A non-calibrated, runoff process-based rainfall-runoff model for prediction of floods in ungauged basins

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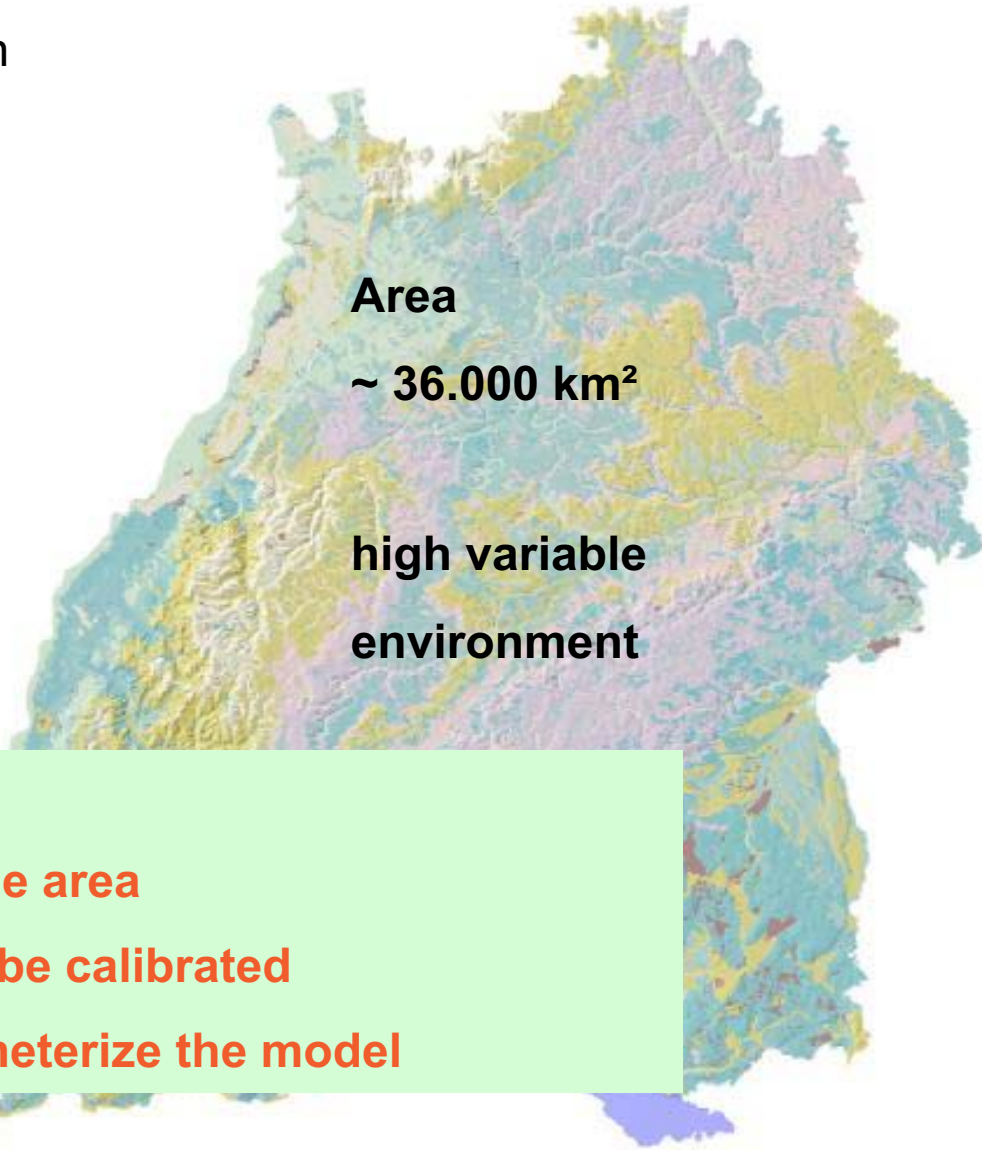
Motivation / Objective

→ Identification and quantification of **flow formation processes** with respect of floods

→ for the whole area of the state of Baden-Württemberg

→ accounting for **different types of precepitation** and **antecedend moisture** conditions



Requirements

→ **Data, available for the whole area**

→ **A model, that needs not to be calibrated**

→ **Expert knowledge to parameterize the model**

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Database (GIS-Data)

→ **Soil, Geology, Hydro-Geology 1:200,000** [soil classes, soil depth, portion of skeleton, available field capacity, transmissibility of of underlaying material]

→ **CORINE-Landcover** [potential depth of roots, density and lentgh of macropores, roughness caracteristics of earth surface]

→ **LIDAR-Data (~ 1*1 m²)** [DEM, hight of vegetation, slope, flow accumulation, depth to groundwater near rivers]

→ **Dergree of sealing of land surface (1*1 m²)** [reduction of infiltration]

→ **River network (1:10,000)** [target to build a river network from the DEM]

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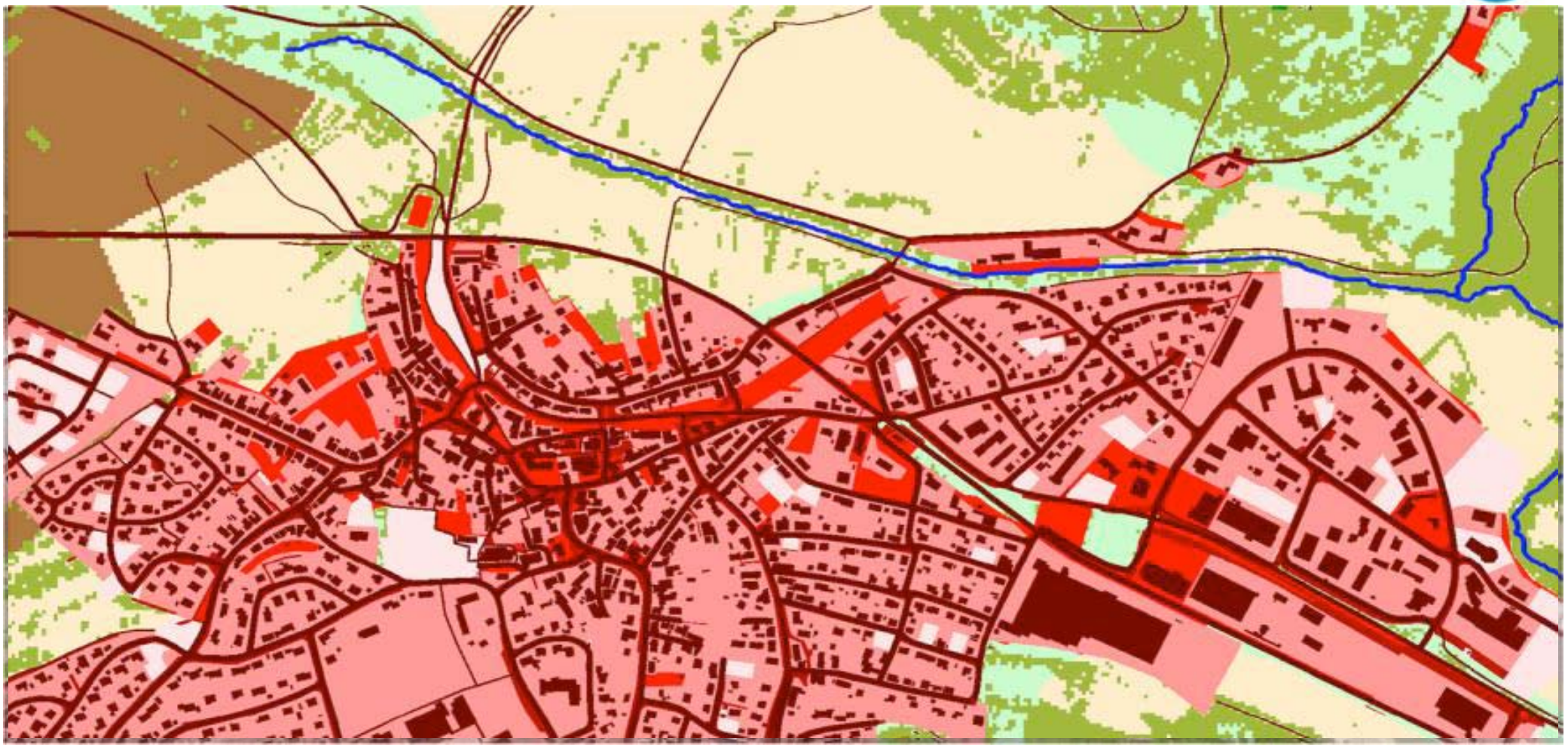
Landcover / degree of sealing



