THE METIS PROJECT NEWSLETTER

THIRD EDITION

WELCOME TO THE THIRD METIS PROJECT NEWSLETTER

With this newsletter we invite you to learn more about the project's latest developments, the partners' achievements, and METIS events. METIS project has the goal to improve current practice for seismic risk assessment analysis by considering the whole analysis chain, from hazard and ground motion to site response, fragility, and risk quantification.

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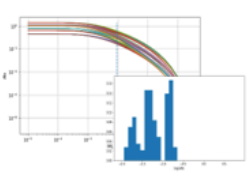
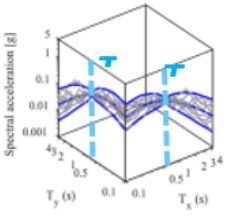
<td>  </td>
<td>  </td>
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<td>Seismic hazard at rock</td>
<td>Site response and ground motion</td>
<td>SSCs response and fragility</td>
<td>Risk quantification</td>
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<td colspan="4">METIS
Seismic Risk Assessment for Nuclear Safety</td>
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The METIS project shares and disseminate best practices and new approaches for seismic risk assessment, building on existing and new opensource tools.

Existing opensource tools for probabilistic seismic hazard assessment (PSHA), structural analysis via the fine element method (FEM), mesh generation, pre-and postprocessing and system analysis are:

New codes are shared on the [openMETIS gitlab repository.]

This newsletter focuses on the recent achievements in:

- New tools for hazard assessment developed in openquake
- New opensource tool PyPSHATest
- Code_aster finite element model developed for METIS case study assessments

This newsletter also gives you a summary of this year's events and an invitation to join us for upcoming events in 2024!

Irmela Zentner (METIS project coordinator)

TOPIC FOCUS

CODE_ASTER REACTOR BUILDING MODEL

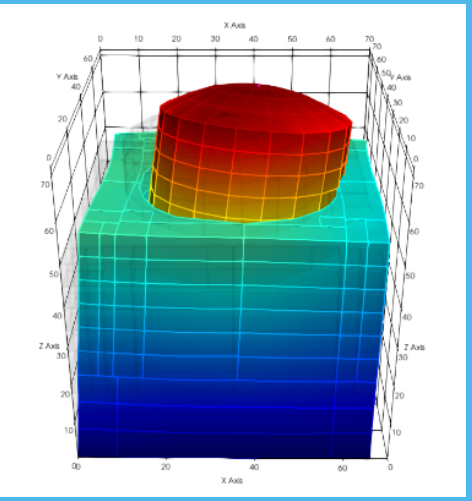
Within the framework of WP6, EDF UK Centre with the support of EDF R&D has developed a numerical model of the reactor building for the METIS study case.

This model serves the purpose of assessing the feasibility and benefit of new approaches for record selection and uncertainty propagation in the framework of an integrated approach including site response and soil structure interaction (SSI) for fragility assessment of nuclear systems structures and components (SSC). The structural model chosen for METIS case study is the containment building of Ukrainian Zaporizhzhia NPP. The data for this purpose has been provided by partner SSTC-NRS. The numerical model was developed using the EDF in-house open-source platform, Salome_meca. Geometry and mesh generation were handled through the GEOM and MESH modules, while dynamic analyses were executed using the **code_aster** finite element method (FEM) solver.

This model is founded upon the methodologies and approaches established in code_aster by EDF R&D, specifically for Soil Structure Interaction and seismic analyses. The approach adopted here for SSI is the FEM-BEM approach where the soil impedance and seismic force are computed by a dedicated boundary element method code (BEM), MISS3D. These methodologies have undergone rigorous validation through a diverse range of test cases.

For the computation of hazard and SSI, METIS case study considers a site in central Italy where soil surface ground motion and associated soil profiles have been developed in WP5.

