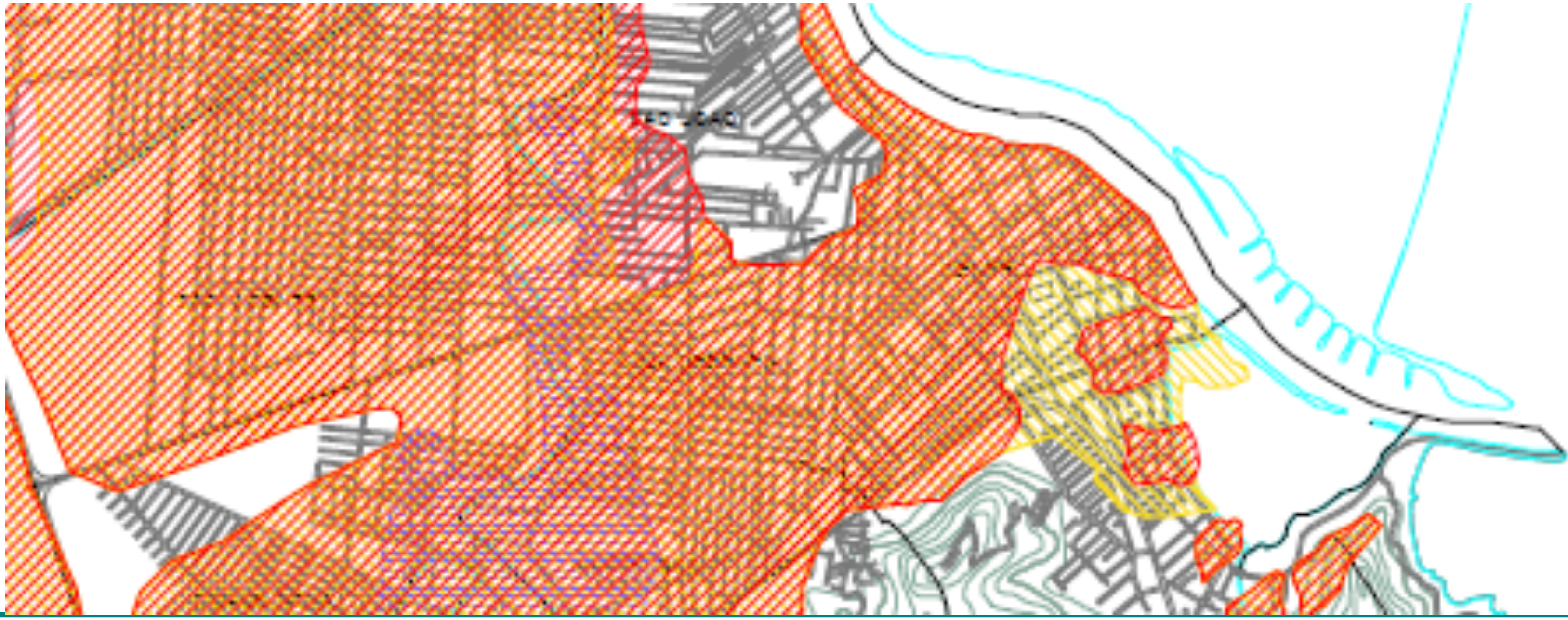
STOCHASTIC MODELLING OF FLUVIAL MORPHODYNAMICS

