Risk Profile – Dominican Republic 1930 Hurricane Reanalysis

1. **The 1930 San Zenon Hurricane caused the destruction of Santo Domingo, and is an important hurricane to reanalyse and attempt to remodel despite the lack of credible hazard data.**
2. **A reanalysis shows that the loss could be in the order of $15 billion or 9.7% of the capital stock of the Dominican Republic, but with an return period of around 400 years.**

Why are we looking at Dominican Republic

- The country has had very few national-level risk studies done, with largely differing estimates of built capital available via existing natural hazards scenarios and PDNAs.
- Building typologies differ greatly across the country meaning that relative vulnerability although decreased compared to 1930, is not necessarily significantly less than previously for particular construction classes such as unreinforced masonry.

Why is this useful to the TTL?

The 1930 San Zenon gives a scenario which is a worst case of a major metropolis being hit head on by a large hurricane, and allows for a planning scenario to be given.

Why are we doing the disaster scenario?

The "Disaster Scenarios" Dominican Republic hurricane model can be applied to a probabilistic or deterministic modelling effort in the future. The building of this model allows for future events to be quickly analysed and losses to be determined more easily in the residential and non-residential sector. By reviewing the loss differences today vs. at the time of the event, a full gambit of scientific studies, knowledge and expertise has been able to be used, which benefits the production of exposure, hazard and vulnerability models for hurricanes anywhere around the world.

Background and historic losses

The 1930 San Zenon hurricane was a significant event causing around 20% of the population and capital to be impacted and a death toll in the range of 5000 and a significant number of homeless.

Disaster Type	Hurricane		**Deaths**	2000 to 8000
Magnitude and Location	Cat 4-5 (S. DR)		**Homeless**	80,000
Date	03/09/1930		**Houses existing at time**	ca. 300,000
Country Population at Time	1,256,000		**People in dam./destr. houses**	200,000
Capital Stock at Time (Res.) - $USDmn			**Houses destroyed**	15,000
Capital Stock at Time (Non-Res.) - $USDmn	110		**Houses damaged**	25,000

The San Zenon hurricane caused somewhere between $15 million and 50 million in losses historically due to property damage at the time:- this hit Santo Domingo head on, and caused massive losses. At the time the GCS was around $100-$110 million for structures - and thus upwards of 15% of capital was destroyed.

How did we remodel the scenario?

The best track archive and HURDAT were both analysed and examined as to the wind speed and also track. Much conflicting information was seen, with some reports indicating that the Cat 5 hurricane had a Rmax of 2km; whereas other assessments had a wider Rmax. There were no downscaled archives of hazard-loss information as a result of the hurricane found in the literature.

