

# Open Science Platform for Disaster Risk Reduction

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# Abstract

This is the abstract.

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## 1. Introduction

A brief introduction to Pathways and the role of the platform in delivering the science outputs. Emphasis on evolving nature of the platform.

## 2. Platform Requirements

To support the Pathways activities a platform with the following features and attributes was required:

- Supports open and collaborative development of science outputs
- Centralizes access to the science outputs
- Provides tools and applications to engage the public and support decision making

### R5 Principles

- Re-runnable (R1)
- Repeatable (R2)
- Reproducible (R3)
- Reusable (R4)
- Replicable (R5)

The generation of science outputs is becoming increasingly reliant on software code to automate processing, quality control, and publishing. Considerable attention was paid to alignment with best practices for Open Science (i.e., FAIR Principles) and scientific software code (i.e., R5 Principles).

## FAIR Principles

- Findable
- Accessible
- Interoperable
- Reusable

The scale and scope of the data involved in the project necessitated an approach that not only streamlined the production of science-based outputs, but also provided for a high degree of collaboration across many disciplines (e.g., policy, technology, and science) and stakeholders (e.g., provincial, municipal).

Decision support requirements were well understood at the outset. A comprehensive set of requirements for a multitude of stakeholders was developed [1: <https://opendrr.github.io/documentation/docs/opendrr-platform.html>]. The diversity of the stakeholders and their specific needs necessitated a multi-channel approach since a single application was deemed to be insufficient to serve all use cases effectively.

With development led out of the Government of Canada the platform had to comply with requirements for publishing science outputs including standardized metadata, open data, support for both official languages, accessibility, and compliance with scientific integrity and publication policies. The scientific integrity and publishing requirements were particularly problematic as they traditionally pushed the development of the science behind closed doors. To comply with policy while supporting the objectives of the project, a balanced approach that prioritizes openness and transparency is needed.

## 3. Overview

GitHub was chosen as the platform to support the development of the science outputs and related software, documentation, and tools. While well known in the software development community, it is lesser-known in the science community. However, the core concepts behind GitHub (e.g., versioning, repositories) were more or less understood by key contributors.

Where possible, runnable code is available to ensure transparency in the science. For example, an interested party could clone a repository and replicate a particular output, e.g., a dataset or even the entirety of the OpenDRR infrastructure. The platform makes heavy use of containerization and infrastructure as code technologies for rapid deployment on personal computing devices or the cloud.

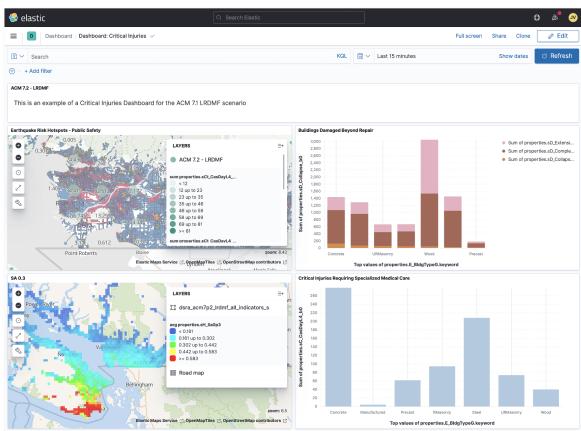
Built-in features of GitHub such as continuous integration and deployment, community building, websites, and secure workspaces are tools for achieving an open and collaborative approach to science, one that seeks to build consensus and drive engagement throughout its lifecycle.

