Performing seismic scenarios in the Luchon-Val d'Aran area, Central Pyrenees

7th EUROGEO, Bologna, Italy,
12th-15th june 2012

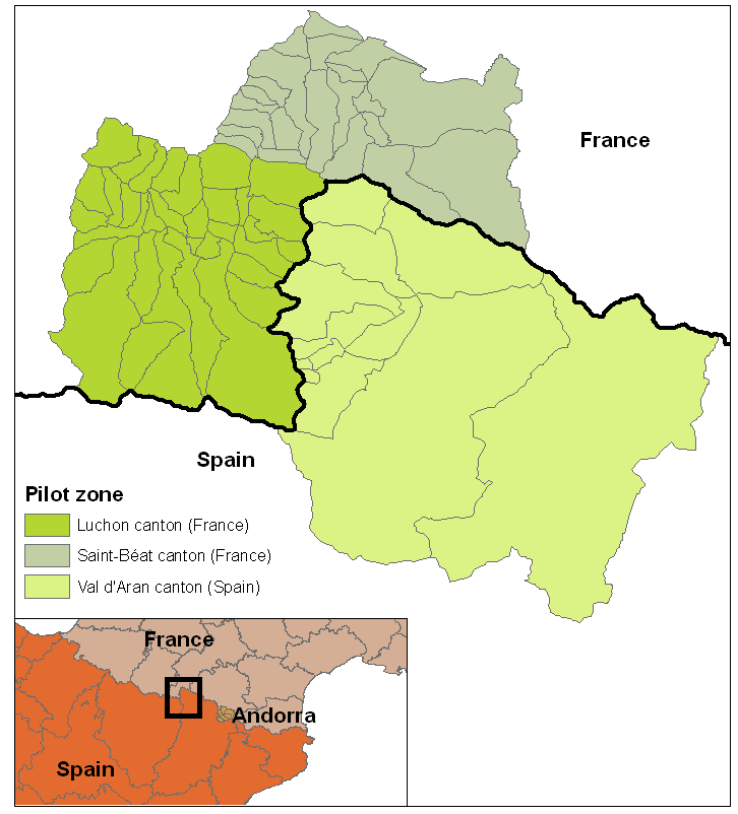
Authors: A. Roullé (BRGM), A. Macau (IGC), S. Figueras (IGC), D. Monfort-Climent (BRGM), N. Lantada (UPC), T. Susagna (IGC), J. Irizarry (IGC)