Bruno Oliveira



STOCHASTIC NUMERICAL MODELLING OF FLUVIAL MORPHODYNAMICS

METHODOLOGY FOR STOCHASTICALLY GENERATING MODEL INPUT

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EXISTING NUMERICAL HYDRODYNAMIC AND MORPHODYNAMIC MODELS

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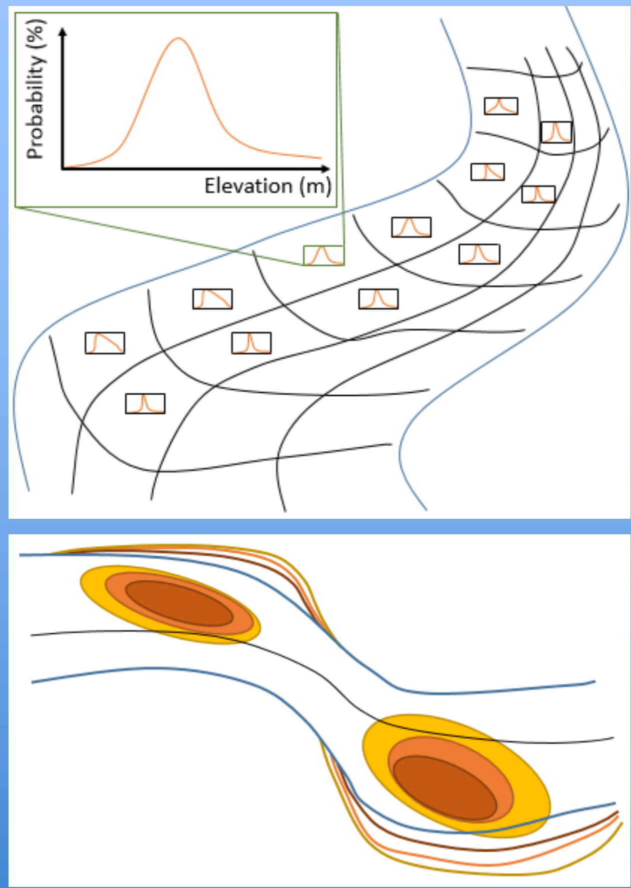
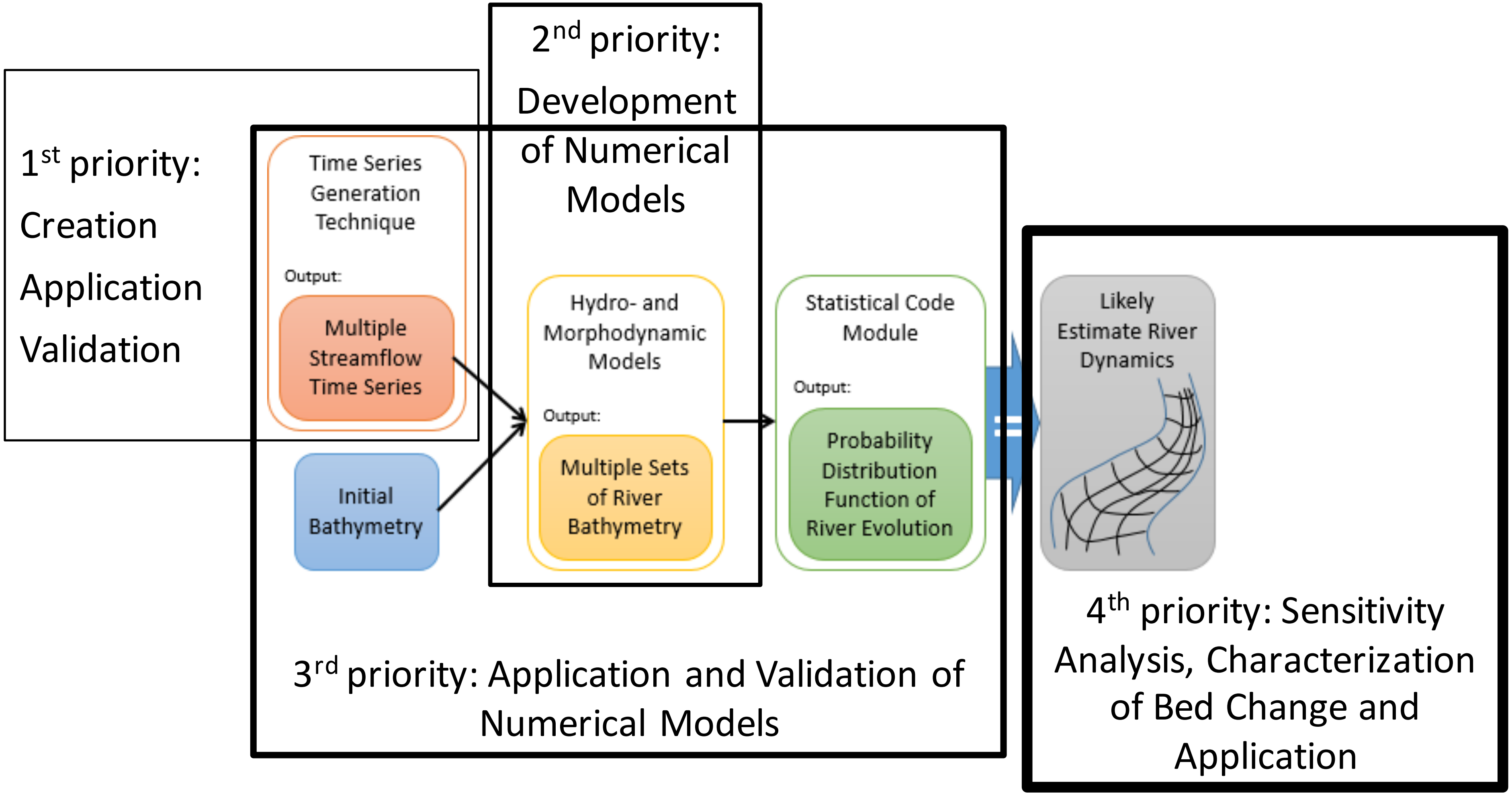
GOAL



Main Objectives

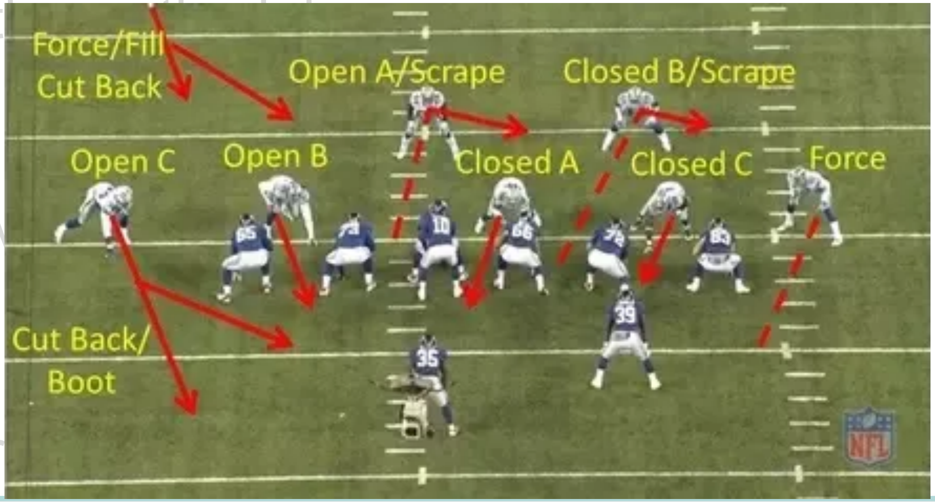


Work Plan

- Collection of in-situ information from case study(ies)
- Collection of historical records
- Stochastic Series Generation
- Development of the hydro- and morphodynamic models
    - Model Selection and Integration
- Application of t
- Sensitivity ana
    - Analysis of
    - Etc.
- Statistical char
- Risk Analysis

Previous year

And now... Defense!

