Report of Transnational Access Projects

(Note: the information here will be publicly disclosed in the Geo-INQUIRE website, do not include sensitive information)

Project ID: *C1-2024*

Principal investigator: *Elena Manea*

Project team (if applicable):

Project title: *Non-Ergodic Ground Motion Models for the Vrancea Intermediate - Depth Source (Romania) and Their Implications for ESHM20*

Project acronym:

Hosting installation: *EF-PSHA (Probabilistic Seismic Hazard Analysis) installation (TA2-542-1), ETH Zurich, Switzerland*

Hosting team: *Laurentiu Danciu*

Period of access: *08 - 12 July & 19-23 July 2024*

Report of activities:

[Around 3000 characters. Describe the activities performed, equipment and software used, key results. Images can be also provided here. Image captions do not count towards the characters number.]

During the Geo-INQUIRE visit, we first evaluated the 2020 European Seismic Hazard Model (ESHM20) against observations from Romania to identify systematic patterns in model performance (Manea et al., 2025). Building on this assessment, the work focused on developing a non-ergodic modelling framework for the Vrancea intermediate-depth seismic source and evaluating its implications for probabilistic seismic-hazard estimates in Romania.

During the first week (08–12 July 2024), we performed a sensitivity analysis of ESHM20 hazard estimates for several Romanian cities using ground-motion recordings and macroseismic observations spanning up to several hundred years. Results indicated consistency between ESHM20 and observations in cities close to the Vrancea intermediate-depth source. Along the Carpathian Mountains, modelled hazard tended to exceed recorded Vrancea ground motions, whereas it tended to be lower at far-field locations outside the Carpathians. The analysis identified potential contributions from local site effects, earthquake source characteristics and differences in ground-motion attenuation, thereby motivating the subsequent non-ergodic modelling work.

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During the second week (19-23 July 2024), we implemented and adapted the non-ergodic ground-motion modelling procedures of Kuehn et al. (2019) and Lavrentiadis et al. (2023), applying them to the ground-motion models of Manea et al. (2022). We also developed alternative Vrancea source models for hazard calculations using polygon-based and three-dimensional approaches. The polygon representation provides a practical geometry for conventional source characterisation, while the three-dimensional approach better represents the depth distribution and spatial geometry of intermediate-depth Vrancea seismicity.

The modifications were incorporated into a probabilistic seismic-hazard computation workflow as a follow-up to the Geo-INQUIRE visit. During and after the visit, we used the computing facilities and seismic-hazard software available at EF-PSHA, together with implementation scripts and data-processing tools for preparing inputs, estimating model components and analysing outputs. The hazard results from the revised source and ground-motion models were compared with the ESHM20 backbone model described by Weatherill et al. (2020). The analysis identified changes in hazard level and spatial distribution and separated the effects of source representation from source, site and path corrections.

The visit and follow-up activities strengthened collaboration between the Romanian research and ETH Zurich teams.

Project outcomes:

Manea, E. F., Danciu, L., Cioflan, C. O., Toma-Danila, D., & Gerstenberger, M. C. (2025). Testing the 2020 European Seismic Hazard Model (ESHM20) against observations from Romania. Natural Hazards and Earth System Sciences, 25(1), 1-12. https://doi.org/10.5194/nhess-25-1-2025

Manea, E. F., Danciu, L., Cioflan, C. O., Toma-Danila, D., & Gerstenberger, M. C.. Testing the ESHM20 model with macroseismic observations and earthquake records in Romania. 102nd Journées Luxembourgeoises de Géodynamique (JLG) & EFEHR Scientific Session 2024

Manea, E. F., Danciu, L., Cioflan (2026). From ESHM20 Evaluation to Model Revision: Romania's 2026 Seismic Hazard Update. In prep for NHESS