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Searching for better model performance and reduced optimization time:

different calibration methods on different watershed locations

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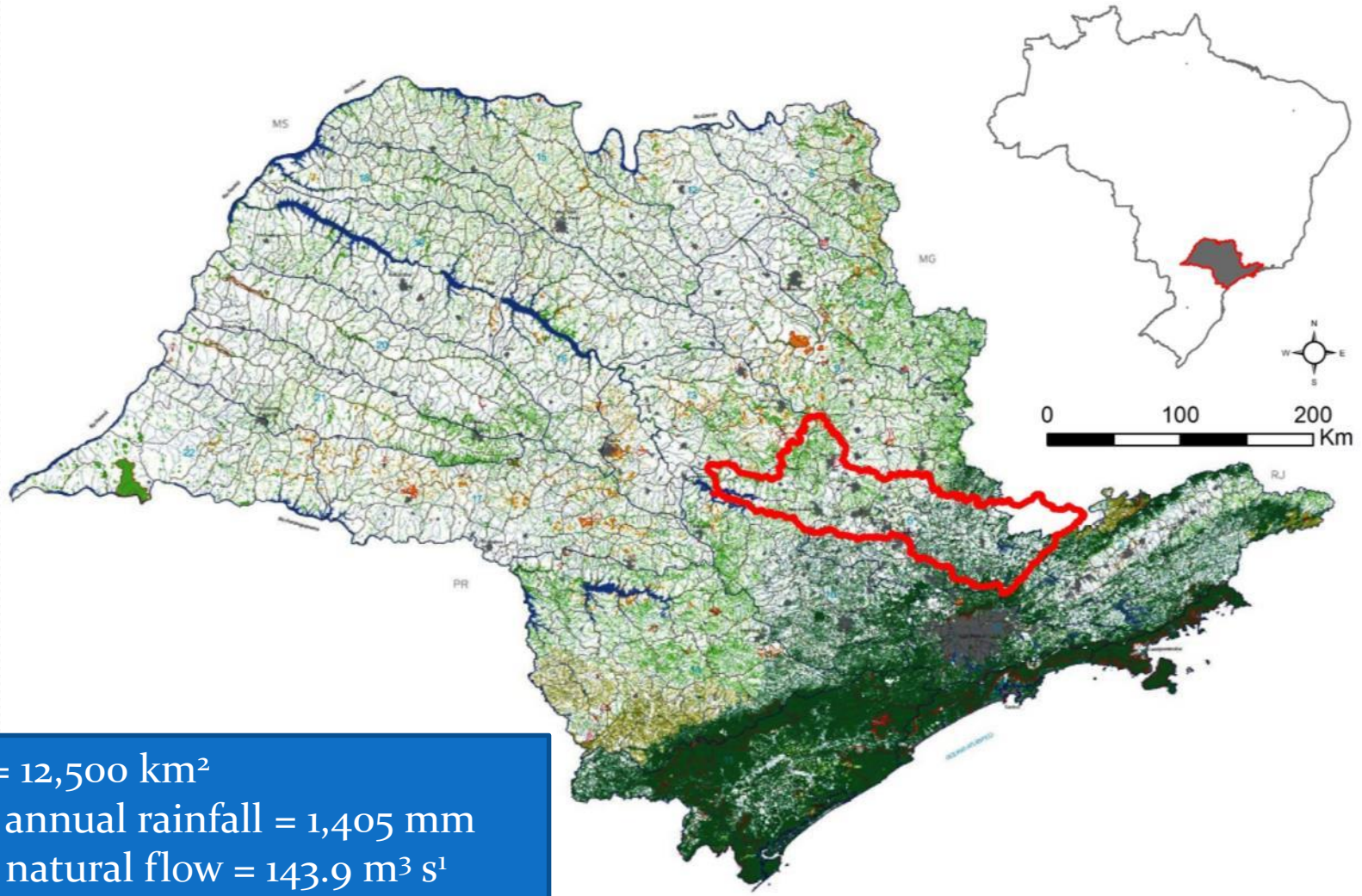
Background

