Rapid Disaster Modelling

Tiegan Hobbs, Drew Rotheram-Clarke, Joost van Ulden (NRCan)

Gurdeep Singh, Evan Timms, Ben Arril (GeoBC)

Yavuz Kaya (MoTI)
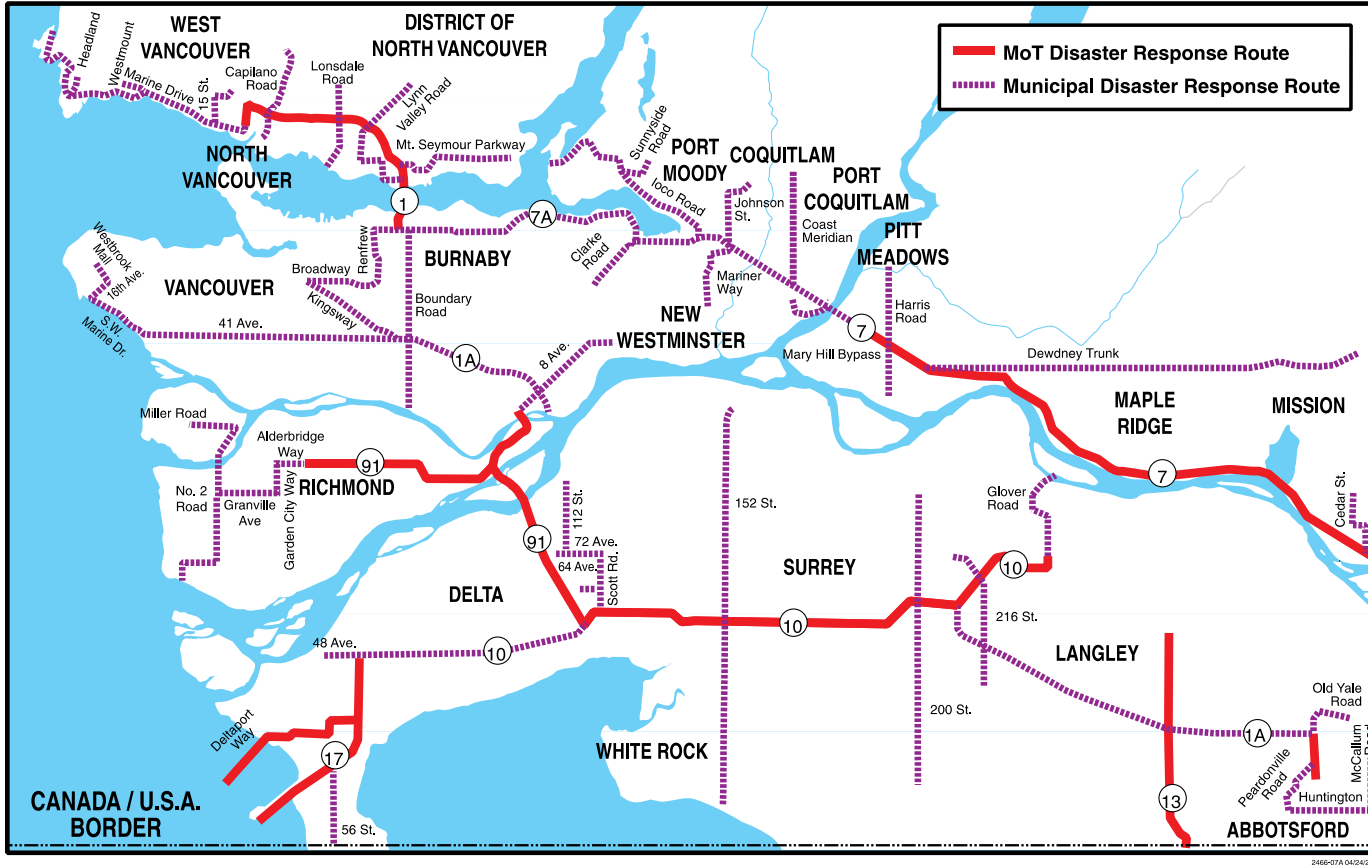
Where will you be?

