DEEP

Innovation for:
De-Risking Enhanced
Geothermal Energy Projects

Deliverable

Deliverable 5.4 - Release of the open-source toolbox for a priori and real-time risk assessment

Report information

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Summary

This report summarized the repository for the codes needed for the use of RT-RAMSIS (Real-time Risk Assessment and Mitigation for Induced Seismicity). The repositories are divided into four main categories:

- **Main repository for RT-RAMIS core.** This software focuses on scheduling and running Seismicity Forecast Models in an operational way. By storing configuration and results in a database, the data is reproducible with recorded origins. Forecasts are scheduled automatically based on user configuration and the status of tasks and model runs is recorded.

- **Forecasting models.** As part of DEEP, two models have been fully implemented for operational purposes. One extra model, presented in the deliverable 3.3, is currently in the implementation phase.

- **Web service for storing and organizing hydraulic data** (HYDWS) and dedicated python client.

- A **web dashboard** for data and forecast results visualization.

Released codes and repositories

The table below summarizes all the available repositories and their dependencies.
All repositories are hosted on a GitLab dedicated account: https://gitlab.seismo.ethz.ch/indu

Table 1. List of repositories

Name	Link	Status	Description & dependency
rt-ramsis	https://gitlab.seismo.ethz.ch/indu/rt-ramsis	open	This software offers an operational way to run Seismicity Forecast Models. By storing configuration and results in a database, the data is reproducible with recorded origins. Forecasts are scheduled automatically based on user configuration and the status of tasks and model runs is recorded.
ramsis.datamodel	https://gitlab.seismo.ethz.ch/indu/ramsis.datamodel	open	This standalone package provides the data model and serialization/deserialization capabilities to a PostgreSQL database, making the data abstraction available as a dependency for seismicity forecast models and future analysis software.
ramsis-ws	https://gitlab.seismo.ethz.ch/indu/ramsis-ws	open	This web service provides easy access to data defined by ramsis.datamodel.
ramsis-worker	https://gitlab.seismo.ethz.ch/indu/ramsis.sfm.worker	open	This standalone package provides the web service interface and job handling for seismicity forecast models, which receive past seismicity catalogs and, in cases of induced seismicity, hydraulic history and plans.
ramsis-model	https://gitlab.seismo.ethz.ch/indu/ramsis-model	open	This parser provides an adapter between the web service provider and the model. This translates the data between that stored by ramsis.datamodel and what is required by the model itself in order to ensure the operationalisation of the model.
ramsis-client	https://gitlab.seismo.ethz.ch/indu/ramsis-client	open	RT-RAMSIS Python Client to access forecastseries and data from a ramsis webservice easily.
ML1	https://gitlab.seismo.ethz.ch/indu/ML1	closed	ML1 Model: Multi-LASSO machine learning model to forecast induced seismicity (Mignan et al., 2024). This repository is not yet open but will be made public in the coming months.
EM1	https://gitlab.seismo.ethz.ch/indu/em1	open	EM1 Model: based on a purely empirical relationship between the injected/produced volume and the seismicity (Shapiro, 2015). Two calibration schemes are implemented: the maximum likelihood estimate (Mignan et al., 2017) and a Bayesian hierarchical framework (Broccardo et al., 2017).

hydws	https://gitlab.seismo.ethz.ch/indu/hydws	open	HYDWS provides a REST API interface for serving borehole hydraulic sample data. This document specifies the URLs, query parameters and expected results. An OpenAPI specification is also available by navigating to the /hydws/docs endpoint on a running instance.
hydws-client	https://gitlab.seismo.ethz.ch/indu/hydws-client	open	The Hydraulic Web Service Client can be used to access the data from a Hydraulic Webservice more comfortably.
indu-dashboard	https://gitlab.seismo.ethz.ch/indu/indu-dashboard	open	A web dashboard for data and forecast results visualization, implemented with dash (Plotly Technologies Inc. 2024) and python3.

References

Broccardo, M., Mignan, A., Wiemer, S., Stojadinovic, B., & Giardini, D. (2017). Hierarchical Bayesian Modeling of Fluid-Induced Seismicity. *Geophysical Research Letters*, *44*(22), 311–357. https://doi.org/10.1002/2017GL075251

Plotly Technologies Inc., "Dash Layout", 2024, https://dash.plotly.com/layout

Mignan, A., Broccardo, M., Wiemer, S., & Giardini, D. (2017). Induced seismicity closed-form traffic light system for actuarial decision-making during deep fluid injections. *Scientific Reports*, *7*(1). https://doi.org/10.1038/s41598-017-13585-9

Mignan, A., Rinaldi, A. P., Lanza, F., & Wiemer, S. (2024). A Multi-LASSO model to forecast induced seismicity at enhanced geothermal systems. *Geoenergy Science and Engineering*, *236*, 212746. https://doi.org/10.1016/j.geoen.2024.212746

Shapiro, S. A. (2015). *Fluid-induced seismicity*. Cambridge University Press.