CAPRA

COMPREHENSIVE APPROACH FOR PROBABILISTIC RISK ASSESSMENT

ERN Evaluación de Riesgos Naturales – América Latina –

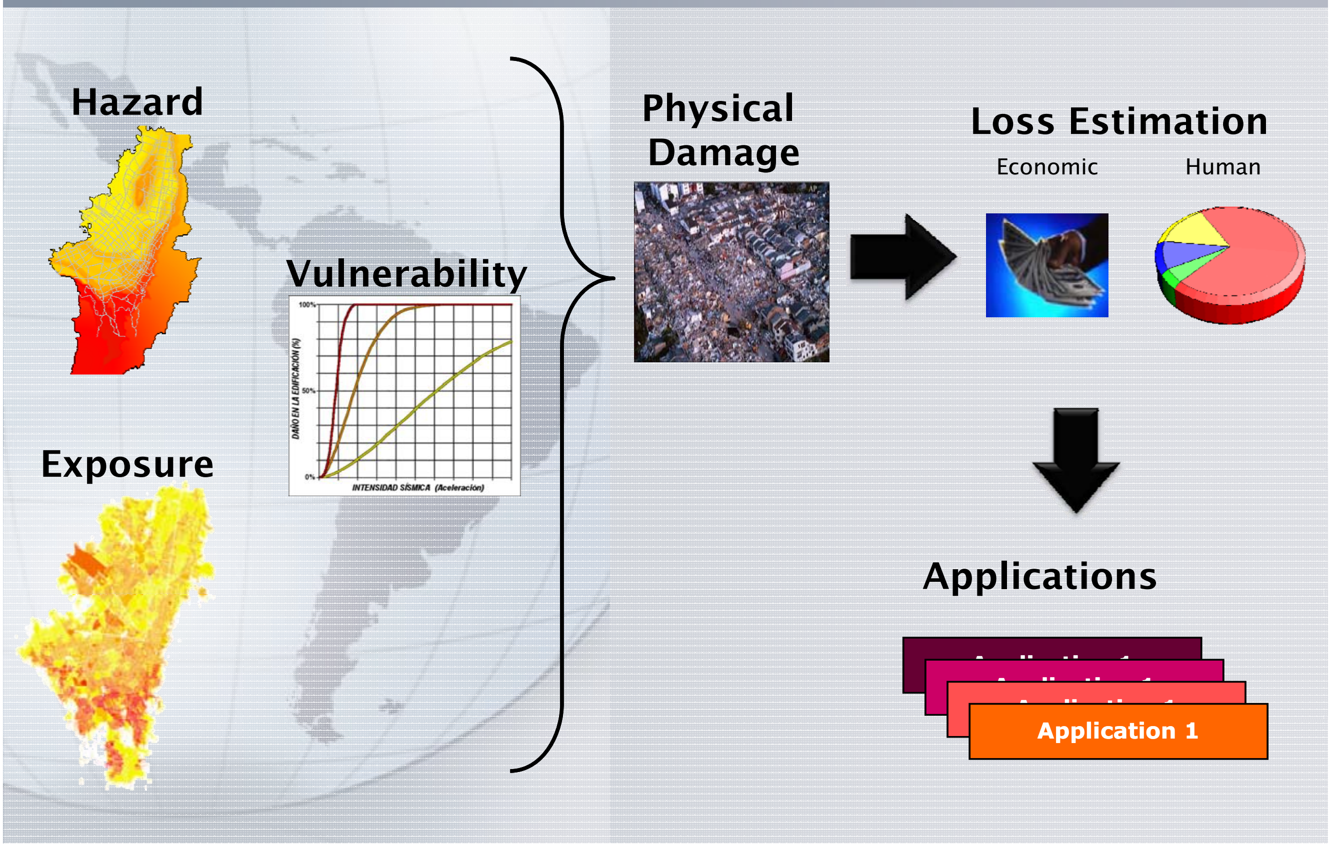
Luis E. Yamin

GFDRR GLOBAL FACILITY FOR DISASTER REDUCTION AND RECOVERY

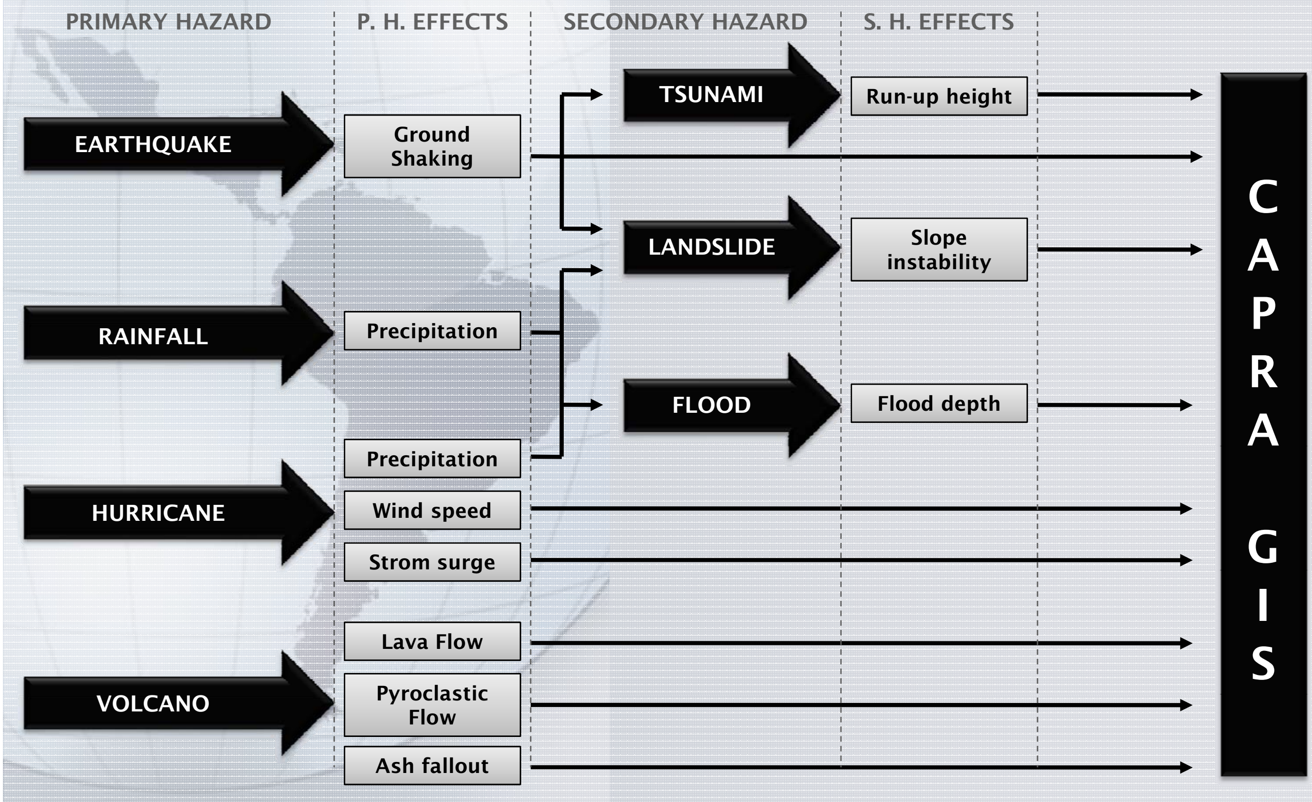
ISDR

IDB

Risk Analysis Methodology



Multi-hazard approach



Hazard representation

Set of stochastic scenarios

.AME FORMAT

- *Mutually exclusive*
- *Collectively exhaustive*
- *Takes into account historical events*
- *Hazard probabilistic representation*

Several intensity measures

Statistical moments

Annual occurrence frequency

Latin America and the Caribbean seismic hazard	
Total stochastic scenarios:	145980
Total intensity measures computed:	23
Structural vibration periods [sec]: 0.0, 0.05 0.1, 0.15, 0.2, 0.25, 0.3, 0.35, 0.4, 0.45, 0.5, 0.55, 0.6, 0.65, 0.7, 0.75, 0.8, 0.85, 0.9, 0.95, 1.0, 1.5, 2.0	

Hazard representation

Hazard integration

$$\nu(a) = \sum_{i=1}^{i=N_E} \Pr(A > a \mid E_i) \cdot F_{E_i}$$

Intensity exceedance rate

Intensity measure

Sum for all scenarios

Exceedance probability of the intensity, conditional to scenario occurrence

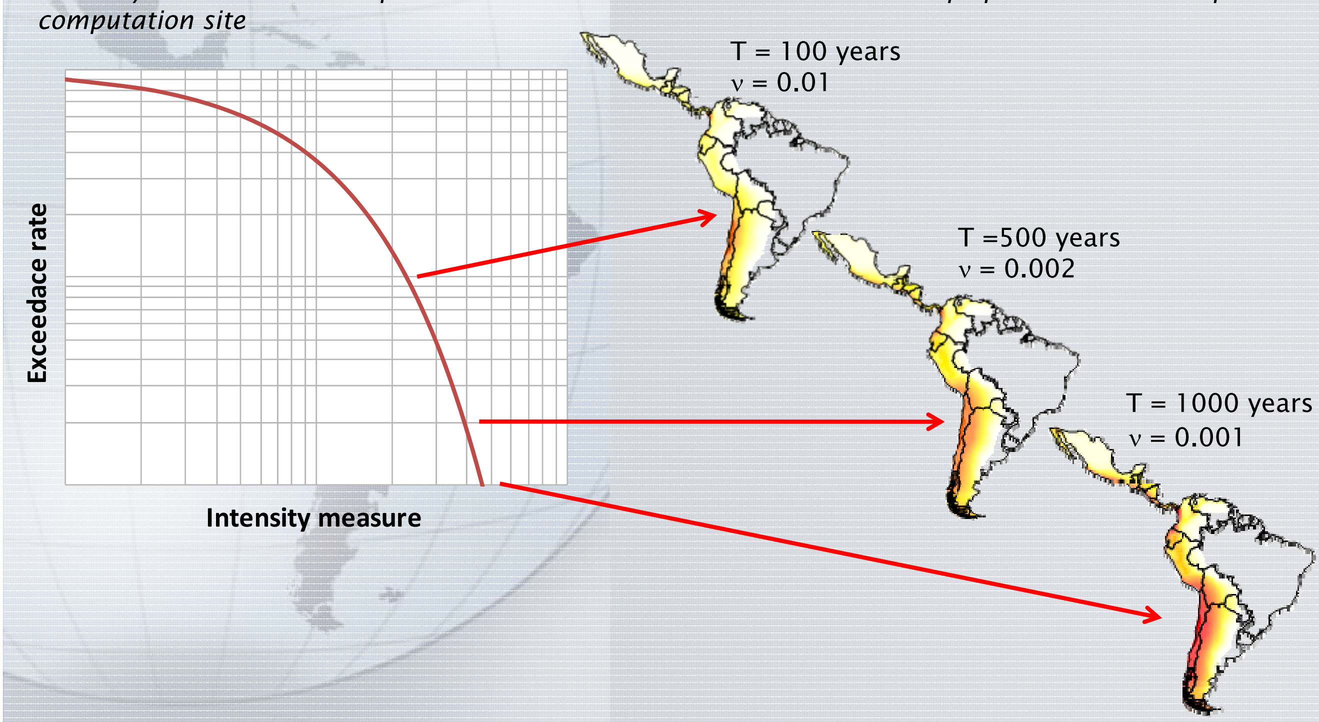
Scenario annual occurrence frequency

Hazard representation

Hazard integration

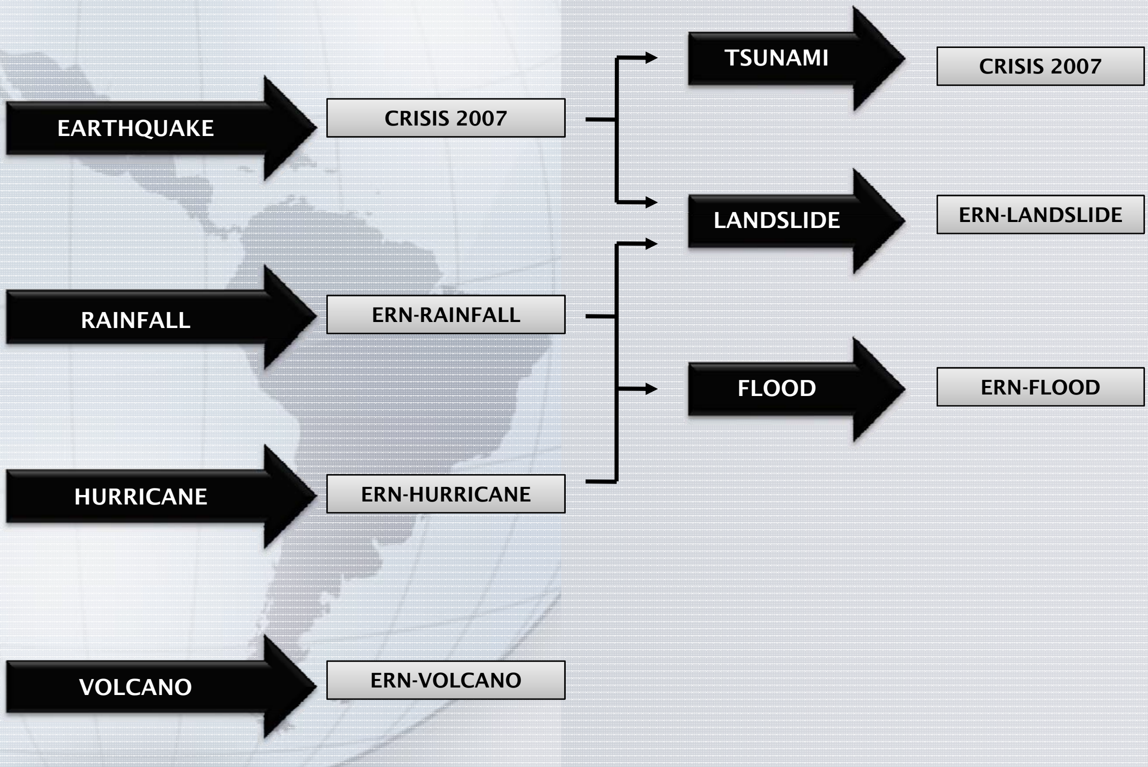
Intensity exceedance curve for each computation site

Hazard maps for several return periods



Hazard assessment tools

Open source software



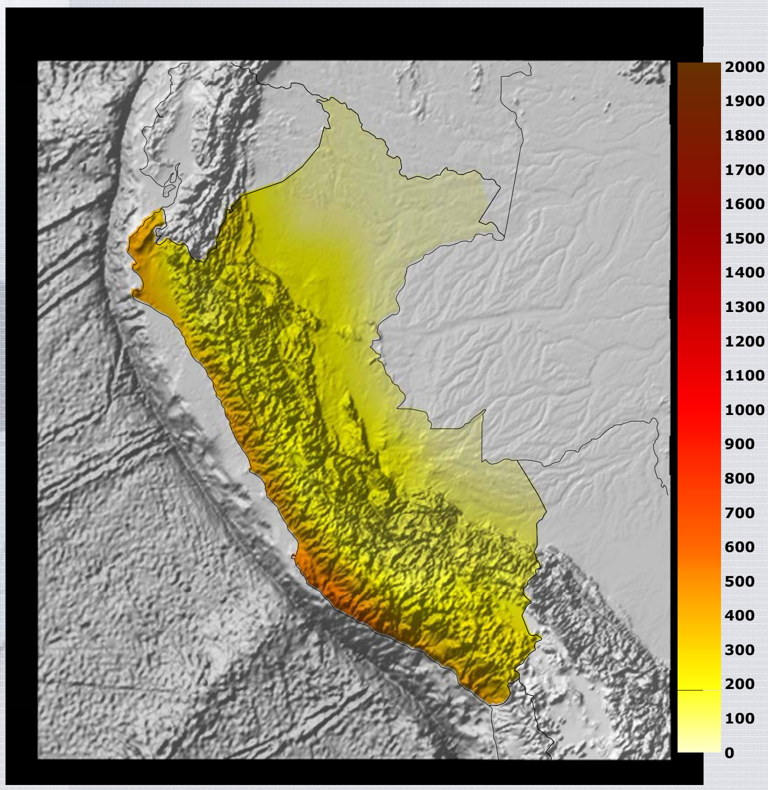
SEISMIC HAZARD

Seismic Hazard

Hazard results for Peru

Peak ground acceleration[cm/s2]

250 years return period

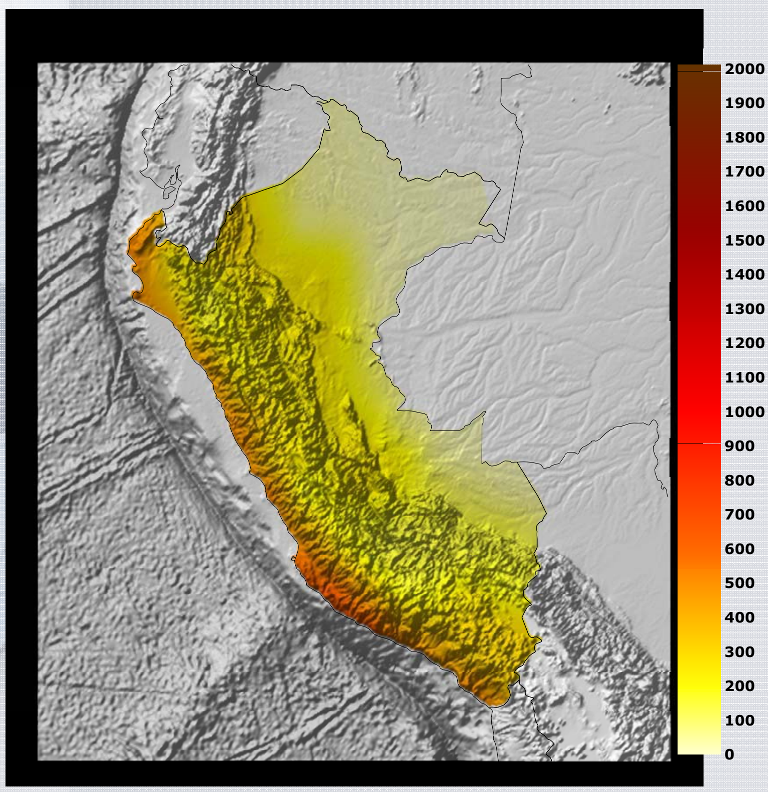


Seismic Hazard

Hazard results for Peru

Peak ground acceleration[cm/s2]

500 years return period

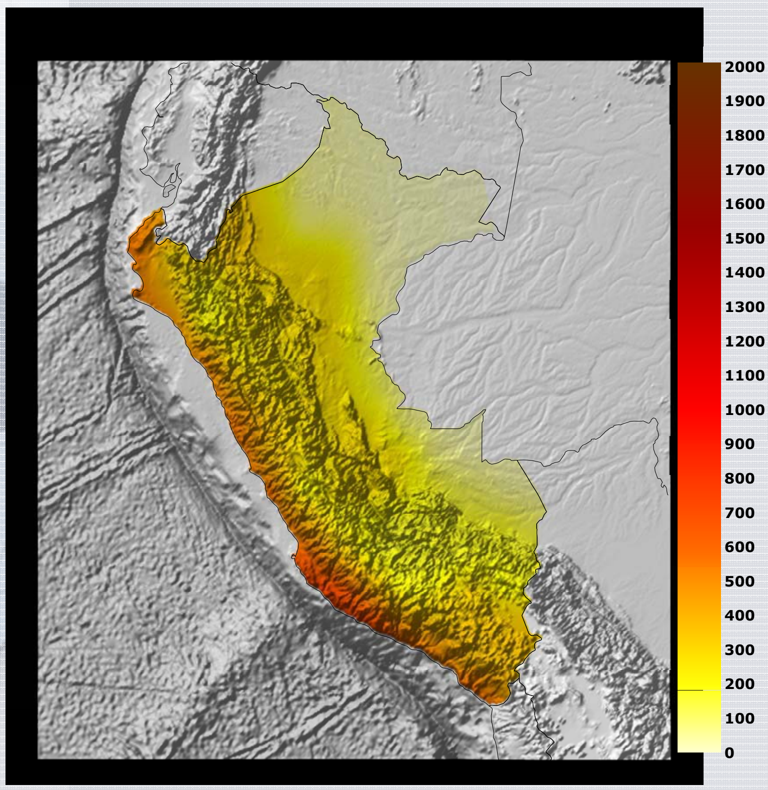


Seismic Hazard

Hazard results for Peru

Peak ground acceleration[cm/s2]

1000 years return period

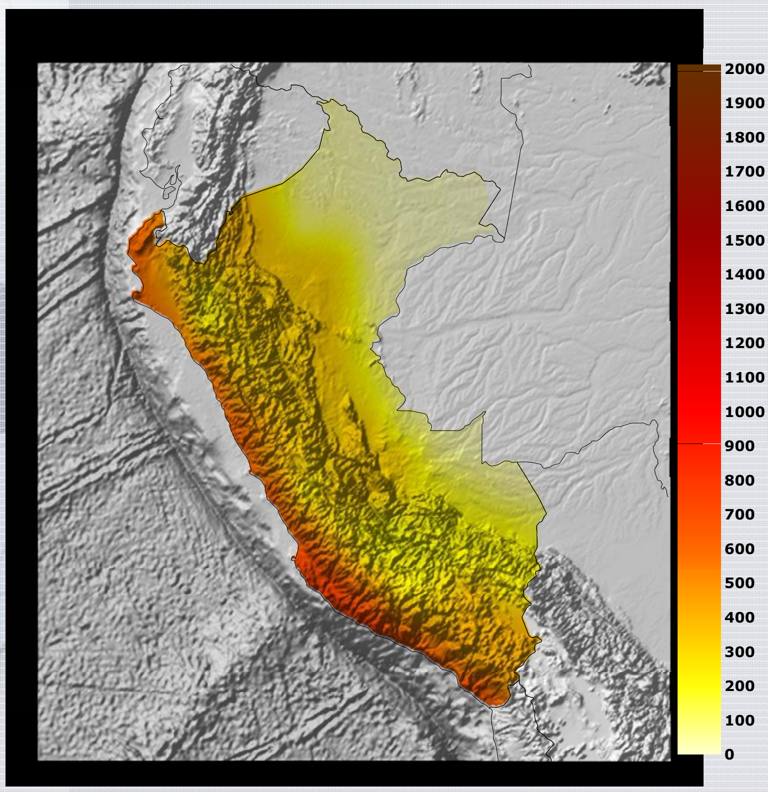


Seismic Hazard

Hazard results for Peru

Peak ground acceleration[cm/s2]

2500 years return period

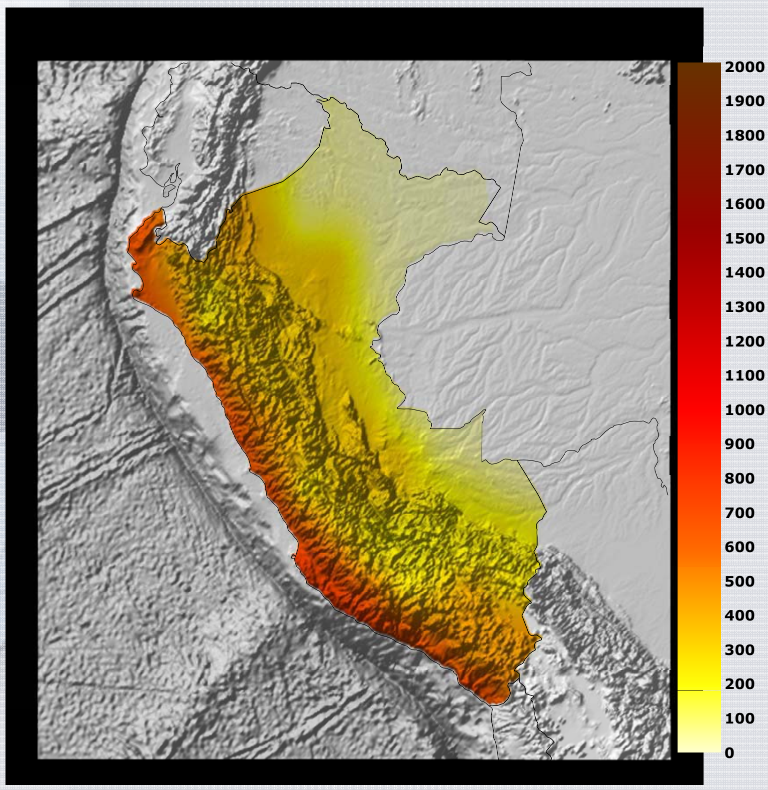


Seismic Hazard

Hazard results for Peru

Peak ground acceleration[cm/s2]

5000 years return period



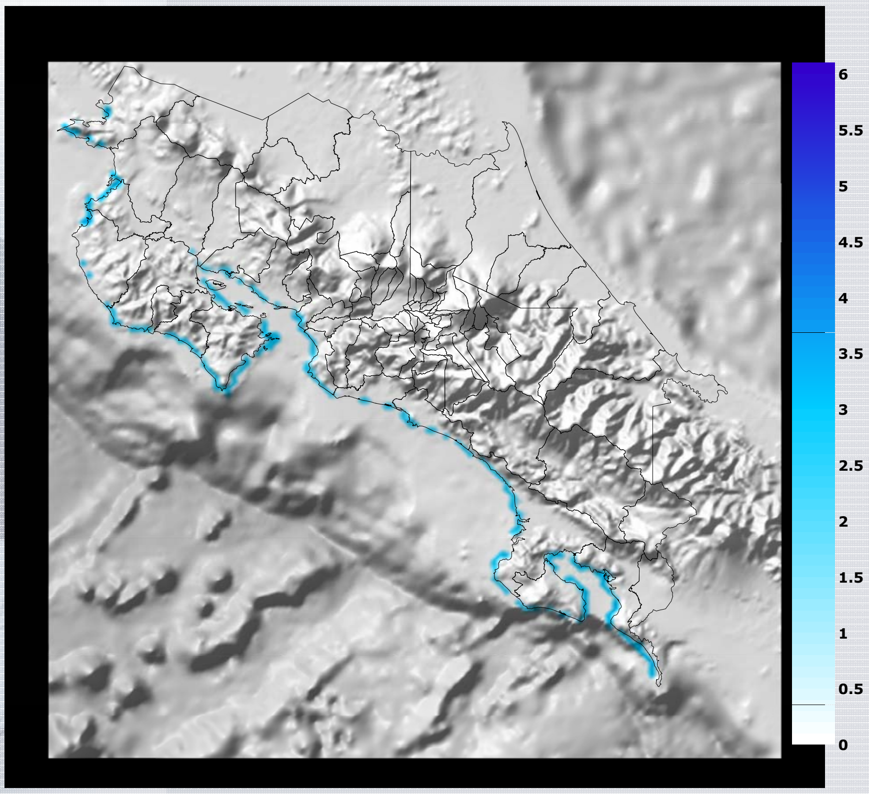
TSUNAMI HAZARD

Tsunami Hazard

Hazard results for Costa Rica

Run-up height [m]