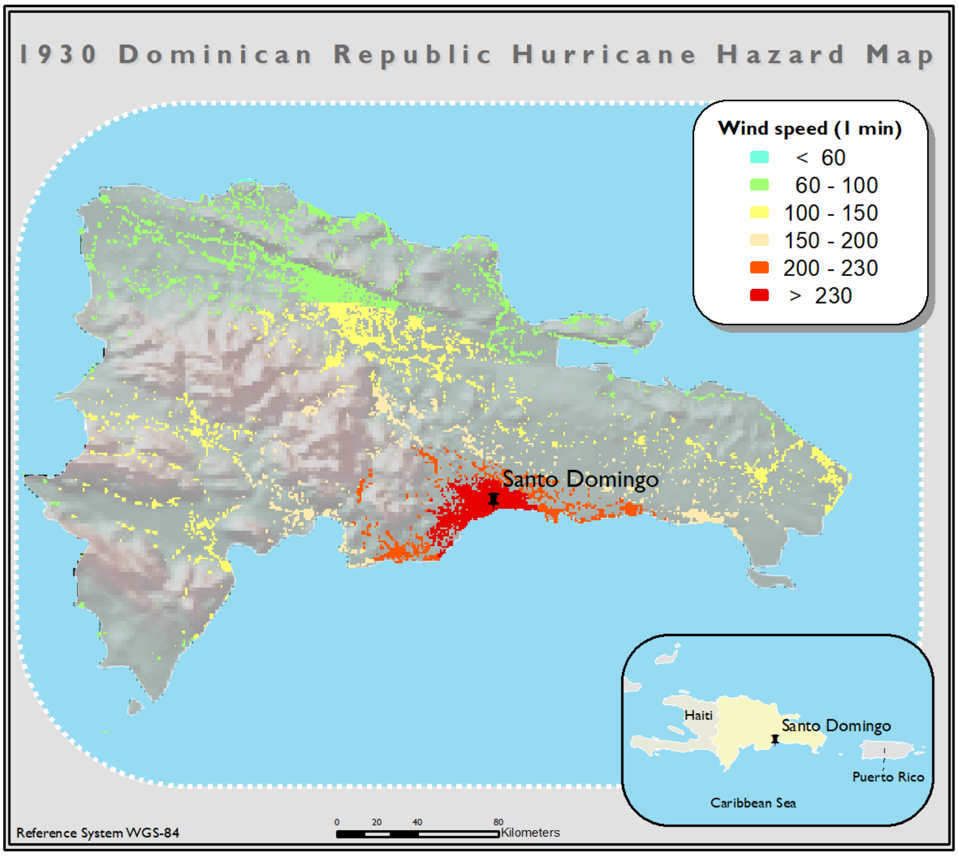

Figure 1: Hazard map of the 1930 reanalysis scenario including wind speed per cell

The assessment of the Dominican Republic residential buildings exposure was developed for the analysis of a repeat in present times of the great September 1930 hurricane. The exposure includes the period of construction according to earthquake code developments (no seismic design provisions prior to 1980 and thereafter) of the numerous houses with concrete block outer walls (category of "*block o concreto*", in the 2010 Population and Housing Census). In addition it includes splits for low (1 to 2 storeys), medium (3 to 5 storeys) and high-rise (6 or more floors) reinforced concrete construction, as there is significant exposure in such buildings especially in the Santo Domingo area (see Fig. 2, showing significant prevalence of concrete slab roofs in the 32 provinces of the Dominican Republic). It is also developed separately for single-family houses and houses found in apartment buildings. This exposure model therefore allows for various scenarios to be examined related to possible rate of adherence to the code by time period and region for cost-benefit analysis as well as examination of possible ground motion amplification effects in urban areas affecting mostly multi-story reinforced concrete buildings. Spatially the exposure was developed using the iURBAN tool which defines three homogeneous inventory regions (metropolitan, remaining urban and rural areas). The 2016 residential exposure was estimated at 101017 million USD and is split into eight main structural typologies (Fig. 3). It is noted that the exposure is roughly equal in the Santo

Domingo area and in the remaining urban areas (mostly around Santo Domingo and in the north), with post-1980 reinforced concrete being more prevalent in Santo Domingo.

