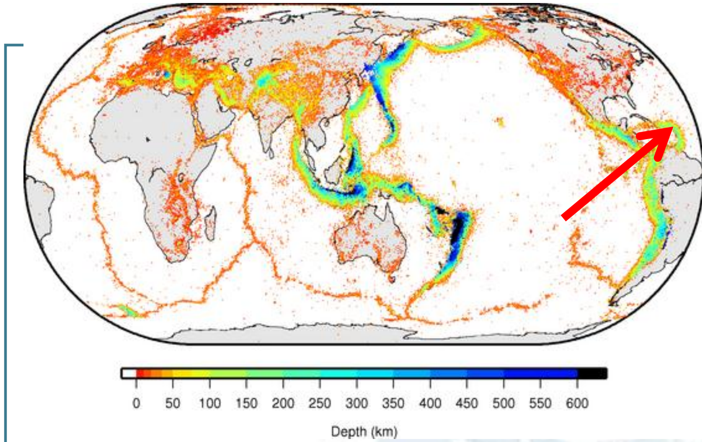
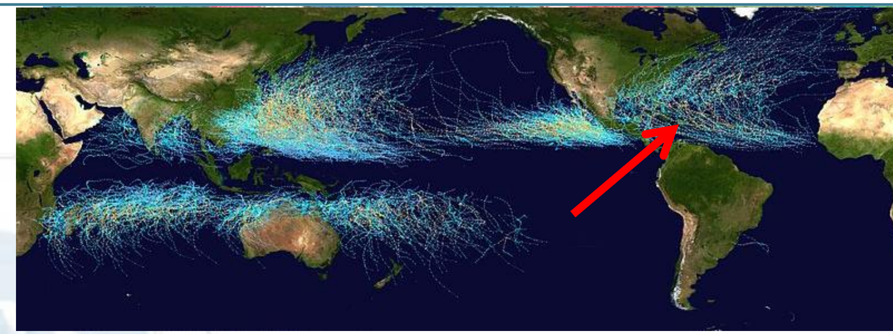


ISC earthquakes locations: 1960 to present



1985 – 2005 cumulative cyclone tracks (NHC / JTWC)

Comparative risk assessments for Guadeloupe: earthquakes and storm surge

Réveillère, Monfort, Lecacheux, Grisanti, Müller, Bertil, Rohmer, Sedan, Douglas, Baills, Modaressi
a.reveillere@brgm.fr

Presentation outline

- **Assets estimation & seismic loss estimation methodology**
- **Validation based Les Saintes 2004 M6.3 earthquake**
- **Probabilistic seismic losses**
- **Probabilistic storm surge hazard methodology**

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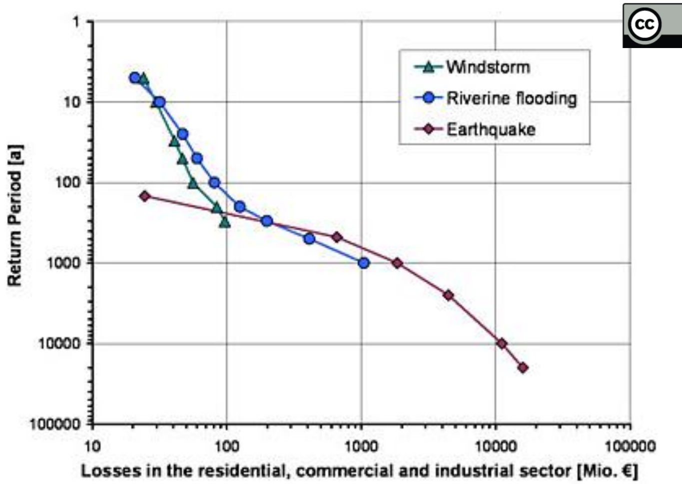
Probabilistic risk assessment & comparison

> Risk is characterized by :

- its likelihood → Return period
- its measurement → Direct economic losses

> Incomplete but quantitative measure of the disaster



Grünthal et al., 2006, for the city of Cologne

		Measurement	
		Tangible	**Intangible**
Form of damage	**Direct**	**Physical damage to assets:** - **buildings** - **contents** - infrastructure	- Loss of life - health effects - Loss of ecological goods
	Indirect	- Loss of industrial production - Traffic disruption - emergency costs	- Inconvenience of post-flood recovery - Increased vulnerability of survivors

