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## Combined InSAR-geophysical-seismological data for high-resolution site-effect modeling and ShakeMap generation, case study of Grenoble, France

Valentin Schindelholz, Aya Cheaib, Emeline Maufroy, Cécile Cornou, Erwan Pathier, Antoine Schlupp, Léna Pellorce, Véronique Mendel, Marc Grunberg

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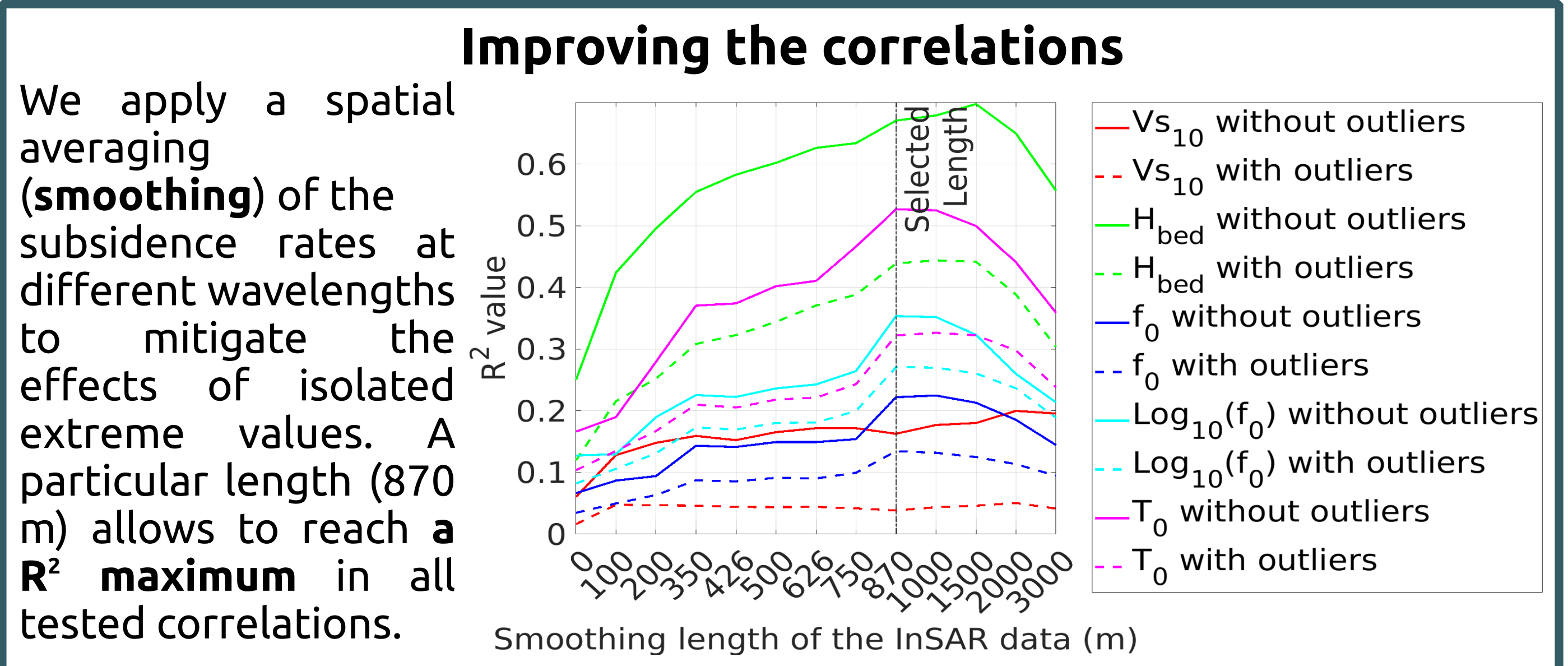
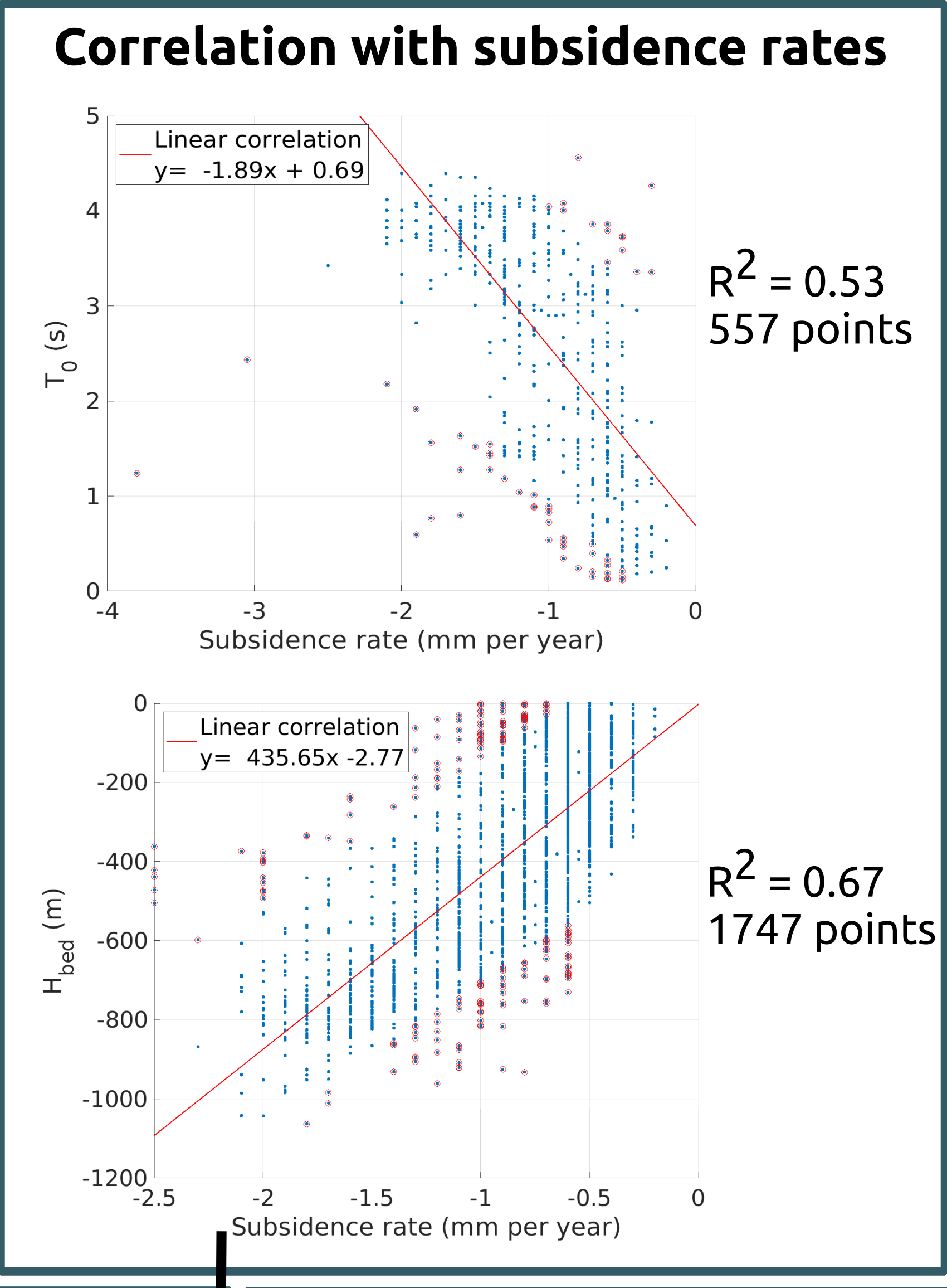
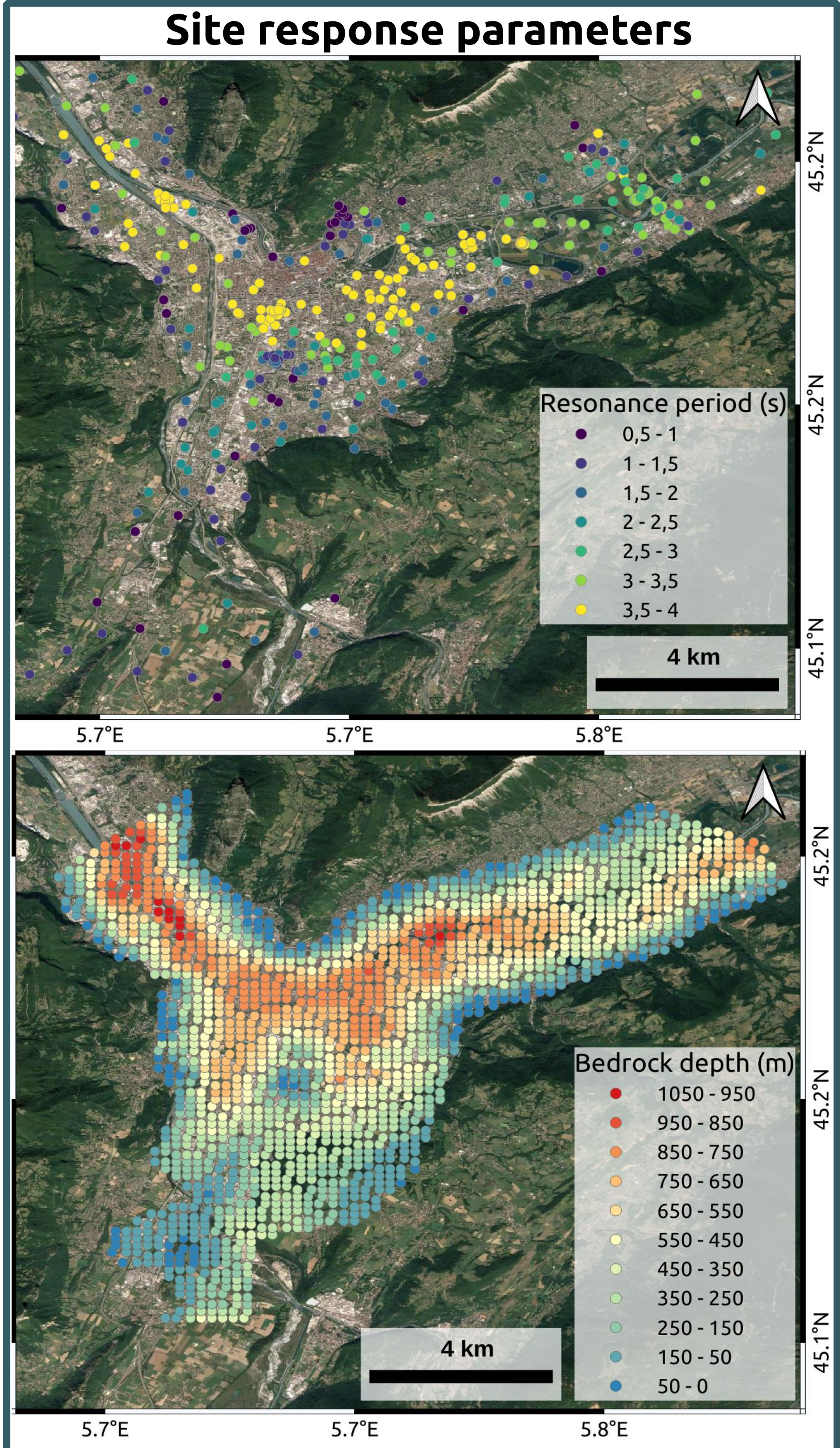
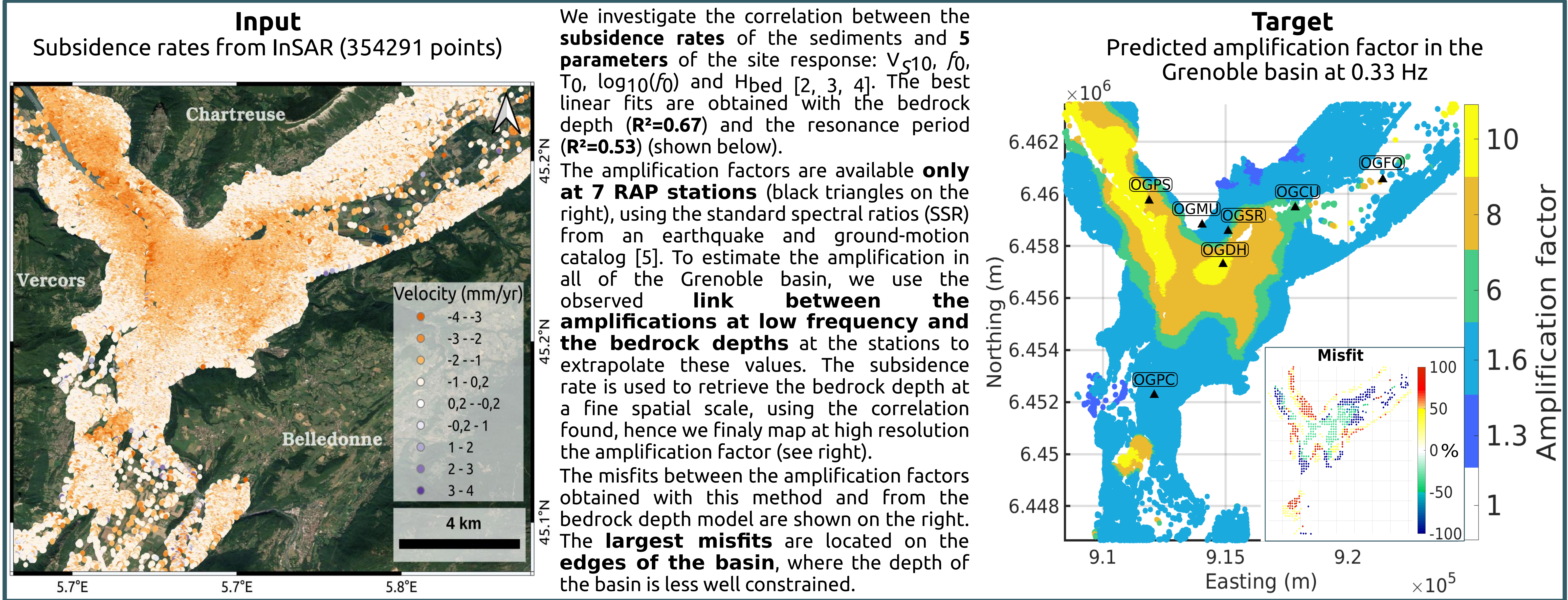
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# Combined InSAR-geophysical-seismological data for high-resolution site-effect modeling and ShakeMap generation, case study of Grenoble, France

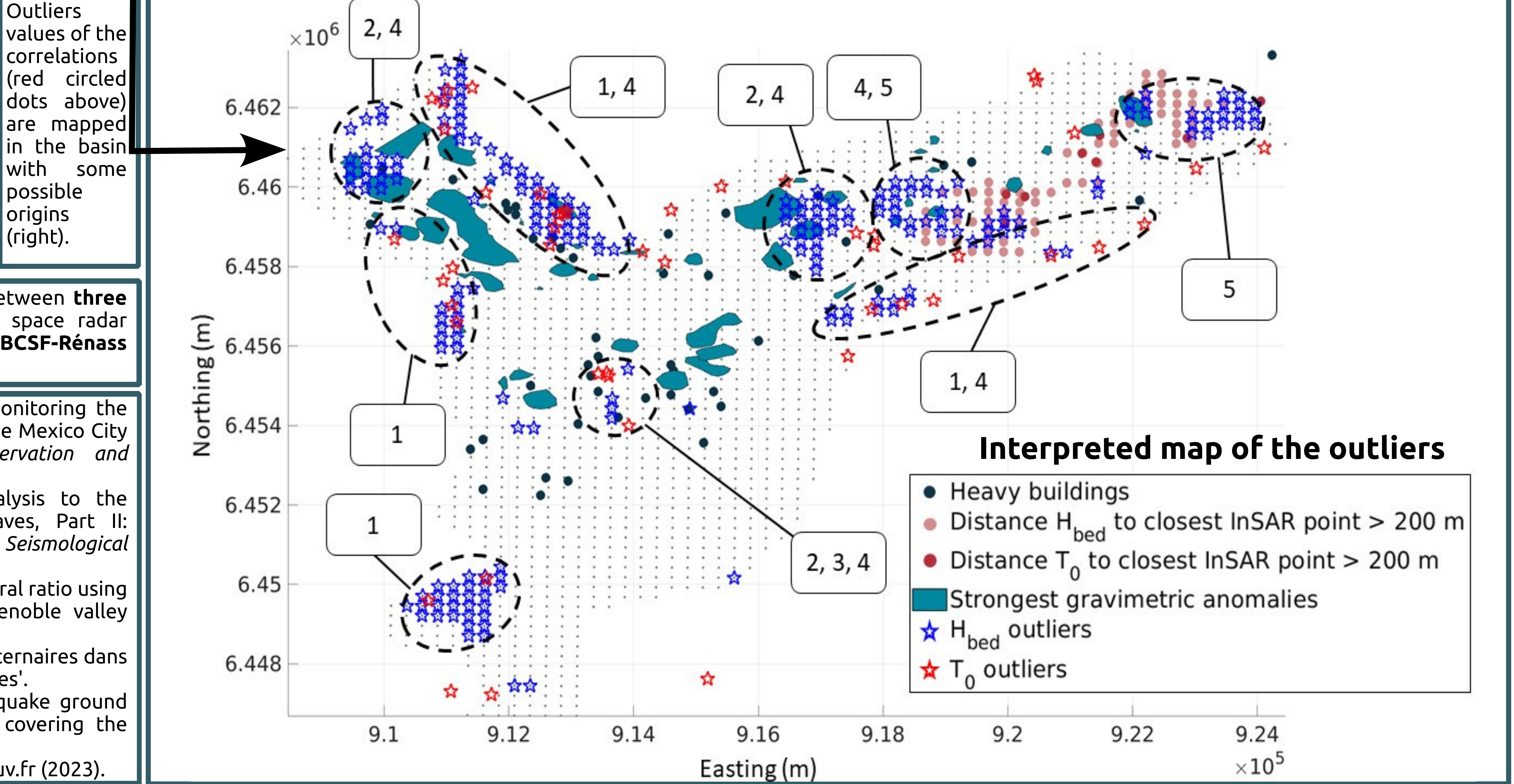
