

International SWAT Conference

Simulating the impact of urbanization on streamflow for reservoir management in the semi-arid San Juan River basin, Northeast Mexico

Eliana Torres Peralta^{1,2}, Shreedhar Maskey¹, Aldo I. Ramirez³

¹ IHE Delft Institute for Water Education, The Netherlands.

² Delft University of Technology, The Netherlands.

³ Monterrey Institute of Technology and Higher Education, Mexico.

CONTENTS

Context

Objective

Methodology

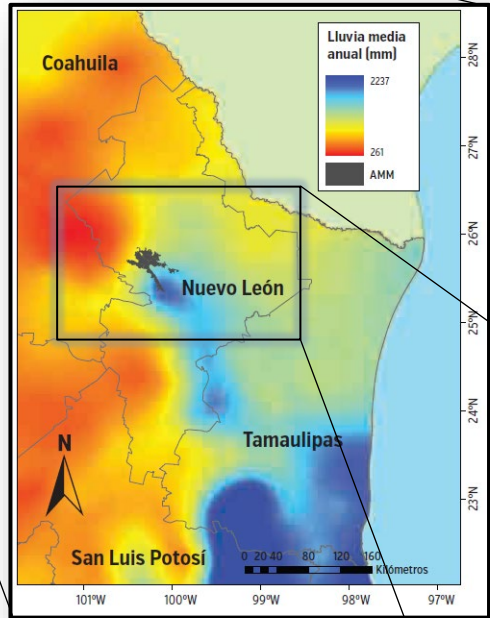
Preliminary results

Conclusion

Next steps

Context

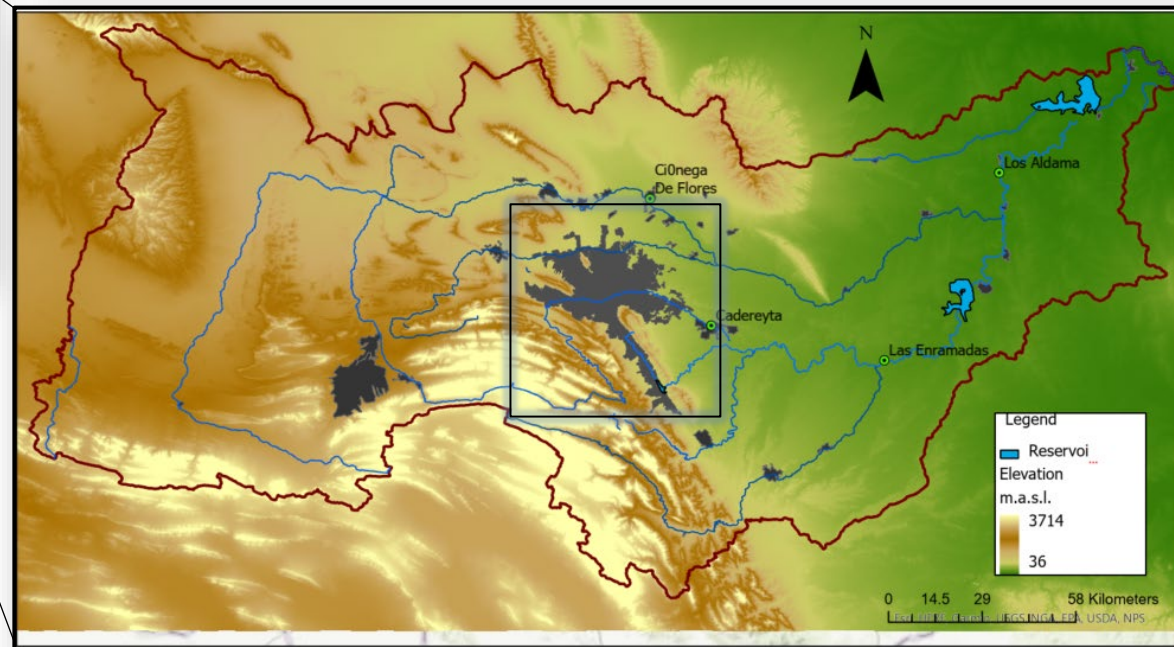
San Juan river basin, Mexico



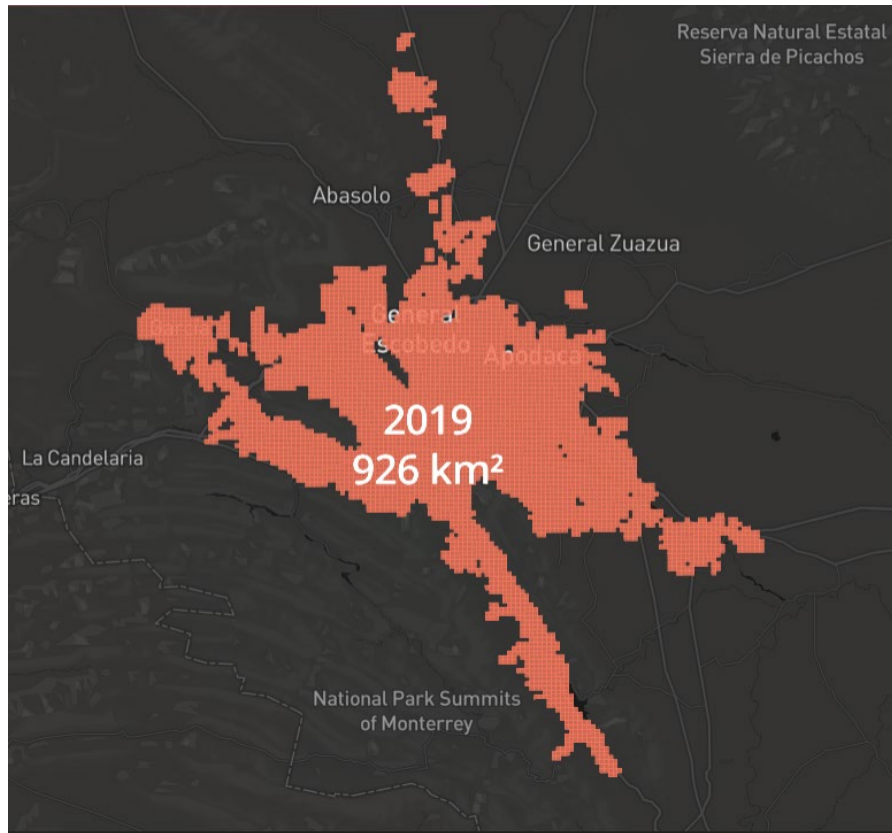
(Source: Aguilar, Sisto, & Ramirez, 2015)



Monterrey
Metropolitan
Area
(5,341,171 inhabitants)



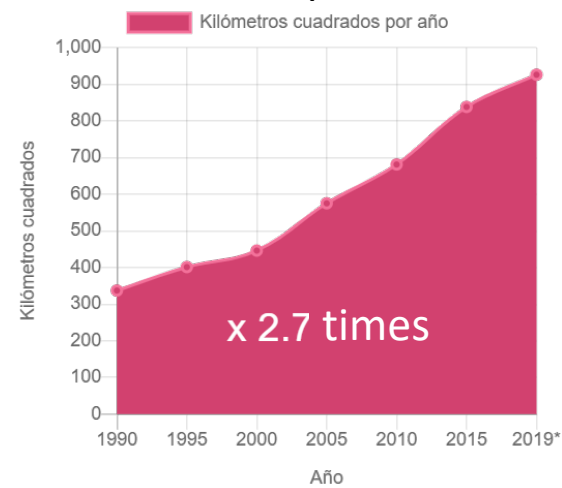
San Juan River
basin
Total Area: 32 415 km²



