# NEAREST NEIGHBOR AND INVERSE DISTANCE WEIGHTING FOR RAINFALL ESTIMATION IN SWAT APPLICATION

Authors: Thais Fujita; M. V. B. de Morais; J. A. F. Monteiro; V. Dos Santos; A. P. Rudke; S. A. A. Rafee; E. B. Santos; L. D. Martins; R. A. F. de Souza; E. D. de Freitas; J. A. Martins.

2018 International SWAT Conference in Brussels – Sensitivity Calibration and Uncertainty

La Plata River Basin – 3.170.000 km²

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Paraná River Basin - 1.500.000 km²

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Paraná River Basin - 1.500.000 km²

Hydrographic Region of Paraná River Basin – 879.860 km²

# HYDROGRAPHIC REGION OF PARANÁ RIVER BASIN

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Intense deforestation ➡ agricuture and pasture.

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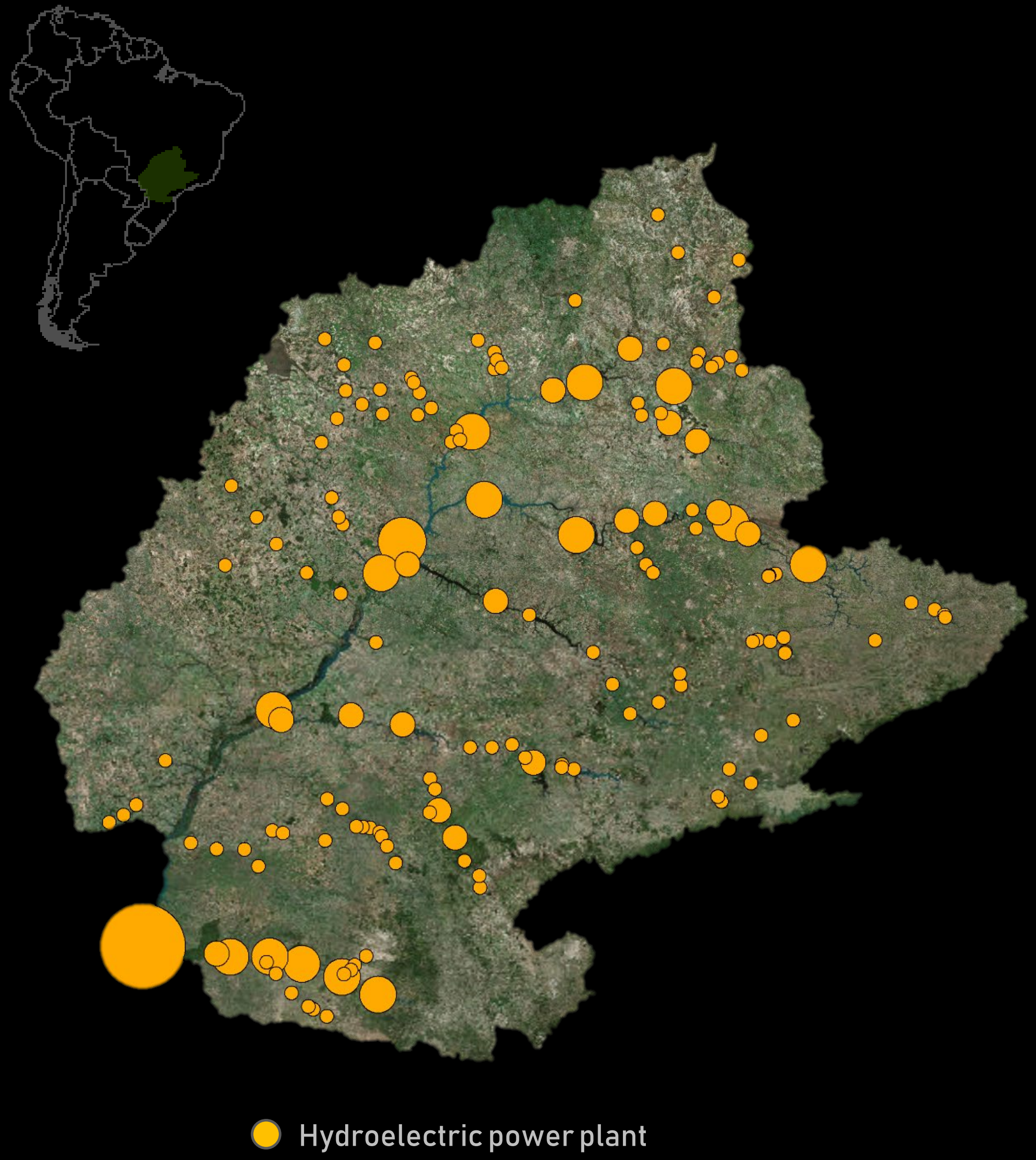



Intense deforestation ➡ agricuture and pasture.

## Aptitude in energy production:

- Hydroelectric generation (~60%)
- Suitable areas for sugar cane plantation
  - Light Fleet Fuel
  - Biomass burnout

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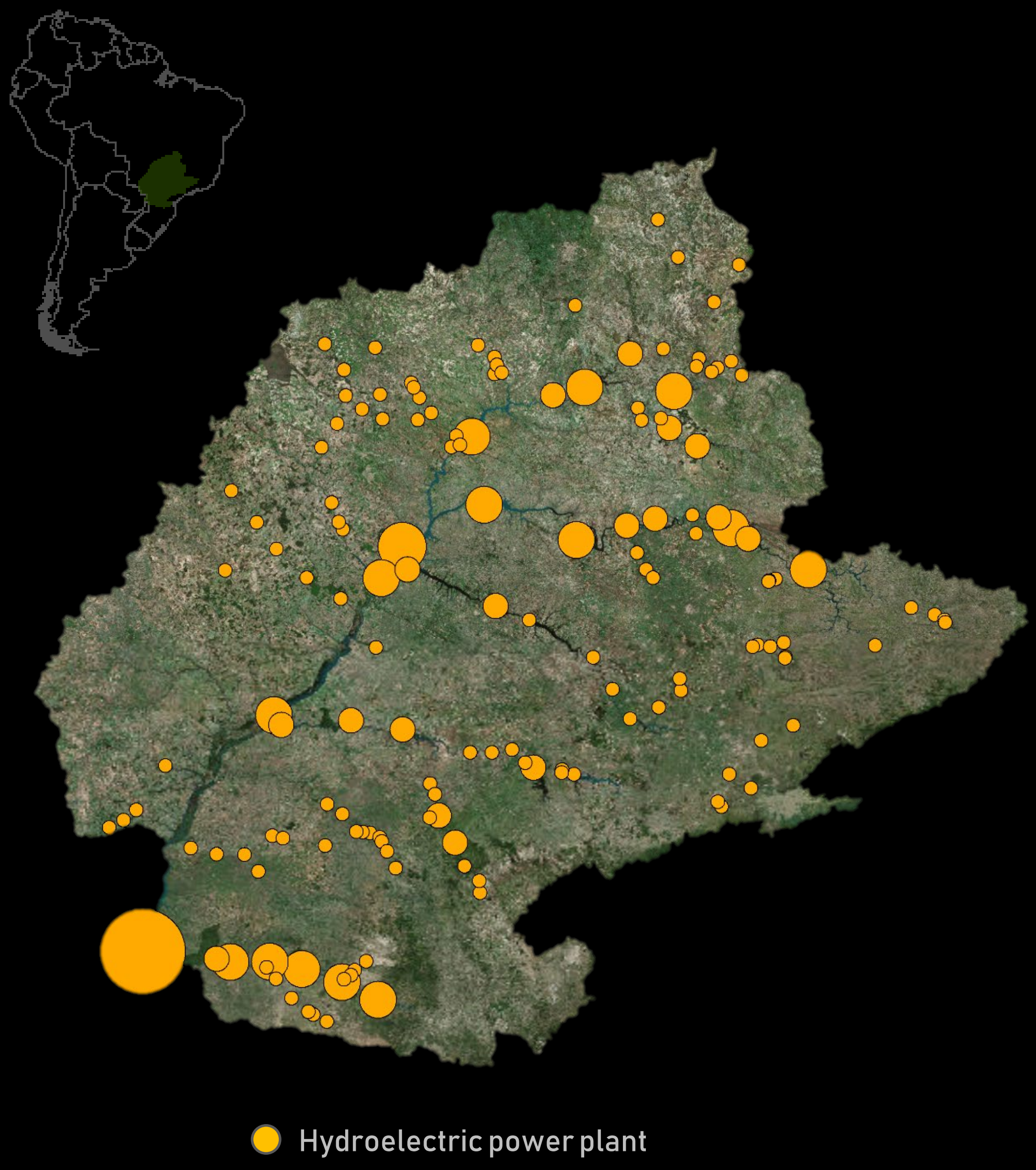


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Great dependence on water resources for economic development, and relies heavily on rainfall regime.

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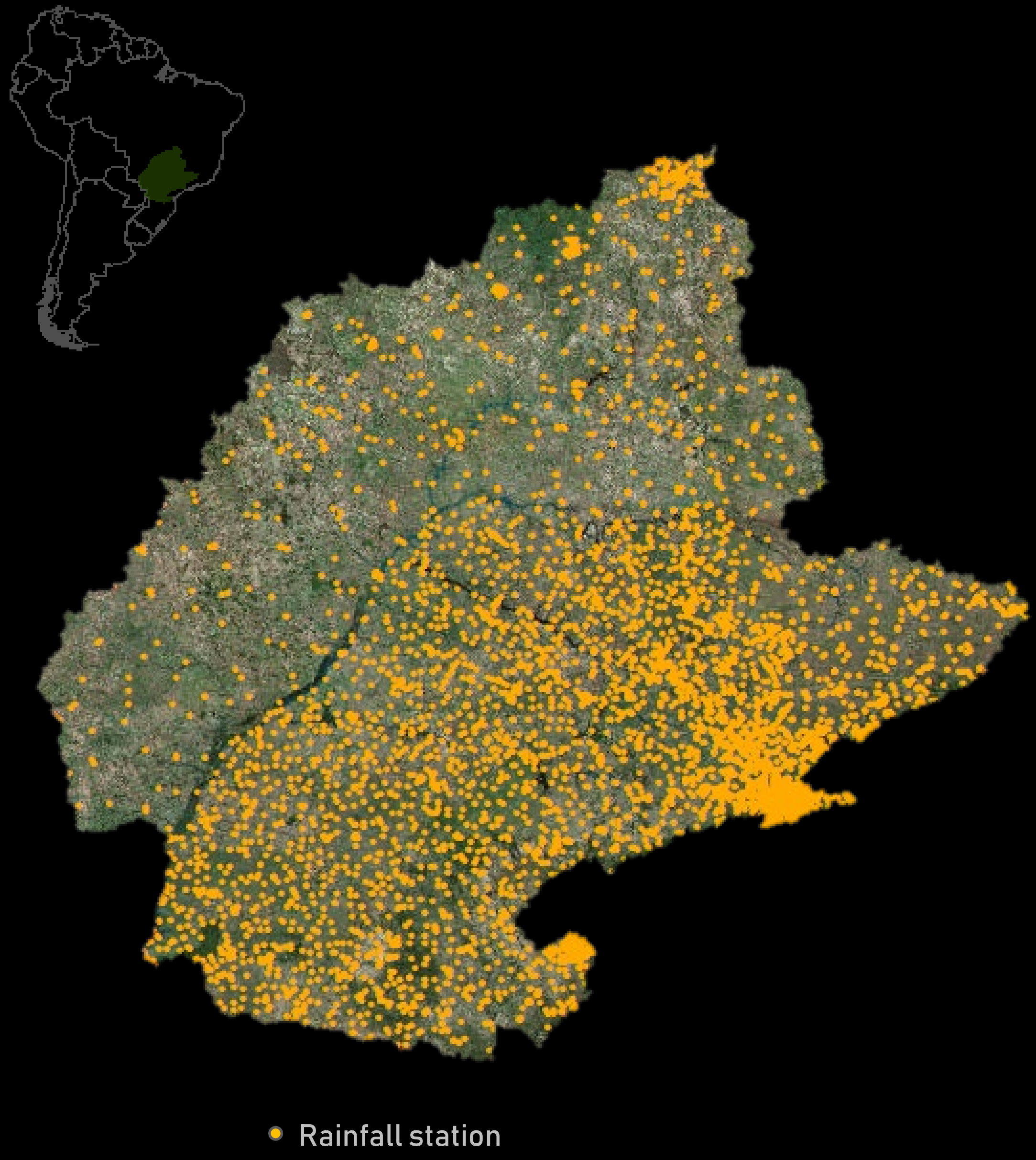