Adapted from Uhlemann et al., 2011

Assets estimation – construction cost / m^2

Building value
per net floor area
per construction type,

> **based on the construction value** rather than on the market value of the building

similarly to Kleist & al., 2006; FEMA, 2003; Dutta et al., 2003

> **Local and recent data** are used, if possible

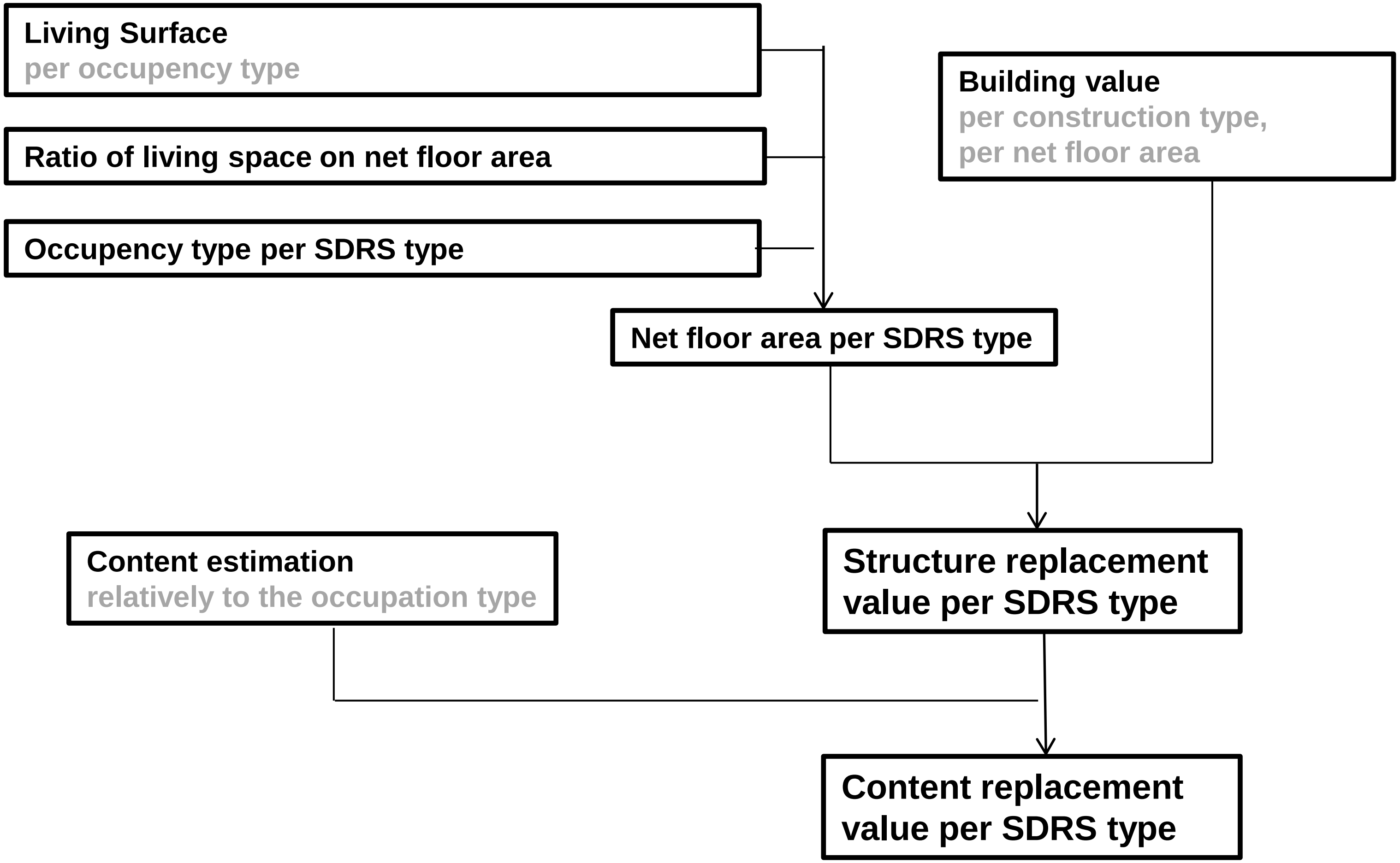
Construction type	**Construction cost (€ per net floor area)**	**Source (incl. year and location)**
Individual housing	1127	EPTB 2010 for Overseas Territories
Collective housing	1000	Based on the average social housing price in Guadeloupe
Shelter	600	Assumption
Industrial / large business	1390	Based on market price

Assets estimation – average surface

Living Surface
per occupancy type

Occupancy type	**Average living space per dwelling**	**Source (incl. year and location)**
Traditional housing	71 m^2	INSEE, 2006, for Guadeloupe
Recent private housing	101 m^2	INSEE, 2006, for Guadeloupe
Villa	150 m^2	Assumption
Collective housing	65 m^2	INSEE, 2009 for France & DGAFP, for France
Makeshift shelters	50 m^2	Assumption
Industrial buildings	300 m^2	CCI, for Guadeloupe

