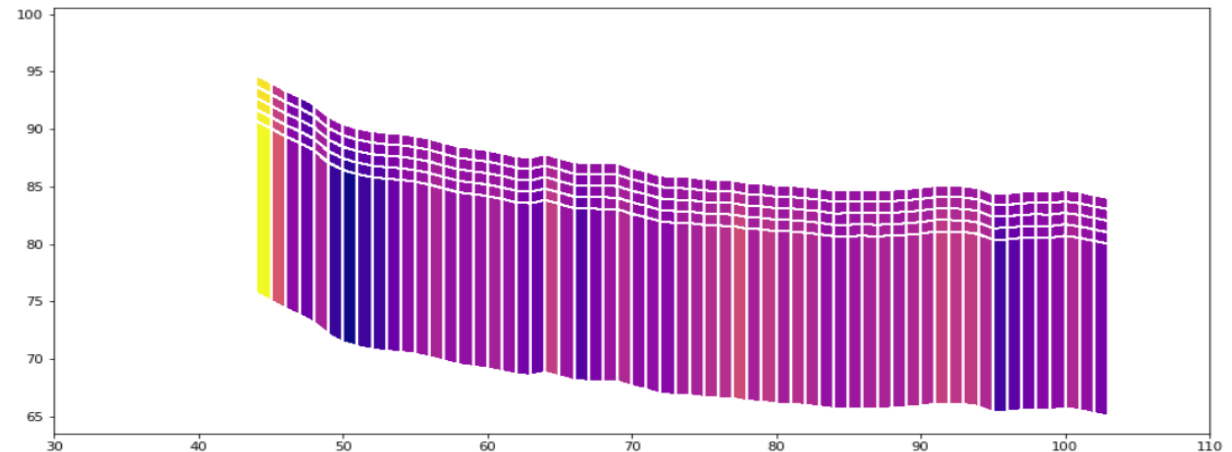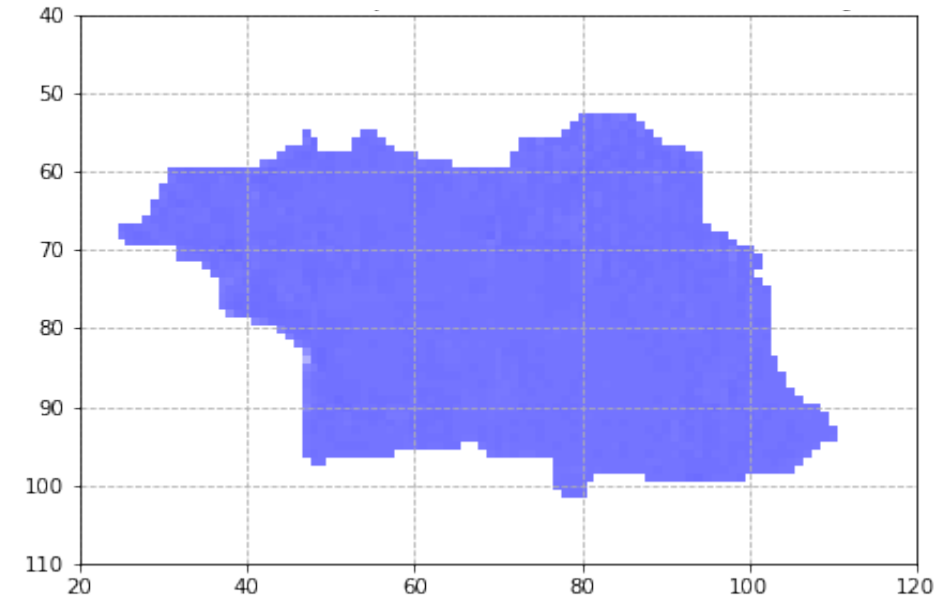
Importance of K-value

- **Baseline scenario (All clay)**

- **Variation of individual K values**
  - Assign mean K value of cluster 1 to all study area
  - Assign mean K value of cluster 2 to all study area

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Variation of individual K values

