Modelling Sea-Level Rise in the Lisbon city coastal area, using Free and Open Source Technologies

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VII JORNADAS DE SIG LIBRE

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State of the art Sea-Level Rise (SLR)

- **Sea-level rise** & **climate change**
  - (Intergovernmental Panel on Climate Change, 1990)

- Currently, **sea-level** is in an **ascendant situation**
  - **Acceleration** since **second half of XX Century**
    - **Greenhouse Gases** & **anthropic activities**

- No consensus on sea-level rise projections
  - Due to complexity of SLR drivers

State of the art Sea-Level Rise (SLR)

- 4 main SLR drivers
  - Thermal expansion of the oceans
  - The melting of Antarctic and Greenland ice sheets
  - Glaciers and ice caps
  - Groundwater depletion and reservoirs

State of the art Sea-Level Rise (SLR)

- Time-scale SLR drivers
  - **Longer** (over millions of years)
    - (a) continental collision; (b) dynamic topography fluctuations due to mantle convection; (c) sedimentation; (d) variations in the mean spreading rate of sea floor
  - **Intermediate** (hundreds of tens of thousands of years)
    - glacial isostatic adjustments
  - **Shorter**
    - **Dynamic**
      - (a) ocean-atmosphere interactions; (b) ocean circulation; (c) ocean tides; (d) salinity; (e) temperature variations
    - **Static**
      - (a) deformational; (b) gravitational; and (c) rotational signatures of mass flux from polar ice sheets and mountain glaciers

Sea-Level Rise Scenarios

- **Two main approaches**
  - **Physical**
    - Considers each of the mentioned drivers individually
  - **Semi-empirical**
    - Direct relationship between a global average near surface air temperature and sea-level rise observed in the past century

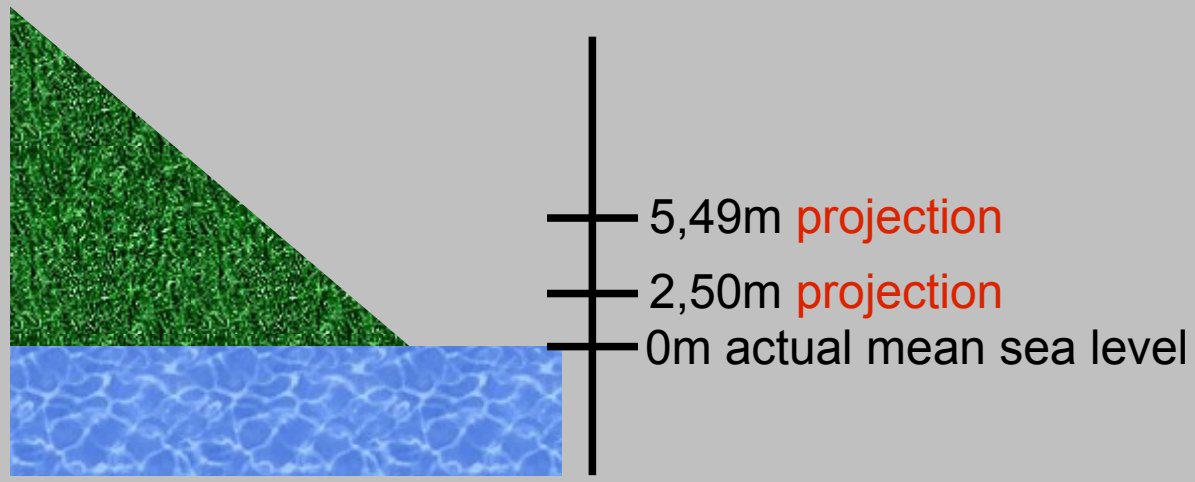
Sea-level Rise Scenarios

Authors	Scenario time-scale	Minimum value	Maximum value
Hansen and Sato, 2012	2095	-	5,00 m
IPCC, 2007	2099	0,18 m	0,59 m
IPCC, 2007	2100	0,19 m	0,63 m
Jevrejeva et al., 2010	2100	0,60 m	1,60 m
Pfeffer et al., 2008	2100	0,80 m	2,00 m
Rahmstorf, 2007	2100	0,50 m	1,40 m
Rohling et al., 2008	2100	0,60 m	2,50 m
Vermeer and Rahmstorf, 2009	2100	0,81 m	1,79 m
WOR, 2010	2300	2,50 m	5,10 m
Jevrejeva et al., 2012	2500	1,84 m	5,49 m

Objectives

Modelling sea-level rise

- **Hydrologic Modelling**
  - Lisbon city (general)
  - São Nicolau parish (particular)
  - Based on two scenarios