Mesh and first eigenmodes:



Transfer functions accounting for SSI:

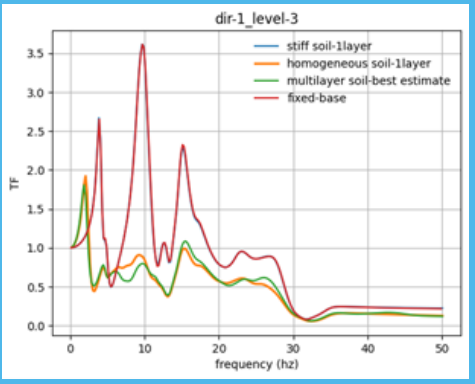
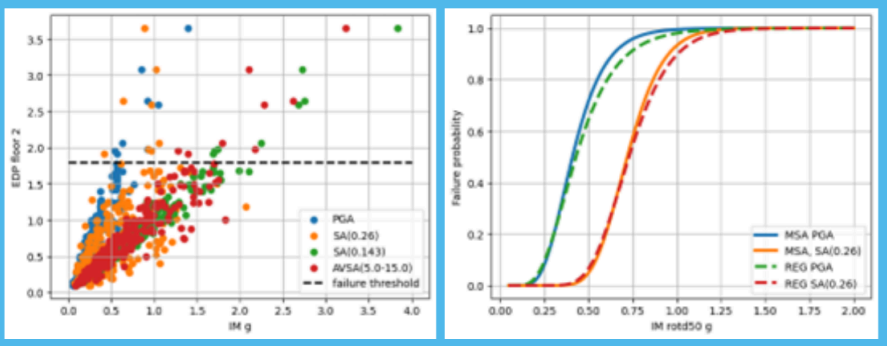


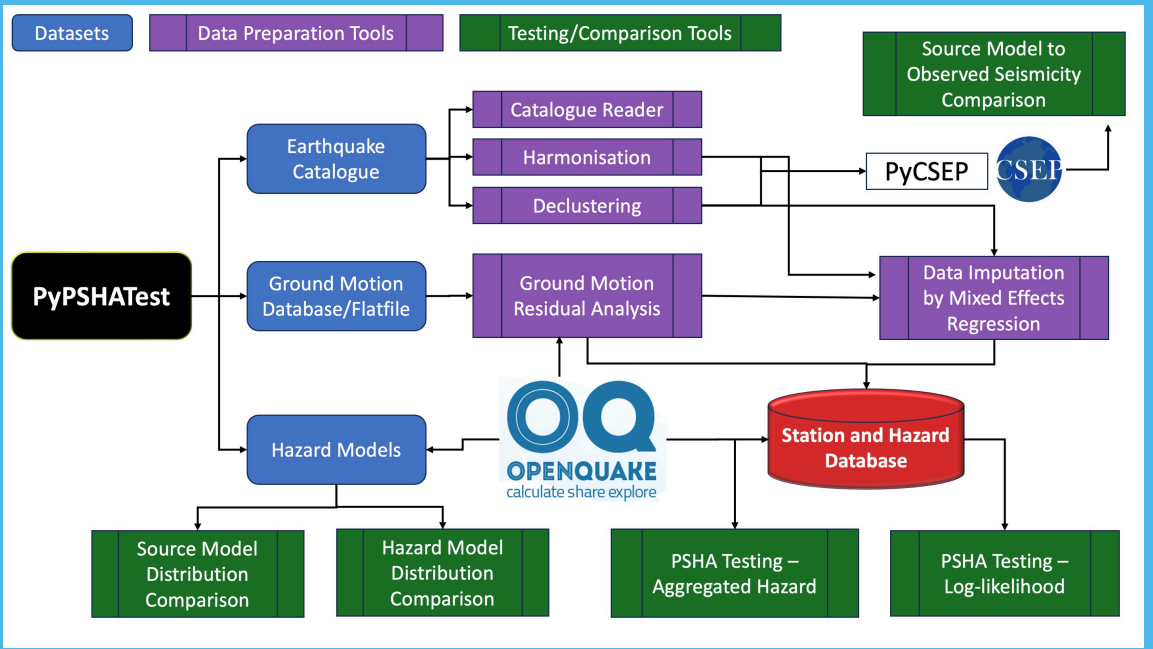
Illustration of floor EDP and fragility curves using different intensity measures and approaches (regression and multiple stripes):



