Seismic hazard assessment at the regional scale: the example of Emilia-Romagna

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1. INTRODUCTION AND AIMS

The mean equivalent propagation velocity of shear waves in the ground ($V_{S_{eq}}$) (**Fig.1**) is a fundamental parameter to improve the knowledge of seismic risk and mitigation thereof.

$$V_{S_{eq}} = \frac{H}{\sum_{i=1}^{n} h_i / V_{S_i}}$$

Figure 1: V_{Seq} equation, where:
H is the depth of the seismic bedrock;
n is the number of considered layers;
h_i is the thickness of the i-th layer;
V_{Si} is the shear wave velocity in the i-th layer.

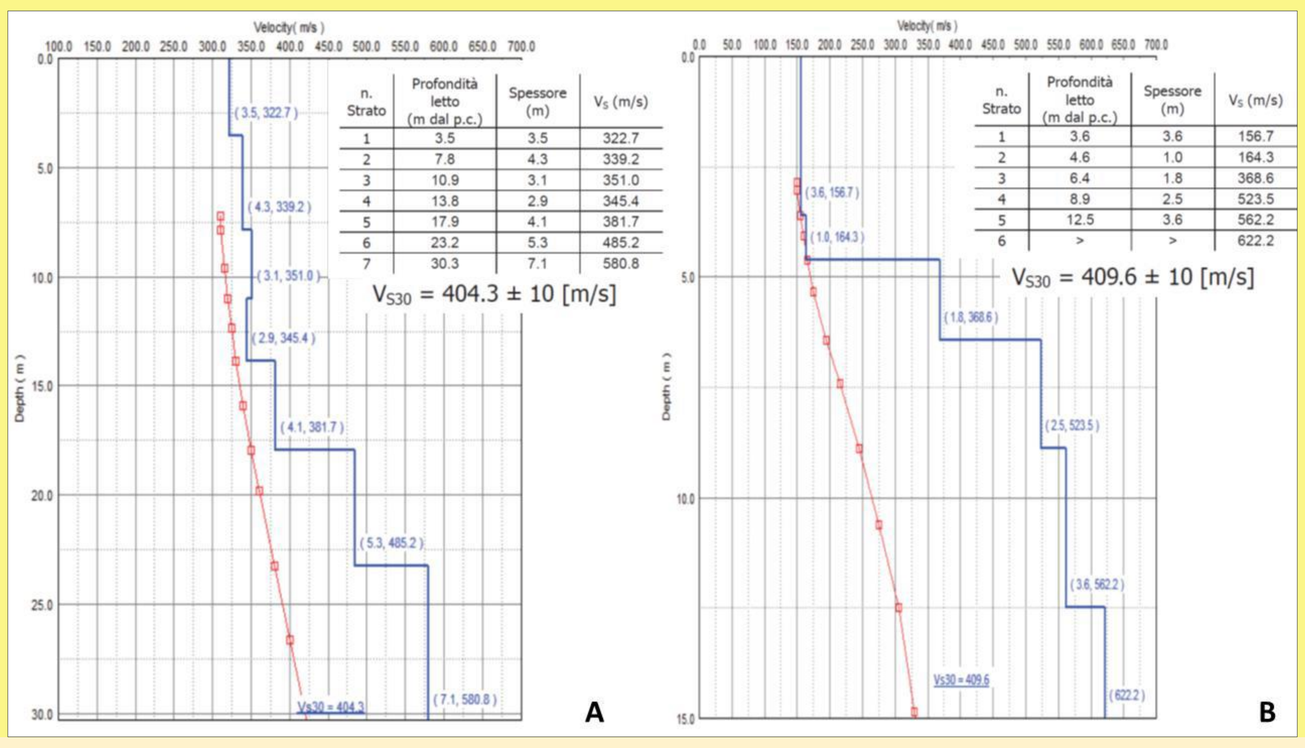
We propose:

- A calculation of the stratigraphic amplification factors at the regional scale from $V_{S_{eq}}$ values.
- An estimation of the expected maximum acceleration at the surface by applying level 2 Seismic Microzonation (MS2) criteria.
- A comparison between NTC18 (*Norme Tecniche per le costruzioni,* 2018) and the MS2 acceleration models.
- The implementation of our work toward developing a new, refined seismic hazard map.