- Distributed and semi-distributed hydrological models involve a **large number of parameters** to represent the **spatial heterogenity** of the watershed and its **physical processes**.
- Many parameters cannot be measured and are **estimated only on the calibration process.**

- This study aims to test **different methods of flow calibration**, to try to understand how much of an increase on **model performance efficiency**, and decrease of **processing time**, can be obtained with different calibration techniques**.**

Study Area – Piracicaba Watershed



- Area = 12,500 km^2
- Mean annual rainfall = 1,405 mm
- Mean natural flow = 143.9 m^3 s^1
- Population = 3.4 x10^6
- Pop density = 272 hab/km^2

Model Set Up e Data Bases

- The Piracicaba Watershed was set up using the ArcSWAT 2012 interface on ArcGIS 10.0

- It was built using freely available data on the web, or provided by Government agencies and Research institutions, after meetings and email and telephone contacts.

Model Set Up and Data Sets

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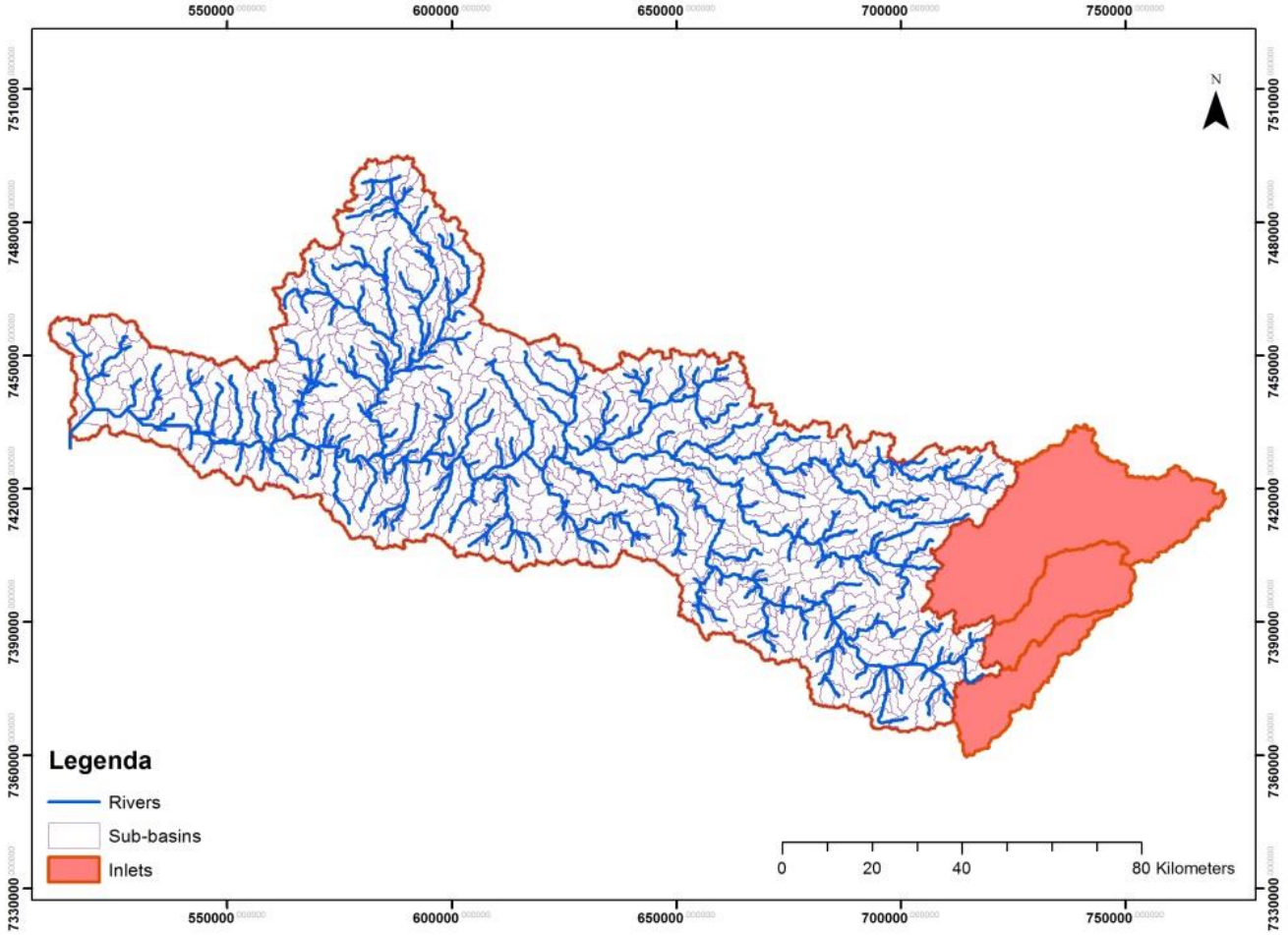


