Setting up SWAT for the Upper Amazon

Michael Strauch, Martin Volk

2014 International SWAT Conference
Porto de Galinhas, July 30 – August 1, 2014

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CENTRE FOR ENVIRONMENTAL RESEARCH – UFZ

ISI-MIP2

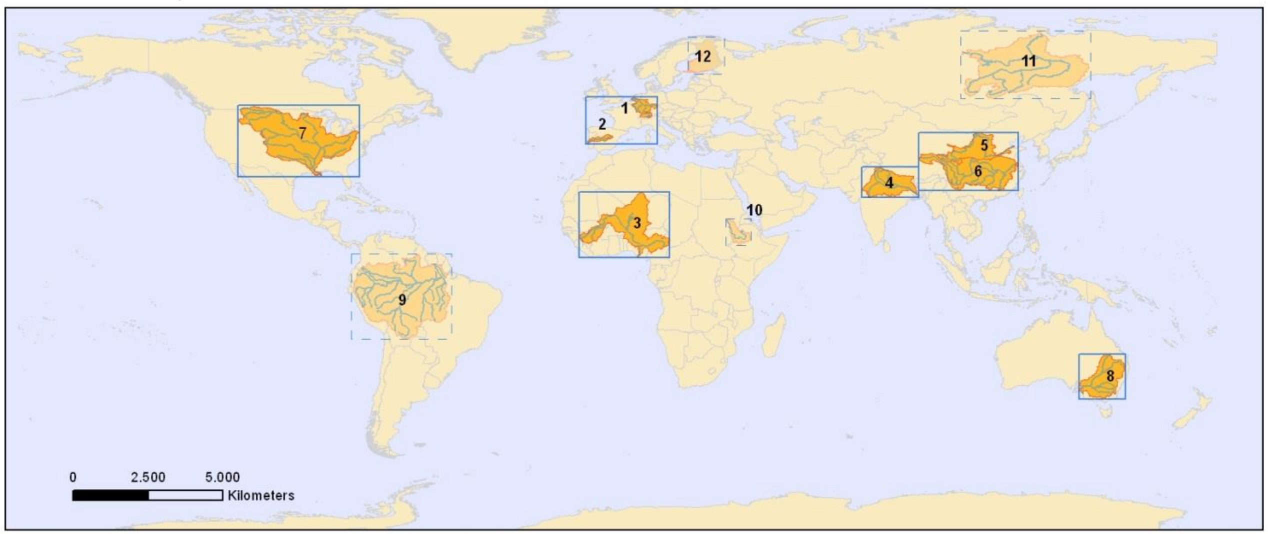
Inter-Sectoral Impact Model Integration and Intercomparison Project

- community-driven modelling effort
- bringing together impact models across sectors and scales
- to create consistent and comprehensive projections of the impacts of different levels of global warming

coordinated by

PIK

Focus regions



Europe	Africa	Asia	N.America	Australia	S.America
1. Rhine	3. Niger	4. Ganges	7. Mississippi	8. Murray Darling	9. Amazon
2. Tagus	10. Blue Nile	5. Yellow			
12. Finland		6. Yangtze			
		11. Lena			

ISI-MIP Framework:

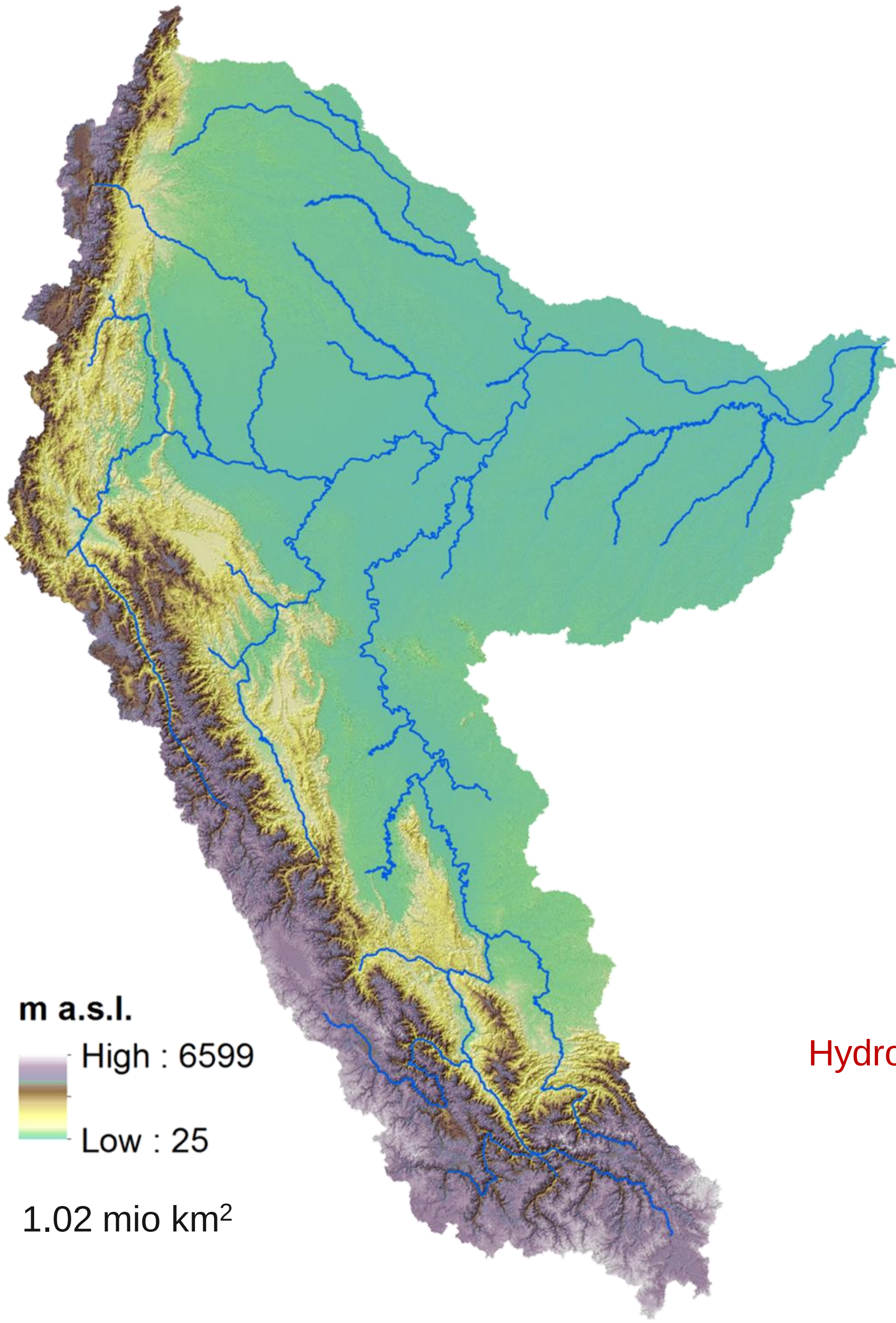
Common set of input data

Common modelling protocol

Central output data archive

SWAT Soil & Water Assessment Tool

Input data	Data source
DEM	HydroSHEDS (SRTM, 90 m, hydrol. conditioned, Lehner et al. 2008)
Soil	Harmonized World Soil Database, Version 1.2, SOL_K calc. using ROSETTA (Schaap et al., 2001)
Land use	GLC2000 product South America (Eva et al., 2002)
Climate	WFD ERA 40 (Weedon et al., 2010)
Calibration/validation	Global Runoff Data Centre (GRDC), Hidroweb (http://hidroweb.ana.gov.br/)

