Supplementary material

Figure 1 - Hydrograms (m³/s) and Flow Duration Curves (m³/s) of Selected Stations, with data from ANA (2022) and Chagas et al. (2021).

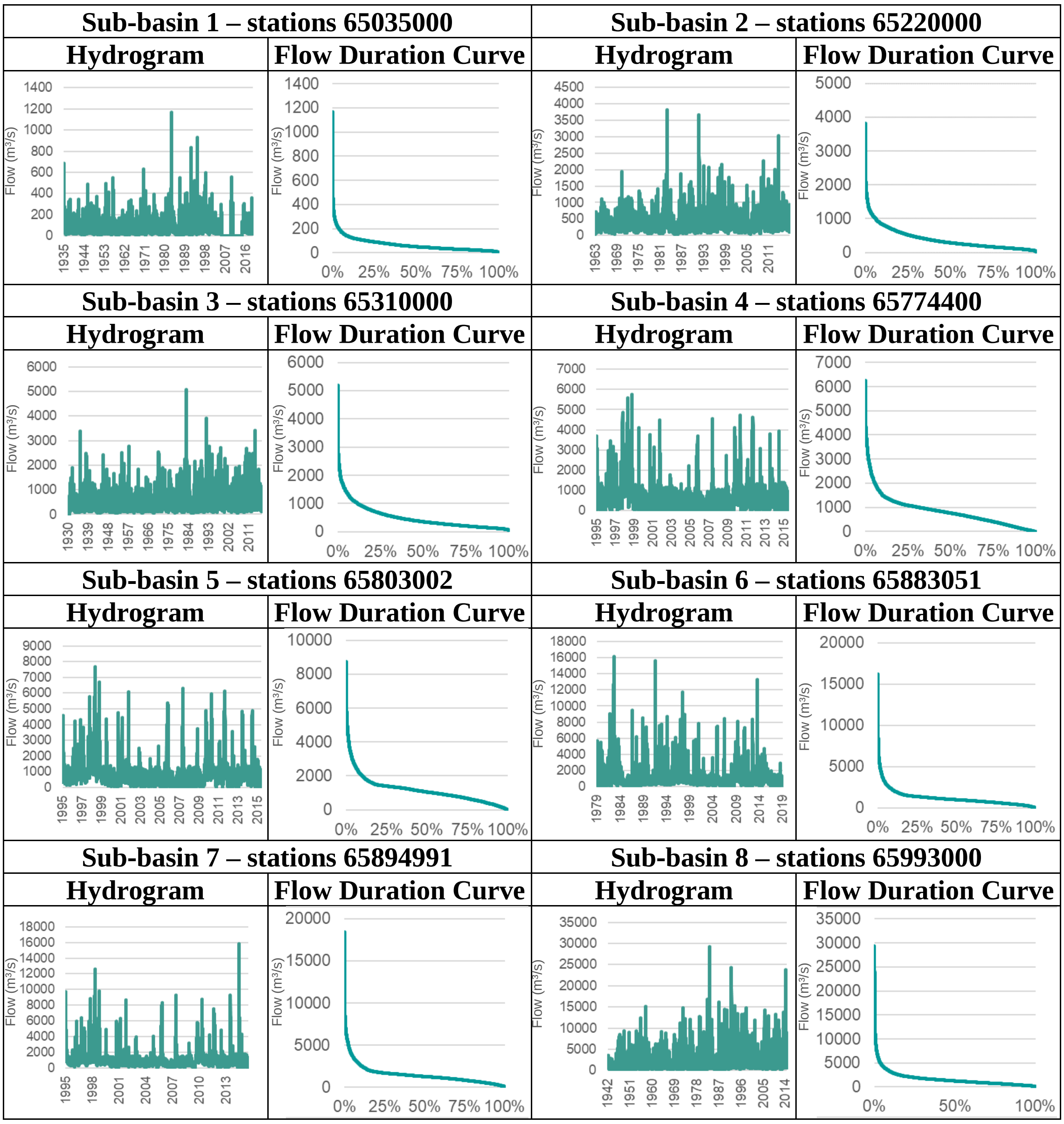


Figure 2 - MGB-IPH model structure (adapted from UFRGS, n.d.).

