



A hurricane loss risk assessment of coastal properties in the caribbean: Evidence from the Bahamas

Kathleen Sullivan Sealy^a, Eric Strobl^{b,*}

^a University of Miami, USA

^b University of Bern, Switzerland



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ABSTRACT

We conduct a risk assessment of losses to coastal properties due to tropical storms in The Bahamas. To this end we use the physical characteristics of a set of synthetically generated storms to estimate local wind and storm surge exposure and couple with these damage functions. Employing these to a unique set of properties on the island of Great Exuma we then calculate out likely losses, in terms of loss of real estate value as well as potential income, due to the storms. Our analysis suggests that while annual expected losses are small, this disguises low probability storms that could cause considerable damage. Moreover, we find that most of the losses are due to storm surge rather than strong winds. This may be particularly important for low-lying islands like The Bahamas facing future challenges of sea-level rise.

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1. Introduction

The amenities and economic benefits associated with living on the coast have resulted in a considerable increase in coastal population across many parts of the world; see (Beach and PEW OCEANS, 2002) Barragrain and de Andres (2015).¹ For example, data by the National Aeronautics and Space Administration (NASA) indicates that the percentage of the world's population living within 1 km of the coast² has more than doubled, from 11 to 23 percent, since 1990. However, this movement towards the ocean has also meant a greater exposure of the built environment to the destructive power of tropical cyclones. As a matter of fact, those countries with a propensity to be struck by such extreme weather events³ have on average 24 percent of their population living near

the coast, and constitute 72 percent of the global coastal population (9 percent of total global population).⁴ It is not surprising then that existing estimates of the cost of tropical cyclones globally suggests that these losses have increased multifold over the last few decades and this trend is likely to continue in the future.

Probably no other part of the world should be more concerned about the tradeoff between locating near the coast and the potential losses from tropical cyclone destruction than the insular Caribbean (Chollett et al., 2012). More specifically, as a group of mostly small island developing states (SIDS), countries in this region tend to have a large part of their population and assets located near the coast for both geographic (small land areas surrounded by the ocean) and economic (the importance of coastal tourism) reasons. As a matter of fact, currently nearly a third of the insular Caribbean population lives within 1 km of the coast, with a little over 20 percent live within 100 m of the shoreline. At the same time the Caribbean is one of the most tropical cyclone prone regions of the world, with on average about 3 hurricane strength storms per year coming within 100 km of at least one of the region's countries/territories.⁵ These storms have at times proved extremely costly for the countries affected. For instance, the 2004 hurricane season alone is estimated to have cost the Caribbean more than US\$2.2

* Corresponding author.

E-mail address: eric.strobl@polytechnique.edu (E. Strobl).

¹ For example, for the US Rappaport and Sachs (2003) have shown that both play an important role for coastal agglomeration but that particularly the attraction of amenities has been constituting an increasing pull.

² Our definition of coastal is restricted here to that identified by the NASA data, namely those living in low elevation coastal zones, where these are areas contiguous to the coast that are no higher than 10 m above sea level.

³ We roughly identified countries potentially exposed to tropical cyclones as those for which since 1950 at least one tropical cyclone came within 500 km of their low elevation coastal zones using tropical cyclone data from The National Oceanic and Atmospheric Administration (NOAA) Ibracs database which provides a comprehensive database of tropical cyclone tracks across the globe.

⁴ See also McGranahan et al. (2007).

⁵ Authors' own calculations.

billion in damages.⁶ In the Bahamas alone, there have been over US\$2.4 billion since 1990 (excluding Hurricane Matthew in October 2016).⁷ Worryingly recent prognosis suggests that with climate change and continued coastal agglomeration the costs of extreme weather events are likely to increase, with some estimates suggesting losses of up to 9 percent of GDP annually by 2030.⁸

Arguably, a detailed assessment of the potential costs of coastal location is essential for Caribbean policymakers in order to be able to calculate the benefits and costs of hurricane risk management strategies and for insurance companies to determine risk premiums if they were to offer appropriate insurance products. Unfortunately there is, however, currently a paucity of publicly available research quantifying these aspects for islands in the Caribbean. The only exception in this regard that we are aware of is the study of the Cayman Islands by Taramelli et al. (2015). More specifically, the authors create an inventory of critical facilities and buildings on Grand Cayman and identify those at risk to storm surge and wind damages. However, while they outline a methodology to undertake a complete risk analysis they only do so for a few sample storms and thus their study does not provide information regarding expected losses.