Valentin Schindelholz<sup>1</sup>, Aya Cheaib<sup>1</sup>, Emeline Maufroy<sup>1</sup>, Cécile Cornou<sup>1</sup>, Erwan Pathier<sup>1</sup>, Antoine Schlupp<sup>2</sup>, Léna Pellorce<sup>3</sup>, Véronique Mendel<sup>3</sup>, Marc Grunberg<sup>3</sup> 1:ISTerre, Grenoble, France 2:ITES, Strasbourg, France 3:EOST, Strasbourg, France Contact: schindev@univ-grenoble-alpes.fr

**Abstract:** In the urbanized valley of Grenoble, a well-known sedimentary basin prone to complex 3D site amplifications of seismic waves, multiple geophysical and seismological data from previous temporary campaigns and from permanent networks are gathered to characterize the basin response to earthquakes. Our goal is to find physical correlations between the parameters available at the highest spatial resolutions and the seismic response that is recorded by seismological stations only at a few sparse points in the basin. If such correlations exist, it would allow us to map the seismic response at a finer spatial scale [1]. We process InSAR data to retrieve the subsidence rate of the sediments at millimetric precision and at 354291 points in the basin. We then test multiple correlations between the subsidence rates and all the available site-effect parameters (as for example the depth of the bedrock below the sediments and the fundamental resonance period), in order to determine a model of aggravation of the ground motion based on the subsidence rates. The obtained model can be applied at a fine spatial scale to predict the Grenoble basin response to earthquakes in high resolution. The modeled response can in turn be used as an input to the ShakeMaps, or to predict earthquake-damage potential at building scale.



By excluding extreme values from the correlations with  $H_{bed}$  and  $T_0$  that we interpret as outliers, we **improve** the  $R^2$  value. We explore the origins of those **potential outliers**. Their location in the Grenoble basin is not aleatory and they tend to group into **clusters**.

