SimCenter NHERI
Center for Computational Modeling and Simulation

Regional Workflow

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University of California, Berkeley

NSF award: CMMI 1612843

Outline

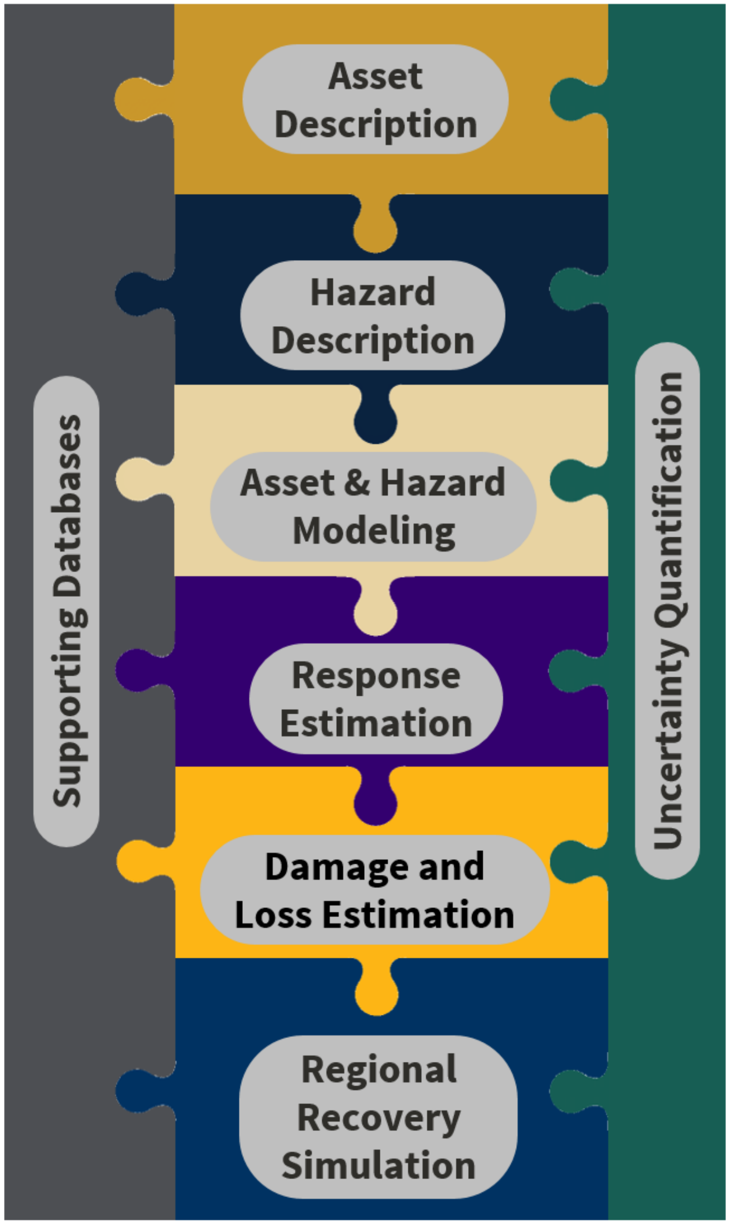
SimCenter Regional Workflow

Running the Anchorage Testbed

SimCenter Software

The SimCenter is providing a **framework** that will enable workflow applications to be built that will enable research in Natural Hazards engineering. The framework will allowing researchers with different applications to work together to build more powerful applications. **Applications to scale from individual buildings to regional scale.**

Resiliency Decision Tool



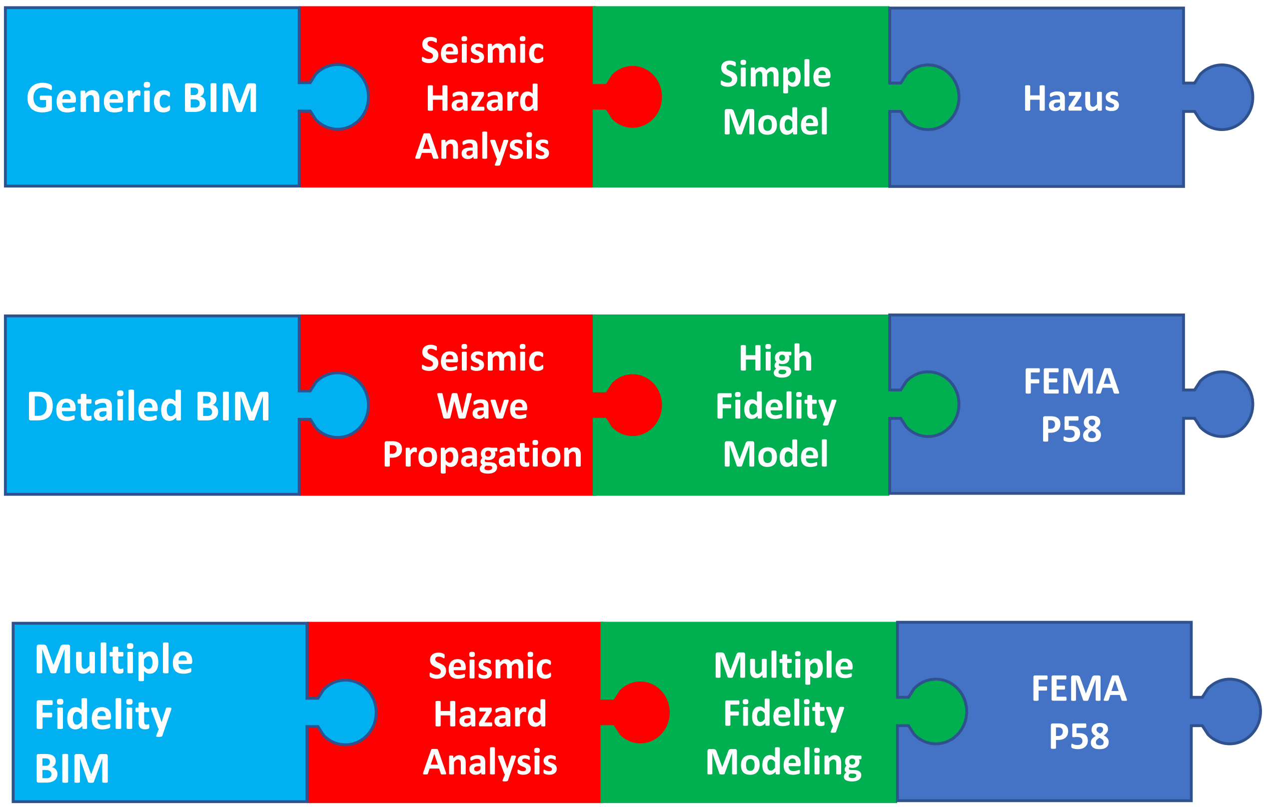
- **describe the region**
  specify characteristics of buildings and infrastructure in the region
- **describe the hazard**
  specify the regional distribution of ground shaking, wind, or water
- for each random region-hazard sample:
  propagate uncertain characteristics of the regional assets and the hazard
  - for each asset in the region:
    - **describe the asset**
      create stochastic models for response, damage, and loss estimation
    - **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
      - **estimate asset response to the event**
        describe the response with engineering demand parameters
    - **estimate asset damage and its consequences**
      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

Backend Application:
Regional Workflow for Hazard And Loss Estimation

rWHALE

Deierlein, Kareem, Conte, Deelman, Deodatis, Kijewski-Correa, Taflanidis & Tien

Frank McKenna & Wael Elhaddad



Current Release V1.1 (Feb 2019)

- Regional earthquake workflow
- Various hazard representations

Future Release V2.0 (Sept 2019)

- Regional storm workflow
- Initial version to consider ASCE7 wind loading and HAZUS type damage and loss

Input File for Regional Earthquake Simulation

Untitled — Edited

Workflow — emacs Workflow1.json — 137×55

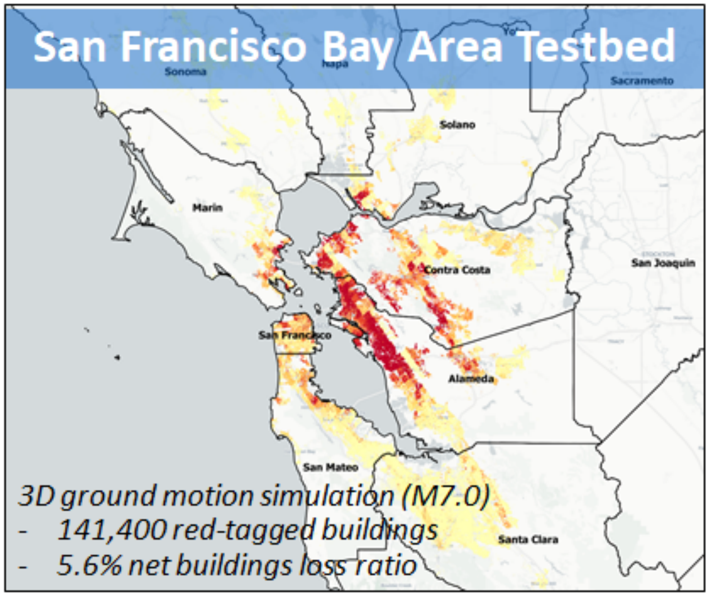

```
{
   "Name": "Workflow 1",
   "Author": "fmk",
   "WorkflowType": "Regional Simulation",
   "buildingFile":"buildings.json",
   "Applications": {
      "Buildings": {
         "BuildingApplication": "UrbanSimDatabase",
         "ApplicationData": {
            "Min": "1",
            "Max":"1856000",
            "parcelsFile":"/Users/fmckenna/NHERI/parcels.csv",
            "buildingsFile":"/Users/fmckenna/NHERI/buildings2010.csv"
         }
      },
      "Events": [
         {
            "EventClassification": "Earthquake",
            "EventApplication": "LLNL-SW4",
            "ApplicationData": {
               "pathSW4results": "/Users/fmckenna/NHERI/Hayward7.0/",
               "filenameHFmeta":"/Users/fmckenna/NHERI/Workflow1.1/createEVENT/HFmeta"
            }
         }
      ],
      "Modeling": {
            "ModelingApplication": "MDOF-LU",
            "ApplicationData": {
               "hazusData":"/Users/fmckenna/NHERI/Workflow1.1/createSAM/data/HazusData.txt"
            }
      },
      "EDP": {
            "EDPApplication": "StandardEarthquakeEDP",
            "ApplicationData": {}
      },
      "Simulation": {
         "SimulationApplication": "OpenSees",
         "ApplicationData": {}
      },
      "UQ-Simulation": {
         "UQApplication": "Dakota-FEM",
         "ApplicationData": {}
      },
      "Damage&Loss": {
         "Damage&LossApplication": "FemaP58-LU",
         "ApplicationData": {
            "filenameSettings":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/settings.ini",
            "pathCurves":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/ATCCurves/",
            "pathNormative":"/Users/fmckenna/NHERI/Workflow1.1/createLOSS/data/normative/"
         }
      }
   }
}
```

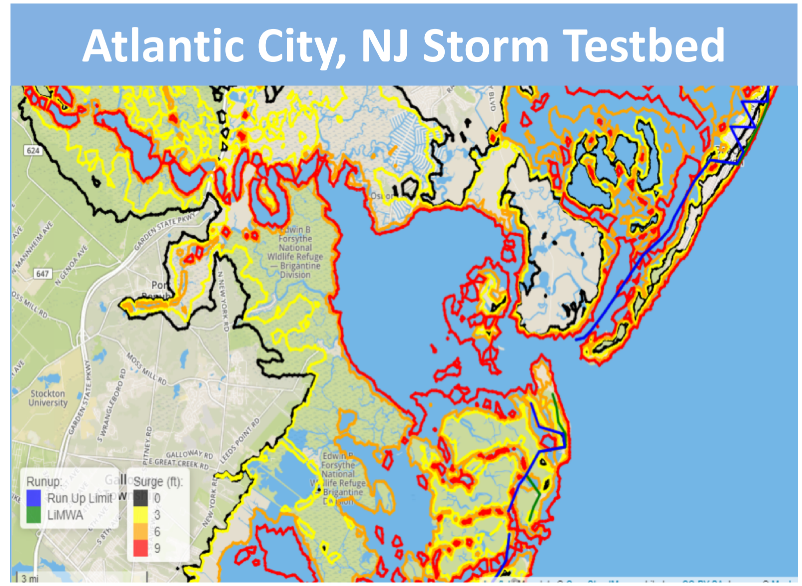

```
-uu-:**-F1  Workflow1.json    Top L11    (Fundamental)----------------------------------------
Auto-saving...done
```

