A new calibration strategy within SWATplusR: The Guajaraz River basin study case

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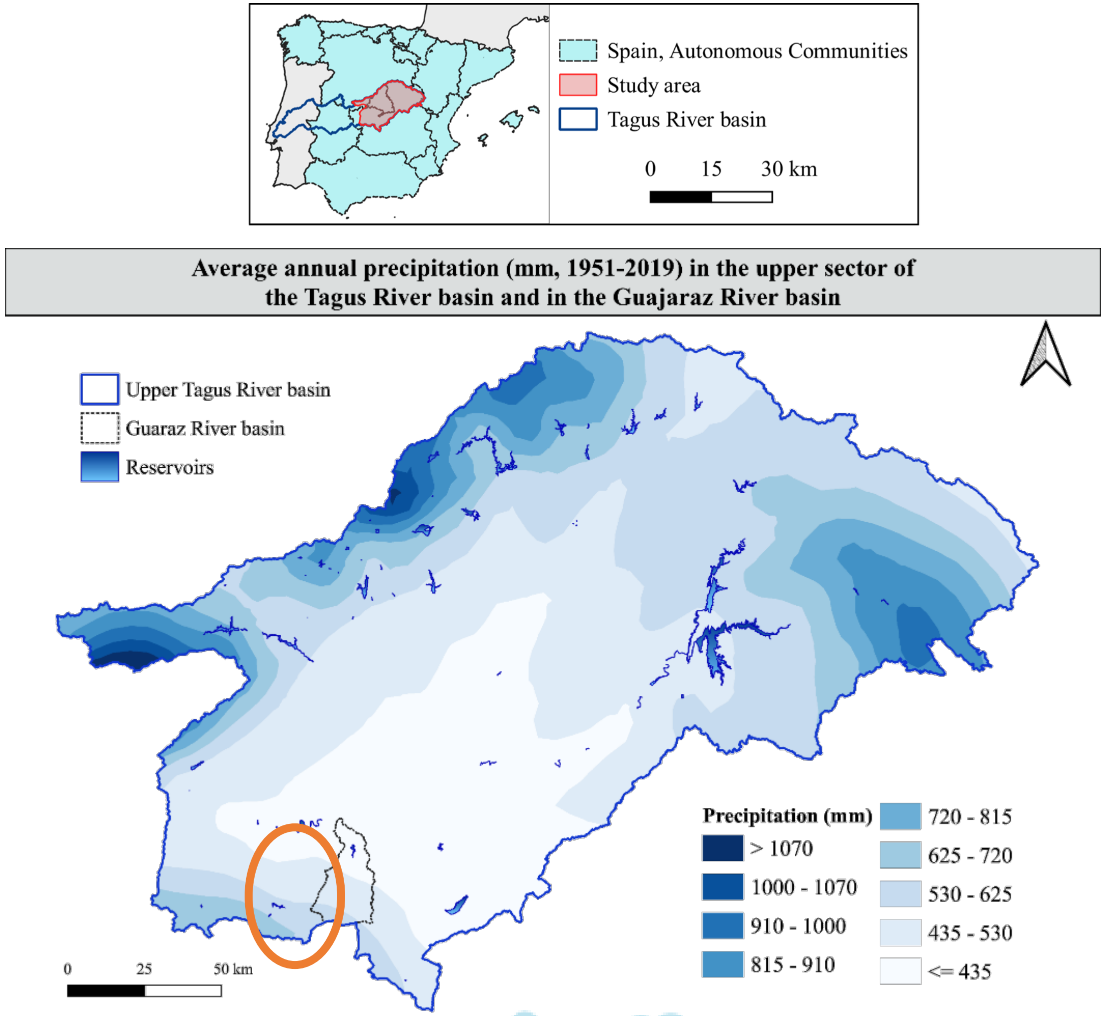
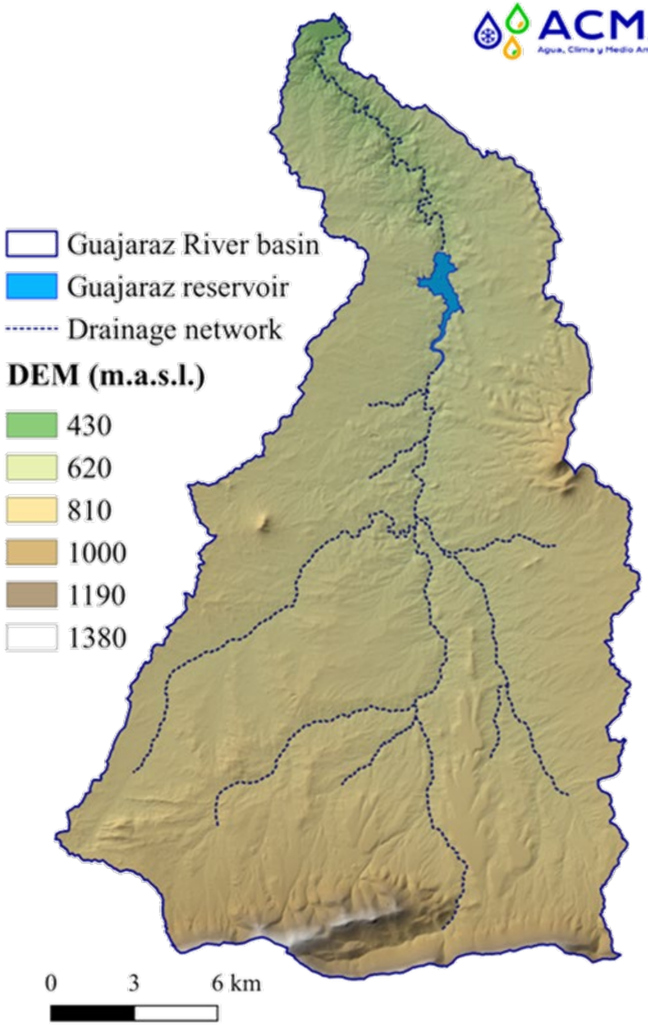
INTRODUCTION

Working context





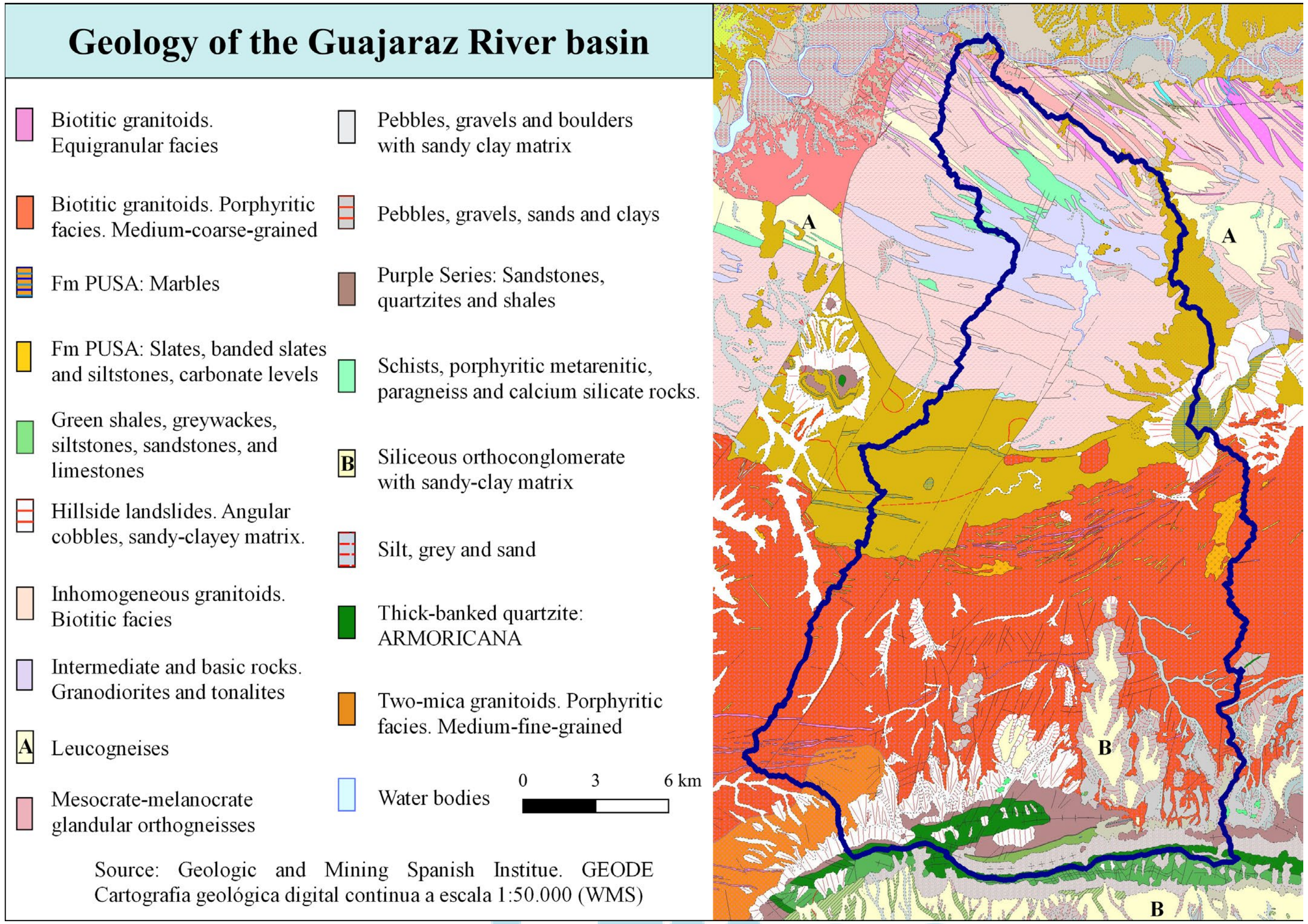
Area: 417 km^2

Average precipitation:

1951 – 2019: **465 mm**
1980 – 2019: **441 mm**

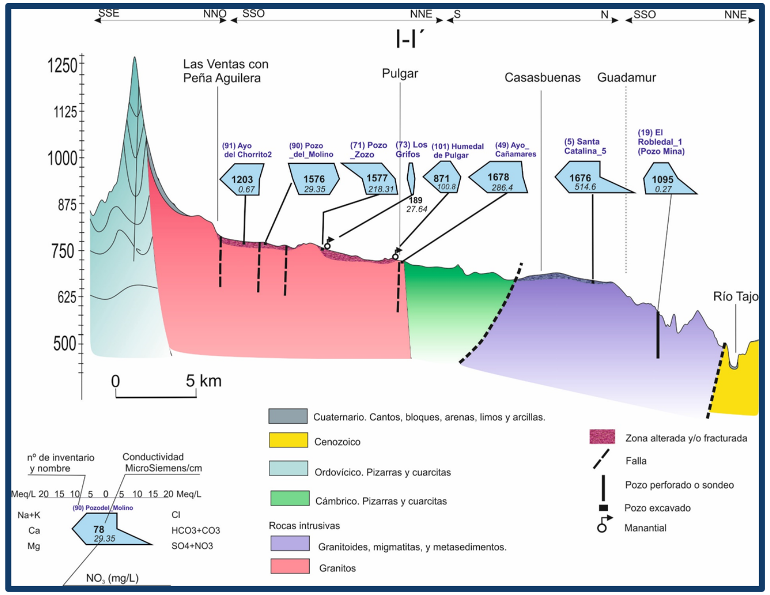
Suntory’s concern about water resources availability

Working context



Global goals

- Quantification of water resources in the Guajaraz River basin
- Hydrogeological characterization

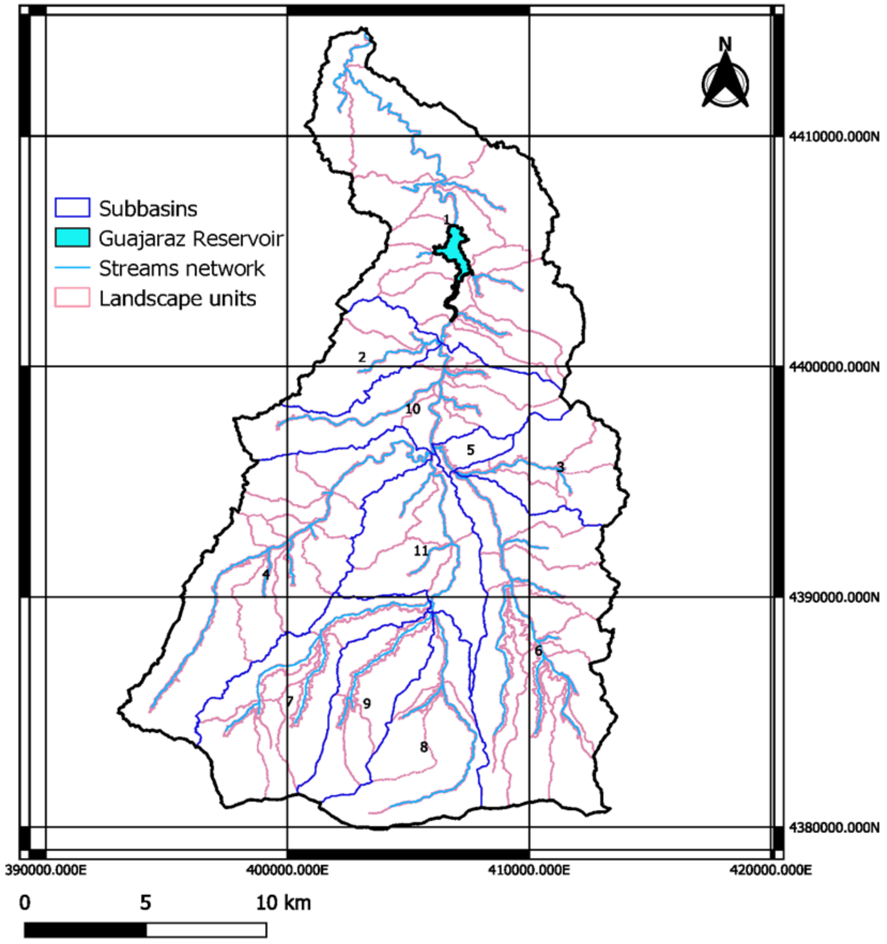


- Hydrological modelling and climate change scenarios simulation

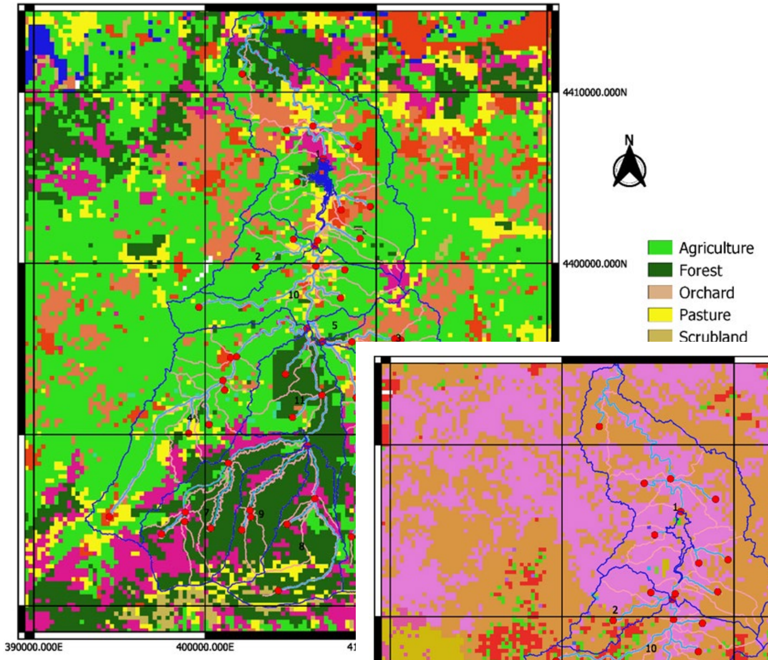
SWAT+

MODEL SET-UP AND DATA COLLECTION

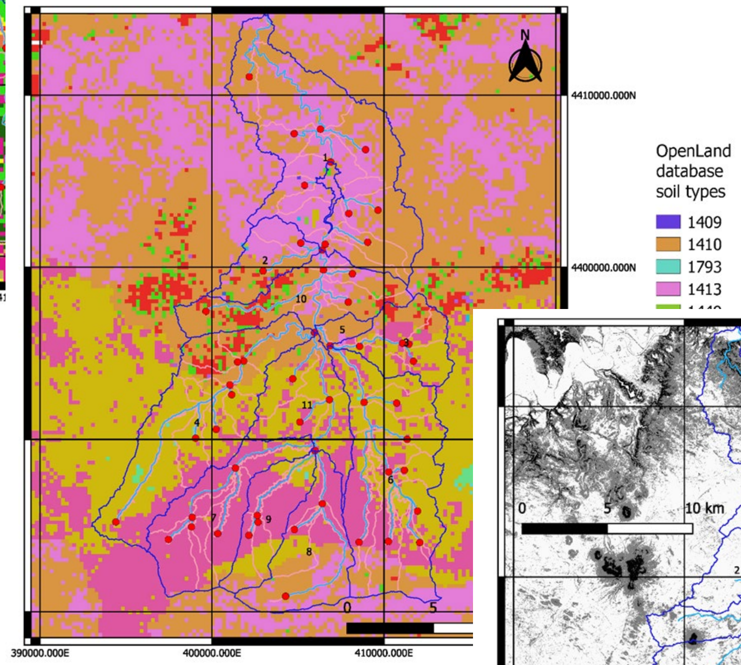
Model set-up



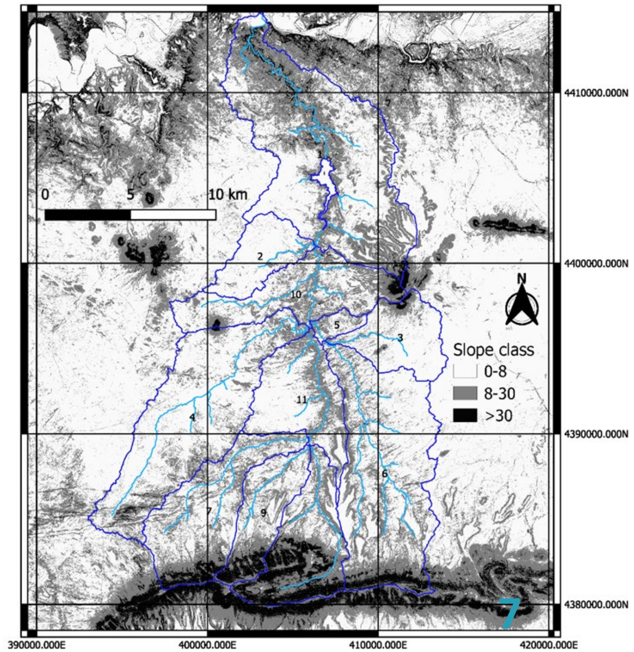
N
Subbasins
Guajaraz Reservoir
Streams network
Landscape units
4410000.000N
4400000.000N
4390000.000N
4380000.000N
390000.000E
400000.000E
410000.000E
420000.000E
0
5
10 km



N
4410000.000N
4400000.000N
390000.000E
400000.000E
Agriculture
Forest
Orchard
Pasture
Scrubland