Baseline Scenario	Cluster 1 K value	Cluster 2 K value
Uniform K=0.004 m/day	Uniform K=0.0054 m/day	Uniform K=0.44 m/day
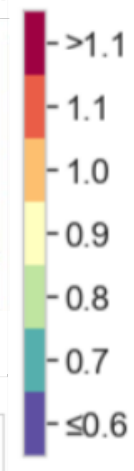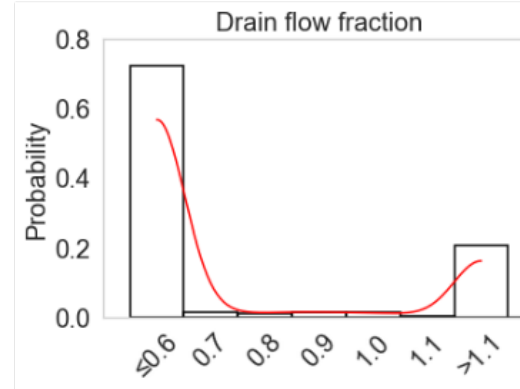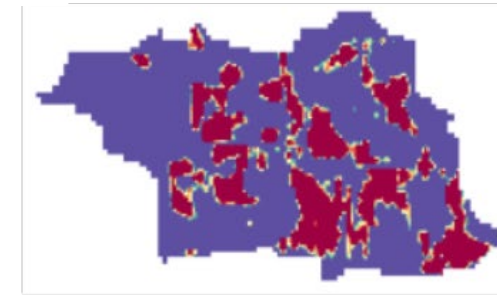
High K tends to reduce the drain flow fraction ratio
While low K increase probability of intermediate drain flow fraction (0.9 - 1.0)

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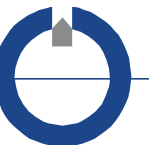
Importance of K-zonation

- **Baseline scenario (uniform K)**

- **Variation of K-zonation based on Ωm-threshold**
    - Delineation of area based on 50 Ωm threshold into two K zones
    - Delineation of area based on 65 Ωm threshold into two K zones
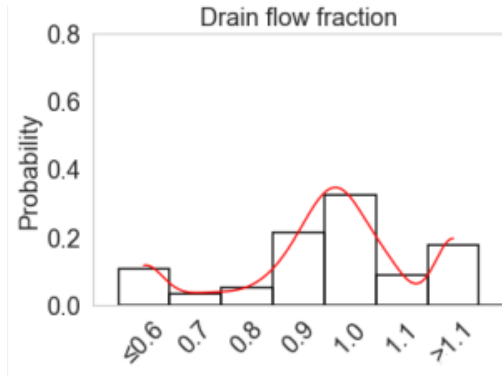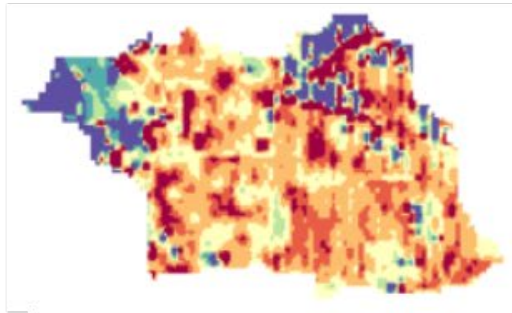   - Delineation of area based on 80 Ωm threshold into two K zones

