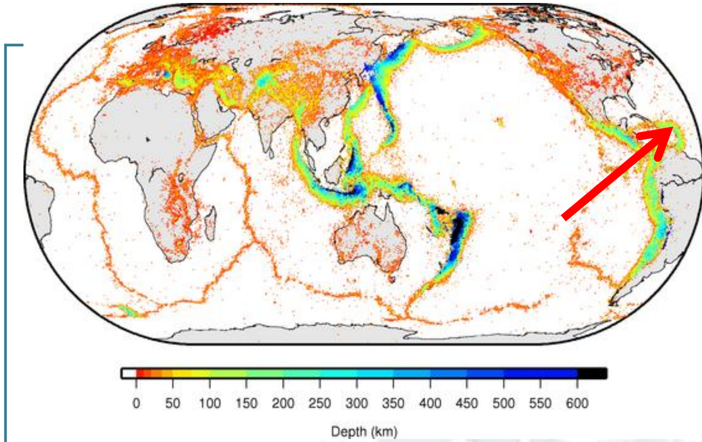
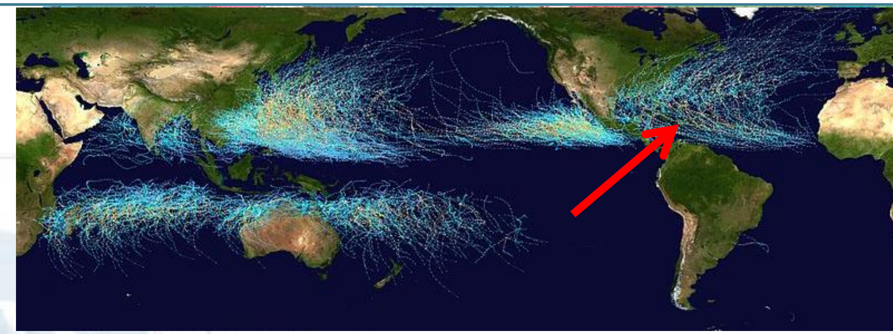
Comparative risk assessments for Guadeloupe: earthquakes and storm surge

Arnaud Réveillère, Daniel Monfort, Sophie Lecacheux, Ludovic Grisanti, Héloise Muller, Didier Bertil, Jeremy Rohmer, Olivier Sedan, John Douglas, Audrey Baills, et al.



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

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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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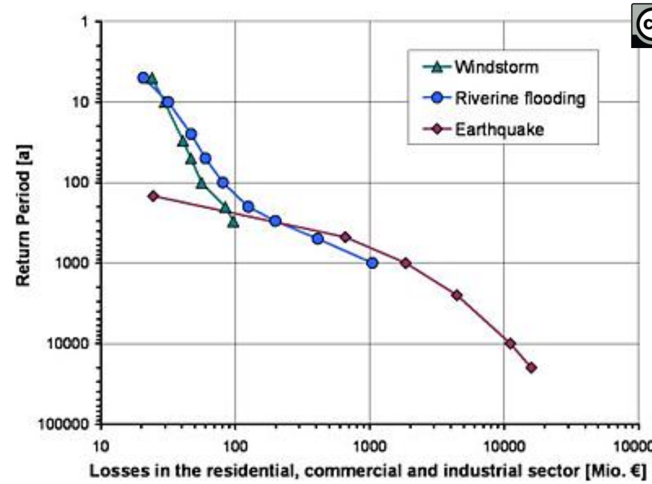
Probabilistic risk assessment & comparison

> Risk is characterized by :

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



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

> Incomplete but quantitative measure of the disaster

		Measurement	
		Tangible	**Intangible**
Form of damage	**Direct**	**Physical damage to assets:** - **buildings** - **contents** - infrastructure	- Loss of life - health effects - Loss of ecological goods
Form of damage	**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

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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