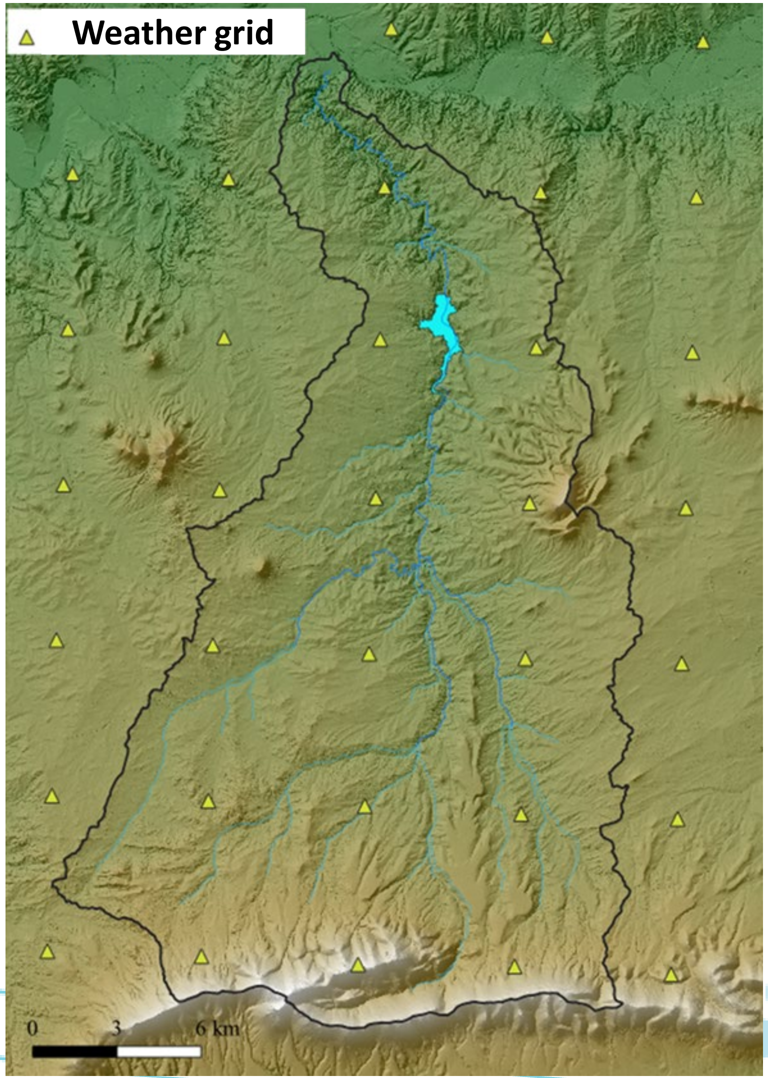


N
4410000.000N
4400000.000N
390000.000E
400000.000E
410000.000E
OpenLand database soil types
1409
1410
1793
1413



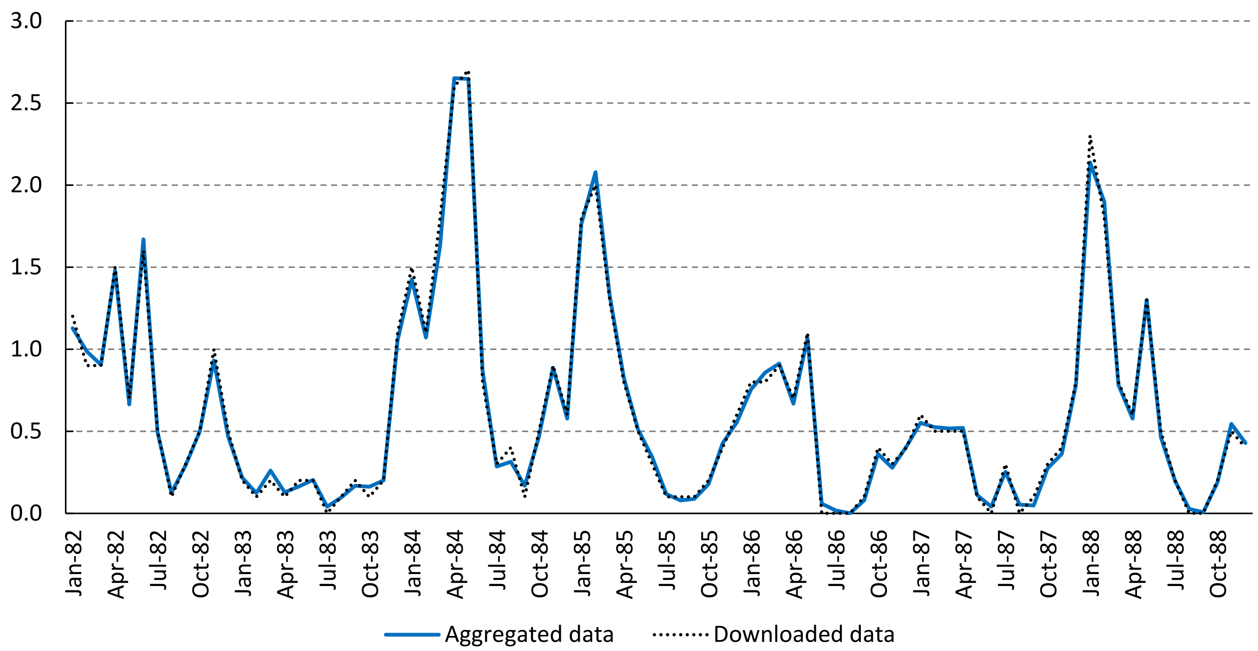
N
0
5
10 km
4410000.000N
4400000.000N
4390000.000N
4380000.000N
390000.000E
400000.000E
410000.000E
420000.000E
Slope class
0-8
8-30
>30

Data collection



- 5 x 5 km weather gridded data
  (Senent-Aparicio et al., 2021)

- Monthly reservoir inflows



MODEL
CALIBRATION

Initial workflow

Sensitivity analysis

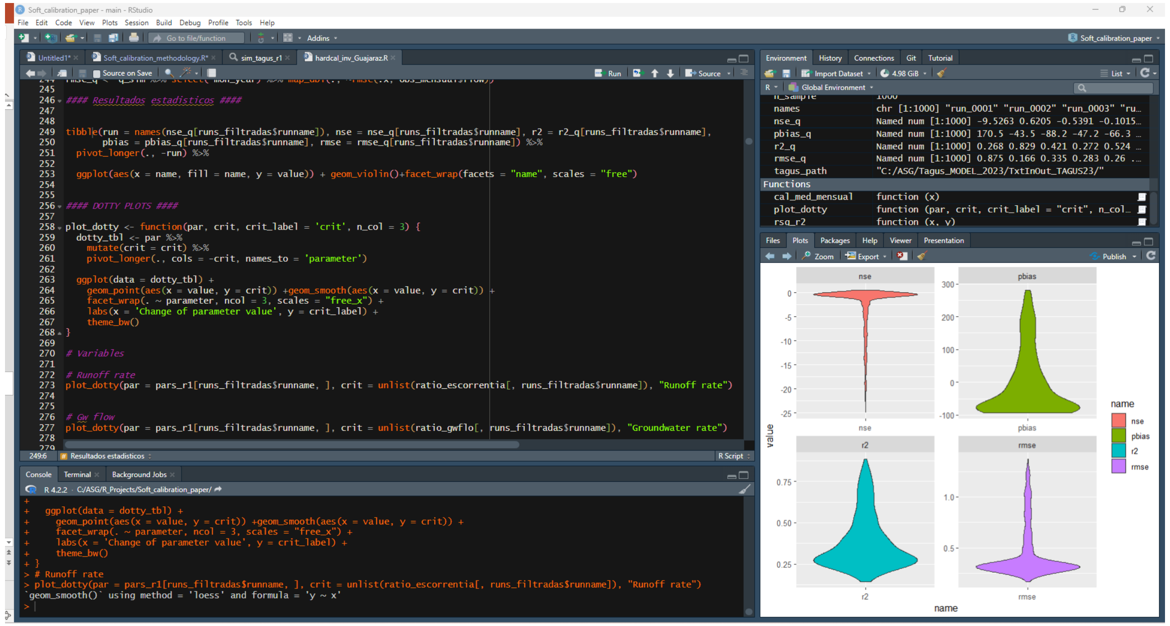
- Initial parameters selection

Soft calibration

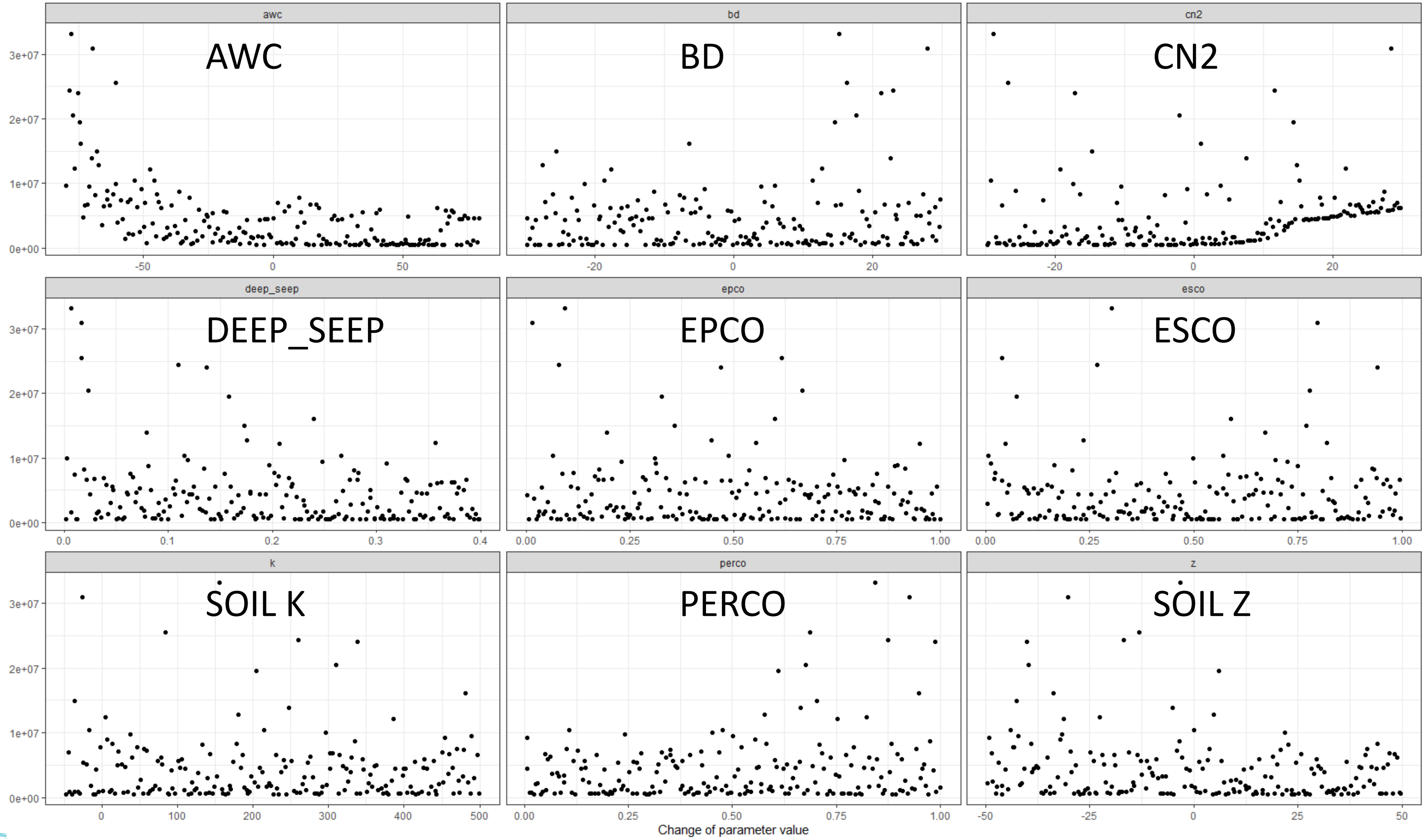
- Parameter ranges restricted

Hard calibration and validation

- New parameters added



Sensitivity analysis



Goal: parameter selection for soft calibration

Two iterations of 200 simulations. Sensitivity tested against several output variables, including reservoir inflow, ET and percolation.

