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Development of a grid-based version of the SWAT landscape model

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Central questions

Why grid-based modeling with SWAT?

How does the grid-based model work?

Does the model perform well?

- Model evaluation daily discharge
- Spatial output
- Existing problems

Introduction

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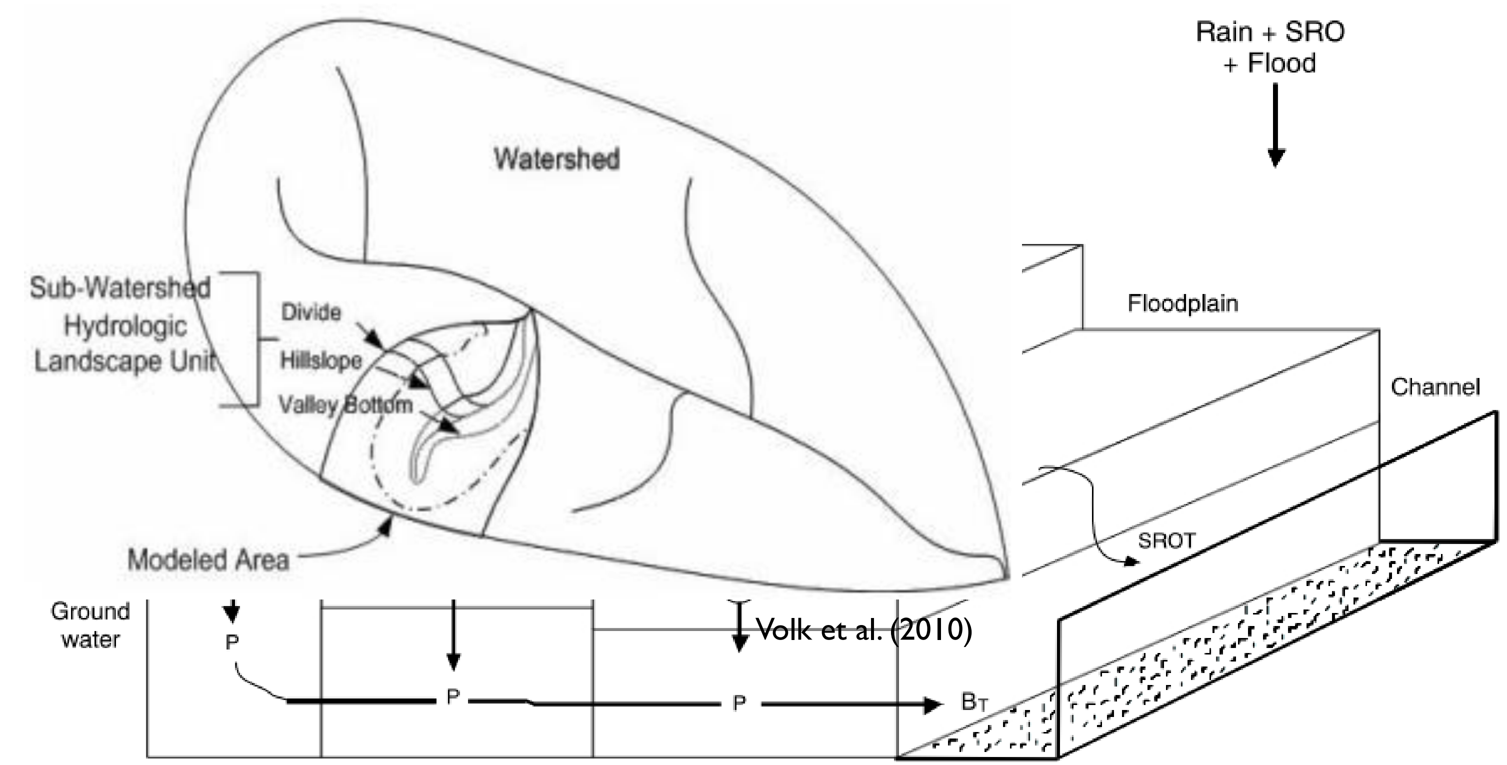
- Integrated river basin models should provide a spatially distributed representation of basin hydrology and transport processes
- HRU approach key weakness of the model
  - inability to model flow and transport from one landscape position to another prior to the entry into the stream
  - the impact of an upslope HRU on a downslope HRU cannot be assessed
- Fulfill the requirements of river basin models
  - developing routing capabilities between landscape units (Volk et al., 2007; Arnold et al., 2010)
  - developing a grid-based SWAT model setup (Rathjens and Oppelt, 2012)