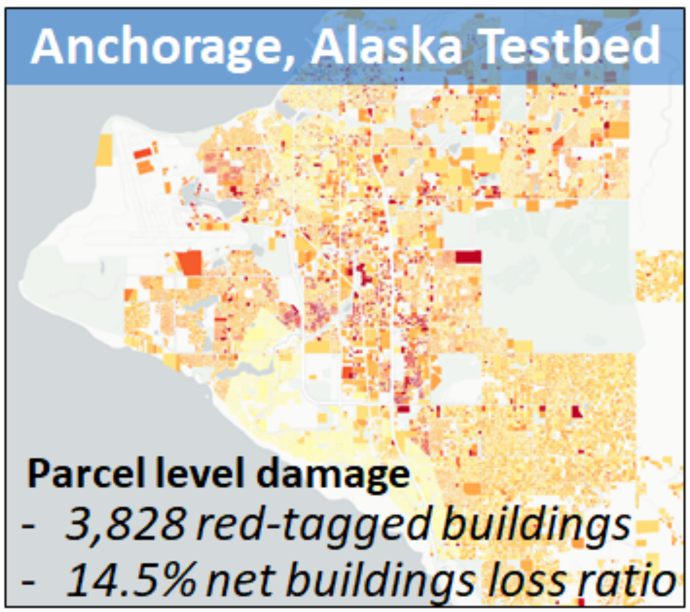
```json
"Events": [
   {
      "EventClassification": "Earthquake",
      "EventApplication": "LLNL-SW4",
      "ApplicationData": {
         "pathSW4results": "/Users/fmckenna/NHERI/Hayward7.0/",
         "filenameHFmeta":"/Users/fmckenna/NHERI/Workflow1.1/createEVENT/HFmeta"
      }
   }
],
"Modeling": {
```

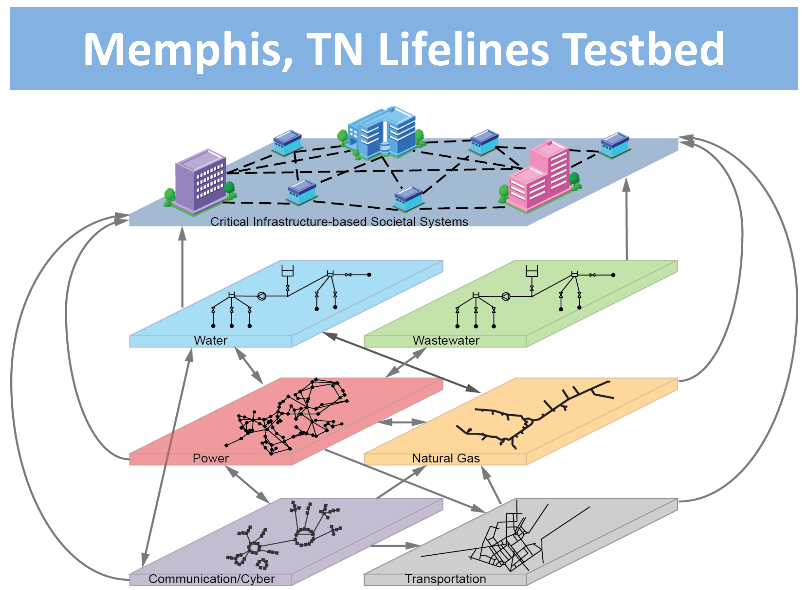
```json
},
"Events": [
   {
      "EventClassification": "Earthquake",
      "EventApplication": "SHA-GM",
      "ApplicationData": {
         "scenarioConfig": "./HayWired7.25.json"
      }
   }
],
"Modeling": {
```

Regional Workflow Testbeds to Verify rWhale



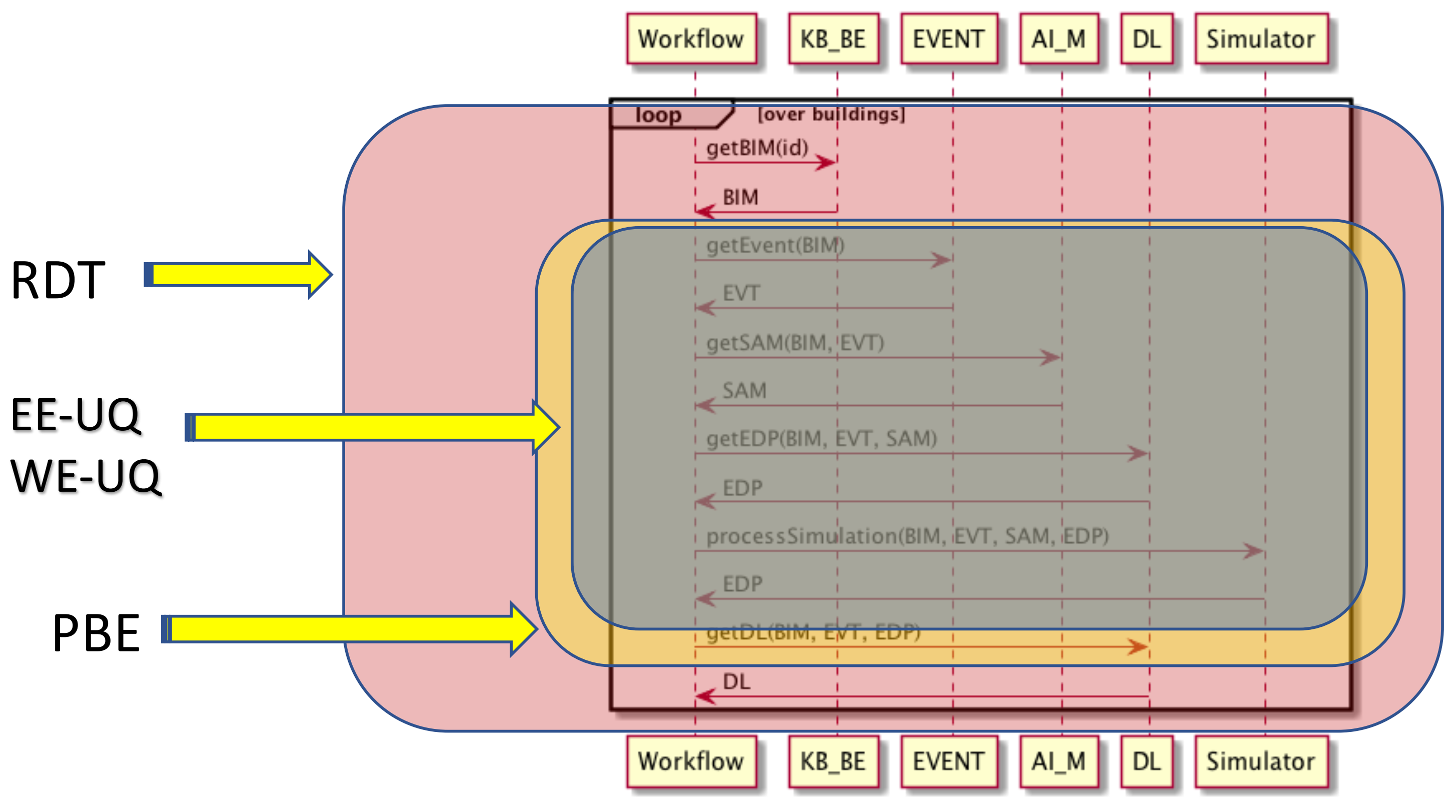




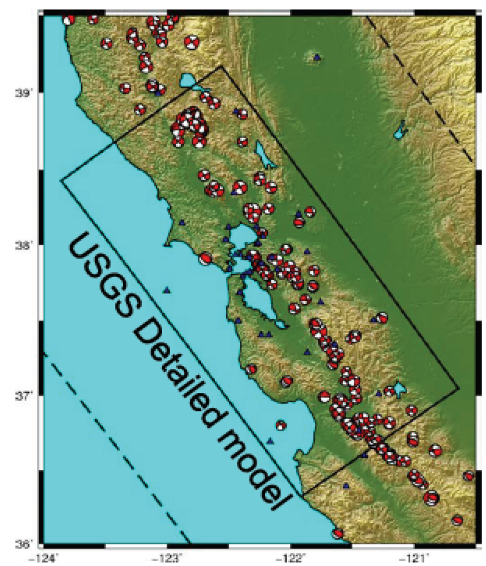


Real Importance of Testbed Workflows?

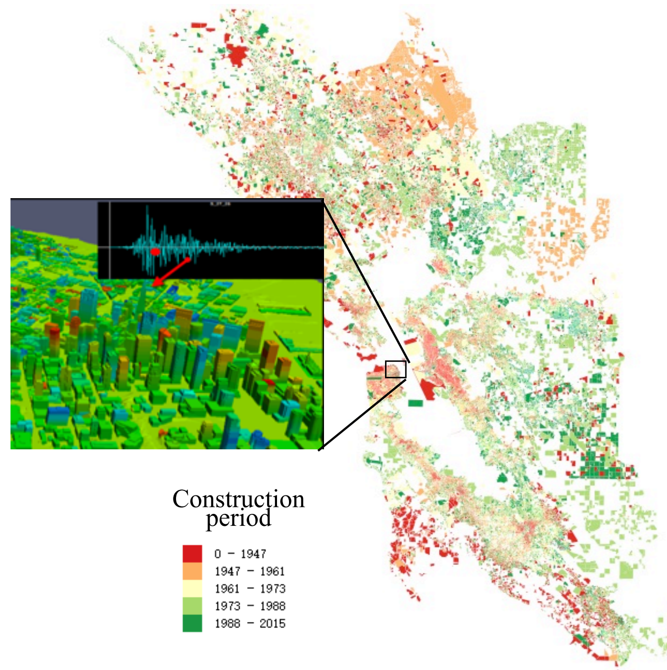
- They Test the Interfaces of Framework for the Different hazards
- They Provide Seed Data & **Example Applications**
- Demonstrate Flexibility & Extensibility of Framework
- Foster Collaboration
- Provide Code For Research Applications