Authors: Assia Khemakhem & Irmela Zentner (EDF)

PyPSHATest – A NEW TOOLKIT FOR PROBALISTIC SEISMIC HAZARD MODEL TO DATA COMPARISON

Rapid growth of instrumental ground motion databases across Europe (and worldwide) provides a wealth of information for quantitative comparison of probabilistic seismic hazard analysis against observed shaking. While the short time-period of instrumental recording prohibits site-specific validation of PSHA, this large body of data can help us to make earthquake hazard model-to-data comparisons at regional scales by aggregating across many recording stations. The instrumental record is seldom a faithful archive of ground shaking in a region, however, and new tools are required to make quantitative comparisons that can exploit the observations we do have and compensate for the incompleteness where ground motion records are missing or unusable. To facilitate such analysis and to explore how hazard models and their components compare to observed data, a new open-source Python toolkit PyPSHATest has been developed within METIS. This toolkit leverages upon OpenQuake and offers a range of functions to help hazard modelers and engineering seismologists explore differences between models and data in greater depth, and to make these comparisons a convenient, transparent and reproducible process in probabilistic seismic hazard model development and application.



openMETIS gitlab repository

Author: Graeme Weatherill, GFZ German Research Centre for Geosciences

NEW OPEN QUAKE TOOLS

Several new advanced features have been implemented by GEM in OpenQuake, (**the open-source tool for seismic hazard assessment**).

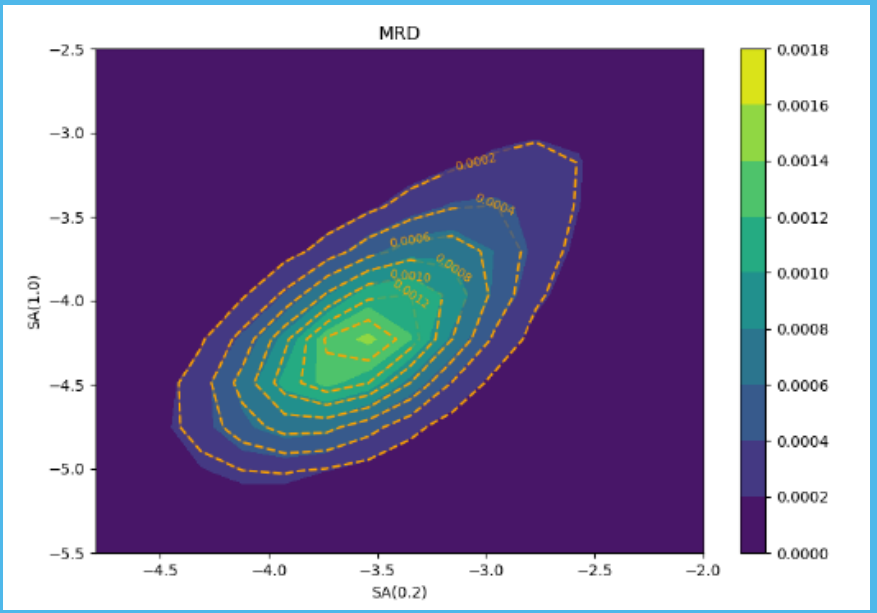
These new features include.
- New and more efficient approach for uncertainty propagation
- Computation of Conditional Spectra (CS)
- Vector Probabilistic Seismic Hazard Assessment (VPSHA)

The new features are ready for use in the openquake engine. Below we give a few details on the implementations.

Uncertainty: In PSHA, the epistemic uncertainties are generally propagated through logic trees. In many site- specific probabilistic seismic hazard models, the number of branches in the logic tree can become particularly large. Then it is important to be able to to efficiently propagate this epistemic uncertainty. The approach proposed here uses the convolution and mixture of discrete probability density functions to propagate the results produced by the processing of logic trees describing the full set of uncertainties admitted by individual sources. The new approach has been tested so far using relatively simple benchmark hazard models. GEM is currently in the process of performing more extensive tests and to extending to typologies of hazard results other than hazard curves.