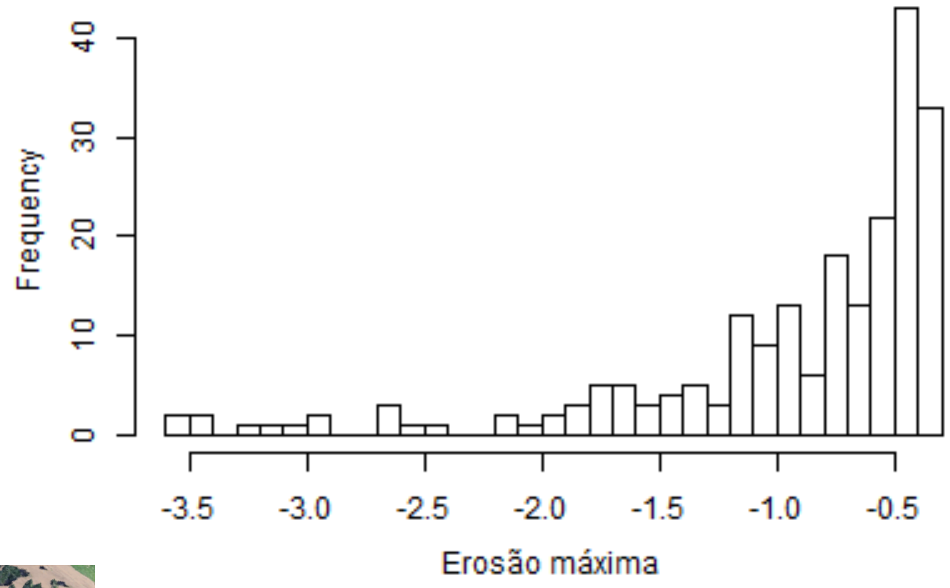


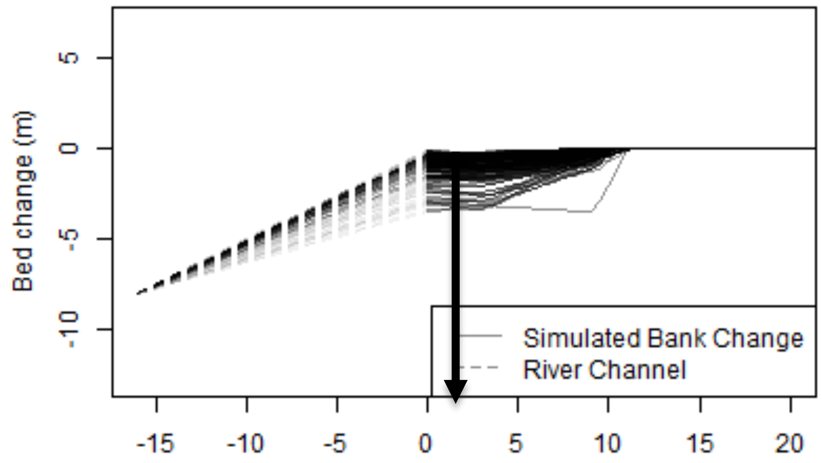
Statistical Characterization of Morphodynamics (Mondego River)

Case study reach

Specific section(s):