523 sub-basins were delimited in SWAT, with an average area of 20Km², the modeled watershed area is of 10,454 Km²

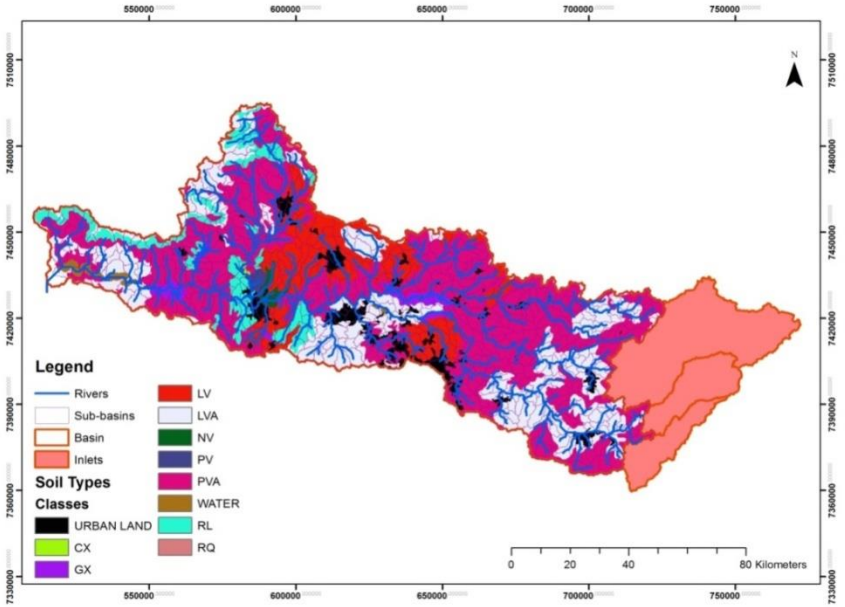
SWAT Model Set-up and Data Sets

Soils Map is the 1:500.000 from OLIVEIRA, J.B. (1999) for São Paulo state

OLIVEIRA, J.B. (1999) legend of profiles

Texture, Organic Matter, and soil depths

Pedotransfer Functions (Saxton & Rawls, 2006)

