Probabilistic Dam Break Flood Mapping via Monte-Carlo Simulations using a 2D Local-inertial Model

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INTRODUCTION

Flooding is the leading cause of natural disasters, impacting over 19 million Brazilians. Approximately 1 million people live within 1 km of one of the 1,220 dams classified as high-risk and high-potential damage in Brazil.

Deterministic event-based approaches typically do not consider the inherent uncertainty arising from the effects governing a dam-break scenario. In this work, a probabilistic dam-break model was developed based on the Monte-Carlo method, coupling a 2D local-inertial hydrodynamic model (HydroPol2D) with Bayesian-generated governing parameters to the dam-break flow propagation problem to capture a set of scenarios with different reservoir initial volumes, breach hydrographs, and terrain roughness.

METHODS

To develop the probabilistic dam-break model, a hydrological-hydraulic model (i.e. HydroPol2D) that solves the shallow water equations with the local-inertial approach and Infiltration calculation using the Green-Ampt Method was used.

(1) Continuity Equation

$$\frac{\partial A}{\partial t} + \frac{\partial Q}{\partial x} = 0,$$

(2) Momentum Equation

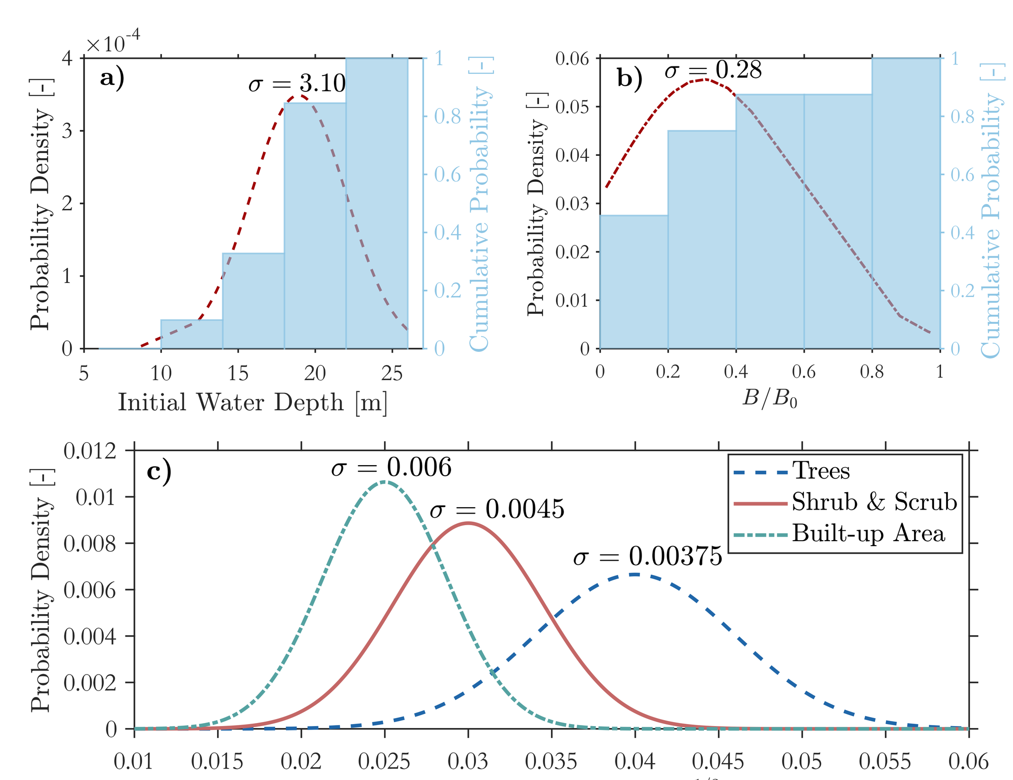
$$\underbrace{gA(S_f - S_0)}_{\text{friction and gravity}} + \underbrace{\frac{gA\partial h}{\partial x}}_{\text{water slope}} + \underbrace{\frac{\partial Q}{\partial t}}_{\text{local acceleration}} = 0$$

The model generates an initial value of the reservoir depth, breach width, and Manning's coefficient for each LULC class based on their probability density functions.

The **Reservoir depths PDF** was derived from a national database for over 15 years in daily time-steps.