Assets estimation – overall methodology



« SDRS type »: building vulnerability typology defined by the « *Regional Scenario for Seismic Risk* » study & surveys. Cf. Bertil et al., 2009

Assets estimation - results

> Per vulnerability type

SDRS type		Building stock in Guadeloupe		Replacement value	
				Building	**Content**
Name	**Description**	Nb of dwellings	Share	€ per dwelling)	(€ per dwelling)
HABFOR	makeshift shelter	6 424	3%	37 500	18 750
MCPIER	stone houses	609	0.3%	100 021	50 011
CASTRA	traditionnal houses (wood)	15 710	7%	100 021	50 011
…	…	…	…	…	…

> →Total assets

Economic sector	Guadeloupe exposed assets		
	Total (G €)	k€/hab	share
Private housing	36.5	91.2	77%
Industry	1.1	2.7	2%
Commerce & service	5.7	14.3	12%
Schools & hospitals	4.4	11.0	9%
Others (roads, energy & water supply, etc.)	0.0	-	0%
Total	47.6	119.1	100%

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Loss estimation per Damage State

Loss ratio per DS
EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement

> Structural repairs

EMS-98 DS	Structure damage ratio	Central damage factor
0	0%	0%
1	0-1%	0.5%
2	1-20%	10%
3	20-60%	40%
4	60-100%	80%
5	100%	100%

From Tyagunov et al. (2006)
for German buildings typology

> Content replacement

EMS-98 DS	Replacement ratio
0	0%
1	1 %
2	2 %
3	12 %
4	25 %
5	50 %

Adapted from FEMA (2003)
for US buildings typology

Validation using les Saintes (2004) EQ

Les Saintes M6.3 EQ hazard sc.

SDRS Seismic vulnerability

Damage State of exposed buildings

Loss ratio per DS
EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement

Assets value
Economic estimation of:
- Structural repair
- Content replacement

Les Saintes losses estimation

Damage & loss model

> Post-seismic damage observations

> Post-disaster cost estimations

Available data

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Validation using les Saintes (2004) EQ

Observations

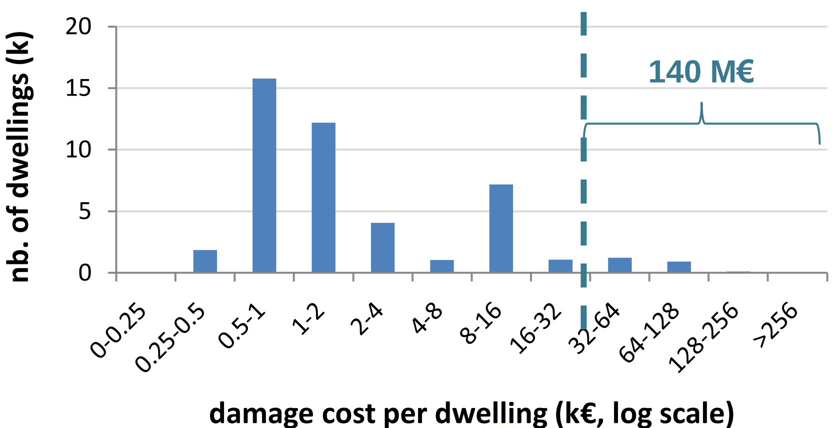
- Damage: a few D4/D5 buidlings, mostly light damages (cracks), concentrated in Les Saintes islands and the South of Basse Terre

- Direct economic losses:
  - CCR (French public reinsurance institution) : estimated 60 M€
  - 43 % of households in Guadeloupe have a home insurance

  → Estimated cost: **140 M€**

Loss modeling

- Damage localization and number coherent but sligthly higher than the post-seismic observations
- Losses: **148 - 513 M€, central damage factor: 325 M€**



