

Center for Computational Modeling and Simulation

Performance Based Engineering Application

https://simcenter.designsafe-ci.org/research-tools/pbe-application/

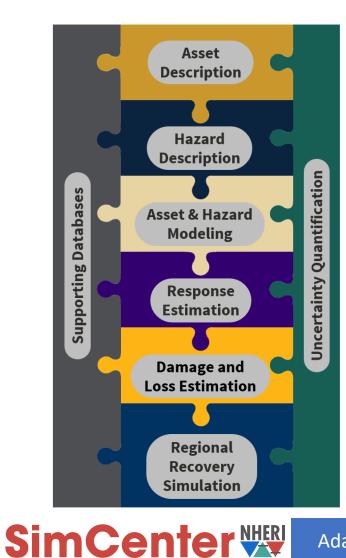
Adam Zsarnóczay adamzs@Stanford.edu



- Introduction to the PBE Application and pelicun
- Simple test examples
- Realistic example
- Limitations, expected new features

What is the PBE Application?

Application Framework



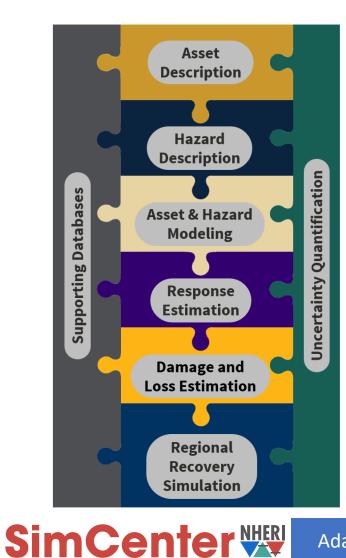
Regional Hazard Workflow

Applications describe the region specify characteristics of buildings and infrastructure in the region describe the hazard specify the regional distribution of ground shaking, wind, or water for each random region-hazard sample: propagate uncertain characteristics of the regional assets and the hazard for each asset in the region: describe the asset CWE create stochastic models for response, damage, and loss estimation EĘ describe the event at the site specify hazard-consistent loads for response estimation for each random asset-event sample: propagate uncertainties in asset models and event description ЧЕМ estimate asset response to the event 0/10 describe the response with engineering demand parameters estimate asset damage and its consequences PBE prepare a stochastic description of damage and loss for the asset describe regional damage and direct losses aggregate damages and losses in the region considering dependencies estimate indirect regional consequences describe regional consequences of infrastructure- and social disruption

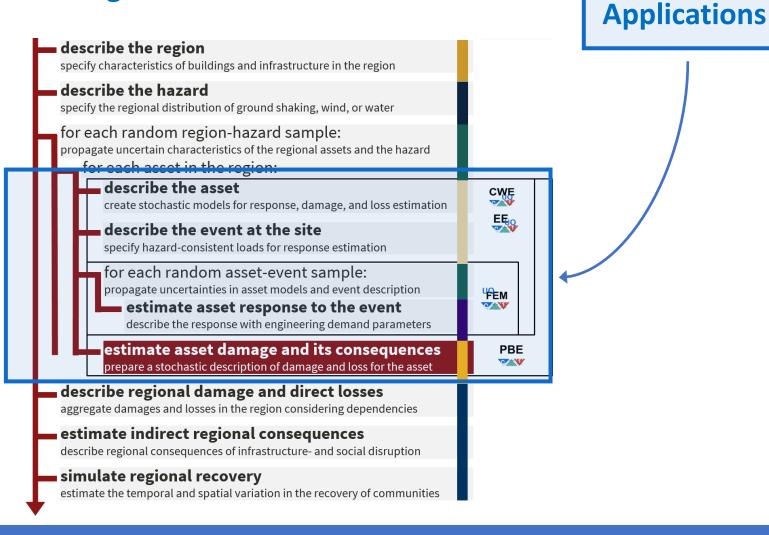
simulate regional recovery estimate the temporal and spatial variation in the recovery of communities Desktop

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Regional Hazard Workflow



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Desktop

Frontend - Desktop Application

Provides a convenient user interface to use the loss assessment workflow for a single building.