SWAT landscape model



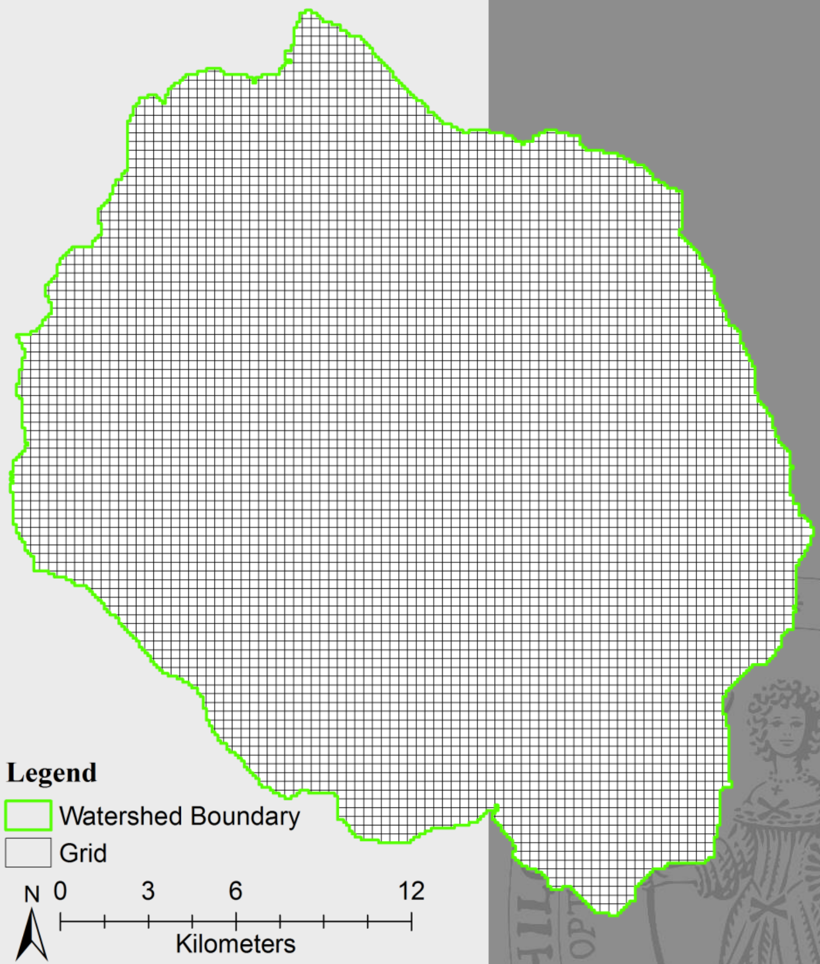
Volk et al. (2010)

Figure 4. Processes considered in landscape routing units.

Arnold et al. (2010)