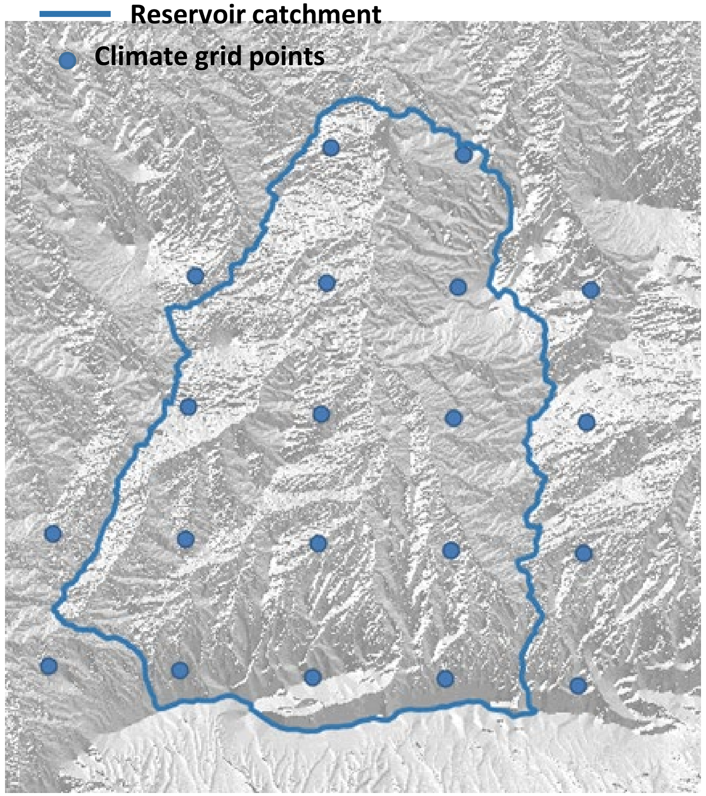
Lateral flow parameters less sensitive: Dismissed

Final parameter selection for soft calibration: 9 parameters

Parameters sensitivity against reservoir inflow

Soft calibration

- **Extraction of soft data for calibration:**
  - Runoff coefficient → ≈ 4%
  - Groundwater contribution to streamflow: estimated from neighbour catchments → ≈ 20%

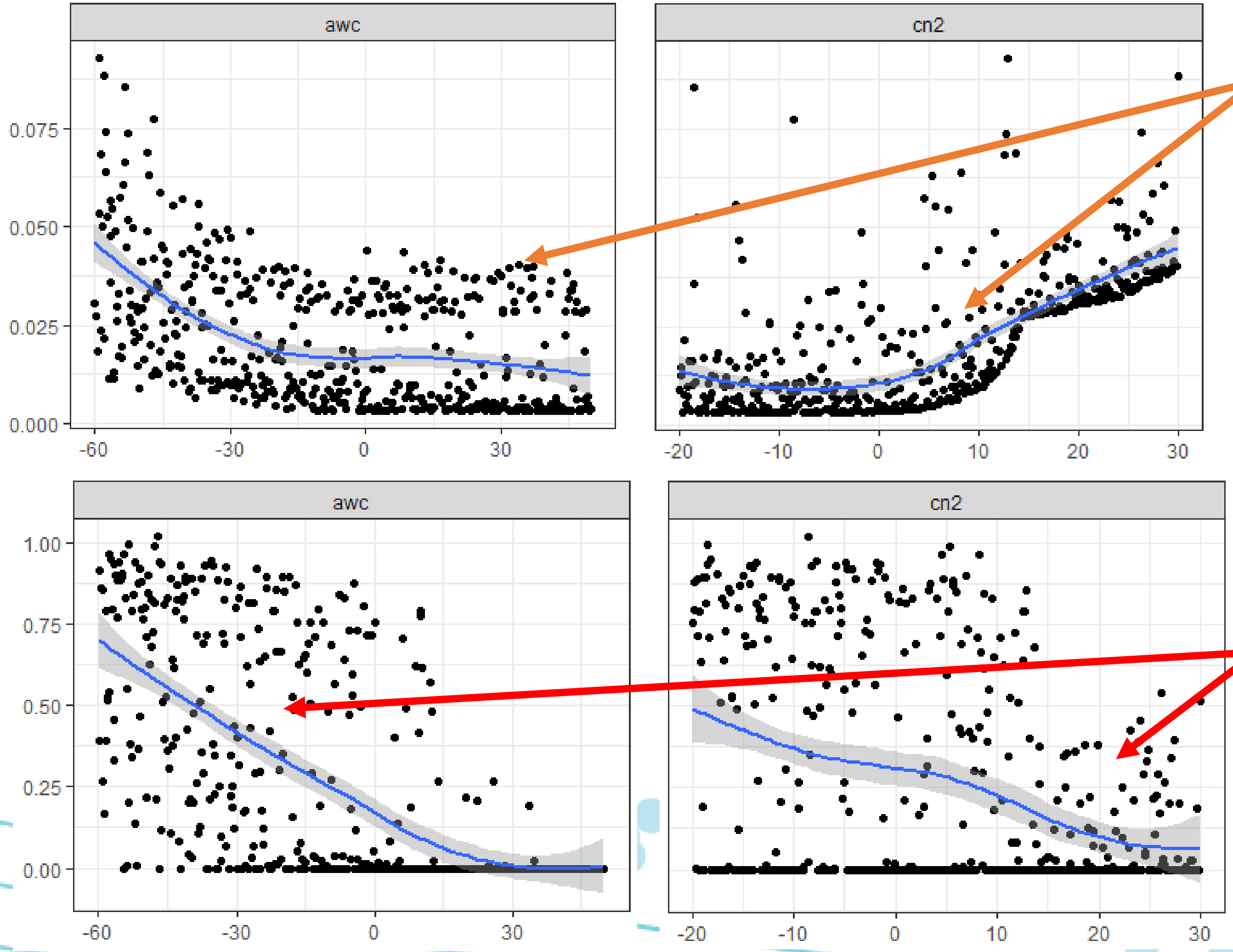


13:30 - 15:00	Session I2: Hydrology Mogens Zieler Stuen, Building 1422	Friday
13:30 - 13:50	Alejandro Sánchez Gómez Soft data collection for realistic hydrological modelling:	

- **Soft calibration:**
  - **GOAL:** Restrict parameter values to guarantee realistic simulation in terms of water balance/streamflow components during subsequent hard calibration.
  - 3 iterations of 500 simulations, constraining ranges after each iterations if trends

Soft calibration

Example Round 2:



Sensitivity for Q coefficient → Target ≈ 4%

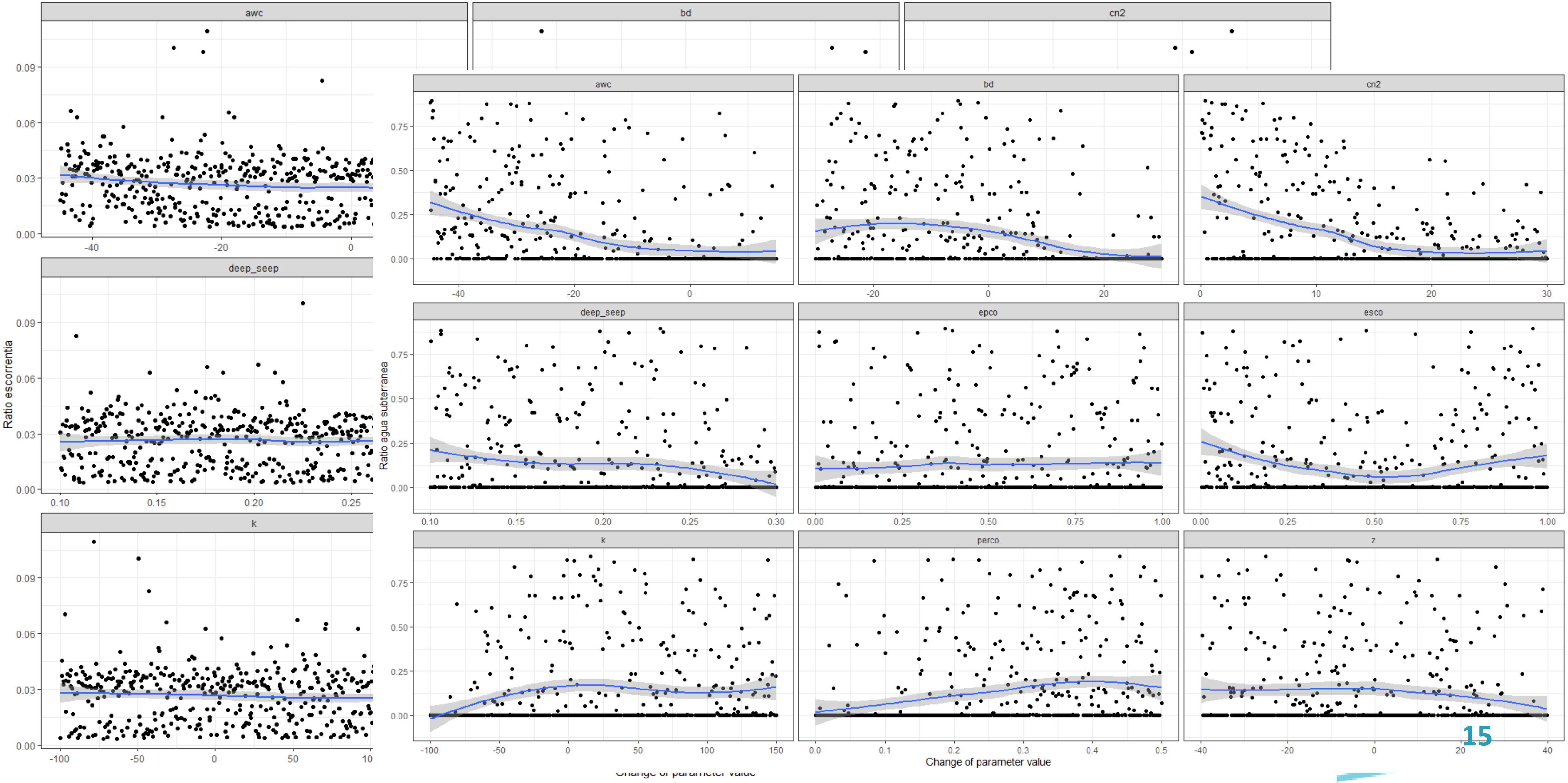
Contradictory = **challenge**

Sensitivity for GW ratio → Target ≈ 20%

Soft calibration

- Parameter restriction:

Parameter	Initial range	Final range	Change type
cn2.hru	-30, 30	0, 30	Percentage
perco.hru	0, 1	0, 0.5	Absolute value
epco.hru	0, 1	0, 1	Absolute value
esco.hru	0, 1	0, 1	Absolute value
z.sol	-50, 50	-40, 40	Percentage
k.sol	-100, 200	-100, 150	Percentage
bd.sol	-30, 30	-30, 30	Percentage
awc.sol	-80, 80	-45, 15	Percentage
deep_seep.aqu	0, 0.4	0.1, 0.3	Absolute value

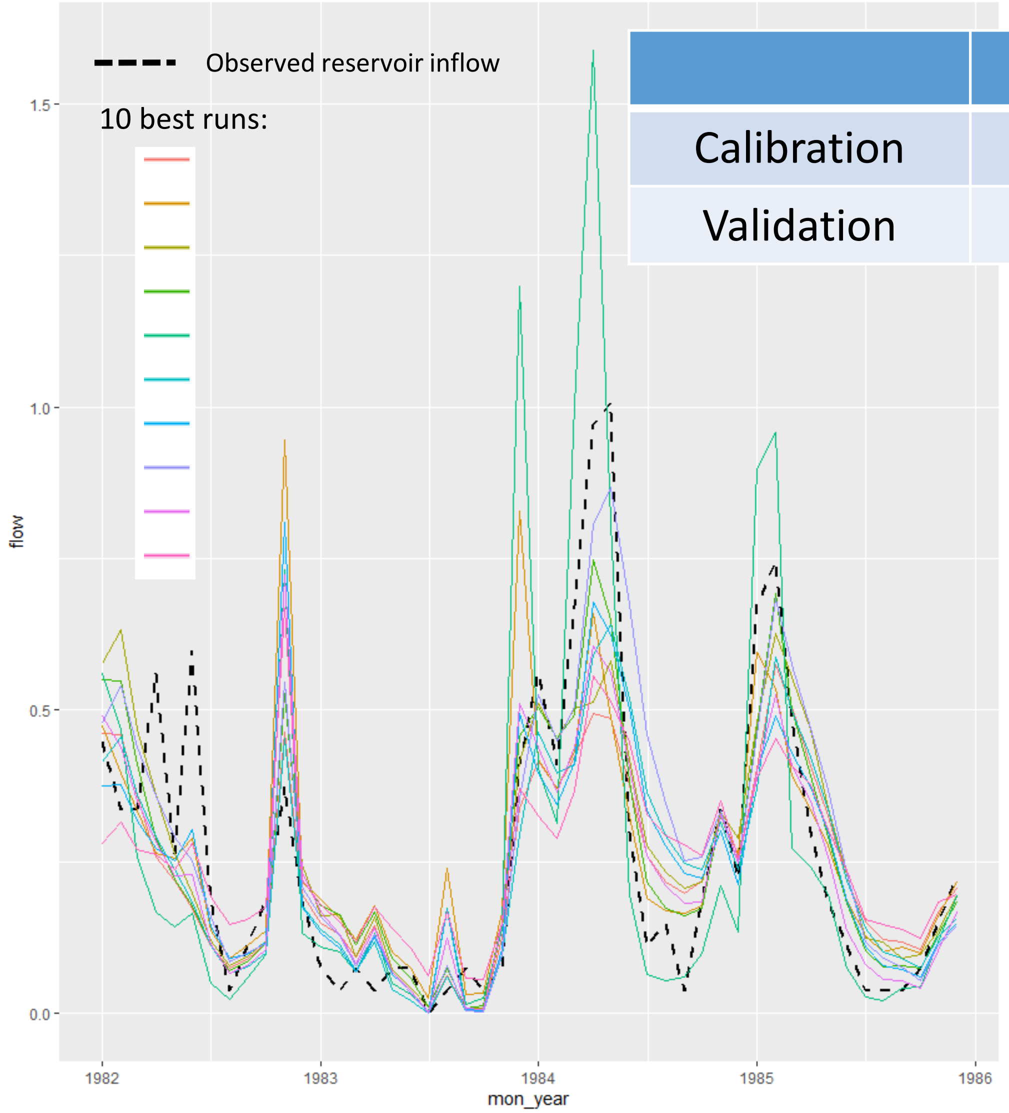

awc
bd
cn2
deep_seep
epco
esco
k
perco
z
Ratio escorrentia
Ratio agua subterranea
Change of parameter value

Hard calibration

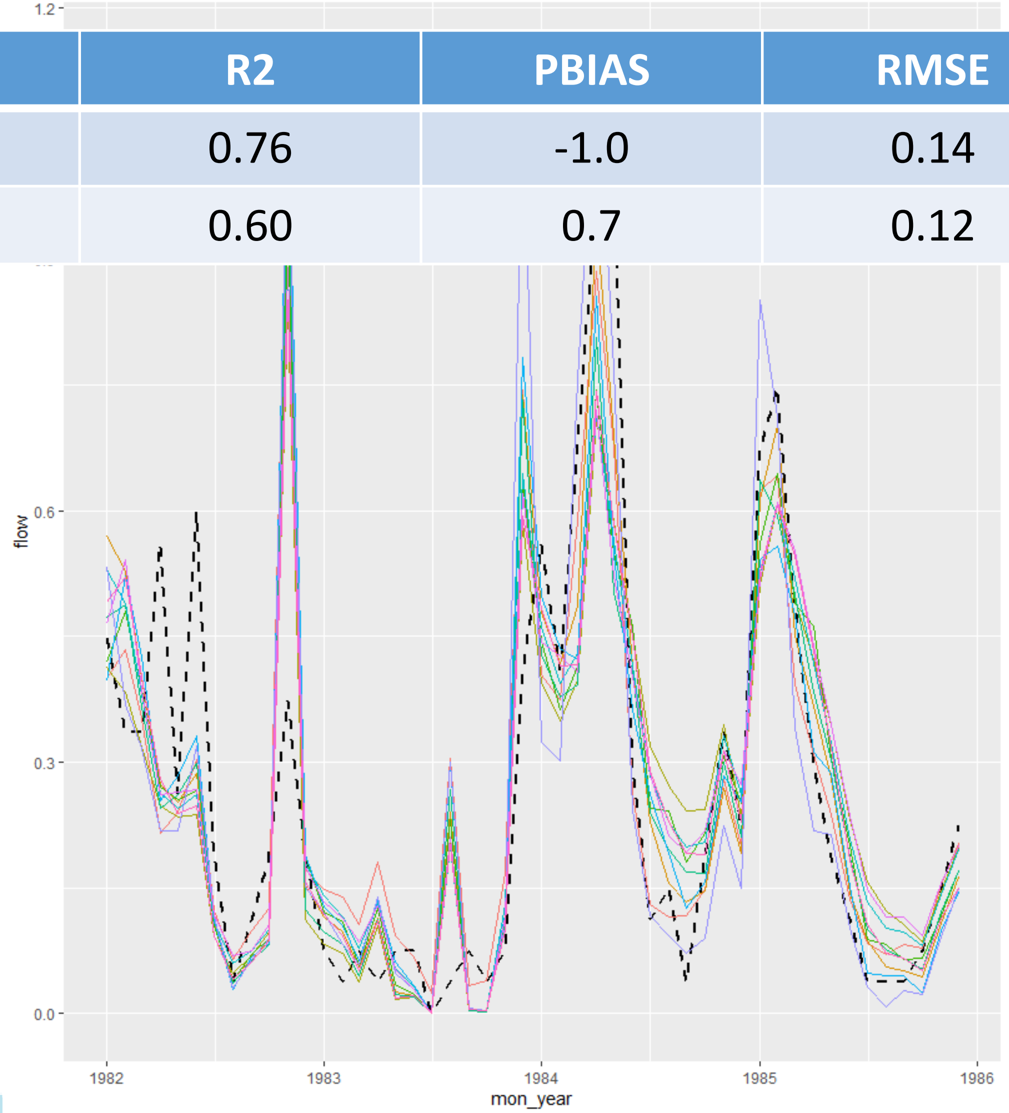
- **GOAL:** To have a final version of the model which reproduces satisfactorily reservoir inflow in a realistic way
- 7 more parameters added based on our experience, related to lateral and groundwater flow.
- 3 additonal iterations of 1000 simulations each
- Each round, restrict parameter values based on both statistics and soft data indices
- Calibration 82-85 , validation 86-88