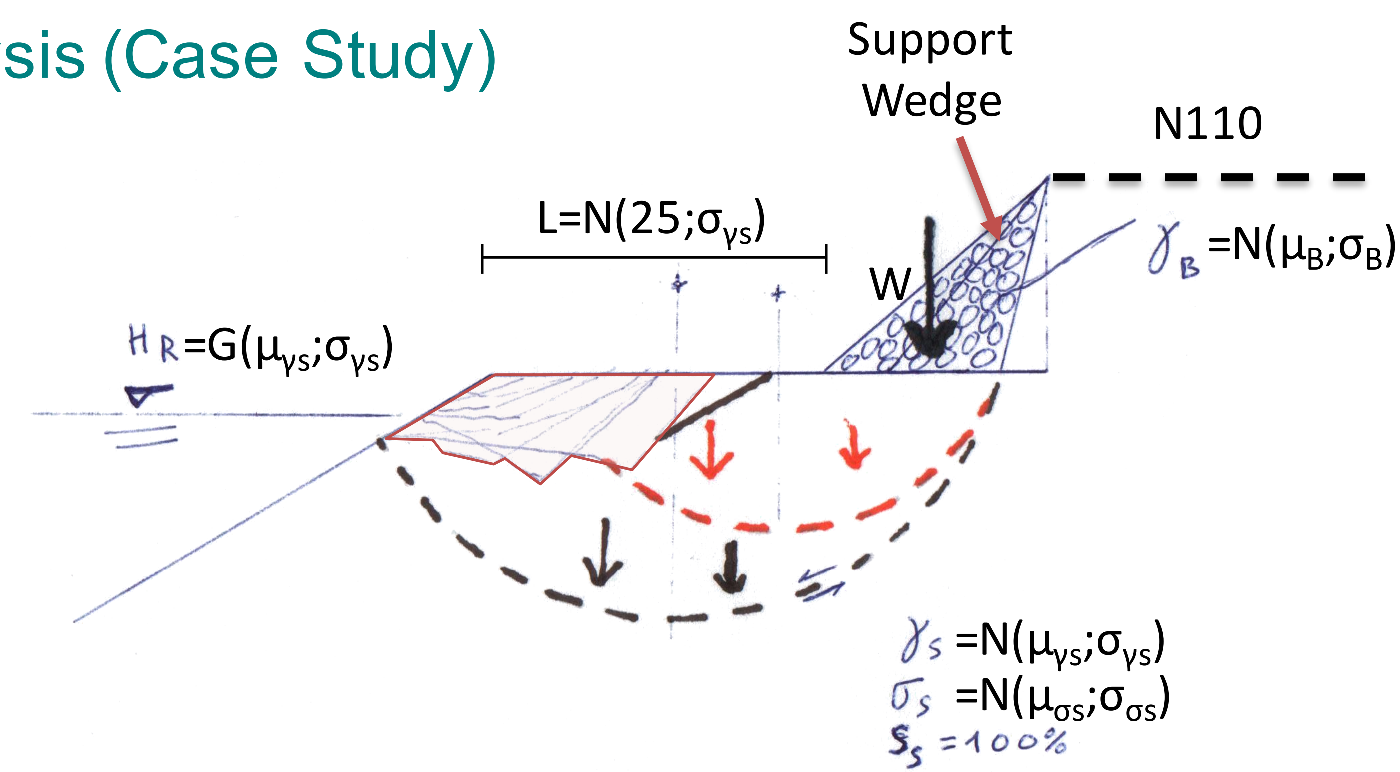
- Erosion magnitude
- Erosion profiles





Risk Analysis

Risk Analysis (Case Study)



Estimating P(x), where x is:

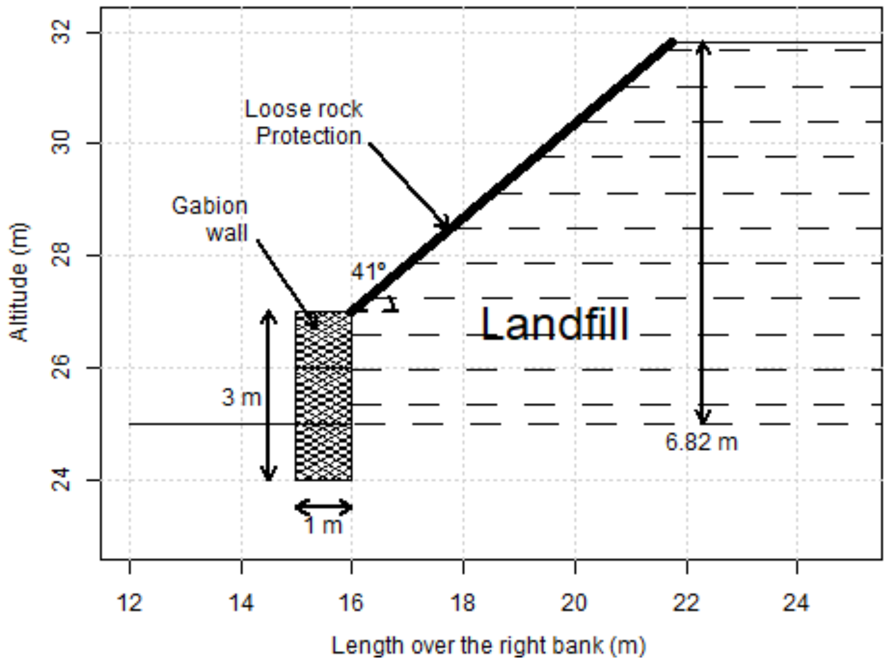
- Rotational failure
- Block failure
- Slide failure

Failure costs/scenarios:

- Complete bank rehabilitation
- Full bank protection
- Active monitoring/rehabilitation

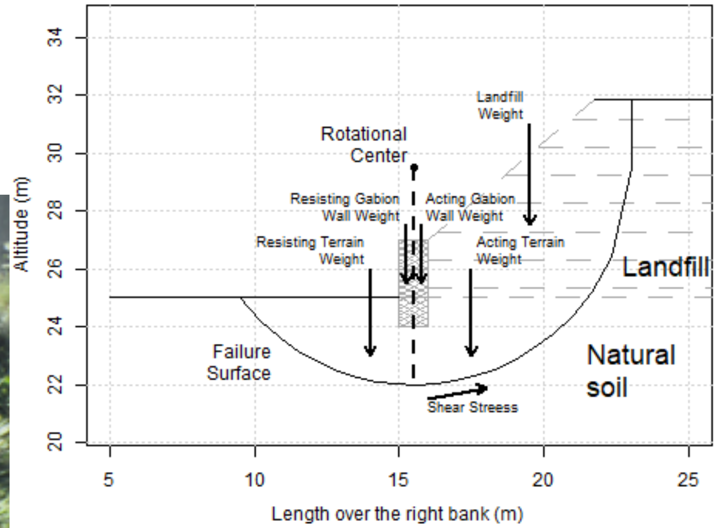
$$P(\%) \times C\ (€) = RISK$$

Risk Analysis (Stability Analysis)



Retention wall situated 20 meters from the river:

- Necessary for N110 road
- Steep implantation slope
- Situated at an exposed edge of the road (due to curvature)