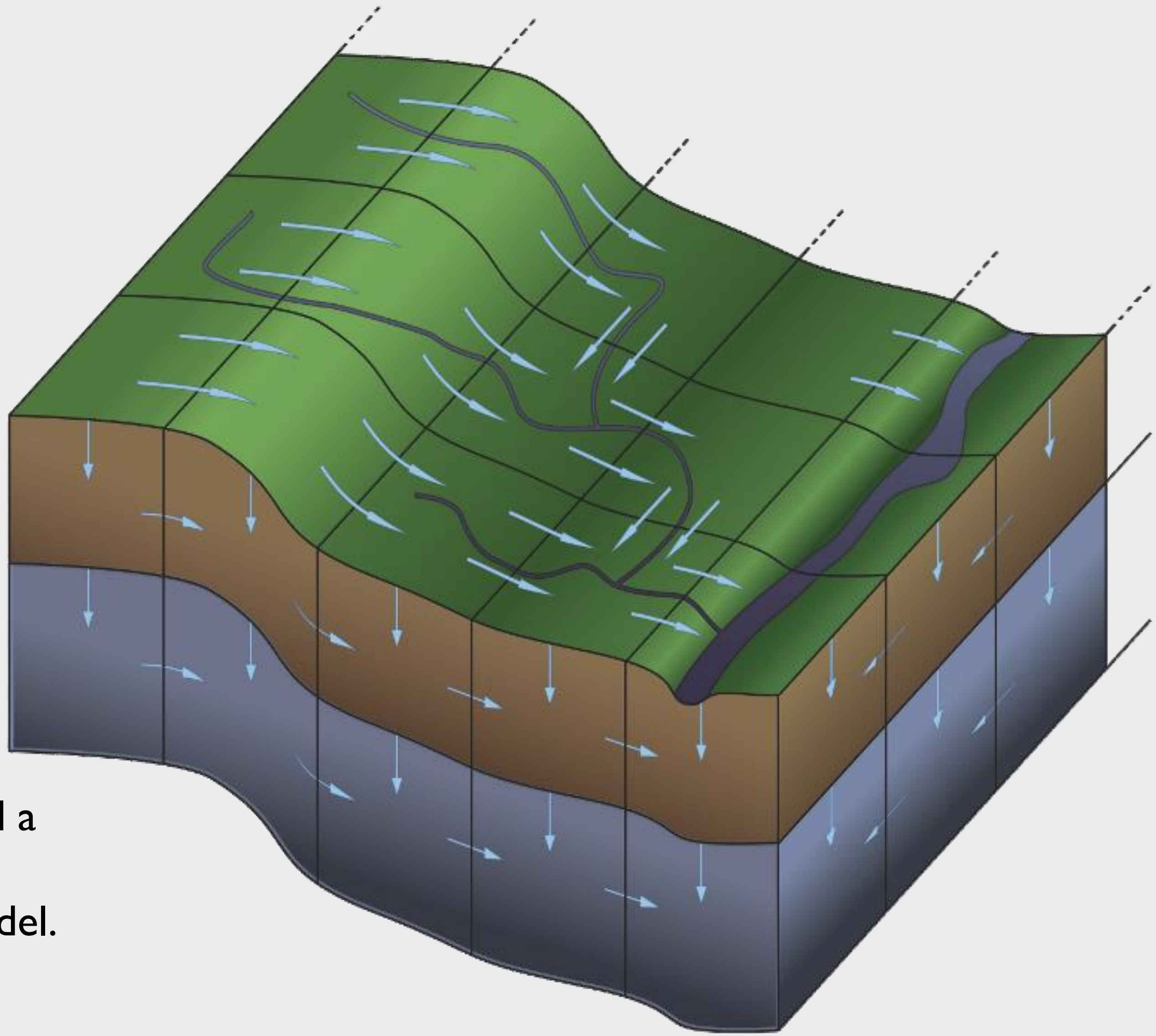
SWATgrid

- Interface for grid-based SWAT setups
- SWAT processes are calculated for each grid cell individually



Grid-based SWAT landscape model

- Channel flow
- Landscape flow
  - Surface runoff
  - Lateral flow
  - Shallow groundwater flow



The combination of the landscape routing model and a grid-based setup provides a spatially fully distributed model.

Grid-based SWAT landscape model

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- Link channel and landscape flow processes to the watershed-scale → spatial description
  - Topographic index

$$\lambda_i = \ln\left(\frac{A_i}{\tan(\beta_i) K_{sat\,i} Z_i}\right) \in \mathbb{R}_{\geq 0}, i = 1, \dots, n$$

