Presentation for the EGU 2025

Fractal Dimension and Multiscale Analysis in Geomorphological Parameter Assessment and Hydrological Modeling

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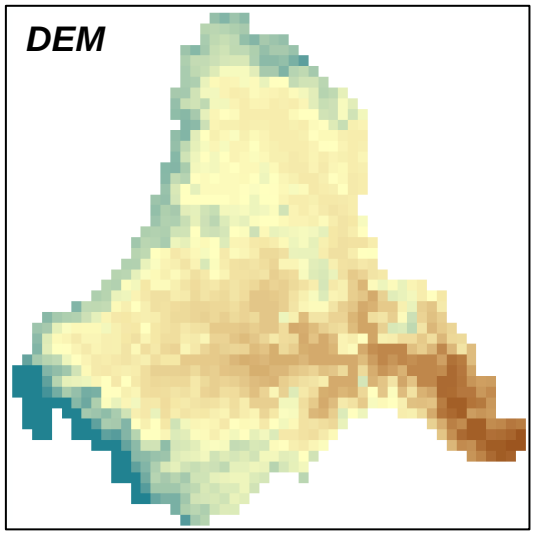
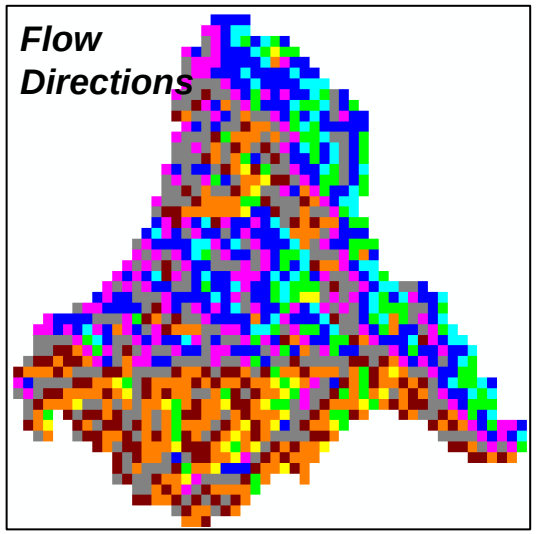
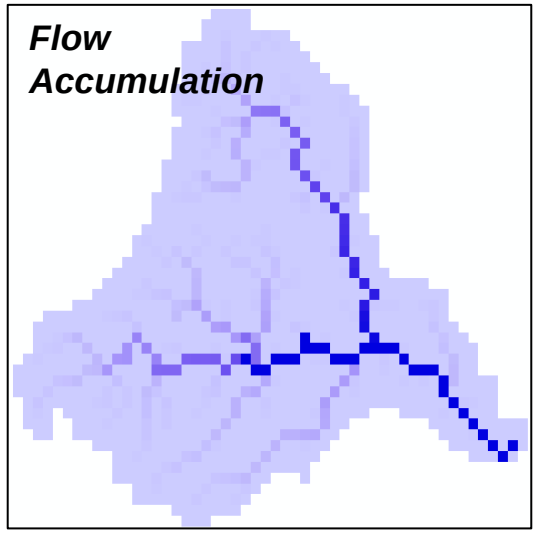
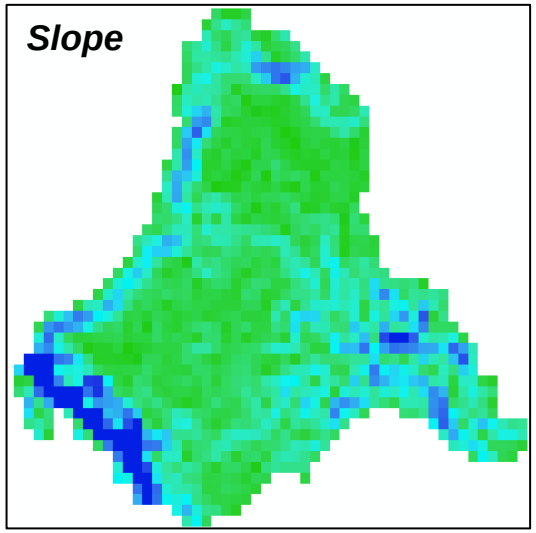
Introduction

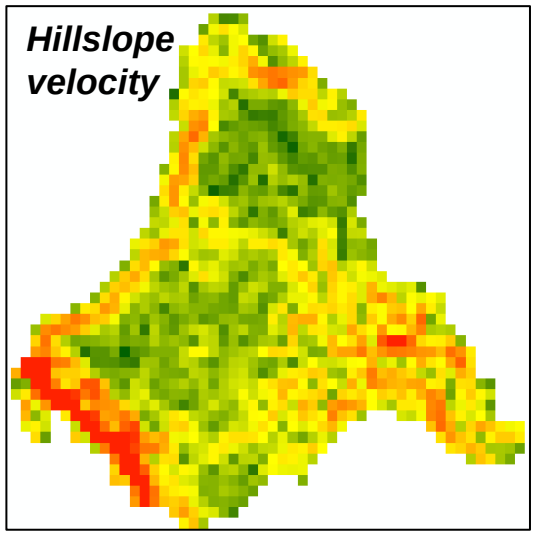
- Relevance of Digital Elevation Models (DEM) for obtaining parameters needed in hydrological modeling
  - Research zones
    - Po basin – Europa
    - Tugela basin – África