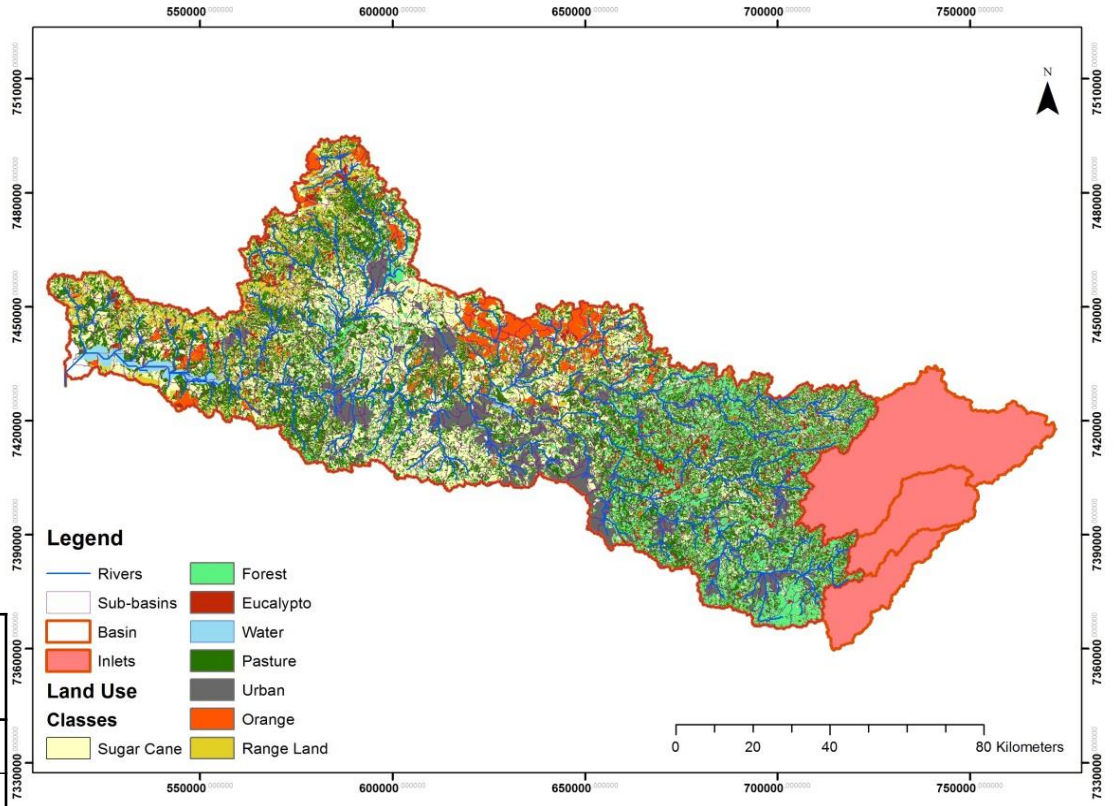


Soil Types	Percentage of Watershed (%)
Argisslo Vermelho Amarelo (PVA)	48.12
Latossolo Vermelho Amarelo (LVA)	24.37
Latossolo Vermelho (LV)	11.77
Neossolo Litólico (RL)	6.5
Urban Land	5.15
Gleissolo Haplicos (GX)	2.01
Water	0.87
Nitossolo Vermelho (NV)	0.64
Argisslo Vermelho (PV)	0.39
Cambissolo Haplicos (CX)	0.12
Neossolo Quartzenico (NQ)	0.05

Model Set Up e Base de Dados

- The 1:50,000 land us
  Landsat 5 TM, super
- For each crop differe
  initial biomass and t
  for growth) and rota

Land Use	Percentage of Watershed (%)
Pasture	34.75
Sugarcane	30.23
Forest Evergreen	11.3
Urban - Residential	8.71
Cerrado/ Range-Brush	5.89
Citrus/ Orange	4.96
Eucalyptus	2.87
Water	1.29