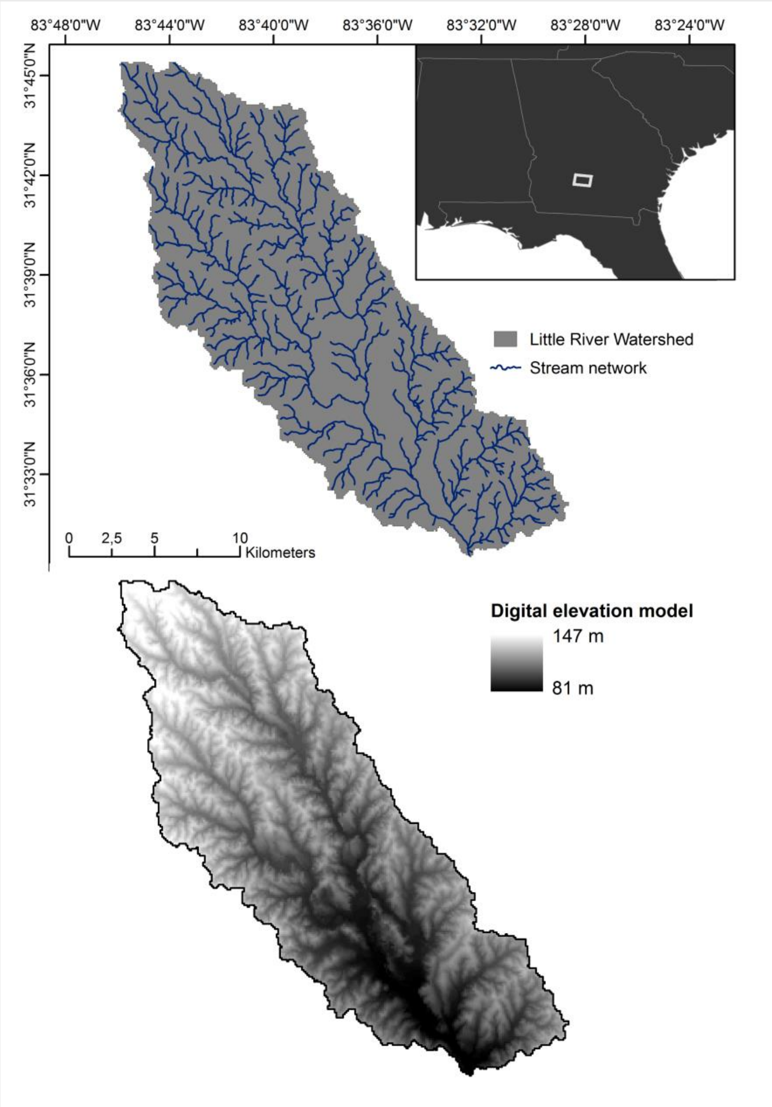
    - normalize
    - adjust to drainage density

Surface slope angle (β_i)
Soil depth (Z_i)
Saturated hydraulic conductivity $(K_{sat,i})$
Upslope contributing area (A_i)

No additional data is necessary!