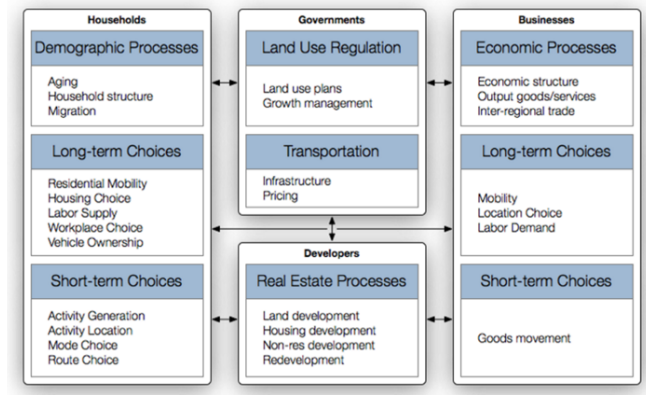
Workflow 1: Hayward 7.0 on Bay Area



M7.0 Hayward Fault



1.8 million buildings in SF Bay Area

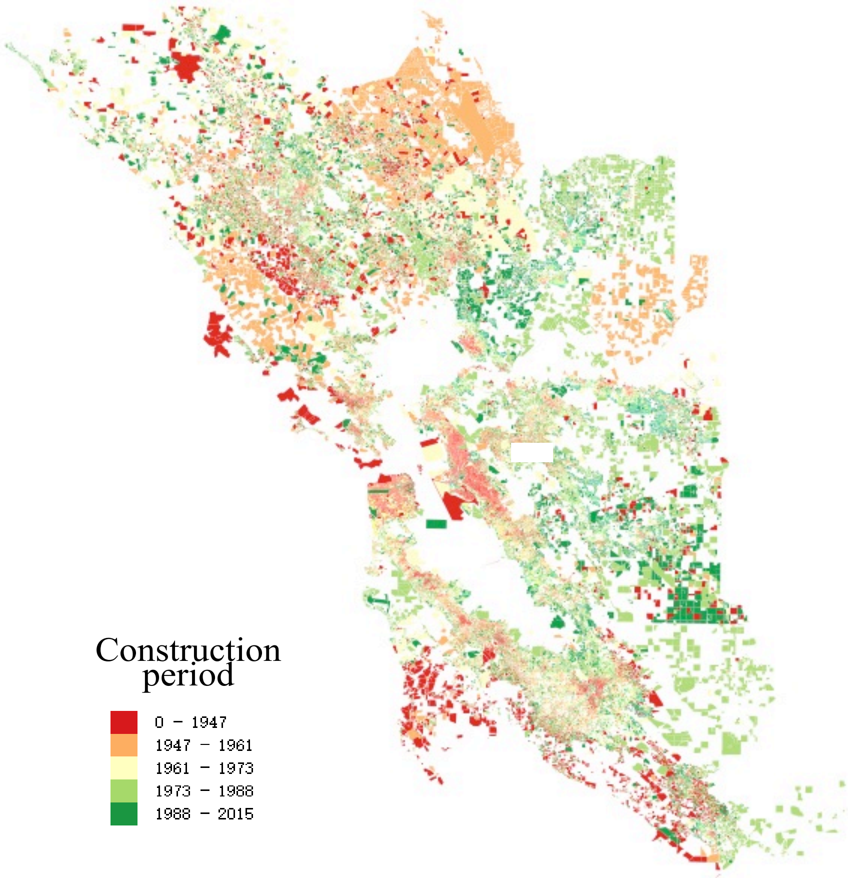


Policy/Planning decision support: *building losses & downtime in 2010 and 2040*

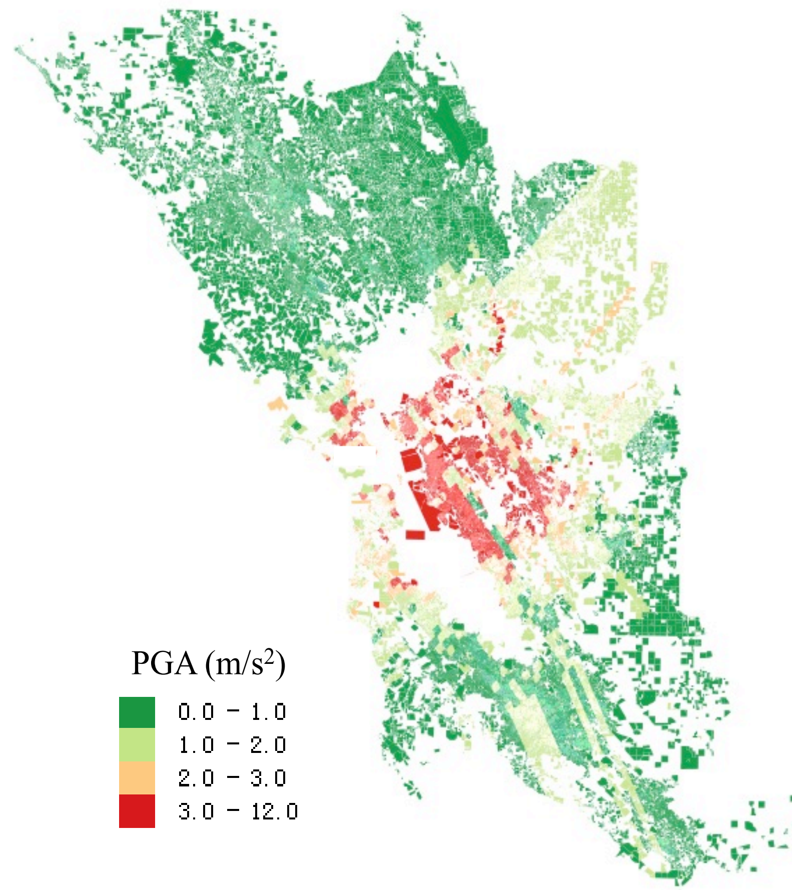
Objective: develop and exercise a workflow to connect software models and systems on a challenging computational model that engages a broad cross-section of NEHRI community

Ground Motions: 3D simulation, GM's at 2km grid (Rodgers, Pitarka & Petersson)
Building Inventory: UrbanSim and DataSF Portal; geometry, age, occupancy
Building Analyses: OpenSees, simplified NL MDOF, FEMA P58 (w/Cheng & Lu, Tsinghua)
Visualization: UrbanSim and 3d Urban Polygon Modeling (Xiong et al., 2015)
Interpretation: UrbanSim; urban growth, damage/loss, displaced occupants/population

Sample Input Data



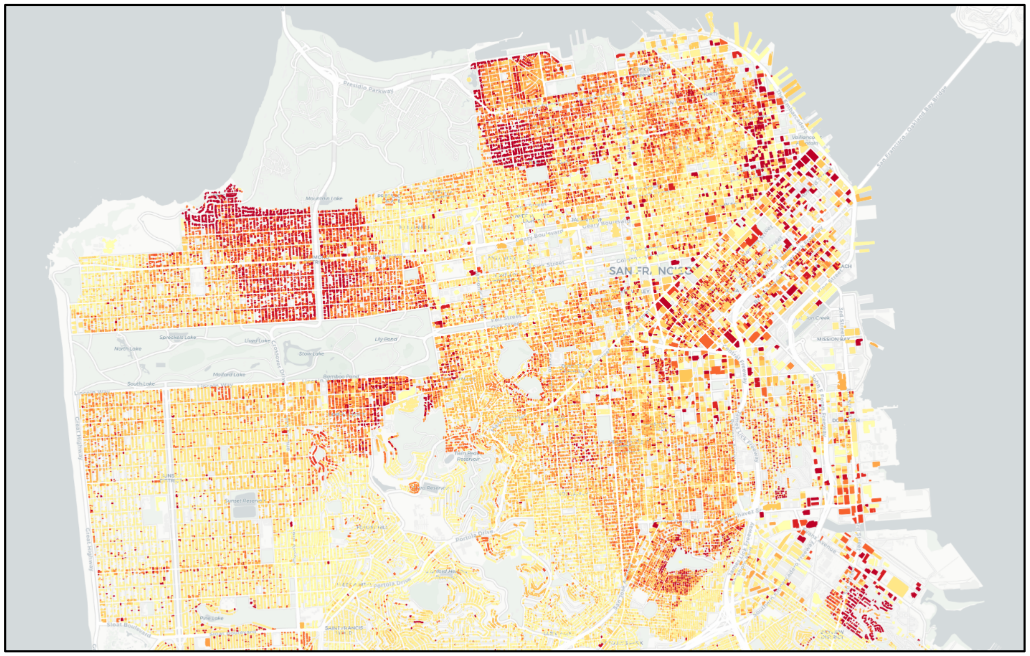
Building Inventory – by Age

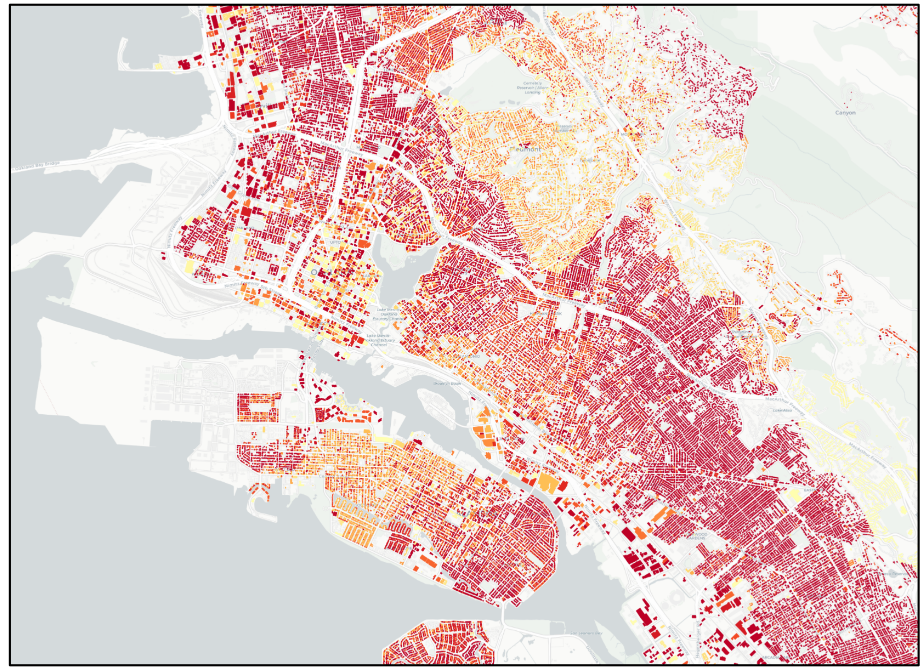


Ground Shaking Intensity (PGA)

High Resolution Results

- **Parcel-level Data of Building Damage**



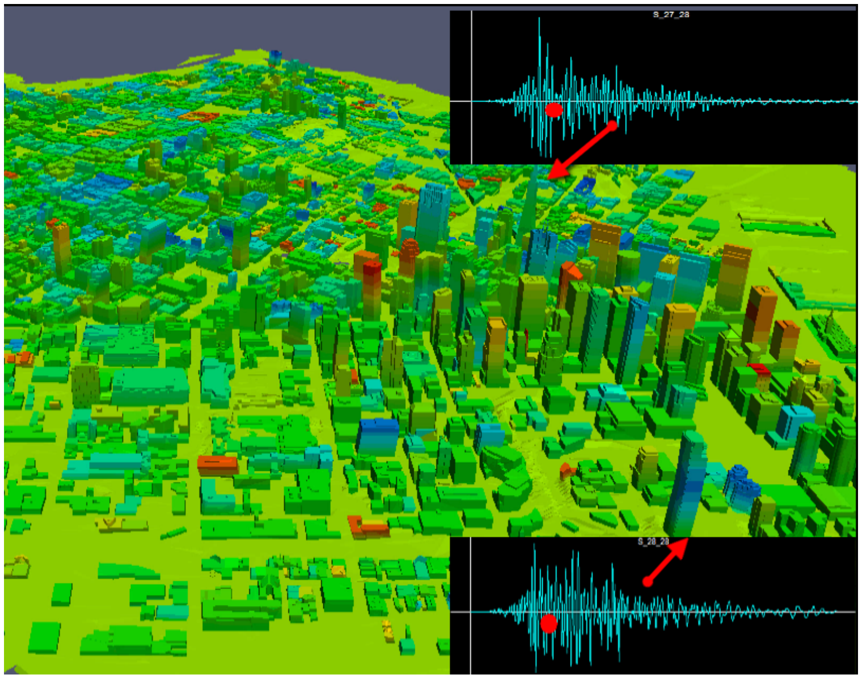


San Francisco

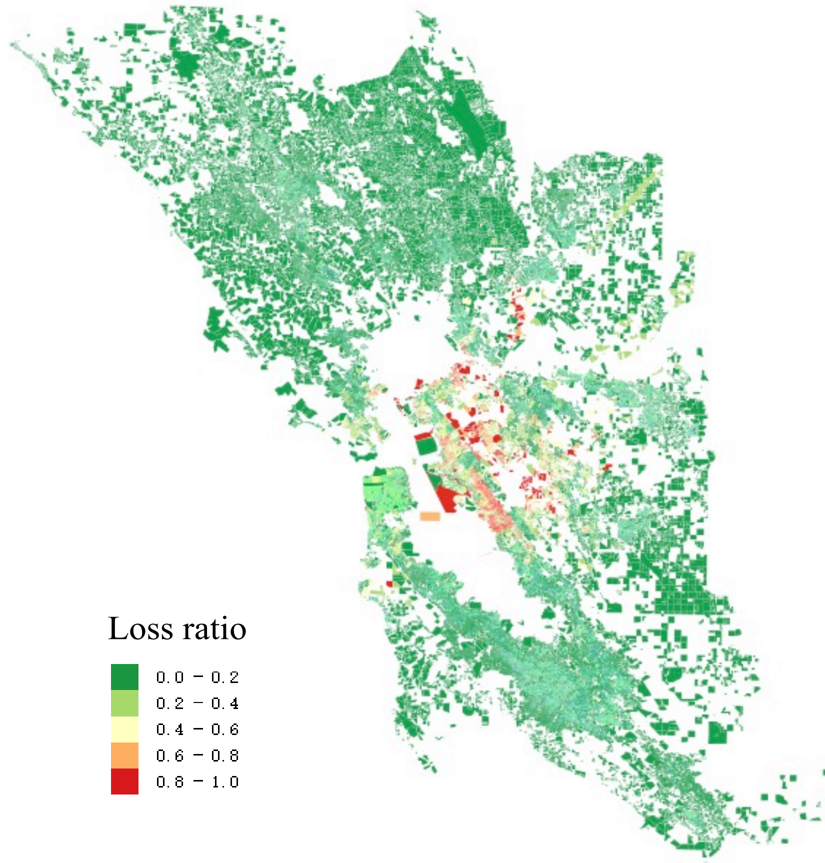
Oakland - Alameda

Opportunities to evaluate planning and policy decisions (land use, retrofit, etc.)