Rohling *et al*., 2008

SLR 2,5m - year 2100

Jevrejeva *et al*., 2012

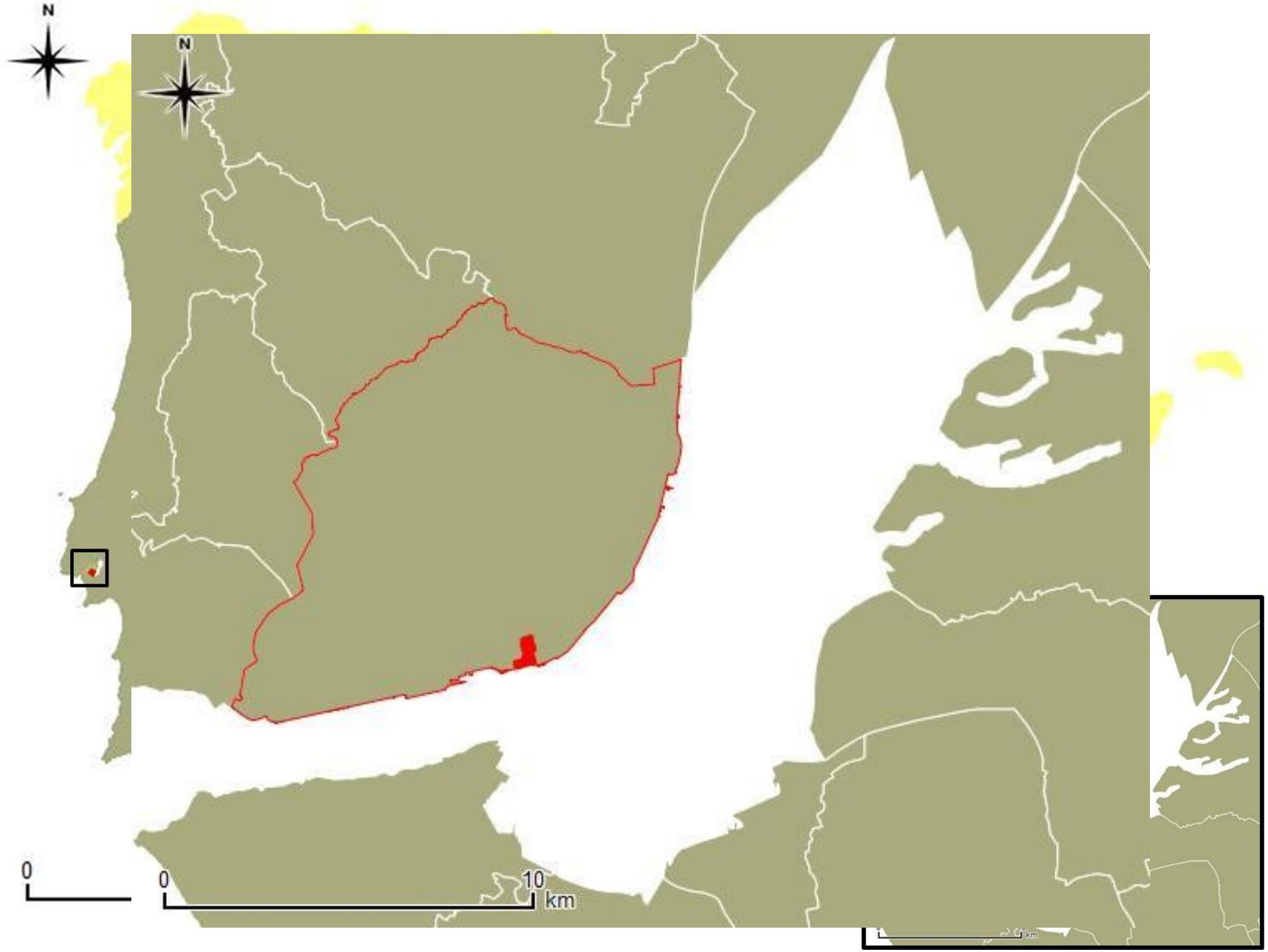
SLR 5,49m - year 2500

Processing: GRASS GIS 6.4.3RC1

Post-processing: Quantum GIS Desktop version 1.8.0 LISBOA

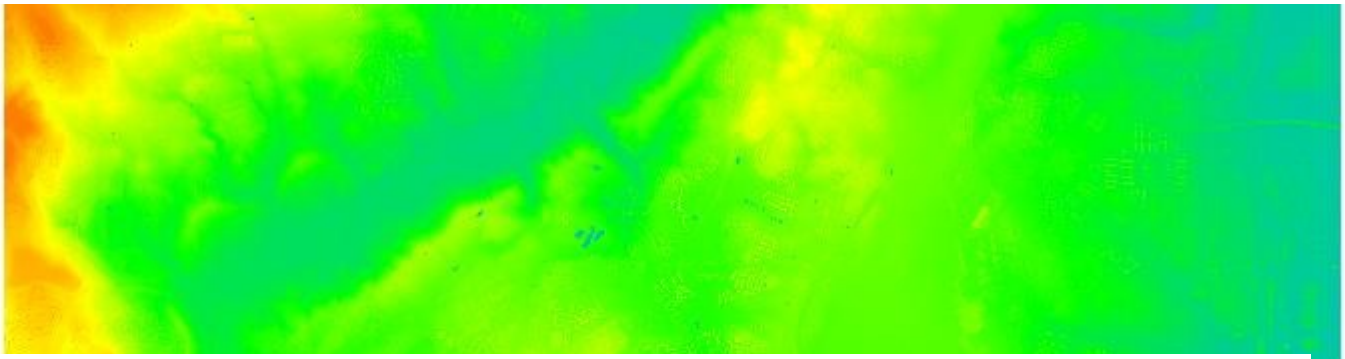
Windows 7 Home Premium, 64-bit Operating System, Service Pack 1, with 8GB RAM in Intel(R) Core(TM) i5-2450M CPU @ 2.50GHz.