Contact: Agathe Roullé (BRGM) – a.roulle@brgm.fr

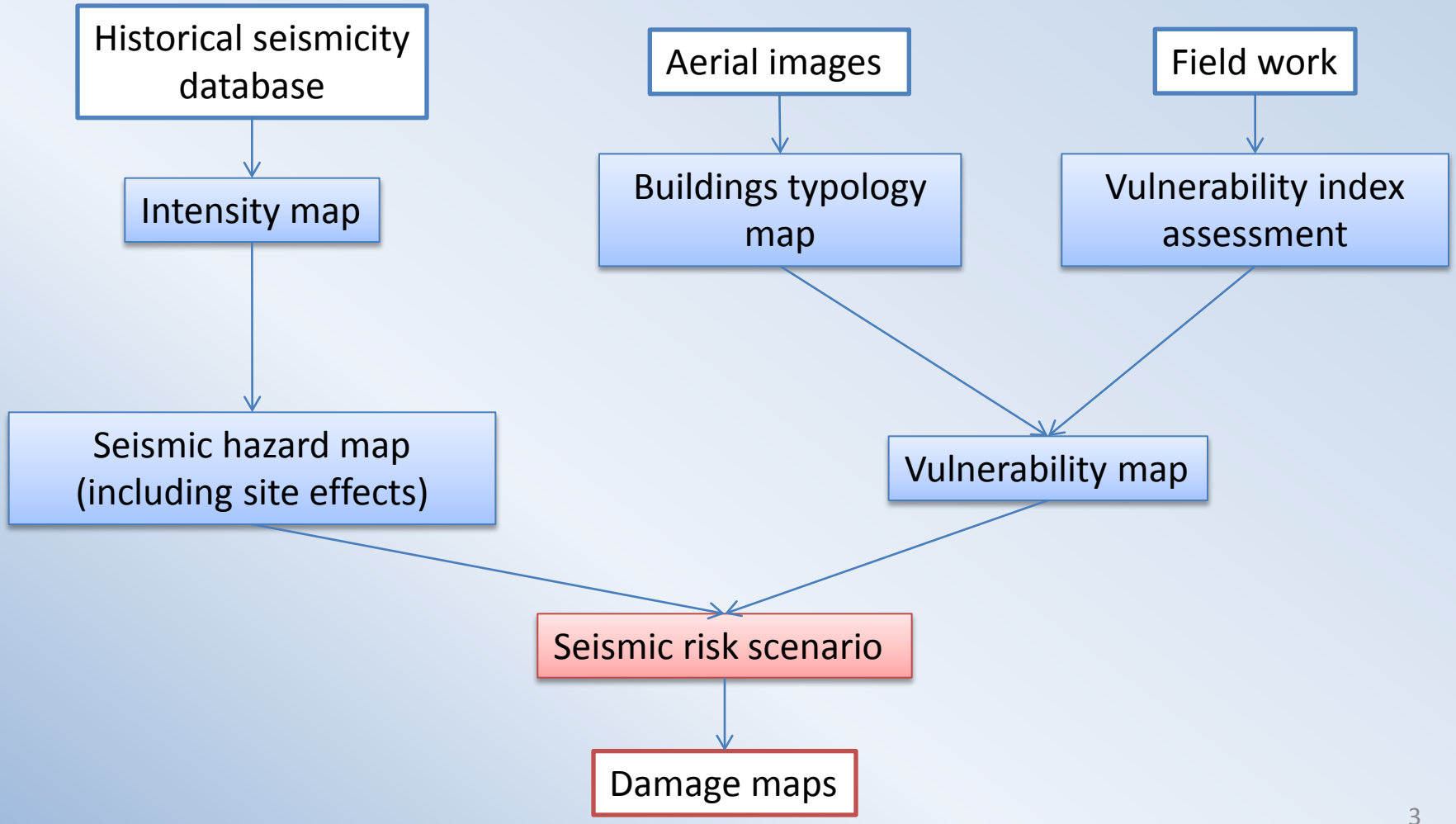
Introduction

- SISPYR project
  - Interreg project between France and Spain
  - M4: Seismic risk mitigation: shakemaps and risk scenarii

- Realization of 2 seismic scenarios in the pilot zone of Val d'Aran and Luchon-Saint Béat (part of the M4 module)
  - Deterministic scenario (1923 earthquake)
  - Probabilistic scenario (period return of 475 years)
- Why here ?
  - Important touristic zone within the Pyrenees. Ski resorts (Baqueira Beret, Superbagnères) and thermal (Bagnères de Luchon).
  - One of the most active zone of France and Spain in terms of seismicity
    - M 4.8 in Lège (France) in 1999
    - Vielha earthquake in 1923. Intensity VIII-VII.