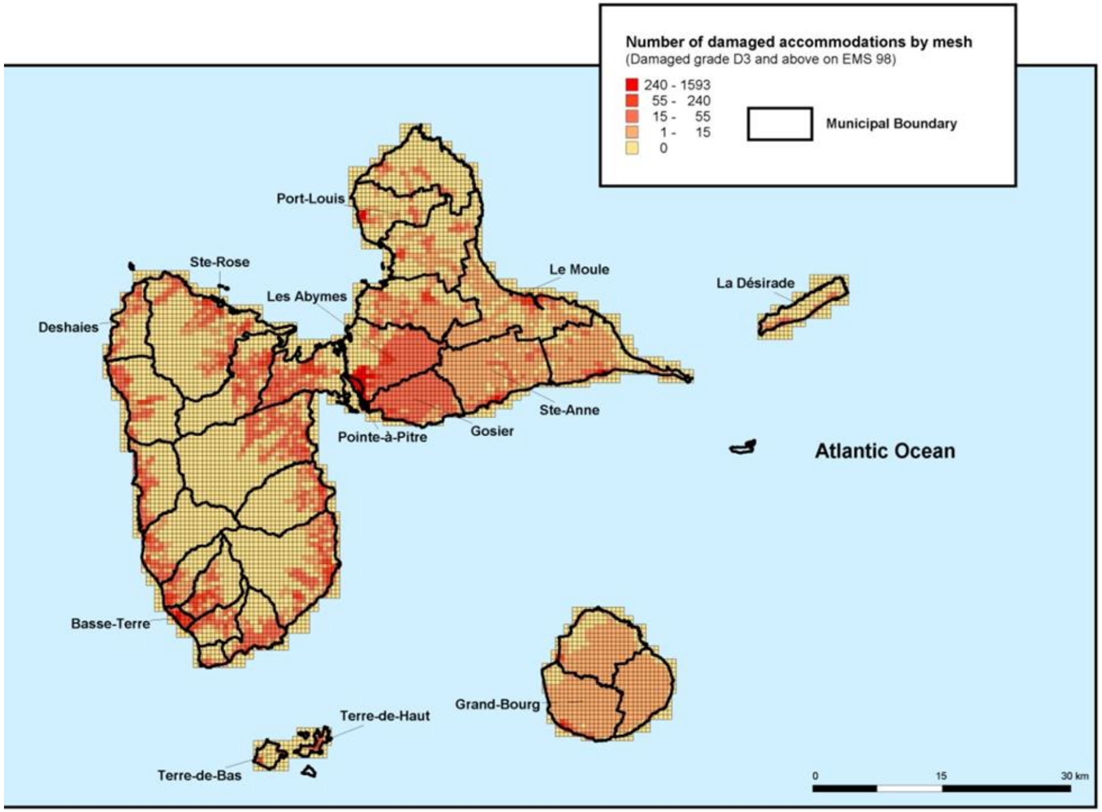
→ **Overestimated cost.** Hypotheses: no reimbursement of light damage (no declaration, insurance excess), signification of the CCR number, %loss - DS relation …

Probabilistic seismic risk: losses (DS)

Probabilistic hazard assessment → **Damage State** of the exposed elements for a range of return time periods

SDRS Seismic vulnerability → **Damage State** of the exposed elements for a range of return time periods

> **Loss calculations are based on a probabilistic seismic hazard map. This approach leads to slightly conservative results (Bommer and Crowley, 2006)**



Sources : BRGM (2008) Design : Grisanti.L (2011)

Damage map obtained using Armagedom loss estimation software (Sedan, 2003)

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Probabilistic seismic risk: losses (€)

Probabilistic hazard assessment

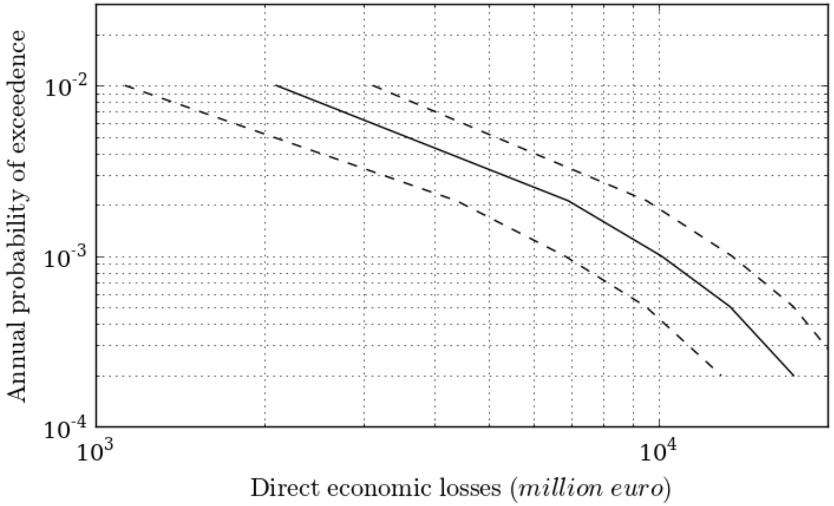
SDRS Seismic vulnerability

Damage State of the exposed elements for a range of return time periods

Loss ratio per DS
EMS 98 DS - % loss relation for:
- Structural repairs
- Content replacement