2. EMILIA-ROMAGNA DATABASE CALCULATIONS

ANALYZED GEOPHYSICAL TESTS

- 5339 MASW
- 2527 ReMi
- 2377 HVSR
- 770 SCPT
- 507 ESAC
- 320 DH
- 39 CH
- 8 SDMT



n. Strato	Profondità letto (m dal p.c.)	Spessore (m)	Vs (m/s)
1	3.5	3.5	322.7
2	7.8	4.3	339.2
3	10.9	3.1	351.0
4	13.8	2.9	345.4
5	17.9	4.1	381.7
6	23.2	5.3	485.2
7	30.3	7.1	580.8

$V_{S30} = 404.3 \pm 10$ [m/s]

n. Strato	Profondità letto (m dal p.c.)	Spessore (m)	Vs (m/s)
1	3.6	3.6	156.7
2	4.6	1.0	164.3
3	6.4	1.8	368.6
4	8.9	2.5	523.5
5	12.5	3.6	562.2
6	>	>	622.2

$V_{S30} = 409.6 \pm 10$ [m/s]

Figure 2 : A) Example of Vs profile for which V_{S30} was estimated, note the gradual increase of Vs with depth; B) Example of Vs profile for which the estimation of V_{S_H} is required; note the discontinuity at -4.6 m and the significant and sudden increase in speed (V_{S_H}=158.3 m/s; V_{S30}=409.6 m/s).

CALCULATED PARAMETERS

- V_{S30}/V_{S_H}
- Amplification factors from NTC subsoil classes and MS2 criteria
- NTC maximum acceleration at the site (a_{max})
- New a_{max} following MS2 criteria

