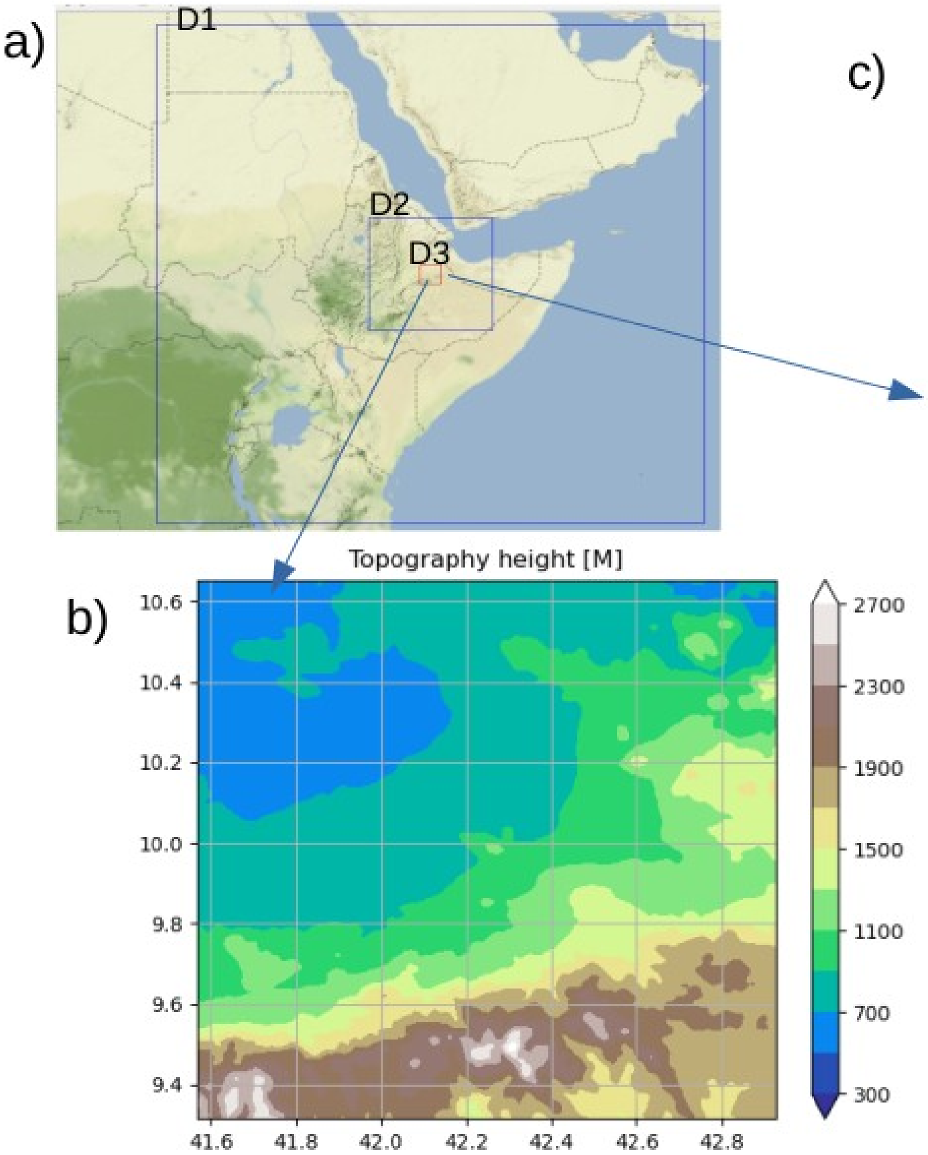
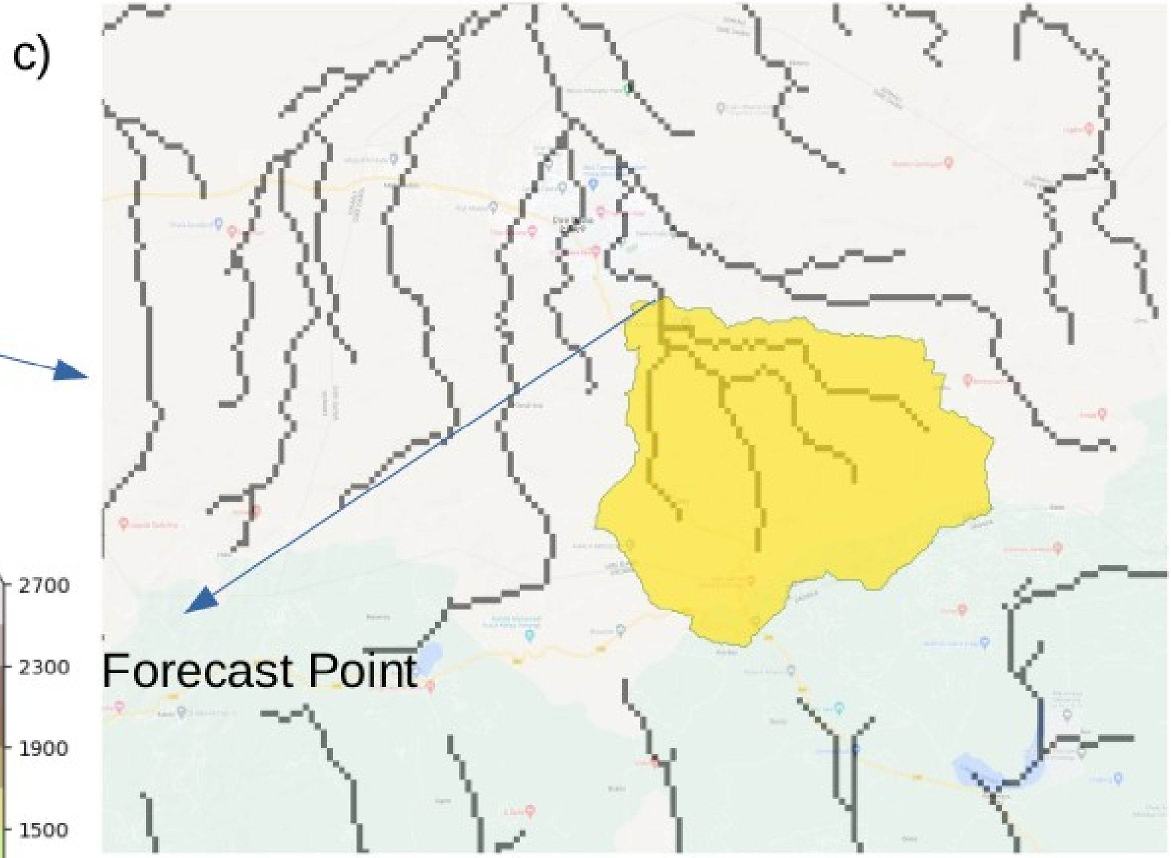
Calibration of the uncopuled WRF-Hydro model