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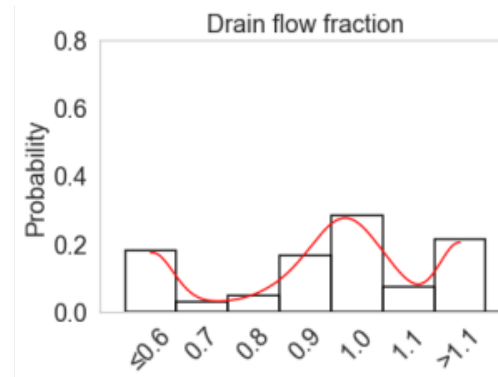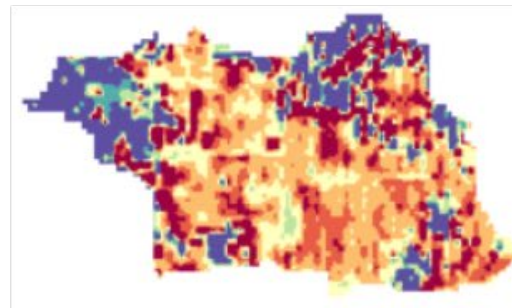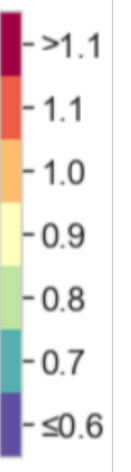AARHUS UNIVERSITY
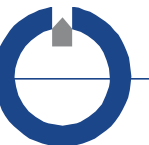
Importance of K-zonation
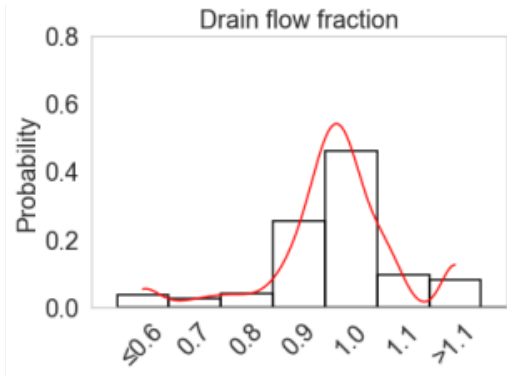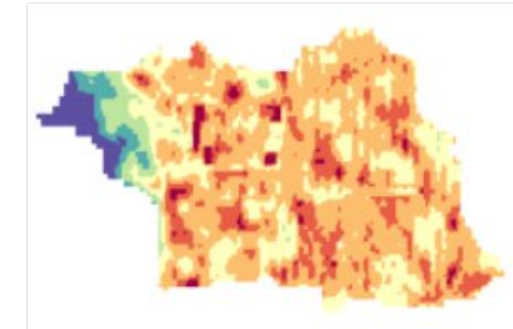
a. Uniform K   b. Threshold 80 ohmm   c. Threshold 65 ohmm   d. Threshold 50 ohmm

Drain flow fraction
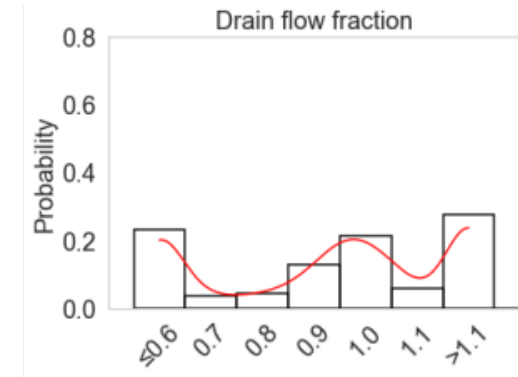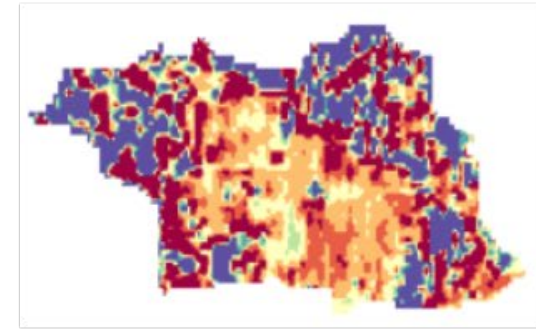
Lower the threshold, more distributed drain flow fraction
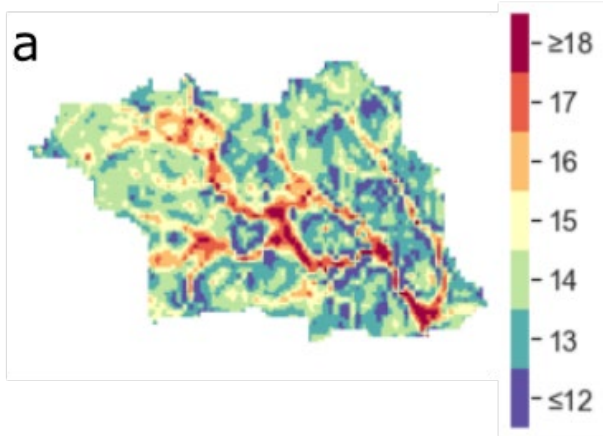
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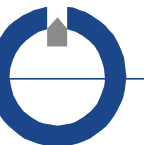
Importance of topographical indices (TI)