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SimCenter W

Prepares an input file for the backend.

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Frontend - Desktop Application

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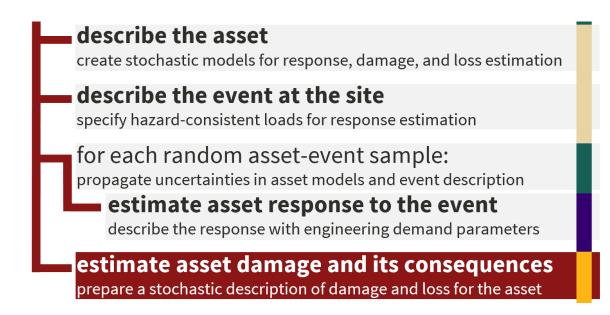
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Frontend - Desktop Application

SimCenter 🚟

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Prepares an input file for the backend.



- G General Information
- SIM Simulation Model
- **EVT** Events = Ground Motions for now
- **FEM FEM Analysis Options**
- **UQ** Uncertainty Quantification
- Damage and Loss Model

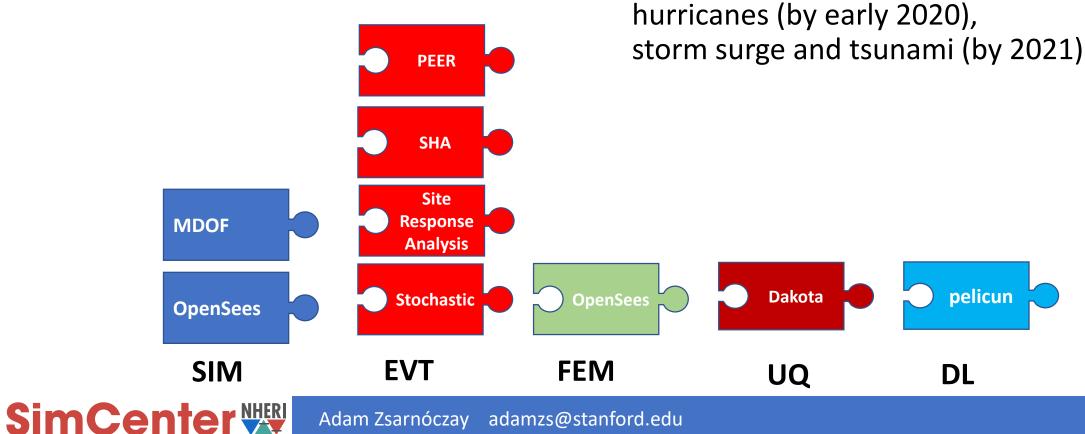
Results

Backend – Workflow (i.e., Python script)

EE-UQ backend extended with loss assessment.

Damage and Loss assessment performed using pelicun (https://github.com/NHERI-SimCenter/pelicun)