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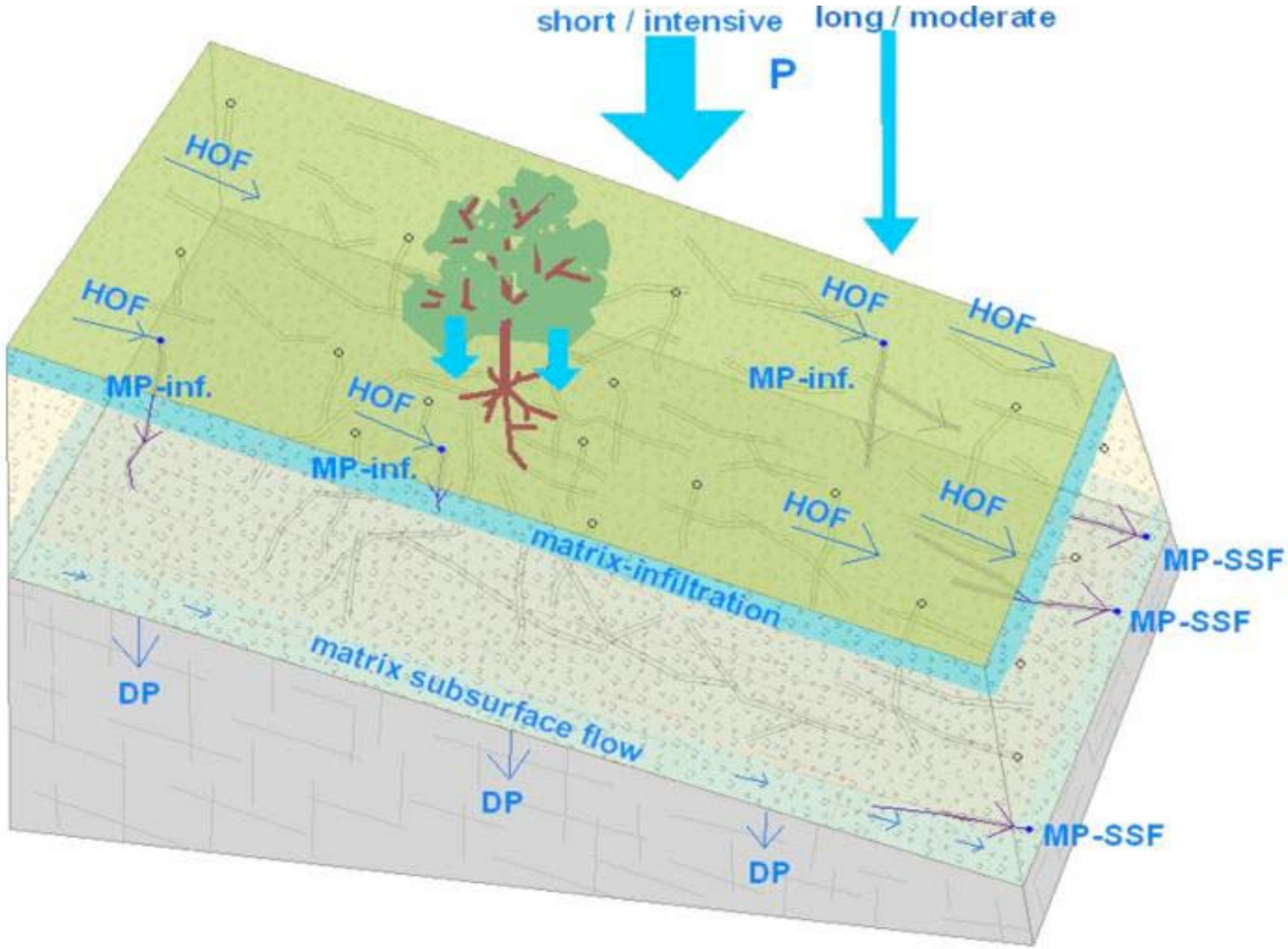
Prozesses, implemented in the model



P = precipitation

HOF = Hortonian overland flow

MP-inf = macropore infiltration

MP-SSF = macropore subsurface flow

DP = deep percolation

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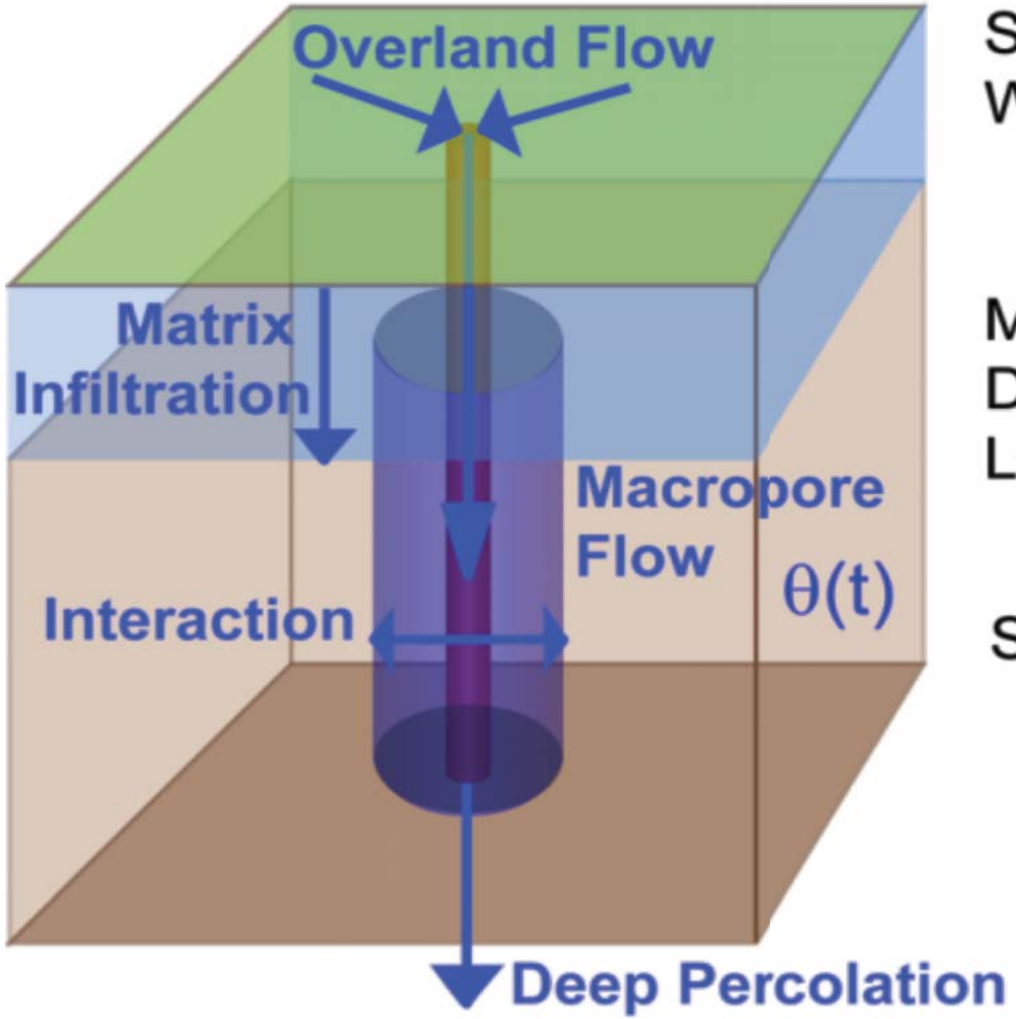
Infiltration (Green & Ampt)



Weiler, 2005, JoH

Soil Matrix:
WFS, θ_i,k_{sat}

matrix infiltration = function (soil class, antecedent moisture, precipitation intensity, precipitation duration)

Macropores:
Density, Radius, Length

macropore interaction = function (soil class, antecedent moisture, active macropore length, macropore radius)

Soil depth

actual macropore infiltration = function (macropore density, macro pore interaction)

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Parameterization of macropores

Landcover	density of vertical macropores [MP/m²]	length of vertical macropores [cm]	density of horizontal macropores [MP/m²]	maximum depth of horizontal macropores [cm]
cropland	75	30	125	40
viniculture	75	50	125	150
fruist	100	50	125	150
pasture	100	80	125	150
garden	100	50	125	150
deciduous forest	150	50	150	150
mixed forest	150	50	150	150
coniferous forest	150	30	150	150
unknown trees	150	50	150	150

modification of macropore density in dependence on portion of skeleton

- nameable portion of skeleton → +10 MP/m²
- rich on skeleton → +20 MP/m²

assumed mean cross sectional area of MP 20 mm² <> (radius ~ 2,5 mm)

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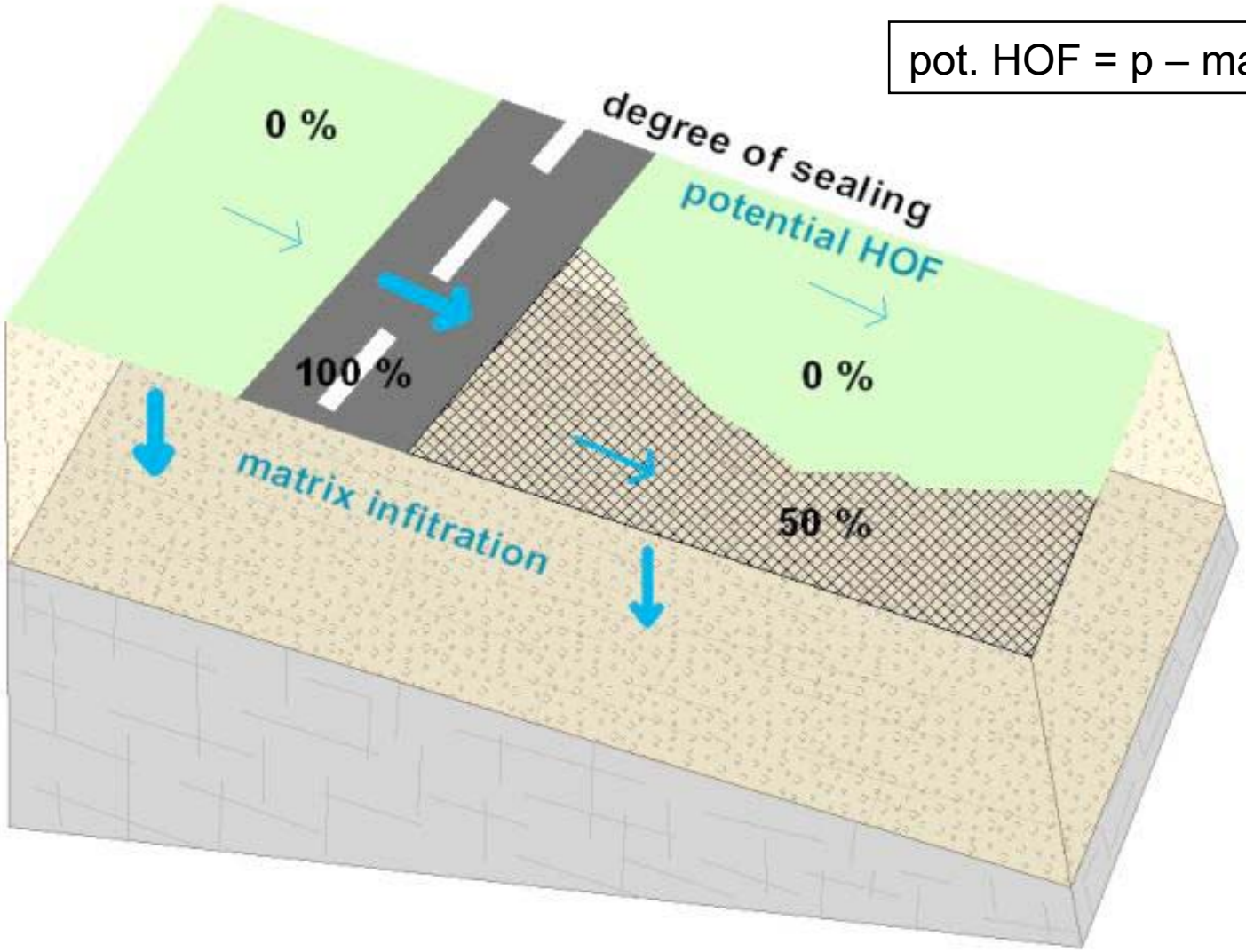
Modification of infiltration by degree of sealing

