BUILDINGS DAMAGE ESTIMATION AT FINE SPATIAL SCALE FOR INTEGRATED SEISMIC RISK MODELING IN BEIRUT (LEBANON)

Rouba ISKANDAR[a, d, e], *Bilal AL-TFAILY*[a], *Christelle SALAMEH*[a], *Pierre-Yves BARD*[a], *Bertrand GUILLIER*[a], *Cécile CORNOU*[a], *Jocelyne GÉRARD*[b], *Jacques HARB*[c], *Rosemary FAYJALOUN*[a], *Élise BECK*[d], *Julie DUGDALE*[e], *Pascal LACROIX*[a], *Stéphane CARTIER*[d]

[a] Univ. Grenoble Alpes, Univ. Savoie Mont Blanc, CNRS, IRD, IFSTTAR. ISTerre, 38000 Grenoble, France
[b] Univ. Saint-Joseph, Département de Géographie, Beyrouth, Liban
[c] Univ. Notre Dame, Département de Génie Civil et Environmental, Zouk Mosbeh, Liban
[d] Univ. Grenoble Alpes, CNRS, Science Po Grenoble, PACTE, 38000 Grenoble, France
[e] Univ. Grenoble Alpes, CNRS, Grenoble INP*, LIG, 38000 Grenoble, France

rouba.iskandar@univ-grenoble-alpes.fr

INTRODUCTION

Artificial neural networks are trained, using a large set of data, to find relations that estimate buildings' earthquake damages, from simple indicators describing the seismic shaking level and the soils' and buildings' vibrational properties. These relations are applied to estimate probable damages in the city of Beirut, Lebanon, for different seismic scenarios.

METHOD

NUMERICAL SIMULATIONS

- The acceleration at the soil's surface is computed with the equivalent linear approach in Shake[1].
- This acceleration is then injected at the base of oscillators with a single degree of freedom to calculate their maximal displacement.

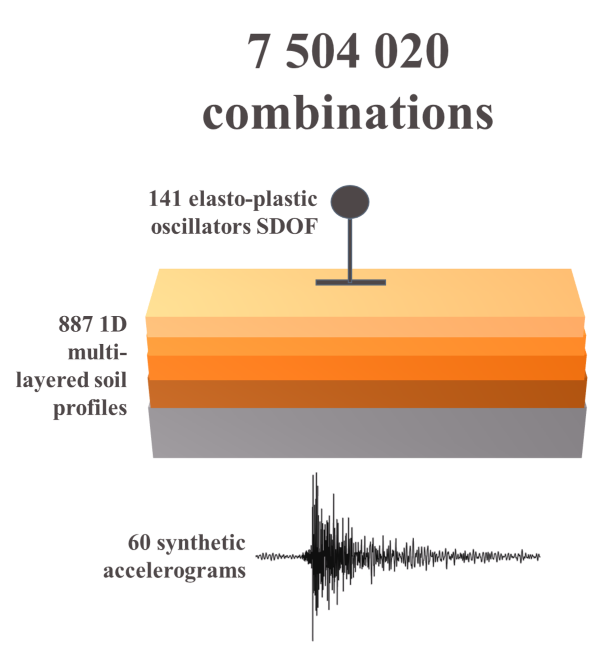

Figure 1: Representation of the numerical simulations' database.

DAMAGES ESTIMATION

- On the oscillators' capacity curves, damage limit states ($S_{d,k}$) and their associated damage levels (D_{Sk}) are identified[2].
- Depending on the maximal displacement reached by the oscillator, the probability (p_{Sk}) of the damages reaching or exceeding a given damage level is estimated using a log-normal cumulative law.
- The mean damages are then computed by: $\mu_{DS} = \sum_{k=1}^{4} k p_{Sk}$.

