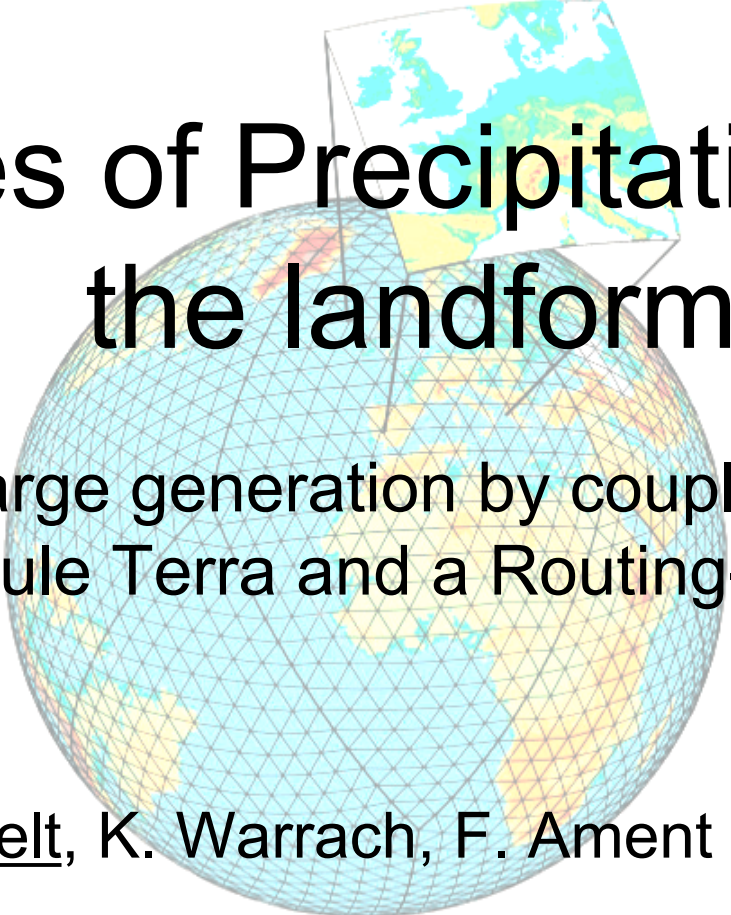


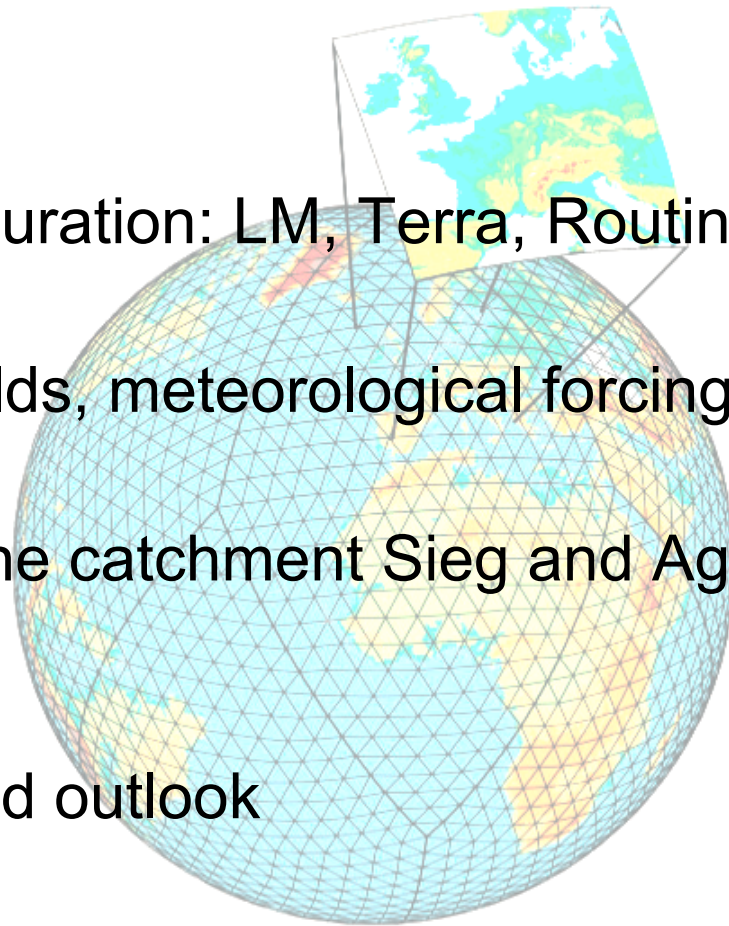
# Scales of Precipitation and the landform



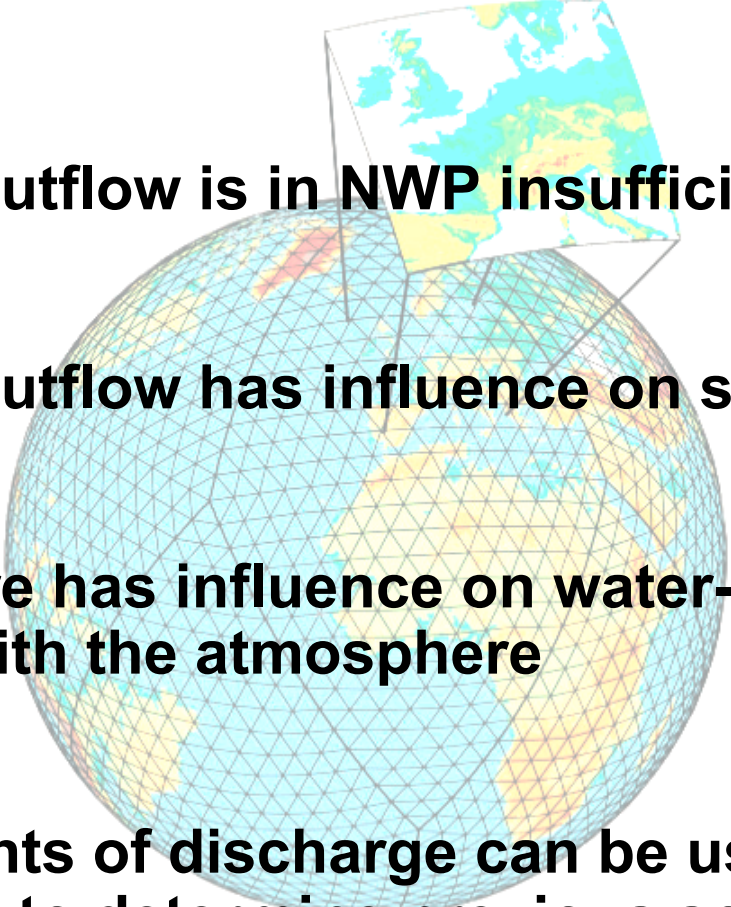
Discharge generation by coupling SVAT-  
Module Terra and a Routing-Scheme

R. Graßelt, K. Warrach, F. Ament and C. Simmer

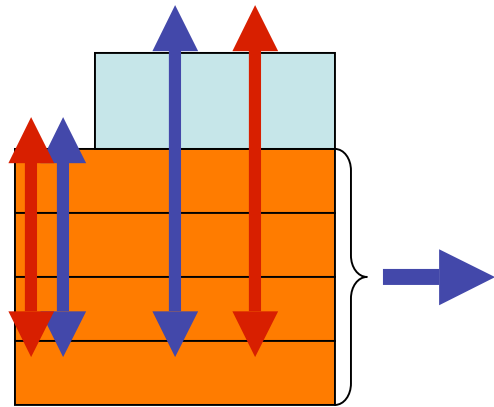
- Introduction
- Model configuration: LM, Terra, Routing-Scheme
- Data: soil fields, meteorological forcing
- Results for the catchment Sieg and Agger (2004/2005)
- Summary and outlook



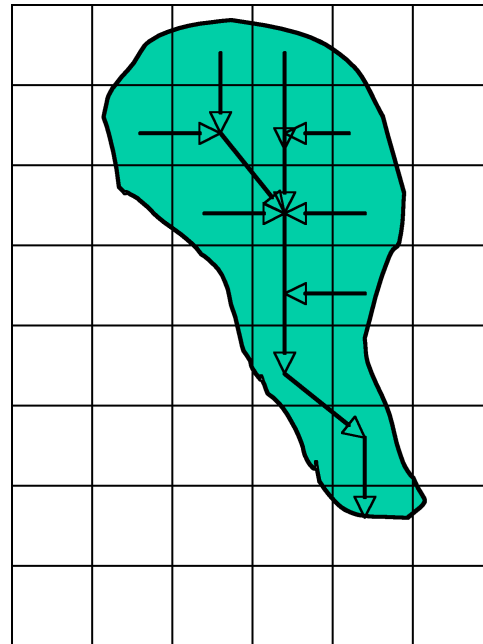
# Introduction:

- **Horizontal outflow is in NWP insufficient considered**
  - **Horizontal outflow has influence on soil moisture**
  - **Soil moisture has influence on water- and energy exchange with the atmosphere**
  - **Measurements of discharge can be used via data assimilation to determine previous soil moistures**
- 
- A globe with a grid overlay, showing a map of Europe and surrounding regions. The globe is rendered in a light blue and yellow color scheme, with a grid of lines representing latitude and longitude. A small inset map of Europe is positioned above the globe, showing a more detailed view of the continent.