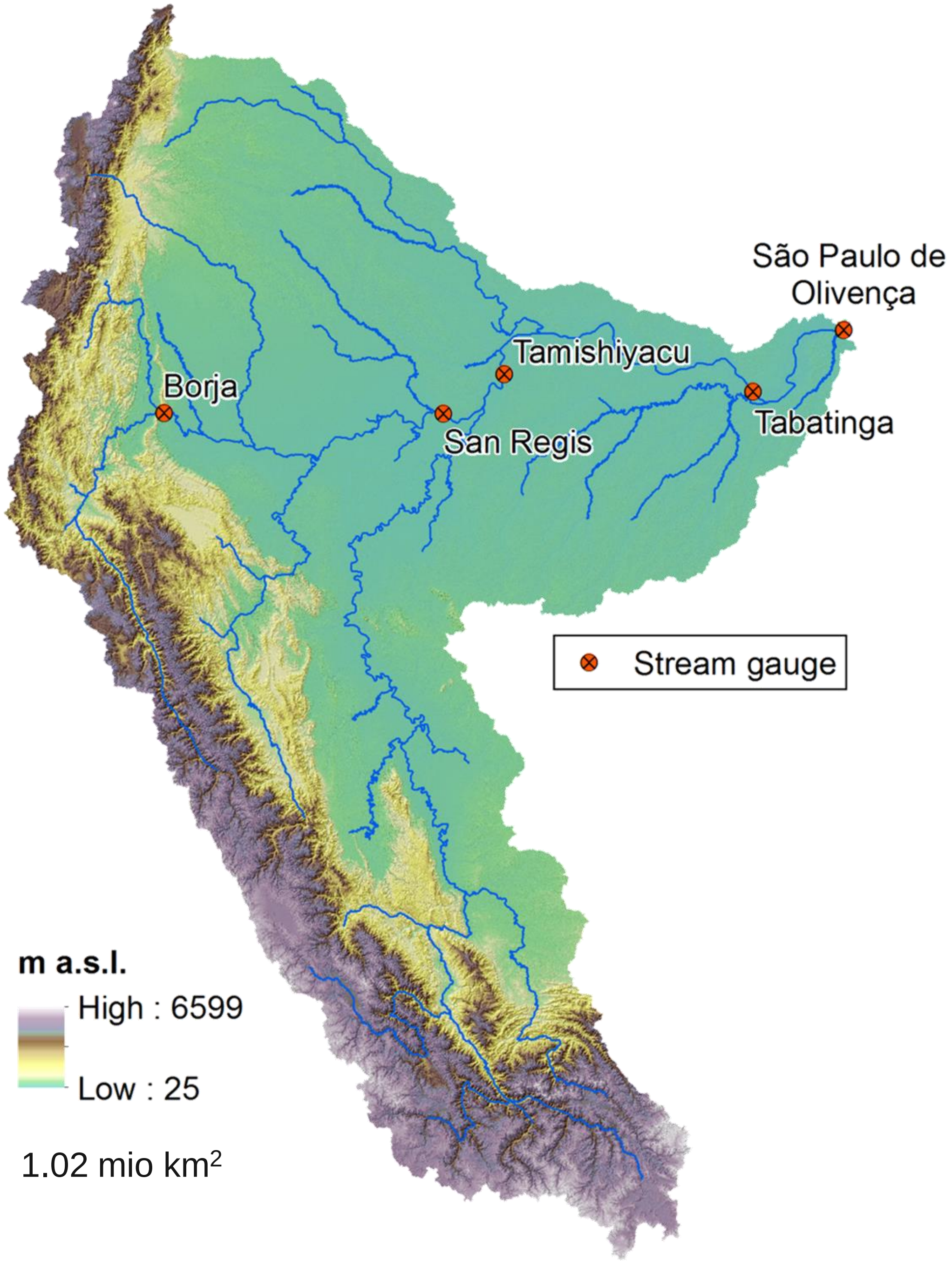


Digital Elevation Model

SRTM 90 m,
hydrologically conditioned

Hydrological data and maps based on SHuttle Elevation Derivatives at multiple Scales (Lehner et al., 2008)

WWF HydroSHEDS

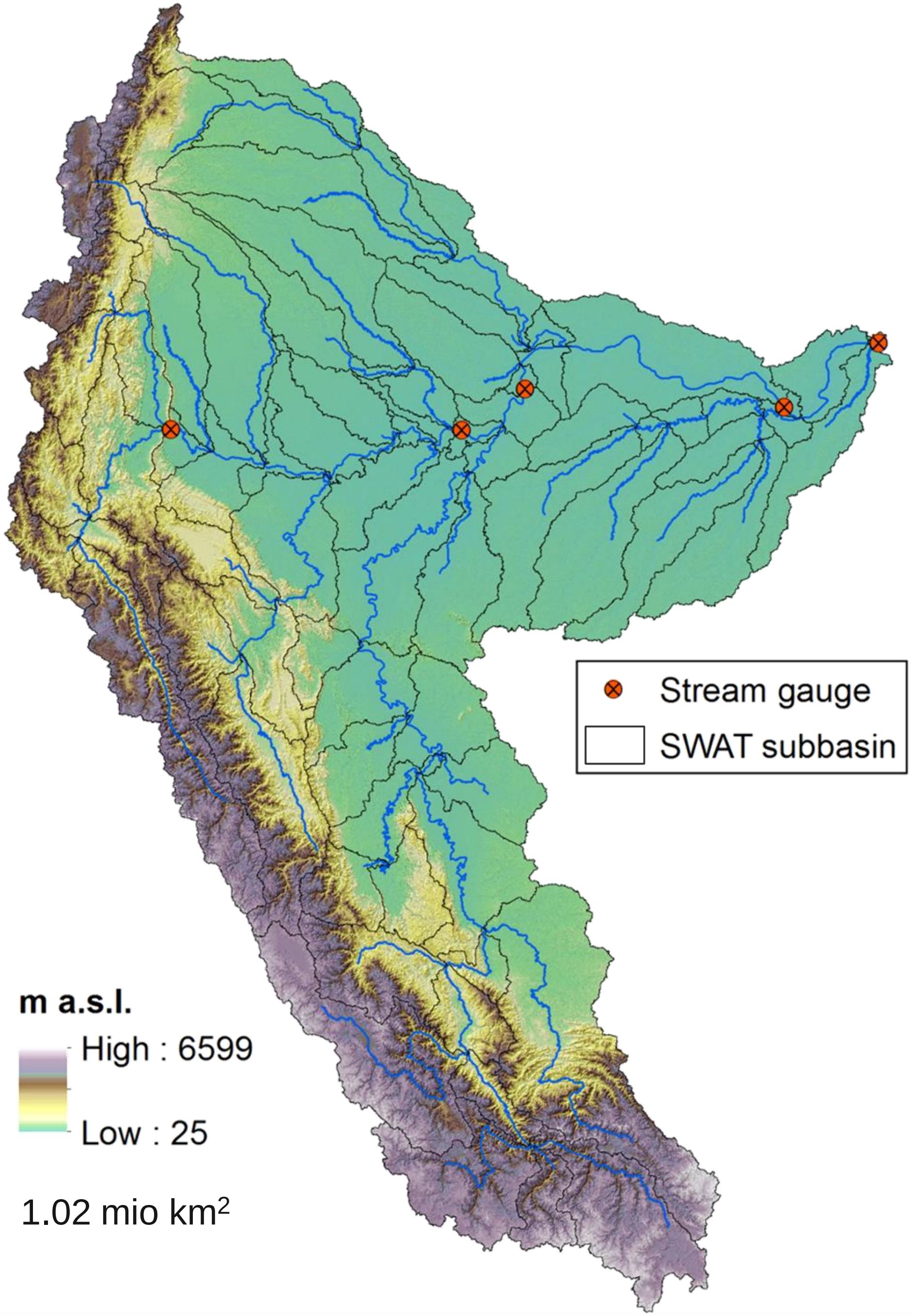


Streamflow data

Global Runoff Data Centre

GRDC

ANA
AGENCIA NACIONAL DE AGUAS
HidroWeb
Sistema de Informações Hidrológicas

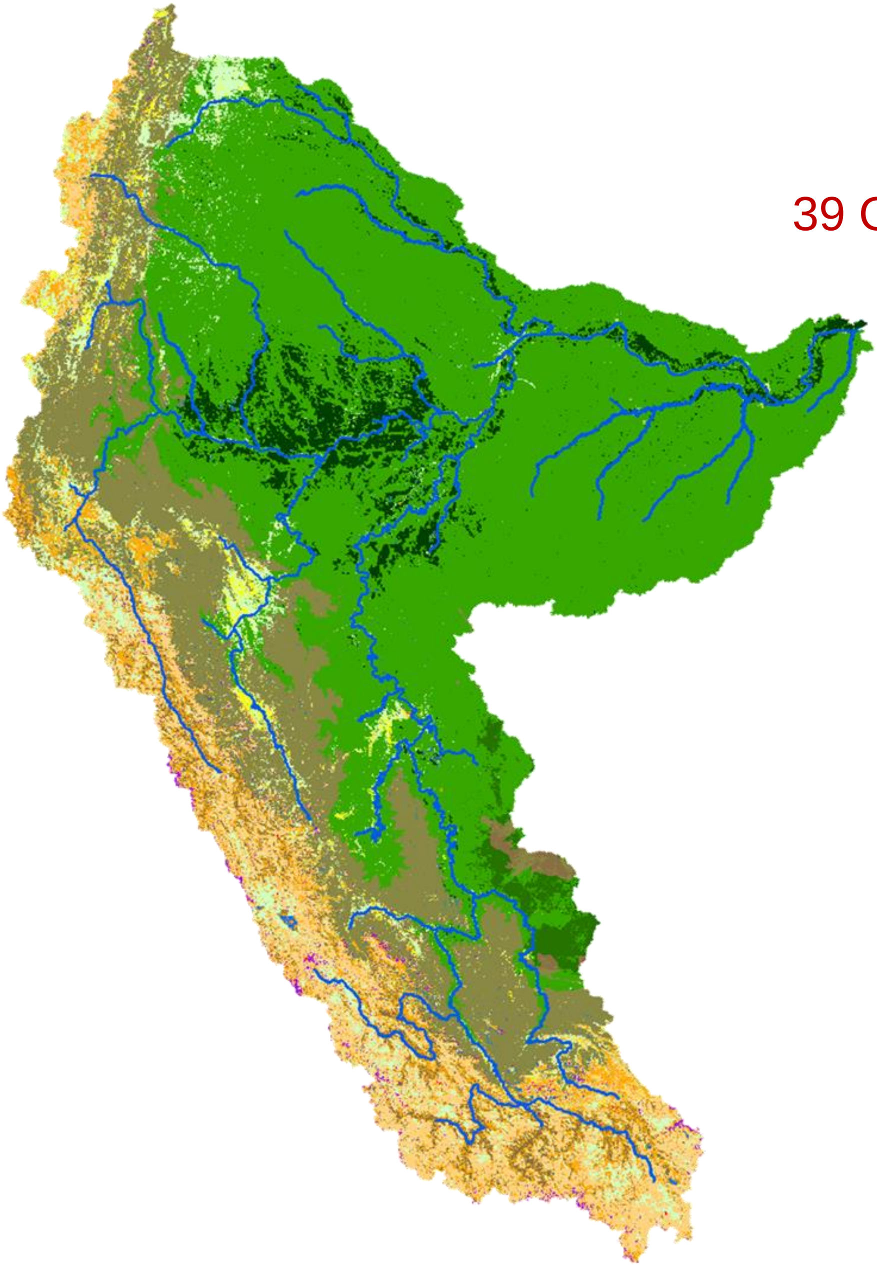


Subbasin delineation

Based on suggested minimum size: 719,600 ha

⇒ 82 subbasins (Ø 12,500 km²)

⇒ too large for physically meaningful Muskingum routing???