matrix infiltration = pot. Matrix infiltration * (1 - (dergee of sealing / 100))

pot. HOF = p – matrix infiltration



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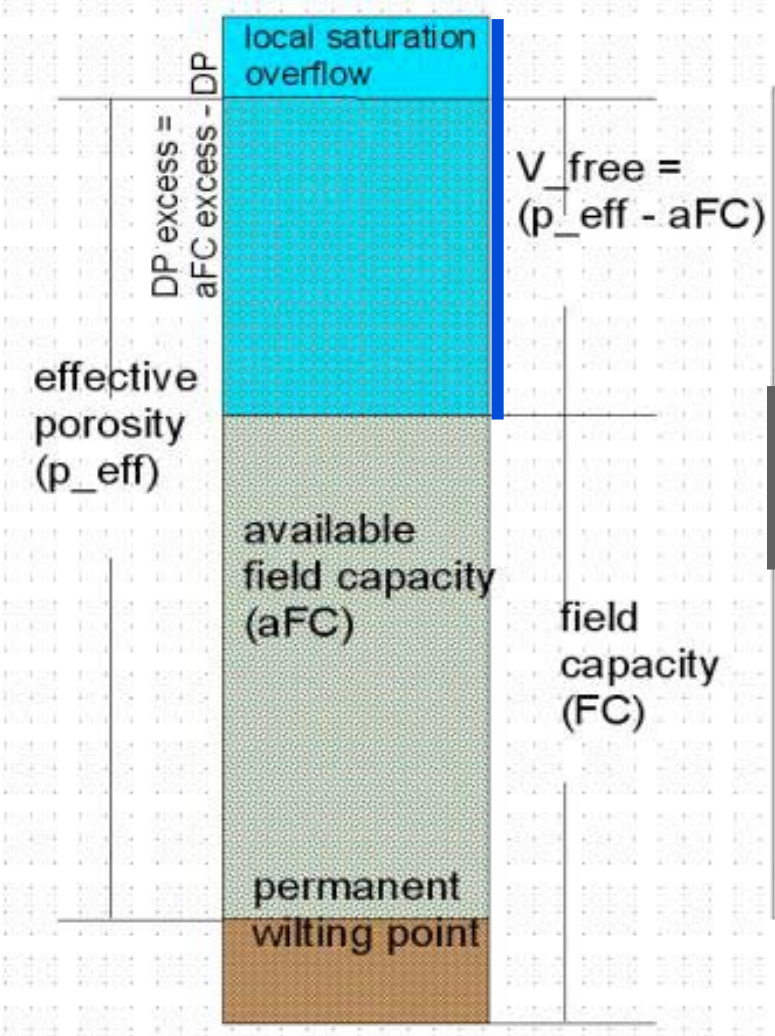
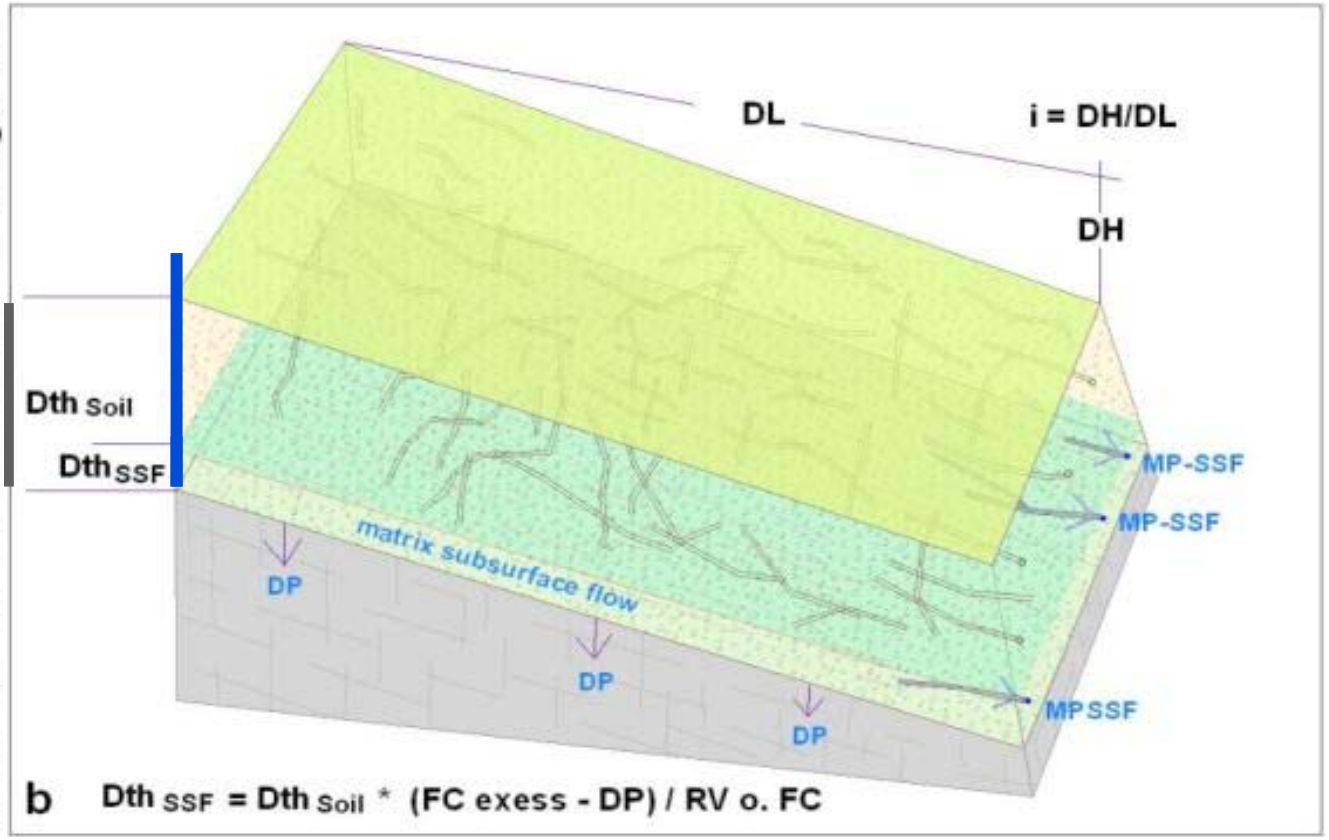
Soil storage – subsurface flow – local saturation overland flow

$$Dth_{SSF} = Dth_{soil} * (aFC_{excess} - DP) / RV$$





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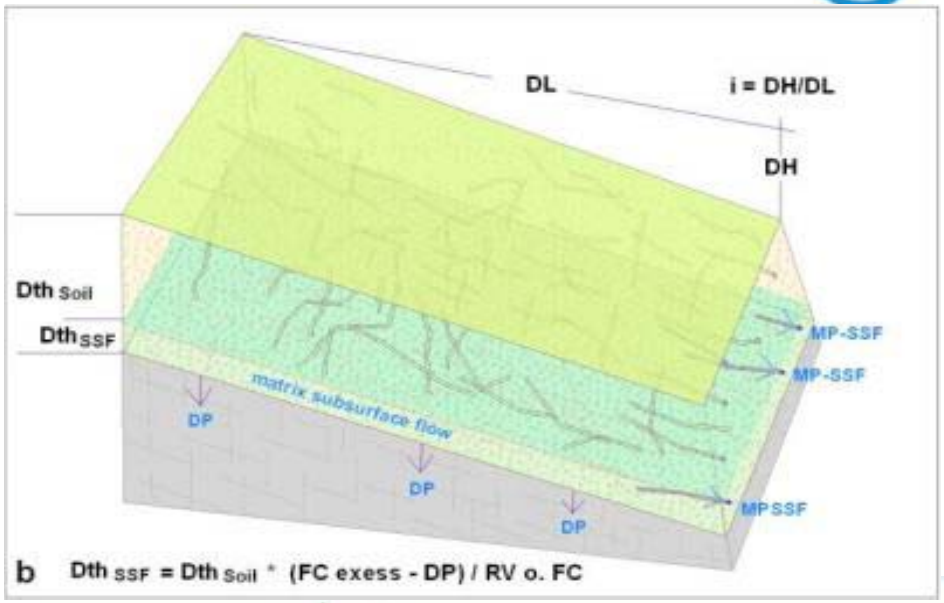
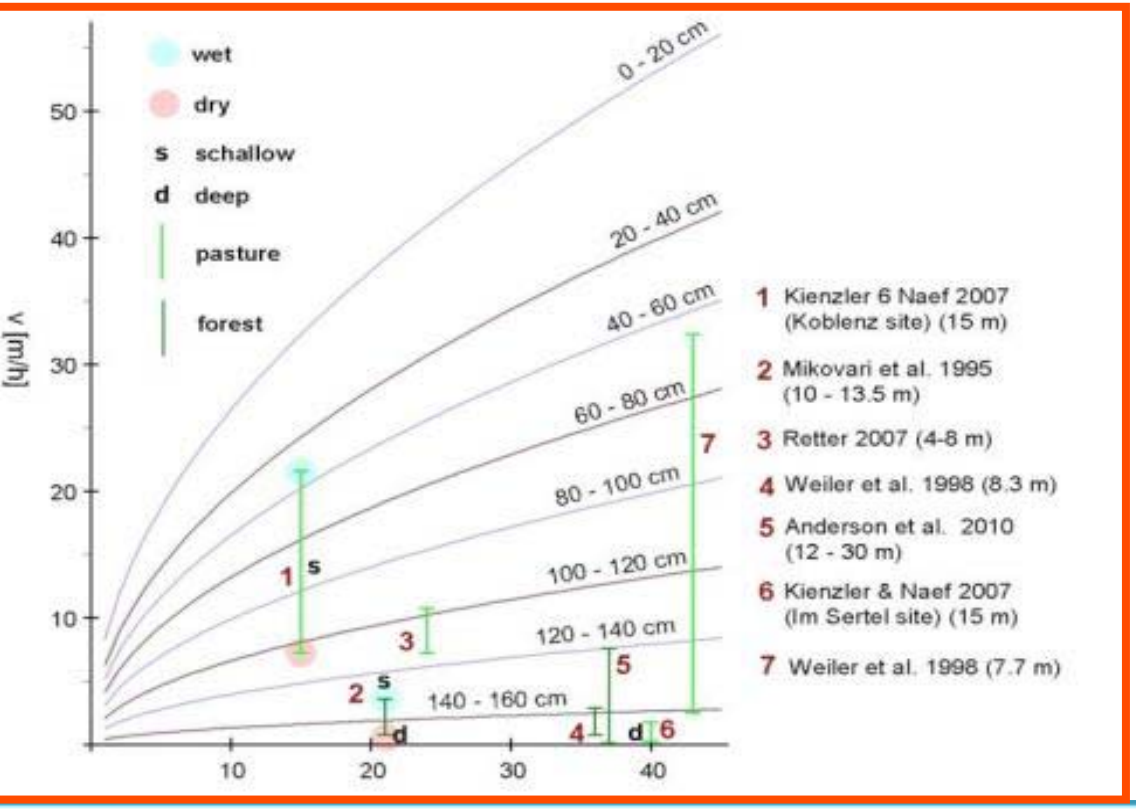
Quantifying subsurface flow

