

# KnowWhereGraph

## Overview & Step-by-Step Examples

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### 1. Introduction

The KnowWhereGraph (KWG) is an openly accessible, W3C-standards-based geographically enriched knowledge graph, with associated tools for representing, exploring and visualizing a growing list of human and environmental data. With sophisticated search capabilities and seamless access to numerous public datasets, KWG rapidly raises the situational awareness of data scientists and decision makers by providing detailed area briefings for any place on Earth within seconds.

KWG incorporates custom ontologies and uses a hierarchical grid for spatial representations. As of April 2022, its size exceeds 12 billion information triples with over 100 classes representing observations of natural hazards (e.g., hurricanes, wildfires, smoke plumes), spatial characteristics related to climate (e.g., temperature, precipitation, air quality), soil properties, crop and land-cover types, demographics, human health, and others (Table 2, [The KnowWhereGraph Schema](#)).

Two main application areas serve as testbeds for KWG: humanitarian disaster relief, and food-related supply chains, including agricultural land use. With guidance from humanitarian organization Direct Relief, we are developing tools to give their responders rapid access to area briefings following a disaster. These include information on previous disaster events, physical properties of the affected regions such as climate variables, medical and transportation infrastructure, and socio-economic and health characteristics of the human populations affected. In addition, KWG can recommend medical and other experts who are likely relevant to a particular disaster response effort by leveraging schema connections between disasters, types of expertise, and places.

In partnership with the Food Industry Association (FMI), we are using KWG to connect data related to climate, soil properties, crop and land-cover types, disasters and other topics that are traditionally siloed. One key goal is to enhance strategic planning during disasters by providing online analysis, forecasting, and alerts to ensure key stakeholders throughout the supply chain are ready with backup strategies to keep products moving. KWG can also help farmers and growers to identify mitigation strategies and build resilience in the face of such events.

The project is funded by the National Science Foundation as part of its Convergence Accelerator program. The team includes members from academia (University of California, Santa Barbara; Kansas State University; Michigan State University; Arizona State University; University of Southern California), the nonprofit sector (Direct Relief); industry (Esri; Oliver Wyman; Hydronos Labs), and the US federal government (US Geological Survey; US Department of Agriculture).

For further information, see

- [Know, Know Where, KnowWhereGraph: A Densely Connected, Cross-Domain Knowledge Graph and Geo-Enrichment Service Stack for Applications in Environmental Intelligence \(AI Magazine, March 2022\)](#)
- [KnowWhereGraph Drives Cross-Domain Knowledge \(ArcUser, Spring 2021\)](#)

## 2. The Graph

The semantic backbone of the KWG graph is the [KnowWhereGraph Schema](#), which describes concepts of individual domain datasets as extensions of concepts from open standard ontologies, namely SOSA, GeoSPARQL, and OWL-Time. The main goals of this schema is to connect previously isolated datasets and establish cross-dataset interoperability. For example, it connects data characterizing a hurricane's trajectory and wind speed with data quantifying human and property damage. We accomplish this by modeling hazard events and environmental observations, as well as their connections via place and time. Thanks to support from [Ontotext](#), the graph is currently served on an endpoint supported by [GraphDB Enterprise](#).

For general purposes, the graph can currently be accessed in two ways:

- Direct query using the SPARQL query language ([Section 3](#))
- Browsing via the Knowledge Explorer semantic browsing tool ([Section 4](#))

### 3. Example SPARQL Queries

To query the graph directly using the SPARQL query language, visit the KWG endpoint: <https://stko-kwg.geog.ucsb.edu/sparql> (KWG repository). Below we provide several example competency questions and their corresponding SPARQL queries. The questions were developed in consultation with our partners in the fields of agriculture, disaster response, and natural resource management. Similar queries are saved in the KWG endpoint as examples:

The screenshot shows the GraphDB Enterprise interface. On the left is a sidebar with icons for Import, Explore, SPARQL (which is highlighted in red), Setup, and Help. The main area is titled "SPARQL Query & Update". A code editor window titled "Unnamed" contains the following SPARQL query:

```
1 select * where
2   ?s ?p ?o
3 } limit 100
4
```

To the right of the code editor is a box containing four competency questions (E1-E4) and their descriptions:

- E1: Show me all Disaster/Hazard Types represented in KWG.
- E2: Show me all Hurricane Events in KWG from 2000-2004 that affected New Orleans.
- E3: How many Experts are documented in the KWG?
- E4: Show me all California wildfires that happened in 2020 or later.