Assets value
Economic estimation of:
- Structural repair
- Content replacement

Probabilistic direct losses for a range a return time periods



Preliminary results

Storm surge hazard

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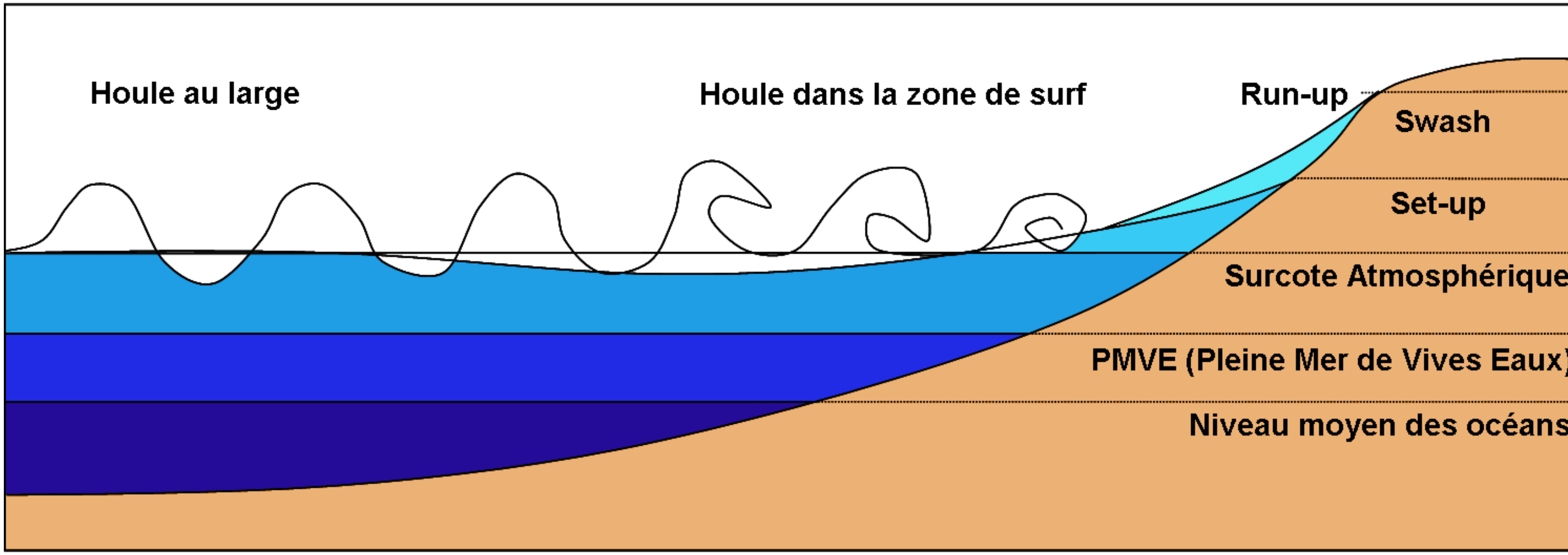

> **The marine submersion of the coastal areas results from the conjugated effects of:**

- the tide
- the atmospheric surge (due to wind and low atmospheric pressure)
- the waves set-up (local elevation of the mean sea level due to wave breaking)