[OpenDRR GitHub] | *opendrr-GitHub-en.png*

*Figure 1. OpenDRR GitHub*

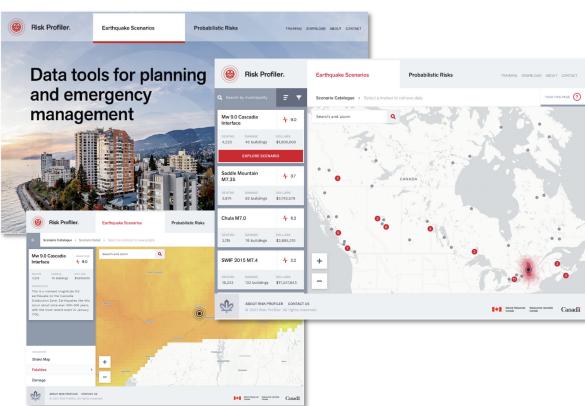
Due to the diversity of use cases and user profiles for the information products (e.g., maps, visualizations), it was clear that a single solution would not be sufficient. It was determined that a purpose-built web application and a dashboard environment would be required to meet the needs of all users.

The dashboard environment, provided by Kibana [2: <https://dashboard.riskprofiler.ca>] connects to an Elasticsearch document store. This environment is highly customizable and allows individuals and organizations to create public or private spaces where they can query and intuitively visualize all available data.



*Figure 2. OpenDRR Kibana*

The purpose-built application, called RiskProfiler [3: <https://riskprofiler.ca>] is a custom web application. Built to be highly scalable and user-friendly, it seeks to communicate the key messages relating to natural hazard risk. It provides basic filtering and visualization in an area of interest, such as a community or region.



*Figure 3. OpenDRR RiskProfiler*

In the initial release, RiskProfiler will focus primarily on earthquake risk, but the intention is to include additional natural hazard risk assessments, e.g., flood, wildfire, landslides, and tsunami.

# 4. Architecture

Brief description of architecture with goals/principles.

Source data for this project includes the National Human Settlement Layers (physical exposure and social vulnerability), the National Seismic Risk model for Canada (CanadaSRM2, probabilistic), Canada's National Earthquake Scenario Catalogue (deterministic), and boundary geometries are stored in the Open Disaster Risk Reduction Platform (OpenDRR) organisation on GitHub.