Hazard-agnostic workflow designed for earthquakes (now),

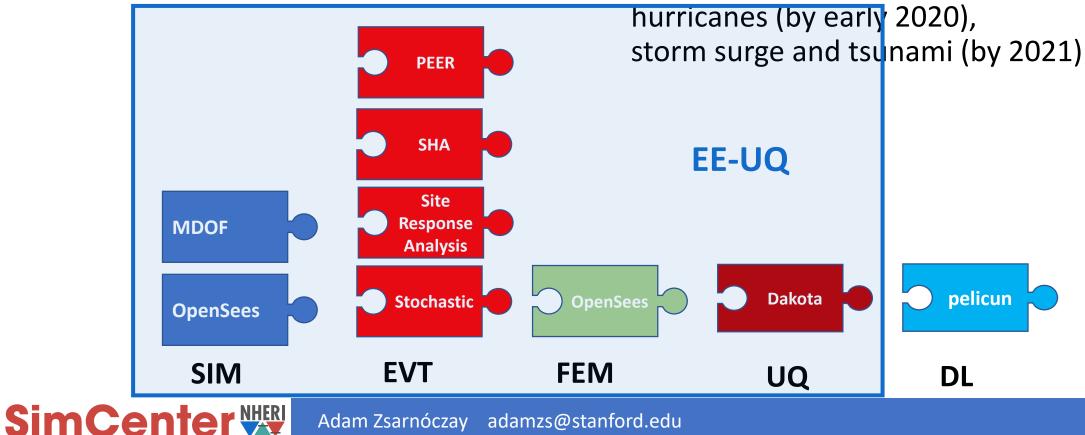


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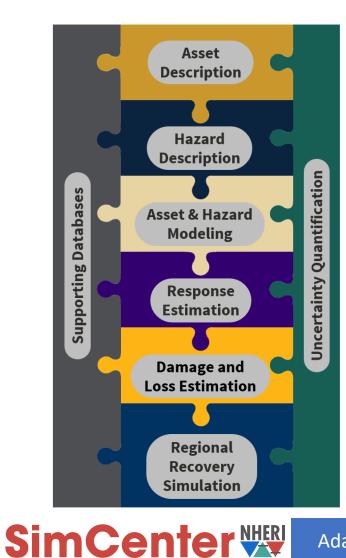
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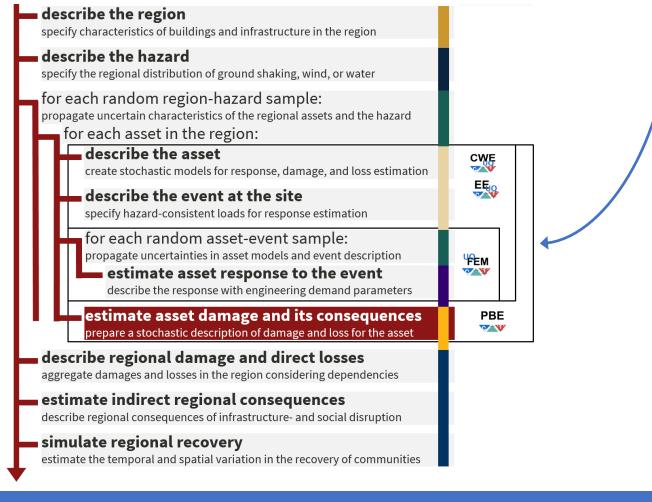
hurricanes (by early 2020), storm surge and tsunami (by 2021) PEER SHA pelicun?? Site Response **MDOF** Analysis pelicun Dakota Stochastic **OpenSees OpenSees** SIM EVT **FEM** UQ DL SimCenter VIII