- **Drain flow fraction is function of TI**

- **TI:**

  Topographical wetness index

  Topographical position index

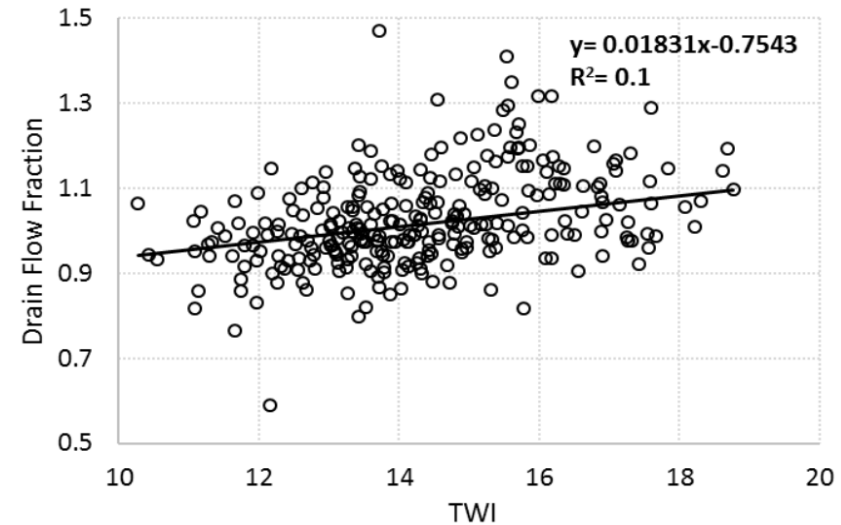- **Linear regression** between TI and drain flow fraction (threshold scenario with best performance)
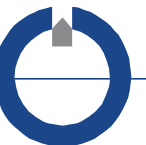
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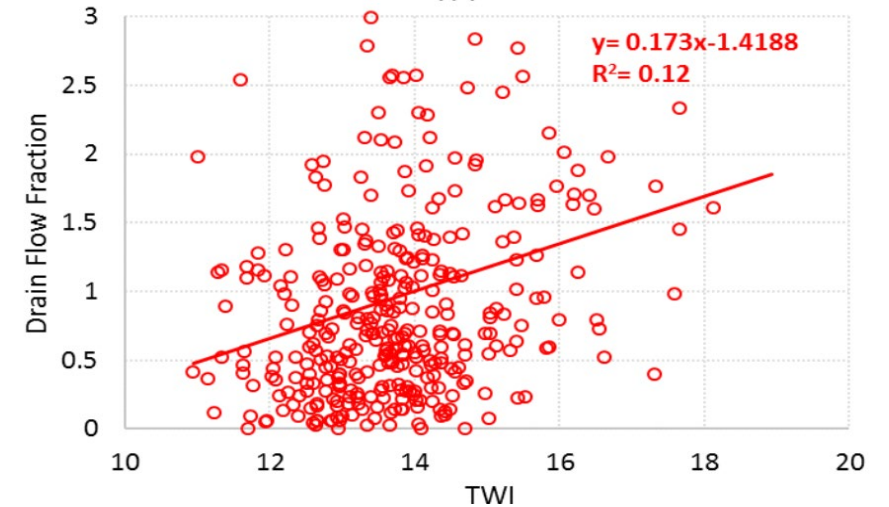AARHUS UNIVERSITY