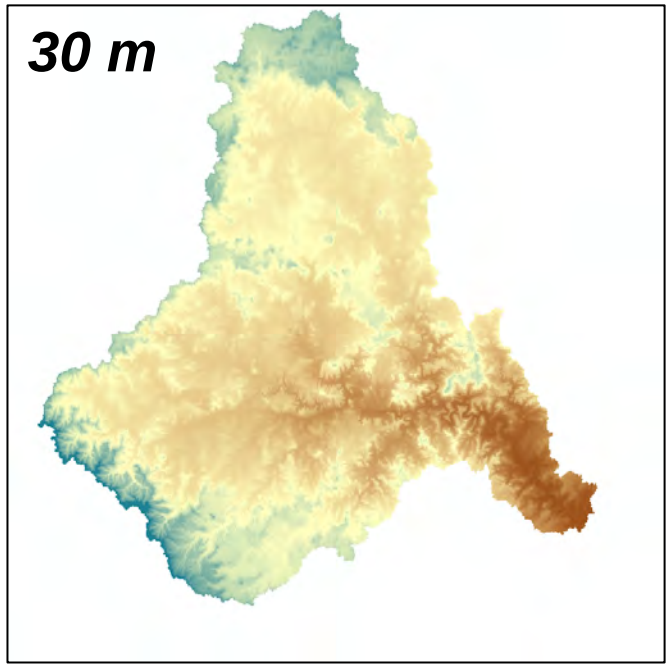


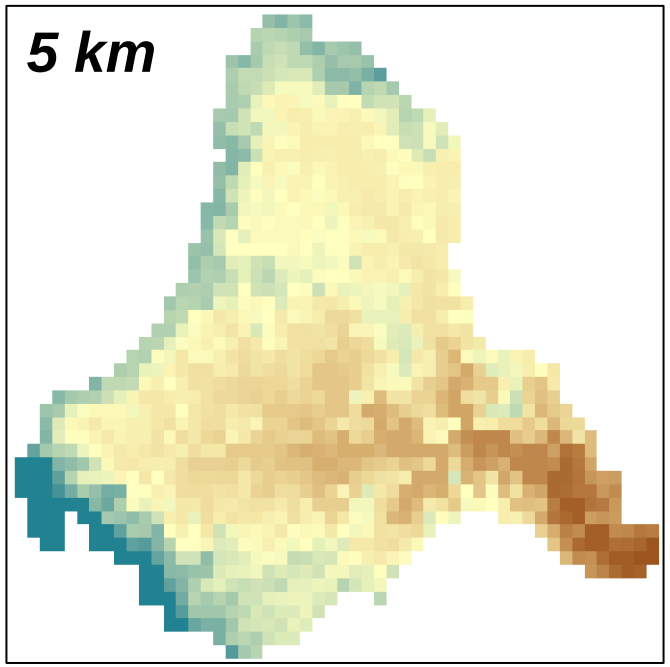




Introduction

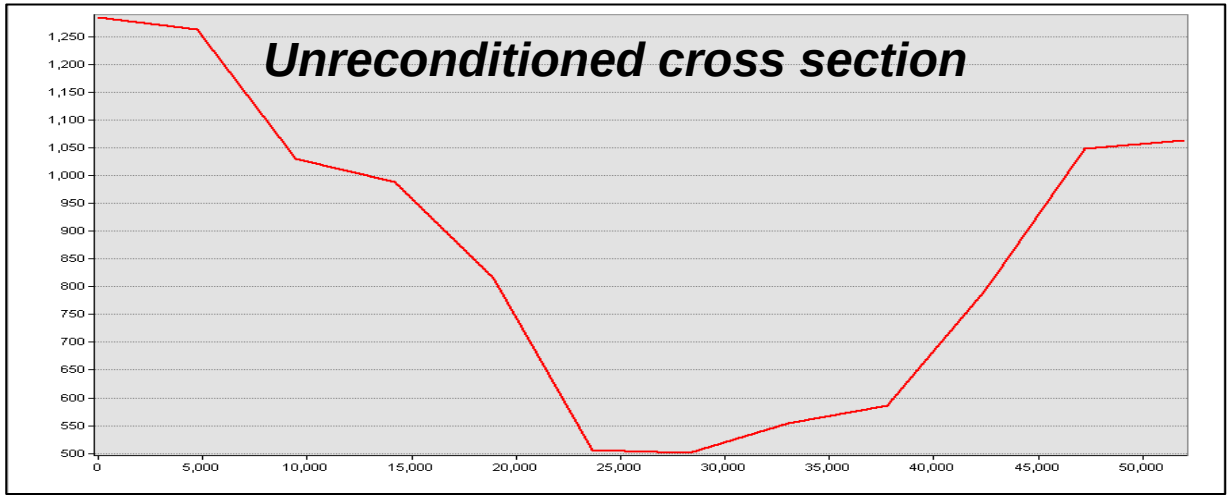
- Relevance of Digital Elevation Models (DEM) for obtaining parameters needed in hydrological modeling
- Spatial scale:
  - Base: 30m
  - Upscaling: 200m, 500m, 1000m, 2500m, 5000m

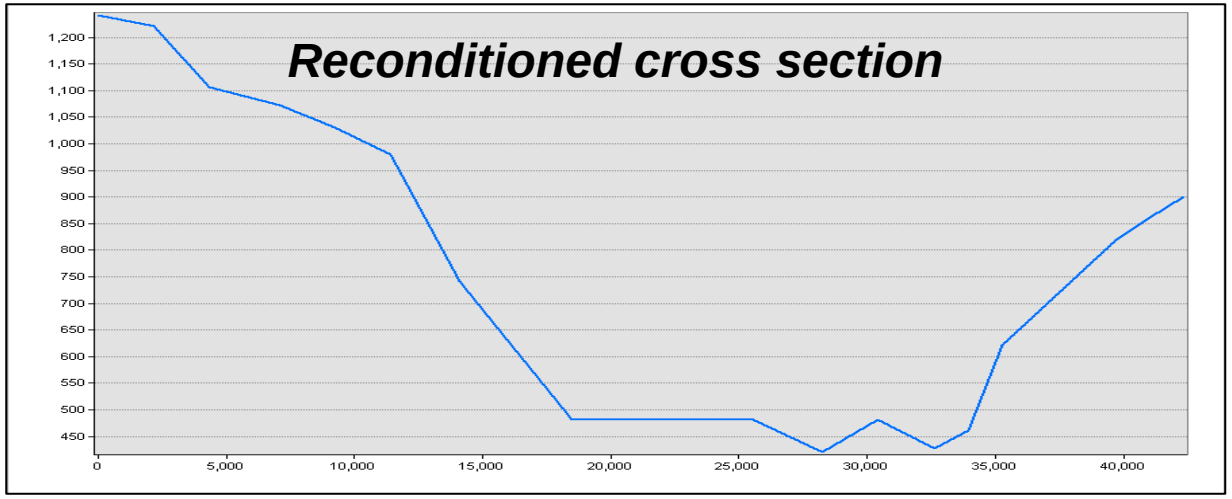




Introduction

- Relevance of Digital Elevation Models (DEM) for obtaining parameters needed in hydrological modeling
- Spatial scale
- DEM reconditioning
  - [B]: Base, no reconditioning
  - [L]: Local, Local stream network reconditioning
  - [G]: Global, Global stream network reconditioning





Methodology

1. STRM 30m

- Download digital elevation models (DEM)