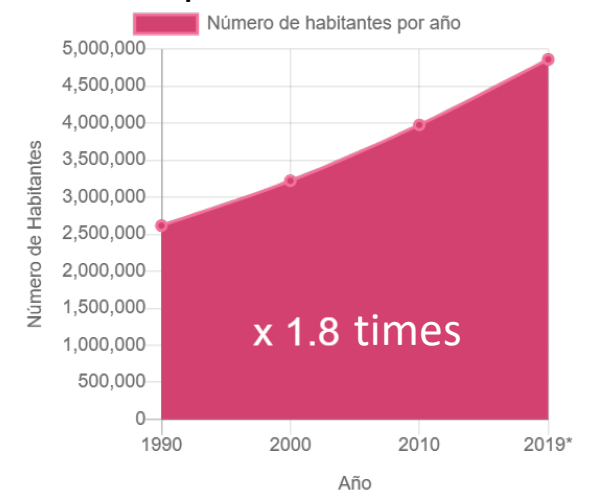
(Source: Expansion urbana de Monterrey, ITESM, 2019)



Urban expansion

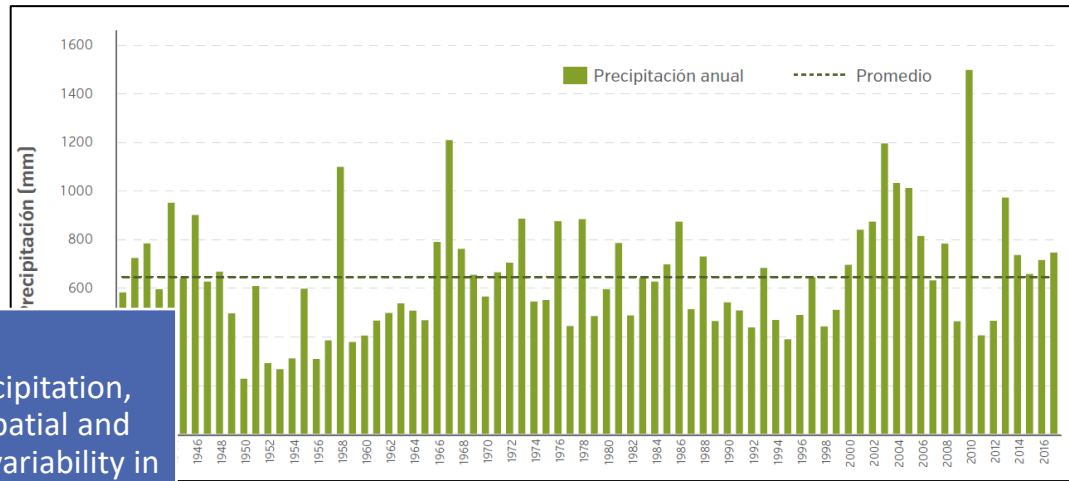


Population increase



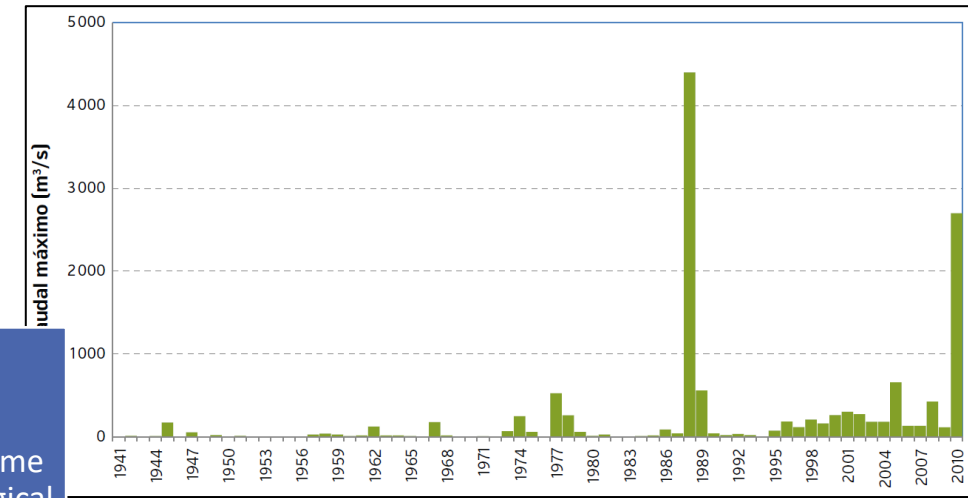
Context

Hydrological complexity



Low precipitation,
strong spatial and
temporal variability in
rainfall

(Source: Aguilar, Sisto, & Ramirez, 2021)