Case study area



Methodologies

- Initial data
  - RASTER Lisbon



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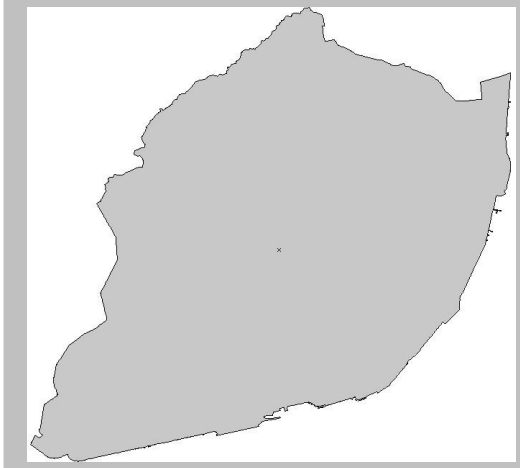
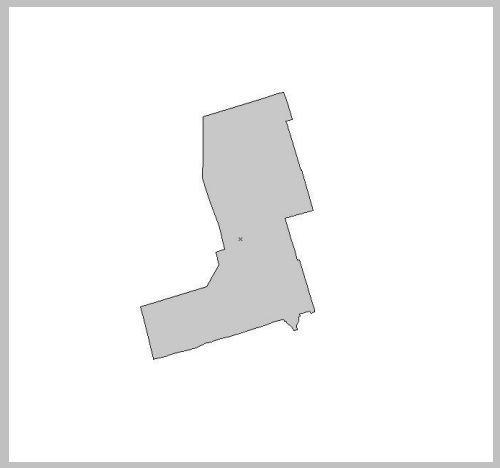
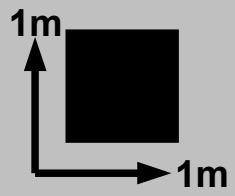
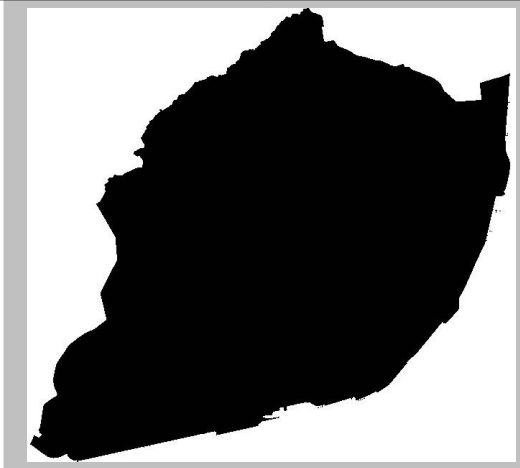
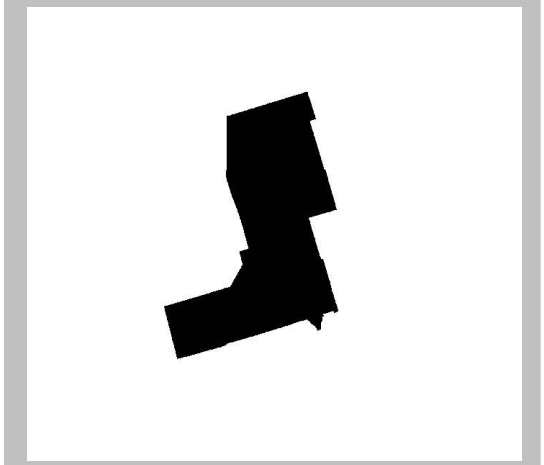
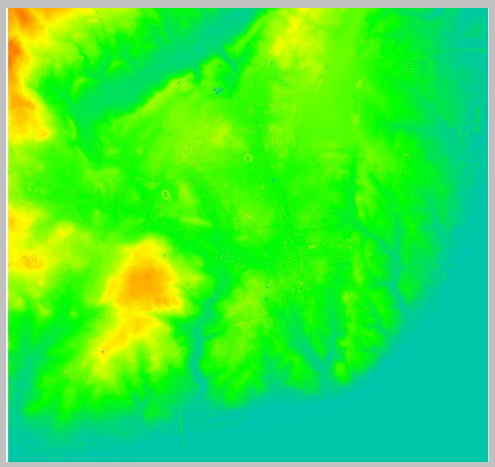
Methodologies

Original Data	Lisbon		São Nicolau
Data selection and conversion		Vector	
	Case study areas		
Pixel dimension 		Raster	