3. V_{SEQ} REGIONAL DISTRIBUTION

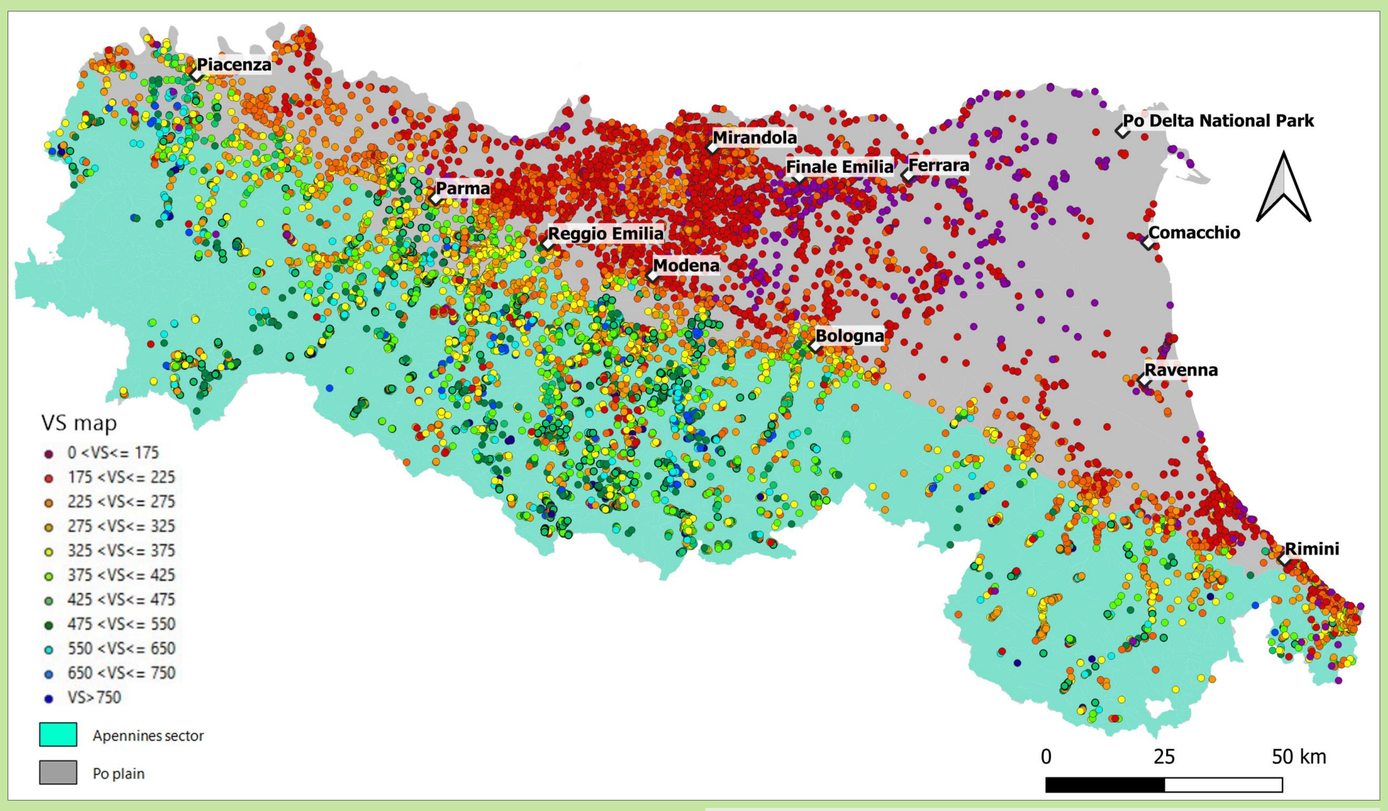
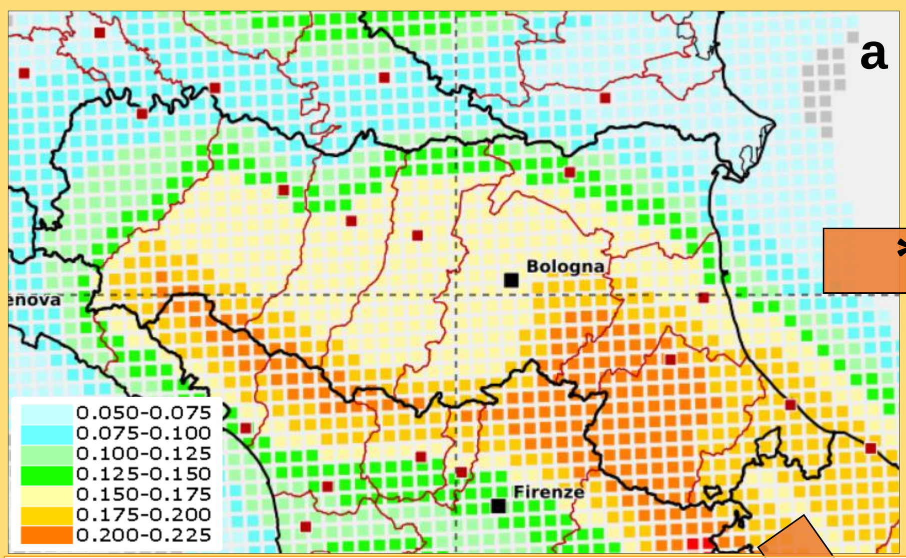