Addisu G. Semie, PhD
Asst. Prof.,Computational Science Program,
Addis Ababa University
Email: addisu.semie@aau.edu.et



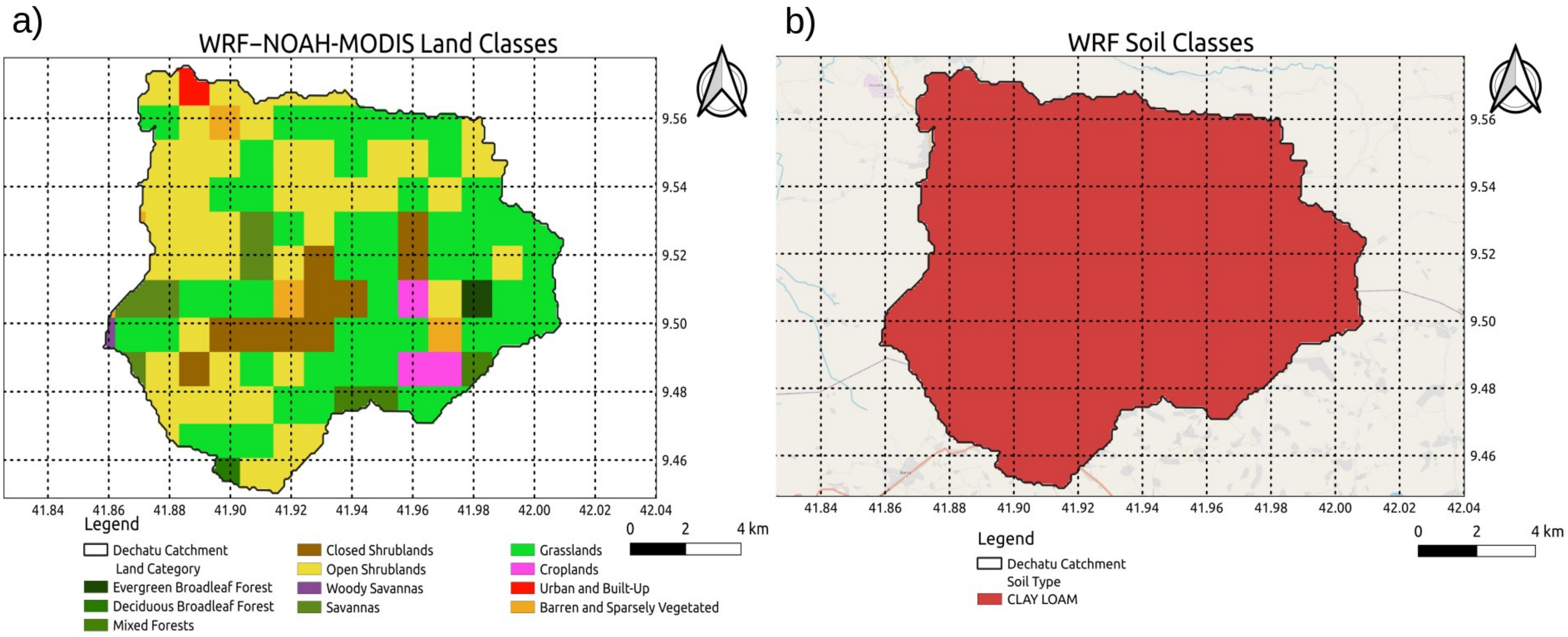


a) Map of East Africa showing the location of model domains at 25, 5 and 1km horizontal resolution (D1, D2 and D3, respectively). D1 is defined by 150 × 150 grid points and extends 0 to 17 0 N and 30 to 55