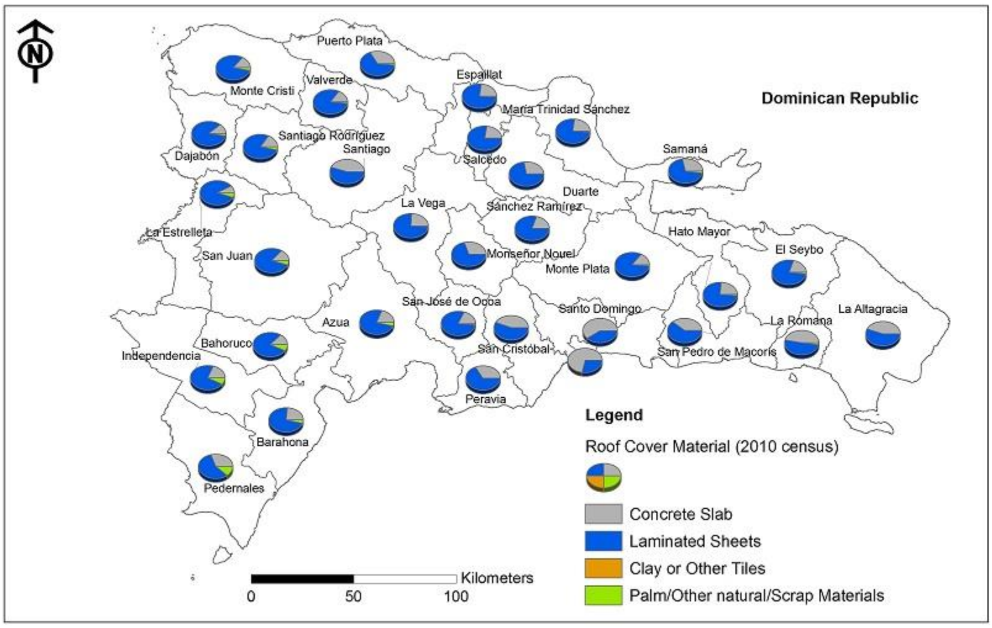

Figure 2: Province-level distribution of housing units by roof cover type in the Dominican Republic (2010). The map shows that prevalence of reinforced concrete slabs is significant in the urbanized provinces (e.g. Santo Domingo, Santiago, etc.).

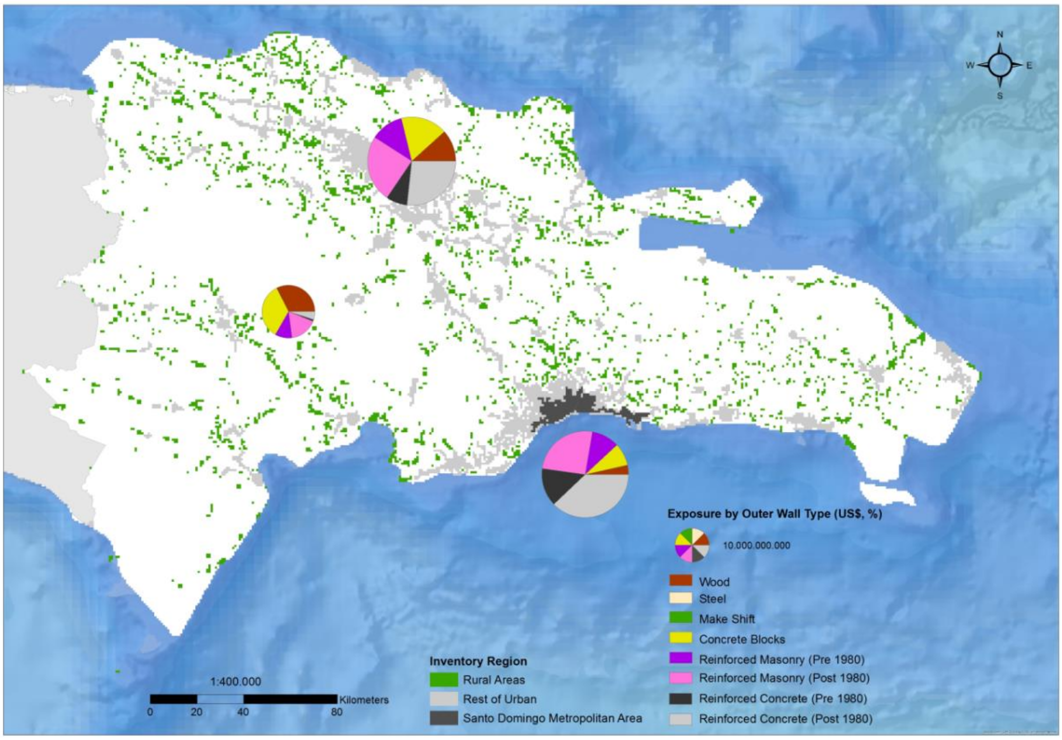

Figure 3: Residential exposure in the Dominican Republic (2016). The map shows the populated patches grouped into three homogeneous inventory regions (metropolitan, rest of urban and rural areas), the size of the exposure in USD (scaled pie charts) and its breakdown into eight vulnerability classes.

The characterisation of the vulnerability of the built structures was informed by the work of Pita et al. (2014), and calibrated using data from historical Caribbean vulnerability curves as per the Dominican Republic CDRP.

What are the potential losses due to the reanalysis?