SSF matrix = k_{sat} * i * Dth SSF

SSF MP = by the thickness of contributing soil depth layers weighted flow capacitys over contributing soil layers





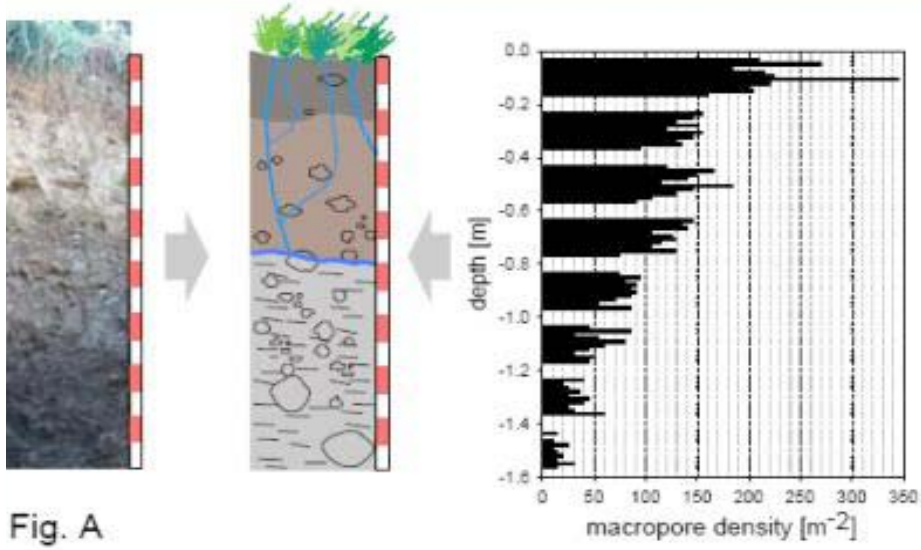


Fig. A

Kienzler & Naef 2004

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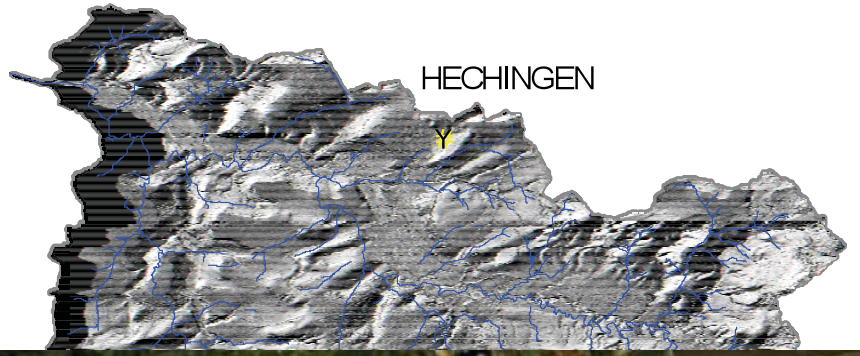
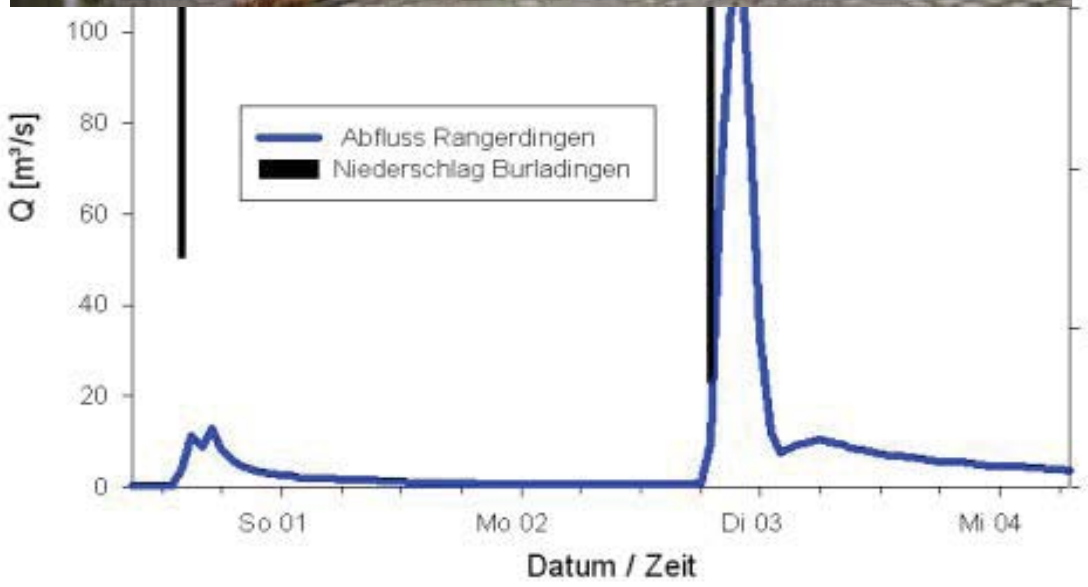
First model application Starzel





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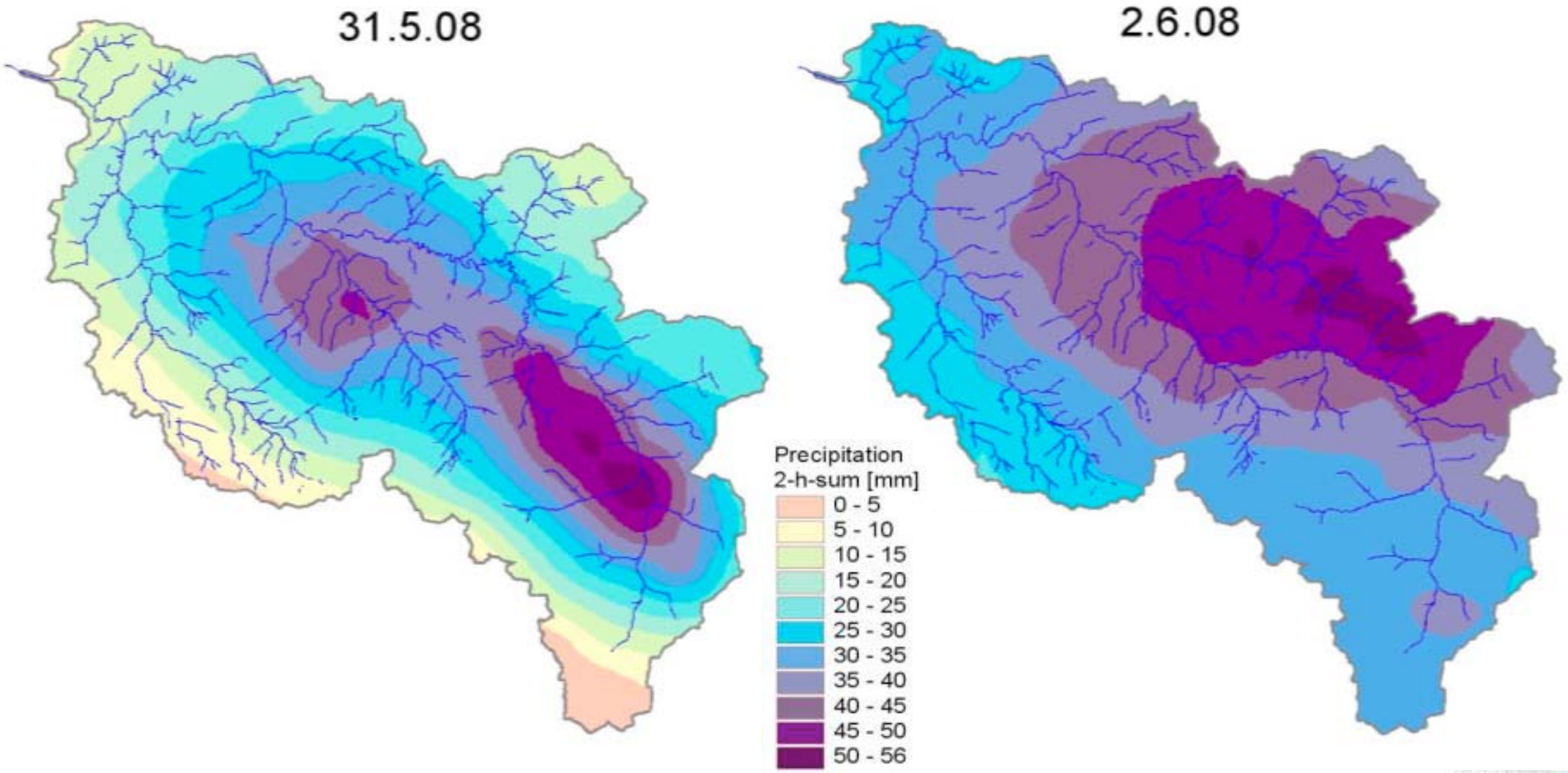
Precipitation (DWD radar)