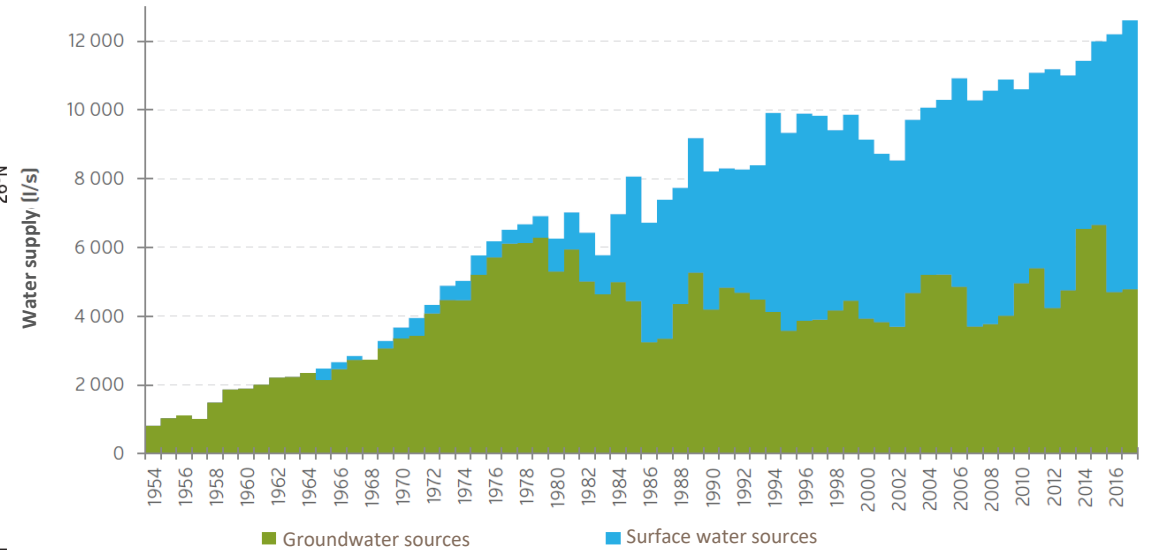
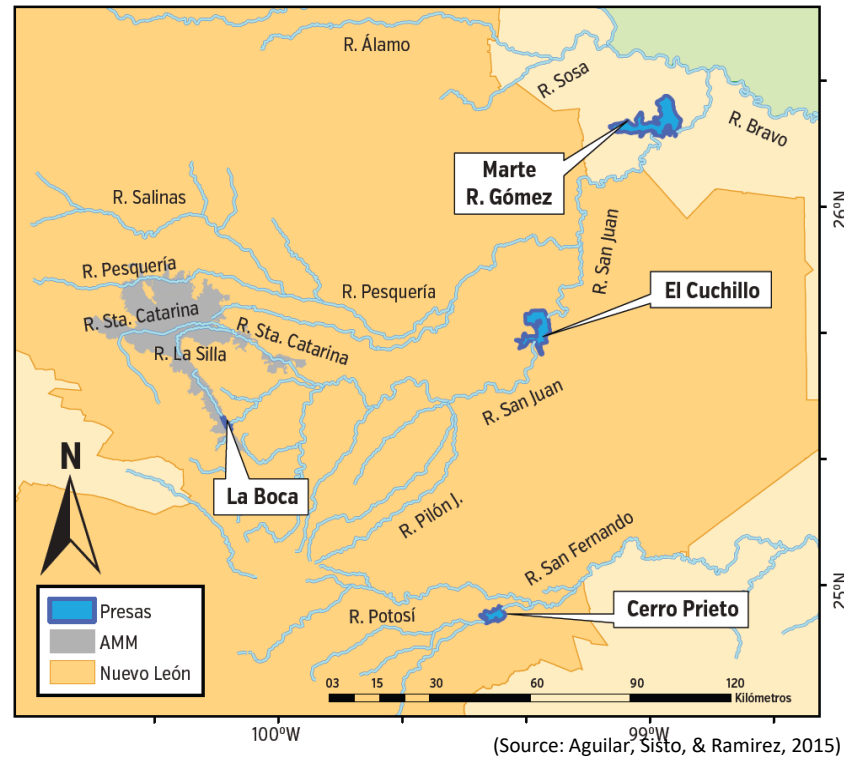


Frequent dry
periods, and
occasional extreme
hydrometeorological
events

(Source: Aguilar, Sisto, & Ramirez, 2021)



Approx 60% of the regional water supply is dependent on reservoir storage

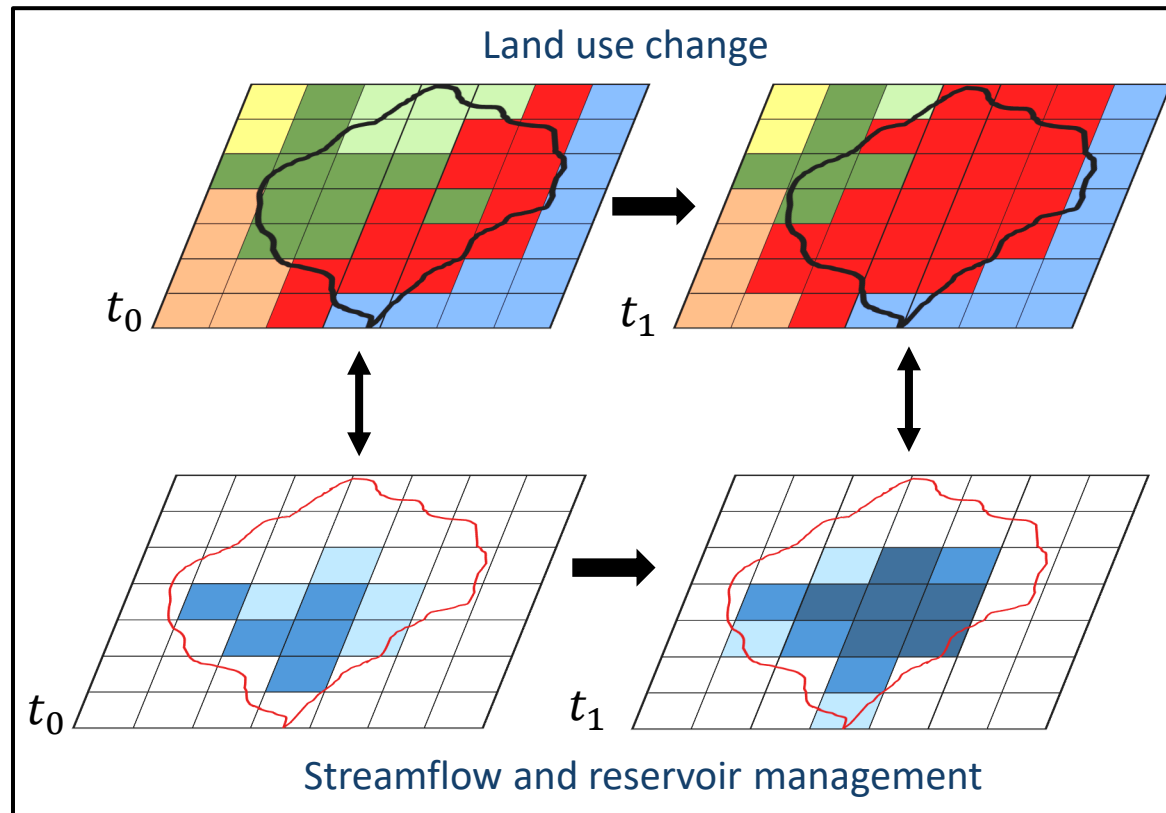


Reservoirs

1. La Boca: 39.5 Mm³
2. El Cuchillo: 1123 Mm³
3. MRG: 781 Mm³

Objective

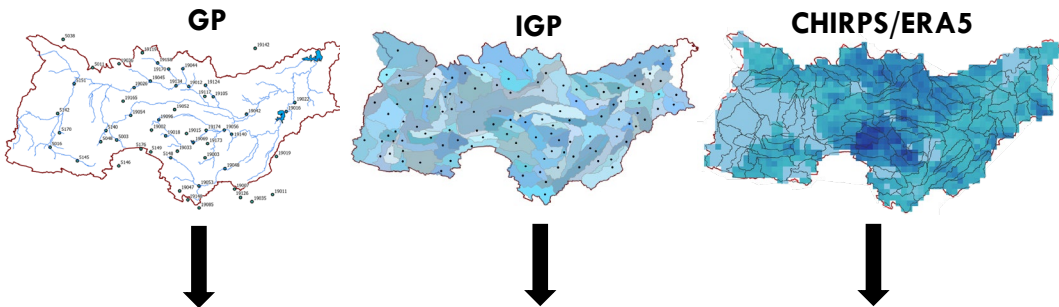
Analyze the impact of urbanization on water resources (streamflow and reservoir management) in the San Juan River Basin.