	Historic (1930)	Modelled
Total Damage (current mn USD)	18	14995
Total Stock (current mn USD)	110	153099
Total exposed stock (over 100kph)		122891
Total Loss Ratio	15.98%	9.79%

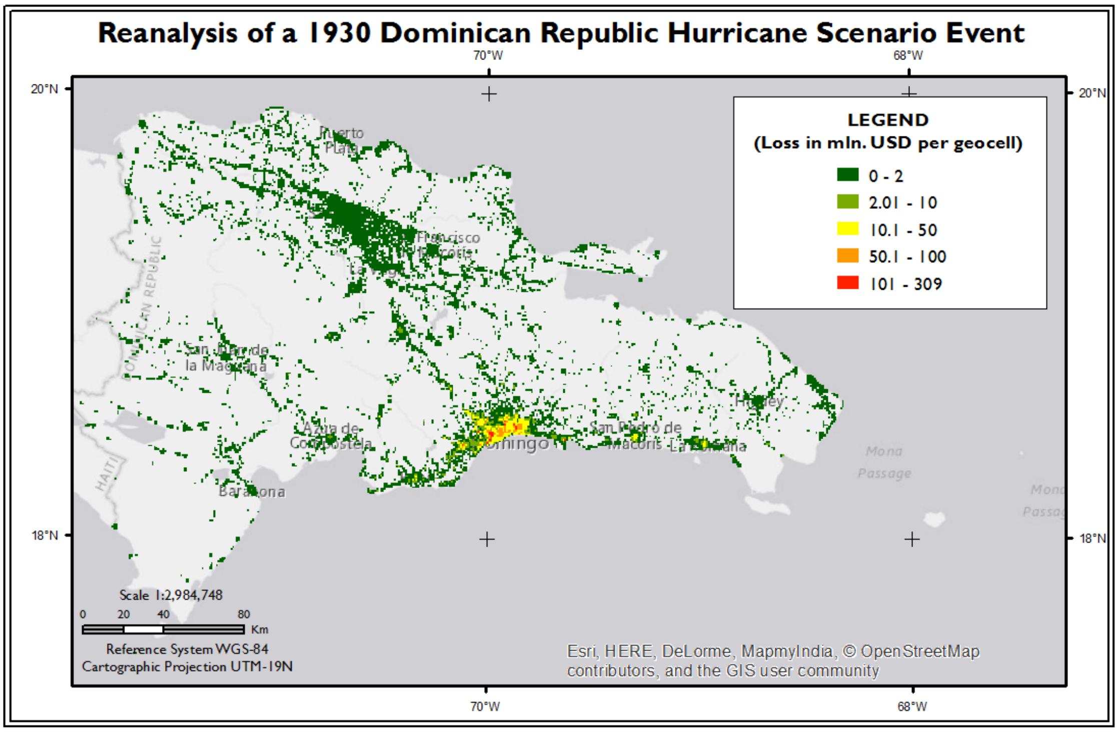

Figure 4: Absolute losses on a 250m gridcell resolution from the 1930 Hurricane scenario