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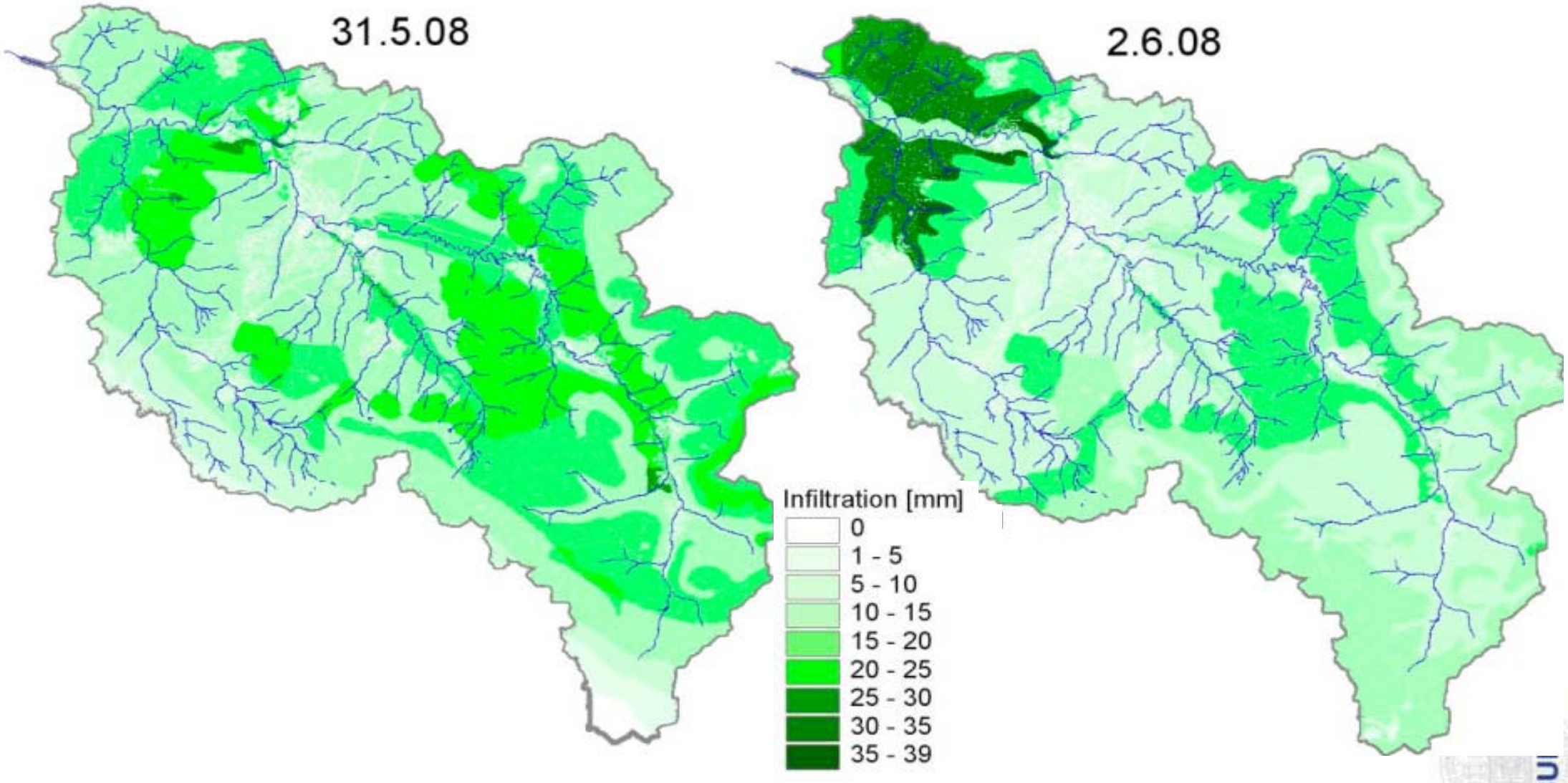
Infiltration

matrix



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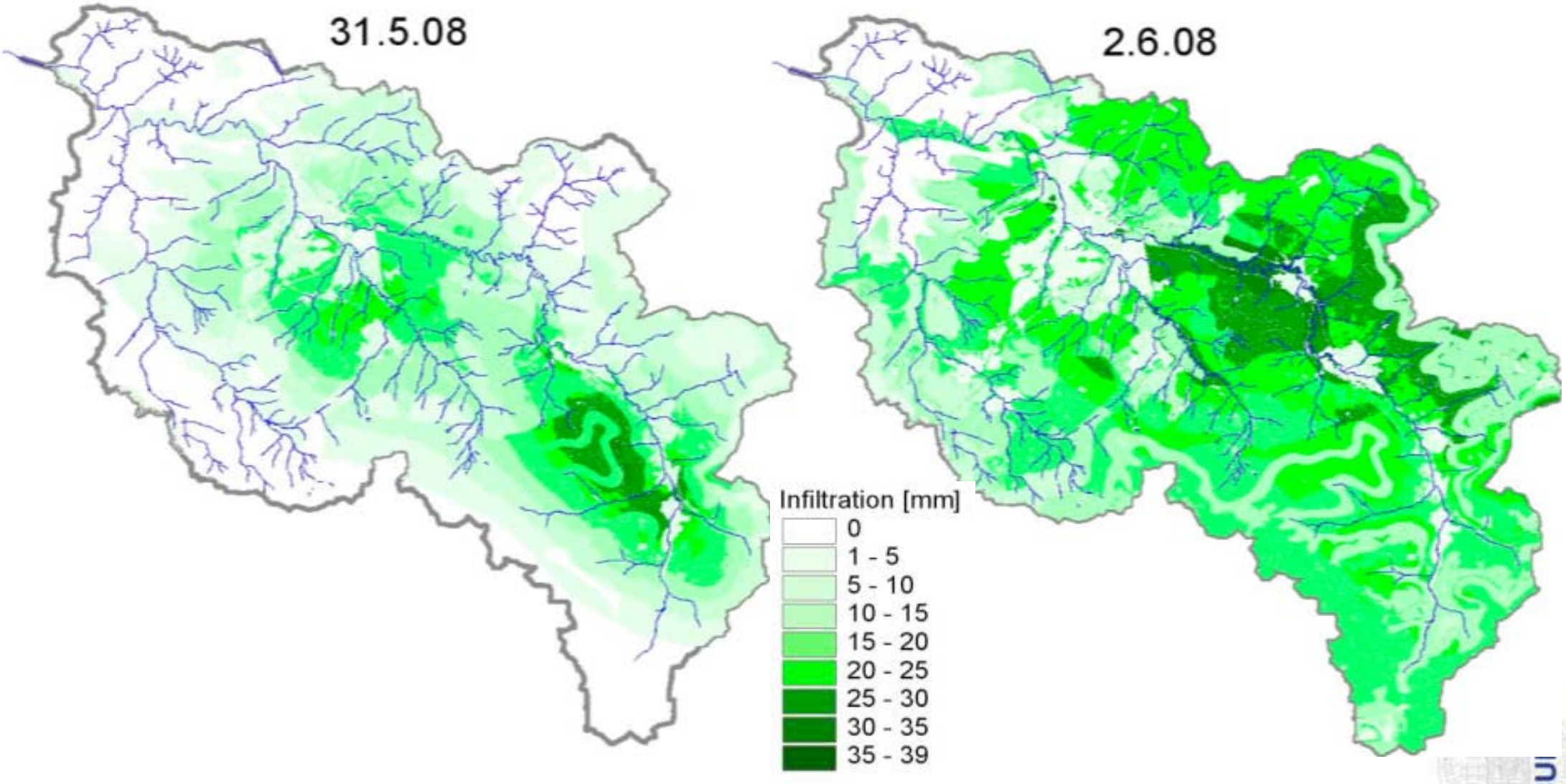
Infiltration