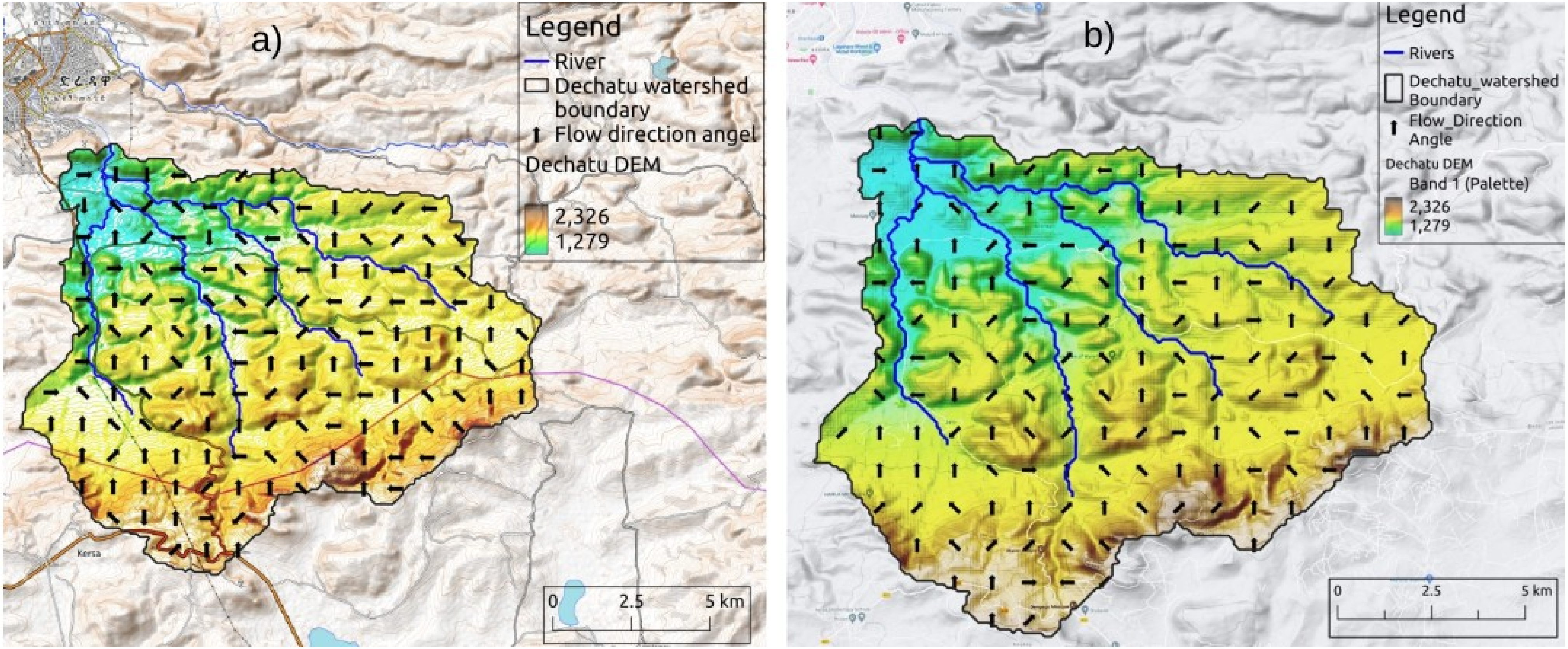
b) Topography of D3 domain

c) river channels in D3 domain with the focus of Dechatu river catchment (yellow shade) and forecast point

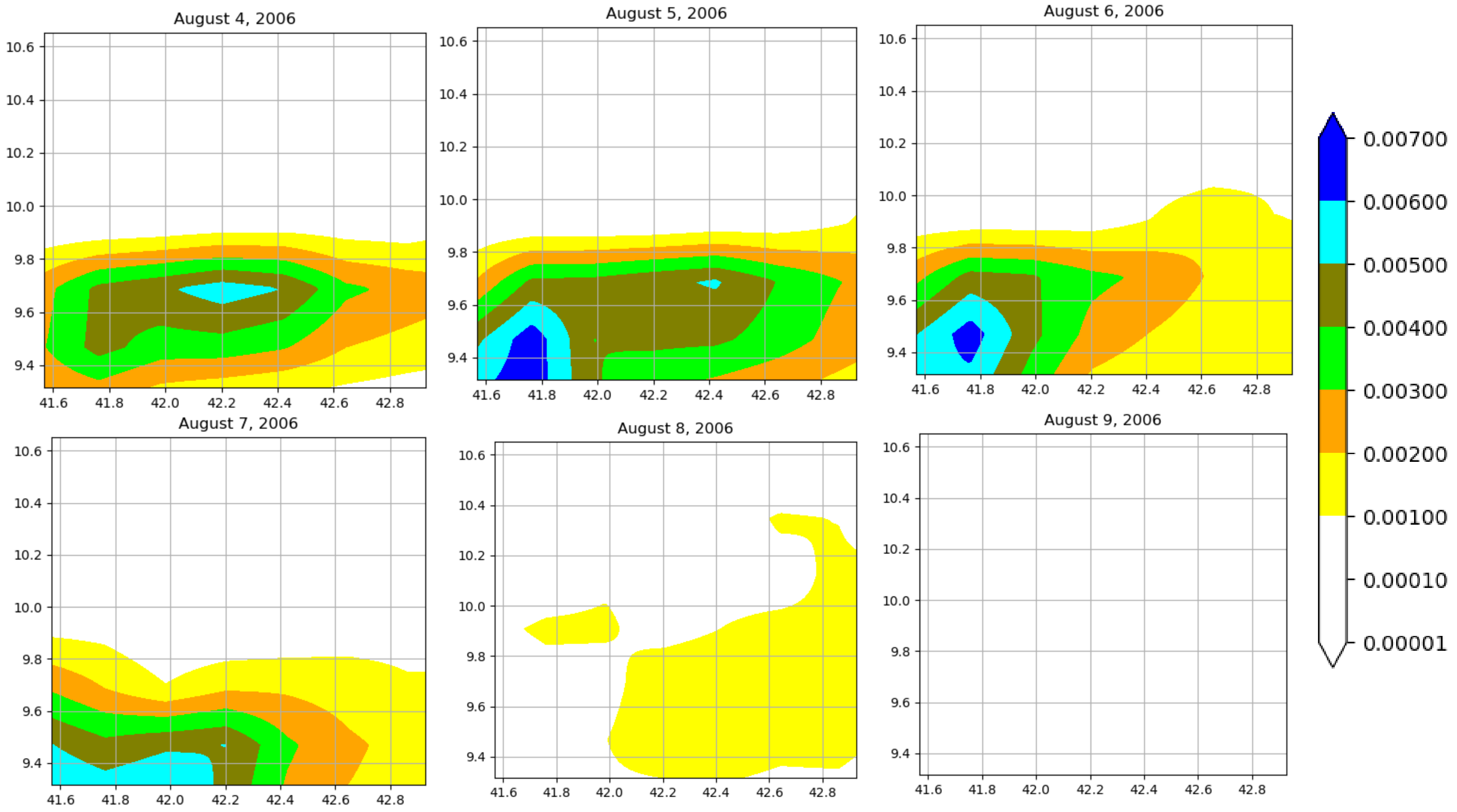
Maps of dominant Land category and soil type of Dachatu river catchment



