IAEA ANSN / ISSC - REGIONAL WORKSHOP ON
“Volcanic, Seismic, and Tsunami Hazard Assessment Related to NPP Siting Activities and Requirements”
Jakarta, Indonesia, 13-17 June 2011

“Seismic hazard assessment – Deterministic and Probabilistic Approaches – Uncertainties treatment”

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INTERNATIONAL SEISMIC SAFETY CENTRE, NSNI/IAEA

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Lecture XX

Case study

Development of a GIS.

General recommendations.

Case study.

General recommendations

- The geological, geophysical, geotechnical and seismological databases should be incorporated to a GIS.
- Also other kind of information (meteorological, economical, social, etc.) should be incorporated.
- The owner of the database should be the applicant.

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General description of a GIS

- **In a siting process, the GIS is formed by a software and the associated information containing all relevant information for the selection of the site.**
- **In a GIS, all data is geo-referenced.**
- **The GIS allows to view, to cross, to compare, to modify, to generate, etc. different types of information**

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General description of a GIS

- **The database is composed of different layers of information (i.e. seismic catalog, geological maps, cross sections, etc.).**

- **Each layer could be a raster image (for example, satellite image) or a vector layer (for instance, seismic catalog).**

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General description of a GIS

- **The vector layers are formed by objects: points (i.e. epicenters), lines (i.e. cross sections) or polygons (i.e. zone diffuse seismicity).**

- **Each object has associated different field information. For example, an earthquake (a point) has associated the magnitude, depth, longitude, latitude, etc. fields.**

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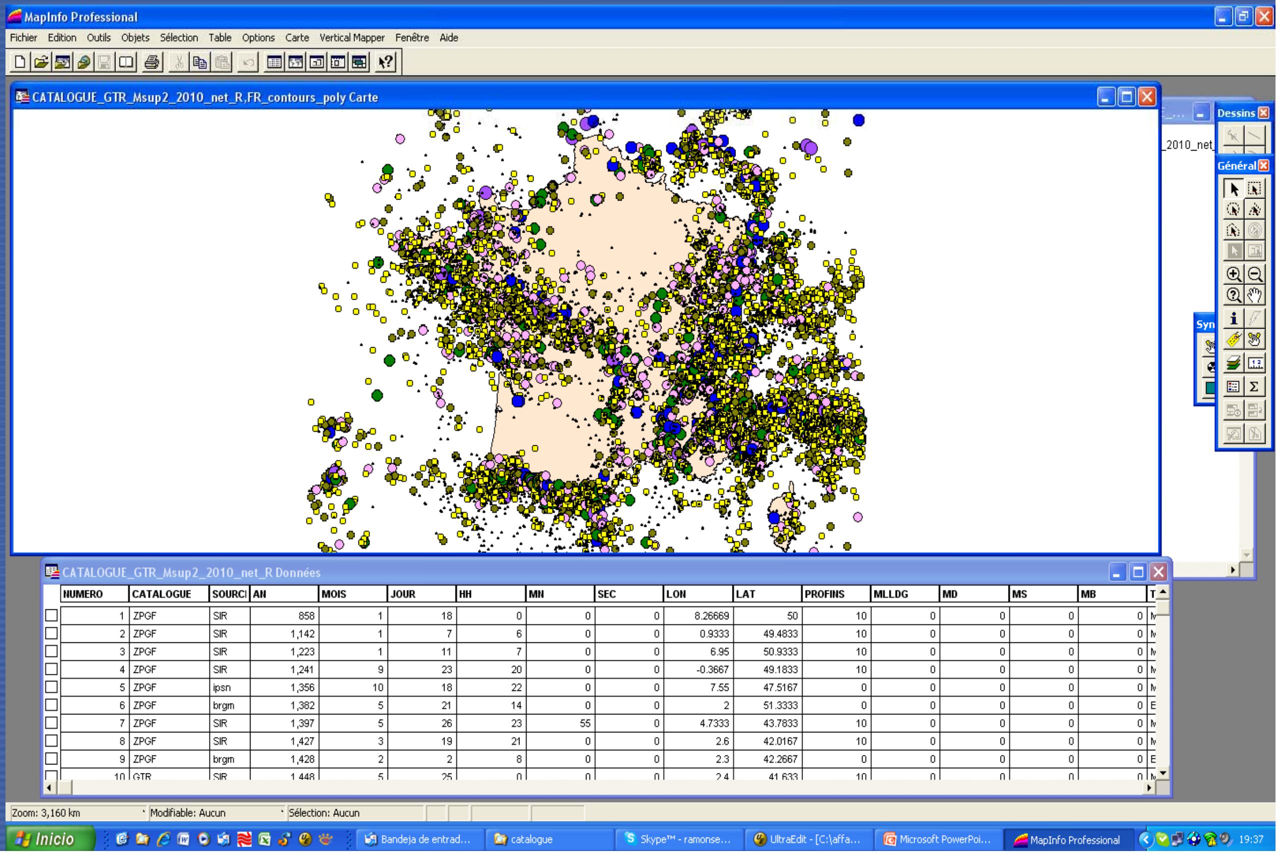
General description of a GIS

- **The database should contain a detailed description of the type of layers, objects and a good description of the field information.**



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Types of presentation of a GIS

1. Case 1: The client has its own GIS (ArcGis, for instance). In this case, the database delivered by consultants is composed by the layers of information in the specific GIS format. A standard GIS is recommended (ArcGis, Mapinfo, etc.).
   - **Advantages**: It is the simplest case. The client can modify information and generate new information.
   - **Disadvantages**: The client needs experience in GIS and it has a economical cost

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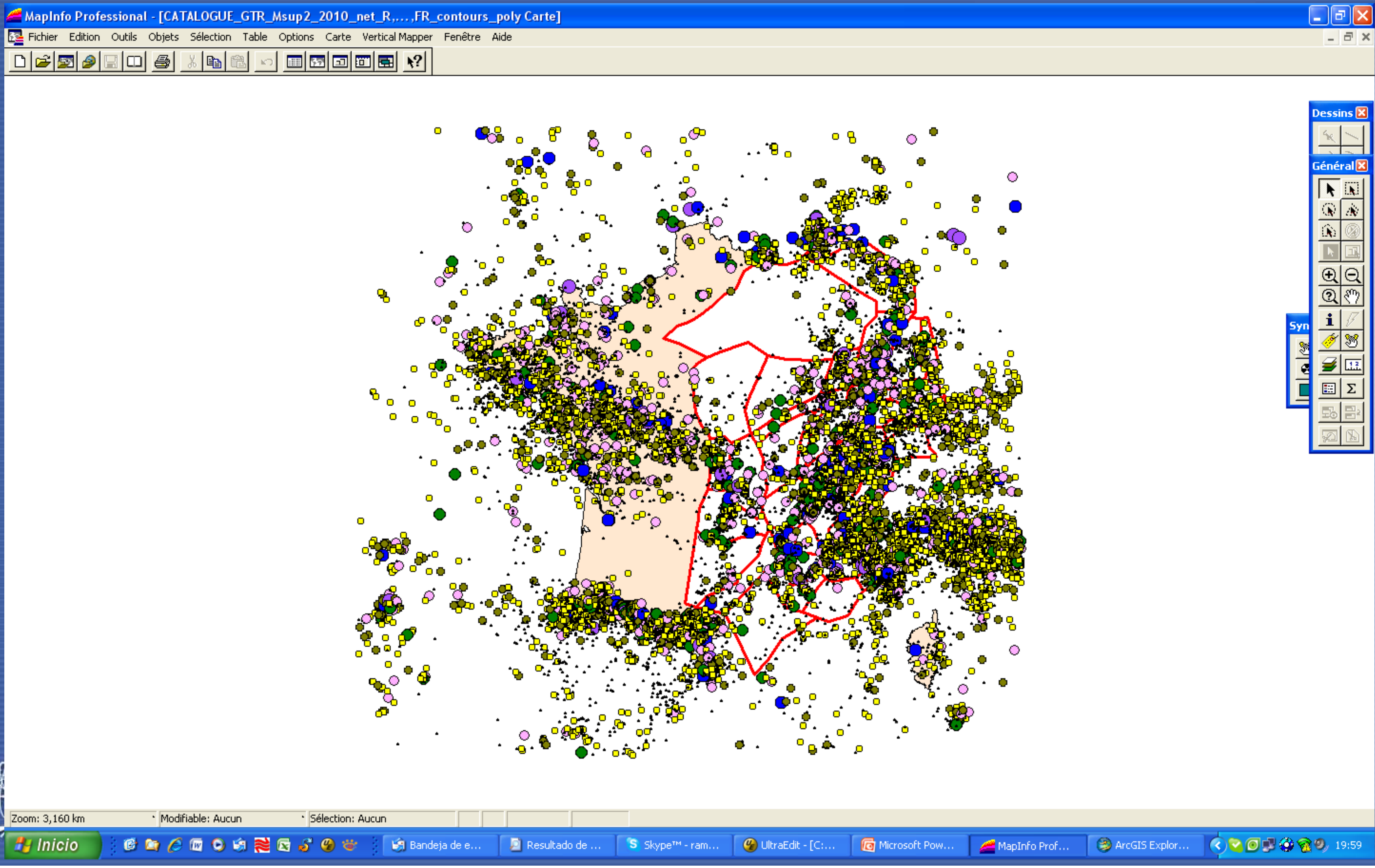
Types of presentation of a GIS

2. Example: Mapinfo, ArcGIS, etc.



Types of presentation of a GIS

2. Case 2: The client has not a GIS software. In this case there are 2 possibilities:
   a) Deliver the database (layers of information) with a viewer (ArcGis Explorer, for instance).
      - Advantages: It is also a very simple case.
      - Disadvantages: The client can view and cross information but he can not to modify or to generate new information

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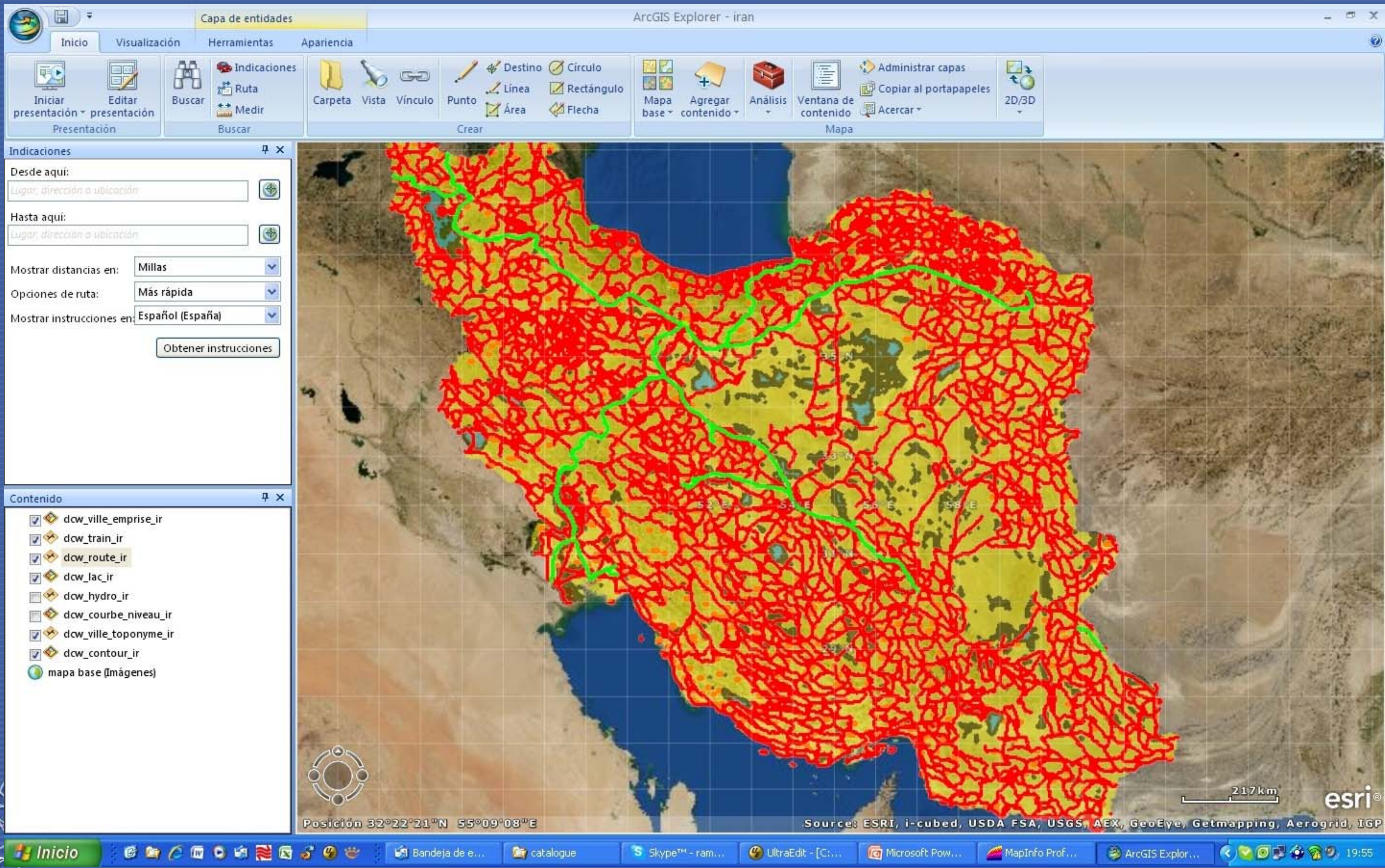
Types of presentation of a GIS

2. Example: ArcGis Explorer, Arc Reader, etc.



Types of presentation of a GIS

2. Case 2: The client has not a GIS software. In this case there are 2 possibilities:

   b) To develop a specific software for the project.