CS approach. This approach is computationally intensive but considers all contributing scenarios and fully propagates uncertainties and all contributions of scenarios. It is implemented in the OQ in a parallelised form to improve calculation efficiency.

VPSHA: A new method for computing vector hazard has been implemented in OQ. It is more efficient than the direct consideration of the vector IMs in the hazard integral or the former indirect approach proposed by Bazzurro et al 2010. More precisely, the method circumvents the limitations of using the results of traditional disaggregation analyses by replacing it with a disaggregation performed in a two-dimensional space considering the median value of ground motion and the standard deviation of the logarithm of ground-motion.



Author: Marco Pagani, Global Earthquake Model Foundation (GEM)

LEARN MORE ABOUT METIS

Discover the new METIS Deliverables

Check out the latest deliverables and project results from the METIS project!

METIS Deliverables

UPCOMING EVENTS

5-7 June 2024 / METIS June 2024 Plenary Meeting (5-6 June) and Training School (7 June) in Ljubljana, Slovenia hosted by partner UL

- The Training School will focus on training for engineers in NPP.

November 2024 / METIS November 2024 Training Session in Germany hosted by METIS partner TUK (date TBD)

- The training session will focus on advances in seismic PSA.

Happening in 2025:

- 28-29 April 2025 - Summer School in Greece (location TBD)
- 21-23 May 2025 - Final METIS Workshop and meeting at EDF Lab Paris-Saclay.

METIS will participate in:

3-8 March 2024 - SMIRT27 2024 JAPAN

- The SMiRT 27 (Structural Mechanics in Reactor Technology) will be held in person in Yokohama, Japan. The conference is the major event for structural mechanics and earthquake engineering in the nuclear sector and METIS will be present with around 10 papers to share recent results and developments with the nuclear community. More information **here.**

30 June – 5 July 2024 / 18th WORLD CONFERENCE ON EARTHQUAKE ENGINEERING (WCEE) 2024 MILAN

- METIS will organise a special session at the upcoming **World Conference for Earthquake Engineering** from 30th June – 5th July 2024 in Milan. SHR-11: Advances in the seismic hazard and risk assessment of nuclear power plants. Convenors: Dimitrios Vamvatsikos, Paolo Bazzurro, Irmela Zentner. More information on the session, **here.**

THE SIXTH PLENARY MEETING

The Sixth METIS Plenary Meeting took place on 16-17 November 2023 at Centro Congressi Giovanni in Italy. The Plenary meeting was hosted by METIS partner GEM with around twenty members of the consortium present.

Read more here

PAST EVENTS

14-15 NOVEMBER 2023 / PSHA WORKSHOP

A site-specific seismic assessment hazard assessment workshop preceded the Sixth METIS Plenary Meeting on 14-15th November 2023 in Bergamo, Italy. It was hosted at Centro Congressi Giovanni by METIS partner GEM. The workshop gathered more than sixty attendees from academia and industry from Europe and overseas. It combined presentations from METIS partners and invited speakers on the topic of site specific probabilistic seismic hazard assessment. State of the art and new approaches to develop site specific hazard in weak to moderate seismicity regions such as encountered in most European nuclear countries were addressed. **The workshop recordings are available at this link.**

30 JUNE-7 JULY 2023 / METIS WEBINAR SERIES

The METIS project organised a series of webinars covering topics of interest relating to innovation in tools and methods for seismic risk assessment of nuclear power plants.

21 JUNE 2023

The first webinar was an introductory webinar where METIS project coordinator Irmela Zentner. This first webinar gave an overview of this project including key achievements to date. Irmela went through all the different work packages outlining key achievements and outcomes so far in this project. This webinar was held on day two of the last Plenary in Kaiserslautern, Germany. There was a mixture of participants being in-person and via Teams. Further information **here.**

Watch the recording

30 JUNE 2023

New tools in OpenQuake Engine webinar" Marco Pagani from our partner GEM (Global Earthquake Model Foundation) gave a presentation on new and improved tools for PSHA implemented in the OQ Engine in the context of the METIS project.