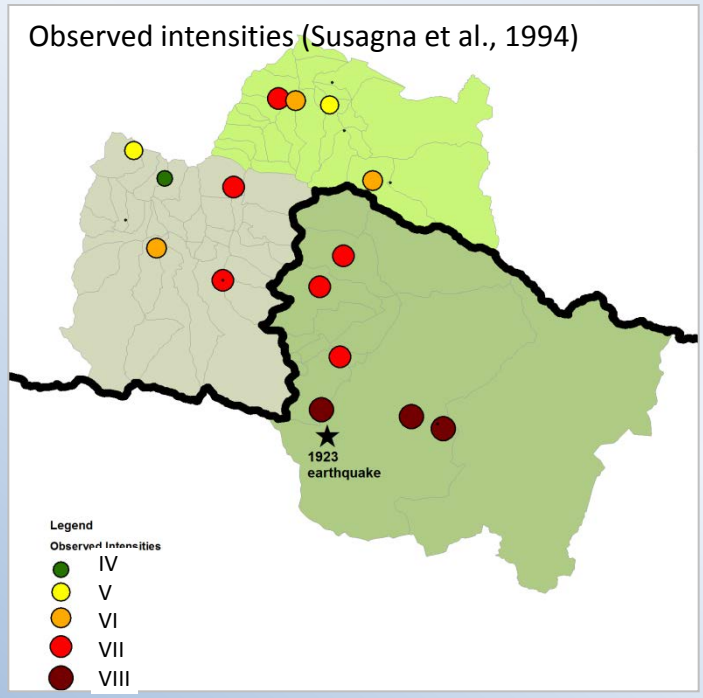


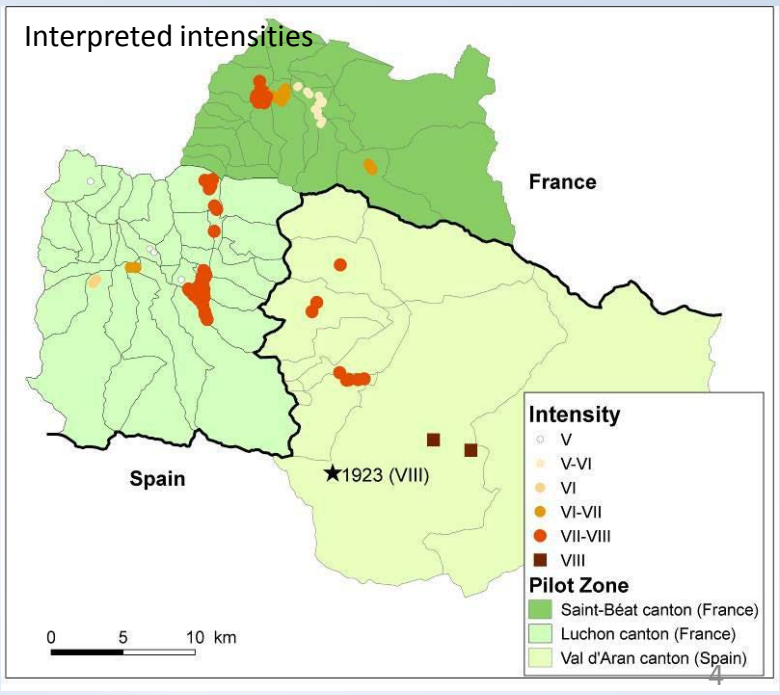
Deterministic scenario scheme



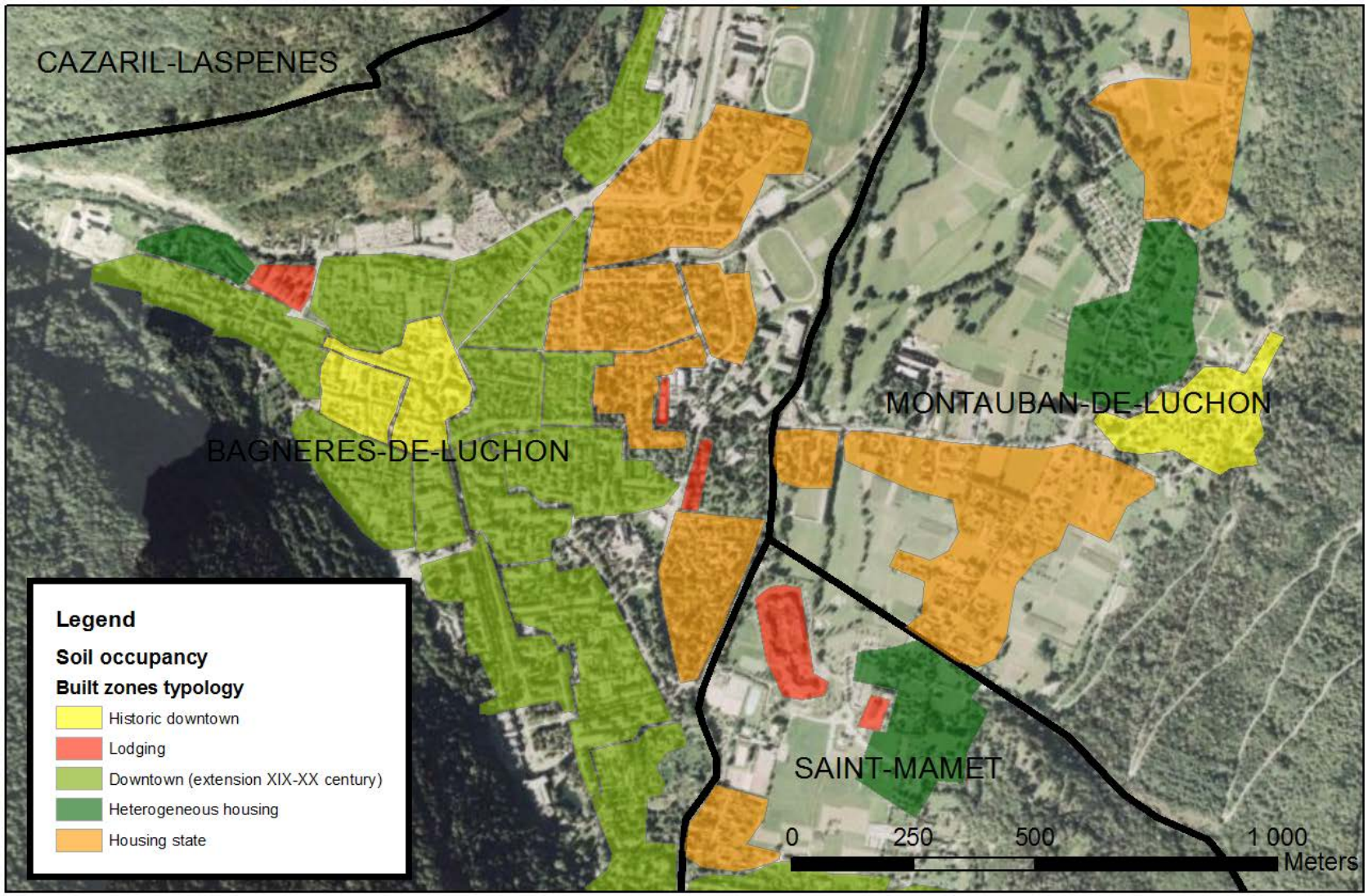
Deterministic scenario: seismic hazard map

- Based on observed intensities from 1923 earthquake
- Epicenter south of Vielha
- In Vielha downtown intensity VIII
- Intensities between VII (valleys) and V



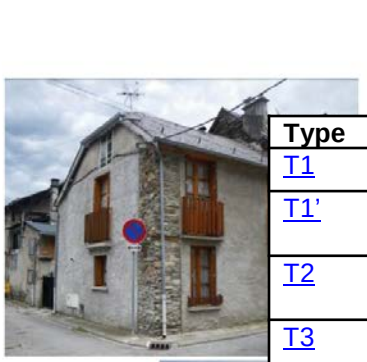


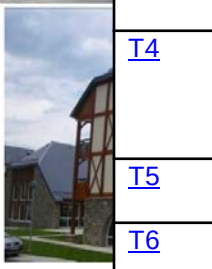
Deterministic scenario: buildings typology map



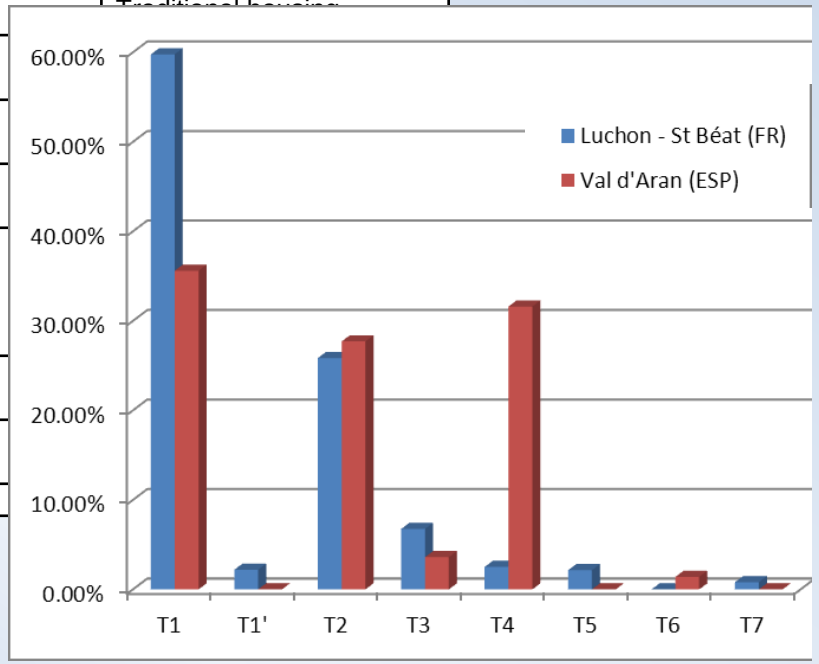
Deterministic scenario: vulnerability index assessment