→The maximum level reached by the water is the run-up

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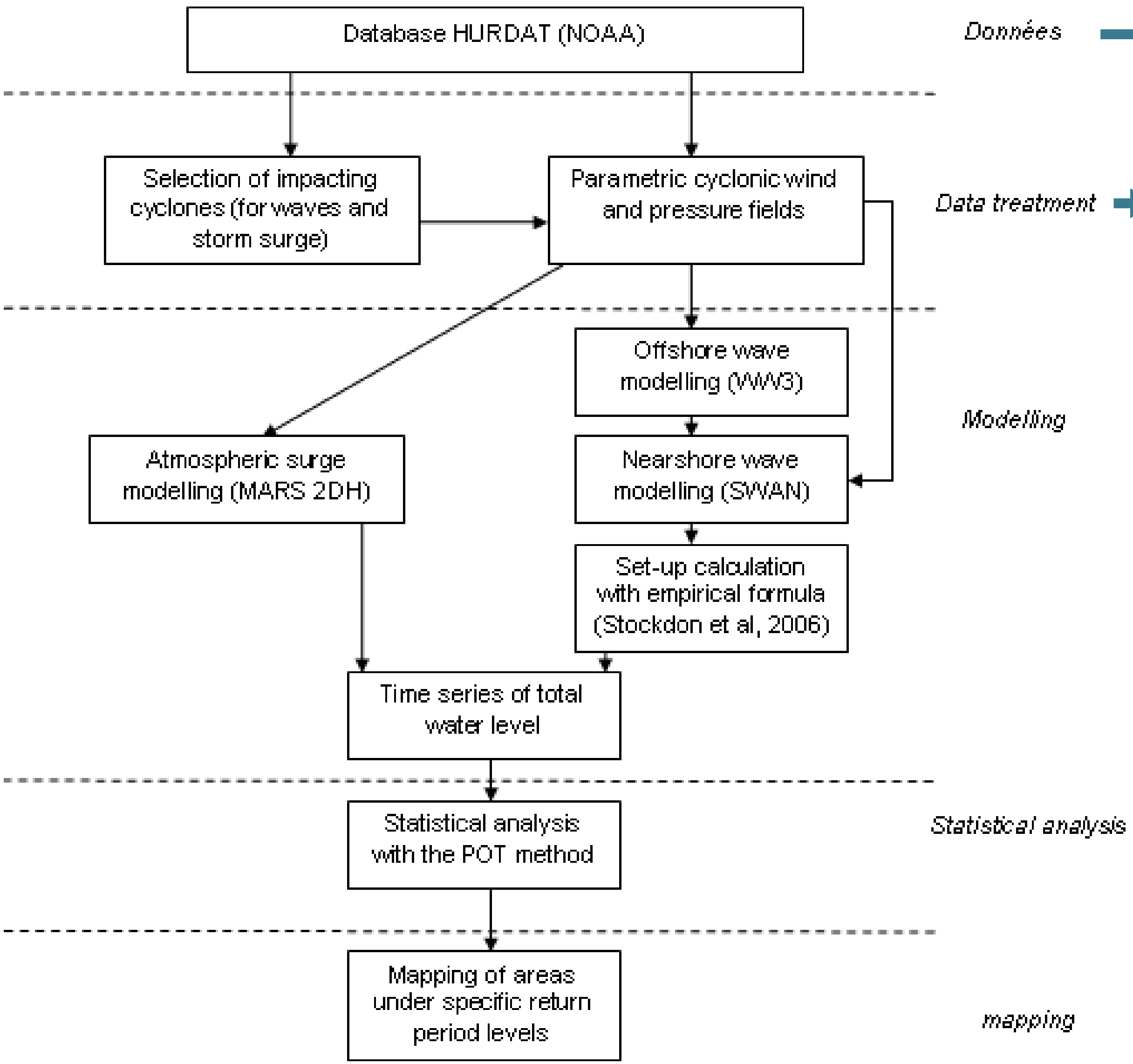
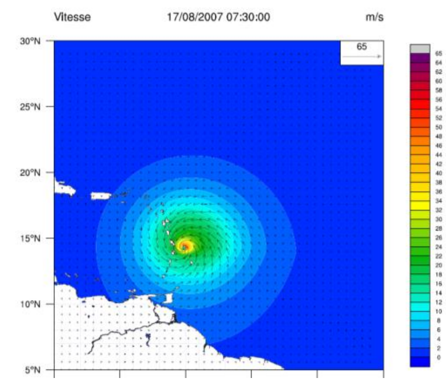
Probabilistic storm surge hazard: methodology



Selection of 291 cyclones between 1910 and 2009

Parametric wind field (Holland's model)



