

# Proposal for Research Initiative at DUSEL

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## Understanding the complexity of the crustal Earth system for geo-scientific and geo-engineering purposes by using new computational methodologies

**Scientific Objectives:** The major research themes outlined in the DUSEL technical report looks at (a) **Seeing** into the Earth (b) **Understanding** the dynamic Earth and (c) **Engineering** the Earth. Research at DUSEL is a unique opportunity to focus on the Earth as a human-nature coupled system, where Earth science and Earth engineering can partner with each other.

As part of this research initiative, I would like to contribute to **understanding the complexity of the Earth system**. Specifically how are rock parameters and features linked and related with each other when directly observing in-situ groundwater and rock mass behavior and seeing into the Earth with indirect geophysical measurement methods.

**Experimental Approach:** I propose developing, testing and validating integrative computational methods that link the afforded opportunities at DUSEL of “Seeing, Understanding, and Engineering the Earth system”. I envision conducting an online-onsite monitoring and interpretation initiative together with experts from the geophysical, geological and engineering communities. This campaign shall focus on characterizing **fluid-gas-rock system behavior** for practical purposes of engineering (e.g., geothermal energy, hydrocarbon recovery) and safety assessments (e.g., zones of weakness). Features and parameters of the multi-dimensional geoscientific data (e.g., wave velocities, electric conductivity, gravity) will be translated into data of need (e.g., fracture density, fluid flow, safety zones). One possible scenario is outlined below:

### Example - Fluid injection experiments

Possible data from:

- 3D geological/geochemical/geobiological data in the area of interest
- active and passive sub/surface geophysical monitoring over time using hammer or sweeper sources and cemented anchors (Klose et al. 2007); technical details can be provided
- gravity measurements (e.g., carbon dioxide/methane detection)
- electric conductivity measurements

Possible methods to be applied:

- conventional data interpretations by experts
- classification of multi-expert results by artificial intelligent methods to determine sensitivities (how many members of the target class were positively identified, e.g., high fractured rock mass) and specificities (how many members of the non-target class were positively identified, e.g., intact rock mass) of their findings
- characterization of multi-parameter/multi-expert interpretations
- application of the automated interpretation methods to predict fluid-gas-rock behavior online and onsite

**Outcomes:** I have previous experience investigating and implementing computational methodologies to prepare complex and multi-dimensional data in a way that the results help experts to understand inter-dependencies of single parameters. Attached you will find two articles explaining more details about the applicability of an artificial intelligent method, called **Self-Organizing Maps** (Klose, 2006; Klose et al. 2007). The abstracts of the attached publications highlight the major findings of applying this method to predict hazardous zones of weakness in the up to 2000 m deep (6000 feet) and 60 km long (38 miles) Gotthard base tunnel crossing the Alps in Europe. The paper represents just one example of how new computational methodologies can help answer (a) safety questions of underground excavations (geo-engineering purpose) and (b) interpretation questions when seeing into the Earth's crust (geo-scientific purpose).