Figure 3: Vs values in Regione Emilia-Romagna

4. WORKFLOW



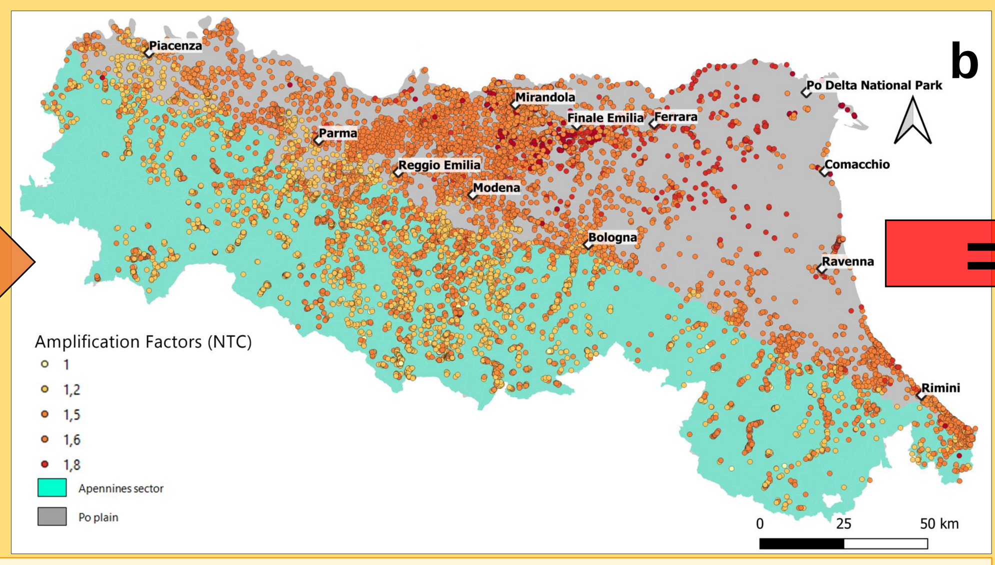
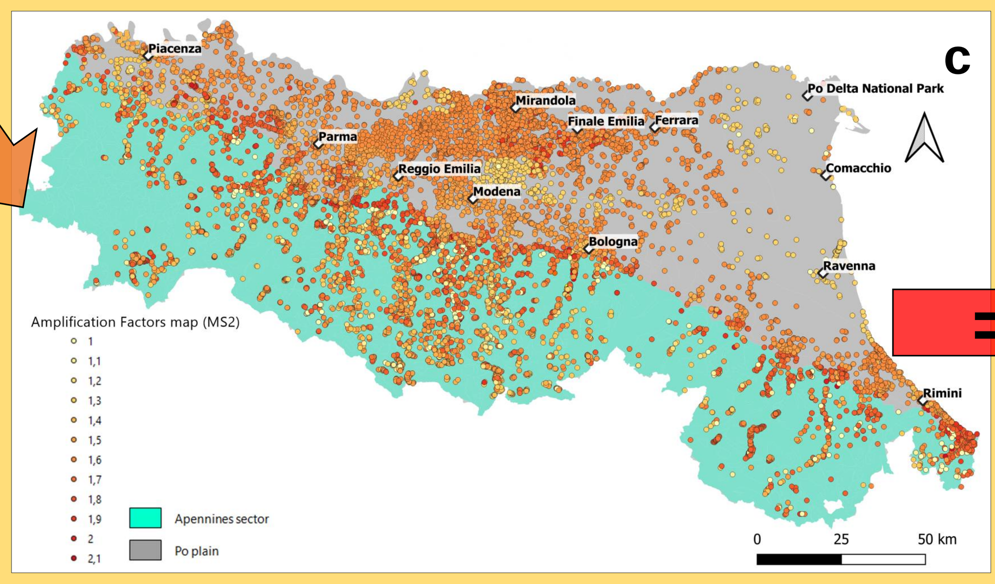


Figure 4: a) Hazard map MPS04, Meletti et al., 2006); b) Amplification Factors map following NTC guidelines; c) Amplification Factors map following MS2 criteria.

The maximum acceleration at any given site a_{max} was calculated by:

$$a_{max} = S * a_g = (S_S * S_T) * a_g$$

where a_g is the peak acceleration on a rigid and flat ground (model MPS04, Meletti et al., 2006 in Fig. 4a), S_S is the stratigraphic amplification coefficient (see Fig. 4b-c) and S_T the topographic amplification coefficient (assumed equal to 1) . Return time TR= 475 years.