Cf. details in Lecacheux et al., 2012

Storm surge hazard: events modelling

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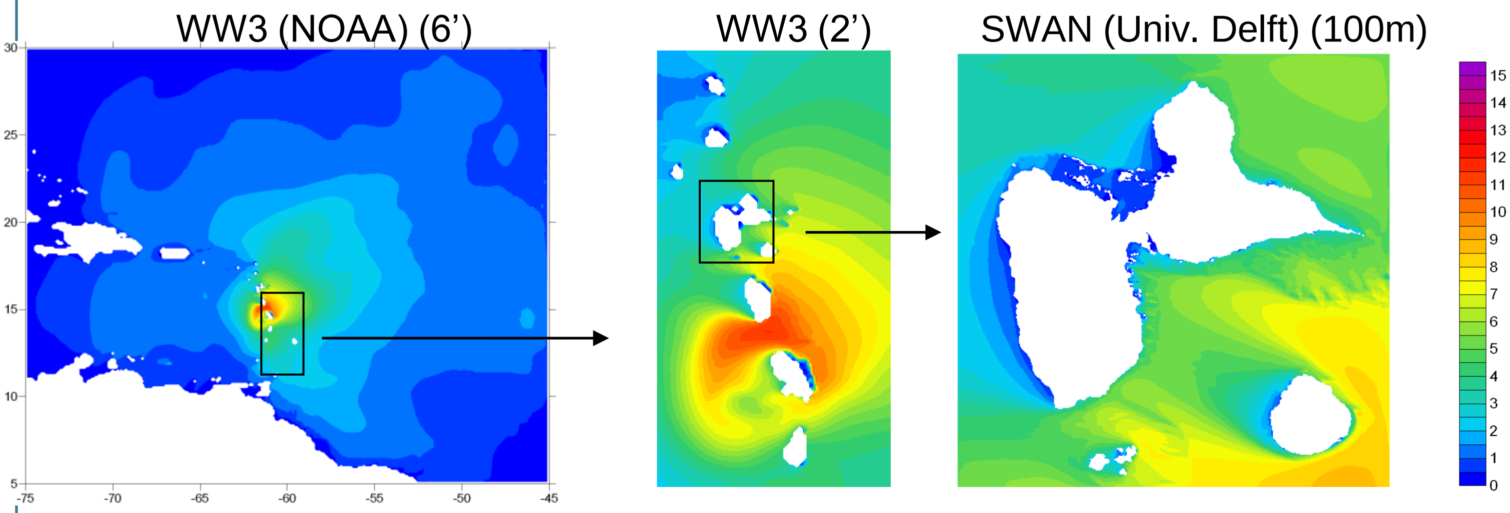
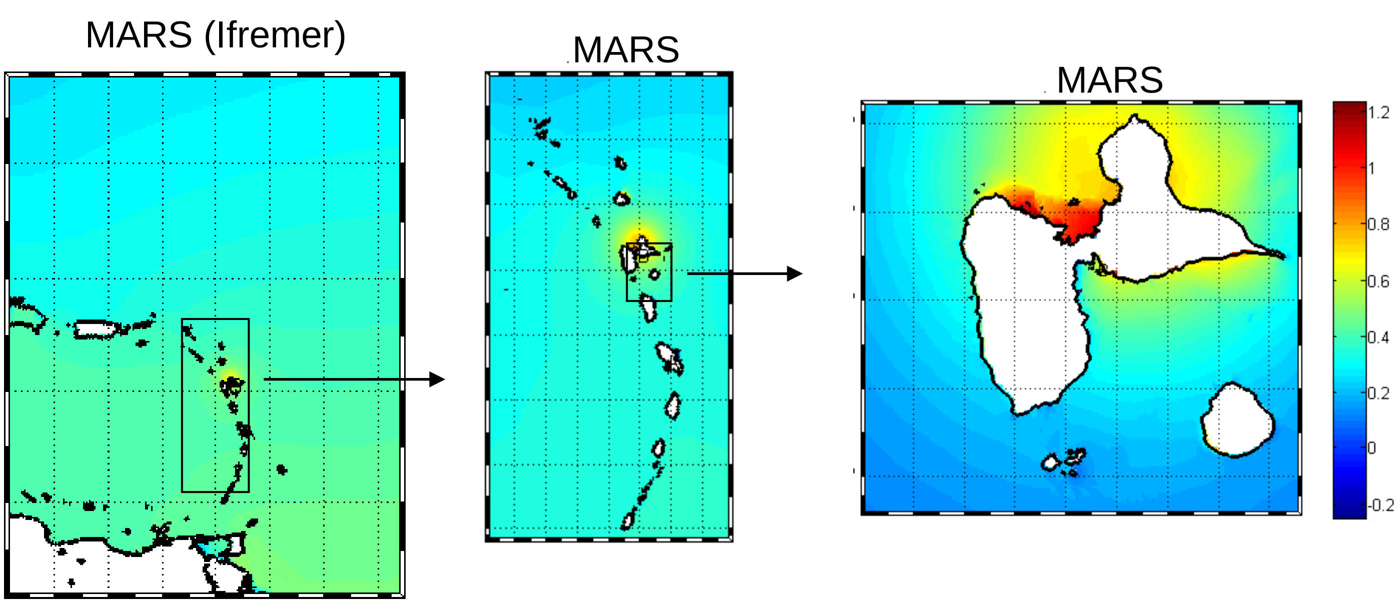


Waves (example : Dean 2007)



Atmospheric surge (example : Hugo 1989)

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Probabilistic storm surge hazard: waves results