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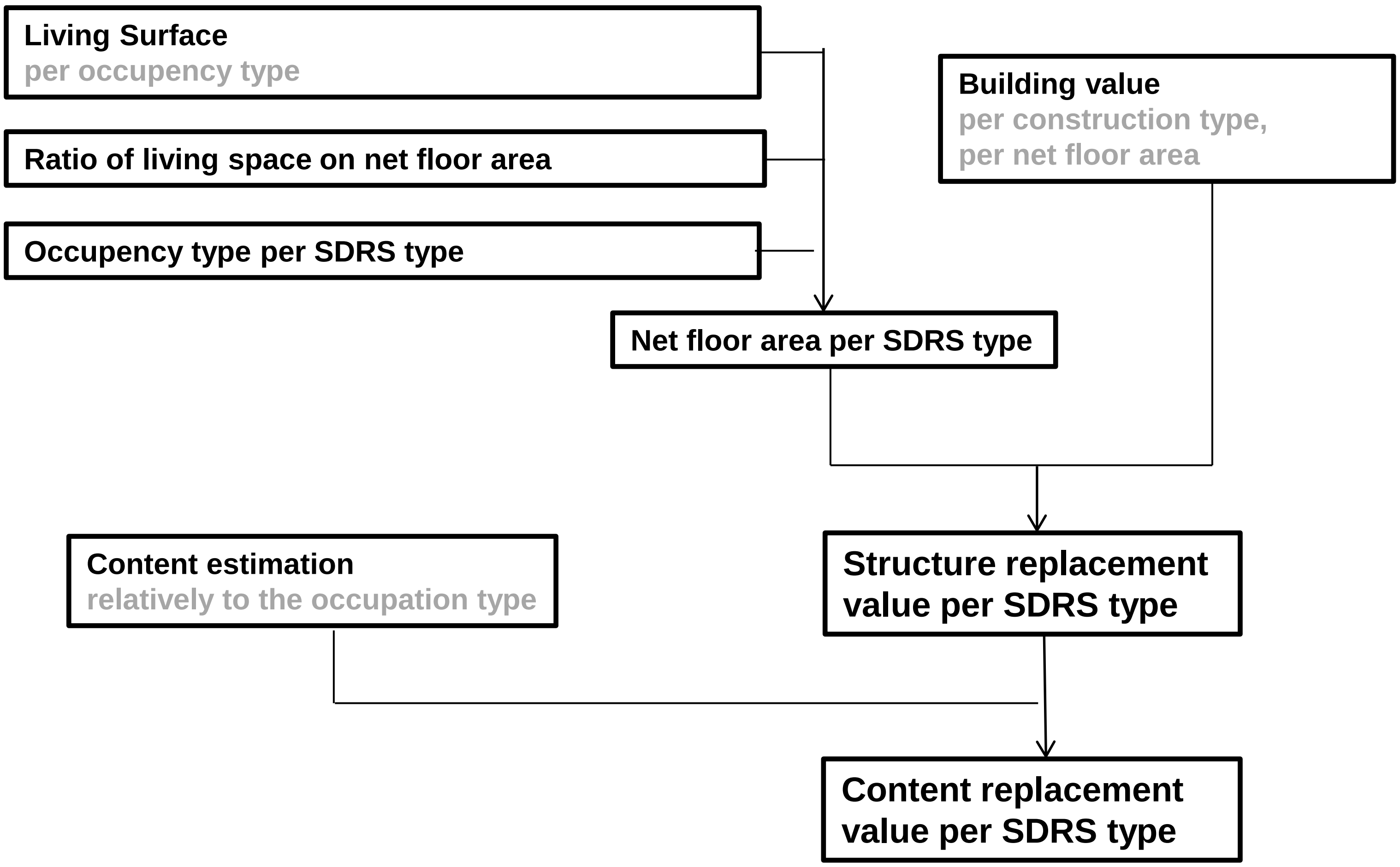
Assets estimation – overall methodology