In this paper, we undertake a hurricane risk loss analysis of properties in the Caribbean using the case study of the island of Great Exuma of The Bahamas. While our approach is similar in spirit to that of Taramelli et al. (2015), in methodology it is much closer to that of Aerts et al. (2013). More particularly, Aerts et al. (2013) use a data set of buildings and their values for New York City to estimate the expected losses due to hurricane induced storm surge.⁹ To this end they utilize a set of synthetically generated storm events within a storm surge model and damage functions to derive property loss probabilities. Here, we similarly use synthetically generated storm events to estimate losses, but extend their approach by calculating not only losses due to storm surge but also that due to high wind exposure, where the latter is generated using a wind field model and a wind damage function. In this regard, one should note that generally studies of this sort tend to either calculate *only* storm surge losses, as in Aerts et al. (2013), or *only* losses due to wind speeds, see Emanuel (2011). Additionally, in our calculation of total losses we not only include property damage estimates, but also derive proxies of lost income for those properties that serve as guest accommodation facilities. We find that expected losses will be about 2 percent of real estate and potential income annually, mostly induced by storm surge rather than wind damage. However, these average annual expected figures disguise low probability, very destructive events that could cause devastating losses to the local economy. For instance, our analysis suggests that a 50 year return period storm would cause a 34 percent loss in coastal value.

The remainder of the paper is organized as follows. In the next section we describe our study region. In Section 3 we outline the properties data set, while Section 4 describes our hurricane wind and storm surge damage functions. In Section 5 we discuss the hurricane synthetic track data set and how we use these to generate losses from our damage functions. Section 6 contains the results of our analysis. The final section concludes.

2. Exuma, the Bahamas

Bahamas is an archipelagic state of the Lucayan Archipelago and consists of more than 700 islands, of which 30 are inhabited. Shown in Fig. 1, these islands, albeit only 14,000 square kilometers in land area, stretch over a total area of 260,000 square kilometers of sea. Importantly, its clear warm waters and white sand beaches, along with its close proximity to the USA, make the Bahamas a prime tourist destination. It is not surprising then that a large part, i.e., about 44 percent, of the income generated comes from tourism and that this sector also accounts for more than half of the country's workforce.¹⁰

Lying well within the hurricane belt, the Bahamas are also one of the most hurricane prone of the Caribbean islands. As a matter of fact, over the period 1944 to 2010, 81 hurricane strength storms came within 111 km of the island group.¹¹ Indeed, using data from EMDAT¹² shows that there were 15 damaging tropical cyclones since 1980 and these caused up to US\$ 2.7 billion in damages. For instance, Hurricane Frances alone is estimated to have caused losses of around US\$ 381 million (ECLAC, 2004).

The Exuma Cays, depicted in red in Fig. 1, is a district of the Bahamas and consists of 365 islands. Our study region is on Great Exuma, shown in Fig. 2, which is the largest of the islands of Exuma and is 60 km in length and 158 square kilometers in area. As such, it serves as one of the Bahamas most important tourist destinations with an international airport offering direct flights from both the US and Canada. Great Exuma is the largest island in the Exuma island chain, with 7314 residents living on the island in six major settlements (Department of Statistics, 2011). There are approximately 546 hotel rooms on Exuma, divided between 16 properties. Sandals Emerald Bay is by the largest with 245 rooms, but other luxury condominium properties (Grand Isle and February Point) account for 114 units). Eight resorts have ten rooms or less (e.g. boutique resorts), and five hotels have 10 to 40 rooms. Tourism produces an estimated 50 to 60 percent of the Gross Domestic Product of The Bahamas; the hospitality industry directly or indirectly employs 50 to 60 percent of the total workforce (NEWSLETTER, 2011), and tourism is the primary economic focus for Exuma. The island is a low-lying, undulating landscape with a maximum elevation of 32 m, with many coastal wetlands and thus potentially very susceptible to storm surge.

3. Building data set

Our properties data set covers all coastal properties as of April 2015 - including home residence, rental, hotel, infrastructure, business, communal amenity and other unattributed buildings - on the east coast of Great Exuma starting north at Rolleville and continues south until February Point Resort in Elizabeth Harbour, where coastal is here defined as being within 1000 m off the coast. As such our study area includes a total of 872 properties and we depict the location of their centroids in Fig. 3. One may want to note that this region encompasses most of the economic activity and population distribution within the island of Great Exuma, the southern shoreline of the island is dominated by low-energy mangrove wetlands (Sealey and Patus, 2015). As can be seen, much of nighttime brightness, reflecting the presence of human

⁶ See <http://reliefweb.int/report/bahamas/hurricane-season-caribbean-causes-more-us22-billion-losses>.

⁷ Source: EM-DAT.

⁸ Caribbean Catastrophe Risk Insurance Facility CCRIF (2010).

⁹ Earlier approaches, such as Hallegatte (2007) and Emanuel (2011), also used synthetic hurricane tracks to calculate out potential damages. However, neither of these studies had access to building level data and instead either historic normalized losses (Hallegatte, 2007) or insurance exposure data (Emanuel, 2011) to infer likely losses at a much more spatially aggregate level.

¹⁰ See WTTC (2015).

¹¹ See <http://stormcarib.com/climatology/freq.htm>.

¹² EMDAT is a widely used disaster database that collects information on the incidence and cost of natural disasters globally. Since the data are believed to be more reliable since the 1980s we only report the tropical cyclone events and associated damages from 1980 onward.

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