On the far right, there are several orange icons: a folder, a link, a double arrow, and a circular nodes icon. At the bottom right of the interface is a red "Run" button and a "keyboard shortcuts" link.

#### 3.1. Show all Hazard types represented in KWG.

```
## Show all Hazard types represented in KWG.

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
SELECT DISTINCT ?type ?label where {

  ?type rdfs:subClassOf kwg-ont:Hazard.
  ?type rdfs:label ?label .

}
```

### 3.2. Show all fire events in KWG from 2010-2020 that affected New Orleans.

```
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX kwgr: <http://stko-kwg.geog.ucsb.edu/lod/resource/>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX time: <http://www.w3.org/2006/time#>
PREFIX sosa: <http://www.w3.org/ns/sosa/>
PREFIX elastic: <http://www.ontotext.com/connectors/elasticsearch#>
PREFIX elastic-index: <http://www.ontotext.com/connectors/elasticsearch/instance#>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
SELECT DISTINCT ?fire ?description ?type ?startTime ?endTime WHERE {

    ?search a elastic-index:kwg_fs_index;
        elastic:query "Orleans";
        elastic:entities ?fire.
    ?fire rdf:type ?eventType;
        rdfs:label ?description;
        sosa:isFeatureOfInterestOf ?observationCollection.
    ?eventType rdfs:subClassOf ?superClass;
        rdfs:label ?type.
    values ?superClass {kgw-ont:Fire}
    ?observationCollection sosa:phenomenonTime ?time.
    ?time time:hasBeginning/time:inXSDDateTime|time:inXSDDate ?startTime;
          time:hasEnd/time:inXSDDateTime|time:inXSDDate
?endTime.
    FILTER (?startTime > "2010-01-01"^^xsd:date && ?endTime > "2010-01-01"^^xsd:date &&
"2020-01-01"^^xsd:date > ?startTime && "2020-01-01"^^xsd:date > ?endTime)
}

}
```

### 3.3. Show all counties that were affected by Hurricane Katrina.

```
## Show all counties that were affected by Hurricane Katrina.

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX gnis: <http://gnis-ld.org/lod/gnis/ontology/>
PREFIX geo: <http://www.opengis.net/ont/geosparql#>
PREFIX gn: <http://www.geonames.org/ontology#>
PREFIX usgs: <http://gnis-ld.org/lod/usgs/ontology/>
PREFIX xsd: <http://www.w3.org/2001/XMLSchema#>
PREFIX sosa: <http://www.w3.org/ns/sosa/>
PREFIX time: <http://www.w3.org/2006/time#>
SELECT DISTINCT ?county ?countyDescription ?time where {

    ?track rdf:type kwg-ont:StormTrack;
        rdfs:label ?stormName;
        kwg-ont:hasStormTracklet ?tracklet.
    ?tracklet kwg-ont:sfWithin ?county.
    ?county rdf:type kwg-ont:AdministrativeRegion_3;
        rdfs:label ?countyDescription.
    ?oc sosa:hasFeatureOfInterest ?tracklet;
        sosa:phenomenonTime ?time.
    ?time time:inXSDgYear ?year.

    FILTER regex(?stormName, "^KATRINA")
    FILTER (?year = "2005"^^xsd:gYear)

}
```

### 3.4. How many experts are documented in KWG?

```
## How many experts are documented in KWG?

PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX iospress: <http://ld.iospress.nl/rdf/ontology/>
SELECT (COUNT( DISTINCT ?expert) as ?count) {

    ?expert rdf:type iospress:Contributor.
    ?expert rdfs:label ?label.
    ?expert kwg-ont:hasExpertise ?expertise.
    ?expertise rdfs:label ?expertLabel.

}
```