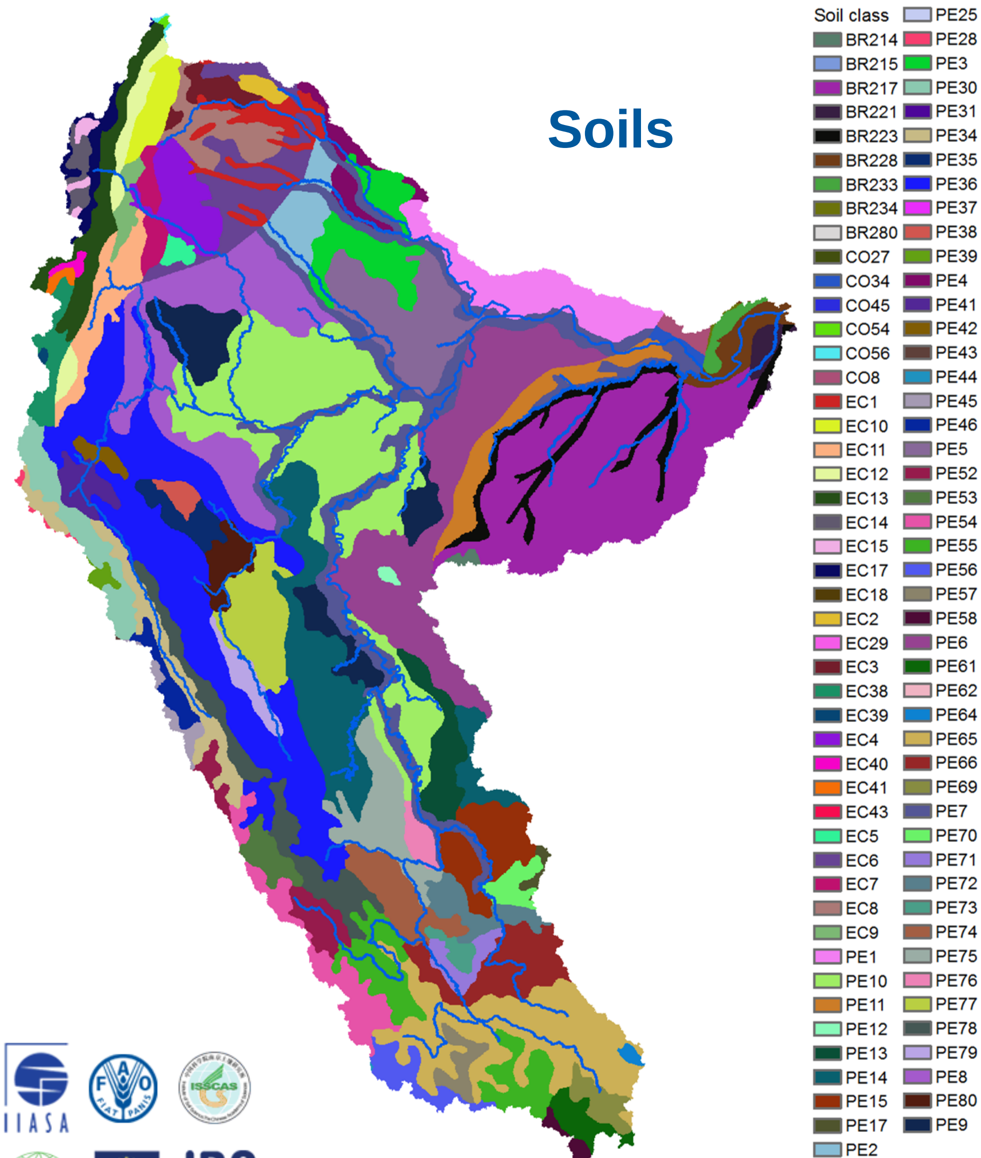


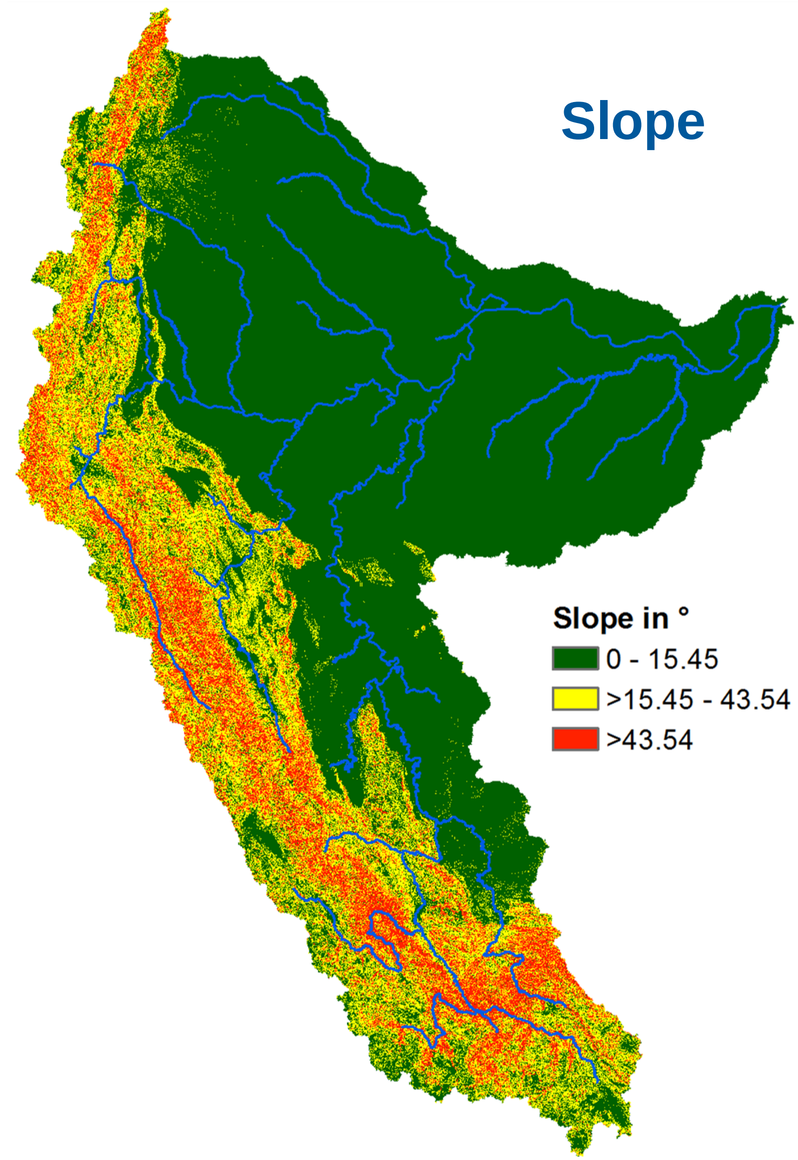
Land use

39 GLC classes aggregated to 16 SWAT classes

- AGRL - Agriculture - intensive
- PAST - Mosaic agriculture / degraded vegetation
- BARR - Barren / bare soil; Desert; Permanent snow/ice
- FRSD - Deciduous forest
- FRSE - Evergreen tropical forest
- FRST - Bamboo dominated and semi-deciduous forest
- FSDM - Montane deciduous forests (>500m)
- FSEM - Montane evergreen forests (>500m)
- FSTM - Montane bamboo / semi-deciduous (>500m)
- RNGB - Shrub savannah and shrublands
- RNGE - Steppe and montane grasslands
- URLD - Urban
- WATR - Water bodies
- WETF - Flooded / permament swamp forest
- WETL - Periodically flooded savannah
- WTFM - Montane flooded forests (>500m)

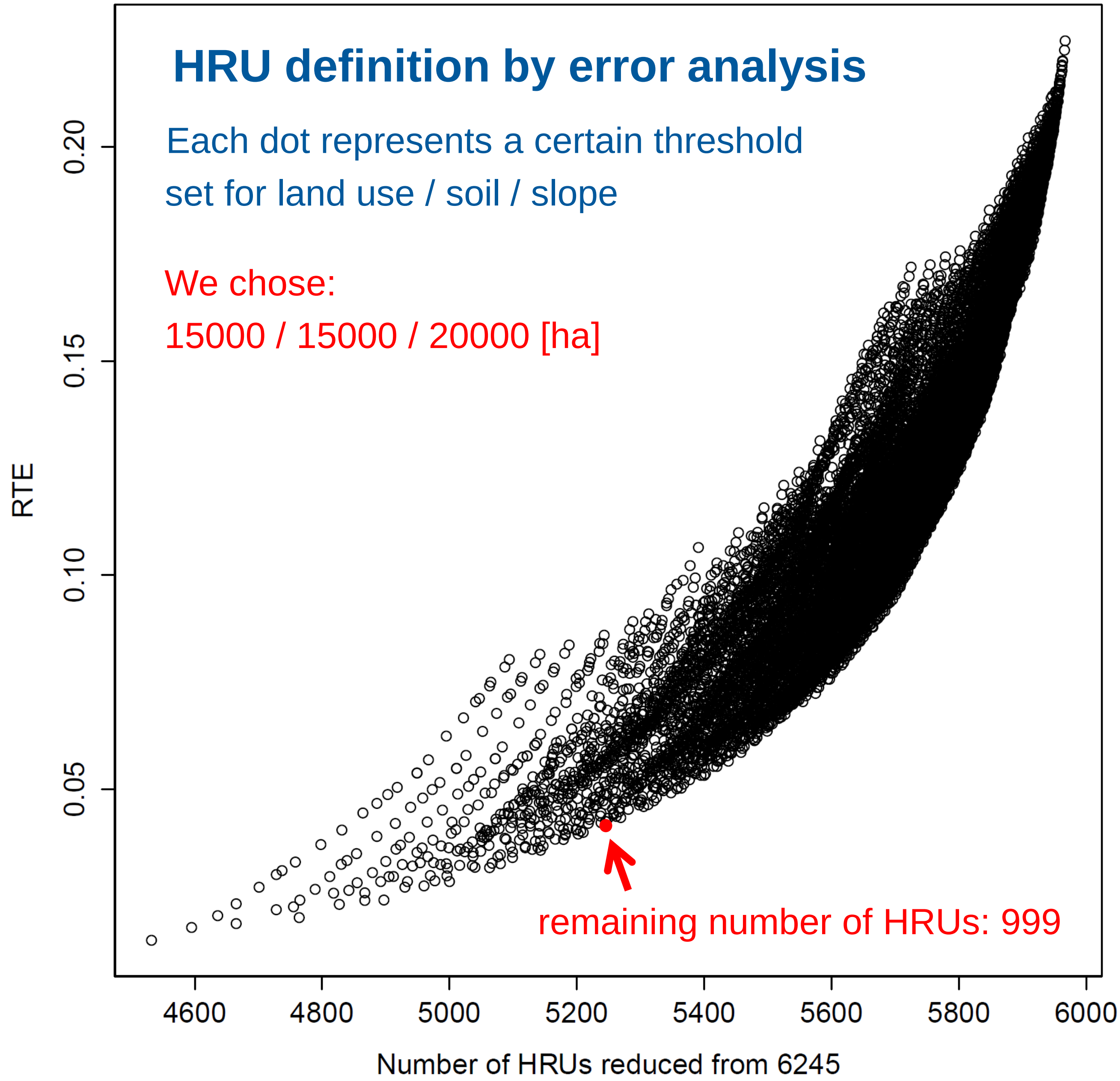
Global Land Cover 2000 product South America (Eva et al., 2002)