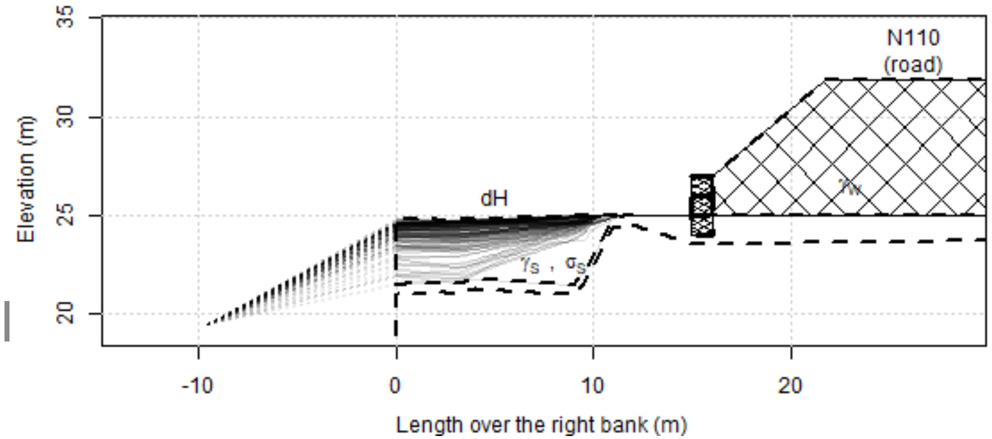
Risk Analysis (Stochastic Modelling)

Included

- 10 values of Shear Angle
- 10 values of Dry Density of Soil
- 10 values of Dry Density of Landfil
- 25 selected erosion profiles
- 140 rotational centres
- Av. 5 radius per centre

≈ 17.5 Mil. Limit State Analysis

For the 1Y and 2Y horizons

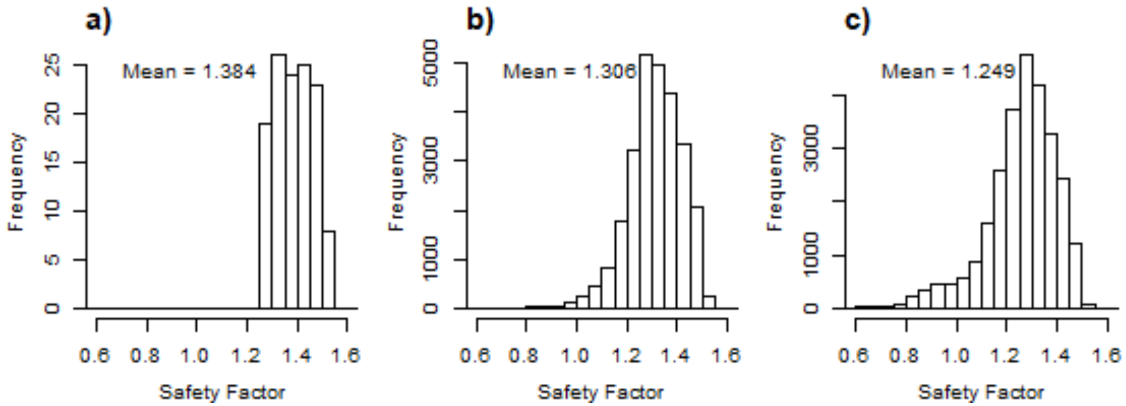


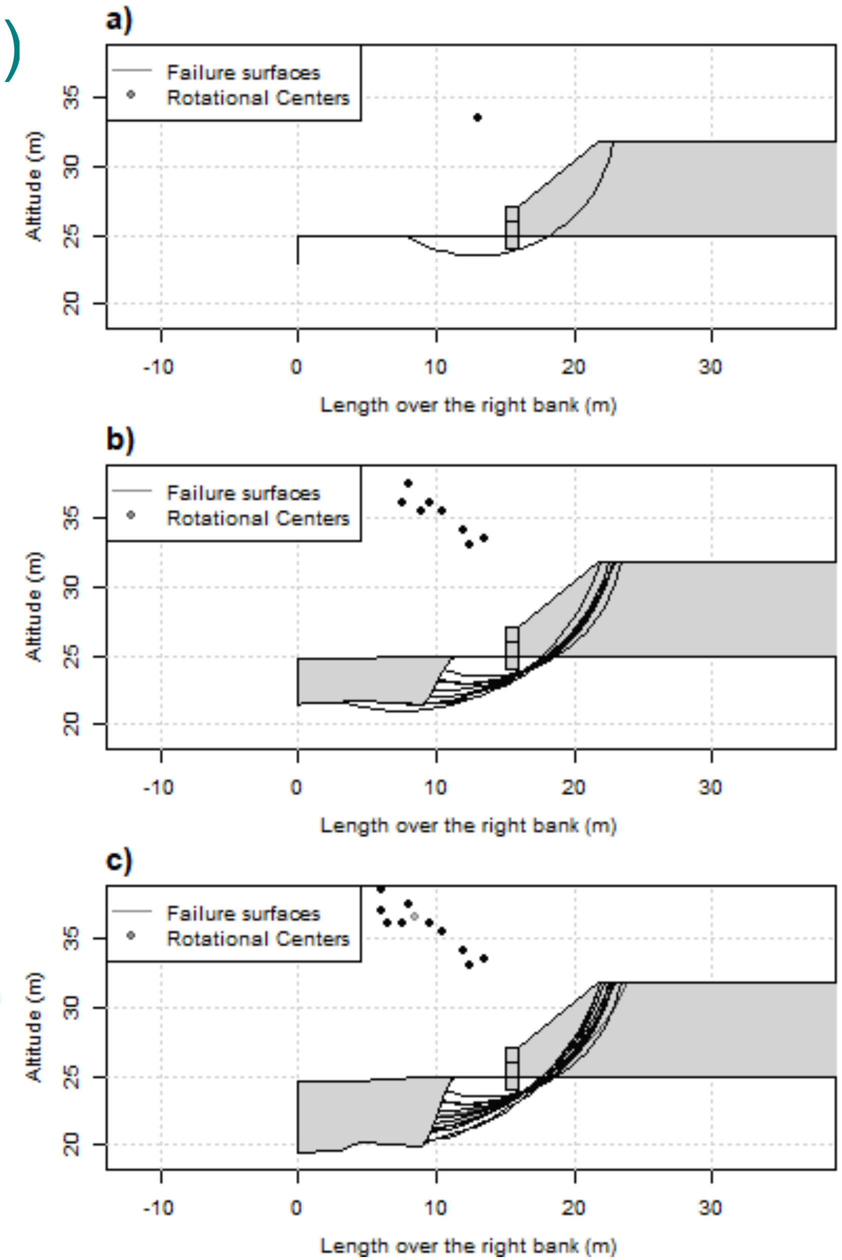
Variable	Symbol	Distribution	Parameters		Units
			a	b	
Shear Angle	Φ_r	Uniform	34	38	º (degrees)
Dry Density of the soil	γ_s	Uniform	20	22	KN/m^3
Dry Density of the landfill	γ_{wall}	Uniform	21	23	KN/m^3