2. DEM scaling

- Bilinear interpolation method

3. DEM reconditioning

- Three-parameter AGREE method

4. Parameter map generation

- Flow directions
- Flow accumulation
- Slope
- Hillslope velocity

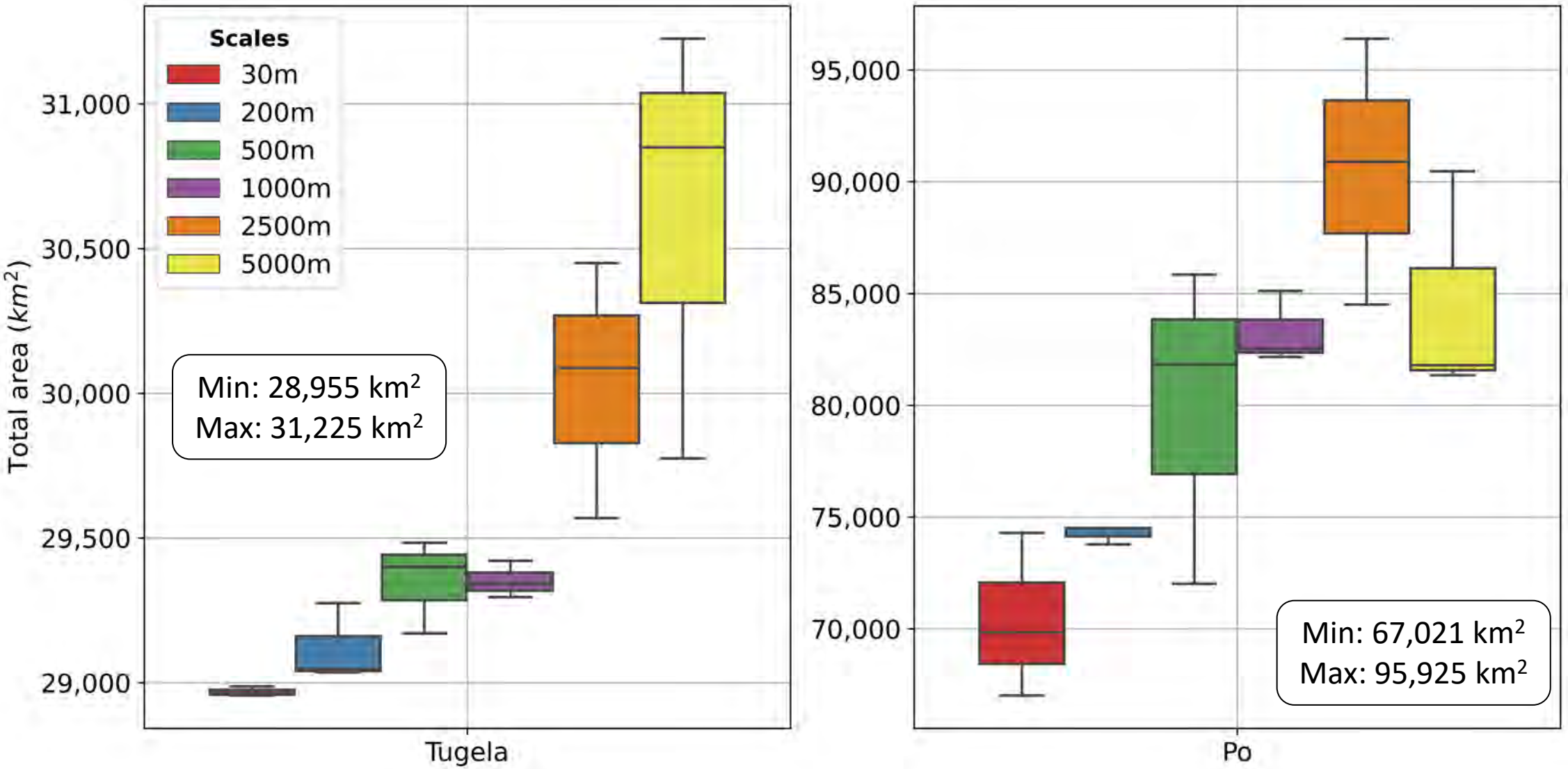
5. Hydrological modeling TETIS V.9.1

- Unit Hydrograph principle
- Impervious surface

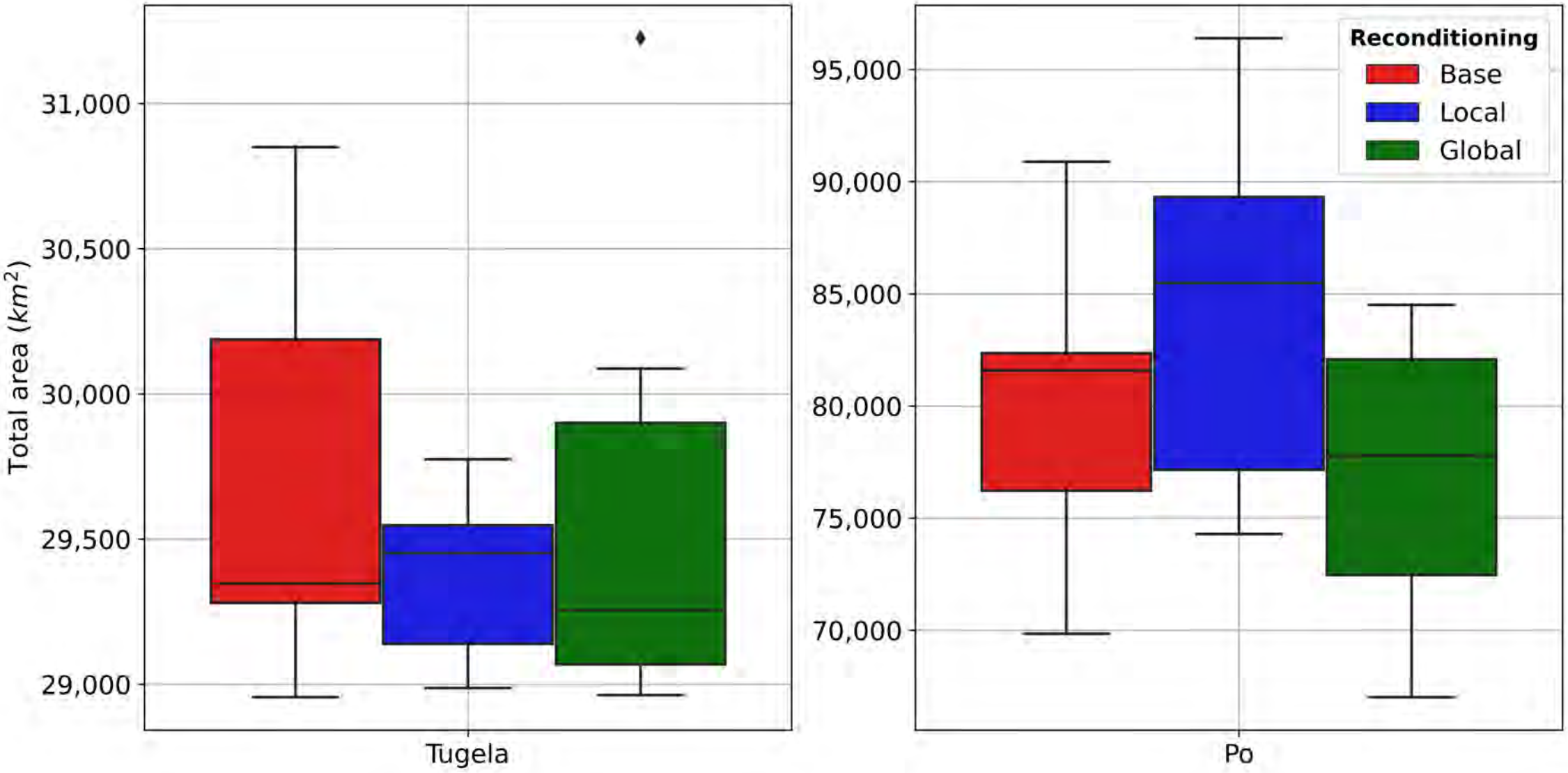
6. Fractal dimension analysis

- 4 geomorphological variables
- Box counting methodology
- Number of regressions points