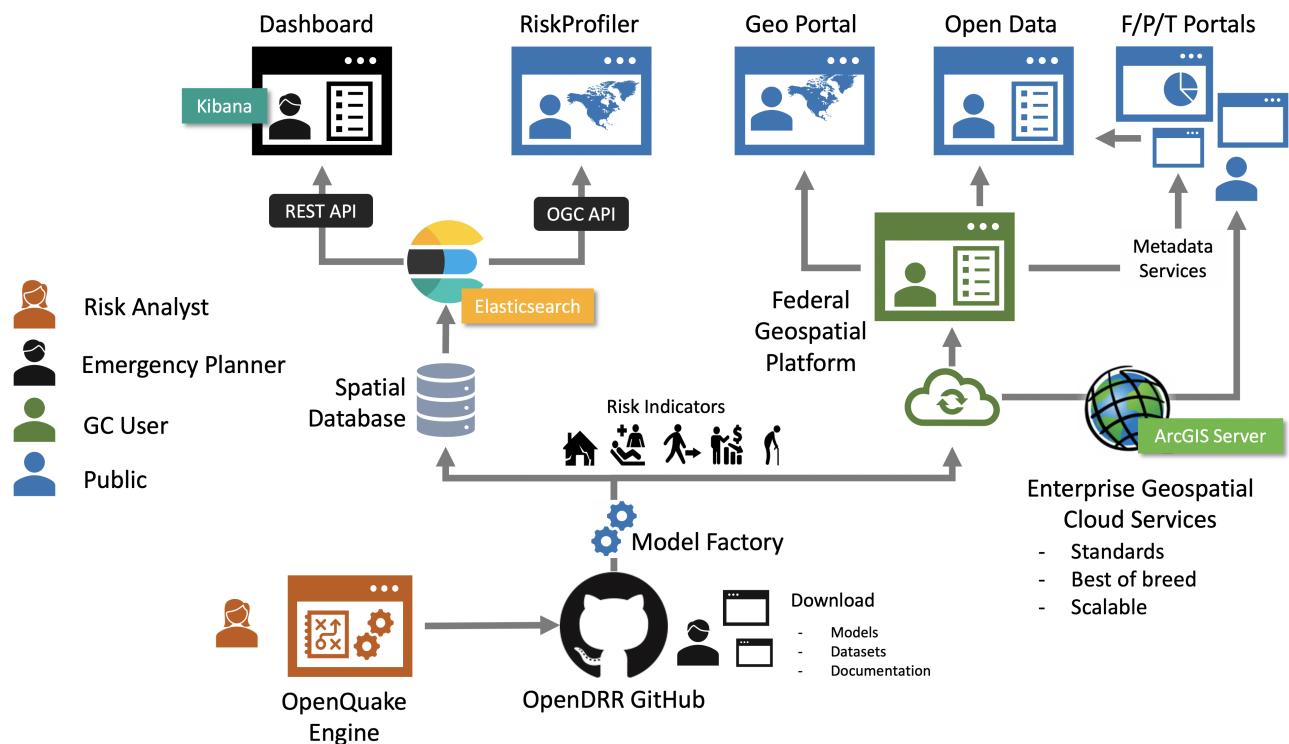


Figure 4. OpenDRR Architecture Overview

## 4.1. Data Processing Pipeline

The OpenDRR platform data processing pipeline is responsible for extracting, transforming and loading (ETL) data. It consists of several open source technologies, namely PostgreSQL with PostGIS extension, Python, ElasticSearch/Kibana, and PyGeoAPI. Each of the applications is containerized using separate Docker containers orchestrated with Docker-Compose.

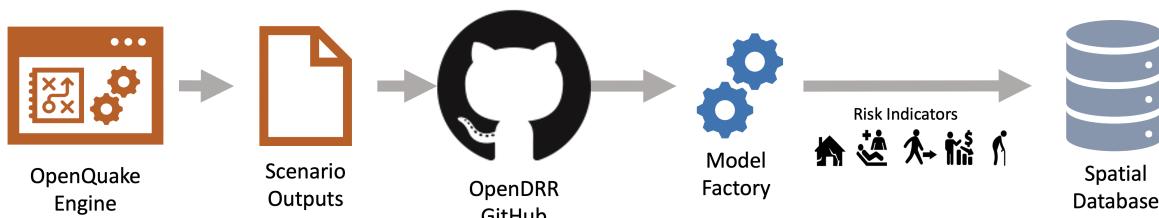


Figure 5. OpenDRR Data Processing Pipeline

The stack of technologies can be configured to run on a local machine with PostgreSQL and ElasticSearch environments running locally or can be configured to communicate with cloud deployments of these services. For example, the stack can be configured to communicate simultaneously with a PostgreSQL database on Amazon Web Services (AWS) Relational Database Service (RDS) and a Containerized ElasticSearch environment on an AWS Elastic Container Service (ECS). A common use case is to run the ETL process on a local desktop or AWS Elastic Compute Cloud (EC2) with a local containerized PostgreSQL environment and a cloud deployed ElasticSearch environment which can support a public or private application programming interface (API).

The ETL process currently relies on a main shell script titled 'add\_data.sh' which downloads the required source data files including comma separated value (csv), and GeoPackages (gpkg) into the local filesystem and performs necessary transformations to load the data into a PostgreSQL database. The script is written to be flexible enough to load any number of conformant deterministic earthquake scenarios and national seismic risk model data? and allows some flexibility in the contents of the input data as long as a minimal number of required fields are present. Once the required source data has been loaded into the database, a number of Structured Query Language (SQL) scripts help transform the data into a framework of meaningful earthquake risk indicators which in turn gets pushed to ES/Kibana ??? .

Discuss the postgresql database? Briefly? Schemas? The PostgreSQL database is created and has PostGIS extension enabled to allow for spatial data queries. The source datas are loaded into their respected schema names and the results are generated into their respected schemas with results\_prefix.????

Results are calculated and/or aggregated at different spatial scales dependent on the data. For National Human Settlement Layers the results are in settled areas. The probabilistic and deterministic data are calculated at the building level and aggregated up to the settled area and census subdivision levels.