- Identification of the main building types within the zone
- Identification of the main vulnerability factors
- Association to RISK-UE types (vulnerability index)





Type	Structure	RISK-UE type	Description
T1	Bearing walls in stone masonry	M1.2	
T1'		M1.2-M1.3	
T2	Unrenforced masonry	M3.3	
T3		M3.4	
T4	RC structures	RC3.2	
T5		RC2	
T6	Steel structures	S3	
T7	Wooden structures	W	



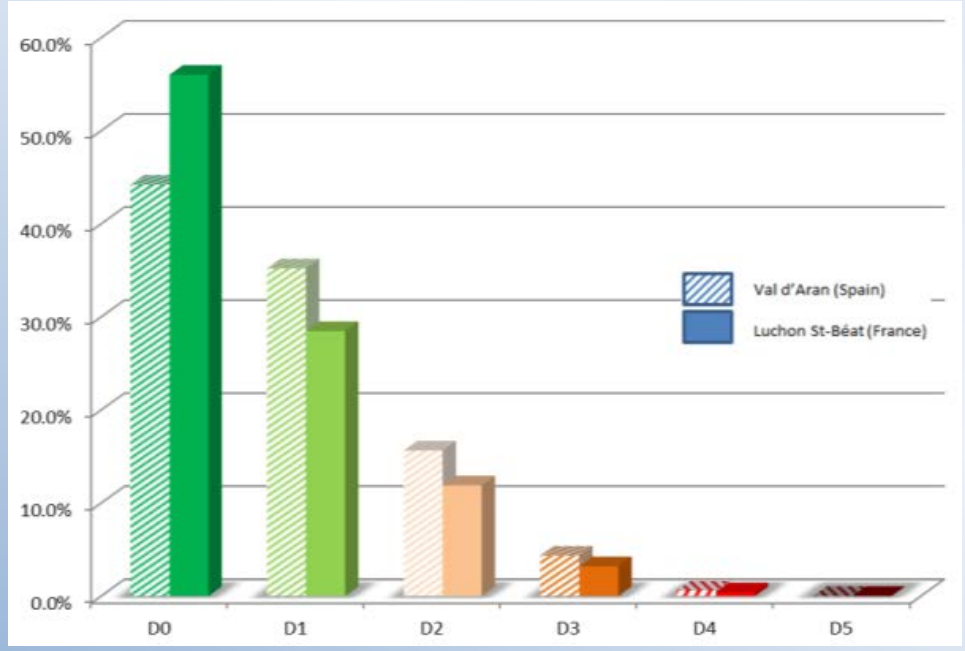
Deterministic scenario: damage calculation (EMS98 scale)

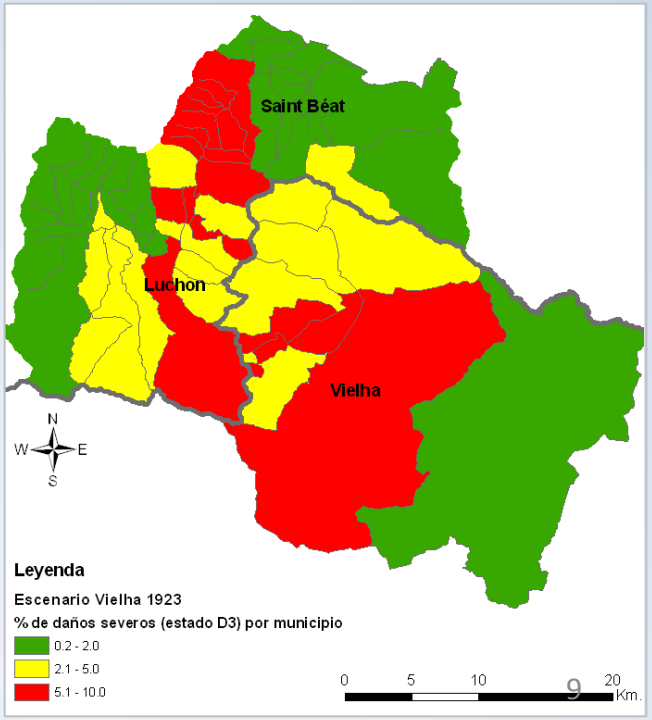
Classification of damage to masonry buildings	
	**Grade 1: Negligible to slight damage** **(no structural damage, slight non-structural damage)** Hair-line cracks in very few walls. Fall of small pieces of plaster only. Fall of loose stones from upper parts of buildings in very few cases.
	**Grade 2: Moderate damage** **(slight structural damage, moderate non-structural damage)** Cracks in many walls. Fall of fairly large pieces of plaster. Partial collapse of chimneys.
	**Grade 3: Substantial to heavy damage** **(moderate structural damage, heavy non-structural damage)** Large and extensive cracks in most walls. Roof tiles detach. Chimneys fracture at the roof line; failure of individual non-structural elements (partitions, gable walls).
	**Grade 4: Very heavy damage** **(heavy structural damage, very heavy non-structural damage)** Serious failure of walls; partial structural failure of roofs and floors.
	**Grade 5: Destruction** **(very heavy structural damage)** Total or near total collapse.