« 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

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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

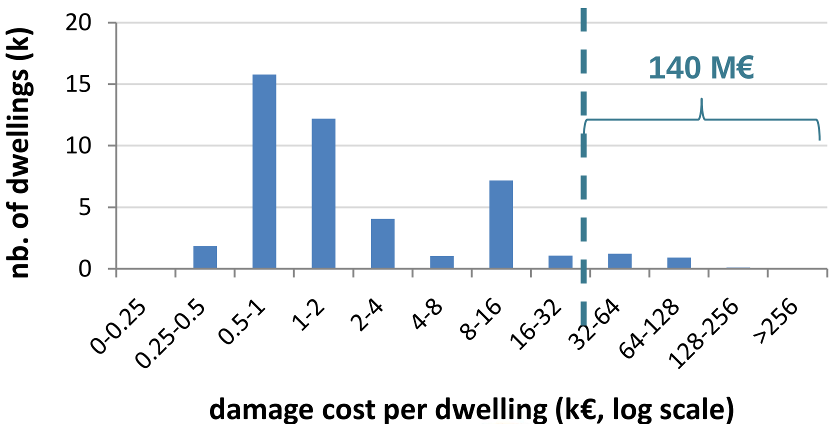
> Observations

- 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)

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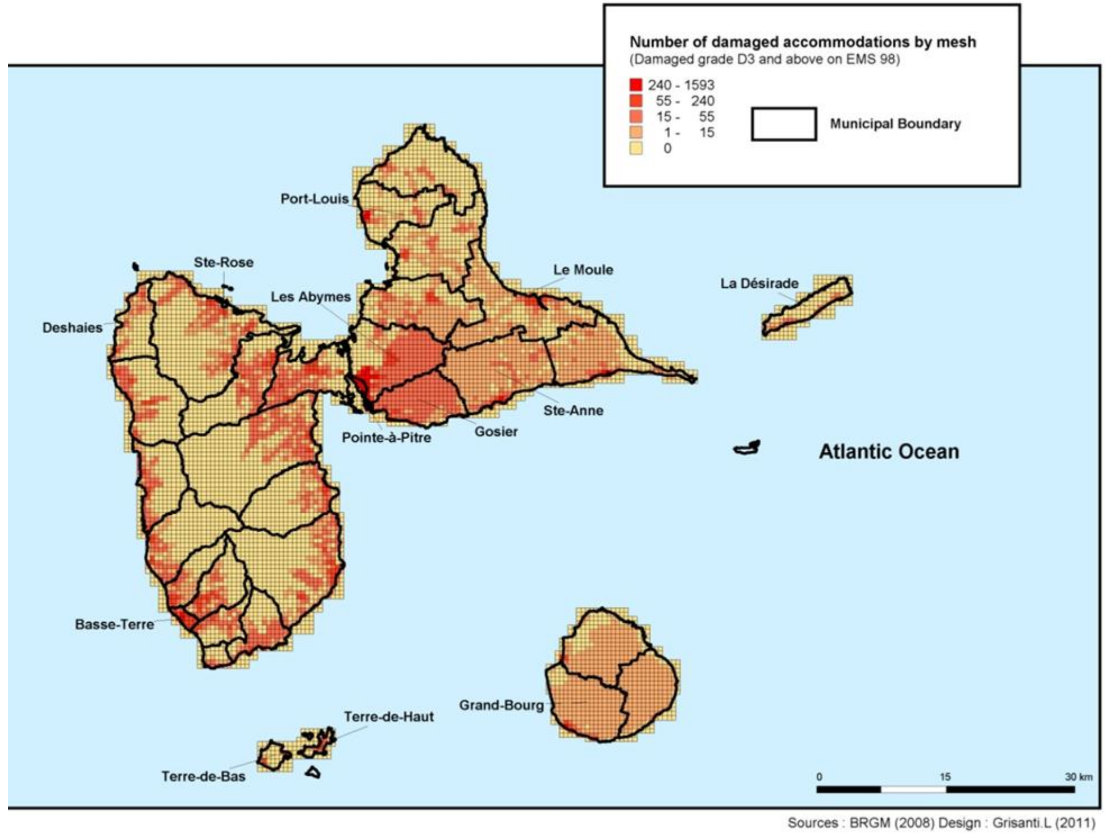
Probabilistic hazard assessment → **Damage State** of the exposed elements for a range of return time periods