These results are aggregated at several different spatial scales, building, sauid, and csd level. The building level is the finest spatial resolution and aggregates all buildings of simmilar construction type for a given neighborhood. The Sauid level of aggregation groups all building types across the whole neighbourhood polygon. The Census Sub-divison (CSD) aggregation is a coarse aggregation of all assets within a given CSD as defined by Statistics Canada.

## 4.2. Data Dissemination

The data dissemination architecture includes API's and applications that are designed to provide mulitple channels for access to scientific datasets and products.

### 4.2.1. GitHub

OpenDRR data products are made available in Geopackage [4: <https://www.ogc.org/standards/geopackage>] (GPKG) format in their respective repositories on GitHub. Datasets can be found in release assets for each release of the product and so they are versioned to ensure that consumers are using the most up to date data.

Checksums are also provided for each file in a dataset, so that consumers can verify the integrity of the data, an important consideration for any data being used to support decision making.

#### 4.2.2. API Stack

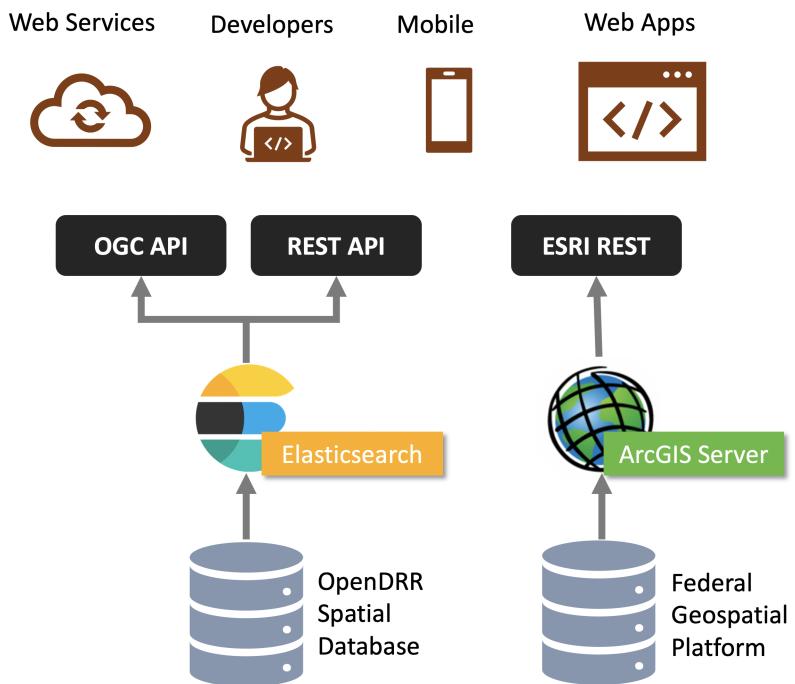


Figure 6. OpenDRR API Stack

The API stack is comprised of three REST endpoints:

##### OGC API - Features

<https://geo-api.riskprofiler.ca>

Complying with Open Geospatial Consortium (OGC) [5: <https://ogcapi.ogc.org/features/>] standards, it provides a geospatial data endpoint for GIS application developers. It is implemented using pygeoapi [6: <https://pygeoapi.io>] deployed in a Docker container. Pygeoapi is connected to an Elasticsearch document store.

A developer portal is provided that can be used to formulate and test queries against the API. At time writing the API supports basic querying due to the evolving nature of OGC API - Features Part 3: Filtering and the Common Query Language (CQL).

**NOTE**

pygeoapi also provides an OGC API - Records [8: <https://ogcapi.ogc.org/records/>] endpoint that is being explored for future use as a metadata API.

##### Elasticsearch

<https://api.riskprofiler.ca>

The Elasticsearch API follows REST [9: <https://www.ics.uci.edu/~fielding/pubs/dissertation/top.htm>] best practices. Configured as a read-only (i.e.: HTTP GET verb) it allows for access to datasets and their properties. Using a proprietary query syntax, developers can issue queries to return summary statistics, geospatial features, and feature properties.