Risk Analysis (Stochastic Modelling)

Failure mechanisms for rotational failure:

Using the simplified Bishop method, each failure surface corresponds to a safety factor:

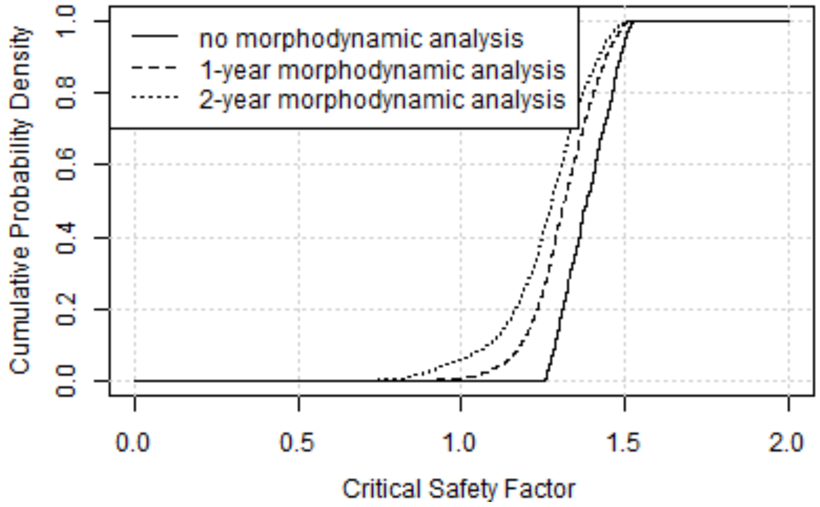




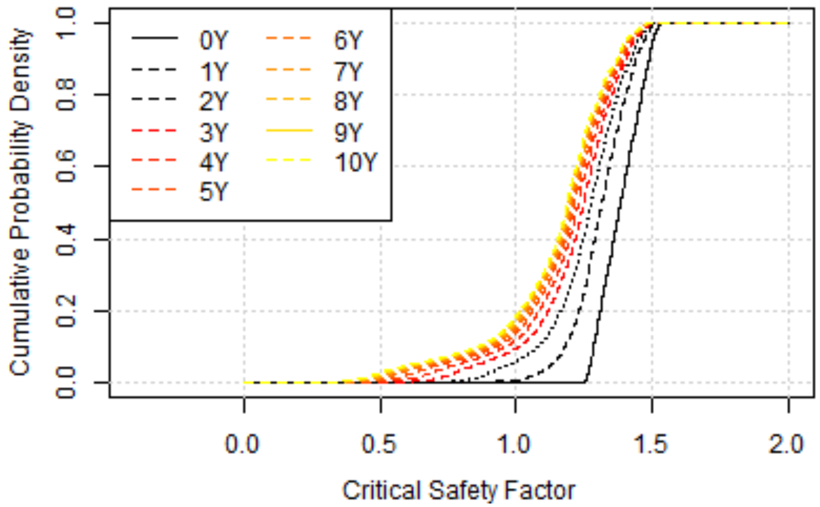
(block and slide failure are uncommon in the context of morphodynamics)

Risk Analysis (Failure Likelihood)

Transformed into a probability distribution of failure as a function of the critical safety factor:



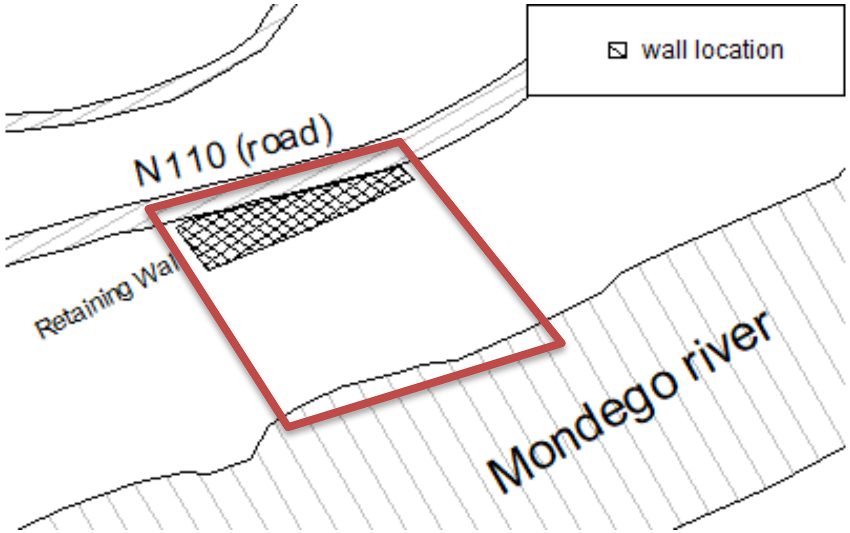
Considering a geometrical decay of the failure likelihood (from bank stabilization):



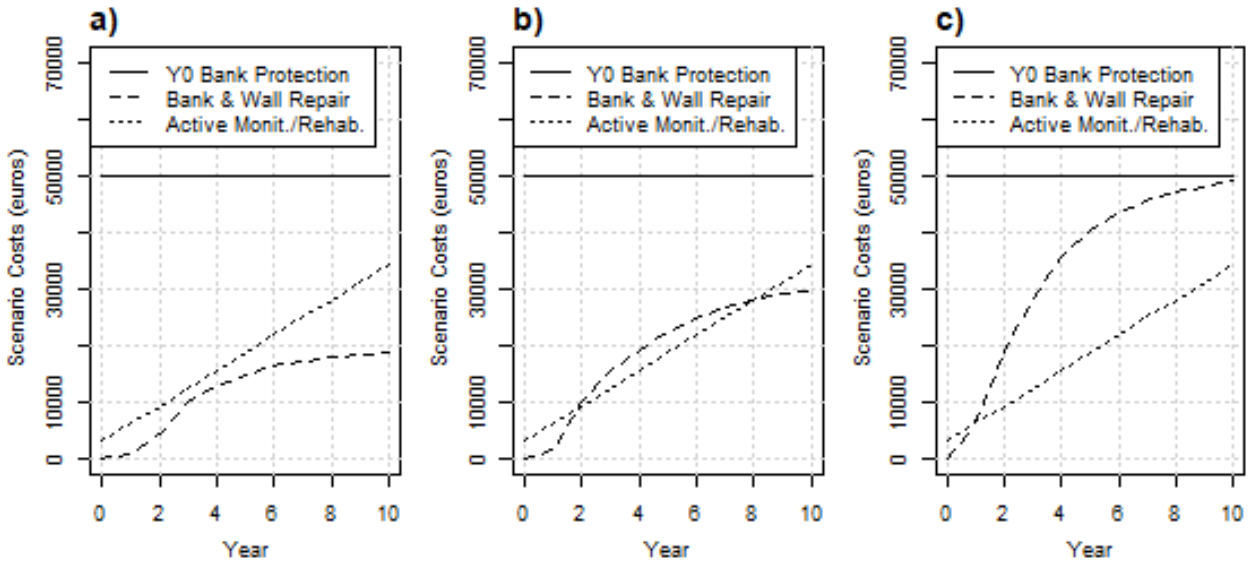
Risk Analysis (Application)

Adding the expected costs from:

- Bank protection (40 000 €)
- Bank and wall repair (160 000 € on collapse)
- Active Monitoring & Rehabilitation (15 000 € + 3 000 €/yr)

