# Surrogate Model Development for Rock Slope Failures using quoFEM

*NHERI Center for Computational Modeling and Simulation*

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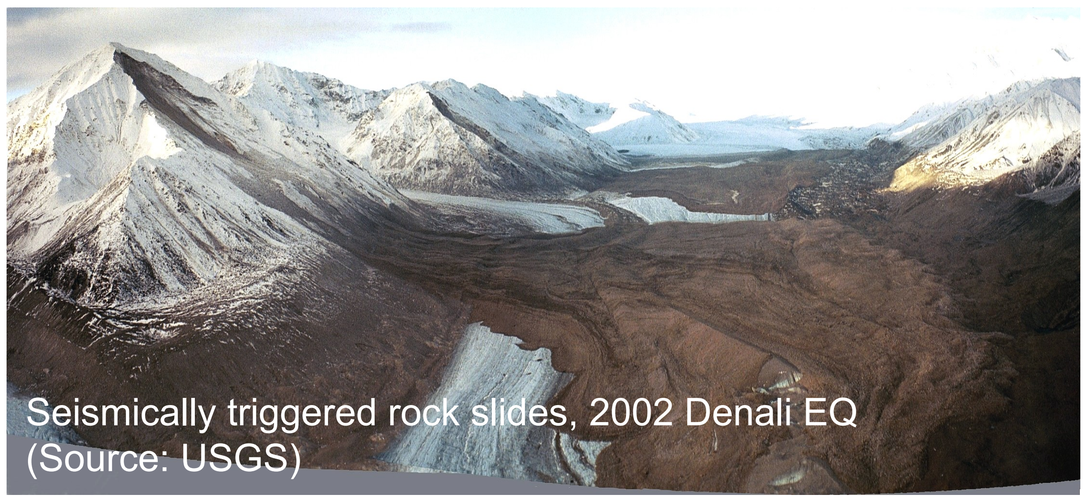


Seismically triggered rock slides, 2002 Denali EQ
(Source: USGS)

## Modeling Fractured Rock


**Capturing Kinematic Response**

Given the inherently blocky nature of jointed and fractured rock masses, the Discrete Element Method (DEM) provides a convenient approach for explicitly modeling the polyhedral shape of individual blocks. A new 3-D DEM application, `rollingRocks`, was developed and is currently being expanded to run in parallel using distributed memory.


**Uncertainty in Describing Joints/Fractures**

Uncertainty in describing joints/fractures:

- Visible parts are limited
- Internal structure cannot be observed
- Limited accuracy in observations

Realizations of fractured rock mass generated using `sparkRocks`

## Surrogate Model Development


**Generate Data for Training/Build Surrogate**

Direct numerical simulations can involve hundreds of thousands of particles/blocks and can be very computationally expensive, making them impractical on a regional scale. Here, we investigate whether Kriging surrogate models are able to capture fractured rock mass response such that they could be scaled up to do regional analyses. In this preliminary investigation, we consider toppling failure and develop surrogates for both displacement and rotation. This was done using DACE in MATLAB, but it is possible to use any other tools, models, or validation techniques

**Random variables to sample**

- Joint geometry
- Failure plane geometry
- Mechanical properties

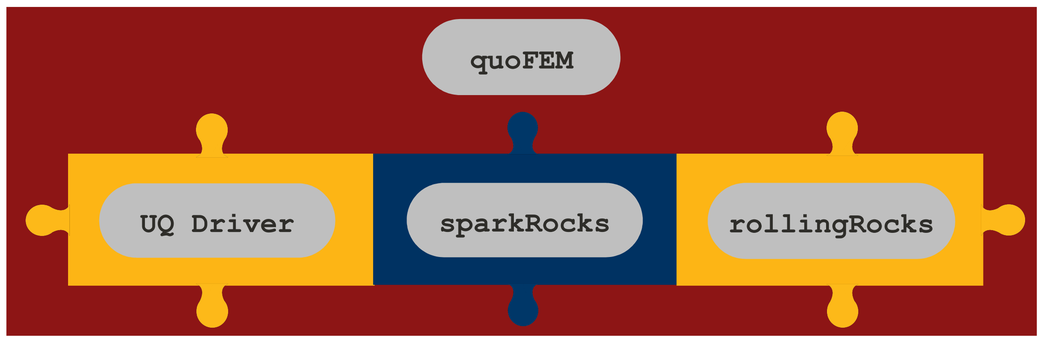
## Objectives:

**Proof of Concept**

- Kriging surrogates for rock slope failure analysis
- Preliminary investigation—goal is to go from detailed simulations to regional analyses

**Extend current SimCenter tools**

- Enable users to quickly wrap UQ functionality around other software
- More than FEM to `quoFEM`