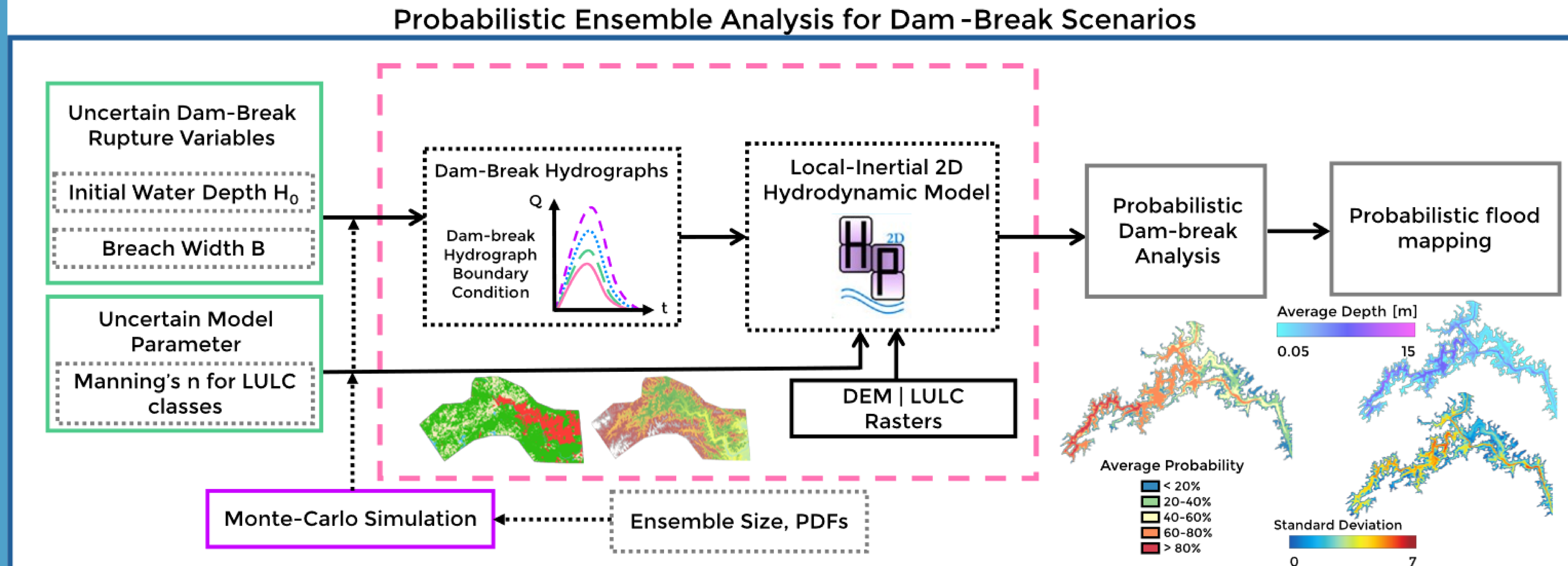
The **Breach width PDF** was obtained from 24 well-documented failures of concrete and masonry dams.

In addition, a coefficient of variation of 0.15 was assumed due to the lack of historical data for **Manning's coefficient**.