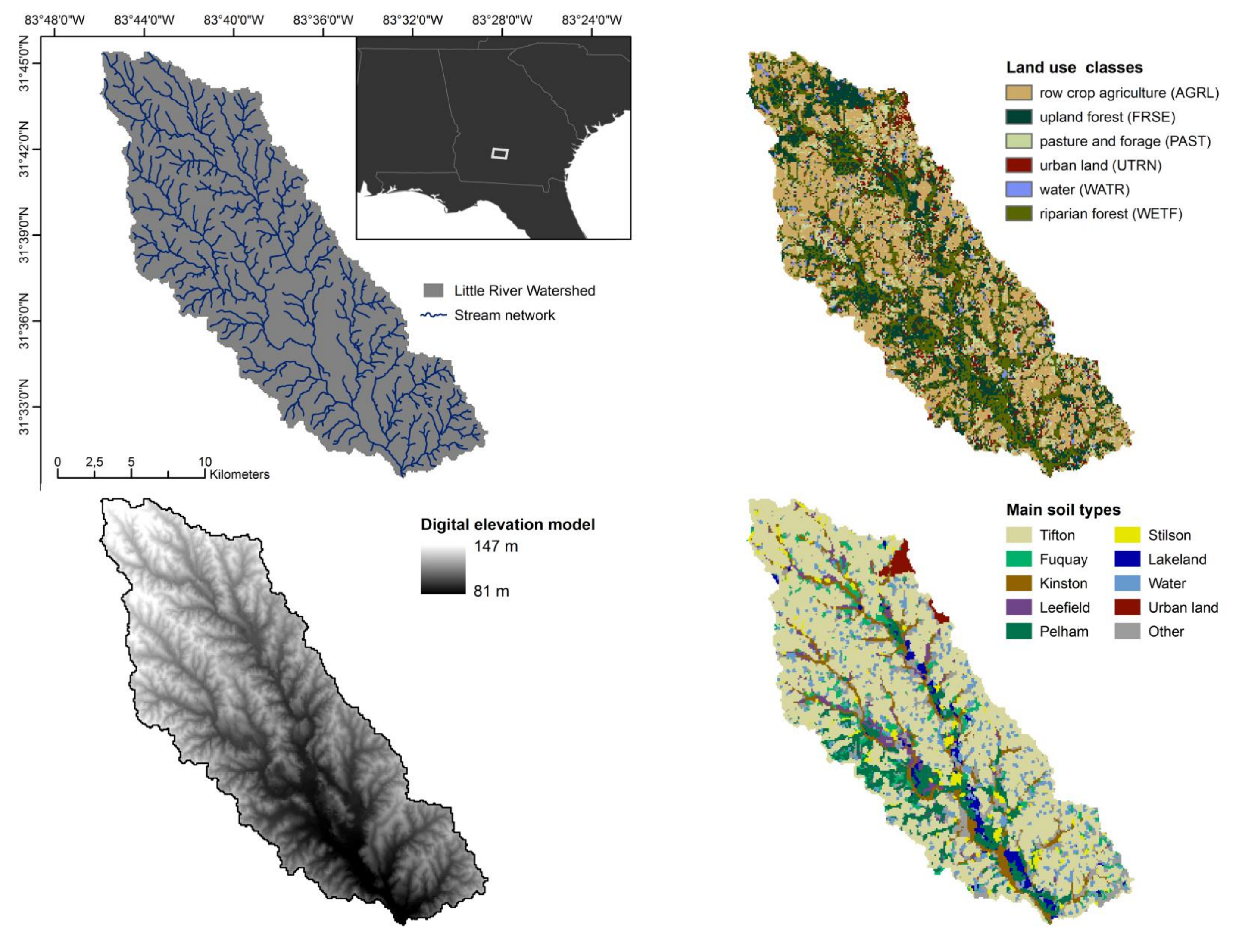
- Flow separation ratio

Study area: Little River Watershed

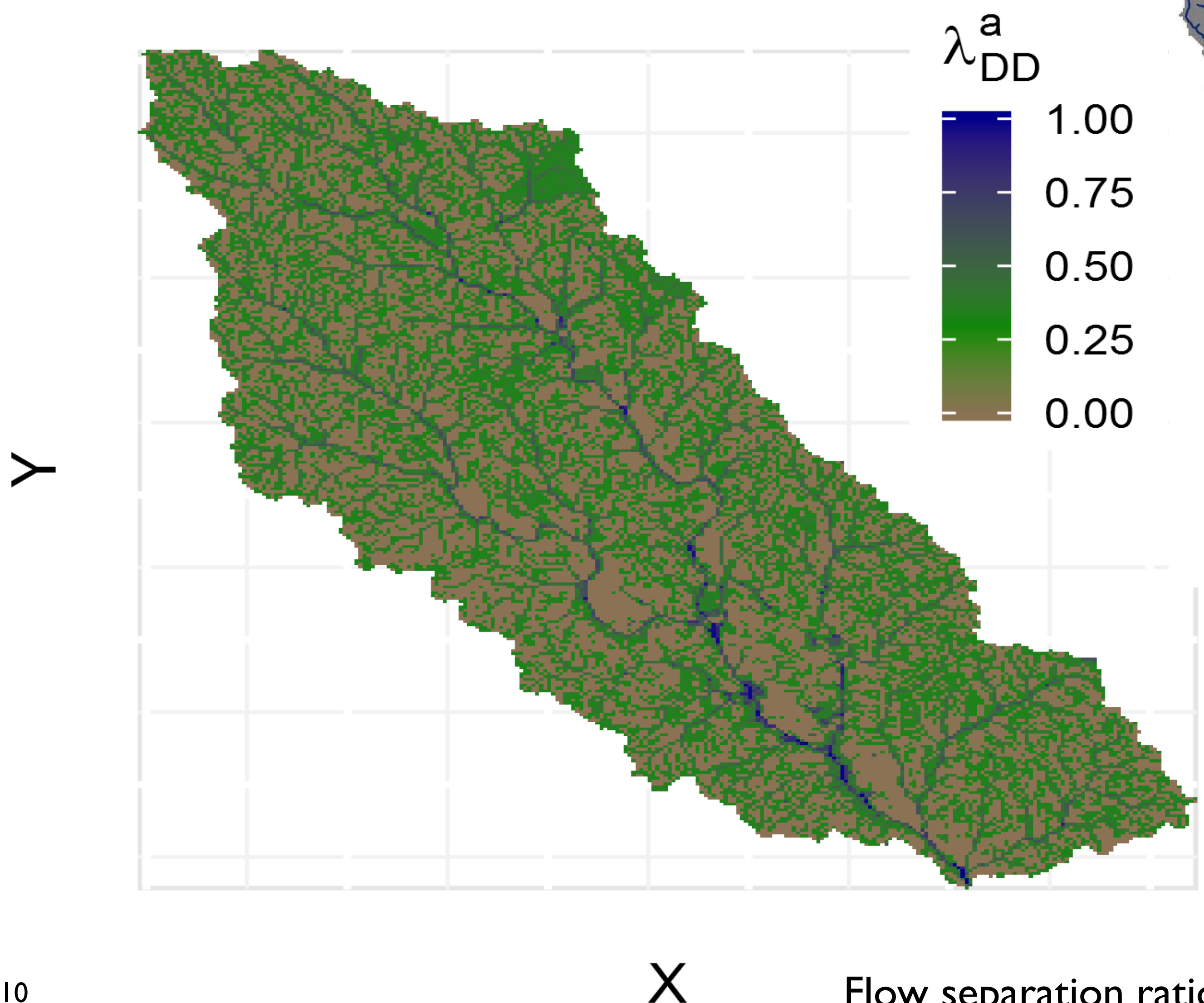


- 334 km², flat topography, gently sloping uplands, dense streamnetwork (1.54 km^{-1})
- Subtropical climate
  - Mean annual TMP 19°C
