

Proposed Roadmap – ORFEUS/SM-SMC Working Group on Seismological Station Installation Effects

Context

Recent studies, including Hollender et al. (2020), Castellaro et al. (2022), and the extensive experimental work recently carried out by Rischette (2026), have demonstrated that the way seismic sensors are installed can significantly affect recorded ground motion, sometimes over frequency ranges directly relevant to engineering seismology applications. Nevertheless, these effects remain insufficiently documented in network metadata and are rarely considered when strong-motion databases are compiled and used. As a consequence, recordings that are not truly representative of free-field conditions may be treated as such, potentially introducing biases in derived quantities—including response spectra, magnitude estimates, and high-frequency attenuation parameters such as κ —and artificially increasing the variability of Ground Motion Models (GMMs). In some cases, installation effects can be of the same order of magnitude as lithological site effects and may produce amplification or deamplification reaching factors as large as 10.

Several families of installation effects need to be considered. Sensors installed at depth, particularly in boreholes, postholes, or tunnels, may exhibit significant deamplification resulting from destructive interference between upgoing and downgoing waves. Stations installed inside buildings may be affected by soil–structure interaction (SSI), a well-known phenomenon whose impact on recorded ground motion is nevertheless often underestimated, with significant perturbations occurring from the building resonance frequencies onwards, particularly at soft-soil sites. At a smaller scale and generally at higher frequencies, micro-SSI effects may also be induced by the devices used to couple the sensor to the ground, including concrete slabs, seismic pillars, manholes, and different embedment or anchoring configurations. Recent experimental results show that apparently similar installation configurations can behave very differently at high frequencies, whereas appropriately designed solutions can provide recordings very close to free-field conditions over a broad frequency range.

In this context, we announce the launch of an ORFEUS/SM-SMC Working Group on Seismological Station Installation Effects. Its overall objective is to promote better consideration of installation effects throughout the entire data lifecycle, from station design and installation to metadata documentation and the use of strong-motion data in European databases.

Objectives

The Working Group would focus on four main objectives:

1. **Communication and awareness among network operators and data users.** The first objective will be to disseminate current knowledge on installation effects and their consequences as widely as possible. Communication should target both network operators responsible for station installation and maintenance and users of strong-motion databases, who often lack sufficient information to assess whether recordings are representative of free-field conditions. Activities could include dedicated presentations and sessions within ORFEUS/SM-SMC meetings, workshops, concise guidance documents illustrating the main categories of installation effects, and eventually reference publications or technical documents for the broader community.

2. **Development of good-practice guidelines for new station installations.** The Working Group will develop practical recommendations for designing and installing new stations, aimed at minimizing installation-induced perturbations. These recommendations should address site selection, proximity to buildings and significant topographic features, installation depth, the choice and geometry of coupling devices, embedment and anchoring methods, and solutions for protecting instrumentation. The objective is not necessarily to prescribe a single standard installation configuration, but rather to provide network operators with criteria for selecting installations with a known and sufficiently broad usable frequency range, consistent with the scientific objectives of the network. Recent experimental results already provide a substantial basis for developing such recommendations.
3. **Improving the use of existing strong-motion databases.** A third objective concerns the large number of stations that are already installed and whose configurations cannot be readily modified. The first step will be to define criteria for identifying stations likely to exhibit significant installation effects and to characterize the frequency range over which their recordings can be considered reliable. The Working Group will also investigate the possibility of associating stations with Station-to-Free-Field (S2FF) functions, describing as a function of frequency the ratio between the motion recorded at the station and the corresponding expected free-field motion. Such functions could ultimately be used either to qualify the recordings and define their usable frequency range or, where sufficiently robust, to correct them towards mimicking free-field conditions. This objective therefore involves both methodological developments and the promotion of additional measurements at key stations. Temporary free-field deployments provide the most direct reference, while ambient-vibration measurements may offer a practical means of diagnosing installation effects, generally up to approximately 10 Hz.
4. **Improving and harmonizing metadata describing installation conditions.** Finally, the Working Group will identify the information required for users to properly assess potential installation effects. Relevant metadata may include installation type—surface, posthole, manhole, borehole, tunnel, basement, etc.—sensor depth, characteristics and dimensions of coupling devices, embedment or anchoring methods, characteristics of the structure housing the station, and proximity to surrounding structures. Where available, more directly usable information could also be provided, such as a recommended usable frequency range or an S2FF function. The Working Group will assess how these parameters can be incorporated into existing metadata exchange formats, particularly FDSN StationXML, promote more systematic documentation using existing fields, and, where necessary, propose and discuss extensions to current standards with the relevant standardization bodies.

Ultimately, the objective is to establish a consistent framework covering the entire chain: better installation of new stations, better documentation of existing stations, improved identification and—where appropriate—correction for installation effects, and provision of sufficient information for database users to make informed decisions regarding the suitability of individual recordings. ORFEUS/SM-SMC provides a particularly appropriate framework for such an initiative, as it sits at the interface between network operators, data providers, and the strong-motion community developing Ground Motion Models and seismic hazard applications.

Participation in the Working Group

All members of the ORFEUS community interested in these issues are warmly invited to contribute to the Working Group. Participation is particularly encouraged from both seismic network operators, who can provide practical experience and knowledge of station installation and maintenance, and strong-motion data users, who can help identify the information and tools needed for an appropriate use of existing datasets. Contributions from researchers working on installation effects, soil–structure interaction, instrumentation, metadata, Ground Motion Models, or related topics are also very welcome. The Working Group is intended to remain open and collaborative, bringing together these different perspectives to develop recommendations and solutions that are both scientifically sound and practically applicable.

References

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