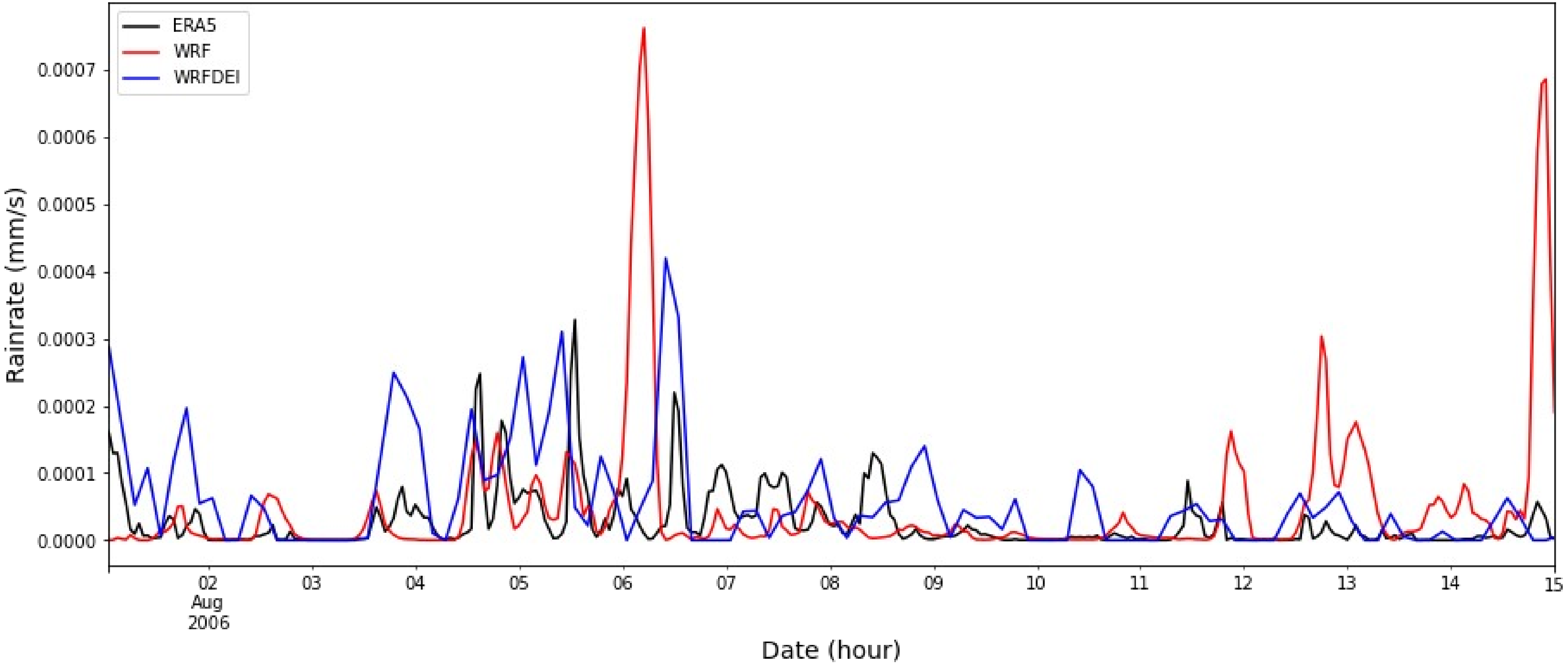
WRFHydro default and Hydroshed flow direction