100 years return period

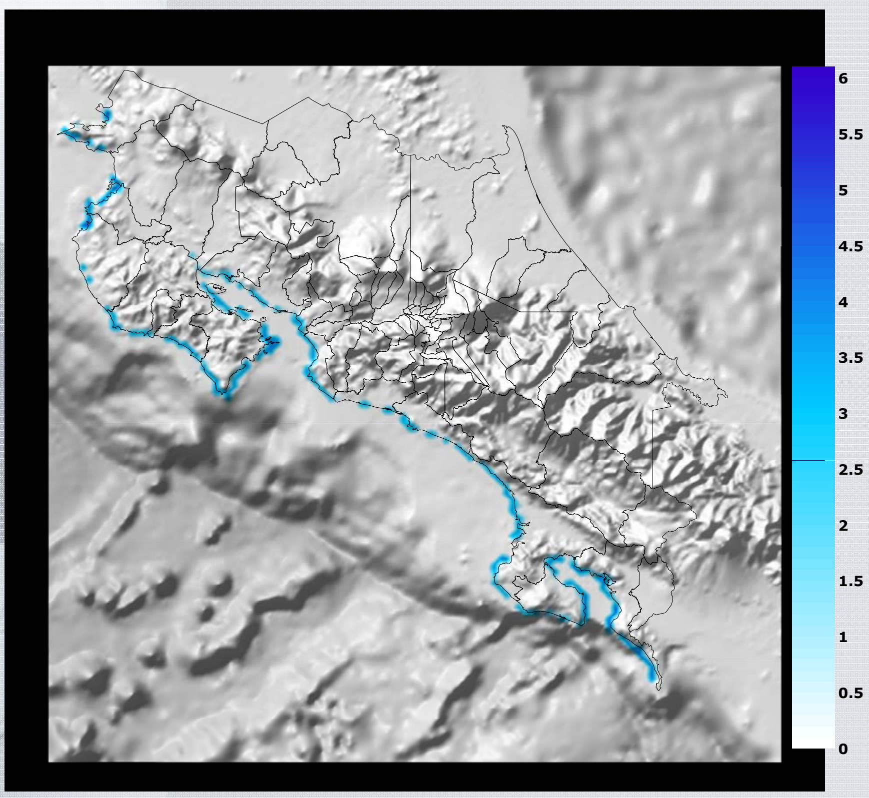


Tsunami Hazard

Hazard results for Costa Rica

Run-up height [m]

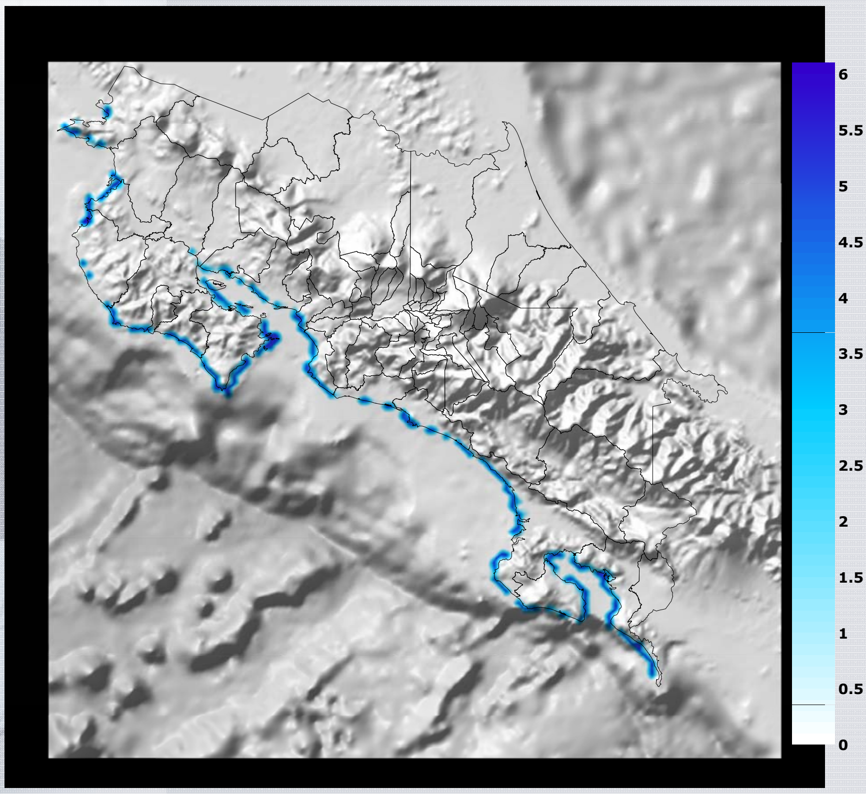
500 years return period



Tsunami Hazard
Hazard results for Costa Rica

Run-up height [m]

1000 years return period



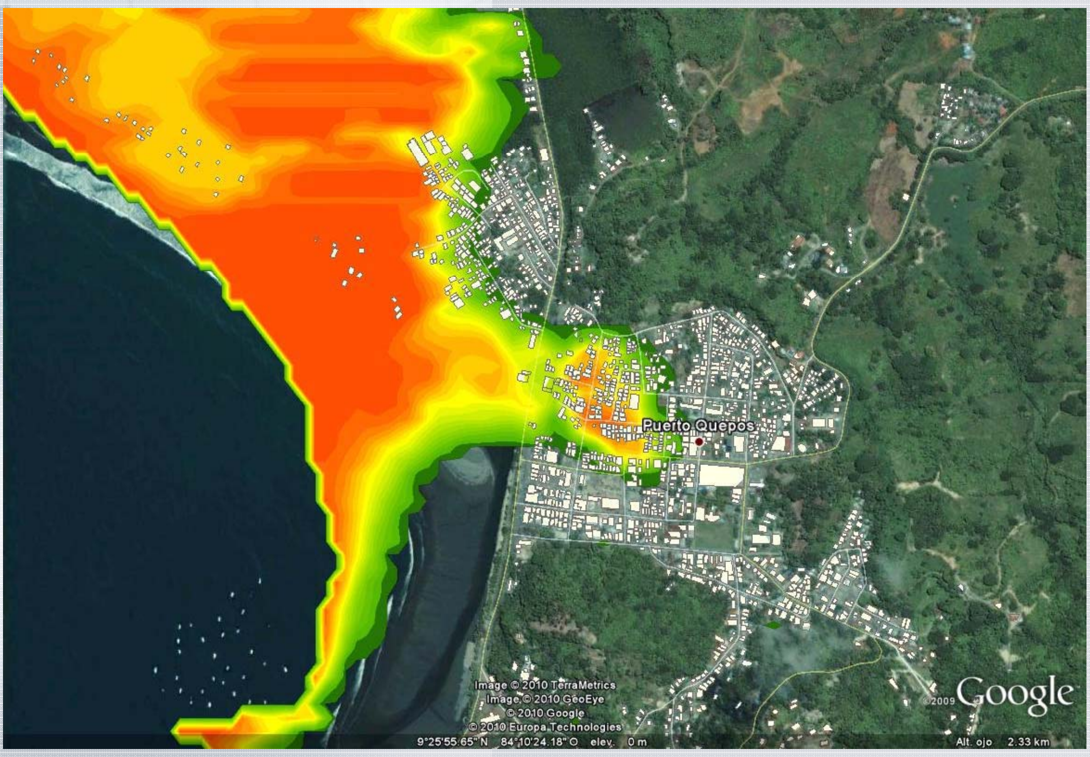
Tsunami Hazard
Hazard results for Costa Rica

Run-up height [m] for Puerto Quepos. 500 years return period

Tsunami Hazard

Hazard results for Costa Rica

Run-up height [m] for Puerto Quepos. 500 years return period



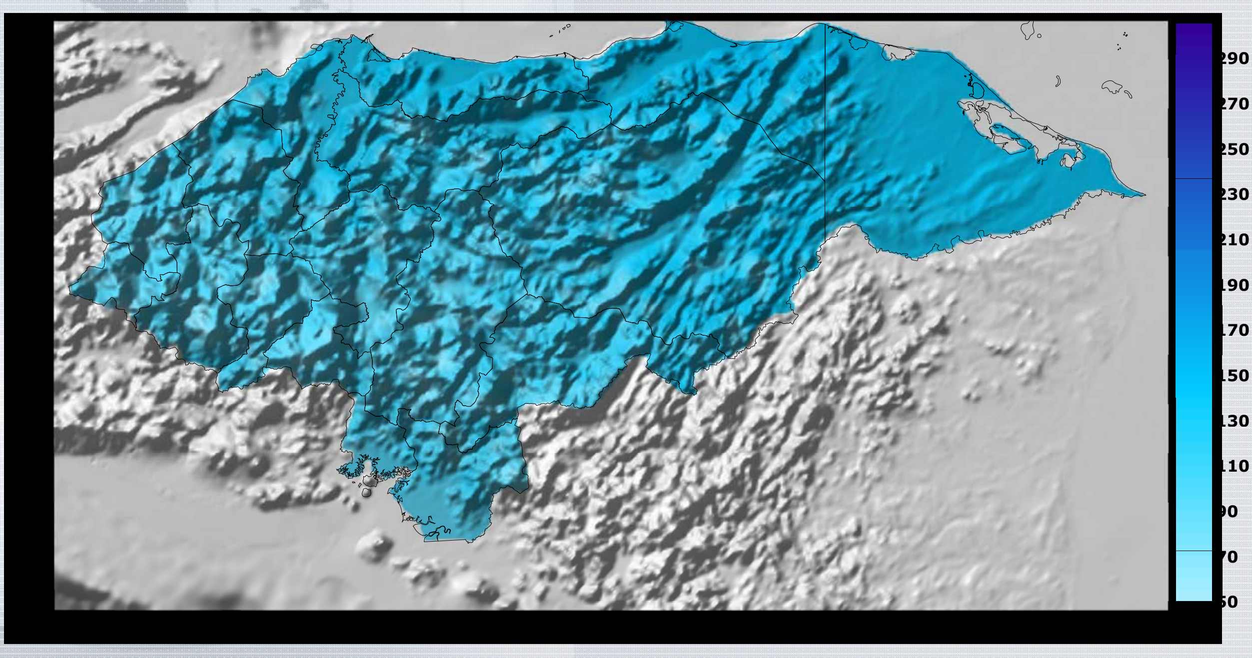
HURRICANE HAZARD

Hurricane Hazard

Hazard results for Honduras

Top wind speed [km/h]

100 years return period

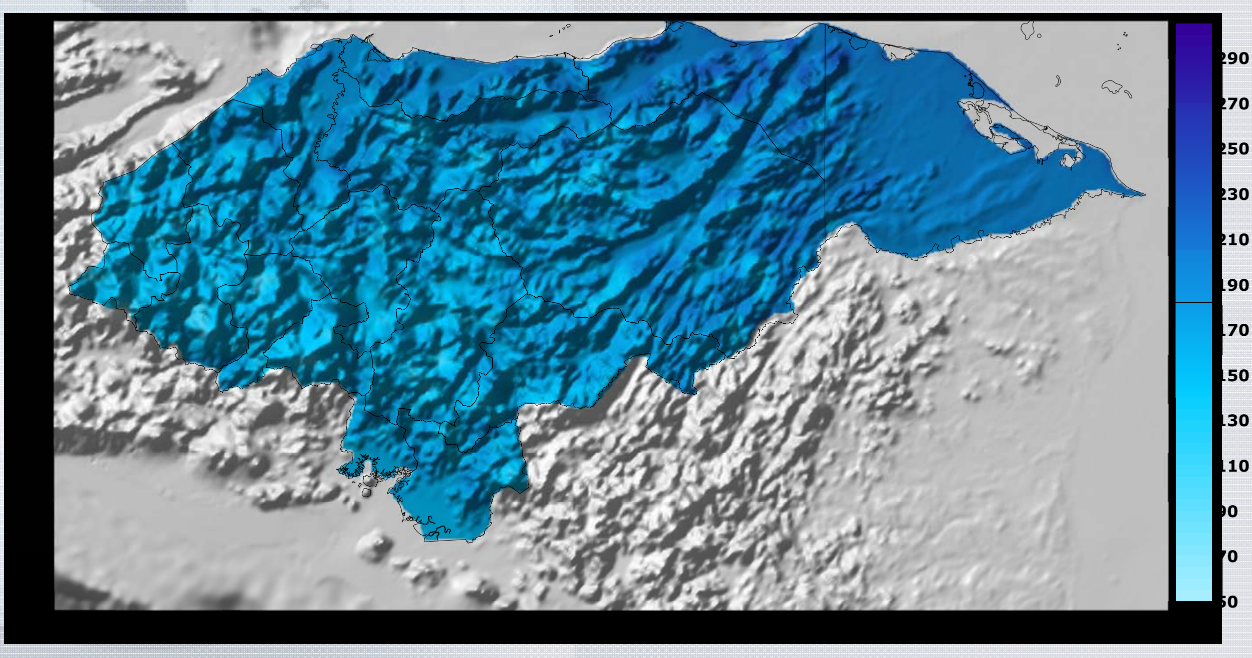


Hurricane Hazard

Hazard results for Honduras

Top wind speed [km/h]

500 years return period

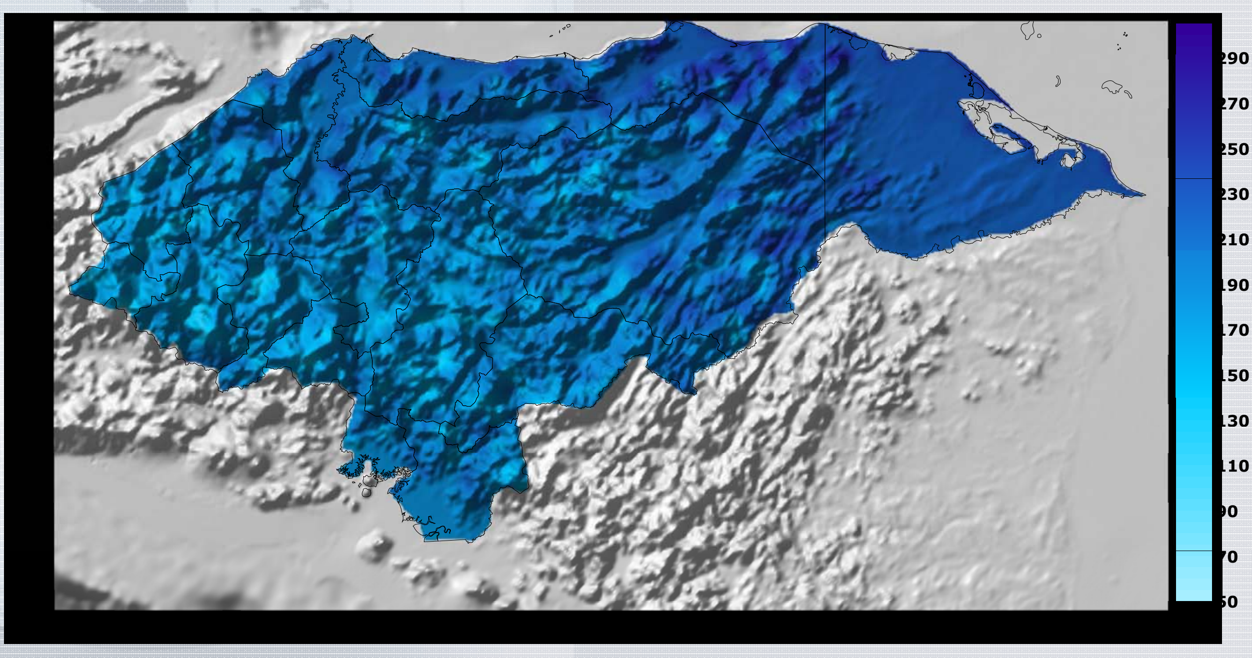


Hurricane Hazard

Hazard results for Honduras

Top wind speed [km/h]

1000 years return period

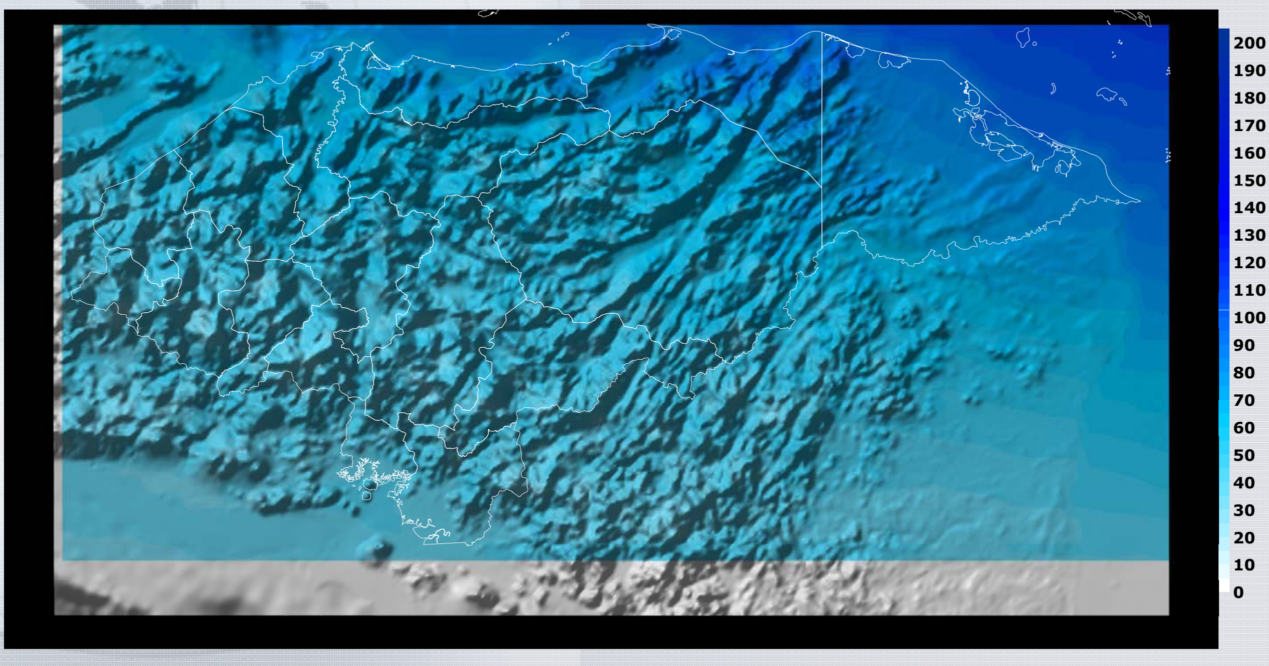


Hurricane Hazard

Hazard results for Honduras

Top wind speed [km/h] for hurricane Mitch simulation

Mean value of wind speed for 100 simulations over Mitch's original path



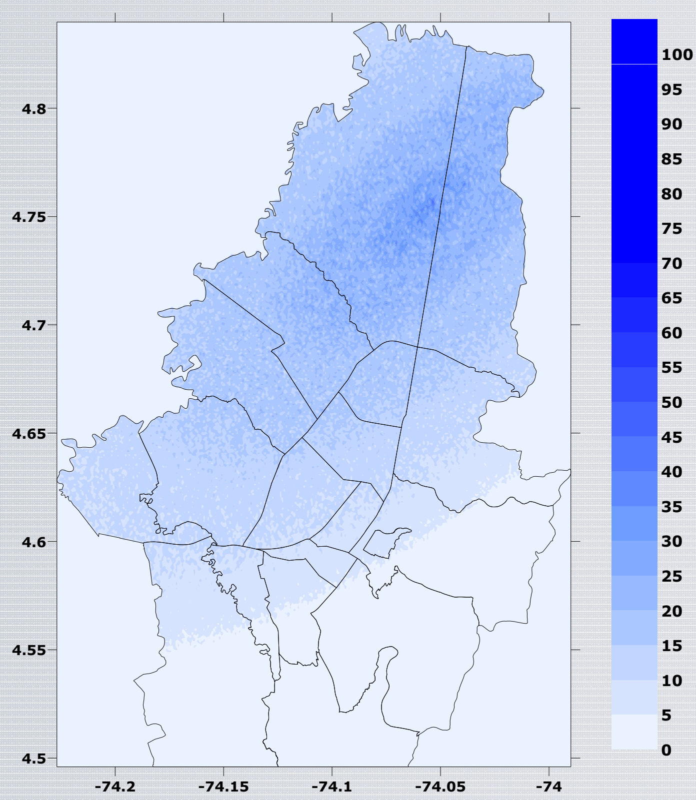
RAINFALL HAZARD

Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms

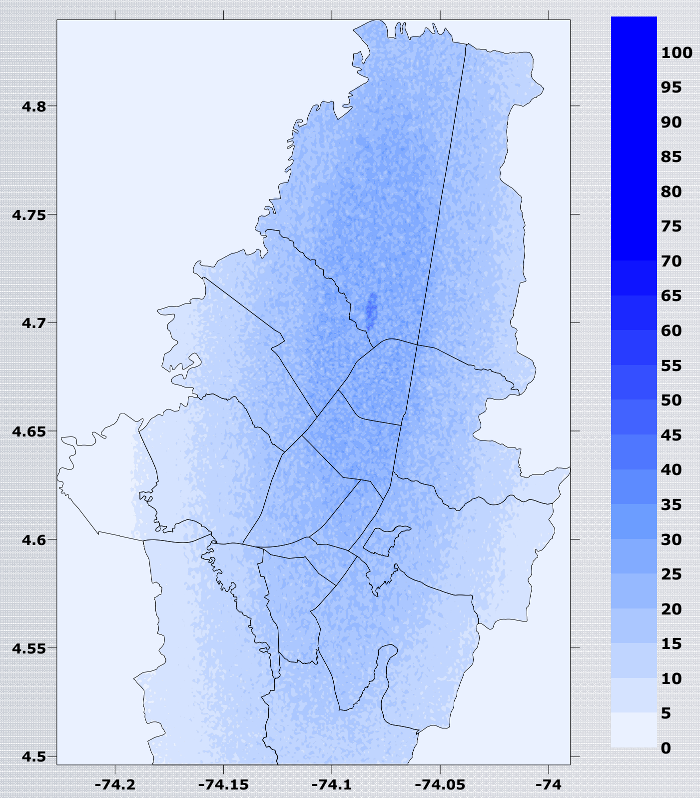


Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms

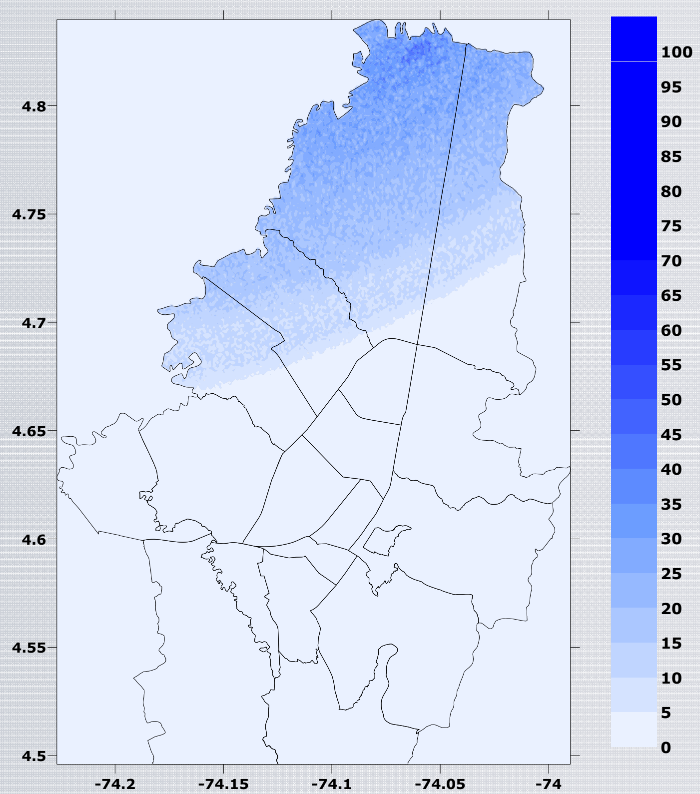


Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms

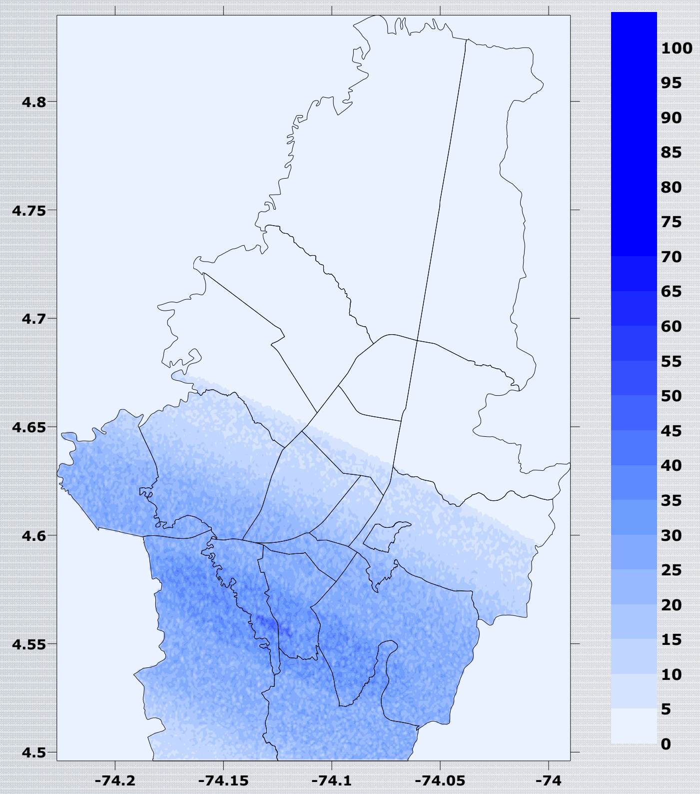


Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms

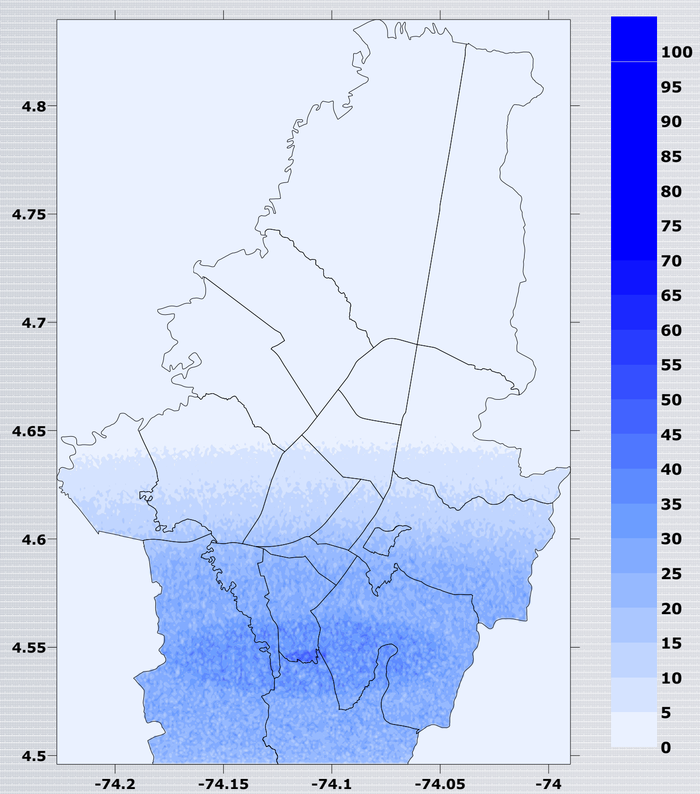


Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms

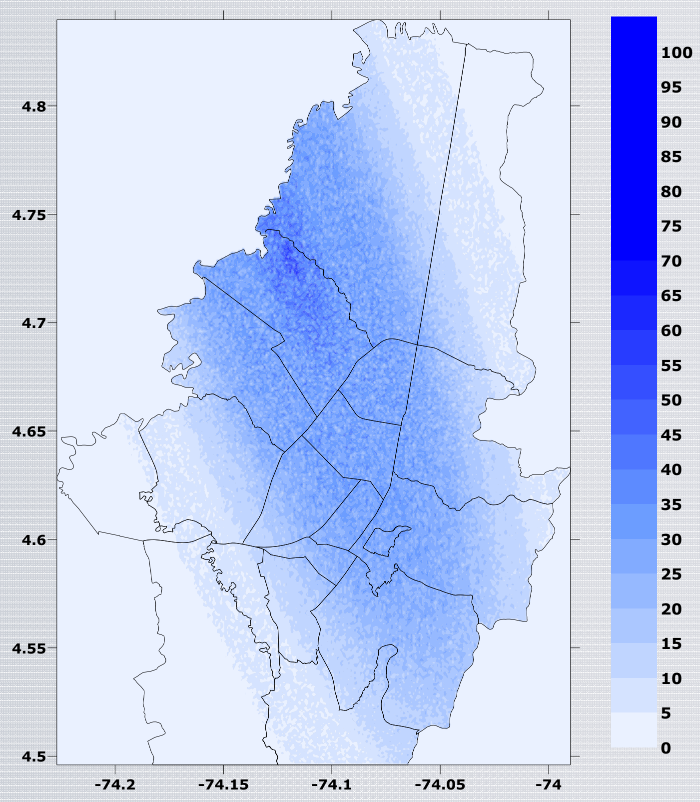


Rainfall Hazard

Hazard results for Bogotá, Colombia

Rainfall precipitation [mm]