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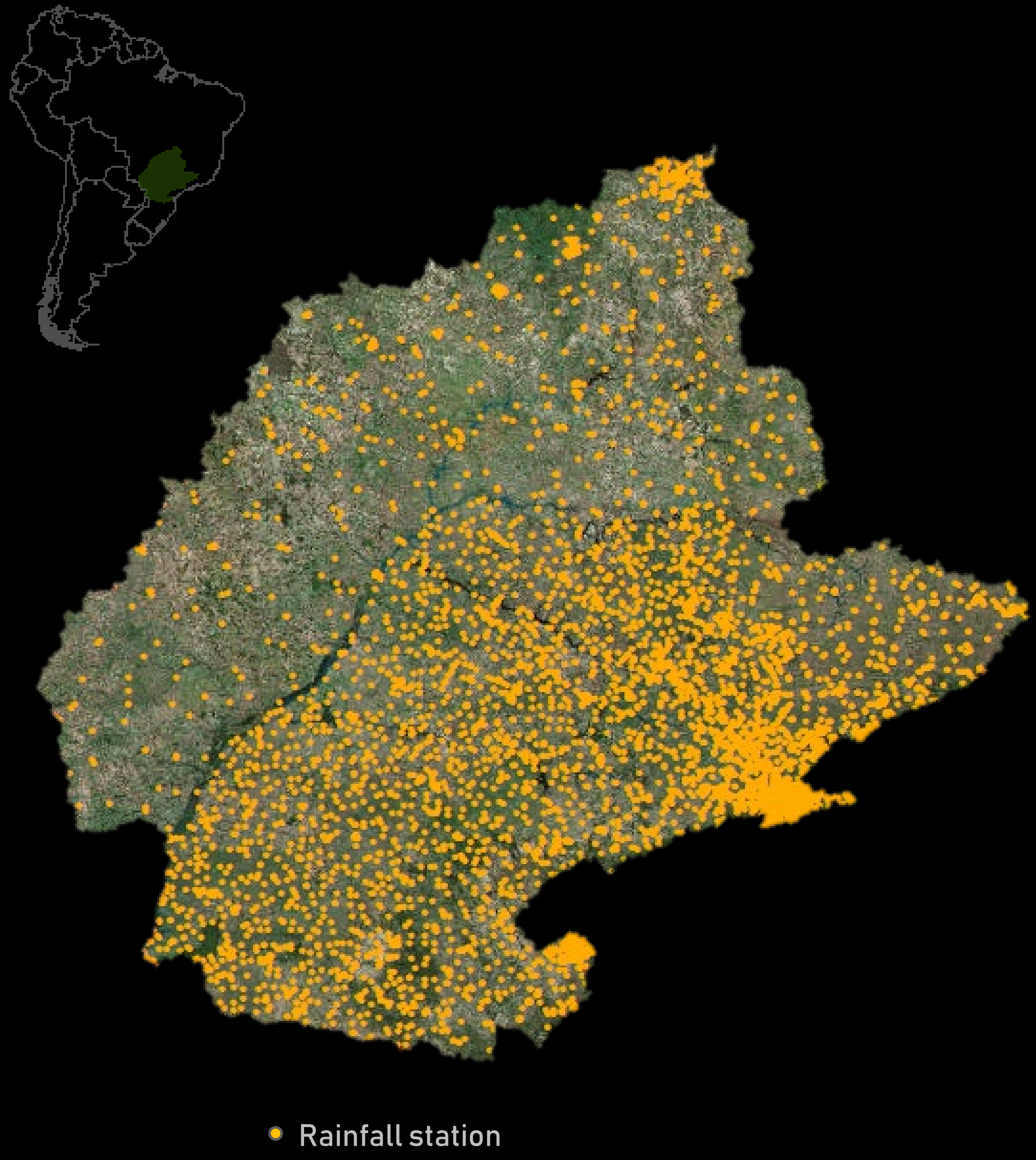


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Aptitude in energy production:

- Hydroelectric generation (~60%)
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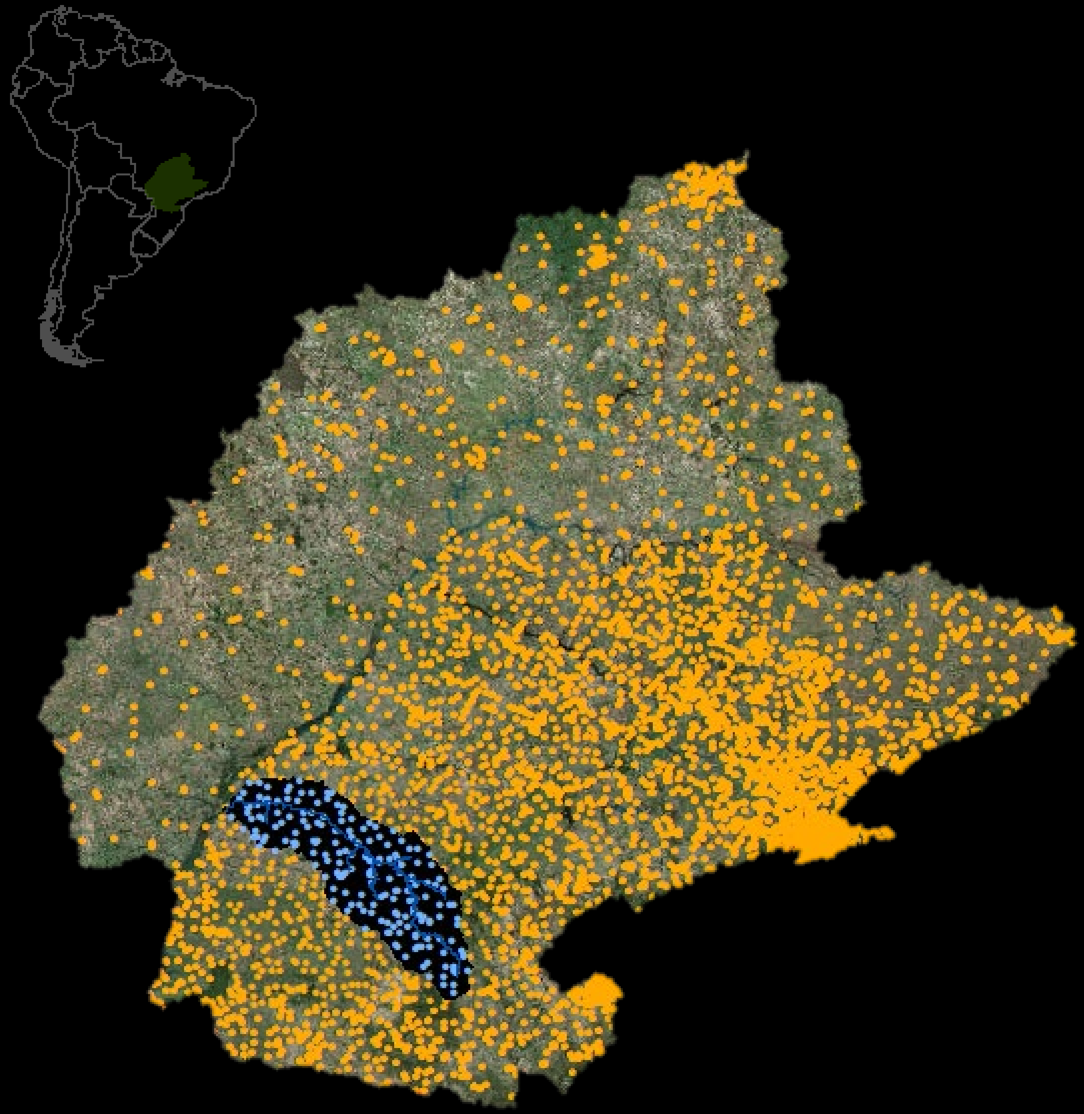
Heterogeneity in rainfall gauges distribution:

- Population distribution
- Not consistent with weather systems that occur
  - Tropical Mesoscale Convective Complexes
  - Cold fronts and Squall lines
  - South America Monsoon System
  - El Niño Southern Oscillation (ENSO)

# MOTIVATION

- What are the implications of such low density in the right river bank?
- How compromised is the rainfall representation?
- What is the minimum density required for hydrological studies?

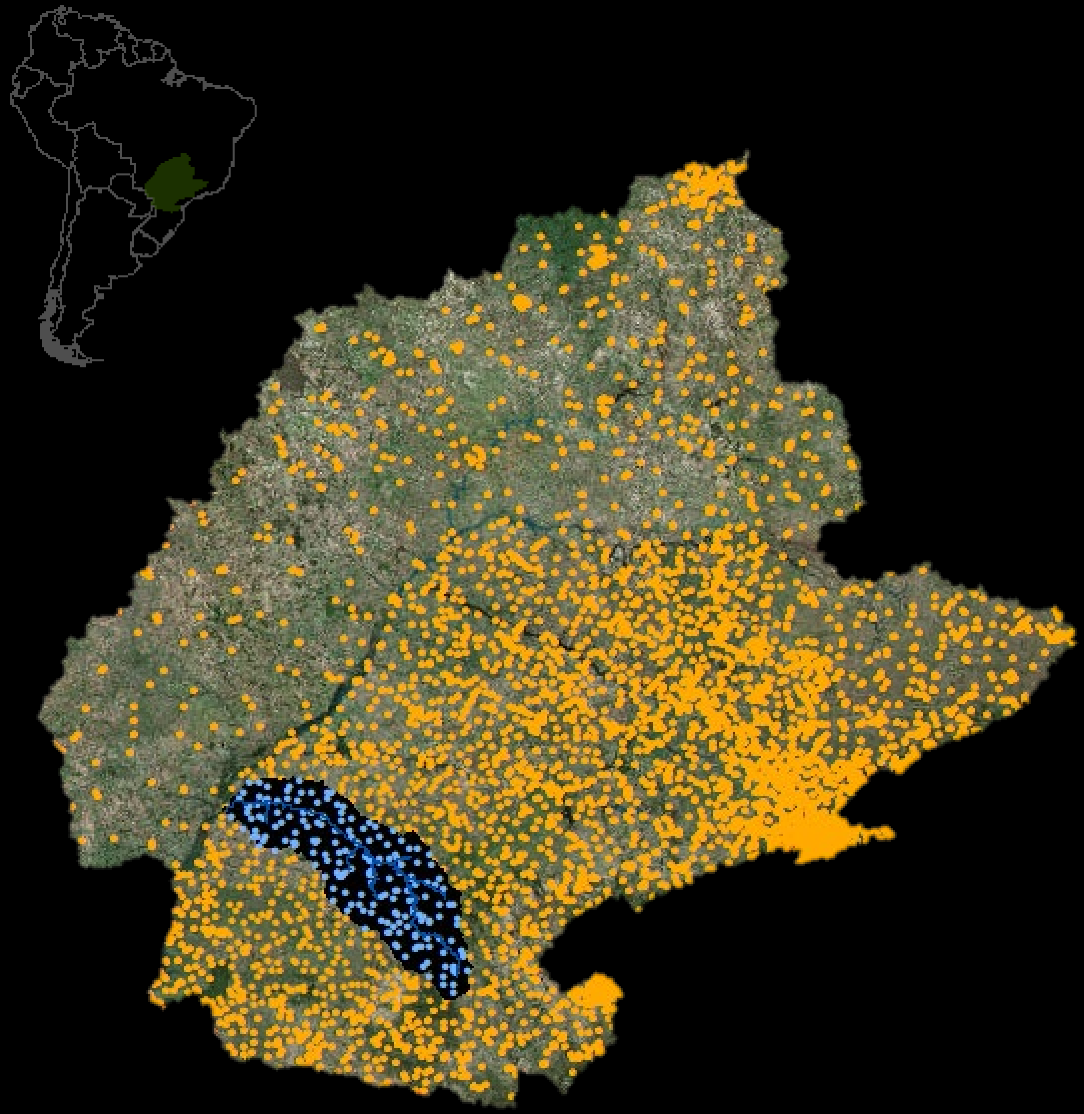
# IVAÍ RIVER BASIN



## Ivaí River Basin – 36.589 km²

- Data availability
- Condition without dams
- Climate variability
- Economic importance

# IVAÍ RIVER BASIN



## Ivaí River Basin – 36.589 $km^2$

- Data availability
- Condition without dams
- Climate variability
- Economic importance

SWAT
Soil & Water Assessment Tool

# IVAÍ RIVER BASIN – physical features:

TOPOGRAPHY

Area: 36,589 km²

Length: 680 km

Source: 800 m

Mouth: 230 m

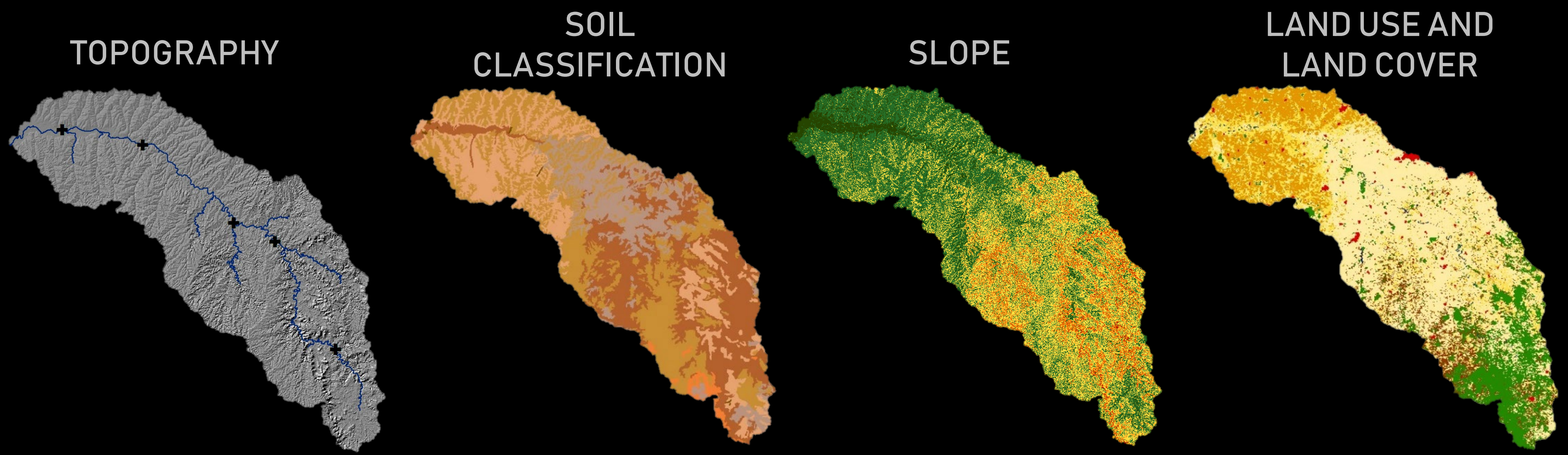
Discharge: 715.32 m³/s

**Selection of fluviometric stations:**

✓ Identification of the simulation period

✓ Model evaluation

# IVAÍ RIVER BASIN – physical features:




**Selection of fluviometric stations:**

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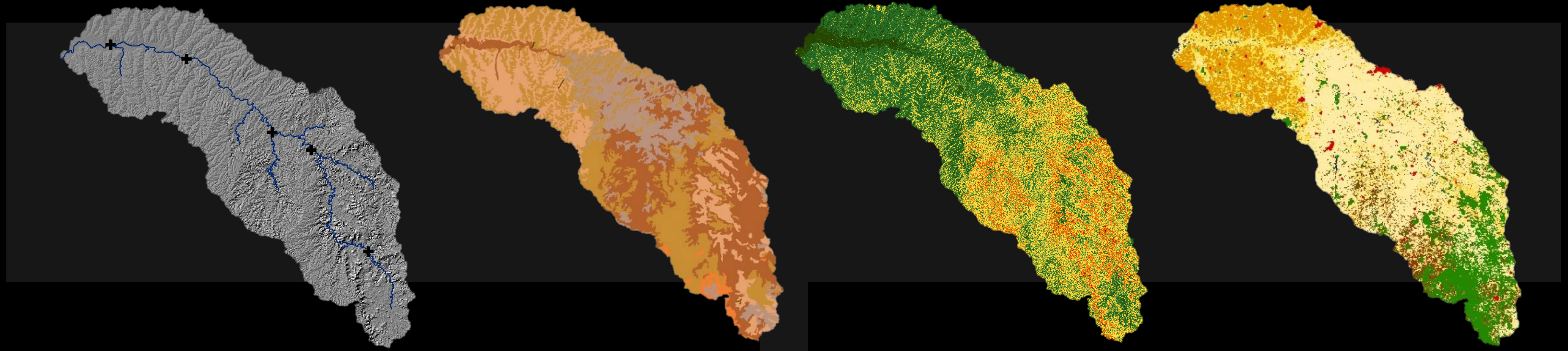
# IVAÍ RIVER BASIN – physical features:

TOPOGRAPHY

SOIL CLASSIFICATION

SLOPE

LAND USE AND LAND COVER



- ✓ 24 subbasins
- ✓ 502 hydrological response unit
- ✓ 5 monitoring fluviometric stations

# IVAÍ RIVER BASIN – weather characterization:

WEATHER DATA:

- ✓ Maximum and minimum temperature - °C
- ✓ Solar radiation – MJ/m².day
- ✓ Wind speed – m/s
- ✓ Air humidity - %

NCEP Climate Forecast System
CFSR
Reanalysis [1979 - 2010]

- ✓ Daily precipitation – mm
  - Acquisition of information
  - Data treatment

ANA
AGÊNCIA NACIONAL DE ÁGUAS

The method of representing weather behaviour relies on the use of one gauge nearest to the centroid of each subbasin (Nearest Neighbor – NN).

This configuration leads to a simplification of the weather records even if there are multiple gauges per sub-basin.

Widely used and accepted by users.

SWAT

Soil & Water Assessment Tool

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We employed Inverse Distance Weighting method to create a continuous spatial rainfall.

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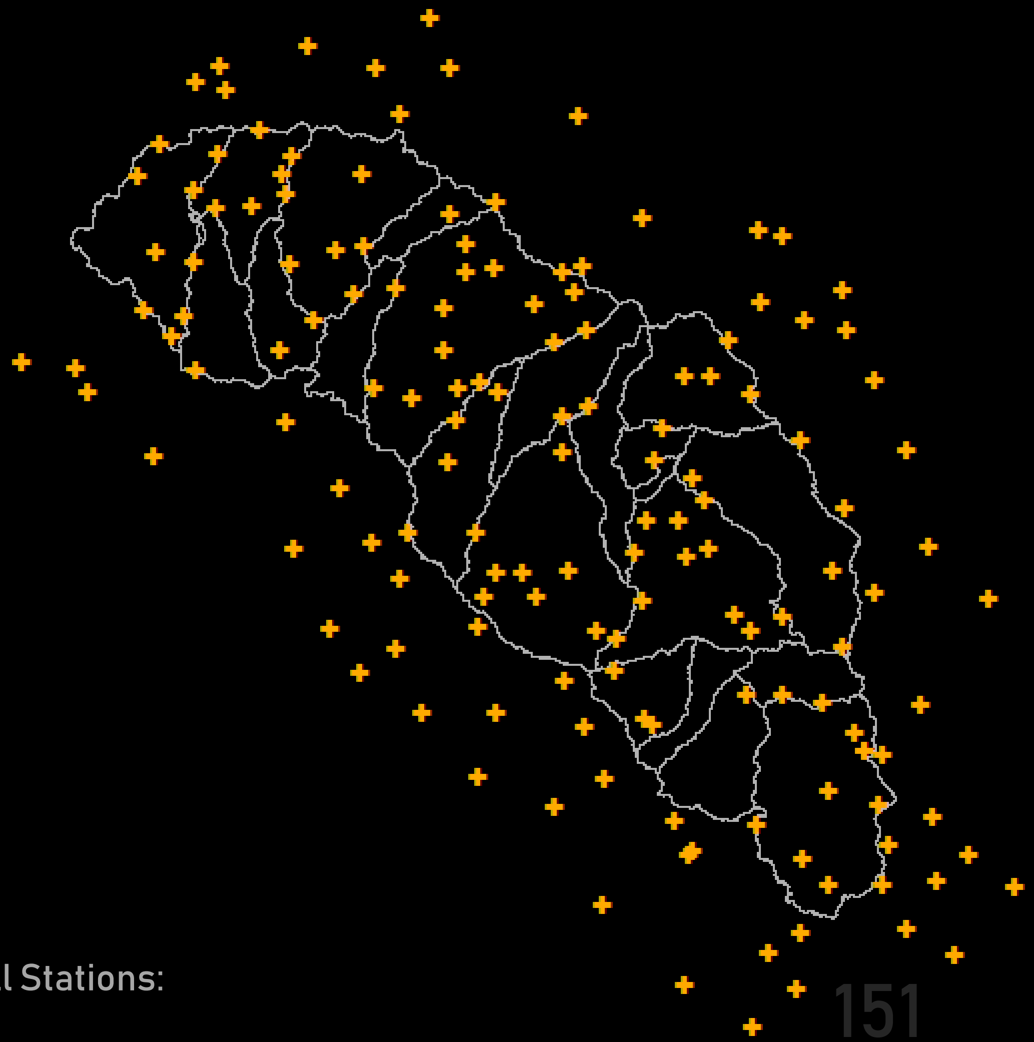
# METHODOLOGY

## INVERSE DISTANCE WEIGHTING:



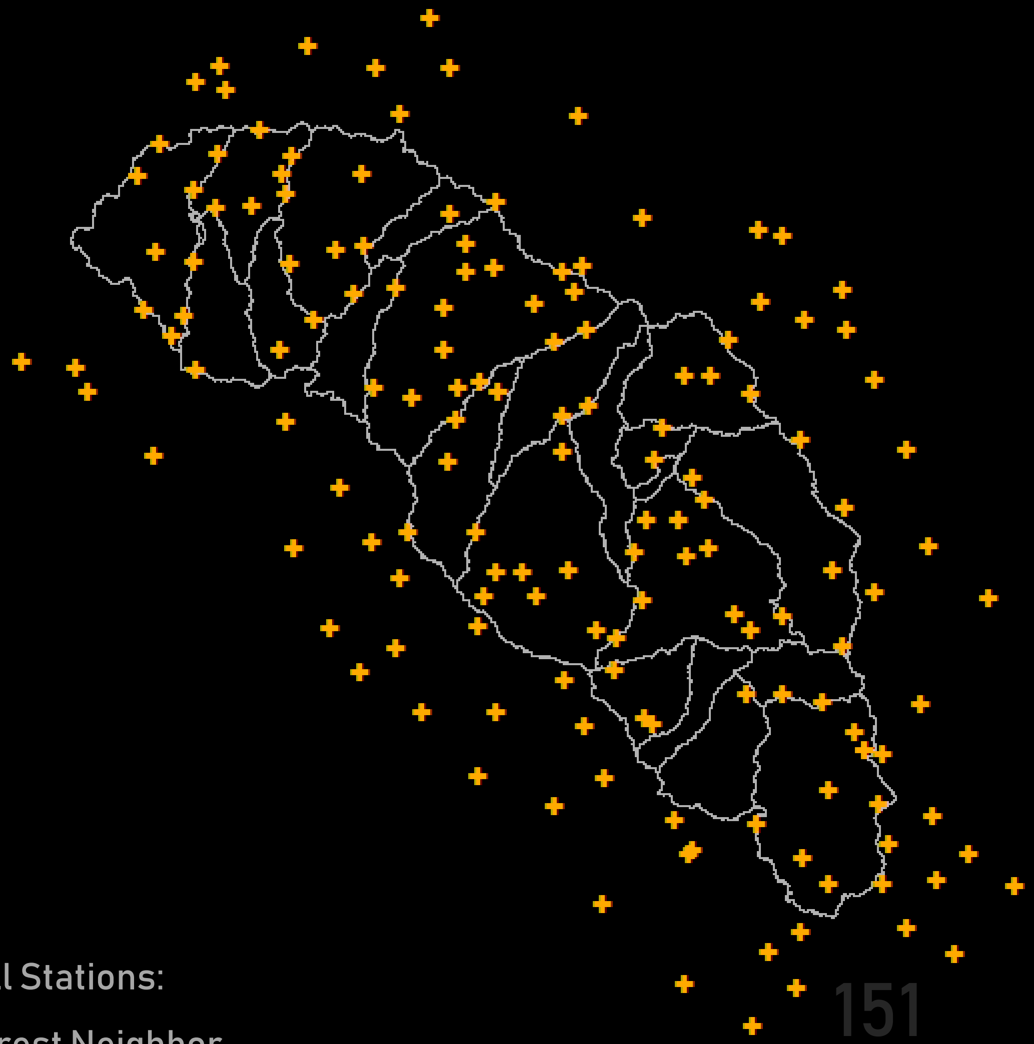
Rainfall Stations:

151

+ Inverse Distance Weighting Interpolation

# METHODOLOGY

## INVERSE DISTANCE WEIGHTING:



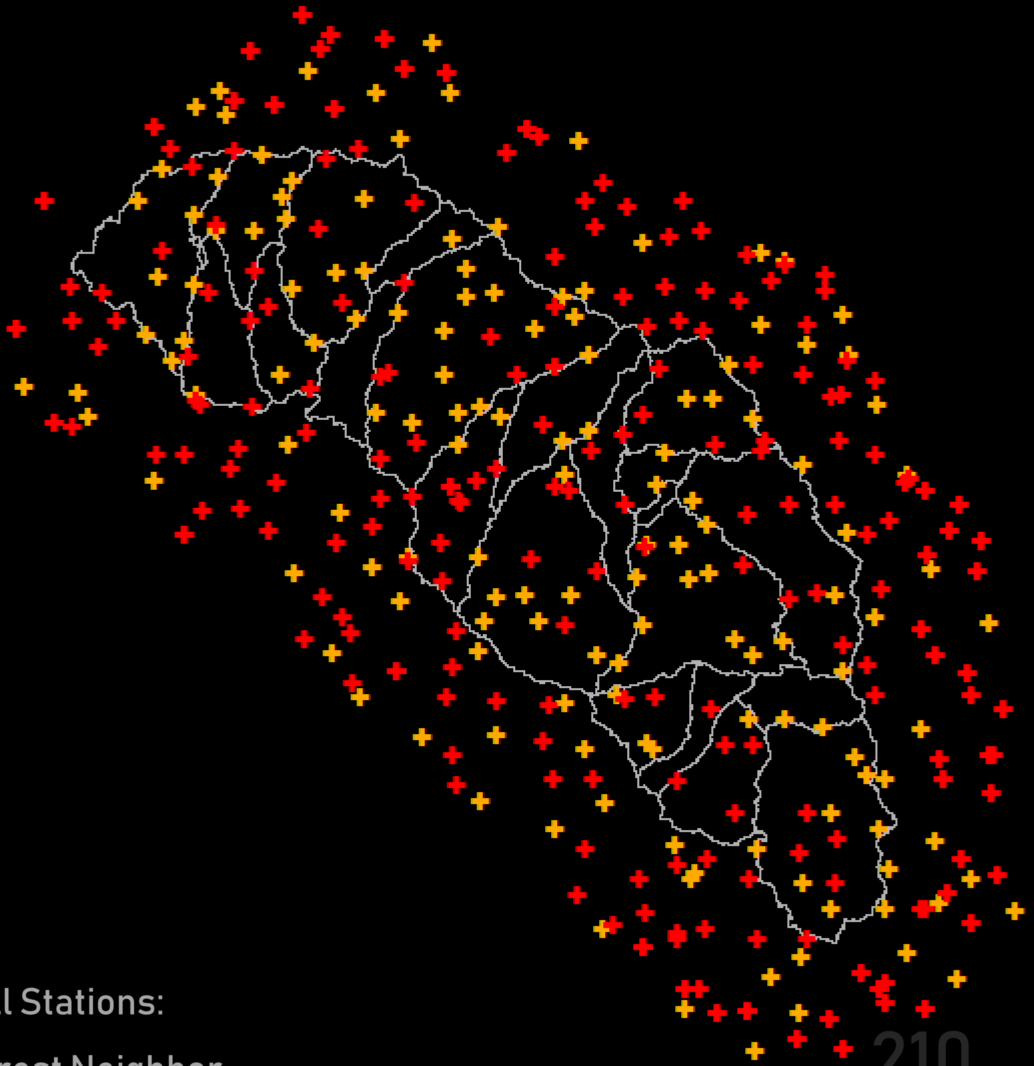

## NEAREST NEIGHBOR:


Rainfall Stations:

- Nearest Neighbor
- Inverse Distance Weighting Interpolation

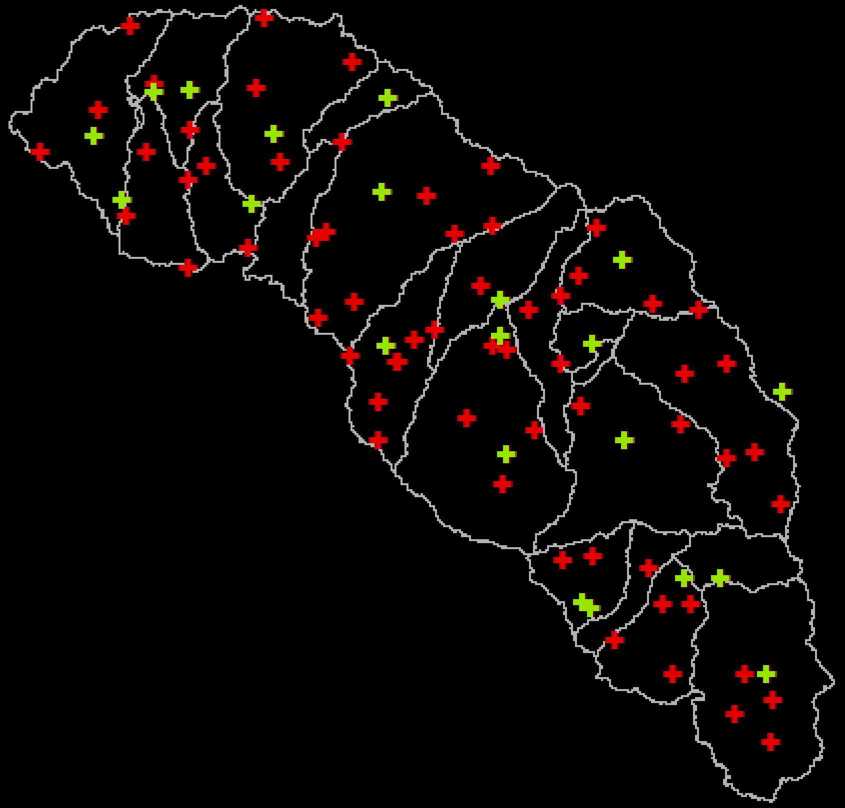
# METHODOLOGY – Validation:

## INVERSE DISTANCE WEIGHTING:



210

## NEAREST NEIGHBOR:



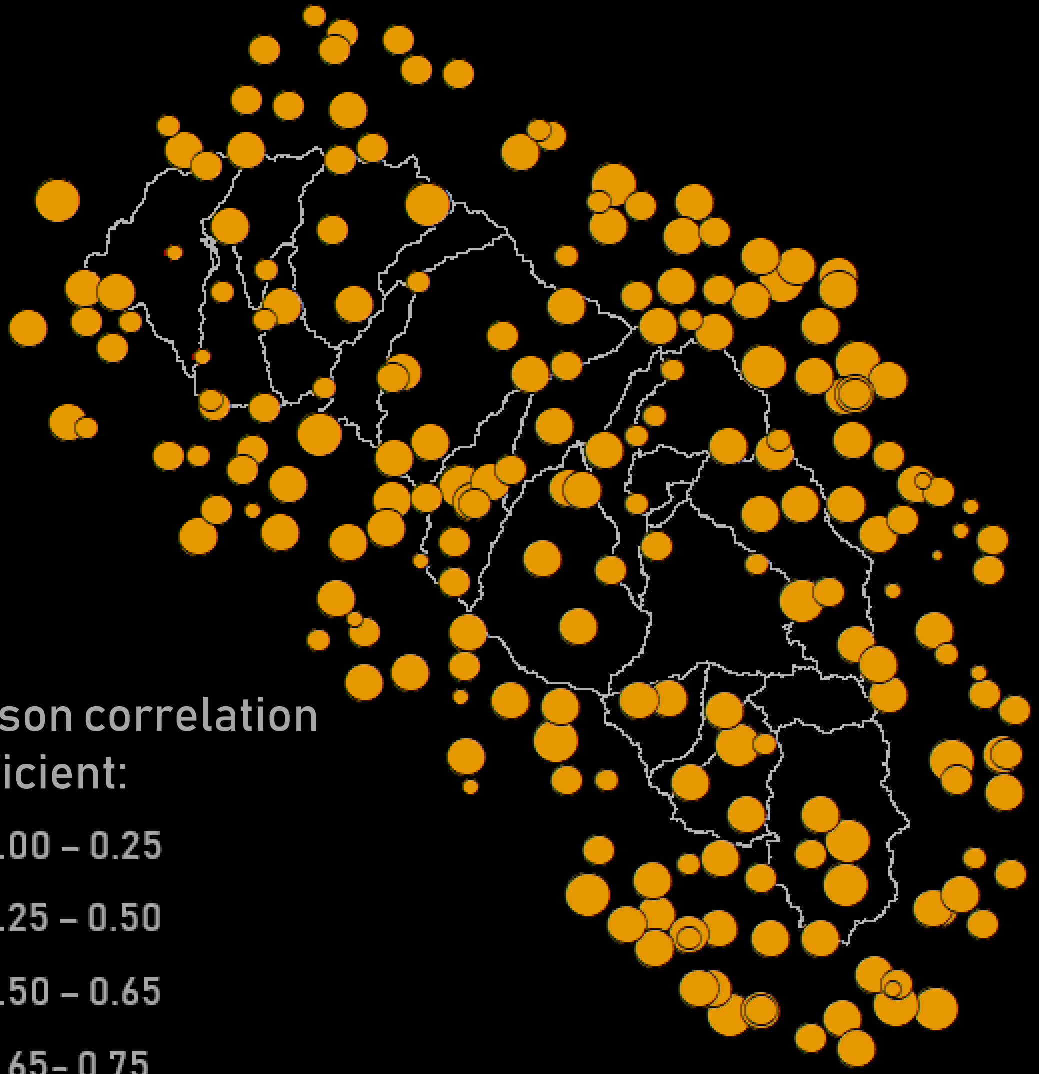
63

Rainfall Stations:

- Nearest Neighbor
- Inverse Distance Weighting Interpolation
- Validation

# METHODOLOGY – Validation:

## INVERSE DISTANCE WEIGHTING:

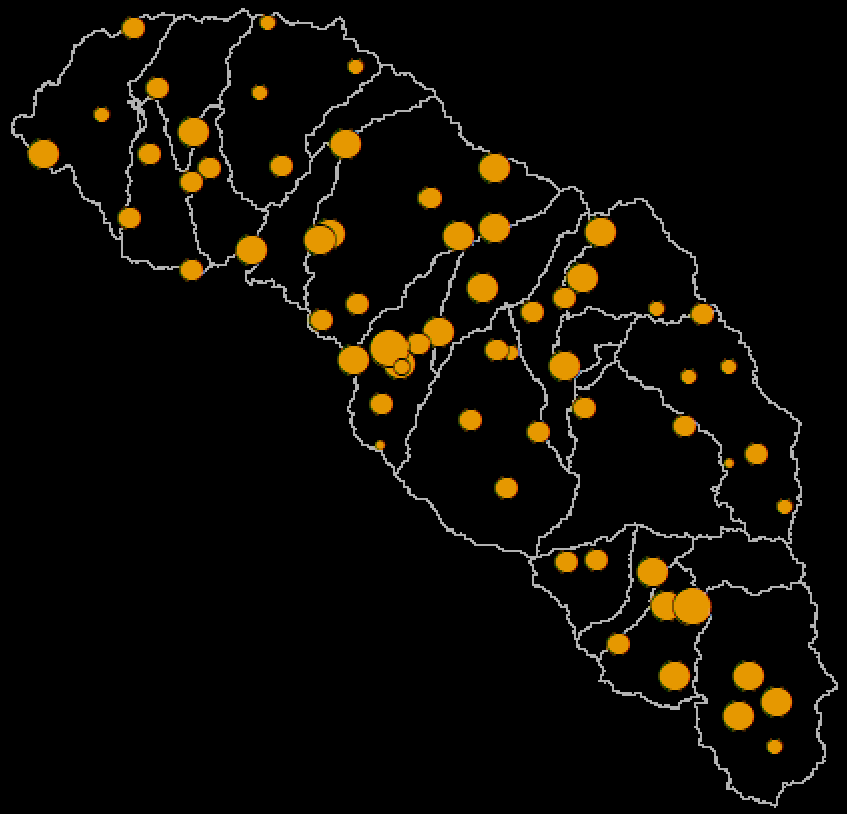


Pearson correlation coefficient:

- 0.00 – 0.25
- 0.25 – 0.50
- 0.50 – 0.65
- 0.65– 0.75
- 0.75 – 0.85
- 0.85 – 1.00

0.726

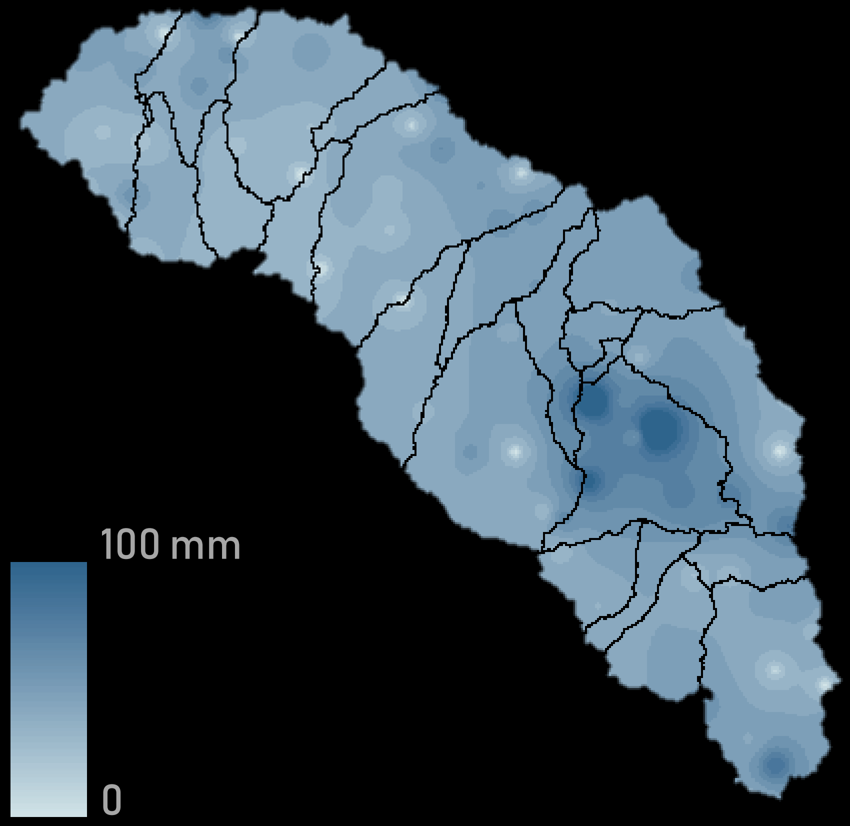
## NEAREST NEIGHBOR:



0.579

# METHODOLOGY – Assimilation:

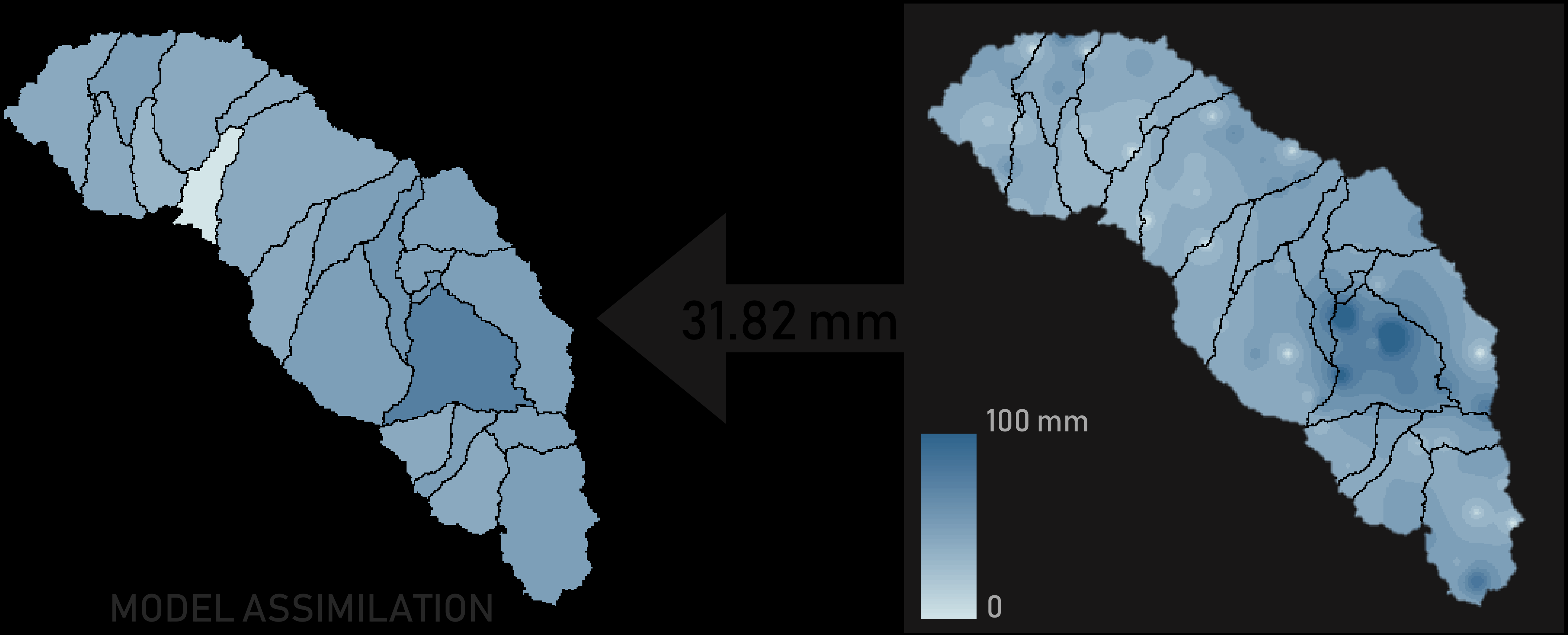
INVERSE DISTANCE WEIGHTING
01/09/1994




31.82 mm

# METHODOLOGY – Assimilation:

## INVERSE DISTANCE WEIGHTING
## 01/09/1994



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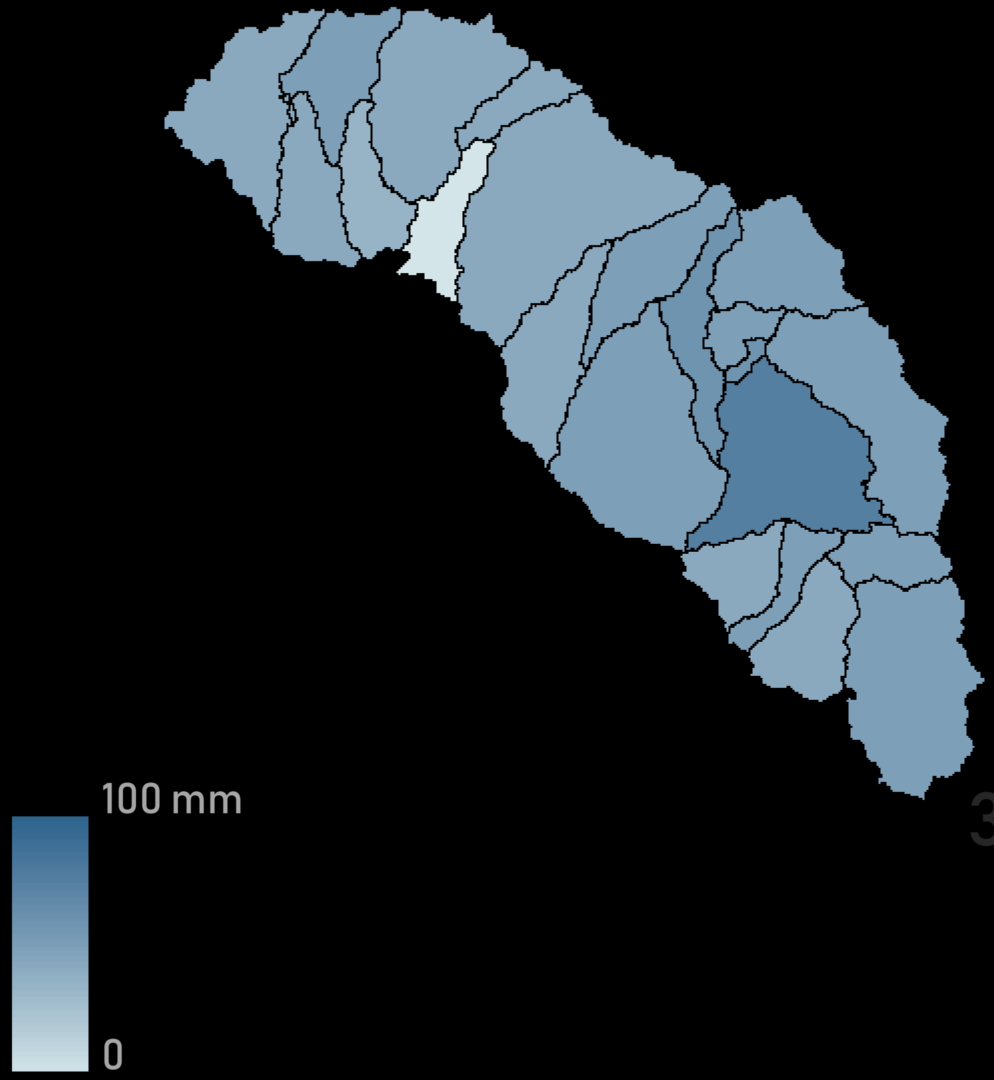


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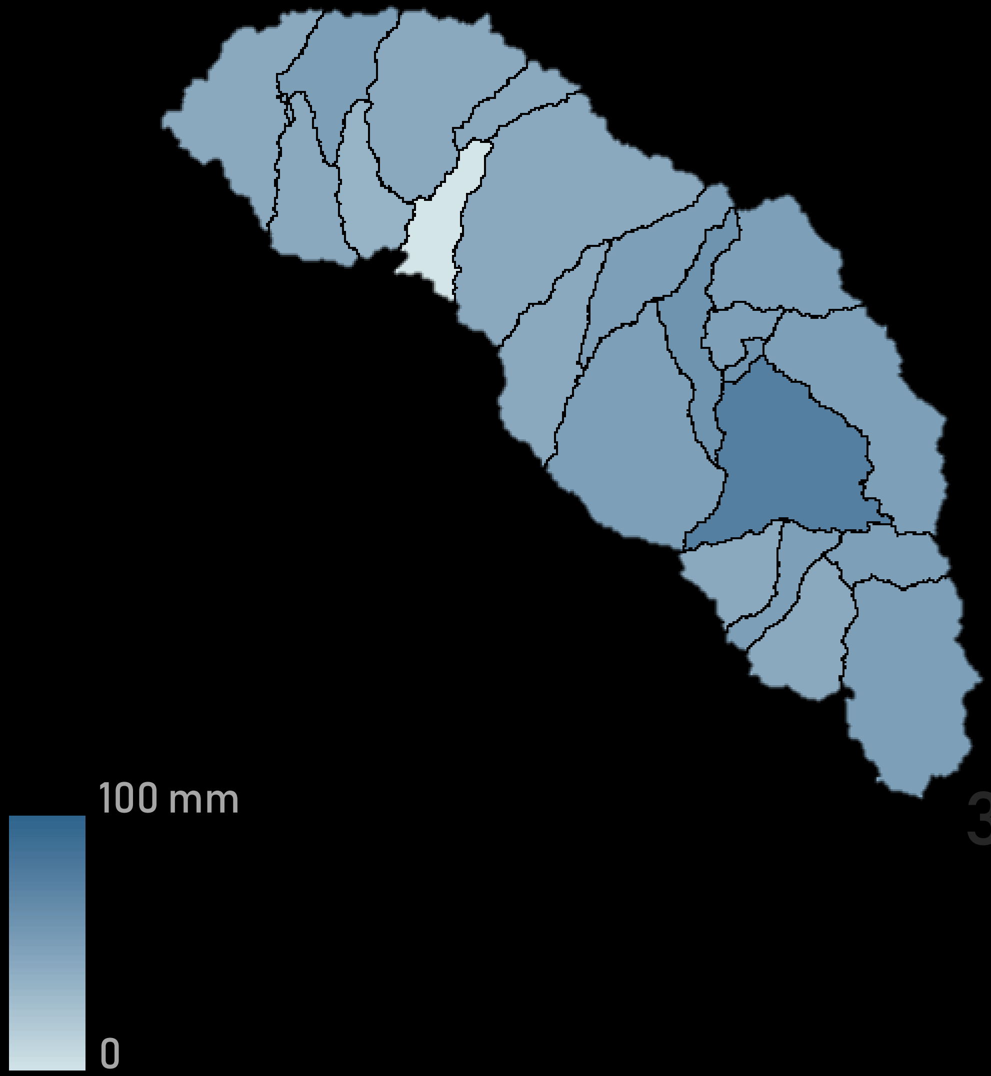
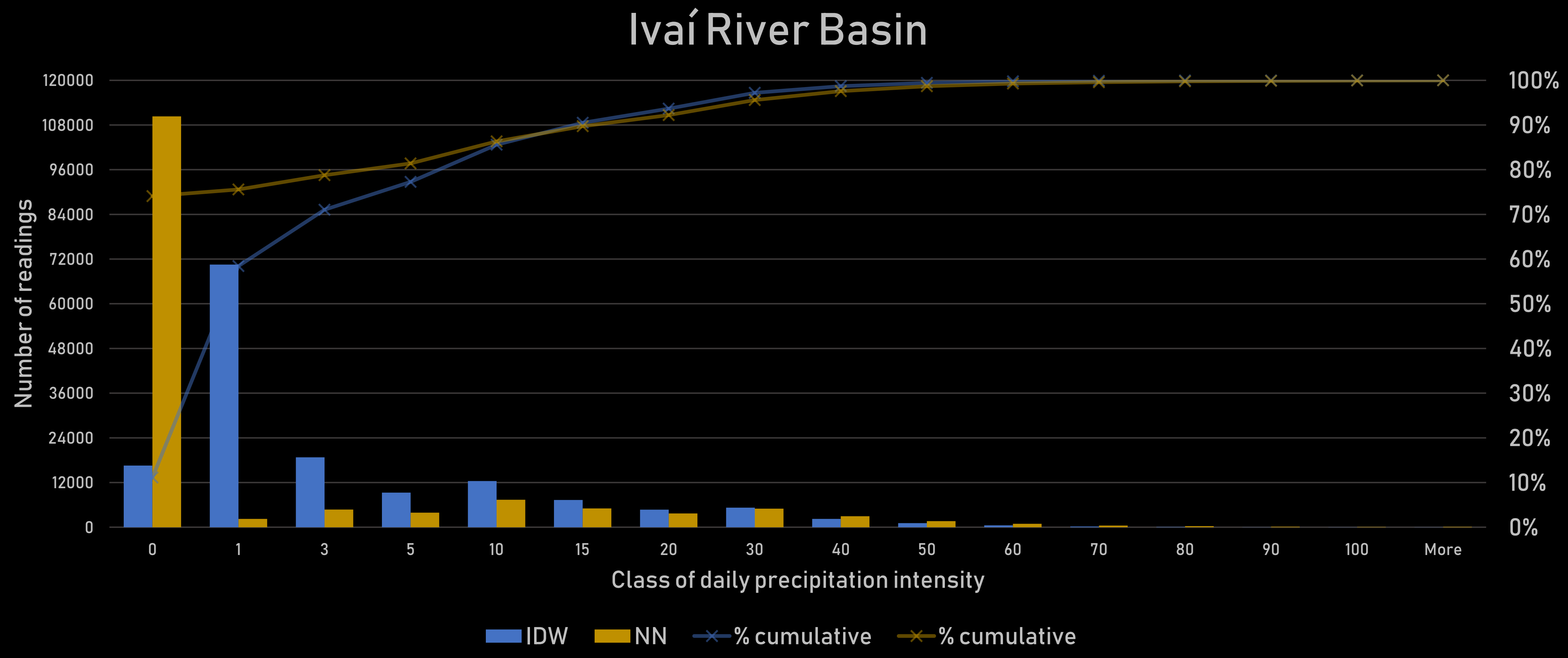


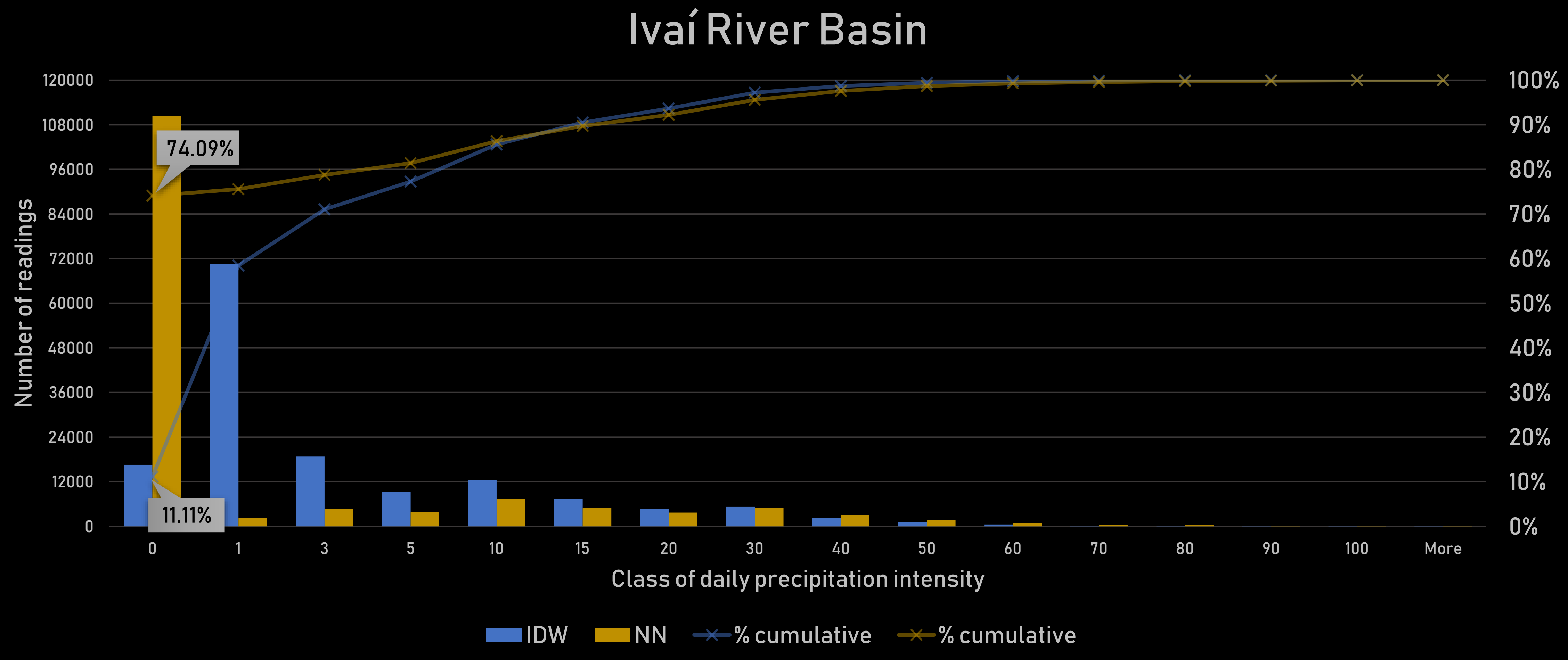

31.82 mm

NEAREST NEIGHBOR:

24.14 mm



Ivaí River Basin
120000
108000
96000
84000
72000
60000
48000
36000
24000
12000
0
Number of readings
100%
90%
80%
70%
60%
50%
40%
30%
20%
10%
0%
0
1
3
5
10
15
20
30
40
50
60
70
80
90
100
More
Class of daily precipitation intensity
IDW
NN
% cumulative
% cumulative



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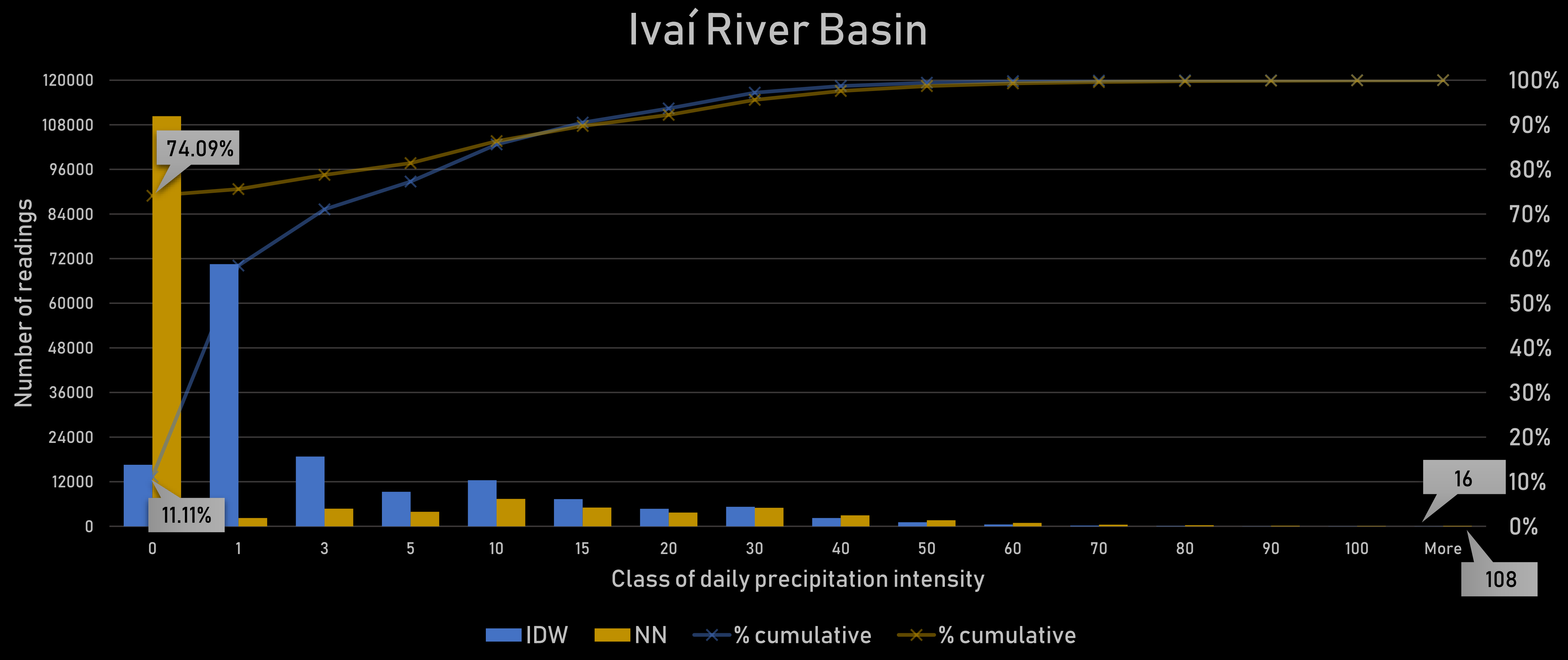

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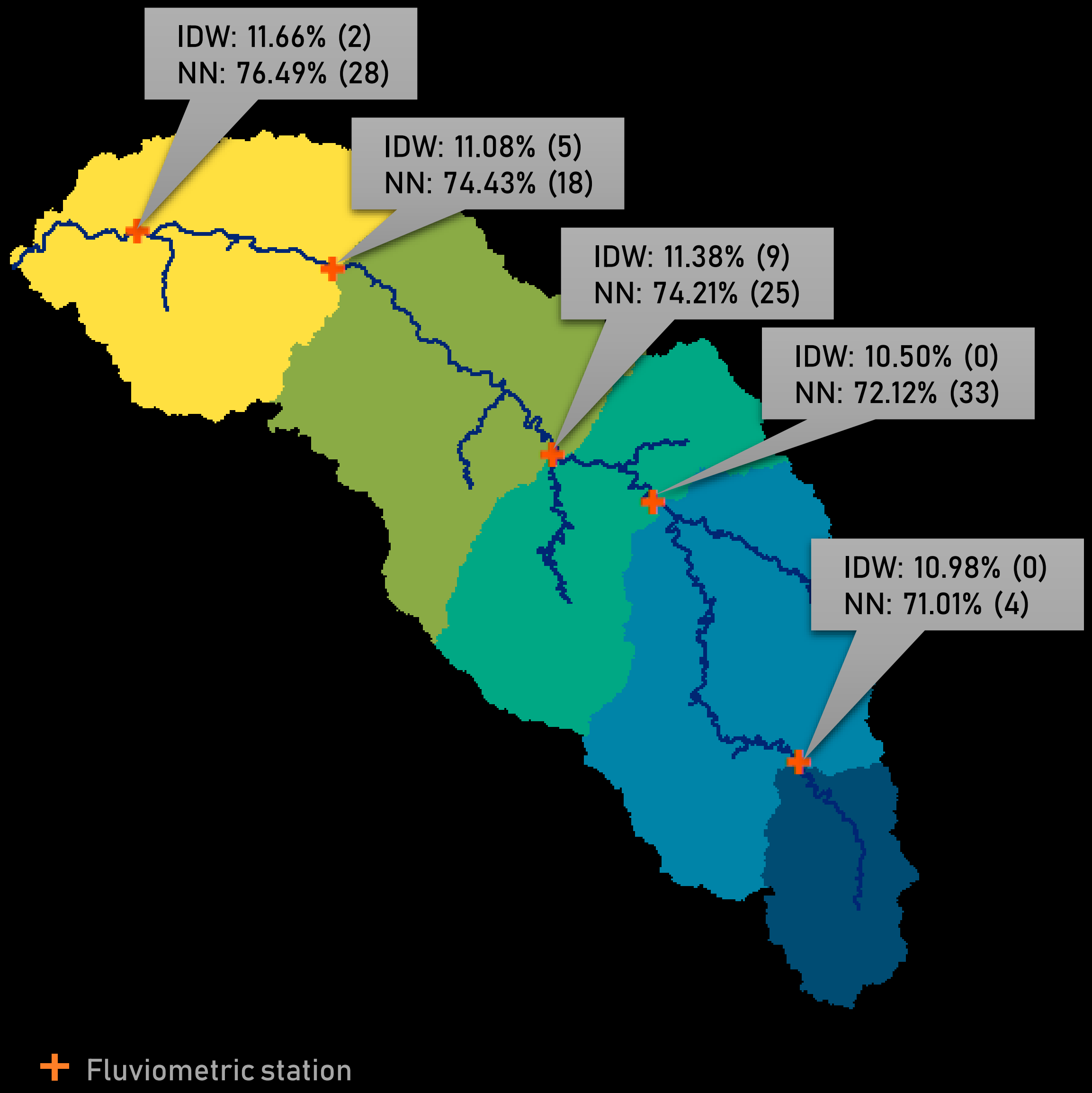
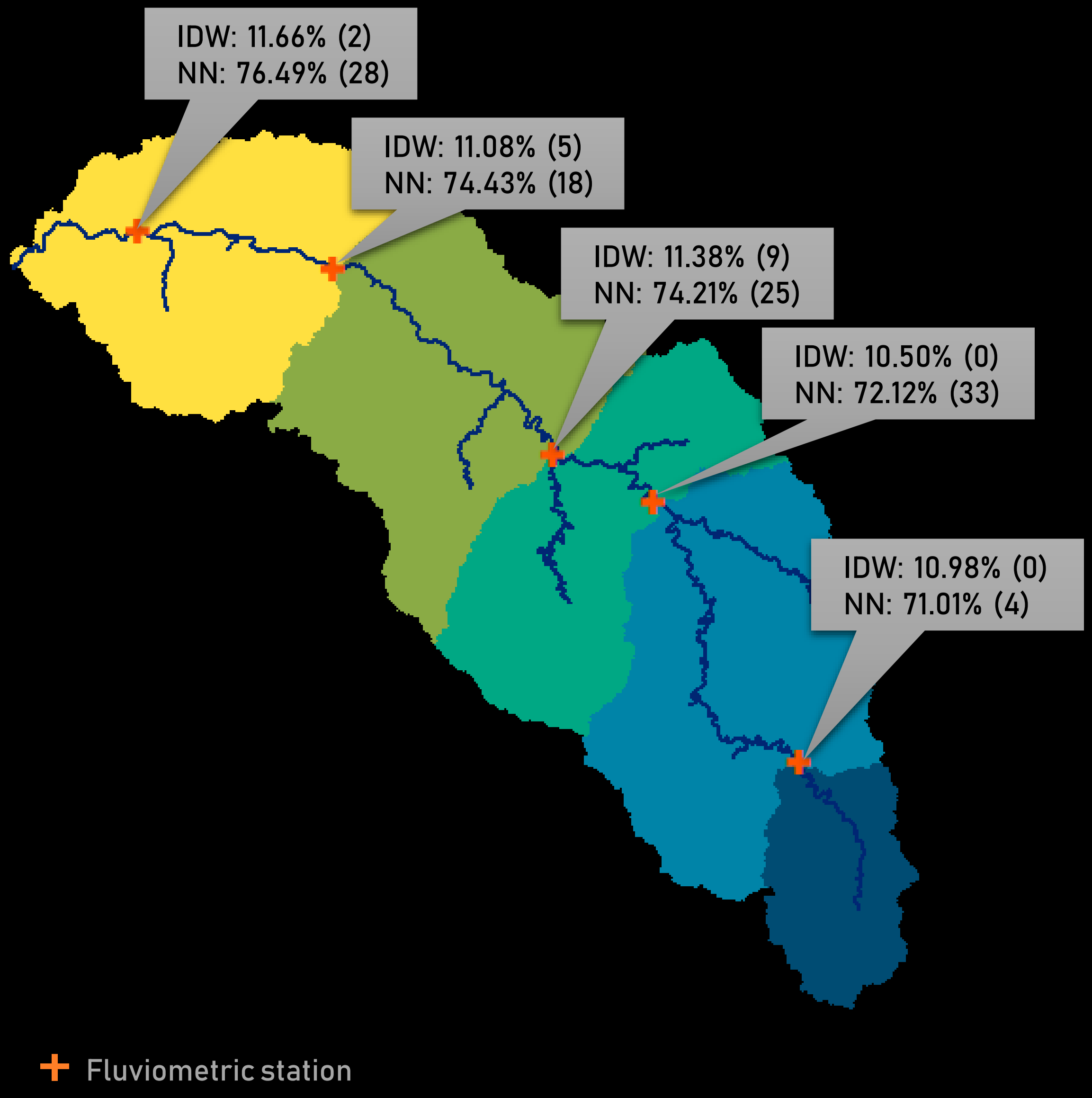



- ✓ NN: conditions of days without rain form the great majority of precipitation data.
- ✓ IDW: null values of precipitation are replaced by the fraction resulting from station in proximity.
- ✓ There is a great disparity between the number of days with extreme precipitation events.