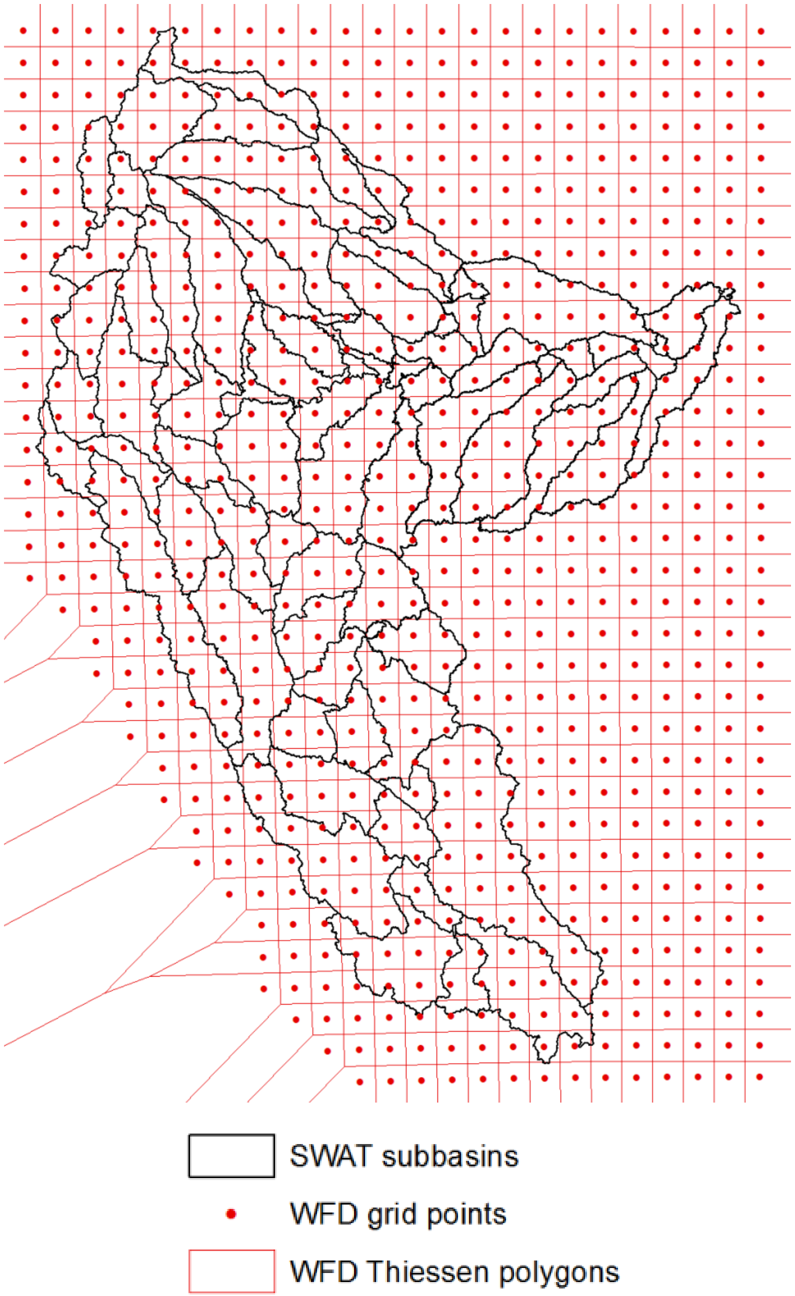


Harmonized World Soil Database, Version 1.2

HRU definition by error analysis



RTE:
Relative Total Error
(of land use, soil, and slope distribution compared to full HRU map)



Weather data

WFD – WATCH Forcing Data (Basis ERA 40), daily for time period 1/1/1958 – 31/12/2001

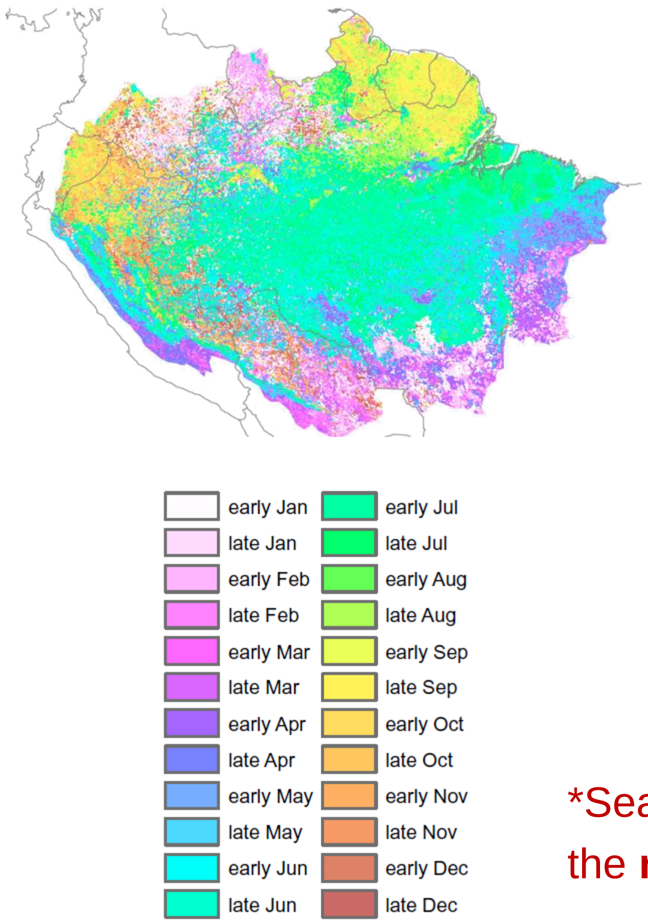
- Temperature (max, min in K)
- Precipitation (in kg/m²/s)
- Wind speed (in m/s)
- Solar radiation (in W/m²)
- Specific humidity (in kg/kg)
- Surface pressure (in Pa)

Weedon et al. (2010)

Model calibration: Plant growth

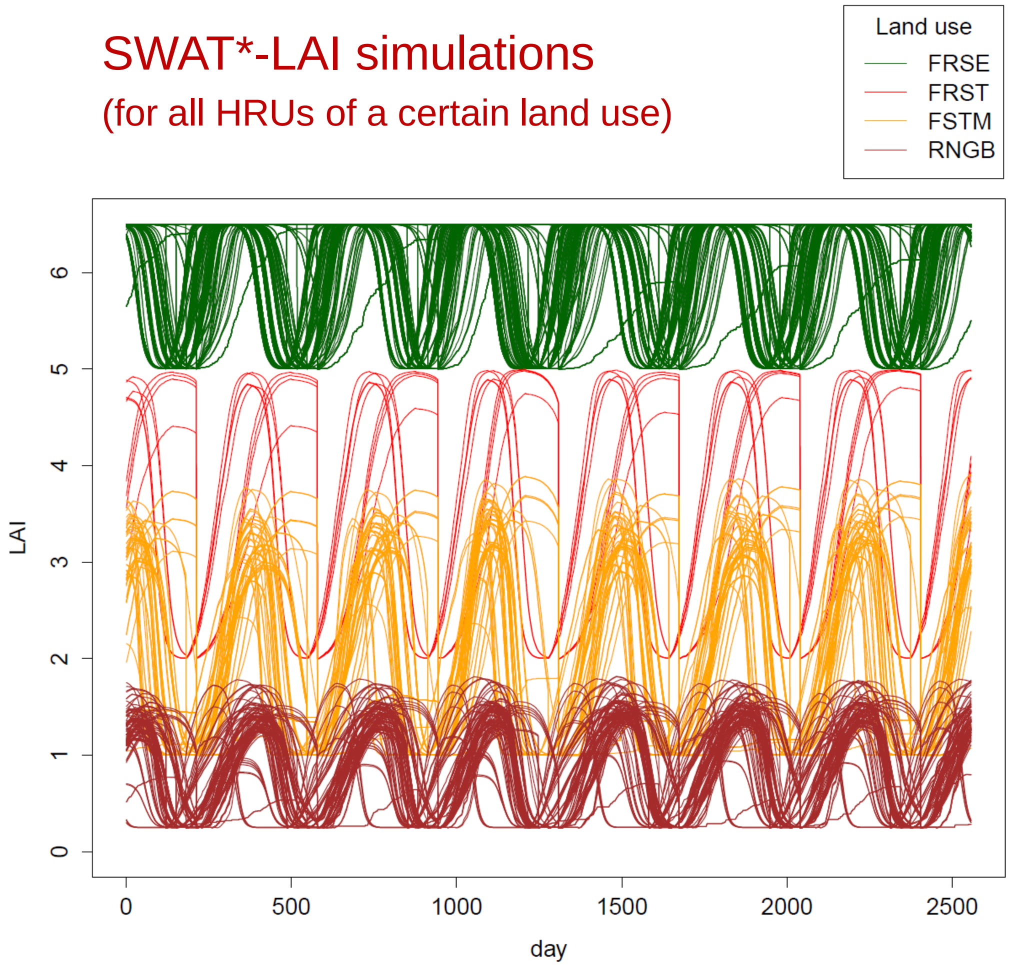
Time of NDVI peaks

(Brando et al., 2010)