Sample Output Data

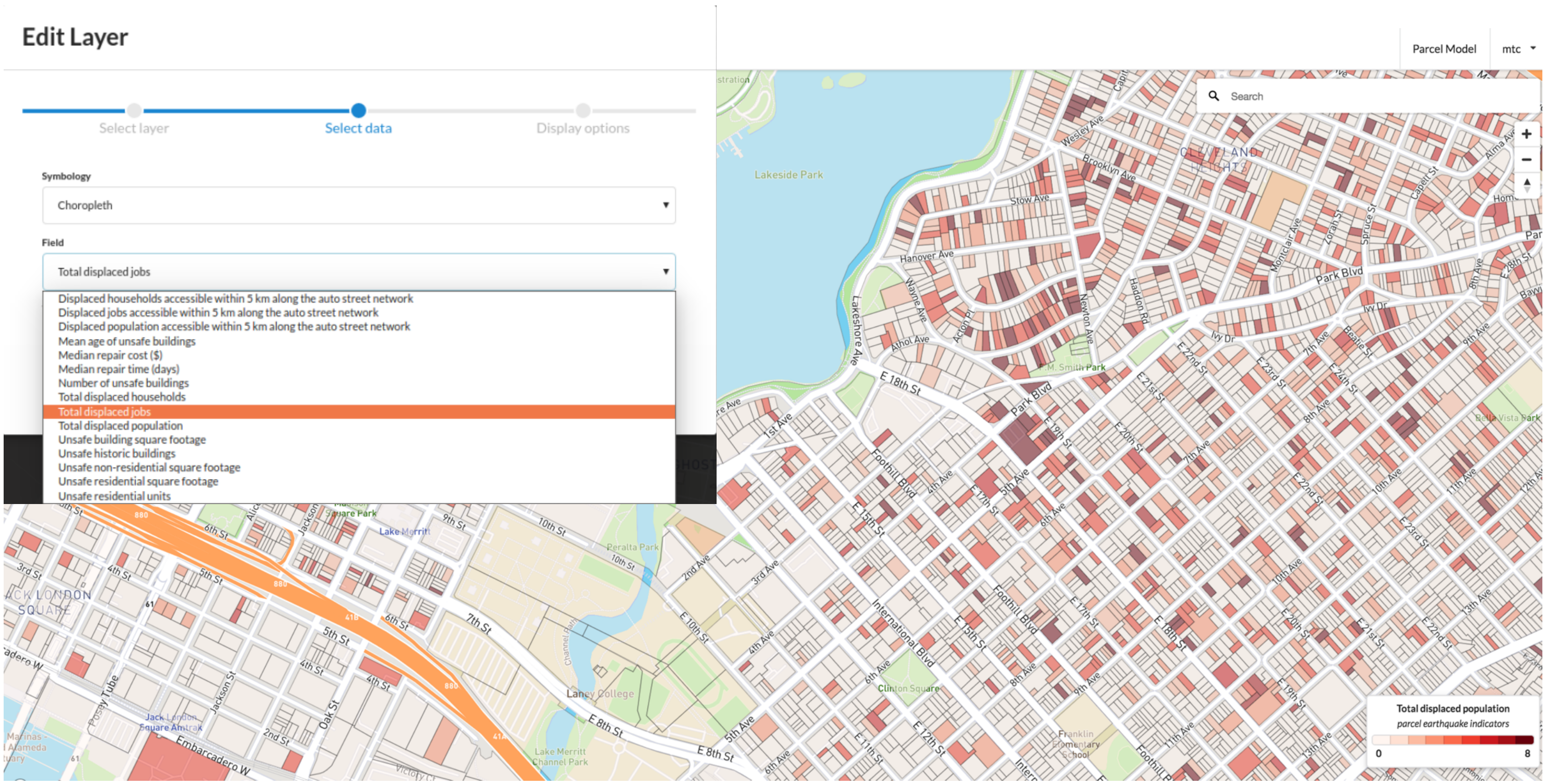


Building Demand Parameters



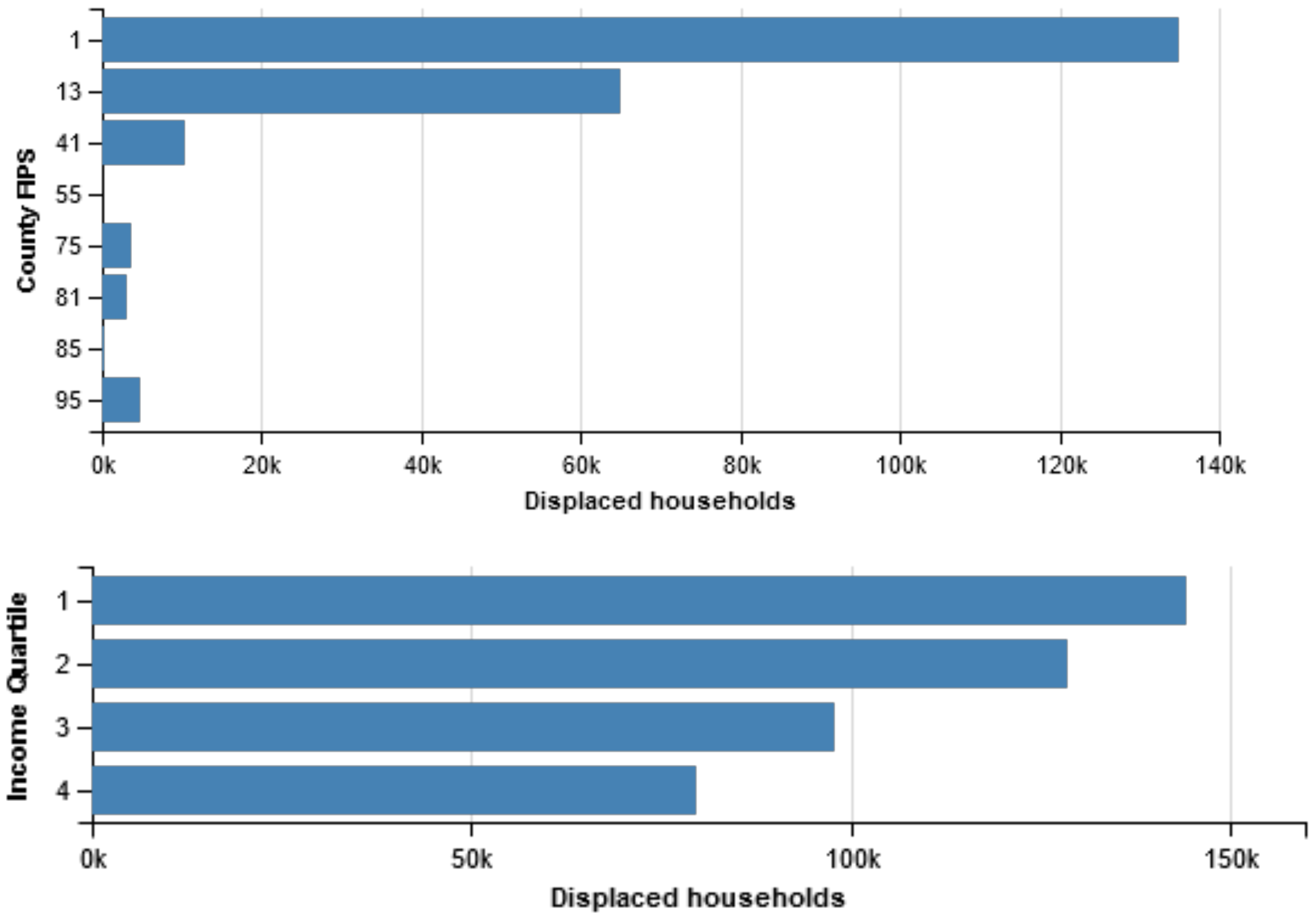
Building Loss Ratio

UrbanSim Output - Sample Results



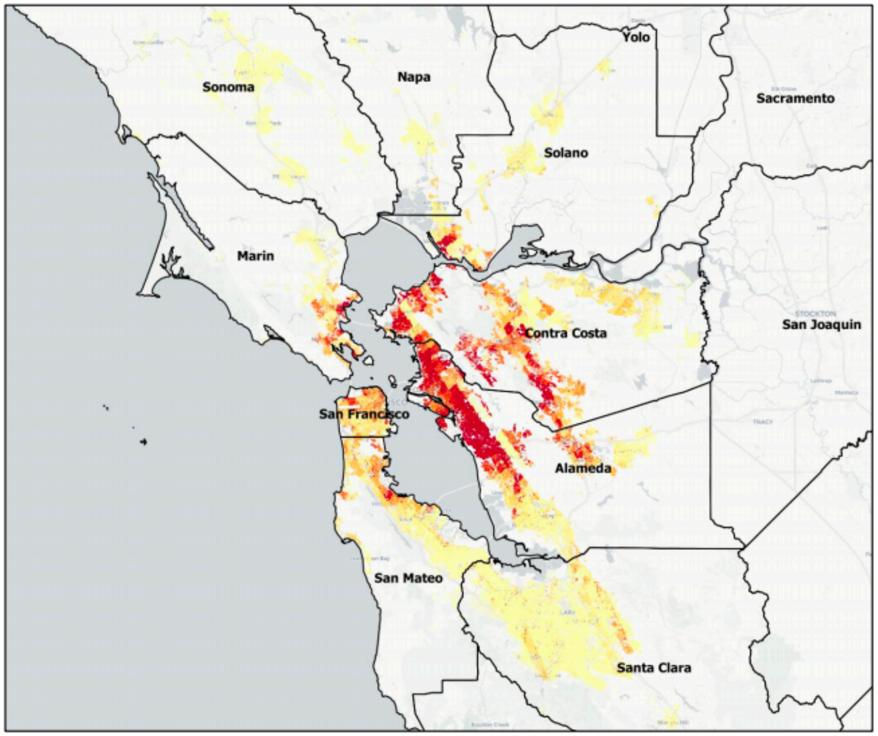
Displaced Population in Residential Construction
(person/parcel; Oakland, Lake Merritt Area)