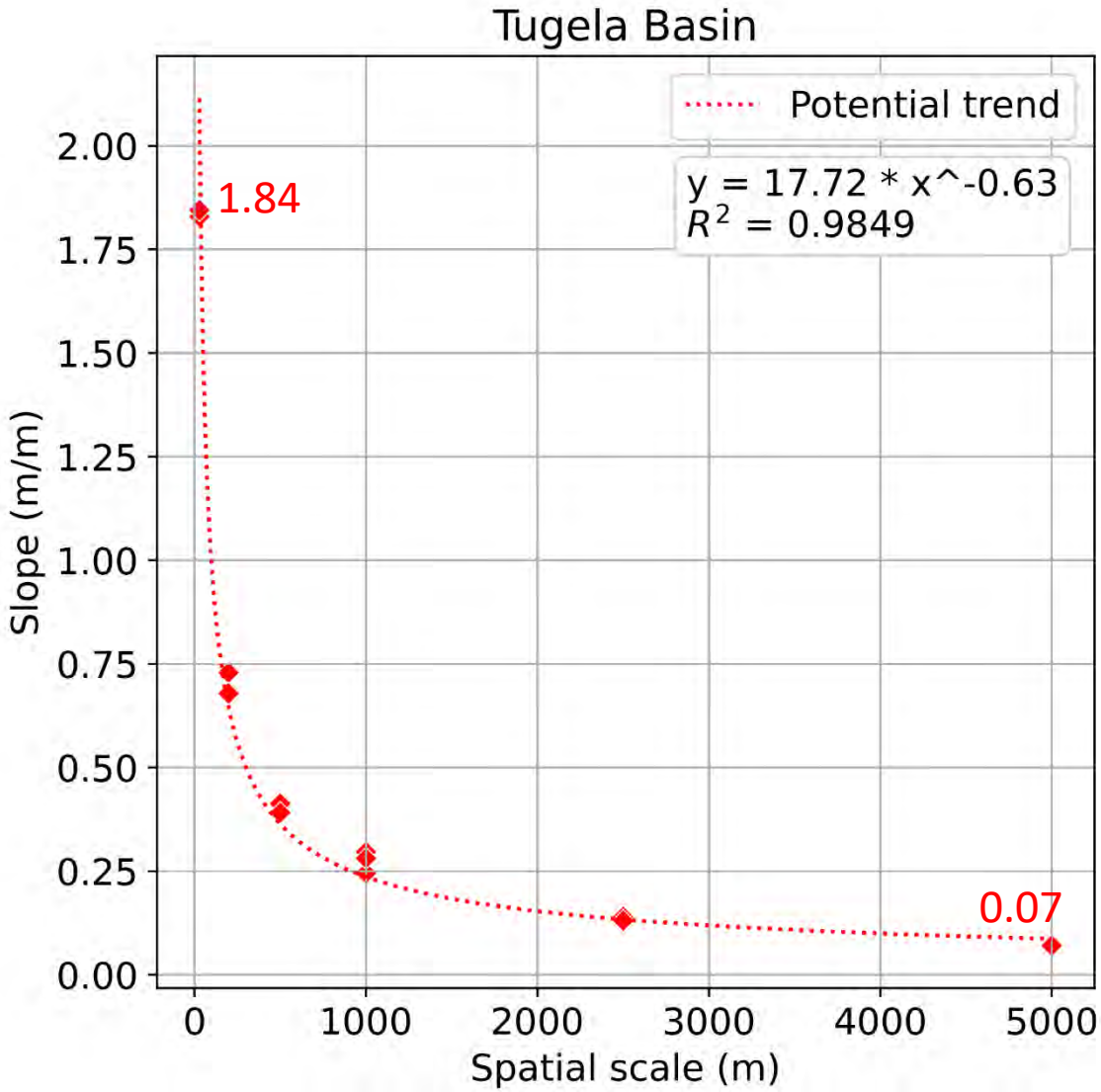
Basin area vs scale

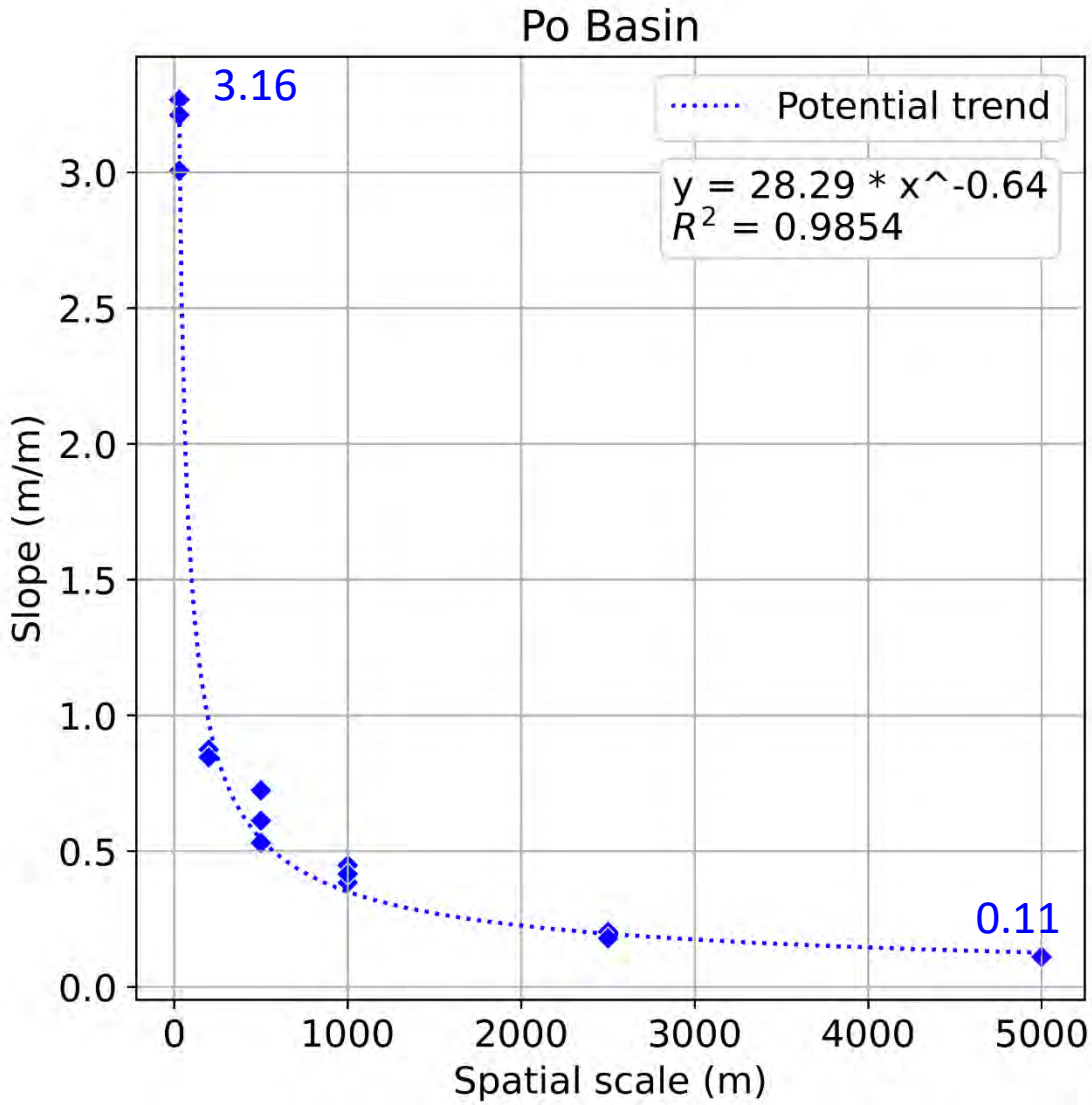


Basin area vs reconditioning

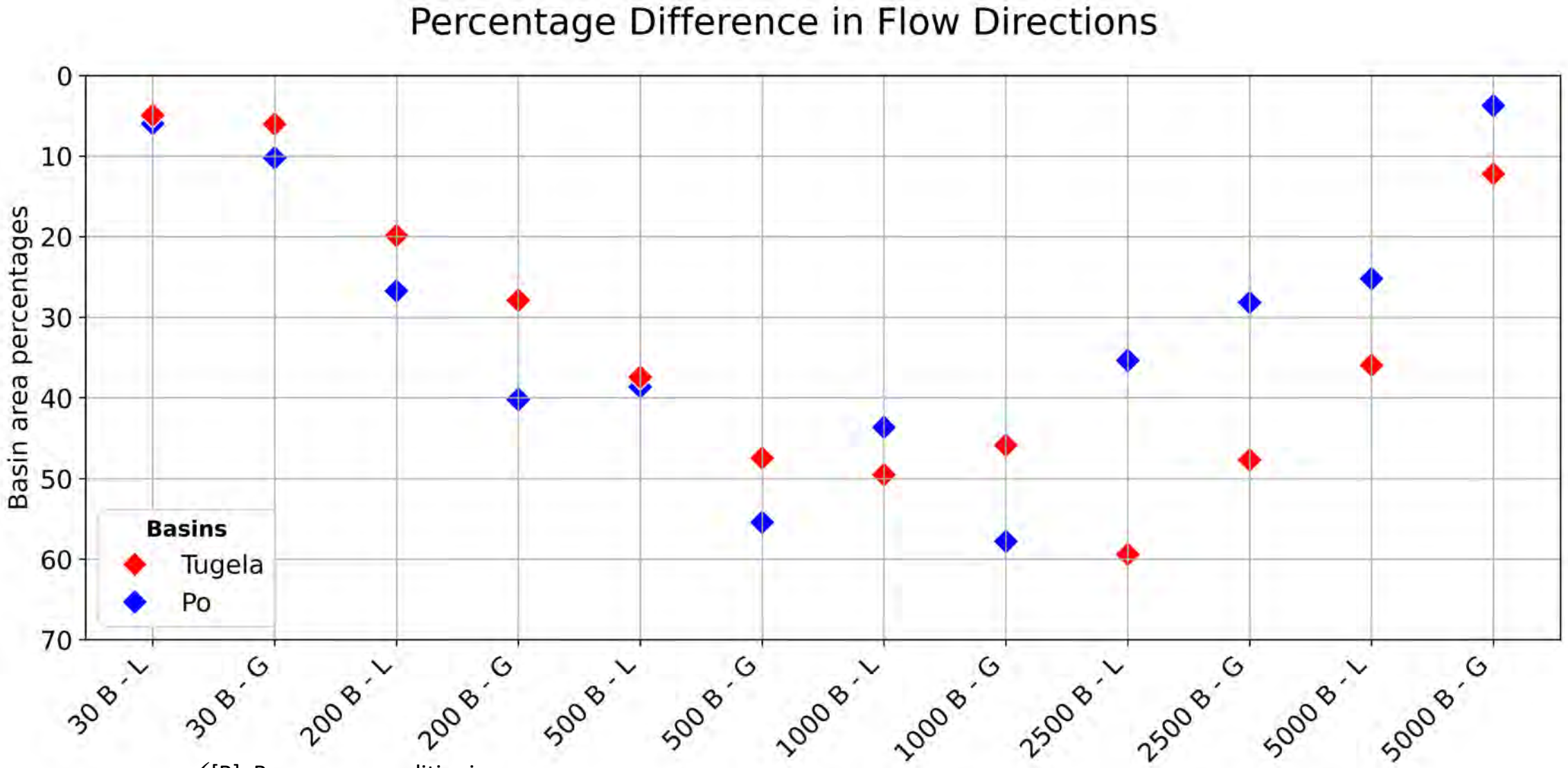


Slope vs scales





Flow direction analysis



✓[B]: Base, no reconditioning