*3.5. Show experts and their affiliations who have publications on hurricane-related topics.*

```
## Show experts and their affiliations who have publications on hurricane-related topics.

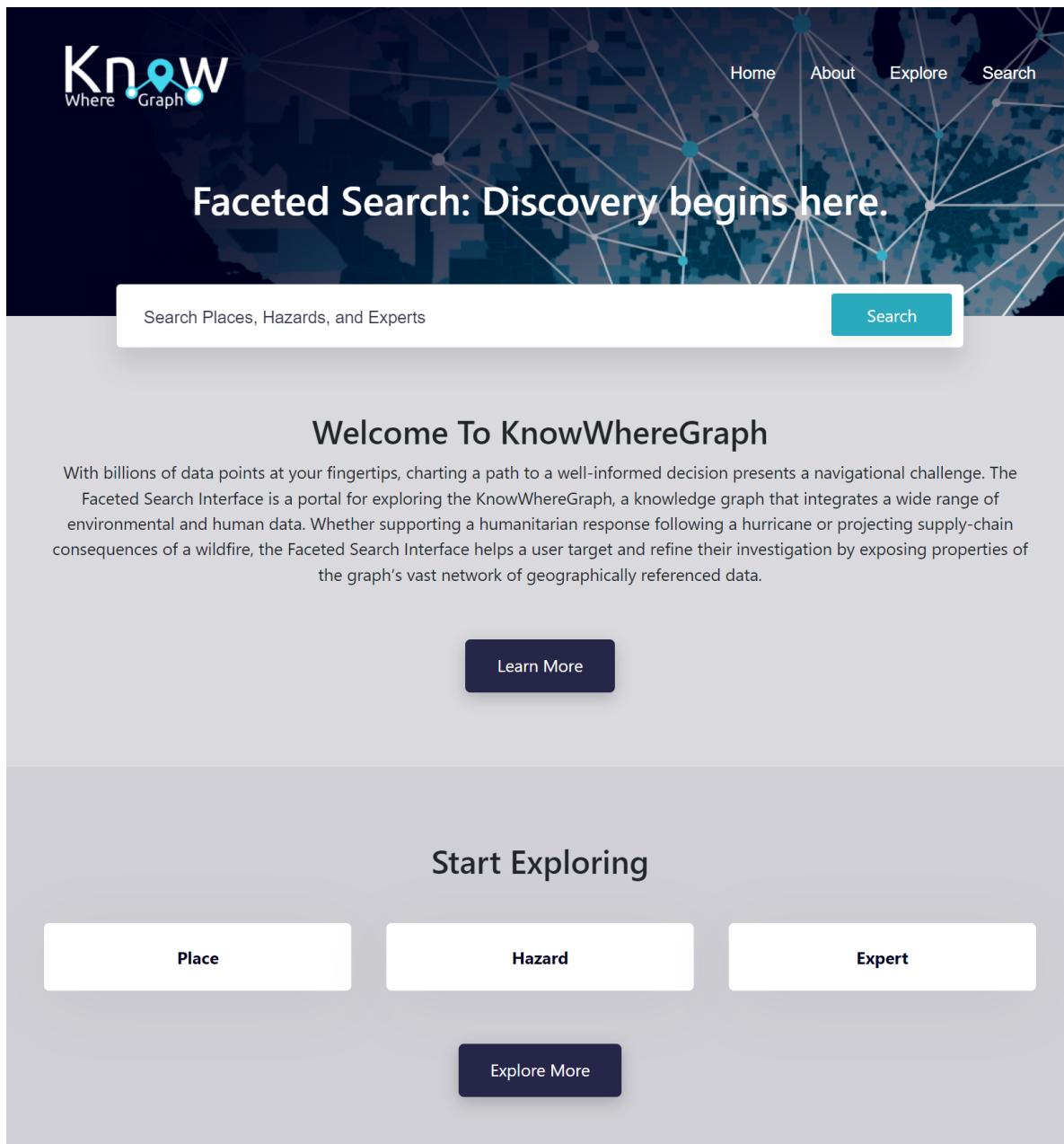
PREFIX rdf: <http://www.w3.org/1999/02/22-rdf-syntax-ns#>
PREFIX rdfs: <http://www.w3.org/2000/01/rdf-schema#>
PREFIX kwg-ont: <http://stko-kwg.geog.ucsb.edu/lod/ontology/>
PREFIX iospress: <http://ld-iospress.nl/rdf/ontology/>
SELECT ?expert ?label ?expertiseTopicLabel ?organization ?orgName WHERE {

    ?expert rdf:type iospress:Contributor;
            rdfs:label ?label;
            kwg-ont:hasExpertise ?expertise;
            iospress:contributorAffiliation ?organization.
    ?expertise rdfs:label ?expertiseTopicLabel.
    ?organization iospress:organizationName ?orgName.
    FILTER regex(?expertiseTopicLabel, "^\u00c9Hurricane")}

}
```