Stochastic storms



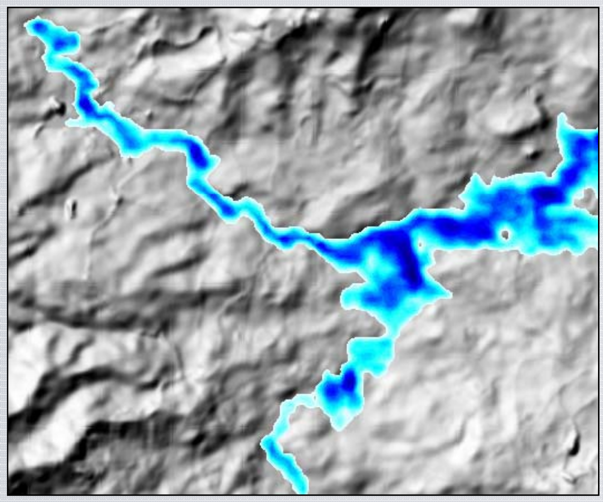
FLOOD HAZARD

Flood Hazard

Hazard results for Nicaragua

Flood depth[m] for hurricane Felix simulation at Cálico river, in the municipality of San Dionisio

Computing hazard



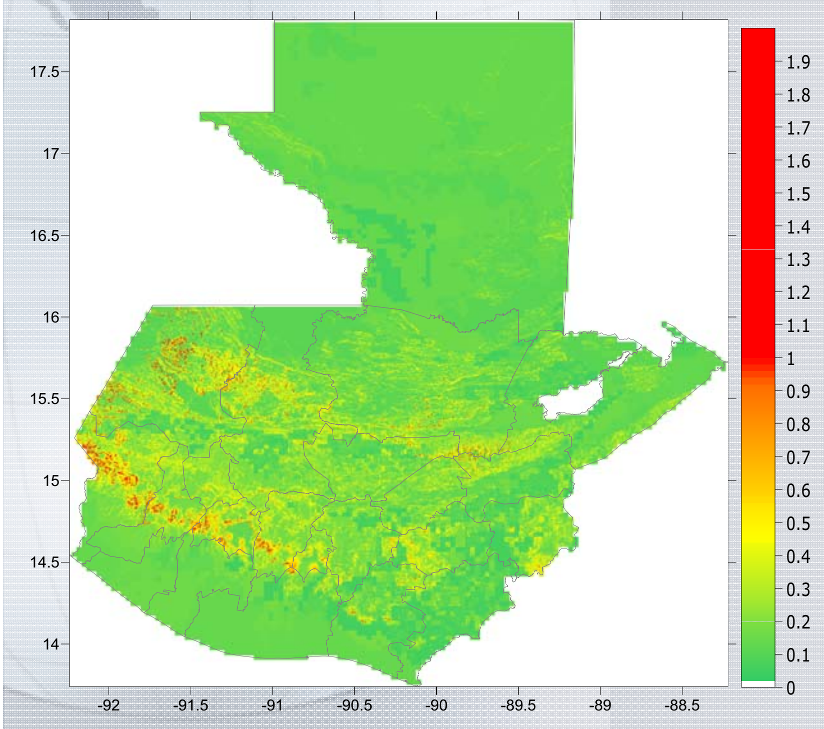
Final result

LANDSLIDE HAZARD

Landslide Hazard

Hazard results for Guatemala

Infinite slope safety factor inverse (forces equilibrium)



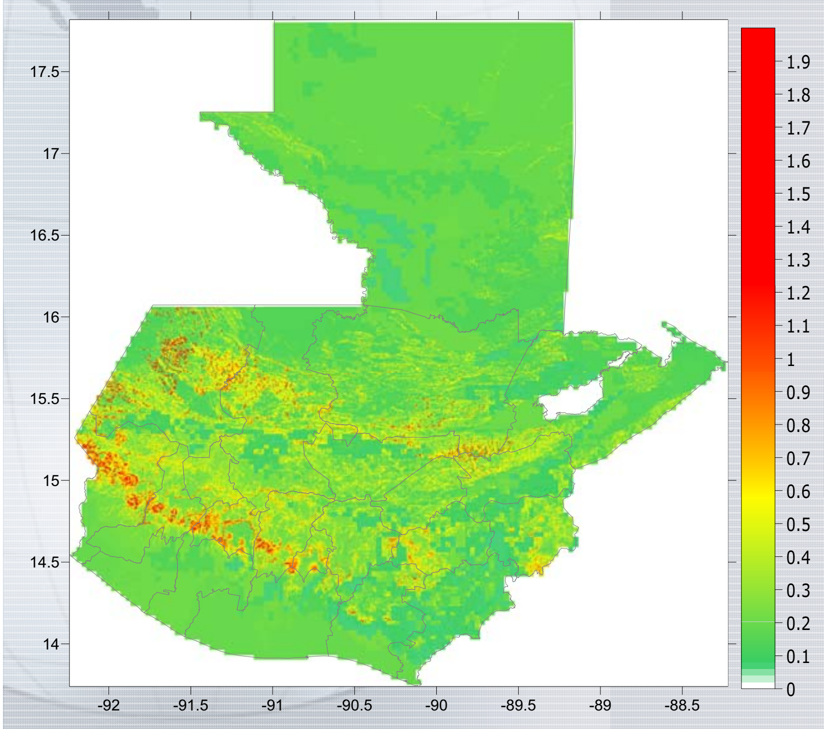
Dry soil condition

No earthquake

Landslide Hazard

Hazard results for Guatemala

Infinite slope safety factor inverse (forces equilibrium)



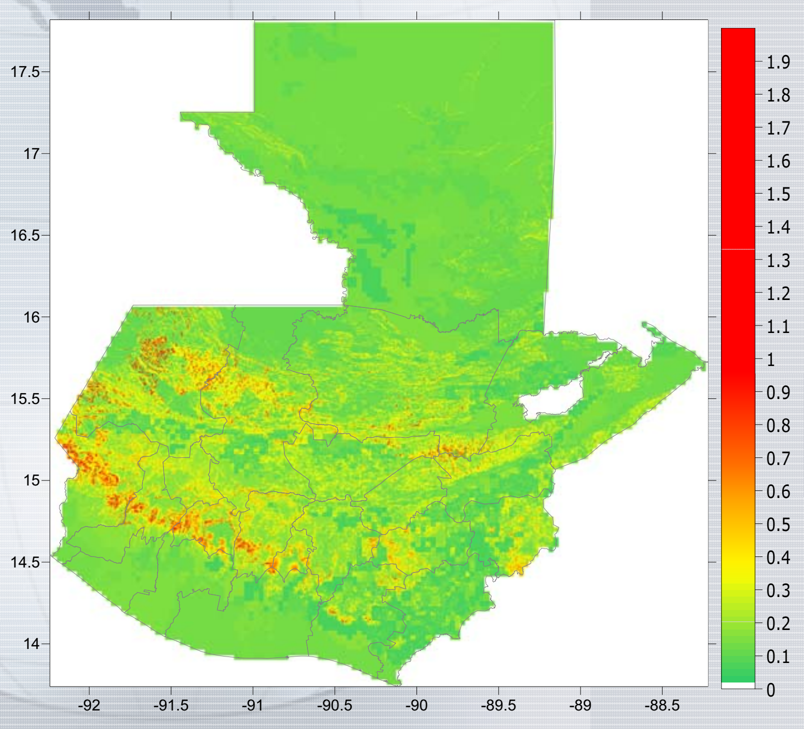
Wet soil condition

No earthquake

Landslide Hazard

Hazard results for Guatemala

Infinite slope safety factor inverse (forces equilibrium)



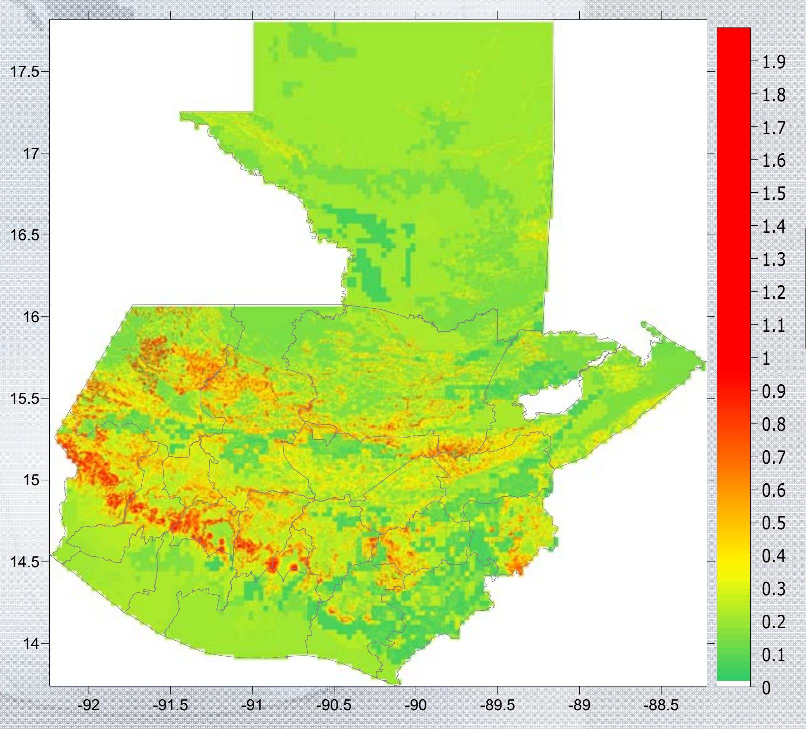
Dry soil condition

Earthquake scenario of 6.8 Mw

Landslide Hazard

Hazard results for Guatemala

Infinite slope safety factor inverse (forces equilibrium)



Wet soil condition

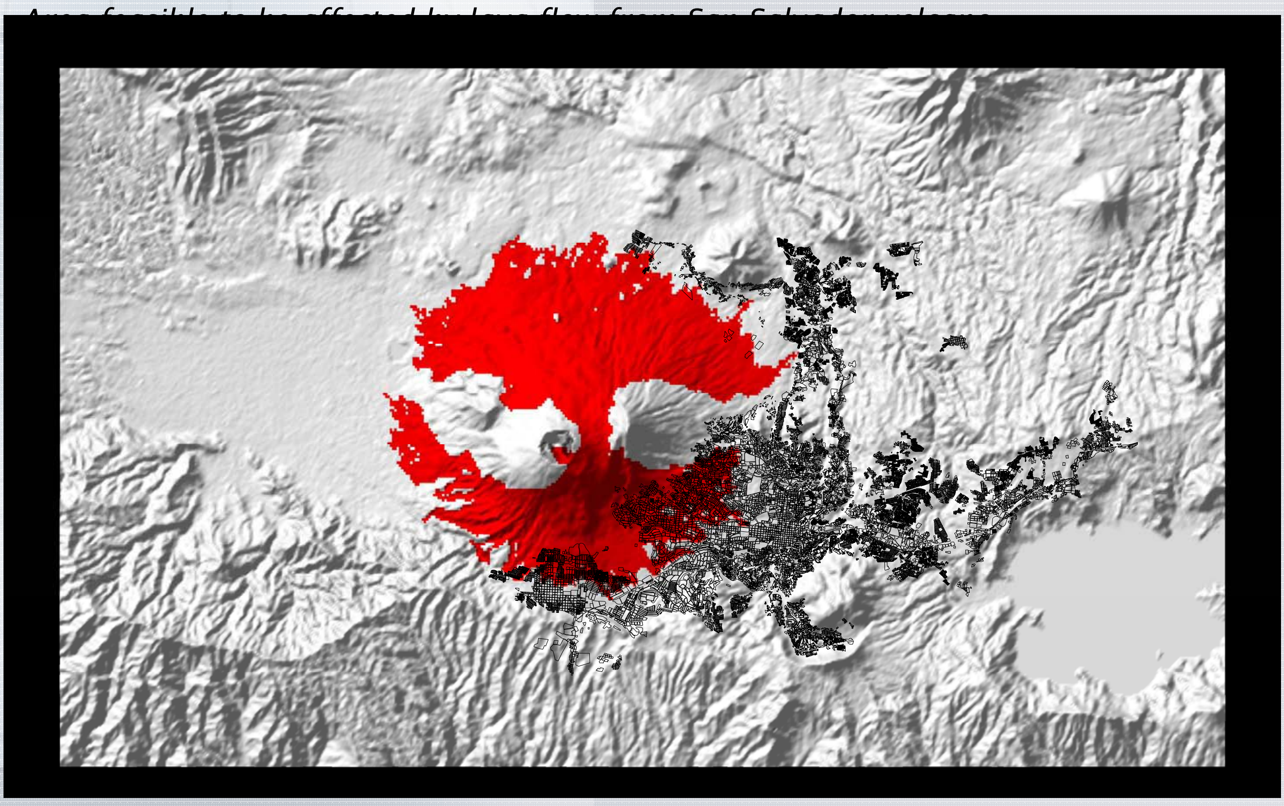
Earthquake scenario of 6.8 Mw

VOLCANIC HAZARD

Volcanic Hazard

Hazard results for El Salvador

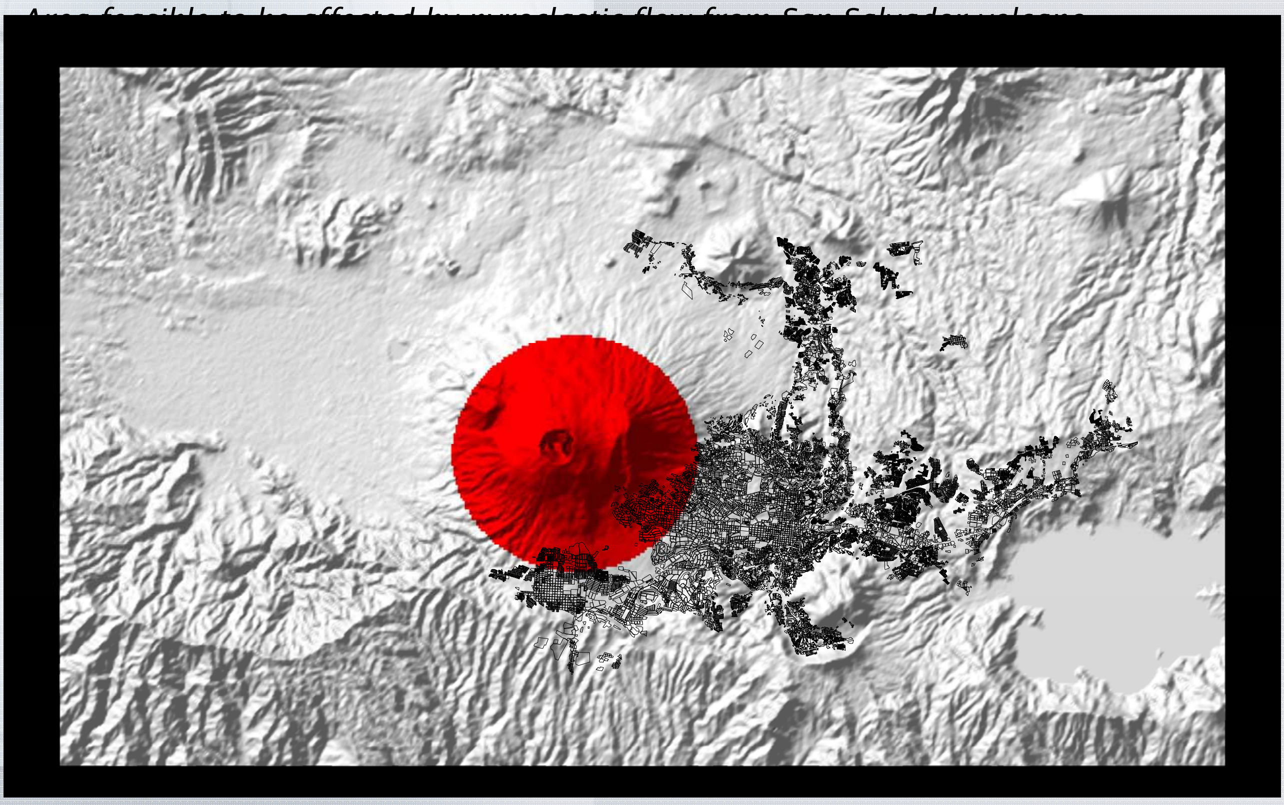
Area feasible to be affected by lava flow from San Salvador volcano



Volcanic Hazard

Hazard results for El Salvador

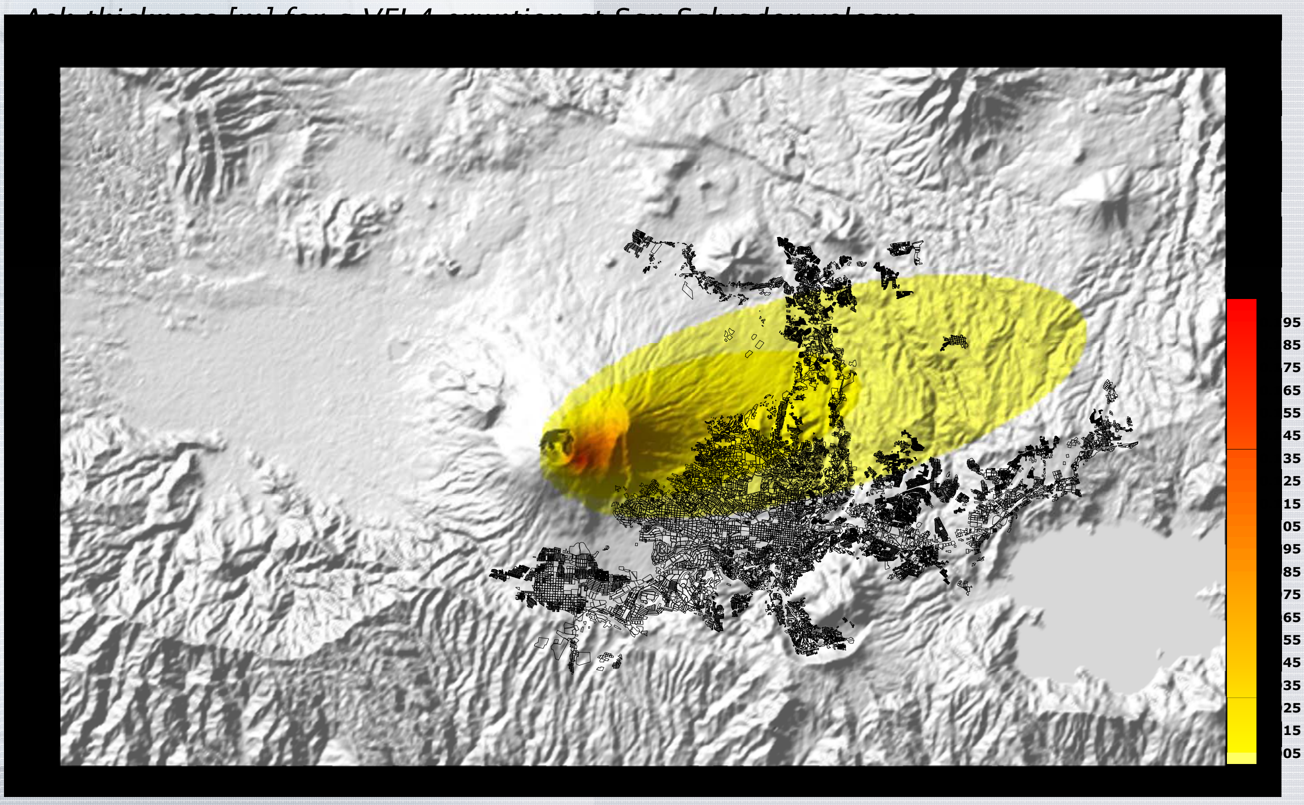
Area feasible to be affected by pyroclastic flow from San Salvador volcano



Volcanic Hazard

Hazard results for El Salvador

Ash thickness [m] for a VEI 4 eruption at San Salvador volcano



"Exposure"

Identify and characterize critical assets susceptible of damage

- ✓Urban buildings and infrastructure
- ✓ Rural constructions
- ✓ Regional and national infrastructure
- ✓ Human exposure

Examples of components at Risk

Buildings (residential, commercial, industrial, health, education, governmental, etc).