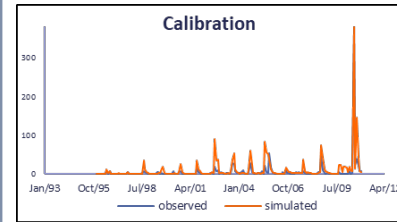
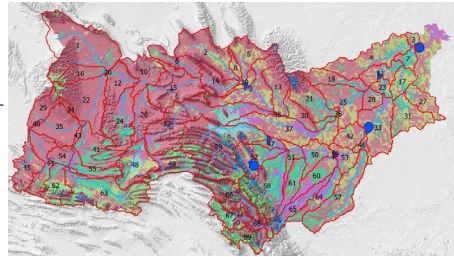
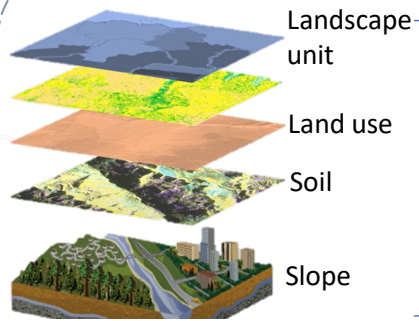
Methodology

FIRST STAGE

1 Evaluation of precipitation inputs on streamflow simulation



Swat+ model

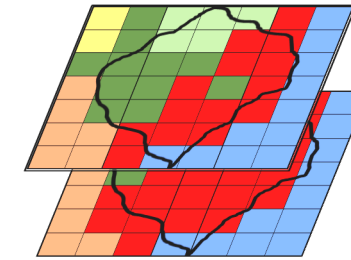


Calibrated model (1995-2012)
with best input

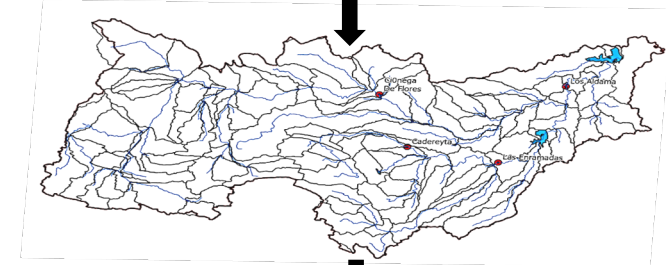


SECOND STAGE

Simulation of the impact of urbanization on streamflow for reservoir management

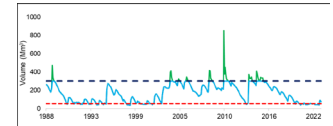
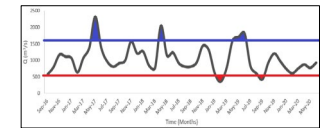
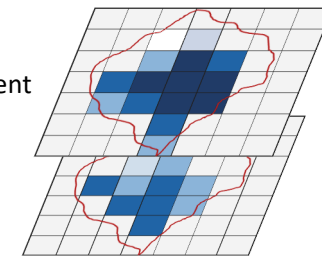
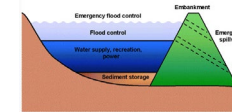


Historical urbanization



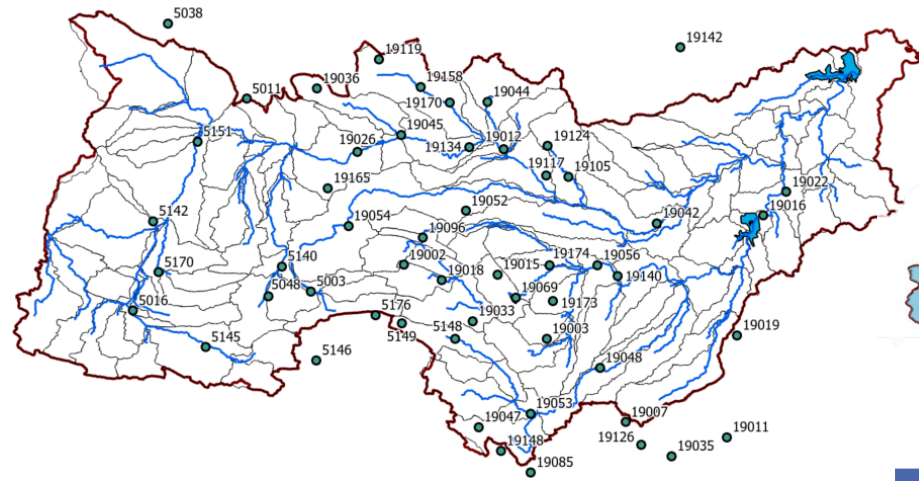
Impact on

- Streamflow changes
- Reservoir management



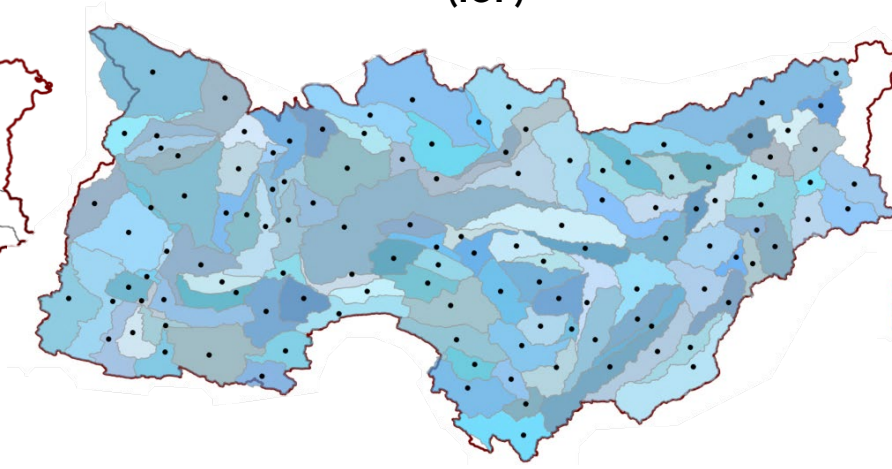
Inputs

**Gauge Precipitation
(GP)**



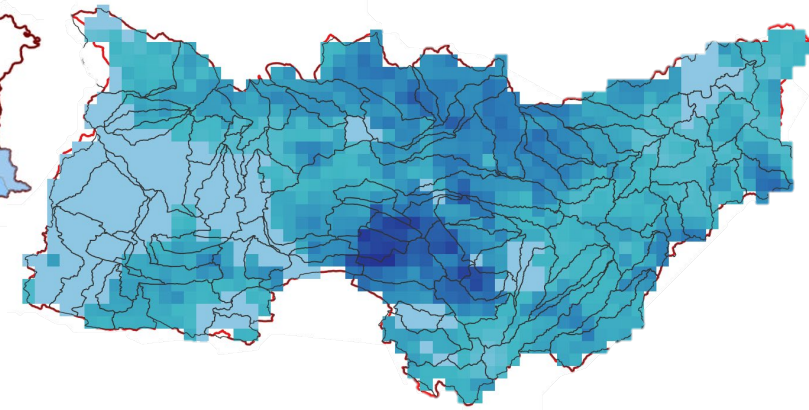
Daily precipitation from 54 stations
(1995-2022)

**Interpolated Gauge Precipitation
(IGP)**



Daily precipitation interpolated using Inverse Distance
Elevation Weighted (IDEW) method from 54 gauges over a
5 km × 5 km grid and averaged over each Landscape unit
Tool: Hykit (Maskey, 2013)