Photos from Lorca earthquake

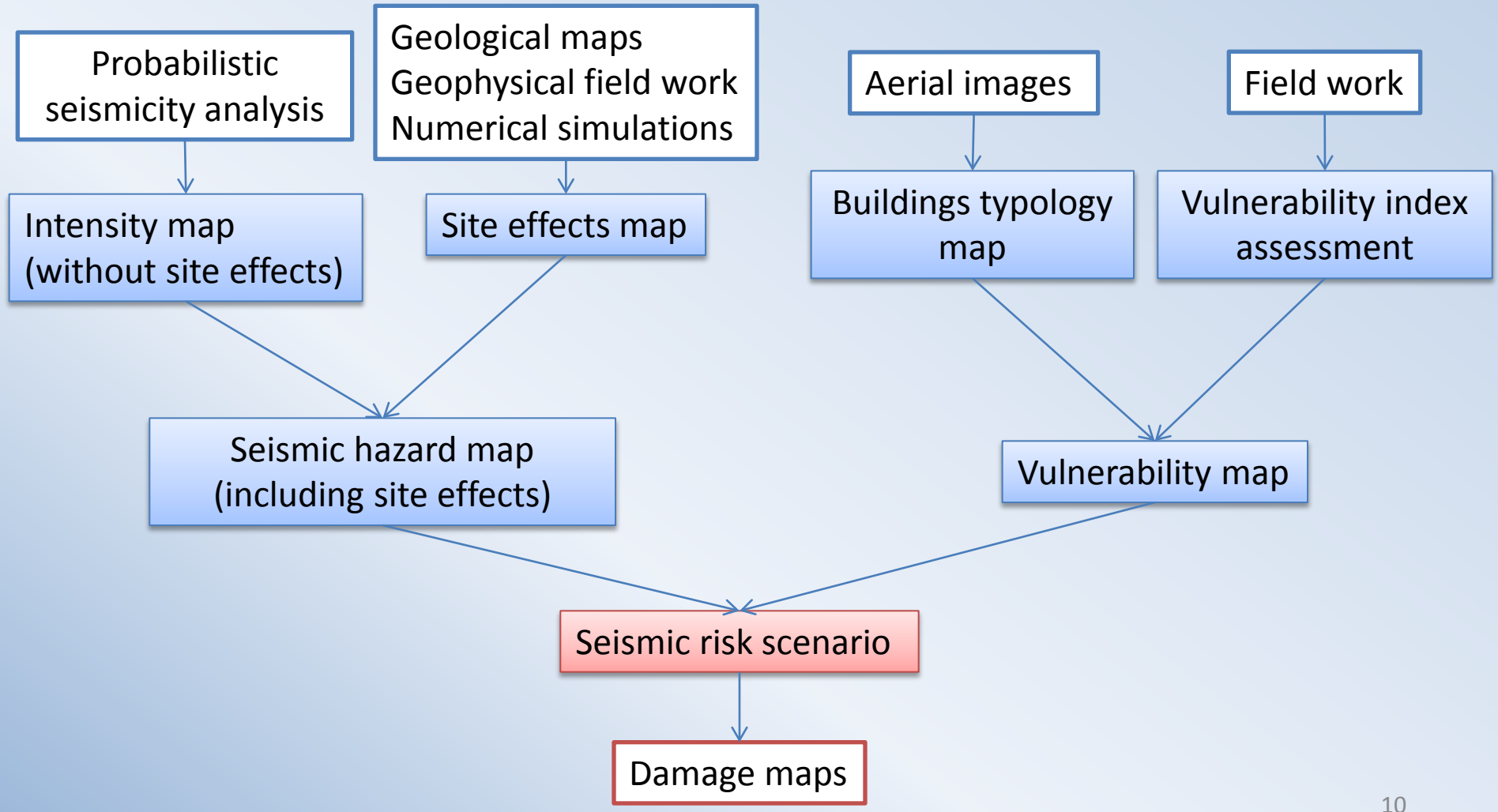
Deterministic scenario: results

- Physical damage to built environment
  - Partial collapse (D4) or complete collapse (D5) minor to 2%
  - Minor damage or no damage for the majority of buildings
  - Strong damage (D3) between 5 and 10% into the most important cities: Bagnères-de-Luchon and Vielha (close to epicenter)
  - No damage in Saint Beat (far from epicenter)