2011 Christchurch Earthquake

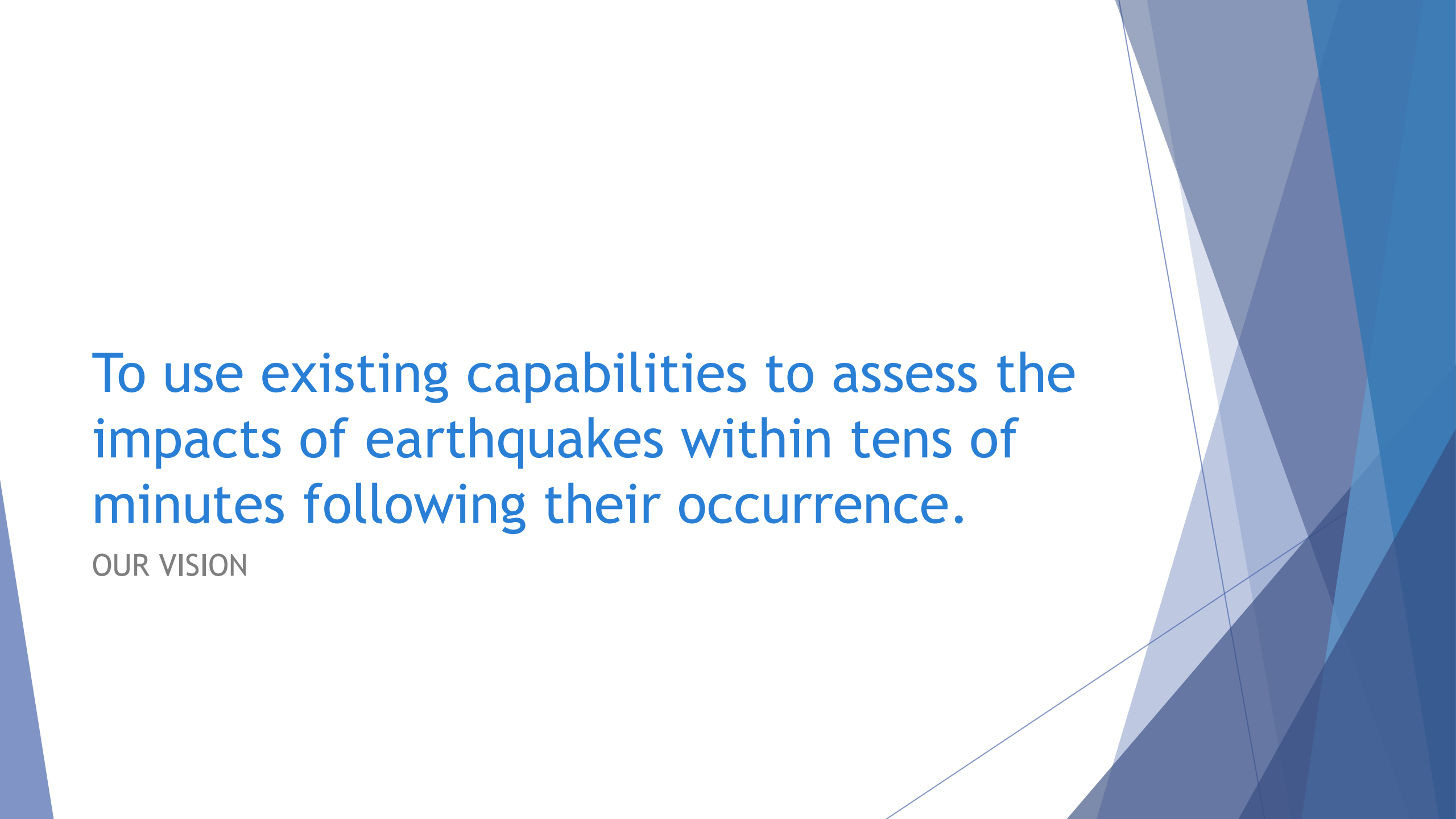# Lower Mainland-Disaster Response Route Network

Join us tomorrow at 9am

https://www.urbc.ca/disastermodellingmethodologyforbc

Rapid Disaster Modelling

Tiegan Hobbs, PhD, MSCE

Geological Survey of Canada

To use existing capabilities to assess the impacts of earthquakes within tens of minutes following their occurrence.

OUR VISION

Motivation

- After the earthquake, it may take hours or days to understand the extent of damage

- BUT we know that we can save more people with timely rescue

Current State

▶ We have rapid information about the shaking after an earthquake

▶ We have information about the building stock, and its vulnerability to shaking

▶ We have a portal to disseminate emergency situational awareness

▶ *Why not combine them?*

Rapid Disaster Modelling Workflow

Retrieve & Reformat ShakeMap from BCSIMS

Calculate Losses, Damages & Consequences

Send Results to Database with REST API Services

GitHub   REST API

Results are pulled by GeoBC's Common Operating Picture

**All triggered by CHIS SOC through Jupyter Notebook Interface**

What you can expect

Within ~ 60 minutes after a major event, you could view estimates of:

▶ Critical injuries and entrapments by Census Dissemination Area (DA)

▶ Economic impact by municipality

▶ Mass care by municipality and neighbourhood

▶ Hospital demand by neighbourhood

▶ Road-blocking debris by DA

What comes next?
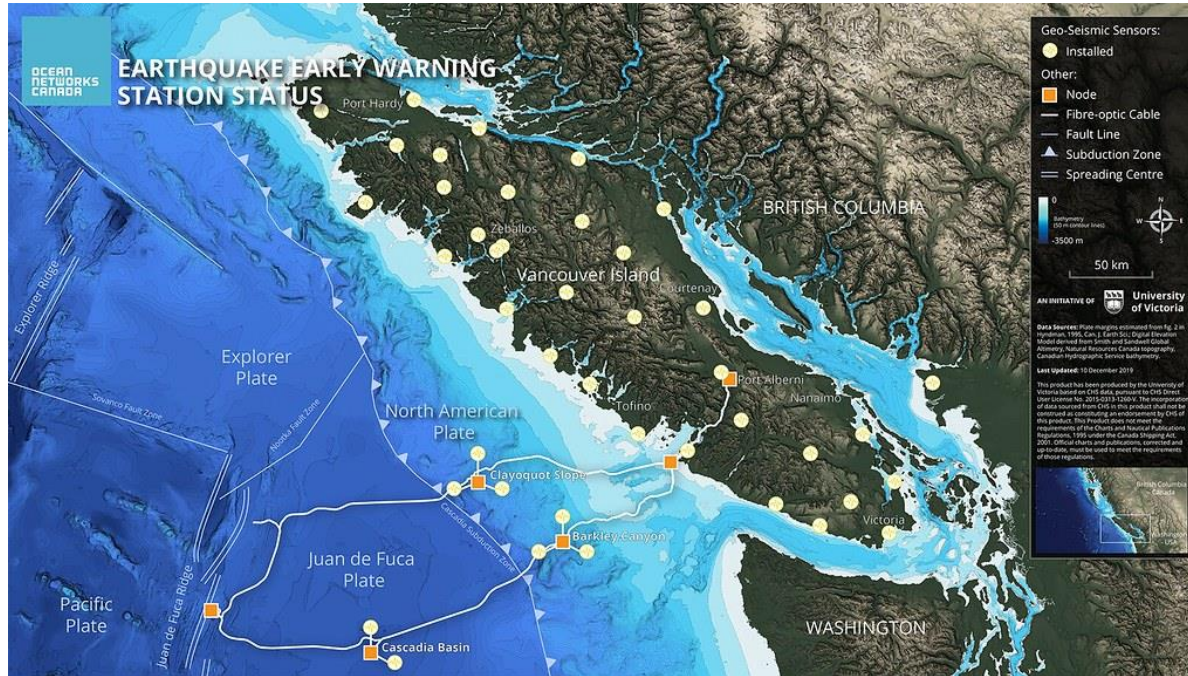
- ▶ Feedback to establish impact, refine approach (today)
- ▶ Implementation within an operational mandate (?)
- ▶ Full implementation of procedure in Jupyter Notebooks & external access (2021)
- ▶ Scaling to national level (2022)
- ▶ Coordination with upcoming Earthquake Early Warning Network (2023+)

What we're doing today

Presentations:

▶ Measuring the Earthquake (Yavuz from MOTI)

▶ Estimating Damage & Automating the Workflow (Tiegan, Drew, & Joost from NRCan)