Marco's presentation focused on some of new seismic hazard methodologies developed within the 'Seismic Hazard' work package of METIS. The focus of the online webinar was on describing a new approach with which it is possible to propagate epistemic uncertainties more efficiently. The methodology proposed is particularly advantageous in models with large logic trees. It can be efficiently used for calculating seismic hazard also at national scale. Further information **here.**

Watch the recording

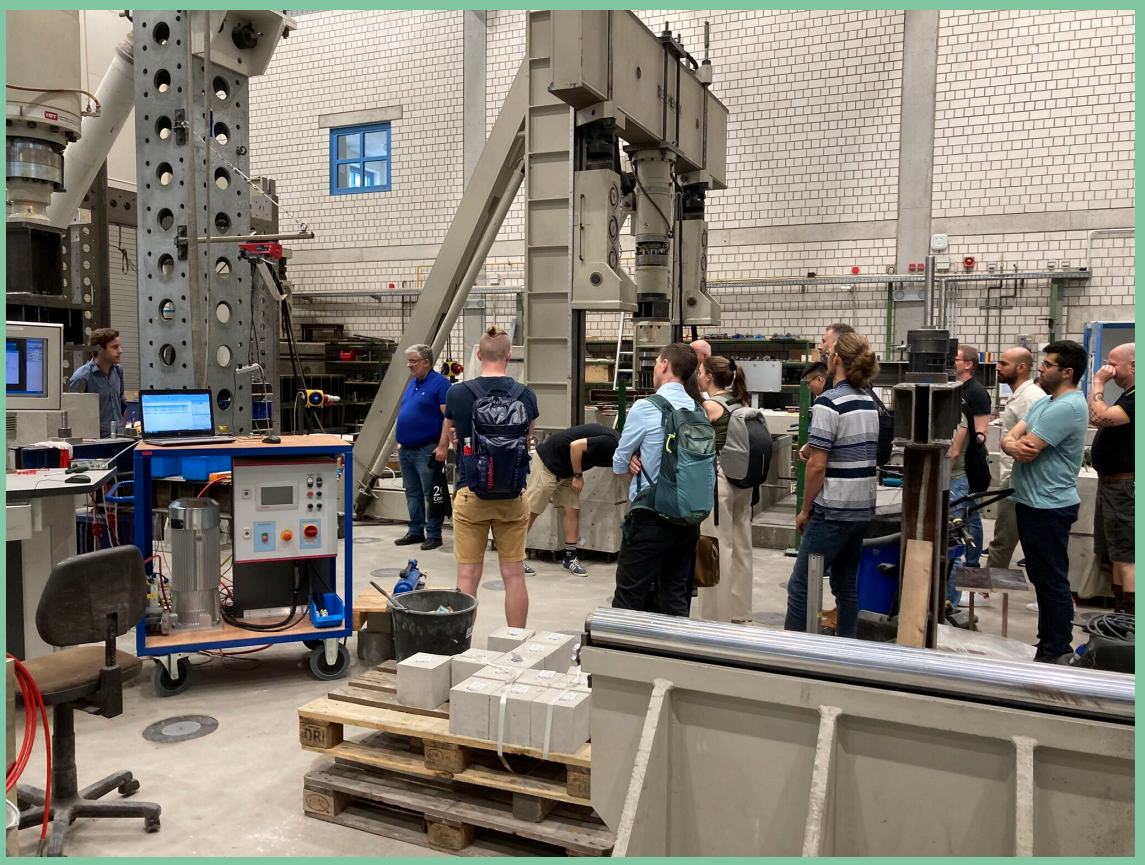
7 JULY 2023

PSHA (Probabilistic Seismic Hazard Assessment) Testing webinar Graeme Weatherill from our partners GFZ presented the new PSHA Testing toolkit for comparing PSHA results to observations. His team are hazard modellers who look at seismic analysis. He also described how to prepare the observational data and referenced the 'leaky data pipeline.' Further information **here.**