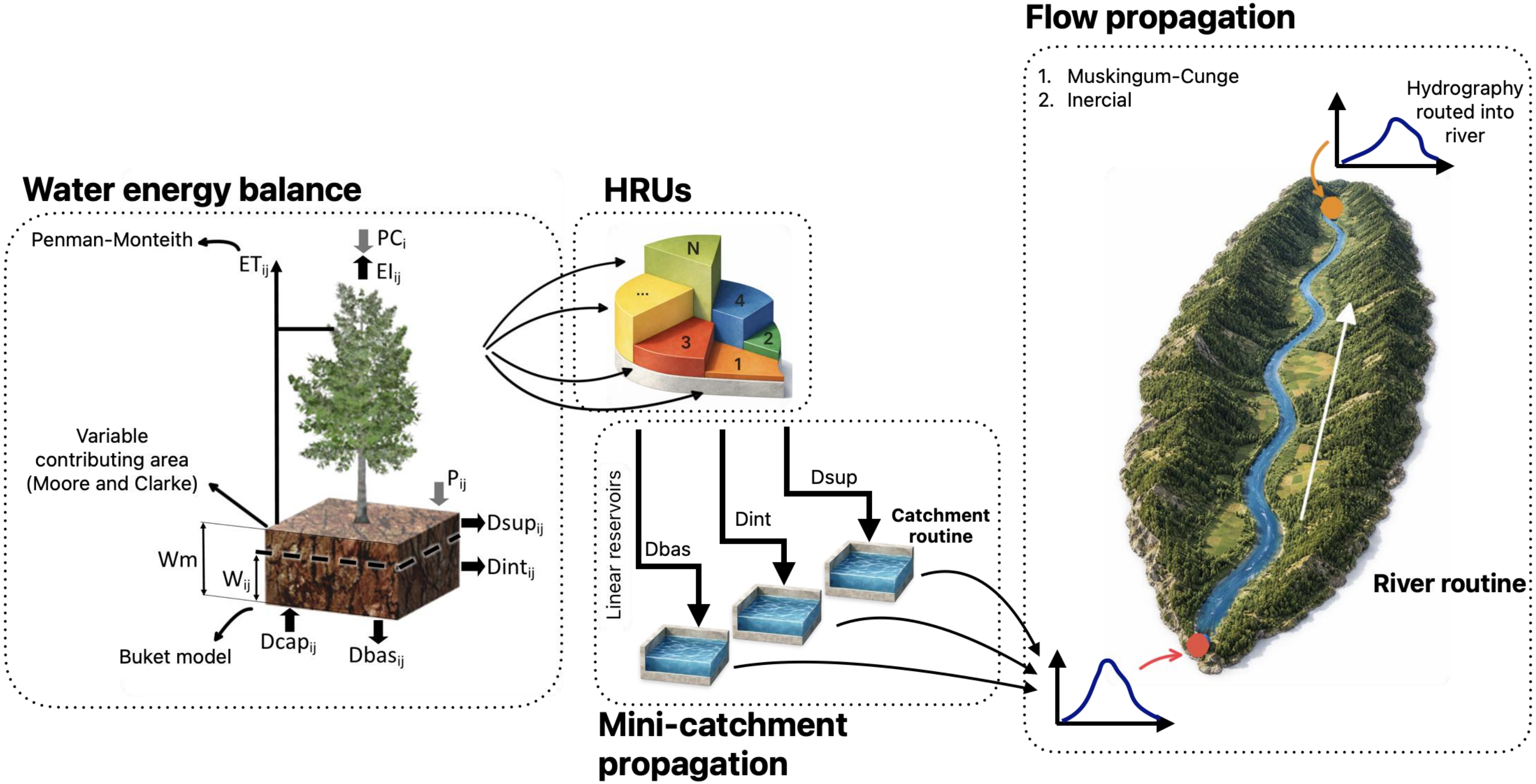
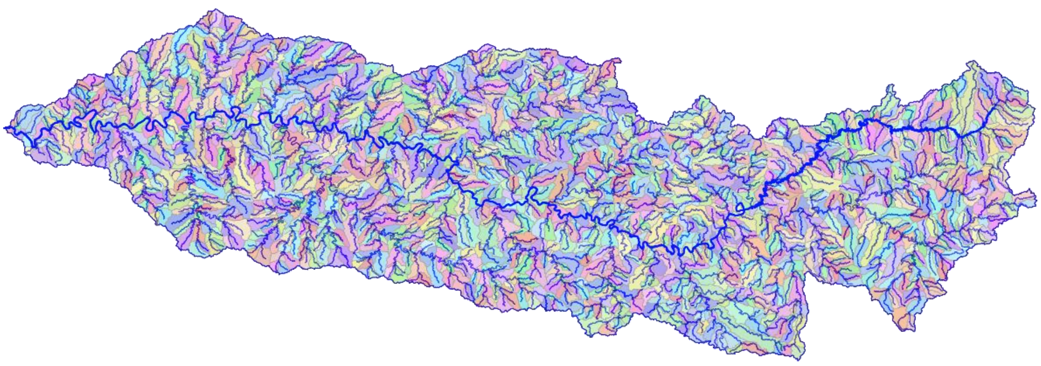


Figure 3 - Basin delineation, drainage network, and resulting mini-basins from IPH-Hydro Tools preprocessing.