UrbanSim Output - Sample Results

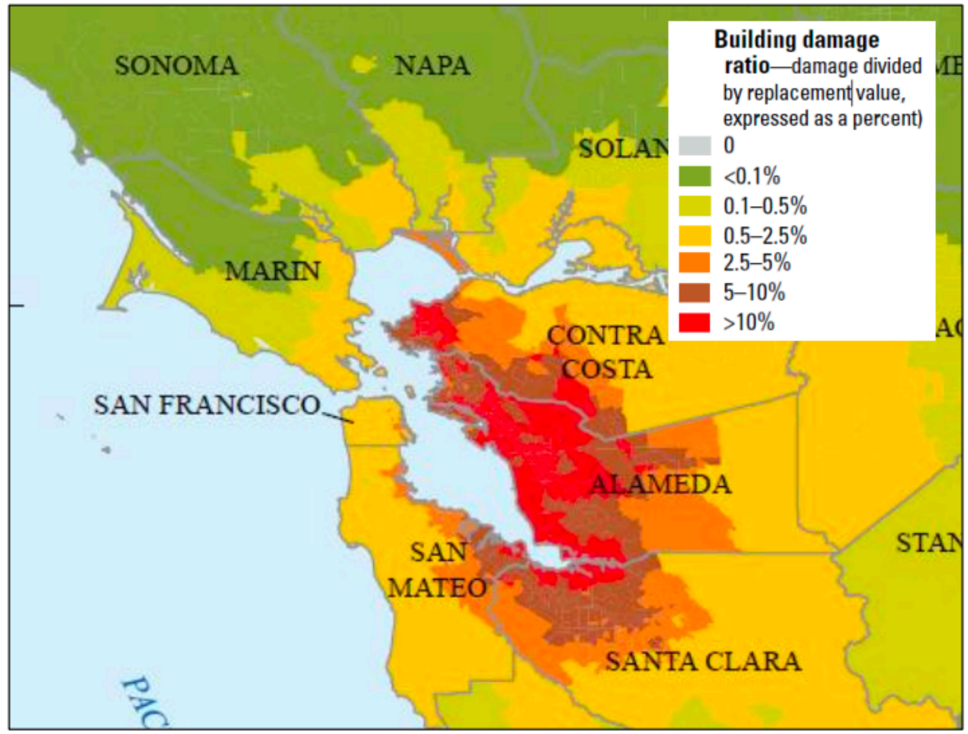


Quantitative Statistics to Evaluate “What-If” Scenarios

How Accurate Is IT?



SimCenter Workflow



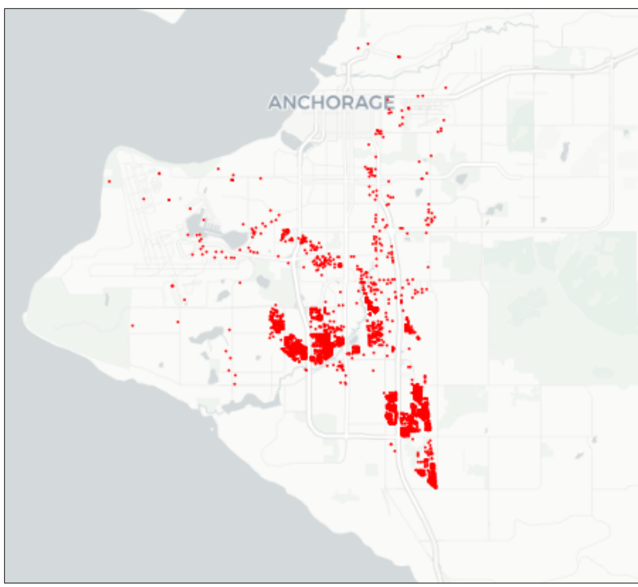
USGS Haywired

If know area, to east of fault there are hills and no construction! **SimCenter Info at parcel level**

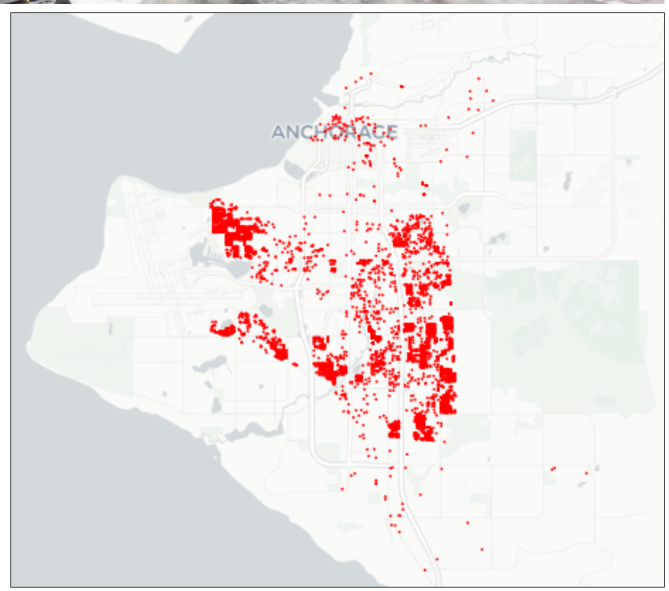
Anchorage M7.0 Nov 1018 Losses

Data for 97,421 tax parcels in the regional simulation

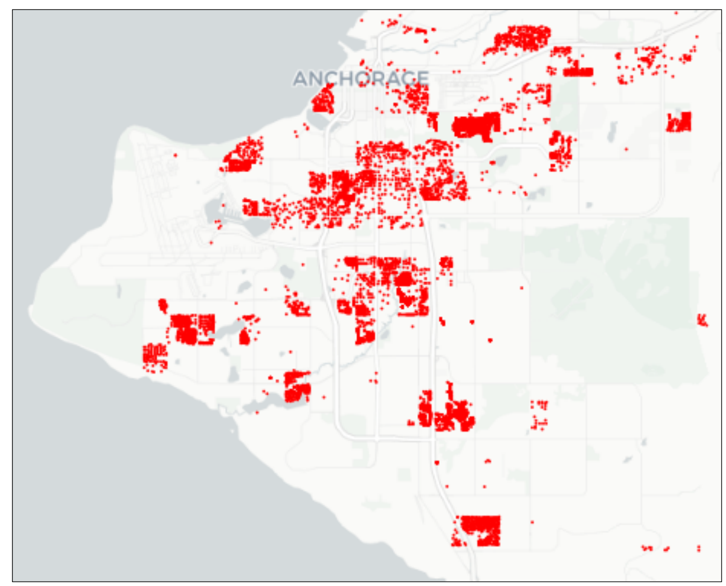
- Red Tags



CESMD



AEC



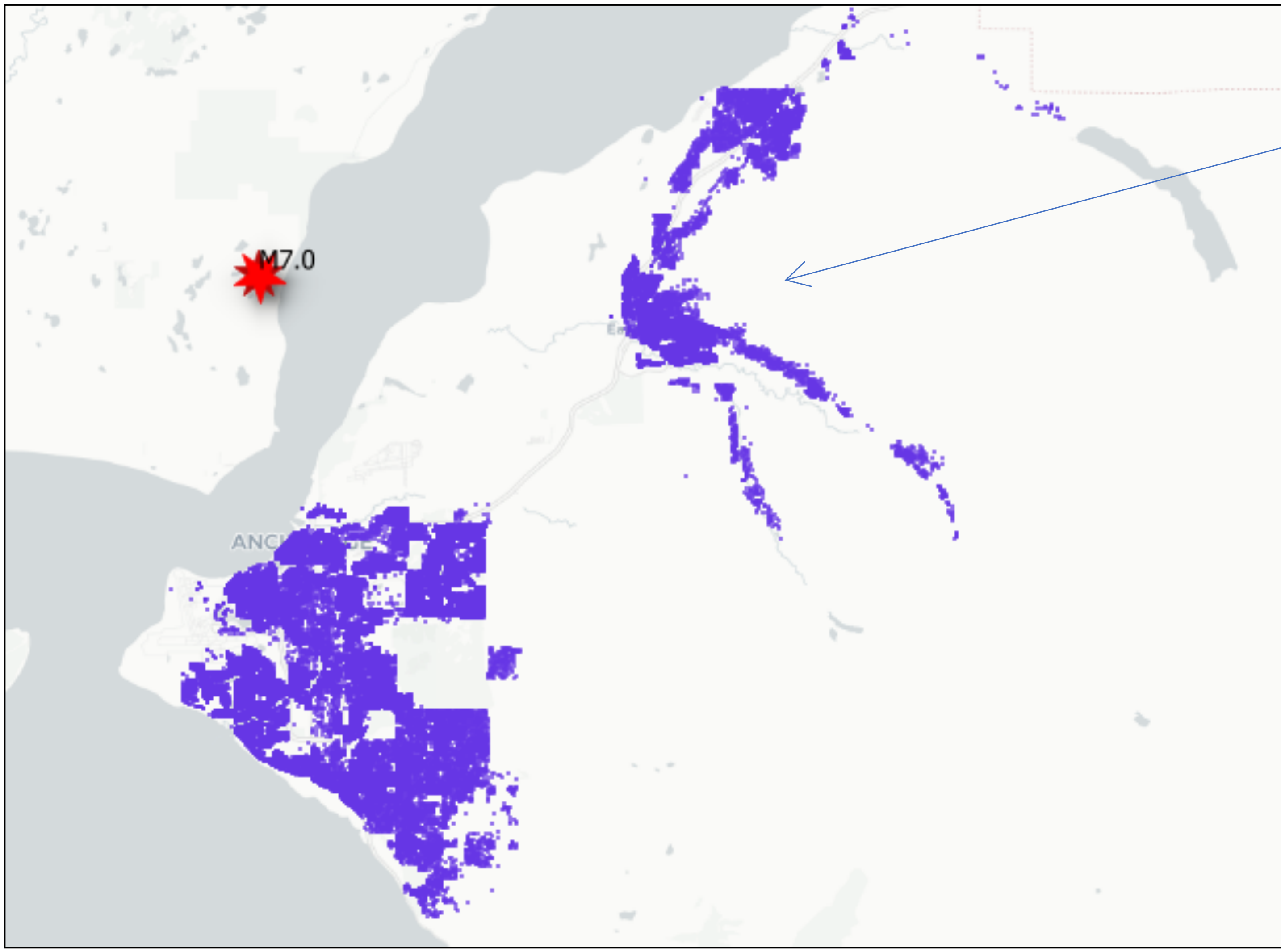
Synthetic

Buildings

- **Tax data for 97,421 buildings/parcels** was obtained from Municipality of Anchorage public property appraisal records
- **Data was processed to obtain BIM**
  - **84435 buildings** records were processed successfully (78509 Residential and 7926 Commercial)
  - 2000 building records failed processing (2.3%)
  - 10512 Parcels were vacant or not buildings (e.g. parking lots)
- **Buildings locations were mapped to parcels locations**
  - 400 Buildings with missing parcels locations