#### 4. The Knowledge Explorer

Access the main landing page of the Knowledge Explorer at <https://stko-kwg.geog.ucsb.edu/#/>:



#### 4.1. Explore by Place

After clicking the [Place button](#), enter a place name, like *Louisiana*, into the keyword search box. The results of your query will appear in the place search interface:

Louisiana

PLACE

Feature Type

Built Up Area ✓  
 Surface Water ✓  
 Terrain ✓

Administrative Region  
[Find an Administrative Region...](#)

Zip Code  
[Find a Zip Code...](#)

FIPS Code  
[Find an FIPS Code...](#)

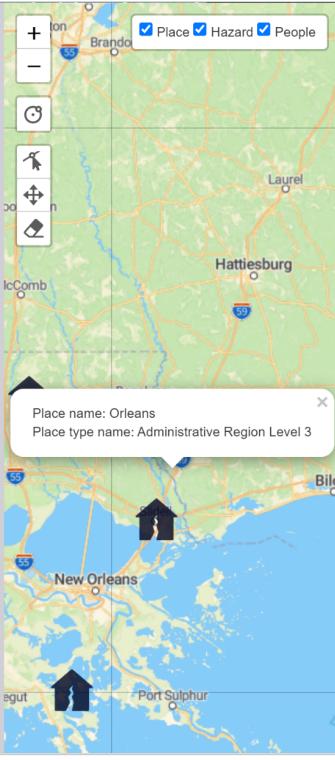
US Climate Division  
[Find a US Climate Division...](#)

National Weather Zone  
[Find a National Weather Zone..](#)

**15 Records**

Place  Hazard  People

Name	Type
Louisiana	Administrative Region Level 2
Lafayette	Administrative Region Level 3
Lafourche	Administrative Region Level 3
Orleans	Administrative Region Level 3
Ouachita	Administrative Region Level 3
Rapides	Administrative Region Level 3
Tangipahoa	Administrative Region Level 3
Terrebonne	Administrative Region Level 3
Bossier	Administrative Region Level 3
Livingston	Administrative Region Level 3



Place name: Orleans  
Place type name: Administrative Region Level 3

The interactive map at right shows the geographic locations associated with the results listed in the center pane. Clicking on a marker displays information associated with it. In the left pane, one can further refine the search by checking the boxes next to the desired feature type and/or entering a ZIP code, climate division, etc., to constrain the search to a specific geographic region.

Selecting one of the results in the center pane (e.g., *Orleans*) brings you to the phuzzy.link interface of the Knowledge Explorer, which lists entities and the predicates that relate them to the selected result:

The screenshot shows the phuzzy.link interface with the search term "Orleans" entered. At the top, there is a map of the New Orleans area with a blue outline highlighting the entity. Below the map is a sidebar with zoom controls (+, -) and the text "Leaflet". The main content area displays a list of predicates for the entity "Orleans", each with a corresponding colored square icon:

- rdf:type** → ■ Administrative Region
  - Administrative Region Level 3
  - Region
  - Feature
  - Spatial Object
  - Feature Of Interest
- rdfs:label** → "Orleans"
- geo:hasDefaultGeometry** → ■ kwgr:geometry.multipolygon.North\_America.United\_States.USA.19.36\_1
- hasGeometry** → ■ kwgr:geometry.multipolygon.North\_America.United\_States.USA.19.36\_1
- sosa:isFeatureOfInterestOf** →
  - Public Health Observation Collection for County Orleans in LA for the year 2017
  - Public Health Observation Collection for County Orleans Parish in Louisiana for the year 2017
  - Social Vulnerability Observation for County Orleans in LA for socialVulnerabilityIndex for the year 2018
- is hasFeatureOfInterest of**
  - Public Health Observation Collection for County Orleans in LA for the year 2017
  - Public Health Observation Collection for County Orleans Parish in Louisiana for the year 2017
  - Social Vulnerability Observation for County Orleans in LA for socialVulnerabilityIndex for the year 2018
- ago:geometry** → ■ kwgr:geometry.multipolygon.North\_America.United\_States.USA.19.36\_1

Scrolling down the page and clicking on an entity, e.g., *Ray Abrams Elementary School (historical)*, calls up its associated entities and predicates. You can continue to browse the structure and contents of the graph by clicking on links in this “follow your nose”-style search.

## 4.2. Explore by People

To see the types of information in the graph related to a particular person, select the [People tab](#) of the Knowledge Explorer's faceted search page. To find experts in a particular topic, filter the results by expanding and selecting expertise topics in the left-hand pane:

Keyword search... Search

**EXPERTISE**

Expert Topic(s)

- Business & Management
- Topic ▾
- Disease-Related Topic ▾
  - Acute Respiratory Disease
  - African Trypanosomiasis
  - Amoebiasis
  - Anthrax
  - Avian Influenza
  - Beriberi
  - Cancer
  - Cardiovascular Disease

**15 Records**

Place Hazard People

Name	Affiliation	Expertise	Place
J. Zhang	University of Miami, NOAA AOML Hurricane research division	Cancer, Cardiovascu... Disease	Miami-Dade
E. Ford	Division of Adult and Community Health, National Center for Chronic Disease Prevention and Health	Cancer, Cardiovascu... Disease	Jackson

Expert name: J. Zhang  
Affiliation name: University of Miami, NOAA AOML Hurricane research division  
Expertise name: Cancer, Cardiovascular Disease  
Place name: Miami-Dade

Map showing the locations of Miami, Homestead, Kendall, Hialeah, and Boynton Beach.

#### 4.3. Explore by Hazard

To browse information on documented wildfires, hurricanes and other hazard events, select the [Hazard tab](#) on the faceted search main landing page. View particular hazard events (e.g., *Earthquake, Fire*) that affected particular places and feature types (e.g., *Airport, Bridge*), by expanding the drop-down menus and selecting the desired filter criteria.

Louisiana

PLACE

Feature Type

- Built Up Area ▾
  - Airport
  - Arch
  - Bar
  - Bridge
  - Building
  - Canal
  - Cemetery
  - Church
  - Crossing
  - Dam

United States ▾

Zip Code

FIPS Code

US Climate Division

National Weather Zone

**20+ Records**

Place  Hazard  People

Name	Type	Place	Start Date	End Date
Marine Thunder...	Wind	Occurred in COASTAL WATERS FROM PORT FOURCHON LOUISIANA TO LOWER ATCHAFALAYA RIVER	2010-08-22	2010-08-22
NOAA	Marine	LOUISIANA OUT 20 NM at 2016-05-20T05:35:0535, CST		
PORT FOURC...	Thunder...	Hazard type name: NOAA Marine Thunderstorm Wind Event		
TO LOWER	Wind Event	Place name: Start date name: 2016-05-20T05:35:00+06:00		
ATCHA...	RIVER	End date name: 2016-05-20T05:35:00+06:00		
LOUISIA...	OUT 20 NM at 2010-08-22-1740, --			

Place  Hazard  People

The map displays a coastal area with several buildings. A specific location is highlighted with a green circle and a white crosshair. Labels on the map include "Halliburton Slip", "16th Street", and "A.J. Estay Road". A legend on the right side of the map interface shows icons for place, hazard, and people, with all three checked.