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)**



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

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Probabilistic seismic risk: losses (€)

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Probabilistic hazard assessment

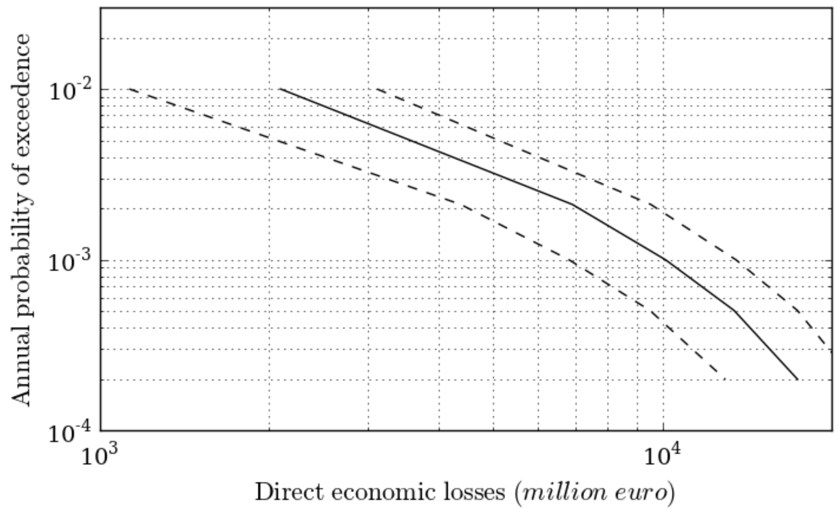
SDRS Seismic vulnerability

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

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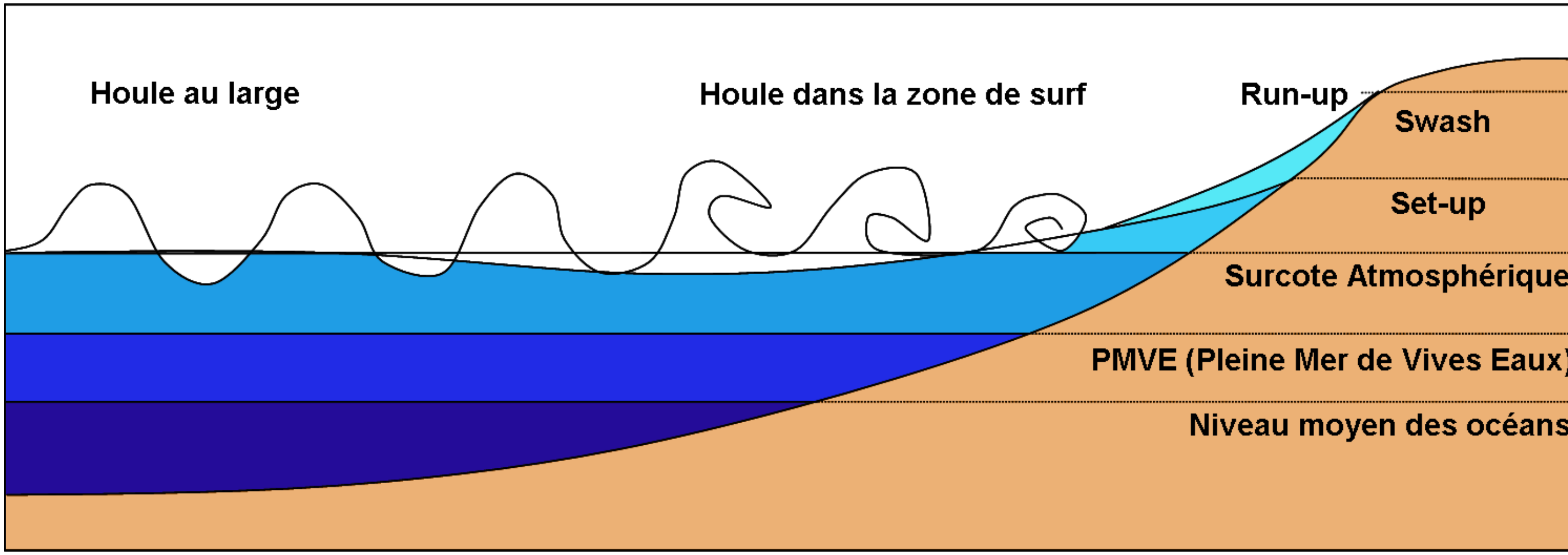
Storm surge hazard