Application Framework



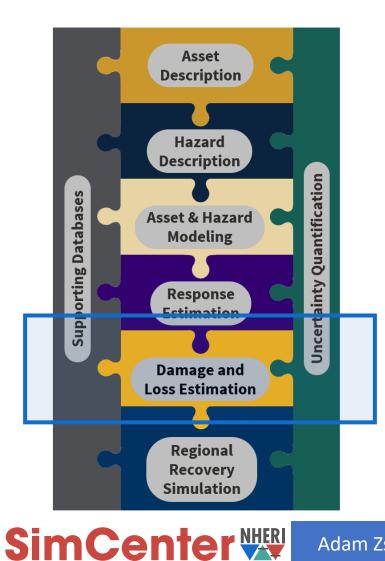
Regional Hazard Workflow

Desktop Applications



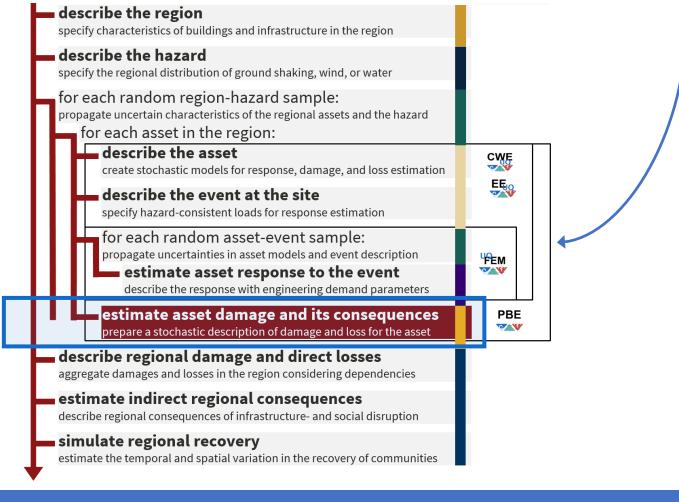
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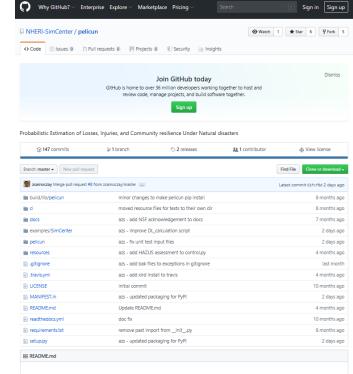
pelicun is an acronym

Probabilistic Estimation of Losses, Injuries, and Community resilience Under Natural disasters



pelicun is a Python package for damage and loss assessment

- not part of the PBE application, but used by its backend workflow





II 10.5281/zenodo.2558558

Probabilistic Estimation of Losses, Injuries, and Community resilience Under Natural disasters



SimCenter VIII

pelicun is a Python package for damage and loss assessment

- not part of the PBE application, but used by its backend workflow
- uses a generic, stochastic damage and loss model
- FEMA P58 and HAZUS earthquake DL methods and fragility data are already available

HAZUS – based on component assemblies, lower fidelity, less input needed

FEMA P58 – based on individual components, lots of input data needed



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- supports user-defined DL methods, EDPs, and fragility data

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- every function is documented, a getting started manual is coming by July
- already has active users -> help discover bugs and suggest new features
- calculations are preformed by C libraries -> fast and efficient

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- free and open source

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General Information

- stories and plan area are important for loss assessment
- pay attention to the units!
- other pieces of information are not used currently

Simulation Model

MDOF

- Uses a shear beam with a bilinear constitutive model. Good for frames, limited applicability for shear walls.
- Allows random variables for parameters.

OpenSees

- Tcl input files for now, but OpenSeesPy support coming in July
- Pay attention to proper definition of the column line!
- Random parameters need to be in the main file.
- EDPs only PID and PFA for now, user-defined EDPs coming by September

Events (ground motions)

Multiple PEER & Multiple Existing

- The difference is only in the data format (PEER and SimCenter)
- Names need to be unique!
- Multi-degree of freedom excitation has not been thoroughly tested
- Load directory allows you to load multiple motions and scale factors quickly

Hazard Based Event

- We need a ground motion database – working on an agreement with PEER

Site Response

- Multiple ground motion support coming in September

Stochastic

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- Other models coming soon

Events (ground motions)

Scenario-based analysis is supported now, time-based coming in September



FEM Analysis

- Pay attention to damping and tolerance!
- *npts* and *dt* parameters are available for the custom analysis script

Uncertainty Quantification

Method

SimCenter www

- I recommend keeping it LHS
- keep in mind: samples = number of NLTH analyses
- also keep in mind: response estimation and loss assessment are decoupled

Random Variables

- Random vars from MDOF, OpenSees Tcl file, and Event settings should show up automatically
- Distributions need to be set up here
- Calibration of models can be done in uqFEM (quoFEM soon) before running PBE
- Constant distribution does not work, don't use it (bug)
- Correlation matrix be careful until the next major release

Demonstrate features in the PBE App





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