Apparently, we can get satisfactory results from the very first iteration

	NSE	R2	PBIAS	RMSE
Calibration	0.75	0.76	-1.0	0.14
Validation	0.57	0.60	0.7	0.12



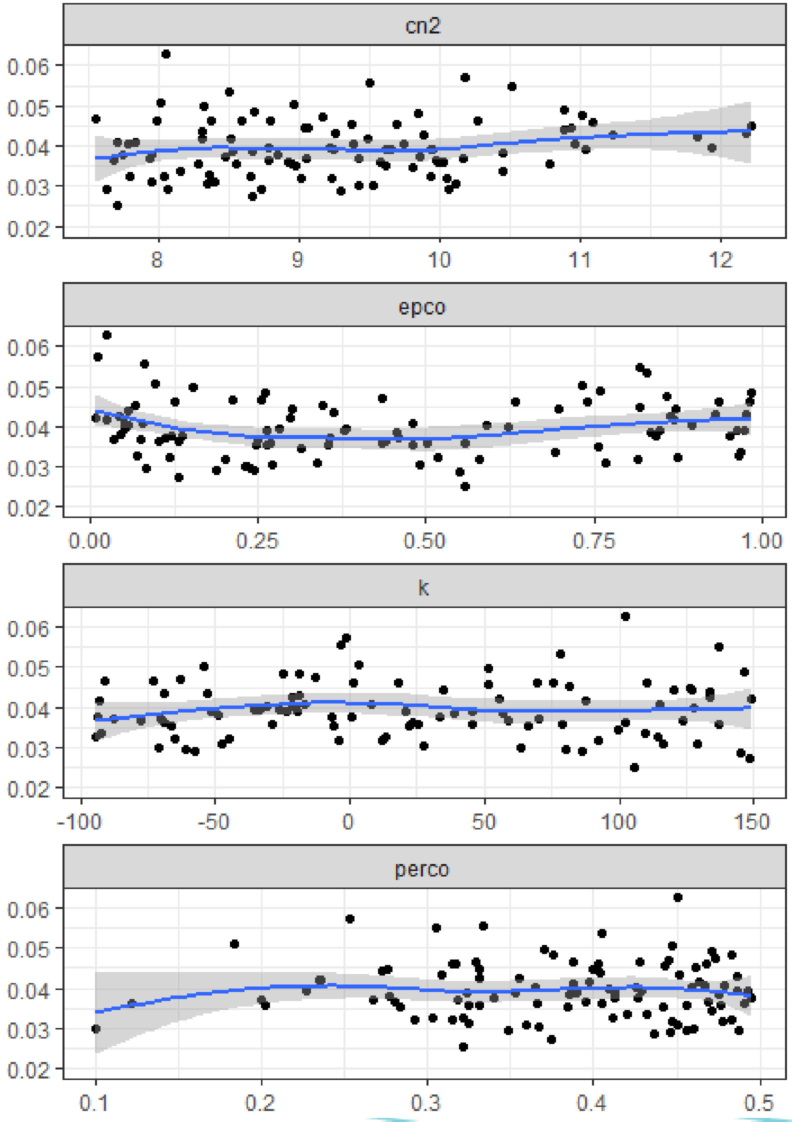
10 statistically-best simulations, 1st iteration



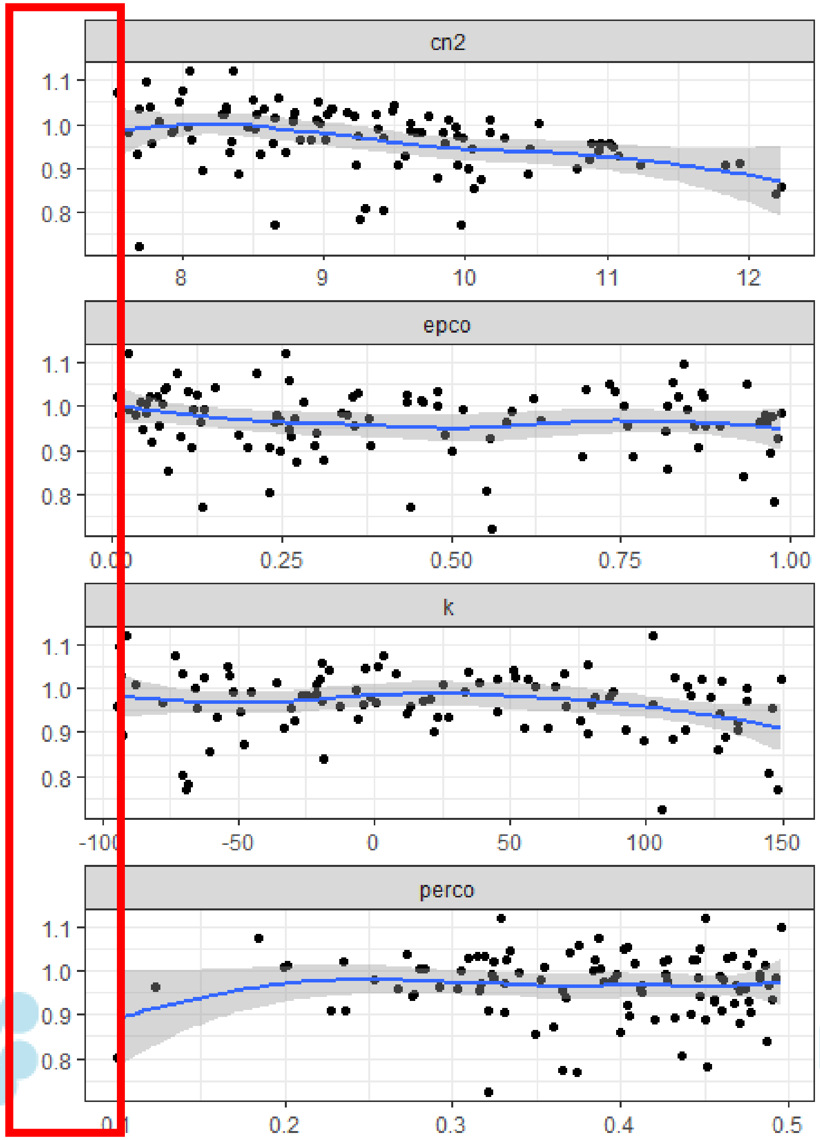
10 statistically-best simulations, 3rd iteration

HOWEVER:

Runoff ratio:



Groundwater index:



We filtered those with GW ratio lower than 0.5, but simulations were not accurate

Assuming that the lack of data could be an issue, we tried an only-calibration scheme, but it did not work either

SOLUTION NEEDED to find another way to optimize model parameters

New workflow: INVERSE CALIBRATION

Hard calibration

- Period 83-85, 1000 sims

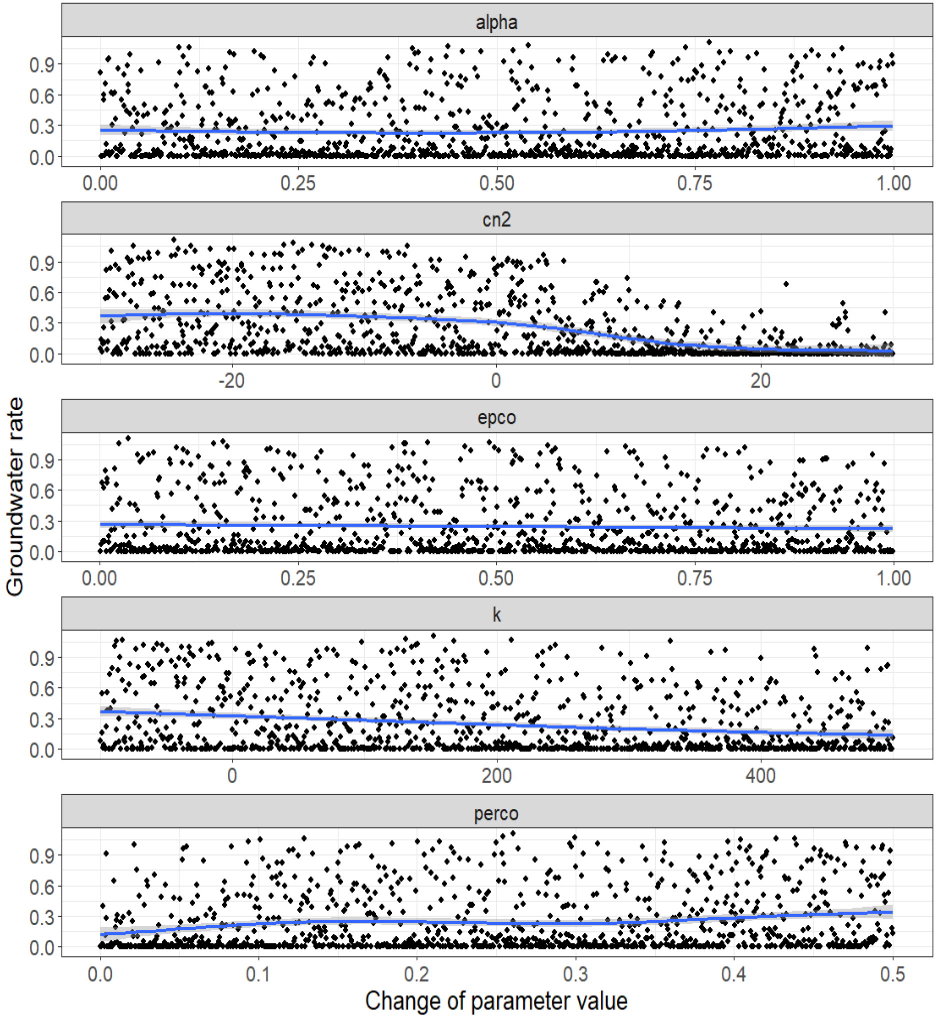
Soft data restriction

- Filter in sims with Q/P < 0.2 and GWQ < 40%

Set new parameter ranges

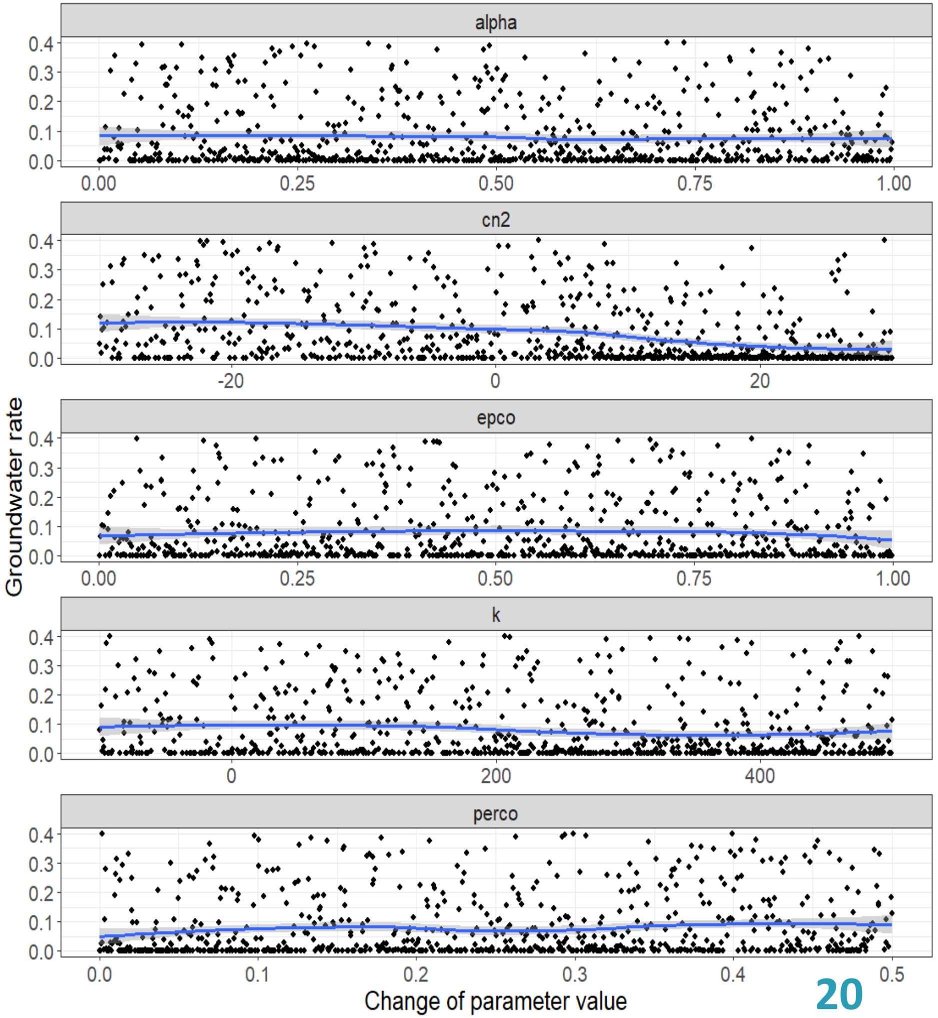
- Run 4 iterations

Soft data restriction after round 1 (filtering)