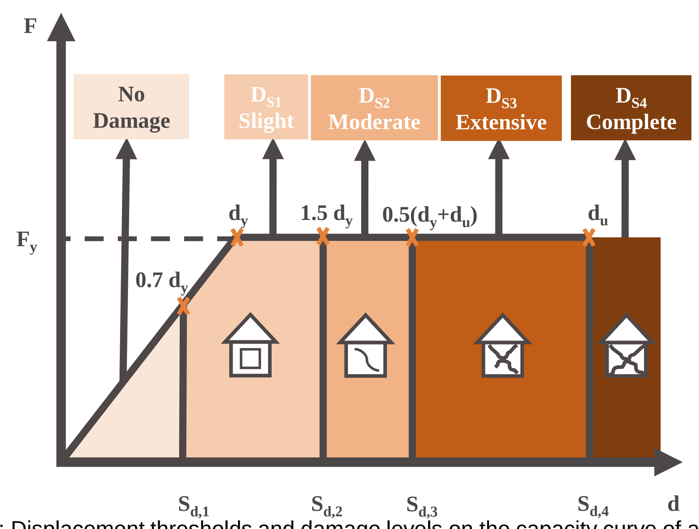

Figure 2: Displacement thresholds and damage levels on the capacity curve of an oscillator.

NEURAL NETWORKS

- Neural networks are defined and calibrated by the results of the numerical simulations and damages estimations.
- Various entry parameters are tested in order to find the best performances in predicting the mean damages.
- The retained parameters are: Peak Ground Acceleration [PGA], Peak Ground Velocity [PGV], Building to soil frequency ratio [f_{bat}/f_{soil}], and H/V peak amplitude [$A_{0H/V}$].

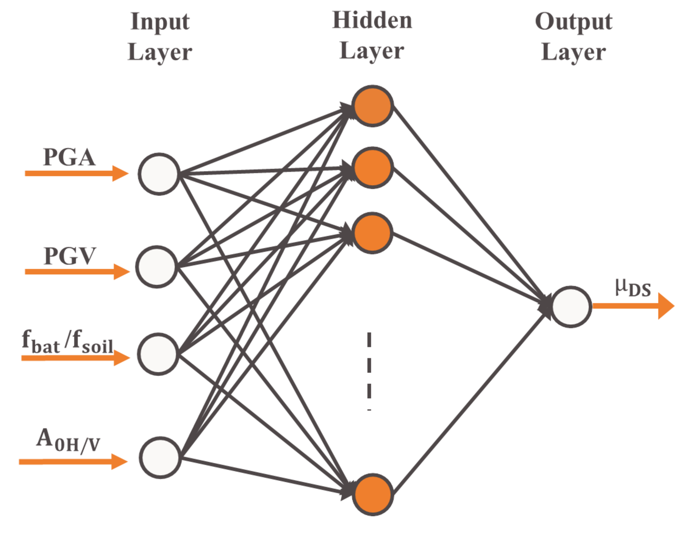

Figure 3: Representation of the neural networks' architecture.

APPLICATION

- The neural networks relations, linking the mean damage to signal, soil and building properties, are applied to the city of Beirut.
- A rich database of around 11 000 buildings is used, as well as seismic noise measurements of soil's resonance frequencies and associated amplitudes from H/V measures on seismic noise [3] [4].