Scale: 1:50,000
MMU: 900m²
Classification: Supervised
Source: Landsat 5 TM

Model Set Up e Base de Dados

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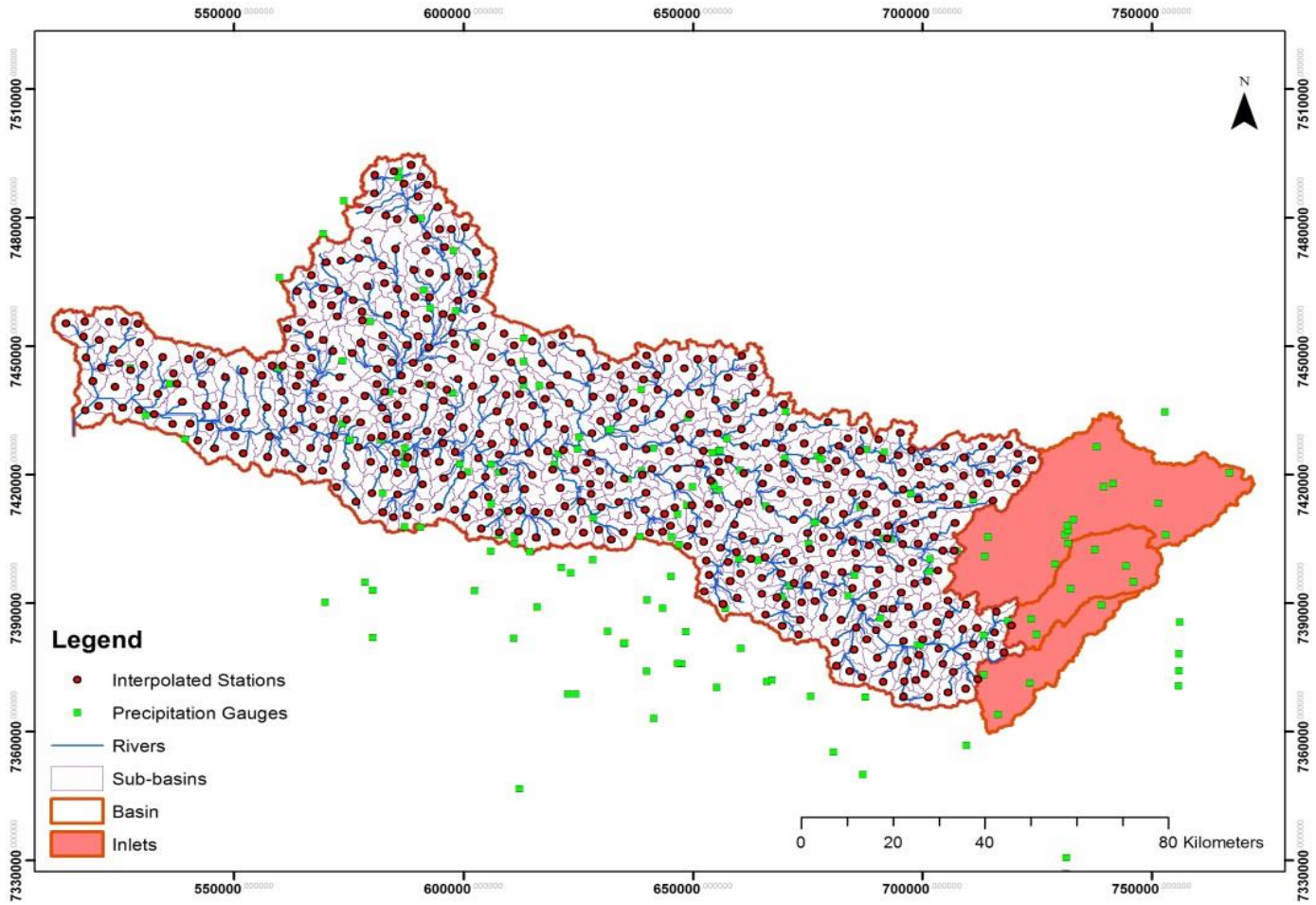
  D…
- C … ,
  s…



First Steps for Calibration

- First PET was compared with literature values for the region. The three methods to calculate the **potential evapotranspiration** were tested and the flow results and average evapotranspiration values for the area were compared, the **Priestley Taylor** method performed better.

- All the different ratios of the water cycle components were also compared with literature values to make sure the yearly average ratios were between expected.

- Biomass production was also compared for the different crops.

- The two methods to calculate the **curve number** were also tested and the daily curve number calculated as a **function of plant evapotranspiration** performed overall better.