      - **Advantages**: The software is user-friendly. Only a minimum knowlegde in GIS is required. It is the most elegant.
      - **Disadvantages**: It is expensive. The client can view and cross information but he can not to modify or to generate new information.

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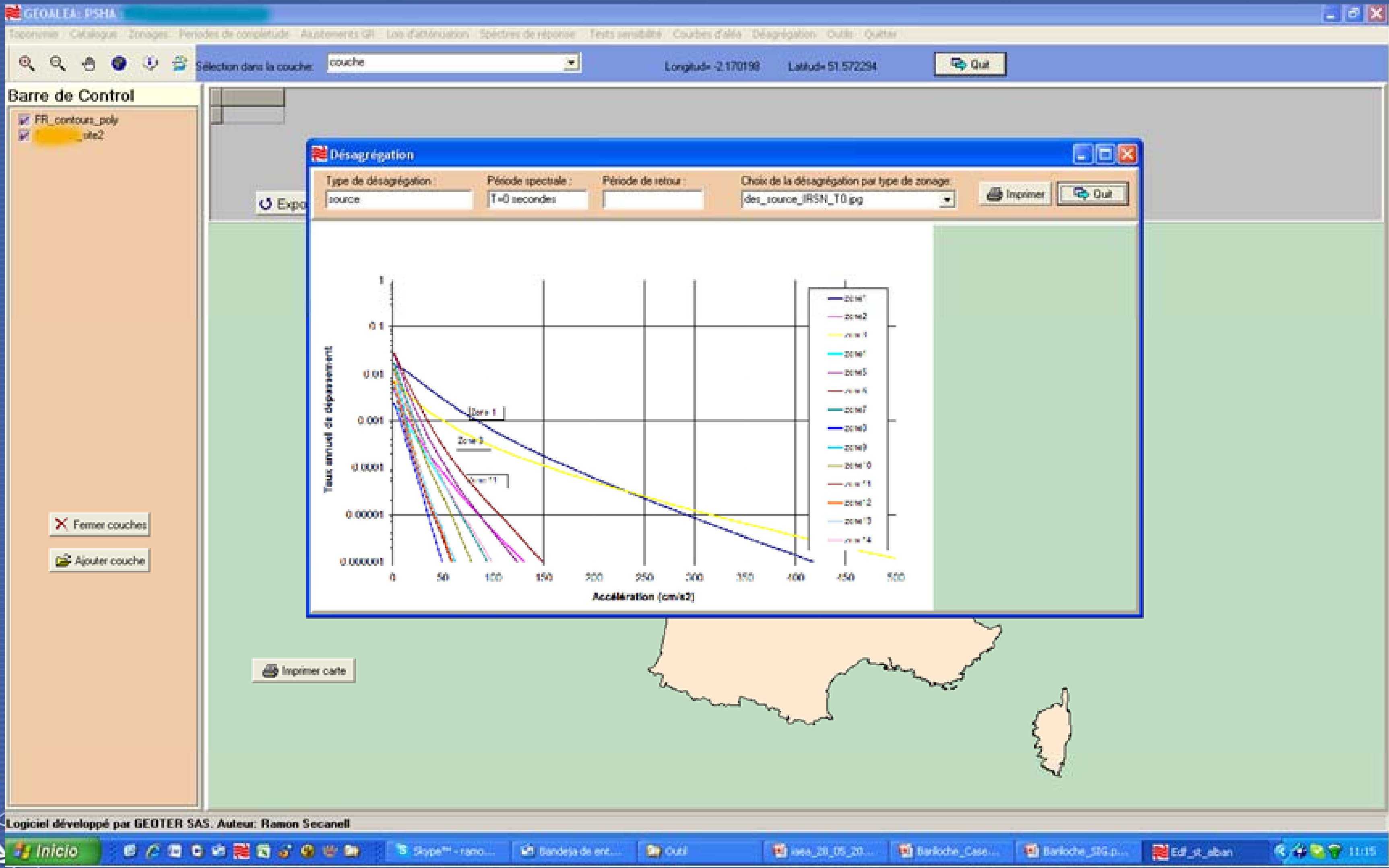
Types of presentation of a GIS

2. Example: GEOTER specific software



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Seismic Hazard Assessment case study.

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Summary of the study:

1. Development of the **database**:
   a) Geological, geophysical and geotechnical database
   b) Seismological database
   c) Geotechnical characterization of the site
   d) Use of a SIG (example)
2. **Seismotectonic models**
   1. Geological characterization
   2. Characterization of the seismic activity
3. **Attenuation relationship**
4. **Sensitivity studies**
5. Ground motion: definition of **response spectra**
6. **Conclusions**

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Geological Database: Collecting information

1. Analyze of old studies and regional studies
2. New data (geology, paleoseismicity, etc)
   a) PALEOSIS project
   b) SAFE (“Slow Active Faults in Europe”) project
   c) GEOFRANCE 3D (Recent deformation) project
   d) ENTEC (tectonics) project
   e) EUCOR-URGENT, studies of CEREGE, Grenoble, CEA, IRSN, etc.

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Seismological database. Main sources:

1. LDG catalogue: homogeneous from 1962
2. Levret et al. 1996 catalogue (revision of 140 historical earthquakes)
3. BRGM (Bles et al. 1998)
4. Sisfrance database (1100 historical earthquakes, 86000 macroseismic data)
5. RAP strong motion database (526 strong motion records selected)

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Relations used to perfom the catalogue:

- Intensity to magnitude: $M = 0.44\ I_O + 1.48\ \log_{10} R + 0.48$
- Ml to Ms: Ambraseys et al. (1985):

$$M_S = 0.09 + 0.93\ ML$$

- Mmacro to Ms (fitted): $Ms = 0.92\ Mmacro + 0.25$
- Ml to Mw (Drouet 2006): $Mw=0.8*Ml(LDG)-0.06$
- Mmacro to Mw (Gruntal et Walstrom 2003):

$$Mw = 0.67 + 0.56 * Mmacro + 0.046 * (Mmacro)^2$$

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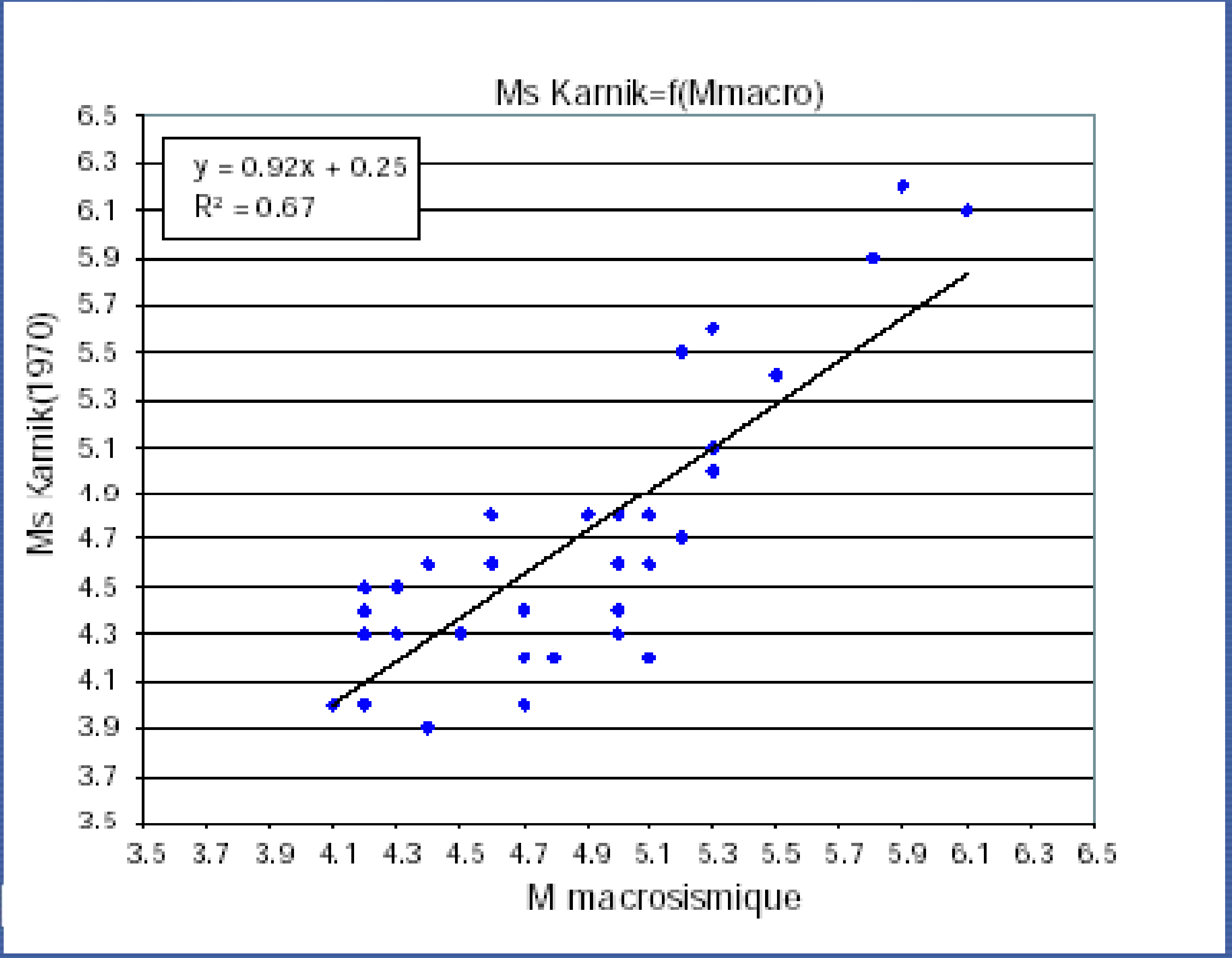
Conversion Mmacro to Ms:



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Elimination of foreshocks and aftershocks using temporal and spatial windows:

Classe de Magnitude du choc principal	Fenêtre temporelle (Mois)	Distance (km)
[4.5-4.9]	1	5
[5.0-5.4]	2	10
[5.5-5.9]	3	15
[6.0-6.4]	4	20
[6.5-6.9]	5	50
[7.0-7.4]	6	80
≥7.5	7	100

Specific GEOTER software used

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Definition of the **periods of completeness**:

- Two types of zone used:
  - zones largely populated
  - zones poorly populated (Alpine and Pyrenean zones)
- Type of methodology used:
  - Stepp plot
  - Year histogram for range of magnitude
- Definition of completeness periods within each zone and with each type of magnitude.

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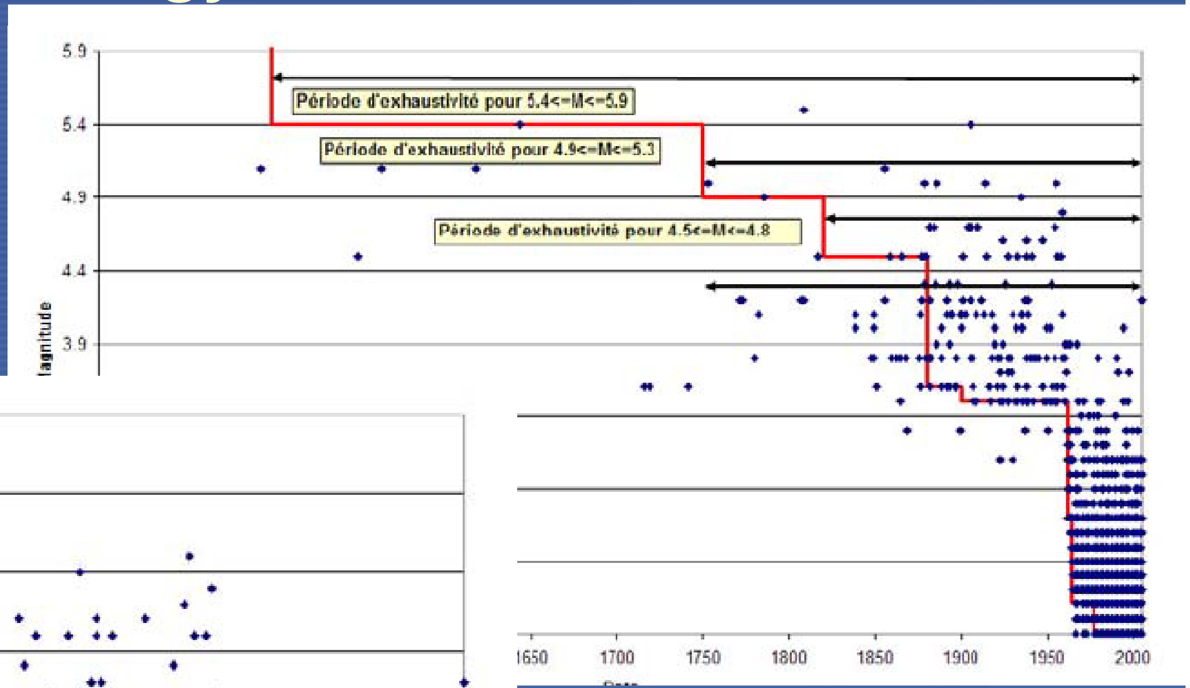
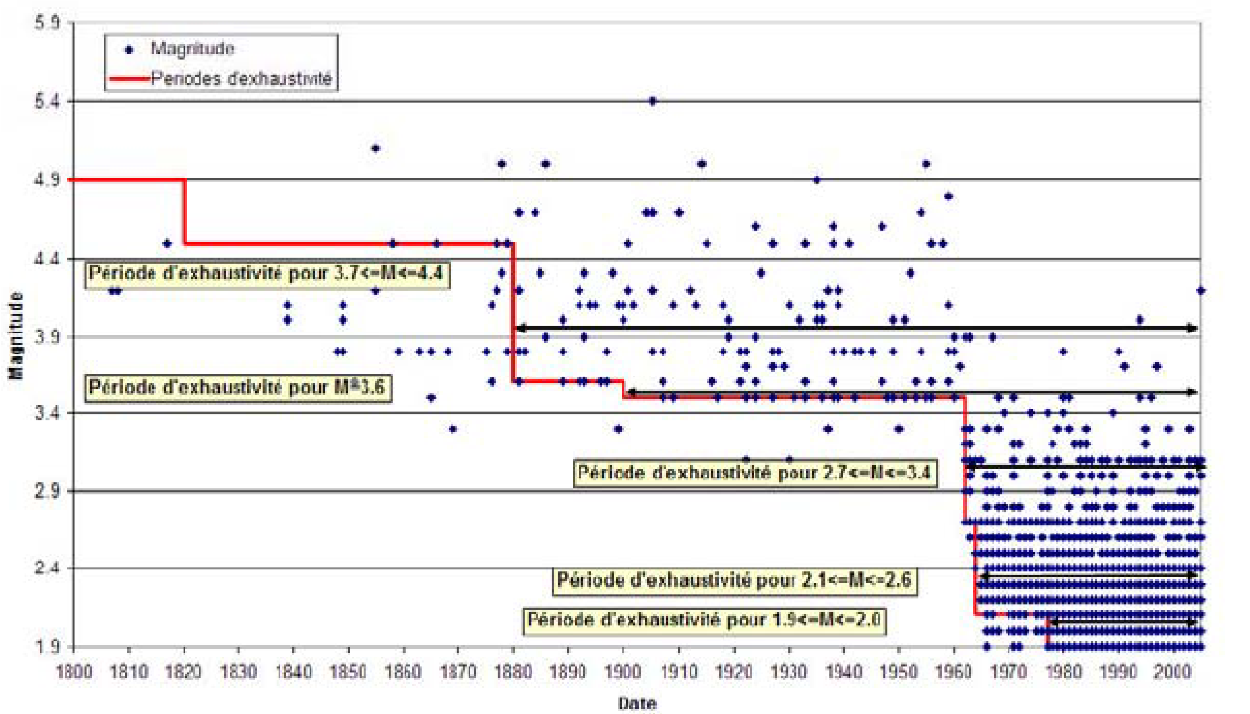
Stepp plot methodology:





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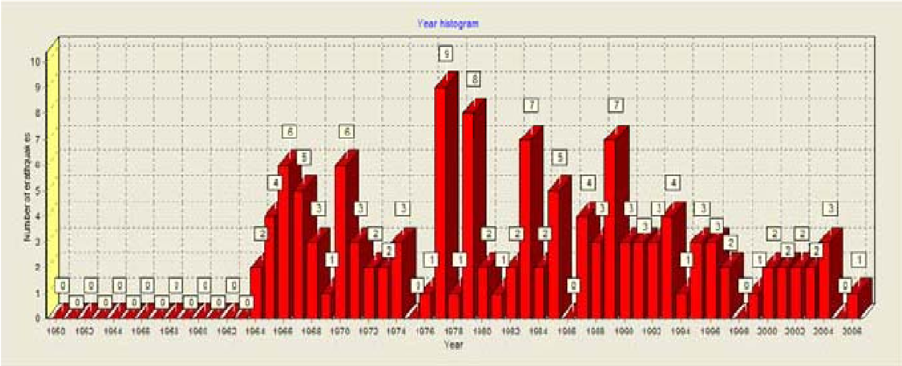
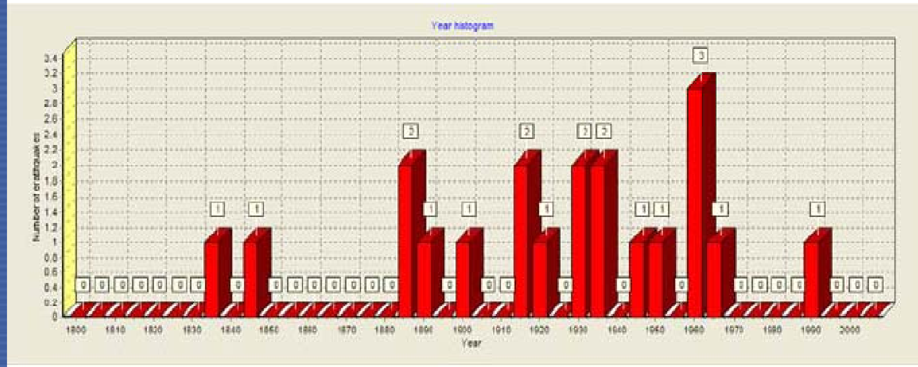
Year histogram methodology:

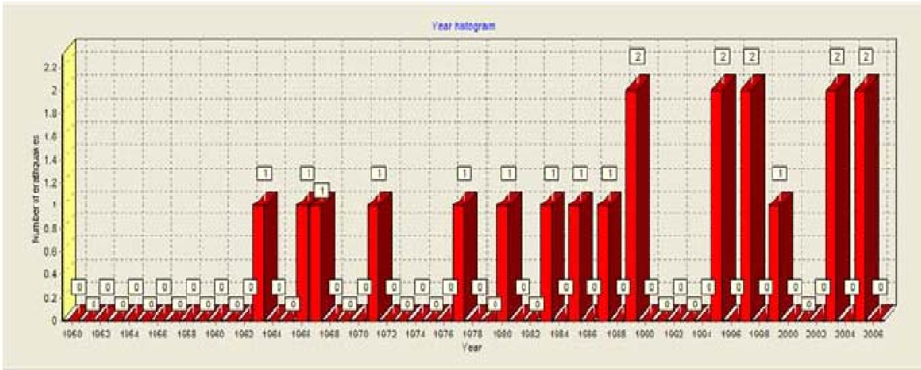
M=2.5



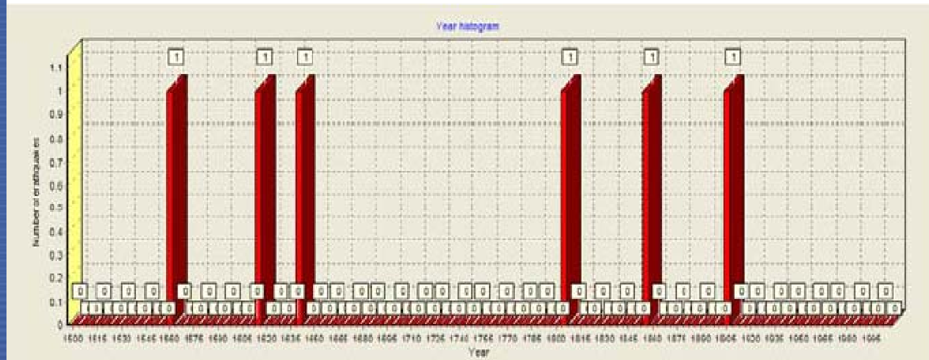
M=3.9-4.0



M=3.0



M=5.1-5.5



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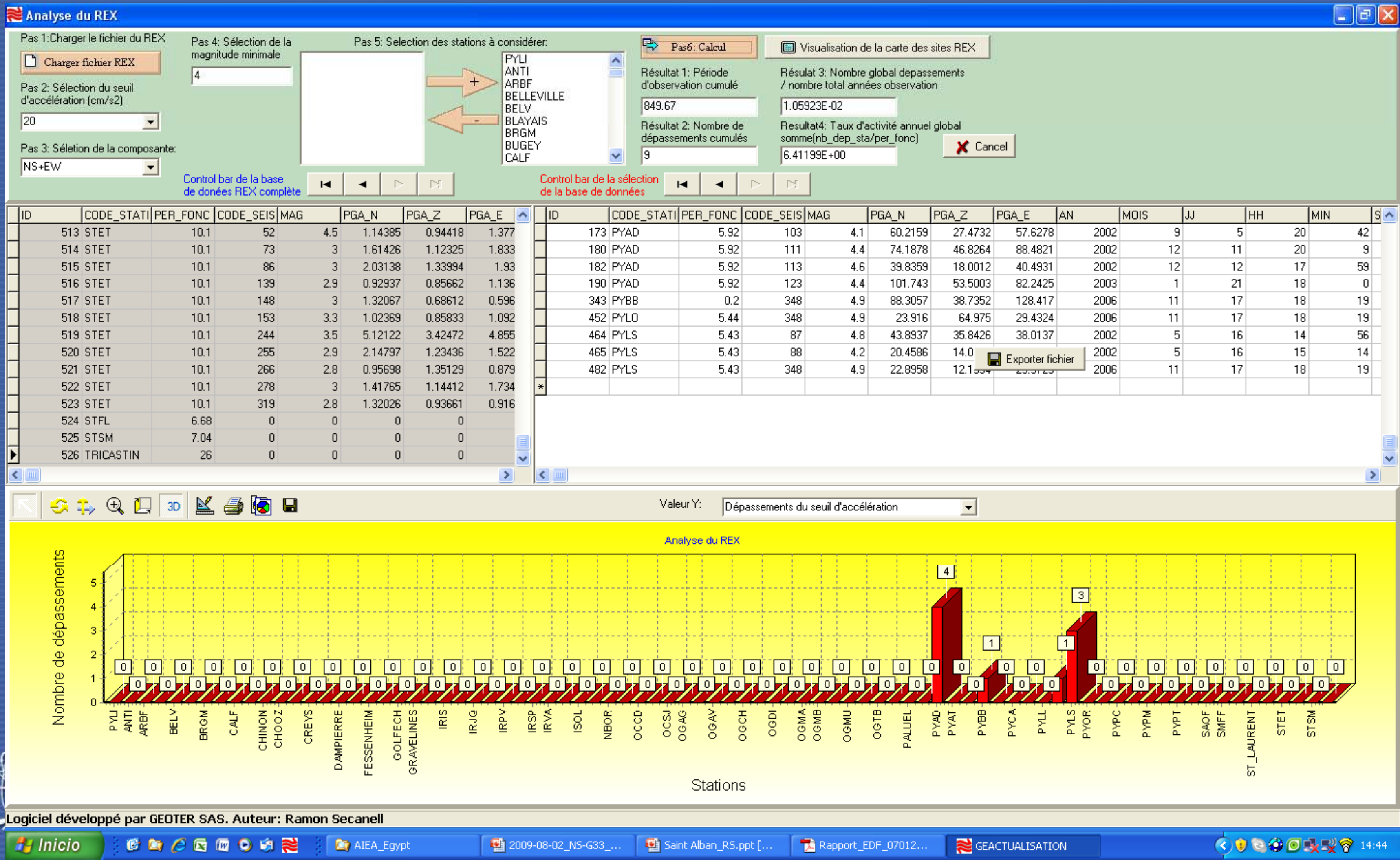
Strong motion database: specific GEOTER software developed to analyze the RAP database



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Seismotectonic model: 3 seismotectonic models have been retained to take into account the different opinions of the scientific community.

1. Model 1
2. Model 2
3. Model 3

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Seismic characterization of the seismic zone sources:

1) Poisson model

- Slope of the GR law (b-value)
- Activity rate (a-value)
- Mmax

2) Characteristic model

- Characteristic magnitude
- Return period
- Elapsed time from last characteristic event

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Adjustment of the GR law: Method of maximum likelihood (Weichert).