5. RESULTS

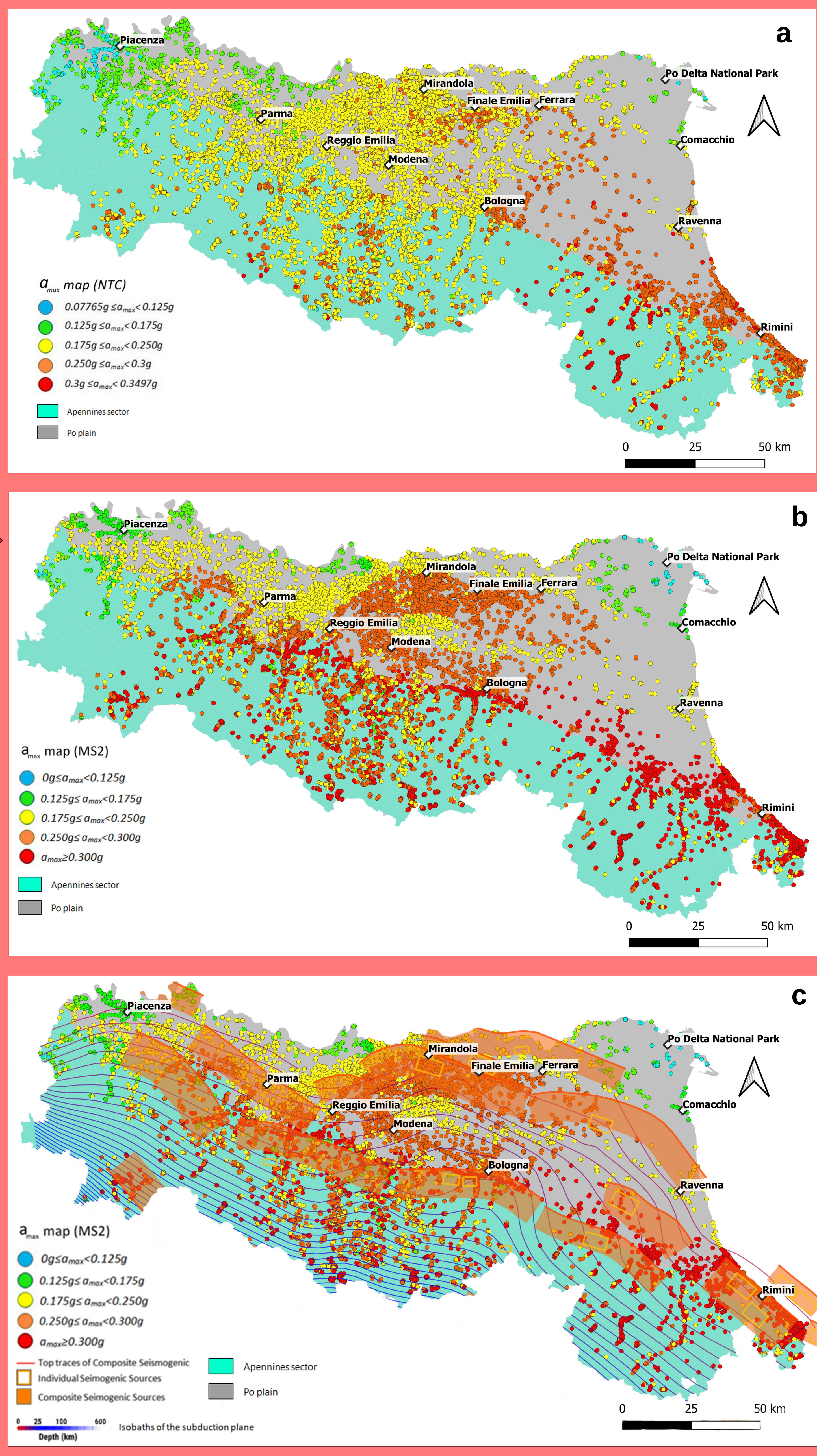


Figure 5: a) a_{max} map based on NTC18 subsoil classes; b) a_{max} map based on regional abacuses for level 2 MS; c) Same as b) integrated with seismogenic sources from the national database DISS.