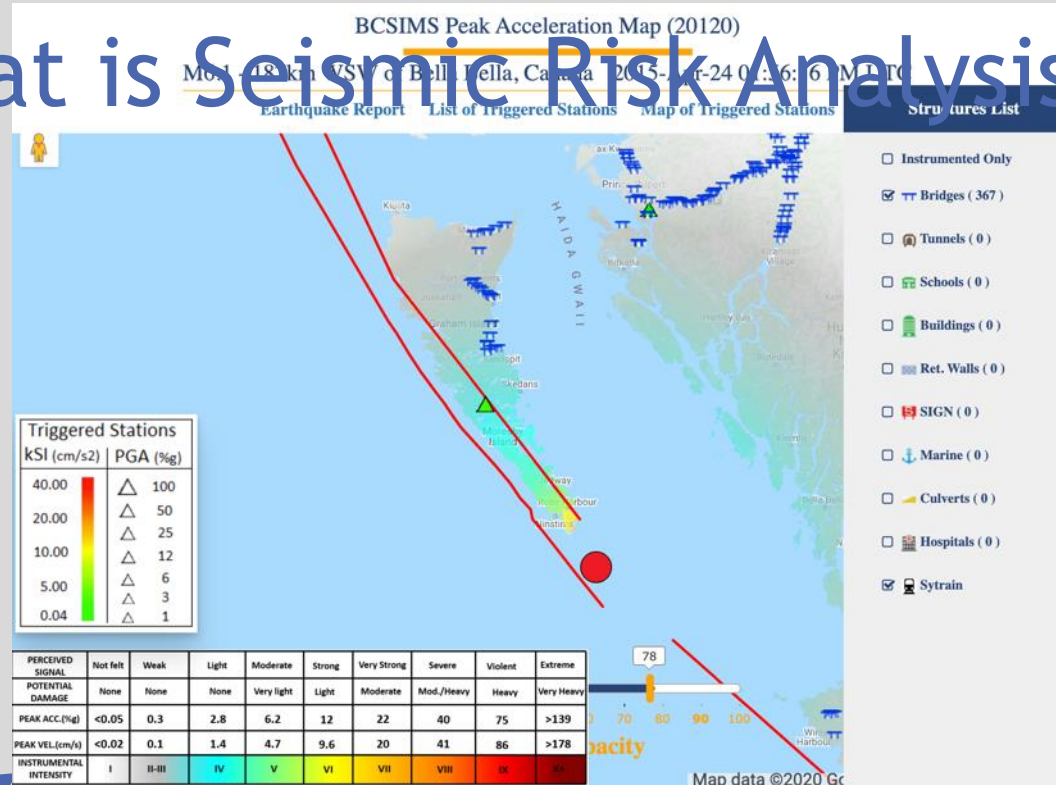▶ Disseminating the Results (Gurdeep & Evan from GeoBC)

Scenario:

▶ Sample data

Discussion:

▶ Give us your feedback!

Using the OpenQuake Engine for Rapid Disaster Modelling

Tiegan Hobbs, PhD, MSCE

Geological Survey of Canada

What is Seismic Risk Analysis?

PHYSICAL SEISMIC RISK

Probability of damage and loss to people and structures due to earthquakes

SEISMIC HAZARD

Probability of ground shaking due to earthquakes

EXPOSURE

Elements at risk

PHYSICAL VULNERABILITY

Vulnerability of structures and their occupants to seismic hazard

PHYSICAL SEISMIC RISK

Probability of damage and loss to people and structures due to earthquakes

SEISMIC HAZARD

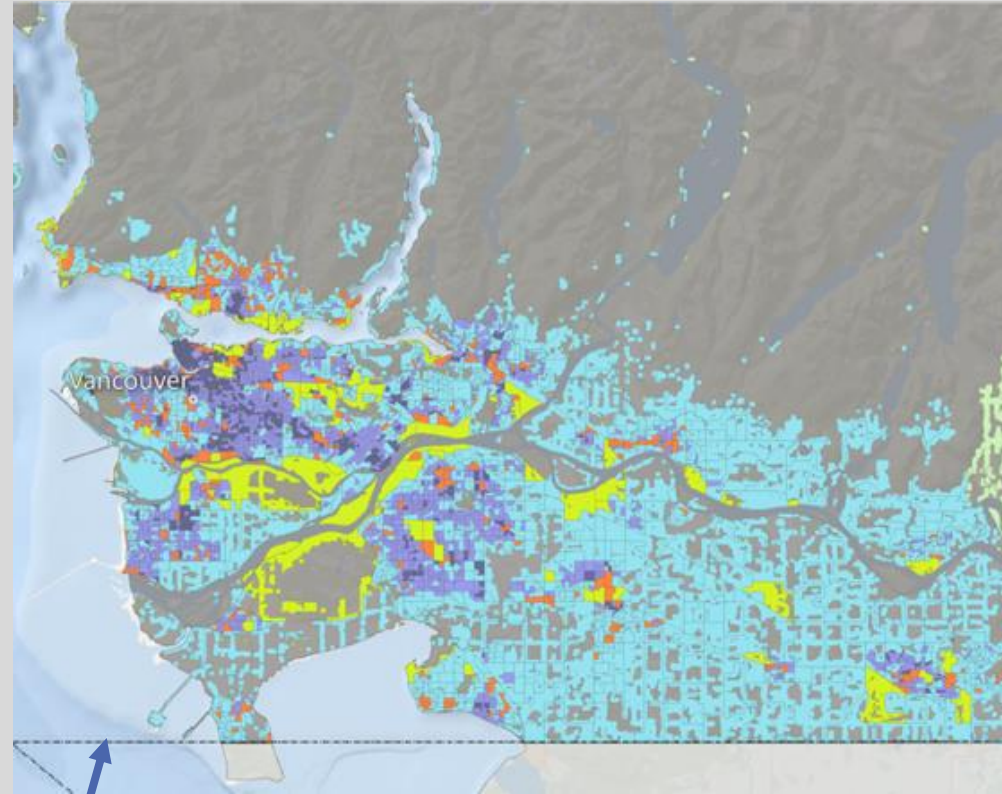Probability of ground shaking due to earthquakes