  - Mean annual PCP 1059 mm

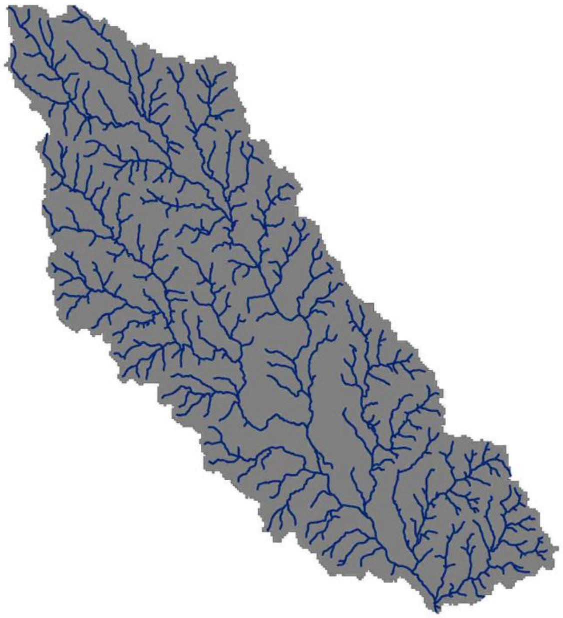
Study area: Little River Watershed



Flow separation ratio



Flow separation ratio



Mapped stream network

Stream flow

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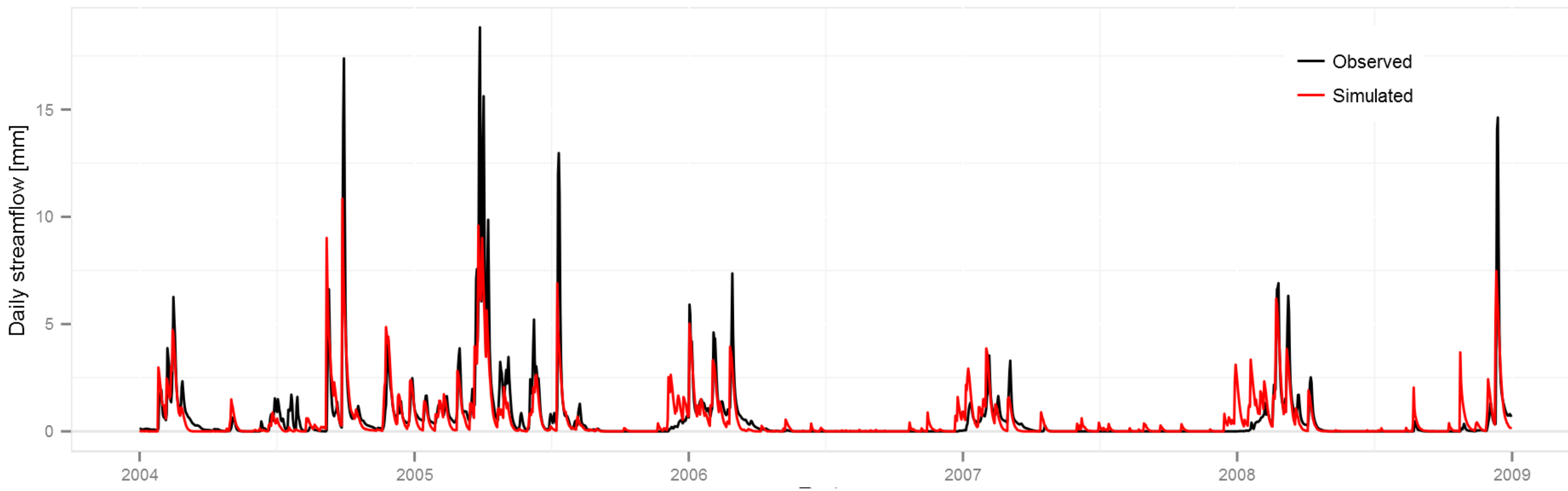