Collected Data in Beirut

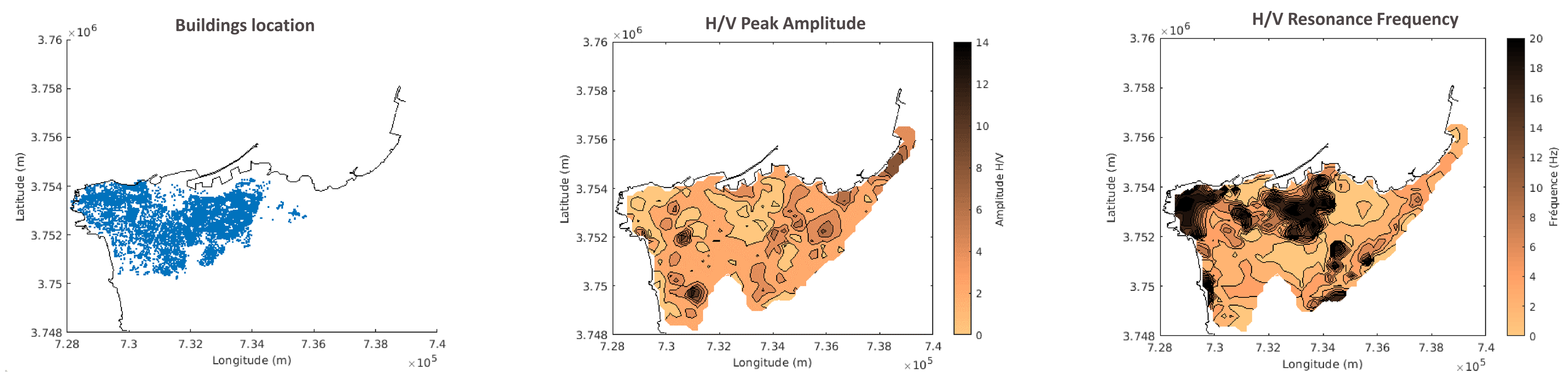

Figure 4: Maps of the collected data on soils and buildings in Beirut.

- Mean damages are estimated with and without considering the soil's vibrational properties, for two seismic scenarios.

Scenario 1: PGA= 0.3g PGV= 25 cm/s

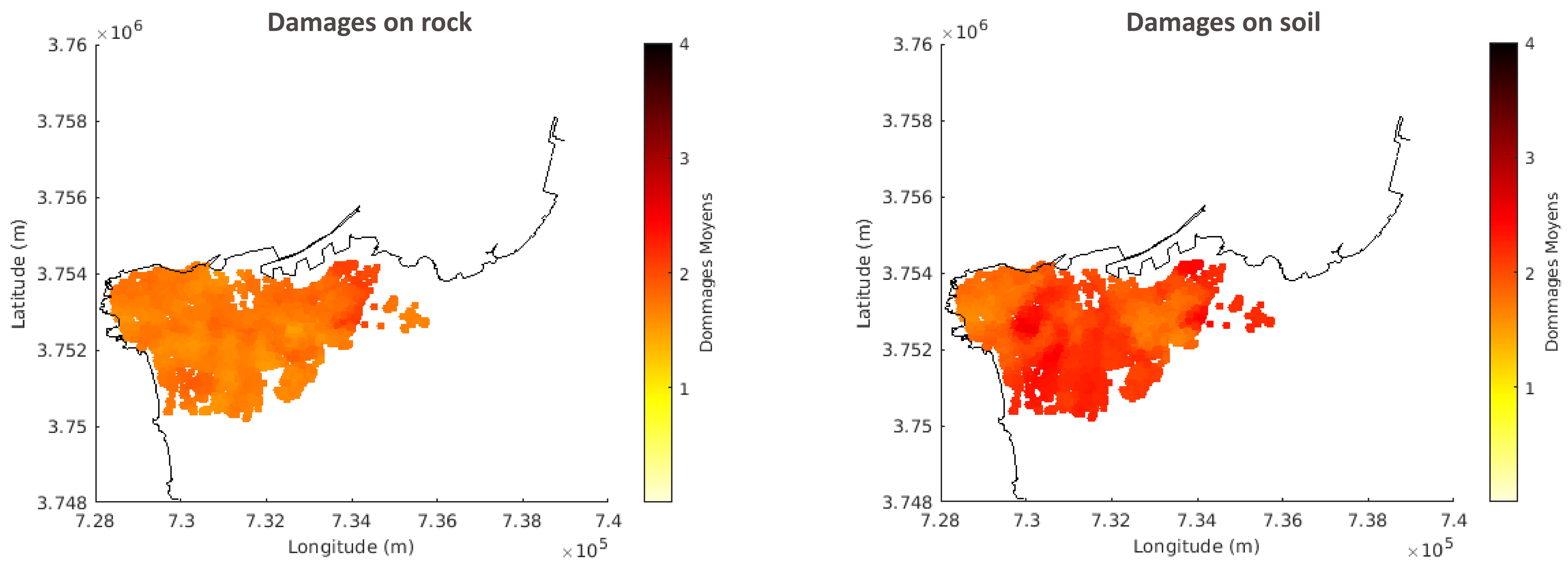

Figure 5: Mean damages maps for Scenario 1.