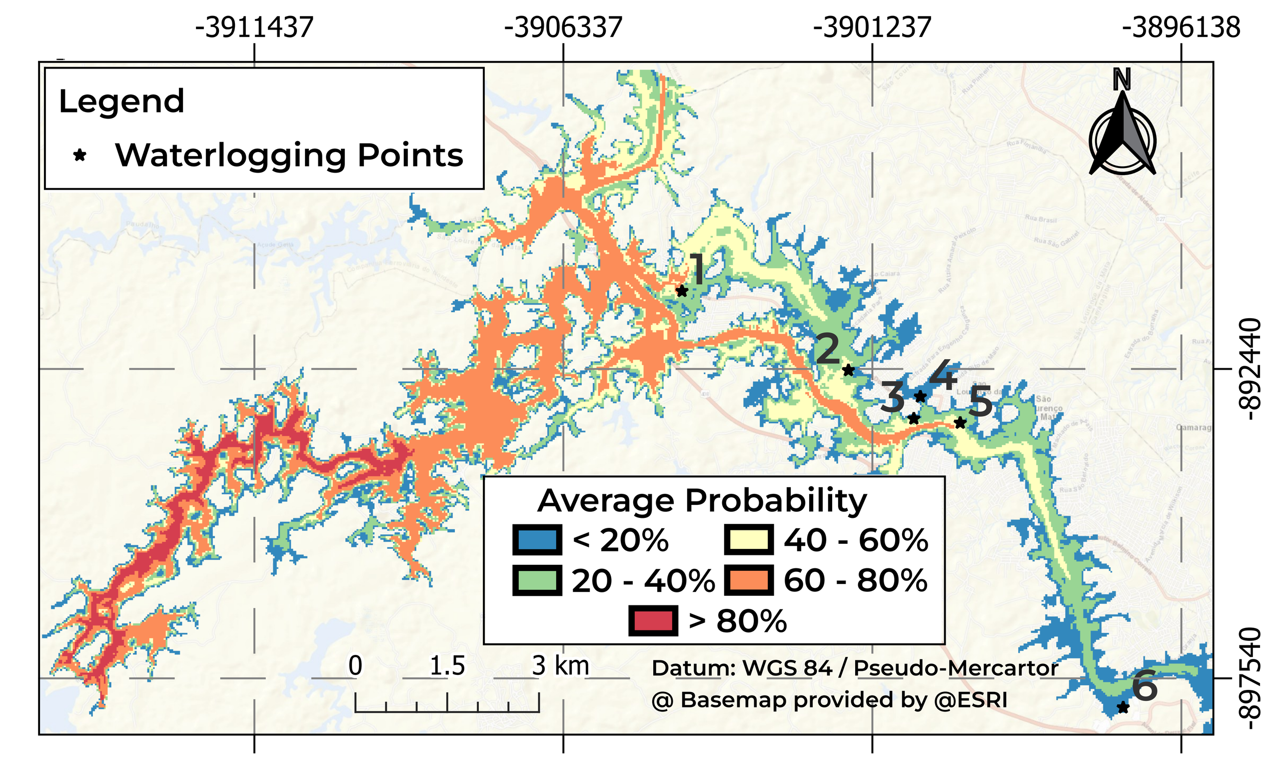


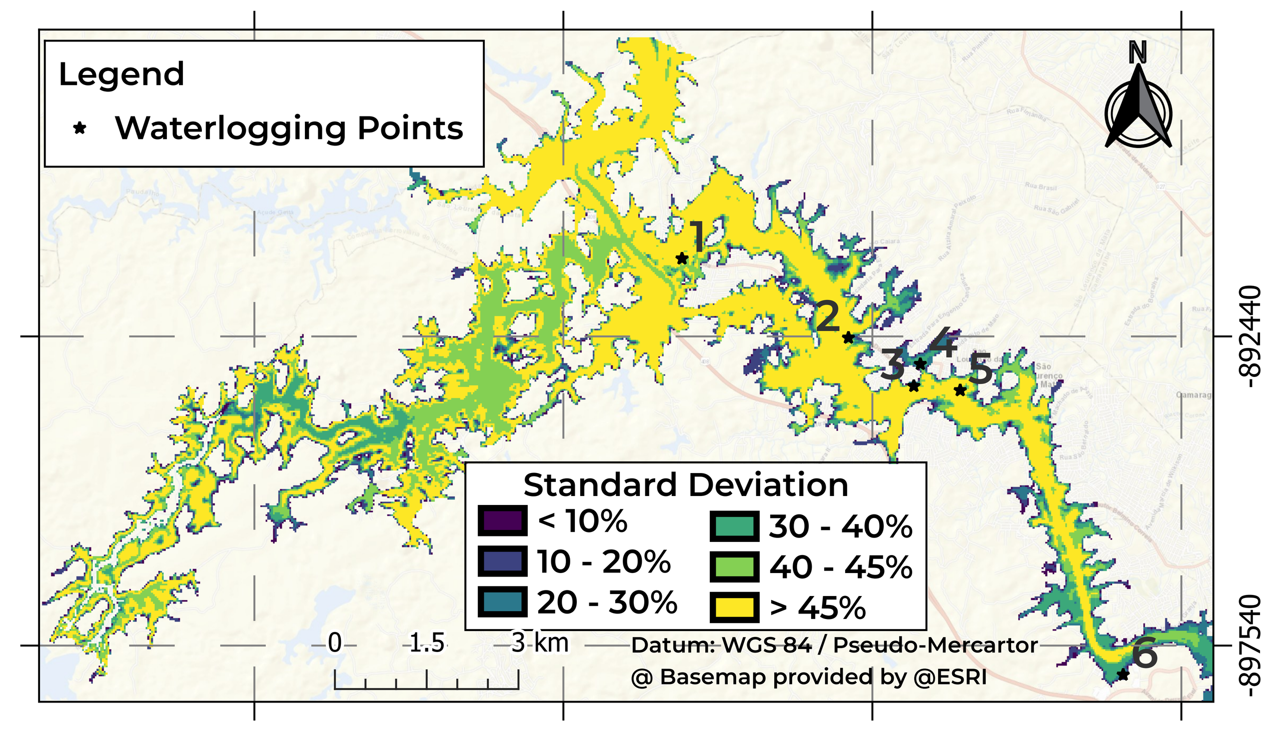
PROBABILISTIC ENSEMBLE ANALYSIS