CHIRPS

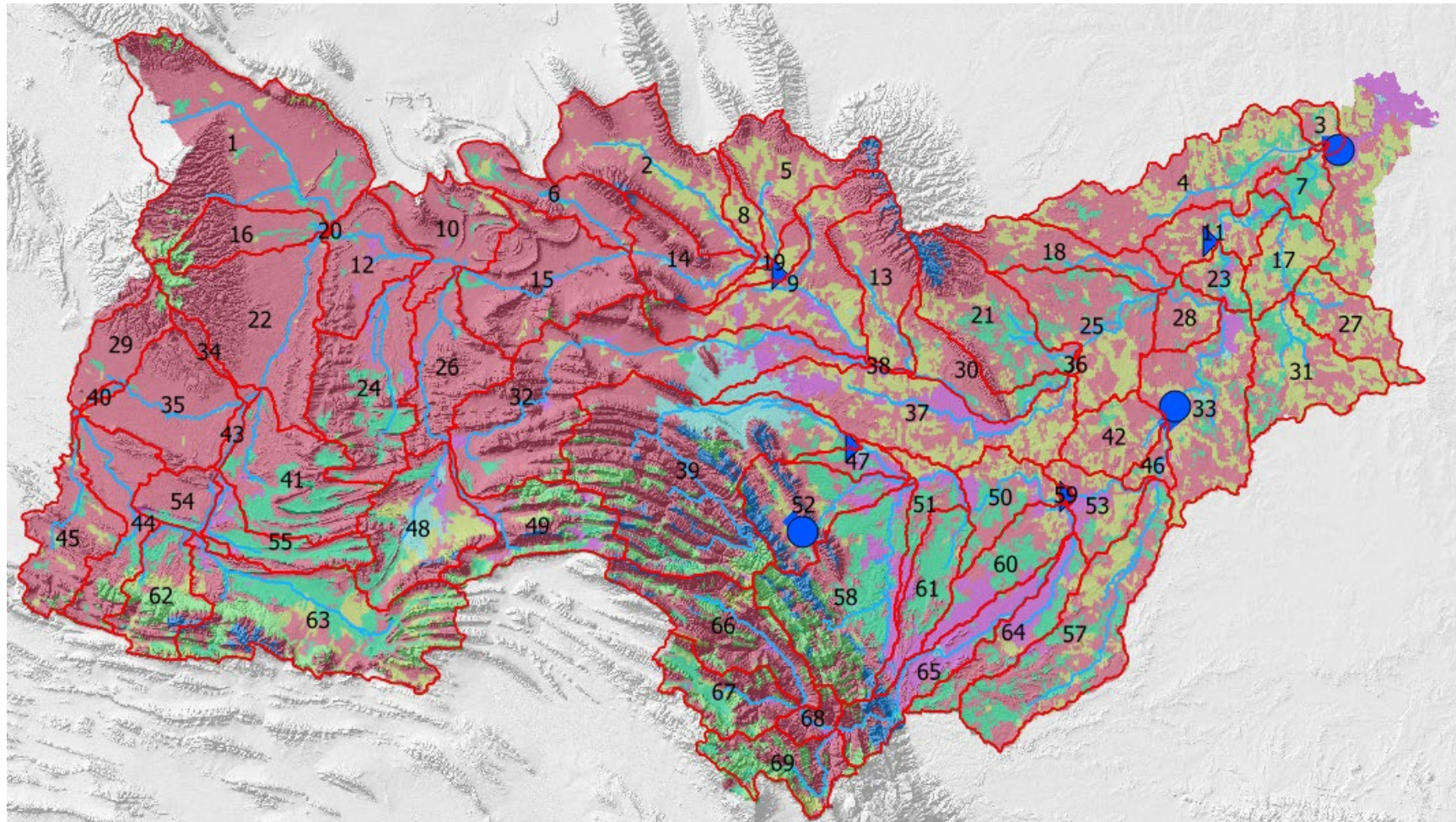


CHIRPS v2.0 daily precipitation from CHIRPS at
0.05° resolution and averaged over each
Landscape unit (1981-2023)

Variable	Source	Spatial/temporal resolution
Land Cover map	INEGI National Institute of Statistics and Geography	2001 (available from 1997 to 2021)
Temperature	CONAGUA – ERA5 (National Water Commission of Mexico)	Gauge stations with more than 70% with data and missing data completed using ERA daily dataset Daily (1981 – 2022)
Streamflow	CONAGUA (National Water Commission of Mexico)	Daily (1995-2017)