EXPOSURE

Elements at risk

PHYSICAL VULNERABILITY

Vulnerability of structures and their occupants to seismic hazard

Fragility HAZUS C2M - Moderate code

PHYSICAL SEISMIC RISK

Probability of damage and loss to people and structures due to earthquakes

SEISMIC HAZARD

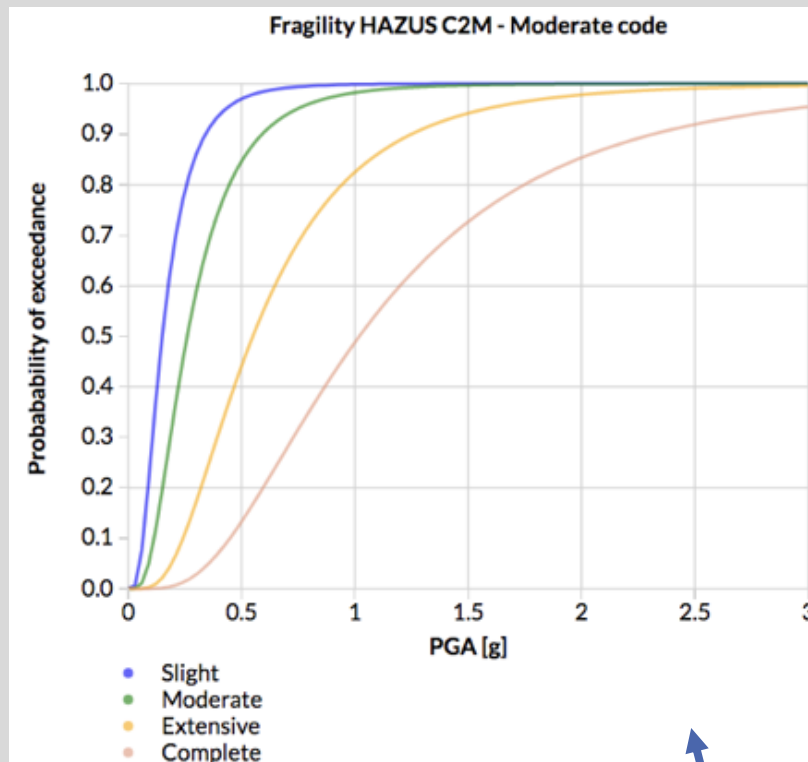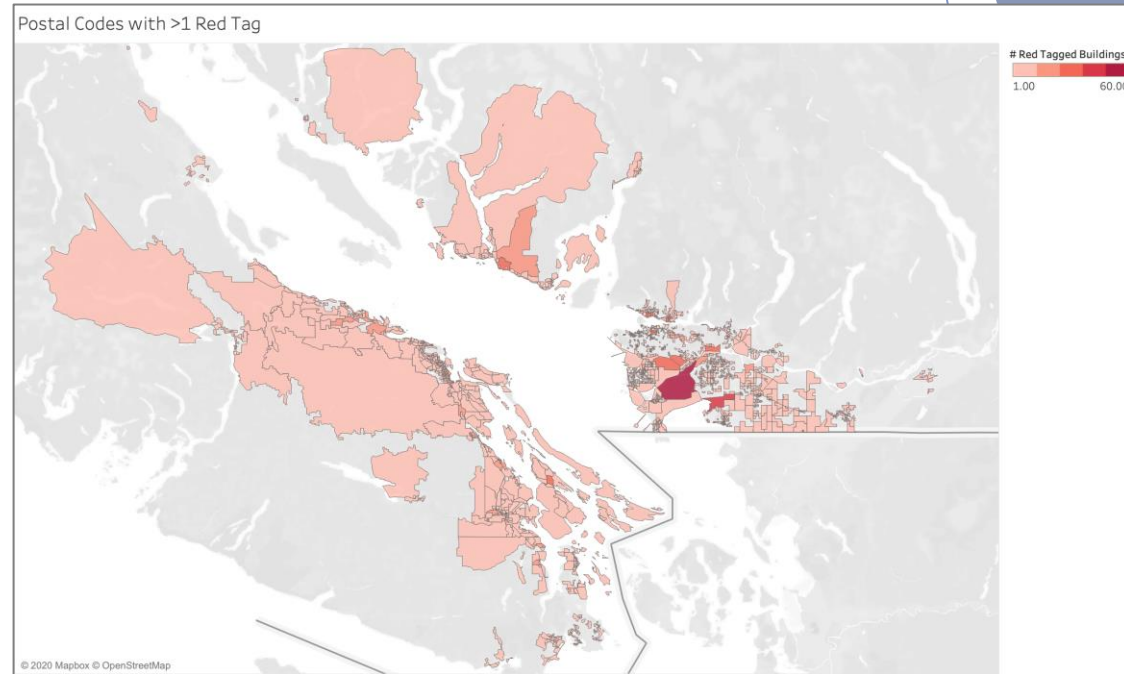Probability of ground shaking due to earthquakes

