METROPOLE PROJECT: AN INTEGRATED FRAMEWORK TO ANALYZE VULNERABILITY AND ADAPTIVE CAPACITY TO CLIMATE CHANGE AND SEA LEVEL RISE: COMMUNITY CASE STUDIES IN **BRAZIL, UK AND US**

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Overview

SIMPÓSIO INTERNACIONAL DE CLIMATOLOGIA

The coastal areas around the world are likely to be among the most affected by climate change and its impacts due to a complex interplay among atmospheric, marine and terrestrial processes, as well to local exposure of coastal areas in terms in infrastructure and occupation.

It is important to understand that communities in different urban areas in coastal regions and from different socio-economic activities face different levels of risk and vulnerability.

The METROPOLE project (funded by the BELMONT Forum) represents a partnership between Brazil, UK and US to investigate impacts of sea level rise and climate change in

What is COAST?

- The COastal Adaptation to Sea level rise Tool (COAST) is software that models flooding damage to assets from storm surge and sea level rise over time
- It can calculate one-time damages from a single event in time; as well as cumulative damage from all possible storms over a given time period
- It then is used to calculate the benefits and costs from various adaptation strategies to determine which strategy is the most fiscally efficient over time
 - COAST uses digital parcels maps to identify the elevation of individual



some three coastal regions around the world (Brazil: Santos-SP, the United Kingdom: Selsey-West Sussex, and the United States: Broward County-Florida). The hypothesis of the project is that risk knowledge is best understood as being co-produced by science and by the social, political and cultural context. The project intends to use:

a) The state of the art in visualization tools developed by Brazil and the United States; b) Surveys, sophisticated questionnaires and tools for evaluation of options for adaptation;

c) Risk studies using the Index of Adaptive Capacity developed in the UK and to be replicated in Brazil.

The expected results include the generation of a new evaluation system for quantifying the influence of the integration of scientific, economic and cultural data in adaptive planning and decision-making. This system aims at improving the ease of interaction between scientists and decision-makers.

The central theme of the METROPOLE project is, therefore, to show, in an integrated way, how some coastal areas under different climate regimes and human pressures would be affected by SLR caused by climate change, and if society and the government would be prepared or not to take proper and fast adaptation measures.

Keywords: Sea level rise, climate change, climate extremes, coastal regions, adaptation

Case study in Brazil: Santos – São Paulo

Due to its location, the region was transformed into a strategic economic center, with a large concentration of industries along the coastal zone. Tourism is also an important economic activity. In contrast, the region has large deficits in infrastructure and about 16% of the population live on unstable slopes of the Serra do Mar, which are highly susceptible to landslides and floods.