Scenario 2: PGA=0.5g PGV= 70 cm/s

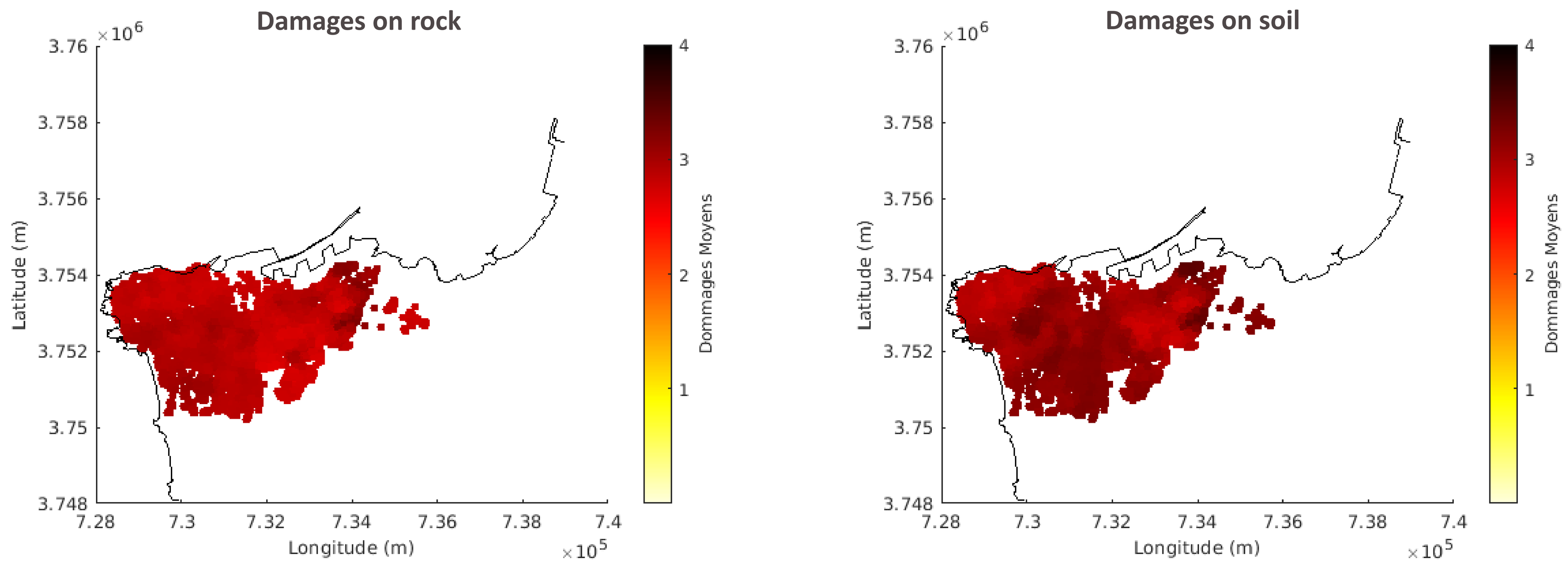

Figure 6: Mean damages maps for Scenario 2.

Observations:
A spatial heterogeneity in the damages, controlled by the spatial variability of the soil's vibrational properties and the considered seismic scenario.

PERSPECTIVES

- These damages, modelled at a fine spatial scale, will be integrated in a multi- agents model to simulate scenarios of seismic crisis in Beirut, including the human behaviour.
- The goal of these simulations is to develop a seismic risk index integrating different risk components: the seismic hazard, the physical and social vulnerabilities, along with the influence of the risk perception and the behaviour in crisis.

REFERENCES

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