- Possible origins for the outliers (labels on the map below):
1. Location close to the **edges of the basin**.
  2. Area with **heavy buildings** [6].
  3. Irregular or **complex bedrock geometry** at depth.
  4. Area corresponding to strong and variable **gravimetric anomalies** [4].
  5. The **distance** between the site-effect parameter and the closest InSAR point is **too large** (> 200 m).



The ANR project **SASHA** relies on the strong collaboration between **three SNOs**: **RAP** (strong-motion data), **ISDeform** (processing of space radar imagery for ground deformation measurements) and **BCSF-Réness** (seismicity, macroseismic intensities and ShakeMaps in France).

[1] - Albano, M. et al. (2016) 'An innovative procedure for monitoring the change in soil seismic response by InSAR data: application to the Mexico City subsidence'. *International Journal of Applied Earth Observation and Geoinformation*.  
 [2] - Cornou, C. (2003) 'Contribution of dense array analysis to the identification and quantification of basin-edge-induced waves, Part II: application to grenoble basin (French Alps)'. *Bulletin of the Seismological Society of America*.  
 [3] - Guéguen, P. et al. (2007) 'On the limitation of the H/V spectral ratio using seismic noise as an exploration tool: application to the Grenoble valley (France), a small apex ratio basin'. *Pure and Applied Geophysics*.  
 [4] - Vallon, M. (2014) 'Estimation de l'épaisseur d'alluvions quaternaires dans la cuvette grenobloise par inversion des anomalies gravimétriques'.  
 [5] - Buscetti et al. 'RESIF RAP and RLBP Database of earthquake ground motion in mainland France: Updated and improved version covering the 1996-2021 period'. In preparation.  
 [6] - Base de données nationale des bâtiments (BDNB) - data.gouv.fr (2023).