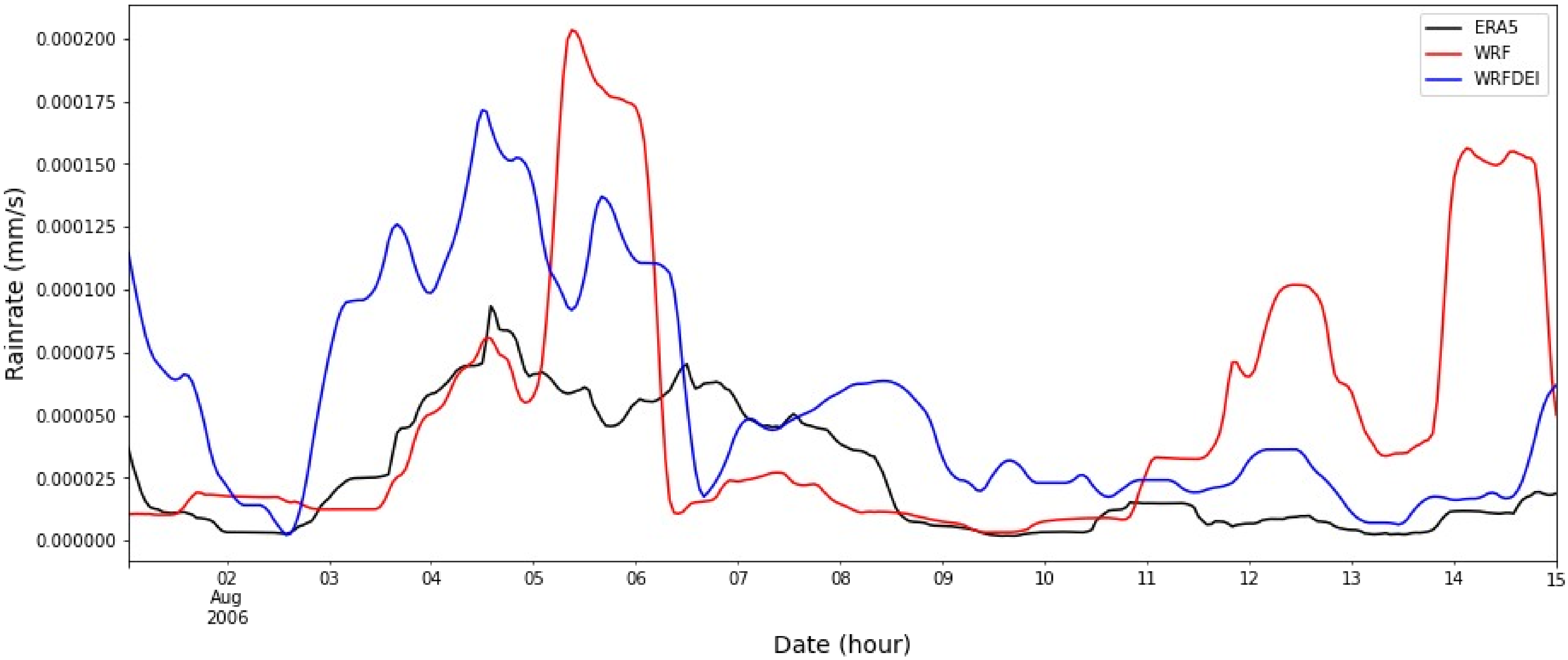
ERA5 Model Forcing – daily cumulative Precipitation



Model Forcing - Precipitation



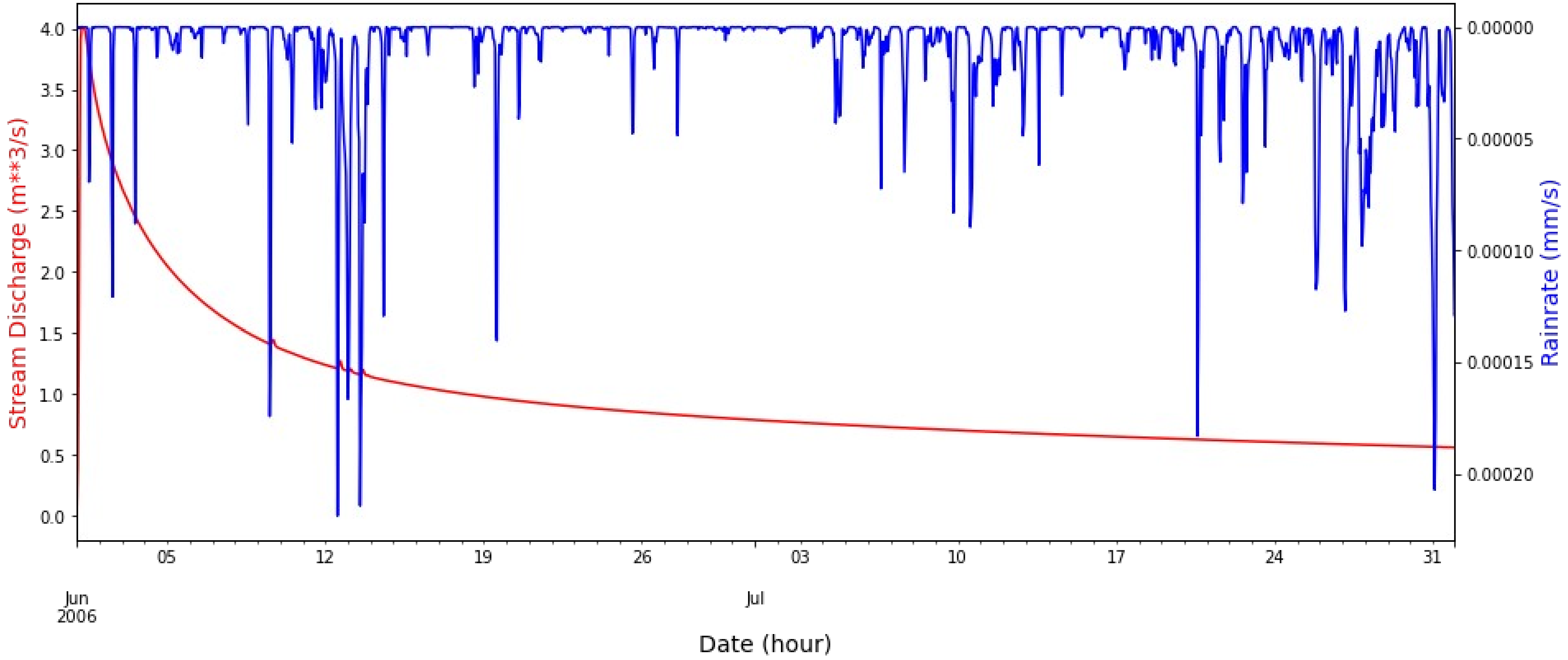
Model Forcing – Precipitation (moving average of 24hrs)