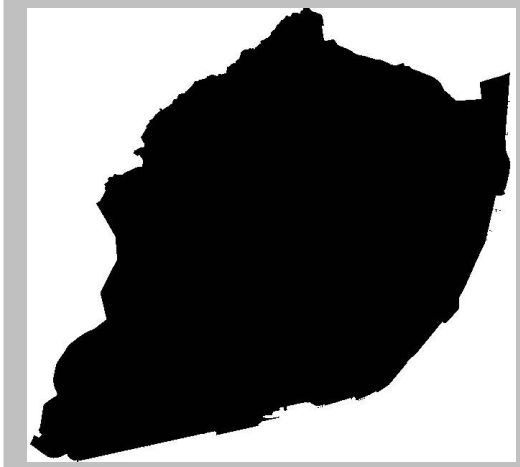
Methodologies

Data selection and conversion

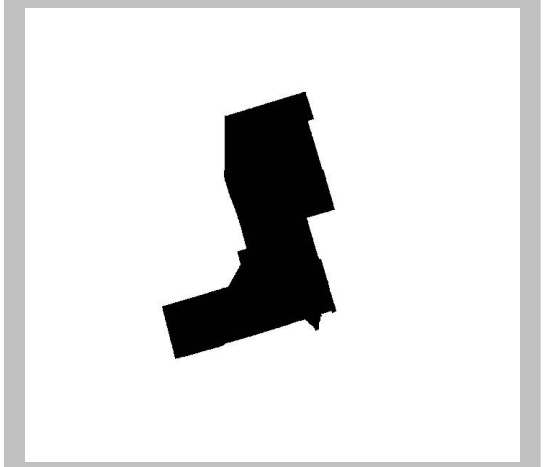
Original RASTER



Lisbon

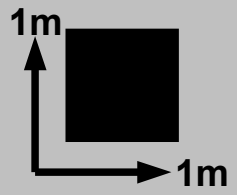


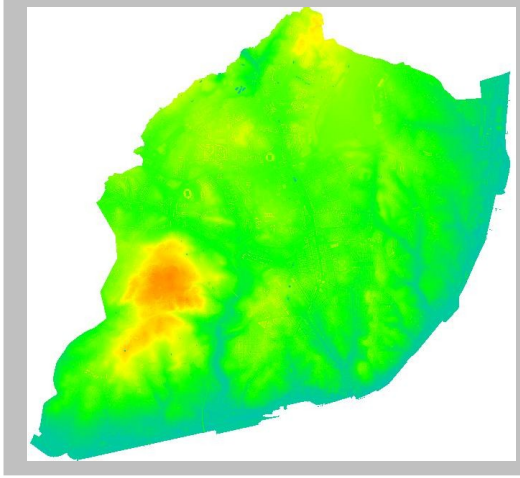
São Nicolau

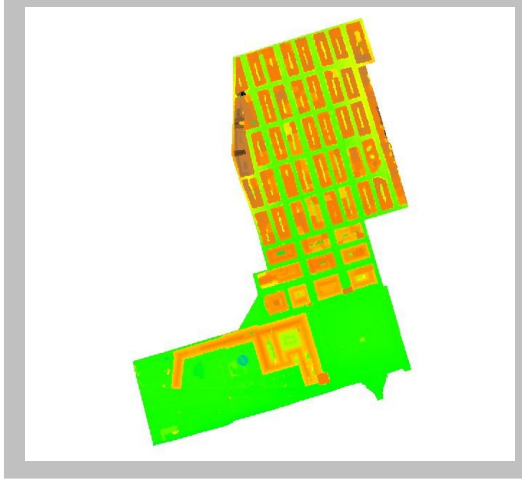


Case study areas

Pixel dimension

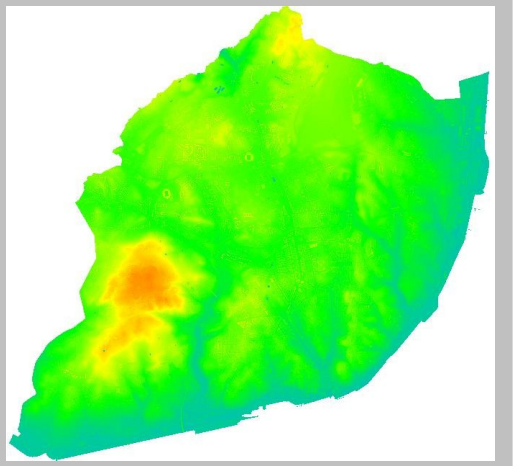
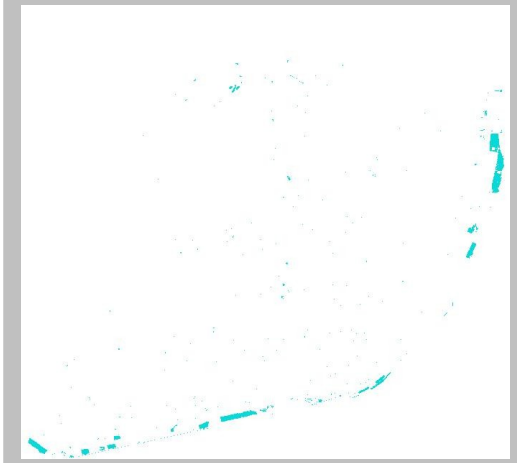
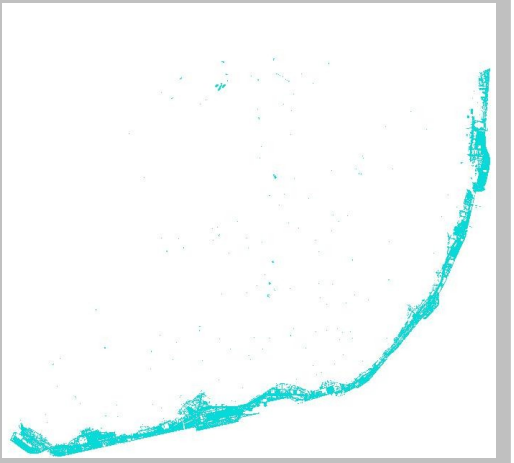
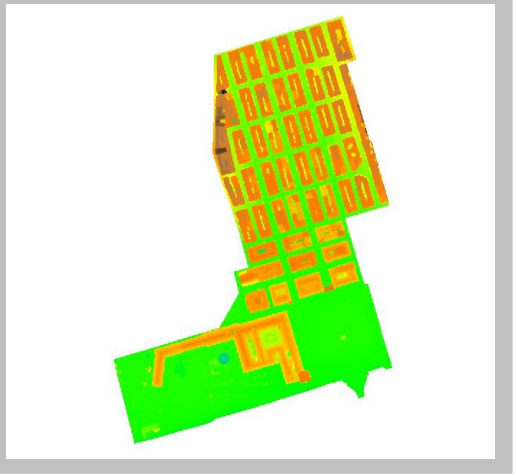
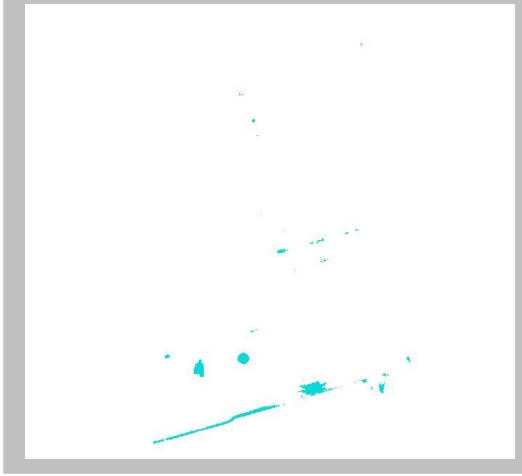