Additional information about preprocessing:

- Threshold contributing area for drainage network creation: 20 km^2
- Drainage network segmentation: ArcHydro (enabling subsequent comparison with ANA's Ottobasins (ANA, 2017))

Sub-basins	**Number of mini-catchments**
1	99
2	473
3	191
4	259
5	201
6	140
7	289
8	392
Total	2.044

Table 1 - Applications of Different Types of Hydrological Models in Water Resources Management, adapted from Tucci (2005)

Name	Type	Structure	Characteristics	Examples of Uses
Precipitation-Runoff	Deterministic Empirical Conceptual	Behavior	Calculates the basin runoff from precipitation	Extension of flow series, sizing, real-time forecasting, land use assessment
Flow-Flow	Deterministic Empirical Conceptual		Calculates the flow at a section based on an upstream point	Extension of flow series, sizing, flood forecasting
Stochastic Flow Generation	Stochastic		Calculates flow based on historical series characteristics	Sizing the volume of a reservoir
Saturated Flow	Deterministic		Determines the movement and potential flow of groundwater based on recharge data, pumping, etc.	Pumping capacity, water table level, river-aquifer interaction, etc.
Hydrodynamic	Deterministic		Synthesizes flows in rivers and channel networks	Simulation of system changes, downstream flow effects
Water Quality of Rivers and Reservoirs	Deterministic		Simulates the concentration of water quality parameters	Impact of effluents, reservoir eutrophication, environmental conditions
Water Quality of Rivers and Reservoirs	Deterministic	Behavior and Optimization	Optimizes conduit diameters and verifies design conditions	Water supply network, irrigation network
Reservoir Operation	Deterministic Stochastic		Determines the optimal operation of reservoir systems	Multiple uses
Reservoir Operation	Deterministic Stochastic	Behavior, Optimization, and Planning	Simulates design and operational conditions of systems (uses various models)	Reservoirs, channels, treatment plants, irrigation, river navigation, etc.

Table 2 - Reference use for supporting the hydrological modelling selection, with data adapted from Muhlenhoff (2023)

Software Name (*) Public Domain			**SWMM ***	**SWAT ***	**HSPF ***	**AGNPS ***	**AnnAGNPS**	**CE-QUAL-**	**MIKE SHE**	**HEC-HMS ***	**STORM ***	**WEPP ***	**MGB***
BASIC GENERAL INFORMATION	Developer		USEPA	Texas A&M	USEPA	USDA-ARS	USDA- ARS /	USACE	DHI	USACE	USACE	USDA-ARS	IPH-UFRGS
	Model Type	Export Coefficients	-	-	-	-	-	-	-	-	●	-	-
		Physically based	●	●	●	●	●	-	●	●	●	●	●
	Spatial Land Use Discretization	Urban	●	●	●	-	-	-	●	●	●	-	●
		Rural	●	●	●	●	●	-	●	●	-	●	●
		Agriculture	●	●	●	●	●	-	●	●	-	●	●
		Forest	●	●	●	-	-	-	●	●	-	●	●
		Rivers	●	●	●	-	-	●	●	●	-	-	●
		Lakes	●	●	●	-	-	●	-	-	-	-	●
		Reservoirs/Dams	●	●	●	-	-	●	●	●	-	-	-
	Temporal Discretization	Event-driven	●	-	-	●	-	-	-	-	-	-	-
		Continuous	●	●	●	-	●	-	-	-	-	-	●
	Simulation Temporal Discretization	Sub-daily	●	-	●	●	-	●	●	●	●	-	●
		Daily	●	●	-	-	●	-	-	-	-	●	●
		Monthly	●	-	-	-	-	-	-	-	-	●	-
MATHEMATICAL EQUATION BASIS	Spatial Representation of the Basin (calculation units)	Concentrated	●	-	-	●	●	-	-	-	●	●	-
		Regular grid with uniform hydrological characteristics	-	-	-	-	-	-	-	-	-	-	-
		Permeable and impermeable areas, channels, and reservoirs	-	-	●	-	-	-	-	-	-	-	●
		Hydrological Response Units (HRUs)	-	●	-	-	-	-	●	●	-	-	●
	Rainfall-Runoff Transformation Model	Nonlinear storage (and Manning's equation)	●	-	-	-	-	-	-	-	-	-	-
		SCS (Soil Conservation Service)	●	●	-	●	●	-	-	●	●	-	-
		Maximum Surface Retention	-	-	●	-	-	-	-	-	-	-	-
		Unit Hydrograph	●	-	-	-	-	-	-	●	●	-	-
		Hydrograph	●	-	-	-	-	-	-	●	-	-	-
		Other	-	-	-	-	-	-	●	●	●	●	●
	Evapotranspiration Model	Hargreave	●	●	-	-	-	-	-	-	-	-	-
		Penman	-	●	-	●	●	-	-	-	-	-	●
		Time series	●	-	-	-	-	-	-	●	●	-	-
		Empirical Relationship	-	-	●	-	-	-	●	●	-	●	-