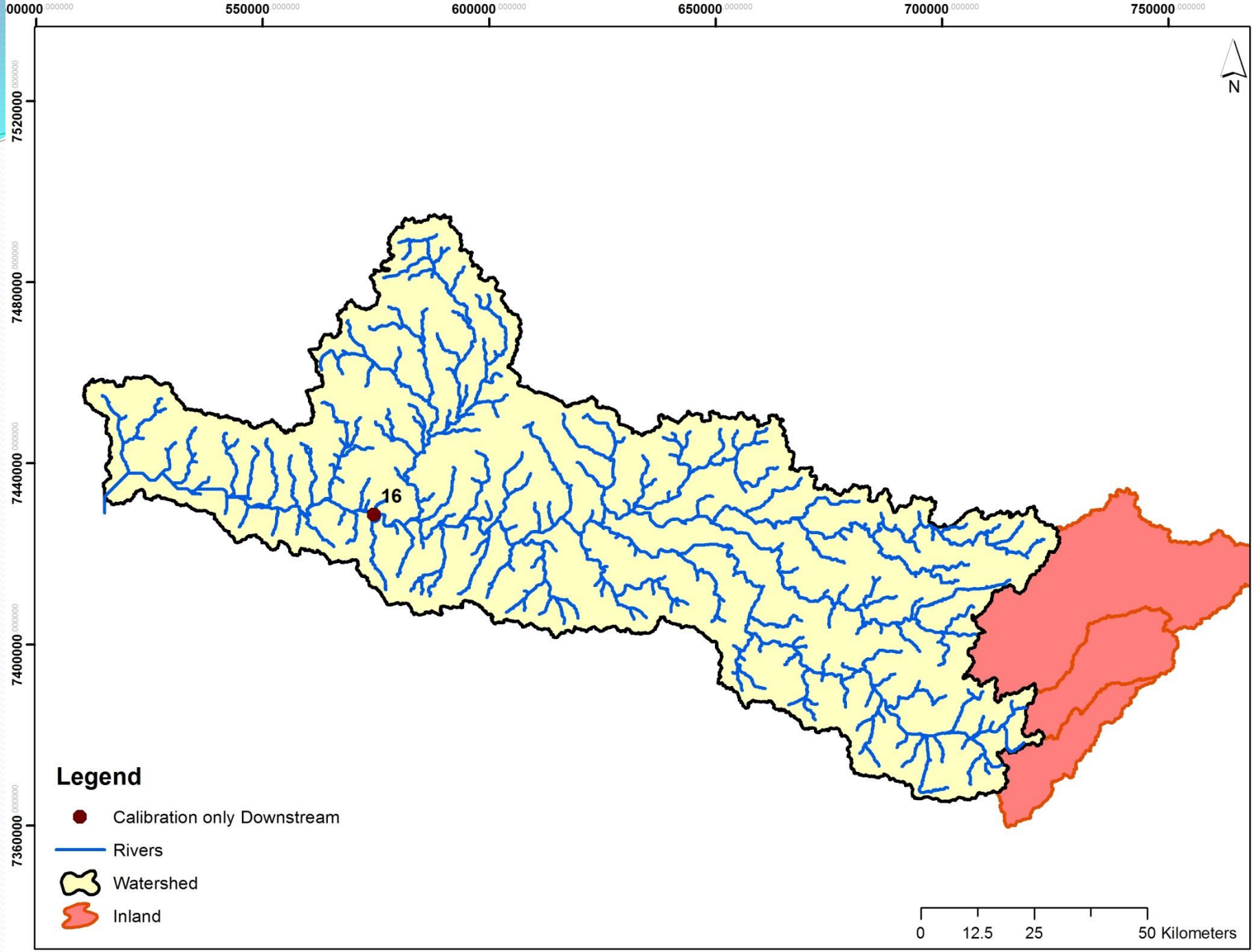
Calibration Techniques

- SWAT-CUP (Abbaspour,et al. ,2011)

- **Sequential Uncertainty Fitting (SUFI-2)**
  - local optimization;
  - consideres all the sources of uncertainty;
  - Latin Hypercube Sampling.
- **Particle Swam Optimization (PSO)**
  - Global optimization algorithm;
  - stochastic optimization
  - similar to genetic algorithms, but without crossover and mutation.