SWAT*-LAI simulations

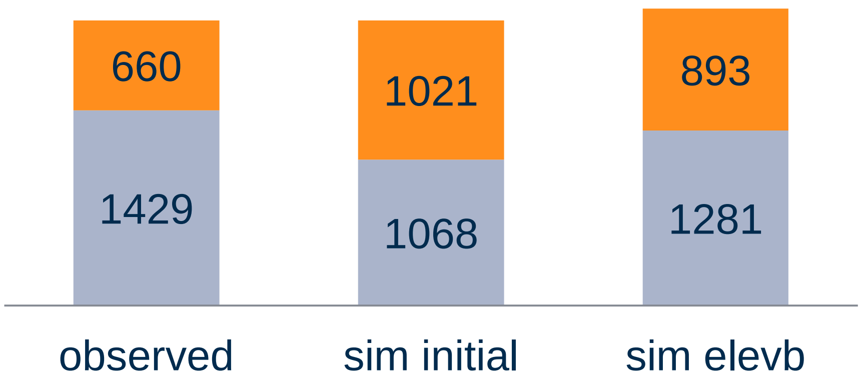
(for all HRUs of a certain land use)



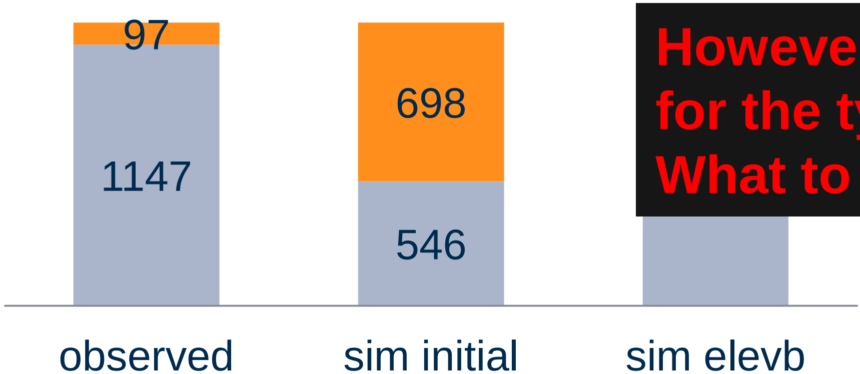
*Seasonal pattern depending on latitude & soil moisture using the **modified SWAT version for tropics**! (Strauch & Volk, 2013)

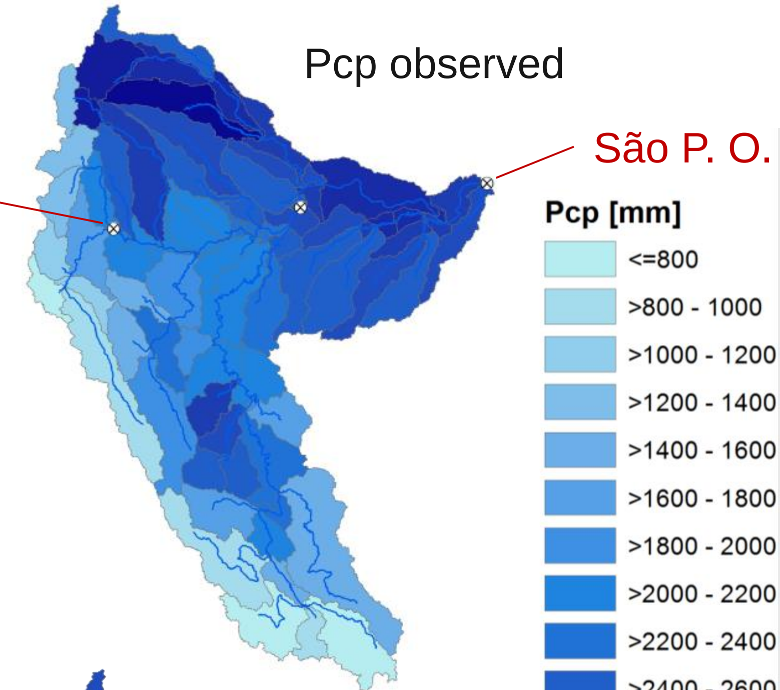
Model calibration: Water balance
(1986-1994)

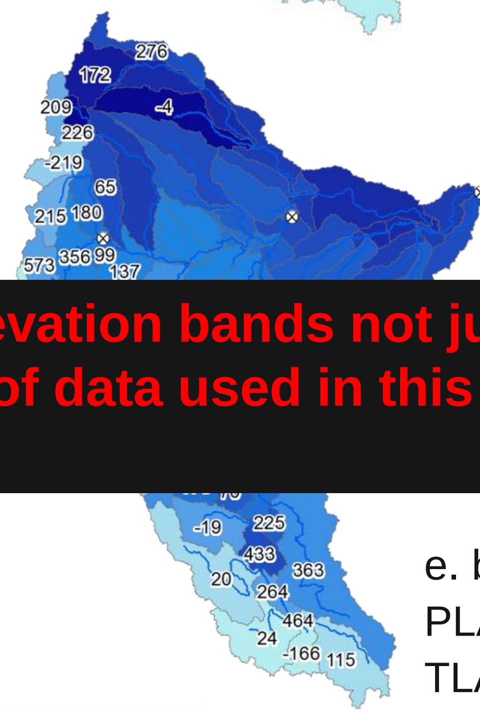
São Paulo de Olivença



Borja





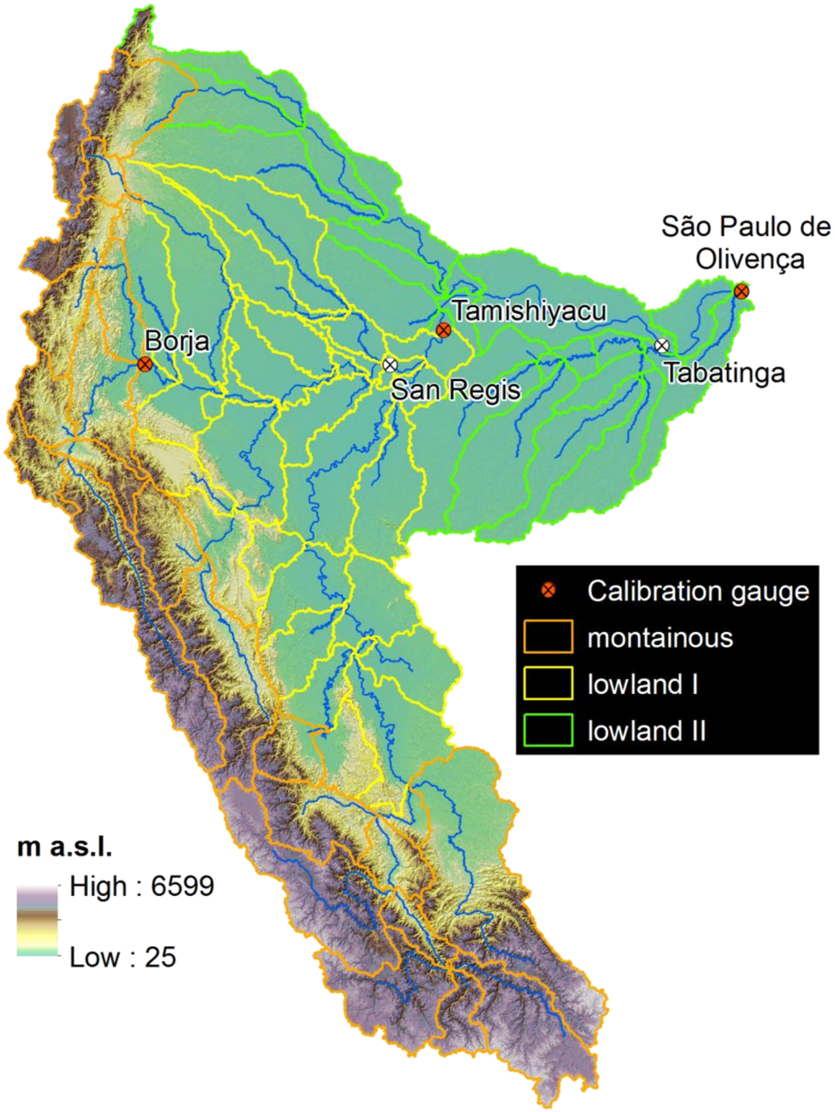


However, elevation bands not justified for the type of data used in this study. What to do?

e. b. from DEM
PLAPS: 500 mm/km
TLAPS: -8 °C/km

Model calibration

Multi-site autocalibration



- **Latin-Hypercube** sampling (n=3000)
- **32 parameters** (5 basin wide + 8 + 11 + 7 regional parameters)
- Best solution defined by **minimum rank sum of 11 performance metrics** over all three calibration gauges
- **Uncertainty interval** (UI) by considering as many (sorted) solutions as necessary that: $\mathbf{width_{UI} = \sigma_{obs}}$

Model evaluation

Rank sum of 11 performance metrics over three gauges

PBIAS	Percent Bias
NSE	Nash-Sutcliff Efficiency
mNSE	Modified Nash-Sutcliff Efficiency
rNSE	Relative Nash-Sutcliff Efficiency
d	Index of Agreement
md	Modified Index of Agreement
rd	Relative Index of Agreement
cp	Persistence Index
bR2	R^2 multiplied by coefficient of regression line between sim and obs
KGE	Kling-Gupta Efficiency
VE	Volumetric Efficiency