EXPOSURE

Elements at risk
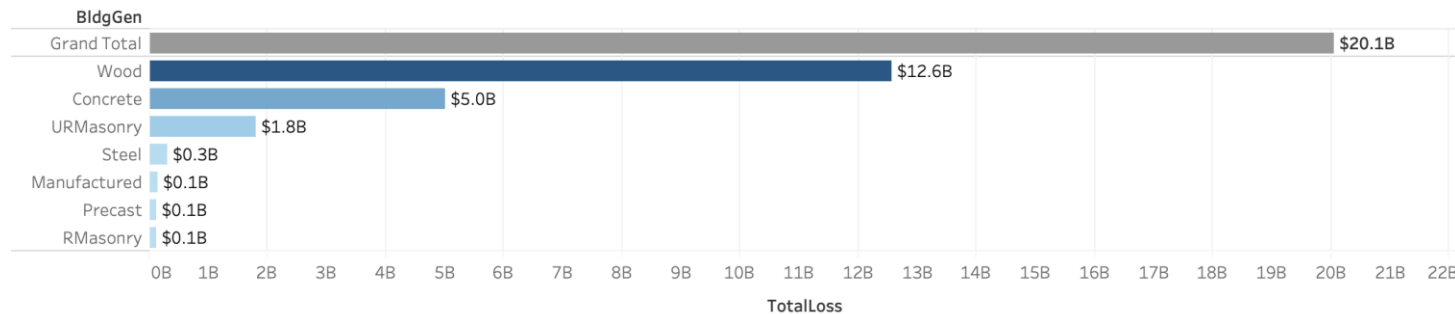
PHYSICAL VULNERABILITY

Vulnerability of structures and their occupants to seismic hazard

Risk Modelling at the GSC

- ▶ We routinely run scenario risk models using the OpenQuake engine

- ▶ The model estimates the damage to the built environment, economic losses, and subsequent impacts to people and businesses

- ▶ Runs take around 4 minutes

- ▶ Results are pushed to GitHub

Postal Codes with >1 Red Tag

Red Tagged Buildings
1.00   60.00

© 2020 Mapbox © OpenStreetMap

Gulf Islands Loss

BldgGen

	TotalLoss
Grand Total	$20.1B
Wood	$12.6B
Concrete	$5.0B
URMasonry	$1.8B
Steel	$0.3B
Manufactured	$0.1B
Precast	$0.1B
RMasonry	$0.1B

0B 1B 2B 3B 4B 5B 6B 7B 8B 9B 10B 11B 12B 13B 14B 15B 16B 17B 18B 19B 20B 21B 22B

TotalLoss

Plan to Operationalize

- Canadian Hazards Information Service (CHIS) has mandate to respond

- Seismologist on Call 24 hrs/day

- Implement workflow in a Jupyter Notebook so little training or additional effort is required

- Spatial data & Totals

Draft of Notebook for Rapid Disaster Modelling (RDM)

Eventually this will be fleshed out to automate the entire process, but for now..

Step 1: Prepare the exposure dataset

```
In [ ]:   source ~/.profile
          oq engine --run initializations/s_preparejob_SMM7p8_HaidaGwaii.ini
```

Step 2: Run the Risk Model & Export

Make sure to change the calculation number to match the previous run.

```
In [ ]:   oq engine --run initializations/s_Risk_SMM7p8_HaidaGwaii.ini --hc 397
          oq export losses_by_asset -1
          mv ./losses_by_asset-rlz-000_399.csv outputs/s_lossesbyasset_SMM7p8_HaidaGwaii_b0_399.csv
```