- a, b, λ, β and its uncertainty.
- Consideration of periods of completeness
- Consideration of number of earthquakes for each range of magnitude
- Consideration of the magnitude level

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Criteria for selection of the attenuation relationship:

- Date of publication of the law
- Access to sources
- Validity domain
- Law defined in many spectral periods
- Consideration of site effects
- Consideration of focal mechanism
- Coherency with strong motion recorded in France. Publications of Sherbaum et al. 2004 and Drouet 2006

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Attenuation relationship retained:

- **RFS 2001-01**: imposed by French regulations and well classified in Sherbaum et al. 2004 and Drouet 2006. Defined in terms of **Ms and Rhypo**.
- **Sabetta & Pugliese (1996):** largely used in Europe (EC8). Defined in terms of **Ml and Rjb**
- **Abrahamson & Silva (1997):** In agreement with French strong motion (Sherbaum et al. 2004 and Drouet 2006). Defined in terms of **Mw and Rrup**.
- **Campbell & Bozorgnia (2008):** NGA attenuation law

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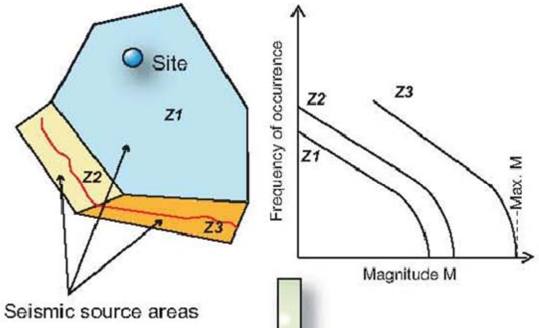
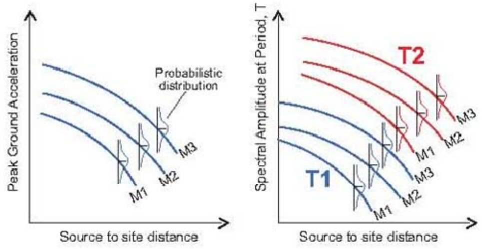
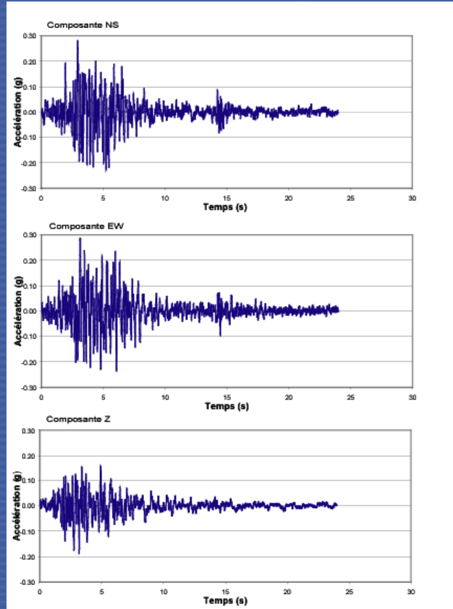
Ground motion: PSHA calculation

1. Definition of seismic sources

2. Definition of the attenuation relationship

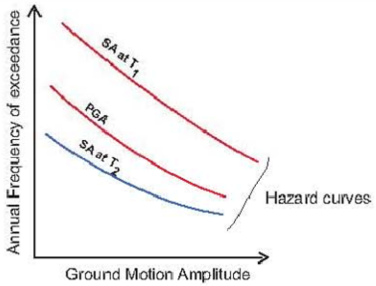




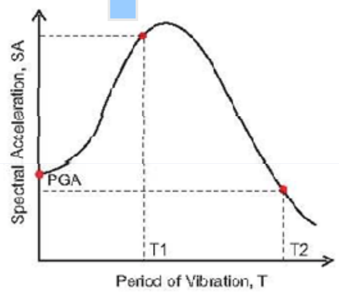


5. Time histories adapted to response spectra

3. PSHA calculation: seismic hazard curves



4. Uniform response spectra



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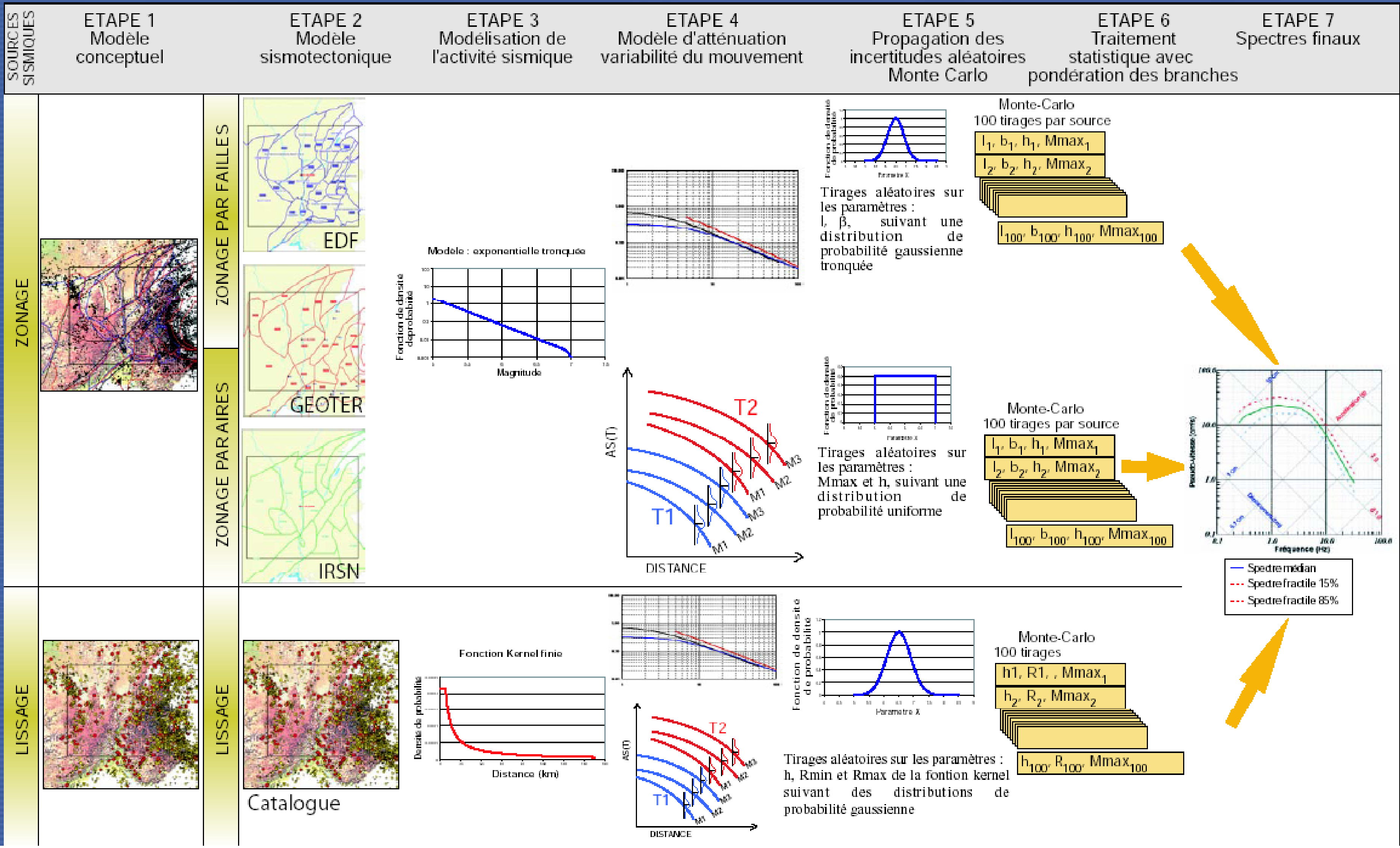
• Ground motion: Logic tree used



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Sensitivity studies:

- Attenuation law and type of magnitude
- Seismotectonic zonation
- 2 or 3 standard deviation in the integration process of the attenuation law
- Mmin
- Mmax

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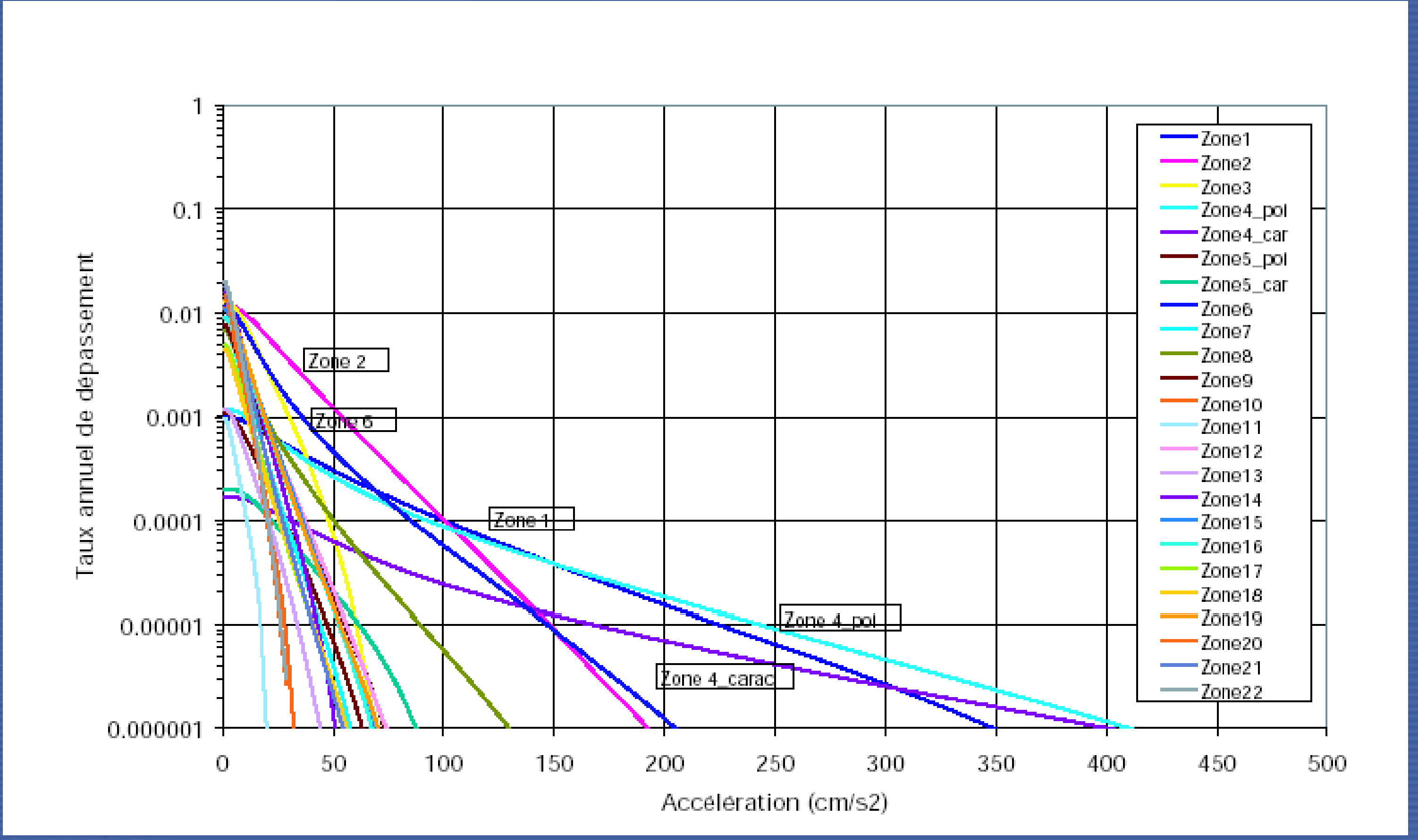
- Example of **deaggregation** by source (EDF model + RFS 2001-01)



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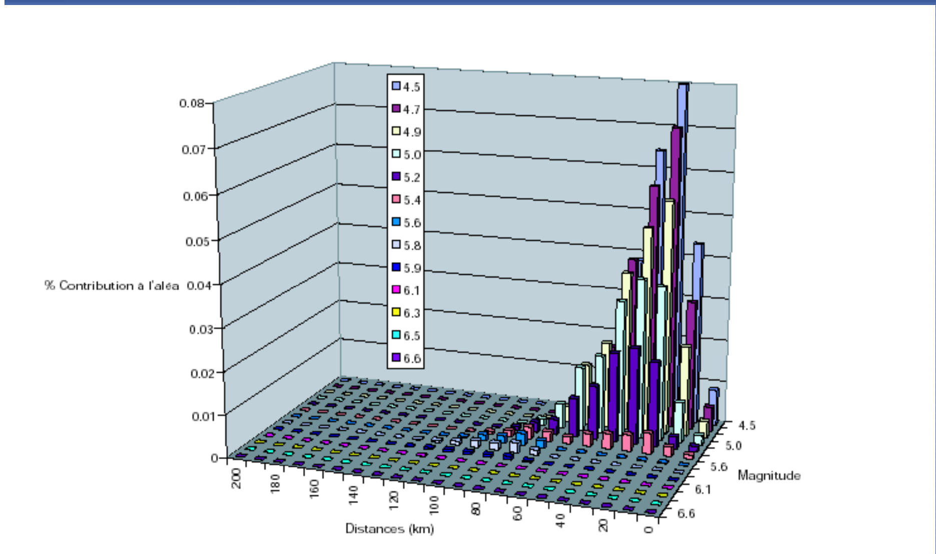
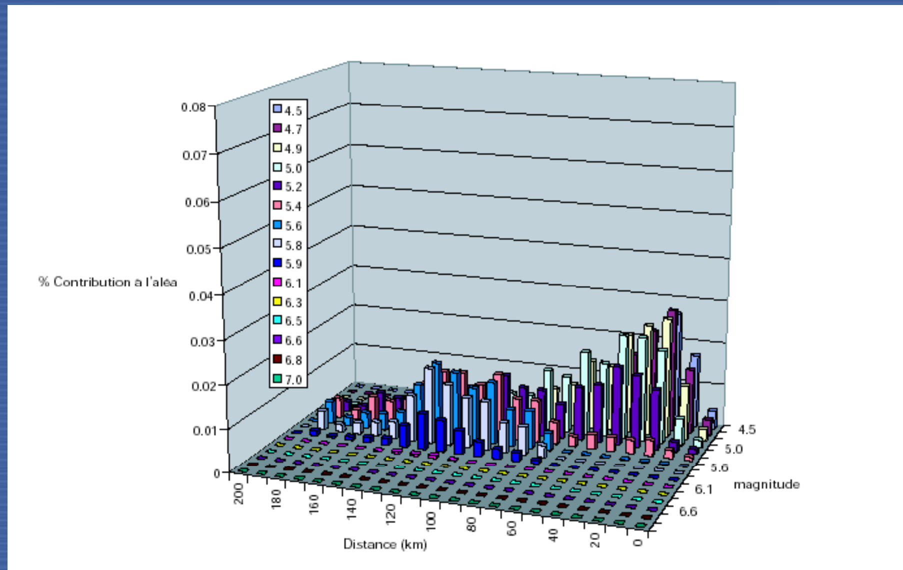
- Example of **deaggregation** by couple magnitude-distance

T=0 s.



T=2 s.



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DSHA. Case study

Deterministic Seismic Hazard Assessment.

Case study.