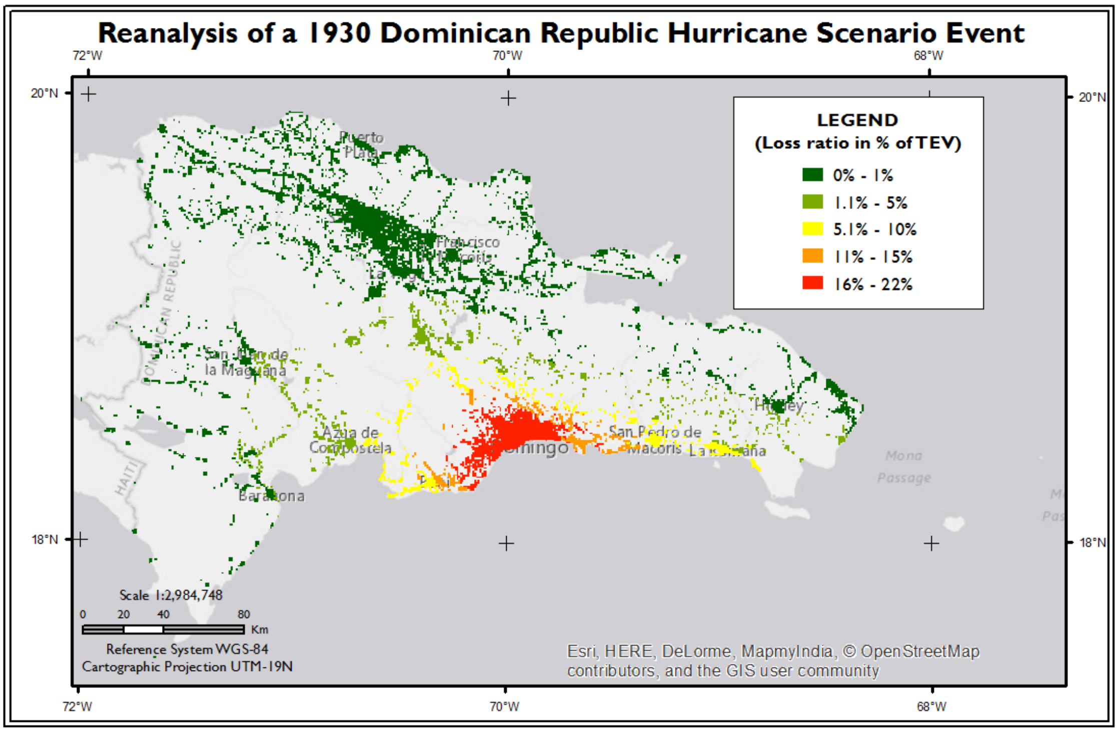

Figure 5: Relative losses on a 250m gridcell resolution from the 1930 Hurricane scenario as a loss ratio in % of total exposed value.

Santo Domingo and the greater metropolitan area is most affected by this storm. Because of the different building styles seen today, although most buildings may have some damage, a large proportion will not collapse and may only lose roofs or have minor damage.

Table: Losses and Exposure by province

Province	Mean Wind (1-min sust.) (kph)	Exposure ($USDm)	Loss ($USDm)	Loss Ratio (%)
Santo Domingo	229	49968.8	8404.0	16.8%
Distrito Nacional	236	24107.6	4113.5	17.1%
San Cristóbal	230	7384.4	1279.3	17.3%
San Pedro de Macorís	198	3799.0	299.8	7.9%
Peravia	211	2518.9	248.3	9.9%
La Romana	181	3797.8	197.9	5.2%
Azua	173	2302.0	95.5	4.1%
Monte Plata	159	1985.0	66.6	3.4%
La Altagracia	129	4641.1	65.6	1.4%
Monseñor Nouel	165	2132.3	60.5	2.8%
San José de Ocoa	198	527.4	40.9	7.8%