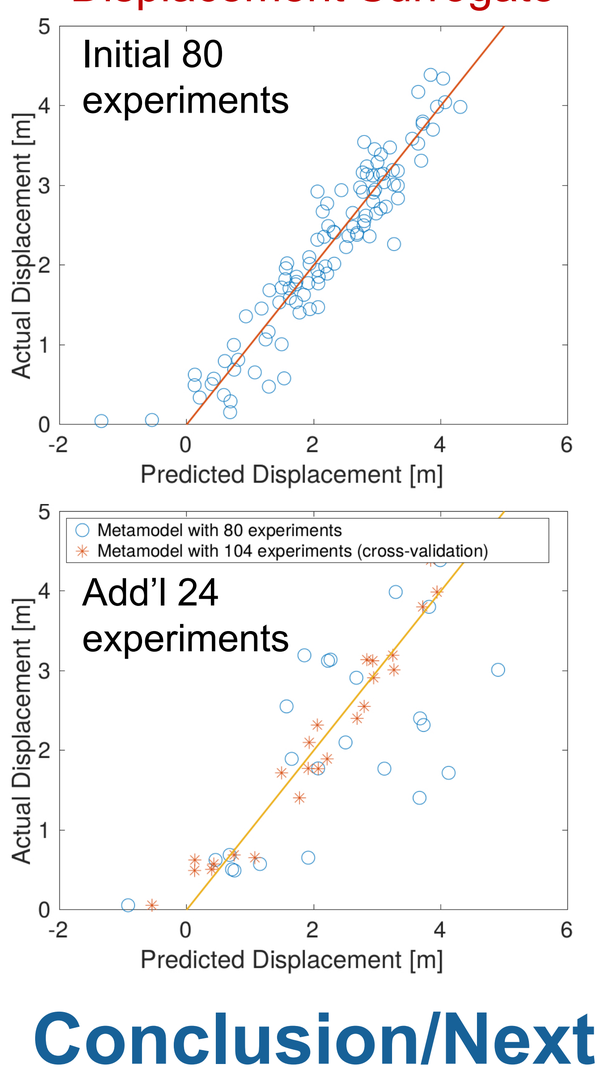


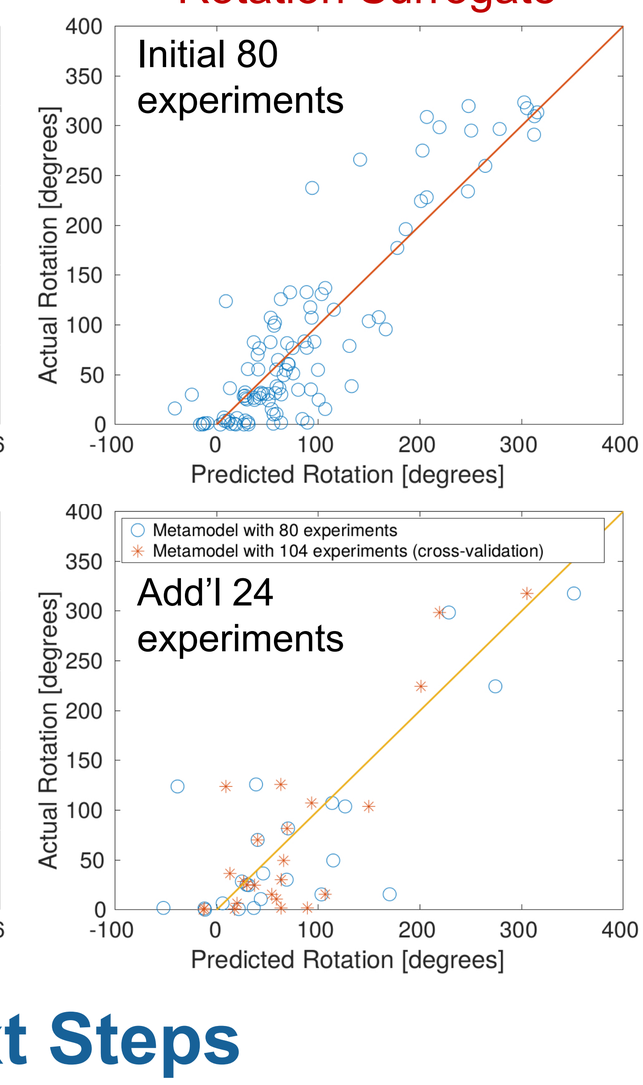

`quoFEM` wrapped around several internal “puzzle-piece” applications

## Results

Displacement Surrogate

Rotation Surrogate










## Conclusion/Next Steps

- Modular Tool Development
  - SimCenter tools can be expanded and applied to wide range of research questions
- `quoFEM` allows for rapid prototyping and is broadly applicable
- Next Steps:
  - Add interface for users to add their own analysis software to `quoFEM` and DesignSafe
  - Develop surrogates for forward prediction of seismically triggered slope failures

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