# Introduction:



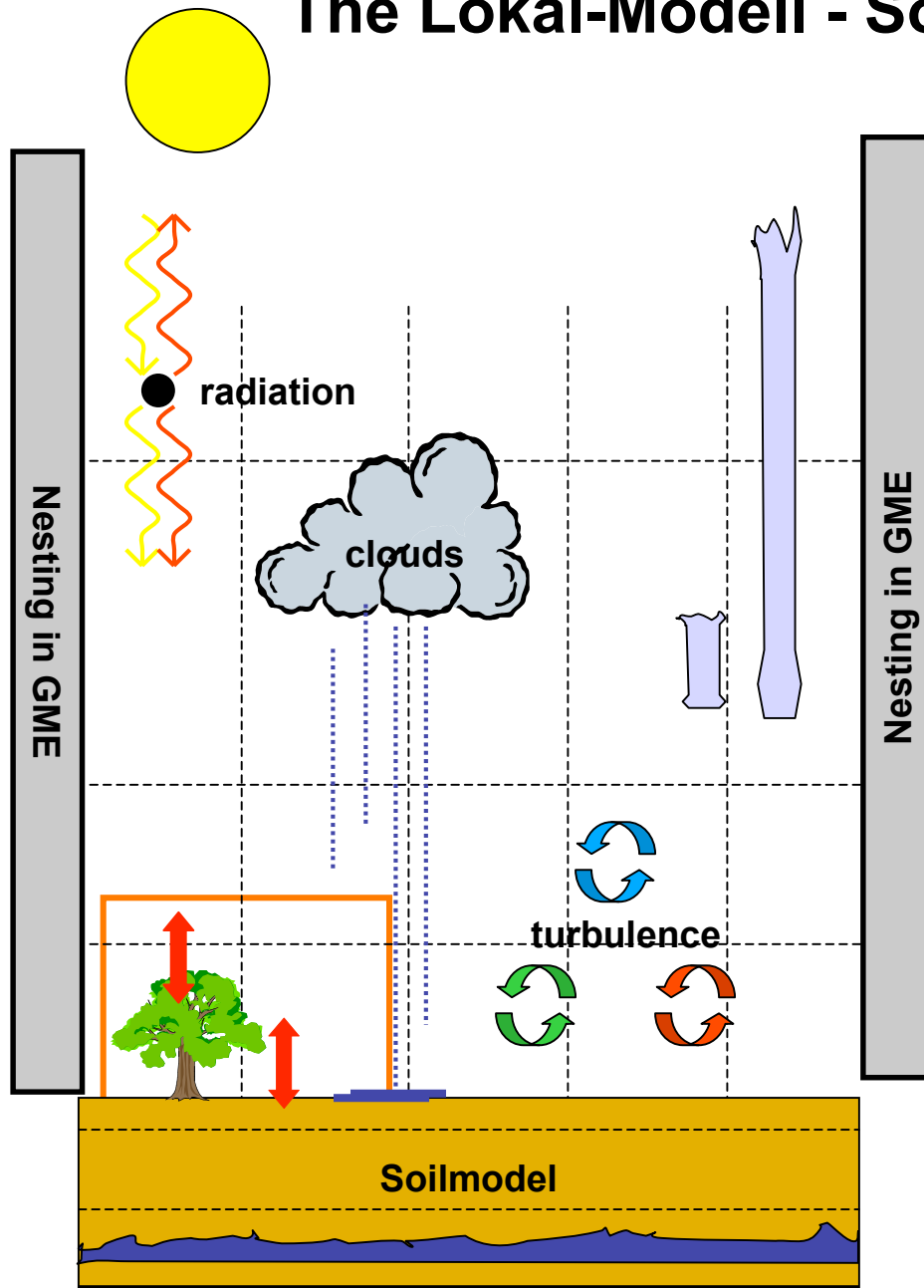
**Soil model  
Terra**



**Transport model  
Routing-Scheme**

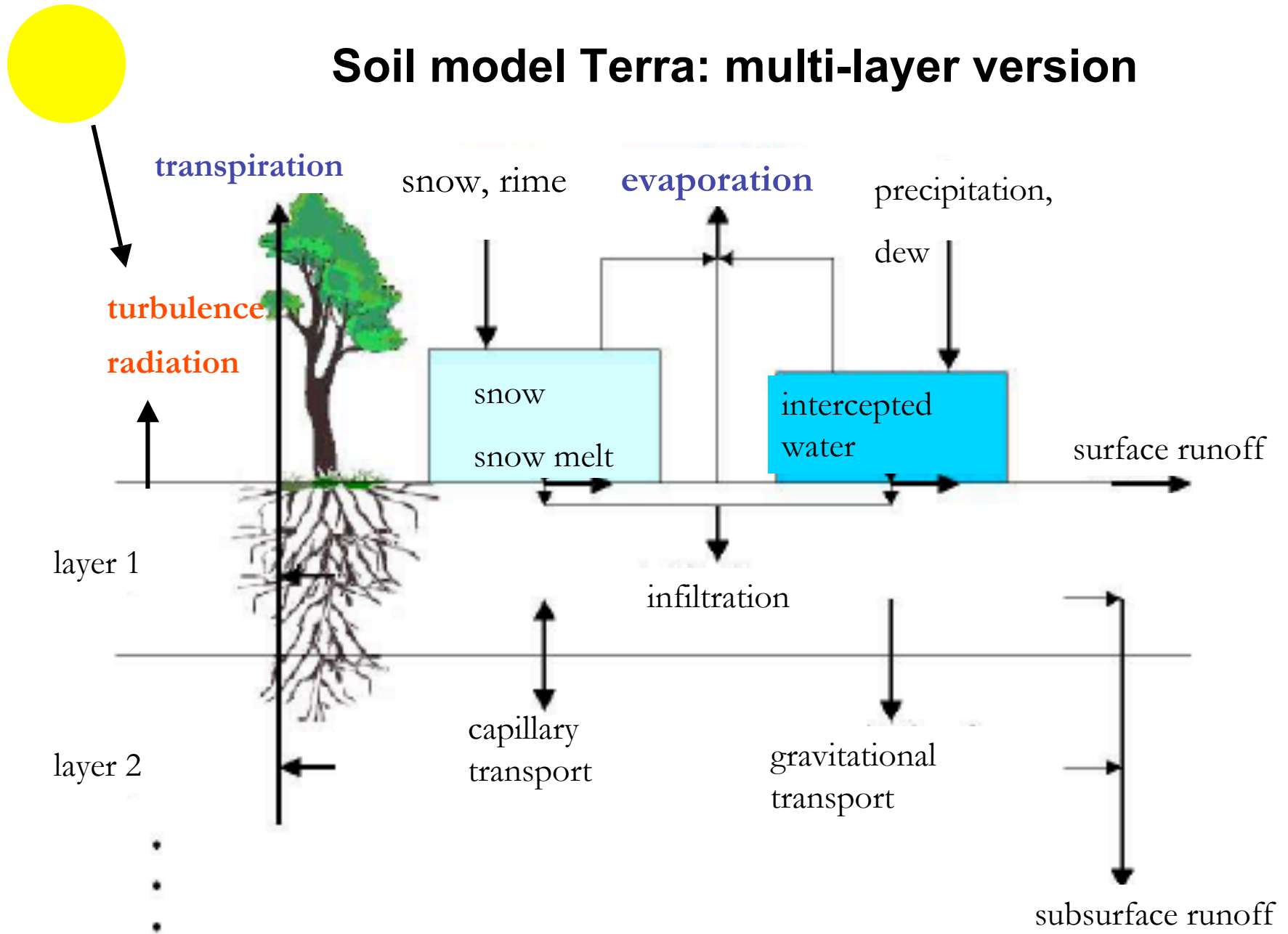
**=> Discharge on Gauges**

# The Lokal-Modell - Soilmodel Terra



- water- and energy exchange between vegetation/soil/snow and atmosphere (SVAT-module)
- vertical water- und energy-flow in soil
- several soil layer
- snow, frost
- surface- and baseflow

# Soil model Terra: multi-layer version



# Model configuration: The Soil model Terra

water content:

$$\rho_w \frac{\partial W_{l,k}}{\partial t} = \partial_{l,k} [E_b + I_s - I_{perc} + (1 - \alpha) P_r - R_{infil}] + F_{k,k+1} - (1 - \partial_{l,k}) F_{k-1,k} + T_{rk} - R_k + S_k$$

water content interception store:

$$\rho_w \frac{\partial W_i}{\partial t} = \alpha \cdot P_r + E_i - I_{perc} - R_{inter}$$

snowstore:

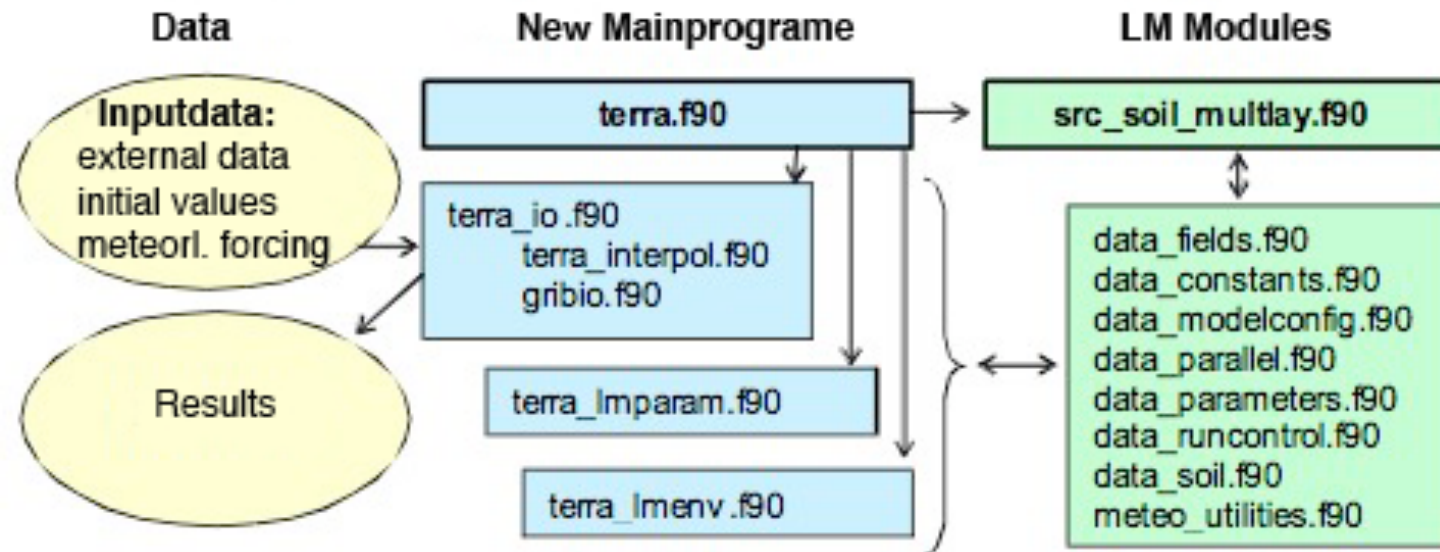
$$\rho_w \frac{\partial W_s}{\partial t} = P_s \cdot E_s - R_s - I_s$$

temperature:

$$\frac{\partial T_{so}}{\partial t} = \frac{1}{(\rho c)} \frac{\partial}{\partial z} \left( \lambda \frac{\partial T_{so}}{\partial z} \right)$$

# Model configuration: The Soil model Terra

based on LM/LME Version 3.16: multi-layer-version



Advantages of offline version:

- advancement of the soil model with low costs
- platform for test and further development of landform schemes
- simple integration in LM

## Model configuration: The Routing-Scheme

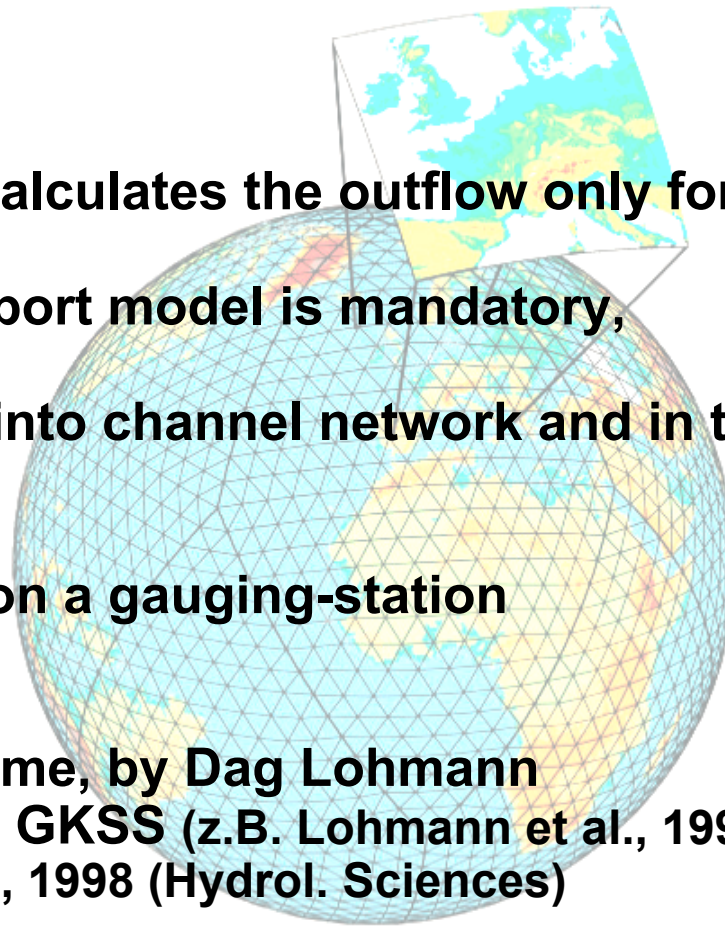
**The soil model calculates the outflow only for each grid cell**

⇒ **outflow transport model is mandatory,**

⇒ **way of water into channel network and in the channel network**

⇒ **outflow data on a gauging-station**

**Routing Scheme, by Dag Lohmann  
developed on GKSS (z.B. Lohmann et al., 1996 (Tellus);  
Lohmann et al., 1998 (Hydrol. Sciences)**



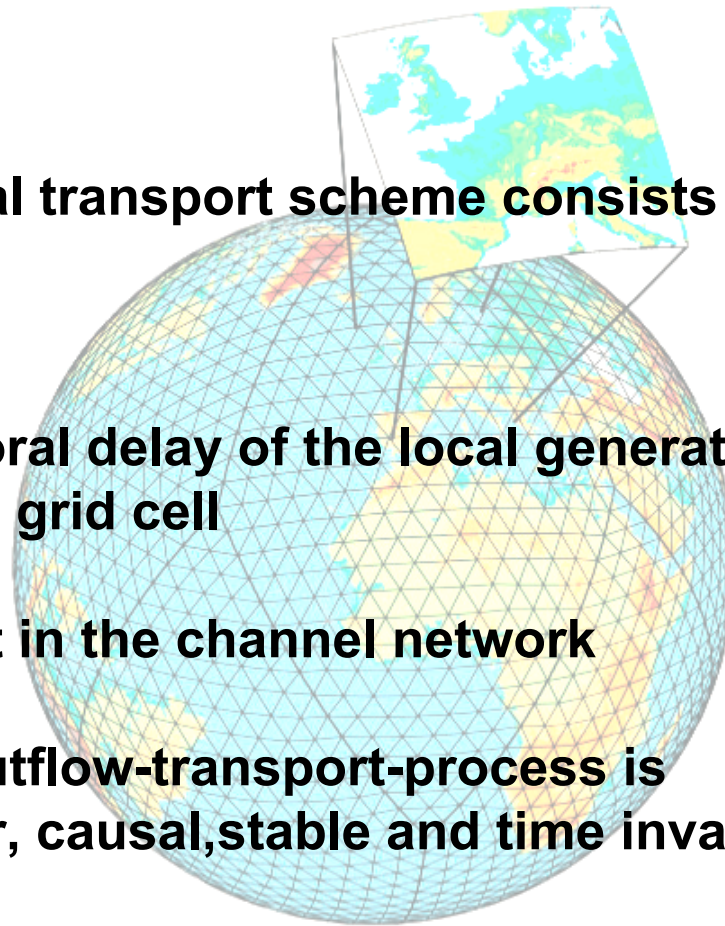
## Model configuration: The Routing-Scheme