Software Name (*) Public Domain			SWMM *	SWAT *	HSPF *	AGNPS *	AnnAGNPS	CE-QUAL-	MIKE SHE	HEC-HMS *	STORM *	WEPP *	MGB*
	Infiltration Model	Horton equation	●	-	-	-	-	-	-	-	-	-	-
		Modified Horton equation	●	-	-	-	-	-	-	-	-	-	-
		Green Ampt	-	●	-	-	-	-	-	●	-	●	-
		SCS (modified CN)	●	-	-	●	●	-	-	●	●	-	-
		Philip equation	-	-	●	-	-	-	-	-	-	-	-
		Other	-	-	-	-	-	-	●	-	-	-	●
	Propagation Model	Saint-Venant equations	-	-	-	-	-	-	-	-	-	-	●
		Diffusion	●	-	-	-	-	-	-	-	-	-	-
		Kinematic Wave	●	-	-	-	-	-	-	●	-	-	-
		Gravitational	-	-	●	-	-	-	-	●	-	-	-
		Muskingum - Cunge	-	-	-	-	-	-	-	●	-	-	●
		Muskingum	-	●	-	-	-	-	-	●	-	-	-
APPLICABILITY	Simulation of Different Land Use Scenarios		●	●	●	●	●	-	-	●	-	●	●
	Compatibility with GIS for Data Input		●	●	●	●	●	-	-	-	-	●	●
	Compatibility with GIS for Model Calibration		-	-	-	-	-	-	-	-	-	-	●
	Water Resources Management Instruments	Water Availability	-	-	-	-	-	-	-	-	-	-	●

Table 3 - Research on Recent Studies Involving Hydrological Modeling and Water Resources Management and Planning (WRM)

Reference	Keywords	Catchment area	Objective	Relation to WRM
Lopes *et al.*, 2018	Hydrological-hydrodynamic modeling; Large-scale modeling; Integrated modeling; River-lake systems	180.000 km²	To simulate catchments and lagoons in a unified manner	No relation
Wongchuig *et al.*, 2019	Hydrological reanalysis, hydrological-hydrodynamic modeling, Data assimilation; Local EnKF; Long-term dataset; Amazon Basin	6e10^9 km²	To develop hydrological reanalysis	No relation
Munar *et al.*, 2018	Hydrological processes, Hydrodynamic processes, Satellite altimetry, Lake Mirim, MBG-IPH, IPH-ECO	58.400 km²	To understand the functioning of a hydrological model coupled with a hydrodynamic model for simulating basin-lagoon behavior	No relation
Pontes *et al.*, 2017	Hydrological-hydrodynamic modeling; MGB model; GIS coupling; Inertial flow routine; Araguaia Basin	390.000 km³	To present improvements to the MGB model, comparing it with the original version	No relation
Swain,*et al.*, 2020	Brahmani, Baitarani, Blue water, Green water, SWAT, Water scarcity	36.790 km² and 12.094 km²	To assess scarcity and its correlation with climate change and land use	No relation
Schuster *et al.*, 2020	Climate change, Laguna dos Patos Basin, Water availability	182.000 km²	To evaluate water availability in the face of climate change	No relation
Oliveira *et al.*, 2019	Water resources management; Hydrological simulation; Sustainability; Agricultural frontier	37.444 km²	To assess water availability and seasonal variations in streamflow	Mentioned, but not in-depth
Vema e Sudheer, 2020	Distributed hydrological models; Model calibration; Parameter transfer; Computational efficiency; SWAT	2.800 km² and 2.245k km²	To evaluate the impacts of input data resolution on the calibration and validation of the model	Mentioned, but not in-depth
Fleischmann *et al.*, 2021	Hydrological modeling, Large-scale modeling, Hydroelectric power, Flood dynamics, Paraná River Basin, MGB	950.000 km²	To represent the interactions between river-floodplain-reservoir through a hydrological-hydrodynamic model and analyze hydraulic variables	

Figure 4 – LULC Classes for the Iguaçu River Basin According to Mapbiomas for the Years 2009 and 2021.