> **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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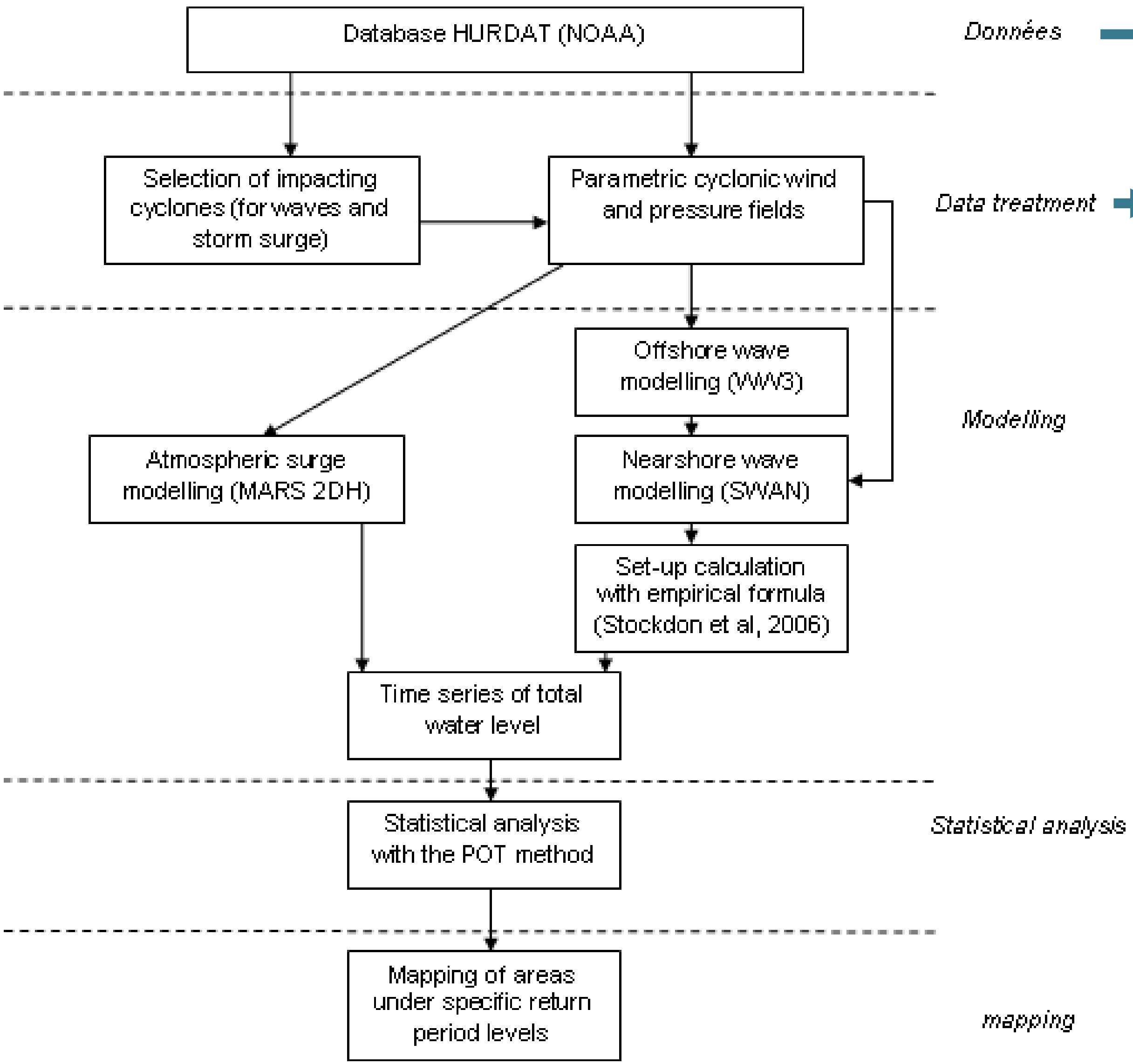
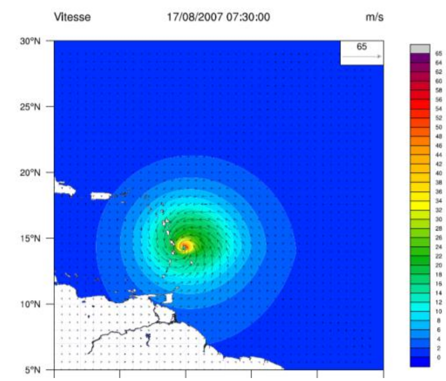
Probabilistic storm surge hazard: methodology