Step 3: Run Damage & Export

```
In [ ]:   oq engine --run initializations/s_Damage_SMM7p8_HaidaGwaii.ini --hc 397
          oq export dmg_by_asset -1
          mv ./dmg_by_asset-rlz-000_401.csv outputs/s_dmgbyasset_SMM7p8_HaidaGwaii_b0_401.csv
```

Step 4: Run Consequences & Rename

```
In [ ]:   python ../scripts/consequencesShakemap.py -1
          mv ./consequences-rlz-000_401.csv outputs/s_consequences_SMM7p8_HaidaGwaii_b0_401.csv
```
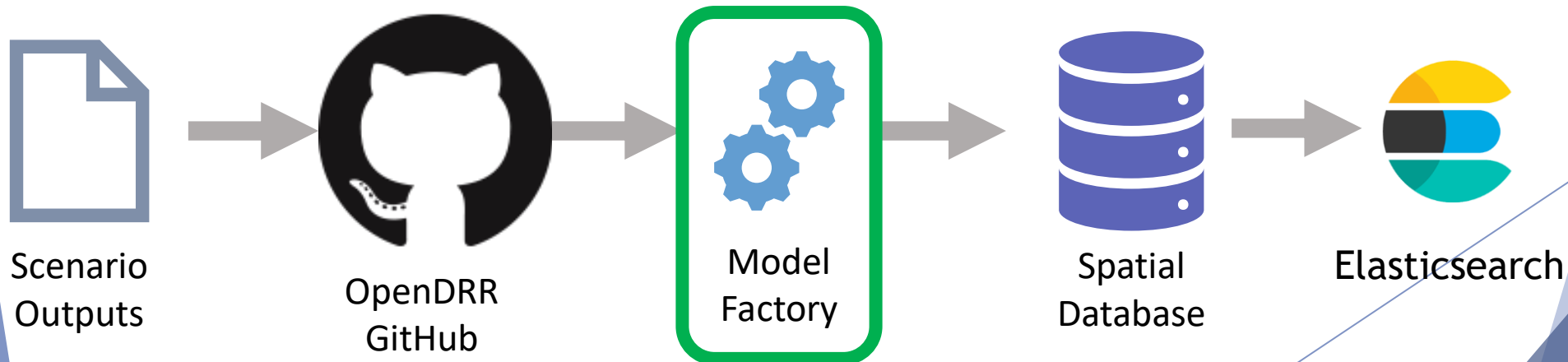
Step 5: Push to GitHub

```
In [ ]:   git commit -m '2012-10-28 03UTC Haida Gwaii Rapid Model'
          git push -u origin master
```

Model Factory

Transform raw earthquake model results into actionable spatial information that can be integrated into a GIS

▶ Process triggered by addition of new scenario outputs added to GitHub

▶ Portable and flexible ETL (Extract Transform Load) processes leveraging Python, SQL and PostGIS

  ▶ Validation of underlying data

  ▶ Data ingest

  ▶ Sendai indicator view generation

  ▶ Index data into API service

  ▶ Aggregated at Neighborhood level

▶ Ongoing development in the open. Source code freely available on Github (https://www.github.com/OpenDRR/model-factory)