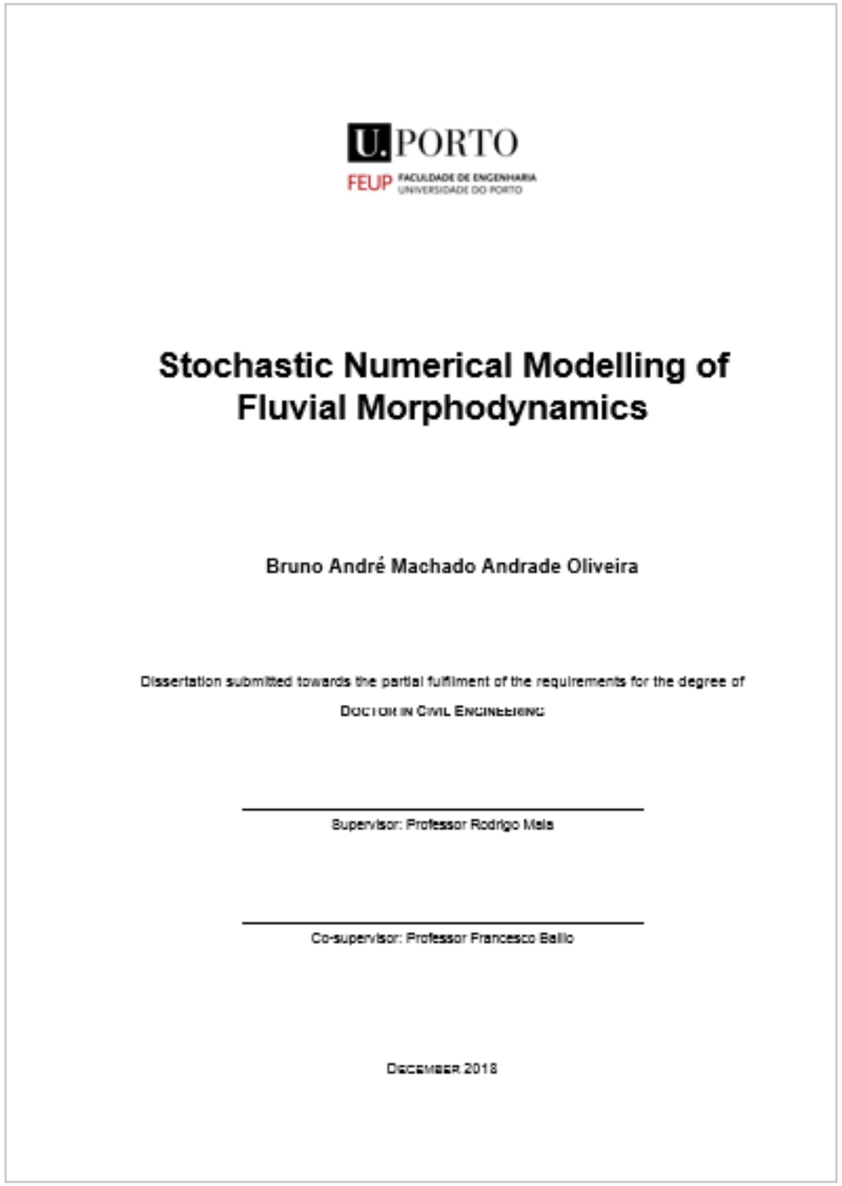


And the corresponding likelihoods:



Finished Products

Thesis



U.PORTO

FEUP FACULDADE DE ENGENHARIA UNIVERSIDADE DO PORTO

Stochastic Numerical Modelling of Fluvial Morphodynamics

Bruno André Machado Andrade Oliveira

Dissertation submitted towards the partial fulfilment of the requirements for the degree of

DOCTOR IN CIVIL ENGINEERING

Supervisor: Professor Rodrigo Maia

Co-supervisor: Professor Francesco Ballio

DECEMBER 2018

Publications:

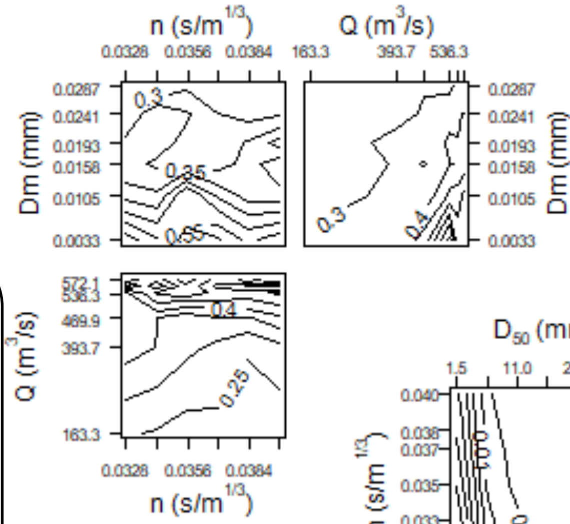
- *Stochastic Generation of Streamflow Time Series*
- *Pre-modelling as tool for optimizing morphodynamical numerical simulations*
- *Sensitivity Analysis of Fluvial Morphodynamics*

Other papers underway...

Manual:

“**APPLICATION METHODOLOGY FOR THE STOCHASTIC MODELLING OF FLUVIAL MORPHODYNAMICS**”

Summary

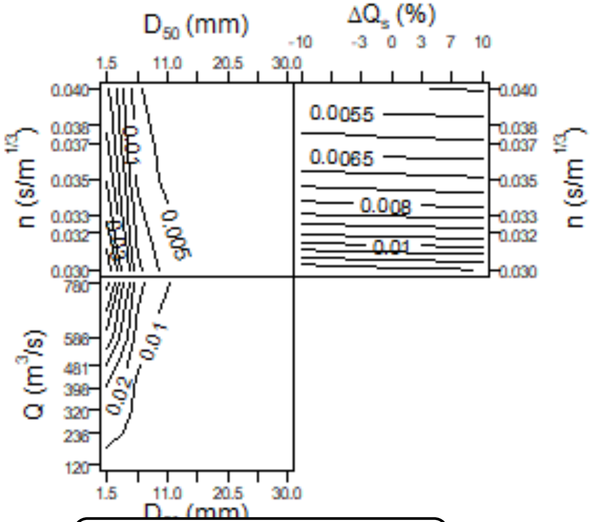


The journey

- The stochastic modelling methodology was developed from the generation input to the analysis of the output

The Validation

- Sensitivity analysis is useful for the validation of stochastic modelling (at least for pairwise comparisons)



The Importance

- Morphodynamics are important for near-bank stability (estimated failure likelihoods exceed one percent)

The Future

- Morphodynamics displayed a clear statistical spatial structure (for generalization and extrapolation)

Questions: More or Less?

About the stochastic modelling:

- Would simulating a large number of quantile-matched values of the variables be equivalent to Crude Monte Carlo? Which is more efficient?
- Can the results of the simulations be extrapolated (i.e., convoluted) over time? Globally or Locally?
- What are the best probability distributions for morphodynamical quantities? (namely for extreme, localized and global values)

About Reliability and Risk Analysis

- How significant are the errors introduced by the applied interpolation?

Thank you for your attention!

The End