The Elasticsearch API provides data to the Kibana dashboard application [10: <https://dashboard.riskprofiler.ca>]. Developers can set up an account in the Kibana dashboard where query formulation and testing tools are provided.

## Esri

The Federal Geospatial Platform (FGP) is a Government of Canada clearing house for geospatial data. The FGP provides enterprise grade geospatial infrastructure and support services to facilitate the dissemination of data. OpenDRR datasets are hosted on the FGP and made available via Esri REST services for organisations that utilize Esri based tools and applications.

# 5. Lessons Learned

## 5.1. Working in the Open

Working in the open is standard practice in the software community, but this is not the case in the scientific community. Despite many science-based institutions promulgating FAIR [11: link-to-FAIR-Principles] and Open Science [12: link-to-Open-Science], they largely ignore the very principles upon which these are based. Instead of working in the open from the outset, science continues to be carried out behind closed doors until such time that a final product is formally published.

The science-based organisation under which the OpenDRR platform is being developed decided to take a more liberal approach, open by default but closed where required. Unfortunately, internal policies regarding Open Science were not yet fully developed so the default approach was to do much of the actual science modeling and development in private repositories until peer review can be completed. An unfortunate consequence of misguided but well-intentioned policies (e.g.: NRCan's Scientific Integrity Policy).

While not ideal, the platform did demonstrate that peer-review of science using GitHub was tractable. Transparency in the science that informs government policy is an important part of any democracy, and so the platform will continue to aspire towards a future where policy-driven decisions are supported by data that is aligned with the principles of FAIR and Open Science.

- (May seem scary at first?) but many benefits
- full openness, transparency, accountability
- GitHub platform offers a lot of features and flexibility that we need
- Industry best practices
- Mutually beneficial relationship with GEM (OpenQuake)

- pygeoapi
- etc.

## 5.2. Continuous Integration

Usage of CI (e.g.: GitHub Actions) to generate release assets, do QA, and run data processing scripts.

## 5.3. Security

Example: Apache Log4j vulnerability

Built-in features in GitHub helped to ensure that code was secure and up to date (e.g.: dependabot).

- We got confirmation from ITSEC that our ES endpoint was attacked. Since we were running 7.12.0 the attack failed. Lesson: keep your software up to date. (Credit: Joost,)
  - [Mitigate Log4j2 / Log4Shell in Elasticsearch](#)
- (a little bit about) keeping up-to-date vs. compatibility-breaking changes (e.g. Python 3.8 to 3.9); be prepared for extra work hours (manpower?) to resolve compatibility issues during upgrade...

## 5.4. The Software Development Lifecycle

Agile works for software but not so well with science!

## 5.5. Github restrictions on file size

The file size restrictions imposed by the GitHub platform were an issue for some repositories.

## 5.6. [optional] opendrr.github.io got falsely flagged as phishing or malicious

- CIRA, Google, VirusTotal; took a while to get off e.g. Microsoft SmartScreen
- Possibly due to the use of non Canada.ca template on a non .ca domain?
- <https://github.com/OpenDRR/opendrr/issues/122>

# 6. Future Development

## 6.1. Risk Profiler (v1)

- Expected to be published before April 2022 (kudos to [HabitatSeven](#))

## **6.2. Increase in scope: Import and process other datasets besides earthquake**

- Flood: <https://github.com/NRCan/CanFlood> (Open-source flood risk modelling toolbox)
- Wildfire
- Mudslides

## **6.3. Continued automation, optimization, etc.**

- Increased use of GitHub Actions workflows
- Full CI (Continuous Integration, Continuous Delivery)
- Cost-savings (e.g. move off Git LFS wherever possible; cheaper alternatives...)
- More automated testing, to catch errors as early as possible (preferably at the pull request stage)
- Test-driven development (TDD) / Behaviour driven development (BDD)?

## **6.4. Promote the project**

- as a model with example that other groups (countries/governments/companies etc.) can use
- (as open-source project) invite participation from open-source, scientific community, and the general public
- through web site(s), seminars/talks, publications

## **6.5. More...**