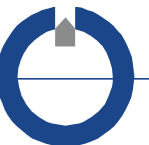
Importance of topographical indices (TI)
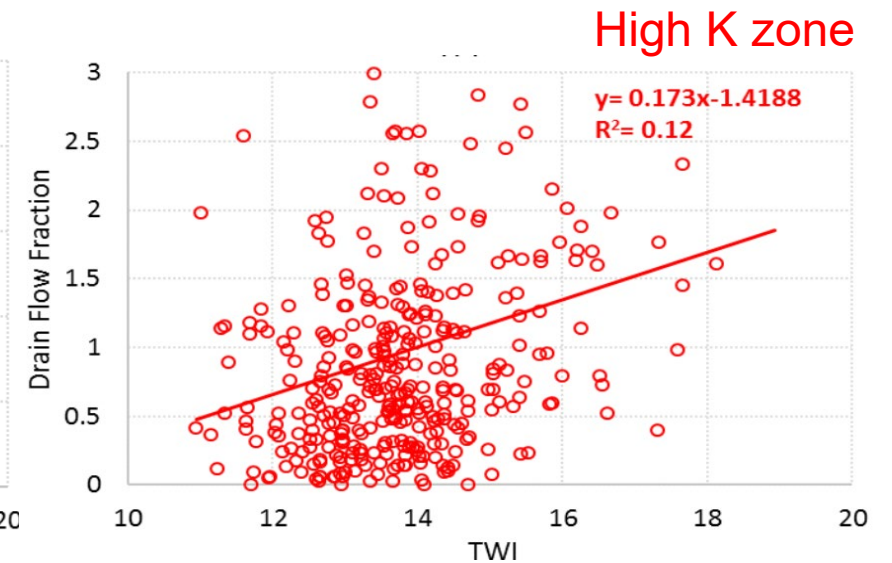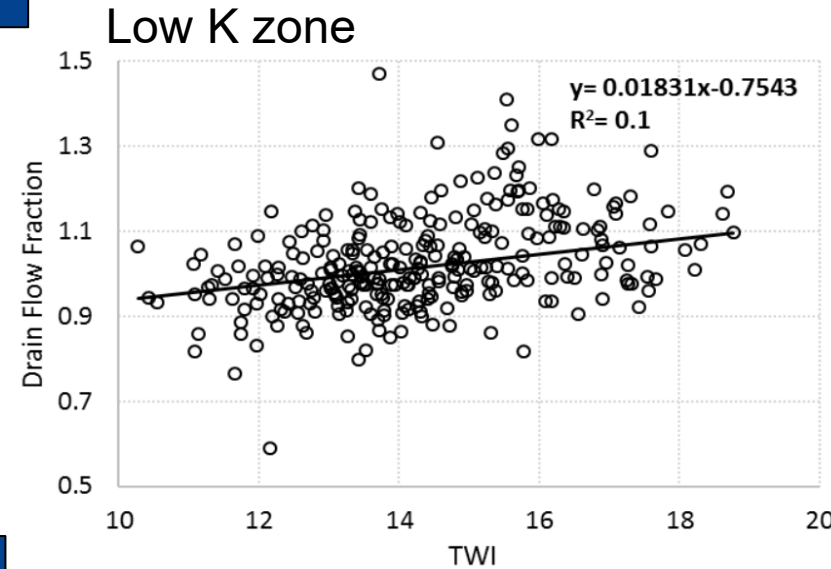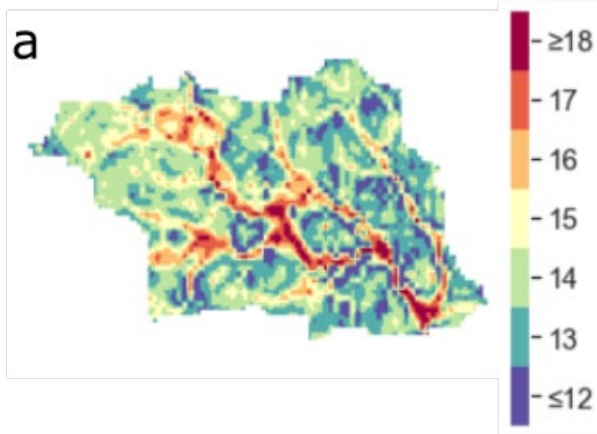
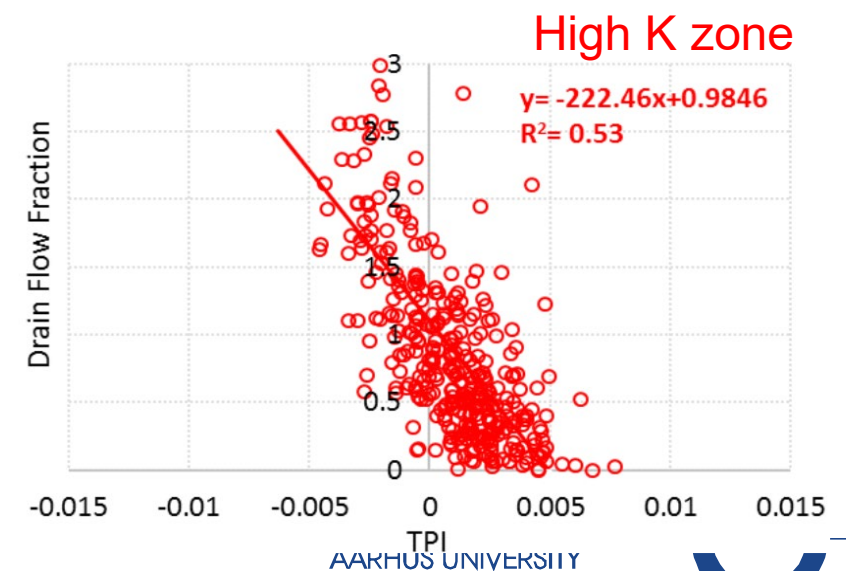Topographical wetness index (TWI)
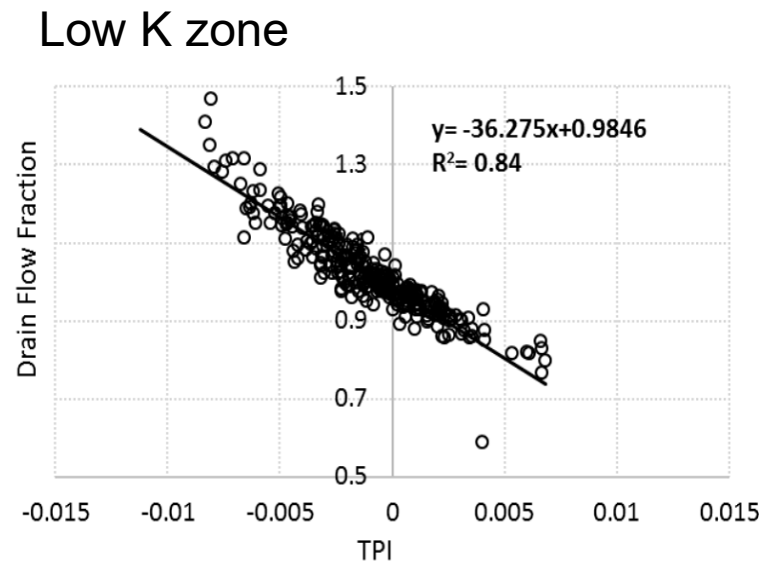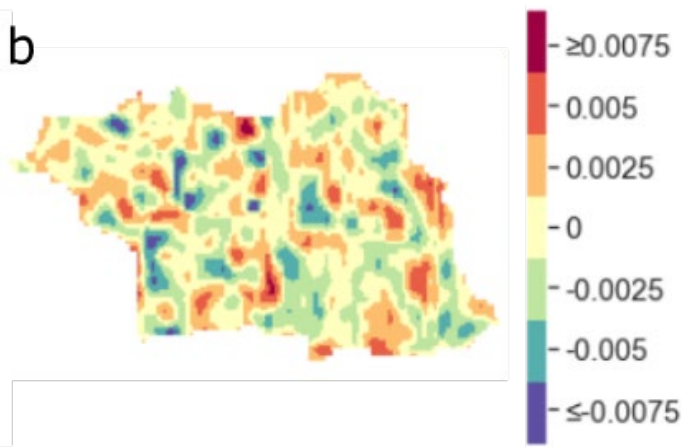
Low K zone

High K zone

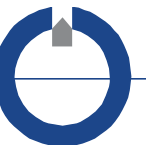# Importance of topographical indices (TI)

Topographical wetness index (TWI)

Topographical position index (TPI)

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Conclusions

- **Promising mapping methodology**

- **Importance of K-zonation**

- **Importance of K values**

- **TPI is promising as predictor for drain flow fraction**

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Any Questions?

Contact: hm@geo.au.dk