Components at Risk

Industrial areas



Components at Risk

Industrial areas




Components at Risk

Water production, treatment and distribution systems




Components at Risk

Communication system (roads, bridges)




Components at Risk

Electric generation system

Components at Risk

Hydro-Electric generation system

Components at Risk

Hydro-Electric generation system

Components at Risk

Electric distribution system

Components at Risk

Telecommunication system

Minimum Information Required

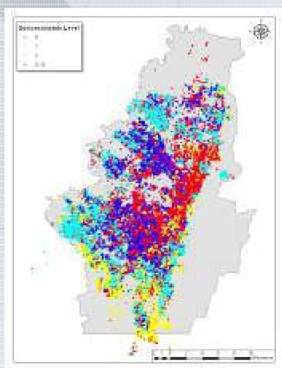
- ✓ ID
- ✓ Geographic location
- ✓ Construction type for vulnerability classification
- ✓ Exposed economic value
- ✓ Human occupation

Format for exposure representation:

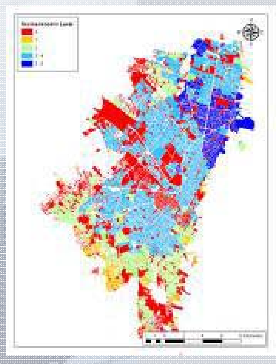
➔ Shape file (polygons, lines, dots)

Resolution at City Level

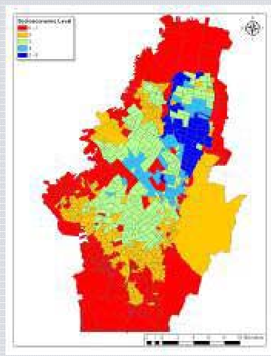
Buildings



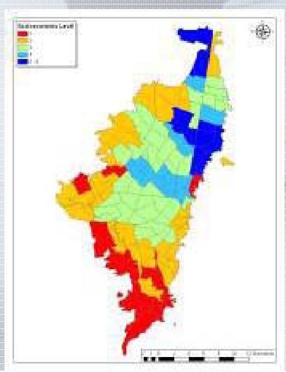
Blocks

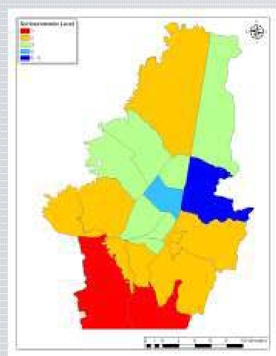


Neighborhood



UPZ





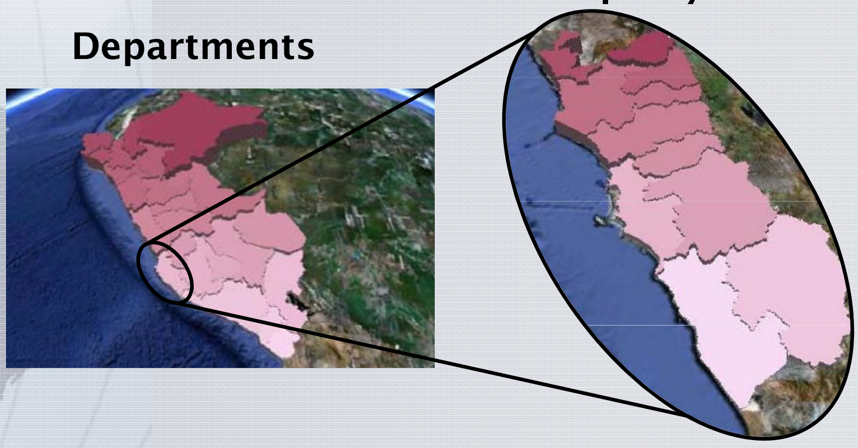
Localities or Towns

Resolution at Country Level

Country

Departments

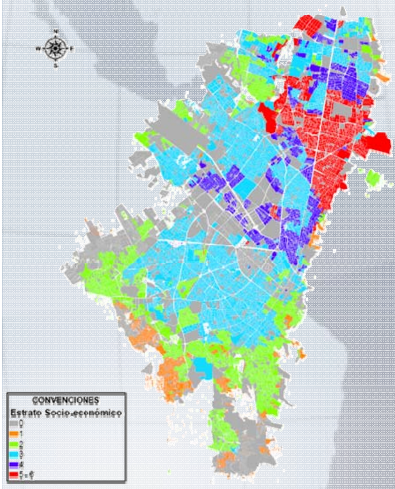
Municipality



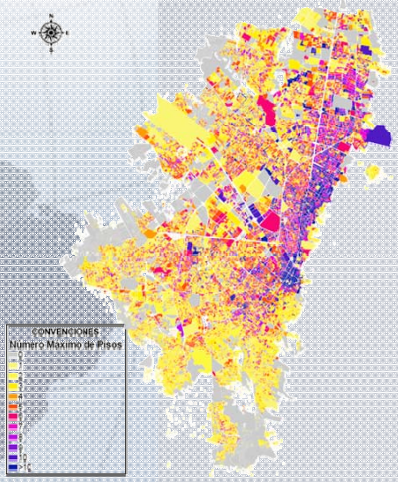
Towns, Localities, Neighbordoods, ……

Detailed Information Available

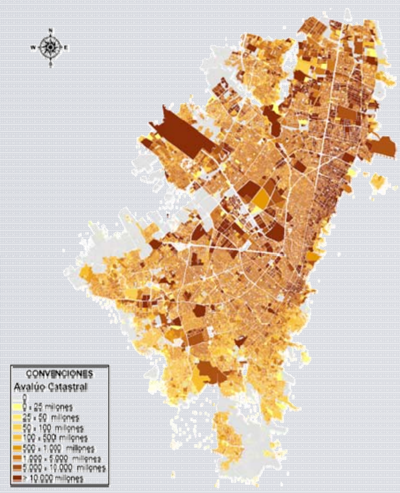
Ideal information at City Level



Socio Economic Level



Number of stories



Cadastral value

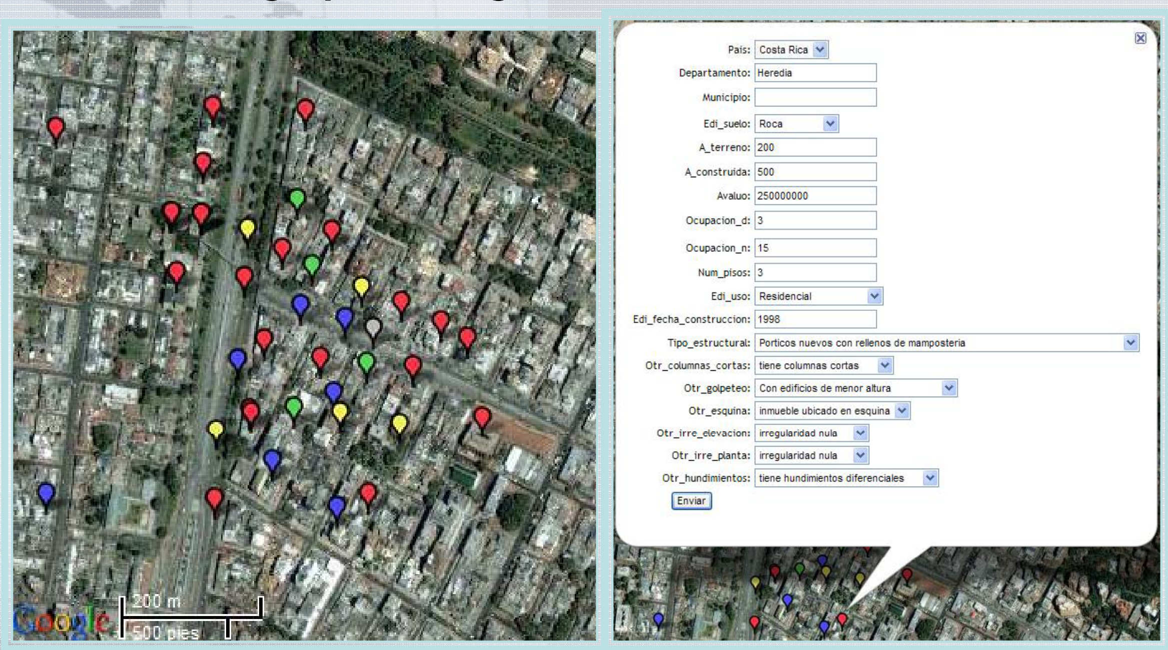
Detailed Information Available

- ✓ With no information available, how do we generate basic information?
- ✓ We need:
  - Geographic coordinates
  - Characteristics: size, height, materials, roof, floors, structural type, partitions, photos, others

Exposure data gathering tools

CAPRA InfoPunt

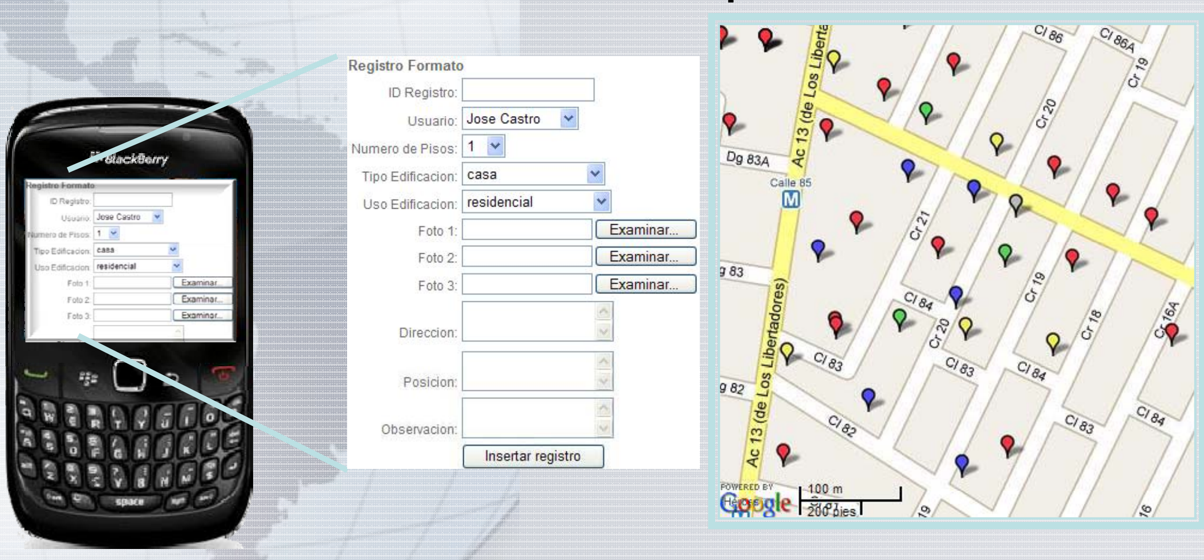
Generation of information in a Google based platform in a building by building basis



Exposure data gathering tools

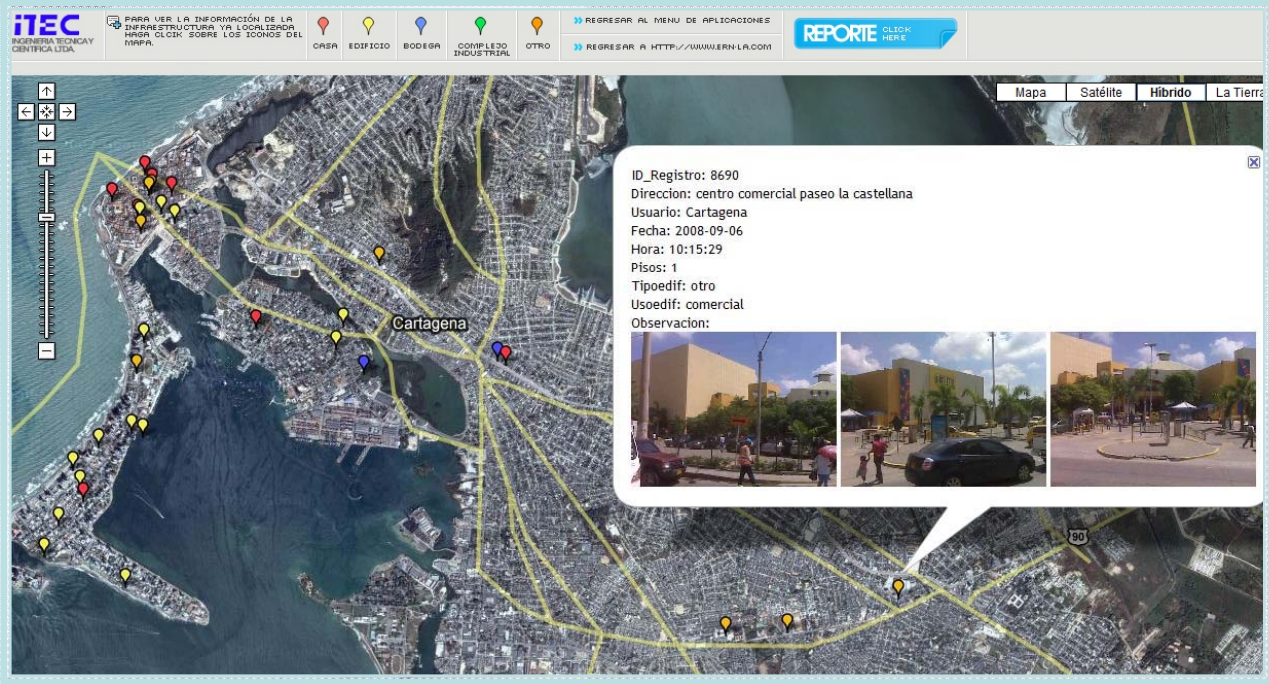
CAPRA InfoMovil

Generate information with a mobile phone with GPS



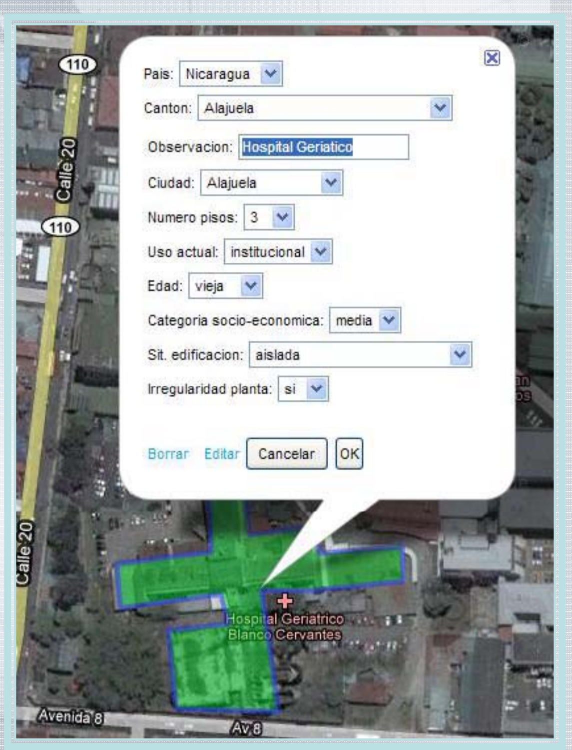
Exposure data gathering tools

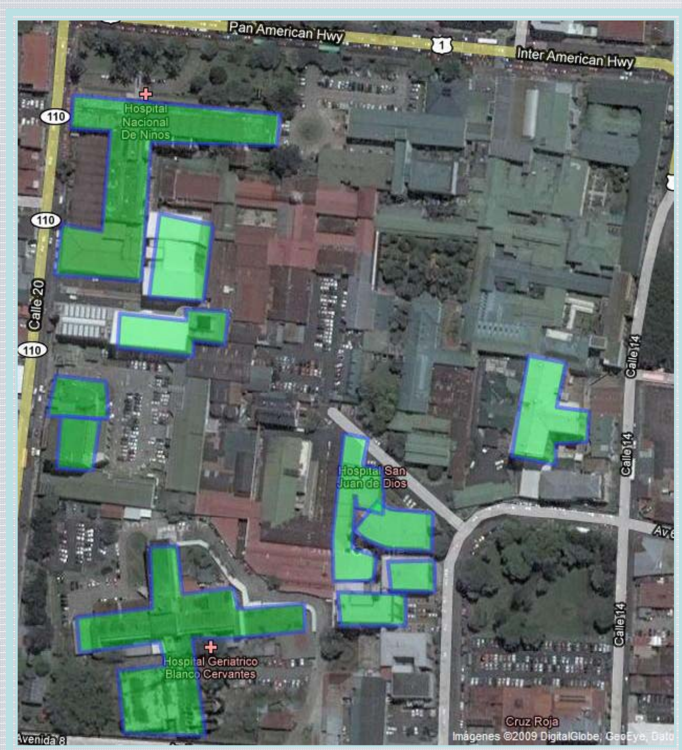
CAPRA InfoMovil



Exposure data gathering tools

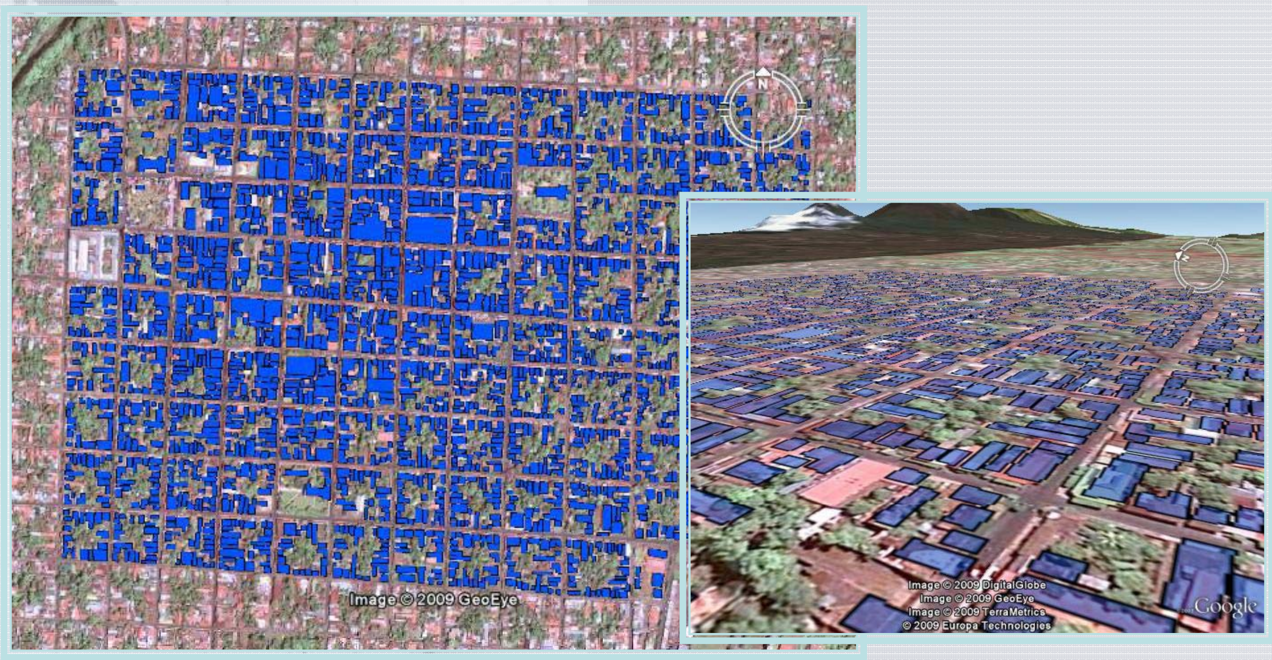
CAPRA InfoPolig





Exposure data gathering tools

CAPRA InfoPolig



Exposure data generated

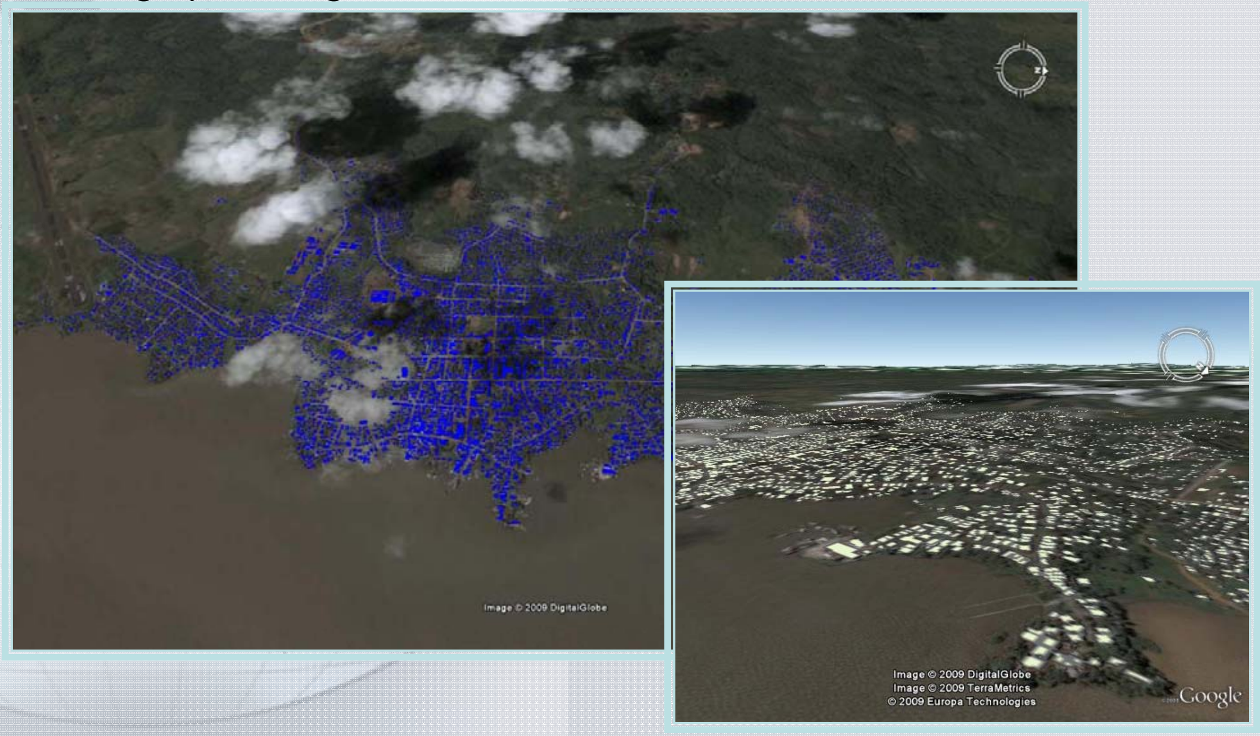
Examples

Managua – Nicaragua Model
Building by building

Exposure data generated

Examples

Bluefields– Nicaragua
Building by building

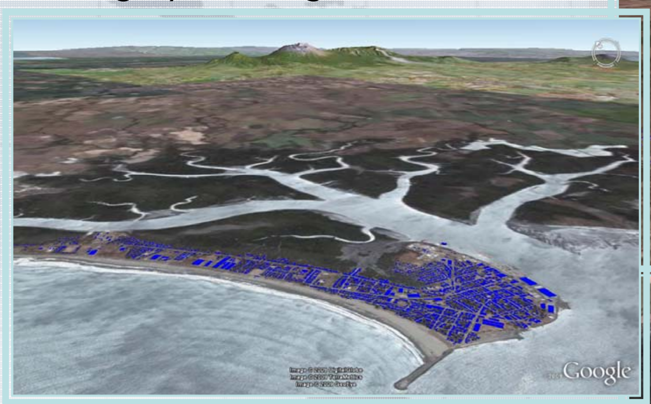


Exposure data generated

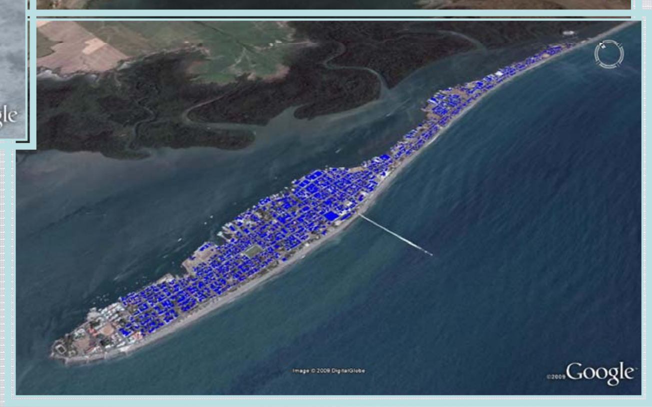
Examples

San Juan del Sur – Nicaragua
Building by building

Corinto – Nicaragua
Building by building



Punta Arenas – Costa Rica
Building by building



Exposure data generated

Examples

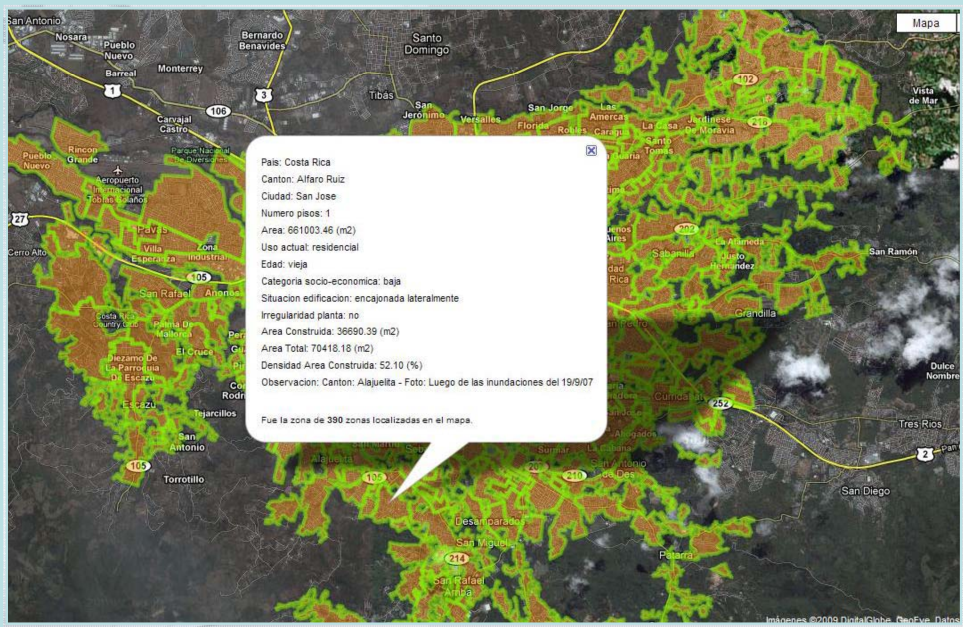
Infrastructure information
Ports and airports

Kingston – Jamaica

Exposure data generated

Examples

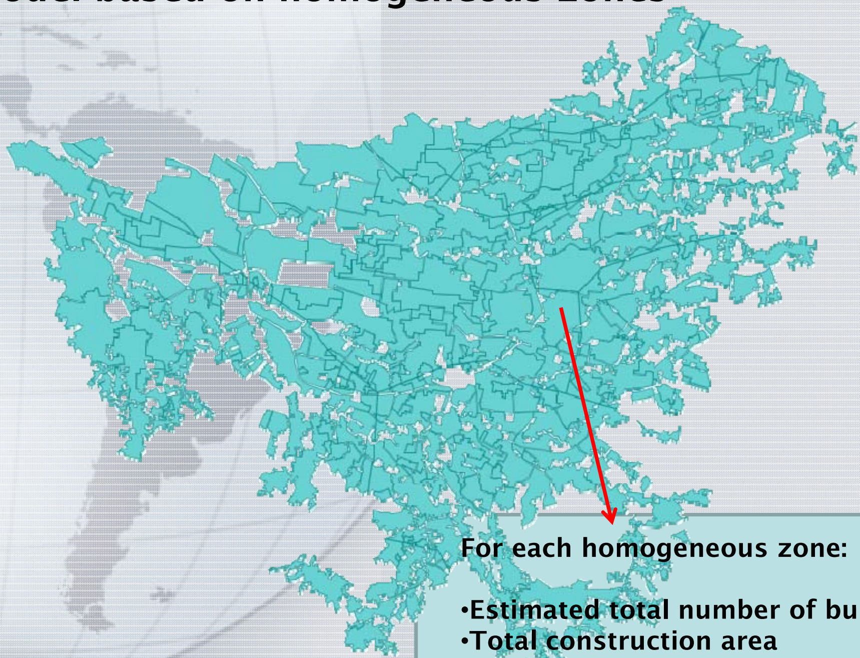
San Jose de Costa Rica
Virtual Model based on homogeneous zones



Exposure data generated

Examples

San Jose de Costa Rica
Virtual Model based on homogeneous zones



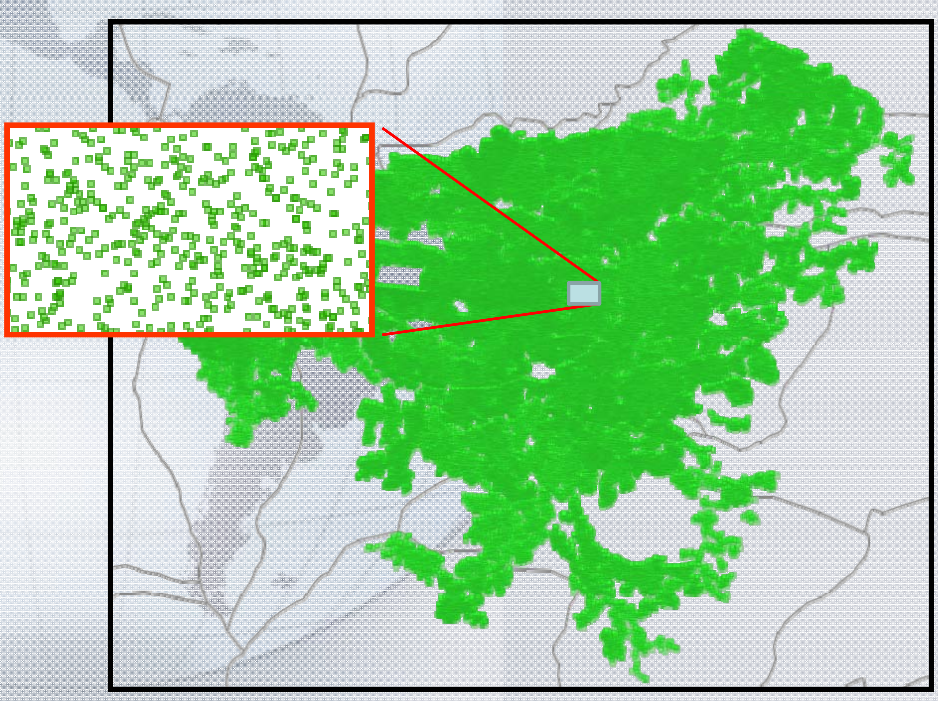
For each homogeneous zone:

- Estimated total number of buildings
- Total construction area
- Total exposed economic value
- Relative distribution of construction types

Exposure data generated

Examples

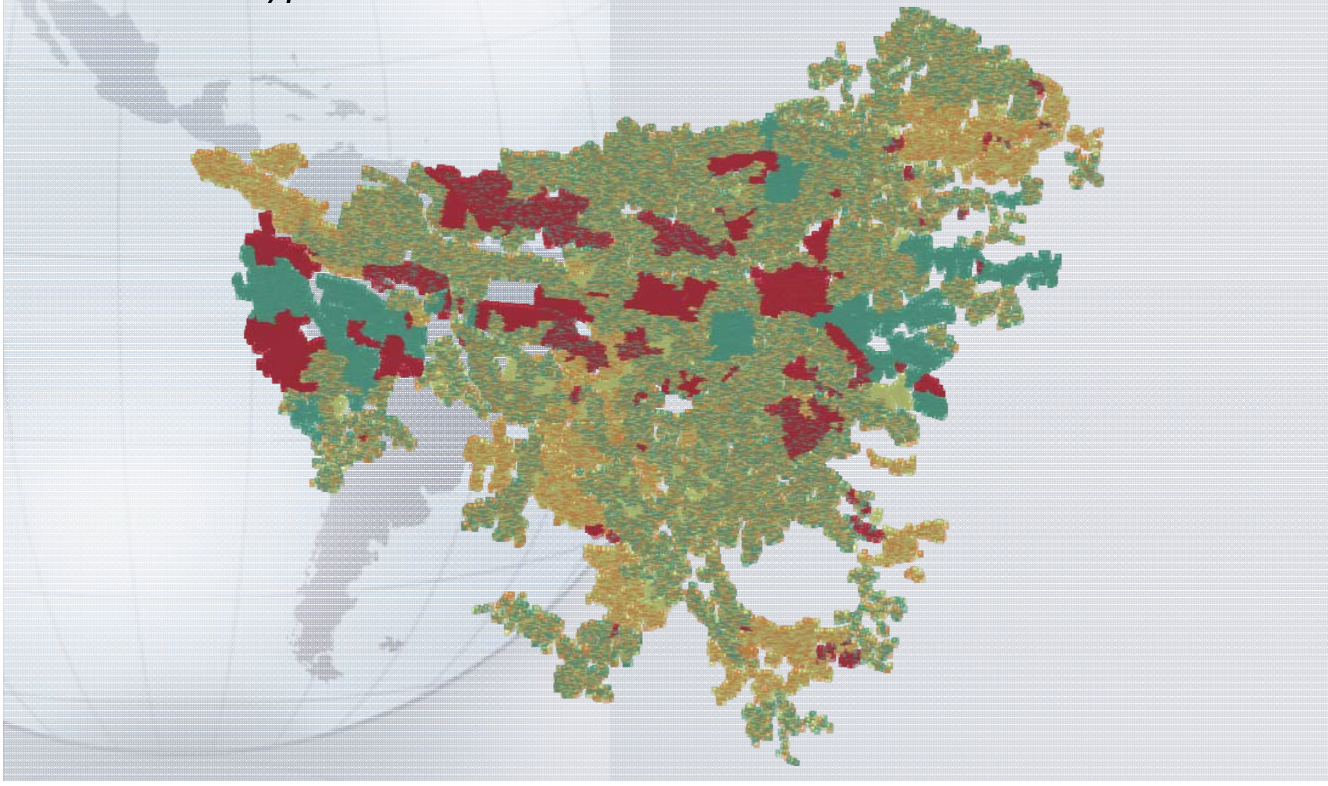
Virtual San Jose - Building by building with parametres compatible to those of each homogeneous zone



Exposure data generated

Visualization of controling parameters

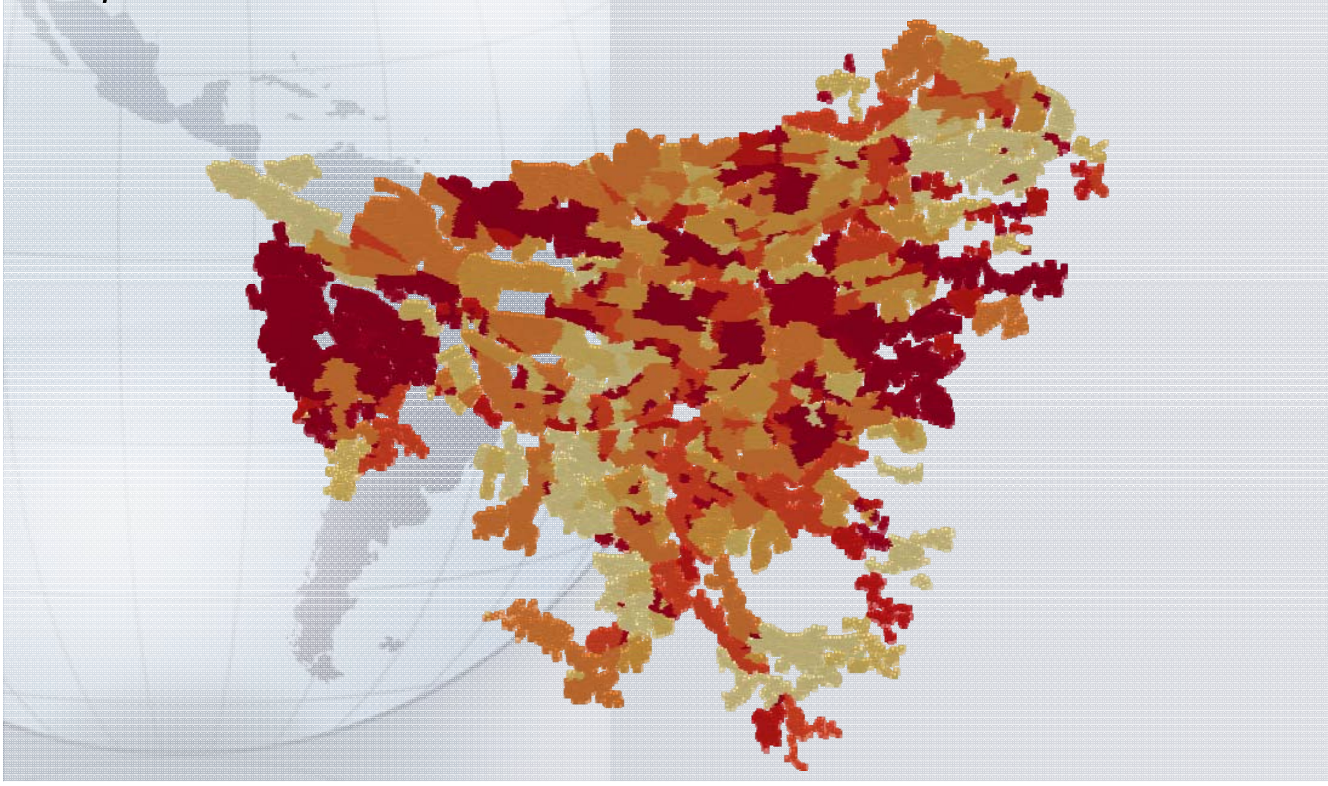
Structural types



Exposure data generated

Visualization of controling parameters

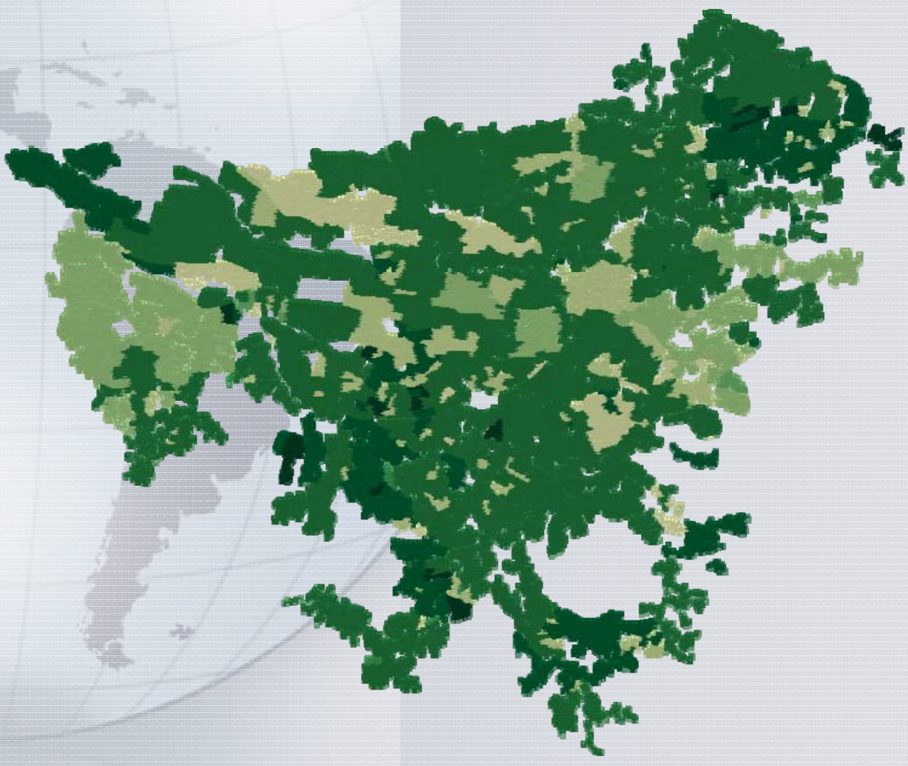
Replacement value



Exposure data generated

Visualization of controling parameters

Human occupation



Exposure data generated

Examples

VIRTUAL CITY 2-D

Exposure data generated

Examples

VIRTUAL CITY 3-D

Exposure Indicators

General

Socio economic Level	M2 per capita	US$/m2
Low	30	120
Medium	40	160
High	60	350

Indicators for urban construction

Infrastructure sector	US$ per capita
Water, wastewater, treatment	250
Electric distribution system	100
Communication systems	120
Gas distribution systems	50

Indicators for infrastructure sector

Exposure Indicators

Urban infrastructure

US$ per capita

City Complexity (Size and population)	Electric distribution system	Communication System	Treatment plants and tanks	Water network	Wastewater network	Gas network
High	100	80	35	50	50	25
Medium	50	40	20	25	25	15
Low	10	8	10	10	10	5

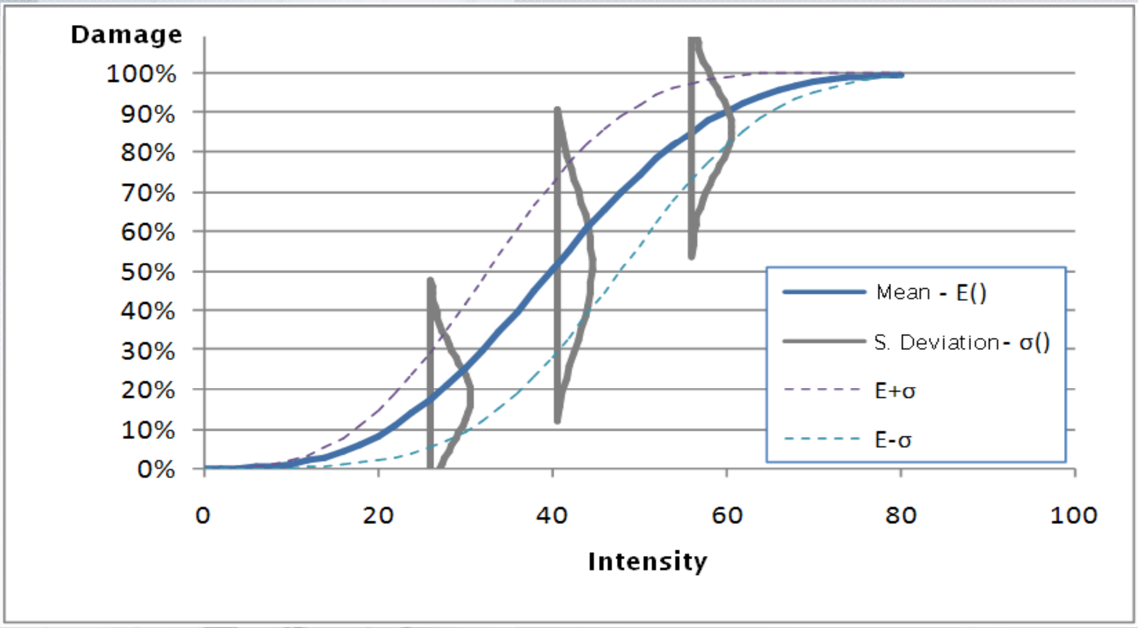
Exposure Database

ID	Geographical Coordinates	Construction Type	Exposed Value US$	Human Occupation

ID	Depto	SubSector	SubSistema	VALFIS	SE	Lat	Long
9653.00	LIMA	Construcciones Privadas	Construcciones ResPB	1130.48	Construcciones ResPB	-76.910350	-12.046130
9658.00	LIMA	Construcciones Privadas	Construcciones ResPM	7730.01	Construcciones ResPM	-76.910350	-12.046130
9663.00	LIMA	Construcciones Privadas	Construcciones ResPA	6871.12	Construcciones ResPA	-76.910350	-12.046130
9668.00	LIMA	Construcciones Privadas	Construcciones Com	2355.70	Construcciones Com	-76.910350	-12.046130
9673.00	LIMA	Construcciones Privadas	Construcciones Ind	13686.32	Construcciones Ind	-76.910350	-12.046130
9678.00	LIMA	Construcciones Privadas	Construcciones SalPri	0.00	Construcciones SalPri	-76.910350	-12.046130
9683.00	LIMA	Construcciones Privadas	Construcciones EduPri	0.00	Construcciones EduPri	-76.910350	-12.046130
9688.00	LIMA	Construcciones Publicas	Construcciones SalPub	0.00	Construcciones SalPub	-76.910350	-12.046130
9693.00	LIMA	Construcciones Publicas	Construcciones EduPub	0.00	Construcciones EduPub	-76.910350	-12.046130
9698.00	LIMA	Construcciones Publicas	Construcciones Gob	168.00	Construcciones Gob	-76.910350	-12.046130
9703.00	LIMA	SubEst electricas	Infraestructura Urbana	676.76	SubEst electricas	-76.910350	-12.046130
9704.00	LIMA	SubEst comunicaciones	Infraestructura Urbana	324.25	SubEst Comunicaciones	-76.910350	-12.046130

Vulnerability functions

Vulnerability representation



Hazard intensity (EQ, Wind, Depth of water,…)

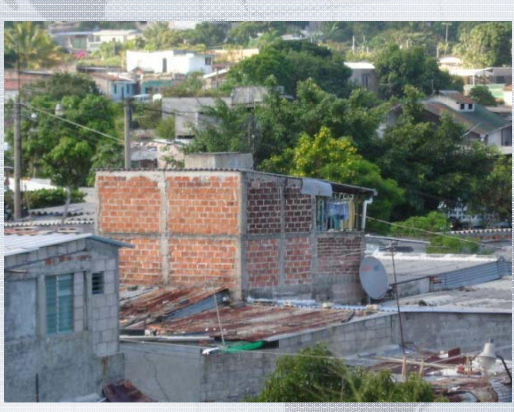
Vulnerability

General classification of Construction types

Unreinforced masonry

Vulnerability
Construction types

Confined masonry



Vulnerability
Construction types

Adobe y Quincha






Vulnerability

Construction types

Reinforced concrete frames






Vulnerability

Construction types

Highrise Buildings Concrete Steel


Vulnerability

Construction types

Wood structures





Vulnerability

Construction types

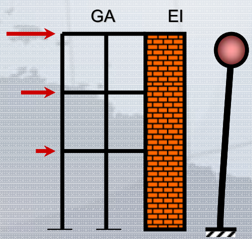
Non-engineered construction

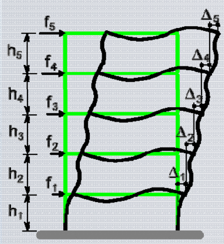



Vulnerability Assessment

Methodology: Drift Sensitive constructions

Analytical



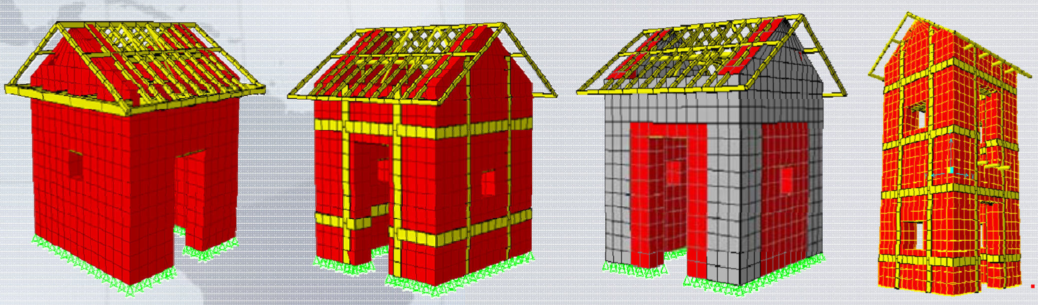


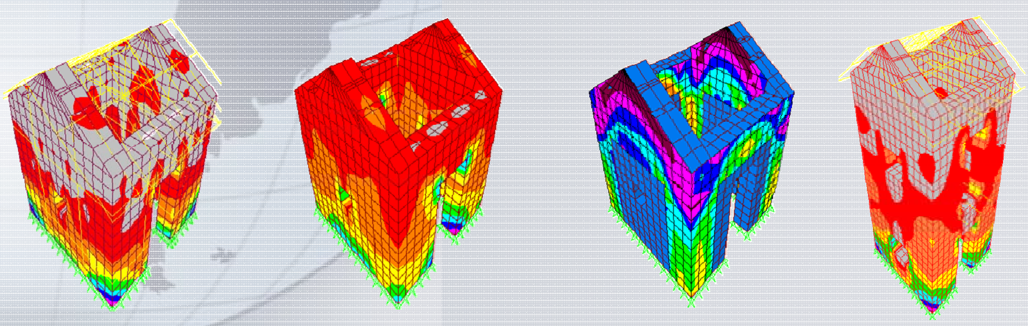
Experimental

Vulnerability Assessment

Methodology : Acceleration sensitive constructions

Analytical Procedures





Vulnerability Assessment

Acceleration sensitive constructions

Experimental procedures

Vulnerability

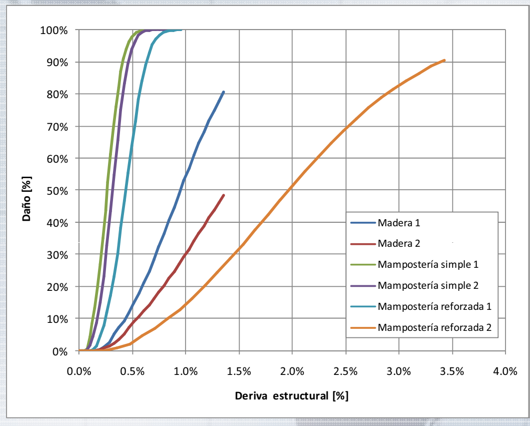
Vulnerability functions library

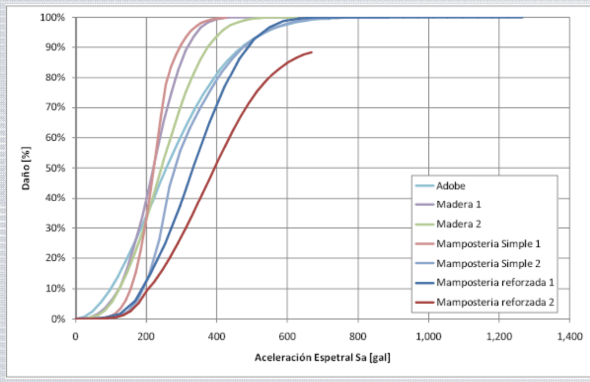
Cod.	Descripción
MR1L	Mamposteria Reforzada Diafragma flexible (madera, acero o prefab.) – Bajos
MR1M	Mamposteria Reforzada Diafragma flexible (madera, acero o prefab.) - Medios
MR2L	Mamposteria Reforzada Diafragma "rigido" (en concreto prefabricado con plaqueta superior o fundido en sitio) - Bajos
MR2M	Mamposteria Reforzada Diafragma "rigido" (en concreto prefabricado con plaqueta superior o fundido en sitio) - Medios
MR2H	Mamposteria Reforzada Diafragma "rigido" (en concreto prefabricado con plaqueta superior o fundido en sitio) - Altos
W1	Madera Porticos Livianos
W2	Madera Comercial-Industrial
S1L	Porticos acero resistentes a momento - Bajos
S1M	Porticos acero resistentes a momento - Medios
S1H	Porticos acero resistentes a momento - Altos
S2L	Porticos acero arriostrados - Bajos
S2M	Porticos acero arriostrados - Medios
S2H	Porticos acero arriostrados - Altos
S3	Porticos acero livianos
S4L	Porticos de acero con muros mamposteria simple - Bajos
S4M	Porticos de acero con muros mamposteria simple - Medios
S4H	Porticos de acero con muros mamposteria simple - Altos
C1L	Porticos concreto resistentes a momentos - Acabados flexibles - Bajos
C1M	Porticos concreto resistentes a momentos - Acabados flexibles - Medios
C1H	Porticos concreto resistentes a momentos - Acabados flexibles - Altos
C2L	Porticos concreto + Muros de cortante - Bajos
C2M	Porticos concreto + Muros de cortante - Medios
C2H	Porticos concreto + Muros de cortante - Altos
CP1	Concreto prefabricado - Tilt-up
CP2L	Concreto prefabricado en porticos con muros estructurales de concreto - Bajos
CP2M	Concreto prefabricado en porticos con muros estructurales de concreto - Medios
CP2H	Concreto prefabricado en porticos con muros estructurales de concreto - Altos