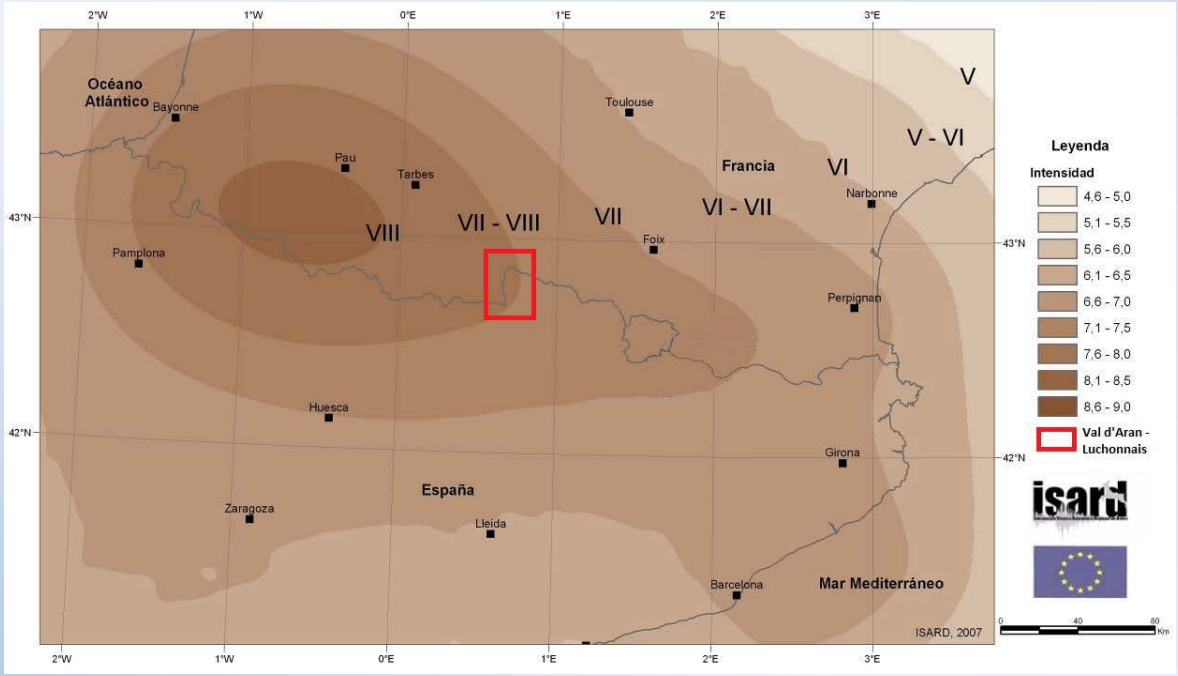


Probabilistic scenario scheme



Probabilistic scenario: intensity map

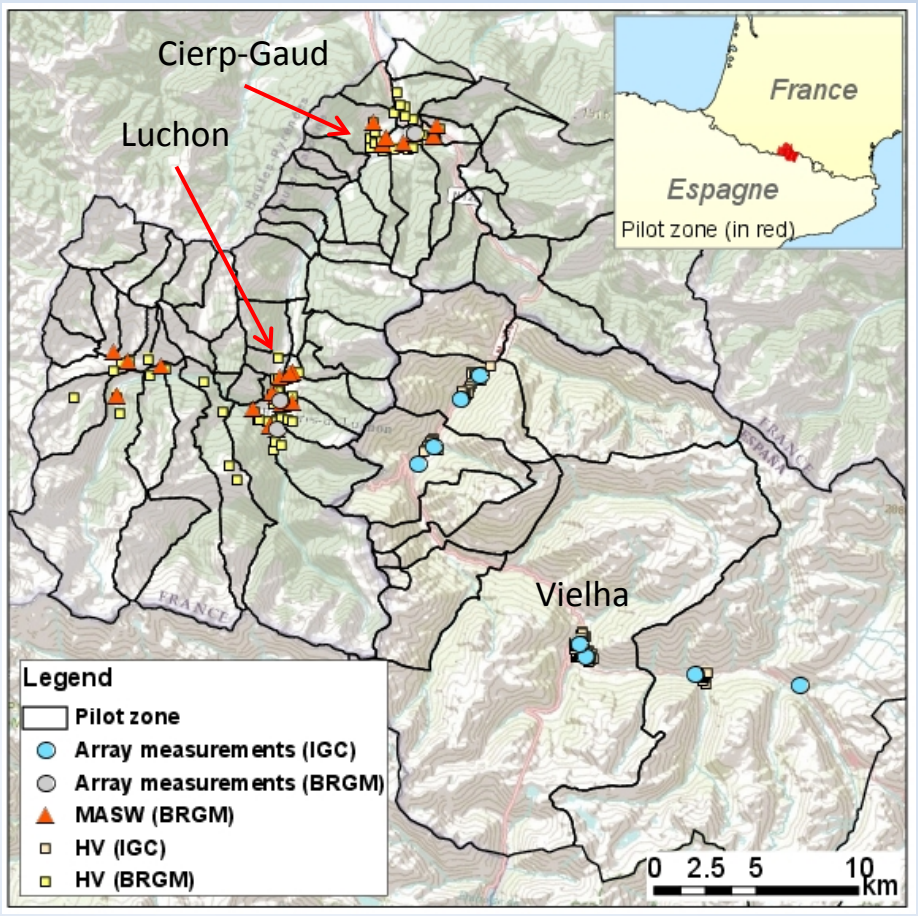
- Intensity map derived from previous works on Pyrenees (ISARD project, 2006) (return period: 475 years)



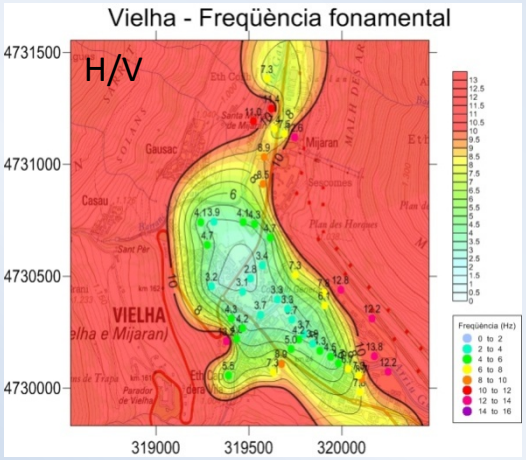
- Intensity used on the whole pilot zone: VII-VIII