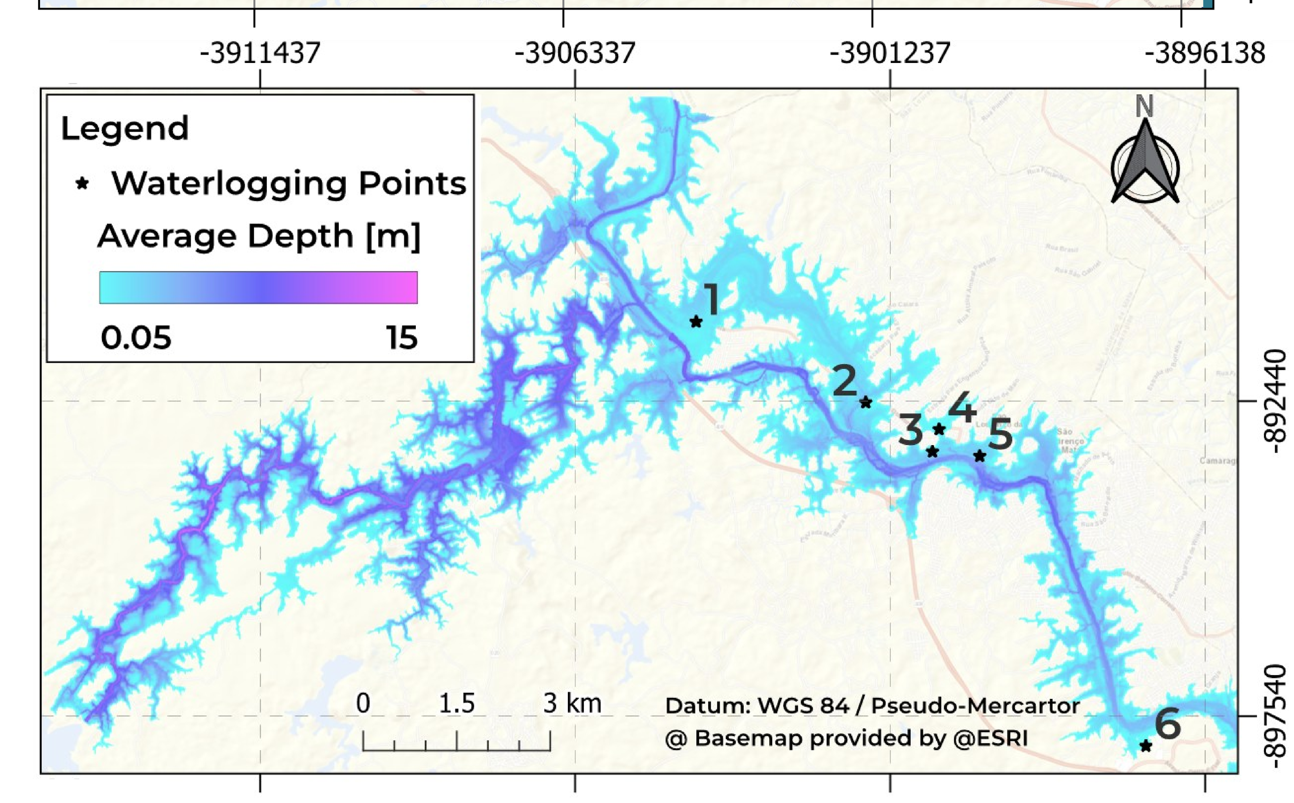
Probabilistic Ensemble Analysis for Dam -Break Scenarios