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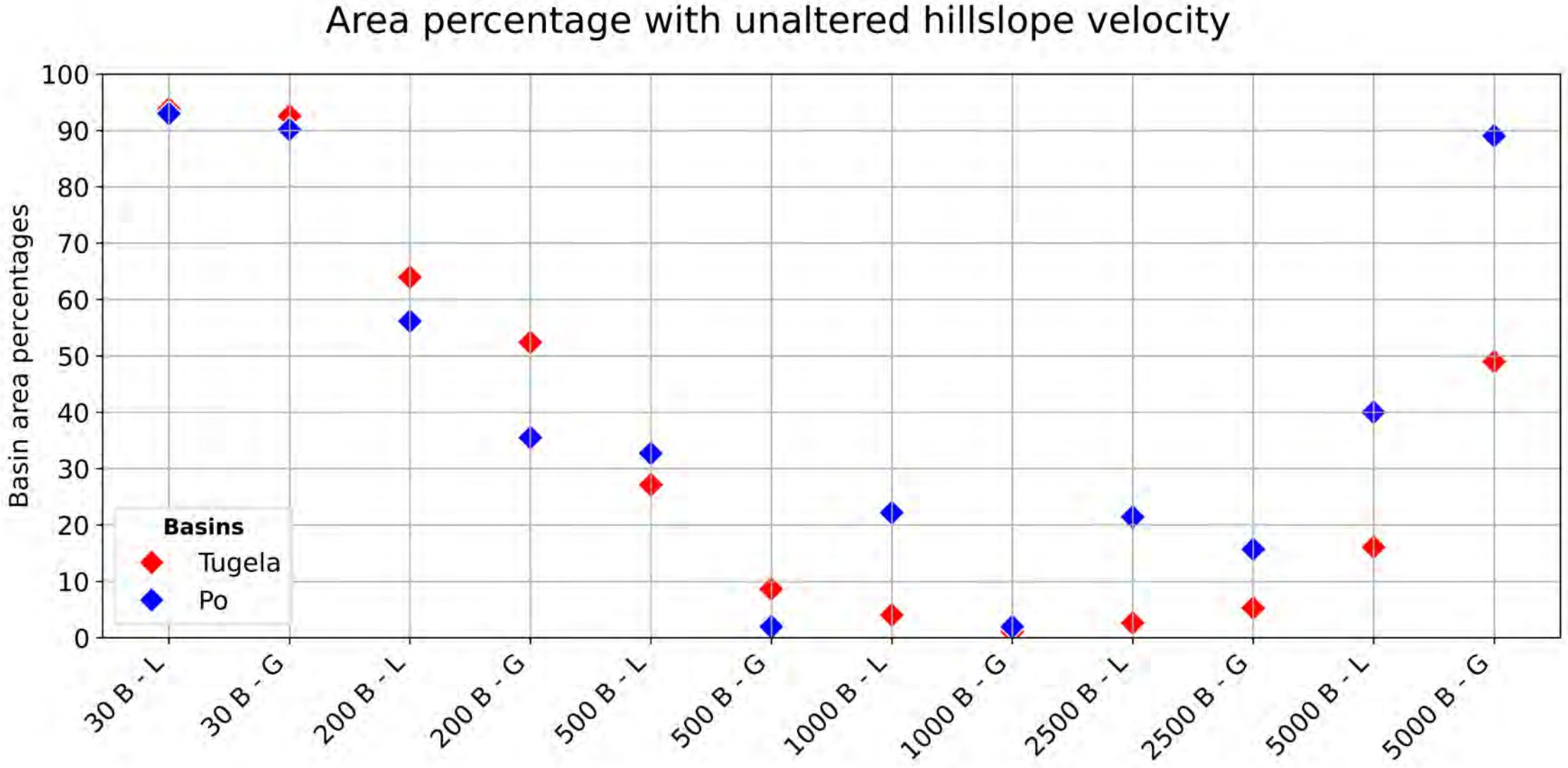
Hillslope velocity analysis



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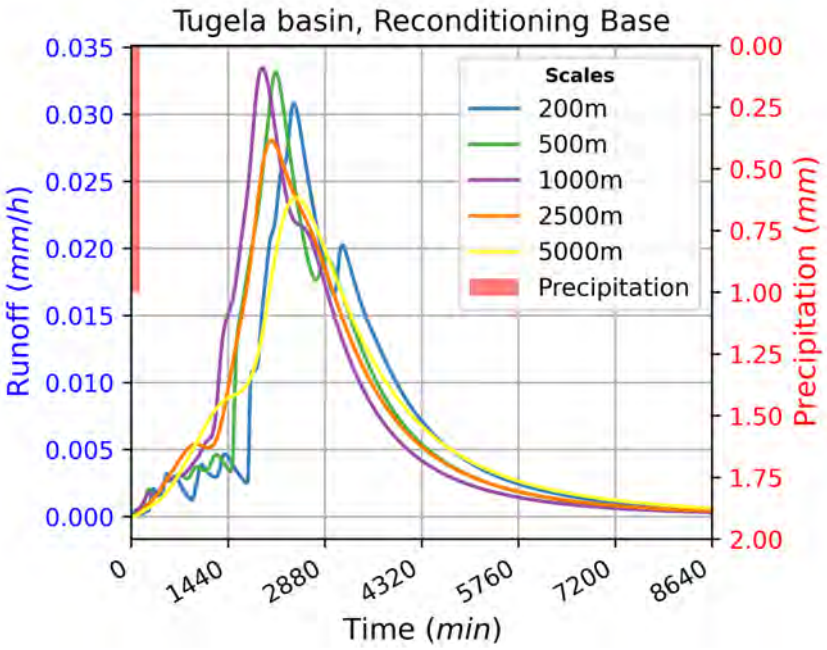
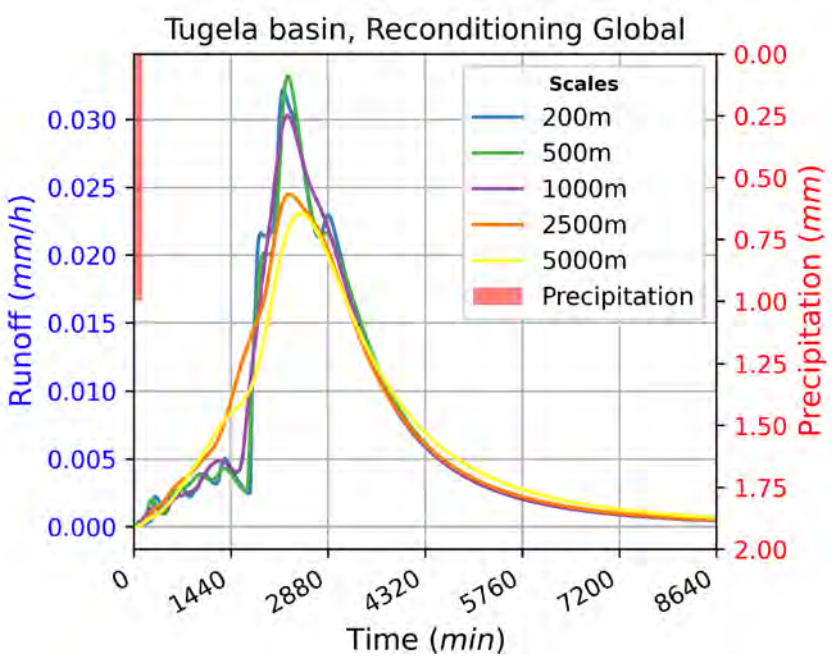
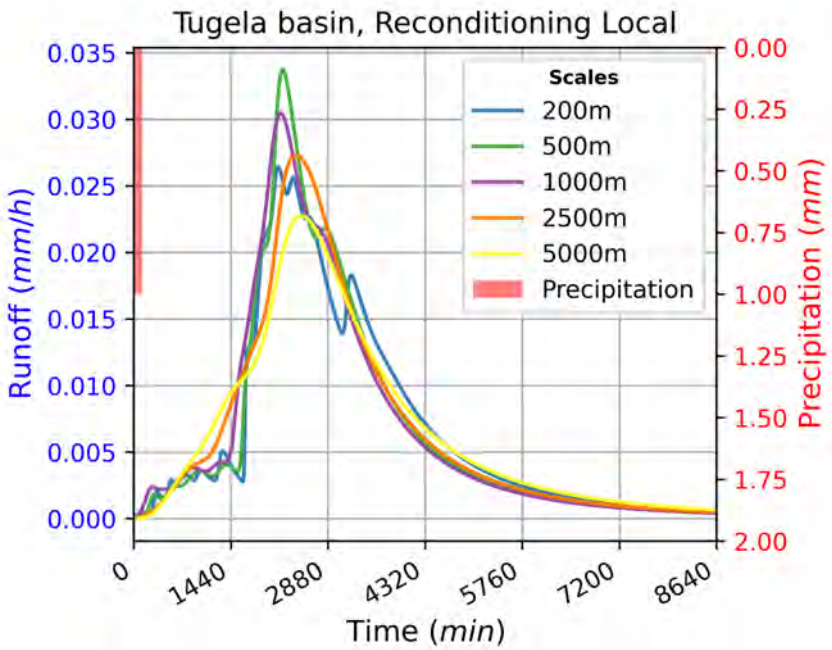
Propagation analysis