Without filter

With filter

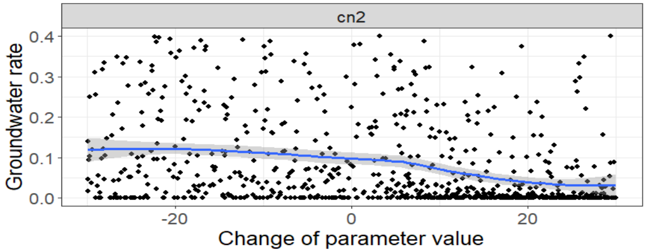


Best simulations

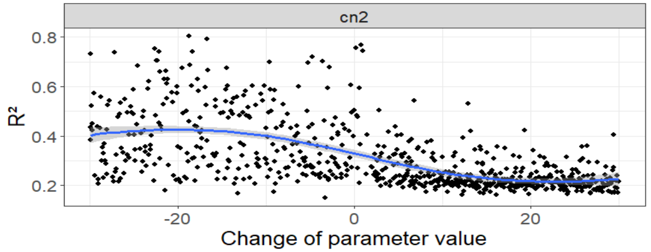
```
> rank_tableGRAN_r1
# A tibble: 719 x 12
   run         nse    r2 pbias  rmse rank_nse rank_r2 rank_rmse rank_pbias rank_run runoff_rate groundw_rate
   <chr>     <dbl> <dbl> <dbl> <dbl>    <dbl>   <dbl>     <dbl>      <dbl>    <dbl>       <dbl>        <dbl>
 1 run_0257 0.611  0.791 -15.7 0.168      719     718       719       626     2782      0.0431        0.265
 2 run_0681 0.420  0.530   5.9 0.205      715     654       715       675     2759      0.0574        0.237
 3 run_0608 0.583  0.740 -30.3 0.174      718     712       718       556     2704      0.0368        0.385
 4 run_0115 0.418  0.753 -36.7 0.206      714     715       714       529     2672      0.0320        0.327
 5 run_0986 0.430  0.767 -40.1 0.204      716     717       716       522.    2670.     0.0308        0.181
 6 run_0294 -0.0250 0.495 -6.8 0.273      676     633       676       670     2655      0.0461        0.313
 7 run_0696 0.493  0.745 -48.9 0.192      717     714       717       500     2648      0.0244        0.379
 8 run_0636 0.337  0.685 -43.8 0.220      712     702       712       514     2640      0.0278        0
 9 run_0135 0.0696 0.419   7.3 0.260      694     583       694       667     2638      0.0596        0.204
10 run_0022 0.311  0.629 -43.2 0.224      710     694       710       515     2629      0.0283        0.239
```

Selecting new parameter ranges

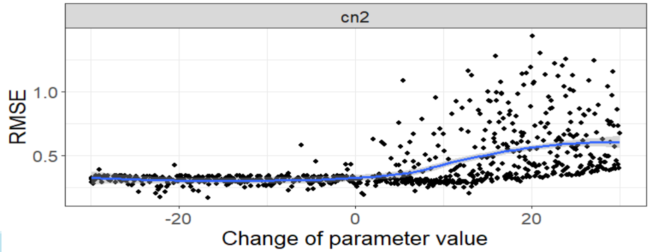
Groundwater rate



R^2

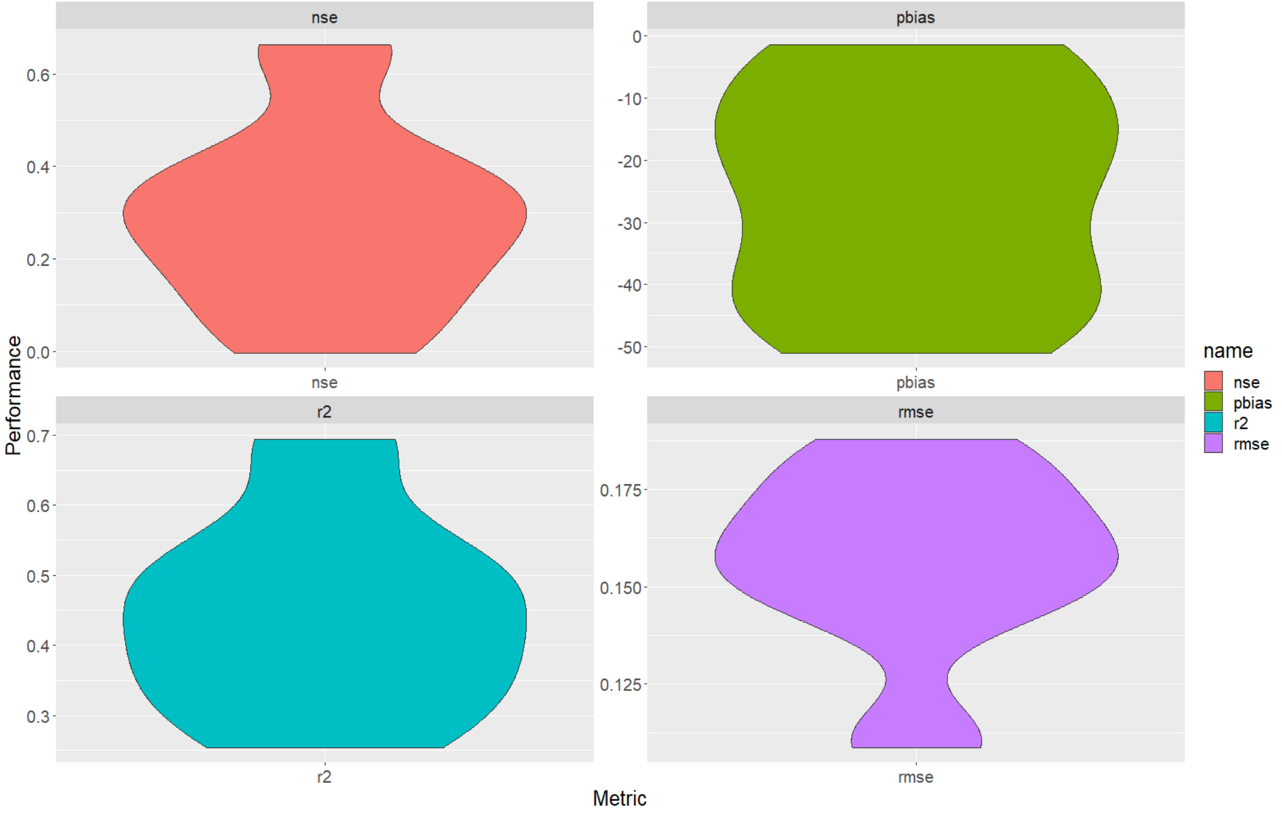


RMSE

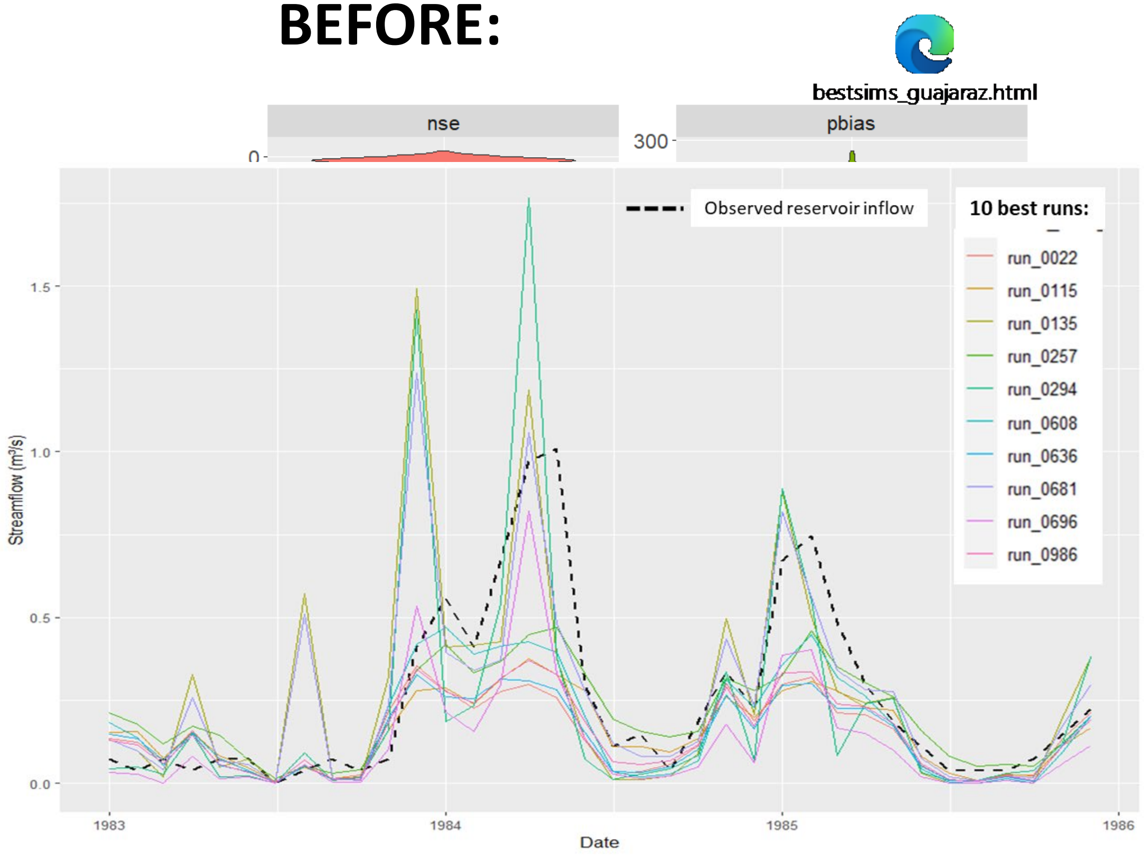


Example for cn2, analysis repeated for the 17 parameters included

Performance overview



BEFORE:



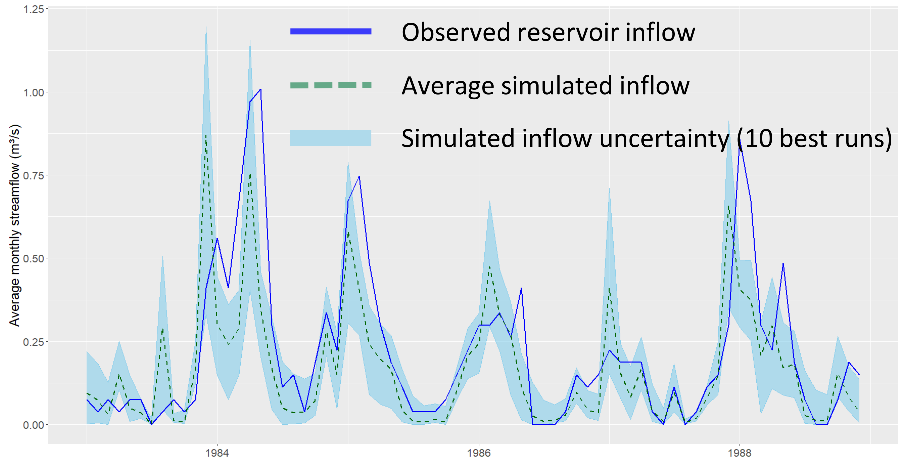
Simulations' selection for validation

14 simulations selected:

Simulation	Round	NSE	R^2	PBIAS	RMSE	Q coef (%)	GW rate (%)
run_0257	R1	0.61	0.79	-15.7	0.168	4.31	26.5
run_0681	R1	0.42	0.53	5.9	0.205	5.74	23.7
run_0608	R1	0.58	0.74	-30.3	0.174	3.68	38.5
run_0309	R2	0.39	0.52	-37.4	0.21	3.4	5.13
run_0740	R2	0.32	0.45	-36	0.223	3.15	22.8
run_0440	R3	0.41	0.50	-26.8	0.208	4.08	34.3
run_0319	R3	0.16	0.54	1.6	0.248	5.35	35.3
run_0338	R3	0.41	0.51	-32.5	0.207	3.66	28.9
run_0655	R3	0.37	0.46	-15	0.215	4.72	39.9
run_1978	R4	0.46	0.57	-6.2	0.197	4.95	25.9
run_1245	R4	0.51	0.57	-17.1	0.188	4.58	31
run_1420	R4	0.30	0.51	-8.5	0.225	4.98	16.7
run_1616	R4	0.43	0.55	-20.2	0.203	4.37	39.6
run_0812	R4	0.59	0.69	-29.3	0.172	3.84	39.8

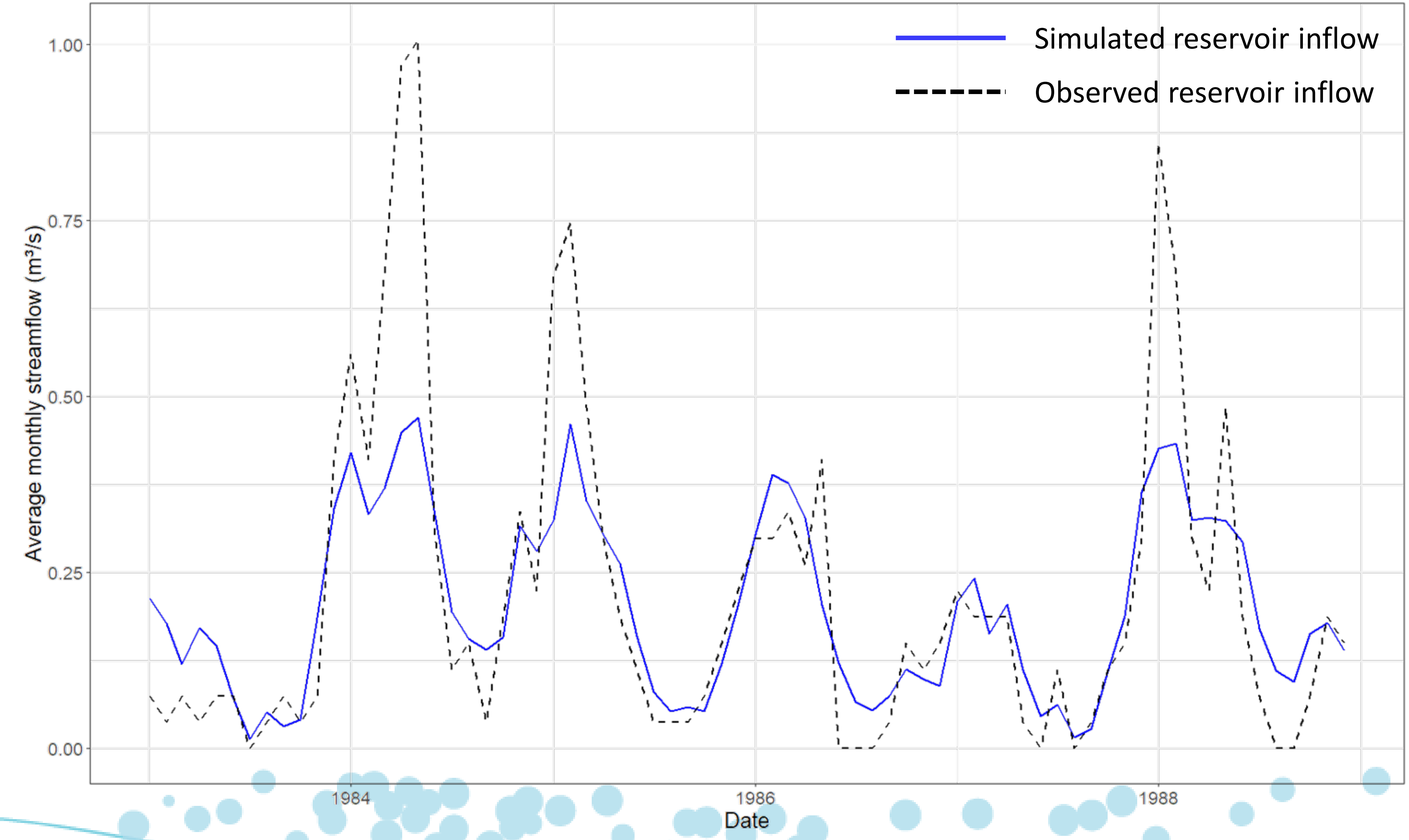
Validation

- **Step 2: Validation + evaluation of selected simulations**
  - Validation period 86-88
  - Assessment of performance metrics and WB indices
  - Final simulation selection



		CALIBRATION						VALIDATION					
Simulation	Round	NSE	R²	PBIAS	RMSE	Q coef (%)	GW rate (%)	NSE	R²	PBIAS	RMSE	Q coef (%)	GW rate (%)
run_0257	R1	0.61	0.79	-15.7	0.17	4.31	26.46	0.64	0.69	-1.50	0.11	3.81	26.90
run_0681	R1	0.42	0.53	5.9	0.21	5.74	23.70	0.17	0.34	-1.40	0.17	3.82	20.45
run_0608	R1	0.58	0.74	-30.3	0.17	3.68	38.49	0.66	0.69	-16.90	0.11	3.20	38.39
run_0309	R2	0.39	0.52	-37.4	0.21	3.40	5.13	0.16	0.37	-43.50	0.17	2.18	2.51
run_0740	R2	0.32	0.45	-36	0.22	3.15	22.82	0.30	0.53	-45.10	0.16	2.11	22.60
run_0440	R3	0.41	0.50	-26.8	0.21	4.08	34.30	0.00	0.25	-45.30	0.19	2.12	24.19
run_0319	R3	0.16	0.54	1.6	0.25	5.35	35.28	0.25	0.42	-21.40	0.16	3.03	40.80
run_0338	R3	0.41	0.51	-32.5	0.21	3.66	28.86	0.27	0.38	-32.50	0.16	2.61	33.93
run_0655	R3	0.37	0.46	-15	0.21	4.72	39.91	0.10	0.27	-24.30	0.18	2.93	47.30
run_1978	R4	0.46	0.57	-6.2	0.20	4.95	25.89	0.42	0.51	-3.90	0.14	3.71	33.59
run_1245	R4	0.51	0.57	-17.1	0.19	4.58	30.97	0.38	0.48	-12.30	0.15	3.39	37.97
run_1420	R4	0.30	0.51	-8.5	0.23	4.98	16.70	0.31	0.46	-15.00	0.16	3.28	20.72
run_1616	R4	0.43	0.55	-20.2	0.20	4.37	39.56	0.02	0.30	-51.00	0.19	1.90	24.33
run_0812	R4	0.59	0.69	-29.3	0.17	3.84	39.82	0.38	0.53	-37.00	0.15	2.43	43.89

Selected simulation hydrograph



CONCLUSIONS

- A SWAT+ model has been set up for the Guajaraz River basin
- Even using a soft calibration prior to a hard one, the statistically satisfactory simulations had a too high GW contribution to streamflow → could lead to unrealistic results
- A new calibration workflow was designed within SWATplusR, restricting simulations after hard calibration based on soft data
- Realistic simulations were obtained and still statistically satisfactory → They will guarantee a more accurate simulation of climate change scenarios

SUNTORY

THANK YOU!

Guardianes del Tajo

MIZU TO IKIRU