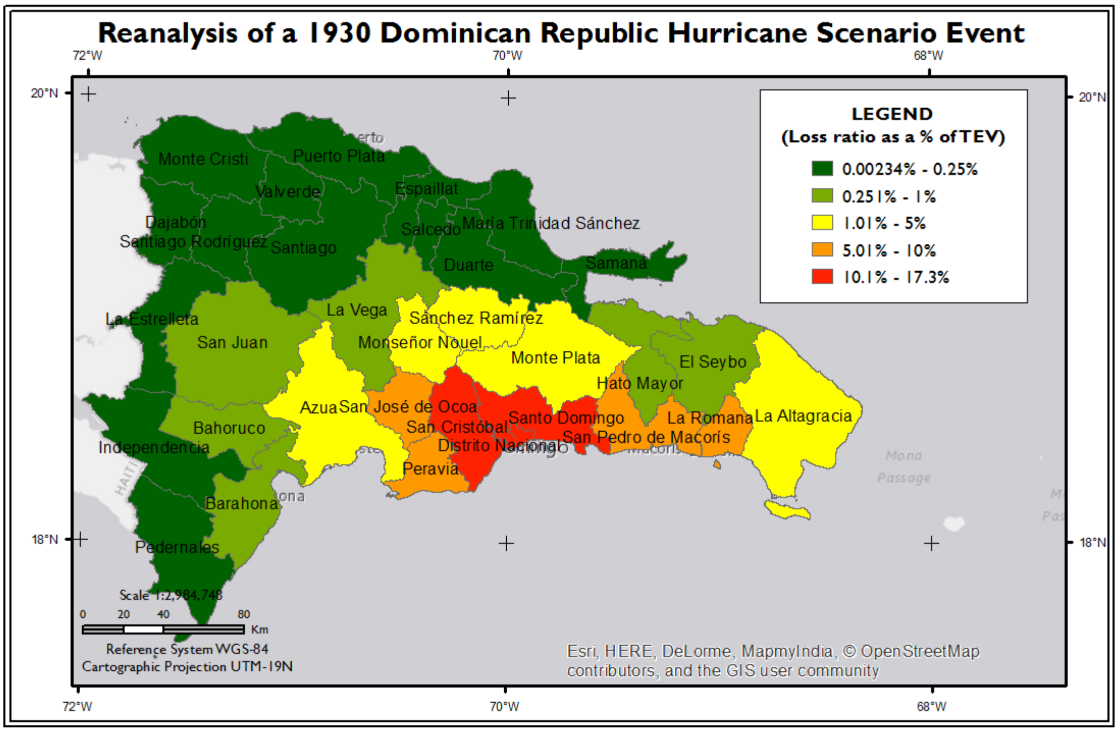

Figure 6: Relative losses on a 250m gridcell resolution from the 1930 Hurricane scenario as a loss ratio in % of total exposed value.

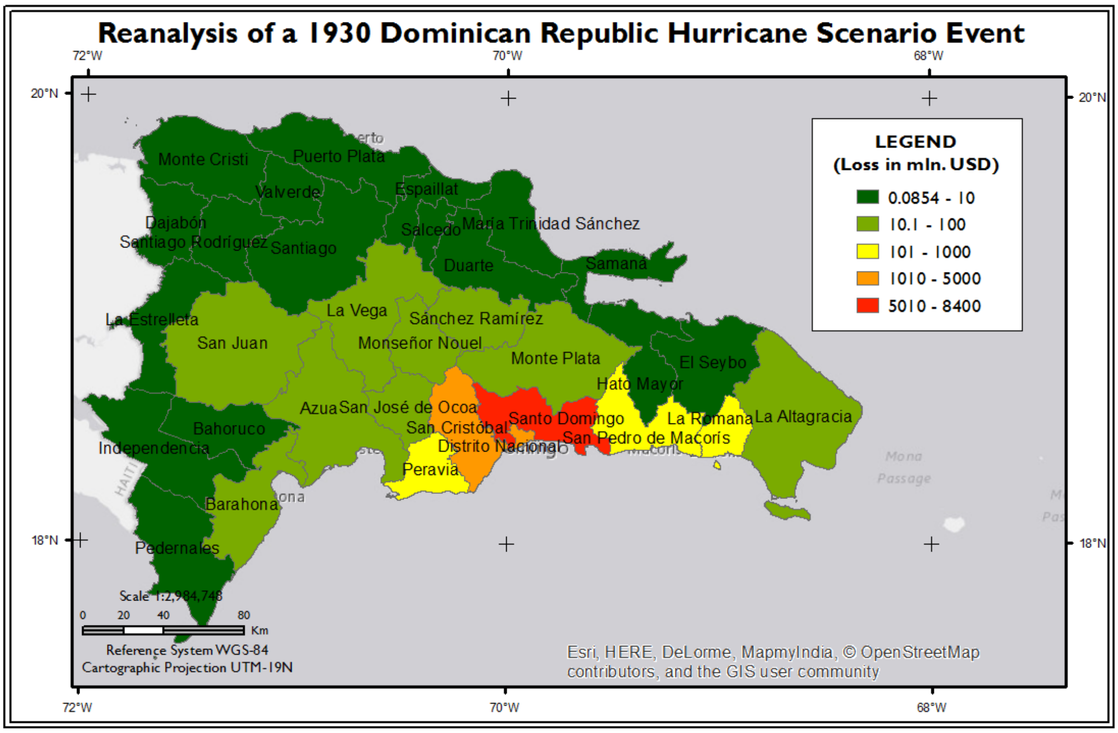

Figure 7: Relative losses on a 250m gridcell resolution from the 1930 Hurricane scenario as a loss ratio in % of total exposed value.

What is the return period of such an event?

Using the CDRP risk profile and the reanalysis of $14.99 billion, 9.7% of GCS, would put it around the 400 year return period mark, which seems reasonable for a direct full hit on Santo Domingo given the length of coastline exposed and number of tracks of this speed possible.

Using GAR2015, a 170 year return period is seen for the loss statistically.

Why was it important to collate the data?

The Dominican Republic event of 1930 was one that affected the metropolis of Santo Domingo and is as such a direct-hit on a major city which do not occur very often. It is important to analyse the potential big events from the past to see what such an impact could be today.