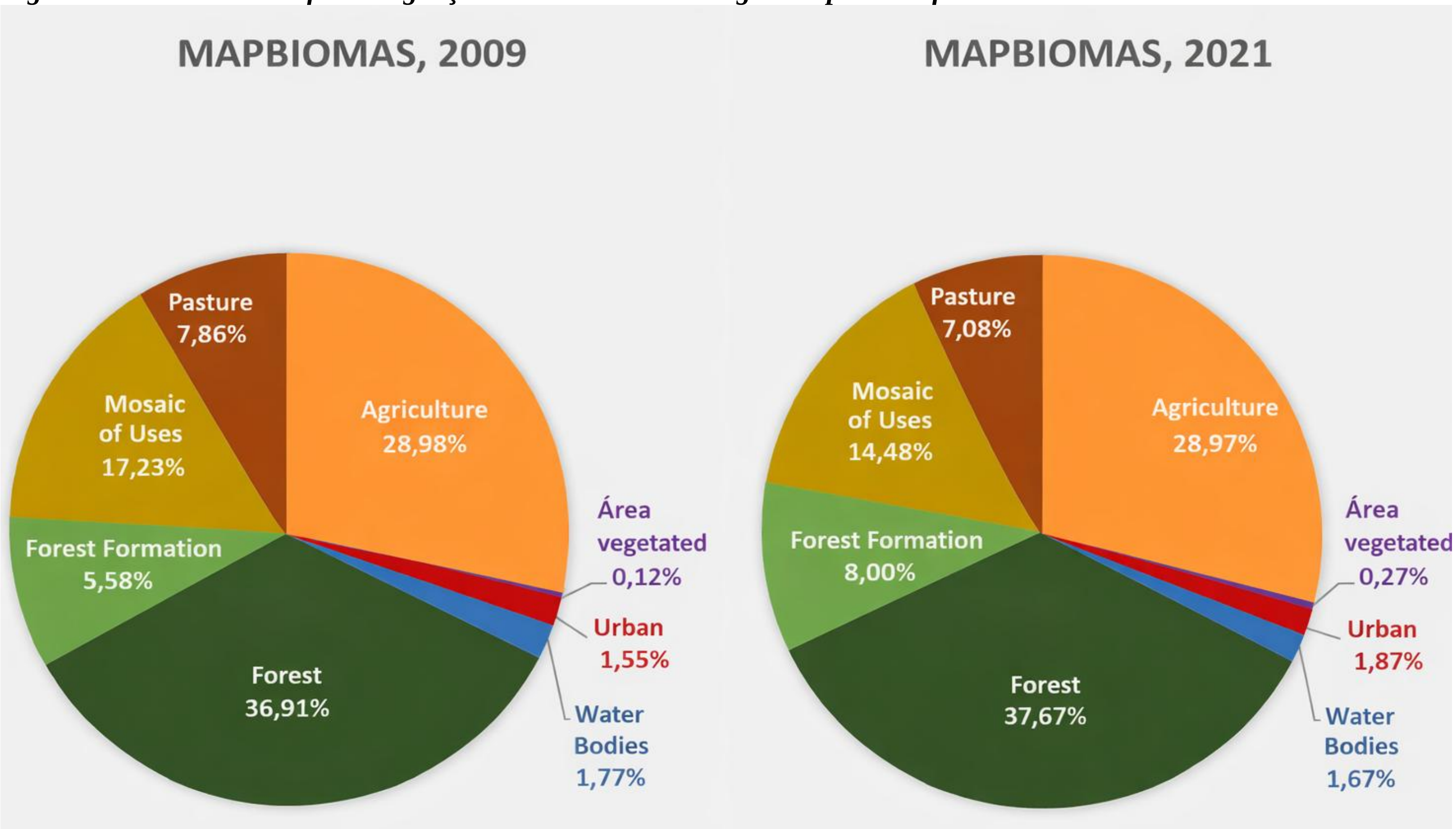
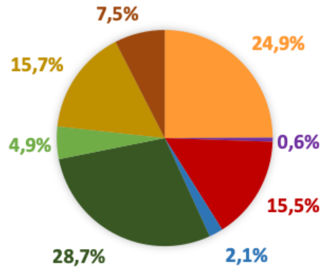
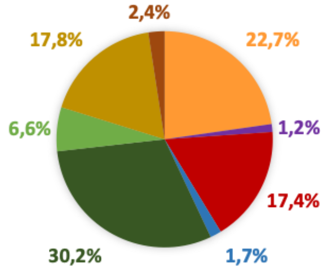
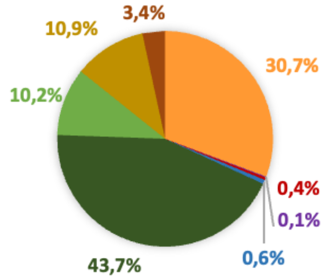
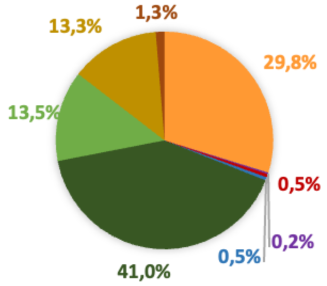
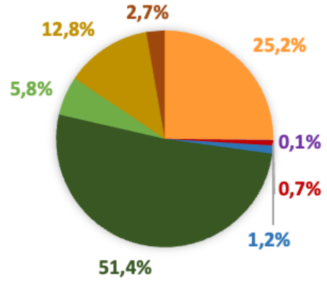
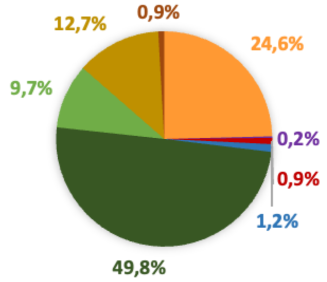
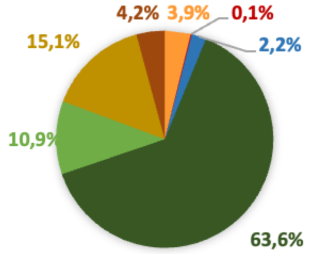
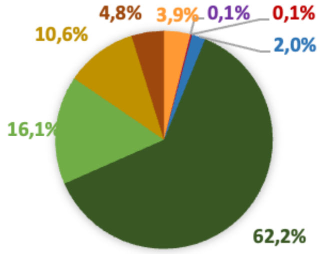