macropore



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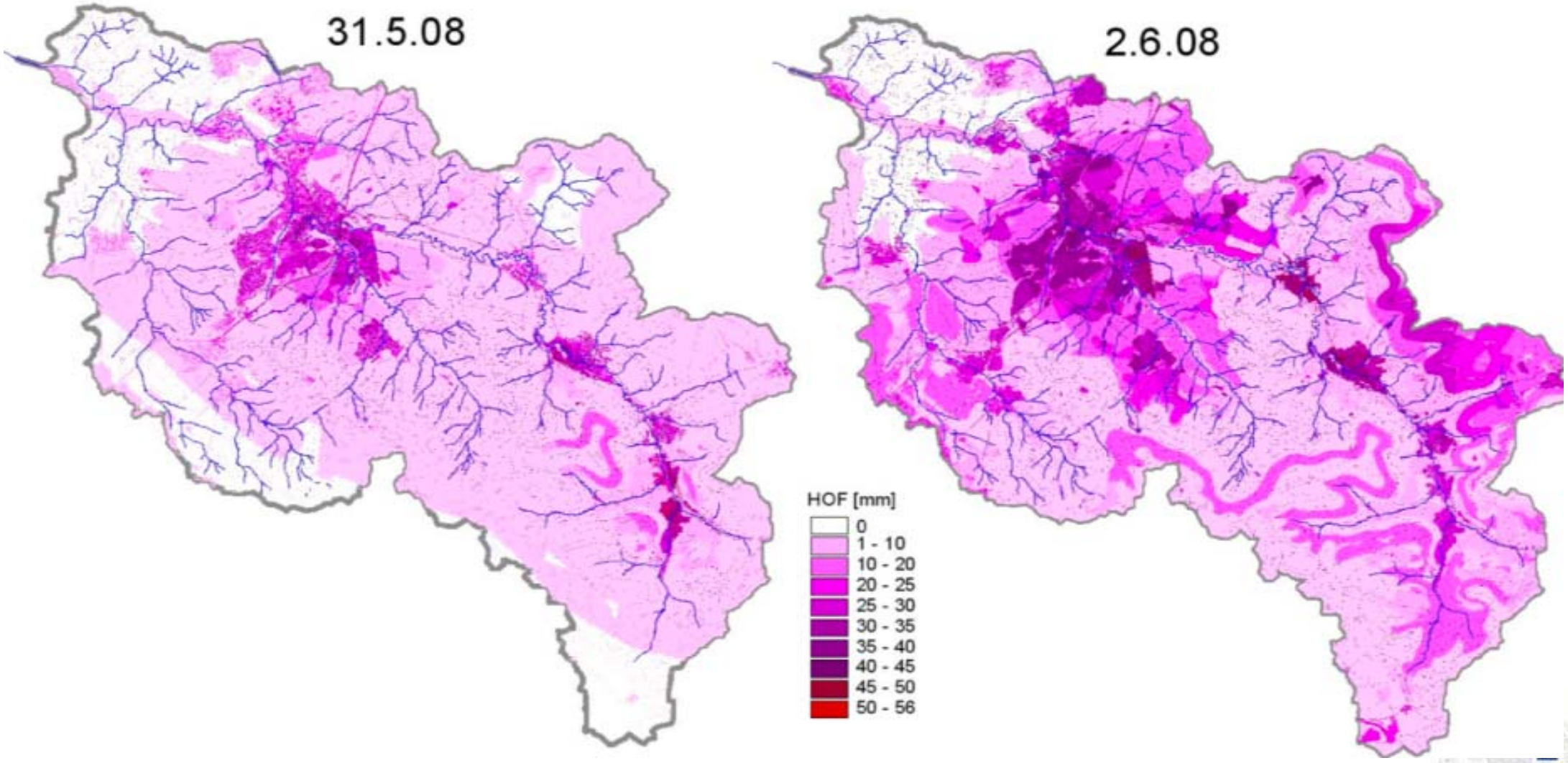
Hortonian Overland Flow



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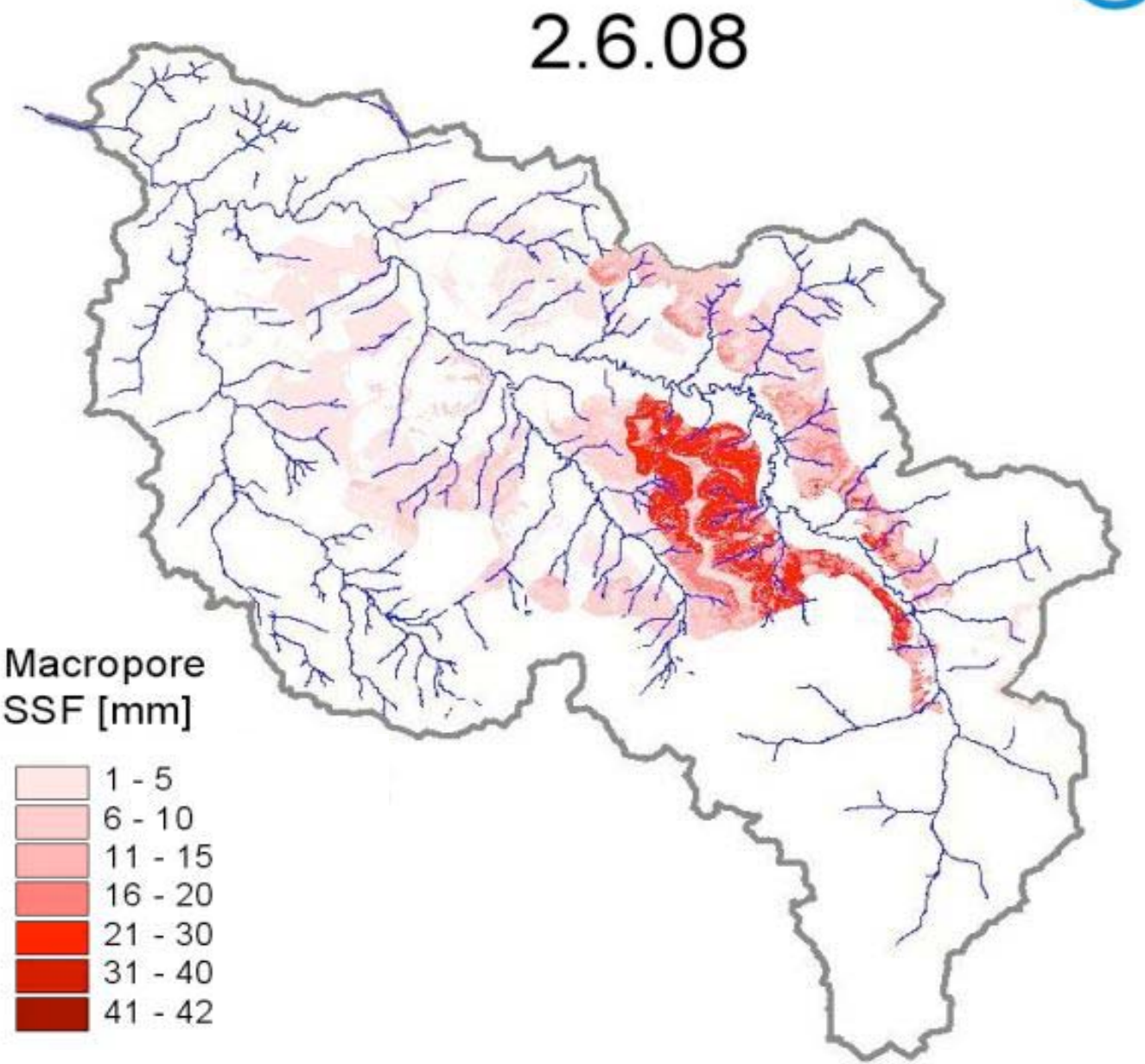
Subsurface flow

no SSF at
1.6.2008

no matrix SSF
while both events



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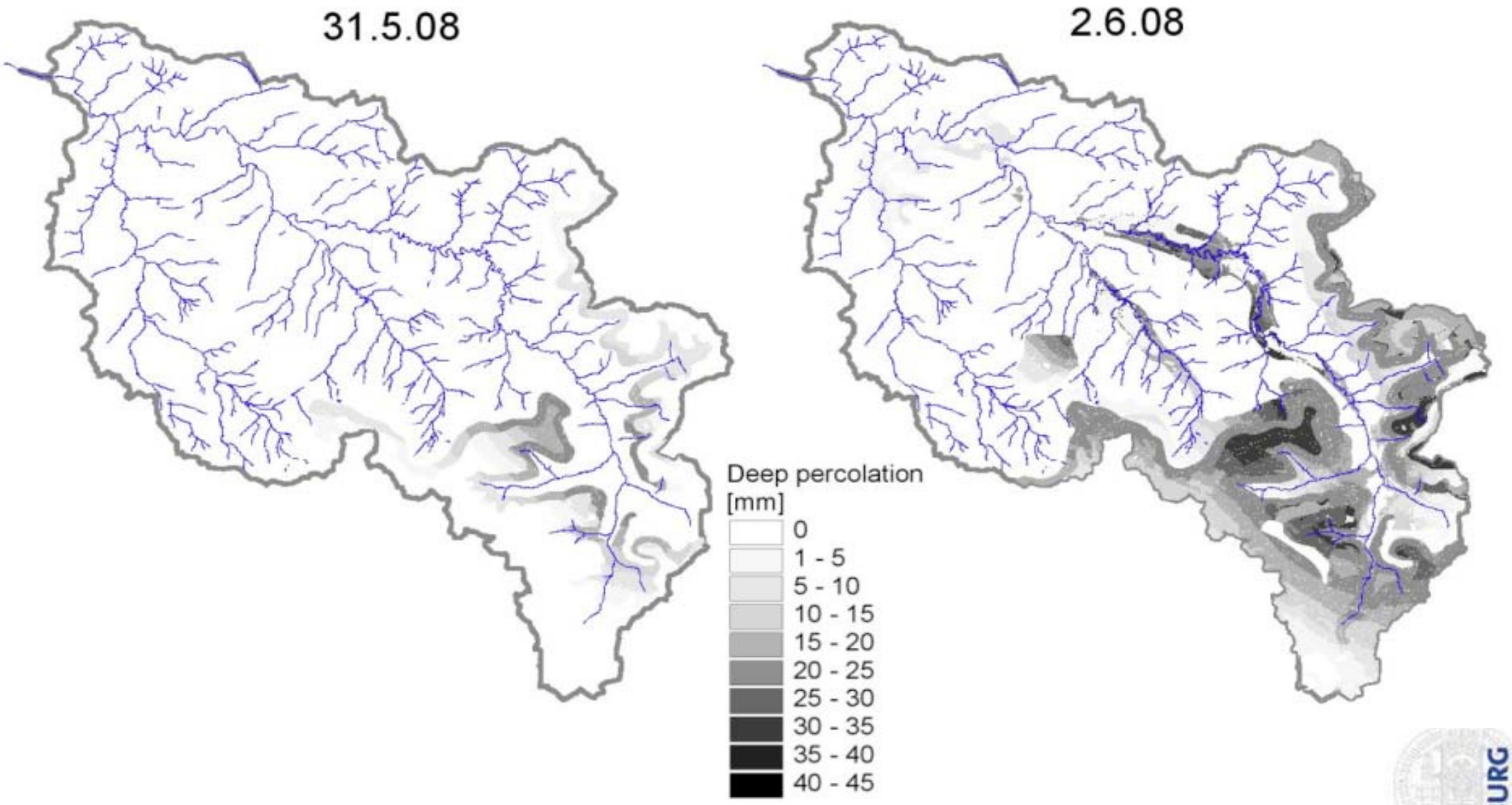
Deep percolation