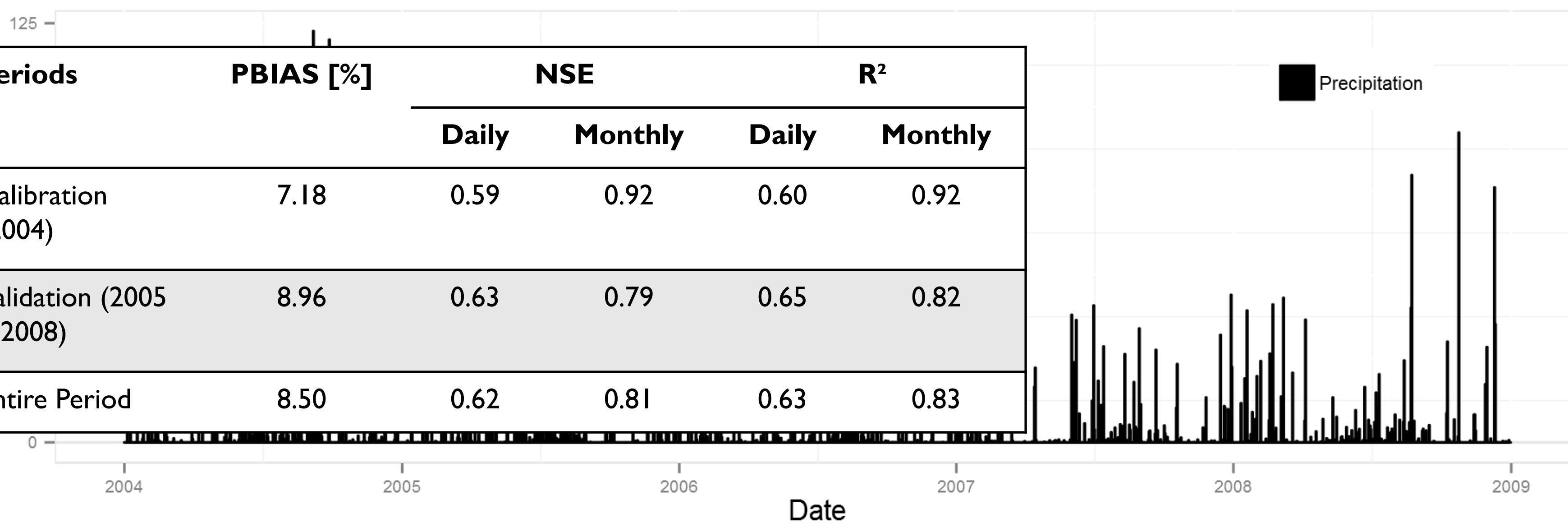

Periods	PBIAS [%]	NSE		R^2	
		Daily	Monthly	Daily	Monthly
Calibration (2004)	7.18	0.59	0.92	0.60	0.92
Validation (2005 – 2008)	8.96	0.63	0.79	0.65	0.82
Entire Period	8.50	0.62	0.81	0.63	0.83