Figure 5 – Spatial distribution of LULC Classes for the sub-basins Iguaçu River Basin According to Mapbiomas for the Years 2009 and 2021.

Legend:

- Agriculture
- Non-vegetated Areas
- Urban Areas
- Water Bodies
- Forest
- Forest Formation
- Mosaic of Land Uses
- Pasture

Sub-basins	Mapbiomas 2009	Mapbiomas 2021
1		
2		
3		
4		

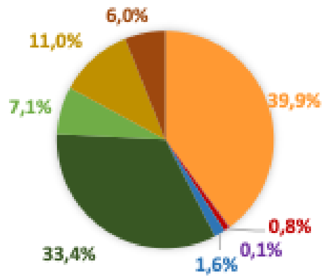
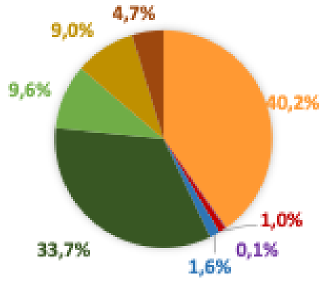
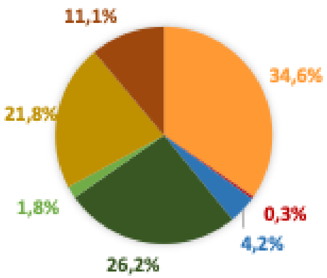
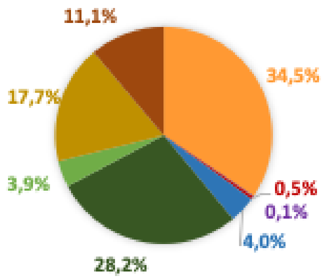
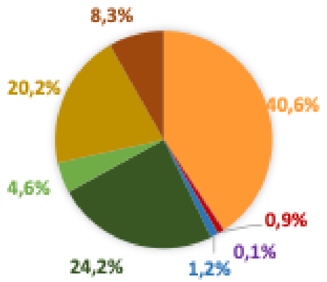
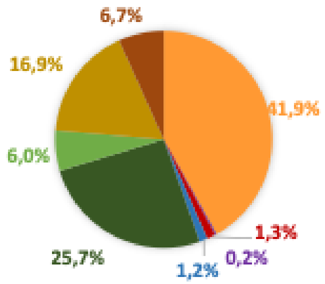
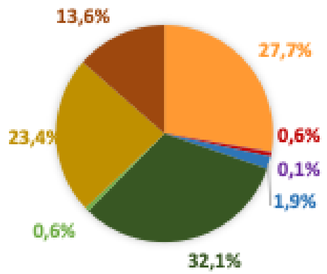
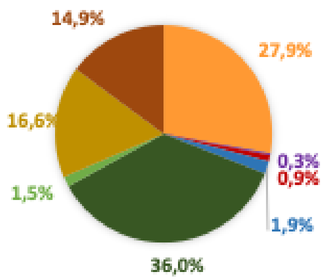
Sub-basins	Mapbiomas 2009	Mapbiomas 2021
5		
6		
7		
8		