DSHA. Case study

Methodology:

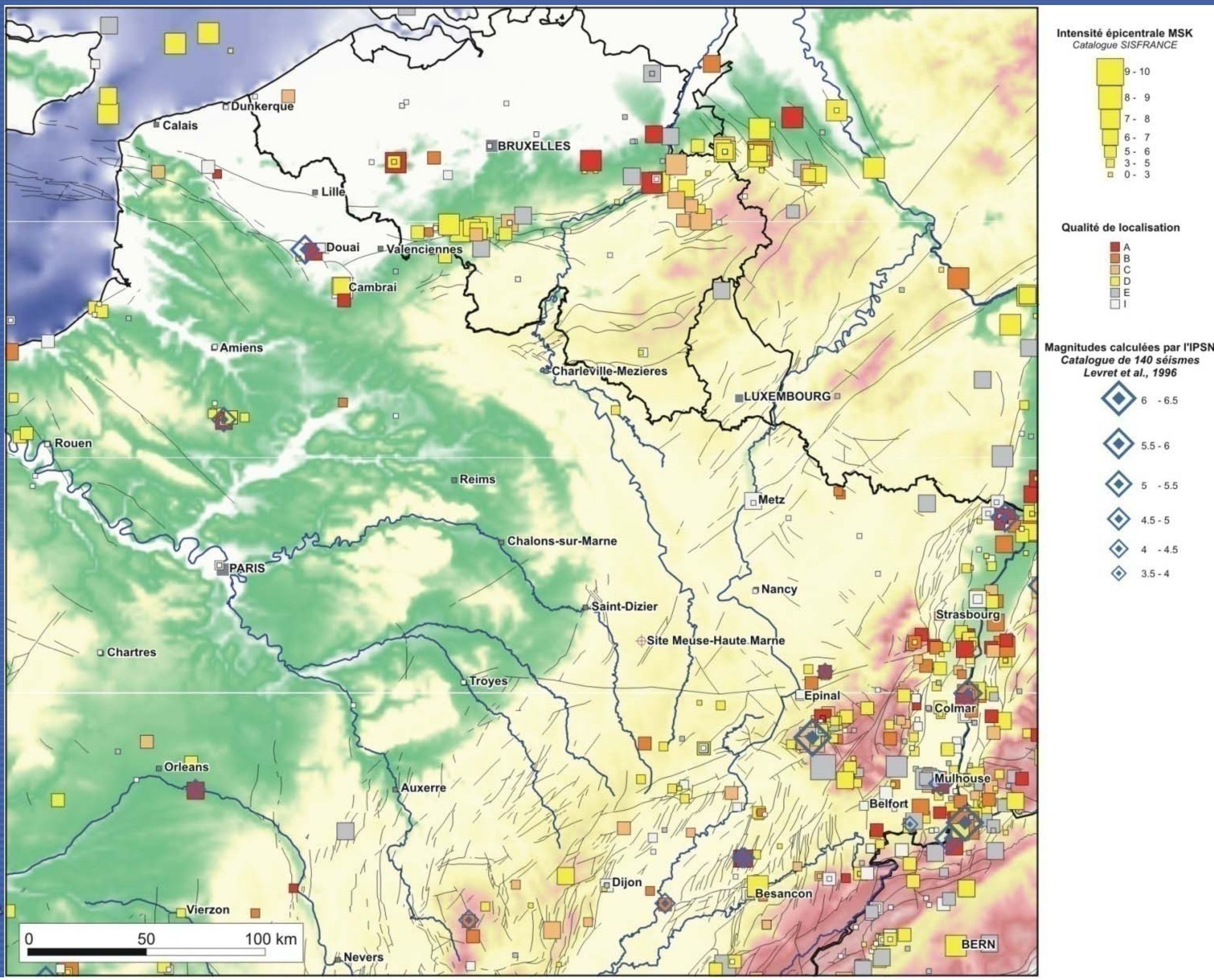
- DATA SELECTION AND VALIDATION
- SEISMOTECTONIC ZONATION
- REFERENCE EARTHQUAKE DEFINITION : SMHV, SMS AND SMPP
- SITE CONDITIONS
- GROUND MOTION CALCULATION

LOGIC TREE and Monte carlo process

- RESPONSE SPECTRA AT SURFACE
- RESPONSE SPECTRA AT DEPTH

DSHA. Case study

Historical seismicity



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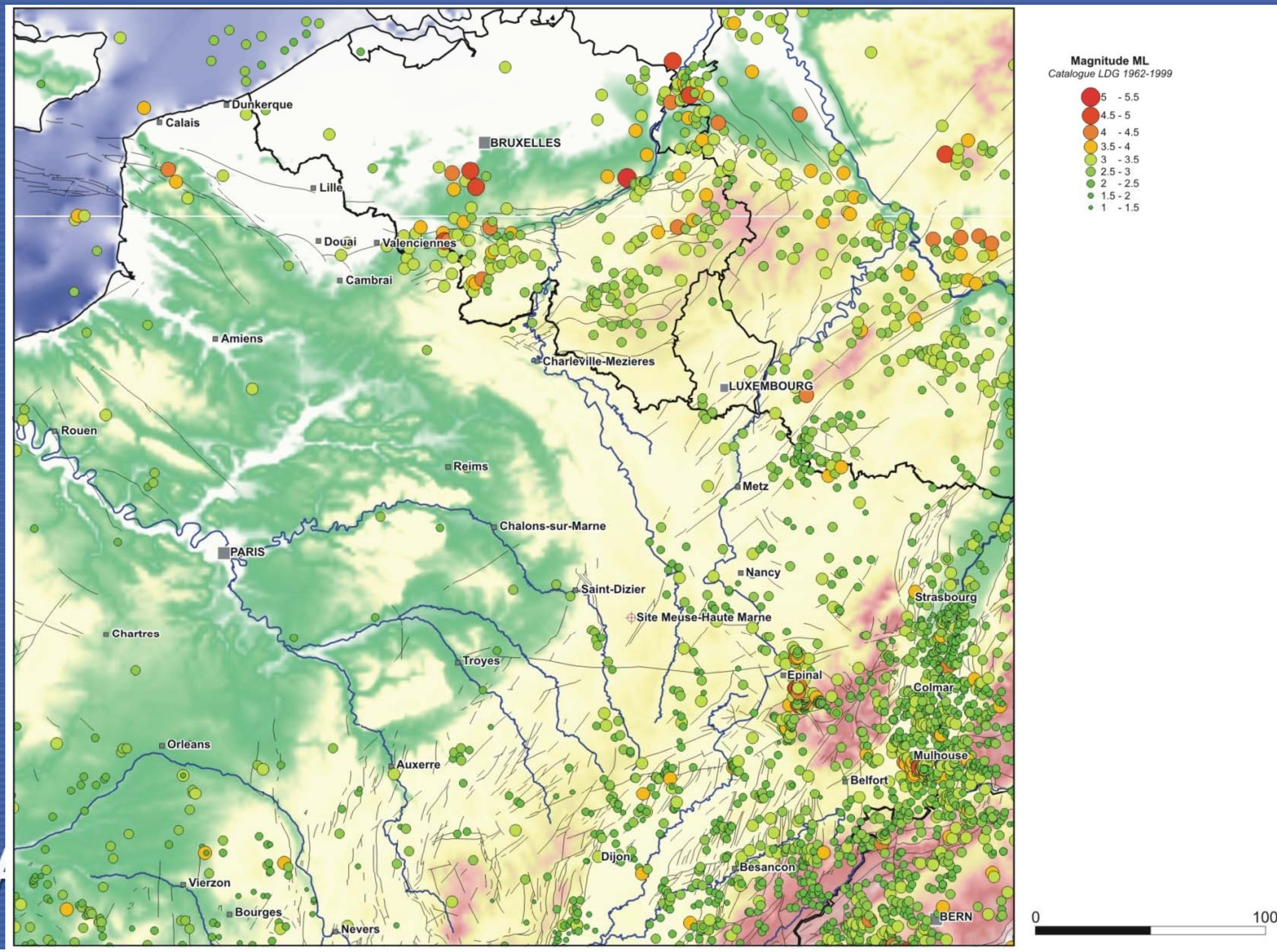
Instrumental seismicity



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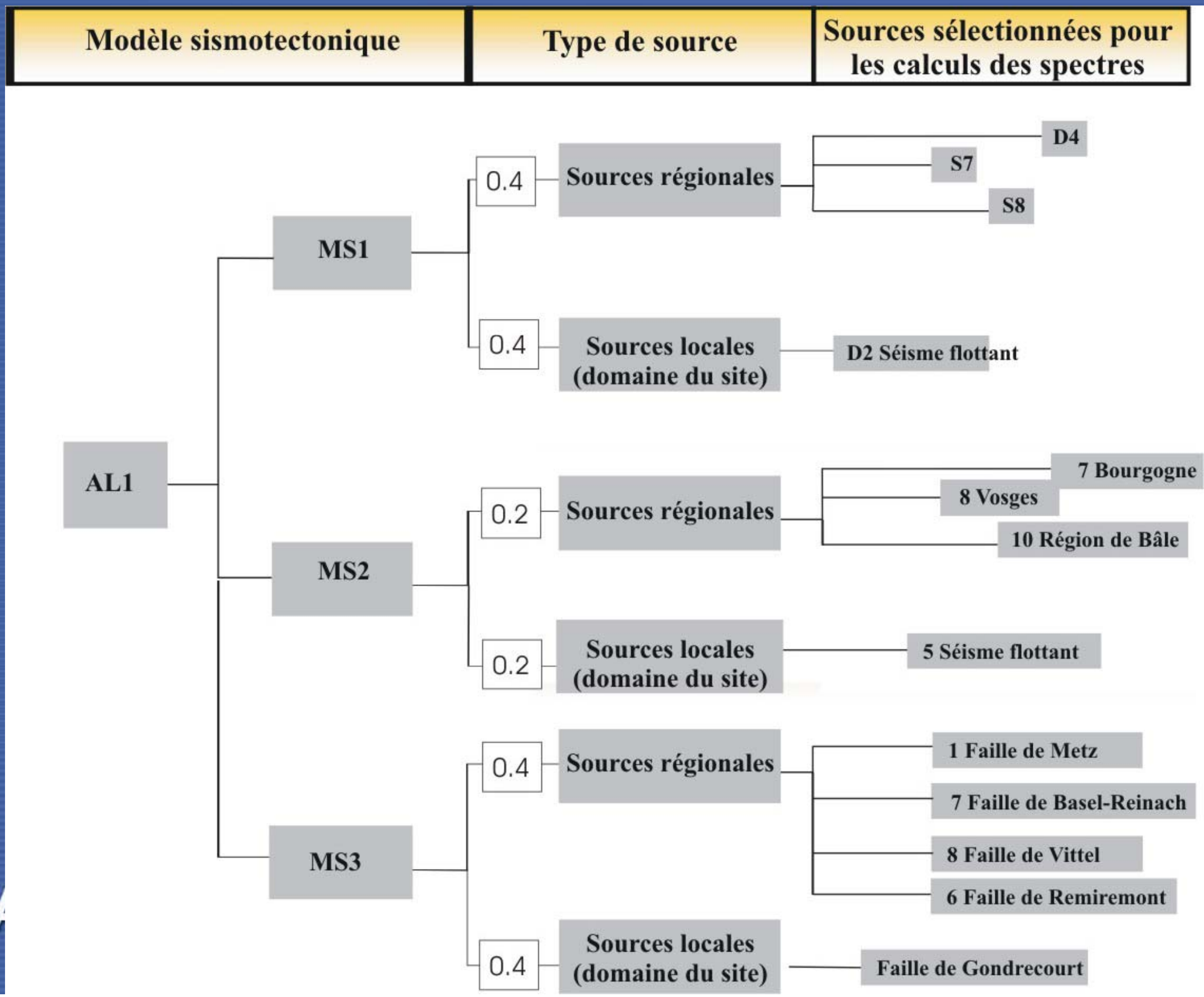
SMHV – Final logic tree :

:



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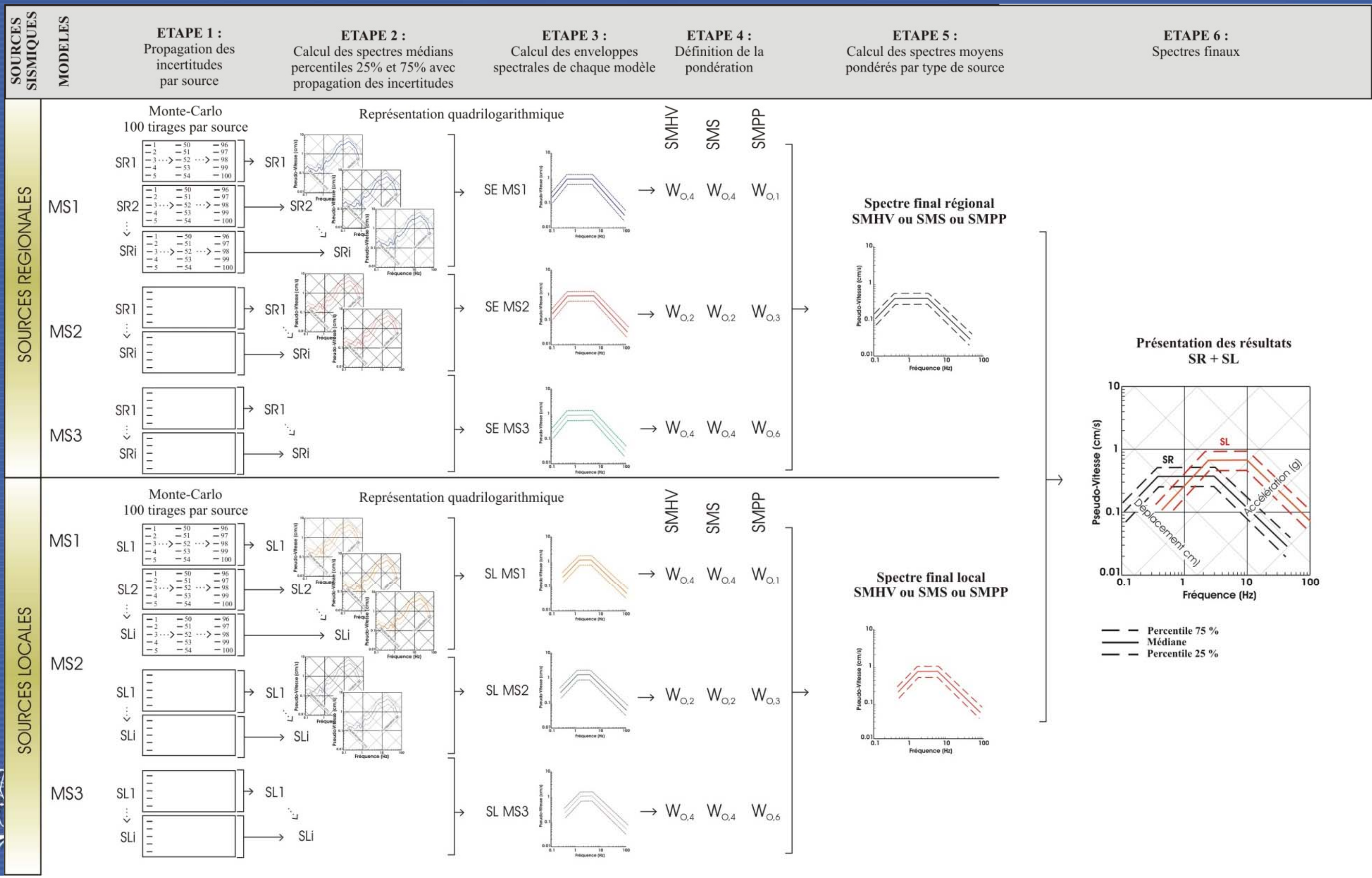
Response spectra calculation process :



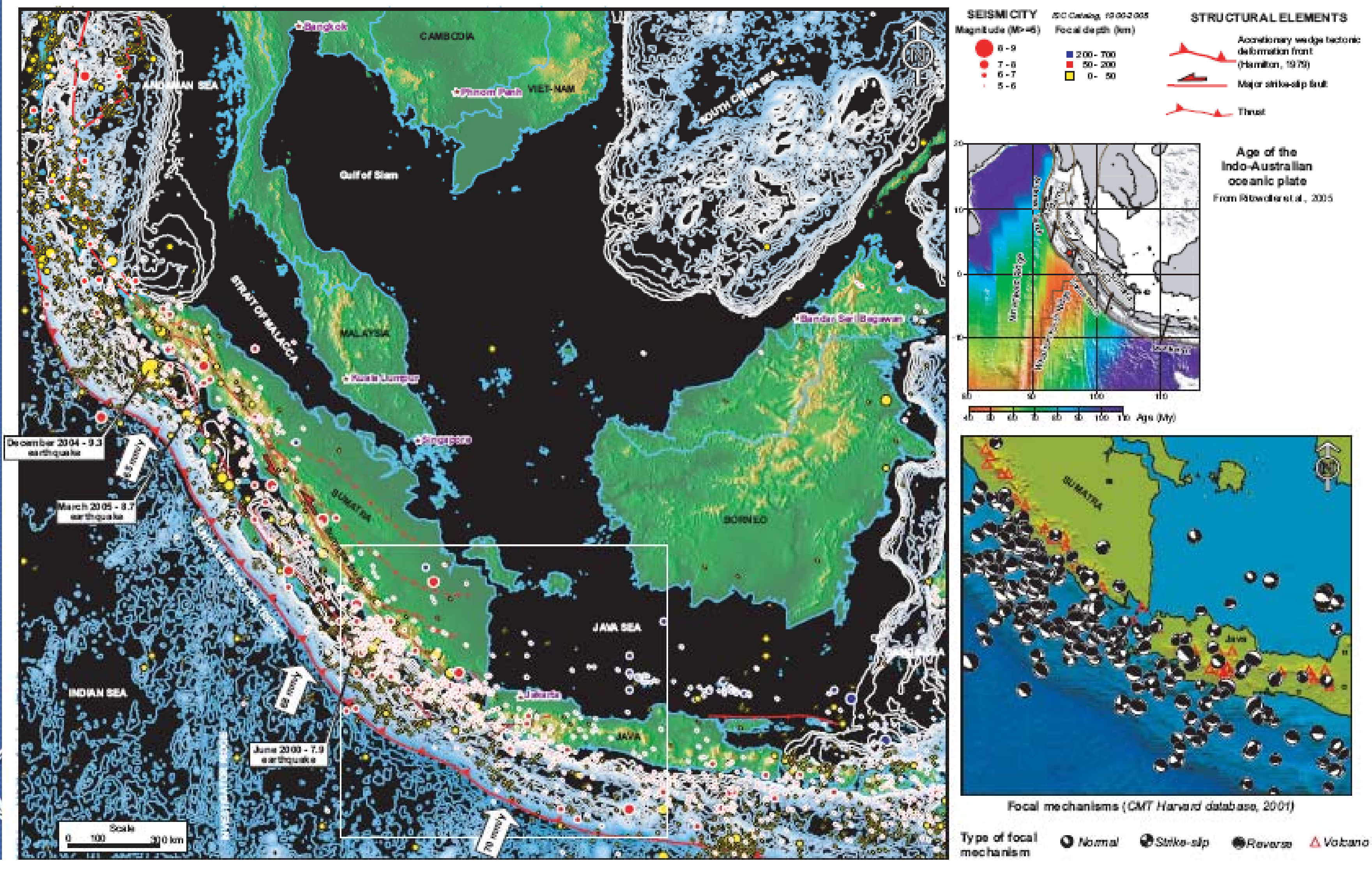
PSHA in Indonesia

PSHA in Indonesia. Case study.

Jakarta

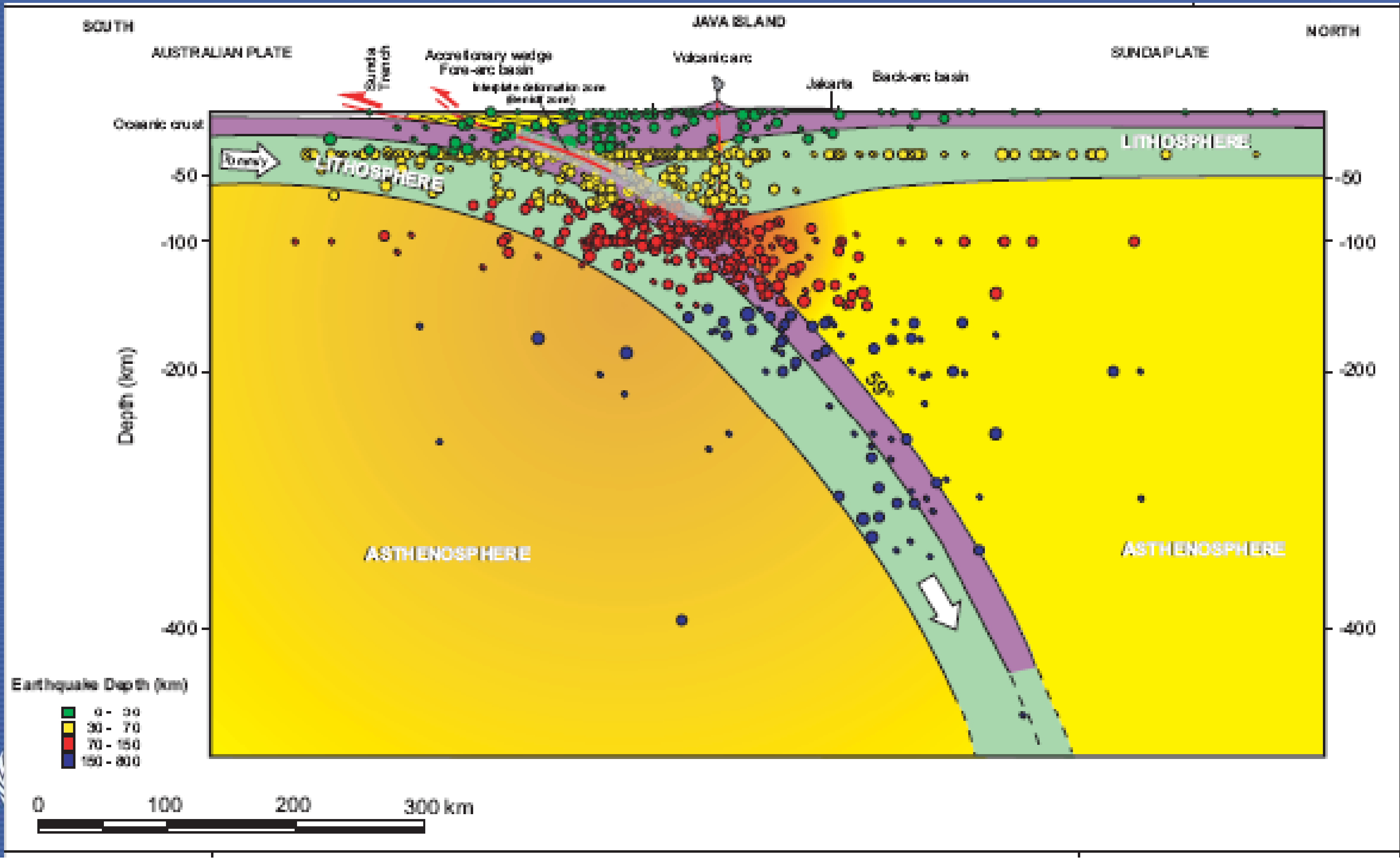
PSHA : Indonesian case

Seismotectonic settings of western Indonesia



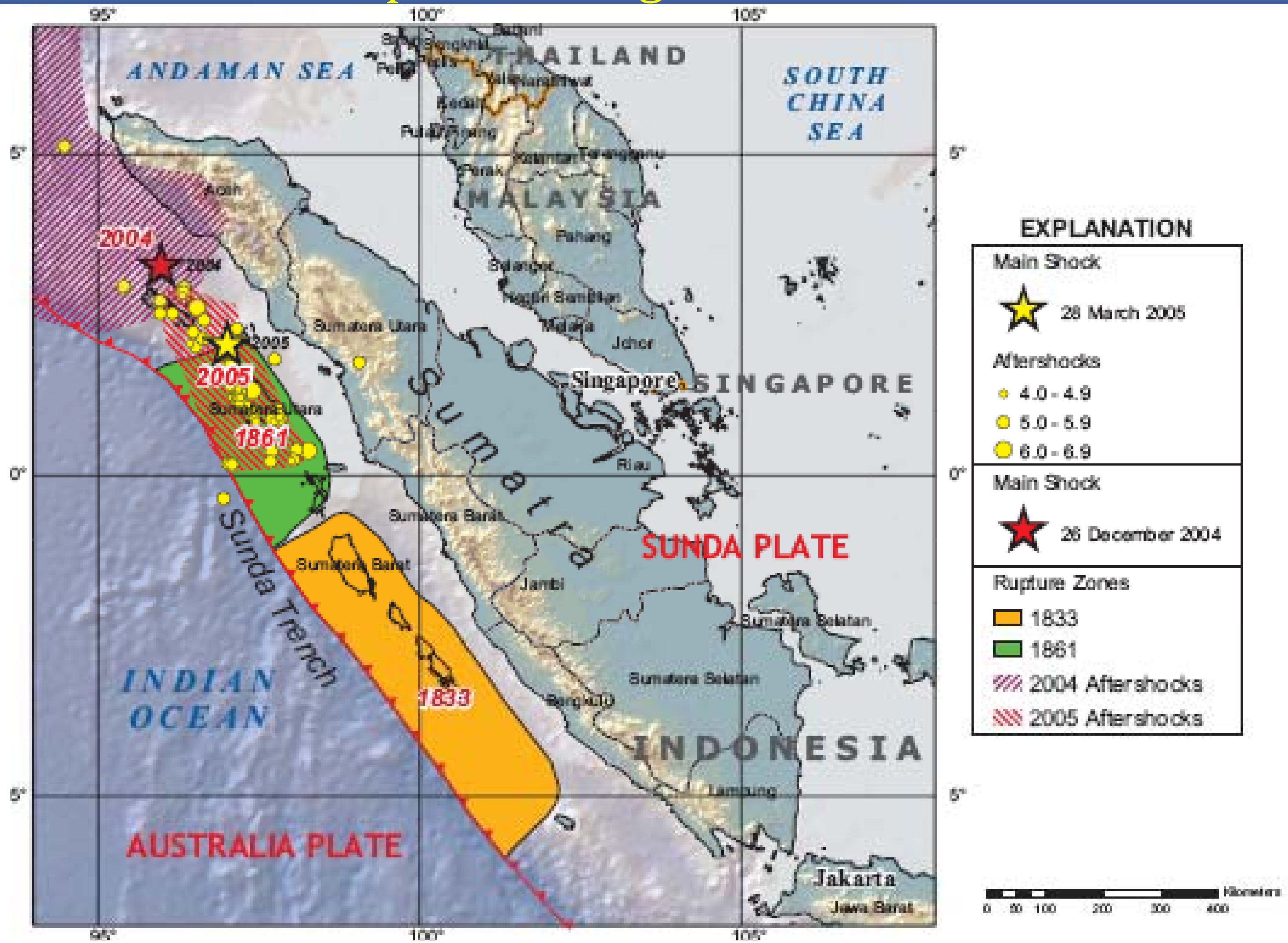
PSHA : Indonesian case

North-South cross-section of the Java subduction and location of hypocenters



PSHA : Indonesian case

Large historical earthquakes and rupture zones due to large earthquakes along the Sumatra subduction