- Unit Hydrograph principle
- Impervious surface







Propagation analysis

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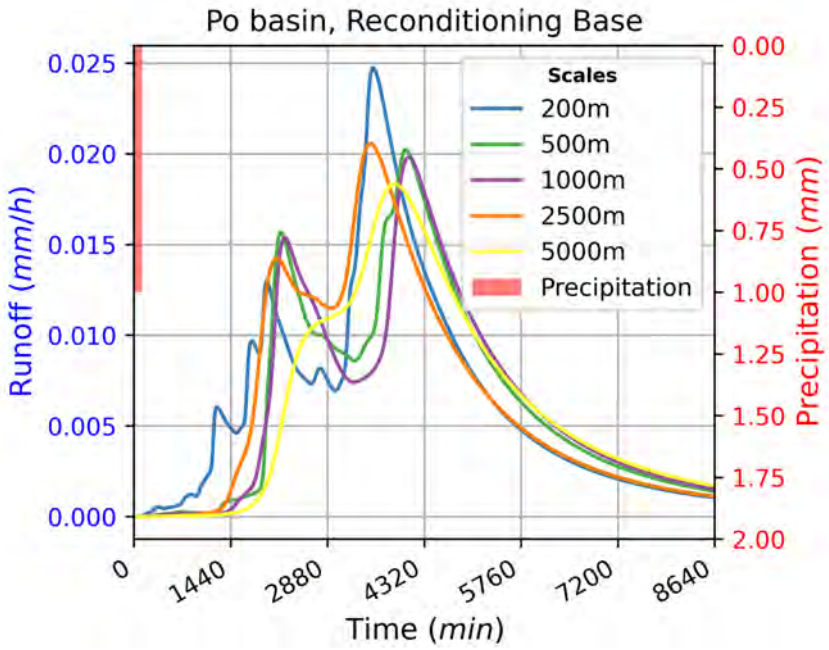
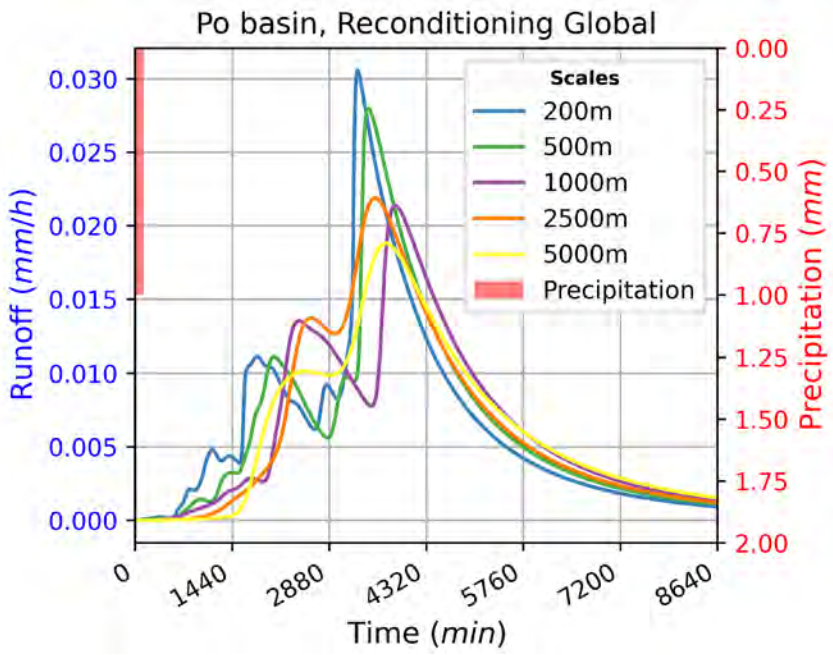
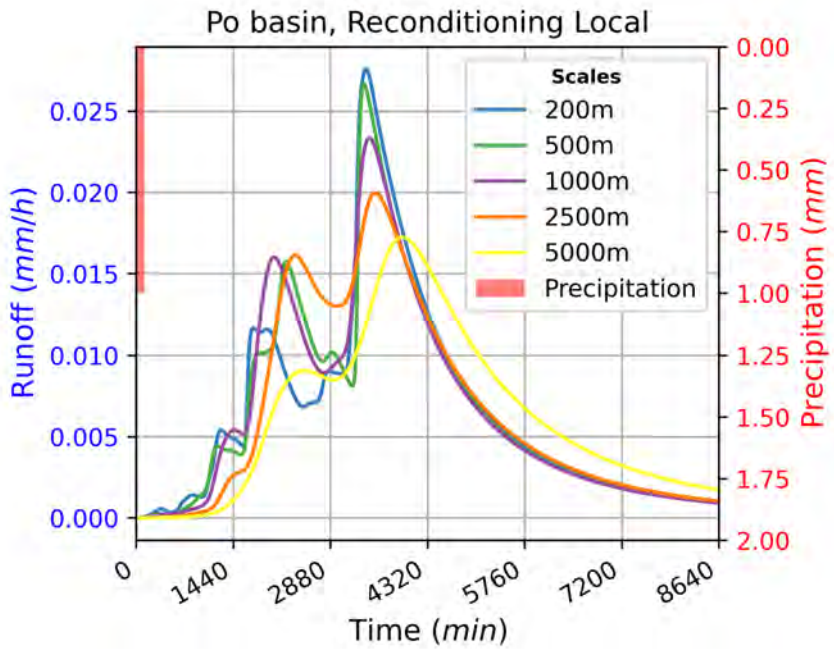
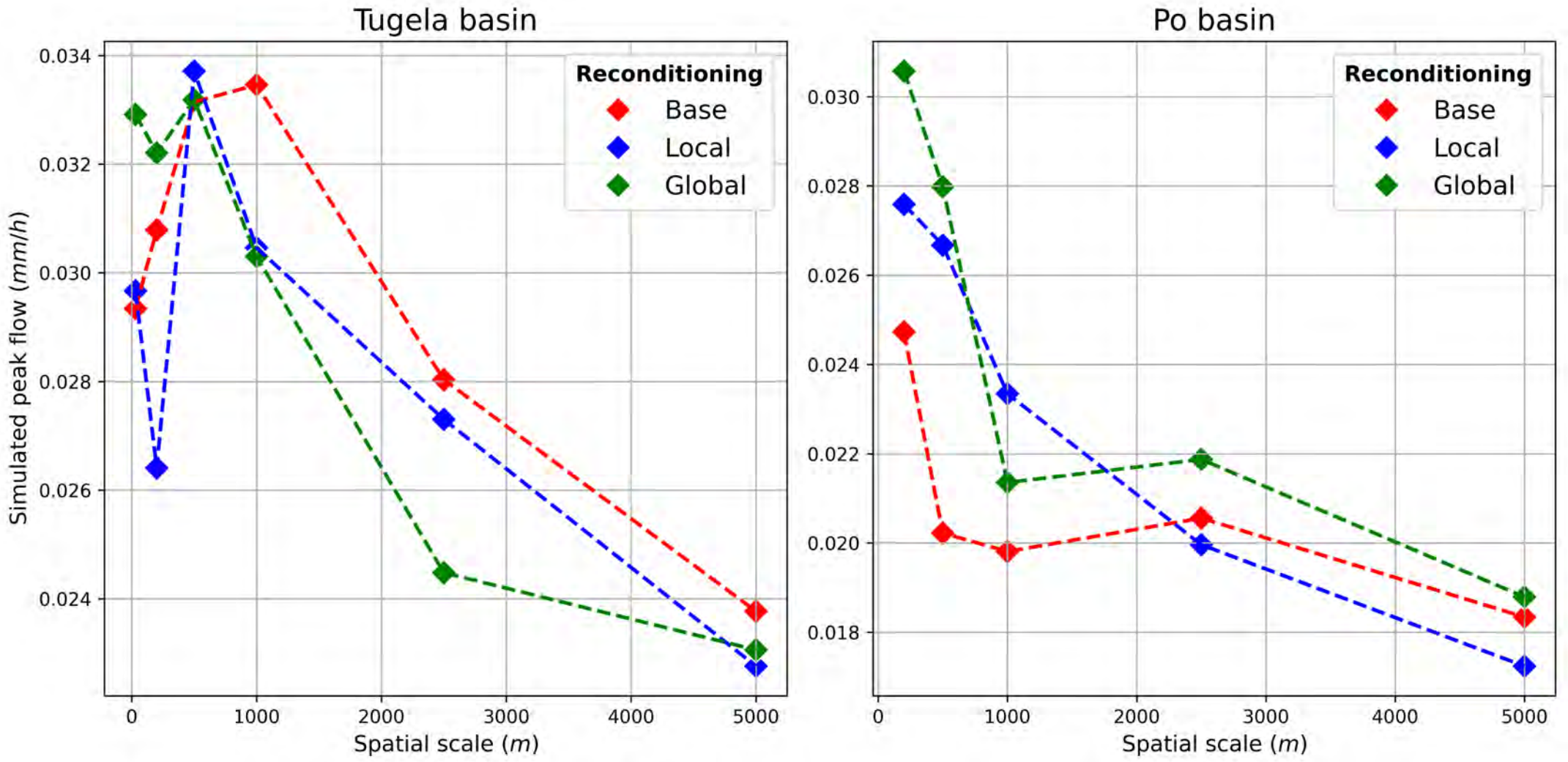