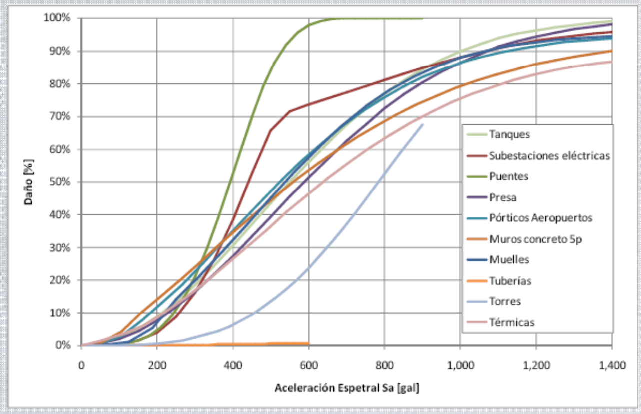
Vulnerability

Typical vulnerability curves

Earthquake



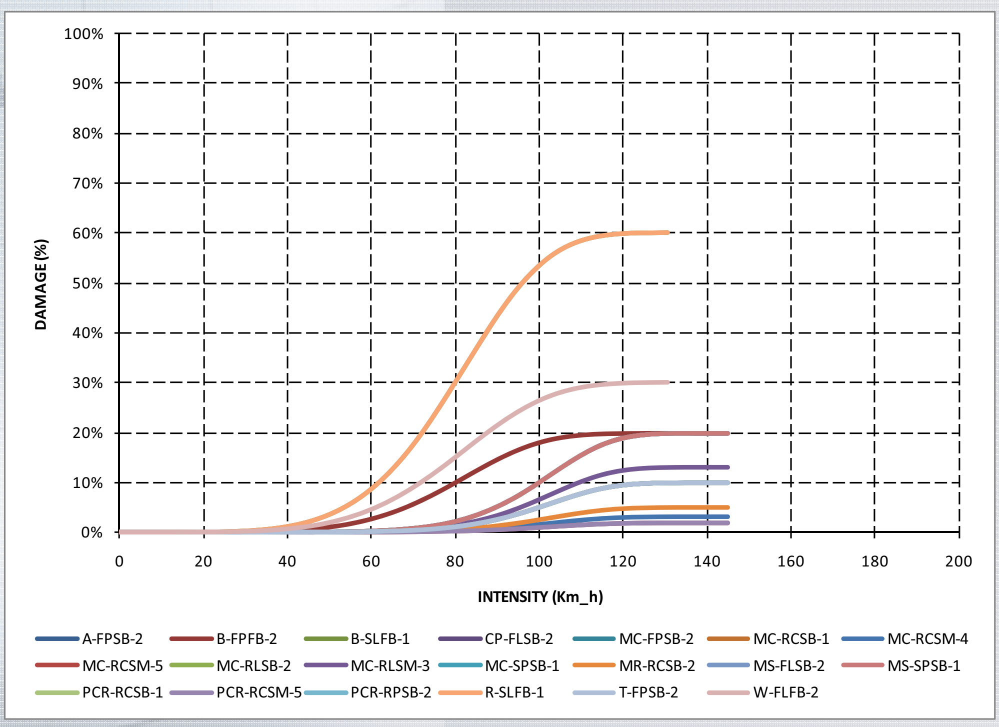




Vulnerability

Typical vulnerability curves

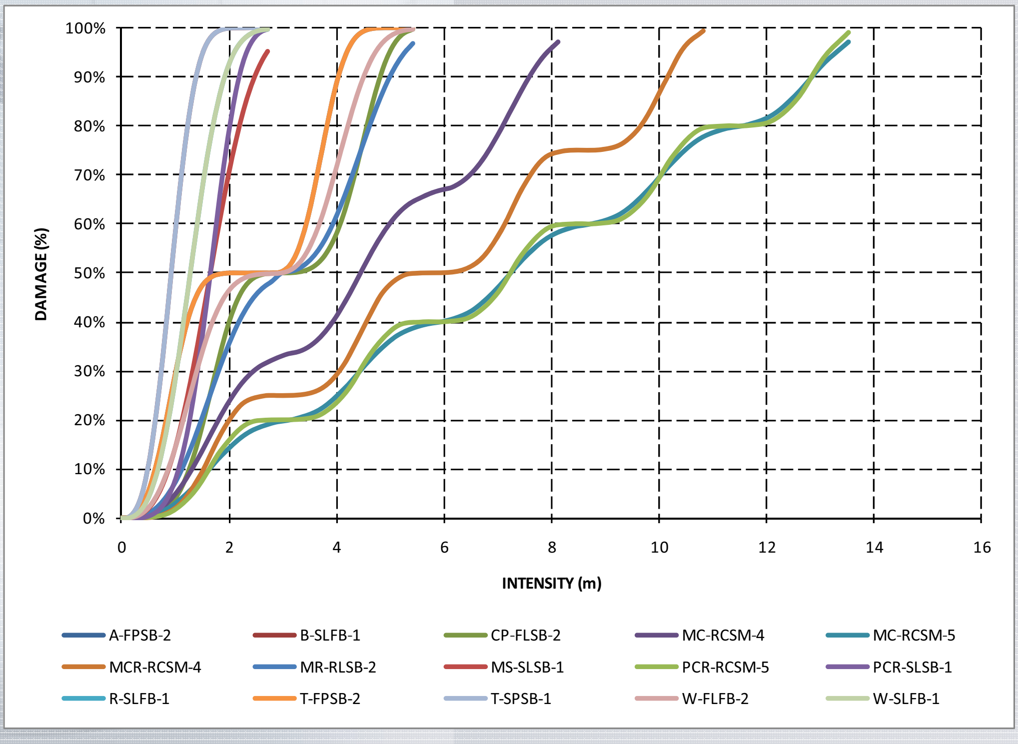
Wind



Vulnerability

Typical vulnerability curves

Flood



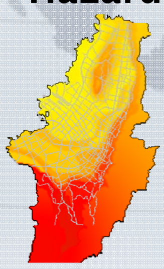
Vulnerability

Microzonation of the city for vulnerability classification

EXAMPLE: LIMA – PERU

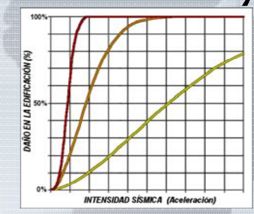
Risk Analysis Methodology

Hazard



Exposure

Vulnerability

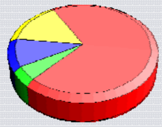


Physical Damage

Loss Estimation

Economic

Human



Applications

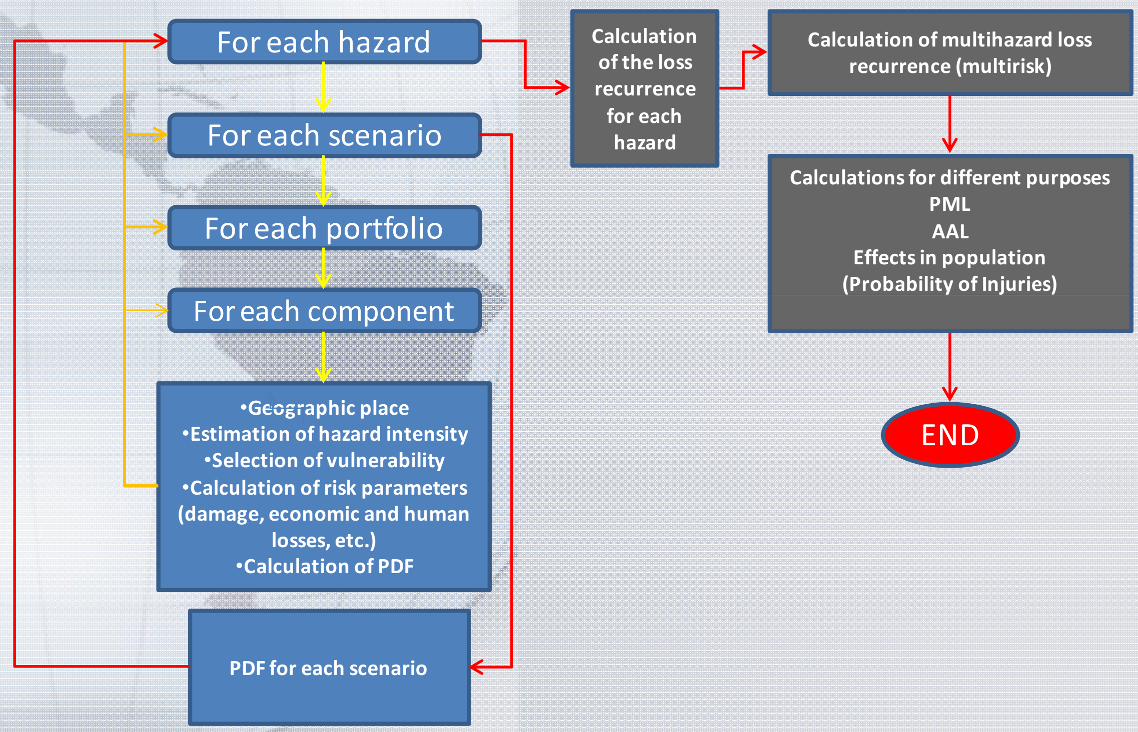
Application 1

PROBABILISTIC RISK MODELING

Challenges and limitations

- ✓ Most catastrophic events have not occurred yet
- ✓ Scarce historical data
- ✓ Short memory for previous disasters
- ✓ Short time data gathering window for modeling hazard events of long recurrence periods
- ✓ Simplified hazard modeling of complex physical phenomena
- ✓ The modeling process requires experience and common sense

MULTI HAZARD PROBABILISTIC RISK ASSESSMENT



MULTIPLE HAZARD "TEMPORALITY"

TEMPORALITY HAZARD ANALYSIS	TEMPORALITY			
Hazard	1	2	3	4
Earthquake				
Tsunami				
Hurricane – Wind				
Hurricane – Storm Surge				
Hurricane - Rain				
Rain (no hurricane)				
Flood				
Slides				
Volcano – Ash fall				
Volcano – Piroclastic flows				
Volcano – Lava flows				

Probabilistic Risk analysis

Risk metrics

Physical and economic losses

- ✓ *Mean Damage Ratio: MDR*
- ✓ *Expected annual loss: EAL*
- ✓ *Pure premium: PP*
- ✓ *Loss excedance curve: LEC*
- ✓ *Probable Maximum Loss:* PML

THE MATHEMATICS OF LOSS ESTIMATION

For each event ***i***, the probability distribution of losses

$$f(p \mid Event\ i) = \int_0^\infty f(p \mid Sa)\, f(Sa \mid Event\ i)\, dSa$$

Vulnerability Functions

Hazard

Probabilistic risk analysis

Expected annual loss

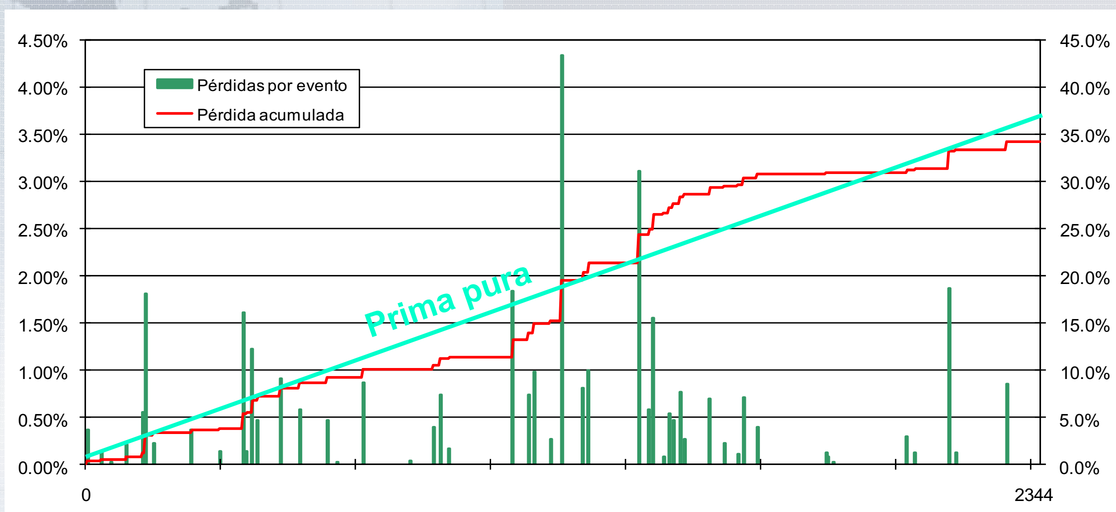
Valor esperado de la pérdida, condicionado a la ocurrencia del evento

$$P_{AE} = \sum_{i=1}^{Eventos} E(P \mid Evento\ \mathrm{i}) F_A(Evento\ \mathrm{i})$$

Frecuencia anual de ocurrencia del evento

Probabilistic risk analysis

Prima pura de riesgo (PPR)



Tiempos de ocurrencia y pérdidas causadas: inciertos

THE MATHEMATICS OF LOSS ESTIMATION

$$\nu(p) = \sum_{i=1}^{Events} \Pr(P > p \mid Event\ \mathrm{i}) F_A(Event\ \mathrm{i})$$

$\nu(p)$ is the annual excedence rate of the loss p

$F_A(Event\ \mathrm{i})$ is the annual frequency of ocurrance of event i

$\Pr(P > p \mid Event\ \mathrm{i})$, probability of loss $P > p$ due to event i

Probabilistic risk analysis

Loss excedance curve

Tasa de excedencia de la pérdida

Probabilidad de excedencia de la pérdida, condicionada a la ocurrencia del evento

$$\nu(p) = \sum_{i=1}^{Eventos} \Pr(P > p \mid Evento\ \mathrm{i}) F_A(Evento\ \mathrm{i})$$

Pérdida física

Frecuencia anual de ocurrencia del evento

Sumatoria para todos los eventos o escenarios

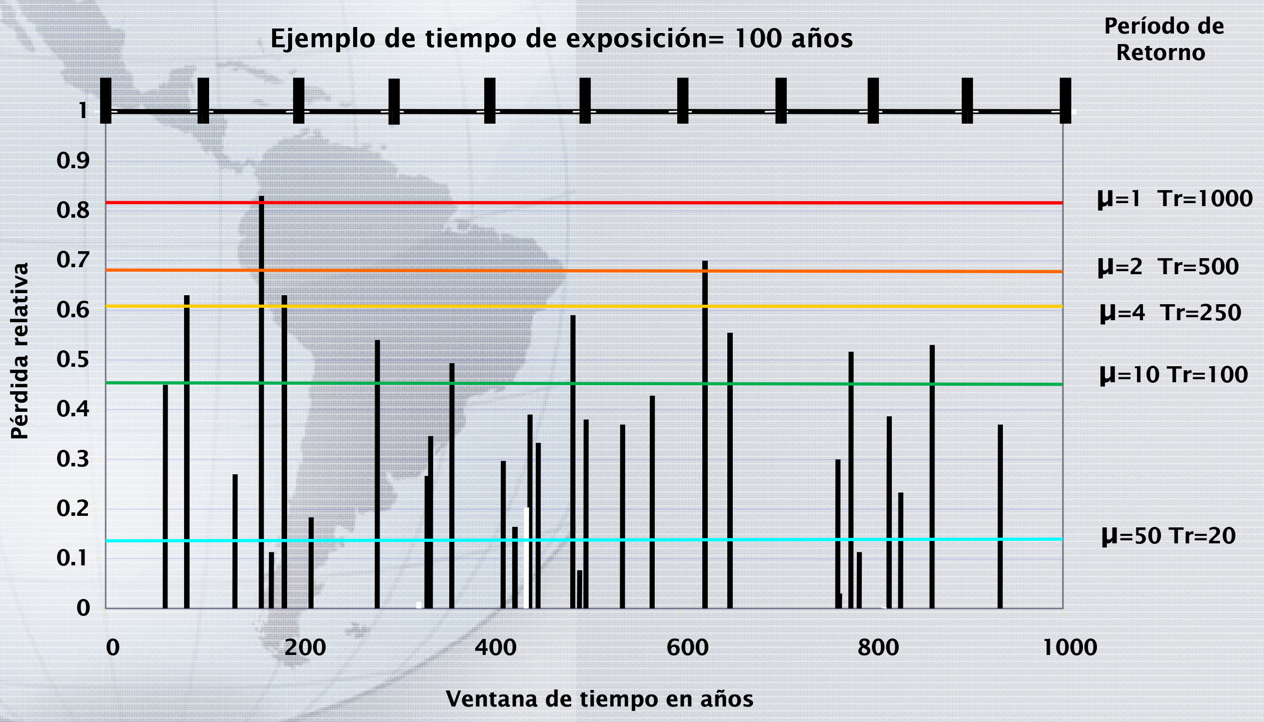
Probabilistic risk analysis

Loss excedance curve

Representa la frecuencia anual con que determinada pérdida económica se verá excedida.

Probabilistic risk analysis

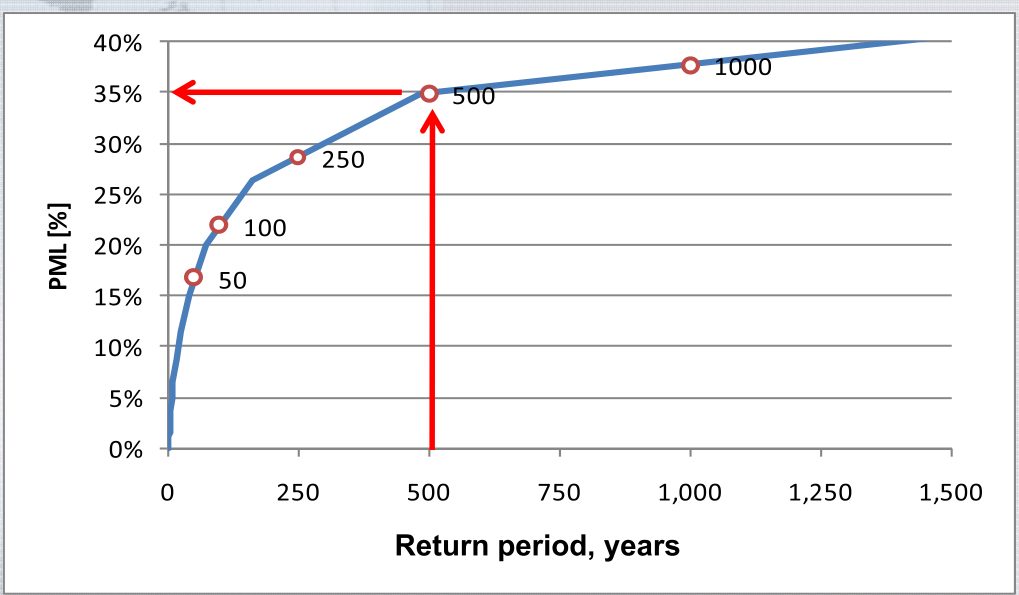
Return period



PML

Probable "Maximum" Loss *PML*

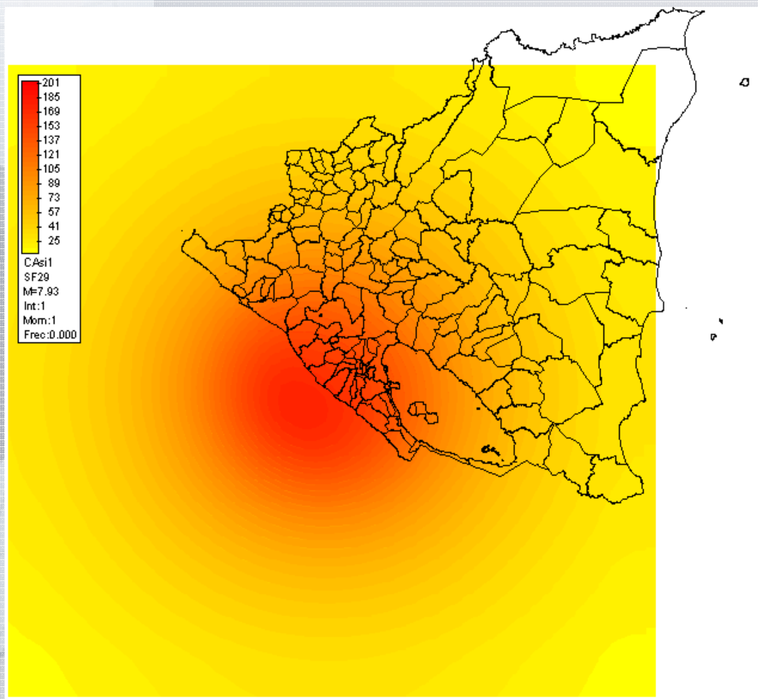
Losses for "long" return periods



SELECTED RESULTS (CAPRA)