Methodologies

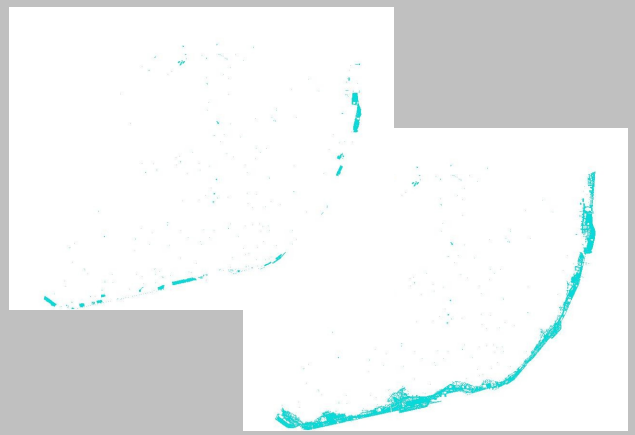
Hidrologic Modelling – Lisbon Scenarios (A1, A2); São Nicolau Scenarios (B1, B2)

Lisboa	A1- SLR 2,5m - 2100	A2 - SLR 5,49m - 2500
		
São Nicolau	**B1- SLR 2,5m - 2100**	**B2 - SLR 5,49m - 2500**
		

Methodologies

Raster reclassification

Lisbon

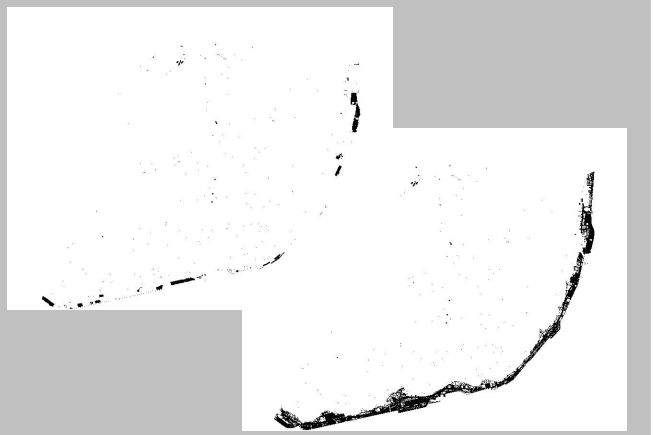


Scenarios