Sensitivity Analysis

	Ranges	
Parameters	**Min**	**Max**
v__SURLAG.bsn	0.05	12
r__ALPHA_BF.gw	-0.05	0.05
v__ESCO.hru	0.65	0.85
r__CN2.mgt	-0.05	0.05
a__GW_DELAY.gw	-20	70
a__GWQMN.gw	3000	4000
v__GW_REVAP.gw	0.02	0.1
a__RCHRG_DP.gw	0	0.1
a__REVAPMN.gw	3500	4000
a__LAT_TTIME.hru	0	15
v__CNCOEF.bsn	0.5	0.75
a__CANMX.hru_____FRSE,PINE,ORAN	0	15
r__SLSUBBSN.hru	-0.05	0.05


00000
550000
600000
650000
700000
750000
7520000
7480000
7440000
7400000
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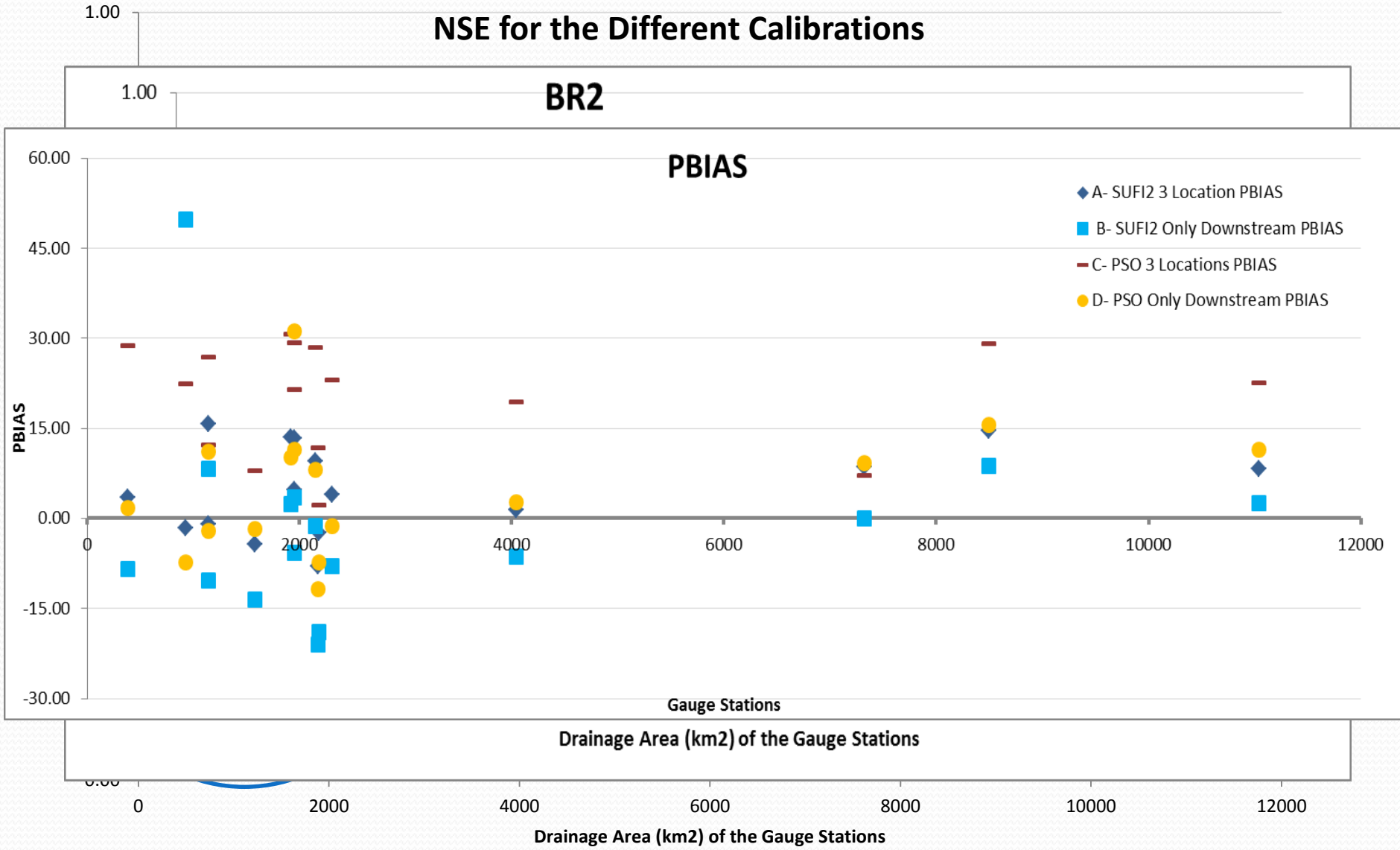
N
16
Legend
Calibration only Downstream
Rivers
Watershed
Inland
0
12.5
25
50 Kilometers