**=> The horizontal transport scheme consists of two components:**

**1.) middle temporal delay of the local generating outflow to the exit of the grid cell**

**2.) The transport in the channel network**

**account: the outflow-transport-process is linear, causal, stable and time invariant**



# Model configuration:

## for each grid box

vegetation,  
soil texture

effective  
parameters

## for every timestep

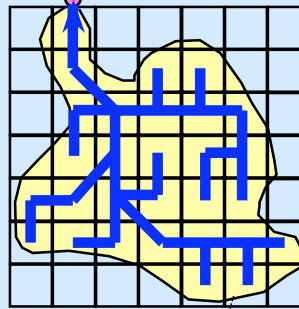
meteorol. data

SVAT model,  
e.g. TERRA

soil moisture and  
temperature,  
surface energy  
and water fluxes

runoff

setup river network



elevation,  
geographical maps

routing parameters

measured discharge  
(and precipitation)  
for calibration period



UH of  
grid box

runoff

Unit Hydrograph

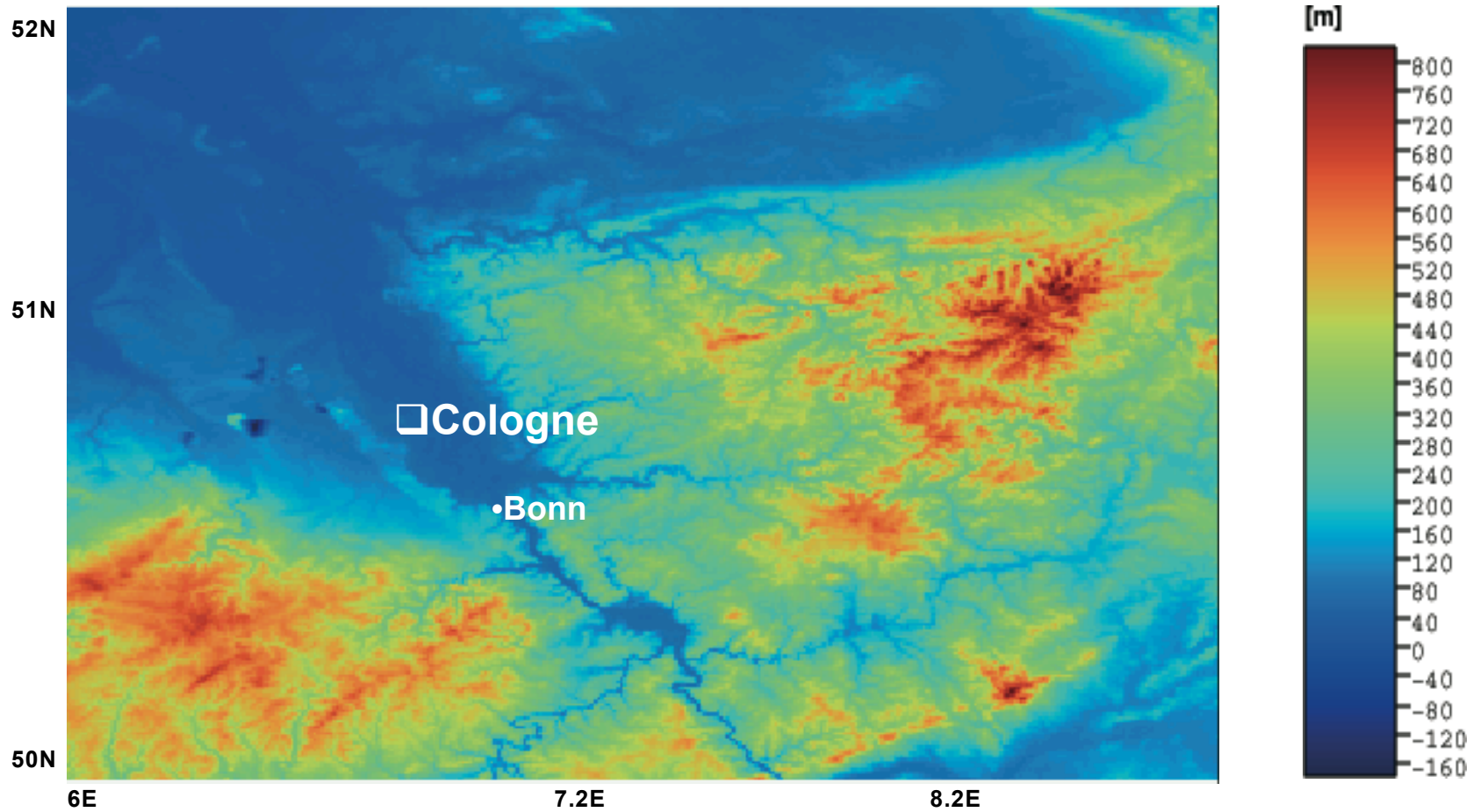
discharge

of grid box

routing model

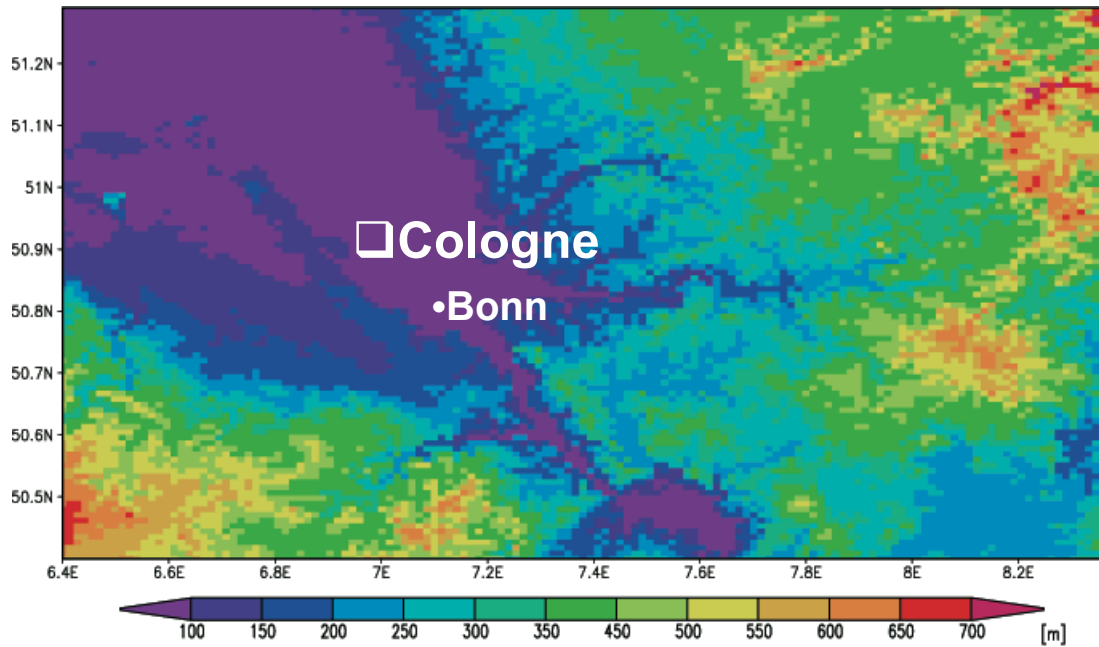
Discharge at gauging station

## Data: topography

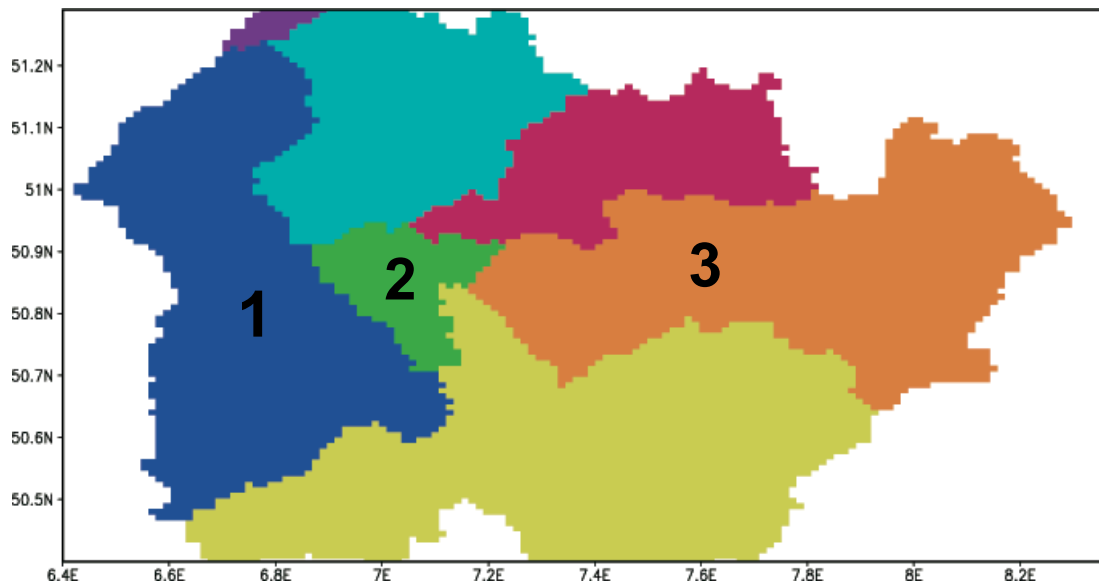


- **NASA-SRTM dataset (Shuttle Radar Topography Mission, 2000)**
- **approx. 90m horizontal resolution**

# Data: topography



- SRTM-NASA aggregate  
to 1 km

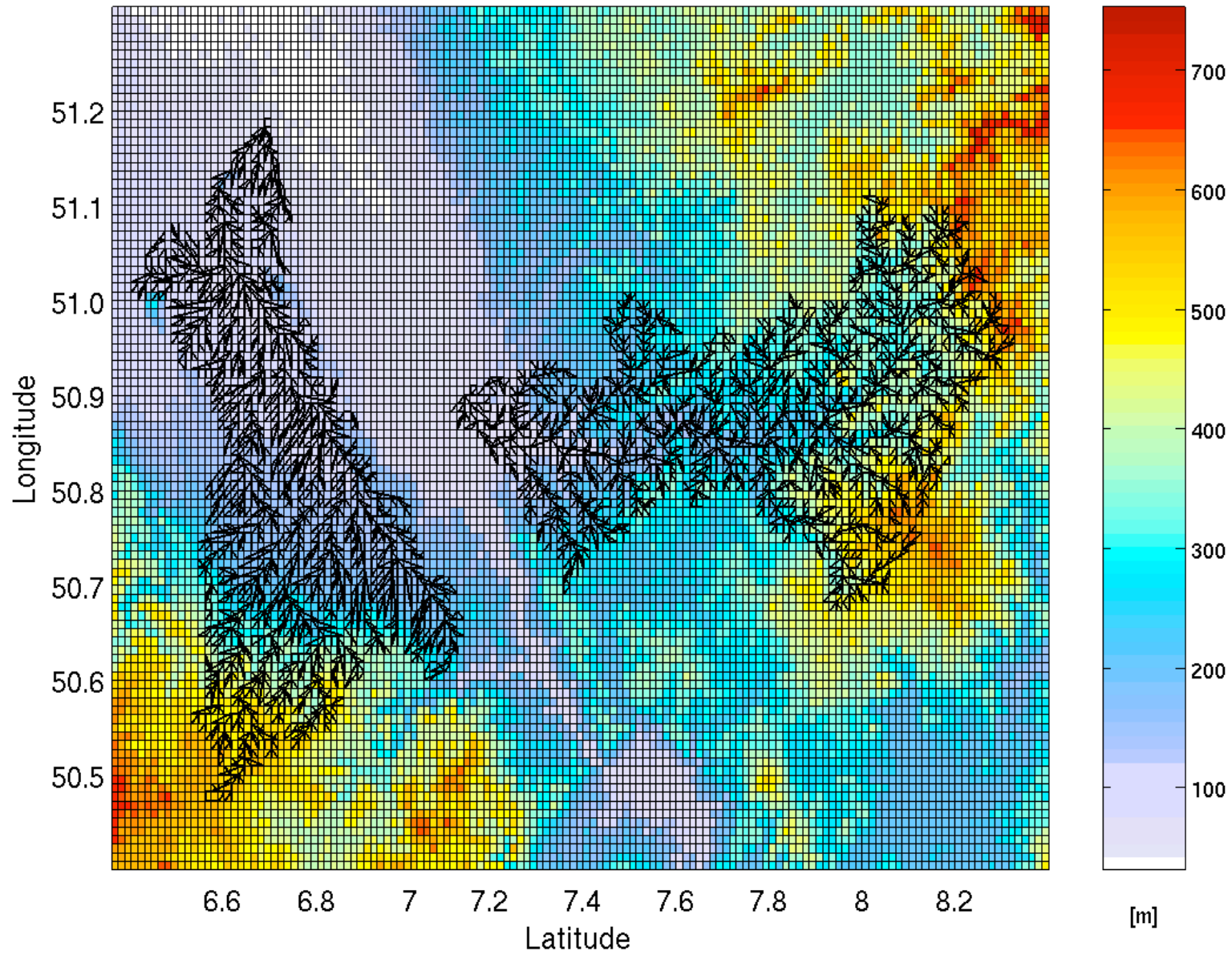


- catchment area/  
- routing parameter

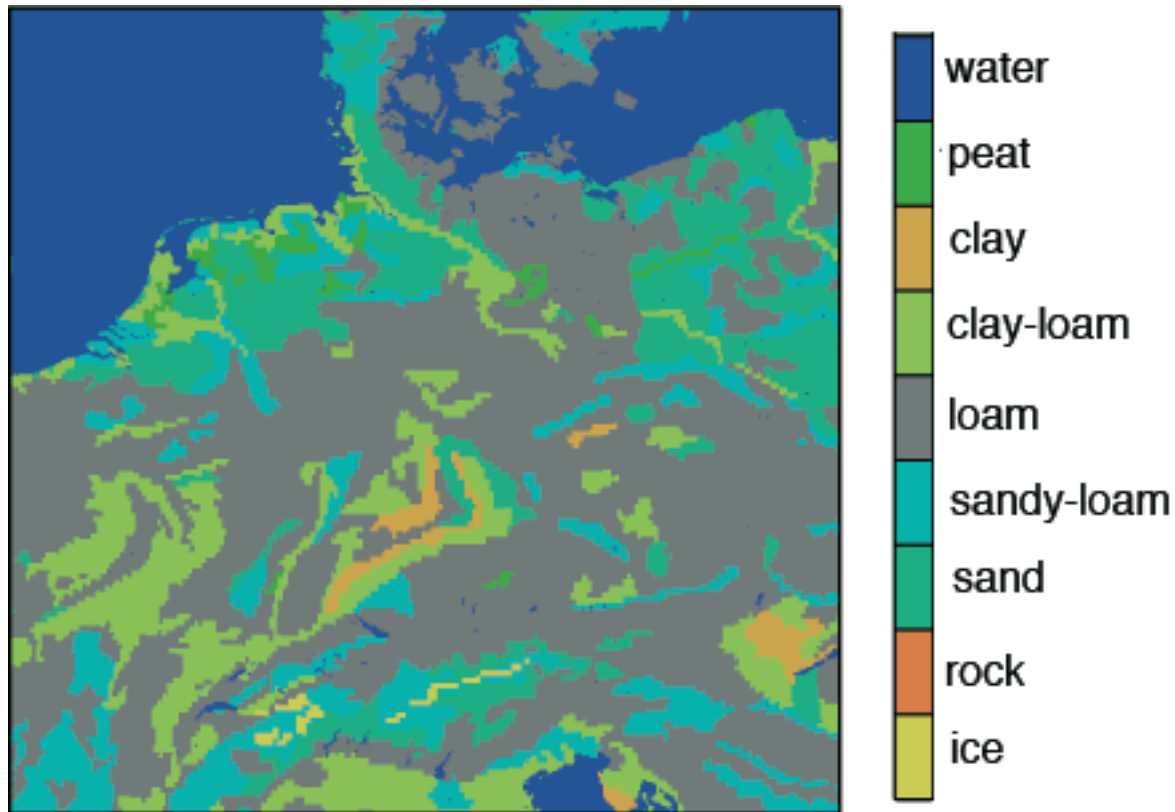
1: Erft catchment  
2: Agger catchment  
3: Sieg catchment