parcels in a given study area

Parcels maps contain market values for both buildings and land

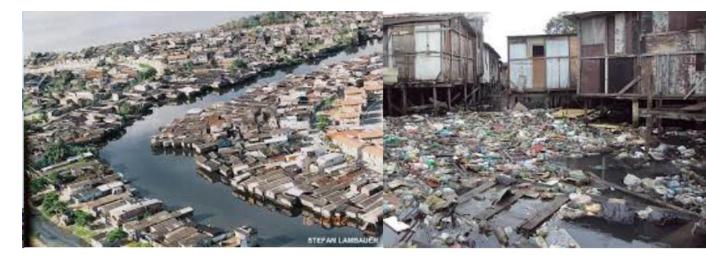
	Final report about high waters in Santos											
	by Dr. Joseph Harari – Institute of Oceanography of											
	the University of Sao Paulo – Sao Paulo – Brazil	TORRE GRANDE (1945-1990) – HOURLY DATA										
	June 2015		Mea	an Min	Max	Observed	Expected	Exp	ected	Expected		
	June 2015		tren		Extr	max	Max	Max	x	Max		
	I - INTRODUCTION		(cm			(m)	10	50		100		
	One set of sea level data was analyzed:		yea	r) (cm/ year)	(cm/ year)		years (m)	yea (m)	I	years (m)		
	1) Tide gauge data in Torre Grande (1945-1990).	Sea level	0.1		0.13	1.46	1.45		.60	1.66		
	The tide gauge is located in Channel of the Port o	Mean										
	computations were performed for sea level (astronomica	sea	0.1	3 0.08	0.06	0.78	0.76	0	.89	0.94		
	surge) and mean sea level (only meteorological effects).	level										
		Information about high water (relative to the mean sea level)										
	 Sea level extremes. Mean sea level extremes. 											
	 Mean sea level extremes. Sea level extremes trends. 			High	High	High	High Wa	ater	Mean	of daily		
	 4) Mean sea level extremes trends. 			Water	Water	Water	Maximu	ım		r level		
	 5) Extreme sea levels for return periods of 10, 50 and 100 y 			Mean (m)	mediar (m)	n std (m)	(m)		(m)			
	 Extreme mean sea levels for return periods of 10, 50 and 	Sea lev		0.44	0.43	0.24	1.46			0.51		
	 7) High water mean, median, standard deviation and maxim 	Mean										
		level		0.20	0.17	0.14	0.78	,	· ·	0.05		
	Sea level extremes were detected by processing sea level tir	Attach	ed:									
	Minimum values at times t were given by satisfying the conc					mes of sea level data:						
	Level (time t-1) > level (time t) < level (time t+1)	matriz_santos_nimar_max_1945_1990.dat File of times and levels of maximum extremes of mean sea level data:										
	And level (time t) \leq mean sea level	matriz_santos_nimed_max_2012_2015.dat										
	Maximum values at times t were given by satisfying the con	III – FINAL REMARK The astronomical tide in Santos produces these mean levels:										
	Level (time t-1) < level (time t) > level (time t+1)											
	And level (time t) ≥ mean sea level						Levels rel mean sea					
			Mean level of maximum spring tides 61.23							3		
		Mean level of maximum neap tides				13.41			_			
		Mean level of minimum neap tides				-13.41						
		Mean level of minimum spring tides					-61.23					
	L.		-					_				

• COAST uses storm surge heights of varrying storm strengths (i.e., 10-year, 50-year, 100-year, etc.) to model one-time damages and cumulative damages from a variety of storms over time

		rease considering se	verar trentas.	
Trends 📄	0.27 ± 0.06	0.36 ± 0.18	0.45	
	cm/year	cm/year	cm/year	
Year	Sea level	Sea level	Sea level	
	increase(cm)	increase (cm)	increase (cm)	
2000	0	0	0	
2015	4.05 cm	5.40 cm	6.75 cm	
2025	6.75 cm	9.00 cm	11.25 cm	
2050	13.50 cm	18.00 cm	22.50 cm	
2075	20.25 cm	27.00 cm	33.75 cm	
2100	27.00 cm	36.00 cm	45.00 cm	

Preliminary Damage Estimates for Santos

100-year Storm in 2100 with Low (0.36 m) Sea Level Rise Southeast Zone Northwest Zone