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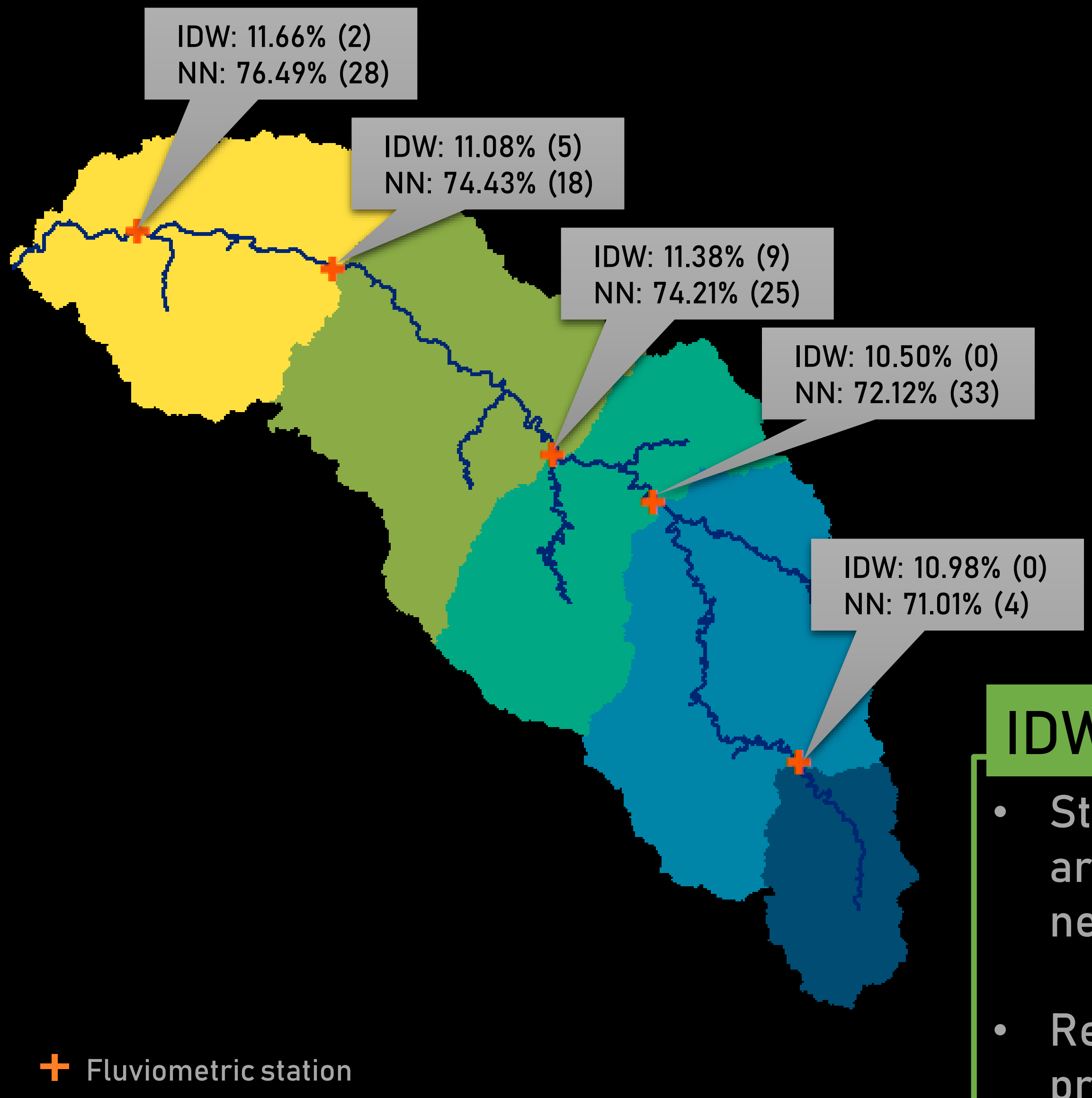
Assess rainfall representation under alternative rainfall gauges networks, so we can answer:
What is the minimum density required for hydrological studies?

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## IDW

- Stability of values: achieved because the effects of disturbances are reduced to small influences by the weighting of the neighboring registers.
- Representativeness of values: by considering more stations, precipitation variability is captured and the most representative values prevail.

# MODEL CALIBRATION:

- ✓ SELECTION OF PARAMETERS SUITABLE FOR FLOW SIMULATIONS IN THE LITERATURE (15).

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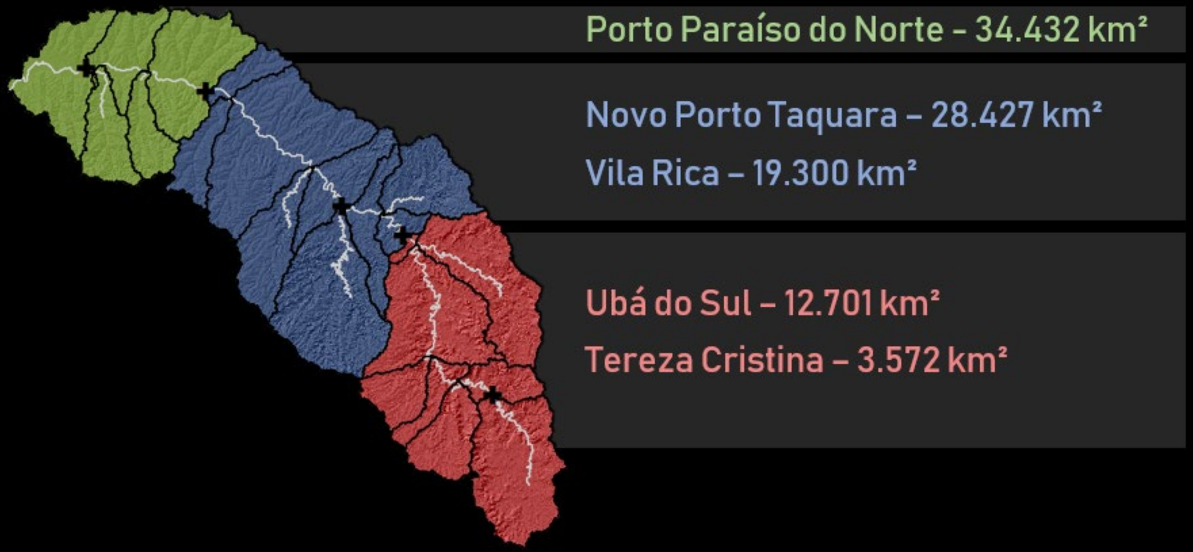


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- ✓ PARAMETERIZATION BY MACROREGIONS.

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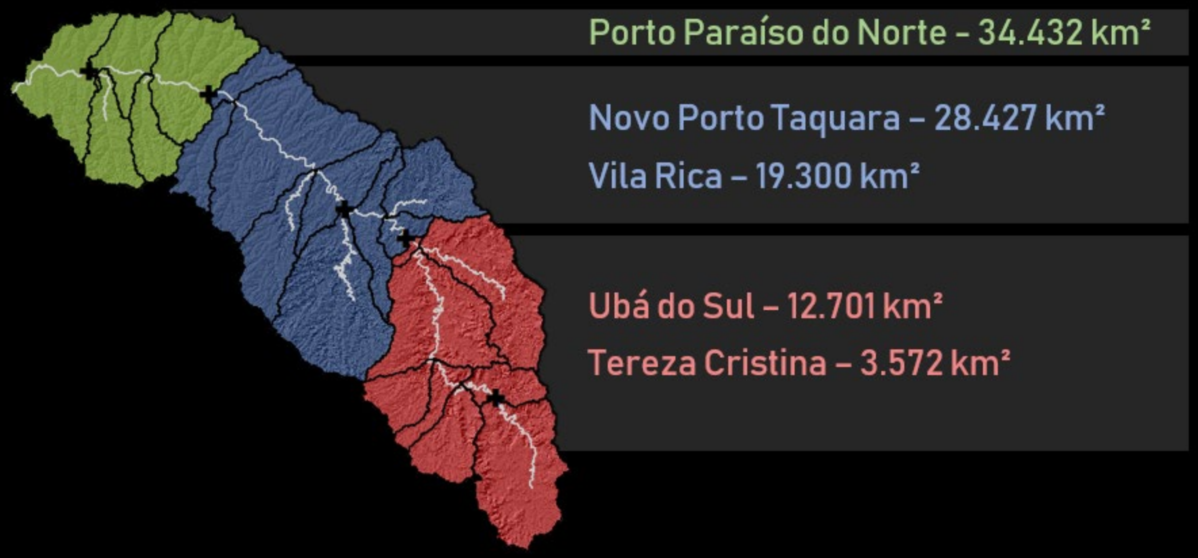


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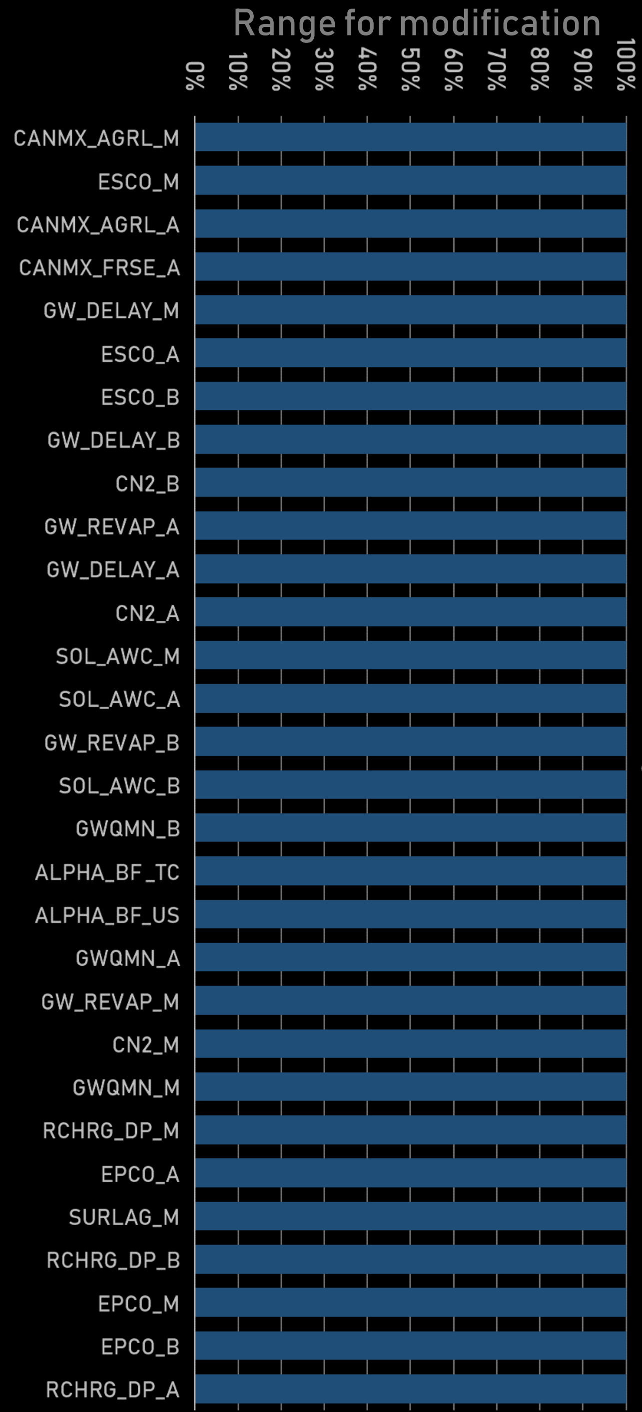
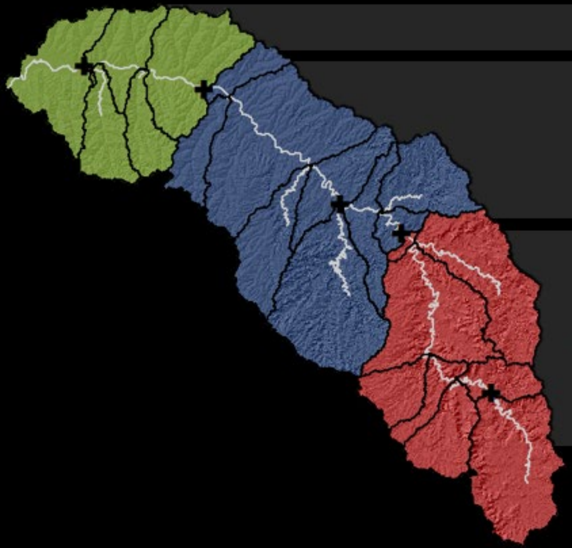
**100%**

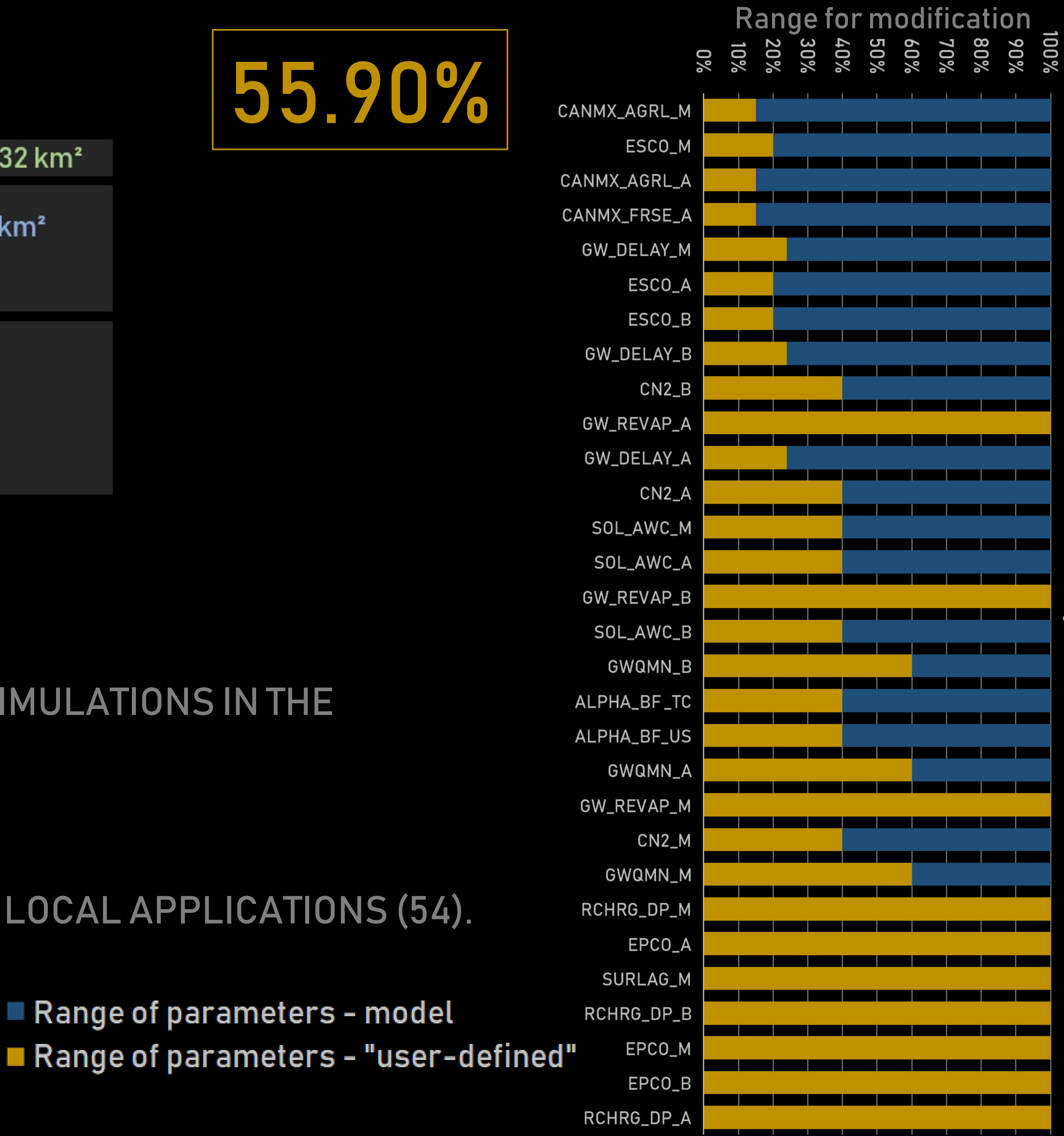



■ Range of parameters - model

# MODEL CALIBRATION:




55.90%

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- ✓ REGIONALIZATION OF PARAMETERS PERFORMED IN LOCAL APPLICATIONS (54).
- ✓ SENSITIVITY ANALYSIS (29).