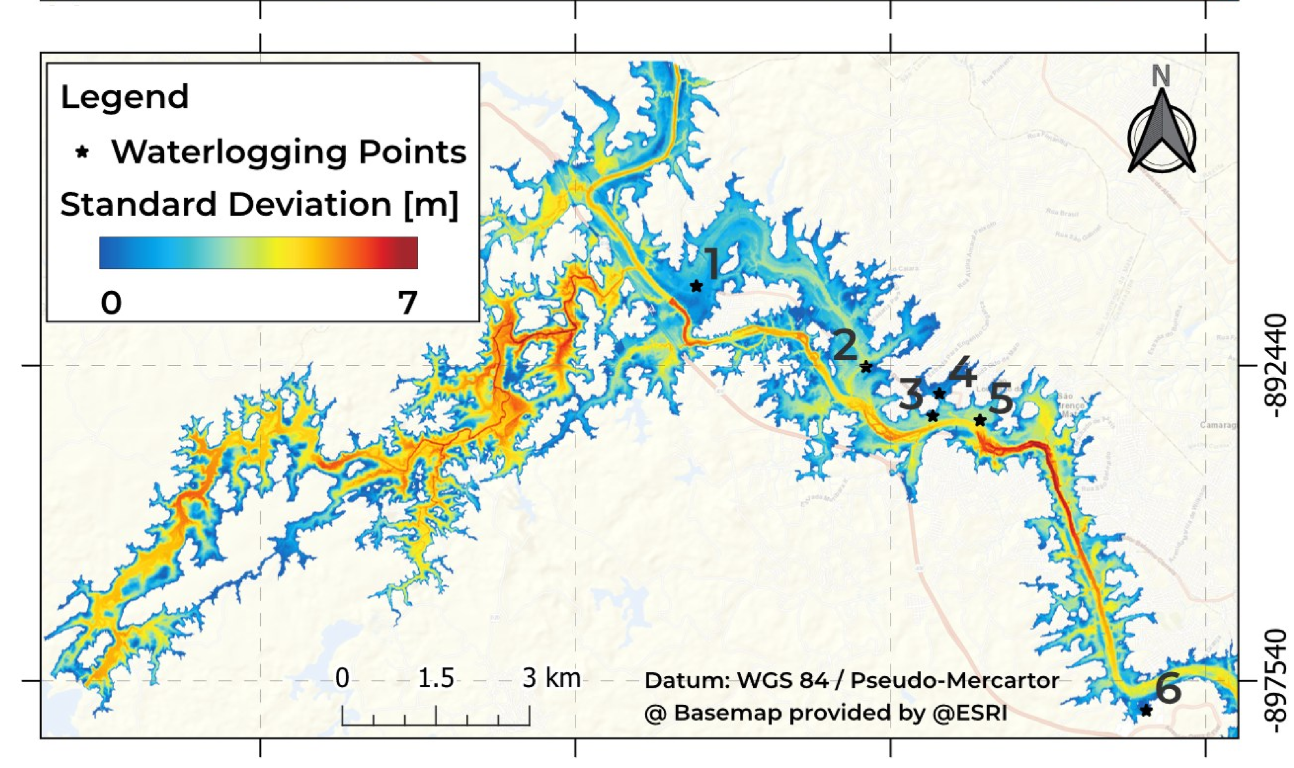


RESULTS









CONCLUSIONS

Accurate results for gradually variable flows and **greater computational efficiency**.

The expected inundation area tends to **increase by approximately 6%** as the spatial resolution decreases by a factor of 3.

The computational times were at least **20 times faster on the CPU** and **8 times faster on the GPU** compared to other studies.

The framework can also be adapted to estimate pluvial and/or fluvial ensemble probabilistic estimation by varying the input probabilistic functions.

REFERENCES AND ACKNOWLEDGMENTS

The present study was supported by Coordenação de Aperfeiçoamento de Pessoal de Nível Superior (CAPES) Scholarship.

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