Slums bordering the São Jorge River

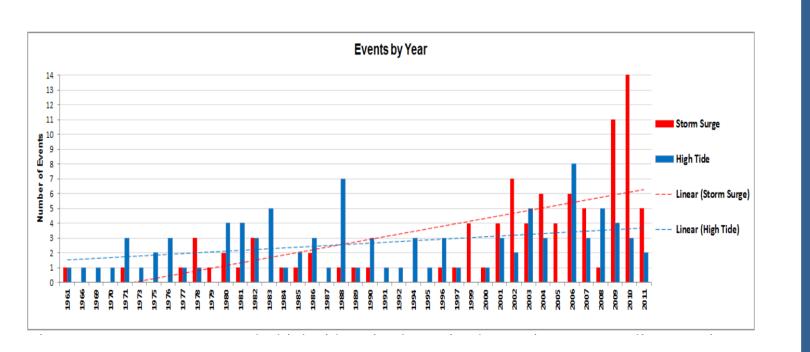


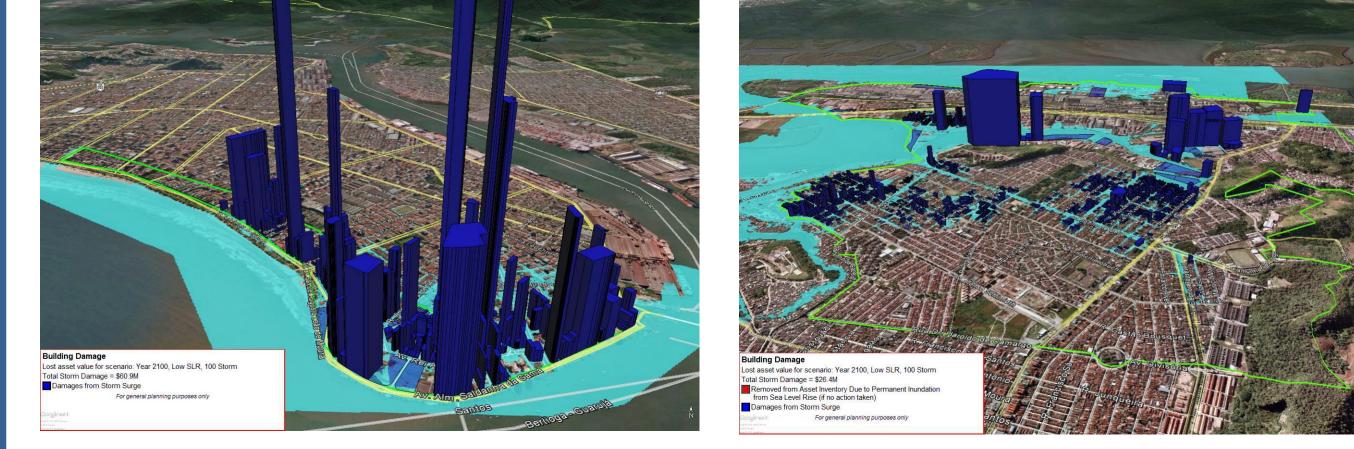
Coastal inundation that affected a parking lot in NW Area

Santos is a portrait of the social asymmetry of the country, featuring upscale neighborhoods, especially near the ocean seafront which, however, are a kilometers from tew neighborhoods where living conditions are very poor, and basic where access to infrastructure is more restricted.



Strong storm surge associated with high tide in Sept. 2009, which invaded the Avenue in front of the beach, at Ponta da Praia neighborhood, that caused temporary interdiction of the way





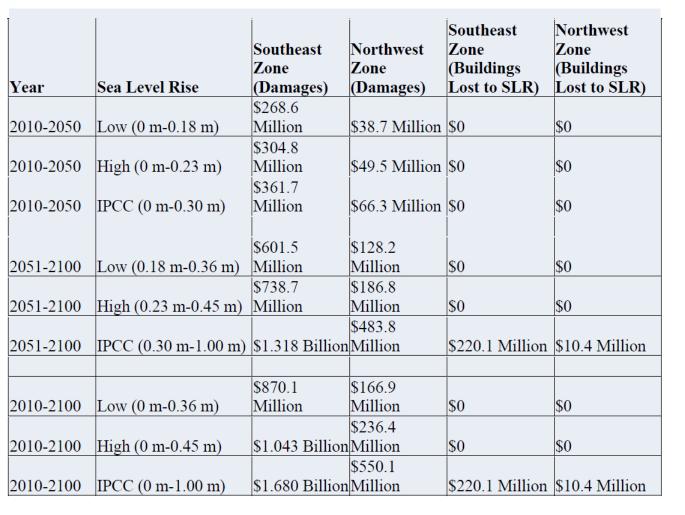
Building damage at a particular location, for this particular one-time event or SLR for the Southeast/Northwest region. The height of each blue bar indicates the amount of damage at that. If the bar is high, the floodwater is deep or the building is very valuable, or both

Cumulative Damages

Adaptation Strategy Examples

Seawalls





Voluntary Relocation Programs



In short, in METROPOLE, scientific groups are working directly in the municipalities of study case, with involvement of the decision and policy makers through surveys, interviews and meetings for data collection and participatory planning workshops, in such a way as to coproduce data and adaptation options.

Storm surges and "high tides" in the Baixada Santista Metropolitan Region between 1961 and 2011, based on newspapers files (Souza *et al.*, 2015).



Two different views of the two areas selected for application of COAST in Santos



Another type of social analyses the application ACI of (Adaptive Capacity Index)

http://www.coastlineconsulting-ct.com/images/bs1.gif

http://media.nj.com/ledgerupdates impact/photo/2011/08/9940723-large.jpg



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