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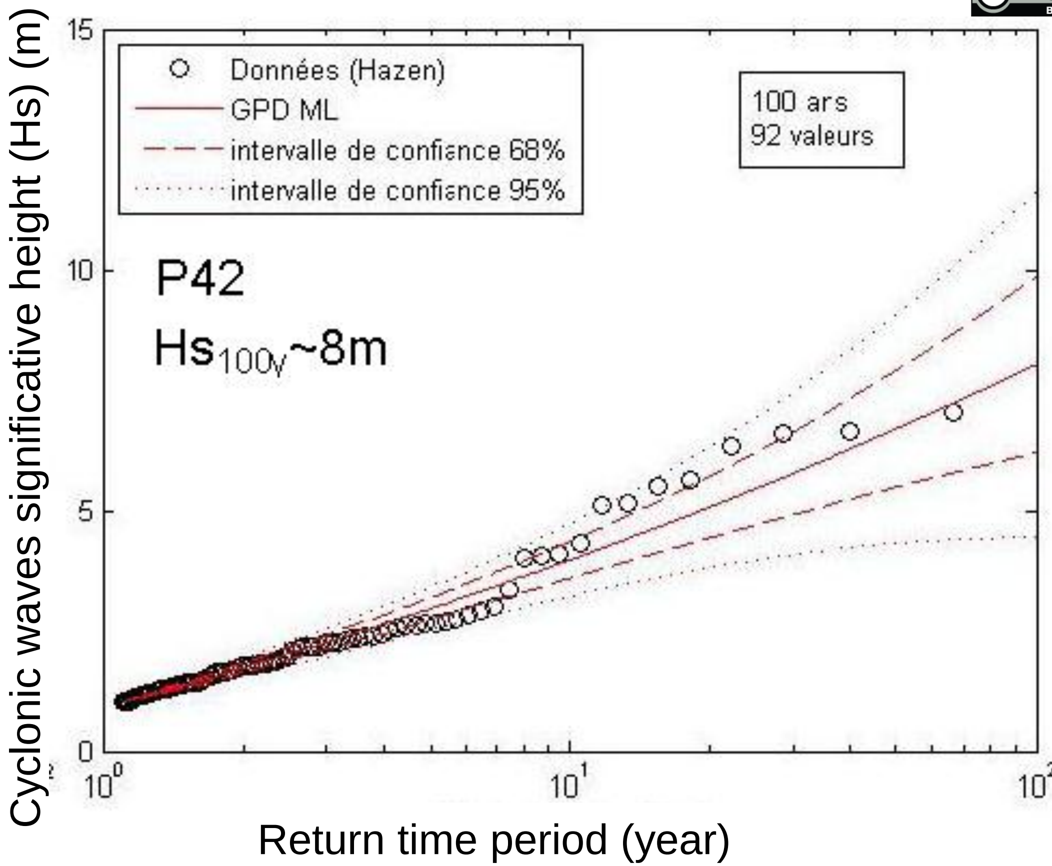
- Peaks Over Threshold sampling of the simulations for different locations around Guadeloupe
- Maximum likelihood fit with a Generalized Pareto Distribution



from Lecacheux et al., 2012

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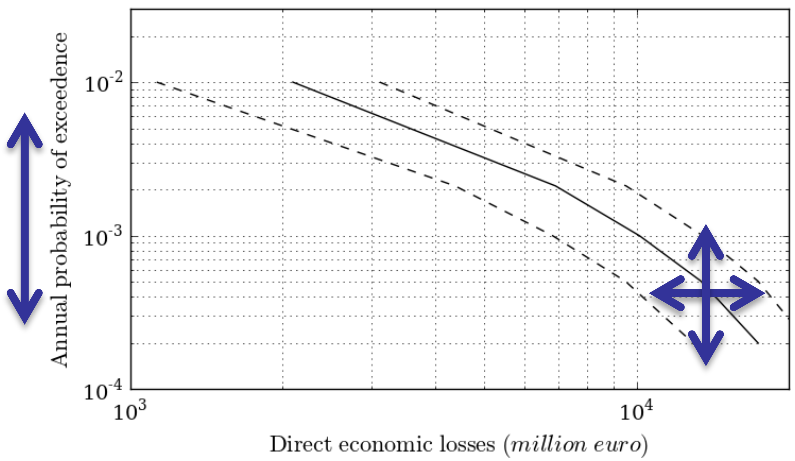
Further steps

> Direct hazard comparison

- Validation of the economic losses (Les Saintes)
- Finalization of the probabilistic storm surge hazard
- Mapping inundated areas and estimating storm surge losses

> Identification, quantification and propagation of uncertainties in the seismic loss calculation

Aleatory variability



Epistemic uncertainty

Conceptual view

→ **Restriction to the area of Pointe à Pitre**

> **Thank you!**

> Acknoledgment

- The research leading to these results has been carried out in the frame of the MATRIX Project, funded by the European Commission's Seventh Framework Program [FP7/2007-2013] under grant agreement n° 265138. The BRGM research project RISCOTE has also co-funded the storm surge part.

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