Probabilistic scenario: site effects assessment

- Analysis based on:
  - Geological maps
  - Geotechnical data (very few on the French side)
  - Geophysical data
    - H/V for site effects detection and resonance frequency measurement
    - MASW for Vs profiles (shallow depths up to 30 meters)
    - Array measurements for Vs profiles (medium depths up to 100 meters)
- Field work performed by IGC and BRGM
  - France: 75 H/V, 21 MASW, 3 arrays
  - Spain: 98 H/V, 8 arrays



Probabilistic scenario: site effects assessment (example of Vielha)



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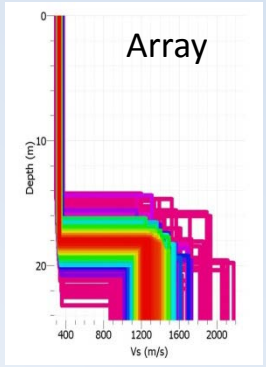
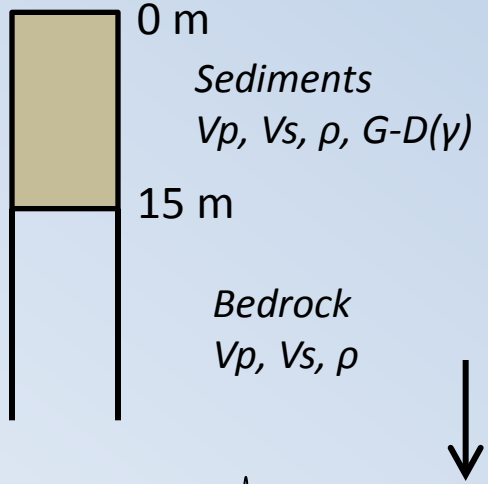
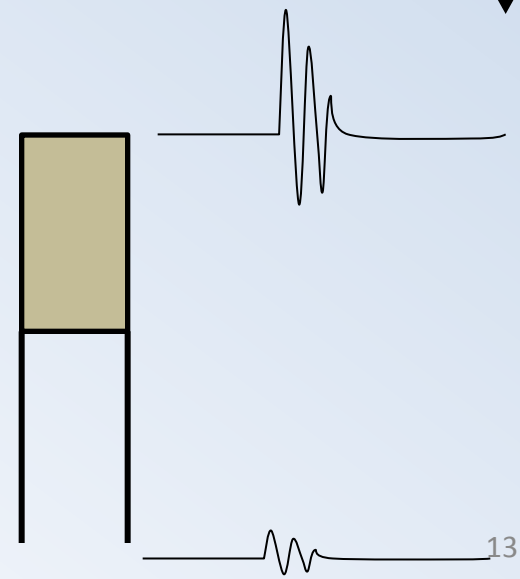
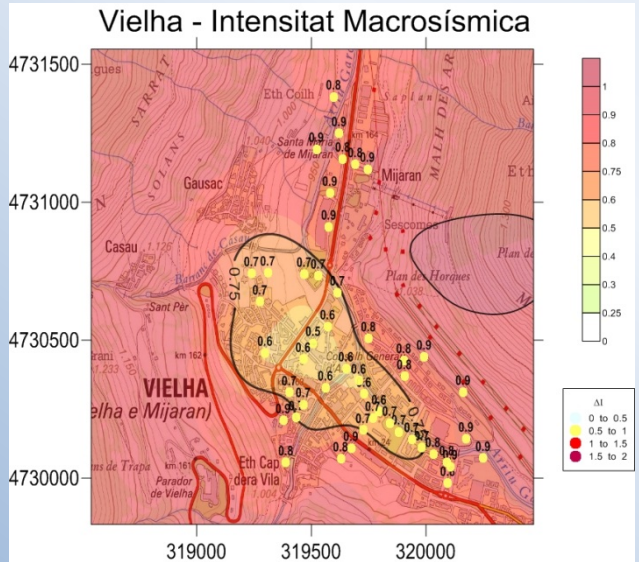