EARTHQUAKE RISK

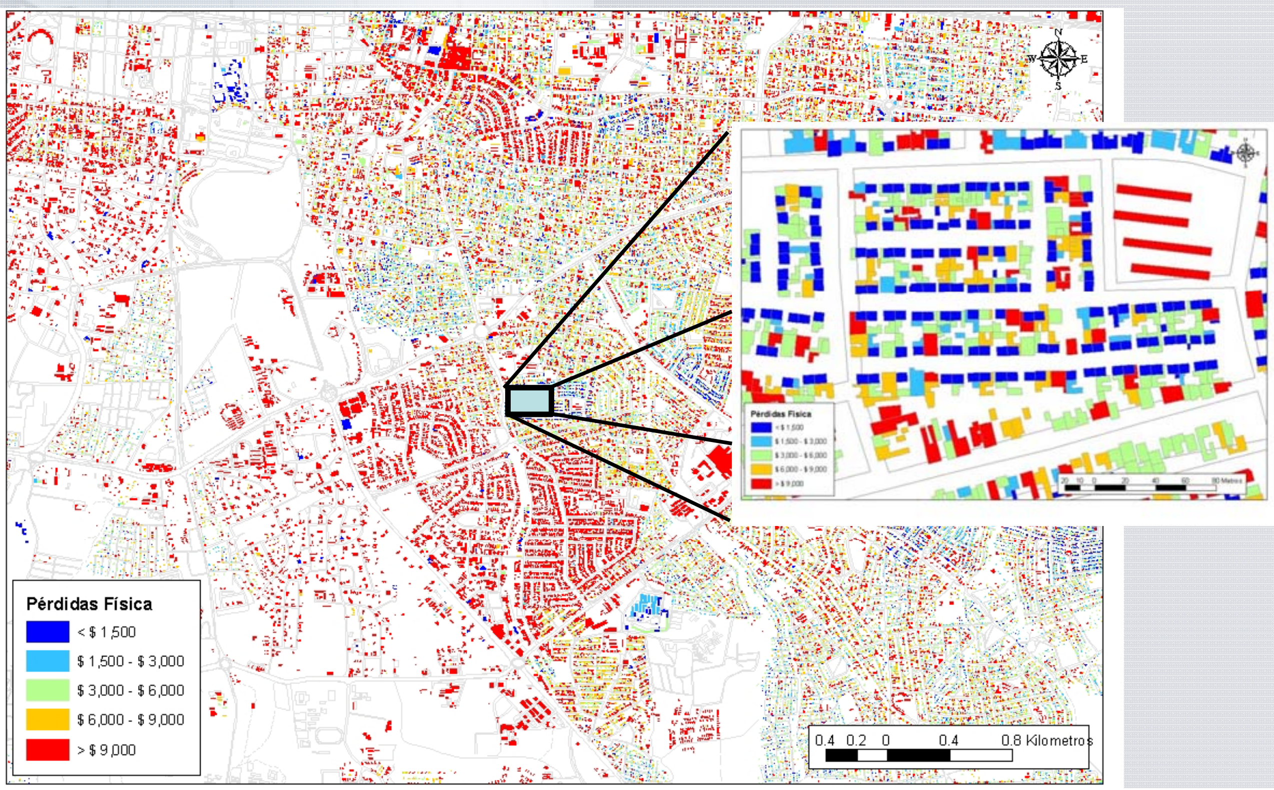
NICARAGUA, DETERMINISTIC SCENARIO



MAGNITUDE 7.9

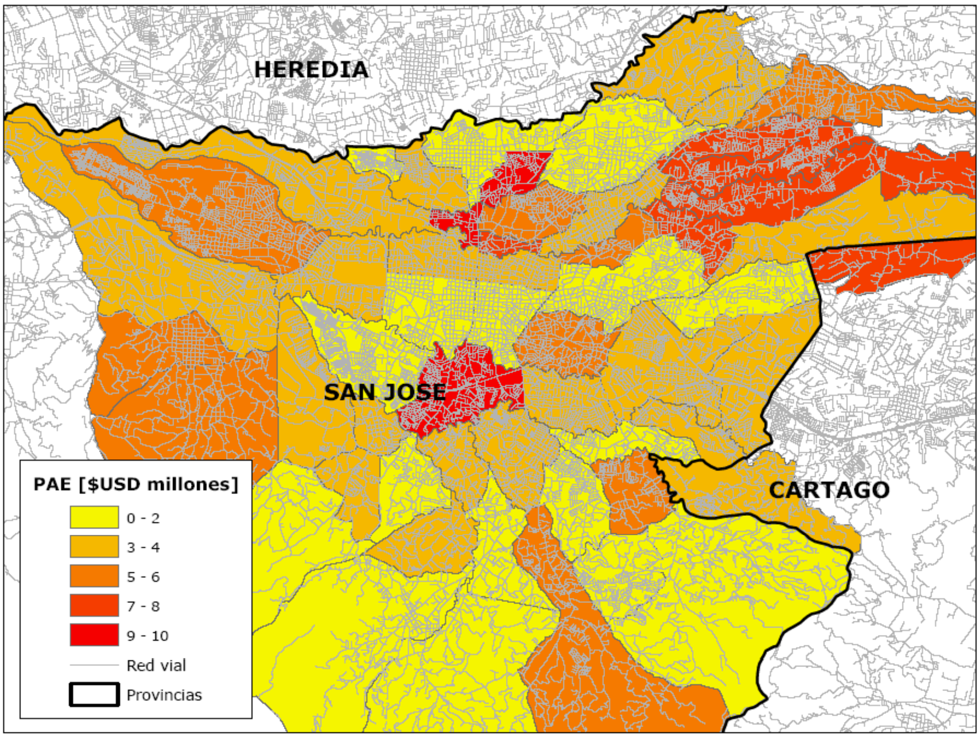
EARTHQUAKE RISK, $

MANAGUA, DETERMINISTIC SCENARIO



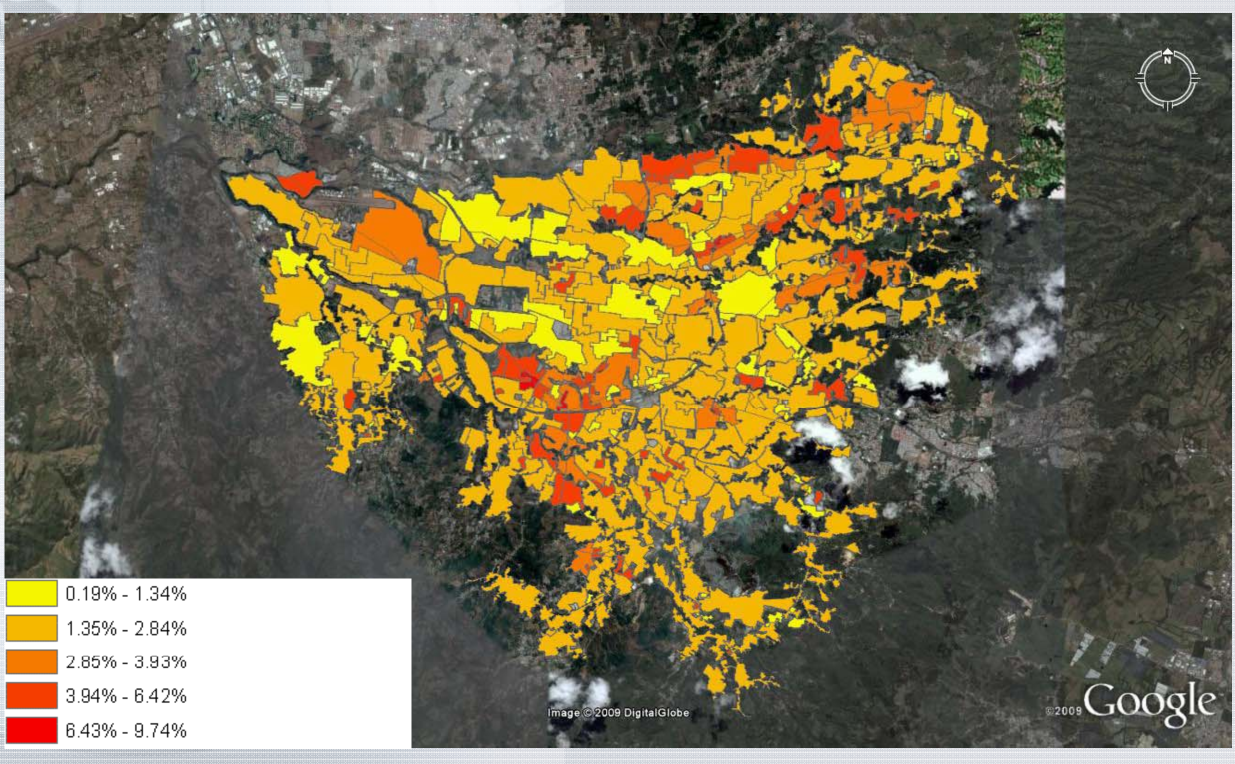
EARTHQUAKE RISK, $

EXPECTED ANNUAL LOSSES



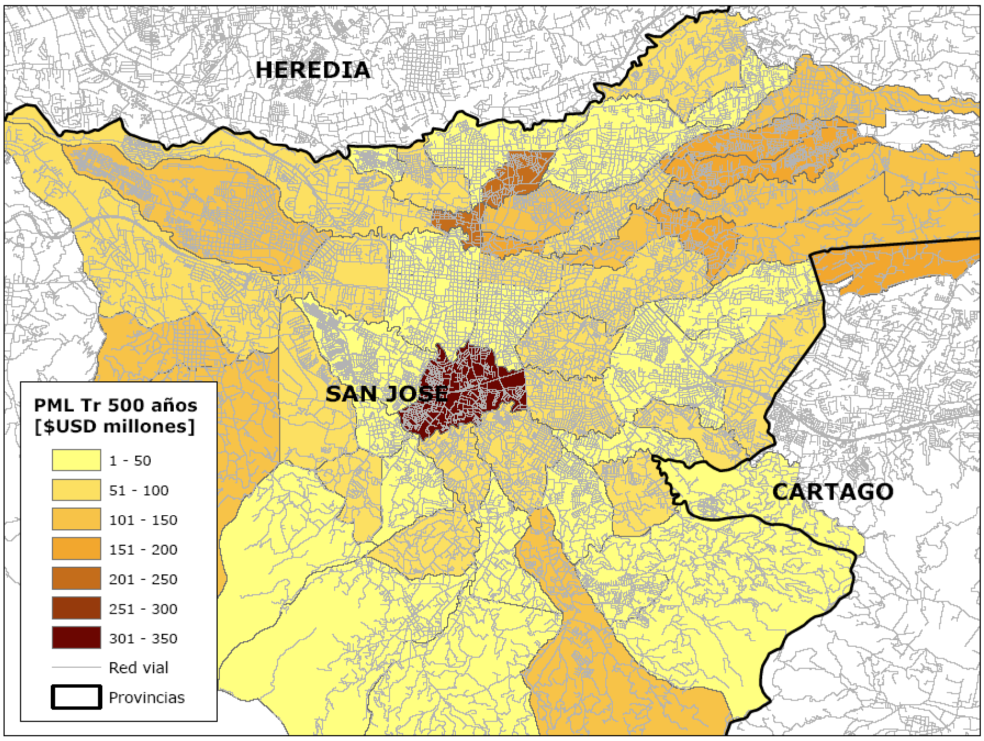
EARTHQUAKE RISK, %

SAN JOSE – COSTA RICA   EXPECTED LOSSES



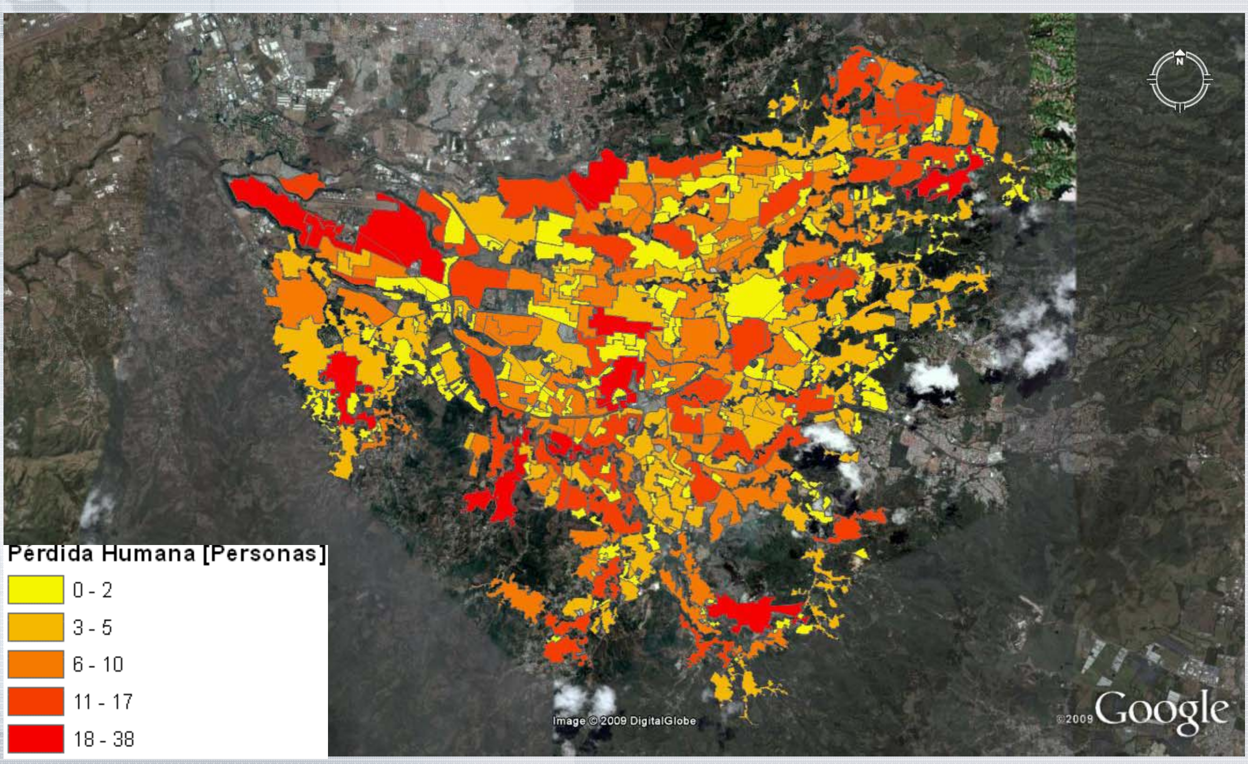
EARTHQUAKE RISK, $

PML by COUNTY or ZIP CODE, T_R = 500 years



EARTHQUAKE RISK

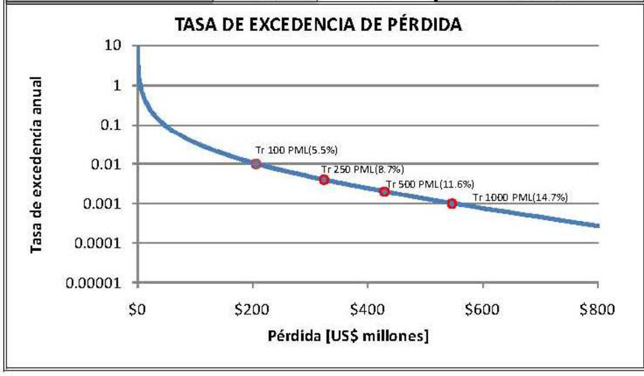
HUMAN EXPECTED LIFE LOSSES

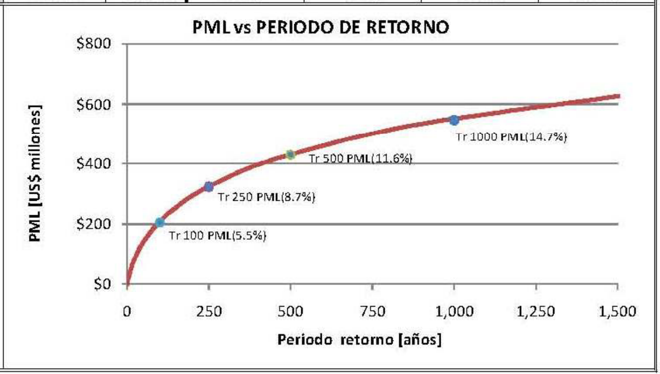


EARTHQUAKE RISK

EL SALVADOR, PUBLIC BUILDINGS

PAÍS	EL SALVADOR		AMENAZA	TERREMOTO		FECHA DE ANÁLISIS		29/10/2009	
Resultados			Pérdida Máxima Probable			Probabilidad de excedencia de valores de PML			
Sector	Construcciones Publicas		Periodo de retorno	US$ $x10^6$	%	20 años	50 años	100 años	500 años
			100 años	$205.61	5.54%	18.13%	39.35%	63.21%	99.33%
Valor Expuesto	US$ $x10^6$	$3,714.08	250 años	$324.07	8.73%	7.69%	18.13%	32.97%	86.47%
Pérdida Anual Esperada	US$ $x10^6$	$27.44	500 años	$429.41	11.56%	3.92%	9.52%	18.13%	63.21%
	‰	7.39	1000 años	$546.52	14.71%	1.98%	4.88%	9.52%	39.35%

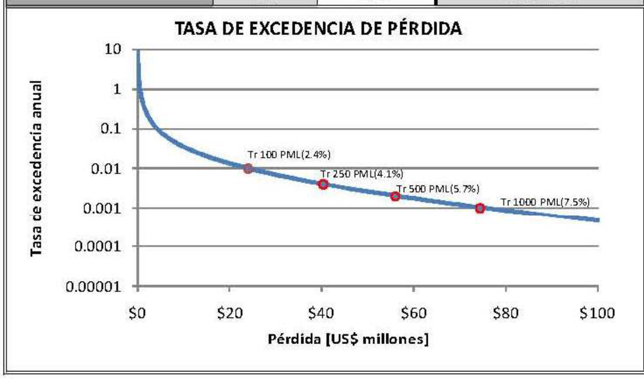


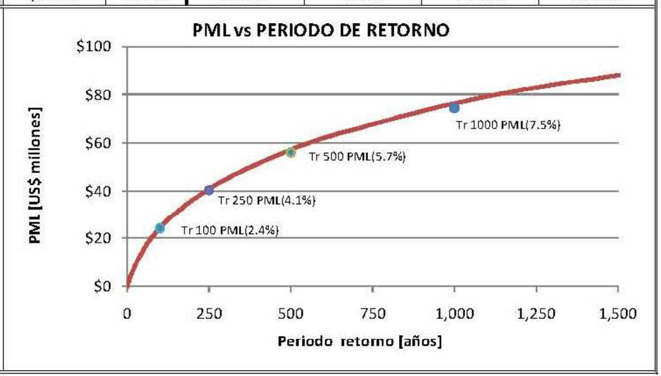


EARTHQUAKE RISK

EL SALVADOR, PRODUCTION & DISTRIBUTION OF ENERGY

PAÍS	EL SALVADOR		AMENAZA	TERREMOTO		FECHA DE ANÁLISIS		29/10/2009	
Resultados			Pérdida Máxima Probable			Probabilidad de excedencia de valores de PML			
Sector	Produccion y distribucion (Energia)		Periodo de retorno	US$ $x10^6$	%	20 años	50 años	100 años	500 años
			100 años	$24.04	2.43%	18.13%	39.35%	63.21%	99.33%
Valor Expuesto	US$ $x10^6$	$988.14	250 años	$40.36	4.08%	7.69%	18.13%	32.97%	86.47%
Pérdida Anual Esperada	US$ $x10^6$	$3.31	500 años	$56.03	5.67%	3.92%	9.52%	18.13%	63.21%
	‰	3.35	1000 años	$74.43	7.53%	1.98%	4.88%	9.52%	39.35%

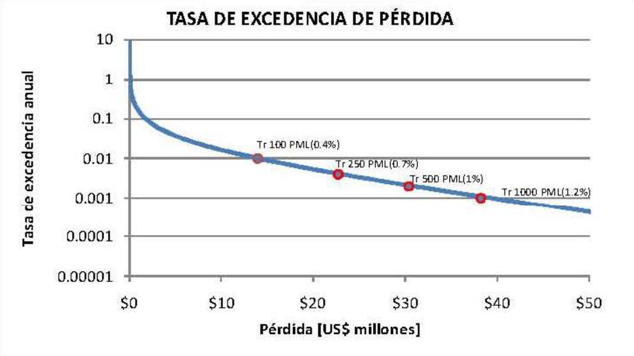


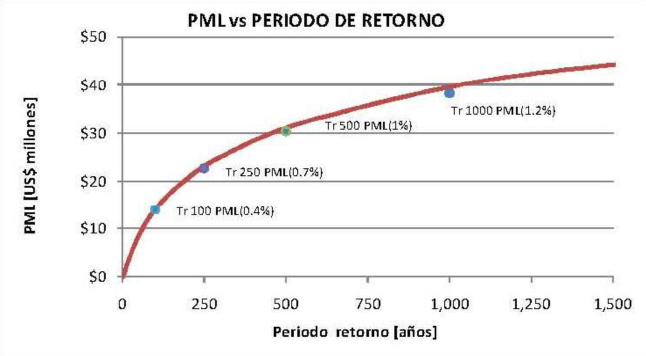


EARTHQUAKE RISK

EL SALVADOR, ROADS & HIGHWAYS

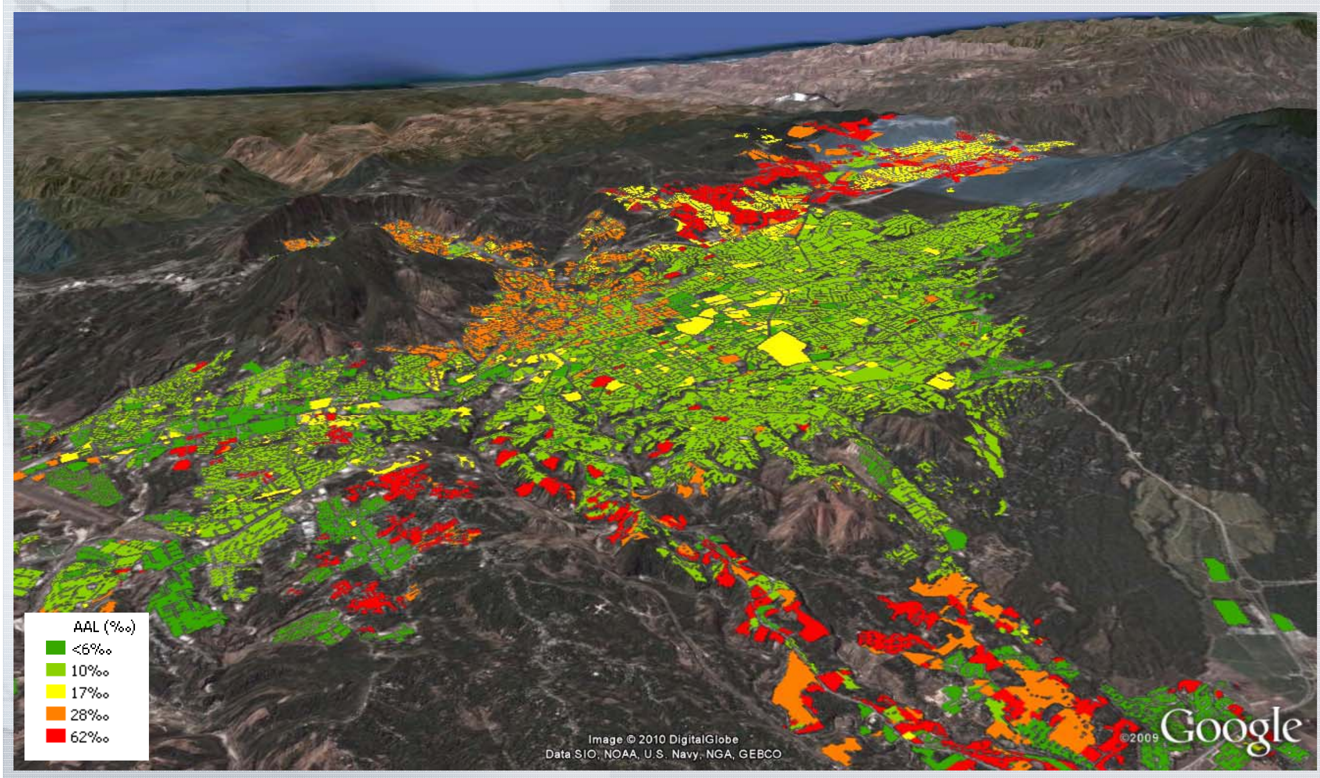
PAÍS	EL SALVADOR		AMENAZA	TERREMOTO		FECHA DE ANÁLISIS		29/10/2009	
Resultados			Pérdida Máxima Probable			Probabilidad de excedencia de valores de PML			
Sector	Vias Nacionales		Periodo de retorno	US$ x10^6	%	20 años	50 años	100 años	500 años
			100 años	$13.95	0.45%	18.13%	39.35%	63.21%	99.33%
Valor Expuesto	US$ x10^6	$3,100.02	250 años	$22.72	0.73%	7.69%	18.13%	32.97%	86.47%
Pérdida Anual Esperada	US$ x10^6	$0.95	500 años	$30.38	0.98%	3.92%	9.52%	18.13%	63.21%
	‰	0.31	1000 años	$38.23	1.23%	1.98%	4.88%	9.52%	39.35%