Borja

NSE = 0.52

PBIAS = 3.5%

d-factor = 1.11

POC = 61%

Tamishiyacu

NSE = 0.63

PBIAS = -4.8%

d-factor = 1.01

POC = 59%

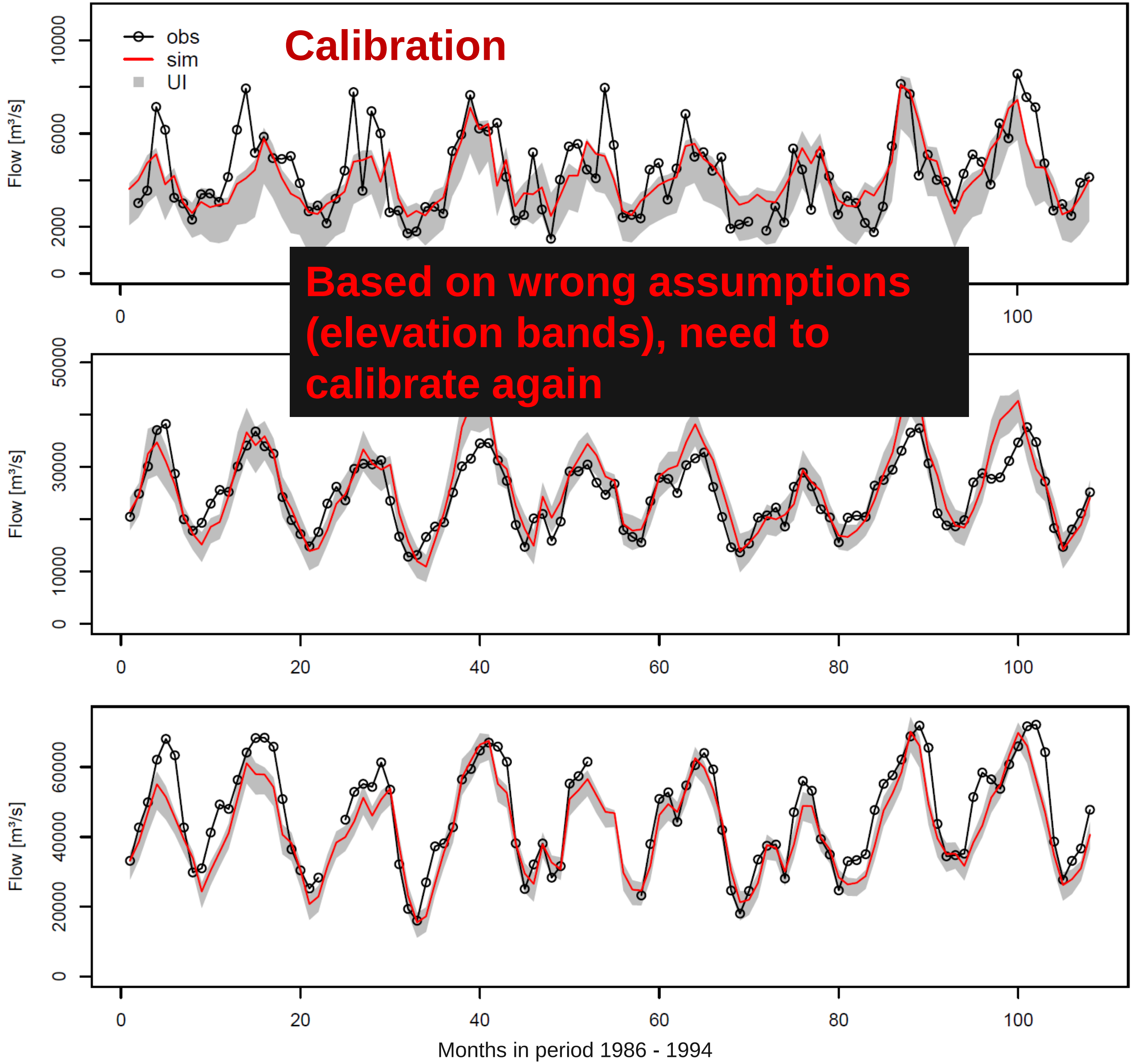
São Paulo de O.

NSE = 0.78

PBIAS = 8.8%

d-factor = 0.51

POC = 43%



Based on wrong assumptions (elevation bands), need to calibrate again

Borja

NSE = 0.65

PBIAS = -3.5%

Tamishiyacu

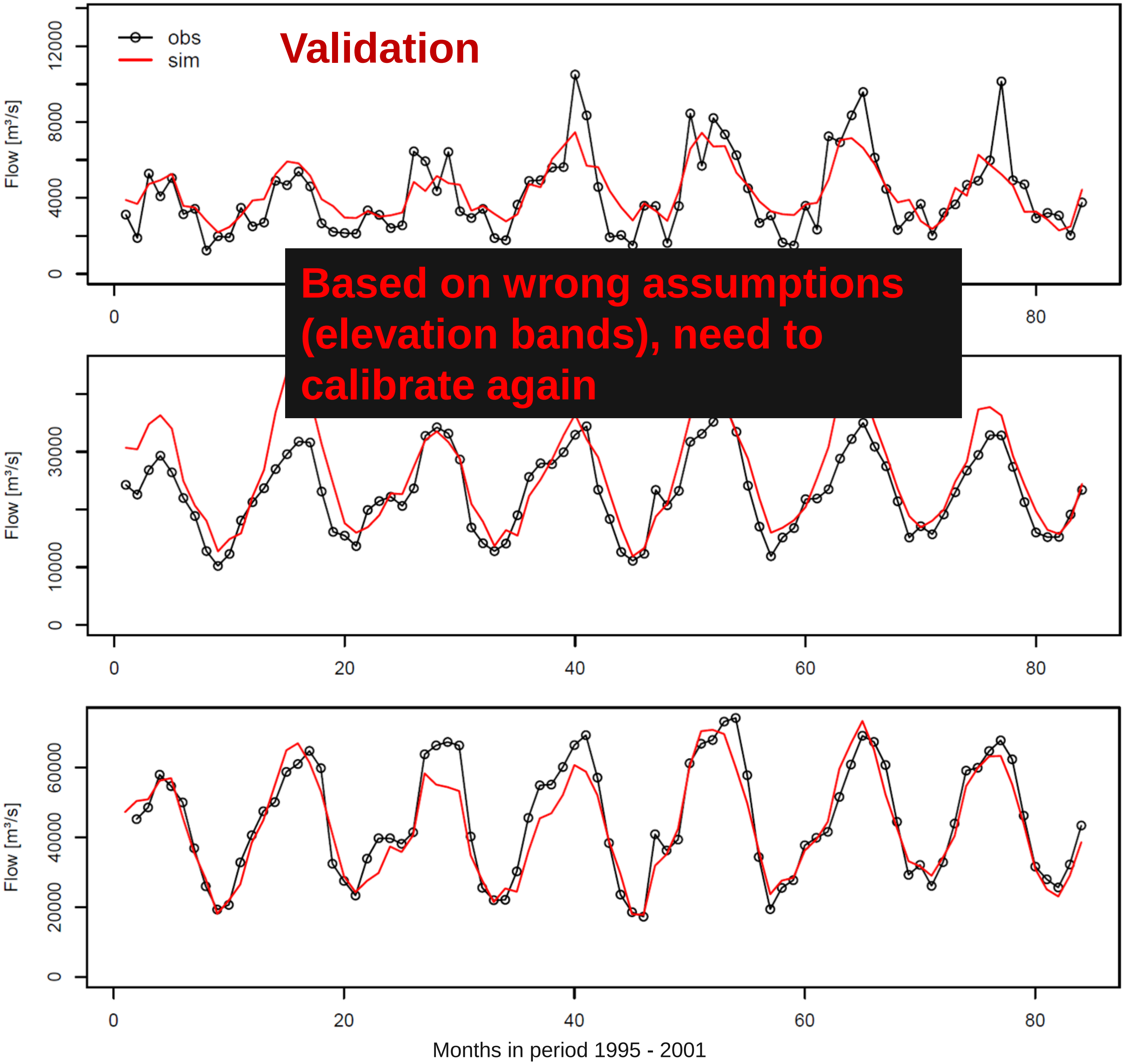
NSE = 0.51

PBIAS = -13.5%

São Paulo de O.

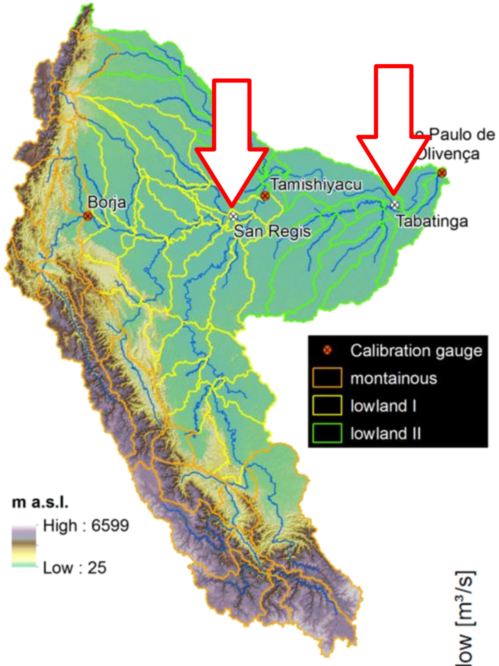
NSE = 0.89

PBIAS = 4%



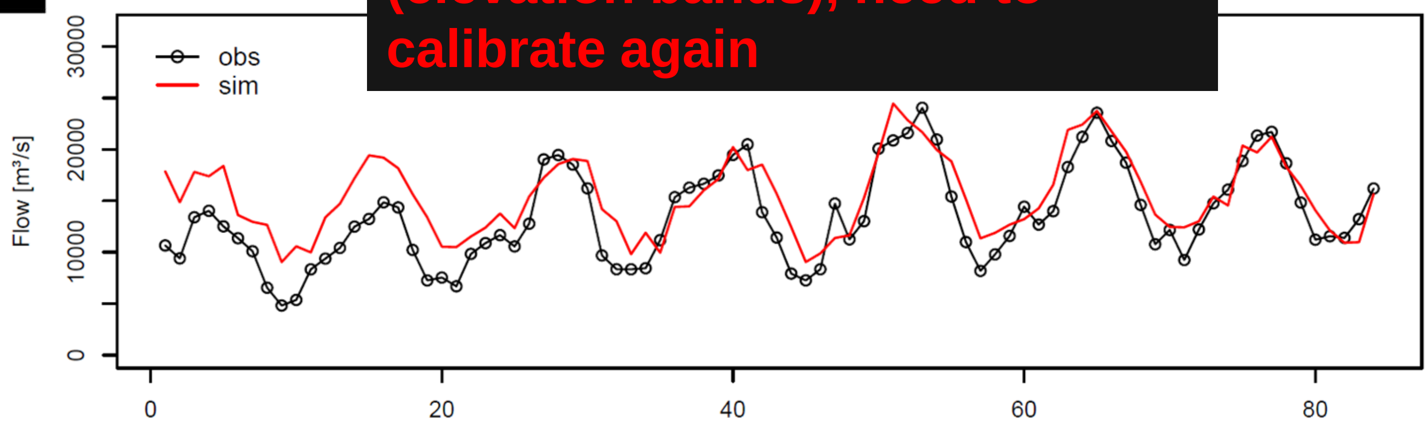
Cross Validation

(at gauges not used for calibration)