Precipitation forcing

- Variations in magnitude and frequency of precipitation are observed
- Rain-rate from WRF model indicated to have higher magnitude compared to ERA5 and WRFDEI precipitation forcing
- WRFDEI meteorological forcing data set has been generated using the same methodology as the widely used WATCH Forcing Data (WFD) by making use of the ERA-Interim reanalysis data.

WRF-Hydro outputs with default configuration



Infiltration excess based surface runoff scheme

Surface runoff, R, equals the difference between precipitation, P, and maximum infiltration, I_{max}:

$$R = P - I_{max}$$

where infiltration maximum I_{max} is computed as an increasing function of the liquid soil moisture deficit of the soil column D_{total}:

$$I_{max} = P_x . \{ \frac{D_{total}[1 - exp(\frac{DKSAT.REFKDT.\Delta t_1}{REFDK})]}{P_x + D_{total}[1 - exp(\frac{DKSAT.REFKDT.\Delta t_1}{REFDK})]} \}$$

Where Δt_1 is the model time step, DKSAT is the saturated hydraulic soil conductivity, depending on soil texture, REFDK is a reference saturated hydraulic conductivity of silty clay loam, assumed spatially constant and equal to $2x10^{-6} m/s$, and REFKDT is the surface infiltration coefficient. The value of REFDK and REFKDT are constant on the whole domain.

I_{max} is the function of spatially varying precipitation inputs and soil properties. P_x is excess precipitation or throughfall from canopy and is given by:

$$P_x = max(0, Q_{wat} . \Delta t)$$

where Q_{wat} is the water input to the soil surface, and Δt is the model time step in hours ($\Delta t = \Delta t_1 .86400$). Q_{wat} is calculated depending on the existence of a snow layer and it accounts for rainwater, melting water from the bottom of the snowpack, soil surface dew rate adjusted for frost.

The term D_{total} is the total soil moisture content that can potentially infiltrate, which depends on soil properties:

$$D_{total} = \sum_{k=1}^{N} \Delta Z_k . (SMCMAX - SMC_k)$$

where ΔZ_k and SMC_k are the thickness and volumetric soil moisture content of the k-th soil layer (k = 1, ..., N = 4), respectively; and SMCMAX is the saturated volumetric soil moisture content dependent on soil type.

Model Performance Evaluation

$$NSE = \frac{\sum_{i=1}^{n}(O_i - \overline{O}) - \sum_{i=1}^{n}(P_i - O_i)^2}{sum_{i=1}^{n}(O_i - \overline{O})^2}$$

$$RMSE = \sqrt{\frac{\sum_{i=1}^{n}(P_i - O_i)^2}{n}}$$

$$RSR = \frac{RMSE}{STDEV_{obs}} = \frac{\sum_{i=1}^{n}(O_i - P_i)^2}{\sum_{i=1}^{n}(O_i - \overline{O})^2}$$

- NashSutcliffe efficiency coefficient (NSE) is -∞ to 1, NSE = 1 denotes a perfect agreement between the observed and anticipated values
- The performance of the model simulation increases with decreasing RMSE observations standard deviation ratio (RSR) and RMSE

REFKDT						
Vaules	0.1	0.3	0.5	1	2	3
NSE	0.324	0.259	0.138	-0.01	-0.085	-0.086
RMSE	0.346	0.363	0.391	0.424	0.439	0.439
RSE	0.822	0.861	0.928	1.005	1.042	1.042
DKSAT						
values	0.3	0.5	0.7	1	1.5	2
NSE	0.051	0.214	0.286	0.324	0.335	0.32
RMSE	0.41	0.374	0.356	0.346	0.344	0.347
RSE	0.974	0.887	0.845	0.822	0.816	0.825
SMCMAX						
values	0.75	0.9	1	1.2	1.5	
NSE	0.317	0.333	0.335	0.325	0.297	
RMSE	0.348	0.344	0.344	0.346	0.353	
RSE	0.826	0.817	0.816	0.822	0.838	

Selective objective criteria NSE, RMSE and RSR between simulated and observed discharges at Dechatu river catchment based on selected parameters