Results – Calibration Metrics

SUFI2		PSO	
3 Locations	Only at Outlet	3 Locations	Only at Outlet
400	**230**	**4500**	**750**

		A- SUFI2 3 Location			B- SUFI2 Only Downstream			C- PSO 3 Locations			D- PSO Only Downstream		
Drainage Area (km2)	**Gauge Station**	**NSE**	**BR2**	**PBIAS**	**NSE**	**BR2**	**PBIAS**	**NSE**	**BR2**	**PBIAS**	**NSE**	**BR2**	**PBIAS**
2308	4	0.76	0.86	3.95	0.75	0.81	-7.98	0.71	0.79	22.98	0.71	0.76	-1.29
1581	12	0.66	0.72	-4.36	0.61	0.68	-13.61	0.64	0.75	7.88	0.61	0.69	-1.74
11040	16	0.83	0.89	8.29	0.83	0.91	2.46	0.78	0.85	22.64	0.78	0.87	11.45

Metrics


NSE for the Different Calibrations
1.00
BR2
1.00
PBIAS
60.00
45.00
30.00
15.00
0.00
-15.00
-30.00
PBIAS
A- SUFI2 3 Location PBIAS
B- SUFI2 Only Downstream PBIAS
C- PSO 3 Locations PBIAS
D- PSO Only Downstream PBIAS
0
2000
4000
6000
8000
10000
12000
Gauge Stations
Drainage Area (km2) of the Gauge Stations
0
2000
4000
6000
8000
10000
12000
Drainage Area (km2) of the Gauge Stations

Classifications

	A- SUFI2 3 Location			SUFI2 Only Downstream			C PSO 3 Locations			D PSO Only Downstream		
	NSE	PBIAS	RSR	NSE	PBIAS	RSR	NSE	PBIAS	RSR	NSE	PBIAS	RSR
Very good	10	12	16	9	11	13	4	3	16	6	9	13
Good	5	3	0	2	2	3	7	2	0	2	5	0
Satisfactory	1	1	0	1	2	0	5	5	0	4	1	0
Unsatisfactory	0	0	0	4	1	0	0	6	0	4	1	3

Categorizations based on Moriasi *et al.* (2007)

Performance Rating	RSR	NSE	PBIAS (%)
Very Good	0.00≤RSR≤0.50	0.75<NSE≤1.00	PBIAS<±10
Good	0.50<RSR≤0.60	0.65<NSE≤0.75	±10≤PBIAS<±15
Satisfactory	0.60<RSR≤0.70	0.50<NSE≤0.65	±15≤PBIAS<±25
Unsatisfactory	RSR>0.70	NSE≤0.50	PBIAS≥±25

Final Remarks

- Ongoing research, uncertainty analysis;
- SUFI2 in 3 locations presented the best results;
- The main results were similar: For the three calibration places the four methods presented good results, although for the 16 cross validation gauges the downstream calibration did not show as good results for some gauges, specially for Nash-Shuttclife coefficient.
- SUFI2 with less runs showed good results;
- Processing time of SUFI2 took a lot less time and was a calibration more oriented. (PSO for 3 places for example had 4500 runs, which took around 46 days, and did not present as good of runs as in SUFI-2 for 3 places)
- The identification of different physical characteristics for calibration was important to better model the different regions with its physical and spatial characteristics taken into account

ACKNOWLEGMENTS

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Muito Obrigada!

Thank you very much!

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