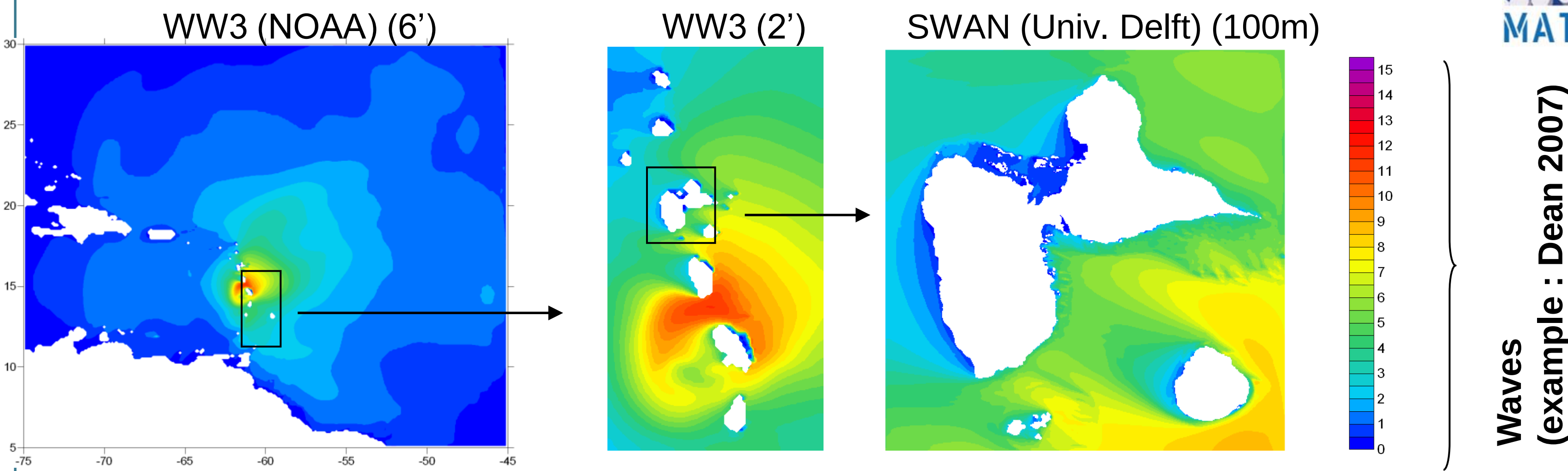
Selection of 291 cyclones between 1910 and 2009