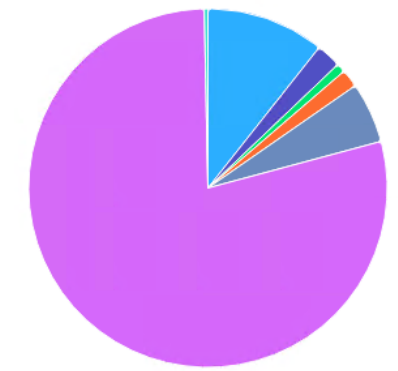
Preliminary results

Swat+ model



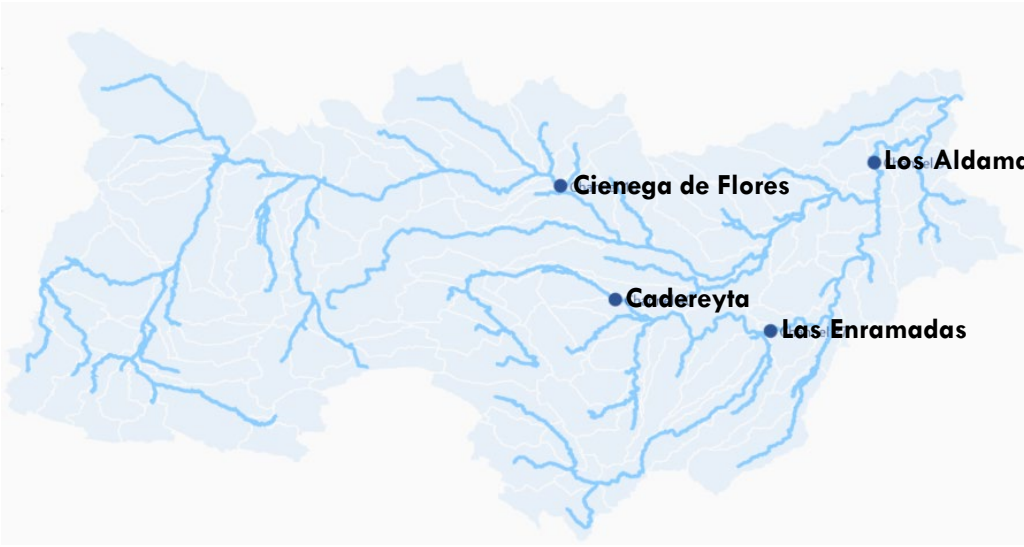
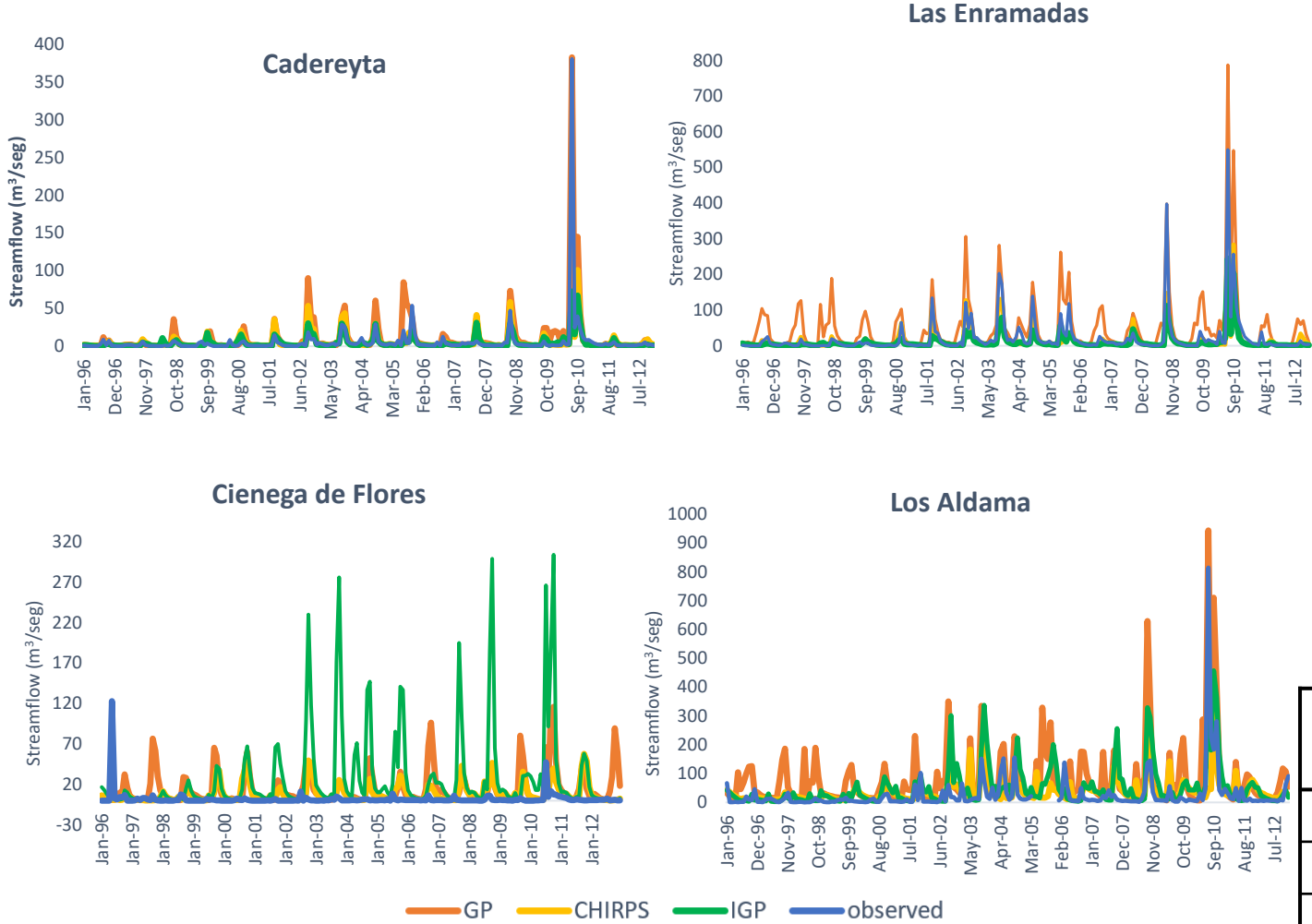
69	Subbasins
139	HRUs
136	Channels
70	Aquifers
3	Reservoirs
139	Routing Units
139	Landscape Units
139	Point Sources / Inlets

Land use distribution



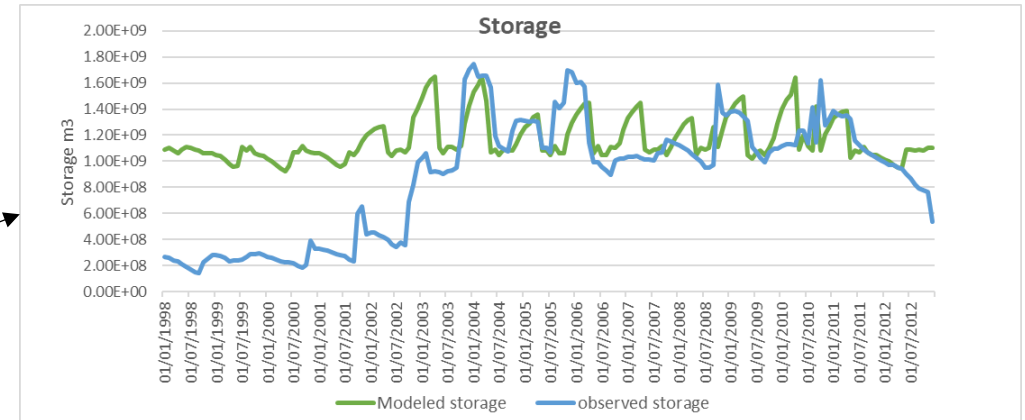
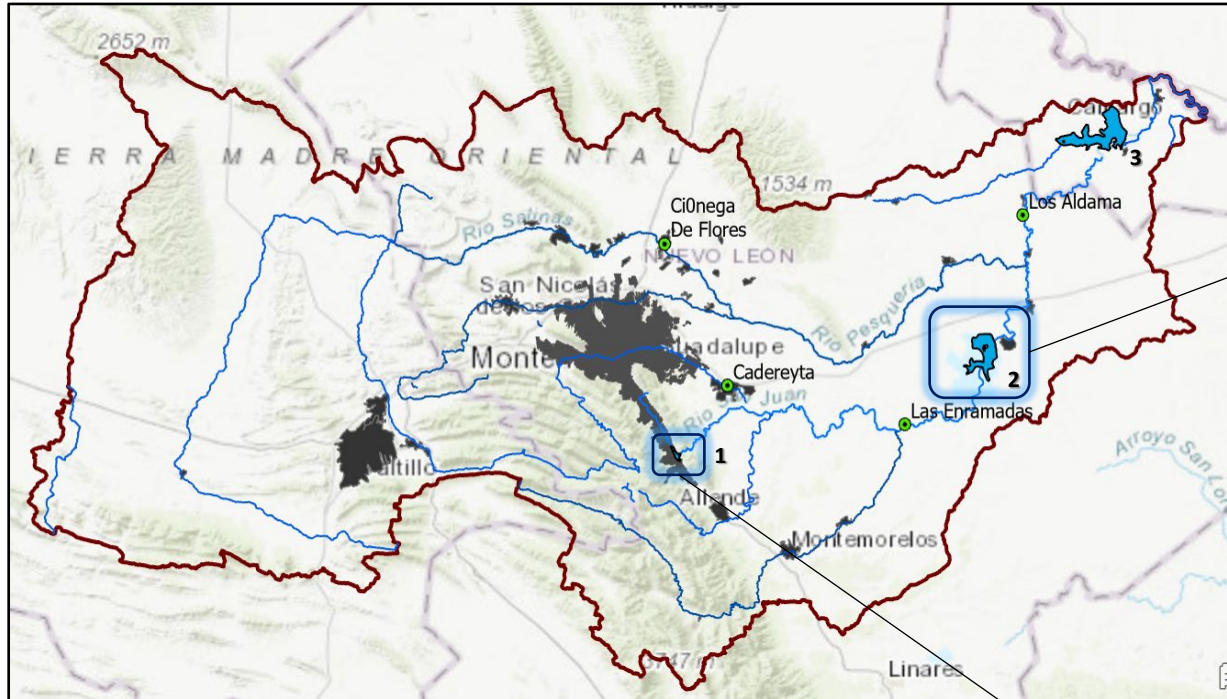
● agrl ● agrr ● frsd ● frse ● past ● rngb ● urbn