Buildings

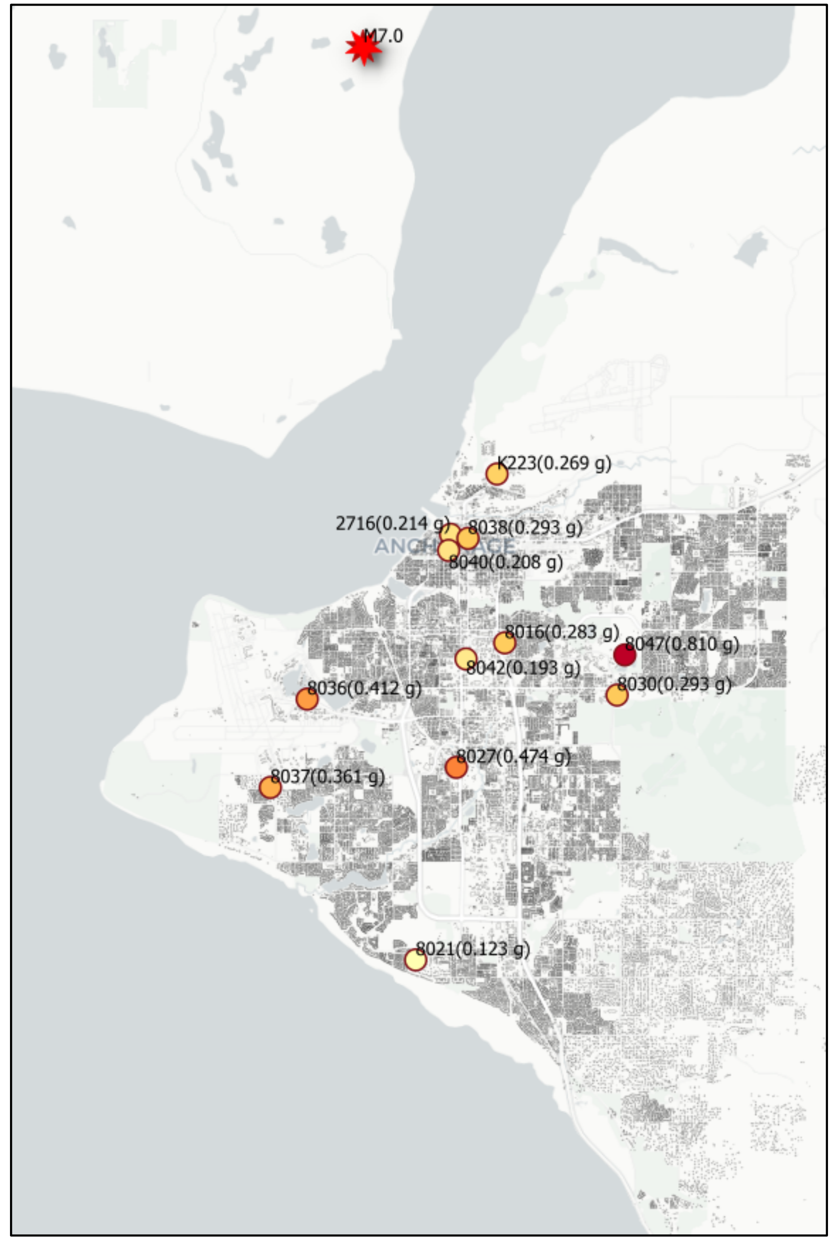
- **Buildings included in the regional simulation**



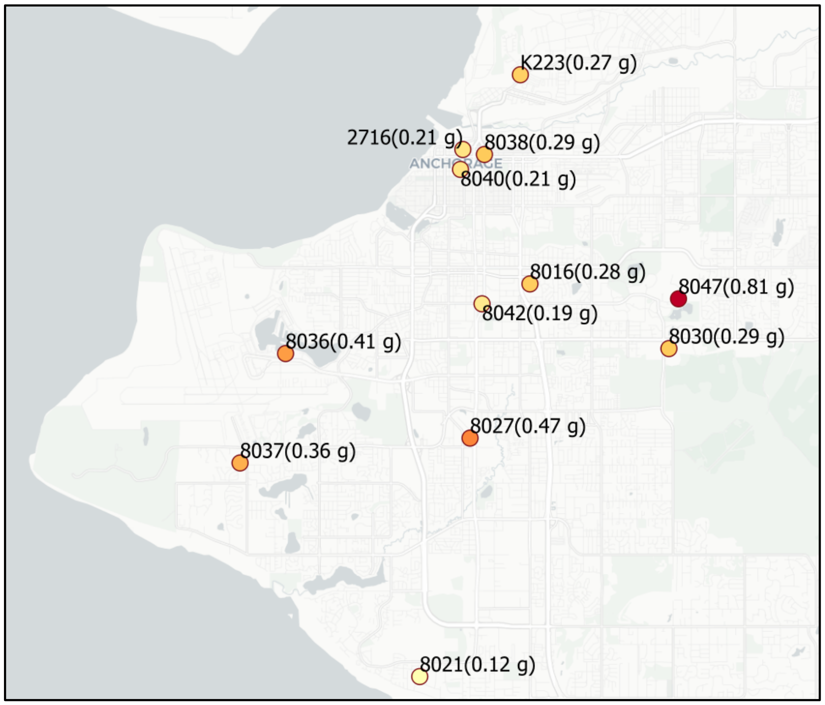
~12,000 buildings in Eagle River

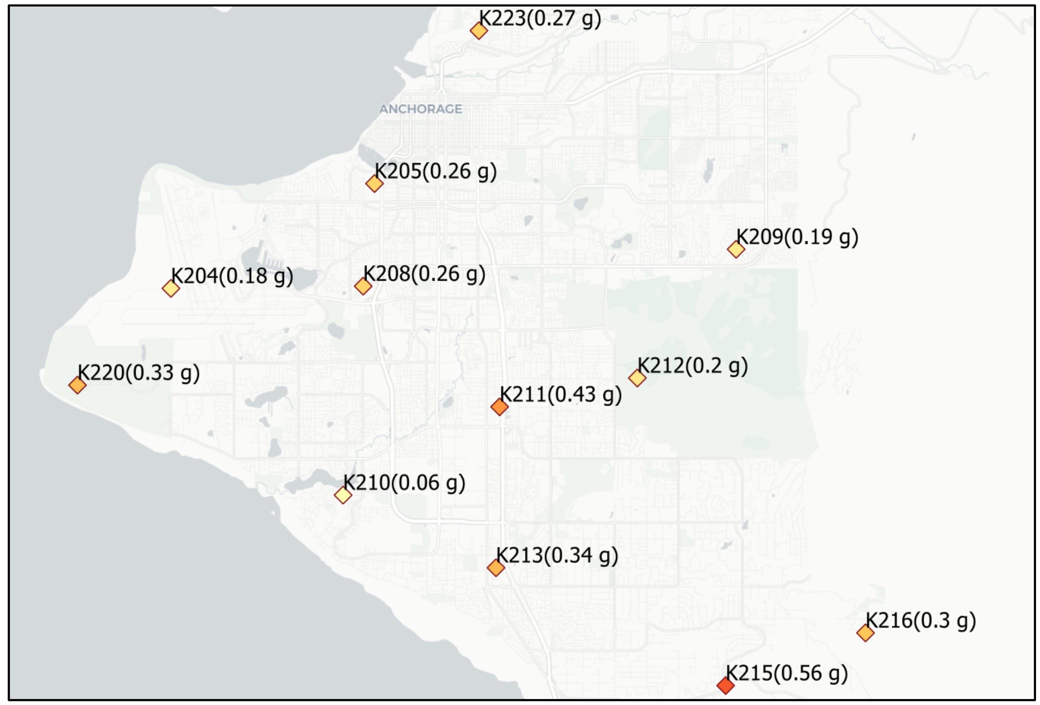
Earthquake Records

- **Event:** Anchorage**,** Alaska Nov 30th 2018 earthquake
  - **7.0MW**, 8:29:28 AKST, 61.340N 149.937W Depth 40.9 km
- Recorded ground motions were obtained from CESMD (12 records) and Alaska Earthquake Center (12 records)
  - Nearest neighbor search was employed to map the ground motion records to buildings
  - One record (PGA = 0.81g) was removed from CESMD website on Dec. 19th



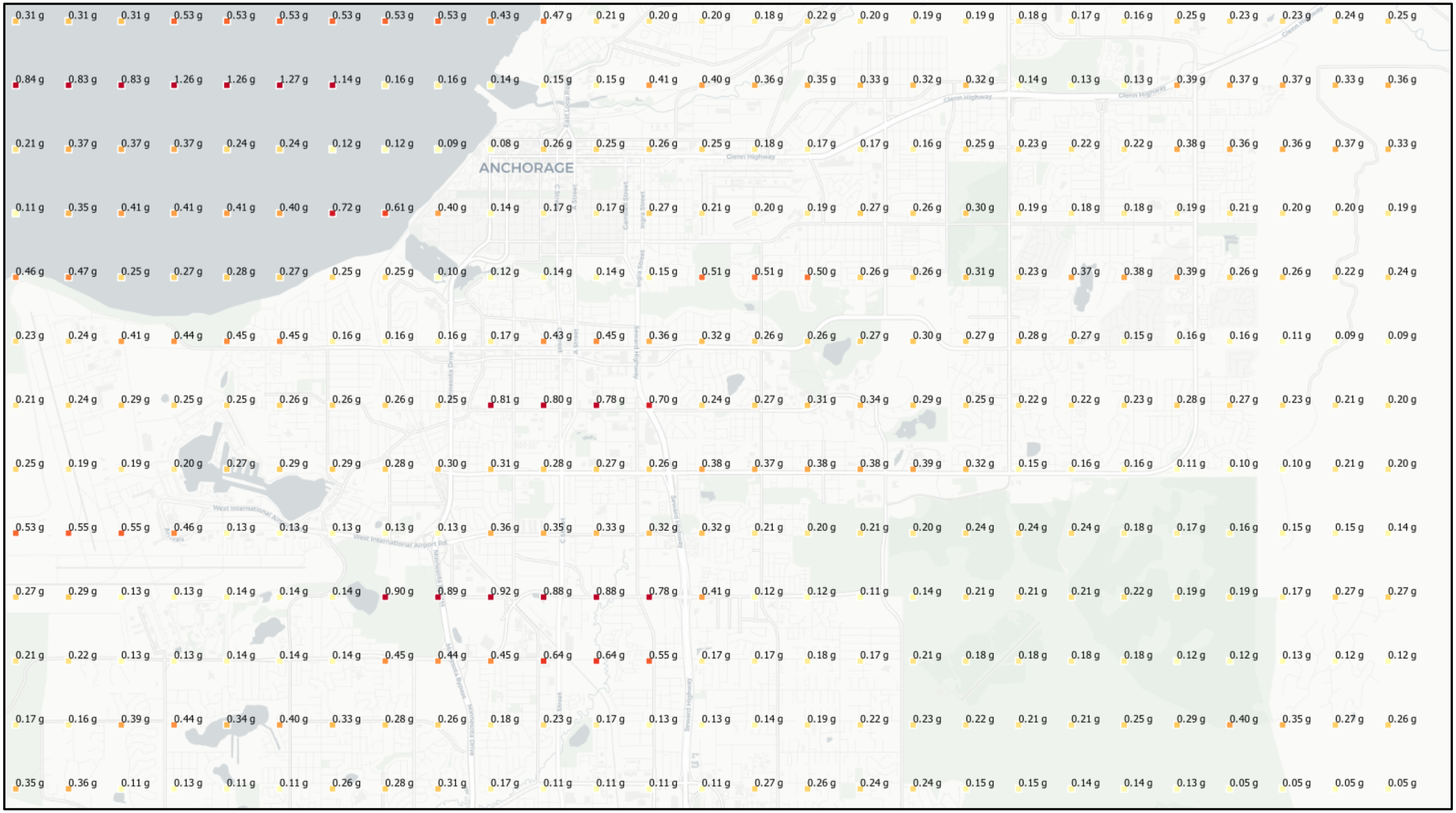
Ground Motion Records





Circles are records the strong motion center (CESMD) and Diamonds are records from Alaska Earthquake Center (AEC)