San Regis

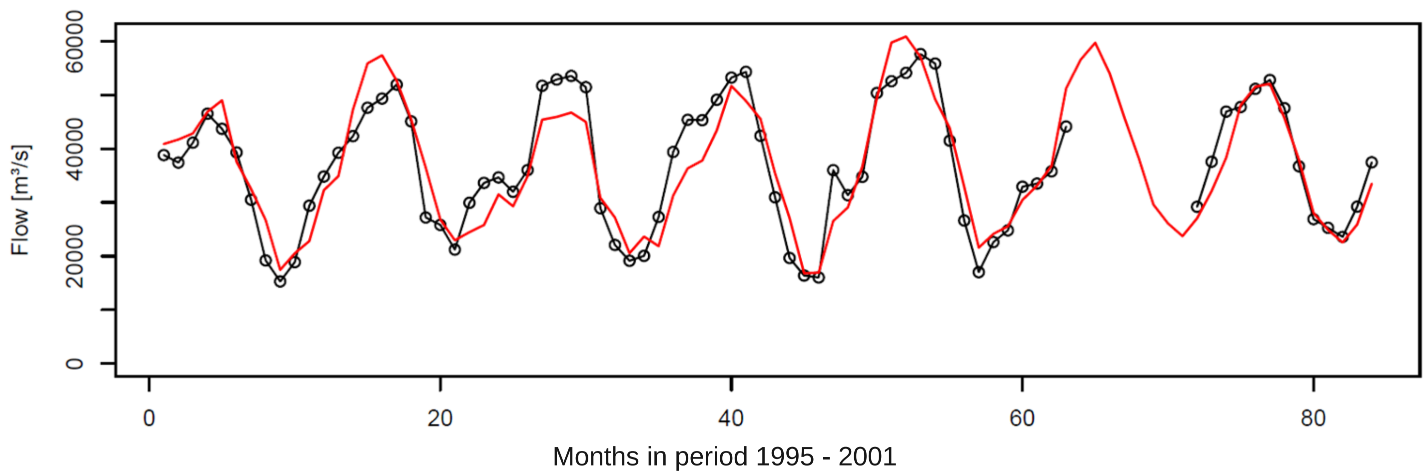
Based on wrong assumptions (elevation bands), need to calibrate again



Tabatinga

NSE = 0.84

PBIAS = 0.8%

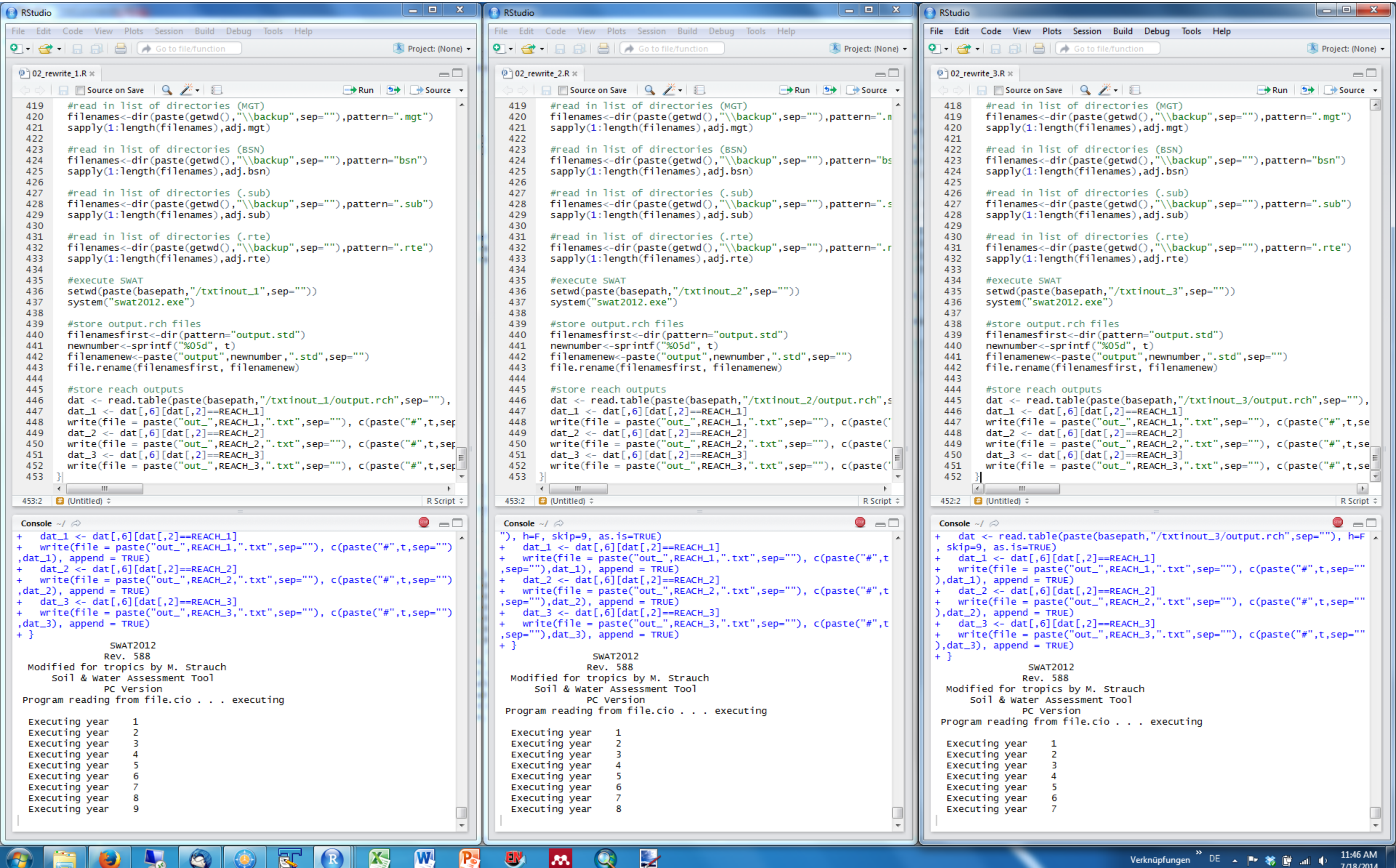


Summary / conclusion

- **Ready-to-use global datasets** for fast model setup **available**
- **However, many tricky issues**:
  - Maximum area of subbasins in large-scale applications?
  - Assigning tropical vegetation types to SWAT land use classes
  - Plant growth seasonal pattern (modified version useful!)
  - Abnormal water balance according observations
  - Elevation bands significantly improved model performance but are not justified when using grid data averaged over subbasins
- **Multi-site autocalibration** and **multi-metrics model evaluation** to provide robust calibration results and uncertainty intervals


Muito obrigado!
ORDEM E PROGRESSO
BRB

Additional slides…



Autocalibration using R

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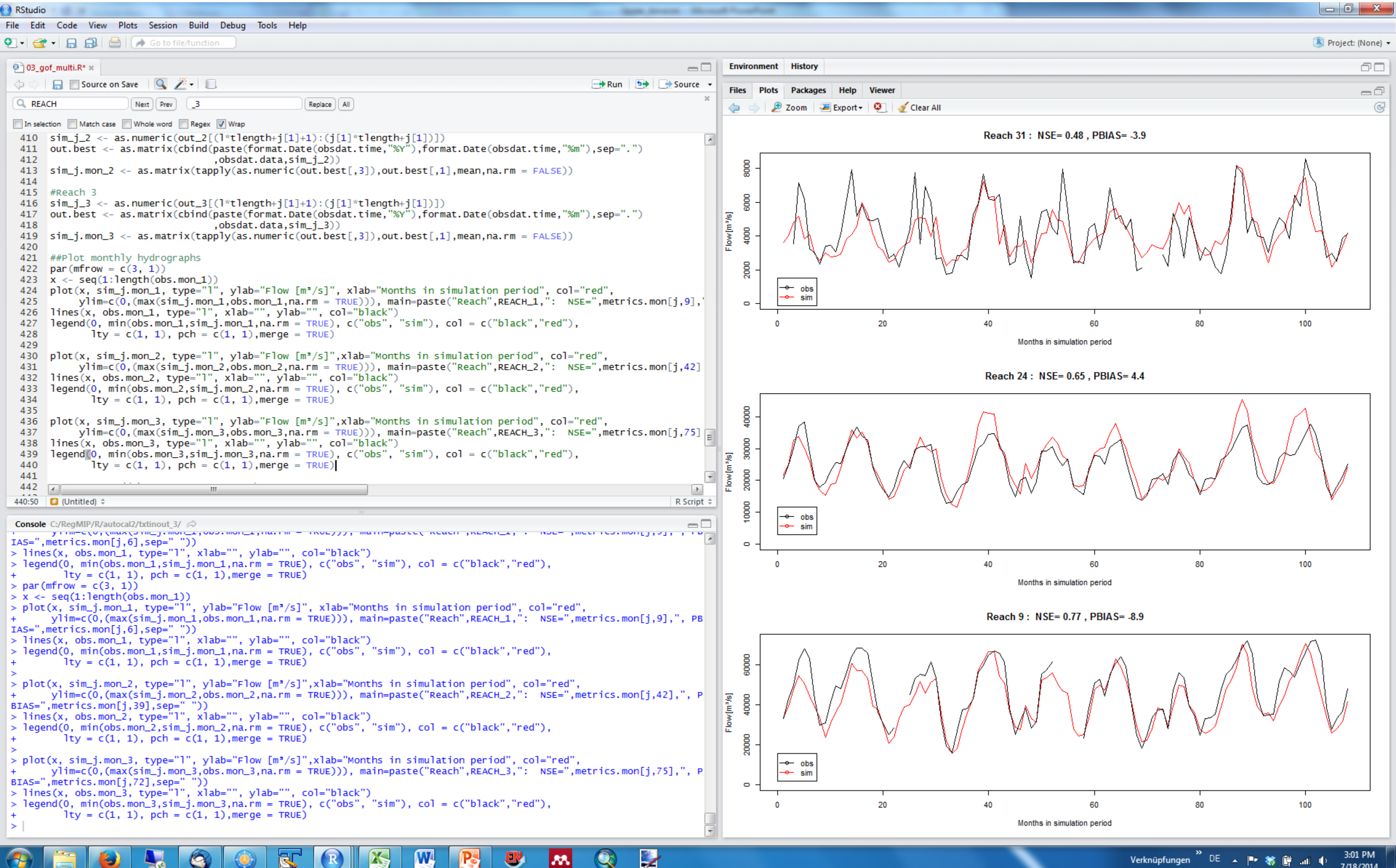