Preliminary results



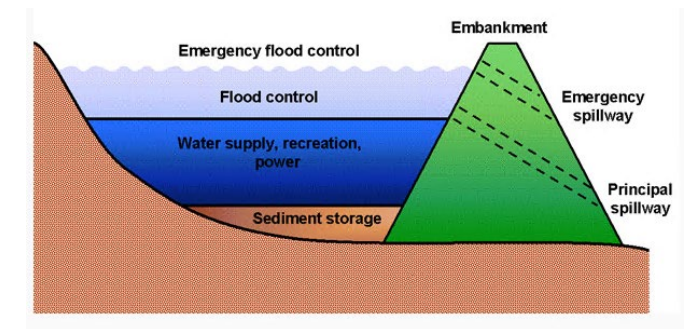
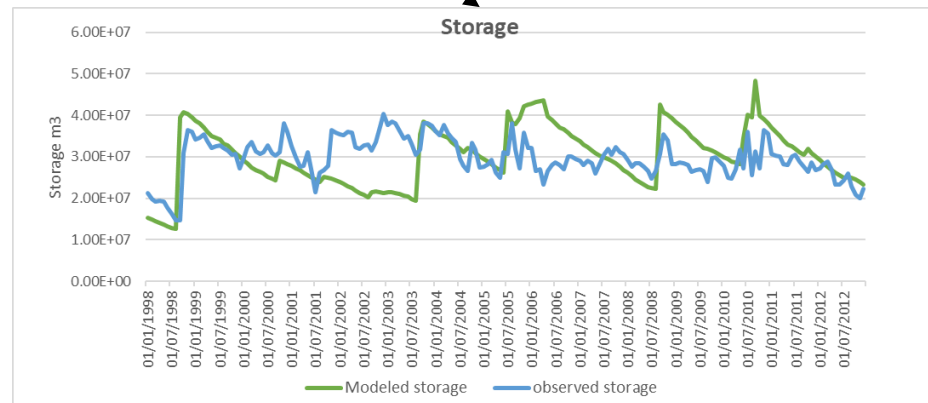
Station	NSE			R ²			PBIAS		
	GP	IGP	CHIRPS	GP	IGP	CHIRPS	GP	IGP	CHIRPS
Cadereyta	0.75	0.34	0.18	0.91	0.69	0.42	-72.72	25.16	5.98
Las Enramadas	0.19	0.59	0.49	0.78	0.90	0.70	-136.33	50.62	35.95
Cienega de Flores	-5.54	-36.03	-1.92	0.09	0.04	-0.05	-562.13	-1228.51	-314.71
Los Aldama	-0.57	0.21	0.09	0.59	0.53	0.26	-193.66	-87.30	-37.62

Preliminary results

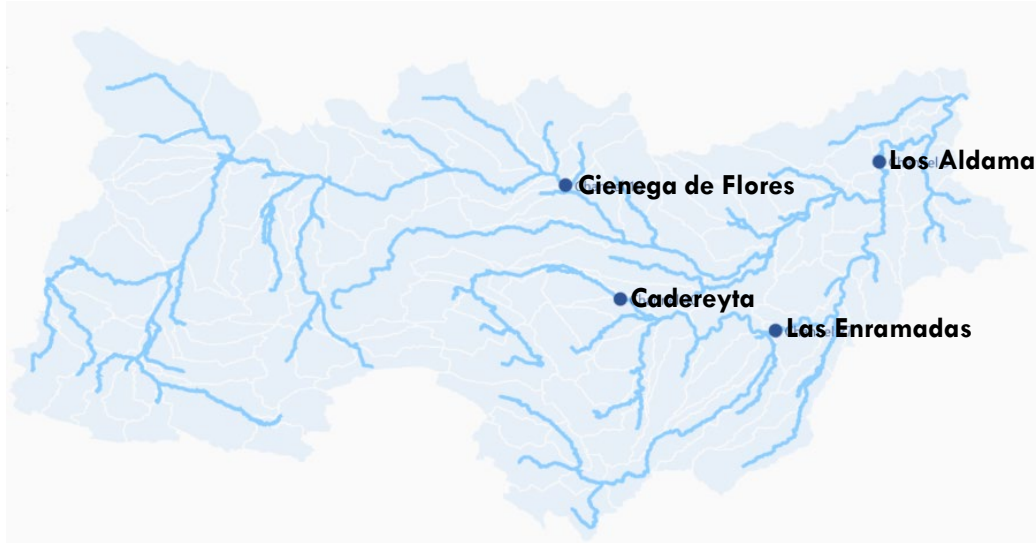


Reservoirs

1. La Boca: 39.5 Mm³
2. El Cuchillo: 1123 Mm³
3. MRG: 781 Mm³

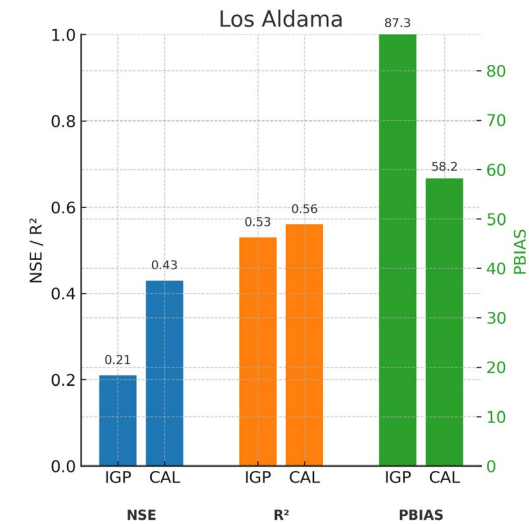
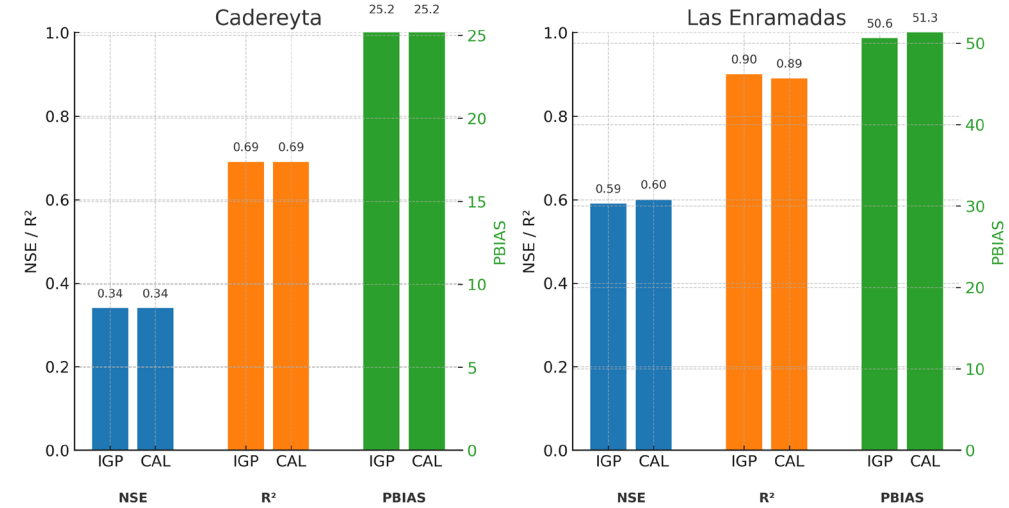