-GIS: ARCVIEW, GRASS,  
SAGA GIS,  
([www.saga-gis.uni.goettingen.de](http://www.saga-gis.uni.goettingen.de))

# Data: topography



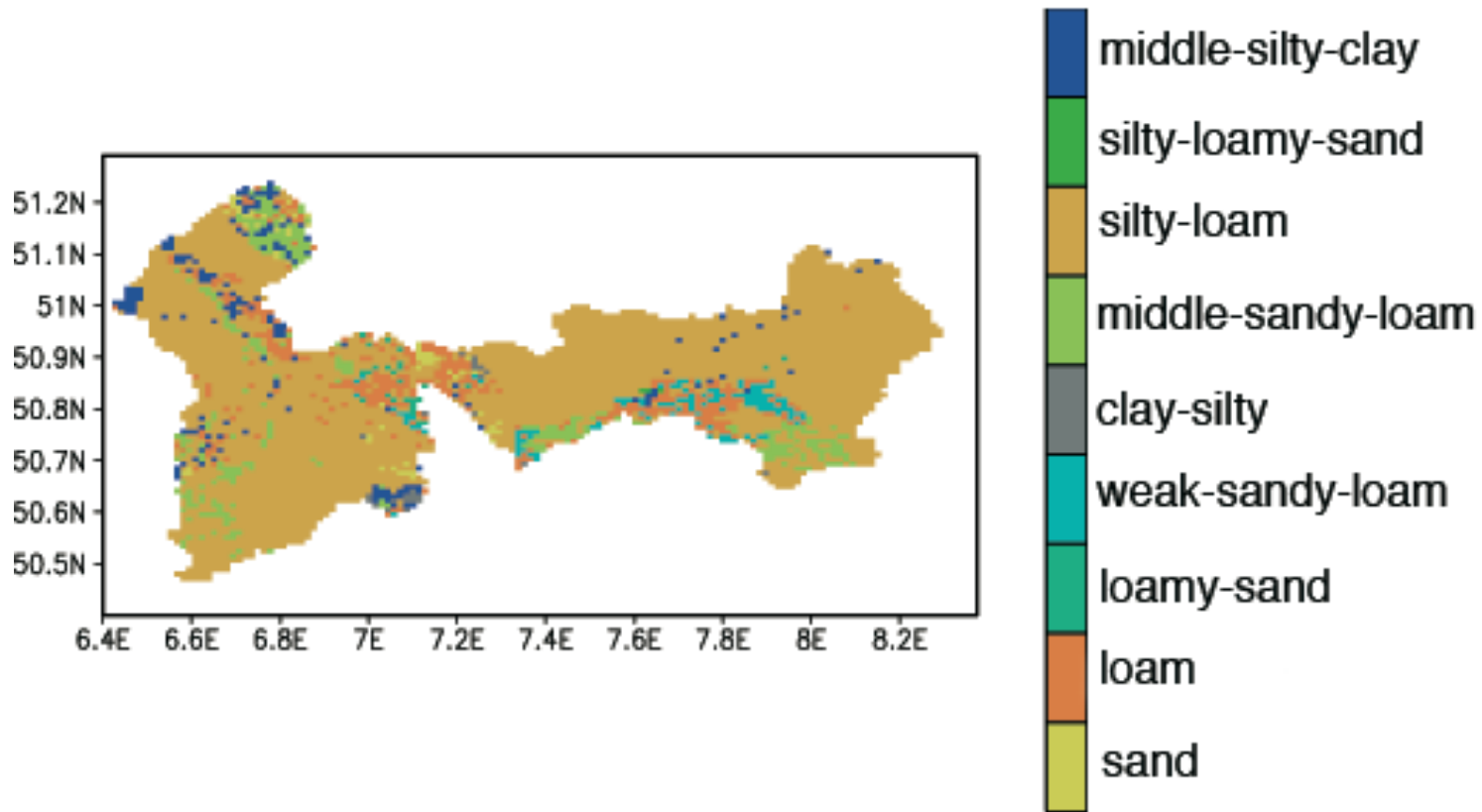
## Data: soil data



- classes of soil textures in the LMK-domain

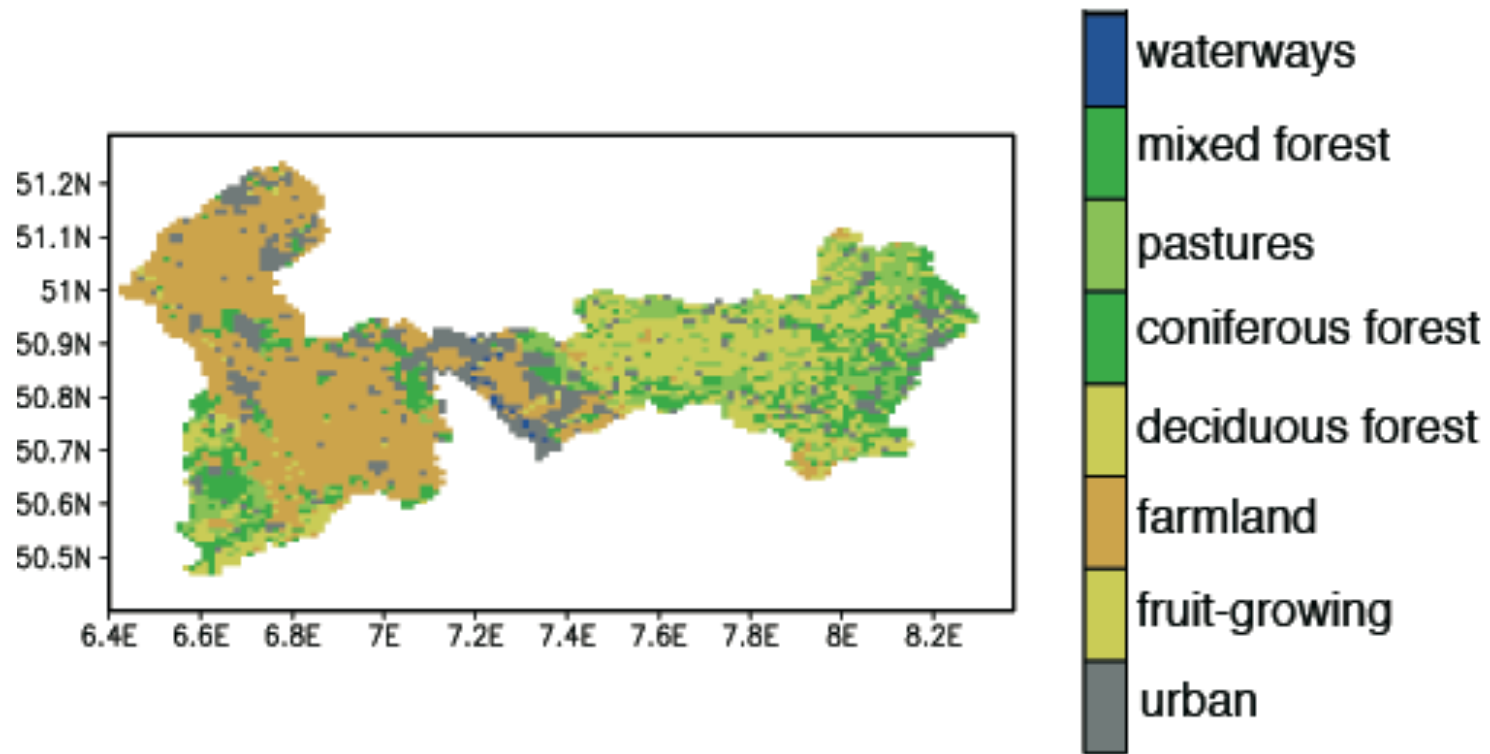
- resolution: 2,8 km

## Data: soil data



- classes of soil textures for the Erft- und Sieg catchment in Terra-Stand-Alone
- BK50 (Geologischen Landesamt NRW, Rheinland Pfalz)
- resolution: 1 km

# Data: vegetation

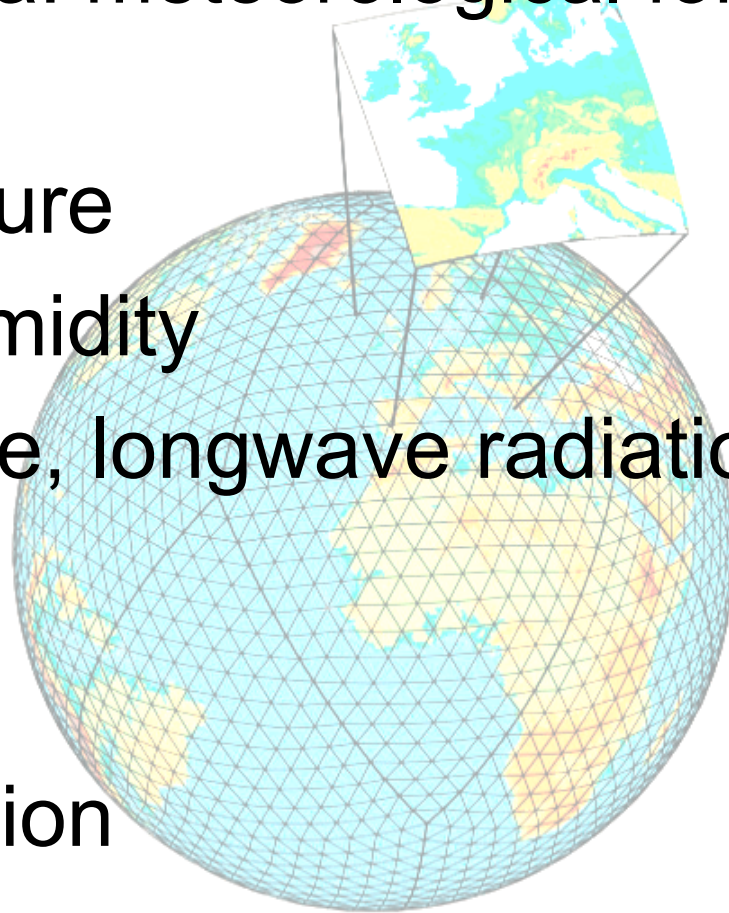


- Corine dataset (1991-1993)

- parameter for Terra: plant cover (seasonal variability),  
leaf area index (seasonal variability),  
root depth, roughness length