Scenario
Outputs

OpenDRR
GitHub

Model
Factory

Spatial
Database

Elasticsearch

Rapid Disaster Model API

Access to near-real-time data using best practices

- Aligned to industry standards
- Scalable architecture hosted on AWS
- Leverage caching for low latency response
- Data will be optimized to support high value queries
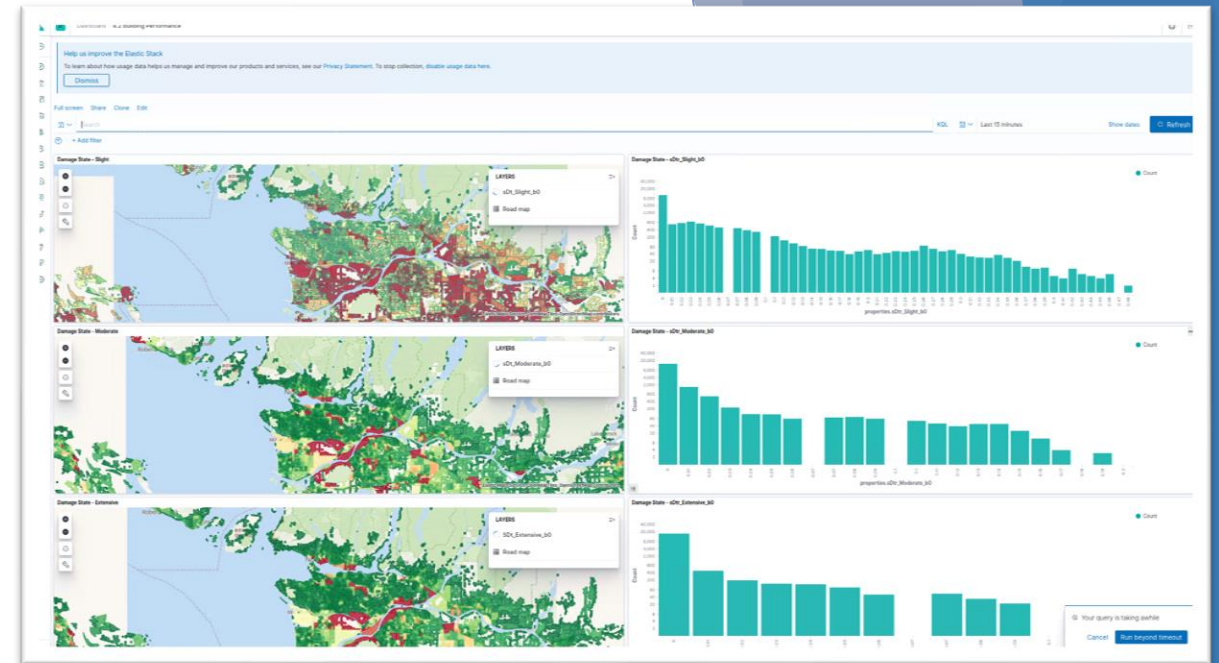- Data provided as SENDAI indicators

COP Portal

REST API

OpenDRR GitHub

ETL Process

Spatial Database

Developer Friendly

Provide multiple points of access to critical data such that it can be integrated into a web applications and desktop GIS

- Developer portal with interactive query builder

- GitHub pages
  - GeoJSON representations of outputs
  - GeoPackage representations available for download
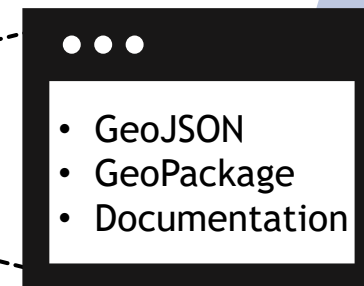 - Scenario documentation

Open API Document
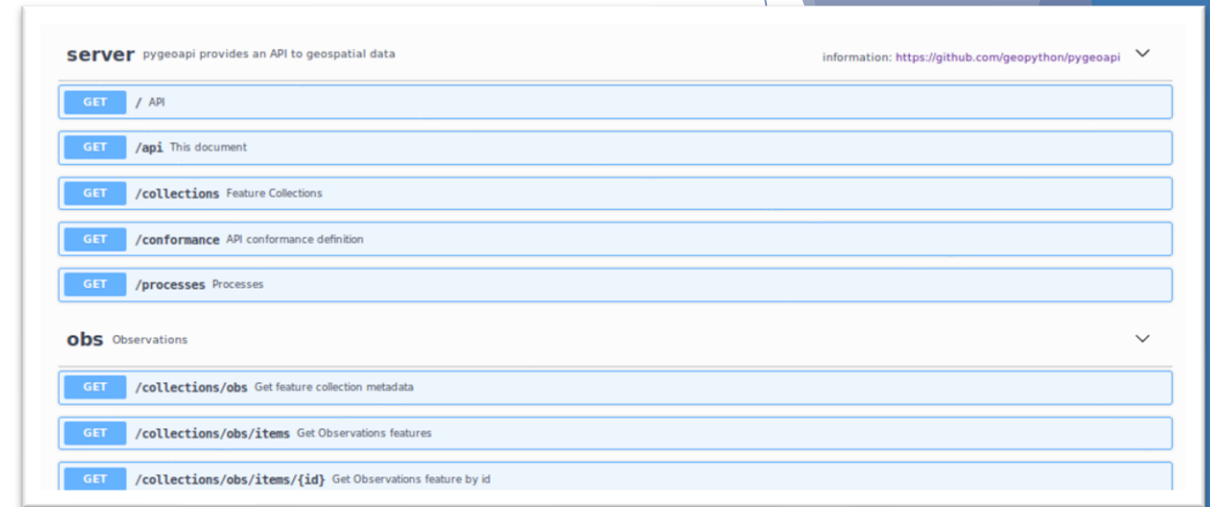
OpenDRR GitHub   GitHub pages

- GeoJSON
- GeoPackage
- Documentation

Deep M$_w$ 6.8 Earthquake

Today's Scenario

If you cannot join us in breakout please provide your thoughts in form below

https://forms.gle/pTR5bbpLE7oVMiNH9