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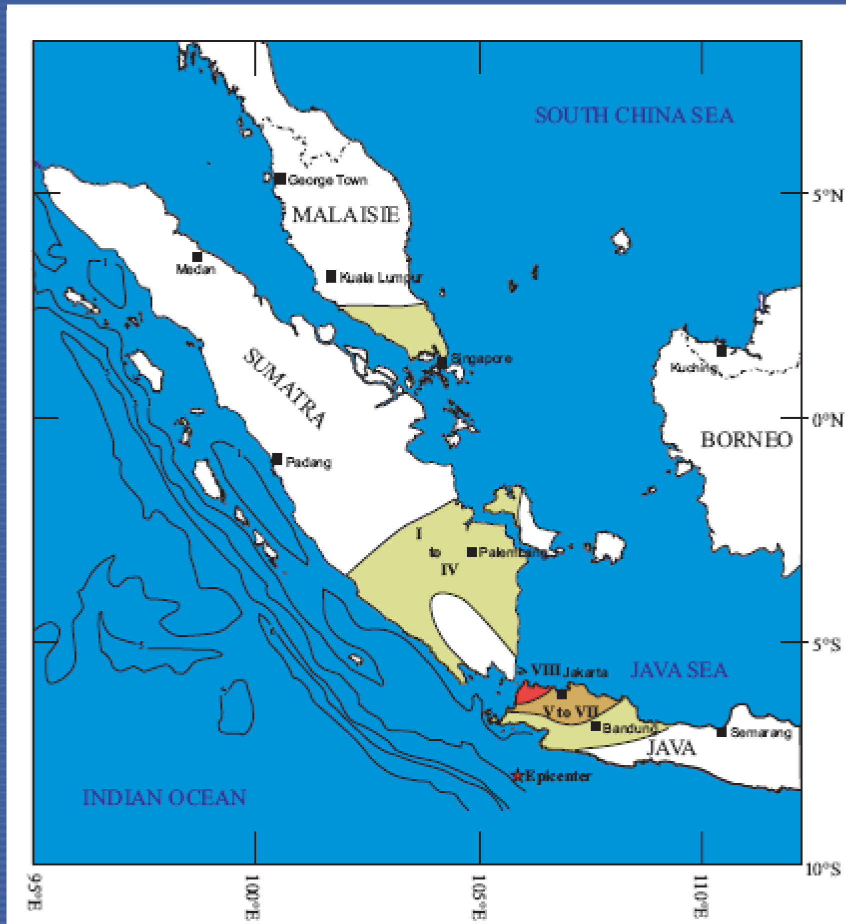
Isoseismal map for the february 27, 1903 Java-Sumatra earthquake



Date: February 27, 1903
Hour: 00.43
Magnitude: 7.6 MS, 7.9 (Kanamori and Abe 1979)
Epicenter: 8.00°S; 106.00°E
Depth: 25 km
★ Epicenter
V Regional Intensity (MM)

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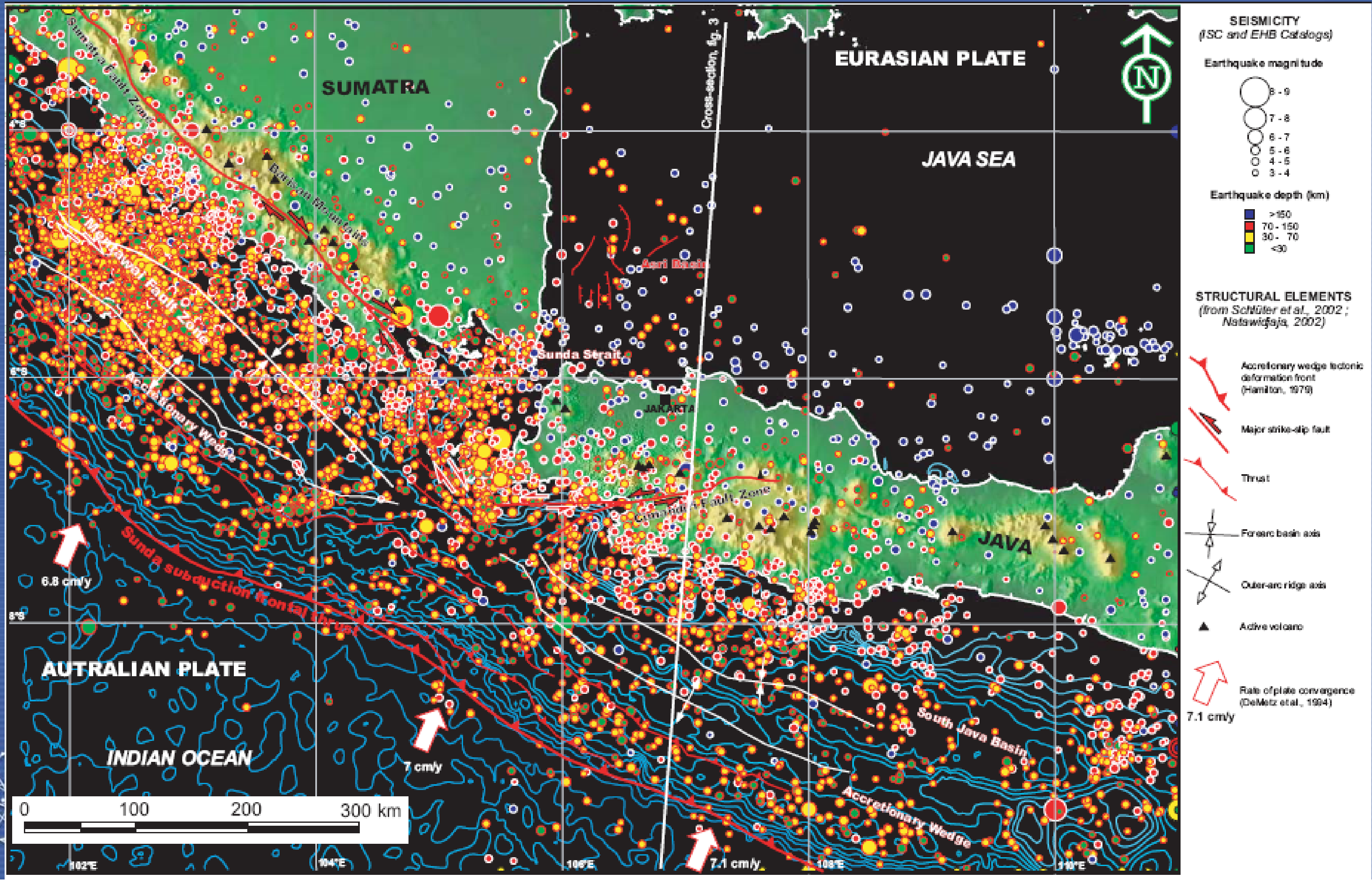
Seismotectonic context of the Sunda Strait, south Sumatra and west Java islands



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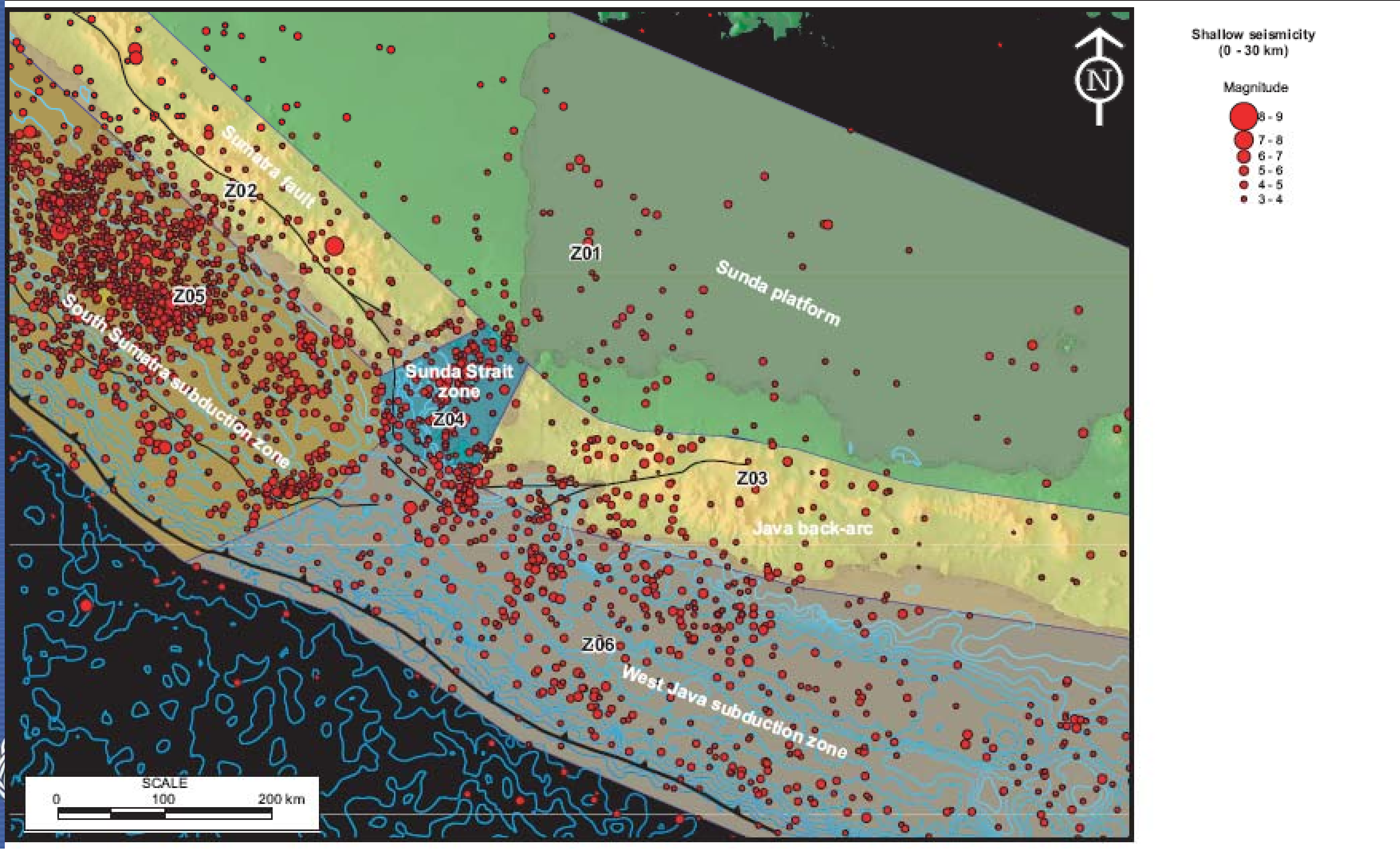
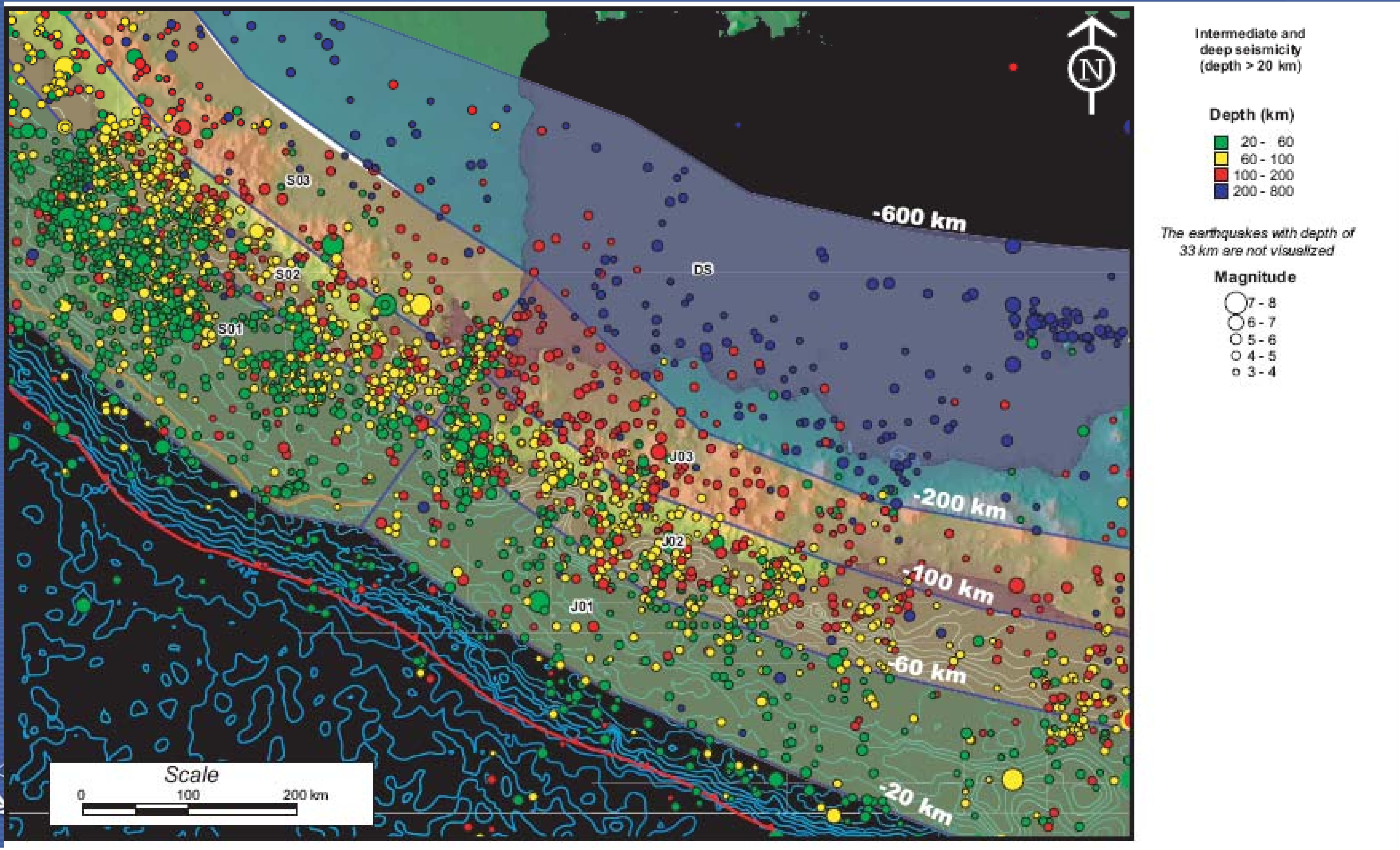
Regional shallow seismic zonation of the south Sumatra and west Java islands, used for the probabilistic seismic hazard assessment of