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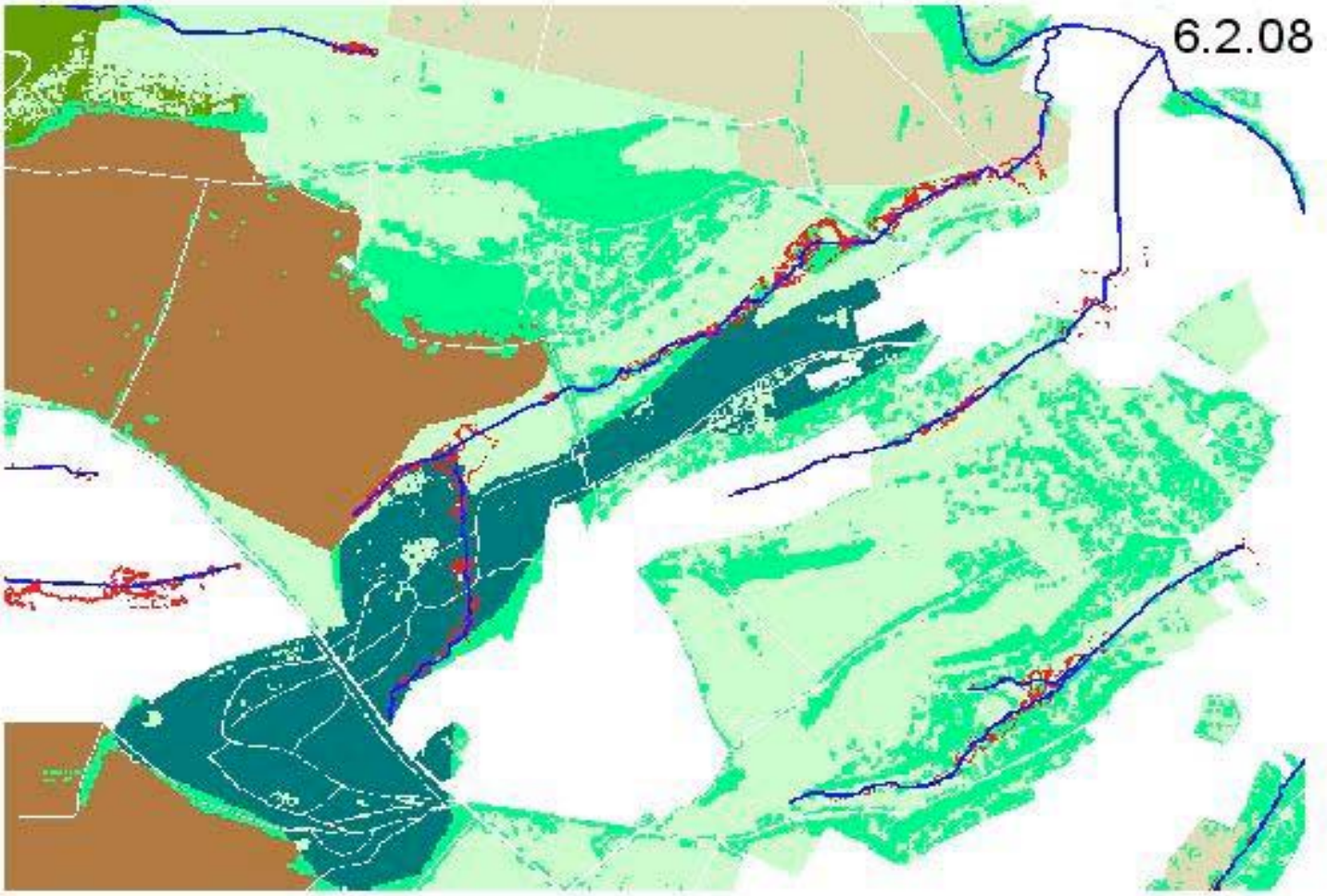
Lokal saturation overland flow

Local SOF only near rivers, where groundwaterer is close to the surface



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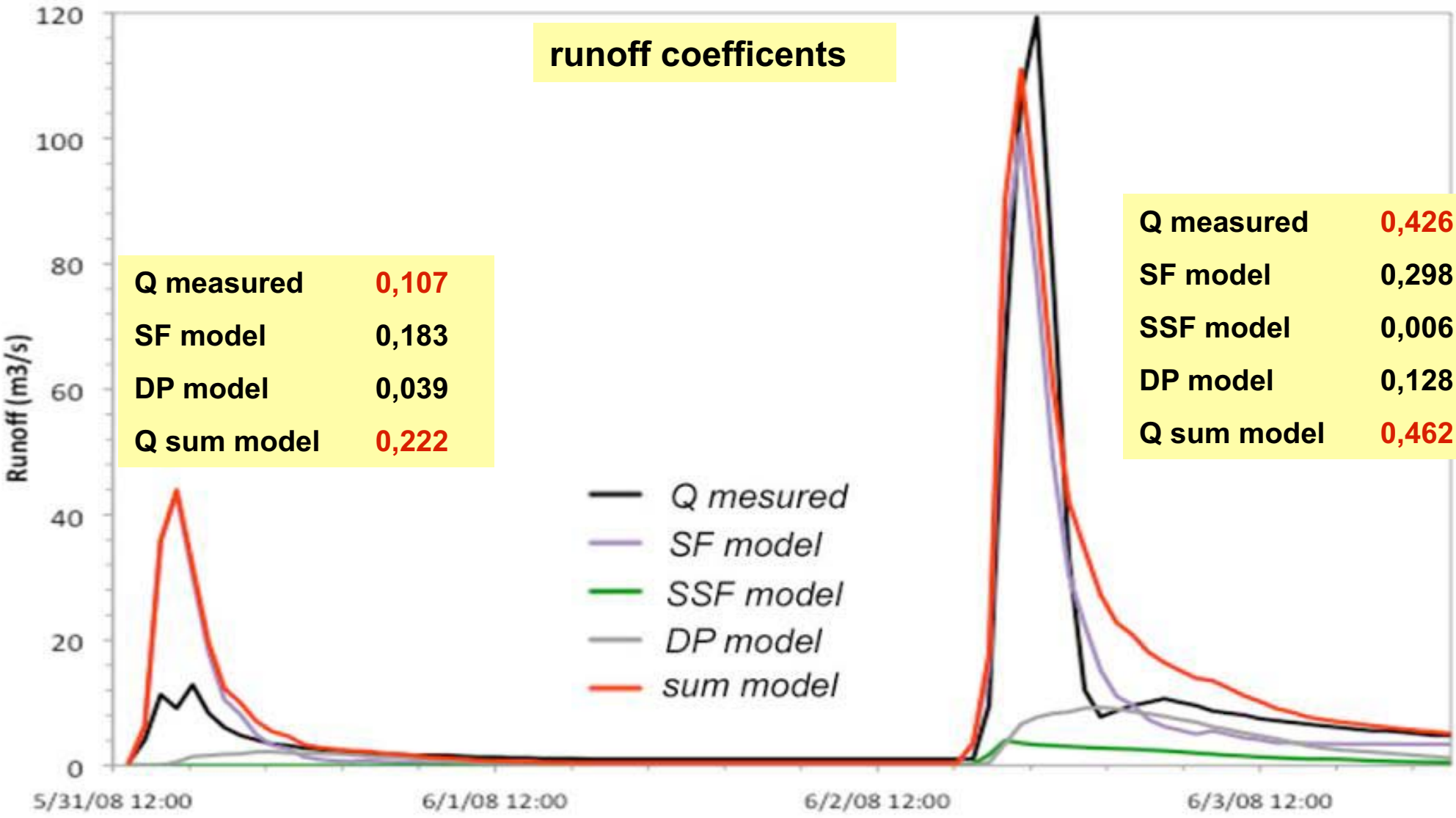
Verification by discharge



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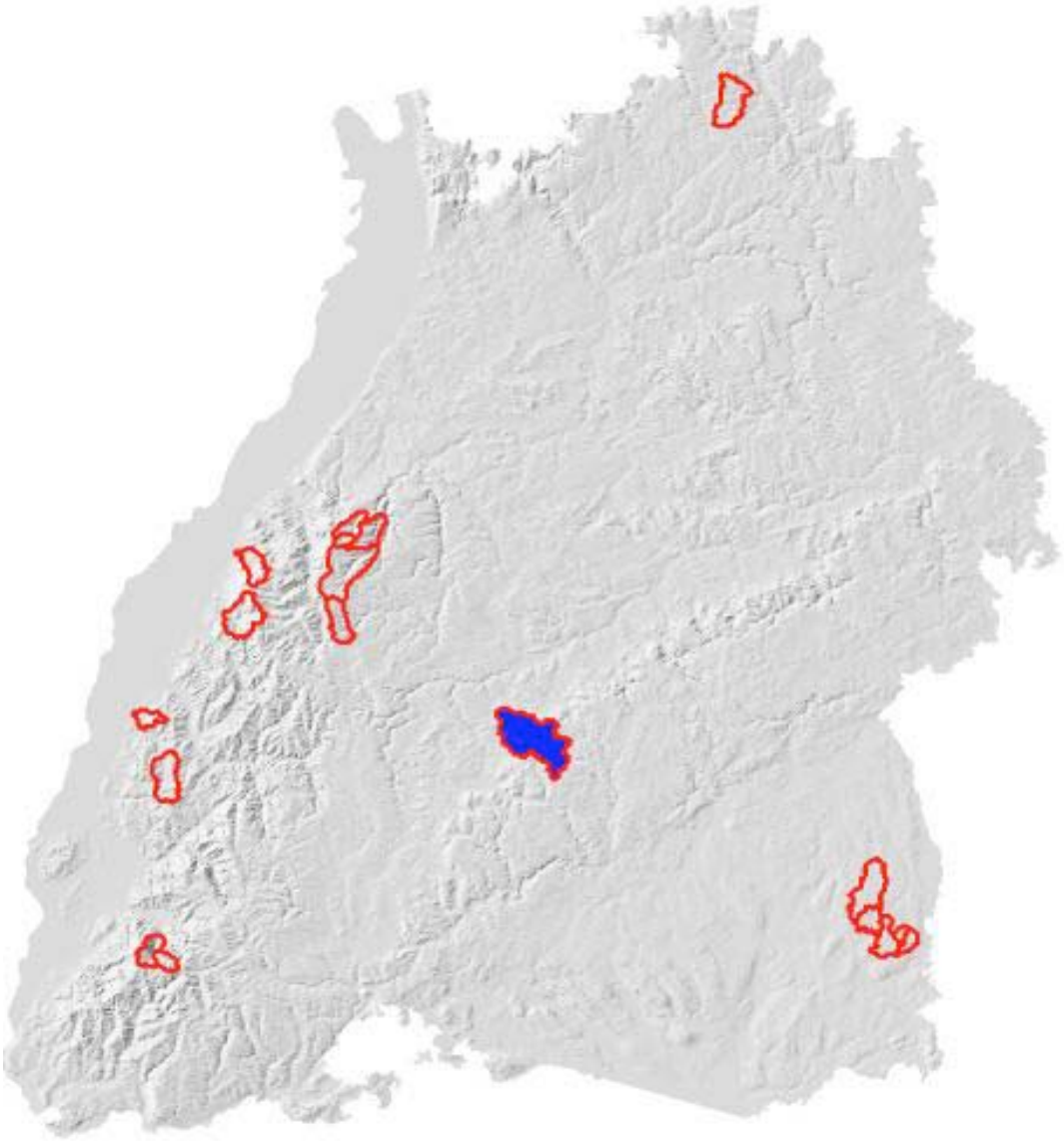
Further steps