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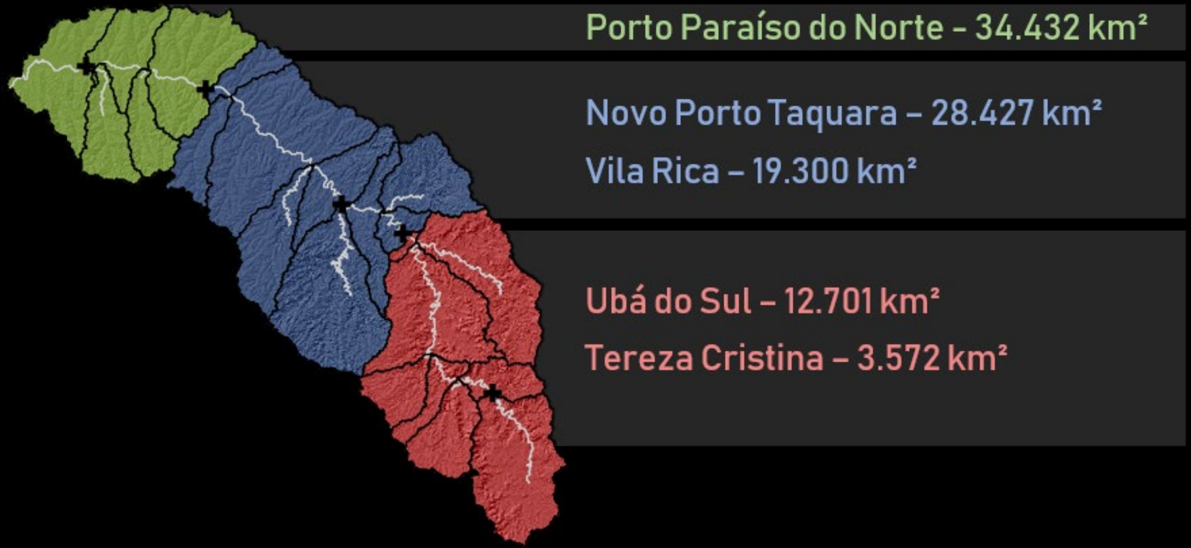
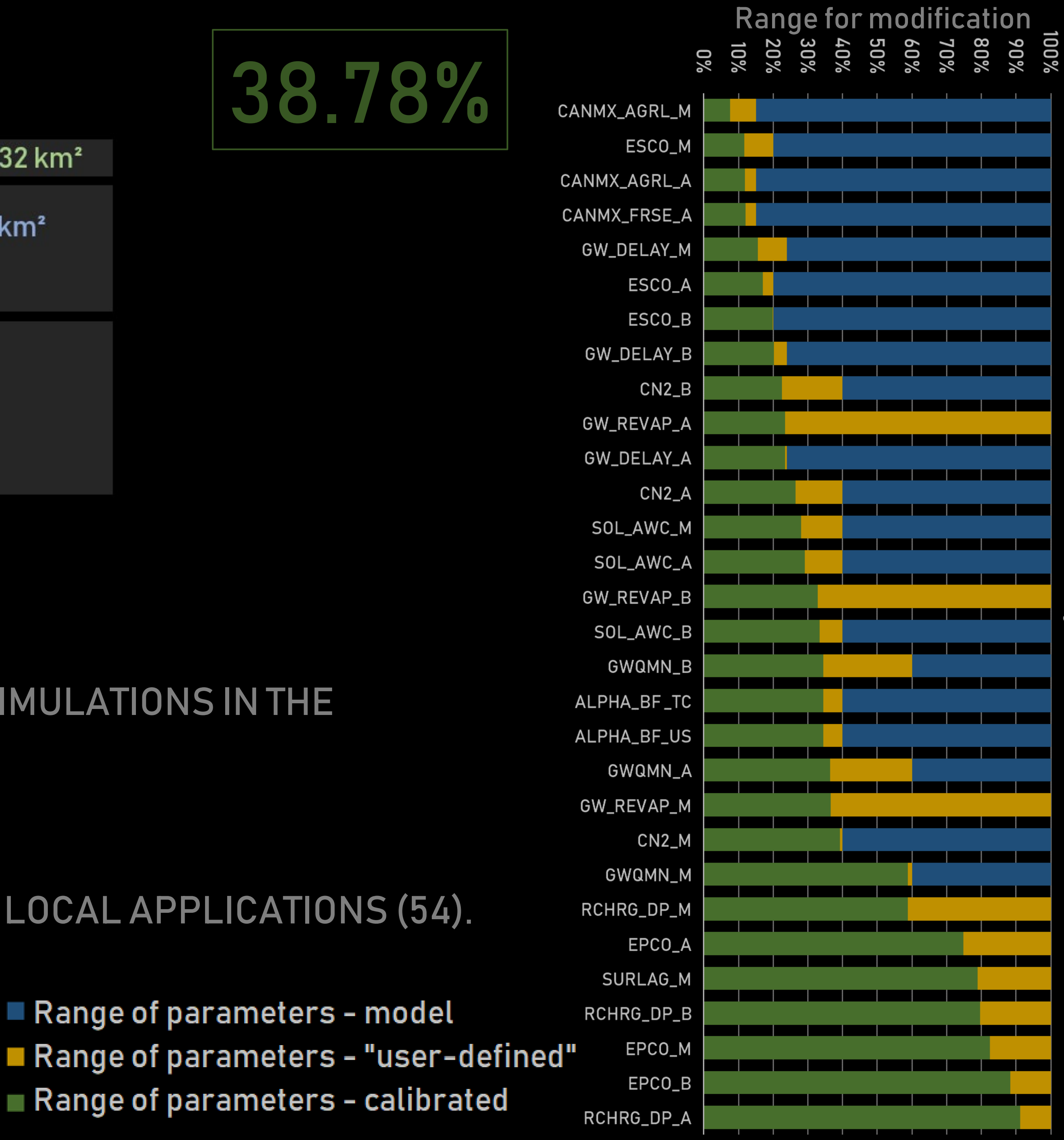



38.78%

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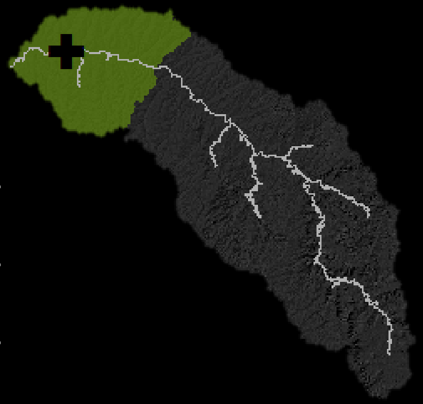
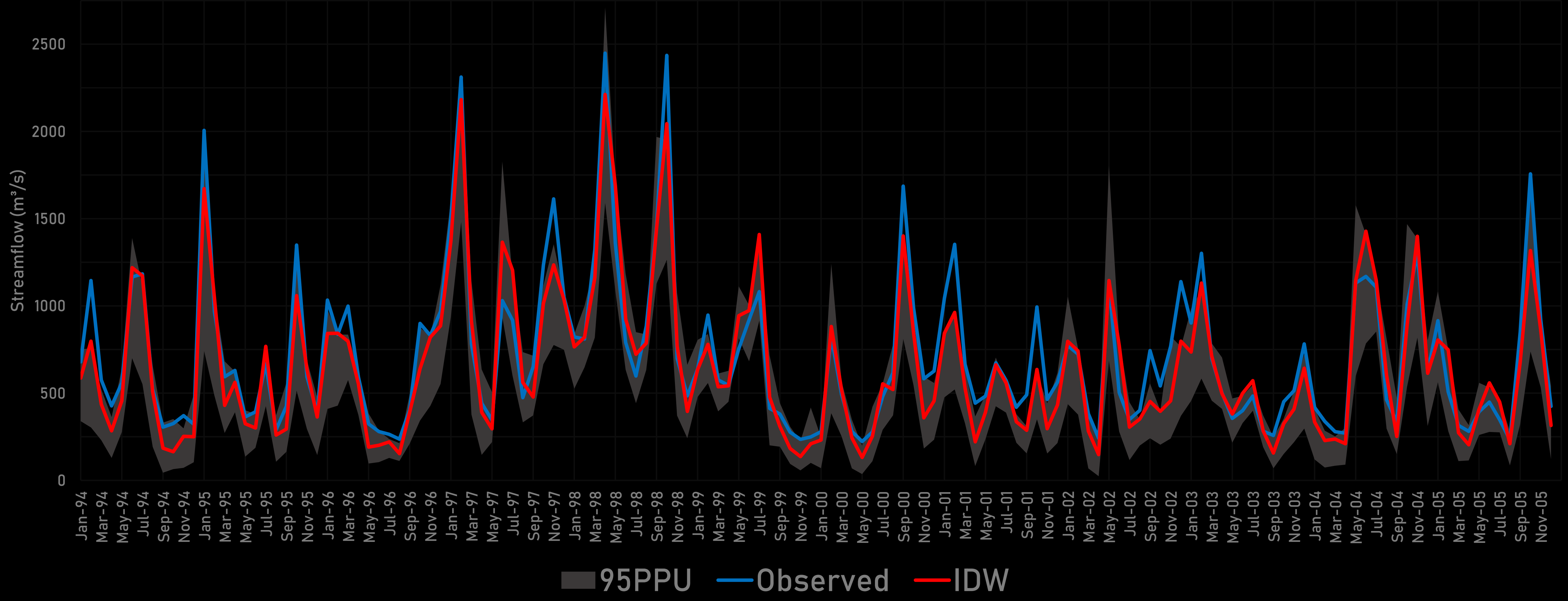
- ✓ SENSITIVITY ANALYSIS (29).
- ✓ CALIBRATION: SWAT-CUP, SUFI-2.

# NOVO PORTO TAQUARA



| | p-factor | r-factor | NS | PBIAS | Streamflow | | |
|---|---|---|---|---|---|---|---|
| | | | | | Std. Deviation | Simulated | Observed |
| IDW | 83% | 0,91 | 0,87 | 8,80% | 422.62 m³/s | 655,04 m³/s | 717,88 m³/s |



# CONCLUSIONS

Our IDW approach:

...allowed us to indirectly consider multiple gauges in the model structure.

...showed good homogeneity within the basin.

# ON GOING...

Calibrated and validated model ➡ Control model.

Removal of the precipitation stations in a sequenced approach until a minimum density is found to sustain satisfactory simulations.

Translate information to water resources managers and expand this methodology through the Hydrographic Region of Paraná River Basin.

# THANK YOU!

DETECTION OF THE ROLE IN CLIMATE CHANGE AND LAND USE AND LAND COVER CONDITIONS IN THE PARANA RIVER BASIN HYDROLOGY

[1] PAST LULC CHANGES AND THE IMPACT ON HYDROLOGY

[2] POTENTIAL IMPACTS OF CLIMATE CHANGE SCENARIOS

[3] EFFECTS OF LARGE-SCALE CLIMATE VARIABILITY

CAPES

ANA
AGÊNCIA NACIONAL DE ÁGUAS

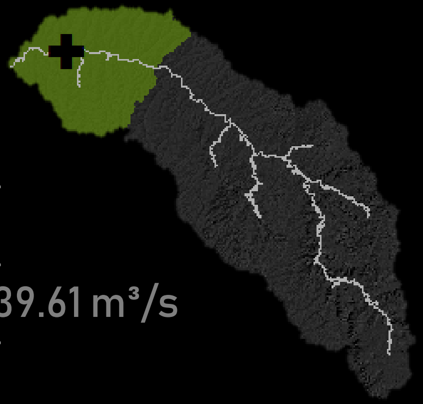
[1] Federal University of Technology – Paraná, PR, Brazil

[2] University of São Paulo, SP, Brazil

[3] State University of Amazonas, AM, Brazil

fujita.thais@gmail.com

# APPENDIX



| | p-factor | r-factor | NS | PBIAS | Streamflow Std. Deviation | Streamflow Simulated | Streamflow Observed |
|---|---|---|---|---|---|---|---|
| IDW | 83% | 0,91 | 0,87 | 8,80% | 422.62 m³/s | 655,04 m³/s | 717,88 m³/s ±439.61 m³/s |
| NN | - | - | 0.81 | 0.35% | 461.71 m³/s | 715.32 m³/s | |