Watch the recording

22-23 JUNE 2023 / TRAINING SCHOOL SEISMIC HAZARD, FRAGILITY, AND RISK

The training school took place at the RPTU premises in Kaiserslautern (Germany) from June 22nd and 23rd 2023, hosted by our partner TUK. The programme was centered around the main principles of probabilistic seismic risk assessment. Participants, including master's and Ph.D. students, and professionals, were provided with a valuable opportunity to explore the fundamental principles of probabilistic seismic risk assessment. Esteemed experts in the field shared their knowledge and insights, enriching the learning experience for all attendees. Furthermore, a laboratory tour was arranged for participants. This tour provided an opportunity for attendees to gain a deeper understanding of the laboratory environment and explore technologies employed in their fields.



21-22 JUNE 2023 / FIFTH METIS PLENARY MEETING

The METIS consortium came together in Kaiserslautern, Germany, for the Fifth Project Plenary meeting, organised by partner RPTU Kaiserslautern-Landau, Konstantin Goldschmidt and Hamid Sadegh-Azar.

The onsite meeting gathered around 30 participants, in particular we were happy to meet again and discuss with our colleagues from SSTC-NRS in the Ukraine. A hybrid onsite and remote meeting, the project coordinator and WP leaders Irmela Zentner, Marco Pagani, Paolo Bazzurro, Shadi FathAbadi and Oleksandr Sevbo presented their updates and milestones. The second day was dedicated to technical focus sessions to discuss progress on METIS Case Study structures, systems and components' (SSCs) models and site response analysis; new approaches for fragility analysis and SSCs response, updates for the development of a methodology for considering aftershocks in seismic PRA including experience feedback.

9 AND 14 FEBRUARY 2023 / METIS AFTERSHOCK WORKSHOP

On 9 and 14 February 2023, an aftershock workshop was organised with participation of EAB and METIS consortium (contributions from all technical WPs.) The workshop was held remote only and allowed to define and refine the final strategy for considering aftershocks in PRA.

15-16 DECEMBER 2022 / FOURTH METIS PLENARY MEETING

The Fourth Plenary meeting was held in Paris and took place from the 15th of December to the 16th of December 2022. The Fourth METIS plenary meeting took place from 14th-15th December Paris, France, hosted by partner IRSN and Benjamin Richard with twenty eight members of the consortium present.

The first day of the meeting, the WP leaders presented their updates and milestones. The second day was dedicated to technical focus sessions with contributions from Dimitrios Vamvatsikos, Irmela Zentner, Paolo Bazzurro, Thomas Langlade, Abhinav Gupta, Thomas Chartier, Baumont David and Emmanuel Viallet to discuss progress on conditional spectra, uncertainty propagation and Bayesian approaches for fragility analysis and SSCs response, PSHA and ground motion developments for METIS case study, and the development of a methodology for considering aftershocks in seismic PRA.

METIS project also welcomed Abhinav Gupta as a new EAB (External Advisory Board) member. The consortium had the chance to exchange onsite with members from METIS EAB and End Users Group and enjoyed social dinner at Montparnasse tower.

PAST CONFERENCES

- METIS participated in the COLLOQUE AFPS 2023 on 7-10 November in Guadeloupe. Work from WP5 was presented focusing on 3D physics-based simulation approach to simulate seismic wave propagation from source to the structure.
- METIS participated in the SECED 2023 on 14-15 September in Cambridge, UK. The conference was organised by the UK Society for Earthquake and Civil Engineering

Dynamics where Dimitrios Vamvatsikos (NTUA) and Irmela Zentner (EDF) gave keynote lectures and presented work related to METIS.

- METIS participated in the Eurodyn XII Conference on 2-5 July in Delft, Netherlands. Work from WP5 related to the implementation of a massively parallel FEM resolution for conducting 3D site response analysis in the framework of domain reduction methods with weak coupling of SEM3D spectral element code and FEM with code_aster.

OUR PARTNERS

This project has received funding from the Euratom research and training programme 2014-2018 under grant agreement n°945121. The content of this document reflects only the author's view. The European Commission is not responsible for any use that may be made of the information it contains.