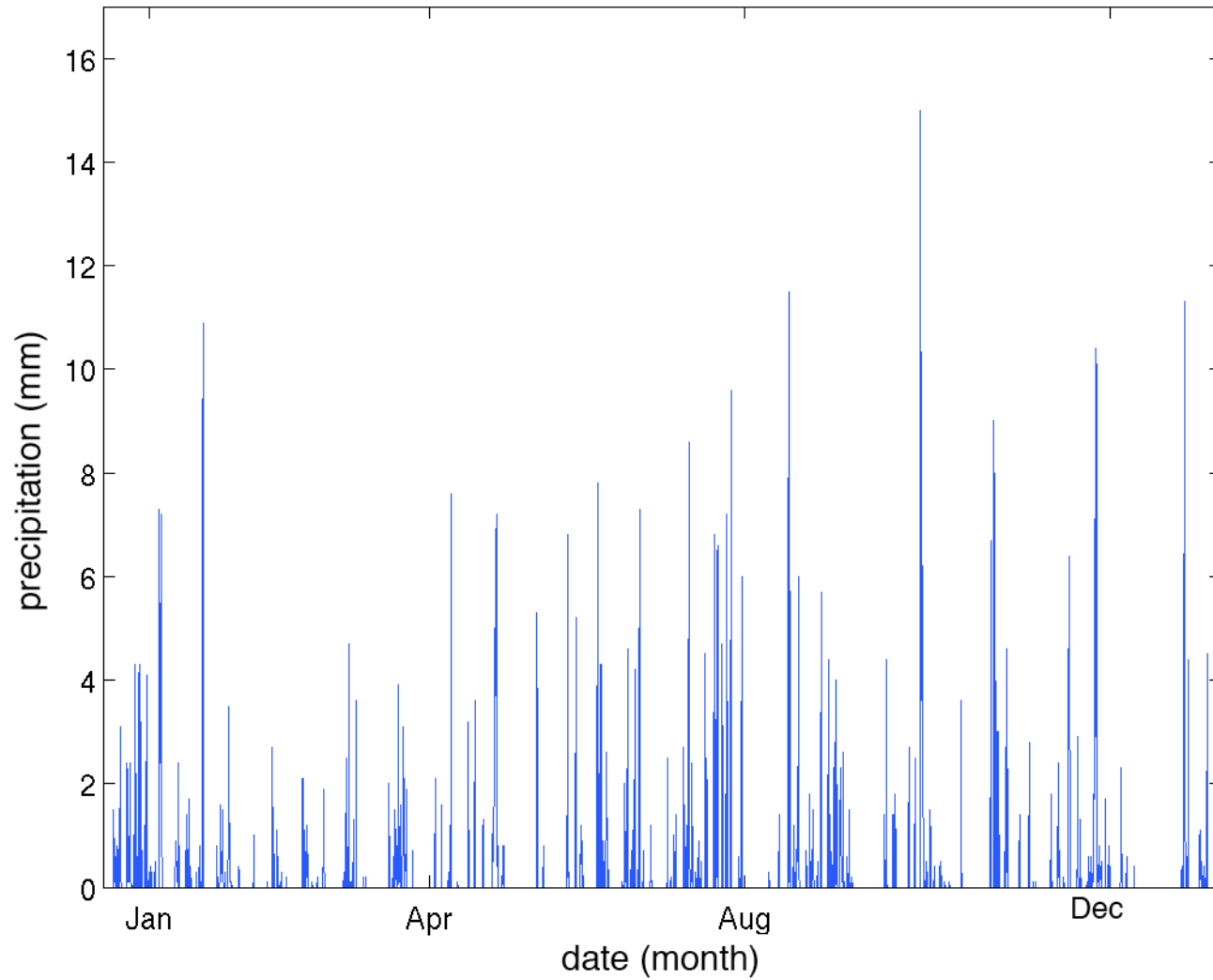
## Data: meteorological forcing

- temperature
- spec. humidity
- shortwave, longwave radiation
- wind
- pressure
- precipitation



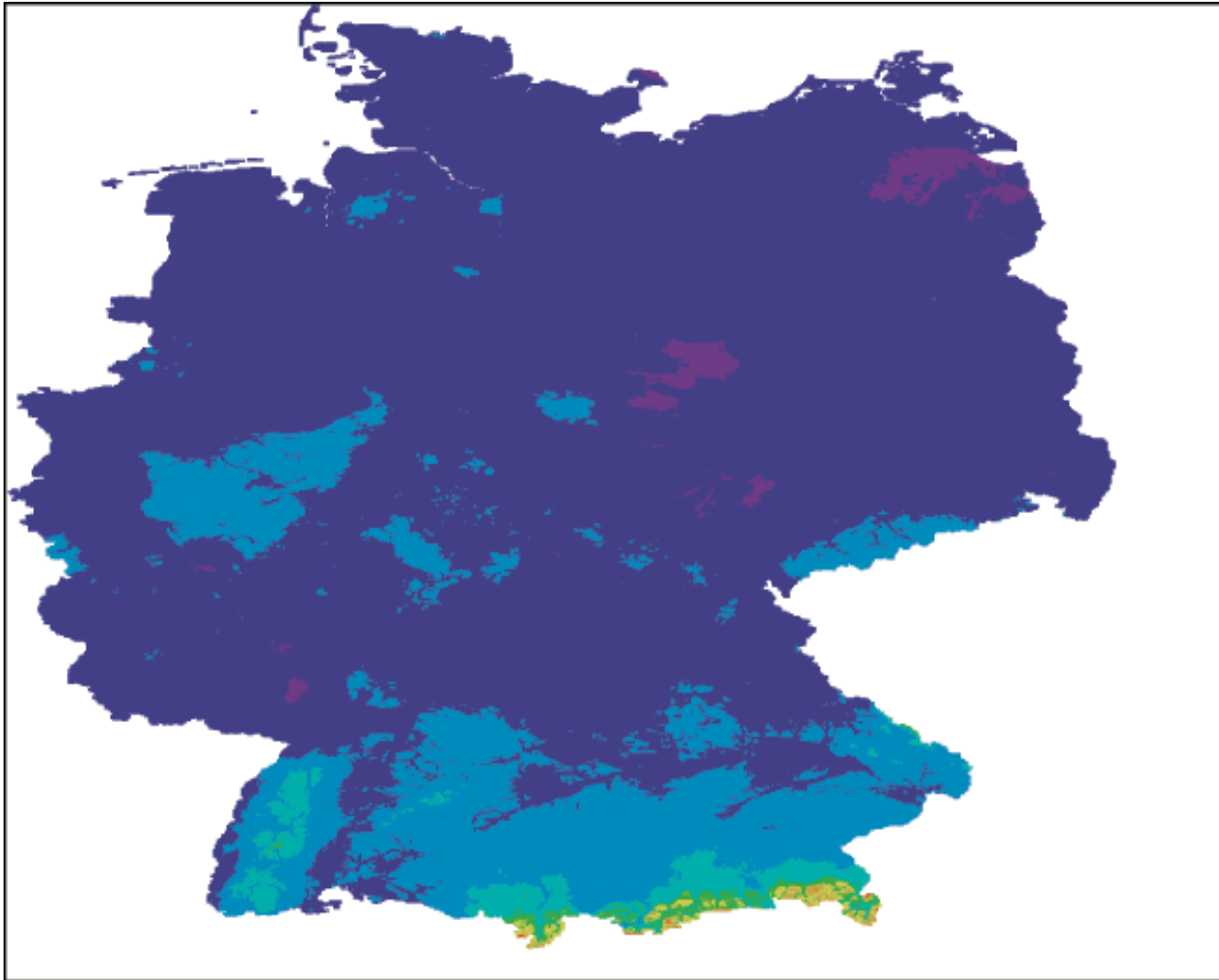
# Precipitation: gauging-station

## Cologne/Bonn airport 2004



# Precipitation: REGNIE-Data

precipitation accumulated 03/2005 - 09/2005

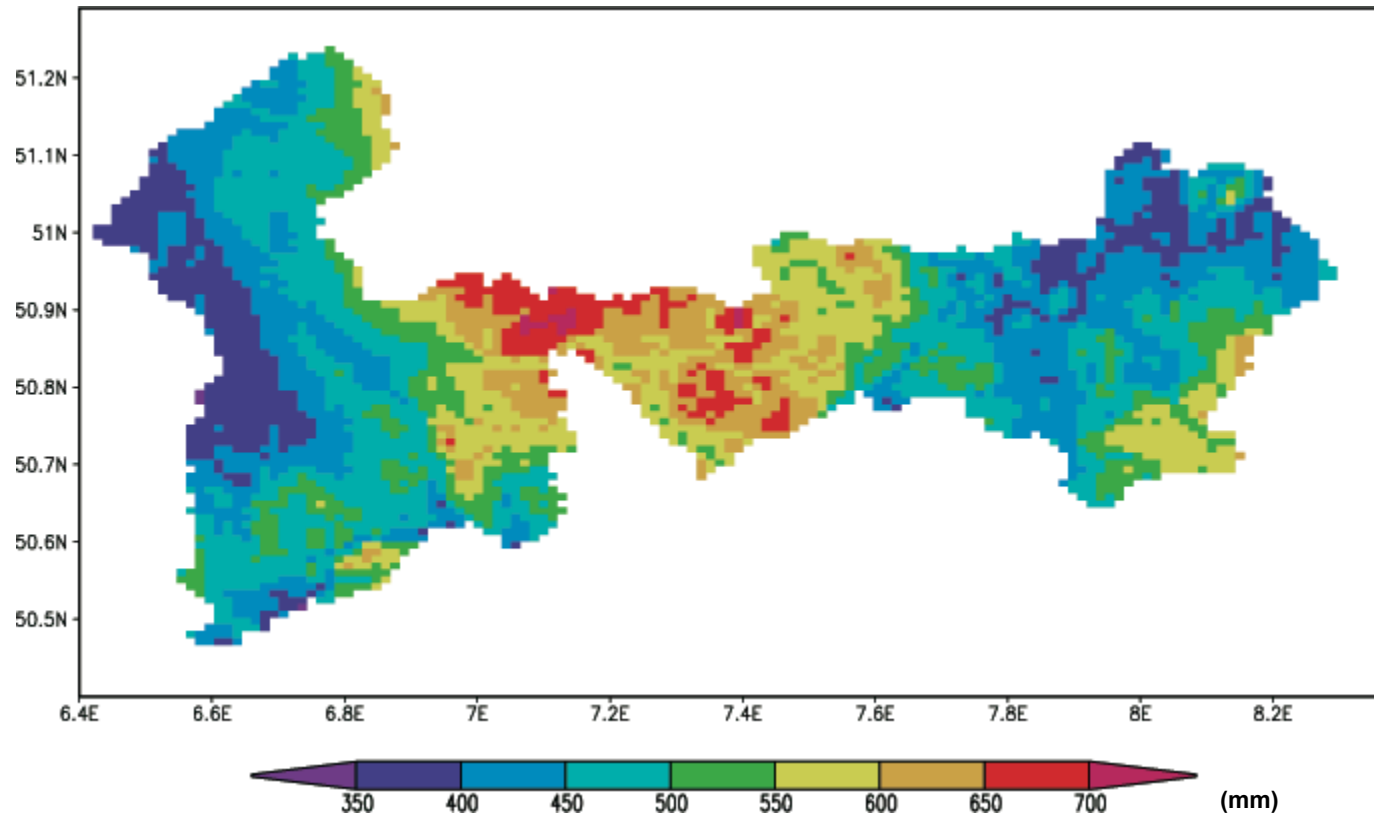


- one km  
gridded  
precipitation  
data (daily)



# Precipitation: REGNIE-Data

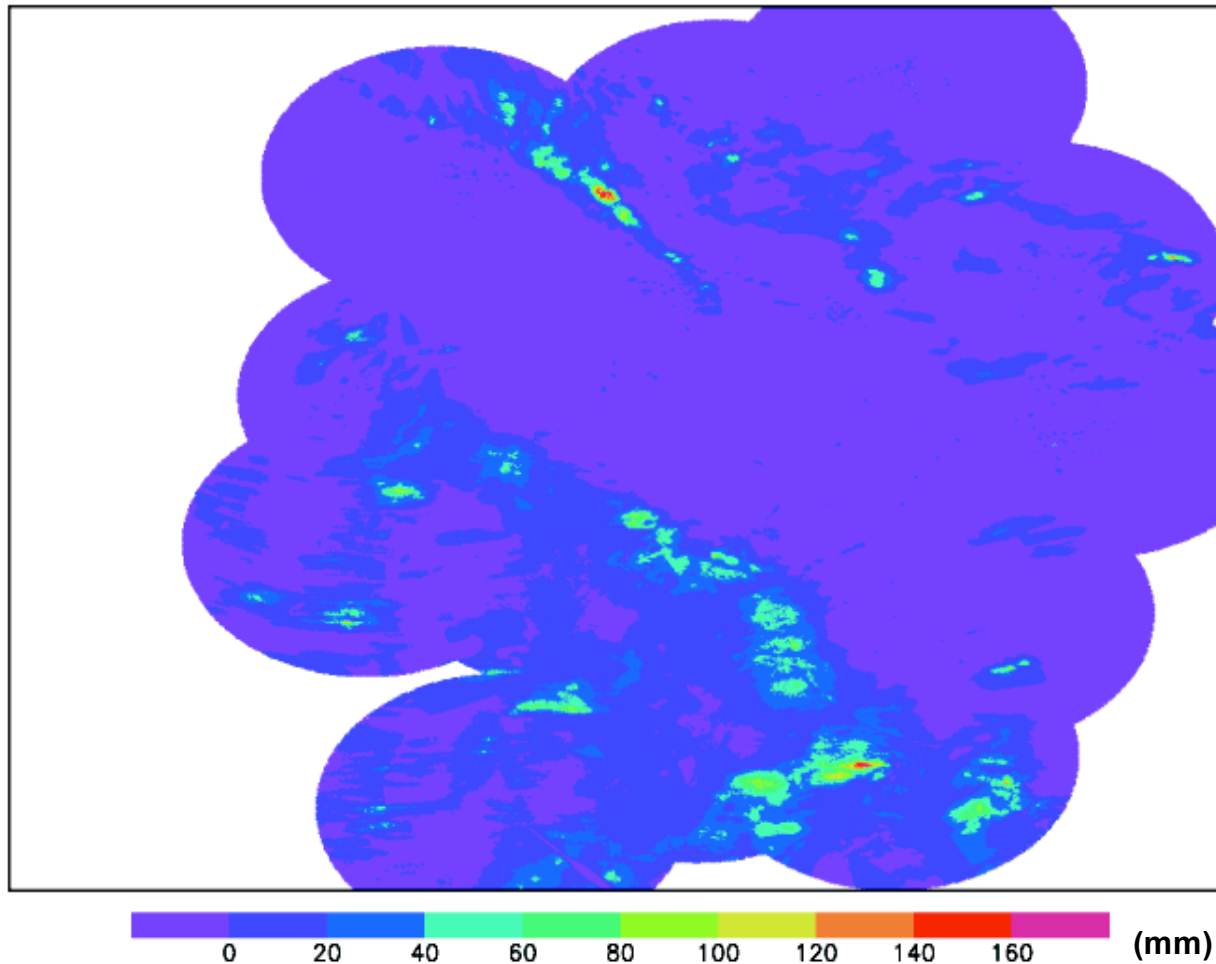
precipitation accumulated 03/2005 - 09/2005