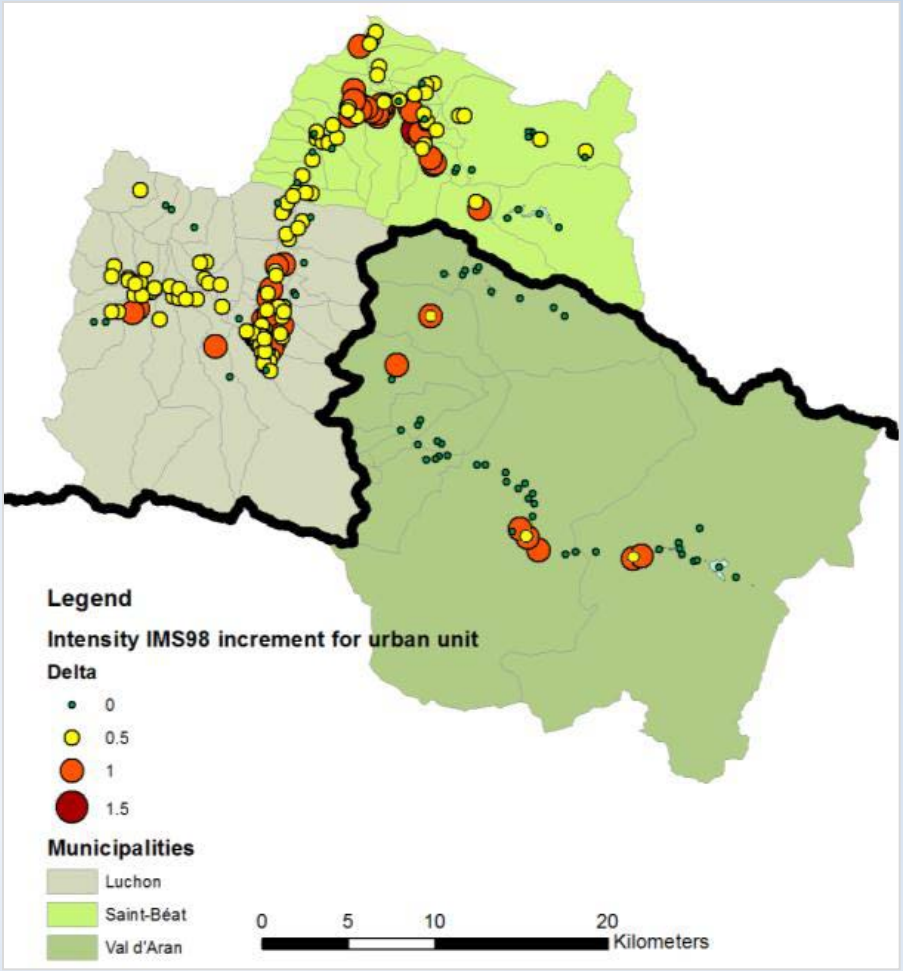






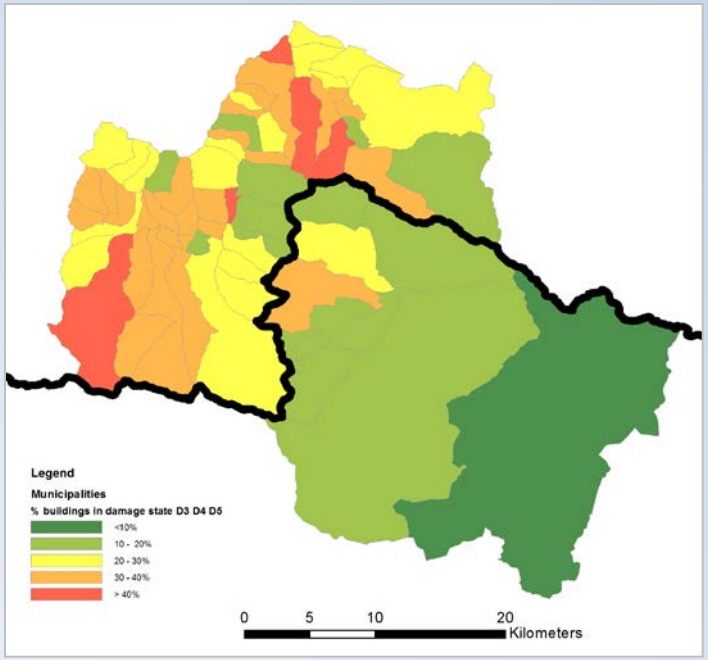
Probabilistic scenario: seismic hazard map

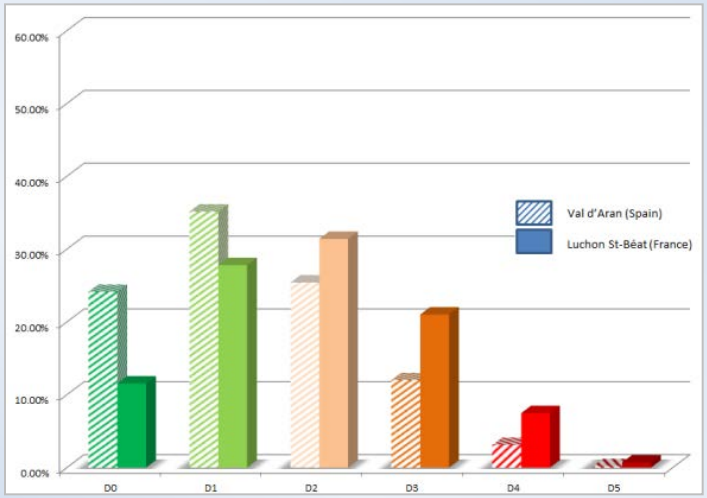
- Intensity increment calculated for each homogeneous site effects zones (with geophysical measurements)
- Extrapolation to zones without geophysical measurements (on base of geology)
- Intensity increment map on the whole pilot zone (EMS98 scale)
- Stronger site effects on the French side (larger valleys with deeper sediments deposits)



Probabilistic scenario: results

- Vulnerability: same as deterministic scenario
- Damage calculation method: same as deterministic scenario
- Physical damage to built environment:
  - Higher expected damage on French side (stronger site effects and vulnerability)
  - Heavy damage (D4 and D5) <10%
  - Big number of buildings on D2-D3 damage state





Conclusions

- Realization of 2 scenarios for seismic risk mitigation purposes
  - A deterministic one (1923 earthquake)
  - A probabilistic one (return period of 475 years)
  - Including:
    - Regional seismicity (regional seismic hazard)
    - Site effects (local seismic hazard)
    - Building stock vulnerability
  - Calculation and mapping of buildings damage distributions

- Both scenarios show:
  - Low ratio of partial or total collapse,
    ➔ reduced number of potential victims
  - Important number of buildings with slight to moderate structural damage
    ➔ important number of people without shelters, important economic loss

- Probabilistic scenario
  - Necessary to avoid bias due to source location for damage comparison between two neighborhoods (attenuation of seismic motion when moving away from epicenter)
  - It highlights the higher vulnerability and higher site effects on the French side (higher expected damage)

- What is next ?
  - Presentation of the results to local authorities (at the end of 2012)

Thank you for your attention