A1 and A2

→

Range of data
to
Unique value



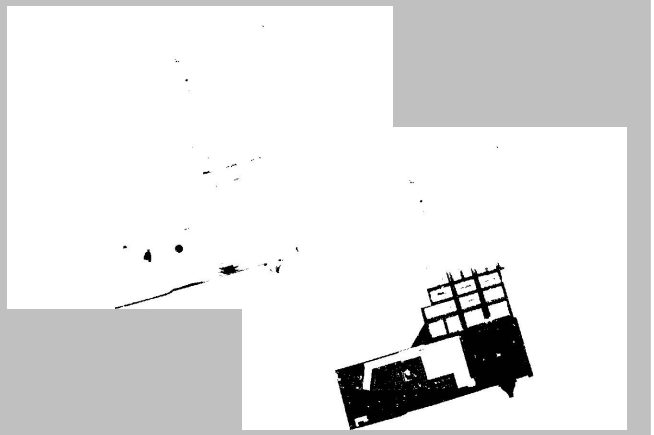
São Nicolau

Senarios

B1 and B2

→

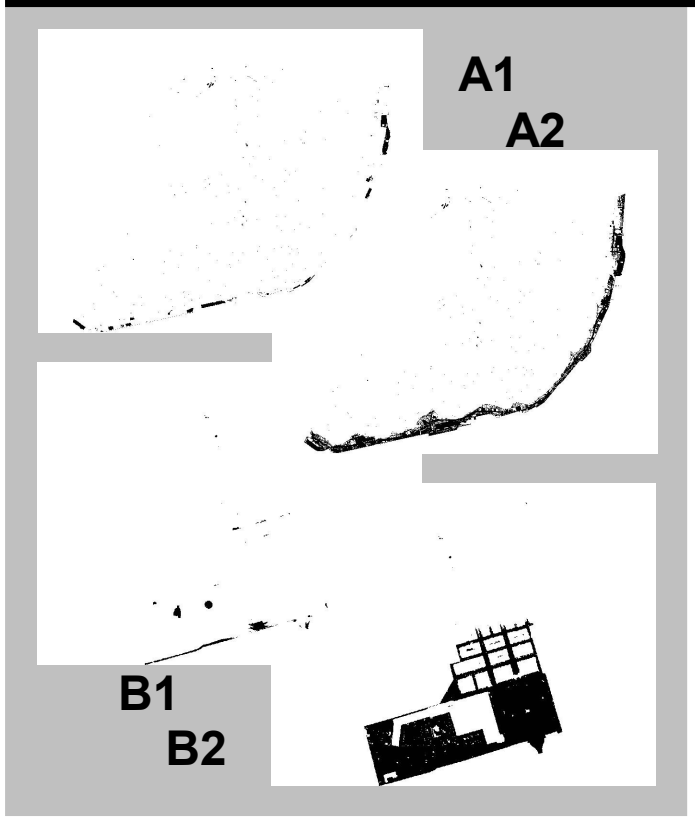
Range of data
to
Unique value



Methodologies

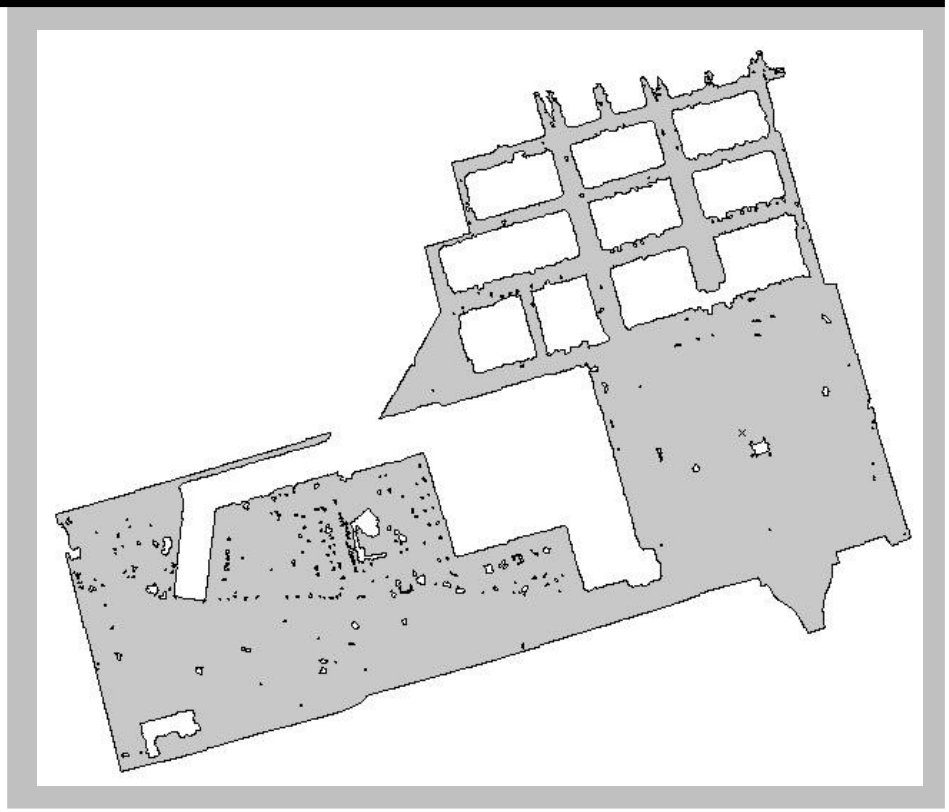
- Map conversion from raster to vector
- Processing to post-processing
- Cleaning of residual information