Spatial results

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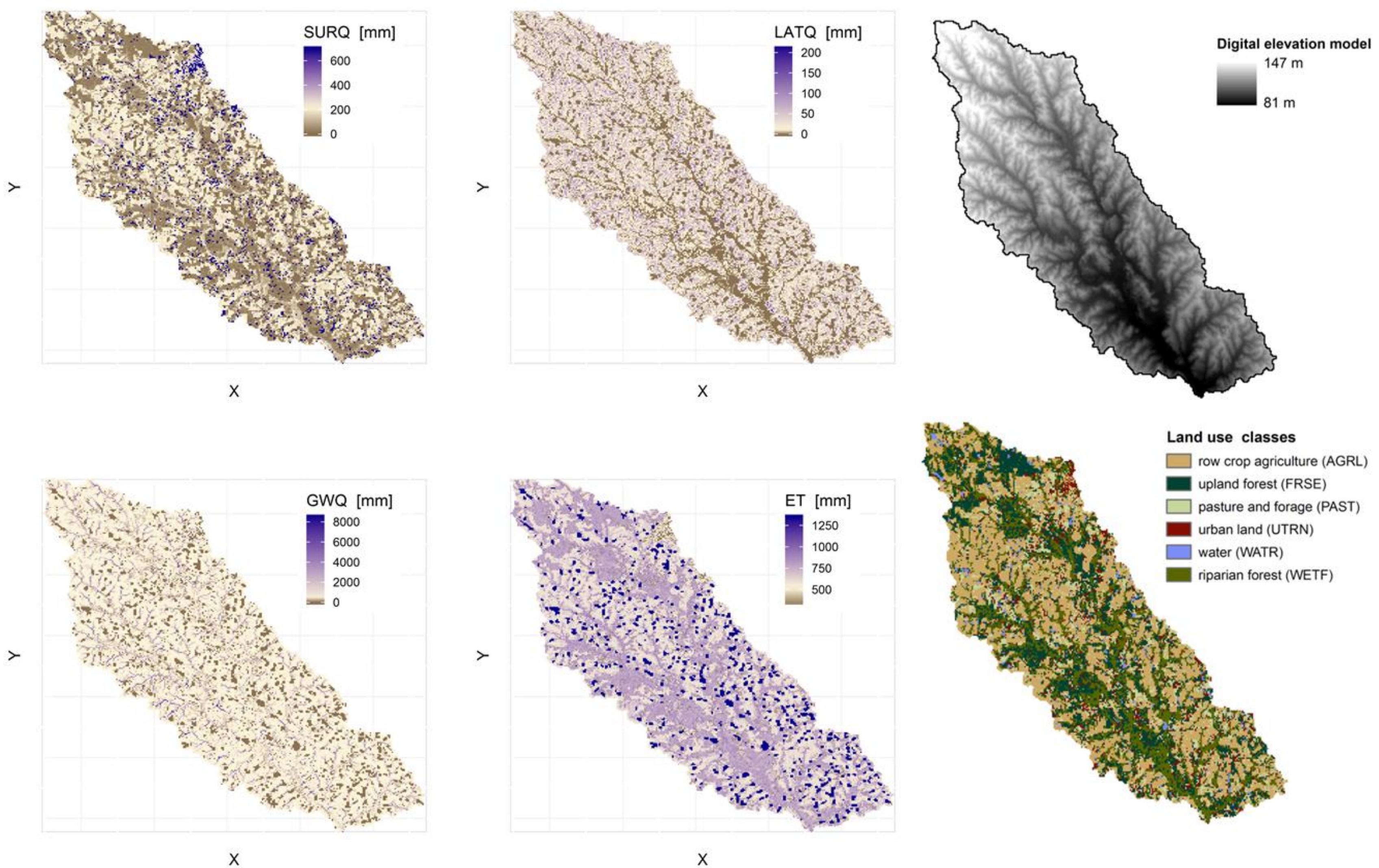

Conclusion

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Why grid-based modeling with SWAT?

- spatially fully distributed model
- spatial output

How does the grid-based model work?

- Combination of a grid-based setup and the SWAT landscape model
- Landscape and channel processes (flow separation ratio)

Does the model perform well?

- The results suggest that the grid-based landscape model performs satisfactory
  - Daily streamflow NSE > 0.59
  - Reasonably simulation of the impact of landscape positions on surface runoff, subsurface flow and evapotranspiration
- Problems and difficulties
  - Computation time (larger watersheds)
  - Requires high resolution input data
  - Uncertainties in flow separation ratio

Thanks for you attention!

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