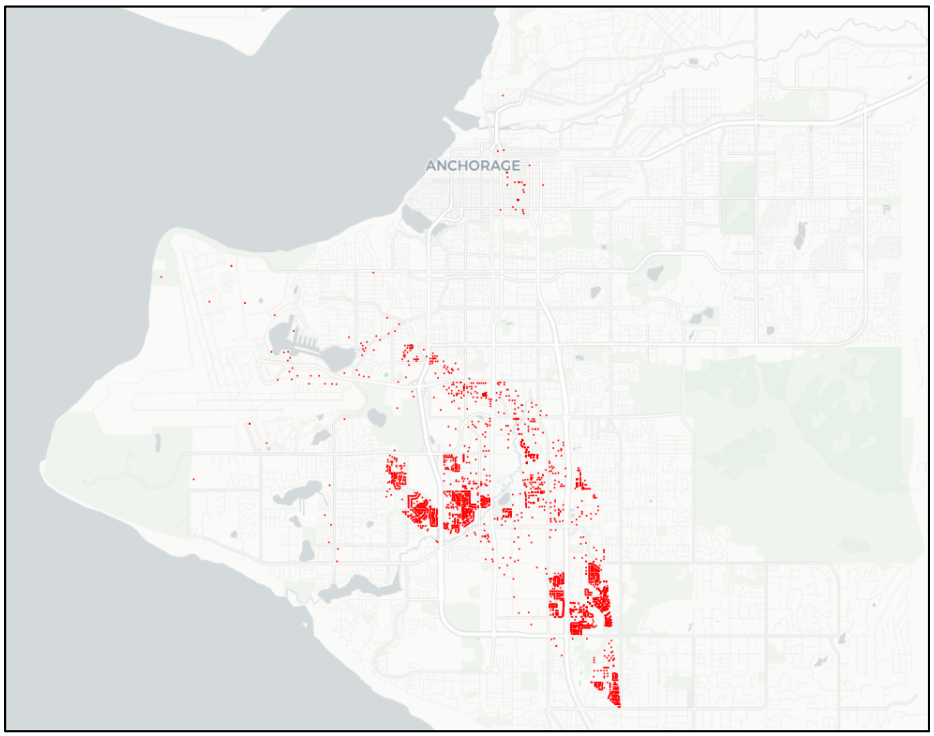
Synthetic Ground Motions



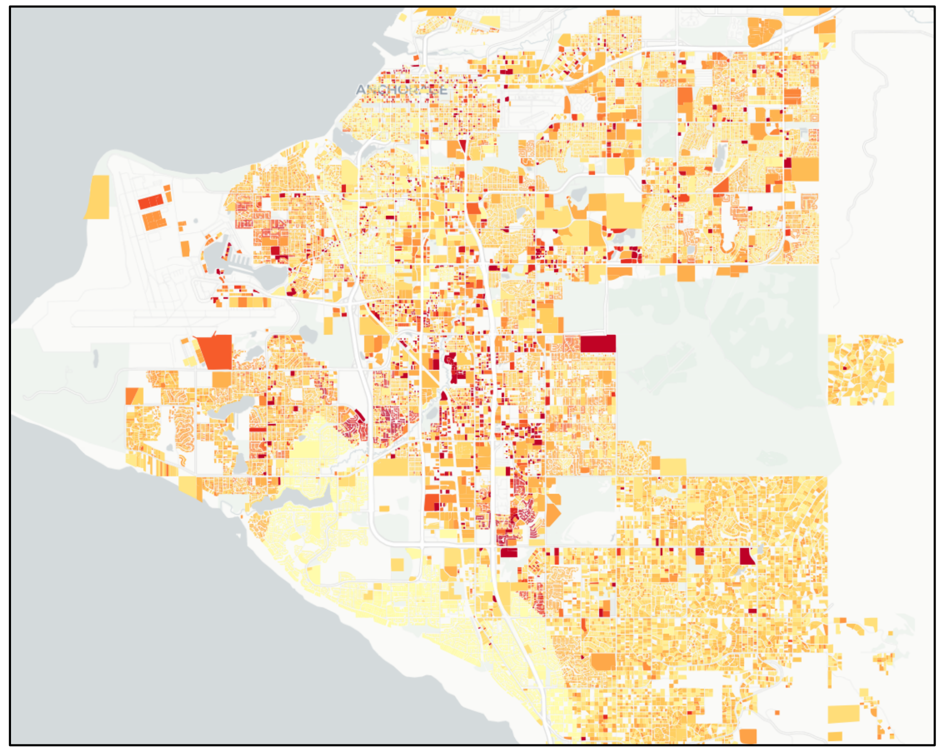
PGA values at stations in Anchorage with synthetic records generated using the stochastic loading library

Losses (CESMD Records)

- ~3828 buildings are red tagged (95% subjected to a record with PGA = 0.47g)
- Total repair cost $7.5 Billion
- Average loss ratio is 14.5%



Locations of red tagged buildings


Parcels color-coded by loss ratios

Losses By Year Built and Stories

Year Built (Seismic Design Level)	Total Count	Red Tags (CESMD GM)
1973 – 2018 (High Code)	63332	3599
1941-1973 (Low Code)	20795	228
1899-1941 (Pre Code)	138	1

Stories	Total Count	Red Tags (CESMD GM)	Average Area (Sqft)	RedTagged Average Area (Sqft)
1	43845	148	2397	13161
2	39153	3674	2785	2838
3	1137	148	9666	14809
4	62	0	55411	
5+	69	0	99558	

Losses By Occupancy

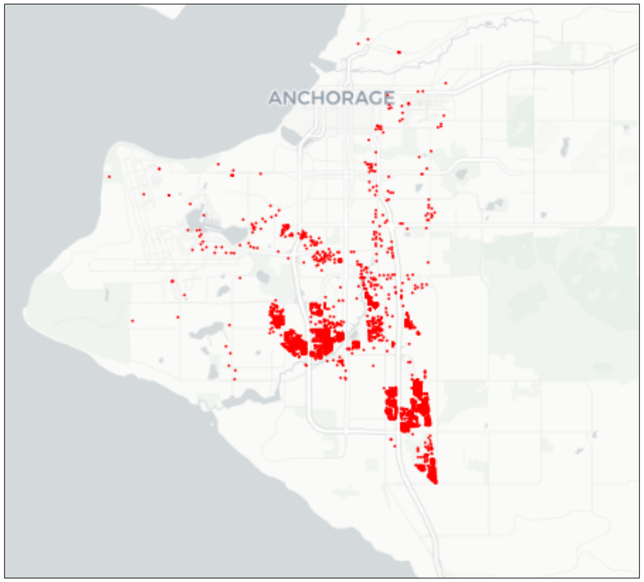
Building Types	Total Count	Red Tags (CESMD GM)
Residential - Single Family	56440	2076
Residential - Town house	4645	133
Residential - Multi-Family	19096	1380
Office	1384	107
Hotel	117	21
Industrial	107	4
Retail	2350	91
Mixed-use Residential	13	0
Mixed-use Office	40	2

Losses

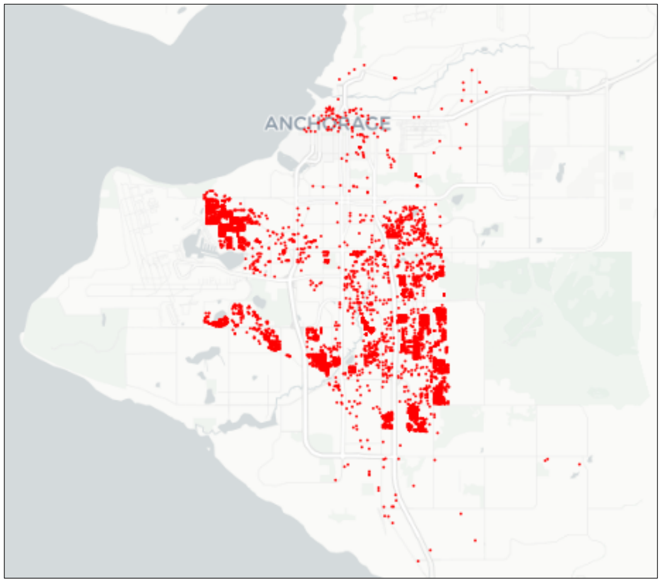
- Losses

Ground Motions	Median Repair	Red Tags	Average Loss Ratio
CESMD	7.5 Billions	3828	14.5
AEC	6.9 Billions	6858	11.8
Synthetic	4.2 Billions	9330	10.4

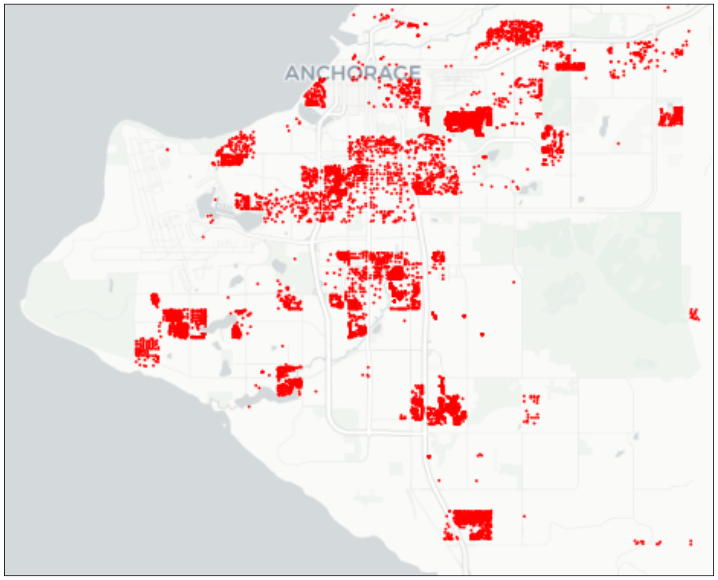
- Red Tags



CESMD



AEC



Synthetic

Actual Losses

- Losses reports
  - With reports of damage growing after the quake and aftershocks, inspectors with the city of Anchorage have identified more than 750 homes and buildings that suffered substantial damage, said Don Hickel, the city of Anchorage's lead structural inspector, on Friday. Another 900 buildings sustained minor damage. And the list keeps growing. About 740 more homes and buildings await inspection.. The state has received more than 6,000 requests for help primarily from people reporting damage to homes.
- USGS Incident Journal (Hazus)
  - 5 Red Tags and 252 Yellow Tags
  - $1.7 Billion Economic Loss

https://www.designsafe-ci.org/community/news/2018/december/spearheading-reconnaissance-alaska/

https://www.adn.com/alaska-news/anchorage/2018/12/30/the-tally-of-anchorage-buildings-significantly-damaged-by-the-quake-surpasses-750-and-counting/

https://fema.maps.arcgis.com/apps/MapJournal/index.html?appid=637ac220386e4e0f8728f0b2ee3d82be

Outline

SimCenter Regional Workflow

Running the Anchorage Testbed

Running An Anchorage Testbed

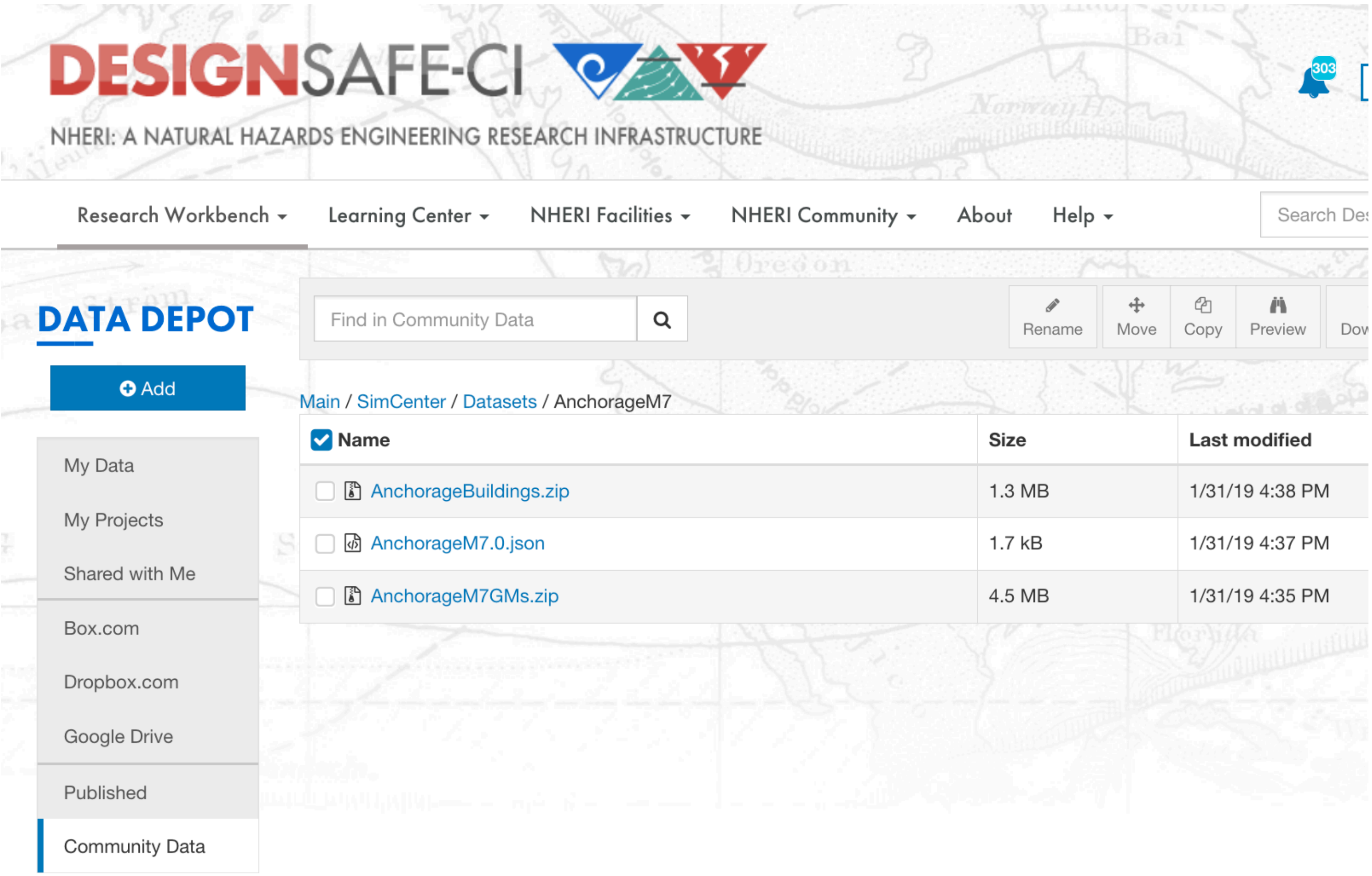
- Datasets on DesignSafe-ci
- Software on Github