**determine spatial balance of current daily precipitation distributions using local precipitation reference values of the years 1961 - 1990**

# Precipitation: RADOLAN (Radar-Online-Calibration)

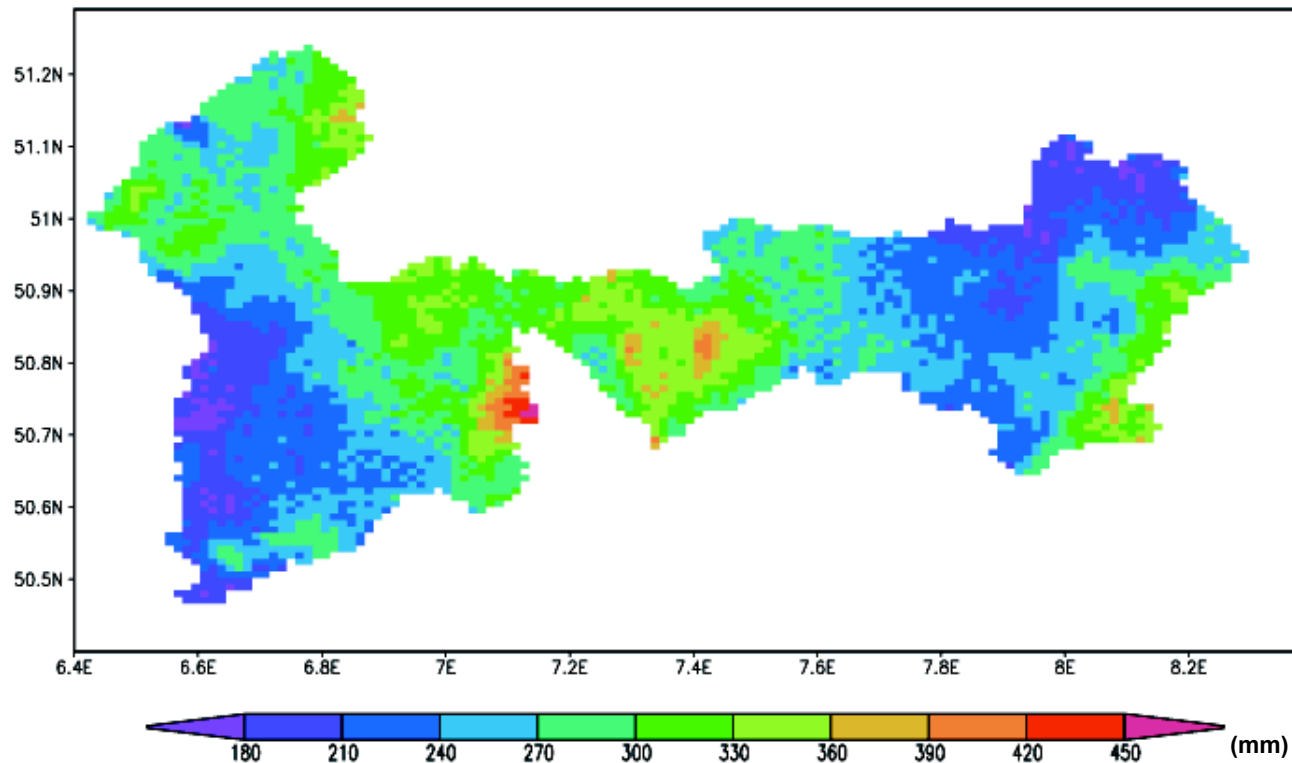
21.07.2005 5 - 6 CEST



- combination between station data and radar data (since june 2005)

# Precipitation: RADOLAN (Radar-Online-Calibration)

precipitation accumulated 15.04.05 - 15.07.05



- product by DWD
- aim: short range precipitation forecast
- temporal resolution: hourly

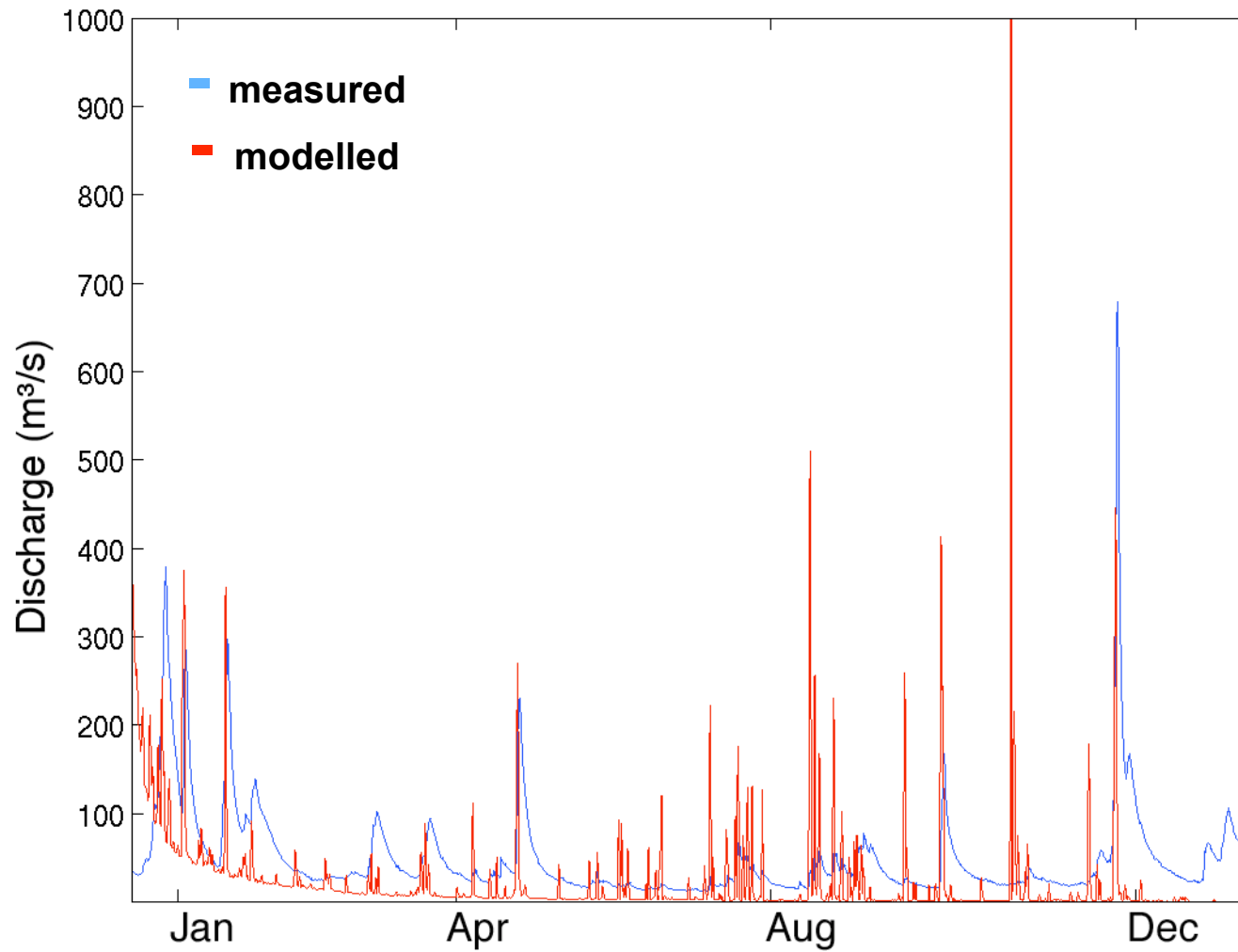
# Validation: gauging-station



- data for the year 2002 bis 2005

# Results: discharge measurement - modelling

**Menden, homogeneous precipitation:**



## Results: vertical watertransport

The flux of soil moisture in unsaturated soil is the sum of drainage and diffusion and can be written as one dimensional Darcy equation:

$$F_{\eta} = K(\eta) + D(\eta) \frac{\partial \eta}{\partial z}$$

hydraulic conductivity and hydraulic diffusivity depend both on the soil moisture and the soil textures. Both functions are parameterised by the exponential laws (Rijtima, 1969):

$$K(\eta) = K_0 \exp\left(K_1 \frac{\eta_{PV} - \eta}{\eta_{PV} - \eta_{ADP}}\right) \quad D(\eta) = D_0 \exp\left(D_1 \frac{\eta_{PV} - \eta}{\eta_{PV} - \eta_{ADP}}\right)$$

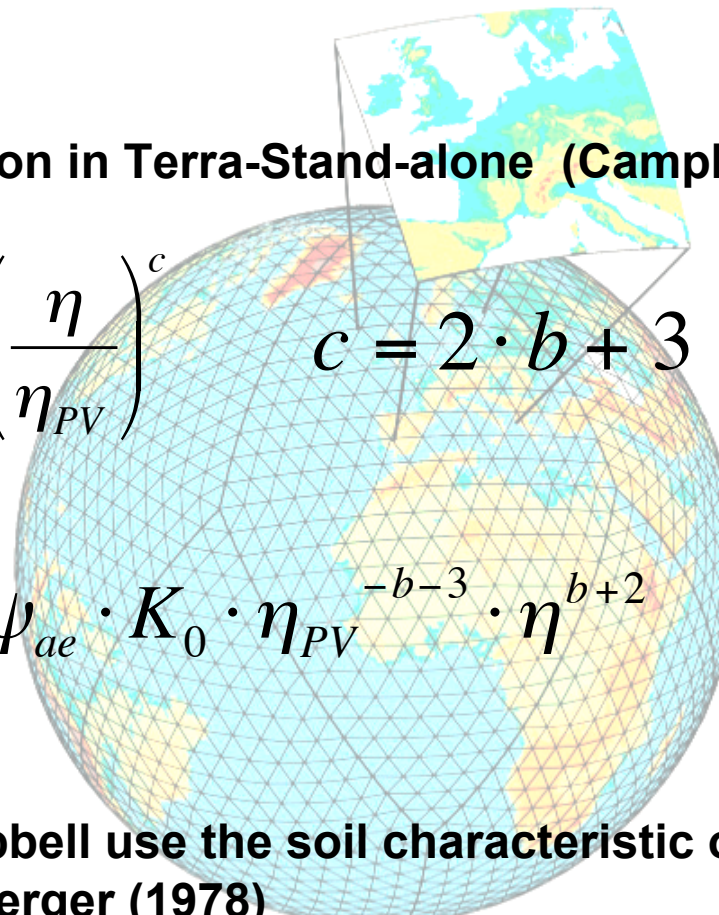
## Results: vertical watertransport

New parameterisation in Terra-Stand-alone (Campbell 1974):

$$K(\eta) = K_0 \cdot \left( \frac{\eta}{\eta_{PV}} \right)^c \quad c = 2 \cdot b + 3$$

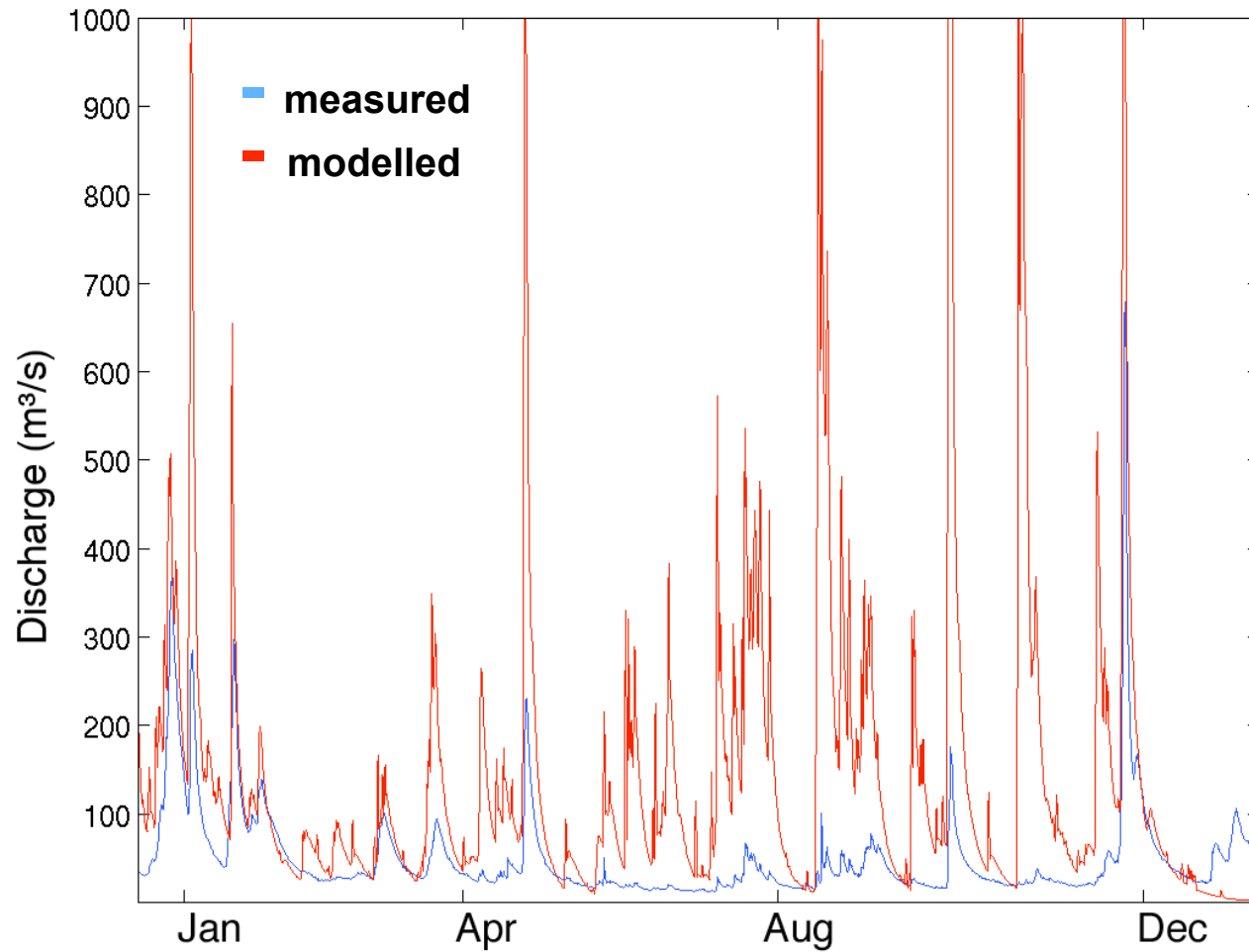
$$D(\eta) = -b \cdot \psi_{ae} \cdot K_0 \cdot \eta_{PV}^{-b-3} \cdot \eta^{b+2}$$