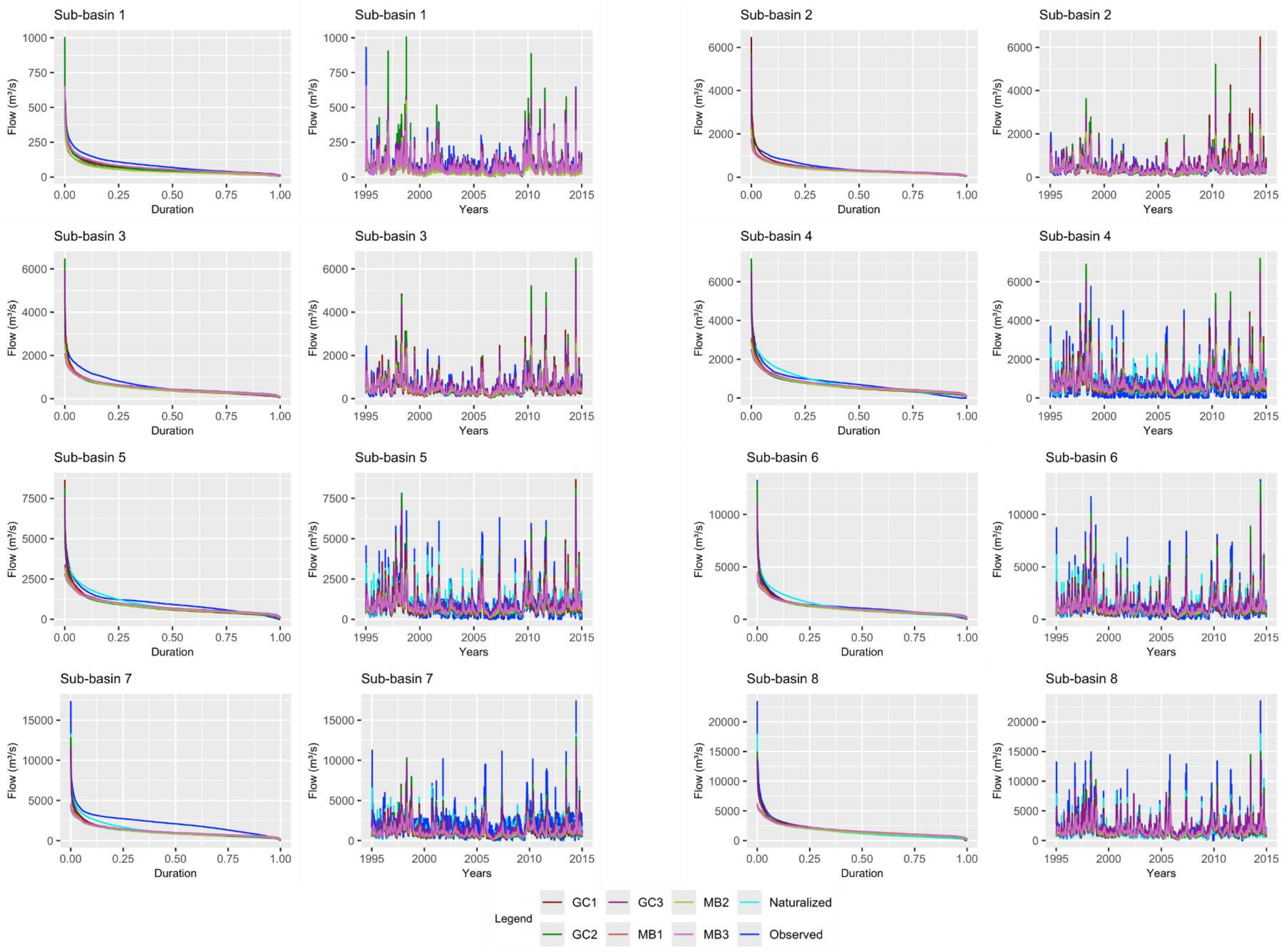
Table 4 – Logarithm of Nash-Sutcliffe Efficiency (logNSE) Coefficients of MGB Calibrations and Validations

HRUs	Calibrations	Periods of time	Sub-basins							
			1	2	3	4	5	6	7	8
HRUs GlobCover (ESA 2009)	GC1	1995-2001	0,619	0,73	0,789	0,165	0,342	0,333	-1,689	0,624
		2002-2007	0,068	0,654	0,734	-0,014	0,123	-0,081	-0,287	0,49
		2008-2014	0,527	0,757	0,813	0,02	0,124	0,045	-0,408	0,396
	GC2	1995-2001	0,425	0,567	0,666	0,158	0,462	0,479	-1,242	0,692
		2002-2007	-0,175	0,479	0,624	-0,012	0,126	-0,019	-0,162	0,638
		2008-2014	0,247	0,585	0,685	0,019	0,136	0,115	-0,26	0,462
	GC3	1995-2001	0,803	0,715	0,759	0,15	0,573	0,506	-0,918	0,7
		2002-2007	0,636	0,695	0,76	-0,058	0,114	-0,072	-0,08	0,489
		2008-2014	0,697	0,716	0,759	0,007	0,138	0,091	-0,2	0,42
HRUs Mapbiomas (2021)	MB1	1995-2001	-0,044	0,652	0,592	0,169	0,257	0,315	-1,501	-0,125
		2002-2007	-1,297	0,528	0,532	0,035	0,172	0,084	-0,131	0,239
		2008-2014	0,046	0,716	0,642	0,06	0,155	-0,29	-0,609	0,062
	MB2	1995-2001	0,079	0,608	0,53	0,154	0,315	0,388	-1,228	-0,007
		2002-2007	-1,067	0,513	0,477	0,026	0,159	0,121	-0,053	0,366
		2008-2014	0,119	0,684	0,594	0,051	0,146	0,193	-0,207	0,132
	MB3	1995-2001	0,662	0,669	0,543	0,144	0,359	0,419	-0,892	0,105
		2002-2007	0,331	0,657	0,562	-0,008	0,144	0,077	0,029	0,441
		2008-2014	0,767	0,706	0,573	0,041	0,145	0,175	-0,124	0,419