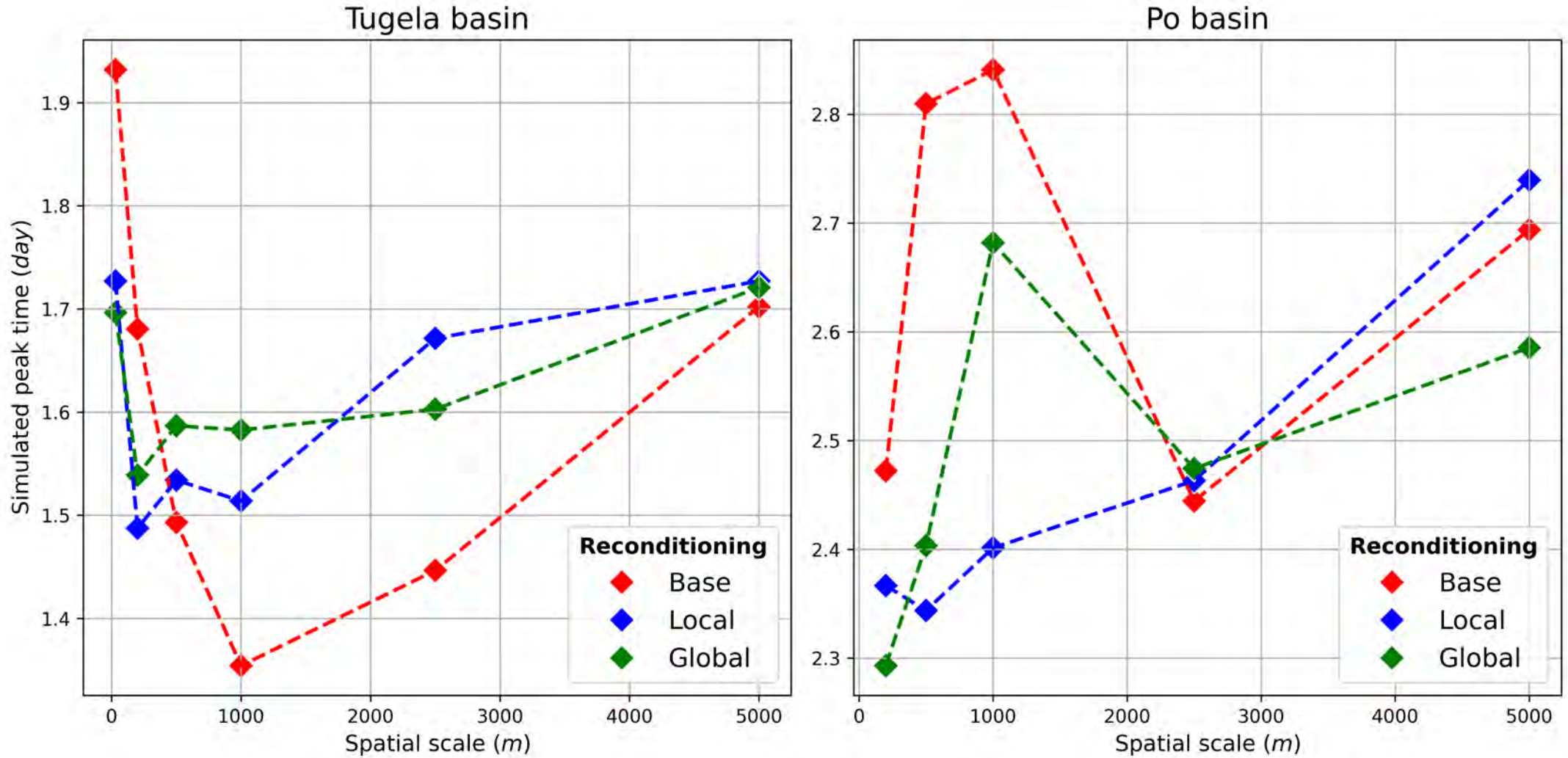




Simulated peak flows



Simulated peak time

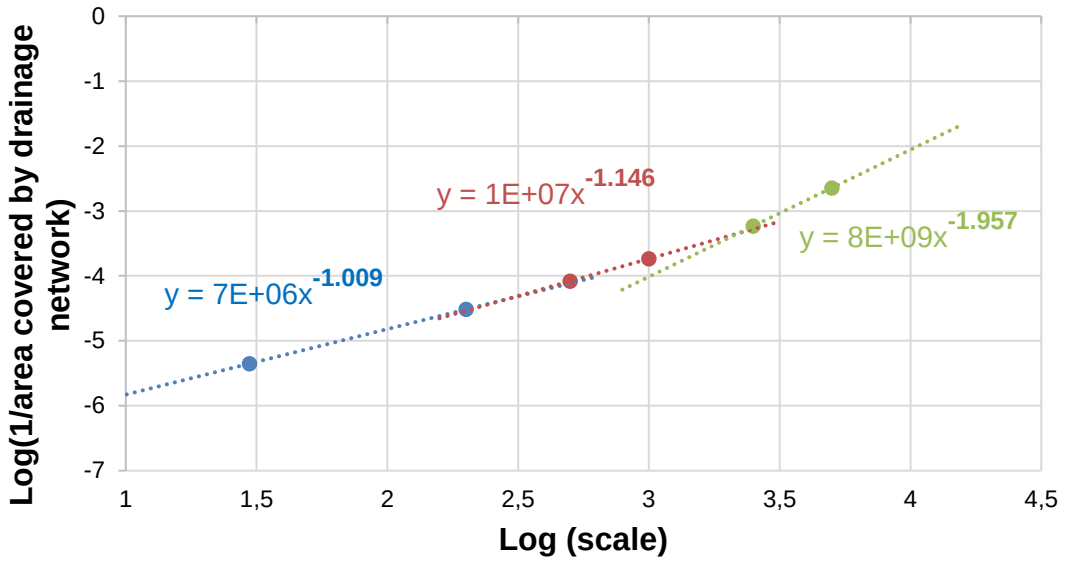


Fractal dimension

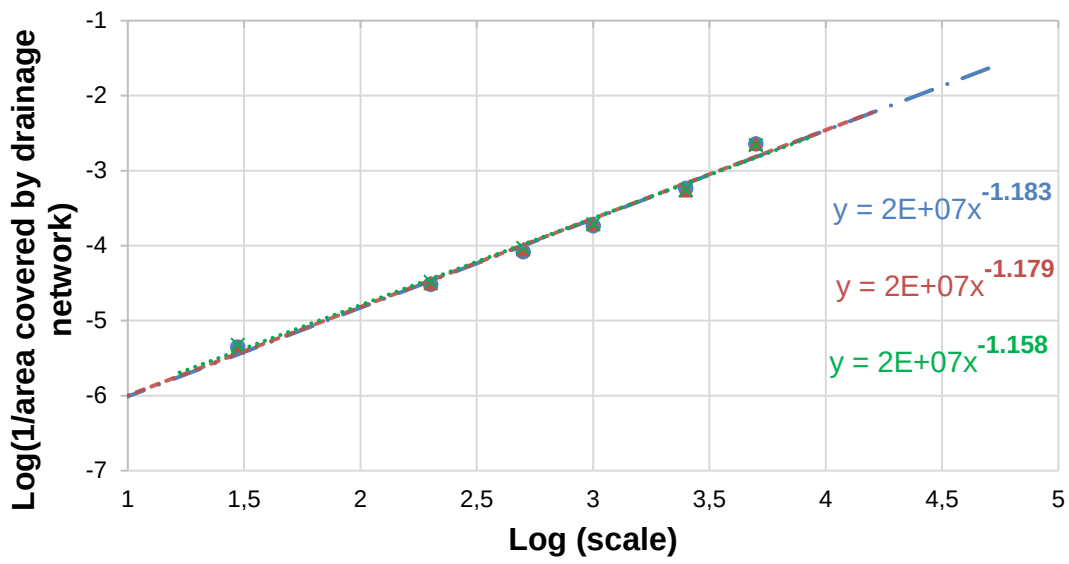
Variables
- Total basin area.
- **Area covered by the drainage network.**
- Drainage network length.
- Drainage density.