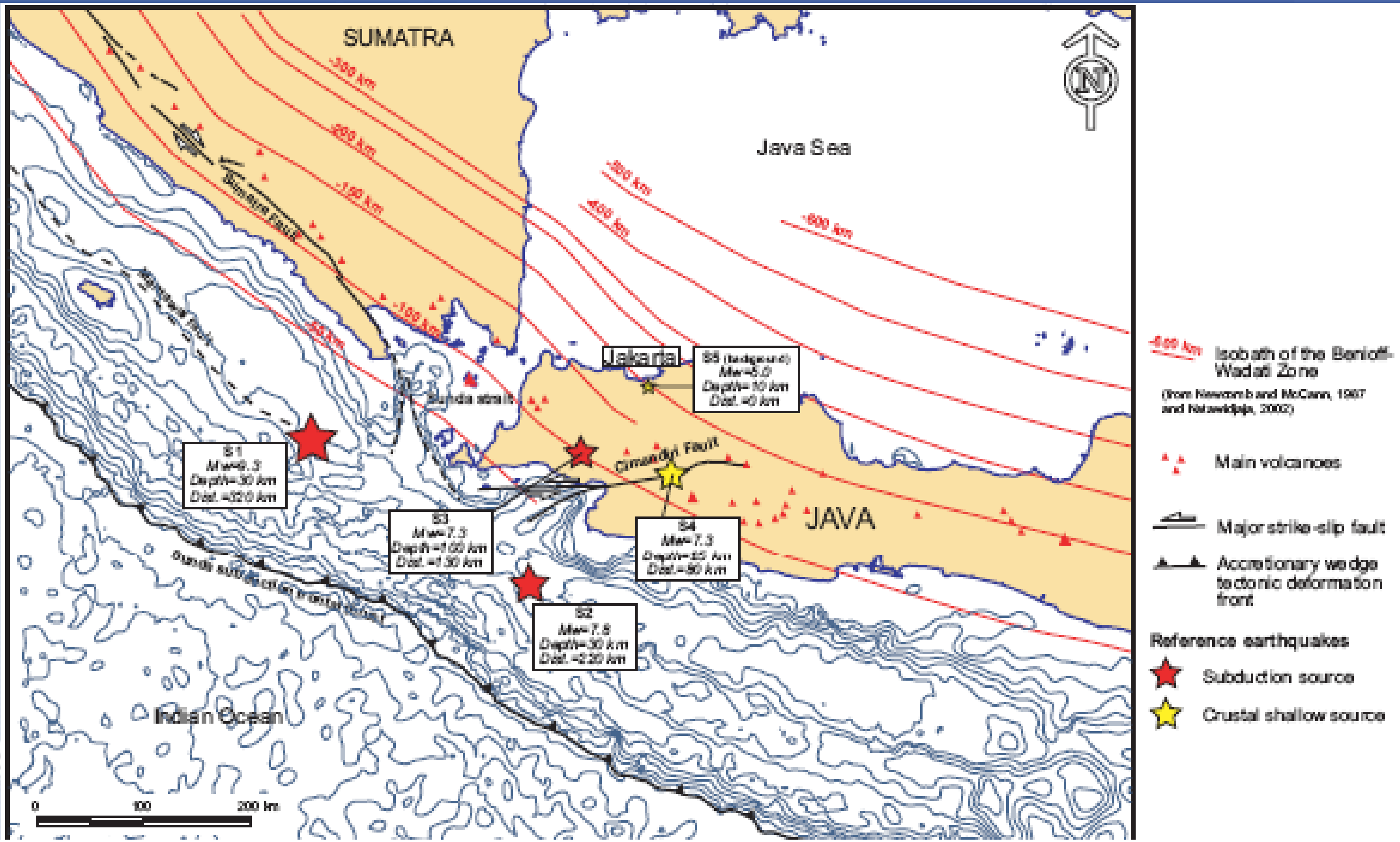
PSHA : Indonesian case

Regional seismic zonation of the Sumatra-Java subduction used for the probabilistic seismic hazard assessment of Jakarta



PSHA : Indonesian case

Isobaths of the Benioff-Wadati zone beneath the South Sumatra and West Java islands and deterministic hypothesis used for the



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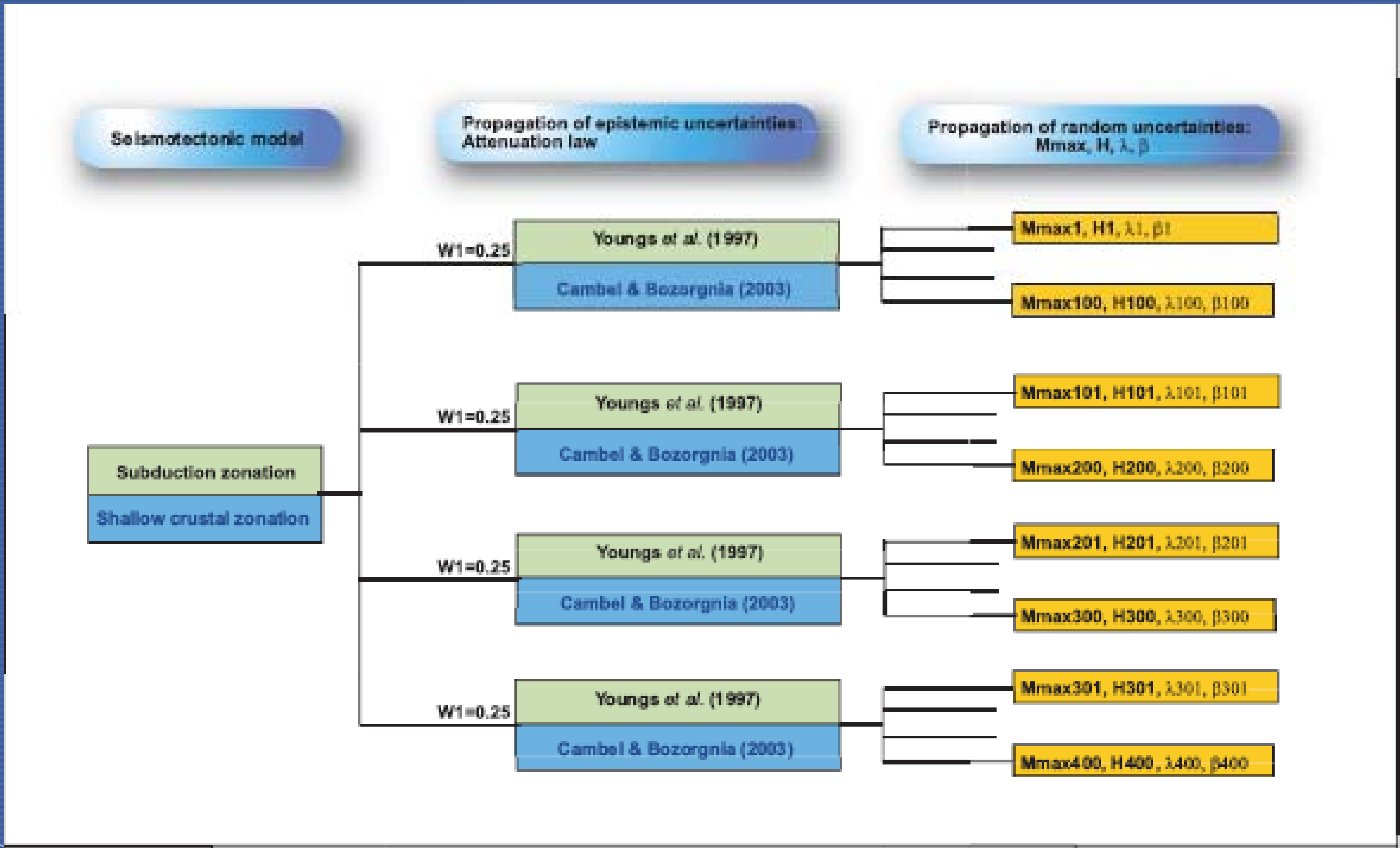
Logic tree implemented for the probabilistic approach



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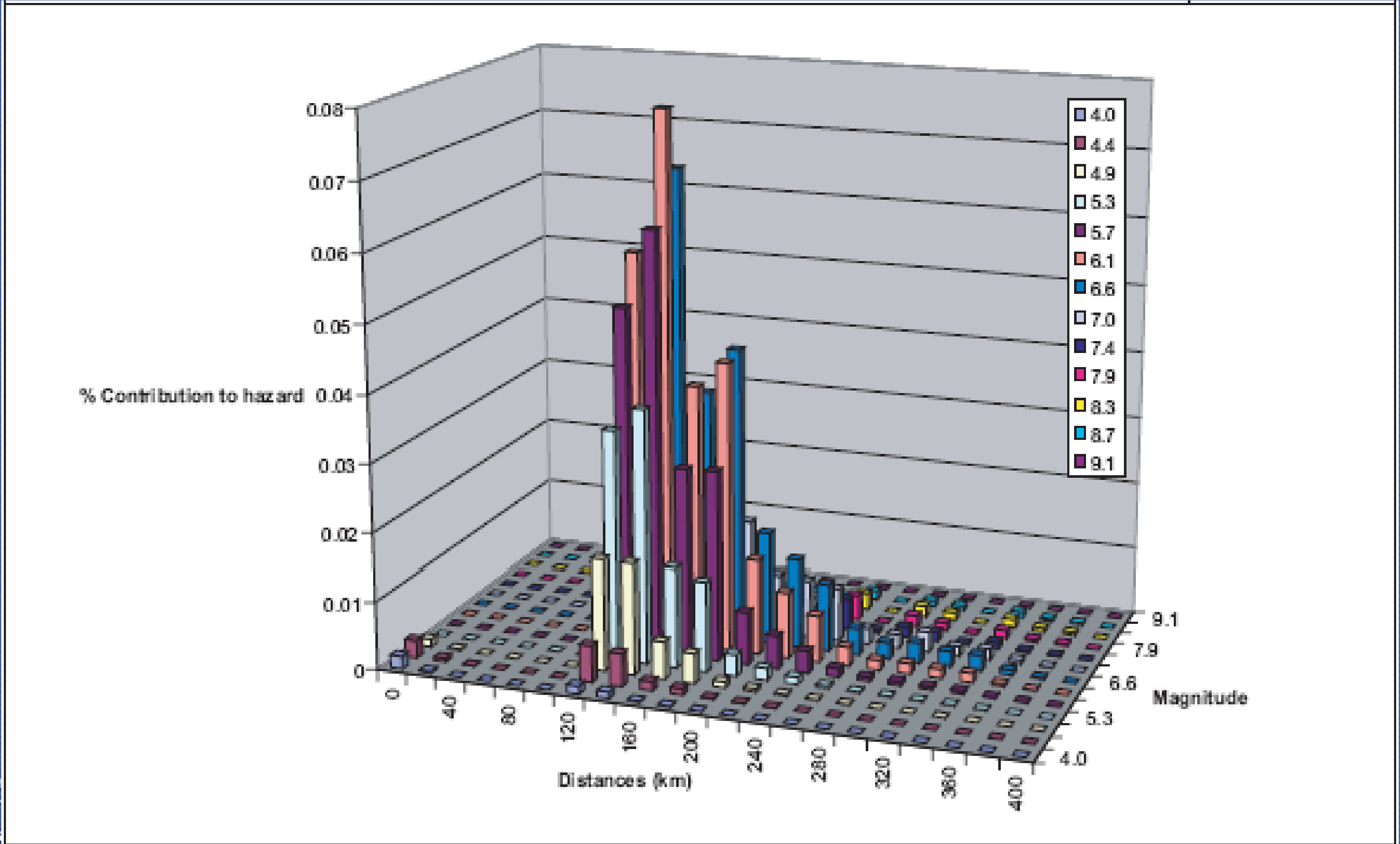
Deaggregation by couple magnitude-distance for PGA and the 475 years of return period



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Thank you for your attention

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