6. CONCLUSIONS

- This new a_{max} map produced according to the MS2 criteria (**Fig. 5b**) allows for the better appreciation of some interesting peculiarities that are otherwise not highlighted by the NTC a_{max} map (**Fig. 5a**), such as, for example, the alignment of a_{max} values between 0.25 and 0.3g from north of Modena to Ferrara along the buried arcs of the Ferrara Folds. There, composite and individual seismogenic sources are mapped in the DISS database and are believed to have played a major role for the 2012 seismic events (**Fig. 5c**).
- In the context of a Ph.D. programme focused on the area between Bologna and Reggio Emilia, this contribution represents an important reference model for understanding V_S propagation in the first meters of the subsoil, as well as the calculated stratigraphic amplification factors for realistic attenuation models (Ground Motion Prediction Equation), which will be used for the creation of a new seimic hazard map following the scheme shown in Fig. 6.

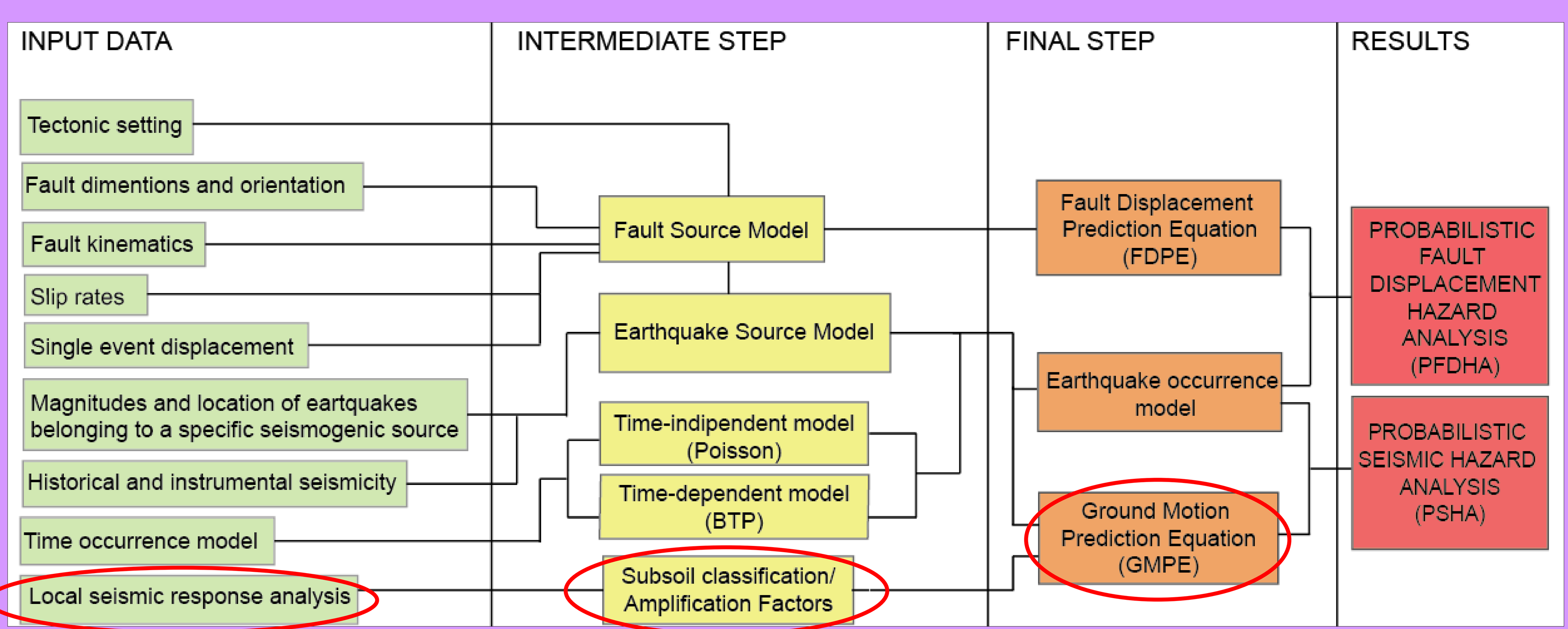


Figure 6: Schematic adopted workflow for Seismic Hazard Assessment in the study area.

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