Scale
- Pixel size.

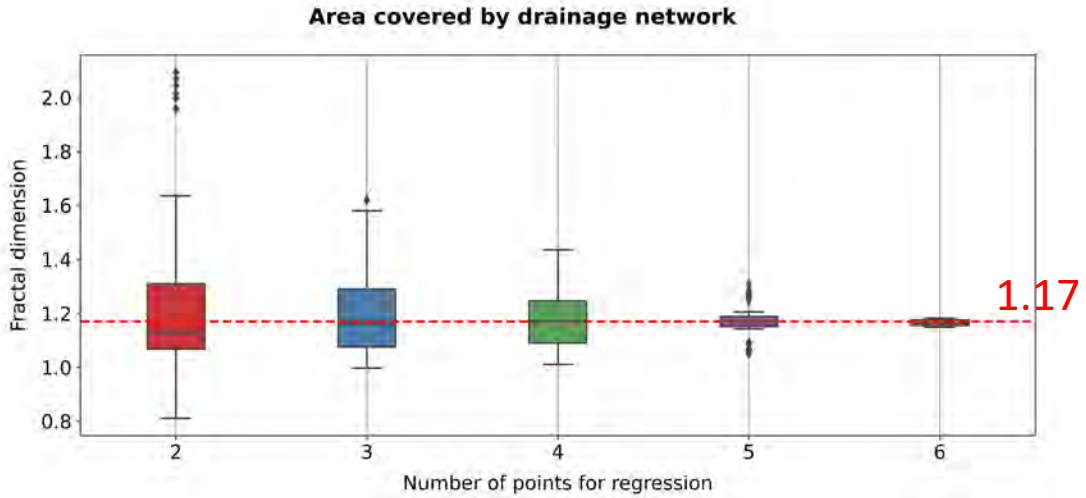
Fractal dimension with two points regression

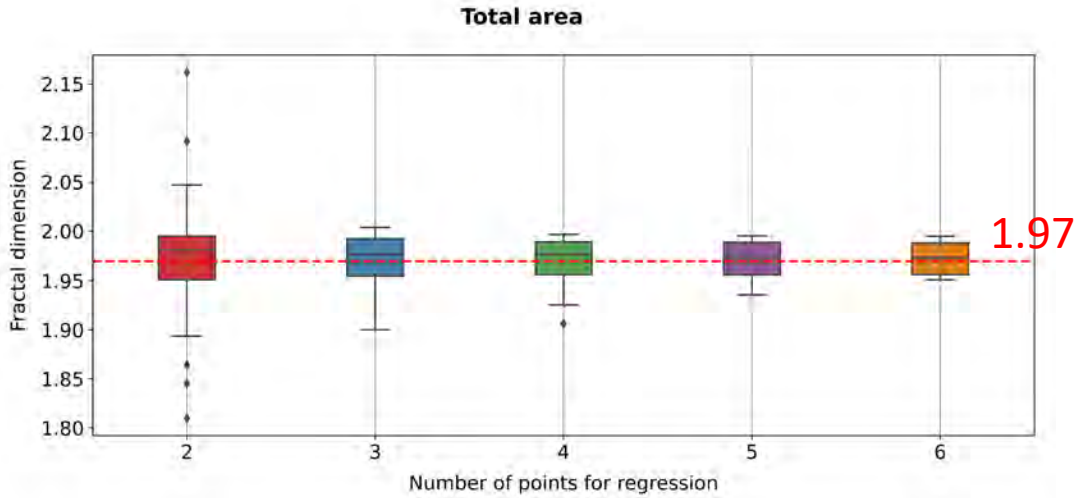


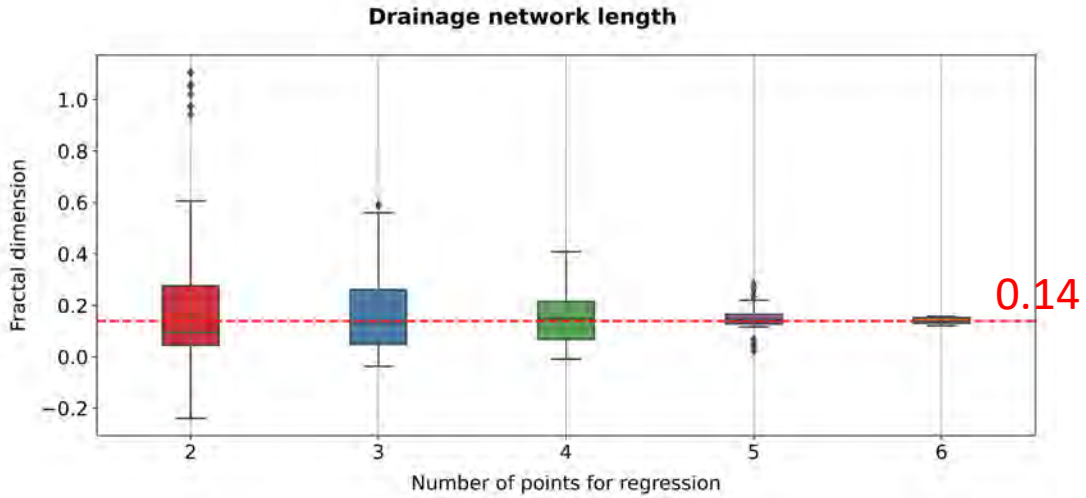
Fractal dimension with six points regression

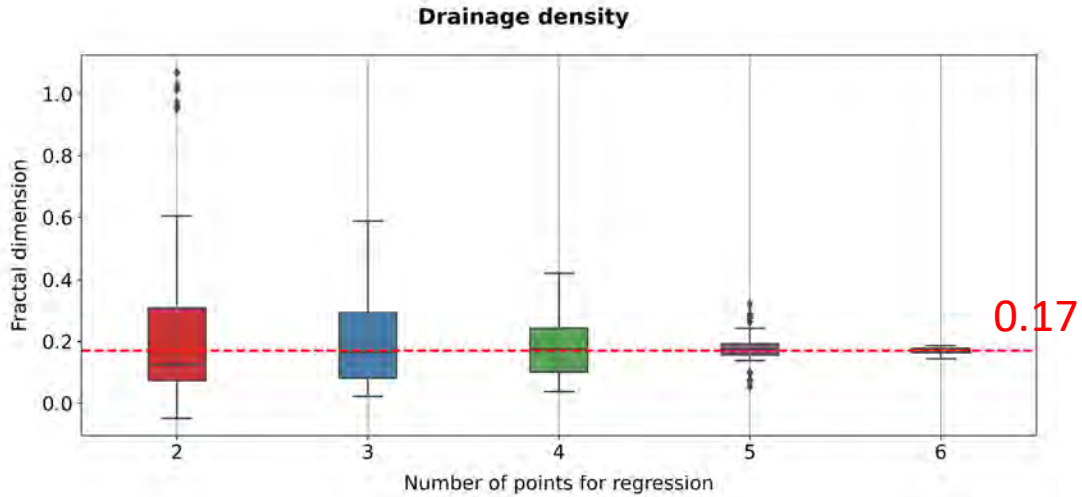


Fractal dimension









Conclusions

- It is evident that both DEM reconditioning and spatial scaling have a considerable impact on hydrological parameters, inducing substantial variations in propagation results.

- In the modeling, scale variations could amplify simulated peak flows by up to 10% or reduce them by up to 26%, while simulated peak times could be delayed by up to 12% or advanced by up to 20%.

- Moreover, the reconditioning process affect the effective parameters for the model. Consequently, each spatial scale will demand specific adjustments to the correction factors to achieve accurate results in hydrological modeling.

- Regarding fractal dimension, the analysis indicated that:
  - Number of regression points to be considered is at least 5.
  - Independent of basin and type of reconditioning.

Thanks for your attention

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