- function of Campbell use the soil characteristic of Clapp and Hornberger (1978)



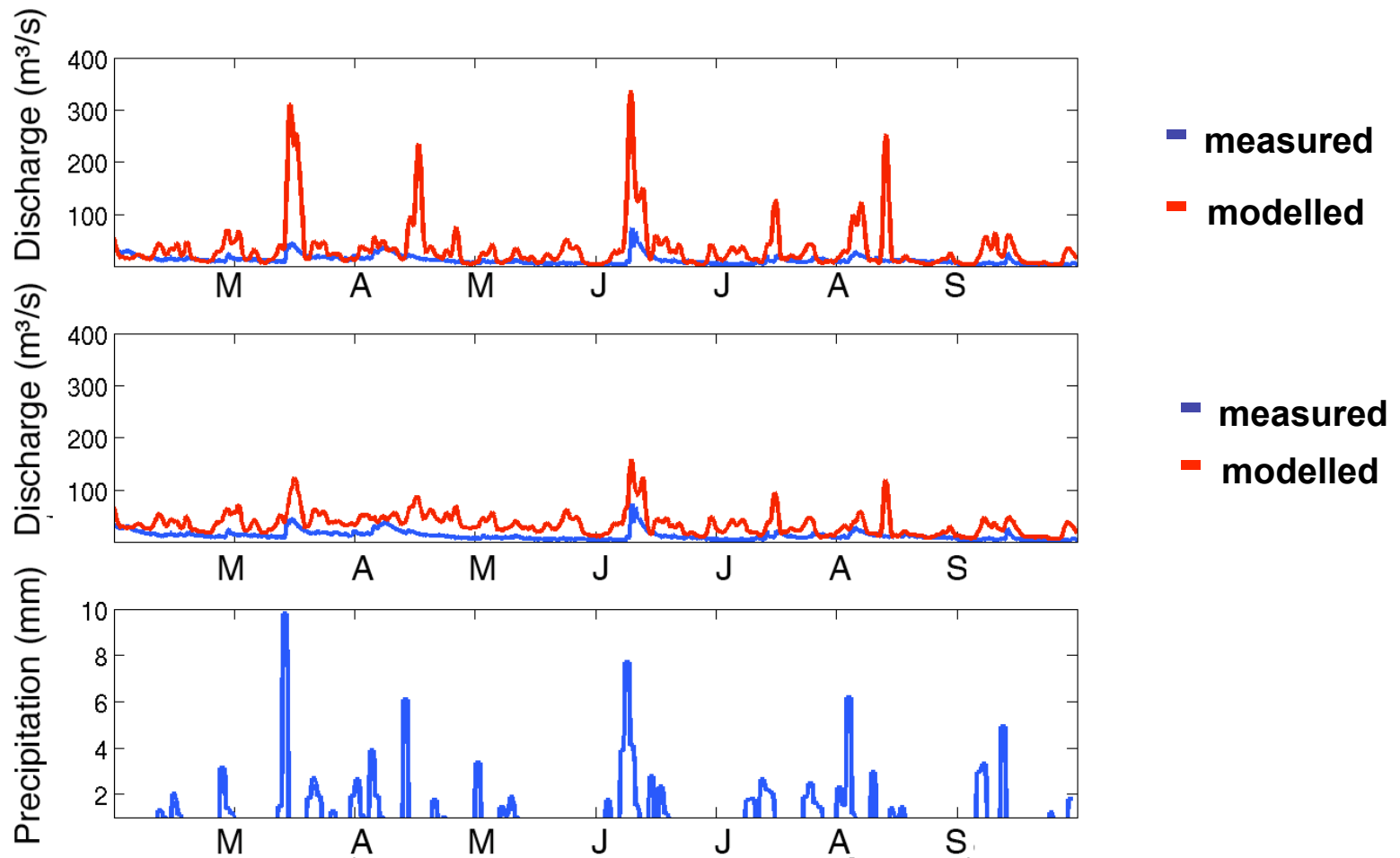
# Results: discharge measurement - modelling

**Menden, homogeneous precipitation:**



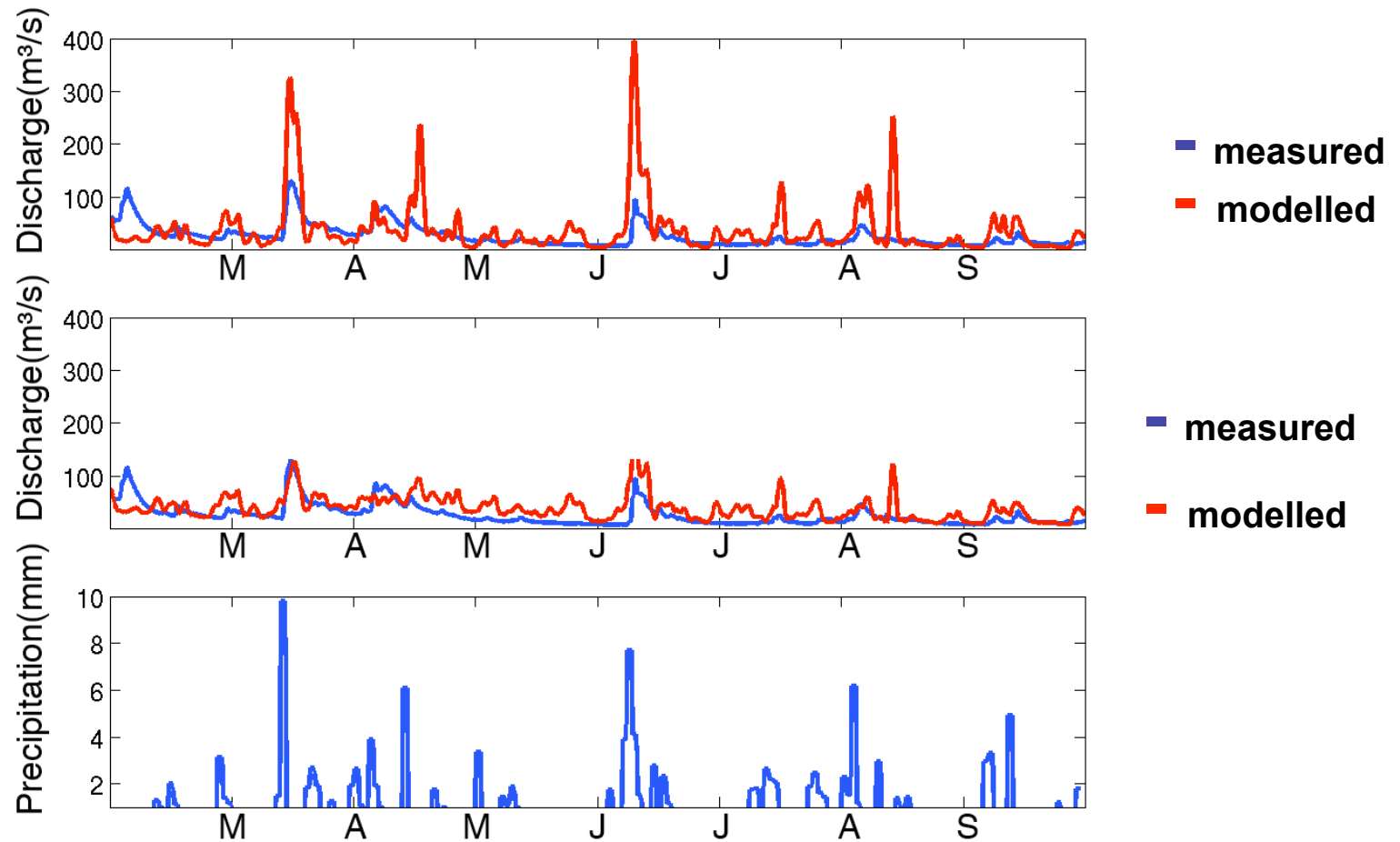
# Results: discharge measurement - modelling

gauging-station Lohmar (Agger) 2005: REGNIE-Data



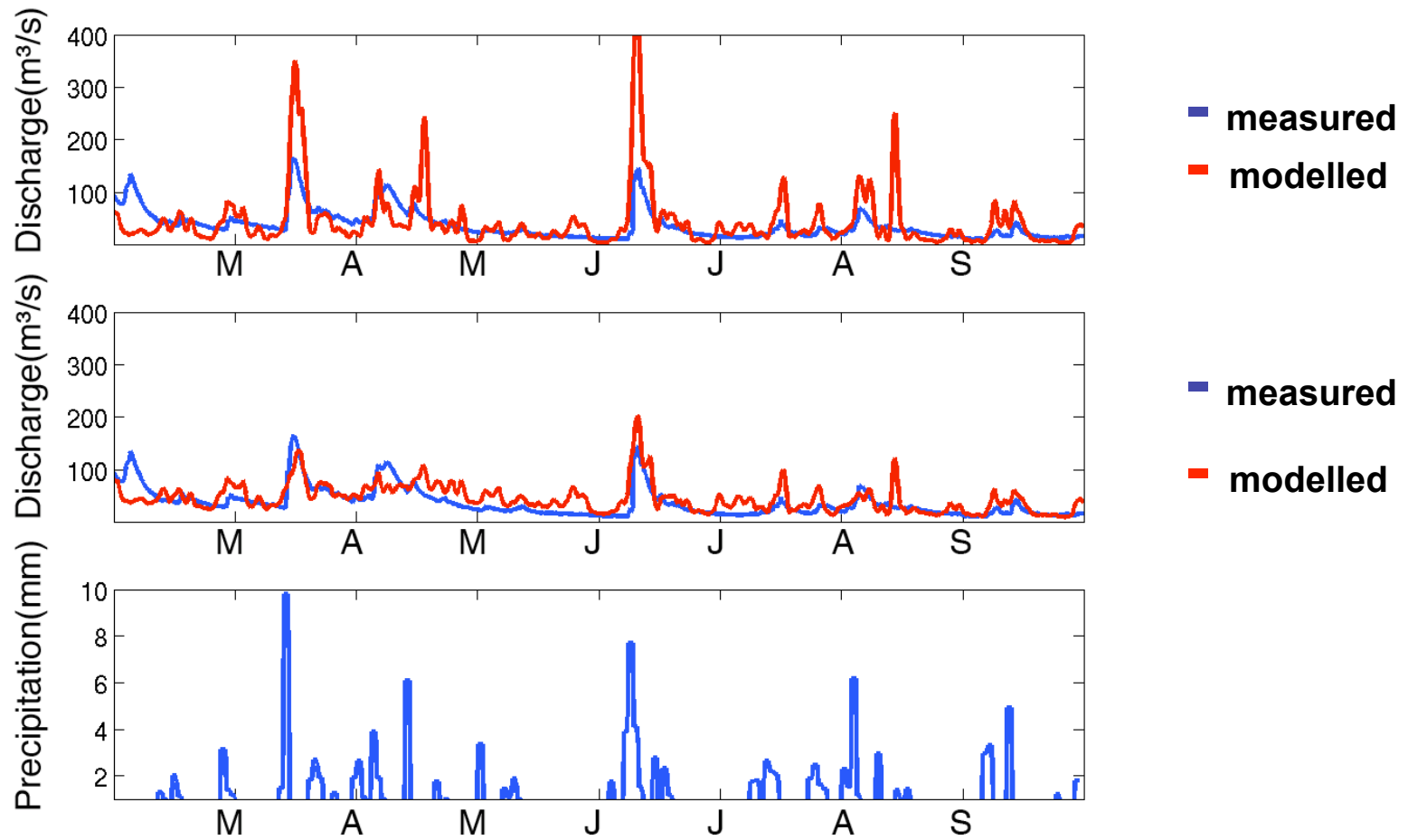
# Results: discharge measurement - modelling