Lisbon & São Nicolau

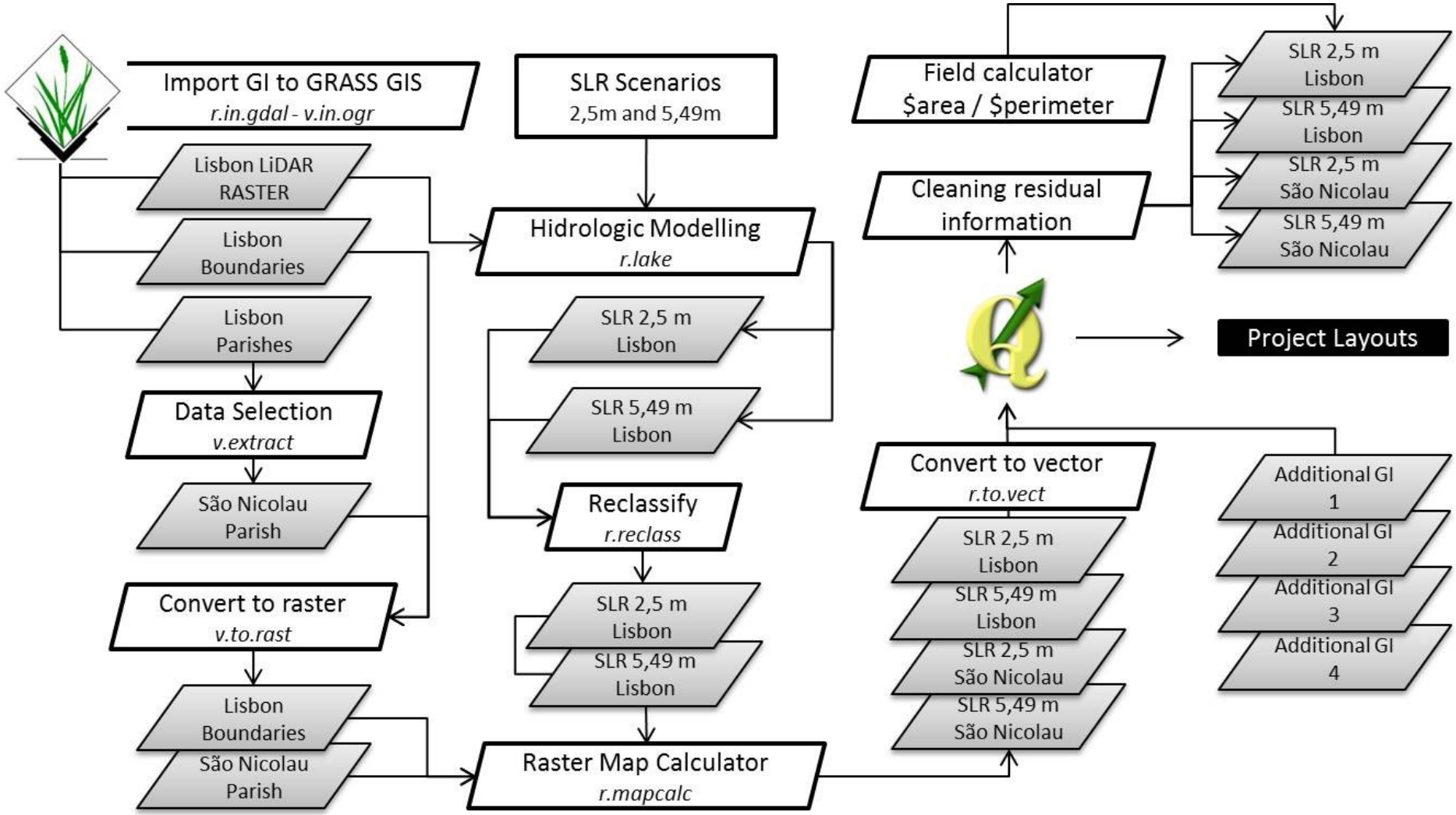


Sample Layer

Scenario B2

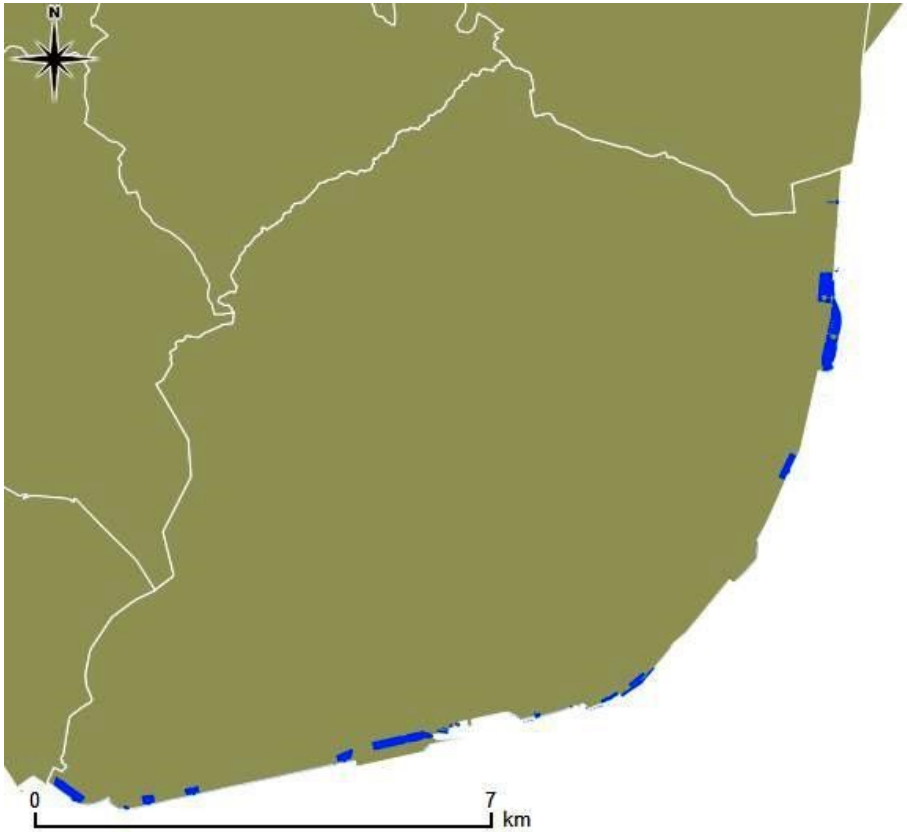


Methodologies



Results

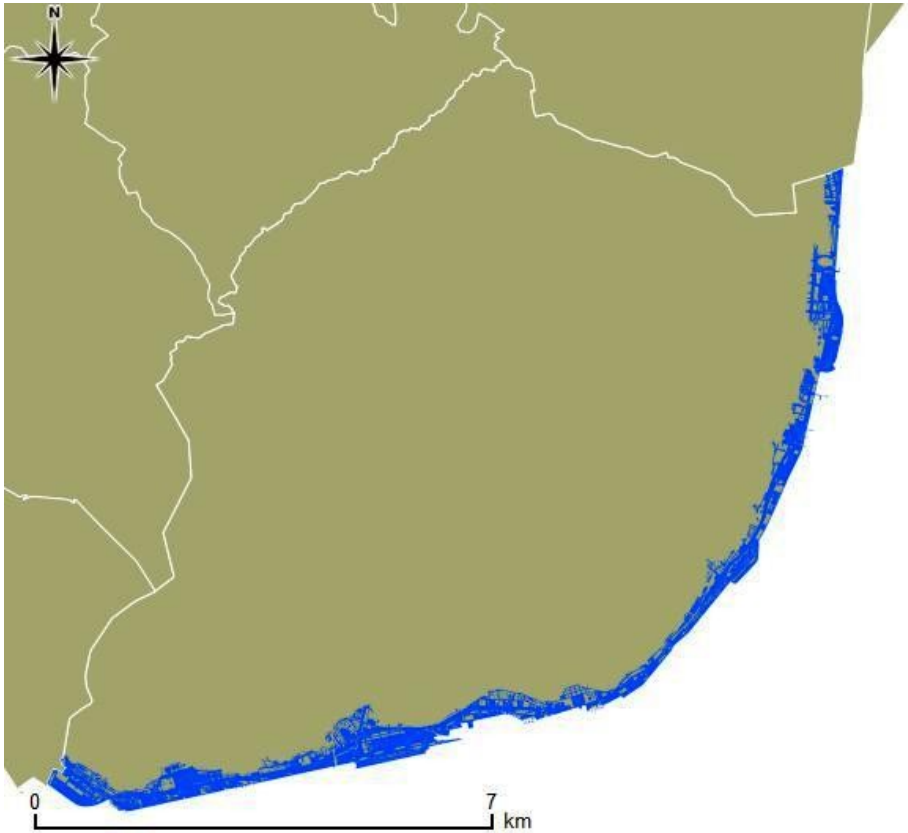
Lisbon - Scenario A1



Total area: 8550,04ha
Flooded area: 66,91ha (0,78%)

Total number of buildings: 65271
Buildings in flooded area: 26 (0,04%)

Scenario A2



Total area: 8550,04ha
Flooded area: 442,95ha (5,18%)

Total number of buildings: 65271
Buildings in flooded area: 1882 (2,88%)

Results

São Nicolau – Scenario B1

Total area: 26,33ha
Flooded area: 0,27ha (1,02%)

Total buildings: 611
Buildings in flooded area: 1 (0,16%)

Scenario B2

Total area: 26,33ha
Flooded area: 9,66ha (36,69%)

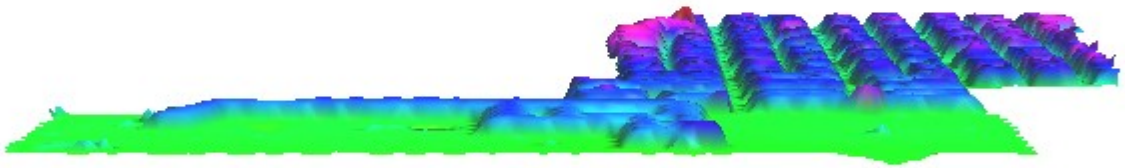
Total buildings: 611
Buildings in flooded area: 85 (13,91%)

Discussion

- Despite uncertainties amongst scientific community on how much sea-level will rise
  - It is factual that sea-level is rising
    - Inclusion on sea-level rise scenarios on land planning and management
- Impacts on scenarios A1 and B1 (year 2100) are punctual
- On A2 and B2 scenarios (year 2500) its impacts are significant
- GRASS GIS 6.4.3RC1 performed well in all requested tasks
- In 3D visualization data, for São Nicolau parish (516 509 cells) GRASS GIS 6.4.3RC1 performed well
- GRASS GIS 6.4.3RC1 crashed performing the 3D of Lisbon (140 621 869 cells)

Future work

- Explore more **Hydrologic modelling** tools
  - Adding tides data
  - Storm surge data
    - Bringing more accuracy to SLR modeling
- Integration of population scenarios
- Additional data of services and infrastructures for more extensive analysis
- Mr. **Z**



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Gràcies

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Acknowledgements

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FCT
Fundação para a Ciência e a Tecnologia