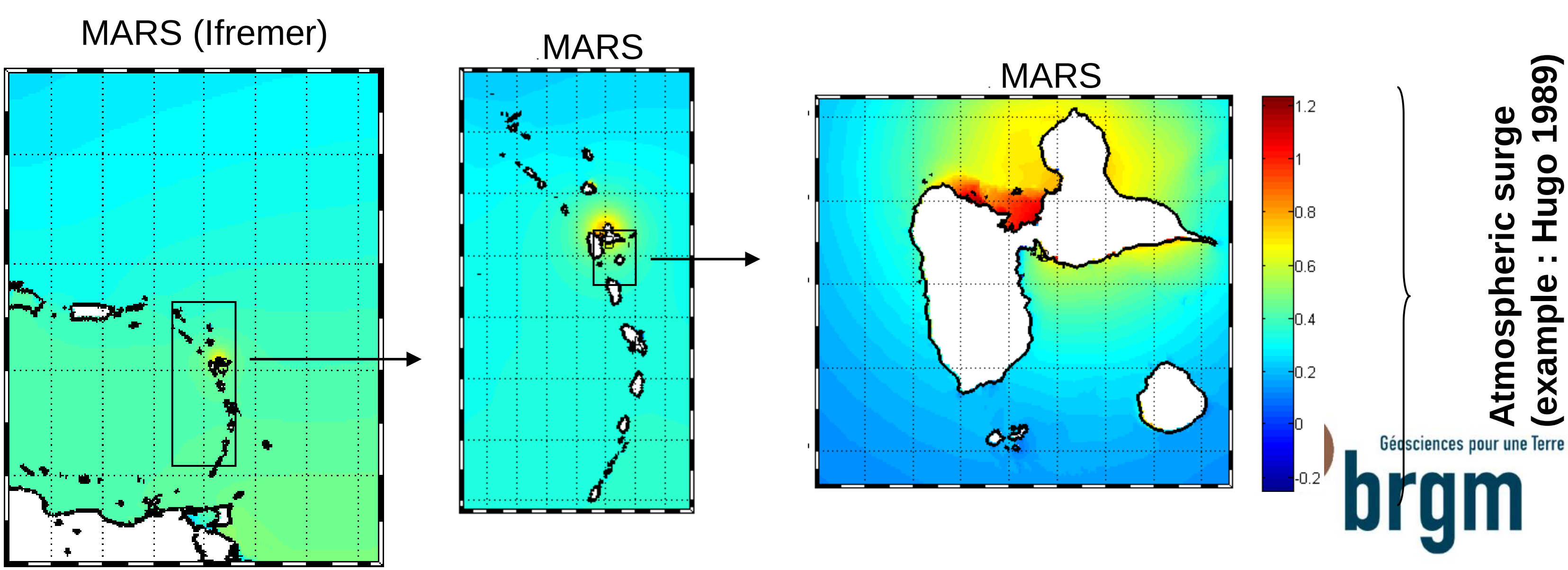
Parametric wind field (Holland's model)