gauging-station Kaldauen (Sieg) 2005: REGNIE-Data



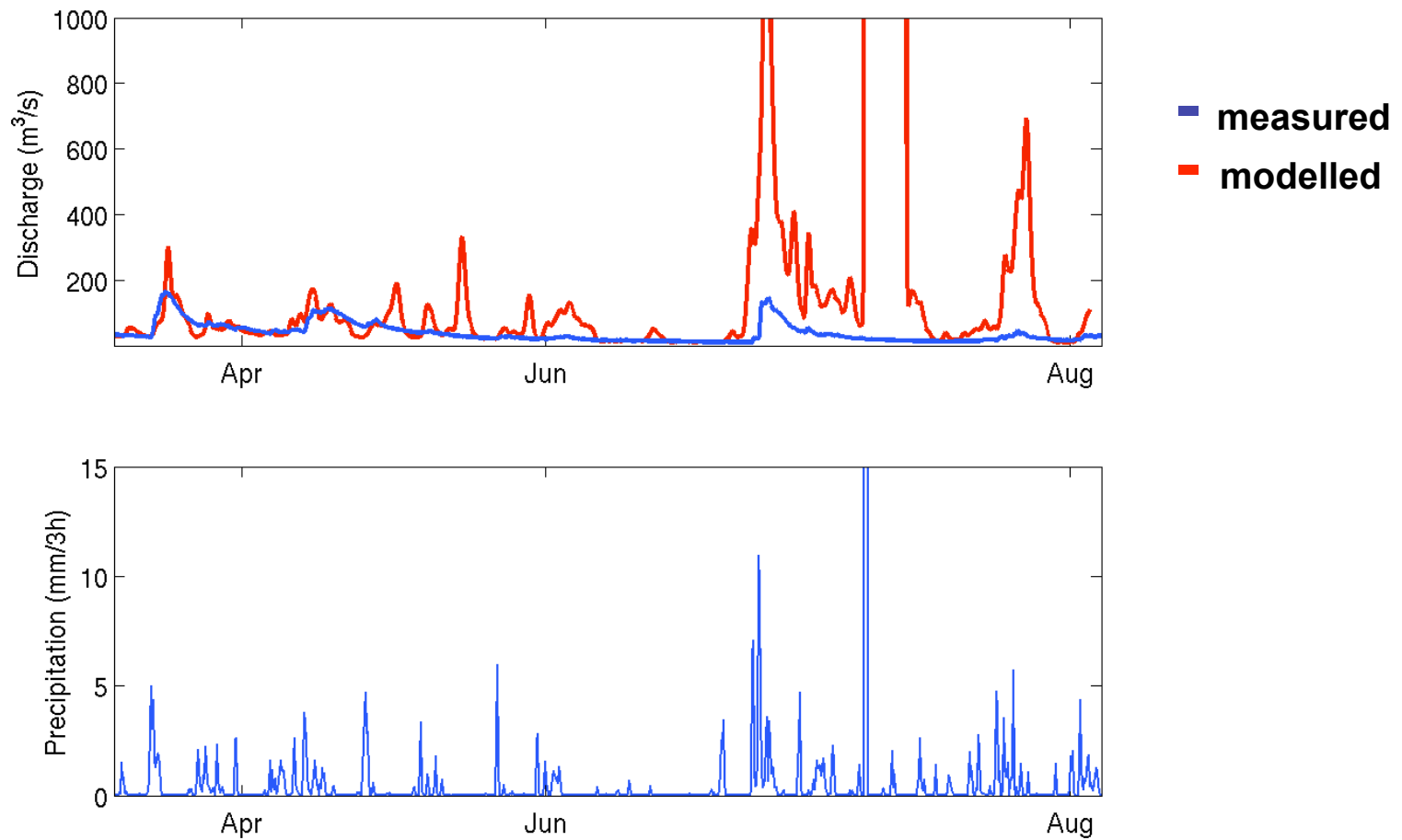
# Results: discharge measurement - modelling

gauging-station Menden (Sieg) 2005: REGNIE-Data



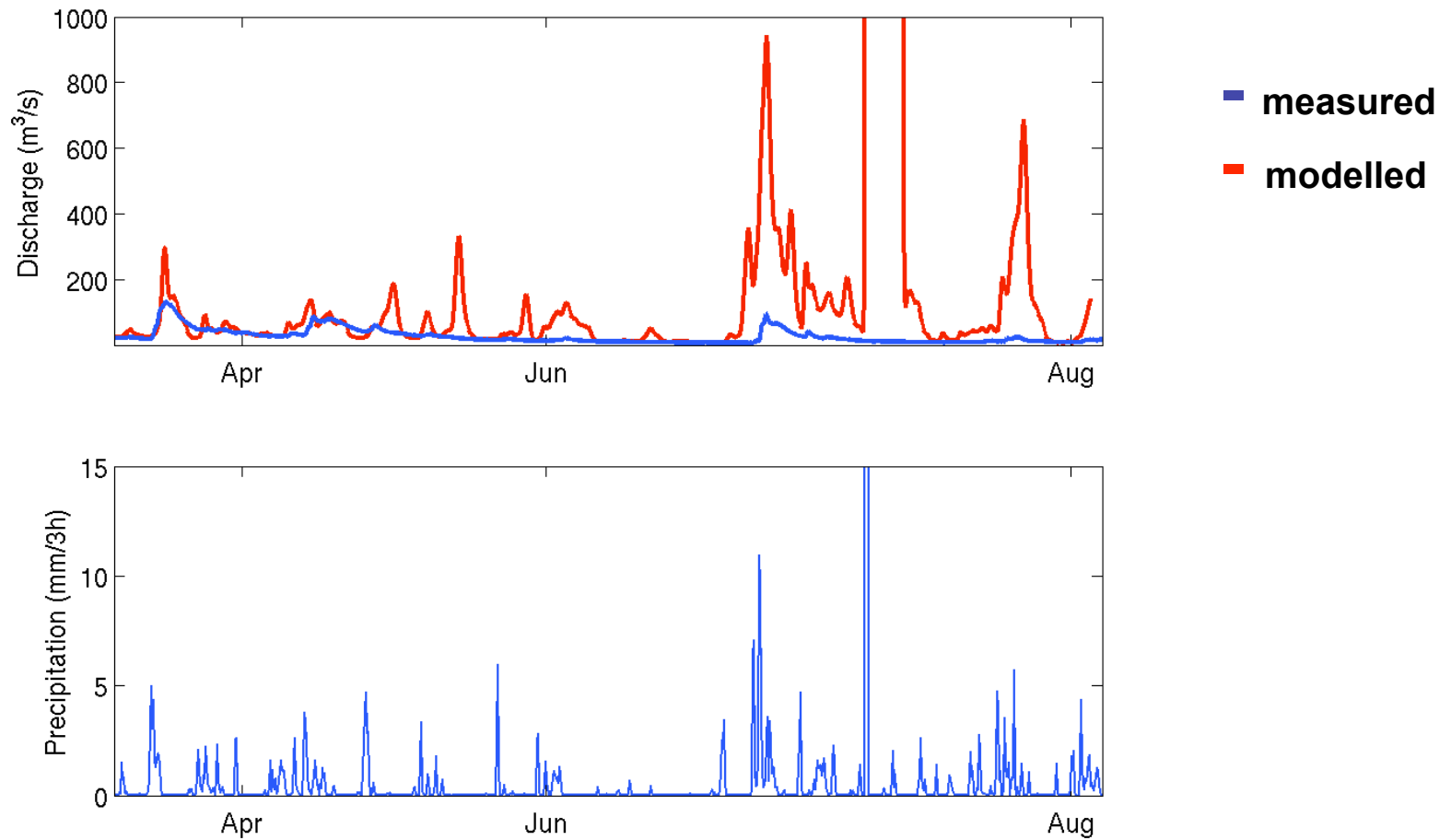
# Results: discharge measurement - modelling

gauging-station Menden, RADOLAN-Data:



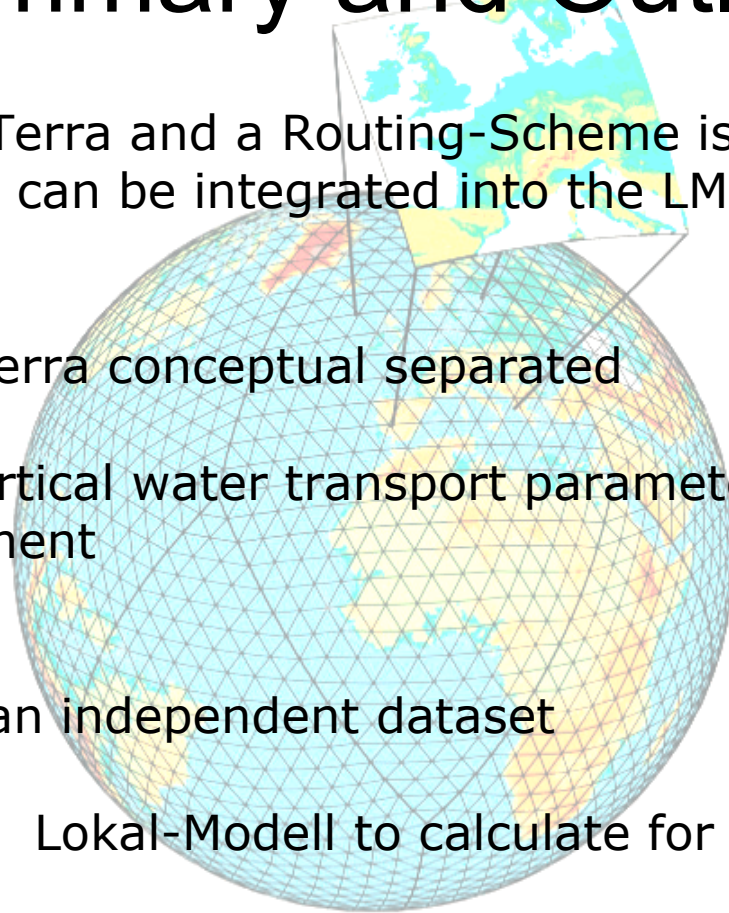
# Results: discharge measurement - modelling

gauging-station Kaldauen, RADOLAN-Data:



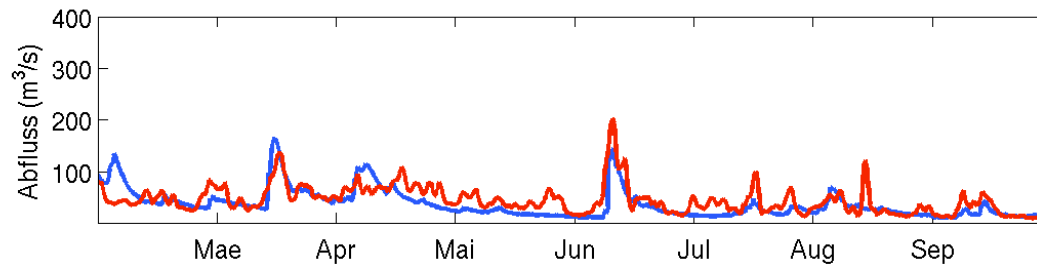
# Summary and Outlook

- A coupling of Terra and a Routing-Scheme is possible without high costs and can be integrated into the LM
- Routing and Terra conceptual separated
- Changes in vertical water transport parameterisation take advancement
- Validation by an independent dataset
- Integration in Lokal-Modell to calculate for case-studies

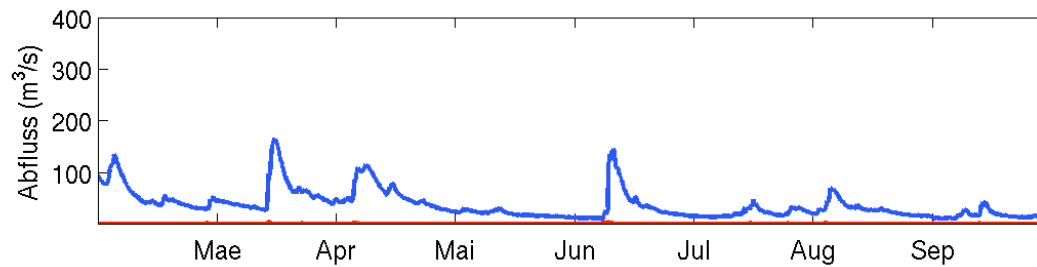


# Ergebnisse: Abfluss Messung - Modellierung

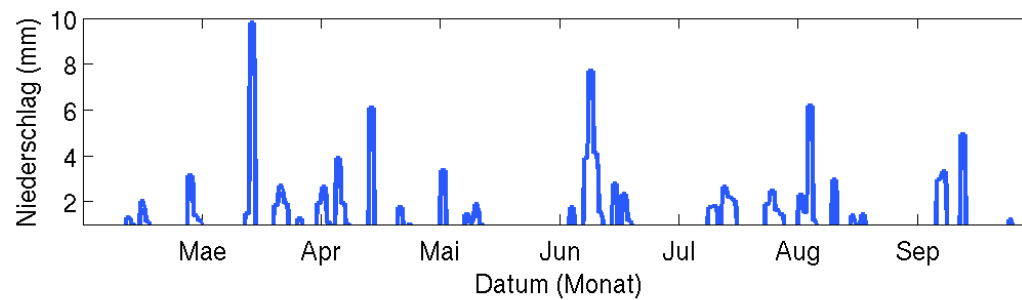
## Sensitivität Menden (Sieg): REGNIE Niederschlag



Gitterzelle 0 0



Gitterzelle 0 -2



# Results: waterbalance