Table 5 – Bias Coefficients of MGB Calibrations and Validations

HRUs	Calibrations	Periods of time	Sub-basins							
			1	**2**	**3**	**4**	**5**	**6**	**7**	**8**
HRUs GlobCover (ESA 2009)	GC1	1995-2001	-24,5%	-17,6%	-16,3%	-14,4%	-20,8%	-10,4%	-36,5%	-7,4%
		2002-2007	-41,2%	-23,2%	-23,3%	-18,4%	-26,1%	-10,8%	-48,8%	-6,4%
		2008-2014	-23,0%	-14,6%	-14,3%	-8,3%	-18,0%	-7,7%	-47,2%	-5,5%
	GC2	1995-2001	-24,7%	-18,2%	-17,0%	-15,1%	-21,4%	-10,9%	-36,9%	-8,0%
		2002-2007	-42,1%	-24,5%	-24,5%	-19,5%	-26,9%	-11,3%	-49,1%	-6,7%
		2008-2014	-23,4%	-15,1%	-14,9%	-8,9%	-18,4%	-8,2%	-47,4%	-6,2%
	GC3	1995-2001	-17,9%	-13,3%	-12,1%	-11,3%	-18,2%	-8,3%	-35,2%	-3,6%
		2002-2007	-22,4%	-1,6%	-2,3%	65,1%	-11,2%	3,7%	-41,0%	9,0%
		2008-2014	-13,0%	-8,5%	-8,1%	-3,1%	-13,6%	-3,8%	-45,0%	0,4%
HRUs Mapbiomas (2021)	MB1	1995-2001	-41,0%	-21,8%	-17,7%	-15,3%	-21,8%	-14,0%	-39,5%	-14,7%
		2002-2007	-59,9%	-28,7%	-24,8%	-19,4%	-27,1%	-16,1%	-52,3%	-16,2%
		2008-2014	-41,1%	-19,0%	-15,8%	-9,4%	-19,0%	-49,7%	-48,9%	-14,3%
	MB2	1995-2001	-40,5%	-22,0%	-18,1%	-15,7%	-22,2%	-14,4%	-39,8%	-14,8%
		2002-2007	-59,5%	-29,1%	-25,6%	-20,2%	-27,7%	-16,5%	-52,5%	-15,7%
		2008-2014	-40,3%	-19,0%	-16,1%	-9,7%	-19,2%	-11,8%	-49,9%	-14,2%
	MB3	1995-2001	-18,6%	-17,7%	-15,6%	-14,2%	-20,9%	-11,6%	-37,7%	-9,0%
		2002-2007	-25,7%	-13,5%	-12,8%	-9,1%	-19,0%	-5,3%	-46,2%	-1,8%
		2008-2014	-14,4%	-13,2%	-12,1%	-6,7%	-16,9%	-7,7%	-47,4%	-5,0%

Figure 6 - Hydrographs and flow duration curves of all simulations for sub-basins analyzed.



Overall, all simulations yielded improved results when combined with the HRUs from GlobCover (Arino et al., 2012), as this served as the database for calibration. Sub-basin 1 exhibited the best performance in terms of efficiency coefficients and the visual analysis of the hydrograph and flow duration curve (Figure 4). This can be attributed to the fact that it is not impacted by reservoirs, allowing the model to simulate the basin's naturalized flows accurately.

A similar pattern was observed in sub-basins 2 and 3, where simulations GC1 and GC3 produced the most favorable results, while simulation GC2 resulted in overestimated peak flows and underestimated minimum flows, as evident in their respective hydrographs. This discrepancy is due to the calibration method employed, which focused on the basin's outlet.

From sub-basin 4 onwards, the observed flow hydrographs (Figure 8) display the characteristic regularization behavior of reservoir inflows, with simulation results converging towards naturalized flows. This effect is particularly pronounced in the flow duration curve (Figure 4) of sub-basin 7, where observed flows are notably higher, suggesting that this sub-basin accumulates the effects of the reservoirs. However, these effects are mitigated in sub-basin 8. Given that the MGB simulates naturalized flows, excluding observed flows from the analysis clarifies the pattern of greater differences in maximum flows, as observed data reflect the impact of reservoirs on flow regularization.

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