Not Needed by You Today

- Agave App rWhale at Designsafe-ci

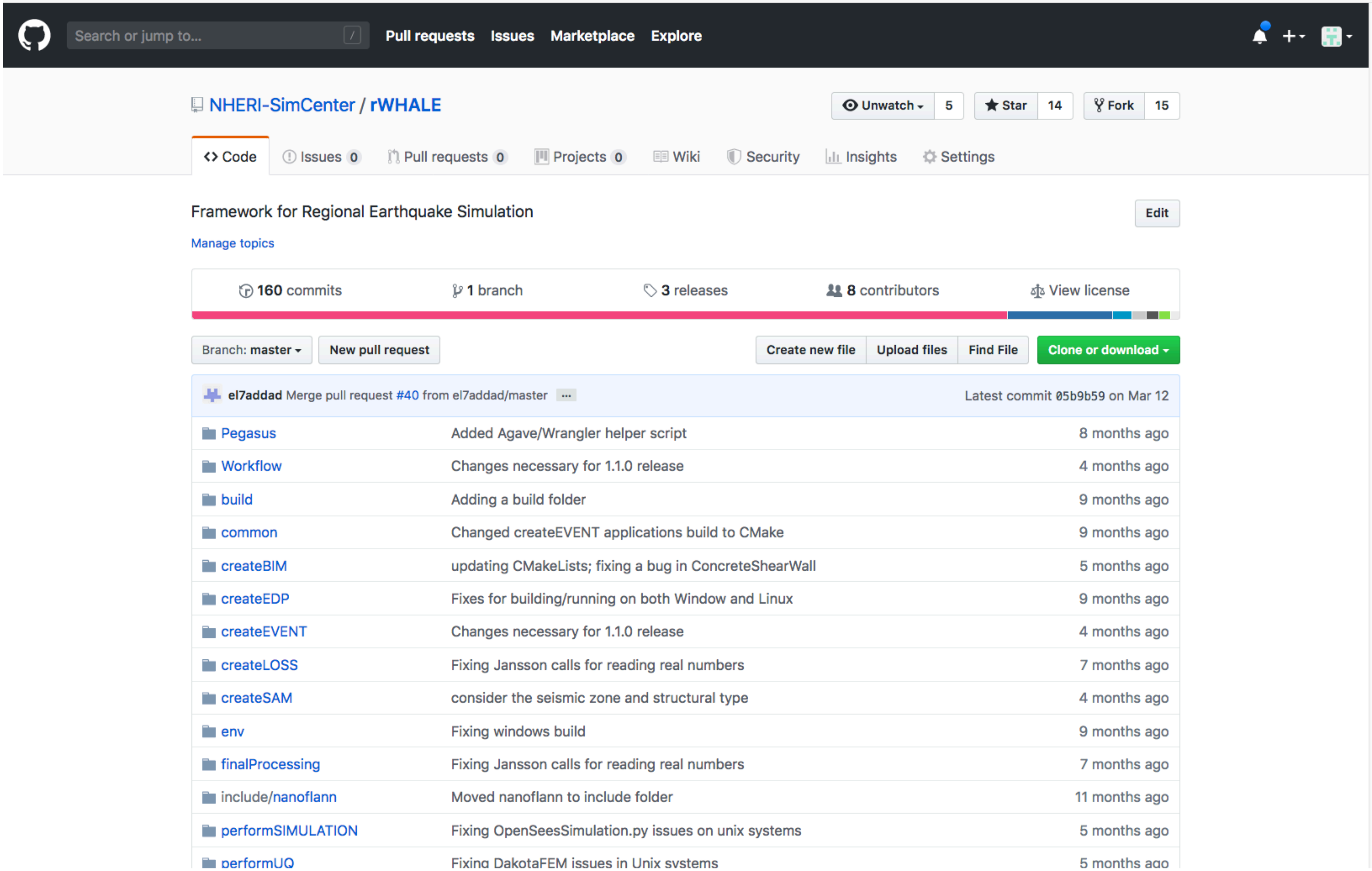
Datasets available on DesignSafe

DataDepot/CommunityData



Building Data, Motion Data & rWhale Input File for Regional Earthquake

Software on Github



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SERVICES; LOSS OF USE, DATA, OR PROFITS; OR BUSINESS INTERRUPTION) HOWEVER
CAUSED AND ON ANY THEORY OF LIABILITY, WHETHER IN CONTRACT, STRICT LIABILITY
```

Building Instructions for Linux & Windows

Building the source code on Unix-like systems

Before building the workflow, the following dependencies will need to be installed:

1. GNU Compiler Collection (gcc & g++) version 4.8.1 or newer.
2. GNU Make.
3. CMake

This repository uses CMake for the build process. The general instructions for building the workflow application is as follows:

1. Install the dependencies using Conan (note that adding the simcenter remote is only needed once)

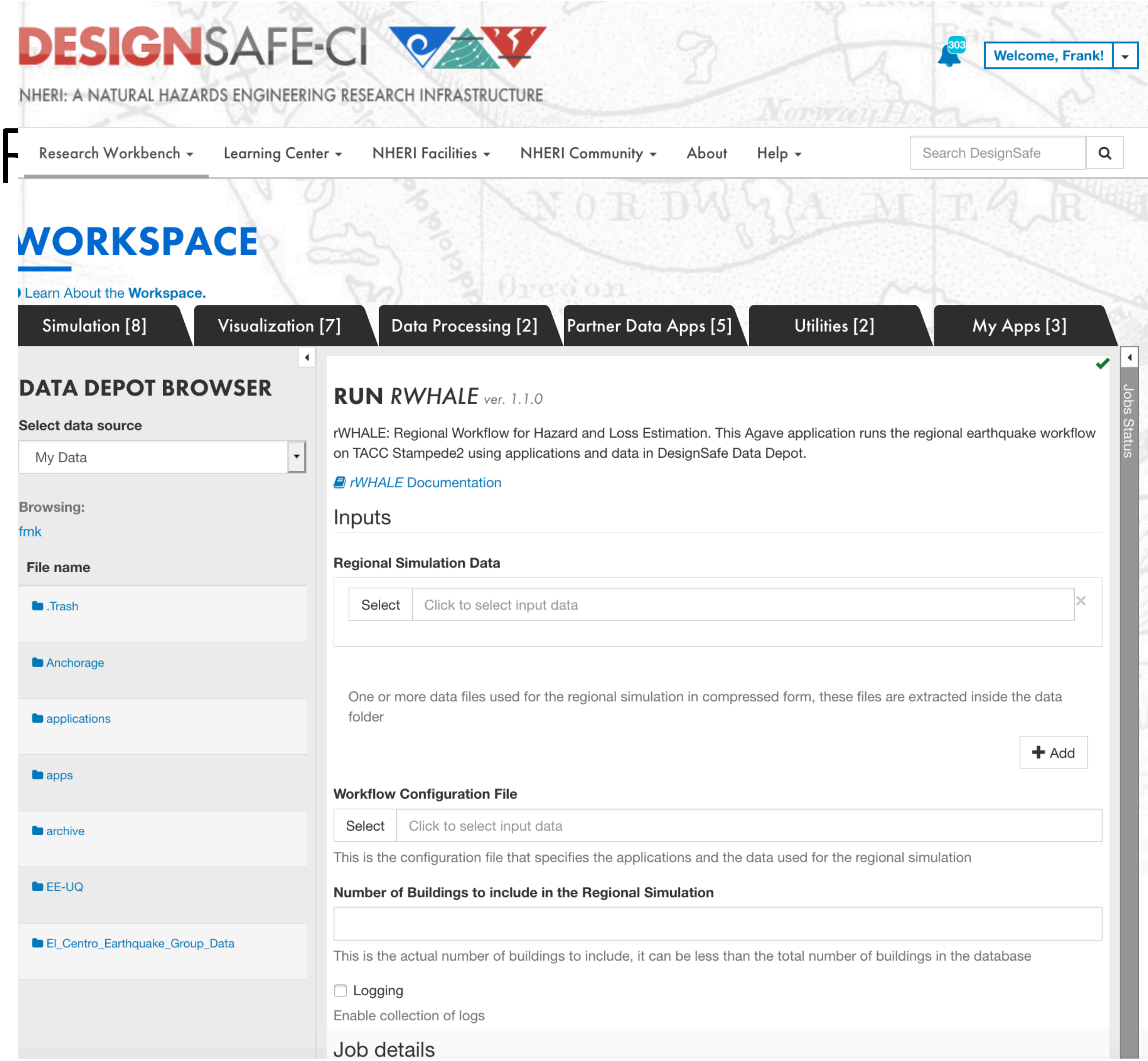
```
conan remote add simcenter https://api.bintray.com/conan/nheri-simcenter/simcenter
conan install ..
```

2. Use CMake to generate the make files

```
cmake ..
```

3. Build the applications using the generated make files

```
make
```


DESIGNSAFE-CI
NHERI: A NATURAL HAZARDS ENGINEERING RESEARCH INFRASTRUCTURE
303
Welcome, Frank!
Research Workbench
Learning Center
NHERI Facilities
NHERI Community
About
Help
Search DesignSafe
WORKSPACE
Learn About the Workspace.
Simulation [8]
Visualization [7]
Data Processing [2]
Partner Data Apps [5]
Utilities [2]
My Apps [3]
DATA DEPOT BROWSER
Select data source
My Data
Browsing:
fmk
File name
.Trash
Anchorage
applications
apps
archive
EE-UQ
El_Centro_Earthquake_Group_Data
RUN RWHALE ver. 1.1.0
rWHALE: Regional Workflow for Hazard and Loss Estimation. This Agave application runs the regional earthquake workflow on TACC Stampede2 using applications and data in DesignSafe Data Depot.
rWHALE Documentation
Inputs
Regional Simulation Data
Select
Click to select input data
One or more data files used for the regional simulation in compressed form, these files are extracted inside the data folder
Add
Workflow Configuration File
Select
Click to select input data
This is the configuration file that specifies the applications and the data used for the regional simulation
Number of Buildings to include in the Regional Simulation
This is the actual number of buildings to include, it can be less than the total number of buildings in the database
Logging
Enable collection of logs
Job details
Jobs Status

Instructions for running on DesignSafe

1. Download files from community data
2. R*eview the files*
3. *Create a directory at DesignSafe in Datadepot*
4. *Start workflow/simulation app rWhale*
5. *add 2 zip files, set input file & set rest of args*
6. *Select RUN*
7. *Wait till finishes and look at csv file*