→Modelling events of different precipitation types in different regions

→Modelling szenarios with different model precipitation types and different antecedent moisture conditions for the entire area of Baden-Württemberg

Thank You for attention

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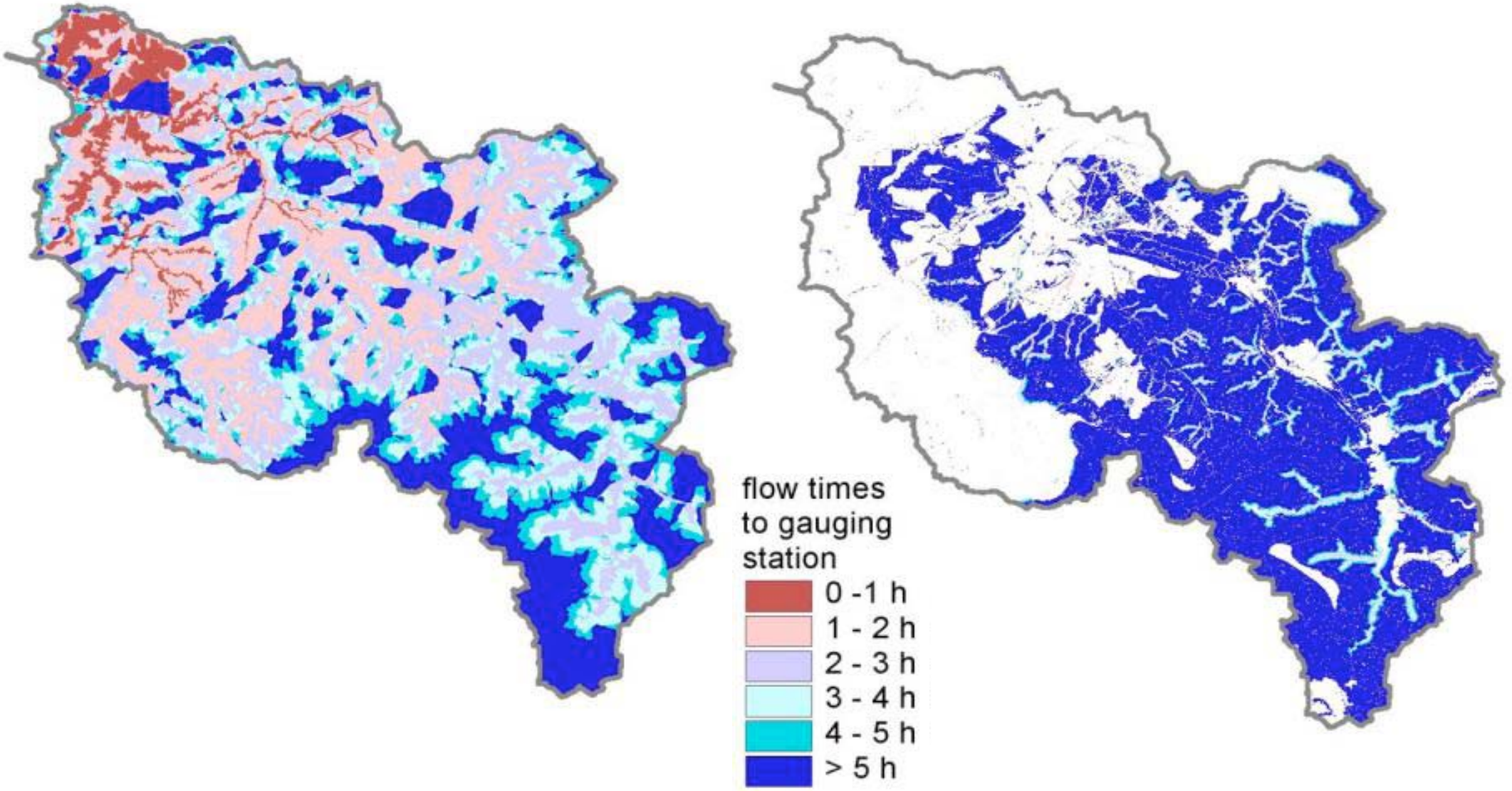
Flow concentration (1m resolution)

Surface runoff

SSF and deep percolation



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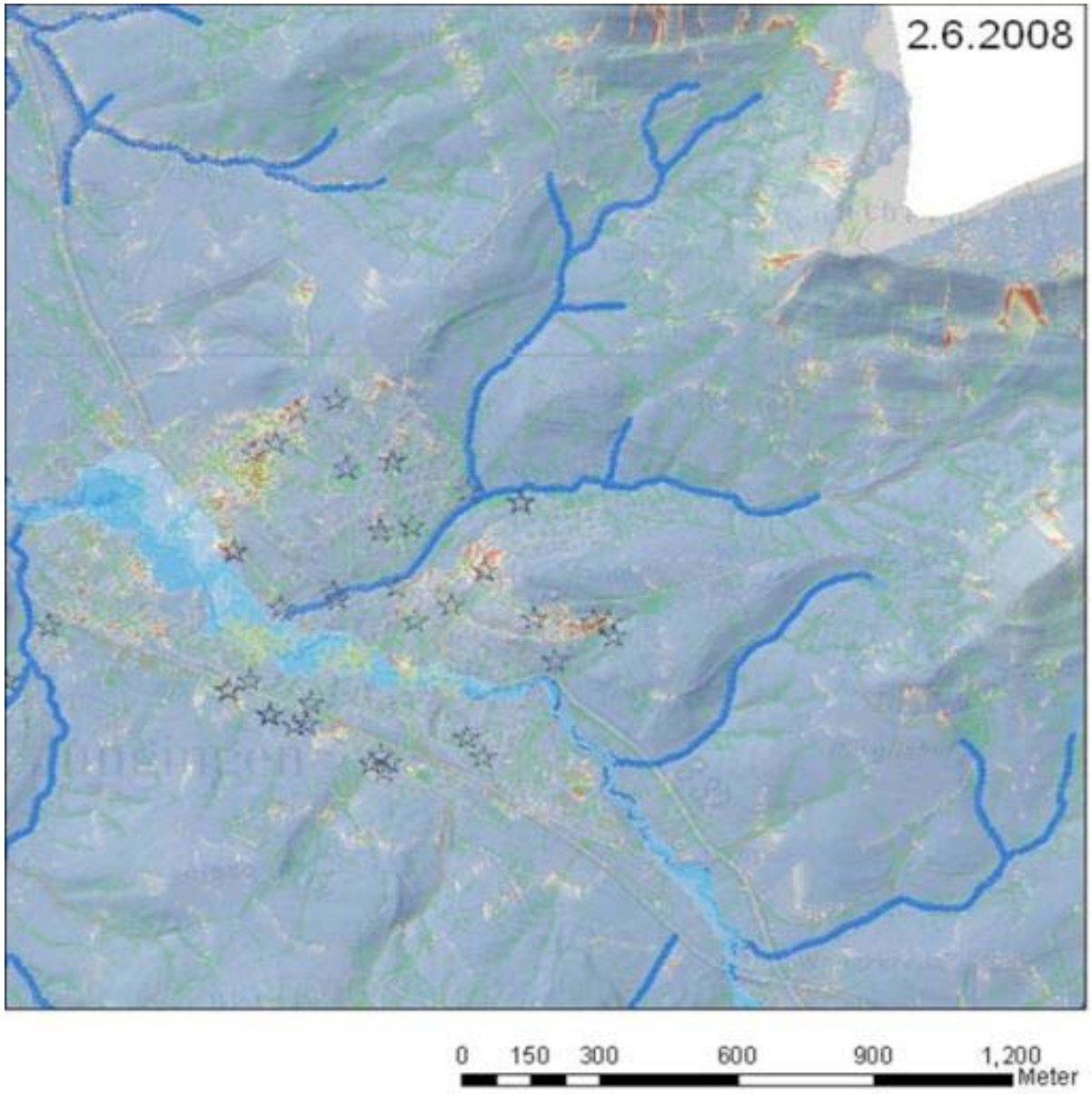
Verification by demage declaration



Flow accumulation within 10 minutes [l] (1-m resolution)

High : 162927

Low : 0

max. value ~ 270 l/s*m²

☆ demage declaration by fire brigade

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Dry-short

50 mm/2h
nFK - 90 mm

Abflussbeiwert
ohne TP 0,16

Wet-short

50 mm/2h
Feldkapazität

Abflussbeiwert
ohne TP 0,31

Dry-long

80 mm/12h
nFK - 90 mm

Abflussbeiwert
ohne TP 0,22

Wet-long

80 mm/12h
Feldkapazität

Abflussbeiwert
ohne TP 0,32

Oberflächen
-abfluss
HOF und
Wasserflächen

OF

SSF

Zwischenabfluss
- Makroporen
- (Matrix)

Abflussanteil an Niederschlag [%]

- 1-10
- 11-20
- 21-30
- 31-40
- 41-50
- 51-60
- 61-70
- 71-80
- 81-90
- 91-100
- Karst

Tiefenperkolation
- Karst
- Matrix

DP

M = 1 / 100.000