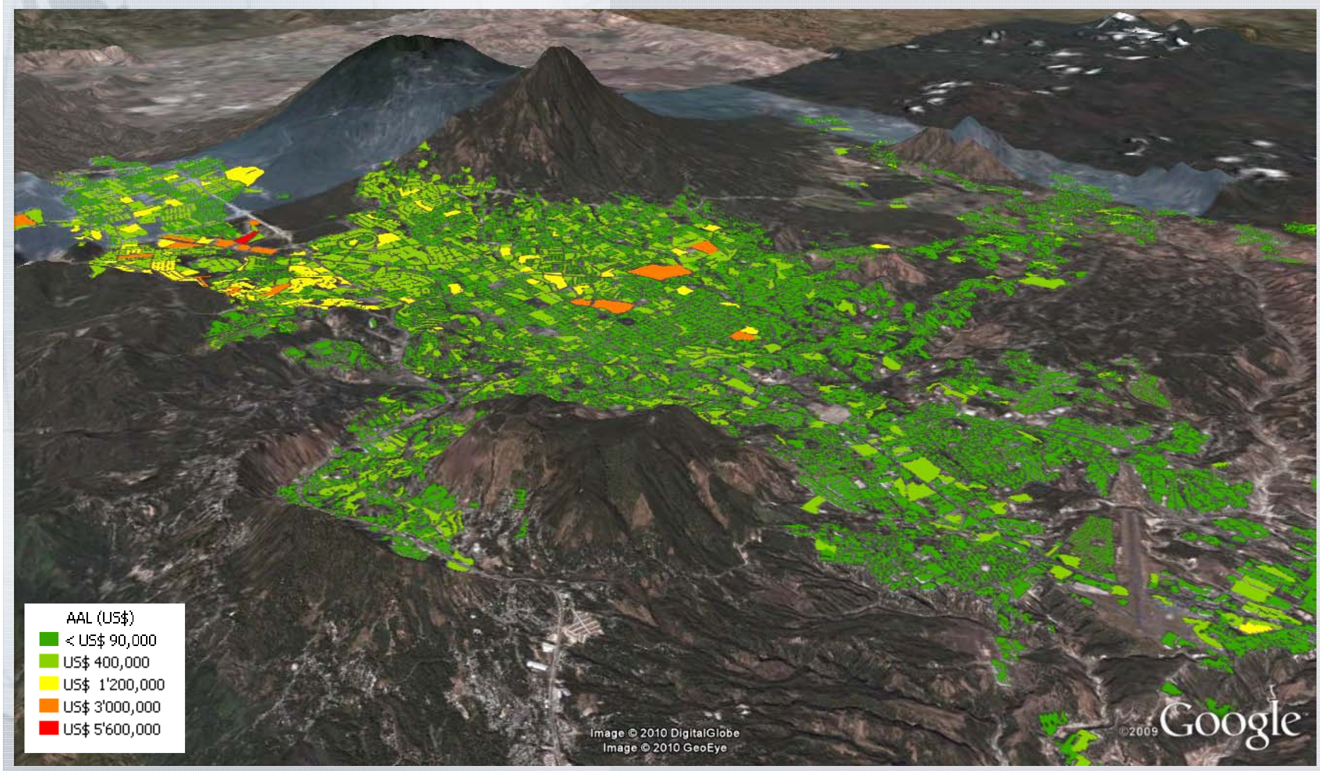
EARTHQUAKE RISK, %

SAN SALVADOR



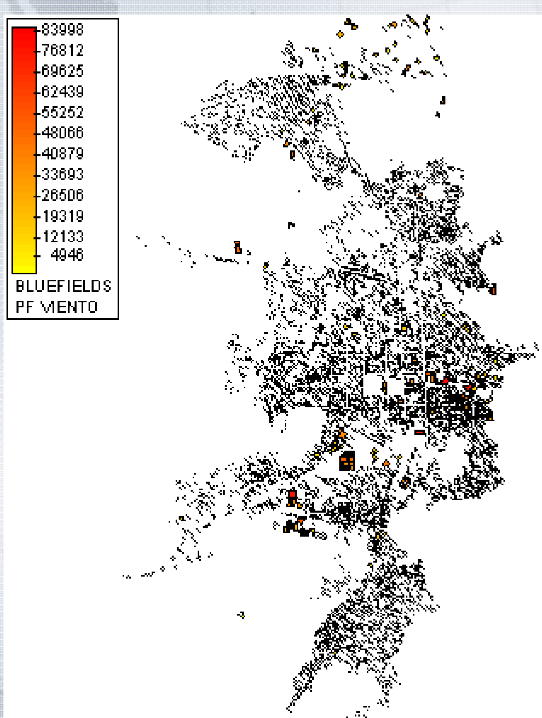
EARTHQUAKE RISK, $

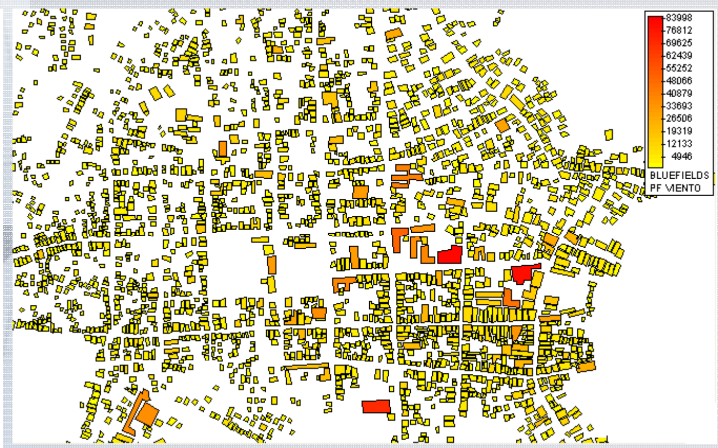
SAN SALVADOR



WIND LOSS, $

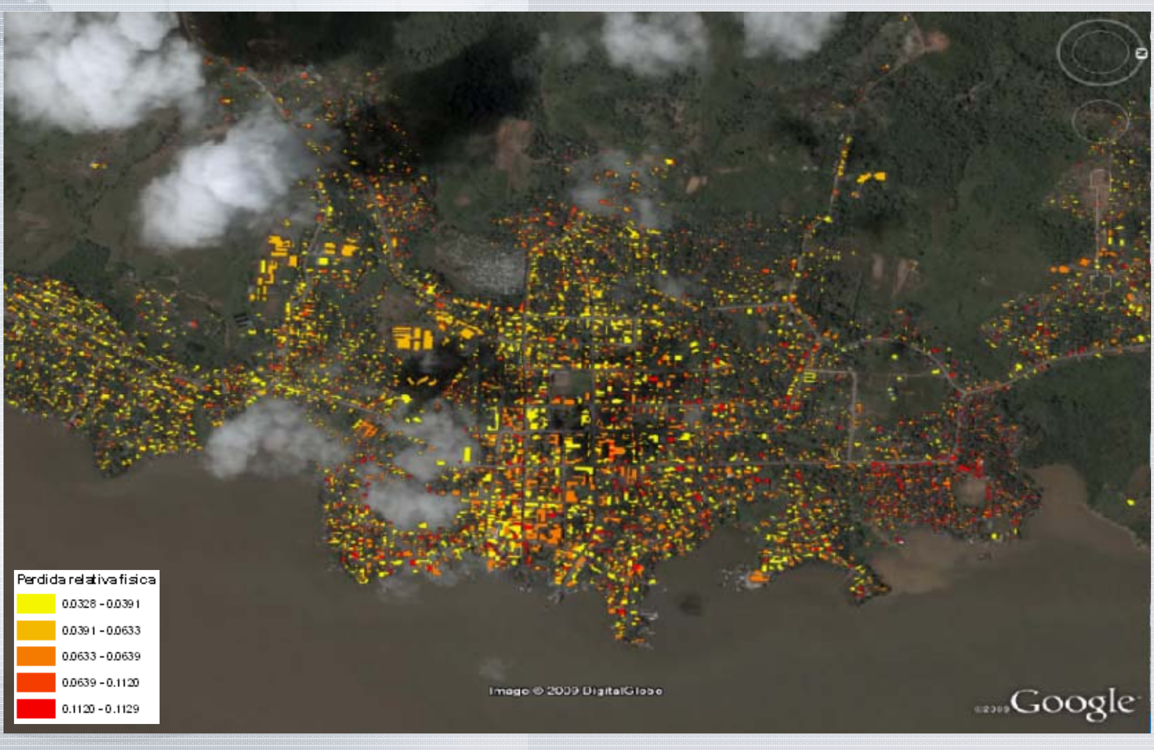
BLUEFIELDS - NICARAGUA





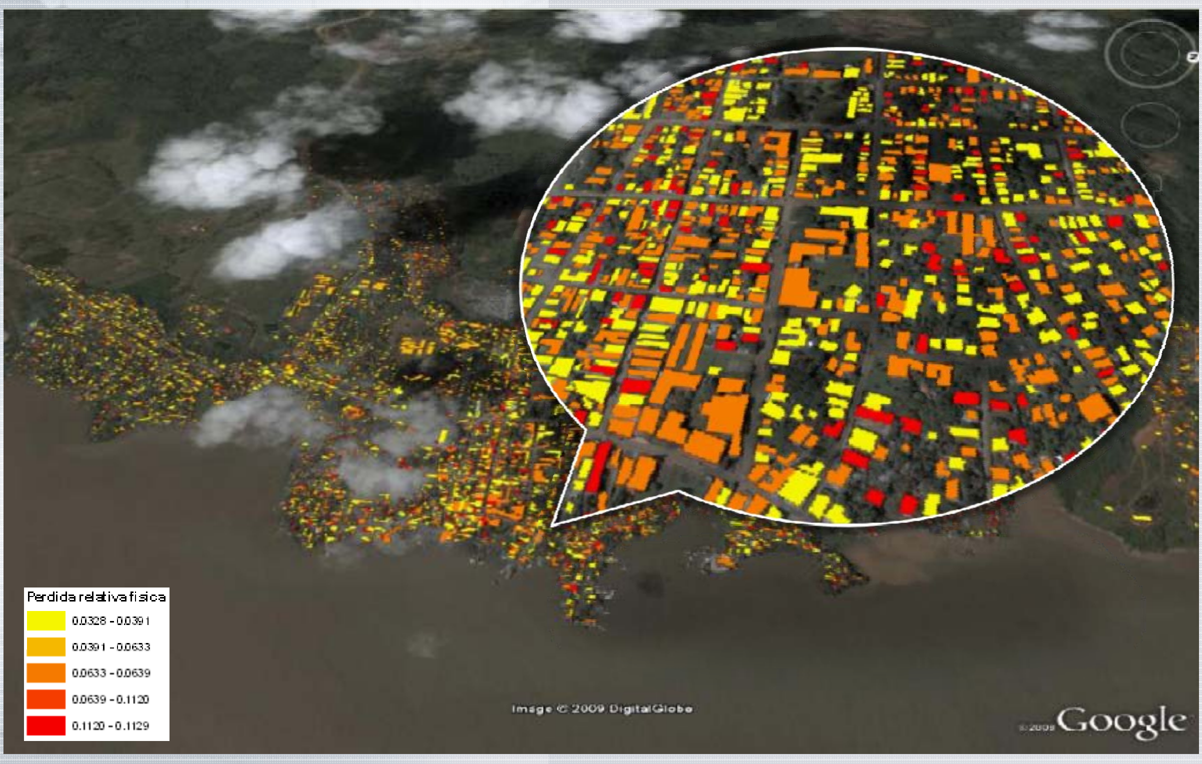
WIND LOSS, %

BLUEFIELDS - NICARAGUA



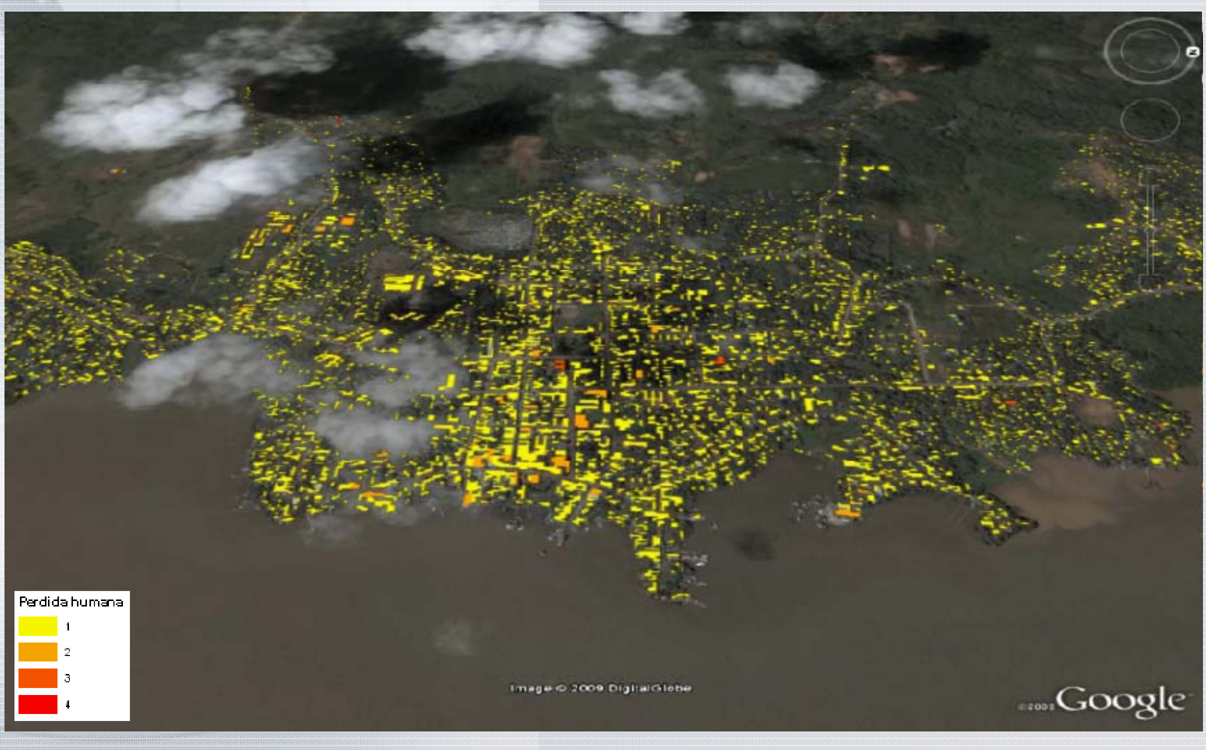
WIND LOSS, %

BLUEFIELDS - NICARAGUA



WIND RISK, HUMAN LOSSES

BLUEFIELDS - NICARAGUA

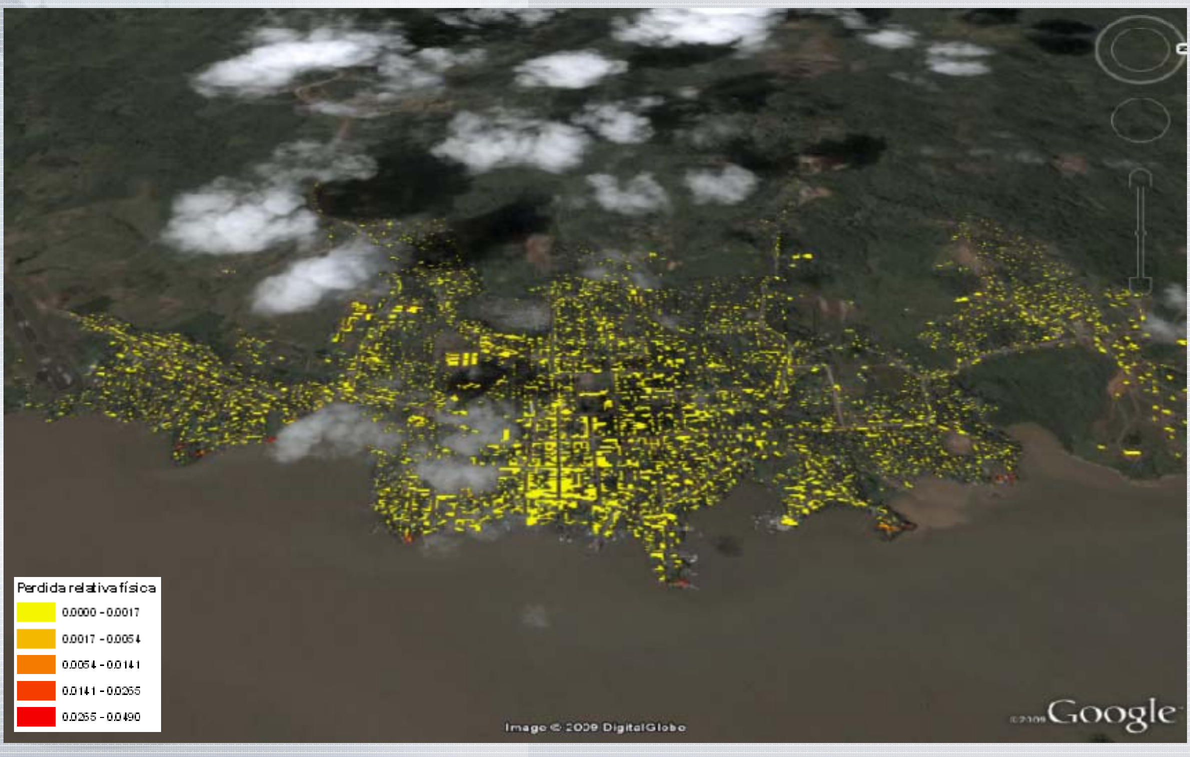


WIND RISK, HUMAN LOSSES

BLUEFIELDS - NICARAGUA

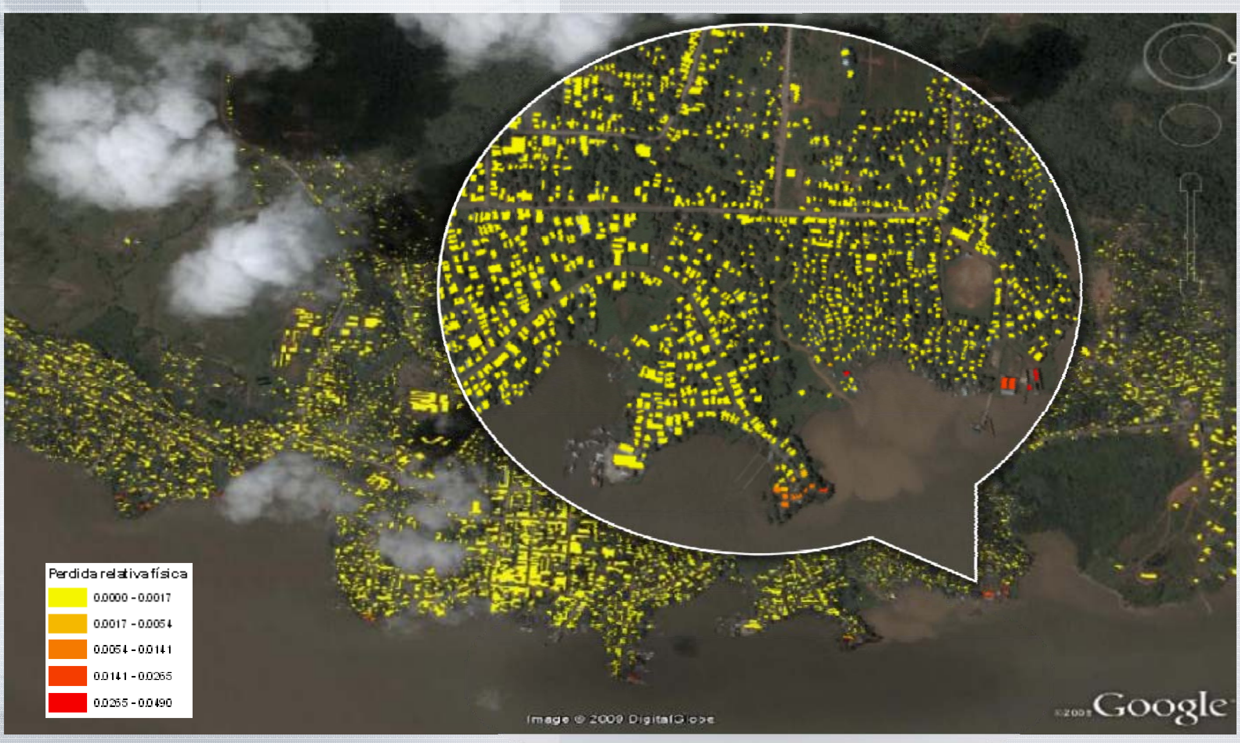
STORM SURGE LOSS, %

BLUEFIELDS - NICARAGUA



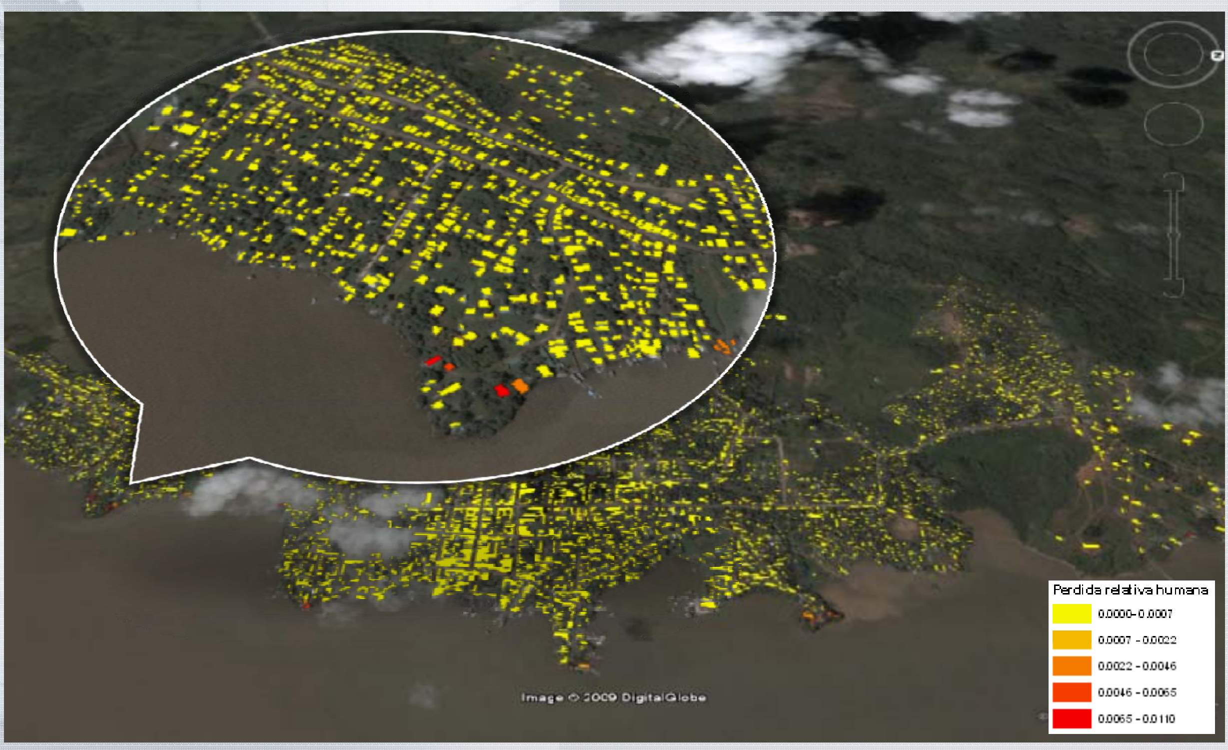
STORM SURGE LOSS, %

BLUEFIELDS - NICARAGUA



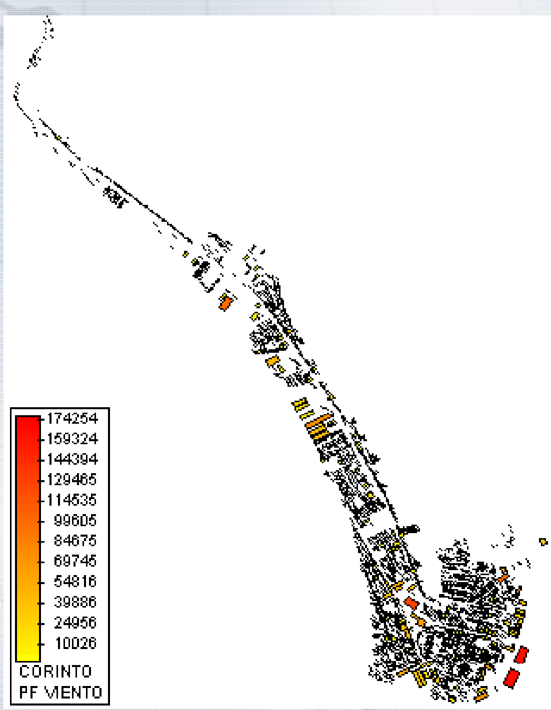
STORM SURGE RISK, HUMAN LOSS

BLUEFIELDS - NICARAGUA



WIND AND STORM SURGE LOSS, $

CORINTO - NICARAGUA



WIND

STORM SURGE

WIND LOSS, %

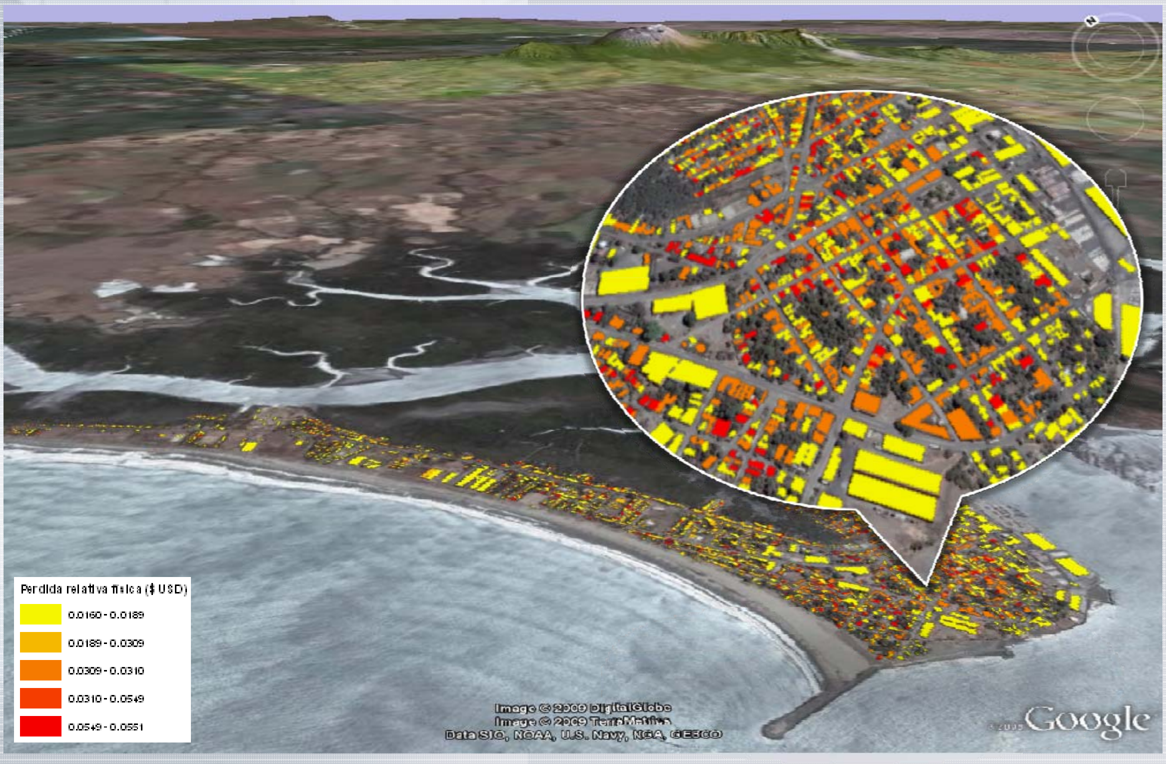
CORINTO - NICARAGUA

WIND LOSS, %

CORINTO - NICARAGUA

WIND LOSS, %

CORINTO - NICARAGUA



WIND RISK, HUMAN EXPECTED LOSS

CORINTO - NICARAGUA

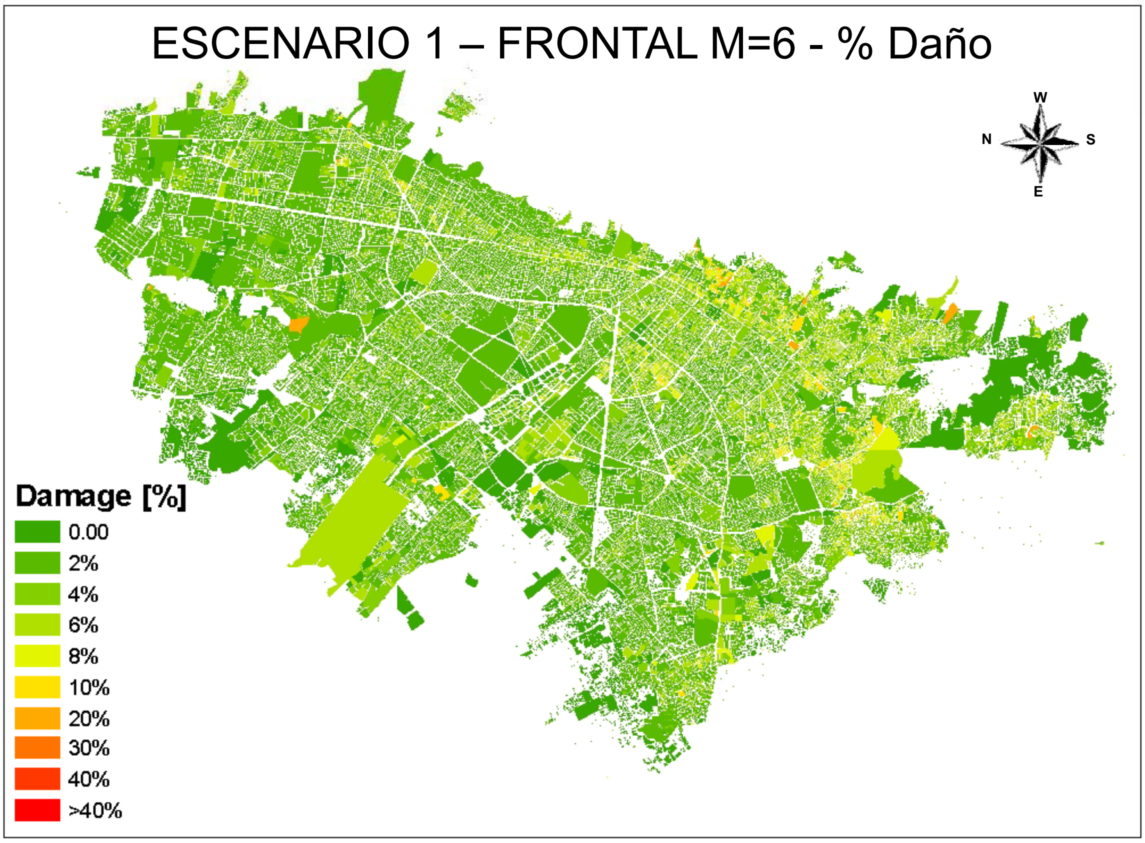
WIND RISK, HUMAN EXPECTED LOSS

CORINTO - NICARAGUA

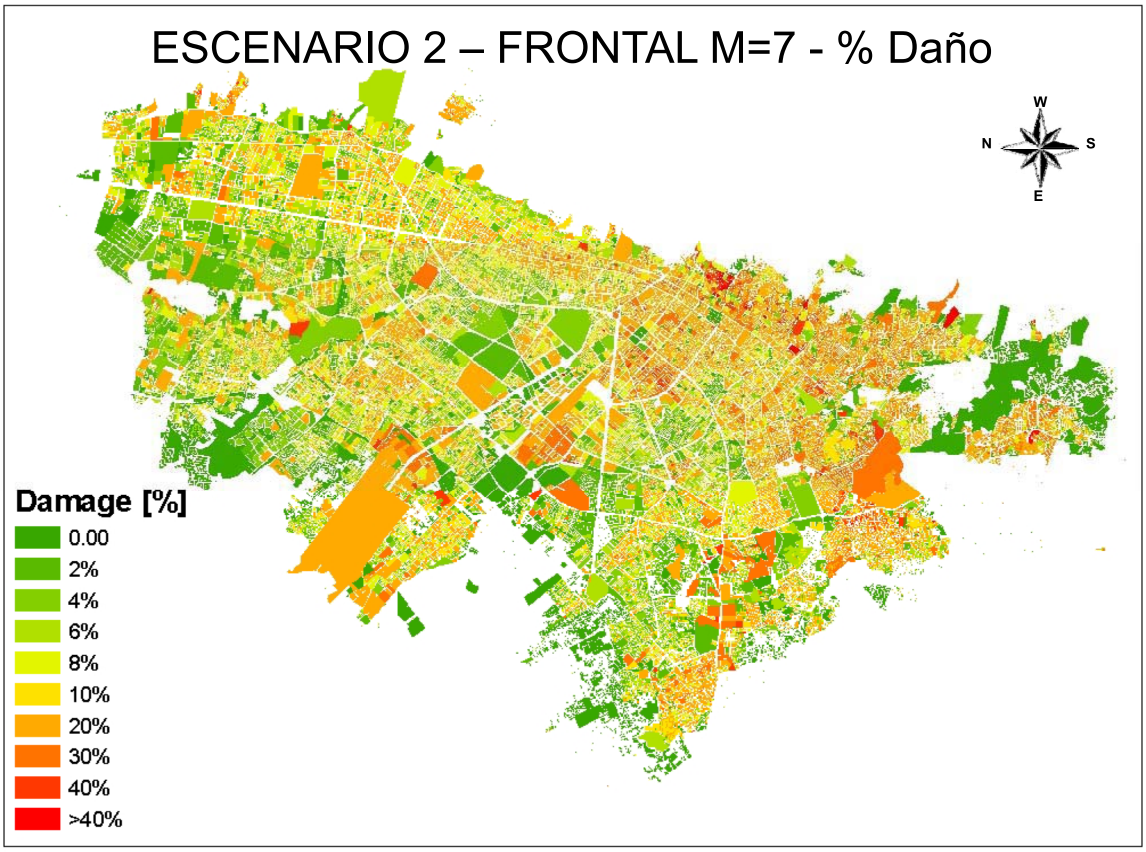
STORM SURGE RISK: %, $, HUMAN LIFE LOSS

CORINTO - NICARAGUA

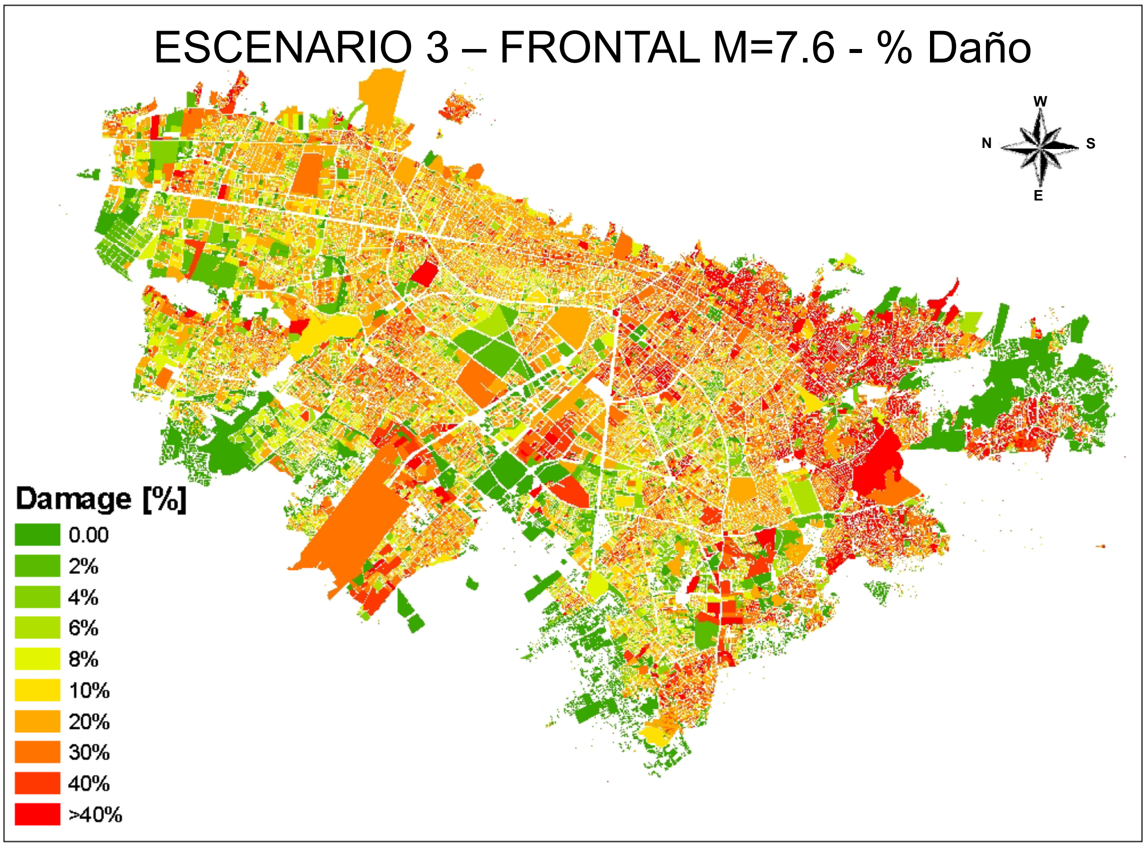
SEISMIC RISK – BOGOTA – BUILDING BY BUILDING



SEISMIC RISK – BOGOTA – BUILDING BY BUILDING



SEISMIC RISK - BOGOTA - BUILDING BY BUILDING



THANK YOU

More Information:

www.ecapra.org

www.ern-la.com

GFDRR GLOBAL FACILITY FOR DISASTER REDUCTION AND RECOVERY

ISDR

IDB