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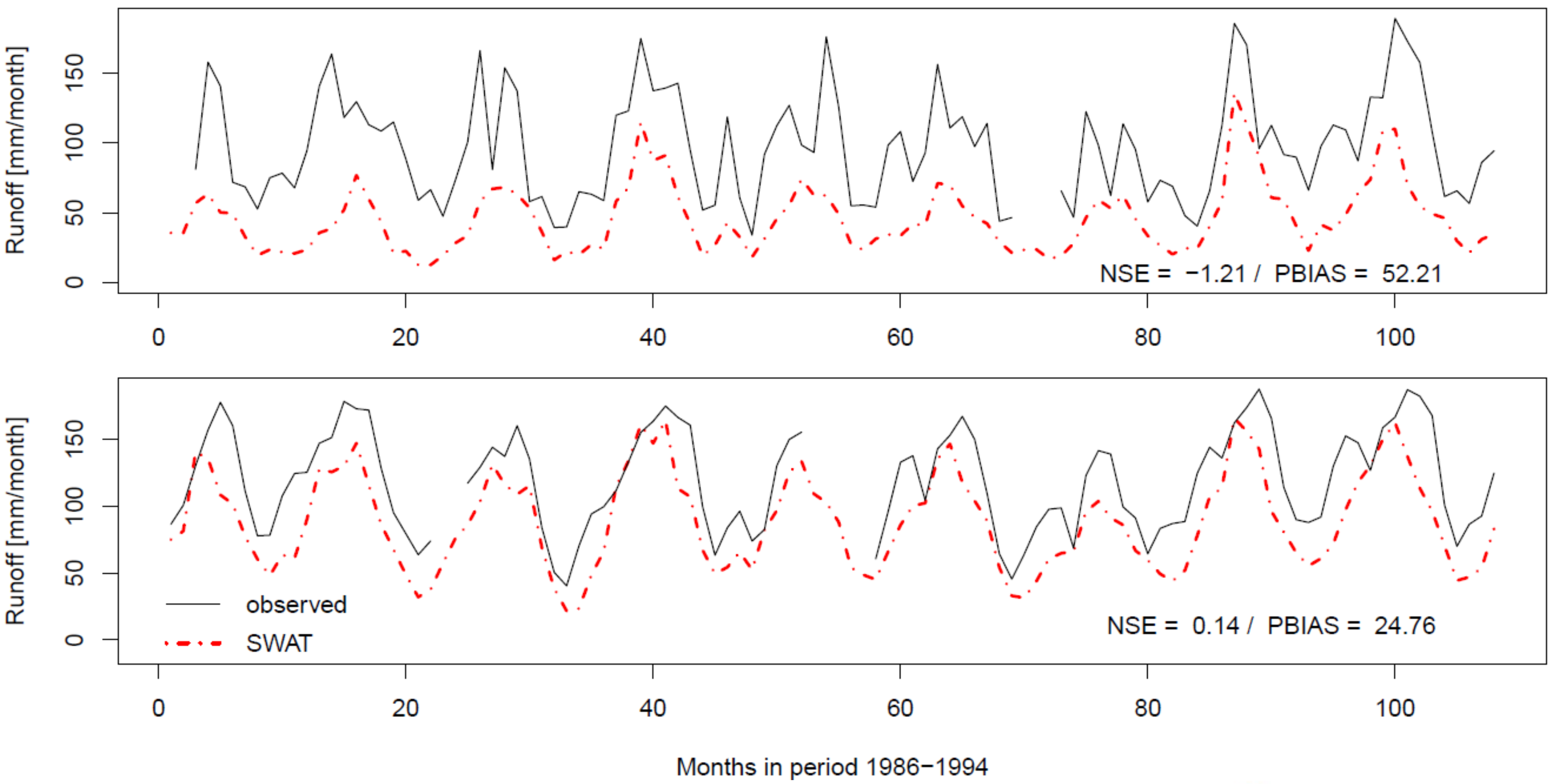
Autocalibration using R

Initial simulations – problem with water balance



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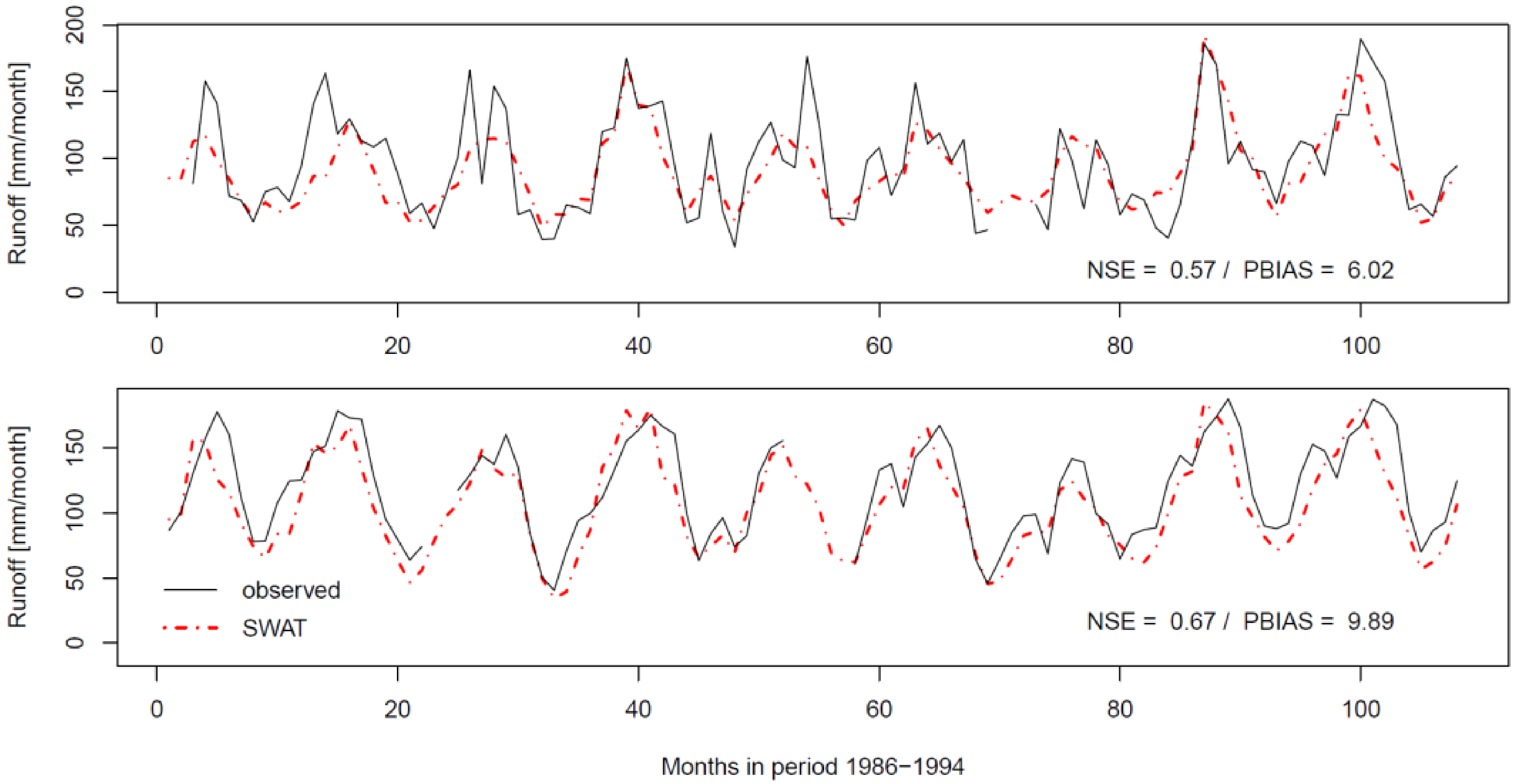
Simulations considering elevation bands



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Calibrated parameter values

Regional	Mountains	Lowlands I	Lowlands II
GW_DELAY	25.36	60.24	14.33
ALPHA_BF	0.03	0.08	0.12
GWQMN	875.75	0.00	0.00
GW_REVAP	0.02	0.06	0.01
REVAPMN	409.76	135.35	0.72
RCHRG_DP	0.00	0.08	0.00
OV_N	0.10	0.11	0.10
EPCO	1.00	0.01	1.00
CH_N2	0.01	0.03	0.01
CN2	0.00	-0.21	0.00
PLAPS	648.49	353.86	334.96
TLAPS	-6.73	-7.16	-8.20

Basin wide	
SFTMP	3.88
SURLAG	0.12
MSK_CO1	0.14
MSK_CO2	1.46
MSK_X	0.01

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