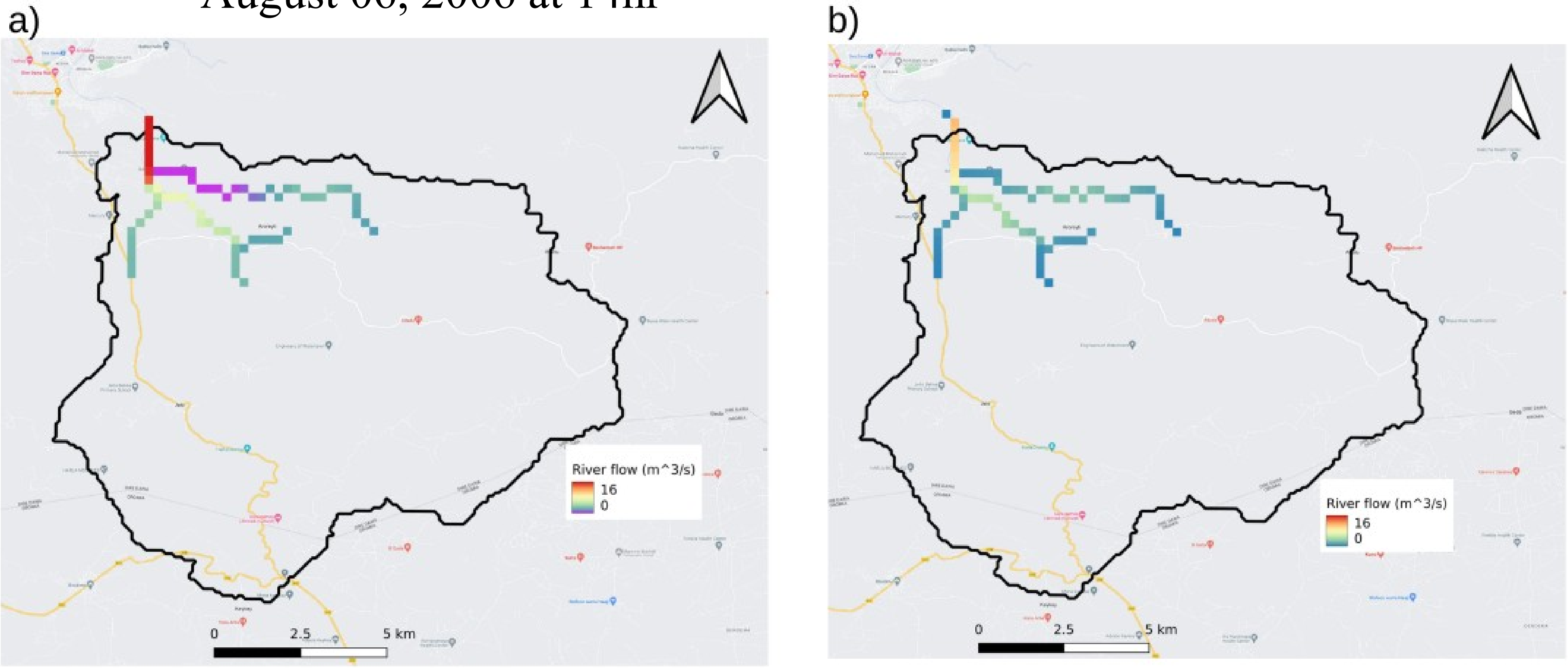
- REFKDT - infiltration runoff
- DKSAT – hydraulic soil conductivity
- SMCMAX - saturated volumetric soil moisture

Results

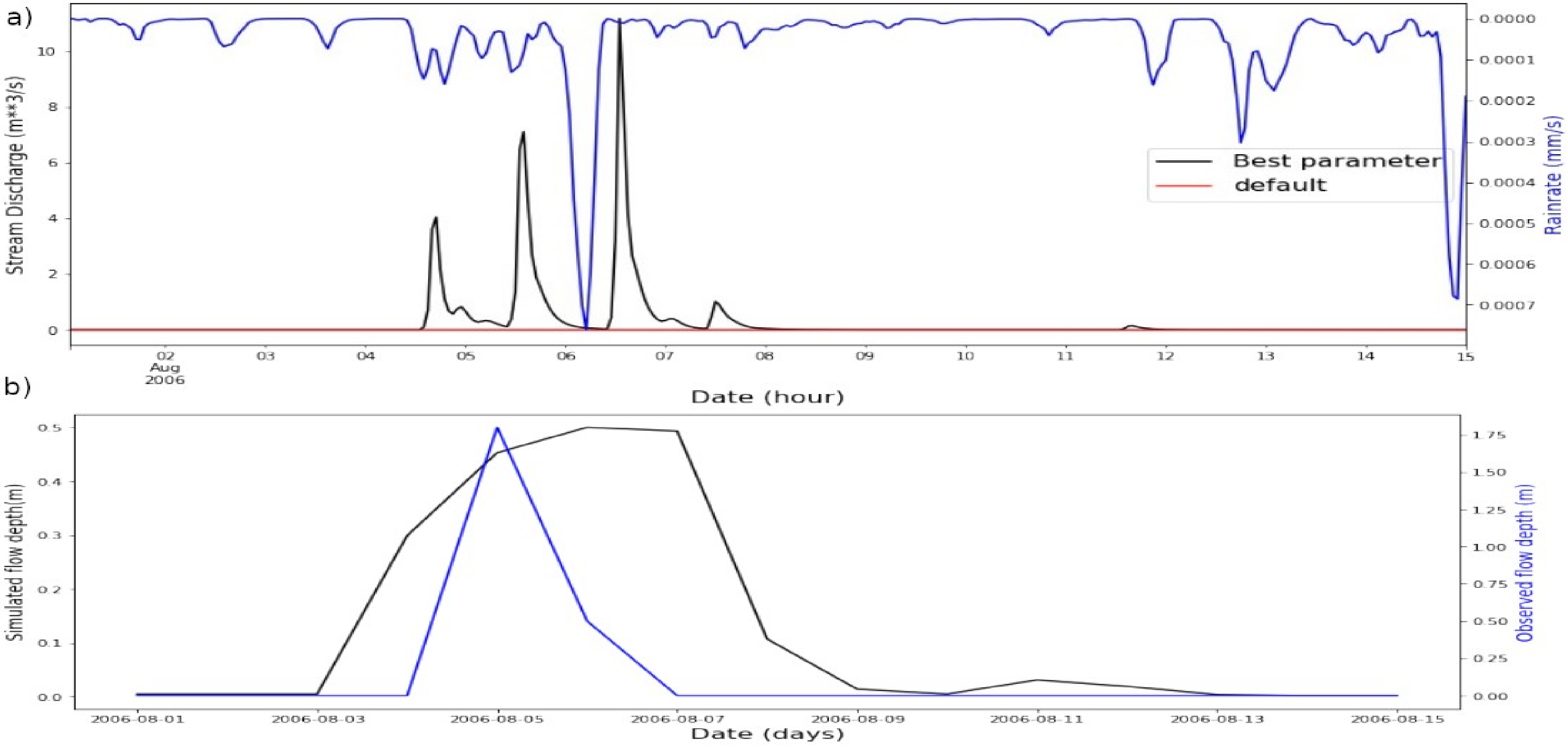
- REFKDT and DKSAT parameters significantly affect surface runoff
- Both of them control maximum infiltration and in turn surface runoff, lower values for both parameters lead to decrease in infiltration capacity of the soil column, which in turn increases surface runoff.
- SMCMAX also affect the soil infiltration capacity and the generated runoff but their influence is not as strong as REFKDT and DKSAT parameters in all experiments.