Calibration - IGP



Parameters:

- Cn2: Curve number
- Revap_min : Threshold depth of water in the shallow aquifer
- ESCO: Soil evaporation compensation factor



Conclusion

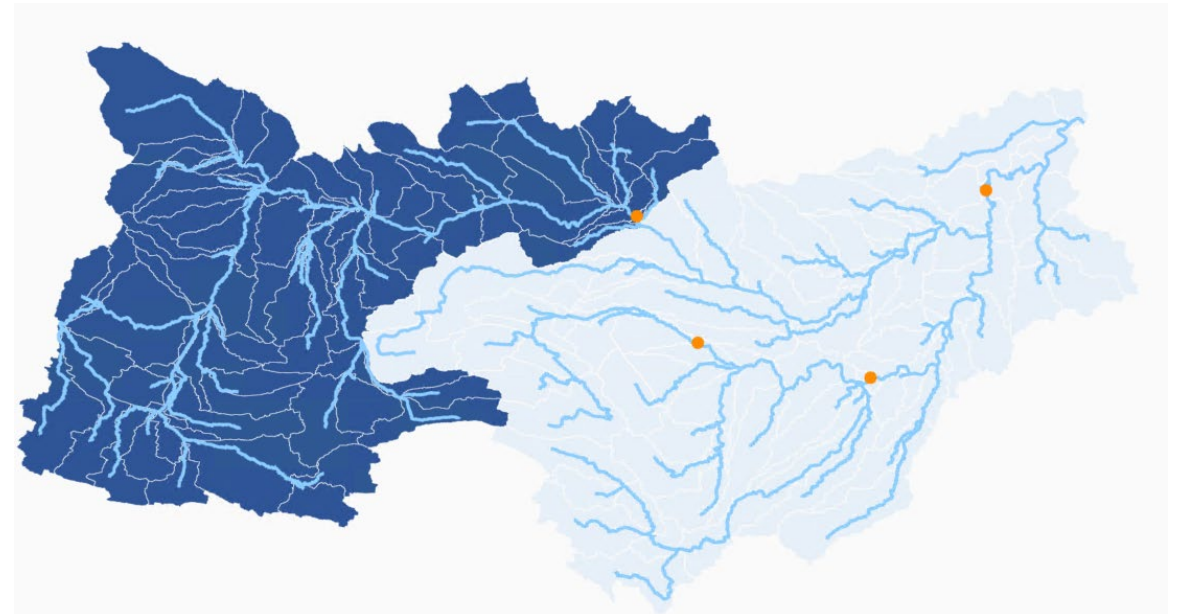
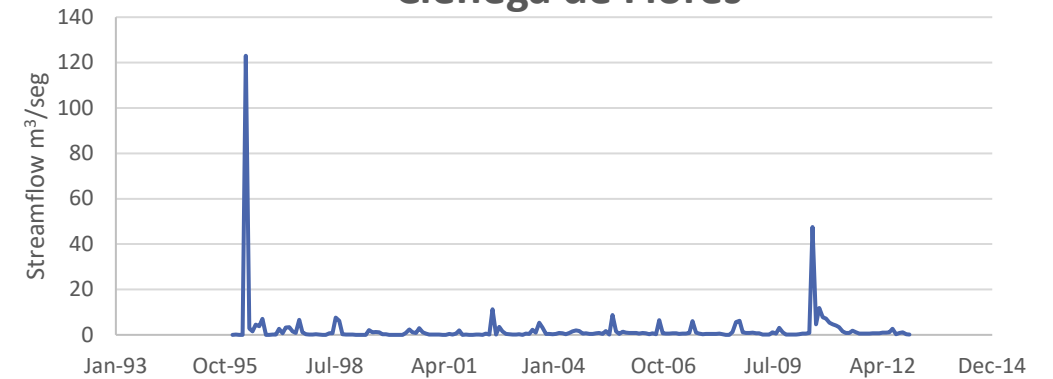
CHALLENGES

- Limited reliability of observed data at one streamflow station
- Simulating reservoir operation rules involving conditional releases and interactions between two reservoirs simultaneously

CONCLUSION

- The model using CHIRPS precipitation showed the lowest PBIAS but did not accurately capture flow variability and peak events, reflected by a lower NSE
- The model using interpolated precipitation showed better performance across statistical indicators, particularly by significantly reducing PBIAS while maintaining similar R^2 and NSE values

Cienega de Flores



Next steps

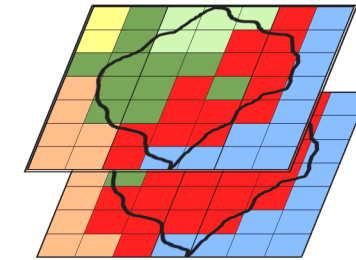
Incorporate historical land use maps to analyse the effects of urbanization on the basin hydrological processes

Analyse the impact of urban expansion on reservoir performance

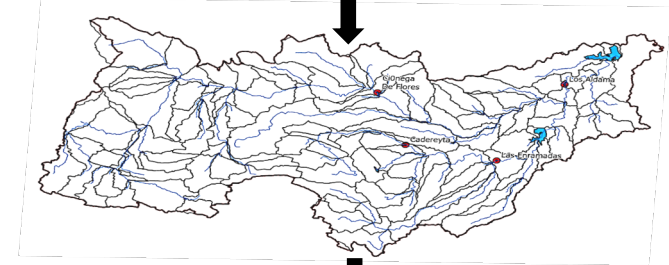
Explore land use change scenarios to support water planning and decision-making

SECOND STAGE

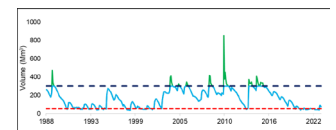
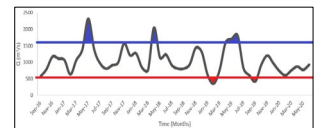
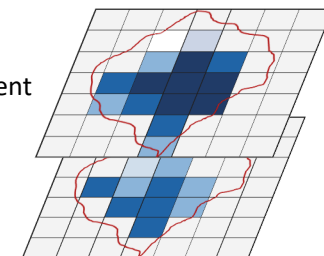
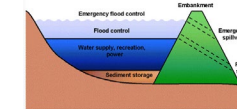
Simulation of the impact of urbanization on streamflow for reservoir management



Historical urbanization



- Impact on
- Streamflow changes
 - Reservoir management



THANK YOU