Cf. details in Lecacheux et al., 2012

Storm surge hazard: events modelling





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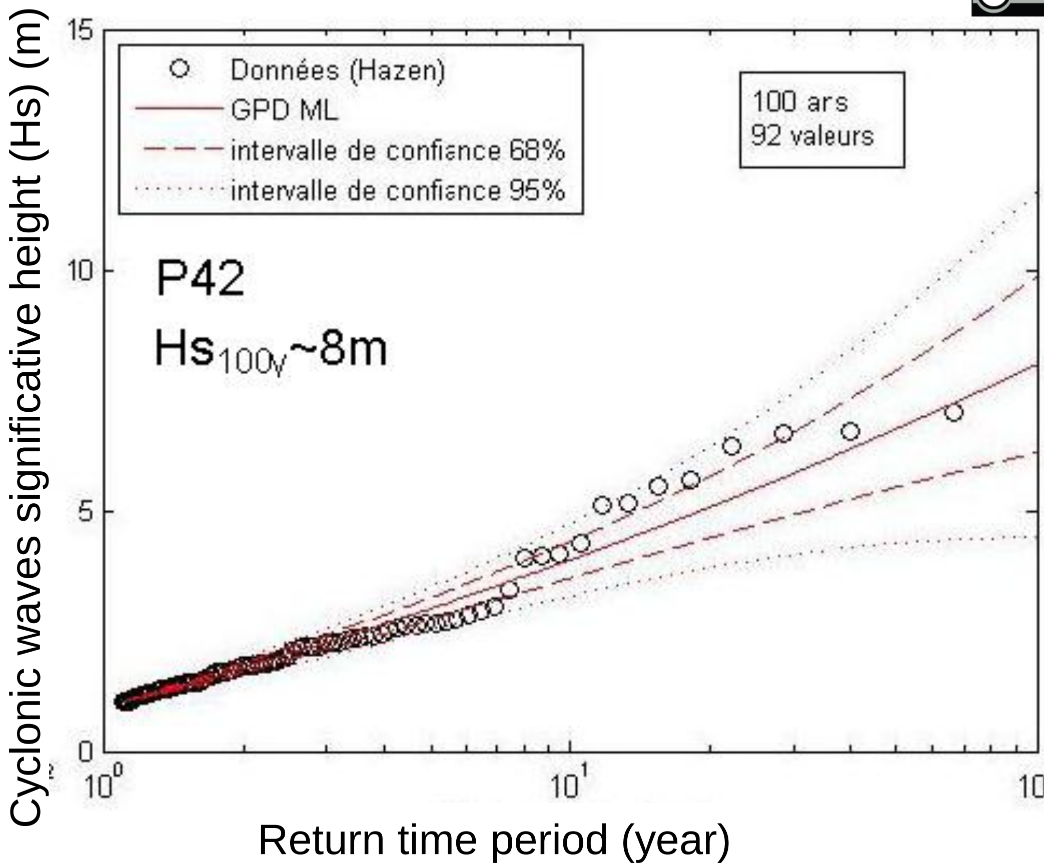
Probabilistic storm surge hazard: waves results

- 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

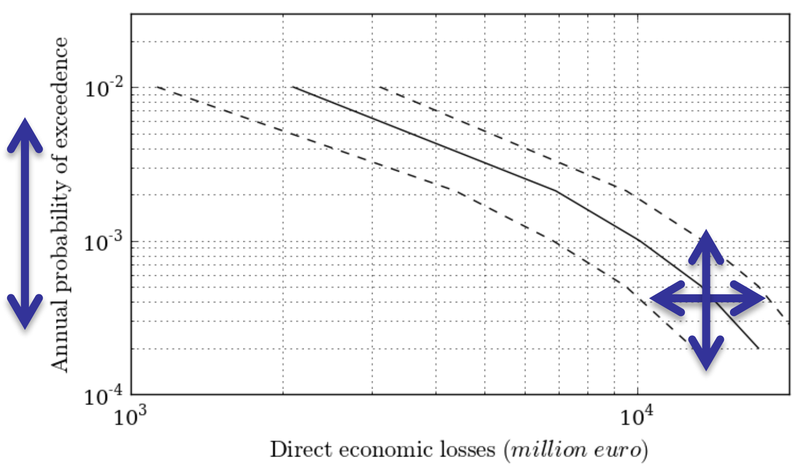
Further steps

> 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**

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> Thank you!

> Acknoledgment

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