River flow that contributes to the Dechatu river at the forecast point

- August 06, 2006 at 13hr
- August 06, 2006 at 14hr

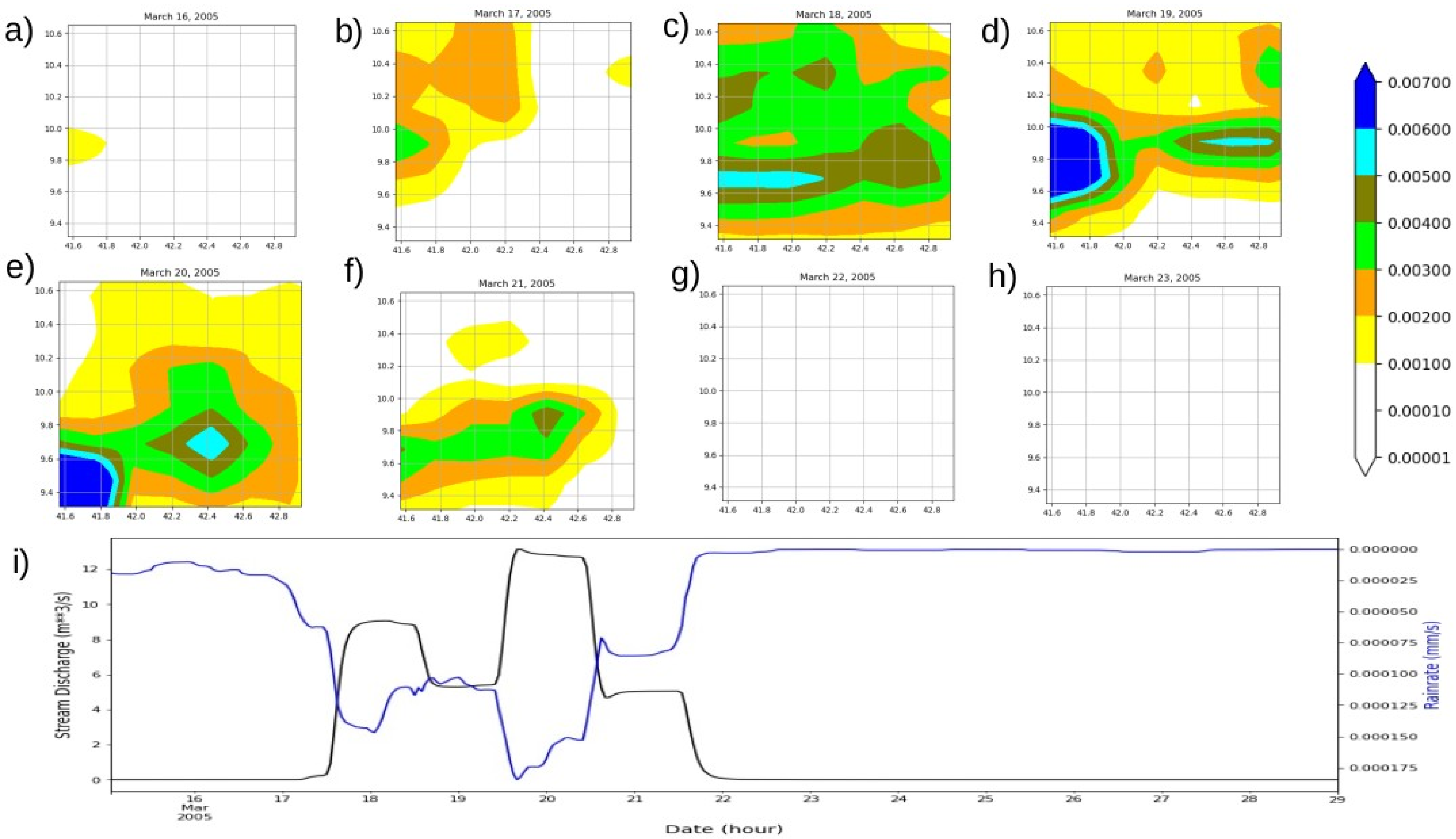


WRF-Hydro hourly stream discharge of default and calibrated parameters compared with the rainrate obtained from ERA5 data for the period of August 1-15, 2006



Daily simulated flow depth is compared with observed flow depth for the duration of August 1-15, 2006.

Case-study of March 2005
The simulation managed to reproduce the March 20, 2005 flood event.



Thank you!

Questions?